Software

Z E T L A B

User manual

LLC “ETMS”.01000-01 34 PO

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Contents

Introduction

This document is an operator manual for work with ***ZETLab*** software. It contains necessary information on the software and its operation procedures.

A single instruction manual may be issued for batches of analyzers up to 10 pcs.

Introduction

ZETLab software is for equipment operation and has the following features:

- ✓FFT Spectrum (of even frequency) analysis;
- ✓construction of spectrograms and transit characteristics for the frequency components;
- ✓Multi-channel oscilloscope;
- ✓signal settings calculation and display; RMS, peak value, frequency, and phase;
- ✓registration of digitized signal long implementation;
- ✓listening of input and recorded signals using a sound card;
- ✓generation of signals of various form and duration;
- ✓graphical display of processing results on the screen;
- ✓spectrum analyzer operation mode control using a mouse, keyboard, sensor screen;
- ✓graphical data copying;
- ✓storing obtained data in digital form on magnetic media and CDs.

Note. The manufacturer reserves the right to make minor changes and improvements to the software, which do not impair the technical specifications, without reflecting such changes and improvements in this operator manual.

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Please notify us using any communication of your convenience on any issues and faults occurring during ZETLab software installation and operation.

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About ZETLAB

ZETLAB software is a virtual laboratory that provides the user with powerful tools for visualization, spectral analysis and measurement of electrical parameters, Signals generator, Signal recording and Play recorded signal.

ZETLAB virtual instruments are designed to solve measurement and control problems in the field of seismic, vibration, thermometry, strain gauge, etc. Programs from the ZETLAB package process signals received on the input channels of spectrum analyzers, seismic stations, strain gauge stations, ADC / DAC boards, smart sensors, etc.

ADC programs (section "Measurement") and DAC programs (section "Signals generator") form the base of the ZETLAB virtual laboratory, on which more complex devices are built (sections "Metrology", "Automation").
The set of supplied ZETLAB programs depends on the type of device used:

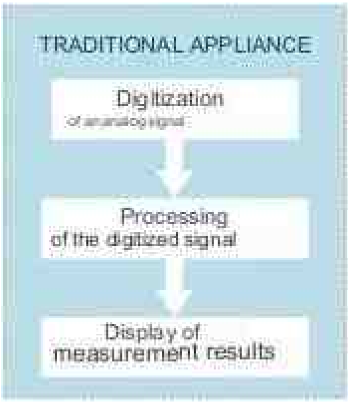
-
- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT Spectrum software
- ZETLAB VIBRO – shaker control systems software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software (option).

In the description of each program in the section "Supported equipment and input data" there is a list of devices with which the program is supplied in the basic configuration or as an option.

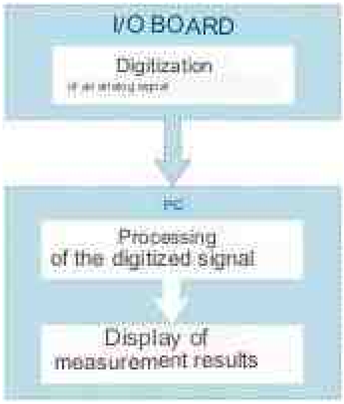
About virtual Instruments

The concept of virtual instruments

The times when measuring systems consisted of many devices and occupied entire laboratories are a thing of the past. Power and availability of modern computers allow them to be used to implement algorithms embedded in traditional devices. Thus, the role of the measuring device is reduced to the digitization of signals, and their processing and displaying the results on the screen is carried out by software:



Structural scheme of an autonomous measuring device



Structural scheme of the virtual instrument

Benefits of virtual Instruments

Since the functional characteristics of a system built on the basis of virtual instruments are determined by software, a simple ADC / DAC board can be a voltmeter, an oscilloscope, a generator, a strain gauge, and any other device at the same time, saving the user's workspace and funds.

Replacing real devices with virtual ones

The use of ADC / DAC modules and laptops with software equivalent to an entire measurement laboratory has greatly expanded the possibilities of measurements in the field.

The use of wireless communication technology between the data digitizer and the computer makes it possible to carry out measurements on moving structural elements. For example, the set of ADC/DAC board + Wi-Fi or Bluetooth module is installed on a moving part (on a rotating shaft of a slowly rotating turbine, on a car), and a PC is installed at a distance of up to 500 m (depending on the supplied antenna) on a fixed area.

Digitization of signals can be carried out offline with recording to a flash drive, and processing - after transferring the recorded signals to a PC. In addition to the actual signal values, for example, the coordinates of the device location can be recorded. When using cartography programs, it is possible to recreate the trajectory of the object during the experiment, simultaneously observing the position of the object and its parameters in each time count.

Separation of hardware and software resources made it possible to build distributed measuring systems. The data collection nodes contain ADC/DAC boards that are connected to the computer via Ethernet lines. With synchronization of devices via GPS and/or GLONASS, signals from all boards enter the computer in a single stream and are processed simultaneously.

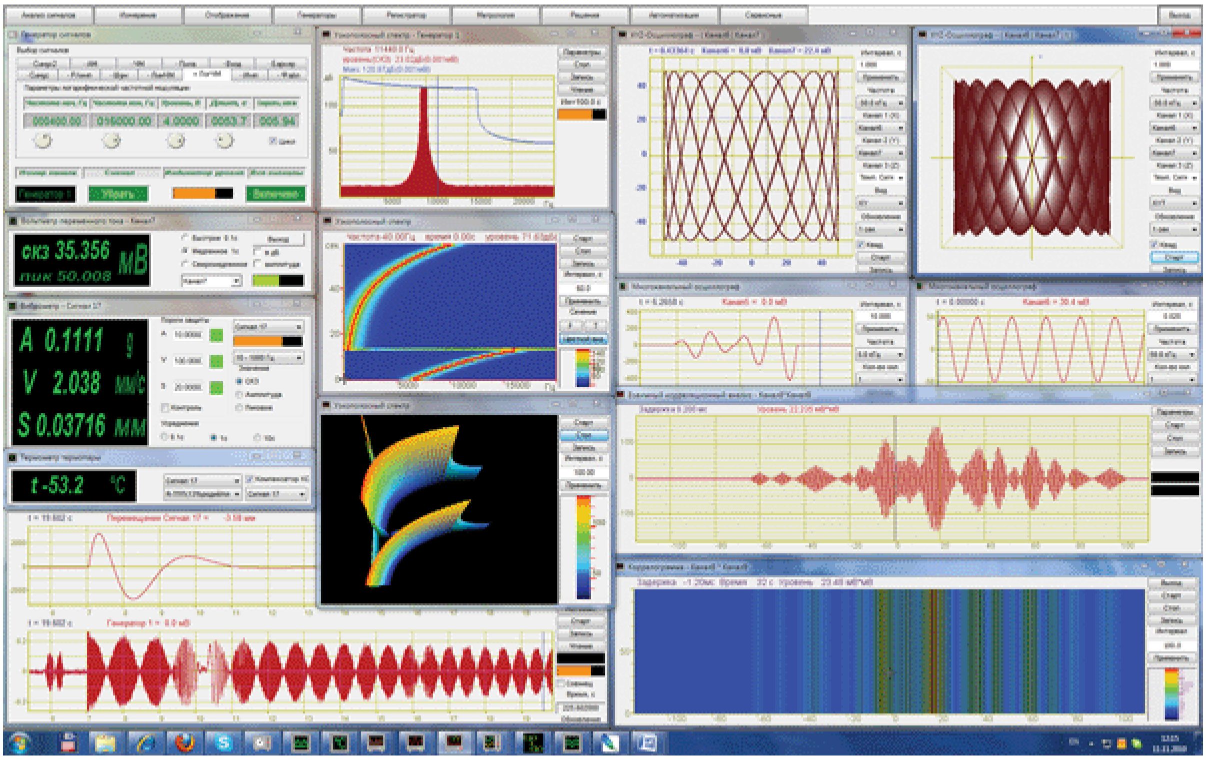
The development of the concept of virtual instruments opened a new stage in the creation of automated systems. The use of object-oriented application software allows you to create unique applications with an analysis system and work scenarios not only for programmers, but, for example, for technologists.

Thus, the following advantages of virtual instruments can be distinguished:

- cost savings saving space in the lab
- parallel analysis of multiple parameters
- expansion of areas of application: in the field, measurements on moving structural elements, offline
- building multichannel distributed systems
- simplification of the creation of automated systems.

ZETLAB virtual instruments

The ZETLAB software is a virtual laboratory of more than 50 instruments. All devices are divided into groups according to their purpose: analysis, measurement, display, generators, etc. Various ADC/DAC devices are supplied with various software packages corresponding to their purpose and characteristics.



Virtual laboratory ZETLAB

Also, **ZETLAB** programs differ in the level of complexity. For example, a voltmeter has only three options: an averaging time switch, a switch to display results in dB, a switch for measuring RMS or peak value. While the generator implements 12 different types of signals, ranging from sinusoidal and impulse, and ending with Barker codes, each of which has its own parameters.

In addition to basic devices such as a voltmeter, generator, etc., ZETLAB provides powerful signal processing tools. The Formula program alone implements dozens of mathematical and measuring functions, contains more than 20 types of filters and allows you to work with both raw and processed signals.

In **ZETLAB**, data can be analyzed in parallel by several programs, in addition, programs can use each other's measurement results. For example, a digitized signal may first be filtered, after which calculations are made, and the final result is displayed on a graph in two or three dimensions.

The **ZETLAB** software also includes solutions such as frequency response measurement with feedback, a regulator, an event detector, which use the results of measurements of some programs (for example, a voltmeter, a thermometer) in their work, while controlling devices connected to a PC using other programs (e.g. generator, switching unit).

Installing and upgrading software and drivers

This section provides information about the latest features of **ZETLAB** software products, known problems and their possible solutions, as well as recommendations and assistance on their use of **ZETLAB** software products.

Hardware requirements

ZETLAB software is developed to be used on PC-s of IBM PC Intel® Pentium®/Celeron®/ type or any other compatible russified or localized OS versions:

- Microsoft® Windows® 10 64 bit.
- Microsoft® Windows® Server 2016 64 bit;
- Microsoft® Windows® Server 2019 64 bit;
- Microsoft® Windows® Server 2022 64 bit.

PC configuration for installation and start of ZETLAB software and devices drivers:

- Dual or more core processor;
- Processor speed - over 1,6 GHz;
- HighSpeed USB 2.0* interface;
- RAM – more than 8 Gb;
- Hard disk free space – more than 20 Gb;
- videocard with 3D-graphical acceleration, support of OrenGL, DirectX, memory - over 1 GB;

- display resolution 1920Ч1080;;
- mouse or any other pointing device (touch screen, track ball, TouchPad, graphic pad);
- standard keyboard or any other input device (sensor screen, graphic pad);
- CD-ROM for software installation.

ZET devices support HighSpeed USB 2.0 interface only. However, it is possible to connect ZET device to PC via USB 3.0, in the case if controller bus is compatible with USB 2.0 interface (e.g., NEC controllers).
Note: currently there may occur mistakes in the course of Asmedia USB 3.0 controllers use (during driver installation error message "10" is displayed). In this case, it is recommended to use USB 2.0 bus for connection to PC.

In the case if industrial PC-s are used for operation on ZETLAB and ZETVIEW software, we recommend to use 64-bit OS Windows.

When using industrial computers to work on them in ZETLAB and ZETVIEW, we recommend you to use the 64-bit version of Windows.*Equipment ZET interface only supports USB 2.0 HighSpeed. But ZET

devices can be connected to a PC via USB 3.0, if the controller of this bus is backward compatible with USB 2.0 interface, such as controllers NEC.
Note: at the moment when working with USB 3.0 controllers Asmedia production problems can occur (if the driver installation, an error occurs with the code "10"). In this case, we recommend to use for PC connection USB 2.0.

When using industrial computers to work on them in ZETLAB and ZETVIEW, we recommend you to use the 64-bit version of Windows

ZETLab software installation

ZETLab software installation

Installing devices designed as a card .....

Attention! Devices designed as a card and PC components contain statics-sensitive elements. Prior to card device installation to the PC, make sure the PC has been powered off and disconnected from the power grid. Use a grounded sleeve when installing card devices to a PC. If such a sleeve is unavailable, touch with both hands a reliably grounded object or a metal object, e.g., the power supply unit casing. Hold the devices to be installed on their edges only and do not touch the circuitry, outputs, and printed conductors. Failure to follow the above requirements may result in serious damage to the mother board and card devices.

Install card devices only when the PC power has been turned off, in the following order:

- disconnect power supply cable from the PC;
- remove the side cover from the computer case;
- find a free PCI slot and make sure that access to it is not obstructed with cables or other components;
- remove the metal blank plank corresponding to the selected PCI slot for installation;
- align the gilded contacts of the card device with the PCI bus slot, insert one end into the slot and press slightly. Then press on the other side of the device to secure the device in the PCI bus slot;
- using a supplied screw fasten the installation plank of the device to the back panel of the computer case;
- place back the side cover from the computer case;
- connect power supply cable from the PC.

Problem with the Drivers .....

When using industrial computers to work on them in ZETLAB and ZETVIEW software, we recommend using a 64-bit version of Windows.

in Windows 10 OS .....

When installing ZETLAB software on Windows 10

In new versions of Windows 10, the requirements for digitally signing kernel-mode drivers have been tightened. If earlier it was enough to sign them yourself with a trusted certificate, now it is necessary that the signature be affixed by Mi Corporationcrosoft.
We have already started the driver certification process with Microsoft, but this may take some time.
For a temporary solution, you can download and install **previous driver version**, since such requirements are not imposed on certificates issued before July 29, 2015. Before installation, it is recommended to close all ZETLAB software programs and disconnect ZETLAB devices from the PC.

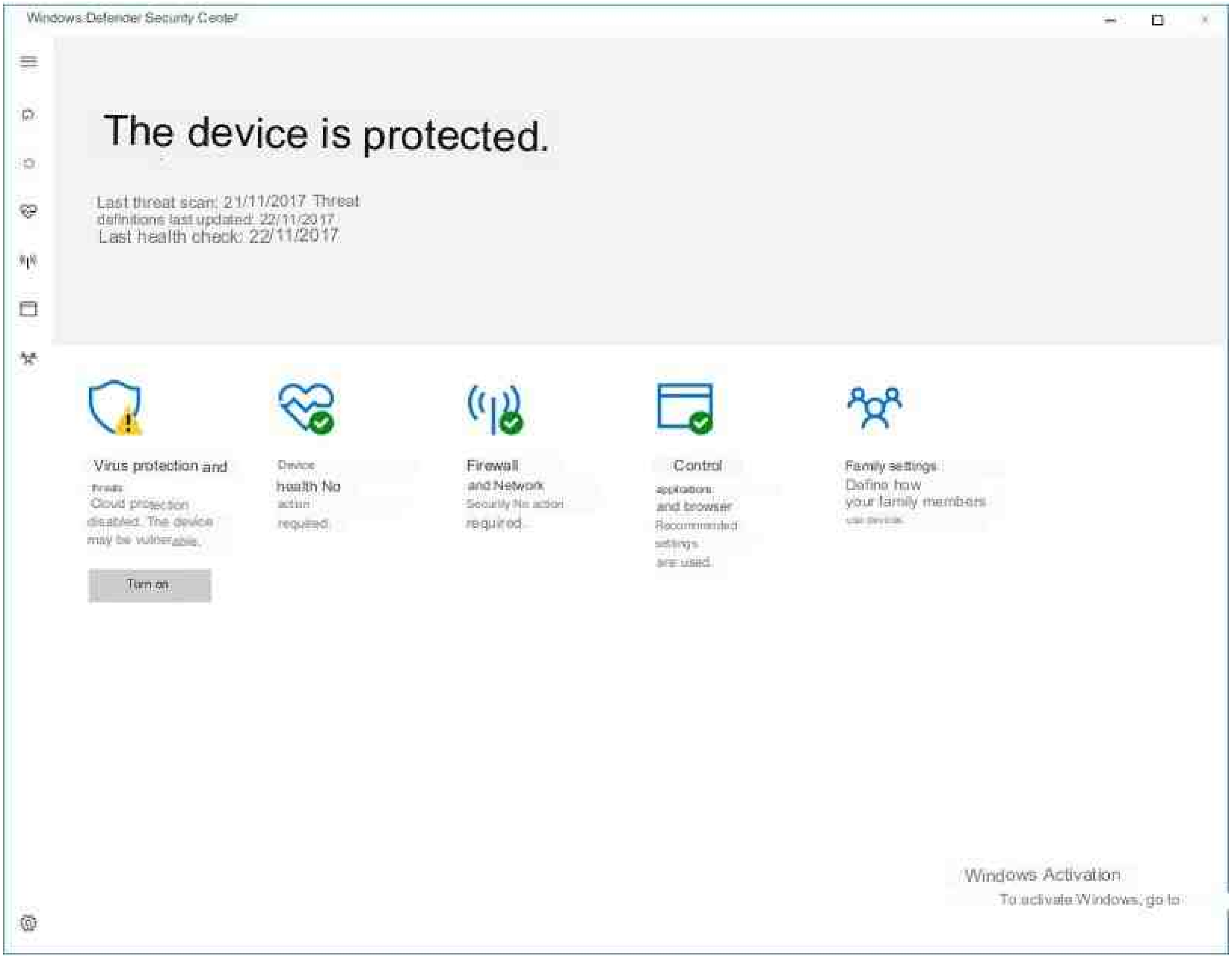
If you have any doubts, you can check the digital signature using Explorer by selecting one of the files (for example, "C:\ZETLabdriverszetusb64.cat" or "C:\ZETLabdriversamd64Kdu8500.sys") and opening its Properties. If you continue to install the drivers (click "Install this driver anyway"), they will work correctly, no warnings will appear. But it is still recommended to install updates for Windows 10.

Software troubleshooting .....

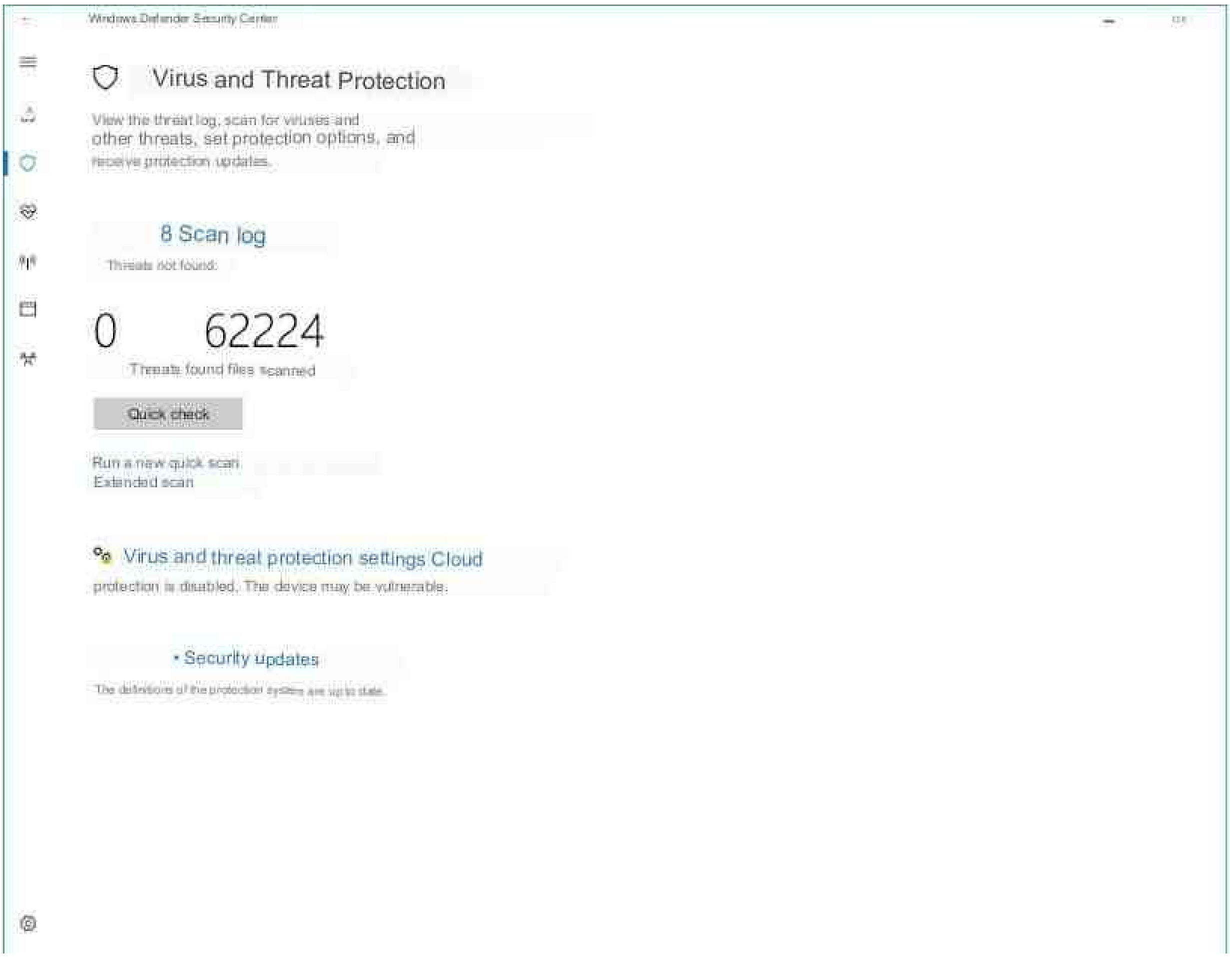
Troubleshooting when working with ZETLAB software

During the operation of some programs from the ZETLAB software, a large number of files are created that may cause antivirus suspicions. He will check them, which will affect the process of creating files and the operation of the program. To increase the speed of saving graphs and program operation, add the folder where saving is made to the antivirus exclusion. The solution to the problem is shown on the example of "Windows Defender".

- •Open Windows Defender and navigate to the Virus & Threat Protection section.

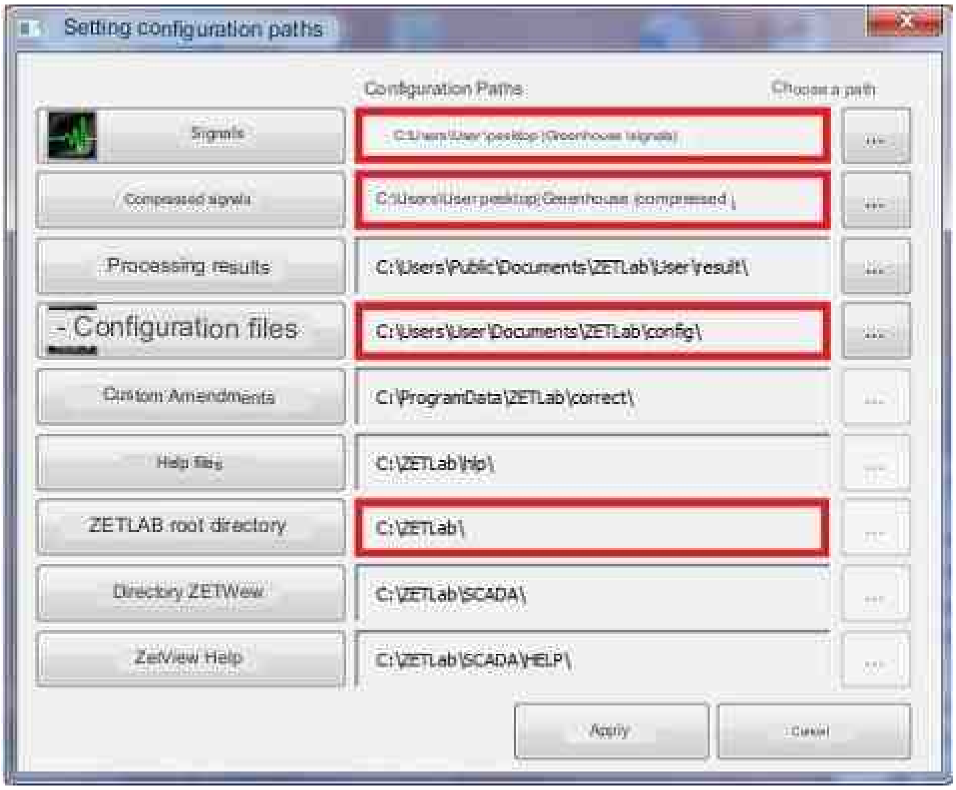


- Go to the "Virus and other threat protection settings" section.



- We find the item "Exceptions" and activate the button "Add or remove exceptions".

- Click "Add to exclusion" and select "Folder" in the drop-down list and add the folder where our files are saved. It is recommended to add the following folders to the exclusion: ZETLab, config, compressed, signals.


Setting configuration paths
Configuration Paths
Choose a path
Signals
Compressed signals
Processing results
C:\Users\Public\Documents\ZETLab\User\result\
Configuration files
C:\Users\User\Documents\ZETLab\config\
Custom Amendments
C:\ProgramData\ZETLab\correct\
Help files
C:\ZETLab\hlp\
ZETLAB root directory
C:\ZETLab\
Directory ZETWew
C:\ZETLab\SCADA\
ZetView Help
C:\ZETLab\SCADA\HELP\
Apply
Cancel

Connecting devices designed as external modules .....

Connecting devices designed as external modules to a PC is performed using the supplied HighSpeed USB 2.0 cable to a HighSpeed USB 2.0 port of the PC, irrelevant of whether the power supply has been disconnected or not. If the scope of supply of module to be connected to HighSpeed USB 2.0 bus includes a power adapter, then proceed as follows:

- ✓insert the plug of the power adapter to the corresponding power supply slot on the module back panel;
- ✓insert the module plug to the power supply grid 220 VAC;
- ✓toggle the power supply switch to ON position. A red LED should light up near the power supply switch to indicated that the module is ON.

Installing ZETLab software .....

To install ***ZETLab*** software, insert the original CD with ***ZETLab*** software into the CD-ROM drive. The system will automatically recognize the CD and launch the ***ZETLab*** software and drivers installation wizard for the inserted (connected) devices.

If the OS failed to launch automatically the ***ZETLab*** software and drivers installation wizard, then start the ***ZETLab*** software and drivers installation program from the root folder on the CD, ***Setup.exe***.

Attention! If no card device has been inserted into the PCI slot, or no external module device has been connected to the HighSpeed USB 2.0 port, then ***ZETLab*** software will not be installed, and a pop-up message, **Supported device is not found**, will be generated by the installation program.

After the wizard launch, an **Installation ZETLab + add-ins** (*Fig. 2 .7*) window will open suggesting to install ***ZETLab*** software and drivers onto the PC. To continue installation, press **Next >** button and license agreement window will appear, as shown in *Fig. 2 .8*.

After getting familiar with the license agreement, to continue installation, one has to accept this agreement by left-clicking **I accept license agreement terms and conditions** inscription and press **Next >**, otherwise the user will exit the installation program.

In the next window of the installation program (Fig. 2 .9), specify the user name and the name of the organization, as well as select the application installation variant: for all PC users or just for one user, and press **Next >** button.

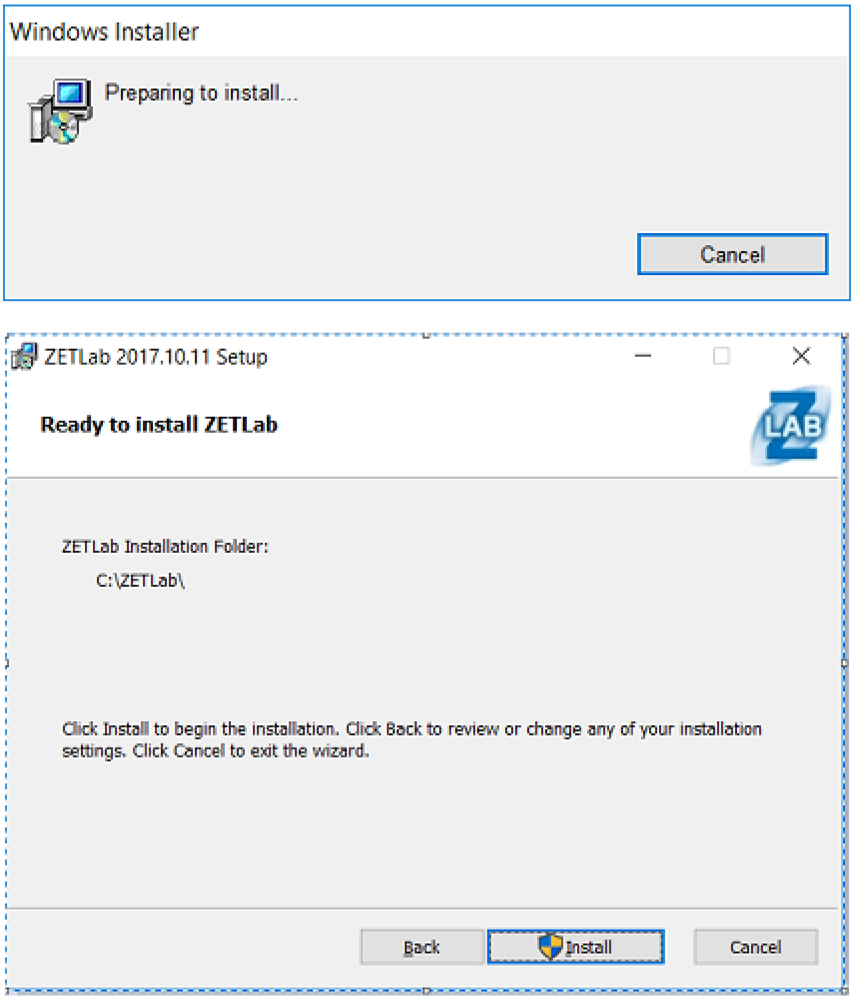


Fig. 2.7

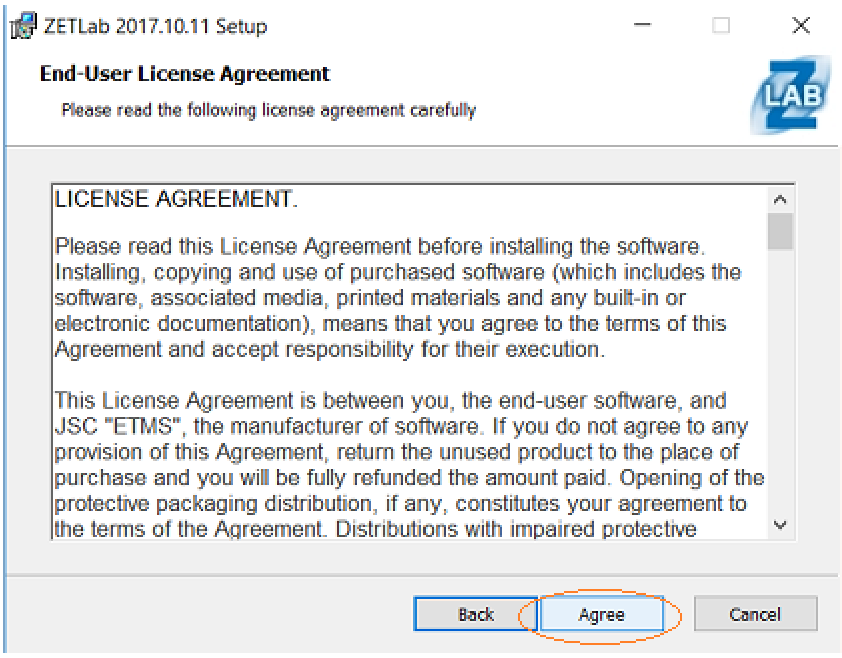


Fig. 2.8

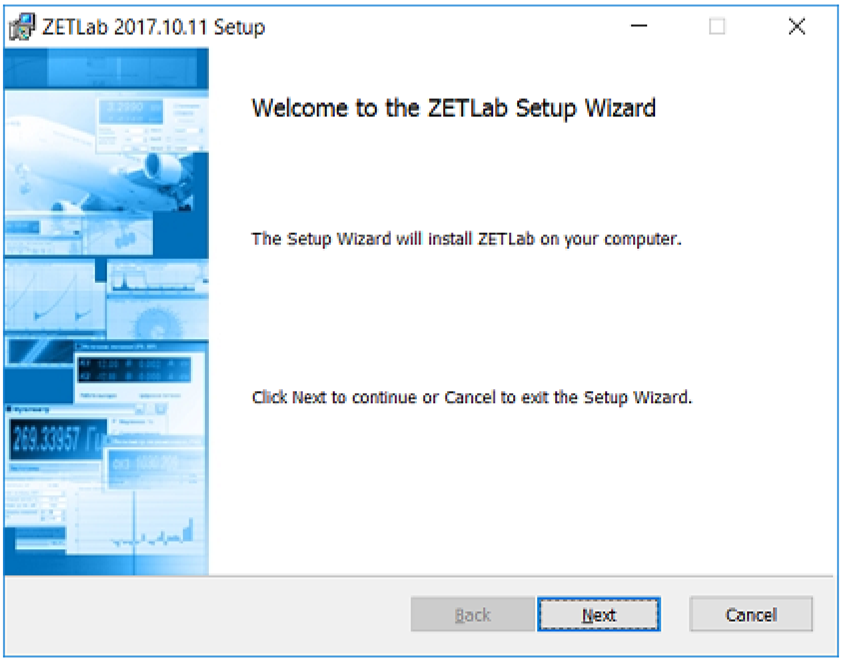


Fig. 2.9

Next, you will prompted to choose the installation directory **ZETLAB**. By default, the **ZETLAB** programs are installed in the directory **ZETLAB** (Fig. 2.10).

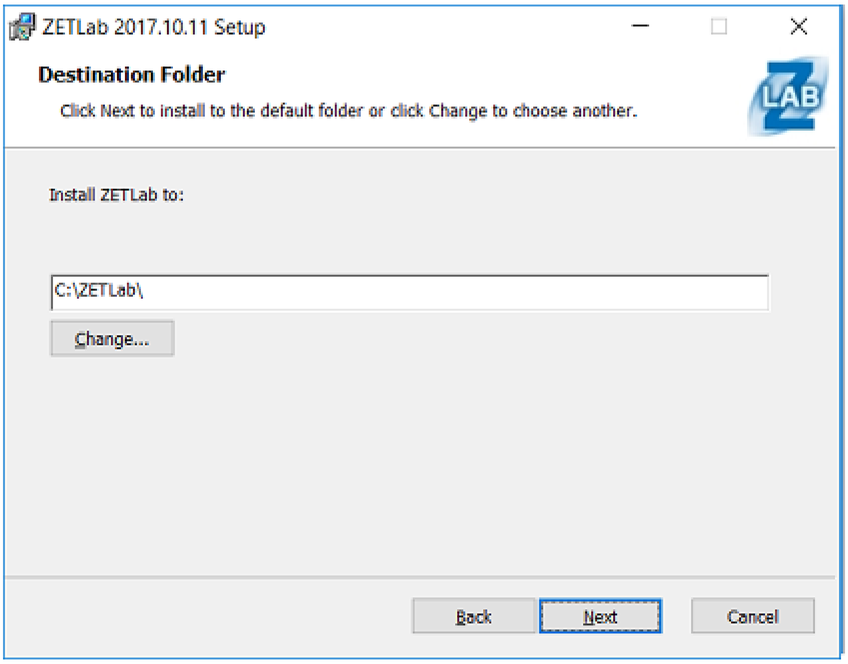


Fig. 2.10

ZETLAB installation will take several minutes. At the end of the installation will become active the Next button to be pressed to complete the installation (Fig. 2.11)

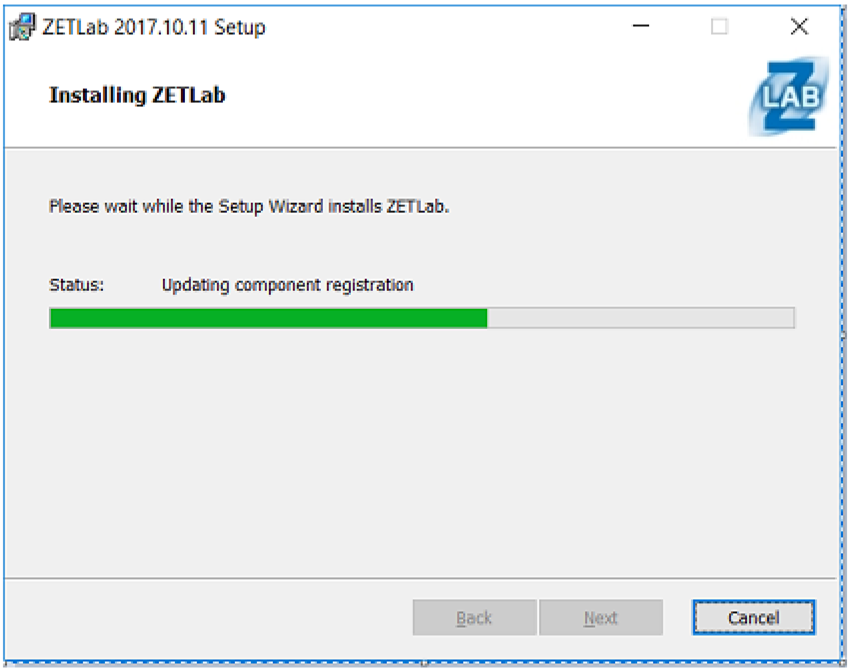


Fig. 2.11

To exit setup, press "Finish" (Fig. 2.11).

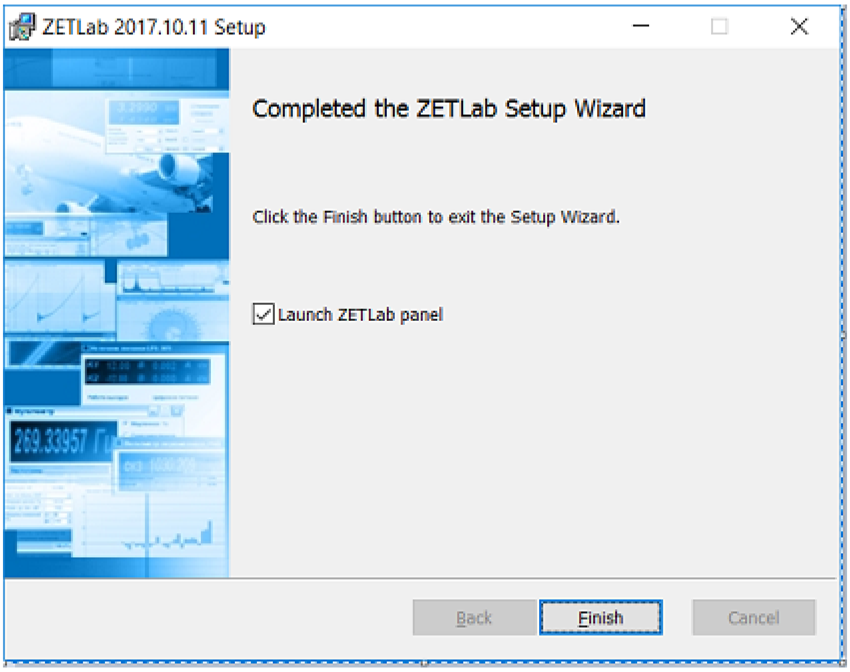


Fig. 2.11

Cocked flag to Run the ZETLab panel allows immediately after installation Setup to launch **ZETlab** without starting with the labels program.

Re-installing ZETLab software .....

Re-installation shall only be performed after removal of the installed ***ZETLab*** software.

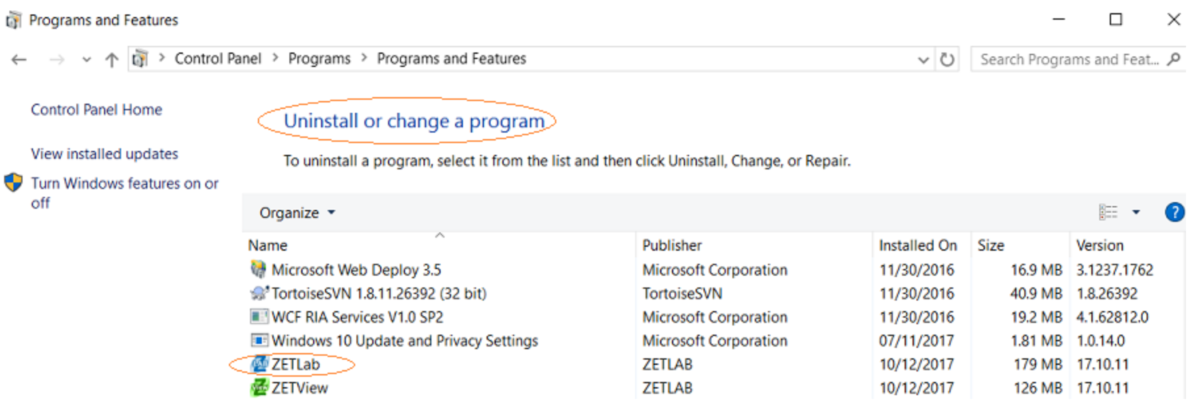
For this purpose, make a double left-click on **My Computer** shortcut, and a double left-click on the **Control Panel** shortcut in **My Computer** window.

Also, from **Start** menu on Windows task panel, select **Setup** command in the→ **Control Panel**. In **Control Panel**, select **Program installation and removal** (Fig. 2 .14), after which the **Program installation and removal** window will launch (Fig. 2 .15).

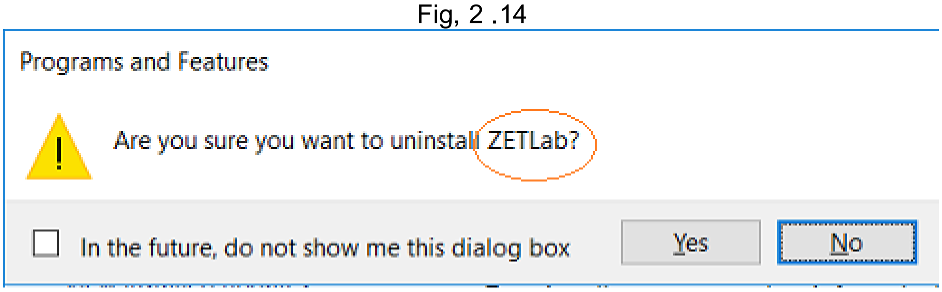
In the **Program installation and removal** window, select the required ***ZETLab*** software package by pressing it with the left mouse button. **Delete** button will appear on the right. After pressing the **Delete** button, an information window (Fig. 2 .16) will appear requesting the confirmation of deletion of ***ZETLab*** software. To confirm deletion, press **Yes** button in this window.

After completion of the deletion process, close the **Program installation and removal** window (Fig. 2 .15) by pressing **Close** button.

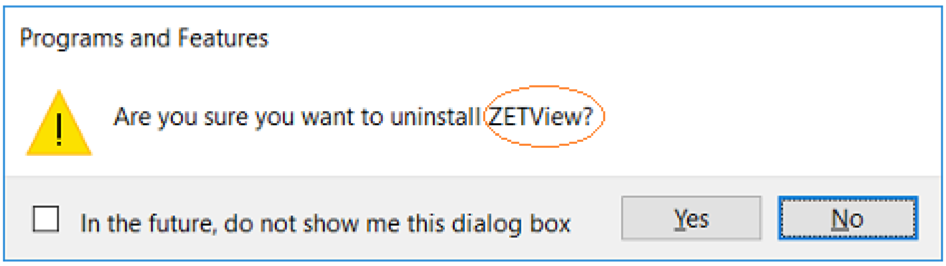
Re-installation shall be performed according to par. **2.4 Installing ZETLab software.**

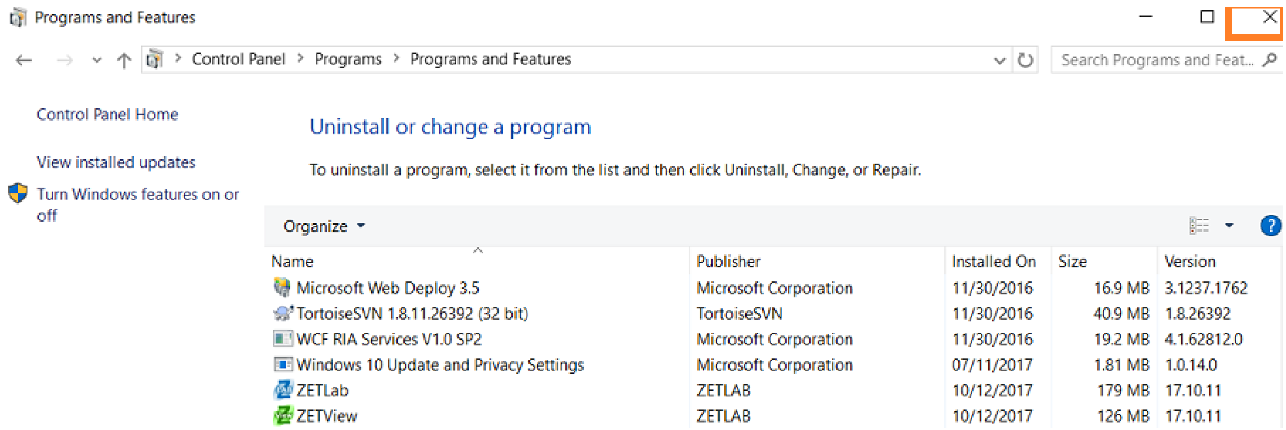


Fig, 2 .14



Fig, 2 .15




Programs and Features
Control Panel > Programs > Programs and Features
Search Programs and Feat...
Control Panel Home
View installed updates
Turn Windows features on or off
Uninstall or change a program
To uninstall a program, select it from the list and then click Uninstall, Change, or Repair.
Organize
Name Publisher Installed On Size Version
Microsoft Web Deploy 3.5 Microsoft Corporation 11/30/2016 16.9 MB 3.1237.1762
TortoiseSVN 1.8.11.26392 (32 bit) TortoiseSVN 11/30/2016 40.9 MB 1.8.26392
WCF RIA Services V1.0 SP2 Microsoft Corporation 11/30/2016 19.2 MB 4.1.62812.0
Windows 10 Update and Privacy Settings Microsoft Corporation 07/11/2017 1.81 MB 1.0.14.0
ZETLab ZETLAB 10/12/2017 179 MB 17.10.11
ZETView ZETLAB 10/12/2017 126 MB 17.10.11

Fig, 2 .16

ZETLAB software updater .....

Installation of ZETLAB updates (as well as ZETSCOPE) is performed only after removing the previously installed software.

***Note** 1: The ZETSCOPE software supplied with the ZET 302 oscilloscopes has the functions of recording measurement results. To view the recorded files, the "View and Process Results" program from the ZETLAB software is used. Thus, to work with ZETSCOPE software, ZETLAB software is not required, but it can be an addition to ZETSCOPE software.*

Procedure

Procedure for updating the software:

Software set	ZETLAB	ZETLAB+ZETSCOPE
1) Remove current versions in sequence:	ZETLAB	1) ZETSCOPE 2) ZETLAB
2) Install new versions in the sequence:	ZETLAB	1) ZETLAB 2) ZETSCOPE

Remove ZETLAB in accordance with subsection Installing ZETLAB software of this document, removal of ZETSCOPE - in accordance with the operator's manuals on them.

Install ZETLAB in accordance with subsection Installing ZETLAB software of this document, the installation of ZETSCOPE - in accordance with the operator's manuals on them.

Following all recommendations for uninstalling and installing the software ensures that ZETLAB and drivers are updated correctly. In subsection Driver update provides instructions for updating drivers if it was not done automatically.

Registry cleaning

If you experience problems following all of the above recommendations after updating ZETLAB, you may need to clean the Windows registry. The sequence of actions is as follows:

1. Remove all ZETLab products through the control panel, starting with ZETView and ending with ZETLab_32 (or ZETLab_64).
2. Manually delete the folder where ZETLab was installed (for example, C:\ZETLab).
3. Launch Registry Editor: Win+R, regedit, Enter
4. In the registry tree, go to the branch: - for a 32-bit system: HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows\CurrentVersion\SharedDLLs - for a 64-bit system: HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432Node\Microsoft\Windows\CurrentVersion\SharedDLLs
5. Find and delete in this branch all lines that start with the installation path (for example, with "C:\ZETLab").
6. Install ZETLab_32 (or ZETLab_64), then other software products.

***Note**: The Windows Registry should be handled with care. Before deleting lines, it is desirable to save this branch so that if the wrong lines are deleted, it will be possible to restore the changes.*

Update drivers .....

During installation of **ZETLAB** software, drivers for ZET equipment (spectrum analyzers, ADC/DAC boards, strain gauges, seismic stations, intelligent sensors, etc.) are copied to the computer. If any ZET device was connected during the installation of the software, the drivers for it were automatically installed and the device is ready for operation upon completion of the installation process.

If the device was not connected during the software installation, then when the device is connected to the PC for the first time, a message about installing the driver software will appear in the system tray (see figure).

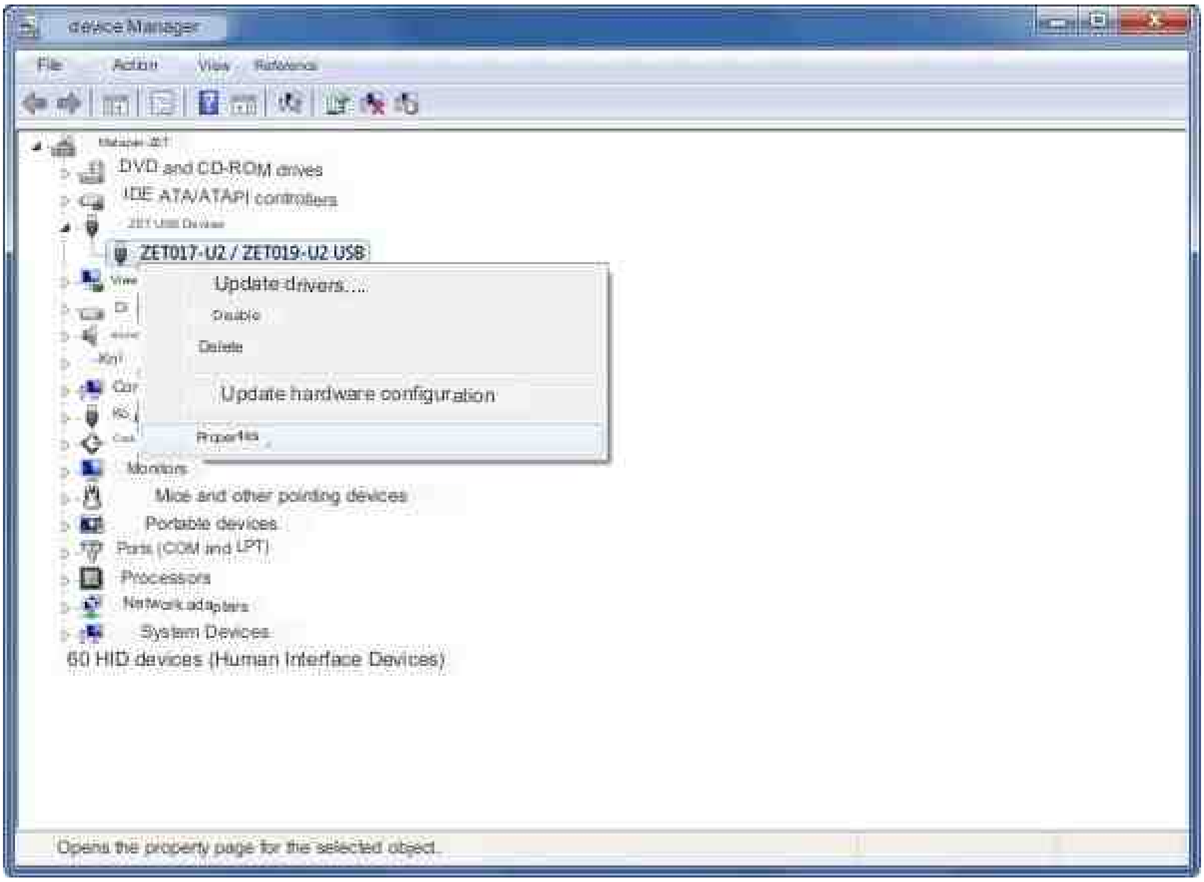
Installing the driver when connecting the instrument to a PC

Installing the driver may take several minutes. When the driver installation is complete, a success message will appear, with the device name displayed in the message header.

Successful driver installation message

If the drivers were not installed automatically (this could happen, for example, when updating **ZETLAB**, if any of the programs worked during the uninstallation), then you can update the drivers yourself. To do this, go to "My computer", call the context menu (by right-clicking the "mouse" on the free field of the "My Computer" window), select "Properties" in the context menu, select "Device Manager in the window that opens (in Windows 10, link "Device Manager" is on the left; in **Windows 10**, in the computer's properties window, go to the "Hardware" tab).

Open the "ZET USB Devices" list in the device manager, select the connected device, call the context menu, select the Properties item.



Device Manager

In the device properties window, go to the "Driver" tab and click the "Update" button.

Driver update

In the window that opens, select "Search for drivers on this computer"

Choosing where to update the driver

Specify the directory of drivers for ZET devices: C:\ZETLab\drivers and click the "Next" button.

Directory of drivers for ZET devices

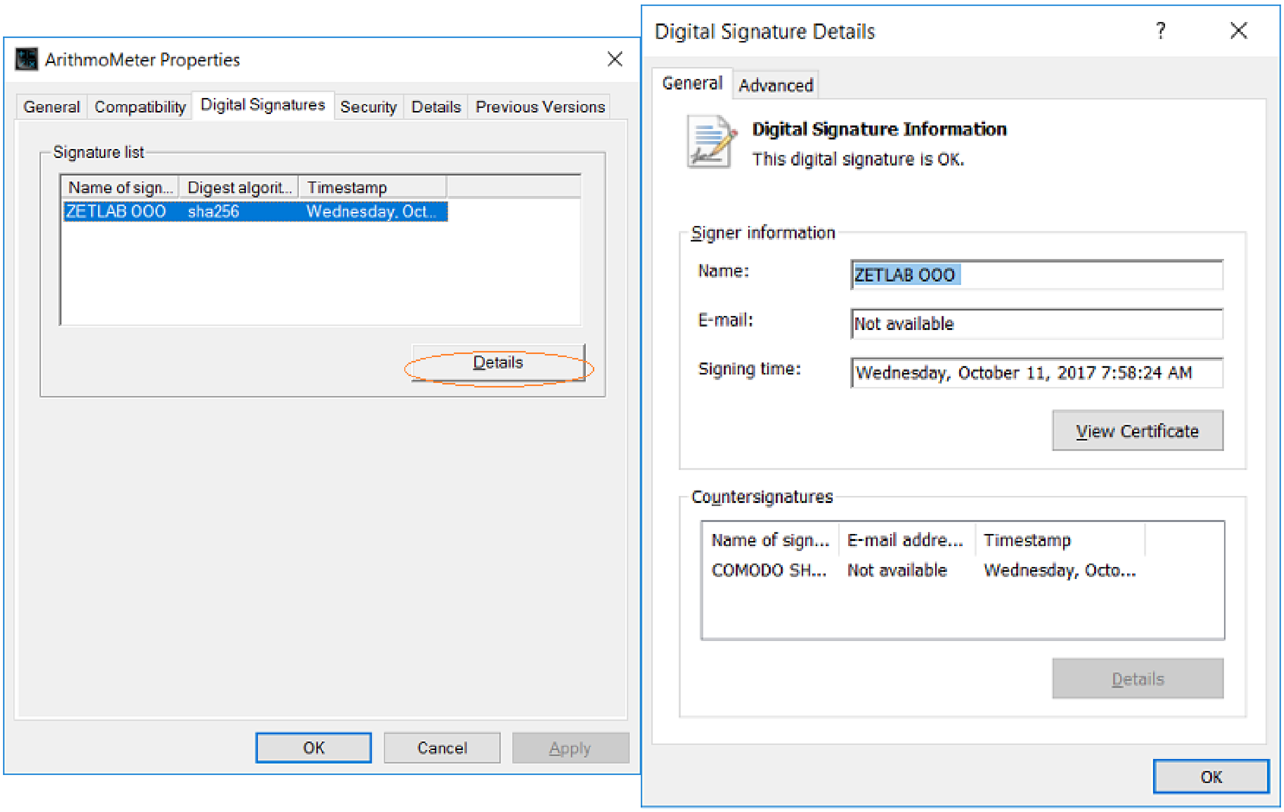
Next, the drivers for the connected equipment will be installed and a message will appear on the successful completion of the installation.

Check the integrity of the installation file distributions ZETLAB .....

Software update, produced by LLC "ETMS", available online (you can download them to the FTP server). To check the integrity of downloaded files, you can use standard Windows tools for checking a digital signature or the checksum md5.

The md5 checksum of the installation file is specified in the same text file. Checked free software downloaded from the Internet.

To verify the digital signature you need to open properties of the installation file (click right mouse button on the file name and select "Properties") in properties window go to the tab "Digital signatures", choose ZETLAB OOO and click the "Information". In the window "digital signature" should be indicated that the digital signature is valid



Connecting devices

Table of contents:

USB connection .....

Connection of ZET devices to the computer is carried out by the included HighSpeed USB 2.0 cable to the HighSpeed USB 2.0 port of the PC, with the computer power off or on.

Note: *The ZETSENSOR smart sensors are connected to the computer using the ZET 7070 or ZET 7174 interface converters.*

If the ZETLAB software is already installed on the computer, then when the ZET device is connected for the first time, the drivers will be installed automatically: when the device is connected, a message will appear stating that the device driver software is being installed, then a message about the successful installation of drivers.

Driver installation message

Successful driver installation message

If the ZETLAB software has not been installed, it must be installed. When installing the ZETLAB software with a connected ZET device, the device drivers will be installed during the ZETLAB installation.

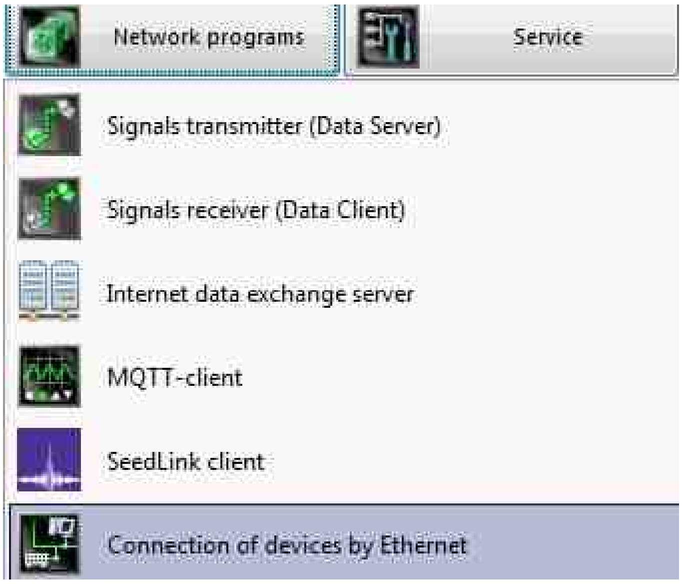
Thus, the drivers for the ZET device will be installed automatically:

- during the installation of ZETLAB, if the device was connected during the installation of ZETLAB,
- or when the device is first connected to the computer on which ZETLAB is installed.

Connection of VCS controller to PC by Ethernet .....

The program **Connection of devices by Ethernet** is available in the **Network programs** menu of ZETLAB software.

Note: the **ZETLab** program (default: c: \ ZETLab \). The name of the startup file: NetWizardNew or NetWizard.exe



Start the "Connection of devices by Ethernet"

Note: *The program window "Connecting Ethernet Devices" has two views: "connection by IP addresses" and "new interface". To change the appearance of the window, you need to call the drop-down menu in the window title area and, depending on the transition, activate "Switch to a new interface" or "Connect by IP addresses"*

Connection of controllers of the ZET 02x, ZET 03x and ZET05x series to the computer .....

1. Connection sequence

During the first connection of the VCS controller to PC, it is necessary to set. Ethernet ports of the controller and PC, so that their network masks and IP-addresses would correspond to a single subnetwork. In order to do that, you can set IP-address of Ethernet port of the PC to the subnetwork of the VCS controller port, or vice versa.

Note: *You can check IP-address of the VCS controller using the instructions specified in section 4.1.3.*

Attention! *The connection of the computer to the controllers involved in working with the UH must be organized in an isolated local network via physical wired cable connections (UTP twisted pair). The use of wireless connections (using WiFi, WiMAX, etc.) is not allowed.*

In the case, if you need to set the IP-address of Ethernet port of the PC to the subnetwork of the VCS controller, follow the instructions specified in section 4.4.

In the case, if you need to set the IP-address of VCS controller Ethernet port to the subnetwork of the PC, follow the instructions specified in section 4.4 to re-set. the initial IP-address of the PC to the subnetwork of the VCS controller, then follow the instructions specified in section 4.5 to re-set. the IP-address of VCS controller to the initial subnetwork of the PC, then restore the value of the PC port IP-address to the initial one.

When the IP-addresses of Ethernet ports of PC and VCS controller are located in the same subnetwork, activate Ethernet channel of the VCS controller. After that the VCS controller will be ready for use.

Note: *If you use several VCS controllers, it is necessary to use Ethernet switch to have the required number of Ethernet ports for connection. The connected ports of VCS controller and PC should belong to the same subnetwork, and there should be no identical IP-addresses.*

2. *Factory setting of the IP address*

The factory setting for the controller is the IP address - 192.168.0.100 with a subnet mask of 255.255.255.0.

Pressing and holding the "Reset" button on the back of the controller for at least 10 seconds will reset the IP address of the controller to the factory setting.

3. *Checking the IP address of the controller*

To check the IP address of the controller on the ZETLAB panel in the "Network programs" menu, activate the "Connecting devices via Ethernet" program and the program window will open (Fig. 4.1).

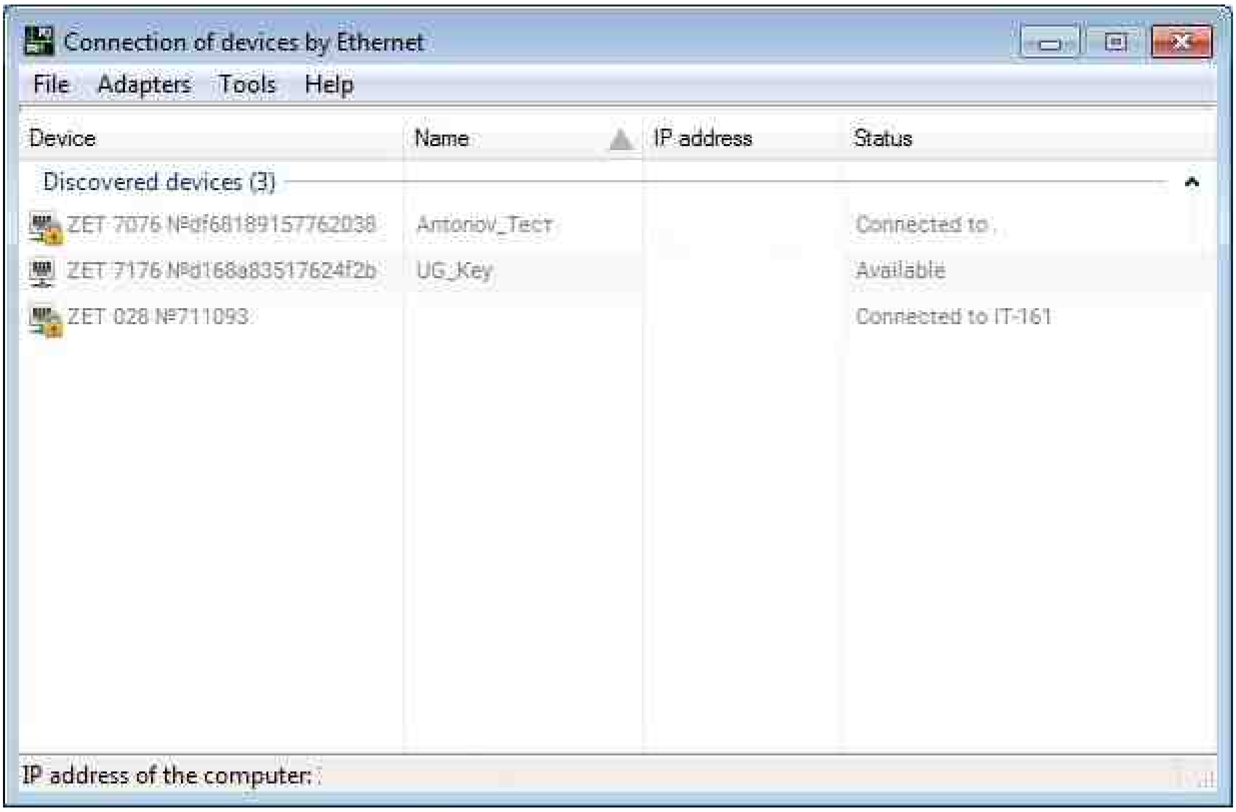


Fig. 4.1 The "Connecting devices via Ethernet" window

If there are several network adapters in the computer to which the controller is connected, then through the "Adapters" menu you can select a specific network adapter to which the controller is connected (*Fig 4.2*).

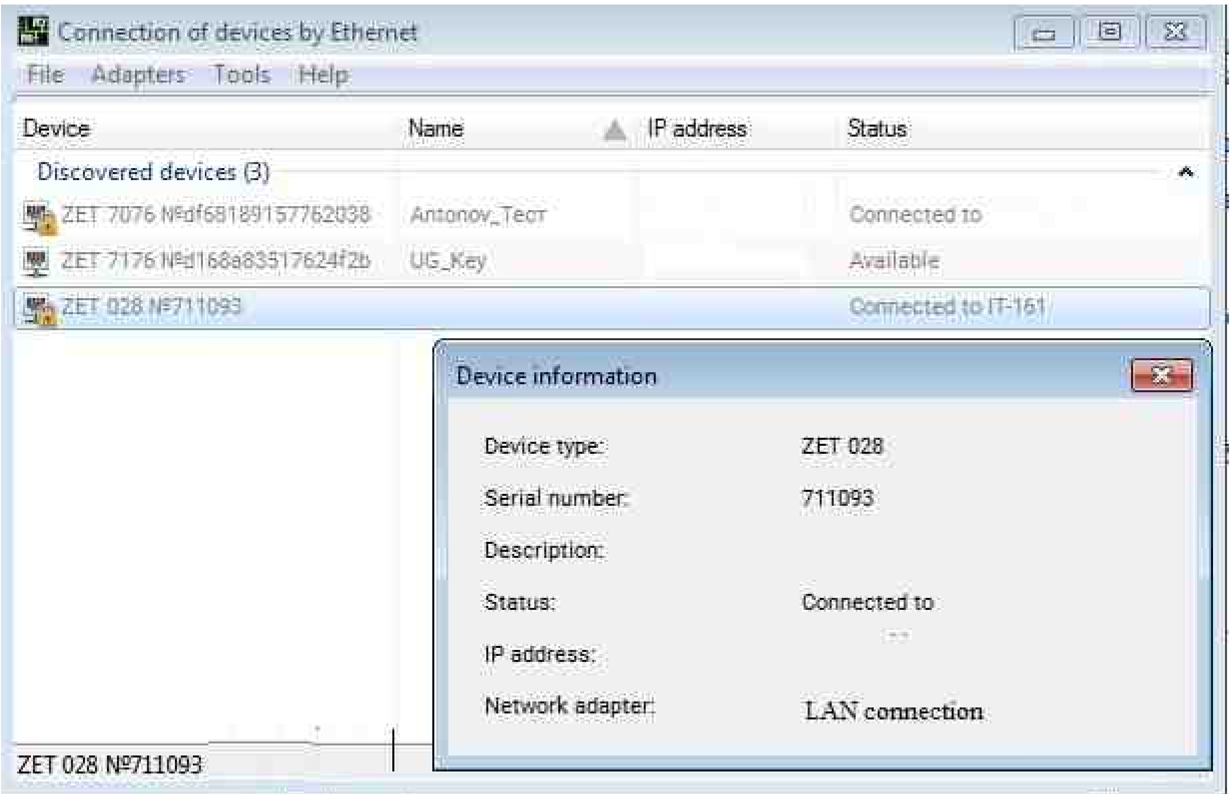


Fig. 4.2 Viewing the IP address of the controller

4. Setting the IP address of the controller

To view the current IP address of the controller, hover the mouse cursor over the name of the controller and read the value of the IP address of the controller (*Fig. 4.3*).

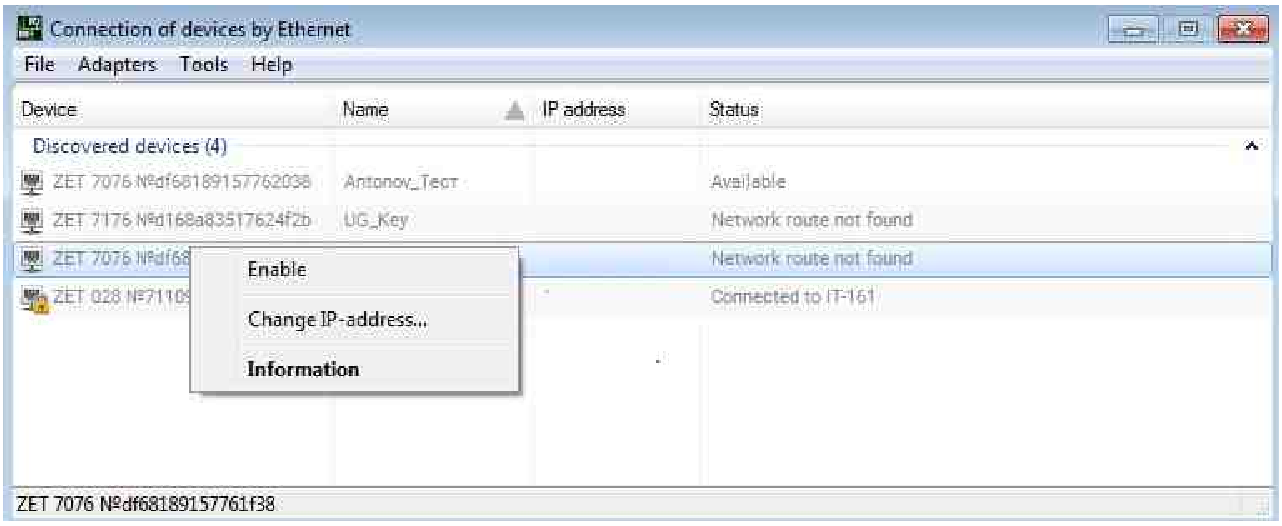


Fig. 4.3 Viewing the IP address of the controller

In the "Change IP address" window that opens, in the "New IP address" line, set the new network address and subnet mask of the controller, and then activate the "Ok" button (*Fig. 4.4*).

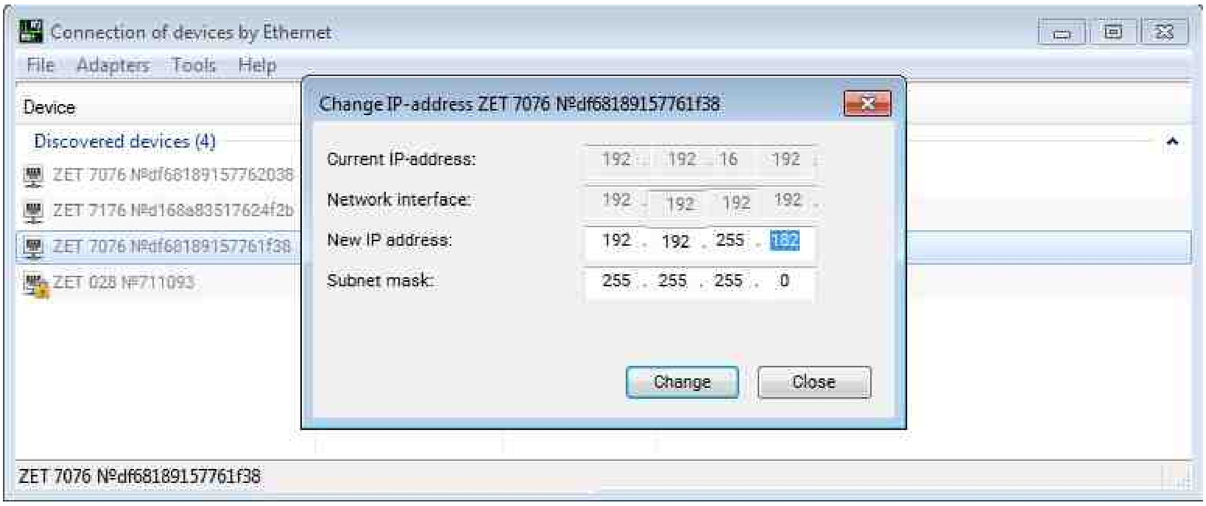


Fig. 4.4 Change IP address

5. Setting the IP address of the controller

To set the IP address of the Ethernet port of the computer, open the "Network Connections" window from the Windows operating system programs and double-click the icon corresponding to the

Ethernet network port set on the computer, and the "Status-Ethernet" window opens (*Fig. 4.5*) the selected port.

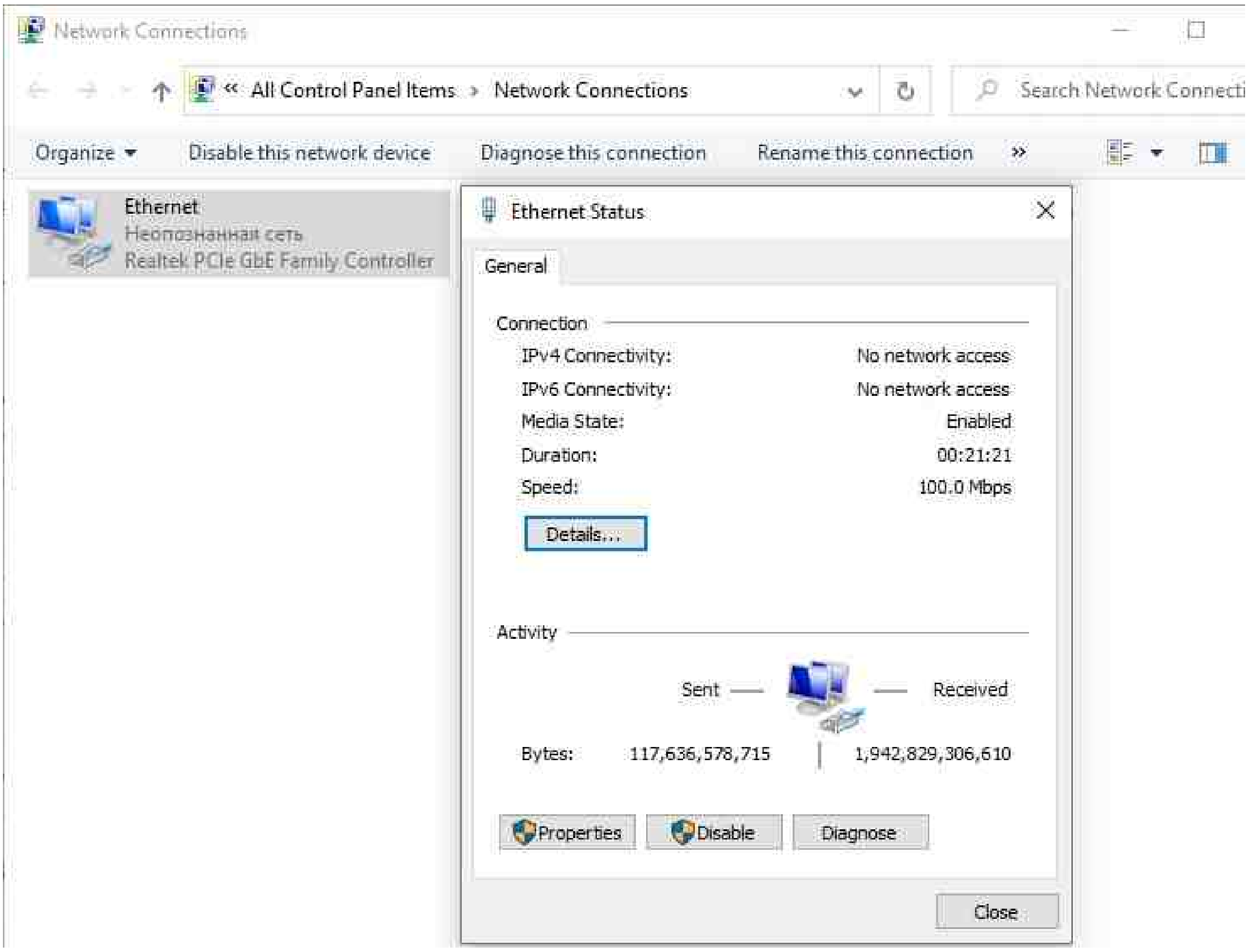


Fig. 4.5 The "Ethernet Status" window

In the "Status-Ethernet" window, activate the "Properties" panel and in the "Ethernet Properties" window that opens (Fig. 4.6), "highlighting" the line "IP version 4(TCP/IPv4)" (as shown in the Fig. 4.6) activate the "Properties" panel.

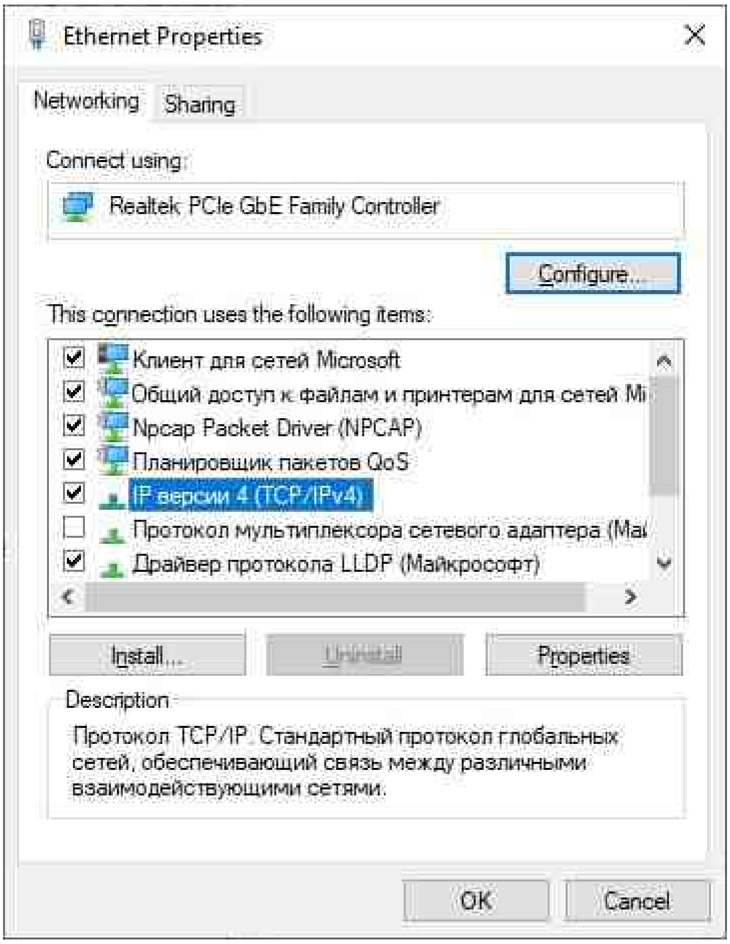


Fig. 4.6 Window "Properties"

In the "Status-Ethernet" window, activate the "Properties" panel and in the "Ethernet Properties" window that opens(*Fig. 4.7*) , "highlighting" the line "IP version 4(TCP/IPv4)" (as shown in the Fig. 4.7) activate the "Properties" panel.

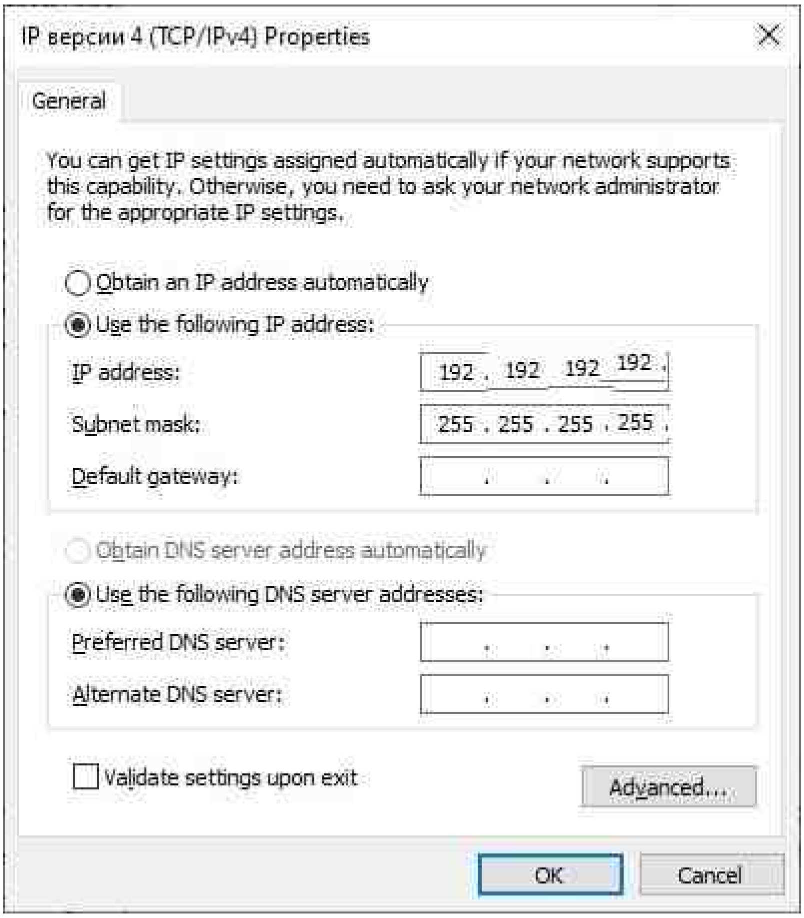


Fig. 4.7 "Properties" window: IP version 4 (TCP/IPv4)"

Note: *Controllers use the mask "255.255.255.0" by default, which defines a class C subnet (in the example, the network address is 192.168.0.xxx, where xxx is the IP addresses of nodes in the range from 1 to 254 (in this example, the controller port 100 and the computer port 29).*

6. Activating an Ethernet connection

To activate an Ethernet connection, it is necessary that the IP addresses of the Ethernet ports of the controller and the computer belong to a single subnet. If necessary, Reset. the IP address of the controller or computer port, according to the sections 4.1.4 or 4.1.5.

To connect the controller to the computer, in the "Connecting devices via Ethernet" program, right-click on the name of the controller to open the context menu and select the "Activate" function (*Fig. 4.8*).

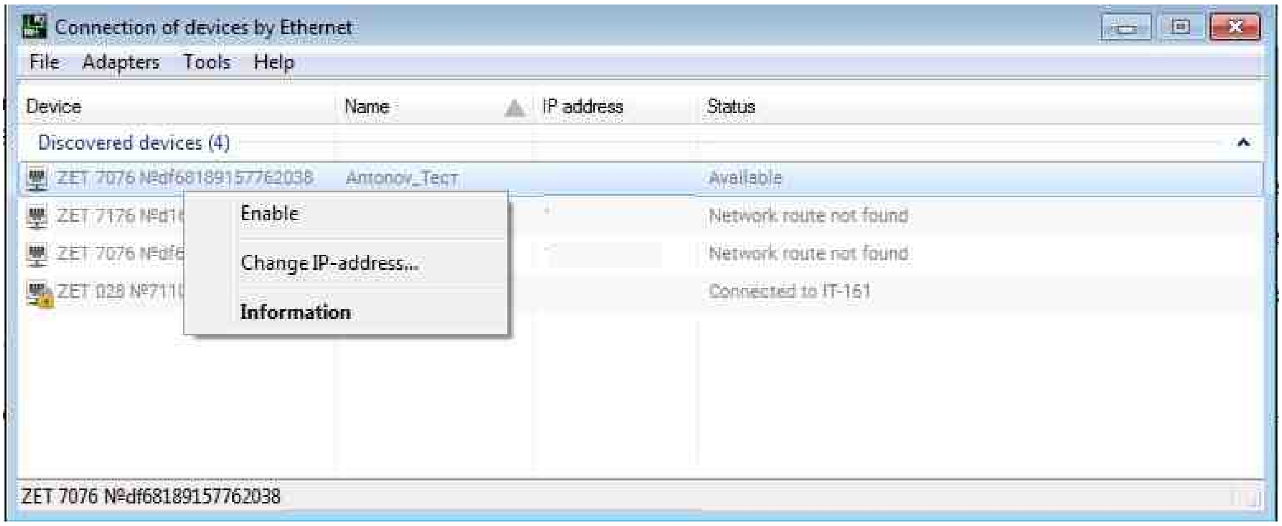


Fig 4.8 Activating the controller

In the "Connecting devices via Ethernet" window, make sure that the status of the involved controller has changed to "Device connected" (*Fig. 4.9*).

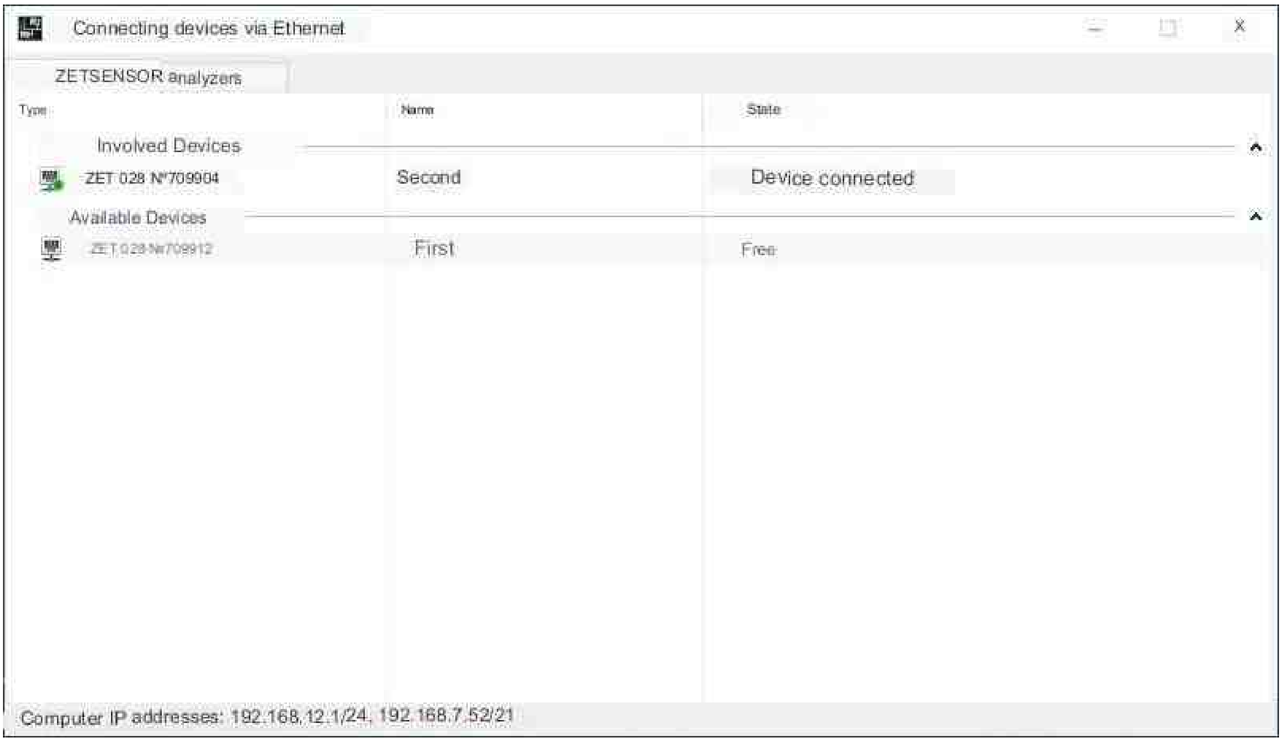


Fig. 4.9 The "Device is connected" status

Connection of ZET 017 series controllers .....

1. Connection sequence

During the first connection of the VCS controller to PC, it is necessary to set Ethernet ports of the controller and PC, so that their network masks and IP-addresses would correspond to a single

subnetwork. In order to do that, you can set. IP-address of Ethernet port of the PC to the subnetwork of the VCS controller port, or vice versa.

Note: *You can check IP-address of the VCS controller using the instructions specified in section 4.1.3.*

Attention! *The connection of the computer to the controllers involved in working with the UH must be organized in an isolated local network via physical wired cable connections (UTP twisted pair). The use of wireless connections (using WiFi, WiMAX, etc.) is not allowed.*

In the case, if you need to set the IP-address of Ethernet port of the PC to the subnetwork of the VCS controller, follow the instructions specified in section 4.1.4.

In the case, if you need to set the IP-address of VCS controller Ethernet port to the subnetwork of the PC, follow the instructions specified in section 4.4 to re-set. the initial IP-address of the PC to the subnetwork of the VCS controller, then follow the instructions specified in section 4.1.5. to Reset. the IP-address of VCS controller to the initial subnetwork of the PC, then restore the value of the PC port IP-address to the initial one.

When the IP-addresses of Ethernet ports of PC and VCS controller are located in the same subnetwork, activate Ethernet channel of the VCS controller. After that the VCS controller will be ready for use.

Note: *If you use several VCS controllers, it is necessary to use Ethernet switch to have the required number of Ethernet ports for connection. The connected ports of VCS controller and PC should belong to the same subnetwork, and there should be no identical IP-addresses.*

2. *Factory setting of the IP address*

The factory setting for the controller is the IP address - 192.168.0.100 with a subnet mask of 255.255.255.0.

Pressing and holding the "Reset" button on the back of the controller for at least 10 seconds will reset the IP address of the controller to the factory setting.

3. *Checking the IP address of the controller*

To check (clarify) the IP address installed in the VCS controller, it is not required that the IP addresses of the Ethernet ports of the VCS controller and the computer belong to a single subnet.

To check the IP address of the VCS controller on the ZETLAB panel in the "Network programs" menu, activate the "Connecting devices via Ethernet" program and the program window will open (*Fig. 4.10*).

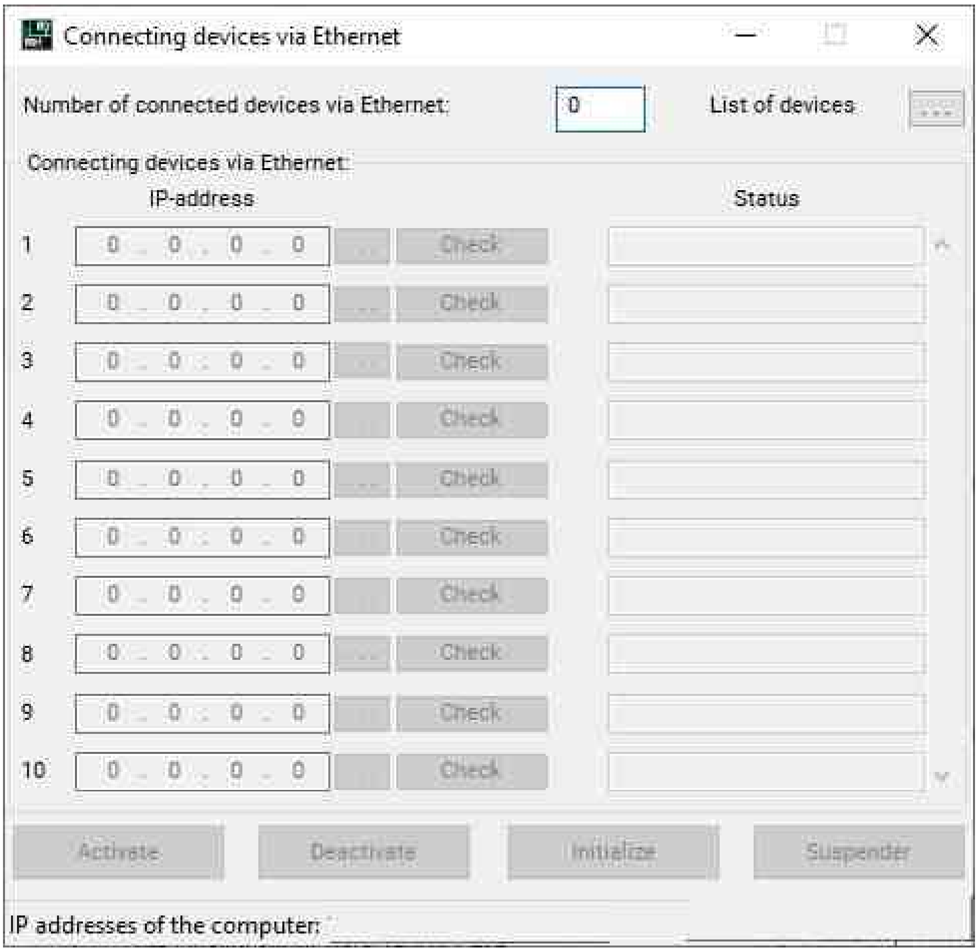


Fig. 4.10 " Connecting devices via Ethernet "

Click the key "···" (List of devices). In the window "List of available devices" (*Fig. 4.2*), you will see the IP-address of the VCS controller.

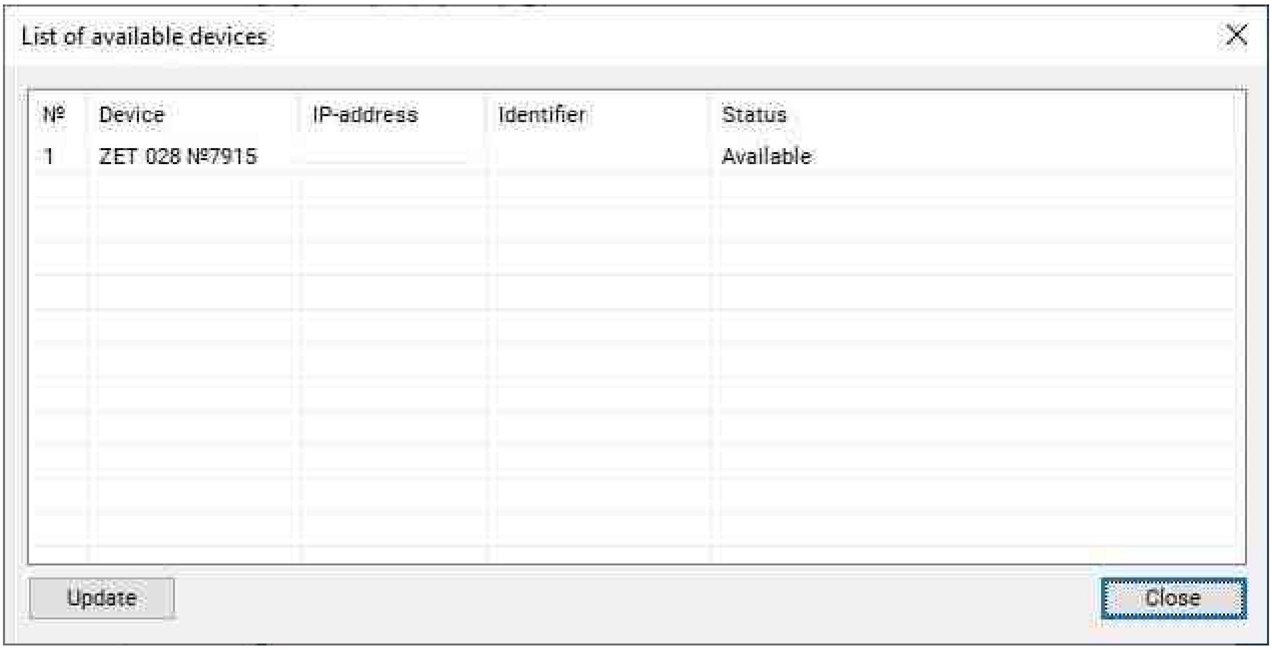


Fig. 4.11 "List of available devices"

4. Setting the IP address of the controller

In order to set the IP-address of the PC port, go to "Network connections" (Fig. 4.12) and double-click the icon corresponding to the relevant Ethernet port. You will see the window "Ethernet Status" (Fig. 4.12) of the selected port.

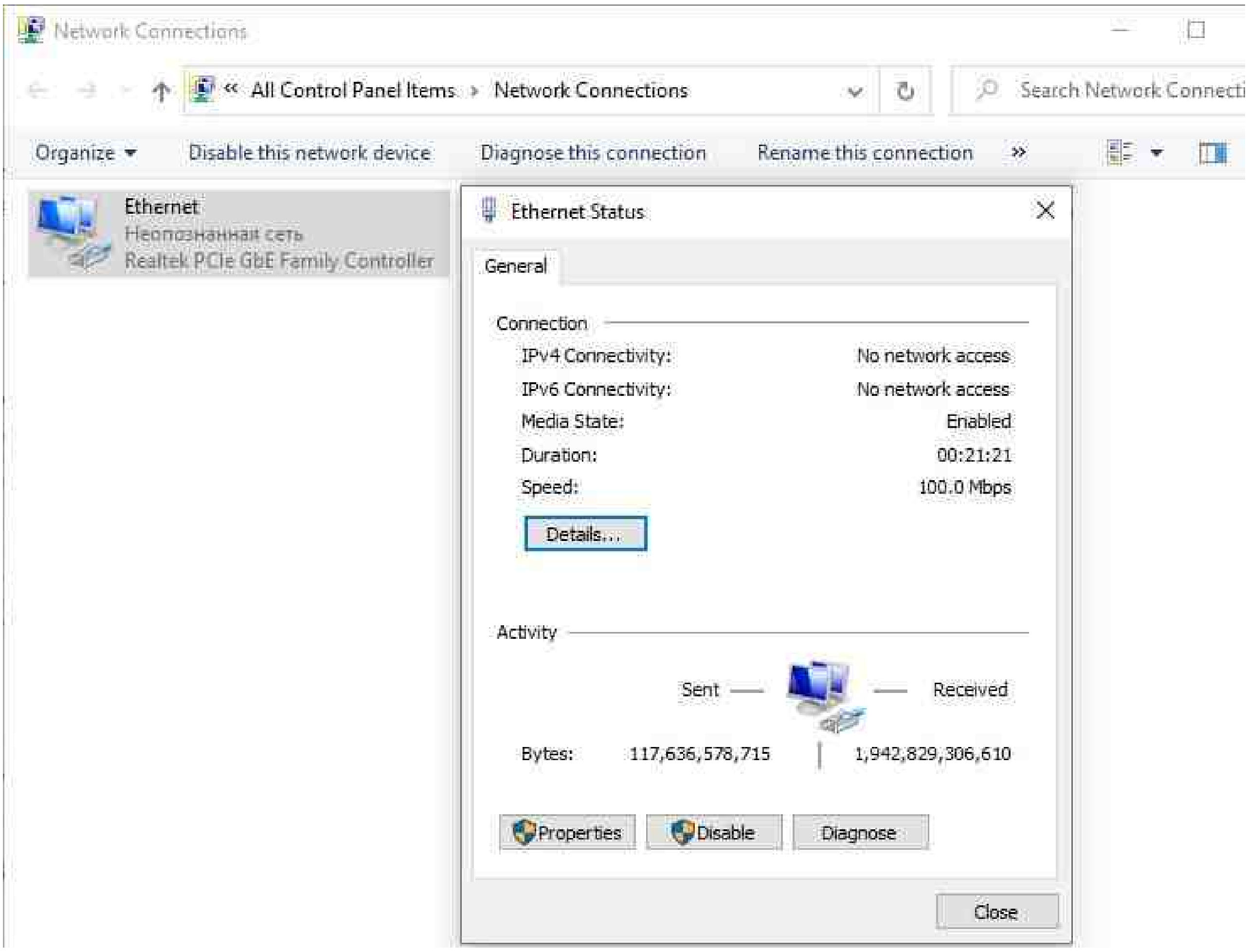


Fig. 4.12 "Status - Ethernet"

In the window " Ethernet Status " activate the panel *"Properties"*. In the window "Ethernet Properties" (Fig. *4.13*) select the line "IP version 4(TCP/IPv4)" (as it is shown in the Fig.) and click the panel "Properties".

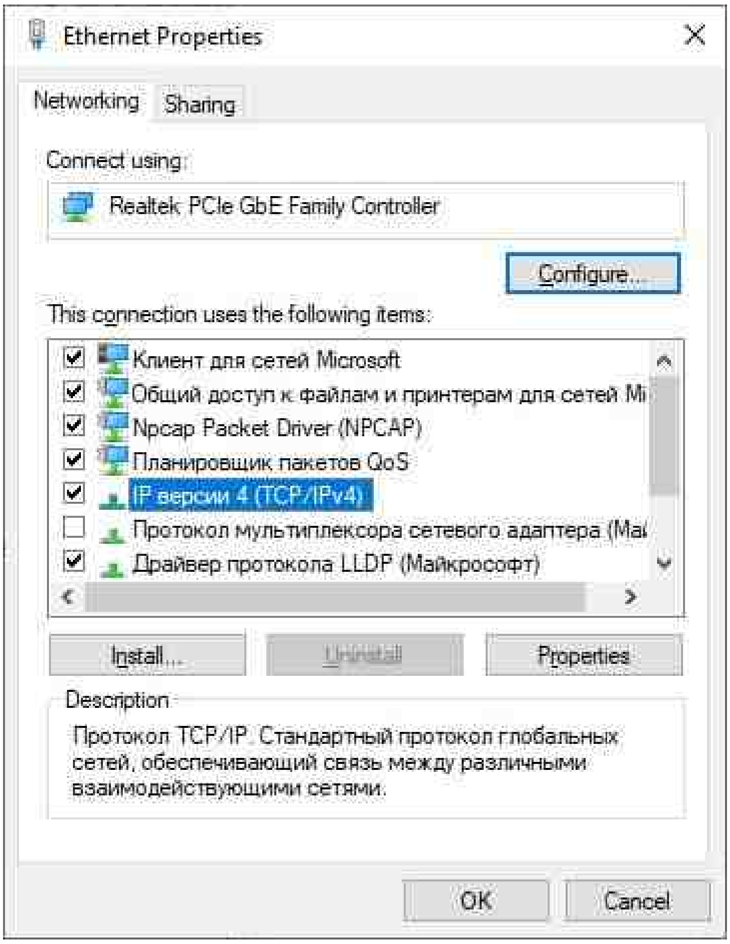


Fig. 4.13 "Properties"

In the window "IP version 4 (TCP/IPv4) Properties" assign IP-address and mask of Ethernet port of the PC (*Fig. 4.14*).

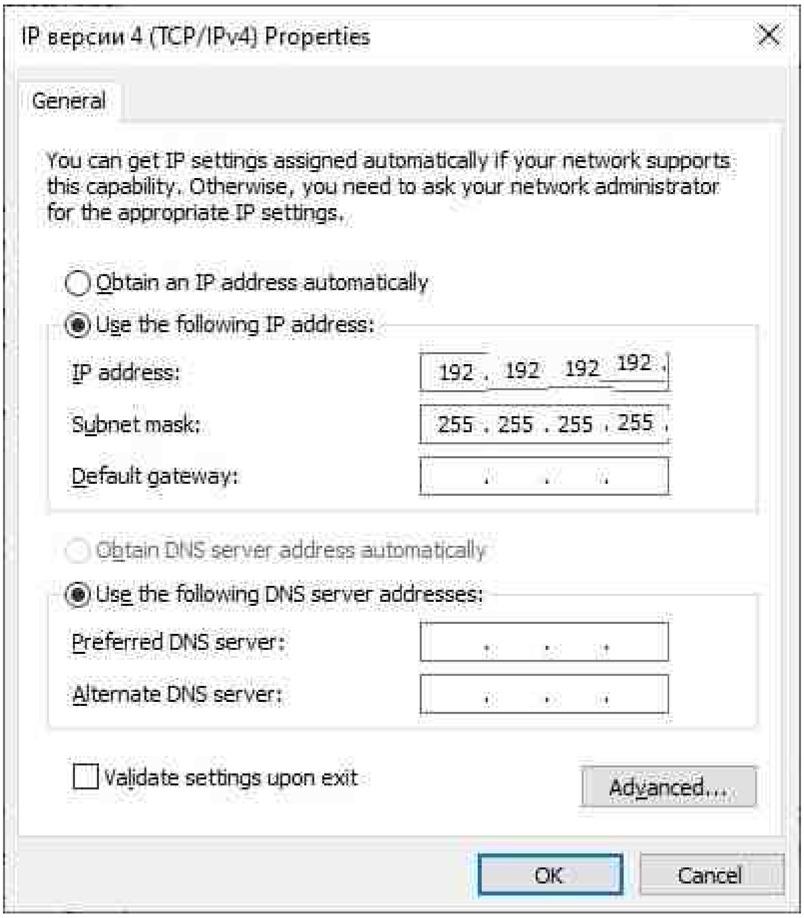


Fig. 4.14 "Properties: IP version 4 (TCP/IPv4)"

Note: *by default, VCS controllers use the mask "255.255.255.0", that corresponds to the sub-net of C-class (in this example, the IP-address is 192.168.12.xxx, where xxx stand for IP-addresses in the range from 1 up to 254 (in this example: 108 for controller port, and 10 for the PC port).*

5. Setting up the IP address of the controller

In order to set the IP-address of the VCS controller, enable Ethernet channel of the VCS controller following the instructions specified in section 4.6.

As the connection to the VCS controller is established, enable the program, "**ZET Device Manager**" in the "Service" section of ZETLAB panel (*Fig. 4.15*)

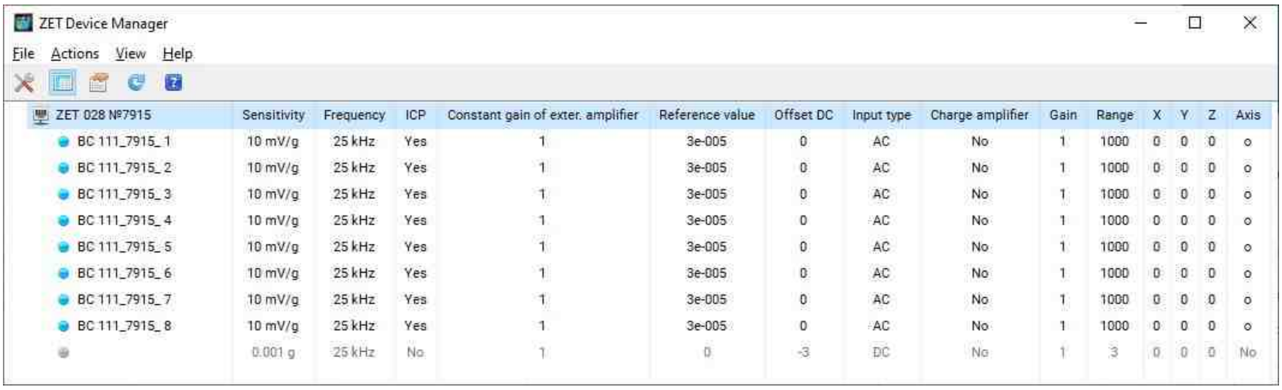


Fig. 4.15 "ZET Device Manager"

In the window of the program "ZET Device Manager" double-click the icon of the VCS controller. In the "Properties" window (*Fig. 4.16*) set the required IP-address and mask of VCS controller subnet (in this example: IP-address 192.168.12.108, mask 255.255.255.0).

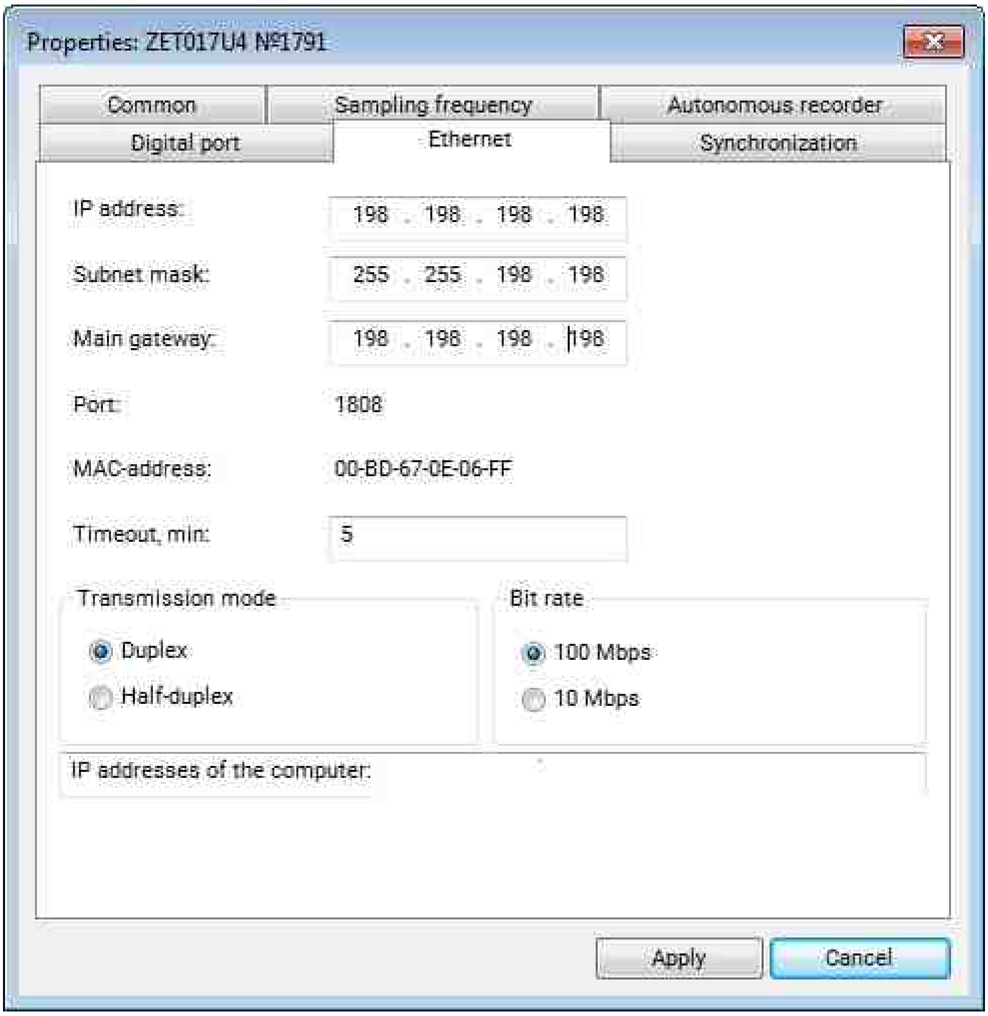


Fig. 4.16 "Ethernet" tab of the window "ZET properties"

Note! *As the IP-address of the controller is changed, its Ethernet channel will be disabled. For further activation, Reset. the IP-address of the PC following the instructions specified in section 4.4, so that it would correspond to the sub-net containing the IP-address of the VCS controller, then activate the Ethernet channel following the instructions specified in section 4.6*

6. Activation of VCS controller Ethernet channel

In order to activate Ethernet channel of VCS controller, make sure, that IP-addresses of VCS controller Ethernet ports and PC belong to the same subnetwork. If necessary, follow the instructions specified in section 4.2.4 to Reset. IP-address of PC Ethernet port to VCS controller subnetwork.

To enable Ethernet channel of VCS controller, go to "Network programs" of ZETLAB panel, and start the program "Connecting devices via Ethernet" (Fig. *4.17*).

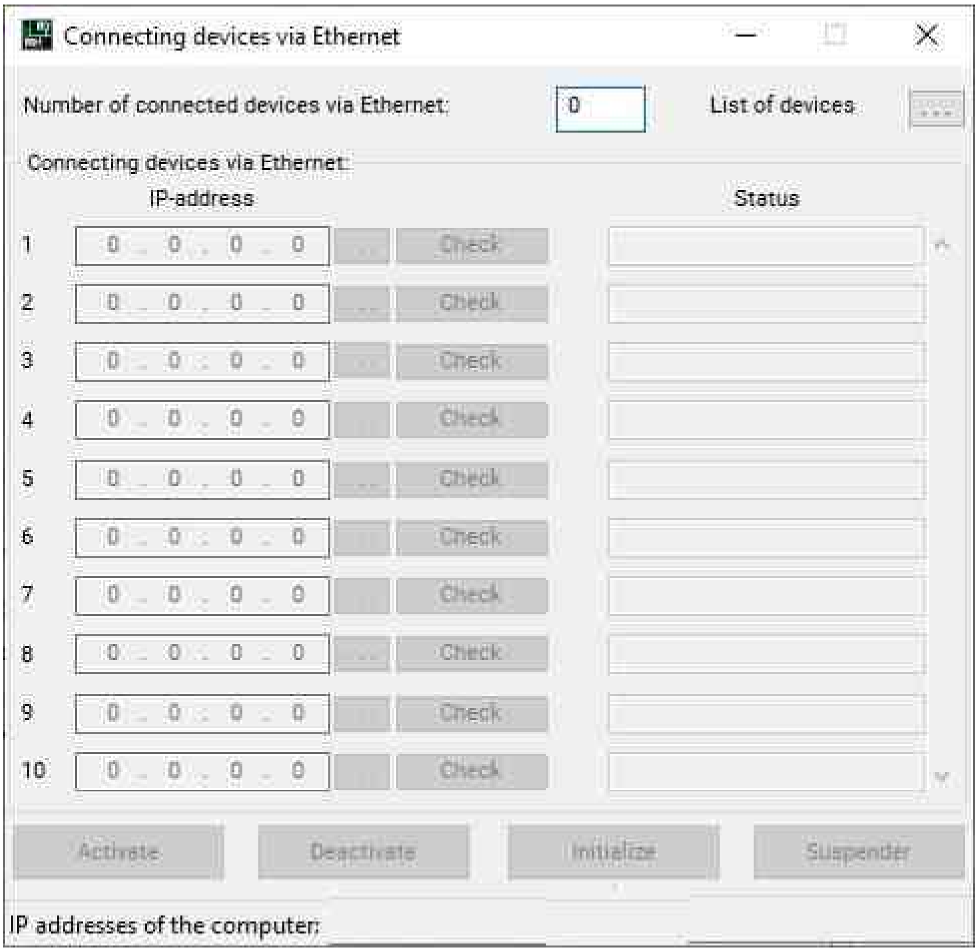


Fig. 4.17 "Connecting devices via Ethernet"

In the field "Number of connected devices via Ethernet" set the value equal to the number of VCS controllers used for vibration testing performance (in this example- "1"). As a result, you will be able to edit the first line of the IP-addresses list (*Fig. 4.18*).

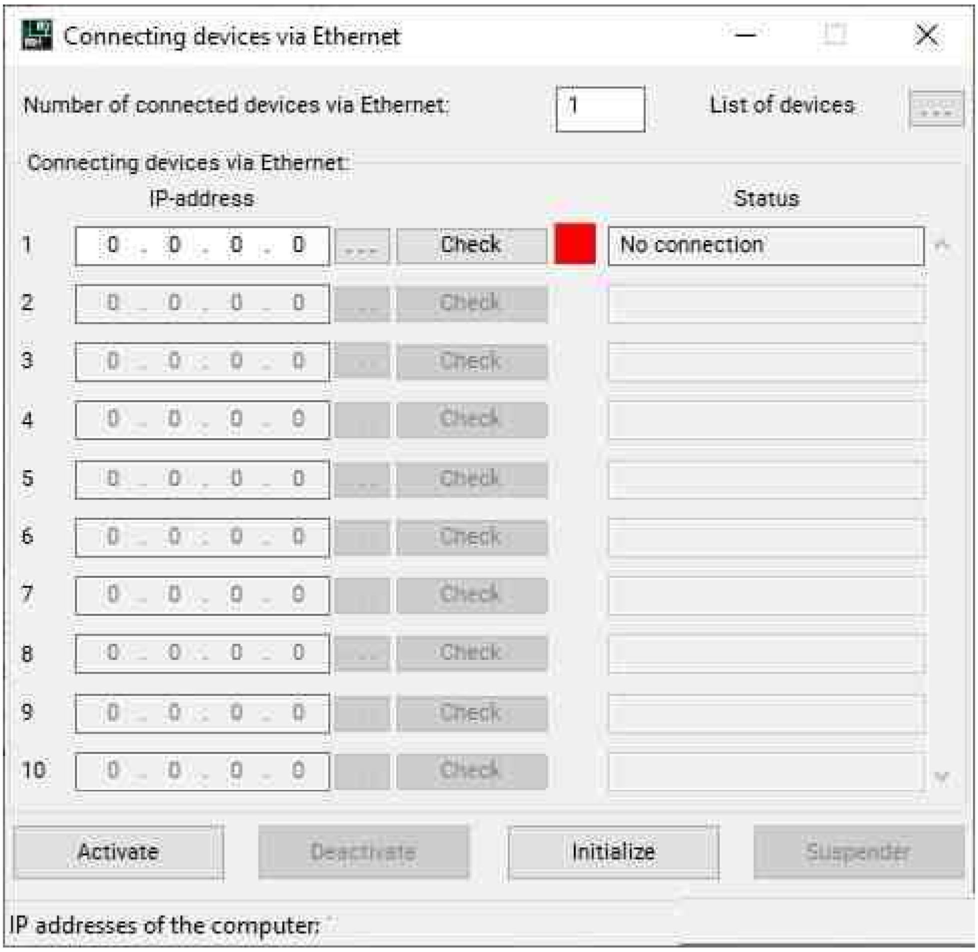


Fig. 4.18 "Connecting devices via Ethernet"

Enter the IP-address of the VCS controller to be activated (in this example - 192.168.12.108) (*Fig. 4.19*). If necessary, check the IP-address of VCS controller following the instructions specified in section 4.3.2

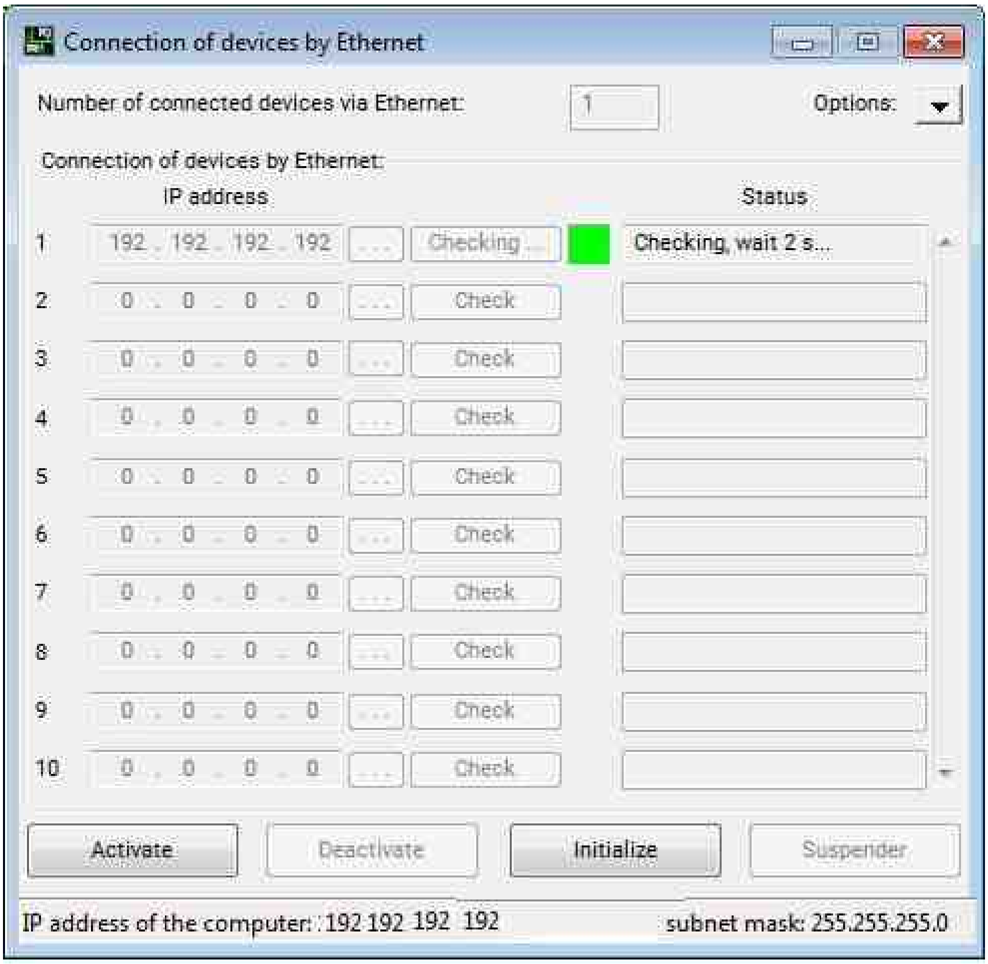


Fig. 4.19 "Connecting devices via Ethernet"

Click the key "Activate". If the VCS controller is successfully connected to the PC, its status in the program "Connecting devices via Ethernet" will change for "Connected" (*Fig. 4.20*).

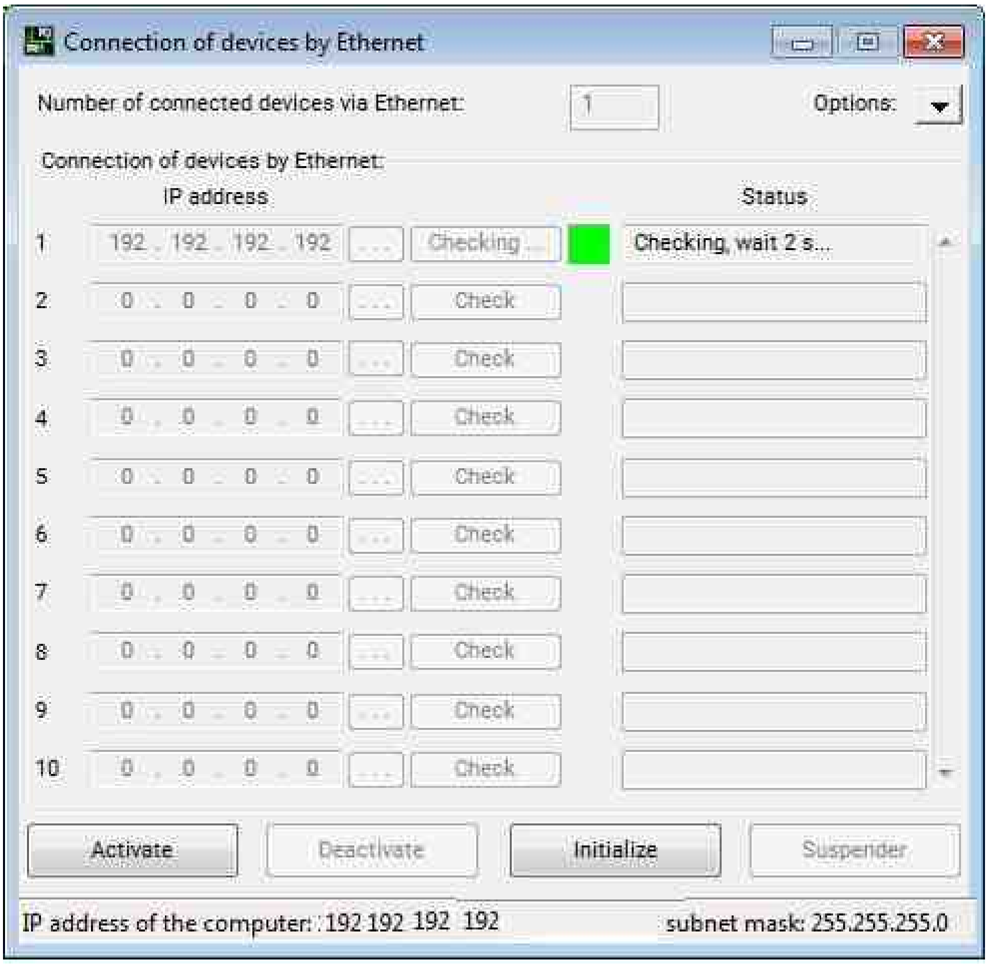


Fig. 4.20 "Connecting devices via Ethernet"

Possible errors in the devices ZETLab .....

List of errors that may occur in connected devices

Warning No.39 Battery charge is below 20% .....

Battery charge is below 20%.

Explanation:
The battery is less than 20%. Connect the equipment to a charger.

Warning No.210 Battery charge is below 50% .....

Battery charge is below 50%.

Explanation:
The battery is less than 50%. Connect the equipment to a charger.

Warning No.250 Program runs in DEMO mode .....

The program runs in DEMO mode. Check the connection of the devices to the computer.

Note:
This alert may indicate that no appropriate license to operate the software **ZETLAB.**

Error No.92 Error №92 Error when accessing the device .....

Bad USB cable - does not support HighSpeedUsb. You need to replace the cable.

Explanation:
Discovered the problem when connecting the equipment the USB interface. This USB cable does not support Hight-Speed USB 2.0. For correct operation of the equipment requires replacement USB cable.

Error No.93 Restarting the ADC due to channel shift .....

Restarting the ADC due to channel shift.

An ADC channel offset has been detected in the device. The main reason is electrostatic noise.

Error No.94 Discovered the problem when connecting the equipment the USB interface .....

Discovered the problem when connecting the equipment the USB interface.

Check connection of USB cable and if necessary, reconnect the equipment

Error No.95 Missing driver for the device. Install the driver .....

Missing driver for the device. Install the driver.

Explanation:
Encountered error when installing device drivers. To re-install the drivers, you should reconnect power to this device.

Error No.96 Error of device synchronization by PTP protocol (Master/Slave) .....

Error of synchronization by PTP protocol.

Note:
Check whether Master and Slave parameters have been assigned properly. To do that, right-click the error message. In the context menu, select the option "Debug". In the new window, check the Master and Slave parameters in the PTP section.

Error No.97 Error of device synchronization by PTP protocol (timing error) .....

Error of device synchronization by PTP protocol.

Note:
Timing parameters are misaligned. In the case if the PTP synchronization parameters have been recently set, it is necessary to wait until the timing parameters will be synchronized.

Error No.98 Error of device synchronization by PTP protocol (domain) .....

Error of device synchronization by PTP protocol.

Note:
It is necessary to set identical domains. To do that, right-click the error message. In the context menu, select the "Debug" option. In the new window, check the corresponding parameter ("Domain" section).

Error No.99 Error of device synchronization by PTP protocol (digital port) .....

Error of device synchronization by PTP protocol.

Note:
Synchronization by digital port is outdated. It is necessary to set the PTP synchronization parameters. To do this, right-click the error message, and select the debug option in the context menu. There will appear a new window, go to the clause "Digital port" and assign "Master" and "Slave" properties in the PTP section.

Error No.100 Uneven data transmission of the device .....

Uneven data transmission of the device

Explanation:
Unstable data transmission over the Ethernet network was diagnosed. Make sure that there is no loading of the local network with traffic not related to the work on ZETLAB (there is no traffic associated with

updating antivirus programs or transferring large amounts of data over the local network by other programs).

Error No.101 Data loss by all channels of the device .....

Contact ZETLAB technical support if this error occurs.

Error No.102 Excessive data by all channels of the device .....

Contact ZETLAB technical support if this error occurs.

Error No.103 Difference of PPS receipt by the devices is more than 100 ms .....

Difference of PPS receipt by the devices is more than 100 ms

Explanation:
Unstable data transmission over the Ethernet network was diagnosed. Make sure that there is no loading of the local network with traffic not related to the work on ZETLAB software (there is no traffic associated with updating antivirus programs or transferring large amounts of data over the local network by other programs).

Error No.104 Connection of devices by Ethernet not found (NetWizard.exe) .....

Connection of devices by Ethernet not found

Explanation:
It is necessary to check the connection of the specified device via Ethernet. To do this, right-click on the error. In the context menu, select "Fix". In the program "Connecting devices via Ethernet" that opens, check the connection. If the device is not detected or there is a connection, then you need to check the connection with this device. If there is no need to work with this device, exclude it from the "Connecting devices via Ethernet" program by right-clicking on the device and selecting Disable.

Error No.105 ADC and DAC are out of synch .....

Contact ZETLAB technical support if this error occurs.

Error No.106 Error RTC. The CR2032 battery in the device is faulty .....

It is necessary to replace the battery of the RTC module of the device. Contact ZETLAB Technical support.

Error No.107 Device not calibrated .....

The device needs to be calibrated. Contact ZETLAB Technical support.

Error No.108 Incorrectly directory .....

For more correct operation of the ZETLab software, we ask you to adhere to the following rules:

- The path must not contain points
- The path must contain only Latin letters
- The path should not be too long.

Error No.109 Connection of devices by Ethernet not found (NetWizardNew.exe) .....

Connection of devices by Ethernet not found

Explanation:
It is necessary to check the connection of the specified device via Ethernet. To do this, right-click on the error. In the context menu, select "Fix". In the program "Connecting devices via Ethernet" that opens, check the connection. If the device is not detected or there is a connection, then you need to check the connection with this device. If there is no need to work with this device, exclude it from the "Connecting devices via Ethernet" program by right-clicking on the device and selecting Disable.

Error No.110 Not enough data for the DAC .....

The data for the DAC was not received by the device in a timely manner.

Possible causes:

1. Unstable data transmission over Ethernet.
Try to eliminate possible delays caused by third-party network traffic. It is recommended to use a "direct" connection when the PC is connected to the device directly through one patch cord or through one switch that does not have access to the local network.
2. High CPU usage on the PC.
Try to reduce the CPU load. It is recommended to close browsers, graphic editors and other resource-intensive applications while working with the device, as well as limit the work of antivirus software.

If the problem persists, contact ZETLAB technical support in case of this error, specifying the version of the ZETLAB software and the serial number of the device.

Error No.111 ADC buffer overflow .....

If the problem persists, contact ZETLAB technical support in case of this error, specifying the version of the ZETLAB software and the serial number of the device.

Error No.112 Significant potential difference between ADC and DAC lands .....

If the problem persists, contact ZETLAB technical support in case of this error, specifying the version of the ZETLAB software and the serial number of the device.

Error No.113 One of the channels of the device is in service mode .....

If the problem persists, contact ZETLAB technical support in case of this error, specifying the version of the ZETLAB software and the serial number of the device.

Error No.120 Loss of data .....

Loss of data.

Note:
Contact the technical support service of ZETLAB in case of this error.

Error No.121 Faulty synchronization .....

Faulty synchronization.

Error No.122 Faulty power supply unit .....

Faulty power supply unit.

Explanation:
Identified problems with the supply of equipment. To continue to operate the device, you must inspect the condition of the power source and continuity of supply.

Error No.123 Data from the device is not reliable .....

Data from the device is not reliable.

Error No.124 For correct operation of the program, close the SensorWork .....

For correct operation of the program, close the SensorWork.

Explanation:

Discovered problems while working with the software ZETLAB. To continue to work with the software necessary to complete the program "SensorWork".

Error No.125 Lost communication with the device .....

Lost communication with the device.

Error No.126 An error occurred when communicating via Modbus .....

An error occurred when communicating via Modbus

Error No.127 Error interface module, the necessary repairs .....

Error interface module, the necessary repairs.

Explanation:
A fault of the Converter interface. To continue the work required to replace the device.

Error No.128 CAN bus load beyond 95% .....

CAN bus load beyond 95%

Note:
Possible solutions to this problem::
1) If possible, increase the bit rate in the wizard interface settings (interface converter). To do this: go to the Device manager -> right-click on the wizard -> select properties -> "CAN" tab;
2) Reduce the sampling frequency of sensors connected to the master. If the sensors support compression, enable. All of the above is performed in the **ZET Device Manager** program, calling the properties of the corresponding sensors.

Error No.129 Detected errors on CAN bus .....

Detected errors on CAN bus

Note:
Contact the technical support service of ZETLAB in case of this error

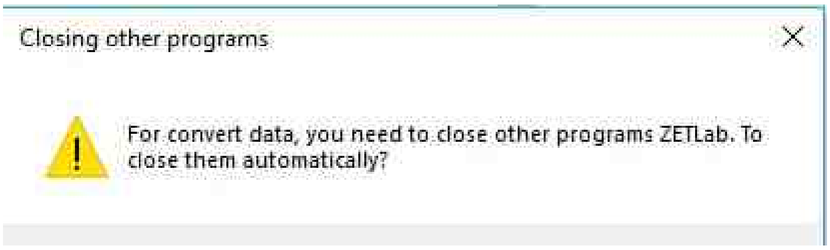
Error No.192 WaterMark problem .....

WaterMark problem

Error No.193 Firmware version check error .....

Firmware version check error

Error checking the firmware version.
Go to the Services tab -> **ZET Device Manager**, select the device.
In the General tab, find the Version field, if the field is empty or there is an error, then you need to turn off and turn on the device again.



If the error persists, please let us know.

Error No.194 Wrong arguments .....

The Silent Converter program is launched in 3 cases

- Automatically from ZETLab program panel;
- From the Offline recorder tab of the **ZET Device Manager**;
- Manually via the ZETLab folder settings.

This error can occur only in the third case, when the user incorrectly entered a command line parameter.

If you need to convert files from an SD card or computer, then the command should be like:

```
PS C:\ZETLab> SilentConverter.exe -flash C:\Users\User\Desktop\folder
```

Fig. 1 Path to the ZET_DATA folder

*The folder folder should contain the ZET_DATA folder with files for conversion.

If you need to convert files from the device directly, then the command should be like:

SilentConverter.exe -device 00 00

Where the first two digits are the device type, the last two digits are the connection type.

Error No.195 SD card error .....

This error will occur if the user has incorrectly created a folder for conversion from a computer or there is no SD card in the connected device

Note:

- The files must be located in the ZET_DATA folder
- In the folder itself there should be nothing but files:

1. "DEVICES.CFG" or "CALIBR.CFG",
2. x.DAT, x.ZDT or session files like: S0001.001

Error No.196 No files for conversion found .....

To solve this problem, check the SD card for recorded files

Go to the Services tab -> [ZET Device Manager](), select the device and go to the Autonomous recorder.

If the status of the flash drive is displayed correctly, then make sure that you have recorded.

If you see the inscription Error working with the SD-flash card, then turn off/turn on the device, if the error persists, let us know.

Error No.197 SD card is empty .....

To solve this problem, check the SD card for recorded files

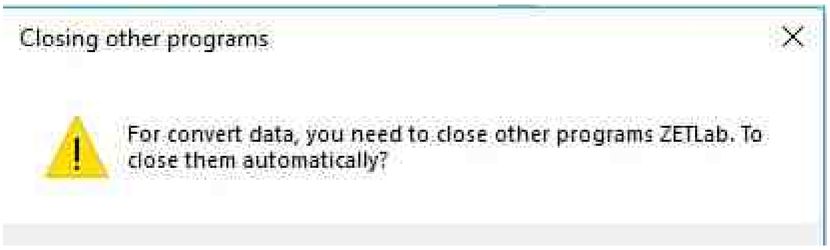
Go to the Services tab -> [ZET Device Manager]() select the device and go to the Autonomous recorder.

If the status of the flash drive is displayed correctly, then make sure that you have recorded.

If you see the inscription Error working with the SD-flash card, then turn off/turn on the device, if the error persists, let us know.

Error No.198 The device is not supported .....

To convert files correctly, Teleconverter needs to enter the exclusive mode, which means that all other programs will not interfere with it.
Therefore, when you start the program, you need necessary to activate the "Yes" button.



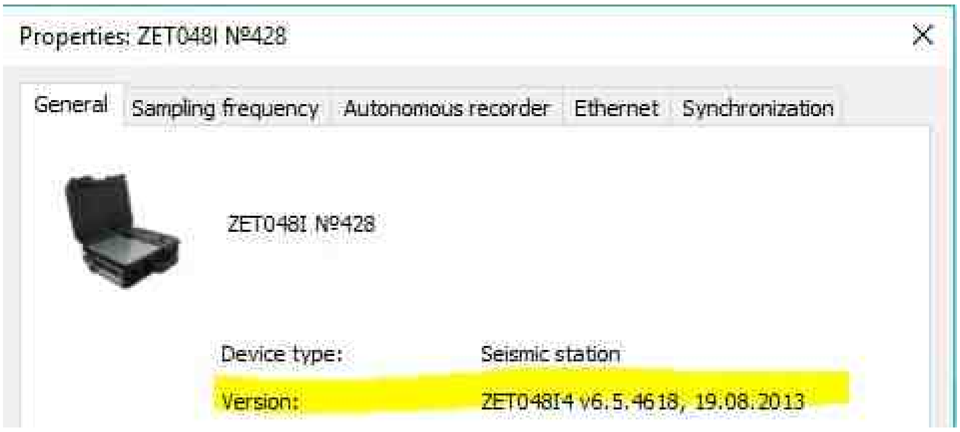
Other methods of solving the problem:

- Turn off/on the device
- Close all programs
- Close the ZETLab program panel

If the error persists, please let us know.

Error No.199 Error of switching to the exclusive mode .....

Error of switching to the exclusive mode


Properties: ZET048I №428
General
Sampling frequency
Autonomous recorder
Ethernet
Synchronization
ZET048I №428
Device type:
Seismic station
Version:
ZET048I4 v6.5.4618, 19.08.2013

About using the zetlab software update

This section will cover general issues of working with the **ZETLAB** software: measuring channel settings, program settings, etc.

Many ZET-devices are universal devices, and when solving a specific problem, the question arises of the correct setting of the measuring channels. In addition, the results obtained directly depend on the settings of the programs. Descriptions of program parameters are provided in the individual program sections, while this chapter covers general principles such as data averaging time, signal sampling rate, and so on.

Getting started

ZETLAB software is designed for processing signals recorded by ZET measuring equipment from various primary transducers (sensors).
Working with ZETLAB software starts with:

- study of operational documentation for software, measuring instruments and sensors,
- software installations,
- connecting the sensors to the measuring device and the measuring device to the PC,
- measurement channels settings,
- program settings.

Description of ZETLAB software installation and Hardware requirements are given in section 2 of this manual"Installing ZETLAB software".

The connection of sensors to the measuring instrument is discussed in the descriptions of measurement programs such as "Thermocouple thermometer", "Thermocouple thermometer", "Strain gauge", as well as on our website http://zetlab.com and in the instruction manuals for measuring instruments and sensors.

Software setup when connecting the measuring instrument to a PC is covered in the section "Connecting appliances" this manual. The procedure for connecting the measuring device to a PC is described in the instruction manual for the device.

So, the documentation has been studied, the sensors are installed at the measurement sites, connected to the instruments, the instruments are connected to the computer. Where to start measuring?

To get results you need:

1. Set up the measuring device, as a minimum, you need to select a suitable signal sampling frequency - see subsection "Data averaging time and sampling frequencycretization of signals" of this document. Sampling frequency is set in the program **ZET Device Manager**.
2. Next, you need to configure the measuring channels. Measurement channels settings depend on the type of connected sensor and the type of software that will be used for measurements. For example, for vibration sensors, the conversion factor and units of measurement are indicated - measurements by the "Vibrometer" program are carried out taking into account these data. The same applies to speed sensors, displacement sensors - in the settings of the measuring channels, the sensitivity (conversion factor) and units of measurement are indicated according to the passport. And when connecting force sensors, thermometers, etc. all settings are set in the measurement programs, and the parameters of the measurement channels must remain set by default. Measurement channels settings are set in the program **ZET Device Manager**.
3. Select a program for analysis or measurement. If necessary, carry out preliminary processing of signals, for example, filtering. A recorder can be used to record the results.

About sensor power supply

Some sensors are powered by an external source, for example, when sensors are connected to ADC/DAC boards through the ZET 410/412 amplifier, built-in current and voltage sources of the amplifier are used.

Sensors of the ICP standard are connected to the spectrum analyzer and the ICP flag is set in the measurement channels settings.

The meter generator (DAC output) can also be used to power the sensors. The control of this generator is carried out using the program "Generator of signals of various forms".

Note: not all ZET devices have a DAC.

Recommended

ZETLAB programs can be launched directly from their installation directory (by default "C:\ZETLab") or from the ZETLAB control panel.

The ZETLAB control panel not only allows you to quickly launch the desired virtual instrument, but also has many useful features, such as saving projects (especially important when working with a large number of programs). Since the ZETLAB panel is not a measuring instrument, users overlook its description and, as a result, lose sight of some convenient features.

Example of working with ZETLAB software .....

1. Connect the necessary devices and sensors to the computer.
2. Turn on the computer. Using the "**ZET Device Manager**" program on the "Service" tab, configure the connected devices.
3. Run all the necessary programs for work. At the same time, each of them can have on its screen (buttons with numbered TVs) and have its own location of the program window on this screen. Set the required parameters for each program.
4. Verify that running programs produce correct results.
5. In the main window of the Zet-panel (the leftmost button of the panel) in the "**ZETLAB** project management" section, click on the "Save project as ..." button. Set a name for the new project and wait for the zpy file to be saved.
6. After completing the work in the main window of the Zet-panel in the "Shutdown" section, click on the "Exit" button. All running programs and the Zet-panel itself will close.

The next day.

1. Make sure that all yesterday's devices are connected to the computer.
2. Turn on the computer. Make sure no one has changed device settings. THIS IS VERY IMPORTANT FOR THE CORRECT OPERATION OF PROGRAMS!
3. Launch the zet-panel. In the main window of the Zet-panel, in the "Recently opened projects" section, click on the name of the saved file. All programs will start downloading. Program download sequence:
   - generator programs;
   - programs that create virtual channels;
   - programs that work with Zet-server channels;
   - other programs.
4. Wait until the programs start up.
5. Make sure that the location of the program windows and their settings correspond to the status before saving the zpy file.
6. Run the generator programs (if necessary).
7. When using the "Signals recording" program, start recording.
8. You can work.

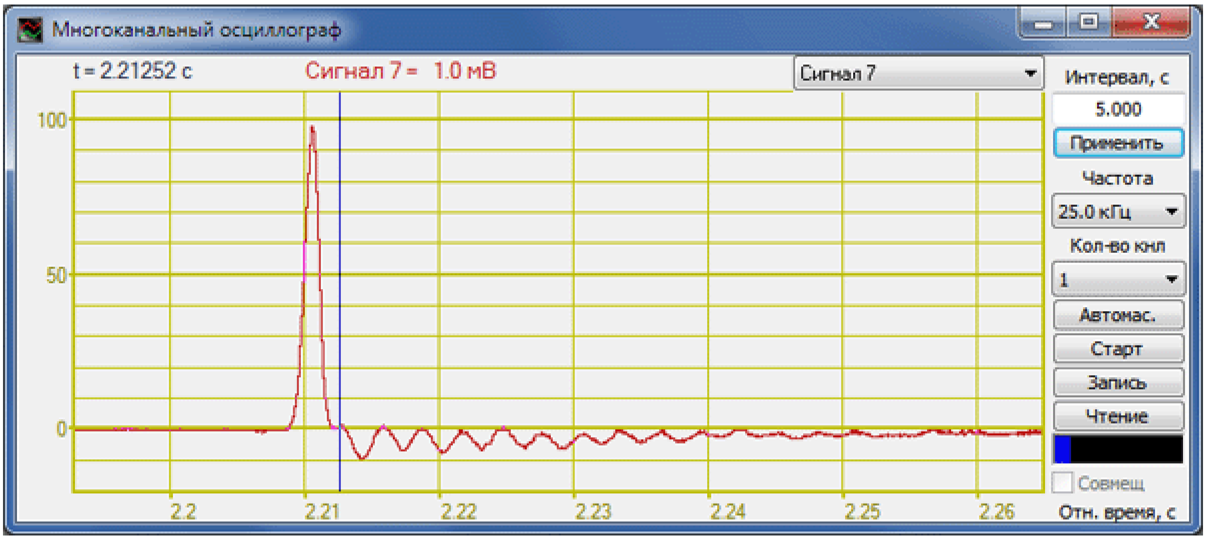
Data average time and sampling frequency

In most ZETLAB programs, there is such a parameter as the data averaging time. What does it affect and what is it connected with? The set averaging time directly affects the resulting measurement result and is inextricably linked to the signal sampling frequency.

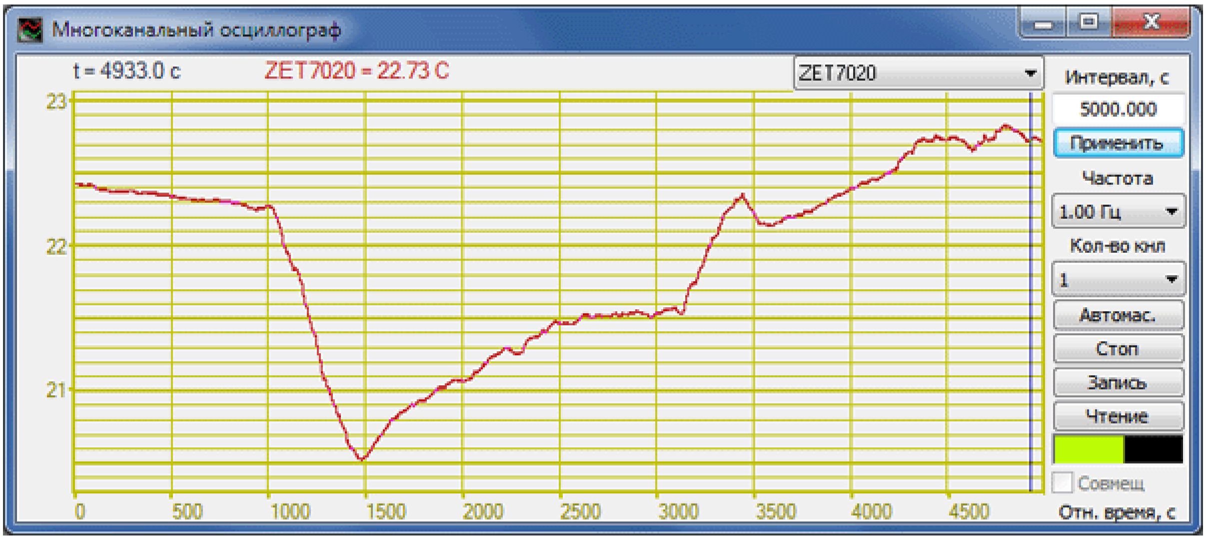
The measurement parameters are directly related to the change in the processed signal over time. In general, there are:

- fast processes (explosions, shocks) or high-frequency
- slow processes (changes in temperature outside) or low-frequency•ultra-slow processes (seismic shocks).

Let's compare 2 signals: one was obtained when testing products on a drum set, the other when monitoring the temperature in the room. To analyze the impact signal, the sweep along the time axis is 0.07 seconds. The temperature signal in the office space will hardly change noticeably during this time. From the above examples, it is obvious that the analysis of different signals must be carried out in different time intervals.



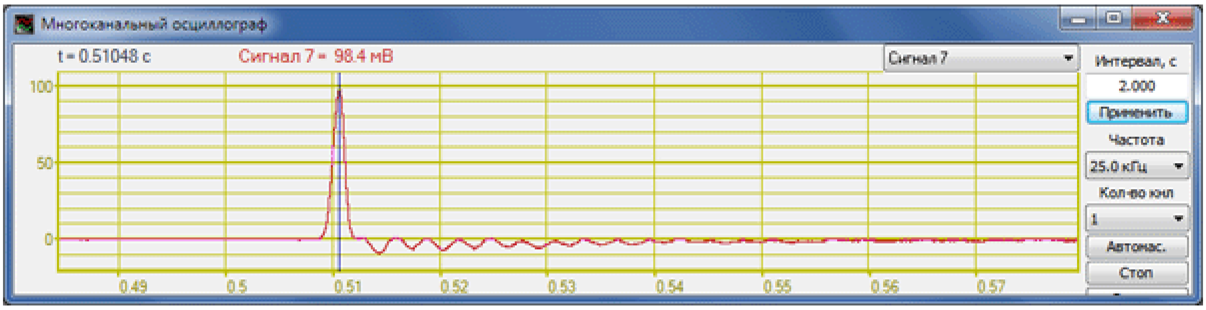
The oscillogram of the impact signal, the display interval 0.07 seconds
The oscillogram of the signal shock



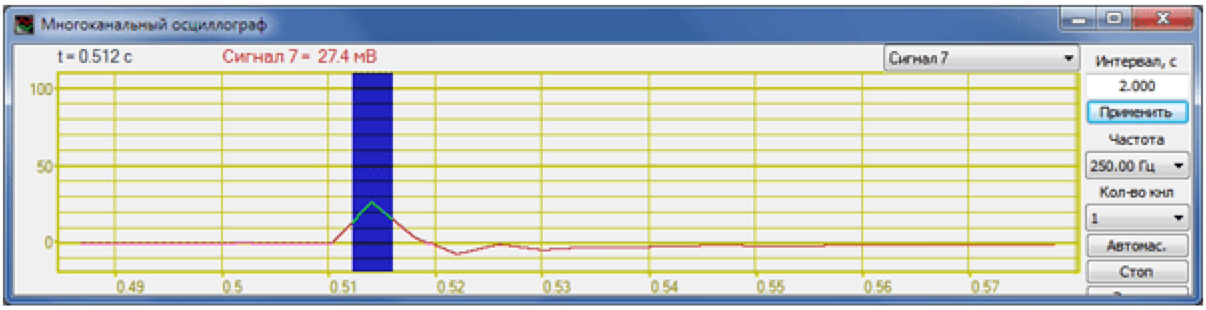
The oscillogram of the temperature signal, the display interval 5000 sec
The oscillogram of the temperature signal

But no program will give reliable results if the original signal has insufficient or, on the contrary, the excessive level of detail.

The Fig.s below shows an example of display of the same signal with different impact frequency: 25 kHz and 250 Hz. The naked eye can see that the second representations of the signal for analysis is not suitable.

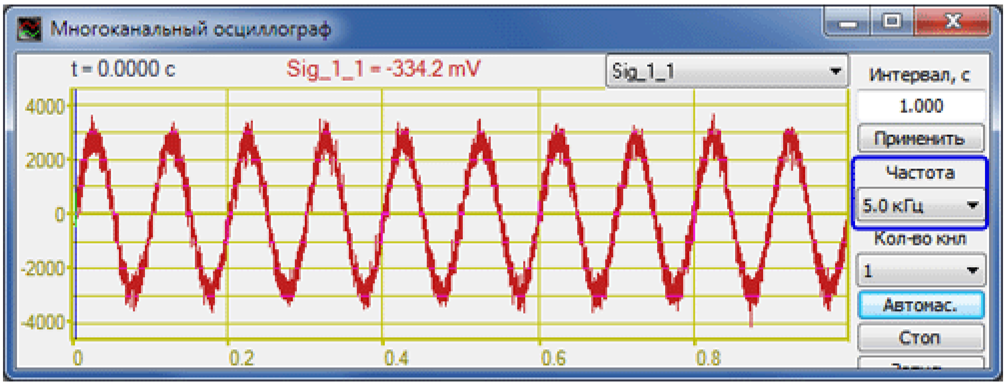


The display of the crash signal with a frequency of 25 kHz

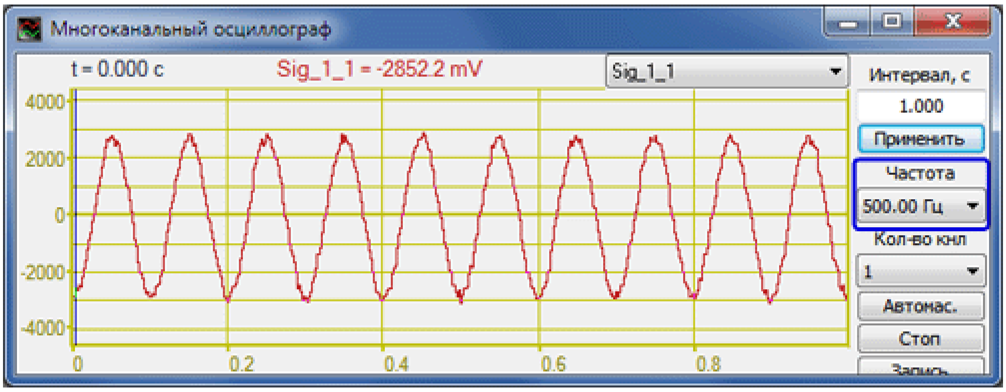


The display of the crash signal with a frequency of 250 Hz

The Fig.s below shows an example of display of the same signal (a sine signal wave with a high level of noise) with different frequencies: 5 kHz and 500 Hz. Since the frequency of the signal is 10 Hz, the frequency representation 500 Hz is enough: one period of the signal accounted for 50 points (500/10=50). But the analysis of a signal with a frequency of 5 kHz representation is redundant.



Display of signal with a frequency of 5 kHz



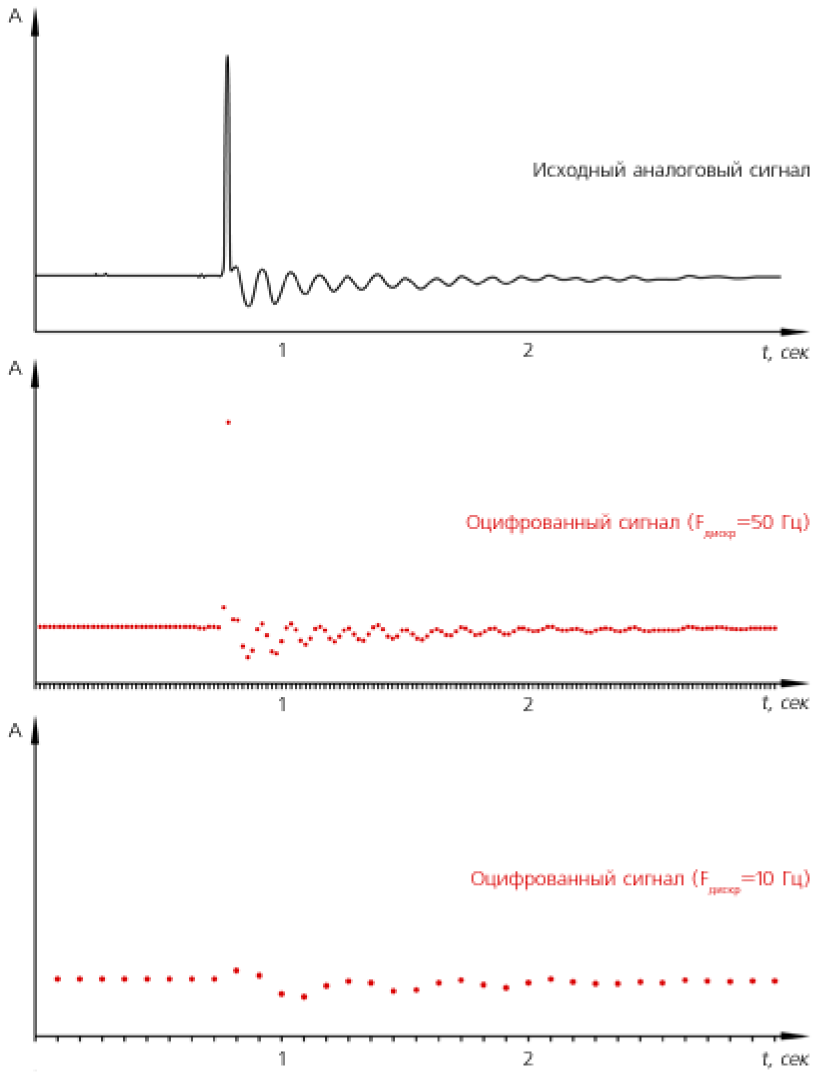
Display of signal with frequency of 500 Hz

The above examples obtained by using the "Multi-channel oscilloscope" and are merely a clear demonstration of the influence of temporal and frequency parameters on the result. Variable in the program "Multi-channel oscilloscope" frequency representation of signals affects only the displayed data, and depends on the sampling frequency of the signal. Not all the **ZETLAB** programs have a setting Frequency representation, but the result of the operation of any programme depends on the sampling frequency of the signal.

The sampling frequency of the signal

Let's start with the fact that the ZETLAB program is designed for the processing of digitized signals. The analog signal from the sensor is sampled by the measuring instrument and the received digital signal is formed as a channel of the data server ZETSERVER. The channel data represents instantaneous samples of the signal to a certain number per second. The number of samples per second is called the sampling frequency.Let's start with the fact that the ZETLAB program is designed for the processing of digitized signals. The analog signal from the sensor is sampled by the measuring instrument and the received digital signal is formed as a channel of the data server ZETSERVER. The channel data represents instantaneous samples of the signal to a certain number per second. The number of samples per second is called the sampling frequency F_{ADC} and is specified for the meter in the program **ZET Device Manager**.

The Fig.s below shows an example of digitizing the same signal with different sampling frequencies. The example demonstrates that the sampling frequency when digitizing a signal should be sufficient for analysis of the investigated process..The Fig.s below shows an example of digitizing the same signal with different sampling frequencies. The example demonstrates that the sampling frequency when digitizing a signal should be sufficient for analysis of the investigated process.



Digitizing the analog signal with different sampling frequencies

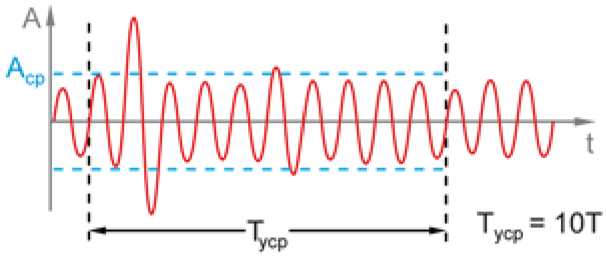
The General rule if you select sampling frequency: the faster the process, the higher should be the sampling frequency.

Frequency range

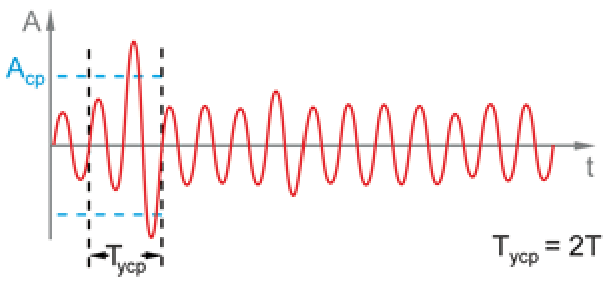
Because the signals are digitized with a certain sampling frequency, analysis may be performed in a limited frequency range. The values of the signal parameters can be computed by the programs, if the signal period is no less than 2-3 points. For example, if the sample rate of the signal is 25 kHz, the analysis in the 10 kHz range**.**

Time averaging data

The digitized signal is a sequence of instantaneous values of the signal. And at this stage all of the time parameters of the measurement there is only one sampling frequency, i.e. the number of points per second. When calculating any parameter of another signal parameter is the time averaging of the data. The Fig.s below shows an example calculation of RMS (root mean square value of the signal) with averaging equal to two periods of the signal T, and averaged, equal to ten periods of the signal So you Need to match the averaging time in accordance with the task. If you want the aliasing interference, it is recommended to increase the averaging time of the data measurements. In transient studies, on the contrary, requires a high degree of detail and fast averaging.



The calculation of the RMS for a time equal to 10 periods of the signal
The calculation of the RMS during the 10T



The calculation of the RMS for a time equal to two periods of the signal

Control and indication elements

ZETLAB programs have an intuitive interface and a convenient control system. When developing ZETLAB programs, generally accepted standards and designations are taken into account, which makes working with them simple and convenient.
This section will describe how to work with controls of ZETLAB programs.

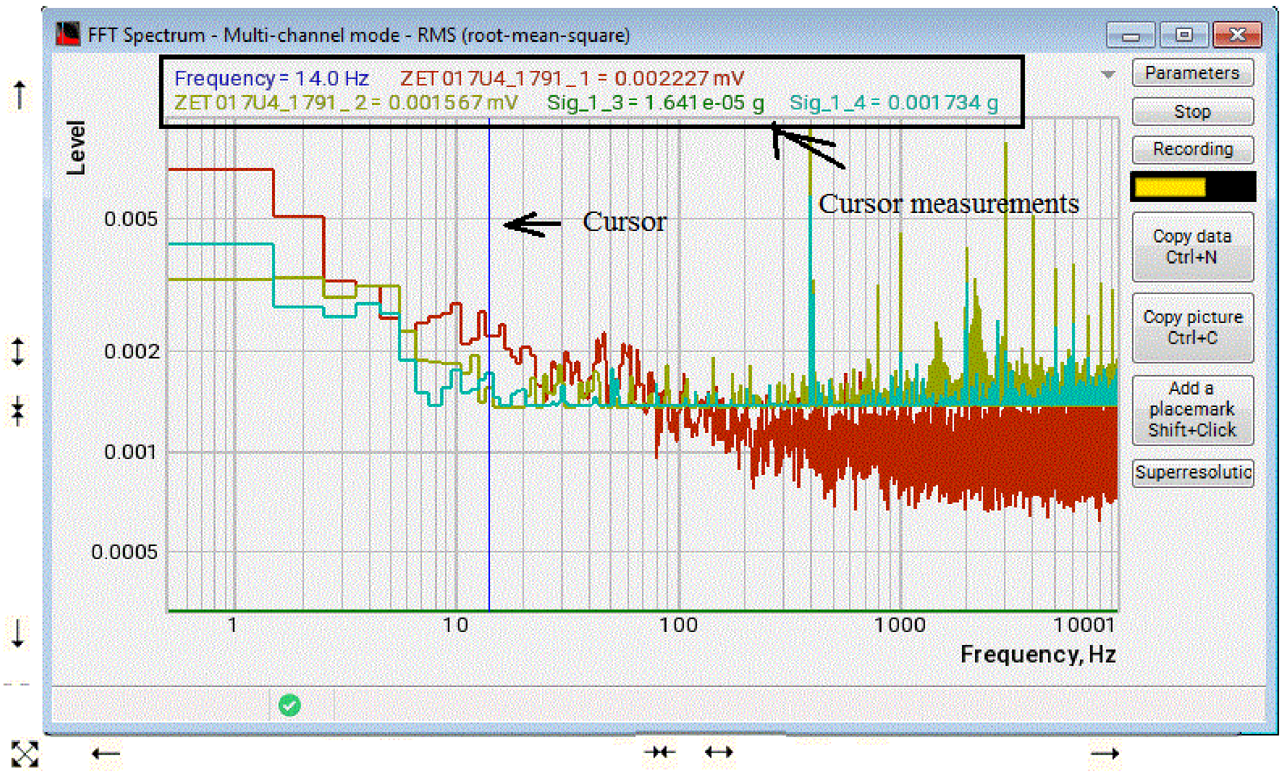
Table of contents:

Cursor control in graphics .....

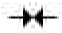
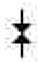
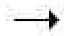
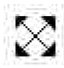
Most of **ZETLAB** program windows that are used for displaying of graphics, have a cursor, which allows to display the values, calculated by the program, at a particular position of the cursor.

Moving the cursor in the window is carried out in any of the following ways:

- move the mouse pointer to the place of interest on the graphic, press and hold the left mouse button until the cursor moves to the specified place;
- when the ZETLAB program window is active (the program window is activated by pressing the left mouse button when positioning its pointer in the window field), using the mouse roller, move the graph cursor until the required frequency value is reached;
- when the ZETLAB program window is active, the cursor is moved to the left by pressing and holding the <A> key on the keyboard (in the Latin layout), to the right - by the <D> keys.



FFT Spectrum cursor control and zoom graphics

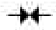
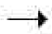
The mouse pointing device is also used for scaling of the numerical axes. As the mouse pointer is moved along the numerical axes, it changes its appearance depending on the currently available graphic scaling option. Left-click it or use the scroll wheel. It is possible to increase / decrease the graphic scale using the following icons: ,  – for horizontal axis and ,  – for vertical axis. Move the graphic to the left / to the right or up / down using the icons ,  – for horizontal axis and , , for vertical axis. If you place the mouse pointer at the cross-section of numerical axes, it will change its appearance: . Left-click this icon for automated scaling of the graphic by signal level.

Scaling the numerical axes of graphics .....

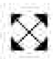
You can scale the numerical axes using mouse.

To scale the numerical axes, place the mouse cursor to the scale axis of the graphic. The cursor will change its appearance depending on its position on the numerical axis:

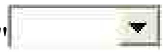
- For horizontal axes: , , , ;
- For vertical axes: , , , .

Symbols  and  stand for extension, and symbols  and  - for compression of the graphic scale by the corresponding axis. Symbols  and  stand for moving to the left and to the right by the horizontal axis, and symbols ,  stand for moving up and down by the vertical axis.

As you select the required action for scaling by numerical axis and the cursor changes its appearance, you can scale the graphic by using the left mouse key, or by using the scroll key.

For auto-scaling of the vertical axis in the registered range of values (which is displayed in horizontal axis of the graph), place the cursor at the crossing of the numerical axes, so that the cursor icon would change for  and left-click it.

Selection from the lists .....

The icon " „ of ZETLAB programs allows the user to select the required parameter value from the list.

In order to select the required parameter from the list, place the cursor at the corresponding symbol. You will see a drop-down list with the available values. Place the cursor at the required value and left-click it. You can switch between the available values using the scroll key, or the keyboard keys <↑> and <↓>.

Setting parameters of display .....

Clicking the right button of "mouse" on the field graphics programs:

- FFT Spectrum Analysis,
- Spectrum CPB Analysis,
- Cross-Spectrum FFT Analysis,
- Cross-Spectrum CPB Analysis,
- Cross-Correlation Analysis,
- Histogram

there is an additional window **Graphics settings.**
When right-click is made on the graphic field of the **FFT Spectrum** program windows, there appears an additional window, **Parameters**.
On the **Display parameters** tab (*Fig. 7.93*), the line type and graphic parameters are set. Graphic line types can be horizontal (jaggies) or angled lines. On this tab, parameters of displaying each graphic, color, thickness, filling (painting) of the graphic area can be set as well.
Fig. 7.94 shows the Grid Settings tab. On this tab, the display of the horizontal and vertical axes marking and grid lines can be turned on or off. Graphic visibility area (display area) can be set on this tab as well: upper, lower, right, and left bounds of graphics.

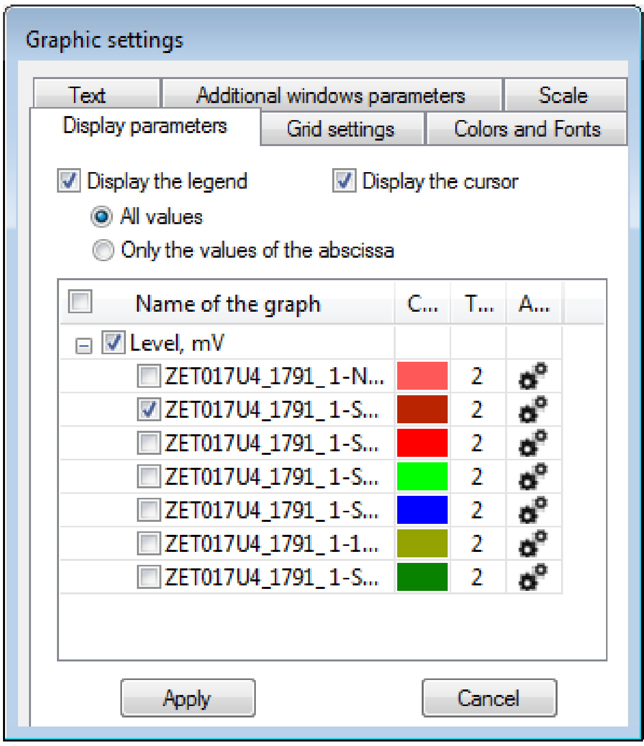


Fig. 7.93

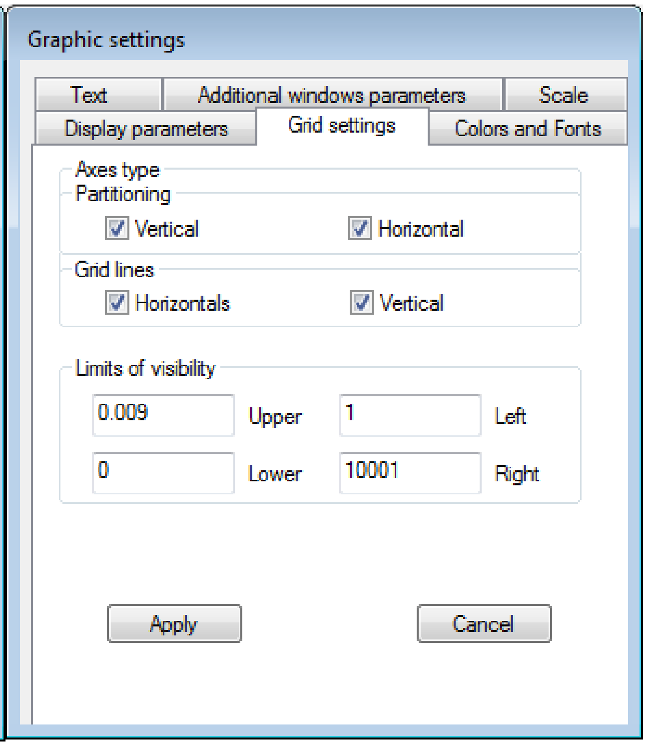


Fig. 7.94

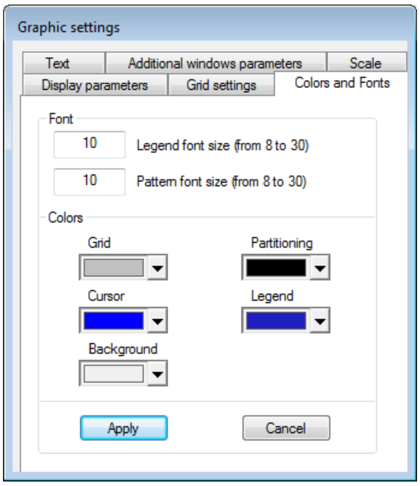


Fig. 7.95

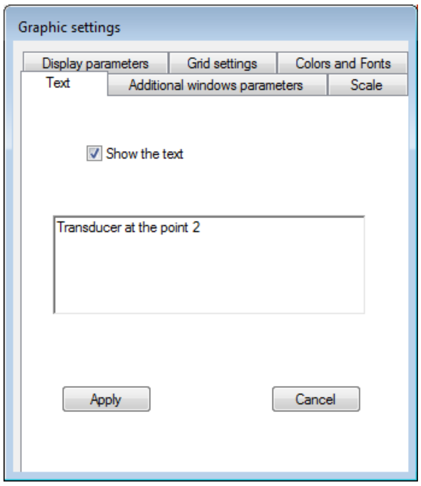


Fig. 7.96

Fig. 7.95 shows the **Colors and fonts** tab. On this tab, the font size of the axes and measured values numerical values can be changed. On this tab, the color of the grid, cursor, background, axes marking, legend can be set as well.
Fig. 7.96 shows the **Text** tab. On this tab, additional text information can be recorded, to be displayed at copying and pasting of spectrum graphics to text documents. To record this information, check the **Show text** checkbox, select the required font of the text, and input the text in the input field.
Fig. 7.97 shows a fragment of the **FFT Spectrum** program working window with some additional information.
Fig. 7.98 shows the **Scale** tab. On this tab, the type of the horizontal and vertical scales representation can be selected. The vertical scale can be represented in the uniform, logarithmic, or decibel form. The horizontal scale can be represented in the uniform, logarithmic, or 1/octave (part-octave form).

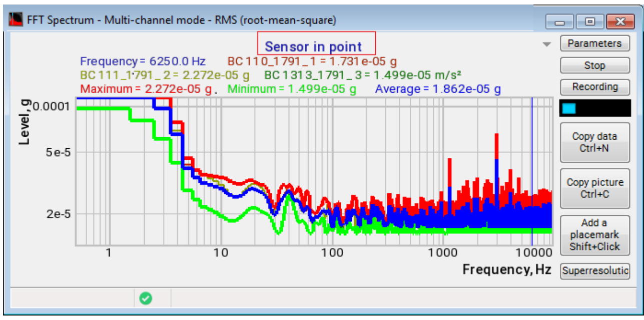


Fig. 7.97

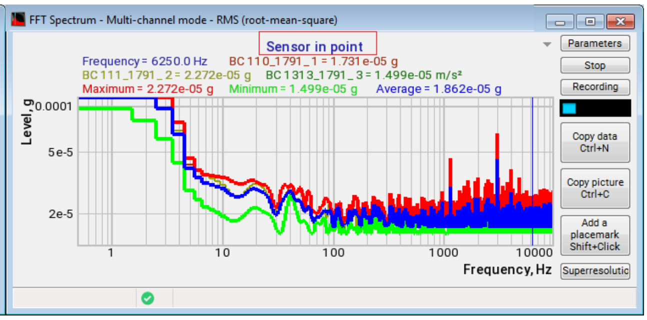


Fig. 7.98

When the vertical scale display representation is selected, the display of numerical values of the measured value over the graphic field relative to the cursor position will be as selected in the FFT Spectrum parameter settings (the FFT Spectrum parameter setting is described in section **7.3** of this **Operator manual**), and the vertical scale grid will be in accordance with the selected view.
Changed setting are saved by pressing **Apply** button; the **Parameters** window will close, and the selected settings will come into force.
To exit the **Parameters** window without saving the settings, press **Cancel** button, or button in the right upper corner of the window, or by clicking any mouse button at  any area of the screen free from the **Parameters** window.

Using signal level indicators .....

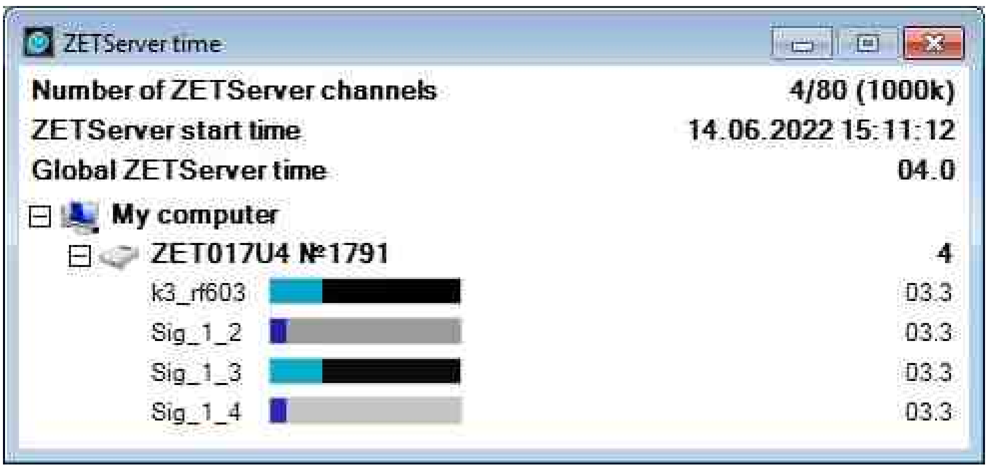
Most of ZETLAB programs used for processing of the registered signals (by the selected measurement channel) have signal level indicators (Fig. 3.7), displaying the current integral level of the signal.

Fig. 3.7 Indicator of signal integral level

Signal level indicator allows the user to evaluate the quality of selection, adjustment, and sensitivity of elements for a particular measurement channel, thus excluding signal processing in the case of overloading and signal failure in the selected measurement channel.

Two thirds of signal level indicator section display the signal level, which is below the maximal admissible value. The higher is the level, the more is indicator value. As the maximal admissible level is exceeded (without the presence of signal distortions), the indicator flashes with red. When overloading by the measurement channel will no longer be detected, the indicator will flash red until the user left-clicks it.

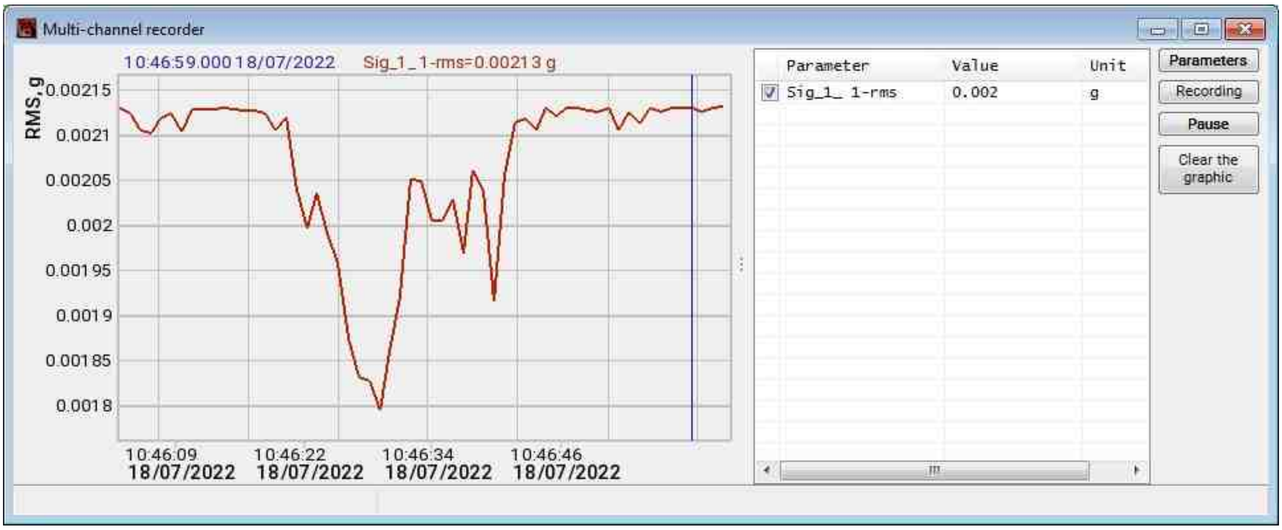
The indicators of the "ZETServerTime" program window are also equipped with the function of changing the color of the background area of the indicator. This function allows you to perform a statistical evaluation of the quality of the recorded signal in the measuring channel. The more the signal resembles white noise in its statistical characteristics, the lighter the background area. The smaller the signal resembles white noise in characteristics, the darker the background. At rest, the signal of a serviceable sensor should show background noise that is close to white in characteristics. The presence of interference (pulse, harmonic, etc.) or a malfunction in the sensor leads to a change in the characteristics of the signal and darkening of the background area of the indicator.

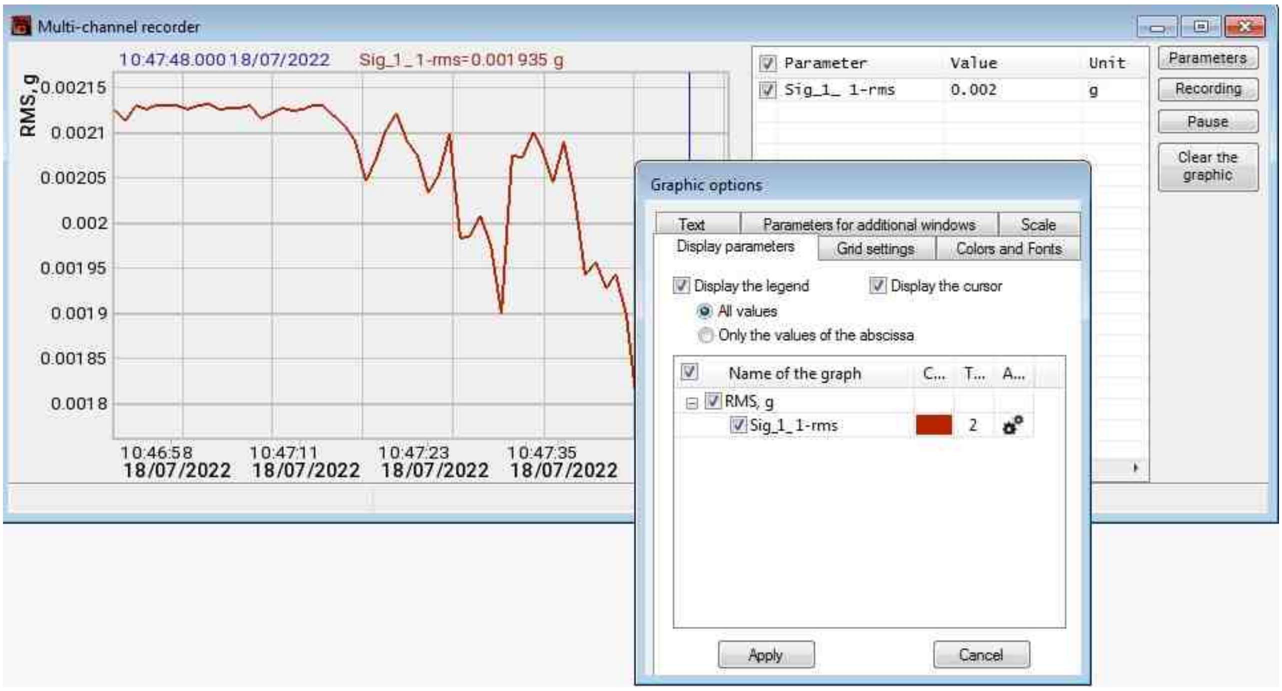


Adjustment of the color scheme used for displaying of the registered signal amplitude values_2 .....

Clicking the right button of "mouse" on the field graphics programs:

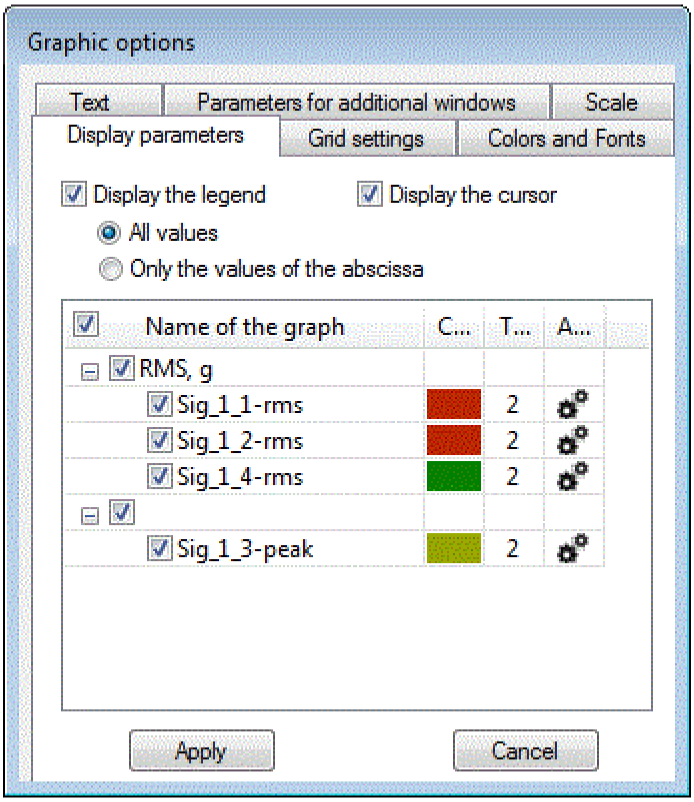
- FFT Spectrum,
- Spectrum CPB Analysis,
- Cross-Spectrum FFT Analysis,
- Cross spectrum octave,
- Cross-Spectrum CPB,
- Cross-Correlation analysis,
- Harmonic Distortion Analysis;
- Modal analysis;
- Histogram;
- STA/LTA detector;
- Shocks recorder;
- Results viewing;
- Multi-channel recorder;
- Programs Vibration control system (VCS).



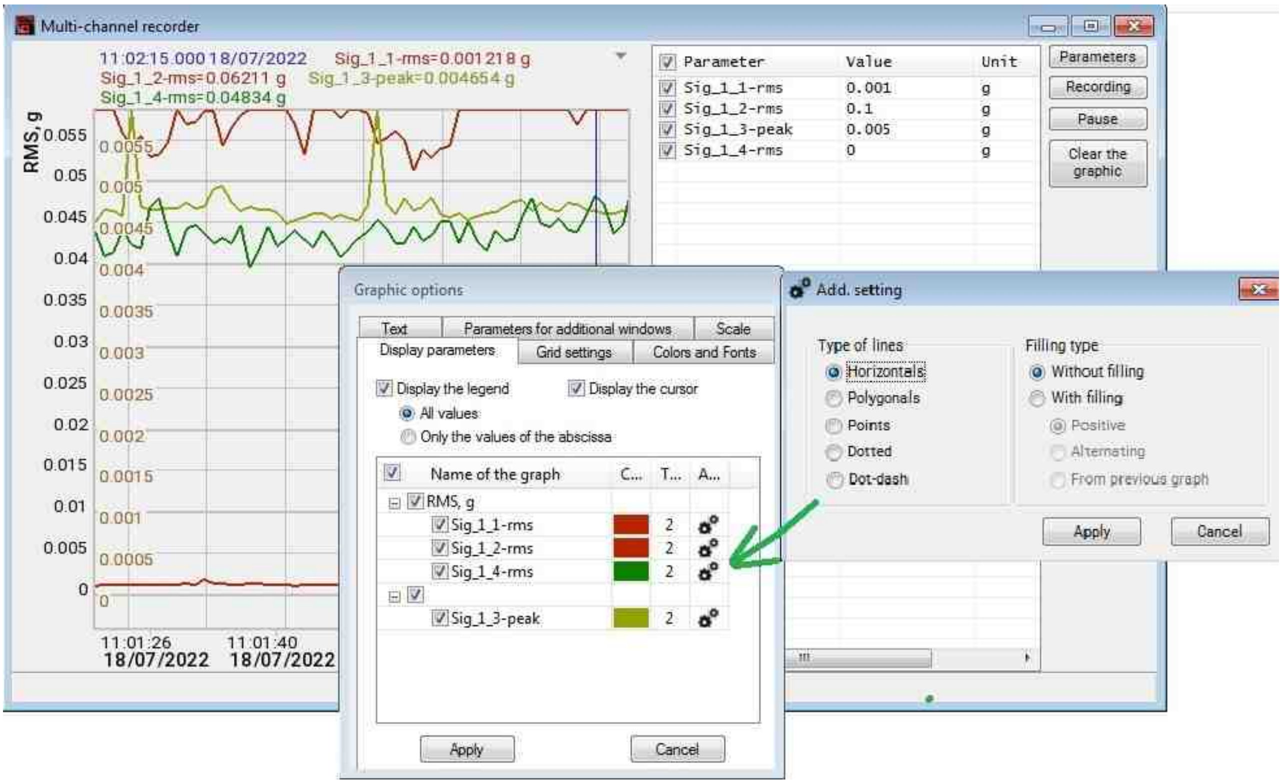


When you click on the graphic display area, an additional **Graphic settings** window appears.

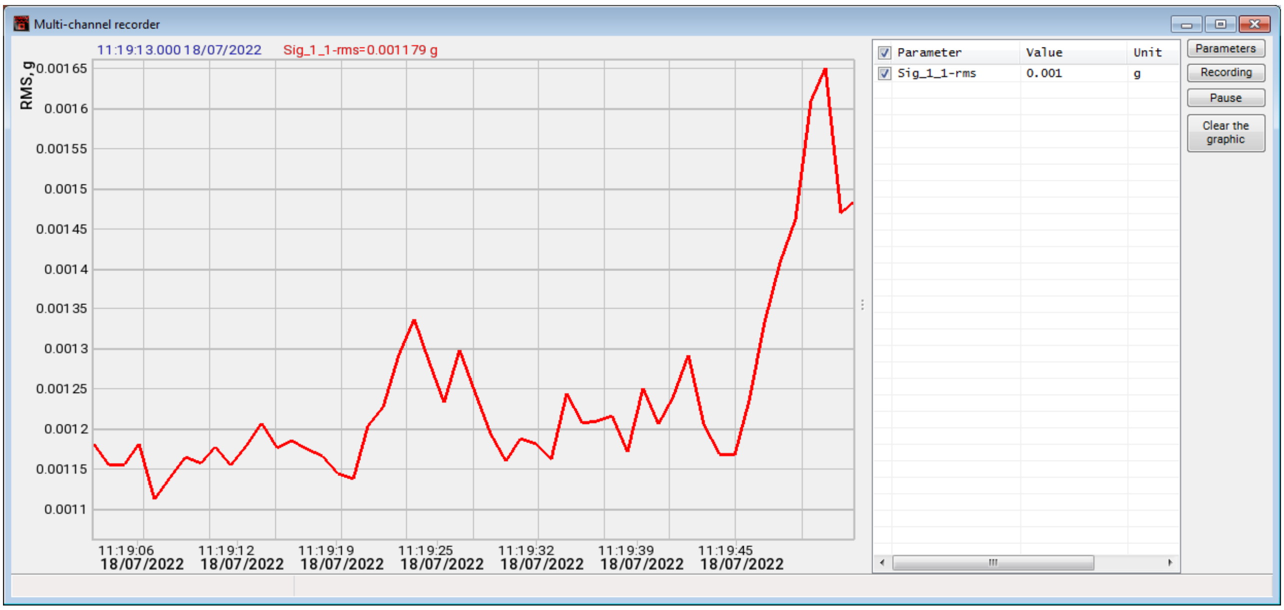
On the **Display parameters** tab, you can set the line type and Graphic settings. Line types of graphics can be in the form of horizontal (steps) or broken lines. This tab also sets the display parameters for each of the graphics, color, thickness, filling (shading) of the graphic area.



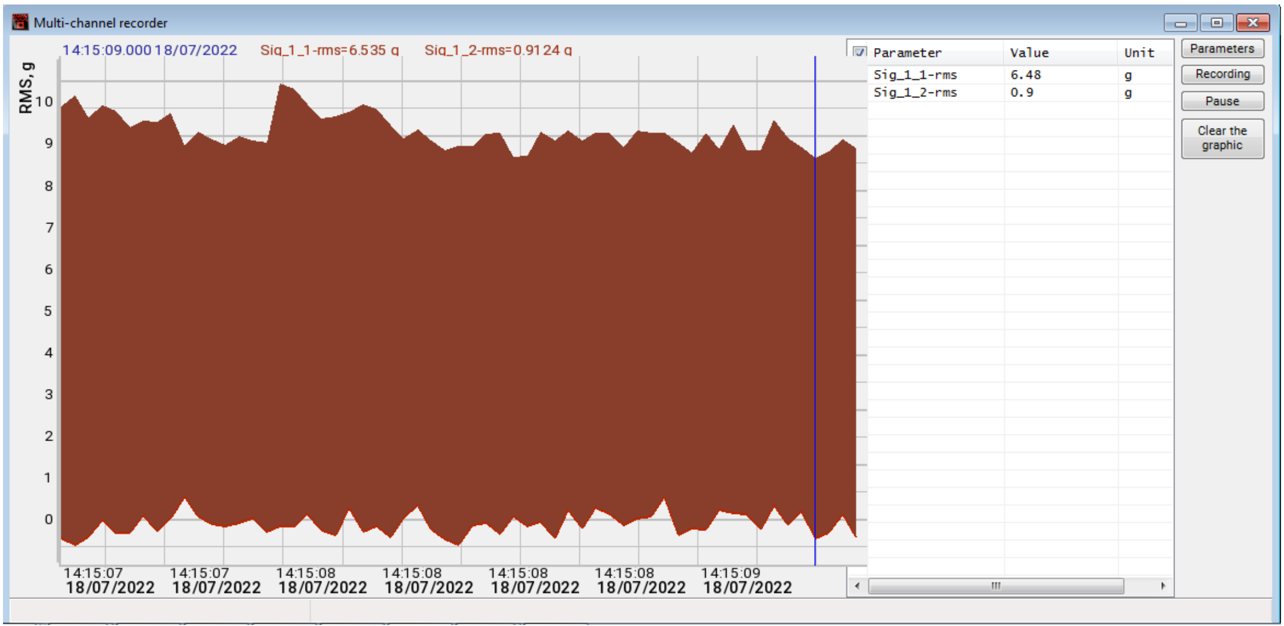
Display parameters



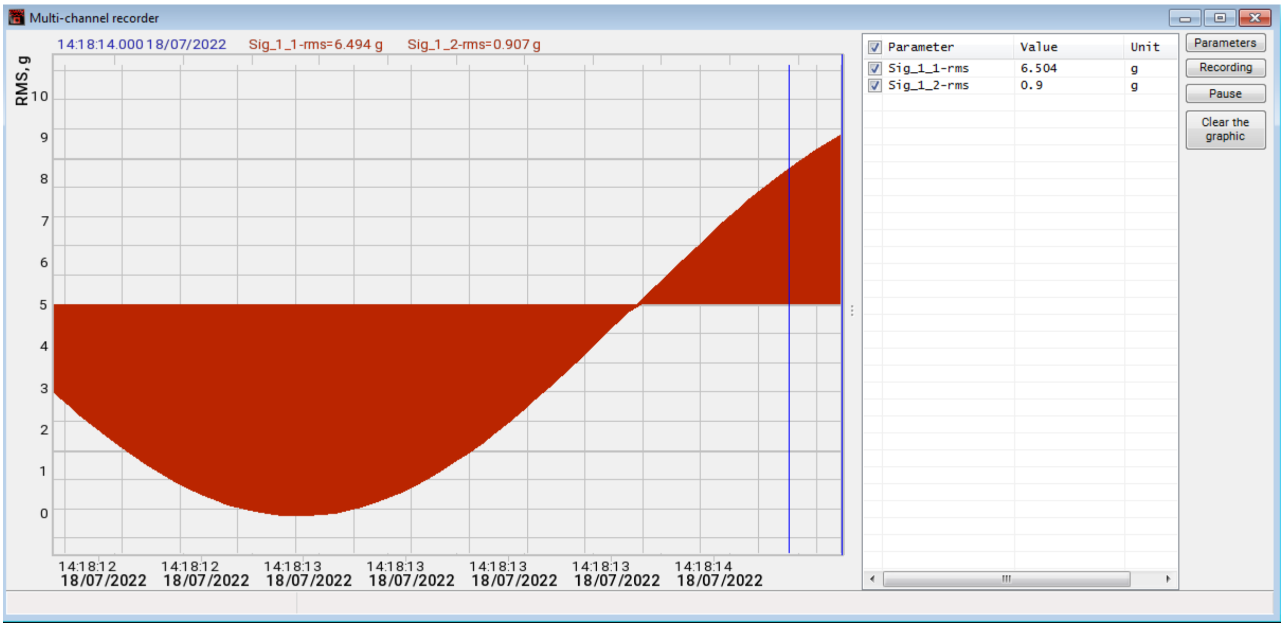
Horizontal lines



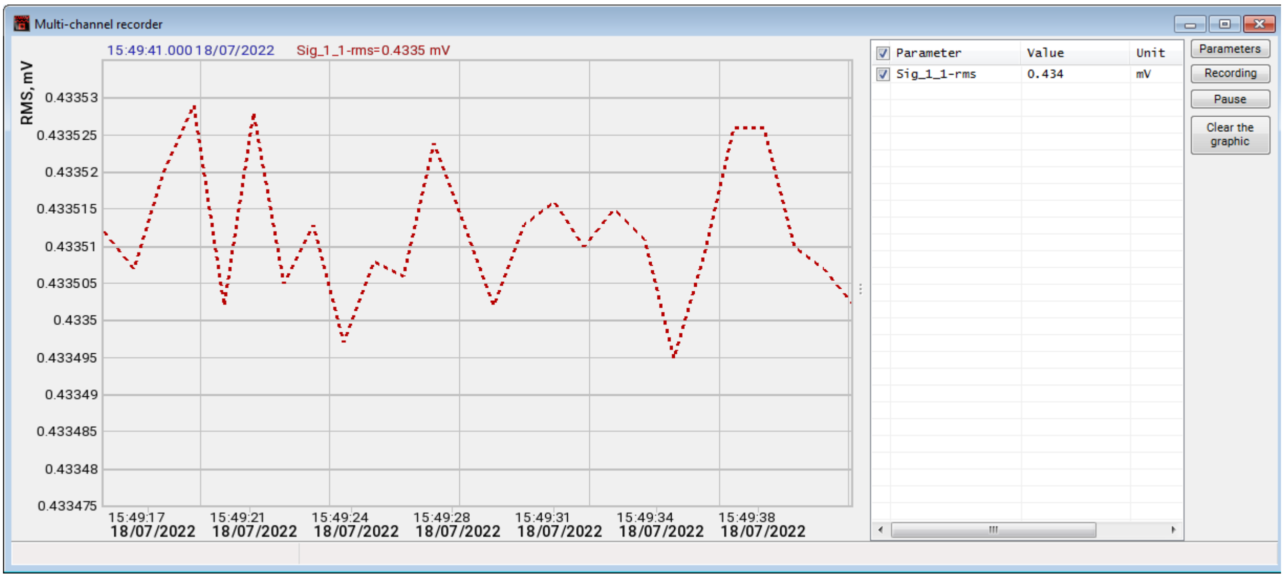
Filling in from the previous graphic



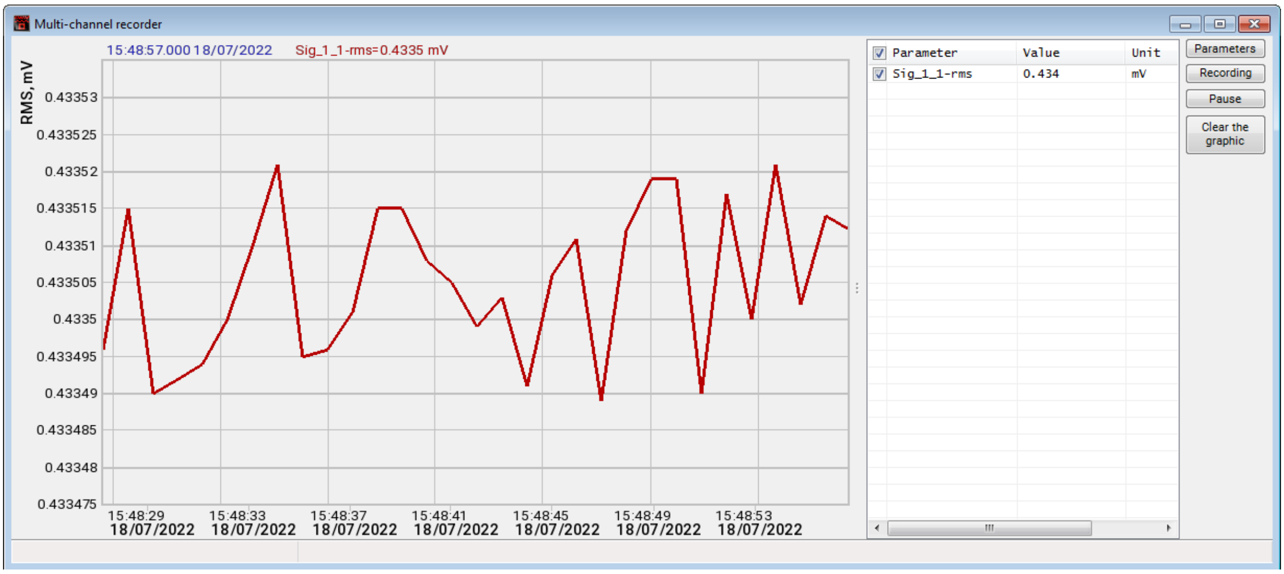
Alternate filling



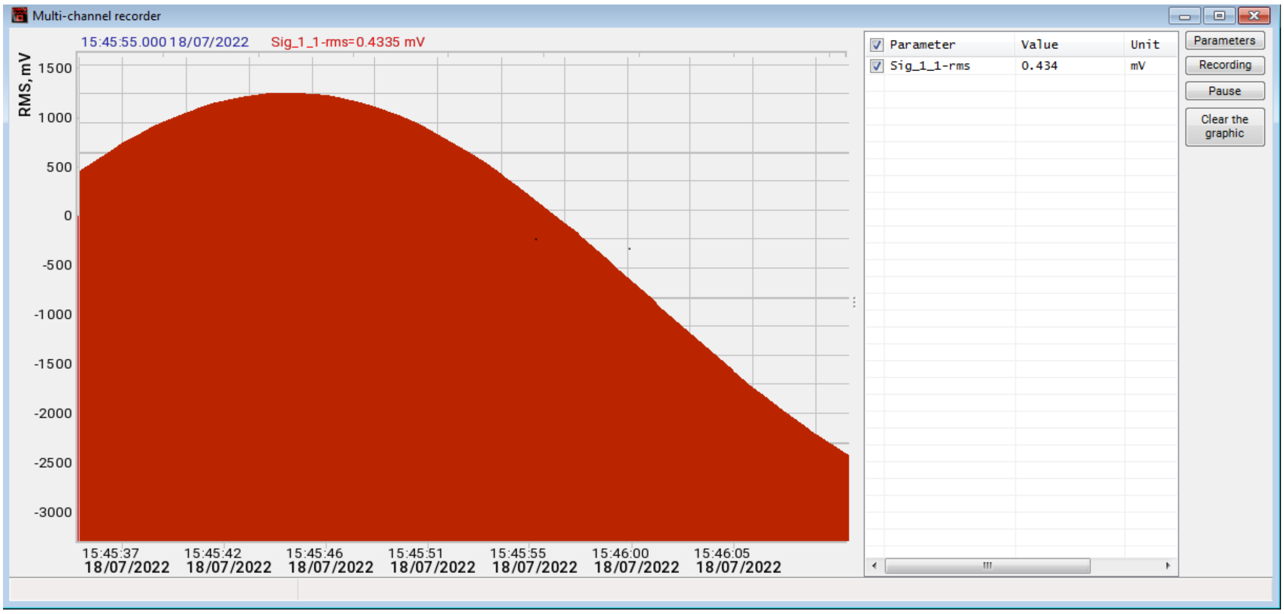
line of points



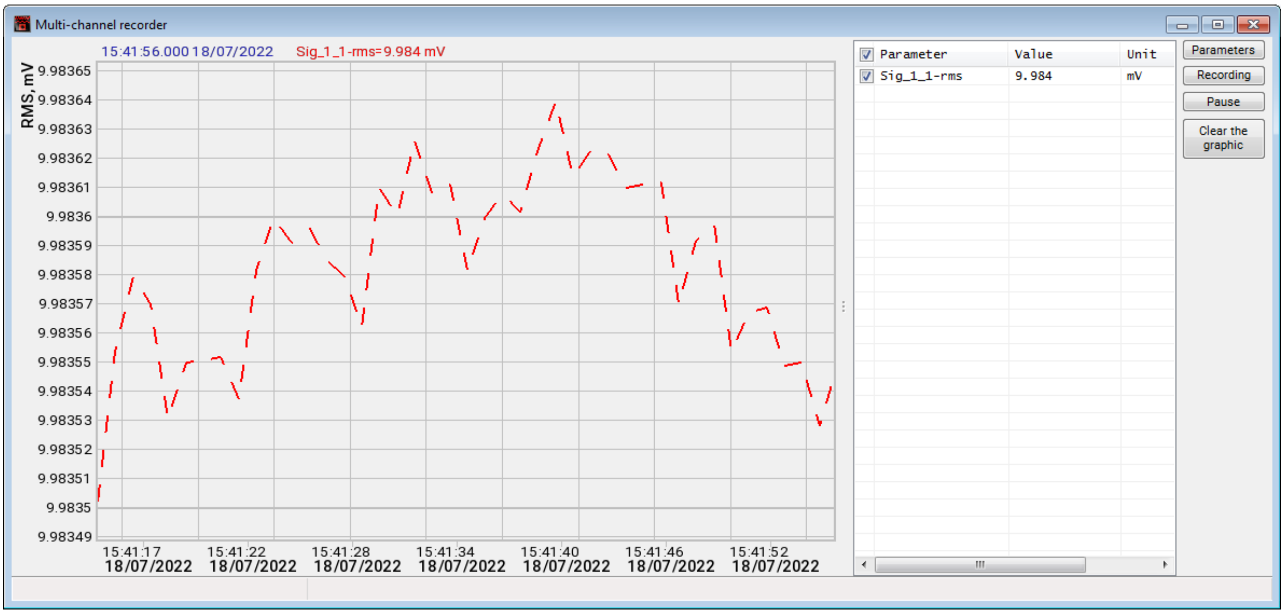
Polygonals lines



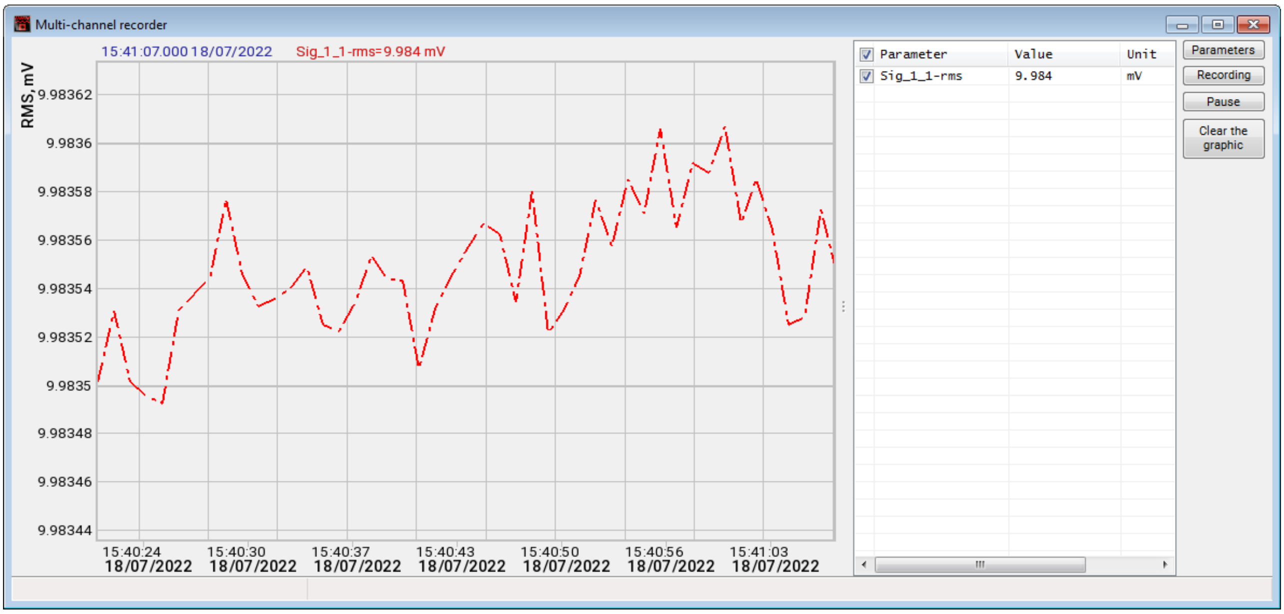
Positive filling



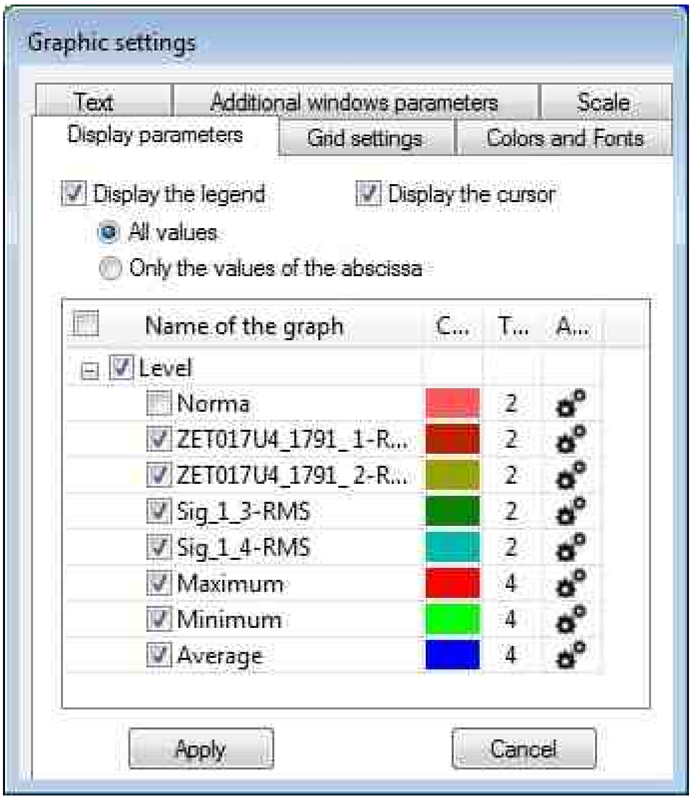
Dotted's lines



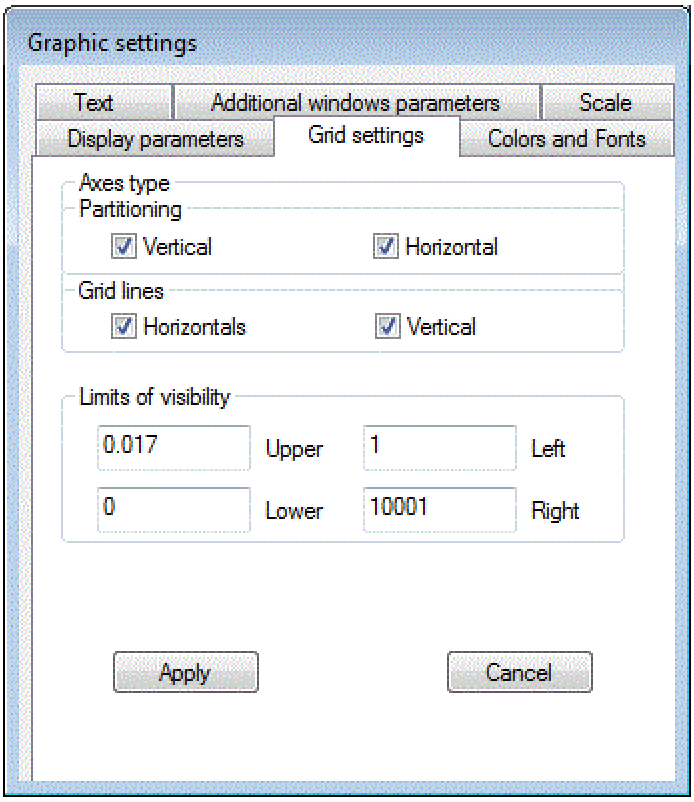
Dot-dash lines



When you click on the **Display parameters** tab in the table, you can change the colors of the graphic, line thickness and additional settings. The inscriptions can be seen if you expand the columns by moving the mouse to the desired border

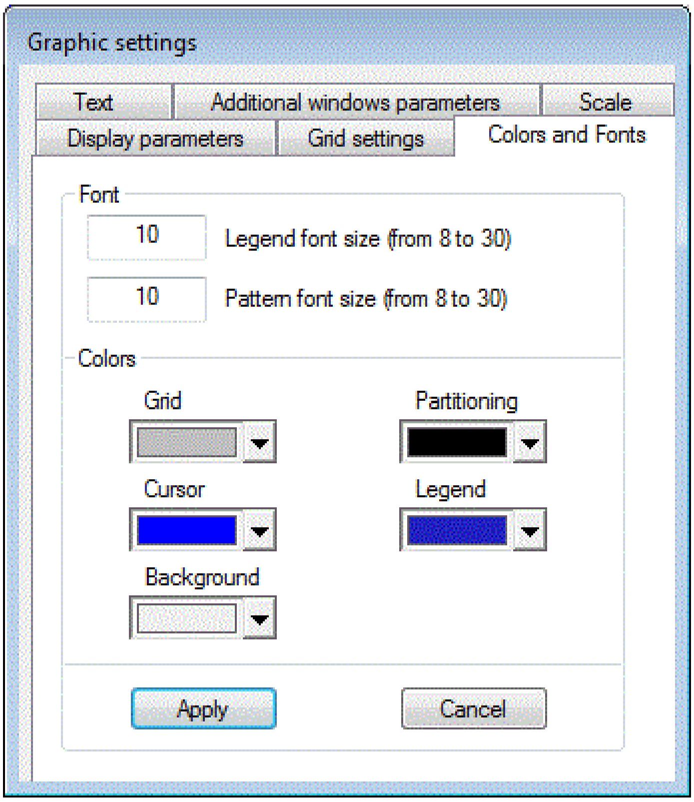


On the Grid settings tab, you can enable or disable the display of horizontal and vertical labeling of axes and grid lines. This tab also sets the visibility area (display area) of graphics: top, bottom, right and left borders of graphics.



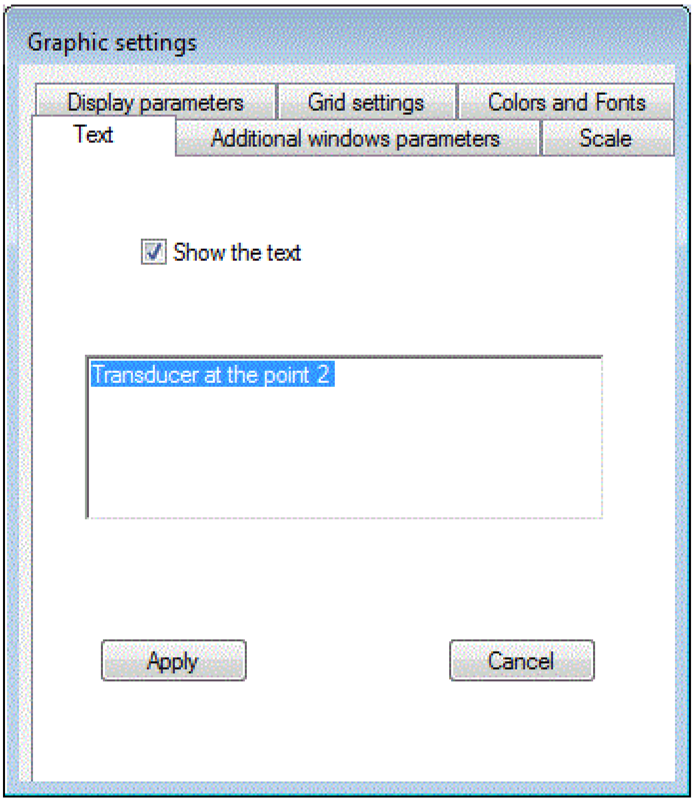
Grid setting

On the Colors and Fonts tab, you can change the font size of the numerical values of the axes and measured values. This tab also sets the color of the grid, cursor, background, axes markings, legends.



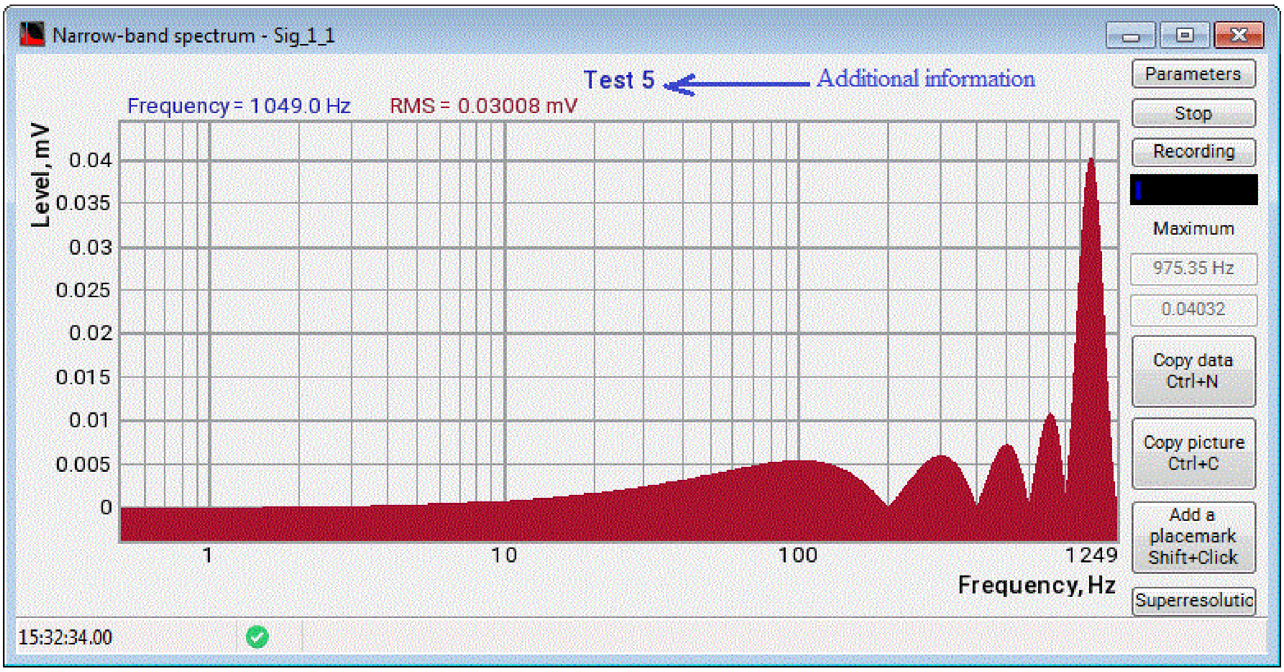
Colors and Fonts

On the Label tab, you can write additional text information that will be displayed when copying and pasting a spectrum graph into a text document. To record this information, you must check the Show caption box, select the required font for input, and type text in the caption input field.



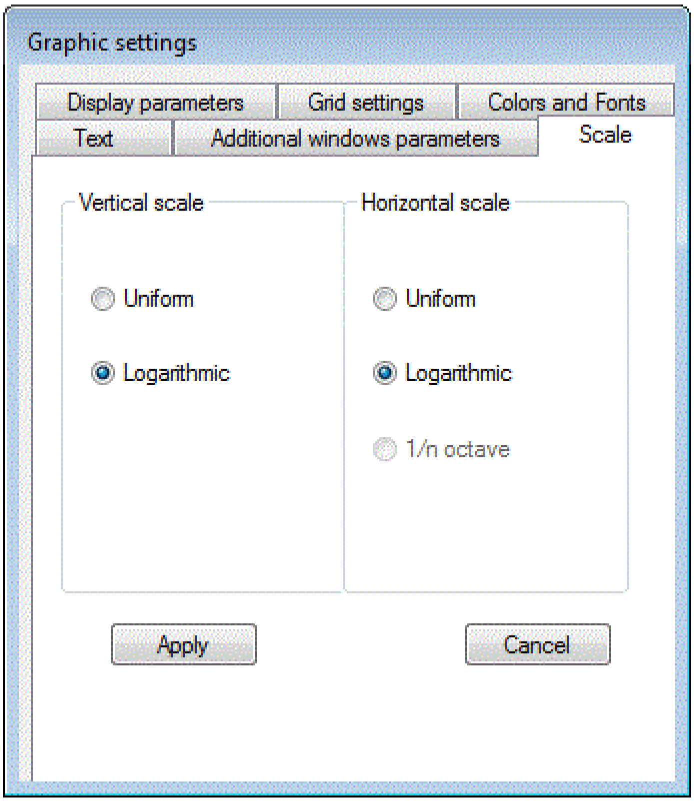
Text

The Fig. below shows the **FFT Spectrum** program window with additional information.



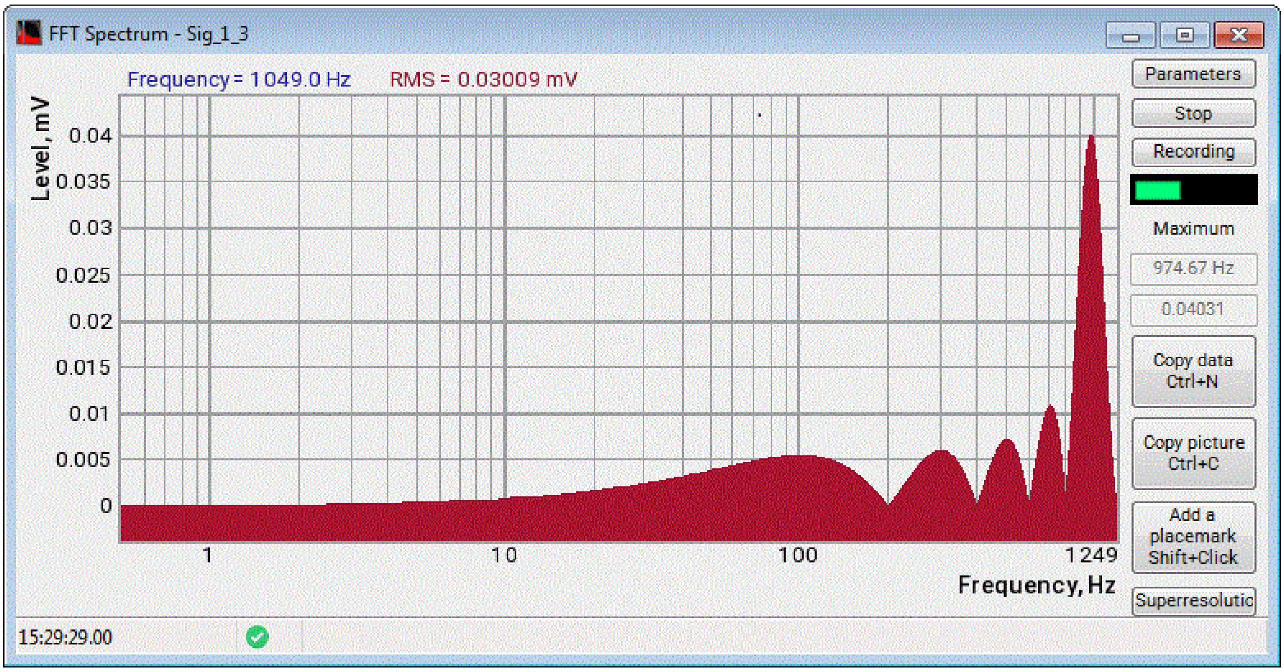
FFT Spectrum window with additional information

On the **Scale** tab, you can select the type of representation of the horizontal and vertical scales.

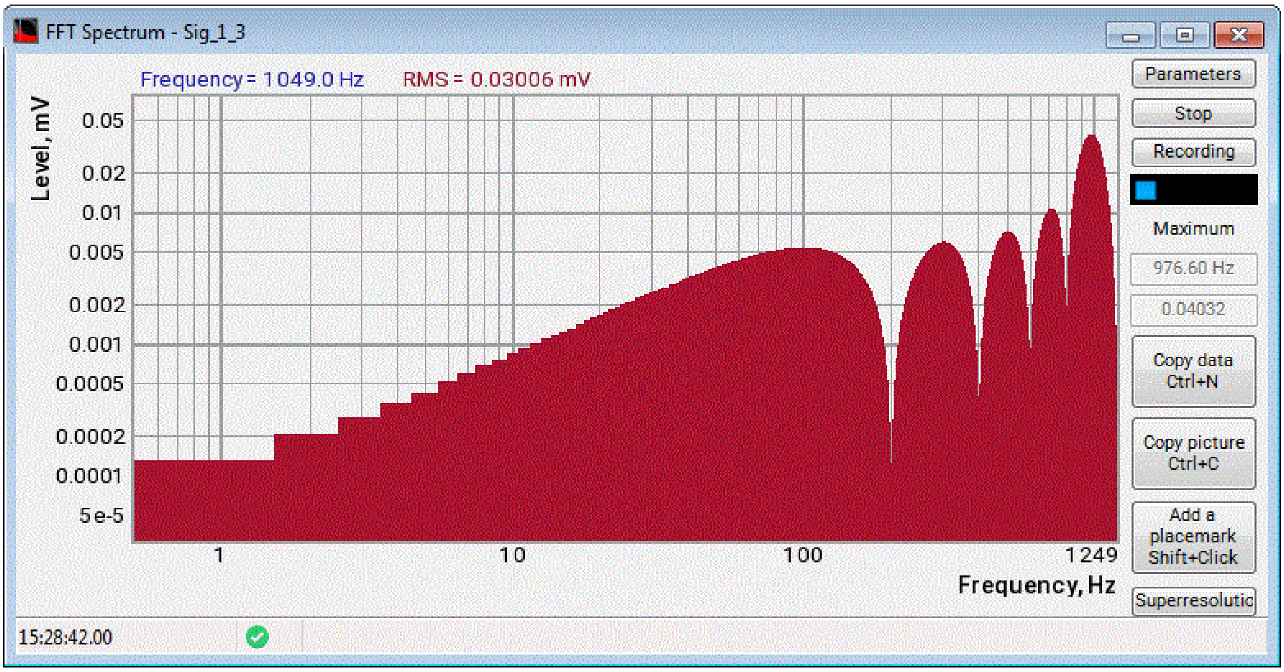


Scale

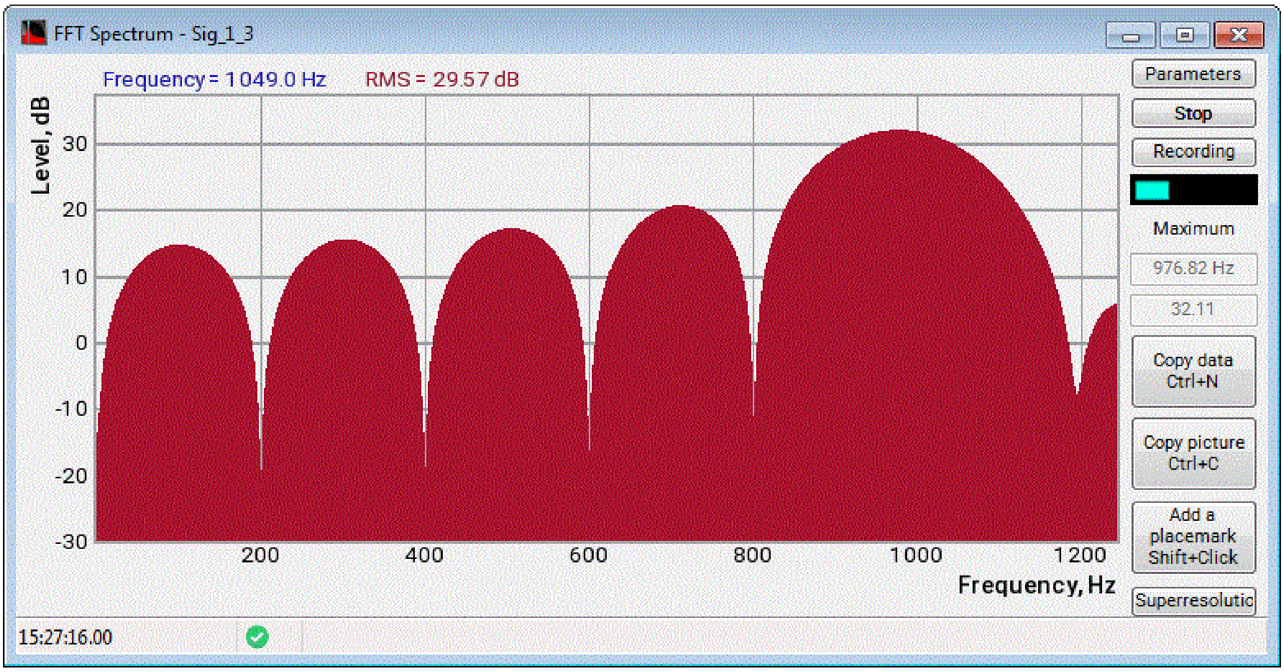
The vertical scale can be represented in uniform, logarithmic or decibel format. When displaying the scale in decibel form, the reference value is used to calculate the signal level in dB, specified in the measurement channel parameters. In this case, the graph values do not change - only the labels along the ordinate axis change. The Fig.s below show the spectrum of the same signal in different sweeps along the y-axis.



Vertical scale: uniform

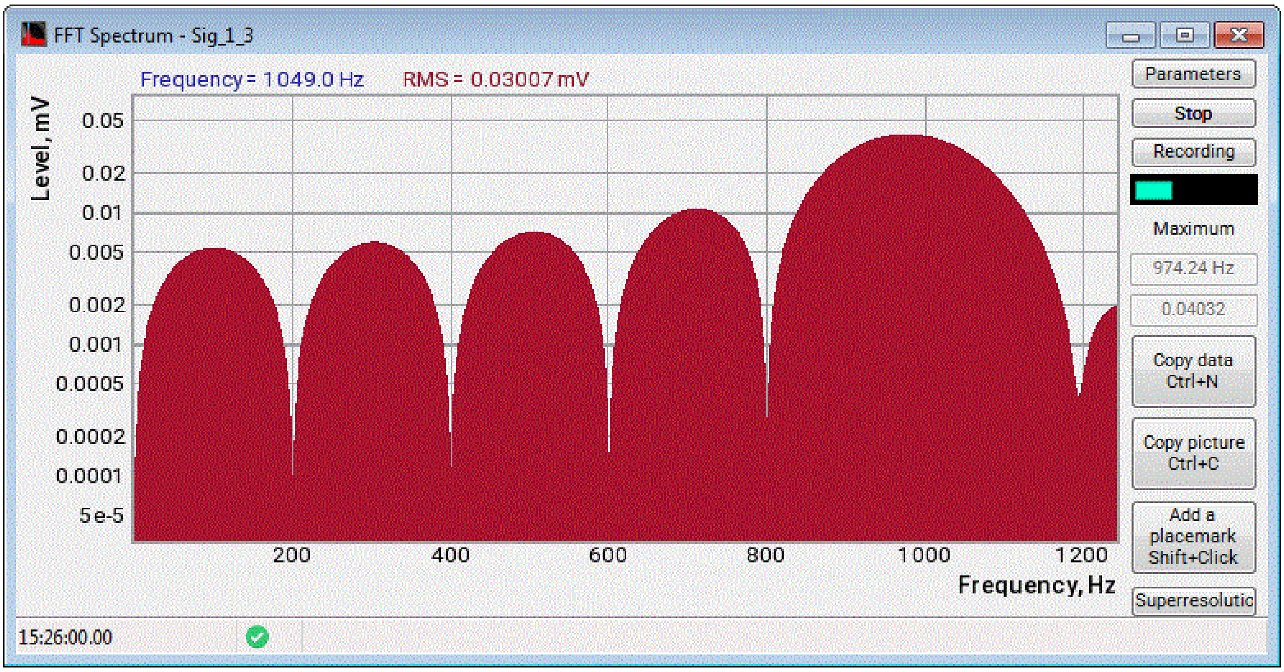


Vertical scale: logarithmic

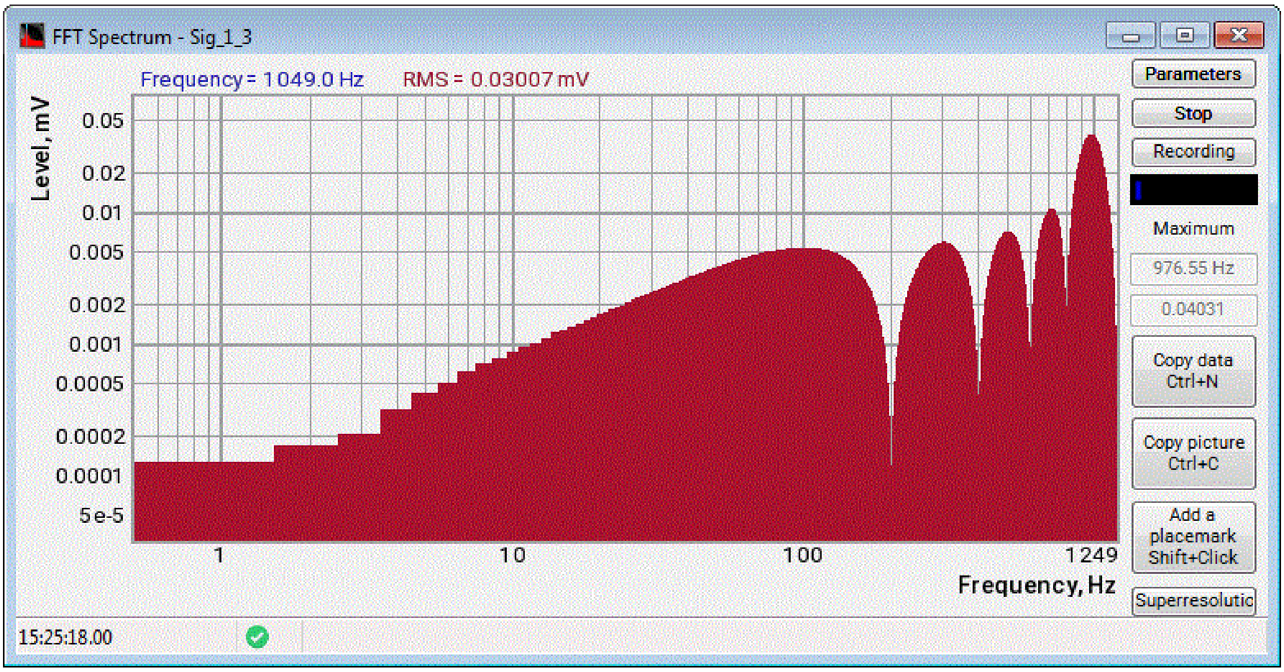


Vertical scale: decibel. Setting within the program

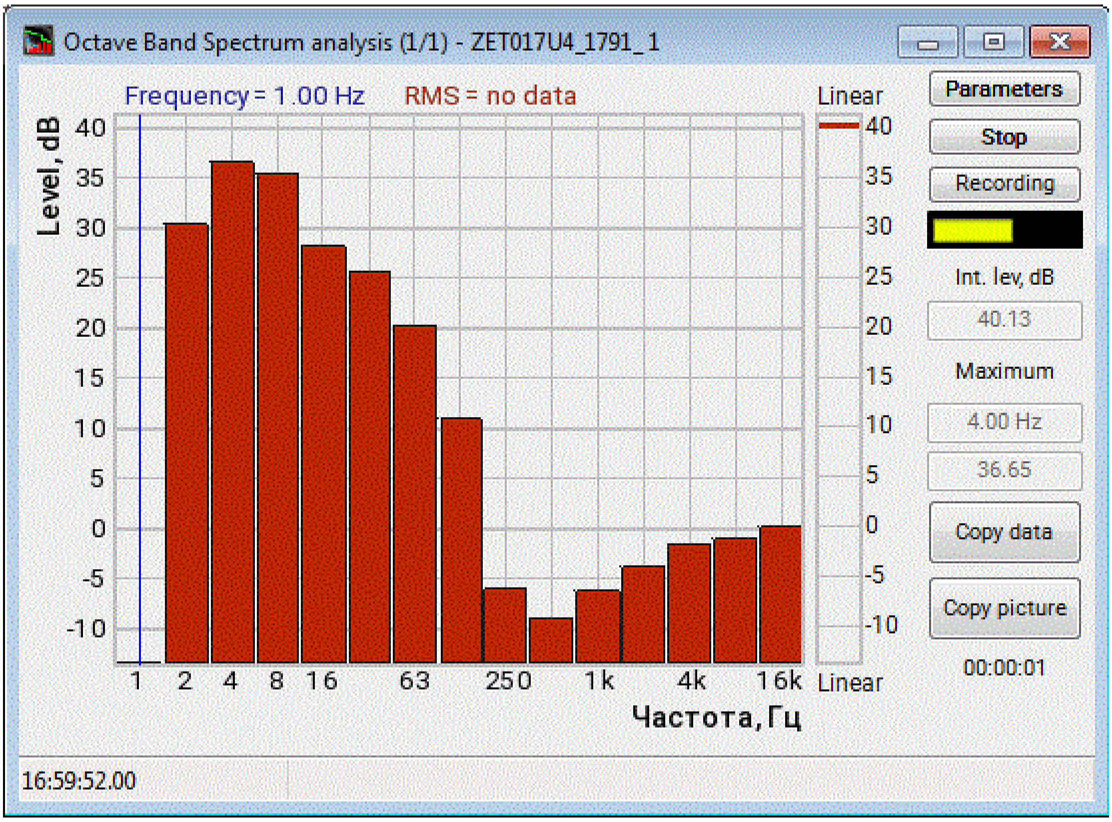
The horizontal scale can be presented in a uniform, logarithmic or 1/n-octave (doleoctave) form. When choosing a non-uniform abscissa scale, the values do not change - only the scale of the representation and/or label along the axis changes. The Fig.s below show the spectrum of the same signal in different sweeps along the x-axis.



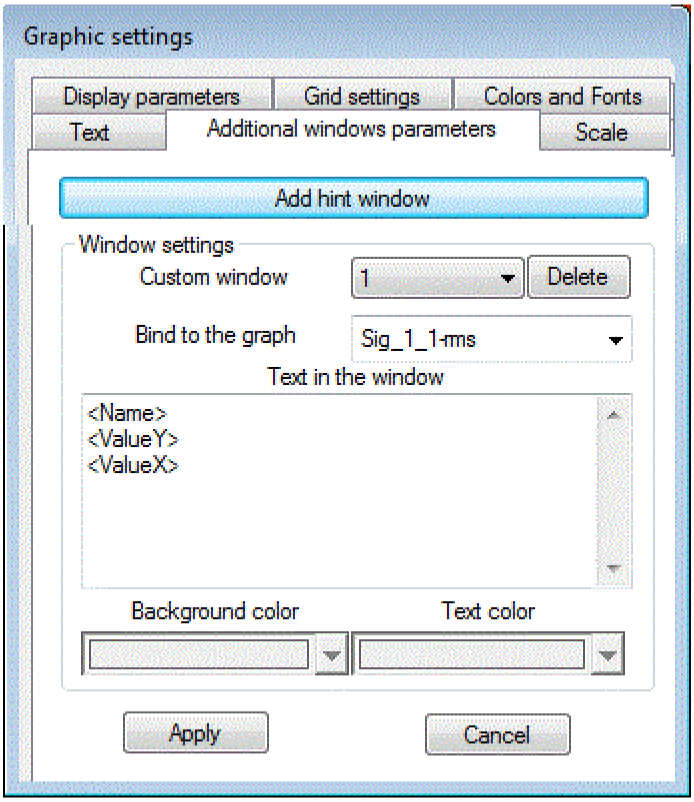
Horizontal scale: uniform



Horizontal scale: logarithmic



Horizontal scale: 1/n octave



Parameters for additional windows with a hint

Save the changed settings is done by clicking the Apply button, in this case the **Parameters** window will close and the selected settings will take effect.

Exit the **Parameters** window without saving the settings is done by clicking the Cancel button, or the "x" button located in the upper right corner of the window, or by pressing any mouse button on any part of the screen that is not occupied by the **Parameters** window.

Graphical and numerical data transfer to text editors .....

ZETLAB programs allow to copy numerical values, graphs, and to convert the displayed graphics into text sequence of numerical values, where the left column corresponds to graphic values by horizontal axis, and the right column – to those by vertical axis.

In order to copy numerical value from ZETLAB program window, place the cursor into the window of the program used for recording of numerical values (e.g., "DC voltmeter", "Encoder", etc.), and left-click it. The data will be copied to the Clipboard. Place the cursor in the window of the text editor program (Microsoft Word, Excel, etc.), right-click it, and select the option "Paste". The numerical value registered by ZETLAB program will be copied to the document.

In order to copy a graphic from ZETLAB program window, place the cursor on the relevant graphic image in the program window (e.g., "narrow-band analysis", "Multi-channel oscilloscope", etc.), and use the key combination<*Ctrl*> + <*C*>, after that the graphic will be copied to the Clipboard. Place the cursor in the window of the text editor program (Microsoft Word, Excel, etc.), right-click it, and select the option "Paste". The relevant graphic will be copied to the document.

In order to convert the graphic into a text sequence of numerical values, place the cursor on the graphic displayed in the program window (e.g., "narrow-band analysis", "Multi-channel oscilloscope", etc.), and press the key <*N*>. The sequence of numerical values will be copied to the clipboard. Place the cursor in the window of the text editor program (Microsoft Word, Excel, etc.), right-click it, and select the option "Paste". The numerical sequence, which corresponds to the displayed graphic will be copied to the document.

In order to copy the graphic values, which correspond to the particular position of the cursor, place the cursor to the required graphic point in the program window (e.g., "narrow-band analysis", "Multi-channel oscilloscope", etc.), and click the key <*T*>. The values will be copied to the clipboard. Place the cursor in the window of the text editor program (Microsoft Word, Excel, etc.), right-click it, and select the option "Paste". The required values will be copied to the document. As you copy the values, which correspond to a particular position of the cursor, the program also copies additional information: name of the program, and name of the channel used for data recording.

You can also use the combination <Ctrl>+<V>.

You can also use the functions "**Copy graphic**" or "**Copy image**" to copy the graphic to the clipboard (in the case, if these functions are available)

You can also copy the sequence of numerical values using the key "Copy data" (if this key is available)

Setting GridGl grid functionality .....

When you click the right mouse button on the graph field in programs, ActiveX GridGl.ocx:

- FFT Spectrum,
- Spectrum CPB Analysis,
- Cross-Spectrum FFT Analysis,
- Cross spectrum octave,
- Cross-Spectrum CPB,
- Cross-Correlation analysis,
- Harmonic Distortion Analysis;
- Modal analysis;
- Histogram;
- STA/LTA detector;
- Shocks recorder;
- Results viewing;
- Multi-channel recorder;
- Programs Vibration control system (VCS).

Cursor control and graphics scaling

1. Key assignments (their combinations):
    - Ctrl + "scrolling the mouse wheel" – scaling along two axes relative to the mouse cursor;
    - Shift + "scrolling the mouse wheel" – vertical scaling relative to the mouse cursor;
    - Alt + "scrolling the mouse wheel" – scaling horizontally relative to the mouse cursor;
    - "Double-click with the left mouse button" or Ctrl + "Single left-click" – when you click on the graph, it is highlighted, an uneditable grid with accompanying information appears (you can remove the selection by double-clicking in an empty area);
    - Shift + "Single left-click" – places the editable grid on the selected graph at the point corresponding to the position of the mouse cursor (if there is no selection, no label is placed. Regardless of the selection of graphs, the label can be placed from the context menu to the position of the grid cursor);
    - Alt + "Pressing the left mouse button" – moving the grid when moving the cursor;
    - Ctrl + "Single left-click" for  – auto-scaling of each of the axes relative to the main one.

2. Functional capability
    1) "Single right click" by grid area corresponds to calling the context menu. The context menu opens with the active tab "Display settings" (if you click on the area of the label being edited, the tab "Settings of additional windows" will open). In this tab, you can disable the display of the cursor, or the legend. In addition, your attention will be presented with a table that occupies most of the tab area. Its functionality:

        a. First column – the name of the graphic with the possibility of its display (hide / show);

        b. Second column – changing the color of the graphic;

        c. Third column – change the graphic line thickness (from 1 to 5);

d. Fourth column – additional settings. You can change the line type and fill type.

2) In the "Parameters for additional windows" tab there was an opportunity to set "macros" for a tag. The right mouse click in the editable text field brings up the context menu:

   a. Graphic name – displaying the name of the graphic to which the label is attached;

   b. Ordinate value - the ordinate value at the point to which the label is attached;

   c. Abscissa value – abscissa value at the point to which the label is attached;

   d. Delta Y – calculates the delta along the ordinate from the current label to the label whose number is specified (Example: <DeltaY><L2>. Delta from the current label to the 2nd label);

   e. Delta X - delta is calculated along the abscissa from the current label to the label, the number of which is specified;

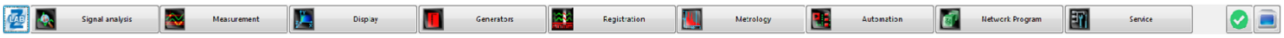
3) An editable label can be moved. To do this, you need to select it (double-click with the left mouse button on the label area). After selection, hold down CTRL and move the mouse cursor to the position you are interested in (in this case, the values added to it corresponding to certain macros will be automatically recalculated). Double-clicking with the left button outside the label area removes its selection. In addition, a label can be deleted by selecting it and pressing the ‘’delete’’ button (or from the context menu).

ZETLab program control panel

Control panel **ZETLAB** is a program that allows you to quickly find the tool in the virtual laboratory **ZETLAB**. Control panel **ZETLAB** also provides the user with tools for convenient operation: no direct access to the recorded files and settings, easy seat Windows programs and conservation work projects, the ability to work in a multi-screen interface.

In the process of installing the software **ZETLAB** on the desktop and in the start menu, Windows creates a shortcut to launch the **ZETLAB** panel:

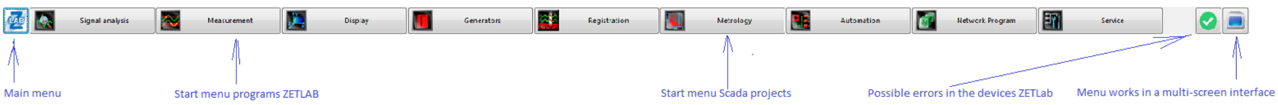
When you run the control panel **ZETLAB** she sits on top of the Windows desktop, and its icon in the system tray.



ZETLab program control panel

ZETLAB icon in the system tray

Control panel **ZETLAB** is a horizontal bar with the main menu, launch different programs and menus work in a multi-screen interface:



Fragment of the ZETLAB panel

Number of start menu programs **ZETLAB** depends on the type ZET-device.

Multi-Screen Interface function

The Multi-Screen Interface function is used to produce effect of using up to 6 working screens.

To turn the Multi-Screen Interface function ON, select the Multi-Screen Interface command in ZETLab panel context menu (Fig. 3.7). The menu will disappear and this function will start, and an icon will appear on the panel  indicating that the Multi-Screen Interface is ON.

In case of a repeated display of the context menu, a flag will be set opposite from Multi-Screen Interface to indicate that the function is ON.

To turn off the function, click on the Multi-Screen Interface command again.

When the Multi-Screen Interface function is ON, there are 6 buttons with numerical icons 1…6 displayed on the left from the Exit button on the ZETLab panel to indicate the screen numbers (*Fig. 3 .48*). When the function is turned ON for the first time, the color of the icons is red and the first screen button is active. The active button means that the relevant screen is active and all launched programs will belong to it.

To select other screens, press the button with the required number: the selected screen will become active, and the windows of the programs launched on this screen will be displayed over the programs launched on other screens.

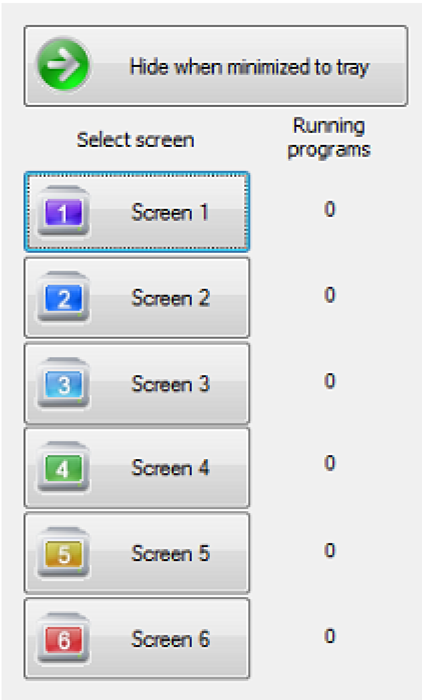


Fig. 3.48 Multi-Screen Interface

Red screen selection button means that no program has been launched on it yet. Green screen selection button means that at least one program has been launched on it.

When the Multi-Screen Interface function is turned OFF, all windows of programs launched on all screens start belonging to a single screen.

Managing launched program windows

To manage launched program windows, the following ZETLab panel context menu commands are available:

Close all open windows: to close windows of all programs launched via the **ZETLab** panel. The **Close all open windows** command will be unavailable unless at least one program has been launched through the **ZETLab** panel.

Hide all open windows: to hide (minimize) all programs launched via the **ZETLab** panel. The Hide all open windows command will be unavailable unless at least one program has been launched through the **ZETLab** panel.

Expand all open windows: to expand all previously hidden (minimized) program windows launched via the **ZETLab** panel. When expanded, the windows are brought to the forefront in the order of their launching and following the order of their screen number (when the **Multi-Screen Interface** mode is ON). The position and unidades of the windows are restored as well. The **Maximize all open windows** command will be unavailable unless at least one program has been launched through the **ZETLab** panel.

Operations with the ZETLab panel.

To manage the ***ZETLab*** panel operation and position, the following context menu commands are available:

Hide panel: to hide the ***ZETLab*** panel window from the monitor screen. When the panel is hidden, its icon in Windows OS task tray notification area has the appearance as shown in *Fig. 3.49*.

Notes

1. The **Hide panel** command will be unavailable if the panel has already been hidden from the monitor screen.
2. When the panel is hidden from the monitor screen, the area occupied by the panel becomes available for launched program windows (if the Automatic windows alignment function is ON, window re-positioning takes place).

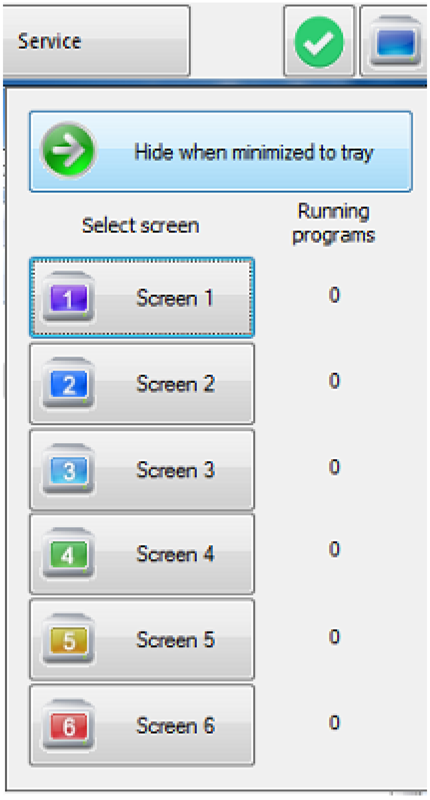


Fig. 3.49

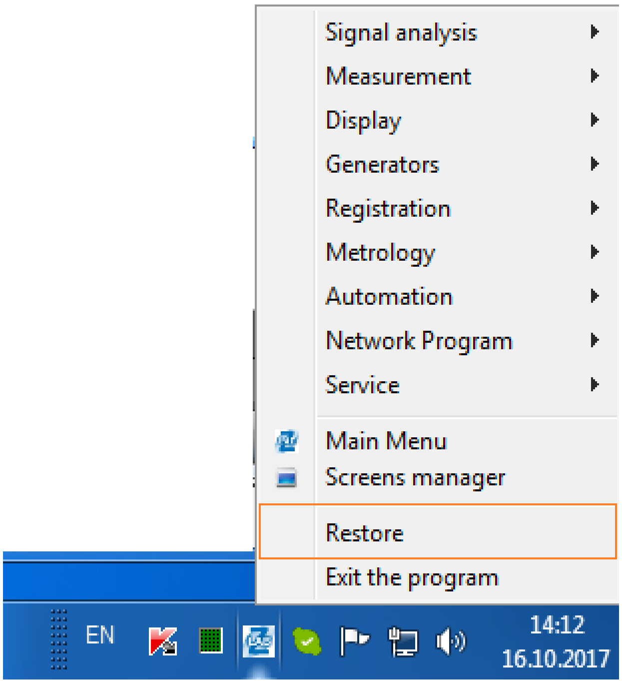


Fig. 3.50

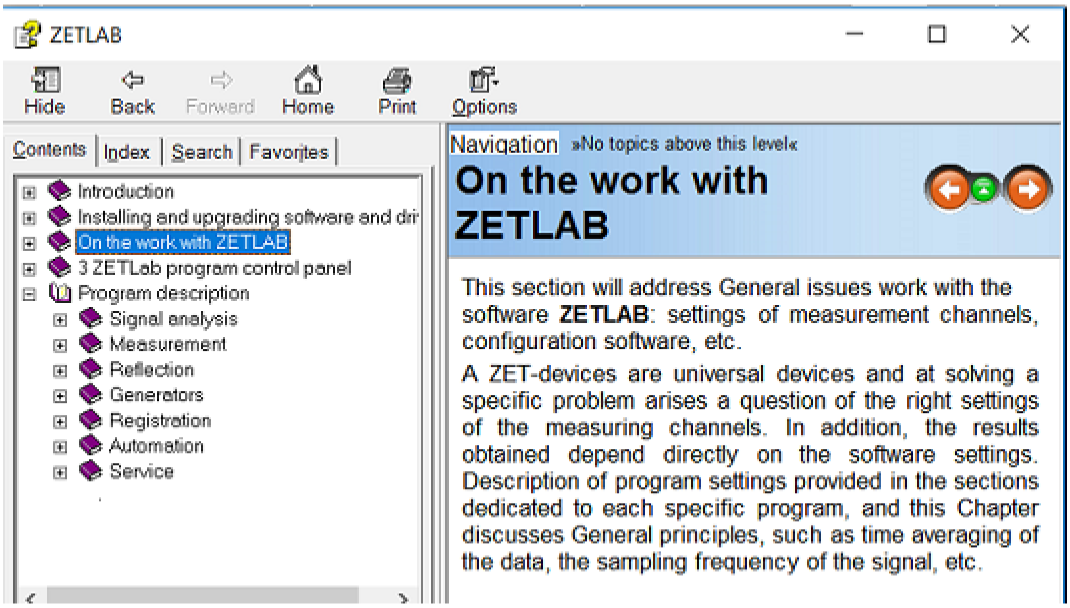
Show panel: to restore (display) the previously hidden ***ZETLab*** panel window on the monitor screen. When the panel is displayed, its icon in Windows OS task tray notification area has the appearance as shown in *Fig. 3 .49*.

Notes

1. The **Show panel** command will be unavailable if the panel is already being displayed on the monitor screen.
2. When the panel is shown on the monitor screen, the area occupied by the panel becomes unavailable for launched program windows (if the **Automatic windows alignment** function is ON, window re-positioning takes place).

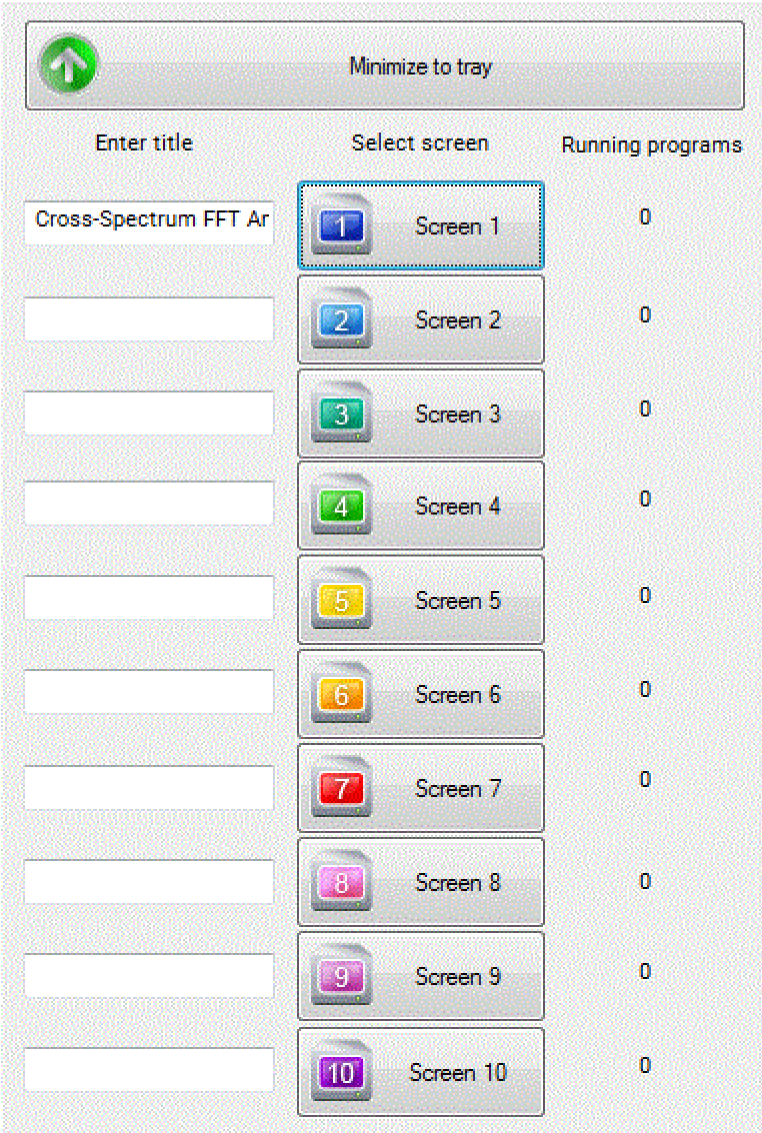
Receiving support information on the ZETLab panel

At any time during the ***ZETLab*** panel operation, the user can use the support information on the panel. To do so, select **Help** command from the context menu. A new window will be displayed (*Fig. 3.55*) containing support information on the Program description, control and settings of the ***ZETLab*** panel. To receive support information, the user can also press F1 key, with the **ZETLab** panel being active.


ZETLAB
Hide
Back
Forward
Home
Print
Options
Contents
Index
Search
Favorites
Introduction
Installing and upgrading software and dri
On the work with ZETLAB
3 ZETLab program control panel
Program description
Signal analysis
Measurement
Reflection
Generators
Registration
Automation
Service
Navigation
»No topics above this level«
On the work with ZETLAB
This section will address General issues work with the software ZETLAB: settings of measurement channels, configuration software, etc.
A ZET-devices are universal devices and at solving a specific problem arises a question of the right settings of the measuring channels. In addition, the results obtained depend directly on the software settings. Description of program settings provided in the sections dedicated to each specific program, and this Chapter discusses General principles, such as time averaging of the data, the sampling frequency of the signal, etc.

Multi-screen interface

Function *The multi-screen interface is designed to create the effect of using up to 10 working screens.*

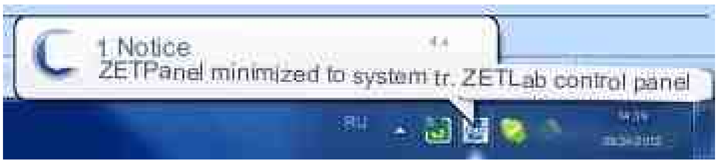


Multi-screen interface

The screen switching menu is located on the right side of the ZETLAB panel. The active screen is marked with a flag, all running programs are displayed in it. When switching to another screen, the windows of programs running on other screens are not visible, including the program icons in the Windows taskbar. This is the convenience of working in a multi-screen interface - programs designed for pre-processing signals (for example, Signal Filtering) or measuring signal parameters (for example, Vibrometer) can be launched on one screen, and a Multi-channel oscilloscope that displays measurement results can be launched in friend. Thus, programs that are necessary for signal processing, but do not carry useful information to the user, can work in a "hidden" mode and are grouped into screens depending on their purpose and functions performed in a particular case. And the programs with which the operator works directly are displayed on a separate screen, which uses the maximum usable area of the Windows desktop.

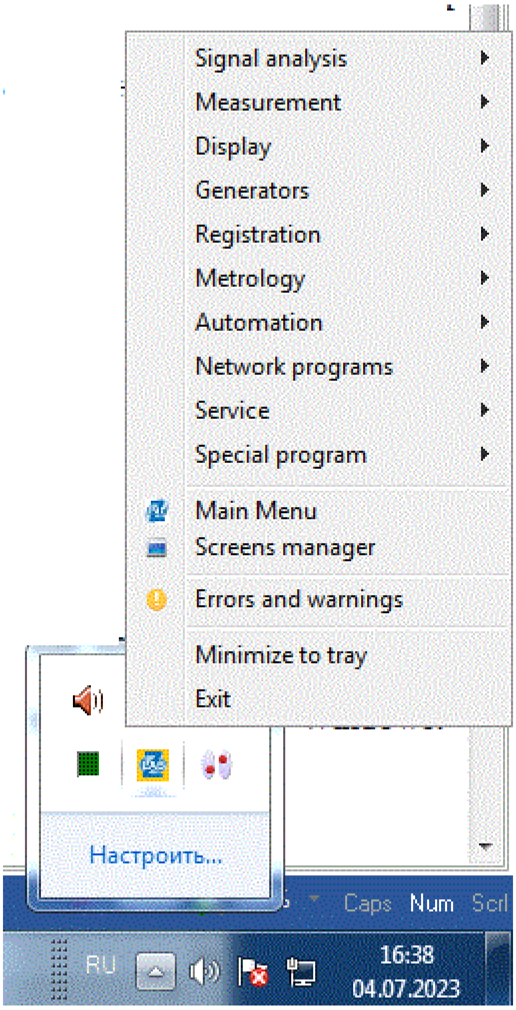
Minimize to tray

When you select the Minimize to Tray command, the ZETLAB panel is minimized to the system tray, and a notification appears:



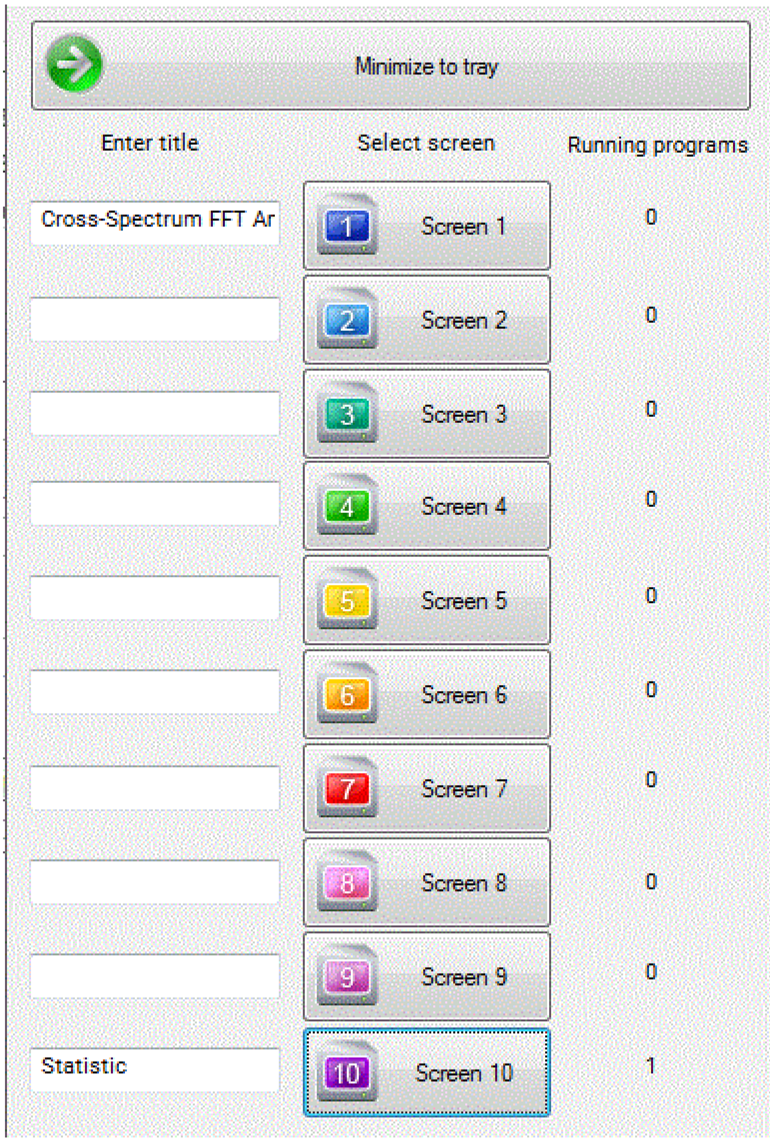
Notification about minimizing the ZETLAB panel to the system tray

Clicking on the ZETLAB panel icon in the system tray opens the ZETLAB panel menu in a compact form (the menu is called regardless of whether the ZETLAB panel is minimized to tray or not):



ZETLAB panel menu opened from system tray

To restore the position of the ZETLAB panel at the top of the Win OS desktopdows, in the ZETLAB panel menu, called from the system tray, select the Work with screens item, and in the window that opens, the Deploy program command.



ZETLAB panel menu, selection of the screen on which the selected programs will be displayed

Purpose of the ZETLab control panel

ZETLab programs are launched using the ***ZETLab control panel***.

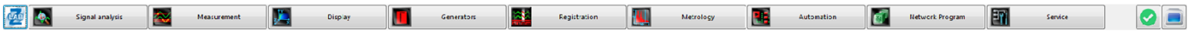


Fig. 3.42

ZETLab control panel (hereinafter referred to as the ***ZETLab*** panel) is a horizontal panel (*Fig. 3.42*) located in the upper part of the screen. On the left part of the ***ZETLab*** panel, there are buttons of program group menu and service icons.

To launch a program, left-click on the name of the relevant menu (group of programs) from the drop-down list of programs mentioned in this section, select the required one and left-click on it.

Each program group menu contains a list of programs, displayed after left-clicking on the program group menu call button on the ***ZETLab*** panel. In the program group drop-down menu, there are icons with program names, **which allow for fast linking of the program startup command with its icon.** When ***ZETLab*** panel is active (it becomes active after left-click on the space of ***ZETLab*** panel free from buttons), pointing the mouse cursor on the buttons of program groups menu, there appear tooltips indicating the full name of the group and the list of programs included.

Starting the zetlab panel control

The ZETLab panel can be launched in several ways:

P-

- by double-clicking the left mouse button on the shortcut to launch the program_located on the desktop of the Microsoft Windows operating system (hereinafter referred to as Windows OS)
- from the Start menu of the Windows OS taskbar by selecting the Programs → ZetLab → Zetlab command (Fig. 3.2).
- using the ZETLab.exe executable file from the C:\ZETLab\ directory.

When the ZETLab panel is launched, its icon will appear in the notification area of the Windows taskbar (Fig. 3.3)and the signal processor of the connected external module manufactured by Electronic Technologies and Metrological Systems LLC will be automatically loaded. In this case, a tooltip appears in the lower right corner of the screen (Fig. 3.4), indicating that the signal processor is loaded. This tooltip will appear when the automatic signal processor loading checkbox is set in the ZETPanel.cfg configuration file of the ZETLab panel. The configuration file ZETPanel.cfg of the ZETLab panel will be described below.

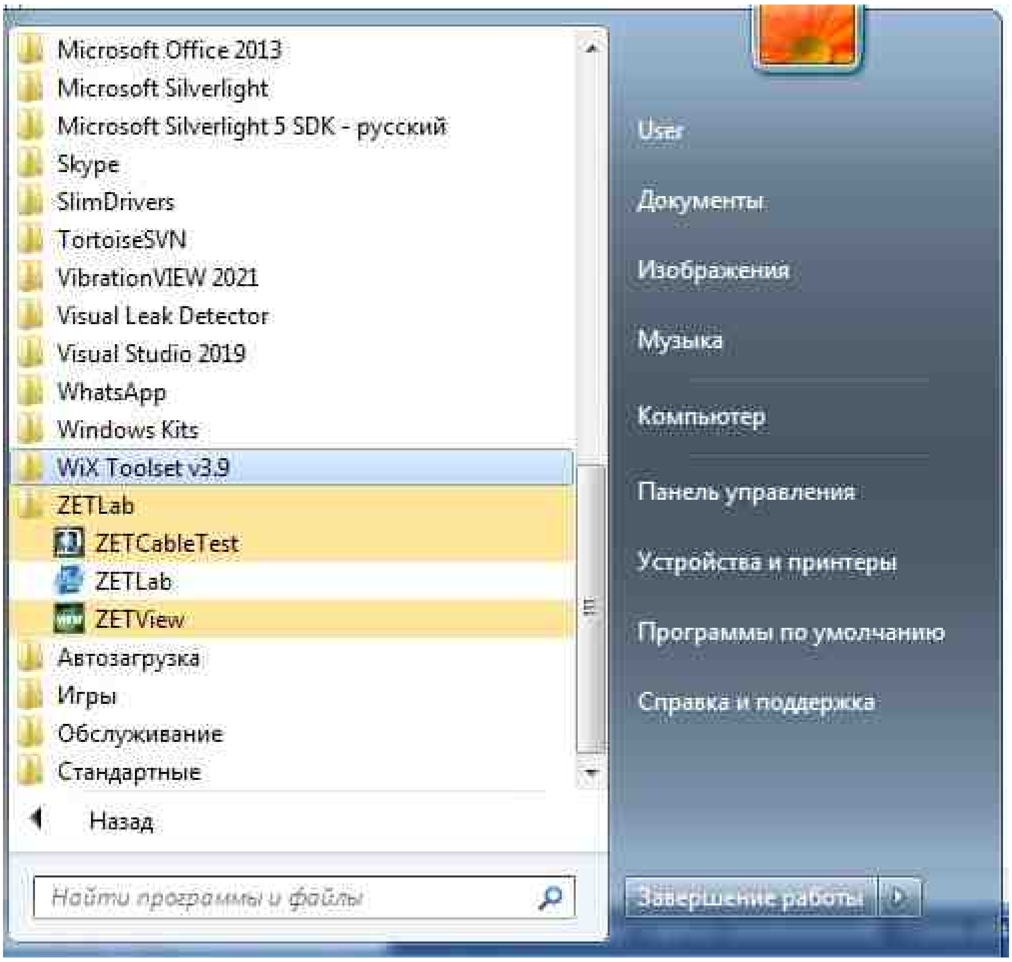


Fig. 3.2 Start the Windows taskbar by selecting a command **Programs a ZetLab a Zetlab**

Fig. 3.3 Toolbar

Fig. 3.4 Opening the toolbar window

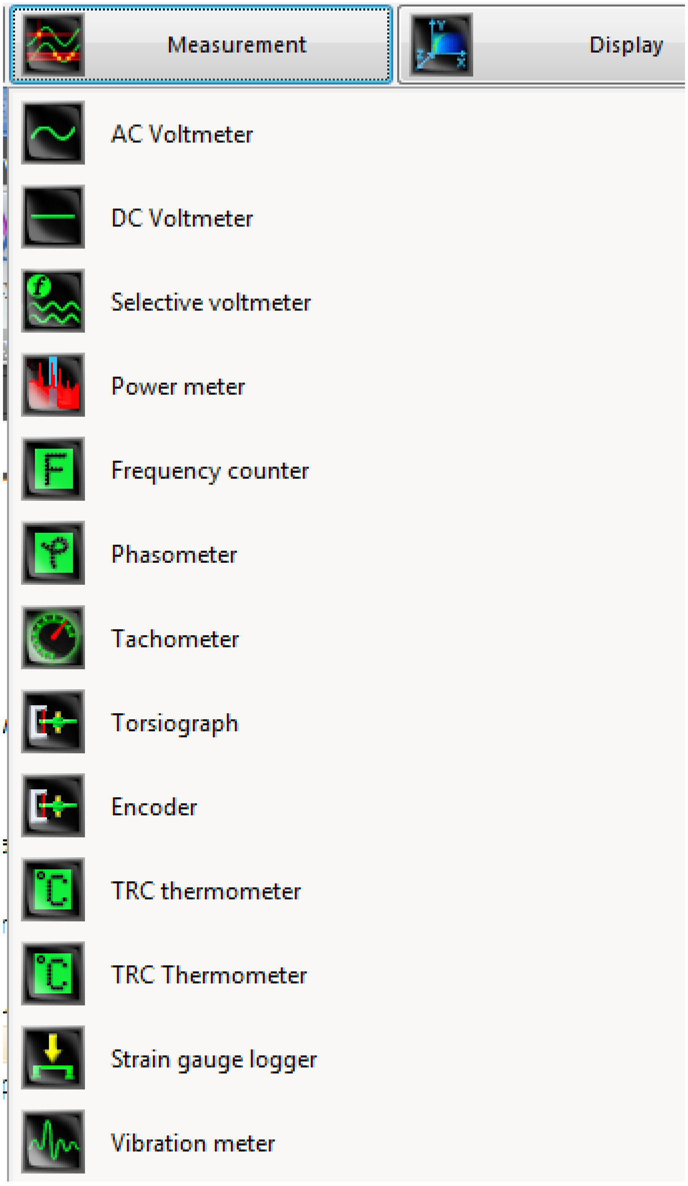
Program starting menu windows

The main part of the **ZETLAB** panel menu run programs **ZETLAB** virtual devices, service and network software programs implemented in the SCADA-system **ZETVIEW**.

Program start

To run any program you have to press the left button of the mouse on the name of the corresponding menu (program group), from the ensuing list of programs in this section to select the desired and click on it with the left button of "mouse".

Each menu program group contains a list of programs that appear when you press the left button of "mouse" on the button menu program group for **ZETLAB** panel. In a drop down menu program group, next to the program names are icons to quickly associate the command run the program with its graphical image. When the cursor is on the name of the program, a tooltip with a brief description of the program.



ZETLAB control panel: "Measurement" menu

The list of menus and the list of programs in each menu depends on the type of ZET-device being connected and is determined by the list of programs supplied with it (basic and optional). The **ZETLAB** panel can have the following menus:

- Most importantly - provides quick access to configuration files and recorded signals, allows to save/load projects that includes automatic placement of Windows and watchdog timer.
- Signal analysis - analysis of signals, using different algorithms: Fourier transform, Wavelet transform, transform, STA/LTA, static analysis, correlation analysis, etc.
- Measurement - program measurement signals.
- The display of a visualization program signals, measurements, and work with the recorded data.
- Generators - generating program signals.
- Registration of the program recording and playback.
- Metrology - the software of AFC and PFC (version ZETLAB since 06/11 not supported, implemented similar projects in ZETVIEW)
- Automation - filtering programs, regulation, administration.
- Network programs - program transmission/reception of data over the network.
- Service - tuning tools.
- Special program - projects, implemented in **SCADA ZETVIEW**.
- Work with screens, menu control function "3 ZETLab program control panel."

Window management of running programs windows

To manage windows of running programs, the following commands of the context menu of the ZETLab panel are provided:

Close all open windows- designed to close the windows of all programs launched through the ZETLab panel. The Close all open windows command will be unavailable if at least one program is not launched through the ZETLab panel.

Minimize all open windows- designed to minimize (minimize) all programs launched through the ZETLab panel. The Minimize all open windows command will be unavailable if at least one program is not launched through the ZETLab panel.

Maximize all open windows- designed to deploy all previously minimized (minimized) programs launched through the ZETLab panel. When maximized, windows are brought to the foreground in the order they were launched and in the order they belong to the screen number (when the Multi-screen interface mode is enabled). The position and size of the windows are also restored. The Maximize all open windows command will be unavailable if at least one program is not launched through the ZETLab panel.

To manage windows of running programs, the following commands of the context menu of the ZETLab panel are provided:

Close all open windows- designed to close the windows of all programs launched through the ZETLab panel. The Close all open windows command will be unavailable if at least one program is not launched through the ZETLab panel.

Minimize all open windows- designed to minimize (minimize) all programs launched through the ZETLab panel. The Minimize all open windows command will be unavailable if at least one program is not launched through the ZETLab panel.

Maximize all open windows- designed to deploy all previously minimized (minimized) programs launched through the ZETLab panel. When maximized, windows are brought to the foreground in the order they were launched and in the order they belong to the screen number (when the Multi-screen interface mode is enabled). The position and size of the windows are also restored. The Maximize all open windows command will be unavailable if at least one program is not launched through the ZETLab panel.

To control the operation and position of the ZETLab panel itself, the following context menu commands are provided:

Hide panel - designed to hide the ZETLab panel window from the monitor screen. When the panel is hidden, its icon in the notification area of the Windows taskbar looks like as shown in *Fig.3.8*.

Window management of running programs for windows

To manage windows of running programs, the following commands of the context menu of the ZETLab panel are provided:

Close all open windows- designed to close the windows of all programs launched through the ZETLab panel. The Close all open windows command will be unavailable if at least one program is not launched through the ZETLab panel.

Minimize all open windows- designed to minimize (minimize) all programs launched through the ZETLab panel. The Minimize all open windows command will be unavailable if at least one program is not launched through the ZETLab panel.

Maximize all open windows- designed to deploy all previously minimized (minimized) programs launched through the ZETLab panel. When maximized, windows are brought to the foreground in the order they were launched and in the order they belong to the screen number (when the Multi-screen interface mode is enabled). The position and size of the windows are also restored. The Maximize all open windows command will be unavailable if at least one program is not launched through the ZETLab panel.

To manage windows of running programs, the following commands of the context menu of the ZETLab panel are provided:

Close all open windows- designed to close the windows of all programs launched through the ZETLab panel. The Close all open windows command will be unavailable if at least one program is not launched through the ZETLab panel.

Minimize all open windows- designed to minimize (minimize) all programs launched through the ZETLab panel. The Minimize all open windows command will be unavailable if at least one program is not launched through the ZETLab panel.

Maximize all open windows- designed to deploy all previously minimized (minimized) programs launched through the ZETLab panel. When maximized, windows are brought to the foreground in the order they were launched and in the order they belong to the screen number (when the Multi-screen interface mode is enabled). The position and size of the windows are also restored. The Maximize all open windows command will be unavailable if at least one program is not launched through the ZETLab panel.

To control the operation and position of the ZETLab panel itself, the following context menu commands are provided:

Hide panel - designed to hide the ZETLab panel window from the monitor screen. When the panel is hidden, its icon in the notification area of the Windows taskbar looks like as shown in *Fig.3.8*.

Notes:

1. The Hide Panel menu command is not available if the panel is already hidden from the monitor screen;
2. When the panel is hidden from the monitor screen, the area of the screen occupied by the panel becomes available for placing windows of running programs in it (windows are rearranged when the Automatic window placement function is enabled).

You can also hide (remove from the desktop) the ZETLab panel by pressing the left mouse button on its icon (*Fig. 3.8*) in the notification area of the Windows taskbar.

Fig. 3.8

Fig. 3.9

Show panel - When the ZETLab panel is displayed on the monitor, its icon in the notification area of the Windows OS taskbar looks like as shown in *Fig. 3.8.*

You can also display the ZETLab panel on the desktop by clicking the left mouse button on its icon (*Fig.3.8*) in the notification area of the Windows taskbar.

Notes:

1. The Show Panel menu command is not available if the panel is already displayed on the monitor screen;
2. When a panel is displayed from the monitor screen, the area of the screen occupied by the panel becomes inaccessible for placing windows of running programs in it (windows are rearranged when the Automatic window placement function is enabled).
3. The menu command Pin a program to the taskbar allows you to launch it for ease of use from the control panel, not the desktop.
4. The Close Window menu command closes the running ZETLab
5. When you double-click on the ZETLab shortcut at the bottom of the taskbar, a message will *Fig. 3.9*. Next, clicking on the ZETLab icon, it becomes possible to control ZETLab

Fig. 3.9

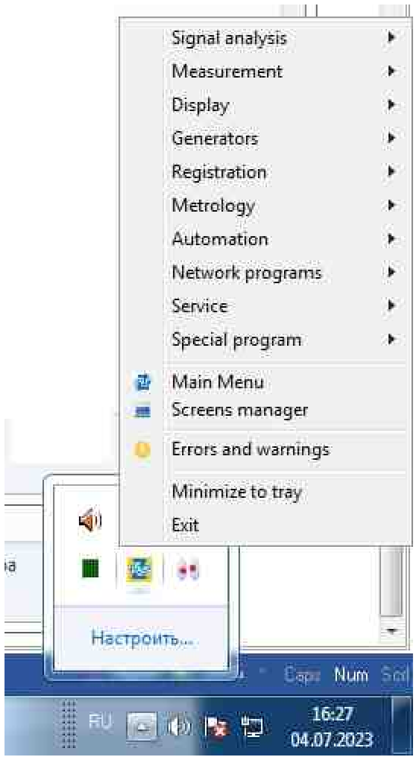


Fig. 3.10

Saving and loading projects

Saving ZETLab projects and their subsequent loading is convenient to use when there are a large number of running programs and setting up these programs, as well as for everyday measurements of the same type. Once, by running all the necessary programs and setting them up properly, the ZETLab project is saved. In the future, simply load the previously saved project and all programs that were launched and configured before saving the ZETLab project will be launched with the same settings and arrangement on the screen (screens), (*Fig. 3.11*) just like when you saved this project.

When saving a project, all running programs, their settings and parameters are saved to a file with *.zpv extension. You can write several different ZETLab projects to different files. ZETLab projects are saved both in single-screen and multi-screen modes.

To save the project, it is necessary in the context menu (*Fig. 3.12*) select the Save project command, after which the Save project window will open. (Fig.3.13). You can also call the Save project dialog box with the active ZETLab panel using the keyboard shortcut - <Ctrl> + <S>. In the Save Project window. you must enter the project name (file name) and click the Recording button, after which the project will be saved to the specified directory. By default, the project file name is Project_01.zpv. The default directory is C:\ZetLab\config\. The user can assign a directory for saving projects, but with each new saving of a ZETLab project, a default directory will be offered for saving.

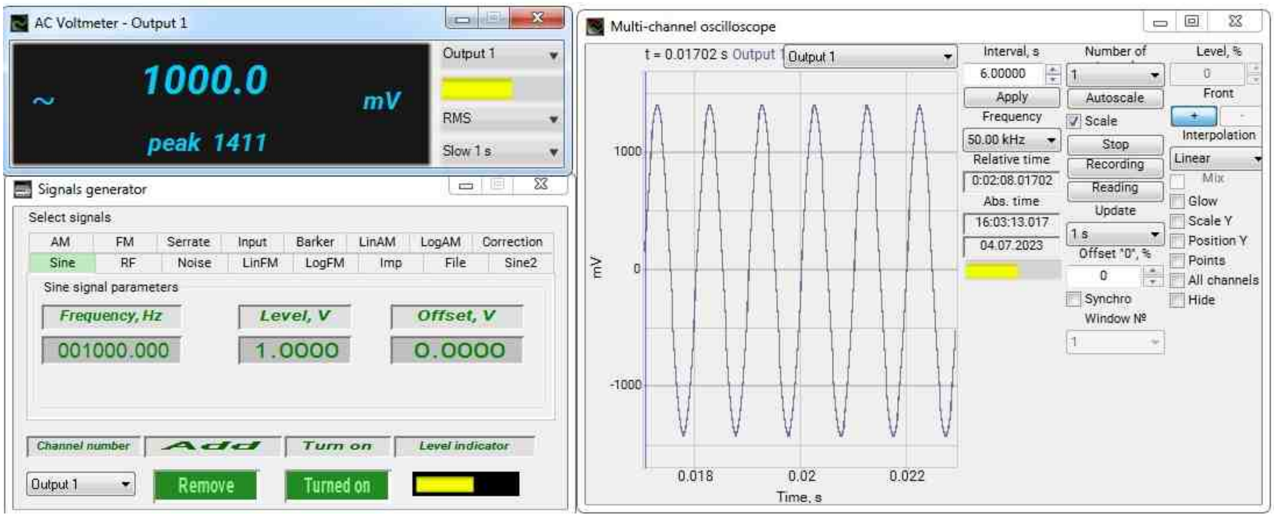


Fig 3.11 Customized ZETLab project

Fig/ 3.12 The configured ZETLab project, and then the Save Project As menu is selected

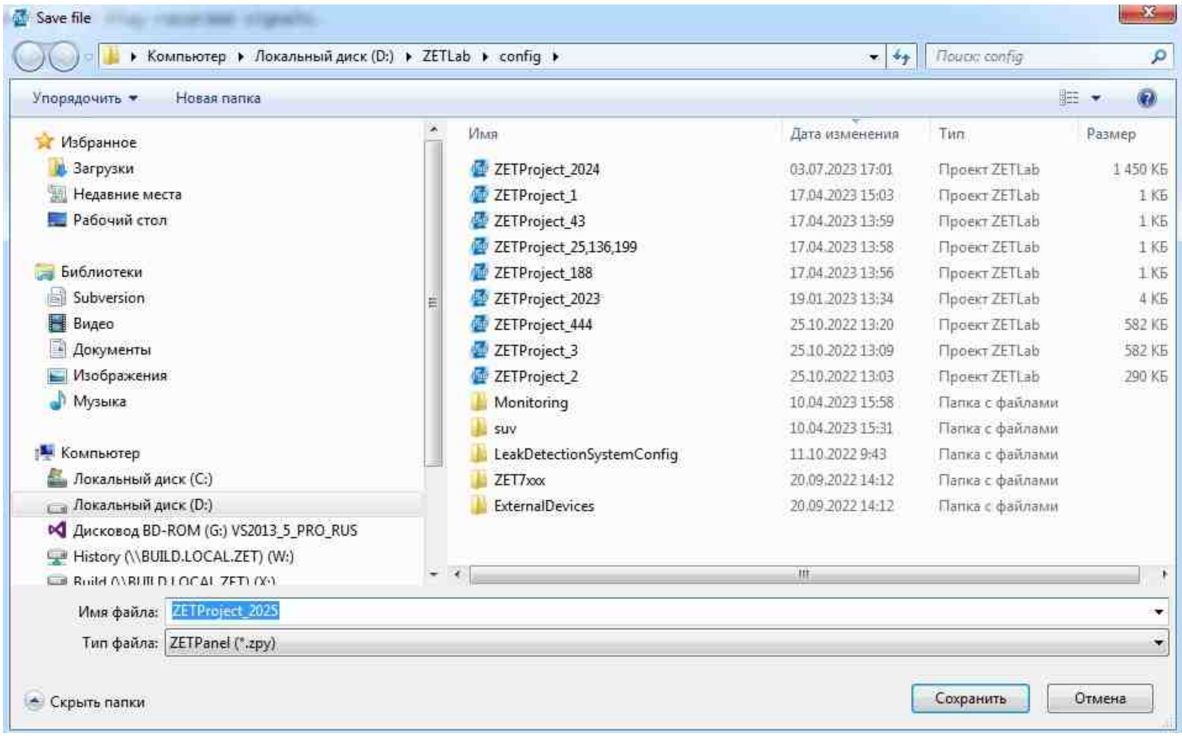


Fig 3.13 After selecting the project name, click Save

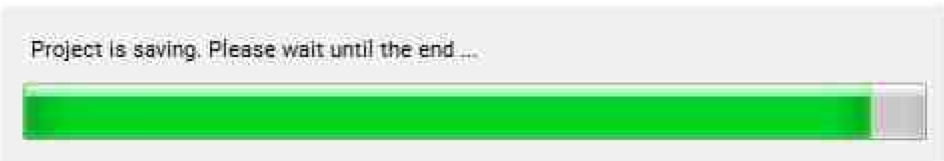


Fig. 3.14 We are waiting for the end of saving the project

Notes:

If there is no option to select Open project in the menu, then this means that some programs are launched from ZETLab which may not be visible to the user. Click on the Close all programs menu (*Fig.3.15*). After that, when you start ZETLAB Project Management, Open Project will appear.

Fig 3.15 Select open project

When selected from the context menu (*Fig. 3.16*) Open Project command opens the Open Project... dialog box (Fig.3.16).
Call the dialog box Load project., with the active ZETLab panel, . In this window, you must select the file name of the previously saved ZETLab project and click the Open button. After clicking on the Open button, the project will be loaded and all programs that were launched and configured before saving the project will be launched, placed and configured, as it was done when the project was saved.
If any programs were launched before loading the ZETLab project, they will complete their work and the programs from the project will be loaded.

Fig 3.16 Select open project

Fig. 3.17 Recently opened projects allow you to launch the desired projects immediately from the menu.

Obtaining help information about the zetlab panel system

At any time of working with the ZETLab panel, you can use the help information about the panel. To do this, select the Help command in the context menu. A new window will appear on the monitor screen (*Fig. 3.18*), containing reference information about the user interface, control and settings of the ZETLab panel. To get help information, you can also use the <F1> key on the keyboard when the ZETLab panel is active.

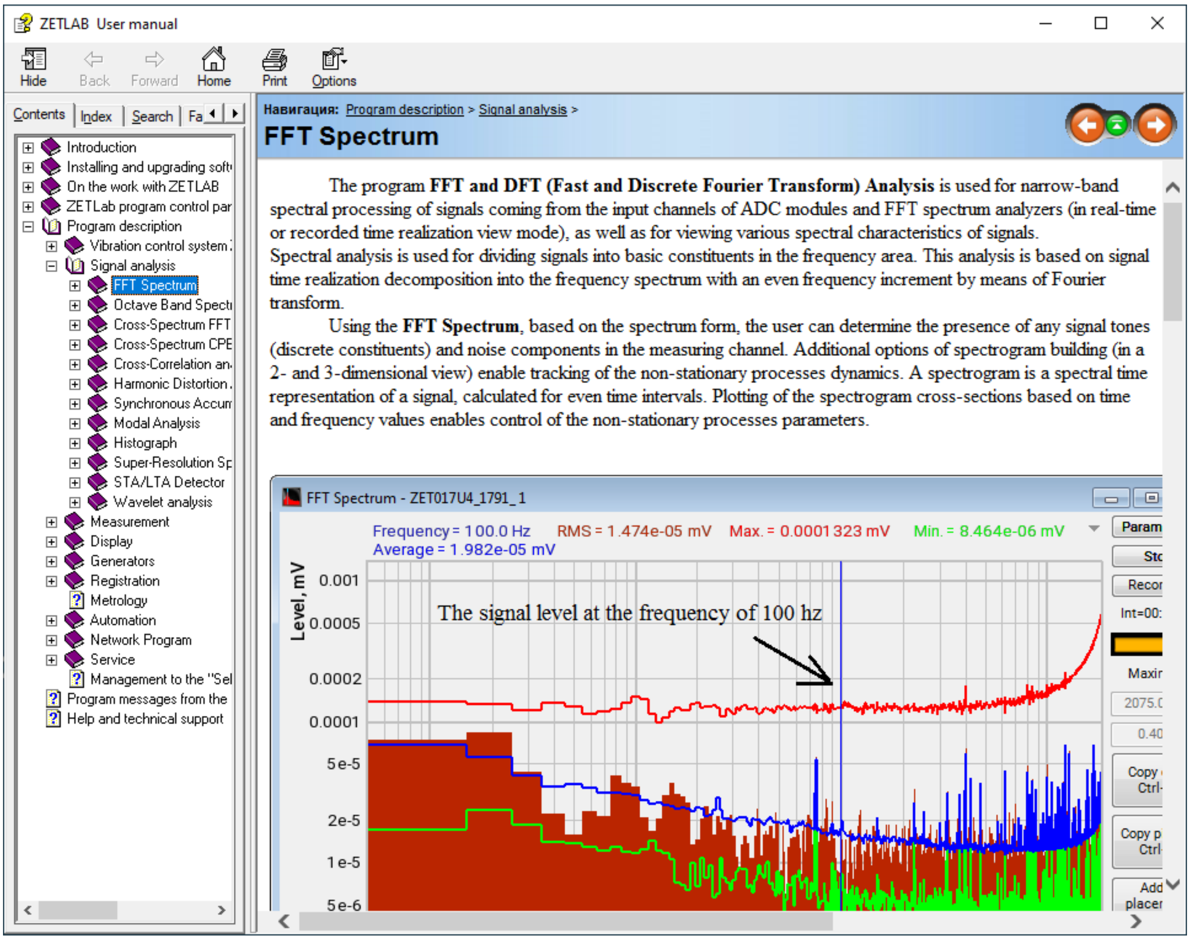
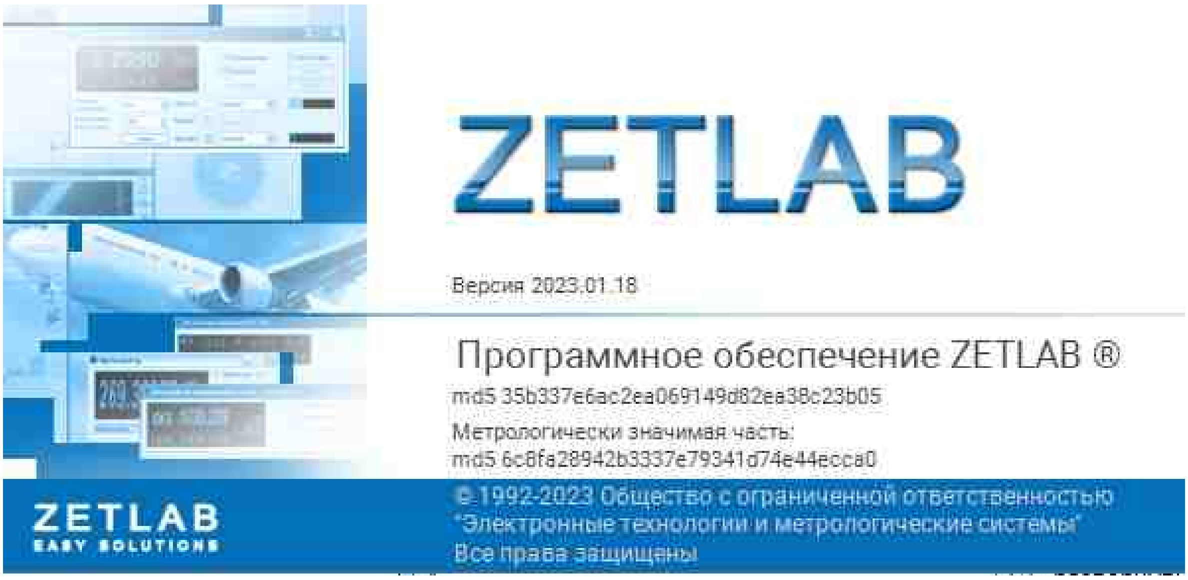


Fig. 3.18


ZETLAB
Версия 2023.01.18
Программное обеспечение ZETLAB ®
md5 35b337e6ac2ea069149d82ea38c23b05
Метрологически значимая часть:
md5 6c8fa28942b3337e79341d74e44ecca0
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"Электронные технологии и метрологические системы"
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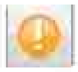
Fig. 3.19

Warning and error alarm system frequency

Changed the window "Status of connected devices", which is called when you click on the button in the upper right corner of the ZetPanel. This button has several visual representations: there are no errors (*Fig. 1*), there is an error (*Fig. 2*), there is a warning (*Fig. 3*). In addition, if the error or warning occurs again (i.e. the problem is not fixed), the button will flash

Fig. 1

Fig. 2



v. 3

- If there is an error or warning, the window looks like a table (if the problem is not corrected, the icon of the corresponding error (warning) will blink). When you right-click on a table element, the context menu is called up. The context menu has the following items (the number varies depending on the error type):

a. "Help" - calling the description of the error;
b. "Copy" - copy the table element;
c. "Ignore" - remove the error (the error will appear again if it is not fixed);
d. "Fix" - this item is not present for all errors. When you click on it, a program will open in which you need to make settings to eliminate this error;
e. "Support Information Resource on zetlab.com" - takes us to the zetlab website to the section corresponding to the device with which the error occurred.

- At the bottom of the window there are three buttons (if there are errors (warnings)):

a. "Send to error log" - sends all errors to "ZETLAB error log";
b.."Clear all" - allows you to eliminate errors. If there are no more errors, the window with the table will be replaced by a window containing information that the devices are operating normally. If the window has not changed, then the table will contain repetitive errors.
c. "OK" - closes the "Status of connected devices" window. In this case, if errors (warnings) no longer occur, the button "Indication of the status of connected devices" changes (*Fig. 1*).

- The changes also affected the ZetLab tray icon (*Fig. 4*).

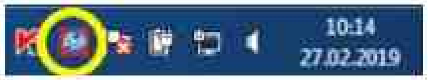


Fig. 4 ZetLab tray icon

Its behavior is similar to the behavior of the “Indication of the status of connected devices” button. When errors (warnings) appear, it changes its color. When the error occurs again, it starts blinking. If there is an error (warning) from the context menu (right-click on the tray icon), you can open the “Status of connected devices” window by selecting the appropriate item (*Fig. 5*).

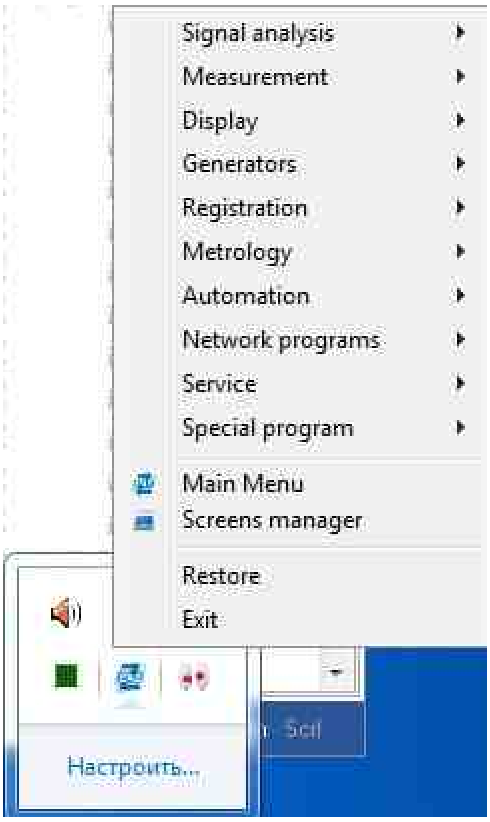


Fig. 5 Connected devices status window

- When you open the “Signals recording” and “Play recorded signals” programs, a button with a unique icon corresponding to the open program appears next to the “Indicate the status of connected devices” button (Fig. 6). When the program starts, the icon starts flashing. When you click on this button, the program will appear in the foreground of the “desktop” (handy when working with multiple screens).
-

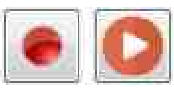


Fig. 6 (“Signals recording” / “Play recorded signals”)

Exit panel ZETLAB

Exit from the ZETLab panel by pressing the Exit button on the right side of the ZETLab panel. This closes all programs launched through the ZETLab panel. You can also exit the ZETLab panel and close all running programs by calling the context menu by right-clicking the mouse on a place free from the buttons of the ZETLab panel or by right-clicking the ZETLab panel icon in the notification area of the Windows taskbar and select the Exit command.

Program description

This section is devoted to the description of virtual **ZETLAB** devices.

Vibration control system ZET 02X (Operator's manual)

Vibration control system
ZET-02X

ETMS.441151.095 34

Operator's manual

Thank you for choosing instruments manufactured by LLC "ETMS"!

Vibration control system ZET 02X is developed and manufactured by LLC "Electronic technologies and metrological systems", located in Zelenograd, Moscow.

Vibration control system ZET 02X is intended for the control of various types of electrodynamic shakers.

The present Operator's manual contains information concerning operation of the vibration control system ZET 02X. Due to the constant updating of the software, this user manual may slightly differ from the software version, that you are currently using. LLC "ETMS" reserves the right to introduce changes in the present Operator's manual, as well as to withdraw it at any time without preliminary notification.

The present Operator's manual contains links to the following documents:

IEC 60068-2-6 "Environmental testing - Part 2-6: Tests - Test Fc: Vibration (Sine)".

IEC 60068-2-64 "Environmental testing - Part 2-64: Tests - Test Fh: Vibration, broad-band random and guidance".

IEC 60068-2-27 "Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock".

MIL-STD-810H "Environmental engineering considerations and laboratory tests".

It should be noted, that vibration testing performance requires certain experience in the course of its preparation and implementation. This issue should be considered both by the Customer and the Manufacturer.

Additional information concerning scope and use of the instruments manufactured by LLC "ETMS" in terms of vibration testing performance is available on our web-site in the section "Shaker control systems".

Warranty agreement

LLC "ETMS" guarantees absence of the defects in the hardware part of the system for the period of ten (10) years from the date of system purchase upon condition of annual periodical verification of the instruments in the manufacturing facility of LLC "ETMS".

LLC "ETMS" does not guarantee error-free operation of the shaker control system and is not responsible for the damage attributed to non-observation of the instructions specified in the present Operator's manual (including wrong commutation of the equipment).

Introduction

Vibration control system ZET 02X (hereinafter referred to as **VCS ZET 02X**) is a hardware and software system used for generation of the signals applied to the input of the shaker amplifier in compliance with the set test profile. The system is also used for recording of the response from the transducers installed at the moving part of the system and at a sample under test.

Depending on the configuration of **VCS ZET 02X** (see Table B.1), the controller can be used for operation of one or up to four shakers.

The scope of **VCS ZET 02X** includes:

- Multi-channel data acquisition system ZET 024, or ZET 028 (hereinafter referred to as **VCS controller**), depending on the configuration, the number of controllers varies from one up to four (see Table B.1);
- Software (software programs) **ZETLAB VIBRO** (to be installed on the PC with Windows OS);
- Primary transducers (accelerometers BC 110, BC 111, etc.).

Table B.0.1

Number of VCS measurement channels	*Number of VCS controllers*		*Number of control channels (signal generator channels)*
	ZET 024	*ZET 028*	

4	*1*	*-*	*1*
8	*-*	*1*	*1*
16	*-*	*2*	*2*
24	*-*	*3*	*3*
32		*4*	*4*
The maximal number of measurement channels can be increased up to 160, in the case if VCS is additionally equipped with FFT Spectrum Analyzers of ZET 034, ZET 038 series.			

ZETLAB VIBRO software is a task-specific software complex by **ZETLAB**. The list of programs included into the scope of **ZETLAB VIBRO** software is specified in Table B.2.

Note! *The Manufacturer reserves the right to introduce changes and improvements, which do not deteriorate performance of VCS ZET 02X, without specifying them in the present Operator's manual. In the case of problems relating to the operation of VCS ZET 02X, please, contact us.*

LLC "Electronic technologies and metrological systems"

Please notify us using any communication of your convenience on any issues and faults occurring during ZETLab software installation and operation.

Manufacturer's address: 14 Konstruktora Lukina str. build.12, Zelenograd, 124460, Moscow, Russia.

GPS COORDINATES 56.008067, 37.153907

Telephone/fax: +7 (495) 739-39-19 (Multichannel)
Technical support: INFO@ZETLAB.COM for issues relating to purchase of standard products
Web site: ZETLAB@ZETLAB.COM information on Company products

OFFICE HOURS Mon-Fri: 9 a.m.–6 p.m. (MSK time)

Table B.0.2

Name of the program	Composition of ZETLAB Software program sets							
	DEMO	ANALI	VIBRO	NOIZE	TENZ	SEISM	BASE	SENSOR

Signal analysis	FFT Spectrum	✓	✓	✓	✓	✓	✓	✓	✓
	Spectrum CPB Analysis	✓	✓	✓	✓		✓		
	Cross-Spectrum FFT Analysis	✓	✓	✓			✓		
	Cross-Spectrum CPB	✓	✓	✓	*		✓		
	Cross-Correlation analysis	✓	✓	✓			✓		
	Harmonic Distortion Analysis	✓	✓	✓	✓	✓	✓		
	Synchronous accumulation	✓	✓	✓	✓	✓	✓		
	Modal analysis	✓	✓	✓	✓	✓	✓		
	Histogram		✓	✓		✓	✓		✓
	Super-resolution spectrum		✓	✓		✓	✓		✓
	STA\LTA detector		✓	✓		✓	✓		✓
	Wavelet analysis		✓	✓		✓	✓		✓
Measurement	AC voltmeter	✓	✓	✓	✓	✓	✓	✓	✓
	DC voltmeter	✓	✓	✓	✓	✓	✓	✓	✓
	Selective voltmeter	✓	✓	✓	✓	✓	✓	✓	✓
	Frequency counter	✓	✓	✓	✓	✓	✓	✓	✓
	Phasemeter	✓	✓	✓	*	✓	✓	✓	✓
	Power meter	✓	✓	✓	✓	✓	✓	✓	✓
	Tachometer		✓	✓	✓	✓	✓		
	Torsiograph		✓	✓	✓	✓	✓		
	Encoder		✓	✓	✓	✓	✓		
	TR thermometer					✓			
	TC thermometer					✓			
	Strain Gauge Meter					✓			
	Vibration meter	✓	✓	✓	✓		✓		
	Data recording from third-party instruments (Agilent, etc.)		option	option	option	option	option	option	
Display	Multi-channel oscilloscope	✓	✓	✓	✓	✓	✓	✓	✓
	XYZ-oscilloscope	✓	✓	✓	*	✓	✓	✓	✓
	XYZ-plotter	✓	✓	✓	*	✓	✓	✓	✓

	Results viewing	✓	✓	✓	✓	✓	✓	✓	✓
	Signals gallery	✓	✓	✓	✓	✓	✓	✓	✓
Generators	Signals generator		✓	✓		✓	✓	✓	option
	Synchronous generator		✓	✓		✓	✓	✓	option
	Shaker parameters editor	✓		✓					
	Feedback generator (Shock)	✓		✓					
	Feedback generator (Vibroshock)	✓		✓					
	Feedback generator (Sine)	✓		✓					
	Feedback generator (Random)	✓		✓					

Table B.0.2 (continued)

		DEMO	ANALI	VIBRO	NOIZE	TENZ	SEISM	BASE	SENSOR
Recording	Signals recording		✓	✓	✓	✓	✓	option	option
	Signals archive converter		✓	✓	✓	✓	✓	option	option
	Signal trends viewing	✓	✓	✓	✓	✓	✓	✓	✓
	Signal trends scanner	✓	✓	✓	✓	✓	✓	✓	✓
	Event trends viewing	✓	✓	✓	✓	✓	✓	✓	✓
	Play recorded signals		✓	✓	✓	✓	✓	option	option
	Multi-channel recorder		✓	✓	✓	✓	✓	option	option
Metrology	AFR measurement log. (AC)		✓	✓			✓		
	AFR - log. scale (with selection of external generator)		✓	✓			✓		
	AFR - log. scale (DC)		✓	✓			✓		
	AFR - log. scale (AC/DC)		✓	✓			✓		
	AFR - lin. scale (AC)		✓	✓			✓		
	AFR - lin. scale (DC)		✓	✓			✓		
	AFR - log. scale (Selective)		✓	✓			✓		
	Log. Ph.-freq. response		✓	✓			✓		
	Lin. Ph.-freq. response		✓	✓			✓		

	Log. Total harmonic distortion factor		✓	✓			✓		
	Frequency response measurement in fixed frequency range (AC)		✓	✓			✓		
	Metrological self-check ZET7xxx		✓	✓			✓		
Automation	ZETView		option	✓	option	option	✓	option	option
	ZETView (exe)		✓	✓	option	option	✓	option	option
	Controller	✓	✓	✓		✓	✓	option	
	Arithmometer	✓	✓	✓	✓	✓	✓	✓	✓
	Adaptive filter 50 Hz	✓	✓	✓	✓	✓	✓	option	✓
	Signals filtration	✓	✓	✓	✓	✓	✓	option	✓
	Synchronization of instruments		*	*	*	*	✓	✓	
	Formula	✓	✓	✓		✓	✓	option	
	Switching unit control	✓	*	*	*	*	✓	✓	*
	Electrical circuits parameters control								
Network	Enable signals transmitter	✓	✓	✓	option	✓	✓	option	✓
	Connect to signals transmitter	✓	✓	✓	✓	✓	✓	✓	✓
	Connection of devices by Ethernet		✓	✓	✓	✓	✓	✓	*
	Connection of devices by Bluetooth	✓	*	*	*	*	*	✓	*
Service	ZETServer time	✓	✓	✓	✓	✓	✓	✓	✓
	Device manager	✓	✓	✓	✓	✓	✓	✓	✓
	Channels listening	✓	✓	✓	✓	✓	✓	✓	✓
	ZETLAB Error journal	✓	✓	✓	✓	✓	✓	✓	✓

Hardware requirements for a PC when working with VCS programs .....

WE PAY ATTENTION TO THE REQUIREMENTS FOR A PERSONAL COMPUTER WHEN WORKING WITH THE ZETLAB VIBRO SOFTWARE.
THE GIVEN REQUIREMENTS ARE RECOMMENDED FOR OPERATION WITH NO MORE THAN 2 CONTROLLER CHANNELS INVOLVED.

MINIMUM PC REQUIREMENTS	
Processor	Dual or more core processor;
Processor speed	over 1,6 GHz;
RAM	more than 4 Gb;
Hard disk free space	more than 20 Gb;
Videocard	with 3D-graphical acceleration, support of OrenGL, DirectX, memory - over 128 Mb;
Display resolution	at least 1600Ч900
Network interface	10/100 Mbps (RJ-45 port)

- interface availability HighSpeed USB 2.0* to install programs.
- mouse or any other pointing device (touch screen, track ball, TouchPad, graphic pad);
- standard keyboard or any other input device (sensor screen, graphic pad); .

Note

TO WORK WITH A LARGE NUMBER OF CHANNELS INVOLVED, YOU SHOULD USE A MORE PRODUCTIVE COMPUTER

RECOMMENDED PC REQUIREMENTS	
Processor	quad-core or more
Processor speed	at least 2.5 GHz
RAM	at least 8 GB
Hard disk free space or SSD drive	at least 512 GB
Videocard	with 3D-graphical acceleration, support of OrenGL, DirectX, memory - over 128 Mb;
Display resolution	at least 1920Ч1080
Network interface	10/100 Mbps (RJ-45 port)
Number of monitors	2

- interface availability HighSpeed USB 2.0* to install programs.
- mouse or any other pointing device (touch screen, track ball, TouchPad, graphic pad);
- standard keyboard or any other input device (sensor screen, graphic pad); .

Common information concerning VCS ZET 02X .....

Common information concerning VCS ZET 02X

Before you start using *VCS ZET 02X*, it is necessary to:

- Study operational documentation to the VCS controller;
- Study operational documentation to the shaker, which is going to be controlled with VCS ZET 02X;
- Study operating principles of ZETLAB VIBRO software programs, and install ZETLAB software to the PC (section 2.1).

In order to start vibration testing, it is necessary to arrange the instruments in compliance with the applied scheme (Fig. *1.1*):

- Connect the VCS controller(s) to the PC via Ethernet (see section 4);
- Install the tool on the shaker and attach a sample under test to it;
- Install the primary transducers (accelerometers) on the specimen in the areas, where it is necessary to control the vibration level in compliance with the requirements specified in "GOST ISO 5348-2002. Vibration and shock. Mechanical mounting of accelerometers";
- Connect the primary transducers (accelerometers) to the inputs of the VCS controller, and connect the output of the VCS controller to the input of shaker amplifier;
- Set parameters of ZETLAB VIBRO software (see section 5) in order to secure the vibration testing performance in compliance with the applicable requirements.
- Implement the test sequence and specify the relevant results in the test protocol.

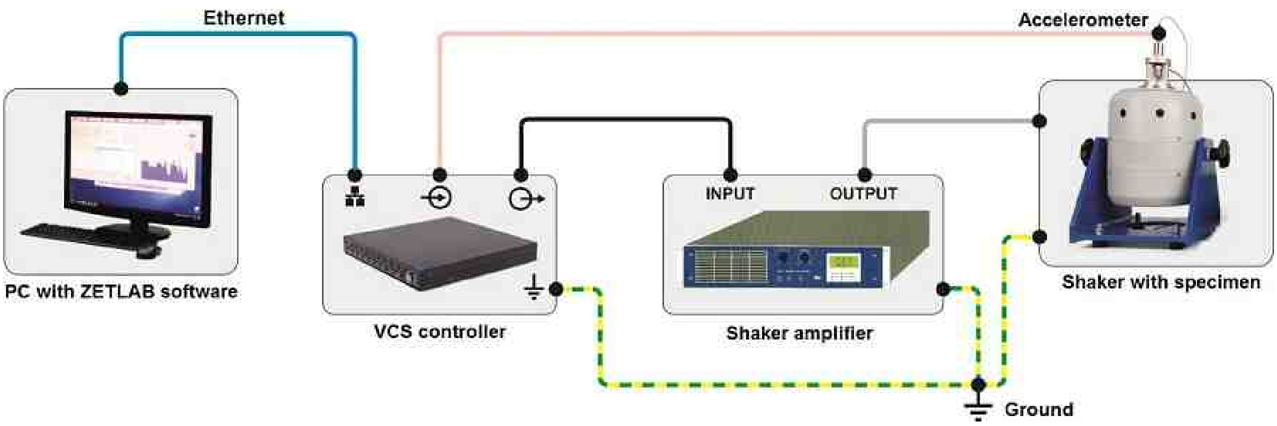


Fig. 1.1 Structural scheme of VCS ZET 02X

Since this scheme implies the use of shaker amplifier, it is necessary to provide grounding for all the components present in the scheme. The shaker and the amplifier are to be grounded in compliance with the relevant operational documentation. The grounding terminal of the VCS controller is located at the rear panel. All grounding wires are to be connected at a single physical point (as a common point you can use the grounding terminal of the amplifier), which is to be connected to the grounding bus.

Note: *Connect the grounding wires to the grounding terminals of the* VCS *controller using the "plug 4mm" connectors that the* VCS *controller is equipped with..*

Grounding of the system components is necessary for securing protection of VCS controller from the cross-talk relating to the amplifier or the shaker. Besides, in many cases, proper grounding allows to reduce the interference from the power supply network (the harmonic signal at the frequency of 50 Hz).

Note: *In order to reduce electrical cross-talk, it is recommended to provide reliable electrical insulation between the primary transducers (accelerometers) and the table (head) of the shaker.*

For the purpose of emergency shut-down of vibration testing process, there is used "Stop" key located at the front panel of VCS controller. Upon activation of the "Stop" key, the system disconnects the output circuit of the VCS controller, and the shaker is switched off. In the case if VCS programs were not stopped automatically, it is necessary to close them in manual mode.

The rules of connecting the sensors (primary transducers) to the VCS controller are described in user manuals for transducers and relevant equipment.

Note: *The connection of the most commonly used sensors in the VCS is given in section* *7.7*.

Attention! *As part of the VCS, controllers of the ZET02x, ZET03x series, as well as ZET058 (strain-gauge station) can be used, however, it should be borne in mind that the generator channels for generating shaker excitation signals can only be used for controllers of the ZET02x series.*

General arrangement of VCS .....

1.1 General arrangement of VCS

Fig. 1.2 displays front panels of VCS controllers ZET 024 and ZET 028, and ***Table 1.1*** describes functions of panel elements.

Fig. 1.2 Front panels of VCS controllers ZET 024 and ZET 028

Table 1. Functions of front panel control elements

Labelling	Function
 (1…8)	Inputs of measurement channels with integrated indicators. Green LED – operation mode "Input by voltage" is enabled. Blue LED – operation mode "ICP input" is enabled.
 (1, 2)	Generator outputs with integrated operation indicators. Green LED – the generator is controlled from PC. Blue LED – standalone operation mode.
	Emergency shutdown of the vibration testing.
	Indicator of operational status of the controller (on/off). As the controller is on, the indicator flashes with green.
	Indicator of controller's operation mode. When the controller is connected to the PC (stationary mode), the indicator flashes with green. If the controller is used for signals recording to SD-card without connection to PC (standalone mode), the indicator flashes with blue.
	Controller synchronization indicator. In the synchronization mode, the "Master" indicator flashes with green. In the synchronization mode, the "Slave" indicator flashes with blue.
	Error indicator. Indicator flashes with red if an error is detected, or input voltage level at the measurement channel is exceeded.

Fig. 1.3 displays the rear panel of VCS controllers ZET 024 and ZET 028, and *Table 1.2* describes functions of the panel control elements.

Fig. 1.3 Rear panel of VCS controllers ZET 024 and ZET 028

Table 1. Functions of rear panel control elements

Labelling	Function
Digital I/O	Digital input/output.
Secure Digital	SD slot for recording signals and files with "*.log" extension in standalone mode. The system supports SD-cards of SD/SDHC format with volume up to 32 Gb.
	Port for connecting controller to the PC via Ethernet 10/100 interface.
Reset	"Reset" key of the Ethernet port address to the default parameters.
DC 12 V	Port for connecting 12 V power supply module. Key "Switching the controller on/off".
	Grounding terminal of the controller.
	Grounding terminal of the controller generator.

Operational conditions of VCS .....

VCS controller can be placed on a table, or in the standard 19" frame with 19" support bracket (option).

Operational conditions:

- Ambient temperature: 5 - 40°C;
- Relative air humidity: up to 90 % at 25 °C;
- Atmospheric pressure (630– 800) mm Hg;
- Power supply network frequency (50 ± 0,5) Hz;
- AC power supply network voltage (220 ± 22) V.

Information concerning ZETLAB VIBRO software .....

ZETLAB VIBRO software contains a list of programs from ZETLAB software, covered by general license. The license for operation of ZETLAB VIBRO software is located in the firmware of VCS controller. Thus, as the controller is connected to the PC, all functions of ZETLAB VIBRO software become available to the user.

Description of ZETLAB software installation process, and the rules of using ZETLAB control panel are available in section 1 of the present manual.

Control and indication elements .....

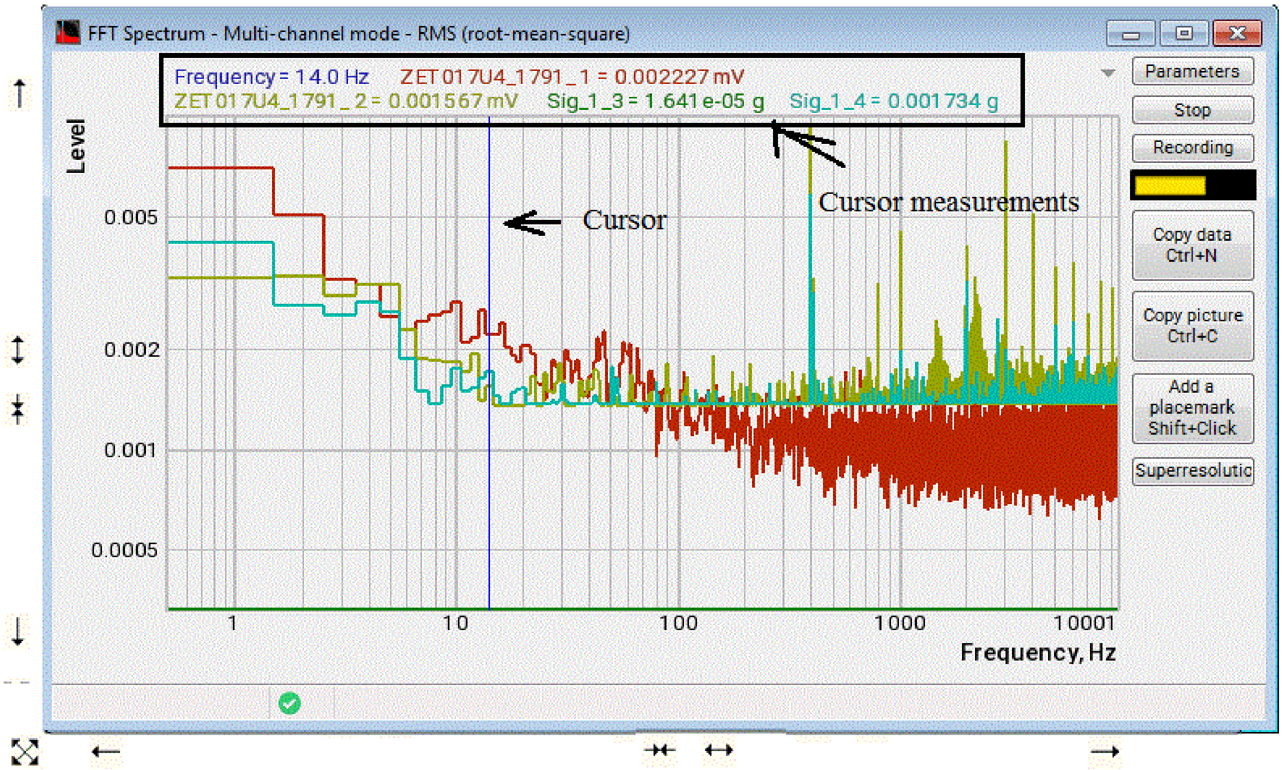
Cursor control in graphs .....

Most of ZETLAB program windows that are used for displaying of graphics, have a cursor, which allows to display the values, calculated by the program, at a particular position of the cursor.

There are several ways of placing the mouse pointer at the required frequency value:

- place the mouse pointer at the required frequency, hold down the left mouse key and wait until the graphic cursor (the vertical line) aligns with the pointer. Hold the left mouse key to move the graphic cursor together with the mouse pointer along the graphic section;
- hold down the left mouse key and move the graphic using the scroll wheel;
- activate the program, use the keys <A> and <D> to move the cursor to the left and to the right respectively.

- in the active window of the program, the cursor can be moved up by pressing and holding pressed <W> key (in Latin layout), down – <S>



FFT Spectrum cursor control and zoom graphics

The mouse pointing device is also used for scaling of the numerical axes. As the mouse pointer is moved along the numerical axes, it changes its appearance depending on the currently available graphic scaling option. Left-click it or use the scroll wheel. It is possible to increase / decrease the graphic scale using the following icons: ↔ , ⇥⇤ – for horizontal axis and ↕ , ⤒⤓ – for vertical axis. Move the graphic to the left / to the right or up / down using the icons ← , → – for horizontal axis and ↑ , ↓ , for vertical axis. If you place the mouse pointer at the cross-section of numerical axes, it will change its appearance: ⤧ . Left-click this icon for automated scaling of the graphic by signal level.

Scaling of numerical axes .....

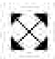
You can scale the numerical axes using mouse.

To scale the numerical axes, place the mouse cursor to the scale axis of the graphic. The cursor will change its appearance depending on its position on the numerical axis:

- For horizontal axes: ↔, →←, ←, →;
- For vertical axes: ↕, ↓↑, ↑, ↓.

Symbols ↔ and ↕ stand for extension, and symbols →← and ↓↑ - for compression of the graphic scale by the corresponding axis. Symbols ← and → stand for moving to the left and to the right by the horizontal axis, and symbols ↑, ↓ stand for moving up and down by the vertical axis.

As you select the required action for scaling by numerical axis and the cursor changes its appearance, you can scale the graphic by using the left mouse key, or by using the scroll key.

For auto-scaling of the vertical axis in the registered range of values (which is displayed in horizontal axis of the graph), place the cursor at the crossing of the numerical axes, so that the cursor icon would change for  and left-click it.

Selection from the lists .....

The icon "„ of ZETLAB programs allows the user to select the required parameter value from the list.

In order to select the required parameter from the list, place the cursor at the corresponding symbol. You will see a drop-down list with the available values. Place the cursor at the required value and left-click it. You can switch between the available values using the scroll key, or the keyboard keys <↑> and <↓>.

Configuration of program windows display parameters .....

Most of ZETLAB programs windows allow the user to change their display parameters. To change the window display parameters, place the cursor at the graphic section of the program to be set, and right-click it. You will see the graphic parameters window (*Fig. 3.1*).

In the tab "Display parameters" (*Fig. 3.1*) you can set the line type and graphic parameters. The graphic can be displayed as a stepped line or as a polygonals line. This tab also allows to set the display parameters for each of the graphics (color, thickness, filling (color) of a particular graphic area). As you set the required parameters, click "Apply" to save the changes.

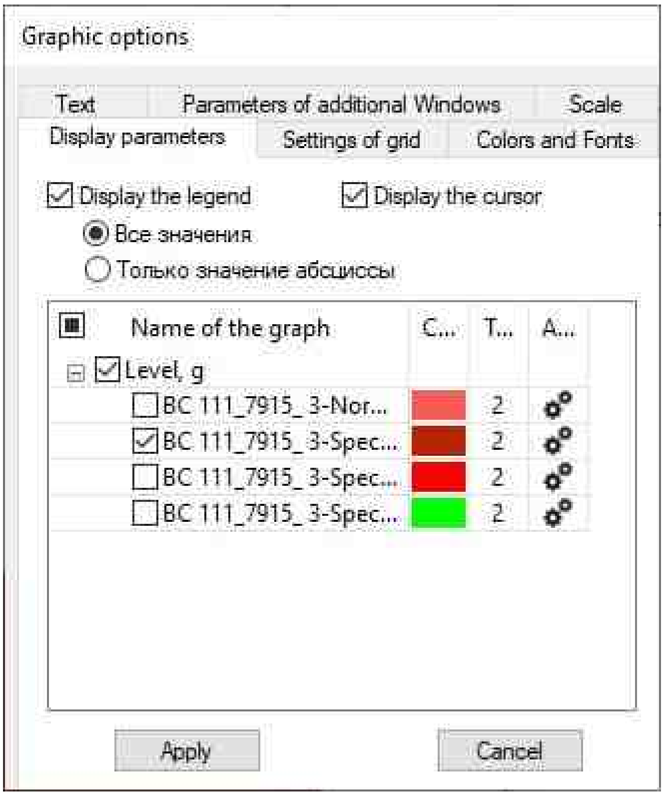


Fig. 3.1 The tab for configuration of graphic display parameters

The tab "Settings of grid" (*Fig. 3.2*) allows to enable/ disable the displaying of horizontal and vertical labelling of axes and grid. In this tab, you can also set the visible area of graphics to be displayed: upper, bottom, left and right boundaries of the graphic. As you set the required parameters, click "Apply" to save the changes.

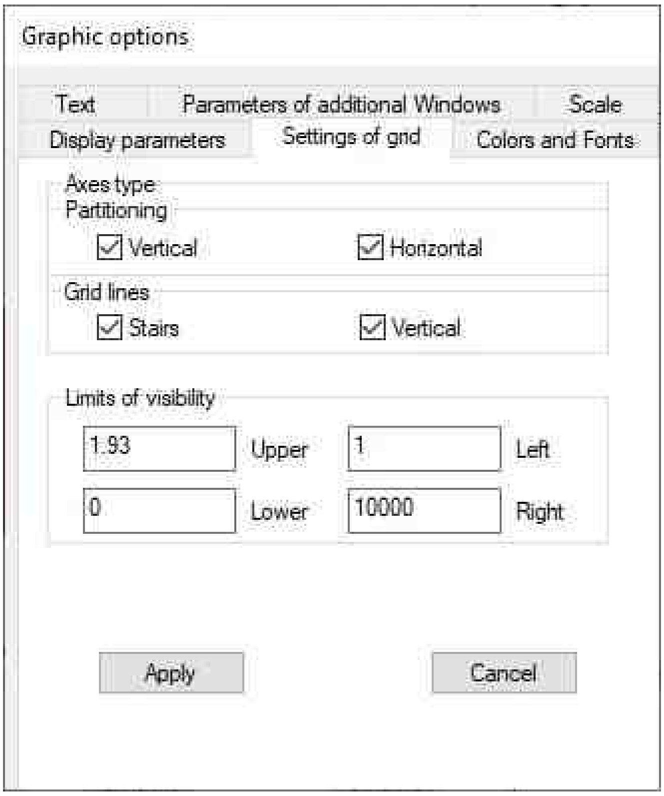


Fig. 3.2 The tab for configuration of graphic grid parameters

The tab "Colors and fonts" (*Fig. 3.3*) allows to set the font size for numerical axes and the measured values. In this tab, you can also set the color of grid, cursor, background, axes marks, legend. As you set the required parameters, click "Apply" to save the changes.

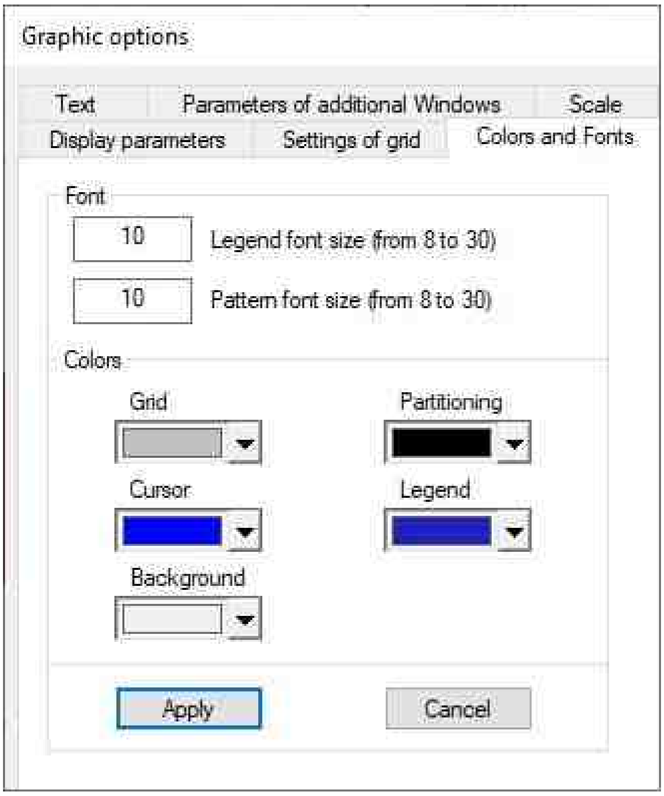


Fig. 3.3 The tab for configuration of color and fonts of the graph

The "Text" tab (*Fig. 3.4*) allows to add text to the graphic (additional clarifying information) to be displayed as the graphic is copied to text documents and reports. To add a text, click the checkbox "Show the text", select the font and enter the text (in this example: "Transducer at the point 2"), then click "Apply" to save the changes.

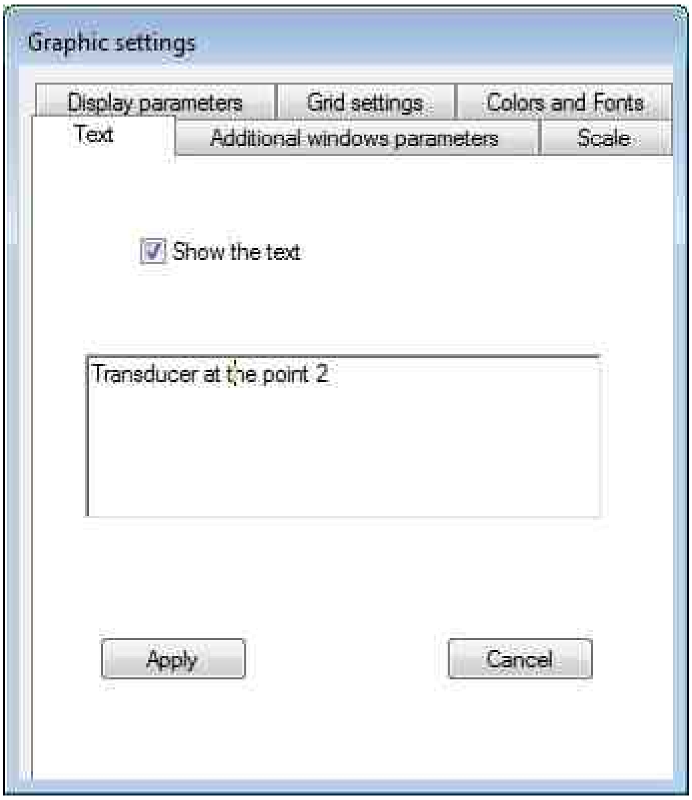


Fig. 3.4 The tab used for adding text to the graph

In this Fig. (*Fig. 3.5*) you can see a section of the program window "FFT Spectrum Analysis" with additional text information- "Transducer at the point 2".

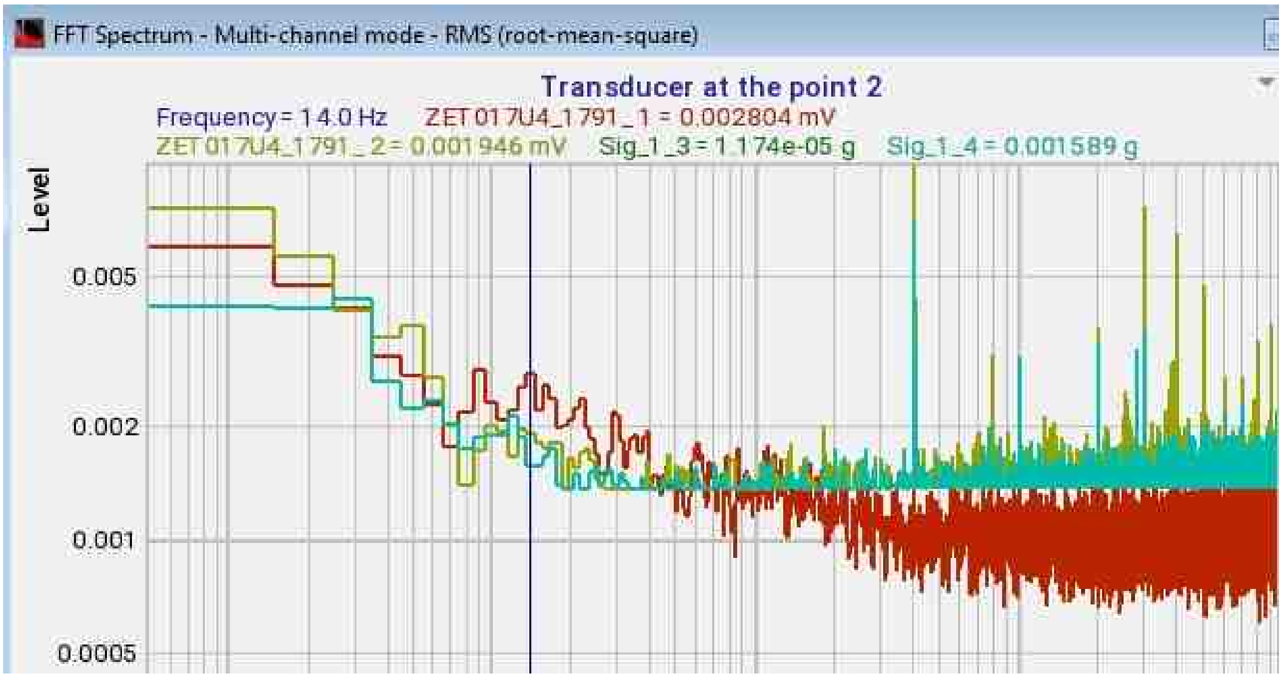


Fig. 3.5 Section of the program window with additional information

The "Scale" tab (*Fig. 3.6*) allows to select the type of vertical and horizontal axes representation. As you set the required parameters, click "Apply" to save the changes.

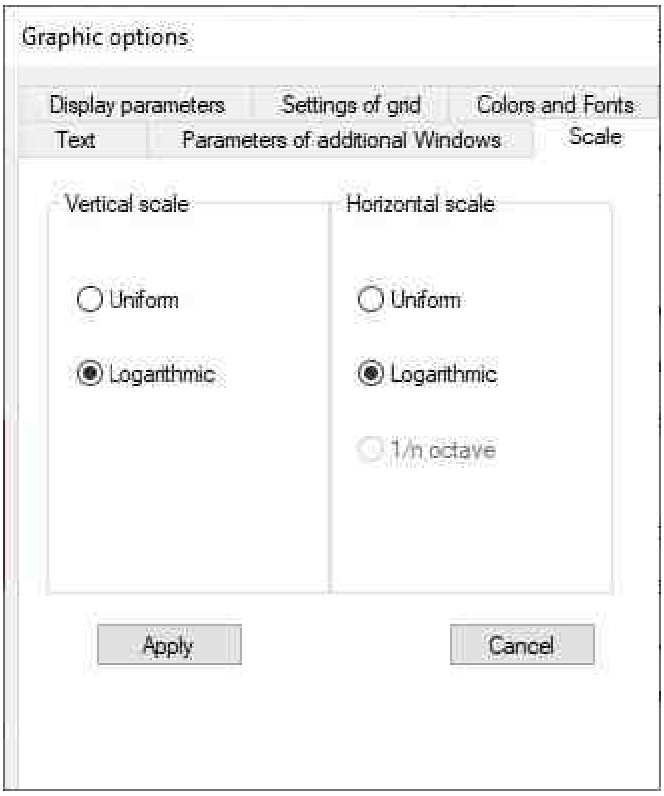


Fig. 3.6 The tab used for configuration of graphic scale

To exit the graphic parameters without saving the changes, click "Cancel", or click outside of the "Graphic parameters" window.

Note: *selection of the representation type depends on the appearance of the displayed graphic and can have limitations both for vertical and horizontal scale.*

Using the keys «Start», «Stop» and «Recording» .....

The "Start" key is used for displaying the graphical information in the program window in compliance with the calculation parameters. In the case, if the program has Additional graphic windows containing previously accumulated data, activation of the "Start" key clears this data, and data accumulation begins again.

The key "Stop" (pause) suspends displaying of graphical data in the program window and stops accumulation of data in Additional graphic windows relating to this program. To resume the data accumulation process, click "Start" key.

The "Recording" key allows to save the graphical information values to a text file with *.*dtx* extension. Upon activation of the "Recording" key, there appears a standard dialog window allowing to set the name of the file and the file directory. The directory by default– C:\ZETLab\User\result. The structure of the text file is described in Table 3.1.

Table 3.

Text file line number	**Corresponding information**
1	Name of the program window
2	Name of the measurement channel
3	Additional text (additional clarifying information set by the user – see section 3.4)
4	Program parameters configuration
5	Data of file recording
6	Time of file recording
7	Headings of columns and saved data
8	Measurement units of columns and saved data
9, etc.	Numerical values of the saved data, distributed by columns and represented in the floating point format, where the symbol "." is used for separation of integer and fractional part

Using signal level indicators .....

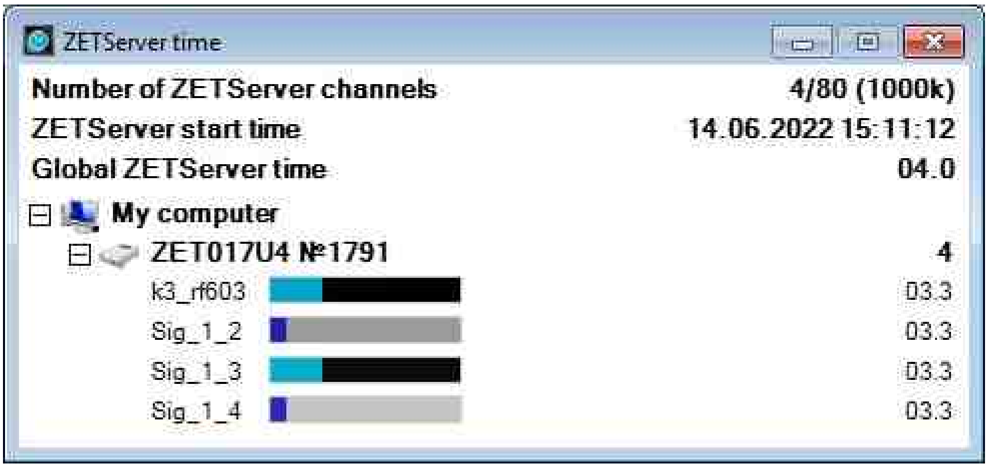
Most of ZETLAB programs used for processing of the registered signals (by the selected measurement channel) have signal level indicators (*Fig. 3.7*), displaying the current integral level of the signal.

Fig. 3.7 Indicator of signal integral level

Signal level indicator allows the user to evaluate the quality of selection, adjustment, and sensitivity of elements for a particular measurement channel, thus excluding signal processing in the case of overloading and signal failure in the selected measurement channel.

Two thirds of signal level indicator section display the signal level, which is below the maximal admissible value. The higher is the level, the more is indicator value. As the maximal admissible level is exceeded (without the presence of signal distortions), the indicator flashes with red. When overloading by the measurement channel will no longer be detected, the indicator will flash red until the user left-clicks it.

The indicators of the "ZET Server Time" program window are also equipped with the function of changing the color of the background area of the indicator. This function allows you to perform a statistical evaluation of the quality of the recorded signal in the measuring channel. The more the signal resembles white noise in its statistical characteristics, the lighter the background area. The smaller the signal resembles white noise in characteristics, the darker the background. At rest, the signal of a serviceable sensor should show background noise that is close to white in characteristics. The presence of interference (pulse, harmonic, etc.) or a malfunction in the sensor leads to a change in the characteristics of the signal and darkening of the background area of the indicator.



Adjustment of the color scheme used for displaying of the registered signal amplitude values .....

ZETLAB program windows used for displaying of the data in 2- or 3-dimensional format have indicators for adjustment of the color scheme of the registered values amplitude (*Fig. 3.8*).

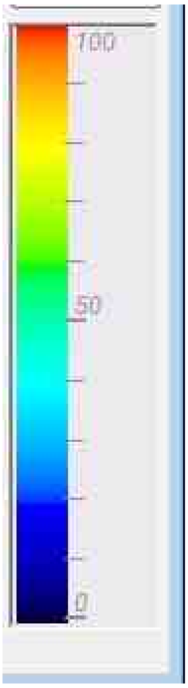
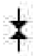
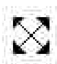
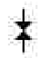
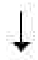
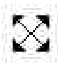


Fig. 3.8 Indicator of the color scheme adjustment

To switch over to the required color scheme and contrast level of the registered values, place the cursor to the right part of the indicator ([Fig. 3.8](#)), the cursor will change its appearance (depending on its particular location):  ,  ,  ,  ,  .

The symbol  is used for extension of the color scheme, and the symbol  allows to compress it, symbol  allows to go to the bottom part of the color scheme, symbol  allows to go to the top section of the color scheme, symbol  is used for auto-scaling.

As you select the required type of scaling, left-click the cursor symbol, or use the scroll key.

Transmission of graphical and numerical data to text editors .....

ZETLAB programs allow to copy numerical values, graphs, and to convert the displayed graphics into text sequence of numerical values, where the left column corresponds to graphic values by horizontal axis, and the right column – to those by vertical axis.

In order to copy numerical value from ZETLAB program window, place the cursor into the window of the program used for recording of numerical values (e.g., "DC voltmeter", "Encoder", etc.), and left-click it. The data will be copied to the Clipboard. Place the cursor in the window of the text editor program (Microsoft Word, Excel, etc.), right-click it, and select the option "Paste". The numerical value registered by ZETLAB program will be copied to the document.

In order to copy a graphic from ZETLAB program window, place the cursor on the relevant graphic image in the program window (e.g., "narrow-band analysis", "Multi-channel oscilloscope", etc.), and use the key combination<*Ctrl*> + <*C*>, after that the graphic will be copied to the Clipboard. Place the cursor in the window of the text editor program (Microsoft Word, Excel, etc.), right-click it, and select the option "Paste". The relevant graphic will be copied to the document.

In order to convert the graphic into a text sequence of numerical values, place the cursor on the graphic displayed in the program window (e.g., "narrow-band analysis", "Multi-channel oscilloscope", etc.), and press the key <*N*>. The sequence of numerical values will be copied to the clipboard. Place the cursor in the window of the text editor program (Microsoft Word, Excel, etc.), right-click it, and select the option "Paste". The numerical sequence, which corresponds to the displayed graphic will be copied to the document.

In order to copy the graphic values, which correspond to the particular position of the cursor, place the cursor to the required graphic point in the program window (e.g., "narrow-band analysis", "Multi-channel oscilloscope", etc.), and click the key <*T*>. The values will be copied to the clipboard. Place the cursor in the window of the text editor program (Microsoft Word, Excel, etc.), right-click it, and select the option "Paste". The required values will be copied to the document. As you copy the values, which correspond to a particular position of the cursor, the program also copies additional information: name of the program, and name of the channel used for data recording.

You can also use the combination <Ctrl>+<V>.

You can also use the functions "**Copy graph**" or "**Copy image**" to copy the graphic to the clipboard (in the case, if these functions are available)

You can also copy the sequence of numerical values using the key "Copy data" (if this key is available)

ZETLAB VIBRO: setting-up procedures .....

Table of contents:

Installing ZETLAB software to PC .....

In order to install ZETLAB software, it is necessary to run installation file ZETLAB.msi (supplied on USB flash-drive) and follow further instructions to install ZETLAB Software to the directory C:\ZETLab.

In order to install ZETLAB software, it is necessary:

1. Insert the supplied flash drive (with ZETLAB software) into the free USB port of the computer on which the measurements will be made.
2. Run the zetlab.msi installer file.
3. Following the instructions of the installation wizard, install the ZETLAB software in the directory C:\ZETLab .
4. To activate the license to work on ZETLAB with digital sensors of the ZET7xxx series, insert the ZETKEY electronic key into the USB port of the computer (*Fig. 2.1*).

Fig. 2.1 Electronic key ZETKEY

Starting ZETLAB control panel .....

In order to start ZEETLAB panel, it is necessary to activate *ZETLAB* icon (*Fig. 2.1*), located at the desktop.

Fig. 2.1 ZETLab icon image

At the top section of the screen there will appear *ZETLAB* panel (*Fig. 2.2*).

Fig. 2.2 ZETLAB control panel

ZETLAB control panel allows to find the required programs by selecting a particular menu section of ZETLAB control panel and finding the required program in the drop-down list.

Images near the names of the programs allow to simplify the search of the required program.

Help information .....

During operation of ZETLAB software programs the user can get access to the help information, which has a tree-coded structure (*Fig. 2.3*).

To get access to the help data for the program, which is currently used, click <F1> in the window of this program.

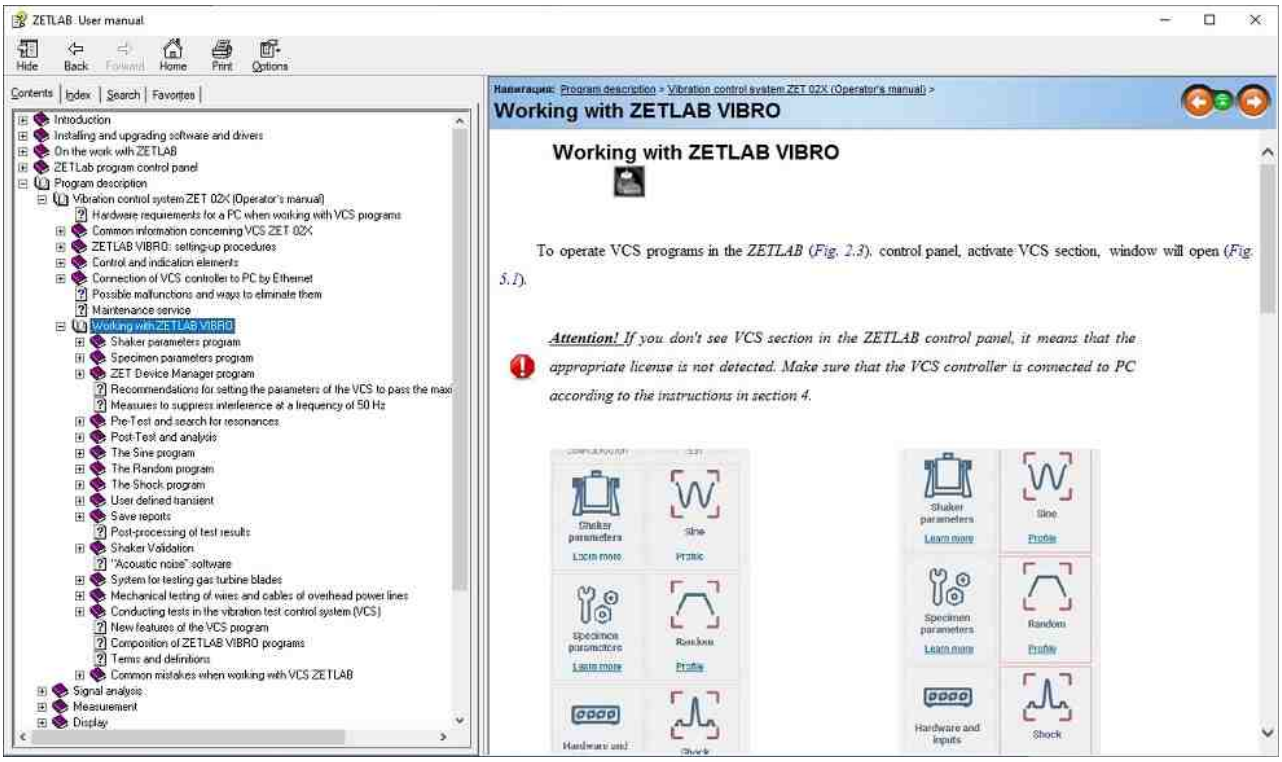


Fig. 2.3 Help information window

User directories configuration .....

User directories configuration

ZETLAB software needs several directories on the PC for proper operation. Some directories are created by the software and cannot be changed, while the other can be set by the user.

The directories containing signals, compressed signals, processing results and configuration files can be set by the user.

To assign user directories, it is necessary to create them (in the case, if they do not exist), and then set user path configuration for them.

To set user path configuration, go to "ZETLAB control panel" (Fig. 2.2), click *ZETLAB* icon, and enable the panel "User path configuration" in the window "Main menu of the control panel" (Fig. 2.4).

Fig. 2.4 Main menu of ZETLAB control panel

In the window "Adjusting configuration access" (*Fig. 2.5*), activate the panel "" for each user directory, which corresponds to the data type to be stored in them (signals, compressed signals, processing results, configuration files). In the window "Choose directory" set the required configuration path, and click "Select folder".

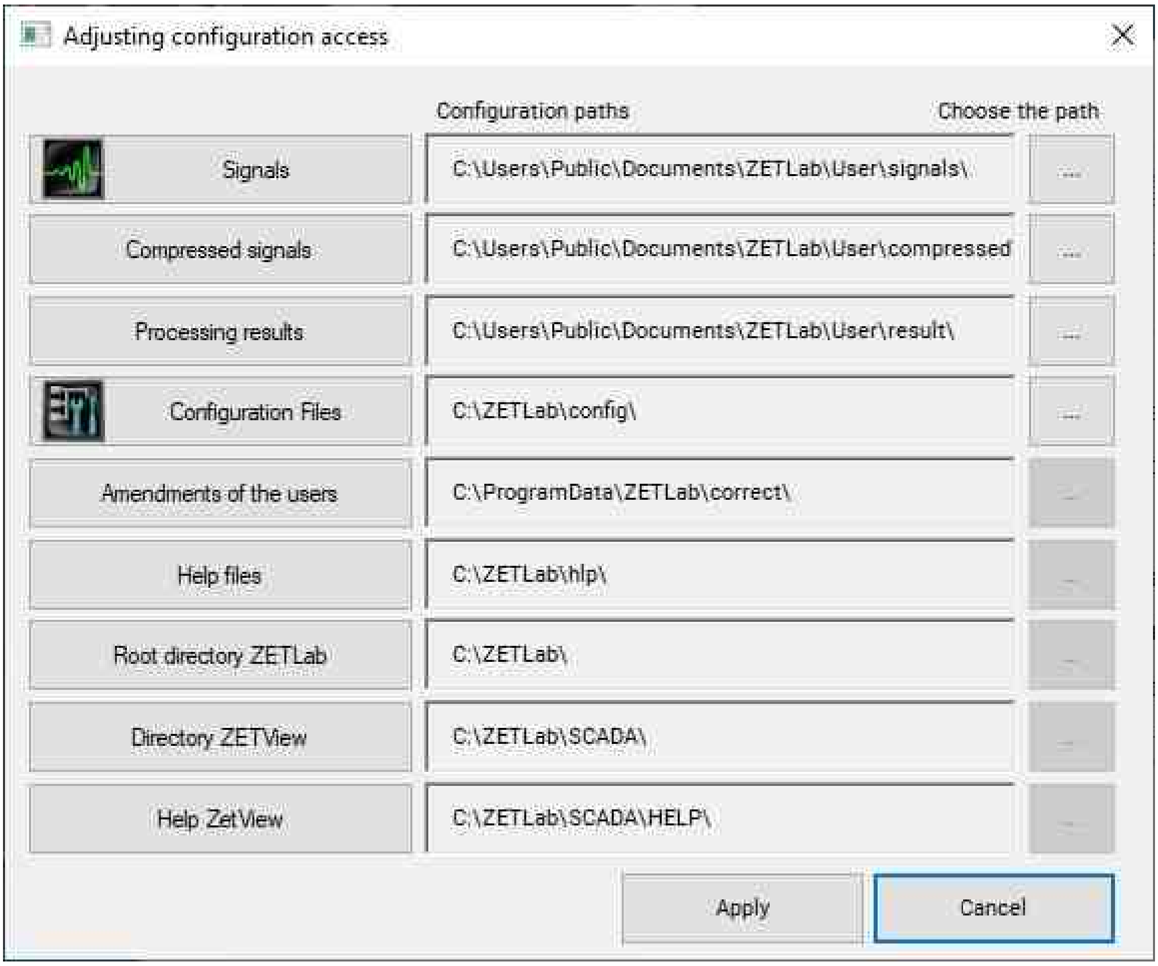


Fig. 2.5 Window "Adjusting configuration access"

Indicator "Status of the connected devices"

Indicator of the connected devices status is located in the right section of ZETLAB panel.

Depending on the results of constant diagnostics of the connected devices manufactured by LLC "ETMS", the indicator may have one of the three indication conditions:

-  Normal mode;
-  Warning;

- Error.

The *Normal mode* condition of the indicator is used in the case if the software does not detect any errors in operation of the hardware and parameters configuration of the software.

In the case, if the software detects minor errors in operation of one or several devices, or parameters configuration error, the system activates "*Warning*" indicator (or "*Error*" indicator in the case if a critical error is detected).

In order to obtain information concerning the reasons of the detected errors, activate the panel with the symbol of the connected devices parameters indicator. You will see a window containing description of the detected error type (*Fig. 2.6*).

Note! *Before you continue using ZETLAB software, you should take measures aimed at elimination of the detected error's reason.*

To obtain additional information, right-click the menu panel (*Fig. 2.7*) and click the line "Help".

In the help information window, (*Fig. 2.8*), you will see information concerning the measures required for elimination of the detected error.

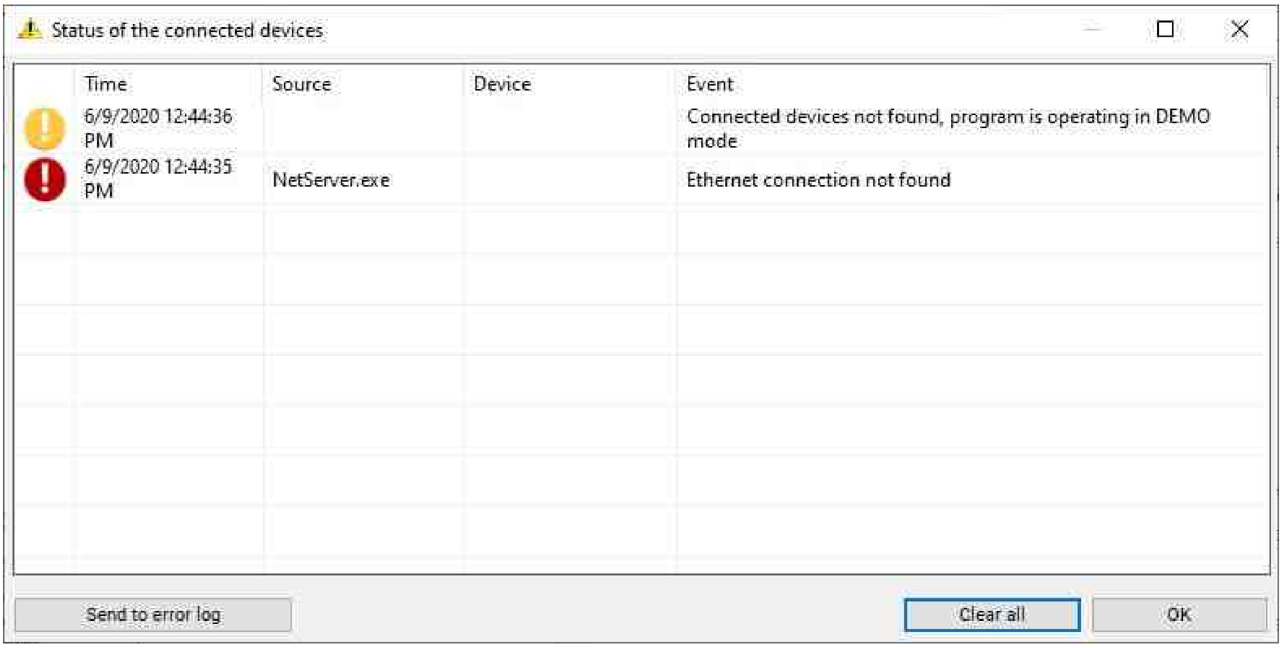


Fig. 2.6 Window "Status of the connected devices"

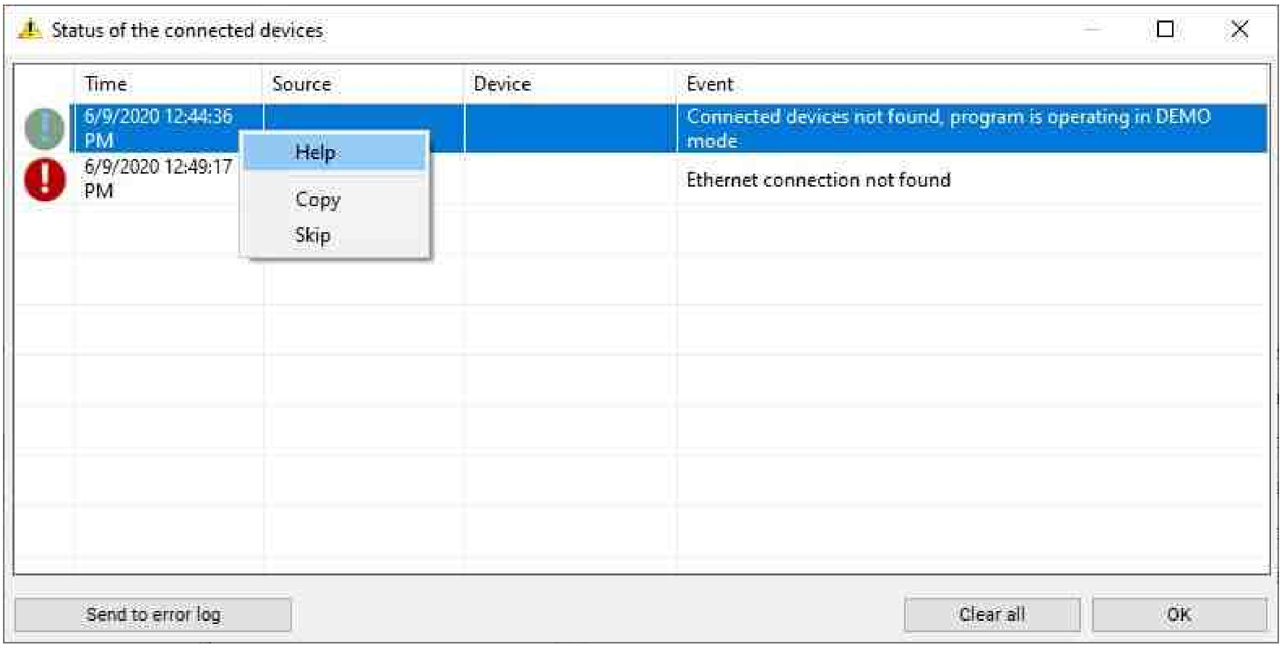


Fig. 2.7 Window "Status of the connected devices" with menu panel

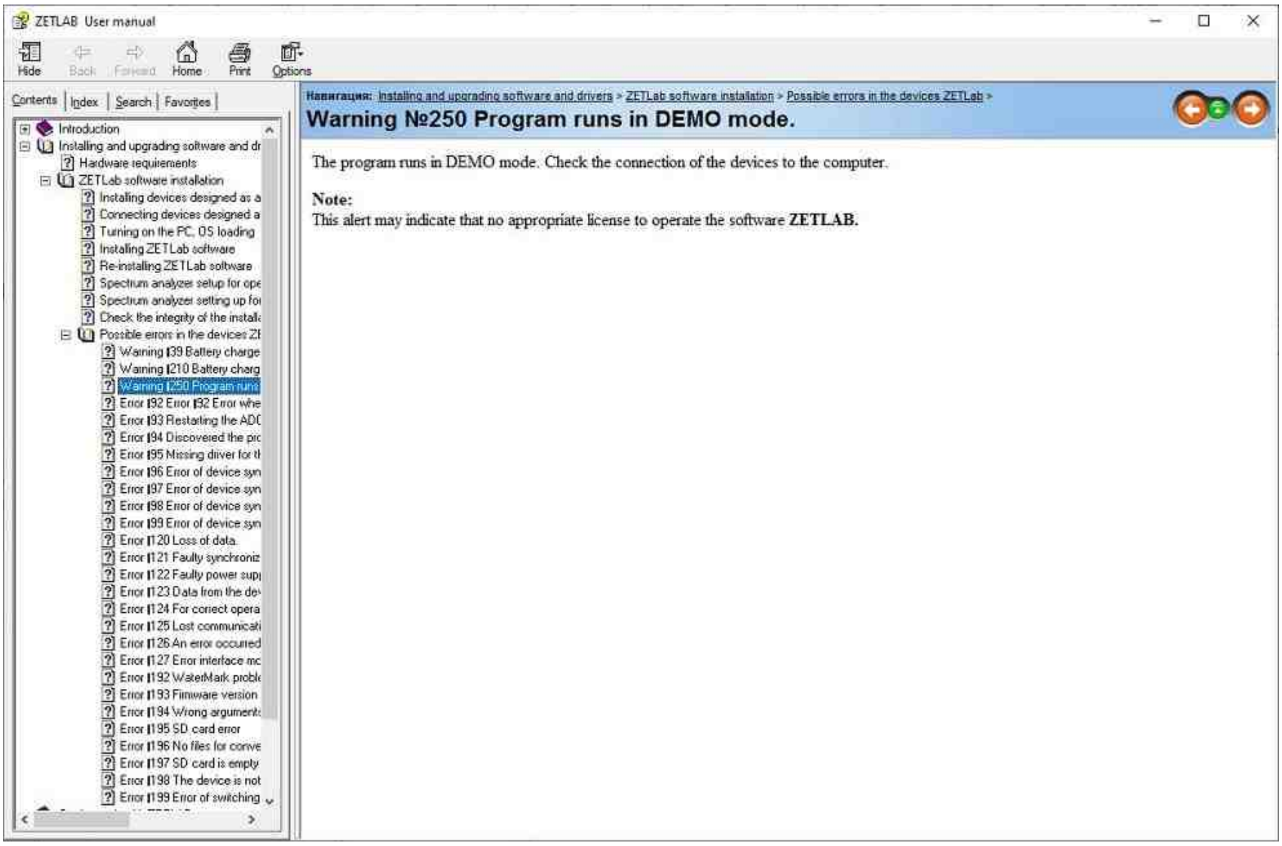


Fig. 2.8 Help information window

In the case, if the reason of the detected error was attributed to settings time or with connection of the devices, and this reason has already been eliminated, then, upon activation of the key "Clear all" in the window "Status of the connected devices" (Fig. 2.6), the indicator of the connected devices status will switch over to "*Normal mode" (*absence of errors). In the case, if the error reason has not been eliminated, the indicator of the connected devices status will display "Error" condition again.

Closing ZETLAB software programs .....

Closing ZETLAB software programs

In order to close all programs, which have been started with the use of ZETLAB control panel, go to "*Main menu of the control panel*" (*Fig. 2.4*), and click the key "*Close all programs*". *ZETLAB* panel will remain active.

Closing ZETLAB software control panel .....

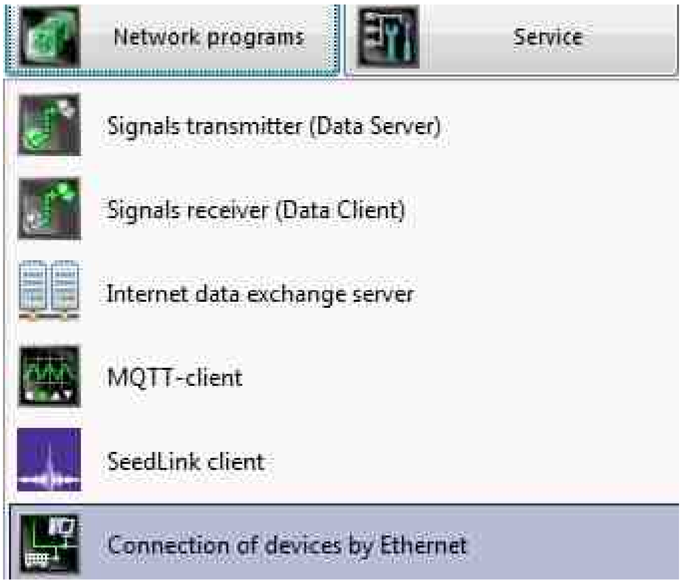
Closing ZETLAB software control panel

In order to close ZETLAB control panel, go to "*Main menu of the control panel*" (*Fig. 2.4*) and click the key "*Exit the program*". The system will close both *ZETLAB* control panel and all active *ZETLAB* programs.

Connection of VCS controller to PC by Ethernet .....

The program **Connection of devices by Ethernet** is available in the **Network programs** menu of ZETLAB software.

Note: the **ZETLab** program (default: c: \ ZETLab \). The name of the startup file: NetWizardNew or NetWizard.exe



Starting the "Connection of devices by Ethernet"

Note: The window of the "**Connection of devices by Ethernet**" program has two types: "connecting by IP addresses" and "new interface". To change the window view, you need to open a drop-down menu in the window name area and activate "Switch to a new interface" or "Connection by IP addresses" depending on the transition

Connection of controllers of the ZET 02x, ZET 03x and ZET05x series to the computer .....

1. Connection sequence

During the first connection of the VCS controller to PC, it is necessary to set Ethernet ports of the controller and PC, so that their network masks and IP-addresses would correspond to a single subnetwork. In order to do that, you can set IP-address of Ethernet port of the PC to the subnetwork of the VCS controller port, or vice versa.

Note: *You can check IP-address of the VCS controller using the instructions specified in section 4.1.3.*

Attention! *The connection of the computer to the controllers involved in working with the UH must be organized in an isolated local network via physical wired cable connections*

(UTP twisted pair). The use of wireless connections (using WiFi, WiMAX, etc.) is not allowed.

In the case, if you need to set the IP-address of Ethernet port of the PC to the subnetwork of the VCS controller, follow the instructions specified in section 4.1.4.

In the case, if you need to set the IP-address of VCS controller Ethernet port to the subnetwork of the PC, follow the instructions specified in section 4.1.5. to Reset. the initial IP-address of the PC to the subnetwork of the VCS controller, then follow the instructions specified in section 4.5 to Reset. the IP-address of VCS controller to the initial subnetwork of the PC, then restore the value of the PC port IP-address to the initial one.

When the IP-addresses of Ethernet ports of PC and VCS controller are located in the same subnetwork, activate Ethernet channel of the VCS controller. After that the VCS controller will be ready for use.

Note: *If you use several VCS controllers, it is necessary to use Ethernet switch to have the required number of Ethernet ports for connection. The connected ports of VCS controller and PC should belong to the same subnetwork, and there should be no identical IP-addresses.*

2. Factory setting of the IP address

The factory setting for the controller is the IP address - 192.168.0.100 with a subnet mask of 255.255.255.0.

Pressing and holding the "Reset" button on the back of the controller for at least 10 seconds will reset the IP address of the controller to the factory setting.

3. Checking the IP address of the controller

To check the IP address of the controller on the ZETLAB panel in the "Network programs" menu, activate the "Connecting devices via Ethernet" program and the program window will open (*Fig. 4.1*).

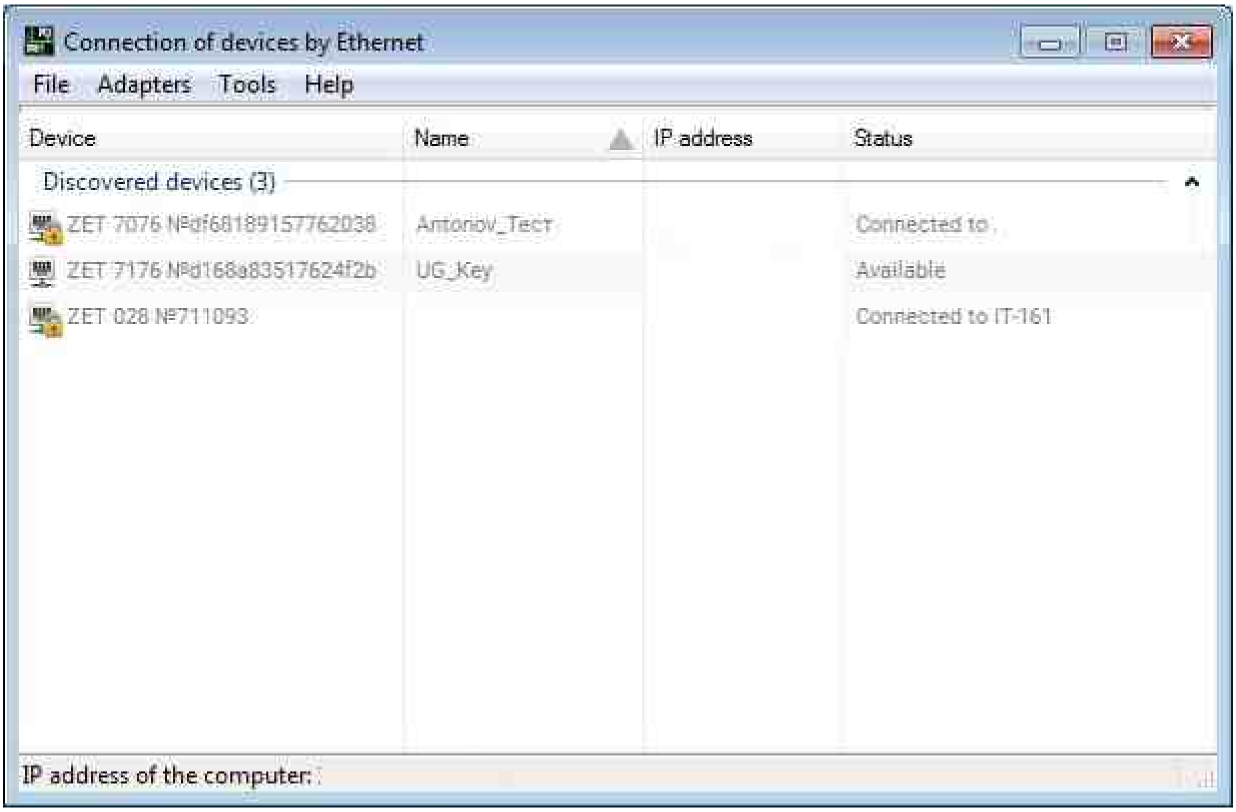


Fig. 4.1 The "Connecting devices via Ethernet" window

If there are several network adapters in the computer to which the controller is connected, then through the "Adapters" menu you can select a specific network adapter to which the controller is connected (*Fig 4.2*).

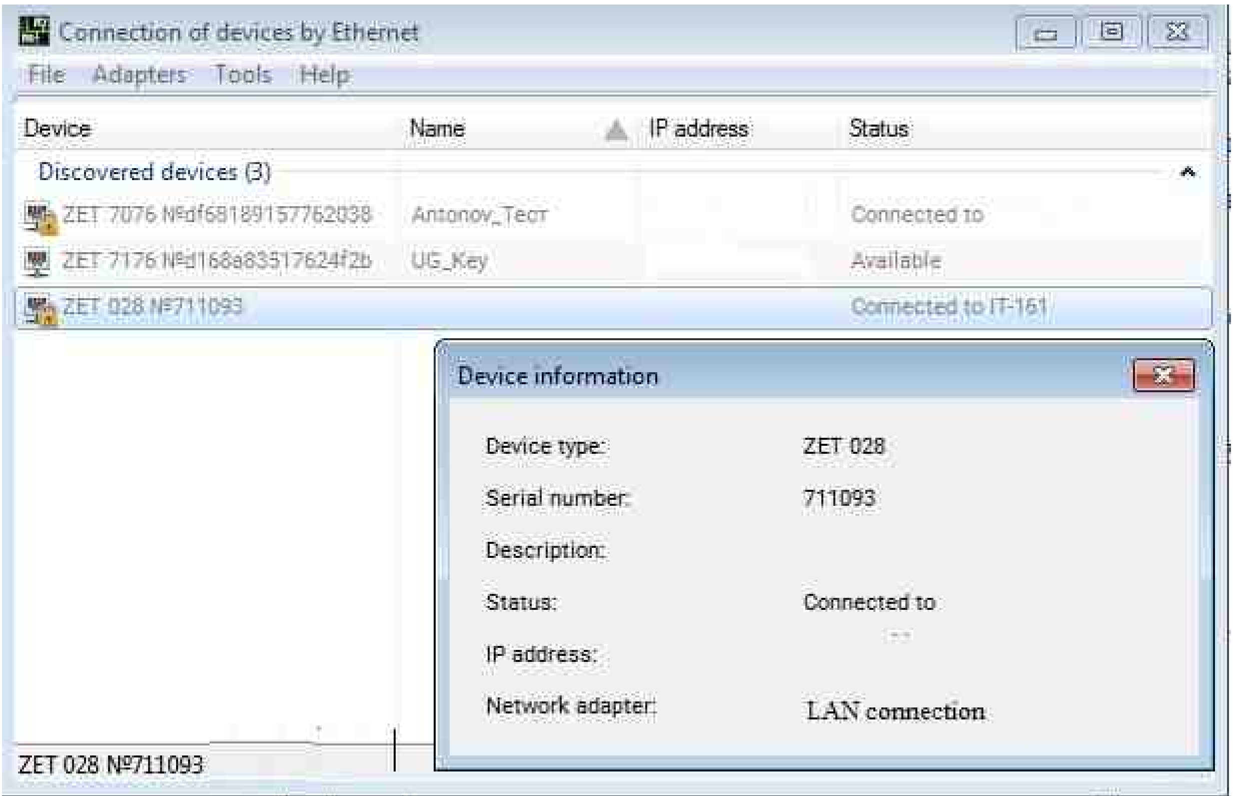


Fig. 4.2 Viewing the IP address of the controller

4. Setting the IP address of the controller

To view the current IP address of the controller, hover the mouse cursor over the name of the controller and read the value of the IP address of the controller (*Fig. 4.3*).

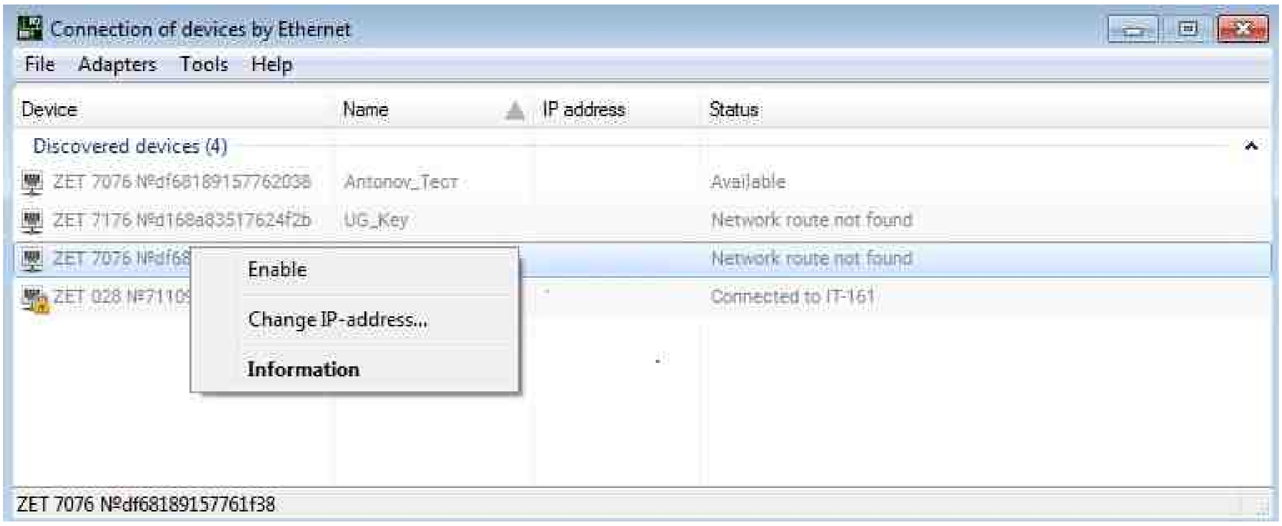


Fig. 4.3 Viewing the IP address of the controller

In the "Change IP address" window that opens, in the "New IP address" line, set the new network address and subnet mask of the controller, and then activate the "Ok" button (*Fig. 4.4*).

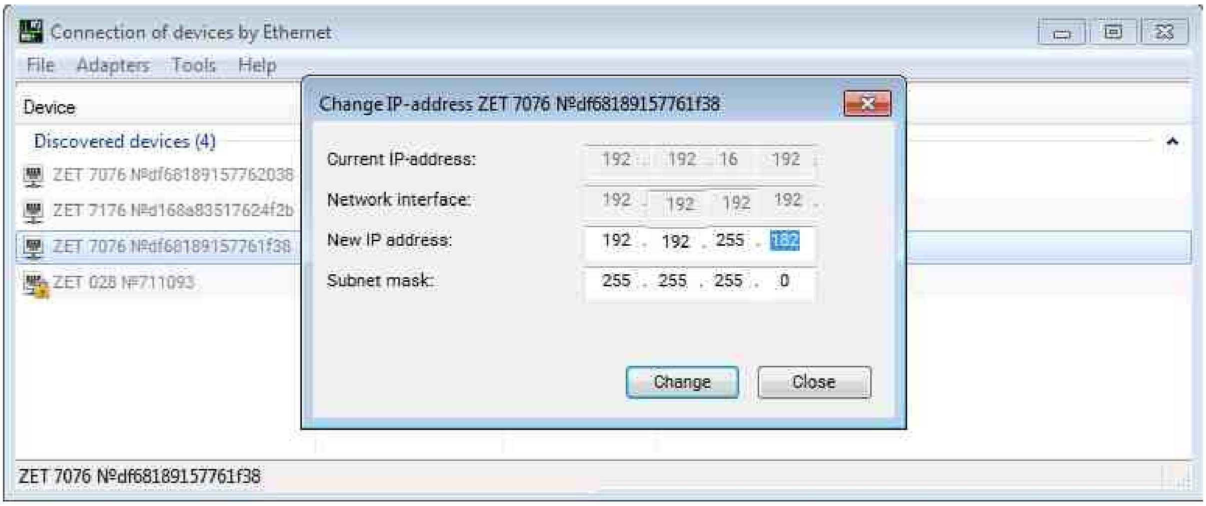


Fig. 4.4 Change IP address

5. Setting the IP address of the controller

To set the IP address of the Ethernet port of the computer, open the "Network Connections" window from the Windows operating system programs and double-click the icon corresponding to the

Ethernet network port set on the computer, and the "Status-Ethernet" window opens (*Fig. 4.5*) the selected port.

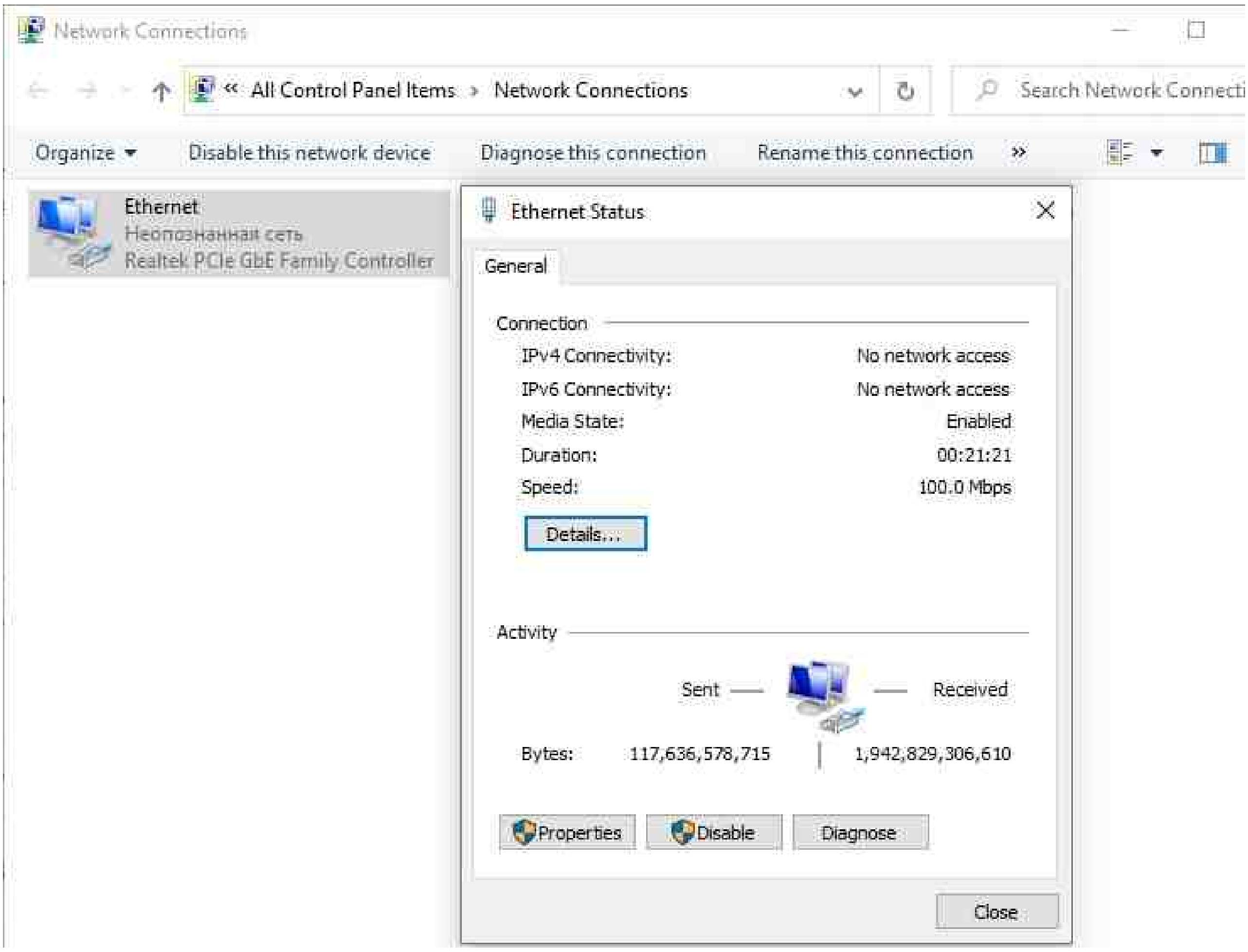


Fig. 4.5 The "Ethernet Status" window

In the "Status-Ethernet" window, activate the "Properties" panel and in the "Ethernet Properties" window that opens (Fig. 4.6), "highlighting" the line "IP version 4(TCP/IPv4)" (as shown in the Fig.) activate the "Properties" panel.

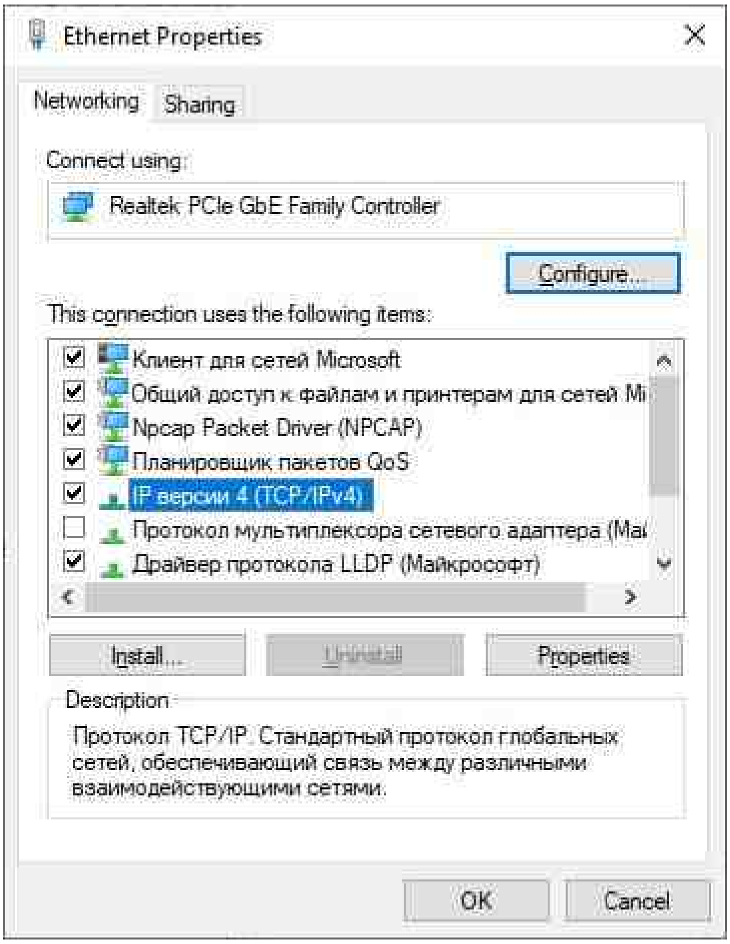


Fig. 4.6 Window "Properties"

In the "Status-Ethernet" window, activate the "Properties" panel and in the "Ethernet Properties" window that opens(*Fig. 4.7*) , "highlighting" the line "IP version 4(TCP/IPv4)" (as shown in the Fig. 4.7) activate the "Properties" panel.

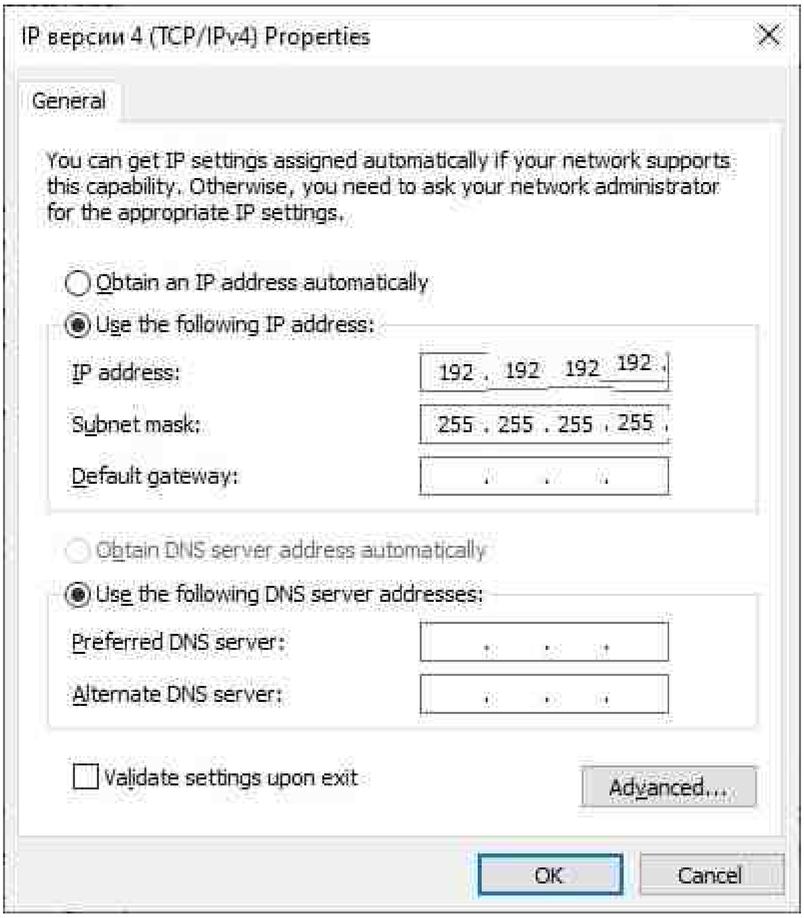


Fig. 4.7 "Properties" window: IP version 4 (TCP/IPv4)"

Note: *Controllers use the mask "255.255.255.0" by default, which defines a class C subnet (in the example, the network address is 192.168.0.xxx, where xxx is the IP addresses of nodes in the range from 1 to 254 (in this example, the controller port 100 and the computer port 29).*

6. Activating an Ethernet connection

To activate an Ethernet connection, it is necessary that the IP addresses of the Ethernet ports of the controller and the computer belong to a single subnet. If necessary, Reset the IP address of the controller or computer port, according to the sections 4.1.4 or 4.1.5.

To connect the controller to the computer, in the "Connecting devices via Ethernet" program, right-click on the name of the controller to open the context menu and select the "Activate" function (*Fig. 4.8*).

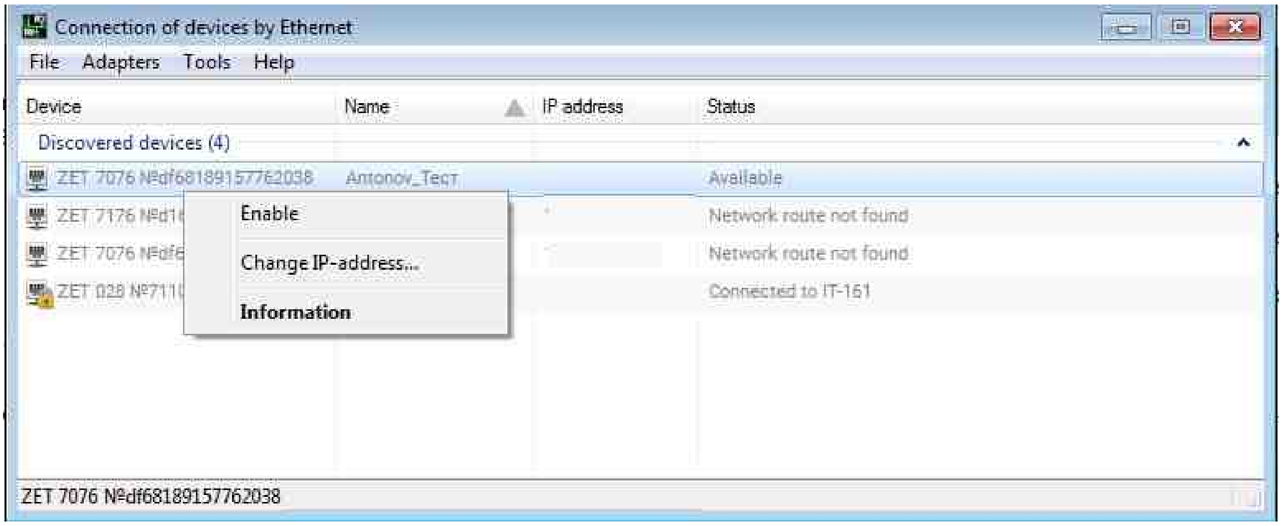


Fig 4.8 Activating the controller

In the "Connecting devices via Ethernet" window, make sure that the status of the involved controller has changed to "Device connected" (*Fig. 4.9*).

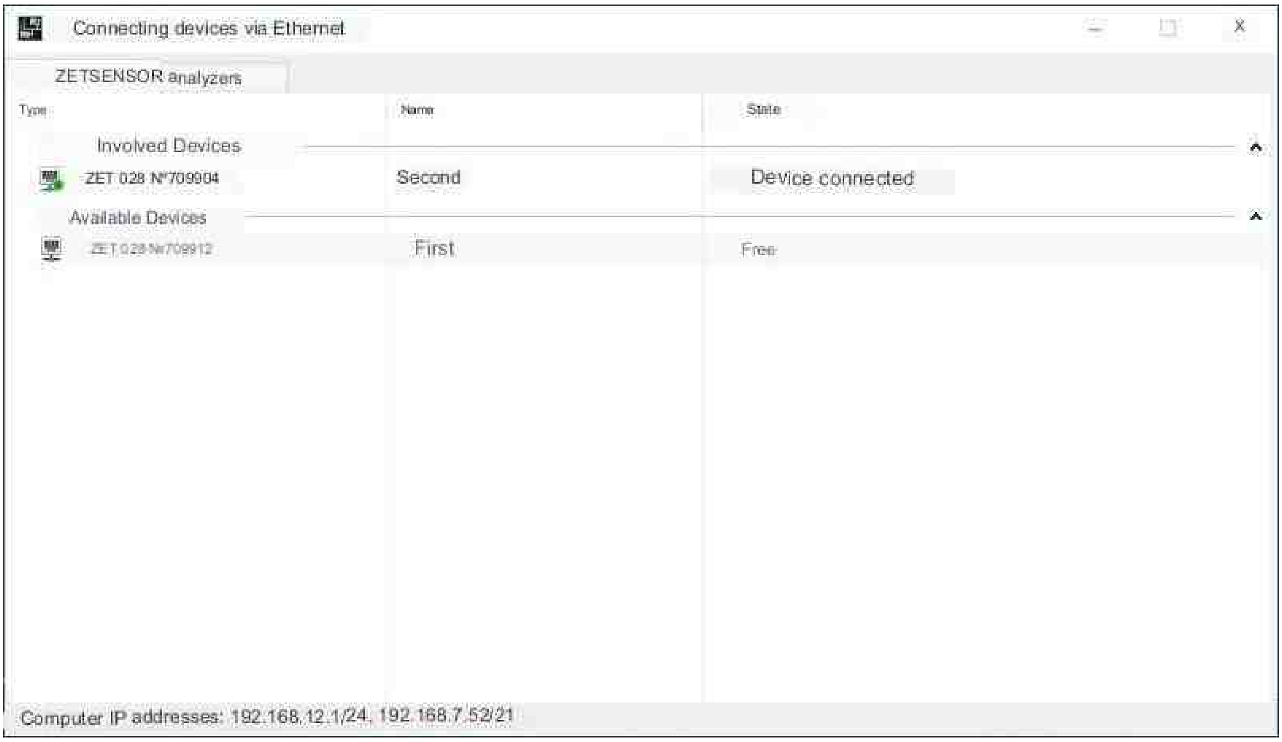


Fig. 4.9 The "Device is connected" status

Connection of ZET 017 series controllers .....

1. Connection sequence

During the first connection of the VCS controller to PC, it is necessary to set Ethernet ports of the controller and PC, so that their network masks and IP-addresses would correspond to a single

subnetwork. In order to do that, you can set IP-address of Ethernet port of the PC to the subnetwork of the VCS controller port, or vice versa.

Note: *You can check IP-address of the VCS controller using the instructions specified in section* *4.1.3*.

Attention! *The connection of the computer to the controllers involved in working with the UH must be organized in an isolated local network via physical wired cable connections (UTP twisted pair). The use of wireless connections (using WiFi, WiMAX, etc.) is not allowed.*

In the case, if you need to set the IP-address of Ethernet port of the PC to the subnetwork of the VCS controller, follow the instructions specified in section 4.4.

In the case, if you need to set the IP-address of VCS controller Ethernet port to the subnetwork of the PC, follow the instructions specified in section 4.4 to Reset. the initial IP-address of the PC to the subnetwork of the VCS controller, then follow the instructions specified in section 4.5 to Reset. the IP-address of VCS controller to the initial subnetwork of the PC, then restore the value of the PC port IP-address to the initial one.

When the IP-addresses of Ethernet ports of PC and VCS controller are located in the same subnetwork, activate Ethernet channel of the VCS controller. After that the VCS controller will be ready for use.

Note: *If you use several VCS controllers, it is necessary to use Ethernet switch to have the required number of Ethernet ports for connection. The connected ports of VCS controller and PC should belong to the same subnetwork, and there should be no identical IP-addresses.*

2. *Factory setting of the IP address*

The factory setting for the controller is the IP address - 192.168.0.100 with a subnet mask of 255.255.255.0.

Pressing and holding the "Reset" button on the back of the controller for at least 10 seconds will reset the IP address of the controller to the factory setting.

3. *Checking the IP address of the controller*

To check (clarify) the IP address installed in the VCS controller, it is not required that the IP addresses of the Ethernet ports of the VCS controller and the computer belong to a single subnet.

To check the IP address of the VCS controller on the ZETLAB panel in the "Network programs" menu, activate the "Connecting devices via Ethernet" program and the program window will open (*Fig. 4.10*).

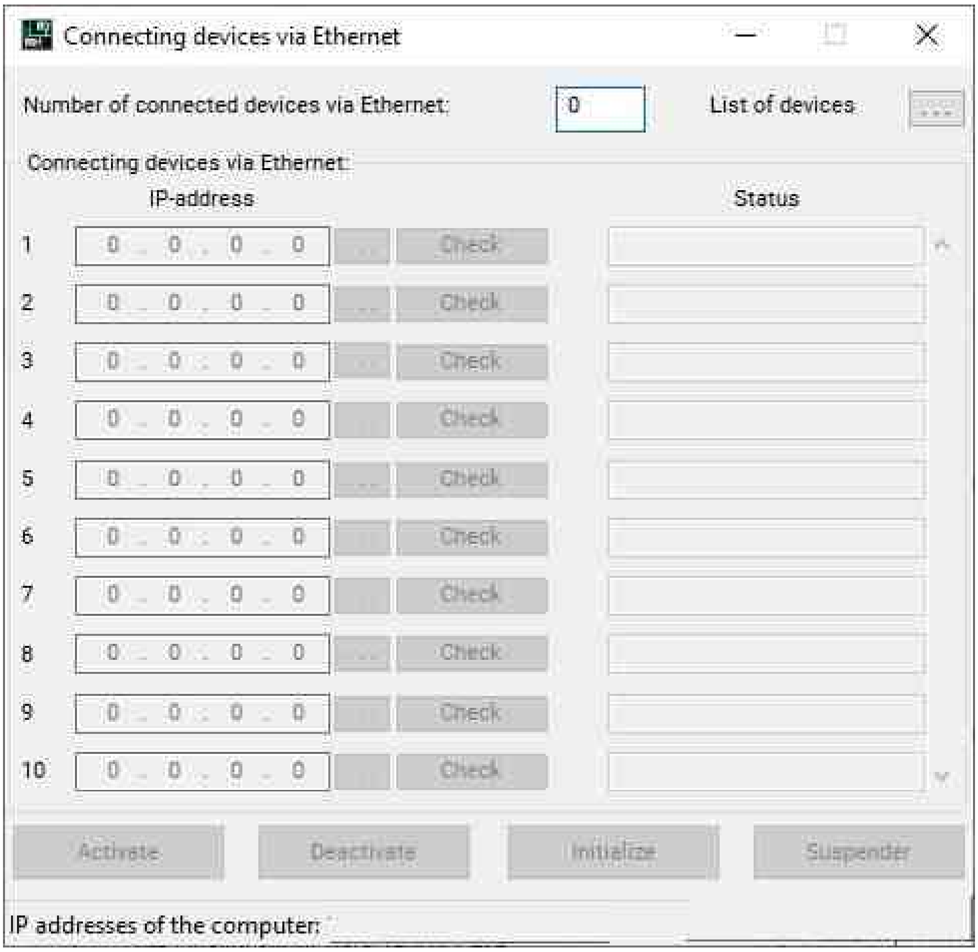


Fig. 4.10 " Connecting devices via Ethernet "

Click the key "⋯" (List of devices). In the window "List of available devices" (*Fig. 4.2*), you will see the IP-address of the VCS controller.

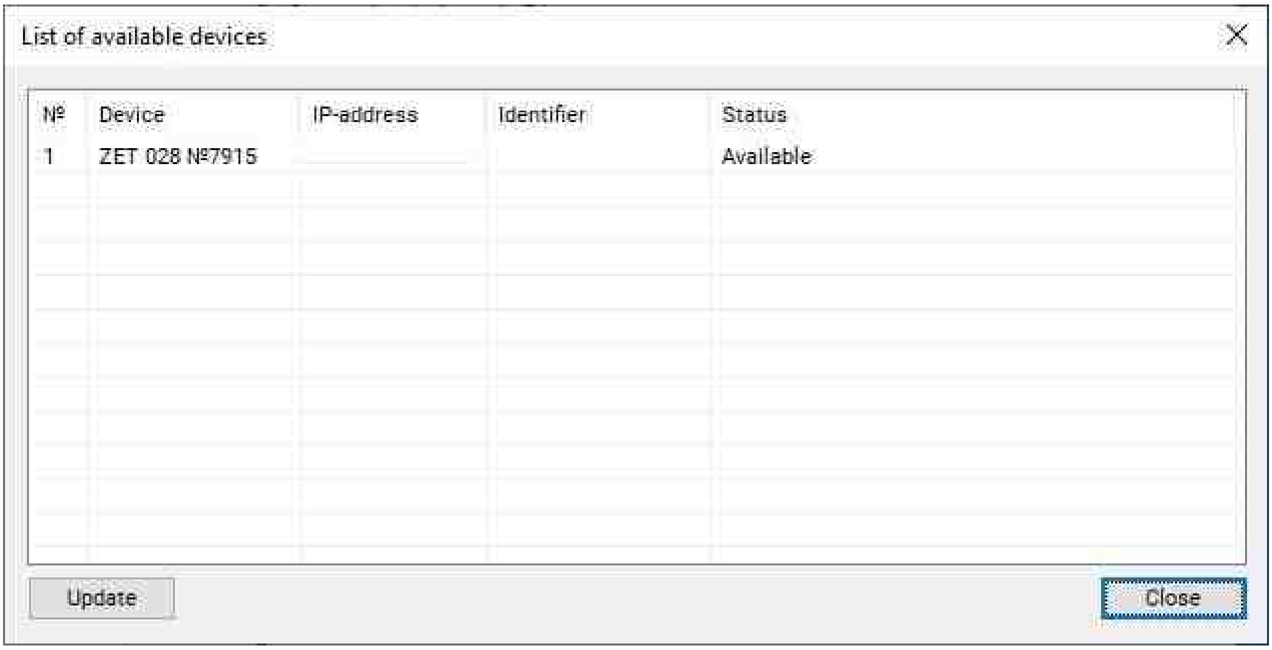


Fig. 4.11 "List of available devices"

4. Setting the IP address of the controller

In order to set the IP-address of the PC port, go to "Network connections" (Fig. 4.12) and double-click the icon corresponding to the relevant Ethernet port. You will see the window "Ethernet Status" (Fig. 4.12) of the selected port.

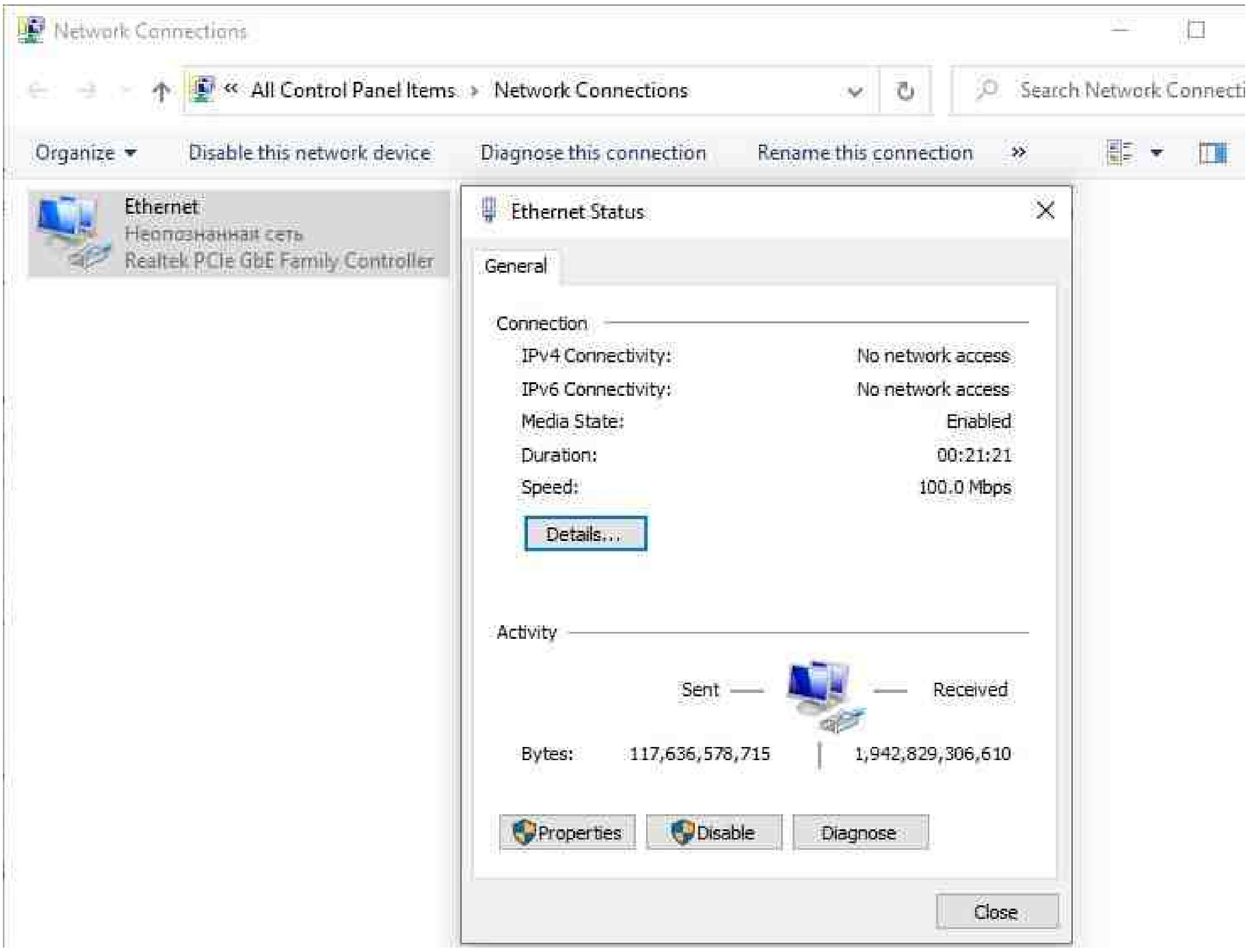


Fig. 4.12 "Status - Ethernet"

In the window " Ethernet Status " activate the panel *"Properties"*. In the window "Ethernet Properties" (Fig. *4.13*) select the line "IP version 4(TCP/IPv4)" (as it is shown in the Fig. 4.13) and click the panel "Properties".

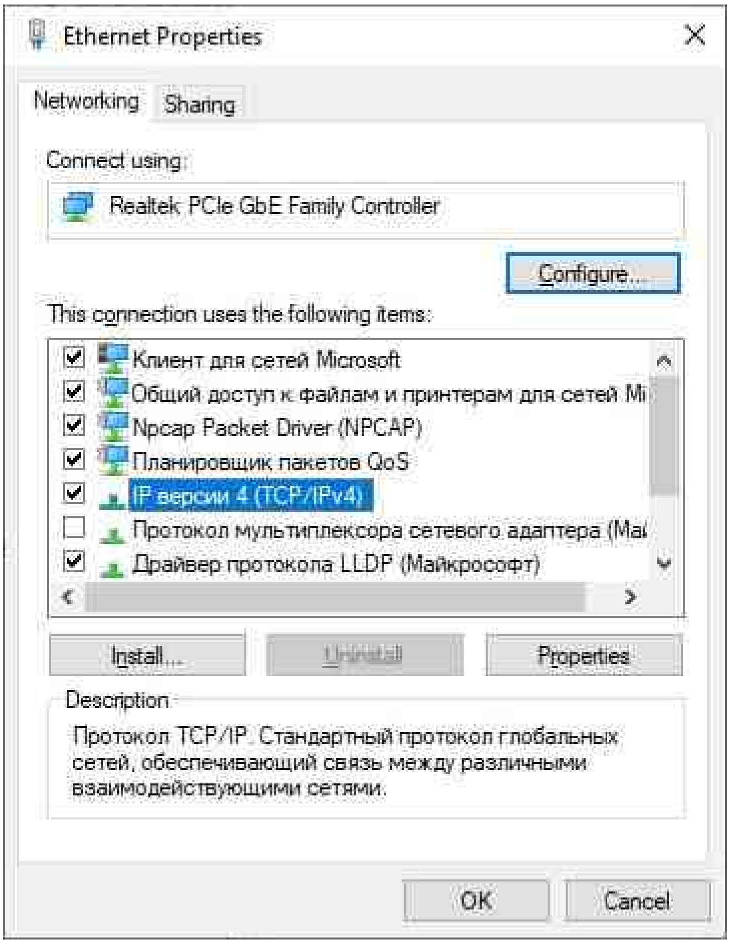


Fig. 4.13 "Properties"

In the window "IP version 4 (TCP/IPv4) Properties" assign IP-address and mask of Ethernet port of the PC (*Fig. 4.14*).

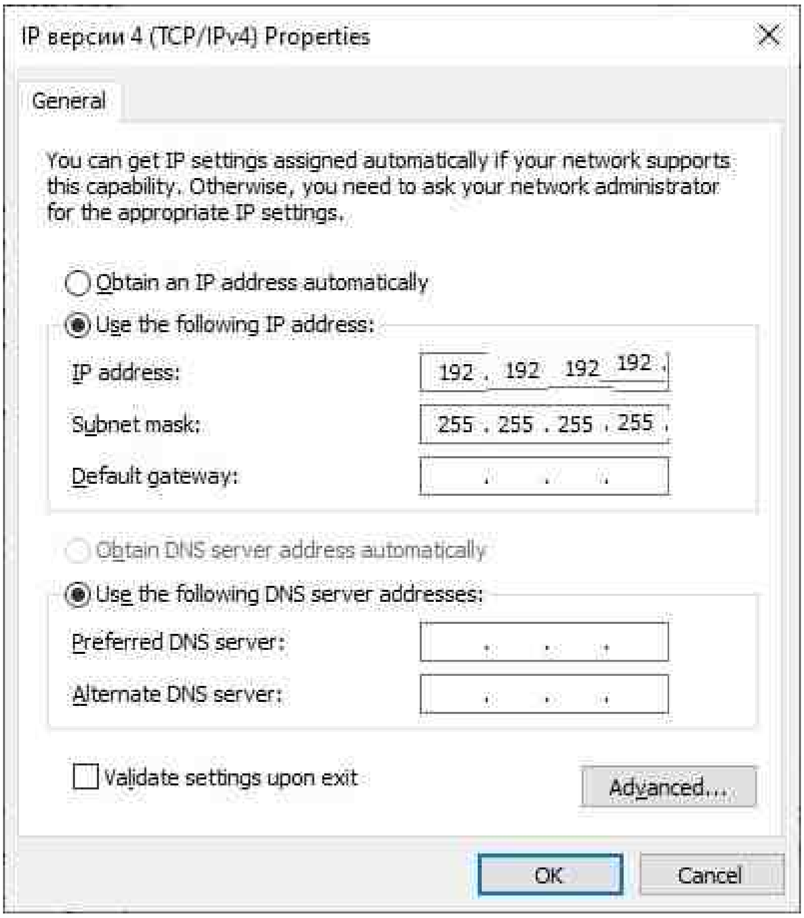


Fig. 4.14 "Properties: IP version 4 (TCP/IPv4)"

Note: *by default, VCS controllers use the mask "255.255.255.0", that corresponds to the sub-net of C-class (in this example, the IP-address is 192.168.12.xxx, where xxx stand for IP-addresses in the range from 1 up to 254 (in this example: 108 for controller port, and 10 for the PC port).*

5. Setting up the IP address of the controller

In order to set IP-address of the VCS controller, enable Ethernet channel of the VCS controller following the instructions specified in section 4.6.

As the connection to the VCS controller is established, enable the program, "**ZET Device Manager**" in the "Service" section of ZETLAB panel (*Fig. 4.15*)

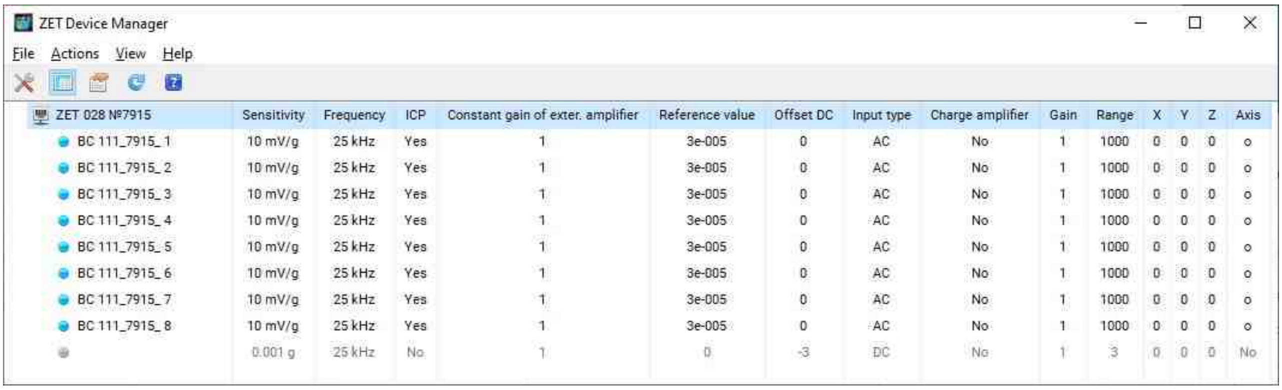


Fig. 4.15 "ZET Device Manager"

In the window of the program "ZET Device Manager" double-click the icon of the VCS controller. In the "Properties" window (*Fig. 4.16*) set the required IP-address and mask of VCS controller subnet (in this example: IP-address 192.168.12.108, mask 255.255.255.0).

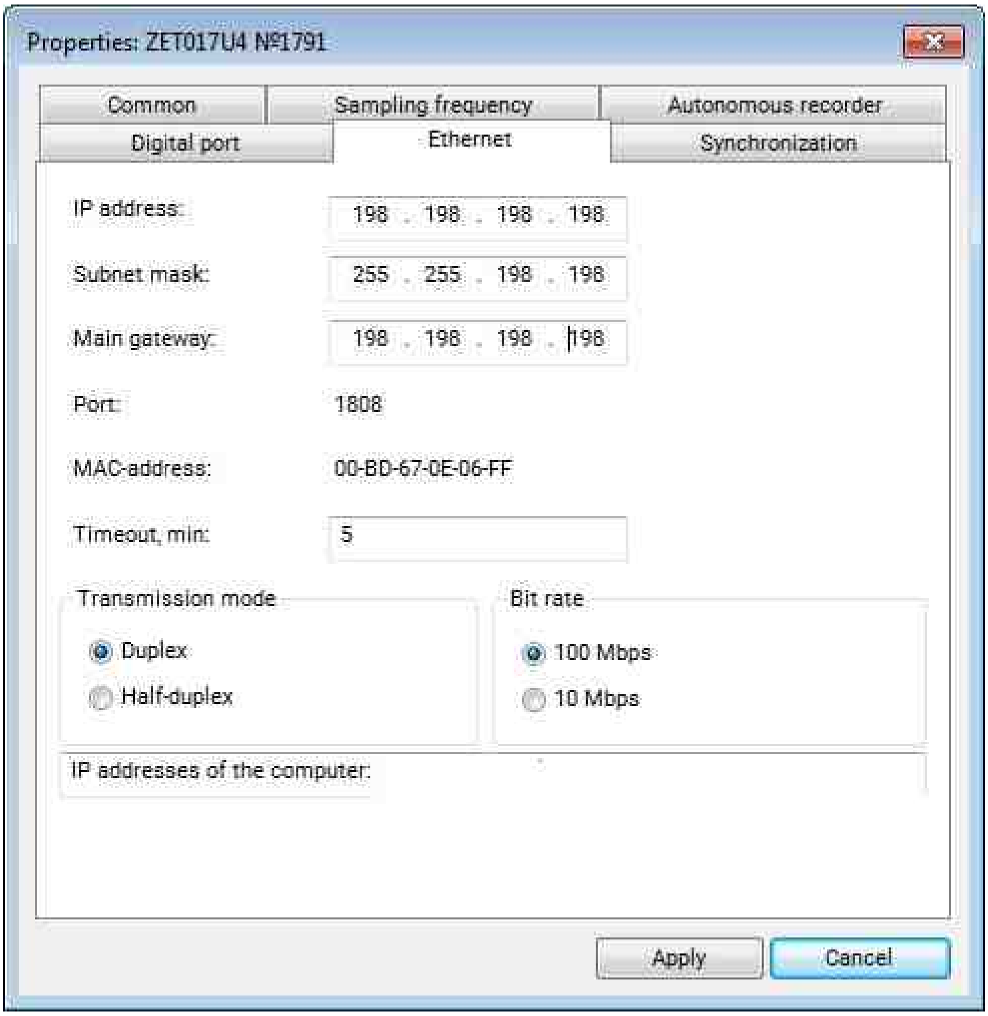


Fig. 4.16 "Ethernet" tab of the window "ZET properties"

Note! *As the IP-address of the controller is changed, its Ethernet channel will be disabled. For further activation, Reset. the IP-address of the PC following the instructions specified in section 4.4, so that it would correspond to the sub-net containing the IP-address of the VCS controller, then activate the Ethernet channel following the instructions specified in section 4.6*

6. Activation of VCS controller Ethernet channel

In order to activate Ethernet channel of VCS controller, make sure, that IP-addresses of VCS controller Ethernet ports and PC belong to the same subnetwork. If necessary, follow the instructions specified in section 4.2.4 to Reset. IP-address of PC Ethernet port to VCS controller subnetwork.

To enable Ethernet channel of VCS controller, go to "Network programs" of ZETLAB panel, and start the program "Connecting devices via Ethernet" (Fig. 4.17).

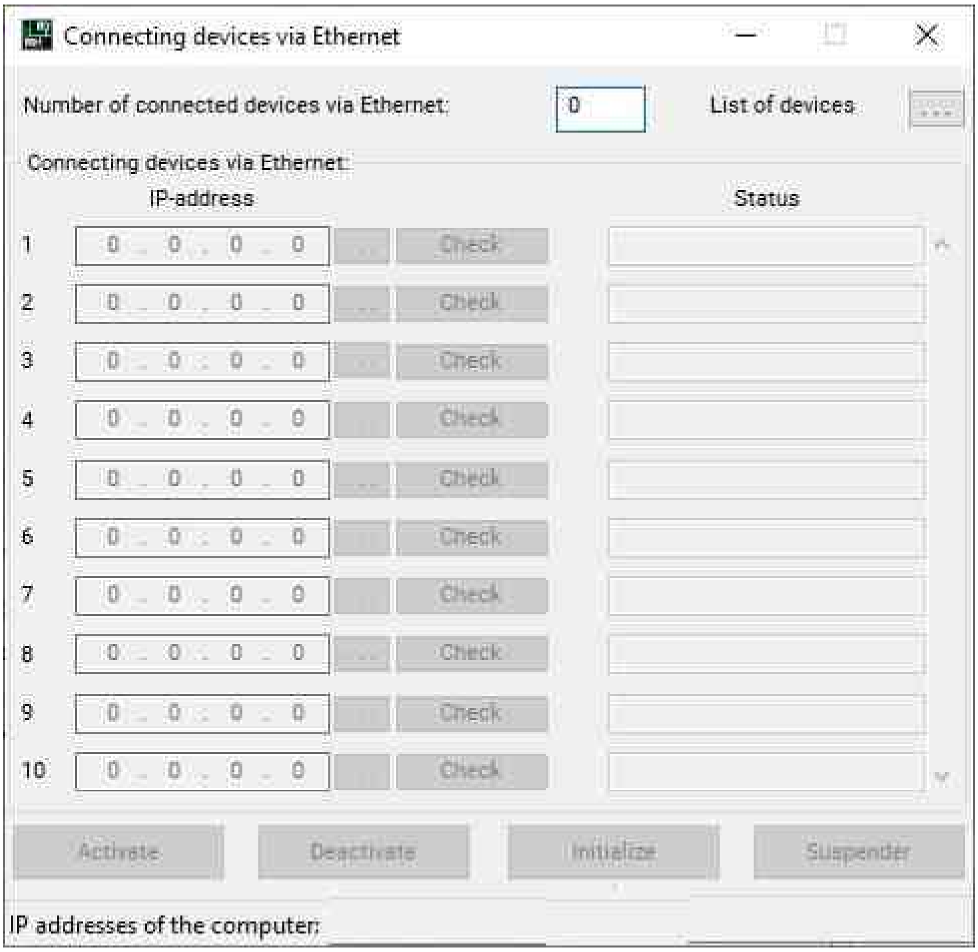


Fig. 4.17 "Connecting devices via Ethernet"

In the field "Number of connected devices via Ethernet" set the value equal to the number of VCS controllers used for vibration testing performance (in this example- "1"). As a result, you will be able to edit the first line of the IP-addresses list (*Fig. 4.18*).

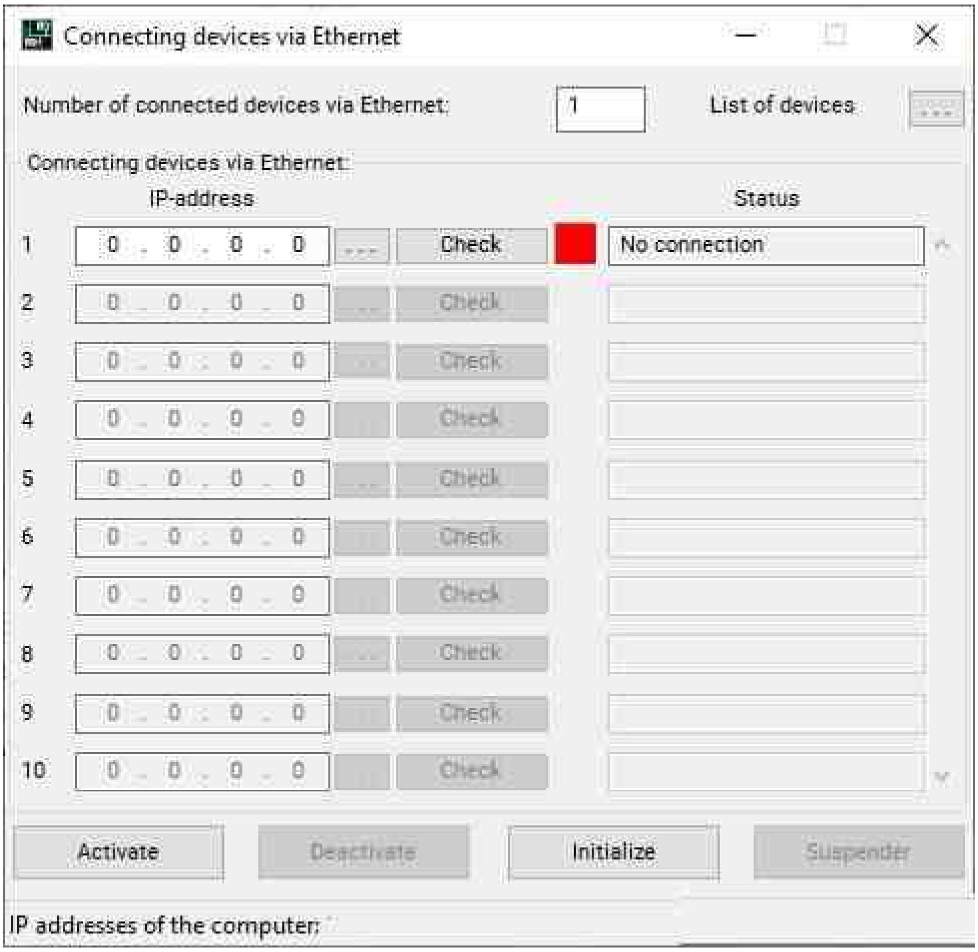


Fig. 4.18 "Connecting devices via Ethernet"

Enter the IP-address of the VCS controller to be activated (in this example - 192.192.192.192) (*Fig. 4.19*). If necessary, check the IP-address of VCS controller following the instructions specified in section 4.3.2

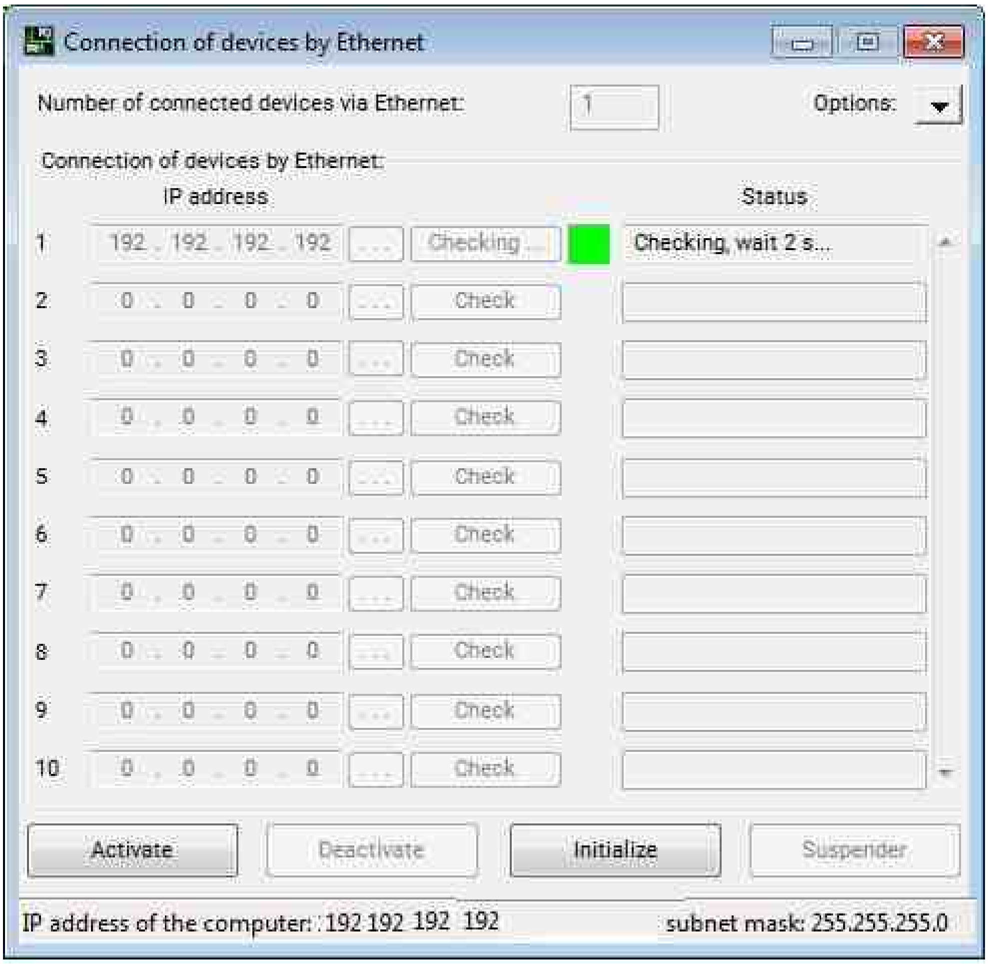


Fig. 4.19 "Connecting devices via Ethernet"

Click the key "Activate". If the VCS controller is successfully connected to the PC, its status in the program "Connecting devices via Ethernet" will change for "Connected" (*Fig. 4.20*).

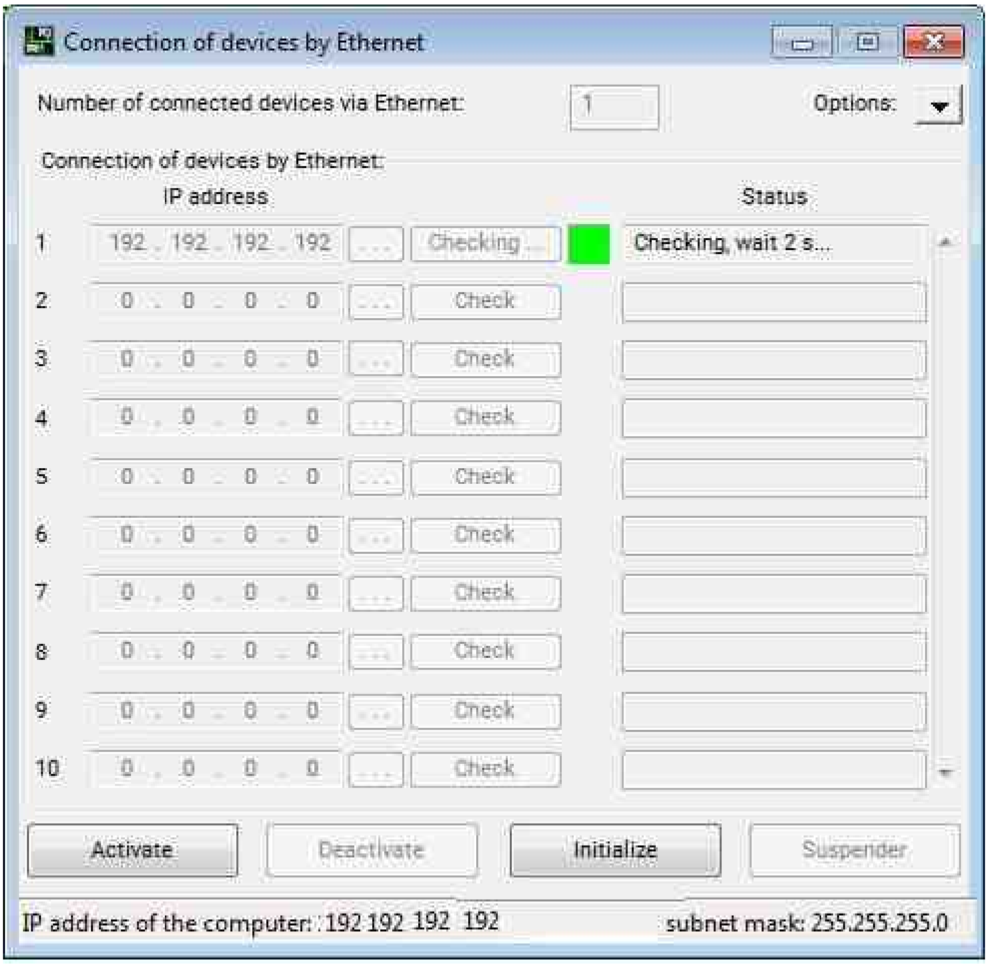


Fig. 4.20 "Connecting devices via Ethernet"

Possible malfunctions and ways to eliminate them .....

When working with the operating system or ZETLAB software, failures may occur, information about which the operating

system or ZETLAB displays on the monitor screen. Such failures are eliminated by the user himself in accordance with the instructions that

are displayed on the monitor screen (see section 2.9).

If, when all actions are performed correctly by the user, the error message continues to appear, you should reinstall

the operating system or ZETLAB software using licensed copies and repeat all previous operations again.

In case of failure of the device, during the warranty period, a complaint should be submitted to the supplier.

The procedure for submitting a complaint to the supplier is carried out in the following cases:

- Termination of the execution of programs specified in the order form or user programs specified in the contract for the supply of the controller;
- Incorrect termination of programs resulting in loss or distortion of data not related to incorrect actions of the operator;
- The presence of systematic failures.

Note: *The criterion for a controller failure is the manifestation of signs of failure, in which repeated actions to solve the test or task are required for further use for their intended purpose.*

Maintenance service .....

The controller does not require special maintenance.

The operation check is carried out automatically every time the controller is turned on.

Before performing work to maintain the normal technical condition of the controller, it is necessary:

Turn off the power supply of the controller and composite devices.

Disconnect all power supply cables of the controller from the mains.

The following daily activities are recommended to maintain the normal technical condition of the controller:

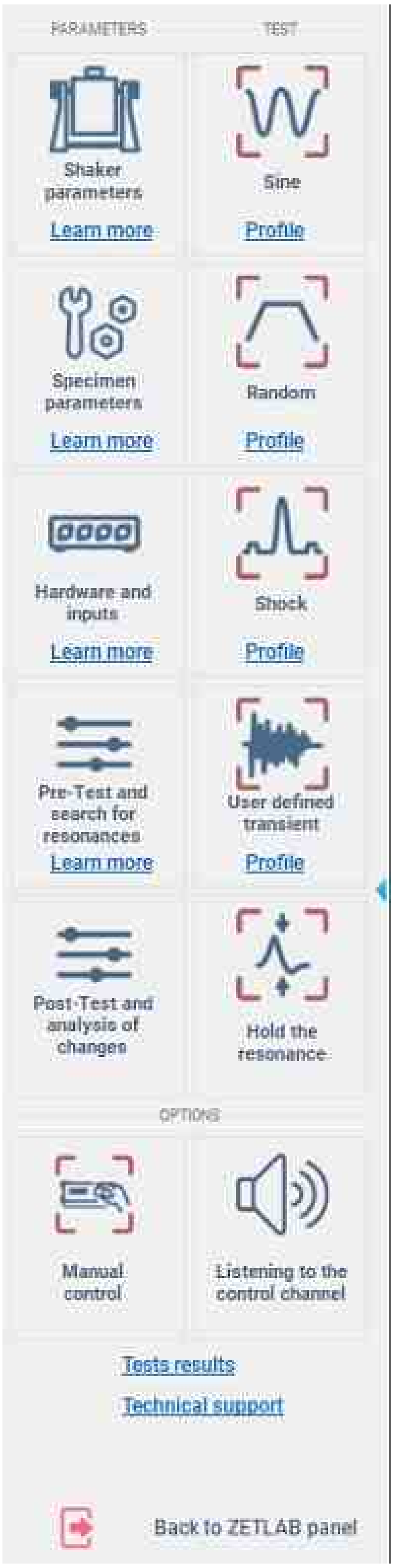
- Visual inspection of the controller in order to detect mechanical damage to the housings or casings;
- Checking the condition of connectors and cables;
- Remove dust from the controller surfaces with a soft, damp cloth.

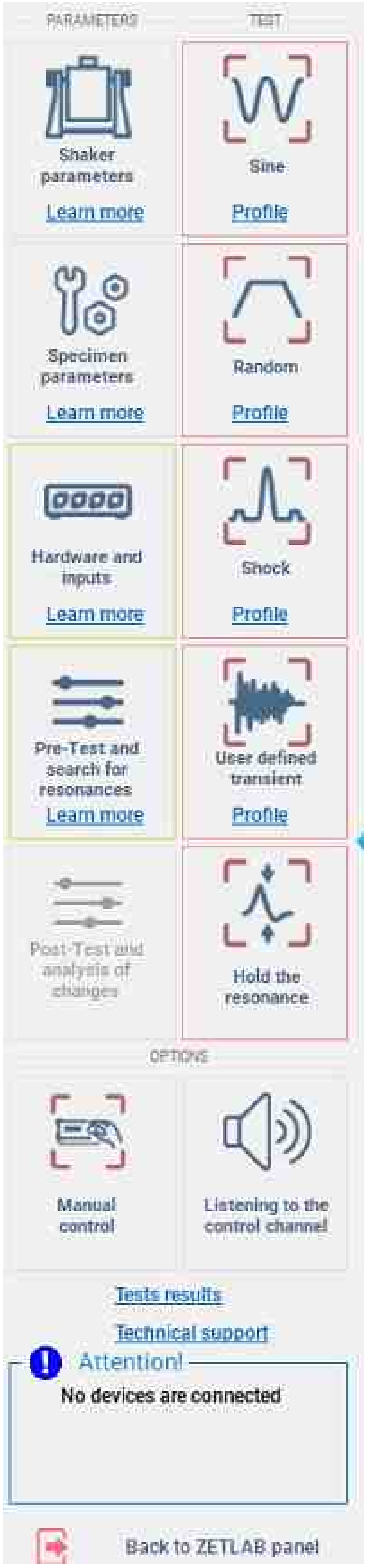
Working with ZETLAB VIBRO .....

Working with ZETLAB VIBRO

To operate VCS programs in the *ZETLAB* (*Fig. 2.3*). control panel, activate VCS section, window will open (*Fig. 5.1*).

Attention! *If you don't see VCS section in the ZETLAB control panel, it means that the appropriate license is not detected. Make sure that the VCS controller is connected to PC according to the instructions in section 4.*





(Standard view) *(In "Demo mode")*

Fig. 5.1 VCS panel

Fig. 4.16 ZETLAB Technical support

***Note**: When you open the VCS control panel, the ZETLAB control panel window will be minimized. If you need to go back to the ZETLAB main panel, press the Back to ZETLAB panel button on the VCS panel.*

On the left side of the VCS panel are grouped the programs necessary to set the system parameters, and on the right – the test programs.

Activation of the VCS panel buttons determines the opening of the corresponding program window.

The "Details" areas are used to open windows with information about the set parameters, and the "Profile" areas are used to navigate to the corresponding "Profile Editing" windows.

The absence of a VCS controller excludes the possibility of testing, but does not limit the ability to create and edit profiles.

If there is no VCS controller on the ZETLAB control panel, the VCS section will be missing, so the VCS panel is launched from the Generators section (*Fig. 4.2*).

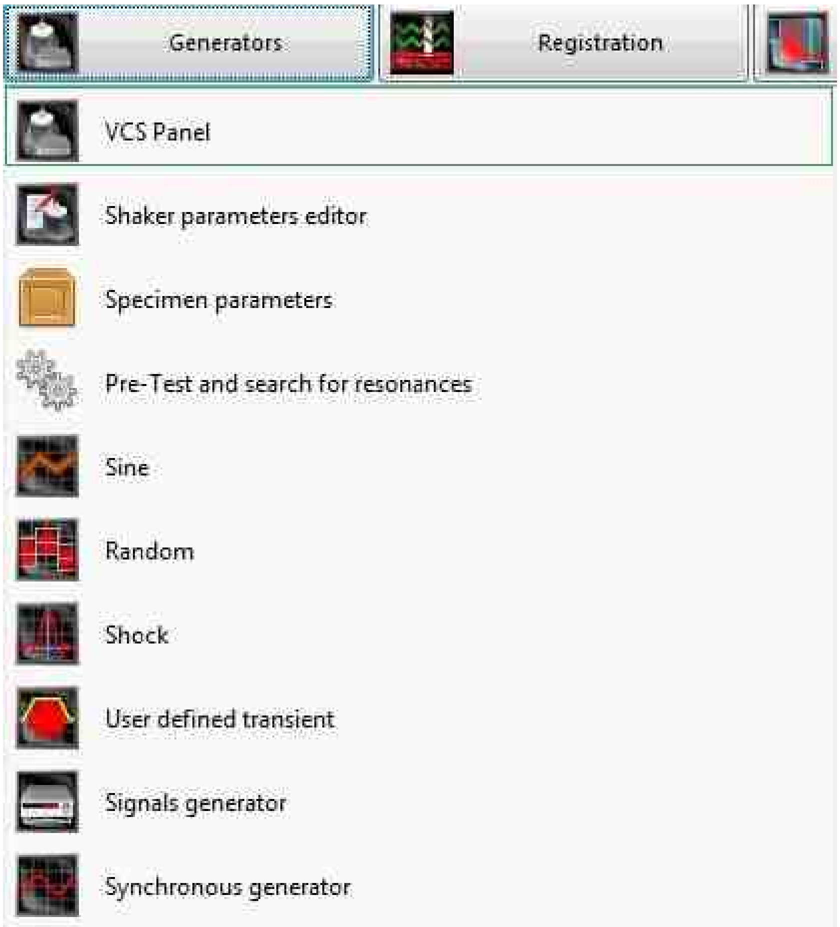


Fig. 4.2 The "Generators" section of the ZETLAB control panel

The VCS panel (*Fig. 4.1*) opened in the absence of a VCS controller informs the user about the program's operation in "demo mode".

To go to the test profile editing window, activate the "Profile" label in the area of the type of test for which you want to edit.

Yellow frames around the parameter areas indicate incomplete configuration in the corresponding section, and red frames around the test program areas indicate that the test program is prohibited from running.

The ban on launching test programs may be due to one of the following reasons:

the lack of an up-to-date result of the Pre-Test;

Shaker parameters program .....

Shaker parameters program

Program Purpose

The program "***Shaker parameters***" is designed to indicate to the software a set of parameter values corresponding to **Shaker parameters** used.

The values specified in the "***Shaker parameters***" program will then be used in all VCS programs to calculate the permissible values of test profiles. It should be noted that the fields "Name of the vibration generator system" and "Serial number of the installation" are entered in the reports, so they must be filled in. According to the name of the Shaker and its serial number, a folder will be created on the computer, in which all the Tests results carried out on this Shaker will be saved. If you transfer a computer (or laptop) with a VCS ZETLAB controller to another Shaker, be sure to update the **Shaker parameters**.

The parameters must be set in the following cases:

- After installing the *ZETLAB* software on your computer, or updates;
- When you start using another model of shaker;
- If you need to change the shaker parameters being used.

Program Operation Principles

To go to the **Shaker parameters** program window, press the *Shaker parameters* button on the VCS panel (*Fig. 5.1*). The **Shaker parameters** window (*Fig. 5.2*) will appear on the screen.

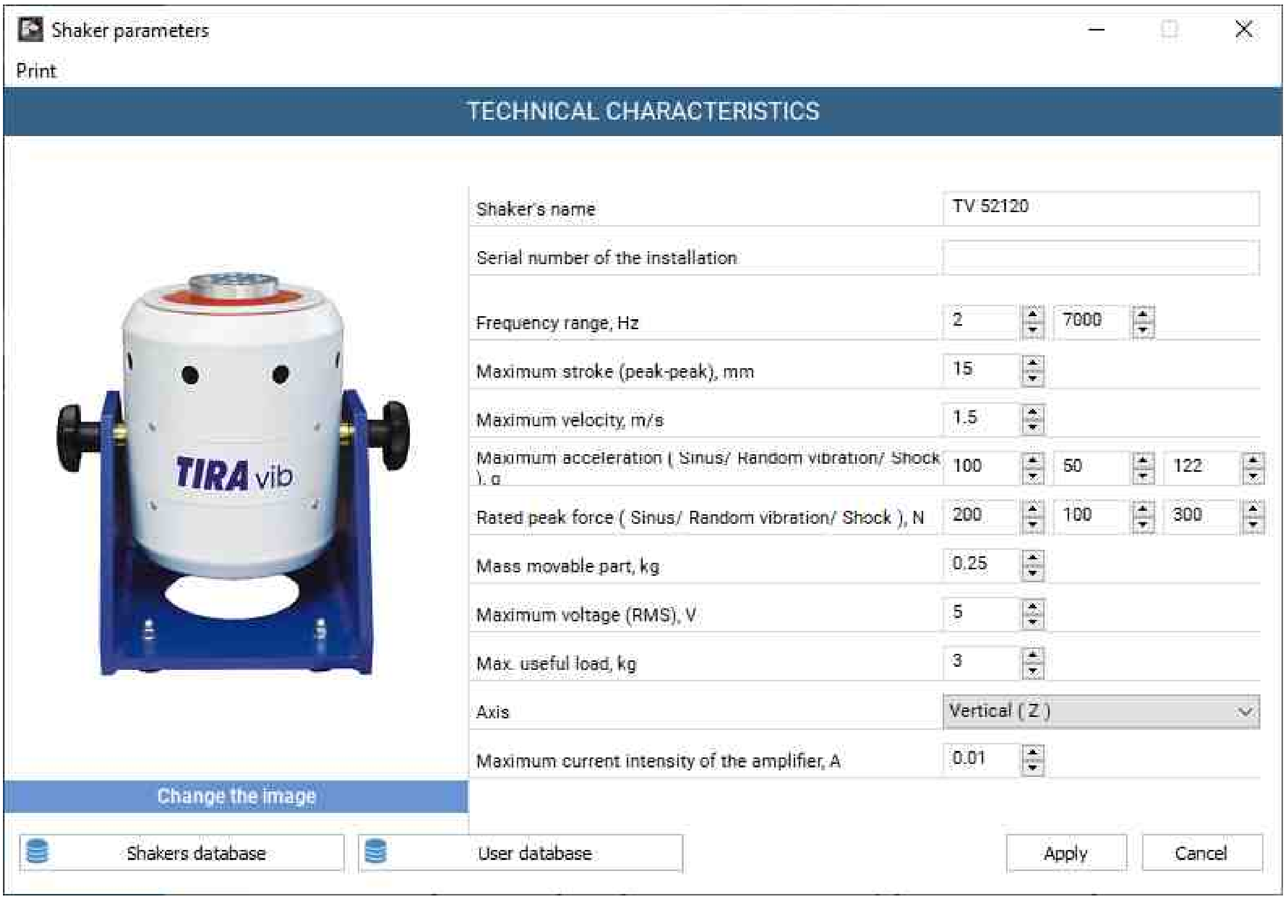


Fig. 5.2 Shaker parameters window

If the software is installed for the first time, the program window will display the default parameters of the shaker.

To go to the shaker database and check whether the database contains the model identical to the model being used, press the *Shaker Database* button, the corresponding window will open (*Fig. 5.3*).

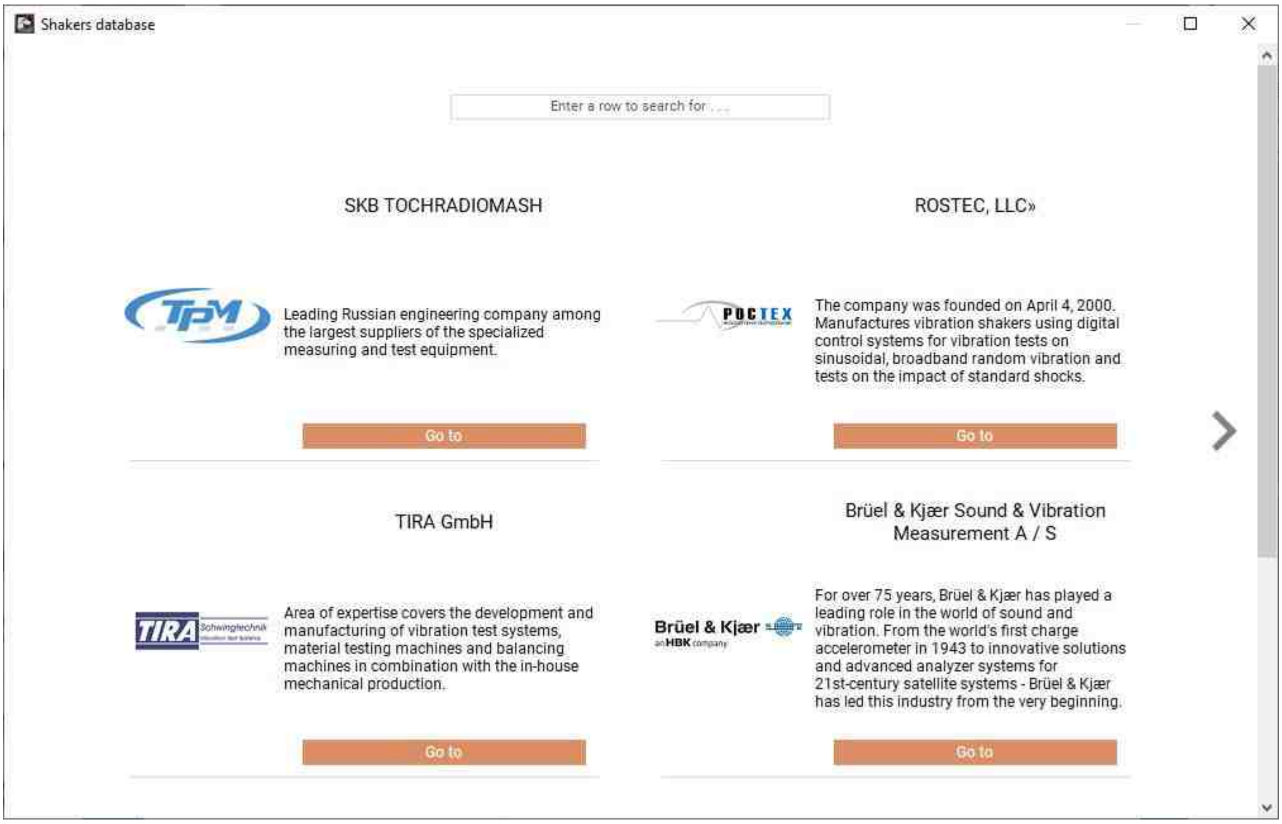


Fig. 5.3 Shaker Database window

In the opened "Shaker database" window, shakers are grouped by manufacturer, where each manufacturer group contains a list of available shakers. To select, click the Go to button under the name of the corresponding manufacturer, and the window will display a list of available shakers. To search for a specific model of the shaker, use the Search field (*Fig. 5.4*).

Fig. 5.4 "Shaker database" window

After the required shaker is found in the "Shaker database" window (*Fig. 5.4*), press the corresponding "Select" button, and the shaker parameters will be displayed in the Shaker parameters window (Fig. 5.2), then press the Apply button to use this type of shaker for the VCS operation.

If the required type of shaker is not found in the database, then in the Shaker parameters window (Fig. 5.2), press the "*User database*" button and the Add symbol in the opened window. The following options will appear:

- New;
- Add the existing;
- Add from database.

When you select New, you will be prompted to fill in the form of the Shaker parameters window, and after filling in the form manually and pressing Save, this type of shaker will be saved in the user database. When you select Add the existing, the type of the shaker displayed in the Shaker parameters window (Fig. 5.2) will be added to the user database. When you select Add from database, the Shaker Database window will open, and after selecting a type of the shaker from the database, it will be added to the user database.

In the user database, you can not only set required ranges and values for the used shakers, but also quickly select the type of shaker for testing (if VSC is periodically used to control various shakers).

Note: *For some types of Shakers, the maximum permissible acceleration values and expulsive force for noise and shock may be unavailable. In this case, you can enter the manufacturer's values of the maximum acceleration and expulsive force parameters for Sine in the corresponding parameter fields.*

If necessary, press the "*Change" the image* button to add a photo of the shaker. The photo in the "Shaker parameters" window provides an additional identification of the shaker in the user database.

Note: *The photo to be added in the shaker parameters window should be in any graphic format with 2/3 (width/height) aspect ratio and in any available directory.*

Examples for the section .....

Example of choosing a Shaker for testing with a known mass of the specimen and acceleration

Example of choosing a Shaker for testing with a known mass of the specimen and acceleration .....

Example of choosing a Shaker for testing with a known mass of the specimen and acceleration

For example, it is necessary to choose a Shaker for testing specimens mass **m=1,5** kg with maximum acceleration $\mathbf{a_{max}=50\ m/s^2}$ in the frequency range from 10 to 2000 Hz.

One of the main parameters of any electrodynamic Shaker is the pushing force F, therefore, the choice of a Shaker should begin with compliance with the conditions of its sufficiency.

Checking the fulfillment of the conditions for the sufficiency of the pushing force is carried out according to the formula:

$$F>k*m_{max}*a_{max}$$

where **k** safety factor (recommended to take equal to 2)

m_{max} – maximum mass, which includes, in addition to the specimen mass, also the tool mass (expansion slot, fastening elements, etc.) and the mass of the movable part of the shaker

Due to the fact that at the stage of selecting the shaker, the connecting unidades of the mounting platform of the movable part of the shaker are not yet known, and therefore the exact value of the tool mass is also not known, it is advisable to take in this case the value of the tool mass equal to the specimen mass.

The mass of the movable part of the shaker until the specific model is determined is also not known, therefore, when performing a preliminary calculation, it can be neglected, taking into account the subsequent verification calculation.

For example , we get F>2*(1,5+1,5)*50=300 H

Thus, to fulfill the conditions, it is necessary to choose a Shaker with a pushing force of at least 300 N. In the example, we will choose a shaker of the TV 51140 series satisfying this condition with a pushing force of 400 N, the mass of the moving part

.First, let's check that the maximum static load is greater than the sum of the specimen mass of the tested and the tool mass for attaching the specimen to the shaker: 6 > 1,5 + 1,5.

The condition is met, therefore, we proceed to the next step and perform a test calculation for the pushing force already taking into account the mass of the moving part of the shaker.

Fcalc= $k*m_{max}*a_{max}$=2*(1,5+1,5+0,4)*50=340 H

Shaker pushing force (400 N) more than the calculated pushing force (340 N), which indicates positive results of the verification calculation.

Finally, check the range of movement of the movable part of the shaker, as a result of which the resulting calculated displacement S must be less than the maximum possible travel of the moving part (for the shaker selected in the example is 20 mm)

Calculation of displacement S is performed according to the formula

$$S = a_{max}*10^3/(2\pi f_{min})^2$$

where f_{min} – minimum frequency in the test range (in the example 10 Hz).

Note: *if a negative result is obtained at any of the stages of the checks, it is necessary to select a shaker with a greater pushing force or with a greater stroke value of the moving part and repeat the calculations given in this section*

Specimen parameters program .....

Specimen parameters program

Program Purpose

You can test any specimen on a shaker. To do this, you only need a properly selected tool mass for reliable attachment to the movable part of the shaker, and so that the total load mass does not exceed the permissible for a particular shaker.

The "**Specimen parameters**" program is designed to set the VCS software parameter values consistent with the **Specimen parameters** sand tooling needed to attach the specimen on the shaker. It is necessary to specify the name of the specimen in it and its serial number (if it is not in a single copy, it will be tested), the specimen mass and the direction of impact (if the test task requires vibration in all axial directions). Tool, with the help of which the specimen is attached to the shaker, it also requires explicit indication of the name, number and mass.

Total mass (specimen mass plus tool mass) it will be used to calculate the maximum permissible acceleration when setting the vibration test profile. Such restrictions are necessary to protect the shaker from overload and breakage.

For the automatic report saving function to work correctly, it is necessary to set the specimen name and its serial number correctly. By specimen name and a folder will be created for its serial number, nested in the folder with the name of the shaker, in which all Tests results will be saved.. If you changed the tool or the tested specimen for another or the same, it does not matter, it is necessary to write new parameters to the "**Specimen parameters**" program. Otherwise, all the results will be saved to the old folder and after a while it will become impossible to Fig. out which results correspond to which specimen.

The **Specimen parameters** program is used in the following cases:

- After installing the *ZETLAB* software on your computer, or updates;
- When changing the specimen type subject to vibration testing;
- When changing the model of tool used for attach the specimen on the shaker.

Program Operation Principles

To go to the ***Specimen parameters*** window, press the ***Specimen parameters*** button on the VCS panel. The monitor screen will display the ***Specimen parameters*** window (*Fig. 6.1*).

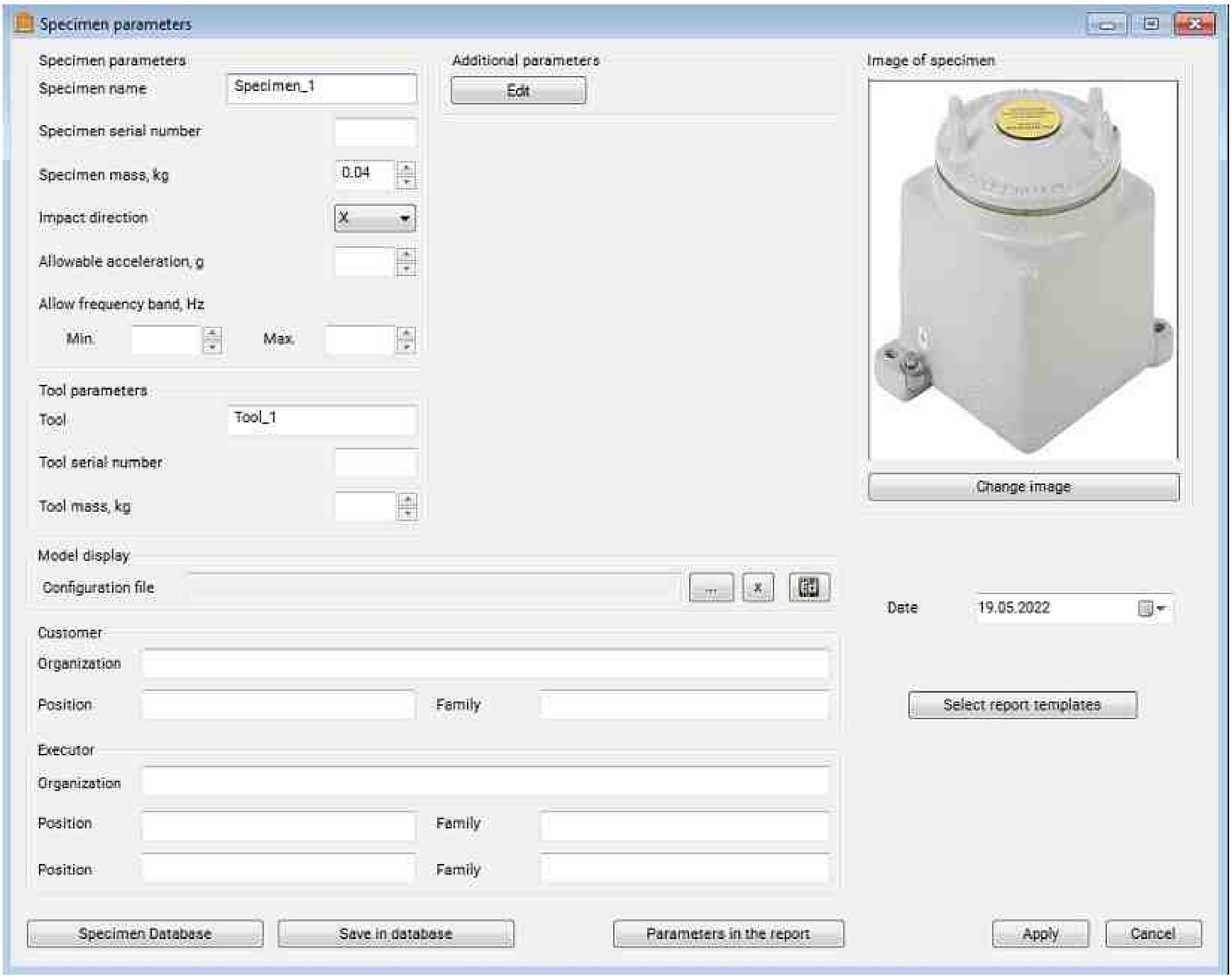


Fig. 6.1 "Specimen parameters" window

Attention! *always specify the parameters "Specimen mass" and "Tool mass" (expansion table, specimen mounting elements, etc.) in order to software VCS provided the correct limitation of the permissible limits of tests in order to minimize the risk of damage to the shaker.*

Note: *it is permissible to specify in the "Specimen mass" parameter the total amount of the specimen mass and the installed specimen mass, in this case, the parameter "Tool mass" it should be left empty (with a zero value).*

Note: *if there are no requirements for limiting the effects on the frequency range and vibration level for the specimen, the fields "Frequency" and "Permissible acceleration" can be omitted, in this case, the restrictions applicable to the shaker will apply according to the corresponding parameters.*

The "Model display" field located in the "Specimen mass" window allows the software to specify a link to a configuration file prepared in the "*.xml" format. The information in the file indicates to the system the layout of the sensors on specimen to be tested, which allows 3d visualization of its waveforms based on the results of the conducted Pre-Test.

Note: *detailed information on the principle of control over the waveforms is given in the section 8.3.2.*

The area [...] in the "Model display" field allows you to select the directory where the prepared configuration file is located, and the area allows you to open the "Configuration editor" window (Fig. 6.2).

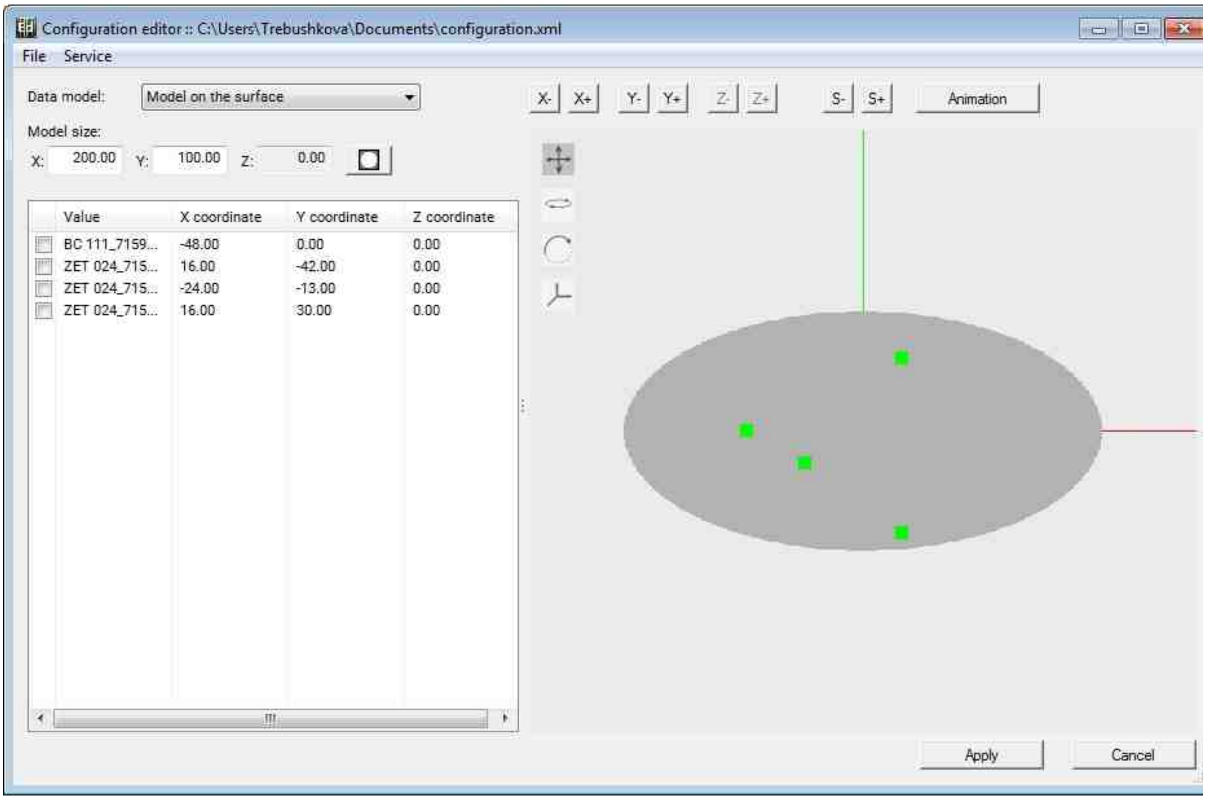


Fig. 6.2 "Configuration editor" window

For the "Data model" parameter in the "Configuration editor" window (*Fig. 6.2*) one of two values can be set: "Model on the pivot", which implies the location of the sensors in the same plane with the setting of the values of the coordinates "X" and "Y" (the Z coordinates are zero) for each sensor and "Model on the rod", which implies the location of the sensors in the nodes of the grid with the setting for each of sensors for the values of the coordinates "X", "Y" and "Z".

By the "Model size" parameter in the "Configuration Editor" window (*Fig. 6.2*) the required size of the area for the placement of sensors is determined.

Note: *when setting the size of an area, it should be taken into account that the zero coordinates are always located in its center.*

If you need to edit a previously created configuration file, activate the "File" menu in the "Configuration editor" window (*Fig. 6.3*) and then "Load configuration", then in the "Open" window (*Fig. 6.4*) specify the configuration file to be edited after which activate the "Open" button.

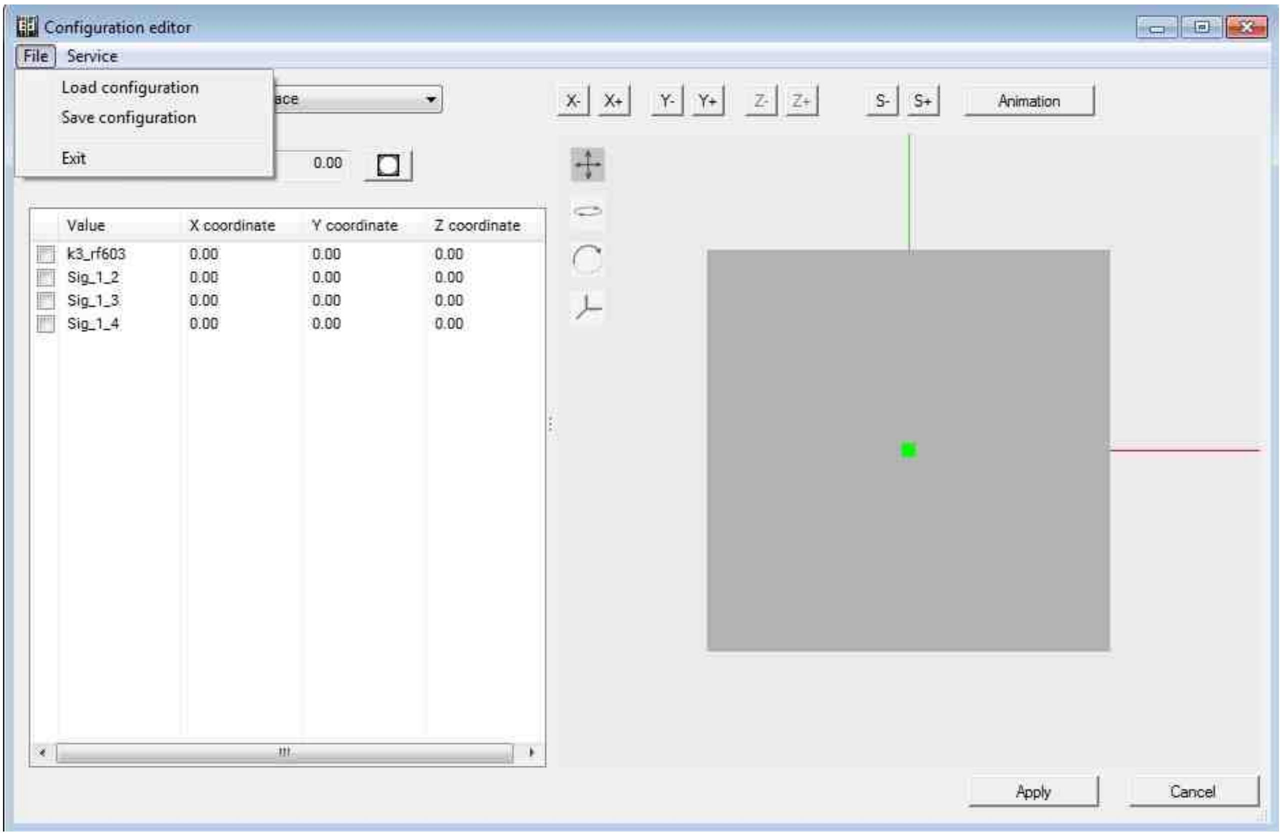


Fig. 6.3 "Configuration editor" window, "File" menu

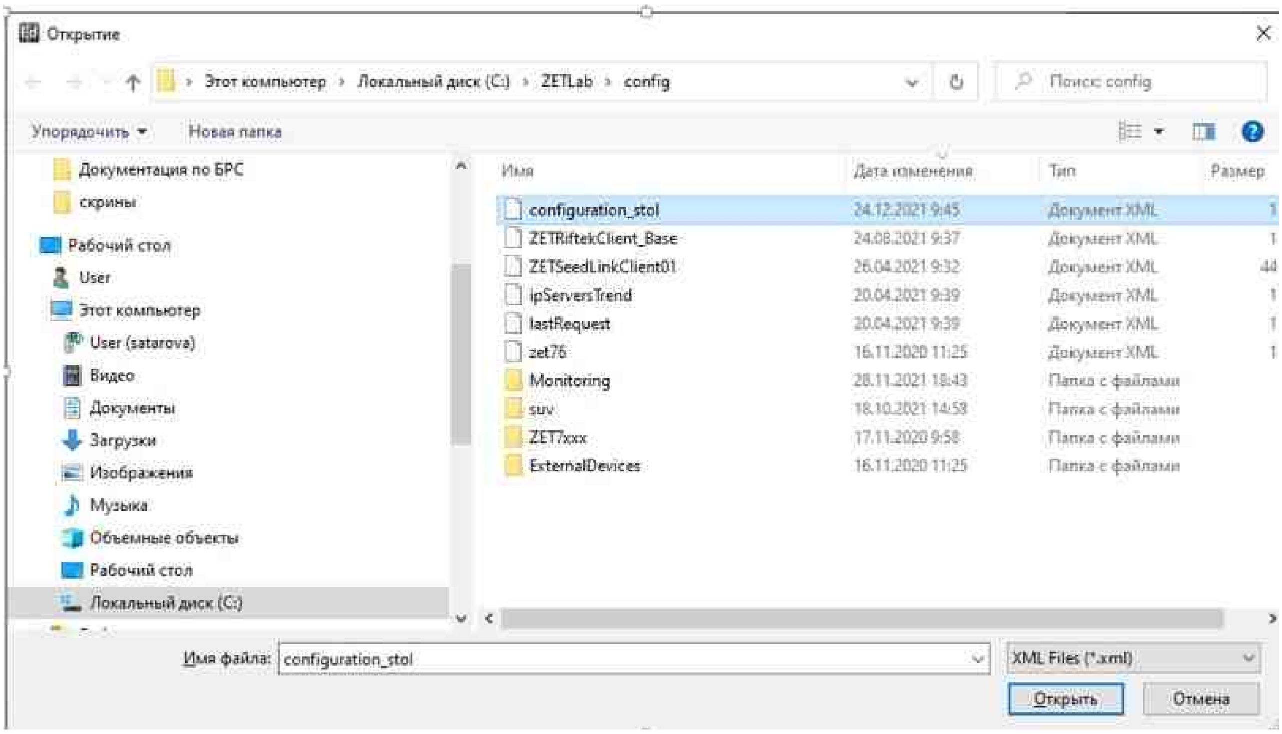


Fig. 6.4 The "Open" window

To save the configuration file in the "File" menu of the "Configuration editor" window (*Fig. 6.4*) than activate "Save configuration" and in the "Save" window (*Fig. 6.5*) specify the path and name to be assigned to the saved file.

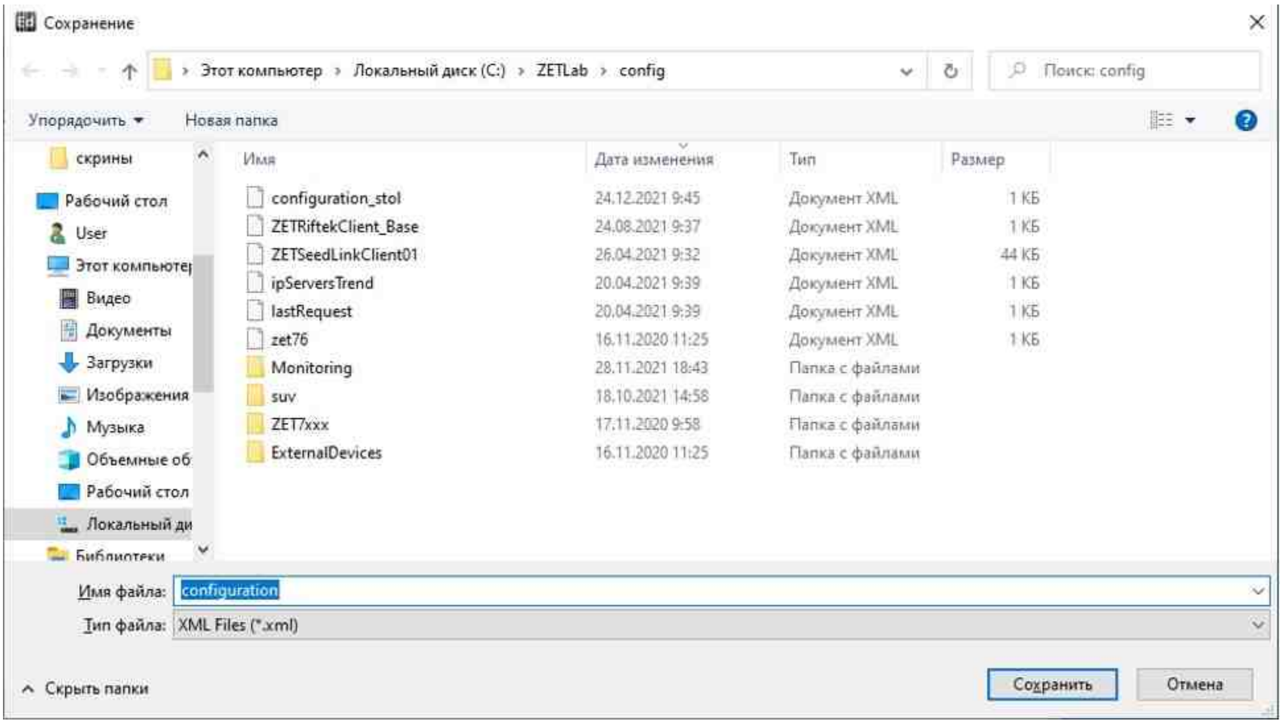


Fig. 6.5 The "Save" window

To edit the list of measuring channels that will be used to control the form of the oscillations, go to the "File" menu of the "Configuration Editor" window (Fig. 6.6) activate the "Channel filter" and in the window that opens (Fig. 6.5) in the checkboxes, mark the channels involved in the control.

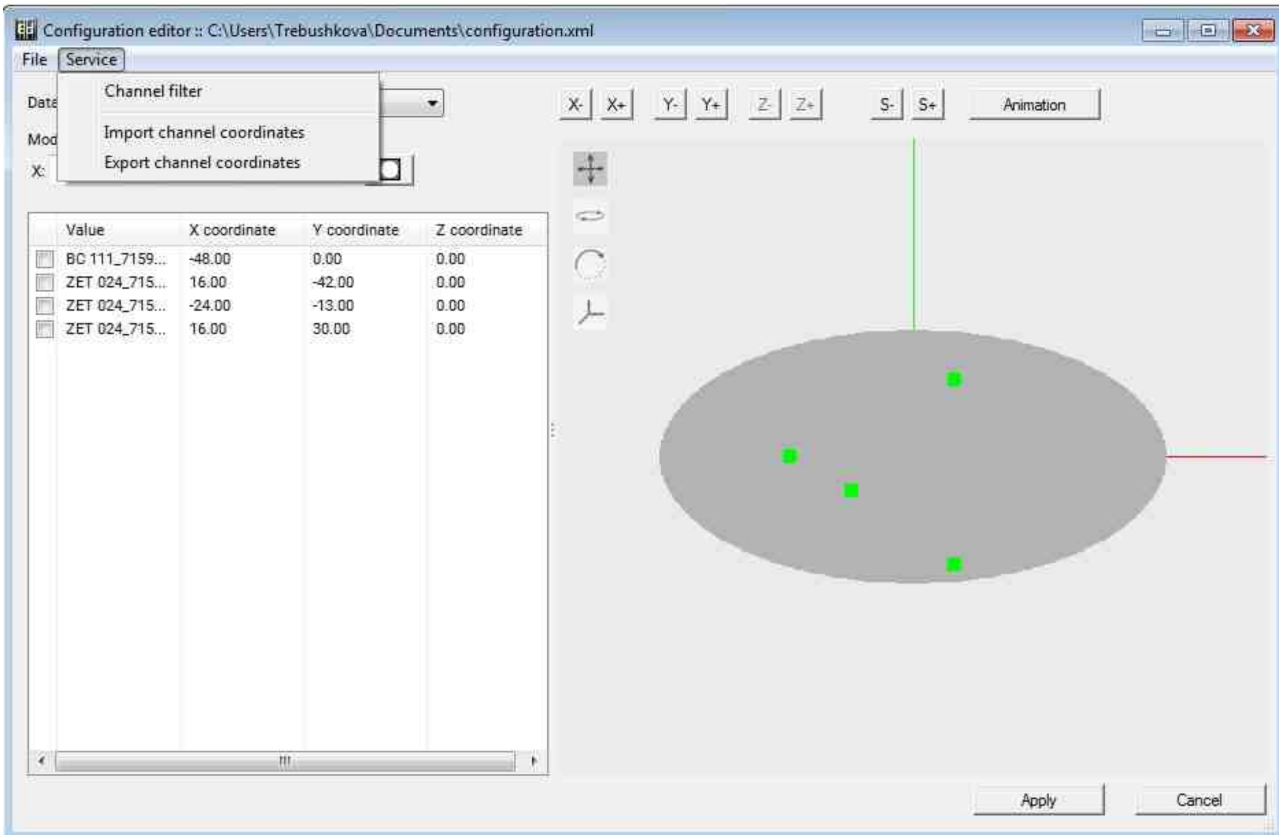


Fig. 6.6 "Configuration Editor" menu "Service" The "Save" window

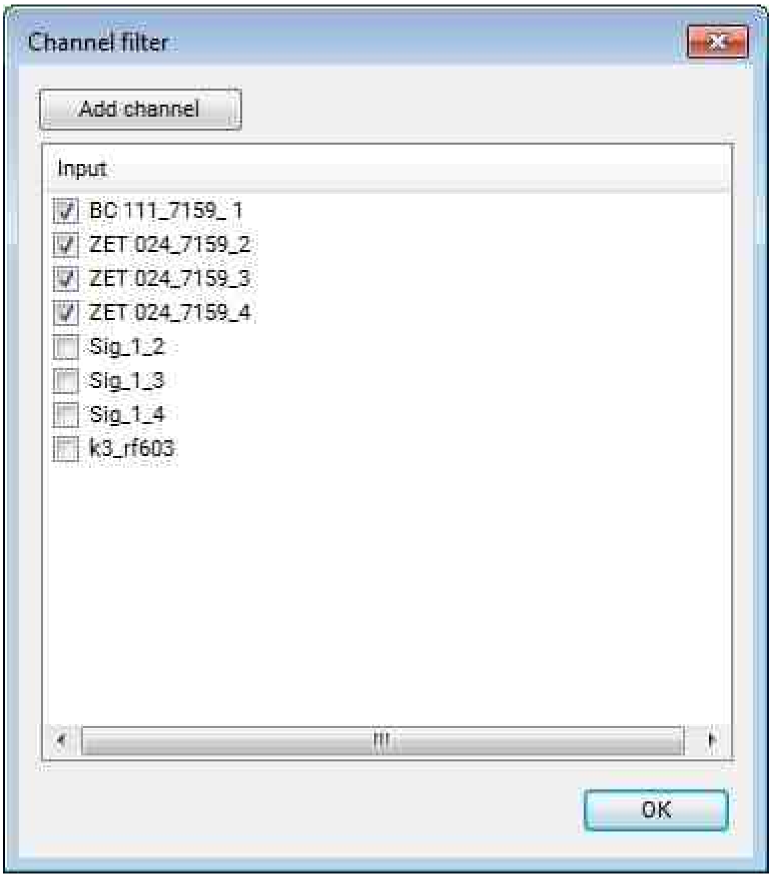


Fig. 6.7 "Channel filter" window

Information from the "Specimen parameters" window (*Fig. 6.1*) it is indicated in the test report. In the "Specimen parameters" window, parameter fields with information about the Customer and the Test Performer are provided by default. If parameters that are not present in the default form are required for saving to the report, then they should be added manually using the "Additional Parameters" area. In this case, in the "Specimen parameters" window (*Fig. 6.8*) necessary activate the "Edit" button, after which each activation of the "Add" button will add one field, in each of which you should then specify the information required to save in the report file.

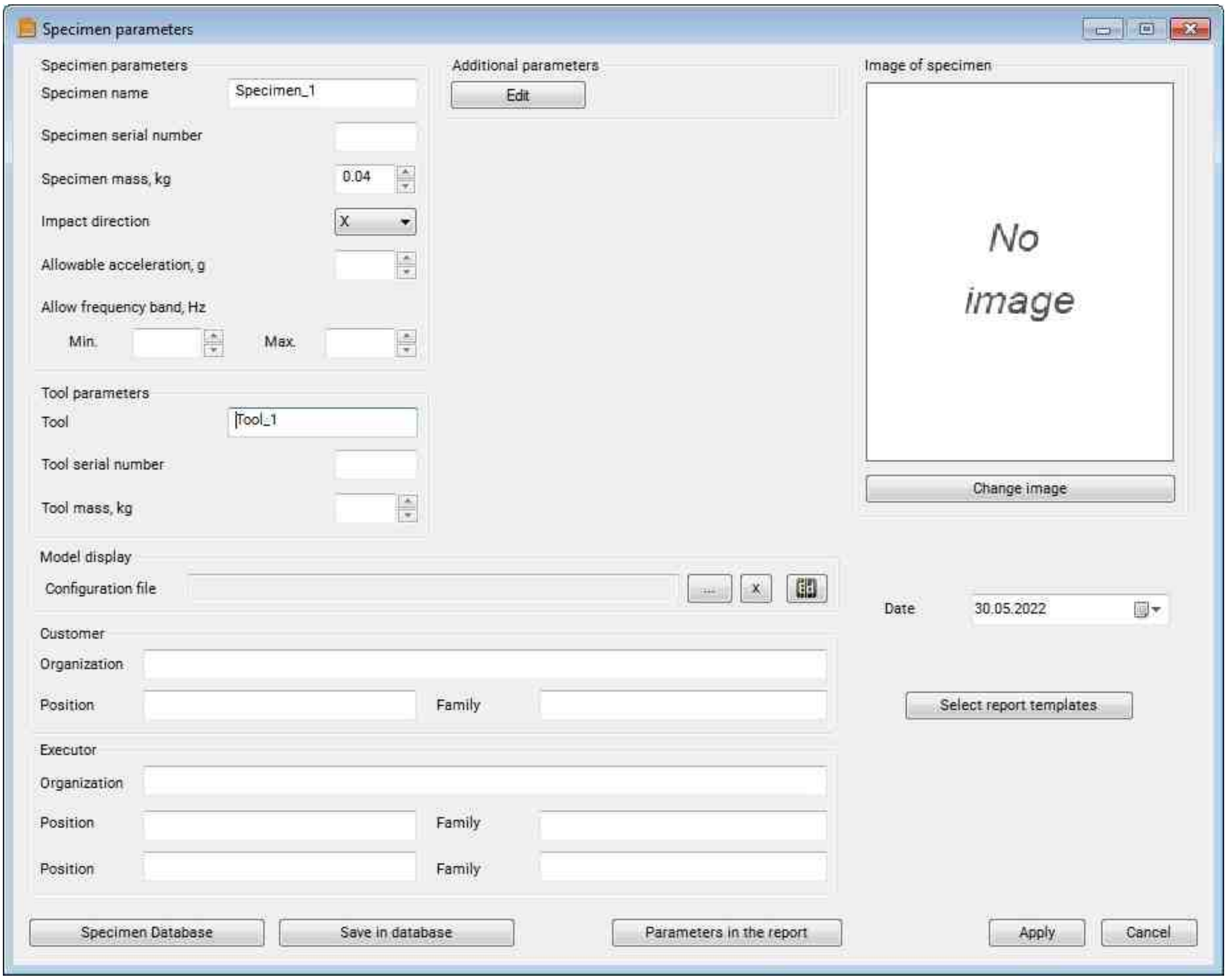


Fig. 6.8 The "Specimen parameters" window with additional parameters

To visualize the names of parameter labels, it is necessary activate the "Parameters in the report" button. Parameter labels (*Fig. 6.9*) provide binding of parameter values to the places in the report to which they will be displayed

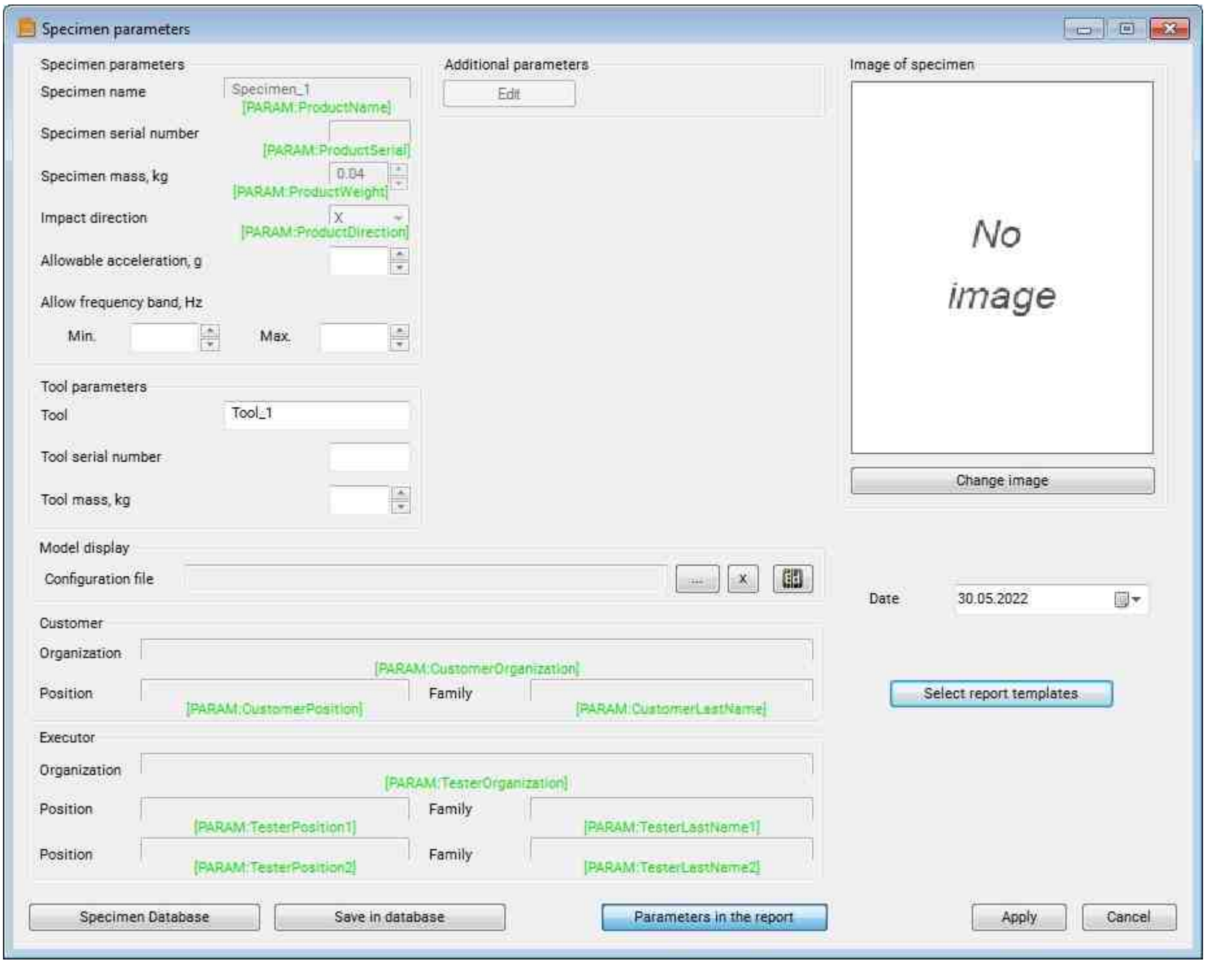


Fig. 6.9 The "Specimen parameters" window with the names of parameter labels

The "Select report template" button is designed to activate the program window (*Fig. 6.10*) which specifies the location directories and file names of report templates for various types of tests.

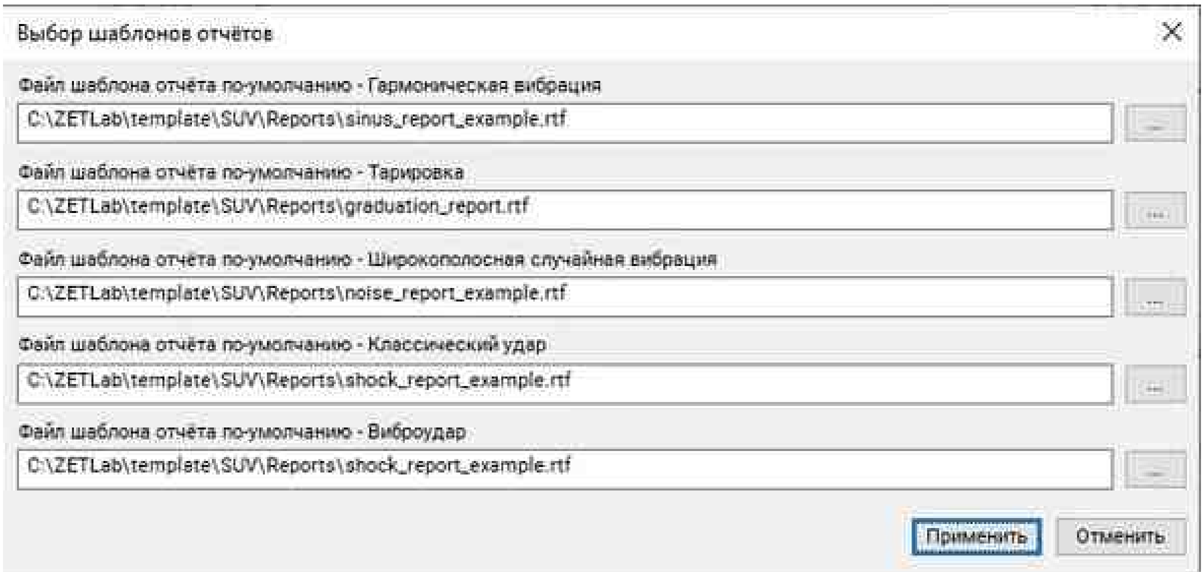
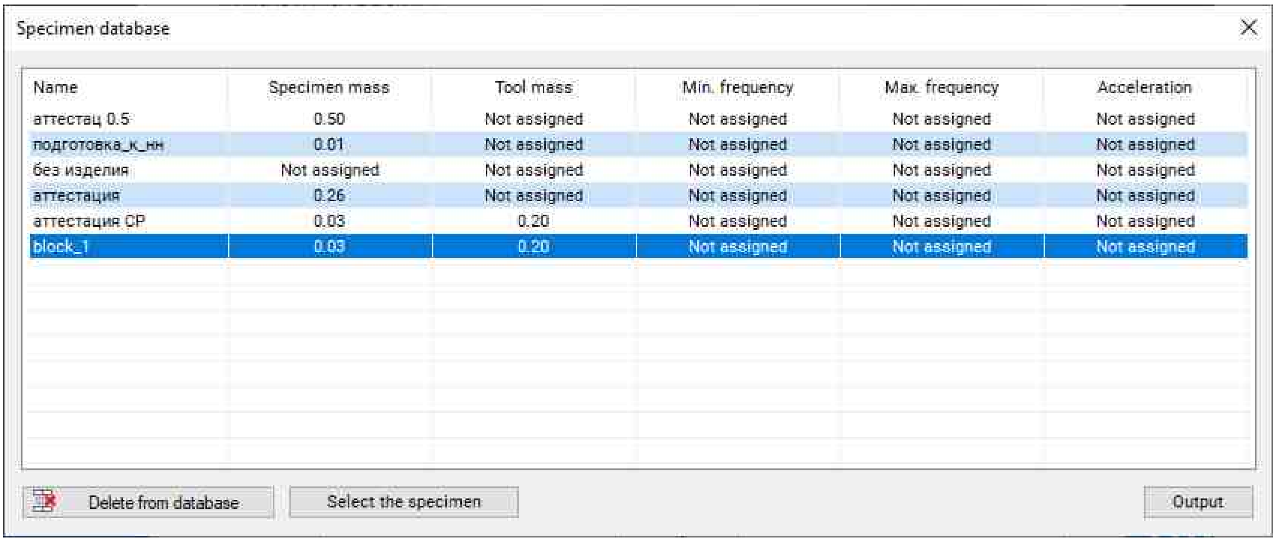


Fig. 6.10 "Select report templates" window

Note: *for more information about the rules for generating reports, see the section 13.*

To add a specimen to the database, press the *Save in database* button. The ***Specimen parameters*** will be saved in the database.

In the subsequent testing of specimens added to the database, select the desired specimen type from the database window (*Fig. 6.11*), and use the *Specimen Database button* in the ***Specimen parameters*** window to go to it.



Name	Specimen mass	Tool mass	Min. frequency	Max. frequency	Acceleration
аттестац 0.5	0.50	Not assigned	Not assigned	Not assigned	Not assigned
подготовка_к_нн	0.01	Not assigned	Not assigned	Not assigned	Not assigned
без изделия	Not assigned	Not assigned	Not assigned	Not assigned	Not assigned
аттестация	0.26	Not assigned	Not assigned	Not assigned	Not assigned
аттестация СР	0.03	0.20	Not assigned	Not assigned	Not assigned
block_1	0.03	0.20	Not assigned	Not assigned	Not assigned

Fig. 6.11 "Specimen Database" window

Press the *Change the image* button to add a specimen photo to the ***Specimen parameters*** window. The photo in the ***Specimen parameters*** window provides an additional specimen identification in the database.

Note: *The specimen photo to be added in the* ***Specimen parameters*** *window should be in any graphic format with 2/3 (width/height) aspect ratio and in any available directory.*

Examples for the section .....

Examples for the section

Example of setting Specimen parameters when using "Model on the pivot"

Example of using 3D visualization in a Pre-Test

Example of setting product parameters when using "Model on the pivot" .....

An example of preparing a configuration file of a "Model on the pivot" for subsequent visualization of the waveforms of the investigated specimen (model)

The example involves a set of VCS equipment VCS, consisting of three controllers ZET028 or 18 accelerometers BC111, mounted on the frame under study, eleven of which are located on the lower horizontally located edge of the frame, and seven – on the upper one.

To perform the configuration, the measuring channels from which the signals from the accelerometers are recorded must be active (enabled). To do this, the measuring channels of the controllers (to which the accelerometers are connected) must be set using the "**ZET Device Manager**" program according to the rules given in section *7*. In the example, the measuring channels are assigned names in the form of numbers from "1" to "18"

The configuration should begin with opening the "***Specimen parameters***" program window, to go to which on the VCS panel you should activate the "***Specimen parameters***" button. The "***Specimen parameters***" program window will be displayed on the monitor screen (*Fig. 6.1*).

Next, you should activate the area and in the "Configuration editor" window, in the "Data model" field, select "**Model on the pivot**" (*Fig. 6.12*).

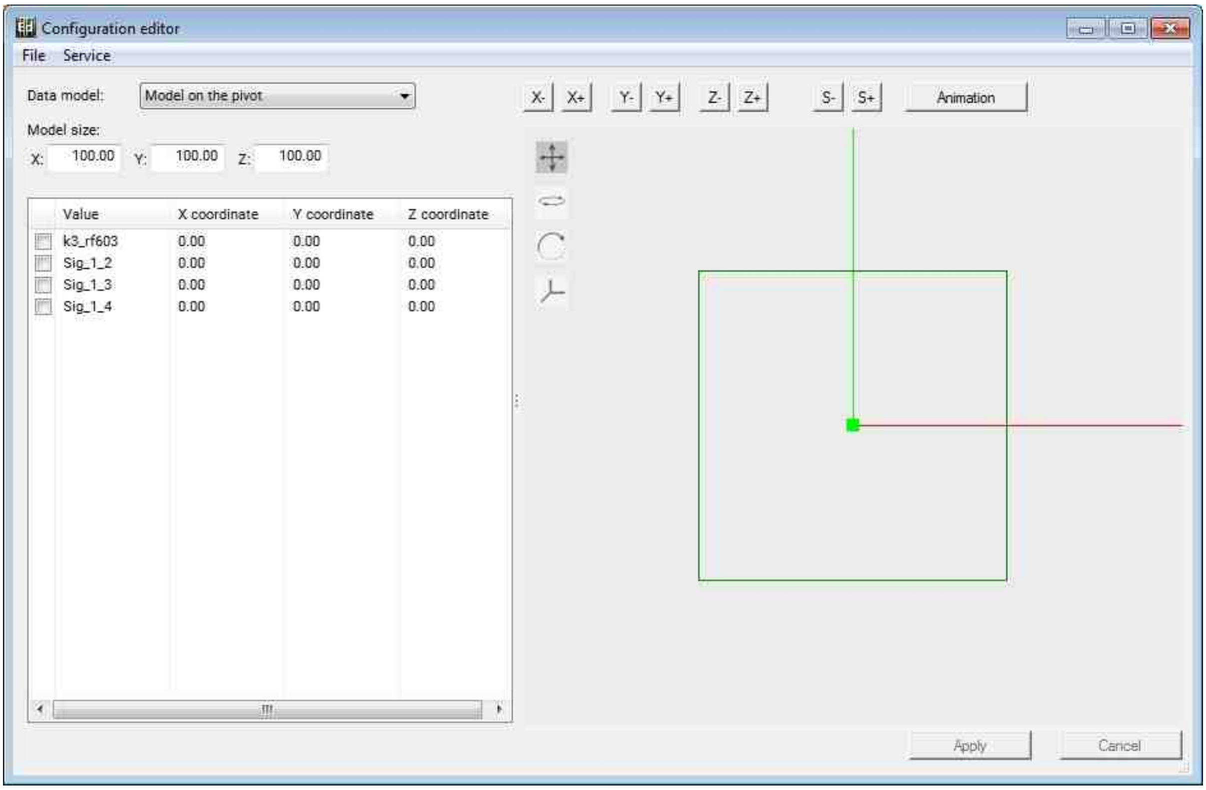


Fig. 6.2 Select the model type in the "Configuration editor" window,

In the columns of the table, enter the values of the X, Y and Z coordinates corresponding to the locations of the accelerometers ([Fig. 6.13](#)).

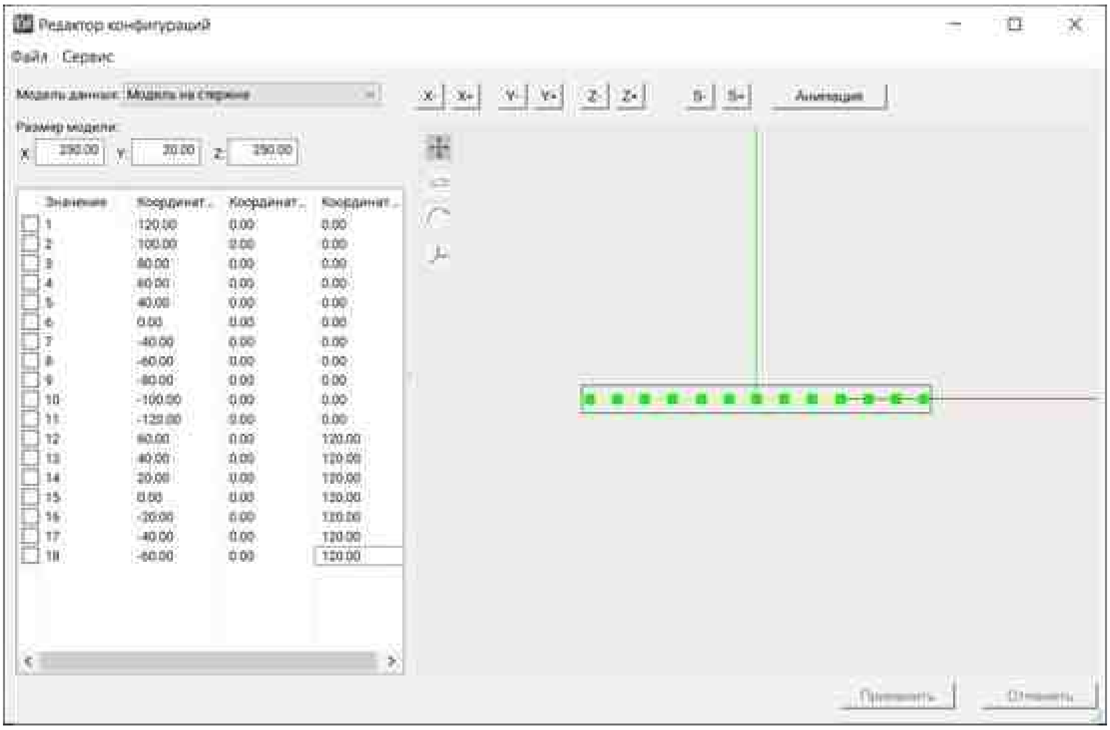


Fig. 6.13 Set sensor coordinates in the "Configuration editor" window

Activate symbols  or  to rotate the model, respectively, in a horizontal or vertical plane and using the mouse manipulator, expand the model to a position convenient for visualization (*Fig. 6.14*).

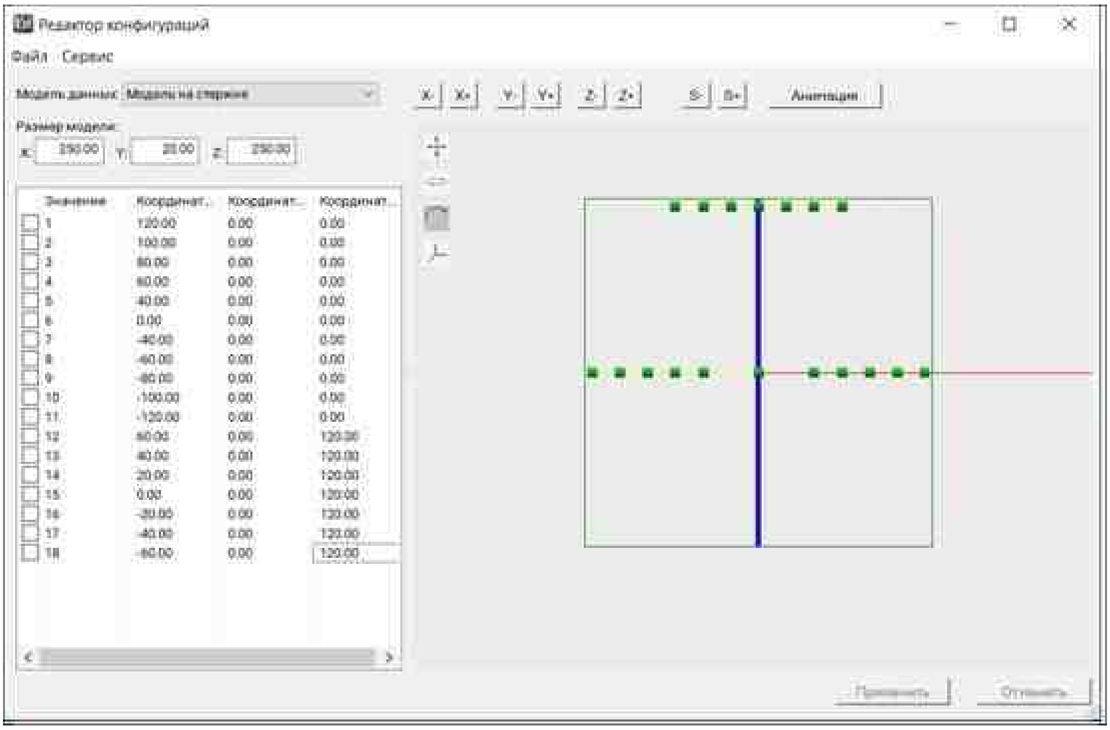


Fig. 6.14 Turning the model into the "Configuration Editor" window

In the "File" menu, select "Save configuration" (*Fig. 6.15*).

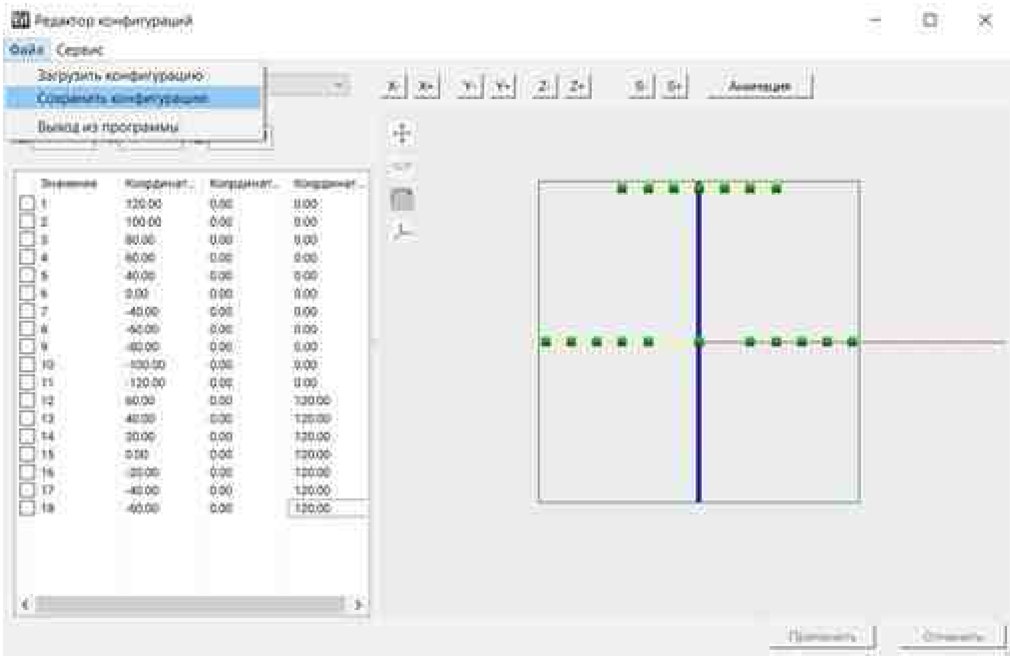


Fig. 6.15 "File" menu in the "Configuration editor" window

In the "Save" window, go to the directory where the configuration file will be saved and assign a name to the saved configuration file (*Fig. 6.16*) after which  activate "Save".

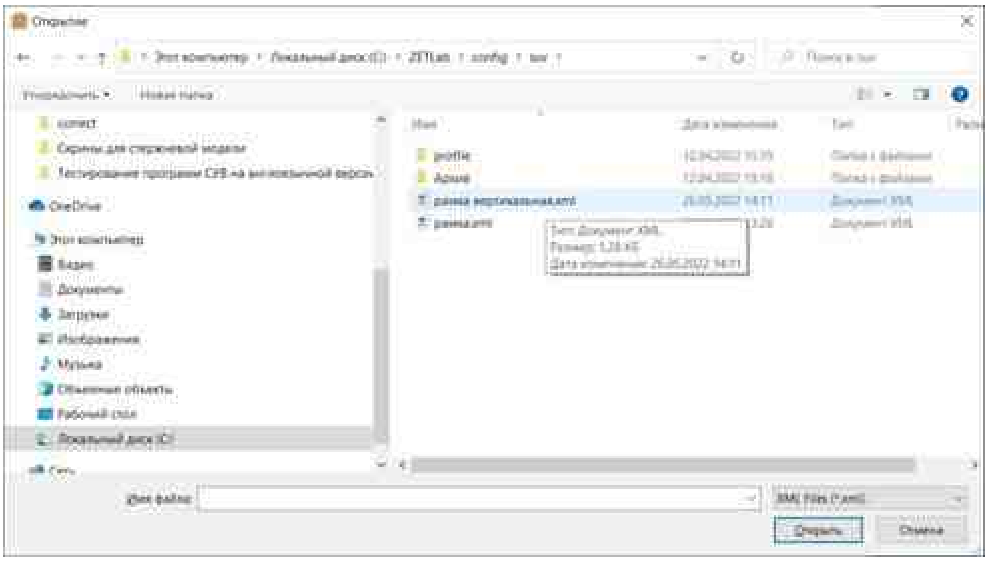


Fig. 6.16 The "Opening" window

The path and name of the configuration file in the "Configuration file" field of the "Model form" area of the "***Specimen parameters***" window (*Fig. 6.17*) indicates the configuration file that will be used by the software when visualizing waveforms.

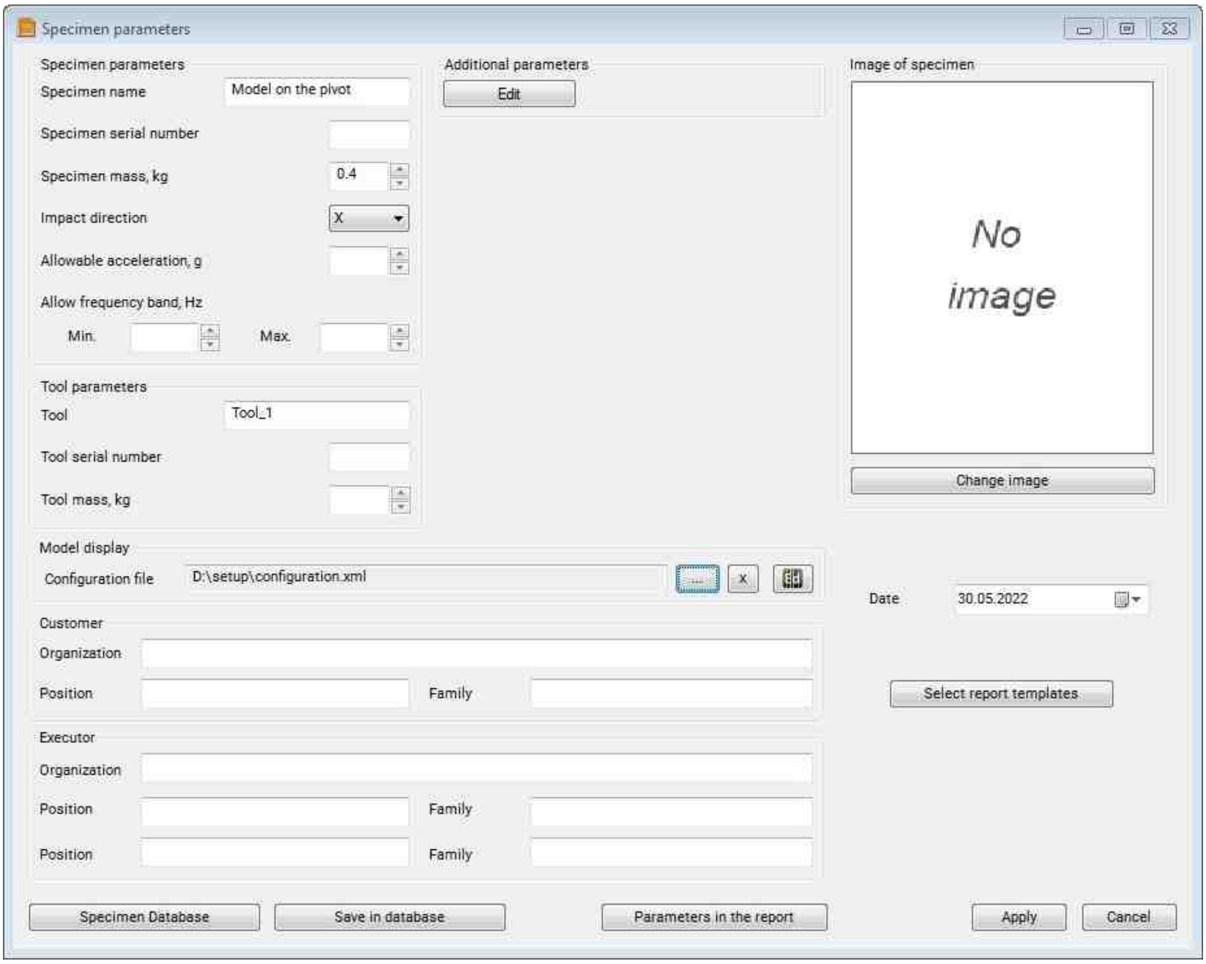


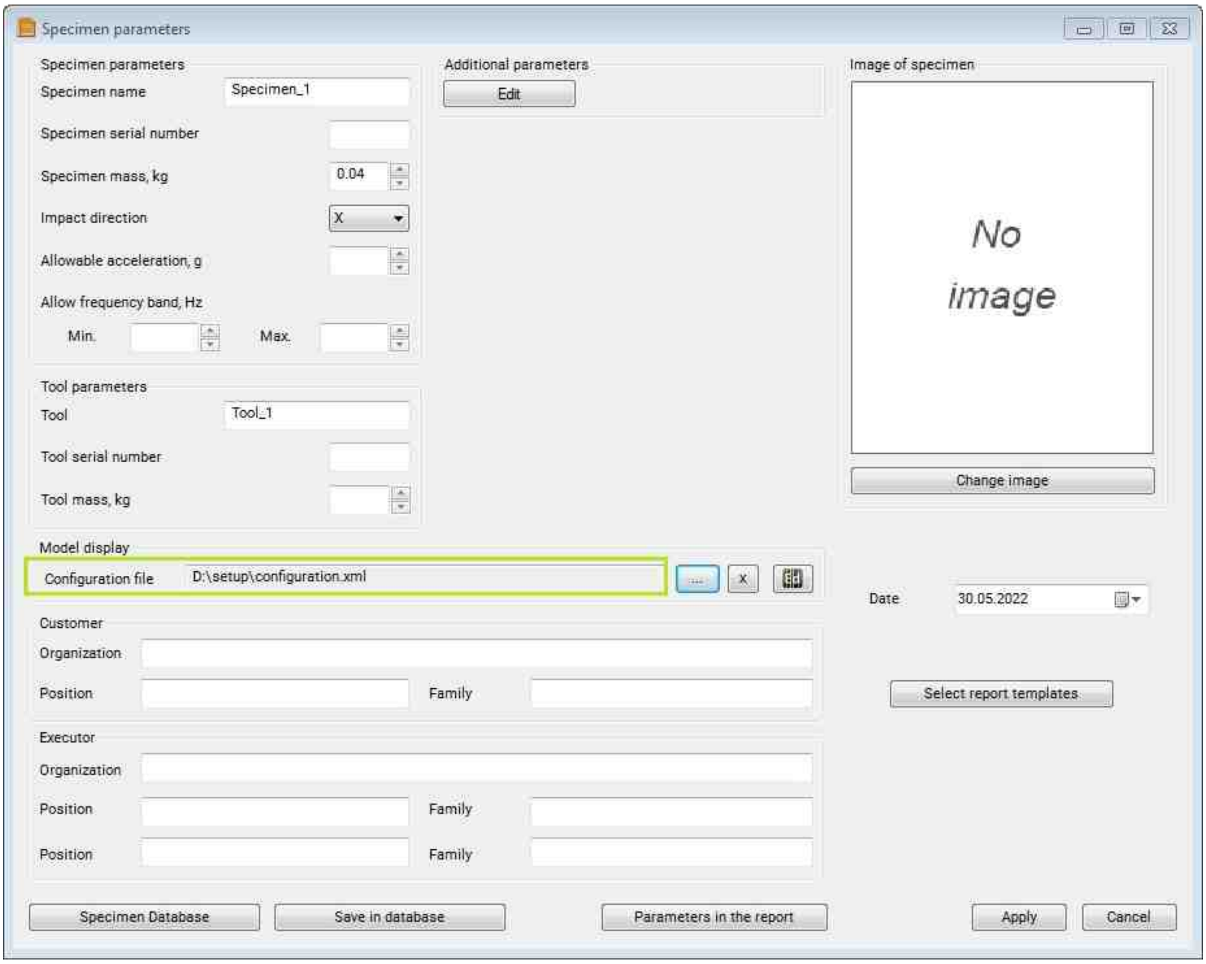
Fig. 6.17 "Specimen parameters" window

Note: *visualization of waveforms is discussed in detail in the section [8.4.2](#)*

Example of using 3D visualization in a Pre-Test .....

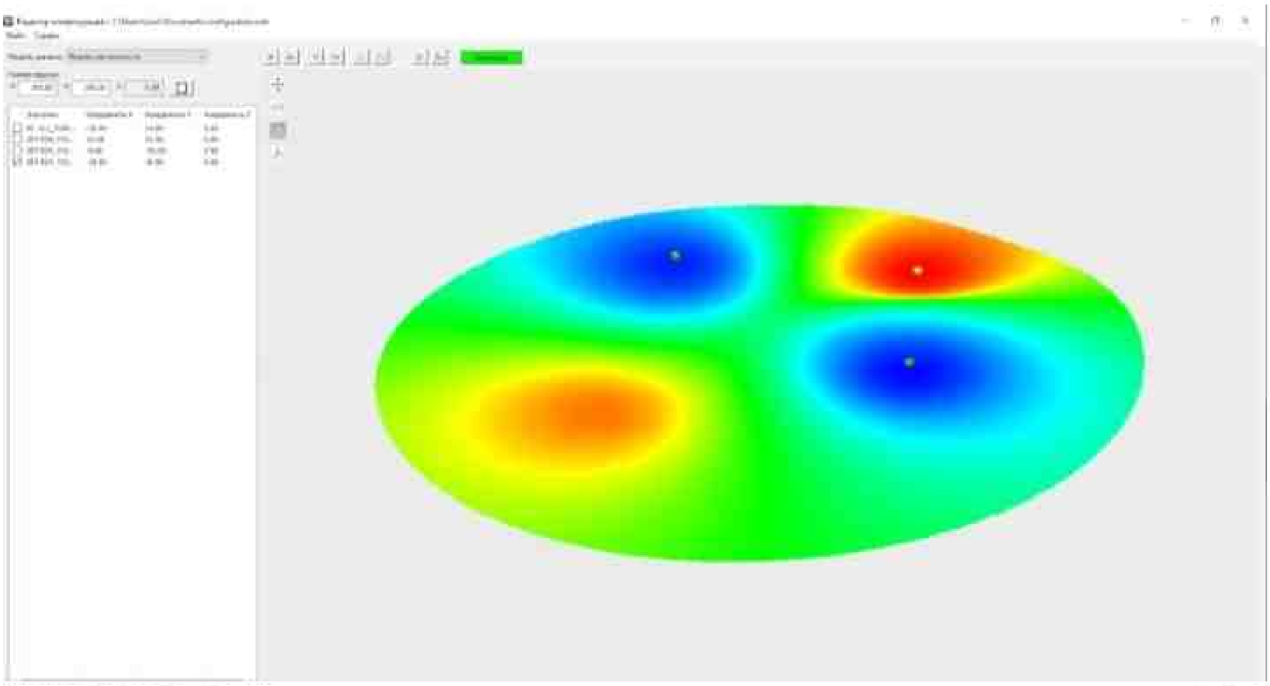
Example of using 3D visualization in a Pre-Test

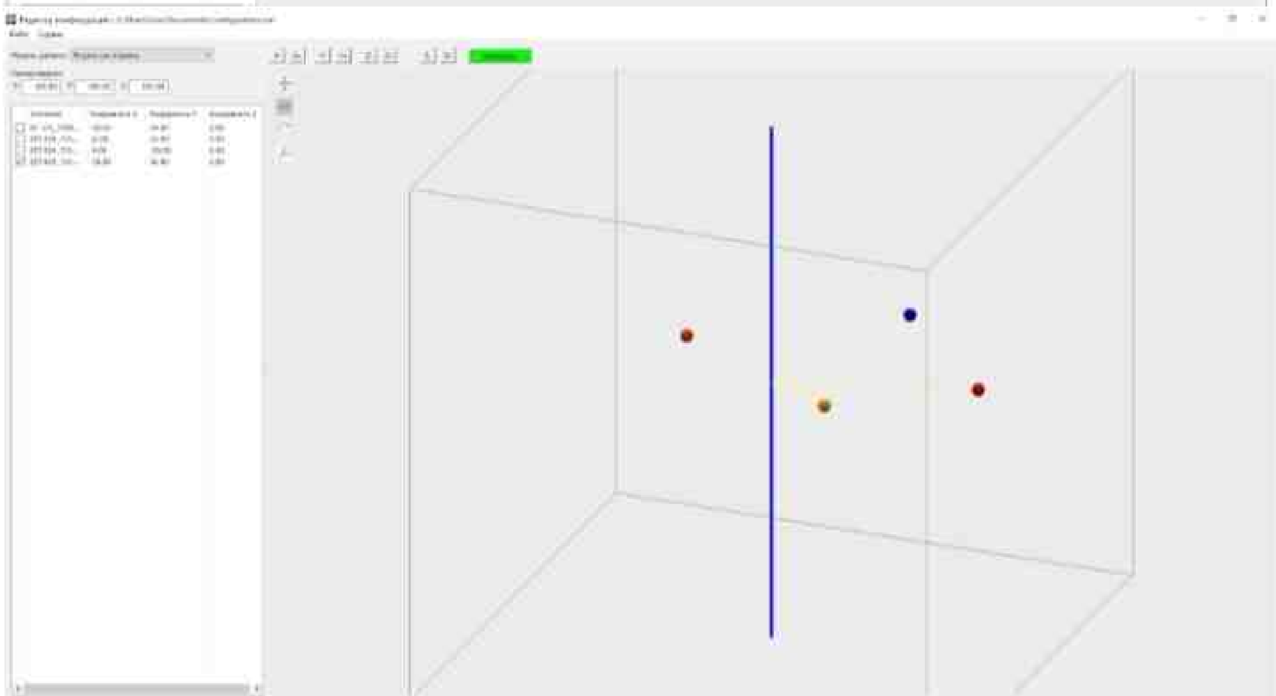
The model of the oscillation form and its visualization have been improved. Now the model configuration is set in the configuration editor, called from the parameters window of the specimen to be tested.



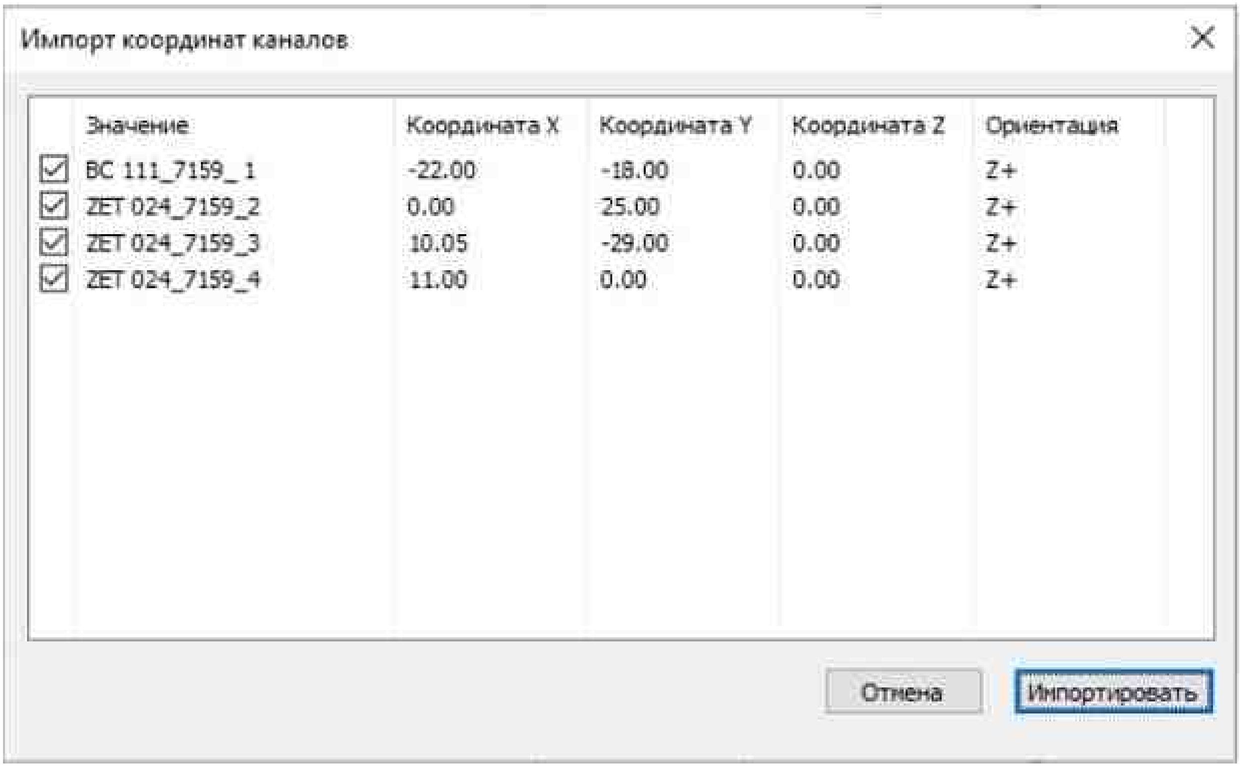
The configuration editor allows you to select the type of vibration testing model - "Model on the surface" or "Model on the pivot", determine the unidades and forma (for a plane), and arrange sensors in a convenient way using visual placement or manual input of coordinates.

Directly in the editor, you can see the model oscillations on random values of the phases/amplitudes of the sensors by turning on the animation mode.

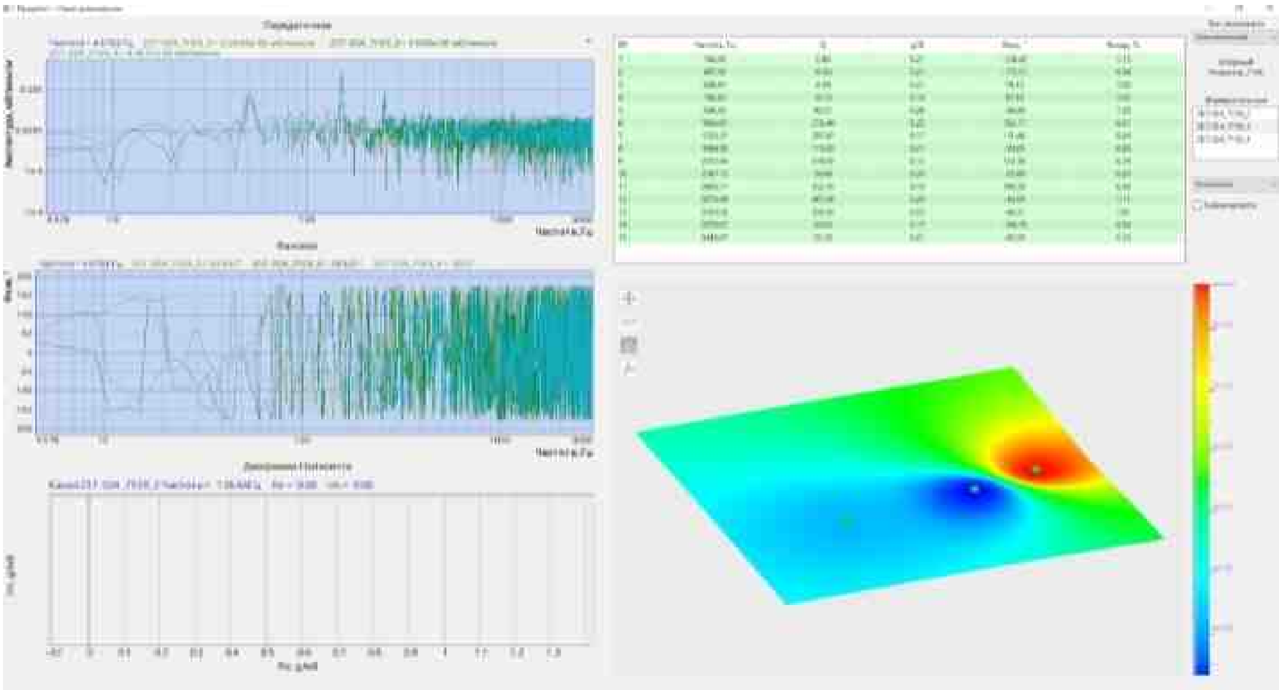




Through the "Service" menu of the editor, you can manage the import / export of device coordinates.



The configuration specified in the parameters window of the item under test will be automatically loaded into the Pre-Test resonance search window.



ZET Device Manager program .....

ZET Device Manager program

Program purpose .....

Program purpose

The **ZET Device Manager** program is designed for both setting of the VCS devices and for setting the measuring channels in accordance with the sensors parameters connected to the inputs of the VCS devices.

In the ZET Device Manager program, you can perform the following operations:

- Set the sample rate of the ADC and DAC controller (go to *Device ID/Properties/Sampling frequency*);
- Set monitoring and changing the IP address of the device (go to *Device ID/Properties/Ethernet*);
- Set the device ID (go to *Device ID/Properties/Identification*);
- Set sync options (go to *Device ID/Properties/Synchronization*).

In the ZET Device Manager program, when setting of the measuring channels allows you to perform the following operations:

- Select a specific type of primary converter connected to the VCS controller's measuring channel from the list (go to *Measurement Channel ID/Properties /Name*);
- Set parameters of primary converters such as sensitivity, gain, range, unit of measurement (go to *Measurement Channel ID/Properties/field corresponding to the parameter being set*);
- Enable/disable the ICP power function for the sensors (go to *Measurement Channel ID/Properties/Use ICP field*);
- Enable/disable the high-pass filter function (go to *Measurement Channel ID/Properties/AC field*).

To carry out vibration tests, sensors that measure acceleration are mainly used - accelerometers, but it is also possible to use sensors that measure other quantities.

By default, at the first start, the channels are named according to the device name and channel number, therefore, in the channel name, you must specify the type of sensor and its serial number, since the channel name appears in the reports. measuring acceleration - accelerometers, but it is also possible to use sensors measuring other quantities.

By default, at the first start, the channels are named according to the device name and channel number, therefore, in the channel name, you must specify the type of sensor and its serial number, since the channel name appears in the reports.

***Note:**. It is useful to logically associate the channel name with the location of the sensor.*

***<u>Attention!</u>** It is important to note that any change in the sensors parameters and their location on the specimen to be tested requires a new Pre-Test, since the amplitude-frequency response of the measuring channel depends on the installation point.*

It is possible that the sensors will have to be rearranged more than once before the start of the tests in search of a point at which the AFR has the most uniform appearance.

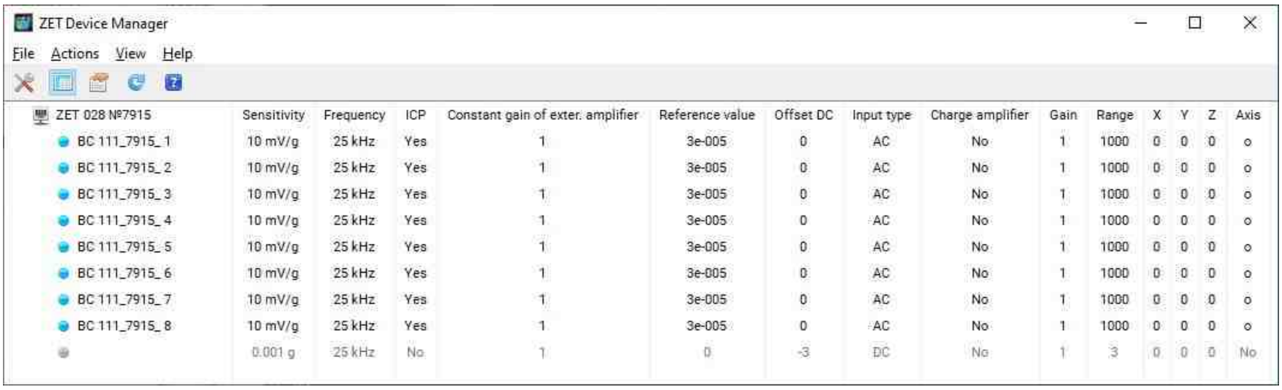
Pre-Test must be carried out every time after any changes, even if the installation point remains the same, and the method of attaching the sensor has changed (wax, plasticine, tape, glue, etc.).

Program operation principles .....

Program Operation Principles

To go to the [**ZET Device Manager**]() window, press the *Hardware and inputs* button on the VCS panel. The ZET Device Manager window will appear on the monitor screen ([*Fig. 7.1*]()).

The program window displays both the identifiers of the VCS devices connected to the computer and the identifiers of the measuring channels corresponding to these devices..



ZET 028 №7915	Sensitivity	Frequency	ICP	Constant gain of exter. amplifier	Reference value	Offset DC	Input type	Charge amplifier	Gain	Range	X	Y	Z	Axis
BC 111_7915_1	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_2	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_3	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_4	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_5	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_6	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_7	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_8	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
	0.001 g	25 kHz	No	1	0	-3	DC	No	1	3	0	0	0	No

Fig. 7.1 ZET Device Manager window

To open and hide measuring channels from the list by activating the symbols "" and "" respectively.

If necessary, you can switch the Device Manager window to a detailed view of channel properties, by activating the symbol "" located on the window panel.

Set sampling frequency .....

Set sampling frequency

In the "[**ZET Device Manager**]()" program window ([*Fig. 7.2*]()) activate the ID corresponding to the controller and select the "Sampling frequency" tab in the "Properties" window.

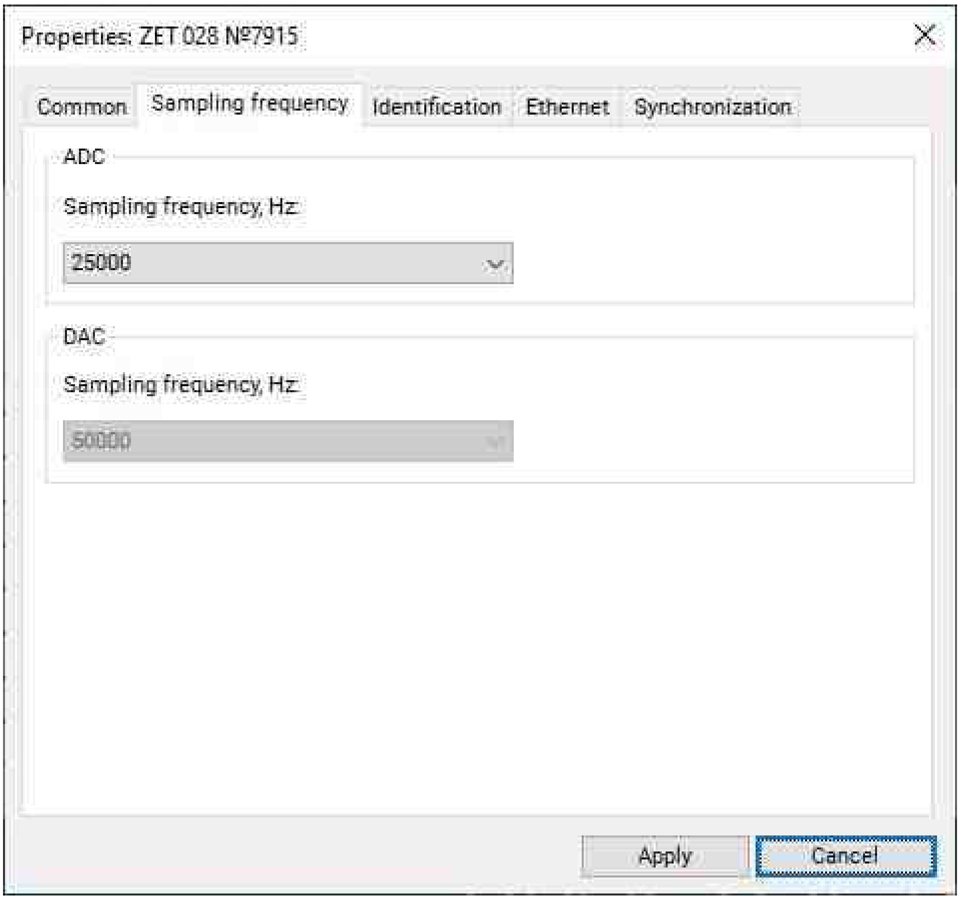


Fig. 7.2 Sampling frequency tab of the "Properties" window

Set the sampling frequency for the controller inputs, for which in the "ADC" field activate the pointer to the drop-down list and select the desired sampling frequency from the list, while the sampling frequency in the "DAC" field will be set automatically by the program.

To save the changes made activate the "Apply" button to exit the window without making changes activate the "Cancel" button.

Note: *For all controllers involved in the VCS, the sampling* frequencys *must be set the same*

The choice of the sampling frequency of the controller depends on the tasks pursued during vibration tests and the type of Shaker used:

- "5 kHz" – provides operation in the frequency range up to 2 kHz and is used if it is necessary to form shocks lasting more than 30 ms;
- "25 kHz" – provides operation in the frequency range up to 10 kHz. This sampling frequency value is set by default and is suitable for most vibration testing options.

- "50 kHz" – provides operation in the frequency range up to 20 kHz and is used when it is necessary to conduct tests in the field of high frequencies..

Set synchronization by PTP[5] protocol

In the "**ZET Device Manager**" program window (*Fig. 7.3*) activate the ID corresponding to the controller and select the "Properties" select the "Synchronization" tab.

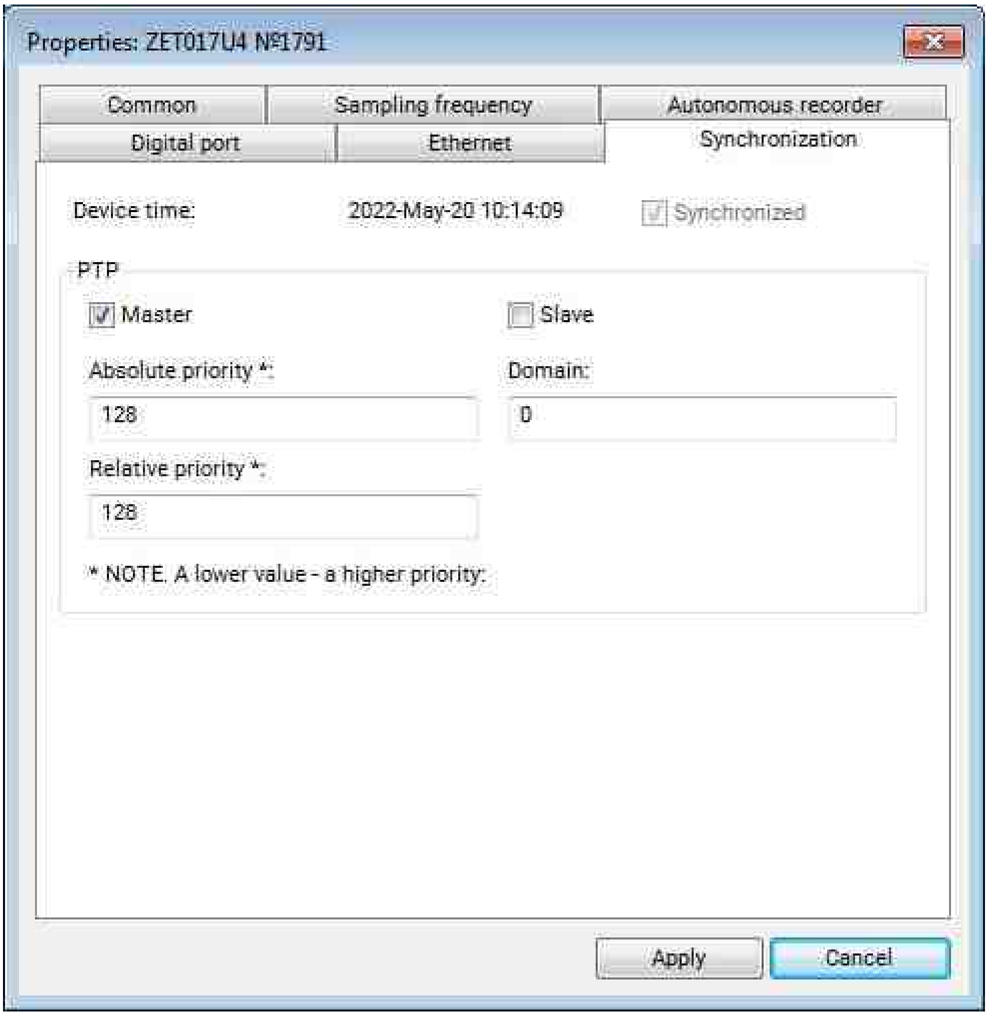


Fig. 7.3 Synchronization tab of the "Properties" window

Set the "Master" flag for the controller that will be used as a synchronization wizard using the RTR protocol, and set the "Slave" flag for controllers that will adapt to the synchronization wizard.

Note: *The synchronization source in the controllers selected as synchronization masters is the built-in quartz oscillator.*

In the "Domain" field (valid value from 0 to 127), specify the number of the group for which (in the Ethernet subnet) synchronization via the RTR protocol between devices will be organized. In this way, it is possible to organize several independently synchronized groups in an Ethernet subnet.

Attention! *Specify the same values in the "Domain" field for devices that are combined into a common synchronization group using the RTR protocol*

In the "Absolute priority" and "Relative priority" fields, if necessary, set the priorities (allowed value from 0 to 255) that will be taken into account by the PTP protocol when choosing a synchronization master if there are several masters.

PTP synchronization is provided for devices adjusted to work in a single Ethernet subnet

Set up the measuring channels of the controllers of the ZET 02x and ZET 03x series .....

Set up the measuring channels of the controllers of the ZET 02x and ZET 03x series

In the "**ZET Device Manager**" program window (*Fig. 7.1*) activate the ID corresponding to the controller. In the Properties window, setting of the measuring channel according to the datasheet for the primary converter and the current test conditions (*Fig. 7.4*).

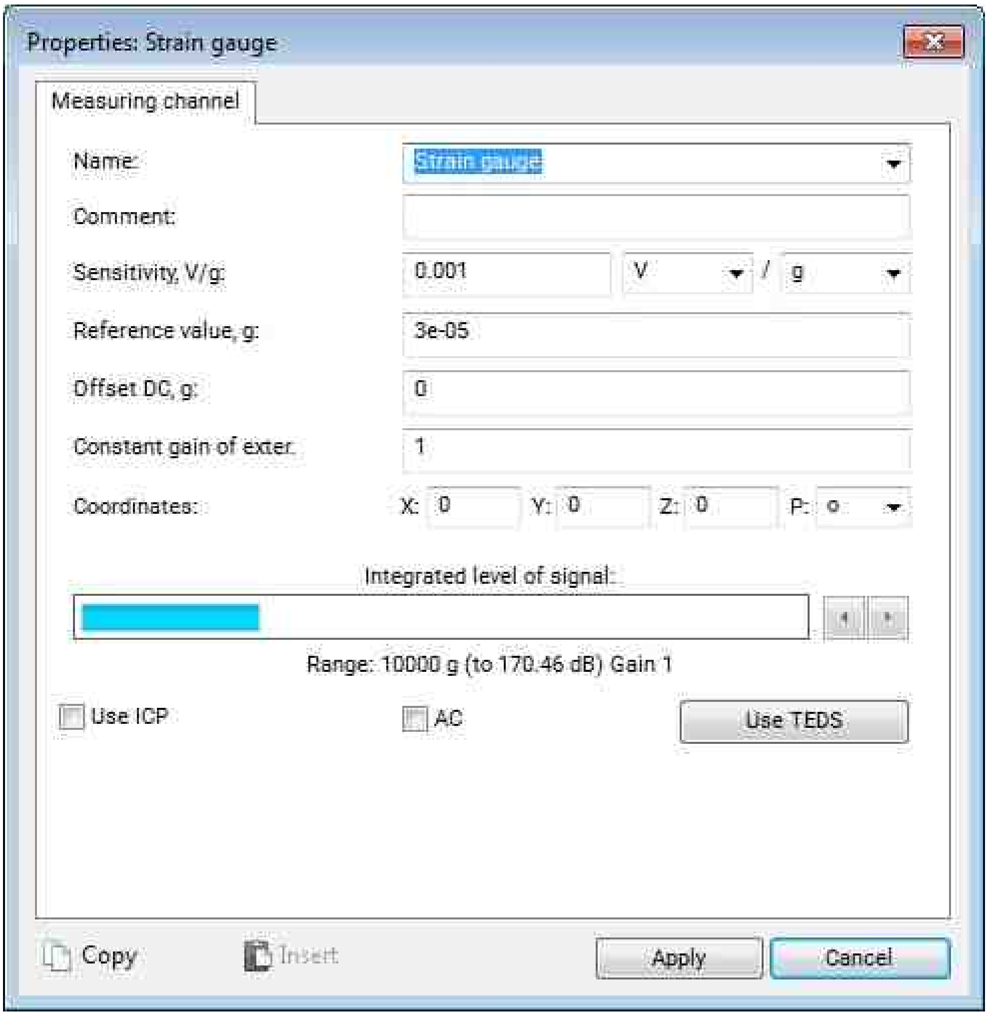


Fig. 7.4 Measuring channel tab of the "Properties" window

In the *Name* field, enter the name of the connected sensor or select it from the drop-down list if its parameters were entered in the sensor database previously.

Note: *when selecting the sensor type from the drop-down list, the parameter values in the "Properties" window will be filled in automatically, however, the sensitivity value should be adjusted in accordance with the sensor verification certificate, as well as the name of the measuring channel should be changed to a convenient one for the operator.*

In the *Sensitivity* field, enter the sensor sensitivity value specified in the verification certificate of this sensor and the sensor's units, or select them from the drop-down list (all frequently used units are listed there).

Attention! *To perform vibration tests, you need measuring channels which are capable of recording Acceleration and set to "g" or "m/s^2" units.*

Attention! *when configuring, first of all, pay attention to the correct setting of the sensitivity of the measuring channels, especially for the channels involved in feedback (status "Control"), since an error in the sensitivity value will lead to a corresponding error in the magnitude of the acceleration generated on the shaker.*

Note: *for testing for sinusoidal vibration in the low frequency region, it is allowed to use a displacement sensor as a feedback channel in this case, this measuring channel must be set to units of measurement "mm".*

In the *Reference value* field, enter the value corresponding to the 0 dB level. For the units in the list, the reference value is set automatically according to GOST.

In the *Offset DC*, enter a constant value for the channel. Enter the offset only after you have set and saved the sensitivity.

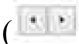
Attention! *change the parameter "Amplification-attenuation coefficient of the external amplifier" only when using an external amplifier with a gain other than one.*

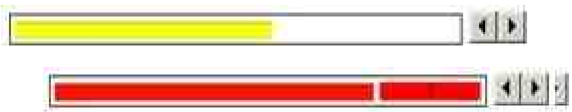
In the *Coordinates* fields, enter the coordinates of the primary converter relative to the shaker table, vibration axis direction according to the vibration direction of the mobile part of the shaker.

Note: *setting the coordinates and direction of the axes is necessary only for multipoint placement of sensors in order to use the VCS functionality for three-dimensional visualization of the vibration forms of the test object.*

Note: *for cases when the "Shaker Validation" program is used in parallel during the testing process, it is necessary to indicate the directions of the axes recorded by the vibration transducers. This parameter is used by the program "Shaker Validation" to take into account the directions of the sensors when calculating both the transverse component and the magnitude of the uneven distribution on the table of the shaker.As a rule, the vertical direction is used as the direction of vibration testing, the horizontal and inclined direction –*

orthogonal to the vertical direction of the axis – transverse directions to the axis of vibration testing.

Scale "Integral signal level" (*Fig. 7.5*) shows the ratio of the current signal level to the maximum possible value specified below in the "Range" line and is equipped with buttons on the right () to change the amplification-attenuation coefficient. Available amplification-attenuation coefficient can be set individually for each measuring channel.



Operating range Overload

Fig. 7.5 Integral signal level indicator

Signal strength indicator (*Fig. 7.5*) allows the user to quickly assess the quality of selection, coordination and sensitivity settings of the elements that make up the measuring channel selected in the program and thereby exclude processing both in case of overload and in the absence of a signal in the selected measuring channel.

Two-thirds of the signal level indicator field is reserved for a level not exceeding the maximum allowable level. The colored rectangle filling the background area of the indicator shows by its color and size the ratio of the registered signal (for a period of 0.1 seconds) to the maximum possible one. The larger the signal in the channel, the wider the color rectangle and the color shade is closer to red. When the maximum permissible signal level is exceeded, the indicator is filled with red. When the overload on the measuring channel ceases to be registered, the indicator area located on the right will remain red until the user resets the overload indication (fixed on the channel) by activating the overload zone of the left "mouse" button.

The value "Range" is determined by the maximum measured voltage at the input of the VCS controller (10 volts), the sensitivity of the measuring channel, as well as the parameters "Constant gain of exter. amplifier" and "Integral signal level".

Using the amplification-attenuation coefficient change buttons, the recorded acceleration range should be matched with the maximum acceleration range required for testing. The ranges are considered consistent when the recorded acceleration range of the measuring channel (the value "Range" under the integral level scale) exceeds the maximum acceleration range for the planned test from 5 to 50 times.

For the sensors requiring external ICP power, check the *Use ICP* option.

Note: *we recommend that when working with VCS, always activate the "AC" parameter (digital high-pass filter), which removes the constant component from the recorded signal, while setting the value for the "Offset parameter. comp." does not make sense (you can not specify).*

By activating the *AC* parameter, you apply a high-pass filter to the signal recorded in the measuring channel at the software level in all operation modes, in order to exclude the constant component from the signal.

Attention! *If you enable the AC parameter in one of the device channels, the signal phase will be shifted in this channel relative to other device channels, where this parameter is disabled, since a high-pass filter with 0.5 Hz cutoff frequency is used. In cases, where several measuring channels are involved, it is recommended to set the same AC parameter value for these channels.*

If a sensor supporting the TEDS format is connected to the input of the VCS controller, activating the "Use TEDS" panel will read the parameter values from the connected sensor and automatically enter them in the "Properties" window.

When connecting a strain-gauge to the input of the VCS controller, it is necessary to activate the "1/4 bridge circuit" parameter, after which the "..." panel becomes available for activation.

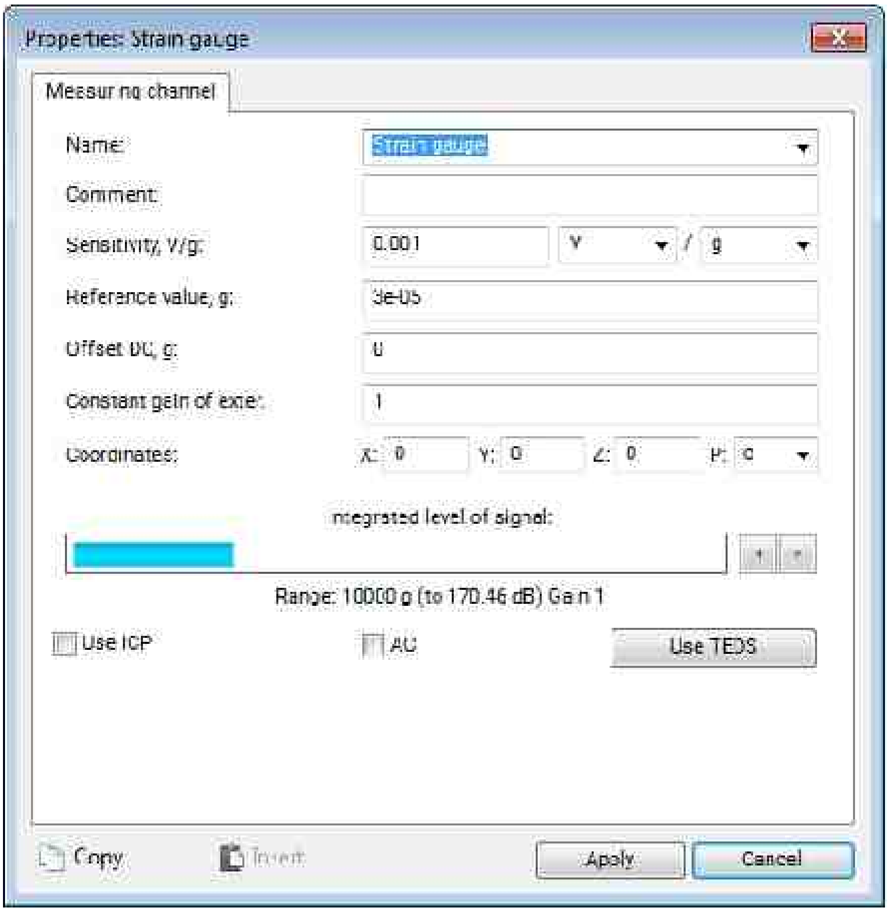


Fig. 7.6 The "Properties" window when connecting a strain-gauge

Activation of the panel "..." allows you to go to the window "Setting parameters of the bridge circuit" (*Fig. 7.7*)

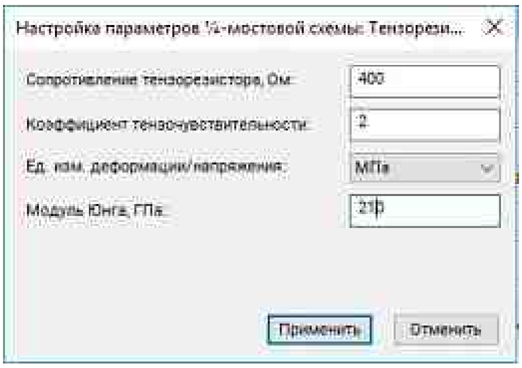


Fig. 7.7 Window "Setting parameters for the j bridge circuit"

For the parameters "Resistance of the strain-gauge" and "Coefficient of strain sensitivity", the values corresponding to the connected strain-gauge are set.

The choice of measurement units (microns/MPa, kPa, MPa or kgf/mm^2) from the list determines the type of recorded physical quantity on this measuring channel.

For the parameter "Young's Modulus", the value of the Young's modulus should be set for the material of the specimen to be tested on which the strain-gauge is glued.

Note: *when registering relative deformation (microns/m), setting the parameter "Young's modulus" is not required*

Set up the measuring channels of controllers of the ZET 058 series .....

Set up the measuring channels of controllers of the ZET 058 series

In the "**ZET Device Manager**" program window (*Fig. 7.1*)  activate the ID corresponding to the controller. In the Properties window, the setting of the measuring channel according to the datasheet for the primary converter and the current test conditions (*Fig. 7.8*).

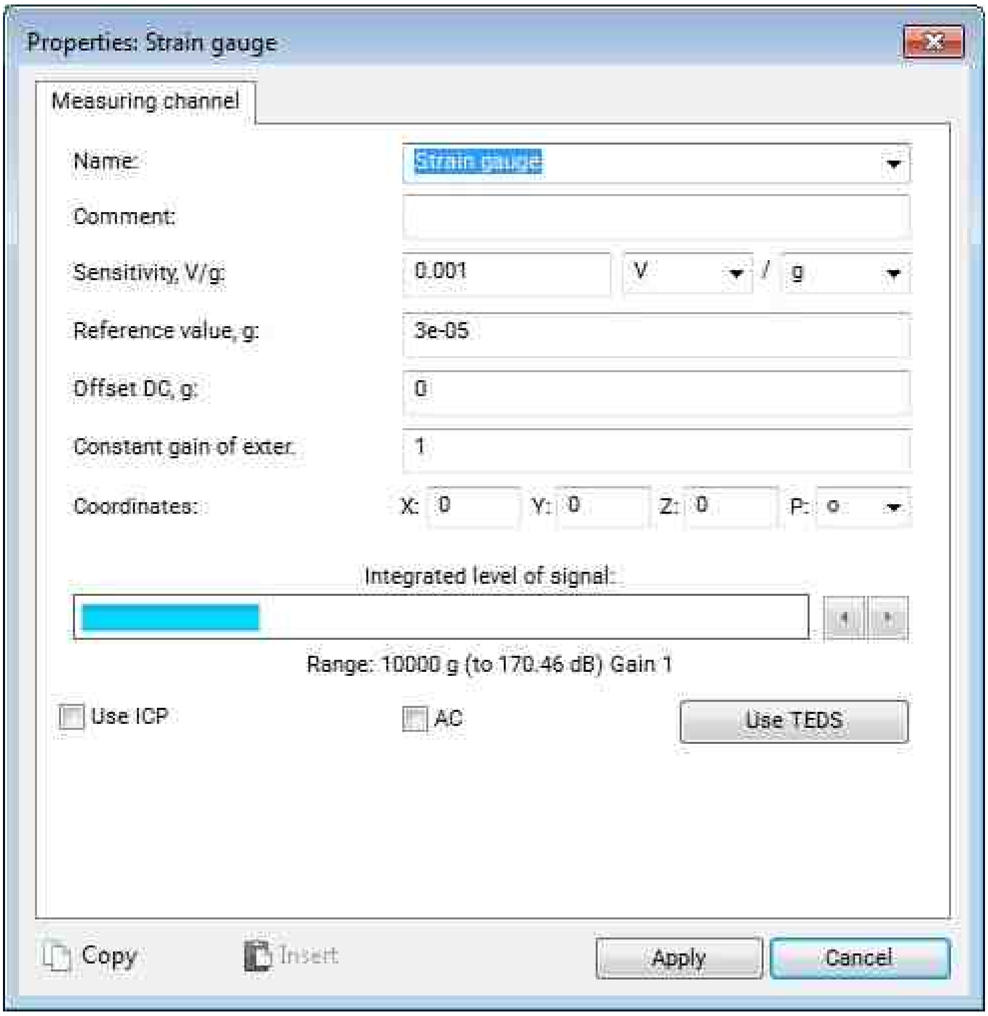


Fig. 7.8 Measuring channel tab of the "Properties" window

Note: *The settings of the measuring channels are adjusted individually for each measuring channel*

Attention! *The settings of the measuring channels are stored in the memory of the strain station. When first connected to a computer, The settings of the measuring channels are determined by the factory (initializing) settings*

Note: *Assigning unique names to measuring channels, including the types of primary converters, provides convenience of identifying measuring channels during subsequent measurements using the ZETLAB software.*

If a sensor is connected to the measuring channel of the controller, information about which has already been added to the database, go to the "Name" field and activate the pointer to the drop-down list (*Fig. 7.9*), select the type of sensor to be connected from the list, and the parameter fields of the "Properties" window will be automatically filled in.

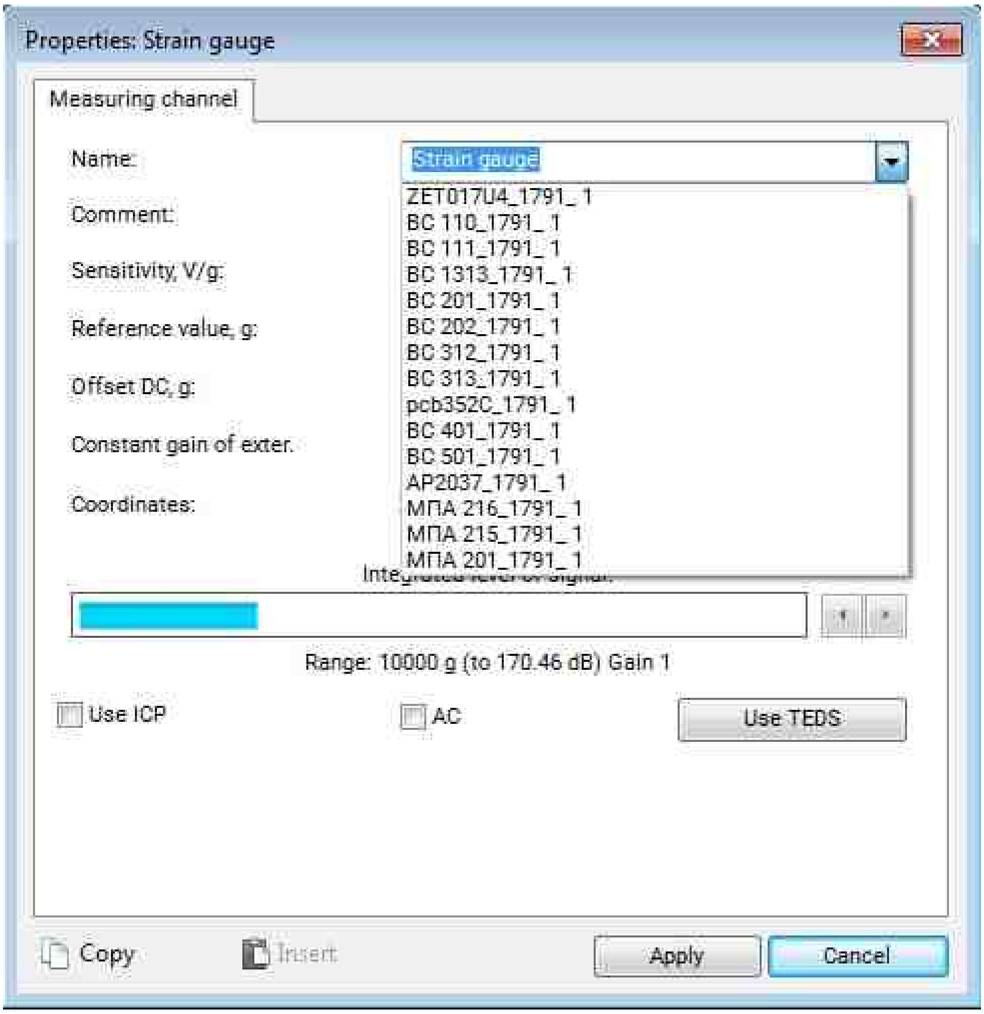


Fig. 7.9 "Properties" window with a list of sensors from the database

Attention! *When selecting the type of sensor to be connected from the "Name" list, the average value for this type of sensors is set in the "Sensitivity" field. It is necessary to manually adjust the value in the "Sensitivity" field so that it corresponds to the value specified in the passport or in the certificate of verification for the sensor.*

If desired, change (by entering from the keyboard) the name of the measuring channel to a convenient one for you.

Attention! *The ZETLAB software allows the assignment of identical names to measuring channels, but their further identification becomes difficult when working with the software*

If a sensor is connected to the measuring channel of the strain station, the type of which is not in the drop-down list, it is necessary to enter the required name of the measuring channel from the keyboard.

Attention! *In the case when you need access to an arbitrary setting for all parameters in the Properties window, in the Name field, select the top row with the identifier "ZET xxxxx" from the list (Fig. 7.9)*

The sensitivity of the measuring channel determines the binding of the recorded values to absolute (certified) values, taking into account the units of measurement. To set the sensitivity of the measuring channel, go to the Properties window.

Using the keyboard in the "Sensitivity" field of the "Properties" window (*Fig. 7.8*) set the required sensitivity value for the measuring channel.

When connecting sensors to the measuring channel of the device, as a rule, the sensitivity value of the sensor is set as the sensitivity value.

Note: *for information about the sensitivity values of the connected sensors, refer to the information provided in the passports or verification certificates.*

To save changes in the "Properties" window, you should activate the "Apply" button.

The most commonly used units of measurement can be selected from the drop-down list (*Fig. 7.10*), by activating the symbol opposite the "Sensitivity" parameter, or manually register the necessary unit of measurement from the keyboard.

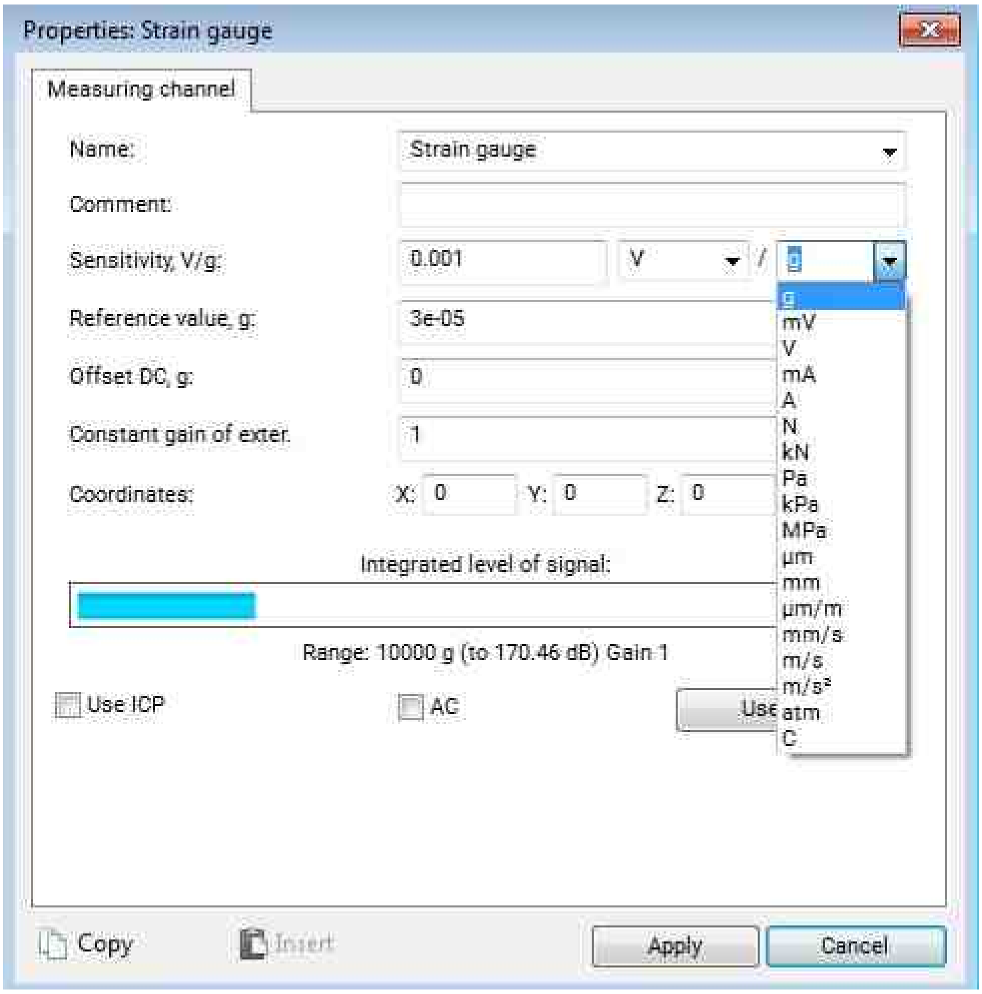


Fig. 7.10 "Properties" window with a list of units of change

Note: *if you need to specify the units of measurement, refer to the information provided in the passport for the connected sensor.*

The reference value is used to recalculate the values recorded in the measuring channel to the dB scale.

Using the keyboard in the "Reference value" field of the "Properties" window (Fig. 7.8), set the required reference value for the measuring channel.

Note: *when selecting units of measurement from the drop-down list, the corresponding reference value will be set automatically.*

Using the keyboard in the "Offset field. comp." windows "Properties" (Fig. 7.8), set the required offset value for the measuring channel.

When connecting sensors using matching amplifiers, their gain factors must be taken into account.

Using the keyboard in the "Constant gain of exter. amplifier" field of the "Properties" window (*Fig. 7.8*), set the values of the constant gain of exter. amplifier.

Note: *in the absence of external amplifiers in the field "Constant gain of exter. amplifier" the value "1" is set.*

Integral signal level indicator of the "Properties" window (*Fig. 7.8*), allows you to estimate the recorded signal level via the measuring channel (*Fig. 7.11*), . The more the indicator scale is painted over (it is painted from left to right) the higher the level of the recorded values of the signal through the measuring channel.

Attention! *Complete coloring of the indicator scale should be avoided (Fig. 7.11), which means an overload of the measuring channel, the consequence of which is the occurrence of non-linear distortion, leading to unreliable measurement results.*

Operating range Overload

Fig. 7.11 Integral signal level indicator

In the Strain-gauge station, individually for each measuring channel, the following amplification-attenuation coefficient values can be set: 1; 10; 100.

If necessary, using symbols  in the "Integral signal level" field, set the desired gain level.

Note: *In the case of a recorded overload on the measuring channel, the gain should be reduced; in the case of a low signal level, it should be increased.*

By activating the *AC* parameter, you apply a high-pass filter to the signal recorded in the measuring channel at the software level in all operation modes, in order to exclude the constant component from the signal.

To balance the strain gauge of the controller connected to the measuring channel in the "Properties" window (Fig. 7.8) necessary activate the "Tenso settings" button, this will open the "Bridge settings" window (Fig. 7.12).

Attention! *Each of the strain-gauge connection schemes requires power supply, therefore, before balancing, the corresponding adjustment of the built-in generator used to power the primary converters must be performed. Rules for setting up the generator are given later in this chapter.*

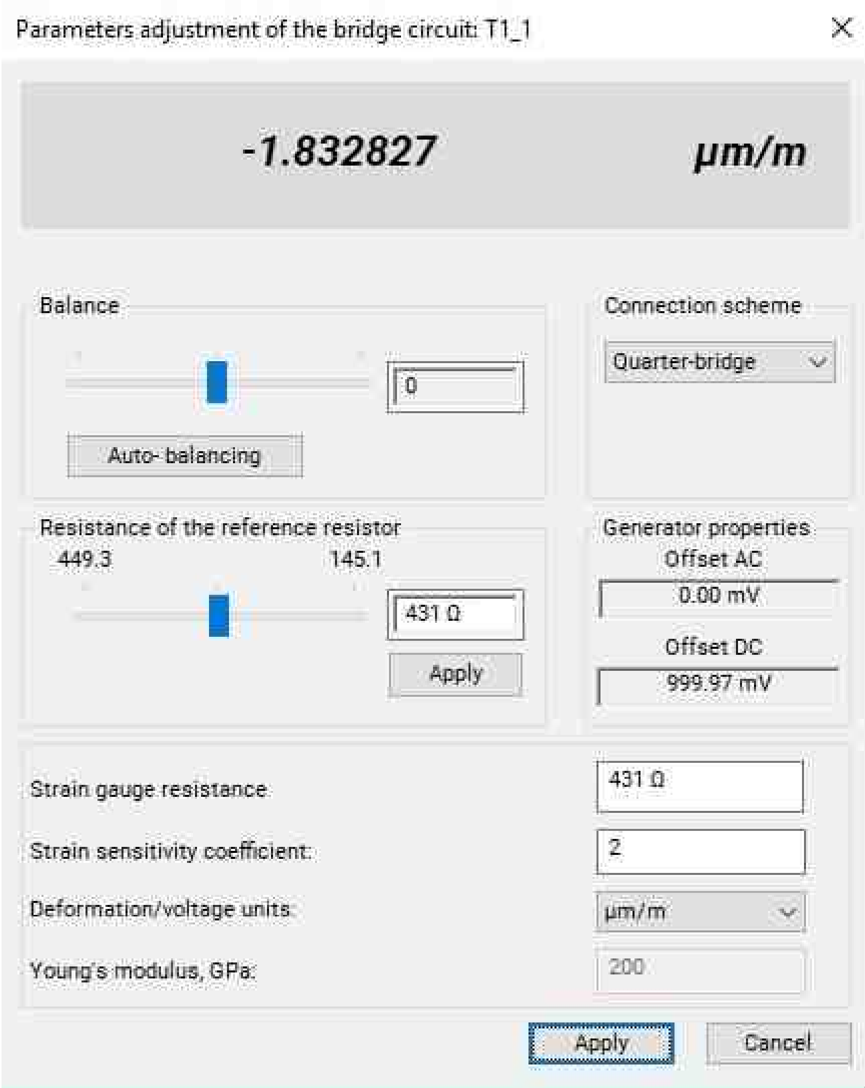


Fig. 7.12 The window "Adjustment bridge circuit parameters"

From the "Connection scheme" drop-down list (Fig. 7.13) select the appropriate connection diagram for the strain gauge:

- Bridge;
- Half-bridge;

- Quarter-bridge.

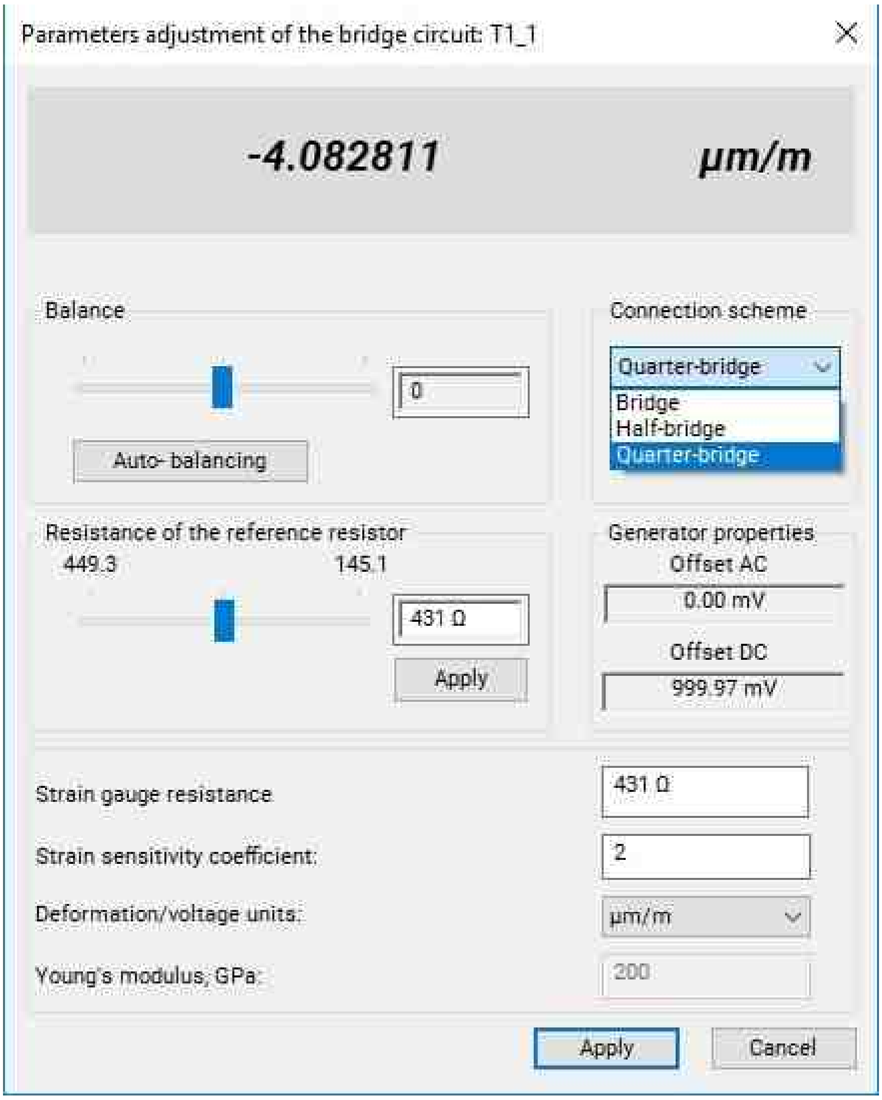


Fig. 7.12 The window "Adjustment bridge circuit parameters"

Note: *if the connection scheme "Quarter-bridge" is selected, it is necessary to set the resistance value of the connected strain gauge in the "Resistance of the quarter-bridge sensor" field (according to the passport data) and activate the "Apply" button.*

To balance the strain gauge , it is necessary activate the "Auto-balancing" button and wait for the end of the balancing process, after which you should apply the changes by activating the "OK" button.

Note: *when changing the value or sign of the supply voltage, it is necessary to perform auto-balancing.*

The units of measurement of the strain-gauge scheme are selected from the drop-down list in the "Settings of parameters of the bridge scheme" window (*Fig. 7.14*).

Note: *when selecting units of measurement other than "µm/m" in the "Young's Modulus" field, it is required to specify the value corresponding to the Young's modulus of the material on which the strain-gauge is glued.*

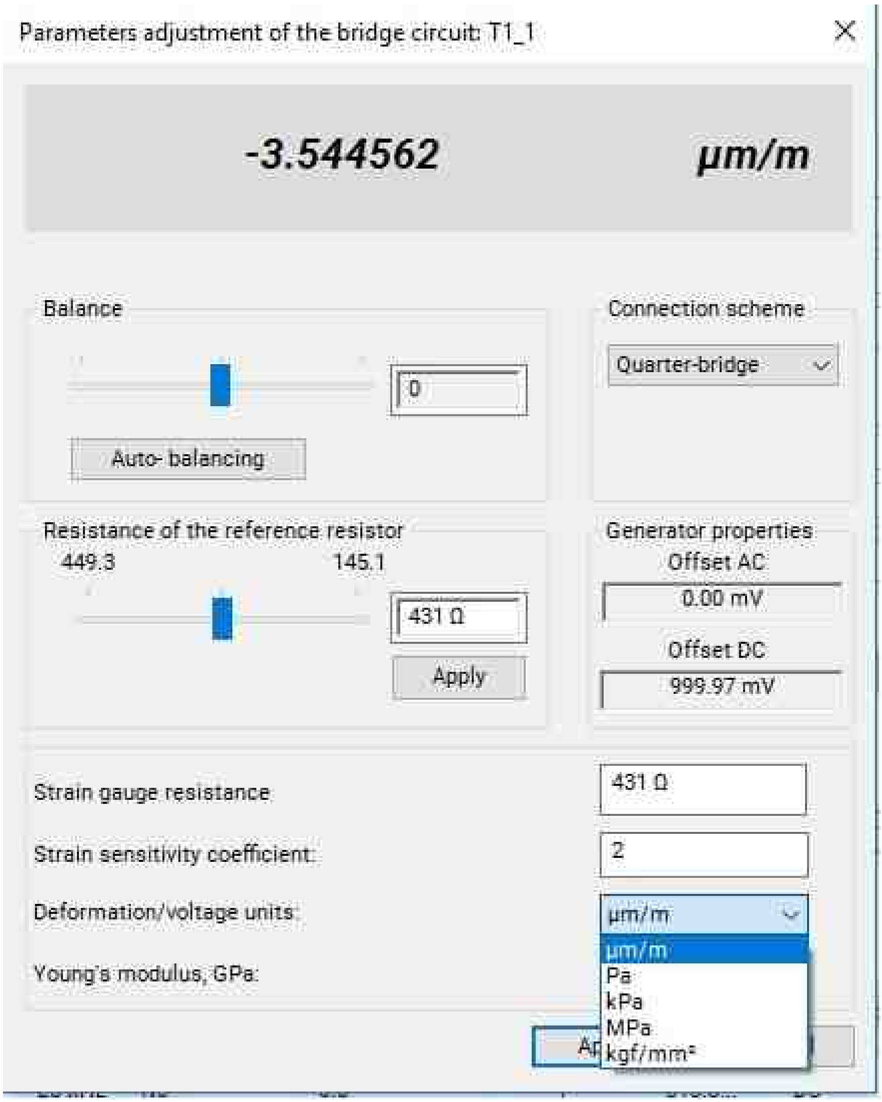


Fig. 7.14 The window "Adjustment bridge circuit parameters"

The ZET 058 controllers provide power to the primary converters with both constant and alternating voltage, due to which they can be used to collect and process signals during static or dynamic measurements.

To turn on the power of the primary converter, it is necessary to open the "Properties" window of the generator channel from the **"Device Manager"** (*Fig. 7.15*).

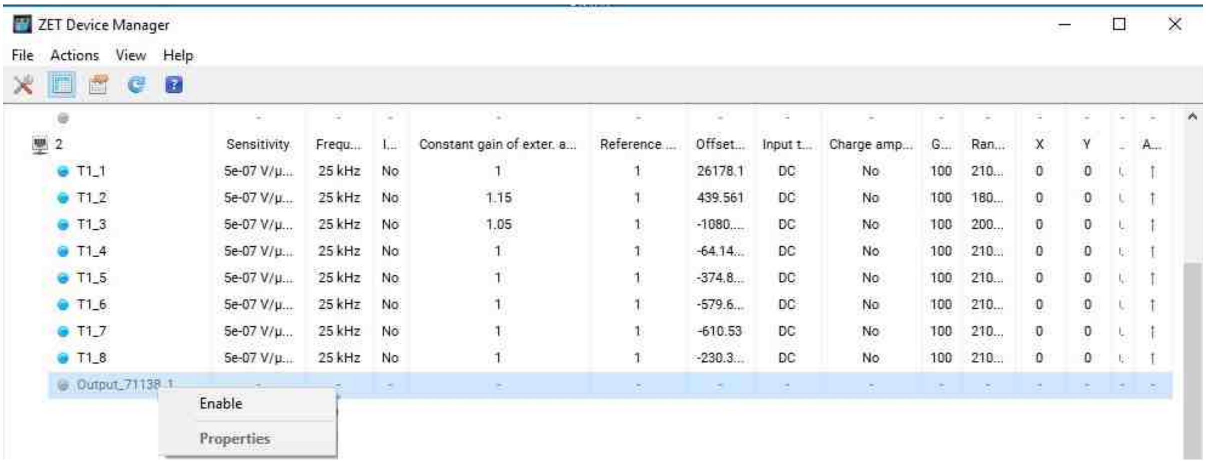


Fig. 7.15 The "Device Manager" window with a drop-down window on a dedicated channel generator

In the "Properties" window that opens, go to the "Sine" tab and set the appropriate power parameters of the primary converter (*Fig. 7.16*).

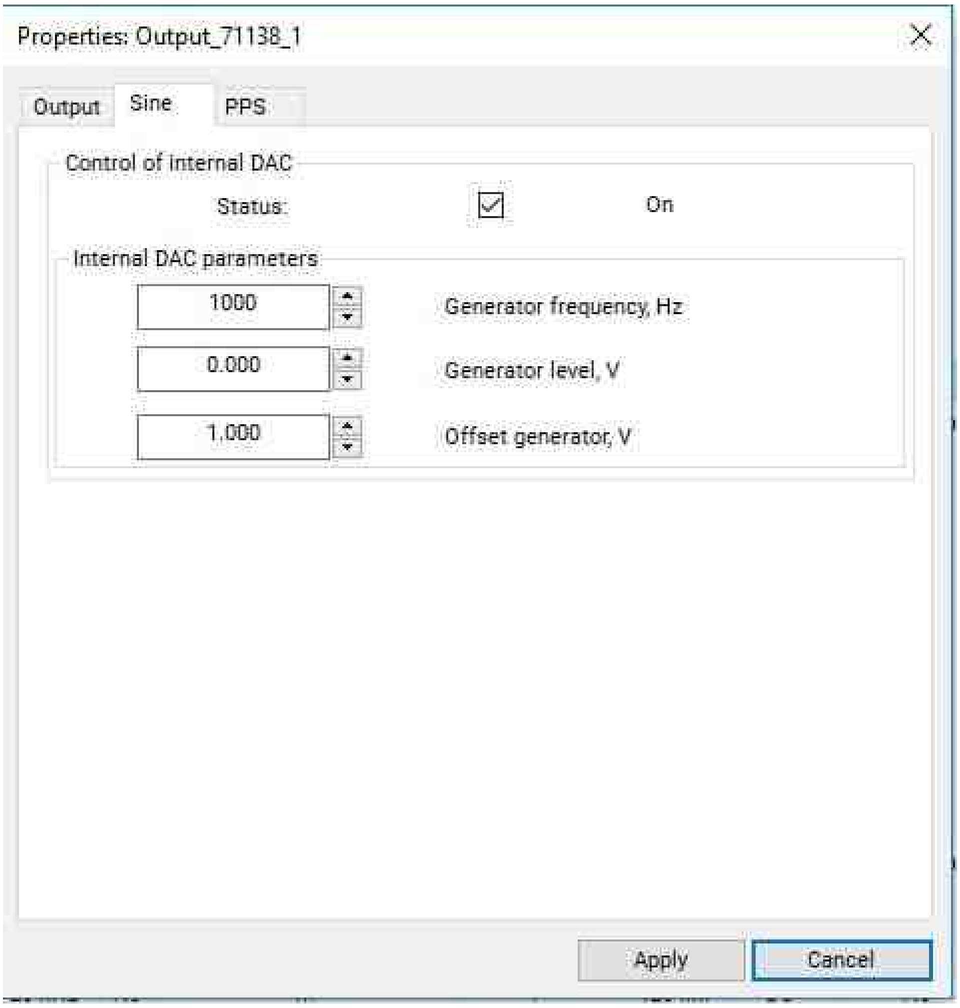


Fig. 7.16 The "Sine" tab of the generator channel

Attention! *It is forbidden to use an alternating voltage to power the j bridge circuit. The RMS value of the current flowing through the resistor should not exceed 5 mA.*

Go to the "Generator" tab and set the "Status" parameter to "Enabled"

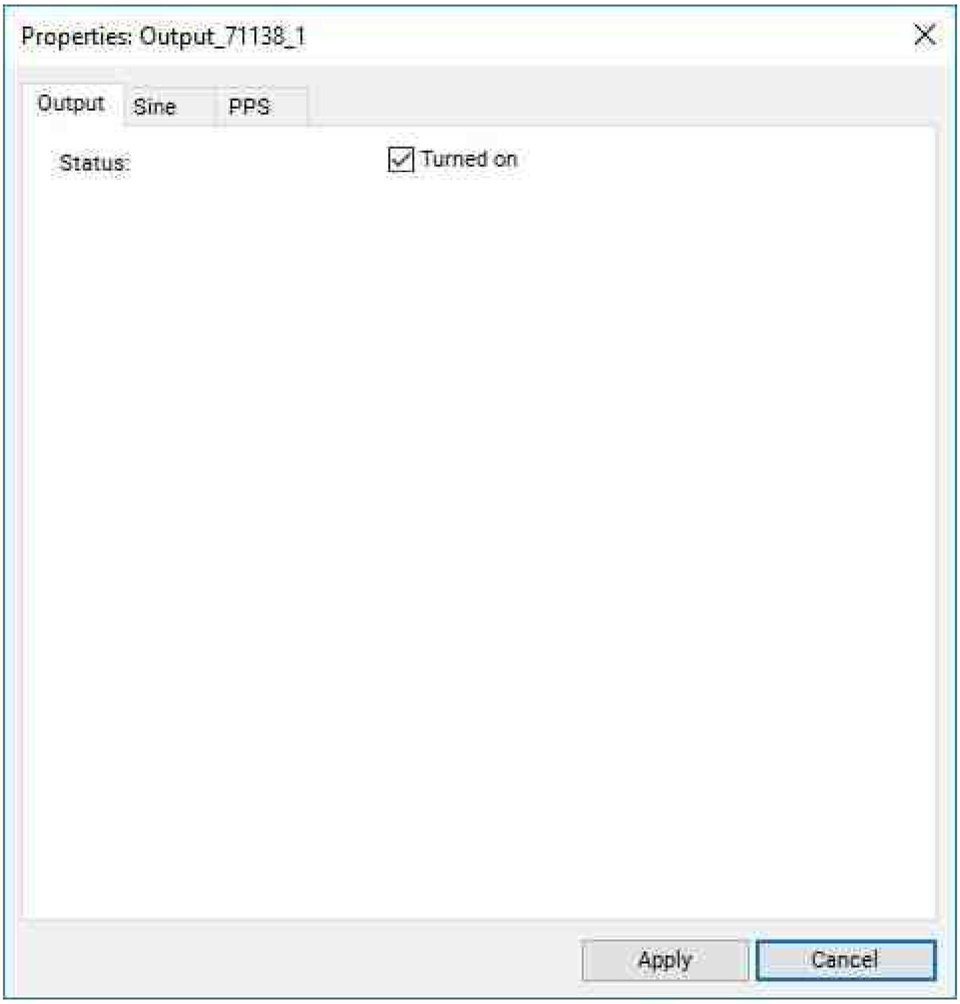


Fig. 7.17 The "Generator" tab of the generator channel

After powering up the primary converters in the "Device Manager" program, the symbol before the name of the generator channel should change color to blue (*Fig. 7.18*).

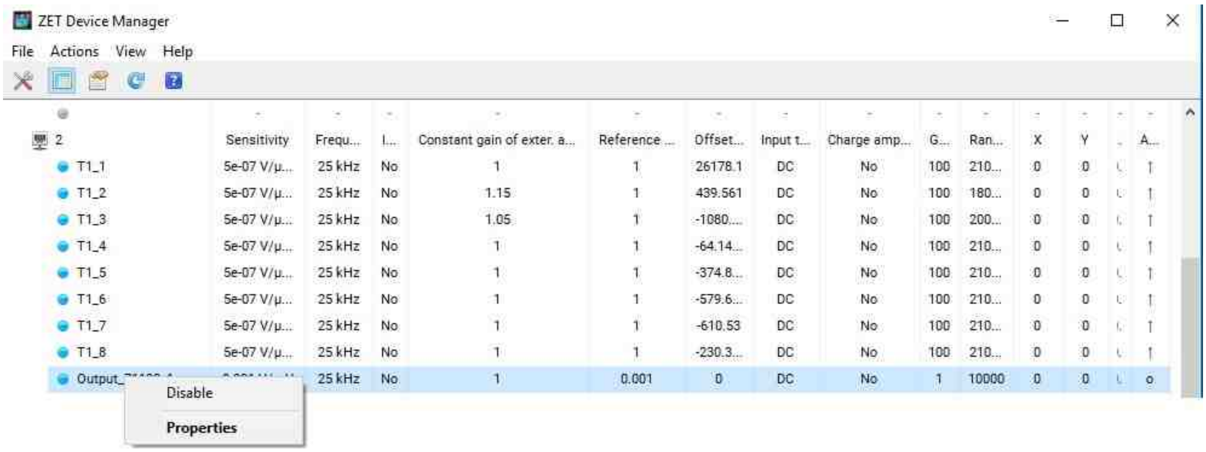


Fig. 7.18 The "Device Manager" program

Examples for the section .....

[Connecting an accelerometer with an ICP]

[Connecting an accelerometer with a charge output]

[Connection of the RF603 laser sensor]

[Connecting a strain-gauge]

[Connection of the ZET 140 force sensor using an AC100 voltage amplifier]

[Connection of the ZET 140 force sensor using an AC100 voltage amplifier and an AC300 attenuator]

Connecting an accelerometer with an ICP .....

Connecting an accelerometer with an ICP

It is required to connect a BC111 model sensor with a sensitivity of 10.1 mV/g to the second input of the VCS controller (assigning the name to the measuring channel "D2")

and coordinate the range of the measuring channel for testing with a maximum acceleration of 100g.

To solve this problem, it is necessary.

Connect the BNC connector of the sensor cable to the second input of the VCS controller.

In the VCS panel activate the Device and Channel Manager program and in the Properties window set the parameters according to the Fig. (Fig. 7.19).

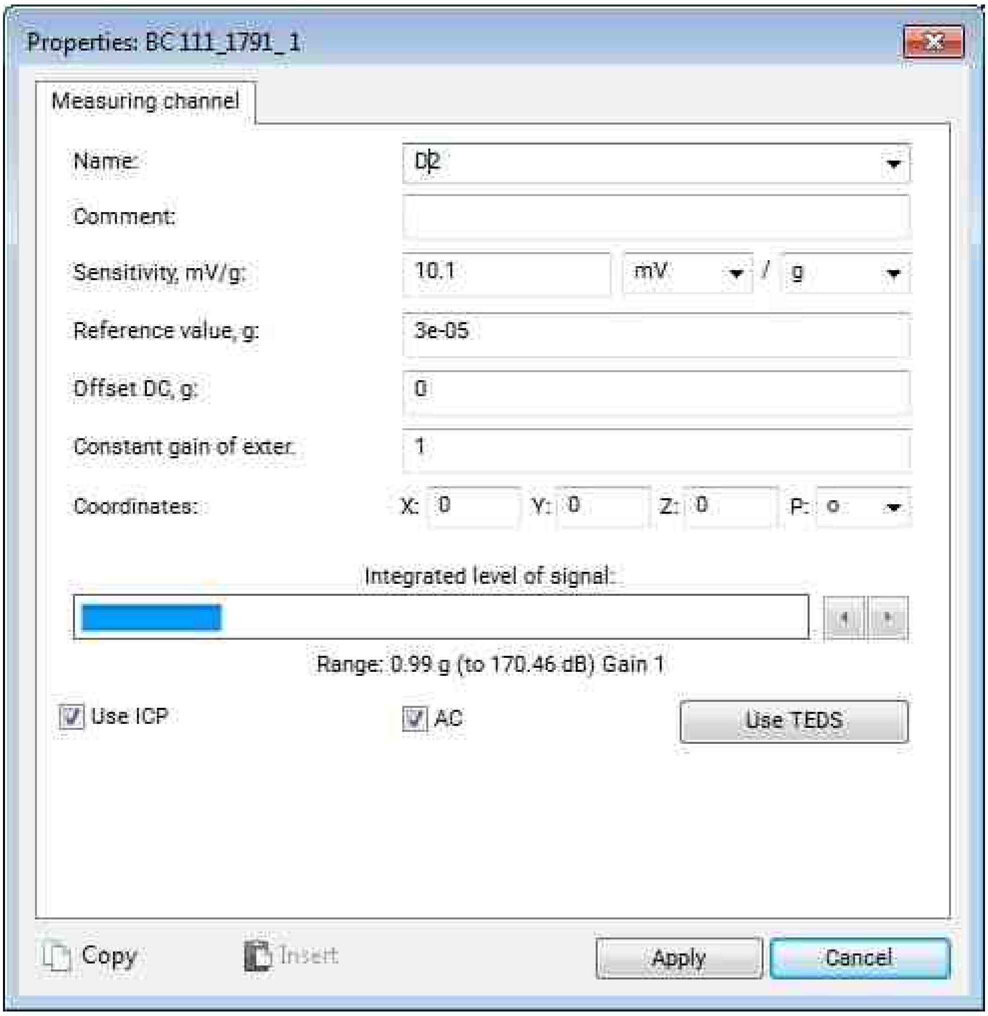


Fig. 7.19 The "Properties" window of the measuring channel

Check the alignment between the measuring channel range (1000g) and the range required for testing (100g).

Changing the gain of the measuring channel is not required because the condition for matching ranges is met: 5 <1000/100<50.

To save the measurement channel settings activate the "Apply" button in the "Properties" window.

Connecting an accelerometer with a charge output .....

Connecting an accelerometer with a charge output

It is required to connect a model B&K 8305 sensor with a sensitivity of 0.12 pC/m/s^2 to the fourth input of the VCS controller by assigning a name to the measuring channel "in_4" and coordinate the range of the measuring channel for testing with a maximum acceleration of 10 g.

To solve this problem, it is necessary.

Connect the BNC connector of the sensor cable to the "Charge" input of the pre-ZET440 amplifier.

Connect (using a BNC-BNC cable) the output of the pre-amplifier with the fourth input of the VCS controller.

Using the buttons on the front panel of the preliminary ZET440 amplifier, set the following parameters: "Gain" to "1"; "HPF" to position "0.1".

In the VCS panel activate the "**ZET Device Manager**" program and in the "Properties" window set the parameters according to the Fig. (*Fig. 7.20*)..

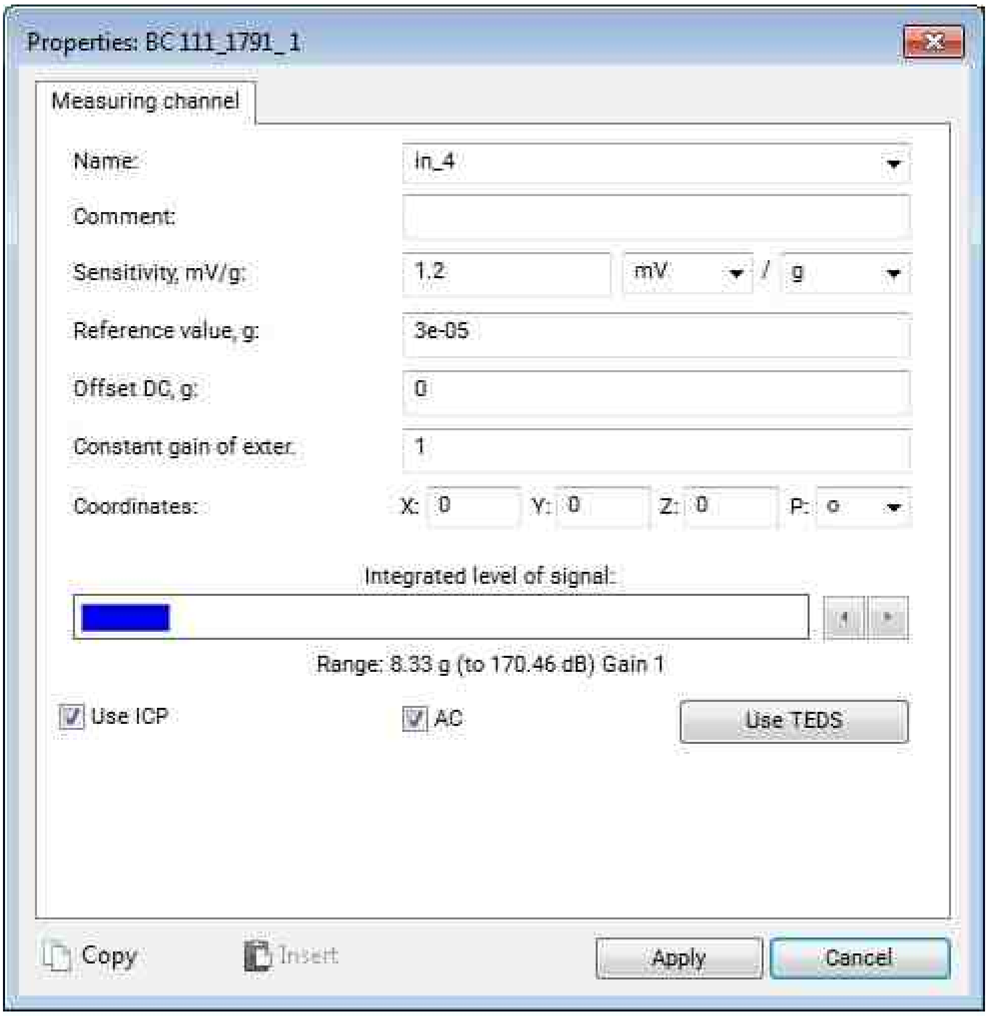


Fig. 7.20 "Properties" window with external amplifier Gain=1

Note: *when connecting sensors with a charge output to the charge input of the pre-ZET 440 amplifier, the following correspondence is provided with pC= mV, thus in the example* $0.12pC/m/s^2 = 1.2pC/g = 1.2mV$.

Check the matching condition between the measuring channel range (8700g) and the range required for testing (10g).

Since the matching condition (5<8700/10<50) is not met, it is necessary to change the "Gain" parameter from the value "1" to the value "100" at the input of the preliminary ZET440 amplifier amplifier (using the button on the front panel), and in the "Properties" window (*Fig. 7.21*) for the parameter "External enter the corresponding value "100".

Make sure that the range matching condition has been reached (5<87/10<50).

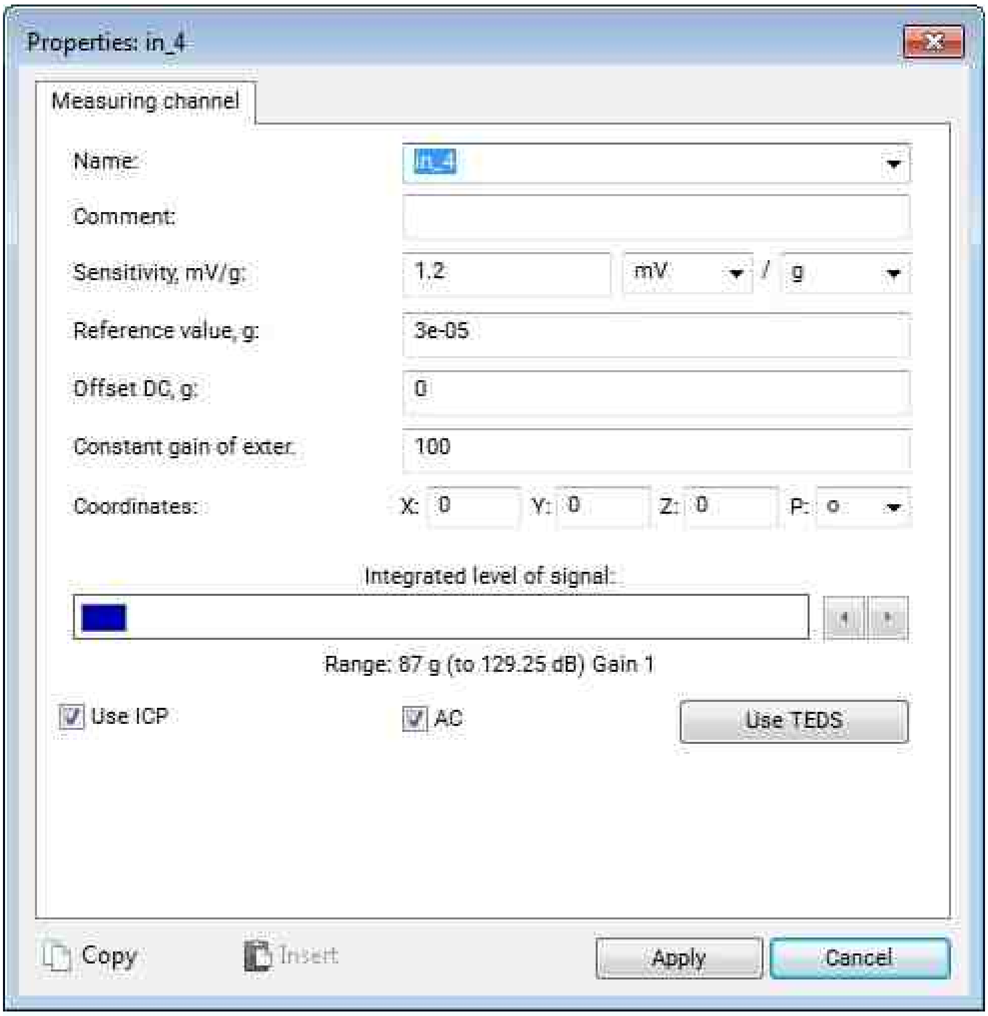


Fig. 7.21 "Properties" window with external amplifier Gain=100

To save the measurement channel settings activate the "Apply" button in the "Properties" window.

Connection of the RF603 laser sensor .....

Example of connecting a laser sensor model RF603

It is required to connect a laser triangulation sensor of the RF603 model to the third input of the VCS controller-60/10-232/ U (the sensor has an analog voltage output and is designed for a base distance of 60 mm and a measuring range of 10 mm) by assigning a name to the measuring channel "k3_rf603" and setting the necessary sensitivity of the measuring channel.

To solve this problem, it is necessary.

Install the RF603 sensor (using a tripod holder) at the measurement site so that the sensor plane with the detecting window is located from the controlled surface at a base distance plus half of the sensor measurement range (60+10/2=65mm).

Connect the cable from the RF603 sensor to the matching device of the A03-69 model.

Connect the power cable to the matching device.

Connect the matching device with the third input of the VCS controller using a BNC-BNC cable.

Calculate the sensor sensitivity value through the ratio of the input voltage range of the measuring channel of the VCS controller (with a single amplification-attenuation coefficient at the input of the VCS controller is "10V") to the measurement range of the RF603 sensor ("10mm"). For example, the sensitivity value will be 10/10 =1V/mm.

Sensitivity values (in units of measurement "V/mm") The corresponding typical measurement ranges of laser displacement sensors are given in ***Table. 7.1***.

Table 7.1 Table of sensitivity values for laser displacement sensors

Sensor measurement range (mm)	Sensitivity value (V/mm)
5	2
10	1
25	0.4
50	0.2
100	0.1
250	0.04

In the VCS panel activate the "**ZET Device Manager**" program and in the "Properties" window set the parameters according to the Fig. (*Fig. 7.22*) and make sure that the value "Range" (under the indicator "Integral signal level") is equal to 10 mm, which corresponds to the measuring range of the RF603 sensor.

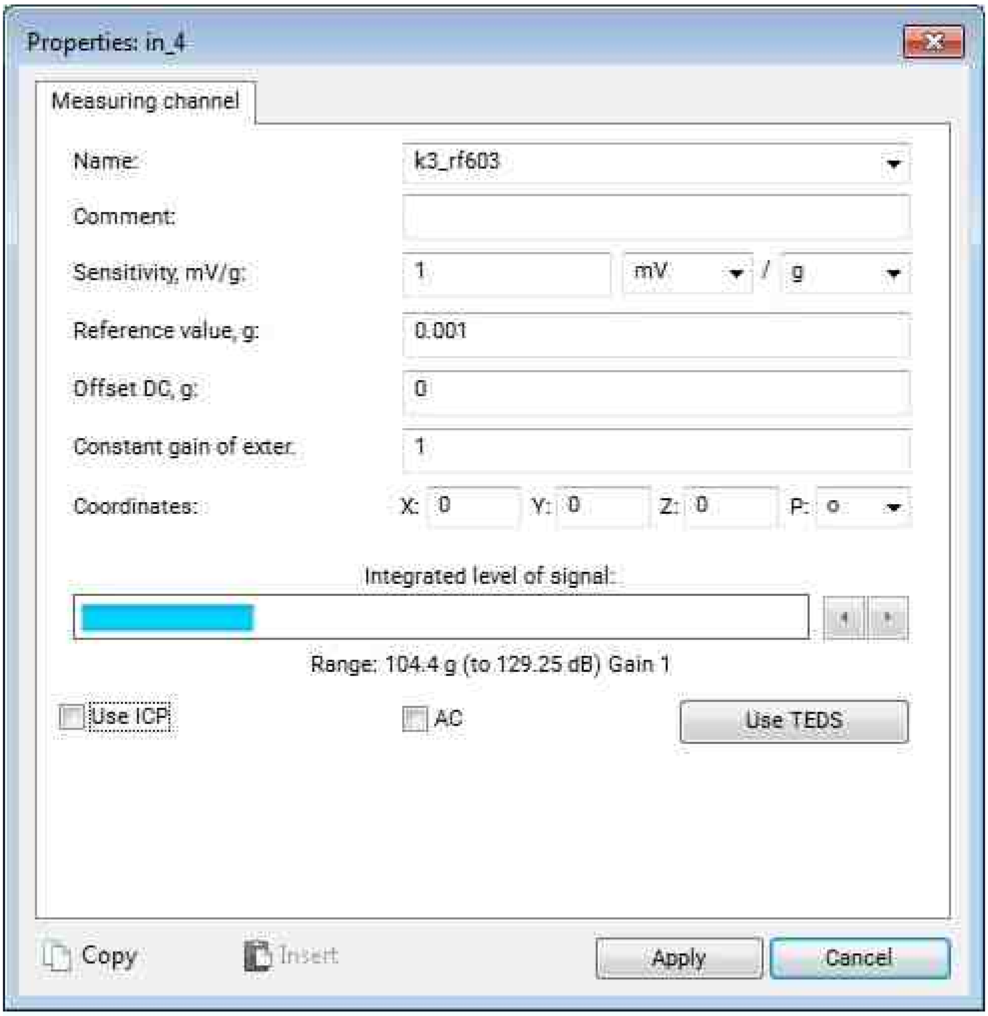


Fig. 7.22 "Properties" window

To save the measurement channel settings activate the "Apply" button in the "Properties" window.

Before taking measurements using the RF603 sensor, it is necessary to check its installation in the central position relative to the boundaries of the measurement range.

Note: *the offset of the sensor position from the central position in the measurement range will limit the measurement range of the displacement. For example: for a sensor with a measuring range of 10 mm at the central position, the measuring range of displacement will* *be ± 5 mm, and in the case of offset of the sensor from the central position by 2 mm, the measuring range of displacement will be ± 3 mm.*

To check the central position of the RF603 sensor, it follows.

In the VCS panel in the "Display" section (*Fig. 7.23*) activate the "Multi-channel oscilloscope" program

Fig. 7.23 The "Display" section of the ZETLAB panel

In the "Multi-channel oscilloscope" program window (*Fig. 7.24*), set the "Number of channels" parameter to "1" and select the measuring channel selection field (*Fig. 7.25*) from the drop-down list to display the name of the measuring channel corresponding to the RF603 sensor.

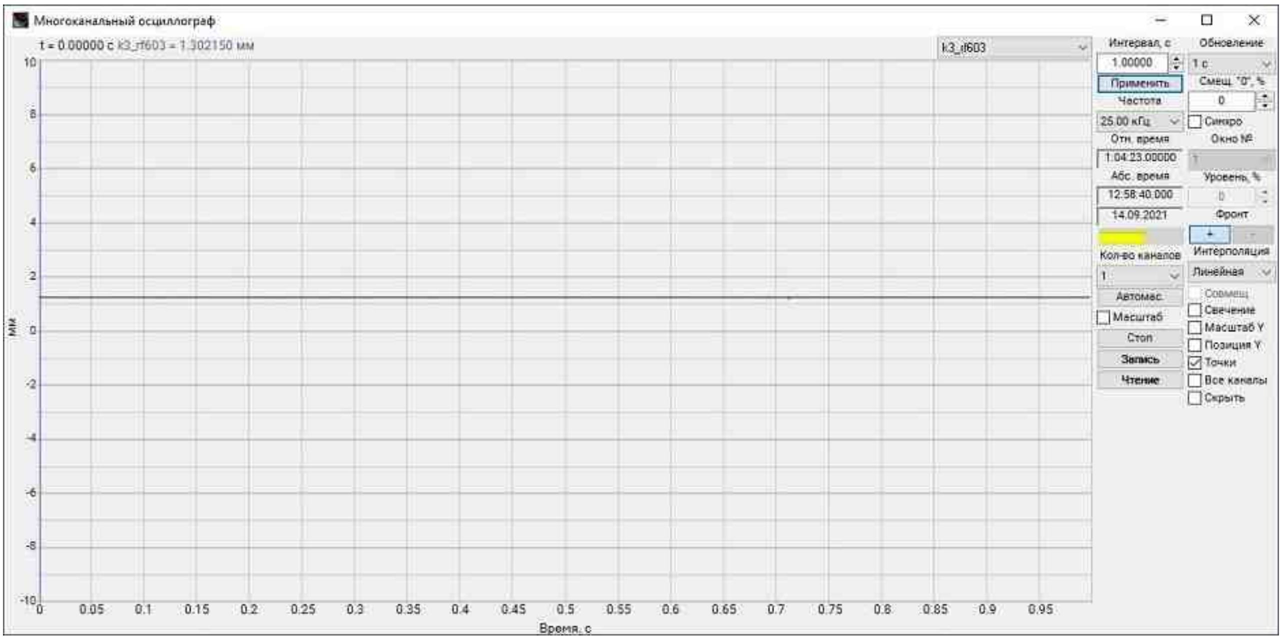


Fig. 7.24 "Multi-channel oscilloscope" program window

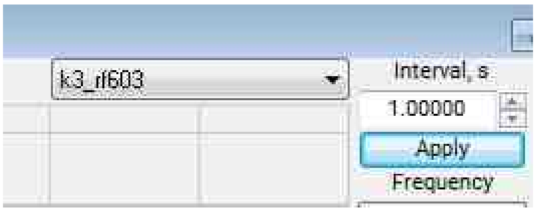


Fig. 7.24 Fragment of the window with the measuring channel selection field

By moving the RF603 sensor to achieve a position at which the oscilloscope readings (Fig. 7.25) will be close to the values of 5 mm, and then fix the sensor in this position.

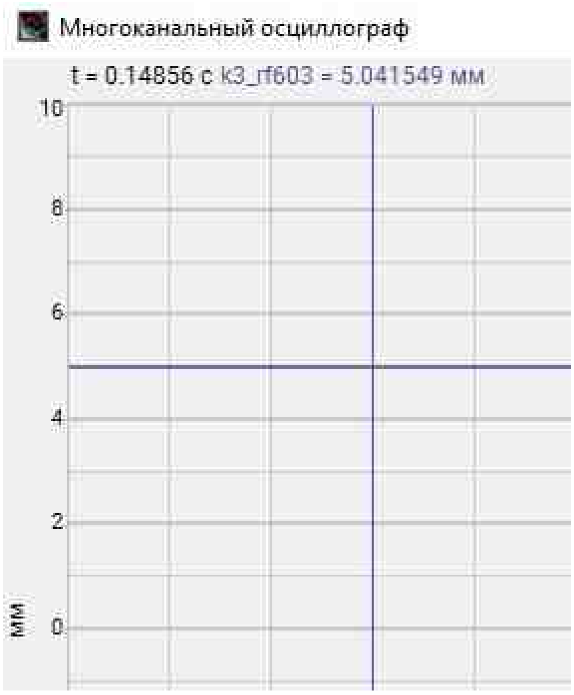


Fig. 7.25 A fragment of the window with the recorded value on the measuring channel

After the sensor is installed in the central position, close the "Multi-channel oscilloscope" program window, and in the "Properties" window (*Fig. 7.26*) activate the "AC" parameter.

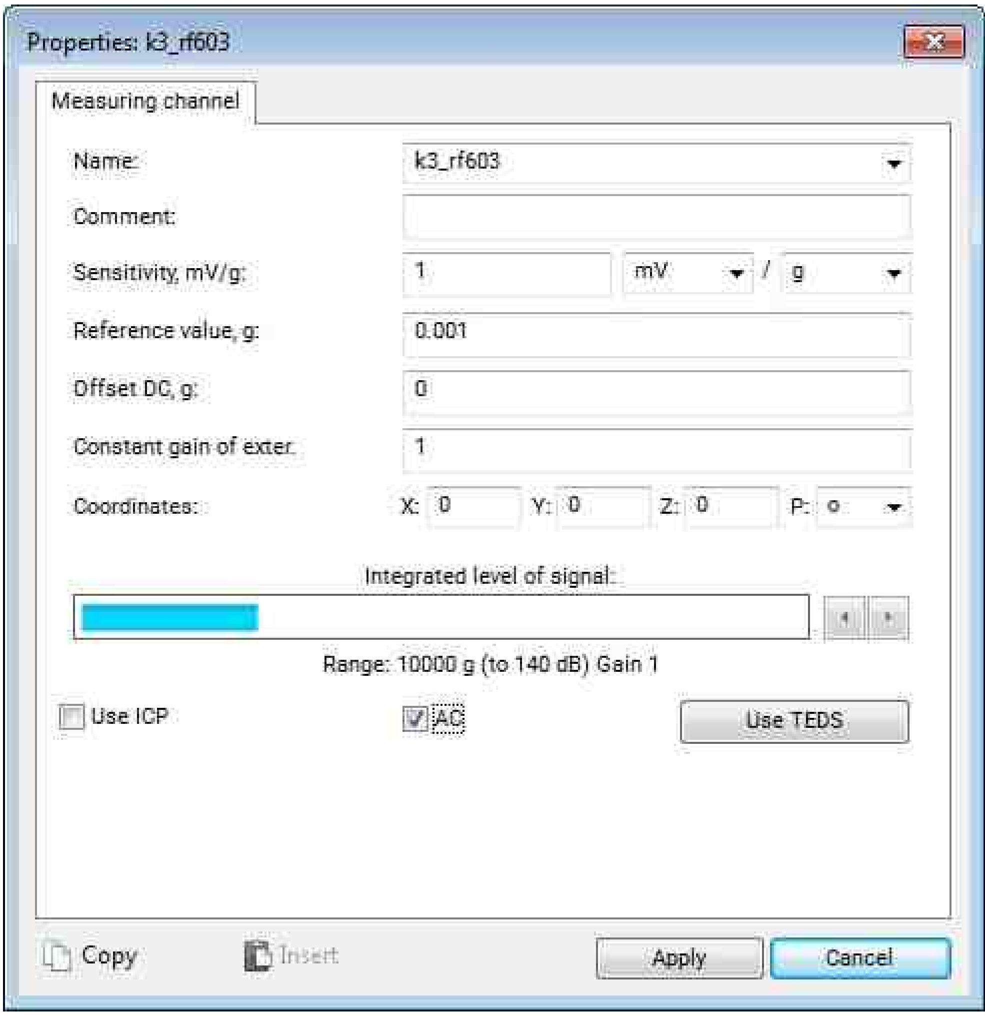


Fig. 7.26 The "Properties" window with the "AC" filter enabled

Connecting a strain gauge .....

In order to measure the relative deformation (in units of µm/m), it is required to connect a strain-gauge with a resistance of 350 Ω and a strain sensitivity coefficient equal to 2 to the first input of the VCS controller by assigning the name to the measuring channel "TR_1".

To solve this problem, it is necessary.

Glue the strain-gauge to the measurement site and the connecting mounting pad next to it so that the terminals of the strain-gauge can be soldered to it.

Solder a two-wire cable to the connecting mounting pad and use the BNC cable adapter to connect it to the first input of the VCS controller.

In the VCS panel activate the "**ZET Device Manager**" program and in the "Properties" window set the parameters enter the name of the measuring channel and activate the "1/4 bridge circuit" parameter (*Fig. 7.27*).

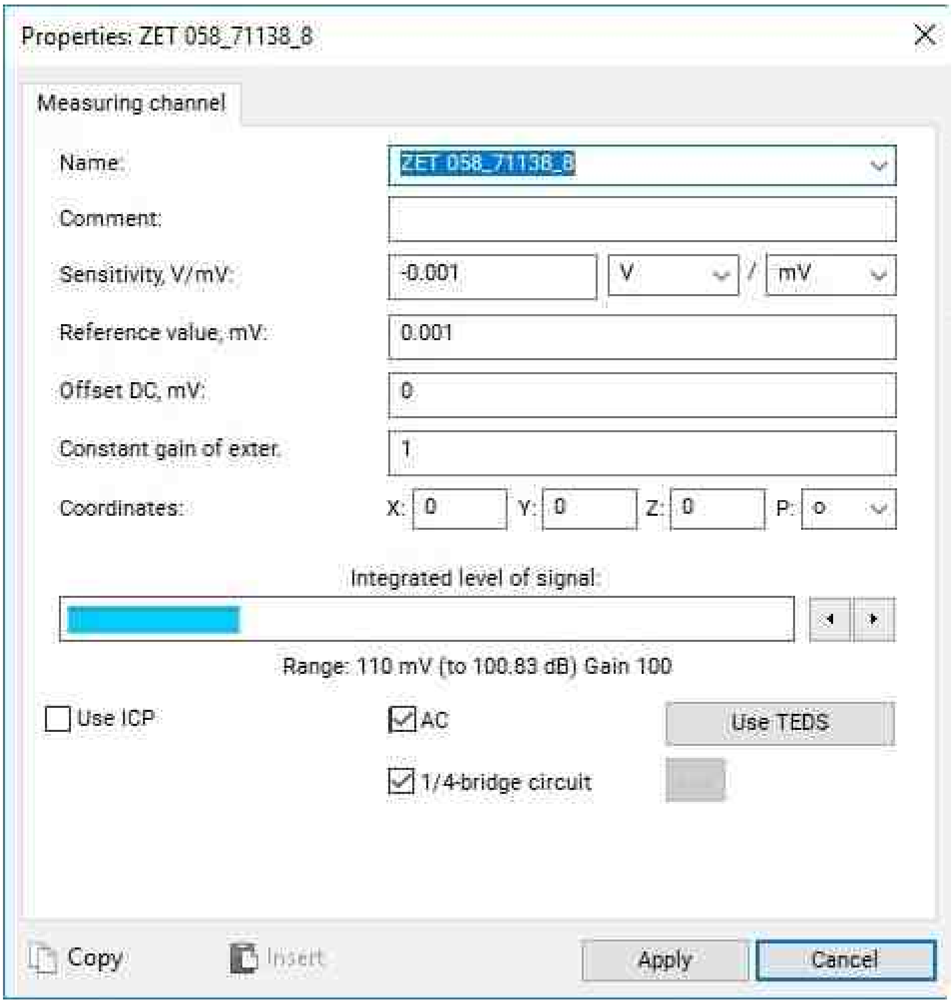


Fig. 7.27 "Properties" Window

Open the window of the strain-gauge setting connection by activating the button (*Fig. 7.28*). located to the right of the "1/4 bridge circuit" parameter and set the parameter values according to the Fig. (*Fig. 7.29*).

Fig. 7.28 Button to open the settings window

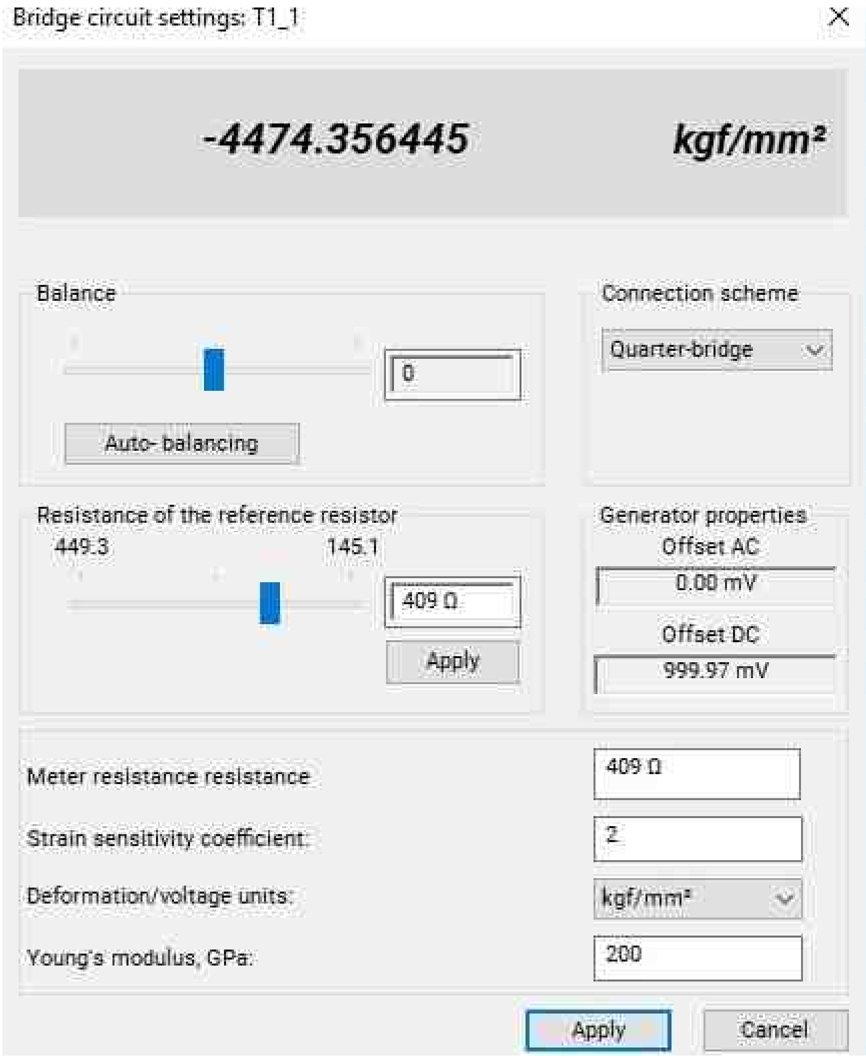


Fig. 7.29 Button to open the settings window

To save the measurement channel settings.in the window "j -bridge circuit setting"  activate the "Apply" button and then the "Apply" button in the "Properties" window.

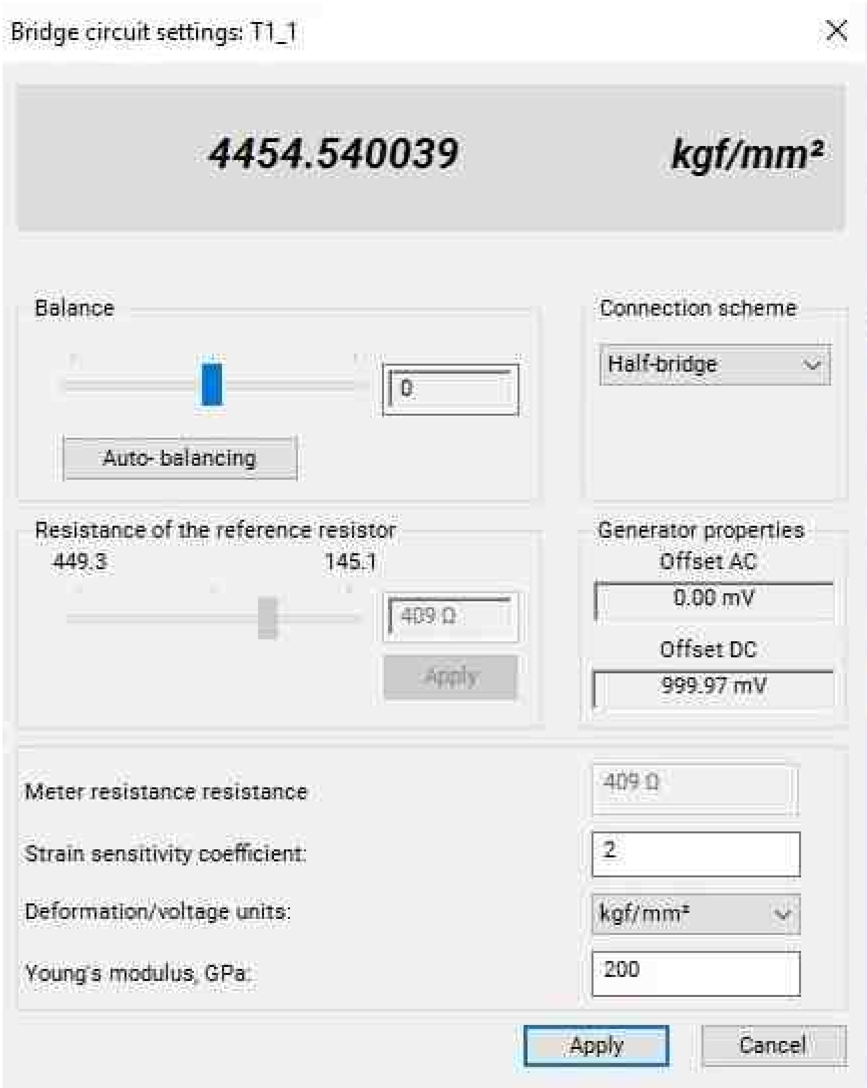


Fig. 7.29a Button to open the settings window

To save the measurement channel settings.in the window "Half-bridge circuit setting" activate the "Apply" button and then the "Apply" button in the "Properties" window.

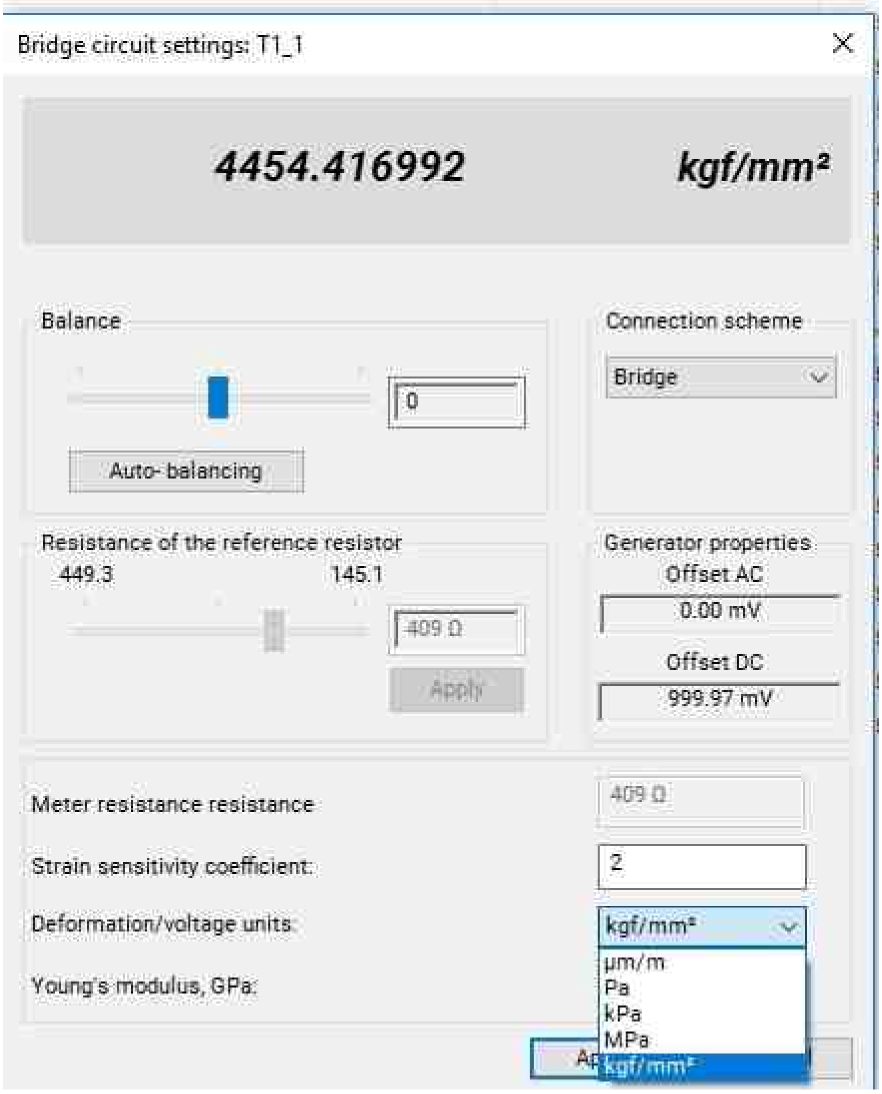


Fig. 7.29b Button to open the settings window

To save the measurement channel settings.in the window "Bridge circuit setting" activate the "Apply" button and then the "Apply" button in the "Properties" window.

Connection of the ZET 140 force sensor using an AC100 voltage amplifier .....

Connection of the ZET 140 force sensor using an AC100 voltage amplifier

It is required to connect a ZET 140 force sensor to the input of the VCS controller. The following passport characteristics are available:

Sd = 42.25 pC/N – sensitivity of the ZET 140 force sensor;

Cd = 1100 pF – electric capacity of ZET 140 power sensor with cable;

Gain=3,97 – the gain of the AC voltage amplifier is 100.

$$S = \frac{S_d}{C_d} = \frac{42{,}25 \text{ pC/N}}{1100 \text{ pF}} = 0{,}0384\text{V/N}$$

In the VCS panel activate the "**ZET Device Manager**" program and in the "Properties" window set the parameters enter the name of the measuring channel, to which the ZET 140 force sensor is connected, set the parameters according to the Fig. (*Fig. 7.31*).

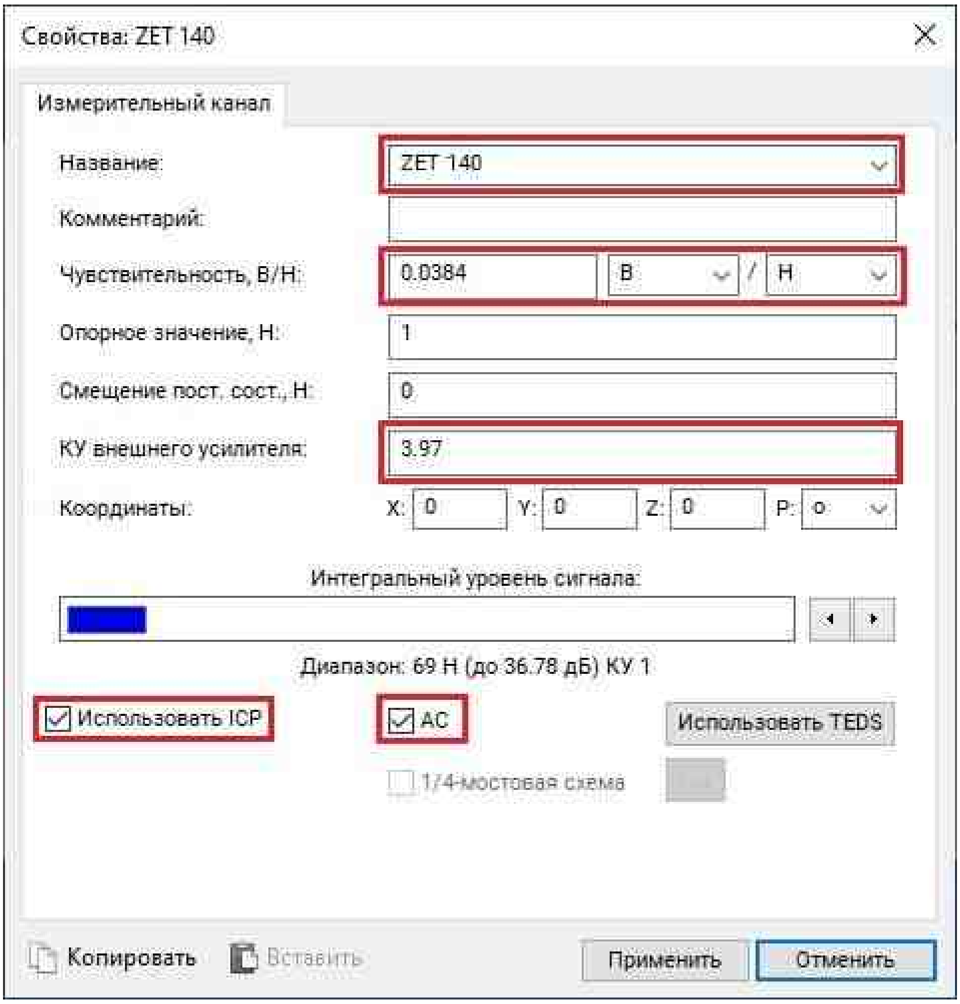


Fig. 7.31 "Properties" Window

- The parameter "Name" is an arbitrary name of the measuring channel;
- The "Sensitivity" parameter is the previously calculated sensitivity value S;
- The parameter "Constant gain of exter. amplifier" is the passport value of the gain of the AC100 voltage amplifier.

To save the measurement channel settings, activate the "Apply" button in the "Properties" window.

Connection of the ZET 140 force sensor using an AC100 voltage amplifier and an AC300 attenuator .....

Connection of the ZET 140 force sensor using an AC100 voltage amplifier and an AC300 attenuator

It is required to connect a ZET 140 force sensor to the input of the VCS controller using an AC300 attenuator to increase the range of force measurement. The following passport characteristics are available:

Sd = 42.25 pC/N – sensitivity of the ZET 140 force sensor;

Cd = 1100 pF – electric capacity of ZET 140 power sensor with cable;

Gain=3,97 – the gain of the AC voltage amplifier is 100.

Ca = 116000 pF – the electrical capacity of the attenuator AC300.

To solve this problem, it is necessary.

Connect the AC100 voltage amplifier to the measuring channel of the VCS controller, then connect the AC300 attenuator and the ZET 140 force sensor.

Calculate the total sensitivity S by the formula:

$$S = \frac{S_d}{C_d - C_a} = \frac{42{,}25\ \text{pC/N}}{117100\ \text{pF}} = 0{,}0003608\ \text{V/N}$$

In the VCS panel activate the "**ZET Device Manager**" program and in the "Properties" window set the parameters enter the name of the measuring channel, to which the ZET 140 force sensor is connected, set the parameters according to the Fig. (*Fig. 7.32*).

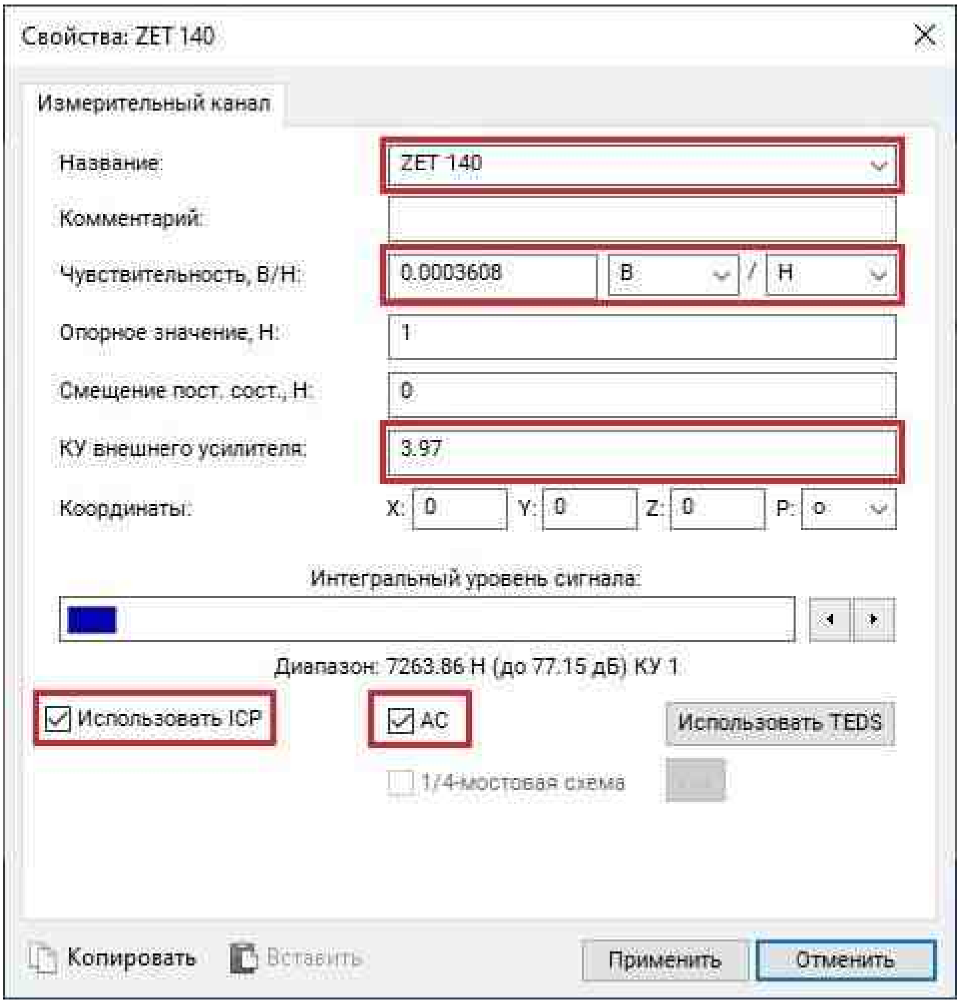


Fig. 7.32 "Properties" Window

- The parameter "Name" is an arbitrary name of the measuring channel;
- The "Sensitivity" parameter is the previously calculated sensitivity value S;
- The parameter "Constant gain of exter. amplifier" is the passport value of the gain of the AC100 voltage amplifier.

To save the measurement channel settings, activate the "Apply" button in the "Properties" window.

Recommendations for setting the parameters of the VCS to pass the maximum profile along the Sine .....

When working at maximum profiles (for example, during the Shaker Validation), it is recommended to set the following parameters for Sine (*Fig. 1*):

(1) - the "Effective" measurement method;

(2) - dynamic range no more than 60 dB;

(3) - use a median filter with a median filter length of 15;

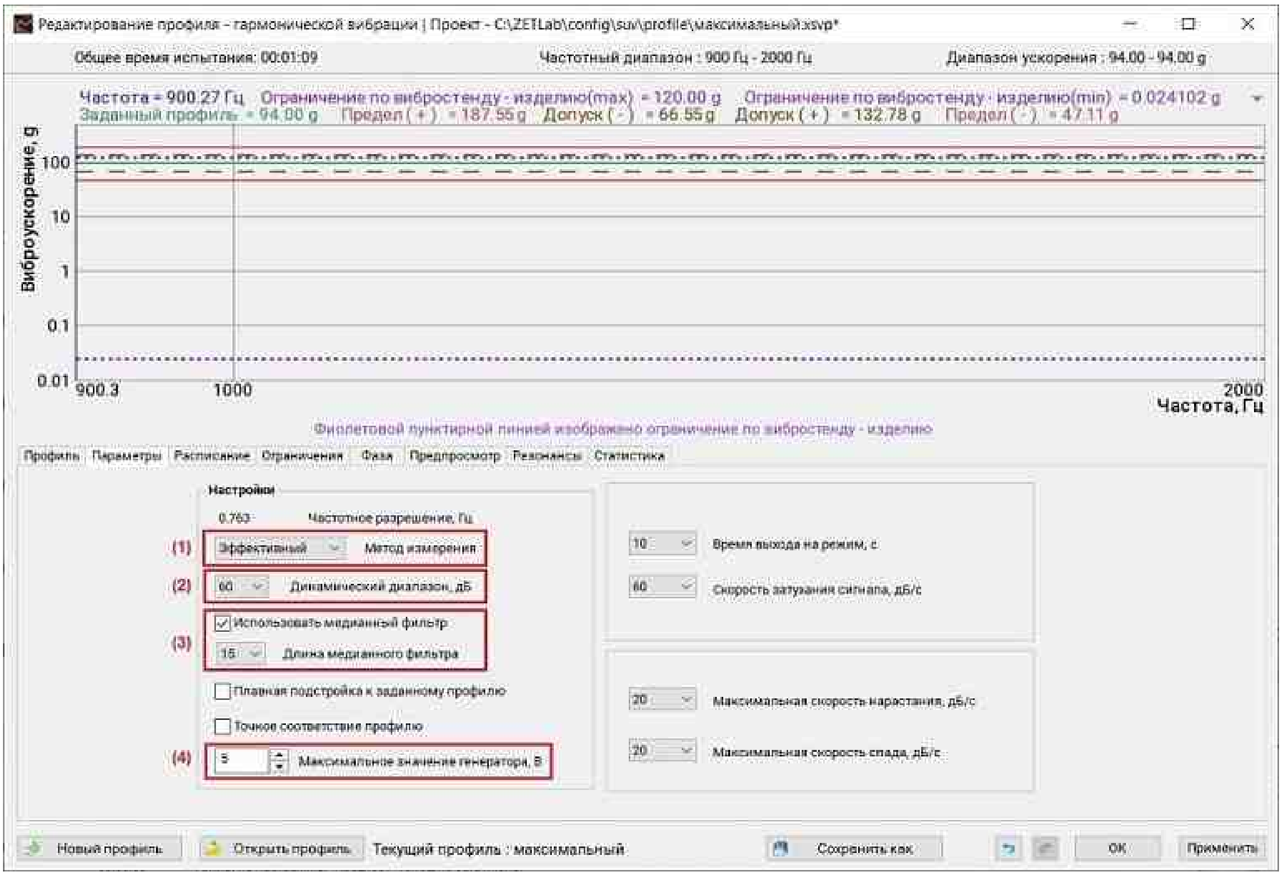


Fig. 1

It is possible to prevent a situation in which current protection is triggered on the power amplifier of the Shaker by limiting the voltage value at the output channel of the generator of the VCS controller (*Fig. 1*).

When testing for maximum profiles, the maximum gain level should be set on the power amplifier of the Shaker, and for such cases, the level of limitation at the output of the generator by the amplitude value is usually in the range from 2000 to 3300 mV.

To correctly select the voltage of the generator limit, go to the Preview tab of the Profile Editing window (*Fig. 2*) and find the area with the highest predicted value of the generator voltage.

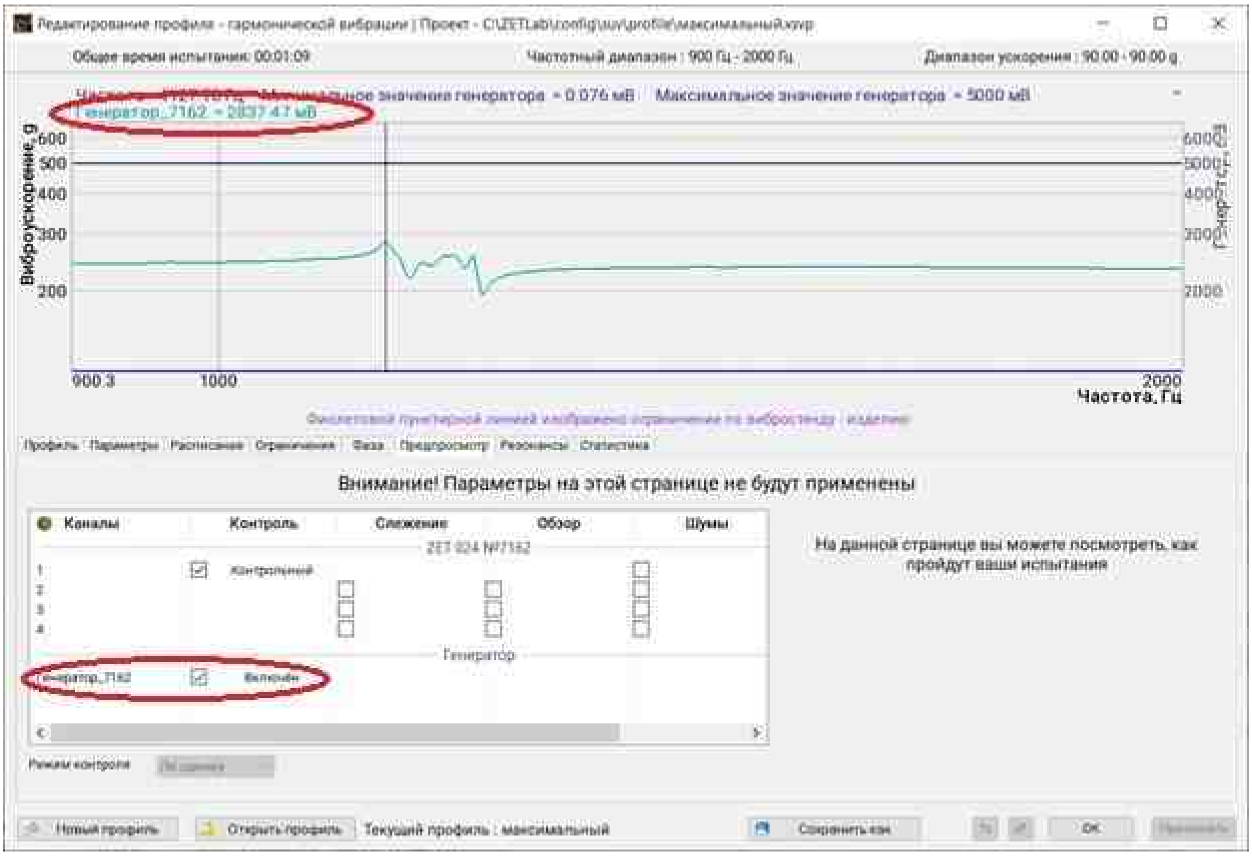


Fig. 2

From the example shown in (*Fig. 2*), it can be seen that the upper blue line at the level of 5000 mV shows the value of the generator limit set in the Shaker parameters, but at the same time the maximum value of the generator during testing (predicted based on the results of the Pre-Test) will not exceed 2837.47 mV. The protection of the power amplifier of the Shaker is most likely to be triggered at the point with the maximum voltage, therefore, for this example, it should be limited to the level of 2800 mV ((*Fig. 4*) replace the value "5 V" with the value "2.8 V").

The level of the generator should not be severely limited, since in this case, when testing in the frequency regions where the vibration generator system reaches power close to the maximum values, there will be an underestimation of the recorded level of Acceleration relative to the level that is set in the test profile.

If there are frequency regions at the installation site (the signal from which is used as feedback) at which deep antiresonances are observed, the largest possible amplitudes along the profile during the passage of such areas will be achievable at the highest frequency sweep rates of the signal (*Fig. 3*). For example, at a sweep rate of 2 or even 5 octaves per minute the probability of passing through areas with antiresonances increases in relation to passing at a typical sweep rate of 1 octave per minute.

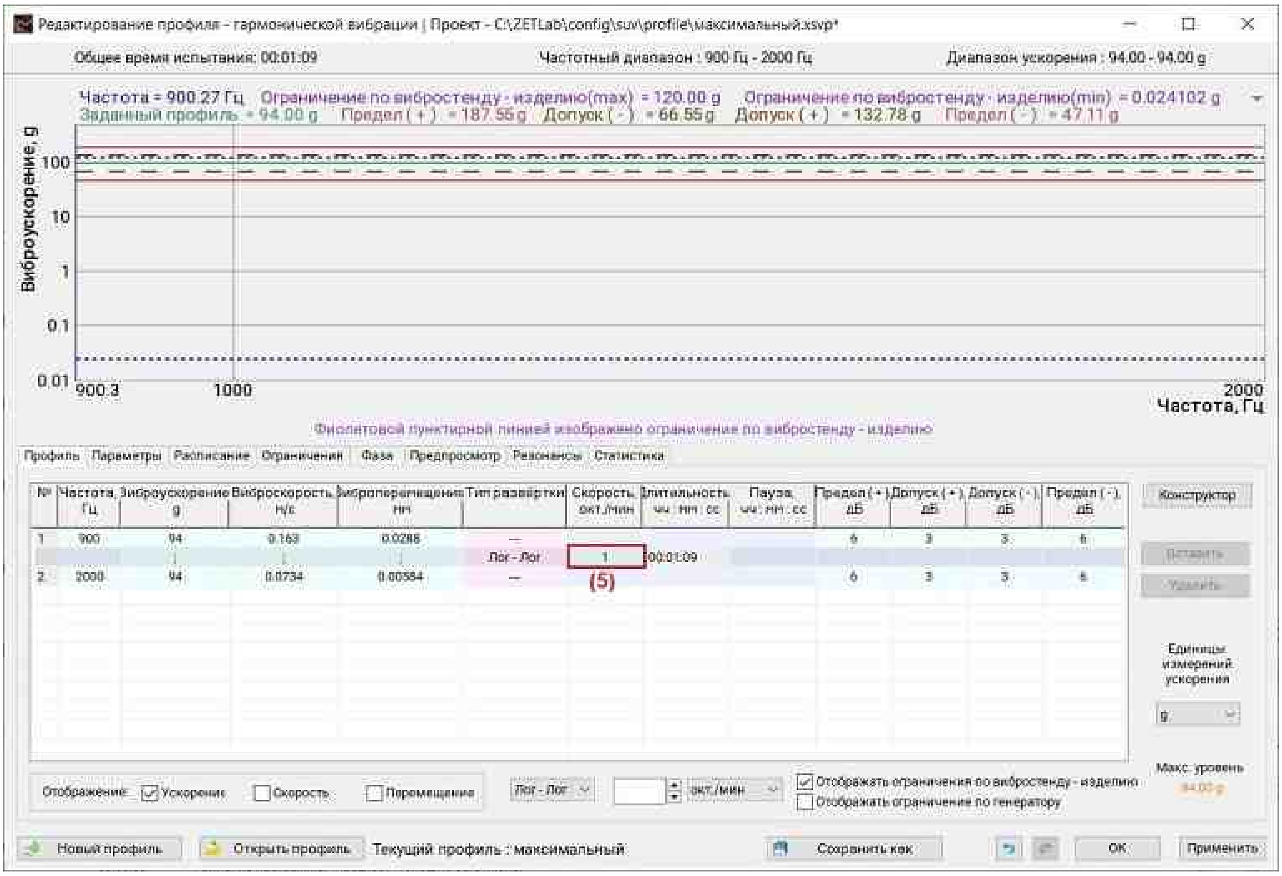


Fig. 3

For ZET028 and ZET024 series controllers, a jumper should be installed between the generator ground and the grounding of the device as shown in (*Fig. 4*).

Fig. 4

Measures to suppress interference at a frequency of 50 Hz .....

There are two main reasons for the occurrence of a high level of interference at a frequency of 50 Hz (and its harmonics), which can lead to difficulty and even impossibility of conducting vibration tests. A high level of interference means interference above the level of 0.3 g (3m/s^2) recorded by an accelerometer mounted on the table of the Shaker.

The first reason is related to electrical interference caused by electromagnetic interference, when the power cable is laid next to the accelerometer cable, or next to the control signal cable (from the output of the VCS controller to the input of the Shaker power amplifier).

The second possible reason is due to the presence of a "ground loop". In the ground loop, the measuring system and sensors are grounded at several points. Since there is more than one grounding point, electrical interference can flow between two grounding points and thereby create a 50 Hz interference.

An example of a connection in which a ground loop occurs is given (*Fig. 5*).

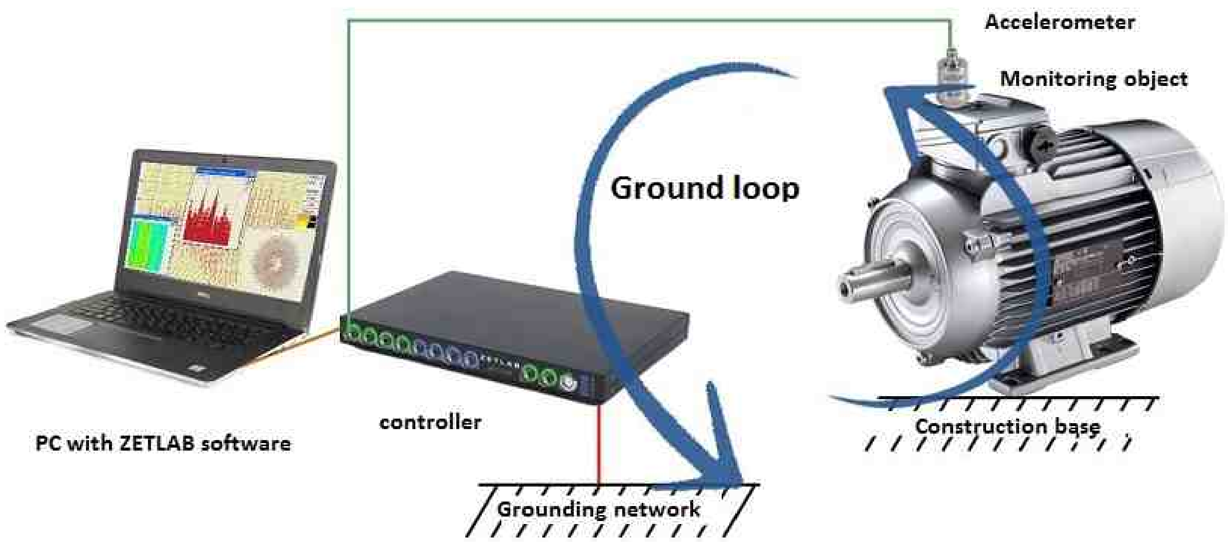


Fig. 5

The ground loop is caused by the fact that the accelerometer housing has direct metal-to-metal contact with the grounded test object.

To eliminate the ground loop, it is necessary to isolate the accelerometer housing from the body of the test object using an insulating gasket (for example, capton tape).

Pre-Test and search for resonances .....

Pre-Test and search for resonances

Program Purpose .....

Program Purpose

Primary converters (accelerometers) are installed on the specimen to be tested according to the test scheme and connected to the measuring channels of the VCS controller. Each measuring channel of the VCS controller can be assigned a specific status (monitoring, tracking, review) during vibration tests.

It is necessary to use the program "***Pre-Test and search for resonances***" Pre-Test (pass a Pre-Test) before conducting tests, since the results obtained during the Pre-Test are necessary for the software to calculate the control signal.

The program "Pre-Test and search for resonances" allows the VCS operator to perform a Pre-Test and before the start of the tests to determine which sensors have the best feedback and are the most suitable for assigning them the status "Control", as well as to make sure that the VCS is ready for testing (there are no: high level of interference, poor contacts in cable connections, sensor malfunctions, configuration errors, etc.).

To activate the Pre-Test, the "Pre-Test" button is located in the "***Pre-Test and search for resonances***" program window.

Pre-Test of the system for the purpose of evaluating the optimal parameters to be used for test performance

When the "Pre-Test" program is running (the time of the test, depending on the setting, is from 20 to 40 seconds), a broadband low-intensity test signal is applied, while the shaker has an effect on the specimen with sensors installed on it. The software analyzes the response to the signals of the measuring channels (from sensors) for compliance with the specified effect and provides recommendations on assigning the status for all available measuring channels of the VCS.

Attention! *Conducting any of the types of vibration testing without the actual result of the Pre-Test is blocked programmatically. Most of the changes critical for the VCS (made by the operator), after which it is necessary to conduct a Pre-Test, are controlled by software that will prohibit access to the tests without the actual result of the Pre-Test. For those cases when the program does not control changes in test conditions (changing sensor mounting locations; changing the tool intended for attach the specimen, or the type of specimen) it is strongly recommended to conduct a Pre-Test before conducting vibration tests, otherwise during the tests the specimen and the vibration generator system may be subjected to excessive loads.*

Attention! *The results of the Pre-Test cease to be relevant after changing the following parameters: Shaker parameters, Specimen parameters, list and parameters of measuring channels, as well as when the time of day changes (when the time reaches 24 hours 00 min 00 sec)*

Program Operation Principles .....

Program Operation Principles

To go to the "***Pre-Test and search for resonances***" window, press the *Pre-Test* button on the VCS panel (*Fig. 4.1*) . The monitor screen displays the "***Pre-Test and search for resonances"*** program window (*Fig. 8.1*).

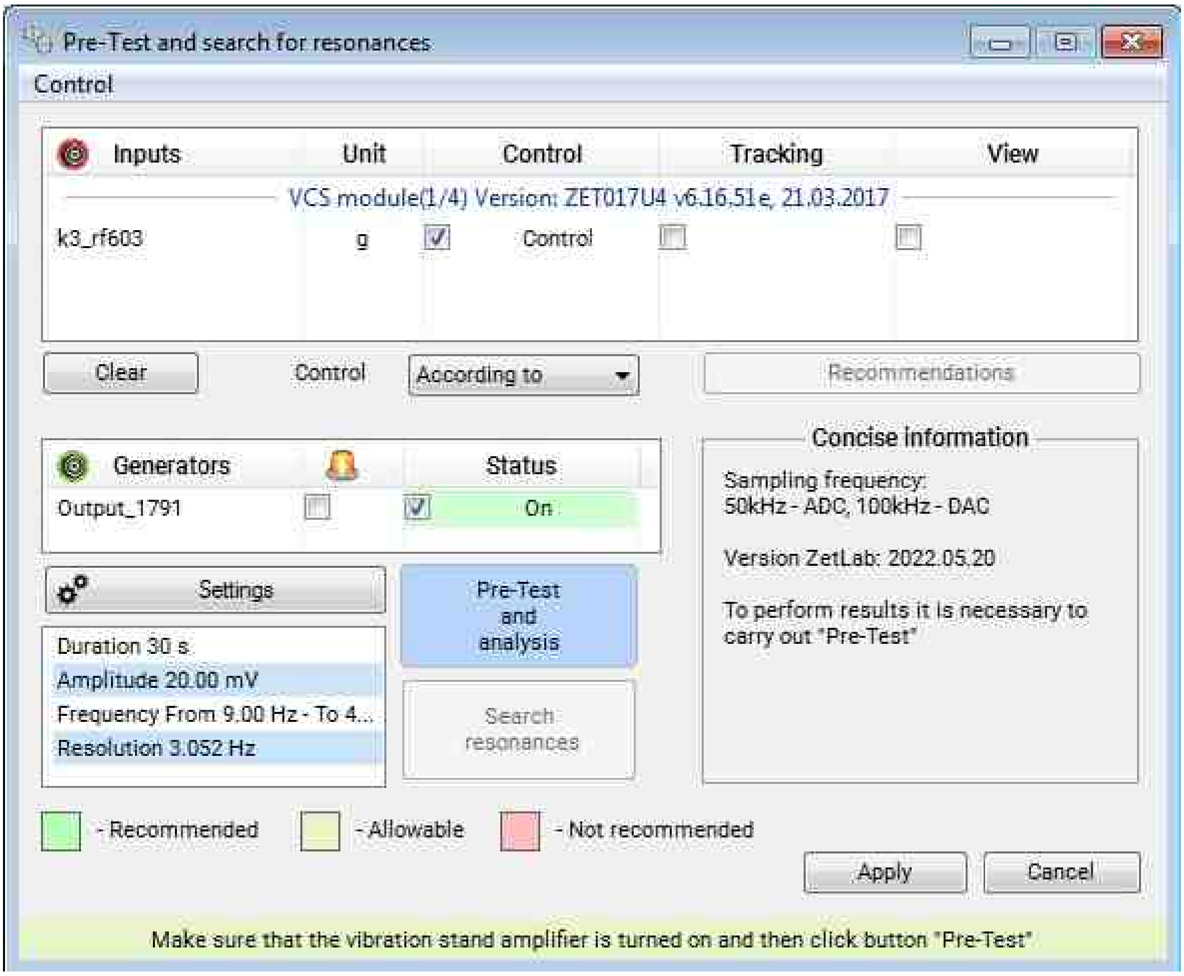


Fig. 8.1 "Pre-Test and search for resonances" window

If necessary, before carrying out the Pre-Test, the parameters with which it will be performed are adjusted.

The "Settings" window (*Fig. 8.2*) is called by activating the corresponding button in the "Pre-Test and search for resonances" program window.

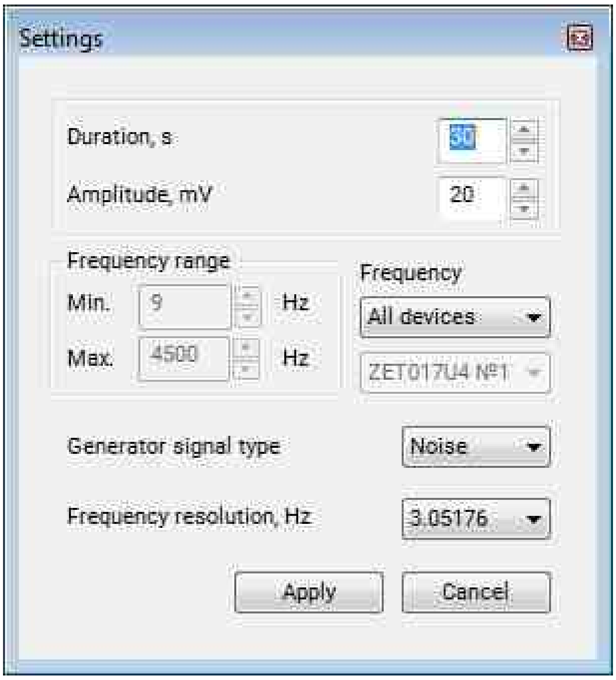


Fig. 8.2 Settings for Pre-Test window

After setting the required values of the Pre-Test parameters in the Settings window, the "Apply" button should be activated to save the changes made.

The Duration parameter determines the duration of the Pre-Test and can be set in the range from 10 to 300 seconds. The optimal value for the time of the Pre-Test is 30 seconds.

The Amplitude parameter determines the level of formation of the Pre-Test signal and can be set in the range from 10 to 50 mV.

Note: *The Amplitude parameter has a limit on the upper value of 50 mV in order to limit the supply of high vibration levels to the Shaker, including at the maximum position of the regulator on the Shaker amplifier.*

Attention! *After the Pre-Test, do not change the position of the regulator on the Shaker amplifier, as this will affect the quality of vibration testing. In case of a change in the position of the regulator on the Shaker amplifier, it is necessary to conduct the Pre-Test again.*

Attention! *Do not set low values for the Amplitude parameter in cases when the position of the regulator on the Shaker amplifier is below 50% of the maximum gain, since in this case the Pre-Test will not be able to provide the necessary level of parameter estimation for conducting vibration tests.*

The choice of possible values of the "Frequency resolution" parameter (*Fig. 8.3*) depends on the selected sampling frequency of the controller, the lower the sampling frequency value, the lower the frequency resolution value can be set.

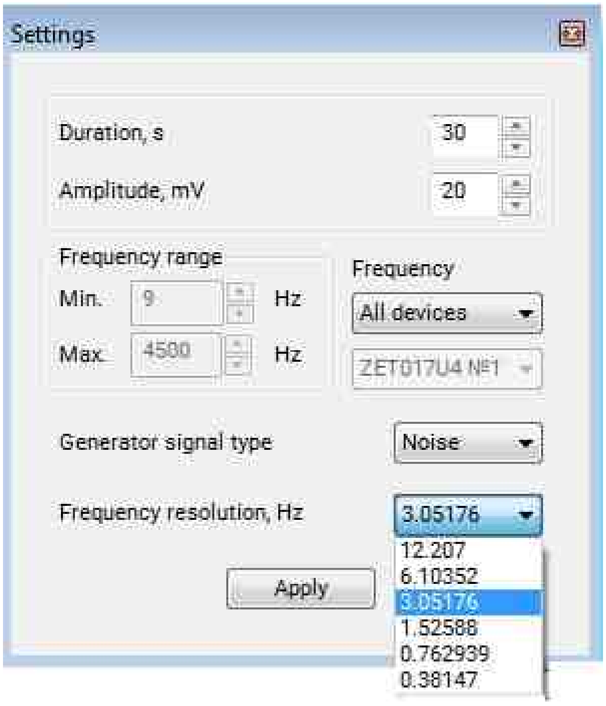


Fig. 8.4 The "Pre-Test settings" window

The "Frequency selection" field allows you to choose one of two options for assigning the frequency range of the Pre-Test: "All devices" or "Individually".

When selecting "All devices", the lower and upper limits of the frequencies of the Pre-Test will be set to the maximum possible.

The maximum possible limits of the frequency range of the Pre-Test are determined by the following rules:

- for the lower limit, the largest of the following is selected: either the tripled value of the specified frequency resolution; or the set value of the lower limit of the frequency range in the "Shaker parameters" window; or the set value of the lower limit of the frequency range in the "Specimen parameters" window;
- for the upper limit, the smallest of the following is selected: either a value two and a half times less than the sampling frequency of the ADC of the VCS controller; or a set value of the upper limit of the frequency range in the "Shaker parameters" window; or a set value of the upper limit of the frequency range in the "Specimen parameters" window.

When selecting "Individually", the program allows you to set the lower and upper limits of the frequency range of the Pre-Test arbitrarily for each of the available VCS controllers, while the boundaries of the arbitrarily set range cannot go beyond the maximum possible limits defined by the rules above.

New Pre-Test modes have been added to the Pre-Test settings. To conduct a Pre-Test, you can select the type of generator signal: noise in a given frequency band, a sine signal with a linear frequency varying or a sine signal with a logarithmic frequency varying.

Note: *We do not recommend setting the width of the frequency range of the Pre-Test to less than three octaves.*

To pass the Pre-Test in the "**Pre-Test and search for resonances**" program window, it is necessary to switch the status of the generator channel (which will be used as a control channel) to the "On" position in the control channel resolution area (*Fig. 8.4*), otherwise the "Pre-Test" button will not be available for activation.

Fig. 8.3 4 Control channel resolution area

Activation of the corresponding field in the graphic "" starts the "Highlight" mode of the VCS controller, in which the light indicators on its front panel are flashing. This mode is designed to quickly find which of the VCS controllers correspond to certain control channels (generators) in the "**Pre-Test and search for resonances**" window when more than one controller is included in the VCS.

Note: *The software allows conducting vibration tests with up to four independent control channels (generators), which requires an appropriate number of* VCS *controllers and Shaker. Generators as control channels during the operation of the* VCS *are available only for* VCS *controllers, the connection of devices such as spectrum analyzers and Strain-gauge station during the operation of the* VCS *provides only an increase in the number and types of connected sensors, but not control channels. If the generator of the* VCS *controller is not used as a control channel, then its status should be in the "Off" status.*

Note: *With multi-channel control, in the program window "***Pre-Test and search for resonances***", the status "On" should be set for the generators of those* VCS *controllers that will participate in the generation of control signals, conduct Pre-Tests for each of them and assign the status "Control" to those measuring channels that will be used by the software as feedback channels for each the controller involved in generating control signals during vibration tests.*

To launch a Pre-Test in the program "**Pre-Test and search for resonances**" window, you should activate the "Pre-Test" button. In the window of the program "Pre-Test" that opens, the process of visualizing the analysis of the response of measuring channels from sensors to the compliance with the specified effect will start (*Fig. 8.5*).

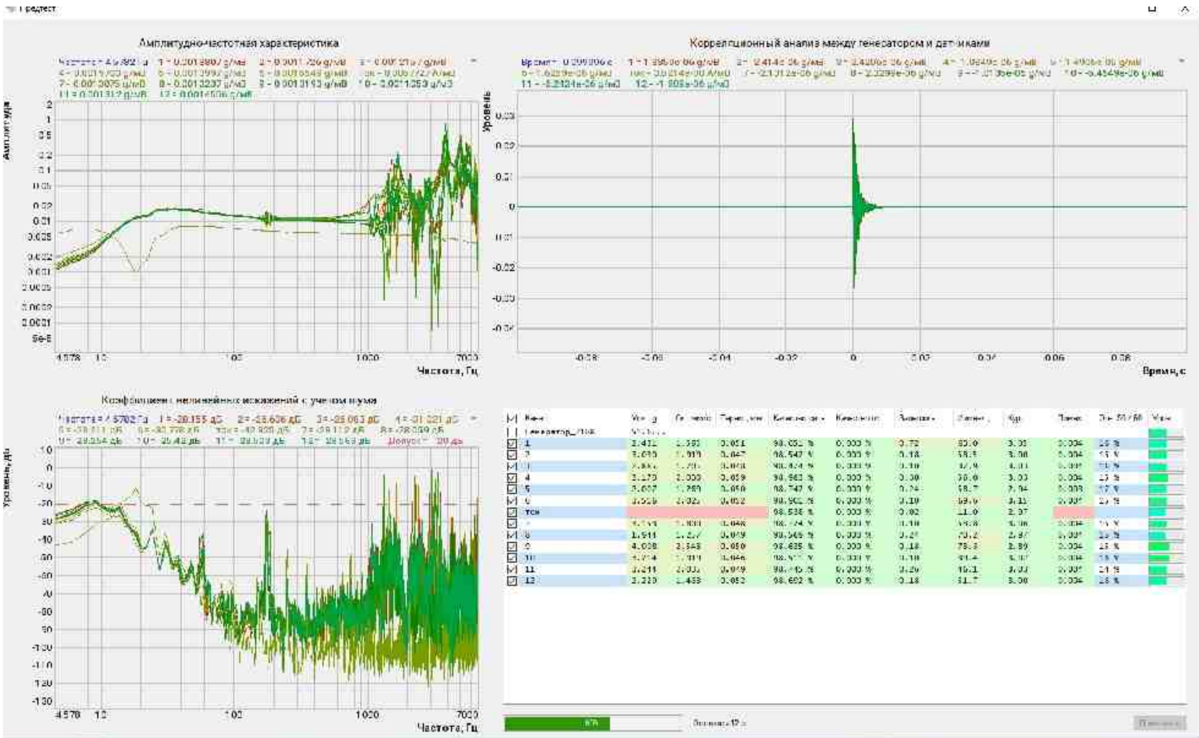


Fig 8.5 The " Pre-Test" window with graphics for all measuring channels

The processing results will be displayed in the area of numerical values located in the lower-right corner of the "Pre-Test" program (*Fig. 8.6*).

Канал	Уск., g	Ск., мм/с	Перем., мм	Качество сигн.	Качество об...	Задержка, ...	Изменч., ...	Курт.	Помех...	Отн. 50 / 60	Уров...
Генератор_7188	49.9...										
1	3.705	2.354	0.070	98.002 %	44.108 %	0.72	44.7	3.00	0.004	16 %	
2	4.374	2.757	0.065	97.684 %	44.065 %	0.18	50.1	3.00	0.004	15 %	
3	4.353	2.545	0.066	97.647 %	63.903 %	0.10	38.0	3.00	0.004	16 %	
4	4.536	2.883	0.075	98.560 %	53.490 %	0.30	57.7	2.99	0.004	15 %	
5	3.038	1.898	0.066	98.086 %	34.479 %	0.24	57.6	3.00	0.003	17 %	
6	5.426	3.102	0.069	98.350 %	32.529 %	0.10	68.0	3.01	0.004	15 %	
ток				98.061 %	99.681 %	0.02	11.0	3.00			
7	4.863	2.762	0.065	98.035 %	49.459 %	0.10	51.0	3.00	0.004	15 %	
8	2.959	1.895	0.066	97.776 %	20.204 %	0.24	65.7	2.99	0.004	15 %	
9	5.665	3.580	0.068	97.898 %	29.062 %	0.18	85.8	3.00	0.004	15 %	
10	4.736	2.805	0.064	97.582 %	67.426 %	0.10	39.0	3.00	0.004	16 %	
11	4.712	2.936	0.066	98.098 %	55.515 %	0.26	46.0	2.99	0.004	14 %	
12	3.389	2.202	0.069	98.048 %	38.299 %	0.18	49.2	2.99	0.004	16 %	

Fig. 8.6 Measured values of the Pre-Tests results

For convenient viewing graphical information in the "Pre-Test" window of the results of the Pre-Test, it is possible to select the number of displayed graphs. The Fig. (*Fig. 8.7*) shows an example with the display of graphical results for only one of the channels, for which only one channel selection field is left activated in the table area (column on the left).

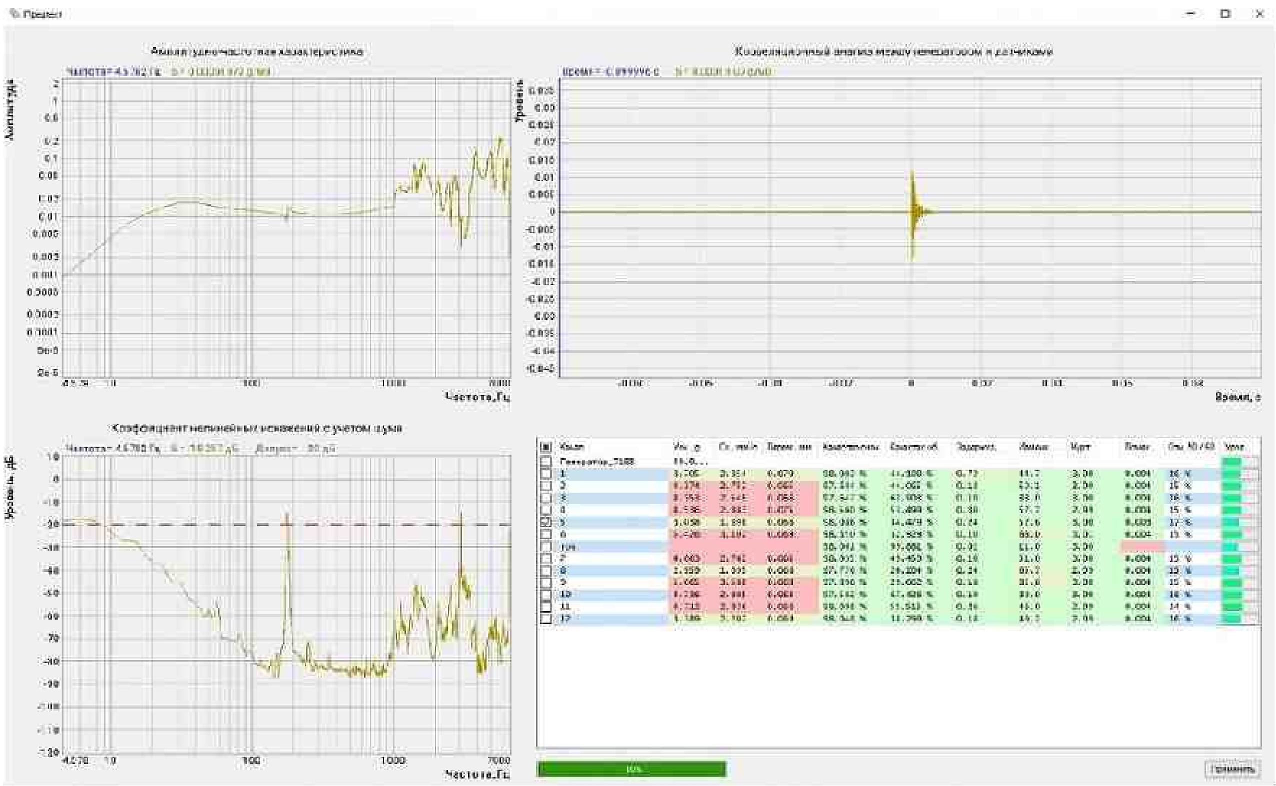


Fig. 8.7 The Pre-Test window with a single channel graph

To save the Pre-Tests results (after the test is completed), you can press the *Apply* button. The Pre-Tests results will be saved and the Pre-Test window will close.

If you save the Pre-Tests results in the Control Parameters window, the measuring channel status selection cells will be colored to indicate the recommendation for assigning the status for each measuring channel: green - recommended, yellow – acceptable, red - not recommended (*Fig. 8.8*).

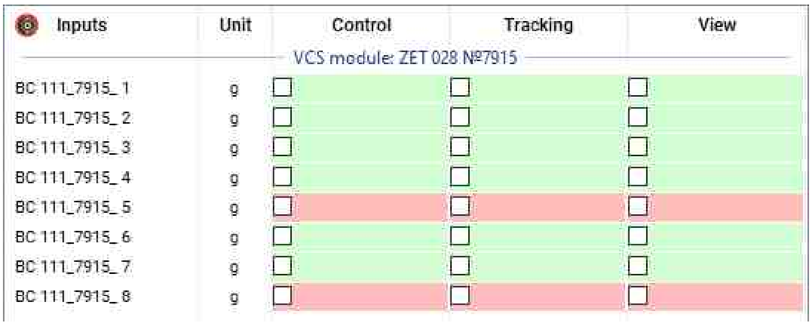


Fig. 8.8 Cells for selecting measuring channel status

To assign the status to the measuring channels (Control, Tracking, View), activate (check) the corresponding cells (*Fig. 8.9*).

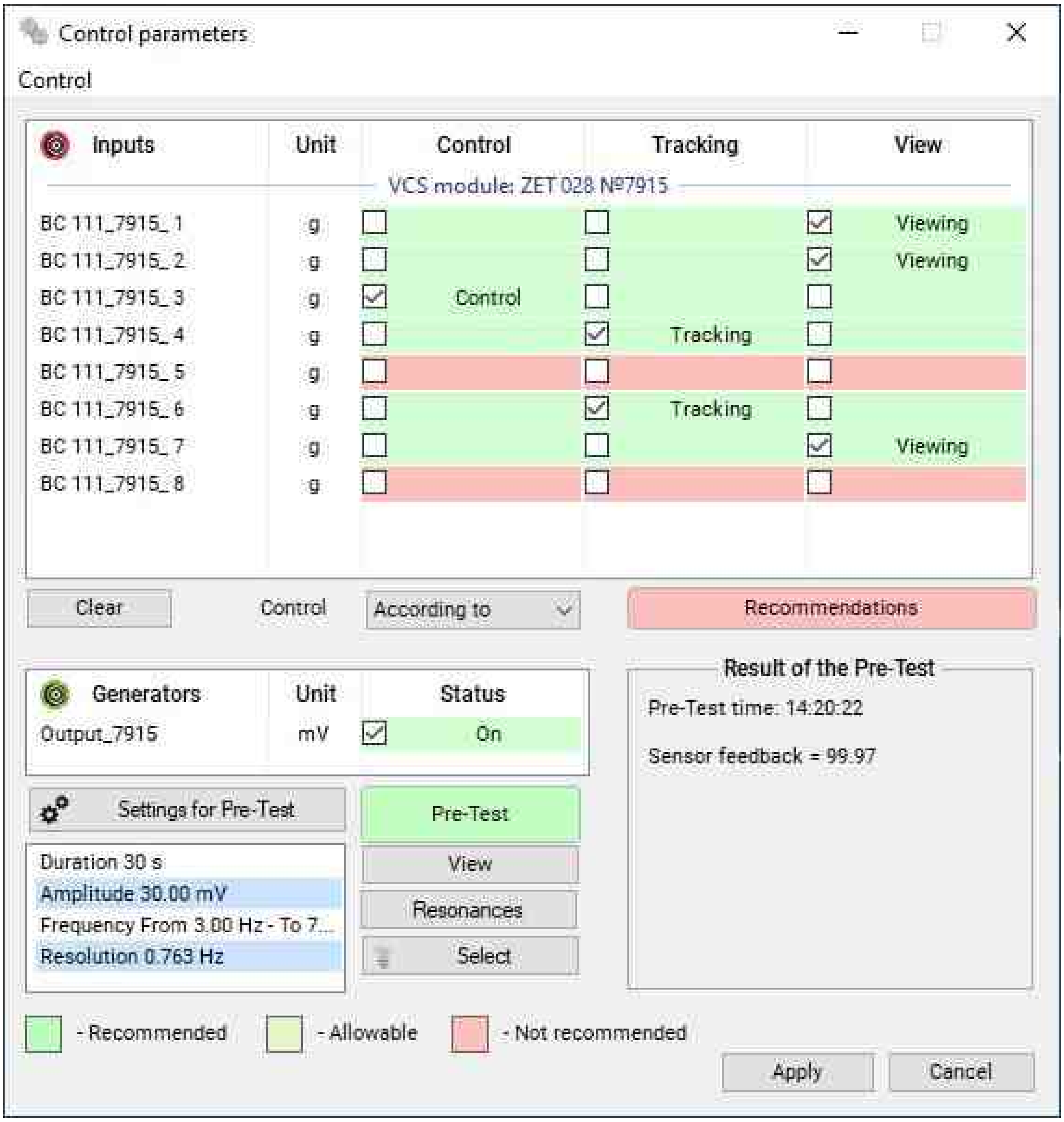


Fig. 8.9 The window "Pre-Test and search for resonances"

The Control status means that the measuring channel is involved in the feedback and that the control system will response when the vibration test stops in case of exceeding the Limit thresholds in the profiles or the parameter values specified on the Control tabs of the profiles.

The Tracking status means that the control system will stop vibration tests if the parameters set on the Tracking tabs of the profiles are exceeded.

The View status means that the channel is monitored only without the control system's response to the values recorded in the channel.

Note! *If necessary, you can assign any status for measuring channels without taking into account the Pre-Test recommendations.*

Attention! *The Control status is mandatory, since the signal recorded by it will be used for feedback during the tests.*

Attention! *You can select channels with the Control status only from the list of measurement channels corresponding to the VCS controller where the control channel is generated, while tracking and viewing channels can be selected from any measurement channels involved in the vibration tests.*

The "Control mode" parameter defines an option for generating a feedback signal for measuring channels with the Control status:

- According to;
- By average;
- By maximum.

The "According" to "Control mode" means that only one measuring channel is involved in generating the feedback signal. The "By average" or "By maximum" control mode means that two or more measuring channels are involved in generating the feedback signal, while VCS generates a feedback channel based on the principle of signal superposition by average values or maximum values recorded in the measuring channels.

Note! *When testing Sine, it is difficult to ensure the required level of specimen vibration in the "by one" mode if the sensor (with the Control status) records deep antiresonances in the tested frequency range. For such cases, it is recommended to use the "by average" or "by maximum" control mode by assigning the Control status to sensors which are not consistent in antiresonances in the test frequency range.*

Attention! *In case of selecting "by average" or "by maximum" control mode, the channels selected for controlling will change their status to tracking, and a virtual channel formed by average or by maximum values becomes the controlling channel, respectively.*

To save the statuses assigned to the measuring channels in the program's "**Pre-Test and search for resonances**" window, press the *Apply* button.

Note! *In cases where it is only needed to change the statuses of the measuring channels, no repeated Pre-Test is required. Open the Control Parameters window, change the statuses of the measuring channels, and then press the Apply button to save the new status configuration.*

In the window of the program "**Pre-Test and search for resonances**" there is an opportunity to select the type of sensors for which feedback will be performed (*Fig. 8.10*). Usually, measuring channels from accelerometers are used as feedback channels. However, in some cases, for example, when non-contact control of the tests is required, a laser displacement sensor can be used. In order for the channel from the displacement sensor to become available as a feedback channel, it is necessary in the "Control" section of the "**Pre-Test and search for resonances**" window activate the "Displacement" selection.

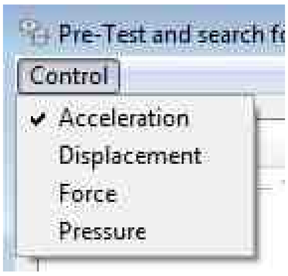


Fig. 8.10 Selecting the type of control in the feedback channel

Attention! *With a type of control other than "Acceleration", not all types of tests are available.*

The "View" button activates a window with the results for the last of the conducted Pre-Tests.

The "Resonances" button activates the window (*Fig. 8.11*), which presents a visualization of the resonances registered as a result of the work of the Pre-Test program.

The window contains fields for visualizing graphics of transfer and phase characteristics, a field for displaying the Nyquist diagram, an area with numerical values of parameters for registered resonances, as well as an area with a three-dimensional representation of the waveform.

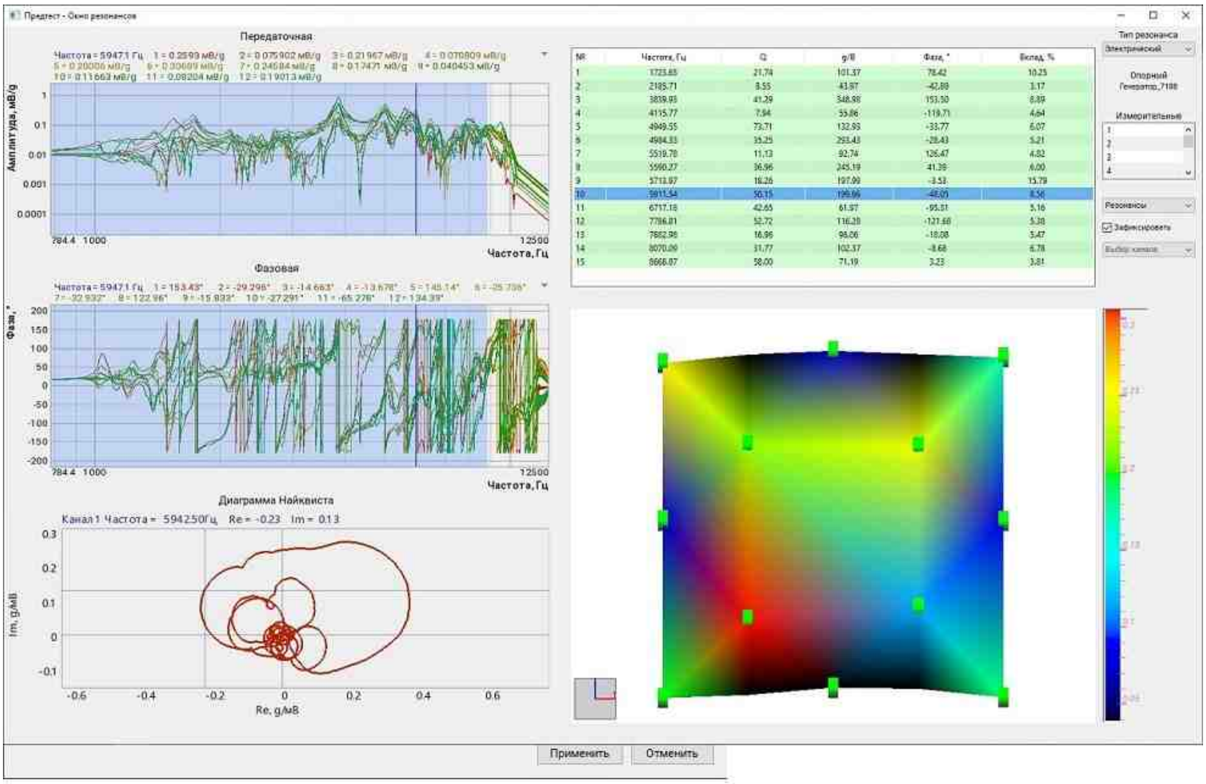


Fig. 8.11 Window view of the program "Pre-Test – Window of resonances"

Note! *To visualize the form of the vibrations of the tested object, vibration transducers must be placed on the object at the control points in an amount that provides the necessary level of detail, while coordinates must be assigned to each sensor with reference to a common coordinate system and a single scale. For example: for the center of the coordinate system, a point located in the center of the surface of the table of the Shaker can be taken, the direction of the Z axis is vertical, and the X and Y axes are orthogonal to each other and are directed according to the location of the object on the table of the Shaker (X axis along the specimen, Y axis - across)*

To visualize the waveform, you can determine the type of resonance "Electric" or "Mechanical". If "Electric" is selected, the generator channel acts as the reference channel. When choosing "Mechanical", it is proposed to use one of the active measuring channels as a reference.

The "Measuring" field allows you to activate and deactivate certain measuring channels for visualization in the field of three-dimensional representation of the waveform.

The "Fix" parameter allows you to build a visualization of the waveform relative to the measuring channel selected as fixed.

The VCS software, after passing the Pre-Test, allows you to detect most of the configuration and switching errors of elements and give diagnostic results in the form of recommendations for their elimination.

After passing the "**Pre-Test and search for resonances"**, the VCS software will detect most configuration errors and element switching errors and output diagnostic results as recommendations for elimination.

You can view the diagnostic information after passing the "**Pre-Test and search for resonances"**. To do this, press the *Recommendations* button in the Control Parameters window. The opened Recommendations for Channels window will display the diagnostic results (*Fig. 8.12*). When you click on the symbol "ⓘ" in the line with the error, a help window will open with a detailed description of the error and recommendations for resolving it.

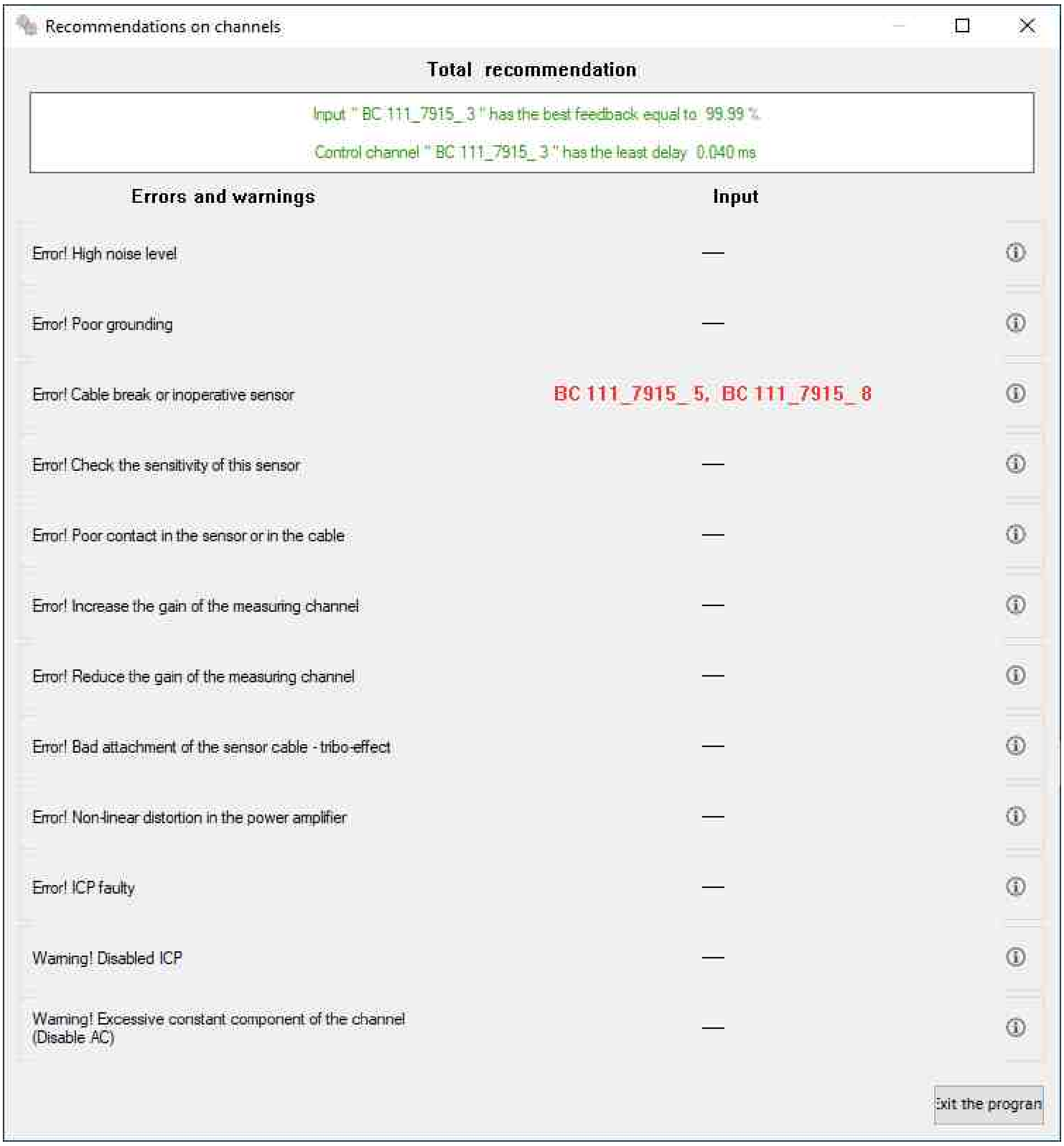


Fig. 5.18 Recommendations for Channels Window

The principle of assigning the "Control" status to measuring channels in the presence of antiresonances .....

The principle of assigning the "Control" status to measuring channels in the presence of antiresonances

Antiresonance is a phenomenon of practically zero response of a dynamic system to periodic external effect of arbitrary amplitude and is the opposite of resonance.

If we explain in simple language for the case of harmonic vibration tests, then we increase the voltage of the output signal from the generator, and the measured acceleration on the control sensor practically does not change.

The phenomenon of antiresonance is most clearly demonstrated by the experience with a stretched string. With periodic exposure to a stretched string with a certain frequency, a standing wave appears on the string, which can even be seen with the naked eye. Depending on the frequency, there will be 1 or more oscillation sections on the string. Points with the maximum amplitude of oscillations are called "antinodes", and fixed points are called "nodes". The antinodes demonstrate the resonance effect to us, and the nodes demonstrate the antiresonance effect.

You can find out about the presence of resonances and antiresonances even before the start of vibration testing based on the results of the "Pre-Test" program. On the graphics in the "Amplitude-frequency response" grid, sharp local maxima will correspond to resonances, and sharp local minima will correspond to antiresonances. You can study the resonances in more detail in the window "Search for resonances", which opens with the corresponding button.

It is best to assign the status "Control" to the measuring channel of the sensor that does not have any peaks, and the form of the graphic is closest to the horizontal line. But if the graphics of all sensors are equally cut, then the following actions can be taken.

Option one - move the sensor .....

Option one - move the sensor.

If there is only one sensor, then you can try to find a more optimal installation location. Most often, the sensors are placed on top of the specimen to be tested or tool and choose a place closer to the center, because this is the most convenient and fastest way to attach the sensor. But in this case, we are guaranteed to get the most "rugged" amplitude-frequency response.

The best point for fixing the control sensor is the movable part of the Shaker. If the tested specimen with the tooling does not occupy the entire surface of the movable part, then install the control sensor on the movable part of the Shaker.

If it is not possible to install the sensor directly on the movable part of the Shaker, then you need to try to install it on the tooling or expansion table, preferably as close as possible to the axis of the Shaker or to the bolts with which the expansion table or tool is attached to the Shaker. At these points, the rigidity of the structure is maximum, which theoretically will help to avoid problems in the low and medium frequencies.

If the sensor should stand on top, it is best to install it in the corner of the tool or close to the fasteners that hold the specimen or tool.

Unfortunately, reality is too diverse and a point with a good frequency response may not be found.

The Fig.s (*Fig. 8.13* ... *Fig. 8.15*) show the amplitude-frequency response graphics for sensors installed at the very edge of the test object (measuring channel "1") and in the center (measuring channel "6").

It can be seen that the amplitude-frequency response of the sensor installed in the center has less variability than that of the sensor installed on the edge. The amplitude-frequency response of sensor No. 1 (measuring channel "1") changes in the specified frequency range by about 1000 times (60 dB), and sensor No. 6 (measuring channel "6") changes only 5 times (14 dB). Thus, it is much easier to conduct tests with control on sensor No. 6 than on sensor No. 1.

Fig. 8.13 Results of the Pre-Test for a sensor mounted on the edge of the test object

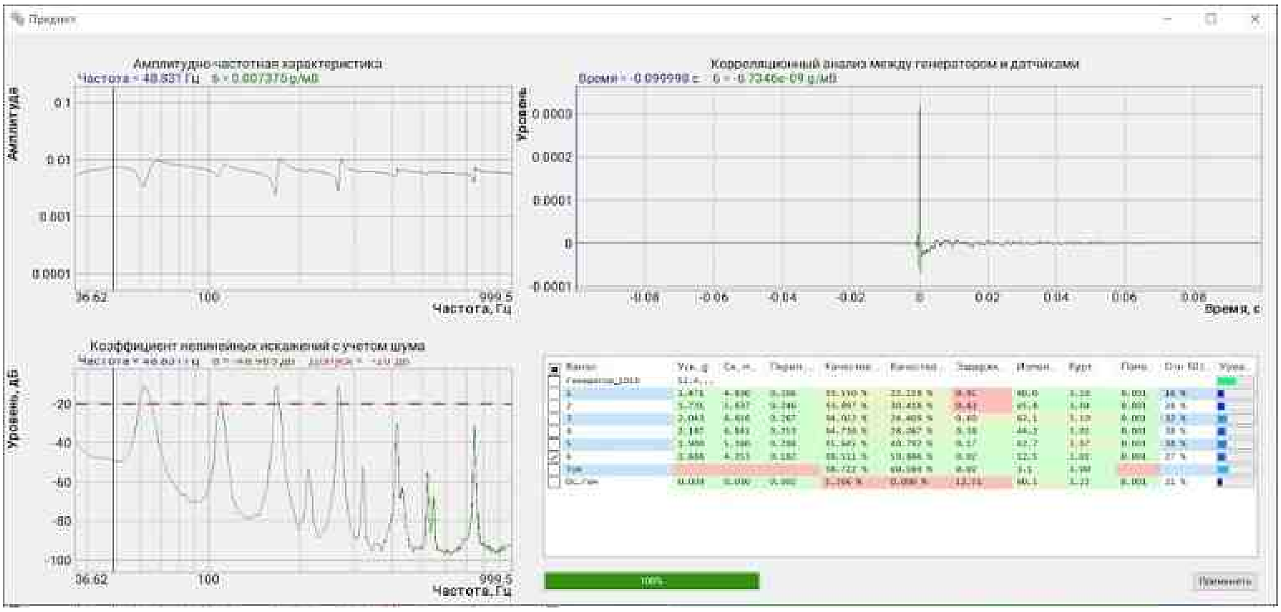


Fig. 8.14 Results of the Pre-Test for the sensor installed in the center

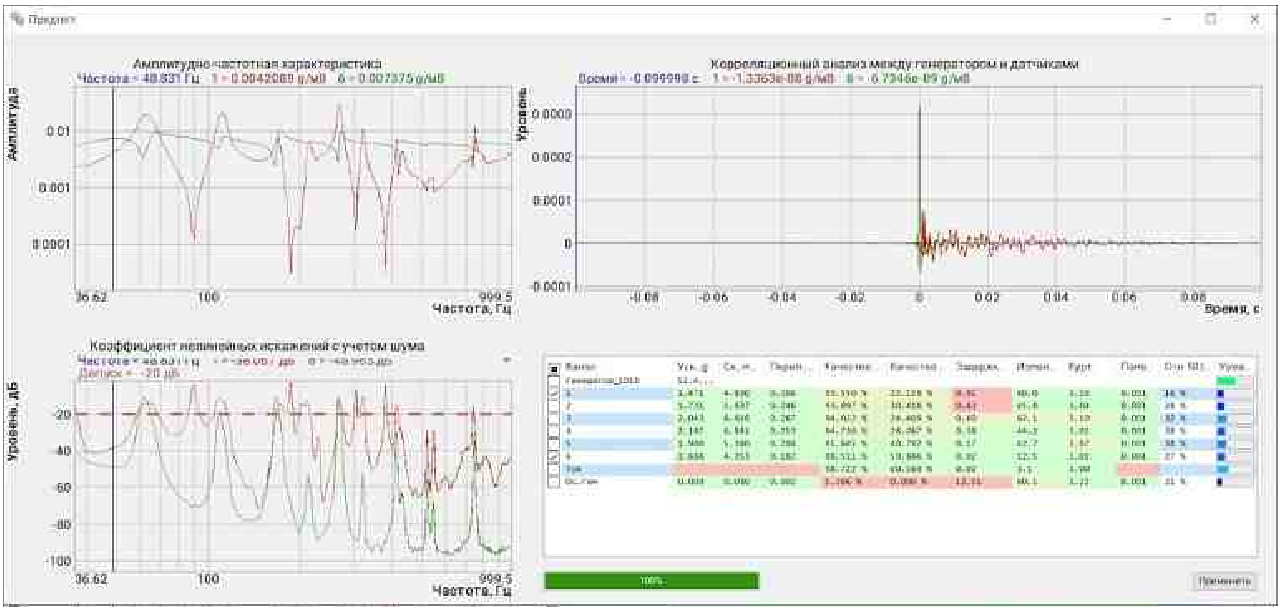


Fig. 8.15 Comparison of the results of the Pre-Test for two sensors installed in different places

Option two is control by multiple sensors .....

Option two is monitoring by multiple sensors.

If it is possible to use several sensors, then it is possible to use the control mode for several control sensors during the tests. In this case, when one of the sensors gets into the antiresonance region and shows a value close to zero, the other sensors will show non-zero results and it is possible to keep the oscillation amplitude at a given level. To do this, it is also important to choose the right sensor installation locations, but the selection criterion will be much easier. It is enough that all the sensors used do not have the same antiresonance frequencies.

The Fig. (*Fig. 8.16*) shows that the choice of the "Control" status for measuring channels "1" and "4" for the frequency range from 270 to 330 Hz is unsuccessful, since in this area the resonances and antiresonances coincide.

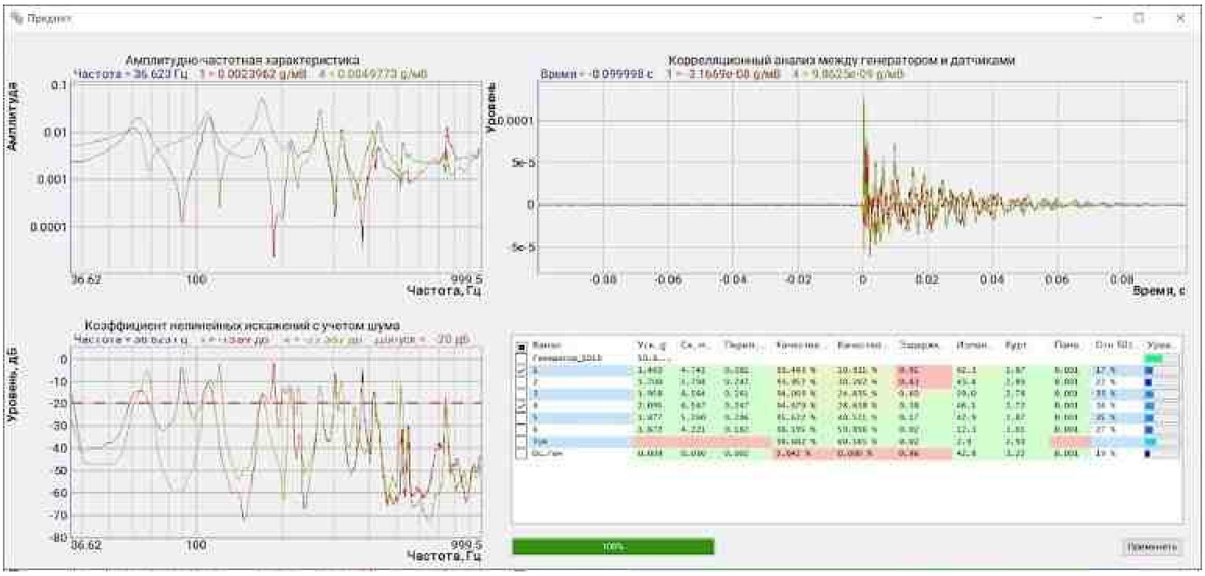


Fig. 8.16 Results of the Pre-Test for two sensors installed in the wrong places

You can check the correctness of the sensor selection in the profile editor on the Preview tab, where you can see how the acceleration graphics will look like along the channels involved, as well as look at the graphic of the expected voltage (*Fig. 8.17*). If there is an acute maximum on the graphic of the expected voltage exceeding the permissible maximum voltage value at the input of the Shaker, then test it won't succeed.

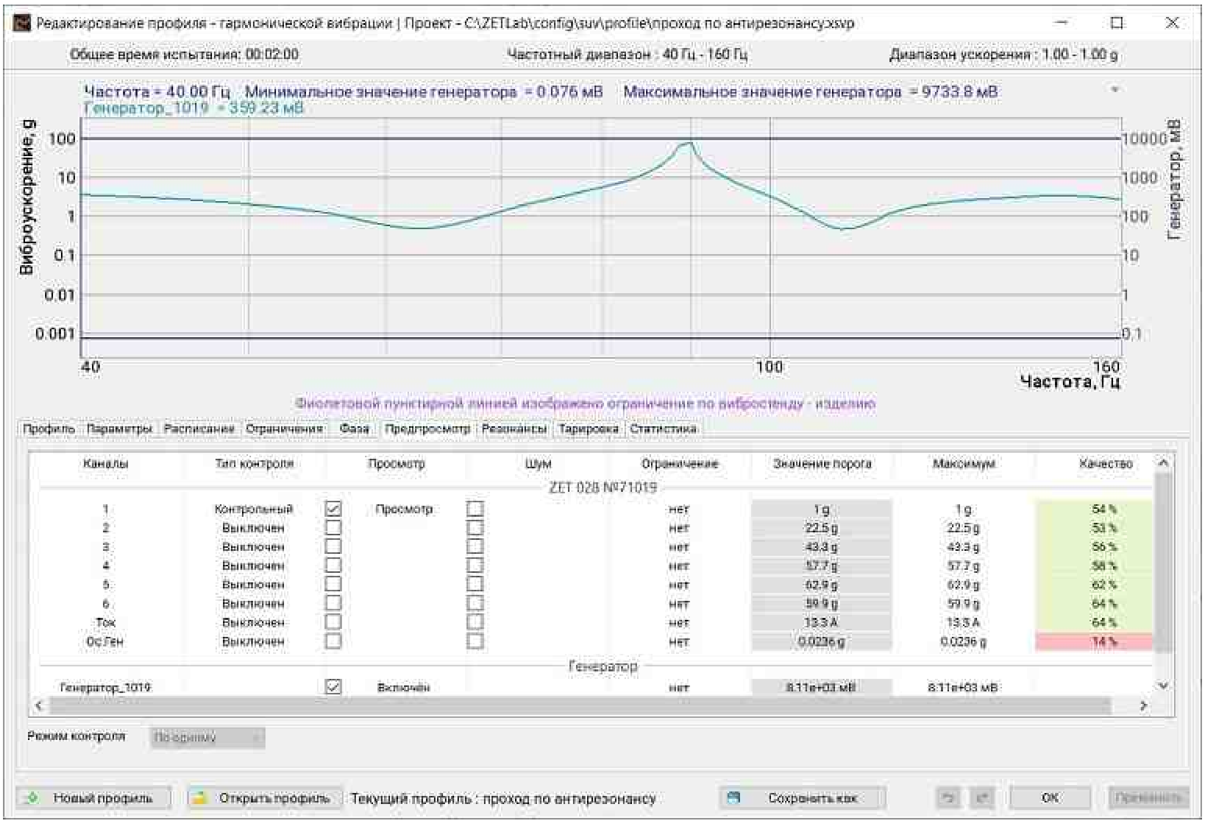


Fig. 8.17 The graphic of the expected output voltage, with the status "Control" on the measuring channel "1"

The Fig. (*Fig. 8.17*) shows that in the frequency range of the test profile, the sensor corresponding to the measuring channel "1" has an antiresonance at a frequency of 90 Hz, and when it passes, the controller will output a voltage of more than 8 volts. If we add the measuring channel "4" as the second control channel, then when passing the entire profile, the output voltage will not exceed 330 mV (*Fig. 8.18*).

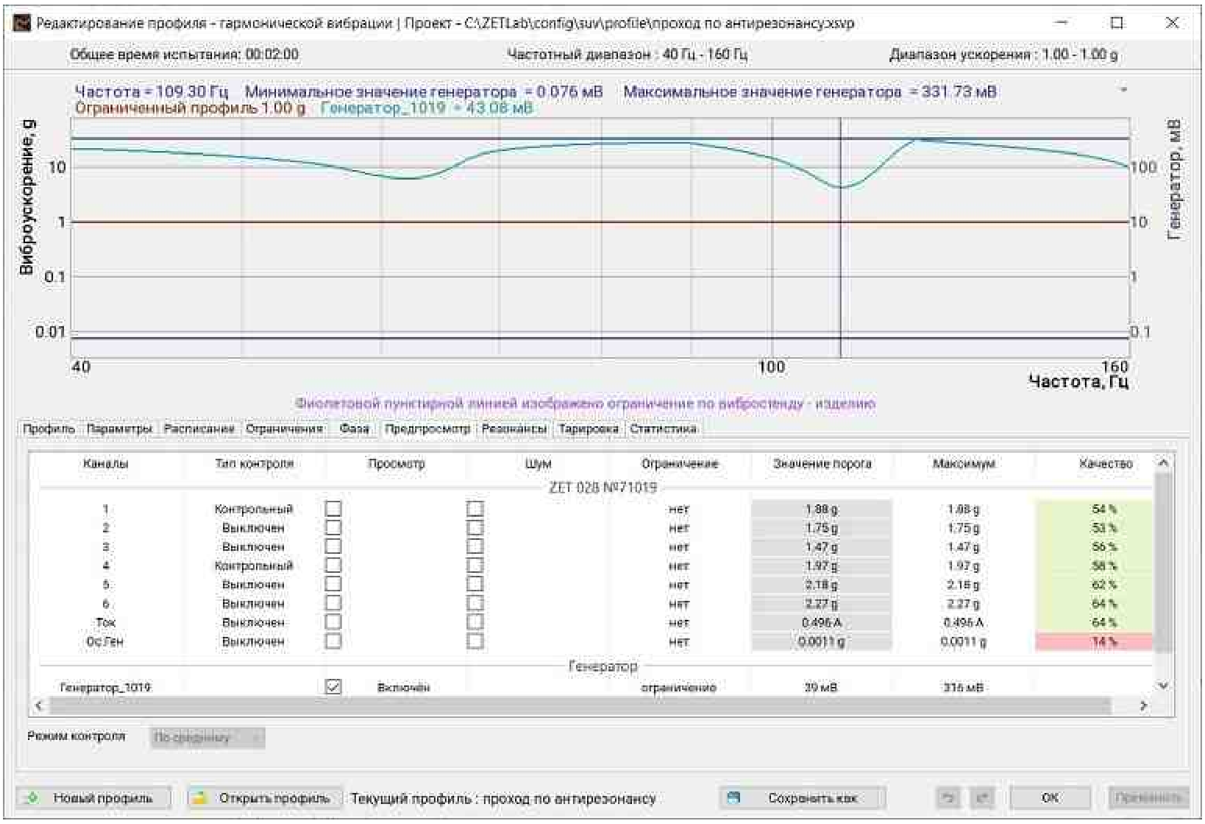


Fig. 8.18 graphic of the expected output voltage, with the status "Control" by the average value on the measuring channels "1" and "4"

The test result (*Fig. 8.19*) corresponds to the preliminary calculation - the expected voltage graphic corresponds to the real one, reaching a voltage limit of 336 mV.

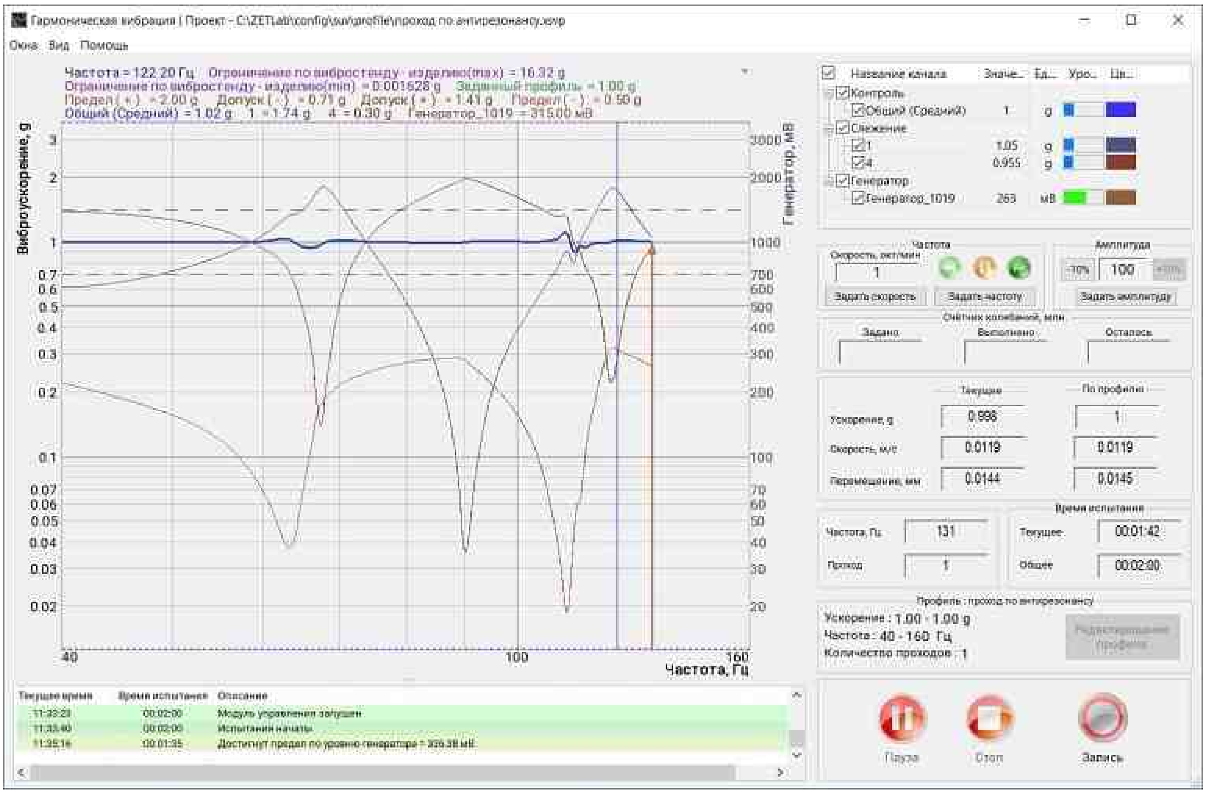


Fig. 8.19 Passage of of vibration testing during operation of the control channel according to the average value formed from the measuring channels "1" and "4"

Examples for the section .....

An example of the search for resonances in the study of a turbine blade .....

An example of the search for resonances in the study of a turbine blade

It is required to determine the parameters (frequency, Q-factor) of the resonances of the turbine blade mounted on the table of the shaker using an accelerometer (in the example, an accelerometer with ICP and a sensitivity of 10.11 mV/g is involved) mounted on a bracket for attaching the blade. The search must be performed in the frequency range from 10 Hz to 1000 Hz. The weight of the blade, taking into account the mounting bracket, is 1 kg.

To solve this problem, it is necessary.

On the VCS panel (*Fig. 4.1*), activate the "Shaker parameters" button.

To go to the Shaker parameters program window, press the *Shaker parameters* button on the VCS panel (*Fig. 8.20*). The Shaker parameters window (*Fig. 8.21*) will appear on the screen.

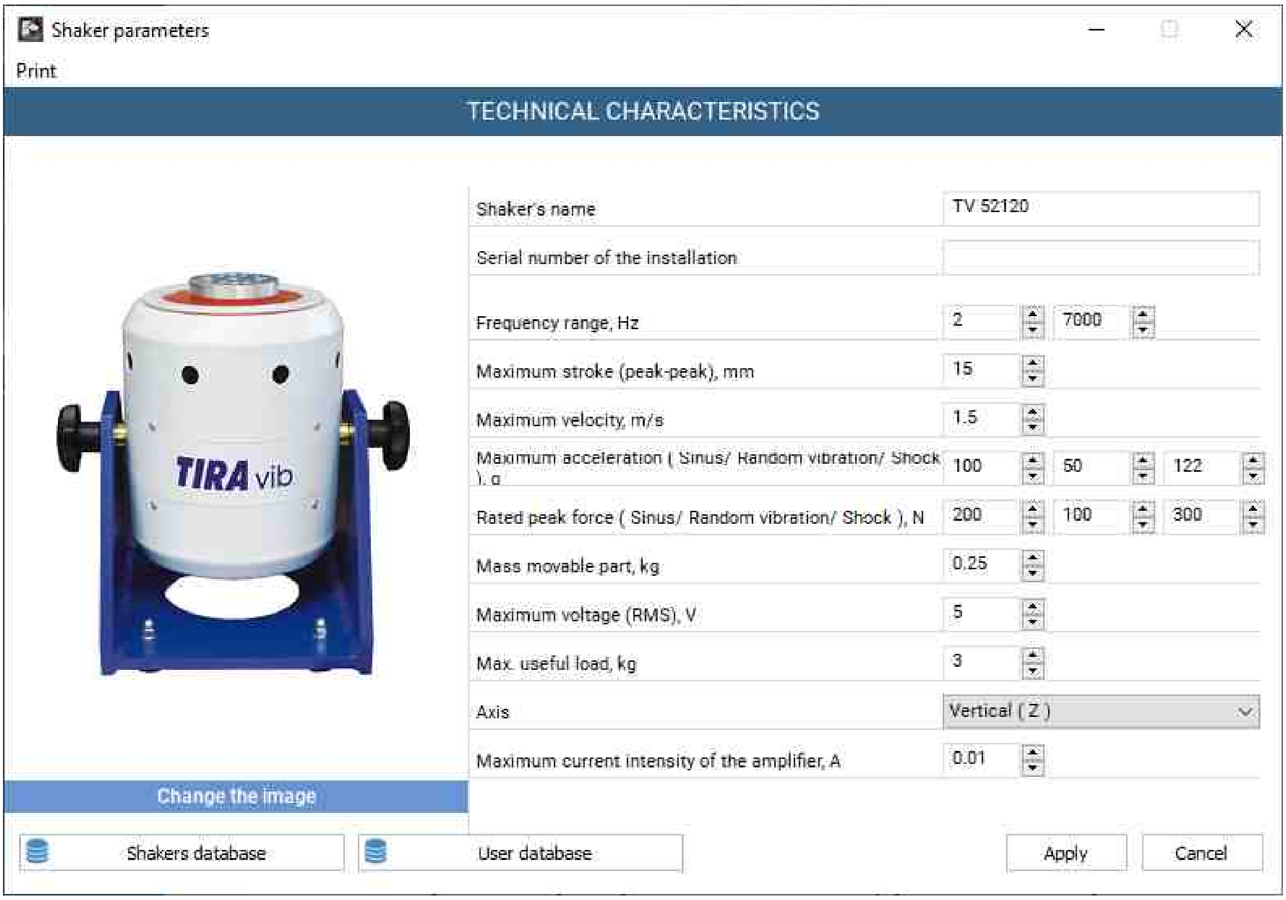


Fig. 8.20 Window "Shaker parameters"

On the VCS panel (*Fig. 4.1*), activate the "Specimen parameters" button.

In the "Specimen parameters" program window, for the "Specimen mass" parameter, specify the value of the blade mass, taking into account the weight of the snap-in for its attachment (*Fig. 8.21*), after which activate the "Apply" button to save the changes made.

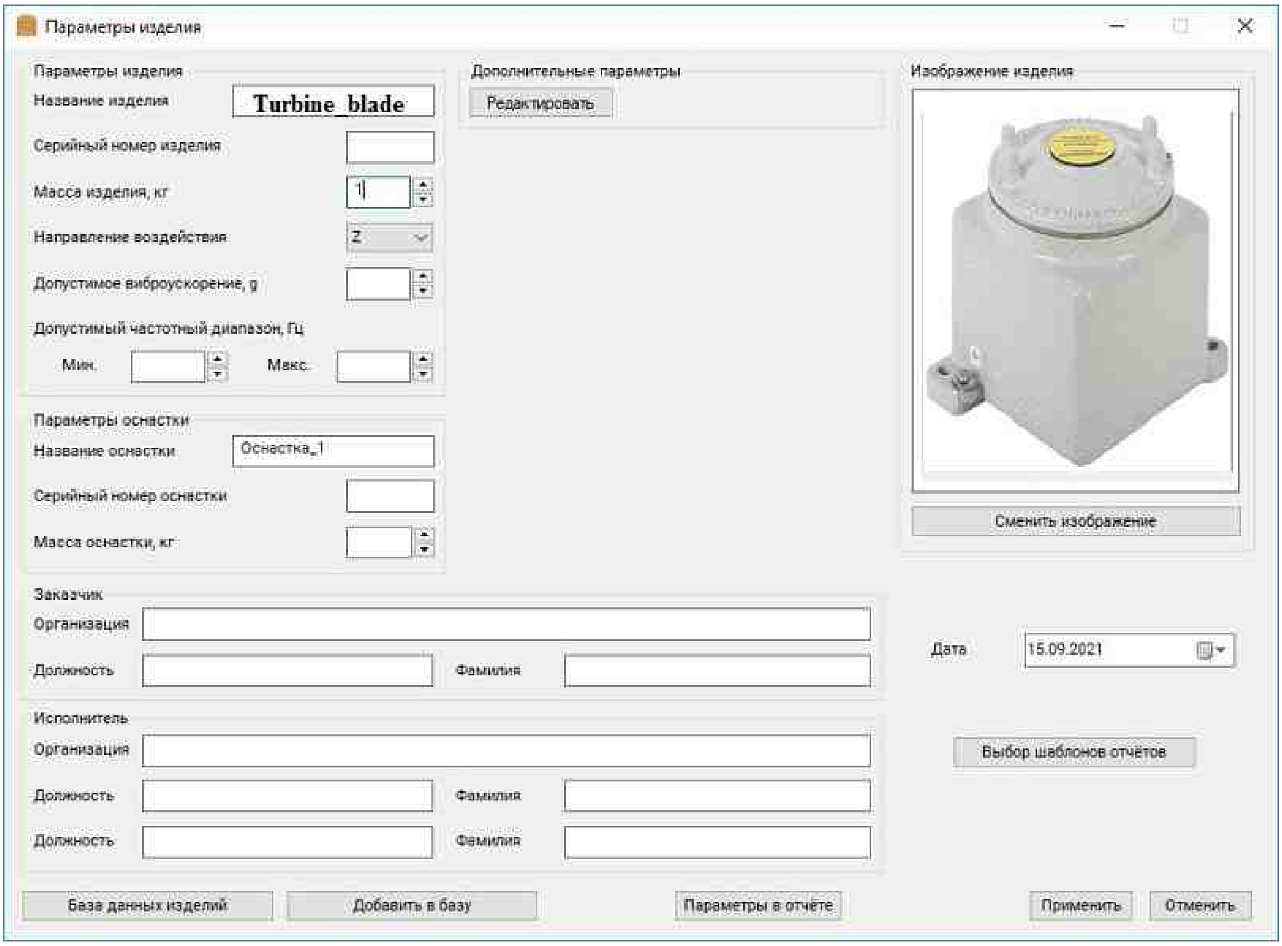


Fig. 8.21 Specimen parameters window

On the control panel (*Fig. 4.1*), activate the "Device Manager" button.

In the "Device Manager" program window (*Fig. 8.22*) activate the ID of the measuring channel with the connected accelerometer (in the example "Accel") and in the "Properties" window (*Fig. 8.23*) setting. the measuring channel according to set the connected accelerometer.

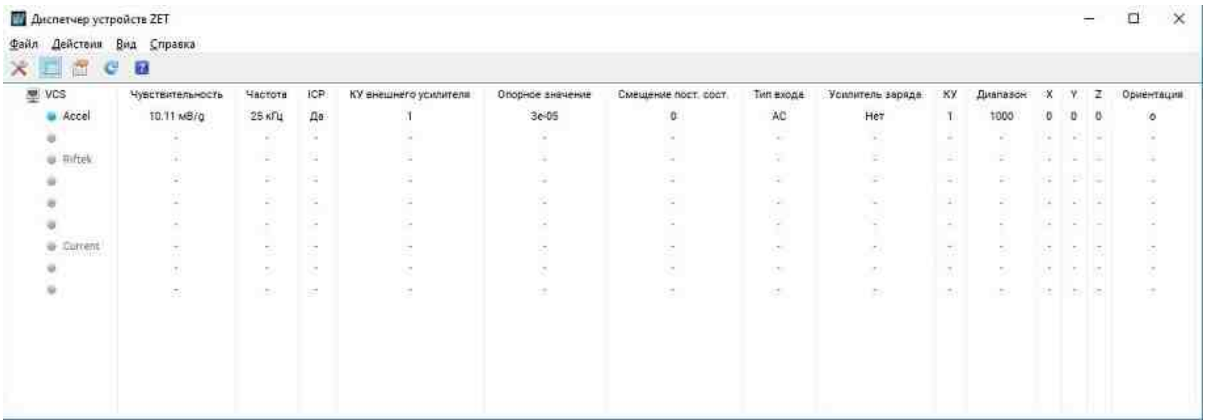


Fig. 8.22 Device Manager window

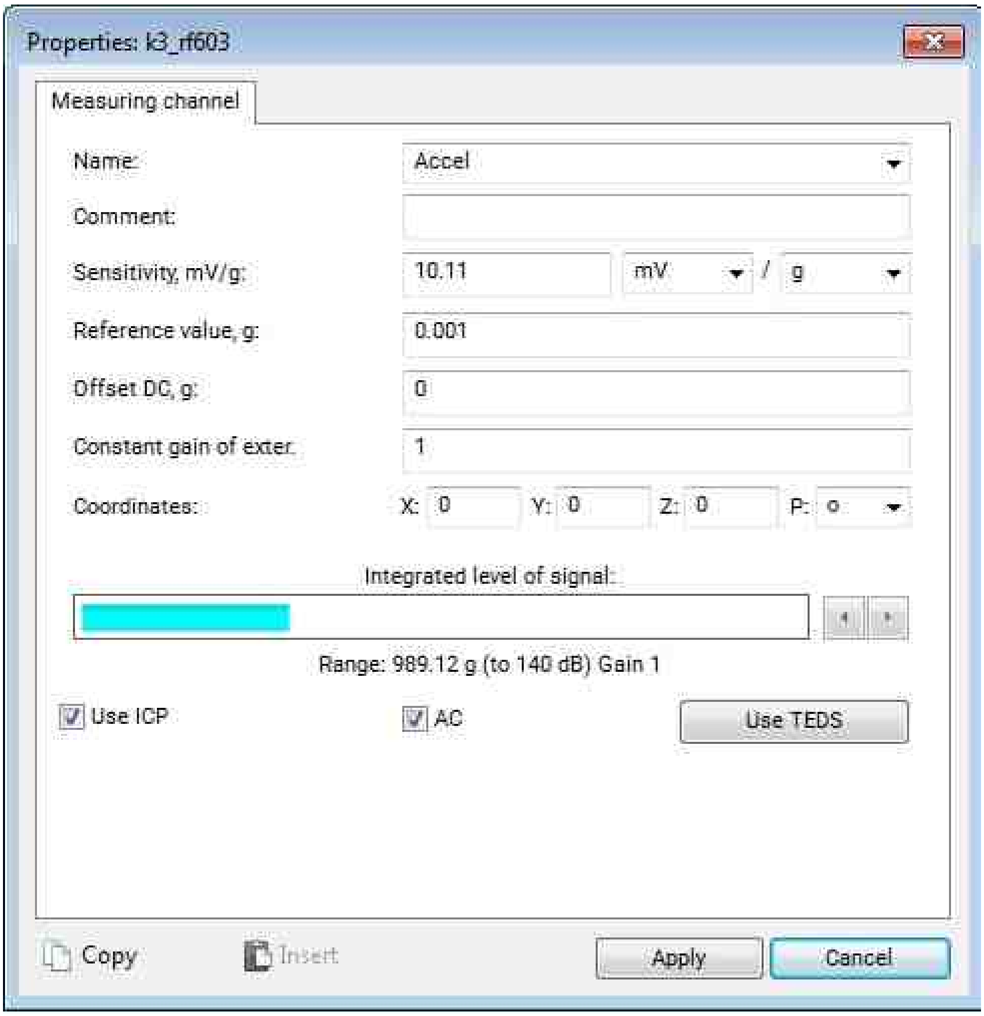


Fig. 8.23 "Properties" window

On the control panel (*Fig. 4.1*), activate the "**Pre-Test and search for resonances**" button.

In the program window "**Pre-Test and search for resonances**" of the test object (measuring channel "1") and in the center (measuring channel "6"). (*Fig. 8.24*) activate the "Setting" button and set the Pre-Test parameters in accordance with the Fig. (*Fig. 8.25*), after which activate the "Apply" button to save the settings.

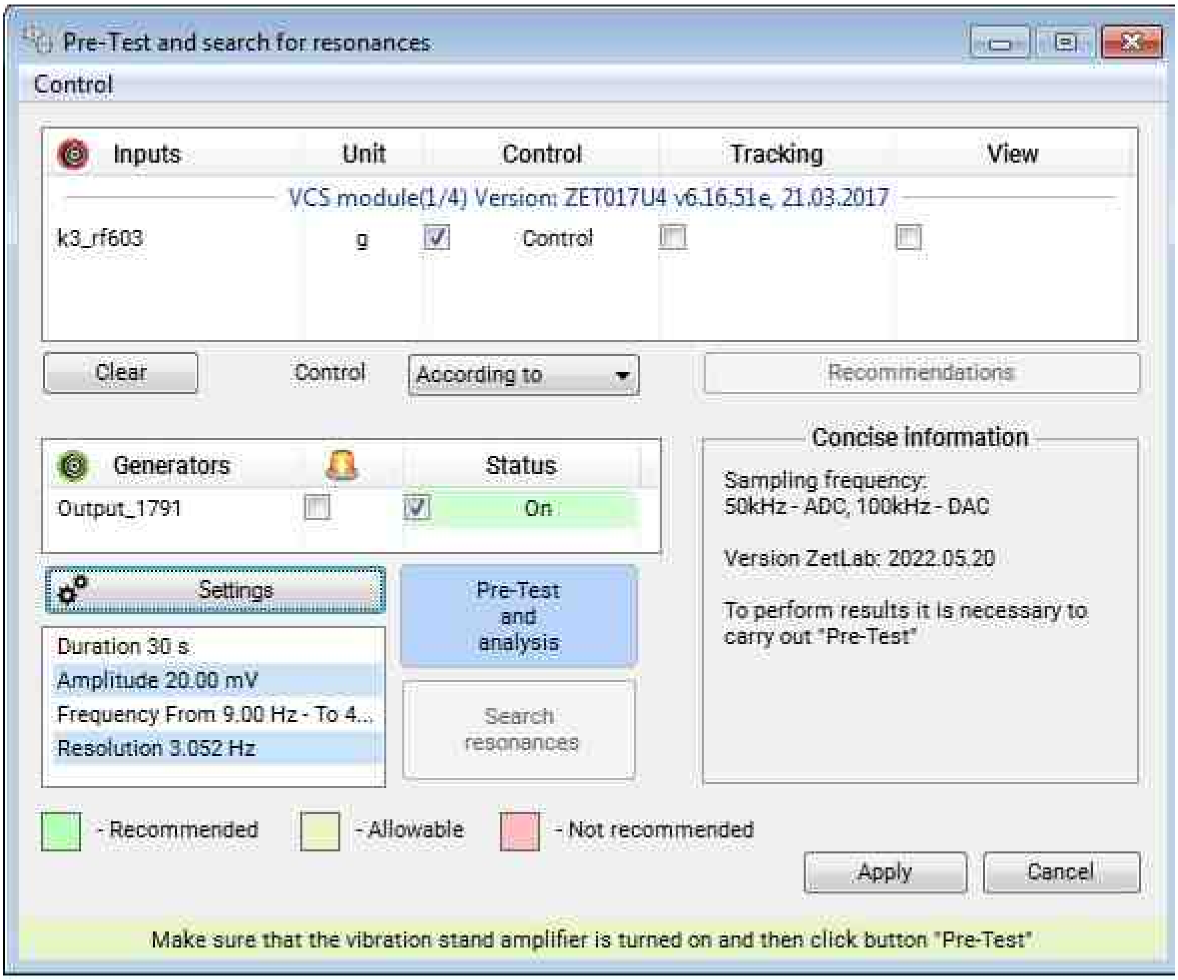


Fig. 8.24 The window "Pre-Test and search for resonances"

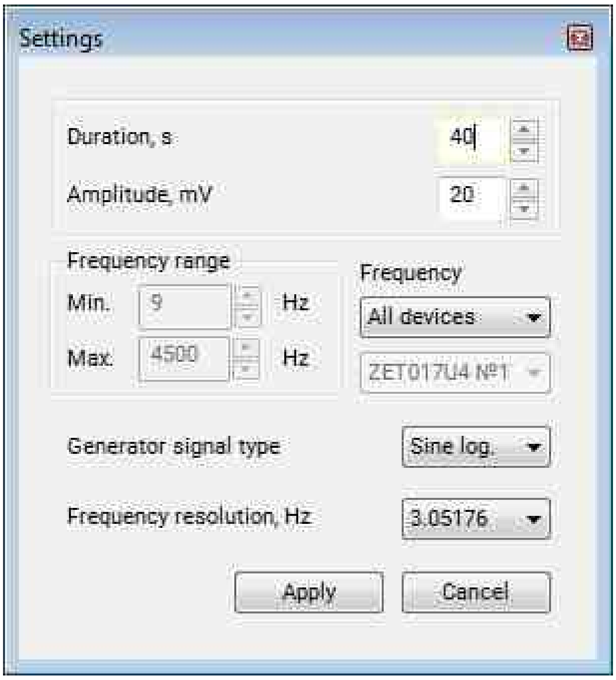


Fig. 8.25 "Settings" window

In the program window "**Pre-Test and search for resonances**" (*Fig. 8.24*) activate the "Pre-Test" button, wait for the results of the Pre-Test upon its completion (*Fig. 8.26*), after which activate the "Apply" button to save the results of the Pre-Test.

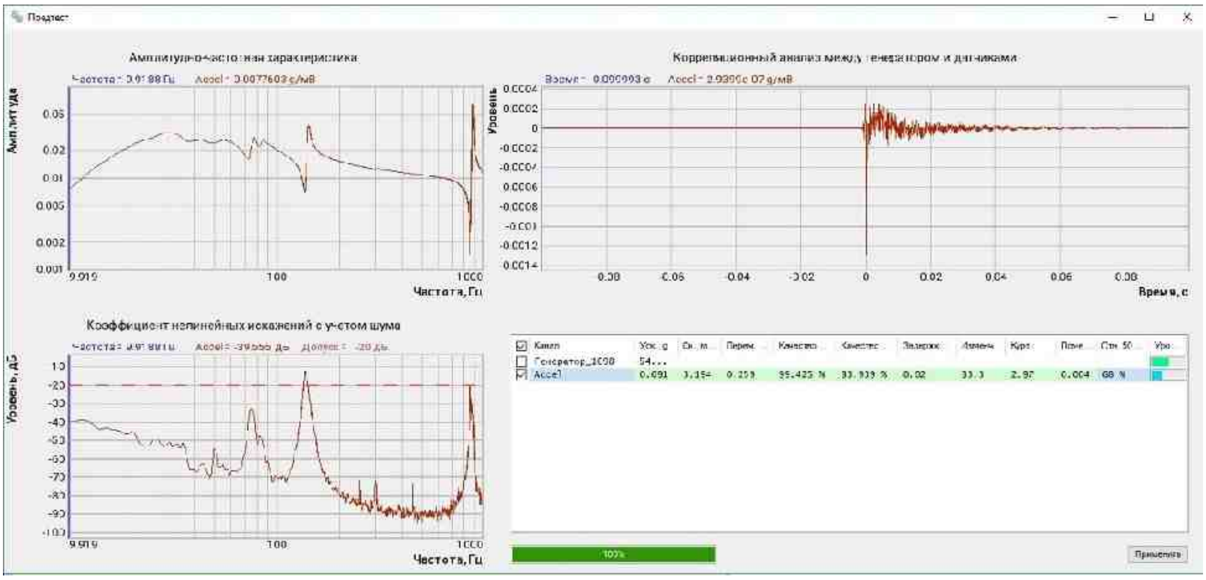


Fig. 8.26 The "Pre-Test" window

In the program window "**Pre-Test and search for resonances**" (*Fig. 8.24*) activate the "Resonances" button and in the "Pre-Test – Window of resonances" (*Fig. 8.27*) set the "Resonance type" parameter to "Electric", and in the "Measuring" field the name of the monitored measuring channel (in the example "Accel").

In the "Pre-Test – Window of Resonances", the registered resonances are marked on the "Transfer" graphic, and the table on the right shows the registered parameters for each of them.

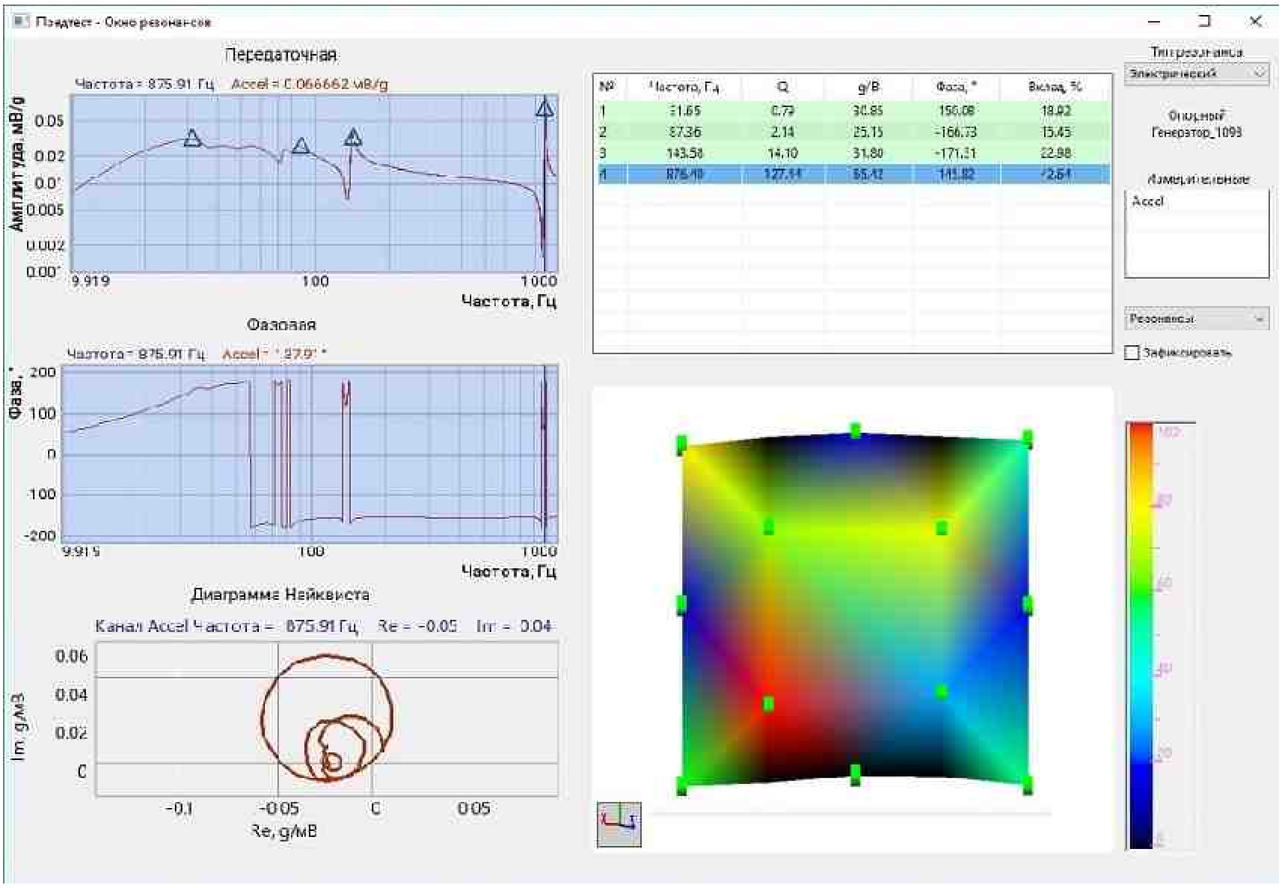


Fig. 8.27 Window "Pre-Test – Window of resonances"

An example of the control of the oscillations form of the expansion table surface .....

An example of the control of the oscillations form of the expansion table surface

The control of the waveform can be performed provided there are enough measuring channels for visualization. In the example under consideration, 12 accelerometers are installed on the surface of the shaker expansion table, the measuring channels of which are set according to the example given in section 7.7.1

To solve this task, you need to perform the following actions.

On the VCS panel (*Fig. 4.1*), activate the "Shaker parameters" button.

In the "Shaker parameters" program window, select the type of Shaker involved.

In the "Specimen parameters" program window ([Fig. 8.28](#)), for the "Specimen mass" parameter, specify the total mass of the installed accelerometers, for the "Tool mass" parameter, specify the mass of the expansion table (in the example 0.7 kg).

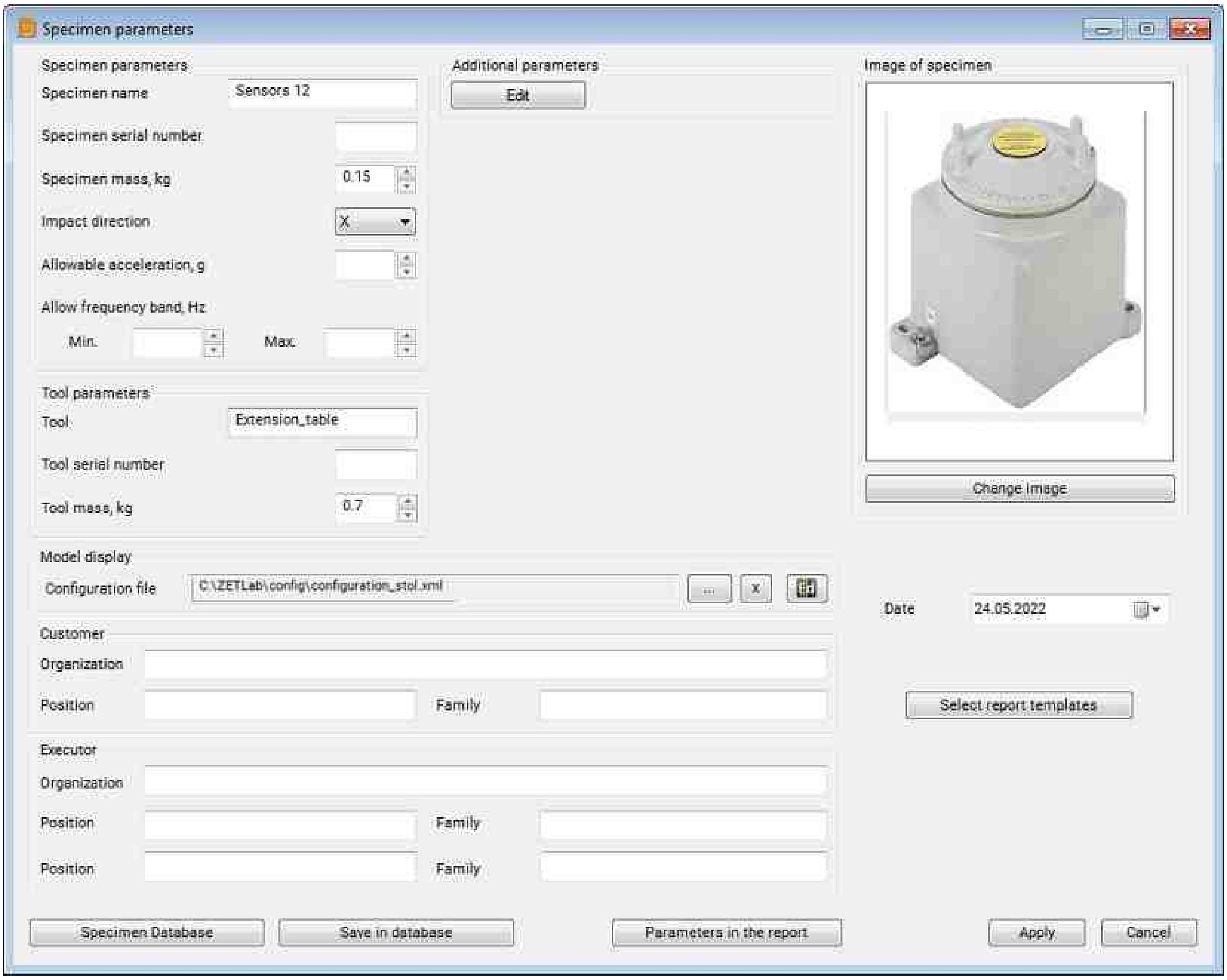


Fig. 8.28 Specimen parameters window

Next, in the "Model display" field, you should  activate the button  this will open the Configuration editor window ([Fig. 8.29](#)) in which it is necessary to determine the layout of accelerometers.

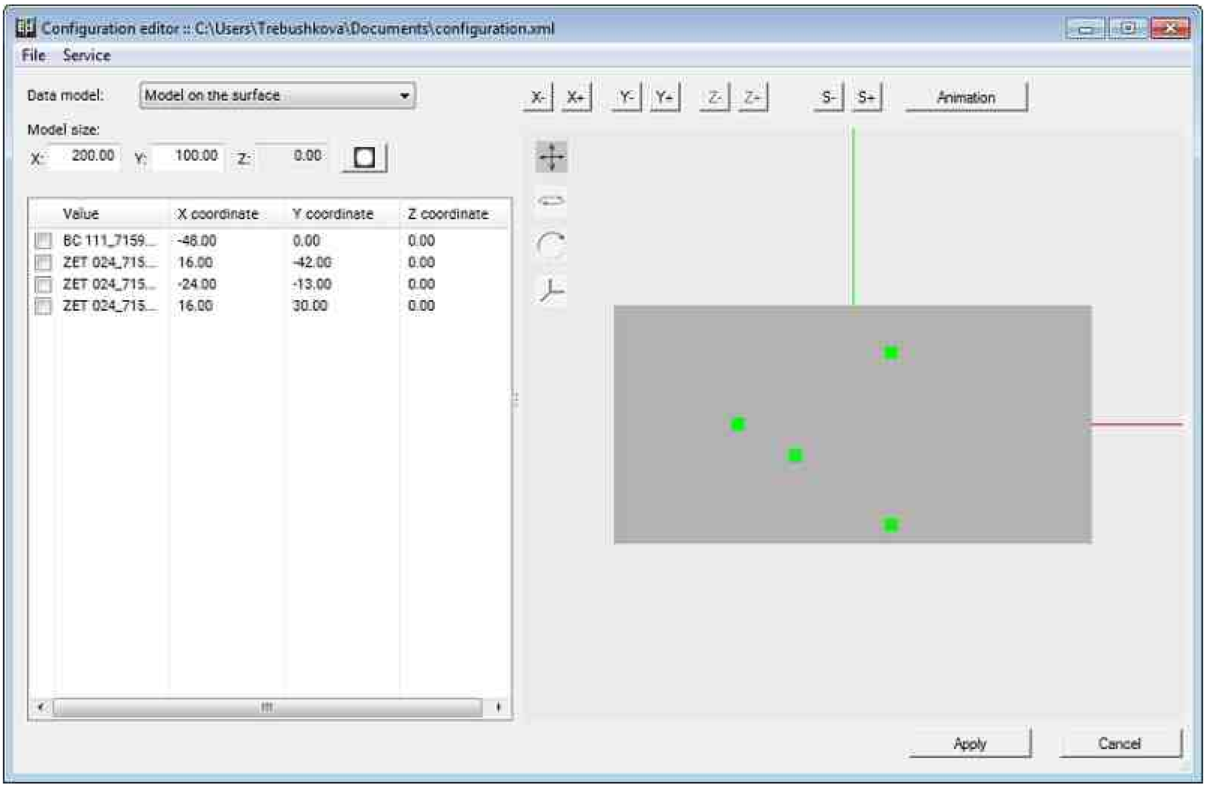


Fig. 8.29 Configuration editor window

In the Configuration editor window, select the value "Model on the surface" for the "Data model" parameter, specify values for the "Model size" parameter, taking into account the unidades of the expansion table, and then set coordinate values (X and Y) in the table for each measuring channel (in the example "1" ... "12") location of accelerometers on the surface of the expansion table (*Fig. 8.30*).

Note: *for a* "Model on the surface"*, the Z coordinate always has zero values.*

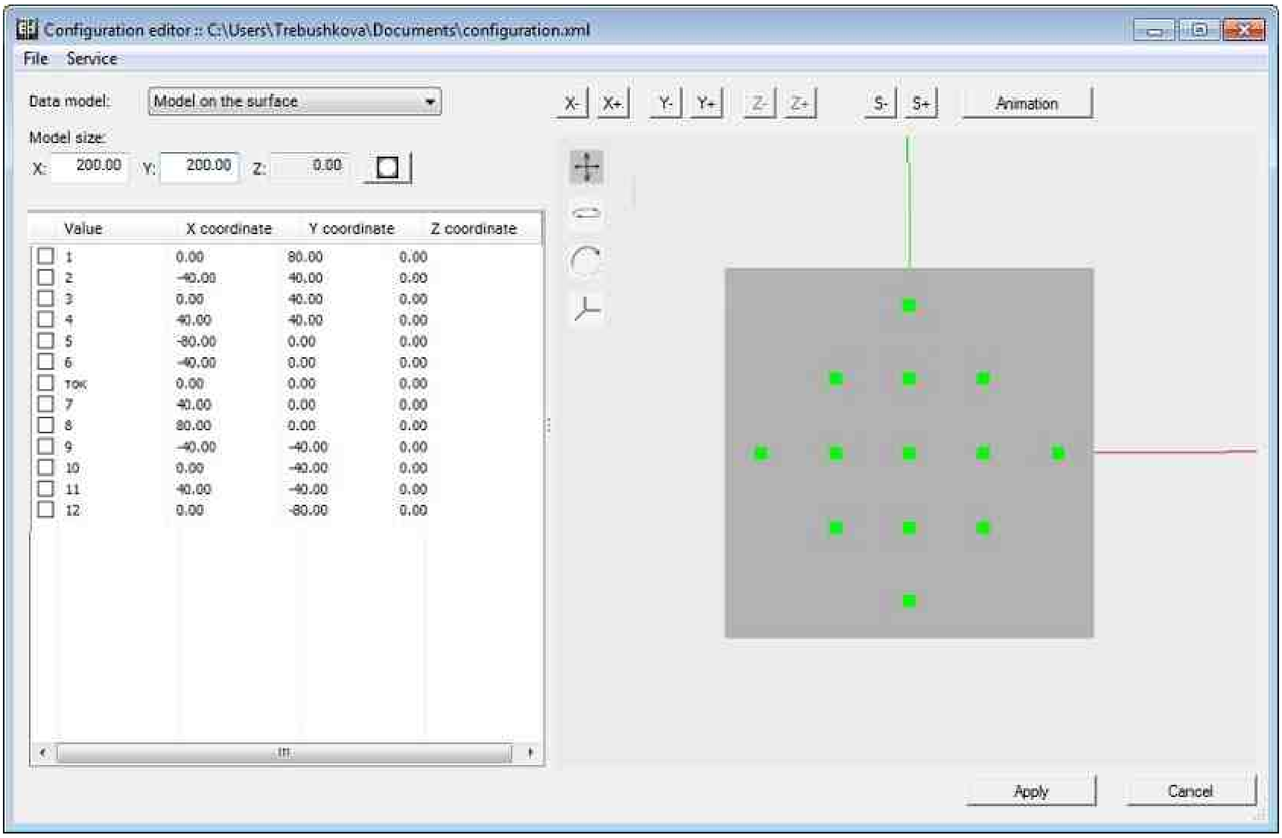


Fig. 8.30 Configuration editor window

Note: *absolute values of the unidades of the object under study are not important for visualization of the waveforms, therefore, coordinate values can be set in any units of measurement "mm", "cm", "m", provided that the proportions of the coordinates of the installation on the object under study are preserved.*

To adjust the list of measuring channels involved in the control of the waveform, it is necessary to select the "Service" menu in the list (*Fig. 8.31*), Configuration editor windows, activate the "Channel filter" and in the corresponding program window (*Fig. 8.32*) mark in the checkboxes those measuring channels that are necessary for visualization.

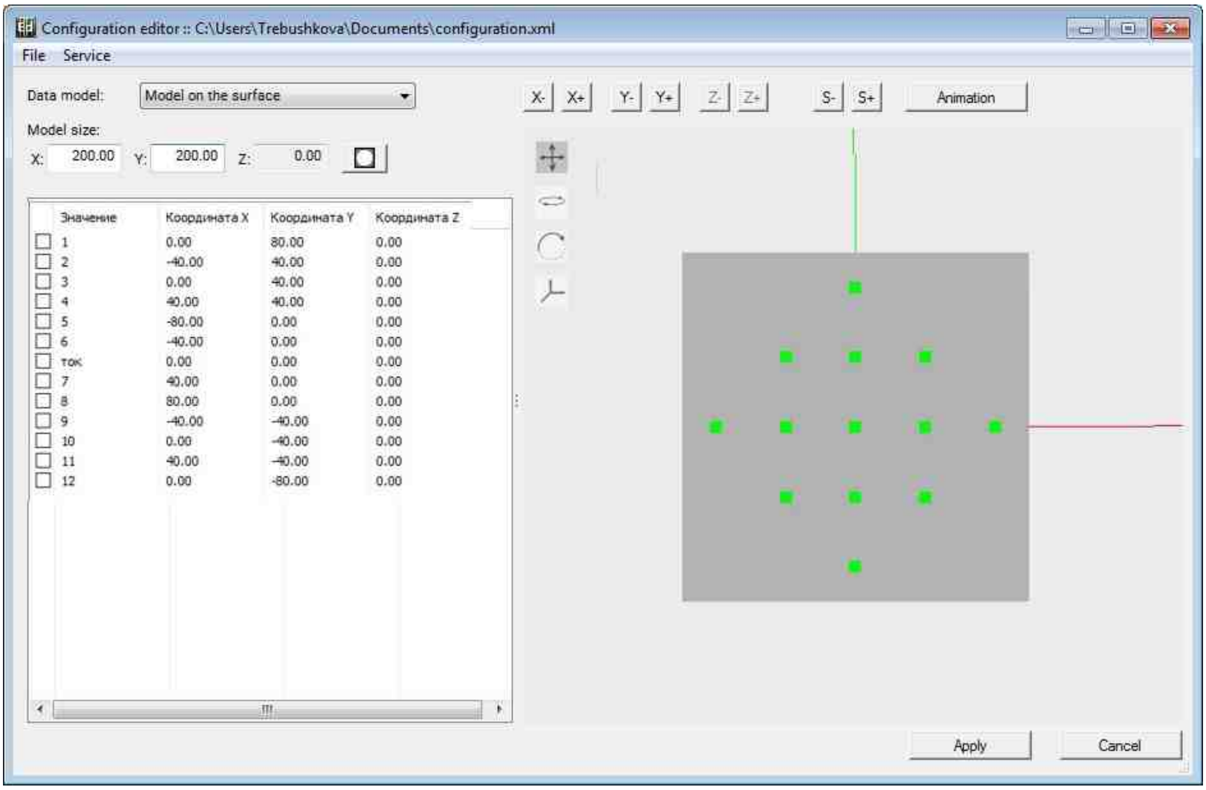


Fig. 8.31 Configuration editor window the "Service" menu

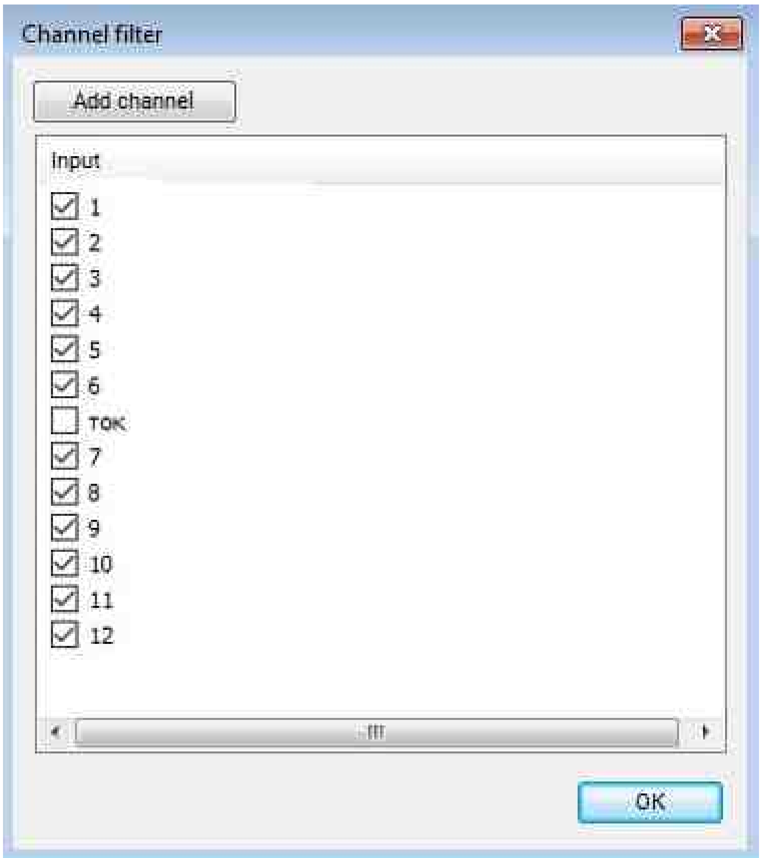


Fig. 8.32 Channel filter window

Note: *in the "*Service*" menu of the "Configuration editor" window, the "Import channel coordinates" program allows you to save the coordinates of measuring channels to the controllers to which these channels belong, and the "Export channel coordinates" programs allow you to read the measurement coordinates from the controllers to the editor*

By default, the contour of the model on the plane is defined by a rectangle with the aspect ratio specified by the parameters in the "Model size" field of the Configuration editor window (*Fig. 8.30*).

In the example under consideration, the extension table has a round form. In order to switch from a rectangular model form to a round one in the Configuration editor window (*Fig. 8.30*) follow activate the button "" after that, in the "Image mask" window that opens (*Fig. 8.33*) follow activate the field "" and in the "Open" window that opens (*Fig. 8.34*):

1) choose the form of the model from the presented templates: square, circle, hexagon or triangle.

2) point to the path to the file prepared in the "bmp" format containing the contour of the specimen (in this example, a circle in the "circle.bmp" file).

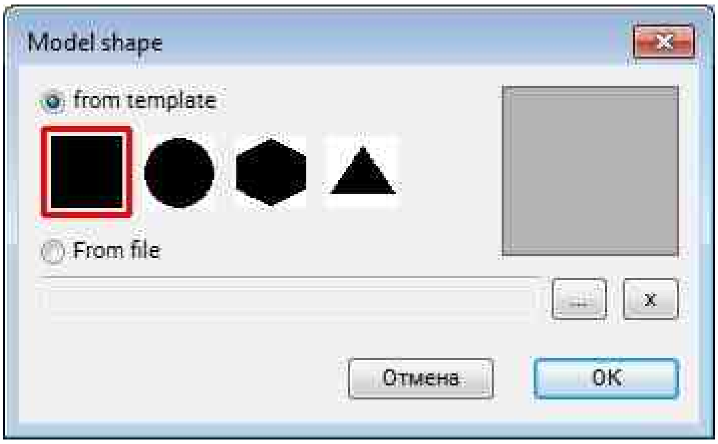


Fig. 8.33 Image mask window

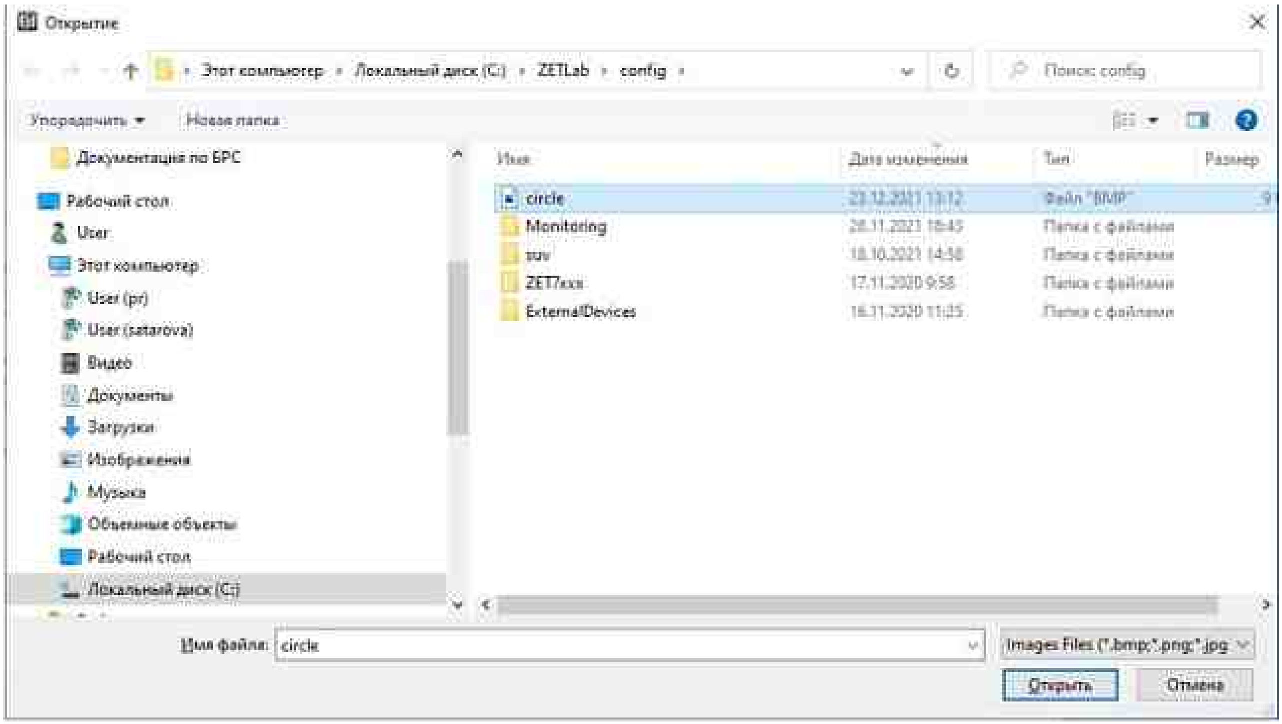


Fig. 8.34 The "Open" window

After activating the "Open" button in the "Open" window (*Fig. 8.34*) the outline of the model will be visualized in the "Model form" window (*Fig. 8.35*).

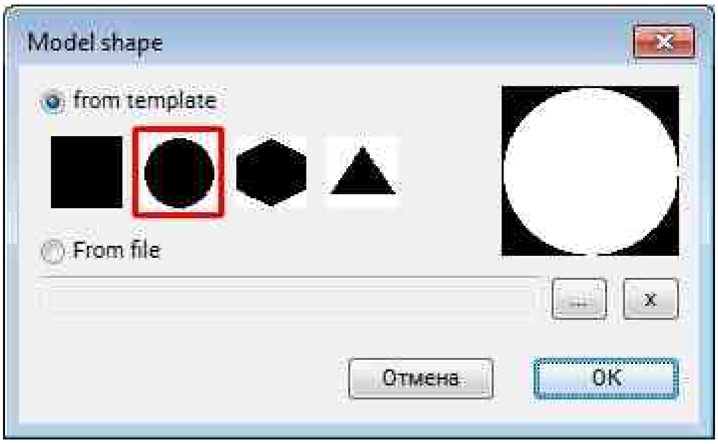


Fig. 8.35 The "Model form " window with the selected contour

As a result of editing, the specified form of the surface of the object under study will be visualized in the Configuration editor window with the display of the accelerometer installation locations (*Fig. 8.36*).

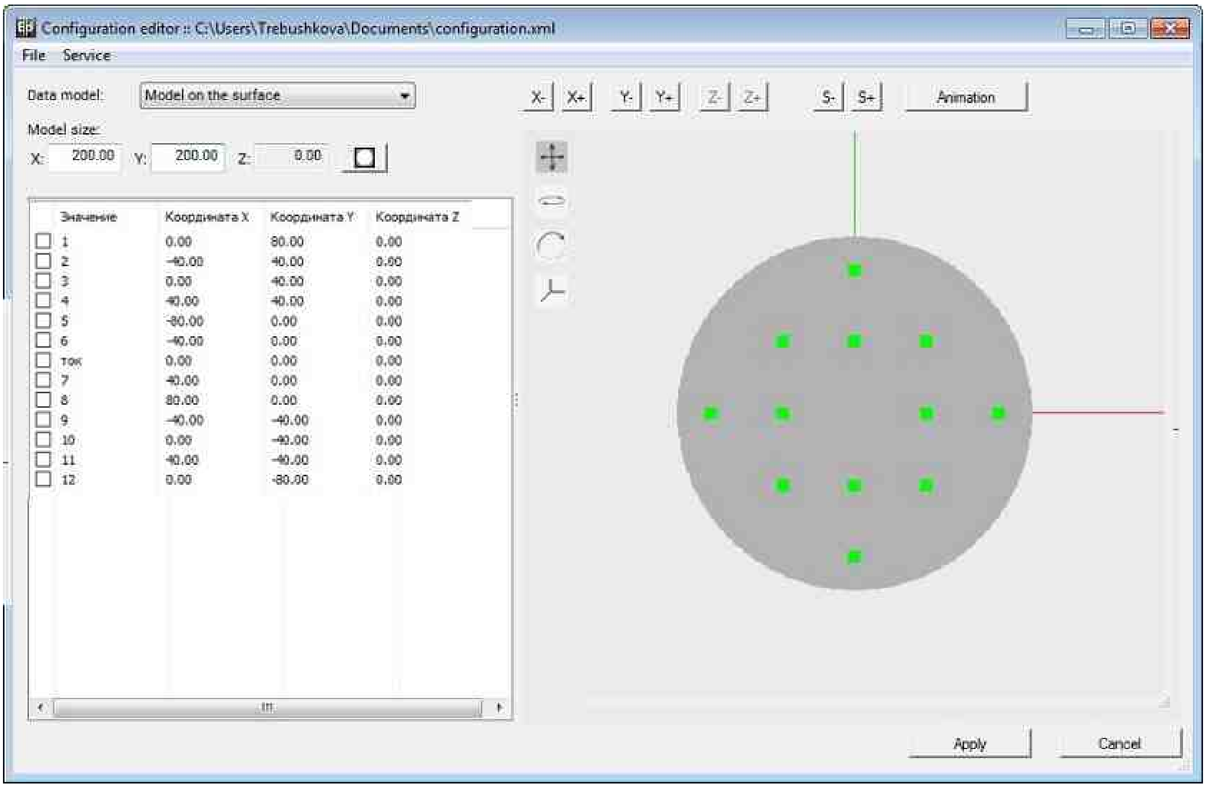


Fig. 8.36 Configuration editor window

After the configuration editing is completed, you should save the configuration file for this in the "File" menu list ([Fig. 8.31](#)) necessary activate "Save configuration" and in the "Save" window ([Fig. 8.37](#)) specify the path and name of the saved file.

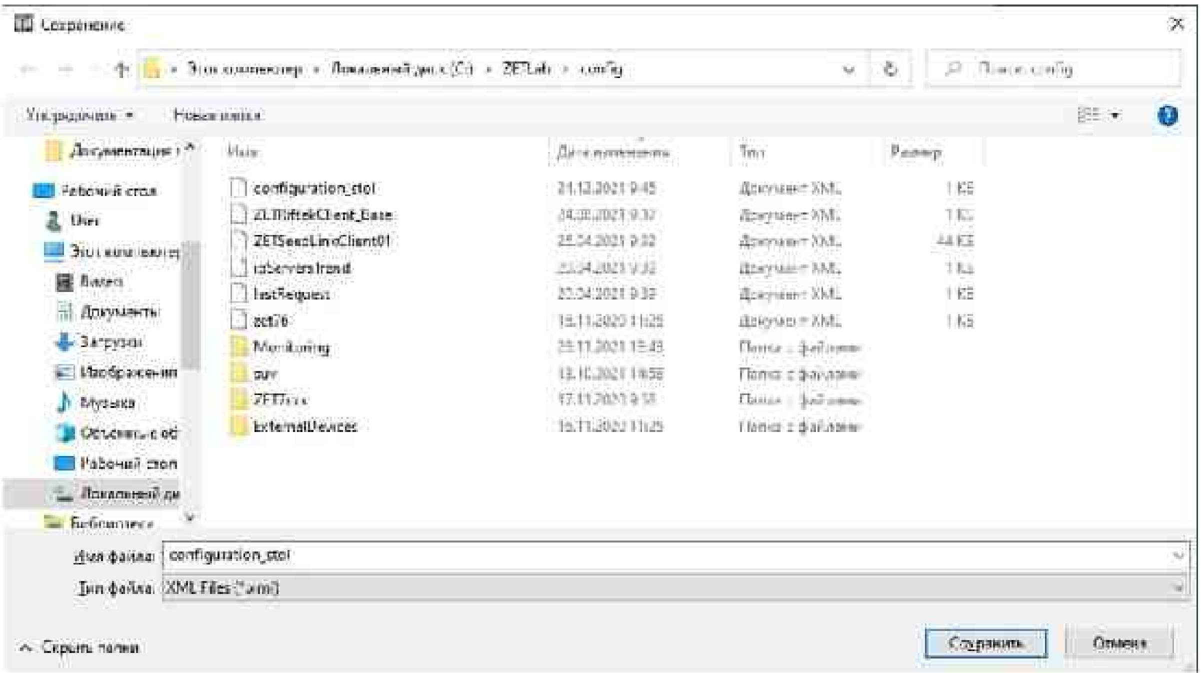


Fig. 8.37 "Save" window

In the "Specimen parameters" window (*Fig. 8.38*) you should also activate the "Apply" button to save the entered information.

Before you start viewing the waveforms, it is necessary to conduct a "Pre-Test". To do this, on the panel VCS (*Fig. 4.1*), activate the "**Pre-Test and search for resonances**" button.

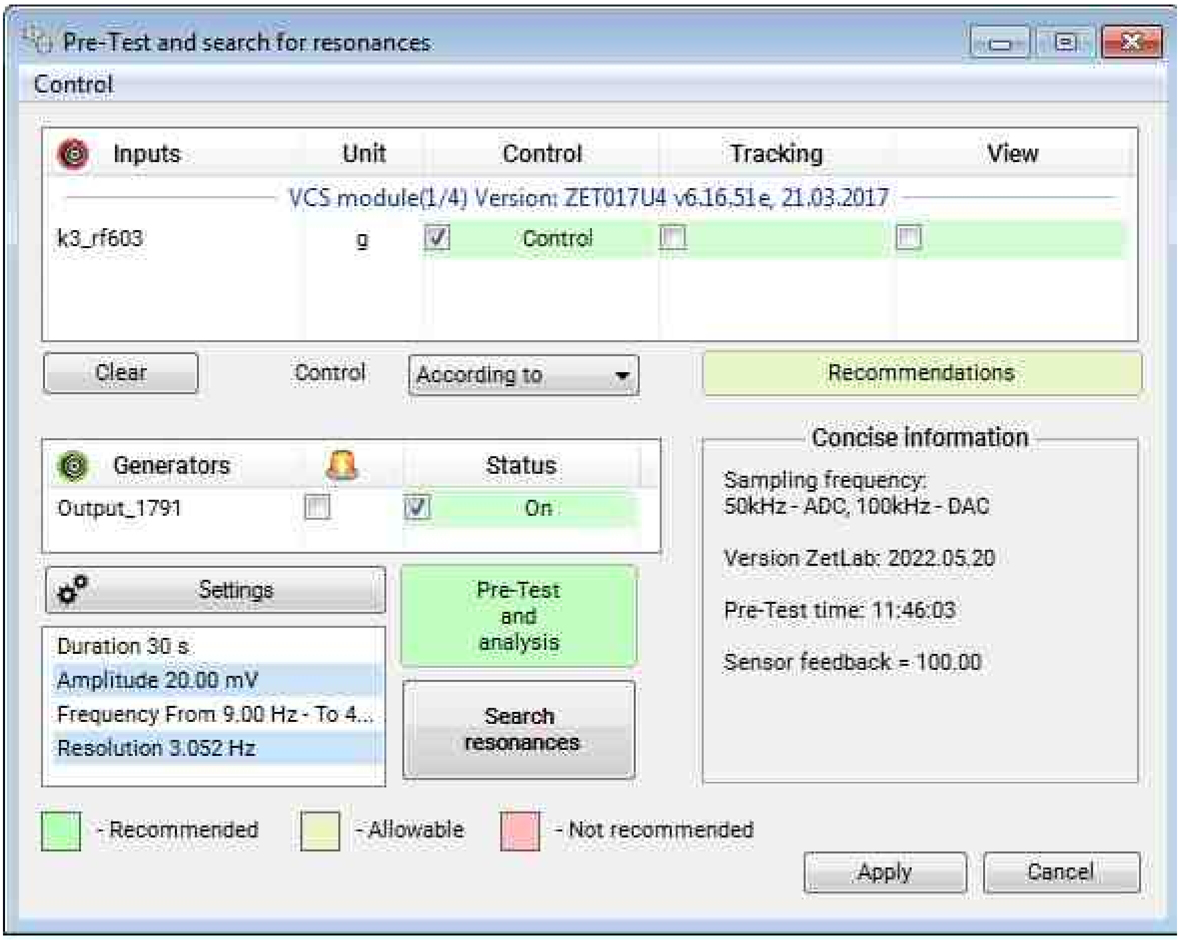


Fig. 8.38 Pre-Test and search for resonances window

To set the Pre-Test parameters in the "**Pre-Test and search for resonances**" window, you should activate the "Setting" button and set the values "Duration" and "Amplitude" (typical values of 50 s and 50 mV, respectively), as well as "Frequency range" and "Frequency resolution". The frequency range determines the frequency domain in which the control of the waveforms will be possible, and the frequency resolution determines the degree of detail of the signal spectrum in the frequency domain.

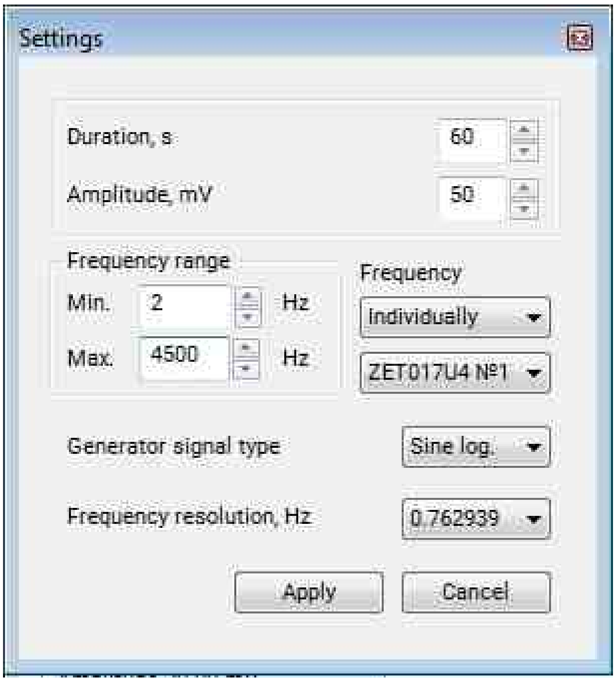


Fig. 8.39 Setting window

Activating the "Apply" button in the "Settings" window will save the changes you have made.

Next, in the window of the program "Pre-Test and search for resonances", the status of the generator of the VCS controller should be switched to the "On" status (*Fig. 8.40*), then activate the corresponding "Pre-Test and analysis" button to perform the Pre-Test.

Note: *In the example under consideration, two VCS controllers are involved, the generator channel is activated only for the VCS controller whose output is connected to the Shaker amplifier*

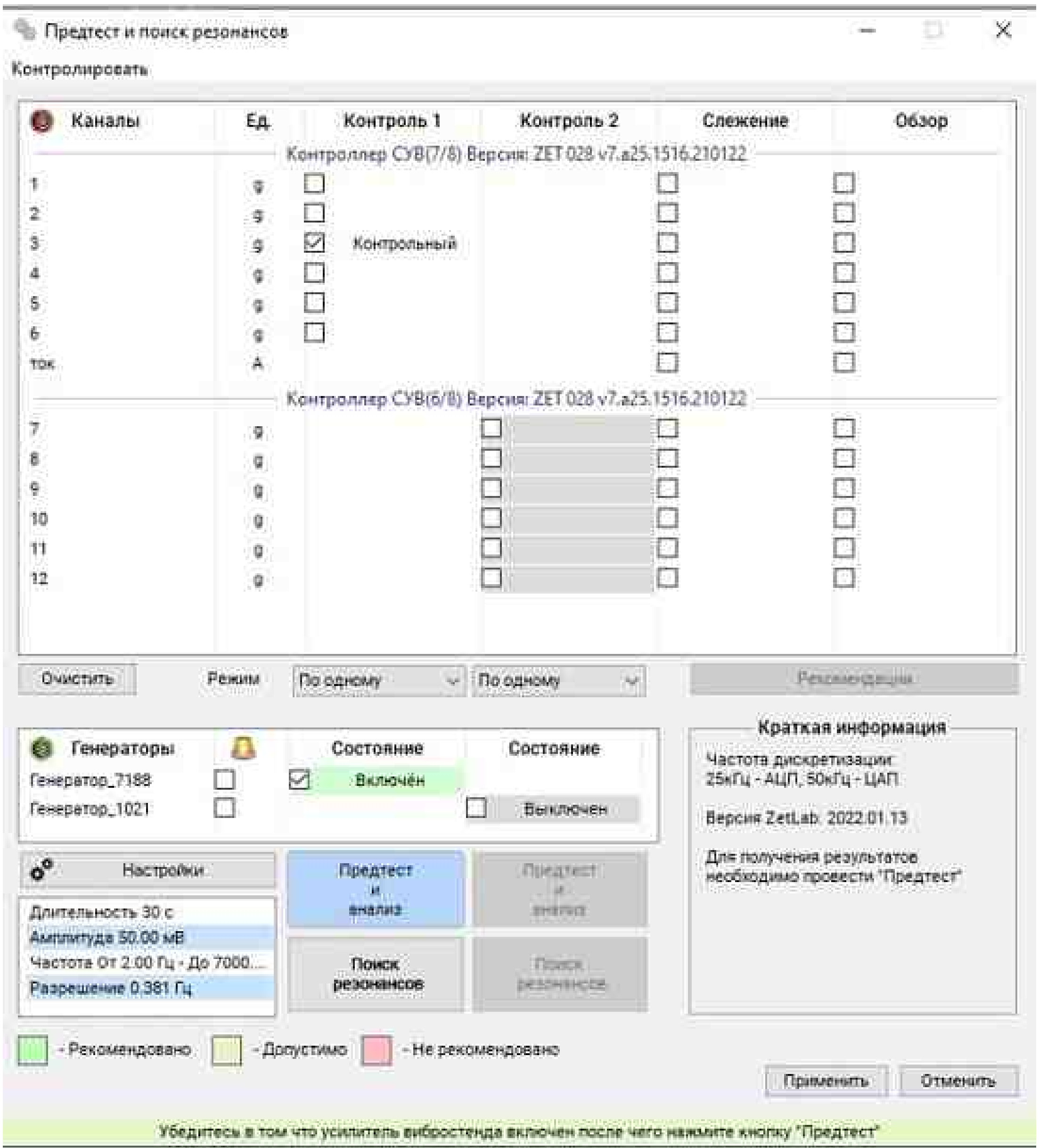


Fig. 8.40 The window "Pre-Test and search for resonances"

Upon completion of the Pre-Test in the "Pre-Test" window ([Fig. 8.41]) then activate the "Apply" button to save its results.

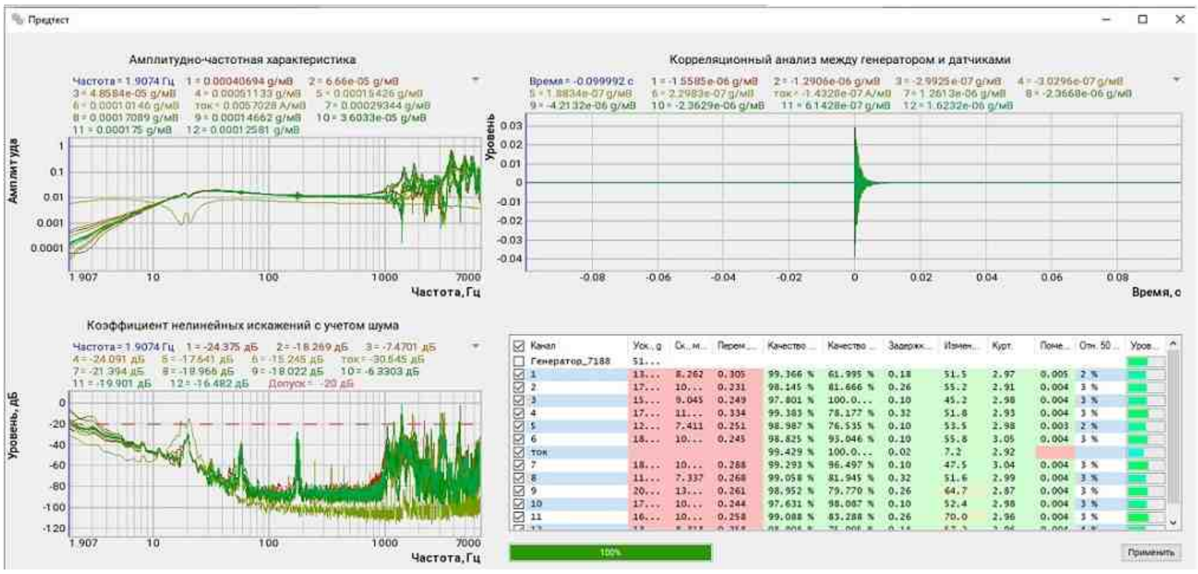


Fig. 8.41 Window "Pre-Test - Window of resonances"

Viewing the waveforms is performed in the window of the program "Pre–Test - Window of resonances (*Fig. 8.42*) to go to which in the "Pre-Test and search for resonances" window (*Fig. 8.40*) than activate the "Resonance search" button located under the "Pre-Test and analysis" button for which the Pre-Test was performed.

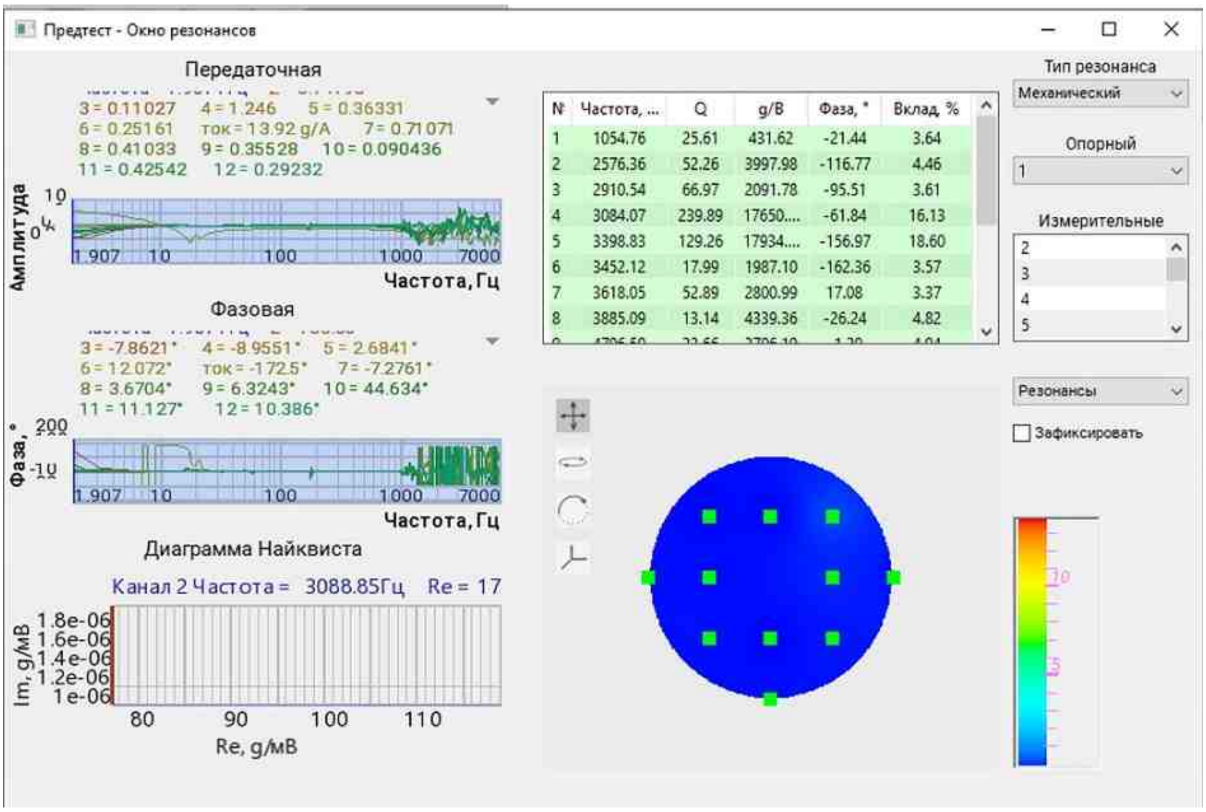


Fig. 8.42 Window "Pre-Test - Window of resonances"

In the "Pre–Test – Window of Resonances" window, set the "Resonance Type" parameter to "Electric" and activate the "Mechanical" field in the "Select channel " window that opens (*Fig. 8.43*) mark in the checkboxes those measuring channels that are to be visualized on the model.

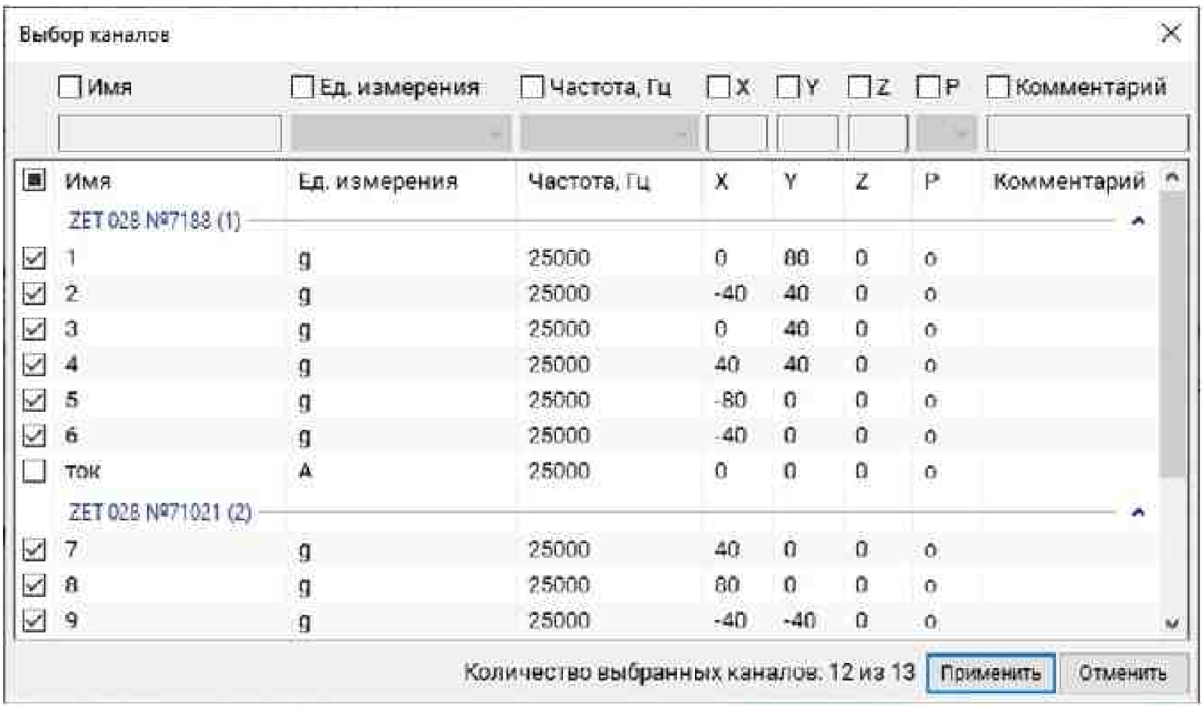


Fig. 8.43 Window "Pre-Test - Window of resonances"

Activation of the "Apply" button in the " Select channel" window completes the stage of preparation for viewing the waveforms.

For ease of operation, scale the "Pre–Test –Window of Resonances" to the full-screen format of the monitor (*Fig. 8.44*).

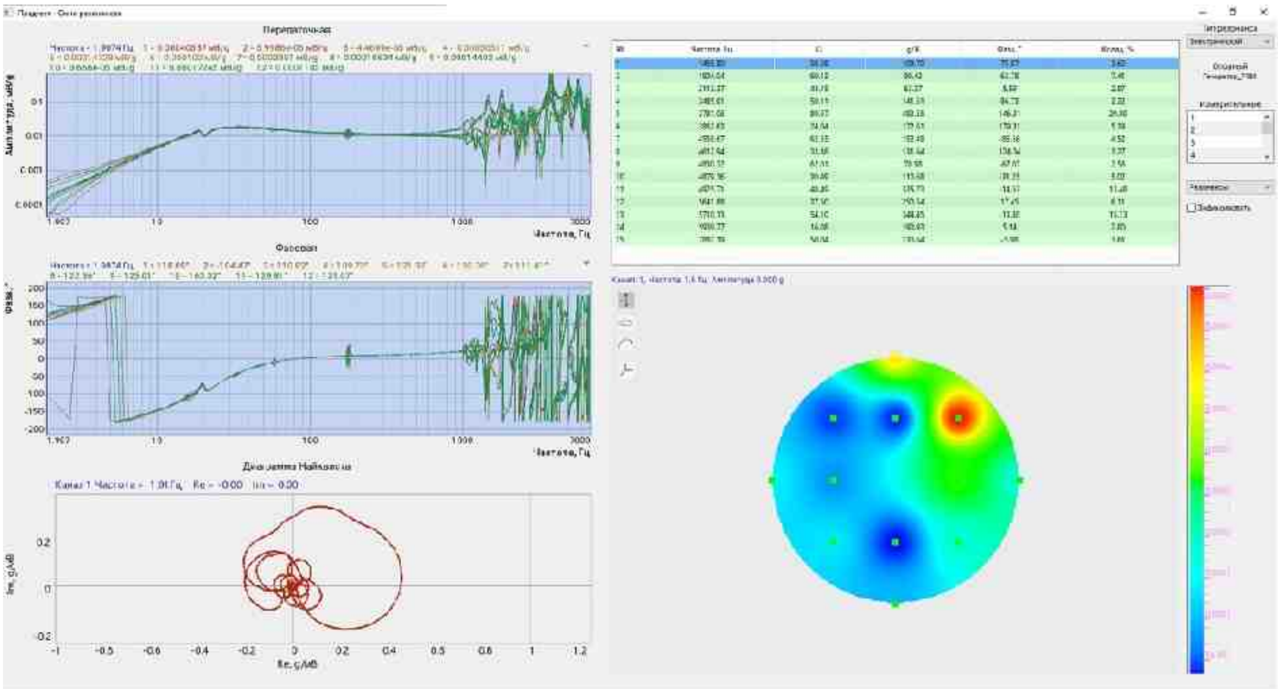


Fig. 8.44 Window "Pre-Test - Window of resonances"

According to the "Transfer" graphic, it can be seen that the expansion table has pronounced resonances in the frequency domain above 1000 Hz.

To control the form of the oscillations, we scale the "Transfer" graphic along the "Frequency" axis to the resonance region and set the pointer (reference line) to the first of the significant resonances at a frequency of 1458.8 Hz (*Fig. 8.45*).

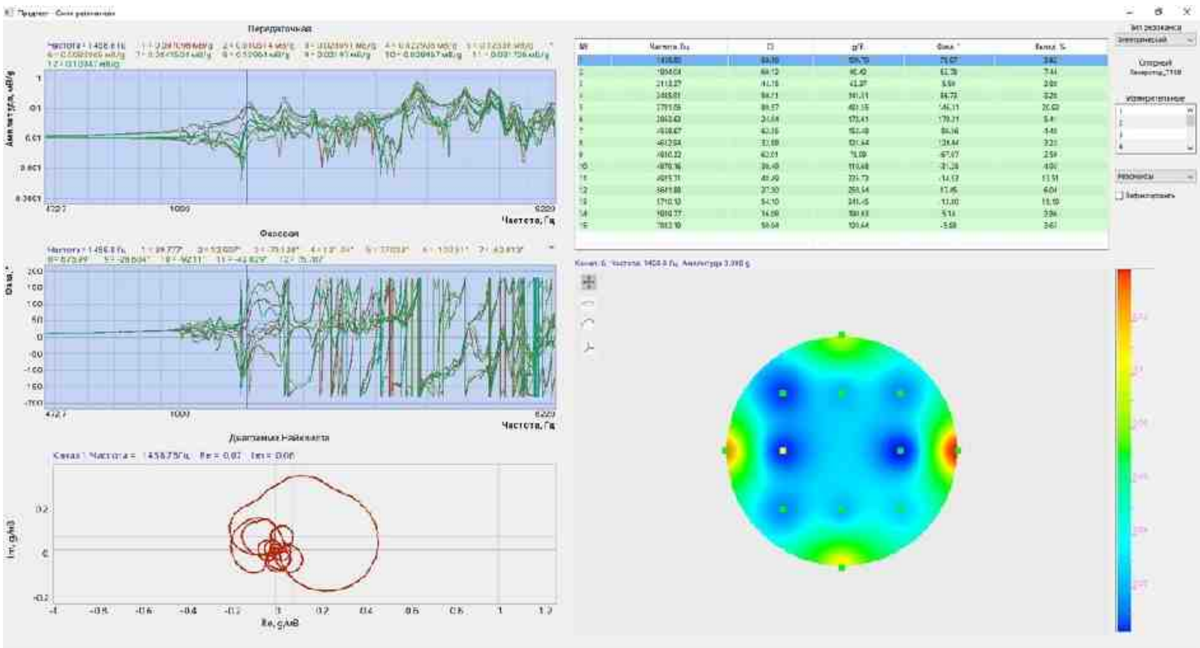


Fig. 8.45 The "Pre-Test - Window of resonances" with visualization at a frequency of 1458.8 Hz

When the pointer is set to the second (frequency 3781.06 Hz) and third (frequency 4925.71 Hz) significant resonances, the visualization will have the form shown on (*Fig. 8.46*) or (*Fig. 8.47*) respectively.

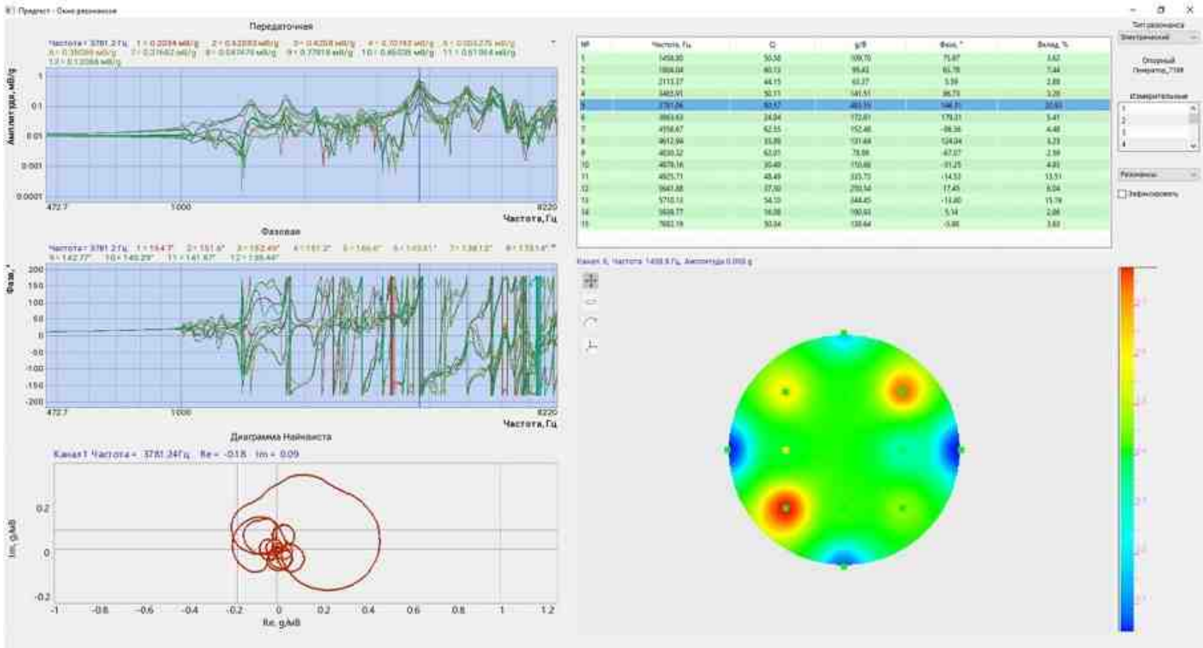


Fig. 8.46 "Pre-Test - Window of resonances" with visualization at a frequency of 3781.06 Hz

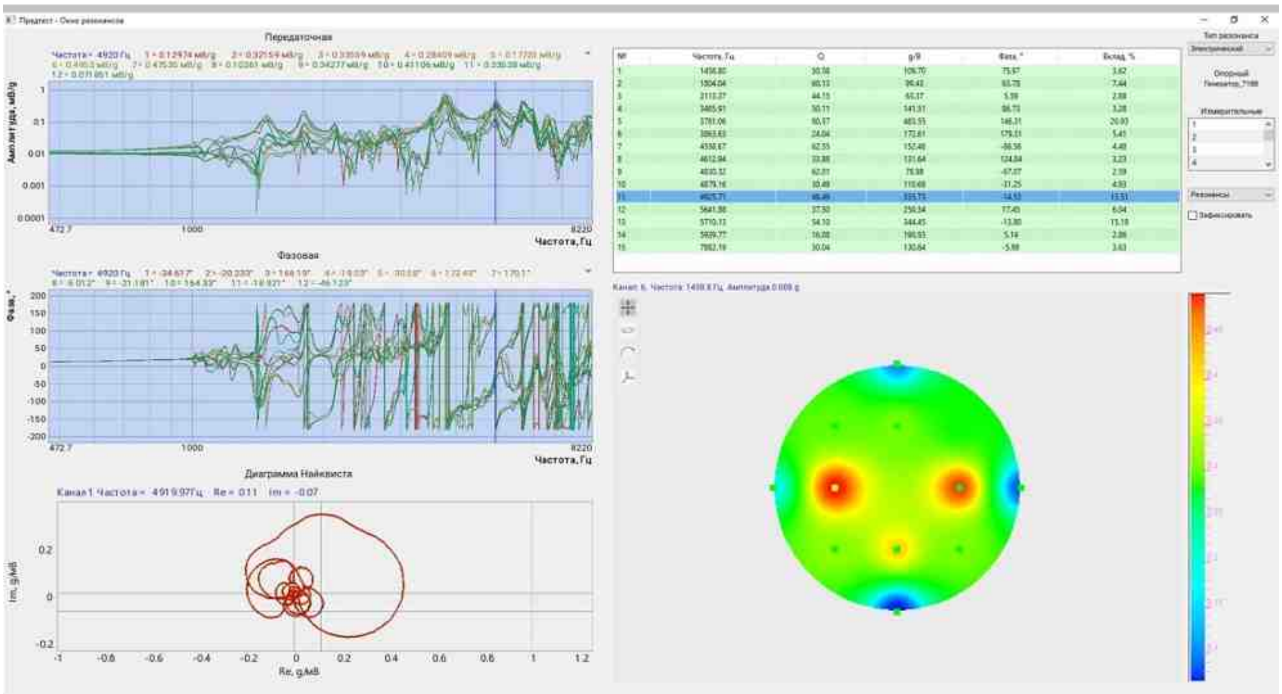


Fig. 8.47 The "Pre-Test - Window of resonances" with visualization at a frequency of 4925.71 Hz

The color scale determines the ratio of the amplitudes of the movements at the monitoring points relative to the level of the generated signal. The areas registering the smallest amplitude are shown in blue, and the largest in red.

It can be seen from the example that for different resonant frequencies, different areas of the expansion table are subjected to an increased level of vibration.

***Note**: The ability to control the form of the vibrations of the tested specimen at resonances in practice makes it possible to improve the quality and reliability of the results obtained during testing*

To switch to 3D mode in the visualization field of the "Pre–Test - Window of Resonances" window (*Fig. 8.48*) activate the inclination symbol "" after that, use the mouse pointer to tilt the model relative to the horizontal axis, and the form of the model's vibrations in space will become visible.

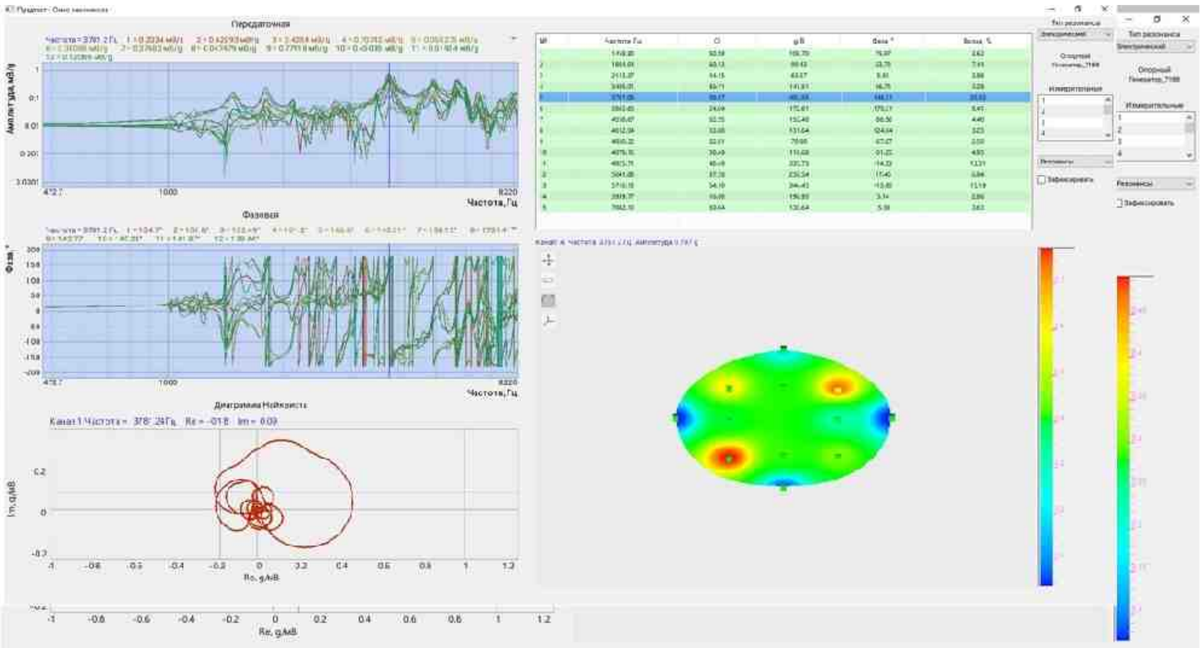


Fig. 8.48 The window "Pre-Test - Window of resonances" with the inclination of the model

If it is necessary to rotate the model in the visualization field of the "Pre–Test - Window of Resonances" (*Fig. 8.49*) activate the turn symbol "".

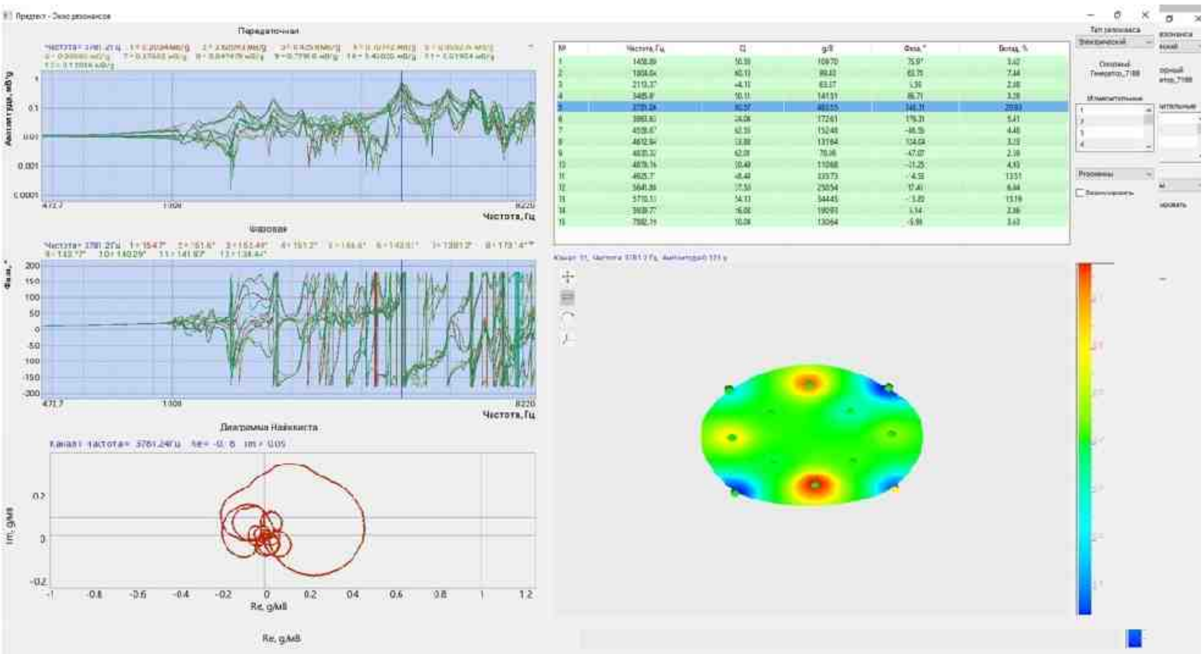
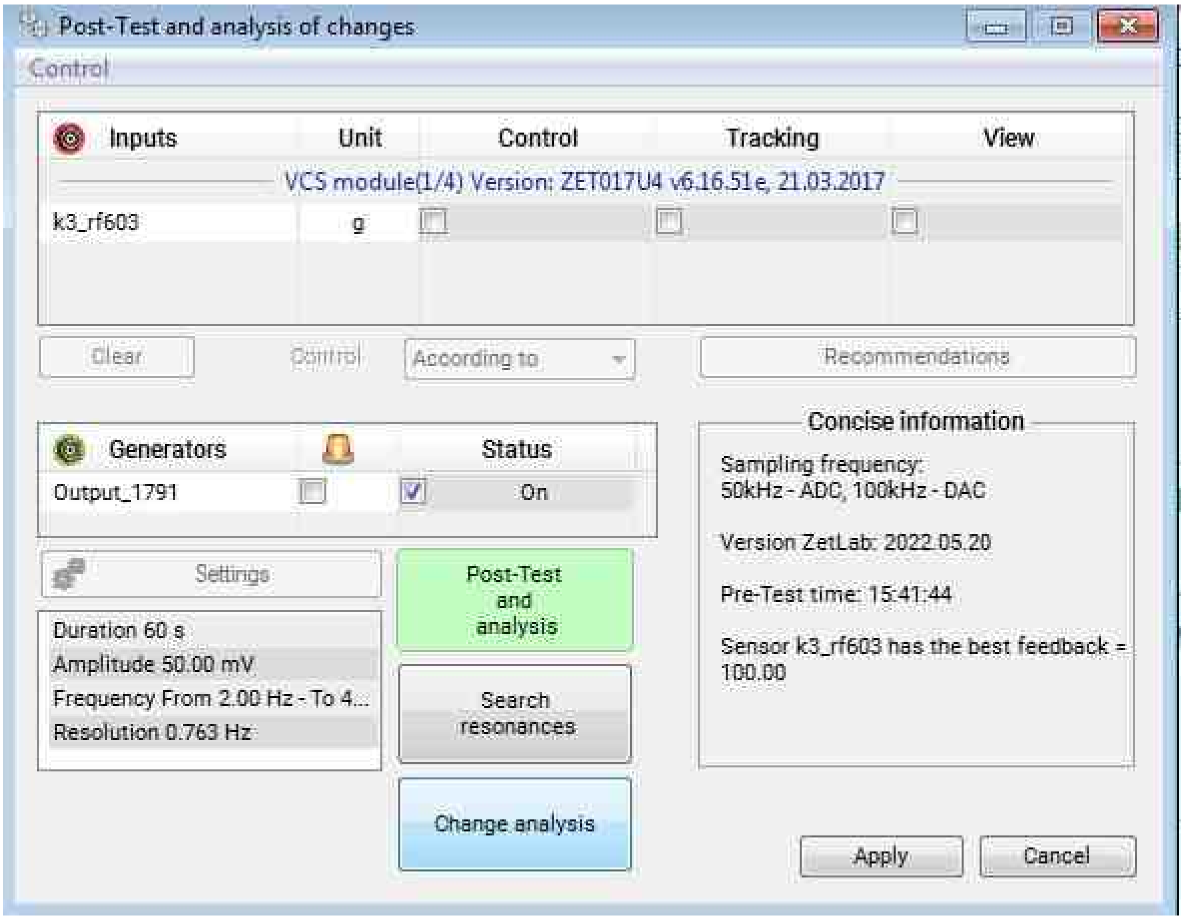


Fig. 8.49 Window "Pre-Test - Window of resonances" with inclination and rotation of the model

Post-Test and analysis .....

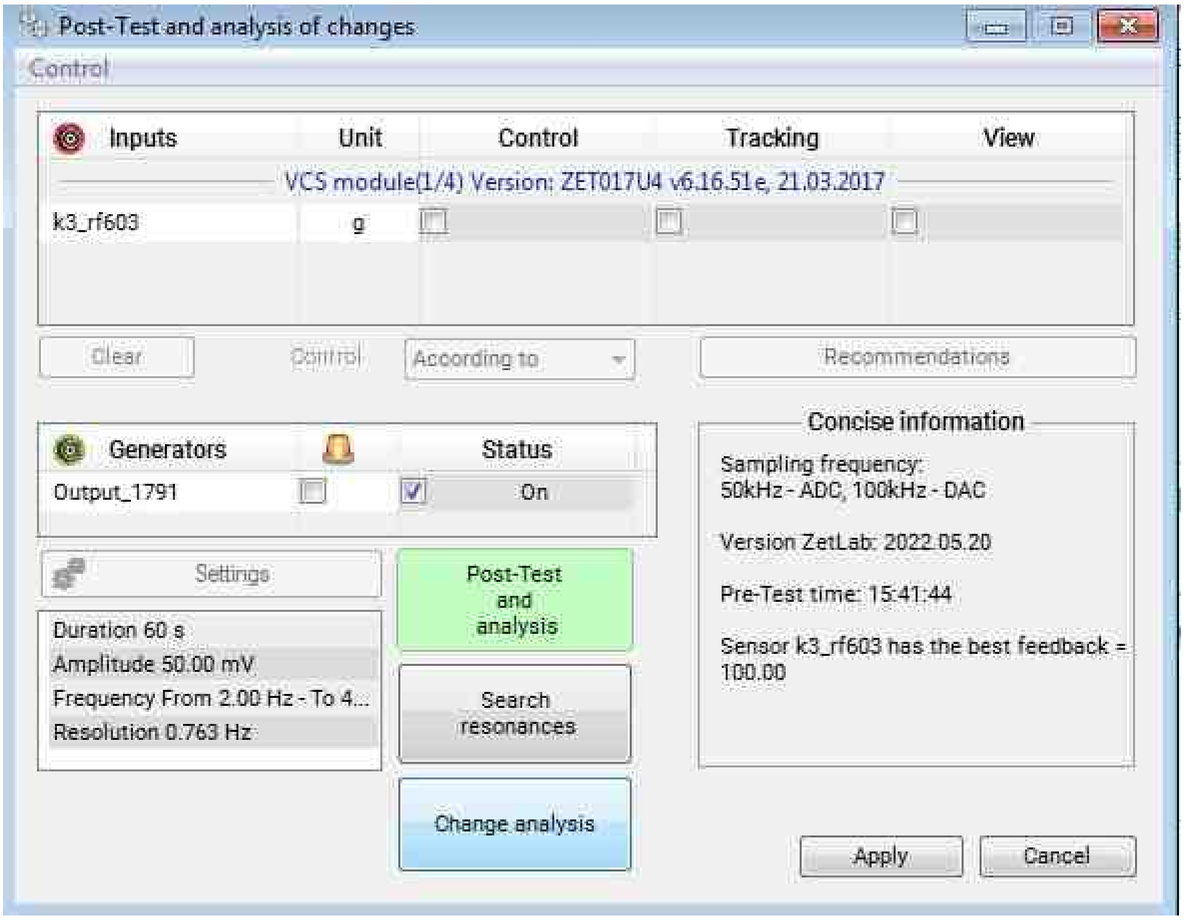
Programm "Post-Test and analysis"



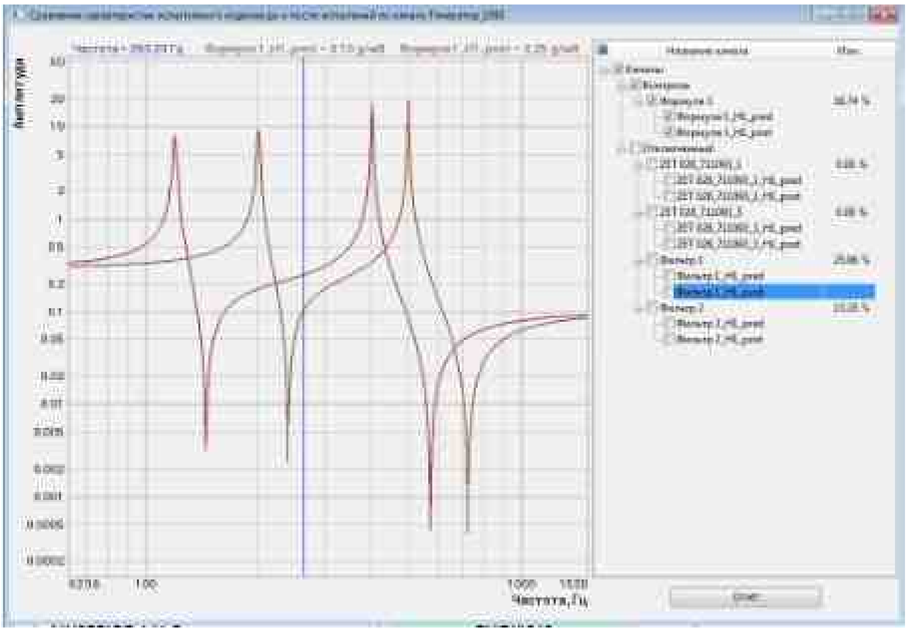
Program Operation Principles .....

Program Operation Principles

The "Post-Test and analysis of changes" button has been added to the "VCS panel" program. When you click it, the program "Post-Test and analysis of changes" is launched. Its interface is similar to the program "Pre-Test and search for resonances", but it does not allow the user to change the elements for setting parameters, selecting control channels, turning generators on and off. After passing the post test, a button will be available to open the window for comparing the amplitude-frequency response of the Pre-Test and Post-Test.



The "Post-Test and analysis of changes" window



Comparison of the characteristics of the specimen to be tested before and after testing via the Generator channel 1063

The Sine program .....

The Sine program

Program Purpose

To test specimens for vibration resistance at different frequencies and in different ranges, the "**Sine**" program is used.

The program "**Sine**" as part of VCS ZET02x provides, in accordance with GOST 28203-89, testing of elements, tool and other specimens that during transportation or operation may be exposed to harmonic vibrations occurring during rotation, pulsation, the presence of alternating forces that can be observed on ships, aircraft, ground transportation means., helicopters, spaceships, and can also be caused by the effect of working mechanisms or seismic waves.

Using the "**Sine**" program, you can test specimen samples for resistance to "**Sine**" both in frequency-sweep modes and at fixed frequencies, including the possibility of holding the frequency in phase and amplitude.

The program "**Sine**" allows you to identify mechanical defects and / or deterioration of the specified characteristics, as well as to compare the results obtained with the requirements of normative technical documentation to determine the degree of validity of the test sample.

Preparing for testing

The sample is mounted on a shaker in accordance with the requirements of GOST 28231-89.

When preparing to sinusoidal vibration testing, set the following parameters (if not set): shaker parameters, specimen parameters, channel parameters (see sections 5.1 to 5.3), and then start Pre-Test according to the section 5.7, after which to conduct a Pre-Test (see the section 8)

Test preparation also includes the creation of a test profile if the required test profile has not been previously created and stored in the profile database.

When preparing to sine vibration testing, set the following parameters (if not set): shaker parameters, specimen parameters, channel parameters (see sections 5.1 to 5.3), and then start Pre-Test according to the section 5.4.

To go to the "Sine" program window, press the "Sine" button on the VCS Panel (*Fig. 4.1*). The "Sine" program window (*Fig. 9.1*) will appear on the monitor screen.

Attention! *The "Sine" button on the VCS panel will only be available if the program detects the Pre-Test results.*

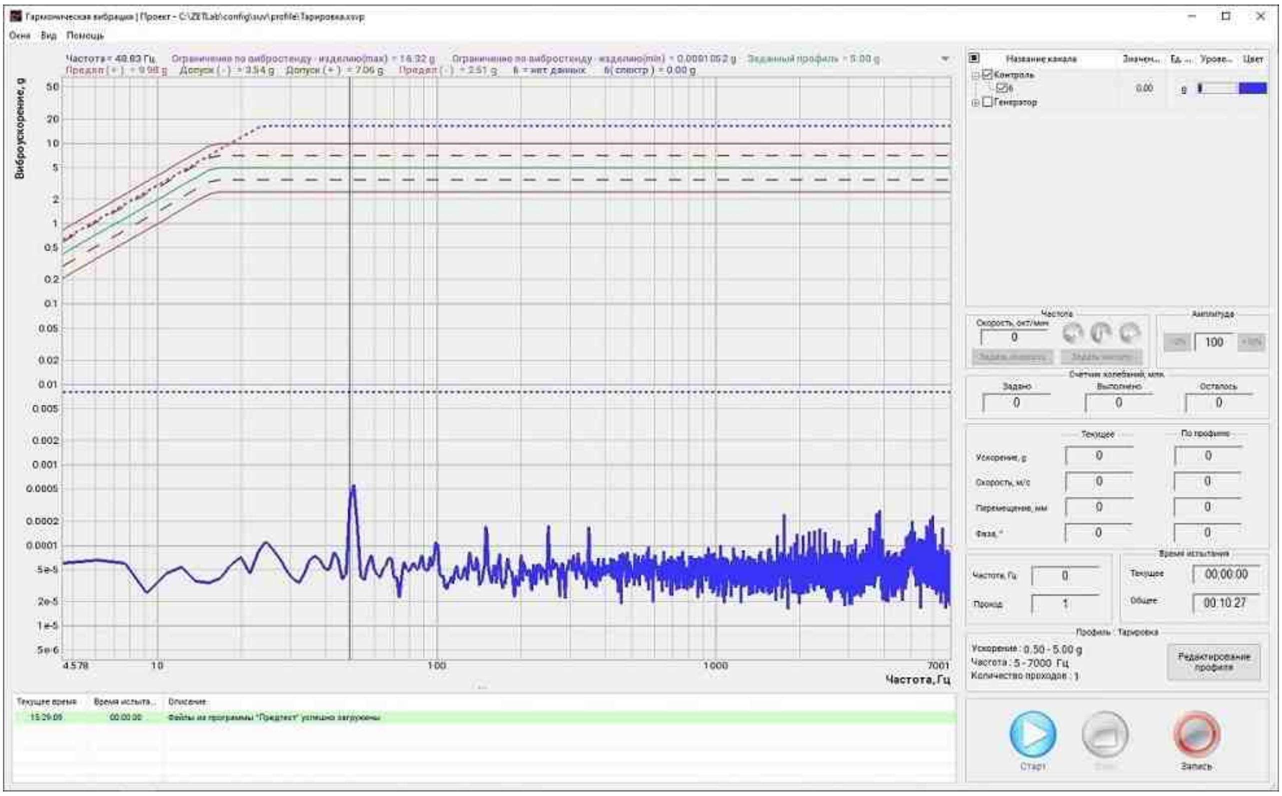


Fig. 9.1 "Sine" window

Configuration of the test profile parameters is performed in the tabs of the program window "Edit profile Sine", the description of which is given in the sections 9.3 - 9.11.

To go to the window of the program "Edit profile Sine" in the window of the program "**Sine**" (Fig. 9.1) than activate the "Edit profile" button.

Additional features of Sine

1. The step on the X-axis has been changed on the graphics, now it is always equal to 0.1 Hz and does not depend on the frequency resolution on the Pre-Test.

2. In the profile editor, in the "Parameters" section, a new type of mode output has been added - "power". At the beginning, the signal amplitude increases rapidly, and approaches the set value very slowly.
3. Controls have been added to the main program window for manually setting the current amplitude of the control channel as a percentage of the specified profile. By default, the controls are hidden and appear when the "Manual control" item is selected in the "View" menu.

The "***Sine"*** program allows to evaluate dynamic characteristics of the tested specimen in "ideal" environment (since in real conditions it is impossible to reproduce a clear Sine). Another function of the program is the detection of main resonance frequencies and mechanical defects in the tested specimen prior to specimen mass .

The "**Sine**" is included into the scope of ZETLAB VIBRO software suite. The program can be started fom VCS control panel upon configuration of the following parameters:

- shaker system parameters,
- test specimen parameters,
- channels parameters,
- Pre-Test and search for resonances.

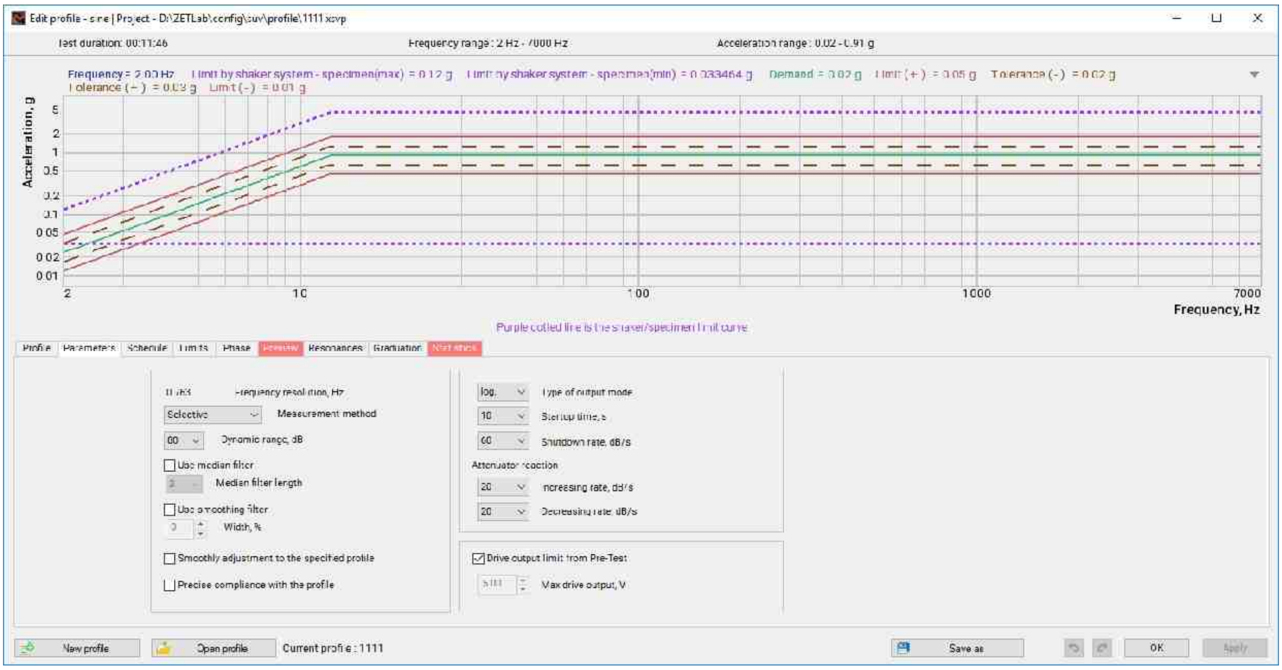


Fig. 9.1a "Edit profile" window, "Parametrs" tab

Configuration of vibration testing parameters includes four stages:

- general settings (equilization, number of loops, profile direction and measurements method);
- display parameters (control value to be used for test profile graph);
- setting sweep type and velocity (if applicable);
- configuration of impulse build-up time and decline rate.

In order to simplify evaluation of tests results in accordance with the set parameters (profile, specimen characteristics, shaker system specifications), one can use the function "Display limits for shaker system and the specimen". In this case, the graphic will also display the maximal admissible level.

The program also automatically calculates the estimated time of a single signal sweep and the total time required for test performance.

he admissible limits of test parameters, used for control of test performance are displayed in the "*Interruption*" tab of the program. If the actual parameters do not correspond to the values specified in this tab, the test procedure will be suspended.

In the case if several independent control channels are used, the corresponding parameters should be set in the "*Phase*" tab:

- if only one device is used, the generator mode should be "*In phase*";
- if two or more devices are used, the generator mode should be "*In phase*", "*In phase opposition*";
- when three or more devices are used, the generator operation mode can be set as "*In phase*", "In phase opposition" and "*Wave*".

Another feature of this new software is the preview of testing results for the set profile, which is produced based on the parameters obtained in the course of the Pre-Test. The correspondings graphics are available in the "*Channels*" section.

Note: *The information displayed at these graphics is intended for general information purposes. It displays the data, that is likely to be obtained for the selected test profile.*

The preview of the test data displays the statistical data relating to the loading of the shaker system in the course of vibration testing. This option allows to evaluate capabilies of the system prior to tests performance, thus ensuring normal operation of the instruments used for testing purposes.

TESTS PERFORMANCE

In the bottom section of "Sine" program window there is Events log, which is used for saving the data, which has been accumulated in the course of program operation.

To start the vibration testing, use the Start key.

The user can start or suspend the recording of electrical signals from active channels of the VCS systems using the Recording key.

During the test process, it is possible to view the changes of the tested specimen parameters via the control channel in real-time mode (this function is available as the "Additional graphics" option).

Edit profile .....

To set the test profile, it is necessary to activate the "Edit profile" button (*Fig. 19.1b*) from the main window of "Random" program .

Fig. 9.1b "Edit profile" button

Profile tab .....

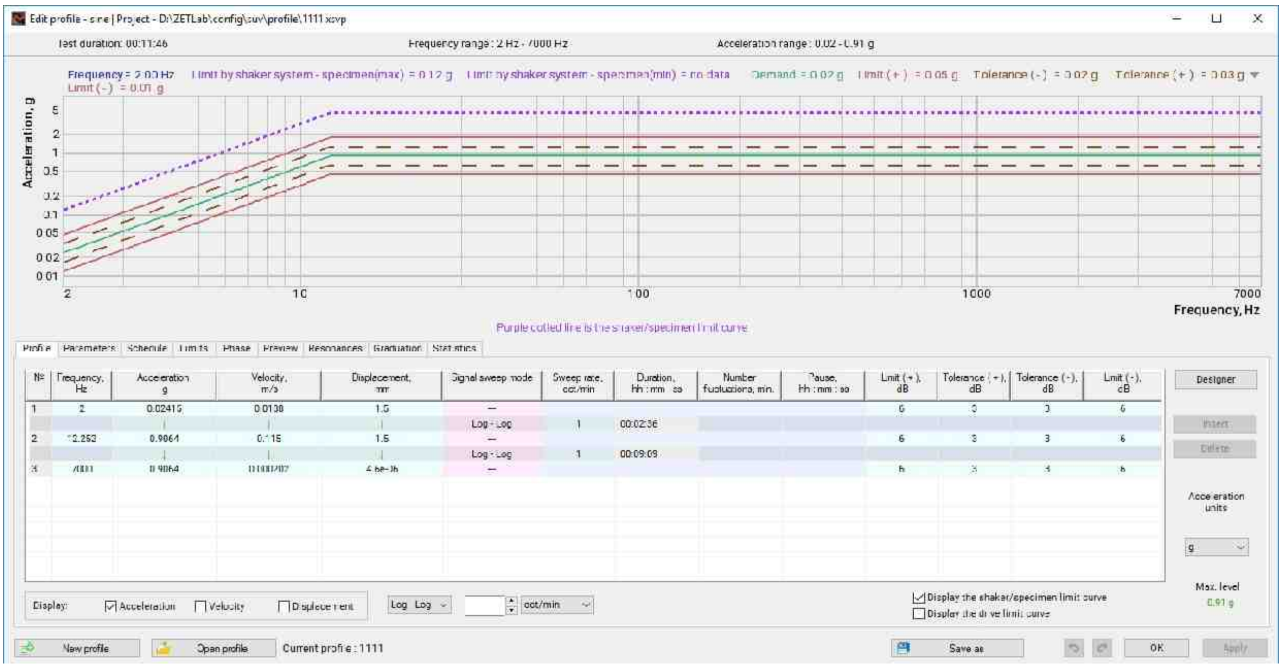


Fig. 9.2 "Edit profile" window, "Profile" tab

Set the vibration test profile on the "Profile" tab. To add or delete new lines to/from the table, you can use the *Insert* or *Delete* buttons after specifying the required place (line) in the table with the mouse.

Another possible option to add and delete profile rows is as follow: using the mouse, point to the place to edit, click the right mouse button to open the context menu, change the number of rows (*Fig. 9.3*) and select the necessary operation, such as insert, insert row above, insert row below, delete.

Note: *Not all operations from the context menu can be available at the same time, it depends on the place to be edited in the table.*

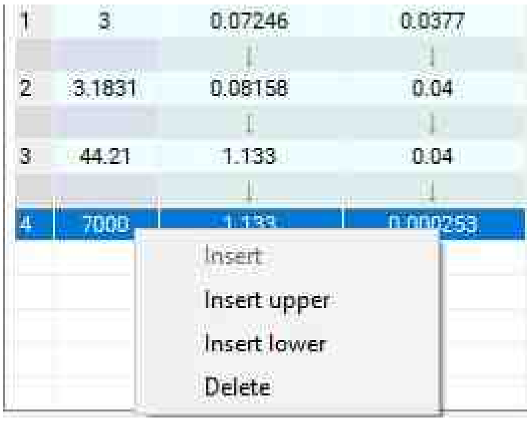


Fig. 9.3 Context menu for changing the number of rows

The vibration test profile consists of a set of segments defined by boundary points. The boundary points have serial numbers in the table and must be ranked by frequency. The boundary points have four main parameters: Frequency, Acceleration, Velocity and Displacement, and their values can be edited manually to set the required parameters of the test profile.

Note: *Activating the arrow symbol in the table field moves the value from the previous row to the next one, thus facilitating the profile editing process.*

Note: *Acceleration, Velocity and Displacement are mutually dependent parameters, and when you enter one of them, the program automatically recalculates the others.*

Attention! *When editing the profile table, only the ascending sequence is allowed in the "Frequency" column. If violations are detected in the frequency value sequence, the software will report these violations by red highlighting the table fields.*

If you point the mouse to the signal sweep mode field, in the context menu (*Fig. 9.4*) you can change the No signal sweep mode to Fix mode and Maintenance of resonance frequency mode. The signal sweep mode can be selected individually for each boundary point.

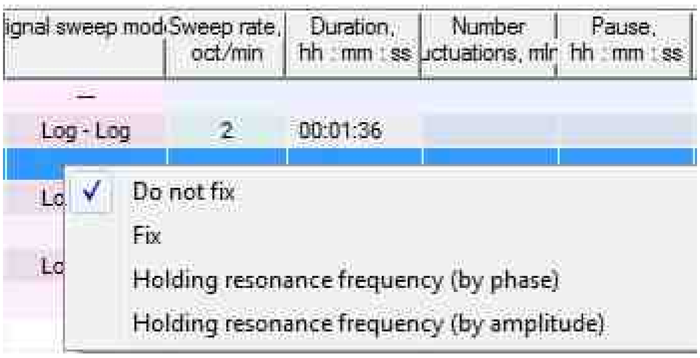


Fig. 9.4 Context menu for the signal sweep mode

If the "Fix" mode is selected, the "Duration" column specifies the fixation time at the frequency specified for this boundary point.

The duration of fixation at the frequency of the boundary point can be set both through the "Duration" parameter and through the associated "Number of oscillations" parameter.

If the modes "Resonance frequency retention (by phase)" (RSTD) or "Resonance frequency retention (by amplitude)" are selected, in addition to specifying the duration of the retention time in the "Duration" column, another graphic is added to the end of the table - "Phase / Amplitude", in which it is necessary to specify the phase value corresponding to the resonance frequency for this boundary point (the value specified in the "Frequency" column), or assign an amplitude retention channel.

The "Pause" column allows you to maintain the specified time pause after the completion of the tests for each row of the table

Each boundary point also has 4 parameters defining the permissible corridor for conducting vibration tests "Tolerance (+)", "Tolerance (-)", "Limit (+)", "Limit (-)". If the values of the parameters "Tolerance (+)", "Tolerance (-)" are exceeded, a warning message will be issued to the user via the control channel. If the values of the parameters "Limit (+)", "Limit (-)" are exceeded, the tests will be interrupted via the control channel. The parameters set the tolerances of the integral acceleration level at each boundary point according to the profile. By default, the tolerances are set at ±3, ±6 dB, respectively, but if necessary, other values can be set manually.

Adjacent boundary points define the profile segments. To edit the profile segment parameters, the table provides scan lines located between the boundary points.

Each scan line in the table has three parameters: "Signal sweep mode", "Velocity" and "Duration".

The parameter "Signal sweep mode" can be "logarithmic", "linear" or "without scan". The absence or presence of a scan can be set individually for each segment, and the type of scan can only be the same for all segments at once where the scan is activated (either all "Log-Log" or all "Lin-Lin").

The "Velocity" parameter determines the rate of frequency change when passing through the sweep between the boundary points. The values of the "Velocity" parameter can be set as general (equal) or individual (different) for profile segments.

The "Duration" parameter (in the line of the profile segment) determines the time it takes to pass vibration tests along the sweep between the boundary points.

Note: *Duration and Velocity are mutually dependent parameters and when you enter one of them, the program automatically recalculates the other one.*

Note: *For the linear scan type, the Velocity parameter is measured in Hertz per second; for the logarithmic scan - in octaves per minute.*

The Designer button opens the corresponding window (*Fig. 9.5*) that allows to quickly create profiles with the necessary Displacement, Velocity, and Acceleration.

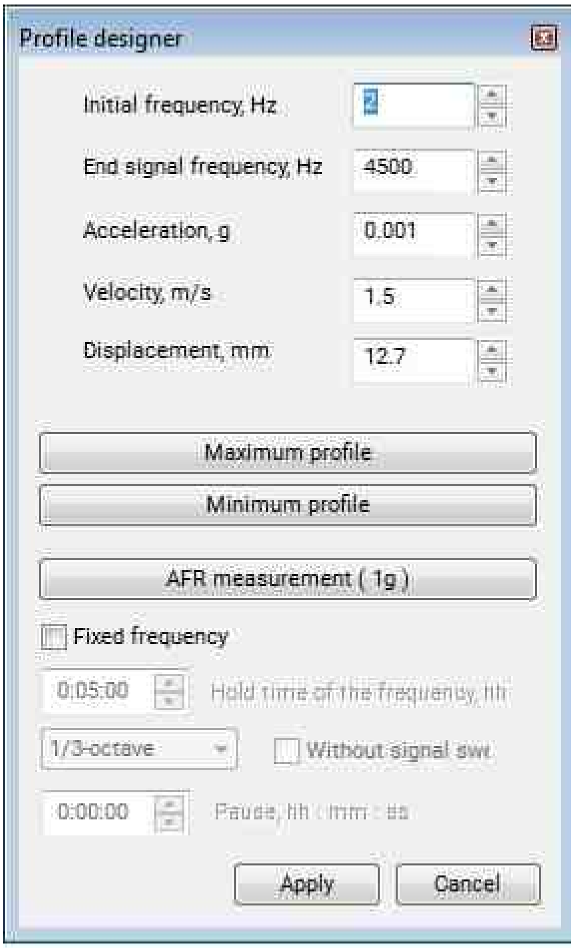


Fig. 9.5 "Profile designer" window

The "Maximum Profile" button in the Profile designer window allows you to automatically rebuild the profile to the maximum allowed values.

The "Minimum Profile" button in the Profile designer window allows you to automatically rebuild the profile to the minimum allowed values.

When you select the "Fixed frequency" parameter, you can automatically create a profile with fixed frequencies of the 1/3-octave or octave band by specifying the required frequency holding time in the corresponding field in the "Profile designer" window.

In the display selection field (Fig. 9.6) in the "Profile" tab of the "Edit profile" window, a reference value is set by which the test profile graphic will be displayed.

Fig. 9.6 Display management

In the Display section of the "Edit profile" window, set a reference value for displaying the test profile graphic. The profile graphic can be represented as the dependence of the frequency on the Acceleration, Velocity or Displacement; to do this, set the switch to the appropriate position. The graphic of the acceleration test profile can be presented in either "g" or "m/s^2".

In the field for selecting the signal sweep mode and rate (*Fig. 9.7*) in the "Profile" tab of the "Edit profile" window, the signal sweep mode and rate for passing segments between boundary points in the test profile is set.

Fig. 9.7 Signal sweep mode and rate

The profile's sweep type can be implemented in two ways: linear (Lin – Lin) and logarithmic (Log – Log). Also, you can set the test pass speed for the profile. For linear sweeping, the sweep rate is set in Hz/s, Hz/min or min/cycle. For logarithmic sweeping, the sweep rate is set in oct/min or min/cycle. If this function is enabled, the sweep rate will be the same for each test segment.

When you select the Display Limits by shaker - specimen parameter, the spectrum graphic in the "**Sine**" window (*Fig. 9.1*) will additionally display graphics of the maximum and minimum acceptable profile values (the range of acceptable profiles).

Note: *The graphics of maximum and minimum acceptable profile values are calculated according to the shaker and specimen parameters, as well as the Pre-Tests results.*

When you select the Display Limits by generator parameter, the spectrum graphic in the "**Sine**" window (*Fig. 9.1*) will additionally display graphics of the maximum and minimum allowable values (the range of acceptable values) of the generator level when generating the control signal.

Note: *The maximum value of the generator level is determined in the shaker parameters and cannot exceed 10V, the minimum value is determined by the Pre-Tests results.*

In the "Current level" field of the "Edit profile" window, the maximum acceleration value in the profile is displayed.

Parameters tab .....

The vibration test parameters can be set on the Parameters tab (*Fig. 9.8*).

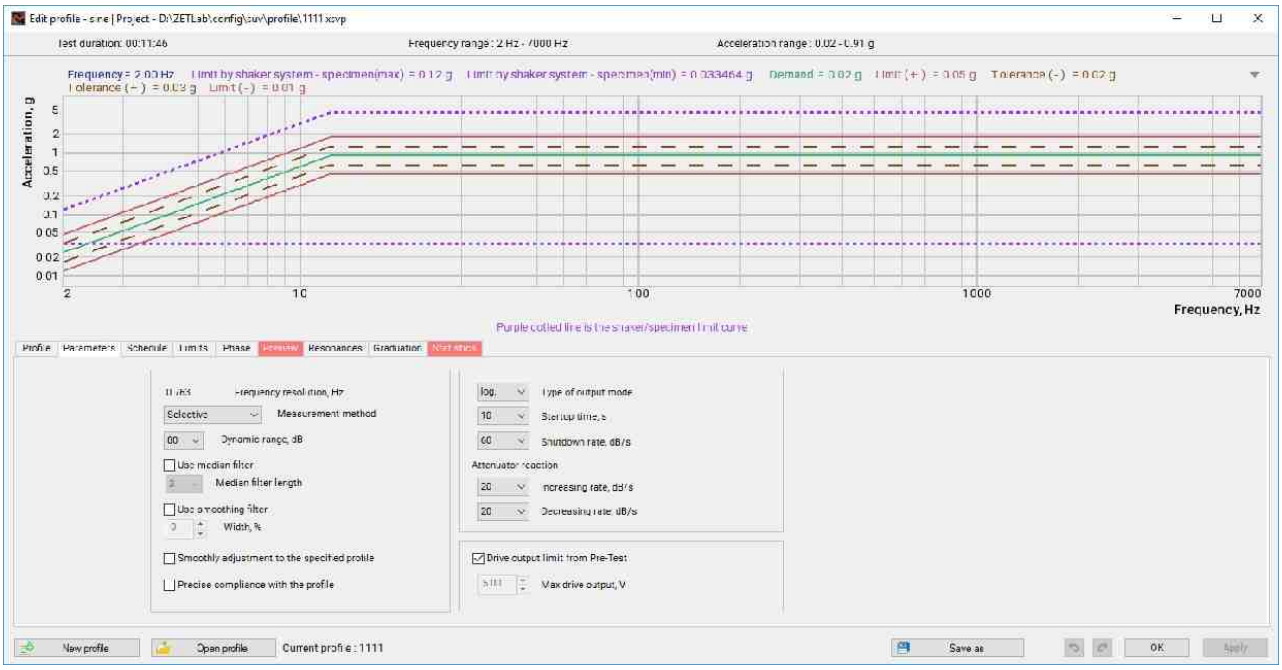


Fig. 9.8 "Edit profile" window, "Parameters" tab

The Frequency resolution parameter displays the value to be used by the program when performing the calculations. The frequency resolution value is changed when setting the Pre-Test parameters (see the section 8).

The Measurement method of parameter sets the method for calculating the spectrum values, which can be Selective or Effective. When the Selective method of measurement is selected, the control channel records the values corresponding to response only at the generated vibration test frequency, if the Effective method is selected, in the entire band of the recorded signal.

The Dynamic range parameter limits the difference between the maximum value and minimum value of the amplitude response.

The Use Median filter length parameter is used to "align" the amplitude response. The greater the value of the Median Filter Length parameter, the greater the alignment value.

When the Use smoothing filter adjustment to the specified profile parameter is selected, the spectrum graphic can return to the test profile when the transfer characteristic changes due to physical changes in the specimen under test or tooling.

The choice of the parameter "Smoothly adjustment to the specified profile" allows you to take into account changes in the transmission characteristics during testing and thereby return to the test profile when it changes.

Note: *Changes in the transfer characteristics can be caused, for example: physical changes in the tested specimen or tool.*

When the "Exact profile matching" parameter is activated, it will be prohibited to go beyond the lower limit of the limit of the specified profile for zones in the frequency range at which antiresonances are detected in the feedback signal. The deactivated status of this parameter gives greater freedom to the VCS when passing the profile in the areas of antiresonance.

The "Type of output mode" parameter allows you to select the type of signal increase in the control channel at the time of reaching the profile level: "logarithmic" or "linear".

The parameter "Startup time" determines the time for which the signal will be increased from the zero level to the profile level.

The parameter "Shutdown rate" determines the rate at which the signal will be reduced at the end of the tests.

The "Emergency shutdown decay time" parameter determines the time for which the signal will be reduced to zero under conditions when the program has diagnosed the need for an emergency stop of tests.

Note: *The attenuation time of the emergency stop makes it possible to eliminate the effect on the Shaker and the specimen that occurs when the control signal is switched off instantly (abruptly).*

The parameters "Increasing rate" and "Decreasing rate" determine the maximum rate of increase and decrease in the signal level during testing.

The parameter "Drive output limit from Pre-Test" allows you to limit the level of the control signal (generator channel) to the value calculated by the software. The automatic limit is calculated by the software taking into account 10% of the margin to the maximum level in the control channel required to pass the specified profile. In case of deactivation of automatic calculation, the operator can set the value of the signal limitation in the control channel (generator) independently.

Note: *Limiting the control signal ensures that the level of the generated signal in the control channel does not rise excessively, however, when testing in frequency regions where there is low coherence in the feedback channel, the level of the control channel may not be sufficient to achieve the test profile.*

Schedule tab .....

On the Schedule tab, you can set the time to enter test mode, as well as the number and direction of passes during the tests (*Fig. 9.9*).

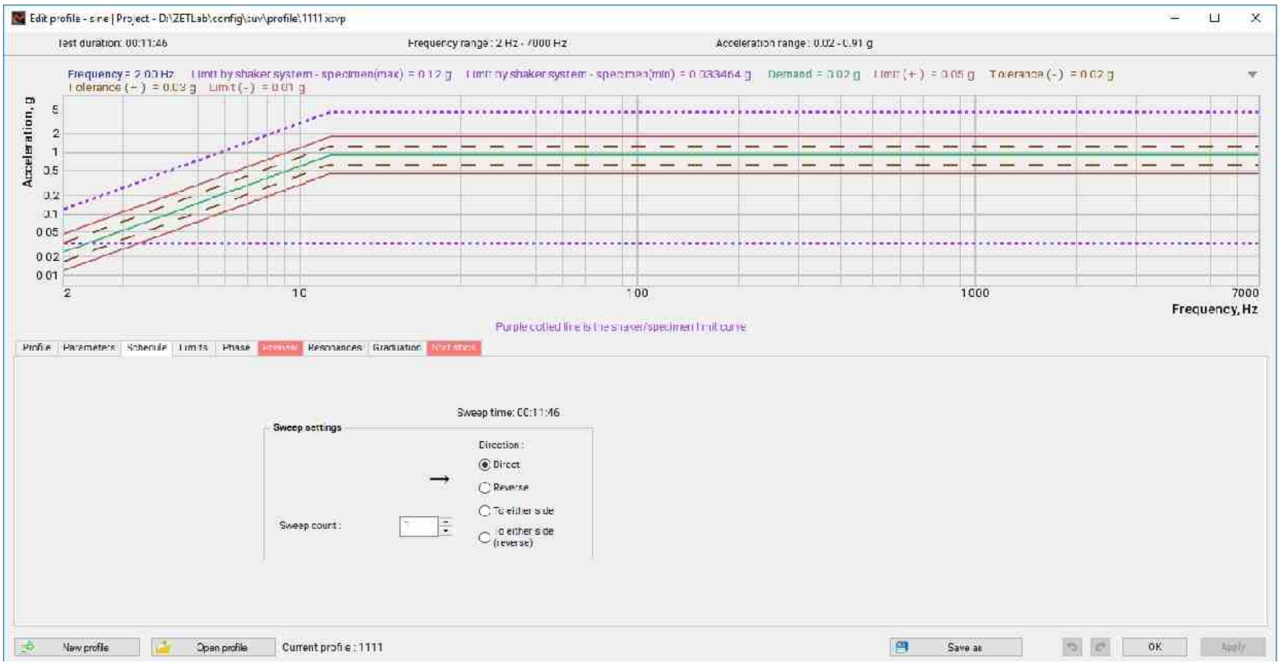


Fig. 9.9 "Edit profile" window, "Schedule" tab

The Direction parameter determines how the vibration test cycles will be counted: Direct - from lesser frequency to greater frequency; Reverse - from greater frequency to lesser frequency; To either side - from low frequency to greater frequency and back.

The Number of Passes parameter determines the number of vibration testing cycles.

Limits tab .....

On the Limits tab (*Fig. 9.10*), you can set the acceptable test limits for the control and tracking measurement channels. According to the parameters with enabled control, (during the tests) exceeding the set parameter values will be monitored, and if they are exceeded, the tests will stop immediately.

Fig. 9.10 "Edit profile" window, "Limits" tab

To enable parameter control, activate (check the cell) the corresponding parameter, and to disable it, deactivate (uncheck the cell).

You can set limits for the following parameters:

- "Maximum permissible deviation" (only for channels with the status "Control")
- "Profile exceedance by amplitude (only for channels with the status "Tracking").
- "Profile exceedance by RMS (only when selecting the measurement method "Effective");
- "Profile exceedance by peak value".

Phase tab .....

On the Phase tab, you can set the operation mode for the VCS generators (*Fig. 9.11*).

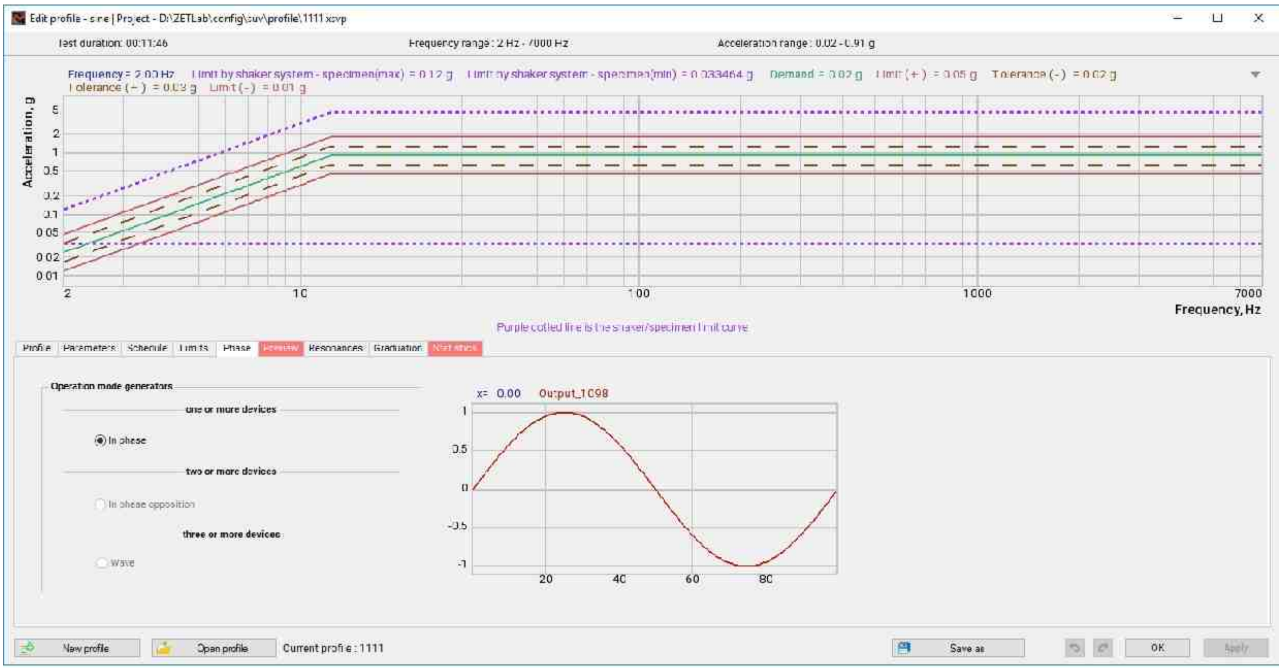


Fig. 9.11 "Profile setting" window, "Phase" tab

Whether it is possible to select the generator's operation mode on this tab depends on the number of simultaneously involved VCS controllers during the vibration tests:

- One VCS controller – In phase
- Two VCS controllers - In phase and In phase opposition
- Three VCS controllers - In phase and Wave.
- Four VCS controllers - In phase, In phase opposition and Wave.

Note: *In the Wave mode, the phase shifts between the controller control channels by 120° when three VCS controllers are involved and by 90° when four VCS controllers are involved.*

Preview tab .....

On the Preview tab, you can preview the vibration test graphics for a given profile obtained by calculation based on the Pre-Tests results (*Fig. 9.12*).

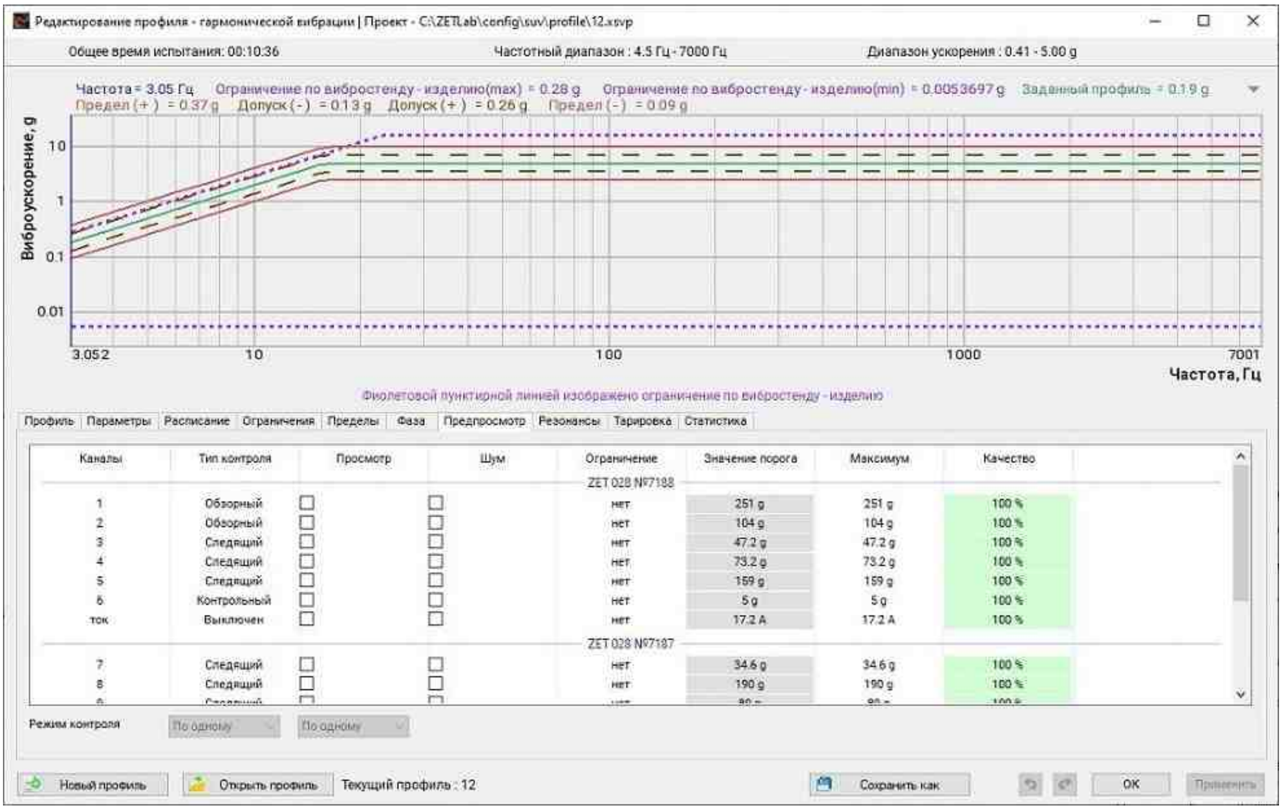


Fig. 9.12 "Edit profile" window, "Preview" tab

It is possible to visualize as graphics of the levels of amplitude values during testing (activation in the "View" column) as well as noise level graphics (activation in the "Noise" column) for all available measuring channels of the VCS, while the statuses of the measuring channels (the "Control type" column) are determined in accordance with the assigned statuses in the "Pre-Test and search for resonances" program window.

In case of activation of control over the calculated level of the generator (activation in the "View" column), the generator graphic is displayed (*Fig. 9.13*) based on the calculation of the provision on the control channel of a given level according to the profile. The graphic also shows the limit line for the upper level of the generator (determined by the set limit) and the limit line for the lower level of the generator (determined by the noise level).

Note: *The graphic information is for reference and intended to inform the VCS user of the expected results to be obtained in the vibration tests for a given profile.*

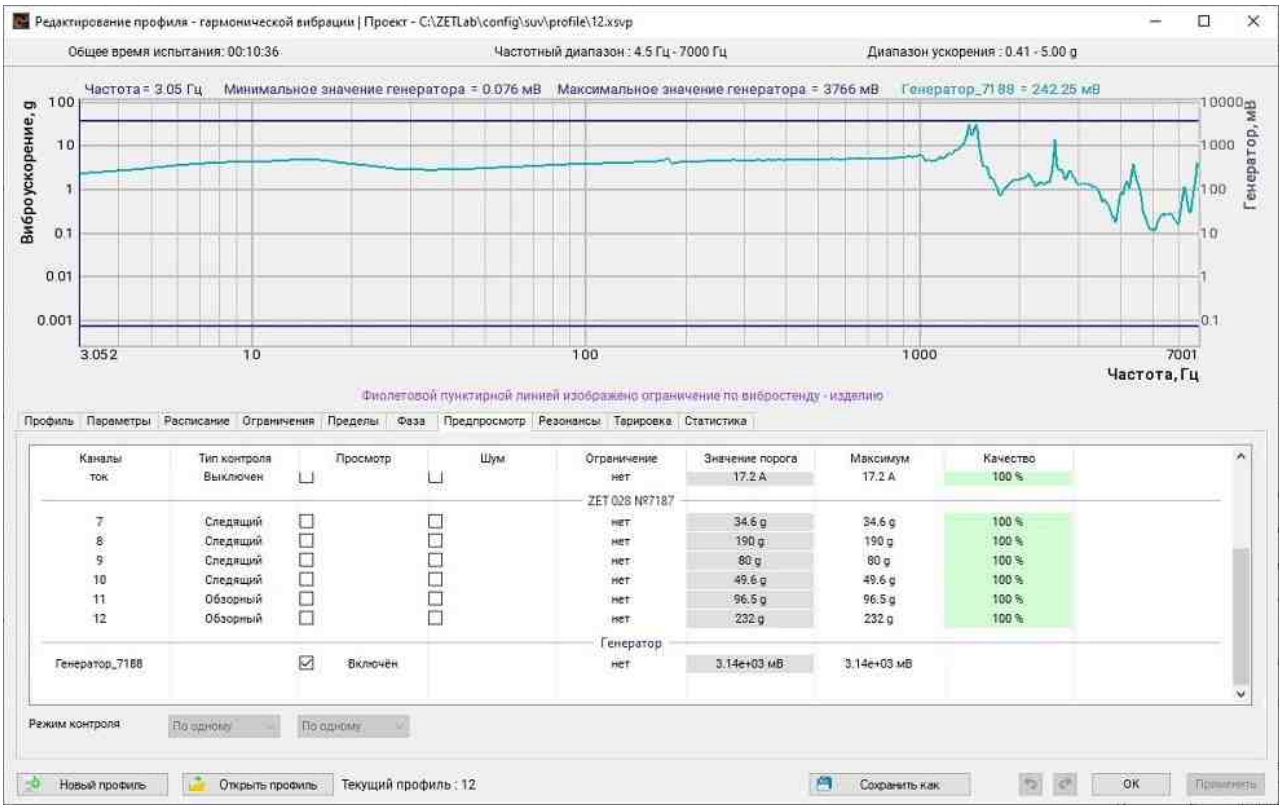


Fig. 9.13 "Profile setting" window, "Preview" tab, output graphic

Resonances tab .....

The Resonances tab contains statistical information calculated based on the results of the Pre-Test. The tab allows the operator to assess the presence of resonances and antiresonances on the amplitude characteristic (*Fig. 9.14*).

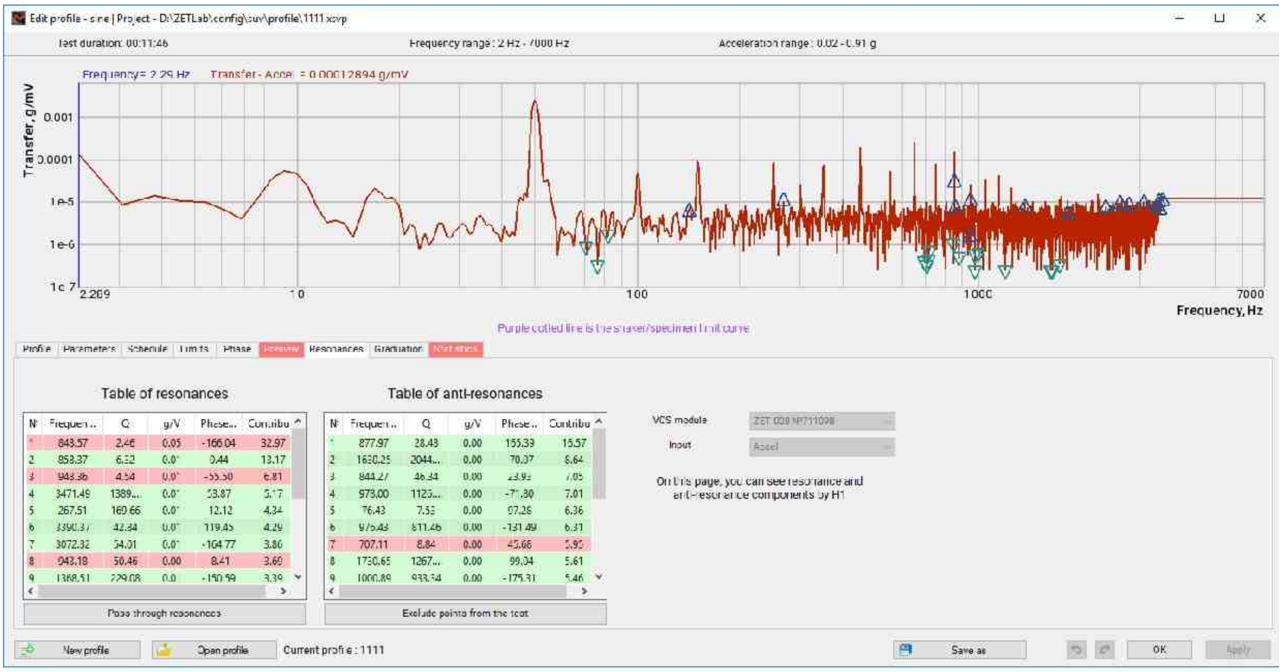


Fig. 9.14 "Edit profile" window, "Resonances" tab

Using the Pass through Resonances button, you can build a profile with frequency holding at the resonances specified in the resonances table.

If necessary (for more detailed consideration), scale the amplitude response on the frequency scale to the area of interest (*Fig. 9.15*), while the table will contain a list of only those resonances and antiresonances that fall into the visualized area of the graphic.

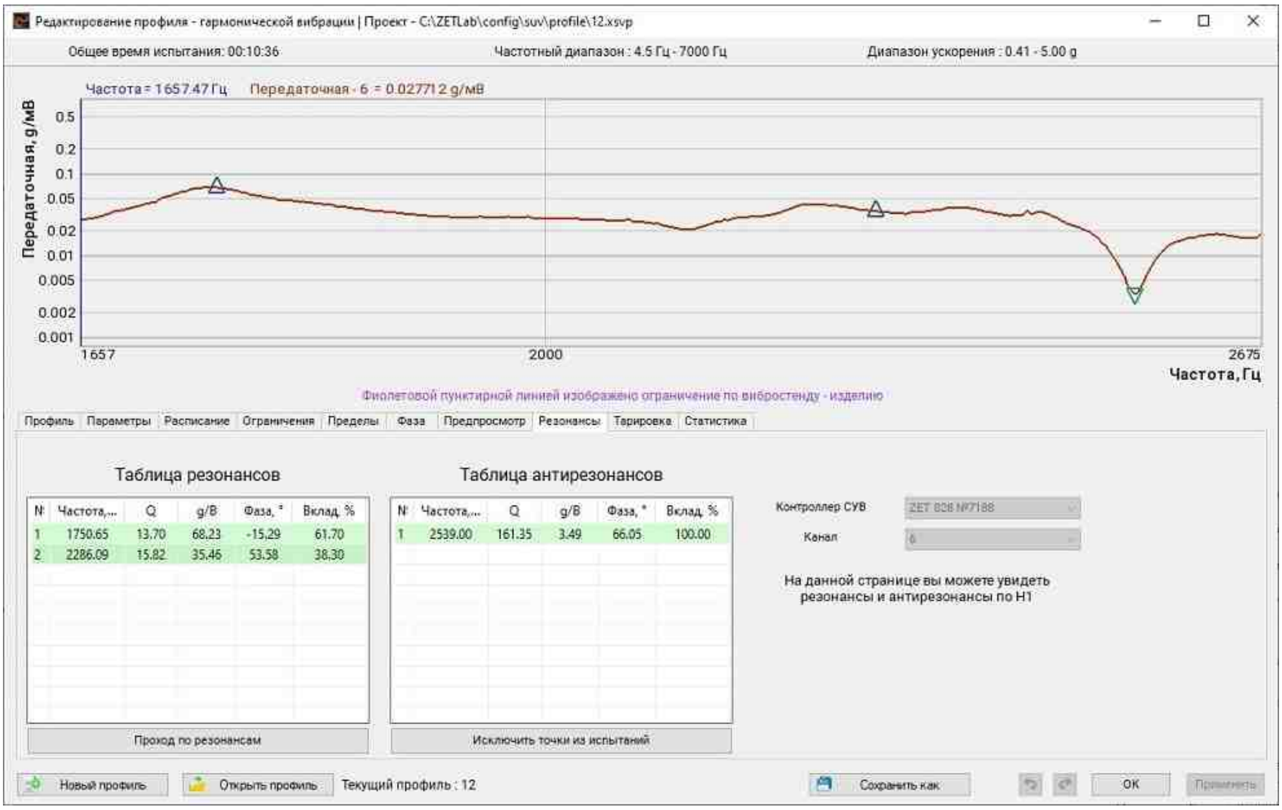


Fig. 9.15 "Edit profile" window, "Resonances" tab, scaled

The "Pass through resonances" button allows you to build a profile with frequency retention at the resonances indicated in the resonances table.

Note: *if necessary, you can edit the profile built automatically with frequency retention at resonances manually, eliminating "unnecessary" boundary points.*

Graduation tab .....

Graduation is designed to monitor the linearity of the amplitude characteristics of the measuring channels of sensors involved in the VCS, and allows, in addition to the Pre-Test, to determine the possible range of tests and the quality of preparation for them.

Attention! *Graduation is used only for modes with a fixed oscillation frequency, or when holding resonances. The information in the "Graduation" tab becomes available after the* *graduation results are carried out and saved.*

Note: *other uses of graduation are given in the section 17.2.*

The graduation will be considered on the example of 12 measuring channels that register signals from accelerometers installed on the expansion table of the Shaker and a measuring channel that registers the current value of the vibration generator system. It is assumed that the measuring channels setting of the sensors are config according to section 1, the Pre-Test is passed according to section 7 and one of the measuring channels of the accelerometer is selected as the measuring feedback channels (status "Control"), and the status "Tracking" is assigned to the remaining measuring channels (*Fig. 9.16*).

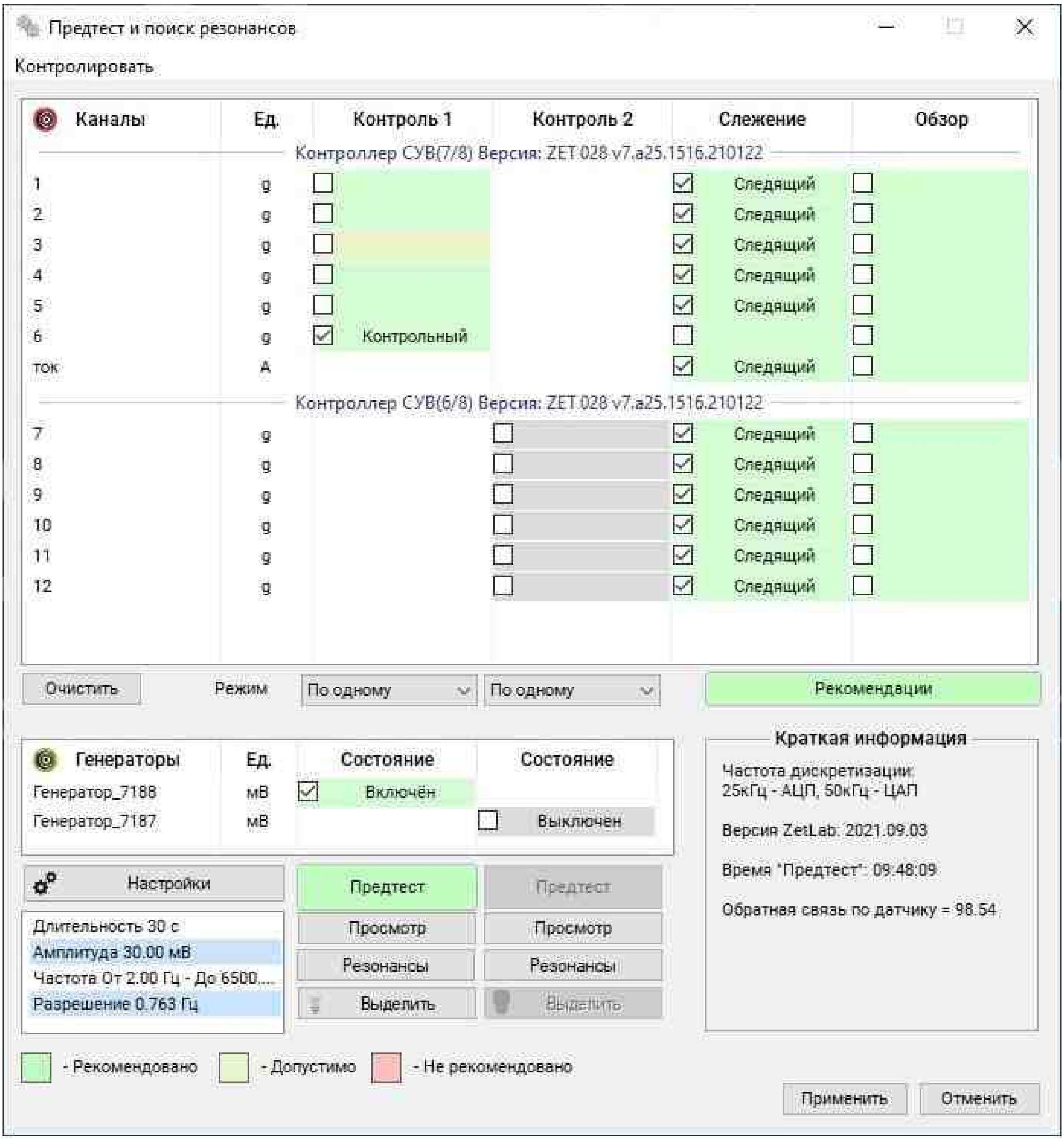


Fig. 9.16 The window "Pre-Test and search for resonances"

To perform graduation, it is necessary to build a profile with the required amplitude at a fixed frequency and with a time on the profile of no more than 10 seconds with an output time of 60 seconds, after which to conduct tests on this profile and save the result.

Note: *as a rule, the graduation amplitude is determined by the maximum amplitude of the profile of the planned vibration tests*

__Note:__ it is recommended to choose a fixed frequency for the graduation profile from the profile area of the planned vibration tests, in which the shaker amplifier operates with maximum loads, while avoiding the choice of a graduation frequency close to the frequencies of resonances and antiresonances

To build a graduation profile from the "Sine" program window, you should activate the "Edit profile" window and in the "Profile" tab (*Fig. 9.17*) leaving only one row in the table column, set the necessary frequency and amplitude values (in the example 160 Hz, 10 g). The signal sweep mode parameter should be set to "Fixed", and the "Duration" parameter - no more than 10 seconds.

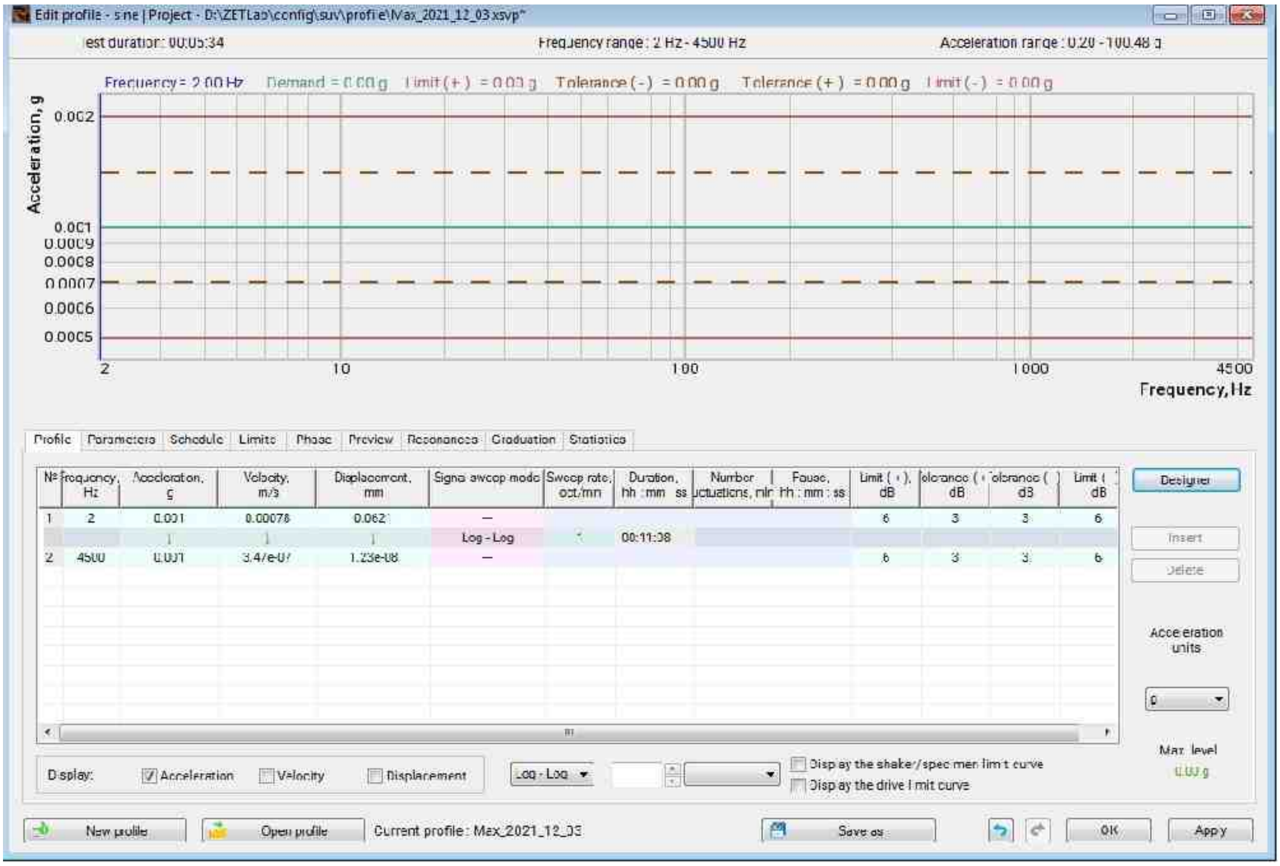


Fig. 9.17 "Edit profile" window, "Profile" tab

In the "Parameters" tab of the "Edit profile" window (*Fig. 9.18*) it is necessary to select the value "Lin" for the parameter "Type of output mode", and the value 60 seconds for the parameter "Startup time", and also set the voltage limit of the generator (*Fig. 9.19*).

__Note:__ it is recommended to slightly increase manually the value of the generator voltage, relative to the calculated in automatic mode

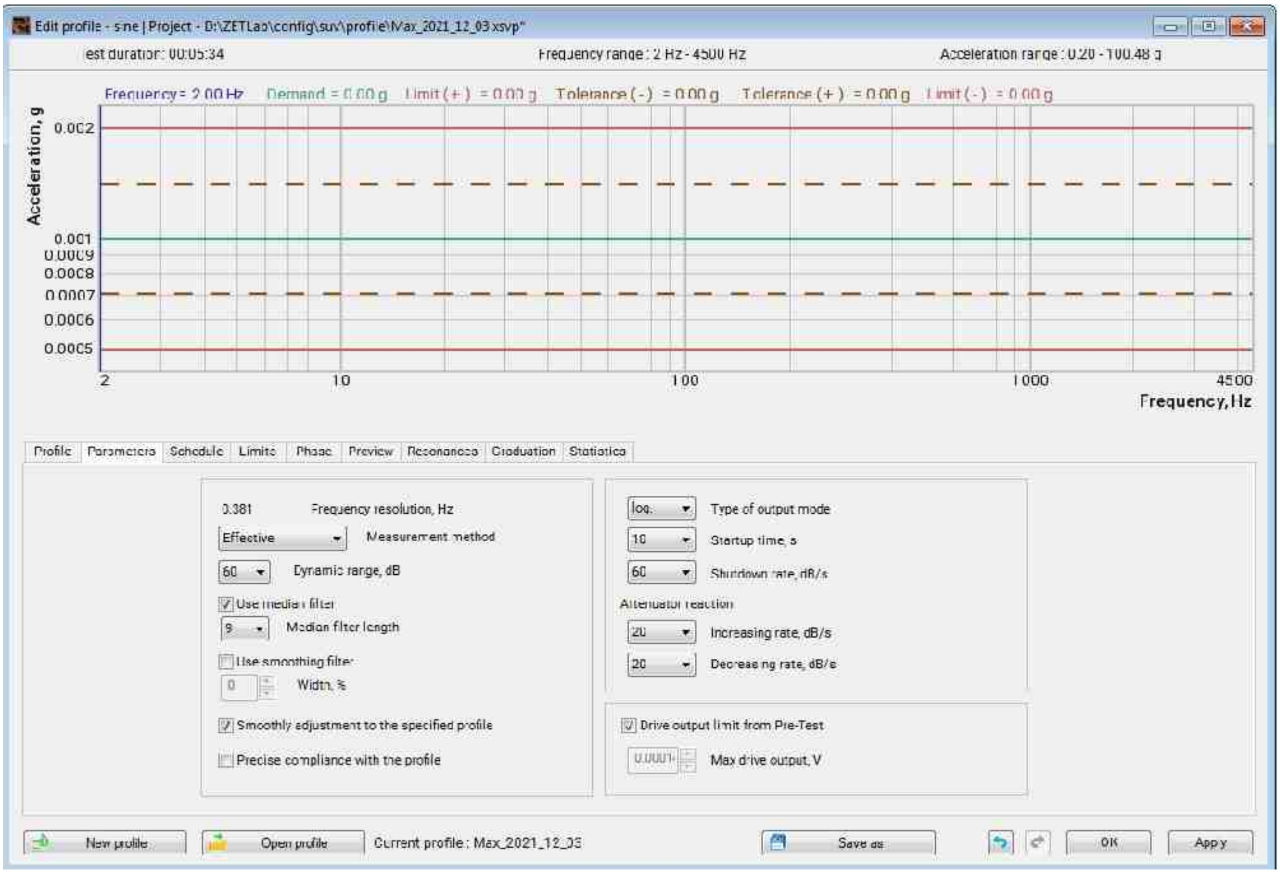


Fig. 9.18 "Edit profile" window, "Profile" tab

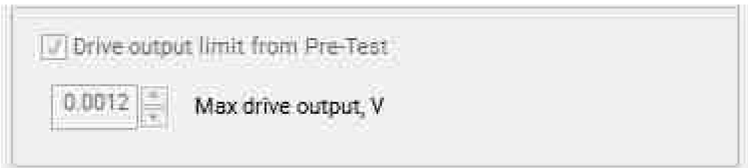
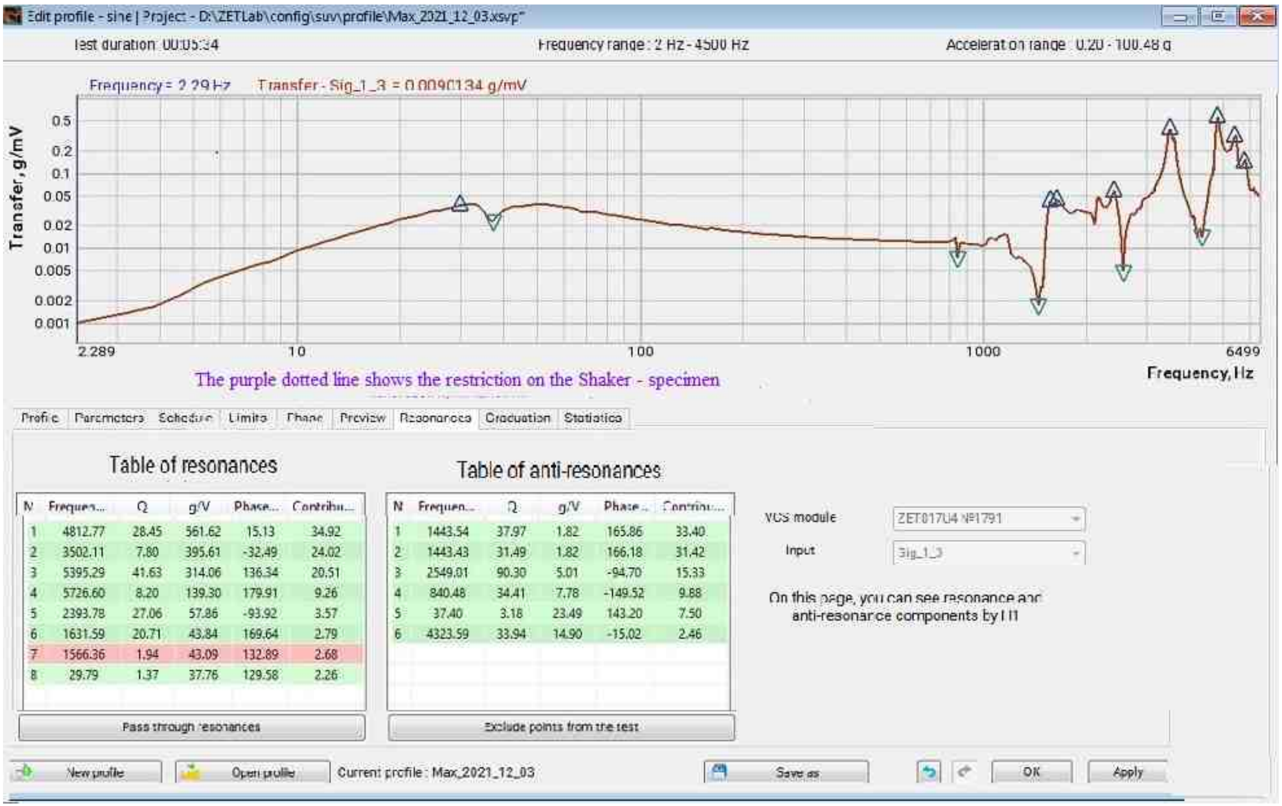


Fig. 9.19 Control channel restriction setting area

Using the information in the "Resonances" tab of the "Edit profile" window (*Fig. 9.20*) make sure that there are no resonances and antiresonances at the graduation frequency (in the example 160 Hz).



N	Frequen...	Q	g/V	Phase...	Contribu...
1	4812.77	28.45	561.62	15.13	34.92
2	3502.11	7.80	395.61	-32.49	24.02
3	5395.29	41.63	314.06	136.34	20.51
4	5726.60	8.20	139.30	179.91	9.26
5	2393.78	27.06	57.86	-93.92	3.57
6	1631.59	20.71	43.84	169.64	2.79
7	1566.36	1.94	43.09	132.89	2.68
8	29.79	1.37	37.76	129.58	2.26

N	Frequen...	Q	g/V	Phase...	Contribu...
1	1443.54	37.97	1.82	165.86	33.40
2	1443.43	31.49	1.82	166.18	31.42
3	2549.01	90.30	5.01	-94.70	15.33
4	840.48	34.41	7.78	-149.52	9.88
5	37.40	3.18	23.49	143.20	7.50
6	4323.59	33.94	14.90	-15.02	2.46

Fig. 9.20 "Edit profile" window, "Profile" tab

Using the information in the "Statistics" tab of the "Edit profile" window (*Fig. 9.21*) make sure there are no parameter limits.

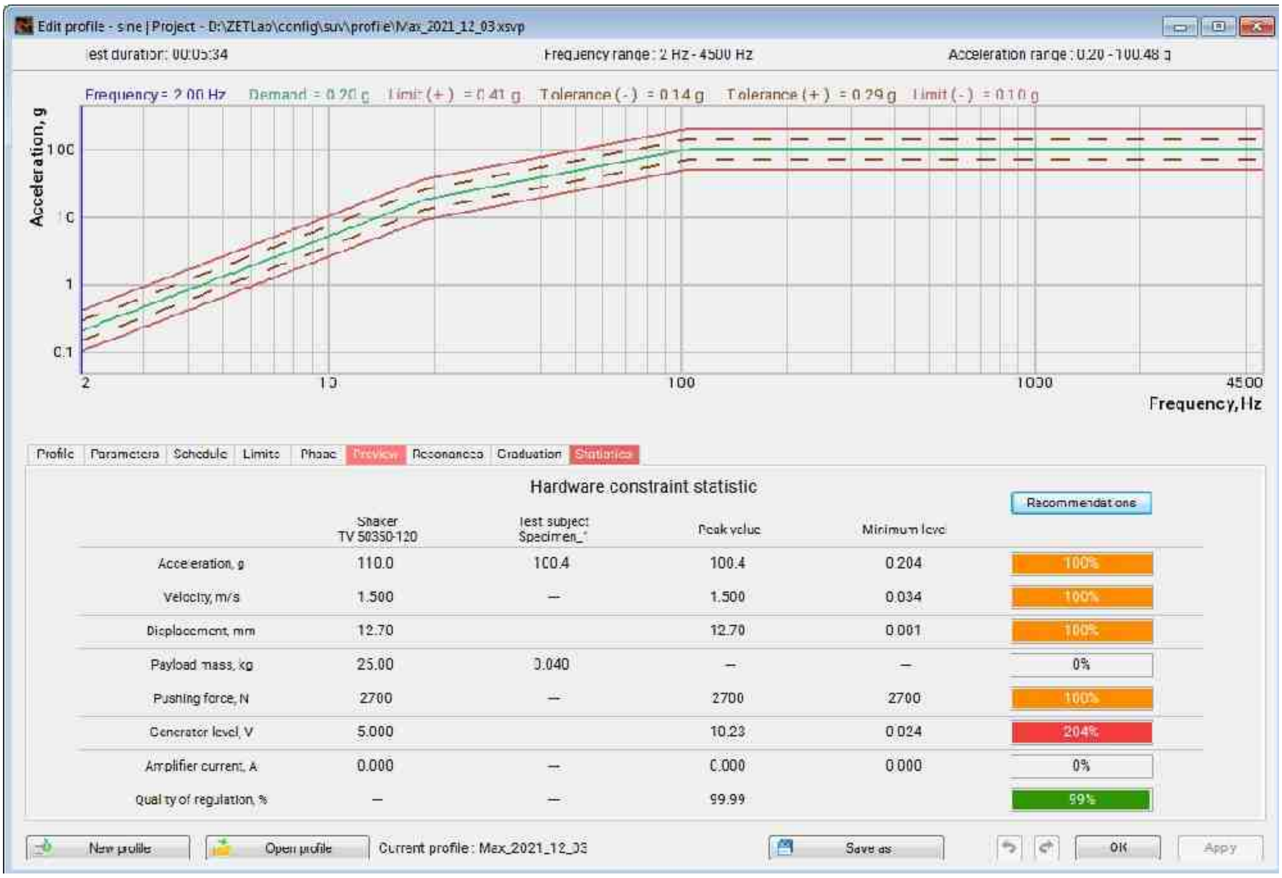


Fig. 9.21 "Edit profile" window, "Statistics" tab

In the "Edit profile" program window activate the "OK" button, after which it will be closed and the "Sine" program (*Fig. 9.22*) it will be prepared for graduation.

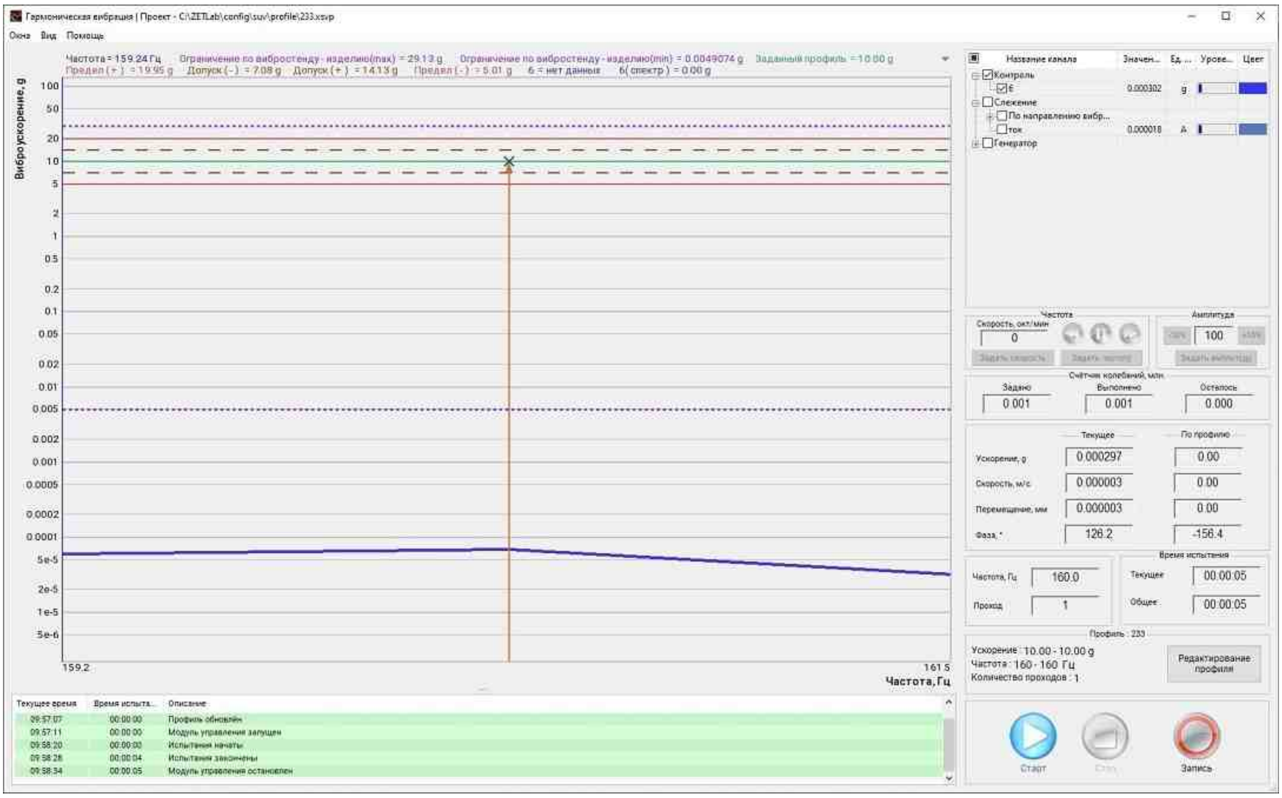


Fig. 9.22 "Sine" Window

The graduation stage consists in performing the prepared profile (activation of the "Start" button in the "Sine" program window).

Graduation is performed during the output mode (within 60 seconds). At the moment of linear rise of the vibration amplitude level, response amplitude graphics are recorded for measuring channels with the status "Tracking" relative to the measuring channel with the status "Control".

To view the calibration results in the "Sine" window in the "Windows" section (Fig. 9.23) you should select "Graduation" and the corresponding window will be opened (Fig. 9.24).

Fig. 9.23 Window "Sine", section "Windows"

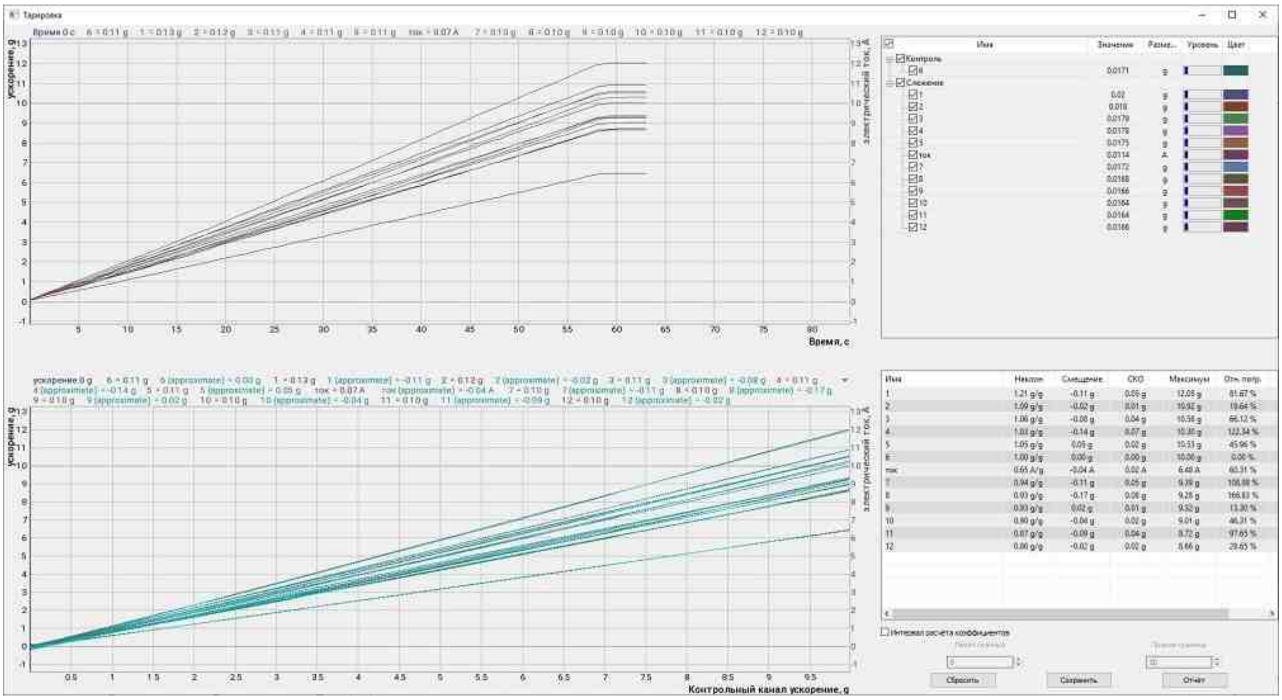


Fig. 9.24 "Graduation" window

checkboxes in the area of the list of measuring channels allow you to disable and enable visualization of the corresponding channels of graphics (*Fig. 9.25*).

In the "Graduation" window, adjust the graduation range (*Fig. 9.25*) by excluding the area of small amplitudes from it (in the example up to 1 g), for this you should activate the parameter "Coefficient calculation interval" and enter the corresponding numerical value.

Note: *it is recommended to exclude the area of small amplitudes from the graduation range due to the possible influence of noise on the graduation result.*

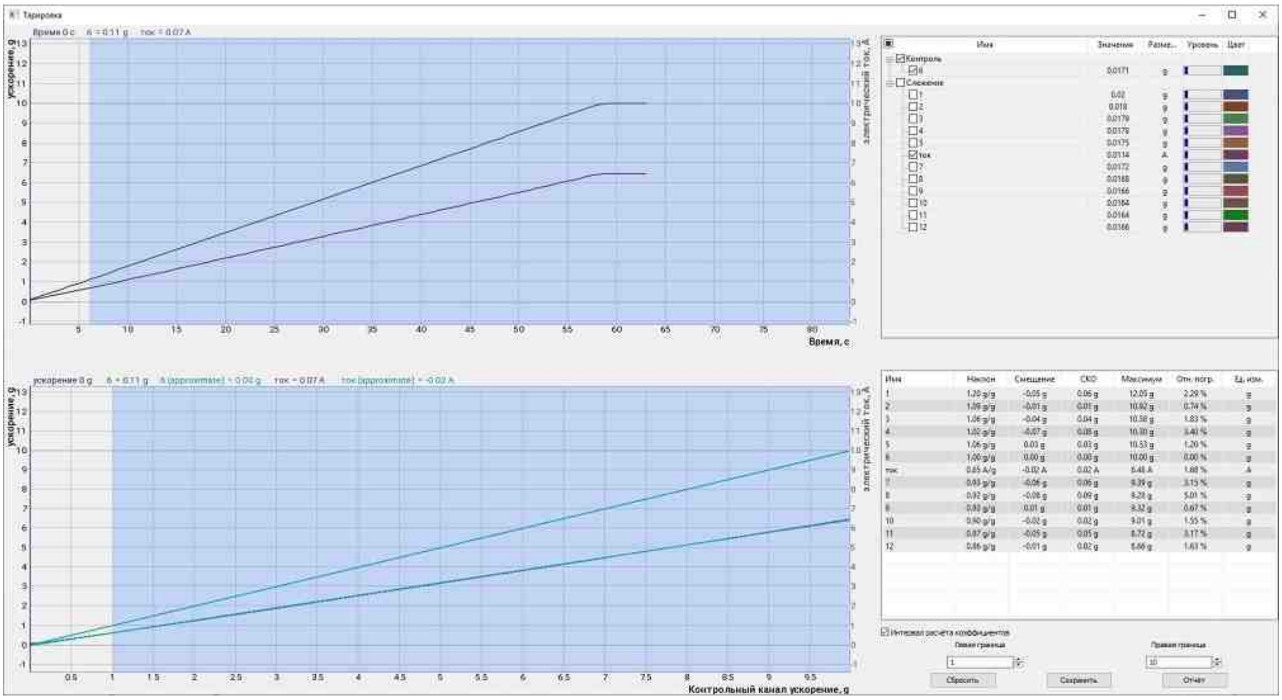


Fig. 9.25 "Graduation" window with range correction

checkboxes in the area of the list of measuring channels allow you to disable and enable visualization of graphics corresponding to channels.

In the field of numerical values, statistical data are output (calculated from the calibration results), which can be used to determine which acceleration values will be recorded by accelerometers during testing, what is the linearity of the amplitude characteristics of accelerometers relative to each other and relative to the current channel, etc..

To save the results in the Graduation window, you should  activate the "Save" button, after which the registered information will be available in the "Graduation" tab of the "Edit profile " window (Fig. 9.26).

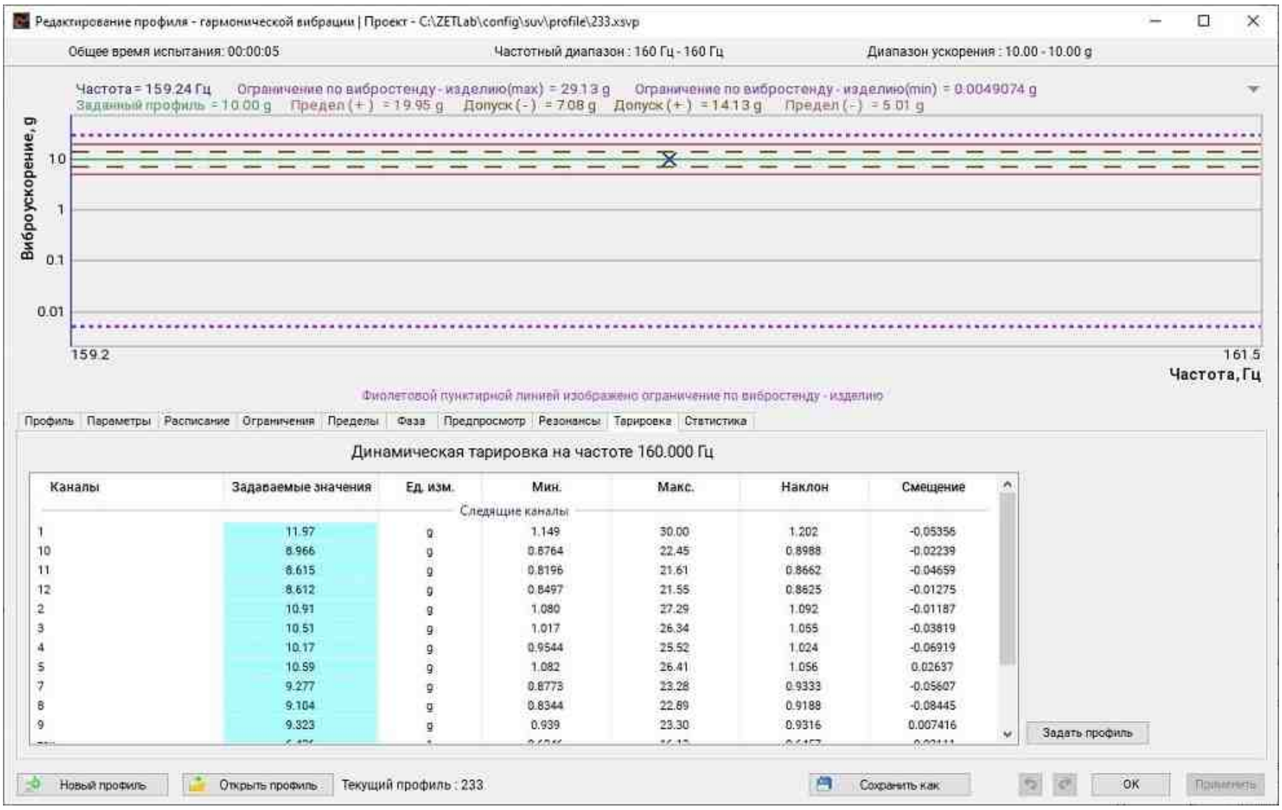


Fig. 9.26 "Edit profile" window, "Graduation" tab

Statistics tab .....

The "Statistics" tab contains statistical information based on the set values for the test profile parameters. It provides the user with a possibility to assess the load of the shaker during vibration tests (*Fig. 9.27*).

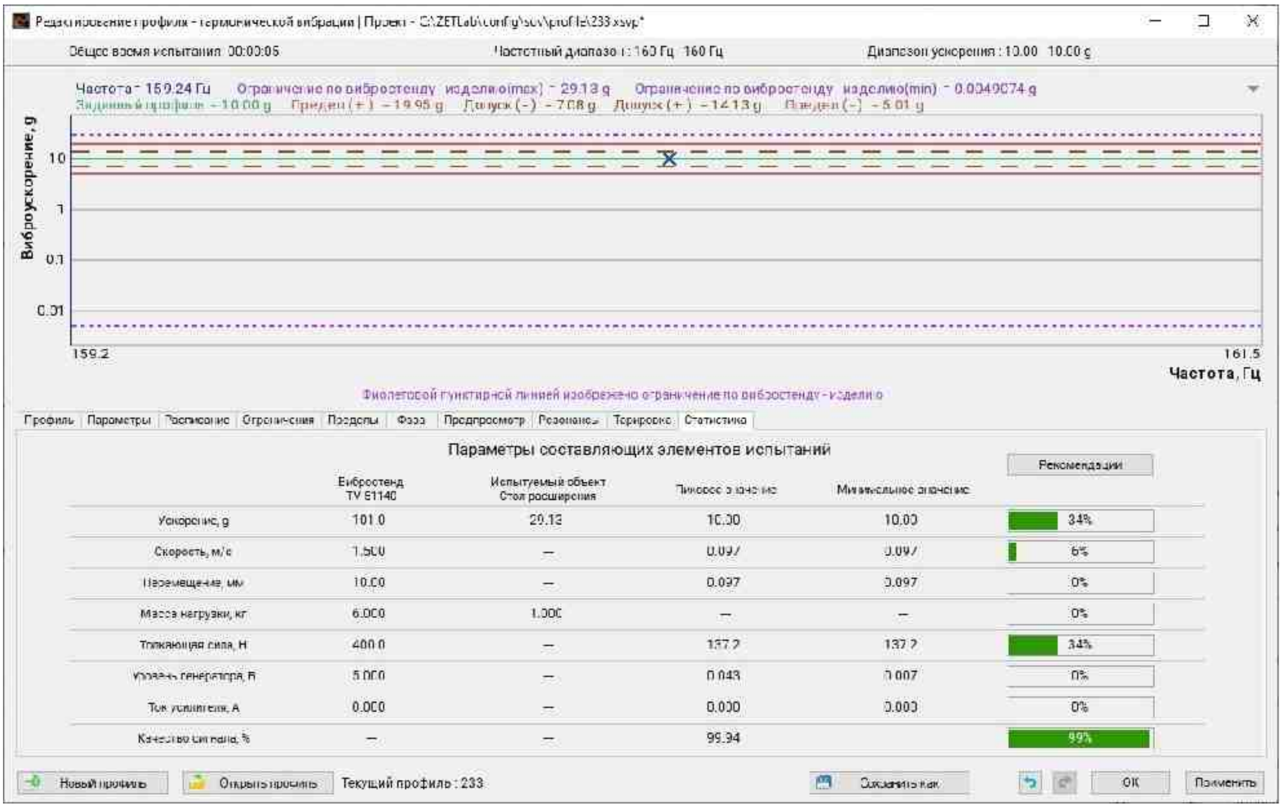


Fig. 9.27 "Edit profile" window, "Statistics" tab

Note: *the maximum acceleration of the Shaker is limited by the sum of the masses of the installed tool and the specimen. The value of the acceleration limit is given in the column "Test object".*

Note: *in the phase-locked resonance mode, the software increases the limit of recorded accelerations by the Q-factor of the resonance. For example, if the vibration generator system (at the specified load level) allows you to give an acceleration of 35g, then when the resonance is held (with a Q factor of 40), the acceleration limit value will be increased to the level of 35 * 40 = 1400g.*

To save the settings in the Edit Profile program, press the Apply button.

Also, the user can save the current test profile as a file which can be downloaded from the Edit Profile window. To save the current test profile, select the Save as function in the Edit Profile window (*Fig. 9.28*).

Fig. 9.28 Button for saving the test profile

In the opened window, set the name of the test profile and specify the path to save, and then press the Recording button ([Fig. 9.59](#)).

Note: *You can save the current profile with any tab open.*

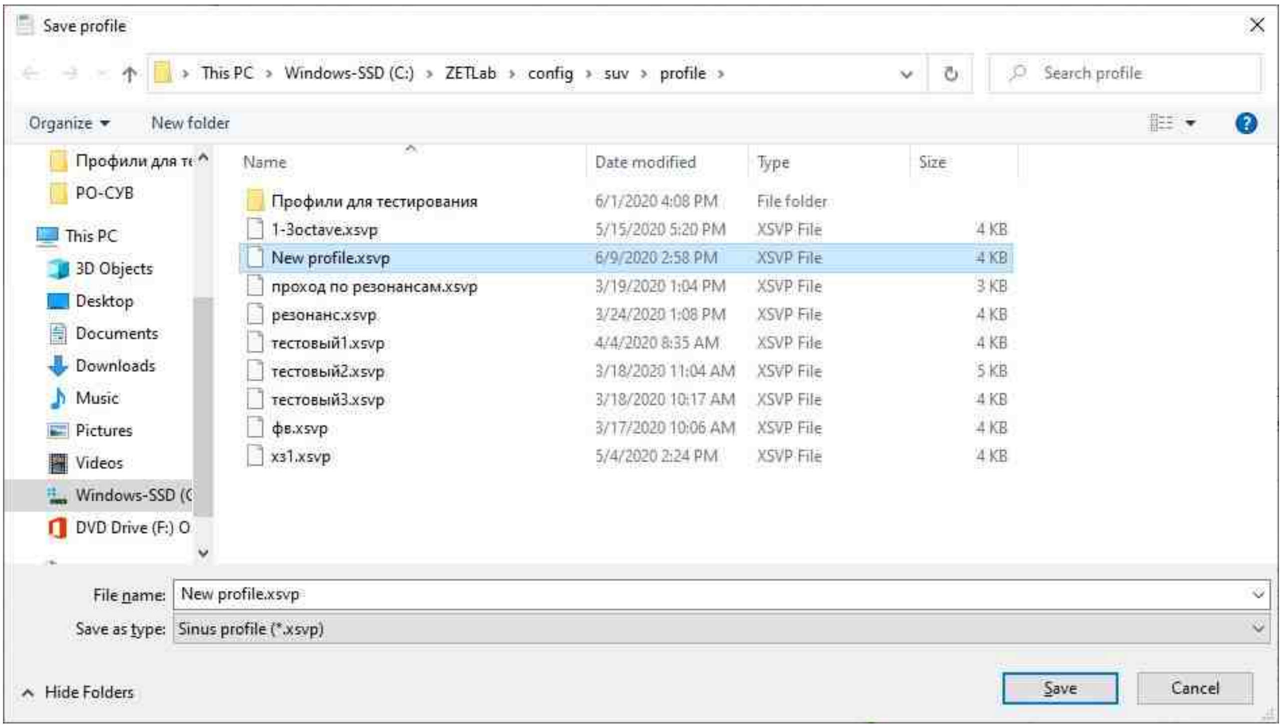


Fig. 9.39 Path to save the test profile

To download a previously saved test profile, select the Open Profile function. In the opened window, select the desired test profile file and press the *Open profile* button.

Saving and loading test profiles .....

To save the settings made in the window of the program "Edit profile - Sine", it is necessary activate the "Apply" button.

In the window of the program "Edit profile - Sine", the user is given the opportunity to both save the currently edited test profile as a file, and open previously saved profiles for editing or for testing.

To save the current test profile, it is necessary to "Edit profile - Sine" in the program window activate the "Save as" panel ([Fig. 9.28](#)).

Fig. 9.28 Button to save the test profile

In the "Profile save" window that opens (*Fig. 9.29*) you need to set the name of the saved test profile and select the directory to save it, after which activate the "Save" button.

Note: *You can save the current profile from any tab of the* "Edit profile - Sine" *window.*

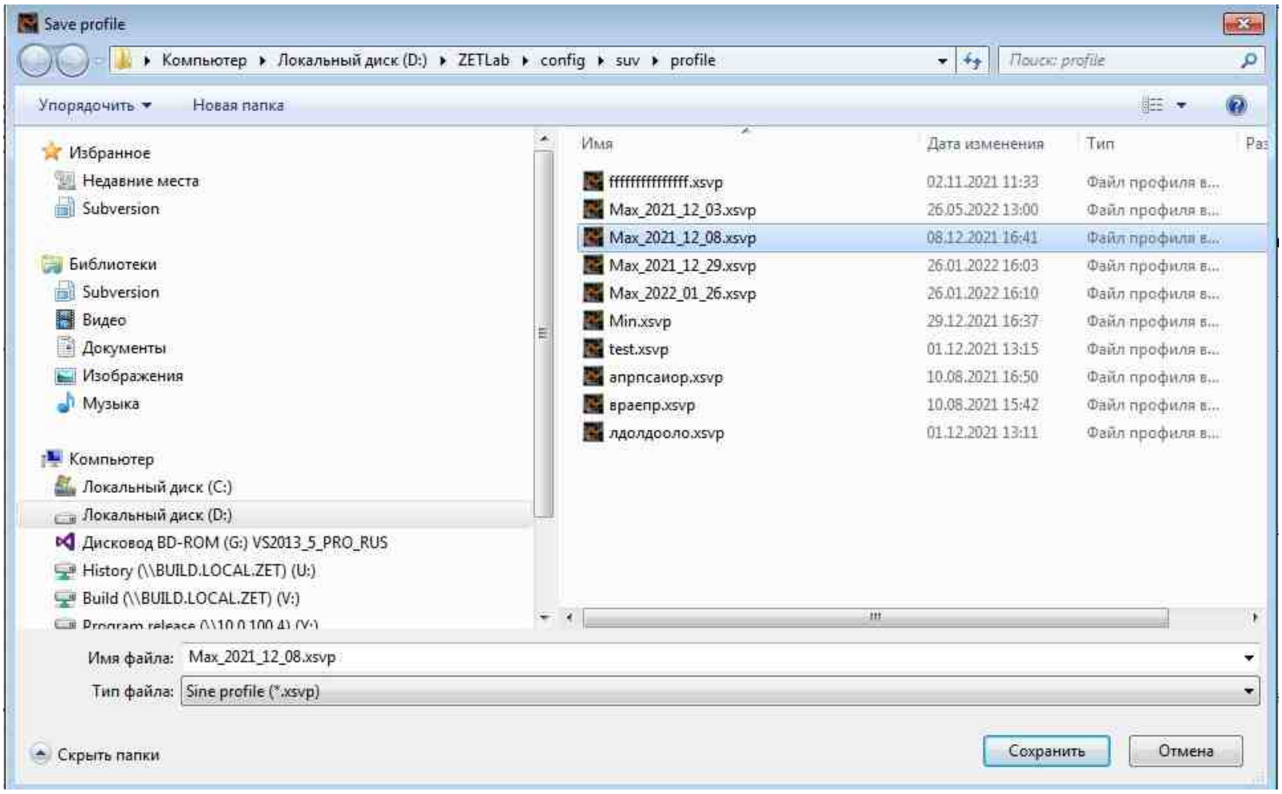


Fig. 9.29 The "Profile save" window

To load (open) a previously saved test profile, you must activate the "Profile open" panel (*Fig. 9.30*).

Fig. 9.30 Panel for opening the test profile

In the "Profile open" window that opens (*Fig. 9.31*) select the desired test profile file and activate the "Open" button.

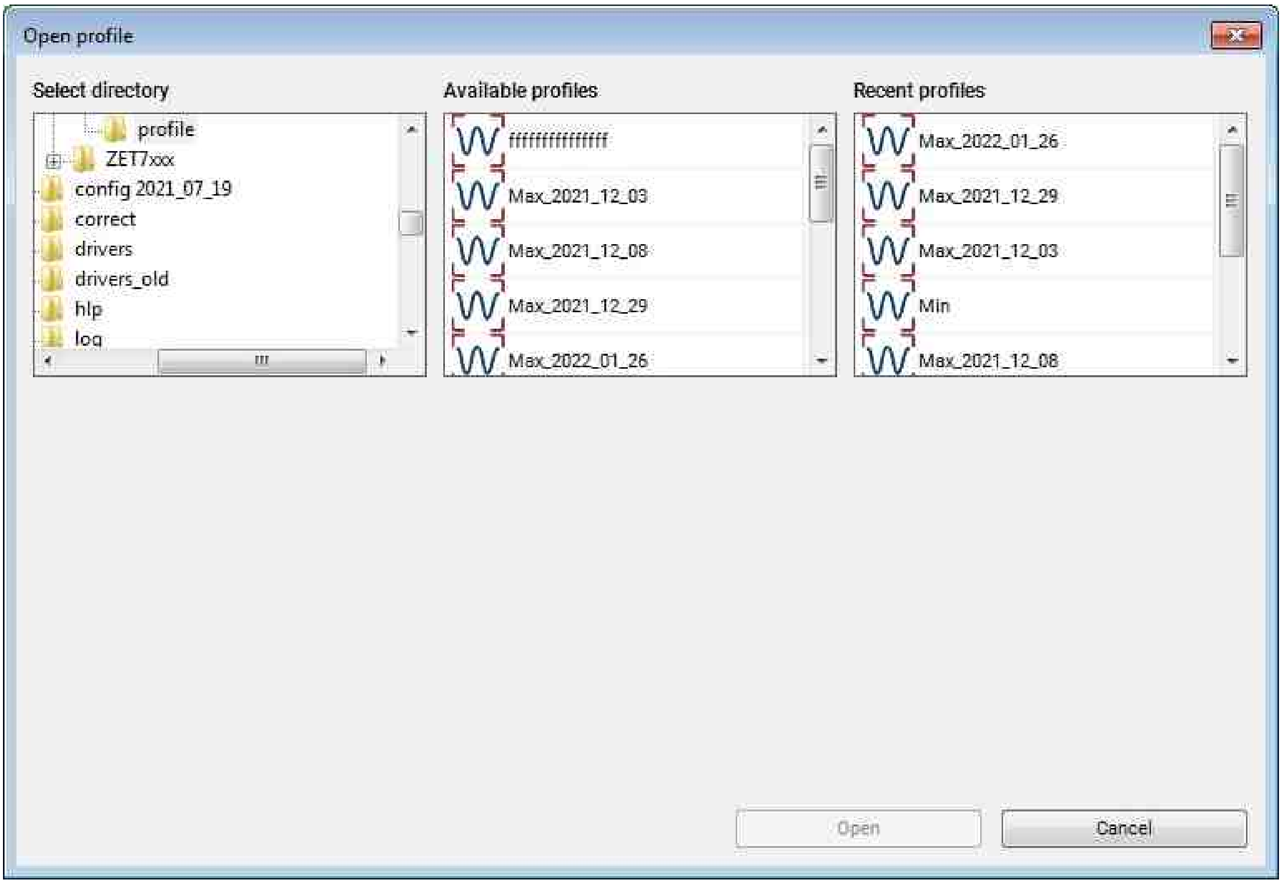


Fig. 9.31 "Profile Open" Window

When activating the "New profile" panel (*Fig. 9.32*) the program will offer to replace the current profile with a profile with default parameters (profile basic).

Fig. 9.32 Panel for creating a new profile

Testing .....

The tests are carried out using the program "Sine" (*Fig. 9.33*).

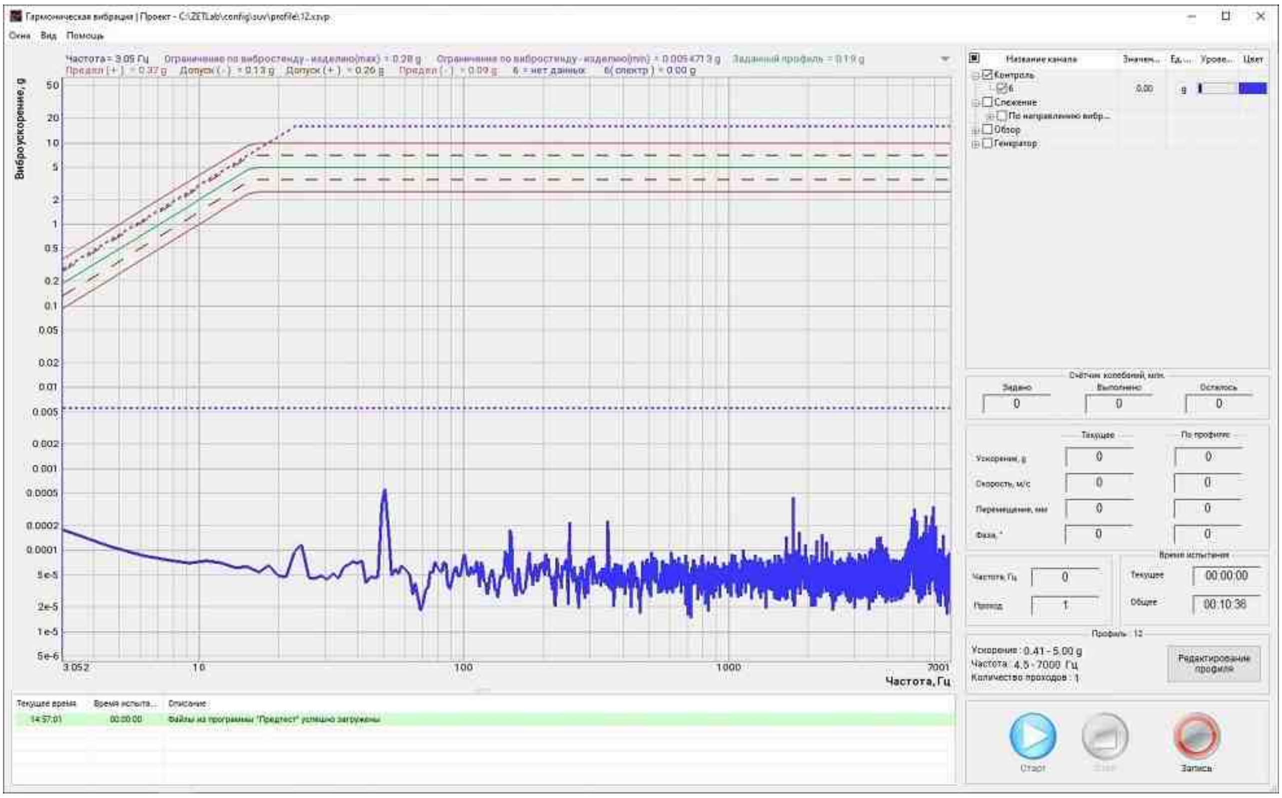


Fig. 9.33 Window of the program "Sine"

The largest part of the Harmonic Vibration program window is allocated to the area of graphics with a coordinate grid in which the following are displayed: a graphic of the selected test profile (green), tolerance lines (dashed red), limits (solid red) and a graphic of the noise level spectrum (blue) recorded via the feedback channel. The graphic area can also display (if this parameter is activated) the lower and upper limits of the possible profile levels (dashed purple line) and the limits (upper and lower) of the control channel level (solid blue lines).

On the right side of the graphic area is the area of recorded values and controls.

During the tests (*Fig. 9.34*) in the areas of graphics and recorded values, the recorded values are displayed both for all available VCS measurement channels and for the control channel(s).

Note: *only those graphics for which the selection is set in the "Channel's name" column in the tabular values area are displayed.*

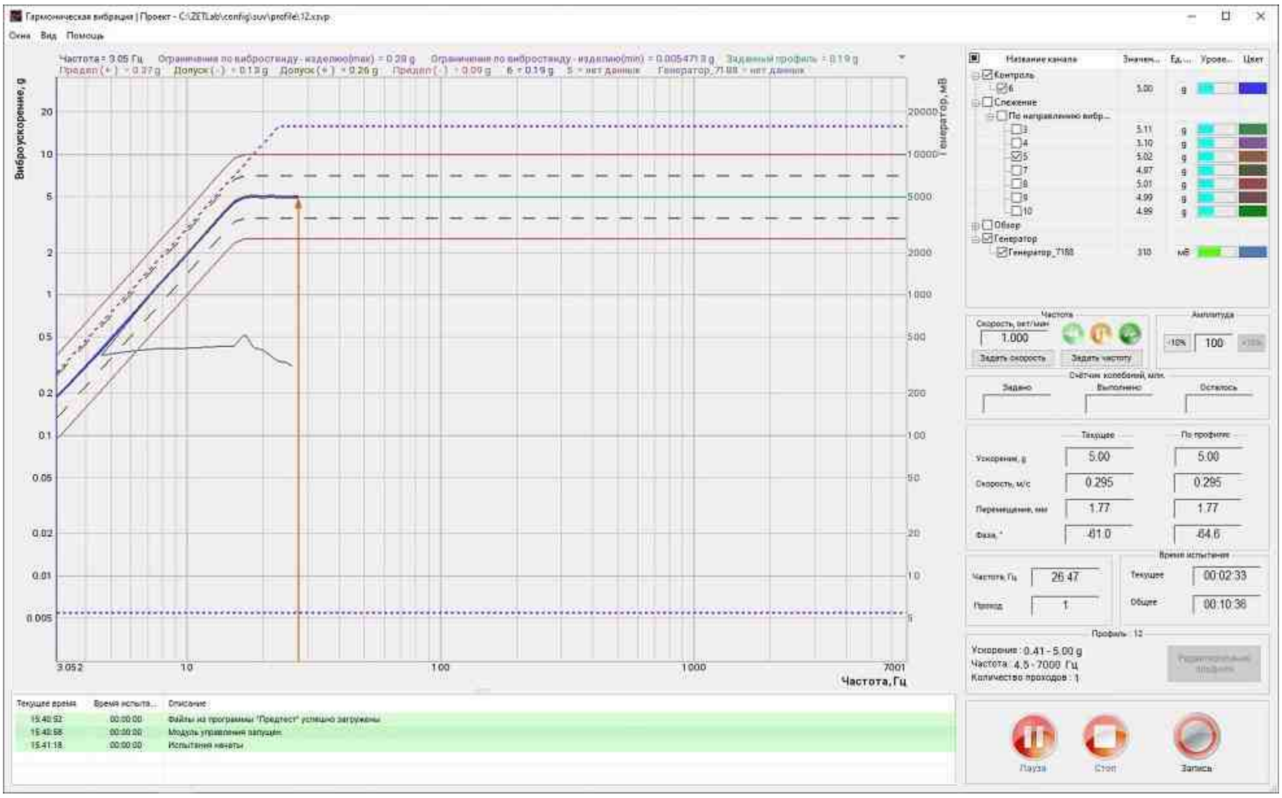


Fig. 9.34 The window of the program "Harmonic vibration" during the tests

Section "View" (*Fig. 9.35*) allows you to visualize in the field of recorded values and control the fields that are necessary for testing.

Note: *it is recommended to hide unused fields in order to remove redundant information from the test window*

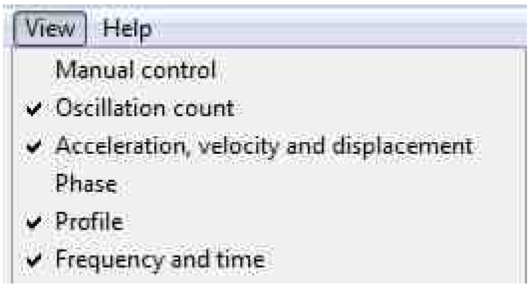


Fig. 9.35 List of the "View" section

The "Manual control" field (*Fig. 9.36*) it is designed to change the acceleration amplitude, the sweep rate and the direction of passage during the test.

Fig. 9.36 The "Manual control" field

Fig. 9.37 Field "Oscillation counter"

The "Integral parameters" field (*Fig. 9.38*) it contains indicators of the current status of parameters (Acceleration, Velocity, Displacement and phase) of vibration testing on the channel with the status "Control", as well as parameter values specified in the test profile..

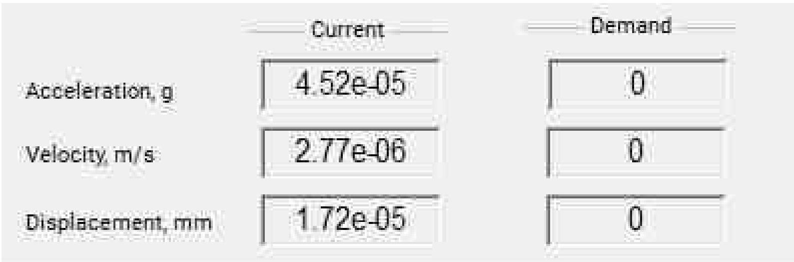


Fig.9.38 The "Integral parameters" field

"Frequency and Time" field (*Fig. 9.39*) contains an indicator of the current frequency and time counters. The "Total time" counter shows the total duration of vibration testing. The "Current time" counter shows the time elapsed since the beginning of the tests.

Fig.9.39 "Frequency and Time" field

The "Profile" field (*Fig. 9.40*) contains information about the current test profile, as well as the "Edit profile" button to open the corresponding program window.

Note: *the "Edit profile" button is deactivated at the time of testing*

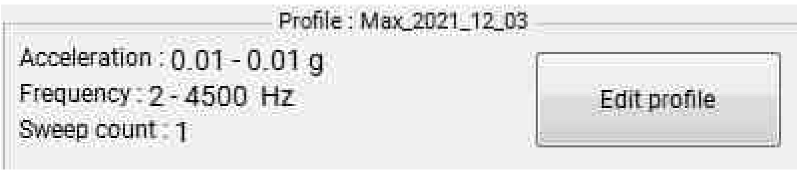


Fig.9.40 The "Profile" field

In the lower part of the window of the program "Sine" there is an event log, where information related to the operation of the program is stored, for example, when the window "Harmonic Vibration" is opened (if the program detects the presence of actual results of the Pre-Test), information about the successful download of the Pre-Test files is displayed in the event log (*Fig. 9.41*).

Current time	Time of testing	Description
15:53:42	00:00:00	Pre-Test files successfully uploaded

Fig. 9.41 Event log of the "Sine" program

Vibration tests are managed from a special menu in the lower-right corner of the program (*Fig. 9.42*).

Fig. 9.42 Control menu of the "Sine" program

To start vibration tests, it is necessary activate the "Start" button. To stop the tests at an arbitrary point in time, it is necessary activate the "Stop" button. To temporarily stop the tests, it is necessary activate the "Pause" button, and to resume the tests – the "Start" button.

Pressing the "Recording" button starts/stops the process of recording electrical signals from all involved channels of the controller

Fig.. 9.43 Disabled (left) and enabled (right) view of the "Recording" button

. ***Note***: *even if the "Recording" button status is disabled, the program will record the last 10 seconds of the tests in order to diagnose the reason for stopping the tests.*

. ***Note:*** *The recorded signals are viewed using the "ZETSignalGallery" program (see ZETLAB software. Operator's Manual).*

After starting the tests (by pressing the "Start" button), the program outputs the control signal to the level specified by the profile in accordance with the set time of entering the mode..

When the current level reaches 95% of the specified profile, the program starts conducting vibration tests according to the specified profile (*Fig. 9.44*).

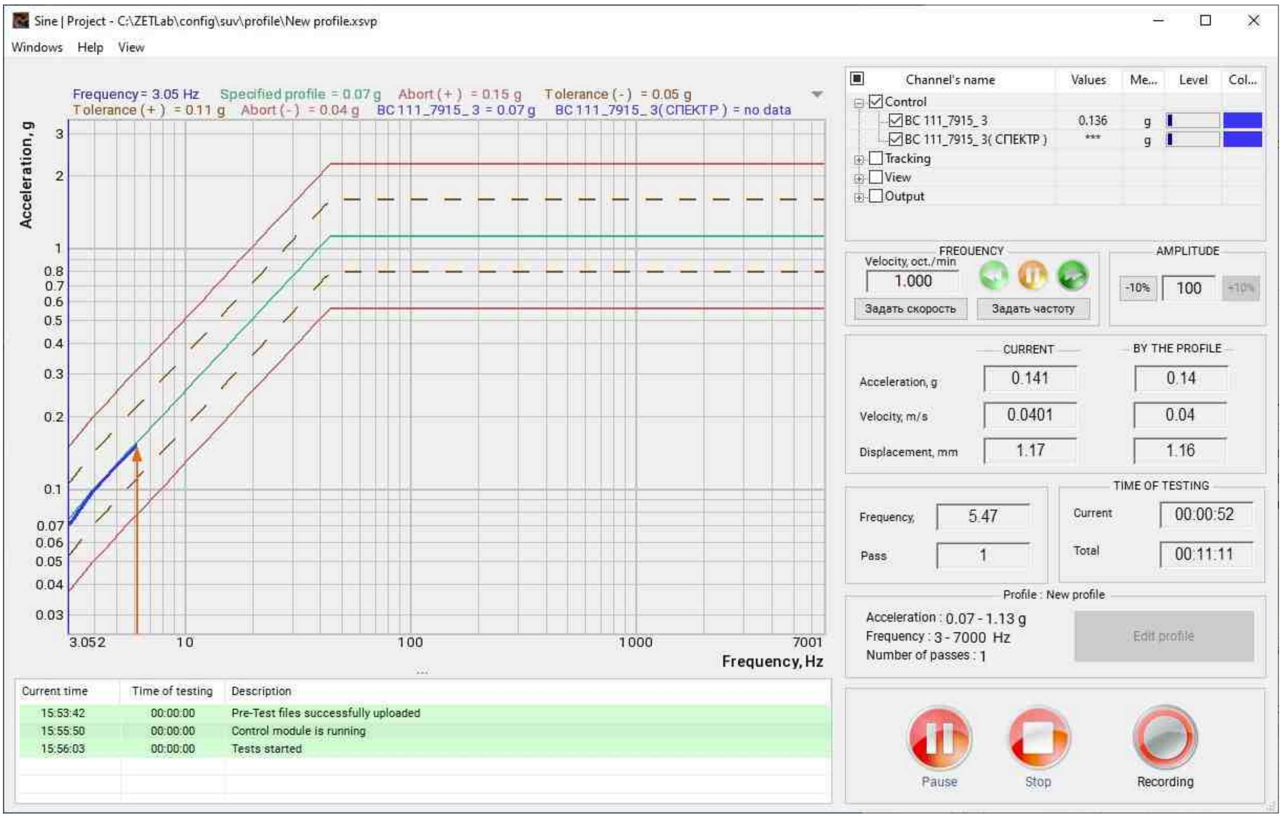


Fig. 9.44 Starting vibration tests

To display a measurement channel on the graphic, select it from the list of channels in the right pane of the program window (*Fig. 9.45*). This list includes all measuring channels for which one of the test control types was selected in the "Pre-Test and search for resonances" program (Control, Tracking, View). The measurement channel line also displays information of the current acceleration and the integral load level for this channel.

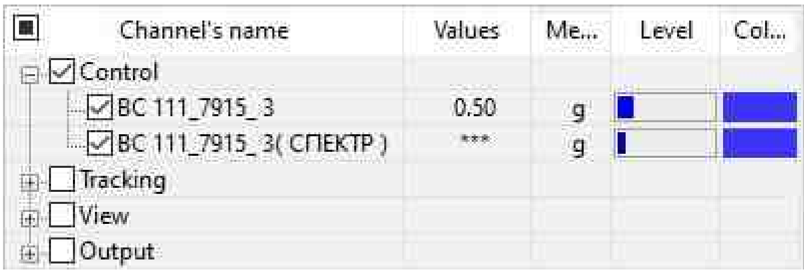


Fig. 9.45 Selecting a channel to display on the graphic

If the Control status was assigned to multiple measuring channels in the "Pre-Test and search for resonances" program, then list of channels in the "Sine" program will contain an additional channel "Total (Medium)" or "Total (Max)", depending on the set parameters ([Fig. 9.46](#)).

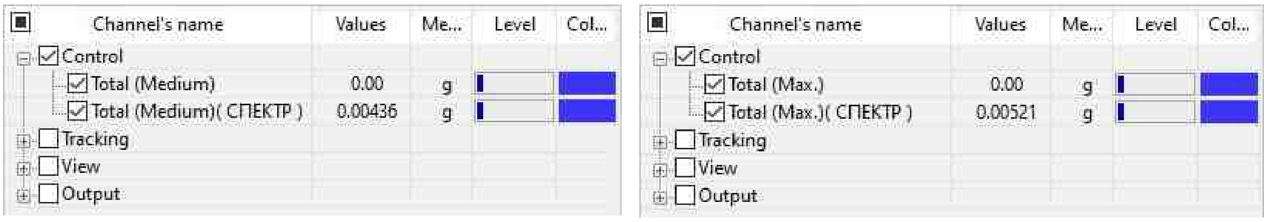


Fig. 9.46 Selecting a channel to display on the graphic

***Note!** If the control mode is selected based on the average value or maximum value, the channels selected with the "Control" status change their status to "Tracking", and a virtual measuring channel formed according to the average value or maximum value respectively becomes a control channel.*

If the value of the control channel exceeds the set limits (exceeding the permissible limits, exceeding the maximum parameters of the shaker, etc.), the tests will stop. The message log will display information of the reasons for interrupting the test. To resume the vibration tests from the moment they stopped, press the Continue button ([Fig. 9.47a](#)).

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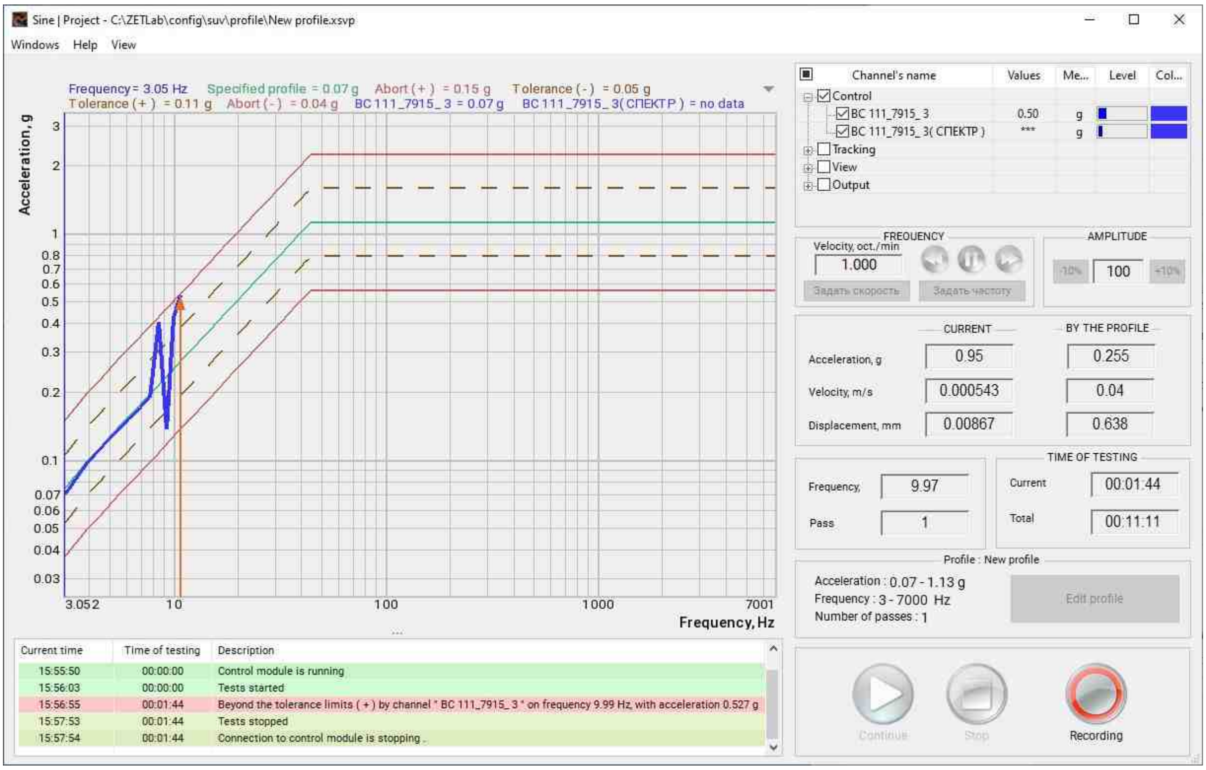

Fig. 9.47a The vibration test interruption

During the tests, it is possible to track changes in the condition of the specimen under test at the point (s) of the control channel setup in real time. To do this, start the Additional Graphics program (Fig. 9.47b) from the Windows menu.

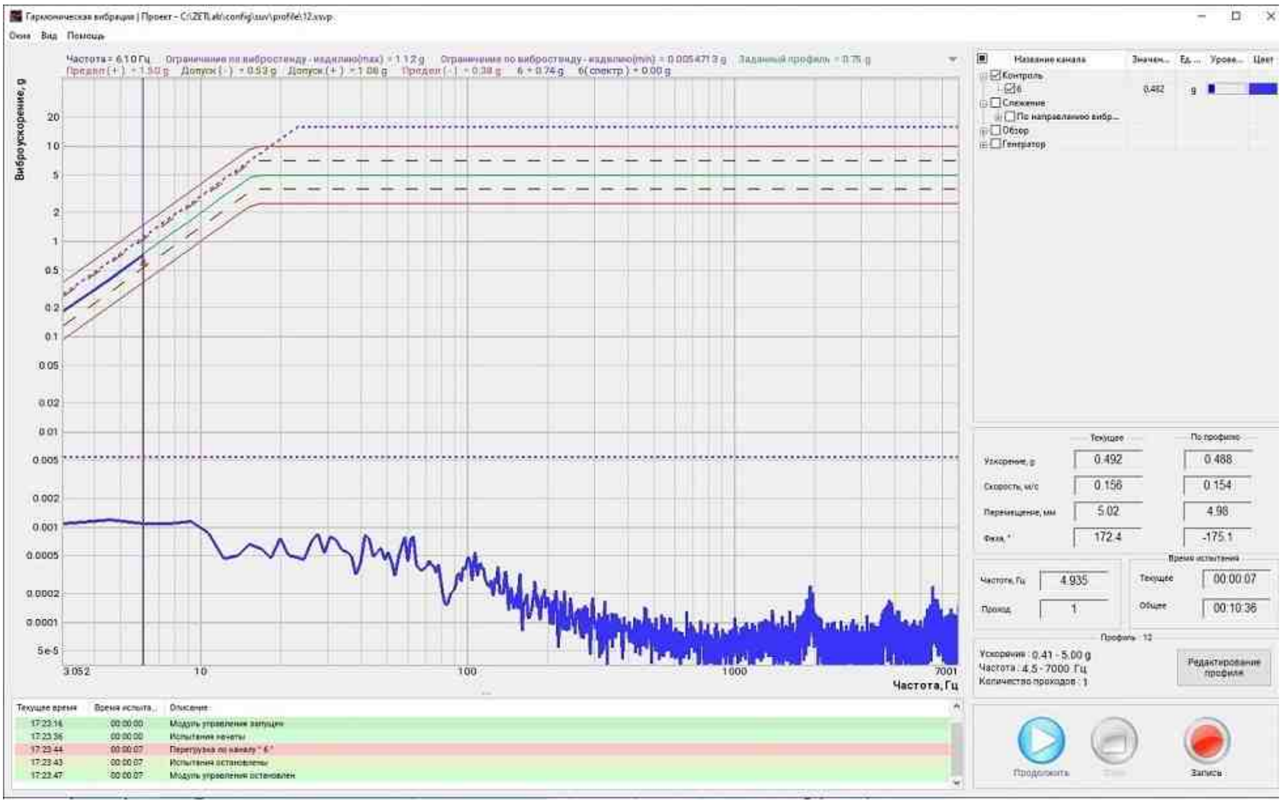

Fig. 9.47b Interruption of vibration testing

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Additional graphics .....

In addition to monitoring the testing performed in the "Sine" window, the software (in real time) provides the ability to comprehensively control a large number of parameters recorded during testing. For these purposes, from the list of the "Windows" section (*Fig. 9.48*) run the necessary programs.

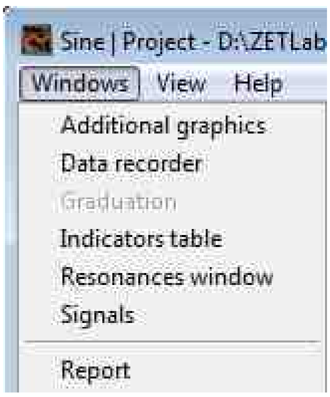


Fig. 9.48 List of programs in the "Windows" section

Program window "Additional graphics" (*Fig. 9.49*) allows you to control the deviations of the values of the spectrum parameters in the measurement channels from the values of the spectrum parameters formed according to the results of the Pre-Test.

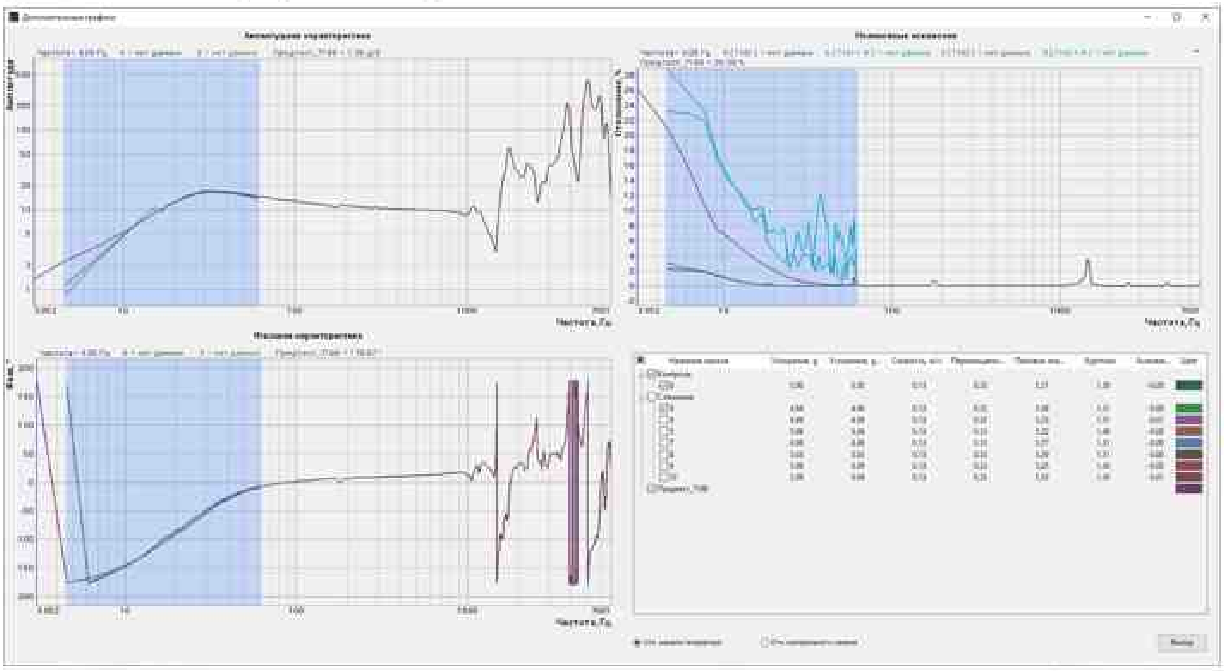


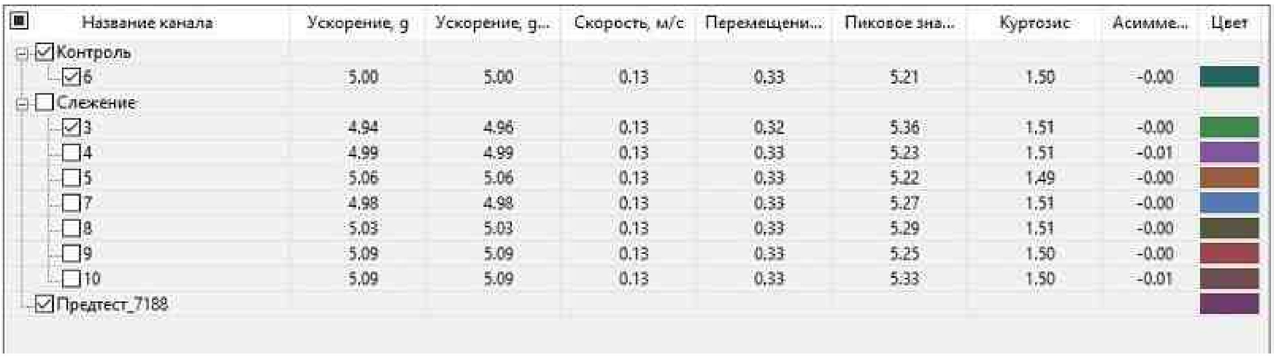
Fig. 9.49 The window of the program "Additional graphics"

Depending on the selected option (*Fig. 9.50*) on the graphics "Transfer function", "Spectrum phasic" and "Total harmonic distortion" the output of the recorded results is carried out either relative to the generator channel, or relative to the control channel.

Note: *when selecting the "rel. control channel" in the "Total harmonic distortion" graphic field, no information is output.*

Fig. 9.50 Calculation parameter selection area

Visualization of the required graphics is carried out by activating (marking the identifiers) of the corresponding channels in the "Channel's name" field of the numeric values area of the "Additional graphics" window (*Fig. 9.51*).



Название канала	Ускорение, g	Ускорение, g...	Скорость, м/с	Перемещени...	Пиковое зна...	Куртозис	Асимме...	Цвет
☑Контроль								
☑6	5.00	5.00	0.13	0.33	5.21	1.50	-0.00	
☐Слежение								
☑3	4.94	4.96	0.13	0.32	5.36	1.51	-0.00	
☐4	4.99	4.99	0.13	0.33	5.23	1.51	-0.01	
☐5	5.06	5.06	0.13	0.33	5.22	1.49	-0.00	
☐7	4.98	4.98	0.13	0.33	5.27	1.51	-0.00	
☐8	5.03	5.03	0.13	0.33	5.29	1.51	-0.00	
☐9	5.09	5.09	0.13	0.33	5.25	1.50	-0.00	
☐10	5.09	5.09	0.13	0.33	5.33	1.50	-0.01	
☑Предтест_7188								

Fig. 9.51 The area of numerical values of the "Additional graphics" window

Data recorder .....

The window of the program "Data recorder" (*Fig. 9.52*) displays information about the temporary implementation of the parameters recorded during the tests.

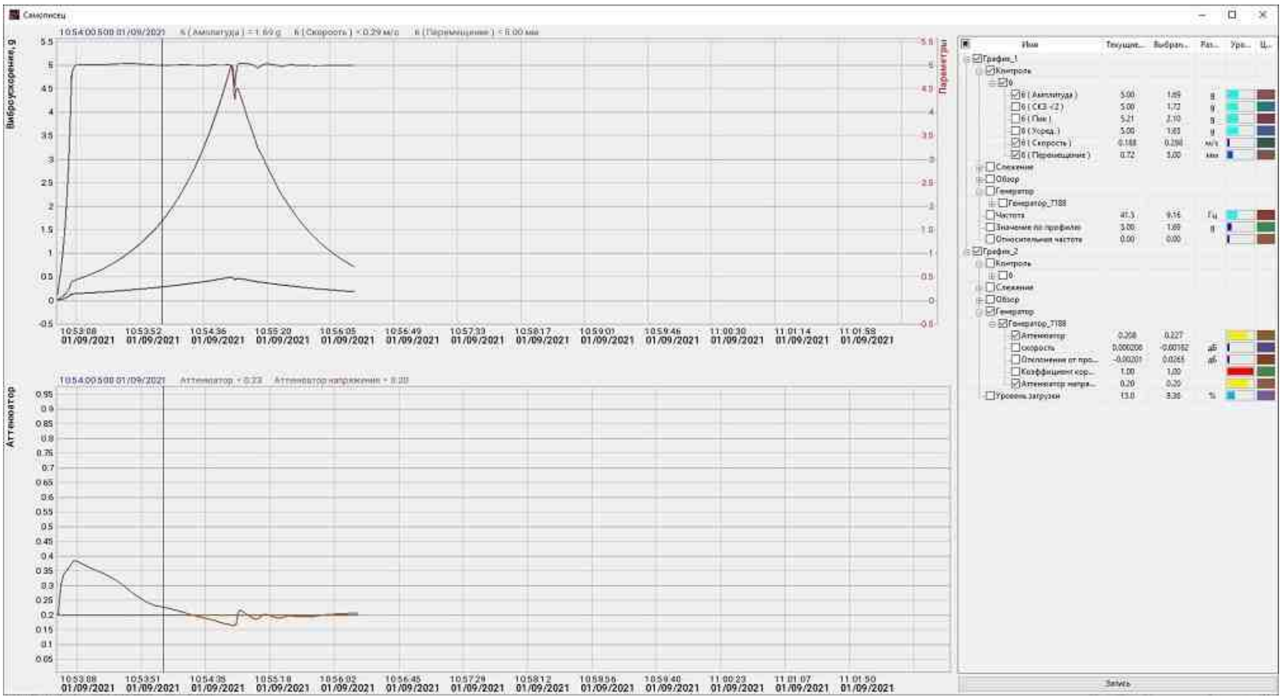


Fig. 9.52 The window of the program "Data recorder"

In the area of numerical values of the program window "Data recorder" (*Fig. 9.53*) the tree of the list of identifiers of measuring channels and parameters for which graphics can be visualized is given.

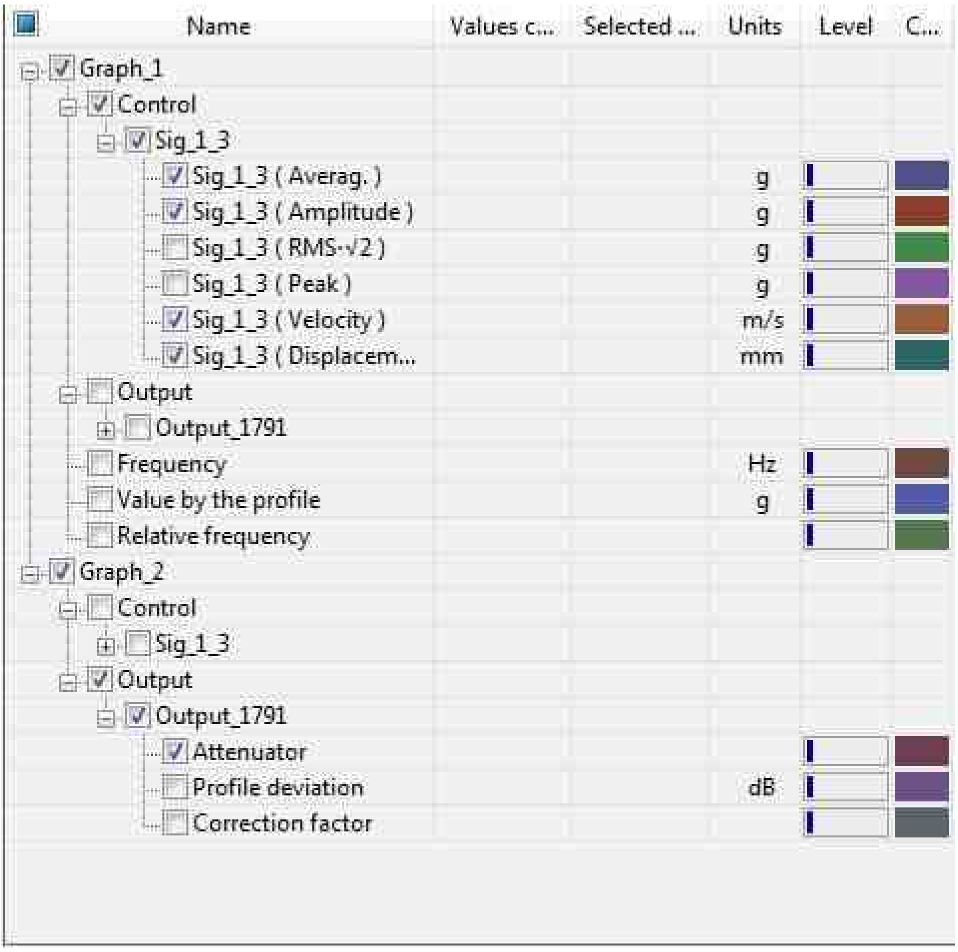


Fig. 9.53 The area of numerical values of the "Additional graphics" window

Visualization of the required graphics is carried out by activating (marking the identifiers) of the corresponding channels in the "Name" field of the numeric values area of the "Data recorder" window.

The color of the graphic can be changed by activating the "Color" parameter in the line of the corresponding graphic.

To save the graphics of the recorder, you need to activate the "Data recorder" button located in the lower right corner of the "Data recorder" window, after which a window will open to select the save directory and specify the name for the saved file.

When saving, two files are formed at once (with the addition of the indexes "_1" and "_2" to the specified name): one for the upper graphics of the recorder, the second for the lower graphs. The files store information on all the graphics of the recorder, regardless of their visualization in the window of the program "Data recorder" at the time of saving.

The information stored in the files can be viewed using the program "Viewing results" from the ZETLAB software.

Program window "Indicators table" (*Fig. 9.54*) provides convenient visualization of numerical values selected at the request of the operator, which are subject to control during vibration tests.

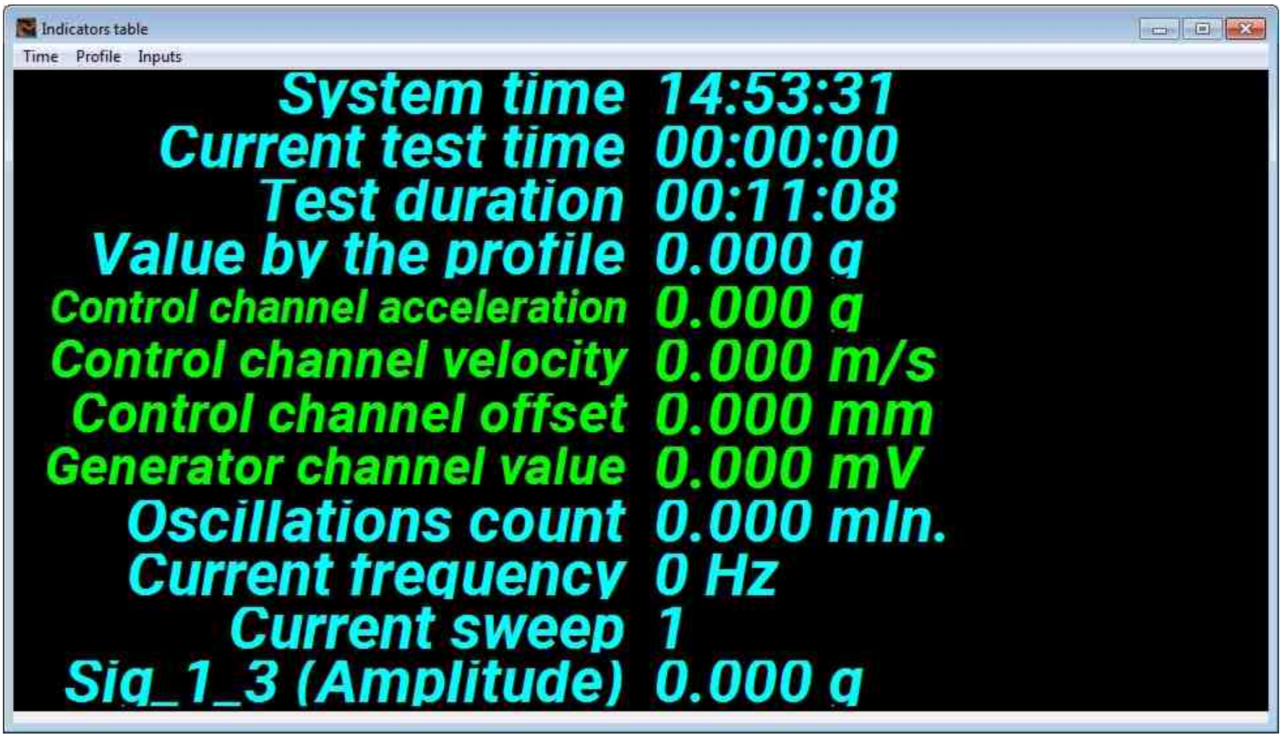


Fig. 9.54 Program window "Indicators table"

Visualization of the necessary parameters is performed through the lists of sections "Time" "Profile" and "Inputs" of the "Indicators table" window (*Fig. 9.55*).

Fig. 9.55 Sections of the "Indicators table" window

In the example (*Fig. 9.56*) the list of values available for visualization for the measuring channel with the identifier (channel name) "3" is given.

Fig. 9.56 Example of the "Inputs" list

The window of the program "Resonance analysis" (*Fig. 9.57*) it is used to display information about resonances and antiresonances.

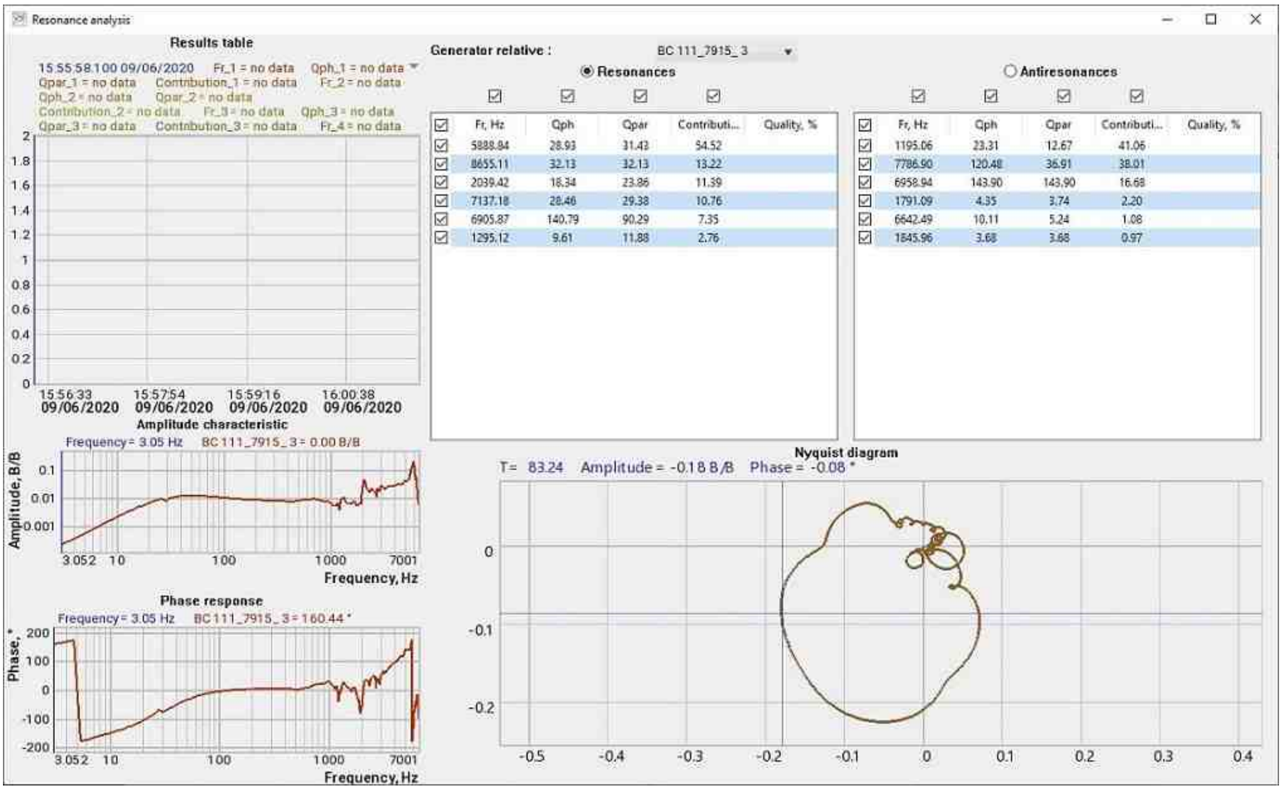


Fig. 9.57 The window of the program "Resonance analysis"

The program "Signals" launches the window of the program "Multi-channel oscilloscope", which allows you to observe the signals recorded from the measuring channels of the VCS

Note: *In cases of problems with the tests: the tests were interrupted for some unknown reason, the tests do not start, there are significant distortions on the profile graphic, etc., to identify the cause, send us an email* ***INFO@ZETLAB.COM*** *an archived folder with files for the current test day. To go to the folders with the information we need, activate the text link "Tests results" on the VCS panel*

Results report .....

To save the report, run the "Report" command from the Windows menu in the "Sine" program. In the opened window, you can specify the name of report file and path to save it, and then press the "Save" button. The report is also saved automatically after the vibration tests are completed (*Fig. 9.58*) .

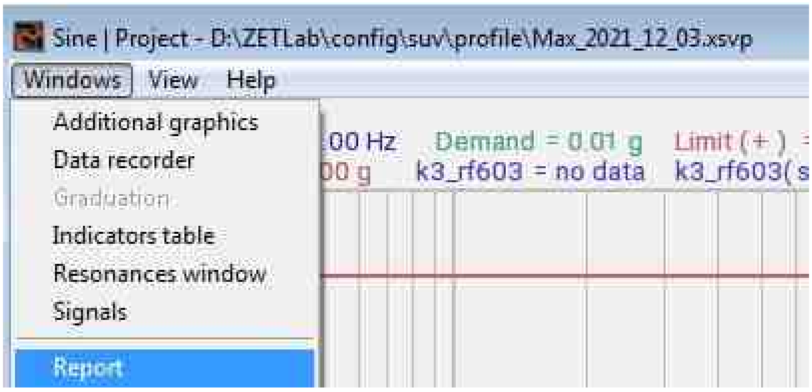


Fig. Fig. 9.58 Menu "Window"

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Note: *regardless of saving the file manually (via the "Report" program in the "Windows" section), the results recorded by the programs (which may be necessary for compiling the report) are always saved automatically to the directory formed by default at each completion of vibration testing.*

To view the report files, press the Tests results button on the VCS panel. In the opened window, select the appropriate test type and go to the Tests results folder. You can view the report files using the Results viewing program. To do this, right-click on the file and select Open in ResultViewer (*Fig. 9.59*) from the context menu.

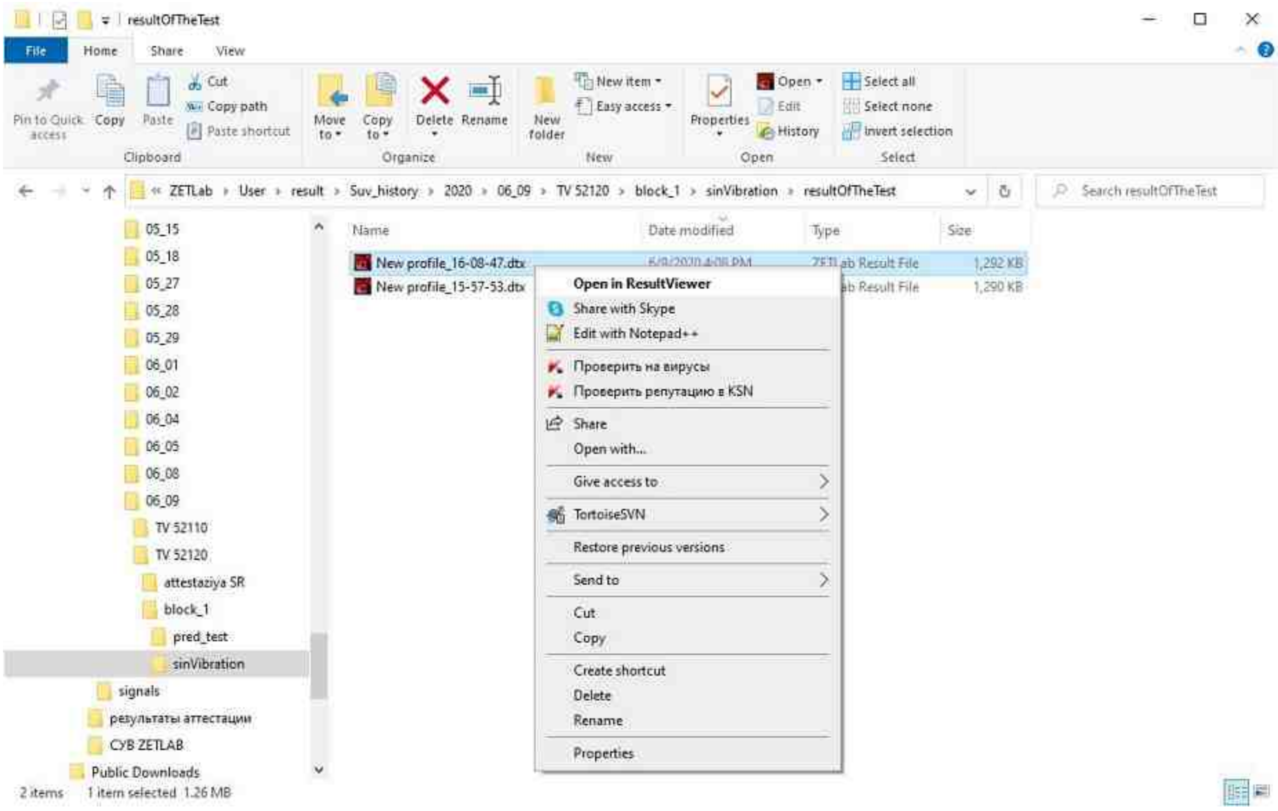


Fig. 9.59 Report Directory

In the Results viewing program, the graphic tab displays the graphical part of the report on the completed test (*Fig. 9.60*).

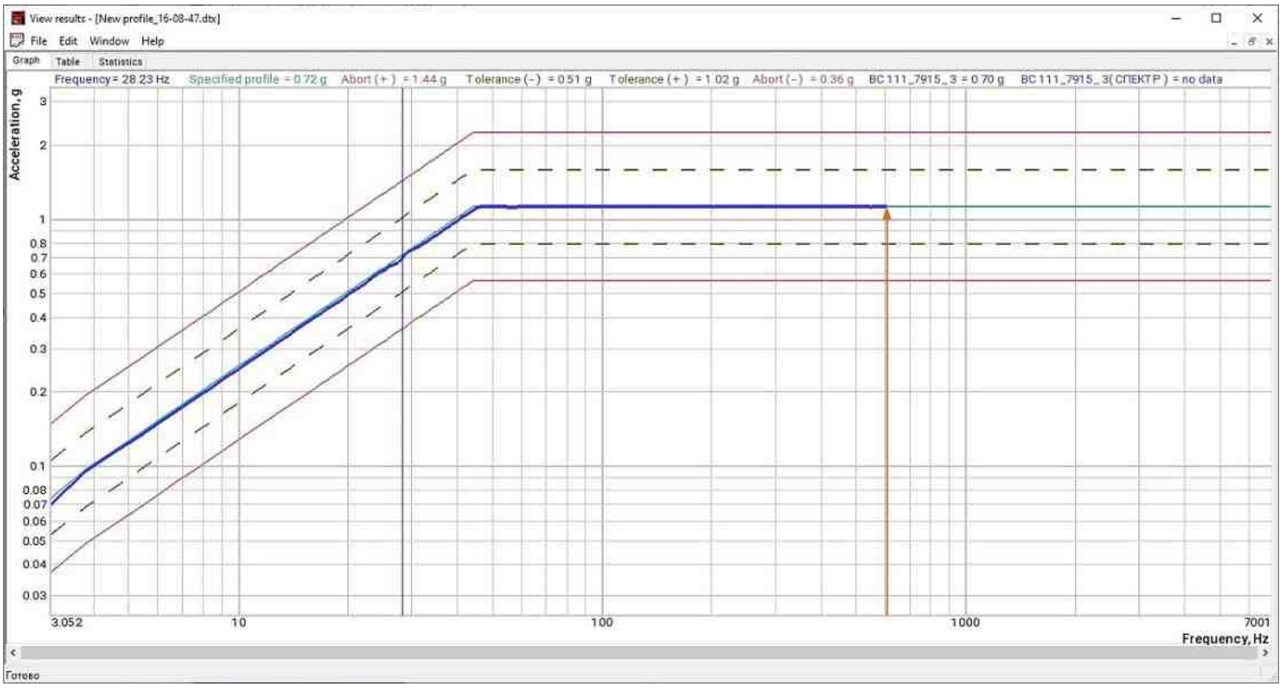
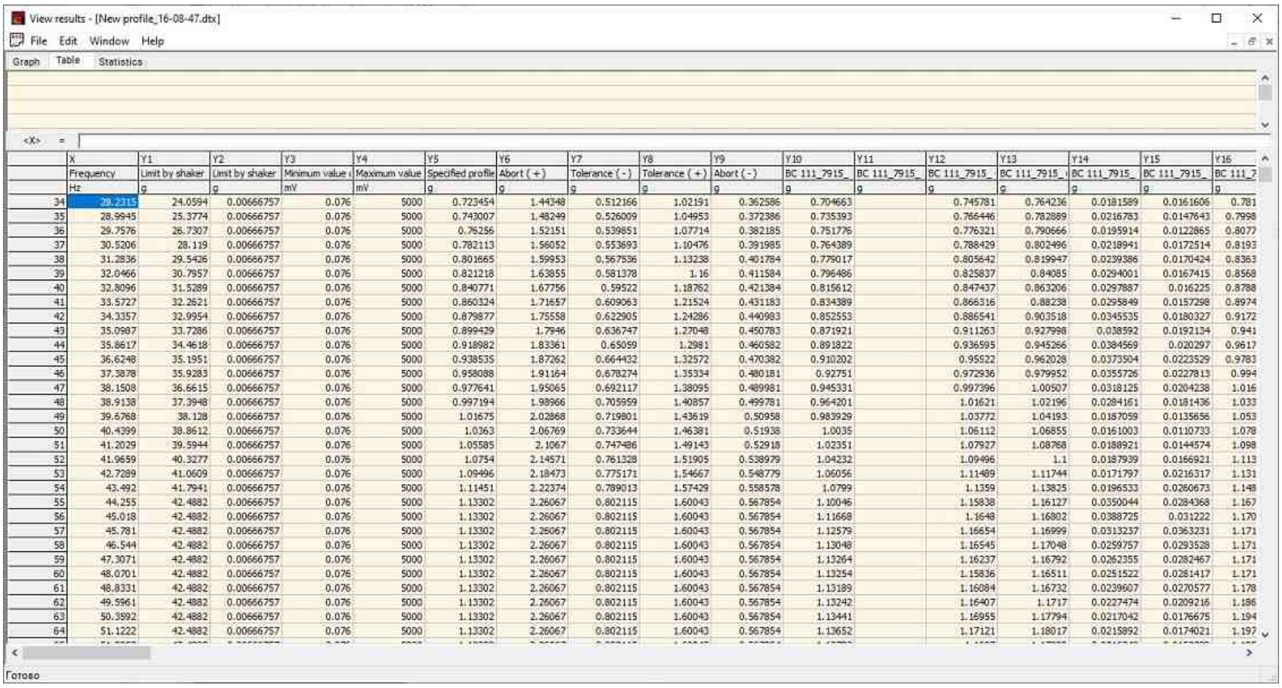


Fig. 9.60 Example of a vibration test report

To view the graphic values in table form, go to the Table tab (*[Fig. 9.60a](#)*).



	X	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16
	Frequency	Limit by shaker	Limit by shaker	Minimum value	Maximum value	Specified profile	Abort (+)	Tolerance (-)	Tolerance (+)	Abort (-)	BC 111_7915_	BC 111_7915_	BC 111_7915_	BC 111_7915_	BC 111_7915_	BC 111_7915_	BC 111_7
	Hz	g	g	mV	mV	g	g	g	g	g	g	g	g	g	g	g	g
34	28.2315	24.0594	0.00666757	0.076	5000	0.723454	1.44348	0.512166	1.02191	0.362586	0.704663		0.745781	0.764236	0.0181589	0.0161606	0.781
35	28.9945	25.3774	0.00666757	0.076	5000	0.743007	1.48249	0.526009	1.04953	0.372386	0.735393		0.766446	0.782889	0.0216783	0.0147643	0.7998
36	29.7576	26.7307	0.00666757	0.076	5000	0.76256	1.52151	0.539851	1.07714	0.382185	0.751776		0.776321	0.790666	0.0195914	0.0122865	0.8077
37	30.5206	28.119	0.00666757	0.076	5000	0.782113	1.56052	0.553693	1.10476	0.391985	0.764389		0.788429	0.802496	0.0218941	0.0172514	0.8193
38	31.2836	29.5426	0.00666757	0.076	5000	0.801665	1.59953	0.567536	1.13238	0.401784	0.779017		0.805642	0.819947	0.0239386	0.0170424	0.8363
39	32.0466	30.7957	0.00666757	0.076	5000	0.821218	1.63855	0.581378	1.16	0.411584	0.796486		0.825837	0.84085	0.0294001	0.0167415	0.8568
40	32.8096	31.5289	0.00666757	0.076	5000	0.840771	1.67756	0.59522	1.18762	0.421384	0.815612		0.847437	0.863206	0.0297887	0.016225	0.8788
41	33.5727	32.2621	0.00666757	0.076	5000	0.860324	1.71657	0.609063	1.21524	0.431183	0.834389		0.866316	0.88238	0.0295849	0.0157298	0.8974
42	34.3357	32.9954	0.00666757	0.076	5000	0.879877	1.75558	0.622905	1.24286	0.440983	0.852553		0.886541	0.903518	0.0345535	0.0180327	0.9172
43	35.0987	33.7286	0.00666757	0.076	5000	0.899429	1.7946	0.636747	1.27048	0.450783	0.871921		0.911263	0.927998	0.038592	0.0192134	0.941
44	35.8617	34.4618	0.00666757	0.076	5000	0.918982	1.83361	0.65059	1.2981	0.460582	0.891822		0.936595	0.945266	0.0384569	0.020297	0.9617
45	36.6248	35.1951	0.00666757	0.076	5000	0.938535	1.87262	0.664432	1.32572	0.470382	0.910202		0.95522	0.962028	0.0373504	0.0223529	0.9783
46	37.3878	35.9283	0.00666757	0.076	5000	0.958088	1.91164	0.678274	1.35334	0.480181	0.92751		0.972936	0.979952	0.0355726	0.0227813	0.994
47	38.1508	36.6615	0.00666757	0.076	5000	0.977641	1.95065	0.692117	1.38095	0.489981	0.945331		0.997396	1.00507	0.0318125	0.0204238	1.016
48	38.9138	37.3948	0.00666757	0.076	5000	0.997194	1.98966	0.705959	1.40857	0.499781	0.964201		1.01621	1.02196	0.0284161	0.0181436	1.033
49	39.6768	38.128	0.00666757	0.076	5000	1.01675	2.02868	0.719801	1.43619	0.50958	0.983929		1.03772	1.04193	0.0187059	0.0135656	1.053
50	40.4399	38.8612	0.00666757	0.076	5000	1.0363	2.06769	0.733644	1.46381	0.51938	1.0035		1.06112	1.06855	0.0161003	0.0110733	1.078
51	41.2029	39.5944	0.00666757	0.076	5000	1.05585	2.1067	0.747486	1.49143	0.52918	1.02351		1.07927	1.08768	0.0188921	0.0144574	1.098
52	41.9659	40.3277	0.00666757	0.076	5000	1.0754	2.14571	0.761328	1.51905	0.538979	1.04232		1.09496	1.1	0.0187939	0.0166921	1.113
53	42.7289	41.0609	0.00666757	0.076	5000	1.09496	2.18473	0.775171	1.54667	0.548779	1.06056		1.11489	1.11744	0.0171797	0.0216317	1.131
54	43.492	41.7941	0.00666757	0.076	5000	1.11451	2.22374	0.789013	1.57429	0.558578	1.0799		1.1359	1.13825	0.0196533	0.0260673	1.148
55	44.255	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.10046		1.15838	1.16127	0.0350044	0.0284368	1.167
56	45.018	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.11668		1.1648	1.16802	0.0388725	0.031222	1.170
57	45.781	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.12579		1.16654	1.16999	0.0313237	0.0363231	1.171
58	46.544	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.13048		1.16545	1.17048	0.0259757	0.0293528	1.171
59	47.3071	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.13264		1.16237	1.16792	0.0262355	0.0282467	1.171
60	48.0701	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.13254		1.15836	1.16511	0.0251522	0.0281417	1.171
61	48.8331	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.13189		1.16084	1.16732	0.0239607	0.0270577	1.178
62	49.5961	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.13242		1.16407	1.1717	0.0227474	0.0209216	1.186
63	50.3592	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.13441		1.16955	1.17794	0.0217042	0.0176675	1.194
64	51.1222	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.13652		1.17121	1.18017	0.0215892	0.0174021	1.197

Fig. 9.60a Example of a vibration test report

Examples for the section .....

Example of degrees of rigidity in frequency swing tests .....

The degree of rigidity of the shock of the test is determined by a combination of three parameters: the frequency range, the amplitude of the vibration and the duration of the impact (expressed by the number of swing cycles or time).

For various types of equipment, GOST 28203-89 determines the choice of appropriate frequency ranges, amplitudes and exposure durations.

In the table (*Fig. 9.61*) the "Sine" parameters recommended in GOST 28203-89 are given by the method of frequency swing intended mainly for elements, and in the tables (*Fig. 9.62* and *Fig. 9.63*) – designed mainly for equipment, respectively, at a low transition frequency (about 9 Hz) and a high transition frequency (about 60 Hz).

Воздействие вибрации методом качания частоты

Диапазон частот, Гц	Число качаний на каждую ось. Амплитуда*: 0,35 мм или $5g_n$	0,75 мм или $10g_n$	1,5 мм или $20g_n$	Примеры применения
10–55	10	10		Крупные мощные промышленные установки, тяжелое вращающееся оборудование, прокатные станы, большие пассажирские и торговые суда
10–500	10	10		Сухопутный транспорт общего назначения, небольшие быстроходные суда (военные и гражданские), авиация общего назначения
10–2000		10	10	Космические корабли (20 g_n). Элементы на двигателе самолета
55–500	10	10		Применимо как для 10–500 Гц, но для прочных элементов малых размеров, у которых отсутствует резонанс ниже 55 Гц
55–2000		10	10	Применимо как для 10–2000 Гц, но для прочных элементов малых размеров, у которых отсутствует резонанс ниже 55 Гц
100–2000		10	10	Применимо как для 55–2000 Гц, но для сверхпрочных образцов очень малых размеров, например транзисторы в капсулах, диоды, резисторы и конденсаторы

* Амплитуда перемещения ниже частоты перехода и амплитуда ускорения выше частоты перехода. Частоты перехода 57–62 Гц (см. п. 5.2, табл. 5).

Fig. 9.61 Table of the degree of rigidity intended for elements

Диапазон частот, Гц	Число качаний на каждую ось			Примеры применения
	Ускорение			
	$0{,}5\ g_n$	$1\ g_n$	$2\ g_n$	
10—150	50	—	—	Стационарная аппаратура, например: компьютеры больших габаритов и прокатные станы. Длительный срок службы
10—150	20	—	—	Стационарная аппаратура, например: радиопередатчики больших габаритов и кондиционеры воздуха. Средний срок службы
10—150	—	20	20	Аппаратура, предназначенная для установки на борту кораблей, железнодорожном или наземном транспорте, а также для перевозки на этих видах транспорта

Fig. 9.62 Table of the degree of rigidity intended for equipment at a low value of the transition frequency

Диапазон частот, Гц	Число качаний на каждую ось				Примеры применения
	Амплитуда*				
	0,15 мм или $2\ g_n$	0,35 мм или $5\ g_n$	0,75 мм или $10\ g_n$	1,5 мм или $20\ g_n$	
1—35**	—	100	100	—	Аппаратура, смонтированная рядом с большими вращающимися механизмами
10—55**	10 20 100	— 20 —	— — —	— — —	Аппаратура, предназначенная для мощных промышленных установок и для общего применения в промышленности
10—150	10 20 100	— 20 —	— — —	— — —	Аппаратура, предназначенная для мощных промышленных установок и для общего применения в промышленности, если известно, что имеются составляющие вибрации с частотами, превышающими 55 Гц
10—500	10	10	—	—	Аппаратура для общего применения в авиации, где высокие уровни вибрации воздействуют на аппаратуру, находящуюся рядом, но не внутри двигателя
10—2000	—	10	10	—	Аппаратура для авиации, где высокие уровни вибрации воздействуют на аппаратуру, находящуюся рядом, но не внутри двигателя
				10	Отсек двигателя

* Амплитуда перемещения ниже частоты перехода и амплитуда ускорения выше частоты перехода 57—62 Гц (табл. 5, п. 5.2).

** Испытание при постоянной амплитуде перемещения.

Fig. 9.63 Table of the degree of rigidity intended for equipment with a high value of the transition frequency

Example of conducting tests with phase resonance retention .....

This example shows the procedure for conducting phase-locked resonance tests. In the example, a steel rod fixed on a Shaker is tested.

An accelerometer was installed at the end of the rod to monitor the resonance.

The following equipment was used during the tests:

- Shaker TIRA TV 52120;
- VCS Controller ZET 028;
- Accelerometer BC111;
- Laptop (computer).

Conducting tests with phase resonance retention includes three stages:

- the stage of preparation for the tests;
- the stage of the Pre-Test and the search for resonances;
- the testing stage.

At the stage of preparation for the tests, it is necessary to perform: connecting the VCS controller to the laptop (section 3), Shaker parameters involved in the tests (*Fig. 9.64*), the Specimen setting (*Fig. 9.65*), connecting the accelerometer cable to the controller input VCS and setting up its measuring channel (*Fig. 9.66*).

Fig. 9.64 "Shaker parameters" window

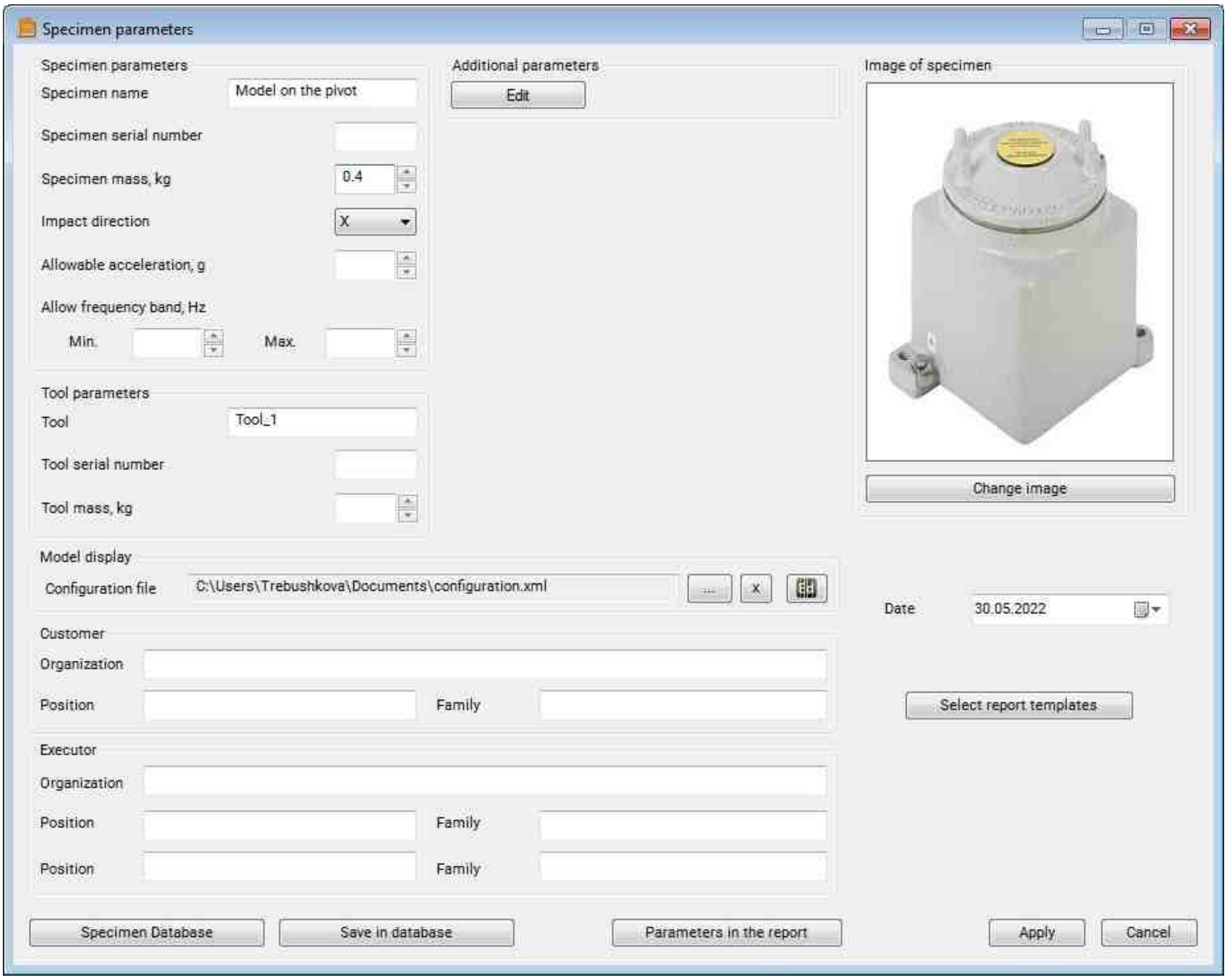


Fig. 9.65 "Specimen parameters" window

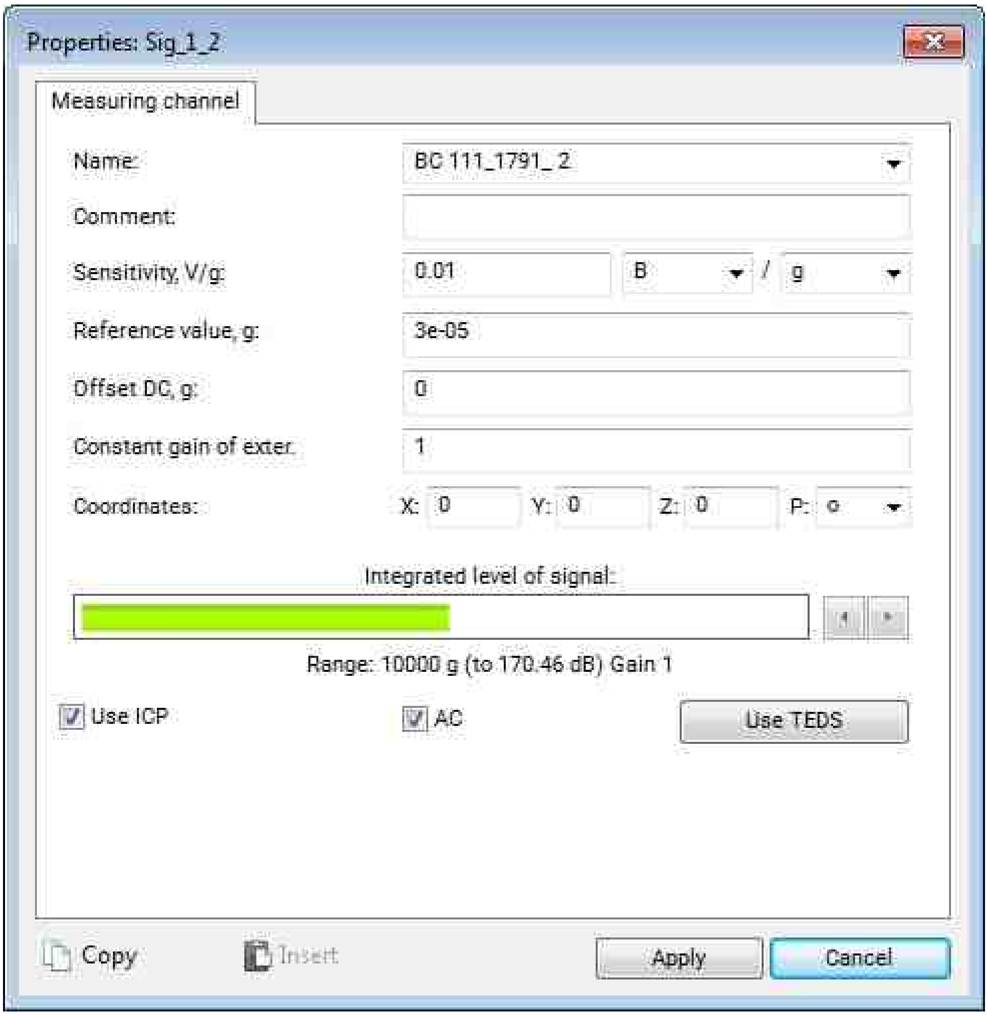


Fig. 9.66 "Properties" window

At the stage of the Pre-Test and the search for resonances, it is necessary to adjust the Pre-Test for this activate the Pre-Test and search for resonances" button on the VCS panel and in the program window that opens (*Fig. 9.67*) activate the "Settings" button.

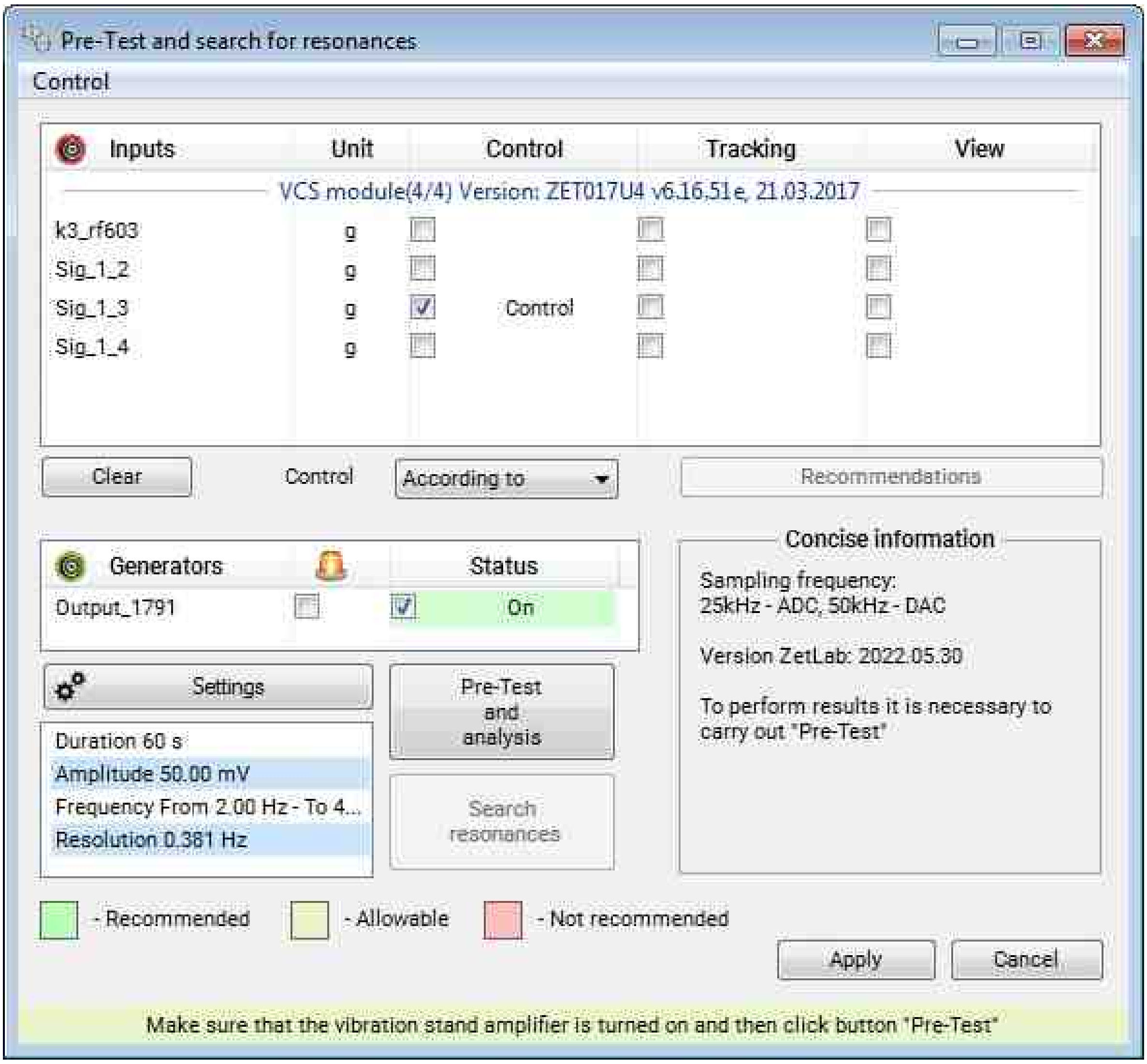


Fig. 9.67 "Pre-Test and search for resonances" window

In the "Settings" window (*Fig. 9.68*) when setting the "Frequency Selection" parameter to "Individually", the program allows you to set the frequency range.

The frequency range should be set in such a way that the resonance on which the tests will be carried out is located within this range.

Note: *if the "Select frequency" parameter is set to "All devices", the frequency range is set to the maximum possible*

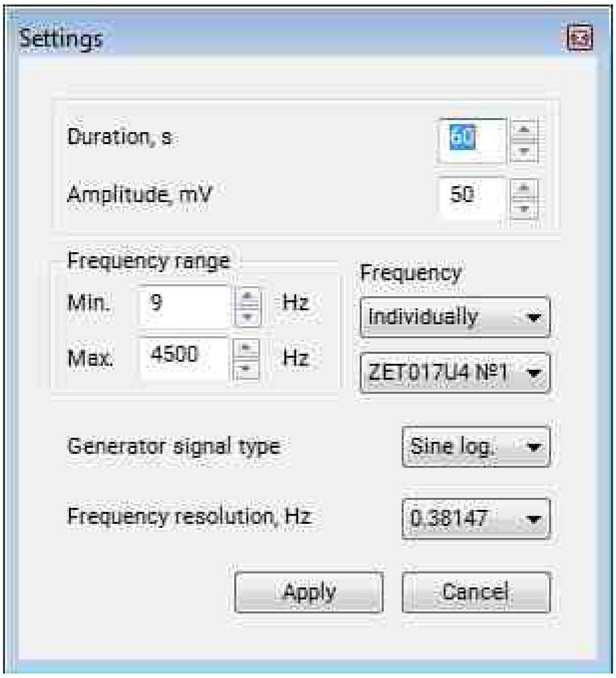


Fig. 9.68 "Settings" wndow

Perform a Pre-Test, for this in the "Pre-Test and search for resonances" window (*[Fig. 9.67](#)*) activate the "Pre-Test and analysis" button.

At the end of the Pre-Test in the "Pre-Test" window (*[Fig. 17.5](#)*) three graphics will be displayed: "Amplitude-frequency response". "Correlation analysis between output and sensors", "Analysis of non-linear distortions taking into account noise".

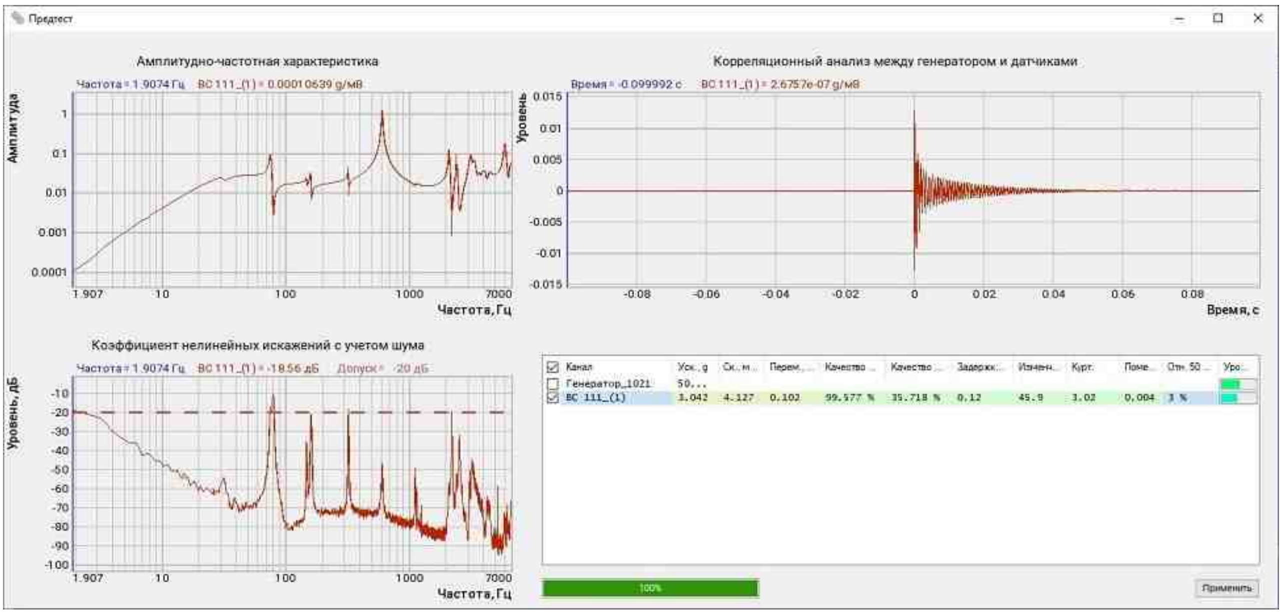


Fig. 9.69 The "Pre- Test" window

According to the graphic in the "Amplitude-frequency response" field, it is possible to estimate the resonant frequencies recorded during the Pre-Test. After a preliminary assessment of the results of the Pre-Test, you should activate the "Apply" button to save it.

Based on the results of the conducted Pre-Test in the "Pre-Test and search for resonances" window (*Fig. 9.70*) the coloring of the status fields ("Control" "Tracking" "View") available to the measuring channel and the "Recommendations" button is given.

If, according to the results of the Pre-Test, the software did not reveal any comments from the system prepared for testing, then the "Recommendations" button is colored green, otherwise (the "Recommendations" button is colored red) you should read the recommendations and eliminate the comments to pass the Pre-Test again.

If the result of the Pre-Test is positive, assign the status "Control" to the measuring channel, after which activate the "Apply" button to save the results of the Pre-Test, taking into account the selection of the status of the measuring channel.

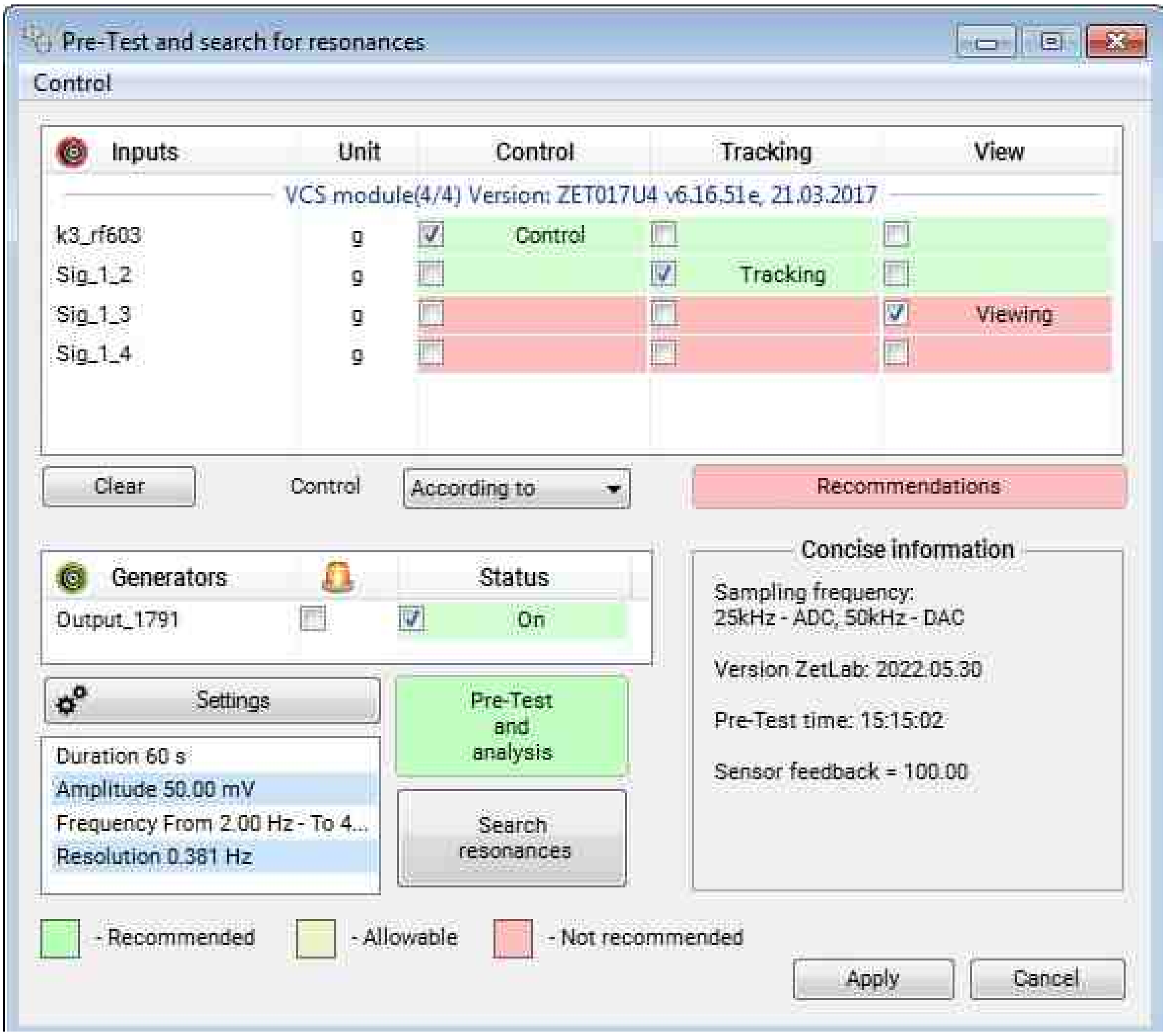


Fig. 9.70 "Pre-Test and search for resonances" window

At the test stage, it is necessary to run the program "Sine" from the VCS panel (*Fig. 9.71*) in the window of which  activate the "Edit profilet" button.

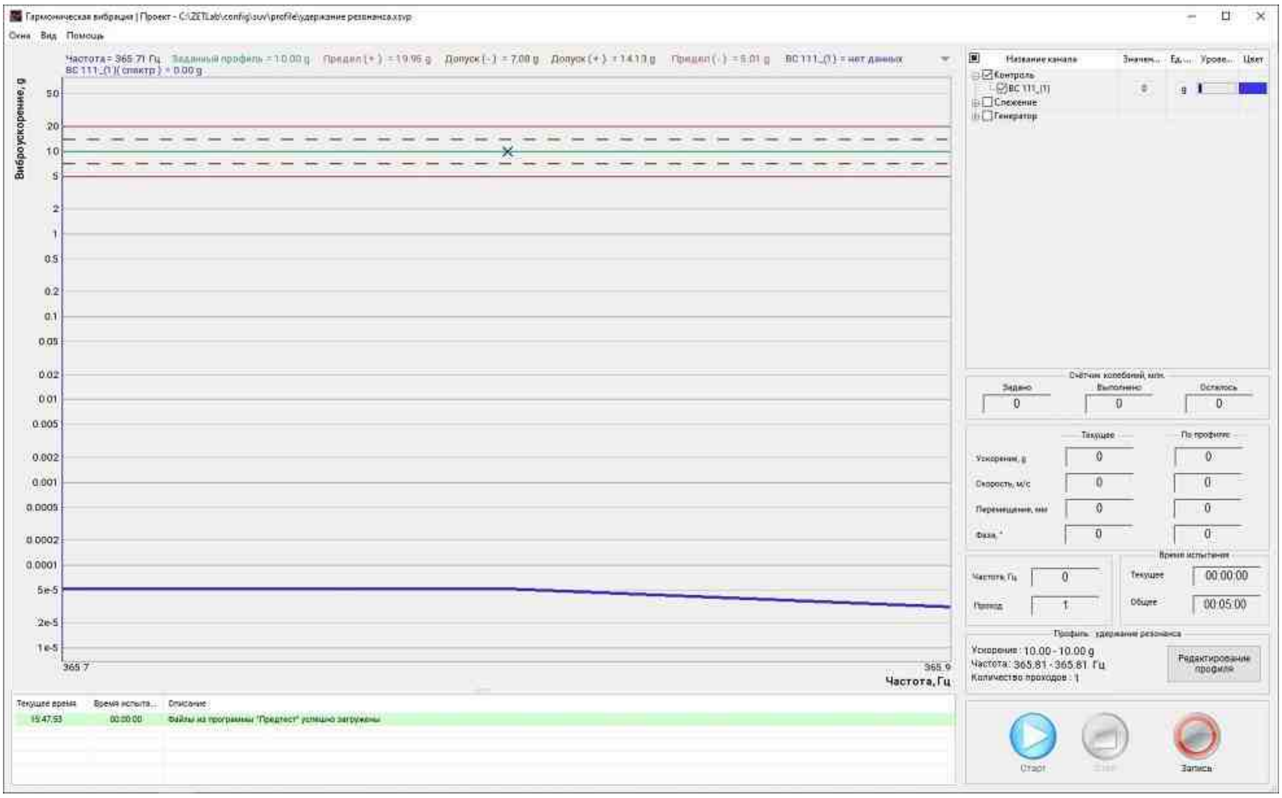
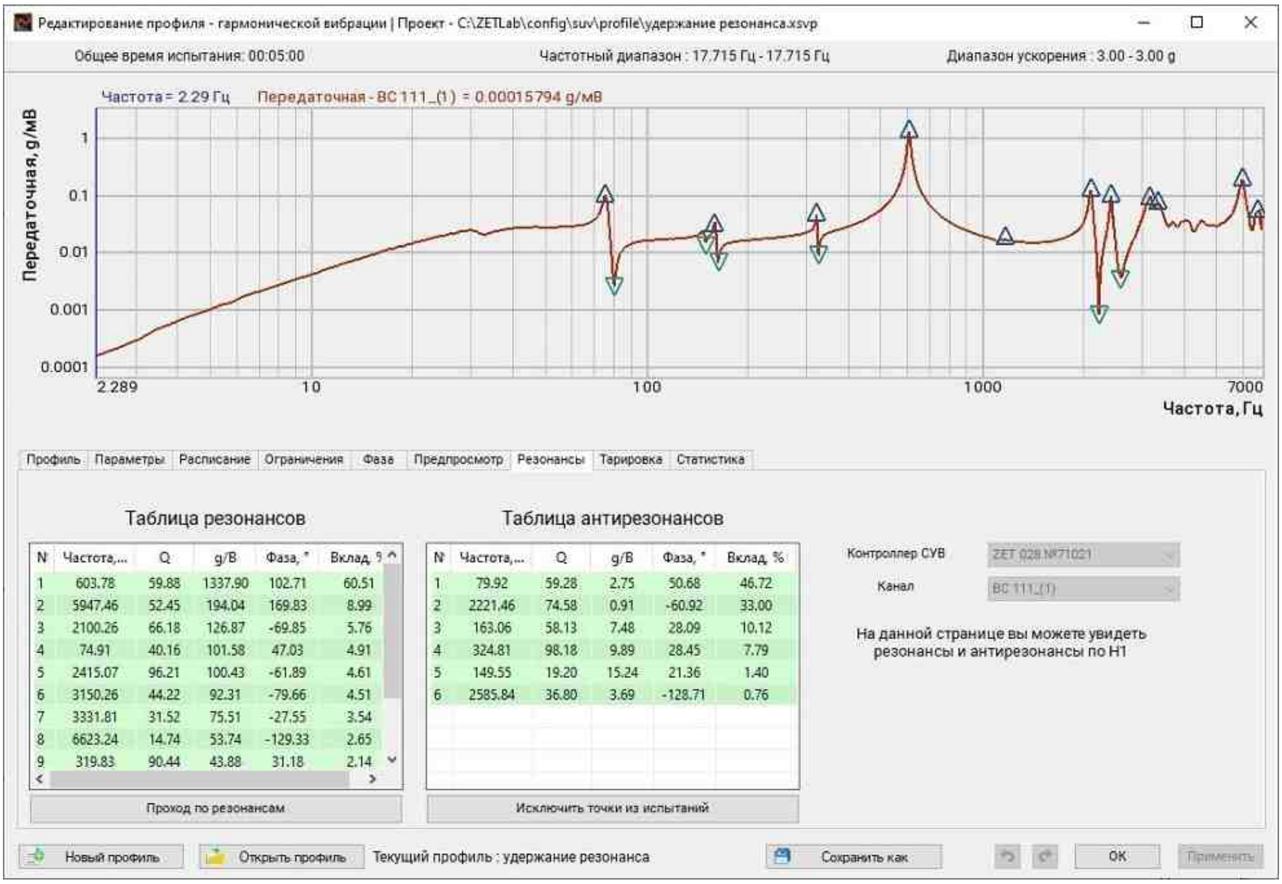


Fig. 9.71 "Sine" window

In the window of the program "Edit profile – Sine" in the tab "Resonances" (*Fig. 9.72*) select the resonance frequency and scale the graphic in the frequency domain so that a fragment of the graphic with the selected resonance remains in the window (*Fig. 9.73*), and in the "Table of resonances" there was only a record corresponding to the selected resonance.



N	Частота,...	Q	g/B	Фаза, °	Вклад, %
1	603.78	59.88	1337.90	102.71	60.51
2	5947.46	52.45	194.04	169.83	8.99
3	2100.26	66.18	126.87	-69.85	5.76
4	74.91	40.16	101.58	47.03	4.91
5	2415.07	96.21	100.43	-61.89	4.61
6	3150.26	44.22	92.31	-79.66	4.51
7	3331.81	31.52	75.51	-27.55	3.54
8	6623.24	14.74	53.74	-129.33	2.65
9	319.83	90.44	43.88	31.18	2.14

N	Частота,...	Q	g/B	Фаза, °	Вклад, %
1	79.92	59.28	2.75	50.68	46.72
2	2221.46	74.58	0.91	-60.92	33.00
3	163.06	58.13	7.48	28.09	10.12
4	324.81	98.18	9.89	28.45	7.79
5	149.55	19.20	15.24	21.36	1.40
6	2585.84	36.80	3.69	-128.71	0.76

Fig. 9.72 "Edit profile – Sine" in the tab "Resonances" window

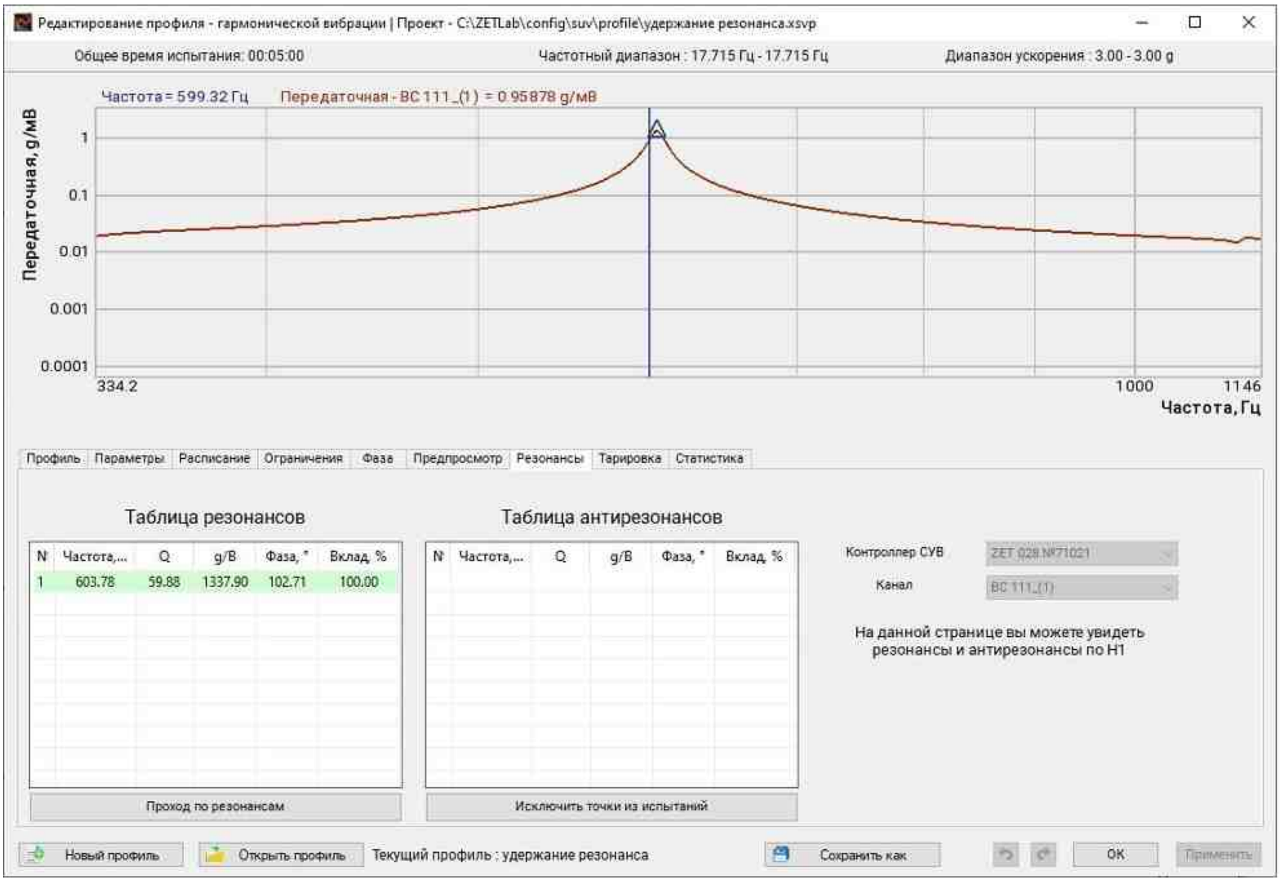


Fig. 9.73 "Edit profile – Sine" in the tab "Resonances" window

After which activate the "Pass through resonances" button and confirm the profile creation in the "SinVibrationProfile" window by activating the "Yes" button (*Fig. 9.74*).

Fig. 9.74 "SinVibrationProfile" window

In the "Edit profile – Sine" window in the "Profile" tab (*Fig. 9.75*) it is necessary to specify the value of the Acceleration amplitude at which the test will be carried out and the test time (in the example, the Acceleration amplitude is 30 g, the test time is 6 hours).

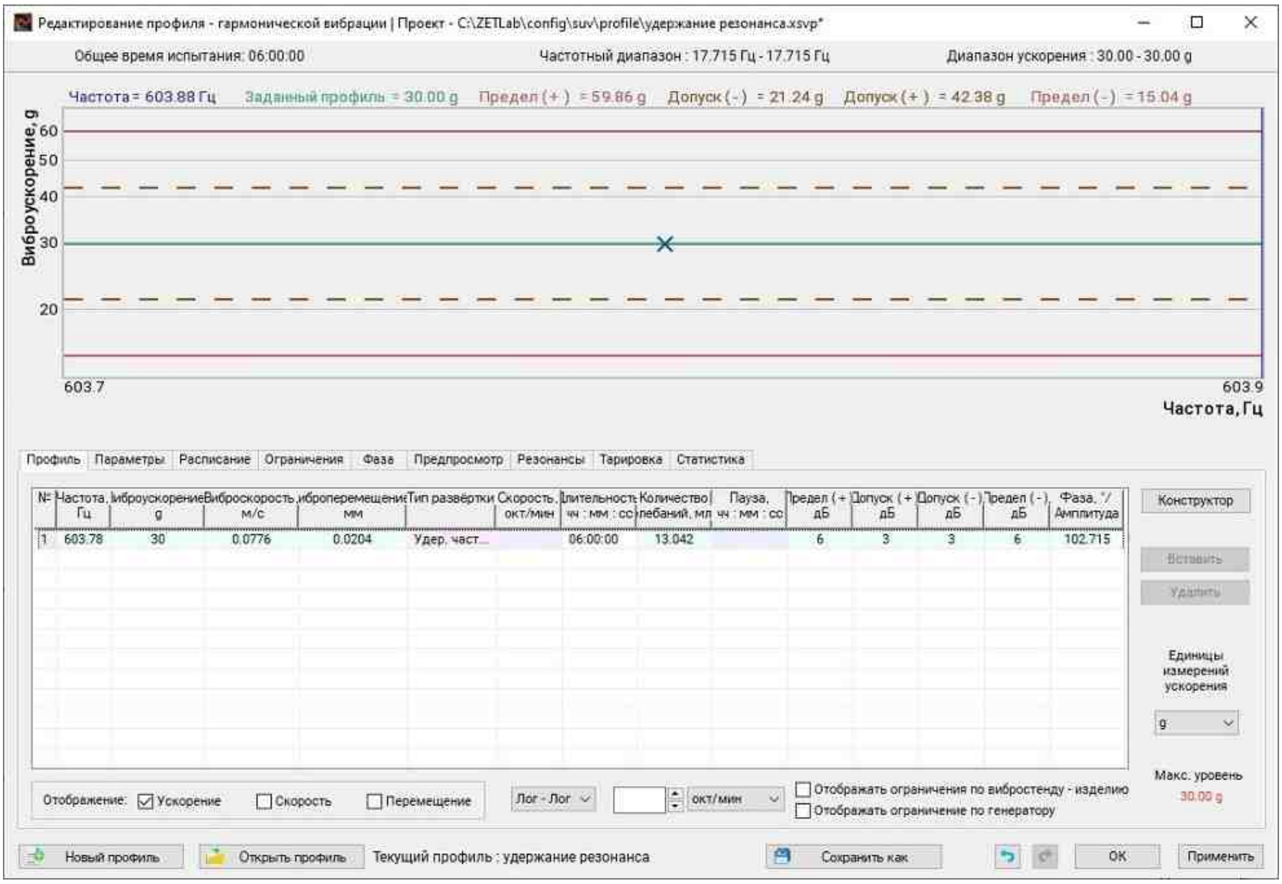


Fig. 9.75 "Edit profile – Sine" in the tab "Profile" window

In the "Edit profile" window, in the "Parameters" tab, set the parameter values according to the ones shown in the Fig. (Fig. 9.76), after which activate the "OK" button to save the test profile.

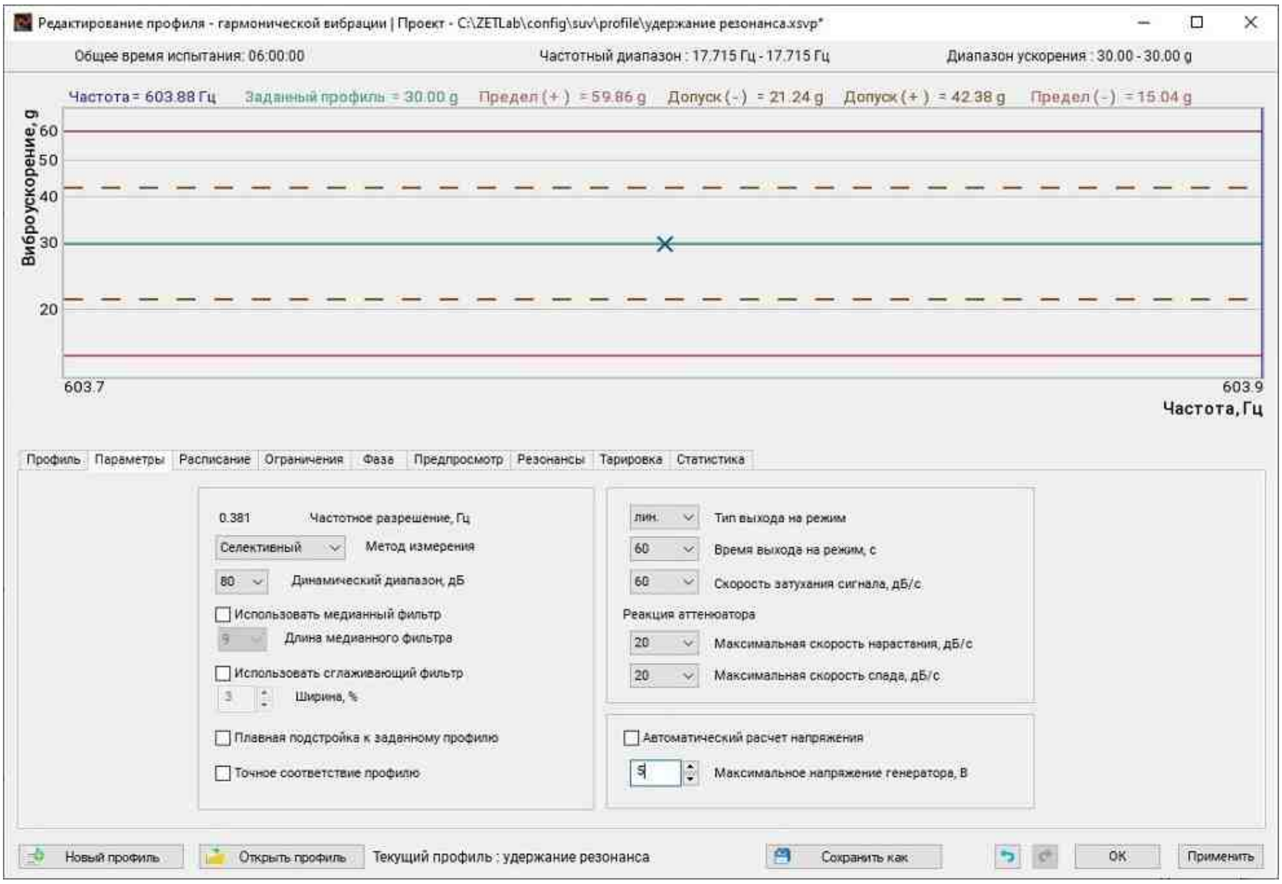


Fig. 9.76 "Edit profile – Sine" in the tab "Parameters"

Run the set profile for execution for this in the window of the program "Sine" activate the "Start" button, after which the profile execution will begin with holding the resonance according to the specified profile (*Fig. 9.77*).

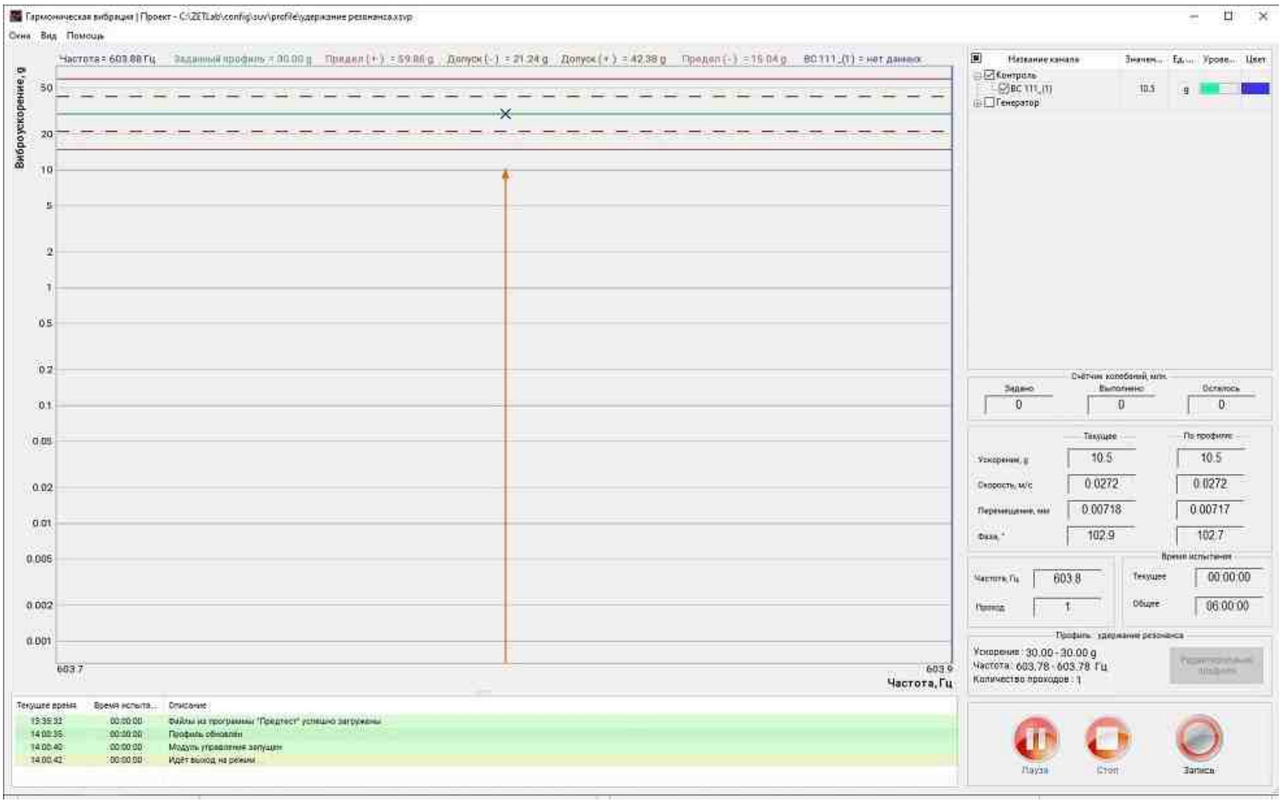


Fig. 9.77 "Sine" window

Monitoring of the current values of the parameters recorded during the tests can be performed as in the "Sine" window (*Fig. 9.77*) so it is in the "Indicators table" window (*Fig. 9.78*)

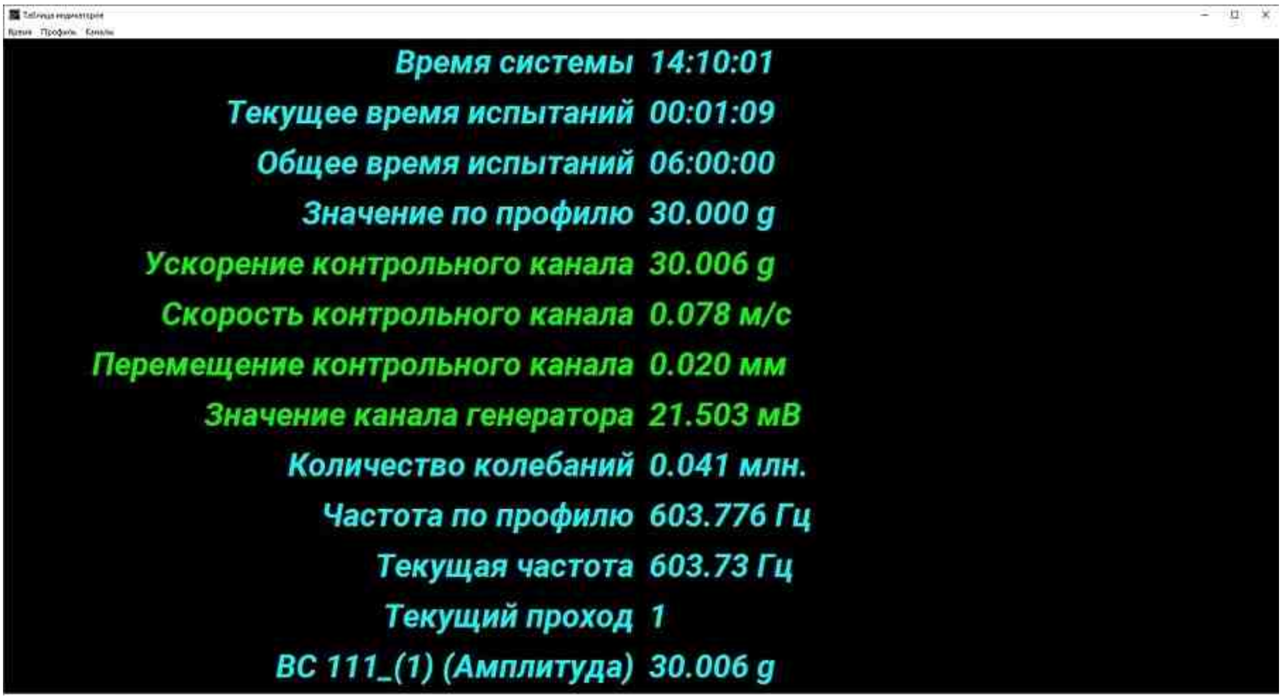


Fig. 9.78 Program window "Table of indicators"

The sections "Time", "Profile" and "Channels" in the "Indicators table" window allow you to form the necessary composition of the parameters displayed in the window.

The "Indicators table" window is called from the "Windows" menu (*Fig. 9.79*) windows "Sine".

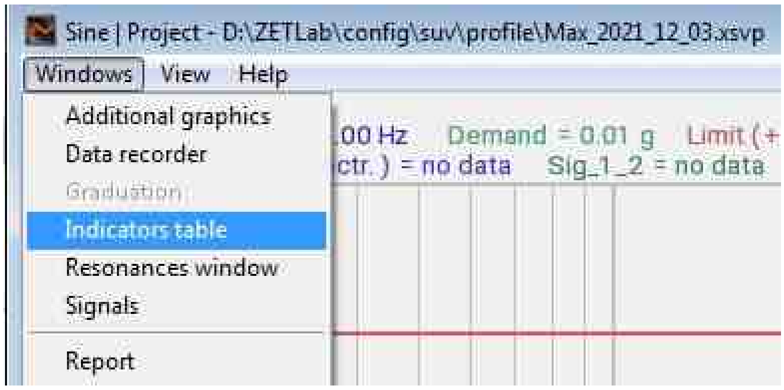


Fig. 9.79 Menu list "Window"

Monitoring of changes in the recorded parameters during the time is performed in the window of the program "Data recorder" (*Fig. 9.80*), in which various types of registered parameters are available for visualization in both graphical and numerical form.

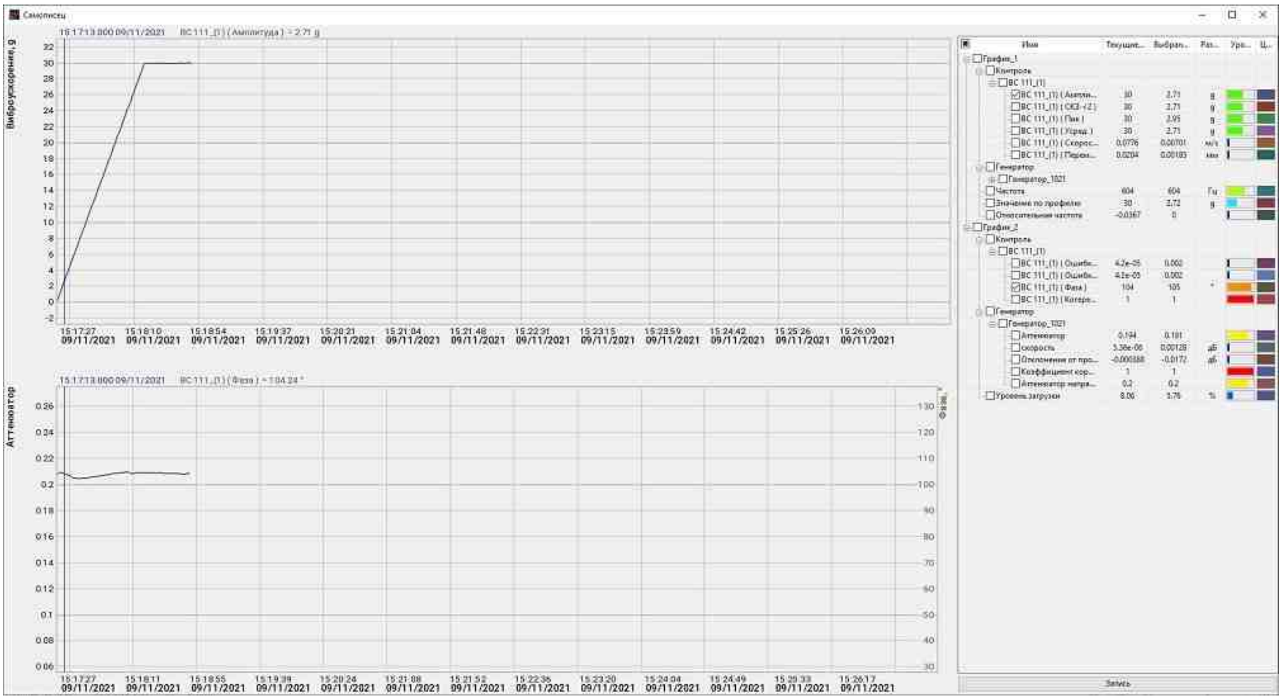


Fig. 9.80 The window of the program "Data recorder"

When conducting tests, it is necessary to exclude from visualization the graphics of those parameters for which control is not required (in the example, the amplitude and phase of the recorded signal are controlled).

The "Indicators table" window is called from the "Windows" menu (*Fig. 9.79*) windows "Sine".

Example of setting up the "Stroboscope" signal .....

The "Stroboscope" signal is formed on pin No. 8 of the digital port connector of the VSC controller and is a (TTL compatible in signal strength) sequence of impulses synchronized with a Sine signal generated on the control channel (generator channel). However, given that the stroboscope requires a recharge time to form a flash, thinning is performed for synchronizing impulses by dividing the frequency of the generator according to the following rule: the pulse frequency of the "Stroboscope" signal is equal to the frequency of the generator divided by the number of integer values obtained from dividing the frequency of the generator by the value 30. Example: For a generator frequency value equal to 100 Hz, the integer value divided by 30 will be "3" (100/30=3.333), so the frequency of the Stroboscope signal will be 100/3 =33.33 Hz.

Note: *The GND circuit is wound up on pin No. 9 of the digital port*

To turn on the Stroboscope signal, it is necessary to set the value "1" in the file "pidRegulator.cfg" (*Fig. 9.81*) for the parameter "Sync signal on the digital port".

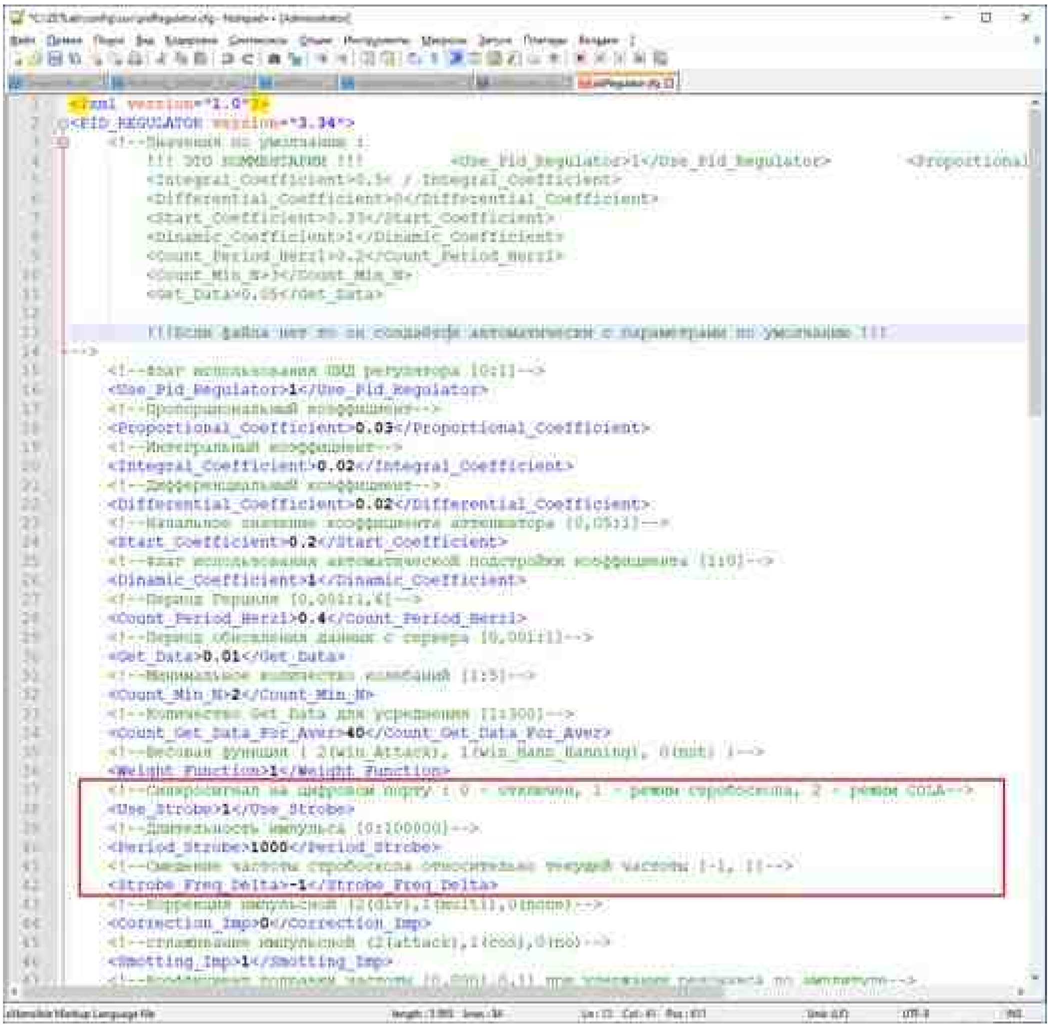


Fig. 9.81 File «pidRegulator.cfg»

Note: *the file "pidRegulator.cfg" is located in the directory C:\ZETLab\config\suv*

The parameter "Impulse duration" determines, in units of measurement "μs", the duration of the signal position at the logical unit level (TTL). For example, if the parameter value is 1000, the impulse duration at the logical unit level will be 1 ms.

The parameter "Stroboscope frequency offset relative to the current frequency" allows you to shift the strobe frequency relative to the oscillator frequency by one Hz up or down.

Example of setting up a COLA signal .....

COLA (Constant Output Level Amplitude) is formed on pin No. 8 of the connector of the digital port of the VCS controller and consists of impulses of constant amplitude (TTL compatible in signal level) formed synchronously with the frequency of the control channel (generator channel).

Note: *The GND circuit is wound up on pin No. 9 of the digital port*

To enable the "COLA" signal, it is necessary to set the value "2" in the file "pidRegulator.cfg" (*Fig. 9.82*) for the parameter "Sync signal on the digital port".

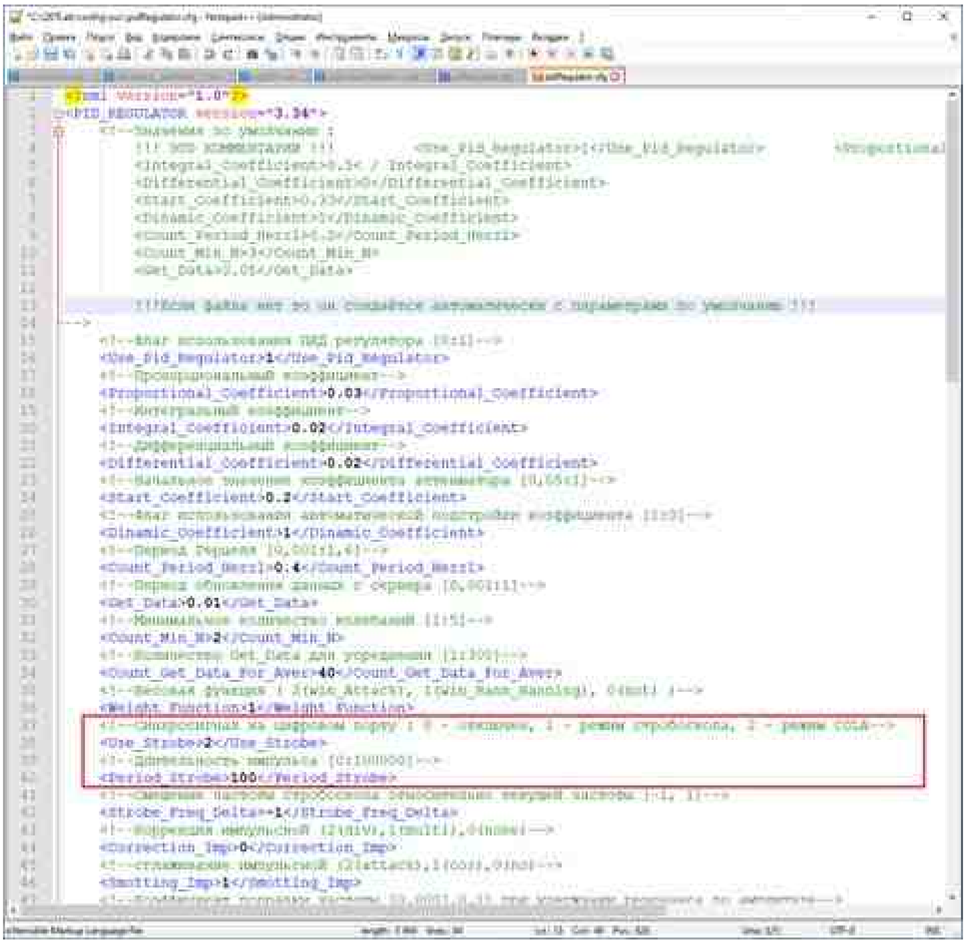


Fig. 9.82 File «pidRegulator.cfg»

Note: *the file "pidRegulator.cfg" is located in the directory C:\ZETLab\config\suv*

The parameter "Impulse duration" determines, in units of measurement "µs", the duration of the signal position at the logical unit level (TTL).

Attention! *do not set the pulse duration parameter to a value greater than half the duration of the Sine vibration period calculated for the maximum test frequency. Example for testing at frequencies up to 8 kHz (the period is 125 microseconds), the parameter value should not exceed "67" (125/2=67.5).*

The Random program .....

The Random program

Program Purpose

The program "Random" is intended for testing the specimen with the use of broad-band random vibration with a particular intensity degree, the VCS program – "Random" is used.

The purpose of the tests is to determine the ability of specimens, elements and equipment to withstand the effect Random of a given degree of rigidity, as well as to identify possible mechanical damage and deterioration of the specified characteristics of specimens to decide the suitability of the sample.

Preparing for testing

During the tests, the sample is exposed to a "Random" with a given level within a wide frequency band. Due to the complex mechanical reaction of the sample and its attachment, this test requires special care in its preparation.

The sample is mounted on a shaker in accordance with the requirements of GOST 28231-89.

When preparing for vibration resistance tests in a wide frequency range, set the following parameters (if not set): shaker parameters, specimen parameters, channel parameters (see sections 5-7), and then perform a Pre-Test according to section *8*.

To go to the Random program window, press the Random button on the VCS Panel (*Fig. 4.1*) activate the "Random" button. The program window "Random" will be displayed on the monitor screen (*Fig. 10.1*).

Attention! *The Random button on the VCS panel will only be available for activation if the program detects the Pre-Tests results.*

a program from the scope of ZETLAB VIBRO software suite

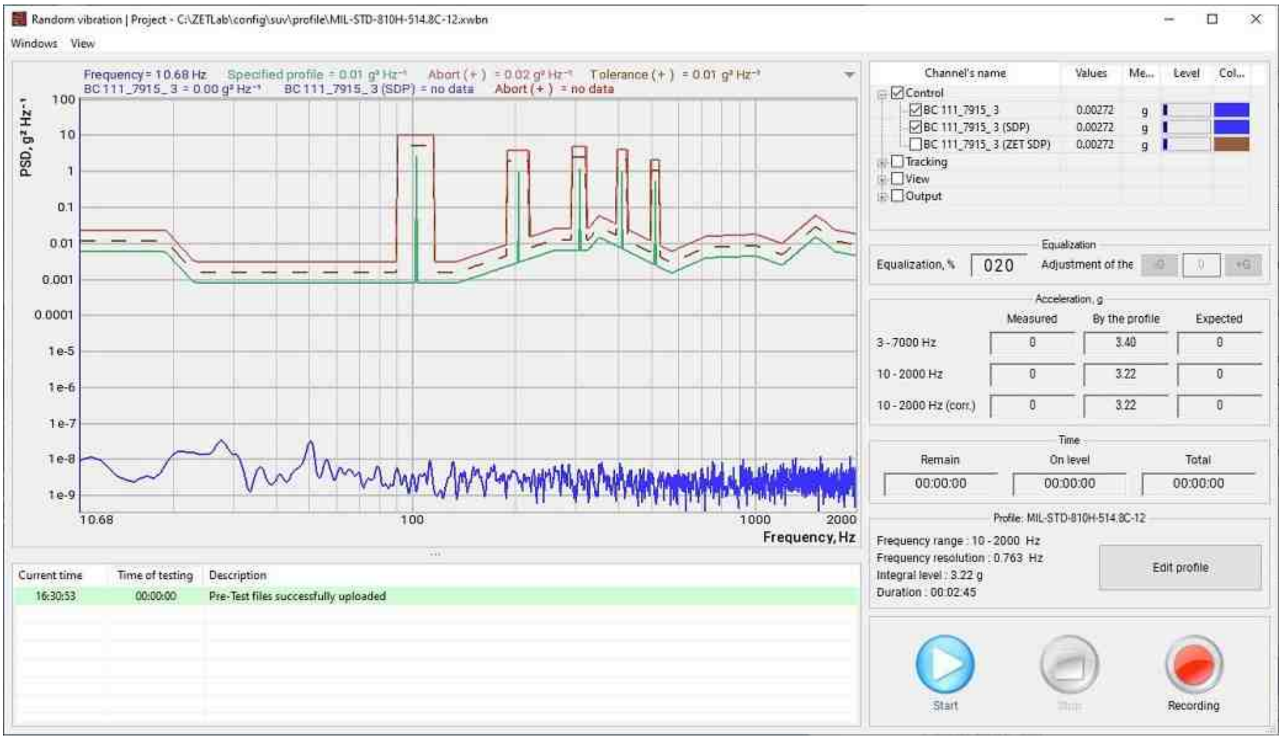


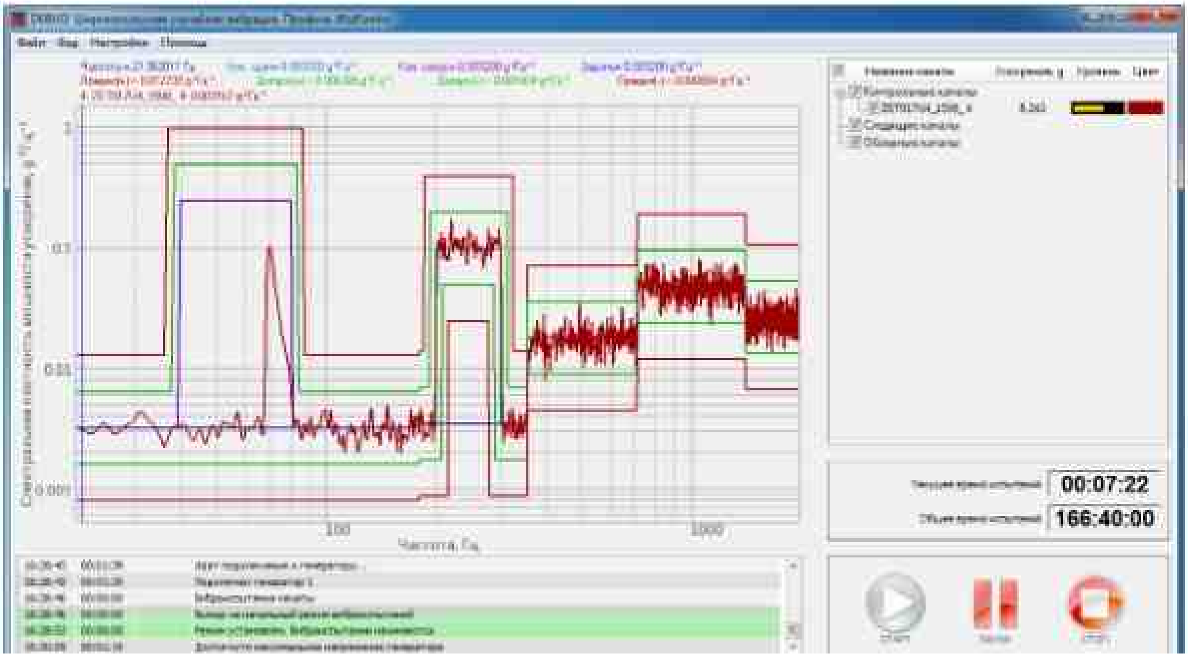
Fig. 10.1 Random program window

Set the required test profile using the "Edit profile" program, which should be launched in the "Random" program window activate the "Edit profile" button.

Modern signal processing algorithms of the ***Random*** program allow to reveal minor defects of the specimen as well as to find the location of the defect based on the signal received from the transducers. The program is also used for detection of the useful signal against the interference environment. This feature can be useful for package and transportation testing, operational testing, evaluation of residual operation life and transition to the pre-fault mode (as the safety factor reaches the level of 75%).

Random program is included into the scope of ZETLAB VIBRO software suite. The program can be started from the VCS control panel. Before starting the program, it is necessary to set the following parameters of the vibration testing procedure:

- shaker system parameters,
- test specimen parameters,
- channels parameters,
- Pre-Test and search for resonances.



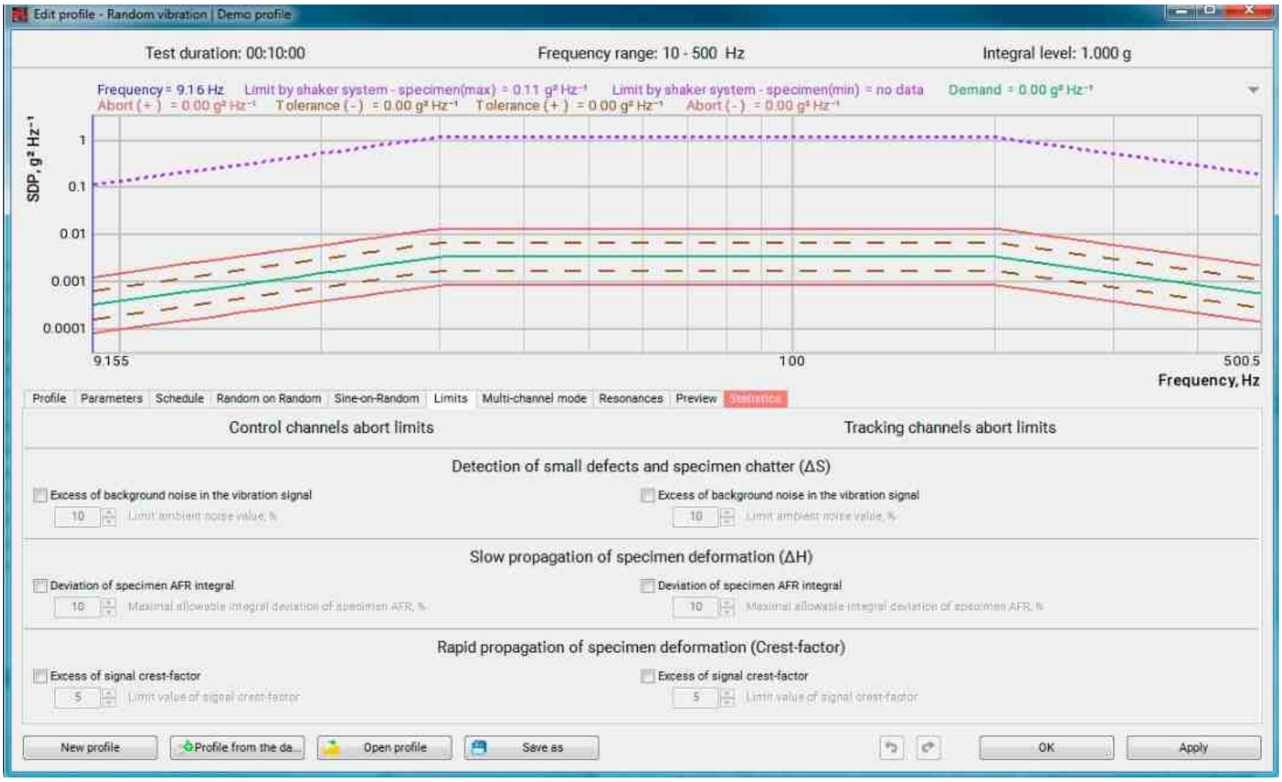
In order to start the vibration testing procedure, it is necessary to select a testing profile consisting of at least two points with different frequency.

Random program supports a wide range of combined tests, including:

- Sine-on-Random
- Random-on-Random
- Sine-and-Random-on-Random.

In order to activate these functions, select the required combination of test impacts ("Sine" and "Noise") in the window of vibration testing profile editor.

The program also has the feature of proportional increase of the general vibrational acceleration level in automated mode. To enable this option, the operator has to set the total acceleration level, and the program will automatically the required coefficients so that the total acceleration level would coincide with the level, which has been assigned by the operator.



Configuration of vibration testing parameters and graphic plotting is conducted in the "Parameters" tab. The configuration options include:

- general parameters of the test procedure: averaging duration, decline rate at the limits of the profile, amplitude characteristic's dynamic range;
- configuration of spectrum displaying: smoothing, median filter parameters; smooth adjustment to the test profile; correction of spectrum based on external interference;
- recording parameters in the case if the testing procedure is suspended.

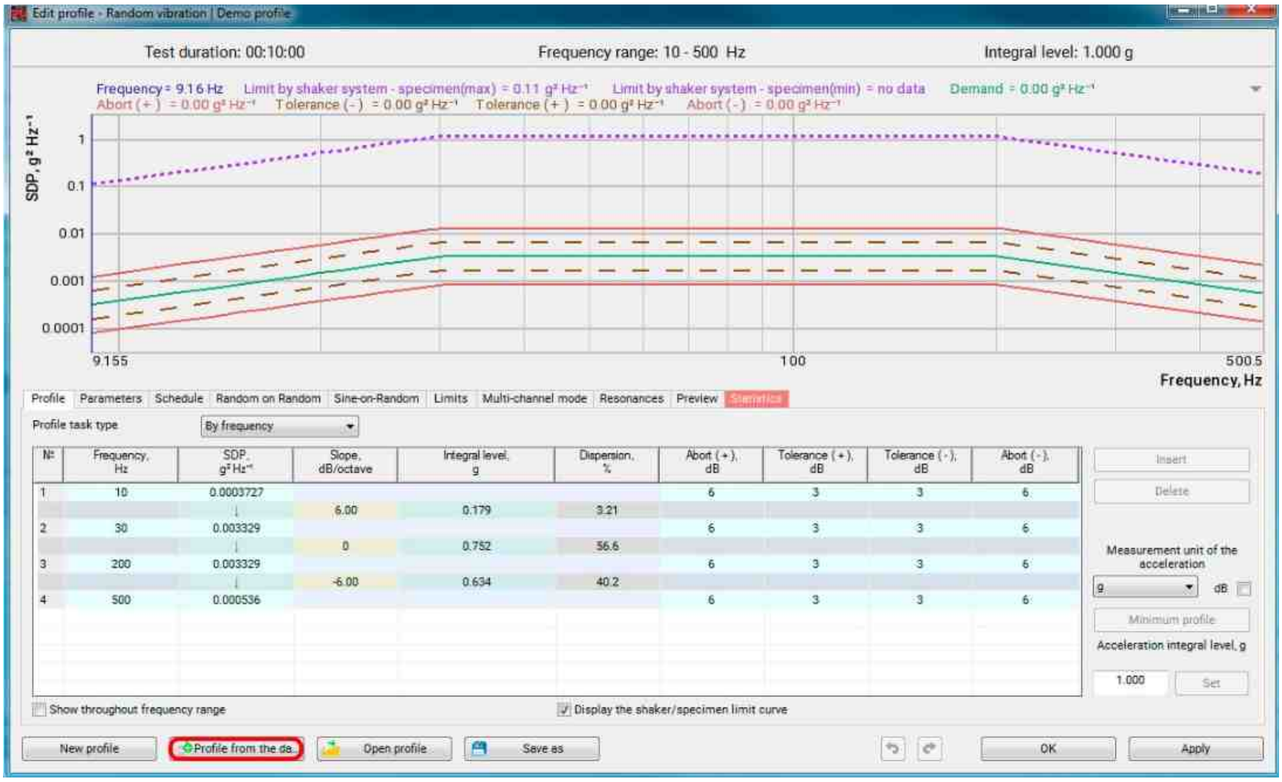
The operator can also set the vibration testing graphic using the "Time" tab. To do that, it is necessary to set the testing range, the duration of each testing step and the ratio of current integral level to the level set in the test profile.

Admissible testing limits, which are used for suspending the vibration testing process, are set in the "*Statistics*" tab.

The integrated safety system is used to monitor parameters of the supervision sensor and all tracking sensors in order to either stop testing immediately or notify on the recorded changes.

In the Limits tab, you can set the permissible test limits for the supervision channels or tracking channels after exceeding or deviating from which tests will be stopped.

The parameters with enabled control (during testing) will be used to monitor whether the set limit values are exceeded, and if so, testing shall be stopped immediately. The program has several most common algorithms: detection of small defects in item connections and contact bouncing in switching devices (buttons, relays, switches, etc.), slow or rapid deformation of items under test.



The additional advantage of the Random is the standard vibration test profile database for vibration test according to the following standards:

- IEC 60068-2-64 Environmental testing — Part 2-64: Tests — Test Fh: Vibration, broad-band random and guidance.
- MIL-STD-810H Military Standard, Environmental Test Methods and Engineering Guidelines.

Besides the profiles in the database which comply with several most widely used standards, the database can also be added with profile templates complying with the standards:

- GMW 3172 General Motors Specification for Electrical/Electronic Components – Environmental/Durability;
- SAE J1455 Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications;
- ISTA 2A, 3A Procedures for Testing Packaged Products;
- ASTM D4169 Standard Practice for Performance Testing of Shipping Containers and Systems;
- ASTM D4728 Standard Test Method for Random Testing of Shipping Containers;
- MIL-STD-202 Department of Defense Test Method Standard for Electronic and Electrical Component Parts;
- RTCA DO-160 Environmental Conditions and Test Procedures for Airborne Equipment;
- MIL-STD-883 (H,G) Department of Defense Test Method Standard for Microcircuits;
- DEF STAN 00-35 Environmental Handbook for Defence Materiel;

- EUROCAE ED-14 Environmental conditions and test procedures for airborne equipment;
- AECTP 400 (403) Mechanical Environmental Tests;
- NAVMAT P-9492 Navy Manufacturing Screening Program.

Another feature of the updated software is the preview of the vibration testing results for the set profile based on the results obtained in the course of the Pre-Test start of the system. The corresponding graphical information is available in the "*Channels*" tab.

Note: *The information displayed on the graphic is intended for informational purposes only. It notifies the user of the estimated results, which are likely to be obtained in the course of vibration testing for a particular profile.*

Depending on the values set for the testing profile parameters, the system calculates statistical parameters based on the current load applied to the vibration exciter. These values are displayed in the "*Statistics*" tab. This option allows to evaluate the capacity of the vibration testing system prior to the beginning of test performance, thus securing the structural integrity of the instruments used.

The resulting testing profile can be saved as a separate file to be loaded using the program "Vibration testing profile configuration".

TESTS PERFORMANCE

The bottom section of the *Random vibration* program interface displays events log, which is used for storage of various data accumulated in the course of program operation.

The beginning of vibration testing process is controlled with the "*Start*" key.

The program initiates the test process as the system reaches 95% of the required vibrational acceleration RMS. In the case, if the value of the controlled channel is higher than the set threshold level, the program will offer the operator to suspend the tests performance.

The program also has a fault detection system. In the case, if the system detects a malfunction, the program produces a message for the operator with description of the fault and recommendations in terms of troubleshooting.

The user can start or suspend the recording of the electrical signals from all active channels of the VCS controller using the "*Recording*" key

In the course of tests performance, it is possible to control the condition of the test specimen in real-time mode using the control channel. To enable this option, use the "*Additional graphics*" program.

The Random is included into the scope of ZETLAB VIBRO software suite. The program can be started fom VCS control panel upon configuration of the following parameters:

- shaker system parameters,
- test specimen parameters,,
- channels parameters,
- control parameters

Edit profile .....

To set the test profile, it is necessary to activate the "Edit profile" button (*Fig. 10.1a*) from the main window of "Random" program .

Fig. 10.1a "Edit profile" button

Profile tab .....

When you start the "Edit profile" program, the "Edit profile – Random" program window opens on the "Profile" tab (*Fig. 10.2*).

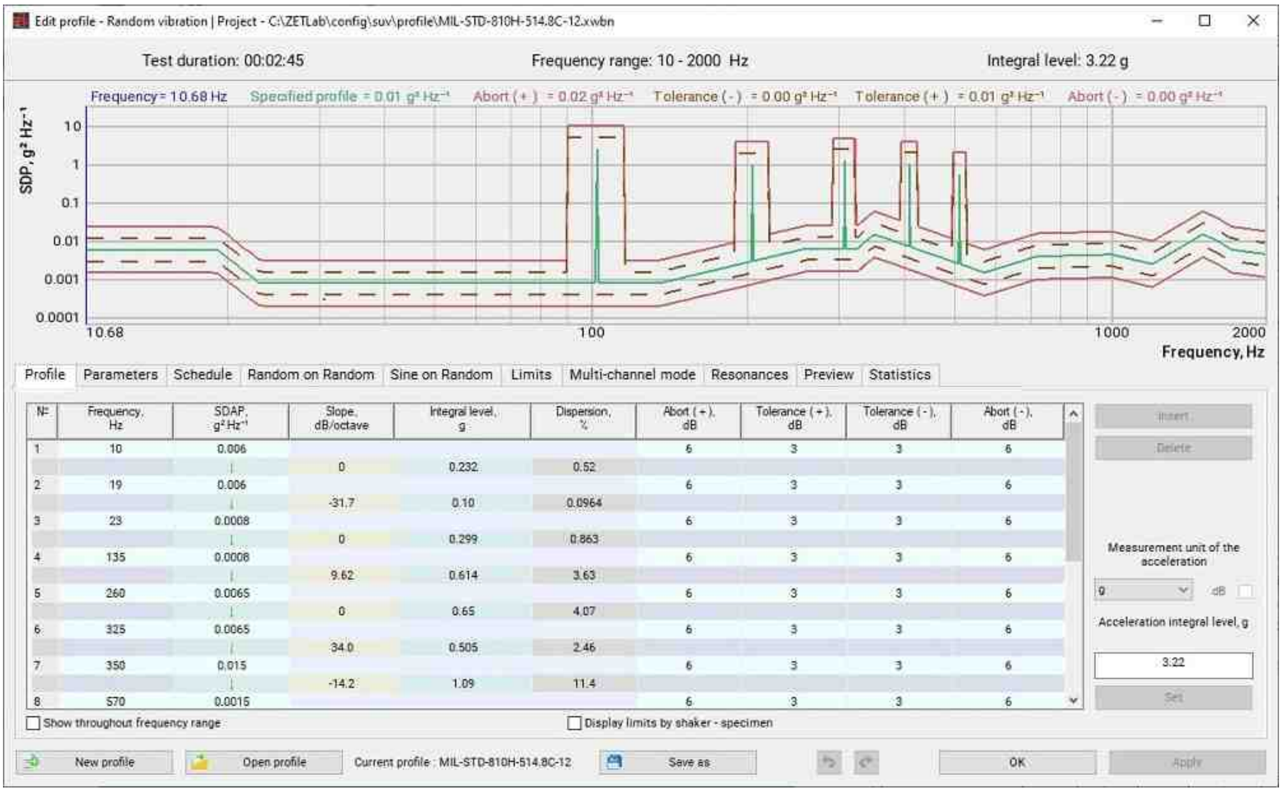


Fig. 10.2 Edit profile – Random window, Profile tab

On the "Profile" tab, you can set the Random test profile in the table. To add a row to the table, select the area in the table where you want to add the row and press the Insert button. In the new row, enter the parameters defining the inflection point. To delete a row, select it with a mouse click and press the Delete button. To start vibration tests, you need a profile consisting of at least two lines with different frequencies.

In addition, each reference point has 4 parameters defining the allowed range for vibration tests: Tolerance (+), Tolerance (-), Abort (+), Abort (-). If the Abort (+) and Abort (-) parameter values are exceeded, the tests in the control channel will stop. The parameters set the integral acceleration level tolerance at each test point according to the profile. By default, the tolerances are set to ±3dB and ±6dB, respectively, but you can edit them manually.

The Measurement unit of the acceleration parameter sets the acceleration unit to g or m/s^2 for the test profile graphic.

To change the overall noise level in proportion, enter the required value in the "Acceleration integral level" field and press the "Set" button. The coefficients in the SDAP table will be automatically recalculated so that the total integral level becomes consistent with the specified number.

Activating the "Show throughout frequency range" parameter displays the entire frequency range set during the Pre-Test on the spectrum graphic.

When you select a parameter "Display the shaker/specimen limit curve", the spectrum graphic in the Random window will additionally display graphics of the maximum and minimum acceptable profile values (range of the allowed profiles).

Note: *The graphics of the maximum and minimum permissible profile values are calculated taking into account the Shaker parameters and the specimen, as well as the Pre-Tests results.*

A graphic of the spectral density of acceleration power with tolerance graphics is displayed in the upper pane of the "Edit profile – Random" program window.

Parameters tab .....

When you start the "Edit profile" program, the "Edit profile – Random" program window opens on the "Parameters" tab (*Fig. 10.3*).

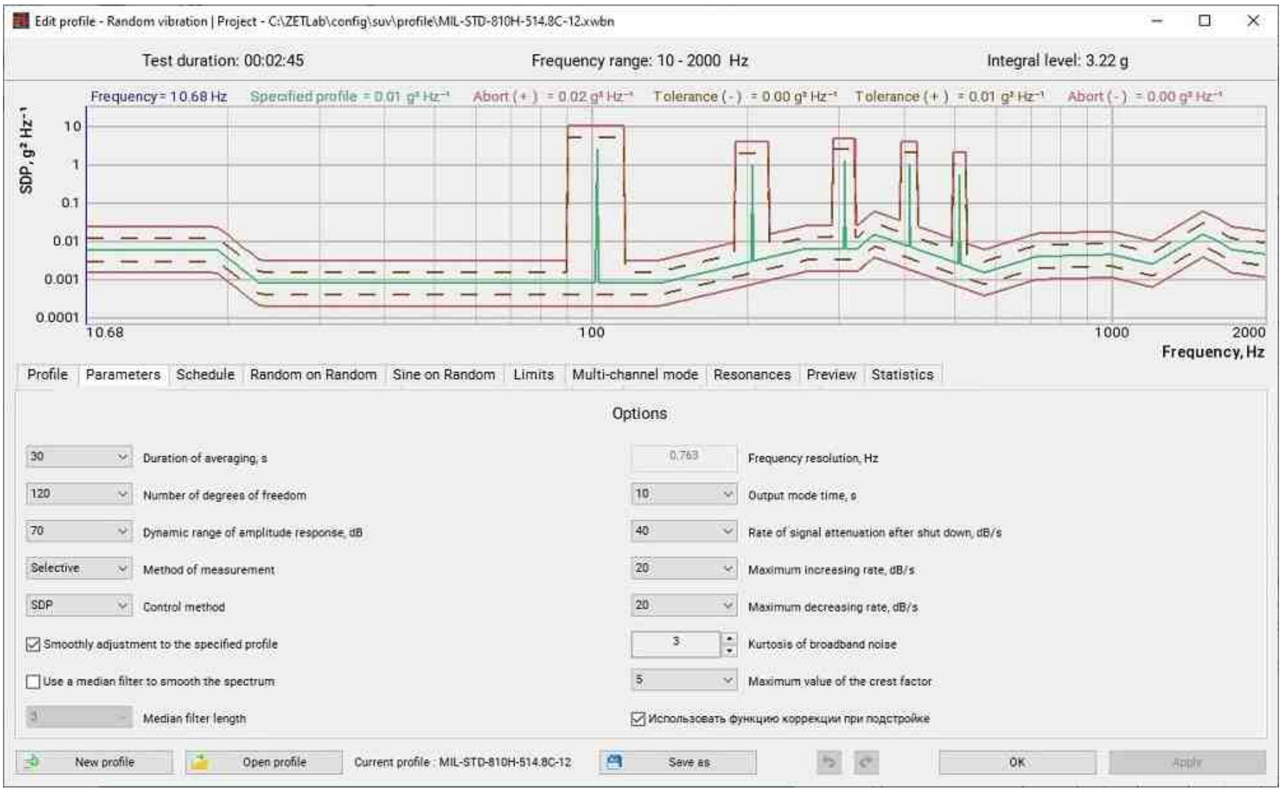


Fig. 10.3 "Edit profile – Random" window, Parameters tab

The "Duration of averaging" parameter sets the interval duration of averaging values on the spectrum graphic. In this way, the spectrum graphic shows the averaged values for a set time period.

The "Number of degrees of freedom" parameter determines the time of data accumulation when calculating the spectrum, taking into account the specified frequency resolution. This parameter is the specimen of the accumulation time and frequency resolution. Thus, the lower the frequency resolution value, the greater the data accumulation time for the same number of degrees of freedom.

For the "Dynamic range of amplitude response" parameter, select a value that sets the difference between the maximum value and minimum value of the amplitude response.

The "Measurement method" parameter sets the method for calculating power spectral density values (PSD). It can be Selective or Effective. With the Selective measurement method, the PSD values will be calculated according to the transfer characteristic H1 (when calculating PSD, only the response signal to the effect is taken into account). With the Effective measurement method, the PSD values will be calculated according to the transfer characteristic Hv (when calculating PSD, the entire recorded signal is taken into account).

The "Control method" parameter sets the method to control and display PSD of the registered signal. It can be PSD or ZET PSD. In the PSD control method, the spectral power of the recorded signal is used as the controlled quantity. The ZET PSD control method additionally includes digital processing of the power spectral density for quick smoothing and clearing the noise on the power spectral density graphic when averaging is insufficient, as well as reducing control errors.

When the "Smoothly adjustment to the specified profile" parameter is selected, the spectrum graphic can return to the test profile when the transfer characteristic changes due to physical changes in the tested specimen or tool.

The "Use median filter" to smooth spectrum parameter is used to eliminate the generated impulses on the spectrum graphic. The larger the value of the "Filter size medium" parameter, the wider the impulse can be cut off.

The "Use noise signal from common source" it is used in cases when several Shaker are involved in the test system, which are controlled from different controllers. To reproduce synchronous vibrations from all Shaker, it is necessary activate this parameter.

The "Frequency resolution" parameter displays the frequency resolution value set in the "Post-Test and analysis" program.

The "Startup time" parameter defines the time for increasing the signal from zero level to the profile level.

The "Rate of signal attenuation after shut down" parameter determines the rate at which the signal attenuates at the end of the test.

The "Increasing rate" and "Decreasing rate" parameters determine the maximum rate of increasing and decreasing signal strength during the tests.

The "Kurtosis of broadband noise" parameter is used for individual configuration of the probability of distribution of noise emissions (pulses) for the generated wave form. Increasing in the level of kurtosis leads to a significant increase in high-power noise emissions (impulses).

The "Maximum level of crest-factor" parameter limits the maximum allowed value of the signal's crest-factor during the vibration tests.

Schedule tab .....

The "Schedule" tab is used for setting the vibration testing graphic: the number of vibration testing stages, the time of each stage, equalization, and enabling / disabling the sine and noise adding function (*Fig. 10.4*).

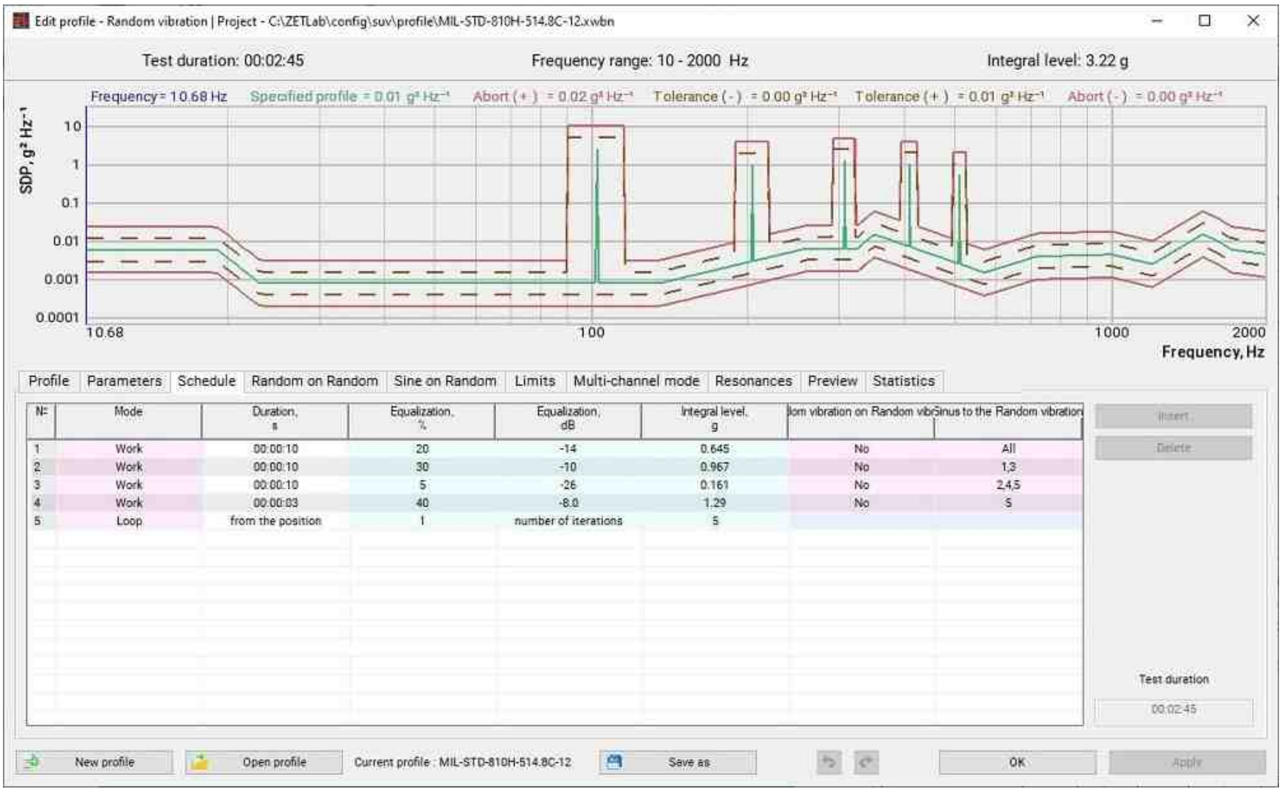


Fig. 10.4 Edit profile – Random window, Schedule tab

The vibration test schedule is a data table. To add new rows to the table, press the Insert button. If vibration tests have multiple stages, add the appropriate number of rows to the table. The configuration is individual for each stage of the test.

The "Mode" parameter has several statuses:

- Work – in this mode, the program is performing tests according to the profile;
- Pause – in this mode, the program is pausing tests for a specified time;
- Loop – in this mode, the program is repeating operations from a specified position a specified number of times.

The "Duration" parameter is used to set the duration of the vibration test stages.

The "Equalization (%)", "Equalization (dB)" and "Integral level, g" parameters are used to set the integral acceleration level ratio at the current test stage to the level determined by the test profile, and the values in one column automatically recalculate the values in other column.

Parameters "Random on Random" or "Sine on Random" the functions of superimposing narrow-band noise or Sine on Random are added in accordance with the settings made on the tabs of the vibration test profile of the same name. To add segments with the imposition of narrow-band noise and sinusoidal oscillations on the Random (Sine-on-Random or Random-on-Random), left-click in the appropriate cells and select the required segments (*Fig. 10.5*).

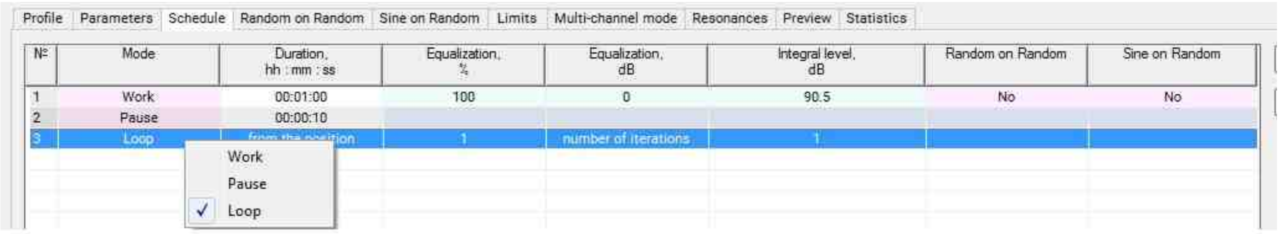


Fig. 10.5 Selection of segments for superimposing the Sine on Random

Random on Random tab .....

In order to enable adding narrow-band noise to Random (Random-on-Random) when performing vibration tests, go to the Random on Random tab (*Fig. 10.6*).

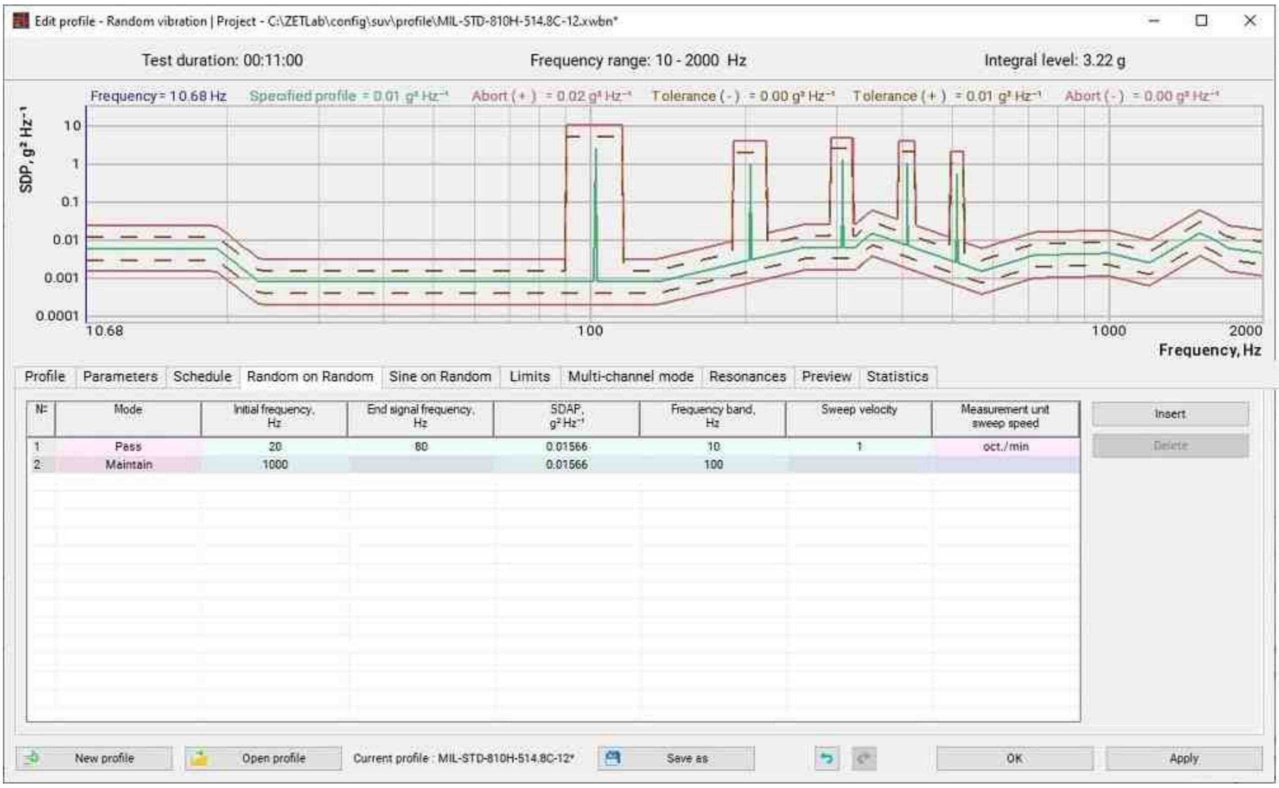


Fig. 10.6 "Edit profile – Random" window, Random on Random tab

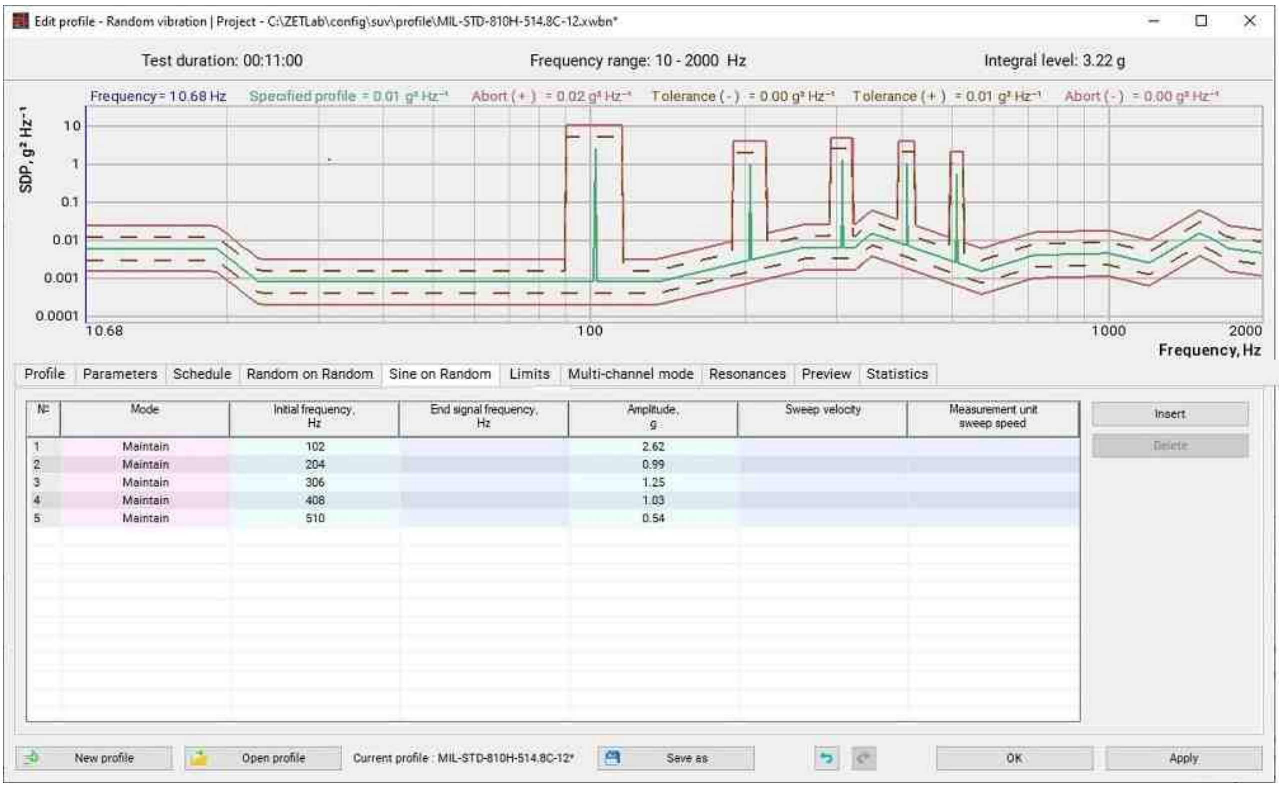
The adding narrow-band noise parameters to Random are listed in a data table. To add new rows to the table, activate the "Insert" button. If there are multiple segments, add the appropriate number of rows to the table. For each test segment, settings are made individually.

The narrow-band noise adding to Random function has two modes:

- "Pass" mode – in this mode, narrow-band noise with a set frequency band is moving from the initial frequency to the final frequency and back. In the table, set the values for the initial frequency and final frequency, frequency band, SDAP, and sweep rate;
- "Maintain" mode – in this mode, narrow-band noise is held in the specified frequency band. In the table, set the values for the initial frequency, frequency band, and SDAP.

Sine on Random tab .....

To enable adding Sine to Random (Sine on Random) when conducting vibration tests, go to the "Sine on Random" tab (*Fig. 10.7*).



№	Mode	Initial frequency, Hz	End signal frequency, Hz	Amplitude, g	Sweep velocity	Measurement unit sweep speed
1	Maintain	102		2.62		
2	Maintain	204		0.99		
3	Maintain	306		1.25		
4	Maintain	408		1.03		
5	Maintain	510		0.54		

Fig. 10.7 Edit profile – Random window, Sine on Random tab

The adding narrow-band noise parameters to Random are listed in a data table. To add new rows to the table, activate the "Insert" button. If there are multiple segments, add the appropriate number of rows to the table. For each test segment, settings are made individually.

The narrow-band noise adding to Random function has two modes:

- "Pass" mode – in this mode, narrow-band noise with a set frequency band is moving from the initial frequency to the final frequency and back. In the table, set the values for the initial frequency and final frequency, frequency band, SDAP, and sweep rate;
- "Maintain" mode – in this mode, sinusoidal oscillations are held at a given frequency. The values of the initial frequency and amplitude must be set in the table.

A graphic of the spectral power density of acceleration with superimposed Sine, as well as tolerance graphics are displayed in the upper part of the program window "Edit profile the vibration test".

Limits tab .....

On the Limits tab (*Fig. 10.8*), you can set the acceptable test limits for the control and tracking measurement channels. According to the parameters with enabled control, (during the tests) exceeding the set parameter values will be monitored, and if they are exceeded, the tests will stop immediately.

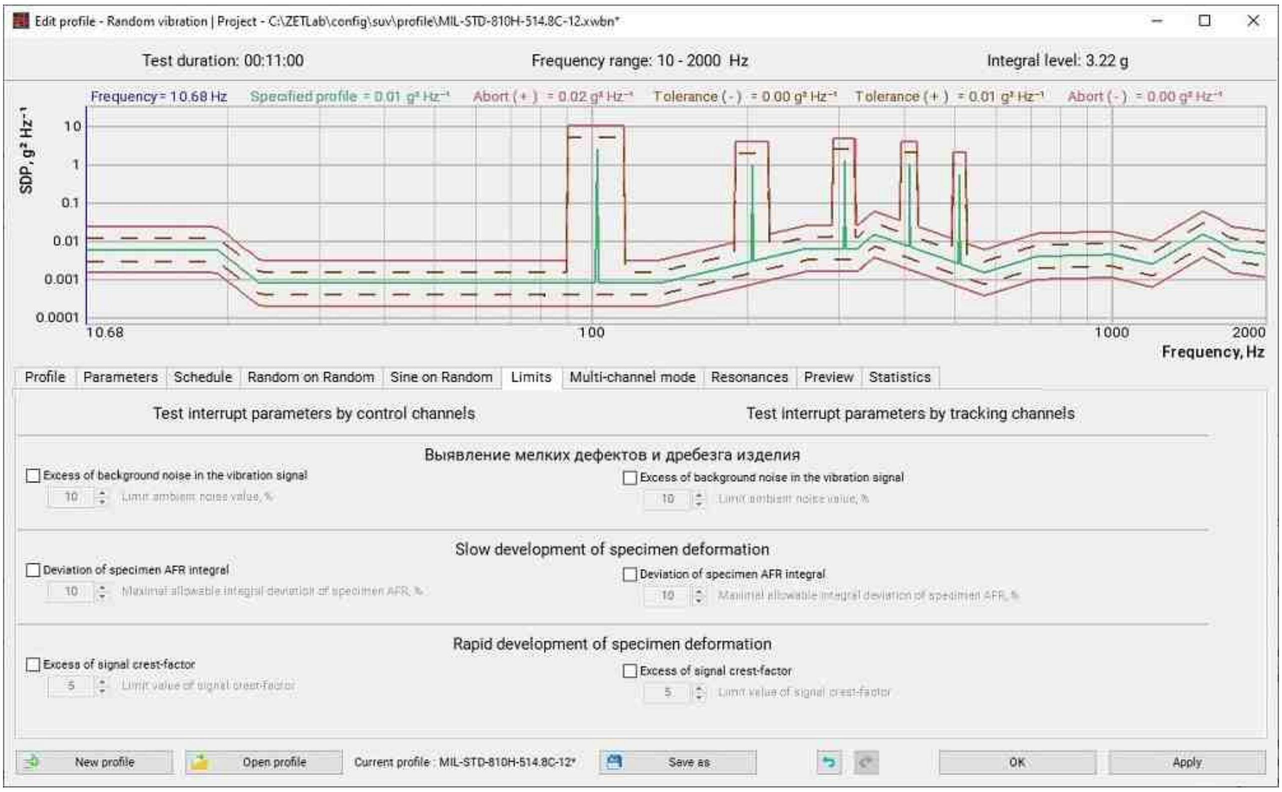


Fig. 10.8 Edit profile – Random window, Limits tab

To enable parameter control, activate (check the cell) the corresponding parameter, and to disable it, deactivate (uncheck the cell).

You can set limits for the following parameters of the monitoring and tracking channels:

- Excess of background noise in the vibration signal;
- Deviation of specimen AFR integral;
- Excess of signal crest-factor.

Resonances tab .....

The Resonances tab contains statistical information based on the Pre-Tests results. On this tab, you can evaluate the presence of resonances and antiresonances on the amplitude response (*Fig. 10.9*).

Note: *If necessary (for more detailed consideration), scale the amplitude response on the frequency scale to the area of interest, and only resonances and antiresonances falling within the visualized graphic area will be left in the table.*

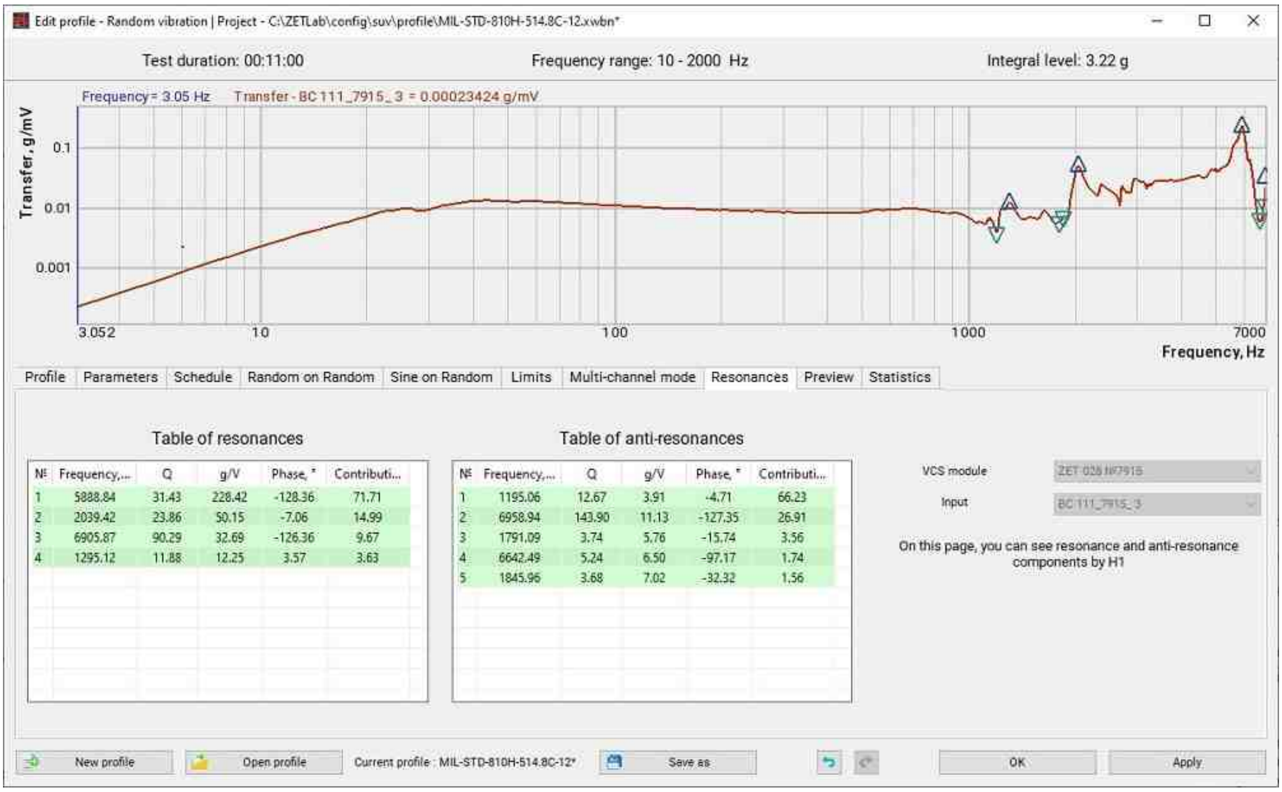


Fig. 10.9 Edit profile – Random window, Resonances tab

Preview tab .....

On the Preview tab, you can preview the vibration test graphics for a given profile obtained by calculation based on the Pre-Tests results (*Fig. 10.10*).

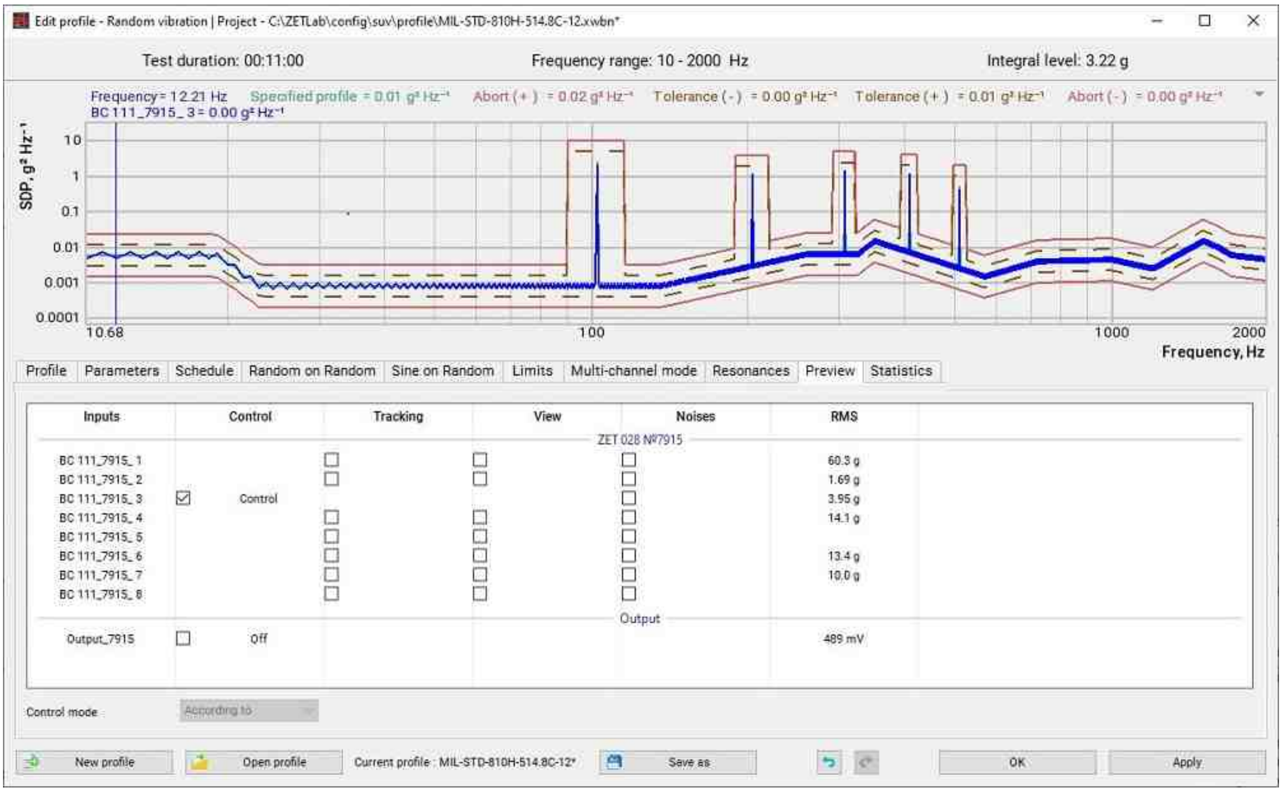


Fig. 10.10 Edit profile – Random window, Preview tab

The graphics are presented for all measuring channels of the VCS controller, and each measuring channels can be assigned any type of control (control, tracking, view, and also check the noise level of the channel). To display the desired vibration graphic, check the corresponding table cell.

Note: *The graphic information is for reference and intended to inform the VCS user of the expected results to be obtained in the vibration tests for a given profile.*

Statistics tab .....

The Statistics tab contains statistical information, so that the user can assess the load of the Shaker during vibration tests (*Fig. 10.11*).

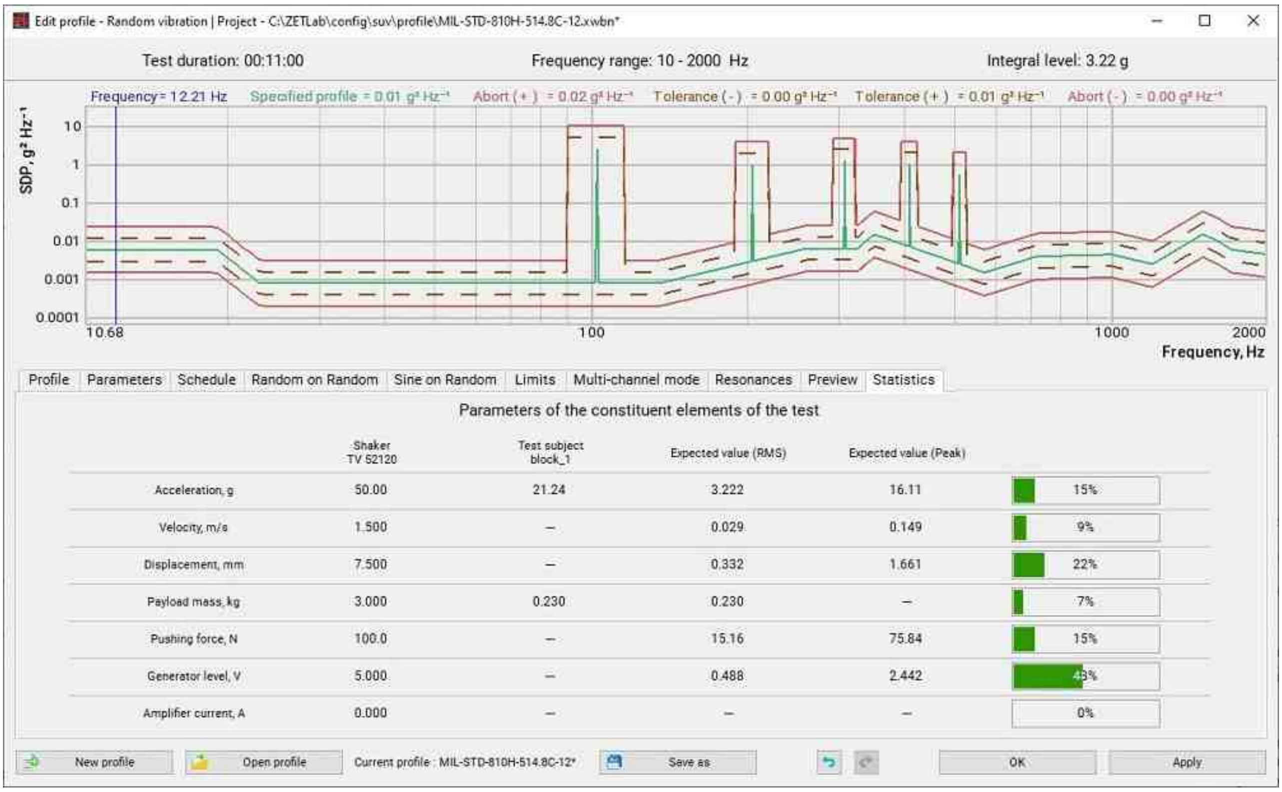


Fig. 10.11 Edit profile – Random window, Statistics tab

Also, the user can save the current test profile as a file which can be downloaded from the Edit Profile window. To save the current test profile, select the Save as function in the Edit Profile window (*Fig. 5.58*).

Fig. 5.58 Save as button to save your profile

In the opened window, set the name of the test profile and specify the path to save, and then press the Recording button (*Fig. 5.59*).

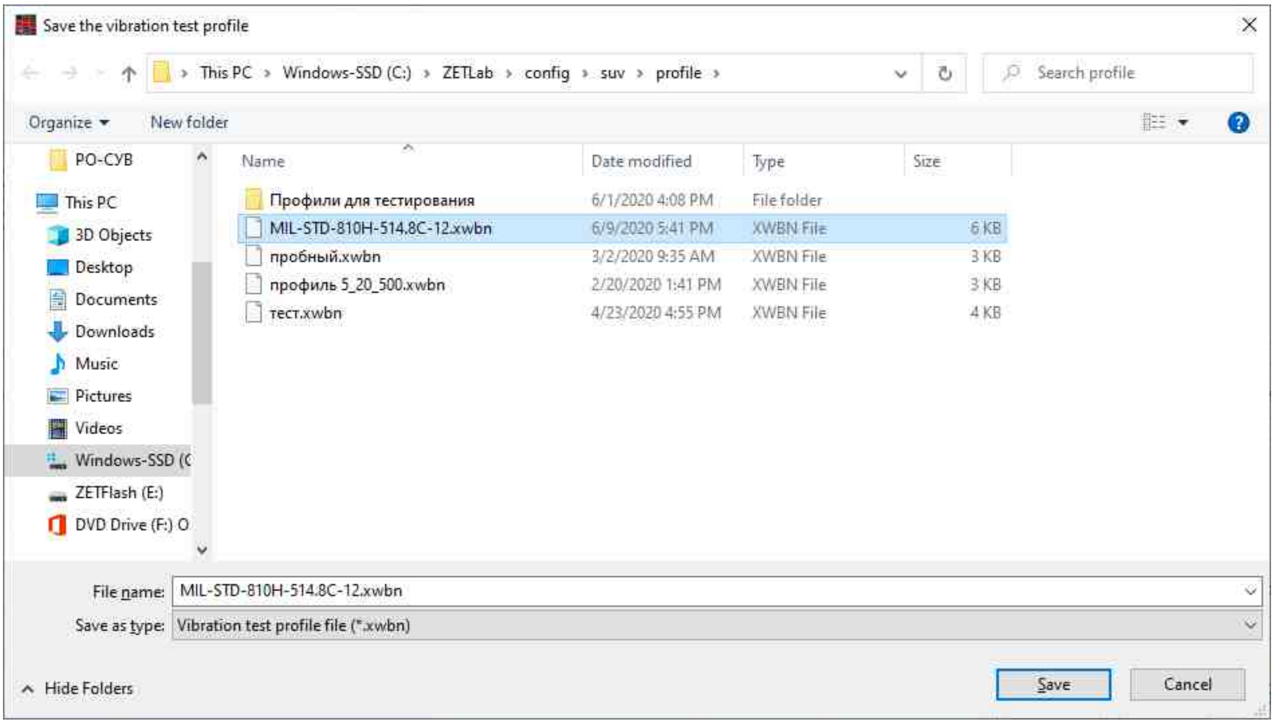


Fig. 5.59 Saving a profile

To download a previously saved test profile, select the Open Profile function. In the opened window, select the desired test profile file and press the Open button.

To apply the settings in the Edit Profile program, press the Apply button and then OK button.

Saving and loading test profiles .....

To save the settings made in the window of the program "Edit profile - Random", it is necessary activate the "Apply" button.

In the window of the program "Edit profile - Random", the user is given the opportunity to both save the currently edited test profile as a file, and open previously saved profiles for editing or for testing.

To save the current test profile, it is necessary to "Edit profile - Random" in the program window activate the "Save as" panel (*Fig. 10.12*).

Fig. 10.12 Button to save the test profile

In the "Profile save" window that opens ([Fig. 10.13](#)) you need to set the name of the saved test profile and select the directory to save it, after which activate the "Save" button.

Note: *You can save the current profile from any tab of the "*Edit profile - *Random" window.*

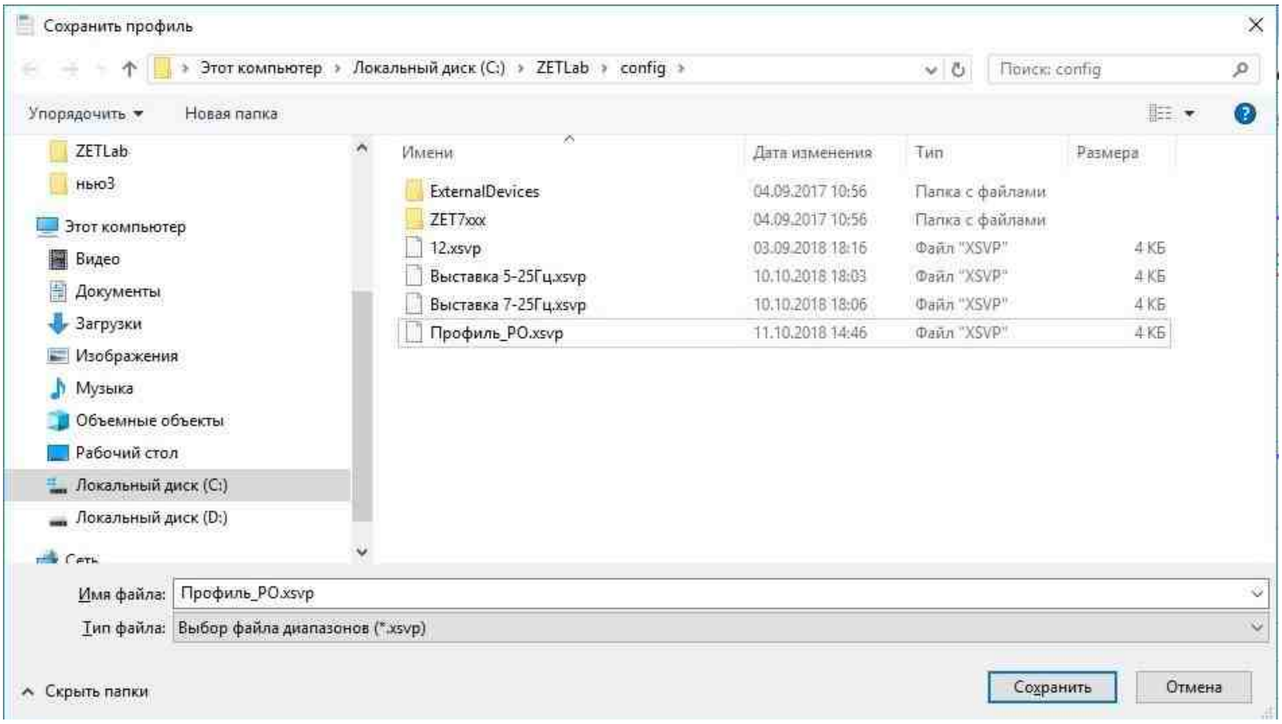


Fig. 10.13 The "Profile save" window

To load (open) a previously saved test profile, you must activate the "Profile open" panel ([Fig. 10.14](#)).

Fig. 10.14 Panel for opening the test profile

In the "Profile open" window that opens ([Fig. 10.15](#)) select the desired test profile file and activate the "Open" button.

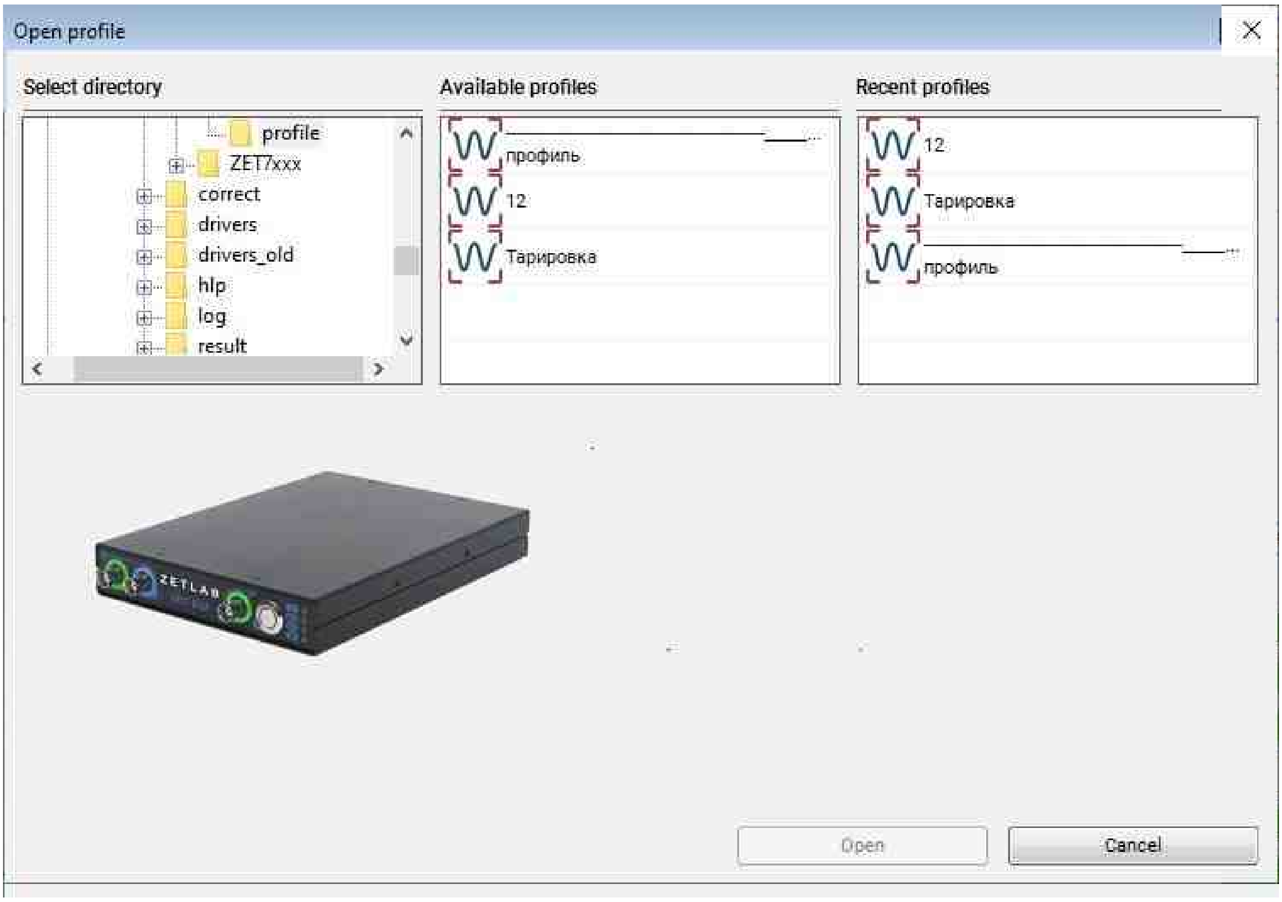


Fig. 10.15 "Profile Open" Window

When activating the "New profile" panel (*Fig. 10.16*) the program will offer to replace the current profile with a profile with default parameters (profile basic).

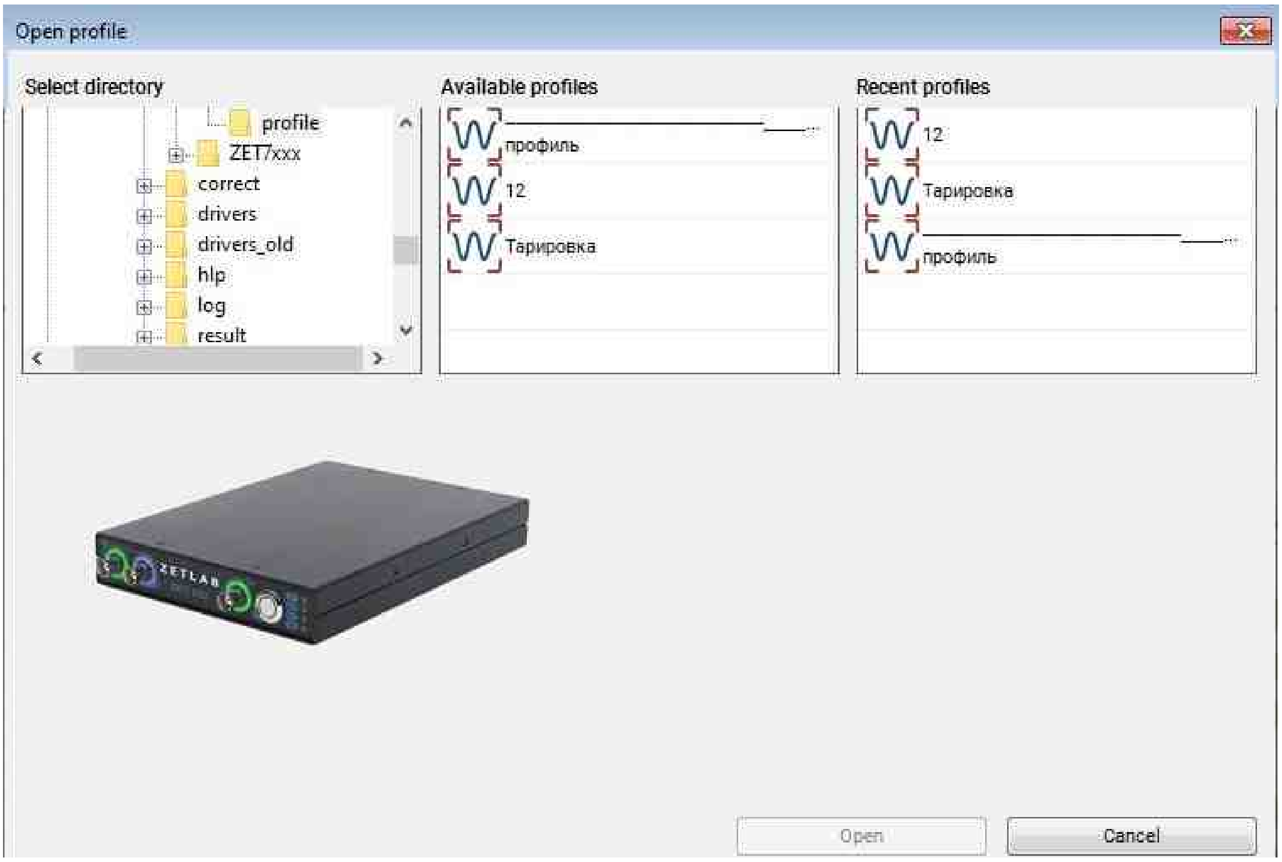


Fig. 10.16 Panel for creating a new profile

When activating the "New profile" panel (*Fig. 10.17*) the program will offer to replace the current profile with a profile with default parameters (profile basic).

Fig. 10.17 Panel for creating a new profile

Testing .....

The lower pane of the "Random" program displays the event log, where important information of the program operation is saved. After starting the program, the event log will display information of successful download of the Pre-Test files (*Fig. 10.17*).

Fig. 10.17 Event log of the "Random" program

Vibration tests are managed from a special menu in the lower-right corner of the program (*Fig. 10.18*).

Fig. 10.18 Control menu of the "Random" program

To start vibration tests, it is necessary activate the "Start" button. To stop the tests at an arbitrary point in time, it is necessary activate the "Stop" button. To temporarily stop the tests, it is necessary activate the "Pause" button, and to resume the tests – the "Start" button.

Pressing the "Recording" button starts/stops the process of recording electrical signals from all involved channels of the controller

Fig.. 10.19 Disabled (left) and enabled (right) view of the "Recording" button

Pressing the Recording button starts/stops recording electrical signals from all involved channels of the VCS controller. You can view the recorded signals in the "Results viewing" program from the ZETLab Panel Display menu (see ZETLAB software. Operator's manual).

To start the vibration tests, press the Start button, and the program will gradually bring the test system to the specified mode (*Fig. 10.20*).

Current time	Time of testing	Description
18:00:50	00:00:00	Pre-Test files successfully uploaded
18:01:19	00:00:00	Is to run the control module
18:01:21	00:00:00	Control module is running
18:01:32	00:00:00	Mode parameters stabilization

Fig. 10.20 Event log

When the required acceleration RMS is reached, the program will start performing vibration tests and report it in the information field (*Fig. 10.21*).

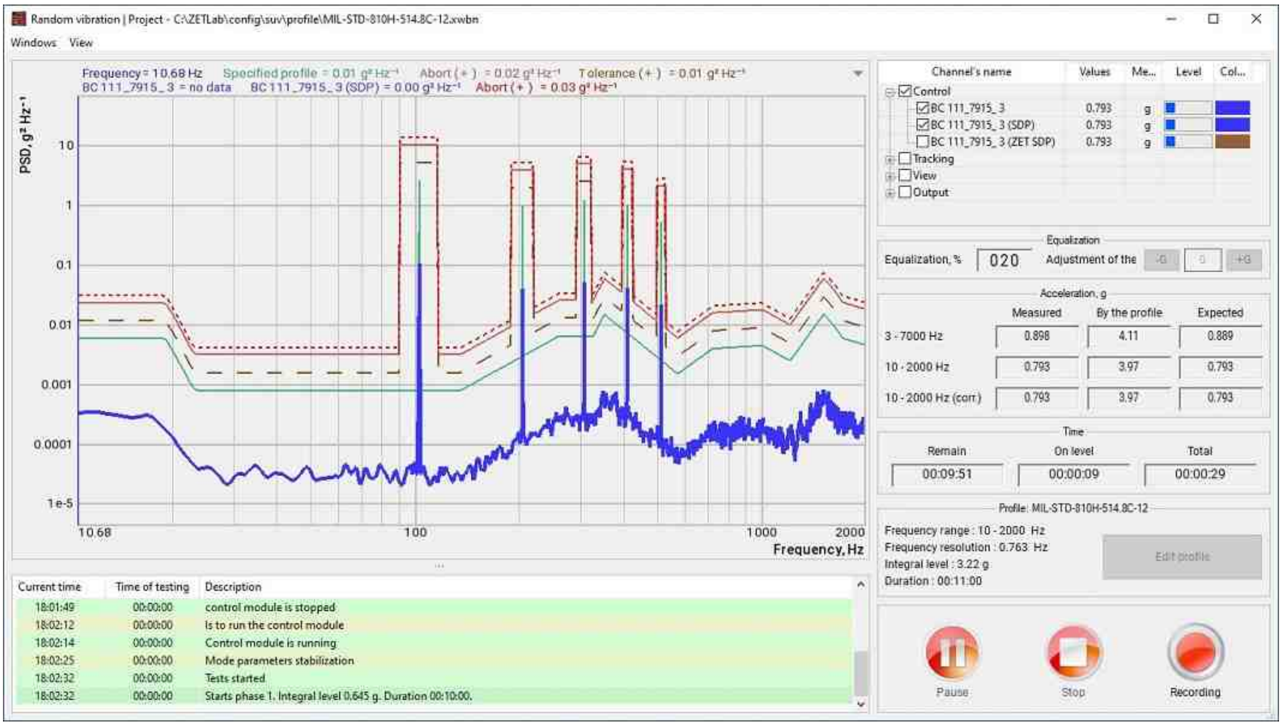


Fig. 10.21 Starting vibration tests

To display a measurement channel on the graphic, select it from the list of channels in the right pane of the program window (*Fig. 10.22*). This list includes all measuring channels for which one of the test control types was selected in the "Pre-Test and search for resonances" program (Control, Tracking, View). The measurement channel line also displays information of the current acceleration and the integral load level for this channel.

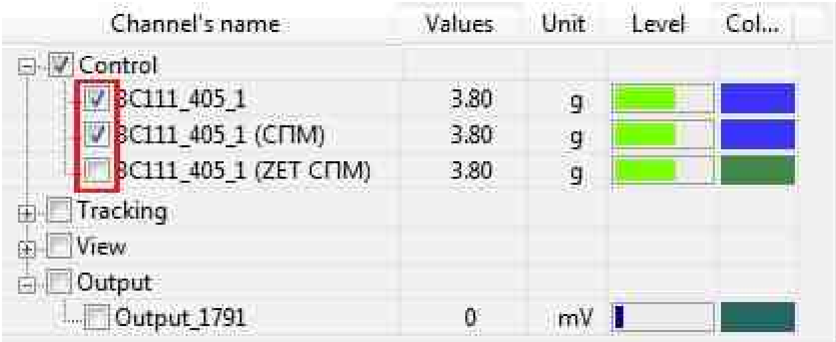


Fig. 10.22 Menu for selecting channels to display on the graphic

If several measurement channels were defined as control channels in the Control Parameters program, list of channels in the Random program will display an additional channel Total (Medium) or Total (Max) depending on the set parameters (*Fig. 10.23*).

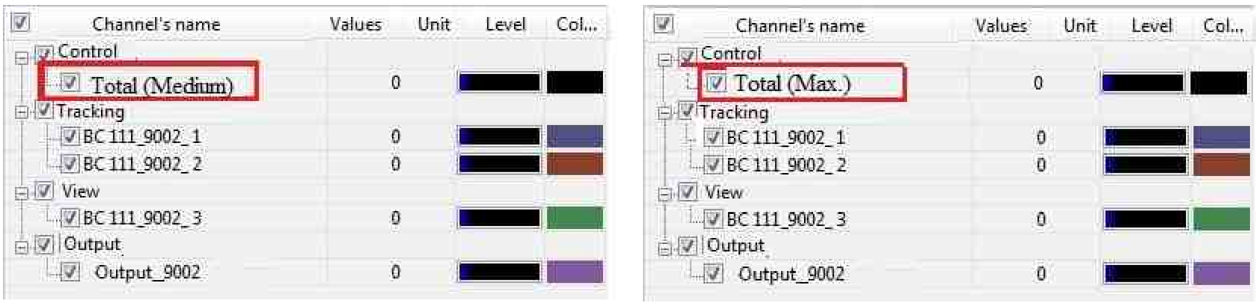


Fig. 10.23 Control channels "General (Medium)" and "General (Max)"

Note! *In case of selecting a control mode by average value or by maximum value, the channels selected for control will change their status to tracking, and a virtual channel formed by average value or by maximum value becomes the control channel, respectively.*

If the value of the control channel exceeds the set limits (exceeding the permissible limits, exceeding the maximum parameters of the shaker, etc.), the tests will stop. The message log will display information of the reasons for interrupting the test. To resume the vibration tests from the moment they stopped, press the Continue button (*Fig 10.24*).

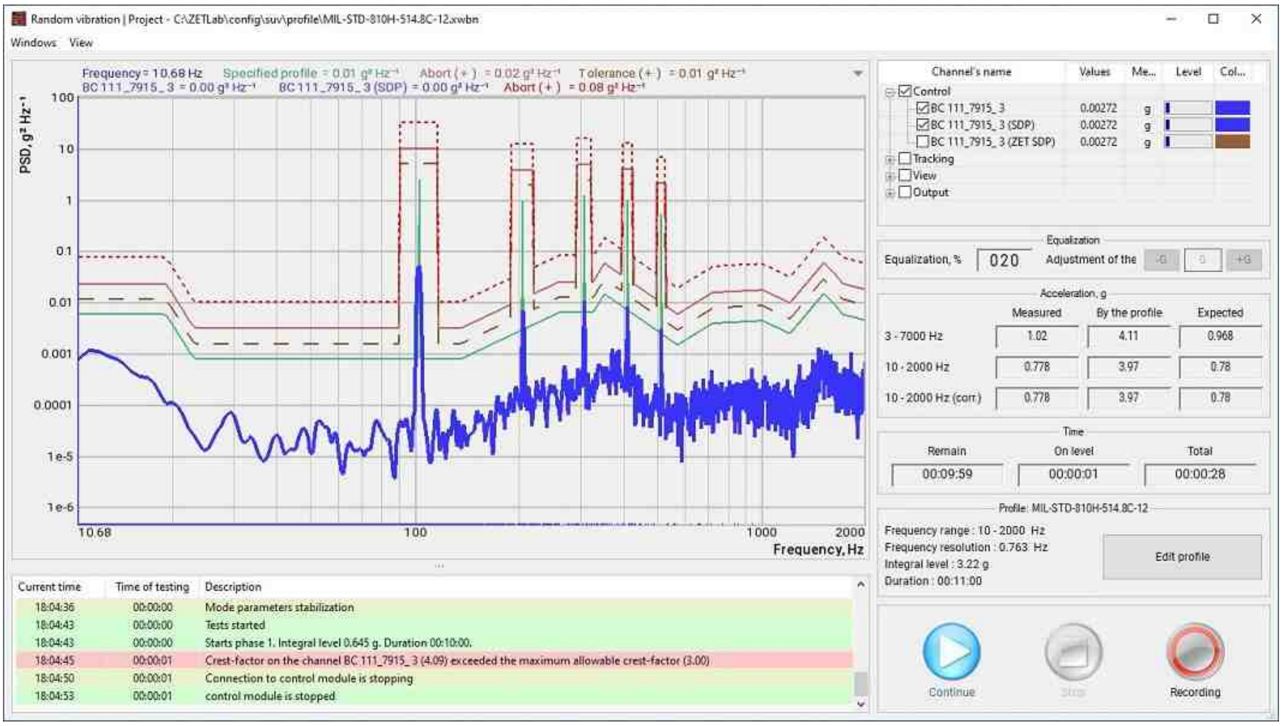


Fig. 10.24 Stop vibration tests

Additional graphics .....

During the tests, it is possible to track changes in the condition of the specimen under test at the point (s) of the control channel setup in real time. To do this, start the Additional graphics program (*Fig. 10.25*) from the Windows menu.

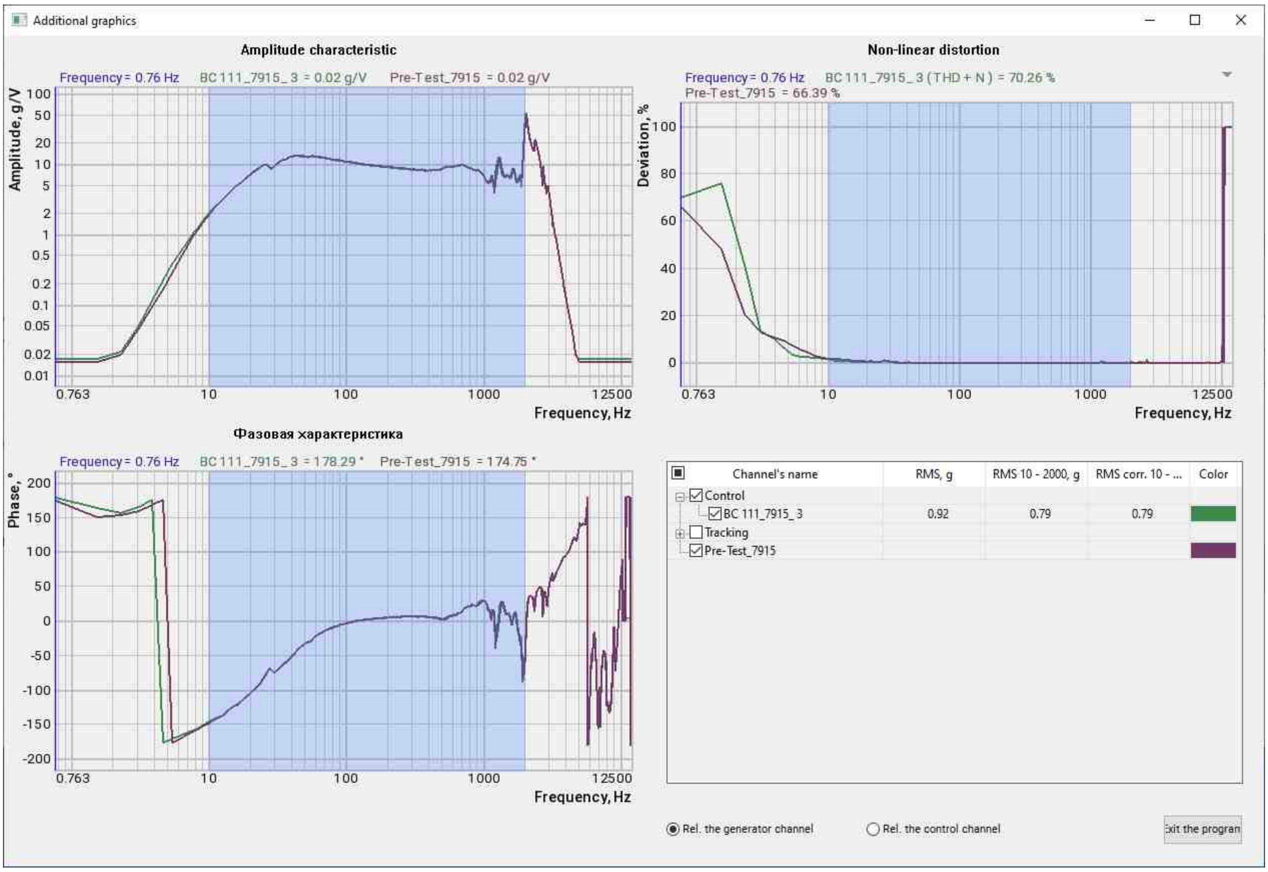


Fig. 10.25 Additional graphics program window

The graphics of the "Additional graphics" program show deviations of the current spectrum parameter values of the selected channel from the spectrum parameter values of the control channel generated in the test profile after passing the Pre-Test.

Data recorder .....

To display information of the temporary implementation of signal parameters, start the "Data recorder" program from the Windows menu of the Random program. The opened Results table window (*Fig. 10.26*) will show information of the vibration test process in the past.

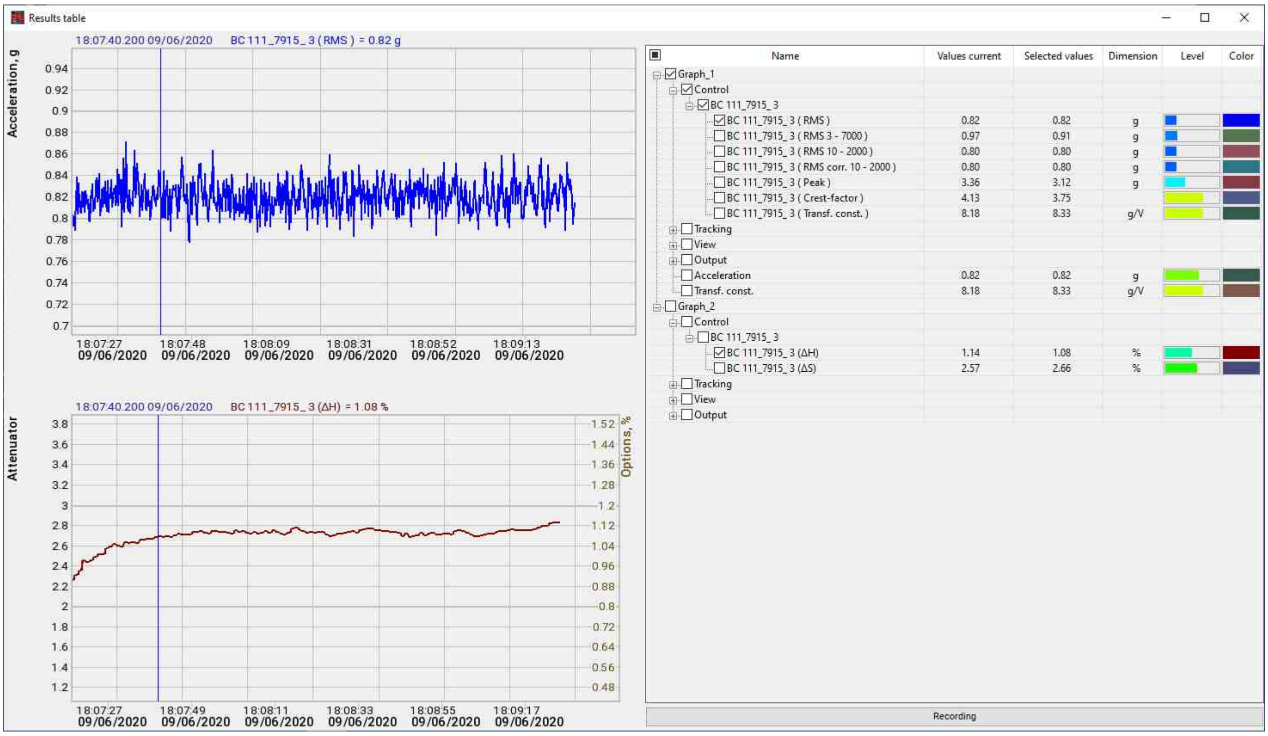


Fig. 10.26 Data recorder program window

The upper-right corner lists the names of channels with "Available graphics". You can change the graphic color by clicking on the colored rectangle. To save the recorder readings, press the "Recording" button. Only selected "Available graphics" in the "Results viewing" program will be saved.

Note: *In cases of problems with the tests: the tests were interrupted for some unknown reason, the tests do not start, there are significant distortions on the profile graphic, etc., to identify the cause, send us an email* ***INFO@ZETLAB.COM*** *an archived folder with files for the current test day. To go to the folders with the information we need, activate the text link "Tests results" on the VCS panel*

Results report .....

To save the report, start the "Report" program from the "Windows" menu of the "Random" program. In the opened window, enter the name of report file and specify the path to save it, then press the "Save" button (*Fig. 10.27*).

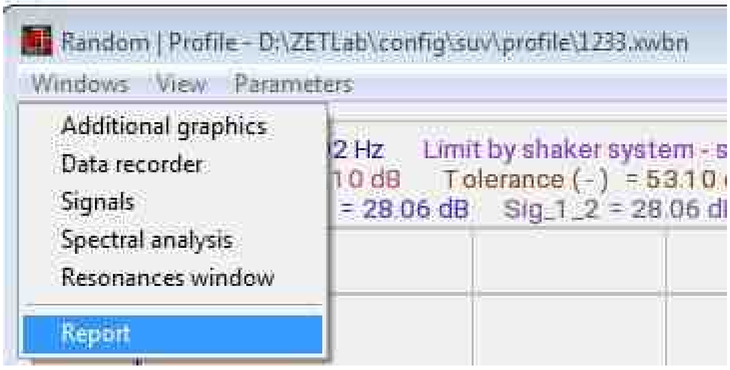


Fig. 10.27 Menu "Window"

. ***Note:*** *regardless of saving the file manually (via the "Report" program in the "Windows" section), the results recorded by the programs (which may be necessary for compiling the report) are always saved automatically to the directory formed by default at each completion of vibration testing.*

To view the report files, press the Tests results button on the VCS panel. In the opened window, select the appropriate test type and go to the Tests results folder. You can view the report files using the Results viewing program. To do this, right-click on the file and select Open in ResultViewer (*Fig. 10.28*) from the context menu.

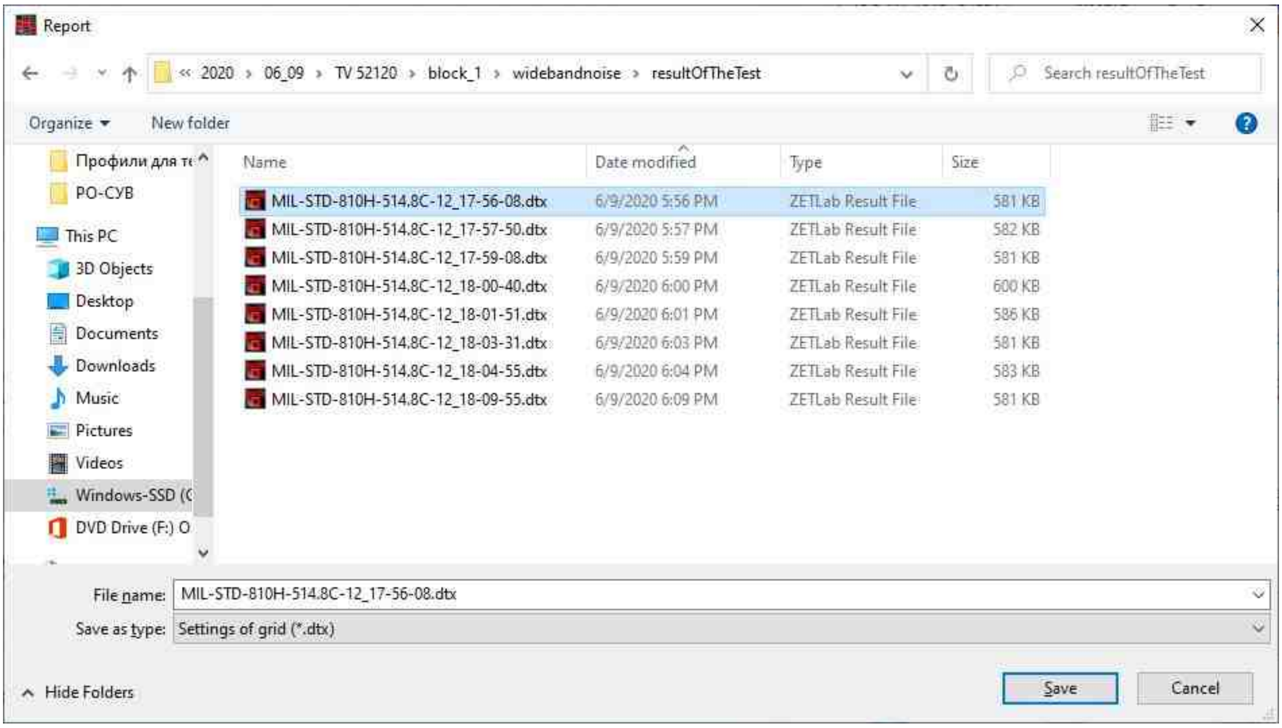


Fig. 10.28 Specifying the file name when saving the Tests results report

You can view the report file using the Results viewing program. To do this, right-click on the file and select Open in ResultViewer (*Fig. 10.29*) from the context menu.

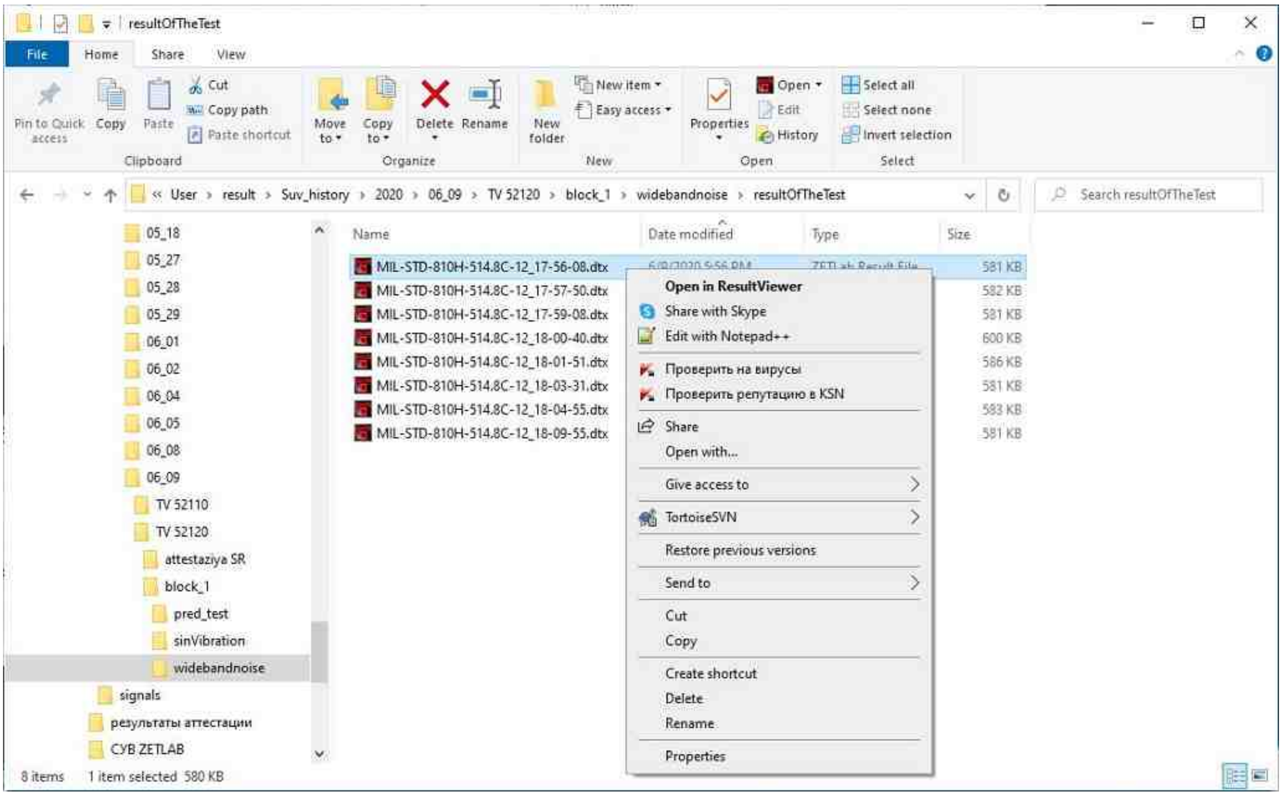


Fig. 10.29 Selecting a file from the Tests results directory

In the Results viewing program, the graphic tab displays the graphical part of the report on the completed test (*Fig. 10.30*).

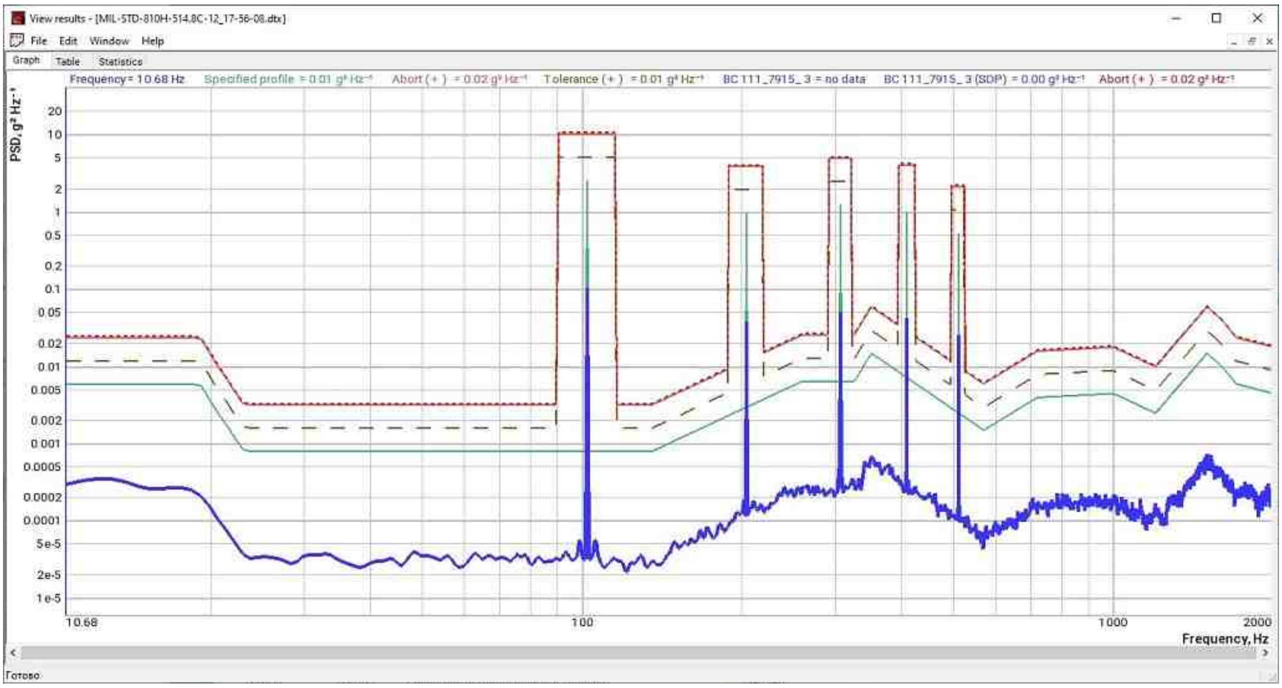


Fig. 10.30 graphic tab of the Results viewing window

To view the graphic values in table form, go to the Table tab (*Fig. 10.31*).

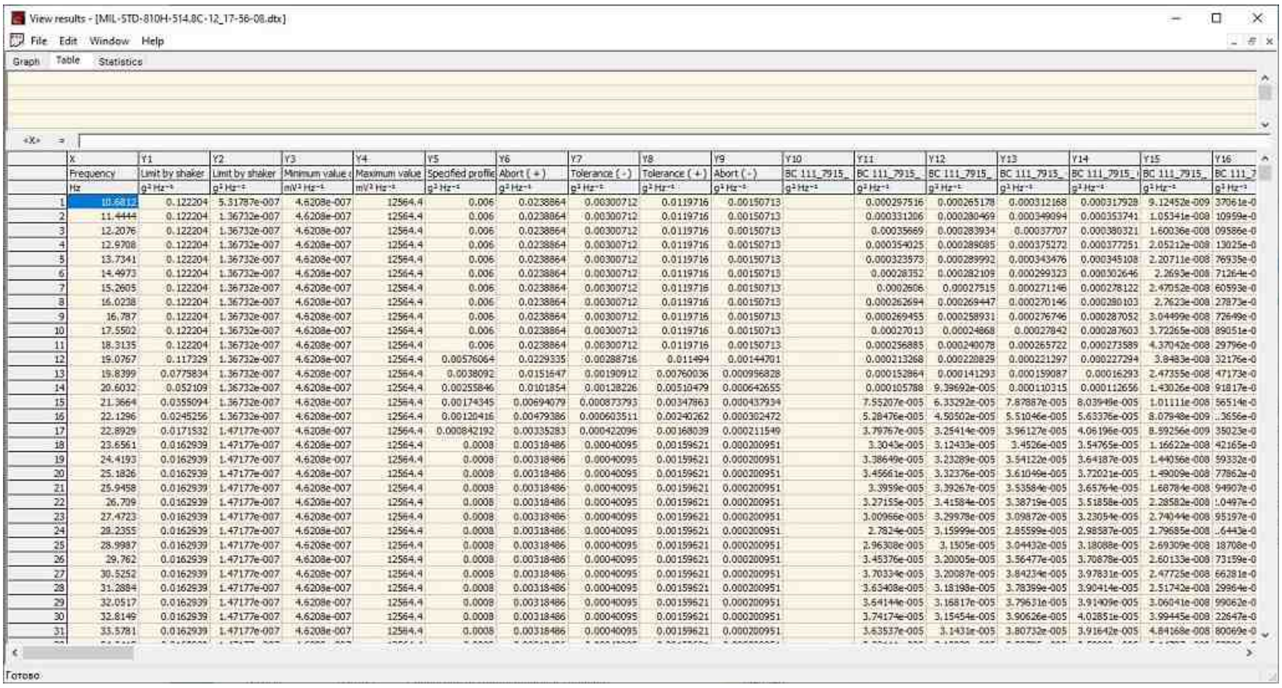


Fig. 10.31 Table tab of the Results viewing window

Examples for the section .....

An example of the theory of testing of Random .....

An example of the theory of testing of Random

Vibration testing of a sample (specimen) of vibration requires a certain degree of reproducibility, especially for qualification and acceptance tests conducted to test the same type of samples by various organizations, such as a supplier and consumer of electronics technology.

As statusd in GOST 28220-89, the word "Reproducibility" does not mean convergence of results, obtained under test conditions and in the operating conditions of the sample (real conditions), a refers to obtaining similar test results obtained in different test centers by different test staff.

Large divergence of requirements for various tolerance values at a certain level of rigidity, as well as ensuring the reliability of test results leads to the introduction of three reproducibility: high, medium and low. For each reproducibility, a choice of confirmation method can be made, taking into account both the dynamic characteristics of the test specimen and the availability of test equipment.

Reproducibility requirements include controlling the level of vibration within a narrow-band frequency. Although narrow-band equalization provides better reproducibility than wideband equalization, narrow-band equalization takes less account of environmental effects on on the test sample. However, broadband equalization causes the resonance within the sample to change the test level enough that peaks and dips can occur. During operation, environmental conditions usually contribute to the occurrence of peaks and dips due to the effect of the environment on the sample. In addition, these peaks and dips are unlikely to coincide with the peaks and dips that occur during testing in the laboratory.

For high and medium repeatability, the sample should be subjected to sinusoidal vibration to obtain frequency response. In this case, the sinusoidal vibration testing is carried out in both directions over the entire frequency range of the tests.

Specifications may also require testing for the detection of resonances, as well as verification of mechanical characteristics before exposure.

During the test, the sample is subjected to vibration in accordance with the requirements of GOST for the corresponding type of test.

After completion of the tests, final measurements are taken, in which the mechanical characteristics of the sample are checked, for comparison with the results of the verification of the mechanical characteristics obtained before testing.

The Shock program

Program Purpose

The ***Shock*** program is designed to test the effect of a classic shock.

According to GOST 28213-89, single shock tests are used for equipment elements that are subjected to relatively infrequent single impacts during transportation or operation. The single effect test can also be used as a way to determine the quality of the design of the sample, as well as to assess its structural strength, and as a means of quality control of the sample. The test is carried out by exposing the sample to single shocks with standard impulse forms of a certain duration and peak acceleration.

The program is used for ***Shock*** test. The program can generate different wave forms: sinusoidal, triangular, rectangular, serrated, and trapezoidal.

Preparing for testing

The sample is mounted on a shaker in accordance with the requirements of GOST 28231-89

When preparing for vibration resistance tests in a wide frequency range, set the following parameters (if not set): shaker parameters, specimen parameters, channel parameters (see sections 5-7), and then perform a Pre-Test according to section 8.

To go to the ***Shock*** program window, press the Shock button on the VCS Panel (Fig. 4.1). The ***Shock*** program window (Fig. 11.1) will appear on the monitor screen.

Attention! *The* ***Shock*** *button on the VCS panel will only be available if the program detects the Pre-Tests results.*

Program from the scope of ZETLAB VIBRO software

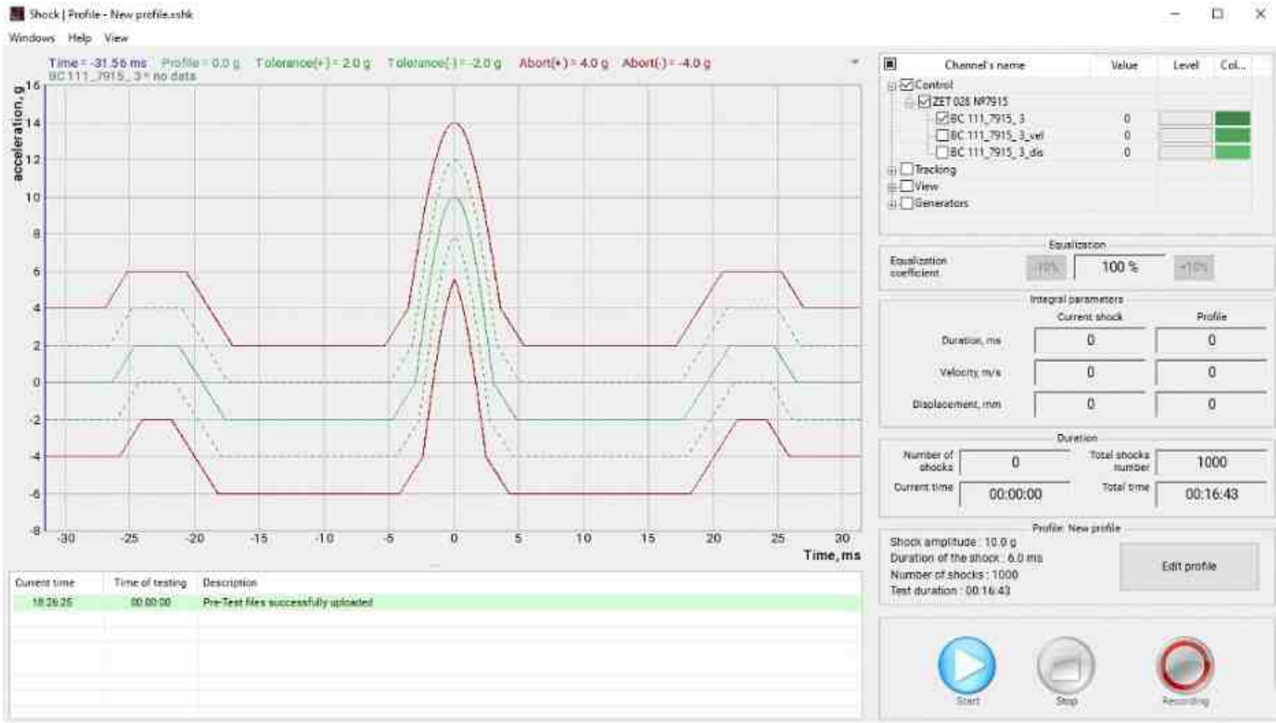


Fig. 11.1 The Shock window

The program Shock is intended for vibration testing performance in compliance with the applicable requirements specified in IEC 60068-2-27 (Environmental testing. Part 2: Tests. Test Ea and guidance: Shock).

Edit profile .....

To set the test profile, it is necessary to  activate the "Edit profile" button (*Fig. 11.1a*) from the main window of ***Shock*** program .

Fig. 10.1a "Edit profile" button

Parameters tab .....

When you start the "Edit profile" program, the "Edit profile – Shock" program window open with the active ***Parameters*** tab (*Fig. 11.2*).

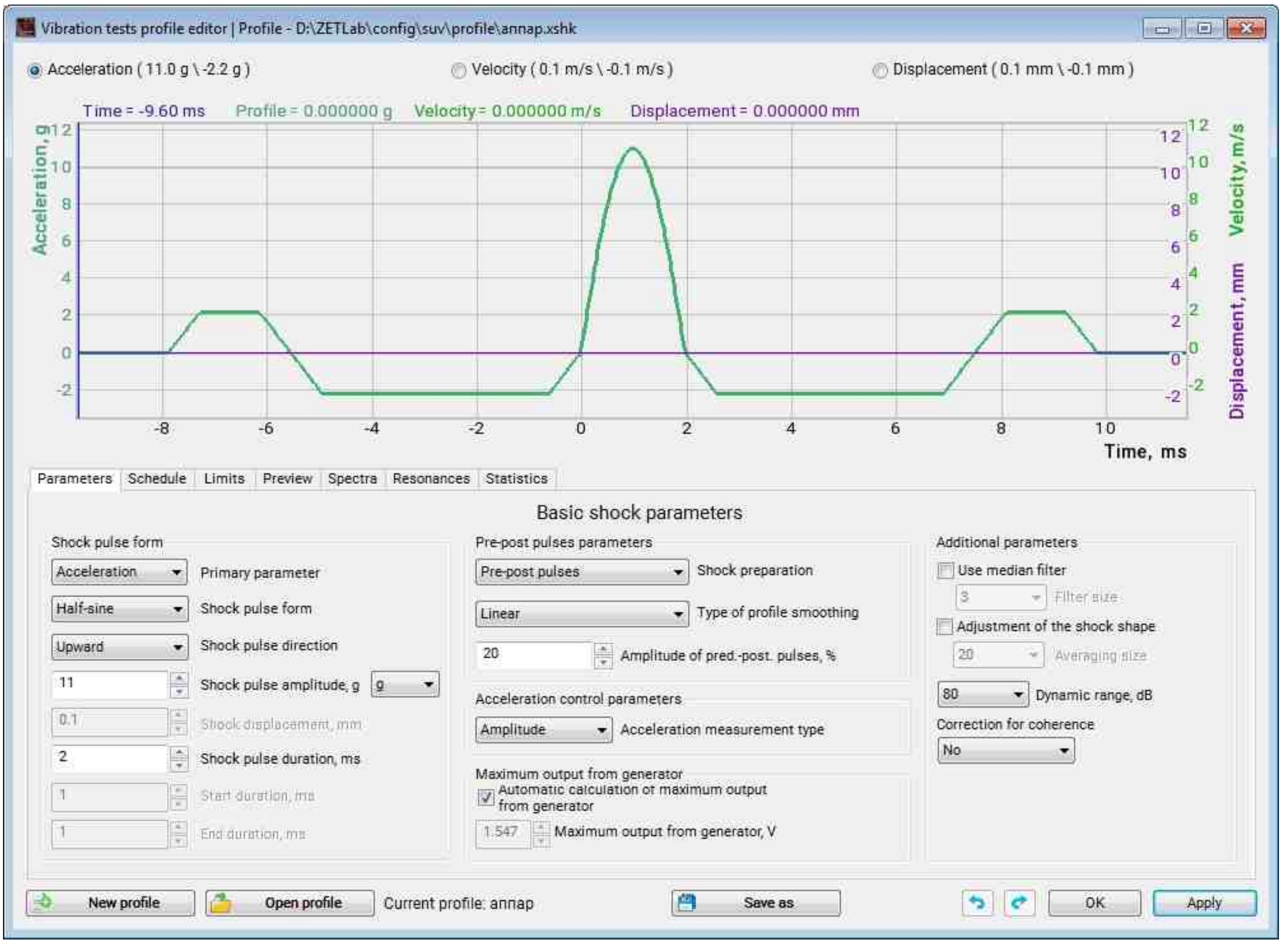


Fig. 11.2 "Edit profile" window, Parameters tab

In the ***Parameters*** tab, you can set the primary parameter to produce the shock: acceleration or displacement.

If the "Acceleration" parameter is selected, specify the amplitude and duration of the produce shocks. If the "Displacement" parameter is selected, specify displacement and duration.

Attention! *The maximum permissible for the **Shaker parameters** "Displacement", "Velocity" and "Acceleration" limit the limits for setting the amplitude and duration of the shock. Before* *starting the tests, check in the Statistics tab the possibility of performing the specified profile on the shaker.*

<u>Attention!</u> *The "Frequency resolution" parameter, set in the Pre-Test settings, affects the maximum possible duration of the generated shocks. To specify shocks with a duration of more than 20 ms, set the sampling frequency of the ADC on the VCS controller to 5 kHz and conduct a Pre-Test with a frequency resolution of no more than 0.5.*

You can set the following as the "Shock impulse form":

- half-sine;
- triangle;
- rectangle;
- serrated (peak in the beginning);
- serrated (peak in the end);
- trapeze;
- haversine.

You can find an example of the shock impulse forms in Appendix A. forms of the shock impulse accelerograms.

The "Direction" parameter sets the direction of the shock - "upward" or "down".

The Pre-Post impulses parameter includes the pre-signals for balancing the velocity and displacement of the shaker. You can select the following as the Pre and Post impulses when producing a shock:

- No Pre-Post impulses;
- Post-impulses only;
- Pre-impulses only;
- Pre-Post impulses.

You can select the following parameters for smoothing the displayed shock profile:

- Without smoothing;
- Linear;

- Hanna;
- Sinusoidal.

To accurately determine the required generator voltage when reproducing a shock impulse, set "Amplitude of Pre.-Post. impulses" parameter. The Pre-Post impulse value is set as a percentage of the value set for the "Shock impulse amplitude" parameter.

The "Adjustment of the shock form" parameter is used to adjust a shock form in the test in case of differences between the registered shock form and shock form in the profile.

The "Use median filter" parameter is used to "Align" the amplitude response. The greater the value of the "Median filter length" parameter, the greater the alignment value.

The "Dynamic range" parameter limits the difference between the maximum value and minimum value of the amplitude response.

Schedule tab .....

When you start the "Edit profile" program, the "Edit profile – Shock" program window open with the active Schedule tab (*Fig. 11.3*).

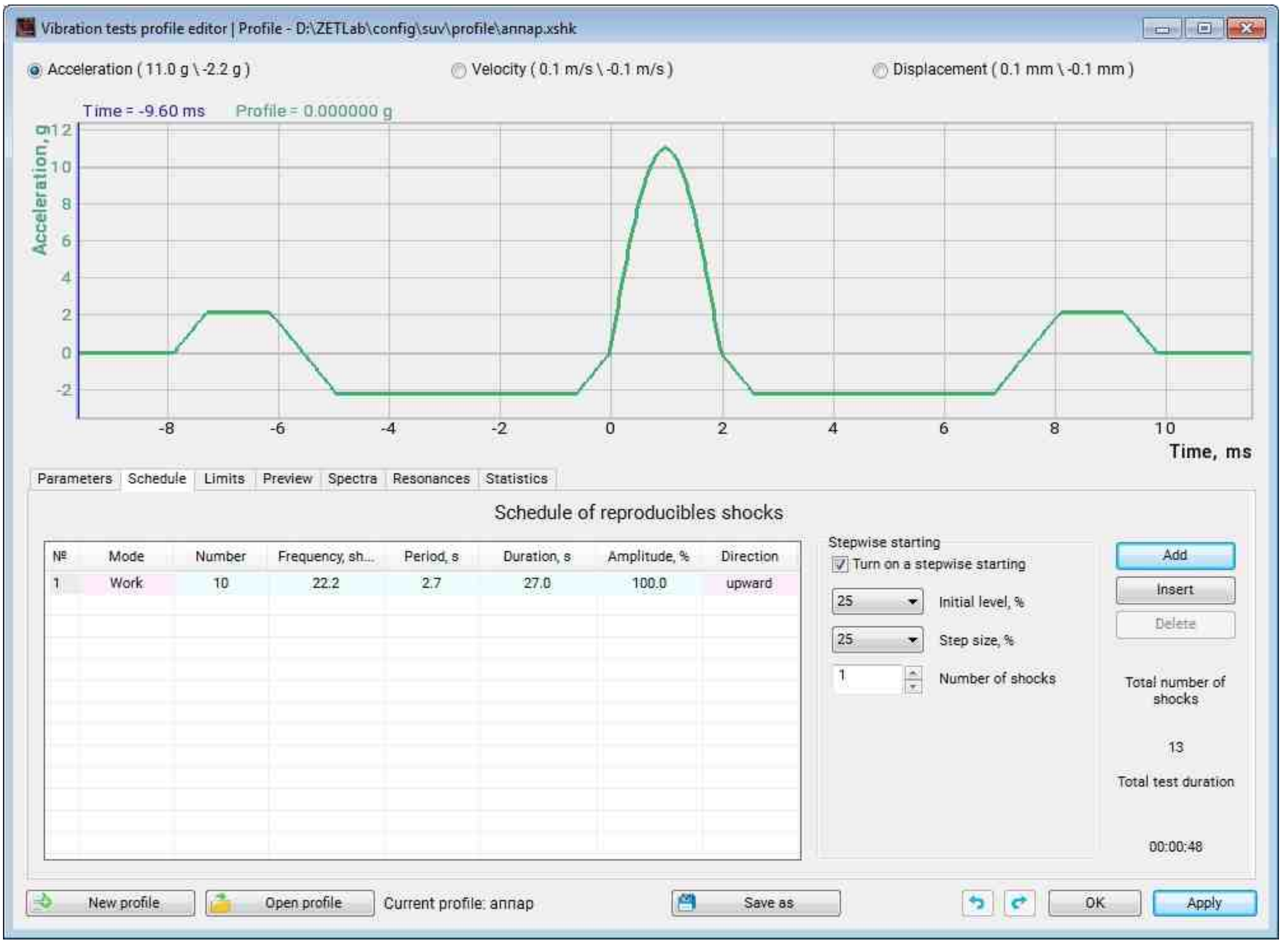


Fig. 11.3 "Edit profile" window, Schedule tab

The vibration test schedule is a data table. To add new rows to a table, activate the "Insert" button.If there are several stages of vibration testing, then the appropriate number of rows should be added to the table. The configuration is individual for each stage of the test.

The "Mode" parameter has several statuses:

- Work – in this mode, the program is performing tests according to the profile;
- Pause – in this mode, the program is pausing tests for a specified time;
- Loop – in this mode, the program is repeating operations from a specified position a specified number of times.

The "Duration" parameter sets the duration of the vibration test stages.

Parameters "Equalization, %", "Equalization, dB" and "Integral level, g" set the ratio of the integral level of acceleration at the current stage of the test to the level determined by the test profile, while the values of one column automatically recalculate the values of the other column.

The "Number" column, you can set the total number of shocks in the test.

The "Frequency, shocks/min" column, you can set the number of shocks per minute.

The "Period, s" column, you can set the period with which the strikes will occur.

The "Duration, s" column, you can set the total time of the test.

The "Amplitude (%)" column, you can set the shock impulse amplitude, as a percentage of the value set for the "Shock impulse amplitude" parameter.

The "Stepwise starting" column, you can set performs a gradual exit to the mode, with each step evenly increasing the level of reproducible shocks.

Limits tab .....

When you start the "Edit profile" program, the "Edit profile – Shock" program window open with the  active Limits tab (*Fig. 11.4*).

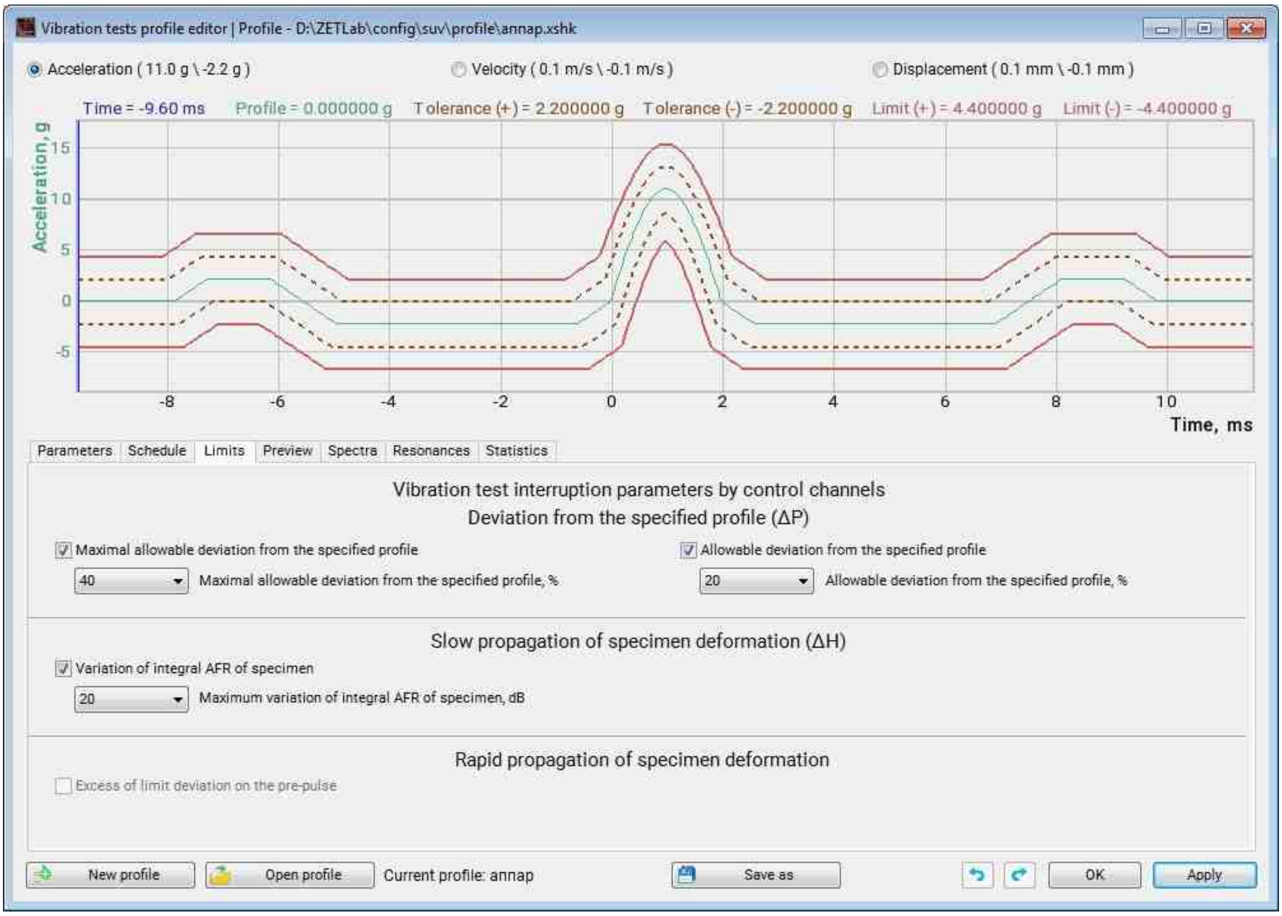


Fig. 11.4 "Edit profile" window, Limits tab

On the Limits tab, you can set the test thresholds (in dB and %) for the control channel. According to the parameters with enabled control, (during the tests) exceeding the set parameter values will be monitored, and if they are exceeded, the tests will stop immediately.

To enable control by parameter, activate (check the cell) the corresponding parameter, and to disable it, deactivate it (uncheck the cell).

You can set limits for the following parameters of a control channel:

- Maximum allowable deviation from the specified profile;
- Allowable deviation from the specified profile;
- Change of the instantaneous rates.

Preview tab .....

When you start the "Edit profile" program, the "Edit profile – Shock" program window open with the active Preview tab (*Fig. 11.5*).

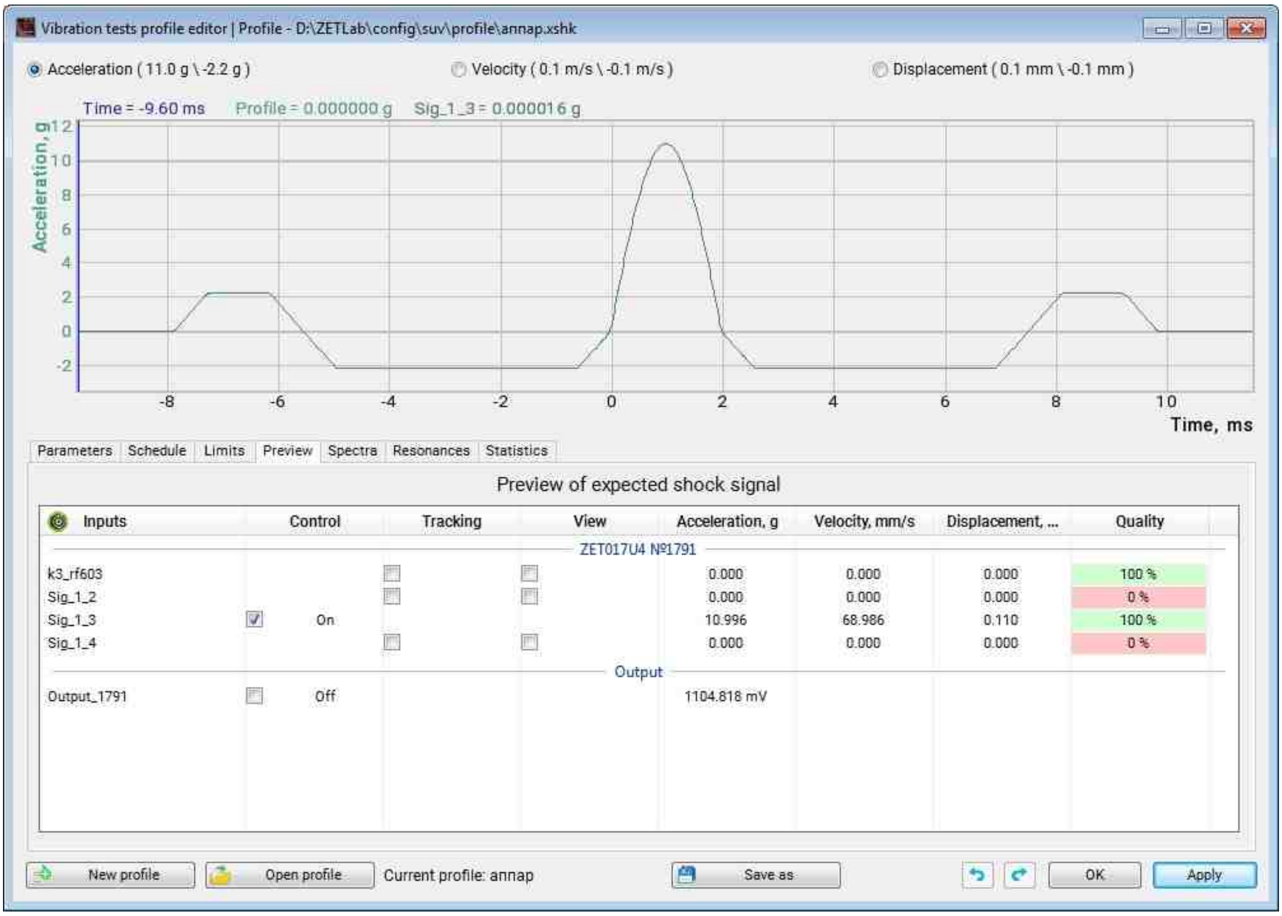


Fig. 11.5 "Edit profile" window, Preview tab

On the Preview tab, you can preview the shock spectrum graphics for a given profile obtained by calculation based on the Pre-Tests results.

The graphics are presented for all measuring channels of the VCS controller selected at the test stage, and each measuring channel can be assigned any type of control (control, tracking, view, and also check the noise level of the channel). To display the desired vibration graphic, check the corresponding table cell.

Note: *The graphic information is for reference and intended to inform the VCS about the expected results that will be obtained during vibration tests for a given profile.*

The graphics are presented for all measuring channels of the VCS controller selected at the test stage, and each measuring channel can be assigned any type of control (control, tracking, view, and also check the noise level of the channel). To display the desired vibration graphic, check the corresponding table cell.

Spectra tab .....

When you start the "Edit profile" program, the "Edit profile – Shock" program window open with the  active Spectra tab (*Fig. 11.6*).

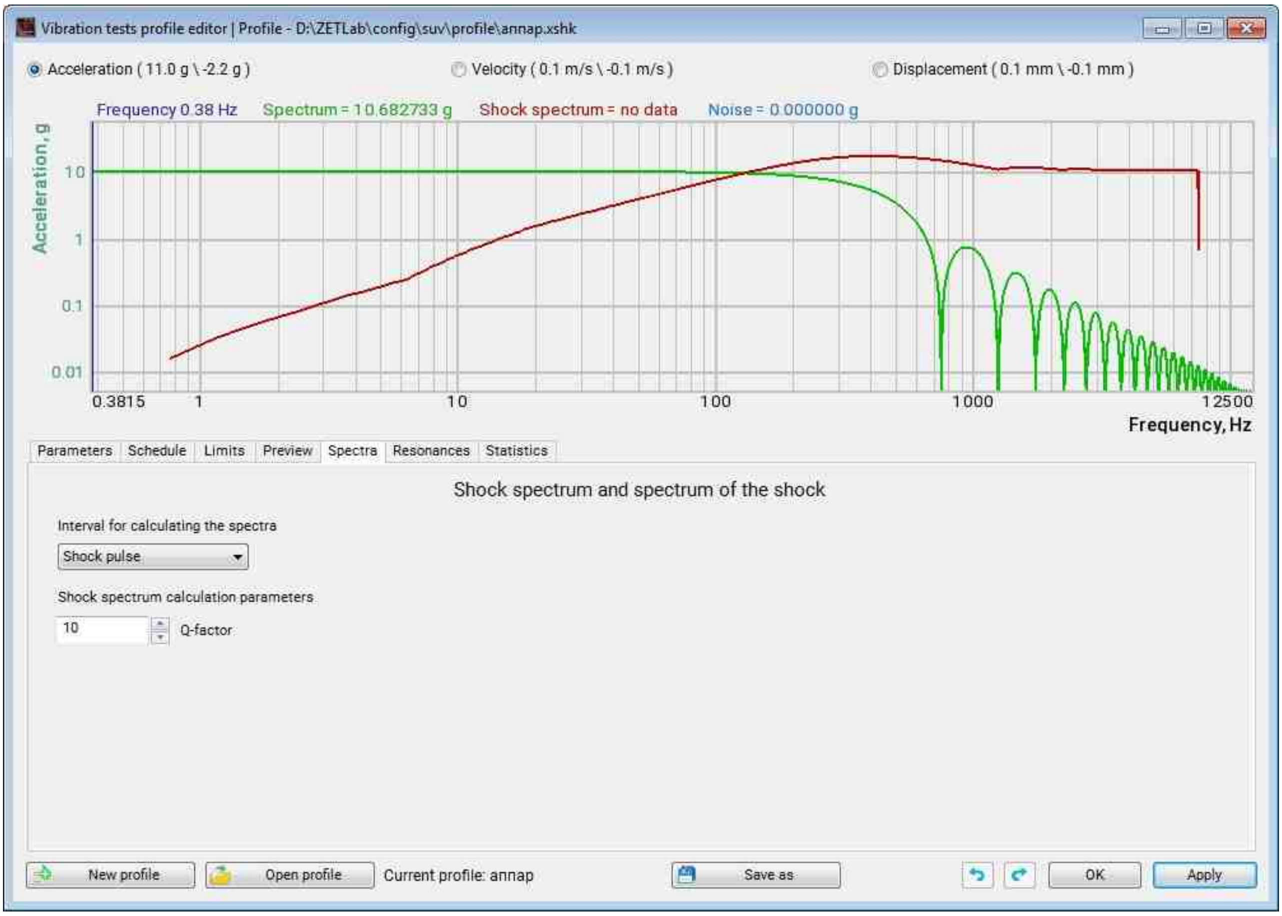


Fig. 11.6 "Edit profile" window, Spectra tab

Resonances tab .....

When you start the "Edit profile" program, the "Edit profile – Shock" program window open with the active Resonances tab (*Fig. 11.7*).

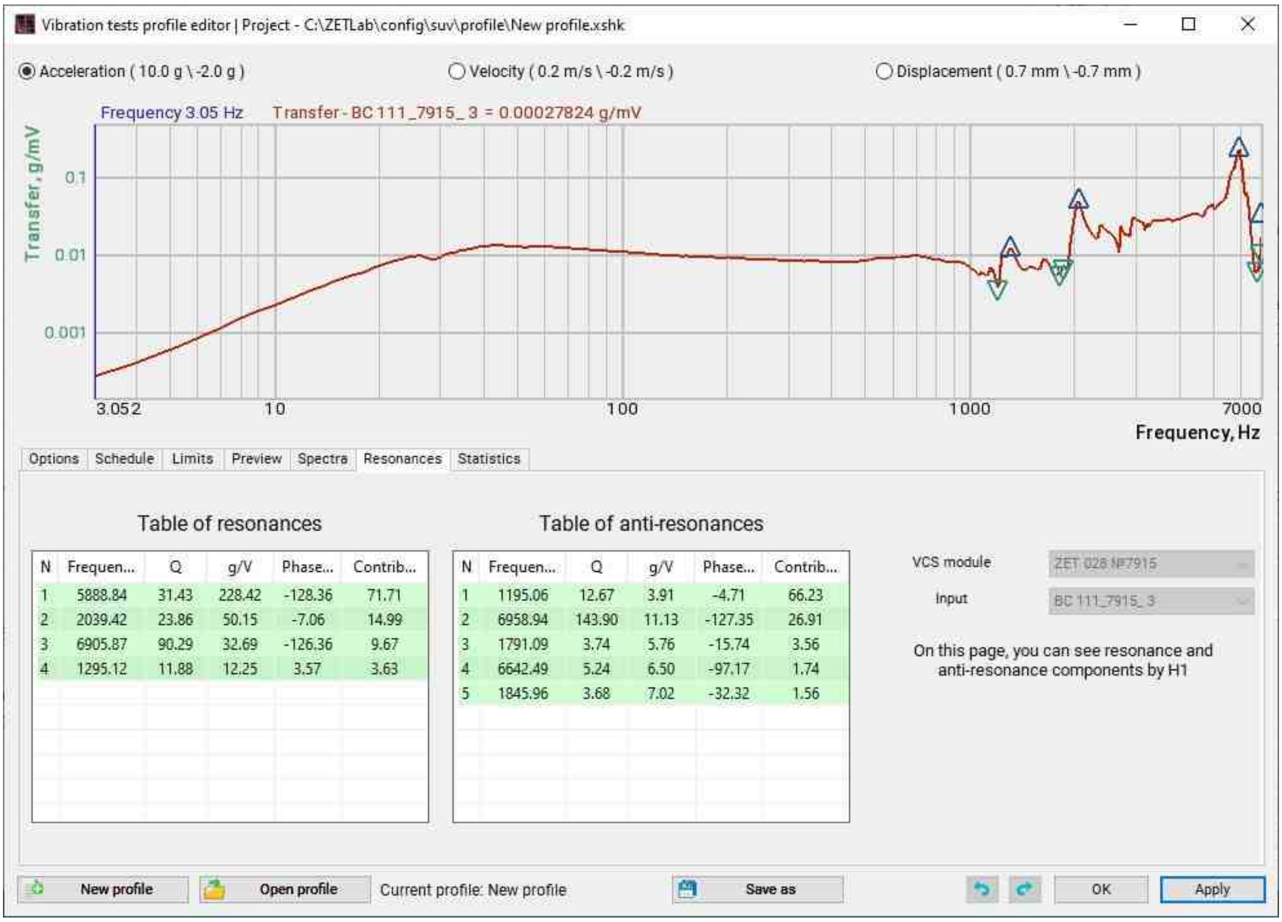


Fig. 11.7 "Edit profile" window, Resonances tab

The Resonances tab contains statistical information based on the Pre-Tests results. On this tab, the operator can evaluate the presence of resonances and antiresonances in the amplitude response.

Note: *If necessary (for more detailed consideration), draw the amplitude response on the frequency scale closer to the area of interest, and only resonances and antiresonances falling within the visualized graphic area will be left in the table.*

Statistics tab .....

When you start the "Edit profile" program, the "Edit profile – Shock" program window open with the active Statistics tab (*Fig. 11.8*).

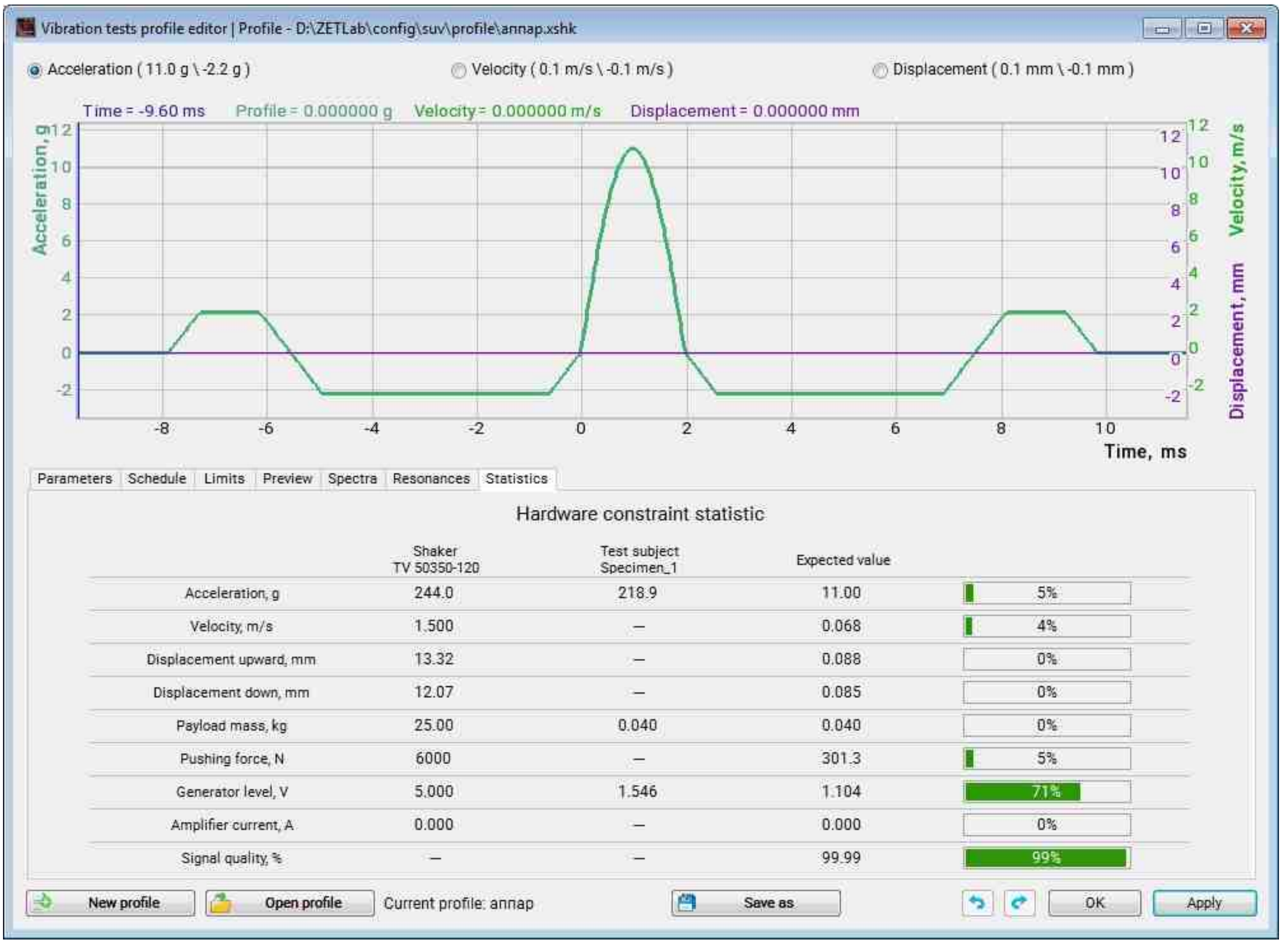


Fig. 11.8 "Edit profile" window, Statistics tab

The Statistics tab contains statistical information based on the set values for the test profile parameters. It provides the user with a possibility to assess the workload of the shaker during vibration tests.

Saving and loading test profiles .....

To save the settings made in the window of the program "Edit profile - Shock", it is necessary activate the "Apply" button.

In the window of the program "Edit profile - Shock", the user is given the opportunity to both save the currently edited test profile as a file, and open previously saved profiles for editing or for testing.

To save the current test profile, it is necessary to "Edit profile - Shock" in the program window activate the "Save as" panel (*Fig. 11.8*).

Fig. 11.8 Button to save the test profile

In the "Profile save" window that opens (*Fig. 11.9*) you need to set the name of the saved test profile and select the directory to save it, after which activate the "Save" button.

Note: *You can save the current profile from any tab of the* "Edit profile - Shock" *window.*

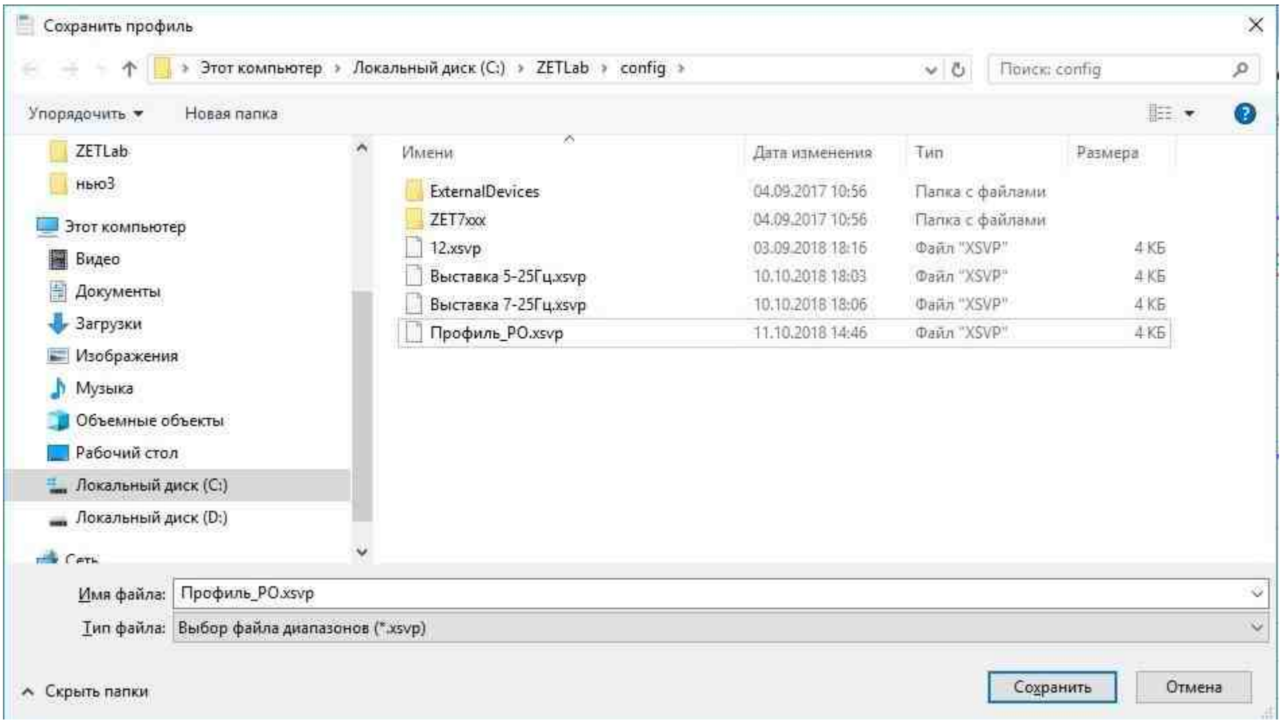


Fig. 11.9 The "Profile save" window

To load (open) a previously saved test profile, you must activate the "Profile open" panel (*Fig. 11.10*).

Fig. 11.10 Panel for opening the test profile

In the "Profile open" window that opens (*Fig. 11.11*) select the desired test profile file and activate the "Open" button.

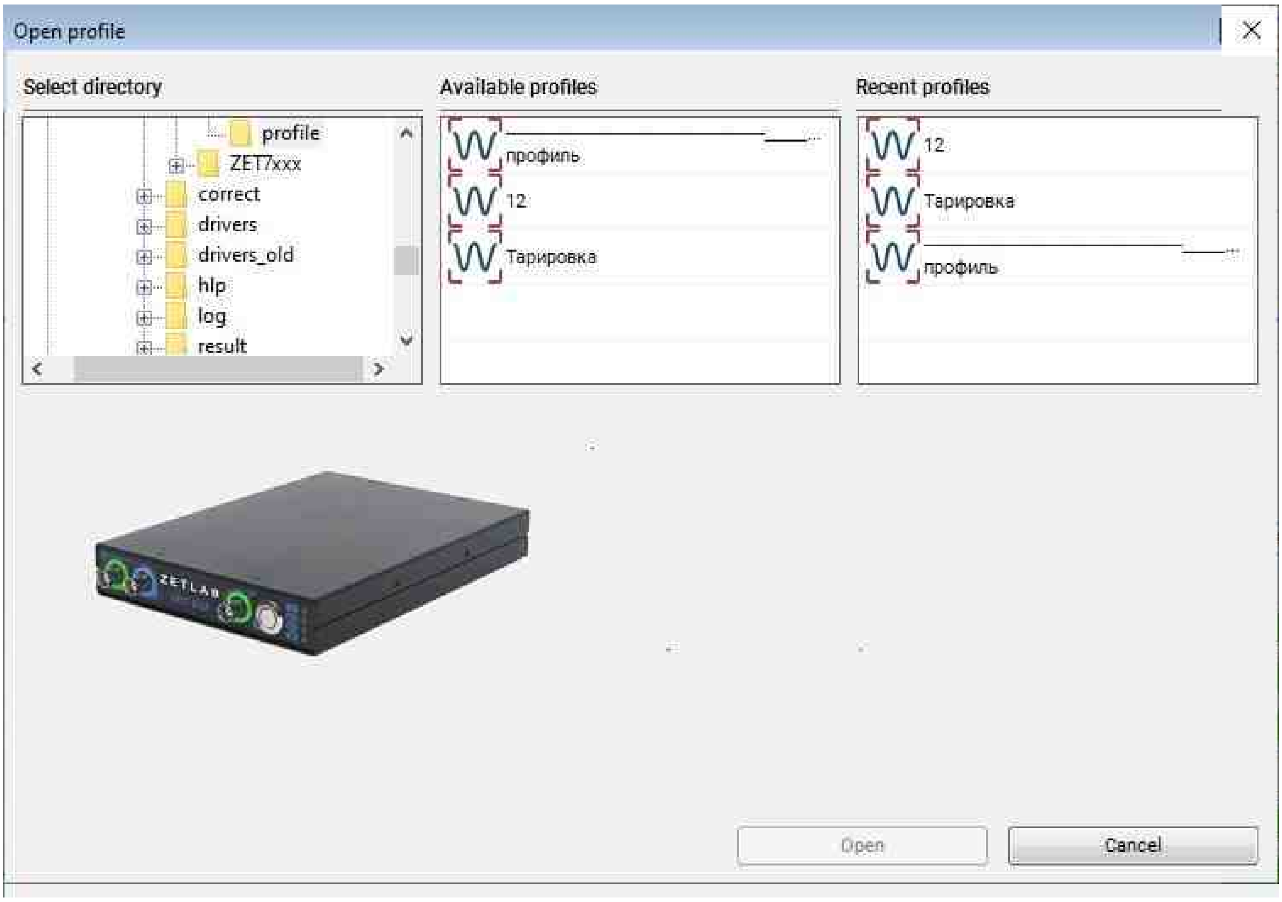


Fig. 11.11 "Profile Open" Window

When activating the "New profile" panel (*Fig. 11.12*) the program will offer to replace the current profile with a profile with default parameters (profile basic).

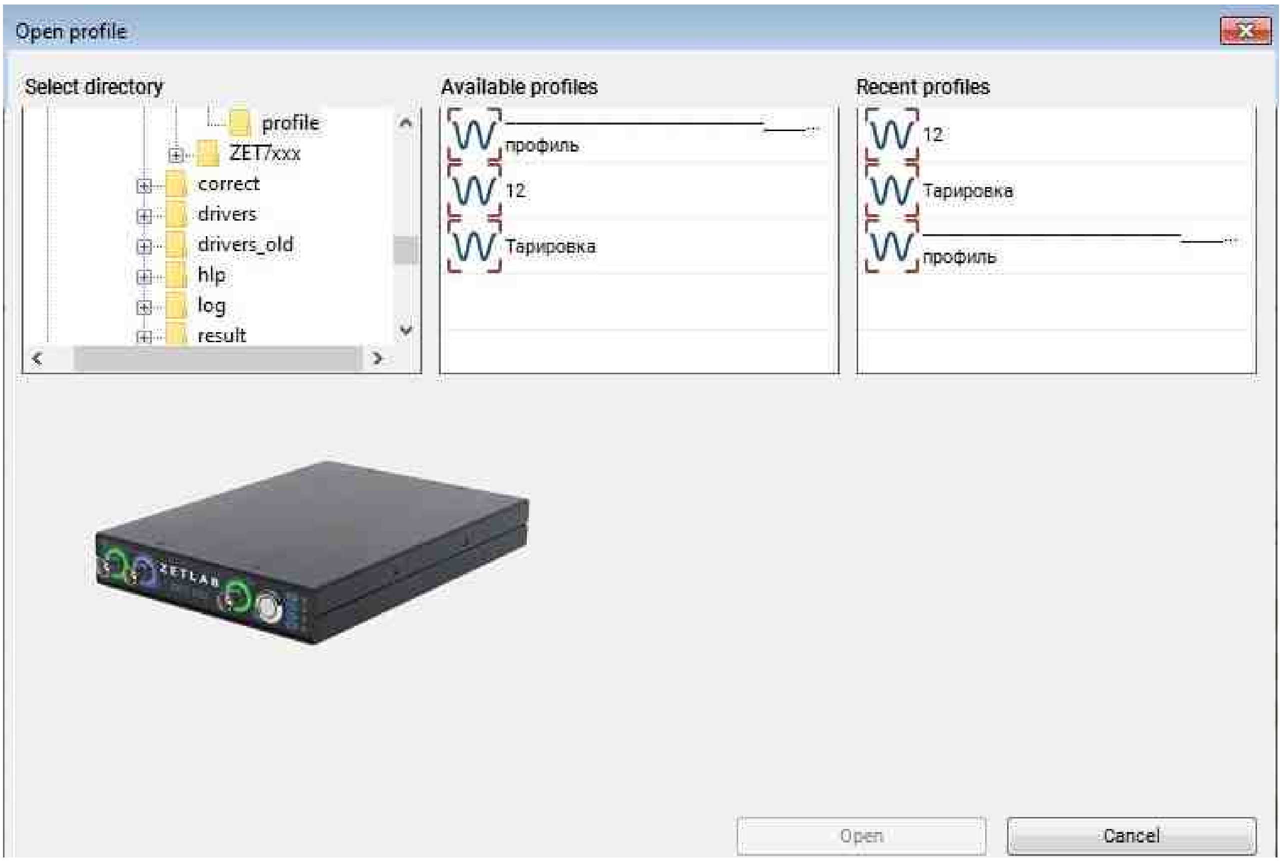


Fig. 11.12 Panel for creating a new profile

When activating the "New profile" panel (*Fig. 11.13*) the program will offer to replace the current profile with a profile with default parameters (profile basic).

Fig. 11.13 Panel for creating a new profile

Testing .....

The lower pane of the "Shock" program displays the event log, where important information of the program operation is saved. After starting the program, the event log will display information of successful download of the Pre-Test files (*Fig. 11.14*).

Current time	Time of testing	Description
15:53:42	00:00:00	Pre-Test files successfully uploaded

Fig. 11.14 Event log of the "Shock" program

Vibration tests are managed from a special menu in the lower-right corner of the program ([Fig. 11.15](#)).

Fig. 11.15 Control menu of the "Shock" program

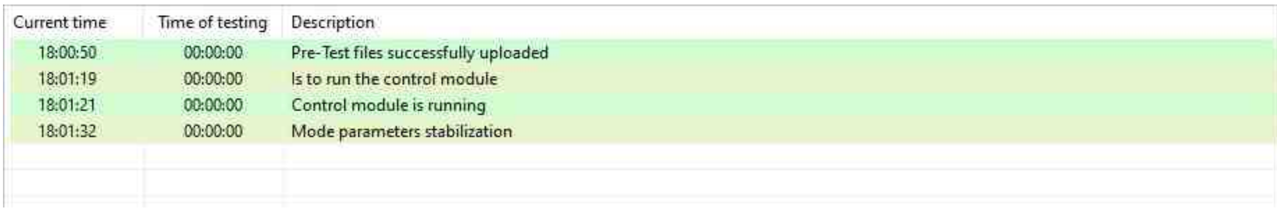
To start vibration tests, it is necessary activate the "Start" button. To stop the tests at an arbitrary point in time, it is necessary activate the "Stop" button. To temporarily stop the tests, it is necessary activate the "Pause" button, and to resume the tests – the "Start" button.

Pressing the "Recording" button starts/stops the process of recording electrical signals from all involved channels of the controller

Fig.. 11.16 Disabled (left) and enabled (right) view of the "Recording" button

Pressing the Recording button starts/stops recording electrical signals from all involved channels of the VCS controller. You can view the recorded signals in the "Results viewing" program from the ZETLab Panel Display menu (see ZETLAB software. Operator's manual).

To start the vibration tests, press the Start button, and the program will gradually bring the test system to the specified mode ([Fig. 11.17](#)).



Current time	Time of testing	Description
18:00:50	00:00:00	Pre-Test files successfully uploaded
18:01:19	00:00:00	Is to run the control module
18:01:21	00:00:00	Control module is running
18:01:32	00:00:00	Mode parameters stabilization

Fig. 11.17 Event log

After clicking on the Start button, the program will start vibration tests and report it in the event log (*Fig. 11.18*).

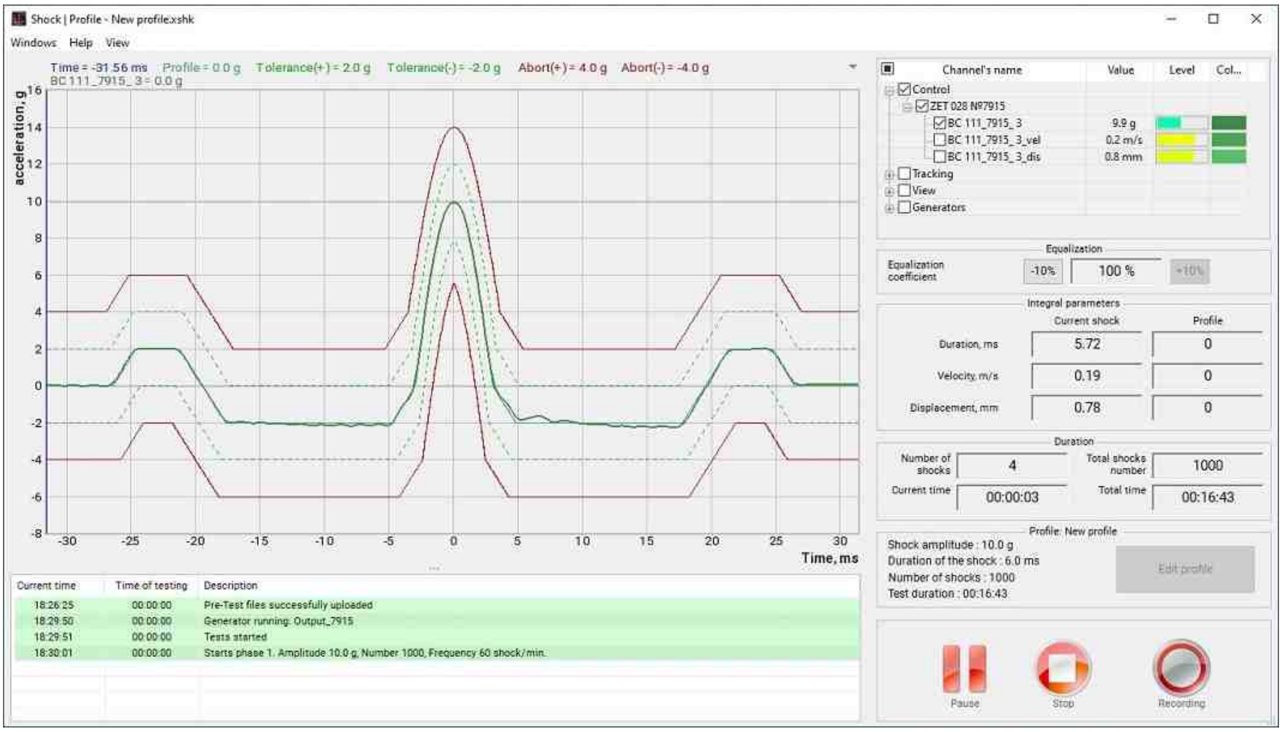


Fig. 11.18 Shock program window

To display a measurement channel on the graphic, select it from the list of channels in the right pane of the program window (*Fig. 11.19*). This list includes all measuring channels for which one of the test control types was selected in the Control Parameters program (Control, Tracking, View). The measurement channel line also displays information of the current acceleration and the integral load level for this channel.

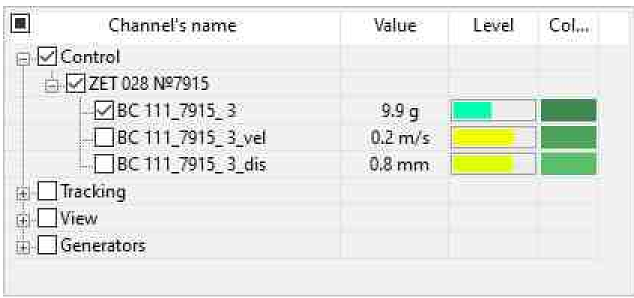


Fig. 11.19 Menu for selecting channels to display on the graphic

During the tests, if the value of the control channel exceeds the thresholds set on the Limits tab, the event log will display information about exceeding the threshold, and the tests will be stopped (*Fig. 11.20*).

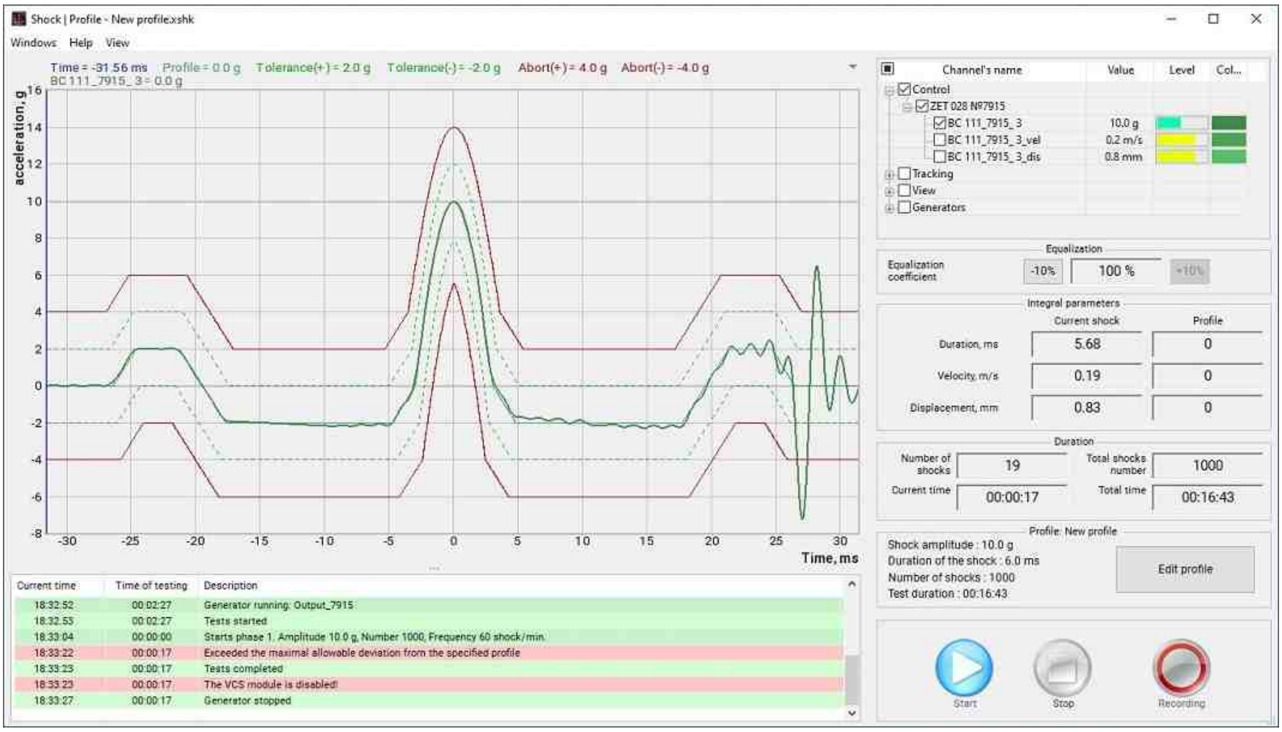


Fig. 11.20 Stopping vibration tests

Additional graphics .....

During the tests, it is possible to track changes in the condition of the specimen under test at the point (s) of the control channel setup in real time. To do this, start the Additional graphics program (*Fig. 11.21*) from the Windows menu.

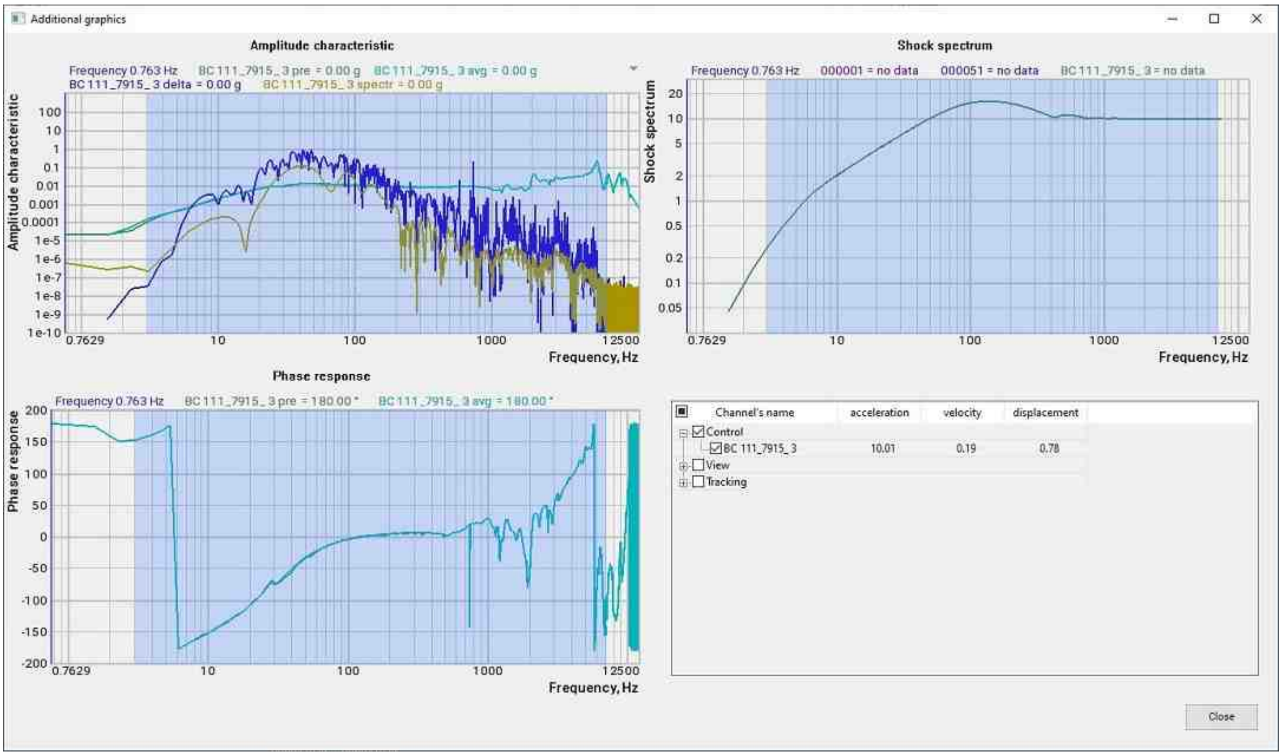


Fig. 11.21 "Additional graphics" program window

The graphics of the "Additional graphics" program show deviations of the current spectrum parameter values of the selected channel from the spectrum parameter values of the control channel generated in the test profile after passing the Pre-Test. The calculation can be performed relative to the control channel or the generator channel.

Data recorder .....

To display information of the temporary implementation of signal parameters, start the Data recorder program from the Windows menu of the Shock program. The opened Results table window (Fig. 11.22) will show information of the vibration test process in the past.

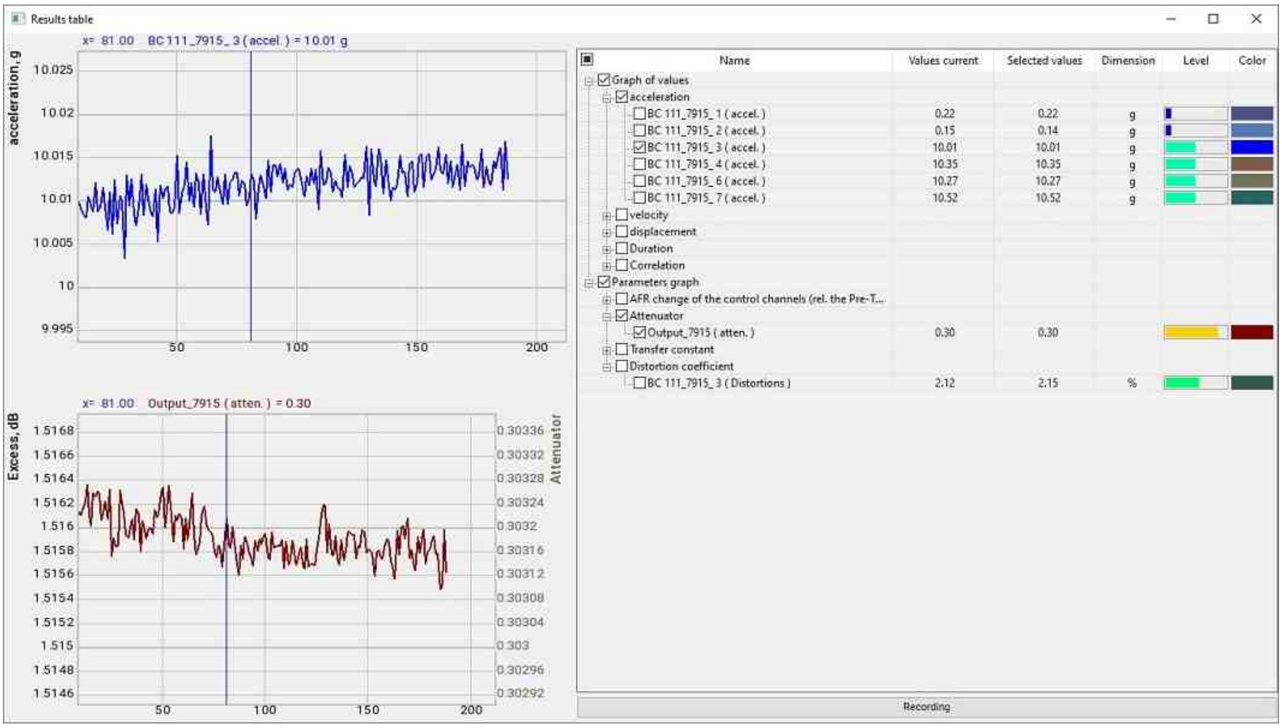


Fig. 11.22 The Data recorder program window

The upper-right corner lists the names of channels with Available graphics. You can change the graphic color by clicking on the colored rectangle. To save the recorder readings,  press the Recording button. Only selected graphics available in the Results viewing program will be saved.

The program "Signals" launches the window of the program "Multi-channel oscilloscope", which allows you to observe the signals recorded from the measuring channels of the VCS

Note*: In cases of problems with the tests: the tests were interrupted for some unknown reason, the tests do not start, there are significant distortions on the profile graphic, etc., to identify the cause, send us an email* [***INFO@ZETLAB.COM***](mailto:INFO@ZETLAB.COM) *an archived folder with files for the current test day. To go to the folders with the information we need, activate the text link "Tests results" on the VCS panel*

Results report .....

To save the report, start the Report program from the Windows menu of the Shock program. In the opened window, enter the name of report file and specify the path to save it, then press the Recording button (*Fig. 11.23*).

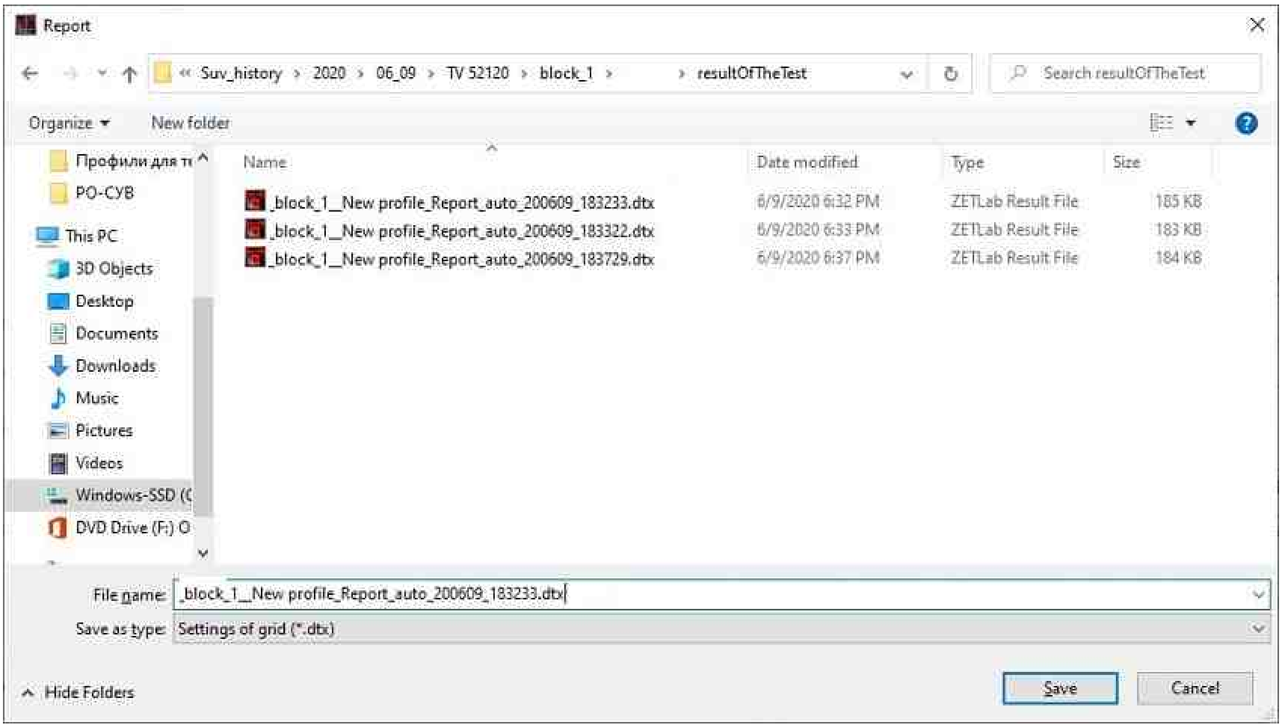


Fig. 11.23 Saving the vibration test report file

You can view the report file using the Results viewing program. To do this, right-click on the file and select Open in ResultViewer (*Fig. 11.24*) from the context menu.

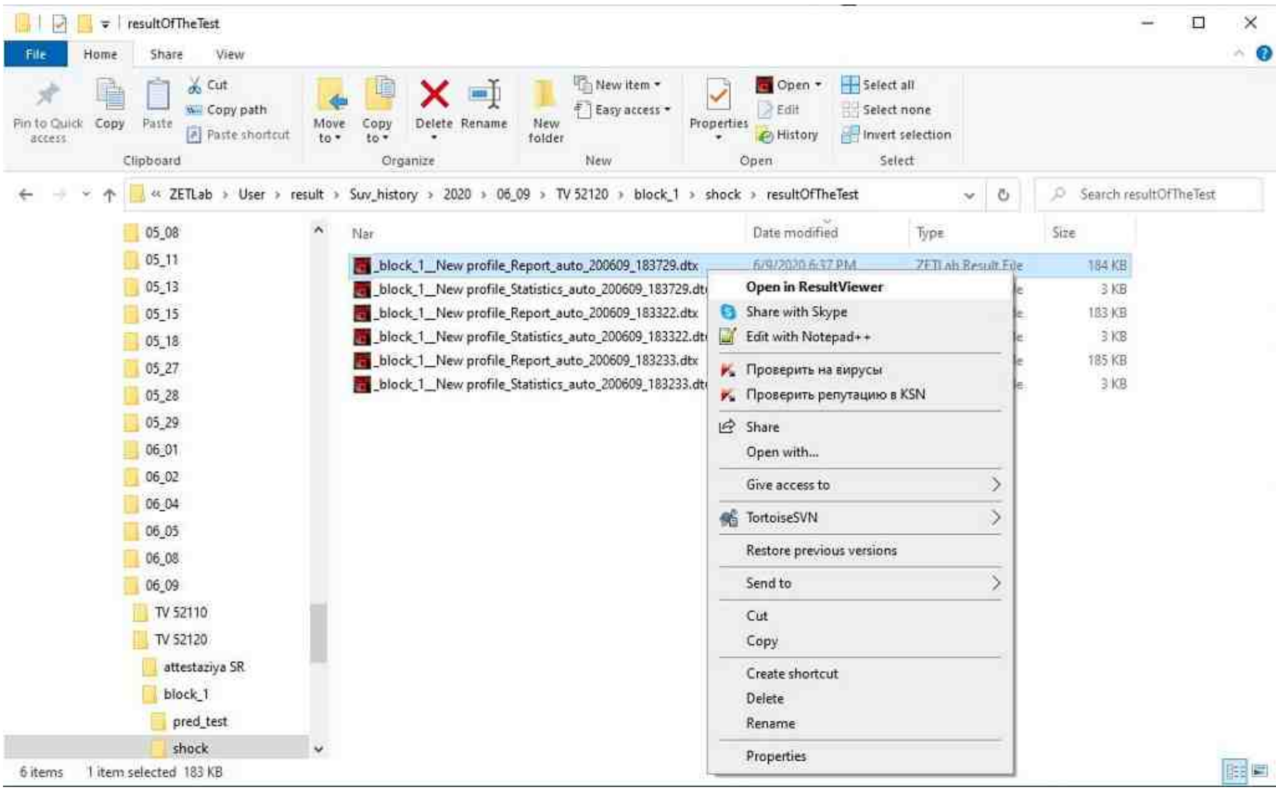


Fig. 11.24 Viewing the vibration test report file

Appendix A. Shapes of the shock pulse accelerograms .....

The ***Fig. A1***-***Fig. A5*** show the accelerogram forms of waveforms being generated with specified parameters.

T (duration of shock, ms) refers to the duration of the signal of the corresponding waveform.

A (amplitude of blow, g) refers to peak value of Acceleration.

T1 (rise time, ms) refers to the time to reach the maximum value for the trapezoidal waveform.

T2 (decay time, ms) refers to the time when the signal drops to the minimum value, for trapezoidal and sawtooth impulses.

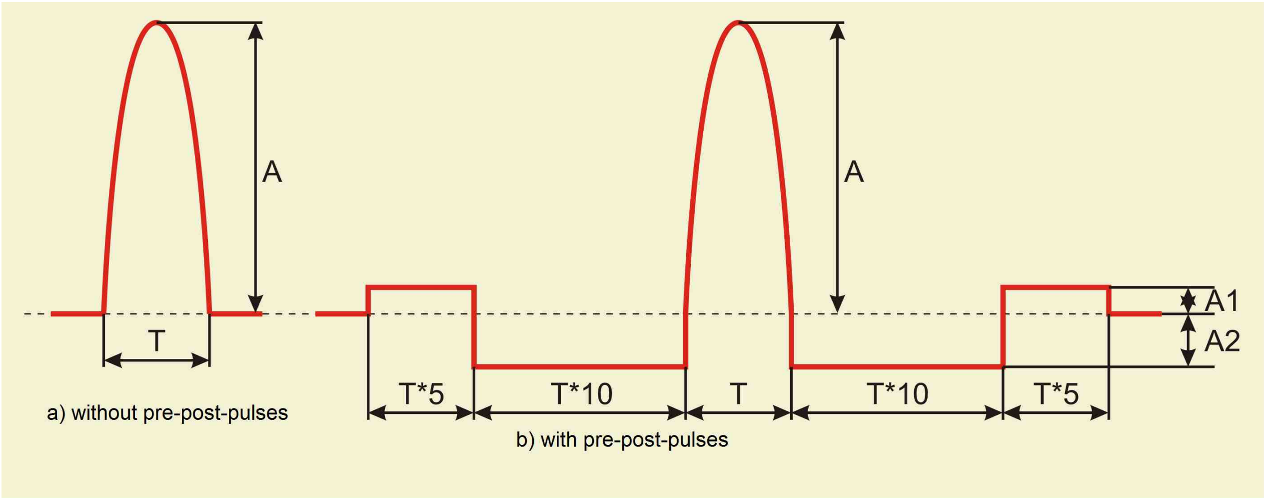


Fig. A.1 Sinusoidal waveform

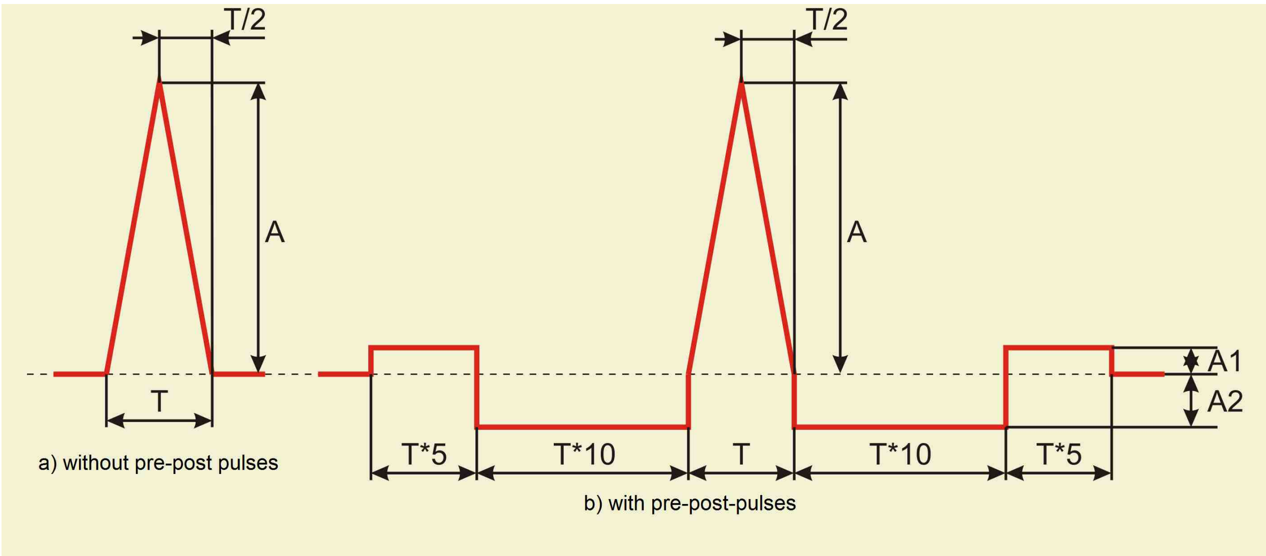


Fig. A.2 Triangular waveform

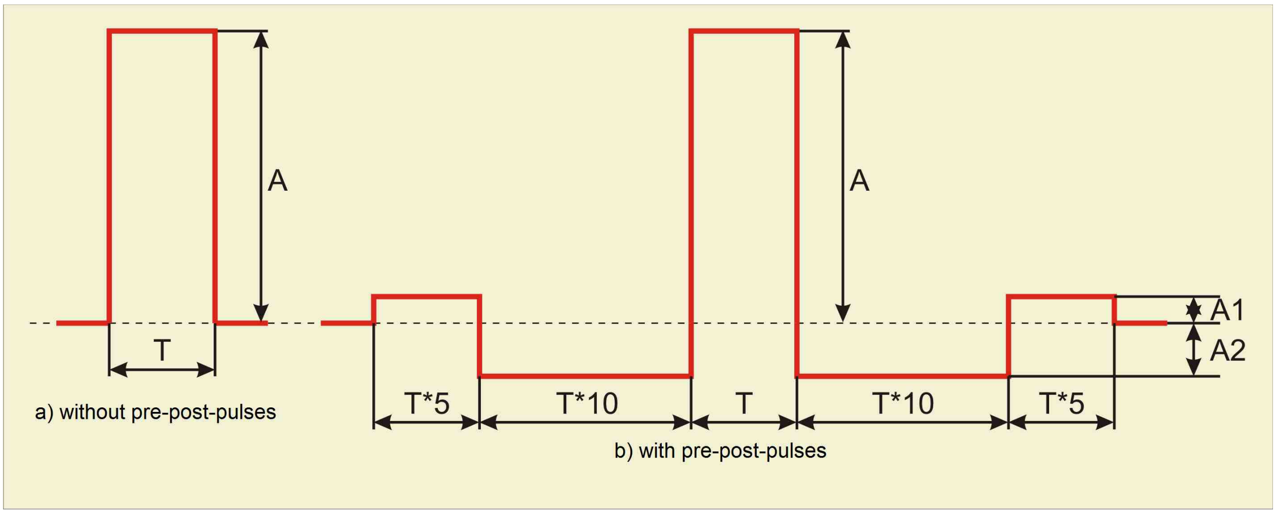


Fig. A.3 Rectangular waveform

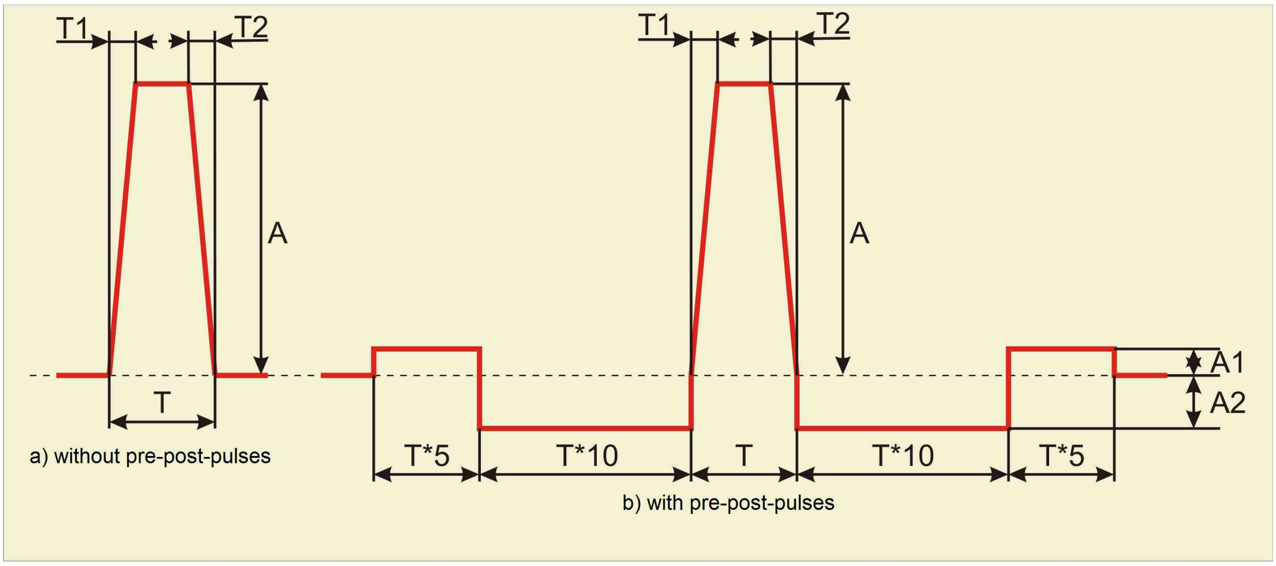


Fig. A.4 Trapezoidal waveform

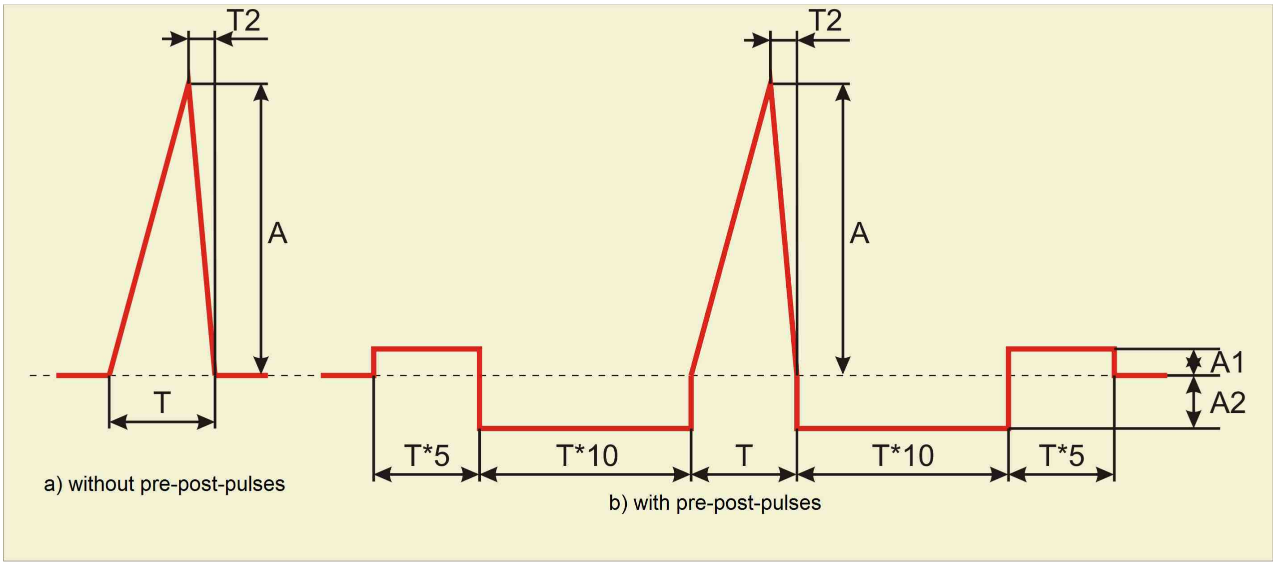


Fig. A.5 Sawtooth waveform

Appendix B. Common errors when operating ZETLAB VCS .....

1. Low Pre-Test quality due to poor contact of the control signal cable

Fig. B.1 shows an example of a negative Pre-Test result obtained on a shaker with an extension table. The conclusion on the low Pre-Test quality is mainly based on the high harmonic distortion factor (close to 0 dB). The Signal Quality parameter (in the results table) also indicates the low results quality. Its value is below 90 % (highlighted in yellow or red).

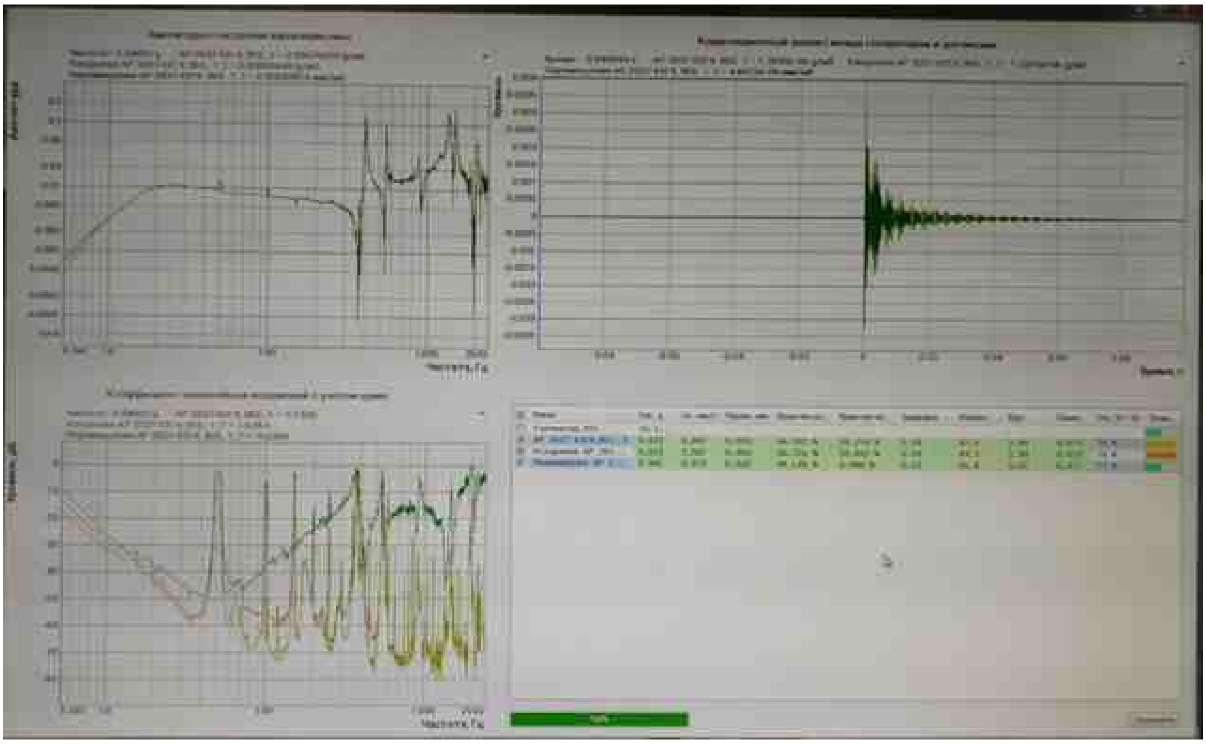


Fig. B.1. Negative Pre-Test result

In this case, it is needed to identify and rectify the cause of the negative Pre-Test result before the commencement of testing. To do this, click the Recommendations button in the Pre-Test program window and in the appeared window check the suggested options of probable failures. Eliminate the cause, if relevant. If nothing of the suggested recommendations gives the result, try the options below, one by one:

- poor grounding,
- poor contact,
- damaged cable,
- failed sensor.

After fault handling, repeat the Pre-Test and make sure that the result is positive. *Fig. B.1* shows an example of a positive Pre-Test result after handling a fault related to poor contact of the control cable.

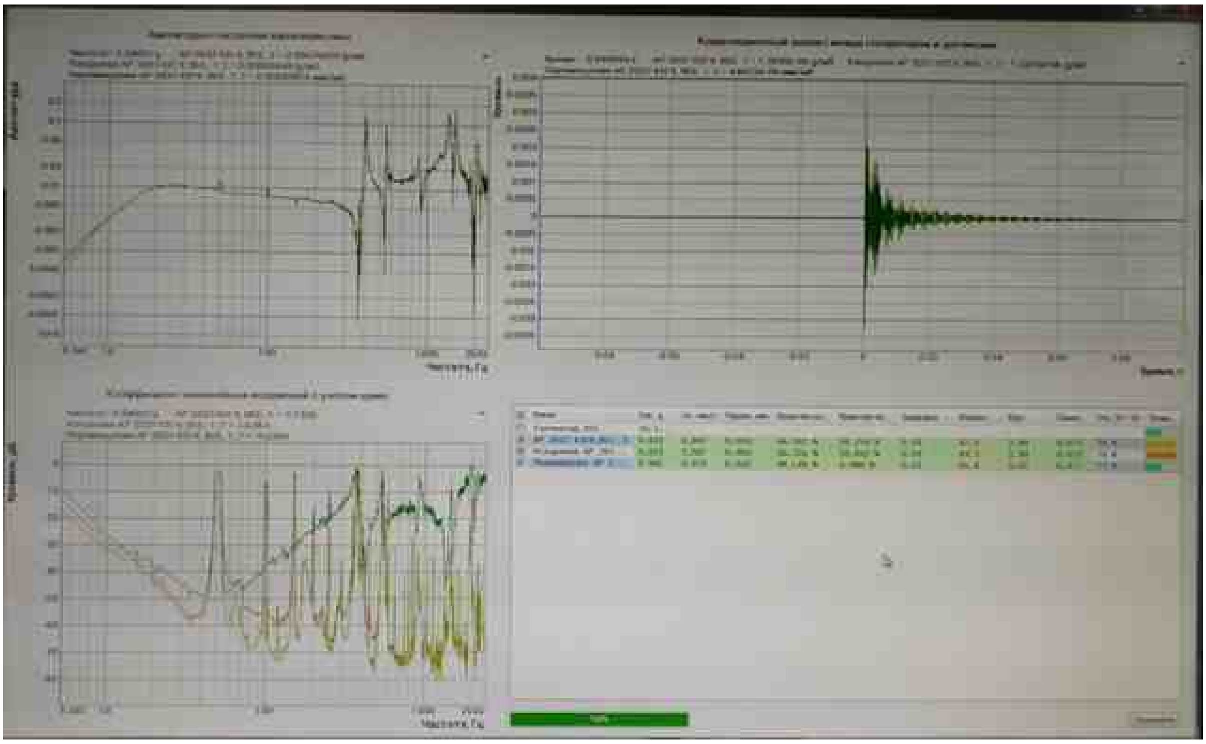


Fig. B.2. Positive Pre-Test result

2. Poor Pre-Test quality due to poor grounding

Fig. B.3 shows an example of low quality of a Pre-Test result obtained on an empty shaker (without an extension table). The conclusion on the low Pre-Test quality is mainly based on the high harmonic distortion factor in the low-frequency region (exceeding -20dB). The Signal Quality parameter (in the results table) also indicates low quality of the Pre-Tests results for an empty shaker. Its value is below 98%. A positive result of Pre-Test (for an empty shaker) is at least 99% signal quality level.

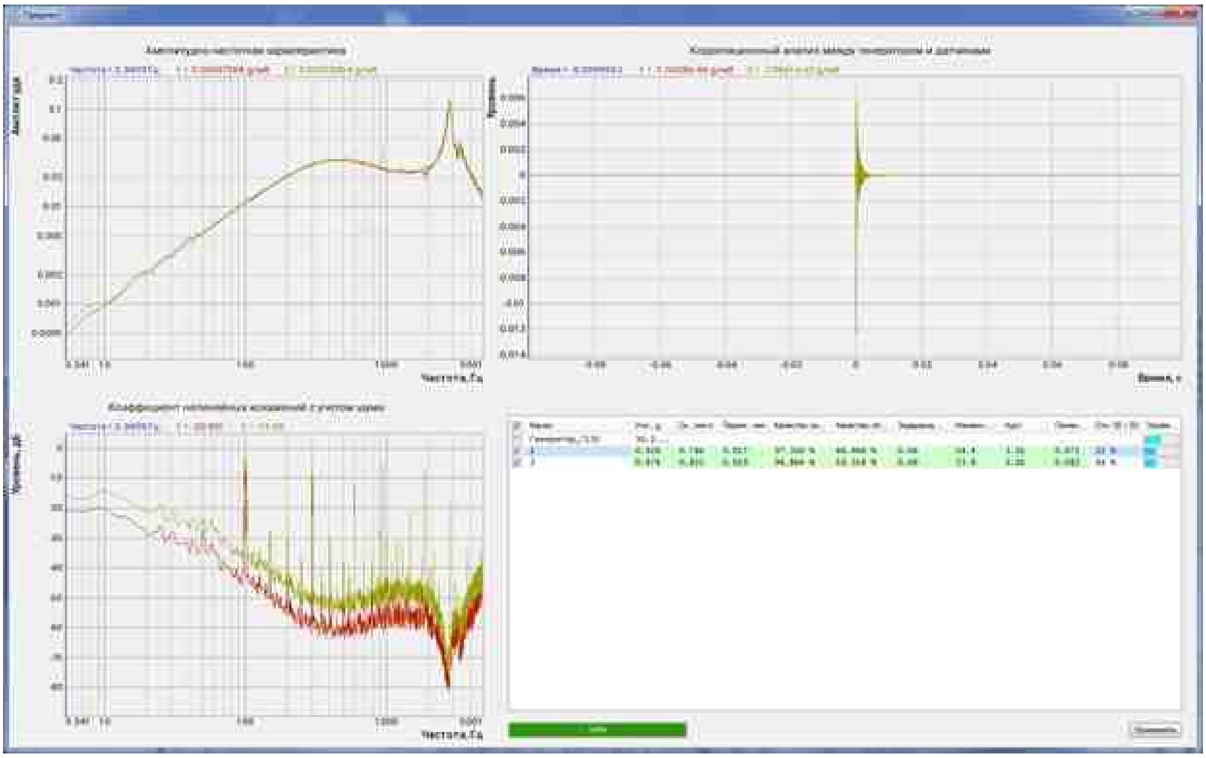


Fig. B.3. Low Pre-Test result quality

After proper grounding, the Pre-Test was repeated. Its results are shown in *Fig. B.4*. The Fig. shows that the harmonic distortion factor decreased significantly (below -30 dB) and the signal quality increased (above 99 %).

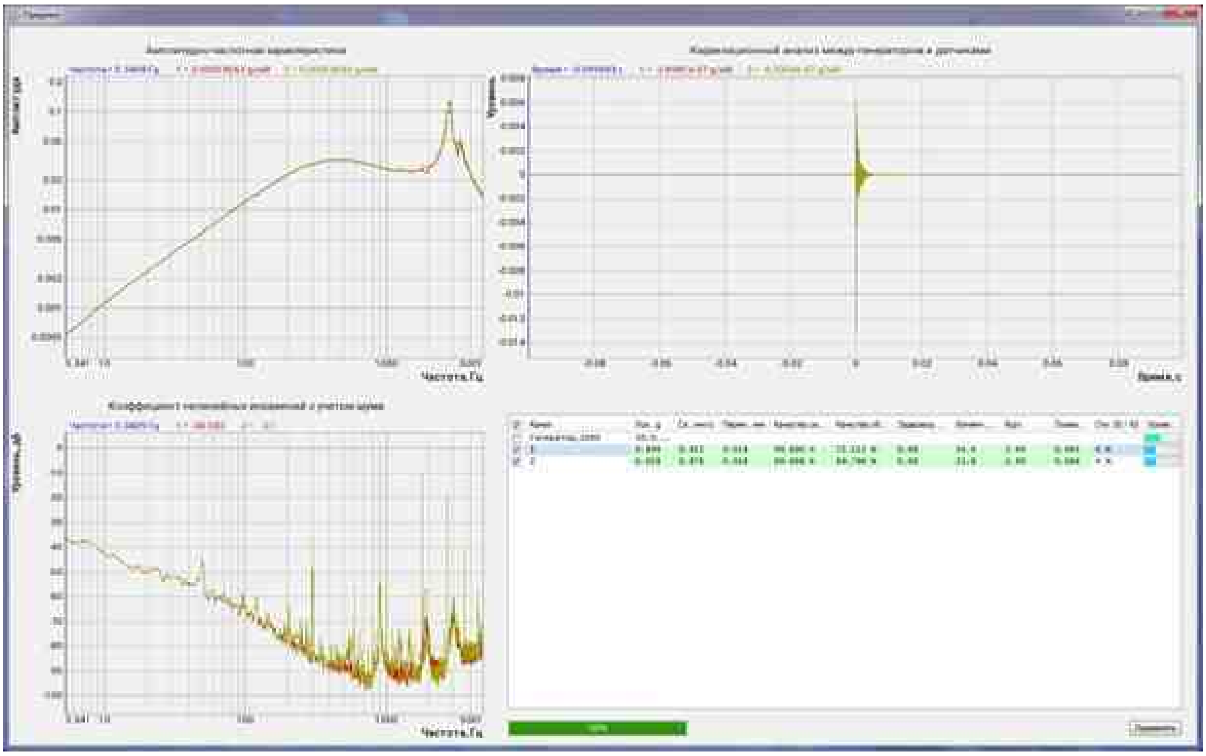


Fig. B.4. High Pre-Test result quality

3. Influence of the shaker frame's horizontal position on the transverse vibration level

Fig. B.5 shows harmonic distortion curve plotted at a small deviation of the shaker frame from the horizontal position (within 2 degrees), while *Fig. B.6*, at the frame horizontal position. During the comparative tests, the shaker was loaded to 60 % of the maximum permissible load, and the effect level was 25 % of the maximum permissible level considering the installed weight.

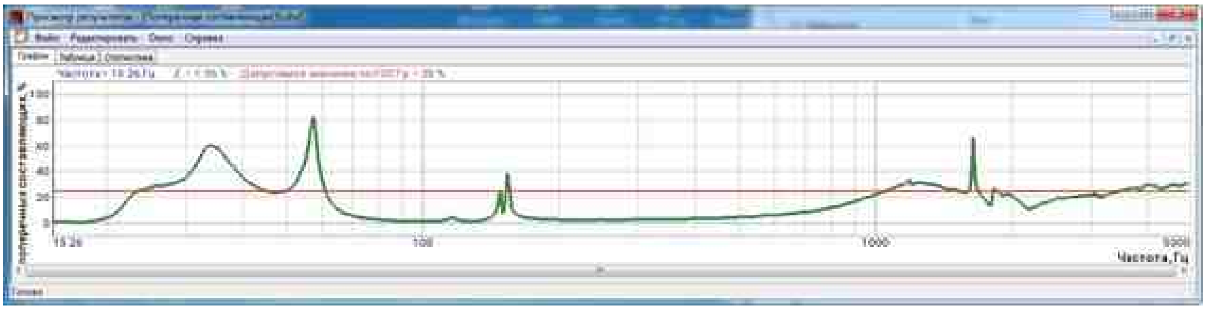


Fig. B.5. Frame deviates from the horizontal position

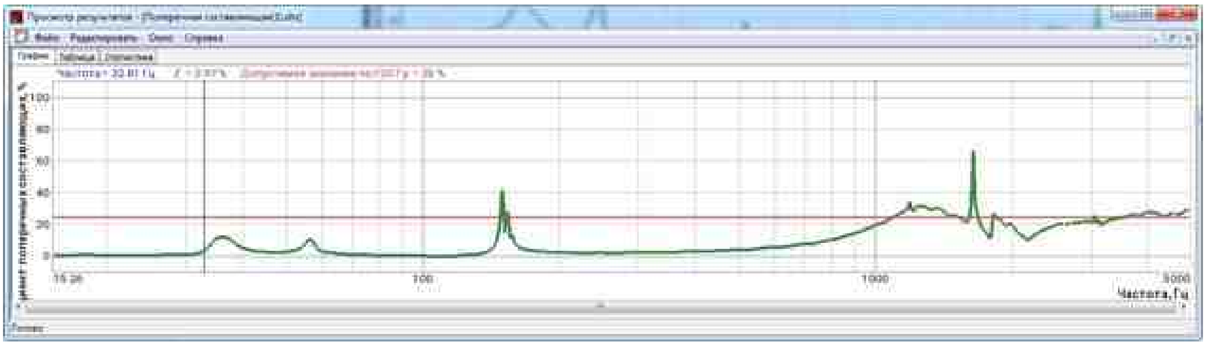


Fig. B.6. Frame is in a horizontal position

The curves show that in the suspension member resonance region (20...50 Hz) even small deviations from the horizontal position may cause significant transverse vibrations on the shaker. This may be an obstacle both at the certification stage as well as during testing, especially when a significant effect level is set.

User defined transient .....

Program purpose

The program is intended for single or multiple vibrational shock testing. In this program, you can generate a series of shocks with pre-set timing parameters filled with noise in a certain frequency band.

Preparation for testing

When preparing for vibration resistance tests in a wide frequency range, set the following parameters (if not set): shaker parameters, specimen parameters, channel parameters (see sections 5-7), and then perform a Pre-Test according to section *8*.

To switch to "User defined transient" program window, click the User defined transient button on the VCS (Vibration Control System) (*Fig. 4.1*). The User defined transient program window will be displayed on the screen (*Fig. 12.1*).

Attention! *The "User defined transient" button on the VCS Panel will be available only if the program detects Pre-Tests results.*

Edit Profile .....

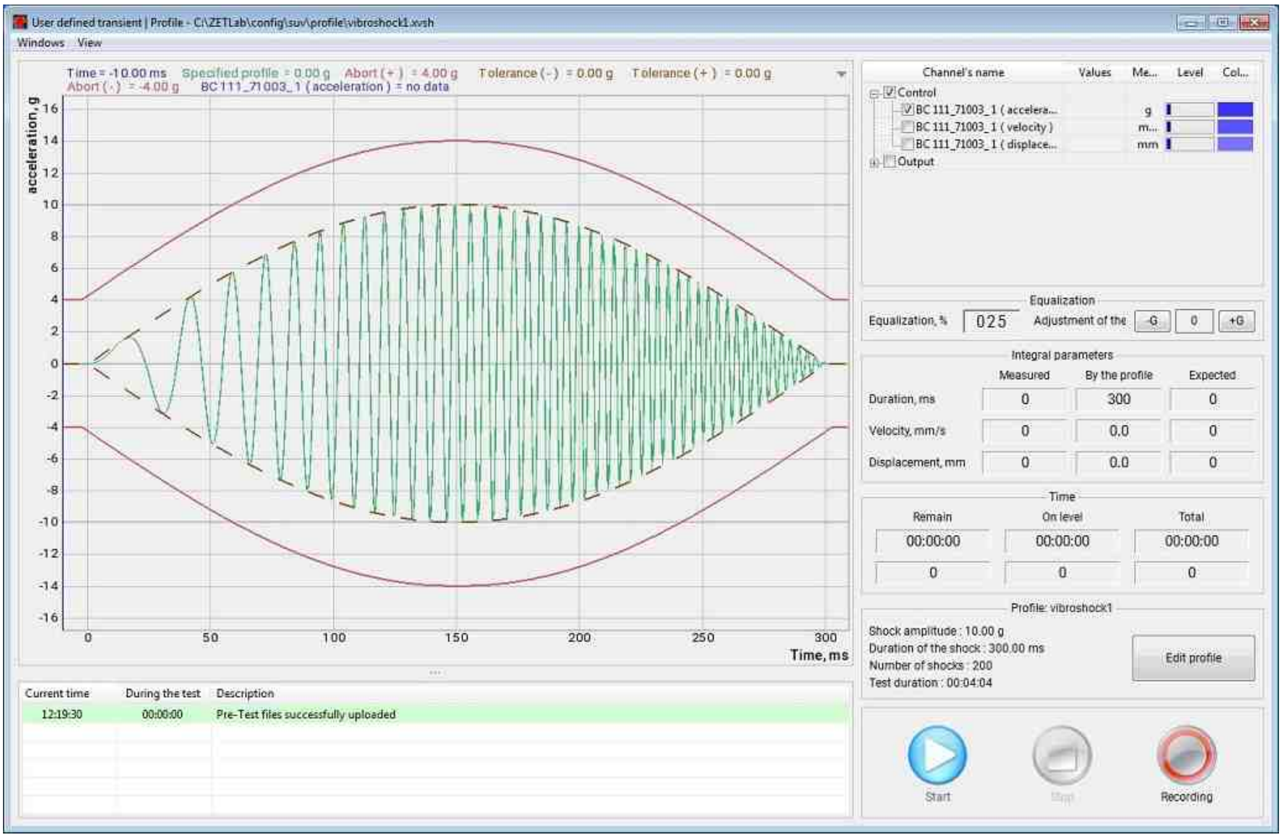


Fig. 12.1 "User defined transient" window

To set a test profile, click the Edit Profile button (*Fig. 12.2*) in the User defined transient window.

Envelope tab .....

When you start the "Vibration tests profile editor" program, the "Edit profile – User defined transient" program window open with the active Envelope tab (*Fig. 12.2*).

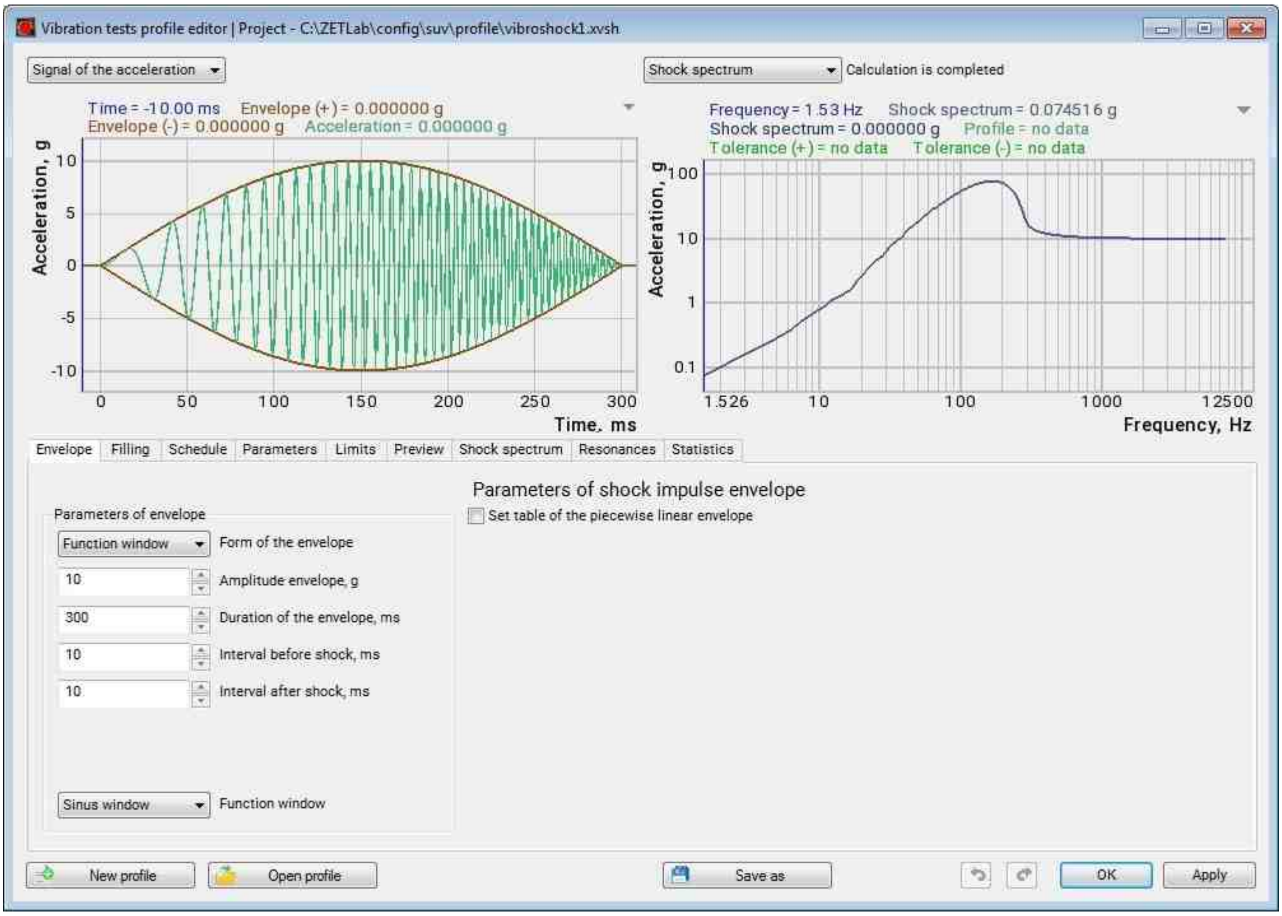


Fig. 12.2 Edit profile with Envelope tab

On the Envelope tab, you can set shock impulse envelope curve parameters.

You can set as the "Envelope form" parameter:

- Rectangular,
- Trapezoidal,
- Damping,
- Teardrop,
- Function window,
- Piecewise linear.

The "Amplitude envelope" parameter defines the maximum amplitude of the shock impulse envelope in "g" units.

The "Envelope duration" parameter defines the shock impulse amplitude duration, in ms.

The "Interval before shock" and "Interval after shock" parameters define intervals before and after the shock, respectively, in ms.

The "Upward slope" and "Downward slope" parameters set the angle of inclination of the side edges of the shock impulse envelope in percentage when the envelope form is selected – "Trapezoidal".

The "Attenuation constant" parameter set the attenuation constant of the shock impulse envelope when the envelope form is set to "Attenuation" or "Teardrop".

The "Window function" parameter becomes active when the "Window function" envelope form is selected. There are two options for the window function to choose from:

- Sine window;
- Hann window.

When you select the form of the envelope "Piecewise linear" for editing, the corresponding table on the "Envelope" tab becomes active.

To add new rows to the table, activate the "Add" button.

Filling tab .....

When you start the "Vibration tests profile editor" program, the "Edit profile – User defined transient" program window open with the active Filling tab (*Fig. 12.3*).

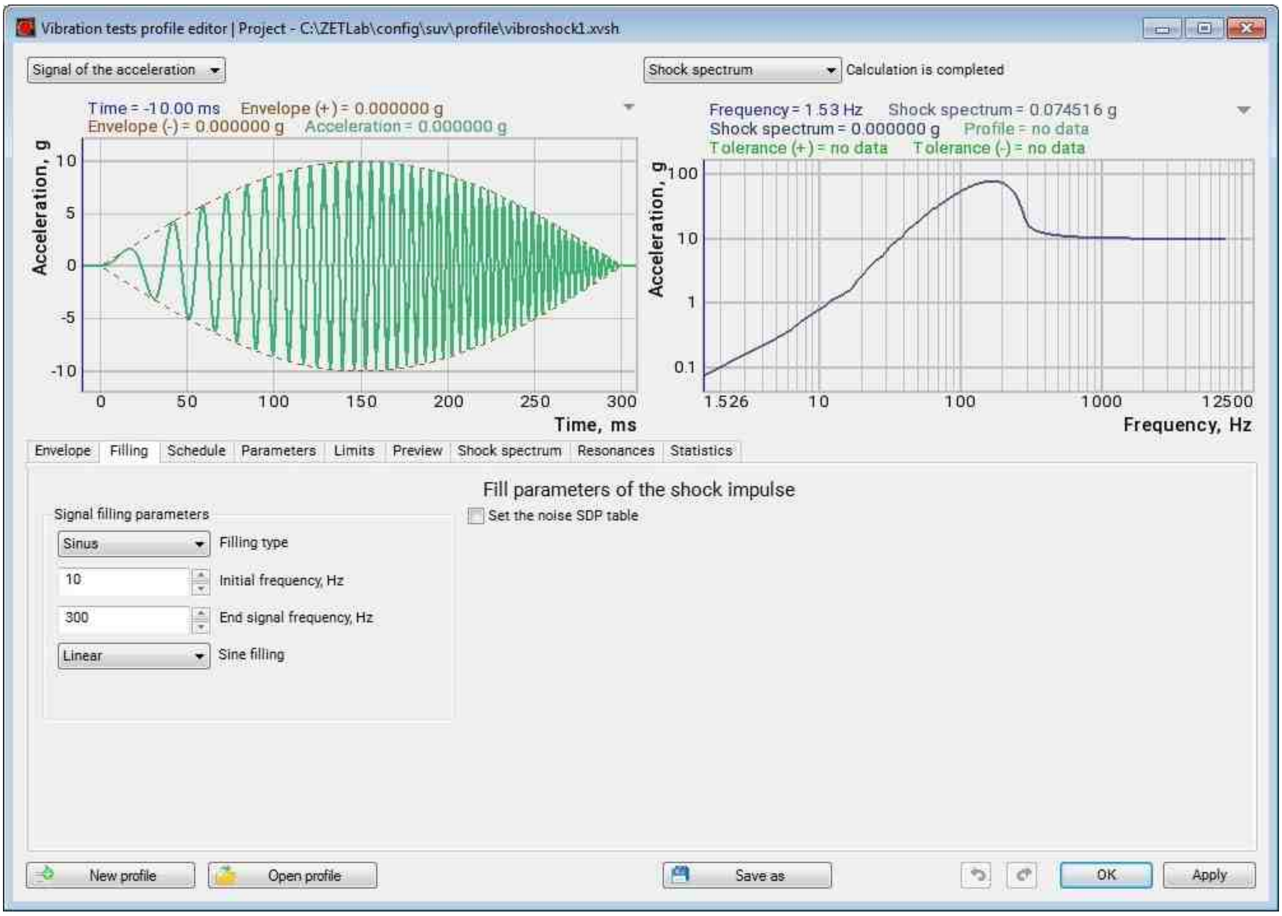


Fig. 12.3 "Edit profile" window, Filling tab

On the Filling tab, shock impulse spectral component parameters can be set.

The following shock impulse fill options are available for the "Signal filling" parameters:

- Sine,
- Noise.

The "Initial Frequency" and "End Signal Frequency" parameters define the frequency band for the shock impulse fill.

For the "Sine" fill, "Linear" and "Logarithmic" fill methods are available.

For the Noise fill, "Uniform" and "Table" fill methods are available.

When choosing the shock impulse filling method

"Tabular" for editing, the corresponding table becomes active on the "Filling" tab. To add new rows to the table, activate the "Add" button.

Schedule tab .....

When you start the "Vibration tests profile editor" program, the "Edit profile – User defined transient" program window open with the active Schedule tab (*Fig. 12.4*).

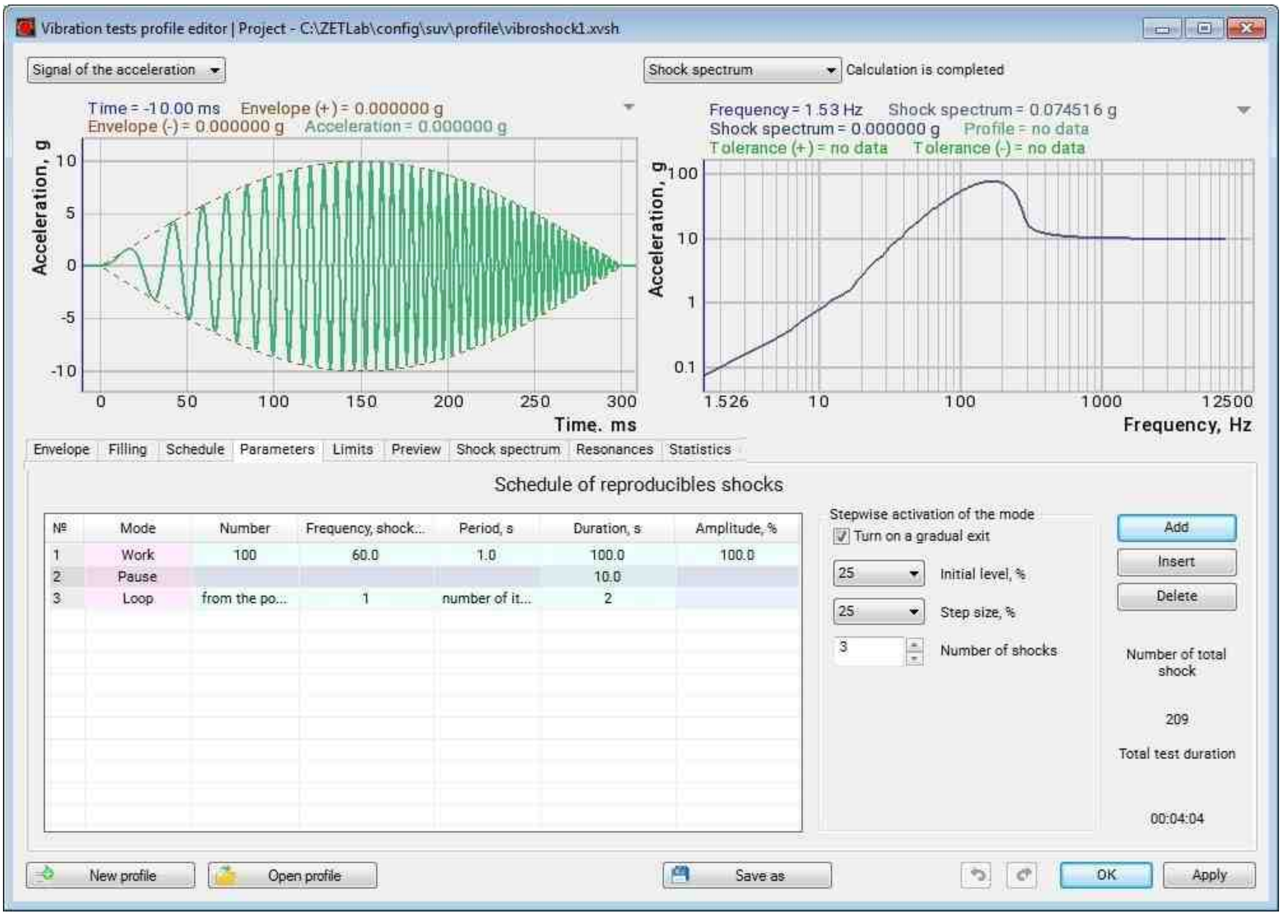


Fig. 12.4 "Edit profile" window, Schedule tab

On the "Schedule" tab, the test schedule is set, in particular, the number of shocks, frequency, duration, period, and the ratio of the current shock amplitude to the amplitude determined by the test profile.

The vibration test schedule is a data table. To add new rows to the "Schedule of reproducible shocks" table, activate the "Add" button as many times as necessary to add test ranges.

The "Number" column sets the total number of hits in the test.

The "Frequency of shocks / min" column sets the number of shocks per minute is set.

The "Duration, s" column sets the total time of the test is set.

In the "Amplitude, %" column, the amplitude of the shock impulse is set, as a percentage of the value set for the "Shock amplitude" parameter.

The "Stepwise starting" activation of the mode parameter defines a gradual process stabilization increasing evenly the repeatable shock level on each stage.

Parameters tab .....

When you start the "Vibration tests profile editor" program, the "Edit profile – User defined transient" program window open with the  active Parameters tab (*Fig. 12.5*).

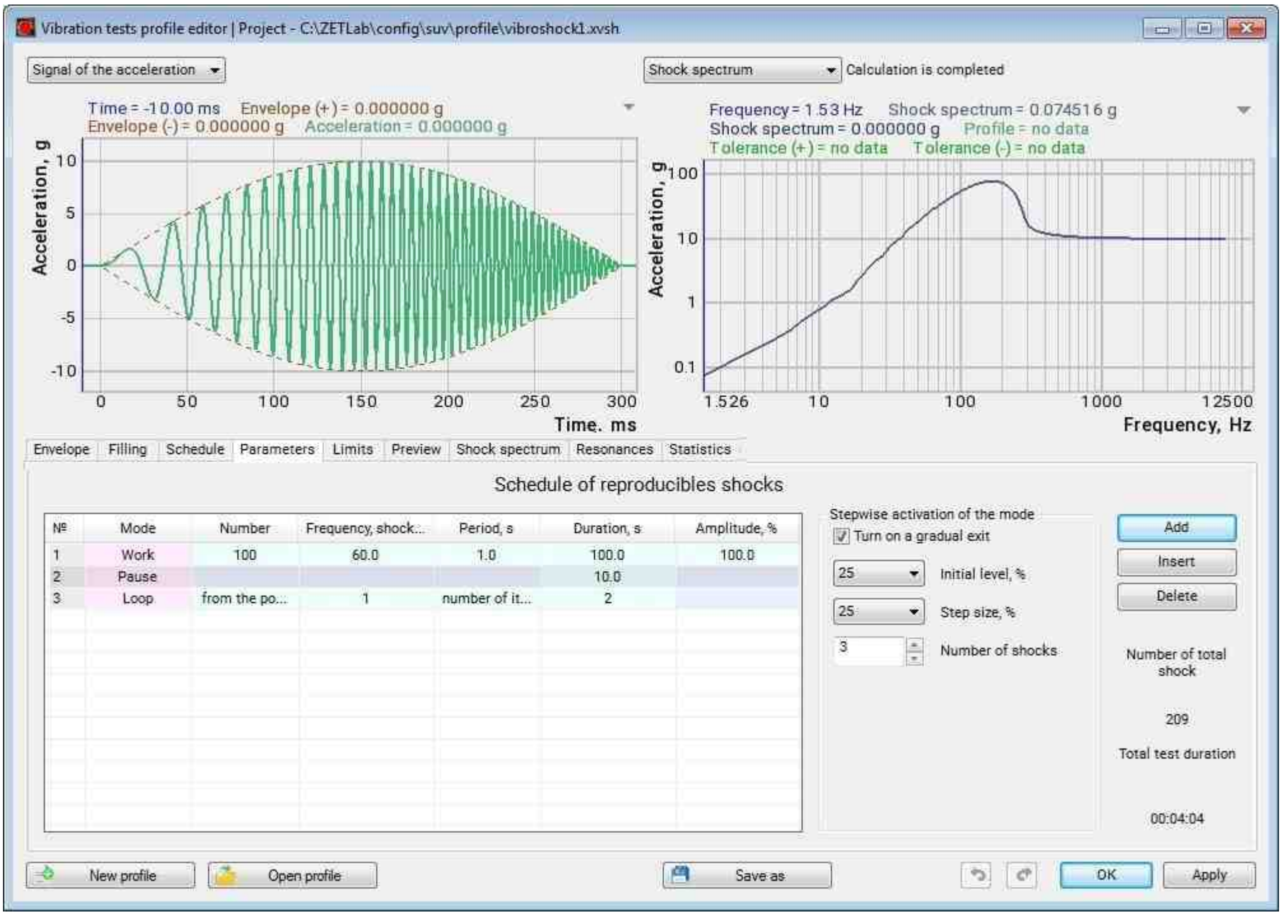


Fig. 12.5 "Edit profile" window, Parameters tab

Limits tab .....

When you start the "Vibration tests profile editor" program, the "Edit profile – User defined transient" program window open with the active Limits tab (*Fig. 12.6*).

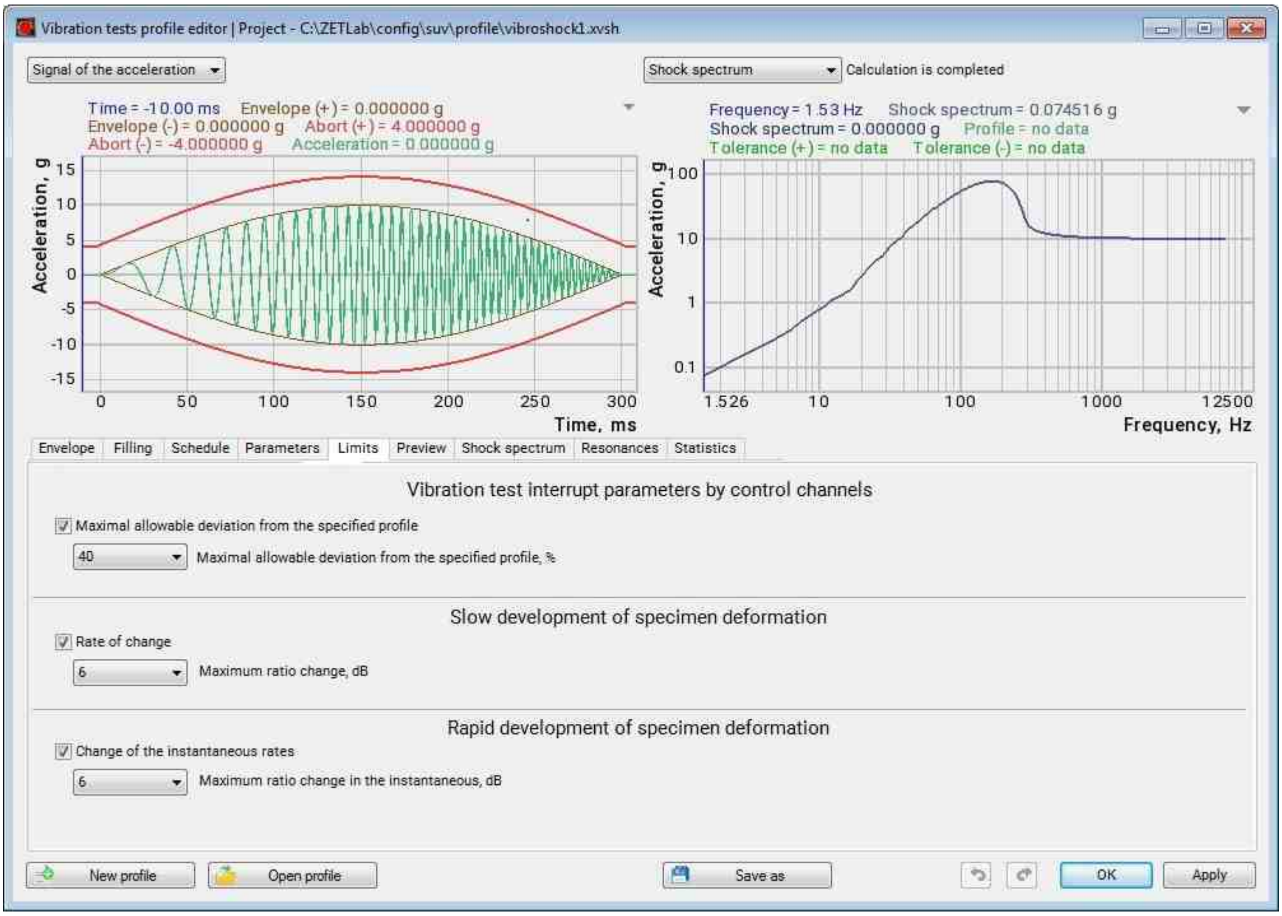


Fig. 12.6 "Edit profile" window, Limits tab

On the Limits tab, you can set the test thresholds (in dB and %) for the control channel. According to the parameters with enabled control, (during the tests) exceeding the set parameter values will be monitored, and if they are exceeded, the tests will stop immediately.

To enable control by parameter, activate (check the cell) the corresponding parameter, and to disable it, deactivate it (uncheck the cell).

You can set limits for the following parameters of a control channel:

- Maximum allowable deviation from the specified profile;
- Allowable deviation from the specified profile;
- Change of the instantaneous rates.

Preview tab .....

When you start the "Vibration tests profile editor" program, the "Edit profile – User defined transient" program window open with the active Preview tab (*Fig. 12.7*).

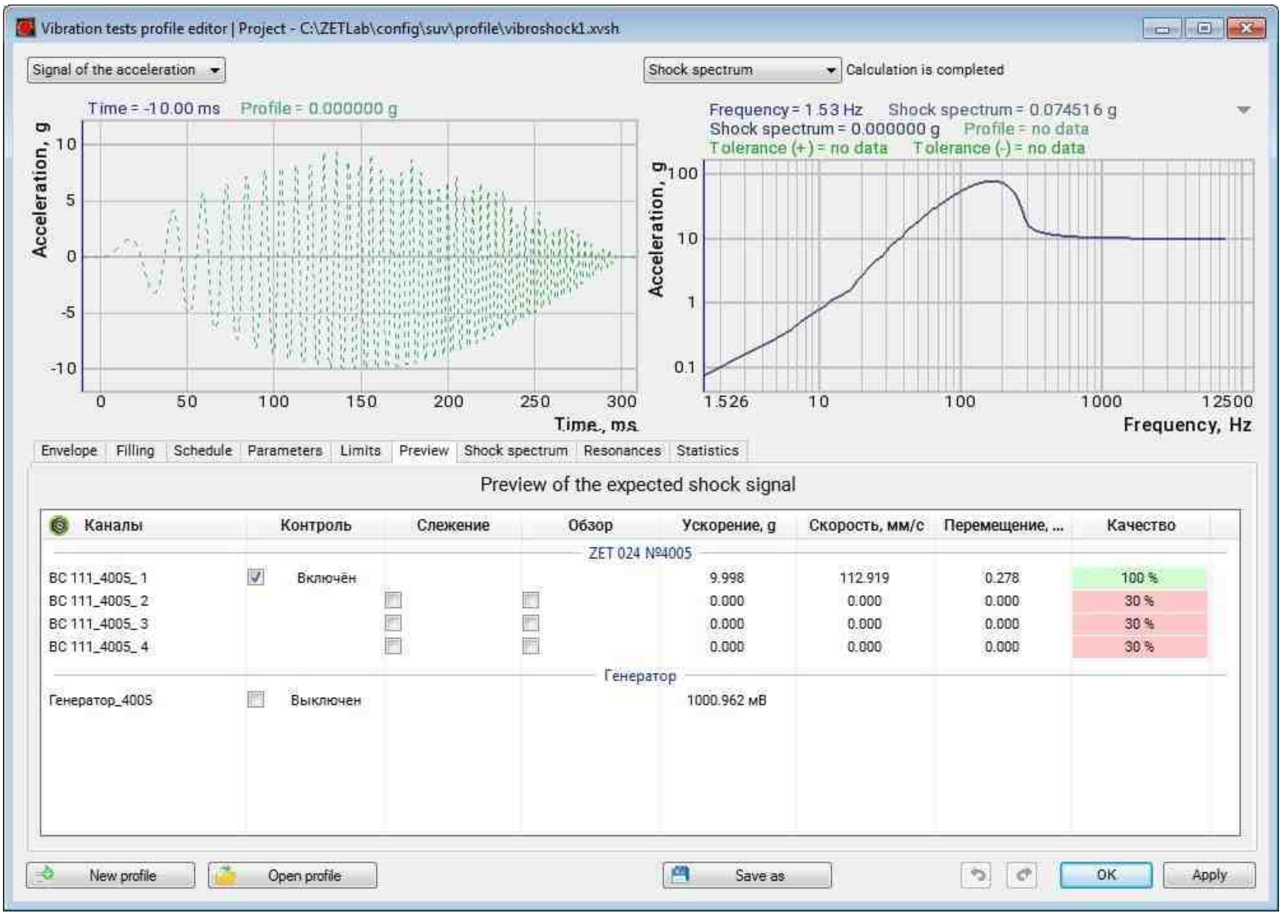


Fig. 12.7 Edit profile window, Preview tab

On the Preview tab, the set shock profile preliminary spectra built through calculations based on the Pre-Test data are displayed.

The spectra are provided for all the VCS controller measurement channels selected on the Pre-Test stage. For each measurement channel, you can set any control type (control, monitor, display) or check noise level in the channel. To display a required vibration spectrum, check the relevant cell in the table.

Note: *Information provided by the spectra is for information only; it is for providing the VCS operator with the expected results to be obtained in vibration tests using the set profile.*

Shock spectrum tab .....

When you start the "Vibration tests profile editor" program, the "Edit profile – User defined transient" program window open with the active Shock spectrum tab (Fig. 12.8).

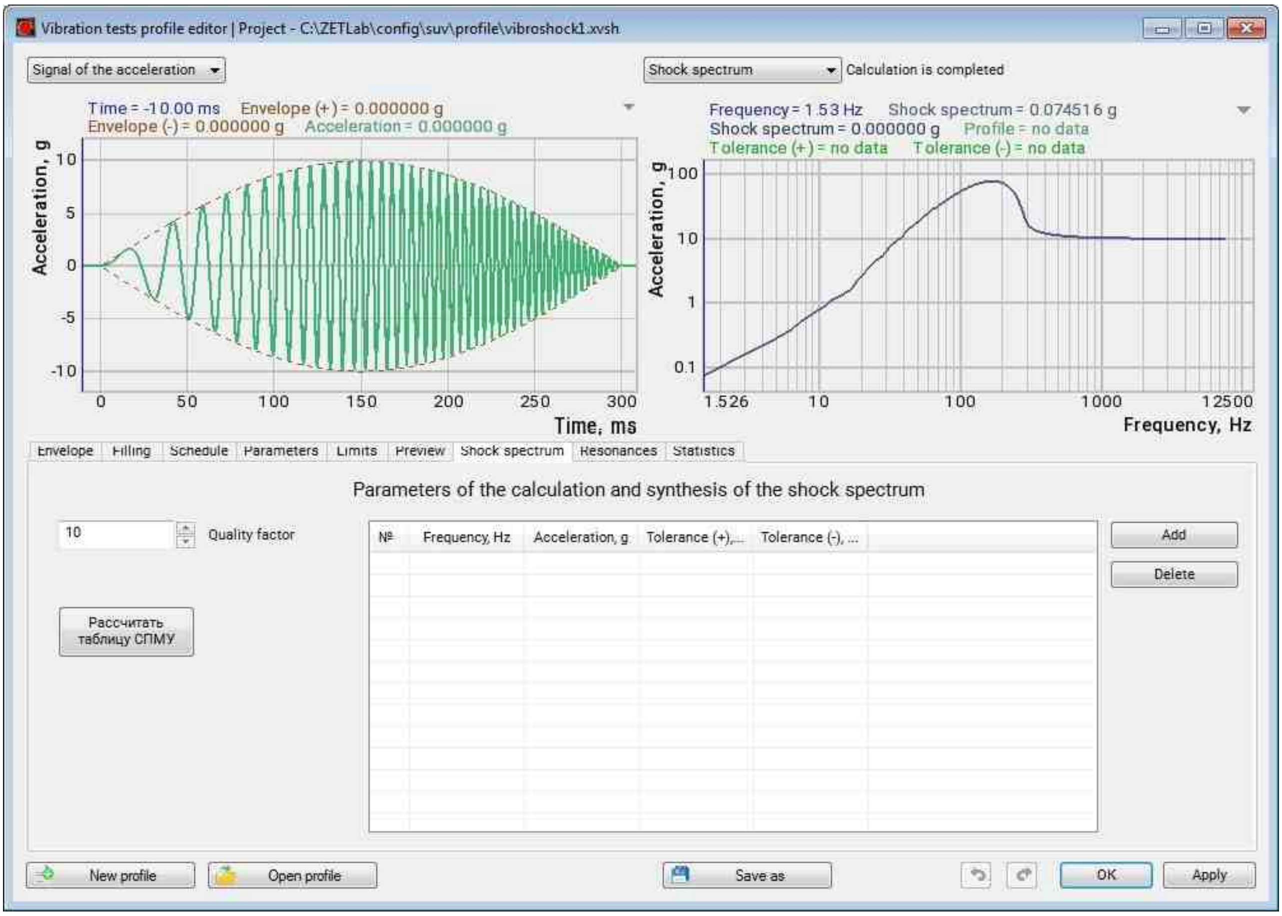


Fig. 12.8 Edit profile window, Shock Spectrum tab

Parameters for shock spectrum calculation are set on the "Shock spectrum" tab.

Resonances tab .....

When you start the "Vibration tests profile editor" program, the "Edit profile – User defined transient" program window open with the active Resonances tab (Fig. 12.9).

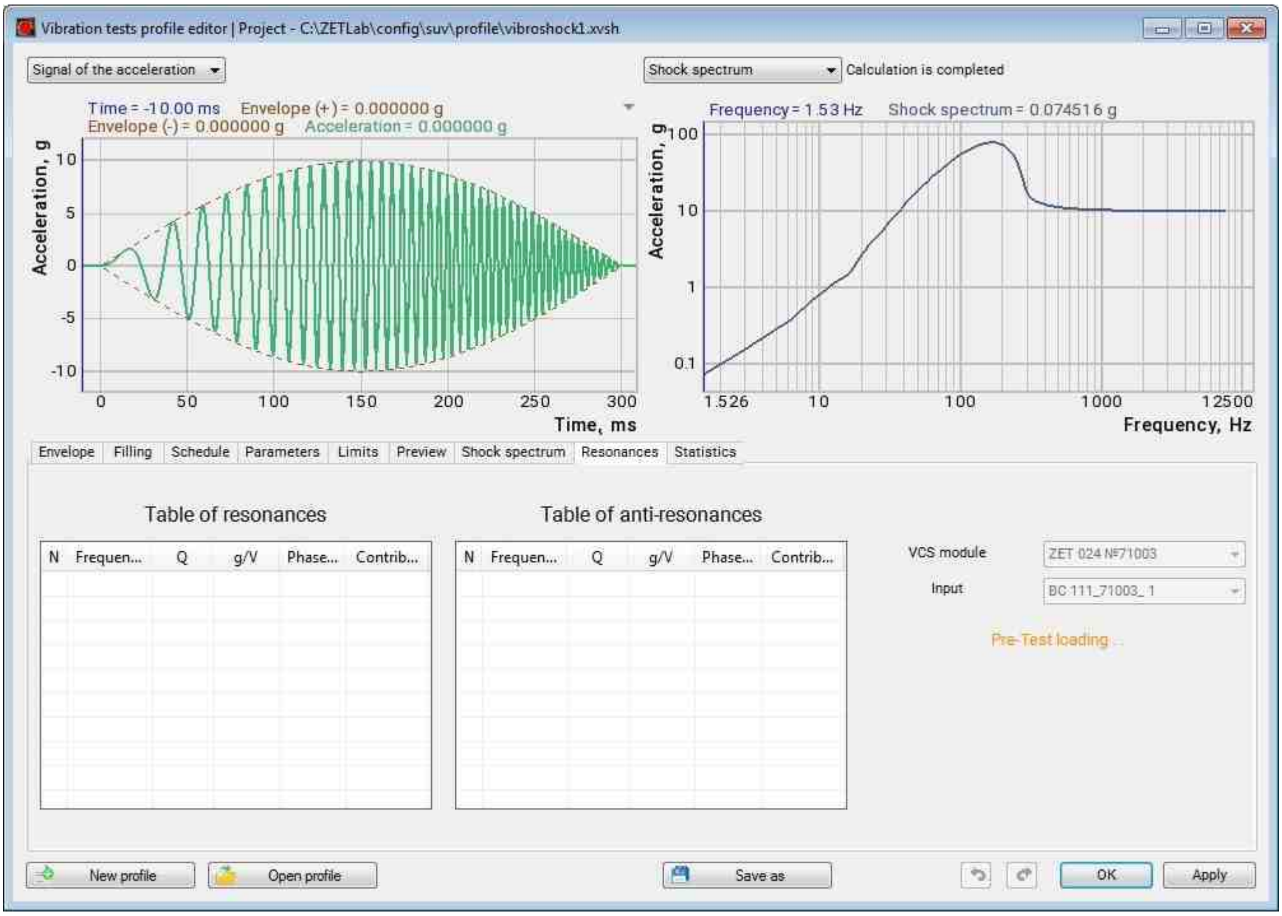


Fig. 12.9 Edit profile window, Resonances tab

The Resonances tab displays the statistical information calculated using the Pre-Tests results. The tab allows the operator to estimate the presence of resonances and antiresonances in the amplitude characteristic curve.

Note: *If required (for more detailed analysis), zoom in the amplitude characteristic curve on a frequency scale in the area of interest, and only those resonances and antiresonances which fall inside the visualized section of the curve will remain in the table.*

Statistics tab .....

When you start the "Vibration tests profile editor" program, the "Edit profile – User defined transient" program window open with the active Statistics tab (*Fig. 12.10*).

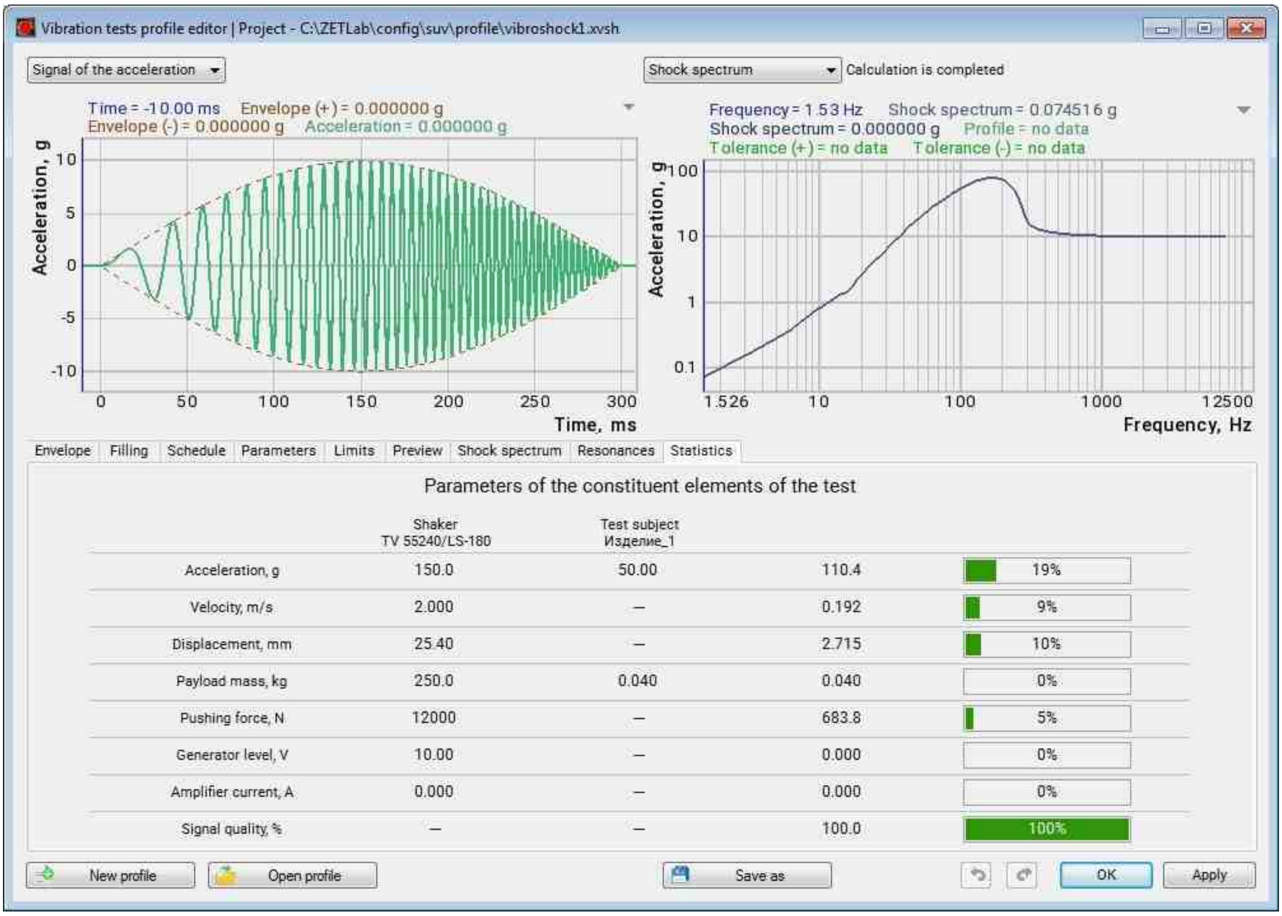


Fig. 12.10 Edit profile window, Statistics tab

The "Statistics" tab displays the statistical information calculated using the set values of the test profile parameters, giving the operator the possibility to estimate the shaker utilization during the vibration tests.

Saving and loading test profiles .....

To save the settings made in the window of the program "Edit profile - User defined transient", it is necessary activate the "Apply" button.

In the window of the program "Edit profile - User defined transient", the user is given the opportunity to both save the currently edited test profile as a file, and open previously saved profiles for editing or for testing.

To save the current test profile, it is necessary to "Edit profile - User defined transient" in the program window activate the "Save as" panel (*Fig. 12.11*).

Fig. 12.10 Button to save the test profile

In the "Profile save" window that opens ([Fig. 12.11]()) you need to set the name of the saved test profile and select the directory to save it, after which activate the "Save" button.

Note: *You can save the current profile from any tab of the* "Edit profile - User defined transient" *window.*

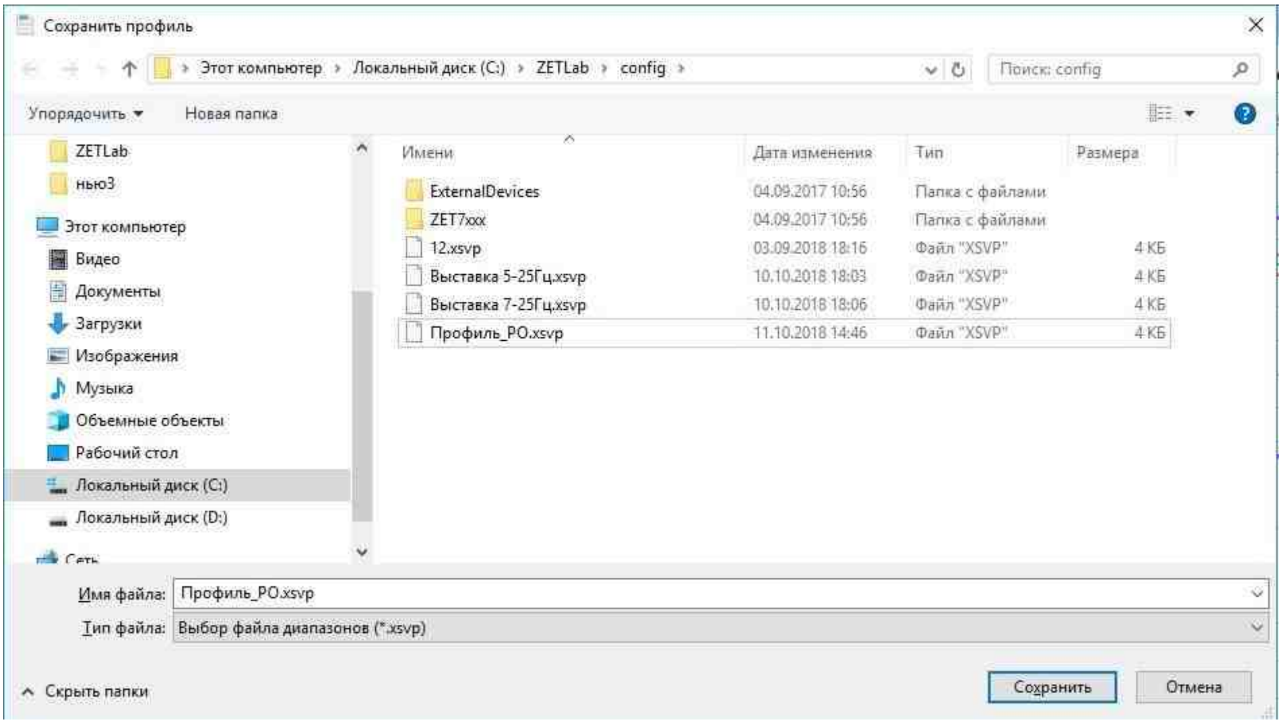


Fig. 12.11 The "Profile save" window

To load (open) a previously saved test profile, you must activate the "Profile open" panel ([Fig. 12.12]()).

Fig. 12.12 Panel for opening the test profile

In the "Profile open" window that opens (*Fig. 12.13*) select the desired test profile file and  activate the "Open" button.

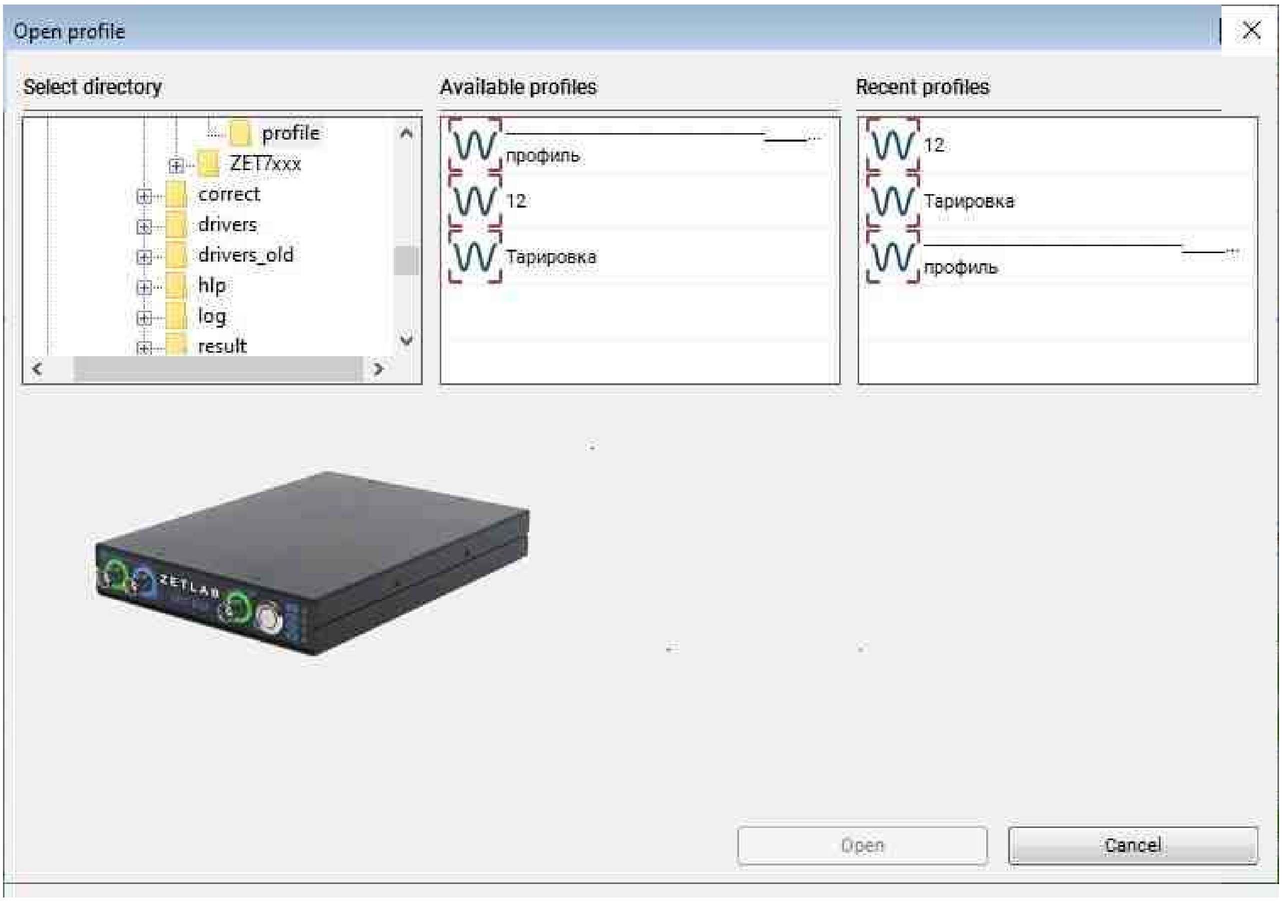


Fig. 12.13 "Profile Open" Window

When activating the "New profile" panel (*Fig. 12.14*) the program will offer to replace the current profile with a profile with default parameters (profile basic).

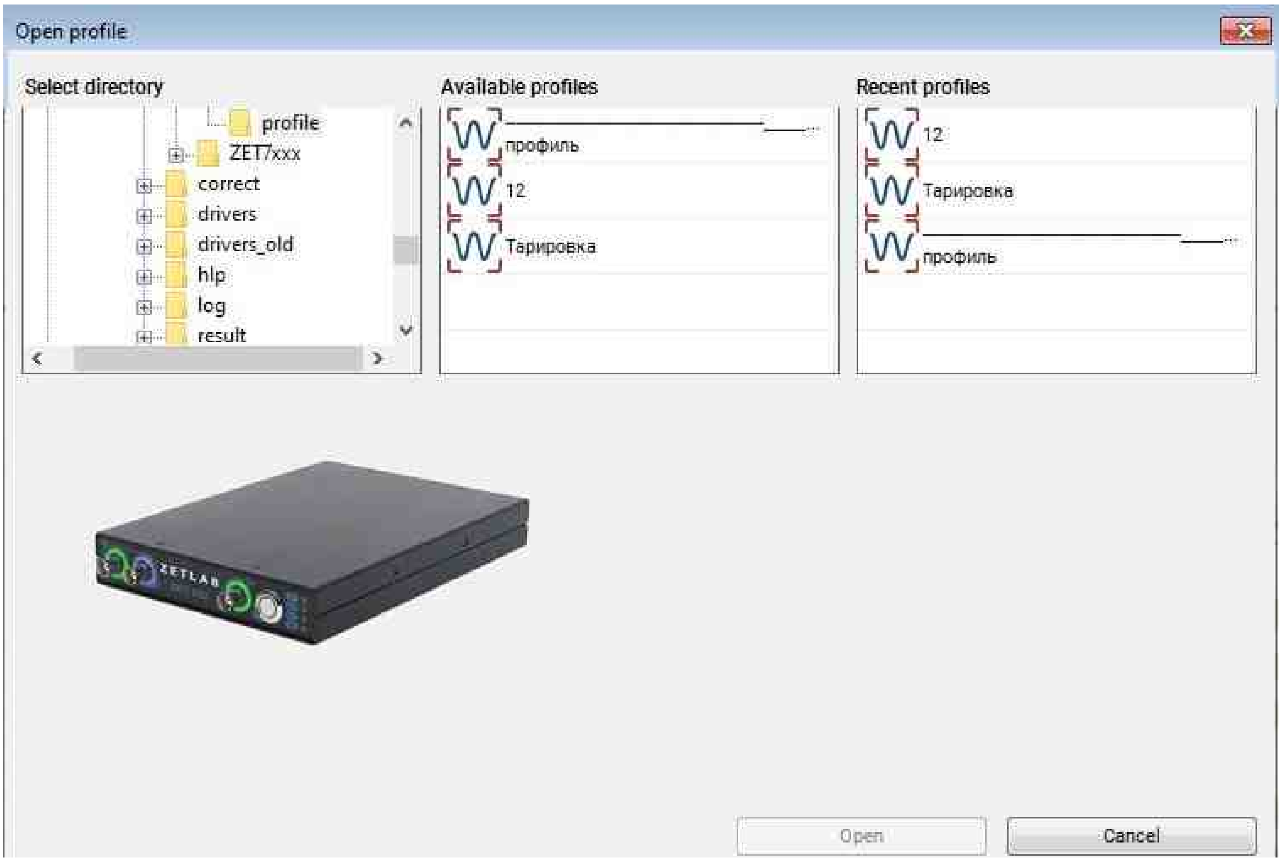


Fig. 12.14 Panel for creating a new profile

When activating the "New profile" panel (*Fig. 12.15*) the program will offer to replace the current profile with a profile with default parameters (profile basic).

Fig. 12.15 Panel for creating a new profile

Testing .....

The lower pane of the "Random" program displays the event log, where important information of the program operation is saved. After starting the program, the event log will display information of successful download of the Pre-Test files (*Fig. 12.16*).

Fig. 12.16 Event log of the "Random" program

Vibration tests are managed from a special menu in the lower-right corner of the program (*Fig. 12.17*).

Fig. 12.17 Control menu of the "Random" program

To start vibration tests, it is necessary activate the "Start" button. To stop the tests at an arbitrary point in time, it is necessary activate the "Stop" button. To temporarily stop the tests, it is necessary activate the "Pause" button, and to resume the tests – the "Start" button.

Pressing the "Recording" button starts/stops the process of recording electrical signals from all involved channels of the controller

Fig.. 12.18 Disabled (left) and enabled (right) view of the "Recording" button

Pressing the Recording button starts/stops recording electrical signals from all involved channels of the VCS controller. You can view the recorded signals in the "Results viewing" program from the ZETLab Panel Display menu (see ZETLAB software. Operator's manual).

To start the vibration tests, press the Start button, and the program will gradually bring the test system to the specified mode (*Fig. 12.19*).

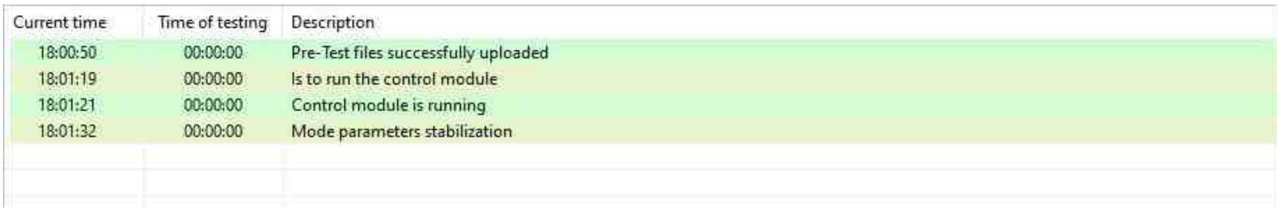


Fig. 12.19 Event log

After clicking the Start button, the program will start vibration testing which will be reported in the event log (*Fig. 12.20*).

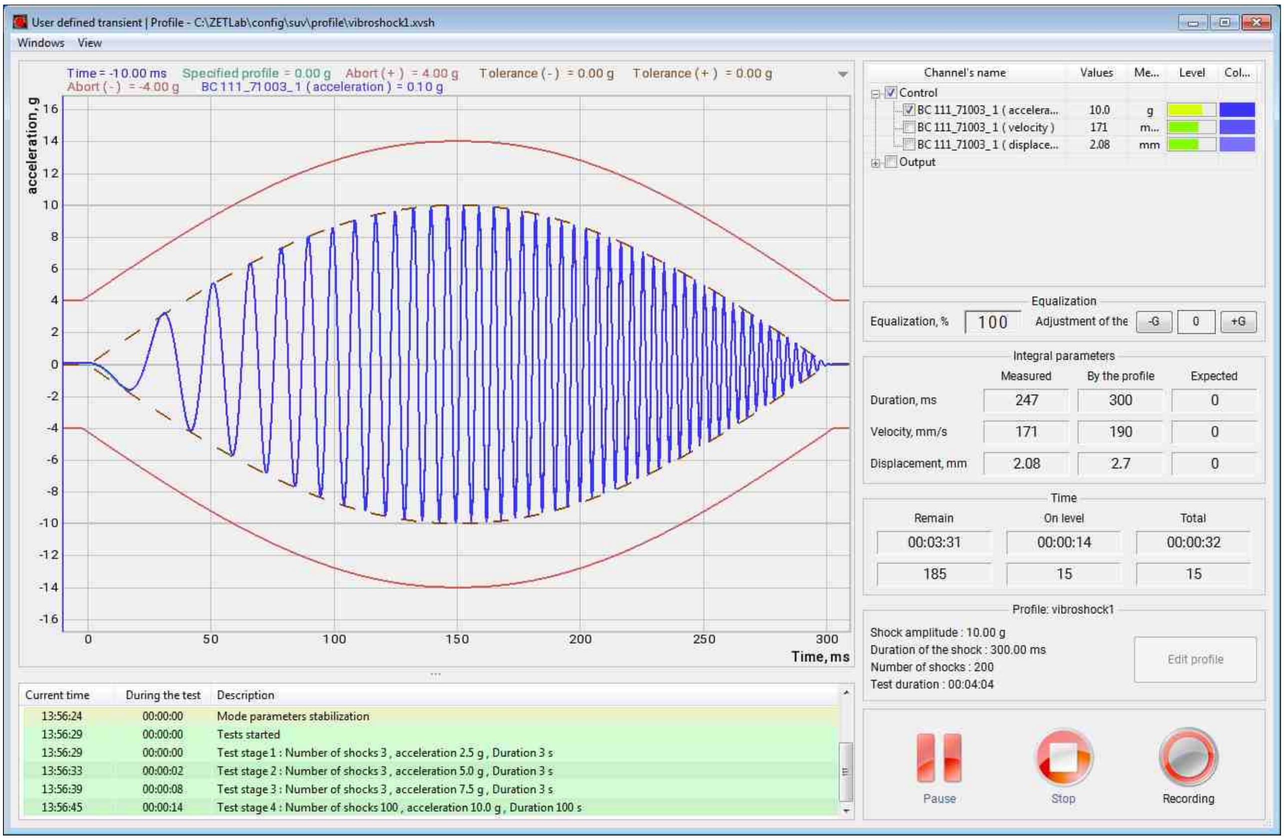


Fig. 12.20 User defined transient window

To display a measurement channel curve, select it from the channel list in the right pane of the program window (*Fig. 12.21*). This list includes all the measurement channels for which one of test control types (Control, Monitor, Display) has been selected in the Control Parameters program. The row with a measurement channel also shows information on the current acceleration and integral channel load.

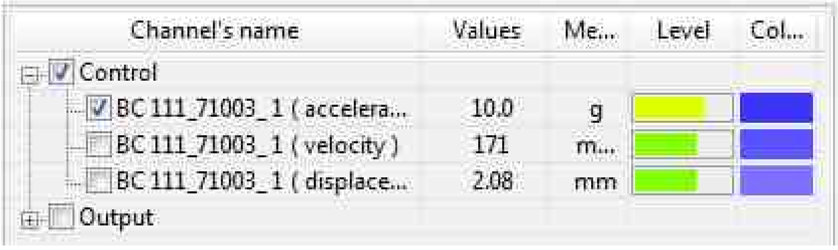


Fig. 12.21 Menu for selecting channels to be displayed

During the test, if a value in the measurement channel exceeds the permissible limits set on the Control tab, it will be displayed in the event log, and the test will be stopped (*Fig. 12.22*).

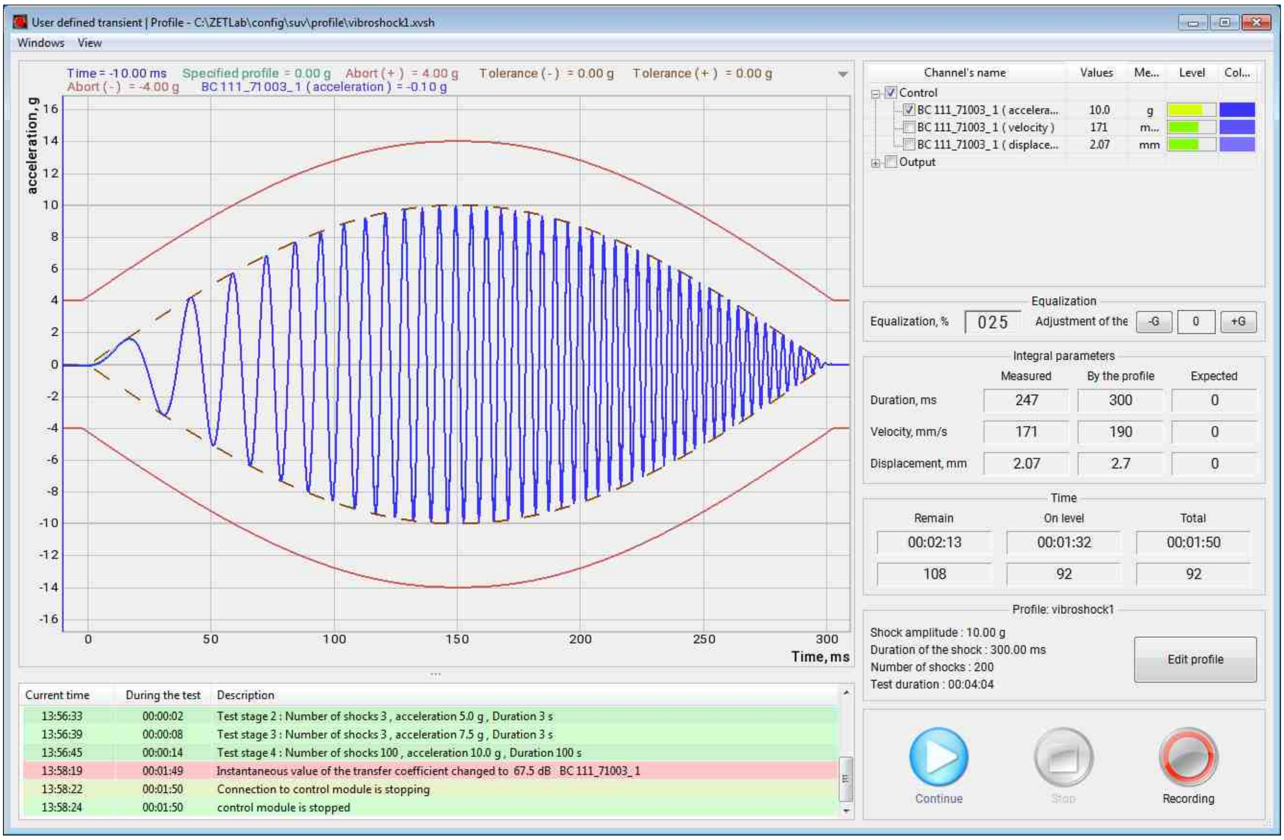


Fig. 12.22 Vibration testing stop

Additional graphics .....

During the tests, it is possible to track changes in the condition of the specimen under test at the point (s) of the control channel setup in real time. To do this, start the Additional graphics program (*Fig. 12.23*).

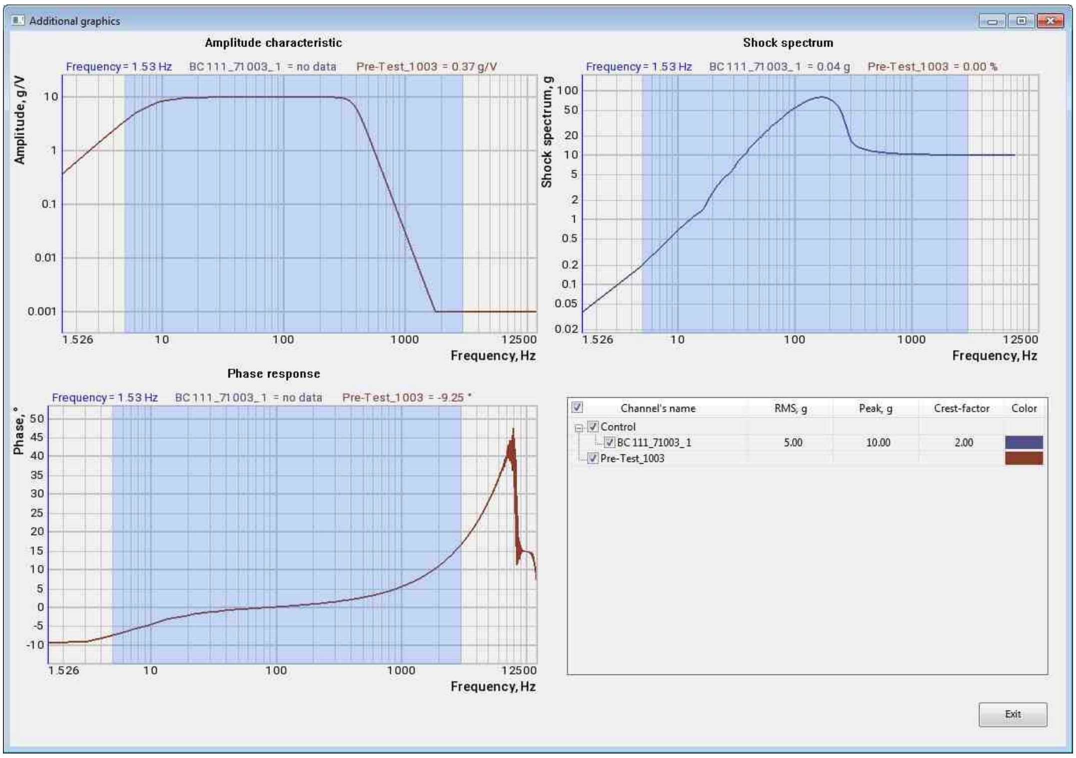


Fig. 12.23 Additional graphics program window

The graphics of the Additional graphics program display the deviations of the current spectrum values of a selected channel from the reference channel spectrum parameter values generated in the test profile after Pre-Test. The calculation may be performed using the reference channel or the oscillator channel.

Data recorder .....

To display information of the temporary implementation of signal parameters, start the Data recorder program from the Windows menu of the User defined transient program. The opened Results table window (*Fig. 12.24*) will show information of the vibration test process in the past.

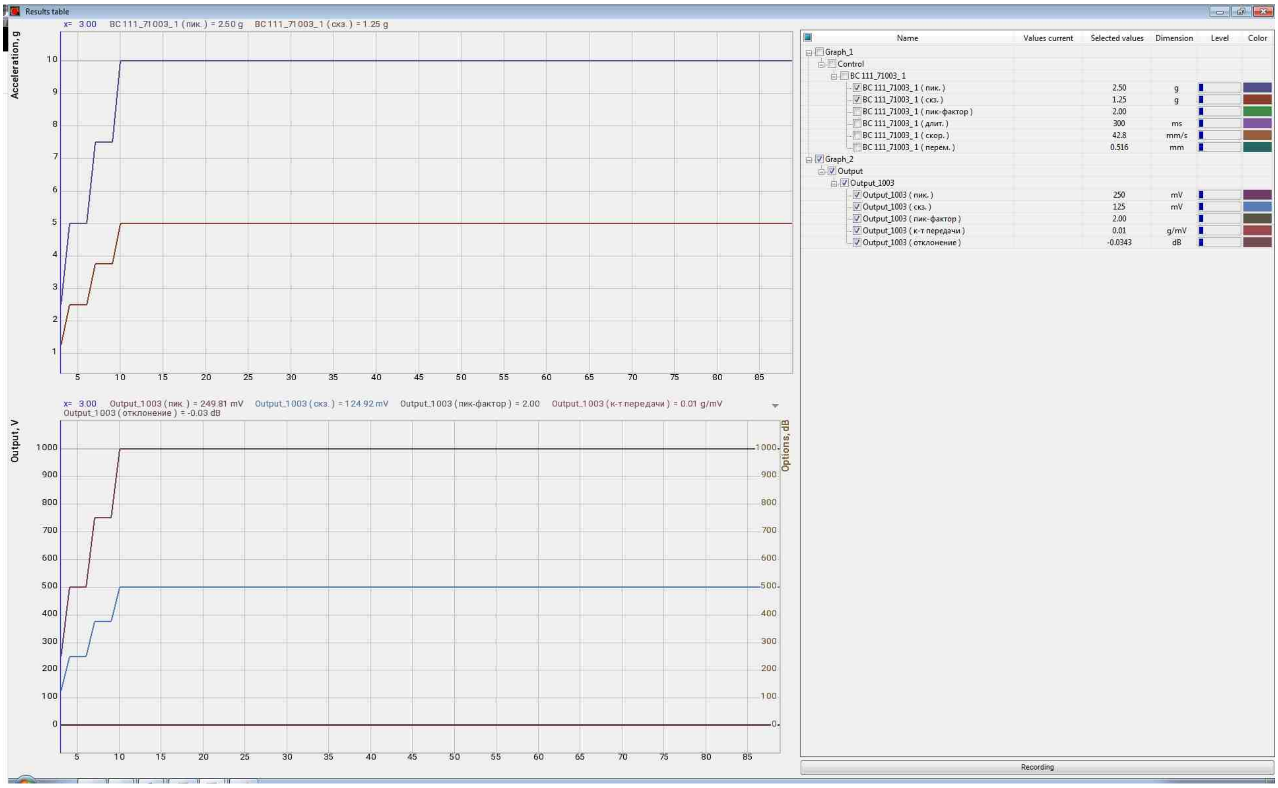


Fig. 12.24 The Data recorder program window

The upper-right corner contains a list of the channels with Available graphics. You can change the graphic color by clicking on the colored rectangle. To save the recorder readings, click the Recording button. Only selected graphics available in the Results viewing program will be saved.

To save the report, run the Report command from the Windows menu in the User defined transient program. In the opened window, you can specify the name of report file and path to save it, and then click the Recording button. The report is also saved automatically after the vibration tests are completed.

***Note**: In cases of problems with the tests: the tests were interrupted for some unknown reason, the tests do not start, there are significant distortions on the profile graphic, etc., to identify the cause, send us an email **INFO@ZETLAB.COM** an archived folder with files for the current test day. To go to the folders with the information we need, activate the text link "Tests results" on the VCS panel*

Results report .....

To view the report files, click the Tests results button on the VCS panel. In the opened window, select the appropriate test type and go to the Tests results folder. You can view the report files using the

Results viewing program. To do this, right-click on the file and select Open in ResultViewer (*Fig. 12.25*) from the context menu.

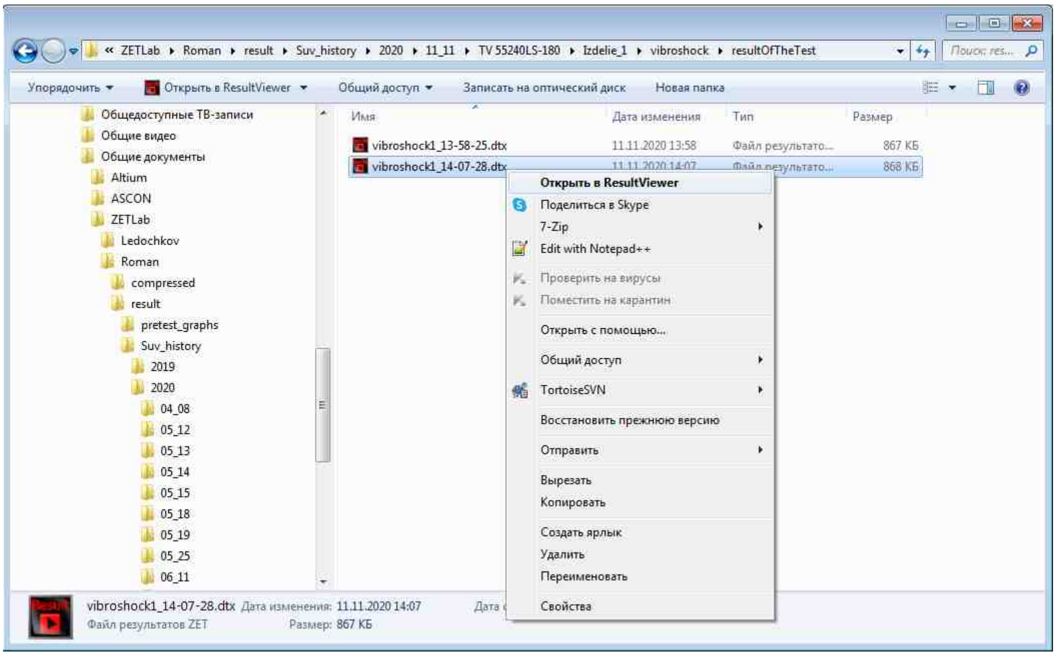


Fig. 12.26 Report Directory

In the Results viewing program, the graphic tab displays the graphical part of the report on the completed test (*Fig. 12.27*).

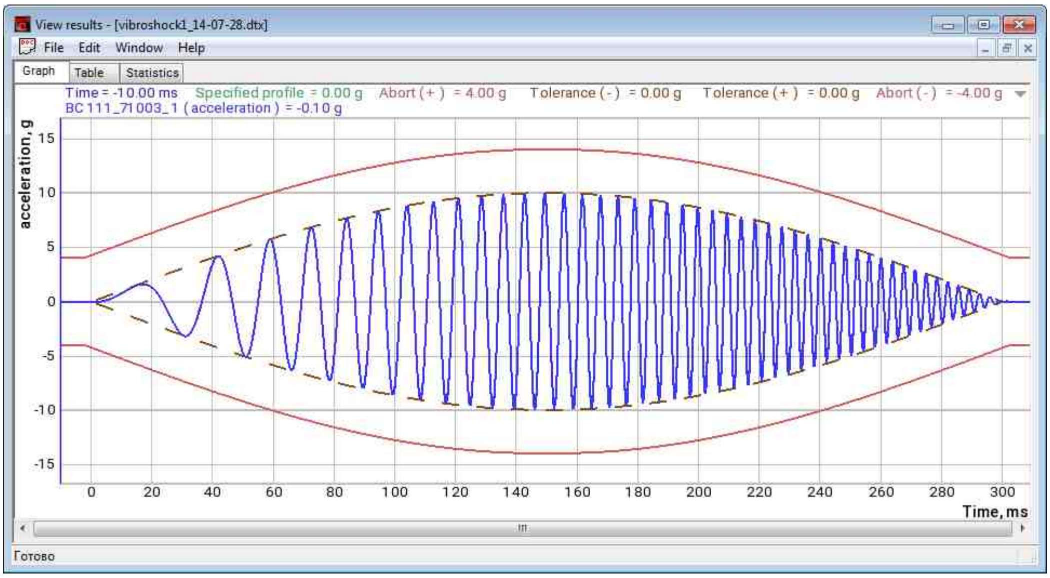


Fig. 12.27 Example of a vibration test report

Save reports .....

Table of contents:

Introduction .....

Introduction

The ZETLAB Vibration Test Control System software (hereinafter as VCS ZETLAB) has a very useful function.

All ZETLAB VCS programs automatically save reports and additional information accompanying the test at the end of the tests: profiles, signals, settings, etc. This makes it possible not only to easily report on successfully conducted tests, but also to analyze tests interrupted for some reason.

For the automatic saving of reports to work correctly, you need to config correctly parameters. Since the programs do not know in advance what they will control, what equipment will be involved, what restrictions they have, etc., then all this information must be specified in the appropriate programs for configuration. Refer to the sections (5…7) to familiarize yourself with the rules for setting parameters.

To go to the test results, activate the link "Test results" on the control panel. This folder contains folders for all types of vibration testing that were conducted on the current day, folders with the results of the Pre-Test and Post-Test, as well as a file with the tested specimen parameters.

Folders with the names of the types of tests contain different information about the tests being conducted. The information is grouped into different folders for ease of use. Each of the programs saves the following files to an individual folder:

"additionalWindow" - it contains graphics of amplitude and phase frequency characteristics, graphics of nonlinear distortions or shock spectra, depending on the type of tests;

"configurationFile" - contains copies of files with the Pre-Test parameters passed before the start of the test, as well as copies of files with parameters of the corresponding types of tests;

"log_file" - contains a log file with all the messages that programs write to the log;

"profile" - contains copies of all profiles with which the tests were run;

recorder - contains graphics of the recorder;

"recordingSignals" - contains recordings of signals made during tests - either during the entire test, or the last 10 seconds before stopping;

"resonanseAnalysis" - contains files with resonance measurement results;

"resultOfTheTest" - contains graphics with test results.

Automatically controlled save of reports .....

Automatically controlled save of reports

The results of the tests performed can be saved by the operator's command to the report file automatically for those parameters that are included in the report template.

For each type of test, there are ready-made templates made in the form of "rtf" format files:

- "Sine" – file "sinus_report_example.rtf";
- "Random" - file "noise_report_example. rtf";
- "Shock" and "User defined transient" - file "shock_report_example.rtf";
- "Graduation" - file "graduation_report.rtf".

The report template indicates to the software in which sequence (in which parts of the file) the information selected for saving on the tests performed will be located. The list of stored information is determined by the list of parameters specified in the report.

An example of a report template for harmonic vibration tests made in the form of a protocol is given in the chapter 13.2.

The report template consists of text information and labels that determine the location of parameters in the report. The main part of the parameters passed to the report is executed from the "Specimen parameters" program window. (*Fig. 13.1*).

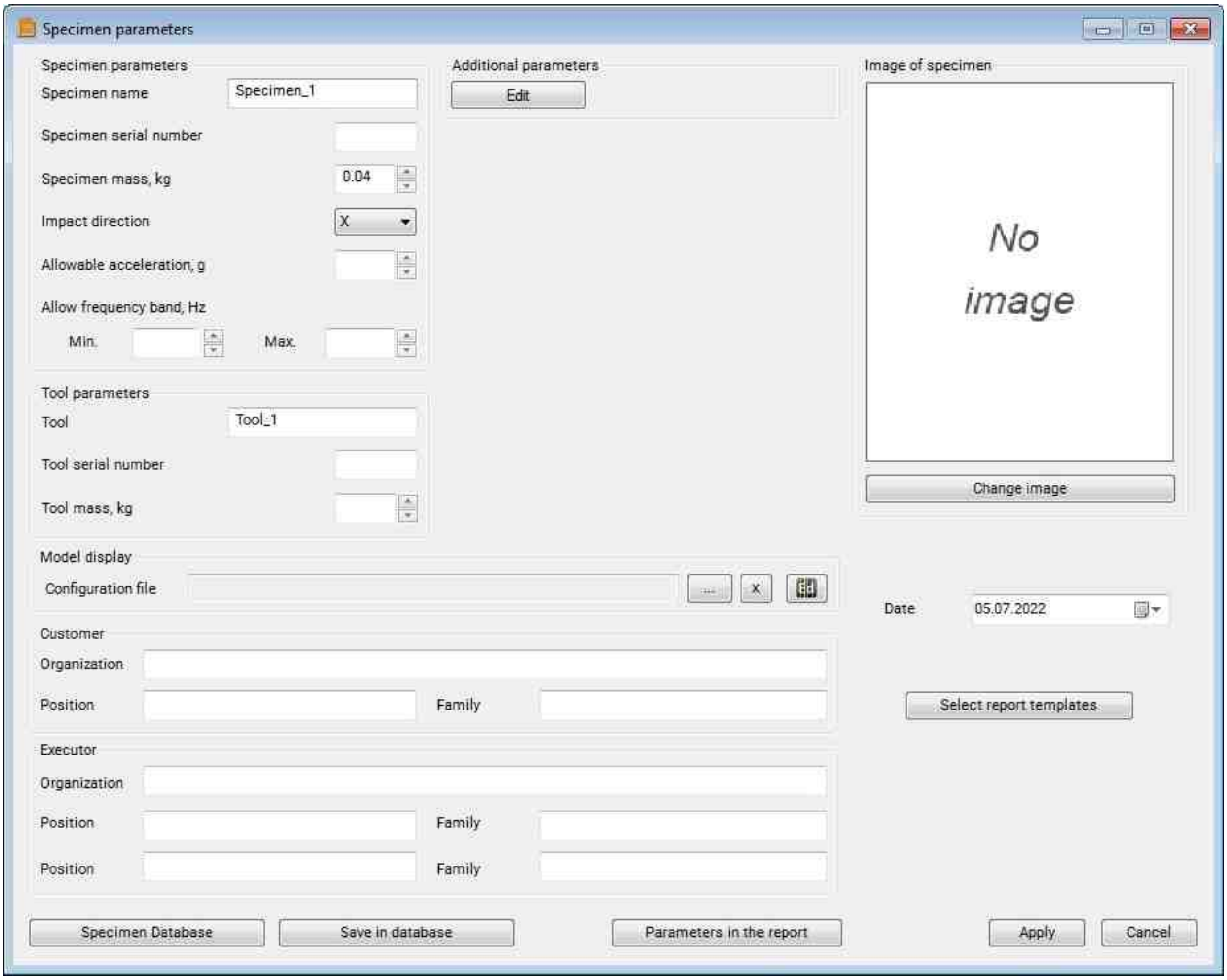


Fig. 13.1 Program window "Specimen parameters"

If necessary, the user can create templates for report files in a convenient form, correcting the composition and order of the parameters stored in the report file.

Activation of the "Parameters in the report" button in the "Specimen parameters" program window (Fig. 13.1) allows you to visualize the names of labels (Fig. 13.2).

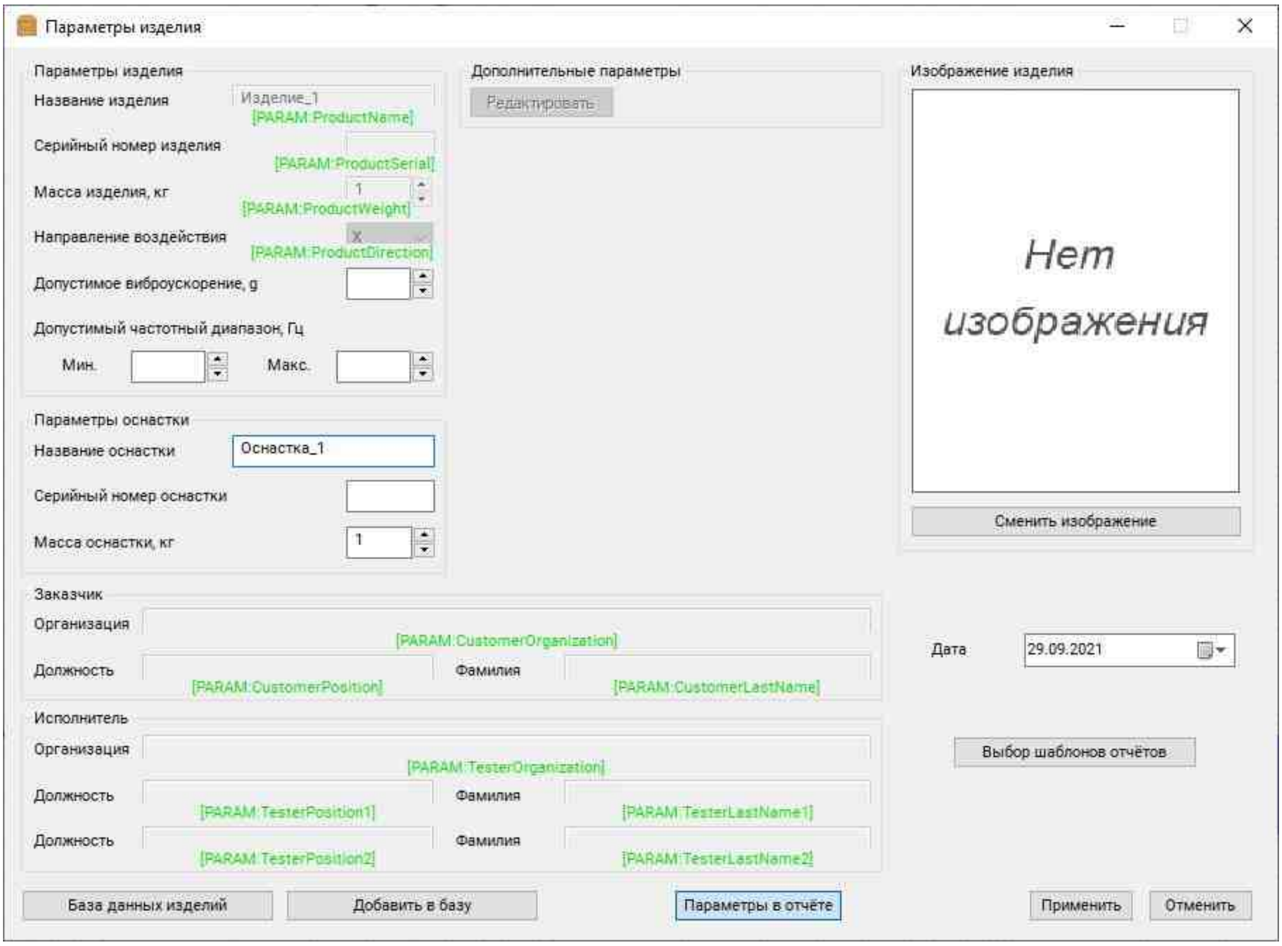


Fig. 13.2 The window of the program "Specimen parameters" with visualization of labels

Note: *if the link to the prepared template file is not executed, the default template will be applied when the report is saved automatically.*

After preparing the required report file templates, the VCS software needs to define a link to them. To do this, in the "Specimen parameters" program window (*Fig. 13.1*) necessary activate the "Select report templates" button and in the program window (*Fig. 13.3*) in the fields (for the corresponding types of tests), specify the locations of the prepared report file templates.

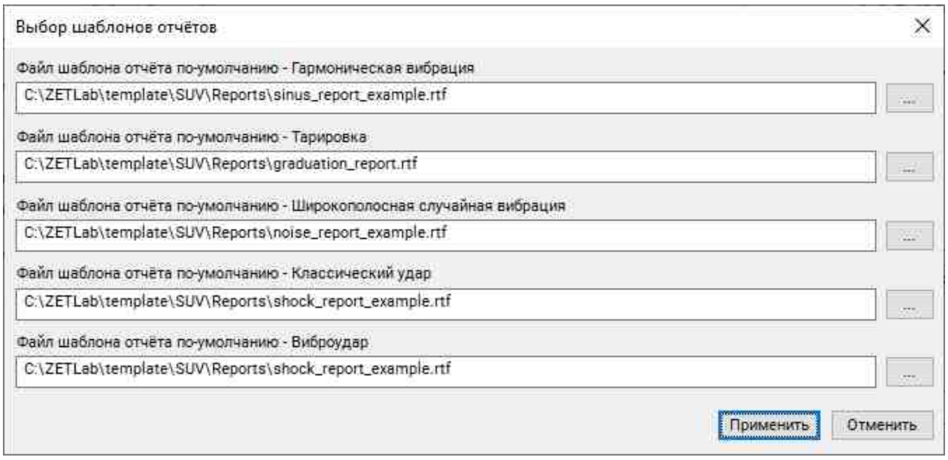


Fig. 13.3 Window "Choice of report templates"

To save the test results report (after they are carried out), it is necessary in the corresponding type of test program window in the "Windows" section activate the field "Report" (*Fig. 13.4*).

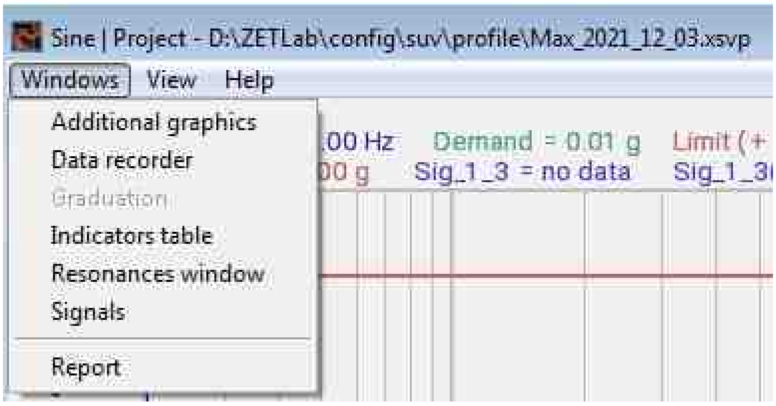


Fig. 13.4 List of the "Windows" section of the "Sine" window

In the "Save report file" window (*Fig. 13.5*) select a directory and specify a name for the saved report file, after which activate "Save".

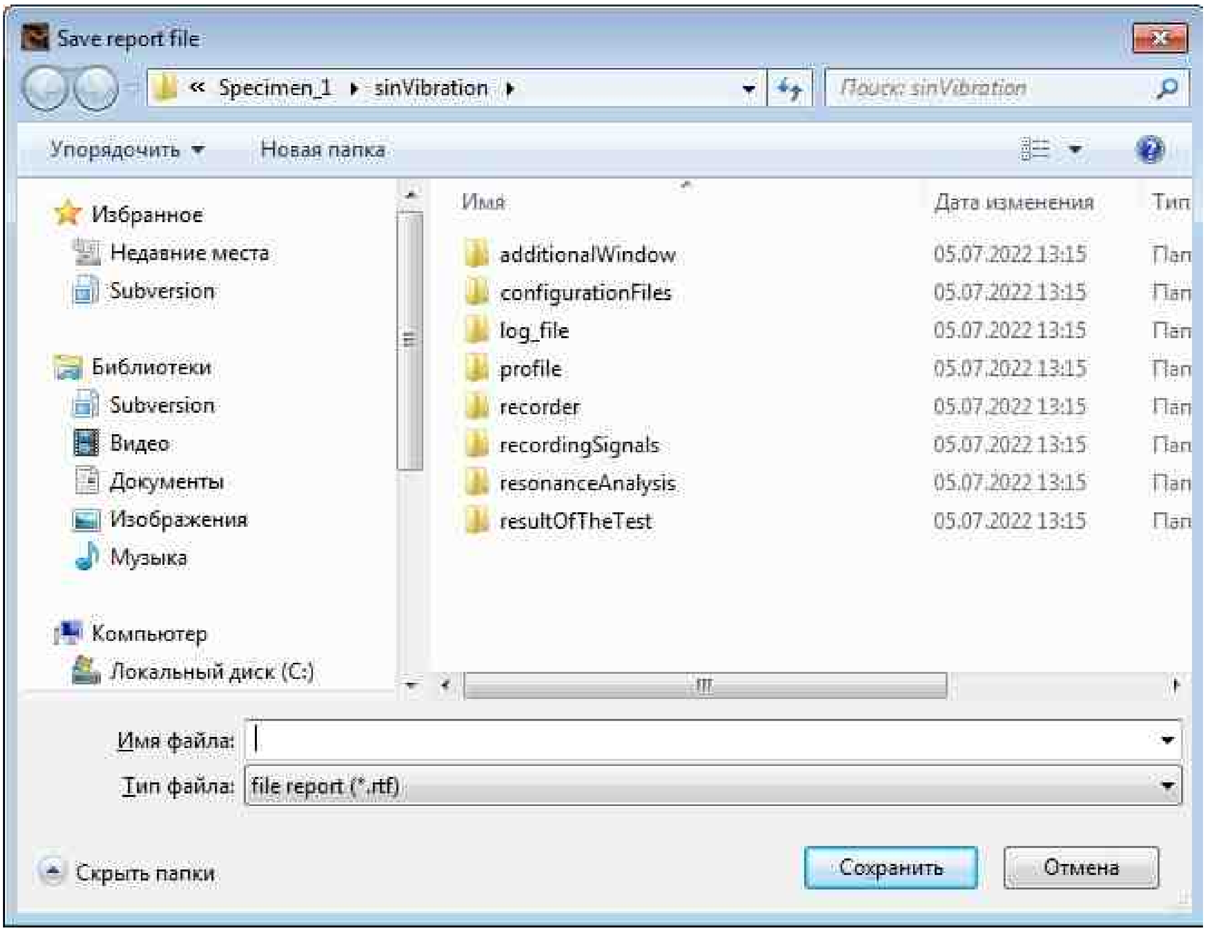


Fig. 13.5 Viewing the vibration test report file

Example of a report file for the program "Sine" .....

Example of a report file for the program "Sine"

This section contains a report file (made in the form of a test report) generated by default to save test results in the **"Sine"** program

Protocol vibration test

[PARAM:TestType]

Test date
Start of the tests - [PARAM:TestStartDate] [PARAM:TestStartTime]
End of the tests - [PARAM:TestEndDate] [PARAM:TestEndTime]
[PARAM:TestDate] [PARAM:TestTime]

Exercise date
[PARAM:ReportDate] [PARAM:ReportTime]

Shaker
[PARAM:ShakerName] [PARAM:ShakerSerial]

The tested specimen
[PARAM:ProductName] [PARAM:ProductSerial]
mass - [PARAM:ProductWeight]
Shock direction - [PARAM:ProductDirection]
[PARAM:ExtraDescr1]: [PARAM:ExtraValue1]
[PARAM:ExtraDescr2]: [PARAM:ExtraValue2]
[PARAM:ExtraDescr3]: [PARAM:ExtraValue3]
[PARAM:ExtraDescr4]: [PARAM:ExtraValue4]
[PARAM:ExtraDescr5]: [PARAM:ExtraValue5]
[PARAM:ExtraDescr6]: [PARAM:ExtraValue6]
[PARAM:ExtraDescr7]: [PARAM:ExtraValue7]
[PARAM:ExtraDescr8]: [PARAM:ExtraValue8]
[PARAM:ExtraDescr9]: [PARAM:ExtraValue9]
[PARAM:ExtraDescr10]: [PARAM:ExtraValue10]

Controllers
[PARAM:Device1Name] [PARAM:Device2Name] [PARAM:Device3Name] [PARAM:Device4Name]

Sensors
[PARAM:Channel1Name] [PARAM:Channel1Sensitivity] [PARAM:Channel1MaxLevel]
[PARAM:Channel2Name] [PARAM:Channel2Sensitivity] [PARAM:Channel2MaxLevel]
[PARAM:Channel3Name] [PARAM:Channel3Sensitivity] [PARAM:Channel3MaxLevel]
[PARAM:Channel4Name] [PARAM:Channel4Sensitivity] [PARAM:Channel4MaxLevel]

Test profile
Total test duration - [PARAM:TotalDuration]
Maximum acceleration - [PARAM:MaxAcceleration]
Maximum velocity - [PARAM:MaxVelocity]
Maximum displacement - [PARAM:MaxDisplacement]
Frequency range - [PARAM:FrequencyBand]
[TABLE:Profile,Velocity,Displacement,Type,Rate,Duration]

Test schedule
[TABLE:Schedule]

Test result
Test duration - [PARAM:TestDuration]

Maximum acceleration via the control channel - [PARAM:ControlAcceleration]
Maximum velocity on the control channel - [PARAM:ControlVelocity]
Maximum displacement through the control channel - [PARAM:ControlDisplacement]
The number of oscillations is set [PARAM:OscillationsSet], performed [PARAM:OscillationsDone]
[GRAPH:Profile]
[GRAPH:Recorder1,xsize=960,ysize=540,autoscale]
[GRAPH:Recorder2,xsize=960,ysize=540,autoscale]

Test customer
[PARAM:CustomerOrganization]
[PARAM:CustomerLastName], [PARAM:CustomerPosition] _______________

Test performer
[PARAM:TesterOrganization]
[PARAM:TesterLastName1], [PARAM:TesterPosition1] _______________

[PARAM:TesterLastName2], [PARAM:TesterPosition2] _______________

Save test results .....

Save test results

When conducting tests, the main results are recorded by a program corresponding to the type of tests being conducted, but in addition, other programs are involved in the registration of information, such as: "Additional graphics"; "Recorder"; "Signals recording".

Each of the programs saves the registered information in files automatically without the operator's participation during the tests.

To access the registered information on the VCS panel (*Fig. 13.6*) should activate "Test results" at the same time a window with directories will be opened (*Fig. 13.7*) in which the results of the latest tests are located.

The recorded information in manual mode (by copying) can be generated or supplemented with a protocol or a report on the tests performed.

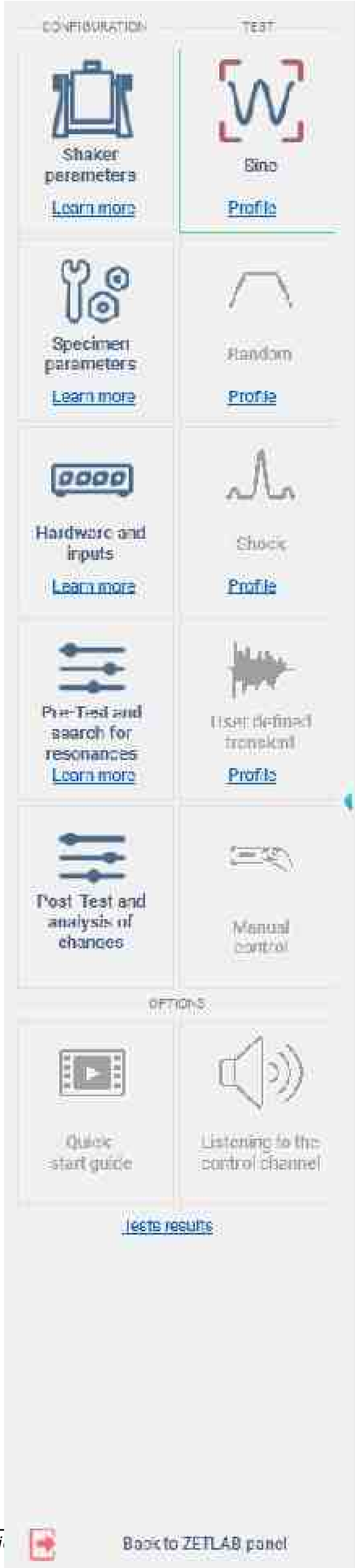

CONFIGURATION
TEST
Shaker parameters
Learn more
Sine
Profile
Specimen parameters
Learn more
Random
Profile
Hardware and inputs
Learn more
Shock
Profile
Pre-Test and search for resonances
Learn more
User defined transient
Profile
Post Test and analysis of changes
Manual control
OPTIONS
Quick start guide
Listening to the control channel
Tests results
Back to ZETLAB panel

Fig. 13.6 VCS Panel

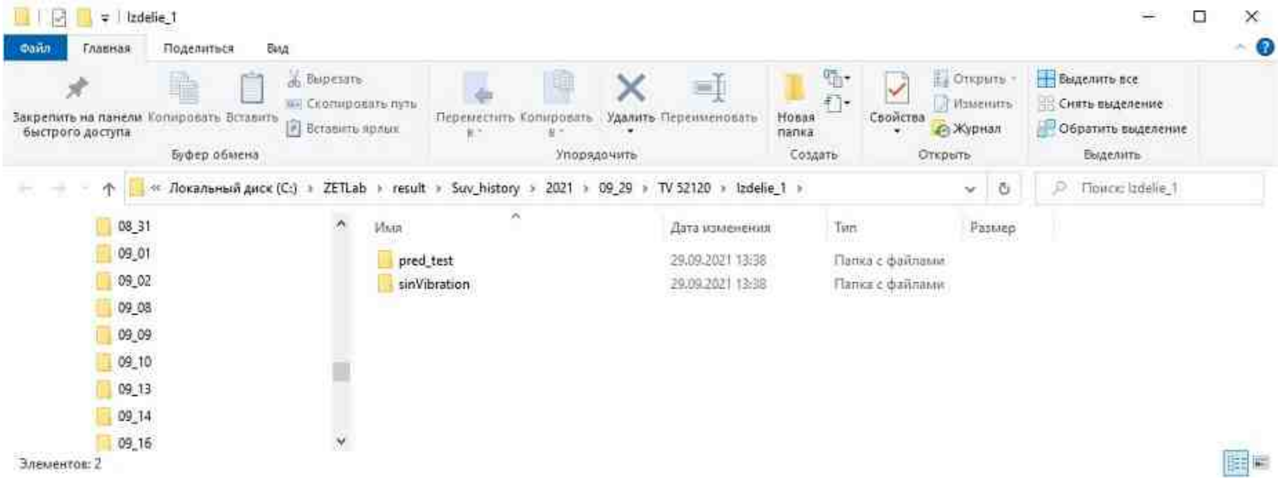


Fig. 13.7 Window with directories

To save files, each of the programs forms the corresponding directories: "Pre-Test" – the "pred_test" directory, "Sine" – the "sinVibration" directory, "Random" - the "widebandnose" directory, "Shock" - the "shock" directory, "User defined transient" – the "vibroshock" directory.

In ***Table 13.1*** the names of the files (and the composition of the information recorded in them) created by the program "Pre-Test" are given, and in the table ***Table 13.2*** – test programs ("Sine", "Random", "Shock" and "User defined transient").

Table 13.1 The composition of the information recorded during the operation of the program "Pret-Test" (directory "pred_test")

File name	**File format**	**Contents of the registered information**
AutoChannel_yyyy_xxxx	dtx	Graphics of auto power spectrum of signals from the measuring channels of the device number "yyyy" calculated relative to the signal of the control channel (generator) generated from the device number "xxxx"
AutoGen_xxxx	dtx	Graphics of auto power spectrum of the control channel (generator)auto power spectrum
AutoSpectr_ yyyy_xxxx	dtx	Graphics of noise auto power spectrum on the measuring channels of the device number "yyyy" calculated relative to the noise on the control channel (generator) of the device number "xxxx"

Coherence_ yyyy_xxxx	dtx	Graphics of the coherence of signals from the measuring channels of the device number "yyyy", calculated relative to the signal of the control channel (generator) generated from the device number "xxxx"
controlParameters	cfg	Parameters of the involved devices and measuring channels as part of the VCS
Correlation_ yyyy_xxxx	dtx	Correlation graphics of signals from the measuring channels of the device number "yyyy", calculated relative to the channel of the control signal (generator) generated from the device number "xxxx"
Impulse_ yyyy_xxxx	dtx	Graphics of impulse responses of signals from the measuring channels of the device number "yyyy", calculated relative to the signal of the control channel (generator) generated from the device number "xxxx"
Phase_ yyyy_xxxx	dtx	Graphics of the phase characteristics of signals from the measuring channels of the device number "yyyy", calculated relative to the signal of the control channel (generator) generated from the device number "xxxx"
Thd_ yyyy_xxxx	dtx	Graphics of non-linear distortions of signals from the measuring channels of the device number "yyyy", calculated taking into account the noise relative to the signal of the control channel (generator) generated from the device number "xxxx"
Transition_ yyyy_xxxx	dtx	Graphics of the transfer characteristics of the measuring channels of the device number "yyyy", calculated relative to the signal of the control channel (generator) generated from the device number "xxxx"
TransitionHi_ yyyy_xxxx	dtx	Graphics of the reverse transfer characteristic of the measuring channels of the device number "yyyy", calculated from the impulse response relative to the signal of the control channel (generator), generated from the device number "xxxx"
TransitionHv_ yyyy_xxxx	dtx	Graphics of the transfer characteristics Hv of the measuring channels of the device number "yyyy", calculated relative to the signal of the control channel (generator) generated from the device number "xxxx"

vSpectr_cplx_ yyyy_xxxx	dtx	Graphics of the complex cross spectrum of the measuring channels of the device number "yyyy", calculated relative to the signal of the control channel (generator) generated from the device number "xxxx"

Table 13.2 The composition of the information recorded in the files, depending on the test programs

File name	File format	Test program	Contents of the registered information
Subdirectory "additionalWindow"			
Nonlinear distortion_hh-mm-ss	dtx	Sine, Random	Graphics of nonlinear distortion levels calculated from signals from measuring channels.
Transfer_hh-mm-ss	dtx	Sine, Random	Graphics of transfer characteristics calculated from signals from measuring channels relative to the control channel
Phase_hh-mm-ss	dtx	Sine, Random	Graphics of phase signals calculated relative to the control channel
Amplitude characterization_hh-mm-ss	dtx	Shock	
Impulse response_ hh-mm-ss	dtx	Shock	
Shock spectrum_ hh-mm-ss	dtx	Shock	
Acceleration_hh-mm-ss	dtx	Shock	
Phase characterization_hh-mm-ss	dtx	Shock	
Subdirectory "configurationFiles"			
controlParameters_hh-mm-ss	cfg	Sine, Random	Parameters of the involved devices and measuring channels as part of the VCS
pidRegulator_hh-mm-ss	cfg	Sine	Values of PID-regulator parameter settings
Subdirectory "log_file"			
SinVibration	log	Sine	Messages log generated during testing

widebandnoise	log	Random	
ClassicShock	log	Shock	
vibroshock	log	User defined transient	
Subdirectory "profile" in the directory "sinVibration"			
name_hh-mm-ss	xsvp	Sine	Test profile file, where "name" is the name of the test profile
	xwbn	Random	
	xshk	Shock	
	xvsh	User defined transient	
Subdirectory "recorder"			
name_hh-mm-ss_1	dtx	Sine, Random, Shock, User defined transient	Graphics from group number 1 (upper window of graphics) of the "Recorder" program, where "name" is the name of the test profile
name_hh-mm-ss_2	dtx	Sine, Random, Shock, User defined transient	Graphics from group number 2 (lower graphic window) of the "Recorder" program, where "name" is the name of the test profile
Subdirectory "recorderSignals"/ sGGMMDD_HHMMSS			
infl	txt	Sine, Random, Shock, User defined transient	Information about testing facilities
sigxxxx	ana	Sine, Random, Shock, User defined transient	Binary file of the initial registered signal on the measuring channel with serial number "xxxx"

sigxxxx	anp	Sine, Random, Shock, User defined transient	Descriptor of parameters of the measuring channel with serial number "xxxx"
sigxxxx	xml	Sine, Random, Shock, User defined transient	Parameters of the measuring channel with serial number "xxxx"
Subdirectory "resultOfTheTest"			
name_hh-mm-ss	dtx	Sine, Random, Shock, User defined transient	Graphics with results by test profile, where "name" is the name of the test profile

Post-processing of test results .....

If necessary, to analyze and process the temporary realizations of the registered signals in real time, open the program "Play recorded signals" (*Fig. 14.1*) from the "Registration" menu of the ZETLAB panel.

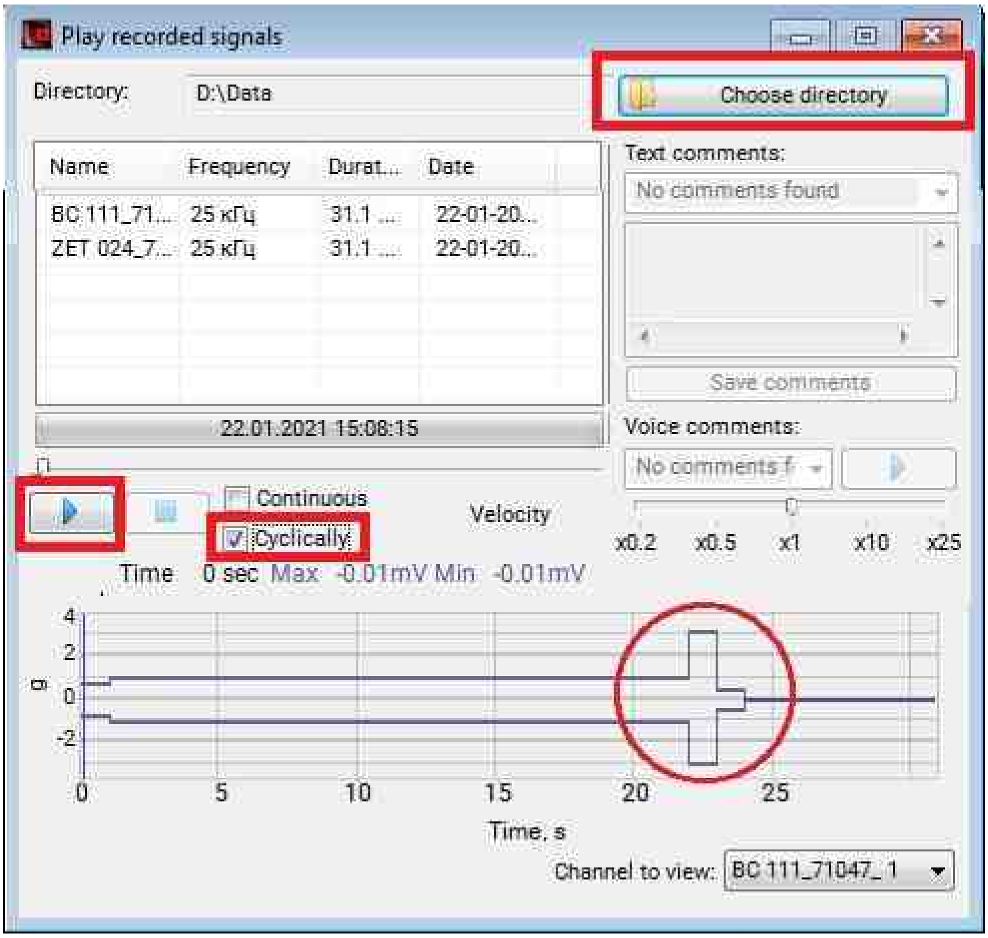


Fig. 14.1 The program "Play recorded signals"

In the program window "Play recorded signals":

1. After which activate "Choose directory" and in the window that opens, set the directory of the location of the folder with the registered signals. To determine the directory of the location of the folder with the registered signals, you should use the VCS Panel activate the "Tests results" menu, from the opened directory go to the folder with the signals of interest in accordance with the example given on [Fig. 14.2](#).

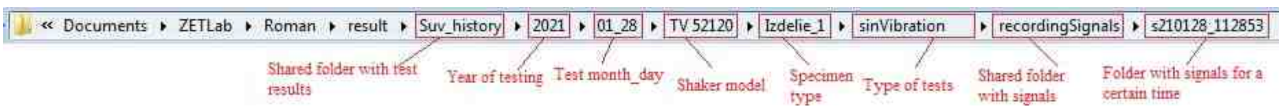


Fig. 14.2 Example of directory location of a folder with registered signals

2. If it is necessary to play the signal recording from a certain point in time on the preview graphic, set the cursor at the appropriate time stamp;
3. To auto-repeat the "Play recorded signals", set the mark in the "Cyclically" field;
4. To start "Play recorded signals", press "".

After starting "Play recorded signals", the recorded signals become available to programs from the ZETLAB software used for signal processing. The most popular programs are:

- "Multi-channel oscilloscope" (ZETLAB panel, "Display" section) – designed to evaluate the waveform and measure instantaneous values *Fig. 14.3*;
- "FFT Spectrum Analysis" (ZETLAB panel, section "Signal analysis") – designed for narrow-band spectral signal processing, as well as viewing various spectral characteristics of signals;
- "Cross-Spectrum FFT Analysis" (ZETLAB panel, section "Signal analysis") – it is designed to determine the relationship of signal parameters from two primary converters installed in different parts of the object under study and can be used for localization of a source of increased noise, measurement and display of phase difference and signal coherence coefficient, measurement and construction of transient and impulse characteristics of signals, analysis of resonances;
- "Signals filtration" (ZETLAB panel, section "Automation") – It is used to filter the signals coming to the input channels of the VCS controller for subsequent processing by ZETLab programs;

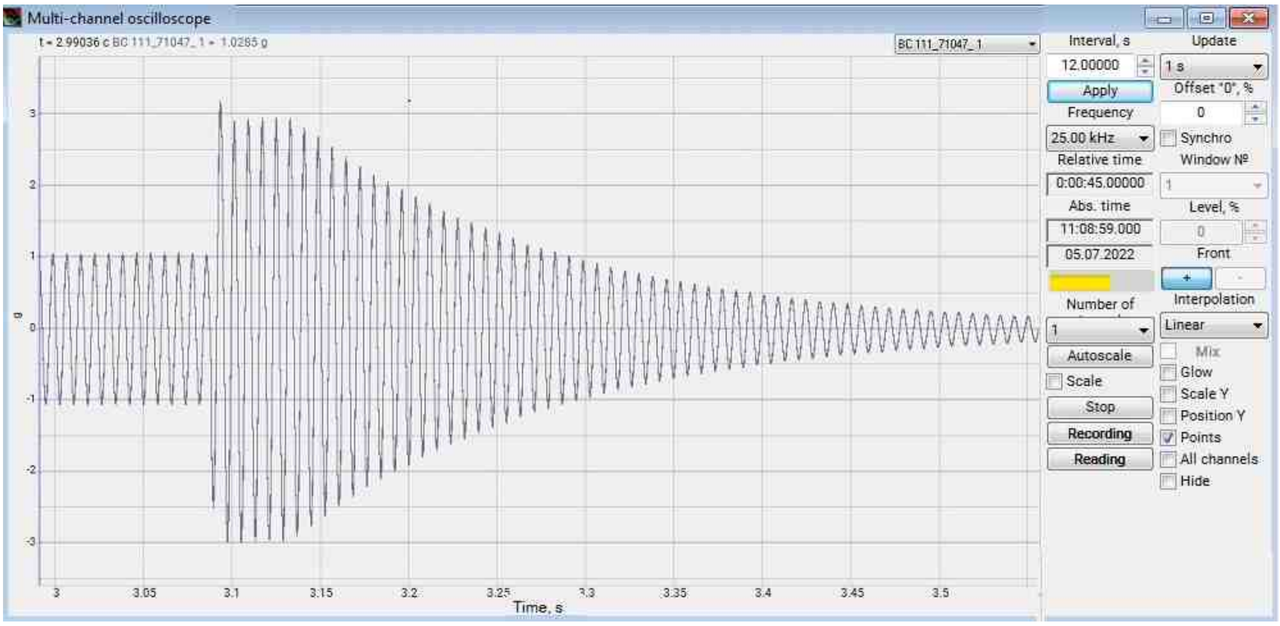


Fig. 14.3 The program "Multi-channel oscilloscope"

***Note:** to access the reference information (being in the window of the program for which you want to get reference information), you should activate the key on the keyboard <F1>.*

Shaker Validation .....

Electrodynamic Shaker Validation using ZETLAB Hardware and Software.

Shaker Validation is a software package intended for certification of electrodynamic shakers in compliance with the applicable requirements, generally described in ISO 5344 2004.

The software package "Shaker Validation" allows to implement the following operations in semi-automated mode:

- Test run of the electrodynamic shaker systems;
- Evaluation of acceleration unevenness;
- Evaluation of acceleration, Displacement, and frequency ranges;
- Evaluation of acceleration and (or) displacement harmonics ratio;
- Evaluation of transverse components ratio;
- Evaluation of distribution unevenness ratio;
- Evaluation of trunnion resonance frequency and the first resonance frequency of the moving part of the system;
- Evaluation of vibration noise level at the shaker table;
- Evaluation of acceleration and (or) displacement maintenance tolerance at the control point;
- Evaluation of system operability in the case of load applied at the right angle towards the operating axis of the shaker;
- Evaluation of system operation under the admissible eccentricity of load;
- Evaluation of frequency maintenance error limit.

Contents

Supported Hardware .....

The source information of the program "Shaker Validation" designed for **Shaker Validation**.

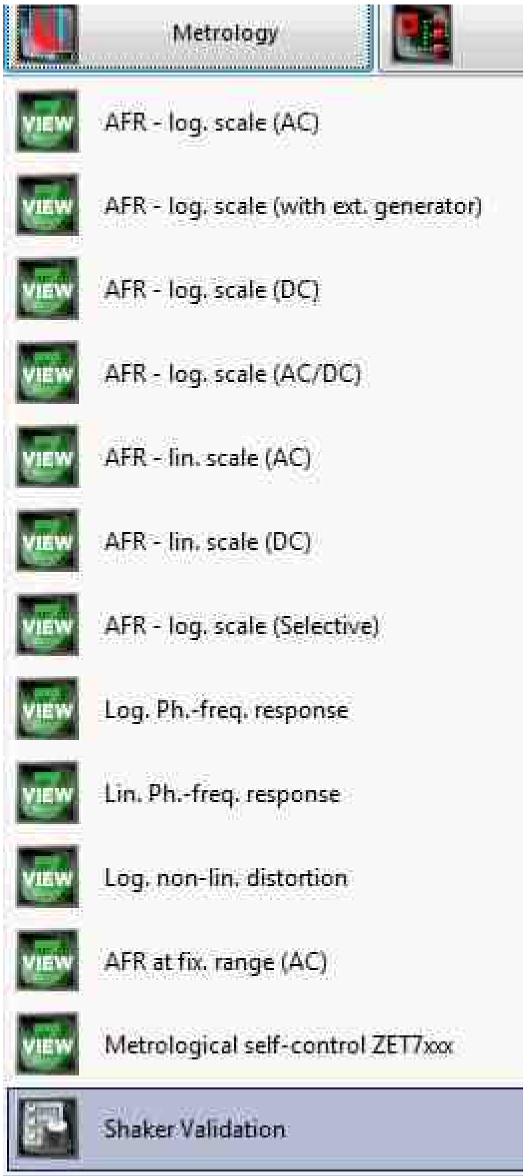
The program "Shaker Validation" is included into the scope of the following software packages:

- ZETLAB ANALIZ — FFT spectrum analyzer software;
- ZETLAB VIBRO — vibration control systems software;

Shaker Validation included in the program group **Metrology**

Program description .....

The program **Shaker Validation** can be started from the Metrology section of *ZETLAB control panel*.



Note: the program **Shaker Validation** can also be started from *ZETLAB directory* (the directory by default: C:\ZETLab\). The name of the file to be started: *QualificationCharacteristics.exe.*

CONTENTS

Introduction .....

This document is based and meets the requirements of ISO 5344 "Electrodynamic vibration generating systems — Performance characteristics" and is a standard of ETMS, LLC.

The document contains rules for using the "Shaker Validation" program in the certification of electrodynamic shakers.

The Shaker Validation program is a part of ZETLAB software.

Hardware and software composition .....

You will need the following for operation:

- PC (laptop)
- ZET 038 FFT spectrum analyzer
- primary transducers: one three-unit and three single-unit accelerometers (or six single-unit accelerometers three of which to be installed on orthogonal edges of AM51 magnet cube)
- ZETLAB software with the Shaker Validation program

Preparing for work .....

Connect ZET 038 FFT spectrum analyzer to the computer via an Ethernet interface.

For detailed information on ZET 038 FFT spectrum analyzer operation, refer to "Multi-Channel Data Collection Controllers. ETMS.411168.008 UM. Operation manual". The document is available on www.zetlab.com, at the following link (QR-code)

In the ZET 038 FFT spectrum analyzer settings, set (if necessary) sampling frequency: ADC: 50 kHz, DAC: 100 kHz.

Install the primary transducers (accelerometers) on the vibration unit table at measurement points.

Place the primary transducer whose signal is to be used as a reference control channel as close to the center of the vibration generator system being certified as possible, while the primary transducers involved in measuring the irregularity of distribution shall be distributed evenly along the table perimeter.

When installing the primary transducers (accelerometers), ensure electric insulation of their bodies from the vibration unit table surface using, for instance, Kapton tape.

Connect the primary transducers (accelerometers) to the ZET 038 FFT spectrum analyzer input.

Set the control channel parameters of the ZET 038 FFT spectrum analyzer according to the specifications of the primary transducers (accelerometers) connected to the respective inputs.

The control channel parameters are set in the "Properties" windows of the Device Manager program.

Set the "P" parameters (control channel orientation) for all the control channels used for the certification in accordance with the orientation of the primary transducers installed.

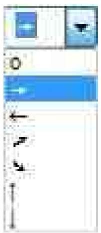


Fig. 3. "P" parameter, control channel orientation

The symbol "↑" is for the control channels of the primary transducers installed along the vibration direction; symbols "→" and "↗" are for the control channels of the orthogonally installed primary transducers.

Shaker Validation Operation Rules .....

Contents

Opening and closing program window

To open the program window (*Fig. 4.1*), activate the Shaker Validation program on the ZETLAB control panel, in Metrology menu.

To close the Validation Characteristics program window, activate the "" symbol in the right upper corner of the window.

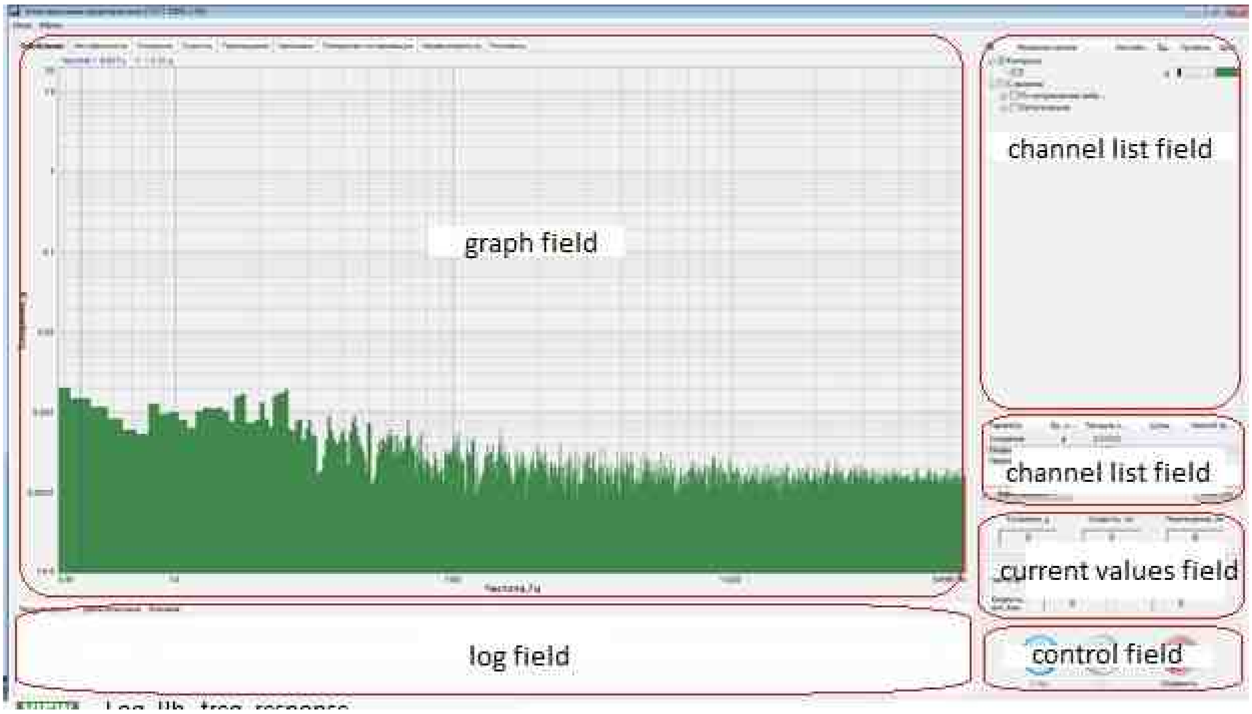


Fig. 4.1 Validation Characteristics window

The parameters required to use the program are set in the Settings window (*Fig. 4.2*).

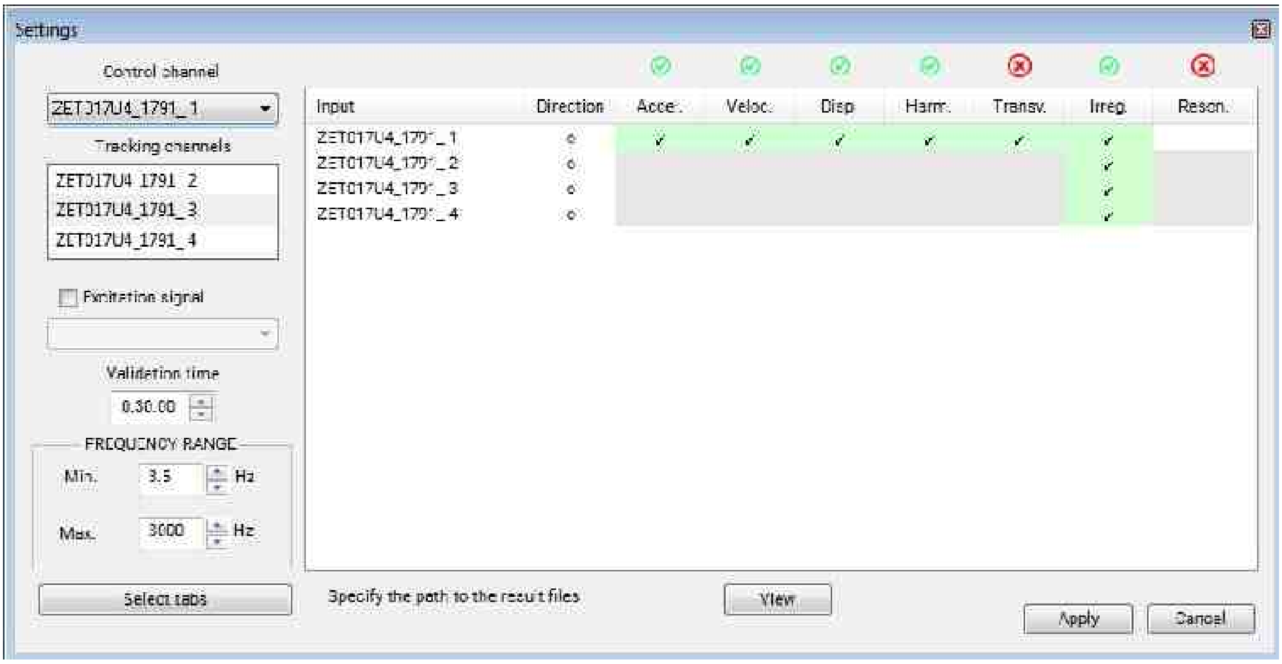


Fig. 4.2 Settings window

To switch to the Setting window, select Setting in the Menu section (of the Validation characteristics program).

The Control channel parameter defines which of the available control channels will be used as a reference.

The Tracking channels window contains a list of available control channels (except for the one selected as a reference).

Activation of the Tracking channels window will open the "Select inputs" window, where you can remove (if necessary) any channels from the program.

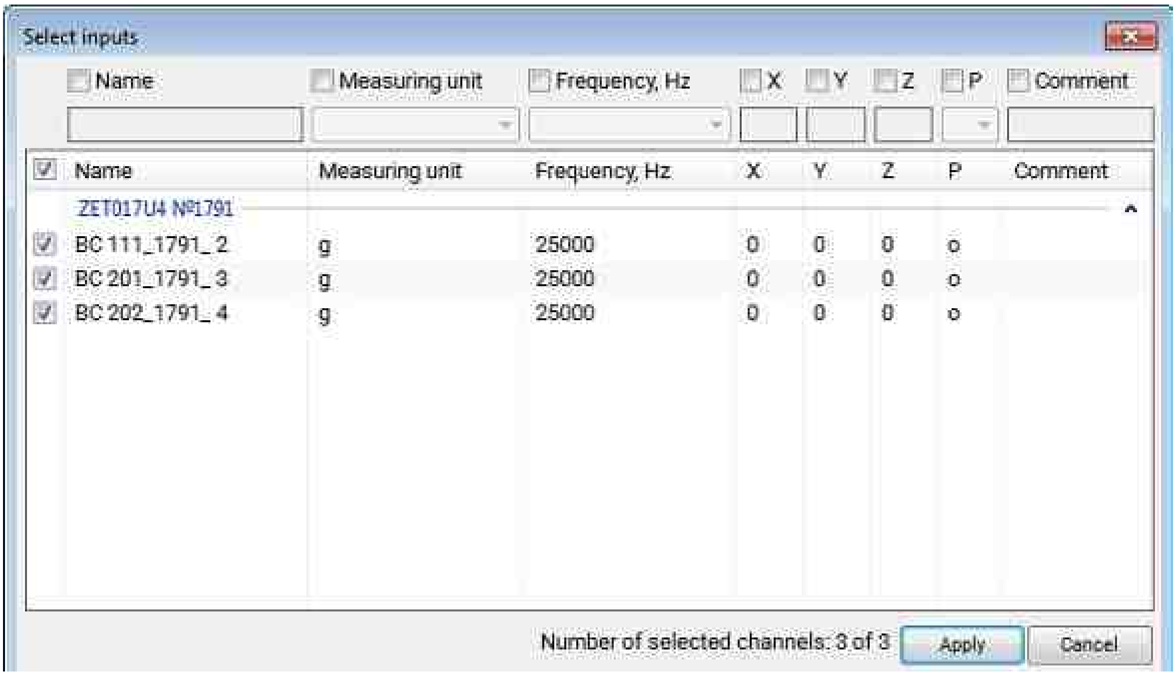


Fig. 4.3 "Select inputs" window

By activating the "Excitation signal" parameter, you can select a control channel used as a reference in resonance analysis (see Section 6.10).

The "Excitation signal" parameter is used by the program only for calculations for the Resonances tab.

The Validation time parameter defines the duration of measuring when determining acceleration and frequency instability (see Section 6.5).

The Validation time parameter is mainly used for determining the time interval for signal generation stability testing, however, in measuring other values, make sure that this duration is not less than the duration required for a single pass along the certification range for the sine signal oscillation with a given frequency sweep rate.

The Frequency range parameter defines the frequency range in which the program will record signals and perform measurements.

The Frequency range parameter shall be set in accordance with the frequency range of the vibration unit being certified.

The right pane of the Settings window contains an area for controlling the selected channels to ensure their correctness and sufficiency for measuring.

The measuring channel selected as a control (the Z channel is taken as an example) is used for all types of measurements.

The measuring channels orthogonal to the reference channel (the X and Y channels in the example) are used for measuring the Transverse Component.

The channels having the same direction with the control channel (e.g., VS 111_7915_4, VS 111_7915_5, and VS 111_7915_6 in the example) are used for measuring the "Unevenness of distribution".

The channel selected as the excitation signal (e.g., VS 111_7915_7) shall be measured in V/mV and used for resonance frequencies detection.

If the software detects any missing or excessive channels for the required calculations, then the red symbol "x" will be displayed for the type of measurement with the inconsistent number of channels.

The validation characteristics program window (Fig. *Fig. 4.1*) has several tabs to determine different types of measurements for certification. The relationship between the tabs and certification checkpoints is shown in Table 5.1.

The results are displayed in the following areas of the Validation characteristics program window:

- graphic area
- event log area
- channel list area
- statistics area
- current values area
- current values area.

The graphic area shows the recorded (at the end of the certification stage) graphical information (depending on the tab selected). To save the graphical information, click the Recording button in the control area.

The graphical information will be saved only for the currently selected tab.

The log area displays information on the program operation stage.

In the channel list area, the available control channels are divided into three statuses:

- control (corresponds to a control channel selected in the program configuration as the reference one)
- along vibration direction (corresponds to the channels from the primary transducers oriented along the control channel)
- orthogonal to vibration direction (corresponds to the control channels from the primary transducers orthogonal to the control).

By activating (in the channel list area) a control channel ID ( ), you can visualize the graphical information relevant to that channel in the graphic area.

Activation of control channel graphical information is not available on "Testing", "Harmonics", "Unevenness", "Instability", and "Resonances" tabs.

The statistics area (depending on the tab selected) displays numeric values of certification results for the relevant tab.

In the current values area, you can control the certification stage processes. The following numeric values are displayed in the area: accelerations, velocities, displacement, frequencies, oscillation rates, and current duration.

The control area contains buttons: Start, Stop, and Save.

The Start button enables the measuring mode (for each certification stage individually). The Start button disables after clicking on it and enables only on completion (termination) of a certification stage, or after clicking the Stop button.

The certification stage is started by clicking the Start button and after detecting the actuating signal on the control channel. The certification stage is completed after detecting the excitation signal loss in the control channel, or by clicking the Stop button

With the Stop button, you can disable the measuring mode at any time.

The Recording button is for saving (in .dtu) the recorded graphical information for the active (selected) tab and the relevant information from the statistics area (in .xls).

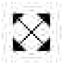
Use the mouse for the number line scaling.

To scale the number line, place the pointer to the graphic number line; the pointer (depending on the number line position) will change its appearance:

- for horizontal axes: , , , ;
- for vertical axes: , , , , .

Symbols and mean elongation, and symbols and mean squeezing of the relevant graphic number line. Symbols and mean "move to the left or right, for the horizontal axis", while symbols and mean "up and down, for the vertical axis".

After selecting the mouse pointer relevant to the required scaling action, perform the scaling by either left-clicking or by scrolling the mouse wheel.

For automatic scaling of the vertical axis within the registered value range (displayed within the graphic horizontal axis), place the mouse pointer on the number line crossing point; the pointer will look like .

Validation operations .....

The validation of vibration generator system according to GOST 25051.3-83 and the tabs of the Shaker Validation program to be used are shown in *Table 15.1*.

Table 15.1 Vibration generator system validation

No. item standard GOST 25051.3-83	Name of operation	Shaker certification program tab	Item No. of the document
4.2	Visual examination	—	15.6.2
4.3	Safety check	—	15.6.3
4.4	Testing	"Testing"	15.6.4
4.5	Vibration acceleration and frequency instability determination	"Instability"	15.6.5
4.6	Acceleration, Displacement (hereinbelow as displacement), and frequency range determination	"Testing" "Acceleration" "Velocity" "Displacement"	15.6.6
4.7	Acceleration and (or) displacement harmonic factor determination	"Harmonics"	15.6.7
4.8	Transverse component factor determination	"Transverse Component"	15.6.8
4.9	Irregularity of distribution determination	"Distribution"	15.6.9
4.10	Determination of the suspension member resonance frequency and the first resonance frequency of the movable system	"Resonances"	15.6.10
4.11	Determination of the stray magnetic field inductance over the shaker table	—	15.6.11

4.12	Determination of the vibration noise on the shaker table	"Testing"	15.6.12
4.13	Determination of the shaker table temperature fluctuation	—	15.6.13
4.14	Determination of error limits for acceleration and (or) displacement maintaining at the reference point	"Acceleration" "Velocity"[1]; "Displacement"	15.6.14
4.15	Determination of error limits for acceleration and displacement repetition error at the reference point	—	15.6.15
4.16	Check of the unit operation under a load applied along the line perpendicular to the shaker's running axis	"Harmonics"	15.6.16
4.17	Check of the unit operation under loading with a permissible moment of the load eccentricity.	"Harmonics"	15.6.17
4.18	Determination of the frequency repetition error limit	"Instability"	15.6.18

1 In case of certification by profiles with limited Velocity

Contents

During the operations, various load masses and various signal sources are used on the shaker table (*Table 6.1*).

Table 6.1

Document Item No.	Load Mass on Shaker Table	Signal Source for Measurements
5.4	0	control accelerometer channel
5.5	m_{nom}	control accelerometer channel
5.6	0; $0.25m_{nom}$	control accelerometer channel

5.7	0	control accelerometer channel
5.8	0; m_{nom}	control accelerometer channel two channels of accelerometers orthogonal to the reference
5.9	0	control accelerometer channel three channels of accelerometers parallel to the control
5.10	0; $0.25m_{nom}$	control accelerometer channel vibration unit's standard control system excitation channel
5.12	0	control accelerometer channel
5.14	0; m_{nom}	control accelerometer channel
5.15	0	control accelerometer channel
5.16	$0.25m_{nom}$; m_{nom}	control accelerometer channel
5.17	$0.25m_{nom}$; m_{nom}	control accelerometer channel
5.18	0	control accelerometer channel

1. During the visual examination of the vibration generator system, check it for mechanical damage.
2. The vibration generator system to be certified shall be supplied with operational documentation.
3. The vibration generator system completeness, location, and installation shall comply with the operation documentation.

The vibration generator system shall comply with "Electrical Installation Regulations".

1. The vibration generator system test includes checking for network interference (50 Hz) and the generation by the vibration generator system of a test excitation signal at a given frequency. On the testing stage, the correct display and activation of alarm and indication on the vibration generator system is checked.

2. Testing shall be performed with no load on the shaker table and with a primary transducer (accelerometer) installed in the center of the table, with the control channel used as a reference.
3. To check for the network interference (50 Hz), switch to the "Testing" tab.
4. Make sure that there is no significant level of network interference (discrete values at 50 Hz frequency and its harmonics exceed the noise level more than 10 times) at the spectrum graphic (*Fig. 6.1*). In case of a significant level of network interference (*Fig. 6.2*), check grounding of the FFT spectrum analyzer and equipment being certified, and take the relevant measures to decrease the network interference.

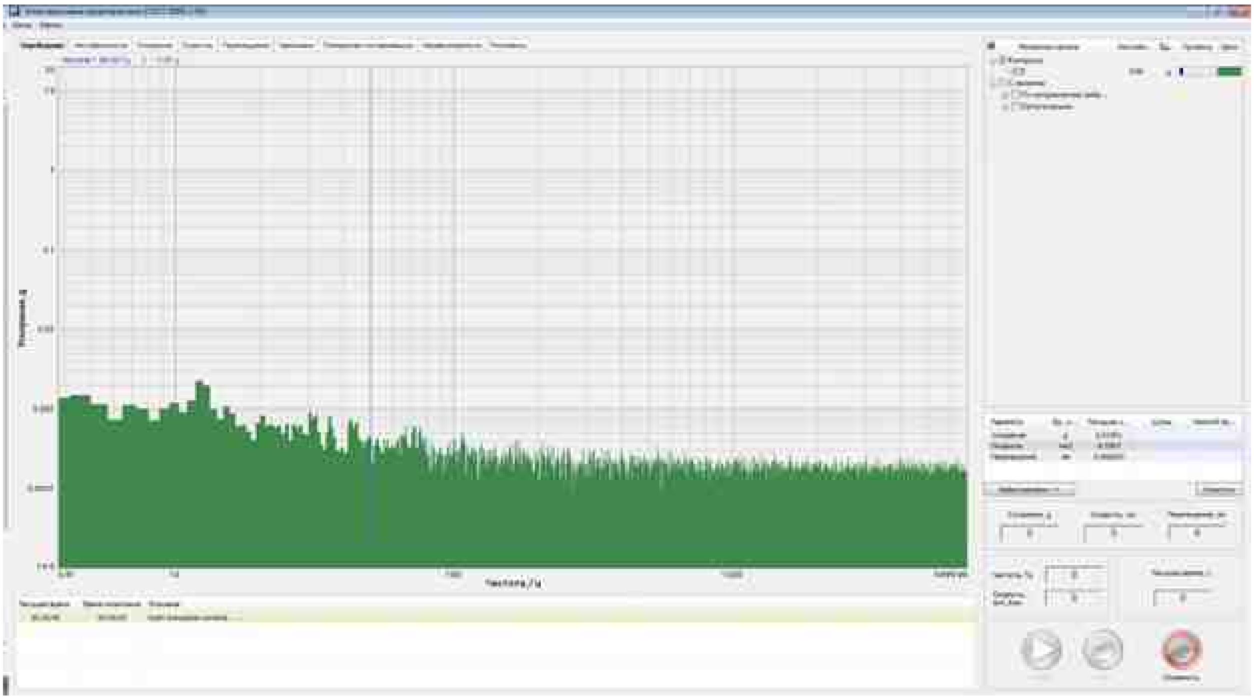


Fig. 6.1 Testing tab. Spectrum at no network interference

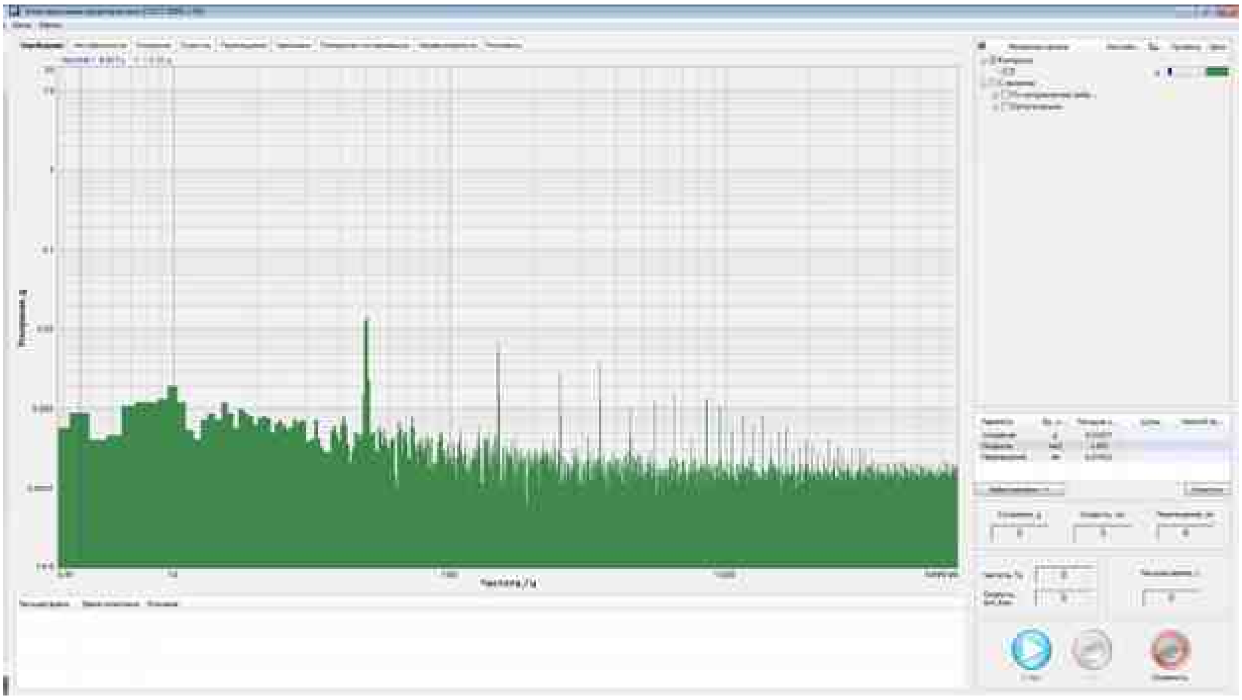


Fig. 6.2 Testing tab. Spectrum with network interference

5. To check the passage of the test actuating signal using the standard control system of the vibration generator system being certified, set a sinusoidal test signal at 400 Hz and 1 g amplitude.
6. Make sure that the discrete component appeared on the spectrum graphic (*Fig. 6.3*) at the given test signal frequency and amplitude.

Acceleration values on the spectrum graphic on the Testing tab are given as RMSV (Fig. 4.2).

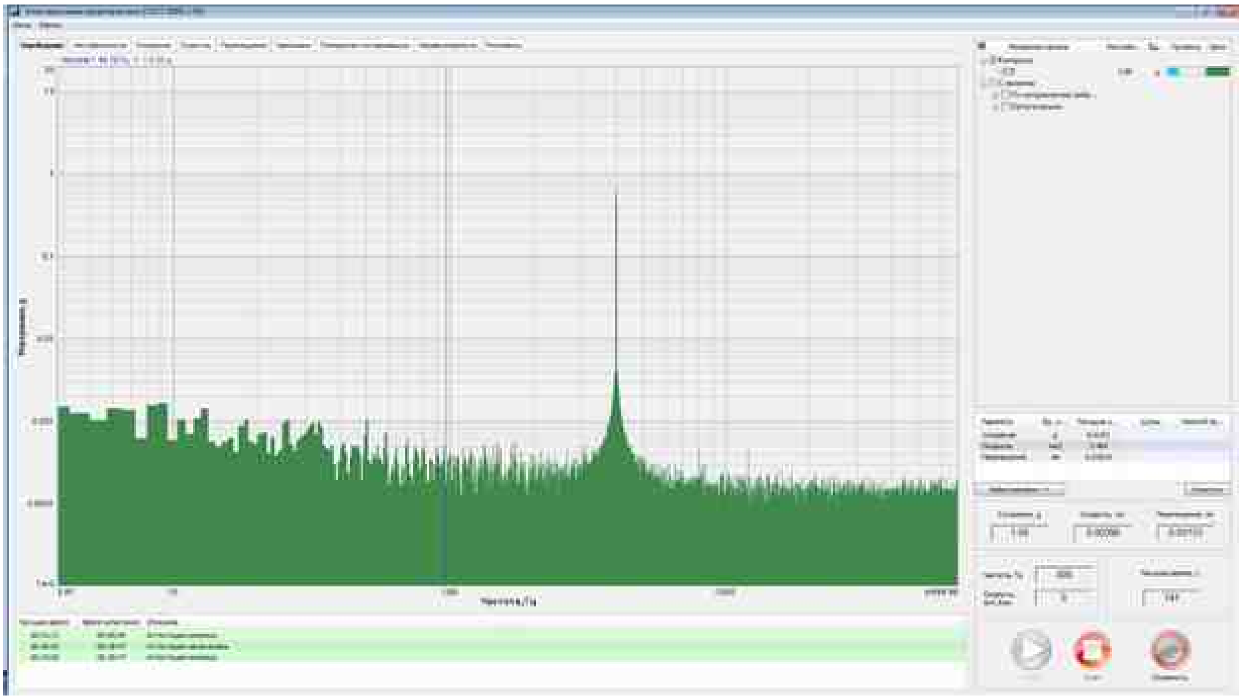


Fig. 6.3 Testing tab. Spectrum graphic with test signal present

1. Acceleration and frequency instability shall be determined at the rated mass load on the shaker table and with the control accelerometer installed in the center.
2. To determine acceleration and frequency instability, turn on the measuring mode by clicking the Start button.
3. Using the standard control system of the vibration generator system being certified, set a sine signal at 400 Hz and amplitude 0.7 of the upper rated (certified) acceleration limit.
4. At the end of measuring, the results obtained will be displayed (in numerical and graphical form) on the Instability tab (Fig. 6.4).

To ensure correct calculation of the maximum deviation, input manually the start and end values of the calculation interval to exclude the testing start and end mode ranges (ranges of the control signal increase and decrease).

Measuring duration is determined by the Validation time parameter set in the Settings window (Fig. 4.2)

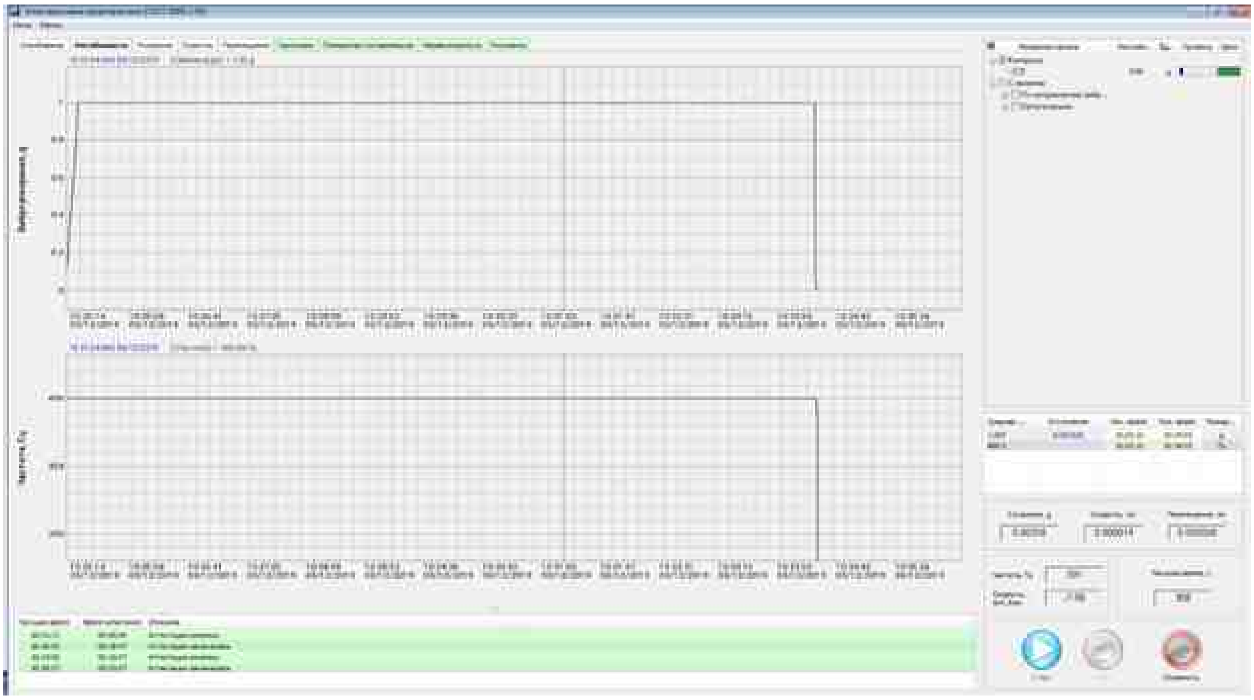


Fig. 6.4 Instability tab

1. Acceleration and frequency ranges shall be determined both in the absence of any load on the shaker table and with a load mass equal to j of the shaker table load, and with a control accelerometer installed in the center.
2. Lower limits, reproducible acceleration, and travel levels shall be measured according to Section 5.12 of this manual.
3. To determine the upper limits of acceleration, travel, and frequency ranges, turn on the measuring mode by clicking the Start button.
4. Using the standard control system of the vibration generator system being certified, set a sine signal with frequency oscillation within the rated (certified) frequency range and amplitude equal to the upper (certified) limits of displacement and acceleration as per ISO 5344.
5. At the end of the sine signal oscillation within the rated frequency range, the certification results recorded will be displayed on Acceleration (Fig. 6.5), Velocity (*Fig. 6.6*), and Displacement (*Fig. 6.7*) tabs (in numerical and graphical forms).

Cyan highlight shows the region for which the program calculates the "Deviation" parameter (see Statistics area). If required, the calculation region may be adjusted manually by setting the initial and final frequencies in the Statistics area.

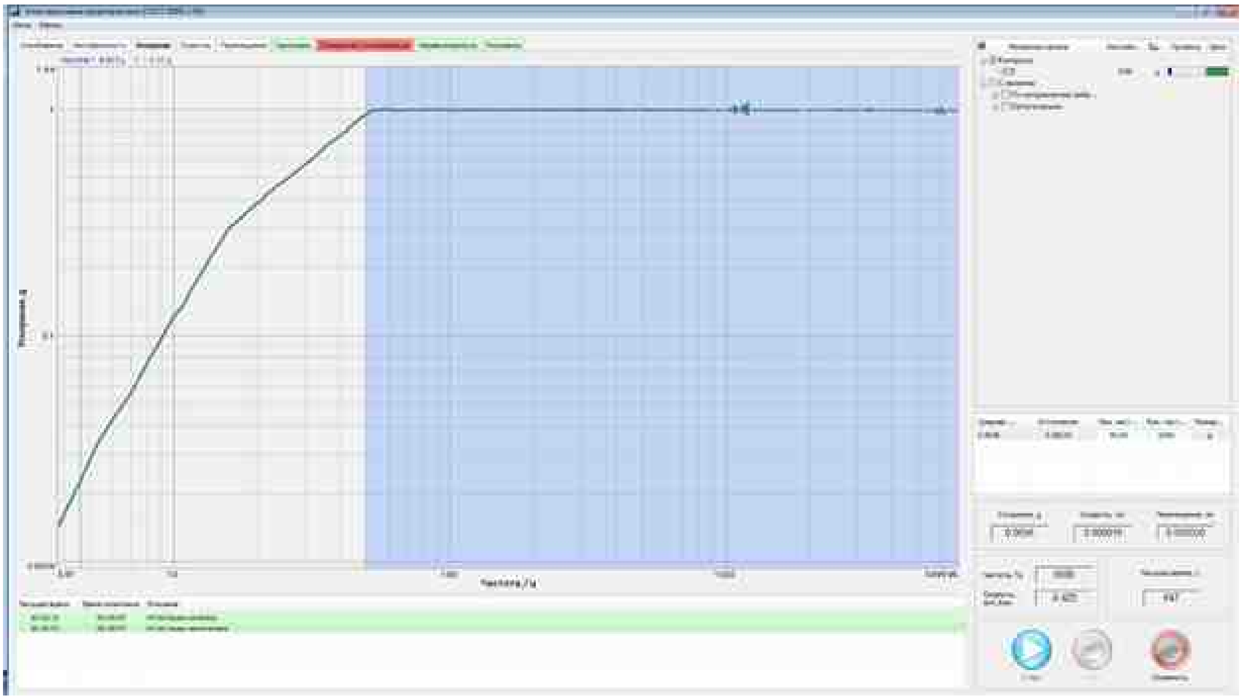


Fig. 6.5 Acceleration tab

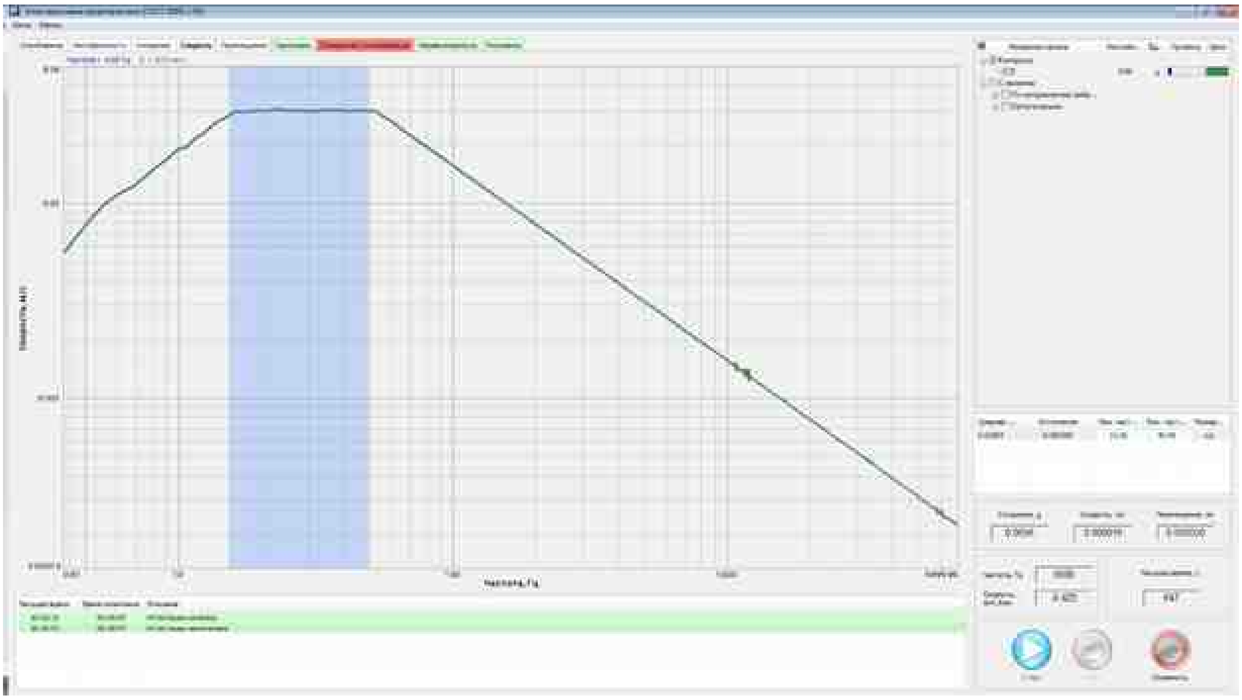


Fig. 6.6 Velocity tab

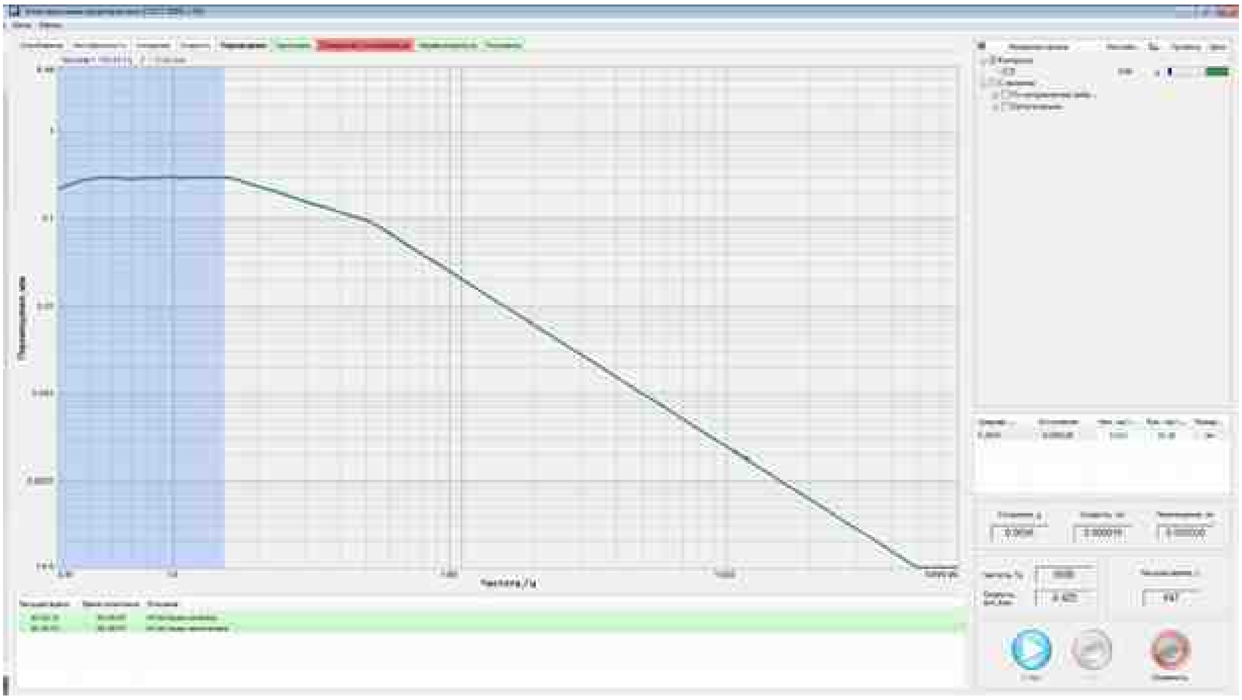


Fig. 6.7 Displacement tab

1. The harmonic factor may be determined jointly with Section 6.6 subject to the load absence on the shaker table and a control accelerometer installed in the center of the shaker.
2. To determine acceleration and/or displacement harmonic factor, turn on the measuring mode by clicking the Start button.
3. Using the standard control system of the vibration generator system being certified, set a sine signal with frequency oscillation within the rated (certified) frequency range and amplitude equal to the upper (certified) limits of displacement and acceleration as per ISO 5344.
4. At the end of the sine signal oscillation within the rated frequency range, the results recorded will be displayed (in numerical and graphical forms) on the Harmonics tab (*Fig. 6.8*).

The red background of the tab name means that the requirements of ISO 5344 are not met. In this case, the upper frequency of the range being certified shall be decreased manually to the level where the requirements of ISO 5344 is met, after that, the tab name background will turn green.

The cyan area in the graphic area shows the range from 0.7 to the upper value of the range being certified.

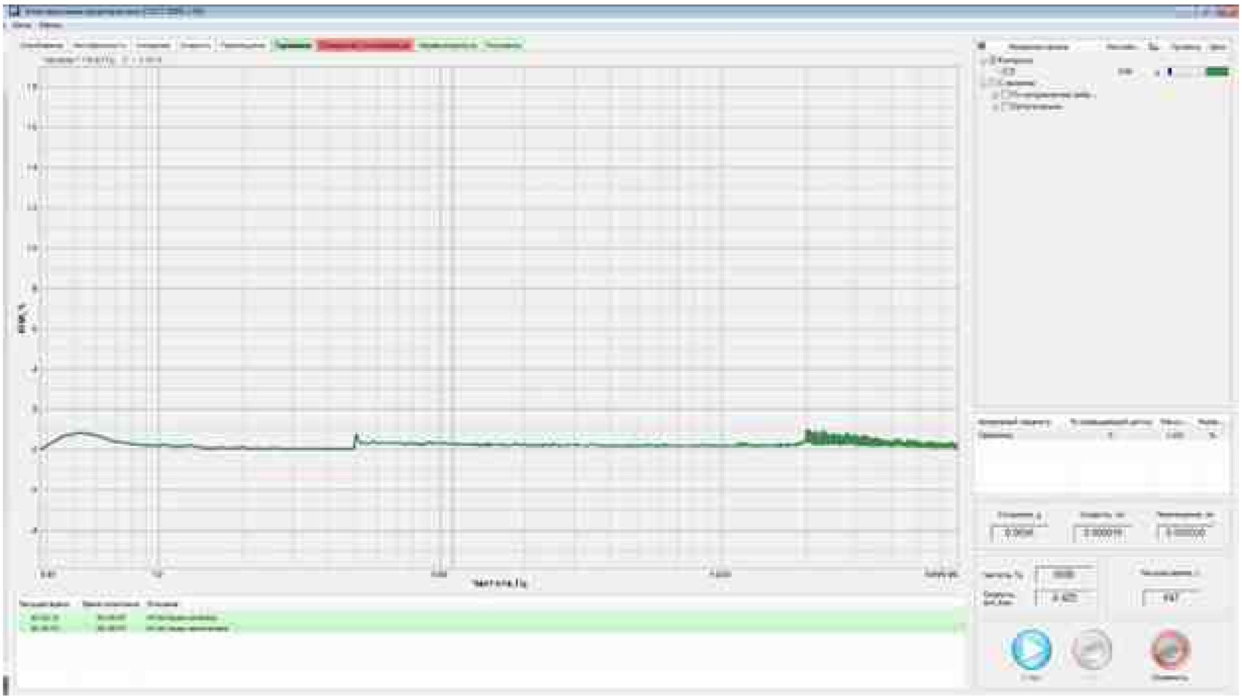


Fig. 6.8 Harmonics tab

1. The transverse component factor may be determined jointly with Section 6.6subject to the load absence on the shaker table and using a three-component accelerometer installed in the shaker table center. The transverse component factor with load mass on the shaker table equal to the rated load mass is determined on a case-by-case basis.
2. To determine the transverse component factor, turn on the measuring mode by clicking the Start button.
3. Using the standard control system of the vibration generator system being certified, set a sine signal with frequency oscillation within the rated (certified) frequency range and amplitude equal to at least 0.3 of the upper (certified) limits of displacement and acceleration as per ISO 5344.
4. At the end of the sine signal oscillation within the rated frequency range, the results recorded will be displayed (in numerical and graphical forms) on the Transverse Component tab (*Fig. 6.9*).

The red background of the tab name means that the requirements of ISO 5344 are not met. In this case, the upper frequency of the range being certified shall be decreased manually to the level where the requirements of ISO 5344 is met, after that, the tab name background will turn green.

The cyan area in the graphic area shows the range from 0.7 to the upper value of the range being certified.

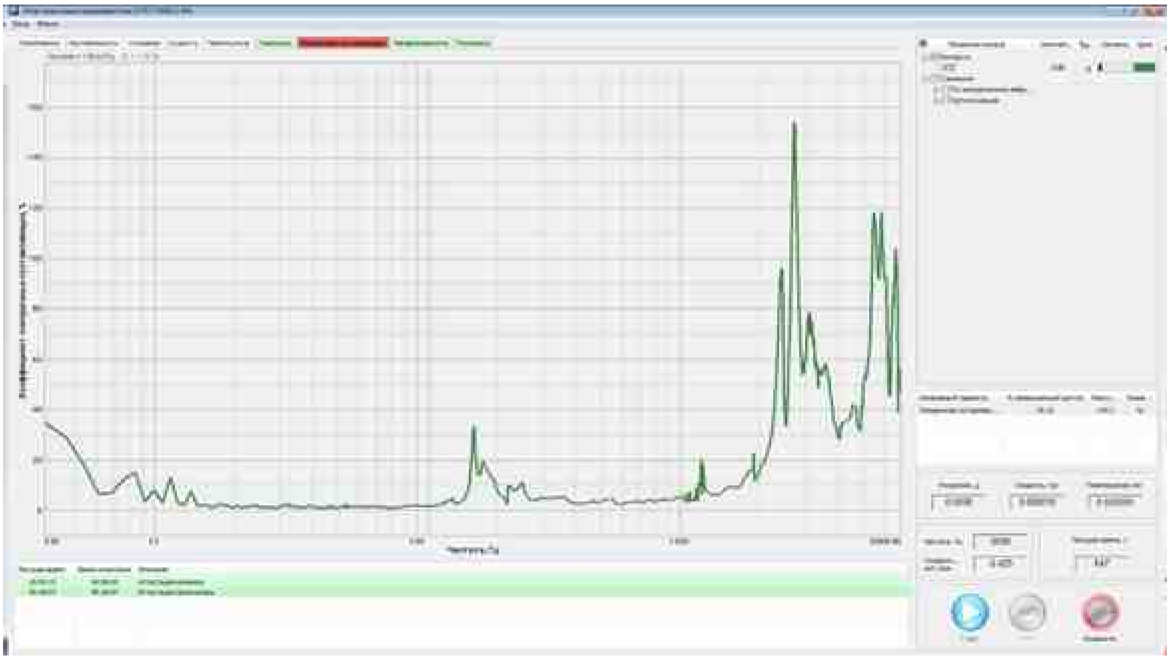


Fig. 6.9 Transverse Component tab

1. Irregularity of distribution may be determined jointly with Section 6.6 using a control accelerometer installed in the shaker table center, as well as at least three accelerometers installed evenly along the table perimeter and in the absence of a load on the shaker table.
2. To determine the irregularity of distribution, turn on the measuring mode by clicking the Start button.
3. Using the standard control system of the vibration generator system being certified, set a sine signal with frequency oscillation within the rated (certified) frequency range and amplitude equal to at least 0.3 of the upper (certified) limits of displacement and acceleration as per ISO 5344.
4. At the end of the sine signal oscillation within the rated frequency range, the results recorded will be displayed (in numerical and graphical forms) on the Distribution Over Table tab (*Fig. 6.10*).

The red background of the tab name means that the requirements of ISO 5344 are not met. In this case, the upper frequency of the range being certified shall be decreased manually to the level where the requirements of ISO 5344 is met, after that, the tab name background will turn green.

The cyan area in the graphic area shows the range from 0.7 to the upper value of the range being certified.

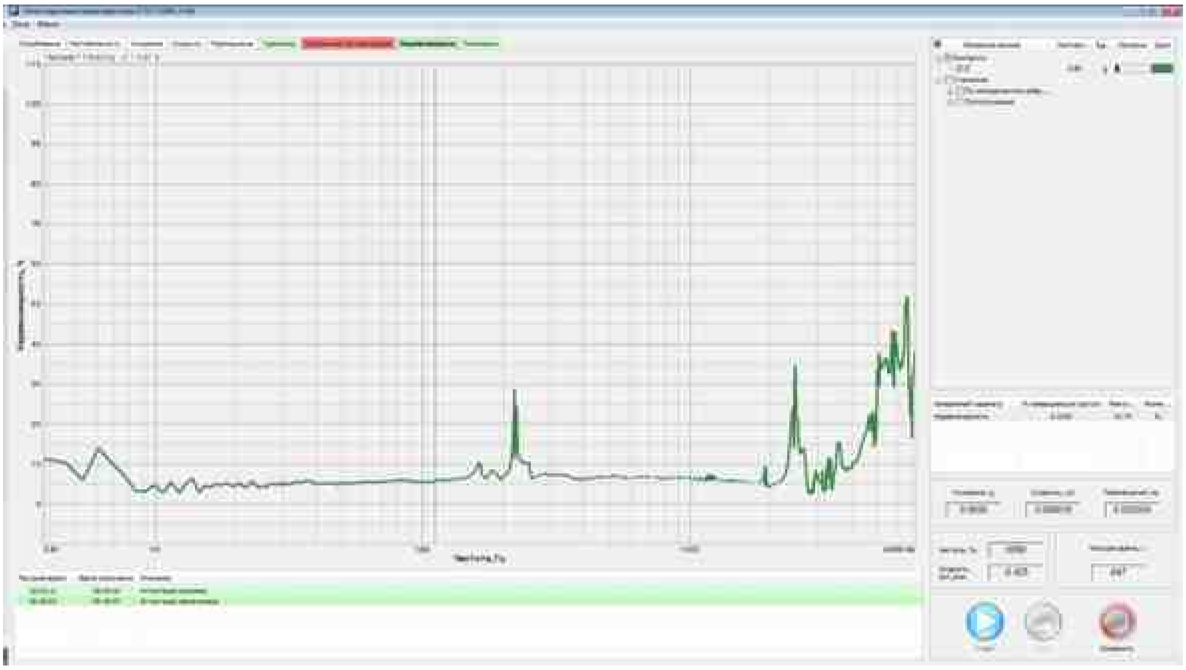


Fig. 6.10 Unevenness of Distribution tab

1. The suspension member resonance frequency and the first resonance frequency of the movable system shall be determined using a control accelerometer installed in the shaker table center, at the mass of the load equal to zero and 0.25 of the rated load mass.
2. Connect an actuating signal (generator output) of the vibration generator system's standard control system to a free input (control channel) of the ZET 038 FFT spectrum analyzer (using a BNC triple adapter and a BNC-BNC cable).
3. In the program settings (*Fig. 4.2*), enable the Excitation Signal parameter and select the ZET 038 FFT spectrum analyzer's control channel which the actuating signal output of the standard control system is connected to (in the example, the channel is named "Reference").
4. To determine the resonance frequency and the first resonance frequency of the movable system, turn on the measuring mode by clicking the Start button.
5. Using the standard control system of the vibration generator system being certified, set a sine signal with frequency oscillation within the rated (certified) frequency range and amplitude equal to at least 0.3 of the upper (certified) limits of displacement and acceleration as per ISO 5344.

6. At the end of the sine signal oscillation within the rated frequency range, determine the resonance frequency of the suspension member and the first resonance frequency of the movable system on the Resonances tab (*Fig. 6.11*).

If required, adjust the resonance frequency values manually in the Statistics area.

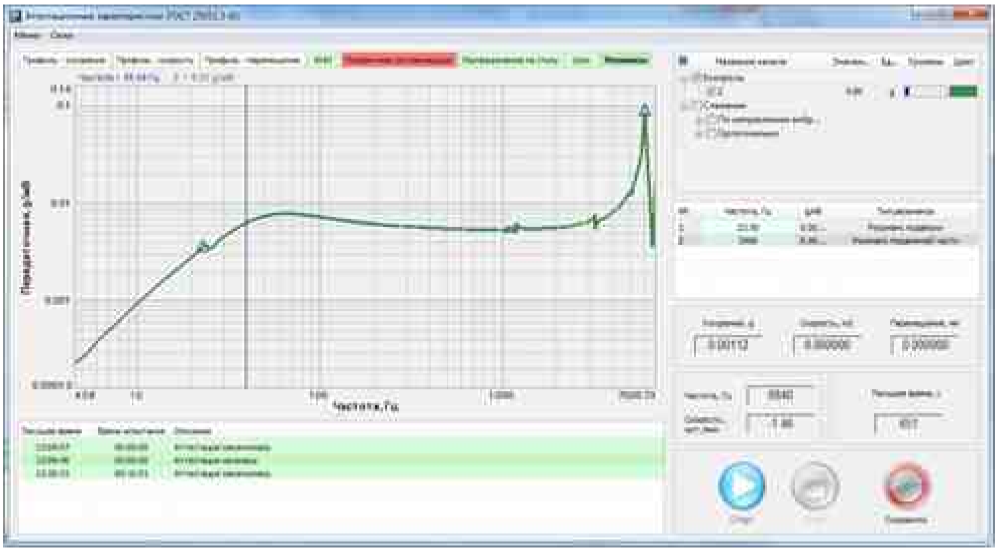


Fig. 6.11 Shaker Validation program, Resonances tab

1. Stray magnetic field inductance shall be determined with polarizing and de-polarizing coils power supply on and in the absence of the actuating signal using magnetic flux density measuring instrument or a milli-flux meter with certified measuring coils.
2. Magnetic flux density shall be measured at points 20 mm above the shaker table surface, along the radius: in the center, at 0.5 R and R distances from the shaker table center, where R is the table radius.
3. Standards and (or) specifications for a unit or a shaker of certain type shall indicate the maximum level of the stray magnetic field inductance over the shaker surface. In case of any requirements regarding the stray magnetic field compensation, the magnetic inductance over the shaker surface shall not exceed 0.001 T.

1. Vibration noise may be determined in the absence of a load on the vibration unit table and with a control accelerometer installed in the shaker center. The measurement shall be performed with the vibration generator system turned on but with no excitation signal.

2. To determine the vibration noise on the shaker table, switch to the Testing tab.
3. Make sure there is no significant level of network interference (discrete at 50 Hz frequency and its harmonics exceed the noise level more than 10 times) at the spectrum graphic (Fig. 6.2).
4. Click the Fix button; lower limits of the *vibration* acceleration, vibration velocity, and Displacement will be calculated (Fig. 6.12).

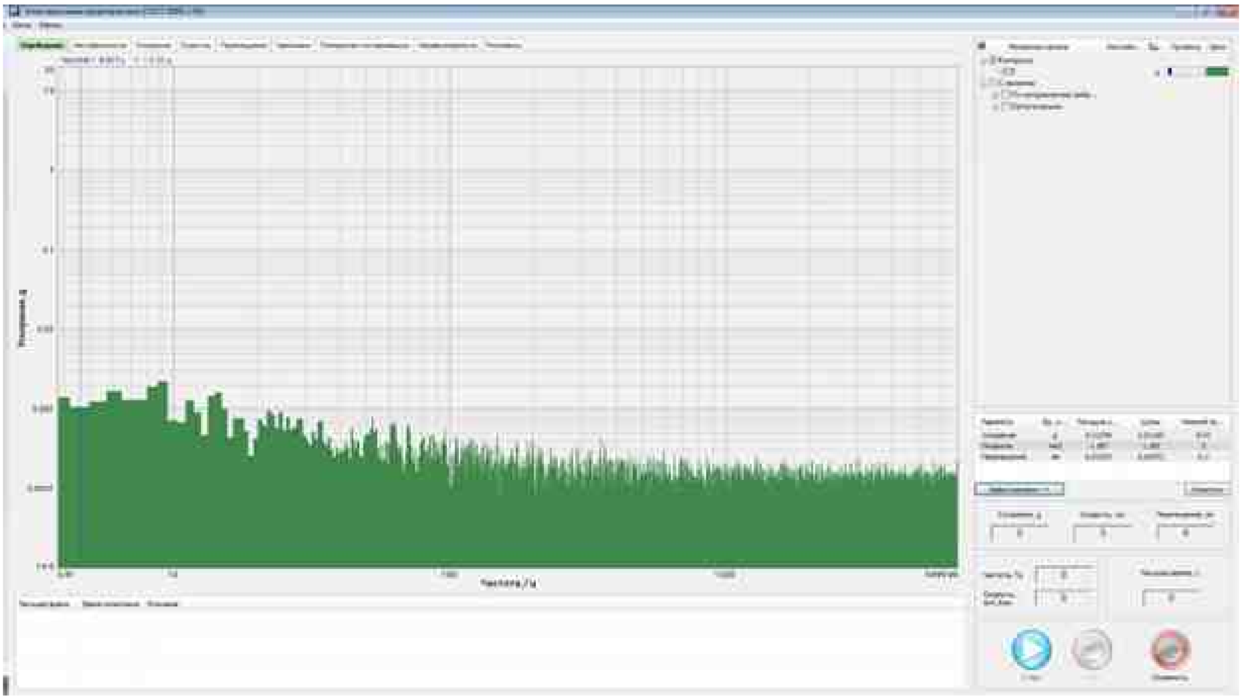


Fig. 6.12 Shaker Validation program, Noise tab

1. Shaker table temperature fluctuation shall be determined at the nominal mass load on the shaker and with the control accelerometer installed in the center..
2. Shaker table temperature fluctuation "ΔT" shall be calculated in centigrade degrees using the following formula: $\Delta T = T_K - T_H$

where "T_K" and "T_H" — are shaker table temperature at the end and at the beginning of the operation as per 6.5 obtained using surface temperature measuring instruments.

3. To measure the temperature, attach a thermometer's sensing element to the shaker table and measure as per ISO 5344.

1. Error limits for acceleration and/or displacement maintaining shall be determined with a control accelerometer installed in the center of the table, at the load mass on the shaker table equal to zero, and at the load mass on the shaker table equal to the rated mass.
2. To determine error limits for acceleration and/or displacement maintaining, turn on the measuring mode by clicking the Start button.
3. Using the standard control system of the vibration generator system being certified, set a sine signal with frequency oscillation within the rated (certified) frequency range and amplitude equal to 0.7 of the upper (certified) limits of displacement and acceleration as per ISO 5344.
4. The end of the sine signal oscillation within the rated frequency range, the certification results recorded will be displayed on Acceleration (*Fig. 6.13*, Velocity, and Displacement tabs (in numerical and graphical forms).

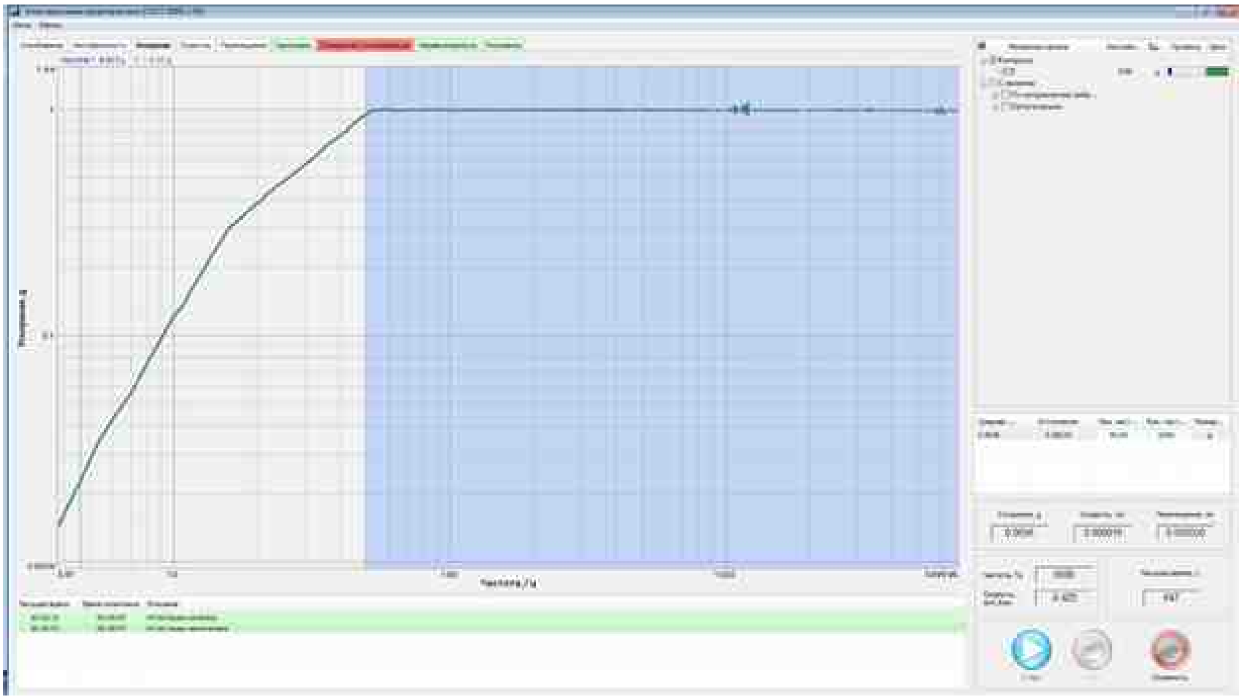


Fig. 6.3 Acceleration tab

1. Acceleration and displacement repetition error limits at the control point are determined by calculations using the results of measurements with no load on the shaker table and with a control accelerometer installed in the table center.
2. Acceleration (displacement) repetition permissible error limits are evaluated as a percentage with confidence probability of 0.9 using the following formula:

$$\delta = \pm 0{,}95\sqrt{\delta_0^2 + \delta_{АЧХ}^2 + \delta_Г^2 + \delta_П^2 + \delta_t^2}$$

where

δ_0 – main vibration passage relative error limit;

$\delta_{АЧХ}$ – vibration passage AFR distortion limit;

$\delta_Г$ – additional measurement error limit due to higher harmonics as a percentage at the measurement of the parameter mean-square value measurement using the following formula:

$$\delta_Г = \left(\sqrt{1 + K_{ГК}^2} - 1\right) \cdot 100\%$$

$K_{ГК}$ - maximum distortion factor at the control point within the frequency range, relative units;

$\delta_П$ – additional measurement error limit due to transverse components measured using the following formula:

$$\delta_П = K_{ПК} \cdot K_{ОП}$$

$K_{ГК}$ -a maximum ratio of the transverse components at the control point within the frequency range, in %;

$K_{ОП}$ - relative transverse bearing change conversion ratio, relative units;

δ_t - additional measurement error limit for the shaker table temperature determined as a percentage using the following formula:

$$\delta_t = K_t \cdot \Delta T$$

where K_t - is the bearing change temperature sensitivity ratio.

3. The measured value of the repetitive acceleration in case of a ±10 % supply voltage variation shall not exceed 0.25 of the acceleration repetition permissible error limit.

1. Check the unit operation under a load applied along the line perpendicular to the shaker's running axis in accordance with the methods set forth in the normative technical documentation for the unit.
2. In the absence of the relevant requirements in the normative technical documentation for the unit, the ratio of the harmonic shall be checked according to Section 6.7 hereof in the mode of horizontal vibration repetition (at the horizontal position of the shaker's movable part) with an equivalent load equal to 0.25 of the rated load or with 100 kg load when the weight of the equivalent load equal to 0.25 of the rated mass exceeds 100 kg.

3. The permissible moments of the limit load applied along the line perpendicular to the shaker's running axis and due to an eccentricity of the load applied along the shaker's running axis shall be specified in the standards and (or) technical specification for the unit and (or) shaker of specific types.

1. Check the unit operation bu loading it with a permissible moment of the load due to the load eccentricity in accordance with the methods set forth in the normative technical documentation for the vibration generator system.
2. In case of no relevant requirements in the normative technical documentation for the vibration generator system, the ratio of the harmonic shall be determined by performing the operation as per Section 6.7 hereof with a load equivalent attached to the shaker with its symmetry axis parallel to the shaker's running axis and displaced from it to a distance of to be calculated in meters using the following formula:

$$e = \frac{M}{P}$$

where "M" — is the maximum permissible moment due to the load eccentricity, N·m,

„$\delta_{Г}$„ — is the load equivalent weight, N.

3. The permissible moments of the limit load applied along the line perpendicular to the shaker's running axis and due to an eccentricity of the load applied along the shaker's running axis shall be specified in the standards and (or) technical specification for the unit and (or) shaker of specific types.

1. Frequency repetition (setting) error limit shall be determined in the absence of a load on the shaker table and with a control accelerometer installed in the center of the table.
2. Frequency repetition error shall be measured by performing the operations as per Section 6.5. When performing measurements, use the vibration generator system's standard control system to set the sine signal as per ISO 5344.

Automatic self-control of the controller .....

Connect the controller to the computer via the Ethernet interface.

Connect the BNC-BNC cable to the connectors of the generator output and the input of the measuring channel of the controller.

On the VCS panel, activate the "Device Manager and channels" button. The window of the ZET Device Manager program will be displayed on the monitor screen (*Fig. 17.1*).

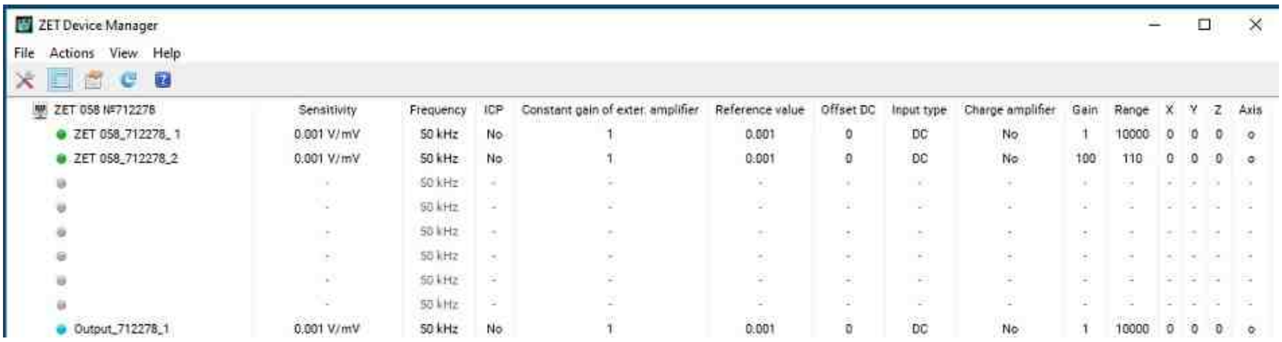


Fig.17.1 The "Device Manager" program

In the "Device Manager" program window, activate the identifier corresponding to the controller and select the "Sampling frequency" tab in the "Properties" window (*Fig. 17.2*).

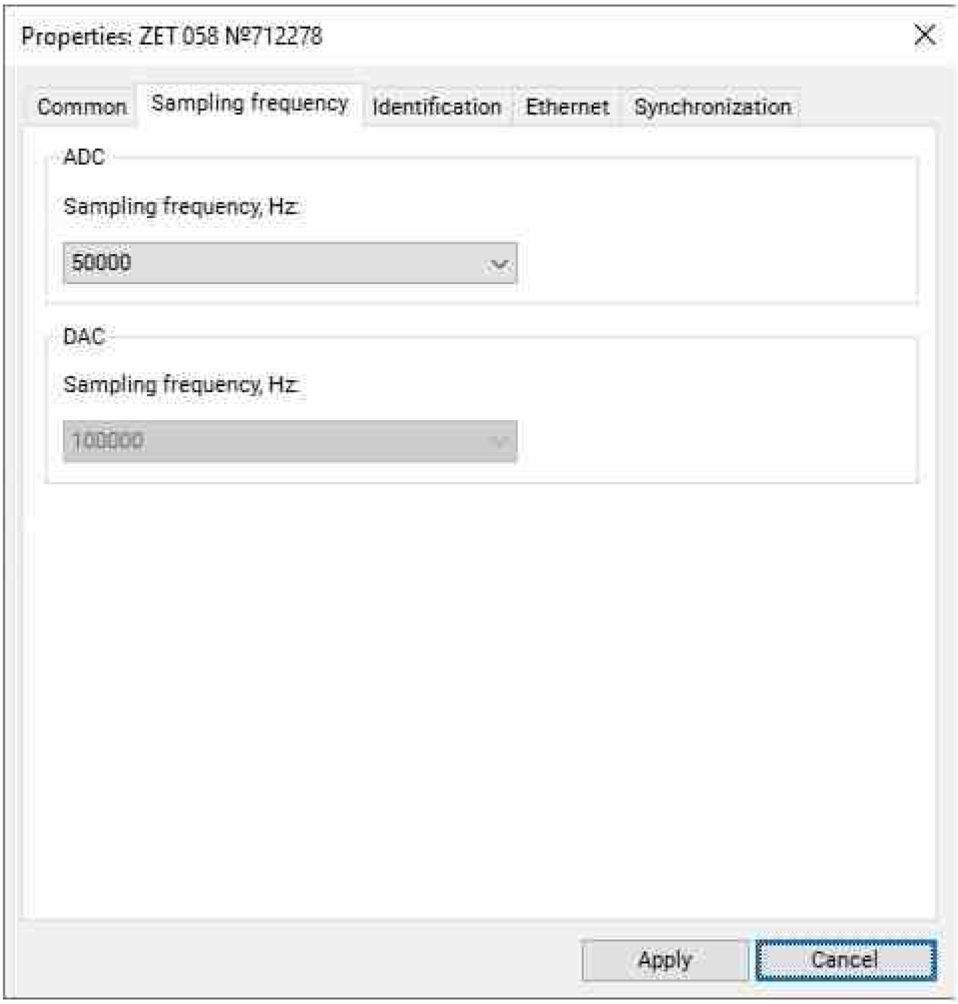


Fig. 17.2 The "Sampling frequency" tab of the Properties window

Set the sampling frequency for the controller inputs, for which in the "ADC" field activate the pointer to the drop-down list and select "50 kHz" from the list, while the sampling frequency in the "DAC" field will be set automatically by the program.

To save the changes made, activate the "Apply" button.

In the "Device Manager" program window, activate the identifier corresponding to the measuring channel of the controller.

In the "Properties" window that opens:..." (Fig. 17.3) set the parameters of the measuring channel:

- The "Sensitivity" parameter is 100 mV/g;
- The "Direction" parameter – ↑;
- The "Gain" parameter – 1;
- The "AC" parameter is enabled.

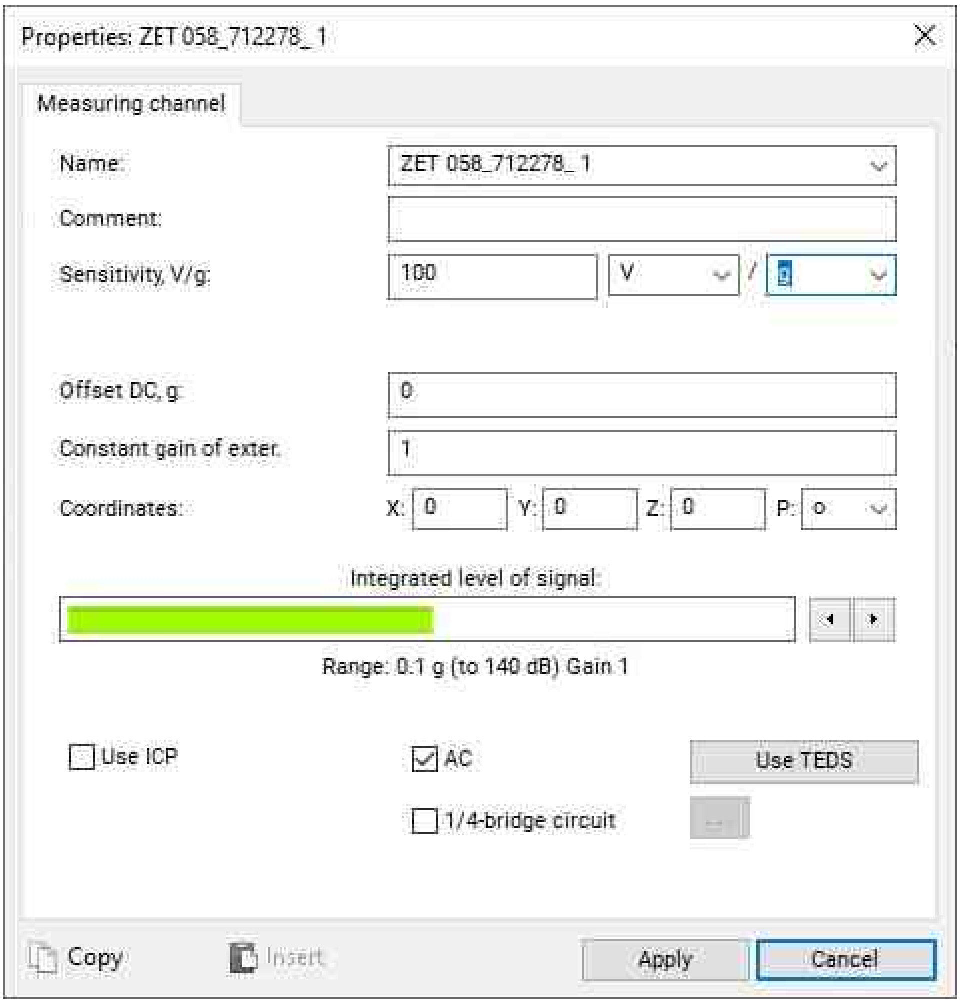


Fig. 17.3 The "Device Manager" program tab of the Properties window

On the panel VCS, you can activate the "Shaker parameters" button. In the opened window of the "Shaker parameters" program, add a new Shaker to the user's database by setting the technical characteristics in accordance with *Fig. 17.4*. To save the changes made, activate the "Apply" button

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The rules for adding a new Shaker to the user database are given in the "Shaker parameters" section in section 7.

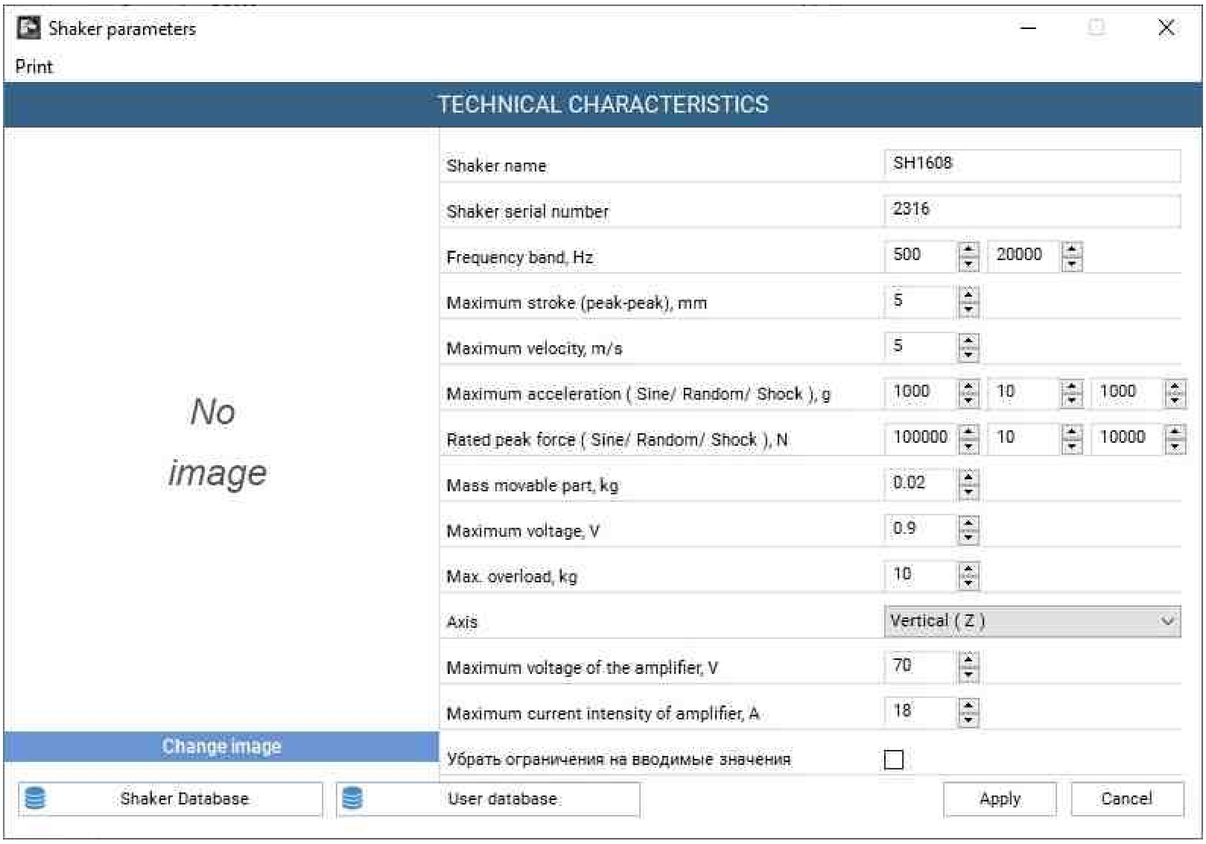


Fig. 17.4 Program "Shaker parameters"

Click the "Select" button in the field of the previously added Shaker. To save the changes made, activate the "Apply" button.

On the panel VCS, you can activate the "Pre-Test and search for resonances" button. In the window of the program "Pre-Test and resonance search" that opens, click the "Settings" button and set the parameters according to *Fig. 17.5*. To save, click the "Apply" button.

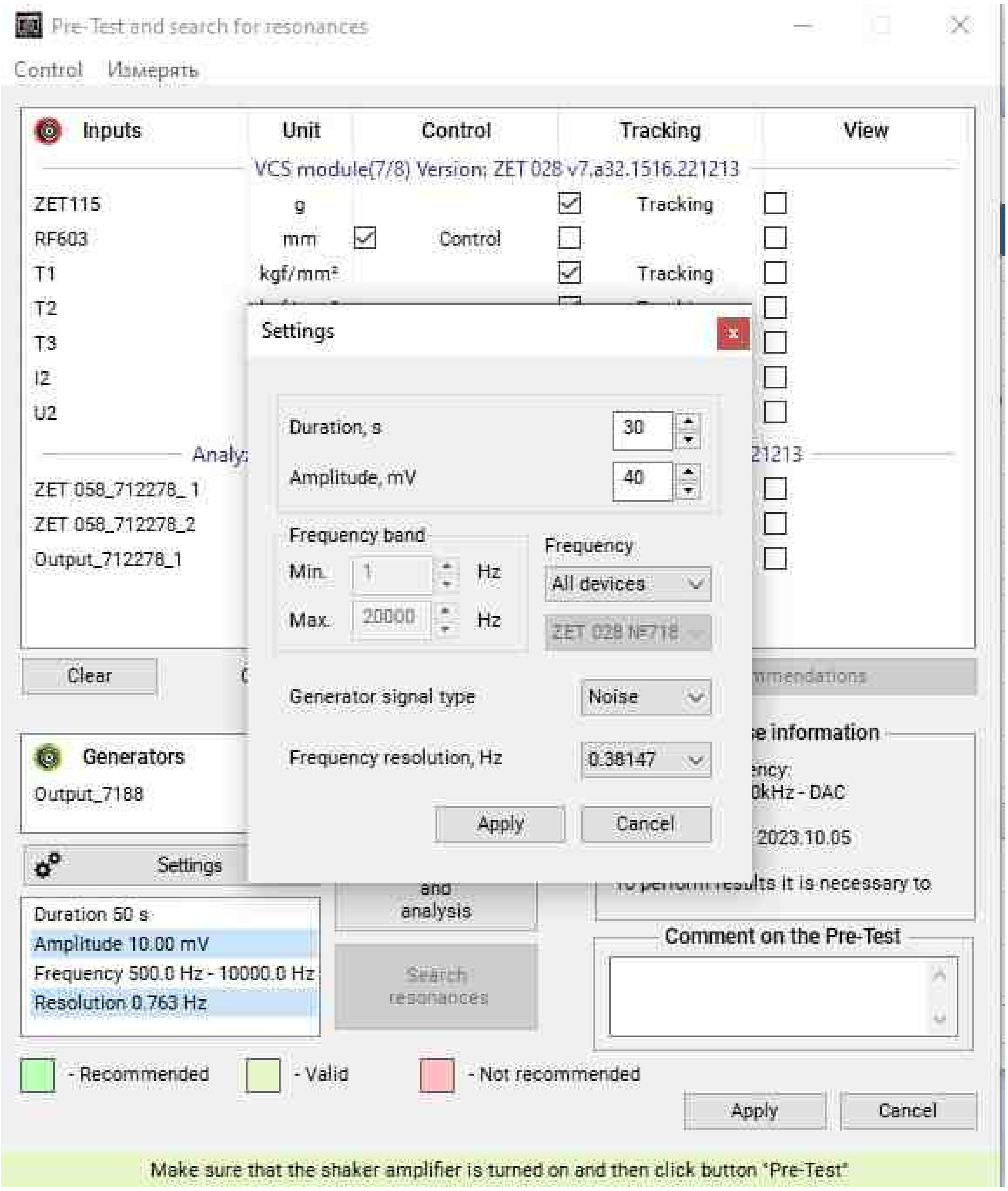


Fig. 17.5 The "Settings" window of the "Pre-Test and resonance search" program

In the program window "Pre-Test and search for resonances" to conduct a Pre-Test. At the end of the Pre-Test, set the status "Control" to the measuring channel of the controller, the input of which is connected to the Output of the Generator (*Fig. 17.6*). To save the changes made, activate the "Apply" button.

Fig. 17.6 The program "Pre-test and search for resonances"

On the panel VCS, you can activate the "Sine" button. In the window of the "Sine" program that opens, click the "Edit profile" button. In the "Edit profile" window on the "Profile" tab (*Fig. 17.7*), set the test profile parameters:

- Frequency range – from 8 to 10000 Hz;
- Acceleration – 10 g;
- Scan type – Log;

- Sweep rate – 1 oct/min.

To save the changes, activate the "Apply" and "OK" buttons.

----

2) The rules for working with the program "Pre-test and search for resonances" are given in section 8.
3) The rules for working with the program "Sine" are given in section 9.

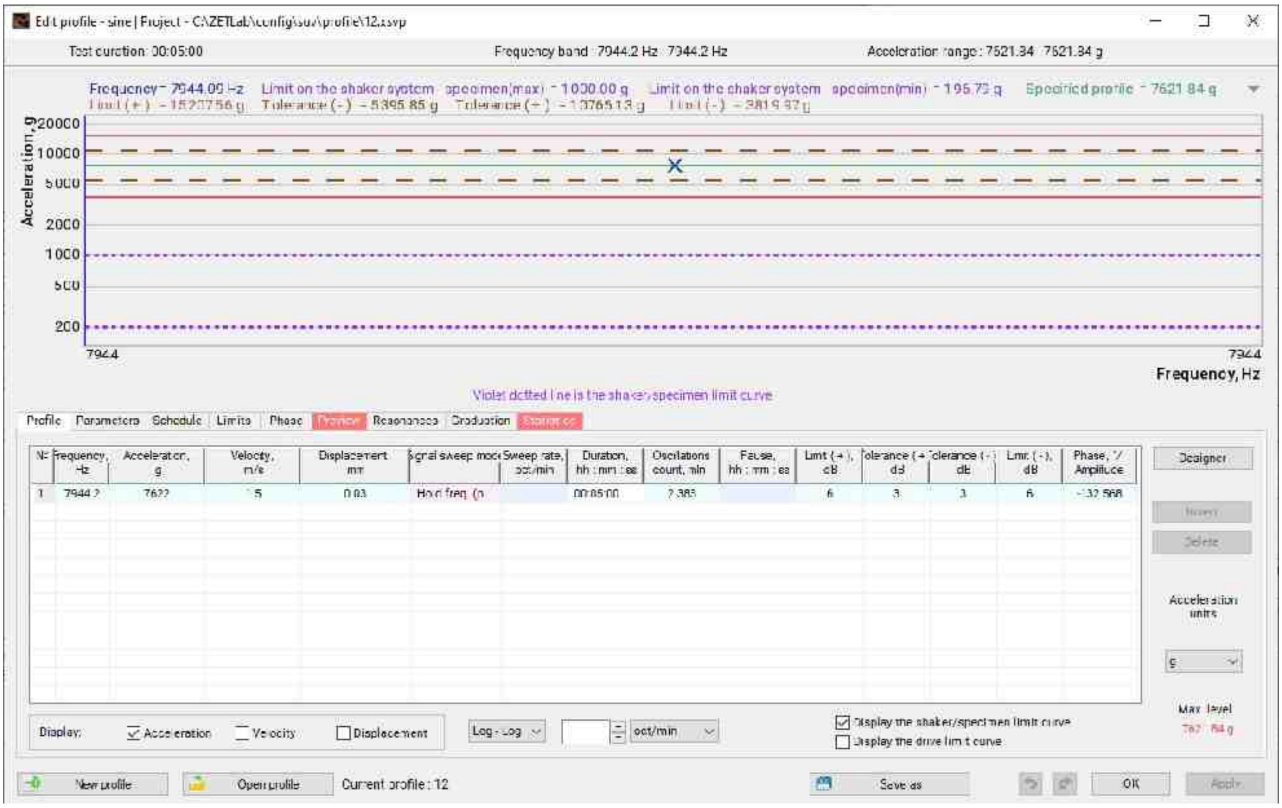


Fig. 17.7 Window "Edit profile" of the program "Sine"

From the "Metrology" tab of the ZETLab panel, start the "Shaker Validation" program. In the "Shaker Validation" program window that opens, click the "Settings" button. In the "Settings" window (*Fig. 17.8*), set the Shaker Validation parameters:

Control channel – the measuring channel of the controller, the input of which is connected to the output of the generator;

Frequency range – from 8 to 10000 Hz;

Shaker Validation time – 30 minutes;

Unit of measurement – g;

Select of tabs – Acceleration, Harmonics.

To save the changes made, activate the "Apply" buttons.

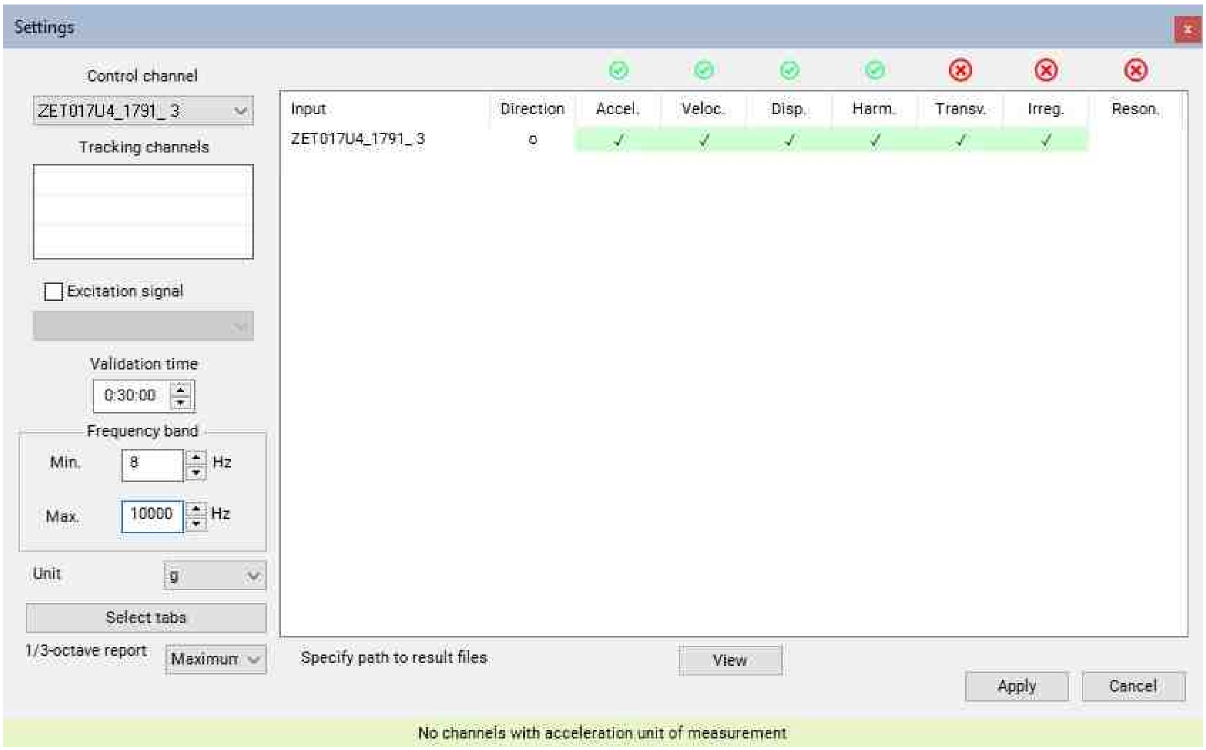


Fig. 17.8 The "Settings" window of the "Shaker Validation" program

To start automatic self-control, activate the "Start" button alternately in the "Shaker Validation" and "Sine" programs.

In the window of the program "Sine", wait for the end of the tests (passing through the specified profile), then in the window of the program "Shaker Validation" press the "Stop" button.

In the program "Shaker Validation" on the tabs "Acceleration" (Fig. 17.9), "Harmonics" (Fig. 17.10), the results of automatic self-control of the controller will be displayed.

The controller is considered to have successfully passed automatic self-control if:

- On the "Acceleration" tab, the maximum value of the acceleration deviation from the one set in the profile (10 g) does not exceed 2 %;
- On the Harmonics tab, the maximum value of the THD (nonlinear distortion coefficient) does not exceed 2%.

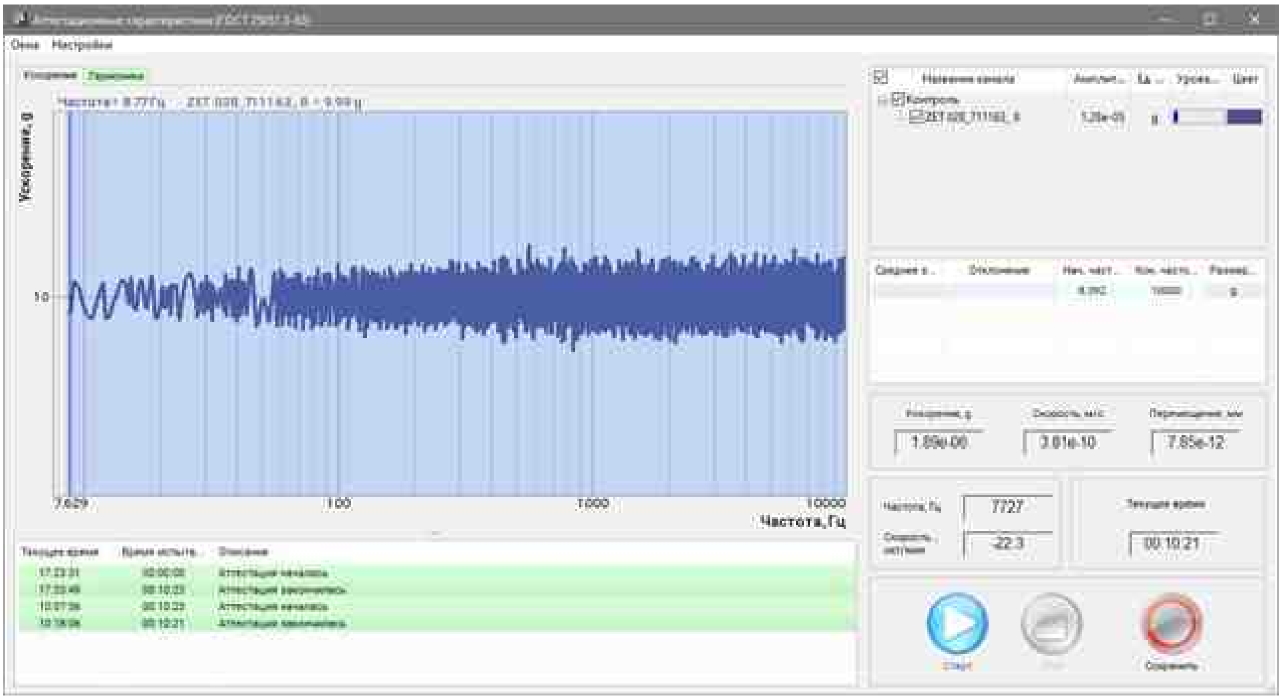


Fig. 17.9 The "Acceleration" tab of the "Shaker Validation" program

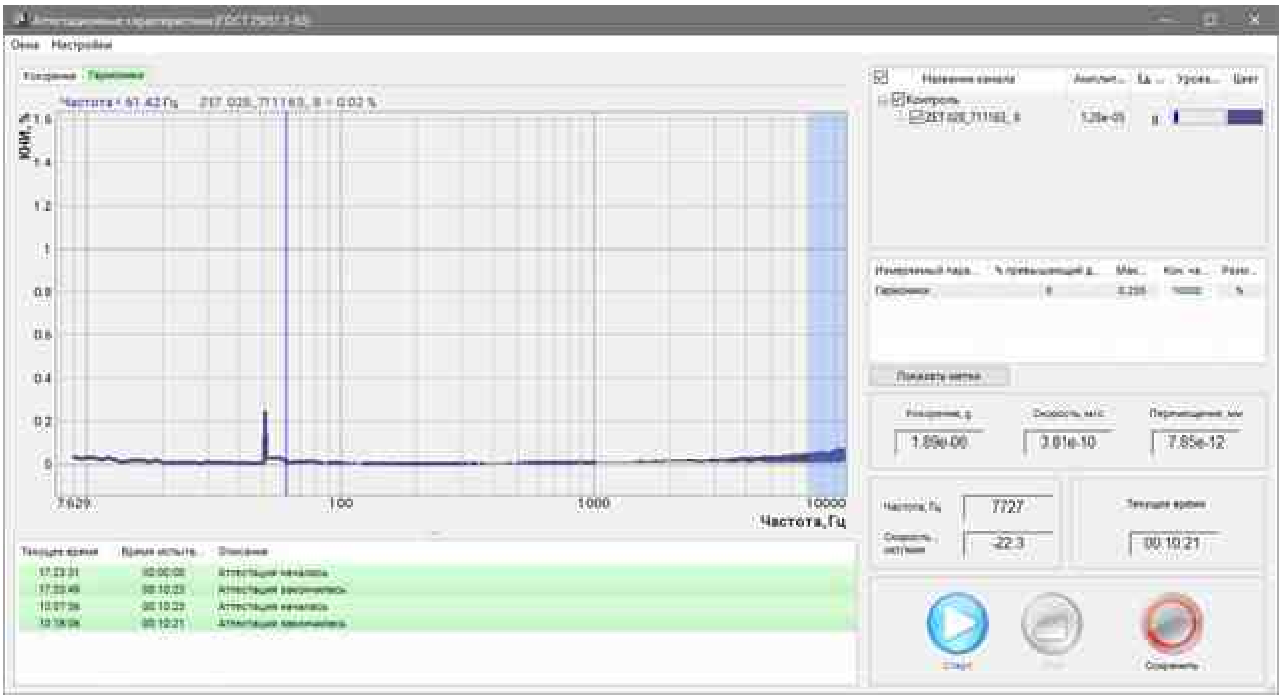


Fig. 17.10 Tab "Harmonics" of the program "Shaker Validation"

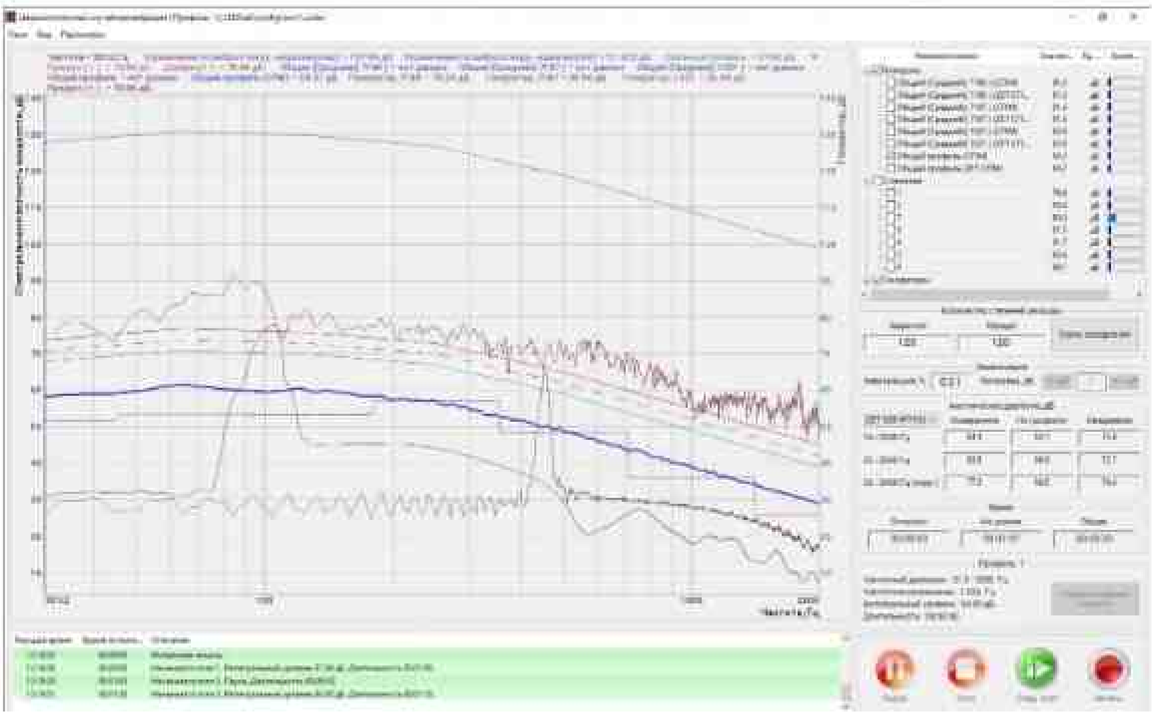
"Acoustic noise“ software .....

"Acoustic noise" software

The program is designed for automated control of sound generators or other installations when testing specimens for effect to normalized high-intensity acoustic noise (acoustic component of vibration testing). The program supports the following types of modes in terms of the sound excitation method:

- effect on the sample of acoustic noise with a uniform spectral density of acceleration / sound pressure in the entire normalized frequency range;
- effect on the sample to a tone of varying frequency in a given frequency range;
- volume resonance test.

Acoustic noise effect can cause vibration of built-in parts of specimens, as a result of which the vibration response of the entire specimen may differ from vibrations caused by external mechanical effects. This leads to the ineffectiveness of vibration protection, and as a result - to the failure of the entire specimen. This type of test is especially relevant for specimens operating in turbulent conditions.

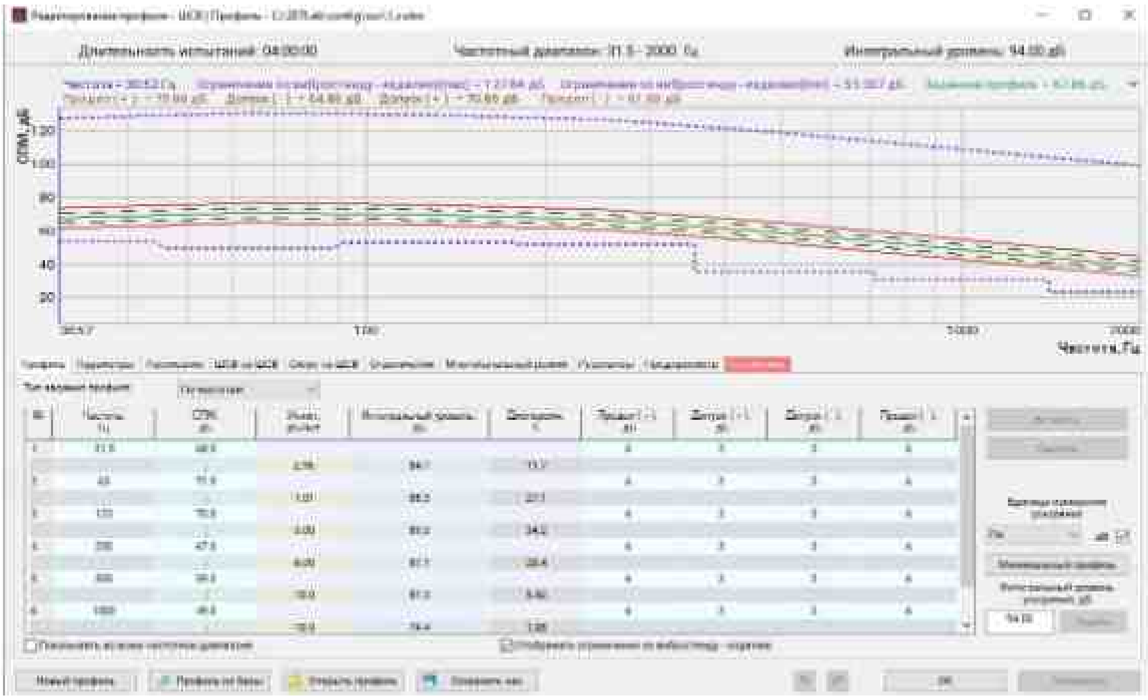


To activate the "Acoustic noise" program, it is necessary to launch the "Random" program from the VCS panel, having previously set the necessary test parameters:

- the main parameters of the acoustic chamber - frequency range and maximum sound pressure;
- specimen parameters - permissible sound pressure;

- make sure that the sensitivity is set the measuring channels in units of measurement corresponding to sound pressure, for example, mV / Pa;
- perform a Pre-Test by selecting the control parameter - pressure.

Before starting, you must set the test profile. By default, the unit of measurement will be set to Pa. For convenience, the graphic can be displayed in dB by setting the flag in the column of the same name on the "Profile" tab.



A high sound pressure level can be obtained using several sound generators operating in different frequency ranges.

The Acoustic noise program supports multi-channel control.

The multi-channel mode parameters are adjustment at the stage of the pretest: it is necessary to set the control mode "According to", set the frequency ranges and sequentially perform a pretest for each generator.

In the test profile editor, on the "Multi-channel mode" tab, the bandwidth is set for each control controller.

If the flag is set in the "Use shared profile mode" field, all control controllers will support the specified test profile in total, that is, each in its own subrange. Otherwise, each controller will support the entire test profile over the entire specified frequency range.

Another feature of the software is a preview of test results for a given profile, obtained by calculation based on data from a Pre-Test run of the system. Graphics can be viewed on the "Preview" tab.

The information on the graphics is for informational purposes only and is intended to inform the user about the expected results obtained when testing with a given profile.

Based on the set values for the test profile parameters, statistical parameters are calculated according to the degree of system load during testing, which can be found on the "Statistics" tab. This option allows you to evaluate the capabilities of the system without starting the test, thereby maintaining the integrity of the equipment.

The generated profile can be saved as a separate file, which can be loaded from the "Edit profile" program.

Testing

The event log is displayed at the bottom of the working window of the "Acoustic noise" program, where important information is stored when working with the program.

The test is started by pressing the "START" button. If the "Quick start" flag is set in the program parameters, then when you press the "START" button, the program will prepare the equipment for launch, while not sending signals to the control channels, and the button will change its color from blue to green.

After that, you need to press the "START" button again, while the start of the test will begin within 3 seconds.

If the value of the control channel goes beyond the set limits (going beyond the allowable limits, exceeding the maximum parameters, etc.), the program will prompt the operator to complete the test.

The program provides a mechanism for detecting faults. If any are detected, the program issues a notification and recommendations for their elimination.

The user can start or stop the recording of electrical signals from all enabled channels of the VCS controller at any time by pressing the "Recording" button.

System for testing gas turbine blades .....

This section provides instructions for using the ZETLAB software for removing stress distribution in a blade, for dynamic graduation, and for testing gas turbine engine blades in accordance with the requirements of GOST RV 2840-001-2008.

Removal of stress distribution in the blade of gas turbine blades .....

Table of contents:

Purpose and possibilities of the program

Removal of voltage distribution in the blade is performed using the program "SDS_GTE(ZET058)", while in addition to the controller model ZET02x, the composition of the VCS must be equipped with strain gauges model ZET058 (up to four pieces), with which up to 32 signals can be recorded simultaneously removed from strain gauges installed on the test object (GTE blade) in accordance with the requirements of Annex A of GOST RV 2840-001-2008 (*Fig. 17.1*).

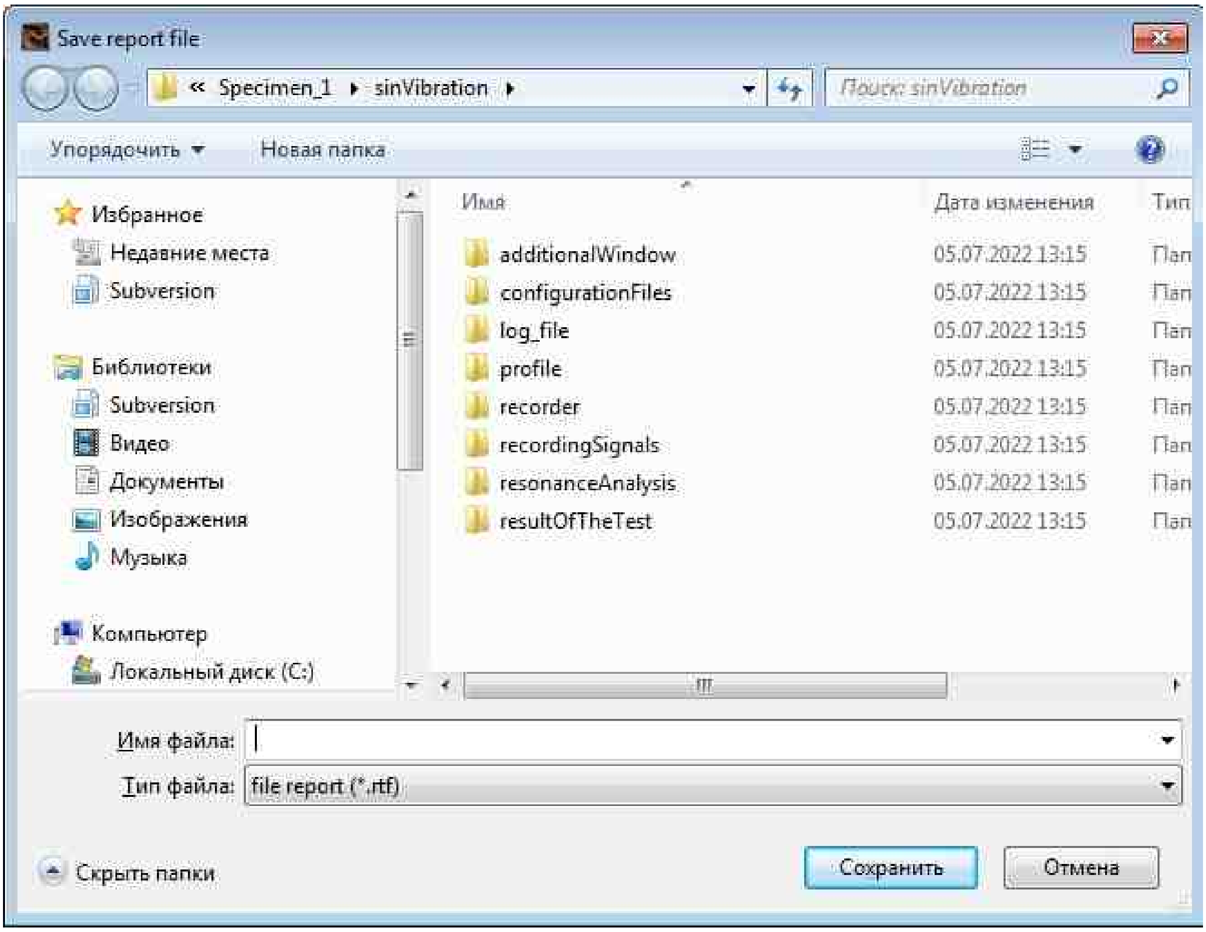


Fig. 17.1 Location of meter resistances on the blade

Interface of the program "Eesting GTE blades" .....

The program "SDS_GTE(ZET058)" (performed in the environment of the ZETVIEW scada system) allows you to quickly obtain and store, both graphically and in tabular form, the values of mechanical stresses (MPa or kgf/mm^2) registered at the points of installation of meter resistances grouped in three zones along the blade (outlet edge, leading edge and back) and in two zones along the end of the blade (back and trough).

To start the program "SDS_GTE(ZET058)" it is necessary to double-click the left mouse button activate the file "SDS_GTE(ZET058)" (*Fig. 17.2*).

Fig. 17.2 Program icon "SDS_GTE(ZET058).exe"

The program window "SDS_GTE(ZET058)" will open. (*Fig. 17.3*).

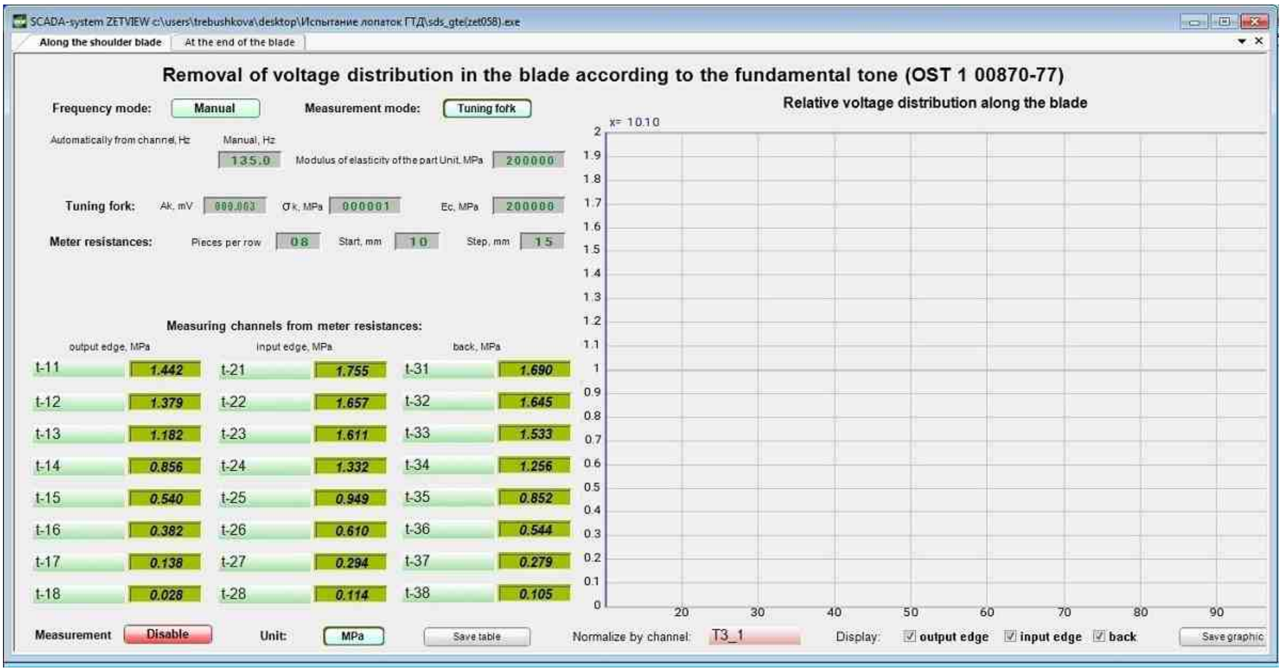


Fig. 17.3 The window of the program "Testing GTE blades"

The program interface includes the following controls and displays:

Frequency mode: "Manual" or "Automatic". This mode indicates the source by which the frequency value will be determined, at which the program (using selective voltmeters with a band of 1 Hz) will measure the amplitude of oscillations recorded from meter resistances.

In the "Manual" mode, the value of the excitation frequency is indicated to the program via the "Manual" selector.

In the "Automatic" mode, the "Automatically from channel" field changes its appearance (*Fig. 17.4*).

Fig. 17.4 The field "Automatically from the channel" in the "Automatic" mode

In this mode, the program automatically captures the frequency from the measuring channel selected by the operator (in the "Automatically from channel" field) as the excitation frequency control channel. To control the stability of the excitation frequency capture, there is an indicator in the "Automatically from the channel" field, which displays the frequency value recorded by the program.

Note: *if the automatic detection of the excitation frequency is not stable, you should use the "Manual" mode*

The Measurement mode: "Meter resistances" or "Tuning fork".

In the "Meter resistances" mode, the program registers the values from the measuring channels and recalculates them to "MPa" or "kgf/mm^2" (depending on the selected units of measurement in the "Unit" field), taking into account the sensitivity coefficient of the measuring channel and the value of the elastic modulus of the part specified in the "Unit" field by the formula:

Ϭk=(Ak*Ec*S)/U

where **Ak** (mV) – the value of the amplitude of the recorded signal at the input of the strain measurement data acquisition modules,

Ec (MPa) – modulus of elasticity of the part under study (SDS_GTE(ZET058),

S=4/K – sensitivity coefficient of the strain measurement data acquisition modules measurement scheme (where **K** – sensitivity coefficient of the meter resistances),

U (mV) – reference supply voltage of the strain gauge measurement circuit.

In the "Tuning Fork" mode, the program recalculates the recorded values taking into account the values of the parameters specified in the "Tuning Fork" field (*Fig. 17.5*) according to the formula::

Ϭk=(Ϭk*Ak*Ec)/(Ak*Ec)

where **Ϭk – the value of the mechanical stress on the tuning fork leg from the passport to the tuning fork,**

Ak (mV) – the value of the amplitude of the recorded signal at the input of the strain measurement data acquisition modules,

Ec (MPa) – modulus of elasticity of the part under study (SDS_GTE(ZET058),

Ak (mV) – the value of the oscillation amplitude of the tuning fork leg,

Ec (MPa) – the modulus of elasticity of the tuning fork leg from the passport to the tuning fork.

Fig. 17.5 Parameters of the "Tuning Fork" field

The field "Meter resistances" (*Fig. 17.6*) defines the following parameters for the program: "Pieces in a row", "Start" and "Step".

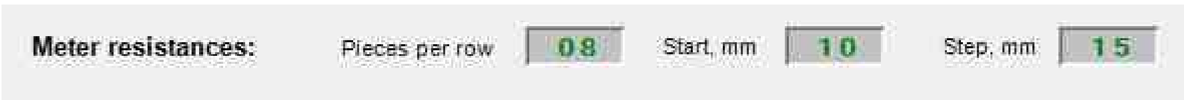


Fig. 17.6 Parameters of the "Meter resistances" field

The field "Pieces in a row" is the number of meter resistances glued to the output edge, input edge and back (the parameter defines the installation range from 4 to 8).

The field "Start" is the coordinate of the location of the first in the row of meter resistances from the sole of the lock (the parameter defines the range from 0 to 99 mm).

The field "Step" is the installation step in a row of meter resistances (the parameter defines a range from 2 to 99 mm).

The field "Reference voltage sources" (*Fig. 17.7*) allows you to specify to the program those measuring channels through which power is generated for bridge circuits (for each of the three seismic stations individually). Thus, during the calculations, the supply voltages of bridge circuits with meter resistances are automatically taken into account.

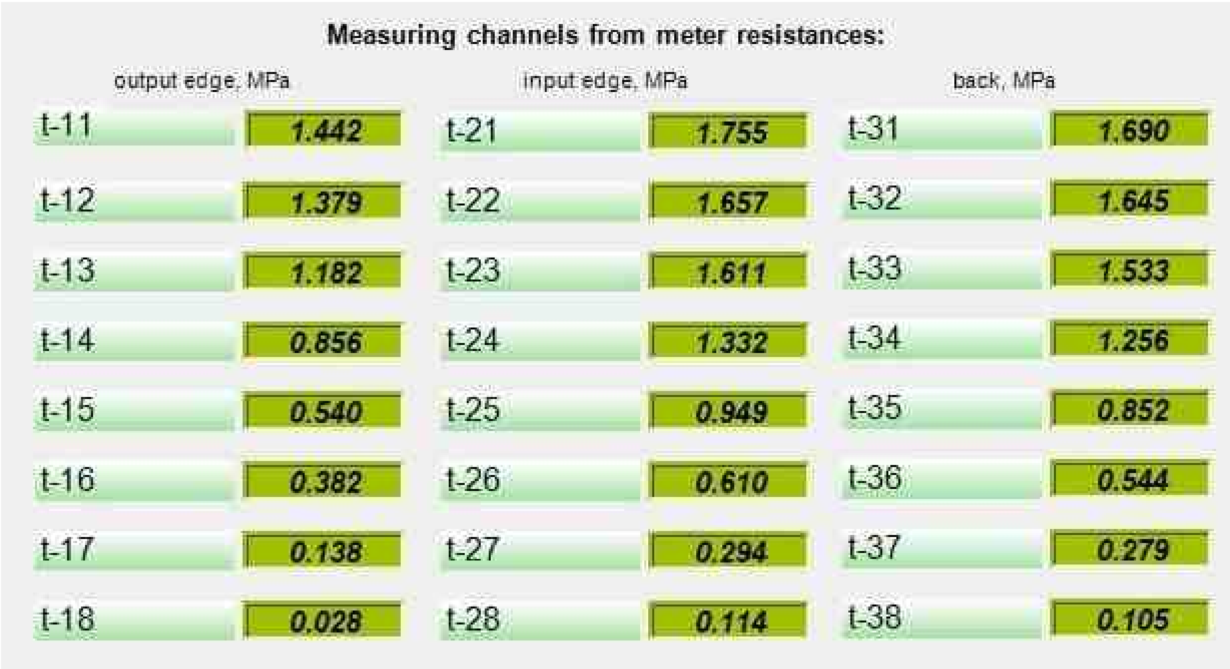


Fig. 17.7 The field "Measuring channels from meter resistances"

The field "Unit" is intended for choosing the display of values on field indicators "Measuring channels from meter resistances" by MPa or kgf/mm^2.

Graphics of the field "Removal of voltage distribution in the blade according to the fundamental tone" is designed to display the values of meter resistances recorded from meter resistances normalized to any of the recorded measuring channels of meter resistances. The choice of channel for normalization is made in the field "Normalize by channel".

In the field "Removal of voltage distribution in the blade according to the fundamental tone" graphics for trailing edge, trailing edge and back are displayed. If necessary, the display of any of the graphics can be disabled using the corresponding parameter in the field "Display".

The field "Measurement" is used to enable and disable the calculations performed by the program.

The field "Save table" or "Save graphic" are used respectively for saving to a file ("*.dtx" format) registered values respectively from the fields "Measuring channels of meter resistances" either "Removal of voltage distribution in the blade according to the fundamental tone".

Procedure for conducting tests .....

Prepare the necessary set of equipment (*Fig. 17.8*) for measurements (Section 17.1.1). Stick the meter resistances on the tested blade and fix it on the Shaker and by the lock using the fastening device and connect the cables from the Strain-gauge stations glued to the blade to the meter resistances inputs.

Fig. 17.8 Equipment set for removal of stress distribution in the blade

Perform configuration of Strain-gauge stations.

Start the program "SDS_GTE(ZET058)".exe".

Specify using the selector in the field "Unit" the value of the elastic modulus of the part in MPa.

Select the desired operating mode "Meter resistances" or "Tuning fork".

If you choose to work in the "Tuning fork" mode, enter the passport values Ϭk and Ec, as well as the value of the Ak amplitude, in the appropriate fields of the program.

When working in the "Tuning fork" mode, the value of the Ak amplitude must be obtained beforehand

In the "Meter resistances" field, set the number of meter resistances in a row, as well as the coordinate of the first one and the step of installing the meter resistances.

In the field "Measuring channels from meter resistances" for each measurement point, select the corresponding measuring channel of the strain measurement data acquisition modules.

For the convenience of identification when naming measuring channels, it is recommended to make a name from the number of the strain measurement data acquisition modules and the channel number according to the account to which the meter resistance is connected, for example: "T1_3" - the first strain measurement data acquisition modules of the trace meter resistance, "T3_5" - the third strain measurement data acquisition modules of the fifth meter resistance

Set the frequency mode to the "Automatic" mode and select the measuring channel on which the excitation frequency will be measured.

Turn on the generator (*Fig. 17.9*) in Sine mode with the required amplitude level at the required frequency (in accordance with the requirements for testing) by applying an excitation signal to the shaker.

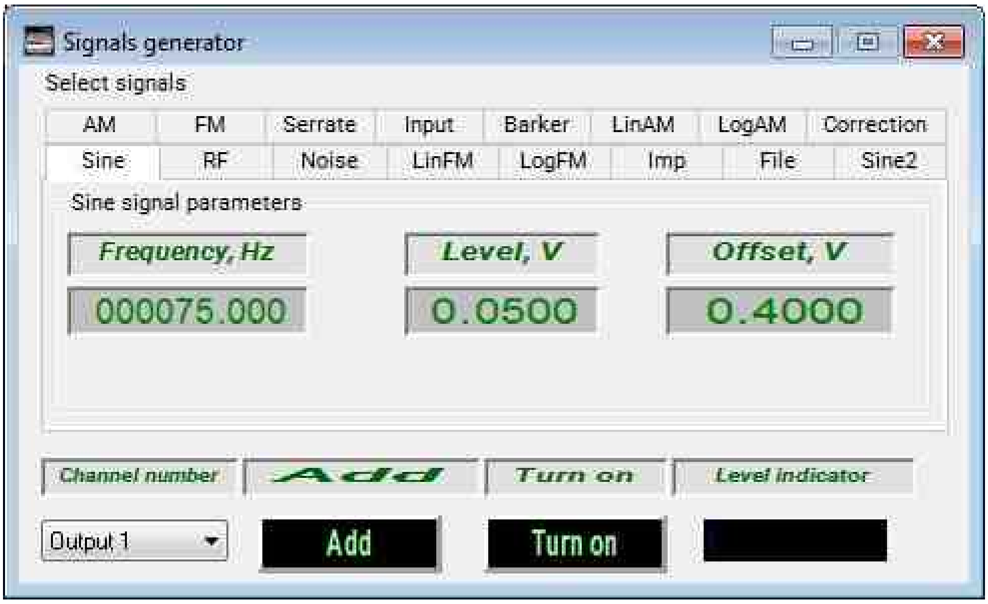


Fig. 17.9 "Signals generator" program window

Switch the program to the "Measurement" mode by switching the corresponding control button to the "Turned on" status.

Make sure that the value of the excitation frequency (supplied from an external generator) is recorded steadily on the indicator in the "Automatically from channel" field, otherwise switch to the "Manual" mode or select a measuring channel through which the excitation frequency is recorded steadily.

During measurements in the field "Measuring channels from meter resistances" (depending on the selected units of measurement) the program will register the values of mechanical stress in MPa, or in kgf/mm^2, , and in the field "Relative stress distribution ..." graphics of the distribution of mechanical stress normalized to the value of one of the selected measuring channels (Fig. 17.10, Fig. 17.11).

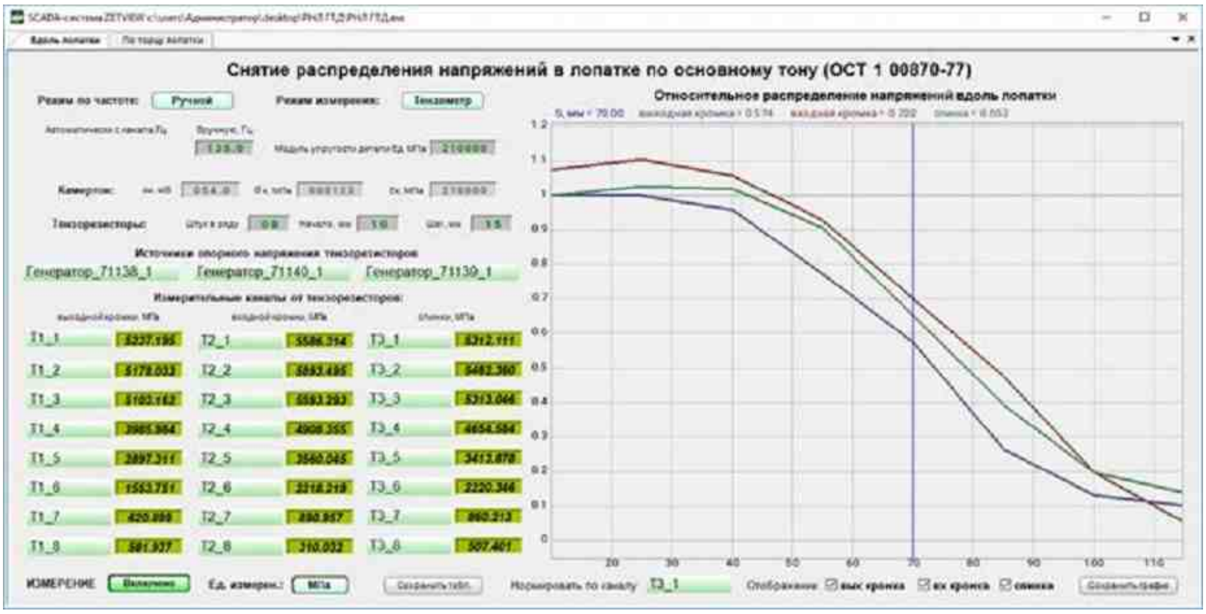


Fig. 17.10 The window of the program "SDS_GTE(ZET058)" during measurements

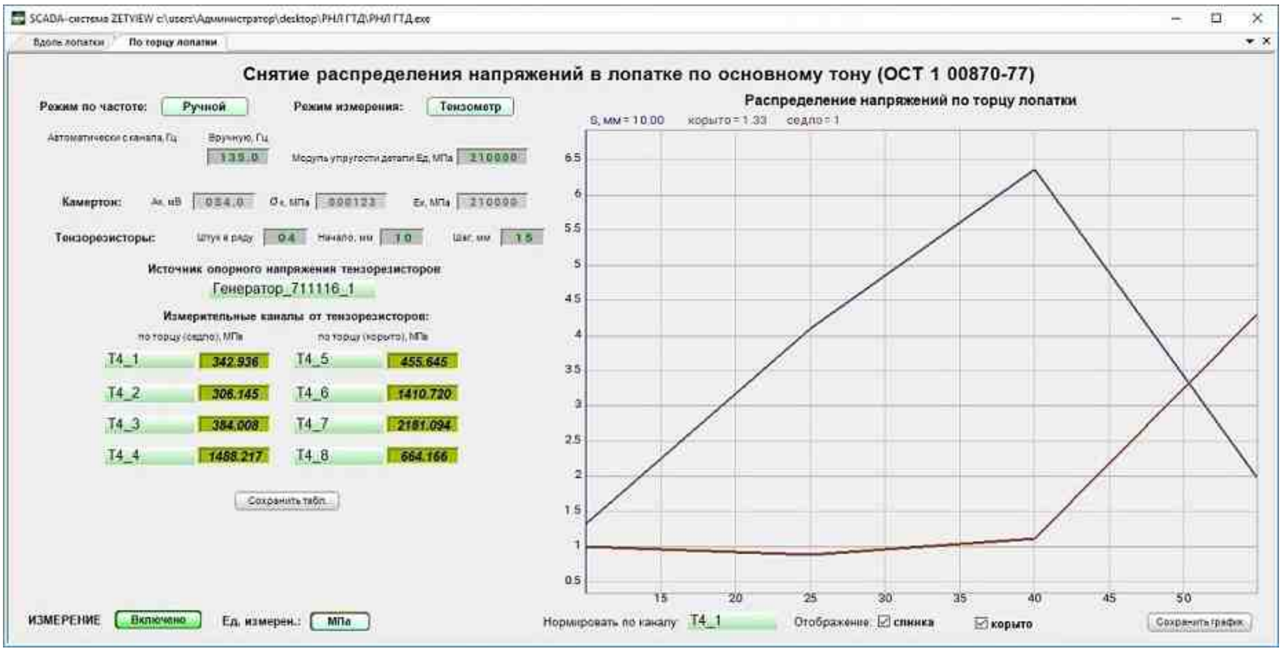


Fig. 17.11 Tab *"At the end of the blade" of the program window "SDS_GTE(ZET058)" during measurements*

At any time during measurements, it is possible to save in numerical and graphical form the registered values from the fields "Measuring channels from meter resistances" and "Voltage distribution in the blade" to files (in the format "*.dtx") by activating the corresponding buttons "Save Table" and "Save graphic".

Viewing saved files (format "*.dtx") is carried out using the program "Results viewing" (from the ZETLAB software). In the program window "Results viewing" in the "Graphic" tab (*Fig. 17.12*) the information is displayed graphically, and in the table tab (*Fig. 17.13*) – in numerical.

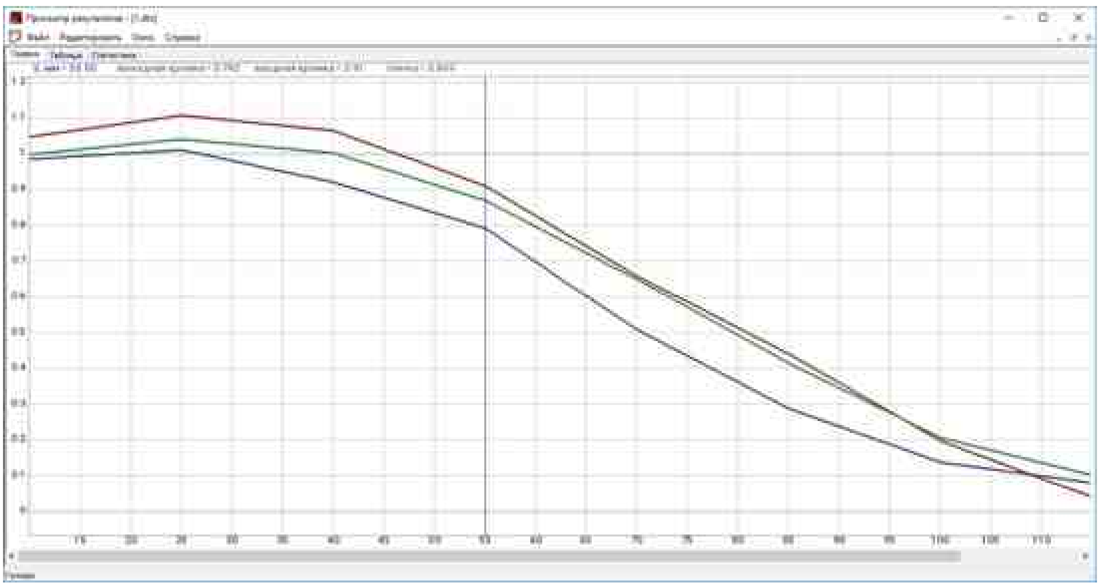


Fig. 17.12 The window of the program "Results viewing", the "Graphic" tab

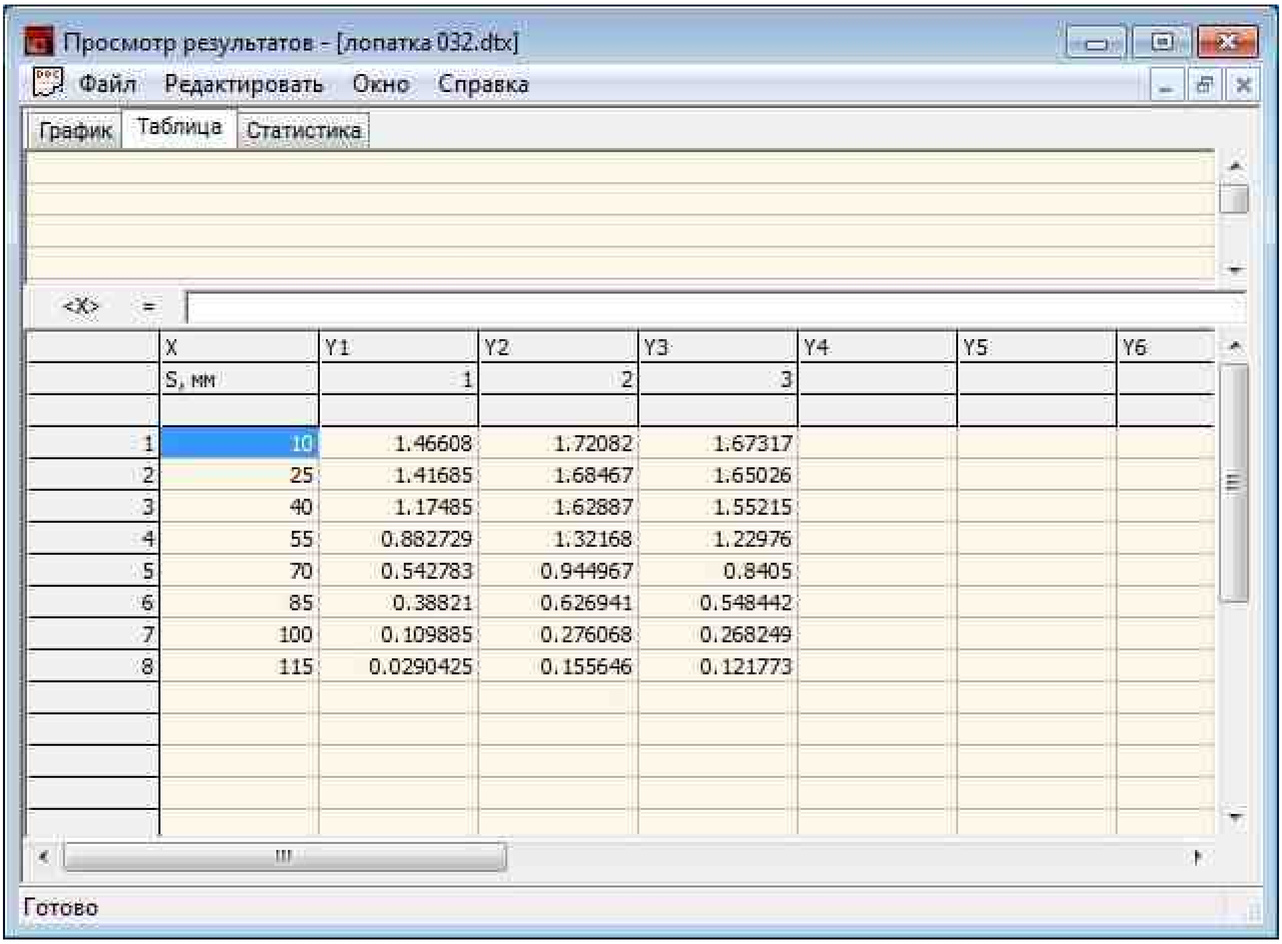


Fig. 17.13 The window of the program "Results viewing", the tab "Table"

Dynamic graduation .....

[Purpose]

[Necessary software and hardware]

[Graduation technique]

[Determining the resonant frequency]

[Building a graduation profile]

[Modern graduation processes]

Purpose .....

Dynamic graduation is performed to obtain the relationship between the amplitude of displacement of the end section of the blade and the amplitude of the voltage on the control meter resistance. The obtained dependence allows, when testing the blade, to maintain the required voltage at the place of installation of the control meter resistance on the blade according to the sensor that registers its end displacement.

Attention! *The software allows you to calibrate only at resonance frequencies*

Note: *it is recommended to carry out calibration (and testing) at the resonant frequency related to the first form of natural oscillations of the blade, as in this case the best quality of measurements is ensured*

Necessary software and hardware .....

For dynamic graduation, VCS software, VCS controller model ZET 02x, RF603 laser sensor and meter resistance are required.

Attention! *The quality of the measurements depends on the correct selection of the laser sensor used. The base distance parameter of the laser sensor should provide the possibility of placing the sensor above the controlled object, and the measurement range should cover the displacements that occur during testing.*

Note: *in the screenshots in the description given in this section, the measuring channel, to which the control strain gauge is connected, has the name "strain gauge", and the measuring channel from the RF603 laser sensor - "RF603"*

Attention! *The software will only allow graduation at resonance frequencies.*

Note: *The maximum acceleration at resonance, achieved during calibration, is determined as the specimen of the maximum acceleration for the shaker at the current load and the quality factor of the resonance at which graduation is carried out.*

Example: *the maximum acceleration for a shaker with a pushing force of 400 N with a load mass of 4 kg (determined by the sum of the masses of the moving part, specimen and equipment) will be 10 g. With a resonance quality factor of 45, the maximum acceleration at resonance will be 10x45 = 450 g*

Graduation technique .....

Glue (if not glued) the meter resistance to the area on the investigated blade, in which the stress-strain status will be controlled.

Fix the investigated blade on the table of the vibrating stand.

Connect meter resistance and laser sensor RF603 to the inputs of the VCS controller (see sections 7.7.4 and 7.7.3).

Attention! *Carefully read sections 7.7.4 and 7.7.3, as the ability to make measurements depends on the correct installation and connection of the strain gauge and laser sensor*

Run a Pre-Test (see section 8).

In the "Pre-Test and search for resonances" program window, as the measuring feedback channel ("Control" status), select the measuring channel to which the RF603 laser sensor is connected, which registers the end displacement of the blade, and assign the status "Tracking" to the measuring channel from the control strain gauge. ".

Next, you need to perform the following steps: determining the resonant frequency of the blade, building a profile required for graduation, performing graduation and saving the results.

Attention! *Graduation is only used for Sine in fixed frequency or resonance holding test modes. The information in the "Graduation" tab of the "Edit profile - Sine" window becomes available after the results are carried out and saved in the "Graduation" program window, which is accessed from the "Windows" section of the "Sine" program.*

Determining the resonant frequency .....

The definition of the resonant frequency is performed in the "Resonances" tab of the "Edit profile" window (*Fig. 17.14*).

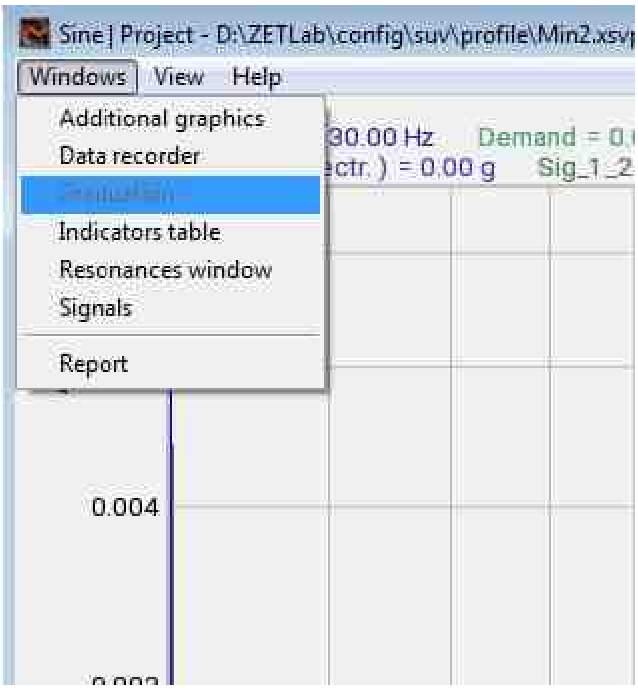


Fig. 17.14 Edit profile window, Resonances tab

On the graphic, you should select the resonance on which the tests will be carried out and scale the window so that only this resonance remains in the window (*Fig. 17.15*), then  activate the "Pass through resonances" button.

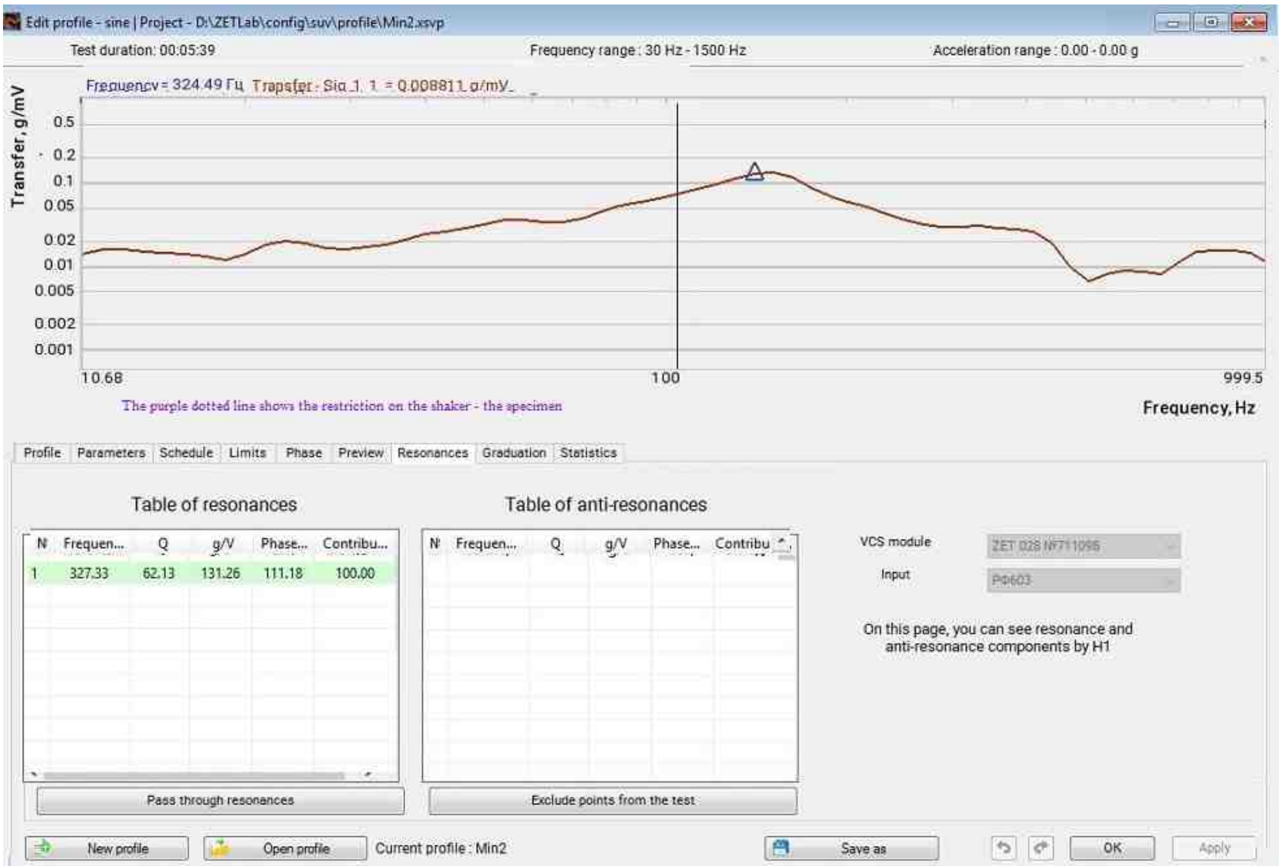


Fig. 17.5 Edit profile window, Resonances tab, scaled

Next, you should agree to the warning of the program (Fig. 17.16) about the creation of a profile, while the program will open the created profile with the retention of resonance in phase.

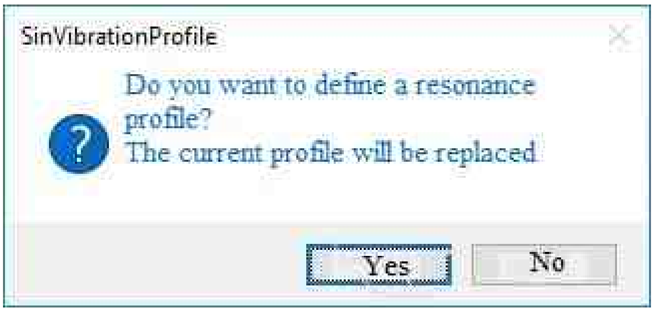


Fig. 17.16 Warning window

Building a graduation profile .....

To build a profile used for graduation, in the "Profile" tab (*Fig. 17.17*) in the table, set the required level of graduation amplitude (in the example of Acceleration 129.4g, which corresponds to Displacement of 0.3 mm) and the parameter "Duration" no more than 10 seconds (in the example 00:00:05).

Note: *in the mode of holding the resonance in phase, the software increases the limit of registered accelerations by the value of the quality factor of the resonance: for example, the vibration generator system (at a given degree of loading) allows you to issue an acceleration of 35g, to hold the resonance (with a quality factor of 40), the maximum allowable acceleration value will be increased to the level of 35 * 40 = 1400g.*

Note: *the amplitude level during graduation should be selected taking into account the required test level and be not less than two and a half times the required test level.*

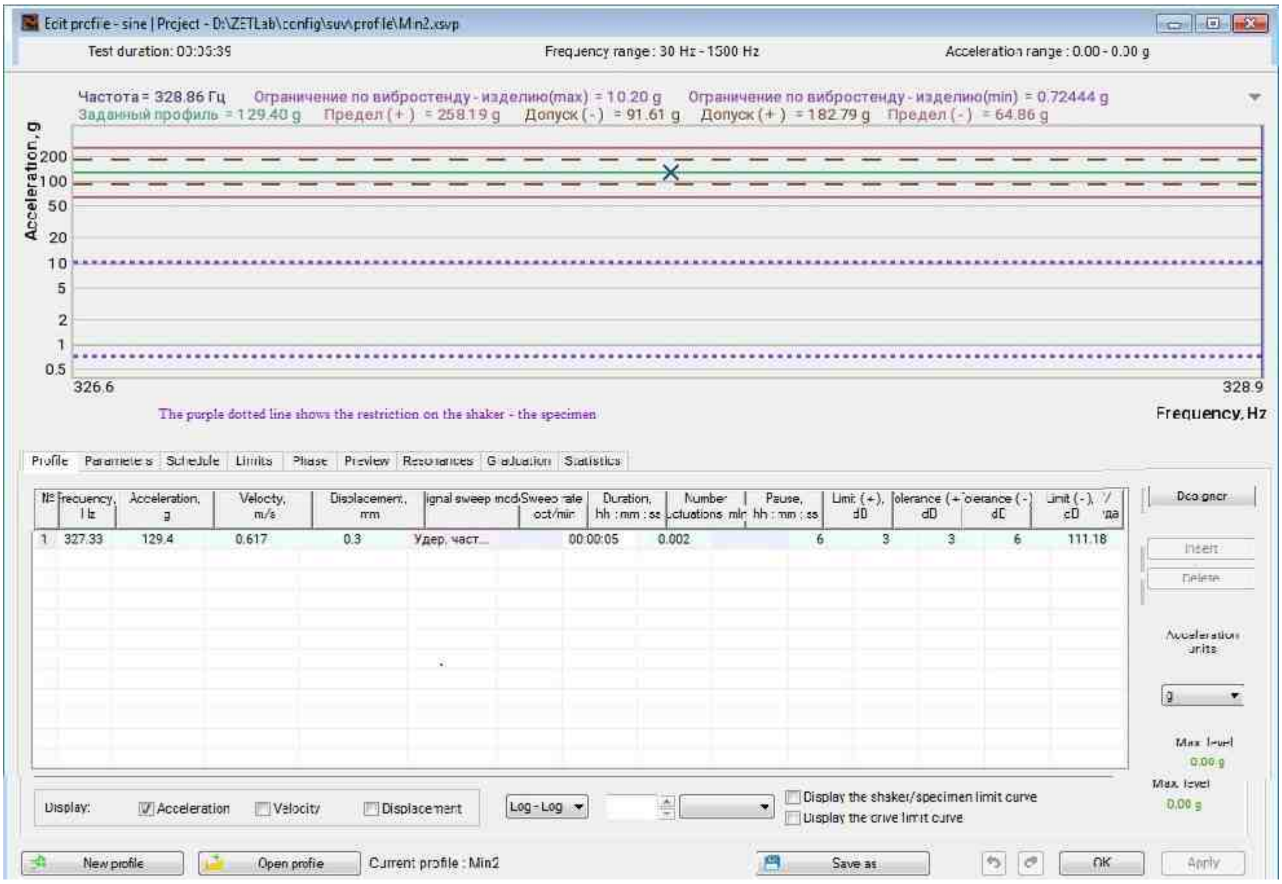


Fig. 17.7 Edit profile window, Profile tab

In the "Parameters" tab (*Fig. 17.18*), you should set: the type of exit to the mode - "lin.", the time to enter the mode - 60 s, and then activate the "Apply" button to save the changes made.

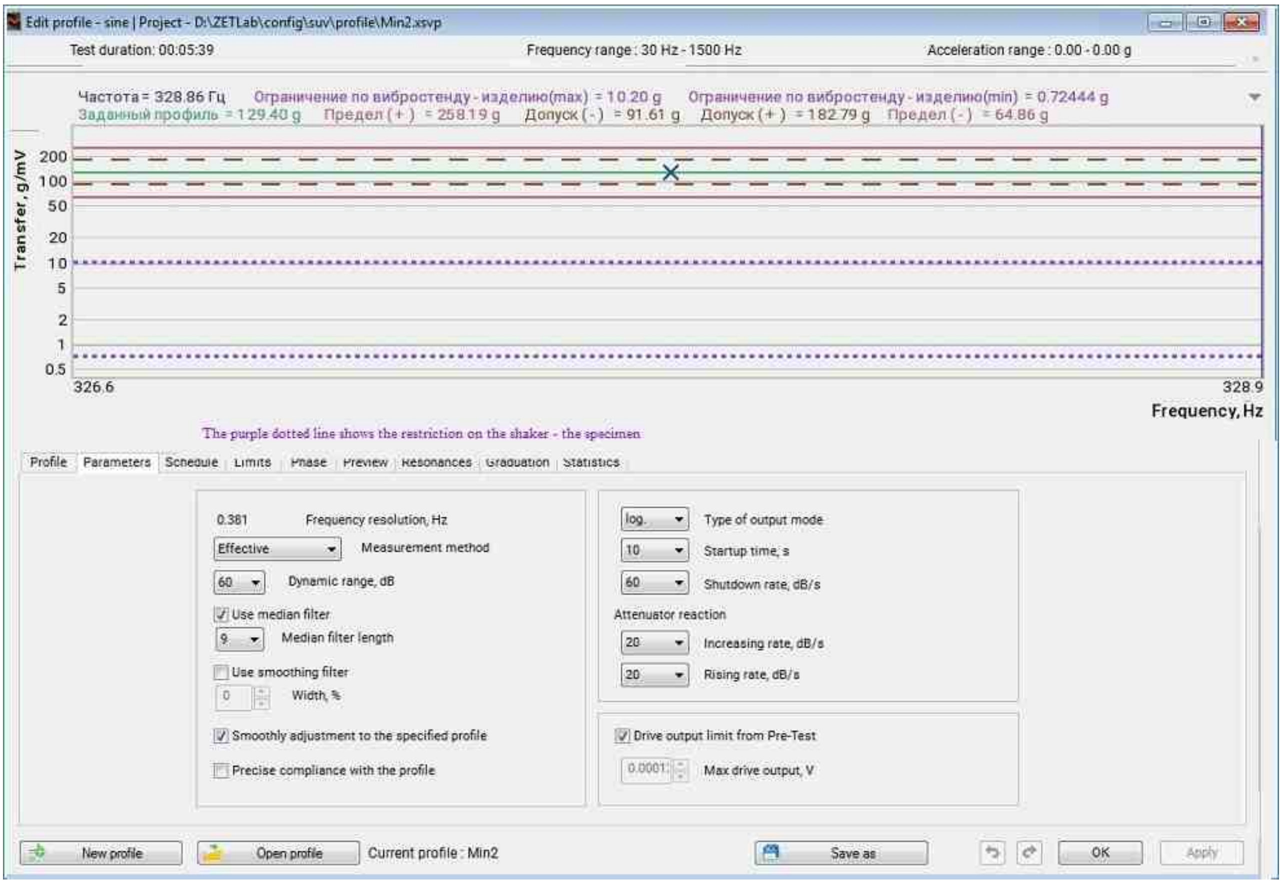


Fig. 17.18 Edit profile window, Parameters tab

Modern graduation processes .....

The stage of graduation consists in launching (in the window of the "Sine" program) a profile prepared for graduation.

Graduation is performed during the exit to the mode (within 60 seconds). At the moment of a smooth rise in the vibration amplitude, the amplitude of the response is recorded along the measuring channels with the "Tracking" status relative to the registered amplitude on the measuring channel with the "Control" status.

To view the results of graduation in the "Sine" window in the "Windows" section (*Fig. 17.19*), select "Graduation" and the corresponding window will open (*Fig. 17.20*).

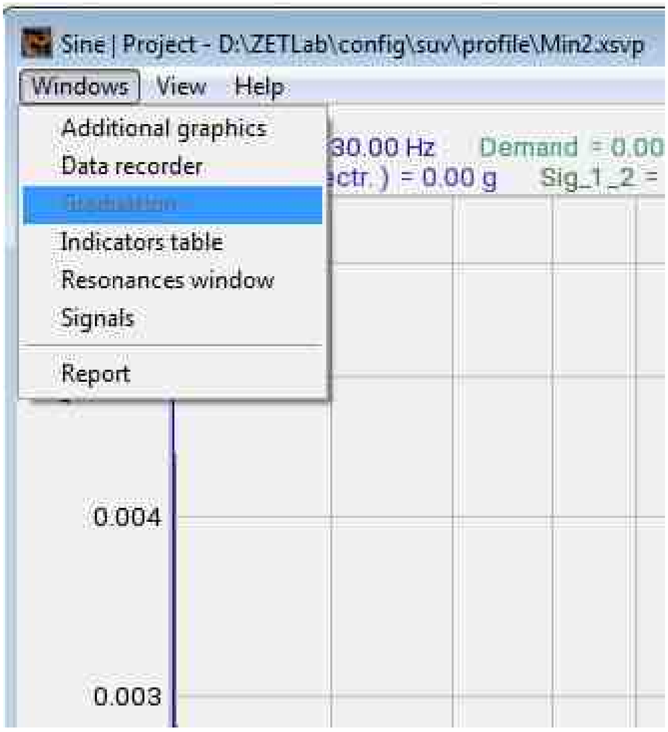


Fig. 17.9 "Sine" window, "Windows" section

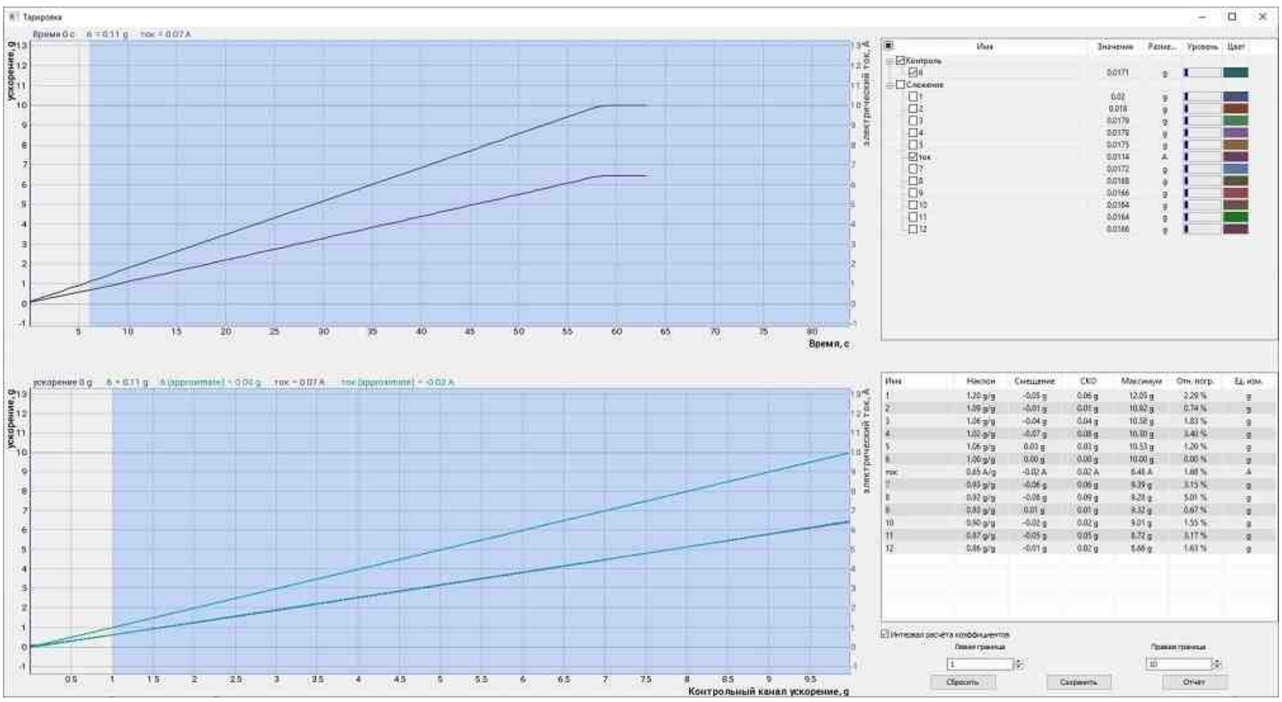


Fig. 17.0 "Graduation" window"

In the "Graduation" window, it is possible to correct the graduation area, excluding from it the range of values with small displacements (in the example, up to 0.1 mm), for this, activate the "interval for calculating coefficients" parameter and enter the corresponding numerical value.

***Note:** it is recommended to exclude the region of small amplitudes from calibration due to the increase in the error associated with the influence of noise at low amplitudes*

To save the graduation results in the "Graduation" window, activate the "Save" button.

After saving the results of graduation, the information will become available in the "Graduation" tab of the "Edit profile - Sine" window (*Fig. 17.21*).

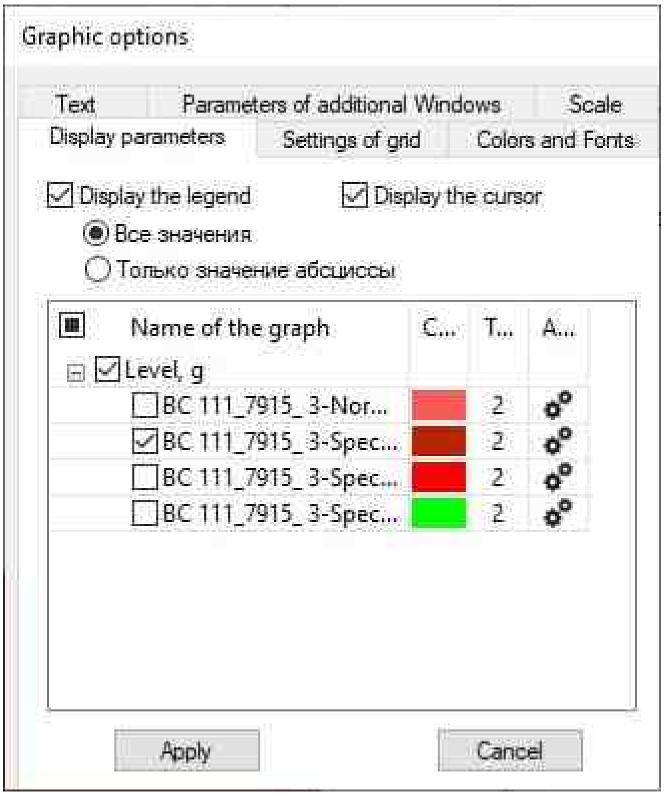


Fig. 17.21 "Edit profile" window, "Graduation" tab

Blade testing SDS .....

GOST RV 2840-001-2008 allows maintaining the amplitude both according to the readings of the control meter resistance and according to the sensor that registers the end displacement of the blade. In this section, we consider the most preferred example with maintaining the amplitude according to the readings of the sensor registering the end displacement of the blade due to the high probability of failure of the strain gauge during testing.

To form a blade test profile, in the "Sine" program window, activate the "Edit profile" button.

To keep the resonance at the level of the required strain, recorded from the control strain gauge in the "Edit Sine profile" window in the "Graduation" tab (*Fig. 17.22*) value corresponding to the value of the end displacement of the blade.

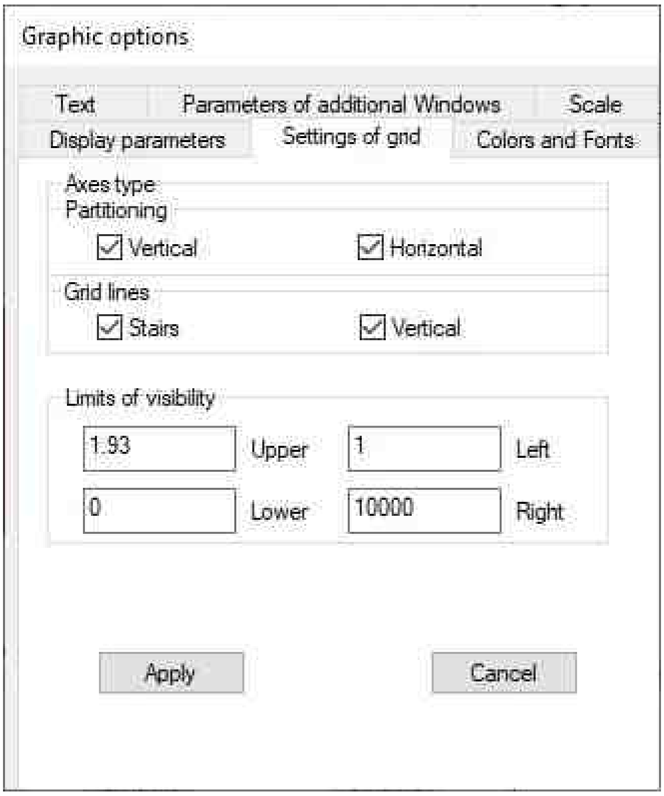


Fig. 17.22 "Edit profile" window, "Graduation" tab

Note: *since in the window "Pre-Test and search for resonances" the status "Control" was assigned to the measuring channel of the RF603 sensor, then the resonance will be held according to the value of the displacement of the end section of the blade (equivalent to the given deformation of the meter resistance)*

Activation of the "Set profile" button and subsequent confirmation of the program's request for permission to replace the current profile with a new one, leads to the transition to the "Parameters" tab of the "Edit Sine profile" window. In this case, a resonance retention profile will be formed with a feedback channel for a non-contact displacement sensor (in the example, the measuring channel "RF603") while maintaining the displacement amplitude (0.3705 mm in the example) equivalent to the deformation amplitude equal to 350 µm/m at the control point of the meter resistance installation.

Mechanical testing of wires and cables of overhead power lines .....

Table of contents:

Necessary hardware and software .....

To perform mechanical tests, you will need: equipment that provides the standard tension of the wire (cable) under test, a shaker with a hinged device for fixing the cable, an VCS controller model ZET02x and software ZETLAB.

Preparation for tests .....

When preparing for the tests, it is necessary to:

Install the test sample (wire or cable) on the stand (with tension according to the regulatory documentation).

Fasten the cable to the movable part of the shaker using a hinged device.

Fasten the cable to the movable part of the shaker using a hinged device.

Fix two accelerometers on a wire (cable): one at a distance of 0.1 ... 0.6 m from the point of attachment of the cable to the shaker (from the hinge device), and the second - in the place of control of the acceleration amplitude (or displacement) according to regulatory documentation.

Note: *the installation locations of the first and second accelerometers should be chosen so that at the test frequency (resonance frequency) the position of the sensors on the cable is close to the midpoints of the antinode zones.*

Note: *further, in the description in this section, the name of the measuring channel for the sensor installed at point 1 is "BC 111_(1)", and for the sensor installed at point 2 – "BC 111_(2)"*

Perform work (if not performed before) by connecting the controller with the VCS according to the section 3.

Perform the selection of the shaker (if not performed earlier) in accordance with the requirements of the section 5.

Perform the installation of the specimen parameters following the section 6. In the column specimen mass, specify a value equal to the mass of two linear meters of the specimen (wire, cable).

In the VCS panel activate the "Device Manager and manager channel" program and then in the "Device Manager" window (*Fig. 17.1*) activate the measurement channel ID to open the "Properties" window.

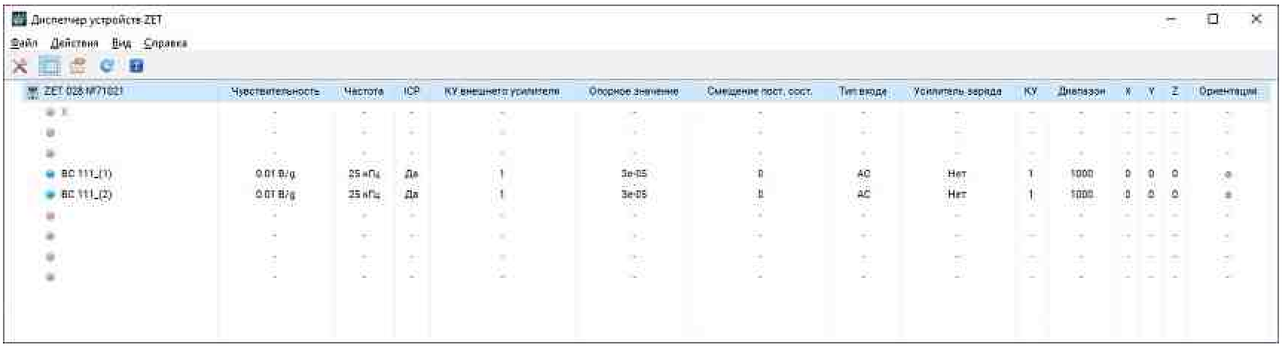


Fig. 17.1 "ZET Device Manager" window

In the "Properties" window (*Fig. 17.2*) for channels to which accelerometers are connected, set (if not previously performed) the sensitivity of the connected accelerometers. The sensitivity value should be taken from the verification certificates corresponding to the accelerometers.

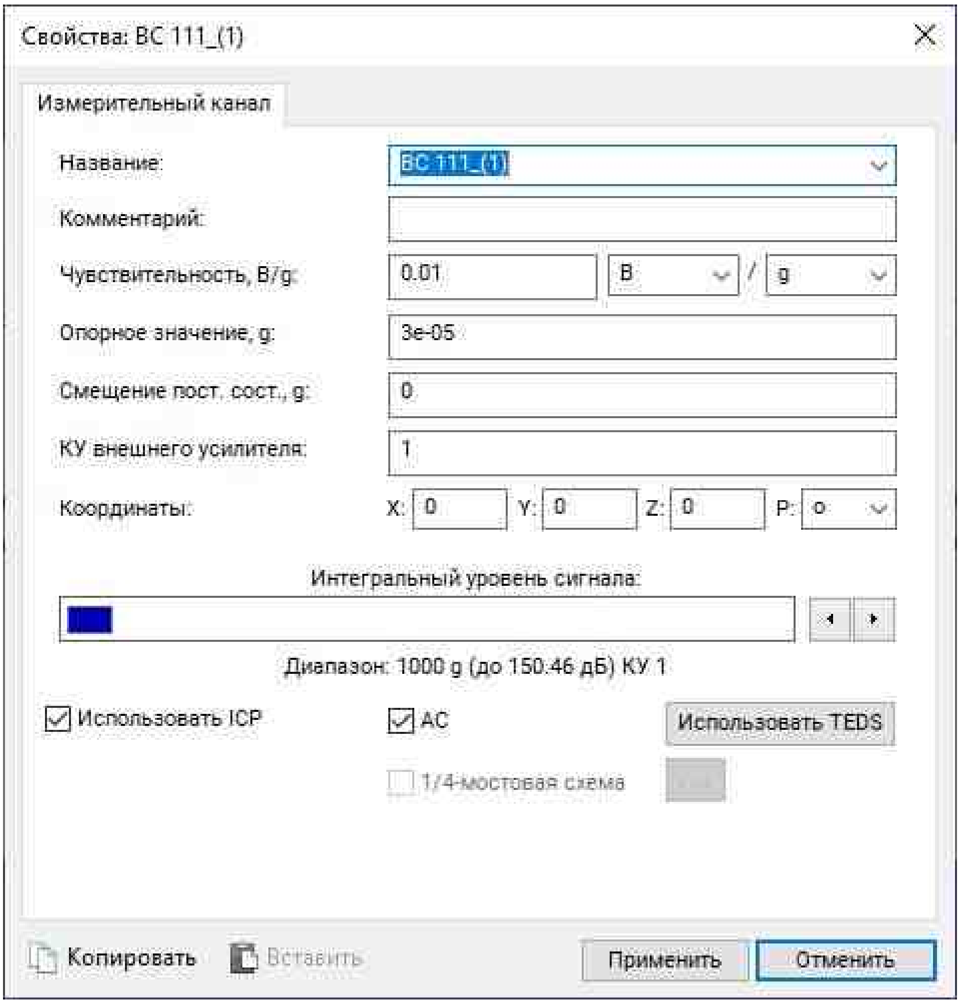


Fig. 17.2 "Properties" window

Make (if not previously made) the Pre-Test settings for this activate the "Pre-Test and search for resonances" button on the control panel and activate the "Setup" button in the program window that opens

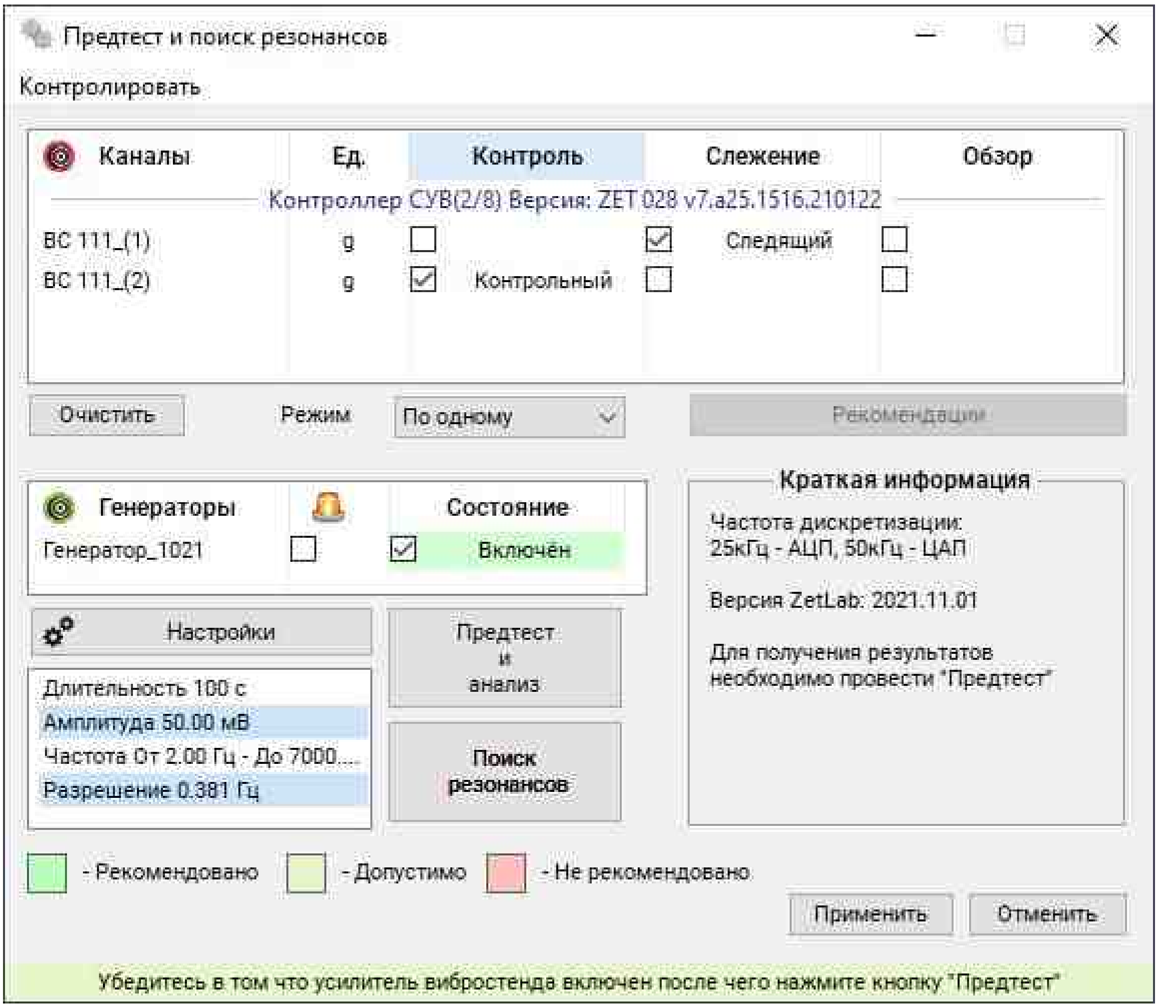


Fig. 17.3 "Pre-Test and search for resonances" window

In the Settings window, set the parameters according to the example shown in the Fig. (*Fig. 17.4*) by activating the "Apply" button to save the parameters.

Note: *the frequency range (in the example 10.100 Hz) should be set so that the resonant frequency of the test sample falls into the frequency range and is closer to the lower limit of the specified range*

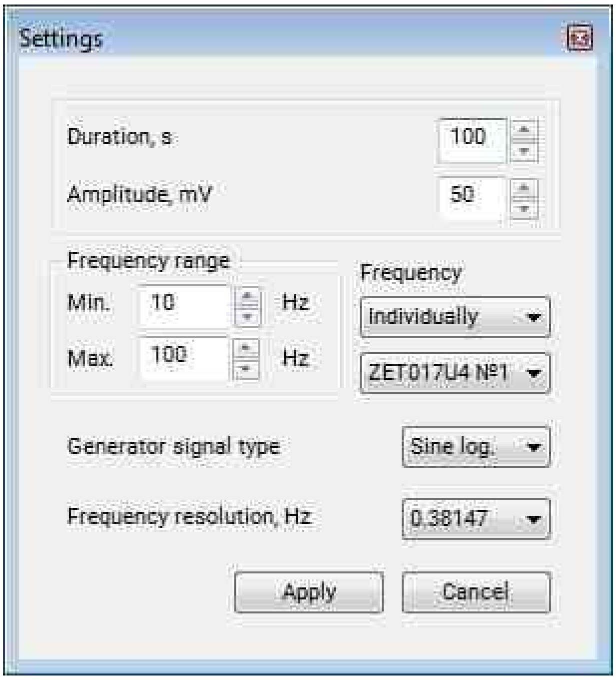


Fig. 17.4 "Settings" window

Perform a Pre-Test for this in the "Pre-Test and search for resonances" window ([Fig. 17.3]) activate the "Pre-Test" button.

At the end of the Pre-Test in the "Pre-Test" window ([Fig. 17.5]) three graphics will be displayed: "Amplitude-frequency response". "Correlation analysis between generator and sensors", "Analysis of nonlinear distortions taking into account noise".

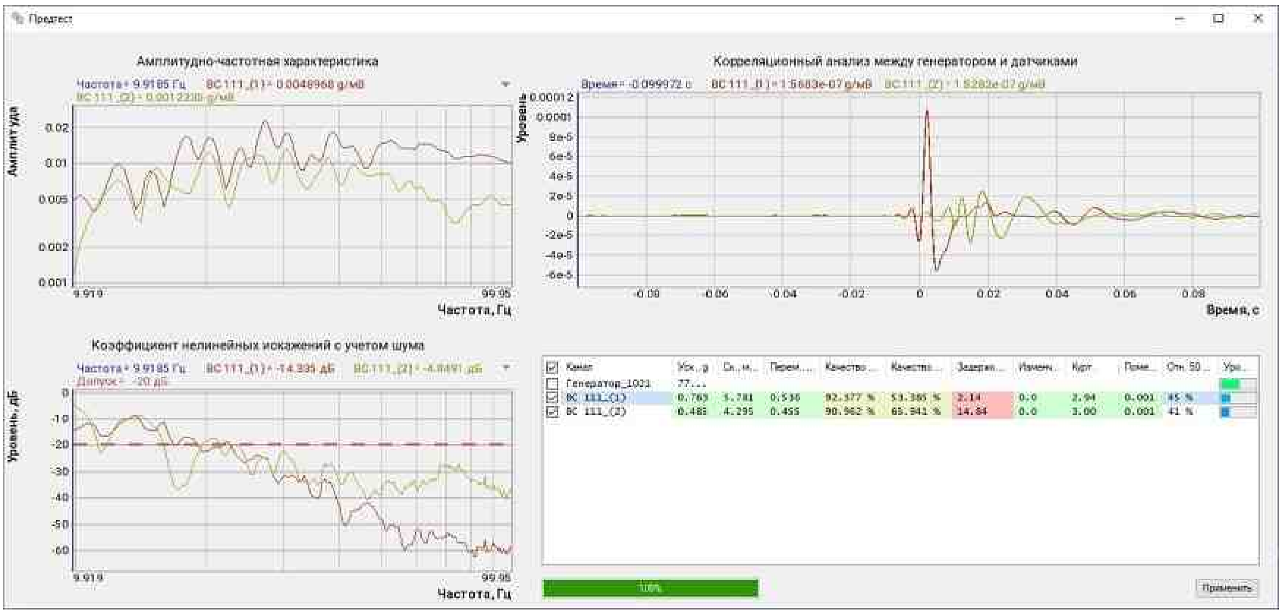


Fig. 17.5 The "Pre-Test" window

According to the graphics in the "Amplitude-frequency response" field, it is possible to estimate the resonant frequencies recorded during the Pre-Test for each of the measuring channels.

According to the graphics in the "Correlation analysis between the generator and sensors" field, it is possible to estimate the delay and the form of the impulse response recorded for each measuring channel.

Note: *the delay value (in units of "ms") is displayed in the table located in the lower right corner of the "Pre-Test" window. It is not recommended to assign the "Control" status to measurement channels for which the delay exceeds 5 ms.*

According to the graphics in the field "Analysis of non-linear distortions with noise", you can evaluate the degree of control over the measurement channel. The lower the dashed line (at minus 20 dB) is the graph, the better the controllability. For frequencies where the graphic is located above the dashed line, the controllability is low.

Evaluating the results of the pretest in the "Pre-Test" window (*Fig. 17.5*) activate the "Apply" button to save the results of the Pre-Test.

According to the results of the pretest in the "Pre-Test and search for resonances" window (*Fig. 17.6*) assign the status "Control" from the sensor located at point 1 (near the place where the cable is attached to the shaker), and the status "Tracking" from the sensor located at point 2, after which activate the "Apply" button to save the set statuses of the measuring channels.

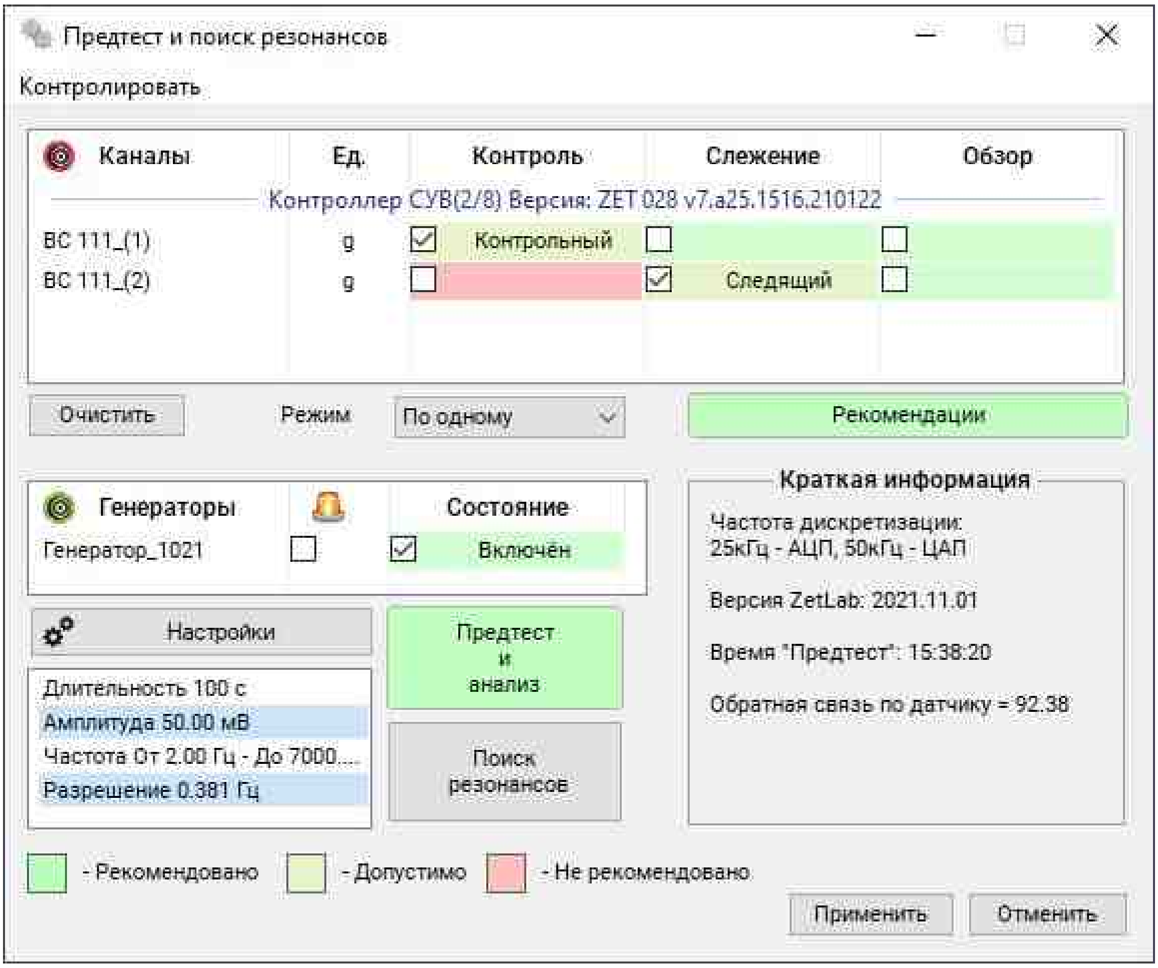


Fig. 17.6 "Pre-Test and search for resonances" window

Go to the dynamic graduation given in the section Performing dynamic graduation.

Performing dynamic graduation .....

Dynamic graduation is performed to obtain the dependence between the acceleration amplitude recorded from the sensor with the Control status (installation point 1) and acceleration amplitude (or displacement), registered from a sensor with the Tracking status (installation point 2). The obtained dependence makes it possible to maintain the amplitude during testing of the wire (cable) (specified in the regulatory documentation) for a sensor located in an area with poor feedback (located at the point 2) by sensor with good feedback (located at the point 1).

For dynamic graduation, the following steps must be performed.

To build a graduation profile from the "Sine" program window, you should activate the "Edit profile" window and in the "Profile" tab (Fig. 9.17) leaving only one row in the table column, set the necessary frequency and amplitude values (in the example 160 Hz, 10 g). The signal sweep mode parameter should be set to "Fixed", and the "Duration" parameter - no more than 10 seconds.

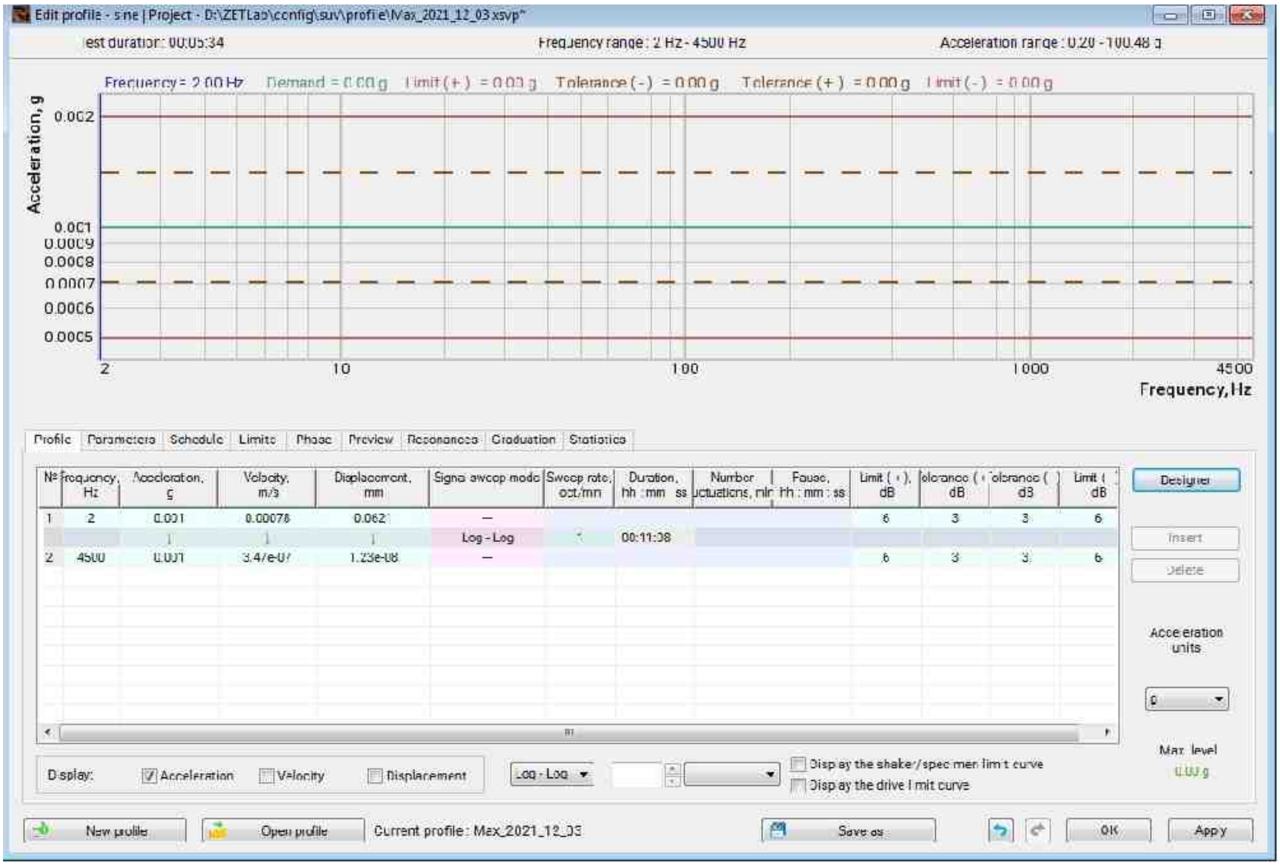


Fig. 9.17 "Edit profile" window, "Profile" tab

In the "Parameters" tab of the "Edit profile" window (*Fig. 9.18*) it is necessary to select the value "Lin" for the parameter "Type of output mode", and the value 60 seconds for the parameter "Startup time", and also set the voltage limit of the generator (*Fig. 9.19*).

Note: *it is recommended to slightly increase manually the value of the generator voltage, relative to the calculated in automatic mode*

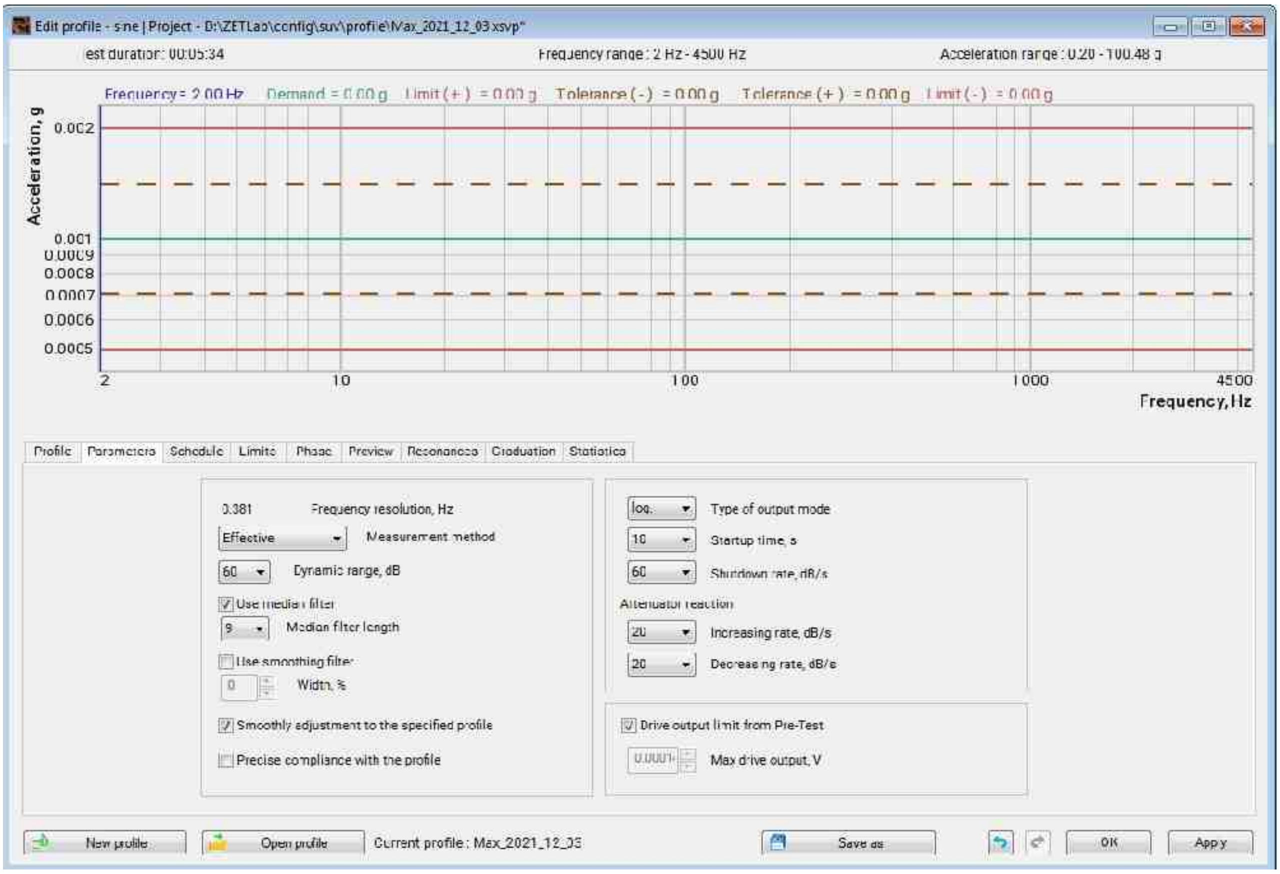


Fig. 9.18 "Edit profile" window, "Profile" tab

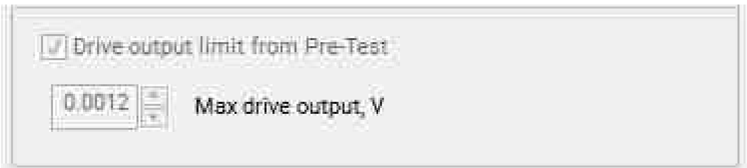


Fig. 9.19 Control channel restriction setting area

Using the information in the "Resonances" tab of the "Edit profile" window (Fig. 9.20) make sure that there are no resonances and antiresonances at the graduation frequency (in the example 160 Hz).

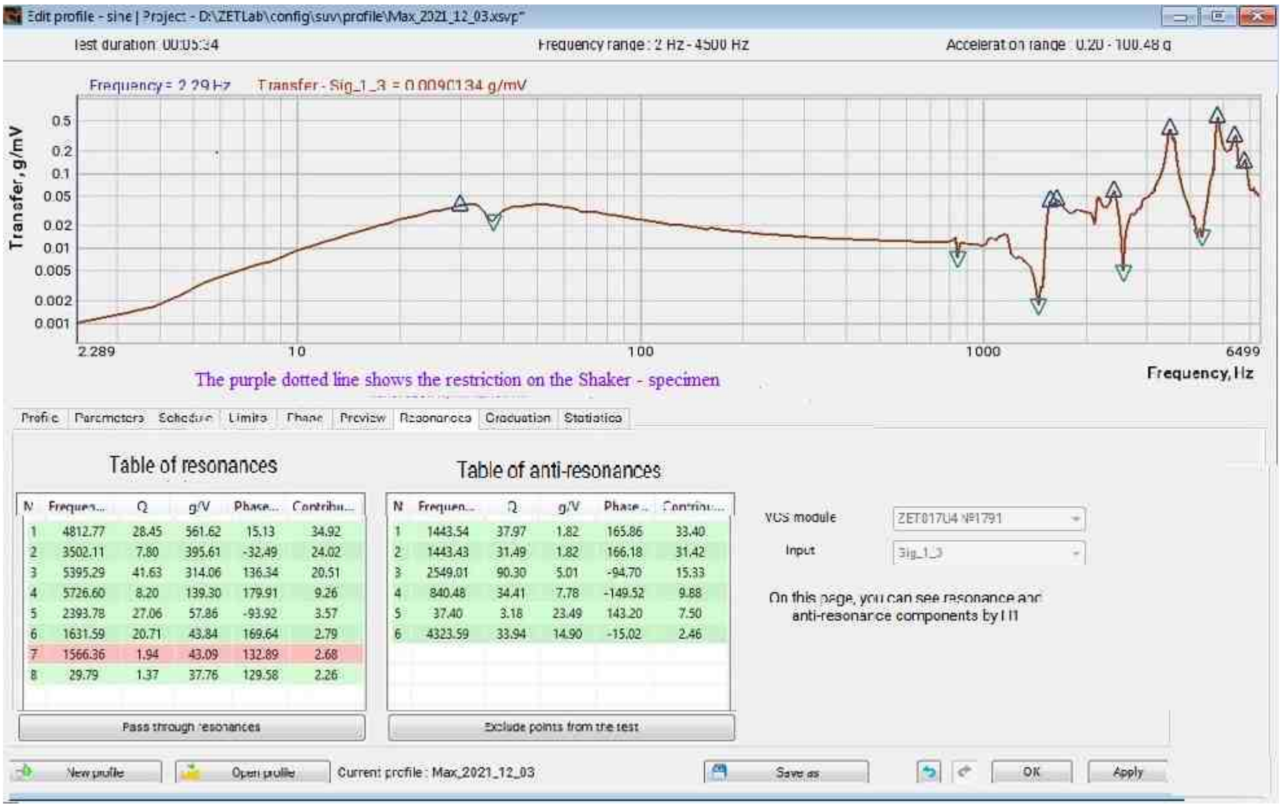


Fig. 9.20 "Edit profile" window, "Profile" tab

Using the information in the "Statistics" tab of the "Edit profile" window (*Fig. 9.21*) make sure there are no parameter limits.

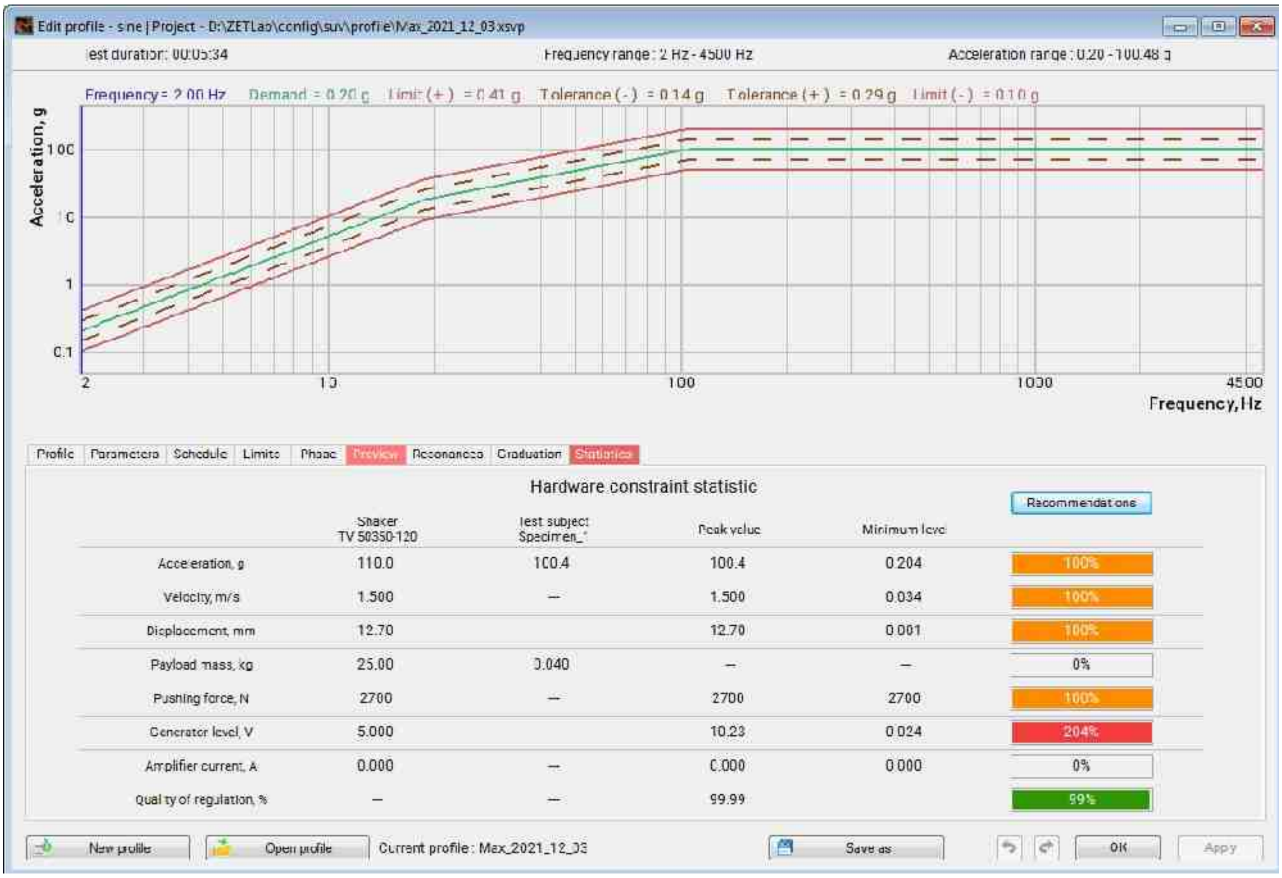


Fig. 9.21 "Edit profile" window, "Statistics" tab

In the "Edit profile" program window activate the "OK" button, after which it will be closed and the "Sine" program (*Fig. 9.22*) it will be prepared for graduation.

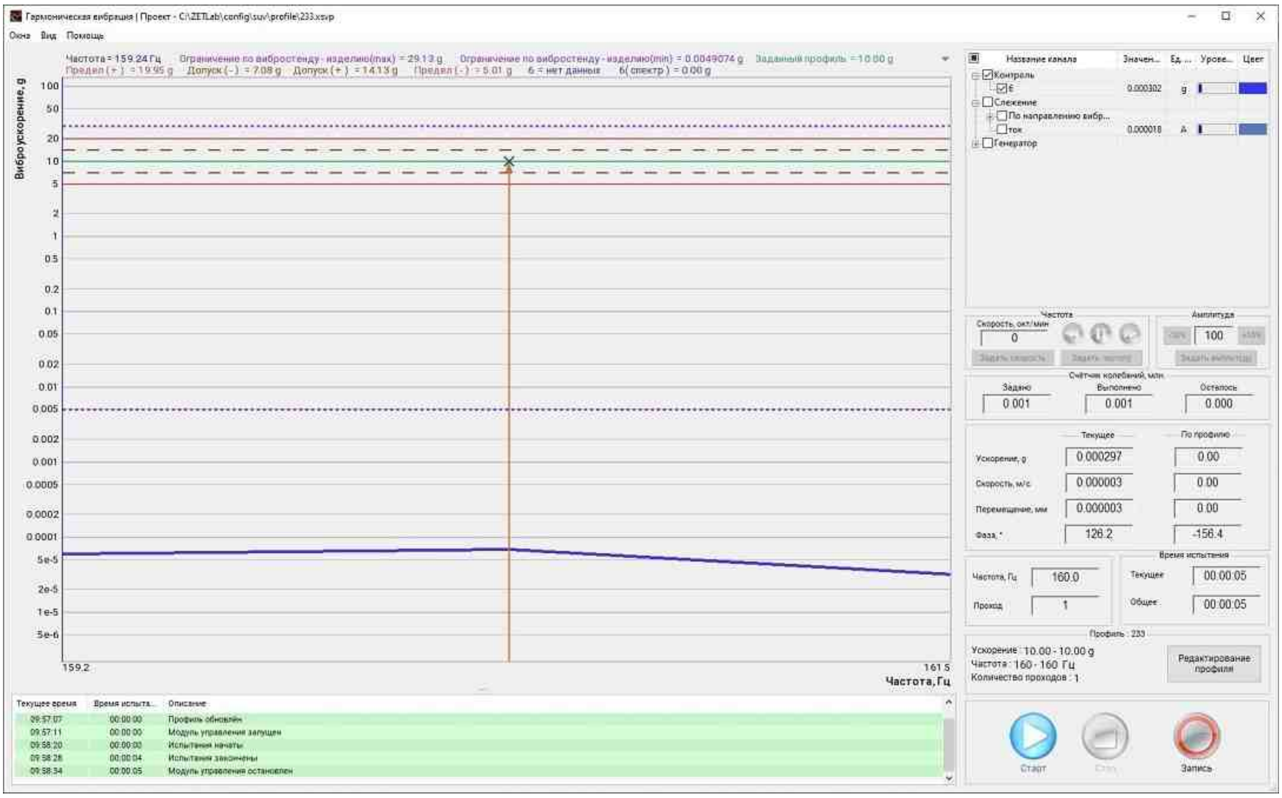


Fig. 9.22 "Sine" Window

The graduation stage consists in performing the prepared profile (activation of the "Start" button in the "Sine" program window).

Graduation is performed during the output mode (within 60 seconds). At the moment of linear rise of the vibration amplitude level, response amplitude graphics are recorded for measuring channels with the status "Tracking" relative to the measuring channel with the status "Control".

To view the calibration results in the "Sine" window in the "Windows" section (Fig. 9.23) you should select "Graduation" and the corresponding window will be opened (Fig. 9.24).

Fig. 9.23 Window "Sine", section "Windows"

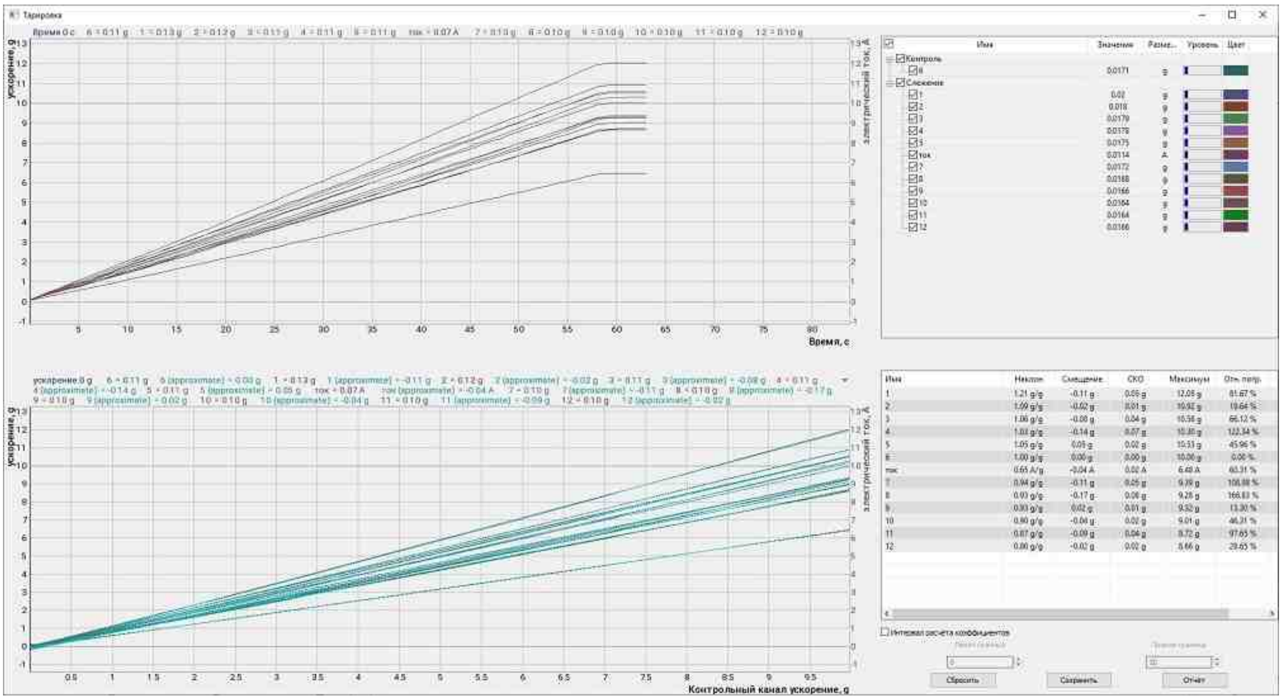


Fig. 9.24 "Graduation" window

checkboxes in the area of the list of measuring channels allow you to disable and enable visualization of the corresponding channels of graphics (*Fig. 9.25*).

In the "Graduation" window, adjust the graduation range (*Fig. 9.25*) by excluding the area of small amplitudes from it (in the example up to 1 g), for this you should activate the parameter "Coefficient calculation interval" and enter the corresponding numerical value.

Note: *it is recommended to exclude the area of small amplitudes from the graduation range due to the possible influence of noise on the graduation result.*

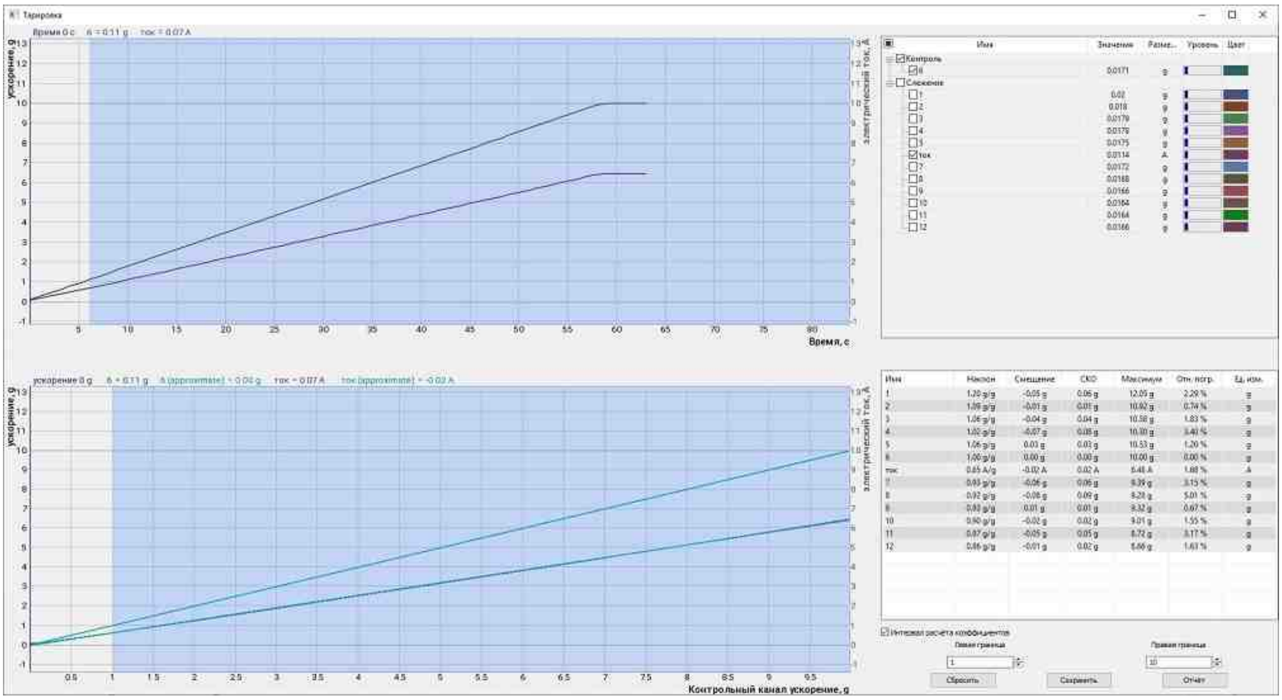


Fig. 9.25 "Graduation" window with range correction

checkboxes in the area of the list of measuring channels allow you to disable and enable visualization of graphics corresponding to channels.

In the field of numerical values, statistical data are output (calculated from the calibration results), which can be used to determine which acceleration values will be recorded by accelerometers during testing, what is the linearity of the amplitude characteristics of accelerometers relative to each other and relative to the current channel, etc..

To save the results in the Graduation window, you should activate the "Save" button, after which the registered information will be available in the "Graduation" tab of the "Edit profile " window (*Fig. 9.26*).

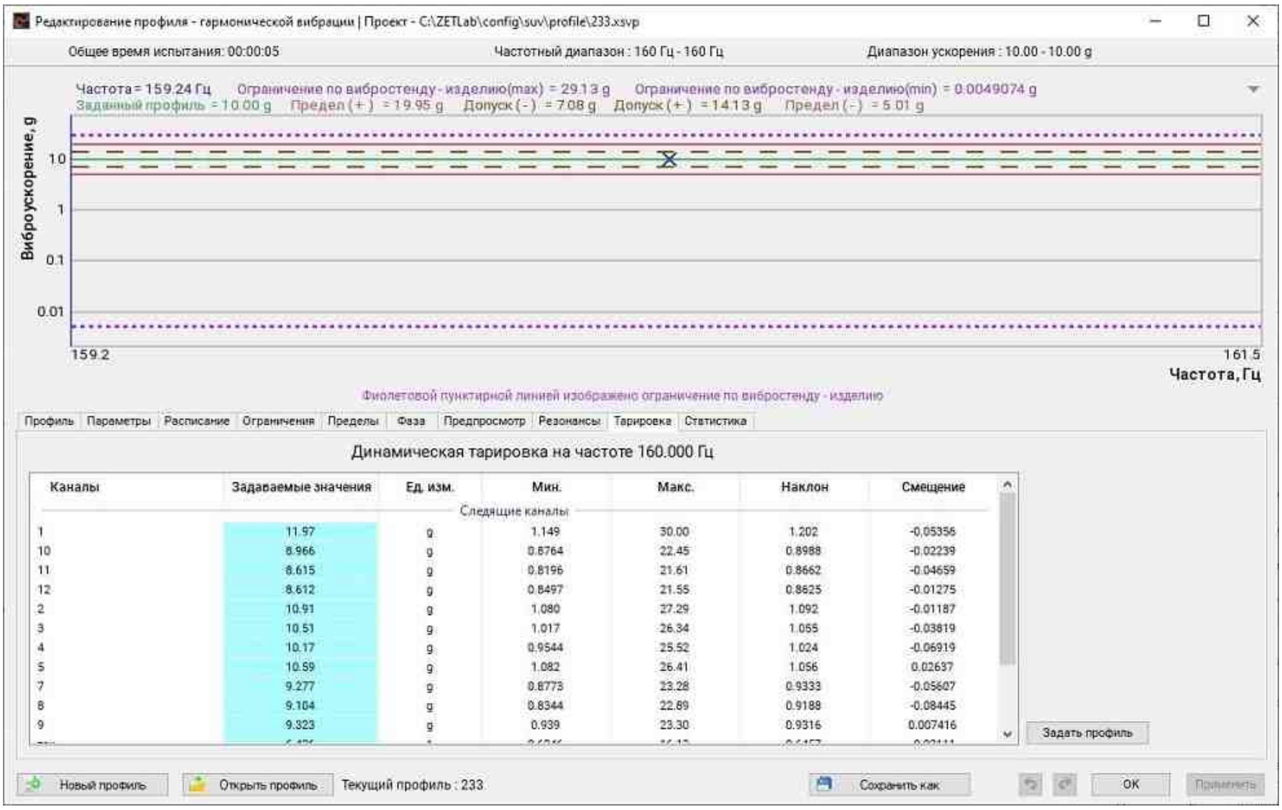


Fig. 9.26 "Edit profile" window, "Graduation" tab

Testing .....

In the window of the program "Sine" activate the "Edit profile" button.

In the window "Edit profile - Sine" in the "Graduation" tab (*Fig. 17.17*) set the value of the acceleration amplitude, which must be maintained during the test for the sensor installed at the control point 2.

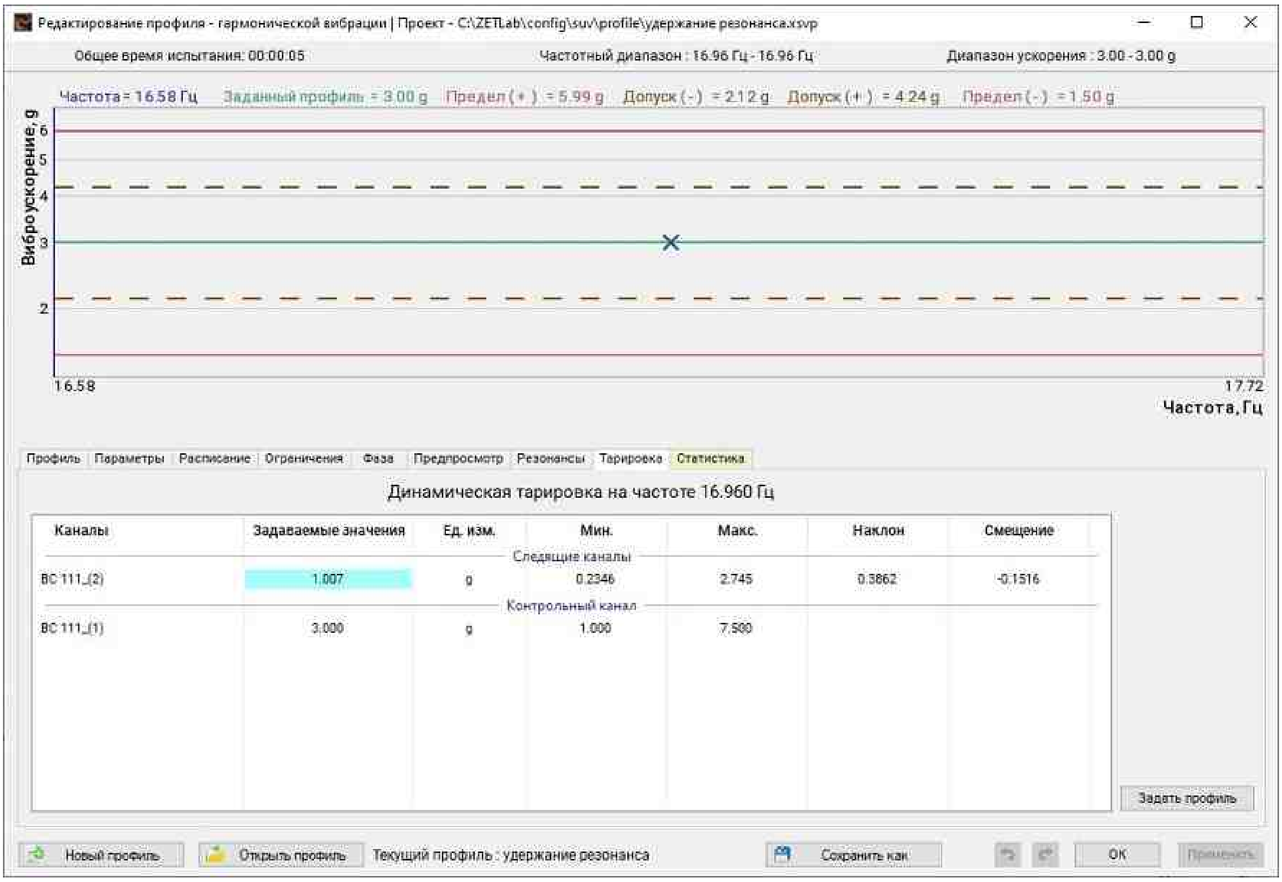


Fig. 17.17 "Edit profile - Sine" window "Graduation" tab

To do this, in the field marked with "blue" enter the required value for example "2g" (*Fig. 17.17*), at the same time, the corresponding acceleration value for the accelerometer set at point 1 will be automatically recalculated (in this example it will be "5.571g").

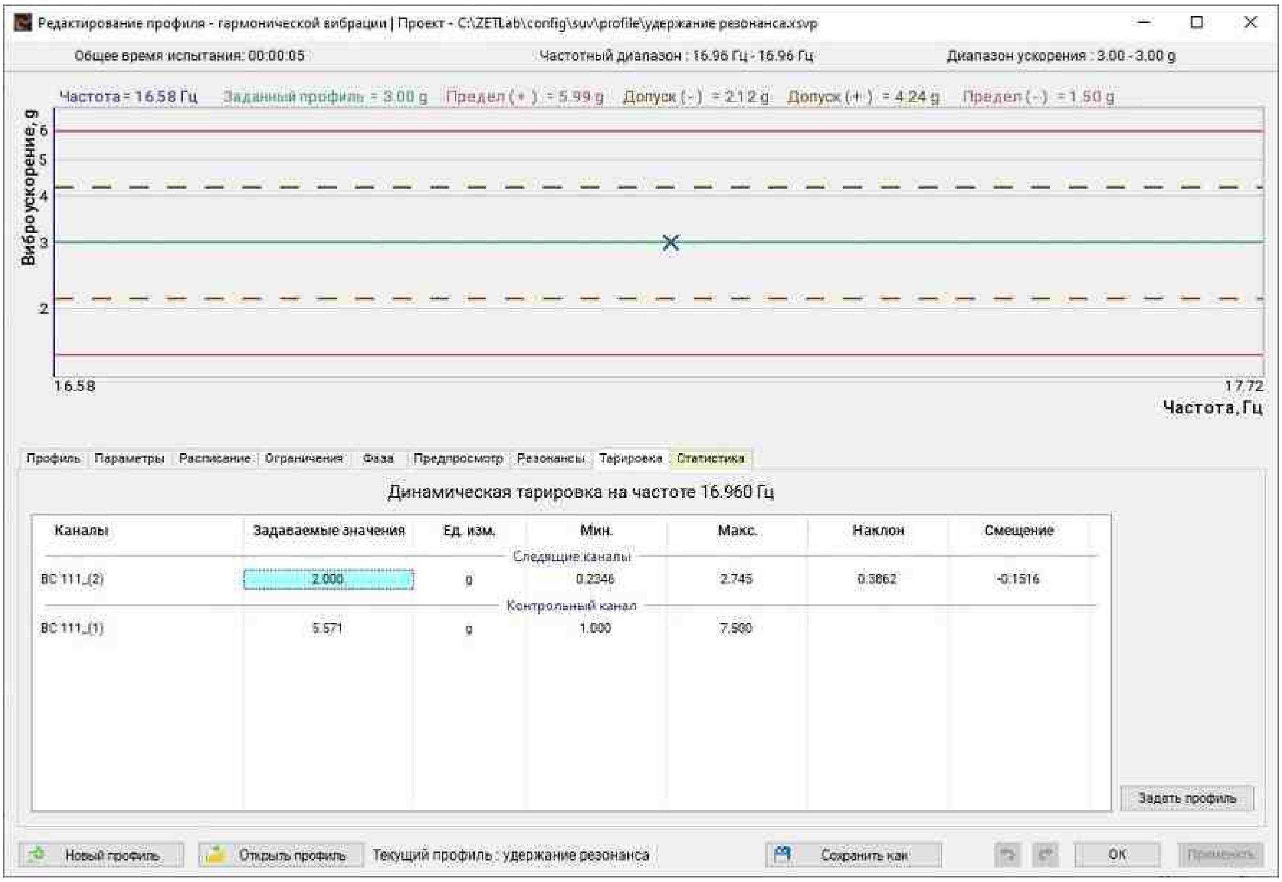


Fig. 17.18 "Edit profile - Sine" window "Graduation" tab

⚠ ***Note:*** *the software in the table of the Graduation window allows you to set the acceleration amplitude two and a half times greater than the amplitude to which the calibration was performed*

After setting the required acceleration amplitude in the "Graduation" tab activate button "Set a profile" and in the window "SinVibrationProfile" confirm the "New profile" activate button "Yes" ([Fig. 17.18](#)).

Fig. 17.19 Window "SinVibrationProfile

In the window "*Edit profile - Sine*" in the "Profile" tab ([Fig. 17.19](#)) in the "Duration" column, the required test time should be set (in the example - 10 hours).

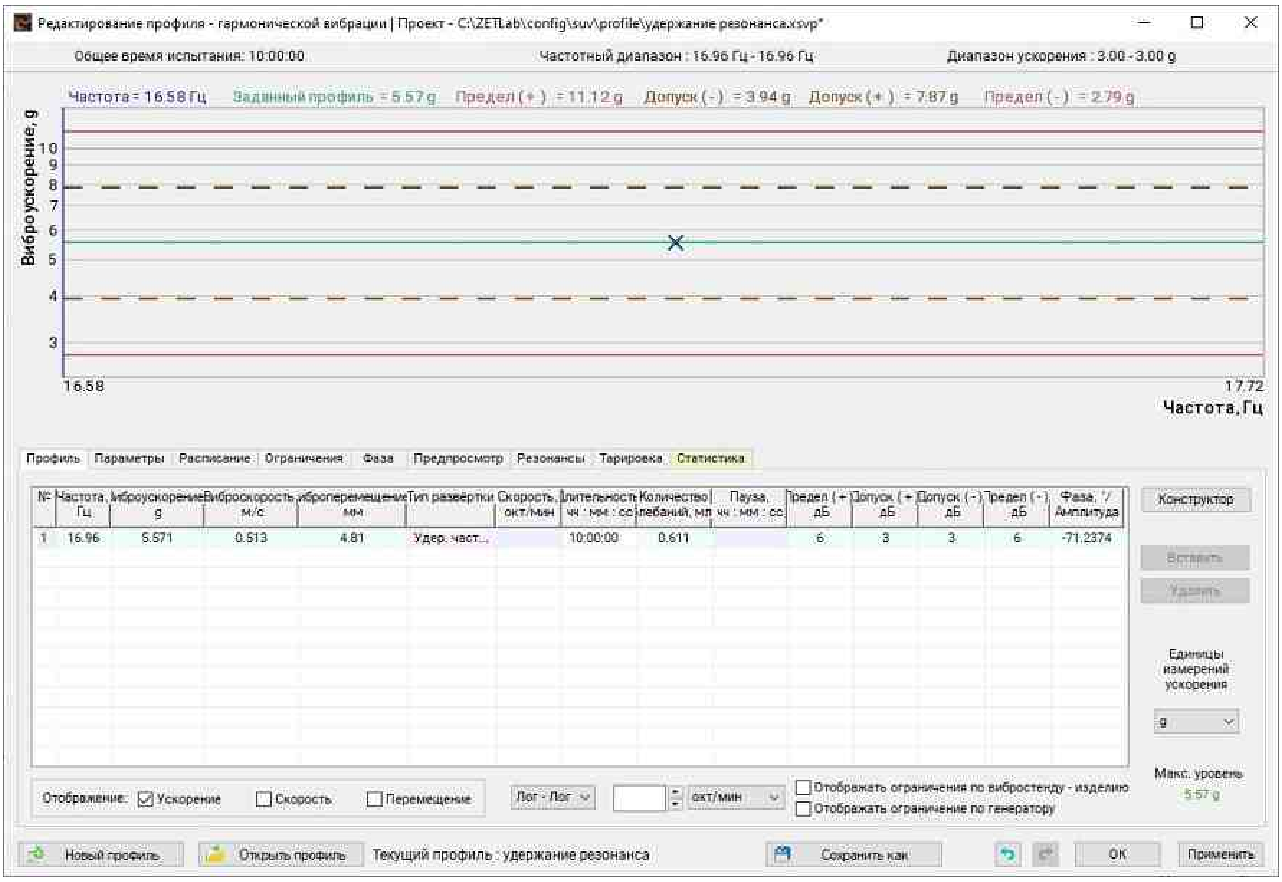


Fig. 17.20 Window "Edit profile - Sine" "Profile" tab

Make sure that in the "Parameters" tab, the parameter values correspond to the values shown in the Fig. ([Fig. 17.12](#)), after which activate the "OK" button to save the test profile.

Run tests by activating the "Start" button in the window "Sine" ([Fig. 17.13](#)).

Control and indication elements .....

Table of contents:

Cursor control in graphics .....

Most of ZETLAB program windows that are used for displaying of graphics, have a cursor, which allows to display the values, calculated by the program, at a particular position of the cursor.

You can move the cursor in the program window using one of the following options:

- Place the cursor at a particular point of the graphic, click and hold the left key until the cursor moves to the specified point;
- In active window of ZETLAB program (to activate the program window, left-click it) use the scroll key to achieve the desired frequency value;
- To move the cursor to the left in active window of ZETLAB program, click and hold <*A*>, to move the cursor to the right, click and hold <*D*>.

Scaling of numerical axes .....

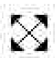
You can scale the numerical axes using mouse.

To scale the numerical axes, place the mouse cursor to the scale axis of the graphic. The cursor will change its appearance depending on its position on the numerical axis:

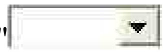
- For horizontal axes: ↔, →←, ←, →;
- For vertical axes: ↕, ↓↑, ↑, ↓.

Symbols ↔ and ↕ stand for extension, and symbols →← and ↓↑ - for compression of the graphic scale by the corresponding axis. Symbols ← and → stand for moving to the left and to the right by the horizontal axis, and symbols ↑, ↓ stand for moving up and down by the vertical axis.

As you select the required action for scaling by numerical axis and the cursor changes its appearance, you can scale the graphic by using the left mouse key, or by using the scroll key.

For auto-scaling of the vertical axis in the registered range of values (which is displayed in horizontal axis of the graph), place the cursor at the crossing of the numerical axes, so that the cursor icon would change for  and left-click it.

Selection from the lists .....

The icon " of ZETLAB programs allows the user to select the required parameter value from the list.

In order to select the required parameter from the list, place the cursor at the corresponding symbol. You will see a drop-down list with the available values. Place the cursor at the required value and left-click it. You can switch between the available values using the scroll key, or the keyboard keys <↑> and <↓>.

Configuration of program windows display parameters .....

Most of ZETLAB programs windows allow the user to change their display parameters. To change the window display parameters, place the cursor at the graphic section of the program to be set, and right-click it. You will see the graphic parameters window (*Fig. 17.1*).

In the tab "Display parameters" (*Fig. 17.1*) you can set the line type and graphic parameters. The graphic can be displayed as a stepped line or as a polygonals line. This tab also allows to set the display parameters for each of the graphics (color, thickness, filling (color) of a particular graphic area). As you set the required parameters, click "Apply" to save the changes.

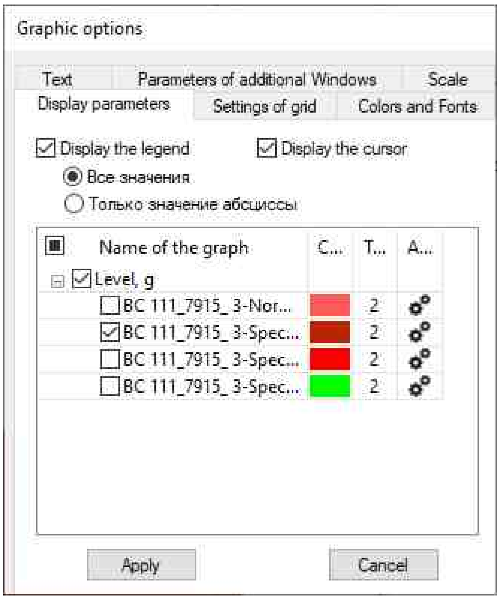


Fig. 17.1 The tab for configuration of graphic display parameters

The tab "Settings of grid" (*Fig. 17.2*) allows to enable/ disable the displaying of horizontal and vertical labelling of axes and grid. In this tab, you can also set the visible area of graphics to be displayed:

upper, bottom, left and right boundaries of the graphic. As you set the required parameters, click "Apply" to save the changes.

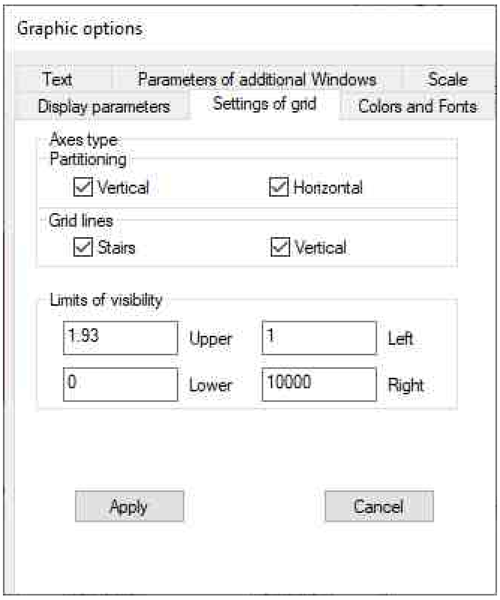


Fig. 17.2 The tab for configuration of graphic grid parameters

The tab "Colors and fonts" (*Fig. 17.3*) allows to set the font size for numerical axes and the measured values. In this tab, you can also set the color of grid, cursor, background, axes marks, legend. As you set the required parameters, click "Apply" to save the changes.

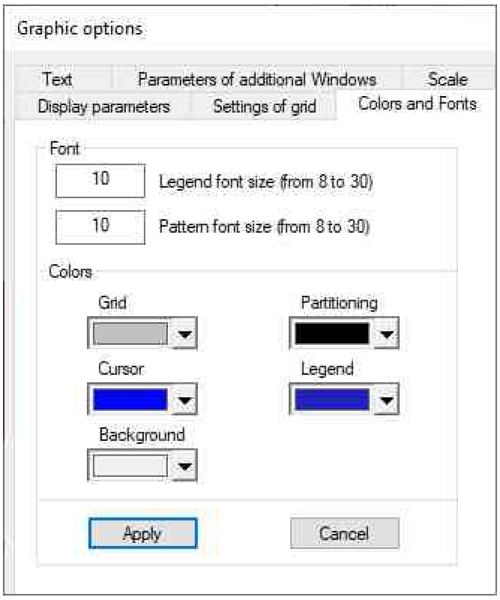


Fig. 17.3 The tab for configuration of color and fonts of the graph

The "Text" tab (*Fig. 17.4*) allows to add text to the graphic (additional clarifying information) to be displayed as the graphic is copied to text documents and reports. To add a text, click the checkbox "Show the text", select the font and enter the text (in this example: "Transducer at the point 2"), then click "Apply" to save the changes.

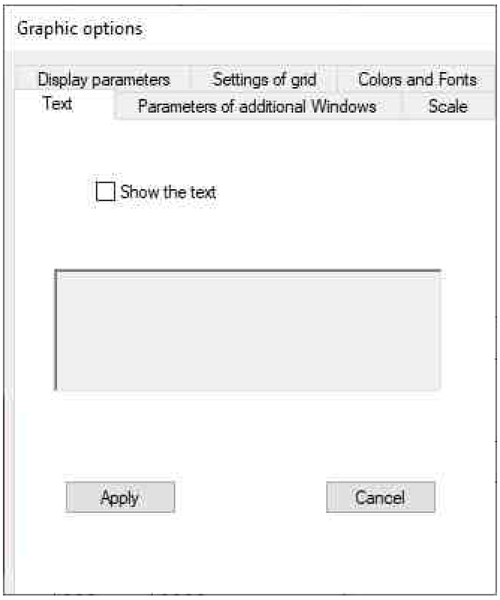


Fig. 17.4 The tab used for adding text to the graph

In this Fig. (*Fig. 17.5*) you can see a section of the program window "FFT Spectrum Analysis" with additional text information- "Transducer at the point 2".

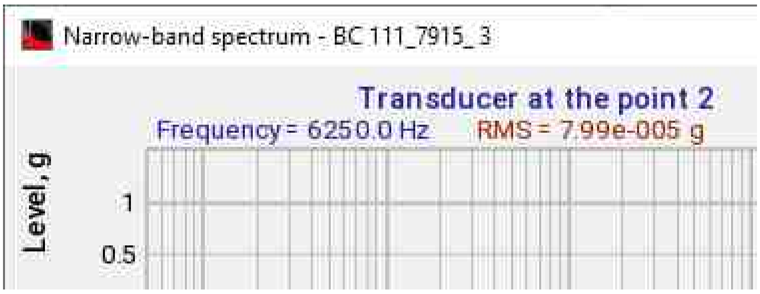


Fig. 17.5 Section of the program window with additional information

The "Scale" tab (*Fig. 17.6*) allows to select the type of vertical and horizontal axes representation. As you set the required parameters, click "Apply" to save the changes.

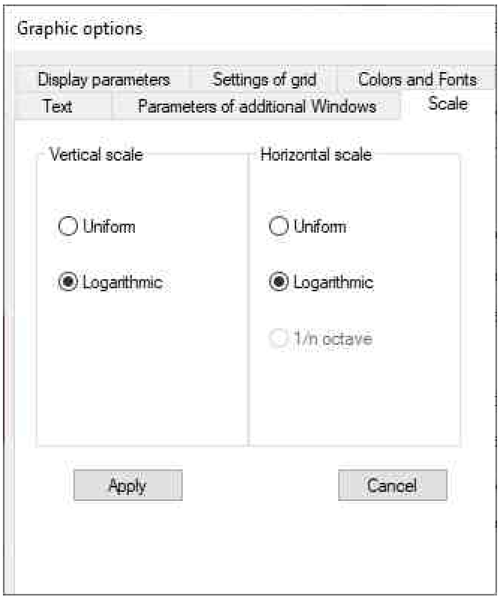


Fig. 17.6 The tab used for configuration of graphic scale

To exit the graphic parameters without saving the changes, click "Cancel", or click outside of the "Graphic parameters" window.

Note: *selection of the representation type depends on the appearance of the displayed graphic and can have limitations both for vertical and horizontal scale.*

Using signal level indicators .....

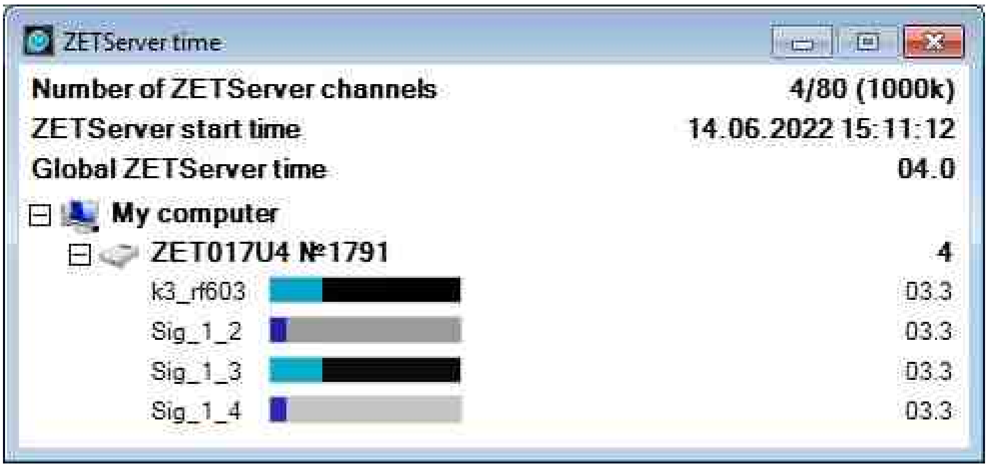
Most of ZETLAB programs used for processing of the registered signals (by the selected measurement channel) have signal level indicators (*Fig. 17.7*), displaying the current integral level of the signal.

Fig. 17.7 Indicator of signal integral level

Signal level indicator allows the user to evaluate the quality of selection, adjustment, and sensitivity of elements for a particular measurement channel, thus excluding signal processing in the case of overloading and signal failure in the selected measurement channel.

Two thirds of signal level indicator section display the signal level, which is below the maximal admissible value. The higher is the level, the more is indicator value. As the maximal admissible level is exceeded (without the presence of signal distortions), the indicator flashes with red. When overloading by the measurement channel will no longer be detected, the indicator will flash red until the user left-clicks it.

The indicators of the "ZET Server Time" program window are also equipped with the function of changing the color of the background area of the indicator. This function allows you to perform a statistical evaluation of the quality of the recorded signal in the measuring channel. The more the signal resembles white noise in its statistical characteristics, the lighter the background area. The smaller the signal resembles white noise in characteristics, the darker the background. At rest, the signal of a serviceable sensor should show background noise that is close to white in characteristics. The presence of interference (pulse, harmonic, etc.) or a malfunction in the sensor leads to a change in the characteristics of the signal and darkening of the background area of the indicator.



Adjustment of the color scheme used for displaying of the registered signal amplitude values .....

ZETLAB program windows used for displaying of the data in 2- or 3-dimensional format have indicators for adjustment of the color scheme of the registered values amplitude (*Fig. 17.8*).

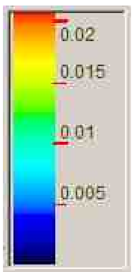
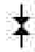
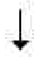
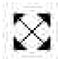


Fig. 17.8 Indicator of the color scheme adjustment

To switch over to the required color scheme and contrast level of the registered values, place the cursor to the right part of the indicator (*Fig. 17.8*), the cursor will change its appearance (depending on its particular location): .

The symbol  is used for extension of the color scheme, and the symbol  allows to compress it, symbol  allows to go to the bottom part of the color scheme, symbol  allows to go to the top section of the color scheme, symbol  is used for auto-scaling.

As you select the required type of scaling, left-click the cursor symbol, or use the scroll key.

TEST OPERATION

Vibration test control system (VCS)

This section presents common questions that most specialists face when conducting vibration resistance and vibration resistance tests.

For ease of perception, the information part is divided into four subTable of contents:

Table of contents:

Tests preparation .....

Hardware requirements .....

ZETLAB software is developed to be used on PC-s of IBM PC Intel® Pentium®/Celeron®/ type or any other compatible russified or localized OS versions:

1 Microsoft® Windows® XP with SP3 or later update package (not supported since 11.07.2014)
2 Microsoft® Windows® Vista with SP1 update package (not supported since 11.07.2014)
3 Microsoft® Windows® 7 32 bit with SP1 update package.
4 Microsoft® Windows® 7 64 bit with SP1 update package.
5 Microsoft® Windows® 8 32 bit.
6 Microsoft® Windows® 8 64 bit.
7 Microsoft® Windows® 8.1 32 bit.
8 Microsoft® Windows® 8.1 64 bit
9 Microsoft® Windows® 10 32 bit.
10 Microsoft® Windows® 10 64 bit.
11 Microsoft® Windows® Server 2003.
12 Microsoft® Windows® Server 2008 32 bit
13 Microsoft® Windows® Server 2008 64 bit with SP2 update package.
14 Microsoft® Windows® Server 2008 R2 with SP1 update package.
15 Microsoft® Windows® Server 2012 64 bit
16 Microsoft® Windows® Server 2012 R2 64 bit
17 Microsoft® Windows® Starter (without limitation on simultaneously used programs).

PC configuration for installation and start of ZETLAB software and devices drivers:

- Dual or more core processor;
- Processor speed - over 1,6 GHz;
- HighSpeed USB 2.0* interface;
- RAM – more than 2 Gb;
- Hard disk free space – more than 20 Gb;

- videocard with 3D-graphical acceleration, support of OrenGL, DirectX, memory - over 128 Mb;
- display resolution 1280Ч1024;
- mouse or any other pointing device (touch screen, track ball, TouchPad, graphic pad);
- standard keyboard or any other input device (sensor screen, graphic pad);
- CD-ROM for software installation.

ZET devices support HighSpeed USB 2.0 interface only. However, it is possible to connect ZET device to PC via USB 3.0, in the case if controller bus is compatible with USB 2.0 interface (e.g., NEC controllers).
Note: currently there may occur mistakes in the course of Asmedia USB 3.0 controllers use (during driver installation error message "10" is displayed). In this case, it is recommended to use USB 2.0 bus for connection to PC.

In the case if industrial PC-s are used for operation on ZETLAB and ZETVIEW software, we recommend to use 64-bit OS Windows.

When using industrial computers to work on them in ZETLAB and ZETVIEW, we recommend you to use the 64-bit version of Windows.*Equipment ZET interface only supports USB 2.0 HighSpeed. But ZET devices can be connected to a PC via USB 3.0, if the controller of this bus is backward compatible with USB 2.0 interface, such as controllers NEC.
Note: at the moment when working with USB 3.0 controllers Asmedia production problems can occur (if the driver installation, an error occurs with the code "10"). In this case, we recommend to use for PC connection USB 2.0.

When using industrial computers to work on them in ZETLAB and ZETVIEW, we recommend you to use the 64-bit version of Windows

WE PAY ATTENTION TO THE REQUIREMENTS FOR A PERSONAL COMPUTER WHEN WORKING WITH THE ZETLAB VIBRO SOFTWARE.
THE GIVEN REQUIREMENTS ARE RECOMMENDED FOR OPERATION WITH NO MORE THAN 2 CONTROLLER CHANNELS INVOLVED.

The ZETLAB VIBRO software is intended for use on personal computers such as IBM PC Intel® Pentium®/Celeron®/ or compatible with them, running a Russian-language (localized) or correctly Russian-language version of operating systems:

18 Microsoft® Windows® 7 32 bit with SP1 update package.
19 Microsoft® Windows® 7 64 bit with SP1 update package.
20 Microsoft® Windows® 8 32 bit.
21 Microsoft® Windows® 8 64 bit.
22 Microsoft® Windows® 8.1 32 bit.
23 Microsoft® Windows® 8.1 64 bit
24 Microsoft® Windows® 10 32 bit.
25 Microsoft® Windows® 10 64 bit.

Note

TO WORK WITH A LARGE NUMBER OF INVOLVED CHANNELS, YOU SHOULD USE A MORE PERFORMING COMPUTER

RECOMMENDED PC REQUIREMENTS	
CPU	quad core or more
Processor speed	at least 2.5 GHz
RAM memory	at least 8 GB
Free space on the hard disk or SSD drive	at least 512 GB
Video card	with 3D graphics accelerator, support for OpenGL, DirectX, at least 4 GB of memory
Screen resolution	at least 1920Ч1080
Network interface	10/100 Mbps (RJ-45 port)
Number of monitors	2
• HighSpeed USB 2.0* interface for software installation • the presence of a mouse or other pointing device (touch screen, trackball (track ball), touchpad (TouchPad), graphic tablet); • the presence of a standard keyboard or other input device (touch screen, graphics tablet).	

Installation and power requirements .....

INSTALLATION AND POWER SUPPLY REQUIREMENTS FOR ELECTRODYNAMIC VIBRATION GENERATOR SYSTEMS

Depending on the type of shaker, it is necessary to follow the recommendations for their installation:

- low-power shakers designed for calibration and verification of sensors (for example, TV 50018) can be placed on tables, bedside tables for the convenience of the operator. Nevertheless, it is worth using special furniture with a thick counter top or installing a shaker over the legs to avoid strong resonance. Similar shakers have rubber feet;
- Shakers of medium power must be installed on the floor or on a pedestal;
- large shakers of high power are installed only on the floor. Large shakers can have pneumatic unloading, which compensates for the vibrations of the shaker itself, performed in antiphase from the vibrations of the tested specimen. For large shakers without pneumatic unloading, it is advisable to prepare a vibration-insulated foundation.

The best base for shakers is a monolithic concrete cube, to which the frame of the shaker is bolted. In the office or laboratory, the shakers should be placed on the floor on rubber feet. But it is not very convenient to work on the floor with a shaker, so the next best placement option is a separate cabinet without shelves, made of thick boards (the thicker the better) with a stiffening rib in the middle.

Below are some types of electrodynamic vibration generator systems and the corresponding recommendations for installation and power supply:

Name of the shaker	Shaker mounting type	Total peak power electrical energy consumption	Type of power supply / number of connection points	
			single-phase network	three-phase network
TV 50009	Rigid trunnion with insulated legs	1 kW	6	—
TV 50018	Rigid trunnion with insulated legs	1 kW	6	—
TV 51110	Rigid trunnion with insulated legs	1 kW	6	—
TV 52110	Rigid trunnion with insulated legs	1 kW	6	—
TV 51120	Rigid trunnion with insulated legs	2 kW	6	—
TV 52120	Rigid trunnion with insulated legs	2 kW	6	—
TV 51140	Rigid trunnion with insulated legs	5 kW	6	—
BCB-133	Rigid trunnion with insulated legs	2 kW	6	—
TV 5220-120	Rigid trunnion with insulated legs	6 kW	6	—
TV 5220/LS-120	Rigid trunnion with insulated legs	6 kW	7	—
TV 54216/LS-130	Rigid trunnion with insulated legs	6 kW	6	—
TV 50350/LS-120	Rigid trunnion with insulated legs	5 kW (~3 * 400V) 1 kW (~1 * 220V)	4	1
TV 55240/LS-180	Rigid trunnion with insulated legs	7 kW (~3 * 400V) 1 kW (~1 * 220V)	4	1
TV 56263/LS-180	Rigid trunnion with insulated legs	15 kW (~3 * 400V) 1 kW (~1 * 220V)	4	1
TV 51010/LS-340	Rigid trunnion with insulated legs/insulated heavy plate	16 kW (~3 * 400V) 1 kW (~1 * 220V)	4	1

TV 51110

Shaker 100 N; 2...7000 Hz; 49 g; 13 mm; Payload weight 1 kg

m030/MA1-CE

Shaker 300 N; DC...3000 Hz; 50 g; 26 mm; Payload weight 13 kg

m060/MA1-CE

Shaker 600 N; DC...3000 Hz; 50 g; 30 mm; Payload weight 15 kg

m120/MA1-CE

Shaker 1200 N; DC...2000 Hz; 50 g; 30 mm; Payload weight 120 kg

LDS V201

Shaker 17,8 N; DC..13000 Hz; 91 g; 5 mm; Payload weight 0,2 kg

Recommendations for protection against electromagnetic fields

when using meter resistances, strain gauges, vibration sensors and sensors with quartz sensing element

The reliability and reliability of the readings of measuring devices depends on their noise immunity in relation to external and internal, random and regular interference. The correct solution of the problem of ensuring the noise immunity of the measuring system depends on its normal functioning during operation. The main share of interference affecting the correctness of readings is due to electromagnetic interference.

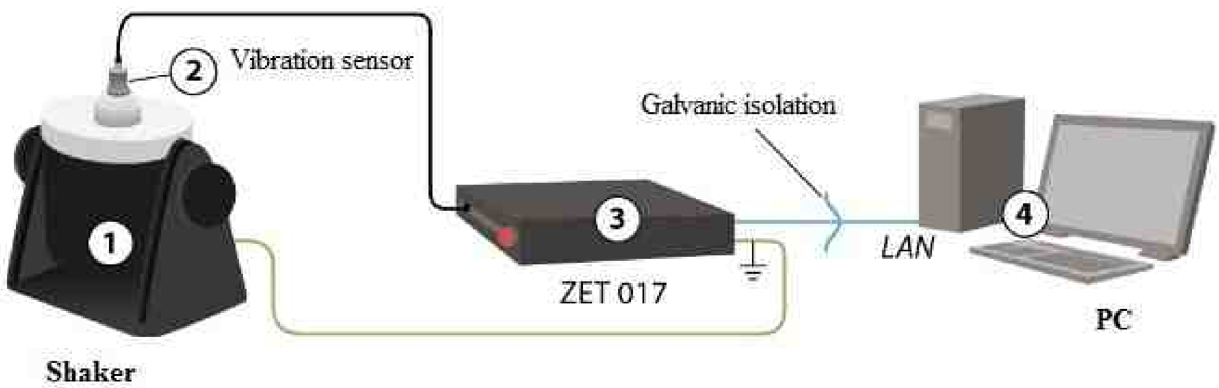
In this article, we will consider several solutions to the problem of excluding this component from the measurement process when using ZETLAB equipment complete with vibration sensors, meter resistances, strain gauges and sensors with a quartz sensing element.

Vibration sensor

Recommendations for protection against electromagnetic interference when working with electrodynamic installations complete with ZETLAB equipment and vibration sensors are as follows:

1. It is necessary to disconnect the VCS ZET 017 or ZET 02X galvanically from the PC and the common "Ground". To do this, it is recommended to use an Ethernet connection.
2. Connect the ZET 017 VCS (ZET 02X) and the shaker housing with the "Ground connection" wire: to do this, connect the contact on the back panel of the analyzer with the marking with a wire ⏚ with a metal part on the body of the shaker (for example, a nut or bolt). The shaker must be connected to the "Ground". The "Ground connection" wire is not included in the delivery package of the VCS ZET 017, ZET 02X.

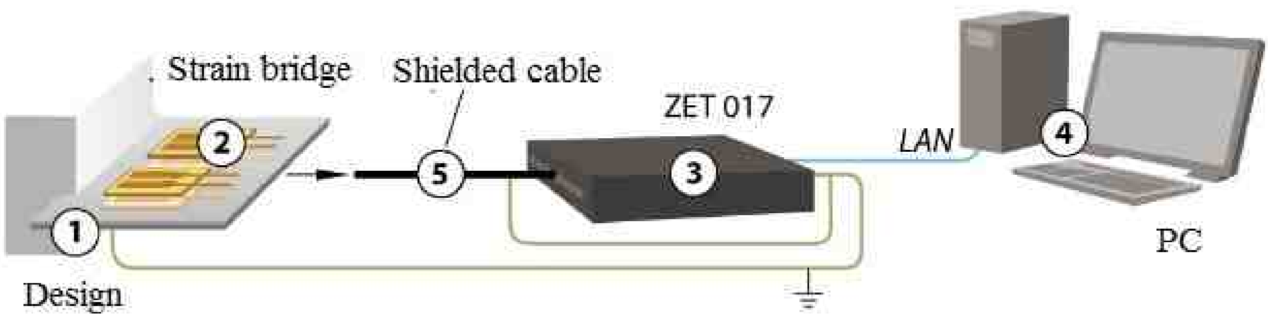
Approximate connection scheme is shown in the Fig.:



Meter resistance

1, Recommendations for protection against electromagnetic interference when working with ZETLAB equipment complete with meter resistances for measuring deformation processes are as follows:

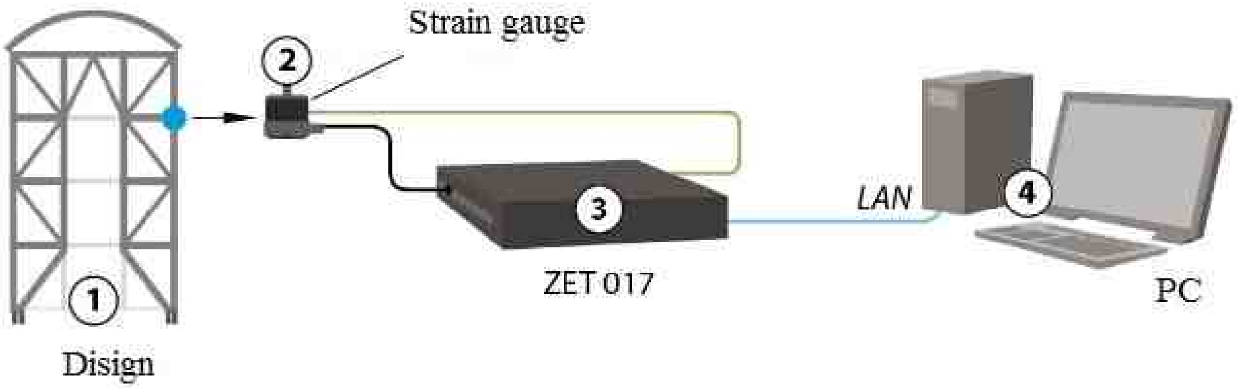
2. A strain-gauge station is needed ZET 017-T or ZET 05X untie galvanically from the PC and the common "Ground". We recommend using an Ethernet connection for this.
3. Wire "Ground" to connect the strain-gauge station ZET 017-T (ZET 05X) and the object of observation: to do this, it is necessary to connect the wire to the contact on the back panel of the strain-gauge station with the marking ⏚ . with metallic part on the structure (for example, a nut or bolt). The "Ground connection" wire is not included in the scope of delivery of the ZET 017-T, ZET 05X strain-gauge station.
4. Requires a cable shield to connect the meter resistances to the strain-gauge station ZET 017-T, ZET 05X connect to the "Ground" strain-gauge station.
5. An example connection diagram is shown in the Fig.:



Strain gauge

1. Recommendations for protection against electromagnetic interference when working with ZETLAB equipment complete with strain gauges for measuring deformation processes in structures are as follows:
2. Strain-gauge station is needed ZET 017-T or ZET 05X untie galvanically from the PC and the common "Ground". To do this, it is recommended to use an Ethernet connection.
3. If the strain gauge body has an electrical contact with the object of observation, the body of the strain-gauge station is necessary ZET 017-T (ZET 05X) connect the wire to the strain gauge housing.

Approximate connection scheme is shown in the Fig.:

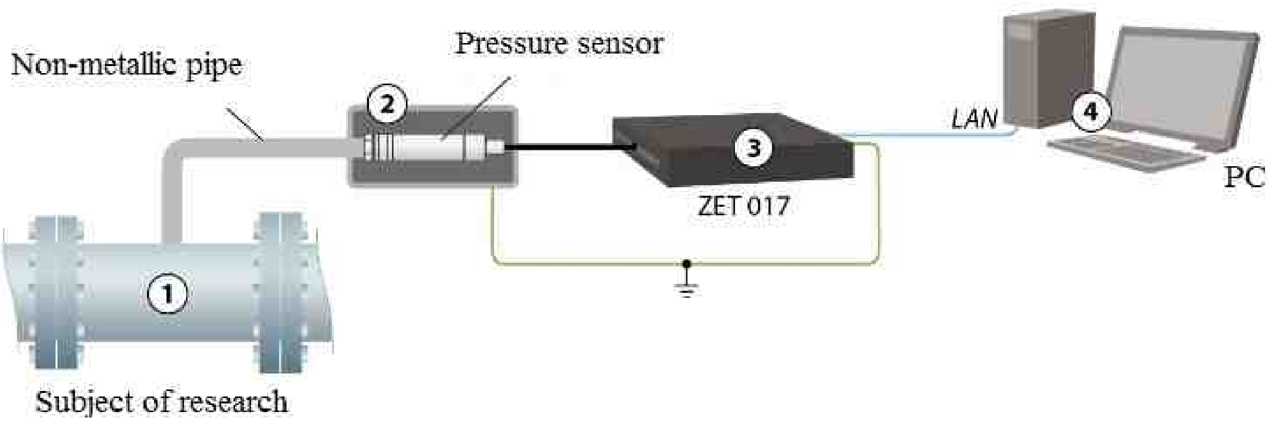


Sensor with quartz sensing element

Recommendations for protection against electromagnetic interference when using sensors with a quartz sensing element in conjunction with ZETLAB equipment are as follows:

1. Spectrum analyzer ZET 017 or ZET 03X must be galvanically from the PC and the common "Ground". To do this, it is recommended to use an Ethernet connection.
2. The pressure sensor must be galvanically disconnected from the object, as well as shielded. To do this, you can use a metal box. The pressure sensor is connected to the object of study using a non-metallic tube. The pressure sensor must not have electrical contact with the metal box.
3. Make ground connection as follows: metal box, spectrum analyzer ZET017 (ZET 03X) and the PC must be connected to the ground bus at one point. If each element is connected to the ground bus, but in different places, then this can only worsen the situation. Therefore, it is mandatory to connect to the earth bus at one point.

Approximate connection scheme is shown in the Fig.:



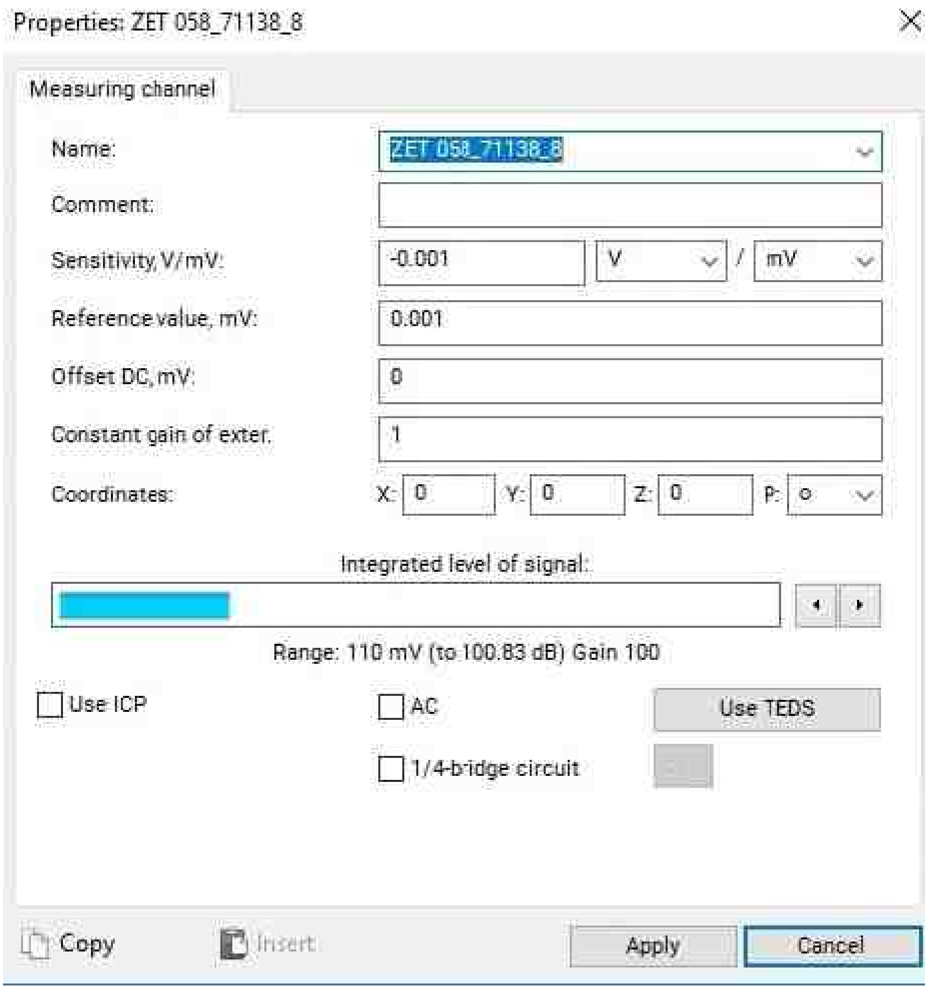
Recommendations for identify ground problems .....

Recommendations for identify ground problems

on the example of VCS controllers ZET 20X

During use of VCS controllers in real conditions, sometimes there is a problem of noise. Most often this is due to the so-called earth loops and/or electromagnetic guidance.
Problems can be caused with an outdated grounding system in a room where it is operated with VCS, or with impulse power plants operating nearby.
The potential difference between the grounding points of the controller and the amplifier can introduce significant noise into the signal, especially when using D-class amplifiers.
The most common sources of interference and ways to eliminate them are listed on the page Recommendations for identifying grounding problems.
If you are unable to localize and eliminate the noise source yourself, you must provide us with diagnostic information by following these steps:

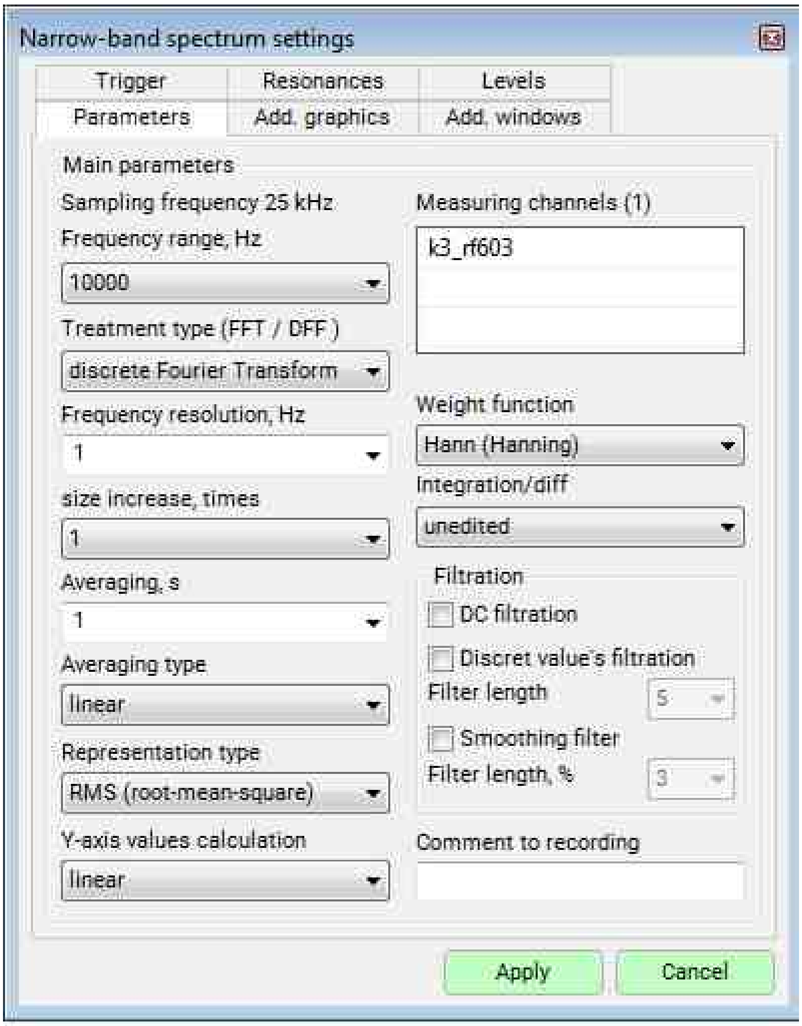
1. Setting the first channel of the controller as follows:
2.



3. Turn off the power to the amplifier and, if possible, all power plants in the room.

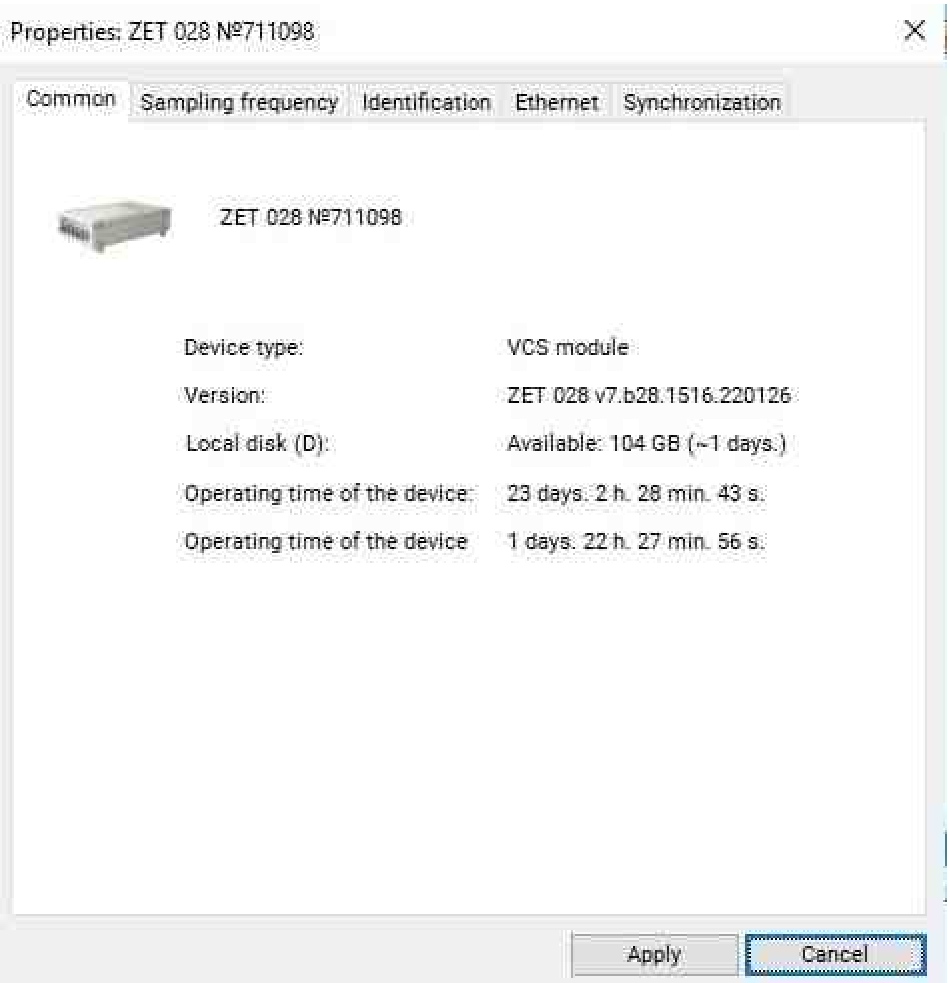
3. Put a 50 ohm plug on the first channel input.

4. Run the "FFT Spectrum Analysis" program from the "Signal analysis" menu of the ZETLAB panel and set the following program settings:



5. After activating the settings, record the signal spectrum by clicking the "Recording" button on the right side of the program window and save it to a file named "base noise.dtx".
6. Connect the accelerometer to the input of the first channel, turn on ICP, place the sensor next to the controller on an insulated surface.
In the "FFT Spectrum Analysis" program, click "Recording" and save the spectrum to a file named "sensor base noise.dtx".
7. Install the accelerometer on the shaker through an insulating tape or gasket.
In the "FFT Spectrum Analysis" program, record the spectrum of the signal from the accelerometer by pressing the button "Recording" in the right part of the program window and save to a file named "sensor shaker noise.dtx".
8. Install the plug on the input of the amplifier and turn on the amplifier to the minimum gain.
In the "FFT Spectrum Analysis" program, click "Recording" and save the spectrum to a file named "amp0 noise.dtx".
9. Without removing the plugs, set the gain to maximum.

In the "FFT Spectrum Analysis" program, click "Recording" and save the spectrum to a file named "amp max noise.dtx".
10. Set the gain to 0, connect the controller to the amplifier without starting the program VCS and the generator, set the gain to maximum again.
In the "FFT Spectrum Analysis" program, click "Recording" and save the spectrum to a file named "out amp max noise.dtx".
11. Set the gain to 0, insert the jumper between the grounding terminals on the back panel, set the gain to maximum again.
In the "FFT Spectrum Analysis" program, click "Recording" and save the spectrum to a file named "out amp coupling max noise.dtx".
12. Send the saved files together with a screen-shot of the Total tab from the Device Manager program to the email address info@zetlab.com.



Commissioning of vibration generator systems .....

Commissioning of vibration generator systems

The vibration generator systems is a complex technological complex, which includes high-power equipment. For the correct operation of the system during commissioning, it is necessary to control a number of parameters, some of which we will consider in this article.

Monitoring of insulation resistances

Before starting installation, the insulation resistances between the windings of the cooling fan motor, as well as between the armature coil and the magnetization coil, should be checked.

The control is performed by a mega-ohmmeter when a test voltage of 500V is applied.

The values of insulation resistances must be at least 10 MΩ.

In cases where the insulation resistance is below 10 MΩ, the switching of the element into the stand is not allowed until the reason for the decrease in insulation resistance is clarified.

Ground resistance control

After the installation of the elements (nodes) that are part of the system, the grounding resistances must be checked before the power supply is applied.

All elements must be grounded to the grounding bus located at the bottom of the amplifier rack and have a grounding resistance of no more than 0.5 Ω, except for the grounding resistances of the shaker and amplifiers, which should not exceed 0.05 Ω. The ground resistance between the ground bus in the amplifier rack and the ground bus in the switchboard should not exceed 0.05 Ω.

Quality control of accelerometer installation

The installation of accelerometers on the table of the shaker must be carried out through a dielectric material that excludes electrical contact.

Checking the absence of an electrical contact is performed by a multimeter in the resistance measurement mode.

The value of the measured resistance between the vibration table and the accelerometer housing must exceed 10 MΩ.

Control of the voltage drop between the neutral wire and the ground wire

The voltage drop between the neutral wire and the ground wire should not exceed 2 V AC.

Control of the voltage and current of the system power supply

The voltage and current of the shaker power supply is controlled at the connection point of the shaker power cable in the switchboard. Galvanically isolated devices for measuring supply voltages and consumption currents are used for monitoring at each of the three phases.

The control is carried out during the entire period of commissioning.

Power amplifier supply voltage control

The control is carried out according to the indications on the panel of the digital logic module.

The value of the power amplifier supply voltage during the operation of the shaker should not exceed the values given in the operational documentation.

Control the efficiency of the cooling system

The temperature readings of the digital logic module indicator are used for control.

The control is carried out by measuring the temperature increase in terms of one kW of power consumption according to the following scheme:

- when switched on, the value from the temperature sensor is recorded (before the voltage is applied to the magnetization coil);
- after the voltage is applied to the magnetization coil, after 30 minutes, the values from the temperature sensor are re-recorded;
- the temperature increase is calculated as the ratio of the difference in temperature readings to the power supplied to the magnetization coil.

Control by generated signal levels

The control is carried out for both vertical and horizontal positions of the shaker.

The control is carried out by comparing the initial graphics of the generated signal (graphics of standards) obtained at the manufacturer when passing the maximum profiles with a sine signal of a swinging frequency, with graphics of the predicted levels of the generator obtained in the "Pre-Test" mode when a Random signal is applied in a given frequency band with a certain amplitude (generator RMS).

In the case of diagnosing significant discrepancies (more than 30%) between the graphics of predicted levels and the graphics of standards, measures should be taken to identify and eliminate the causes of such discrepancies.

Classic shock control

Galvanically isolated current and voltage sensors installed at the connection points of the shaker armature in the amplifier rack are used for control.

The control is carried out during the formation of shocks with a duration of 3 ms with a repetition frequency of 1 Hz and a gradual increase in the intensity of shocks (with a 10% lever) in the range from 10% to 100% relative to the maximum permissible level of shock. In this case, at each step, the linearity of the increase in armature current is checked.

Armature current and voltage control

Galvanically isolated current and voltage sensors installed at the connection points of the shaker armature in the amplifier rack are used for control.

The control is carried out by analyzing the nature of the current and voltage graphics recorded during the passage of profiles by a sine signal of a swinging frequency.

The current graphic should not have significant fluctuations (deviate significantly from a constant level) when the shaker is operating in the profile area with constant acceleration.

The current and voltage graphics obtained during the passage of profiles with different degrees of equalization should not change their characteristic image.

Nuances in carrying out classical types of tests .....

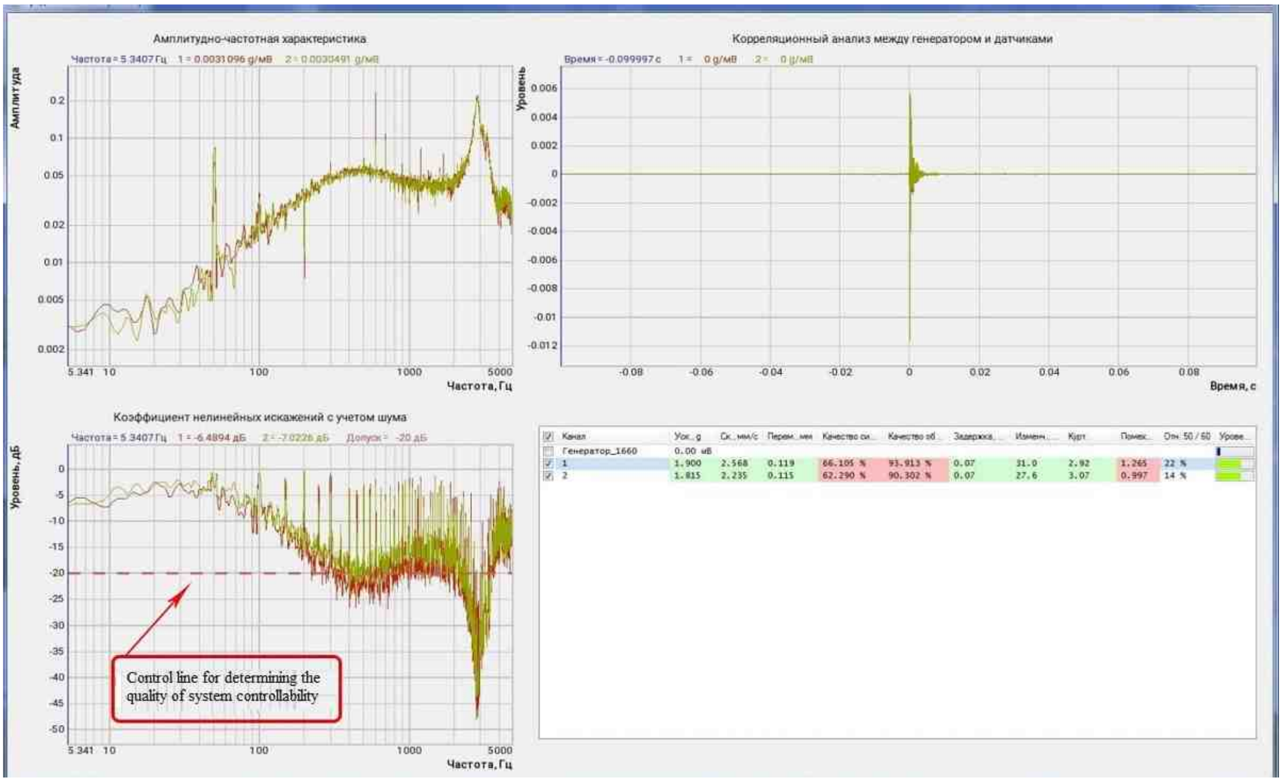
Interpretation of the results of the Pre-Test .....

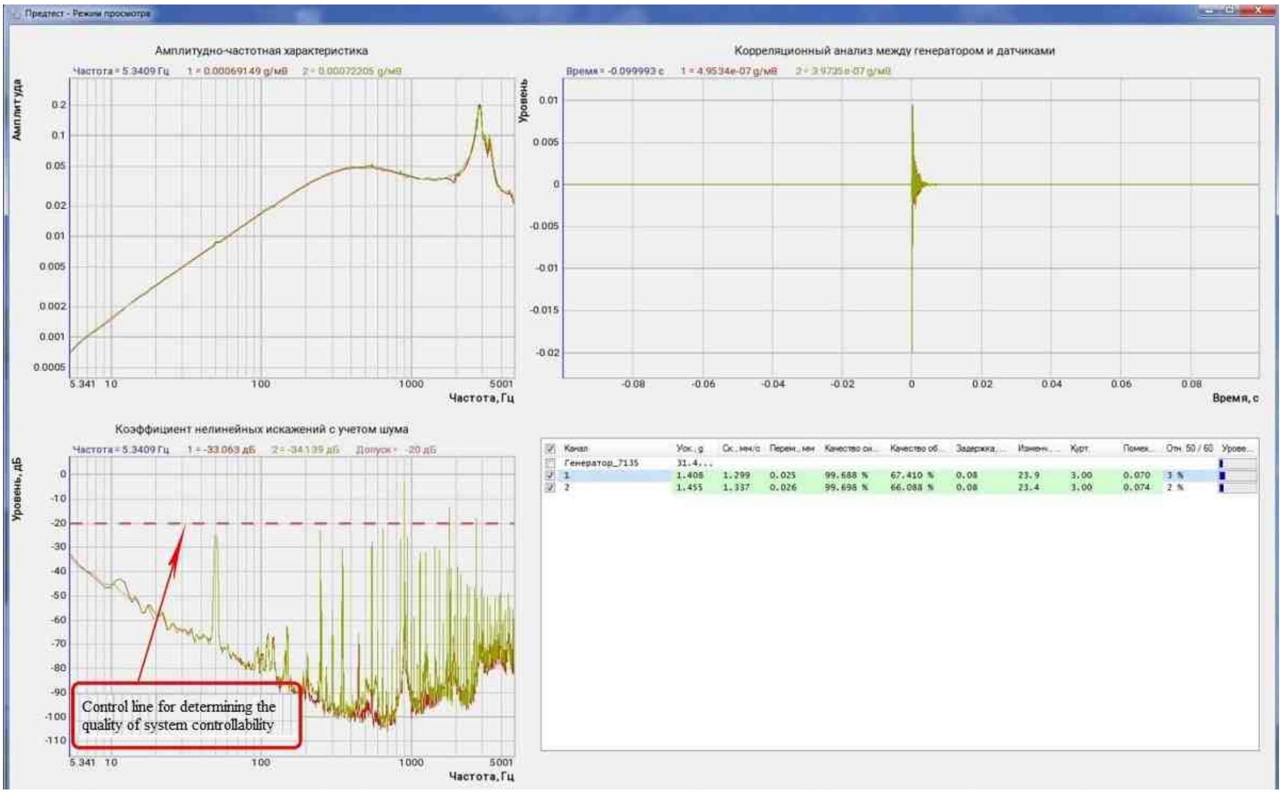
Testing specimens for the effects of mechanical factors, in particular vibration, determines how ready the specimen is for its intended use. In this connection, the correctness of the obtained results depends on whether the specimen will correspond to the declared service life in working conditions.

Now the question arises: how to determine how correctly the tests were carried out and whether all conditions were met?

One of the decisive factors is the choice of an appropriate vibration test control system. Most modern vibration test control systems as part of the software have the function of preliminary analysis of the system for the possibility of controlling and passing the specified levels.

Let's analyze the principle of interpretation of the results obtained by the example of passing a Pre-Test of two vibration control systems [vibration control systems ZET 017-U or ZET 028] under the same conditions of strong electromagnetic guidance.





The window of the Pre-Test program is divided into four areas, each of which displays characteristics that allow you to collectively assess the degree of controllability:

- Amplitude-frequency response;
- Correlation between signal generator and sensors;
- The value of the total harmonic distortion;
- Analytic's for each channel separately.

Interpretation of the first two graphics is not difficult for specialists working in the field of vibration testing.

Difficulties may arise with the third graphic — the coefficient of nonlinear distortion taking into account noise. This parameter is used to express the influence of high—frequency signal components on the control channel of the system, and, accordingly, the possibility of high-quality control of vibration testing. The lower the value of the nonlinear distortion coefficient, the more accurate the control will be.

For the convenience of interpreting the results, a control line is plotted on the graphic corresponding to the value of the coefficient of nonlinear distortion with a low quality of controllability of the system. The location of the graphic below the control line indicates a sufficient quality of controllability, above — unsatisfactory.

In our concrete example, we can see that the value of the nonlinear distortion coefficient with the ZET 017-U system is much higher than the value of the same coefficient with the ZET 028 vibration control system. The main reason is the influence of electromagnetic interference.

This is due to the fact that in the controllers of the new generation ZET 028, designed to control vibration tests on electrodynamic shakers, the electromagnetic interference protection system has been upgraded. Accordingly, in conditions of strong electromagnetic interference, it is preferable to use ZET 028 control systems.

In addition to the graphical displays, all the main parameters for each sensor used, including the level of interference, are shown in tabular form..

The most common problems when working with VCS ZETLAB

Vibration test control systems refer to equipment that requires certain skills and abilities when working with it. Due to certain features, users may have difficulties when starting the system for the first time.

In this article, we will consider the most common problems associated with start the system:

On *Fig. 1* an example of a negative result of passing a Pre-Test performed on a Shaker with an expansion table is presented

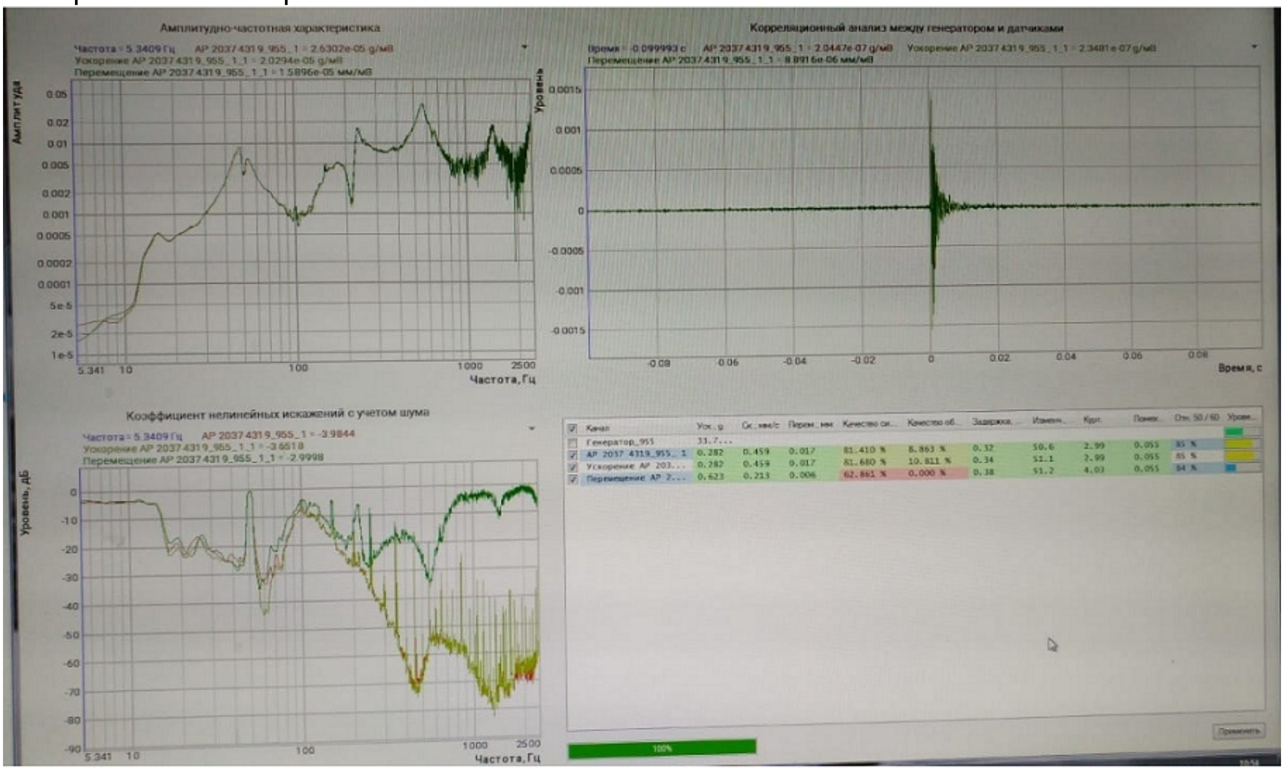


Fig. 1. Negative result of the Pre-Test

The conclusion about the low quality of the results of the Pre-Test was made primarily by the high level of the coefficient of nonlinear distortion (a level close to 0 dB). The parameter "Signal quality" (in the results table) also indicates a low quality of the results of the Pre-Test and has a value less than 90% (divided in yellow or red).

In this case, before starting the tests, it is necessary to understand the cause of the negative result of the Pre-Test. To do this, in the "Pre-Test" program window, you should activate the "Recommendations" button and in the window that opens, pay attention to the proposed options for possible malfunctions and, if necessary, eliminate them.

If none of the suggestions in the recommendations helps, try to check the suggested options sequentially below:

- poor grounding;
- bad contact;
- faulty cable;
- faulty sensor.

After troubleshooting, it is necessary to re-pass the Pre-Test and make sure that the result of passing the Pre-Test is positive. In *Fig. 2* shows an example of a positive result of passing the Pre-Test after troubleshooting a malfunction associated with a bad contact in the control cable.

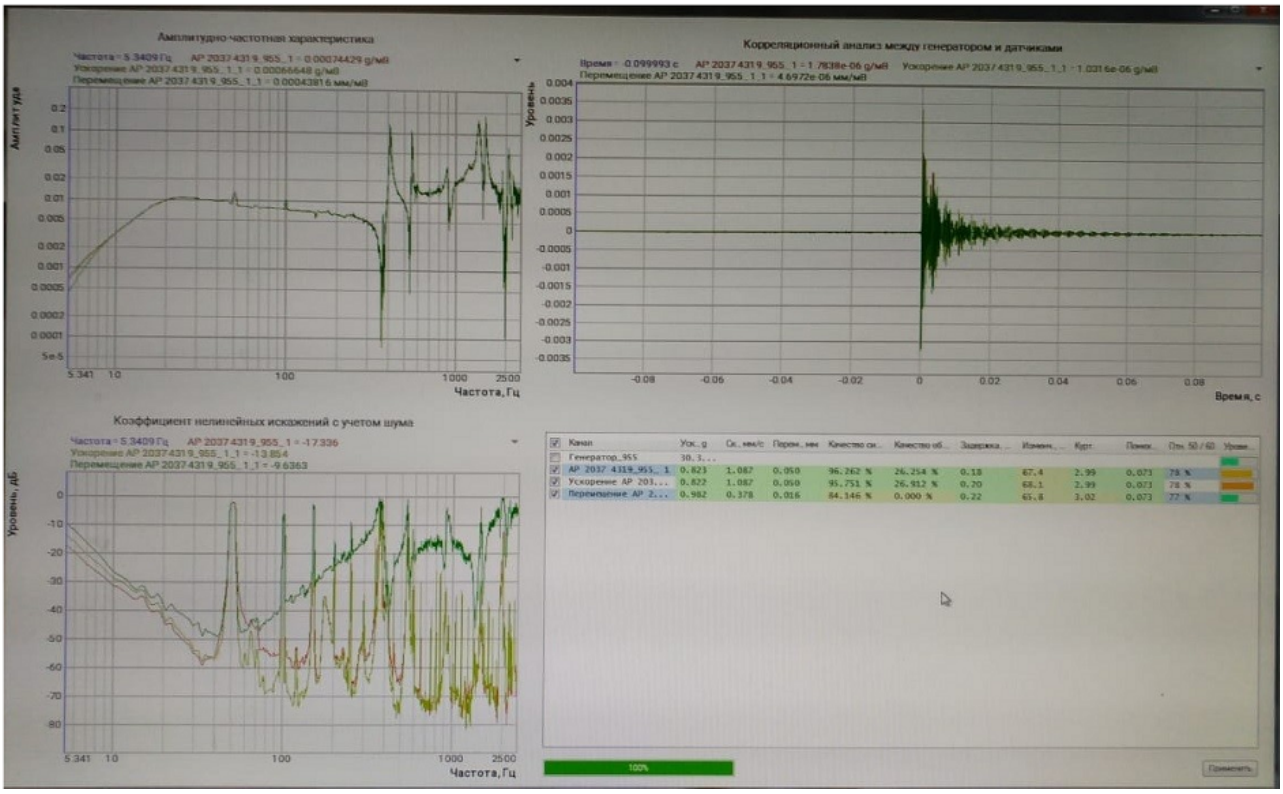


Fig. 2. Positive result of the Pre-Test

On *Fig. 3* an example of a low quality result of passing a Pre-Test performed on an empty Shaker (without an expansion table) is presented. The conclusion about the low quality of the results of the Pre-Test was made primarily by the high level of the coefficient of nonlinear distortion in the low-frequency region (the level is higher than minus 20 dB). The "Signal quality" parameter (in the results table) also indicates a low quality of the results of the Pre-Test for an empty Shaker and has a value less than 98%. A positive result of the results of the Pre-Test (for an empty table of the Shaker) is considered to be a signal quality level of at least 99%.

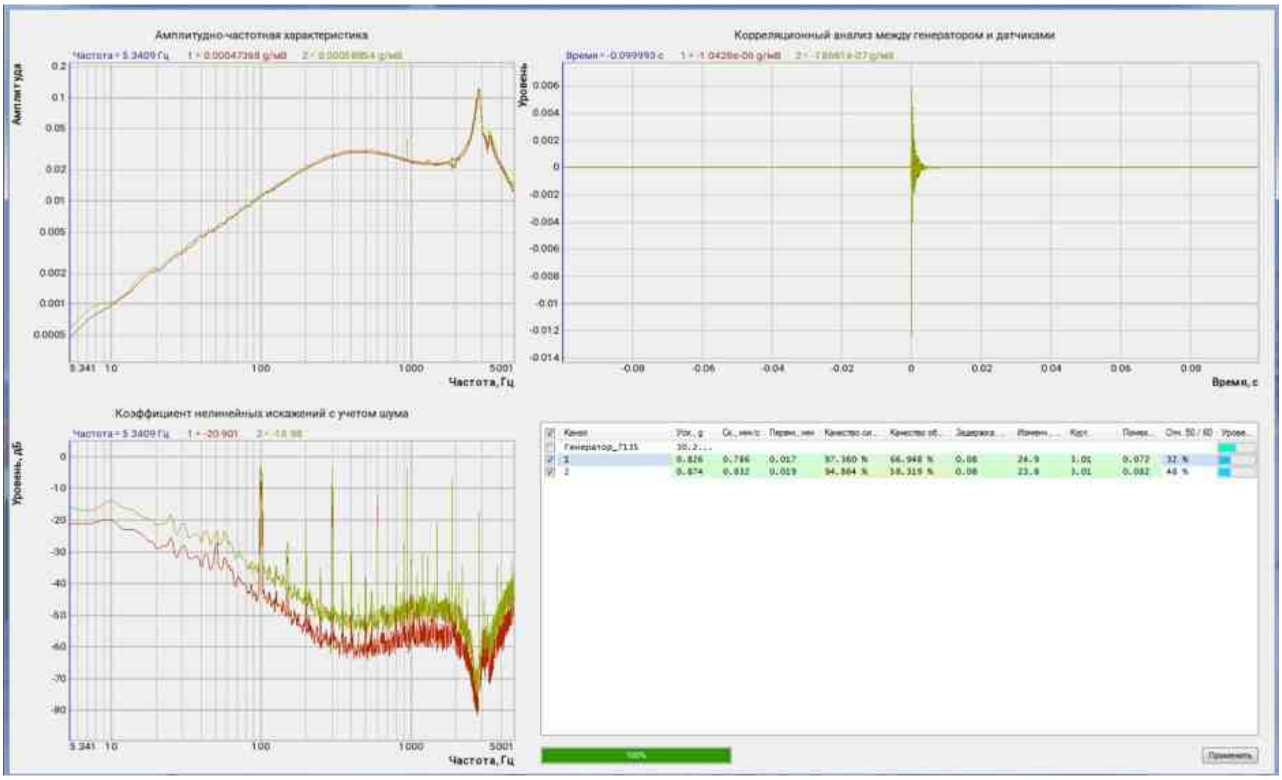


Fig. 3. Poor quality of the Pre-Test result

After the grounding was performed, the Pre-Test was repeated, the results of which are shown in *Fig. 4.* The Fig. shows that the level of the coefficient of nonlinear distortion in the low-frequency region has significantly decreased (it has become lower than minus 30 dB), and the signal quality has also increased (it has become higher than 99%).

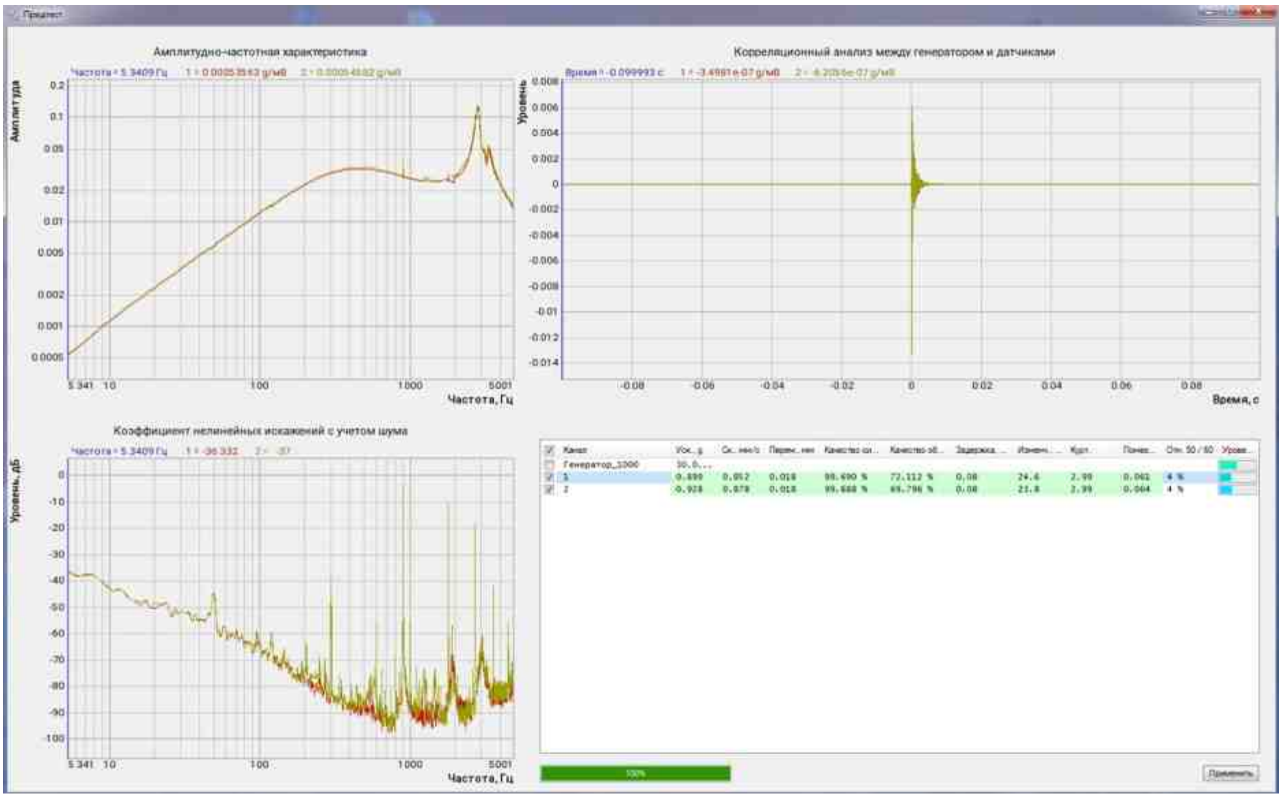


Fig. 4. High quality of the Pre-Test result

Effect of the horizon of the installation of the Shaker frame on the amount of transverse vibration

On *Fig. 5* a graphic of nonlinear distortions is presented, taken with a slight deviation of the Shaker frame from the horizon (the deviation of the frame is within 2 degrees), and in *Fig. 6* — with the horizontal position of the frame. During comparative tests, the Shaker was loaded at 60% of the maximum permissible load weight, and the impact level was 25% of the maximum permissible, taking into account the established mass.

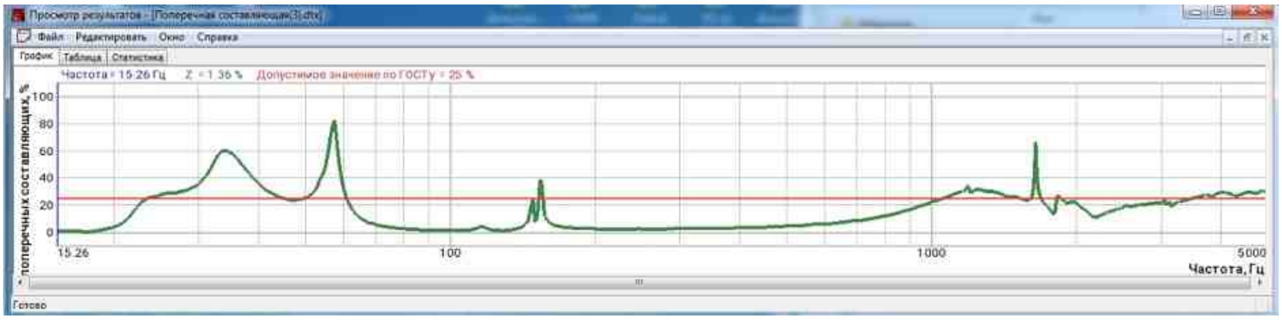


Fig. 5. The frame deflected from the horizon

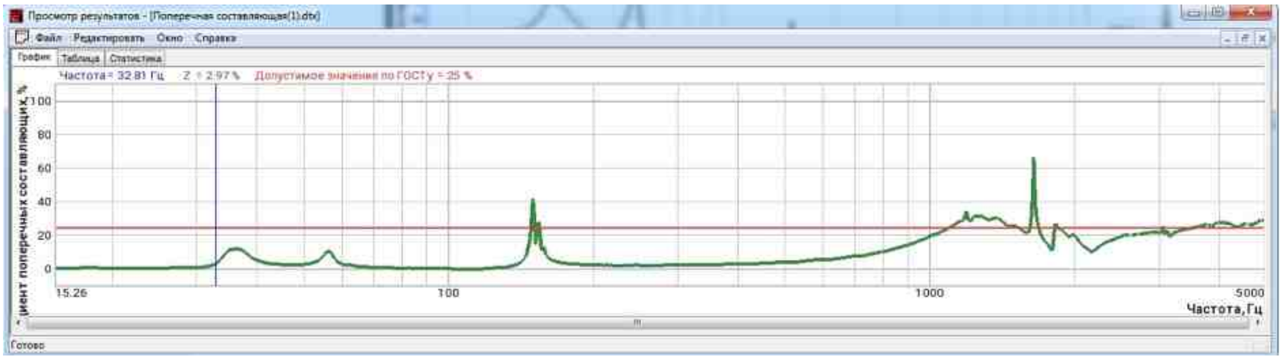


Fig. 6. The frame is exposed horizontally

The graphics show that in the resonance region of the suspension (20 ... 50 Hz), even with minor deviations from the horizontal, a significant level of transverse vibrations occurs on the Shaker, which can be a hindrance both at the stage of certification and during testing, especially when setting significant levels of effects.

Laser sensors in vibration test control systems

Accelerometers are traditional sensors when testing products for chatter stability, vibration resistance or transport vibration. With all the advantages of these sensors, it is not always possible to use them. The main problem lies in the installation of sensors on the objects of study, since accelerometers imply a rigid contact attachment in order to obtain the most accurate response of the structure to the input effect.

In cases where mechanical fastening is not permissible, contact-less vibration sensors are used — optical (laser sensors) or eddy current.

Today we will consider the procedure for connecting laser sensors to ZET 028 vibration test control systems, setting up the measuring channel and test management features, if a laser sensor is selected as a control one. In our case, we will use optical displacement sensor RF603.

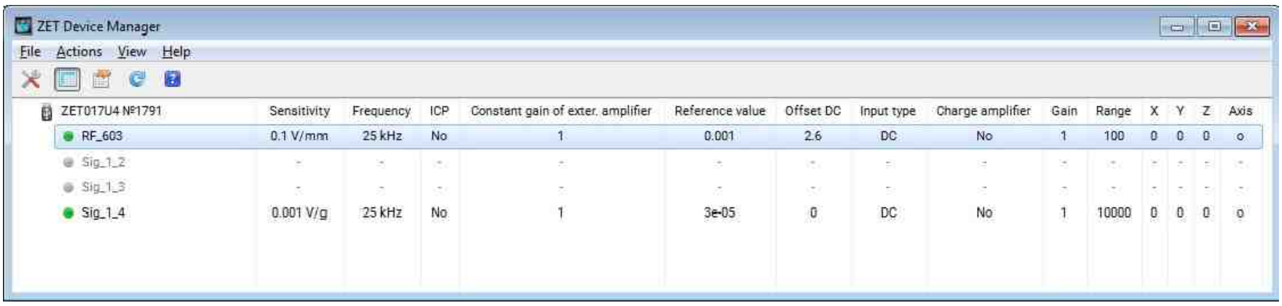
If there is an analog voltage output, the RF603 sensors are connected directly to the ZET 028 controllers, taking into account the external power supply. The ZETLAB software also supports the ability to connect this type of sensors via the Ethernet interface.

To obtain the most reliable results, the sensor must be installed in such a way that the base distance to the target does not exceed that statusd in the documentation, and the target itself has a good reflection coefficient. It is not allowed to use a target with an uneven texture and noticeable damage (cracks, scratches), location on a flat surface without depressions and drops, since all these factors greatly affect the measurement accuracy.

Measurement channel setting

The measurement channel is set in the "Device Manager" program, which is launched by pressing the "Channels parameters" button on the VCS panel.

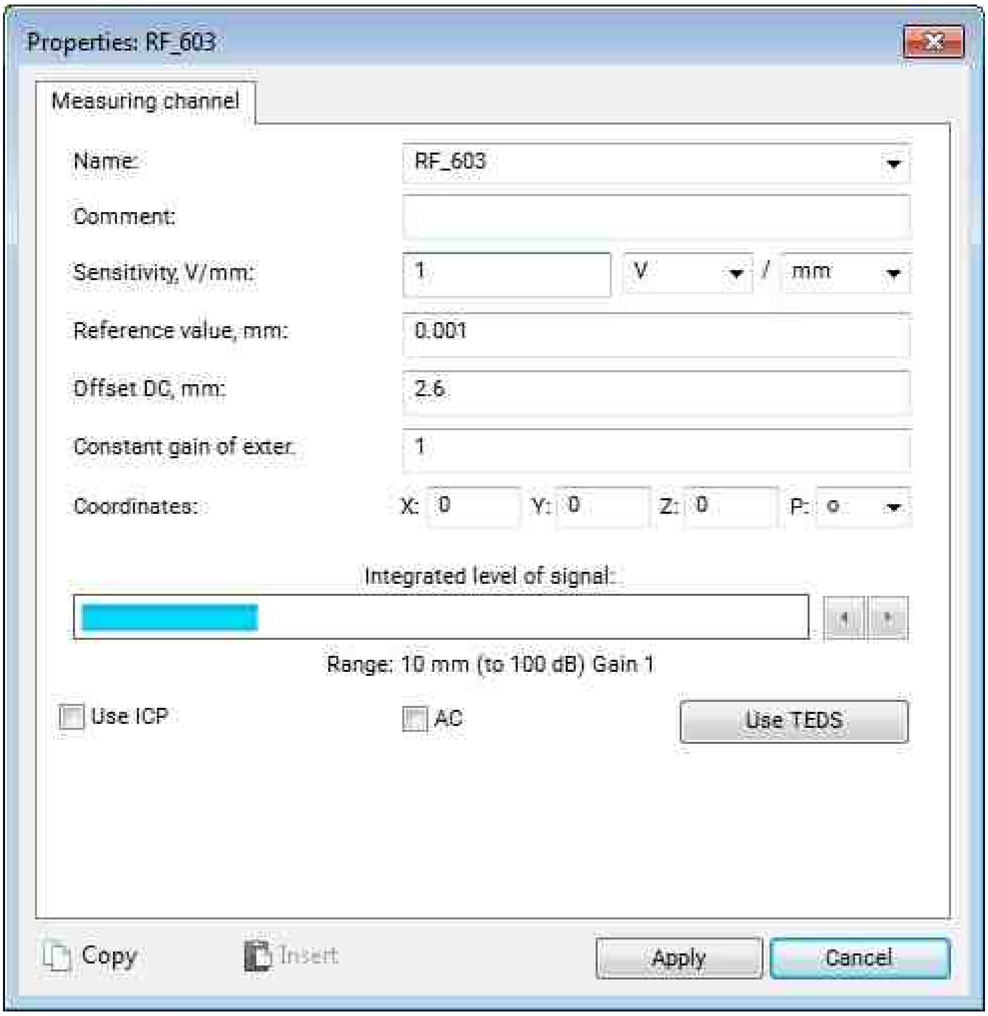
First of all, it is necessary to set the sensitivity in units of V/mm. In our case, the sensor has a measuring range of 10 mm, and the maximum input voltage of the ZET 028 controller with a unit gain is 10 V, respectively, the sensitivity of the sensor used is 1 V/mm.



ZET Device Manager

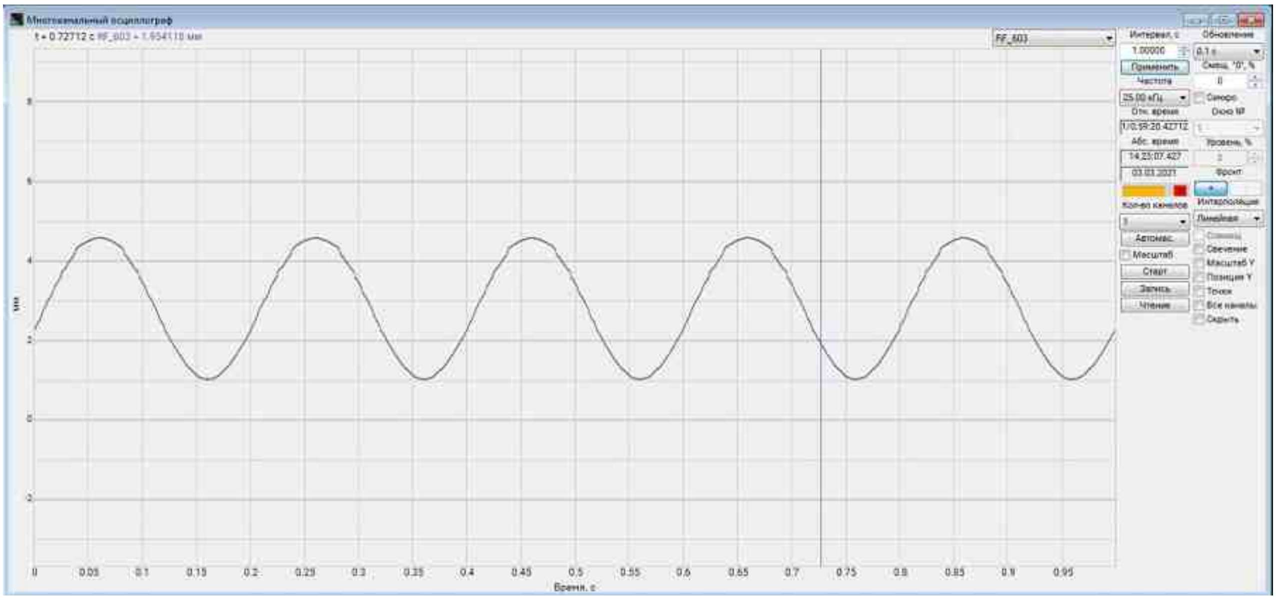
File Actions View Help

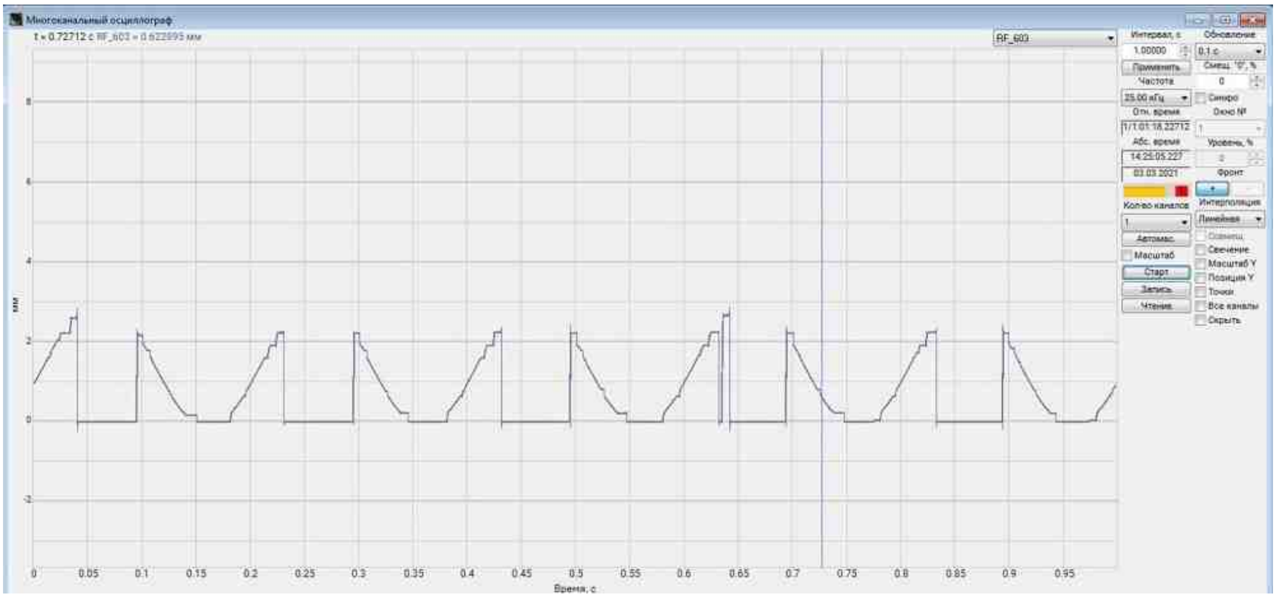
ZET017U4 №1791	Sensitivity	Frequency	ICP	Constant gain of exter. amplifier	Reference value	Offset DC	Input type	Charge amplifier	Gain	Range	X	Y	Z	Axis
RF_603	0.1 V/mm	25 kHz	No	1	0.001	2.6	DC	No	1	100	0	0	0	o
Sig_1_2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sig_1_3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sig_1_4	0.001 V/g	25 kHz	No	1	3e-05	0	DC	No	1	10000	0	0	0	o

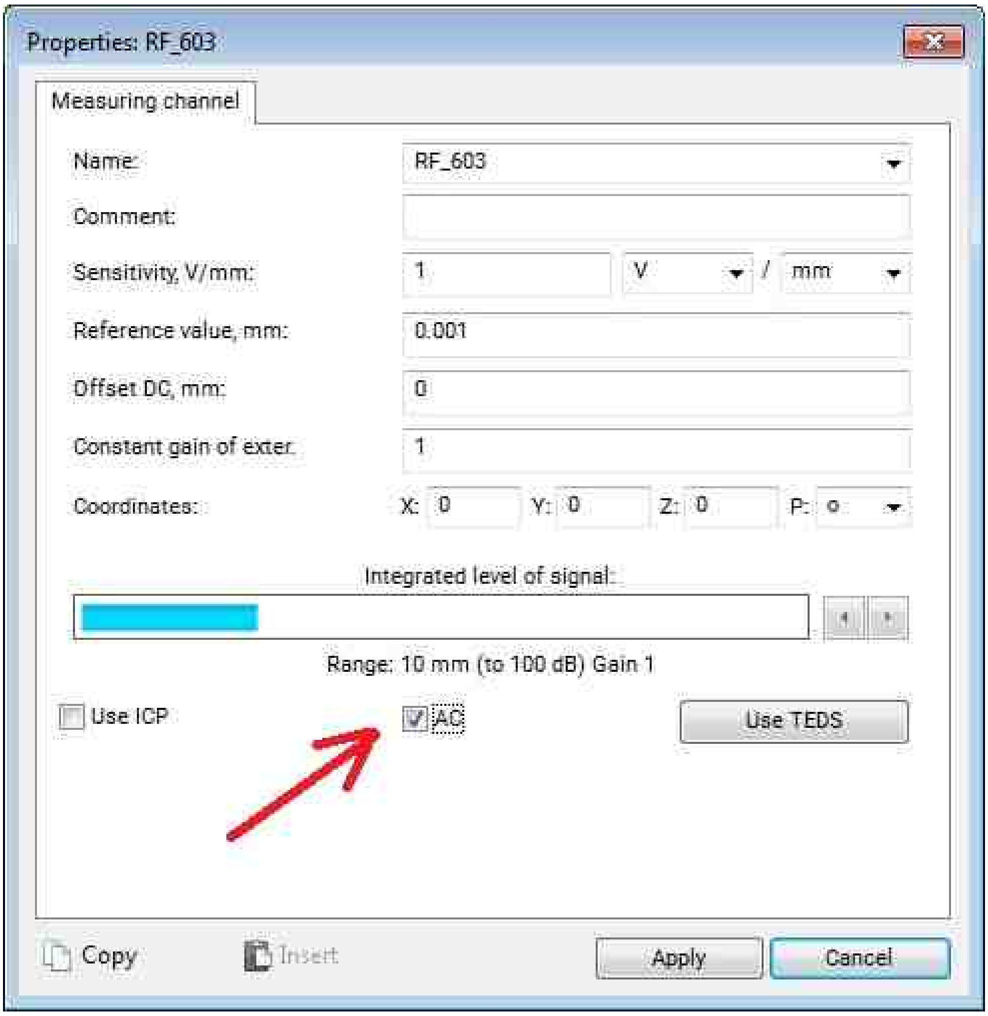


The next mandatory step in setting up optical sensors as part of vibration control systems is their alignment. The correct positioning of the sensor can be achieved by following several steps:

1. Launch the *Multi-channel oscilloscope*, select the displayed channel — the connection channel of the optical sensor.
2. By adjusting the position of the sensor, to achieve on the oscillogram readings corresponding to approximately the middle of the measurement range (in our case — 5 mm).
3. Launch the Generator in manual mode with the following parameters: Sine, Frequency — 5 Hz, Amplitude — no more than 10 mV.
4. Gradually increasing the amplitude of the signal, check the measuring range of the sensor and make sure that there are no signal breaks (examples of waveforms are given below).
5. Disable the signal generator. Open the Device Manager program, and in the properties of the measuring channel of the laser sensor, set the flag next to the AC value to exclude the constant component of the signal.


Многоканальный осциллограф
Время, с
мм


Многоканальный осциллограф
Время, с
мм

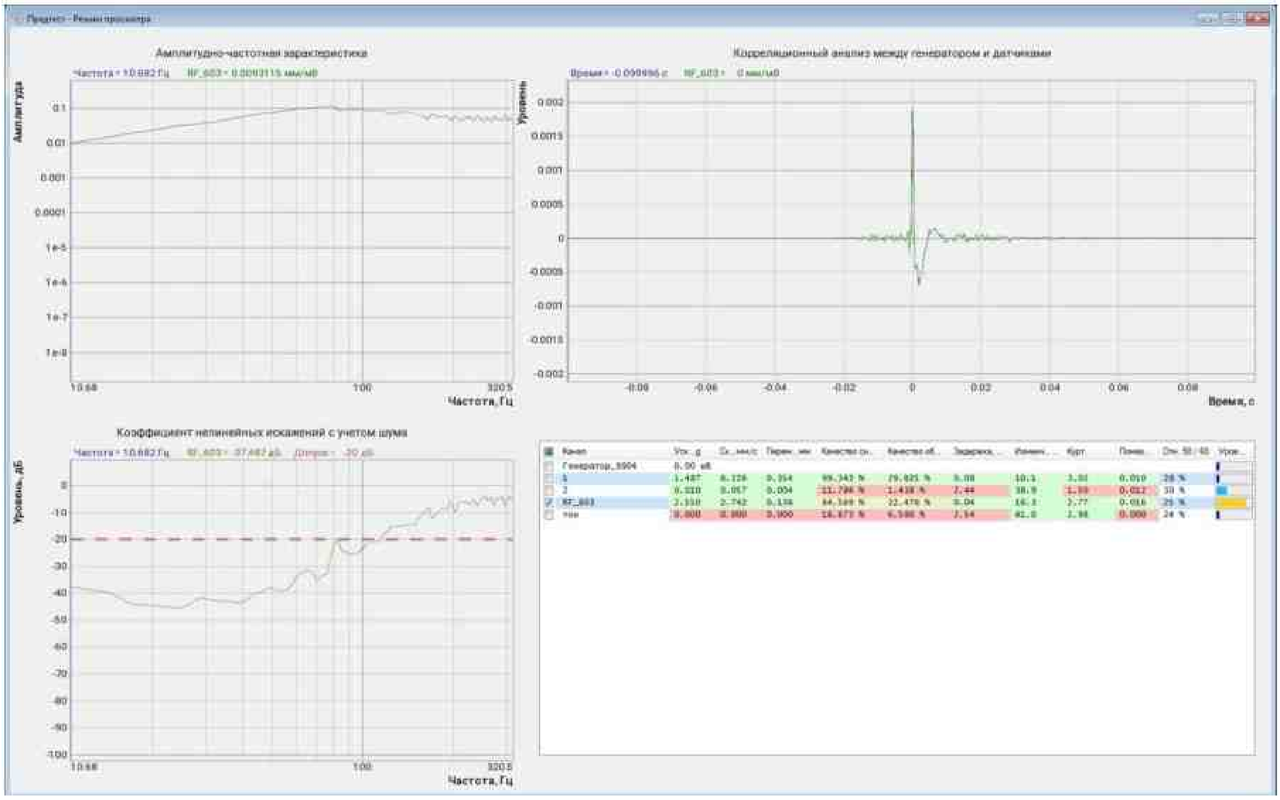


Using a laser sensor as a control

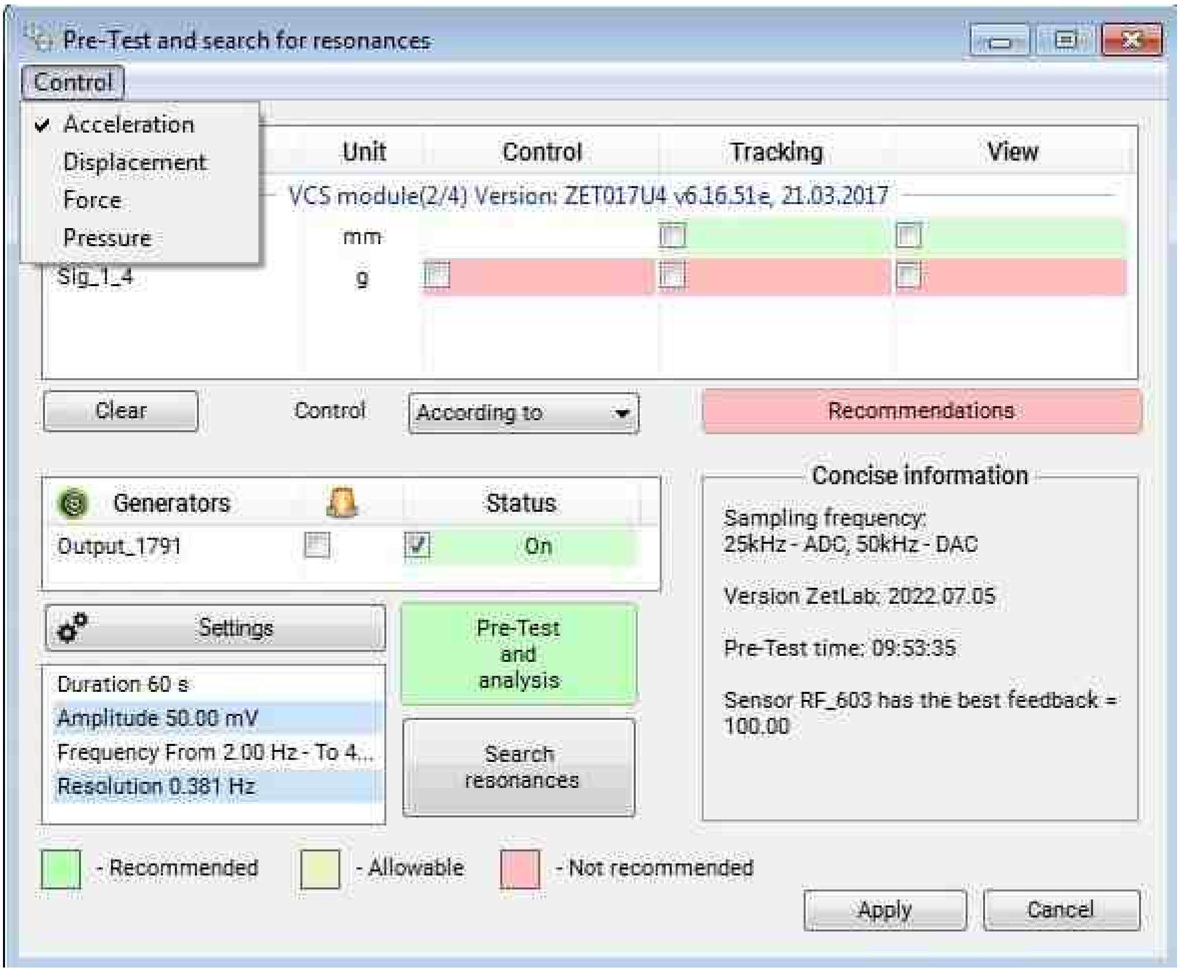
After the adjustment of the measuring channel has been carried out in full, you can proceed directly to the tests.

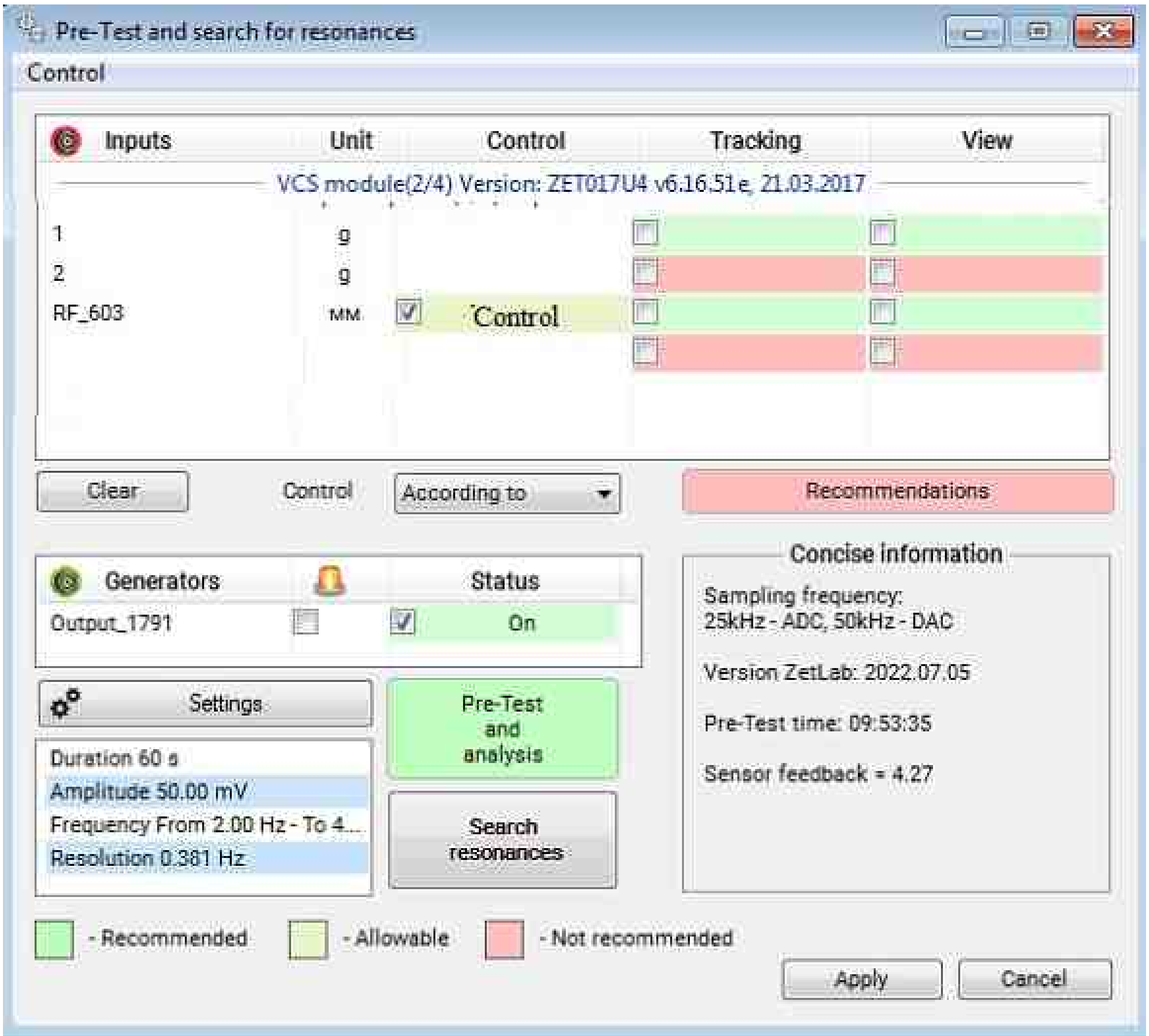
If you are not using the ZET 028 vibration control system for the first time, then you probably know that you can switch to setting up the necessary impact only after passing the Pre-Test.

Run the Pre-Test program and wait for the results of the passage (full information on the page **Interpretation of the results of the Pre-Test**).

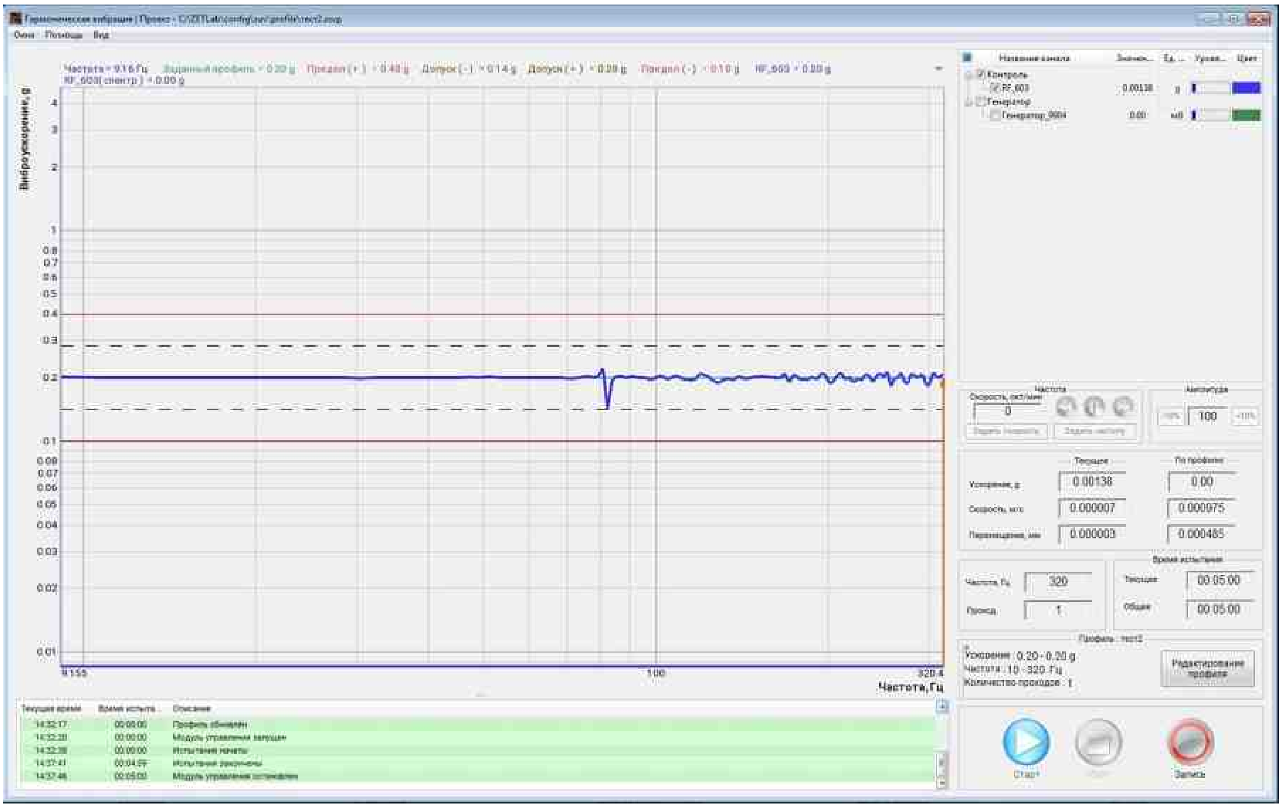


Since in this case, we are considering a way to control tests using an optical sensor, it is necessary to change the type of control from Acceleration to Displacement. After that, the program will allow you to select a channel with a connected laser sensor as a control.


Pre-Test and search for resonances
Control
Acceleration
Displacement
Force
Pressure
Unit
Control
Tracking
View
VCS module(2/4) Version: ZET017U4 v6.16.51e, 21.03.2017
mm
Sig_1_4
g
Clear
Control
According to
Recommendations
Generators
Status
Output_1791
On
Concise information
Sampling frequency:
25kHz - ADC, 50kHz - DAC
Version ZetLab: 2022.07.05
Pre-Test time: 09:53:35
Sensor RF_603 has the best feedback = 100.00
Settings
Pre-Test and analysis
Duration 60 s
Amplitude 50.00 mV
Frequency From 2.00 Hz - To 4...
Resolution 0.381 Hz
Search resonances
- Recommended
- Allowable
- Not recommended
Apply
Cancel



It should be noted that operation in feedback mode on the sensor registering Displacement is supported only for Sine tests. Therefore, after installing the laser sensor as a control, only one type of test will be available for selection — Sine.



In conclusion, it can be noted that the use of non-contact vibration sensors when exposure vibration tests certainly has many advantages. However, the correctness of the results obtained will greatly depend on the professional level of the tester, as well as on the type of sensor being connected.

Passing tests at multiple resonances

using the software function of the vibration control system

All vibration test control systems are focused on full automation when controlling impacts on any types of Shakers, which ensures the efficiency of the tester, the exclusion of damage to the tested specimens and the reduction of the time of the entire procedure.

The system, based on input signals from sensors installed on the test object, allows you to instantly estimate the amplitude of accelerations, compare with the programmed value and adjust the output signal level of the generator in accordance with a given profile. But in cases where the specimen has multiple resonances, not every control system is able to quickly process the signal and adjust the appropriate level, due to antiresonances.

For example, the task is to pass a given test profile of a composite specimen on which control sensors are located in a certain way. During the experiment, multiple resonances may occur in certain parts of the specimen, which greatly contribute to the signal level on the control sensor, as a result of which the tests are automatically interrupted without passing the profile to the end. The antiresonance compensation software function is the solution to the problem.

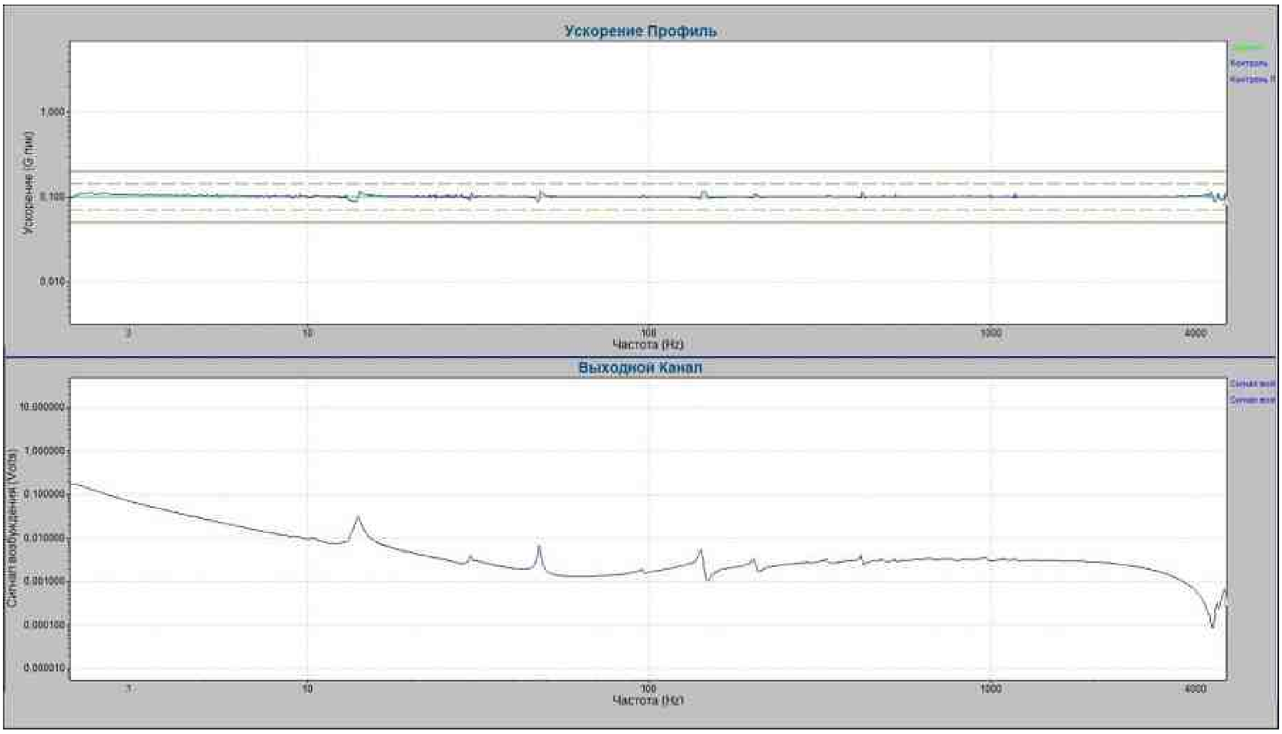
We will conduct an experiment to identify the possibility of implementing this algorithm for different vibration control systems.

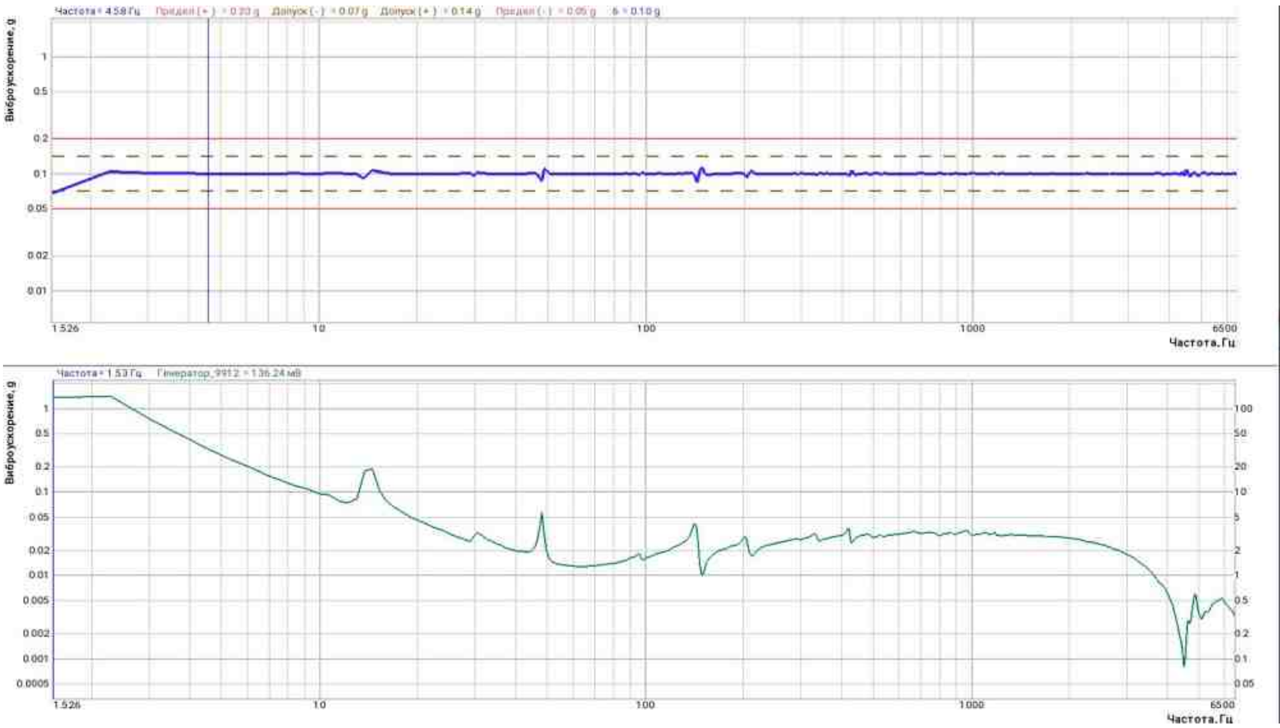
As a specimen, a metal rectangular frame was used, on which accelerometers are located from the center to the edge with numbers 6, 5, 4 and 3, respectively.

The results of passing tests on a given rectangular frame profile, under the control of two different systems, with the sequential selection of sensors 6, 5, 4 and 3 as the control are presented below.

CONTROL SENSOR No. 6

Passing the test profile with sensor No. 6 as a control did not cause difficulties for any vibration control system. Since the sensor is rigidly installed in the center of the vibration table, it is not affected by resonances and has good feedback quality.

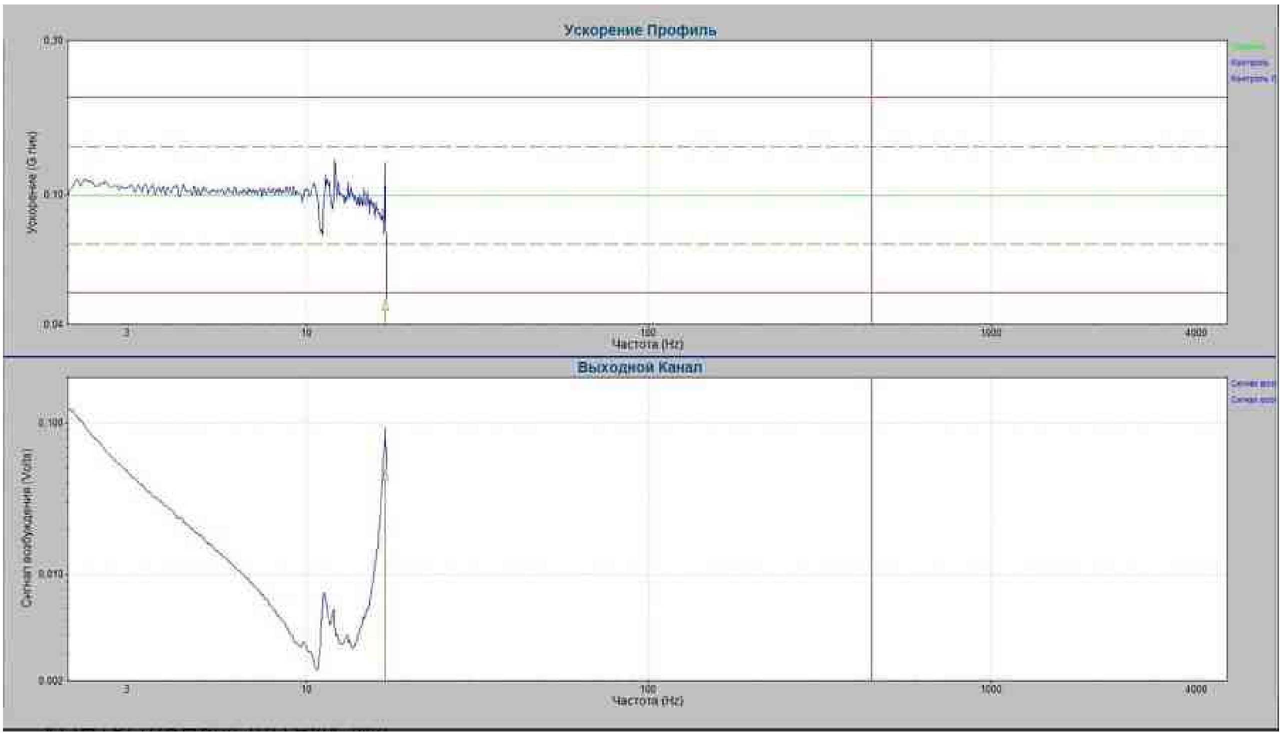


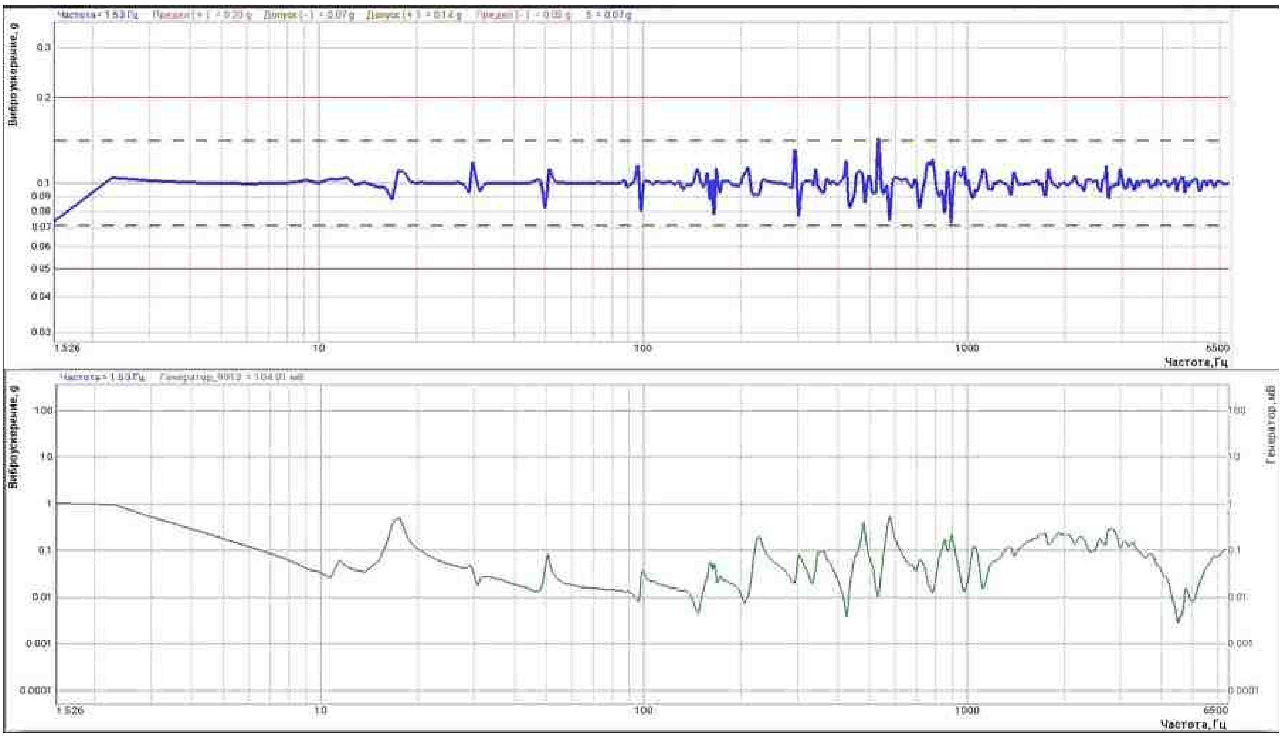


CONTROL SENSOR No. 5

When selecting sensor No. 5 as a control, the first control system interrupted the tests at a frequency of 17.01 Hz.

The ZET 028 vibration test control system coped with the specified profile, while the signal from the sensor began to slightly approach the first threshold line only in the frequency range of 550 Hz.

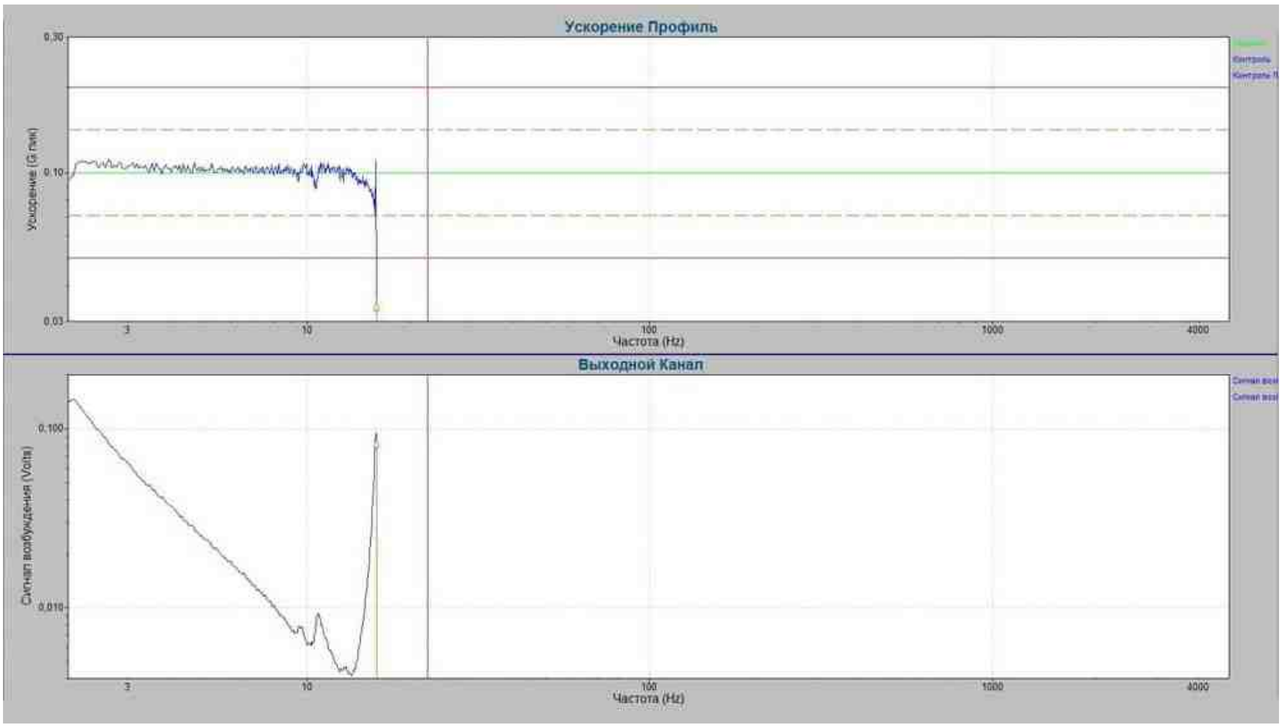


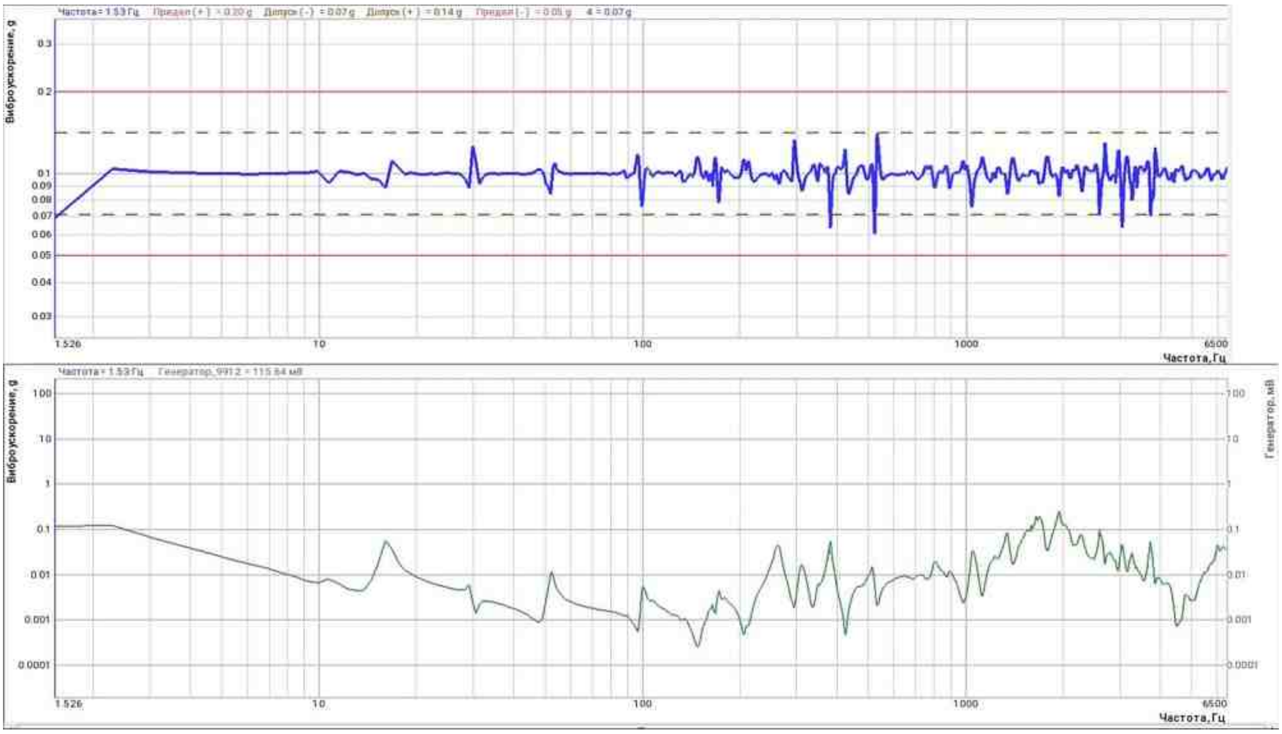


CONTROL SENSOR No. 4

When selecting sensor No. 4 as a control, the first control system interrupted the tests at a frequency of 15.94 Hz.

The ZET 028 vibration test control system coped with the specified profile, the signal from the sensor crossed the first threshold line several times starting from 380 Hz.

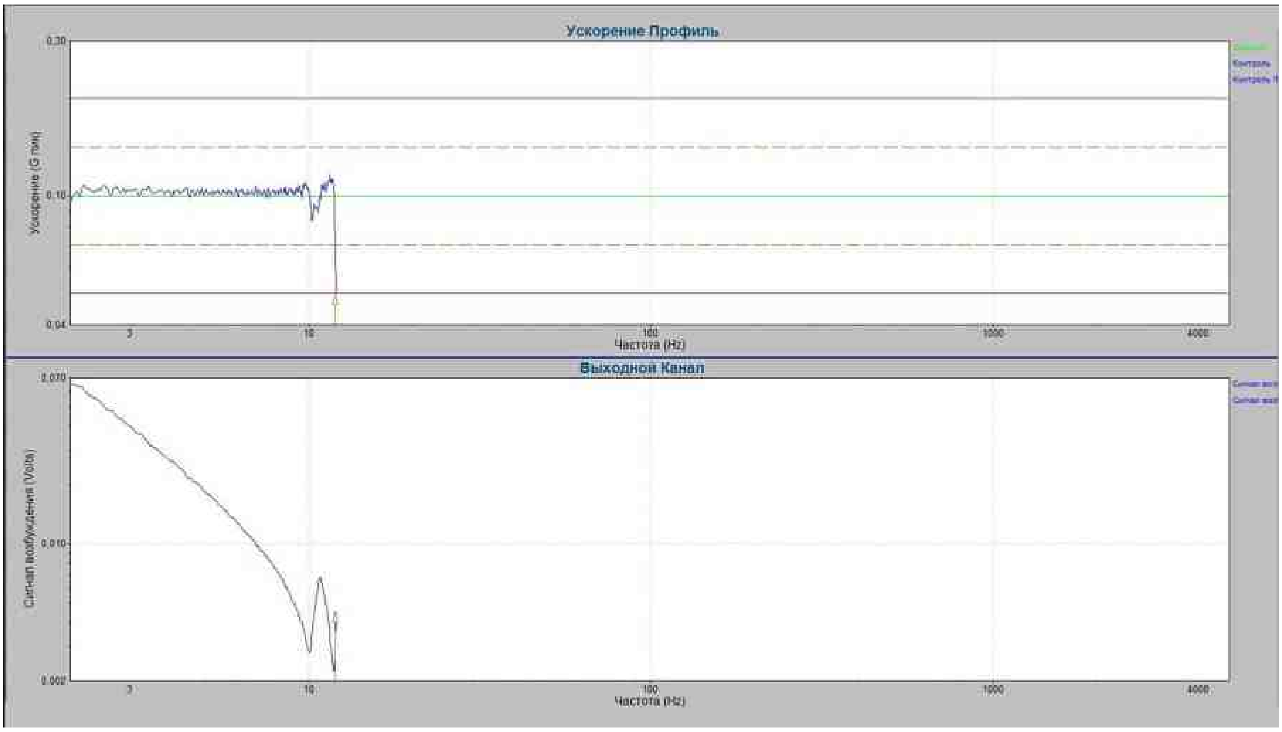


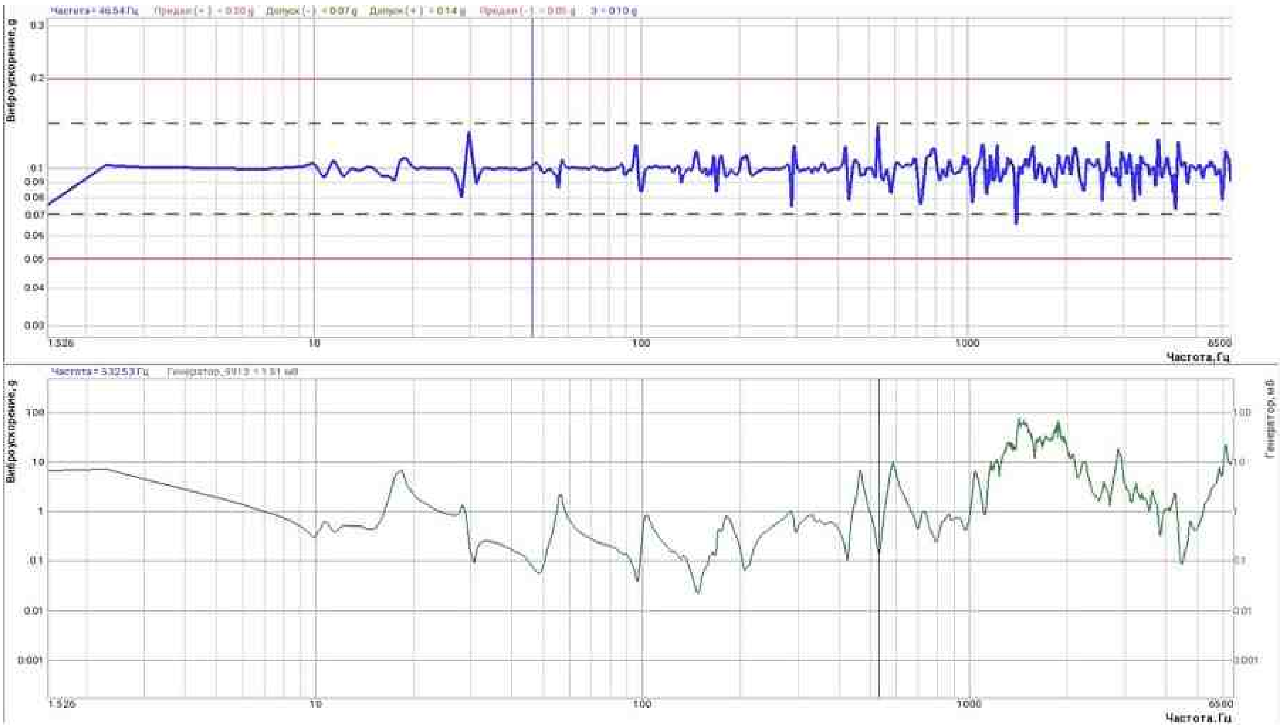


CONTROL SENSOR No. 3

When selecting sensor No. 3 as a control, the first control system interrupted the tests at a frequency of 11.97 Hz.

The ZET 028 vibration test control system coped with the specified profile, the signal from the sensor crossed the first threshold line several times starting from 380 Hz, as in the previous experiment with sensor No. 4.





The experiment shows that one of the control systems had difficulties with passing the test profile as the control sensor was removed from the central part of the vibration table. Moreover, the further the sensor was located, the faster the protection was triggered.

The ZET 028 vibration test control system coped with the passage of the profile in all four cases, due to the use of the antiresonance compensation software function.

Passing tests in the presence of antiresonances

Antiresonance — this is the phenomenon of an almost zero response of a dynamic system to a periodic external influence of an arbitrary amplitude. It is the opposite of resonance.

If we explain in simple language for the case of Sine tests, then we increase the voltage of the output signal from the generator, and the measured acceleration on the control sensor practically does not change.

The antiresonance phenomenon is most clearly demonstrated by the experience with a stretched string. With periodic exposure to a stretched string with a certain frequency, a standing wave appears on the string, which can even be seen with the naked eye. Depending on the frequency, there will be 1 or more oscillation sections on the string. Points with the maximum amplitude of oscillations are called "anti-nodes", and fixed points are called "nodes". The anti-nodes demonstrate the resonance effect to us, and the nodes demonstrate the antiresonance effect.

You can find out about the presence of resonances and antiresonances even before the start of vibration testing based on the results of the "Pre-Test" program. On the graphics in the "Amplitude-frequency response" grid, sharp local maximum will correspond to resonances, and sharp local minimum will correspond to antiresonances. You can study the resonances in more detail in the window "Search for resonances", which opens with the corresponding button.

It is best to choose as a control sensor the one that has no peaks and the form of the graphic is closest to a horizontal line. But if the graphics of all sensors are equally cut, then the following actions can be taken.

Option one - move the sensor

If there is only one sensor, then you can try to find a more optimal installation location. Most often, the sensors are placed on top of the tested specimen or on the tooling and choose a place closer to the center, because this is the most convenient and fastest way to attach the sensor. But in this case, we are guaranteed to get the most "rugged" frequency response.

The best point for fixing the control sensor is the movable part of the Shaker. If the tested specimen with the tooling does not occupy the entire surface of the movable part, then install the control sensor on the movable part of the Shaker.

If it is not possible to install the sensor directly on the movable part of the Shaker, then you need to try to install it on the tool or expansion table, preferably as close as possible to the axis of the Shaker or to the bolts with which the expansion table or equipment is attached to the Shaker. At these points, the rigidity of the structure is maximum, which theoretically will help to avoid problems in the low and medium frequencies.

If the sensor should be on top, then it is best to install it in the corner of the tool or close to the fasteners that hold the specimen or tool.

Unfortunately, reality is too diverse and a point with a good AFR may not be found.

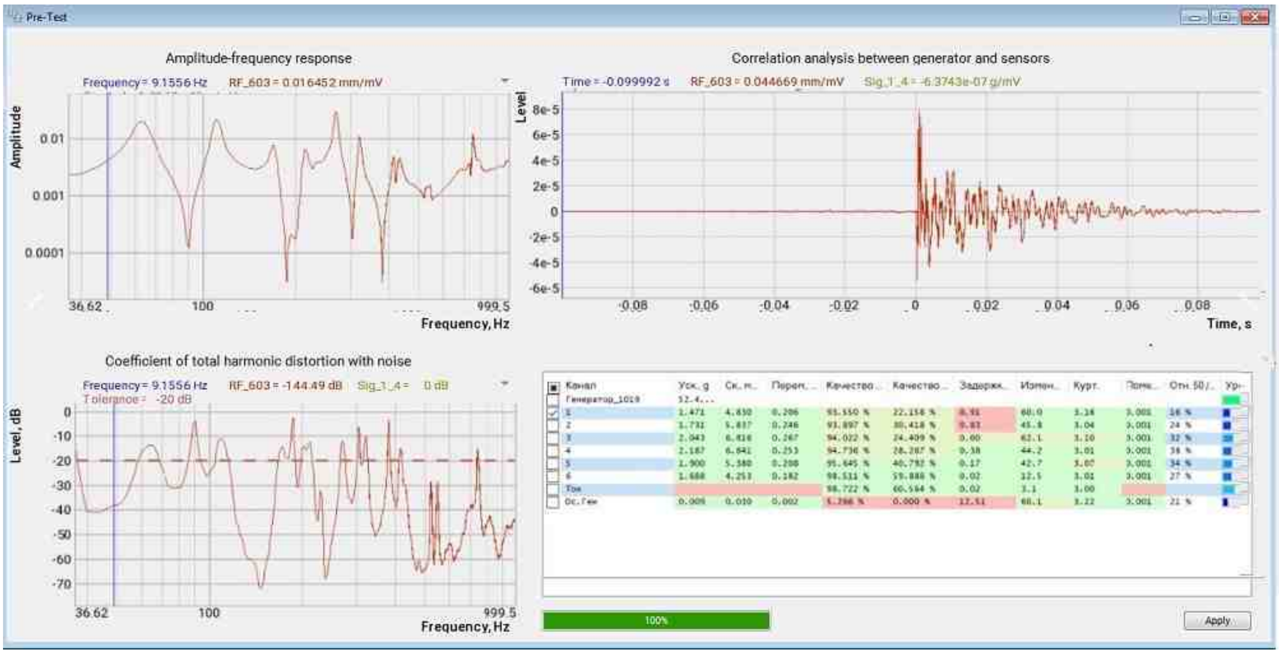


Fig. 1. Results of the Pre-Test for a sensor installed far from the center

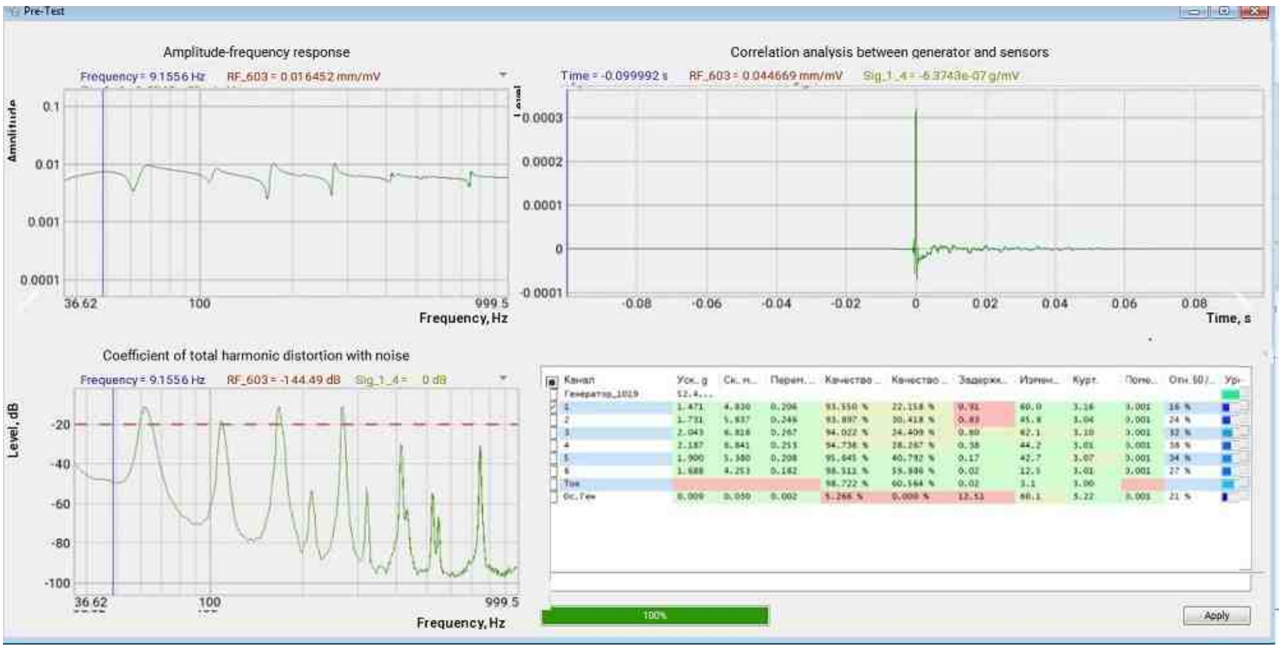


Fig 2. Results of the Pre-Test for the sensor installed in the center

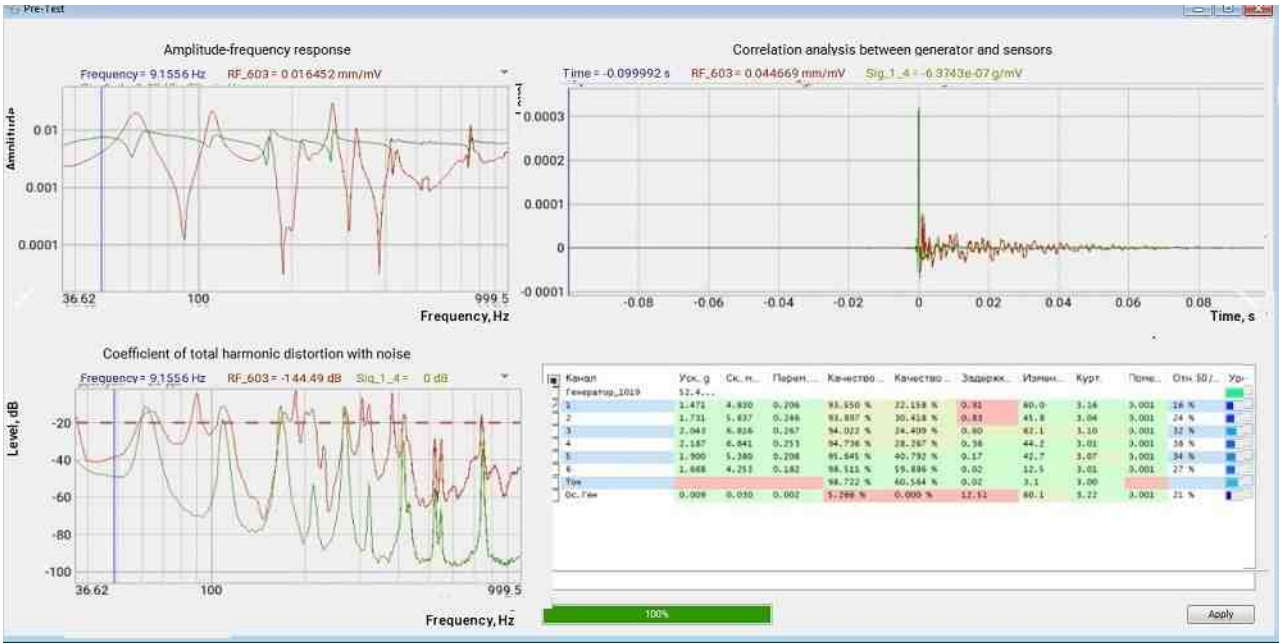


Fig 3. Comparison of the results of the Pre-Test for two sensors installed in different places

The Fig.s show real AFR graphics for sensors installed at the very edge of the test object (No. 1) and in the center of the test object (No. 6). The naked eye can see that the AFR of the sensor installed in the center has less variability than the sensor on the edge. The AFR of a sensor installed far from the center varies in the specified frequency range by about 1000 times (60 dB), and that of a sensor installed in the center varies only 5 times (14 dB). Thus, it is much easier to conduct tests with control on sensor No. 6 than on sensor No. 1.

Option two - control by several sensors

If it is possible to use several sensors, then it is possible to use the control mode for several control sensors during the tests. In this case, when one of the sensors gets into the antiresonance region and shows a value close to zero, the other sensors will show non-zero results and it is possible to keep the amplitude of the oscillations at a given level. To do this, it is also important to choose the right sensor installation locations, but the selection criterion will be much easier. It is enough that all the sensors used do not have the same antiresonance frequencies.

You can check the correctness of the sensor selection in the profile editor. On the "Preview" tab, you can see how the acceleration graphics will look for all the channels involved, as well as look at the graphic of the expected voltage. If there is an acute maximum on the graphic of the expected voltage exceeding the maximum value of the voltage at the input of the Shaker, then the tests will not be able to be carried out.

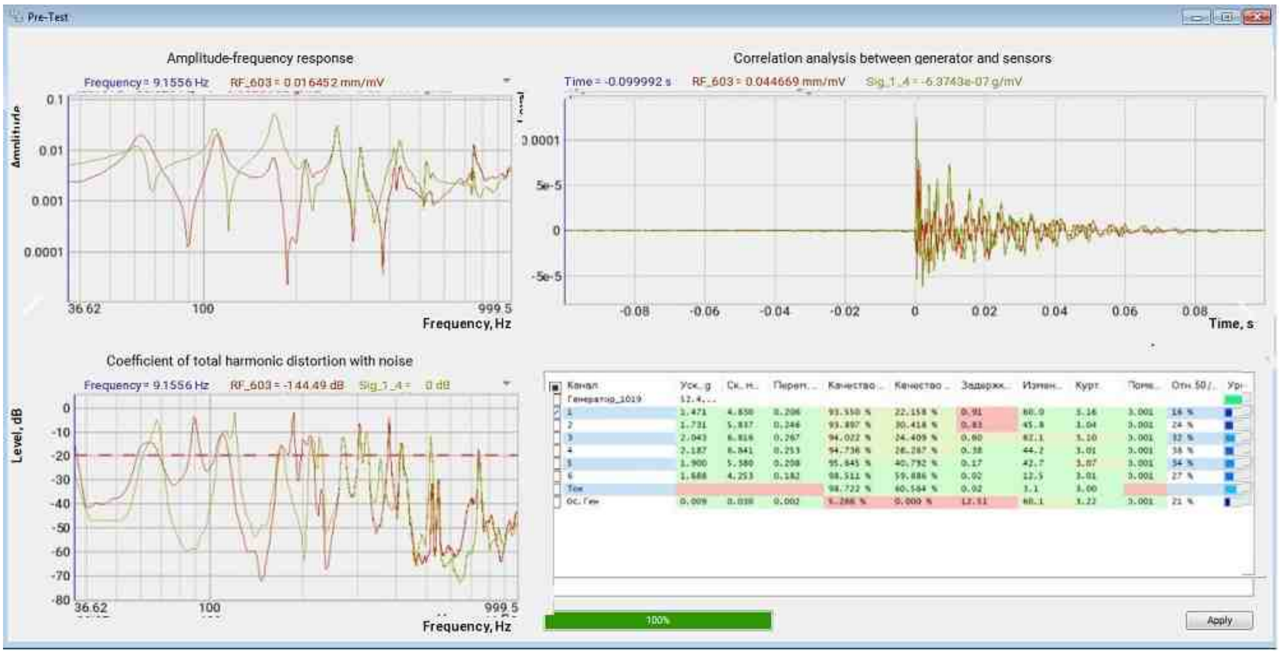


Fig. 4. The results of the Pre-Test for two sensors installed in the wrong places

In another example, it was not possible to find a good point for one control sensor, and we chose two sensors with "bad" AFR to control the arithmetic mean of the measurements of both sensors.

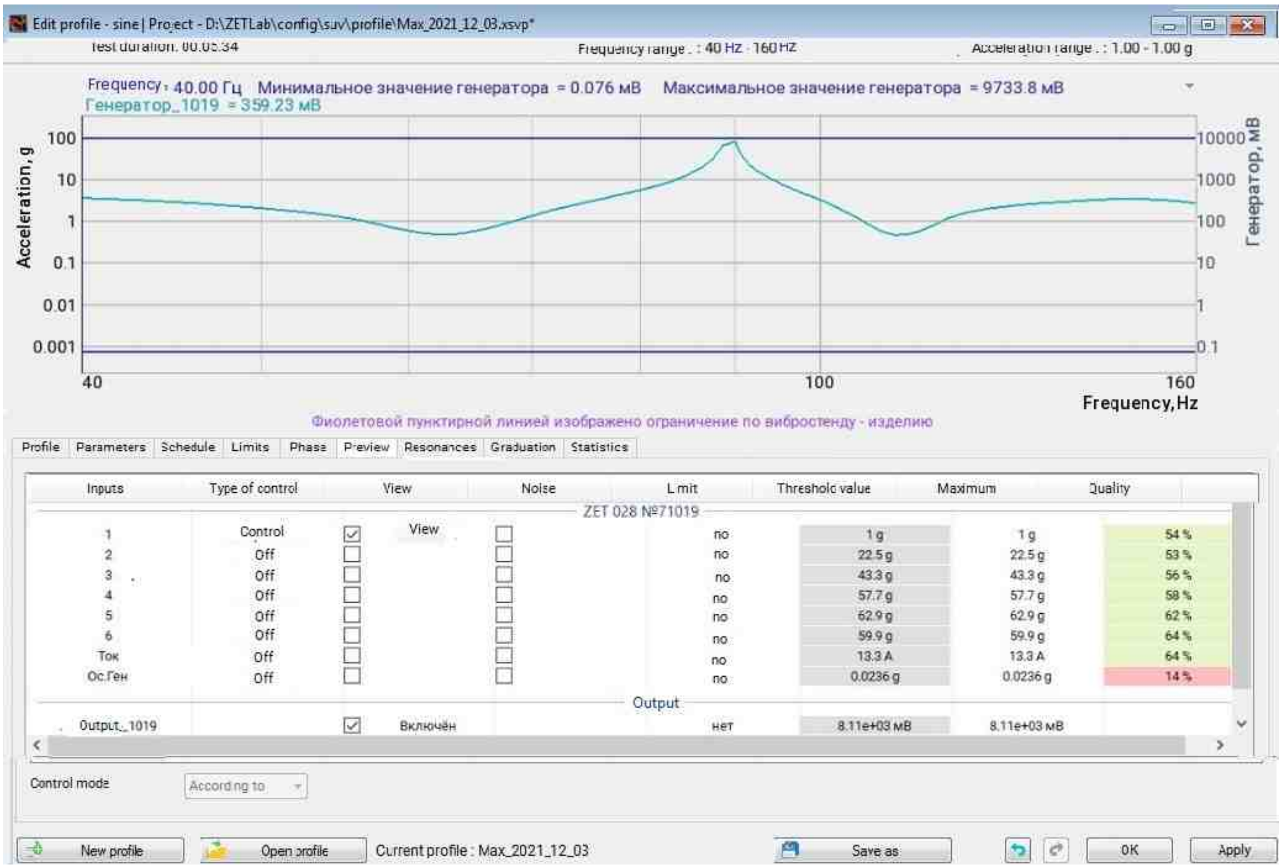


Fig. 5. The graphic of the expected output voltage, when monitored by sensor No. 1

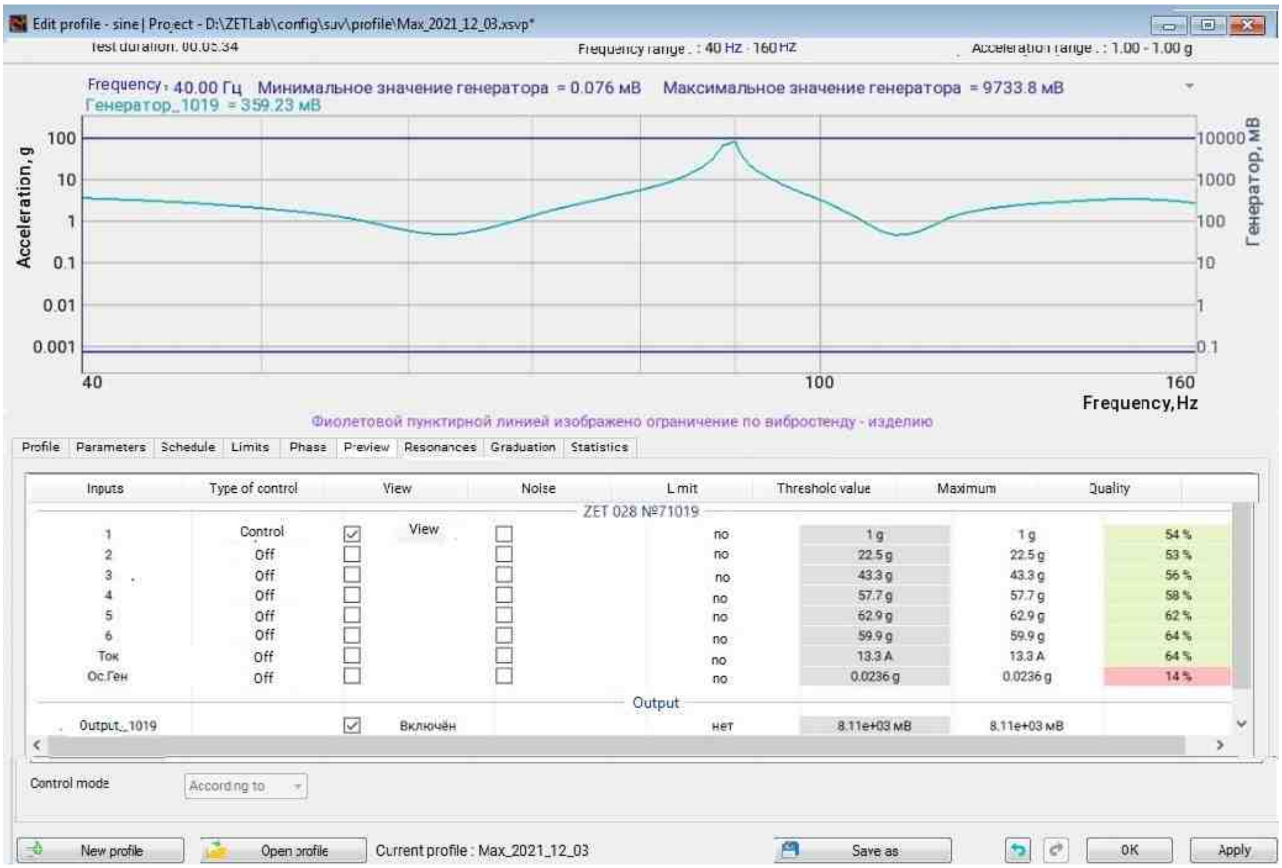


Fig. 6. The graphic of the expected output voltage, when monitored by the average value from sensors No. 1 and No. 4

The first image shows that in the frequency range of the test profile, sensor No. 1 has an antiresonance at a frequency of 90 Hz, and when it passes, the controller will output a voltage of more than 8 volts. If we add channel No. 4 as the second control, then when passing the entire profile, the output voltage will be no more than 330 mV, as can be seen in Fig. 6. Test result on Fig. 7 corresponds very well to the preliminary calculation. The expected voltage graphic corresponds to the real one, reaching a voltage limit of 336 mV.

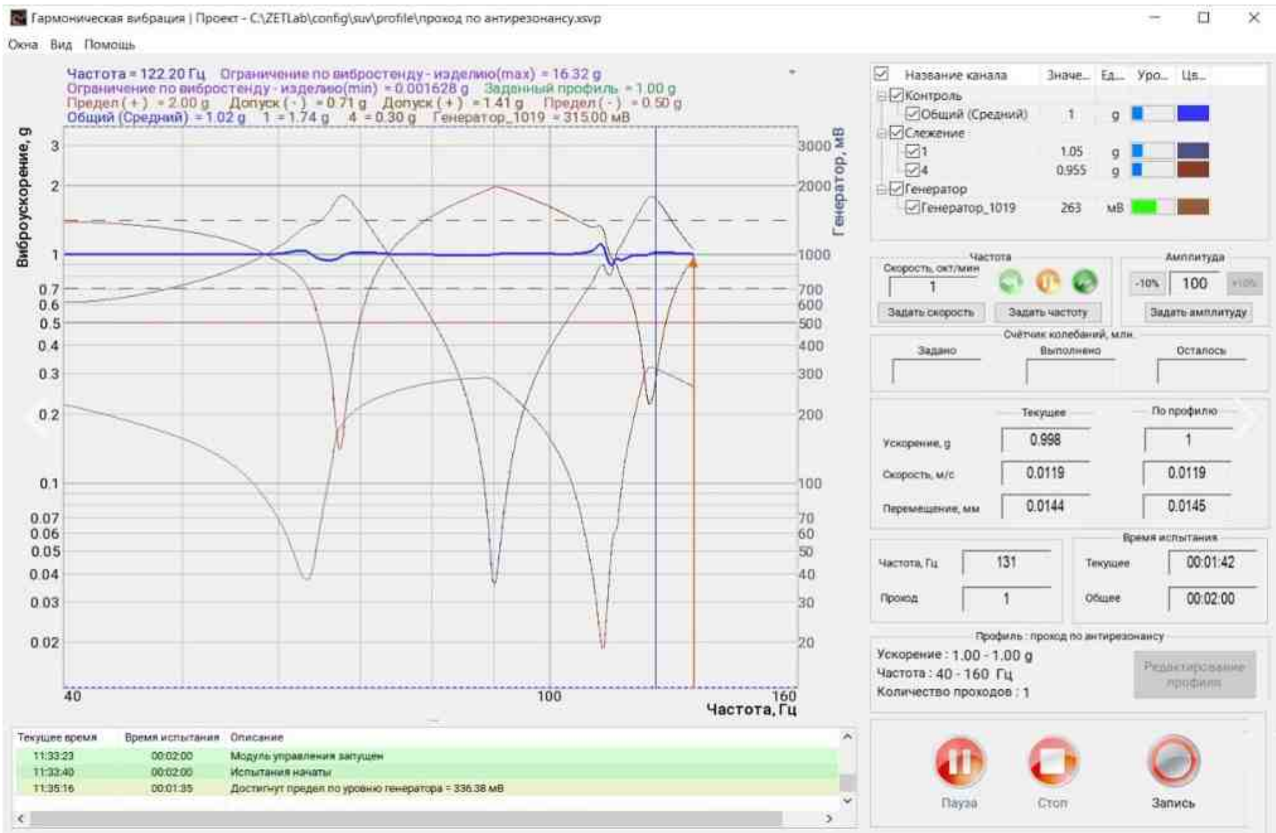


Fig. 7. Passage of vibration testing through two control channels

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P.S. An attentive reader may notice that in Fig. 4, the AFR of sensors No. 1 and No. 4 coincide in the frequency range from 270 to 330 Hz and have two resonances and one antiresonance in this area. If the frequency range of the test profile was wider and included this section, then we would have to select another pair of sensors to pass the tests. Or even three sensors.

Option three - limited

If the previous options for some reason are not suitable for a specific test option, then you can set a limit either on the level of tracking sensors or on the level of the generator. To do this, in the profile editor, on the "Preview" tab in the "Limite" column of the table, select the "Limite" option, and in the "Threshold value" column, set the value that the channel should not exceed during the tests. The limit can be set both by measuring channels and by generator channels. After setting the threshold value, a "Limited profile" graphic will appear on the grid, which will show the expected form of the control channel graphic. In the "View" column, you can enable the display of the expected form of the graphics during the tests. Graphs of expected values can help when choosing a constraint value.

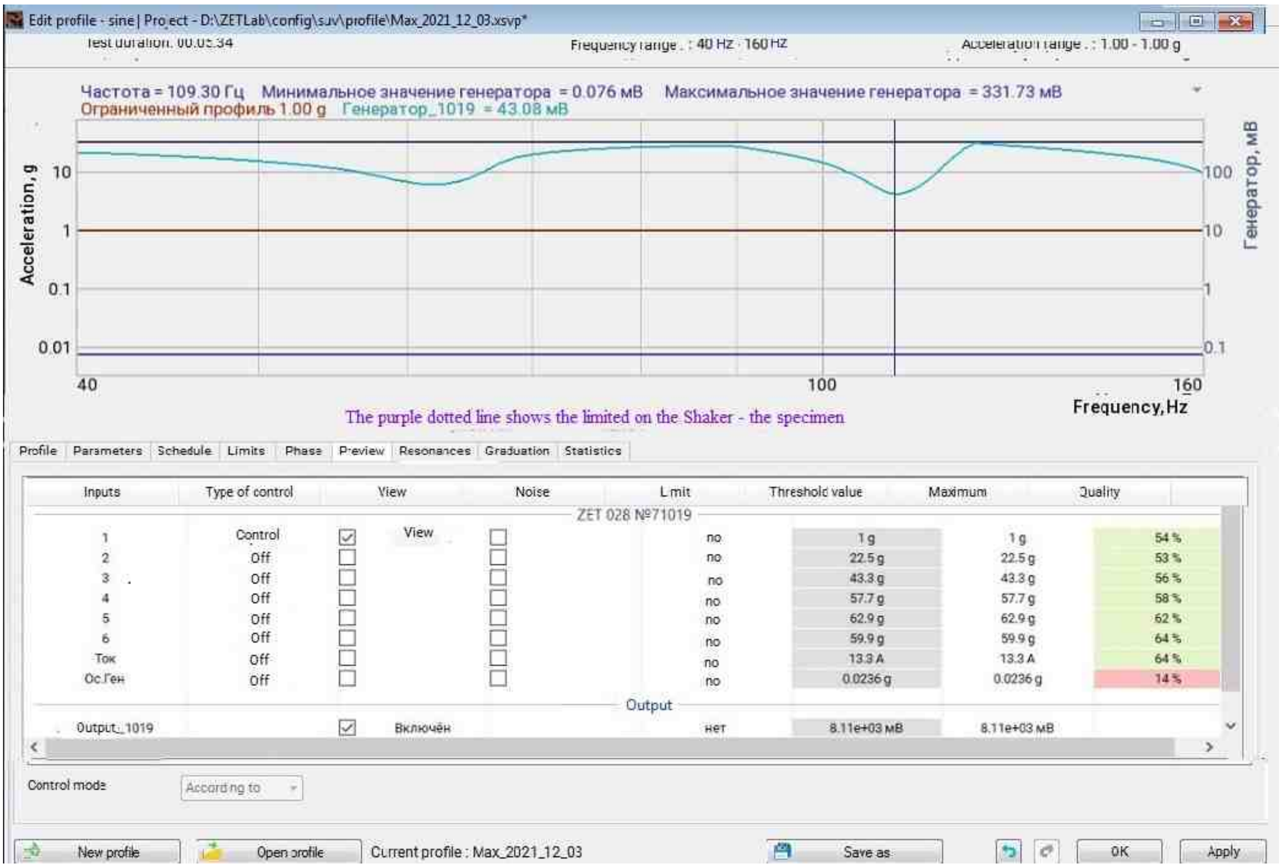


Fig. 8 Limited on resonances at the extreme sensor when selecting the value of the restriction.

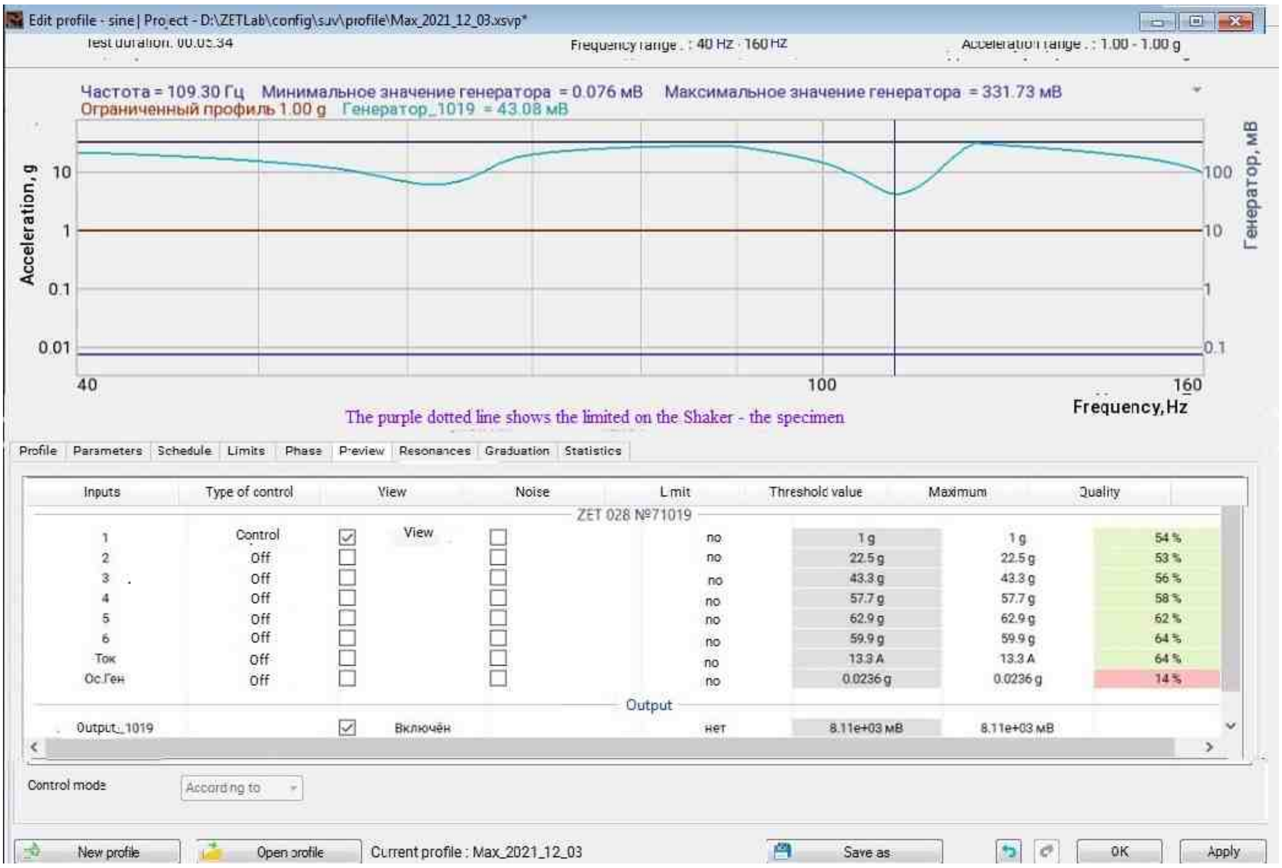


Fig. 9 Limited at the antiresonance point along the extreme sensor

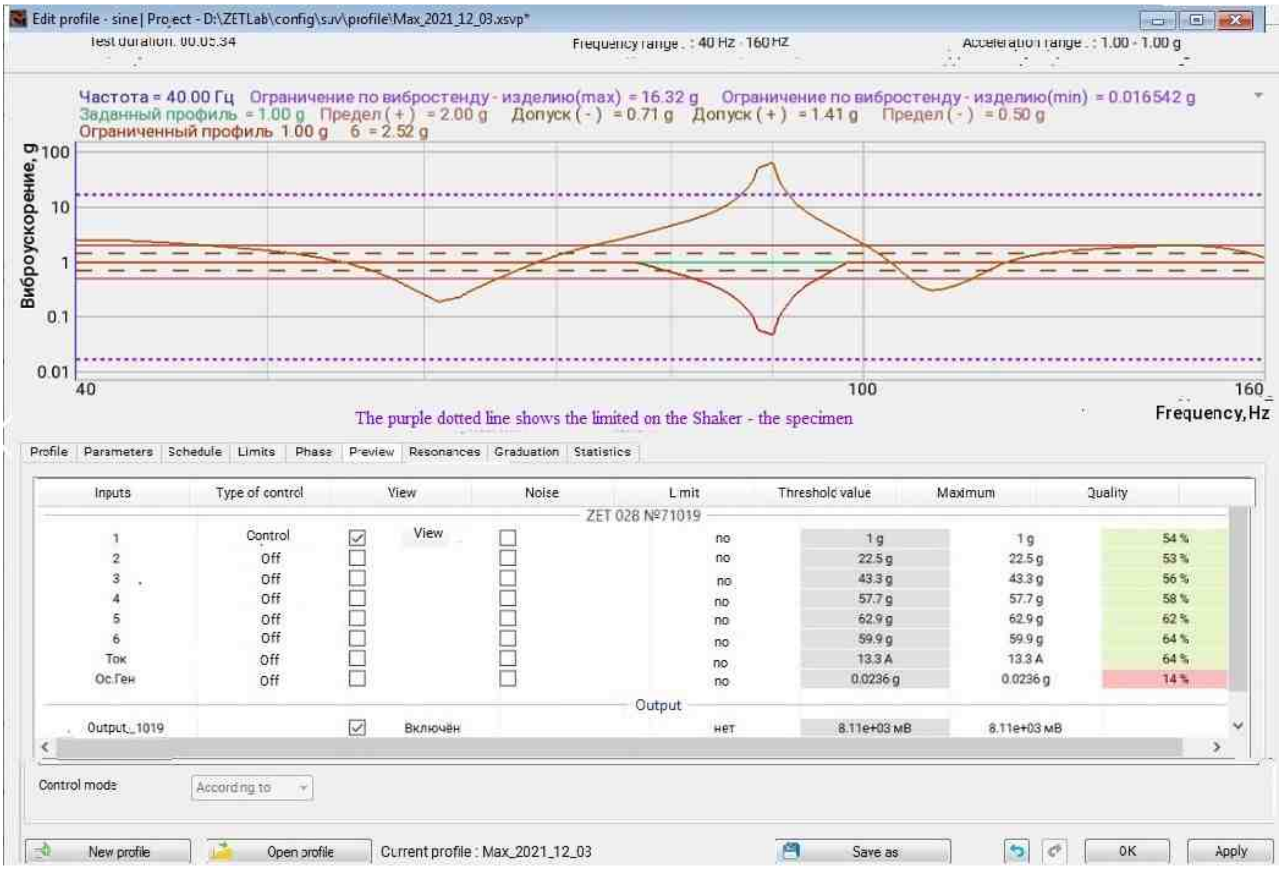


Fig. 10. Limited at the antiresonance point along the generator channel

When Passing tests on the profile in which the limited was enabled, the graphic of the lower critical limit will be hidden and the tests will not stop when the graphic of the control channel falls below it. In our example, sensor No. 1 is located at the very edge of the specimen, and sensor No. 6 is located in the center. The AFR of these sensors was given above in Fig. 3.

When the control is carried out by sensor No. 6, we will see two resonances on the edge of the specimen. Enabling the limited on sensor No. 1 will allow us to pass the tests without exciting resonances in the tested specimen. The result of such a test is shown in Fig. 11.

When the control is carried out by sensor No. 1, we will see an increase in the amplitude of the oscillations during the passage of the antiresonance. The test program will keep the amplitude of the control at a given level by increasing the voltage and this will lead to an increase in the overall vibration of the tested specimen. The effect of a limited on sensor No. 6 or on the generator channel will protect the tested specimen from breakage. The result of such a test is shown in Fig. 12.

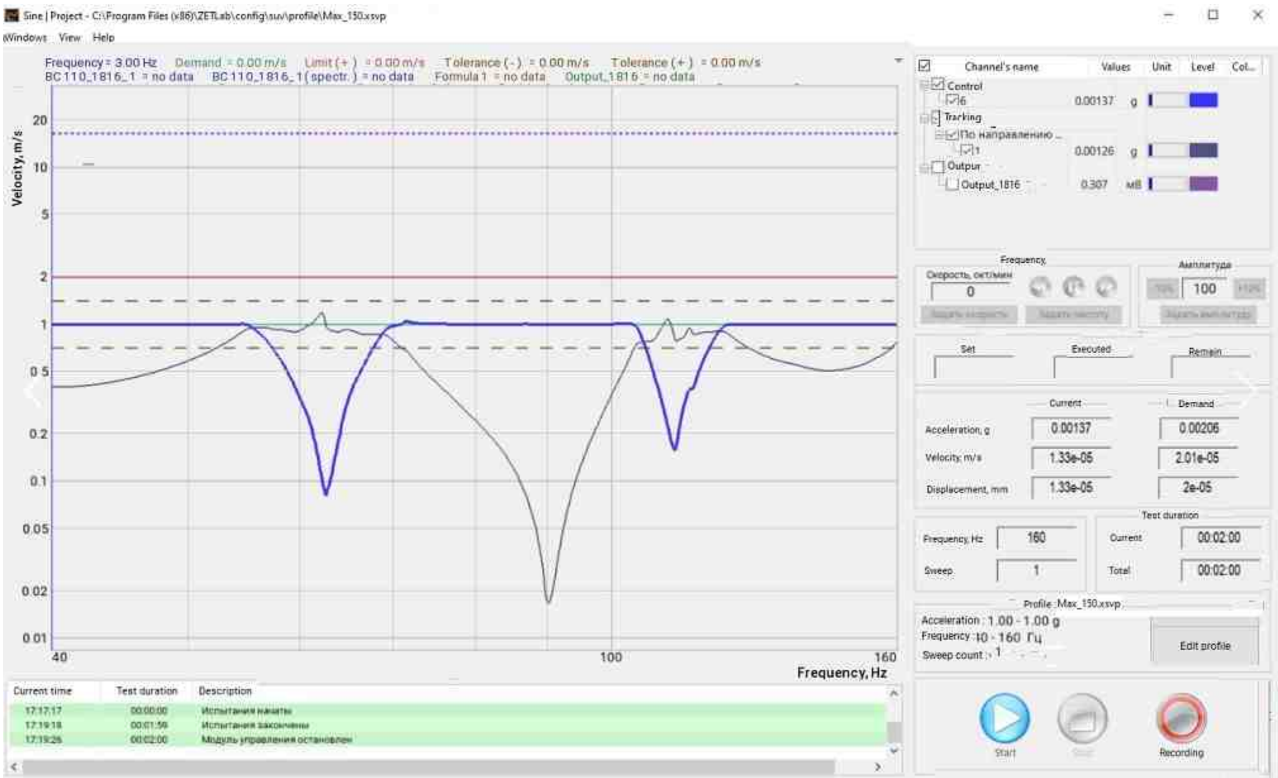


Fig.11. Passing tests with limited resonances on the extreme channel

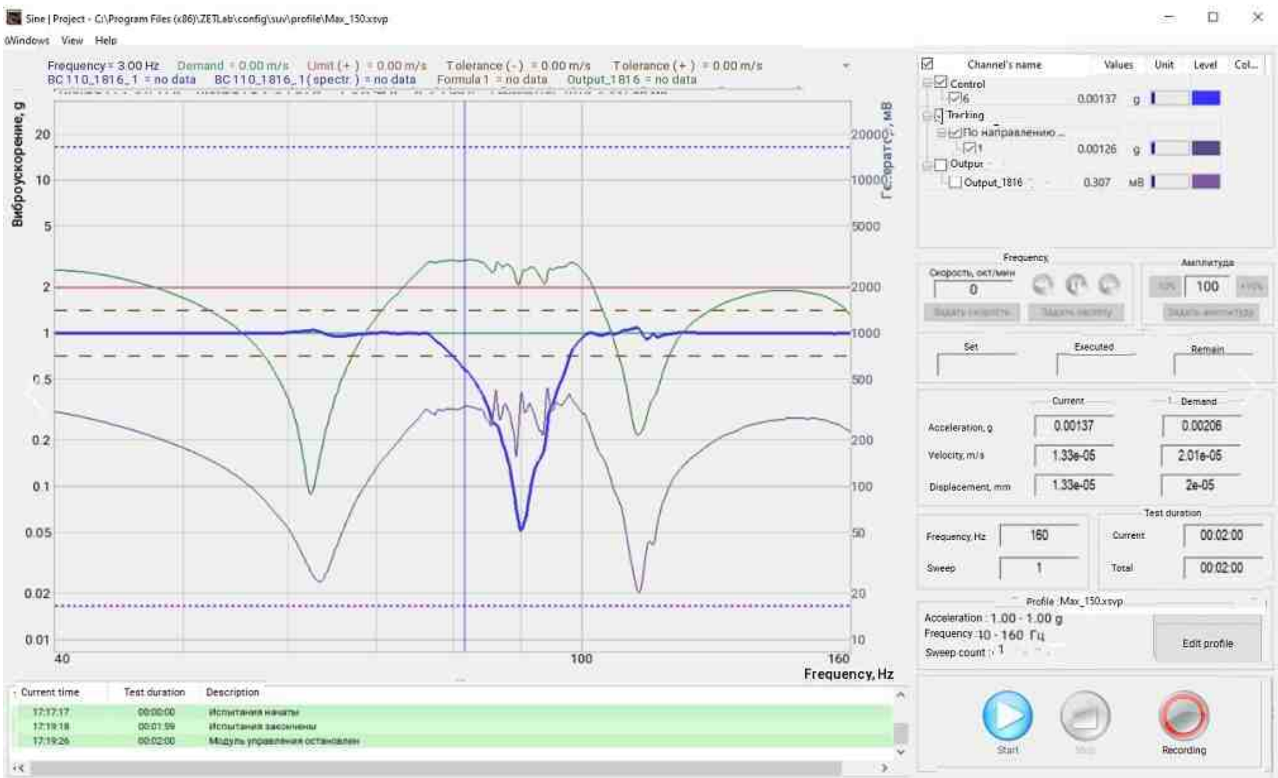


Fig.12. Passing tests when the extreme sensor is limited at the antiresonance point

Shaker Validations in the Random mode .....

Shaker Validations in the Random mode

Random reproduction mode

When testing the specimen for the effects of Random, the conditions of real operation are reproduced more accurately, therefore, the reproduction of this type of vibration by a Shaker is an essential element of testing the specimen for chatter stability and vibration resistance. The article presents the main provisions of OST 1 02705-90, which defines the procedure for Shaker Validations in the mode of reproduction of Random, including requirements for its frequency and sequence of operations performed, including their description.

One of the main requirements put forward in the design, creation and operation of modern types of equipment is high resistance to external effects, one of which is vibration. Most of the vibration effects on the specimen are described by a basic mathematical model involving the use of Sine, Random and Shock.

The impact of these factors on the specimen is checked on special installations, which in general cases include a Shaker with fixed sensors (accelerometers), an amplifier, a Vibration test control system and a computer that provides control of tests, registration, analysis and display of their results in a given form.

Tests for the effects of Random are carried out in order to neutralize the main disadvantage of Sine, when only one harmonic with a given period (frequency) and amplitude is present in the signal. In addition, there are practically no ideal sine waves in nature.

Real vibration consists of arbitrary short-term shock vibrations propagating in wide areas of the spectrum; in the case of Random, a random signal containing all frequencies of a given range acts on the specimen, which makes it possible to most accurately reproduce the operating conditions of the specimen when the frequency components of the signal are characterized by a random phase and amplitude.

Therefore, the reproduction of Random by the Shaker is the most important element of testing the specimen for chatter stability and vibration resistance.

Shaker Validations in the Random is carried out in accordance with the requirements of OST 1 02705-90 "Vibration test installations. The procedure for certification in the mode of reproduction of Random".

The purpose of the certification is to confirm their ability to reproduce test conditions within acceptable deviations, as well as to establish the suitability of Shakers for use in accordance with their purpose.

The frequency of certification is determined depending on the operating conditions of the installation and its intensity, as well as on the stability of accuracy characteristics. If the Shaker Validations in harmonic mode has been carried out, and its results, together with the data of the control check of the control equipment of the Random, confirm the previous ones, periodic certification in the Random mode can not be carried out.

When carrying out the certification of test vibration installations equipped with Random control equipment, in accordance with the requirements of OST 1 02705-90, the following operations are performed:

- **external inspection** (section 6.1 of the specified Standard): it checks the absence of mechanical damage and compliance with the requirements concerning the complete set of technical documentation, verification of safety requirements, certificates of verification of measuring instruments, as well as verification of the control equipment Random (accuracy characteristics) for compliance with technical documentation;

- **testing** (section 6.2): when performing this operation, the grounding (correctness and reliability), the inclusion and operation of the Shaker are checked, including warming up during the time specified by the technical documentation;
- **determination of the nominal range of the reproducible acceleration spectral density - ASD** (section 6.3): the ASD recording of the noise signal is performed, the lower and upper limits of the reproducible ASD level are calculated;
- **determination of the unevenness of the ASD task** (section 6.4): the operation is performed at the control point of the table and the three attachment points furthest from the center of the table during the initial attestation and at one control point during periodic or unscheduled attestation. During the operation, the ASD graphic is reproduced (using Random control equipment) and the fulfillment of the requirement to find a given acceleration in the nominal frequency range in a given range is checked. Then, with the help of measuring instruments, ASD is recorded in the nominal frequency range and the unevenness of its assignment is determined;
- **determination of the relative acceleration level outside the nominal frequency range** (section 6.5) is performed when setting the ASD graphic, taking into account the fulfillment of the condition determined by finding the specified acceleration in the nominal frequency range in the specified range;
- **determination of the limits of the relative error of reproduction of the root-mean-square value (RMS) of acceleration** (section 6.6) is performed with a confidence probability of 0.9 depending on the limit of the relative error of the vibrometer from the installation and the limit of the additional error from the non-uniformity AFR of the vibrometer.
- **determination of the limit of the relative error of ASD reproduction** (section 6.7) is also performed with a confidence probability of 0.9 depending on the limits of the AFR irregularity of the vibrometer, the relative error of the spectrum analyzer when measuring the normalized values of the amplitudes of the spectrum components, the non-excluded systematic error of the recorder, as well as the unevenness of the ASD setting in control point and assessment of the analysis error (residual ripple), which is determined in accordance with GOST 28222-89 "Basic test methods for external factors. Part 2. Tests. ASD testing: Random. Average reproducibility".

The operations listed above are mandatory both during the primary certification, and periodic or extraordinary. The only exception is the operation according to section 6.5, which is not performed during a periodic or extraordinary inspection.

The certification results are documented in a protocol in accordance with the requirements of OST 1 00422-2005.

The values of the parameters obtained during the certification are compared with the permissible values established by the normative and technical documentation for the shaker. If the results obtained during testing correspond to the established requirements, the metrological service issues a certificate drawn up in accordance with the requirements of OST 00422. At the same time, the values of the operational parameters subject to periodic monitoring are copied from the protocol into the vibration stand form, drawn up in accordance with GOST 2.601-2013 "Unified system for design documentation. operational documents".

If the certification results are negative, the certificate is not issued and an entry is made in the test report about the inadmissibility of the shaker operation.

Sine vibration tests .....

Sine vibration tests according by GOST 28203 (IEC 68-2-6)

The purpose of this test is to identify mechanical defects and / or deterioration of the specified characteristics, as well as to compare the results obtained with the requirements of the relevant NTD to determine the degree of suitability of elements, equipment and other specimens (hereinafter referred to as the sample) to the vibration testing of a given degree of rigidity. In some cases, this test can be used to determine the structural strength of specimens and/or study their dynamic characteristics. In addition, on the basis of the degrees of rigidity, the elements can be classified into different categories. The relevant NTD should also specify whether the specimen is to operate during the test or only withstand the test conditions.

The degree of rigidity of the test is determined by a combination of the following three parameters: frequency range, vibration amplitude and duration of vibration testing (expressed by the number of swing cycles or time).

Recommended frequency bands: 1…35, 1…100, 10…55, 10…150, 10…500, 10…2000, 10…5000, 55…500, 55…2000, 55…5000, 100…2000 Hz.

Vibration amplitude (acceleration and displacement or both) must be specified in the relevant NTD. Below a set frequency, known as the transition frequency, all amplitudes are set as constant displacement, above this frequency as constant acceleration. Each displacement amplitude value is associated with the corresponding acceleration amplitude value in such a way that the vibration level is the same at the transition frequency. Up to an upper frequency of 10 Hz, it is usually convenient to indicate the amplitude of displacement over the entire frequency range.

The relevant NTD must select the duration of vibration testing from those recommended below. If the duration of exposure is 10 hours or more for each direction or frequency, the time may be divided into periods, provided that the mechanical stresses in the sample (due to heating or other causes) are not reduced.

When subjected to vibration by the swing frequency method, the duration of vibration in the direction of each axis must be determined by the number of swing cycles set in the relevant NTD from the following series: 1, 2, 5, 10, 20, 50, 100.

Vibration effects at fixed frequencies are of two types: at critical frequencies and at predetermined frequencies. When exposed to vibration at critical frequencies, the holding time in each direction should be selected from the following range: (10 ± 0.5) min; (30±1) min; (90±1) min; 10 h ±5 min. When exposed to vibration at predetermined frequencies, the duration specified in the relevant specification should take into account the total time during which the sample is subjected to vibration during operation. An upper limit of 10^7 oscillations must be applied for each combination of frequency and axis direction.

At initial measurements, if the relevant NTD specifies a need, electrical measurements and mechanical performance checks must be made before exposure. In the relevant NTD, the number of axes in the direction of which the vibration is applied, and their relative location, must be established. If this is not specified, then the sample shall be vibrated in turn in three mutually perpendicular directions, which are chosen in such a way that it is easy to detect damage.

The control signal is generated using a signal from one or more control points. In the second case, the signals are subjected to either continuous arithmetic averaging or processing, which is specified in the corresponding NTD.

The test method to be applied must be selected when developing the appropriate NTD from the steps below. In general, the test steps should be carried out sequentially in the direction of the same axis and then repeated for other axes. Special care must be taken when specimens normally operated with shock absorbers are tested without them. If necessary, the control of the required vibration amplitude is supplemented by the simultaneous limitation of the maximum level of the exciting force supplied to the vibration installation.

Test stages:
- study of the response of the sample to vibration exposure;
- vibration effect.

Generally, a study of sample response when subjected to vibration in the required frequency range should be carried out throughout the entire swing cycle under the same conditions as during exposure, but vibration amplitude and swing speed can be reduced compared to nominal values if it is necessary to determine the response of the product more accurately. to vibration effects. At the same time, an excessive increase in the duration of exposure to vibration should be avoided. The relevant NTD may specify the need for the specimen to function while testing the specimen's response to vibration. At this stage, the sample is examined to identify critical frequencies at which:
- there is a failure of the sample and / or deterioration of its characteristics, depending on the vibration;
- mechanical resonances or other phenomena associated with them, such as rattling, occur.

The response of the sample, as well as all frequencies and amplitudes at which these phenomena occur, must be recorded.

When vibrating the sample, two methods are considered:
- exposure to vibration by the frequency sweep method;
- exposure to vibration at fixed frequencies.

Swept vibration exposure is preferred. The frequency must change within the frequency range, the amplitude and duration of exposure must be set in the appropriate NTD. If necessary, the frequency range can be divided into several subranges, provided that the mechanical stresses in the sample do not decrease.

When subjected to vibration at fixed frequencies, the sample is subjected to vibration at the frequencies identified in the study of the behavior of the sample when subjected to vibration and at predetermined frequencies set in the appropriate NTD.

Tests for the effect of sinusoidal vibration (according to GOST 28203 (ST IEC 68-2-6)) in automatic mode are carried out using the shaker control system **ZET 017-U** *through the program interface* **Sine**.

Random vibration tests for specimens

according to GOST 28220 (IEC 68-2-34)

Random vibration tests is a complex test. In this type of test, the term "acceleration spectral density (ASD)" is often used. It should be understood as "the spectral density of the acceleration of a random vibration, expressed in units of" acceleration squared divided by frequency (g^2/Hz)". The ASD spectrum determines how the ASD changes within a frequency range.

The purpose of the test is to determine the ability of products, elements and equipment to withstand the impact of random vibration of a given degree of rigidity, as well as to identify possible mechanical damage and / or deterioration of the specified characteristics of the product to decide on the suitability of the sample. During the test, the sample is subjected to random vibration at a specified level over a wide frequency band. Due to the complex mechanical response of the sample and its mounting, this test requires special care in its preparation and execution.

To facilitate the use of test methods, the test program is divided into 4 Table of contents:

- test Fd. ST IEC 68-2-34 (GOST 28220);
- test Fda. ST IEC 68-2-35 (GOST 28221);
- test Fdb. ST IEC 68-2-36 (GOST 28222);
- test Fdc. ST IEC 68-2-37 (GOST 28223).

Each of the last three sections is a complete test method with recommended validation methods contained in the annexes. All information required by the developer of the relevant NTD is given in test Fd. The information needed by the test engineer is given in tests Fda, Fdb, Fdc (depending on which one is required).

Test theory

All test methods require a certain degree of reproducibility, especially for qualification or acceptance tests conducted to test the same type of sample by different organizations such as the supplier and consumer of electronic specimens.

The word "reproducibility" as used here does not mean the convergence of results obtained under test conditions and in real conditions; it means obtaining similar test results, which are carried out in different laboratories by different service personnel. A large divergence of requirements for different tolerance values at a certain level of severity, as well as ensuring the reliability of test results, lead to the introduction of three reproducibility: high (tolerance at control points: ±3 dB; at measuring points: ±5 dB), medium (± 6 dB in control points), and low (tolerances are not set). For each reproducibility, a choice of confirmation method can be made, taking into account both the dynamic characteristics of the test sample and the availability of test equipment.

Reproducibility requirements include controlling the level of vibration within a narrow frequency band. Although narrow-band equalization provides better reproducibility than wide-band equalization, narrow-band equalization takes less account of environmental effects on the test sample. However, broadband equalization causes the resonance within the sample to change the test level so much that peaks and dips can occur. During operation, actual environmental conditions typically contribute to the occurrence of peaks and dips due to the influence of the environment on the sample. In addition, these peaks and dips are unlikely to coincide with the peaks and dips that occur during testing in the laboratory.

For this test, the degree of vibration rigidity is determined by the ratio of the following parameters:
- frequency range;
- ASD level;
- exposure time.

For simplicity, a uniform spectrum is used in this test. Under special circumstances, another form of the spectrum may be possible, given as a function of frequency.

The most commonly used frequency bands are: 20…150, 20…500, 20…2 000 Hz.

The nominal ASD level in a given frequency range should be selected from the following values: 0.0005; 0.001; 0.002; 0.01; 0.02; 0.05; 0.1; 0.2; 0.5; one; 2; 5; 10 g^2/Hz.

The exposure time should be selected from the values given below. If the required duration is equal to or more than 10 hours in each direction, then this time may be divided into periods of 5 hours each, provided that the stresses arising in the specimen (due to heating, etc.) are not reduced. Any given duration is the total dwell time, which must be equally divided between each given directions: 30 s, 90 s, 3 min, 9 min, 30 min, 90 min, 3 h, 9 h, 30 h.

Before testing, it is necessary to subject the sample to a sine vibration to remove the frequency response, and also to perform tests to detect resonant frequencies.

When taking the frequency response tests for sine vibration are carried out over the entire frequency range in both directions, and the amplitude of the sine excitation depends on the specified degree of rigidity of the test for random vibration.

The resonant frequency test compares the frequencies at which mechanical resonances and other frequency-dependent phenomena (e.g., abnormal operation) occur in order to obtain additional information on residual phenomena caused by the random vibration test. The relevant NTD should indicate what to do if any changes in resonant frequency occur.

At initial measurements, if the relevant NTD specifies a need, electrical measurements and mechanical performance checks must be made before exposure. During the exposure, the sample is subjected to random vibration at a given level. The samples are subjected to vibration in three mutually perpendicular axes in turn, unless otherwise specified in the relevant NTD. The directions of vibration exposure are chosen in such a way that all defects in the sample can be easily identified. Unless otherwise specified in the relevant NTD, the apparatus shall be in working order, if possible, in order to be able to determine both the performance of the sample and its mechanical defects. The relevant NTD should status whether electrical measurements and mechanical performance checks are required during exposure and at what stage they should be carried out.

There are three random vibration test methods:
- exposure to broad-band random vibration;
- narrow-band random vibration at fixed frequencies;
- random vibration by sweeping frequency method.

These three vibration test methods are not considered equivalent and should therefore be submitted as separate tests. Broadband testing is considered first, and from a technical point of view, this type of testing is the most advanced.

Random vibration test methods complement the existing sine vibration tests according to ST IEC 68-2-6 (GOST 28203), which is another step forward in reproducing the type of vibration that exists in real conditions, as well as to simulate the effects on the sample, more accurately reproducing operating conditions. The random vibration test should be used whenever economically feasible. there are damages that are not detected by sine vibration and can be easily detected by random vibration testing.

Shock vibration tests .....

according to GOST 28213 (single shock) and GOST 28215 (multiple shocks)

Shock vibration tests are carried out for elements, equipment and other electrical specimens in order to determine their resistance to single (GOST 28213) and multiple (GOST 28215) shock loads. How are these tests carried out? What equipment is required? What parameters should be set? These issues will be discussed in this section.

Any electrical equipment during operation and transportation is exposed to external factors, including shocks, single or multiple, of various nature and impact levels. Shock vibration test according to GOST 28213 provides a convenient method for determining the ability of samples to withstand the impact of a single shock. For repeated shocks, the test should be carried out in accordance with GOST 28215.

First of all, it should be understood that the purpose of testing in accordance with GOST 28213 and GOST 28215 is to determine mechanical defects and (or) deterioration of specified characteristics, as well as to use this information together with the requirements of normative technical documentation to determine the structural strength of samples or as a means of controlling their quality.

Testing apparatus

Depending on the complexity of the tests, the impact on the sample of the shock load can be carried out using a shock unit, on an electrodynamic Shaker, by free fall, etc. On shock installations, the shock parameters are controlled according to the readings of the force sensor. When conducting tests on electrodynamic Shakers, the reproducible acceleration is monitored according to the accelerometer readings and a graphic of the acceleration versus time is plotted to obtain the real form of the impulse. The criterion for the impulse form to fall within a given tolerance can be the correspondence of the Velocity value obtained by integrating the acceleration-time curve to the value from Table 1. When testing a sample using the free fall method, the velocity change is determined by the height of the fall and rebound, while the sample experiences constant acceleration.

Select equipment

The test equipment must ensure the reproduction of the required parameters with the specified accuracy. The characteristics of the measuring system must be such that the value of the actual impulse can be recorded.

Electrodynamic Shakers allow you to reproduce all the waveforms described in GOST 28213. The Shaker parameters determine the degree of rigidity during testing. To conduct tests on an electrodynamic Shaker, you will also need: an accelerometer to determine the reproducible parameters vibration, a spectrum analyzer to measure the signal from the accelerometer and control the Shaker, software that allows you to perform tests in automatic mode according to a given profile with continuous control of all parameters.

When choosing equipment, special attention should be paid to the values of reproducible acceleration, velocity and displacement, as well as the frequency range of not only the Shaker itself, but also the accelerometer, and the measuring and setting equipment used in the tests. An important parameter is the maximum load weight of the Shaker, since testing of some products is required to be carried out in packaging, which, sometimes, is commensurate with the weight of the device itself.

Test parameters

The degree of rigidity and the form of the shock impulse acting on the sample should, if possible, be determined by the external conditions to which the sample is subjected during operation and transportation. However, since specimens are often subjected to impacts of varying amplitudes that are complex and random in nature, the aim of the test is not to accurately reproduce these impacts. The test parameters are standardized and the tolerances are chosen so that similar results can be obtained when tested in different laboratories by different service personnel. Standardization of parameter values allows you to group specimens into categories according to their ability to withstand certain degrees of rigidity specified in GOST 28213 and GOST 28215.

Definitions:

- the degree of rigidity shock is a combination of peak acceleration and impulse duration;
- the degree of rigidity of multiple shocks - a combination of peak acceleration, impulse duration and number of shocks;
- the form of the impulse is the time dependence of the nominal acceleration reproduced by the installation and acting on the sample;
- velocity change (shock acceleration impulse) - the absolute value of the instantaneous velocity increment in time from the applied acceleration.

When testing for the effects of single shocks, it is necessary to choose the form (half-sine, trapezoidal or sawtooth), amplitude and duration of the impulse. The change in velocity must be within 15% of the rated impulse.

Tests for the effects of multiple shocks are carried out by the action of half-sine impulses of a certain amplitude, duration and repetition rate. The change in velocity must be within 20% of the rated impulse.

When testing for shock loads, the acceleration of the specimen in the direction perpendicular to the impact shall not exceed 30% of the acceleration in the specified direction.

Test operation

When performing shock tests, the sample is always fixed to the fixture or jarring table.

When conducting tests for the effect of a single shock, three consecutive shocks should be applied in each direction along three mutually perpendicular axes of the sample, i.e. the total number of shocks is 18.

When testing samples of the "element" type for the effect of multiple shocks, the specified number of shocks (see Table 3) must be applied in each direction along three mutually perpendicular axes of the sample.

When testing the equipment for the effects of multiple shocks, the specified number of shocks (see Table 3) must be applied in each direction along three mutually perpendicular axes of the sample. If the position of the sample during installation or transportation is known and if during installation the strongest shocks affect in one direction, then it is allowed to apply a specified number of shocks only in this position of the sample or direction.

Choice of parameters

The table below shows the values of the velocity and duration of impulses during tests for the effect of single shocks recommended by GOST 28213 and the corresponding values of the change in velocity for each type of impulse. Preferred combinations are marked with dark lines.

Table 1. Acceleration, impulse duration and velocity variation for different types of signals

Peak acceleration, A, g	The corresponding duration of the nominal impulse, D, ms	Corresponding changes in the impulse velocity Δv, $m \cdot s^{-1}$		
		semi - sinusoidal $\Delta v=(2/P)$ ADЧ10^{-3}	sawtooth with a peak at the end of the impulse $\Delta v=0,5AD\times10^{-3}$	trapezoidal $\Delta v=0,9AD\times10^{-3}$
5	30	1,0	—	—
15	11	1,0	0,8	1,5
30	18	3,4	2,6	4,8
30	11	2,1	1,6	2,9
30	6	1,1	0,9	1,6
50	11	3,4	2,7	4,9
50	3	0,9	0,7	1,3
100	11	6,9	5,4	9,7
100	6	3,7	2,9	5,3
200	6	7,5	5,9	10,6
200	3	3,7	2,9	5,3
500	1	3,1	—	—
1000	1	6,2	—	—
1500	0,5	4,7	—	—
3000	0,2	3,7	—	—

The table below shows the impulse forms and degrees of rigidity recommended for testing various samples for the effects of a single shock according to GOST 28213.

Table 2. Examples of shock impulse forms and degrees of rigidity used in shock tests for various applications according to GOST 28213-

Degree of rigidity		Impulse form	Elements	Equipment
peak acceleration, g	duration, ms			
15	11	Decay sawtooth, half-sine, trapezoidal		The main test for determining strength, during loading and unloading and transportation. Stationary equipment transported only by road, rail and air in protective shockproof packaging
30	18	Decay sawtooth, half-sine, trapezoidal		Strength test of the equipment fastening structure. Apparatus installed or transported in a fixed position on rail, road or air transport
50	11	Decay sawtooth, half-sine, trapezoidal	Items in protective packaging transported by wheeled vehicles (by road and rail), subsonic and supersonic aircraft, merchant ships or light warships.	Equipment installed and transported in a fixed position by off-road vehicles. Equipment transported in an unsecured position on roads and railways for a long time.
			Elements installed in equipment transported or installed on wheeled vehicles moving by road or rail, on subsonic and supersonic transport aircraft, merchant ships and light warships..	Apparatus used in industry and subjected to impacts during mechanical loading and unloading operations, for example, dock cranes, forklifts.
			Elements installed in equipment intended for heavy industry	
100	6	Decay sawtooth, half-sine, trapezoidal	Items in protective packaging transported by off-road vehicles.	Individual shocks during loading and unloading operations on road or rail transport
			Elements installed in equipment transported or placed on off-road vehicles	Shocks of high launch intensity, separation of parts of rockets (spaceships), aerodynamic impact and when a spacecraft enters the dense layers of the atmosphere
			Elements installed in equipment placed on subsonic and	Portable equipment

			supersonic transport aircraft. Elements installed in equipment transported loose by road or rail for a long time	
500	1	Half-sine	Structural strength testing of semiconductor devices, integrated circuits, microcircuits and microassemblies	Shocks caused by an explosion on the ground, in the water or in the air
1500	0,5	Half-sine	Structural strength testing of semiconductor devices, integrated circuits, microcircuits and microassemblies	

The table below shows the degrees of rigidity recommended when testing various samples for the impact of multiple shocks in accordance with GOST 28215.

Table 3. Examples of severity levels for multiple shocks tests typical for various applications according to GOST 28215

Degrees of rigidity			Elements	Equipment
Peak acceleration, g	Duration, ms	Number of shocks in each direction		
10	16	1000	Transportation of fragile specimens in factory packaging by road, excluding rough terrain	Routine strength test for equipment installed or transported in a fixed position and transported on a road wheeled vehicle
15	6	4000	Checking the minimum strength for general specimens with the main mechanical loads that occur during transportation	Equipment installed permanently or on heavy mobile equipment, such as near a power plant
25	6	1000	—	Equipment installed or transported in a fixed position on all-terrain vehicles. Apparatus mounted on mechanical handling devices, such as harbor cranes, forklifts.
40	6	1000	Transportation of specimens in the manufacturer's packaging intended for use in non-portable equipment	Equipment that can be transported loose on wheeled vehicles (by rail or road) for occasional transport, such as delivery

40	6	4000	Specimens intended for equipment used on mobile vehicles	Mobile equipment transported by any type of transport (by rail, road, cross-country) in an unsecured status
100	2	4000	Lamps and spring contacts, e.g. for key switches, telephones, switches	

For samples weighing less than 100 kg, it is recommended to use hardness levels of 25 g and 40 g. For heavier products - the degree of rigidity is 10 g.

The table below shows the nominal values of the change in velocity for various degrees of rigidity when testing samples for the impact of multiple shocks according to GOST 28215.

Table 4. Acceleration, impulse duration and corresponding velocity change

Peak acceleration, g	Impulse duration, ms	The corresponding change in the impulse velocity Δv, $m \cdot s^{-1}$
10	16	1,0
15	6	0,6
25	6	0,9
40	6	1,5
100	2	1,5

See also

The Generator with "Shock" program, which is part of the specialized ZETLab software of the Shakers control systems, allows testing various specimens for resistance to shock vibration. The program provides control of an electrodynamic Shaker with vibration parameters in accordance with GOST 28213 and GOST 28215.

Article on the topic "Shock spectrum and Duhamel integrals"

Profile of the Shock .....

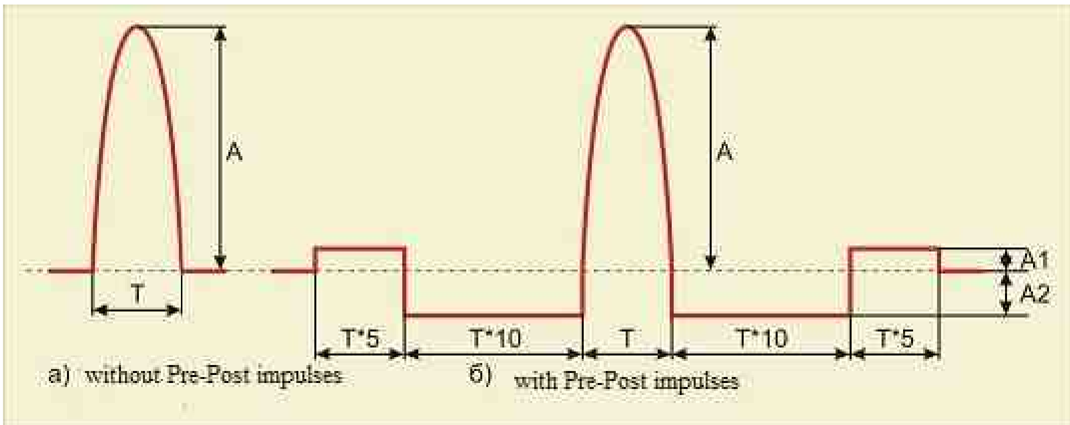
The profile of the Shock

Measuring equipment, radio-electronic equipment and other specimens subjected to single or multiple shocks during operation and transportation must be tested for resistance to shock loads. Test methods are given in GOST 28215 "Basic test methods for external factors. Part 2. Tests. Test Eb and guidance: Multiple shocks" and GOST 28213 "Basic test methods for external factors. Part 2. Tests. Ea Trial and Guide: Single shock.

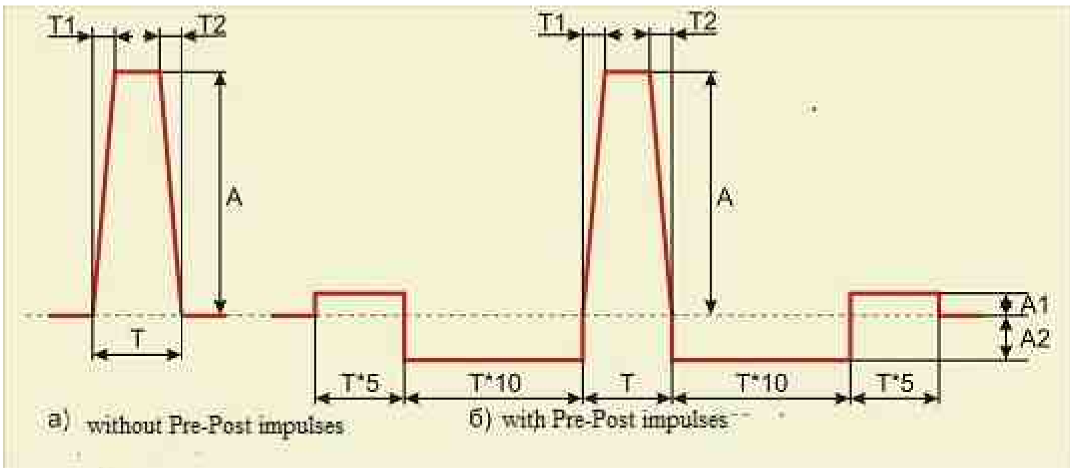
Shoks testing can be used to determine the quality of a sample's design as well as its structural strength. The tests are carried out by exposing the sample to single or repeated shocks with standard impulse forms of a certain duration and peak acceleration. Below are the forms of shock impulses reproduced by the program VCS - Shock with the designation of the parameters specified when setting up the program.

Shock signals can be reproduced with or without Pre-Post impulses. In the Fig.s: **T** is the duration of the shock; **A** is the shock amplitude. The duration of the Pre- and Post-impulses is 10 times greater than the duration of the shock impulse itself. The amplitude of the Pre- and Post-pulses is 10 times less than the amplitude of the shock impulse itself. For a trapezoidal signal, the additional parameters to be set are the rise and fall times of the signal (T1 and T2 in the Fig.). For a signal serrated, an additional parameter to be set is the decay time of the signal (T2 in the Fig.).

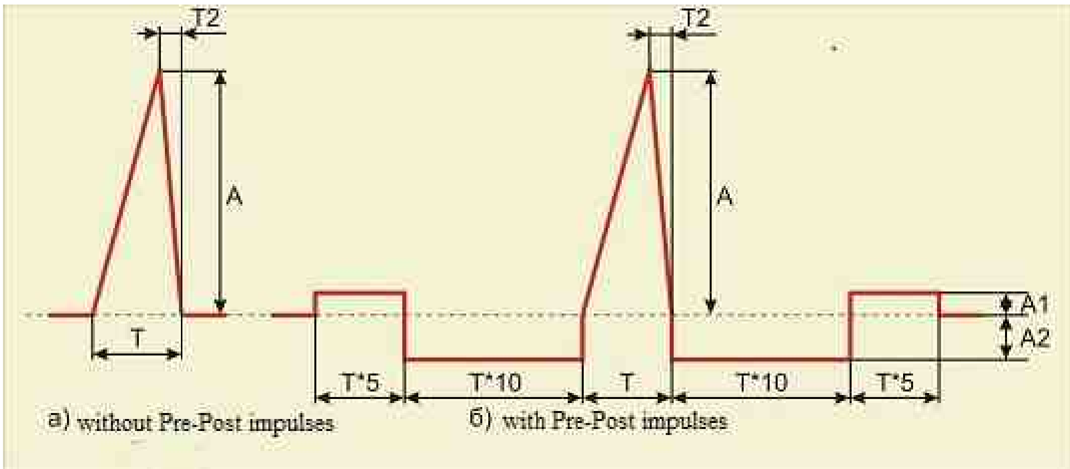
Semi-sine impulse is used to reproduce the impact that occurs when a linear mobile system collides or abruptly decelerates, for example, a shock that is elastic in its structure.



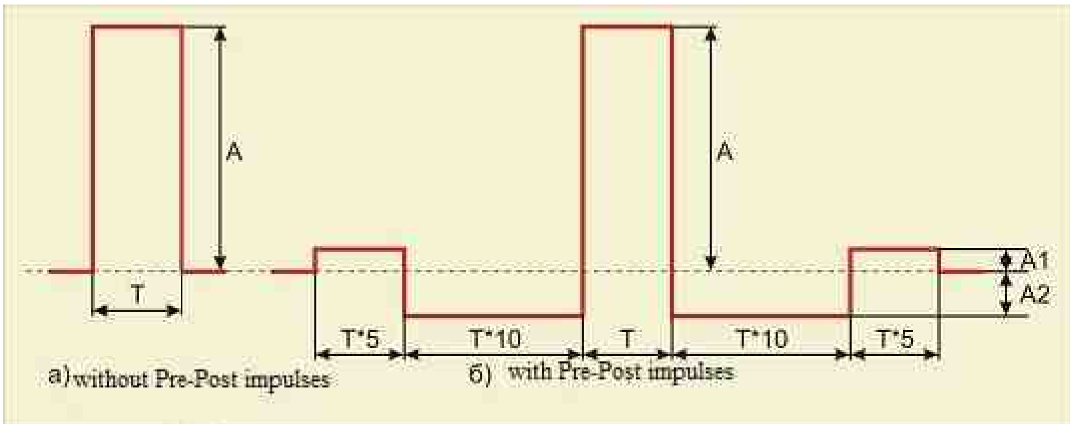
Trapezoidal impulse it causes a higher response in a wide frequency spectrum compared to a semi-sine one. It is used when the purpose of the test is to reproduce shock effects, such as during the Starting of a space probe or satellite during the "bolt shooting" phase. Designed mainly for hardware.



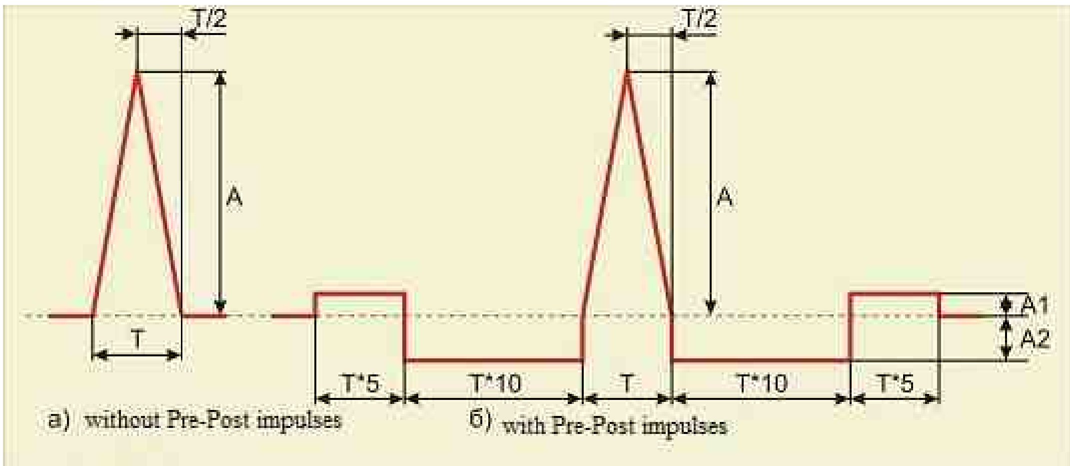
Serrate impulse with a peak at the end has a more uniform spectrum compared to a semi-sine or trapezoidal impulse.



Rectangular impulse is a special case of a trapezoidal impulse



Triangular impulse is a special case of a serrate impulse



Imitation of small arms and cannon shock .....

VCS ZET 017-U

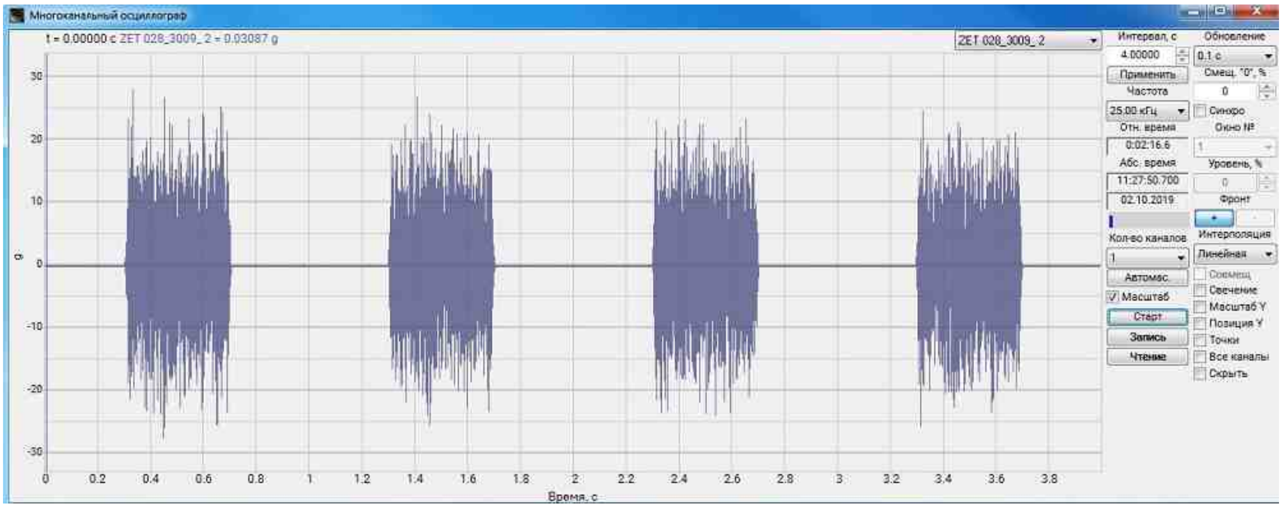
Imitation of small arms and cannon shock

For testing specimens for resistance to random vibration in the mode of simulating the shooting and cannon shock (SACS) program is used "User defined transient" of ZETLAB VIBRO – Shaker controller software, supplied with the ZET 017-U Shaker control system.

For the mode SACS mode, is set acceleration spectral density of the power and frequency.

When you turn on the SACS mode, the equalization mode is automatically turned on. The generator is switched on in the SACS mode and a smooth transition to the preset integral level of the preset equalization graphic is made, and at the preset time intervals.

In the SACS mode, the noise signal, set in accordance with the file-norm, will be impulsed from the output channel of the analyzer to the vibration generator system at the set time intervals. The Fig. below shows the waveform of the generated signal in the SACS mode.

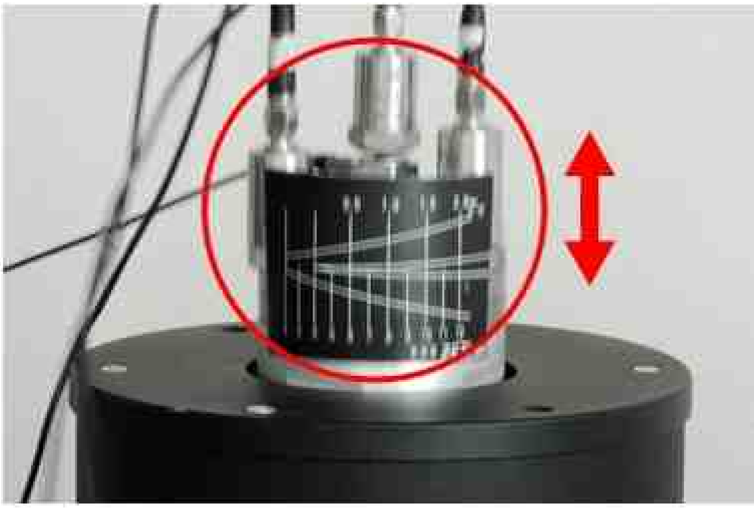


Definition of Displacement "By eye" .....

Definition of Displacement "By eye"

To determine the Displacement during sine vibration at low frequencies (but not lower than 16 Hz), a "graphic wedge" is used - a sticker with two lines connected at an acute angle.

The essence of the method is to determine the intersection of two lines during vibration tests. At a frame rate above 16 hertz, a person no longer perceives individual frames, but sees continuous action. In addition, the extreme positions of the vibrating table are distinguished by the human eye, since at these moments the Displacement, Velocity is practically zero. Line points located at a distance equal to twice the Displacement during vibration tests will periodically be in the same place at the extreme positions of the vibrating table, which gives a clear mark against the background of blurry lines.



The image was obtained during testing of BC-112 accelerometers by comparison with a standard vibration sensor (AP10) on a BC-133 type setup. Voltage was supplied to the Shaker from the built-in generator of the ZET 017 spectrum analyzer. The Displacement was also controlled by the "Vibrometer" program.

Monitoring of changes in spectral characteristics .....

Monitoring of changes in spectral characteristics

during vibration tests

One of the important stages in the production of technical specimens is testing for resistance to mechanical factors. These tests are carried out to identify design flaws, manufacturing defects, and determine performance under difficult operating specimens. The complexity of testing for the impact of mechanical factors lies in the possibility of partial or complete destruction of the test sample. When a test specimen breaks, information about the progress of the test can help to determine the cause of the failure, and the more detailed and broad the information, the better. If the destruction of the test sample is unacceptable, then it is necessary to determine the moment of stopping the tests.

During Shock tests, a significant force is applied to the test sample for a short period of time. Most of the energy transmitted to the test sample goes to move the table of the Shaker with the sample fixed on it, the remaining energy is absorbed by it and goes to deformation. The amount of energy absorbed by the body during vibration tests determines the degree of deformation of the test sample. The task is to determine the degree of deformation of the test sample and its dynamics by changing the response of the system to the input action without the use of flaw detectors during testing.

Fig. 1 — arrangement of sensors during the experiment

In the experiment, a piece of plasticine weighing 100 grams was used as a damper, which was given the form of a cube with sides 41 Ч 41 Ч 41 mm (Fig. 1). A piece of plasticine was placed in the center of the expansion table of the Shaker. The first sensor was installed next to a piece of plasticine on an expansion table, the second one was installed directly on the plasticine. The tests were carried out using the ZETLAB shaker control system - software for controlling Shakers based on the ZET 017 spectrum analyzer, controller ZET 024. During the vibration tests, a half-sine Shock with an amplitude of 1 g and a duration of 4 ms was performed. An input signal is applied to the input of the vibratory installation in such a way that the control accelerometer shows a impulse of a given form on the oscillogram. In this experiment, the control accelerometer "VK", the required form of the Shock impulse is half a sinusoid.

In Fig. 2, in the "Multi-channel oscilloscope" program, the "dip" at the peak of the signal taken from the second sensor is clearly visible. This "failure" is associated with the damping properties of plasticine. The energy expended on the movement of the Shaker rod is partially absorbed by plasticine, which leads to its deformation. In the "Modal Analysis" program, various parameters of the measured system are calculated from the sensor signals, including the work - "Integral F * s". According to the results of measurements, plasticine absorbed:

$\Delta E=E_1-E_2=0{,}0938-0{,}0510=0{,}0428$ J

This energy went to the deformation of plasticine and dissipated in the form of heat. When plasticine is deformed, the amplitude-frequency characteristic will change. The change in the amplitude-frequency characteristics is clearly visible in the FFT Spectrum.

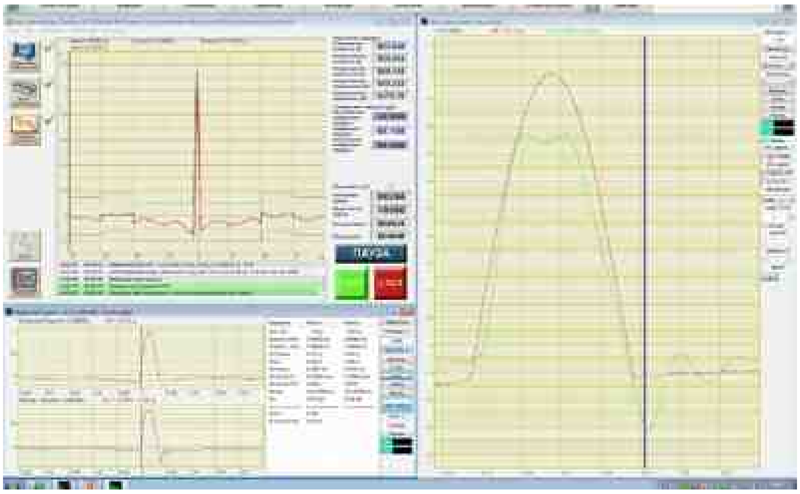


Fig. 2 — conducting an experiment in a virtual laboratory ZETLab: programs "Shock " (top left), "Modal analysis" (bottom), "Multi-channel oscilloscope" (right)

On Fig. 3 shows the graphics of the instantaneous spectrum at the end of the vibration tests, the graphic of the averaged spectrum for the first 100 seconds, and the graphic of the difference between the first two graphics. Fig.3 clearly shows that the greatest discrepancy between the spectrum graphics is observed in the band from 110 Hz to 150 Hz. Since the acting signal is a half wave of a sinusoid and has a duration of 4 ms, the full period is 8 ms, respectively, and the frequency is 125 Hz. That is, the greatest changes in the amplitude-frequency characteristic of a piece of plasticine occurred in the region of the affecting frequency, which indicates the reliability of the results.

Fig. 3 — shock spectra: instantaneous, averaged and their difference

The RMS of the instantaneous spectrum was 0.001316 g, the RMS of the average spectrum was 0.001293 g, the RMS of the spectrum difference was 0.000075 g, and the relative change was 5.8%.

During long-term tests, deformations in the test sample will accumulate gradually. To determine the magnitude of the deformation, we use the method of comparing the sample of the shock impulse with the exemplary spectrum. As an exemplary spectrum, we take the arithmetic mean of the spectra of the first shock impulses. During vibration tests, the sensor mounted on plasticine deviated from the vertical position, which undoubtedly affected the transfer characteristic.

During the test, real-time monitoring of deviations from the reference spectrum is required, and not the calculation of the deviation after they are completed. The control program operation algorithm is quite simple: during the specified time at the beginning of the tests, spectrum measurements are accumulated to calculate the reference spectrum, and then, during the entire test period, they are compared with it and a deviation graphic is plotted. If the specified threshold level of deviations is exceeded, a signal is given to the operator.

This program was implemented in the ZETVIEW SCADA system. Fig. 4 shows a project that implements the algorithm described above. In the upper left corner of the project there is an element "input channel", from which the signal (blue circles and connecting lines) enters the input of the "FFT Spectrum Analysis". At the output of the "FFT Spectrum Analysis", spectrum and frequency band arrays (purple circles and connecting lines) are formed and displayed on the "spectrum graphic". The spectrum array also goes to the "array summation" element, which element-wise sums the spectrum array with the result of the previous summation during the first 100 seconds. The number of seconds is set in the element "number of averaging's", counts their element "increment" (in the lower left corner). After the specified amount of time, the "multiplexer" will switch to the first channel, through which a zero array of the same size as the spectrum is transmitted from the "array of zeros" element. After dividing the array element by element by the number of averaging's in the "averaged spectrum" element, an array of the spectrum averaged over 100 seconds is obtained, which is fed to the "spectrum graph" and subtracted from the instantaneous spectrum. From the array at the output of the "spectra subtraction" element, the root-mean-square value is calculated (green circles and connecting lines), which is compared with the "threshold value", displayed on the "rms difference" indicator and recorded by the "graphic timer" signal (red circles and connecting lines) to the end of the "deviation" array. At the same time, according to the "graphic timer" signal in the "incrementation" element (on the right), the time elapsed since the beginning of the experiment is calculated, which is displayed on the "measurement counter" element and written to the end of the "time" array. The "deviation" arrays are displayed on the "diagram rms difference" along the axis specified by the "time" array.

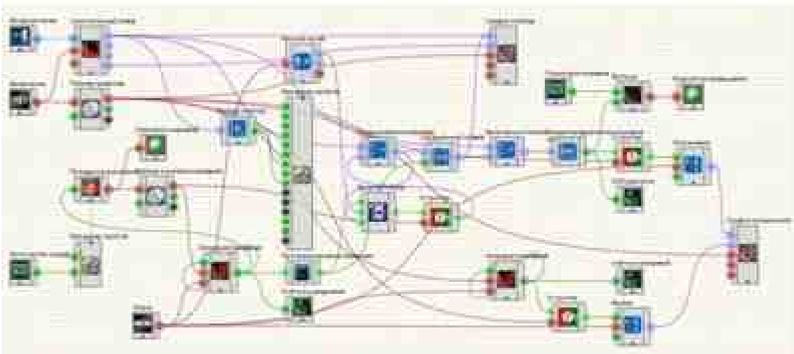


Fig. 4 — SCADA-project ZETView registration of deviations from the averaged spectrum

The ZETView SCADA project consists of two parts: a design view (Fig. 4) and an operator view (Fig. 5). The operator sees only the information he needs about the progress of the project in the form of graphics, digital indicators and project control buttons. The project is started by pressing the "Enable" button (in this case, the button changes its name to "Enabled"), to restart the measurements there is a "Reset" button. After the specified "accumulation time" was exceeded, the color indicator changed to red. The lower digital indicators display the current "rms deviation" of the instantaneous spectrum from the average and the current test time. When the "deviation threshold" is exceeded, the color indicator changes to red. The top graphic shows the averaged spectrum and the instantaneous spectrum. The lower graphic shows the deviation of the instantaneous spectrum from the average over the test time.

In the lower graphic, it is clearly seen that the difference between the averaged spectrum at the beginning of the tests and the instantaneous spectrum increases with time. Random external influences sometimes give a "splash" on the graphic, but the minimum values of the difference are constantly increasing. The constant growth of the minimum deviation values indicates the appearance of irreversible deformations in plasticine and their accumulation. With longer and more intensive tests, plasticine deformations will become noticeable even to the naked eye.

Since plasticine is a plastic material, the accumulation of deformations will not lead to its rupture. Specimens made of more brittle materials (such as hardened steel, glass, and others), with the accumulation of a certain amount of deformation, break into pieces completely or partially. Therefore, monitoring the change in the amplitude-frequency characteristics will determine the moment of destruction of the tested specimen. With the accumulation of a sufficient amount of statistics of the spectral characteristics and the results of flaw detection, it is possible to confidently determine the degree of deformation by changing the spectral characteristics.

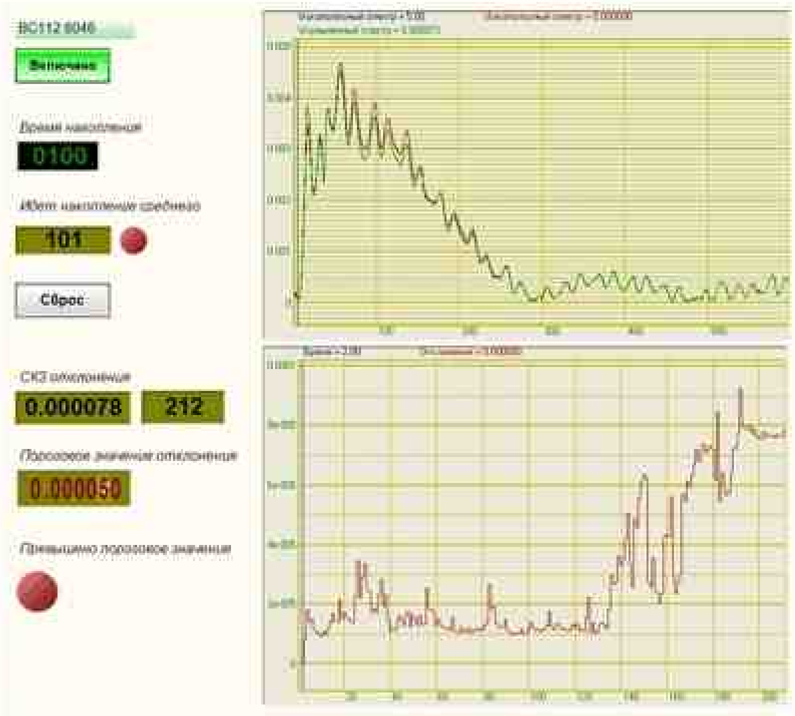


Fig. 5 — SCADA-project ZETView registration of deviations from the average spectrum, operator view

The ZETView SCADA system allows you to easily and quickly (the described project was implemented in 1 hour) implement algorithms of any complexity and present the results in a form convenient for the operator. The execution of all signal processing operations is presented in a visual form, which shows the sequence of actions. The ZETView SCADA system is a very simple and intuitive system. An inexperienced user, not being a programmer, in a relatively short time (from several minutes to several hours) is able to create a complex program for collecting data and managing objects, which has a beautiful and convenient human-machine interface.

Problems of control of spectral characteristics arise not only during vibration tests, but also in many other areas of science and technology. Similar problems also arise when controlling the deformation of buildings (changes in natural vibration frequencies of buildings), detecting defects in machines, and others. The above algorithm and its implementation in the ZETView SCADA system can be easily applied to solve other similar problems.

Notching - safe vibration tests with limited tracking channels .....

The main purpose of vibration testing is to determine the resistance of specimens to the influence of external factors in the form of vibration during operation or transportation. Experts carefully measure these conditions and translate the results into vibration test profiles. During vibration tests, the control system maintains the vibration parameters specified by the profile only in the area where the item under test is attached to the tooling. At other points of the tested product, due to the presence of resonances, the vibration amplitude can be many times higher than the amplitude at the attachment point, which will inevitably lead to breakage of the tested specimen.

Control of vibration tests with control over several points is appropriate only if they are all points of attachment of the item under test to the tooling. Inclusion of test points that are not in the mounting area may result in insufficient load on the specimen under test.

The way out of this situation can be control with a limited on observation points - Notching. The introduction of such limits will, firstly, reduce the areas where the control system is forced to reduce the vibration load, and secondly, prevent the destruction of the specimen under test.

Notching option in ZETLAB vibration control systems

The solution to the above problem is possible when using ZETLAB vibration test control systems - ZET 024 or ZET 028.

The basic ZETLAB VIBRO software can be supplemented with a tracking channel restriction function (Notching).

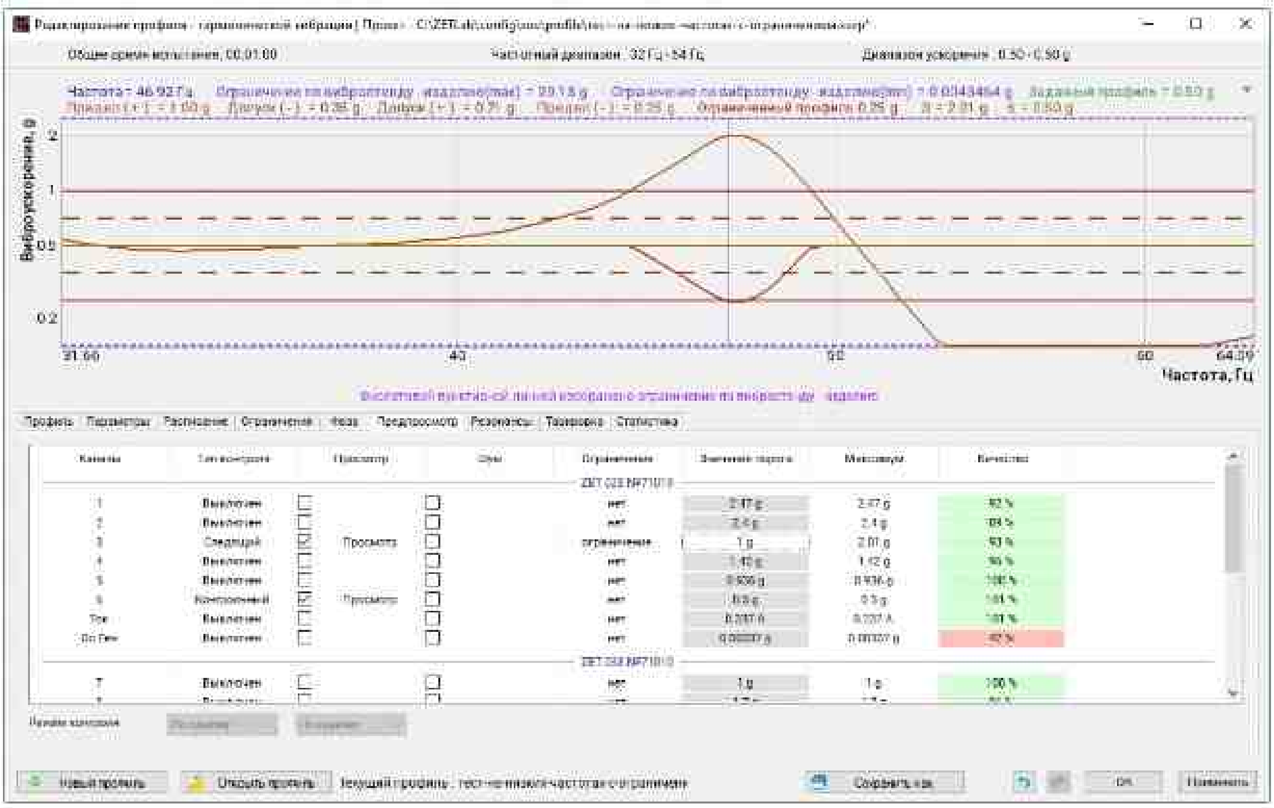
The decision on the need to use this functionality is made based on the results of a preliminary measurement of the amplitude-frequency characteristics at the attachment points of the vibration sensors, which allow you to see the presence of resonances and antiresonances in the tested specimen before testing, evaluate the maximum acceleration values and set adequate thresholds for tracking channels.

The Fig. shows the results of the Pre-Test. If the control system maintains an acceleration of 0.5 g on the control channel "6" over the entire frequency range, then on the tracking channel "3" the acceleration will reach 2.0 g.

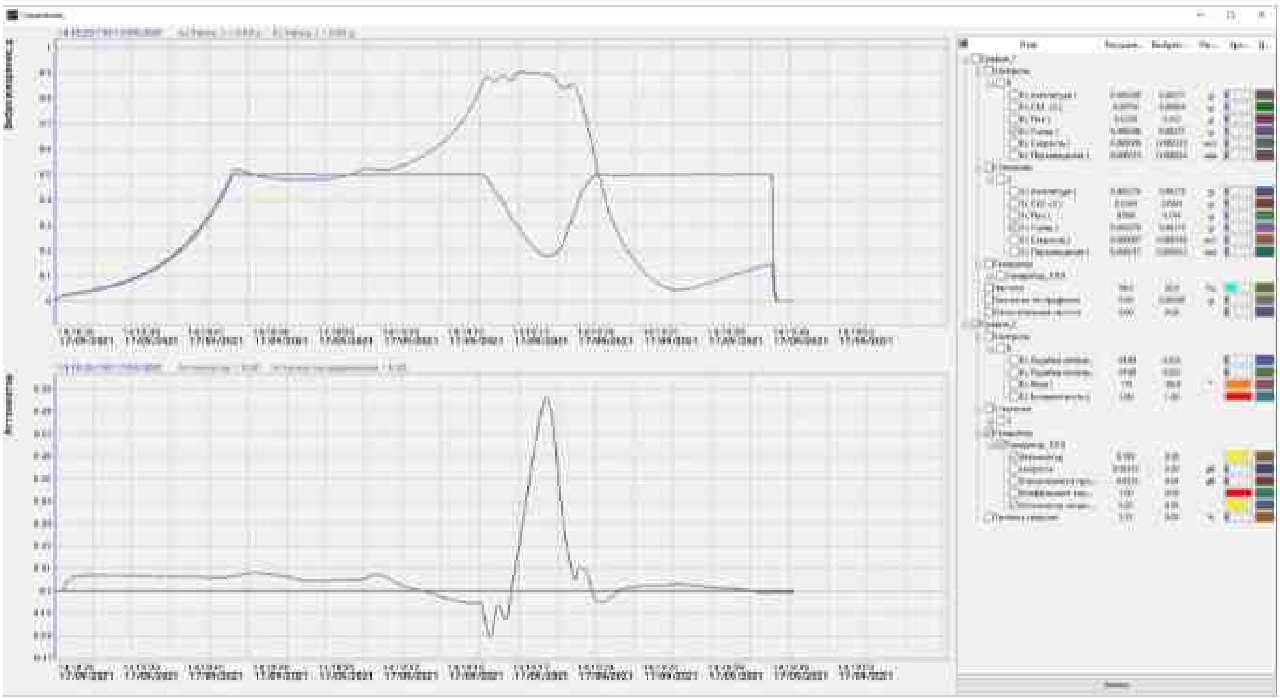
Without the included limitation, the amplitude of vibrations becomes threatening to the integrity of the frame, and in addition to vibrations in the plane of the frame, vibrations in the perpendicular direction will appear.

When setting a limit of 1.0 g on tracking channel "3", a graphic appeared showing the expected dip in the limit area. During testing, the result obtained may differ from the expected.

As the oscillator frequency approaches the resonance frequency, the loop oscillations will become more and more pronounced, but due to the given limitation, the loop as a whole will oscillate with an acceptable amplitude.



An example of the program operation with the tracking channel limited option, as well as accelerograms of the results of passing this type of test, are shown in the Fig.s below.



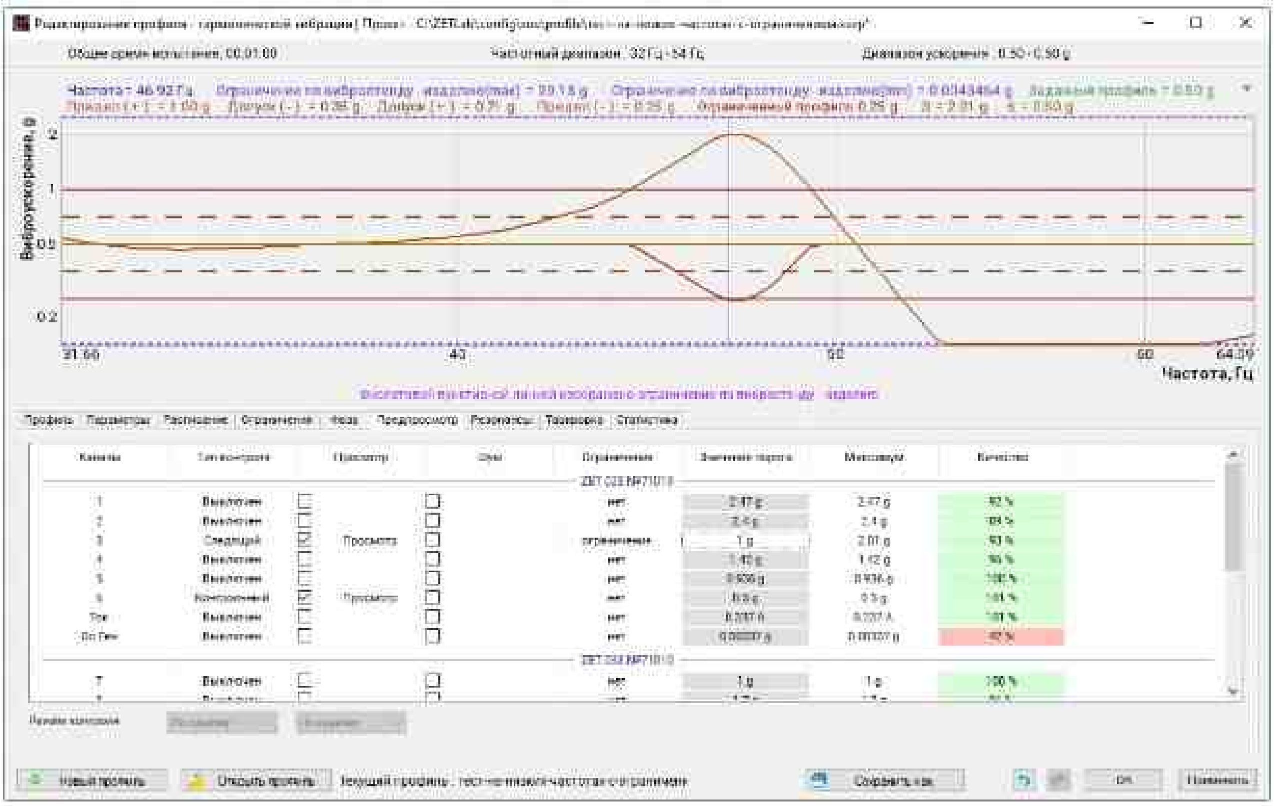
A demonstration of the restriction function on tracking channels (Notching) is presented in the video tutorial "Conducting tests with limited on tracking channels" on our Zetlab Public YouTube channel, and also in the section Video lesson.

Limiting effort by tracking channels is an economical method of preventing excessive vibration effects associated with rigid specimen mounting.

This is a technique that limits vibration levels at various frequencies. Its purpose is to prevent unnecessary excitation of any large resonances that may occur during a vibration test. Effort limiting does not remove frequencies from the spectrum, but rather limits peak oscillations in a selected region to prevent any resonances in the specimen from being driven too far.

At the time of the Pre-Test, the software forms the response of the specimen to the applied impact at the points of installation of the sensors. This procedure allows you to see the presence of resonances and antiresonances in the tested specimen before starting the main tests, to estimate the maximum amplitude of acceleration and, based on these data, to conclude that it is necessary to use the tracking channel limitation function.

To activate the function of limited on tracking channels (Notching) during vibration tests, go to the Preview tab in the Harmonic vibration profile editor, determine which channels the level of Acceleration exceeds the allowable limit limits and set the threshold value. This will display the graphic, with the expected dip in the limitation area.



International standards .....

IEC 60068-2-64:1993 Environmental testing. Part 2-64. Test methods. Test Fh: Vibration, broad-band random (digital control) and guidance.

Improving and improving the quality of the specimens and services around us is an integral part of progress. Compliance and interchangeability of devices from various manufacturers, both domestic and foreign, creates a supply and demand market for a specific task and according to the capabilities of each.

But behind achieving this interchangeability, there are a number of organizations that form the World Standardization Cooperation (World Standards Cooperation - WSC).

The main goals pursued by global cooperation in standardization:

- convergence of the quality level of products manufactured in different countries;
- ensuring the interchangeability of elements of complex specimens;
- promotion of international trade;
- promotion of mutual exchange of scientific and technical information and acceleration of scientific and technological progress.

This means that international standards are an important tool for global trade and economic development. They provide a coherent, stable and globally recognized framework for the diffusion and use of technology. Increase market relevance and acceptance and are the cornerstone of global trade and development.

The international standardization community consists of three organizations:

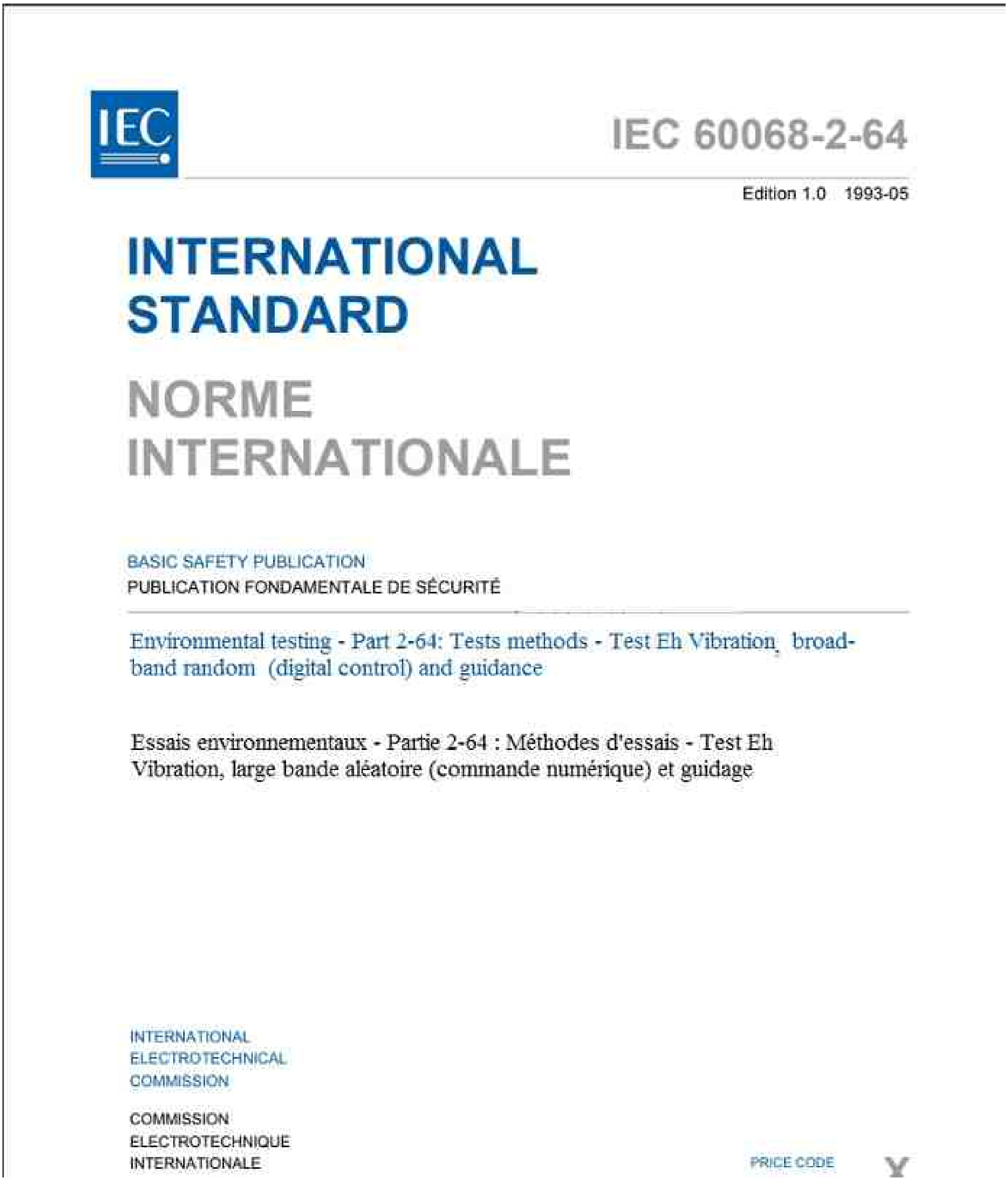
1) International Organization for Standardization (ISO)

2) International Electrotechnical Commission (IEC)

3) International Telecommunication Union (ITU) - Zetlab Public channel, and also in the section Video lesson.

Today we will focus on the international standard developed and published in 1993 by technical committee 104 (Environmental conditions, classification and test methods) of the International Electrotechnical Commission (IEC):

IEC 60068-2-64:1993 Corrigendum 1. Environmental testing. Part 2-64. Test methods. Test Fh: Vibration, broad-band random (digital control) and guidance.



IEC 60068-2-64

Edition 1.0 1993-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

Environmental testing - Part 2-64: Tests methods - Test Eh Vibration, broad-band random (digital control) and guidance

Essais environnementaux - Partie 2-64 : Méthodes d'essais - Test Eh Vibration, large bande aléatoire (commande numérique) et guidage

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE Y

This International Standard specifies the resistance of specimens to dynamic loading without unacceptable degradation of their functional and/or structural integrity when subjected to certain random vibration test requirements. Broad-band random vibration can be used to detect accumulated stress effects and resulting mechanical weaknesses and performance degradation. This information, in combination with the appropriate specification, can be used to evaluate the acceptability of samples.

This standard is also applicable to samples that may be subjected to random (stochastic) vibrations as a result of transport or operation, such as in aircraft, space vehicles and ground vehicles. It is intended primarily for unpackaged samples, and for items in their shipping container where the latter can be considered part of the sample itself.

The method and procedures of this International Standard are based on the digital control of random vibration.

Why did we choose this particular standard? Everything is very simple. We, as manufacturers of a digital vibration test control system, are primarily interested in updating our devices to modern world trends in testing.

In Russia, this standard was developed and introduced only 6 years after the publication of the original source by the Technical Committee for Standardization TC 183 "Vibration and Shock" and put into effect in 1999:

GOST R 51502-99 (IEC 60068-2-64-93) Test methods for resistance to mechanical external factors of machines, devices and other technical products. Random broad-band vibration testing using a digital test management system.

The second edition of the standard was released in 2002 under a modified degree of compliance (MOD) with respect to the original source (international standard IEC 60068-2-64:1993).

In 2008, an updated supplemented version of the international standard IEC 60068-2-64:2008 was released.

Despite this fact, the GOST 30630.1.9-2002 standard is still taken as the basis for testing specimens for resistance to mechanical factors.

Inconsistency in standards can be identified from the first pages, at least by the number of terms and definitions given.

The new edition of the IEC 60068-2-64:2008 standard contains recommendations on the sequence of test actions during testing for each of the mutually perpendicular axes:
- analysis of the initial frequency response to a sinusoidal or low-level Random impact;
- exposure to random as a mechanical or test load;
- a final analysis of the frequency response to compare the new results with the original and identify the presence of possible mechanical damage based on the change in dynamic characteristics.

Recommendations are given on the frequency characteristics of the measuring system as a whole (including the transducer, signal processing device, data acquisition and processing system), since it has a significant impact on the measurement accuracy.

The list of information that must be included in the specifications for testing has also been supplemented, and the information that must be indicated in the test report has been provided.

In addition, for informational purposes, the annex of the standard contains standard test profiles, in particular for various types of transport.

Accordingly, the State Standard GOST 30630.1.9-2002 does not contain complete information on testing in accordance with the requirements of international standardization. In addition to this, the structure of the standard itself has been revised to comply with the status standards of Russia and a number of sections and appendices have been omitted due to references to the relevant standards, which leads to the inconvenience of using this document.

Vibration control systems ZETLAB allow to carry out all types of tests for the impact of external mechanical factors, both in accordance with status standards and in accordance with international ones. You will find all the features of the ZETLAB VCS hardware and software system on the pages of our website.

In the aggregate of all the possibilities and advantages, it can be summed up that ZETLAB vibration test control systems:

• Correspond to modern international trends in the field of testing, in particular, they have the ability to conduct tests with an increased level of kurtosis.

• Allow to analyze changes in the characteristics of specimens during type and periodic tests.

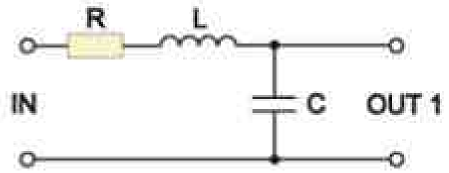
• Able to create a worthy competition to the equipment of the world's leading manufacturers in this field.

Search and retention of resonances .....

Using an RLC circuit .....

Using an RLC circuit to stimulate the mechanical resonance of a real Shaker

Tests for resistance to various vibrations pass a significant number of goods and specimens. With the development of a technocratic society, the range and scale of production is increasing, and accordingly, the need for vibration test facilities will also grow. To automate the vibration testing process, special vibration testing control systems are being created. When conducting vibration tests, all testers are faced with the phenomenon of resonance, the cause of which may be the vibration stand itself, the mounting table, and the object under test itself. Regardless of the causes of resonance, the shaker control system must ensure the passage of a given profile with allowable deviations. Since a lot of Shaker control systems have been written, the question arises of comparing the characteristics of these systems. One of these characteristics is the signal retention in the tolerance band (6 dB) for a given profile during the passage of resonance with a high quality factor. The use of a reference shaker to compare shaker control systems according to this characteristic requires significant material and organizational costs. Based on the fact that the entire Shaker control system does not receive data from the shaker itself, but from various vibration sensors that convert mechanical vibrations into electrical signals, an electrical oscillatory circuit can be used to simulate resonance. This method is much cheaper and easier to implement, since the theoretical base is well studied and the elements are cheap and available.

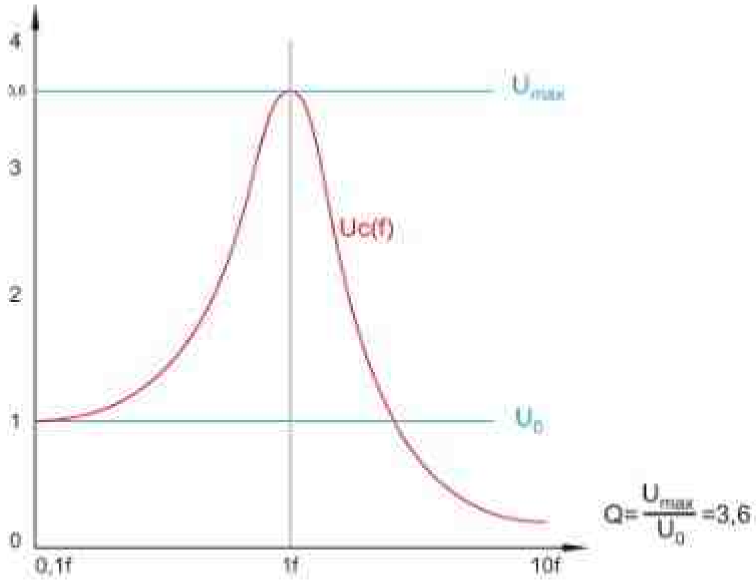


Schematic diagram of a series electrical oscillatory circuit
Resonant frequency of the electric oscillatory circuit::

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

Quality factor of the electric oscillatory circuit:

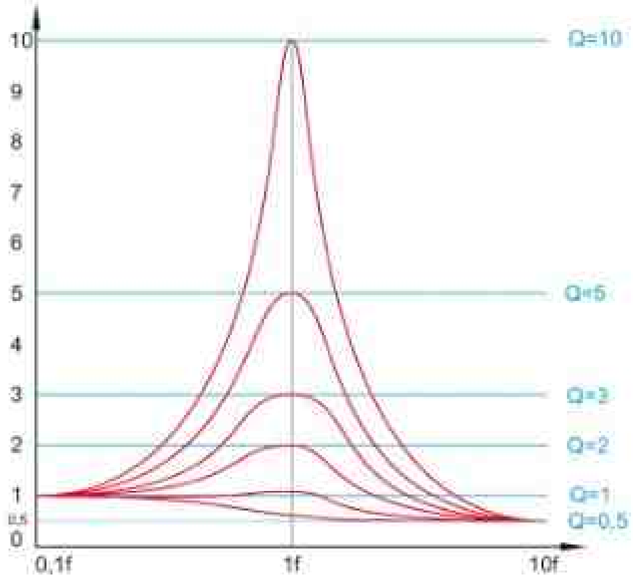
$$Q = \frac{1}{R}\cdot\sqrt{\frac{L}{C}} = \frac{U_{max}}{U_0}$$



Capacitor voltage versus frequency graphic

The Fig. above shows a graphic of the voltage across a capacitor, which shows a characteristic resonant peak. To measure the sharpness of the resonance, the quality factor of the oscillatory circuit is determined. For an electric oscillatory circuit, the quality factor is defined as the ratio of the wave impedance of the circuit to the resistive resistance, or as the ratio of the voltage at the resonant frequency to the voltage at zero frequency (ie, the voltage of the power source). For mechanical and electromechanical systems, the quality factor of the resonance is determined only experimentally.

The higher the quality factor of the oscillatory circuit, the sharper and higher the resonance, the more difficult it is for the Shaker control system to keep the signal within the specified limits, since at a constant sweep rate the transfer characteristic of the shaker changes faster.



Graphics of resonances with different quality factors

The Fig. above shows graphics of electrical oscillatory circuits with the same resonant frequency, but different quality factors. It is possible to vary the quality factor of an electric oscillatory circuit by changing the value of active resistance without changing the reactive elements (inductor and capacitor). The greater the resistance of the resistor, the lower the quality factor of the circuit, and vice versa, the lower the resistance of the resistor, the higher the quality factor. It is impossible to achieve an infinitely high quality factor by throwing out a resistor, since there is active resistance in the wires of the inductor.

Resonant frequencies of oscillatory circuits, Hz

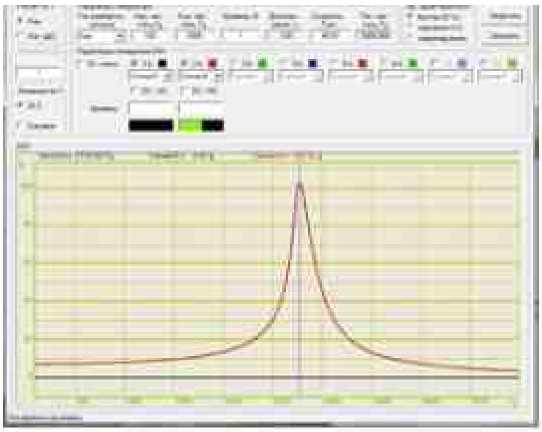
	10 mH	12 mH	15 mH	18 mH	20 mH	22 mH
0,10 мкФ	5032,9	4,594,4	4,109,4	3,751,3	3558,8	3393,2
0,22 мкФ	3393,2	3097,5	2770,5	2529,1	2399,4	2287,7
0,33 мкФ	2770,5	2529,1	2262,1	2065,0	1959,1	1867,9
0,47 мкФ	3231,5	2119,2	1895,5	1730,4	1641,6	1565,2
0,56 мкФ	2126,8	1941,5	1736,5	1585,2	1503,9	1433,9
0,68 мкФ	1930,0	1761,9	2575,9	1438,6	1364,7	1301,2
1,00 мкФ	1591,5	1452,9	1299,5	1186,3	1125,4	1073,0
1,50 мкФ	1299,5	1186,3	1061,0	986,6	918,9	876,1
1,80 мкФ	1186,3	1082,9	968,6	884,2	838,8	799,8
2,20 мкФ	1070,0	979,5	876,1	799,8	758,7	723,4
2,70 мкФ	968,6	884,2	790,8	721,9	684,9	653,0
3,30 мкФ	876,1	799,8	715,3	653,0	619,5	590,7
3,90 мкФ	805,9	735,7	658,0	600,7	569,9	543,3
4,70 мкФ	734,1	670,2	599,4	547,2	519,1	494,9

Quality factor of the oscillatory circuit (at R=1OΩ)

	10 mH	12 mH	15 mH	18 mH	20 mH	22 mH
0,10 мкФ	316,23	346,41	387,30	424,26	447,21	469,04
0,22 мкФ	213,20	233,55	261,12	286,04	301,51	316,23
0,33 мкФ	174,08	190,69	213,20	233,55	246,18	258,20
0,47 мкФ	145,86	159,79	178,65	195,70	206,28	216,35
0,56 мкФ	133,63	146,39	163,66	179,28	188,98	198,21
0,68 мкФ	121,27	132,84	148,52	162,70	171,50	179,87
1,00 мкФ	100,00	109,54	122,47	134,16	141,42	148,32
1,50 мкФ	81,65	89,44	100,00	109,54	115,47	121,11
1,80 мкФ	74,54	81,65	91,29	100,00	105,41	110,55
2,20 мкФ	67,42	73,85	82,57	90,45	95,35	100,00
2,70 мкФ	60,86	66,67	74,54	81,65	86,07	90,27
3,30 мкФ	55,05	60,30	67,42	73,85	77,85	81,65
3,90 мкФ	50,64	55,47	62,02	67,94	71,61	75,11
4,70 мкФ	46,13	50,53	56,49	61,89	65,23	68,42

An example of an electrical resonant circuit

Design parameters of the oscillatory circuit: C=0.19uF, L=18mH, R_L=15.5Ω, R=0Ω, f=2721Hz, Q=18.6.

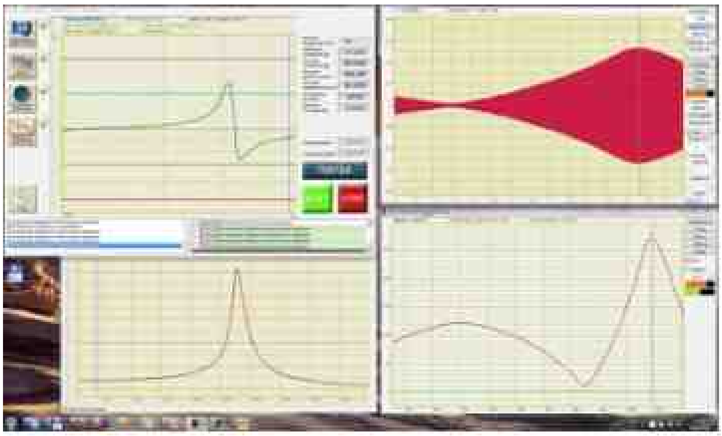


Measured AFR of a real oscillatory circuit

The Fig. above shows the AFR of a real electrical oscillatory circuit assembled from the above elements. The AFR measurement program is located in the "Metrology" tab on the ZETLAB control panel and is included in the basic package.

Measured parameters of the oscillatory circuit: f=2770 Hz, Q=15

Resonance retention control system for Shakers SinVibration "ZETLAB"

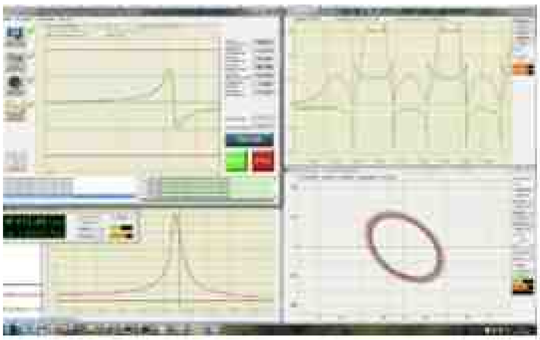


Resonance passing

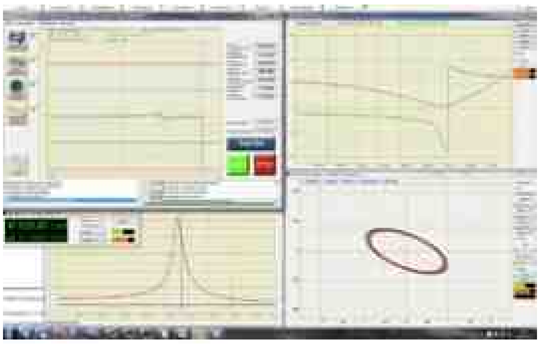
The Fig. above is a screenshot of the SinVibration shaker control system, a Multi-channel oscilloscope and a multi-channel recorder. The oscilloscope and recorder display the voltage at the generator. The shaker control system displays a given vibration test profile and a signal graphic via the feedback channel.

Set profile

- starting point 1000 Hz 1g ,
- end point 5000 Hz 1g.
- sweep rate 10 oct/min,
- limit deviations ±6 dB.



Resonance hold with a Q factor of 15 at 10 oct/min



Resonance hold with a Q factor of 15 at a speed of 1 oct/min

See also: Methods for measuring the quality factor of an electrical oscillating circuit

The article was published in the journal "Automation in Industry" No. 11, 2010

Article author: Begishev S.V.

The following literature was used in the article:

"Electrical engineering", Usoltsev A.A.

Determination of the modulus of elasticity of wood .....

according to the method of GOST 16483.31-74 "Wood. Resonance method for determining the moduli of elasticity and shear and vibration decrement"

To determine the modulus of elasticity of wood, the resonance method is used, described in GOST 16483.31-74 "Wood. Resonance method for determining the moduli of elasticity and shear and damping decrement".

According to GOST 16483.31-74, the essence of the method is to excite the sample with free ends of longitudinal vibrations of the fundamental harmonic and bending vibrations of the second overtone; the elastic modulus and the shear modulus are determined from the frequencies of resonant vibrations, and the logarithmic damping decrement is determined from the width of the resonant peaks.

Accordingly, to determine the dynamic modulus of elasticity, it is necessary to determine the resonant frequency of longitudinal vibrations of the sample with high accuracy.

ZETLAB specialists conducted an experiment to determine the resonant frequency using ZETLAB software and measuring devices.

A piece of wood, 35 mm long, was used as a sample:

COMPOSITION OF THE TEST SET

In order to measure the resonant frequency of the material, an installation of the following composition was assembled:

1) TV 51140 vibration system
2) Vibration test control system ZET 028
3) Accelerometers BC 111
4) PC with installed ZETLAB software for processing results..

The sample was fixed on the shaker table with a pin in the longitudinal direction.

Accelerometers were installed on the ends of the sample:

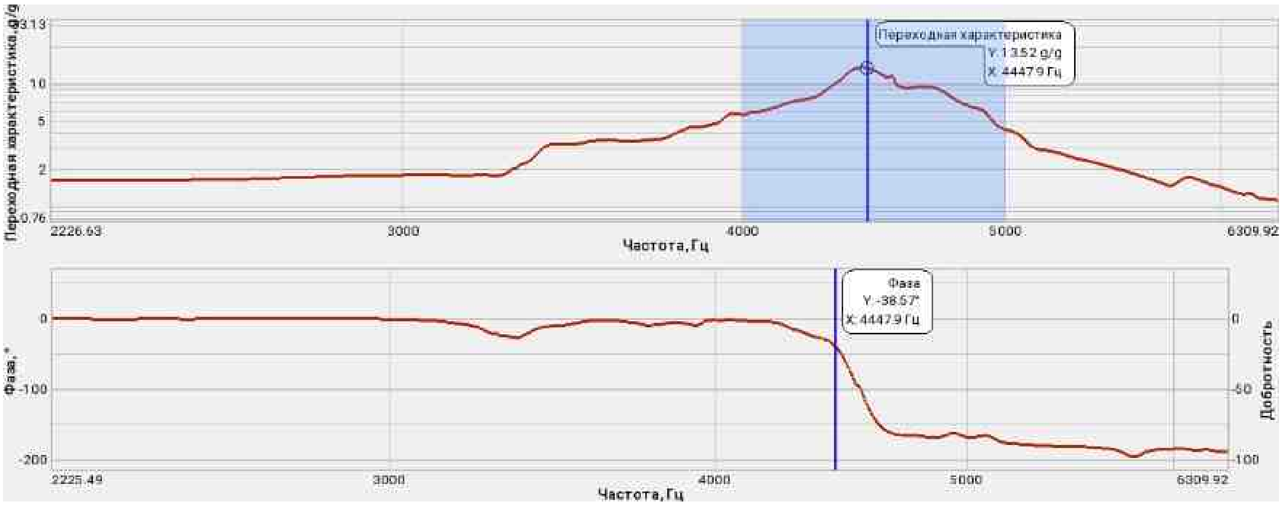
TESTING

Using the ZET 028 vibration control system controller, the sample was subjected to vibration through a vibration stand.

The signals from the accelerometers were processed in the "Cross-Spectrum FFT Analysis" program, which makes it possible to analyze the frequency characteristics of physical systems that receive some perturbation as input.

Performance evaluation is shown in the graphics below:

1) The graphic shows the amplitude and phase characteristics of the test object. As can be seen, the amplitude characteristic has a distinct peak at a frequency of □ 4447.9 Hz, while the phase characteristic changes sharply at the same frequency. This indicates the first normal mode of the object, which will be monitored.



2) The resonant frequency is recorded in the table and additional parameters corresponding to this mode of oscillation are calculated:

F0, Гц	Fr, Гц	dF, Гц	Qph	Qpar	Фаза, °	Ампл., g/g	Вклад, %	A1, м
4449.8	4442.7	306.3	14.5	12.4	-36.6	13.7	100.0	0,00

3) During the tests, the signal recorder records all recorded values of the resonant frequency of the sample.

The graphic shows that the resonant frequency throughout the tests (in this case, 10 minutes) is determined with high accuracy (the error is not more than 0.1%).

The subsequent processing of the results is carried out using calculations.

The modulus of elasticity is calculated by the formula:

$$E = 4\frac{l \cdot m \cdot \beta^2}{b \cdot h} \cdot f^2$$

where b, h, l – accordingly, the width, height and length of the sample, m
m – sample weight, kg
f – resonant frequency, Hz
β – correction for the mass of the attached sensors and the stift, equal to the ratio of the mass of the sample with additional weight to the mass of the sample without it.
The experiment showed that with the help of ZETLAB software and devices, it is possible to determine the required characteristics with high accuracy, as well as automate the process of determining the resonant frequency of the tree, and, accordingly, the elastic modulus.

Determination of the dynamic modulus of elasticity by the resonance method .....

Determination of the dynamic modulus of elasticity of a material makes it possible to draw conclusions about the resistance of the tested material to deformations acting in a given direction.

The principle of determining the dynamic modulus of elasticity by the resonance method consists in excitation of longitudinal vibrations of a sample in the form of a plate of a certain length at the frequency of natural vibrations (at the resonant frequency). The resonant frequency is determined at the maximum amplitude of the sample oscillations.

The dynamic modulus of elasticity is determined from the rate of sound propagation in the sample in the longitudinal direction in accordance with the formula:

$$E_{dyn} = v_s^2 \times \rho_R$$

where, E_{dyn} — dynamic modulus of elasticity, in GPa;

v_s — longitudinal rate of sound, m/s;

ρ_R — sample density, in kg/m^3.

The calculation of the rate of sound is made through the frequency of natural vibrations in accordance with the formula:

$$v_s = 2\,\text{Ч}\,l \times f_0,$$

where, l — sample length, m;

f_0 — resonant frequency of the sample, Hz.

Therefore, the resonant frequency is used to determine the dynamic modulus according to the formula:

$$E_{dyn} = 4 Ч l^2 \times f_0^2 \times \rho_R$$

For testing to determine the dynamic modulus of elasticity by the resonance method, a sample was selected with the following characteristics:

copper plate, 0.203 m long.

Installation composition

To determine the dynamic modulus of elasticity of a copper plate, ZETLAB specialists assembled a setup, which includes:

- vibrating installation TV 50018;;
- ZET 024 controller to control the vibration generator,
- accelerometer BC 111 to determine the vibration parameters of the sample;
- specialized software function "Resonance analysis" from the composition programs "Cross-Spectrum FFT Analysis" to determine the resonant frequency of the sample in an automated mode.

Test results

- The graphic shows the amplitude characteristic of the copper plate, taken using the program "Cross-Spectrum FFT Analysis":

The value of the resonant frequency is recorded in the table:

F0, Гц	Fc, Гц	dF, Гц	Qph	Qpar	Фаза, °	Ампл., g/мВ	Вклад, %	A1, м
9136.7	9136.5	49.6	183.5	138.5	-26.4	0.00095	65.0	16.
10410	10411	44.9	232.1	232.1	165.2	0.00015	10.7	14.
8716.8	8719.2	111.6	78.1	78.1	-94.7	0.00014	10.1	23.
8214.8	8213.4	105.8	77.6	37.9	-110.6	0.000083	5.09	22.
10991	10994	127.9	86.0	86.0	-161.7	0.000033	2.09	25.

The most significant contribution is determined at a frequency of 9136.7 Hz, which in turn is the frequency of the main resonance of the plate.

The convergence of the results was verified by determining the rate of propagation of a sound wave in a solid.

According to the theory, the wave propagation rate is:

$$\upsilon = \lambda \cdot f_{рез}$$

Where, λ – this is the wavelength equal to the value $2l$

f_{res} – the resonant frequency of the sample.

Where from:

$$\upsilon = 0{,}406 \cdot 9136{,}7 = 3709{,}5 \text{ m/s}$$

According to the source "Technical Encyclopedia", the longitudinal velocity of sound propagation in copper corresponds to 3710 m/s.

Which indicates the high accuracy of the results obtained.

The dynamic modulus of elasticity is calculated according to the formula:

$$E_d = 4{,}08 \cdot \rho \cdot (l \cdot f)^2,$$

Where Ed – modulus of elasticity, Pa;

ρ – sample material density, kg/m^3;

l – sample length, m;

f – resonant frequency, Hz.

As a result, the dynamic modulus of elasticity of the copper sample corresponds to 125.3 GPa.

Carrying out fatigue tests .....

Control of deformation of specimens during vibration tests

Control of deformation of specimens during vibration tests .....

Vibration exposure at certain frequencies can cause mechanical stress in certain parts of the specimen, which can subsequently lead to destruction.

The simplest and most cost-effective way to control the stress-strain status is the use of meter resistances.

The main difficulties that may arise when using this method:

- the need for additional hardware, since most vibration test control systems do not support the possibility of connecting strain-resistant sensors;
- increasing the processing time of test results, due to additional procedures for studying the effect of vibration on the mechanical stress of the specimen;
- the absence of the possibility of emergency interruption of vibration tests, in case of reaching the limit values of the stress-strain status.

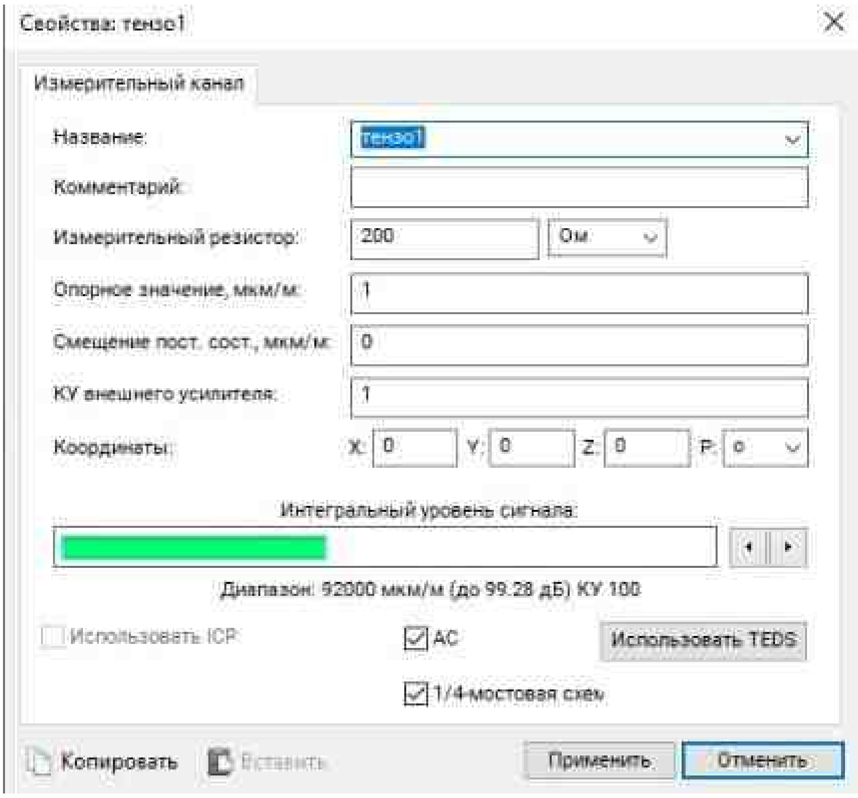
Vibration testing control systems ZET 024 and ZET 028 support the connection of single meter resistances in a 1/4-bridge circuit directly to the controller input, as well as the ability to use the meter resistance channel as an Viewing channel in the software during vibration testing.

Measurement channel setting

The measurement channel is set in the program *Device Manager*, which is launched by pressing the "Channels parameters" button on the VCS panel.

In the channel properties settings, you must set the flag next to the value "1/4-bridge circuit", after which the strain measurement mode will be activated in the program and the "Measuring meter resistance" field will become available, where you must enter the nominal resistance of the meter resistance used. To expand the measuring range, you can set the gain = 100.

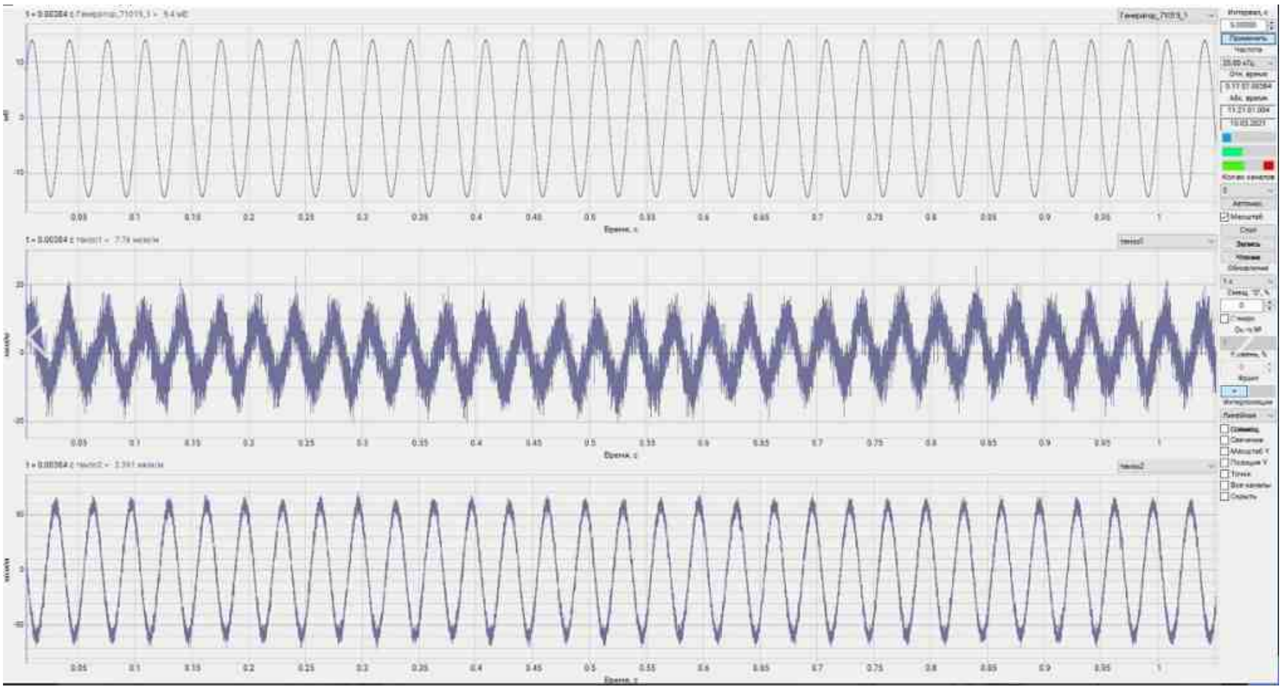
When you have finished setting up the channel, you must save the changes by clicking the Apply button.

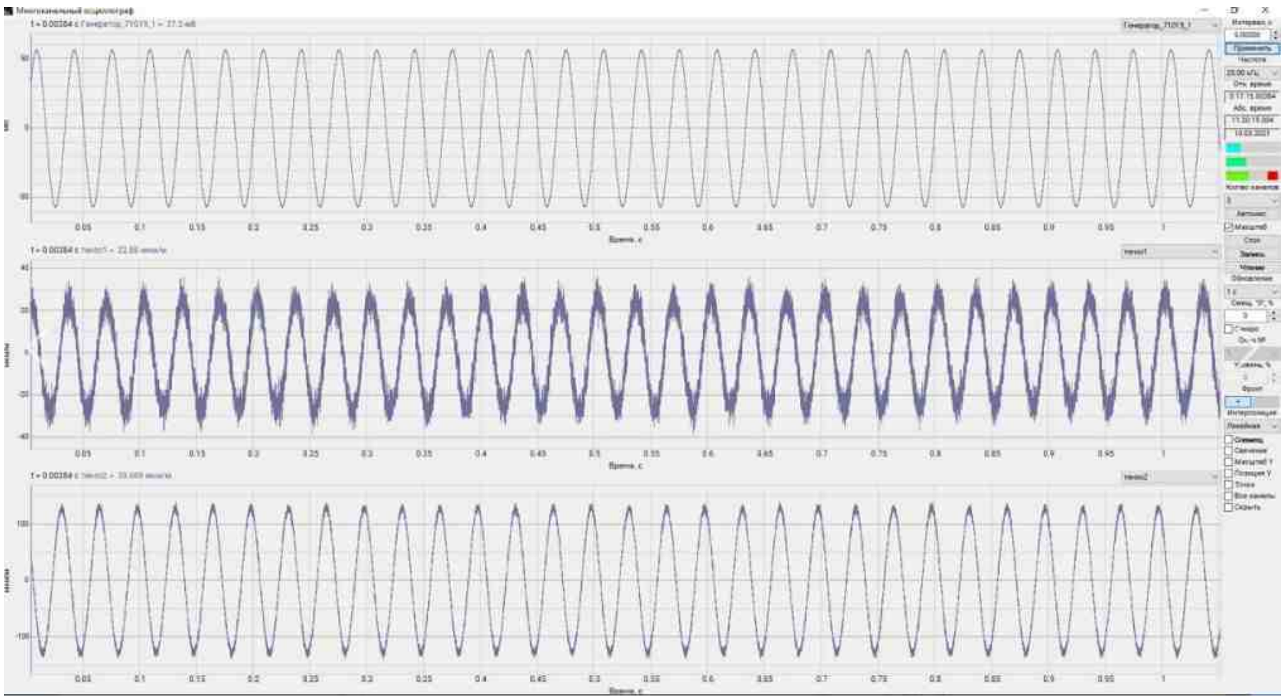


1. You can check the operation of the channel in the following way:
2. Run the program Multi-channel oscilloscope, select the displayed channel — the meter resistance connection channel.
1. Run the program Generator in manual mode with the following parameters: Sine, Frequency - 30 Hz, Amplitude - no more than 10 mV.
2. Gradually increasing the signal amplitude, check the change in the readings of the meter resistance and make sure that there are no signal breaks (examples of the oscillograms are given below).

Vibration tests with control over relative deformation

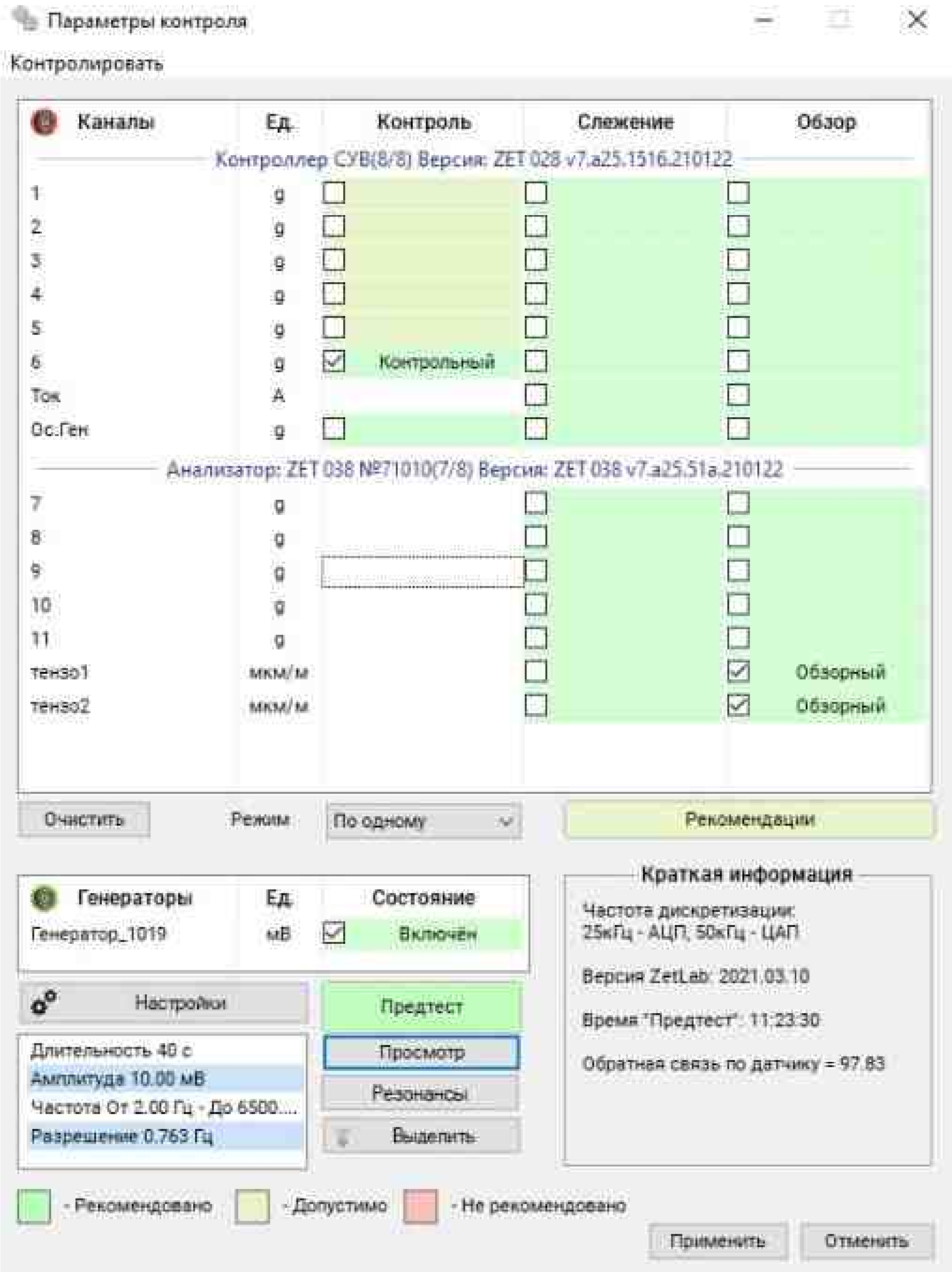
Testing must begin with *Pre-Test*. Run the program *Pre-Test* from the VCS panel and wait for the results of the passage (full information on the page **Interpreting Pre-Test result**).

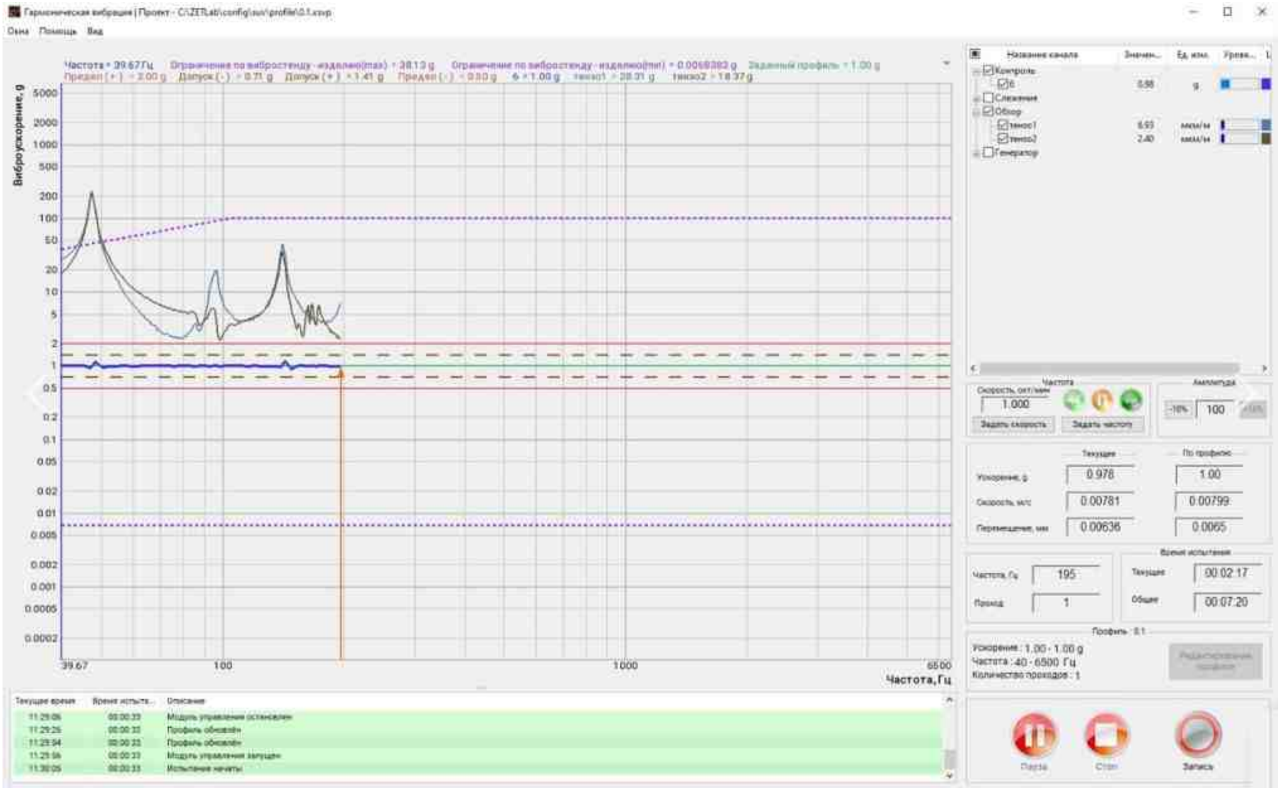




It should be noted that operation in the meter resistance feedback mode is not provided. This channel can be used as an viewing channel and during vibration tests of any type, monitor the mechanical stress of the specimen directly in the program window.


Амплитудно-частотная характеристика
Корреляционный анализ между генератором и датчиками
Коэффициент нелинейных искажений с учетом шума
Частота, Гц
Время, с
Уровень, дБ


Параметры контроля
Контролировать
Каналы
Ед.
Контроль
Слежение
Обзор
Контроллер СУВ(8/8) Версия: ZET 028 v7.a25.1516.210122
1
2
3
4
5
6
Контрольный
Ток
Ос.Ген
Анализатор: ZET 038 №71010(7/8) Версия: ZET 038 v7.a25.51a.210122
7
8
9
10
11
тензо1
тензо2
мкм/м
Обзорный
Очистить
Режим
По одному
Рекомендации
Генераторы
Состояние
Генератор_1019
мВ
Включён
Краткая информация
Частота дискретизации:
25кГц - АЦП, 50кГц - ЦАП
Версия ZetLab: 2021.03.10
Время "Предтест": 11:23:30
Обратная связь по датчику = 97.83
Настройки
Предтест
Просмотр
Резонансы
Выделить
Длительность 40 с
Амплитуда 10.00 мВ
Частота От 2.00 Гц - До 6500....
Разрешение 0.763 Гц
- Рекомендовано
- Допустимо
- Не рекомендовано
Применить
Отменить



New features of the VCS program .....

New features of the VCS program (Total)

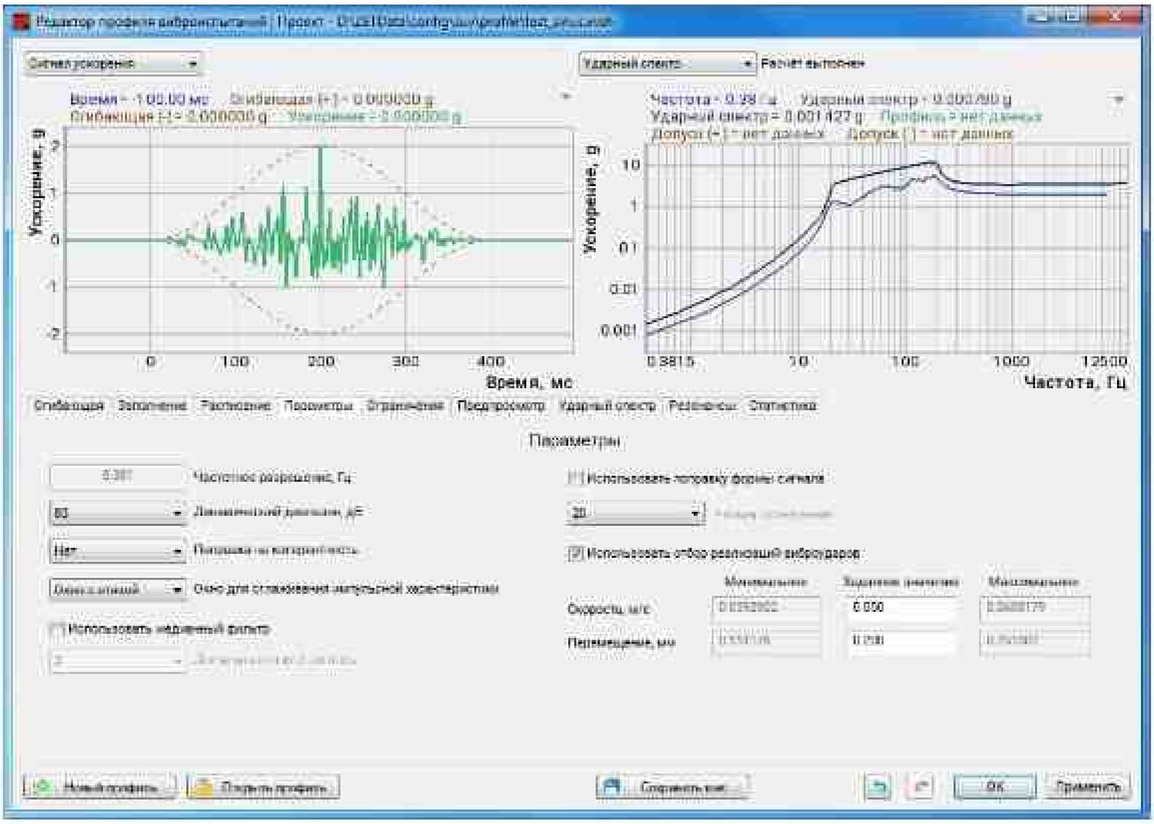
1) Added the ability to work with high-frequency versions of VCS controllers

Vibration test control system (Random)

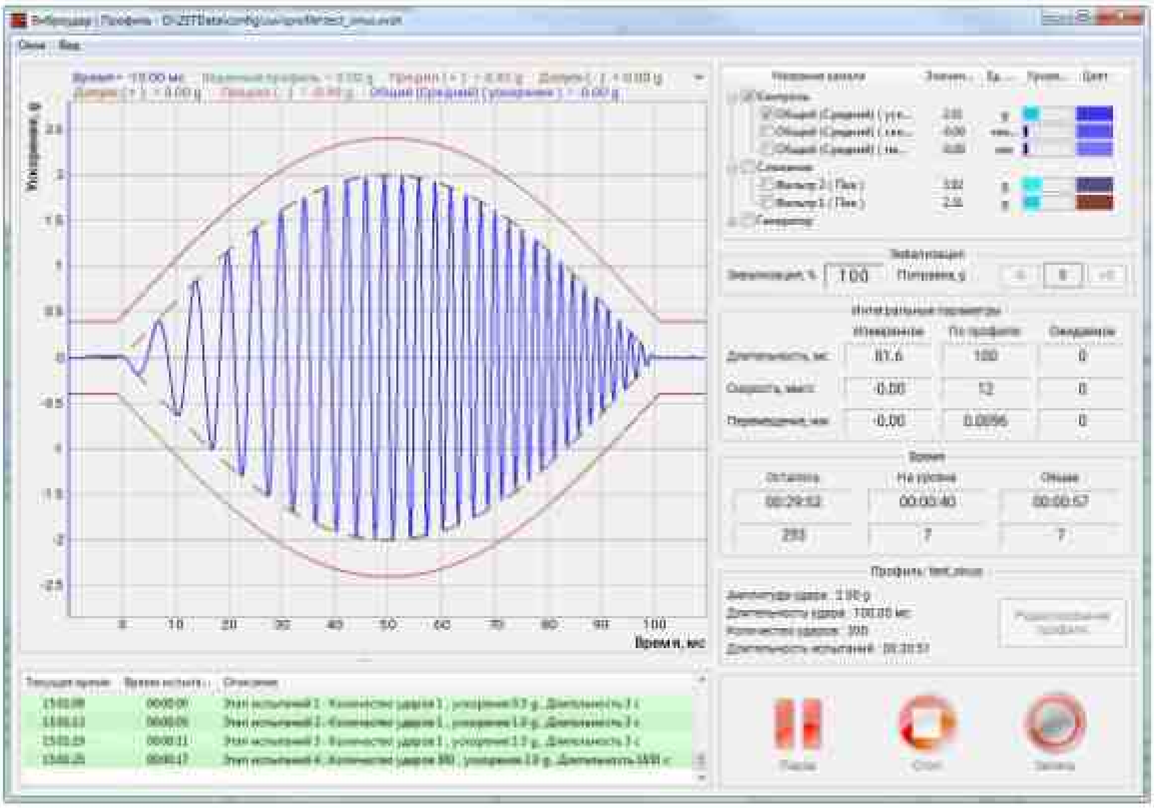
1) Adding calculation of Displacement and Velocity.
2) Improvements have been made related to improving the reliability and stability of the program in the process of testing. The identified inaccuracies have been eliminated.

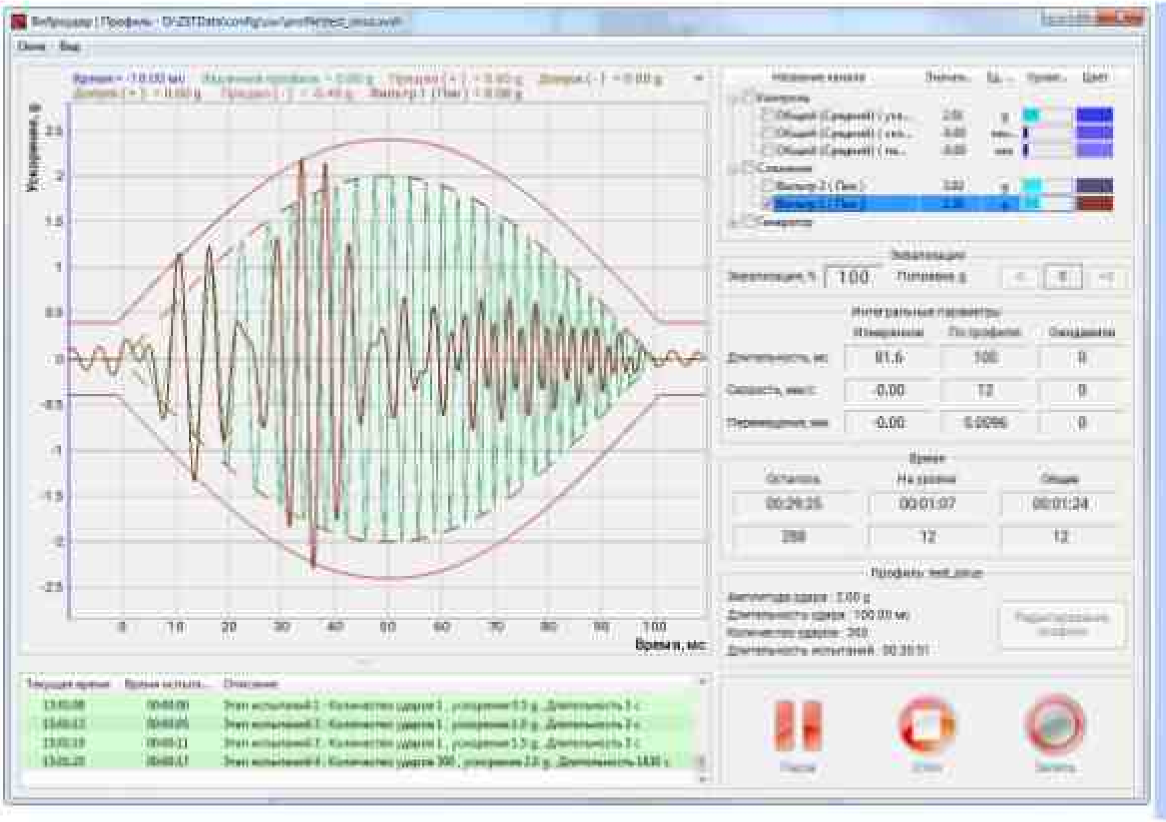
Vibration test control system (User defined transient)

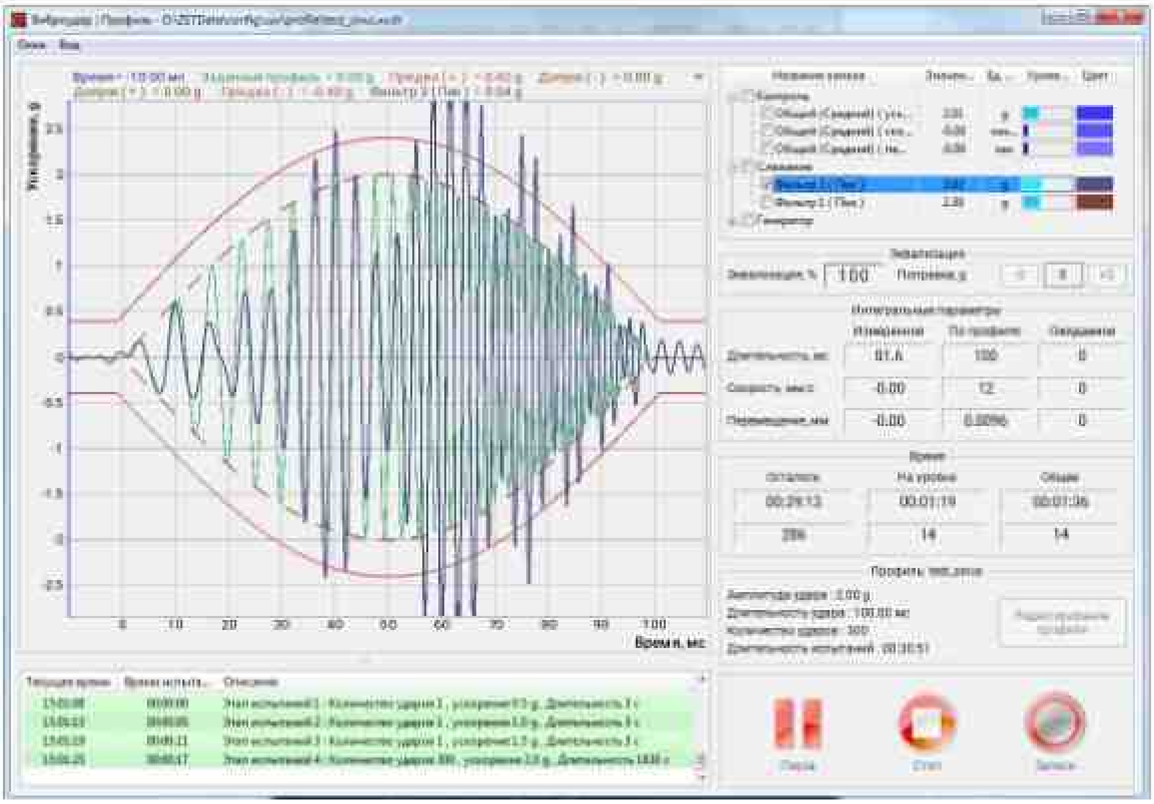
1) Added the ability to set limits on the expected values of Velocity and Displacement when implementing a "User defined transient" with noise filling.

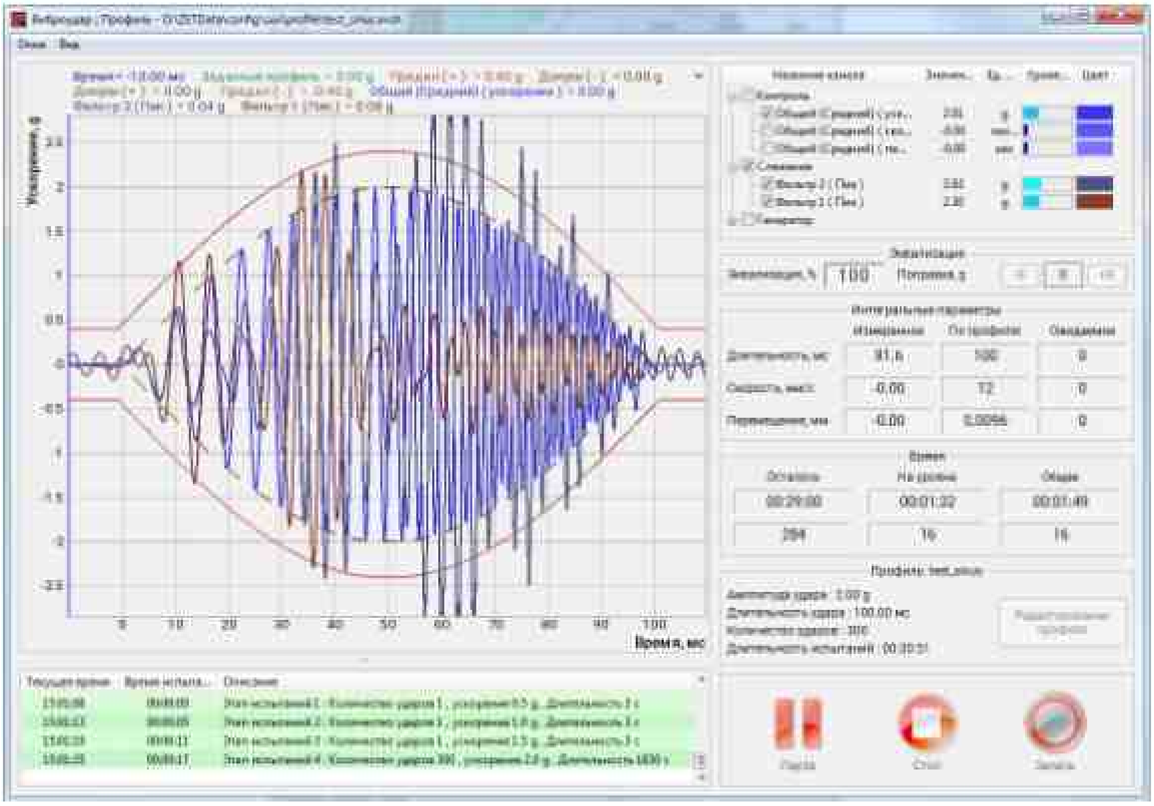


2) The "User defined transient" test program, the ability to control vibration tests via a common control channel has been added.



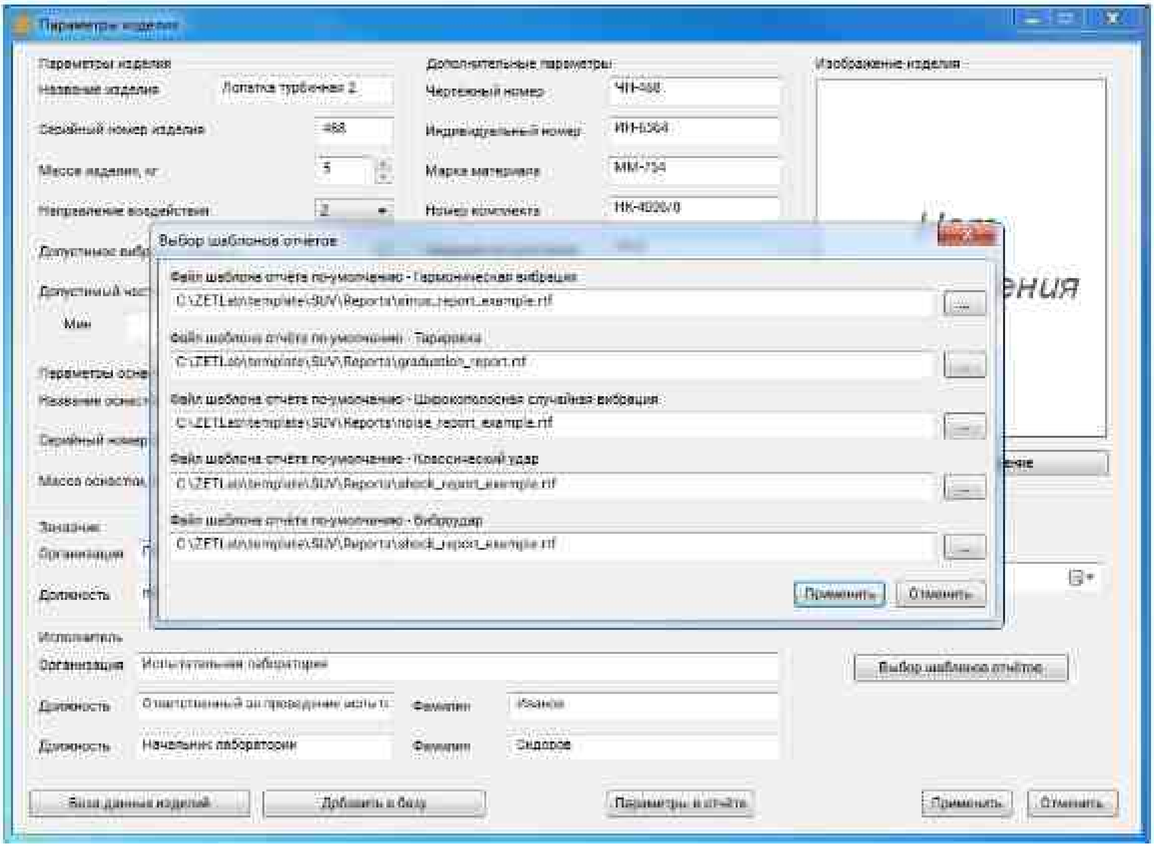




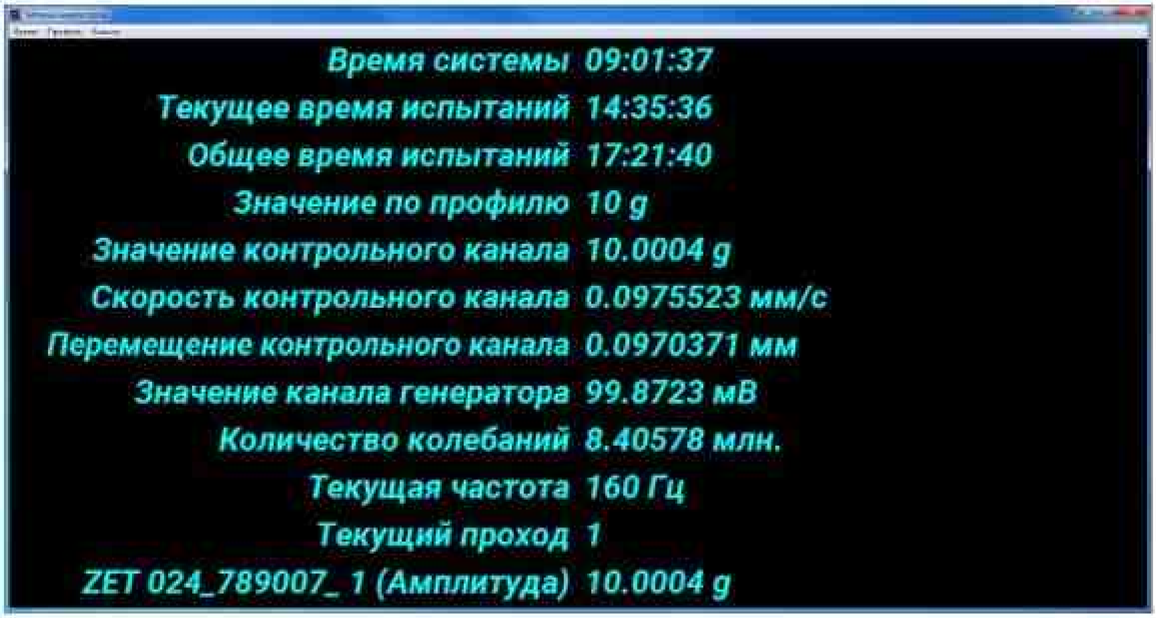


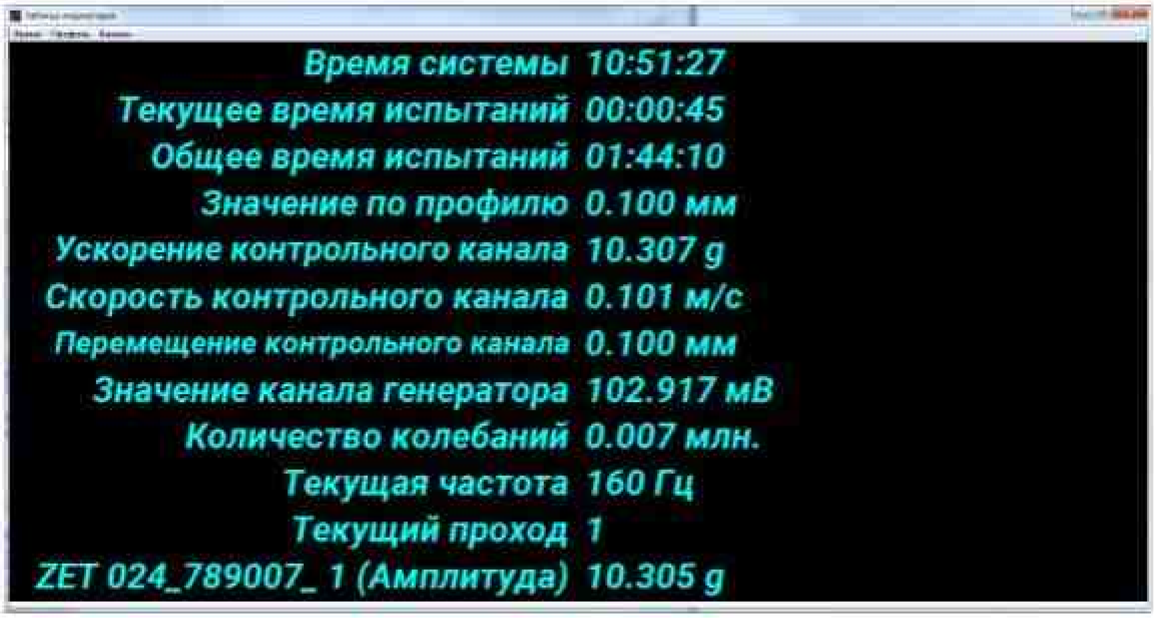
Vibration test control system (Sine)

1) Added the ability to create a template for a report and save a report on the results of vibration tests in RTF format.

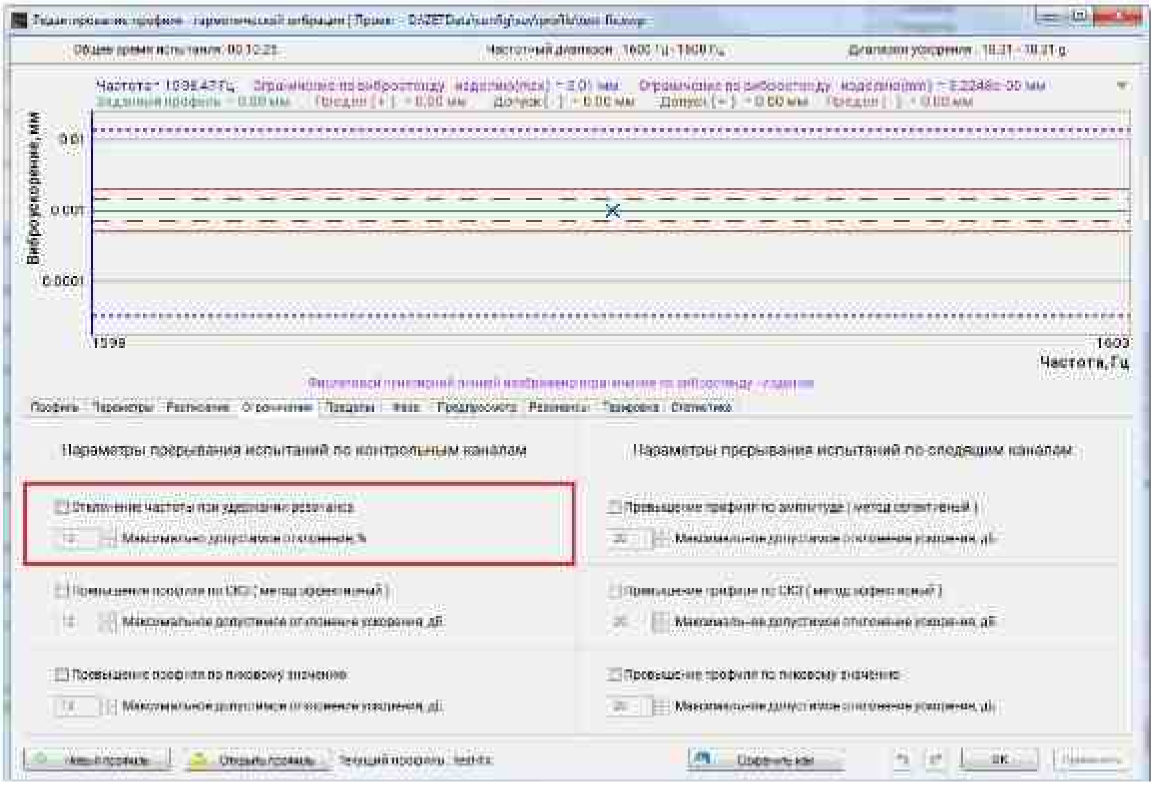


2) Added an additional window with large colored indicators of current parameters.

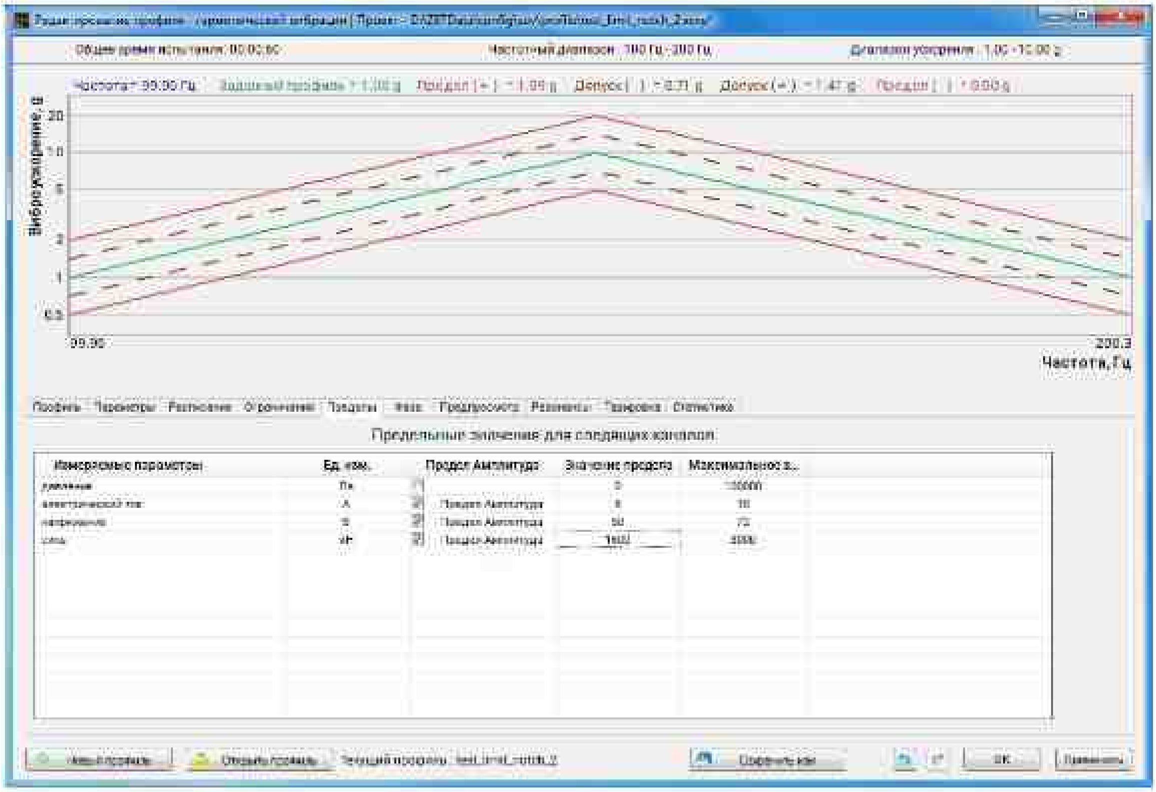




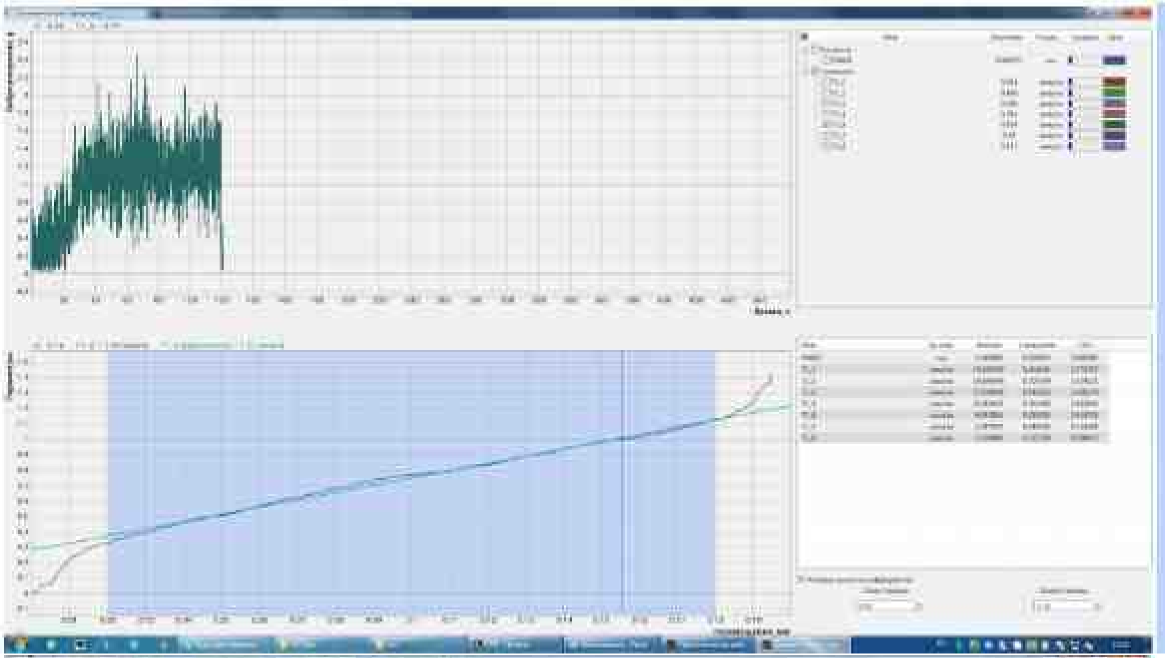
3) An option has been added in the profile editor to stop tests when the resonance frequency deviates from the initial one.

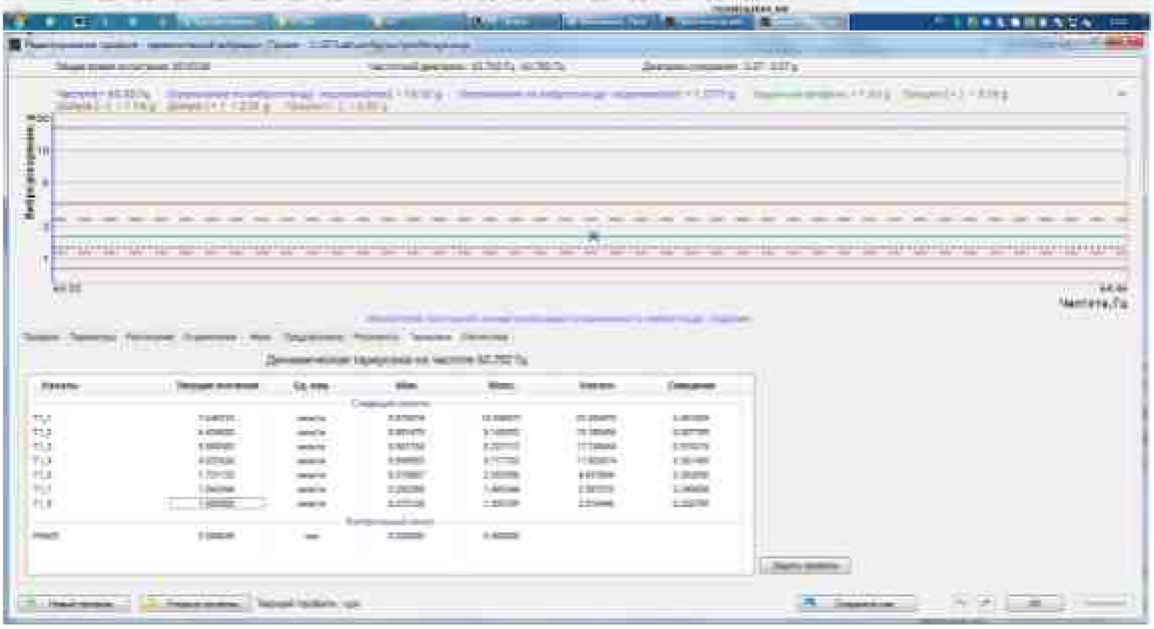


4) In the program for editing the test profile, the ability to set the parameters for interrupting tests when the specified limit of the measured physical quantity is exceeded



5) Added the option of dynamic graduation and measuring the non-linearity of the amplitude characteristic. Based on the results of dynamic graduation, you can also create a report in RTF format.





Composition of ZETLAB VIBRO programs .....

ZETLAB VIBRO – Shaker controller software,

<table>
<tr><th rowspan="2">Name of the program</th><th colspan="8">Composition of ZETLAB Software program sets</th></tr>
<tr><th>DEMO</th><th>ANALI</th><th>VIBRO</th><th>NOIZE</th><th>TENZ</th><th>SEISM</th><th>BASE</th><th>SENSOR</th></tr>
</table>

Signal analysis	FFT Spectrum	✓	✓	✓	✓	✓	✓	✓	✓
	Spectrum CPB Analysis	✓	✓	✓	✓		✓		
	Cross-Spectrum FFT Analysis	✓	✓	✓			✓		
	Cross-Spectrum CPB	✓	✓	✓	*		✓		
	Cross-Correlation analysis	✓	✓	✓			✓		
	Harmonic Distortion Analysis	✓	✓	✓	✓	✓	✓		
	Synchronous accumulation	✓	✓	✓	✓	✓	✓		
	Modal analysis	✓	✓	✓	✓	✓	✓		
	Histogram		✓	✓		✓	✓		✓
	Super-resolution spectrum		✓	✓		✓	✓		✓
	STA\LTA detector		✓	✓		✓	✓		✓
	Wavelet analysis		✓	✓		✓	✓		✓
Measurement	AC voltmeter	✓	✓	✓	✓	✓	✓	✓	✓
	DC voltmeter	✓	✓	✓	✓	✓	✓	✓	✓
	Selective voltmeter	✓	✓	✓	✓	✓	✓	✓	✓
	Frequency counter	✓	✓	✓	✓	✓	✓	✓	✓
	Phasemeter	✓	✓	✓	*	✓	✓	✓	✓
	Power meter	✓	✓	✓	✓	✓	✓	✓	✓
	Tachometer		✓	✓	✓	✓	✓		
	Torsiograph		✓	✓	✓	✓	✓		
	Encoder		✓	✓	✓	✓	✓		
	TR thermometer					✓			
	TC thermometer					✓			
	Strain Gauge Meter					✓			
	Vibration meter	✓	✓	✓	✓		✓		
	Data recording from third-party instruments (Agilent, etc.)		option	option	option	option	option	option	
Display	Multi-channel oscilloscope	✓	✓	✓	✓	✓	✓	✓	✓
	XYZ-oscilloscope	✓	✓	✓	*	✓	✓	✓	✓
	XYZ-plotter	✓	✓	✓	*	✓	✓	✓	✓

	Results viewing	✓	✓	✓	✓	✓	✓	✓	✓
	Signals gallery	✓	✓	✓	✓	✓	✓	✓	✓
Generators	Signals generator		✓	✓		✓	✓	✓	option
	Synchronous generator		✓	✓		✓	✓	✓	option
	Shaker parameters editor	✓		✓					
	Feedback generator (Shock)	✓		✓					
	Feedback generator (Vibroshock)	✓		✓					
	Feedback generator (Sine)	✓		✓					
	Feedback generator (Random)	✓		✓					

Table B.0.2 (continued)

		DEMO	ANALI	VIBRO	NOIZE	TENZ	SEISM	BASE	SENSOR
Recording	Signals recording		✓	✓	✓	✓	✓	option	option
	Signals archive converter		✓	✓	✓	✓	✓	option	option
	Signal trends viewing	✓	✓	✓	✓	✓	✓	✓	✓
	Signal trends scanner	✓	✓	✓	✓	✓	✓	✓	✓
	Event trends viewing	✓	✓	✓	✓	✓	✓	✓	✓
	Play recorded signals		✓	✓	✓	✓	✓	option	option
	Multi-channel recorder		✓	✓	✓	✓	✓	option	option
Metrology	AFR measurement log. (AC)		✓	✓			✓		
	AFR - log. scale (with selection of external generator)		✓	✓			✓		
	AFR - log. scale (DC)		✓	✓			✓		
	AFR - log. scale (AC/DC)		✓	✓			✓		
	AFR - lin. scale (AC)		✓	✓			✓		
	AFR - lin. scale (DC)		✓	✓			✓		
	AFR - log. scale (Selective)		✓	✓			✓		
	Log. Ph.-freq. response		✓	✓			✓		
	Lin. Ph.-freq. response		✓	✓			✓		

	Log. Total harmonic distortion factor		✓	✓			✓		
	Frequency response measurement in fixed frequency range (AC)		✓	✓			✓		
	Metrological self-check ZET7xxx		✓	✓			✓		
Automation	ZETView		option	✓	option	option	✓	option	option
	ZETView (exe)		✓	✓	option	option	✓	option	option
	Controller	✓	✓	✓		✓	✓	option	
	Arithmometer	✓	✓	✓	✓	✓	✓	✓	✓
	Adaptive filter 50 Hz	✓	✓	✓	✓	✓	✓	option	✓
	Signals filtration	✓	✓	✓	✓	✓	✓	option	✓
	Synchronization of instruments		*	*	*	*	✓	✓	
	Formula	✓	✓	✓		✓	✓	option	
	Switching unit control	✓	*	*	*	*	✓	✓	*
	Electrical circuits parameters control								
Network	Enable signals transmitter	✓	✓	✓	option	✓	✓	option	✓
	Connect to signals transmitter	✓	✓	✓	✓	✓	✓	✓	✓
	Connection of devices by Ethernet		✓	✓	✓	✓	✓	✓	*
	Connection of devices by Bluetooth	✓	*	*	*	*	*	✓	*
Service	ZETServer time	✓	✓	✓	✓	✓	✓	✓	✓
	Device manager	✓	✓	✓	✓	✓	✓	✓	✓
	Channels listening	✓	✓	✓	✓	✓	✓	✓	✓
	ZETLAB Error journal	✓	✓	✓	✓	✓	✓	✓	✓

Terms and definitions .....

The main terms and definitions are listed in the table (Table 61).

Table 61

Accelerogram	Recording displacement, velocity, or acceleration as a time function
Accelerometer	Primary converter (sensor) generating an electrical signal proportional to the registered acceleration
Amplitude	The largest (by module) instantaneous values determining the signal for the averaging period
Amplitude-frequency response (AFR)	The dependence of the amplitude of steady-status oscillations of the output signal of a certain system on the frequency of its input harmonic signal. Amplitude-frequency response is one of the types of "frequency response" of the system along with the phase-frequency response (PFR) and Amplitude-phase-frequency response (AFC)
Antiresonance	The frequency at which the response to the control signal (oscillator) is decreasing sharply (very small). Do not install sensors that will be assigned the Monitoring status (feedback channel) in areas of the test object with large antiresonances. If there are high value antiresonances, you can use multipoint control (by selecting "by average" or "by maximum" control mode in the Pre-Test) for several sensors with Monitoring status whose antiresonances are inconsistent in frequency.
Fast Fourier transform (FFT) spectrum analyser	Is now being used increasingly to improve performance reduce costs in RF design, electronics manufacturing test, service, repair. With increasing use of wireless technology used in the electronic circuit design of electronic devices, improved performance from spectrum analyzers is growing in importance. As the name suggests the FFT spectrum analyzer is an item of RF test equipment that uses Fourier analysis and digital signal processing techniques to provide spectrum analysis.
Cross-Spectrum CPB (Constant Percentage Bandwidth) Analysis	The program is used for transfer fractional octave (1/1, 1/3, 1/12, and 1/24 octave) spectral analysis of signals coming from the input channels of FFT Spectrum Analyzers (in real time or recorded time realization view mode), as well as for viewing various spectral characteristics of signals.
Gas turbine blades (SDS)	This is a separate component that makes up the turbine section of a gas turbine or steam turbine <159.>. The vanes are responsible for extracting energy from the high-temperature, high-pressure gas produced by the

	combustion chamber. Turbine blades are often the limiting element of gas turbines.
Gas turbine engines (GTE)	This is an engine that works by heating compressed gas, which in turn is fed to the shaft of a gas turbine. Compressed atmospheric air from the compressor enters the combustion chamber, then fuel is supplied there, which, when burned, forms a large amount of combustion products under high pressure. Then, in the gas turbine, the energy of the gaseous products of combustion is converted into mechanical work due to the rotation of the blades by the gas jet, part of which is spent on compressing the air in the compressor. The rest of the work is transferred to the driven unit. The work consumed by this unit is the useful work of the engine. Gas turbine engines have the highest specific power among internal combustion engines, up to 6 kW/kg. Anything that burns can be used as fuel, from gasoline to crushed coal.
Vibration generator system	The equipment including a Shaker with a power amplifier
Imaginary reference point	A reference point to which a certain signal is assigned, produced by vibration signals from several verification points (with measuring channels in the Control status) and used to control the test mode (multipoint control) so that to meet the test requirements
Reproducibility	The proximity of measurement results of the same unidad with the same value carried out by different methods, with different primary converters (sensors), by different operators, in different testing laboratories, at different times, the interval between which is significantly longer than the time of one measurement.
Averaging time	The time interval for sampling instantaneous signal from the recorded stream to the instantaneous value array for further processing of the array.
Boundary points	The points used for building vibration test profiles for Sine and Random
Effective vibration	Vibration characterized by signal from a sensor installed at the reference point.
Decibel (dB)	The unit of measurement of a physical quantity relative to the selected reference value, expressed as the logarithm lg (based on 10) of the ratio of the physical quantity value to the reference value. In the ZETLab vibration control system, the reference value is equal to one; therefore, for converting values in linear physical quantities "x" to dB, the formula is: dB = 20lg(x), and in the case of physical quantities with the power unidad "x2", the formula is: dB=10lg(x2)
Dynamic range of the measuring channel	It is defined as the ratio of the maximum level of recorded signals to the minimum recorded level. The theoretical limit for a 24-bit ADC is 140 dB,

	but the actual dynamic range is reduced due to interference and distortion in the system.
Dynamic range of the control signal	It is defined as the ratio of the maximum value of the signal generated on the control channel to its minimum value. For Sine mode, if the control signal changes from 1 mV to 10 V, the dynamic range is 10000 times = 80 dB. For Random (BRV) mode, the maximum value and minimum value of the control signal are measured by the power spectral density. The dynamic range of the vibrating system in whole is determined not only by the dynamic range of the VCS's DAC controller, but in any particular test may be limited to other factors, such as noise level at the Shaker table (recorded without control signal), a dynamic range of the vibratory installation, the maximum allowable vibration level in testing, etc.
Duration of the shock impulse	The time interval from the beginning to the end of the shock impulse which is a strong part of the accelerograms.
Quality factor	This is a measure of resonance sharpness which is inversely proportional to the logarithmic decrement of attenuation. When testing specimens with high-quality resonances for sinusoidal effects, set high frequency resolution (a large number of frequency bands) and reduce the sweep rate
Units	You can connect sensors to the VCS controllers inputs to record various physical quantities, such as acceleration (m/s^2, mm/s^2, g), displacement (m, mm, micron), velocity (m/s, mm/s), therefore, to obtain valid results, for the measurement channels set units which correspond to the types of sensors being connected. *Note: Units of measurement for primary converters (accelerometers) are listed in their respective datasheets.*
Strong part of **the accelerogram**	For a classic shock: a part of the accelerogram between two points in time, when the signal reaches 10% of the peak value for the first time and when it falls below this level for the last time. For a vibration shock: a part of the accelerogram between two points in time, when the signal reaches 25% of the peak value for the first time and when it falls below this level for the last time
Measuring channel (control/tracking/viewing)	The input channel (ADC channel) of the VCS controller with connected primary converter used for vibration tests. Measuring channels can be assigned the Control, Tracking, and Viewing status during vibration testing. The Control status determines that data from the measuring channel are used for generating a control signal, including an emergency stop of vibration tests upon exceeding the thresholds defined on the Profile tab of the test profile editor window.

	The tracking status indicates that measurement channel data are used to initiate an emergency stop of vibration tests when the thresholds defined on the Stop tab of the test profile editor window are exceeded. The Viewing status indicates that measurement channel data are not involved in the vibration tests control and are only used for visualization of the recorded signals.
Instrumental error	A set of errors introduced by both analog devices connected to the controller inputs and the VCS controller itself.
True spectral density of acceleration	The spectral density of acceleration affecting the specimen under test.
Feedback channel	The control system channel is used for: signal digitization at the reference point, signal processing and conversion of the processed signal into analog format to feed to the power amplifier of the Shaker.
Control channel	The VCS controller's oscillator channel used for generating the control signal.
Emergency stop button	The button located to the right on the front panel of the VCS controller and intended for emergency stop (STOP mode) of transmitting control signal to the Shaker.
VCS controller	ZET 024 or ZET 028 model devices provide one output control channel (DAC) and, respectively, four or eight measurement channels (ADC).
Reference point	One of the verification points (with the measuring channel with Control status), the signal from which is used to control the test mode (single-point control) in a way to meet the test requirements.
Correction	Procedure for minimizing the error in reproducing the acceleration spectral density
Maximum control voltage	Voltage threshold at the control channel (oscillator) output of the VCS controller
Instantaneous value of the signal	The signal amplitude value registered for a single ADC count.
Multipoint control	Control by signals averaged by analog method or other suitable mean, recorded by measuring channels from vibration sensors installed at several verification points.
Observed acceleration spectral density	Visualized acceleration spectral density on the VCS monitor, including instrumental error, random error, and offset.
Normative technical documentation (NTD)	State standard, enterprise standard, specifications, technical descriptions, regulations and other documentation fixing the requirements for specimen quality
Test Object	A specimen subjected to vibration tests.

Single-point control	Control by a signal recorded by the measuring channel from the vibration sensor installed at the reference point, to keep the specified vibration level at this point.
Cutoff of the drive signal	Limiting the maximum drive signal at the level determined by the peak factor value.
Primary converters	Sensors converting various physical quantities (acceleration, velocity, displacement, deformation, temperature, etc.) into an electrical signal proportional to the effect of the physical quantity.
Peak factor	The ratio of the peak value to RMS value of the signal.
Measure of inaccuracy in reproducing the acceleration spectral density	The difference between the specified acceleration spectral density and the acceleration spectral density of the control signal.
Transverse vibration	Vibration acting in a direction other than the specified direction (usually defined in two orthogonal axes in a plane perpendicular to the specified direction of movement. Please note that the transverse vibration must be measured close to the attachment points.
Preferred directions of vibration action	Three mutually orthogonal directions chosen to ensure the maximum probability of damage to the test object in case of vibration exposure in these directions.
Verification point	The sensor installation points (with measuring channels with Tracking status) on the attachment device, vibration table or test object, located as close as possible to the attachment points of the test object (rigid connection) and used to monitor compliance with the test requirements.
Vibration test profile	Defines a profile required by the test conditions, which must be provided during vibration tests by generating a required signal through the control channel. For tests with Random and Sine, the profile is determined in the frequency domain, and for tests in shock mode - in the time domain.
The frequency resolution	The width of the frequency increment interval in the acceleration spectral density view (in Hz)
Recording	Processing a set of readings (recorded in measuring channels at regular intervals) using the fast Fourier transform algorithm.
Control mode (by one, by average, by maximum)	There are three control modes used as a basis for generating control signal: in "by one" mode, the control signal is generated based on data recorded in a single control channel. In the "by average" mode, the control signal is generated based on the average values recorded in a group of channels selected for control. In the "by maximum" mode, the control signal is generated based on the maximum values recorded in a group of channels

	selected for control. The "by average" mode and "by maximum" mode refer to multipoint control.
STOP mode	In this mode, the emergency stop button on the right pane of the front panel of the VCS controller is pressed.
RPM (Rounds Per Minutes)	is an instrument for measuring the speed of rotation on a shaft or on a disk, as in an engine or other machine.
Resonance	The frequency at which the response to the control signal (oscillator) increases sharply (very high). When examining the specimen's fatigue characteristics, exposure to resonant frequencies is used.
Results of the Pre-Test	A list of parameters saved based on the results of the Pre-Test and relevant until the next one or until the expiration of the time of day in which the Pre-Test was conducted
Profile segment	A section of the vibration test profile bounded by adjacent frequency boundary points
Control signal	Output voltage of the control channel (oscillator) of the VCS controller used to excite the Shaker
Vibration control system (VCS)	Is a hardware and software system used for generation of the signals applied to the input of the shaker amplifier in compliance with the set test profile. The system is also used for recording of the response from the transducers installed at the moving part of the system and at a sample under test.
Signal attenuation rate	When stopping vibration tests, the control signal (oscillator) must attenuate smoothly, otherwise the test object may be subjected to shock. The control signal strength reduction can be selected from 20 dB/s to 60 dB/s
Random inaccuracy	Estimation error the acceleration spectral density that varies from one measurement to another and is caused by finite time of signal averaging and the finite filter bandwidth
High-frequency roll-off	A section of the acceleration spectral density at frequencies higher than the upper limit of the effective test frequency range
Low-frequency roll-off	A section of the acceleration spectral density at frequencies lower than the lower limit of the effective test frequency range
Acceleration spectral density (ASD)	Frequency function defined as the limiting ratio of the mean square value of the acceleration signal after it passes through a narrow-band filter whose geometric mean frequency coincides with the specified one, to the filter bandwidth as the bandwidth tends to zero and the averaging time to infinity.
The acceleration spectral density of the control signal	Acceleration spectral density of a signal measured at a reference point (real or imaginary)

Signal root-mean-square (RMS)	The square root of the sum of squares of instantaneous signal values recorded during averaging
Standard deviation	The characteristic of a random time signal that is consistent with the RMS value for a vibration signal
Static degree of freedom	A value that characterizes the properties of estimating the acceleration spectral density obtained by random samples with time averaging method, and depends on the frequency resolution and time of averaging.
Small arms and cannon shock (SACS)	For testing specimens for resistance to random vibration in the mode SACS
Steady-status accuracy	The ratio of true acceleration spectral density to the observed one
The current value of the parameter (TP)	Used in Object Monitoring in the Parameters Editor
Response measurement point	Sensor installation points (with measuring channels with Viewing status) on the test object, the signals from which are not involved in the vibration test control, but used only for examining its frequency response.
Attachment point	A part of the test object which is in contact with the attachment device or vibration table in the place where it is usually attached during operation. If a device used during the operation of the test object is used for testing, the attachment point is determined on this device rather than on the test object.
Control by the maximum value	A method for determining the signal in multipoint control by selecting the maximum value of the controlled parameter for each frequency component at least in two verification points whose measuring channels are assigned the "Monitoring" status
Control by average value	Method for determining the signal for multipoint control by averaging each frequency component at least in two verification points whose measuring channels are assigned the "Monitoring" status.
Acceleration	A vector value determining the degree of velocity change over time.
Acceleration of gravity	Acceleration of gravity is rounded to the closest integer, i.e. up to 10 m/s^2.
Averaging (linear/exponential)	The time interval during which instantaneous signal values are sampled from the recorded data stream to the array for further array processing. It is used to improve statistical accuracy or suppress interferences. In case of linear averaging, each data element contributes the same amount to the average value. Linear averaging is usually used for limited time intervals, since for large time intervals, the last added values actually no longer affect the resulting averaged value. In case of exponential averaging, each last averaged value has a greater weight than those involved in the averaging earlier, so it can be used at infinite intervals. The average value will dynamically reflect the influence of the new recorded values involved in averaging, and the influence

	of the previous ones will decrease as they age. The degree of exponential averaging is determined by a weighting factor calculated as reciprocal value of the number of averaging.
Frequency	The number of vibrations or cycles per unit of time. Unit of measurement is Hz.
Sampling frequency (sampling)	In relation to the measuring channels, it refers to the number of analog-to-digital conversions per second for each recorded measuring channel, in relation to the control signal, it refers to the number of digital-to-analog conversions per second when generating the control signal. The ZETLAB programs processing a digital signal require a data array from a set of recorded instantaneous values of the processed signal amplitude accumulated during averaging, and the frequency of recording instantaneous values is determined by the sampling frequency. Thus, the higher the sampling frequency, the larger the array becomes at the same averaging time. The accuracy of the measurement results is directly related to whether the averaging time and sampling frequency are properly set. The best measurement results are achieved when providing the required level of detail without unneccesary redundancy. For VCS with max. 48 channels, the sample rates are set to 25 kHz for measuring channels and 50 kHz for control channels. For VCS with 49 to 160 channels, the sample rate values are set to 2.5 kHz for measuring channels and 5 kHz for control channels.
Resonance frequency	The frequency value typical for an object susceptible to vibration, at which the following is recorded: increase in vibration amplitude of the object and the difference between the vibration effect phase and oscillation phase of the object equal to 90 degrees
Frequency range for testing	The range between the lower and upper limit in the frequency domain defined in the test profile.
Number of degrees of freedom	Indicates the number of independent variables used in calculating the average value. It is used in averaging for the Random control. Each averaging adds two degrees of freedom. The more degrees of freedom, the more accurately the spectral power density of the broadband signal is calculated
The peak width at -3 dB	The bandwidth between two frequency response points located at 0.708 of its maximum value, assuming that the frequency response in this bandwidth describes a single resonance peak
Random	The signal generated on the control channel (when testing Random) is noise randomly distributed over a wide range in the frequency range
Stage of tests	A test program element occupying a line in the schedule table
Effective test frequency range	The range between the lower and upper limit in the frequency domain defined in the test profile. Remember that beyond the effective frequency range, there

	are also signal components due to lack of sharp drop in the acceleration spectral density curve at the profile boundaries.

Common mistakes when working with VCS ZETLAB .....

Contents

Influence of the installation horizon of the shaker frame on the amount of transverse vibration .....

Influence of the installation horizon of the Shaker frame on the amount of transverse vibration

On *Fig. 21.1* a graphic of non-linear distortions is presented, taken with a slight deviation of the Shaker frame from the horizon (frame deviation within 2 degrees), and *Fig. 21.2* - with a horizontal position of the bed. The Shaker during comparative tests was loaded at 60% of the maximum allowable load weight, and the impact level was 25% of the maximum allowable, taking into account the established mass.

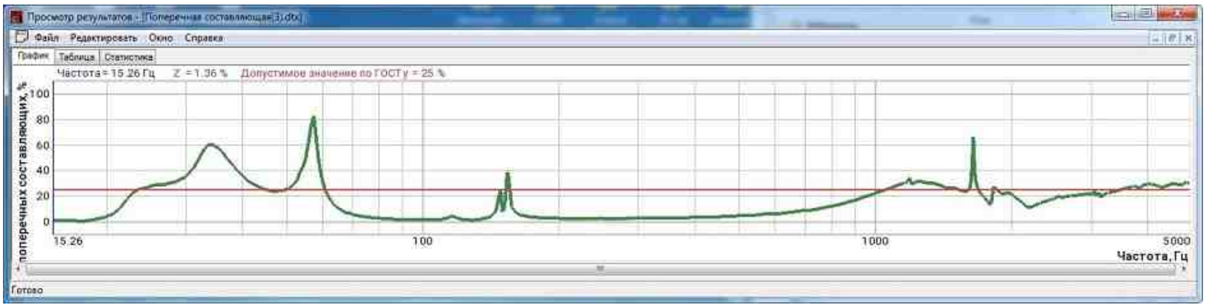


Fig. 21.1. The frame is deflected from the horizontal

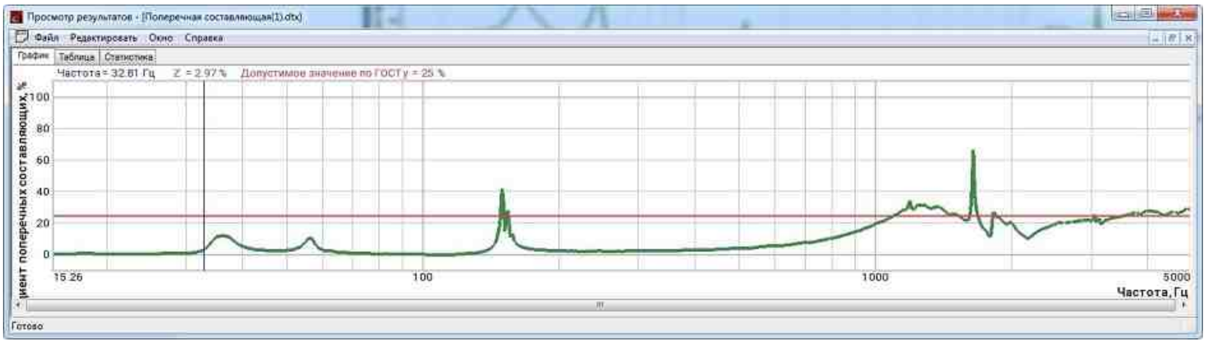


Fig. 21.2. The frame is set horizontally

The graphics show that in the resonance region of the suspension (20 ... 50 Hz) even with slight deviations from the horizontal, a significant level of transverse oscillations occurs on the Shaker, which can be an obstacle both at the stage of certification and during testing, especially when setting significant levels of impact.

Bad contact in the control signal cable .....

Bad contact in the control signal cable

On *Fig. 21.3* an example of a negative result of passing a Pre-Test performed on a Shaker with an expansion table is presented. The conclusion about the low quality of the results of the Pre-Test is made primarily by the high level of the coefficient of nonlinear distortion (a level close to 0 dB). The "Signal quality" parameter (in the results table) also indicates a low quality of the results of the Pre-Test and has a value less than 90% (highlighted in yellow or red).

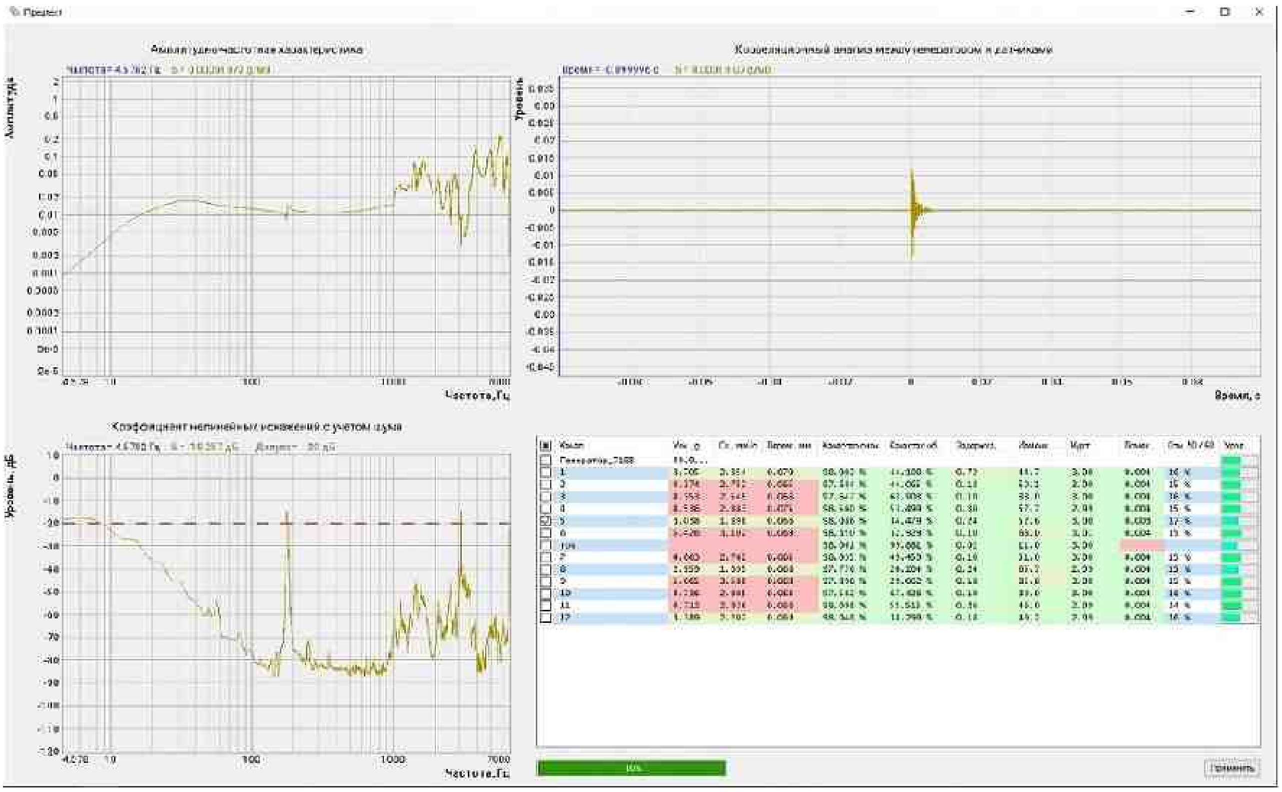


Fig. 21.3. Negative result of the Pre-Test

In this case, before starting the tests, it is necessary to understand the cause of the negative result of the Pre-Test. To do this, in the "Pre-Test" program window, you should  activate the "Recommendations" button and in the window that opens, pay attention to the proposed options for possible malfunctions and, if necessary, eliminate them. If none of the recommendations offered help, try to check the options proposed below sequentially:

- poor grounding;
- bad contact;
- faulty cable;
- faulty sensor;

After troubleshooting, it is necessary to re-pass the Pre-Test and make sure that the result of passing the Pre-Test is positive. On *Fig. 21.4* an example of a positive result of passing the Pre-Test after troubleshooting a malfunction associated with a bad contact in the control cable is presented.

Канал	Уск., g	Ск., мм/с	Перем., мм	Качество сигн.	Качество об...	Задержка, ...	Изменч., ...	Курт.	Помех...	Отн. 50 / 60	Уров...
Генератор_7188	49.9...										
1	3.705	2.354	0.070	98.002 %	44.108 %	0.72	44.7	3.00	0.004	16 %	
2	4.374	2.752	0.065	97.684 %	44.065 %	0.18	50.1	3.00	0.004	15 %	
3	4.353	2.545	0.066	97.647 %	63.903 %	0.10	38.0	3.00	0.004	16 %	
4	4.536	2.883	0.075	98.560 %	53.499 %	0.30	57.7	2.99	0.004	15 %	
5	3.038	1.898	0.066	98.086 %	34.479 %	0.24	52.6	3.00	0.003	17 %	
6	5.426	3.102	0.069	98.350 %	32.929 %	0.10	68.0	3.01	0.004	15 %	
ток				98.061 %	99.681 %	0.02	11.0	3.00			
7	4.863	2.762	0.065	98.035 %	49.459 %	0.10	51.0	3.00	0.004	15 %	
8	2.959	1.895	0.066	97.776 %	20.204 %	0.24	65.7	2.99	0.004	15 %	
9	5.665	3.580	0.068	97.898 %	29.062 %	0.18	85.8	3.00	0.004	15 %	
10	4.736	2.805	0.064	97.582 %	67.426 %	0.10	39.0	3.00	0.004	16 %	
11	4.712	2.936	0.066	98.098 %	55.515 %	0.26	46.0	2.99	0.004	14 %	
12	3.389	2.202	0.069	98.048 %	38.299 %	0.18	49.2	2.99	0.004	16 %	

Fig. 21.4. Positive result of the Pre-Test

Poor Pre-Test quality due to poor grounding .....

Poor Pre-Test quality due to poor grounding

On *Fig. 21.5* an example of a low quality result of passing a Pre-Test performed on an empty Shaker (without an expansion table) is presented. The conclusion about the low quality of the results of the Pre-Test was made primarily by the high level of the coefficient of non-linear distortion in the low-frequency region (the level is higher than minus 20 dB). The "Signal quality" parameter (in the results table) also indicates a low quality of the results of the Pre-Test for an empty Shaker and has a value less than 98%. A positive result of the results of the Pre-Test (for an empty table of the Shaker) is considered to be a signal quality level of at least 99%.

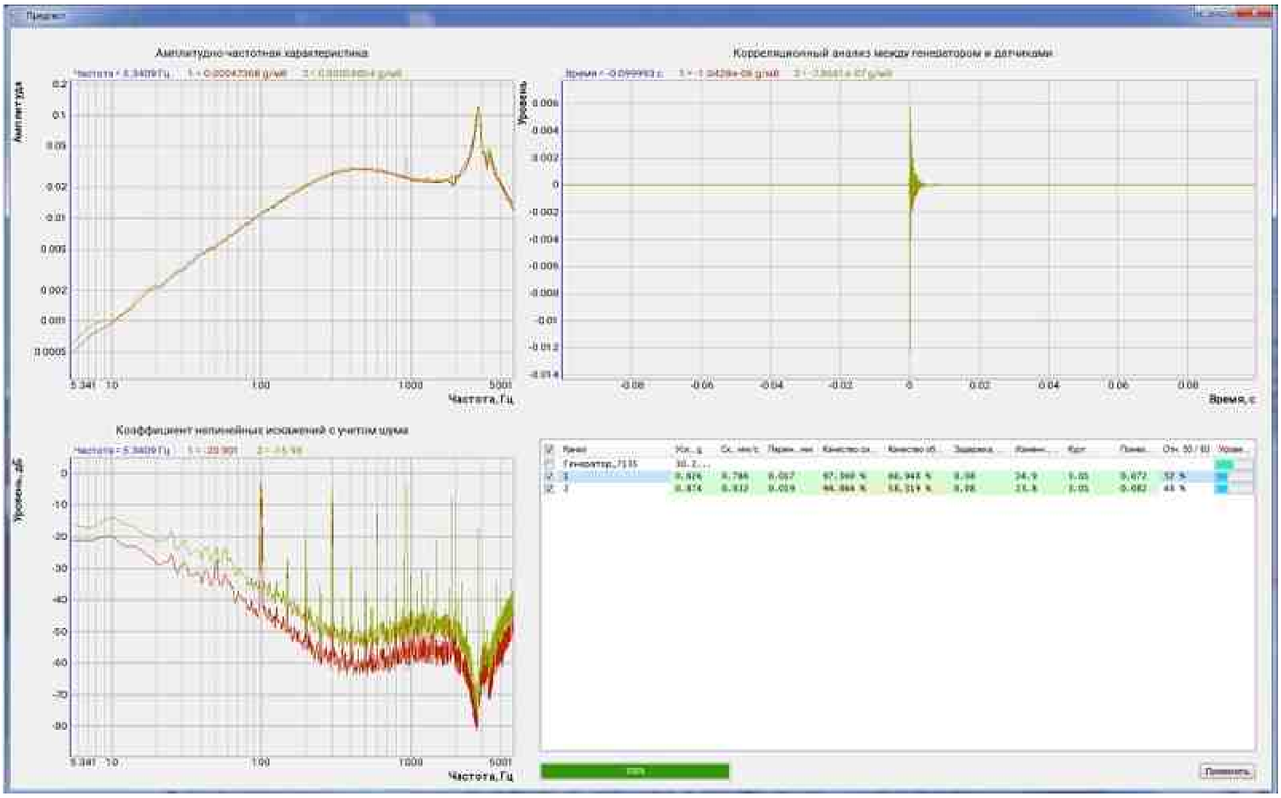


Fig. 21.5.Poor quality of the Pre-Test result

After the grounding was completed, the Pre-Test was repeated, the results of which are shown on *Fig. 21.6*. The Fig. shows that the level of the coefficient of non-linear distortion in the low-frequency region has significantly decreased (it has become lower than minus 30 dB), and the signal quality has also increased (it has become higher than 99%).

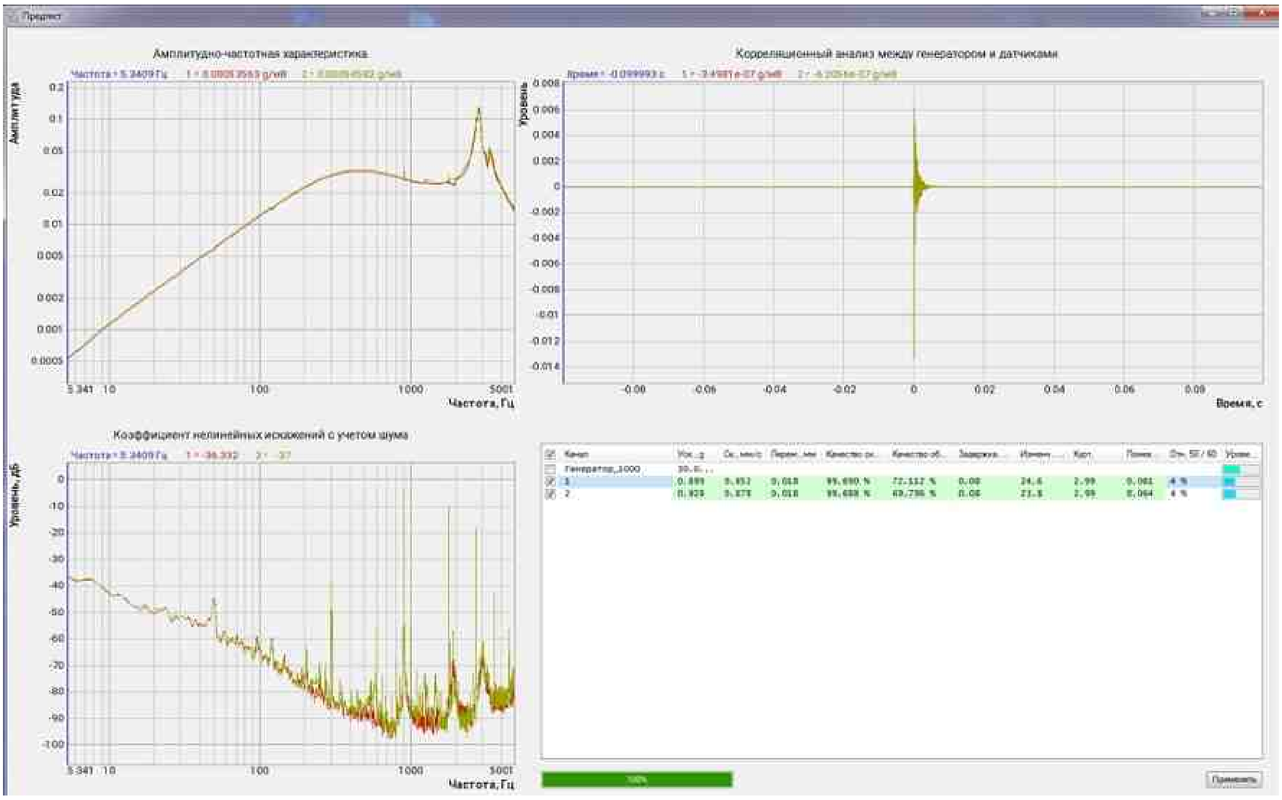


Fig. 21.6 High quality of the Pre-Test result

High level of non-linear distortion .....

High level of non-linear distortion

In accordance with the requirements of GOST25051.4-83, the harmonic coefficient for electrodynamic shakers is set at a level not higher than 10%, however, at medium and high power of the Shaker amplifier, one can often encounter a situation in which, in a significant region of the frequency range, there is an excess of 10% of the level (*Fig. 21.7*).

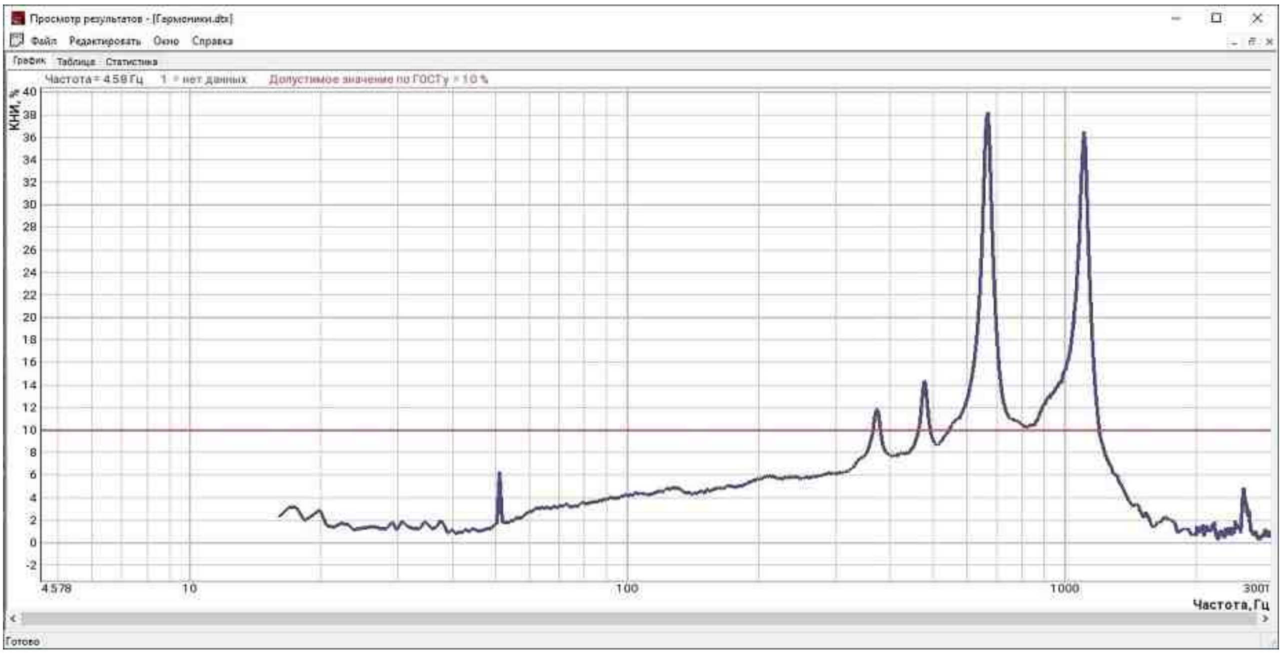


Fig. 21.7. Total harmonic distortions on a Shaker with suspension resonance 3300 Hz

The reason for the high level of non-linear distortions recorded on electrodynamic shakers is most often the amplification of harmonics present in the signal at the output of the Shaker amplifier by the resonance of the moving part of the Shaker.

On the Fig. *Fig. 22.7* you can see the excess of the permissible level of 10% where the peaks of the excess correspond to the coincidence with the resonance (at a frequency of 3300 Hz) of the moving part, respectively, of the ninth, seventh, fifth and third harmonics of the applied sine signal.

Thus, even relatively small (within 1%) levels of non-linear distortion at the amplifier output, when multiplied by the quality factor of the resonance, lead to the non-linear distortion recorded in the signal from the sensor installed on the moving part of the Shaker going beyond the tolerance.

On the grafic (*Fig. 22.8*) the nonlinear distortions in the signal generated at the output of the Shaker amplifier are shown, and on the graphic (*Fig. 22.9*) non-linear distortions recorded already from the sensor of the Shaker located on the table (with a resonant frequency of the moving part of 6000 Hz and a quality factor of 35). It can be seen that with a total harmonic level of about 4%, the contribution of each of the harmonics (amplified by a factor of 35 at the resonance frequency) leads to an excess of the allowable level of 10%.

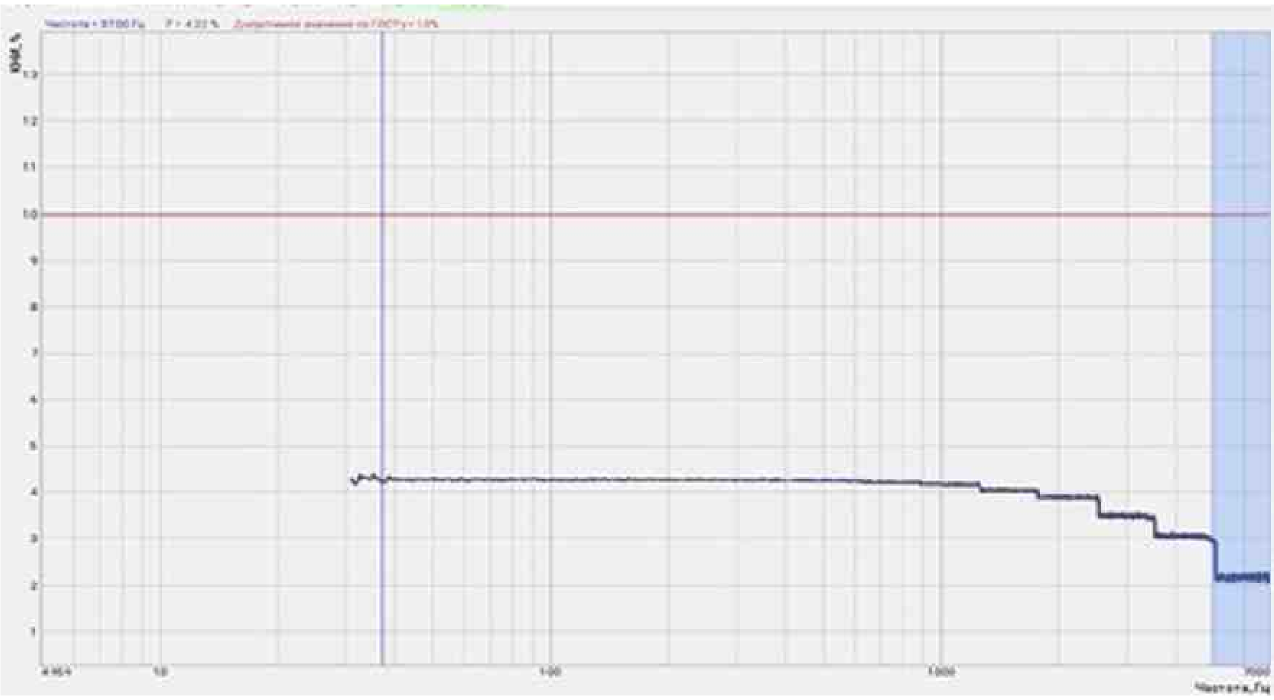


Fig. 21.8. Total harmonic distortions at the output of the Shaker amplifier

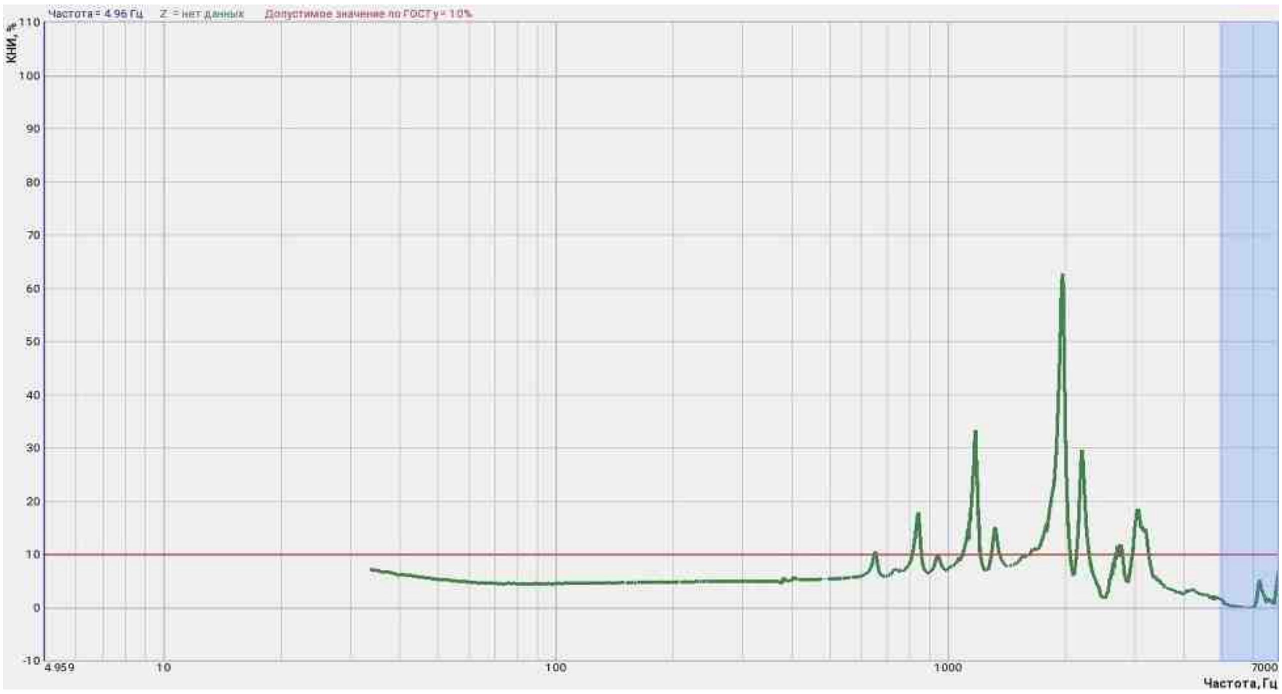


Fig. 21.9. Total harmonic distortion on a Shaker with 6000 Hz suspension resonance

Signal analysis

Program in signal Analysis allow the analysis of signals, using different algorithms.

There are programs for vibration analysis program for the analysis of seismic signals and General analysis programs.

Many of the programs analysis formed the basis of ready-made solutions such as for system control of seismic effects, for system monitoring and diagnostics of structures of buildings, to balancing rotors and shafts, etc..Program in signal Analysis allow the analysis of signals, using different algorithms.

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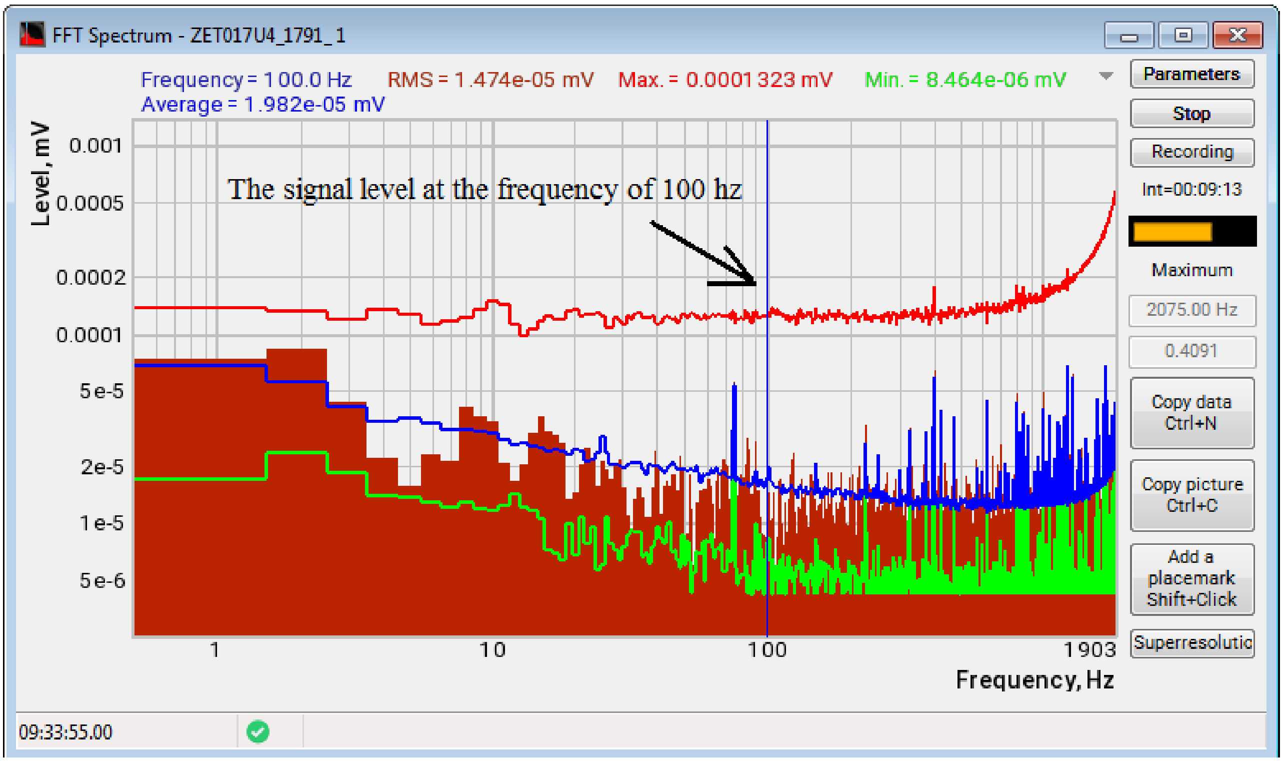
FFT Spectrum Analysis .....

The program **FFT and DFT (Fast and Discrete Fourier Transform) Analysis (FFT Spectrum)** is used for narrow-band spectral processing of signals coming from the input channels of ADC modules and FFT Spectrum Analyzers (in real-time or recorded time realization view mode), as well as for viewing various spectral characteristics of signals.

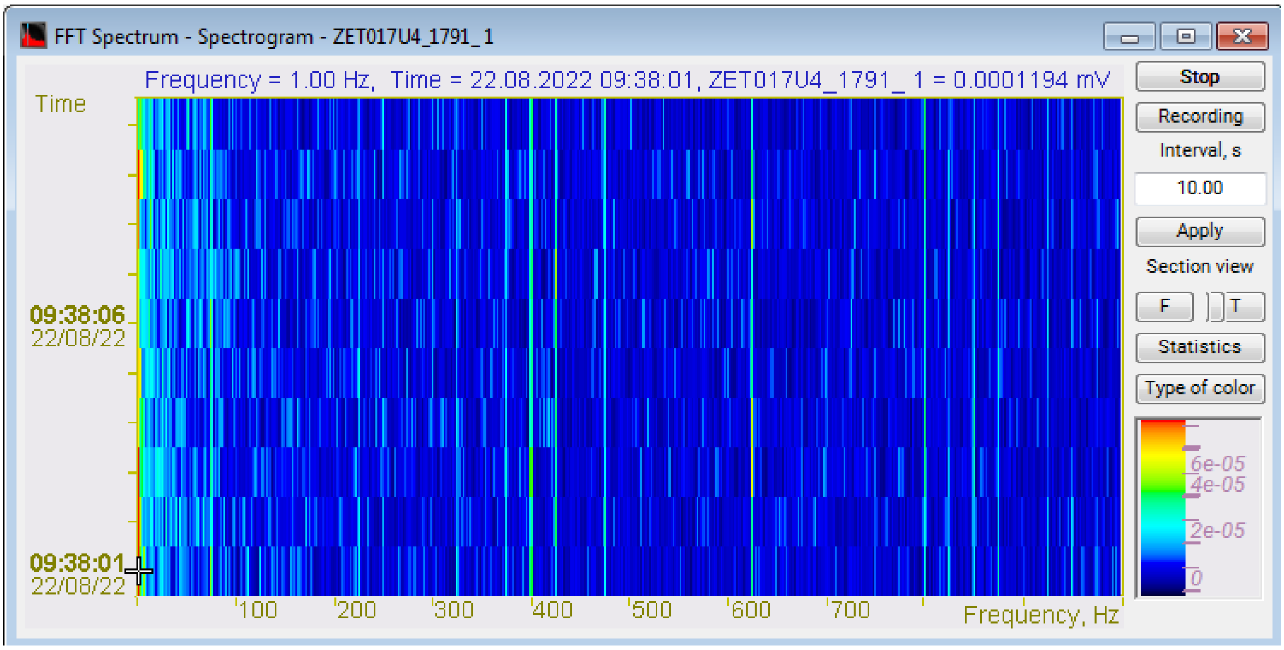
Spectral analysis is used for dividing signals into basic constituents in the frequency area. This analysis is based on signal time realization decomposition into the frequency spectrum with an even frequency increment by means of Fourier transform.

Using the **FFT Spectrum Analysis**, based on the spectrum form, the user can determine the presence of any signal tones (discrete constituents) and noise components in the measuring channel. Additional options of spectrogram building (in a 2- and 3-dimensional view) enable tracking of the non-stationary processes dynamics. A spectrogram is a spectral time representation of a signal, calculated for even time intervals. Plotting of the spectrogram cross-sections based on time and frequency values enables control of the non-stationary processes parameters.



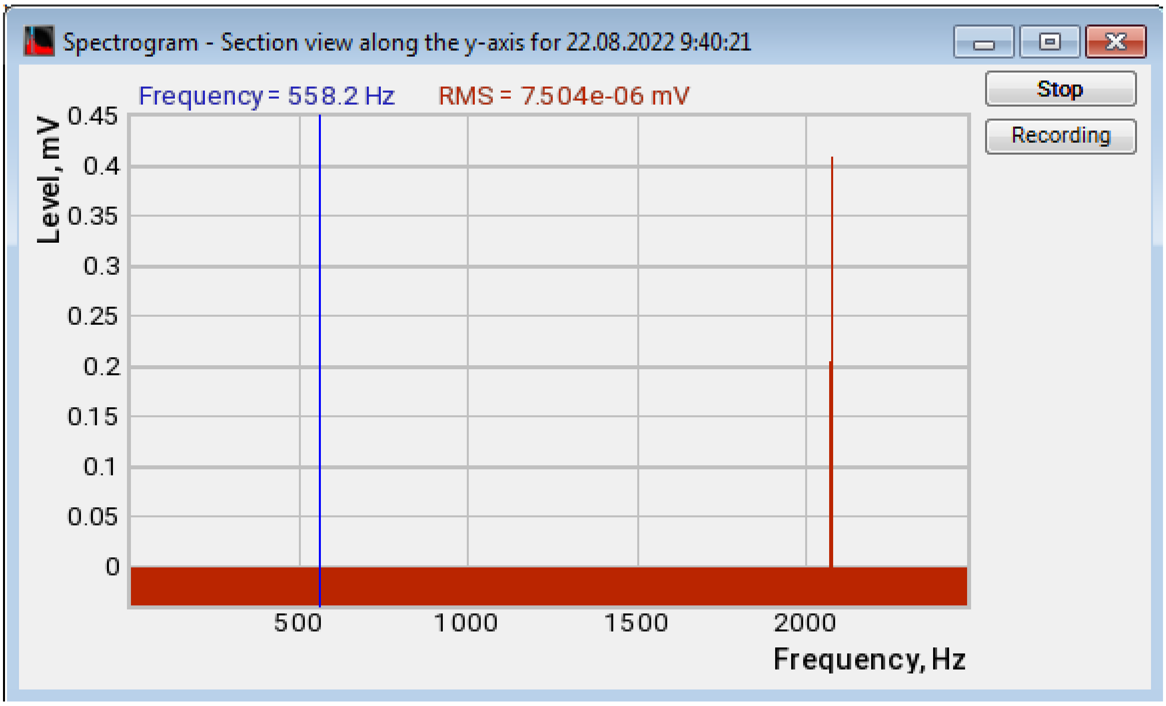
Signal FFT Spectrum

The possibility to obtain the maximum and averaged spectra values and to compare them with their pre-set spectra (norm) enables evaluation of the difference between the pre-set and actual spectrum level.

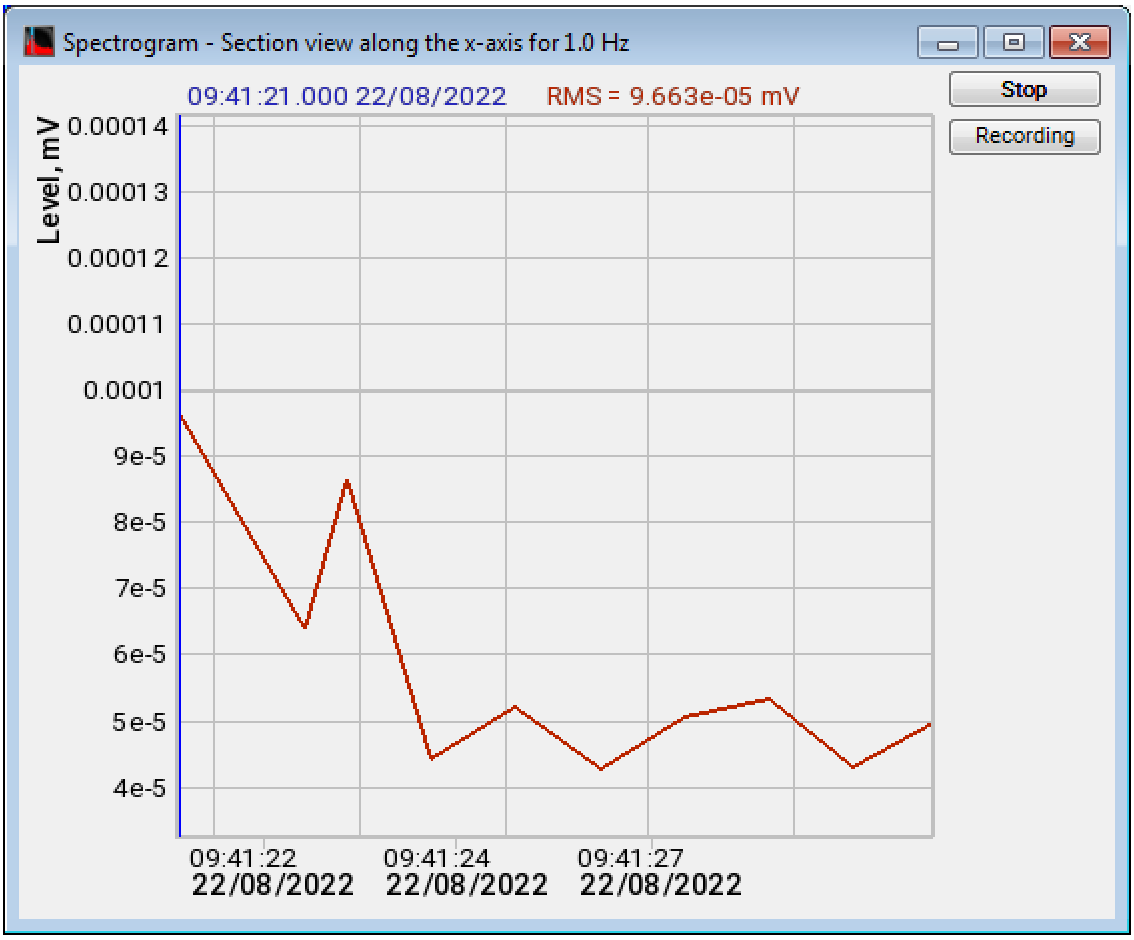


The spectrogram of the signal FFT Spectrum

The construction of sections of the spectrogram in time and frequency makes it possible to measure the parameters of non-stationary processes.



Spectrogram - Cross-section along y-axis



Spectrogram - Cross-section along x-axis

The possibility to obtain the maximum and averaged spectra values and to compare them with their pre-set spectra (norm) enables evaluation of the difference between the pre-set and actual spectrum level. This option is necessary for various types of equipment monitoring, input/output control.
Simultaneous spectral analysis in various frequency bands of one and the same signal allows to observe the spectrum both in the entire frequency band (panoramic mode) and a detailed spectral analysis in the selected frequency bands. It is necessary if the signal has several high or low-frequency discrete constituents.

High-frequency resolution (up to 32,000 bands) allows to accurately determine the frequency of a stationary signal tone and to divide several adjacent frequency components. Such situation often occurs during vibroacoustic analysis of various mechanisms with electric drive. In the range about 50 Hz, several discrete constituents are typically determined, which are related to the electromagnetic blast, mechanical oscillations caused by the rotation of an asynchronous engine. All of these sources are typically located in a band of up to 0.5 Hz.

When analyzing noise components, discrete constituents on the spectrum could be quite disturbing. The program provides an option *Clearing spectrum from discrete constituents (DC)*. This function suppresses all stationary signal tones.

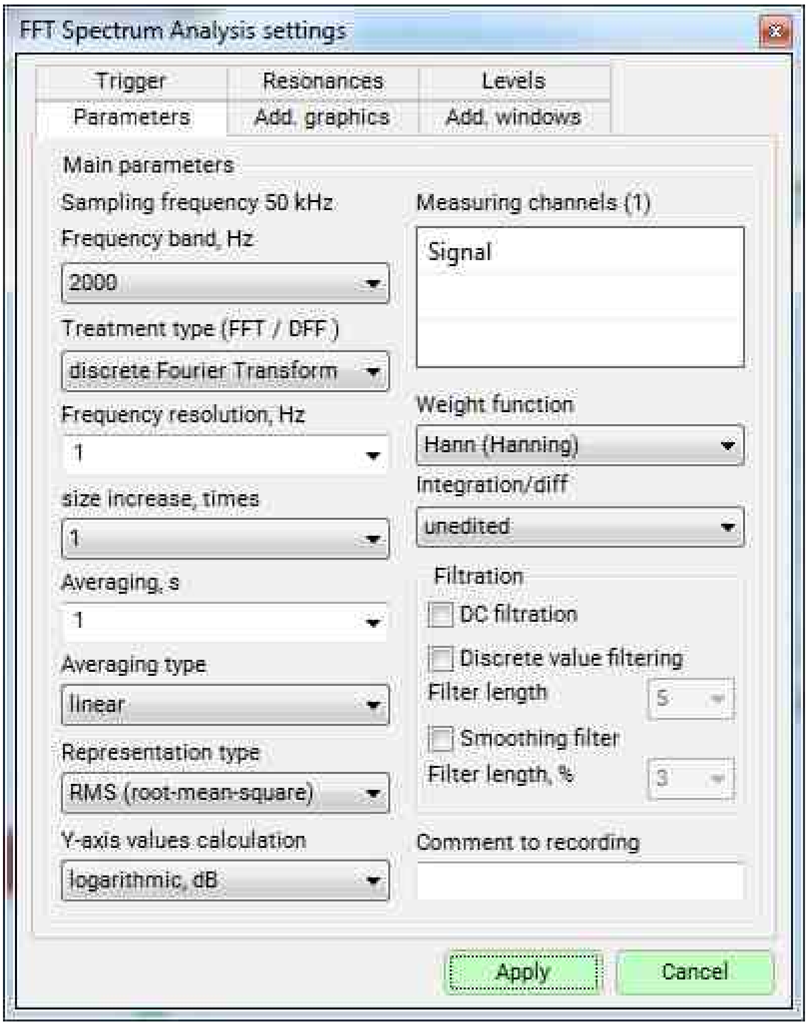
Piezoelectric accelerometers are usually used for vibroacoustic analysis. These sensors send a signal proportional to the acceleration at the attachment point. Norms for vibration levels and their spectral composition are usually determined by the vibrational velocity value. To obtain a vibrational velocity signal, it is necessary to integrate the vibrational acceleration signal based on the time. For balancing, it is necessary to obtain the vibrational displacement value at the sensor attachment point. A vibrational signal time-based double integral allows for obtaining a vibrational displacement signal. These additional signal integration and differentiation functions are available in the described program.

For measuring the discrete constituents level, the root-mean-square (RMS) value is usually measured in the filter band. In this case, the level of the discrete constituent does not really change against the analysis band. For measuring the level of noise components, it is necessary to measure the spectral power density (SPD) which is set in $^{\text{unit of measurement}}/\sqrt{\text{Hz}}$. This is necessary because the noise spectral power density does not depend on the analysis band. **FFT Spectrum Analysis** allows to calculate the spectra based on RMS, SPD, and amplitude values.

The user can also set the representation parameters of the **FFT Spectrum Analysis** program in accordance with his requirements. In order to activate the graphic display parameters window, right-click the graphic area.

The user can set the following parameters:

- In addition to the standard settings, the **FFT Spectrum Analysis** program provides additional features, such as:
- calculation of resonances;
- trigger;
- additional graphs: display of the maximum, minimum and average levels with a certain calculation interval, display of the norm monitoring graphic, one-third octave spectrum graphic, response spectrum graphic;
- additional windows: cepstrum, spectrogram, 3D-spectrogram, signal Transit characteristic, signal phase characteristic.
- levels.



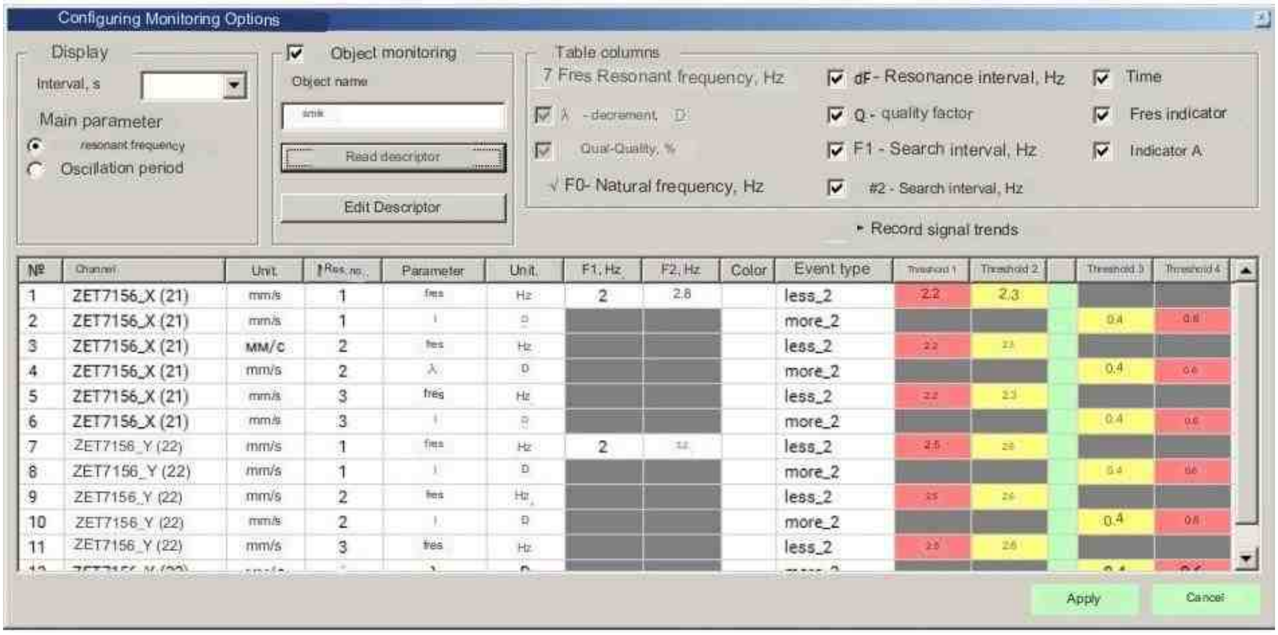
Calculation of resonances

In the **FFT Spectrum Analysis** program, a mode for calculating resonances is implemented. The main area of application for the resonance calculation option is the monitoring of building structures or installations subject to strong vibrations during operation.

Since, in any structure (be it a high-rise building, a bridge or industrial equipment), when forced and natural vibrations coincide, a resonance occurs that can lead to emergency consequences, an effective software tool has been developed that allows you to select all resonant frequencies and monitor the most dangerous zones.

To activate the mode, you need to set the flag next to the "Calculation of resonances" parameter in the Narrow-band spectrum parameters settings on the Resonances tab and save the settings, after which activate the "Apply" button.
The program will launch an additional window: **FFT Spectrum Analysis** - Resonances, which will display the calculated parameters of resonant frequencies, the tracking zone and the resonant frequency trend to analyze the behavior of the structure.
The tracking parameters are formed in the Monitoring parameters settings, to start which you need to press the button of the same name in the program window.
Also, two quick control buttons are available in the program window: "Stop" and "Record", for prompt response to events.
The following parameters are available to the user for management in the "Configuring monitoring parameters" window:

- Display: calculation interval and main parameter (resonant frequency or oscillation period);
- Object monitoring: activating this option allows you to set certain thresholds corresponding to the parameters of the monitored object and control the signal going beyond the specified thresholds;
- Table columns: control of parameters, the values of which will be calculated and displayed in the table for each selected measuring channel;
- Recording Signal Trends: Save long-term monitoring data.



Setting and setting of threshold values is carried out in the xml-file "Monitoring.xml", which is opened using the "Edit descriptor" button in the "Object monitoring" field. For the parameters specified in the descriptor to take effect, you must activate the "Read description" button. For clarity, the type of thresholds in the table is presented in color combinations.

Trigger

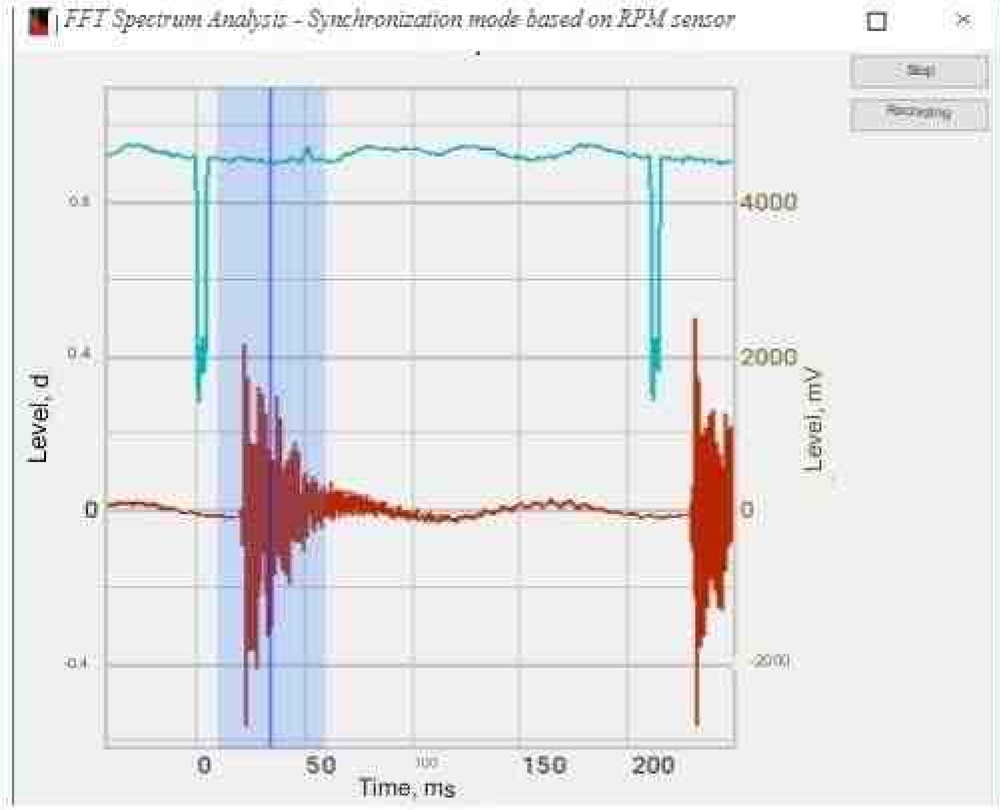
It is not uncommon in practice that there are tasks when it is important to calculate the spectrum of a signal at a certain point in time or for a certain event, for a detailed analysis of the behavior of the frequency components of the sample under study.

The Narrowband Spectrum Analysis program has a trigger function for two modes of operation:

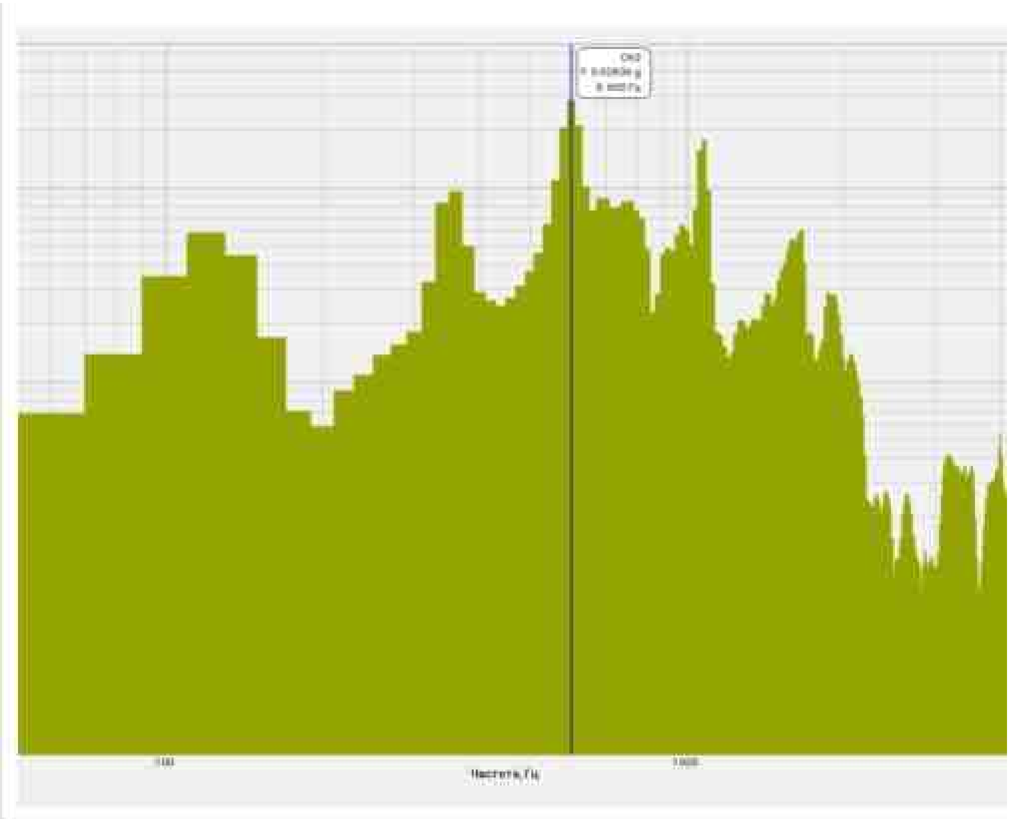
- through the speed sensor channel;
- by the value of the signal level.

The type of synchromarks is determined by the speed sensor channel. The repetition rate of synchromarks must be at least 1.5 Hz. Pulses can be of any polarity and any amplitude.

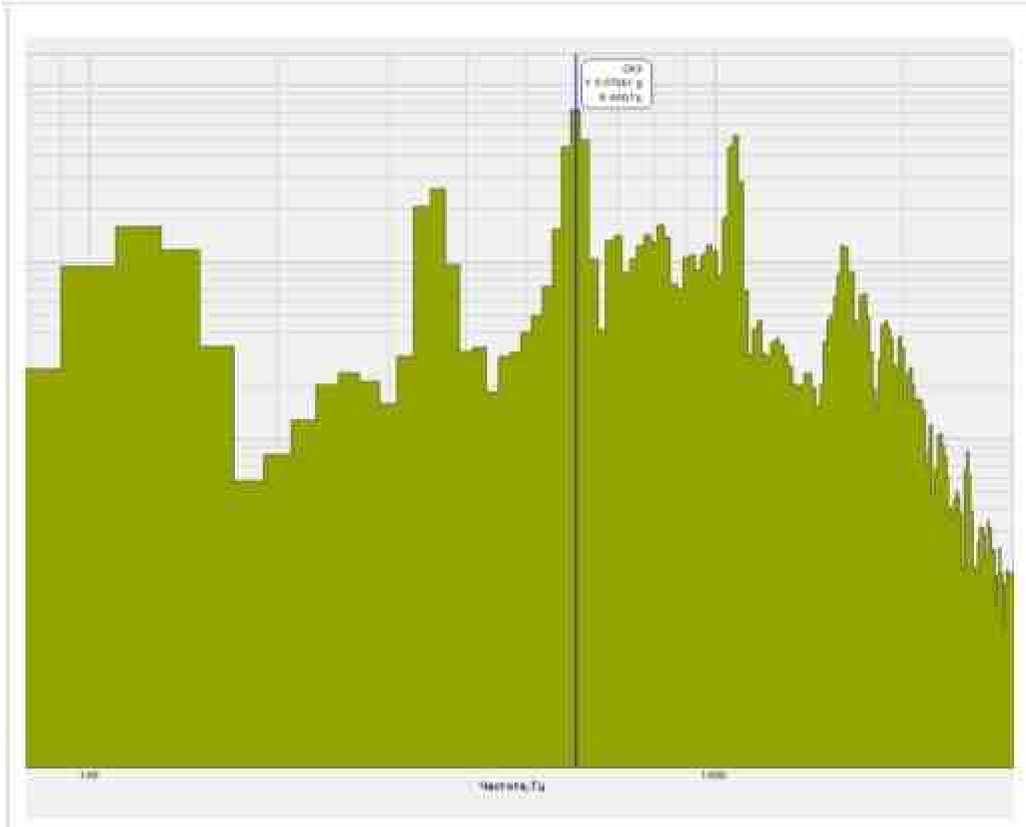
The spectrum is calculated in a narrow band based on the signal from the speed sensor. This type of analysis allows you to select the segment of the spectrum that makes the greatest contribution at the level of total interference. It is convenient in the analysis of structural units containing rotating mechanisms.



Synchronization mode based on RPM sensor



FFT Spectrum Analysis without triggers



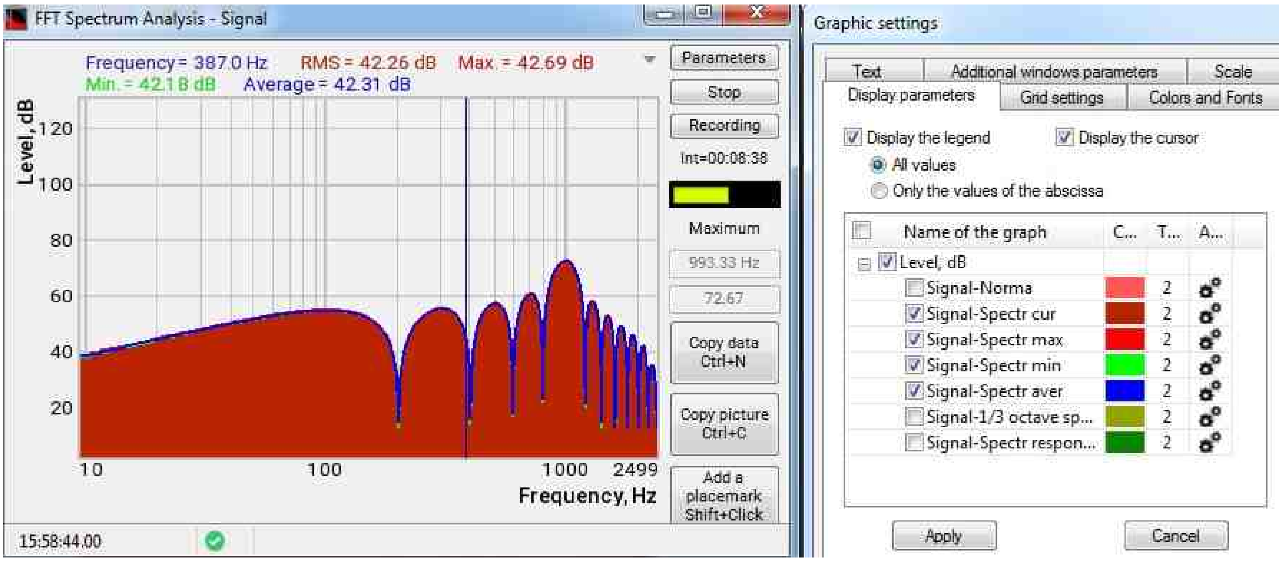
FFT Spectrum Analysis triggered

Spectrum calculation can also be carried out according to the set value of the signal level in the following options:

- greater than a positive value;
- between them;
- less than a negative value;

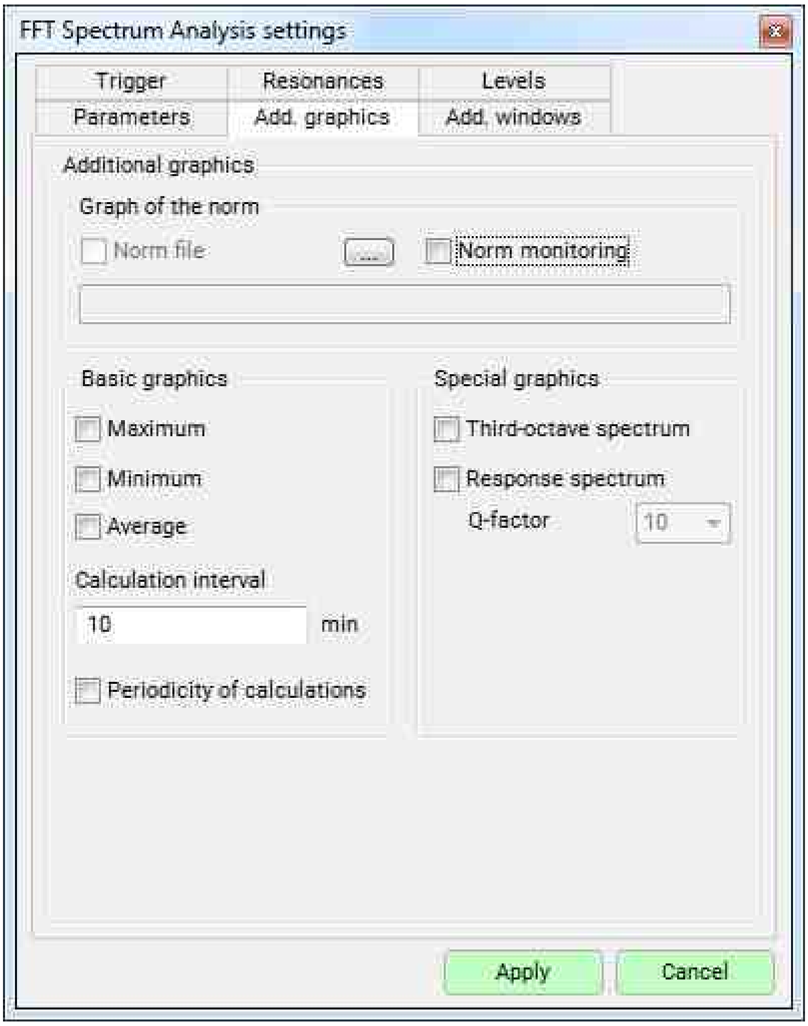
or by amplitude at the set signal threshold:

- more than a threshold;
- less than the threshold.

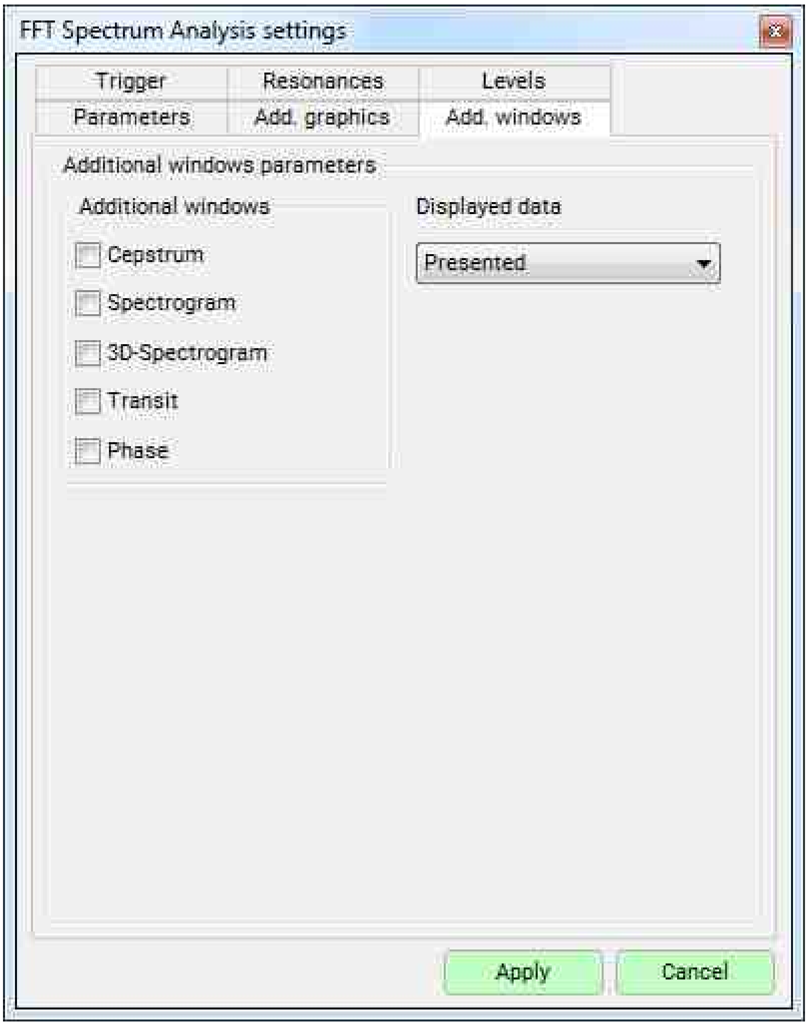


Attention: Refinement of programs (included in the Z-panel and having CFG) in terms of saving the main window parameters when closing the program and saving projects, so old projects and programs must be resaved with new settings.

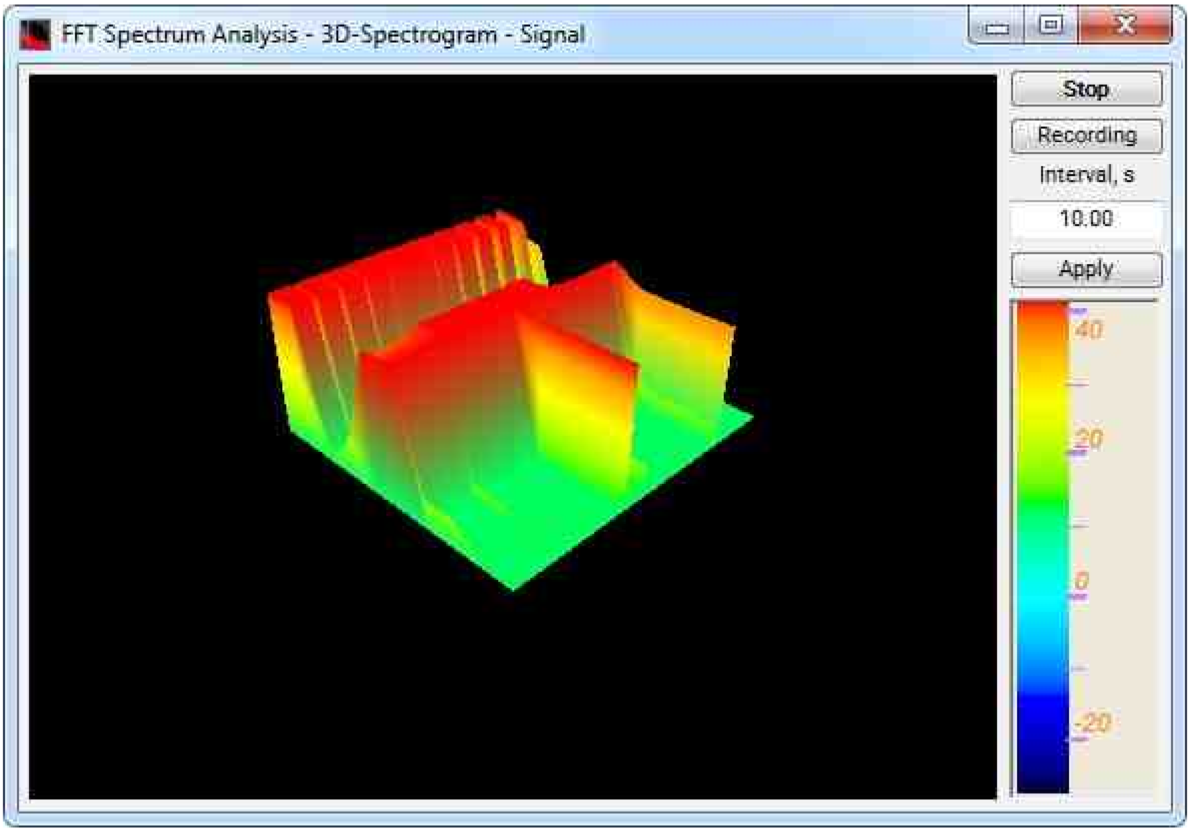
Additional graphics



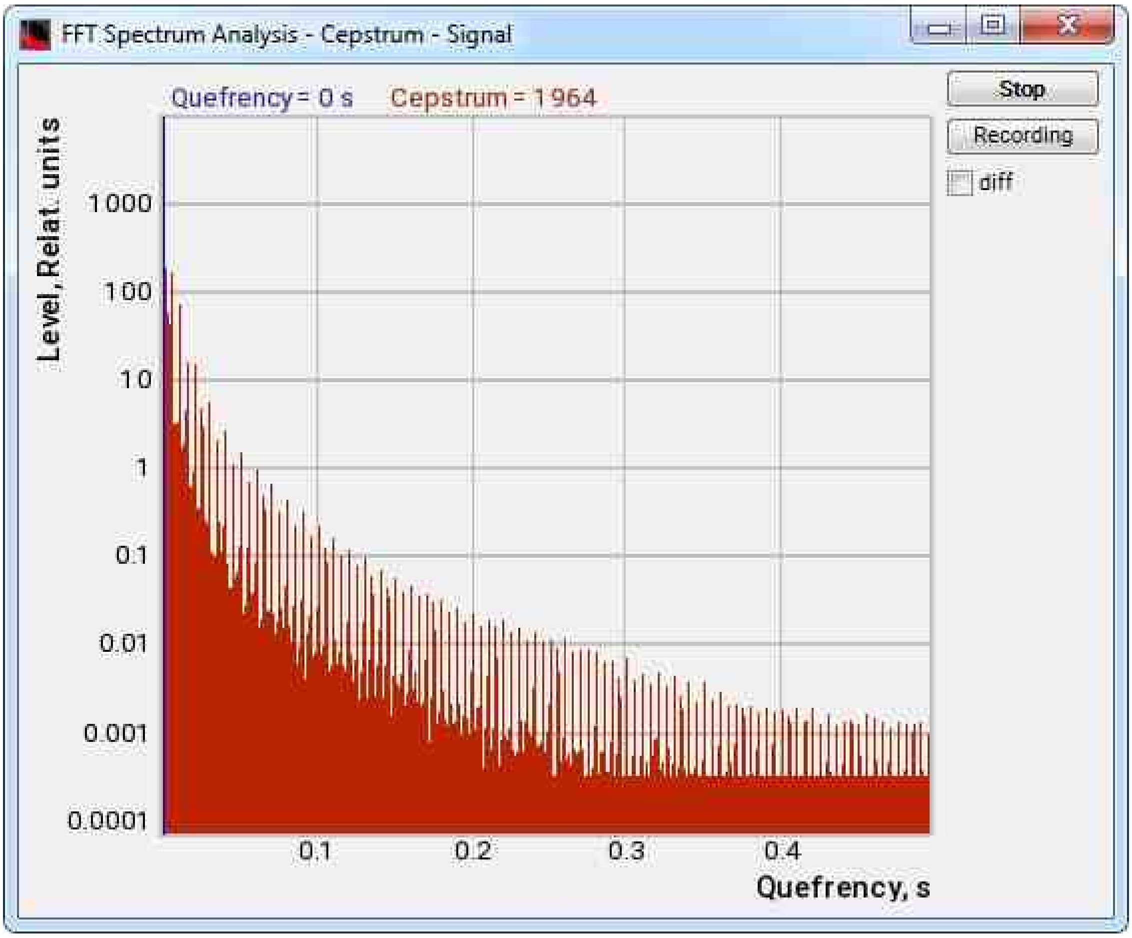
Additional windows



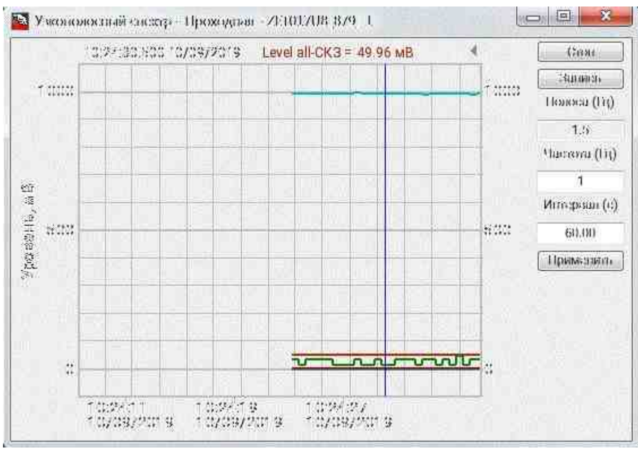
3D - Spectrogram

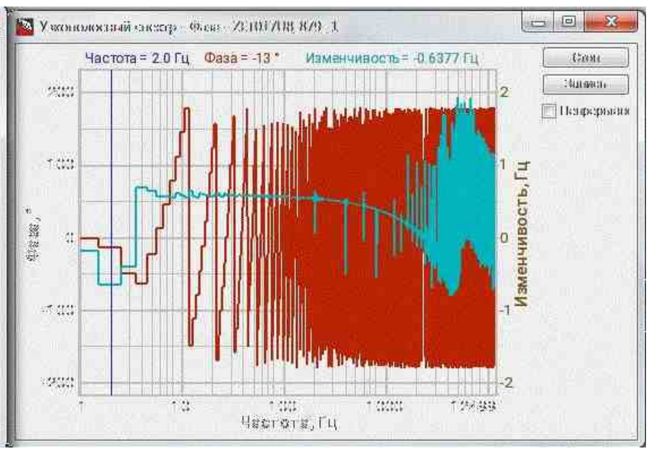

FFT Spectrum Analysis - 3D-Spectrogram - Signal
Stop
Recording
Interval, s
10.00
Apply
40
20
0
-20

3D - Cepstrum

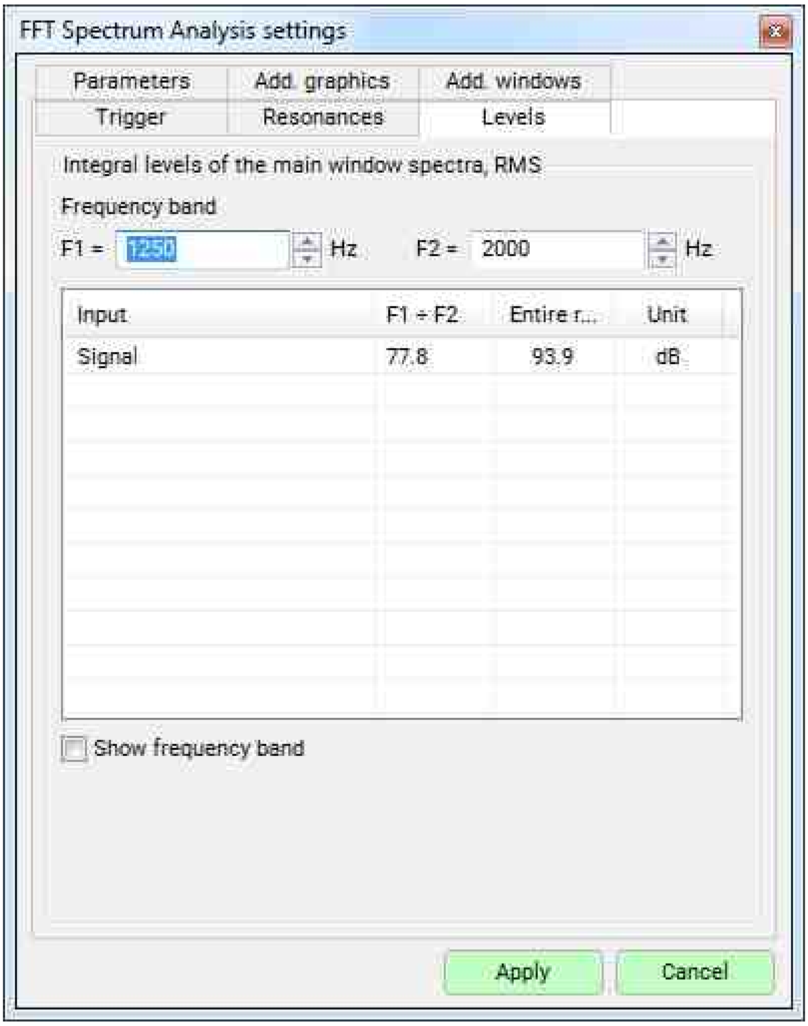


Through and phase





Levels



New features of the FFT Spectrum Analysis program

A new type of graph representation has been added - “Peak Detector”, which displays on the graph the maximum values obtained during the averaging time. The new representation type will be useful in detecting impulses and shifts in the signal.

In the single-channel mode, it became possible to recalculate the spectrum graphic in one-third octave bands and display it as an additional graphics.

In the single-channel mode, for the spectrum representation types “Peak value” and “Peak detector”, it is now possible to plot the response spectrum with a given quality factor and display it as an additional graphics.

Supported Hardware .....

Input data for **FFT Spectrum** includes digital data of the ZETLAB server channel.

For the purpose of analog signals digital processing, it is possible to use *FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01, noise- and vibration-meters ZET 110* and *seismic recorder ZET 048*.

FFT Spectrum is a part of the following software:

- ZETLAB BASE – ADC/DAC module software,
- ZETLAB ANALIZ – FFT spectrum analyzer software
- ZETLAB VIBRO – Shaker controller software,
- ZETLAB TENZO – Strain-gauge station software,
- ZETLAB SEISMO – Seismic station software,
- ZETLAB NOISE – vibration meter-noise meter software,
- ZETLAB SENSOR – digital ZETSENSOR sensor software.

FFT Spectrum is included into the **Signal Analysis** software group.

Main Features .....

- signal level measurement in narrow spectral bands. The number of bands can be equal to the power of 2 (64, 128, 256, 512, 1024, 2048, …, 32768) or to an arbitrary integer number (50, 100, 200, 500, …, 50 000);
- spectral analysis dynamic range: 170 dB;
- averaging of the analyzed signal: from 0,01 up to 1000 seconds;
- averaging types: linear, exponential;
- implementation of weighting functions: rectangular, Hann, Hamming, Blackmann, Bartlett;
- signal integration/ differentiation;
- signal processing based on particular algorithms: fast (FFT) and discrete (DFT) Fourier transform;
- type of the analyzed signal representation: spectral density, spectral power, RMS or amplitude value;
- implementation of median filter for elimination of spectrum discrete components.
- calculation and display of signal cepstrum (reverse Fourier transform);
- calculation and display of the transient characteristics;
- calculation and display of spectral graphics in 2-dimensional format (with color indication of signal level) and in 3-dimensional format;

- calculation and display of maximum and averaged values for a set period of time;
- graphics overlay option for transient processes analysis;
- harmonic components analysis;
- recording and Play recorded signals of program configuration for the repeated measurement processes;
- integrated correction function for the FR characteristics.

Analysis frequency range of the program *FFT Spectrum* for **FFT spectrum analyzer ZET 017-U**

DEVICE SAMPLE RATE *F, HZ*	RANGE, HZ FREQUENCY RESOLUTION, HZ				
50,000	0…20 000	0…2000	0…200	0…20	0…2
	from 0.5 to 500	from 0.05 to 50	from 0.005 to 5	from 0.0005 to 0.5	from 0.00005 to 0.25
25 000	0…10 000	0…1000	0…100	0…10	0…1
	from 0.25 to 250	from 0.025 to 25	from 0.0025 to 2.5	from 0.00025 to 0.25	from 0.000025 to 0.025
5000	0…2000	0…200	0…20	0…2	0…0.2
	from 0.05 to 50	from 0.005 to 5	from 0.0005 to 0.5	from 0.00005 to 0.05	from 0.000005 to 0.005
2500	0…1000	0…100	0…10	0…1	0…0.1
	from 0.25 to 25	from 0.025 to 2.5	from 0.0025 to 0.25	from 0.00025 to 0.025	from 0.000025 to 0.0025

Analysis frequency range of the program ***FFT Spectrum Analysis*** for **FFT spectrum analyzer A19**

DEVICE SAMPLE RATE *F, HZ*	RANGE, HZ FREQUENCY RESOLUTION, HZ				
250 000	0…100 000	0…10 000	0…1000	0…100	0…10
	from 2.5 to 2500	from 0.25 to 250	from 0.025 to 25	from 0.0025 to 2.5	from 0.00025 to 0.25
50,000	0…20 000	0…2000	0…200	0…20	0…2
	from 0.5 to 500	from 0.05 to 50	from 0.005 to 5	from 0.0005 to 0.5	from 0.00005 to 0.25

25 000	0…10 000	0…1000	0…100	0…10	0…1
	from 0.25 to 250	from 0.025 to 25	from 0.0025 to 2.5	from 0.00025 to 0.25	from 0.000025 to 0.025
5000	0…2000	0…200	0…20	0…2	0…0.2
	from 0.05 to 50	from 0.005 to 5	from 0.0005 to 0.5	from 0.00005 to 0.05	from 0.000005 to 0.005

Program description .....

The program **FFT Spectrum Analysis** is available in the Analysis menu of ZETLAB software.

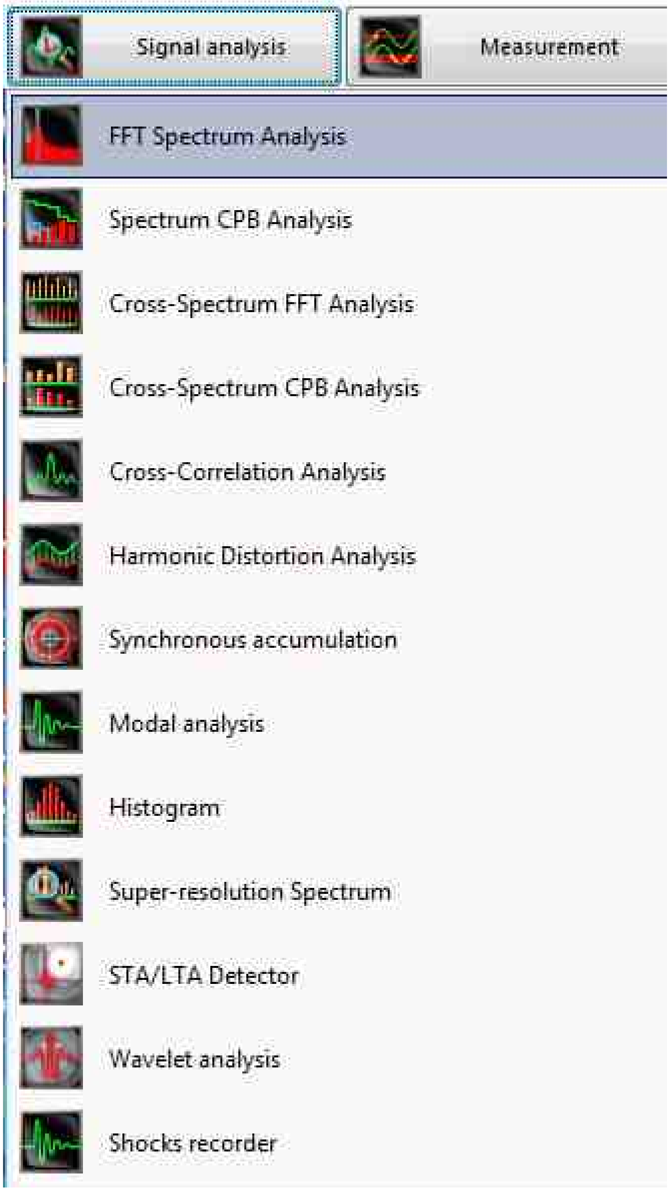
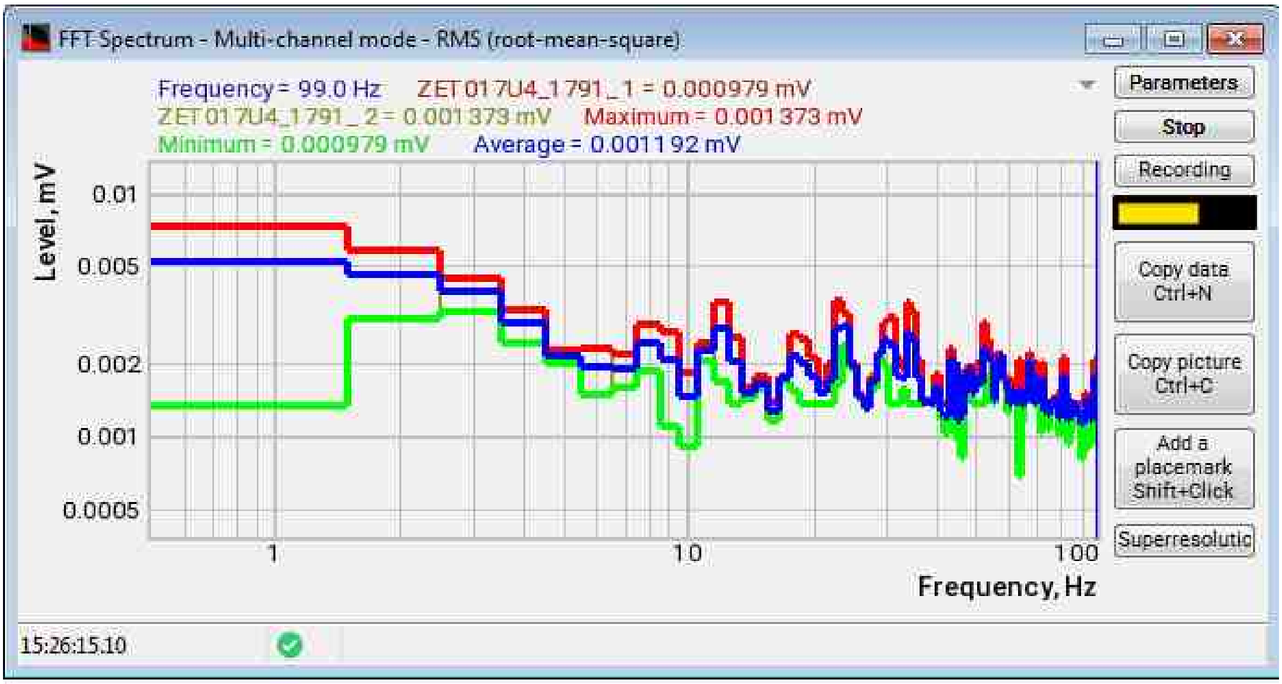


Fig. 1. Starting the "FFT Spectrum Analysis"

The heading of the program window depicts the program name and the name of the channel selected for the analysis. Above the spectrum graphic, the user can see the values of the measured parameters (frequency, signal level) depending on the cursor position.



"FFT Spectrum Analysis" program window

Note: the program can be started from ZETLAB directory (by default: C:\ZETLAB\). Name of the file: spectr.exe

The main part of the FFT Spectrum Analysis program is represented by the section displaying measurement results: signal spectrum and Additional graphics.

The right part of the program window contains control keys and indicators:

- ***Parameters*** – the key provides access to program settings: measuring channel, analysis parameters, etc.
- ***Start/Stop*** – allows to start or suspend the analysis process.
- ***Recording*** – saves the measurement results to a file (the file structure is described in the sub clause "*Record the results in a file*").
- ***Yn=..s*** - the time interval that has elapsed since the start of measurements. This parameter is relevant only to the calculation of additional graphs. In the settings of the FFT Spectrum Analysisprogram, the time for calculating additional graphs is specified. After the specified time has elapsed, the calculation will end, additional graphics will stop, and the set calculation interval (duration) will be displayed in the field
- The fields under the label ***Maximum*** indicate the frequency and value of the current maximum of the spectrum.
- ***Using signal level indicators*** display the ratio of the current signal value to the maximum measurement range. Allows you to quickly assess the signal level and displays the overload on the channel.

See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Setting parameters of display
- Using signal level indicators
- Adjustment of the color scheme used for displaying of the registered signal amplitude values
- Graphical and numerical data transfer to text editors
- Setting GridGl grid functionality

Control element .....

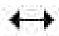
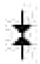
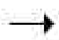
ZETLAB programs have user-friendly interface and convenient control system. In the course of ZETLAB programs development we take into consideration the generally accepted standards and symbols, which contributes to easy and convenient operation of the programs.

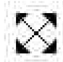
This section describes the use of **ZETLAB** programs control elements.

Cursor control in graphics .....

Graphic cursor can be moved to the required frequency using any of the following methods:

- move the pointer to the required frequency, left-click and, holding the left button pressed, wait until the graphic cursor (vertical line) coincides with the mouse pointer. With the mouse left button held pressed, the graphic cursor will follow the movements of the mouse pointer along the graphic;
- in the active window of the **FFT Spectrum** program, left-click on the graphic field and, rotating the mouse wheel, move the graphic cursor;
- in the active window of the **FFT Spectrum** program, the cursor can be moved to the left by pressing and holding pressed <A> key (in Latin layout), and <D>, to the right.

Number line scaling is performed using the mouse. When the mouse pointer is moving along the numerical values on the axes, it will change its appearance depending on the expected action: graphic scaling. After the pointer is set to the required position, left-click or rotate the wheel. Graphic up- and down-scaling is performed using the pointers which will look like this: , , for the horizontal axis, and , , for the vertical axis. The graphic can be moved to the left/right or up/down using the pointers which will look like this: , , for the horizontal axis, and , , for the vertical axis.

When moved onto the numerical axes crossing point, the cursor will look like this: . When the pointer looks like above, left-clicking will result in signal-level autoscaling.

Using signal level indicators .....

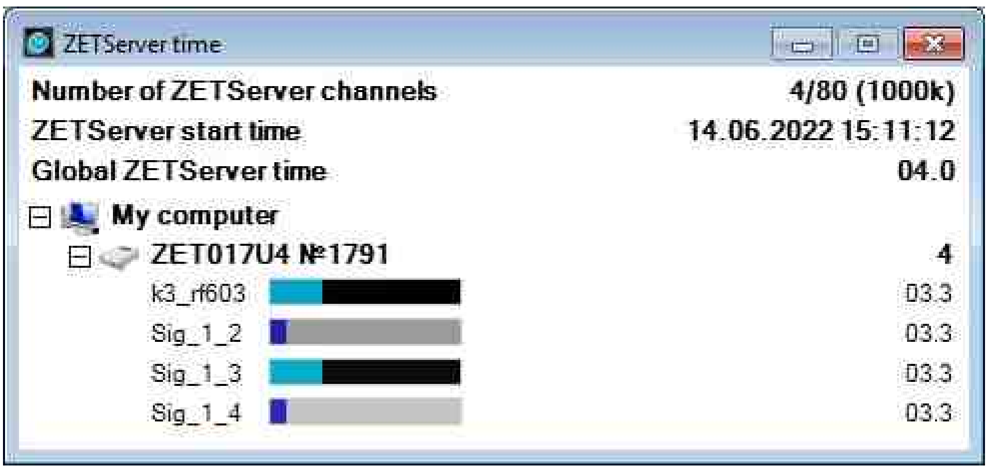
Most of ZETLAB programs used for processing of the registered signals (by the selected measurement channel) have signal level indicators (Fig. 3.7), displaying the current integral level of the signal.

Fig. 3.7 Indicator of signal integral level

Signal level indicator allows the user to evaluate the quality of selection, adjustment, and sensitivity of elements for a particular measurement channel, thus excluding signal processing in the case of overloading and signal failure in the selected measurement channel.

Two thirds of signal level indicator section display the signal level, which is below the maximal admissible value. The higher is the level, the more is indicator value. As the maximal admissible level is exceeded (without the presence of signal distortions), the indicator flashes with red. When overloading by the measurement channel will no longer be detected, the indicator will flash red until the user left-clicks it.

The indicators of the "ZET Server Time" program window are also equipped with the function of changing the color of the background area of the indicator. This function allows you to perform a statistical evaluation of the quality of the recorded signal in the measuring channel. The more the signal resembles white noise in its statistical characteristics, the lighter the background area. The smaller the signal resembles white noise in characteristics, the darker the background. At rest, the signal of a serviceable sensor should show background noise that is close to white in characteristics. The presence of interference (pulse, harmonic, etc.) or a malfunction in the sensor leads to a change in the characteristics of the signal and darkening of the background area of the indicator.



Graphical and numerical data transfer to text editors .....

To copy a spectrum graphic, left-click on the graphic and press hotkey combination: <Ctrl> +< C>. The graphic will be saved in the Clipboard. The graphic can be pasted to any opened Microsoft Word or Excel document by pressing hotkeys <Ctrl> + <V>, or right-clicking and selecting Paste command from the context menu.

To copy any accompanying information, left-click in the graphic field and press <T> key (Latin layout). The information can be pasted to any opened text document by pressing hotkeys <Ctrl> + <V>, or right-clicking and selecting Paste command from the context menu.

The accompanying information has the following structure: first line contains the header of the source window (in this case, the program name is FFT Spectrum) and the name of the displayed channel; the second and third lines contain measured values (namely: frequency and level values corresponding to the graphic cursor position). If the additional graphics are ON (Maximum, Average, and File (norm)), their values will be in the following lines.

To copy any numerical values of frequency and level of the visible part of the graphic, left-click in the graphic field and press <N> key (Latin layout). The information can be pasted to any opened text document by pressing hotkeys <Ctrl> + <V>, or right-clicking and selecting Paste command from the context menu. The information pasted to a text document will have the following structure: first, there will be the accompanying information; the following lines will contain the frequencies and the relevant levels at those frequencies. If the additional graphics are ON (Maximum, Average, and File (norm)), their level values will be added to the main level lines. When the frequency and level values are copied and pasted to Excel documents, this information can be processed and graphics, constructed.

Setting parameters of display .....

When right-click is made on the graphic field of the **FFT Spectrum** program windows, there appears an additional window, **Parameters**.

On the **Display parameters** tab (*Fig. 7 .93*), the line type and graphic parameters are set. Graphic line types can be horizontal (Polygonals) or points lines. On this tab, parameters of displaying each graphic, color, thickness, filling (painting) of the graphic area can be set as well.

Fig. 7 .94 shows the **Grid Settings** tab. On this tab, the display of the horizontal and vertical axes marking and grid lines can be turned on or off. Graphic visibility area (display area) can be set on this tab as well: upper, lower, right, and left bounds of graphics.

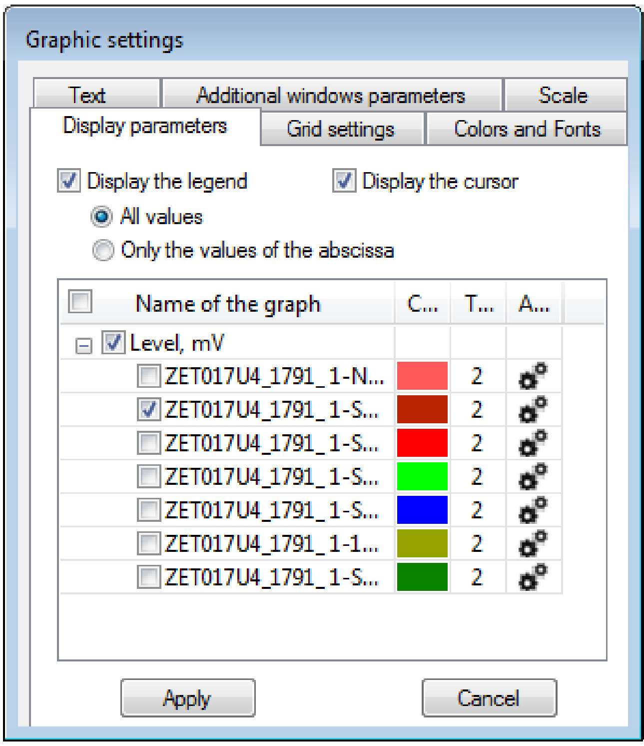


Fig. 7.93

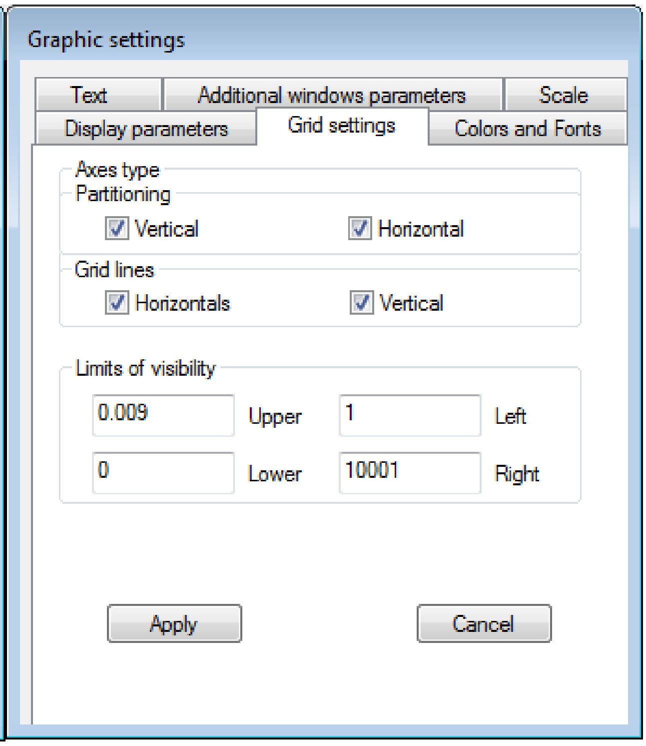


Fig. 7.94

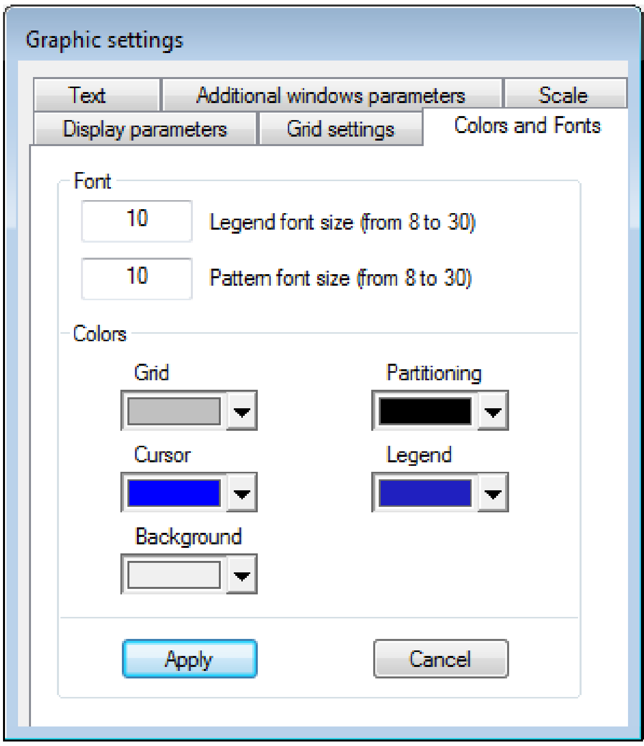


Fig. 7.95

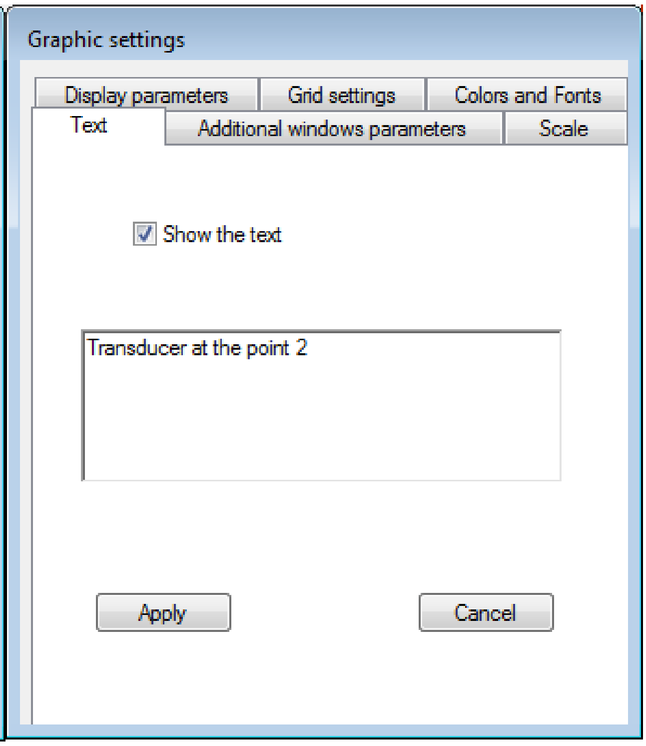
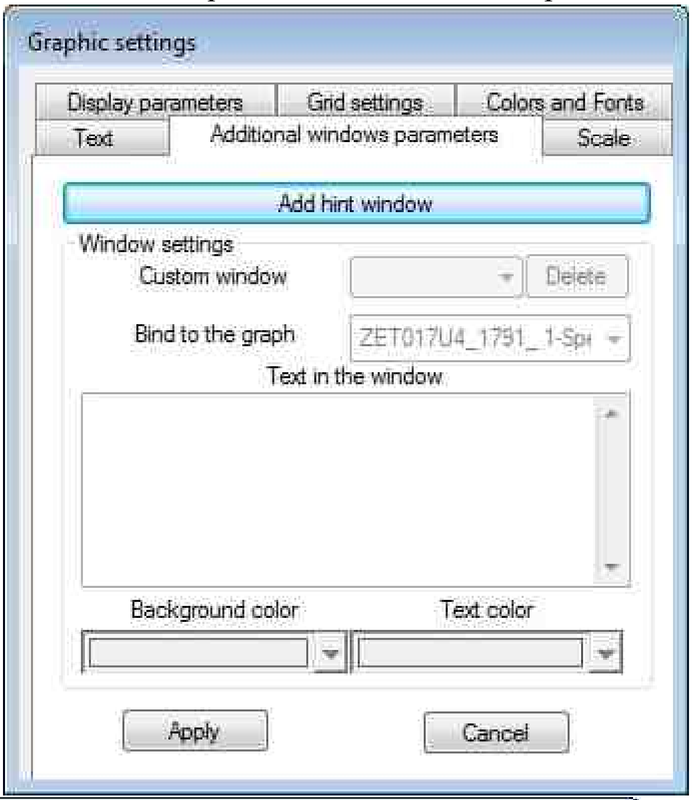


Fig. 7.96

Fig. 7 .95 shows the **Colors and fonts** tab. On this tab, the font size of the axes and measured values numerical values can be changed. On this tab, the color of the grid, cursor, background, axes marking, legend can be set as well.

Fig. 7 .96 shows the **Text** tab. On this tab, additional text information can be recorded, to be displayed at copying and pasting of spectrum graphics to text documents. To record this information, check the **Show text** checkbox, select the required font of the text, and input the text in the input field.



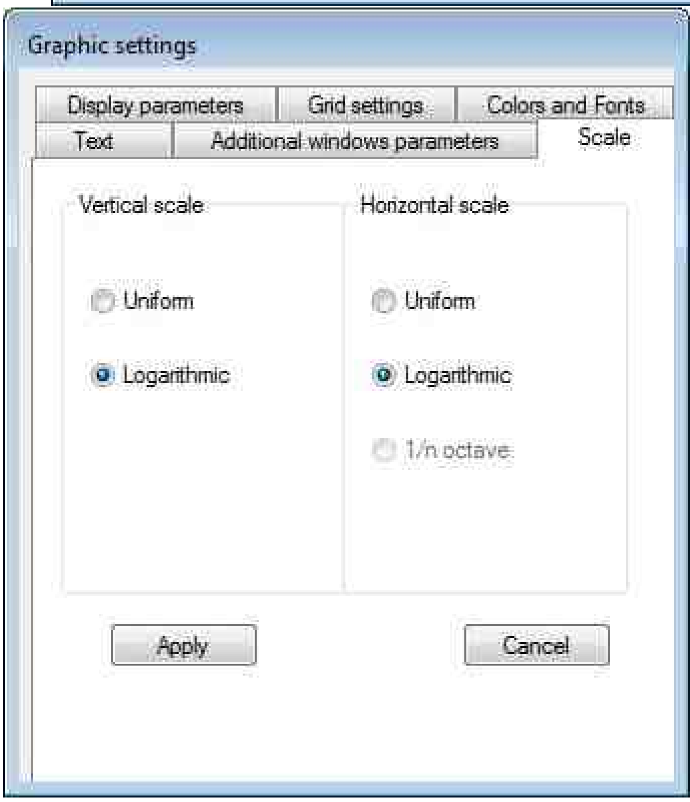


Fig. 7 .97

Fig. 7 .97 shows a fragment of the **FFT Spectrum Analysis** program working window with Additional windows parameters and scale.

Fig. 7 .98 shows a fragment of the **FFT Spectrum Analysis** program working window with some additional information.

Fig. 7 .99 shows the **Scale** tab. On this tab, the type of the horizontal and vertical scales representation can be selected. The vertical scale can be represented in the uniform, logarithmic, or decibel form. The horizontal scale can be represented in the uniform, logarithmic, or 1/octave (part-octave form).

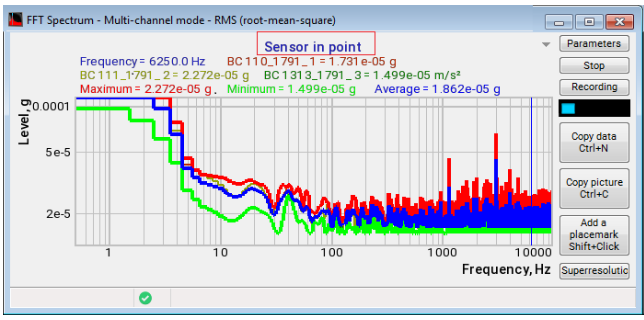


Fig. 7.98

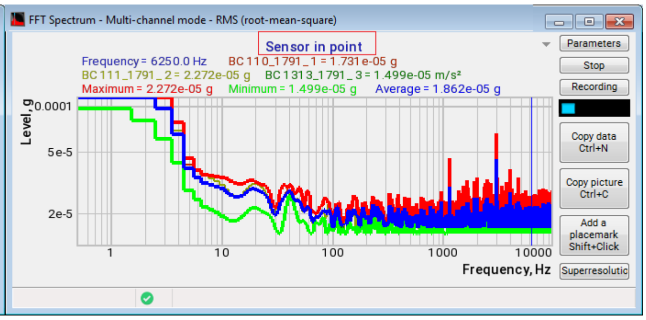


Fig. 7.99

When the vertical scale display representation is selected, the display of numerical values of the measured value over the graphic field relative to the cursor position will be as selected in the FFT Spectrum parameter settings (the FFT Spectrum Analysis setting is described in section **7.3** of this **Operator manual**), and the vertical scale grid will be in accordance with the selected view.

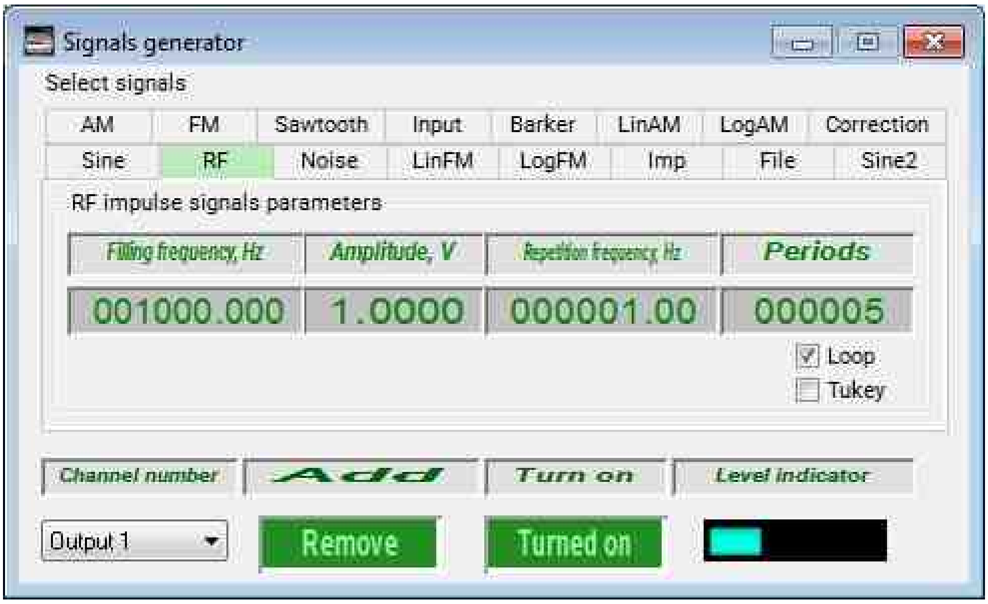
Changed setting are saved by pressing **Apply** button; the **Parameters** window will close, and the selected settings will come into force.

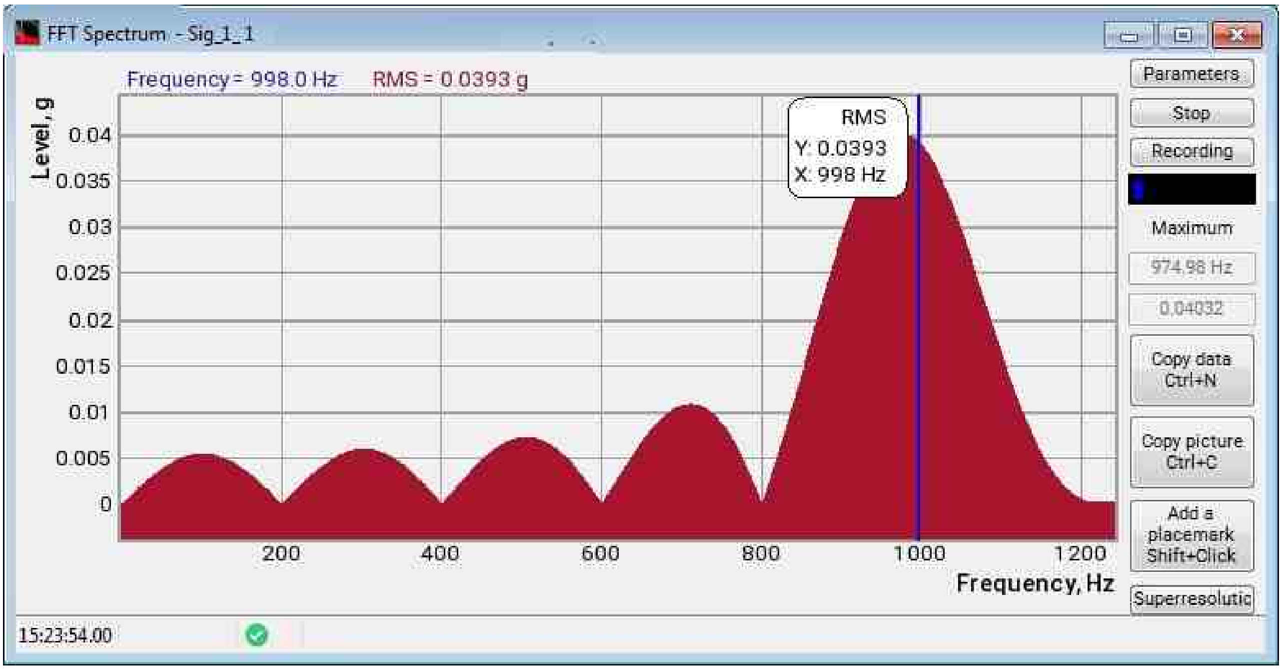
To exit the **Parameters** window without saving the settings, press **Cancel** button, or button in the right upper corner of the window, or by clicking any mouse button at any area of the screen free from the **Parameters** window.

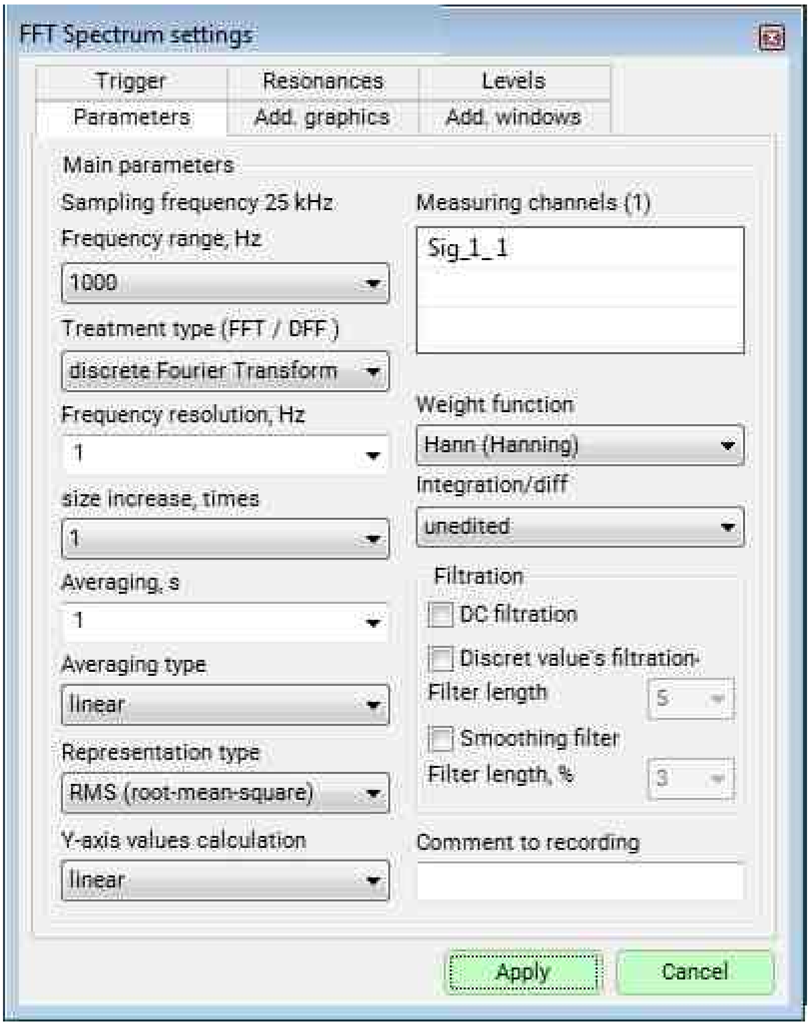
Program settings .....

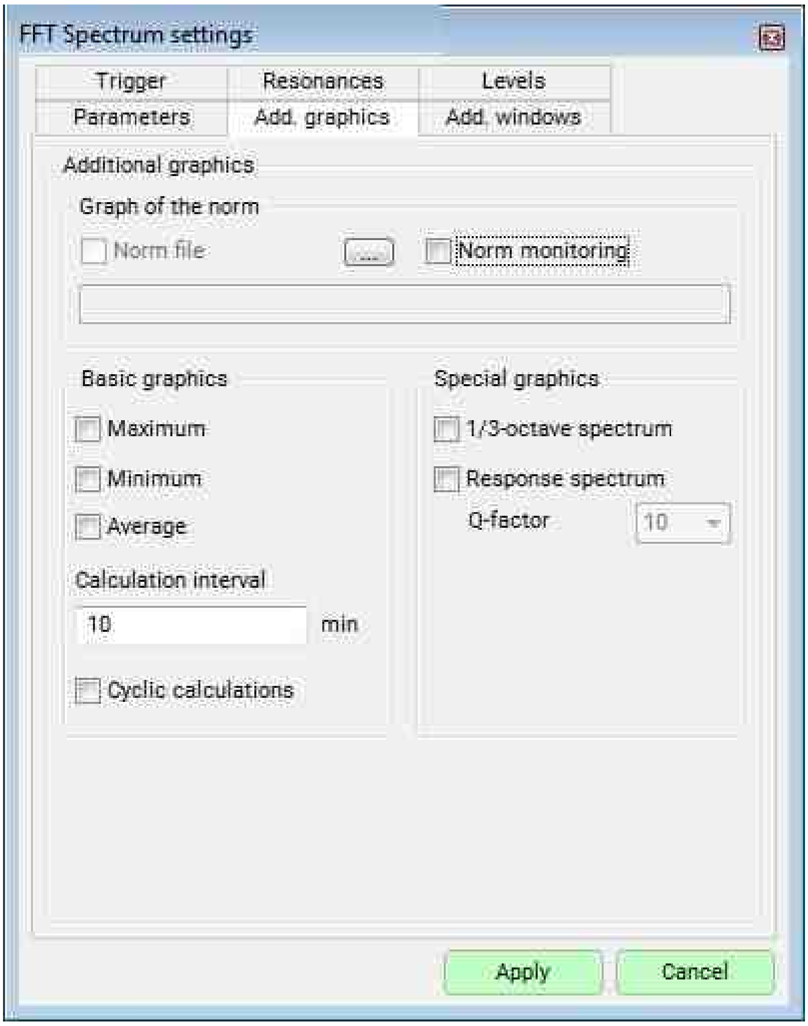
In order to set the program **FFT Spectrum Analysis** program, left-click the **"Parameters** button, which is located in the upper right corner, after which the **FFT Spectrum settings** window will be displayed. The **FFT Spectrum Analysis settings** window can also be called by pressing the <Esc> key on the keyboard while the **FFT Spectrum Analysis** program window is active.

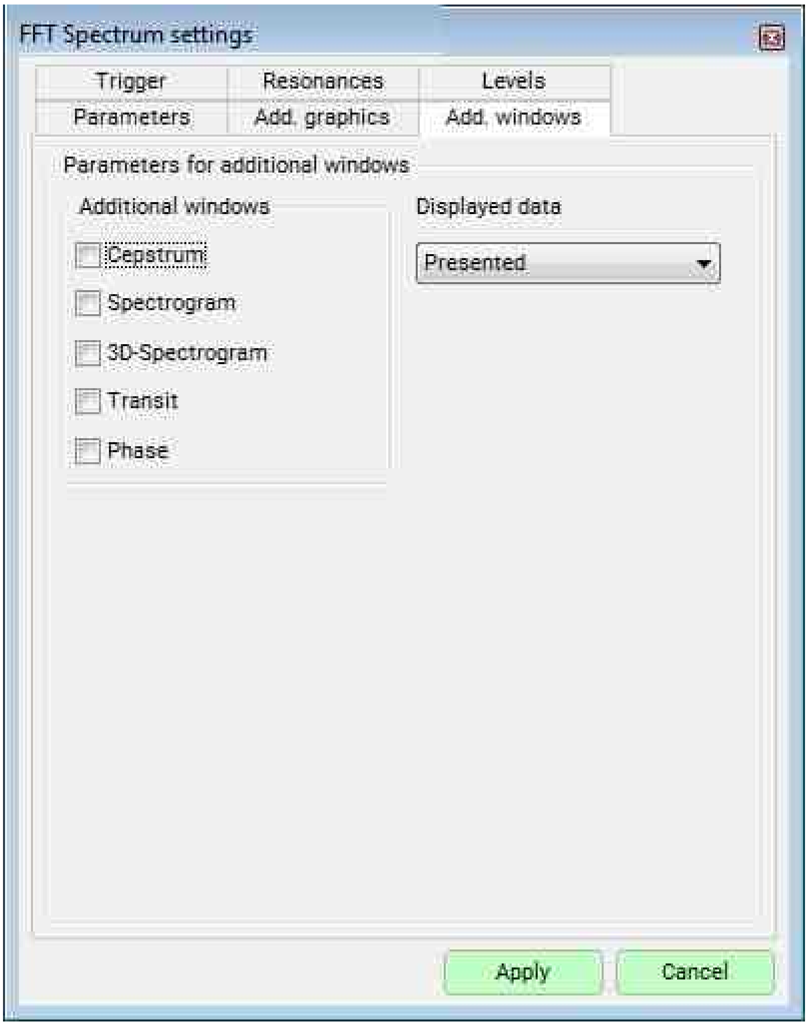
The set sampling frequency in Hz will be displayed in the upper part of the window (the sampling frequency is set in the **ZET Device Manager**. program.

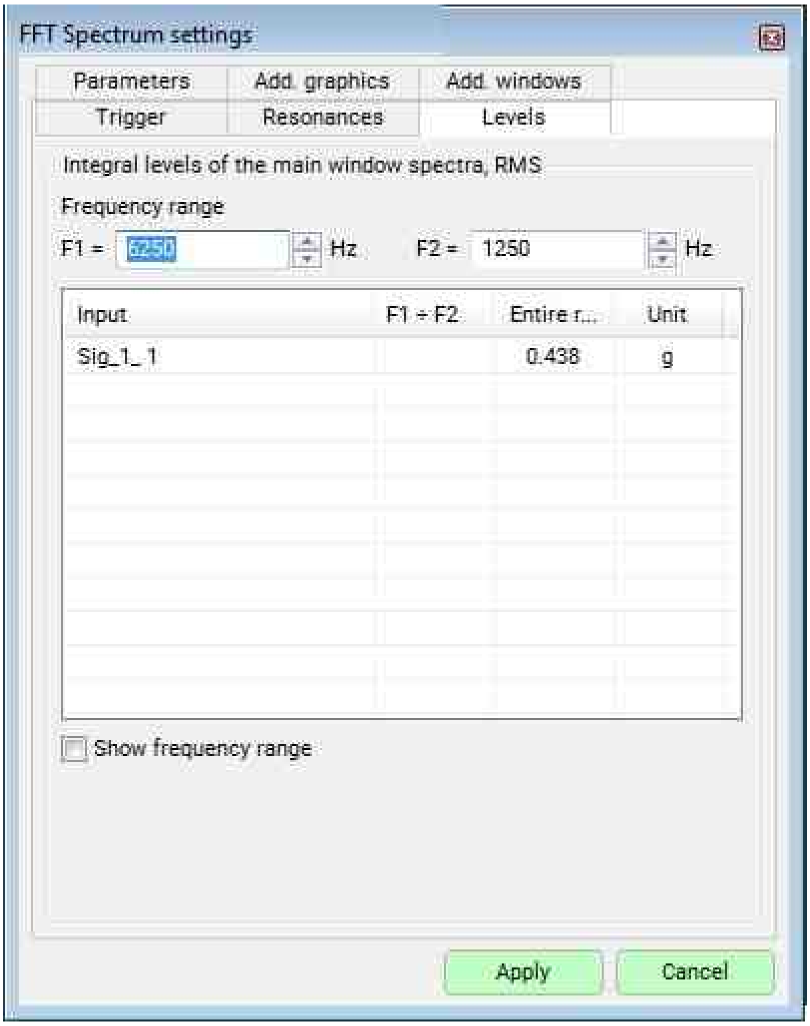

Signals generator
Select signals
AM
FM
Sawtooth
Input
Barker
LinAM
LogAM
Correction
Sine
RF
Noise
LinFM
LogFM
Imp
File
Sine2
RF impulse signals parameters
Filling frequency, Hz
Amplitude, V
Repetition frequency, Hz
Periods
001000.000
1.0000
000001.00
000005
Loop
Tukey
Channel number
Add
Turn on
Level indicator
Output 1
Remove
Turned on

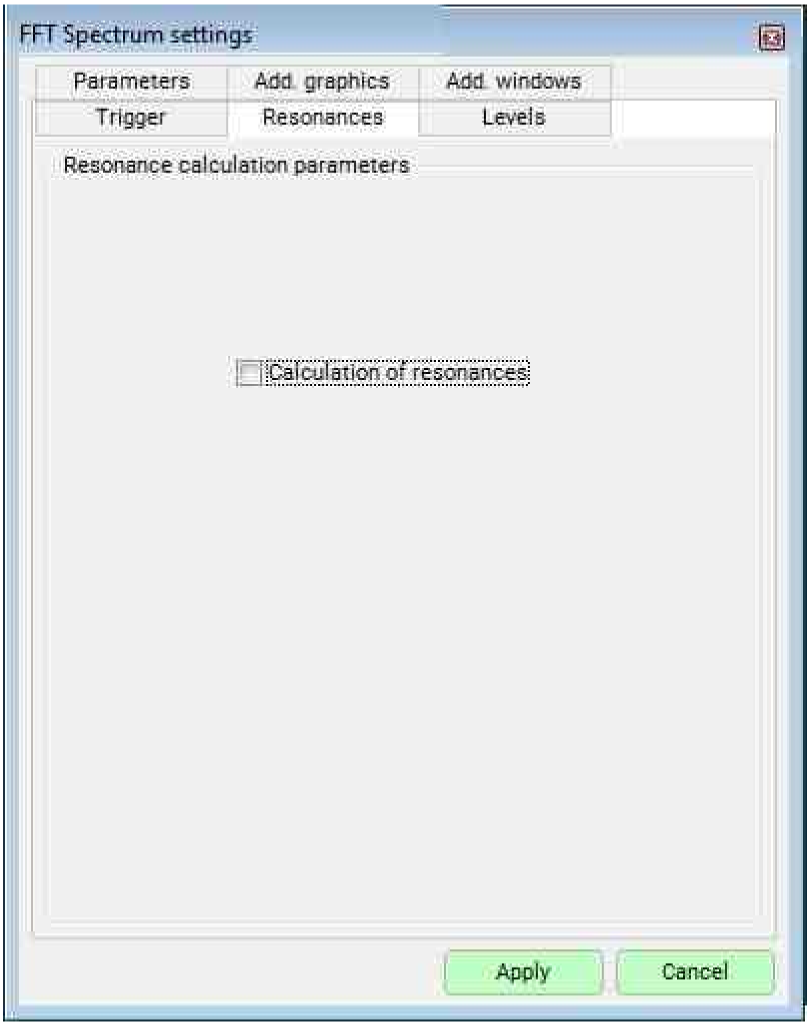

FFT Spectrum - Sig_1_1
Frequency = 998.0 Hz
RMS = 0.0393 g
Level, g
RMS
Y: 0.0393
X: 998 Hz
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
200
400
600
800
1000
1200
Frequency, Hz
Parameters
Stop
Recording
Maximum
974.98 Hz
0.04032
Copy data Ctrl+N
Copy picture Ctrl+C
Add a placemark Shift+Click
Superresolutic
15:23:54.00

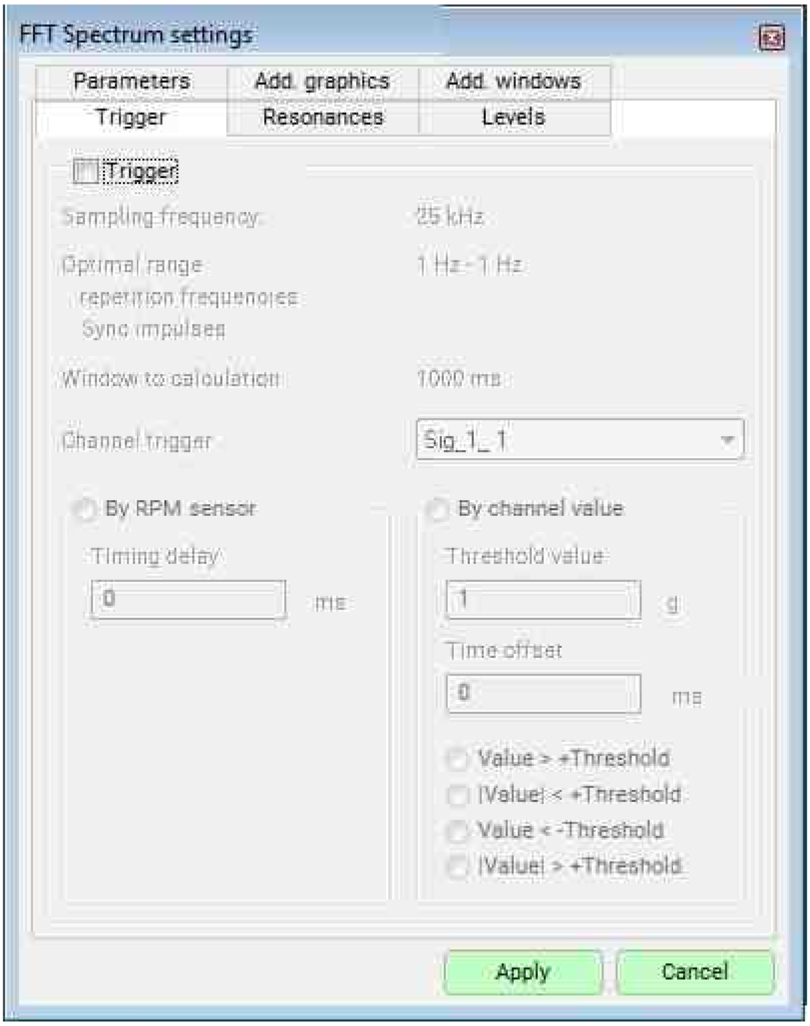

FFT Spectrum settings
Trigger
Resonances
Levels
Parameters
Add. graphics
Add. windows
Main parameters
Sampling frequency 25 kHz
Frequency range, Hz
1000
Treatment type (FFT / DFF)
discrete Fourier Transform
Frequency resolution, Hz
1
size increase, times
1
Averaging, s
1
Averaging type
linear
Representation type
RMS (root-mean-square)
Y-axis values calculation
linear
Measuring channels (1)
Sig_1_1
Weight function
Hann (Hanning)
Integration/diff
unedited
Filtration
DC filtration
Discret value's filtration
Filter length
5
Smoothing filter
Filter length, %
3
Comment to recording
Apply
Cancel


FFT Spectrum settings
Trigger
Resonances
Levels
Parameters
Add. graphics
Add. windows
Additional graphics
Graph of the norm
Norm file
...
Norm monitoring
Basic graphics
Maximum
Minimum
Average
Calculation interval
10
min
Cyclic calculations
Special graphics
1/3-octave spectrum
Response spectrum
Q-factor
10
Apply
Cancel


FFT Spectrum settings
Trigger
Resonances
Levels
Parameters
Add. graphics
Add. windows
Parameters for additional windows
Additional windows
Displayed data
Cepstrum
Spectrogram
3D-Spectrogram
Transit
Phase
Presented
Apply
Cancel


FFT Spectrum settings
Parameters
Add. graphics
Add. windows
Trigger
Resonances
Levels
Integral levels of the main window spectra, RMS
Frequency range
F1 = 6250 Hz
F2 = 1250 Hz
Input
F1 ÷ F2
Entire r...
Unit
Sig_1_1
0.438
g
Show frequency range
Apply
Cancel


FFT Spectrum settings
Parameters
Add. graphics
Add. windows
Trigger
Resonances
Levels
Resonance calculation parameters
Calculation of resonances
Apply
Cancel



FFT Spectrum Analysis settings

The list **Frequency range**, Hz is used for setting the frequency range (analysis bandwidth) in which the signal analysis will be performed. The values available in the list depend on the sampling frequency of the particular channel.

The list **Measurement channel** allows to select physical or virtual channel, graphic of which will be depicted in the **FFT Spectrum** program.

The list **Frequency resolution**, **Hz** is used for selection of the frequency resolution (i.e. the interval between fast or discrete Fourier transform).

The list Weight function is used for selection of the weight function type (weighting window) used for the spectral analysis. The weight function describes the dependence between the previous control signals counts and the calculated spectrum. It is possible to select one of the following weight functions:

The list below the line "**Averaging, s**" is used for setting spectra averaging duration in seconds. The averaging values can be selected from the list or be entered from the keyboard. The maximum averaging value is 100 s, the minimum possible – 0,1 s.

The list below the line "**Weight function**" allows to select the type of the weighting function to be used for spectral analysis. The list shows possible types of the weighting

Multi-channel mode

If it is necessary to calculate signal spectra for a large number of channels, the user can use the Multi-channel mode function.

To calculate the spectra for several channels at the same time, it is enough to run one program **FFT Spectrum Analysis** and in the program settings menu in the Multi-channel mode field specify the number of channels and select one displayed channel to set its parameters.

To save all changes in the configuration file, after configuring each channel, you must check the box in the General CFG line and apply the appropriate settings.

Graphics display settings

If desired, the user can customize the display of the graphic in the **FFT Spectrum** program at his discretion. To call the graphic settings panel, you need to  activate the right mouse button on the graphic grid.

The user can settings:

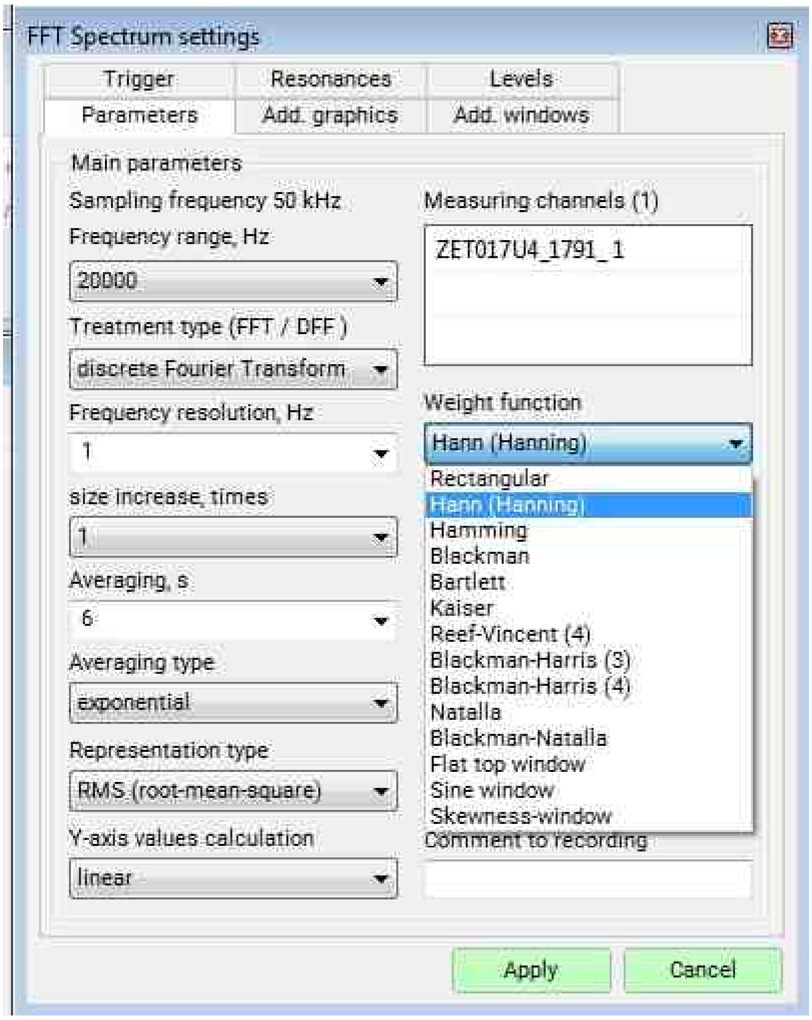
- setting the unidad of the vertical and horizontal scale (uniform, logarithmic, decibel/1/n octave);
- setting grid parameters;
- setting display parameters - line type, graphic color, line thickness, etc.;
- setting the grid color and font size;
- adding windows with hints - a note on the graphic with reference to a specific point with the ability to add explanations.

Weight functions

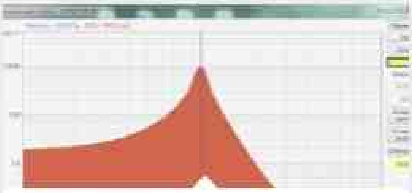
The **FFT Spectrum Analysis** program implements various weighting functions - data windows, also known as trimming functions. The main task of the data window is to reduce the amount of bias in the periodogram spectral estimates. Windowing is used to control the effects due to the presence of side lobes in spectral estimates. Discrete-time window functions from among those proposed at different times for use in spectral analysis, available for selection in the program, are as follows:

Functions:

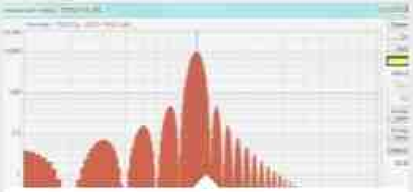
- Rectangular;
- Hann;
- Hanning;
- Hamming;
- Blackman;
- Bartlett;
- Kaiser;
- Reef-Vincent (4);
- Blackman-Harris (3);
- Blackman-Harris (4);
- Natalla;
- Blackman-Natalla;
- flat top window;
- Sine window;
- Skewness-window;



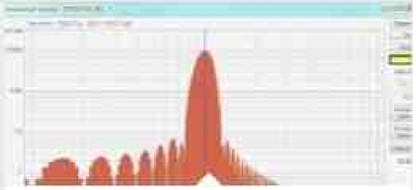
The following are examples of frequency responses obtained by calculating the discrete-time Fourier transform of each window:



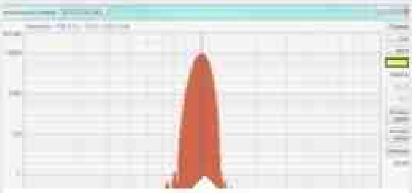
Weight function Skewness-window



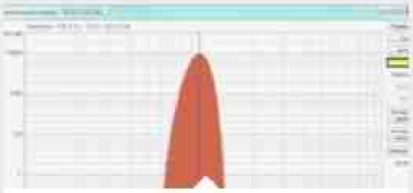
Weight function Bartlett



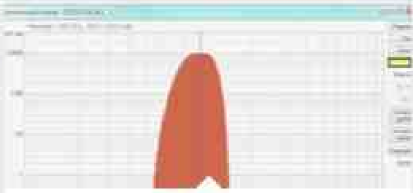
Weight function Blackman-Harris (3);



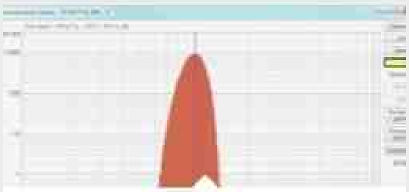
Weight function Kaiser



Weight function Natalla



Weight function Flat top window

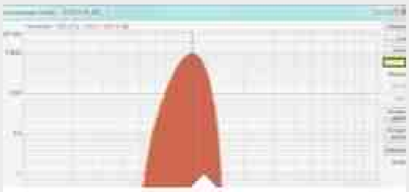


Weight function Blackman-Harris (4)

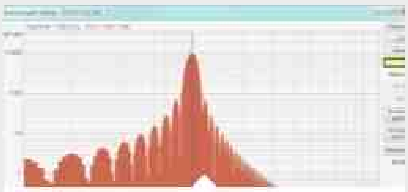
Weight function Blackman

Weight function Blackman-Natalla

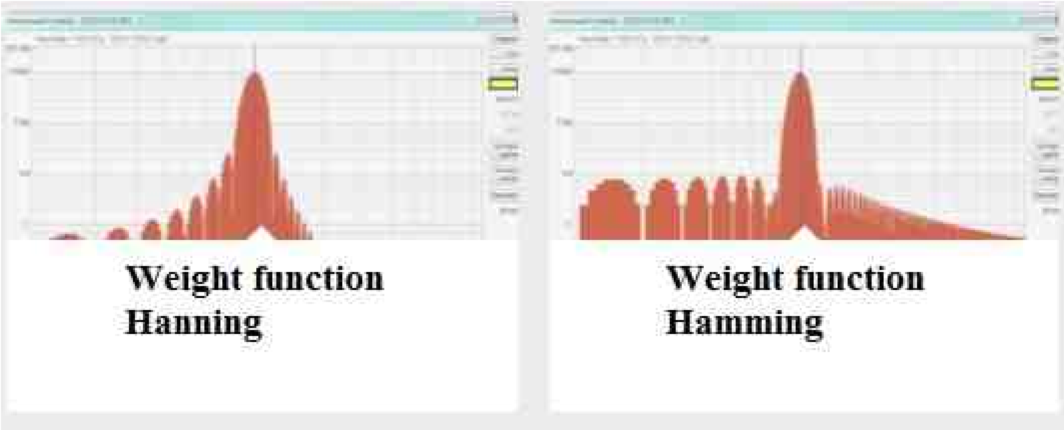
Weight function Rectangular



Weight function Reef-Vincent (4)



Weight function Sine window



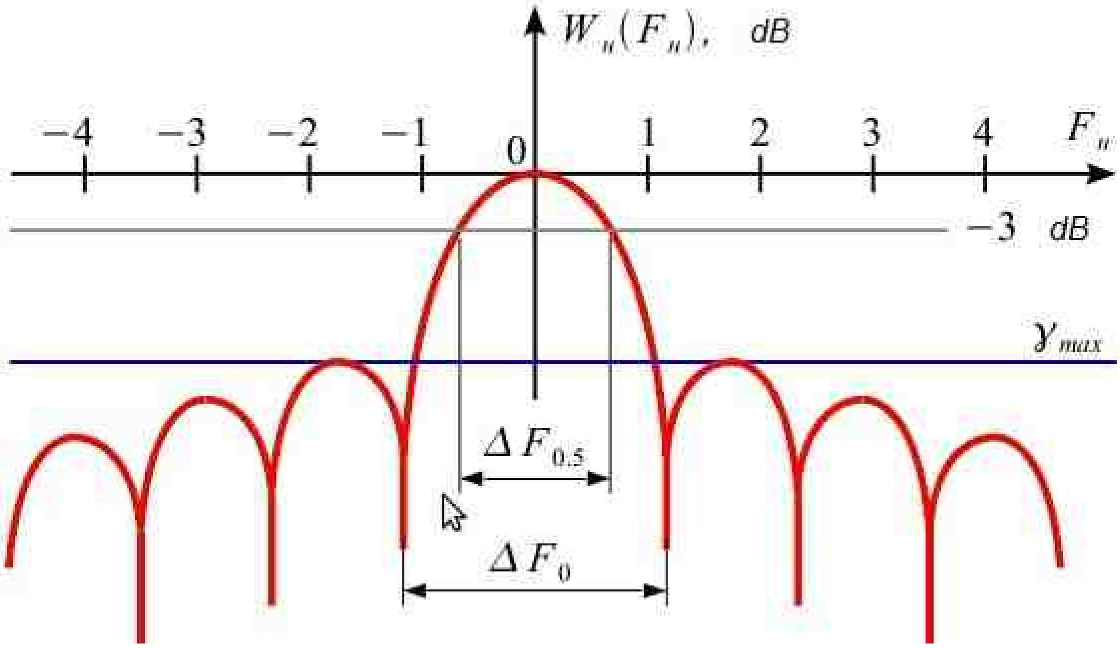


Fig. 1. Normalized amplitude-frequency response of a window function

ΔF_0 - normalized width of main lobe

$\Delta F_{0.5}$ - normalized width of the main lobe at the level of 0.5 (3 dB)

γ_{max} - maximum level of side lobes

Weighting function name	Admissible deviation of average filter frequency 1000 Hz, %	Equivalent noise band, Hz	Band by	Deviation of filter

			level 3 dB, Hz	band width, Hz
Rectangular	1,00	0,89	-13	Rectangular
Hann	2,00	1,50	-31,5	Hann
Hamming	2,00	1,33	-42	Hamming
Blackmann	3,00	1,70	-58	Blackmann
Bartlett	2,00	1,33	-26,5	Bartlett
Kaiser	1,50	1,43	-45,9	Kaiser
Reef-Vincent	-	-	-84	Reef-Vincent
Blackman-Harris	4,00	1,97	-92	Blackman-Harris
Natalla	4,00	1,98	-93	Natalla
Balckman-Natalla	4,00	1,94	-98	Balckman-Natalla
A window with flat top	5,00	3,86	-69	A window with flat top

The list below the title "**Averaging type**" allows to select the mode of spectra accumulation and averaging (i.e. the averaging type): linear or exponential.

The list below the title "**Integration/differentiation**" allows to select the signal processing type: differentiation, double differentiation, unedited, integration, double integration. These options may prove to be useful for operations with velocity and acceleration transducers.

The field under the title "**Processing type**" is used for activation of fast or discrete Fourier transform.

The **FFT Spectrum Analysisis** calculated by means of Fourier transform with the use of weight functions.

By discrete Fourier transform there are meant two biunique transforms:

direct transform

$$X(k)=\sum_{n=0}^{N-1}x(n)e^{-j\frac{2\pi}{N}nk}$$, k = 0, 1, …, N-1;

reverse transform

$$x(n)=\frac{1}{N}\sum_{k=0}^{N-1}X(k)e^{j\frac{2\pi}{N}nk}$$, n = 0, 1, …, N-1.

where:

x(n), n=0, 1, …, N-1 – sequence in time domain (material or complex);

X(k), k=0, 1, …, N-1 – discrete Fourier ratios (material or complex) – a single sequential period in frequency domain;

k – sequence counting number X(k), corresponding to the frequency $k\Delta\omega$;

$e^{-j\frac{2\pi}{N}nk}$ - twiddle factor showing the rotation angle at a circle unit of a complex Z-plane.

By the Fast Fourier transform there is meant a set of algorithms intended for fast calculation of the Discrete Fourier transform. For the Fast Fourier transform the length N of the source sequence should be equal to N=2v, where v – is an integer positive number.

The number of filters in the narrow-band analysis can be equal to 2n or (1, 2, 4, 5, 8)*10n. The central frequencies of the narrow-band filters are calculated as follows:

$f_m = f_{sample} m/N/2$

where f_{sample} – is the sampling frequency, m – the number of filter, N – the number of analysis bands.

The list **Representation type** allows to select representation type: spectral density, spectral power, RMS, peak value.

The field "**Comments for record**" allows to enter all necessary information. The maximum length of the textual information for this section is 200 characters. This textual information will be saved to a *.dtx file as a comment to the results of the signal processing.

The menu **"Y-axis values calculation"** allows to select spectrum representation type: logarithmic, dB (logarithmic scale in relation to the reference value for calculation in dB), or linear (linear scale in measurement units). The reference value for calculation in dB is set in the program ZET Device manager.

The checkbox **"Median filter"** allows to enable/ disable the elimination of discrete components from the signal spectrum.

The menu **"Additional windows"** allows to use additional windows with signal analysis graphics. The list of additional windows is shown below:

- **Cepstrum**.
- **Spectrogram**
- **3D spectrogram**
- **Spectrogram - Cross-section along y-axis**
- **Spectrogram - Cross-section along x-axis**
- **Transit and phase**

The section "***Calculation interval***" is used for setting the time interval for the calculation of Additional graphics (*Average* and *Maximum*). The minimum calculation time is 10 seconds, the maximum – 1000 seconds.

The checkboxes "***Recording in a log – Current spectrum***" allow to activate a logging system for the controlled events display and representation.

Is it possible to represent the measurement data in user-friendly format with a lot of additional information, thus, turning ordinary graphics into an animated object? We have developed a program "***Results view***" especially for this purpose – this program is included into the scope of ZETLAB Software package and is used for viewing and analysis of the historical data, recorded by means of ZETLAB Software for a long-term period of time.

Questions and answers:

Question: I am trying to get an understanding of the new function "***Recording in a log***" – could you please describe its functional application.

Answer: The function "***Recording in a log***" is used to record the spectrum as a sequence of events, that can be viewed in the program "***View historical events***" in the "***Registration***" tab. You can find detailed description of the program by the link below:
https://zetlab.com/en/shop/virtual-devices/functions-zetlab/register/view-of-historical-events/

The section "***Additional graphics***" contains checkboxes for representation of average and maximum spectra. The option "***File (norm)***" allows to display the graphic of a spectrum with pre-set parameters.

In the case if "***Average***" and "***Maximum***" options are selected, there will be displayed two Additional graphics. In addition to that, in the text field under the "***Recording***" button there will appear a line "***Int=***" with a corresponding time interval, which has been set for the calculation of the Additional graphics (i.e., "***Average***" and "***Maximum***" graphs).

If the user wants to obtain a spectrum graphic with a pre-set parameters ("*File (norm)*" option), then it is necessary to enter the directory address containing the file with the necessary spectrum parameters. To do that, enter the "*FFT Spectrum Analysis settings*" window, click the key to the right from the "*File* *(norm)*" option, there will appear a dialog window in which it is necessary to set the directory containing the file with the necessary spectrum parameters. The default directory address is C:\ZETLab\config\. Then it will be possible to enable/ disable representation of the spectrum with the pre-set parameters by checking/ unchecking the checkbox "*File (norm)*". This function is often used when it is necessary to control the signal level exceeding the specified spectral characteristic value.

Any text editor, e.g. NotePad (it should support *.nrm extension) can be used to create or edit the File (norm). The file has the following structure:

1.	80.
10.	70.
100.0	80.
1000.0	90.
10000.0	100.

The left column contains frequencies in ascending order (in Hz), the second column depicts level in dB. The frequency value and corresponding signal level are separated by a space mark.

The key "**Apply**" is used for entering the data to the program and for closing the settings window.

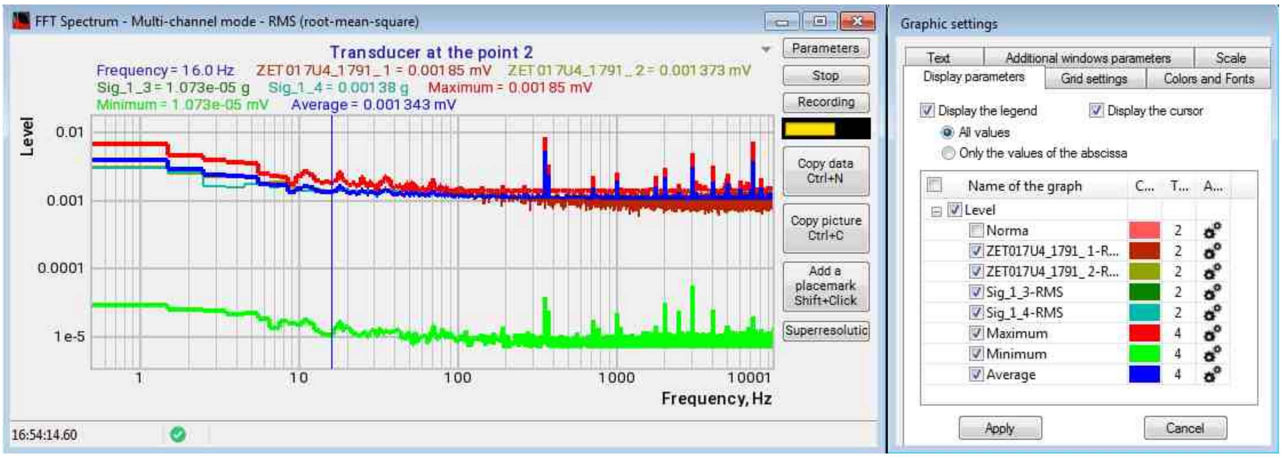
The key "**Cancel**" is used to cancel the parameters configuration and to close the settings window.

The parameters setting window can also be closed using the key in the top right section of the window.

Additional features .....

In addition to the standard settings, the program **FFT Spectrum Analysis** has additional functions, such as:

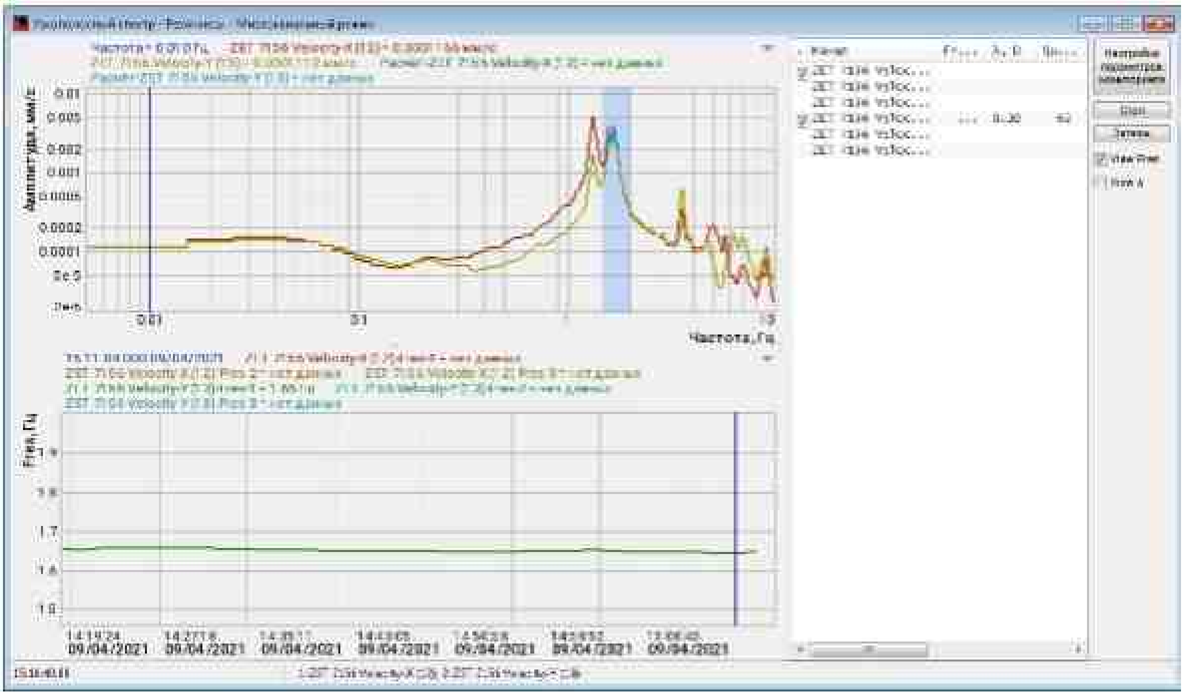
- calculation of resonances;
- trigger;
- additional graphs: display of the maximum, minimum and average levels with a certain calculation interval, display of the norm graphic, a graphic of the third Spectrum CPB Analysis, a graphic of the response spectrum;
- additional windows: kepstr, spectrogram, 3D spectrogram, pass-through characteristic of the signal, phase characteristic of the signal.



Calculation of resonances .....

The **FFT Spectrum Analysis** program implements a mode for calculating resonances. The main area of application of the resonance calculation option is the monitoring of building structures or installations subject to strong vibrations during operation.

Because, in any construction (be it a high-rise building, a bridge or industrial equipment) when forced and natural oscillations coincide, a resonance occurs that can lead to emergency consequences, an effective software tool has been developed that allows you to isolate all resonant frequencies and monitor the most dangerous zones.



To activate the mode, in the **FFT Spectrum Analysis settings** on the Resonances tab, set the flag next to the **Calculation of resonances** parameter and save the settings by clicking the "Apply" button.

The program will launch an additional window: **FFT Spectrum Analysis - Resonances**, which will display the calculated parameters of resonant frequencies, the tracking zone and the resonant frequency trend to analyze the behavior of the structure.

The formation of tracking parameters is carried out in the M**onitoring settings**, to start which you need to press the button of the same name in the program window.

Also, two quick control buttons are available in the program window: "Stop" and "Record", for prompt response to events.

The following parameters are available to the user for management in the **Monitoring settings** window:

- Display: calculation interval and main parameter (resonant frequency or oscillation period);
- Object monitoring: activating this option allows you to set certain thresholds corresponding to the monitored parameters object and control the signal going beyond the specified thresholds;
- Table columns: control of parameters, the values of which will be calculated and displayed in the table for each selected measuring channel;
- Signal trend recording: store long-term monitoring data.

Setting and setting of threshold values is carried out in the xml-file "Monitoring.xml", which is opened using the "Edit descriptor" button in the "Object monitoring" field. For the parameters specified in the descriptor to take effect, you must activate the "Read descriptor" button. For clarity, the type of logs in the table is presented in color combinations.

Trigger .....

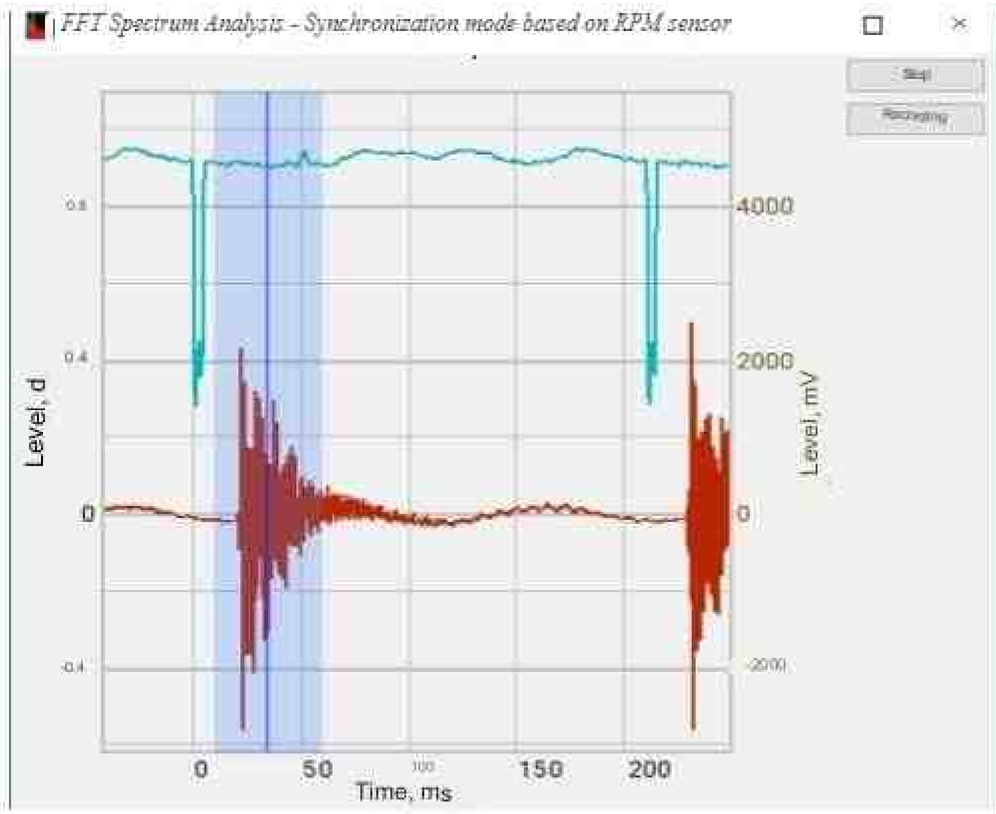
It is not uncommon in practice that there are tasks when it is important to calculate the spectrum of a signal at a certain point in time or for a certain event, for a detailed analysis of the behavior of the frequency components of the sample under study.

The **FFT Spectrum Analysis** program has a trigger function for two modes of operation:

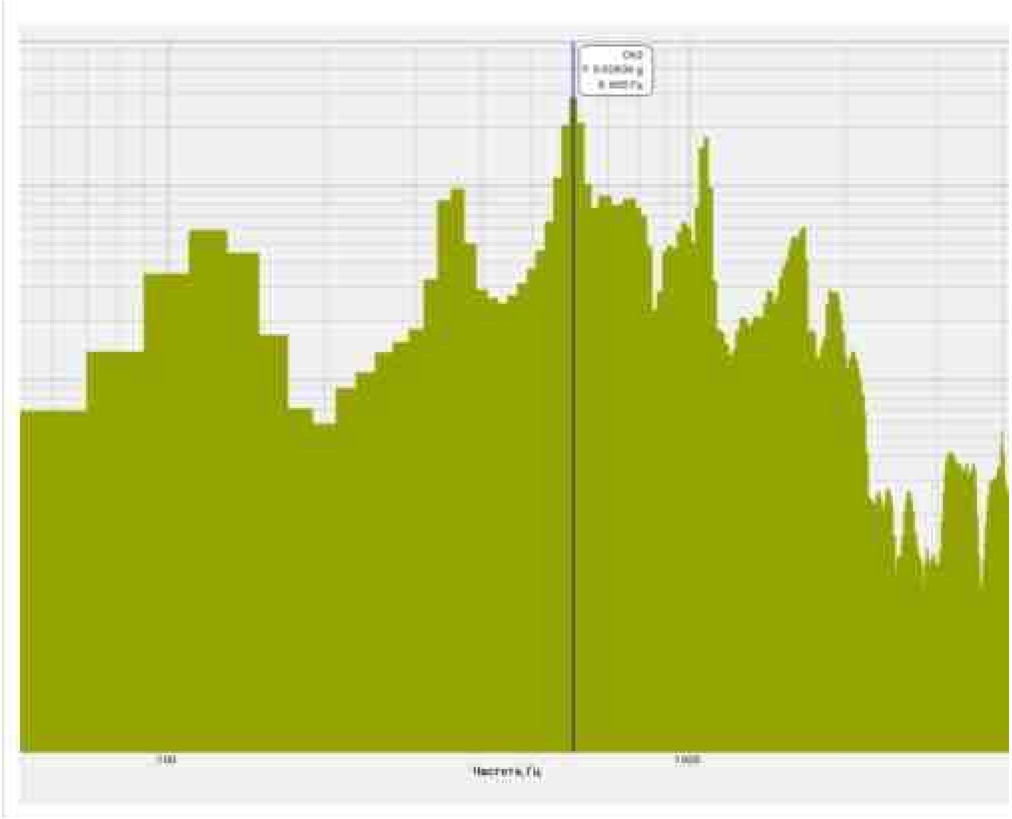
- RPM sensor channel;
- by the value of the signal level.

The type of synchromarks is determined by the RPM sensor. The repetition rate of synchromarks must be at least 1.5 Hz. Pulses can be of any polarity and any amplitude.

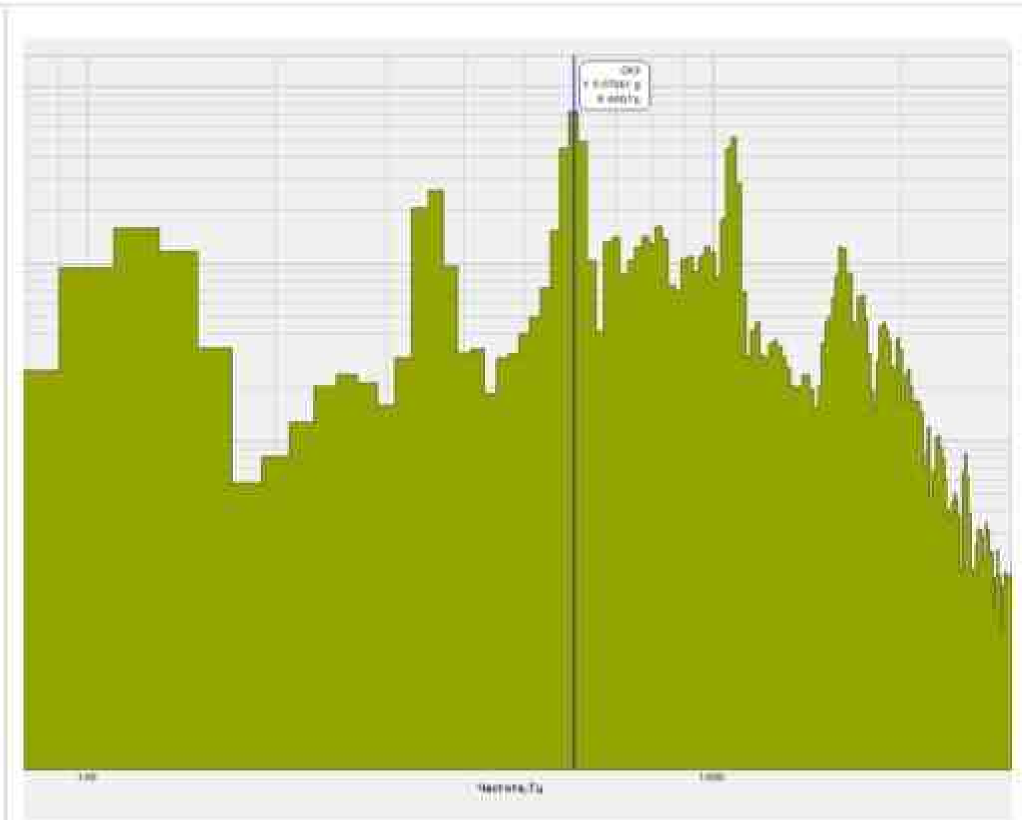
The spectrum is calculated in a narrow band based on the signal from the speed sensor. This type of analysis allows you to select the segment of the spectrum that makes the greatest contribution at the level of total interference. It is convenient in the analysis of structural units containing rotating mechanisms.It is not uncommon in practice that there are tasks when it is important to calculate the spectrum of a signal at a certain point in time or for a certain event, for a detailed analysis of the behavior of the frequency components of the sample under study.



Synchronization mode based on RPM sensor



FFT Spectrum Analysis without triggers



FFT Spectrum Analysis triggered

Spectrum calculation can also be carried out according to the set value of the signal level in the following options:

- greater than a positive value;
- between them;
- less than a negative value;

or by amplitude at the set signal threshold:

- more than a threshold;
- less than the threshold.

Additional windows .....

FFT Spectrum program has the following additional features:

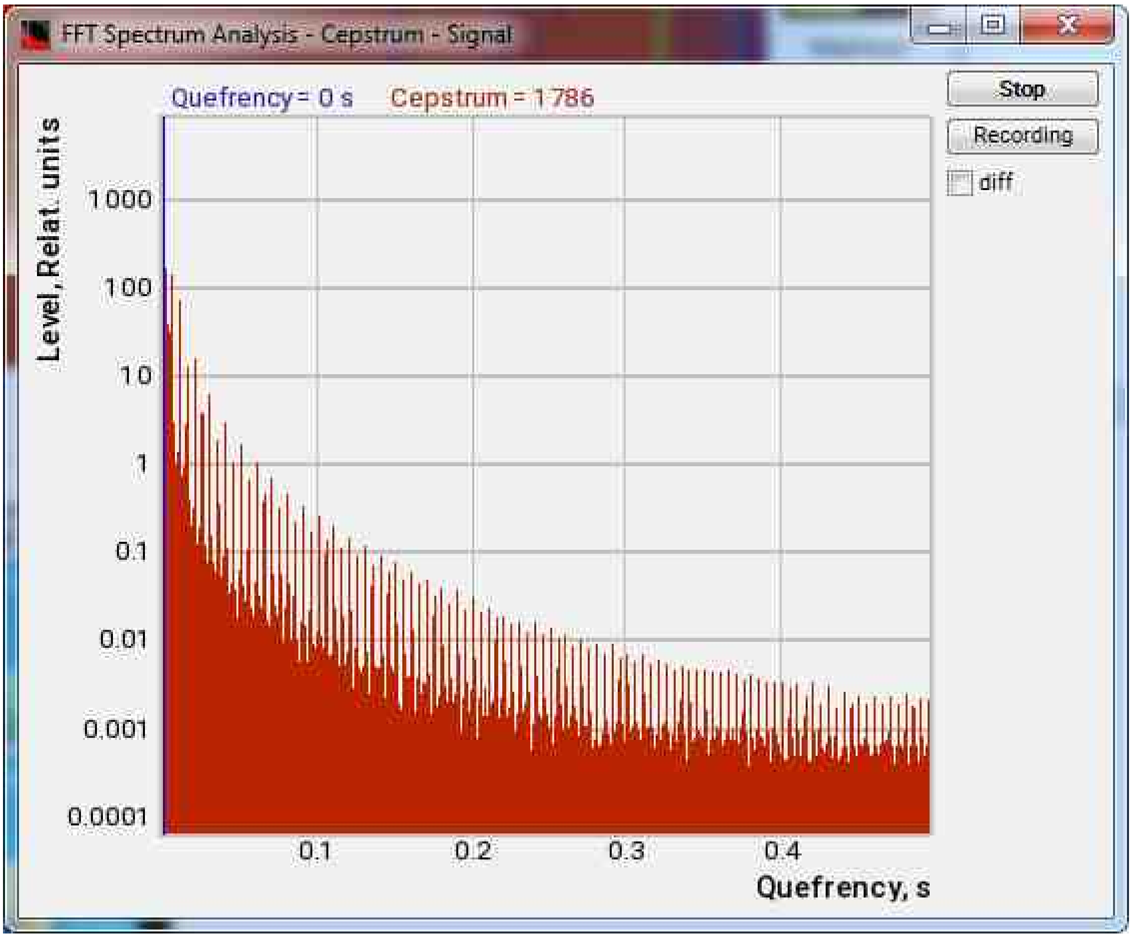
- Building **Cepstrum**.
- Building **Spectrogram**
- Building **3D spectrogram**
- Building **Spectrogram - Cross-section along y-axis**
- Building **Spectrogram - Cross-section along x-axis**
- Building **Transit and phase**

Cepstrum .....

When you check the Cepstrum box in the Additional windows frame. Setting parameters of **FFT Spectrum Analysis** opens an additional window of cepstral analysis **FFT Spectrum Analysis** - Cepstrum. The window title contains the name of the spectrum itself (**FFT Spectrum Analysis**), the name of the additional window (Cepstr) separated by a dash, and the channel name separated by a dash (for example, Signal 1).

Cepstrum is the inverse Fourier transform of the logarithm of the spectrum and has the dimension of time.

Cepstral analysis is applicable, for example, in the analysis of speech to determine the frequency of the fundamental tone and allows you to separate the slowly changing component of the spectrum from the rapidly changing one.



Cepstrum analysis of the FFT Spectrum

See also:

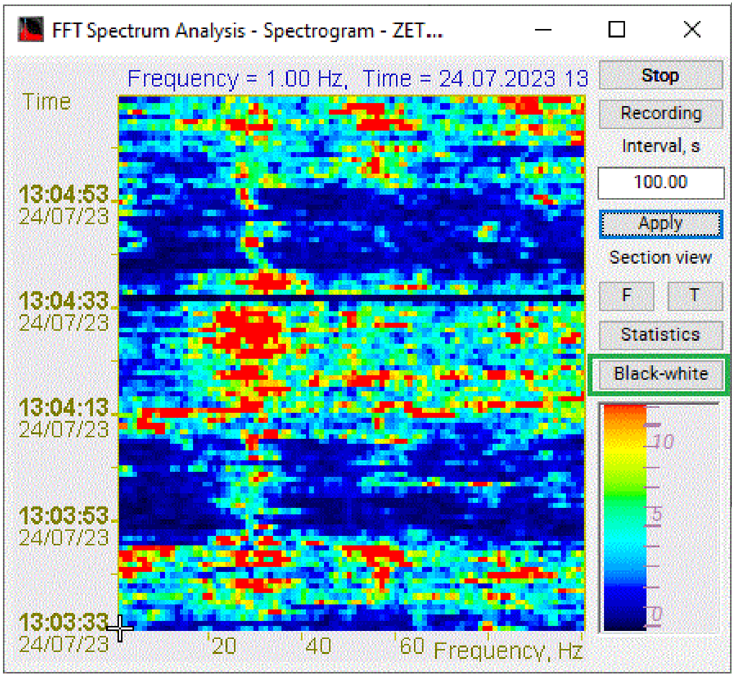
- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Setting parameters of display
- Using signal level indicators
- Adjustment of the color scheme used for displaying of the registered signal amplitude values
- Graphical and numerical data transfer to text editors
- Setting GridGl grid functionality

Spectrogram .....

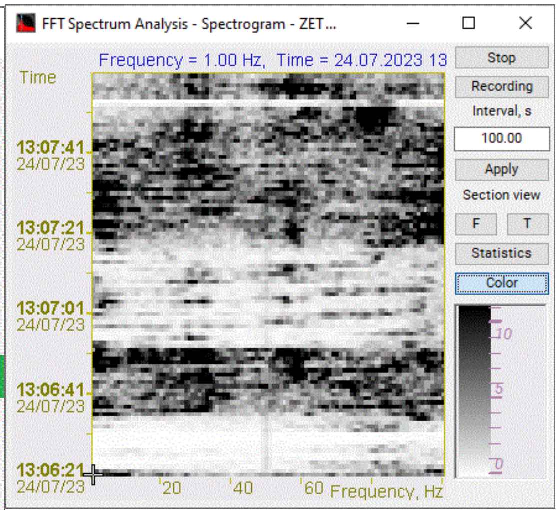
When the ***Spectrogram*** checkbox is selected, there appears an **additional window** of time-frequency distribution of the **FFT Spectrum**, i.e. the spectrogram.

The **spectrogram** is used for evaluation of the spectrum frequencies distribution along the time domain.

The name of the window contains the spectrum name (**FFT Spectrum**), the name of Additional graphic (**Spectrogram**) and the name of the channel.



FFT Spectrum - Spectrogram color view - Color



FFT Spectrum - Spectrogram color view - Black-white

FFT Spectrum - spectrogram

The color indication corresponds to the spectrum level. Low levels are displayed in black color, high levels – in red color.

The spectrum level is displayed in accordance with **FFT Spectrum program** settings: RMS, peak, dB, spectral density, spectral power, integrated/ differentiated, etc.

To move the graphic cursor, set the cursor at the crossing between frequency ant time value and left-click this area. The scaling of the Spectrogram graphic is the same as in the main window of the **FFT Spectrum Analysis program** (see the Clause "ZETLAB Software – Cursor control in graphics"). To perform the scaling by level, move the cursor to the vertical axis and left-click the corresponding icon of the cursor.

The transfer of graphical and numerical data is similar to that in the **FFT Spectrum Analysis program** (see the Clause "ZETLAB Software – Graphical and numerical data transfer to text editors").

The ***Start*** key is used to start spectra accumulation for the **Spectrogram** (previously accumulated spectra are reset).

The key "***Stop (pause)***" allows to suspend the spectra accumulation for the spectrogram. As the Stop key is activated, operation of active cross-section windows is also suspended (cross-section by frequency and cross-section by time). Operation of spectrogram cross-section window is described below. To resume spectra accumulation process, click the *Start* key again.

The record key allows to save the accumulated spectra to a text file with *.gru extension. Activation of the key starts a standard dialogue window, allowing the user to set the directory for saving the file as well as the name of the file. This data can be further used for creation of a 3D representation of the recorded data in various 3D programs. The directory by default is C:\ZETLab\Result\. The file structure is described in the section Recording results to a file.

In the section below *Interval* key, the user can set the time interval of spectra accumulation for spectrogram. The interval is set in seconds, the values are entered from the keyboard. To set the interval value, click "***Apply***" button or <Enter> key.

The "**F**" key under the "*Cross-section*" sign is used to activate "*Spectrogram – cross-section by frequency*" window.

The "**T**" key under the "*Cross-section*" sign is used to activate "*Spectrogram – cross-section by time*" window.

The key "***Type of color***" is used for color display of the spectrogram (it is active by default).

If the key is not active, then the spectrogram and the vertical axis of the spectrogram (analog of signal level) will be displayed in black-and-white mode. This may be useful in the case if it is necessary to print the spectrogram.

The vertical scale of the spectrogram located under the key "***Type of color***" shows the relation of spectrogram color to its level.

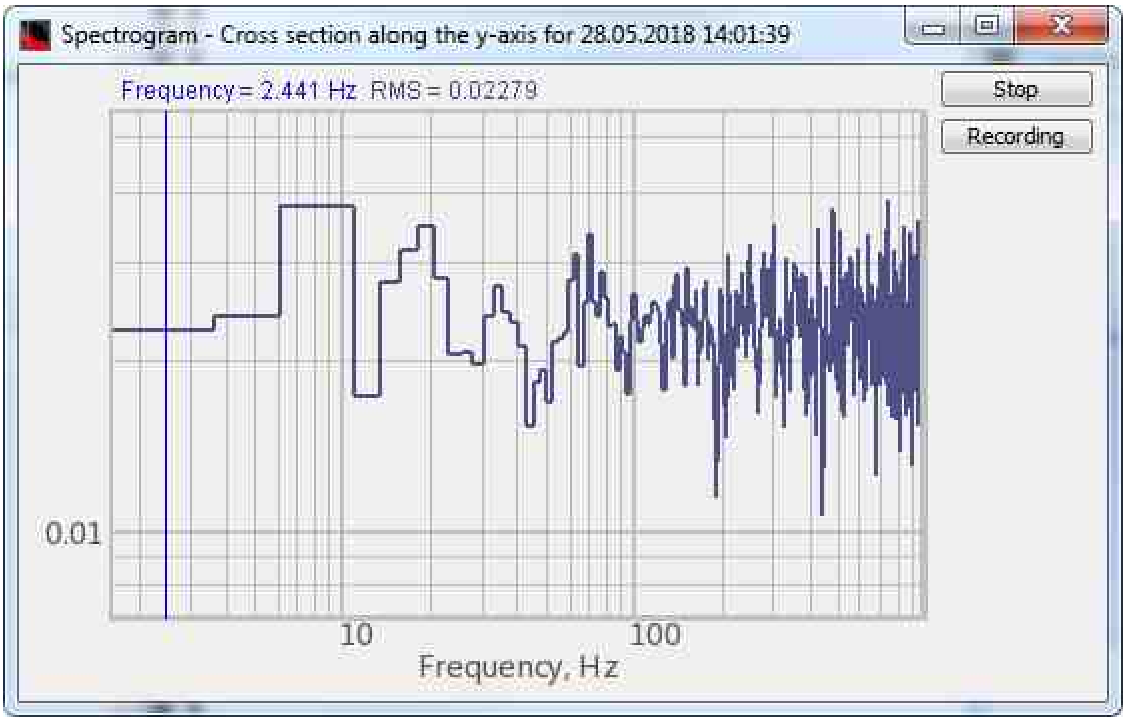
If you want to close the Spectrogram window, uncheck the "**Spectrogram**" checkbox in the "**Additional windows**" boxed of the "FFT Spectrum Analysis settings", or click "X" in the top right section of the window (in this case the "**Spectrogram**" checkbox will be automatically unchecked).

See also:

- Cursor control in graphics
- Using signal level indicators

Spectrogram - Cross-section along y-axis .....

Upon activation of the key **F** in the window **"FFT Spectrum - Spectrogram"** there appears the window **"Cross-section along y-axis"**, i.e. the signal graphic displays dependence of the displayed function on the delay (in seconds). The displayed value depends on the cursor position at the **spectrogram** graphic (see the Fig.).

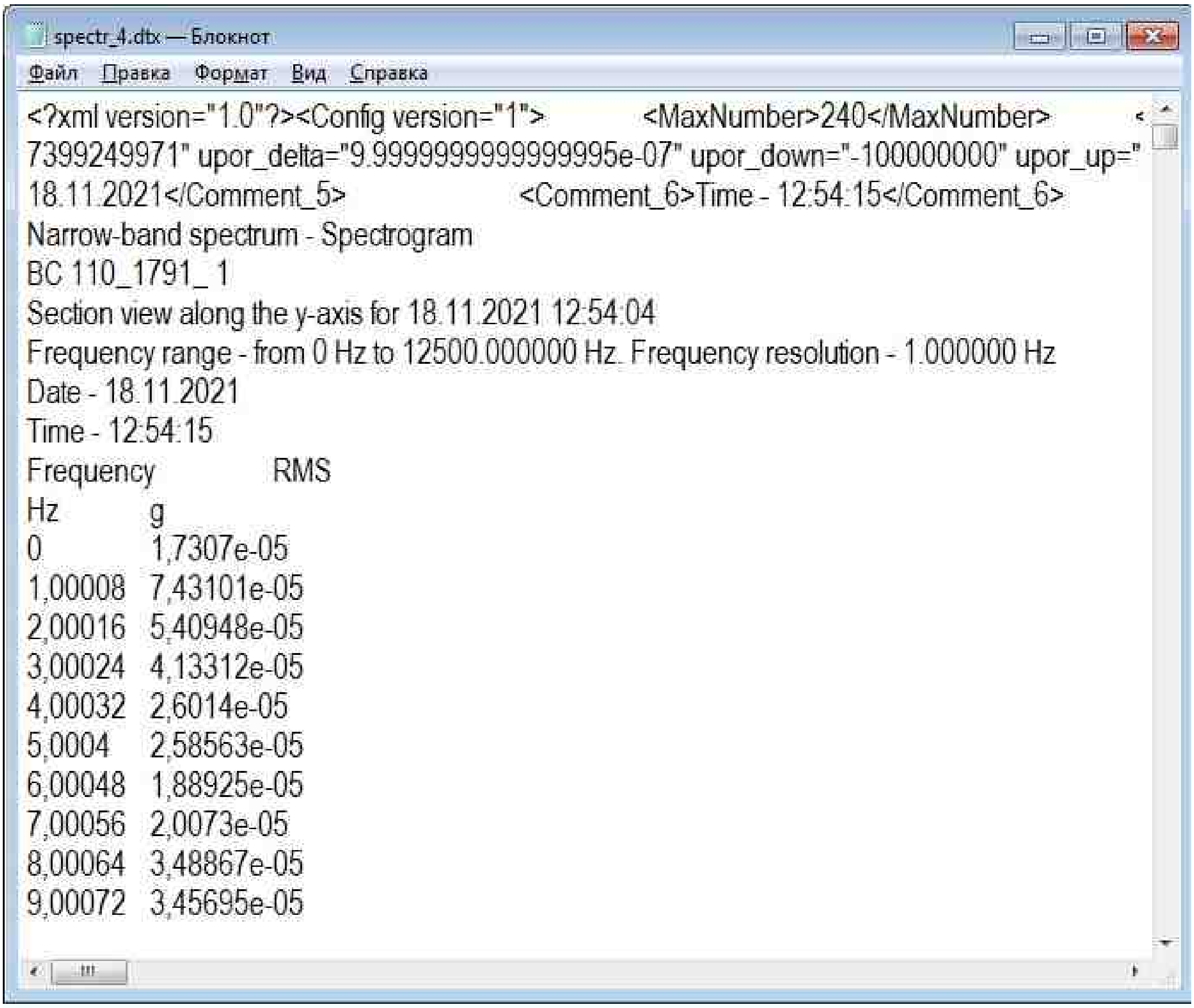


FFT Spectrum Analysis - Spectrogram - Cross-section along y-axis"

By moving the cursor along the graphic section of the program "**FFT Spectrum Analysis - Spectrogram"**, it is possible to analyze the spectrum characteristics at any particular time point. By setting the cursor at the required time point, it is possible to view the required section of frequency characteristics of the accumulated **Spectrogram**. Cursor control and graphics scaling, as well as transfer of graphical and numerical data are implemented in the same way, as in the main window of "**FFT Spectrum Analysis** program (see the clause "Cursor control in graphics – "Graphical and numerical data transfer to text editors ").

The "**Recording**" key allows to record the instant values of the displayed frequency cross-section to a text file with *.dtx extension. Activation of the key starts a standard dialog window allowing the user to set file name and directory. The directory by default is C:\ZetLab\result\. The file structure is shown in the graphic.

To close the window "**Cross-section along x-axis"**, click the **F** key in the window **"FFT Spectrum Analysis - Spectrogram"** again or use the key in the top right section of the program interface.



spectr_4.dtx — Блокнот

Файл Правка Формат Вид Справка

<?xml version="1.0"?><Config version="1"> <MaxNumber>240</MaxNumber> <
7399249971" upor_delta="9.9999999999999995e-07" upor_down="-100000000" upor_up="
18.11.2021</Comment_5> <Comment_6>Time - 12:54:15</Comment_6>

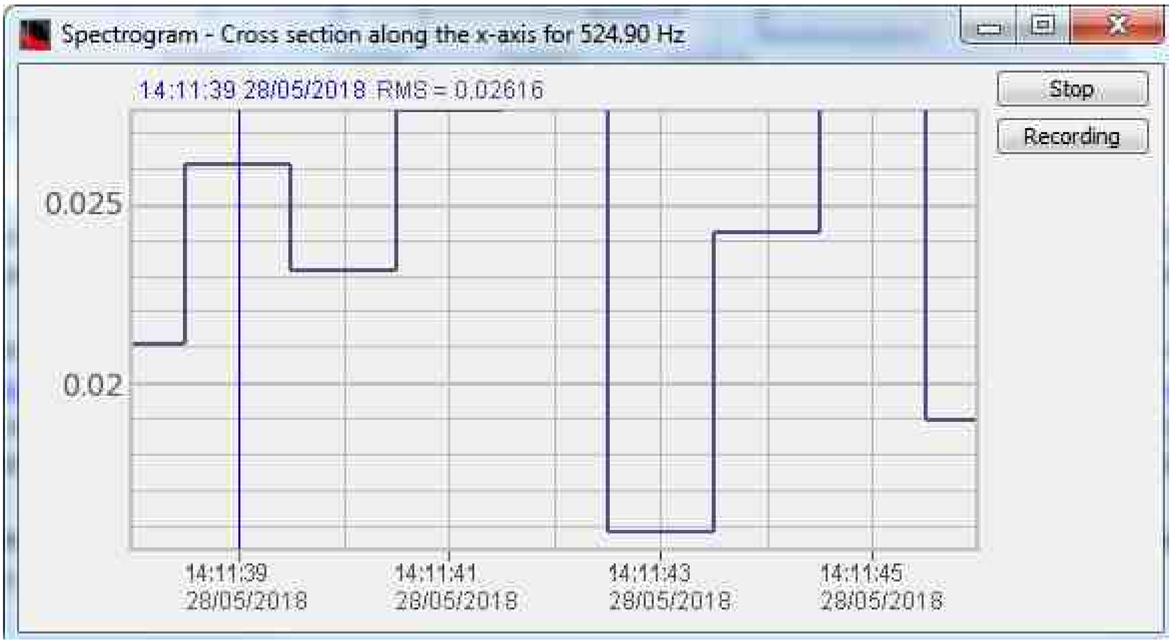
Narrow-band spectrum - Spectrogram
BC 110_1791_ 1
Section view along the y-axis for 18.11.2021 12:54:04
Frequency range - from 0 Hz to 12500.000000 Hz. Frequency resolution - 1.000000 Hz
Date - 18.11.2021
Time - 12:54:15

Frequency	RMS
Hz	g
0	1,7307e-05
1,00008	7,43101e-05
2,00016	5,40948e-05
3,00024	4,13312e-05
4,00032	2,6014e-05
5,0004	2,58563e-05
6,00048	1,88925e-05
7,00056	2,0073e-05
8,00064	3,48867e-05
9,00072	3,45695e-05

Results file Results file records by the program "FFT Spectrum - Spectrogram - Cross-section along y-axis"

Spectrogram - Cross-section along x-axis .....

Upon activation of the key **T** in the window "**FFT Spectrum Analysis**- **Spectrogram"** there appears the window "**Cross-section along x-axis"**, i.e. the signal graphic displays dependence of the displayed function on the absolute time of the delay (in seconds). The displayed value depends on the cursor position at the **spectrogram** graphic.

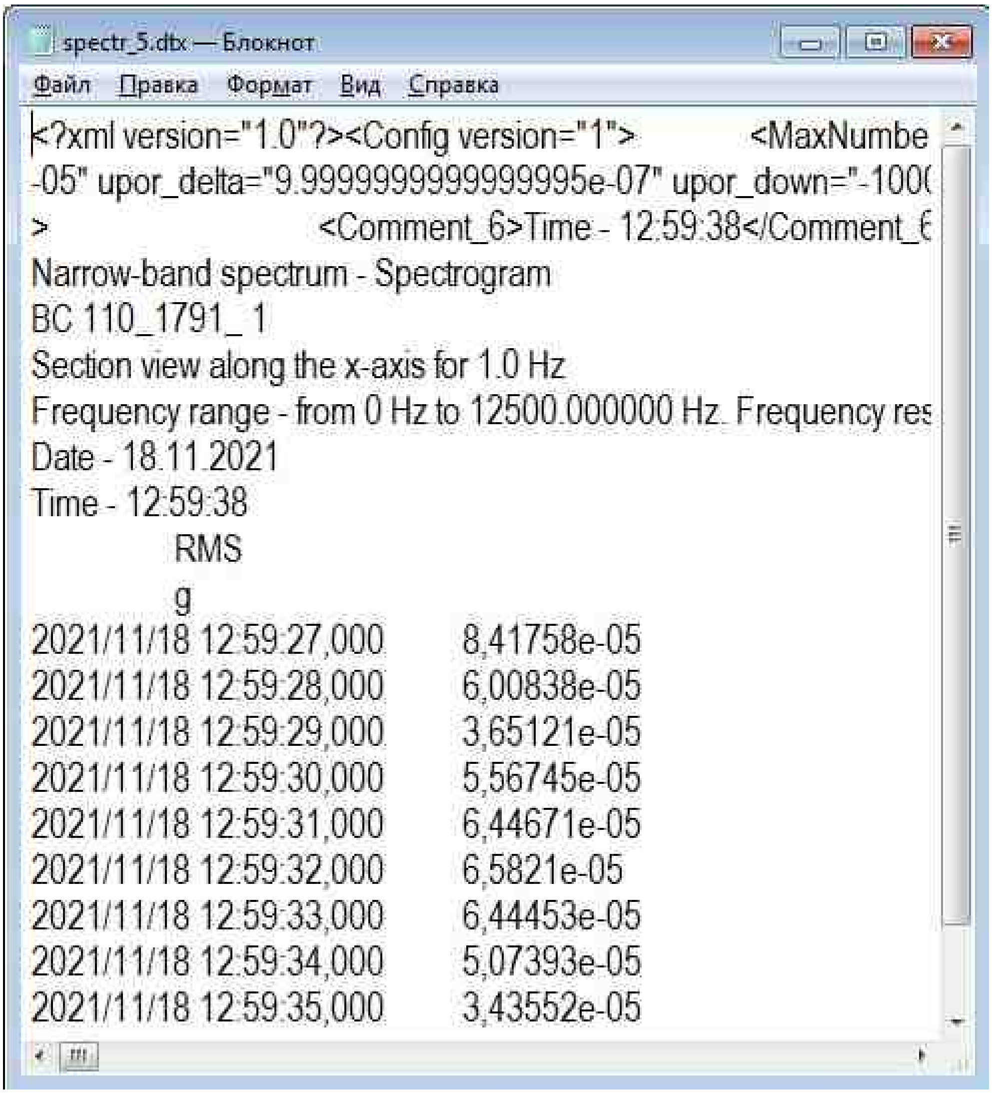


FFT Spectrum Analysis - Spectrogram - Cross-section along x-axis"

By moving the cursor along the graphic section of the program "**FFT Spectrum Analysis - Spectrogram"**, it is possible to analyze the spectrum characteristics at any particular time point. By setting the cursor at the required time point, it is possible to view the required section of frequency characteristics of the accumulated s**pectrogram**. Cursor control and graphics scaling, as well as transfer of graphical and numerical data are implemented in the same way, as in the main window of "**FFT Spectrum Analysis** program (see the clause "Cursor control in graphics – "Graphical and numerical data transfer to text editors ").

The "**Recording**" key allows to record the instant values of the displayed frequency cross-section to a text file with *.dtx extension. Activation of the key starts a standard dialog window allowing the user to set file name and directory. The directory by default is C:\ZetLab\result\. The file structure is shown in the graphic.

To close the window "**Cross-section along x-axis"**, click the **F** key in the window **"FFT Spectrum Analysis - Spectrogram"** again or use the key in the top right section of the program interface.



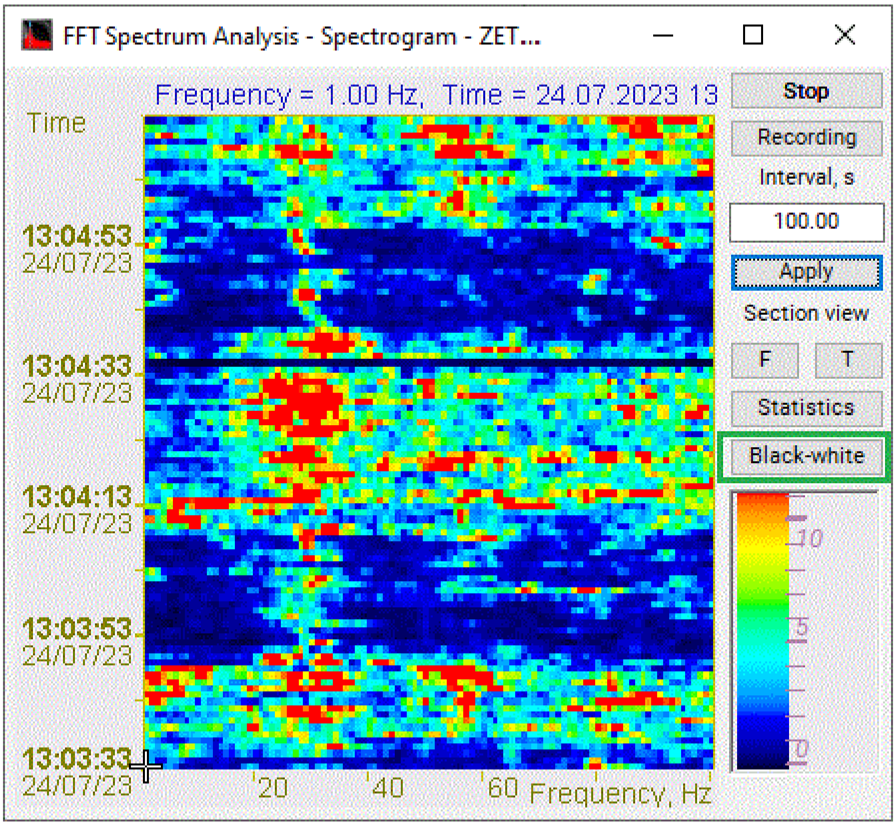
<?xml version="1.0"?><Config version="1"> <MaxNumbe
-05" upor_delta="9.9999999999999995e-07" upor_down="-100(
> <Comment_6>Time - 12:59:38</Comment_6
Narrow-band spectrum - Spectrogram
BC 110_1791_ 1
Section view along the x-axis for 1.0 Hz
Frequency range - from 0 Hz to 12500.000000 Hz. Frequency res
Date - 18.11.2021
Time - 12:59:38

	RMS
	g
2021/11/18 12:59:27,000	8,41758e-05
2021/11/18 12:59:28,000	6,00838e-05
2021/11/18 12:59:29,000	3,65121e-05
2021/11/18 12:59:30,000	5,56745e-05
2021/11/18 12:59:31,000	6,44671e-05
2021/11/18 12:59:32,000	6,5821e-05
2021/11/18 12:59:33,000	6,44453e-05
2021/11/18 12:59:34,000	5,07393e-05
2021/11/18 12:59:35,000	3,43552e-05

Recording results to a file by the program "FFT Spectrum - Spectrogram - Cross-section along x-axis"

3D-spectrogram .....

If the checkbox "***3D spectrogram***" from the "***Additional windows***" section of the "**FFT Spectrum Analysis settings**" window is activated, there appears an additional window with time-frequency distribution of the **FFT Spectrum Analysis** – i.e. 3D spectrogram. This window will depict a three-dimensional time-frequency signal distribution. The three-dimensional spectrogram enables evaluation of envelope curve dynamics in time domain.



3D spectrogram FFT Spectrum Analysis

The title of the window contains the spectrum name (FFT Spectrum), name of the additional window (3D-spectrogram) and the name of the channel (e.g., Signal 2).

The color indication corresponds to the spectrum level. Low levels are indicated with black color, high levels are highlighted in red.

It is possible to scale the 3D spectrogram by left-clicking the changing icon of the cursor in the vertical scale of the 3D spectrogram located under the "*Apply*" key.

By default, the background color of the 3D spectrogram is black. Make a double right-click at the graphical section of the spectrogram to change the background color for white and vice-versa.

It is possible to view the 3D spectrogram from any side by rotating it along three mutually transverse axes. The rotation along three mutually transverse axes is performed in the following way: hold down the left mouse button and move it along the 3D spectrogram, thus rotating it by X and Y axes. To rotate the 3D spectrogram along Z axis, hold down the right mouse button and move it along the 3D spectrogram.

Use the scroll wheel to change the scale of the 3D spectrogram.

Double-click the graphical section of the 3D-spectrogram to set it back to initial scale and position along the axes.

The "***Start***" key allows to begin spectra accumulation to a three-dimensional spectrogram (all the previously recorded spectra will be reset).

The "***Stop*** **(*pause*)**" key allows to suspend accumulation of the current spectra to a three-dimensional spectrogram. Further accumulation of the spectra is activated with "*Start*" key.

The "***Recording***" key allows to save the values of the accumulated spectra to a *.grn file. Activation of the key allows to open a dialog window, which offers the user to set the directory for saving the file and the name of the file. This data can be further used for creation of a three-dimensional image of the recorded information in a 3D design program.
The directory by default is C:\ZETLab\Result\.
The structure of the 3-dimensional spectrogram is similar to that of a 2-dimensional spectrogram (see the description in the clause Recording results to a file).

The section under the "***Interval, s***" sign allows to set the time interval of spectra accumulation for spectrogram. The interval is set in seconds, the interval value is entered from a keyboard. To activate the set time interval value for spectra accumulation, click "Apply" button of <Enter> key.

The vertical scale of the spectrogram, located under the "***Apply***" key, shows the relation of spectrogram color to its level.

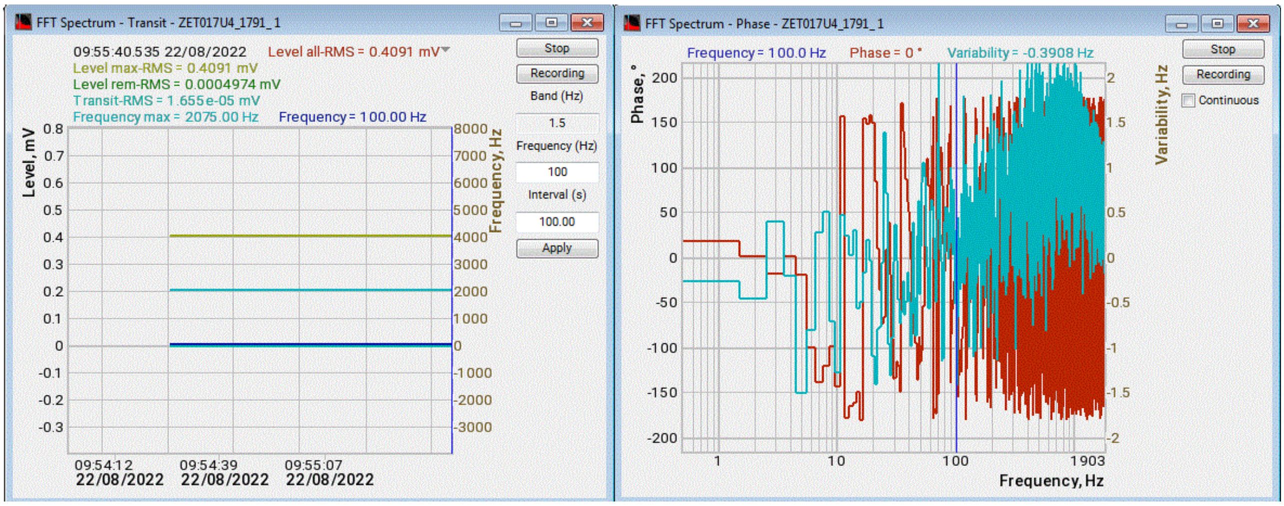
To close the window of the 3D-spectrogram, uncheck the option 3D-spectrogram in the "***Additional windows***" tab, or click "X" in the top right section of the window (the checkbox 3D spectrogram will be automatically unchecked).

Transit and phase .....

In many books and teaching materials on "Circuit engineering" and "Automatic devices" the term "Transit" is used. The flow characteristic is a functional relationship between the information parameters of the output and input processes in the steady status of operation. In a spectrum, the flow characteristic is actually the frequency cutoff for the spectrogram.

When the *Transit* flag is set in the Additional windows frame. **FFT Spectrum Analysis settings** opens an additional window **FFT Spectrum Analysis - Transit**. This window will display the throughput characteristic of the signal at a given frequency.

The Fig. below shows the flow of a harmonic signal at its carrier frequency of 1 Hz. The graphic illustrates the signal accumulation process - in the main window of the **FFT Spectrum Analysis** program, the 1 Hz component increases gradually, and the slew rate depends on the analysis band: the narrower the band, the longer the signal accumulation takes, but at the same time, the more accurate the measurement result..



FFT Spectrum Analysis - Transit and Phase

The title of the window contains the name of the spectrum itself (**FFT Spectrum Analysis**), after a dash the name of the additional window (**Transit**) and, after a dash, the name of the channel (eg Sig_1_1).

The ***Start*** button starts the accumulation of frequency gate data, while the accumulated data is reset to zero

The ***Stop*** button (pause) stops the accumulation process. Further continuation of the accumulation process is carried out by pressing the *Start* button, described above.

The ***Recording*** button allows you to record the accumulated data of the Transit signal at a given frequency to a text file with *.dtx extension. Pressing the button opens a standard dialog box that prompts you to specify the directory to save the file and the name of this file. The default directory is C:\ZETLab\Result\. The file structure is described in the Recording results to a file. section.

The indicator under the label ***Band, Hz*** shows the bandwidth value in hertz. The bandwidth characterizes the signal level at the output of a narrow-band filter at a carrier frequency in a frequency band depending on the frequency resolution and weight function set in the **FFT Spectrum Analysis** program.

The field under the label ***Frequency, Hz*** is used to set the carrier frequency relative to which accumulation will be made in a given time interval. The frequency is set in hertz. The frequency value is entered from the keyboard. To do this, place the mouse cursor on this field, press the left mouse button and use the keyboard to enter the required frequency value from the set frequency range in the **FFT Spectrum Analysis** program.

The field under the label ***Interval, s*** is intended for setting the interval of accumulation of the Transit. The interval is set in minutes. The minimum value of the interval is 10 seconds, the maximum is determined by the computer parameters. The interval values are entered from the keyboard. To do this, by placing the mouse cursor on this field, press the left mouse button and enter the required interval time value from the keyboard. To set the entered time interval, press the Apply button or the <Enter> keyboard key.

To close the ***Transit*** window, either in the **FFT Spectrum Analysis settings** window, remove the *Transit* flag in the ***Additional Window*** frame, or press the "x" button located in the upper right corner of the window, and the *Transit* flag will be automatically removed.keyboards.

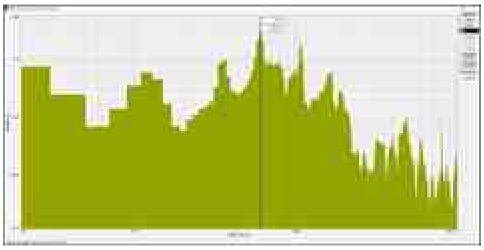
See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Setting parameters of display
- Using signal level indicators
- Adjustment of the color scheme used for displaying of the registered signal amplitude values
- Graphical and numerical data transfer to text editors
- Setting GridGl grid functionality

Recording results to a file .....

Spectrum recording

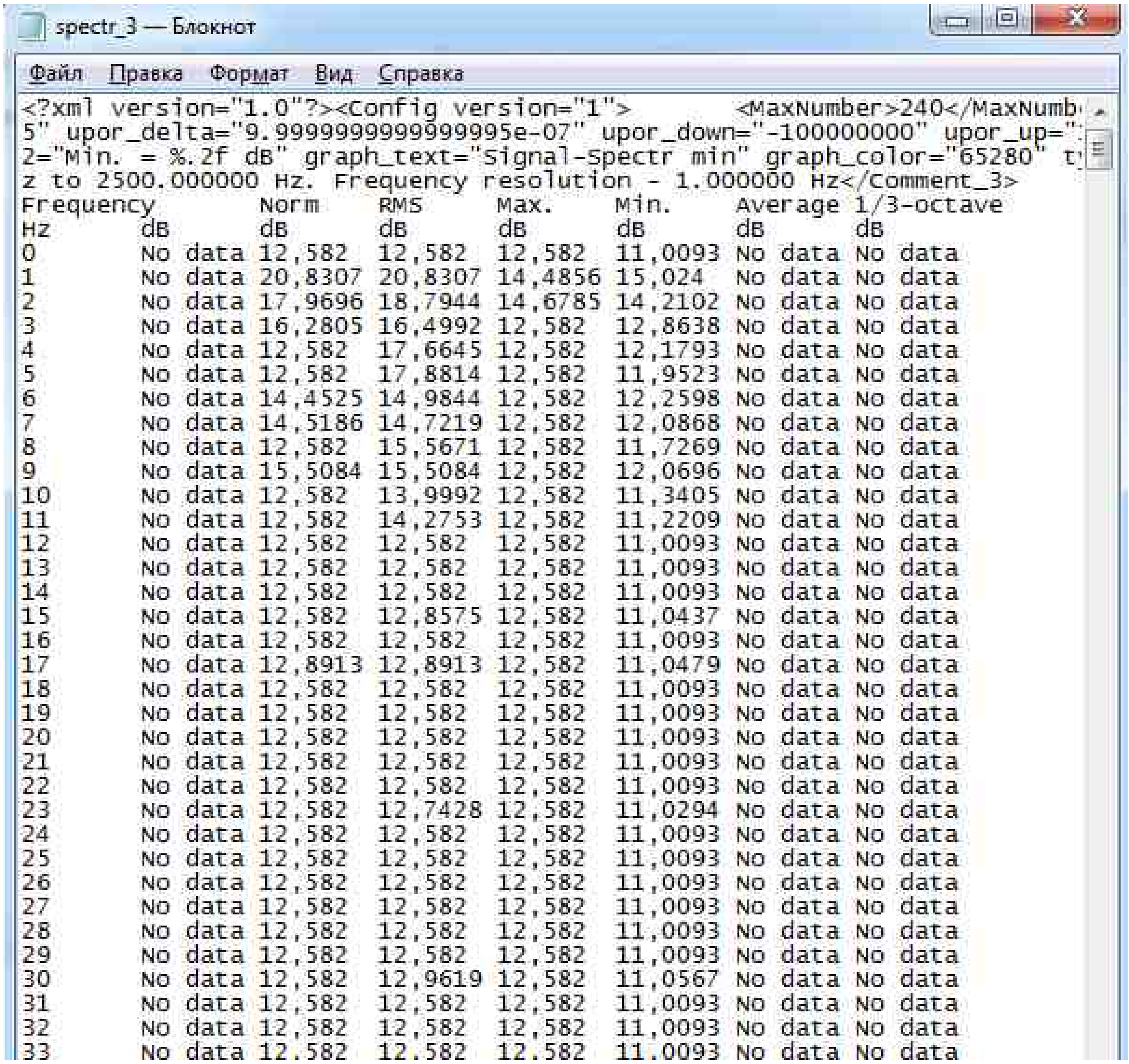
The FFT Spectrum Analysis program provides the ability to write the instantaneous value of the displayed spectrum to a text file with *.dtx extension. When you click the Write button in the FFT Spectrum Analysis program window, a standard dialog box opens, in which you are asked to specify the directory to save the file and the name of this file. The default directory is C:\ZETLab\result.



Note:

When opening dtx files in Excel (they are in UTF-8 format), you need to correctly select the file format (UTF-8) and the separator character (tab character). When opening a file by default, apparently, these settings are not used.

An example file is shown in the figure below.


spectr_3 — Блокнот

Файл Правка Формат Вид Справка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<?xml version="1.0"?><Config version="1">      <MaxNumber>240</MaxNumb
5" upor_delta="9.9999999999999995e-07" upor_down="-100000000" upor_up="
2="Min. = %.2f dB" graph_text="Signal-Spectr min" graph_color="65280" t
z to 2500.000000 Hz. Frequency resolution - 1.000000 Hz</Comment_3>
```


Frequency		Norm	RMS	Max.	Min.	Average	1/3-octave
Hz	dB	dB	dB	dB	dB	dB	dB
0	No data	12,582	12,582	12,582	11,0093	No data	No data
1	No data	20,8307	20,8307	14,4856	15,024	No data	No data
2	No data	17,9696	18,7944	14,6785	14,2102	No data	No data
3	No data	16,2805	16,4992	12,582	12,8638	No data	No data
4	No data	12,582	17,6645	12,582	12,1793	No data	No data
5	No data	12,582	17,8814	12,582	11,9523	No data	No data
6	No data	14,4525	14,9844	12,582	12,2598	No data	No data
7	No data	14,5186	14,7219	12,582	12,0868	No data	No data
8	No data	12,582	15,5671	12,582	11,7269	No data	No data
9	No data	15,5084	15,5084	12,582	12,0696	No data	No data
10	No data	12,582	13,9992	12,582	11,3405	No data	No data
11	No data	12,582	14,2753	12,582	11,2209	No data	No data
12	No data	12,582	12,582	12,582	11,0093	No data	No data
13	No data	12,582	12,582	12,582	11,0093	No data	No data
14	No data	12,582	12,582	12,582	11,0093	No data	No data
15	No data	12,582	12,8575	12,582	11,0437	No data	No data
16	No data	12,582	12,582	12,582	11,0093	No data	No data
17	No data	12,8913	12,8913	12,582	11,0479	No data	No data
18	No data	12,582	12,582	12,582	11,0093	No data	No data
19	No data	12,582	12,582	12,582	11,0093	No data	No data
20	No data	12,582	12,582	12,582	11,0093	No data	No data
21	No data	12,582	12,582	12,582	11,0093	No data	No data
22	No data	12,582	12,582	12,582	11,0093	No data	No data
23	No data	12,582	12,7428	12,582	11,0294	No data	No data
24	No data	12,582	12,582	12,582	11,0093	No data	No data
25	No data	12,582	12,582	12,582	11,0093	No data	No data
26	No data	12,582	12,582	12,582	11,0093	No data	No data
27	No data	12,582	12,582	12,582	11,0093	No data	No data
28	No data	12,582	12,582	12,582	11,0093	No data	No data
29	No data	12,582	12,582	12,582	11,0093	No data	No data
30	No data	12,582	12,9619	12,582	11,0567	No data	No data
31	No data	12,582	12,582	12,582	11,0093	No data	No data
32	No data	12,582	12,582	12,582	11,0093	No data	No data
33	No data	12.582	12.582	12.582	11.0093	No data	No data

Results file, recorded with the program "FFT Spectrum Analysis"

Monitoring of objects in the FFT Spectrum Analysis .....

In the FFT Spectrum Analysis program, a mode for calculating resonances is implemented. The main area of application for the resonance calculation option is the monitoring of building structures or installations subject to strong vibrations during operation.

Since, in any structure (be it a high-rise building, a bridge or industrial equipment), when forced and natural vibrations coincide, a resonance occurs that can lead to emergency consequences, an effective software tool has been developed that allows you to select all resonant frequencies and monitor the most dangerous zones.

To activate the mode, you need to set the flag next to the "Calculation of resonances" parameter in the FFT Spectrum Analysis parameters settings on the Resonances tab and save the settings, after which  activate the "Apply" button.

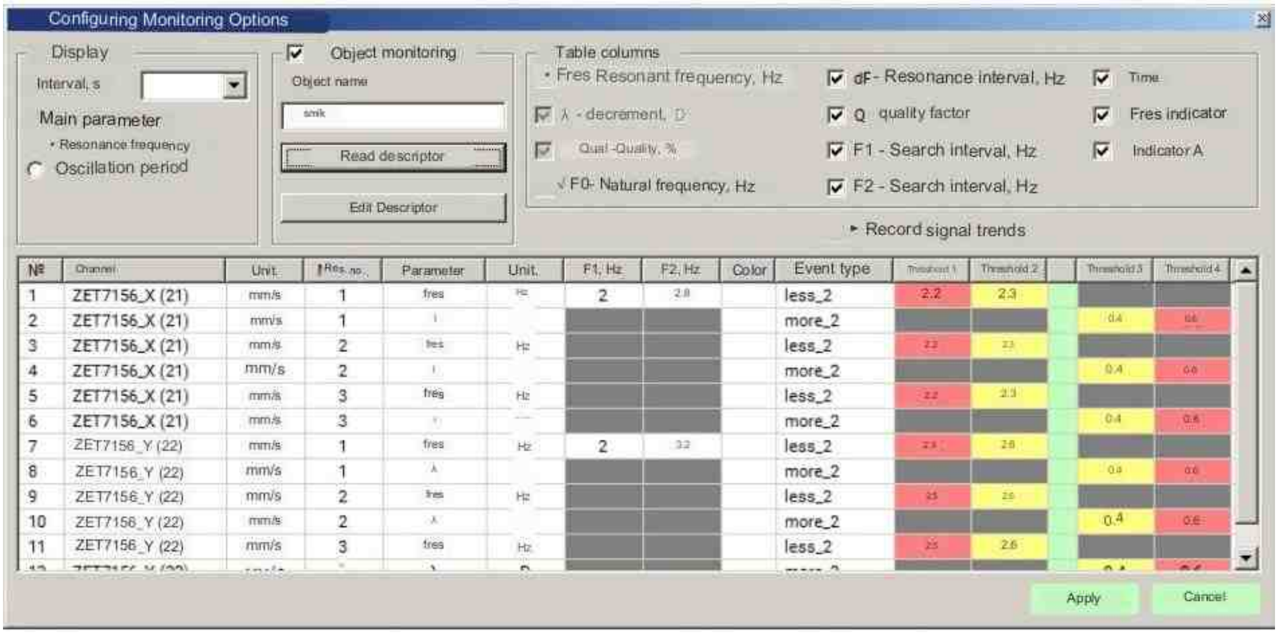
The program will launch an additional window: FFT Spectrum Analysis - Resonances, which will display the calculated parameters of resonant frequencies, the tracking zone and the resonant frequency trend to analyze the behavior of the structure.

The tracking parameters are formed in the Monitoring parameters settings, to start which you need to press the button of the same name in the program window.

Also, two quick control buttons are available in the program window: "Stop" and "Record", for prompt response to events.

The following parameters are available to the user for management in the "Configuring monitoring parameters" window:

- Display: calculation interval and main parameter (resonant frequency or oscillation period);
- Object monitoring: activating this option allows you to set certain thresholds corresponding to the parameters of the monitored object and control the signal going beyond the specified thresholds;
- Table columns: control of parameters, the values of which will be calculated and displayed in the table for each selected measuring channel;
- Recording Signal Trends: Save long-term monitoring data.



Setting and setting of threshold values is carried out in the xml-file "Monitoring.xml", which is opened using the "Edit descriptor" button in the "Object monitoring" field. For the parameters specified in the descriptor to take effect, you must activate the "Read description" button. For clarity, the type of thresholds in the table is presented in color combinations.

Example for a section .....

Table of contents

Application in practice .....

Application in practice

To demonstrate the operation of monitoring events, consider the operation of a car with an internal combustion engine.

Real monitoring software uses a 20% hysteresis when determining whether an event has ended in order to prevent "bounce" of operation.

So, with the type of events “More than threshold”, the event P4 ends at (**TP** < P4m), provided that the event was observed, where P4m = 0.8 * P4. If the same condition is met with the type of events "More than 2 thresholds", the event P4 ends. But the P3 event will end at (TZP < P3m) provided that the event was observed, where P3m = 0.8 * P3. For event types “Less than threshold” and “Less than 2 thresholds”, event P1 ends at (P1p < TST) provided that the event was observed, where P1p = 1.2 * P1. In this case, the P2 event ends at (P2p < **TP**) provided that the event was observed, where P2p = 1.2 * P2. Similarly, for event types "Out of interval" and "Out of 2 intervals":

- the event P1 ends at (P1m < **TP**) provided that the event was observed;
- the P2 event ends at (P2m < **TP**) provided that the event was observed;
- the P3 event ends at (**TP** < P3p) provided that the event was observed;
- the P4 event ends at (**TP** < P4p) provided that the event was observed.

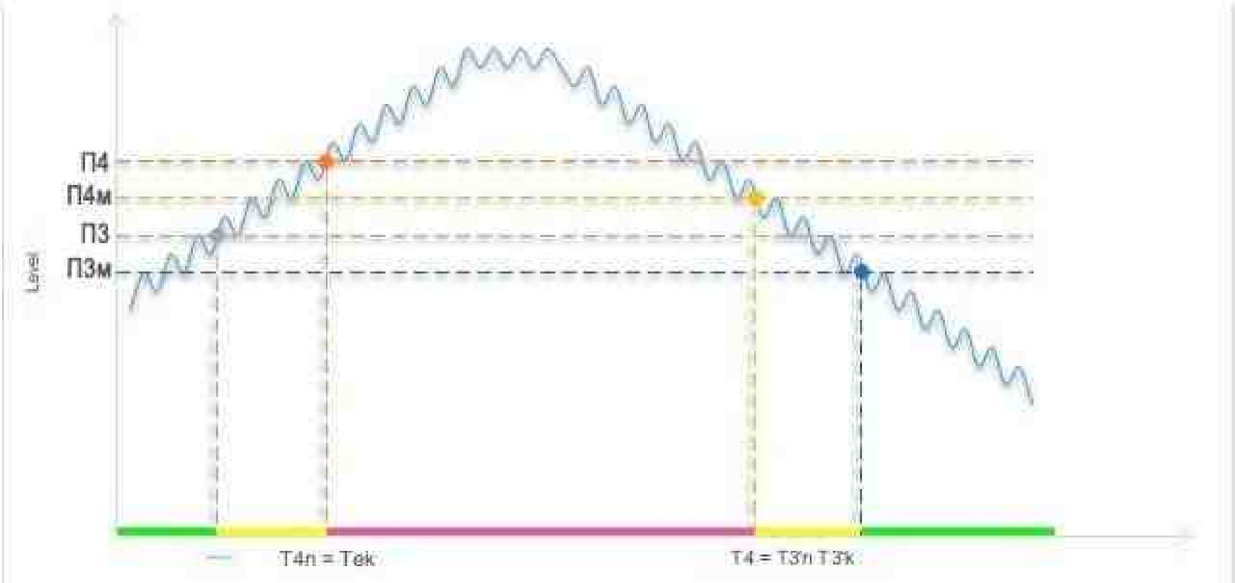
For clarity, the examples in the images show color indication of zones where:

- green zone — no monitoring event;
- yellow zone - an event of the "Warning" type is observed, i.e. P2 or P3;
- red zone - an event of the "Danger" type is observed, i.e. P1 or P4.

Event type "More than threshold"

The "Over Threshold" event type is suitable for monitoring engine temperature. At P4 = 105 °C, the "Danger" event indicates a malfunction in the cooling system and, as a result, the impossibility of continuing the operation of the engine due to the high risk of its failure (jamming).

More than threshold



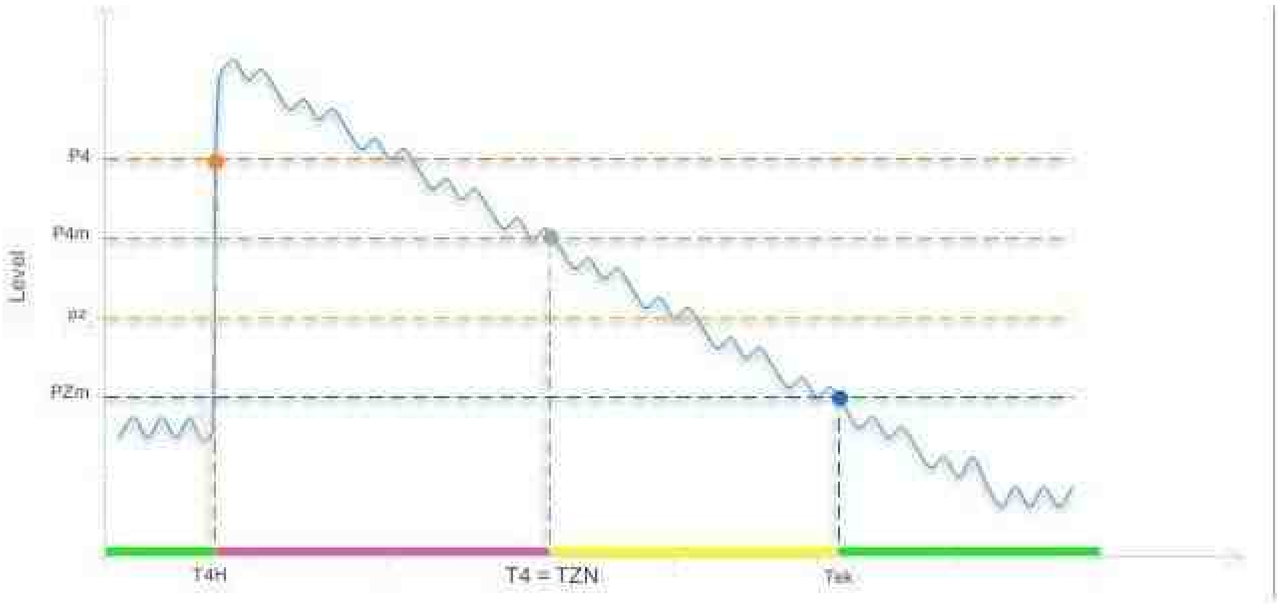
Time

T4n— start time of event P4;
T4k— end time of event P4.

Event type "More than 2 thresholds"

Using the event type "More than 2 thresholds" in this case may additionally issue a preliminary event of the type "Warning". At P3 = 100 °C, this event indicates the beginning of problems.

More than 2 thresholds



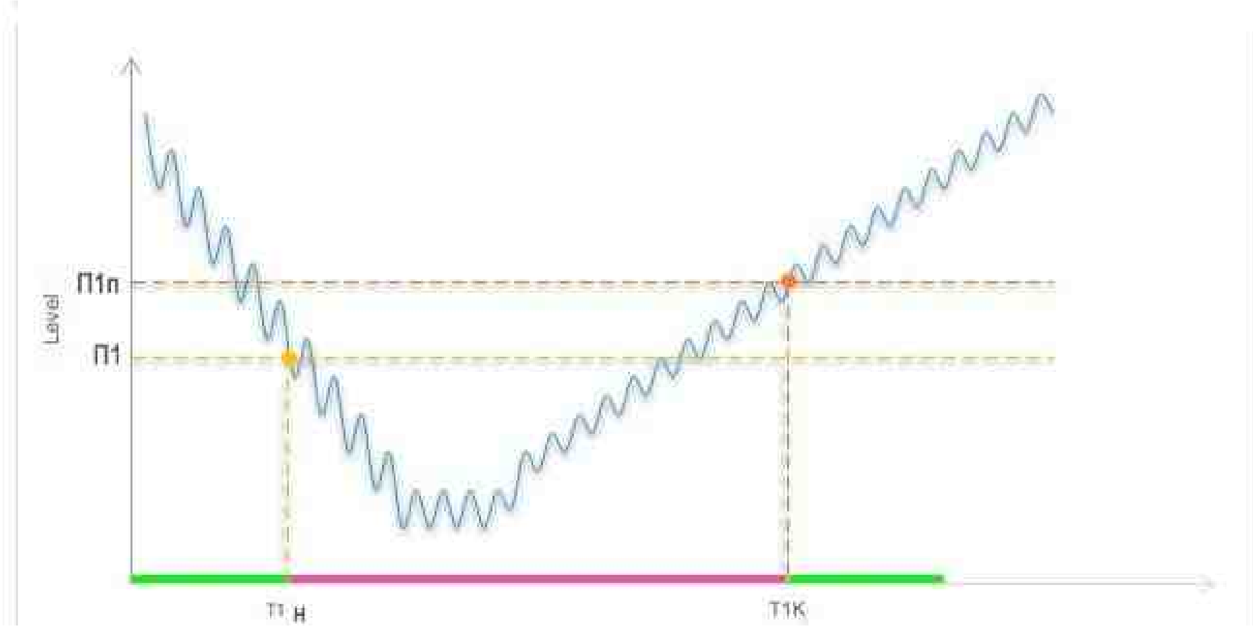
Time

In this case, the P4 event was observed from T4n to T4k, and the P3 event was observed 2 times: from T3n to T3k and from T3n to T3k, while T4n = T3k and T4k = T3n.

Event type "Less than threshold"

The "Less than threshold" event type is suitable for monitoring the amount of fuel in a car's tank. At P1 = 2 liters, the "Danger" event indicates a critical fuel level and, as a result, the impossibility of continuing engine operation due to the high risk of failure of the high-pressure submersible fuel pump.

Less than threshold

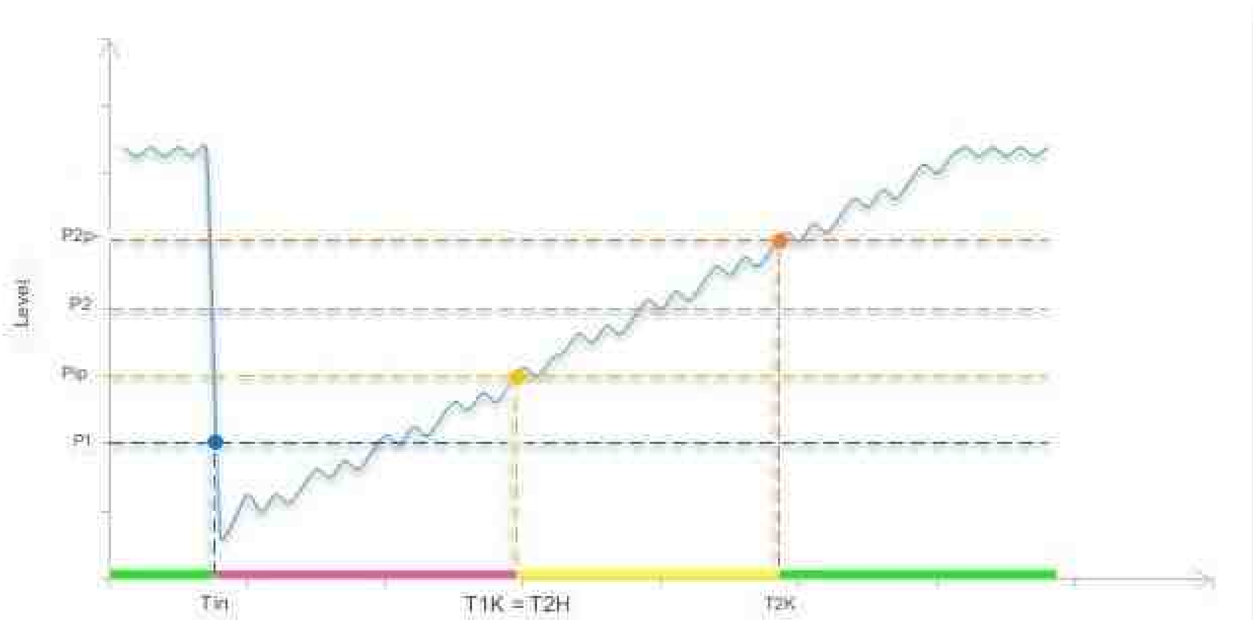


Time

Event type "Less than 2 thresholds"

Using the event type "Less than 2 thresholds" in this case may additionally issue a preliminary event of the type "Warning". With P2 = 5 liters, this event indicates the need for refueling.

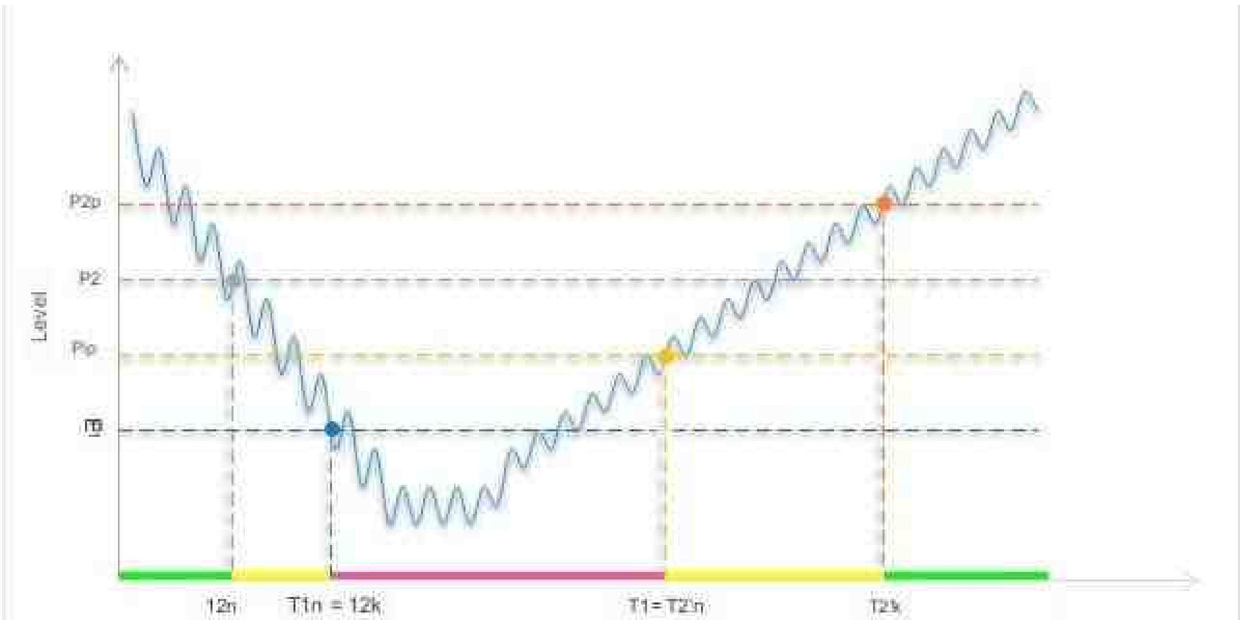
Less than 2 thresholds



Time

In this example, the P1 event was observed from T1n to T1k, and the P2 event was observed from T2n to T2k.
In this case, T1k = T2n.

Less than 2 thresholds



Time

In this example, event P1 was observed from T1n to T1k, and event P2 was observed twice: from T2n to T2k and from T2'n to T2'k.
In this case, T1n = T2k and T1k = T2'n.

The Out of Range event type is suitable for monitoring engine speed. At P1 = 500 rpm, the “Danger” event indicates that there are problems in the engine power supply system and that the engine can stall at any second. At P4 = 7000 rpm, the "Danger" event indicates that the engine is experiencing heavy loads, the long-term impact of which greatly reduces the engine's service life, and engine failure is also possible.

Using the event type "Out of 2 intervals" in this case may additionally generate pre-events of the "Warning" type. At P2 = 700 rpm, the "Warning" event indicates the beginning of problems in the power system. At P3 = 5000 rpm, the "Warning" event indicates the beginning of heavy loads on the engine.

Spectrum CPB analysis (Constant Percentage Bandwidth) Analysis .....

The program "**Spectrum CPB Analysis**" is used for frequency analysis of the signal. Based on the time realization of the signal, it is possible to detect signal response using a set of frequency filters. The central frequencies of the filters are distributed along the frequency axis in geometrical series.

The program has an integrated control and automation module from the scope of ZETLab-Studio software package. The module enables easy creation of individual software measurement suites.

Octave and 1/3 – octave analysis is widely implemented for noise and vibration measurements. The limit vibration and noise levels are specified in sanitary and operational norms for integral, 1/3 – octave and octave frequency bands.

1/12 and 1/24 – octave analysis is intended for a more comprehensive frequency analysis of the signals and its discrete and noise components.

Additional functions of spectral graphics creation (a set of spectra, calculated in consecutive time periods and displayed in 2- and 3-dimensional formats) enable tracking of non-stationary processes dynamics.

Spectral graphics cross-sections in time and frequency domain are used for non-stationary processes parameters evaluation.

The possibility of obtaining maximal, minimal and instant spectra and comparing them with the set spectrum (the norm) allows the user to find the difference between the set and the real spectral level. It may be necessary for equipment control purposes, input / output check, commissioning tests.

Piezoelectrical accelorometers are normally used for the vibroacoustic analysis purposes. These transducers produce a signal proportional to the acceleration level at the transducer mounting point. The norms for vibration level and spectral components are often set based on the vibration velocity value. In order to obtain the vibration velocity signal, it is necessary to integrate the Acceleration signal by time. For balancing purposes, it is also necessary to control the Displacement value at the mounting point of the transducer. Double integration of the Acceleration signal is used to obtain the Displacement signal. The program "**Spectrum CPB Analysis**" has these additional functions of integration and differentiation.

In the course of air noise measurements, it is often necessary to use the corrective filters A, B, C, and D. Upon activation of the corrective filter, the program displays integral levels of the signal (with implementation of the selected corrective filter and without it). However, the spectrum is displayed based on the implementation of the selected corrective filter.

Basic functions and parameters of the program:

- measurement of signal levels in octave, 1/3-, 1/12-, 1/24-octave spectral bands. The number of lanes is 17, 51, 204, 406, respectively. Octave and 1/3-octave filters comply with GOST 17168-82 "Electronic octave and one-third octave filters. General technical requirements and test methods" for the first class of accuracy;
- measurement of signal levels in octave, 1/3-, 1/12-, 1/24-octave spectral bands. The number of lanes is 17, 51, 204, 406, respectively. Octave and 1/3-octave filters comply with GOST 17168-82 "Electronic octave and one-third octave filters. General technical requirements and test methods" for the first class of accuracy;
- Octave and 1/3-octave filters comply with GOST R 8.714-2010 "State system for ensuring the uniformity of measurements. Bandpass octave and fractional octave filters. Technical requirements and test methods"
- analysis of harmonic components;
- writing and reading the program configuration to facilitate measurements in cases where repeatability of actions is required;
- built-in AFR correction.
- measured signal averaging: from 0,1 up to 10 sec;
- averaging types: linear, exponential;

correction types: linear frequency-response characteristics, A, B, C, D correction;

- signals integration /differentiation;
- analyzed signal representation type: spectral density, average RMS or peak value;
- calculation and representation of transient characteristic, general transient and transient harmonics;
- calculation and display of spectral graphic in 2-dimensional mode with color indication of levels, and in 3-dimensional mode;
- calculation and display of maximal, minimal and average values for a set period of time;
- possibility of the normalized graphic overlay for the purpose of transient processes characteristics evaluation;

The program "**Spectrum CPB Analysis**" is a virtual measurement instrument, which can be used within the scope of SCADA-system ZETVIEW for the purpose of measurements automation.

The program "**Spectrum CPB Analysis**" is used for evaluation of signals' Cross-Spectrum characteristics.

Supported Hardware .....

The input data of the program "Spectrum CPB Analysis" is the digital information of **ZETLAB** server channel, which, in its turn, is represented by digitized arbitrary alternating signal.

For the purpose of analog signals digital processing, it is possible to use *FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01, noise- and vibration-meters ZET 110* and *seismic recorder ZET 048*.

It is possible to view channels parameters selected for measurements in the program Input data program "Device Manager".

The program **Spectrum CPB Analysis** is designed to run on computer hardware which meets the requirements set forth in the "Hardware requirements" section of this manual. The computer should have **ZETLAB** software installed.

The software Spectrum CPB Analysis is included into the following software packages:

- ZETLAB ANALIZ – FFT Spectrum software
- ZETLAB VIBRO – Shaker controller systems software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software.

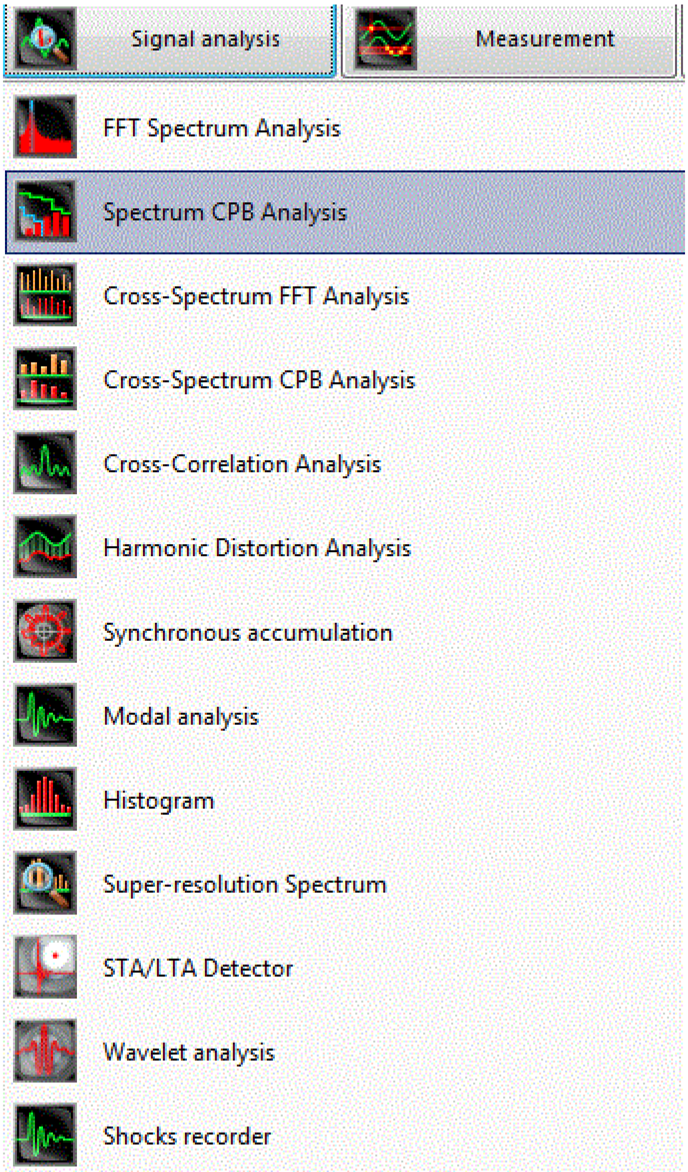
Spectrum CPB Analysis is included in the **Signal analysis** software group.

Program description .....

The program "**Spectrum CPB Analysis**" can be started from "**Signal analysis**" menu of ZETLAB Control panel.

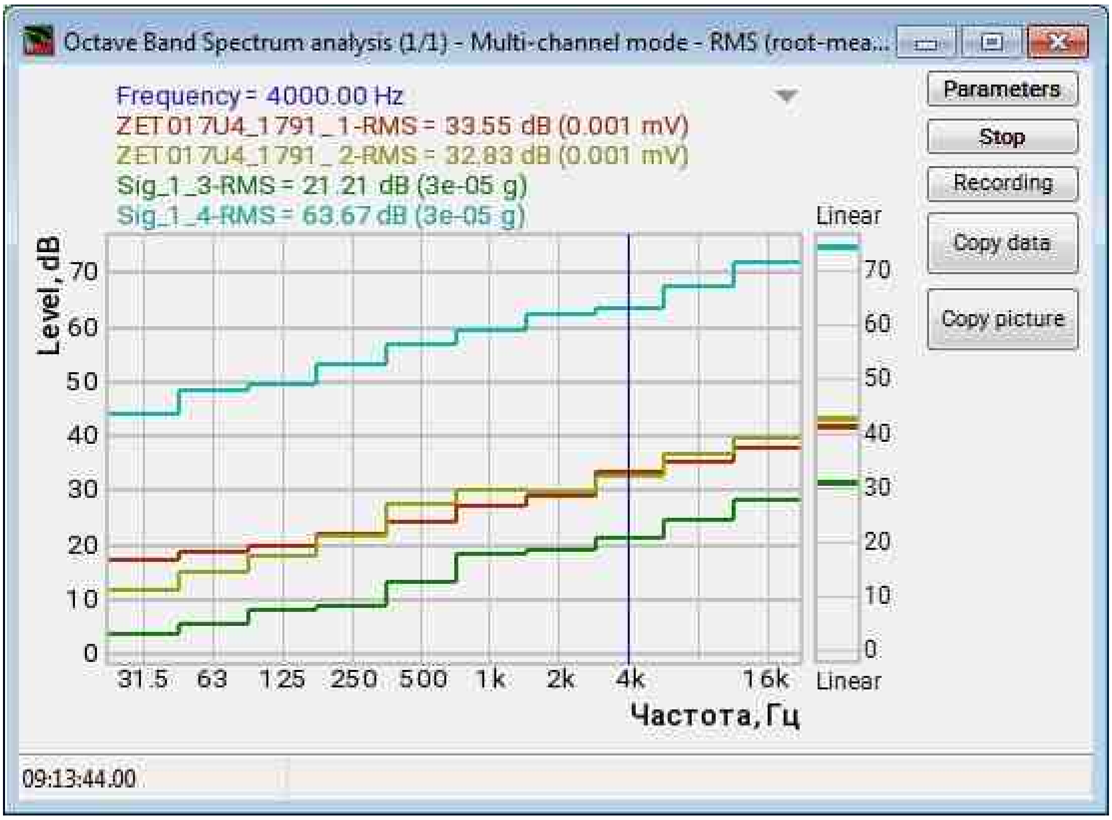
Starting the program "**Spectrum CPB Analysis**"

The heading of the window depicts the program name and the name of the channel selected for analysis. Above the spectrum graphic, you can see the measured parameters (frequency, signal level), corresponding to the graphic cursor position.



Starting the "Spectrum CPB Analysis"

The title of the window will display the name of the program itself and, through a dash, the name of the channel selected for analysis. The measured values (frequency, signal level) corresponding to the position of the graph cursor are displayed above the spectrum graphic.



Program window "Spectrum CPB Analysis"

Note: the program can be started directly from ZETLAB directory (by default: C:\ZETLAB\). Name of the file to be started: dspectr.exe

The main part of the program "***Spectrum CPB Analysis***" consists of a field used for representation of measurements results – signal spectrum and Additional graphics. The indicator to the right from the graphic shows signal integral level with their linear-frequency response (to the left) and corresponding frequency characteristics of A-D type (to the right). The type of frequency characteristics can be selected in the window "**Spectrum CPB Analysis settings**" (see the section "Integral level"). It is possible to enable/ disable the indicator in the menu "**Spectrum CPB Analysis settings**" using the checkbox "Integral level".

The right section of the program window contains a number of control keys and indicators:

- Options – the key activates the settings menu of the program: measurement channels, analysis parameters, etc.

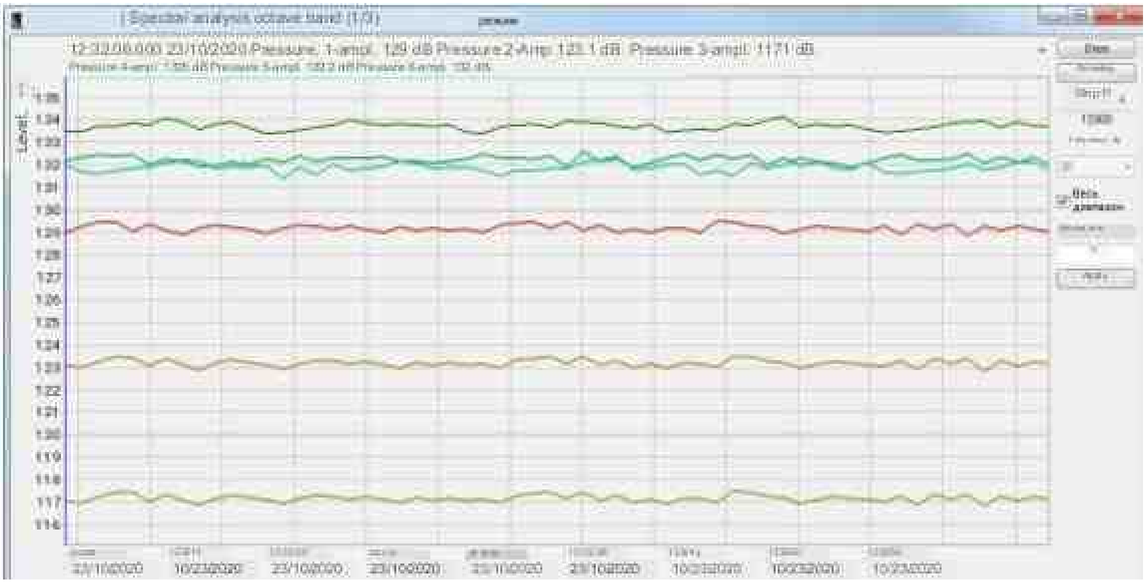
- Start/stop – analysis process control. By default, the key "Start" is active at the first start of the program. If the user sets the calculation interval for Additional graphics, then, upon activation of the key, the accumulated data is set to zero and the calculation process begins again.
- Recording – the key is used for saving the measurements results to a file. The structure of the file is described in the corresponding section "Saving the results in a file".
- Int=... s – the time interval from the beginning of the measurements process. This parameter is only applicable to calculation of the Additional graphics. The time interval for calculation of the Additional graphics can be set in the settings of the program "Spectrum CPB Analysis". Upon completion of the corresponding period, the calculation process of the Additional graphics is suspended and duration of the corresponding interval is displayed.
- The "Maximum" section specifies frequency and value of the current spectrum maximal value.
- The integral level indicator displays the relation displays the relation of current signal to the maximum value of the measurement range. This allows to evaluate the signal level and overloading by a particular channel.

See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Setting parameters of display
- Using signal level indicators
- Adjustment of the color scheme used for displaying of the registered signal amplitude values
- Graphical and numerical data transfer to text editors
- Setting GridGl grid functionality

Multi-channel Spectrum CPB analysis .....

An additional graphic, “Transit”, now works in Multi-channel mode. For display in the pass-through, you can choose not only the value of one of the bands, but also the integral level of the spectrum as a whole.



Measurement of vibration and acoustic characteristics of specimens .....

The set of equipment is designed to measure and standardize vibration levels and noise levels during bench vibroacoustic tests under various operating modes of the tested equipment to determine compliance with technical requirements.

The equipment is intended for registration of both stationary and non-stationary processes. Measurements are carried out in accordance with the requirements of noise and vibration control and standardization procedures (MKSHS-81, MKVSh-80, MKGSh-82).

- spectrum analyzers ZET 017-U8;
- measuring microphones;
- vibration sensors;
- amplifiers and converters;
- software:
- measurement of vibration and acoustic characteristics of products;
- 1/3 octave spectrum analysis;
- multi channel oscilloscope;
- multi channel recorder.

The system provides measurements for various requirements for the product under test - using 1/3-octave, narrow-band and cross-spectrum analysis. For each requirement, there is a separate subroutine window, which includes a set of all parameters that must be taken into account during testing.

When measuring the levels of vibration and noise parameters of the product, the user can use the "Preview" function, with which it will be possible to determine the correct installation of the product and, after that, start the experiment.

After the accumulation and averaging of the spectra according to different algorithms, the function of viewing the results will be useful, with which it will be possible to determine the correctness of the test and decide on the feasibility of repeating the measurements.

All measurement data are stored in protocol files in MS Excel format.

Software for measuring vibration and acoustic characteristics of specimens:

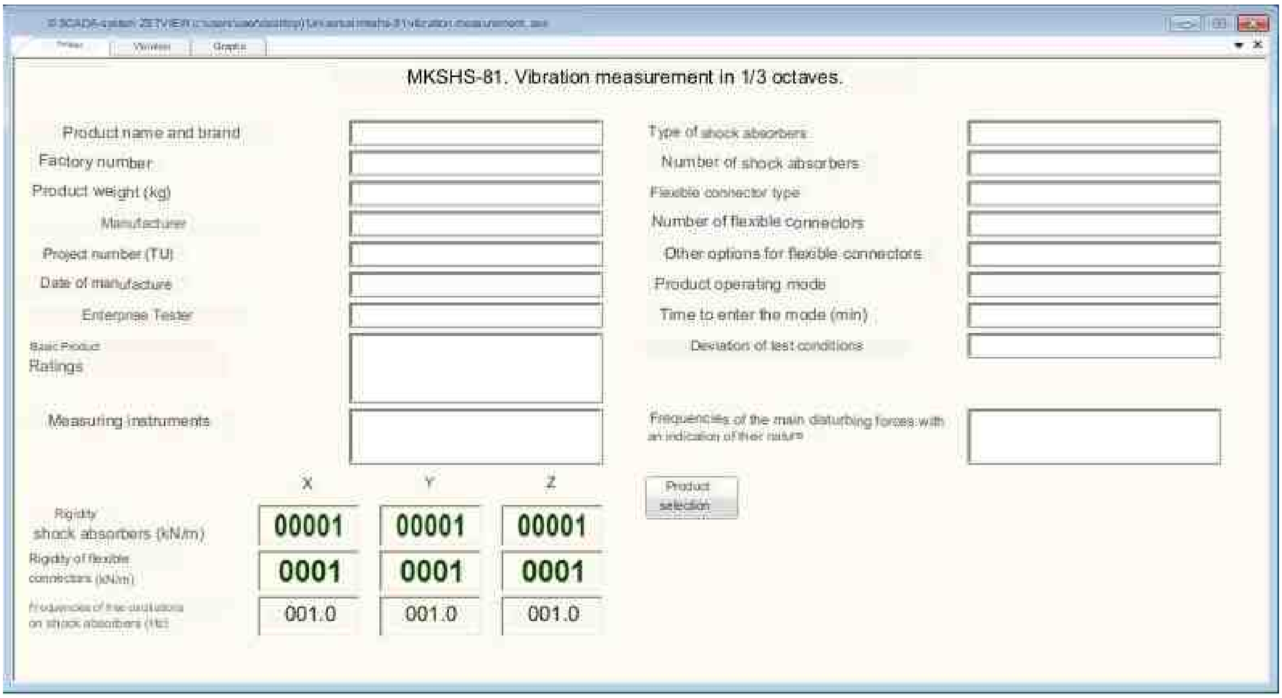
The program is designed to test and measure the vibroacoustic characteristics of various specimens, such as submersible pumps, to determine compliance with technical requirements. Measurements are carried out in accordance with the requirements of noise and vibration control and standardization procedures (MKSHS-81, MKVSh-80, MKGSh-82).

The software for measuring vibration and airborne noise levels according to MKSS-81 includes two working projects:

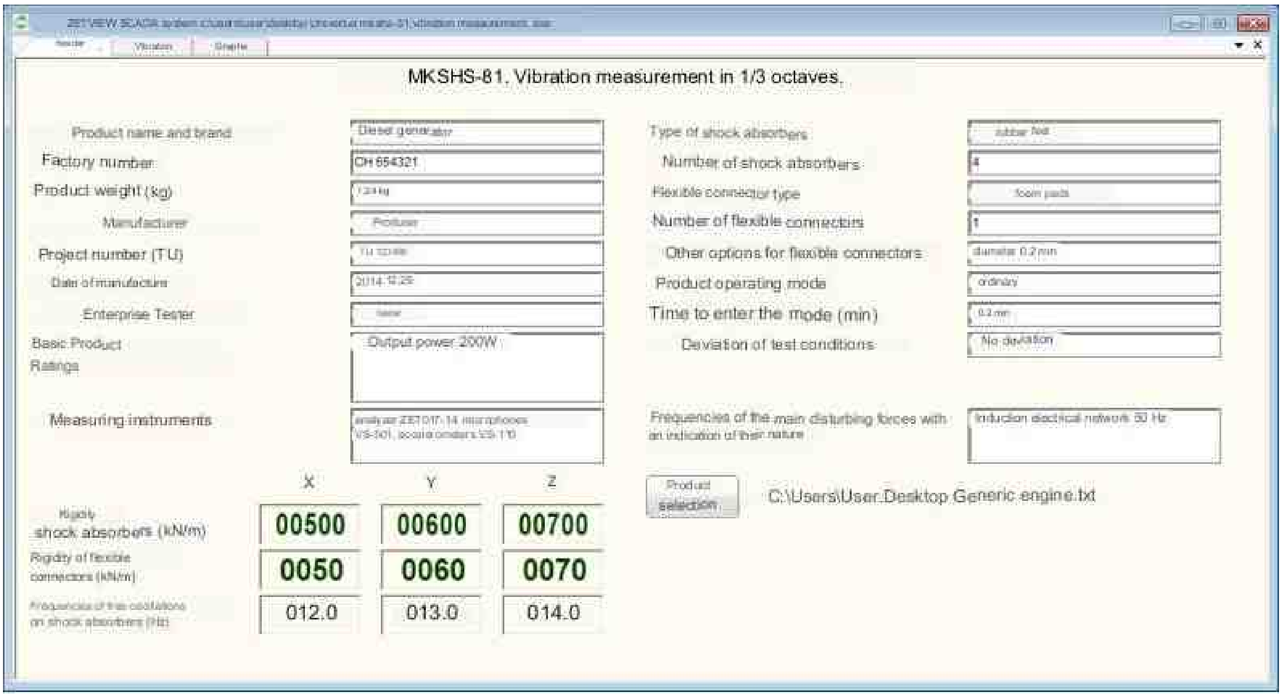
- Vibration measurement in 1/3-octave frequency bands
- Airborne noise measurement in octave bands

Working projects were completed in ZETVIEW SCADA. For projects to work, you must have ZETLAB and ZETVIEW software installed on your computer.

Vibration measurement in 1/3 octave bands



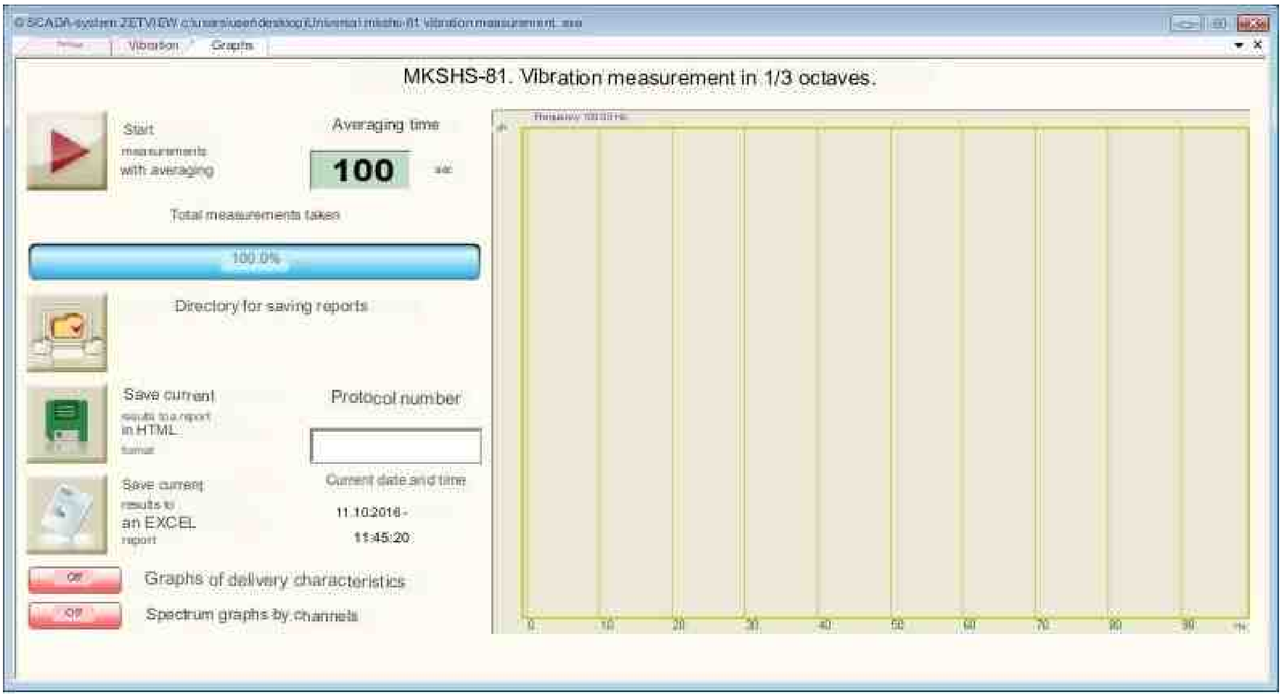
Header Page



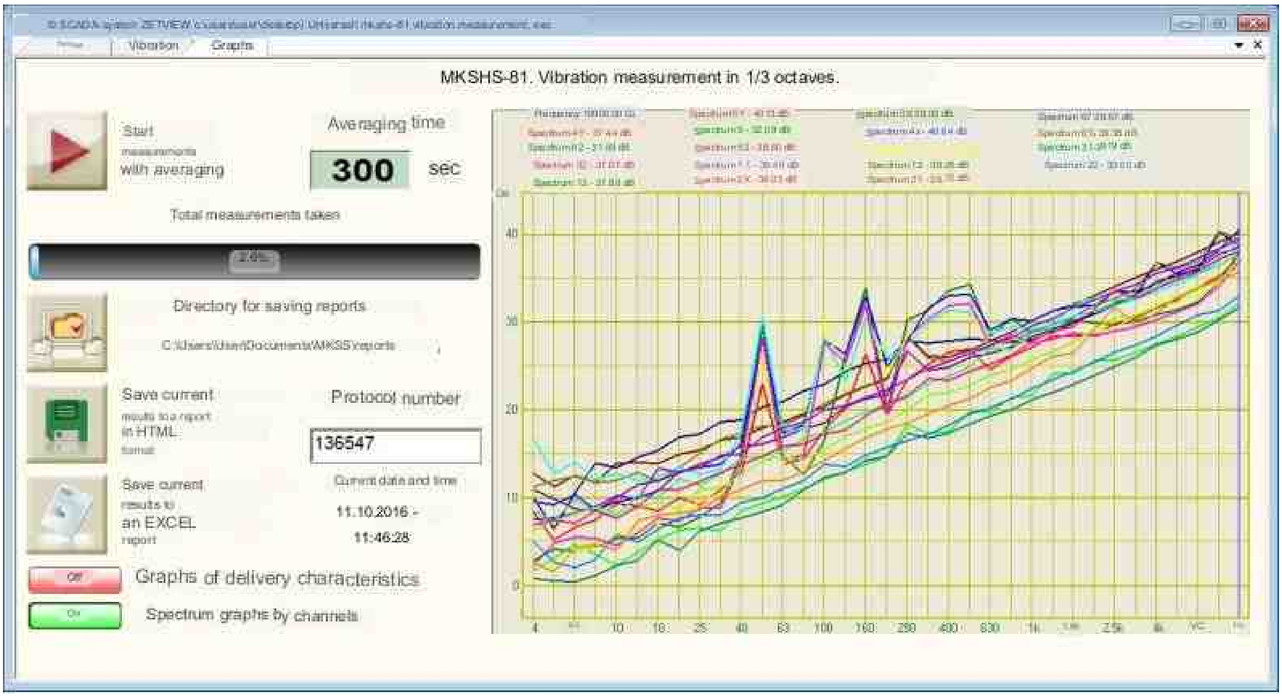
Setting the parameters of the measured product

Vibration

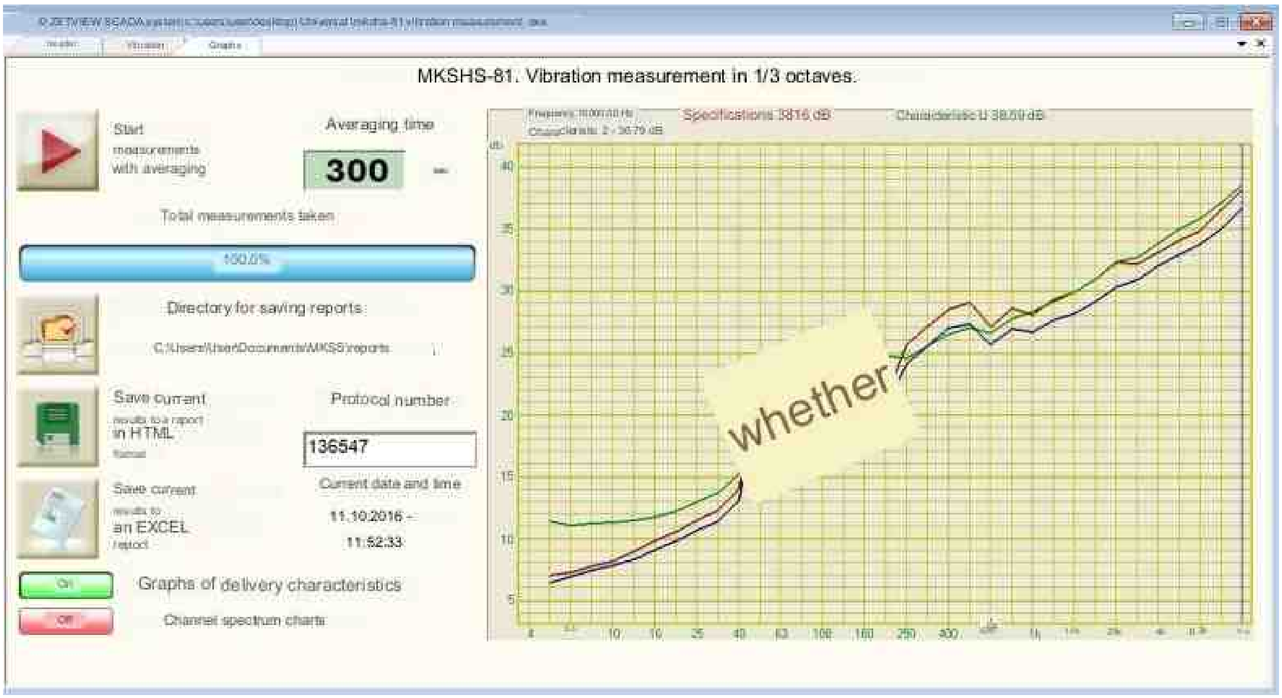
Vibration *window*



Graphs *window*



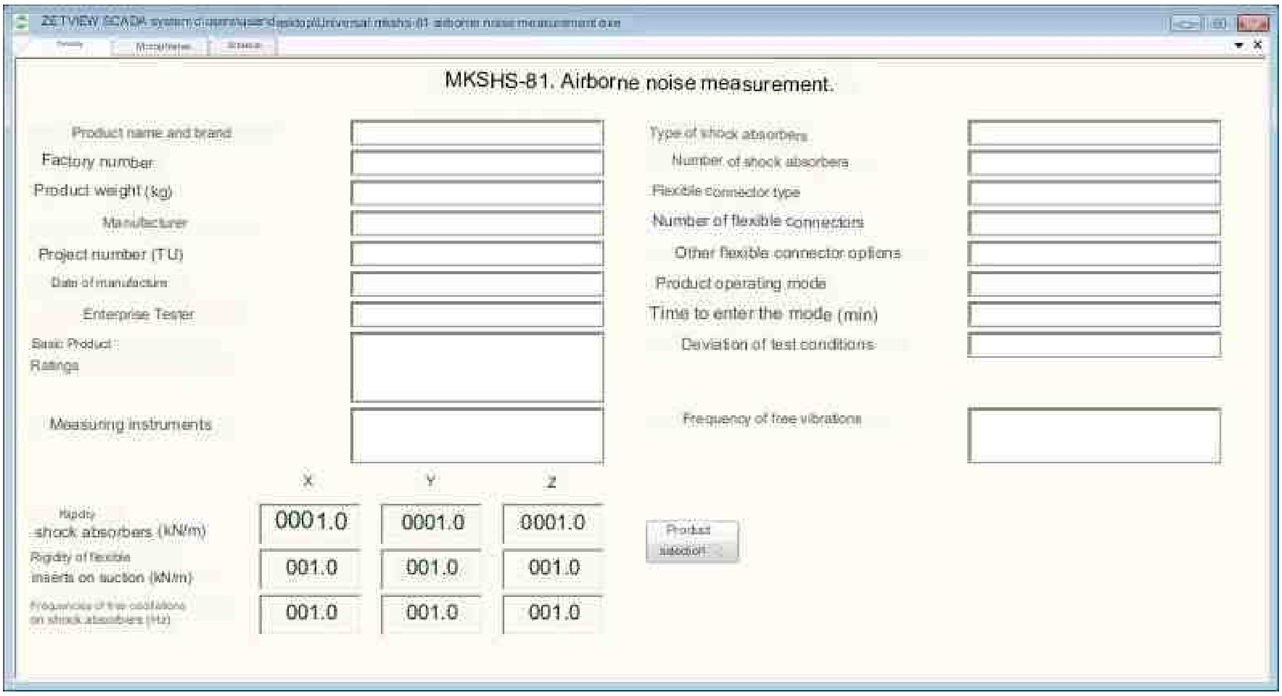
Vibration measurement process



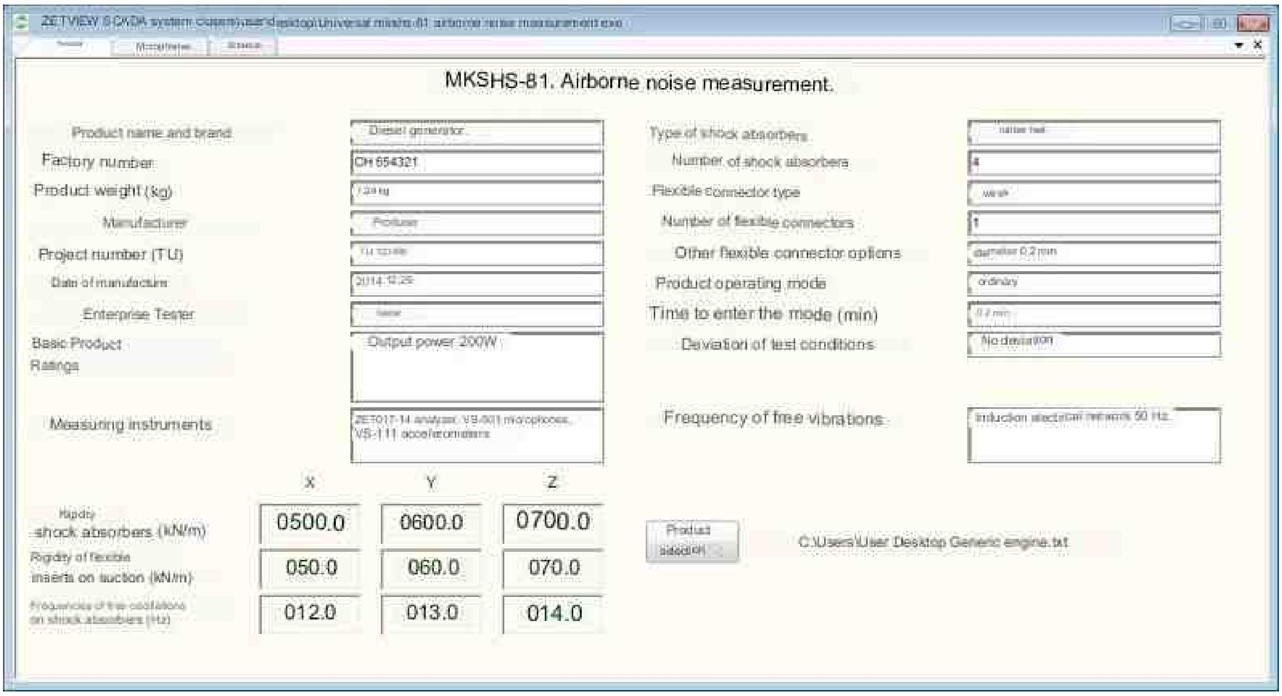
Vibration measurement results

To save the report, you must click one of the two buttons "Save current results in a report in HTML format" with an icon in the form of a green diskette or "Save current results in a report in EXCEL format" with an icon in the form of a document. The reports will be saved to the specified directory with a name that includes the name of the measured object, the current date and time, and the protocol number.

Noise measurement in octave bands



Title *Window*



Select the parameters of the measured product

Microphones

Microphones window

Graphic

Graphic *window*

Airborne noise measurement result

To save the report, you must click one of the two buttons "Save current results in a report in HTML format" with an icon in the form of a green diskette or "Save current results in a report in EXCEL format" with an icon in the form of a document. The reports will be saved to the specified directory with a name that includes the name of the measured object, the current date and time, and the protocol number.

Reporting

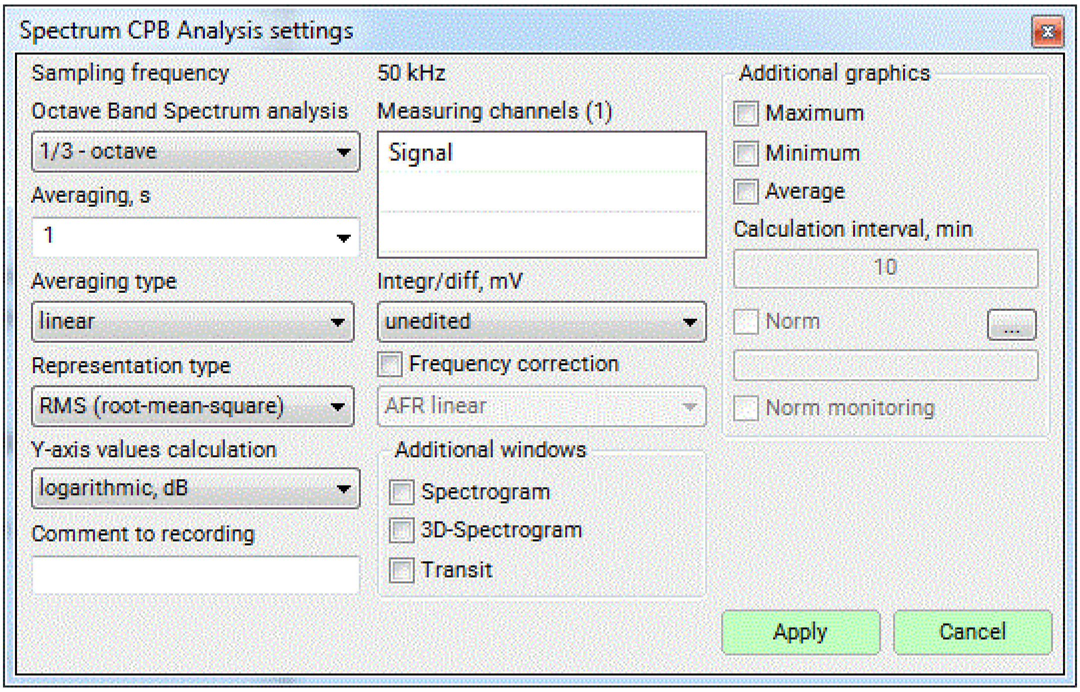
When saving the current results to a report in EXCEL format, the report files will have the XLSX extension. You can open such files with the appropriate program from the Microsoft Office 2013, LibreOffice, OpenOffice office suite.

When saving current results to a report in HTML format, Report files will have the extension HTML. You can open such files using the browser program Internet Explorer, Opera, Chrome, Firefox, or others.

Program settings .....

In order to set the program "**Spectrum CPB Analysis setting**", left-click the "**Parameters**" key in the top right section of the program window. You will see the window "**Spectrum CPB Analysis settings**". This window can also be activated with <Esc> key.

The top section of the window show the set value of the sampling frequency in Hz (the sampling frequency is set in the "Device Manager" program in "Device properties ZET" tab).



Spectrum CPB Analysis settings

The window "**Spectrum CPB Analysis settings**"

The "**Spectrum CPB Analysis**" menu allows the user to select one of the following options: 1/3, 1/12, 1/24 – octave.

The octave and 1/3 – octave filters correspond to Class 0 precision as specified in IEC 1260. Fractional-octave analysis is implemented based on parallel use of digital filters. The number of filters used in octave analysis – 13, for 1/3 – octave analysis – 51, for 1/12 – octave – 200, for 1/24 - 400.

The central frequencies of octave and 1/3 – octave filters meet the requirements specified in IEC 1260 and are calculated by the formula:

$$f_m = (G^{x/b})(f_r)$$

G = 103/10 - octave ratio (2 – for binary filters and 1,995 – for decimal filters, this particular program uses decade filtering recommended in IEC 1260)

fr - reference frequency 1000 Hz;

b - octave fraction of the filter – "1" for octave filter, and "3" – for 1/3 – octave filter.

The table below specifies filter number (based on the provisions of IEC 1260 and GOST 17168) and precise and nominal value of the filter frequency.

Filter number based on IEC 1260	Filter number based on GOST 17168	Precise value of filter average geometrical frequency, Hz	Nominal value of filter average geometrical frequency, Hz	Octave filters	1/3 – octave filters
-31	-1	0,794	0,8	–	+
-30	0	1,000	1,0	+	+
-29	1	1,259	1,25	–	+
-28	2	1,585	1,6	–	+
-27	3	1,995	2	+	+
-26	4	2,512	2,5	–	+
-25	5	3,162	3,15	–	+
-24	6	3,981	4	+	+
-23	7	5,012	5	–	+
-22	8	6,310	6,3	–	+
-21	9	7,943	8	+	+
-20	10	10,000	10	–	+
-19	11	12,589	12,5	–	+
-18	12	15,849	16	+	+
-17	13	19,953	20	–	+
-16	14	25,119	25	–	+
-15	15	31,623	31,5	+	+
-14	16	39,811	40	–	+
-13	17	50,119	50	–	+
-12	18	63,096	63	+	+
-11	19	79,433	80	–	+
-10	20	100,00	100	–	+
-9	21	125,89	125	+	+
-8	22	158,49	160	–	+
-7	23	199,53	200	–	+

Filter number based on IEC 1260	Filter number based on GOST 17168	Precise value of filter average geometrical frequency, Hz	Nominal value of filter average geometrical frequency, Hz	Octave filters	1/3 – octave filters
-6 -5	24 25	251,19 316,23	250 315	+ –	+ +
-4 -3 -2	26 27 28	398,11 501,19 630,96	400 500 630	– + –	+ + +
-1 0 1	29 30 31	794,33 1 000,0 1 258,9	800 1 000 1 250	– + –	+ + +
2 3 4	32 33 34	1 584,9 1 995,3 2 511,9	1 600 2 000 2 500	– + –	+ + +
5 6 7	35 36 37	3 162,3 3 981,1 5 011,9	3 150 4 000 5 000	– + –	+ + +
8 9 10	38 39 40	6 309,6 7 943,3 10 000	6 300 8 000 10 000	– + –	+ + +
11 12 13	41 42 43	12 589 15 849 19 953	12 500 16 000 20 000	– + –	+ + +
14 15 16	44 45 46	25 188 31 622 39 811	25 000 31 500 40 000	– + –	+ + +
17 18 19	47 48 49	50 119 63 096 79 433	50 000 63 000 80 000	– + –	+ + +
20	50	100 000	100 000	–	+

The central frequencies of 1/12-octave and 1/24-octave filters meet the requirements of IEC 1260 and are calculated by the formula:

$$f_m = (G^{(2x+1)/2b})(f_r)$$

b – octave fraction of the filter: "12" for 1/12-octave filter and "24" for 1/24-octave filter.

Limit frequencies of the filters are calculated by the formula:

$$f_1 = (G^{-1/(2b)})(f_m),\ f_2 = (G^{+1/(2b)})(f_m)$$

he effective bandwidth of the octave filters is f2 – f1.

The basic damping of the filters for relative frequency f/f_m is equal to the nominal filter damping with the acceptable deviation level as per values specified in the tables below.

Relative damping limits for octave filters of the 1^{-st} precision class in compliance with GOST 17168

Relative frequency, f/fm	Damping, dB (for octave filters of the 1^{-st} precision class)
≥0,125	From +65.0 up to +<><>
0,25	From +50.0 up to +<><>
0,5	From +23.0 up to +<><>
0,7071	From -0.5 up to +6,0
0,8409	From -0.5 up to +1,0
1,0000	From -0.5 up to +1,0
1,1892	From -0.5 up to +1,0
1,4142	From -0.5 up to +6,0
2	From +23.0 up to +<><>
4	From +50.0 up to +<><>
≥8	From +65.0 up to +<><>

Relative damping limits for 0 Class octave filters in compliance with IEC 1260. (G = 103/10)

Relative frequency, f/f_m	Damping, dB, for octave filters of 0 Class
G^{0}	–0,15; +0,15
$G^{\pm 1/8}$	–0,15; +0,2
$G^{\pm 1/4}$	–0,15; +0,4
$G^{\pm 3/8}$	–0,15; +1,1
$<G^{+1/2}$ $>G^{-1/2}$	–0,15; +4,5
$G^{\pm 1/2}$	+2,3; +4,5
$G^{\pm 1}$	+18,0; +<><>

Relative frequency, f/f_m	Damping, dB, for octave filters of 0 Class
$G^{\pm 2}$	+42,5; +<><>
$G^{\pm 3}$	+62; +<><>
$\geq G^{+4}$ $\leq G^{-4}$	+75; +<><>

Relative damping limits for 1/3 – octave filters of the first precision class in compliance with GOST 17168

Relative frequency, f/fm	Damping, dB, for 1/3 – octave filters of the 1-st precision class
0,2	from +75,0 up to +<><>
0,25	from +68,0 up to +<><>
0,5	from +45,0 up to +<><>
0,7937	from +14,0 up to +<><>
0,8909	rom –0,5 up to +6,0
0,9439	from –0,5 up to +1,0
1,0000	from –0,5 up to +0,5
1,0595	from –0,5 up to +1,0
1,1225	from –0,5 up to +6,0
1,2599	from +14,0 up to +<><>
2	from +45,0 up to +<><>
4	from +68,0 up to +<><>
5	from +75,0 up to +<><>

Relative damping limits for 1/3 – octave filters of 0 Class precision in compliance with the requirements of IEC 1260

Relative frequency, f/fm	Damping, dB, for 1/3 – octave filter of 0 Class precision
1,000 00	–0,15; +0,15
1,026 67 0,974 02	–0,15; +0,2
1,055 75 0,947 19	–0,15; +0,4
1,087 46 0,919 58	–0,15; +1,1
<1,122 02 >0,891 25	–0,15; +4,5
<1,122 02 >0,891 25	+2,3; +4,5

Relative frequency, f/fm	Damping, dB, for 1/3 – octave filter of 0 Class precision
1,294 37 0,772 57	+18,0; +<><>
1,881 73 0,531 43	+42,5; +<><>
3,053 65 0,327 48	+62; +<><>
≥5,391 95 ≤0,185 46	+75; +<><>

The list "**Measurement channel**" enables selection of physical or virtual channel (its signal spectrum will be displayed in the program "Spectral analysis").

The list "**Averaging, s**" – allows to set the averaging interval for instant spectrum values in seconds. The averaging value can be selected from the list or entered with the keyboard. The maximum averaging interval is 100 seconds, the minimal possible – 0,1 seconds.

The checkbox "**Integral level**" is used to enable / disable display of linear-frequency response characteristics indicator and A, B, C, D frequency characteristics. Activate the checkbox "Integral level", select the type of frequency response: linear (without correction), or relative frequency response (A, B, C, D). For noise meters, it is necessary to select A. The noise meters with microphones can have additional characteristics B, C, D, or a combination of them. The checkbox "Integral level" activates vertical indicators and a scale with the values of integral level without correction (linear FR) and with the correction of selected type. The signal spectrum is displayed based on the selected type of correction. The maximal, minimal and average spectra are calculated based on the correction of selected type.

Nominal frequency, Hz	Relative frequency characteristics of the noise meter, dB			
	A	B	C	D
10	–70,4	–38,2	–14,3	–26,6
12,5	–63,4	–33,2	–11,2	–24,6
16	–56,7	–28,5	–8,5	–22,6
20	–50,5	–24,2	–6,2	–20,6
25	–44,7	–20,4	–4,4	–18,7
31,5	–39,4	–17,1	–3,0	–16,7
40	–34,6	–14,2	–2,0	–14,7
50	–30,2	–11,6	–1,3	–12,8

Nominal frequency, Hz	Relative frequency characteristics of the noise meter, dB			
	A	B	C	D
63	–26,2	–9,3	–0,8	–10,9
80	–22,5	–7,4	–0,5	–9,0
100	–19,1	–5,6	–0,3	–7,2
125	–16,1	–4,2	–0,2	–5,5
160	–13,4	–3,0	–0,1	–4,0
200	–10,9	–2,0	0	–2,6
250	–8,6	–1,3	0	–1,6
315	–6,6	–0,8	0	–0,8
400	–4,8	–0,5	0	–0,4
500	–3,2	–0,3	0	–0,3
630	–1,9	–0,1	0	–0,5
800	–0,8	0	0	–0,6
1 000	0	0	0	0
1 250	+0,6	0	0	+2,0
1 600	+1,0	0	–0,1	+4,9
2 000	+1,2	–0,1	–0,2	+7,9
2 500	+1,3	–0,2	-0,3	+10,4
3 150	+1,2	–0,4	–0,5	+11,6
4 000	+1,0	–0,7	–0,8	+11,1
5 000	+0,5	–1,2	–1,3	+9,6
6 300	–0,1	–1,9	–2,0	+7,6
8 000	–1,1	–2,9	–3,0	+5,5
10 000	–2,5	–4,3	–4,4	+3,4
12 500	–4,3	–6,1	–6,2	+1,4
16 000	–6,6	–8,4	–8,5	–0,7
20 000	–9,3	–11,1	–11,2	–2,7

The list "**Averaging type**" is used to select the type of spectra accumulation mode and averaging: linear, exponential.

The list "**Integration / differentiation**" allows to select the type of signal processing: differentiation, double differentiation, unedited, integration, double integration. This function is useful for various operations with velocity and acceleration transducers.

The list "**Representation type**" is used to select the representation type: RMS or peak value.

The field "**Comments for record**" is used for entering additional information (the maximum length is 200 characters). When the results of signal processing will be saved to a file, this information will be saved as a comment.

The list "**Graphic view in Y - coordinates**" is used to select logarithmic (in dB, in relation to the reference value in dB) or linear (in measurement units) scale for spectrum representation. The reference value for calculations in dB is set in the program "Device Manager".

The field "**Calculation interval, sec**" allows to set the time interval (in seconds) for the calculation of Additional graphics. The maximal possible value of the interval is 100 seconds, the minimal possible – 10 seconds.

The checkbox "**Additional windows**" allows to view the following characteristics of the signal: Spectrogram, 3D-spectrogram, Transit.

The section "**Additional graphics**" of the "Spectrum CPB Analysis" program enables display of maximum, minimum, and average graphics, as well as display of the set spectrum (File (norm)) with the use of the corresponding checkboxes.

As the options of "**Maximum**", "**Minimum**" and "**Average**" graphics are activated, in the main program window there appear corresponding Additional graphics, while indicators located under the "Recording" key start the count of the intervals set for the Additional graphics (Maximum, Minimum, and Average) calculation.

In the multichannel mode of the program "**Spectrum CPB Analysis**", Additional graphics are calculated not by time, but by graphics of all channels. The points of the maximum (minimum) graphic are the maximum (minimum) value of the spectrum at a given frequency among all selected channels. The points of the average graphic are the average values among the spectrum values at a given frequency of all selected channels.

In the "**File (norm)**" option the user can select a normalized spectrum file (using the menu to the right from this option). As the file is selected, use the checkbox "File (norm)" to enable / disable representation of the selected spectrum.

This function is quite useful when it is necessary to control the signal excess over the set spectral characteristics.

The File (norm) can be created or edited in any text editor, e.g., in NotePad and it should have *.nrm extension. The file has the following structure:

1. 80.

10.	70.
100.0	80.
1000.0	90.
10000.0	100.

The left column contains frequencies (in Hz) in ascending order, the second column contains the signal level values (in dB). The "space" sign is used as a separator between the frequency level and the corresponding value of the signal level.

The "**Apply**" key is used to set the settings of the program "Spectrum CPB Analysis", it is also used to close the window "**Spectrum CPB Analysis settings**".
The "**Cancel**" key allows to close the window "Spectrum CPB Analysis settings" without saving the configuration changes.

It is also possible to close the window "**Spectrum CPB Analysis settings**" without changing any settings of the program "**Spectrum CPB Analysis**" using the icon "x" located in the top right section of the program window.

Additional windows .....

The program "**Spectrum CPB Analysis**" has the following additional options:

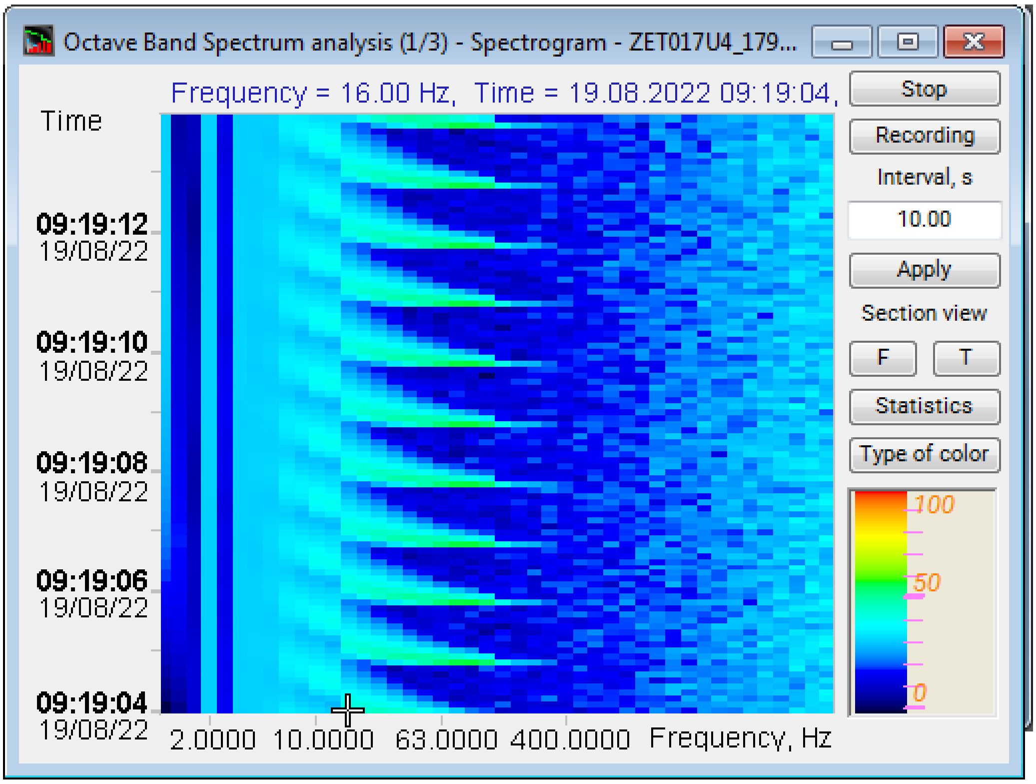
- Building Spectrogram
- Building 3D-Spectrogram
- Building Transit

Spectrogram .....

The checkbox "**Spectrogram**" in the "**Spectrum CPB Analysis settings**" is used to activate an additional window of signal’s time-frequency distribution.

The Spectrogram is used for the analysis of signal's time-frequency distribution at various time periods.

The name of the window depicts the name of the spectrum (**Spectrum CPB Analysis**), the name of the additional window (Spectrogram) and the name of the channel.



Spectrum CPB Analysis - Spectrogram window

Spectrum CPB Analysis - Spectrogram

The main part of the window is occupied by the spectrogram display field, the graph legend displays the values of the measured values (in this case, frequency, time and level) at the cursor position.

The color indicates the level of the spectrum. Low levels are shown in black, high levels in red.

The spectrum level is displayed according to the program settings Spectral analysis of the octave band: RMS, peak, integrated /differentiated signal, etc.

Moving the graphic cursor is carried out by setting the mouse pointer to the intersection of the frequency and time of interest and pressing the left mouse button. Scaling of the spectrogram graph is carried out in the same way as in the main window of the Spectral analysis of the octave band program (see About working with ZETLAB software - Cursor control on graphs). Scaling by level in the spectrogram is carried out by pressing the left mouse button, when the corresponding graphical views of the cursor appear, on the vertical scale of the spectrogram, which is located under the Color View button.

Transfer graphical and numerical information, see About working with ZETLAB software - *Transfer graphical and numerical information to text editors*.

The **Start** button starts the accumulation of spectra into a spectrogram, while the accumulated spectra are reset.

The **Stop button (pause)** stops the accumulation of the current spectra in the spectrogram. Also, when the Stop button is pressed, the enabled cross-section windows (Section by frequency and Cross-section by time) are stopped. Spectrogram cross-section windows are described below. Further continuation of the spectrum accumulation process is carried out by pressing the Start button described above.

The **Recording** button allows you to write the values of the accumulated spectra to a text file with *.gru extension. Pressing the button opens a standard dialog box that prompts you to specify the directory to save the file and the name of this file. In the future, these data can be used when building a three-dimensional image of the recorded data in three-dimensional modeling programs. The default directory is C:\ZETLab\Result\. The file structure is described in the section Recording results to a file.

In the field under the inscription Interval, s, the time interval for the accumulation of spectra in the spectrogram is set. The interval is set in seconds. Interval values are entered from the keyboard. To set the entered spectrum accumulation time interval, press the Apply button or the <Enter> key of the keyboard.

The F button, under the Cross section, turns on the cross section window for the frequency of the spectrogram.

The T button, under the inscription Cross section, includes a window of the cross section by time of the spectrogram.

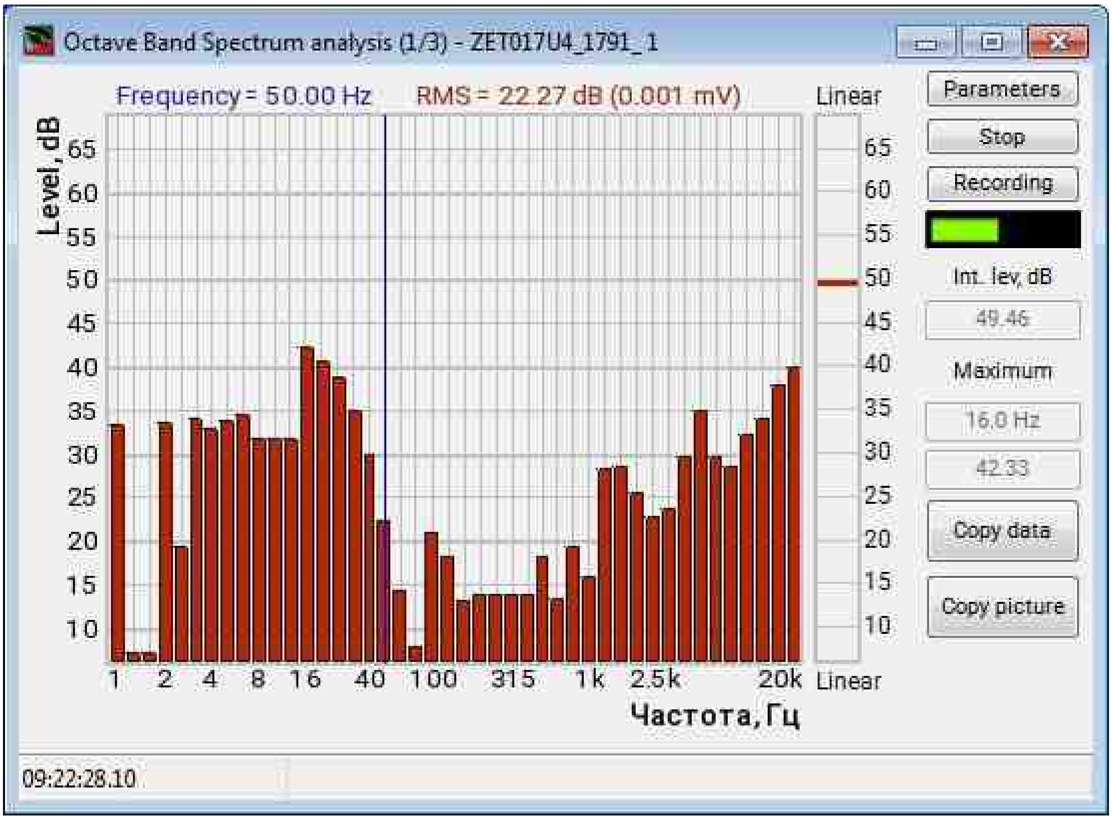
color view – when the button is pressed, the spectrograms are displayed in color (by default). If the button is released, then the spectrogram and the vertical scale of the spectrogram (the color analogue of the signal level) will turn black and white. This is convenient when preparing a spectrogram for printing.

The vertical scale of the spectrogram, which is located under the Color View button, shows the ratio of the color of the spectrogram to the level.

To close the Spectrogram window, either uncheck the **Spectrogram** flag in the *Additional windows* frame in the **Spectrum CPB Analysis settings** window, or click the "x" button located in the upper right corner of the window, and the Spectrogram flag will be automatically unchecked.

Spectrogram - Frequency section .....

To enter the tab **"Spectrogram – Frequency section"**, click the **F** key in the **"Spectrogram"** window of the **"Octave Band Spectrum analysis"** program.



Spectrogram - Frequency section window opens

Moving the graphic cursor in the **Spectrum CPB Analysis program - Spectrogram** window along the time axis, the user can analyze the spectrum behavior at any selected moment of time. When the cursor in the spectrogram window is set on the time of interest, the frequency section of the accumulated spectrogram will be displayed in the **Spectrogram - Frequency section** window.

Cursor control and graphic scaling as well as the transfer of the graphical and numerical data are performed in the same way as in the main window of the **Spectrum CPB Analysis program** program (see About working with **ZETLAB**).

The **Save** button allows the user to save the instantaneous values of the displayed frequency section at the time shown by the cursor on the spectrogram to a text file with **.dtx* extension. Pressing the button will result in opening of a standard dialog window suggesting to show the directory for saving the file, and the name of this file. Default directory: C:\ZetLab\result\. The file structure is shown in Table.

To close the **Spectrogram - Frequency section** window, either click the **F** key in the **Spectrum CPB Analysis program - Spectrogram** window, or press the button in the right upper section of the window.

Line No	Lines	Description
1	Spectrogram - section by frequency at the moment	Spectrogram sections window name
2	BC 110_289_ 1	Signal input channel name
3	Sensor at point 2	User's comment
4	Frequency range - from 0.10 Hz to 10000.00 Hz	The set Octave Band Spectrum frequency range
5	Date: 25-01-2018	File recording date
6	Time: 13:50:02	File recording start time
7	Frequency Level	Data column headings
8	Hz g	Measurement unit (by columns)
9th and subsequent lines	Contain numerical values of the data, represented in the floating-point format. The separator of the integer and fractional parts is dot.	

structure is shown in Table

Spectrogram - Time section .....

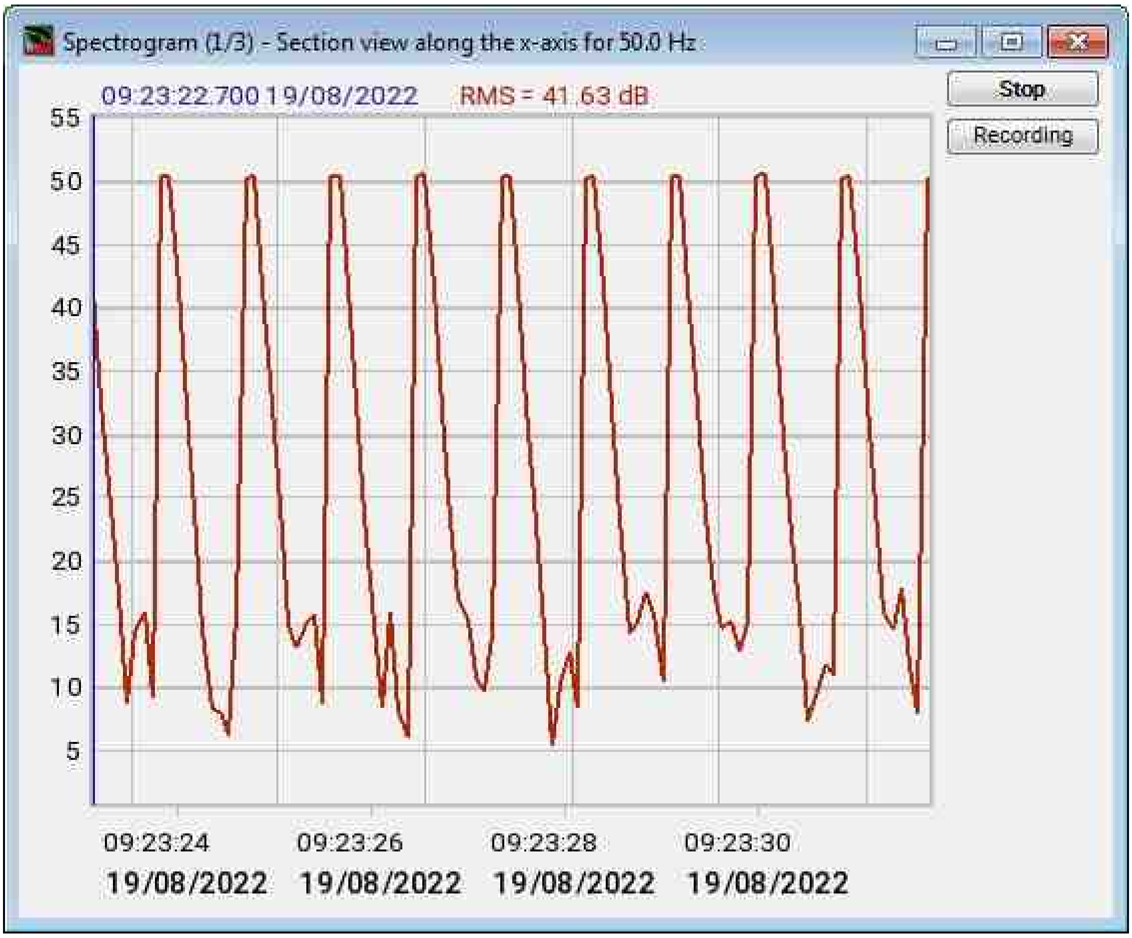
When the **T** button is pressed in the **Spectrum CPB Analysis program - Spectrogram** window, the **Spectrogram - Time section** window opens.

Moving the graphic cursor in the **Spectrum CPB Analysis program - Spectrogram** window along the time axis, the user can analyze the spectrum behavior at any selected moment of time. When the cursor in the spectrogram window is set on the frequencies of interest, the time section (time period during which the spectra accumulation took place) of the accumulated spectrogram will be displayed in the **Spectrogram - Time section** window.

Cursor control and graphic scaling as well as the transfer of the graphical and numerical data are performed in the same way as in the main window of the **Spectrum CPB Analysis program** program (see About working with **ZETLAB**).

The **Save** button allows the user to save the instantaneous values of the displayed frequency section at the time shown by the cursor on the spectrogram to a text file with **.dtx* extension. Pressing the button will result in opening of a standard dialog window suggesting to show the directory for saving the file, and the name of this file. Default directory: C:\ZetLab\result\. The file structure is shown in Table.

To close the **Spectrogram - Time section** window, either release the **T** section call button in the **Spectrum CPB Analysis program - Spectrogram** window, or press the button in the right upper corner of the window.



Spectrogram - Time section window opens

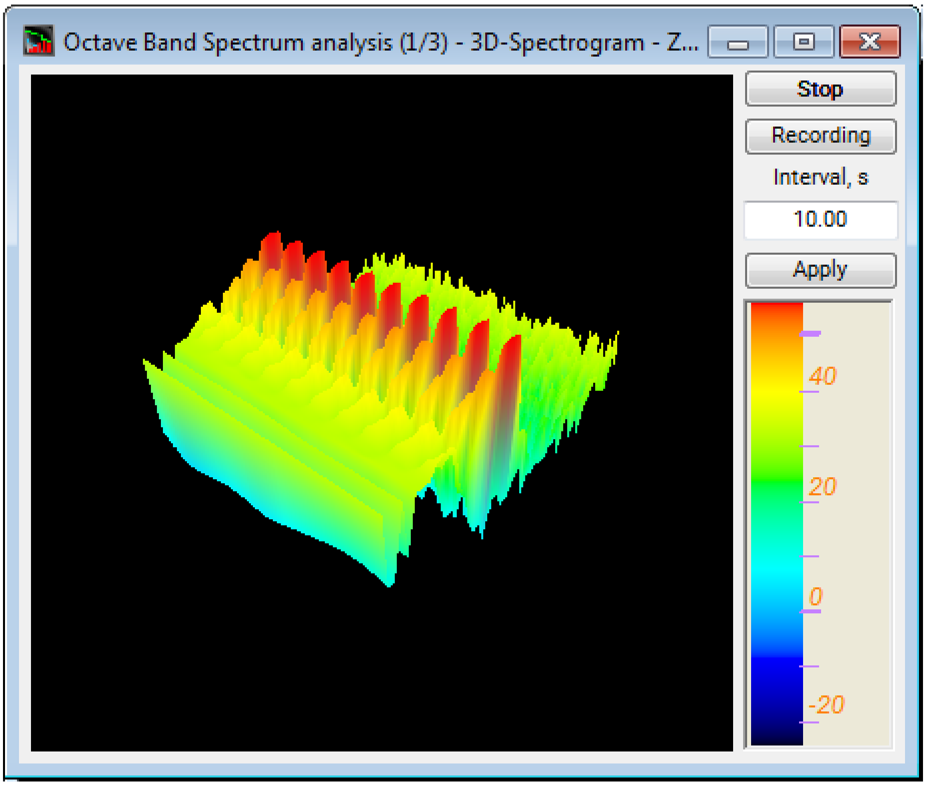
Line No	Lines	Description
1	Spectrogram - section by time at frequency	Spectrogram sections window name
2	BC 110_289_ 1	Signal input channel name
3	Sensor at point 2	User comment (is input in the **Spectrum CPB Analysis program parameter setting** window)
4	Time range - 10.00 s	Time set for accumulation to the spectrogram
5	Date: 25-01-2018	File recording date
6	Time: 13:58:26	File recording start time
7	Time Level	Data column headings
8	s g	Measurement unit (by columns)
9th and subsequent lines	Contain numerical values of the data, represented in the floating-point format. The separator of the integer and fractional parts is dot.	

structure is shown in Table

3D spectrogram .....

The option "**3D-Spectrogram**" (in the "Additional windows" menu of the "**Spectrum CPB Analysis settings** window") is used to activate an additional window of signal's time-frequency distribution. This window displays 3D view of signal's time-frequency distribution, which is used for analysis of signal dynamics.

3D-spectrogram



Spectrum CPB Analysis - 3D spectrogram

The name of the window contains the name of the spectrum (**Spectrum CPB Analysis**), the name of additional window (3D-spectrogram), and the name of the channel (e.g., Signal 9).

The color is used to indicate spectrum level. Low levels are shown in black color, high levels – in red respectively.

In order to scale the 3D-spectrogram by level, left-click the icon appearing near the vertical axis of the spectrogram level (under the "Apply" key).

By default, he background color of the **3D-Spectrogram** is black. Double click the right mouse button to change the background color for white (and vice versa).

It is possible to view the **3D-spectrogram** from any side by rotating it along three mutually transverse axes. Rotation of the 3D-spectrogram along the three mutually transverse axes is performed in the following way:

Hold the let mouse key and move it along the spectrogram to rotate the 3D-spectrogram along X and Y axes. Using the right mouse key, you can rotate the **3D-spectrogram** around Z axis.

The scroll wheel is used to increase / decrease the size of the 3D-spectrogram.

Double-click the **3D-spectrogram** to restore its initial scale and position in relation to axes.

The "**Start**" key is used to start the process of spectra accumulation for the **3D-spectrogram** (the previously accumulated spectra are set to zero).

The key "**Stop (pause)**" is used to suspend the accumulation process of the current spectra. To resume the current spectra accumulation process, click the "Start" key again.

The "**Recording**" key allows to save the accumulated spectra data to a text file with .gru extension. The key activates a standard dialog window allowing the user to select directory and name of the file. This data can be further used for creation of a 3D-image in special 3D-modelling programs. The directory by default is C:\ZETLab\Result\. The file structure of 3D- Spectrogram is identical to that of the 2D-diagram and is described in the section "Recording results to a file.".

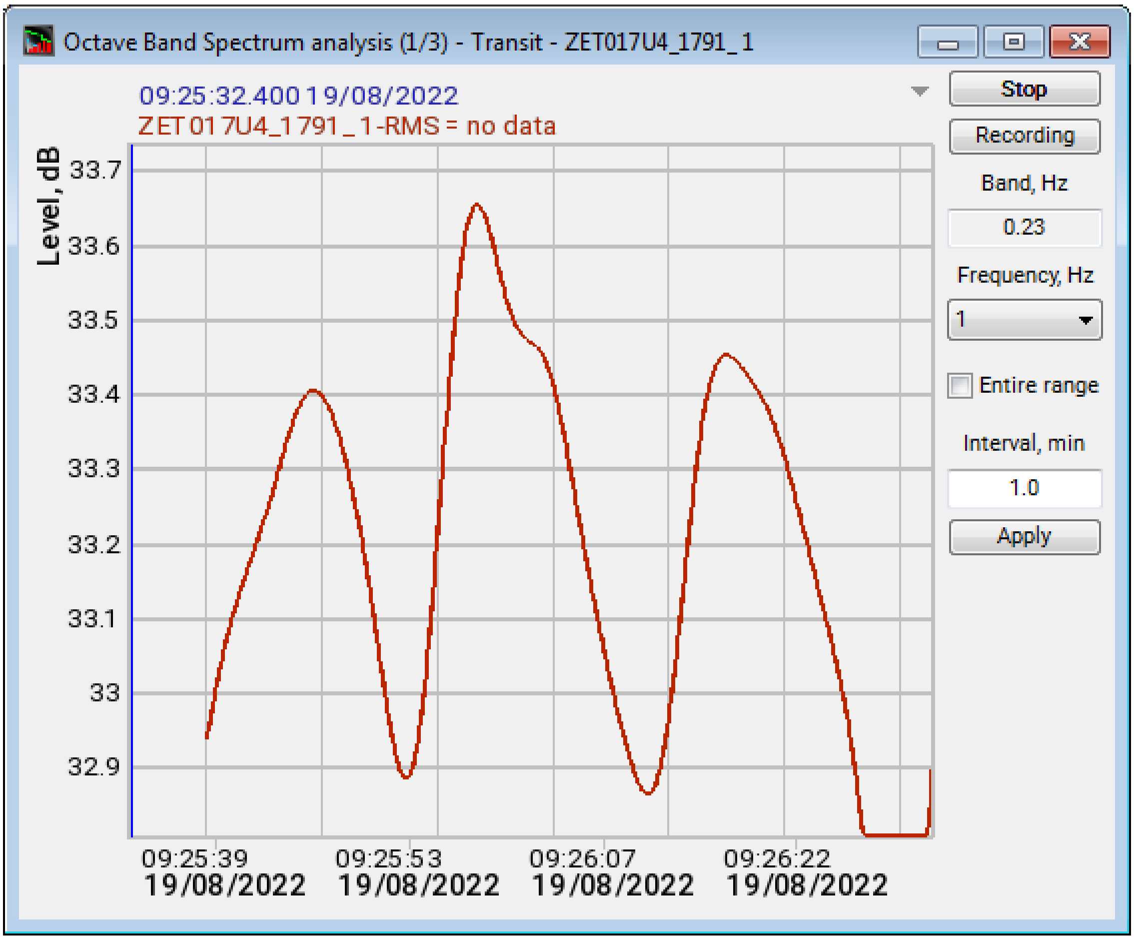
The field under the section "**Interval, s**" is used to set the time interval of spectra accumulation to the spectrogram (in seconds). The value of the interval is entered from the keyboard. To apply the new interval value, use the "Apply" button or <Enter> key.

The vertical axis of the spectrogram located under the "**Apply**" key shows the relation between spectrogram color and its level.

To close the 3D-spectrogram window, uncheck the corresponding option in the "**Spectrum CPB Analysis settings**", or click the icon "x" in the top right section of the program window (in this case the option "3D-spectrogram will be switched off automatically").

Transit .....

The checkbox "**Transit**" in the "**Spectrum CPB Analysis settings**" window of the "**Spectrum CPB Analysis**" program activates an additional window used for the analysis of signal's transient characteristics at the set frequency level.



Spectrum CPB Analysis - Transit

Spectrum CPB Analysis – transient characteristics

The name of the window shows the name of the spectrum, the name of the additional window, and the name of the channel (e.g., Signal 11).

The algorithm of cursor control and graphic scaling is the same as in the case of the main window of the program **Spectrum CPB Analysis** (see the clause "*Cursor control in graphics*").

Transfer of graphical and numerical data to text editors is performed in the same way as in the case of the program "Spectrum CPB Analysis" (see the clause "Transfer of graphical and numerical data" to text editors).

The algorithm of cursor control and graphic scaling is the same as in the case of the main window of the program "**Spectrum CPB Analysis**" (see the Clause "*Cursor control in graphics*"). To scale the spectrogram graphic by level, click the corresponding icons appearing as the mouse pointer is moved along the graphic section of the window.

Transfer of graphical and numerical data to text editors is performed in the same way as in the case of the program "Spectrum CPB Analysis" (see the clause "*Graphical and numerical data transfer to text editors*".

The key "**Start**" activates accumulation of frequency transient characteristics and sets to zero the previously accumulated data.

The key "**Stop (pause)**" suspends the process of data accumulation. Further accumulation of data is activated with the same key.

The "**Recording**" key is used for recording of signal transient characteristics at the set frequency to a text file with *.dtx extension. This key activates a standard dialog widow allowing the user to assign directory and name of the file. The directory by default is C:\ZETLab\Result\. The file structure is described in the section "Recording results to a file.".

The field **"Frequency, Hz"** displays frequency level of the analysis band. The band pass has a direct dependence on the frequency parameter, i.e. as the frequency value is changed, the band pass should be re-calculated.

The frequency value is set in the section "**Frequency, Hz**" (the value is entered from the keyboard).

The field "**Interval, min**" allows to set the calculation interval (in minutes).The minimal possible value is 1 minute, the maximal possible value depends on the PC parameters.

The button "**Apply**" or <Enter> key can be used to start the program with the new parameters.

In order to close the "**Transit**" window, uncheck the option "Transit" in the "Additional graphics" menu or use the icon "x" at the top right section of the window (in this case, the **"Transit"** option will be switched off automatically).

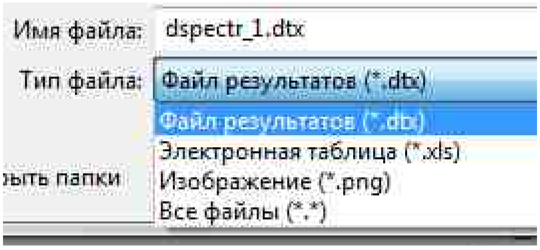
Recording results to a file .....

Spectrum recording

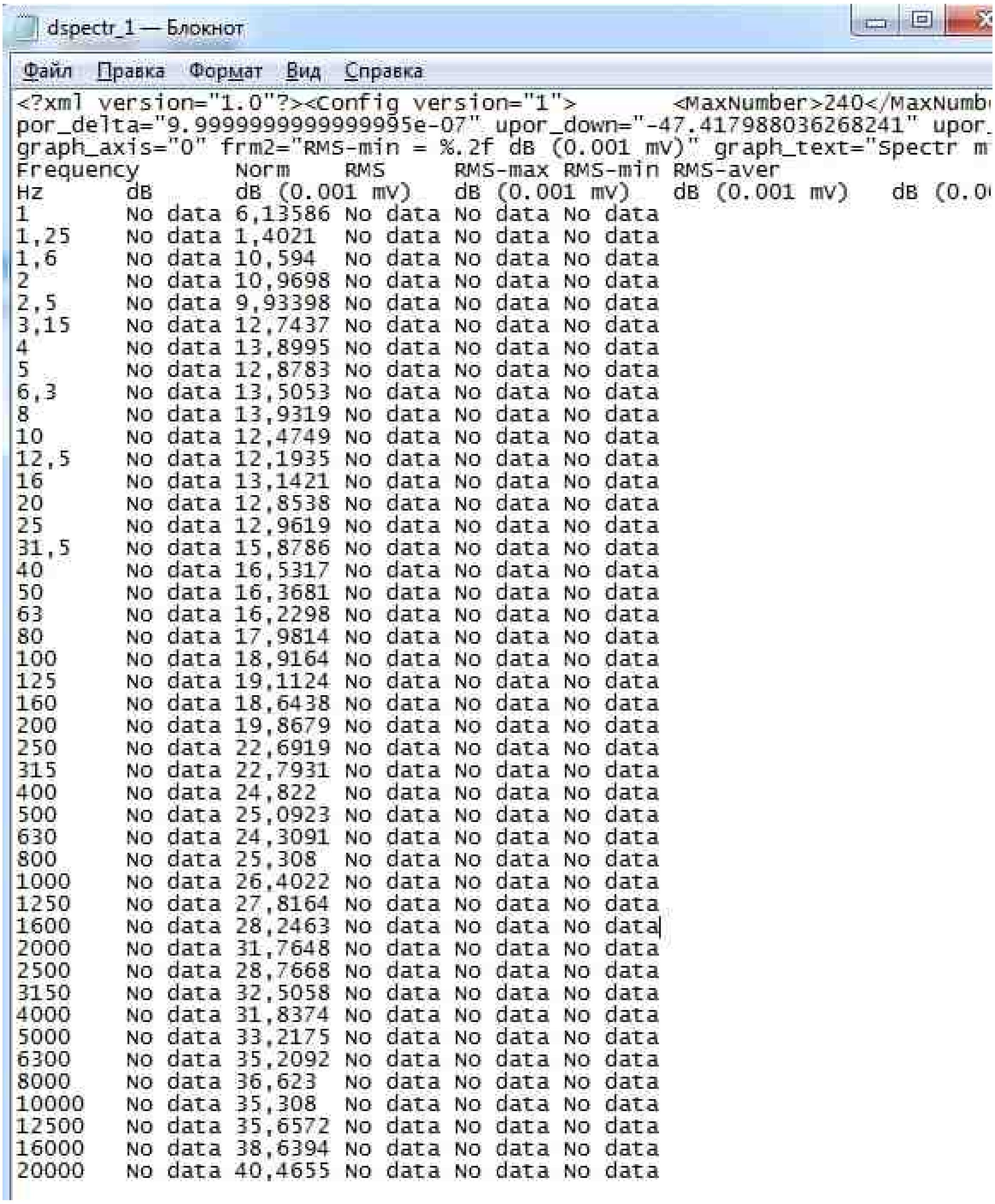
The program Spectral analysis of the octave band provides the ability to write the instantaneous value of the displayed spectrum to a text file with *.dtx extension. When you click the Record button in the Octave Band Spectral Analysis program window, a standard dialog box opens, prompting you to specify the directory to save the file and the name of this file. The default directory is C:\ZETLab\result.

Note:

When opening dtu files in Excel (they are in UTF-8 format), you need to correctly select the file format (UTF-8) and the separator character (tab character). When opening a file by default, apparently, these settings are not used.



An example file is shown in the figure below.



<?xml version="1.0"?><Config version="1"> <MaxNumber>240</MaxNumb
por_delta="9.9999999999999995e-07" upor_down="-47.417988036268241" upor_
graph_axis="0" frm2="RMS-min = %.2f dB (0.001 mV)" graph_text="spectr m

Frequency		Norm	RMS	RMS-max	RMS-min	RMS-aver
Hz	dB	dB (0.001 mV)		dB (0.001 mV)		dB (0.001 mV) dB (0.0
1	No data	6,13586	No data	No data	No data	
1,25	No data	1,4021	No data	No data	No data	
1,6	No data	10,594	No data	No data	No data	
2	No data	10,9698	No data	No data	No data	
2,5	No data	9,93398	No data	No data	No data	
3,15	No data	12,7437	No data	No data	No data	
4	No data	13,8995	No data	No data	No data	
5	No data	12,8783	No data	No data	No data	
6,3	No data	13,5053	No data	No data	No data	
8	No data	13,9319	No data	No data	No data	
10	No data	12,4749	No data	No data	No data	
12,5	No data	12,1935	No data	No data	No data	
16	No data	13,1421	No data	No data	No data	
20	No data	12,8538	No data	No data	No data	
25	No data	12,9619	No data	No data	No data	
31,5	No data	15,8786	No data	No data	No data	
40	No data	16,5317	No data	No data	No data	
50	No data	16,3681	No data	No data	No data	
63	No data	16,2298	No data	No data	No data	
80	No data	17,9814	No data	No data	No data	
100	No data	18,9164	No data	No data	No data	
125	No data	19,1124	No data	No data	No data	
160	No data	18,6438	No data	No data	No data	
200	No data	19,8679	No data	No data	No data	
250	No data	22,6919	No data	No data	No data	
315	No data	22,7931	No data	No data	No data	
400	No data	24,822	No data	No data	No data	
500	No data	25,0923	No data	No data	No data	
630	No data	24,3091	No data	No data	No data	
800	No data	25,308	No data	No data	No data	
1000	No data	26,4022	No data	No data	No data	
1250	No data	27,8164	No data	No data	No data	
1600	No data	28,2463	No data	No data	No data	
2000	No data	31,7648	No data	No data	No data	
2500	No data	28,7668	No data	No data	No data	
3150	No data	32,5058	No data	No data	No data	
4000	No data	31,8374	No data	No data	No data	
5000	No data	33,2175	No data	No data	No data	
6300	No data	35,2092	No data	No data	No data	
8000	No data	36,623	No data	No data	No data	
10000	No data	35,308	No data	No data	No data	
12500	No data	35,6572	No data	No data	No data	
16000	No data	38,6394	No data	No data	No data	
20000	No data	40,4655	No data	No data	No data	

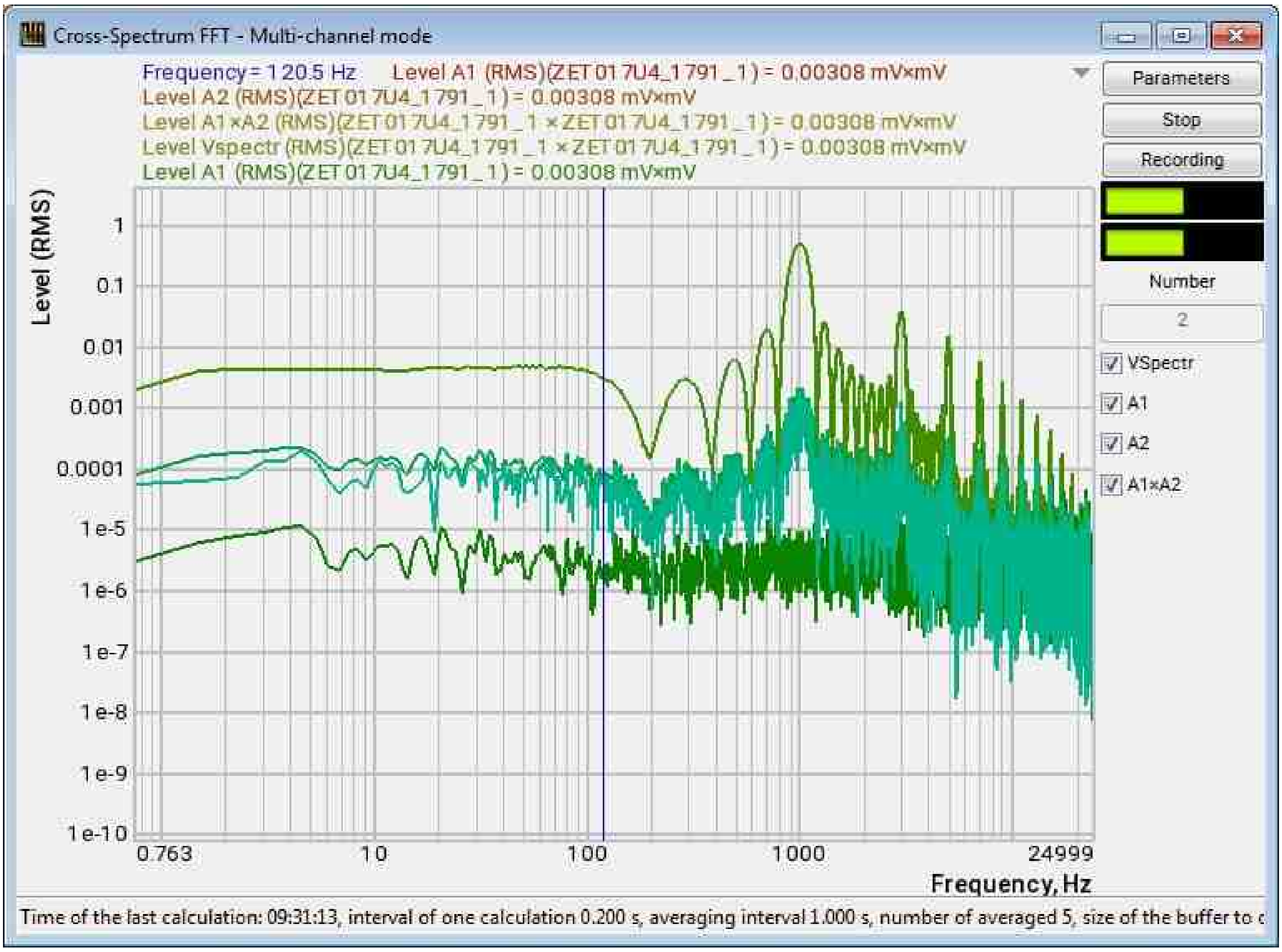
Results file, recorded with the program "Spectrum CPB Analysis"

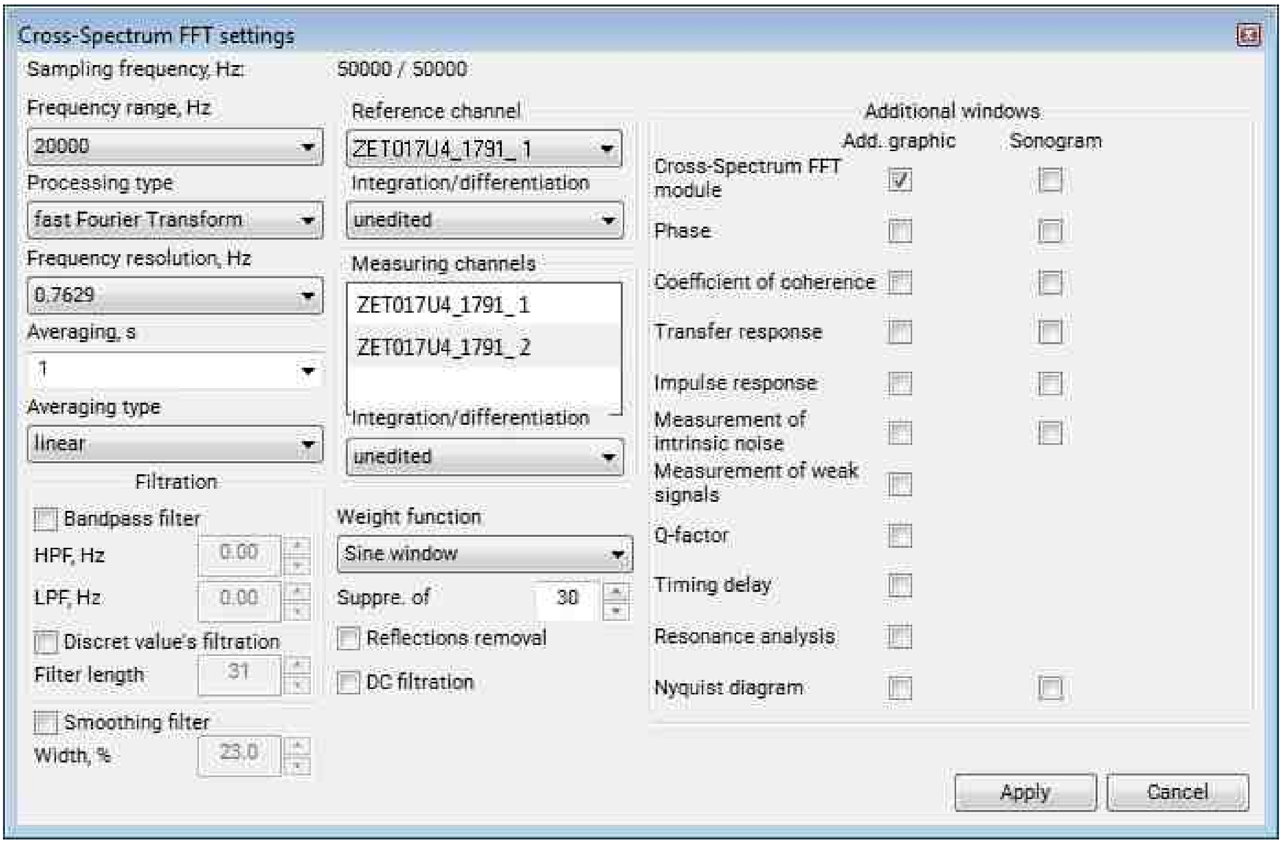
Cross-Spectrum FFT Analysis .....

The program ***Cross-Spectrum FFT Analysis*** is used for evaluation of the interrelation of the signals' parameters obtained from the two primary transducers installed at various parts of the controlled object. This program can be used for detection of noise source location, for sound absorption level evaluation and the researched object acoustic properties control, for evaluation of space-time distribution of the directional energy flux (Poynting vector), for the ground cross-section FR characteristic evaluation (Nakamura method), etc.
The program ***Cross-Spectrum FFT Analysis*** is used for calculation of power cross-spectrum, phase spectra, coherence spectra, impulse-response characteristics, as well as for resonance calculation.

Integrated control and automation module from the scope of ZETLab-Studio software package allows the user to create software measurement systems of his own.

Cross-Spectrum FFT Analysis program enables graphical representation of various spectral characteristics of the signals, thus, allowing to reveal the enhanced vibration amplitudes at resonance frequencies of the researched object or the components of a complex system. These functions allow to timely reveal the defects and to undertake corresponding preventive measures.
Implementation of the Cross-Spectrum FFT Analysis of the signals received from the input channels of the FFT Spectrum Analyzers is possible both in the real-time mode and the accumulated data post-processing mode.
Cross-Spectrum FFT Analysis belongs to the group of classical signal analysis methods and is widely applicable for almost all classes of signals having stationary properties.


Cross-Spectrum FFT - Multi-channel mode
Frequency = 120.5 Hz Level A1 (RMS)(ZET017U4_1791_1) = 0.00308 mV×mV
Level A2 (RMS)(ZET017U4_1791_1) = 0.00308 mV×mV
Level A1×A2 (RMS)(ZET017U4_1791_1 × ZET017U4_1791_1) = 0.00308 mV×mV
Level Vspectr (RMS)(ZET017U4_1791_1 × ZET017U4_1791_1) = 0.00308 mV×mV
Level A1 (RMS)(ZET017U4_1791_1) = 0.00308 mV×mV
Parameters
Stop
Recording
Number
2
VSpectr
A1
A2
A1×A2
Level (RMS)
Frequency, Hz
Time of the last calculation: 09:31:13, interval of one calculation 0.200 s, averaging interval 1.000 s, number of averaged 5, size of the buffer to


Cross-Spectrum FFT settings
Sampling frequency, Hz: 50000 / 50000
Frequency range, Hz
20000
Processing type
fast Fourier Transform
Frequency resolution, Hz
0.7629
Averaging, s
1
Averaging type
linear
Filtration
Bandpass filter
HPF, Hz 0.00
LPF, Hz 0.00
Discret value's filtration
Filter length 31
Smoothing filter
Width, % 23.0
Reference channel
ZET017U4_1791_1
Integration/differentiation
unedited
Measuring channels
ZET017U4_1791_1
ZET017U4_1791_2
Integration/differentiation
unedited
Weight function
Sine window
Suppre. of 30
Reflections removal
DC filtration
Additional windows
Add. graphic
Sonogram
Cross-Spectrum FFT module
Phase
Coefficient of coherence
Transfer response
Impulse response
Measurement of intrinsic noise
Measurement of weak signals
Q-factor
Timing delay
Resonance analysis
Nyquist diagram
Apply
Cancel

Main functions of the program

- measurement and representation of the signal in narrow spectral bands. The number of bands can be equal to the power of two (128, 256, 512, …, 262144) or to an arbitrary number (e.g., 100, 200, 500, …, 250000) with the use of Z-conversion;
- measurement and representation of signal spectral characteristics with various averaging types (linear, exponential), processing (integration, differentiation) and representation (RMS or peak value);
- measurement and representation of real and imaginary part of the signal, phase difference and signals coherence coefficient;
- measurement and displaying of the instant spectrum modulus;
- measurement of the complex frequency response and coherent power of the spectral component;
- measurement and graphical representation of signals transfer characteristics.

The software allows to use additional dialog windows with a graphical representation of the following parameters:

- Real part – representation of the source signal co-phase component amplitude;
- Imaginary part – representation of the source signal two-phase component;
- Phase – joint representation of the signal source components;
- Coefficient of coherence – representation of phase synchronization of the two signals;
- Transient characteristic – representation of the controlled object response to a single stepwise impact;
- Impulse characteristic – representation of the controlled object response to a single impulse impact;
- Impulse characteristic (coherent) – representation of the controlled object response to a single impulse impact taking into consideration the phase synchronization of the signals;
- Calculation of resonances – search and representation of the controlled object natural oscillations.
- Nyquist diagram – representation of amplitude-frequency response (AFR);

Despite the fact that for accurate estimates of the frequency characteristics, it is necessary to satisfy the condition on the linearity of the system (and in practical situations, linearity is one of the most rarely fulfilled properties), mutual spectral analysis allows one to obtain quite meaningful results that describe the best (in the root-mean-square sense) linear approximations for systems under study. This is especially important when it comes to studying statistics of extreme values, such as predicting catastrophic failures under random loads. [J. Bendat, A. Pearsol "Applications of Correlation and Spectral Analysis", 1983].

Cross spectral densities give results as a function of frequency. This fact greatly expands the range of possible applications of spectral analysis to engineering problems in those areas where correlation methods were previously used.

An important advantage of mutual spectral analysis compared to correlation analysis is that in order to obtain significant results, it is not necessary to require that the medium be without dispersion.

Mutual spectral analysis is used in solving problems of signal source localization.

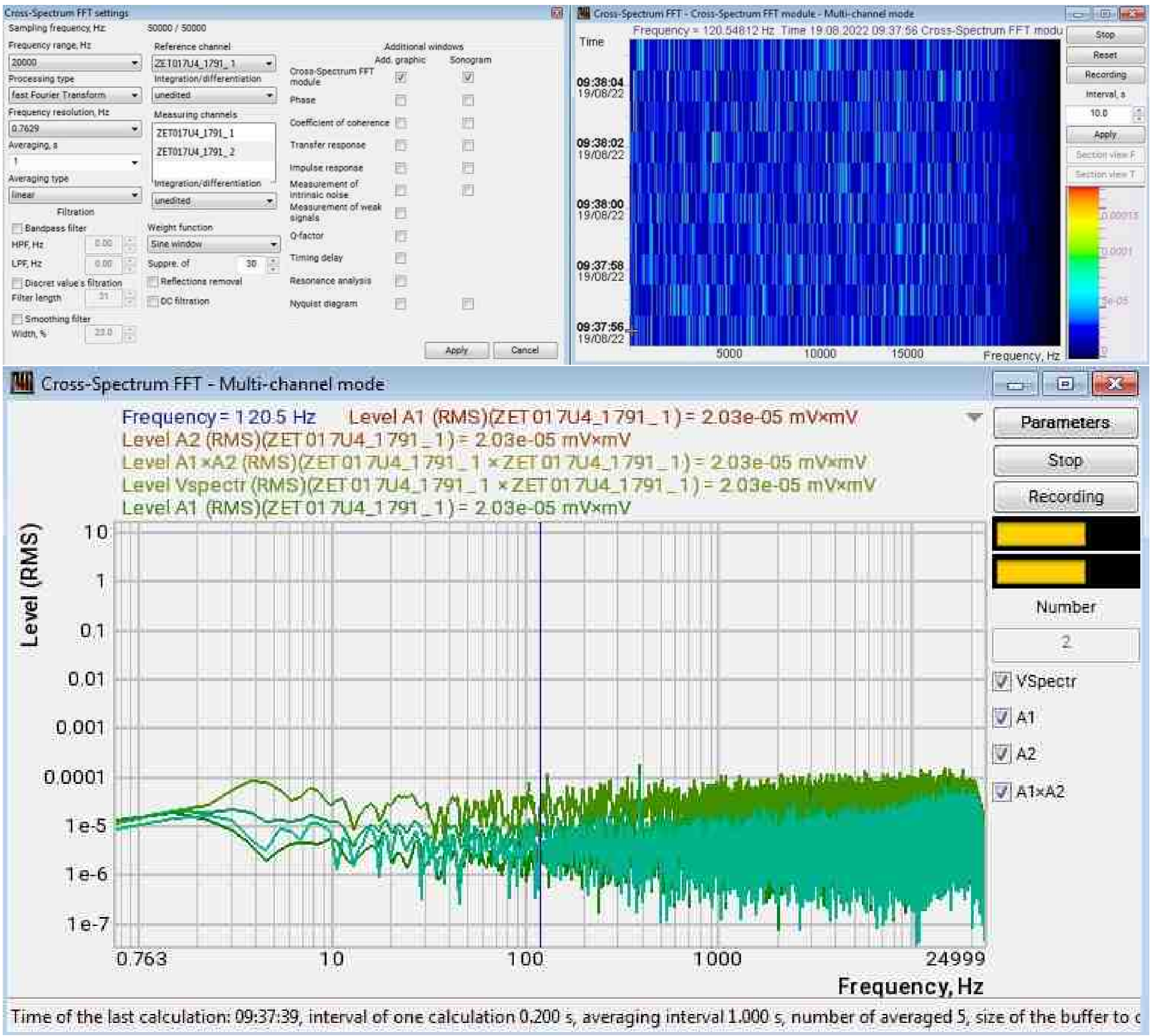
Spectral densities provide a convenient means for directly estimating the properties of physical systems from input and output observations, which can easily be extended to multidimensional systems.

Additional features of the program

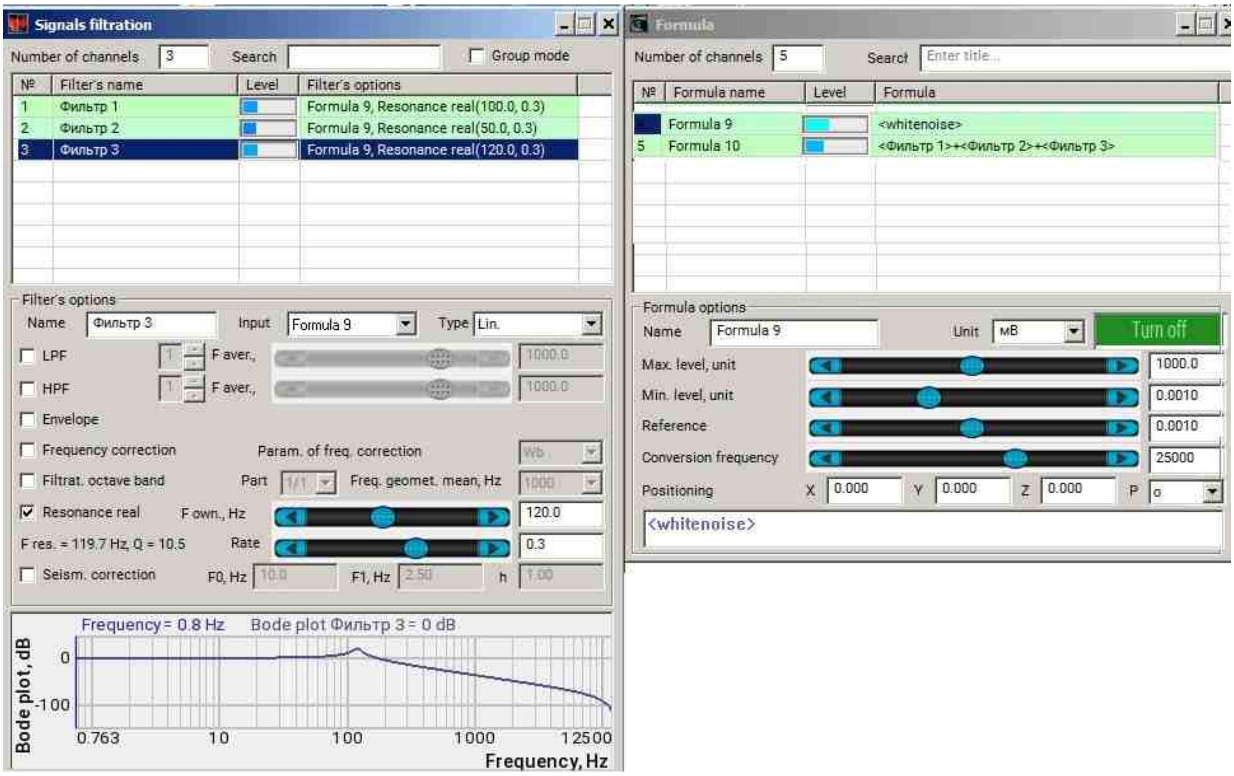
Statistics

When conducting long-term experimental measurements, it is very important to obtain not only the result, but also its uncertainty. To meet such needs, the option of calculating statistics based on the obtained measurement results was added to the "Cross-Spectrum FFT Analysis" program. To work with it, it is enough to launch any spectrogram and open the statistics window in the spectrogram window.

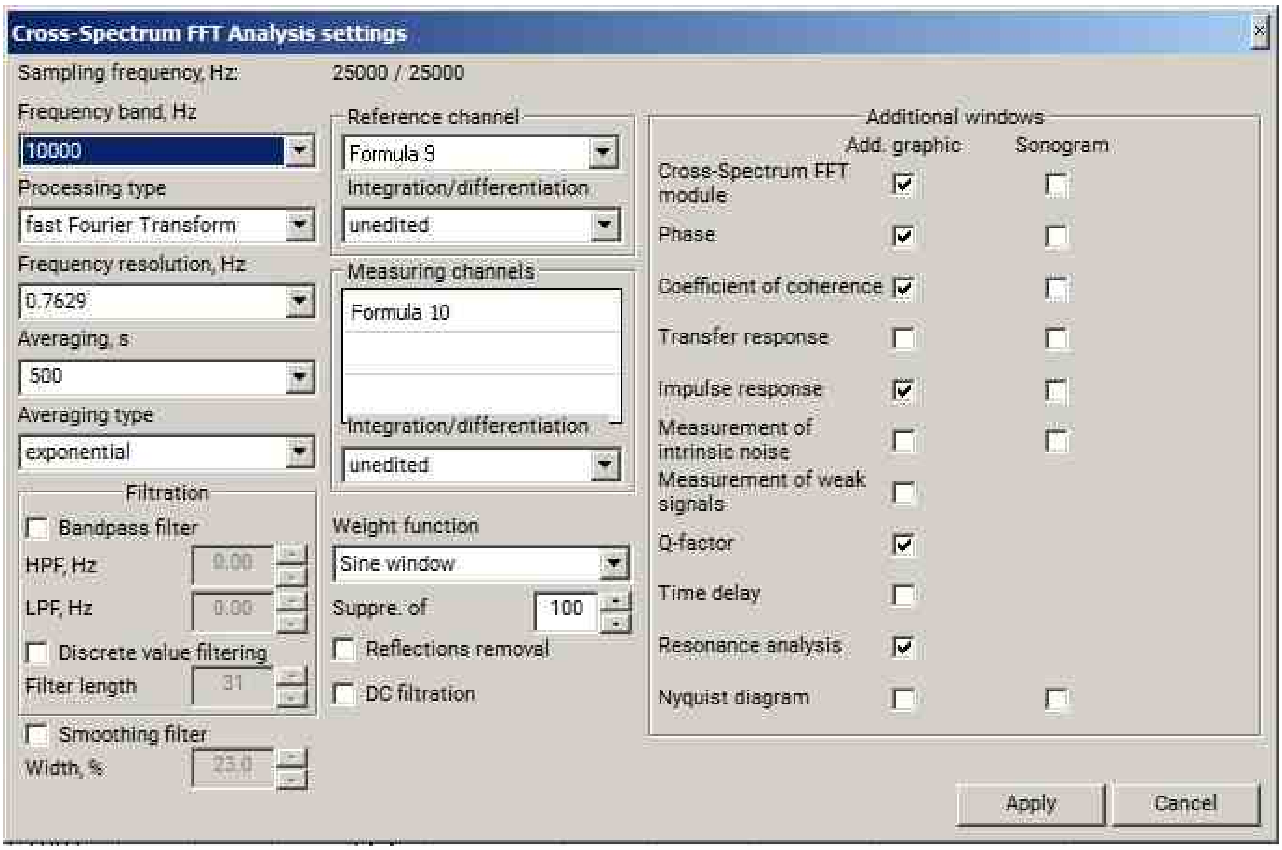
As a result of the calculation of statistics, graphs of the minimum, maximum, average values for the measurement time, as well as the standard deviation (Standard deviation may be abbreviated RMSD) in each frequency band, will be obtained.



Cross-Spectrum FFT Analysis parameters for examples



Settings of the Signal Formula and Filter to create resonances



Cross-Spectrum FFT Analysis settings for creating resonances

PEAK DETECTOR

is a special type of signal averaging in the program Cross-Spectrum FFT Analysis

Providing measurement of the signal parameters of a rapidly changing process is one of the main tasks of modern equipment. When choosing this tool, experts often compare the speed of registration and the possibility of conducting a correct signal analysis.

For implement this task, the functionality of the program "**Cross-Spectrum FFT Analysis**" was supplemented with a special function — a Peak detector.

The peak detector is a new type of averaging that allows you to capture the parameters of a useful signal without distorting it with subsequent interference during the process.

The principle of operation of this mechanism is as follows: instant averaging occurs only of those signals whose level at the time of registration is lower than the selected reference signal by 3 dB. Thus, extremely useful signals are recorded, eliminating the possibility of noise.

MEASUREMENT OF AMPLITUDE-FREQUENCY

CHARACTERISTICS

using the Peak detector function

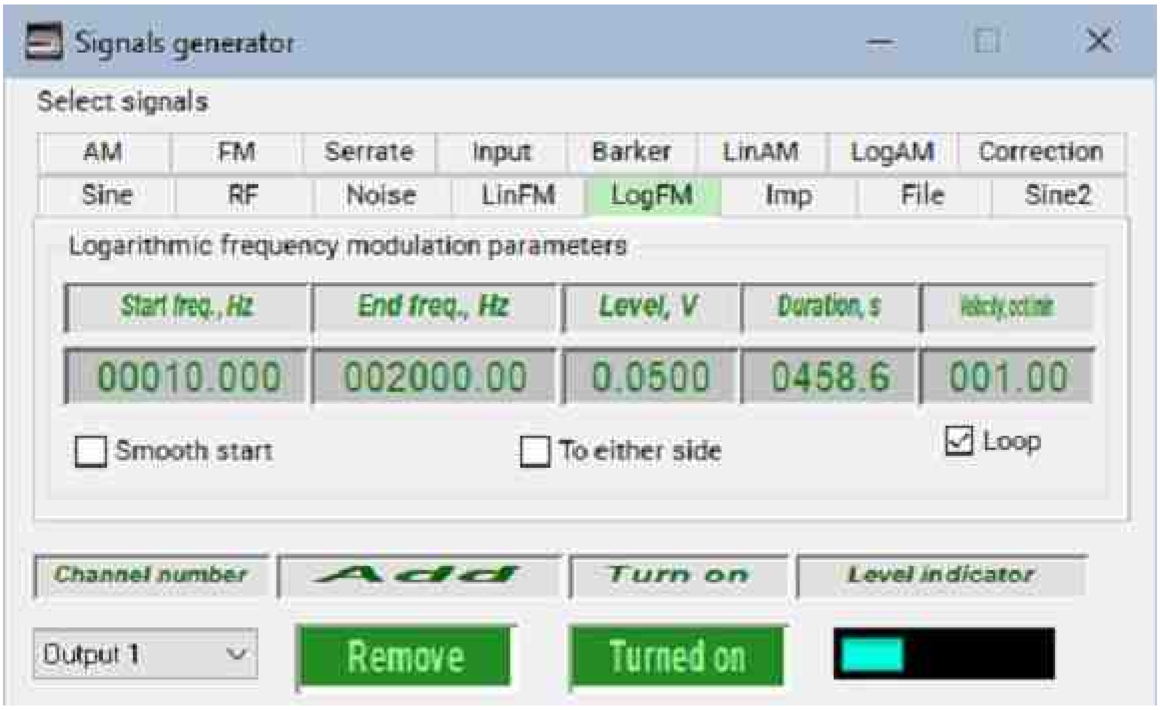
The measurement of amplitude-frequency characteristics (hereinafter — AFR) occupies an important place among radio engineering and radio electronic measurements, since it is a necessary characteristic in determining the quality indicators of processing and detection of useful signals against the background of both natural and artificial interference.

Taking this fact into account, specialists in this field have been developing various methods for measuring AFR for many years, constantly improving them and simplifying functionality.

The ZETLAB software allows you to measure the AFR using various methods, however, we do not stand still and every time we try to add new features for more accurate and faster obtaining of characteristics.

Let's consider two ways to obtain the frequency response: using the "**FFT Spectrum Analysis**" program and using the "**Cross-Spectrum FFT Analysis**" program, with the Peak detector function.

A signals generator will be used as a "Signals generator" - a scanning sine in the frequency range from 10 Hz to 2000 Hz, to more clearly demonstrate the measurement results.



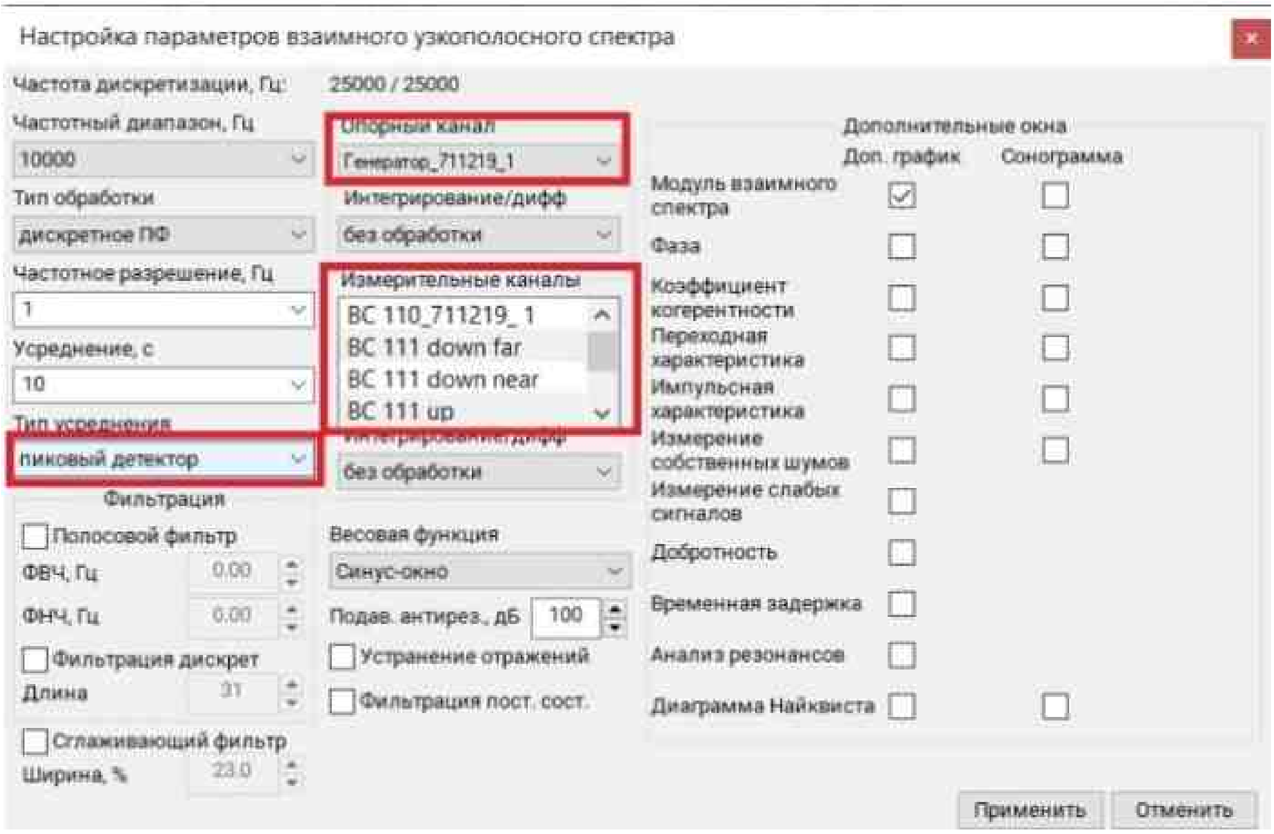
It is necessary to configure the programs.

In the "**FFT Spectrum Analysis**" program, we will set the frequency range, select the averaging time and select the measuring channels. Also, for clarity, in the Additional graphics tab, set the flag opposite the Maximum level.

After setting the necessary settings, activate the *Apply* button - the working dialog box of the "**FFT Spectrum Analysis**" program will open.

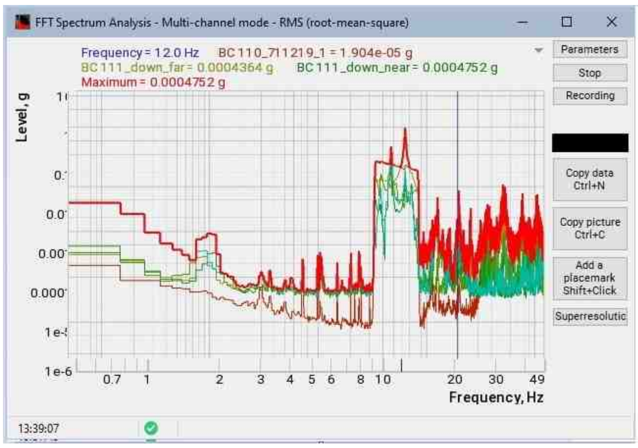
In the "**Cross-Spectrum FFT Analysis**" program, in the program settings window, set:

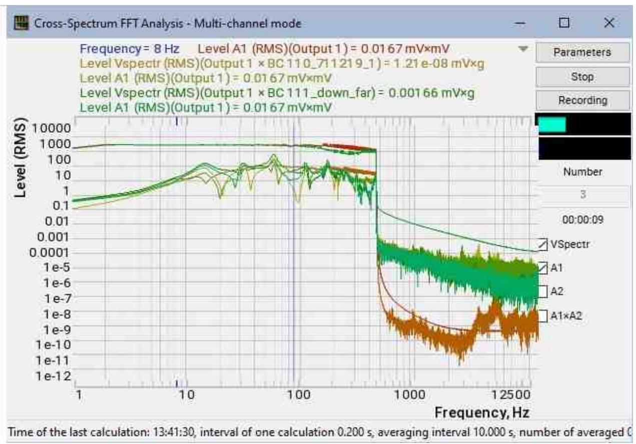
- required frequency range;
- averaging type - peak detector;;
- select reference channel;
- set measuring channels;
- set the flag opposite the Transient response value in the Additional graphics section.



After setting the necessary settings, activate the Apply button - two working dialog boxes will open: the "**Cross-Spectrum FFT Analysis**" and "Transient response" programs.

Below are the spectra of signals obtained in the "**FFT Spectrum Analysis**" (left) and "**Cross-Spectrum FFT Analysis**" (right) programs.

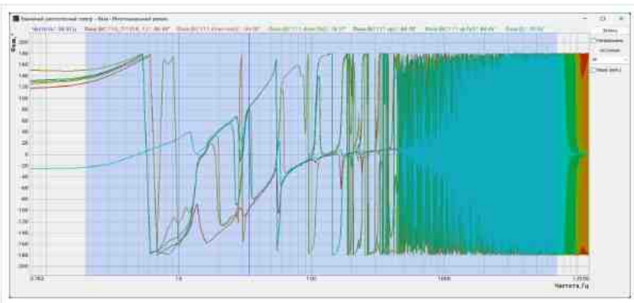


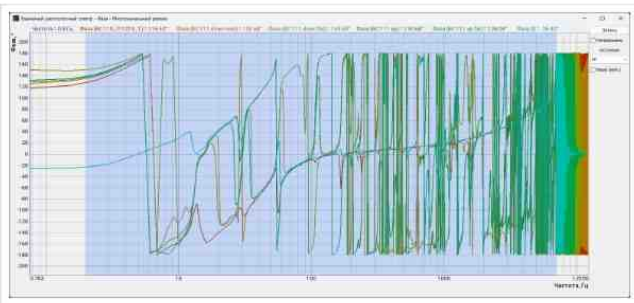


As can be seen from the graphs, the signal spectrum in the "**FFT Spectrum Analysis**" program is a rather uneven characteristic that constantly changes depending on the frequency of the generator, which makes it difficult to correctly estimate the real AFR of the signal. This is due to the specifics of the signal processing algorithm embedded in this program.

At the same time, the signal spectrum in the "**Cross-Spectrum FFT Analysis**" program with the Peak detector function is an even characteristic that is not affected by the frequency of the generator signal. Thanks to the Peak detector averaging algorithm, the signal remains unchanged in the zone where the generator signal has already passed, which in turn makes it possible to obtain a real AFR. The AFR is evaluated in the program window "Transient response".

To a signal averaged by the Peak detector type, all the functionality of the "**Cross-Spectrum FFT Analysis**" program can be applied, namely, the use of all additional windows is available for detailed analysis.





Work order

The use of the Signals generator and "**Cross-Spectrum FFT Analysis**" programs with the Peak detector function makes it easy to organize an automated process for determining amplitude-frequency characteristics.

For perform the frequency response removal procedure, you will need a spectrum analyzer, for example ZET 034 or ZET 017-U8.

The order of operation is as follows:

1. In the "Signals generator" program, select the "LogFM" tab, set the value of the initial and final frequency, set the signal level, duration and velocity of AFR removal. After entering all the parameters, activate the *Add* and *Turn on* buttons sequentially.

2. Launch the program "**Cross-Spectrum FFT Analysis**", setting the program according to the method specified above. As a reference channel, install the generator channel, as measuring channels, through which you want to remove the AFR. Set the *Transient characteristic* flag in the additional additional windows.
3. Monitor the automated process of determining AFR through selected channels.

That's how in three steps you can remove the frequency response simultaneously on a large number of channels!

This method will be convenient when carrying out the certification of vibration stands, when it is necessary to measure their AFR, evaluate the operating frequency range and determine the resonant frequencies

Supported Hardware .....

Cross-Spectrum FFT Analysis is included into the following software packages:

For the purpose of analog signals digital processing, it is possible to use *FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01* and *seismic recorder ZET 048*.

- ZETLAB ANALIZ – FFT Spectrum Analyzers software;
- ZETLAB VIBRO – Shaker controller software;
- ZETLAB SEISMO – seismic station software;

Cross-Spectrum FFT Analysis is included in the **Signal analysis** software group.

Program description .....

To start the program "**Cross-Spectrum FFT Analysis**", go to "Signal analysis" menu (Fig. 1) of ZETLab panel, and select the program "**Cross-Spectrum FFT Analysis**". You will see the main window of the program (*Fig. 2*). The top section of the program will depict the name of the program and the name of the channel selected for the analysis. Above the spectrum graphic, you will see the measured values (frequency, signal level), corresponding to the particular point of the graphic. The instant value of the cross-spectrum is calculated by means of multiplication of the two channels spectra obtained by means of the Fourier transform.

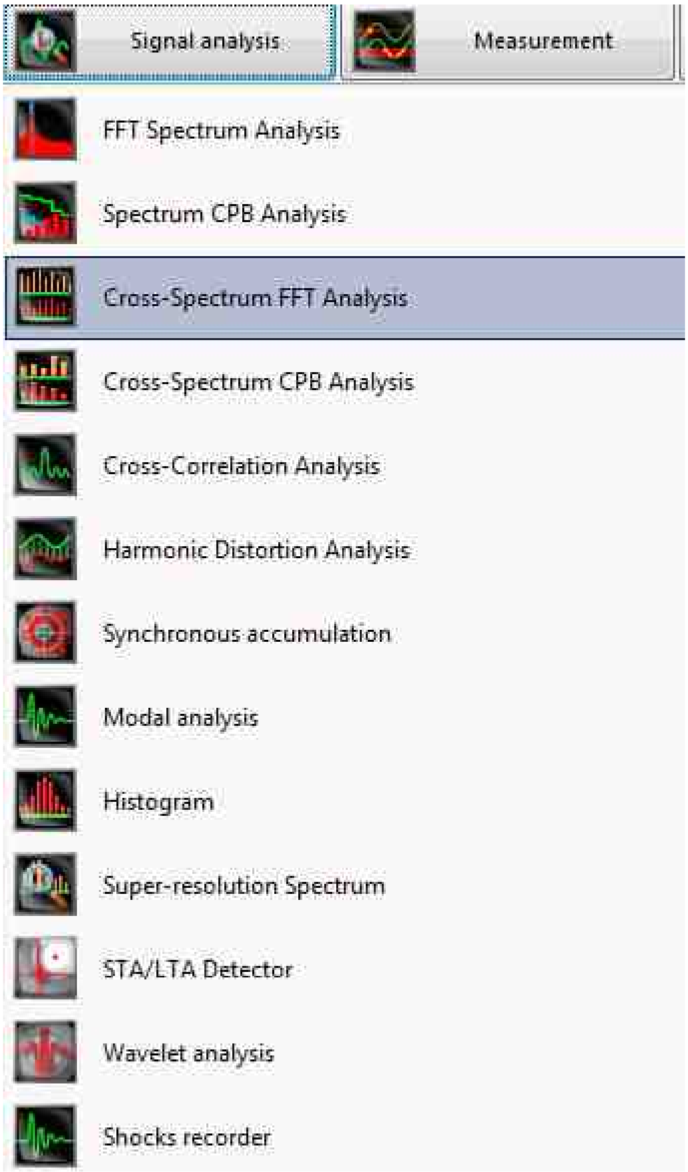


Fig. 1. Starting the "Cross-Spectrum FFT Analysis"

The title of the window shows the name of the spectrum and the names of the displayed channels. Below you can see the measured parameters, cursor values and measurement units.

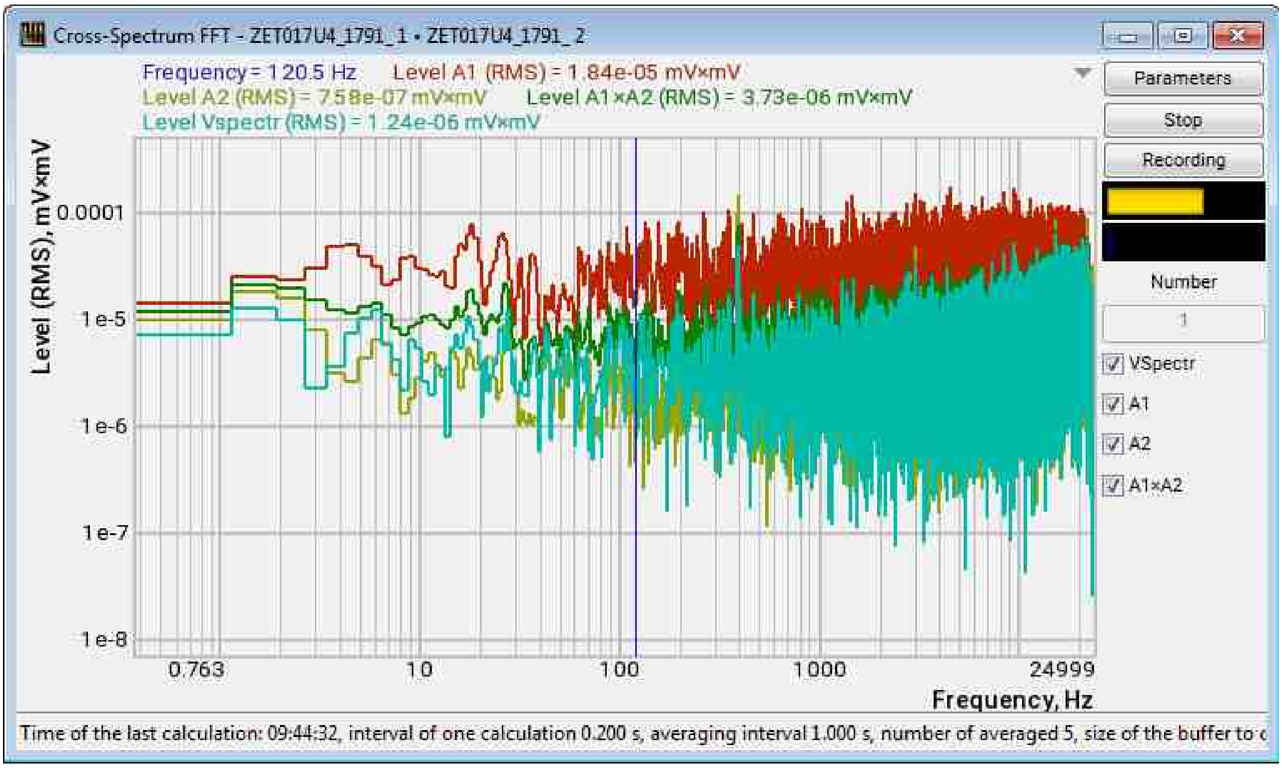


Fig. 2 Example of the main program window

"Cross-Spectrum FFT Analysis program: control

"**Parameters**" key allows to activate the window "**Cross-Spectrum FFT Analysis setting**".

The "**Start**" key is used to display the signal. Upon activation of the program "**Cross-Spectrum FFT Analysis**", the "Start" key is active by default.

The "**Stop**" key allows to suspend both signal displaying process and data update. However, the server continues data accumulation process and all other programs continue their operation.

The "**Recording**" key activates a standard dialog window "Recording the results in a file", allowing the user to select the file name as well as to assign the directory for saving the file (directory by default - C:\ZetLab\result\). The file is saved with *.dtx extension. The file contains information description, data in floating point format (a point is used for separation between fractional and integer numbers).

The indicator depicts integral level of the signal and overloading. In the case, if the signal exceeds the maximal acceptable level, the indicator turns completely red without any black section at the right part. The right section of the indicator will remain red until the user left-clicks it.

In order to exit the program "**Cross-Spectrum FFT Analysis**", click the corresponding key in the top right section of the program interface.

See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Setting parameters of display
- Using signal level indicators
- Adjustment of the color scheme used for displaying of the registered signal amplitude values
- Graphical and numerical data transfer to text editors
- Setting GridGl grid functionality

Phase (Phase response of the signal) .....

Cross-Spectrum FFT Analysis

It is most convenient to describe the dynamic characteristics of physical systems in the frequency domain using the Fourier transform of the impulse transient function, called the frequency response of the system.

The frequency response of a system is generally a complex function of frequency, described by the amplitude response (modulus) and phase response (argument) of the system.

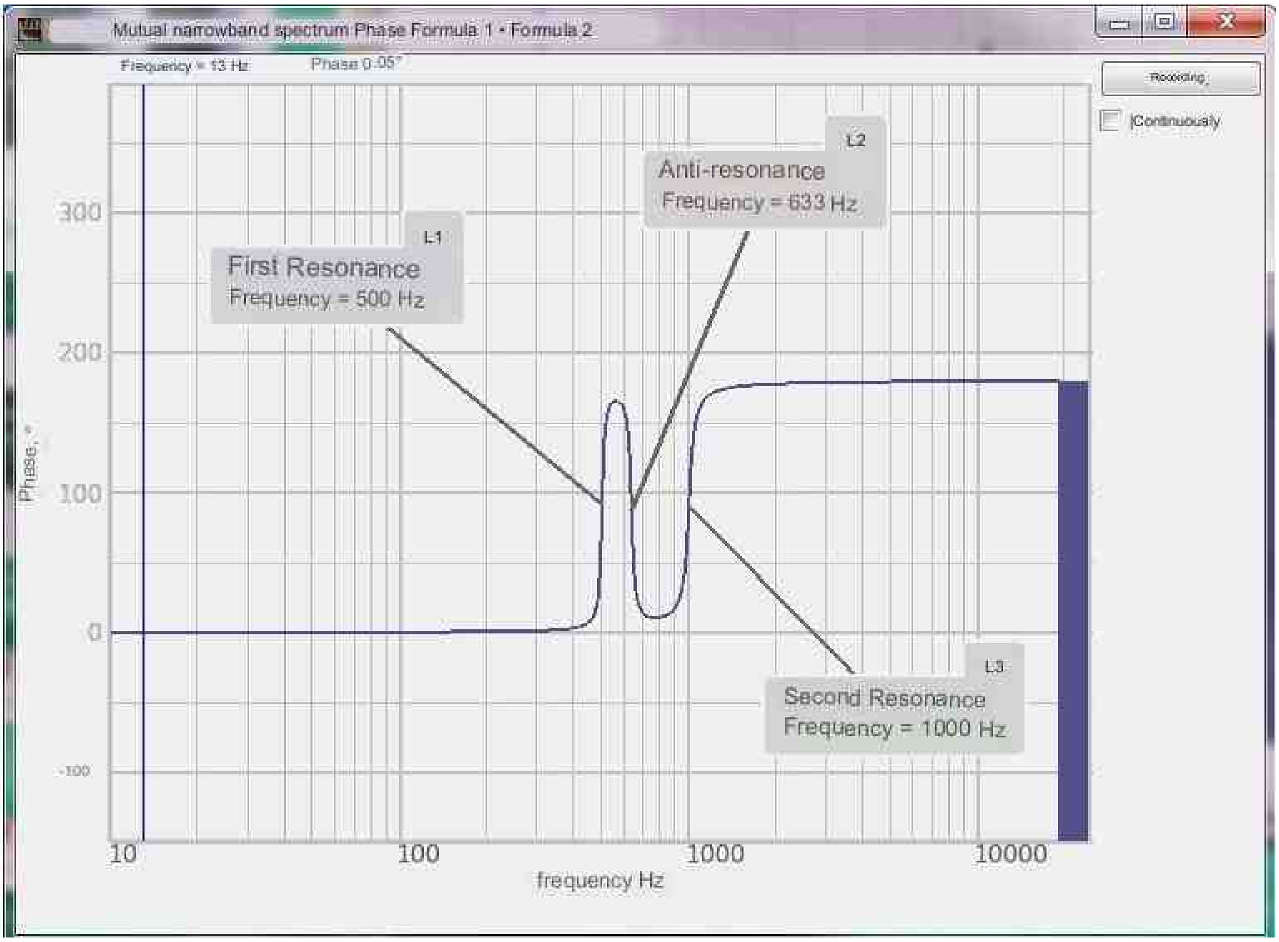
If a harmonic signal arrives at the input of the system, then at the output (after the completion of the transient process) harmonic oscillations will be established with the same frequency, but different values of amplitude and phase, by which one can judge the dynamic properties of the system.

Phase is one of the additional features of the ***Cross-Spectrum FFT Analysis*** program, which allows you to monitor the phase characteristic of the system, the input of which is affected.

To activate the dialog box of the ***Phase*** program, in the ***Cross-Spectrum FFT Analysis*** program window open the window ***Cross-Spectrum FFT Analysis settings*** by clicking the ***Parameters*** button. In the Additional windows field, set the flag opposite the ***Phase*** line in the ***Additional window*** column. graphic. and activate the Apply button.

To launch an additional graphic with the phase of the signal, in the *Additional windows* field, set the flag opposite the ***Phase*** line in the Additional column graphic. Please note that for the correct construction of the corresponding graph, it is necessary to set the frequency resolution to no more than 10 Hz.

After setting the required settings activate the ***Apply*** button - a working dialog box will open.



The graphic can be recorded in *.dtx format by activating the Recording button in the upper right corner of the dialog box.
Program

Cross-Spectrum FFT Analysis also includes:

- Phase (Phase response of the signal)
- Coefficient of coherence
- Transfer response
- Impulse response
- Measurement of intrinsic noise
- Measurement of weak signals
- Time delay
- Q -factor
- Resonance analysis
- Nyquist diagram

Coefficient of coherence .....

Cross-Spectrum FFT Analysis

The ***Coefficient of coherence*** is one of the additional features of the **Cross-Spectrum FFT Analysis** program, which allows you to evaluate the statistical reliability of frequency response measurements.

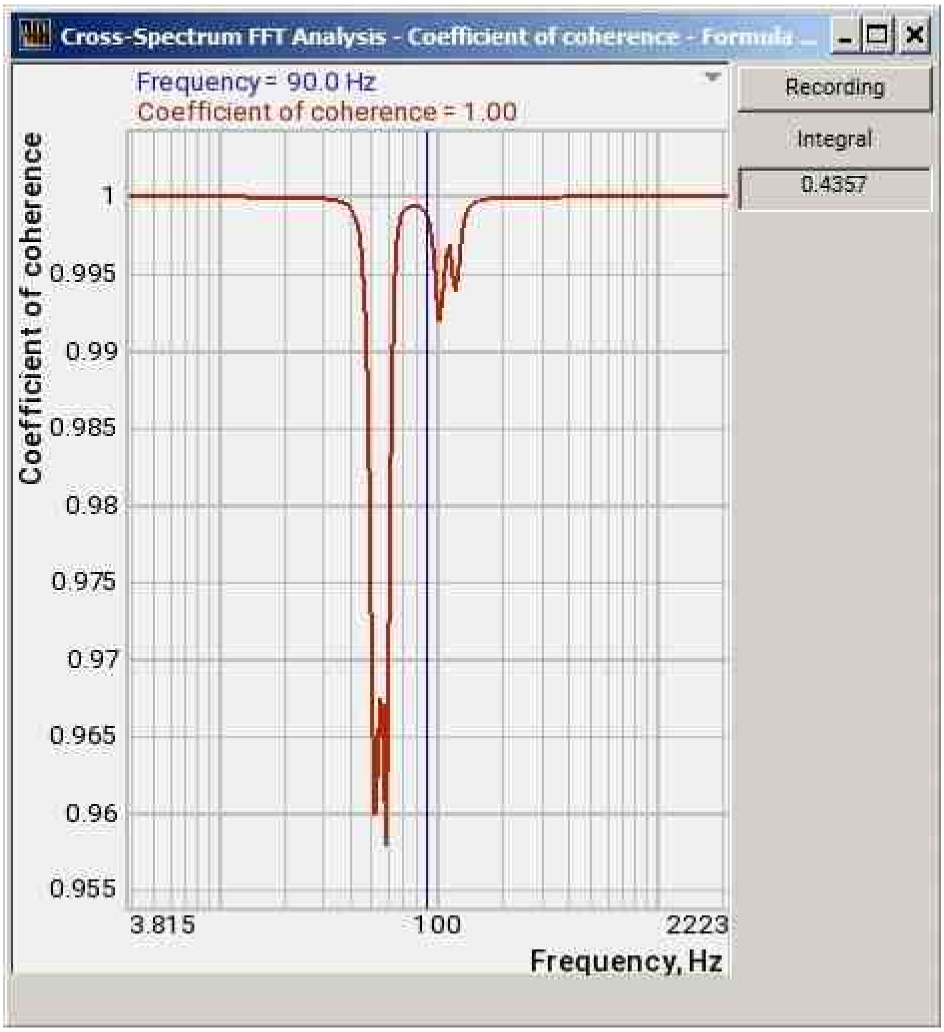
Coherence is used as a purely secondary characteristic - only to assess the significance of other cross-spectral characteristics and to determine the degree of influence of noise and / or nonlinearity on them.

The value of the coherence function is in the range from 0 to 1. Under ideal conditions, the coherence function is identically equal to one at all frequencies. Any deviation from the ideal conditions results in a coherence value less than one (in practice, the estimate of the coherence coefficient is often less than one).

The main reasons that can affect the decrease in the values of the coherence coefficient are as follows:
1) the presence of uncorrelated noise in the signals, which determine the instability of the phase of the mutual spectrum in time;
2) the presence of a nonlinear relationship between processes;
3) power leakage determined by insufficient frequency resolution, i.e. insufficiently long observation interval;
4) the presence of a time delay in the transfer of interaction between two processes, commensurate with the observation interval.

To activate the ***Coefficient of coherence*** program dialog box, in the **Cross-Spectrum FFT Analysis** program window, open the window ***Cross-Spectrum FFT analysis*** *settings* by clicking the *Parameters* button. In the ***Additional windows*** field, set the flag opposite the ***Coefficient of coherence*** line in the ***Additional window*** column. graphic. and activate the Apply button.

To launch an additional graphic with a coherence coefficient, in the Additional windows field, set the flag opposite the ***Coefficient of coherence*** line in the Additional column. graphic.
After setting the required settings activate the *Apply* button - a working dialog box will open.



Small values of coherence may indicate the insignificance of other cross-spectral characteristics at a given frequency or be a sign of the need to increase the number of averaging's to eliminate the effect of noise.

Signals of physical origin often contain stationary harmonics generated by real sources. By registering signals at different points, at any time at a frequency, for example, of a specific radio station, we will have a fixed phase difference (determined by the distance of the measurement points from the source). If noise is present at this frequency, then the phase of the cross spectrum of this harmonic will vary to some extent, and coherence allows one to estimate such variability, and an increase in averaging allows one to reduce it.

The graphic can be recorded in *.dtx format by activating the Recording button in the upper right corner of the dialog box.
Program

Cross-Spectrum FFT Analysis also includes:

- Phase (Phase response of the signal)
- Coefficient of coherence
- Transfer response
- Impulse response
- Measurement of intrinsic noise
- Measurement of weak signals

- Time delay
- Q -factor
- Resonance analysis
- Nyquist diagram

Transfer response .....

Cross-Spectrum FFT Analysis

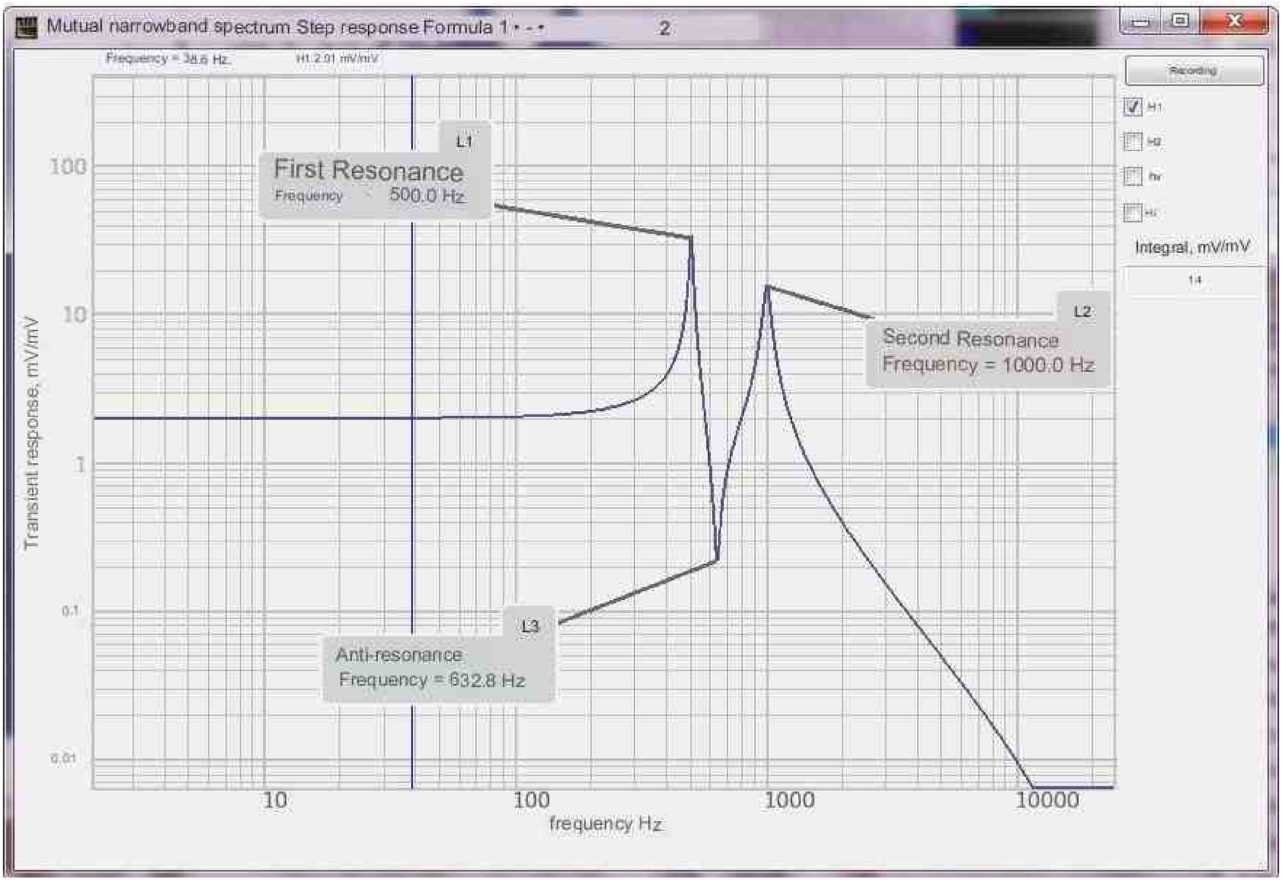
The ***Transfer response*** is one of the additional features of the ***Cross-Spectrum FFT Analysis*** program, which allows you to evaluate the frequency response of the system.

Using the frequency response *H(f)*, one can describe the dynamic properties of the system, since it is the Fourier transform of the impulse transition function corresponding to this system.

In the case of a linear system with constant parameters, the frequency response *H(f)* depends only on the frequency and does not depend on time or on the type of input signal. In the case of a nonlinear system, *H(f)* may depend on the input signal of the system. If the system parameters are not constant, then *H(f)* depends on time.

To activate the dialog box of the program ***Transfer response***, in the program window Cross-Spectrum FFT Analysis, open the window ***Cross-Spectrum FFT analysis settings*** by clicking the *Parameters* button.. In the ***Additional windows*** field, set the flag opposite the ***Transfer response*** line in the ***Additional window*** column. graphic. and activate the Apply button.

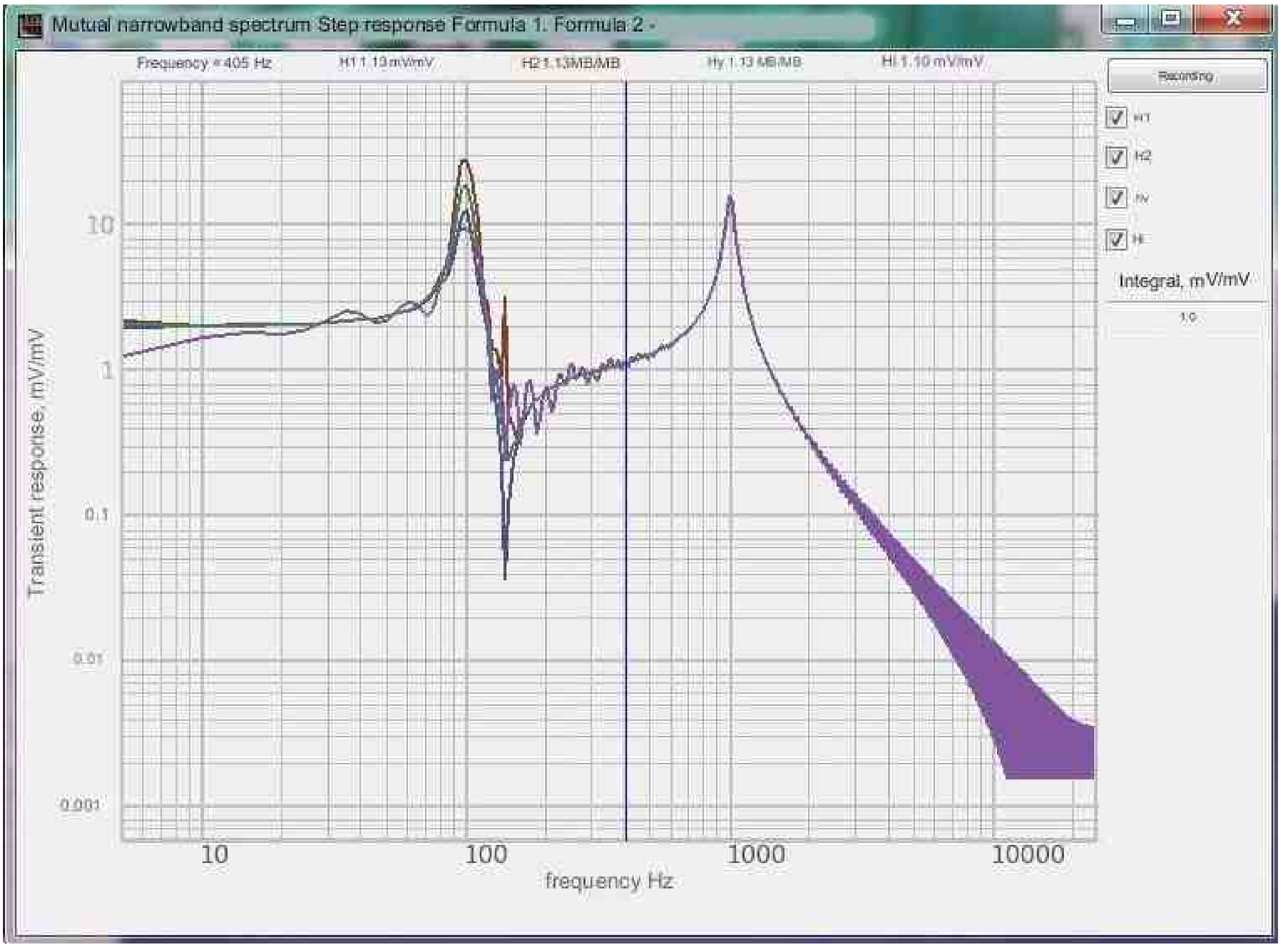
To launch an additional graphic with a ***Transfer response***, in the Additional windows field, set the flag opposite the ***Transfer response*** line in the Additional column. graphic. After Adjustment the required settings activate the *Apply* button - a working dialog box will open.



The software allows you to evaluate the frequency response *H(f)* of the system in several ways:

- H_1 — a statistical estimate of the frequency response of a system based on the assumption that there is no external noise affecting the input signal. The statistical estimate H_1 is the least square estimate of the system *H(f)*. The statistical estimate H_1 is always distorted due to the limited frequency resolution.
- H_2 — a statistical estimate of the frequency response of a system based on the assumption that the main external noise is present in the input signal. As with the H_1 statistical estimate, in the presence of noise at the output, the H_2 statistical estimate is an RMS estimate of the parameter *H(f)* and there will also be distortion due to the limited range of frequency resolution.
- H_v — a statistical estimate of the frequency response of a system in general cases where external noise occurs in both the input and output signals. The statistical estimate of H_v assumes that all external noise sources are not coherent with the actual input and output signals.
- H_c — statistical evaluation
- H_i — Fourier transform of the impulse response.

The basis for the development of software tools for evaluating the frequency response in the framework of the described methods are the scientific works of Anders Brandt, set out in the book *"Noise and Vibration Analysis: Signal Analysis and Experimental Procedures", Anders Brandt, ISBN 978-0-470-74644-8.*



The graphic can be recorded in *.dtx format by activating the Recording button in the upper right corner of the dialog box.

Program

Cross-Spectrum FFT Analysis also also includes:

- Phase (Phase response of the signal)
- Coefficient of coherence
- Transfer response
- Impulse response
- Measurement of intrinsic noise
- Measurement of weak signals
- Time delay
- Q -factor
- Resonance analysis
- Nyquist diagram

Impulse response .....

Cross-Spectrum FFT Analysis

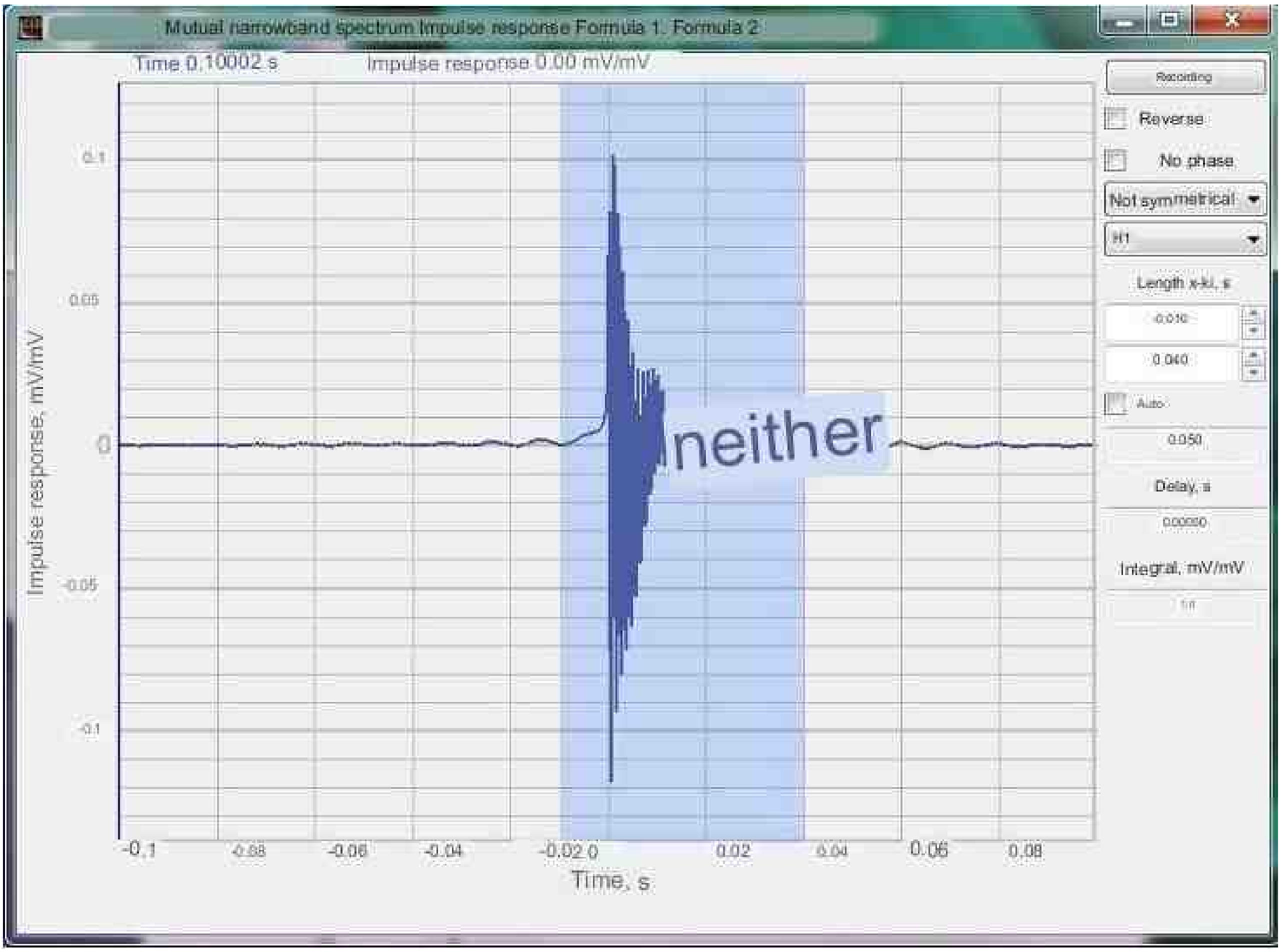
The dynamic characteristics of the system can be described by an impulse transient function (***Impulse response***), which is defined as a reaction at an arbitrary point in time to an impulse action that arrived at the input of the system τ units of time before this moment.

The ***Impulse response*** allows you to guess what the output of the system will look like in the time domain. For discrete and continuous time systems, the ***Impulse response*** is useful because it allows the output of these systems to be calculated for any input signal; the output is just the input signal convolved with the impulse response function.

To activate the dialog window of the program ***Impulse response***, in the window of the program ***Cross-Spectrum FFT Analysis***, open the window ***Cross-Spectrum FFT analysis settings*** by clicking the ***Parameters*** button. In the ***Additional windows*** field, set the flag opposite the ***Impulse response*** line in the Additional window column. graphic. and activate the *Apply* button.

The ***Impulse response*** is the main characteristic of systems in the time domain. In order to fully characterize the behavior of the system, one of the characteristics is sufficient - impulse (impulse response) or transient (frequency response); impulse response is useful when working in the time domain, and frequency response is useful when analyzing behavior in the frequency band.

The ***Impulse response*** program, in addition to the system's response to the impact, displays the history with the ability to adjust the length of the characteristic.



Using the recorded impulse response, it is possible to correct the impulse response of a similar output path, for example, to suppress noise present in the output signal.

The graphic can be recorded in *.dtx format by activating the Recording button in the upper right corner of the dialog box.
Program

Cross-Spectrum FFT Analysis also includes:

- Phase (Phase response of the signal)
- Coefficient of coherence
- Transfer response
- Impulse response
- Measurement of intrinsic noise
- Measurement of weak signals
- Time delay
- Q -factor
- Resonance analysis
- Nyquist diagram

Measurement of intrinsic noise .....

Cross-Spectrum FFT Analysis

Measurement of intrinsic noise is one of the additional features of the ***Cross-Spectrum FFT Analysis*** program. Allows you to estimate the level of the useful signal against the background of noise by the method of spectral subtraction.

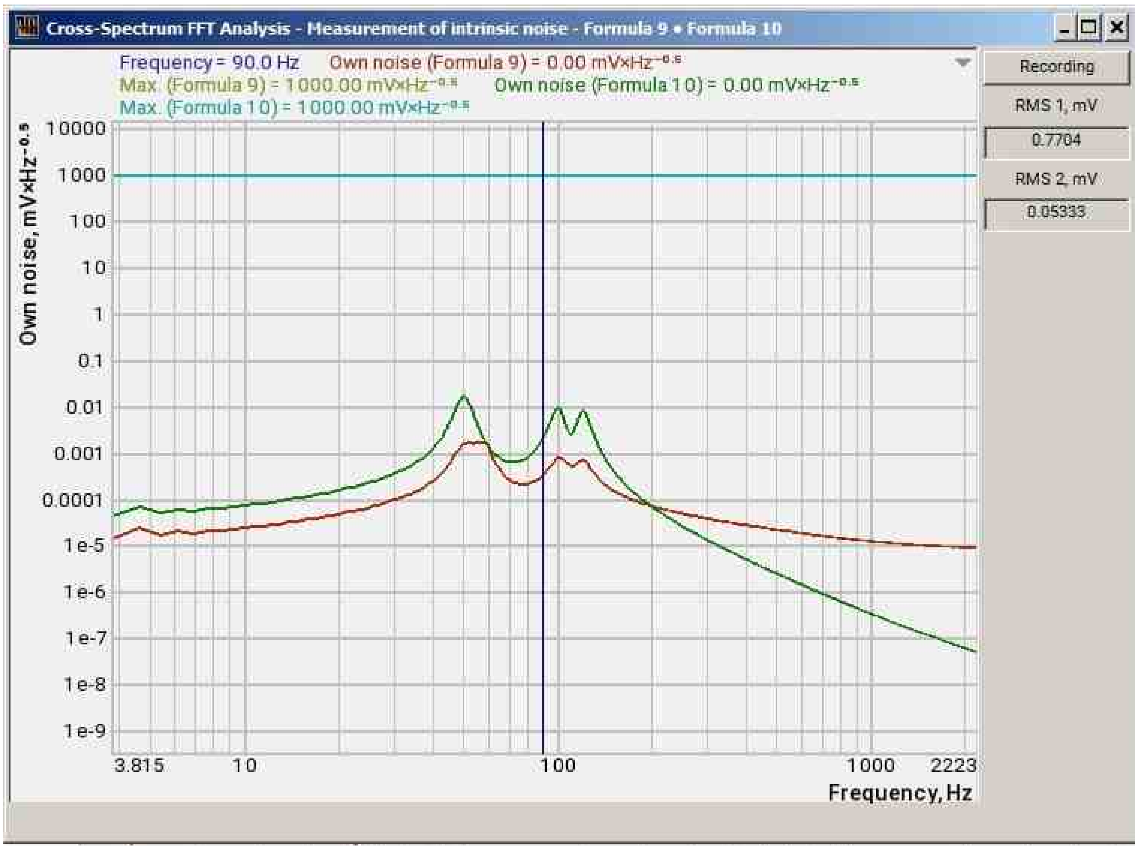
This method is implemented at the software level due to the redundancy of the received signals from two identical sources. The algorithm for calculating intrinsic noise is based on the method of recording the same process with two identical devices.

To determine the intrinsic noise using the ***Cross-Spectrum FFT Analysis*** program, you need to install two identical devices side by side. The theory of calculation is as follows: it is assumed that the noise of the devices is incoherent, and the common signal for them is the background ground acceleration. Based on these assumptions, the spectral power densities of the output signal for each of the devices are calculated, a component coherent with the output signals of each device is extracted from the power Cross-Spectrum FFT Analysis of the output signals, the normalized coherence function between the output signals of the devices is determined, and the intrinsic noise of each measuring channel is calculated.

To activate the dialog window of the program Measuring intrinsic noise, in the window of the program ***Cross-Spectrum FFT Analysis***, open the window ***Cross-Spectrum FFT analysis settings*** by clicking the ***Parameters*** button. In the ***Additional windows*** field, set the flag opposite the ***Measurement of intrinsic noise*** line in the ***Additional window*** column. graphic. and activate the *Apply* button

In the window that opens, Adjustment of Cross-Spectrum FFT Analysis, set the following parameters:

- Averaging, s — 1000;
- Weight function - Sine window;
- Averaging type - linear;
- Integration/diff - unedited;
- Processing type - discrete Fourir Transform;
- Discret value's filtration - set the checkbox in the checkbox field;
- Noise measurement — checkbox in the checkbox.
- After setting the required settings activate the *Apply* button - a working dialog box will open.



In addition to the signal received from the input channels (if the units of the input channel are set to m/s^2; m/s), the graph displays the models of atmospheric seismic noise of the Earth NLNM (New Low Noise Model) and NHLM (New Hight Noise Model), built by J. Peterson (1993). It also displays the maximum allowable level of intrinsic noise of the measuring device (in our case, the spectrum analyzer).

The graphic can be recorded in *.dtx format by activating the Recording button in the upper right corner of the dialog box.
Program

Cross-Spectrum FFT Analysis also includes:

- Phase (Phase response of the signal)
- Coefficient of coherence
- Transfer response
- Impulse response
- Measurement of intrinsic noise
- Measurement of weak signals
- Time delay
- Q -factor
- Resonance analysis
- Nyquist diagram

Measurement of weak signals .....

Cross-Spectrum FFT Analysis

The problem of determining the weak parameters signals at the level of high interference remains one of the most acute in the modern world. Specialists need a reliable tool that will allow them to calculate parameters of a useful weak signal with the required accuracy.

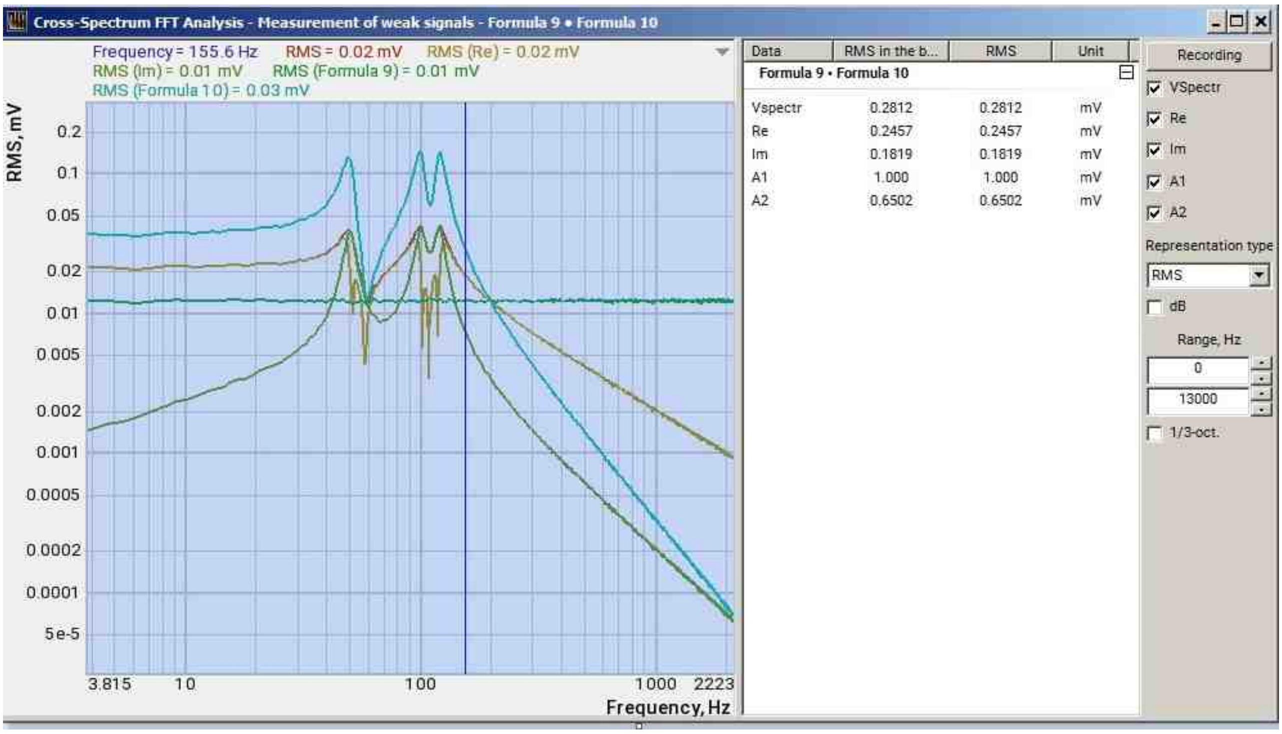
To solve this problem, a new function of the program "**Cross-Spectrum FFT Analysis**" - "***Measurement of weak signals***" has been developed, which allows you to expand the standard functionality of the ZETLAB controller to a selective voltmeter. The measurement is carried out using two channels.

The essence of the method is reduced to the analysis of the spectra of signals coming to two input channels in order to isolate a useful low-power signal and high unwanted interference by long-term accumulation and averaging.

As a result of the calculation, you can get:

- Common spectral noise level;
- Parameters of noise characteristics in the selected frequency band (RMS - rms value; signal amplitude; SD - spectral density and PSD - power spectral density), which is below the common noise level;
- Uncertainty of measured signal parameters.

To activate the dialog window of the program ***Measurement of weak signals***, in the window of the program ***Cross-Spectrum FFT Analysis***, open the window ***Cross-Spectrum FFT Analysis settings*** by clicking the ***Parameters*** button. In the Additional windows field, set the flag opposite the ***Measurement of weak signals*** line in the ***Additional window*** column. graphic. and activate the *Apply* button



The graphic can be recorded in *.dtx format by activating the Recording button in the upper right corner of the dialog box.

Program

Cross-Spectrum FFT Analysis also includes:

- Phase (Phase response of the signal)
- Coefficient of coherence
- Transfer response
- Impulse response
- Measurement of intrinsic noise
- Measurement of weak signals
- Time delay
- Q -factor
- Resonance analysis
- Nyquist diagram

Q -factor .....

Cross-Spectrum FFT Analysis

In physics and engineering, the quality factor or Q factor is a dimensionless parameter that describes how underdamped an oscillator or resonator is. It is defined as the ratio of the initial energy stored in the resonator to the energy lost in one radian of the cycle of oscillation. Q factor is alternatively defined as the ratio of a resonator's centre frequency to its bandwidth when subject to an oscillating driving force. These two definitions give numerically similar, but not identical, results. Higher Q indicates a lower rate of energy loss and the oscillations die out more slowly. A pendulum suspended from a high-quality bearing, oscillating in air, has a high Q, while a pendulum immersed in oil has a low one. Resonators with high quality factors have low damping, so that they ring or vibrate longer.

As a result of the calculation, you can get:

- Sourse H1 or H2;

To activate the dialog window of the program ***Q - factor***, in the window of the program ***Cross-Spectrum FFT Analysis***, open the window ***Cross-Spectrum FFT Analysis settings*** by clicking the ***Parameters*** button. In the Additional windows field, set the flag opposite the ***Q - factor*** line in the ***Additional window*** column. graphic. and activate the *Apply* button

The graphic can be recorded in *.dtx format by activating the Recording button in the upper right corner of the dialog box.

Program

Cross-Spectrum FFT Analysis also includes:

- Phase (Phase response of the signal)
- Coefficient of coherence
- Transfer response
- Impulse response
- Measurement of intrinsic noise
- Measurement of weak signals
- Time delay
- Q -factor
- Resonance analysis
- Nyquist diagram

Time delay .....

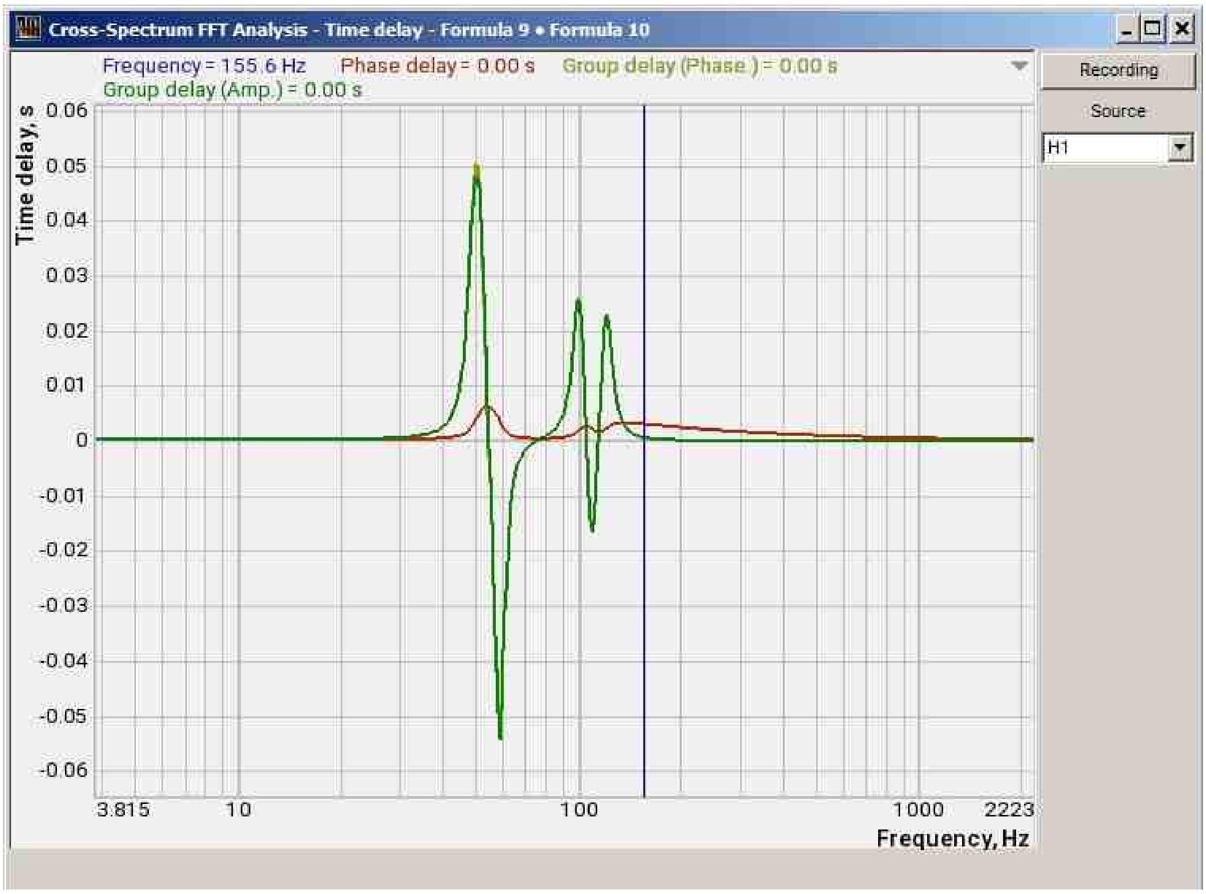
Cross-Spectrum FFT Analysis

It is designed to generate a delay in the transmission of input data by a given amount.

As a result of the calculation, you can get:

- Sourse H1 or H2;

To activate the dialog window of the program **Time delay**, in the window of the program ***Cross-Spectrum FFT Analysis***, open the window ***Cross-Spectrum FFT Analysis settings*** by clicking the ***Parameters*** button. In the Additional windows field, set the flag opposite the **Time delay** line in the ***Additional window*** column. graphic. and activate the *Apply* button



The graphic can be recorded in *.dtx format by activating the Recording button in the upper right corner of the dialog box.

Program

Cross-Spectrum FFT Analysis also includes:

- Phase (Phase response of the signal)
- Coefficient of coherence
- Transfer response
- Impulse response
- Measurement of intrinsic noise
- Measurement of weak signals
- Time delay
- Q -factor
- Resonance analysis
- Nyquist diagram

Resonance analysis .....

Cross-Spectrum FFT Analysis

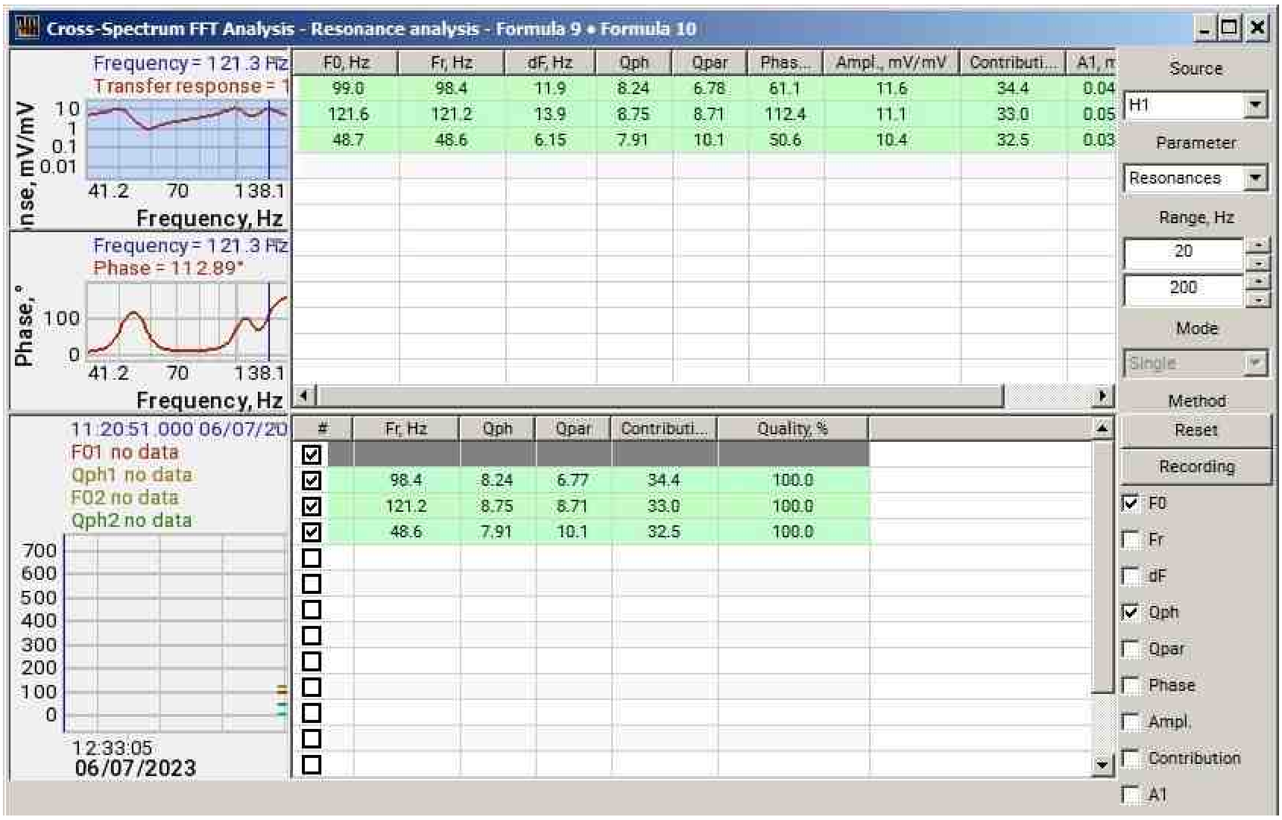
"***Analysis of resonances***" - an additional feature of the ***Cross-Spectrum FFT Analysis*** program, allows you to analyze the frequency characteristics of physical systems, the input of which is some perturbation. The resonance between the input action (input signal) and the system's response to this action (output signal) is determined.

To activate the ***Resonance analysis*** program dialog box, in the ***Cross-Spectrum FFT Analysis*** analysis program window, open ***Cross-Spectrum FFT analysis settings*** by clicking the ***Parameters*** button. In the Additional windows field, set the flag opposite the ***Analysis of resonances*** line in the *Additional window* column. graphic. and activate the *Apply* button

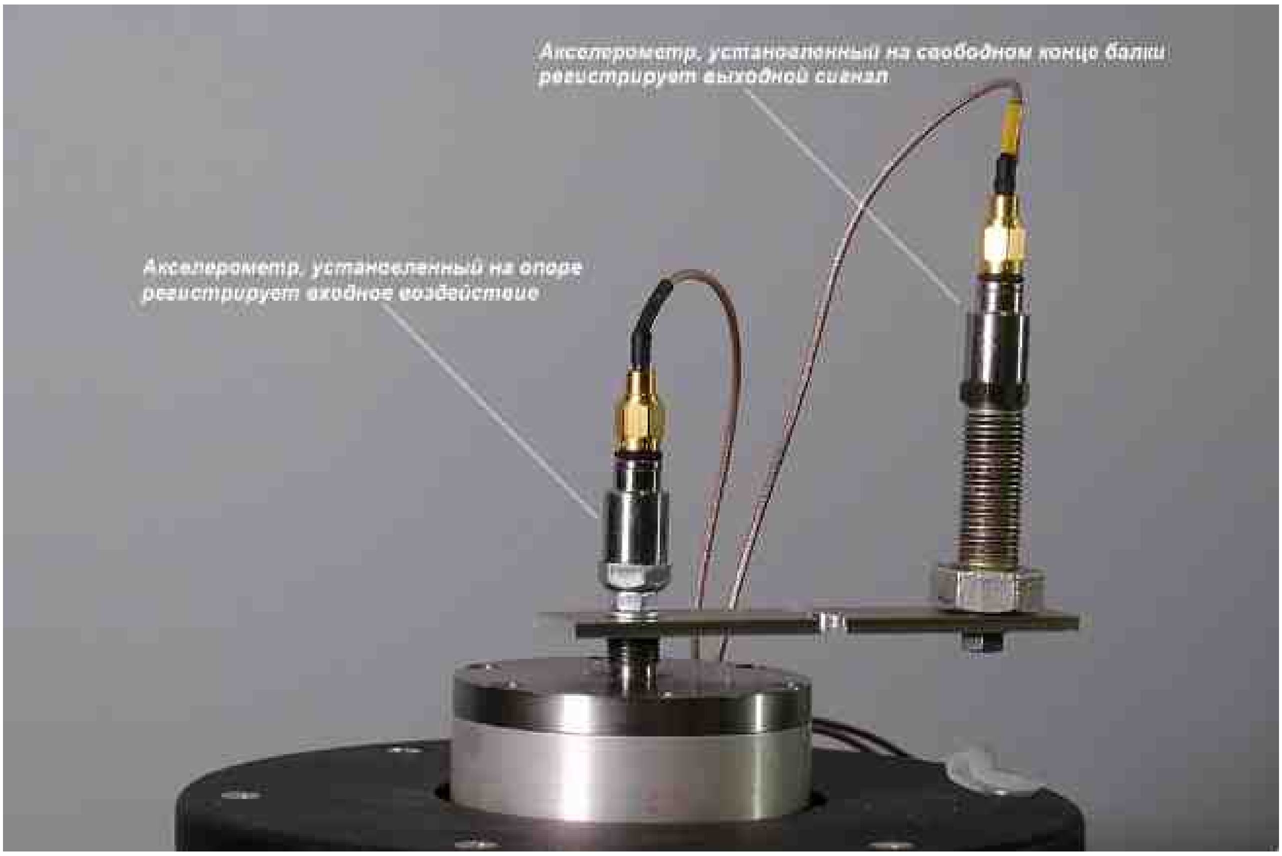
To launch the program window, in the ***Additional windows*** field, set the flag opposite the Resonance analysis line in the ***Additional window*** column. graphic. Please note that in order to search for resonant frequencies, it is necessary to set a more detailed frequency resolution.

After setting the required settings activate the *Apply* button - a working dialog box will open.

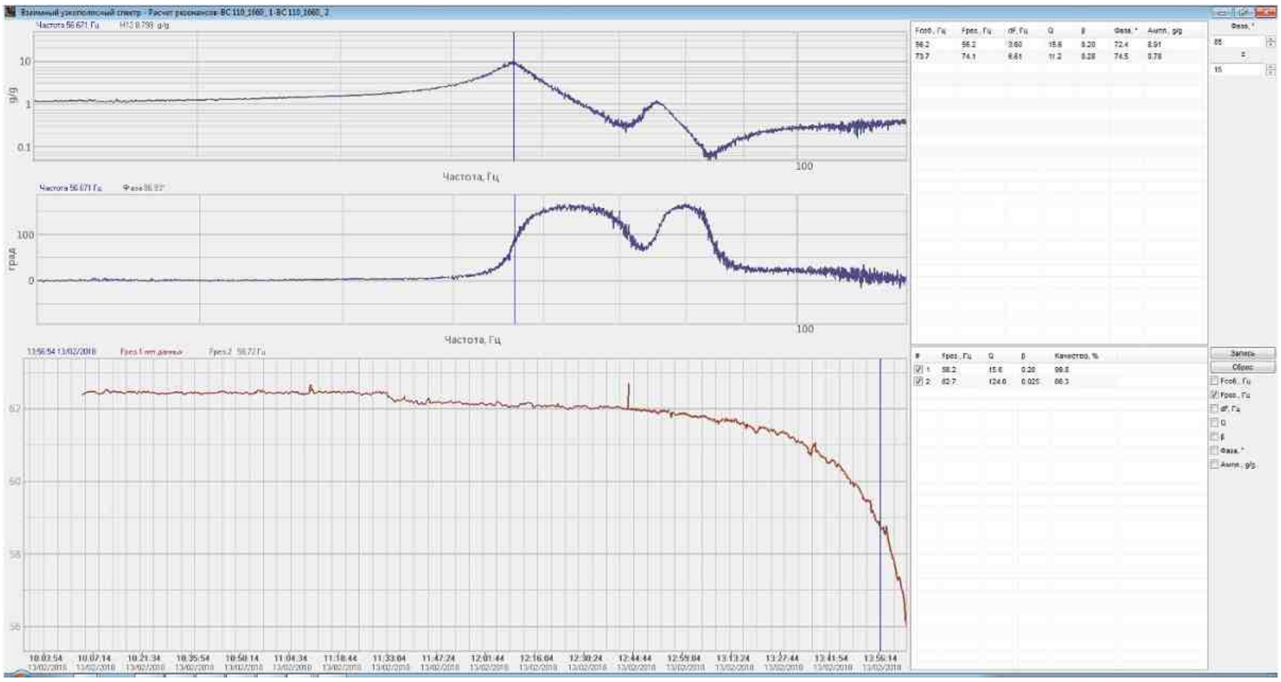
The dialog box is divided into five areas to display the parameters at the current time. In the upper part of the window there is a graphical display of the transient response, a graphical display of the phase, a log with fixed resonant frequencies and their corresponding parameters (natural frequency, resonant frequency, quality factor, decrement, phase and amplitude). The lower part of the window is intended for continuous recording, displaying a user-selected parameter (one or more) corresponding to the current resonant frequency, and tracking the dynamics of the behavior of the characteristics of the object under study. The displayed parameters are selected by checking the box next to the corresponding name. The following are available for graphical display: natural frequency of the object ($F_{ev.}$), resonant frequency ($F_{res.}$), quality factor (Q), decrement (β), phase and amplitude.



Using the ***Resonance analysis*** program, ZETLAB specialists reproduced one of the early laboratory experiments on estimating the frequency characteristics of systems with one degree of freedom, first performed by Barnosky according to the following scheme: a cantilever beam is fixed on the armature of the shaker in such a way that one edge of the beam is rigidly fixed in the center of the vibrating table and the other one is free. The control of the frequency characteristics of the beam is carried out using two accelerometers - one is located on the support and records the input action, the other registers the output signal at the free end of the beam. The input action is a band noise specified using the program from the ZETLAB software "Noise generator".



Estimates of the amplitude and phase characteristics are shown on the graphs at the top of the program window. As can be seen, the amplitude characteristic has a distinct peak at a frequency of 56 Hz, and the phase characteristic changes dramatically at the same frequency (characteristic graphs for physical systems with one degree of freedom). This indicates the first normal mode of the beam, which will be monitored.



The experiment showed that the *Resonance analysis* program is a simple and convenient way to determine the frequency characteristics, which allows you to obtain sufficiently meaningful results for the systems under study.

The graphic can be recorded in *.dtx format by activating the Recording button in the upper right corner of the dialog box.
Program

Cross-Spectrum FFT Analysis also includes:

- Phase (Phase response of the signal)
- Coefficient of coherence
- Transfer response
- Impulse response
- Measurement of intrinsic noise
- Measurement of weak signals
- Time delay
- Q -factor
- Resonance analysis
- Nyquist diagram

Nyquist diagram .....

Cross-Spectrum FFT Analysis

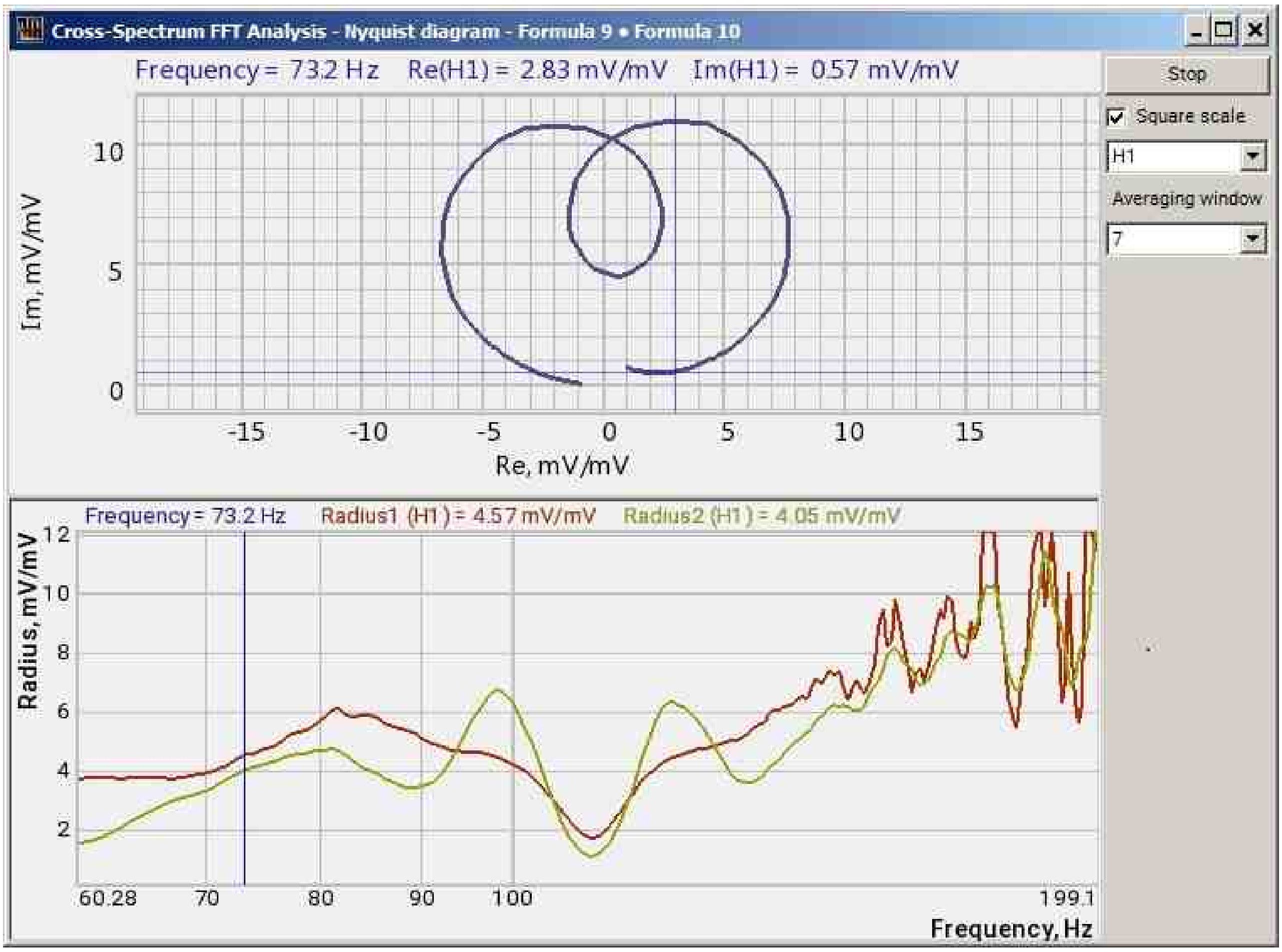
The ***Nyquist diagram*** is one of the additional features of the ***Cross-Spectrum FFT Analysis*** program, which allows you to judge the stability of the system by the amplitude-phase frequency response (APFR) of the open loop of the system. By stability it is customary to understand the property of a system to restore the status of equilibrium from which it was brought out under the influence of perturbing factors after the termination of their influence.

To activate the dialog box of the ***Nyquist diagram*** program, in the ***Cross-Spectrum FFT Analysis*** program window open ***Cross-Spectrum FFT analysis settings*** by clicking the ***Parameters*** button. In the ***Additional windows*** field, set the flag opposite the ***Nyquist diagram*** line in the ***Additional window*** column. graphic. and activate the *Apply* button.

.

The amplitude-phase frequency response is a convenient representation of the frequency response of a linear stationary dynamic system as a graph in complex coordinates. This graph combines the amplitude-frequency and phase-frequency characteristics on the same plane.

The ***Nyquist diagram*** program allows you to display the AFC in various coordinate systems, for an understandable presentation of the system behavior to each user.



The most common use of the ***Nyquist diagram*** is to evaluate the stability of a feedback system. The advantage of this type of analysis is that the diagram can be built on the basis of steady status measurements. This is the only applicable method in cases where the open-loop transfer function is not specified explicitly or is defined by an asymptotic curve.

Program

Cross-Spectrum FFT Analysis also includes:

- Phase (Phase response of the signal)
- Coefficient of coherence
- Transfer response
- Impulse response
- Measurement of intrinsic noise
- Measurement of weak signals
- Time delay
- Q -factor
- Resonance analysis
- Nyquist diagram

Cross-FFT Spectrum settings .....

The key "**Parameters**" is located in the top right section of the "**Cross-Spectrum FFT Analysis**" program. Upon activation of the key "Parameters" or after right-clicking the main program window there appears the "**Cross-Spectrum FFT Analysis settings**" window (see *Fig. 3.2*).

The window "**Cross-Spectrum FFT Analysis settings**" can be also activated with "Esc" key when the **Cross-FFT Spectrum** window is active.

In the top section of the window, you can see the sampling frequency, Hz.

In the menus with drop-down lists, it is possible to select the necessary value in two ways: click the necessary element of the drop-down list or select it with the scroll key.

The list below the line "**Frequency range, Hz**" is used for displaying the signal in various frequency ranges.

The list below the line "**Frequency resolution, Hz**" is used for setting the necessary frequency resolution, Hz.

The list below the line "**Measurement channel 1**" and "**Measurement channel 2**" is used for selection of modulus channels. For calculation of the cross-spectrum it is necessary to select two different channels.

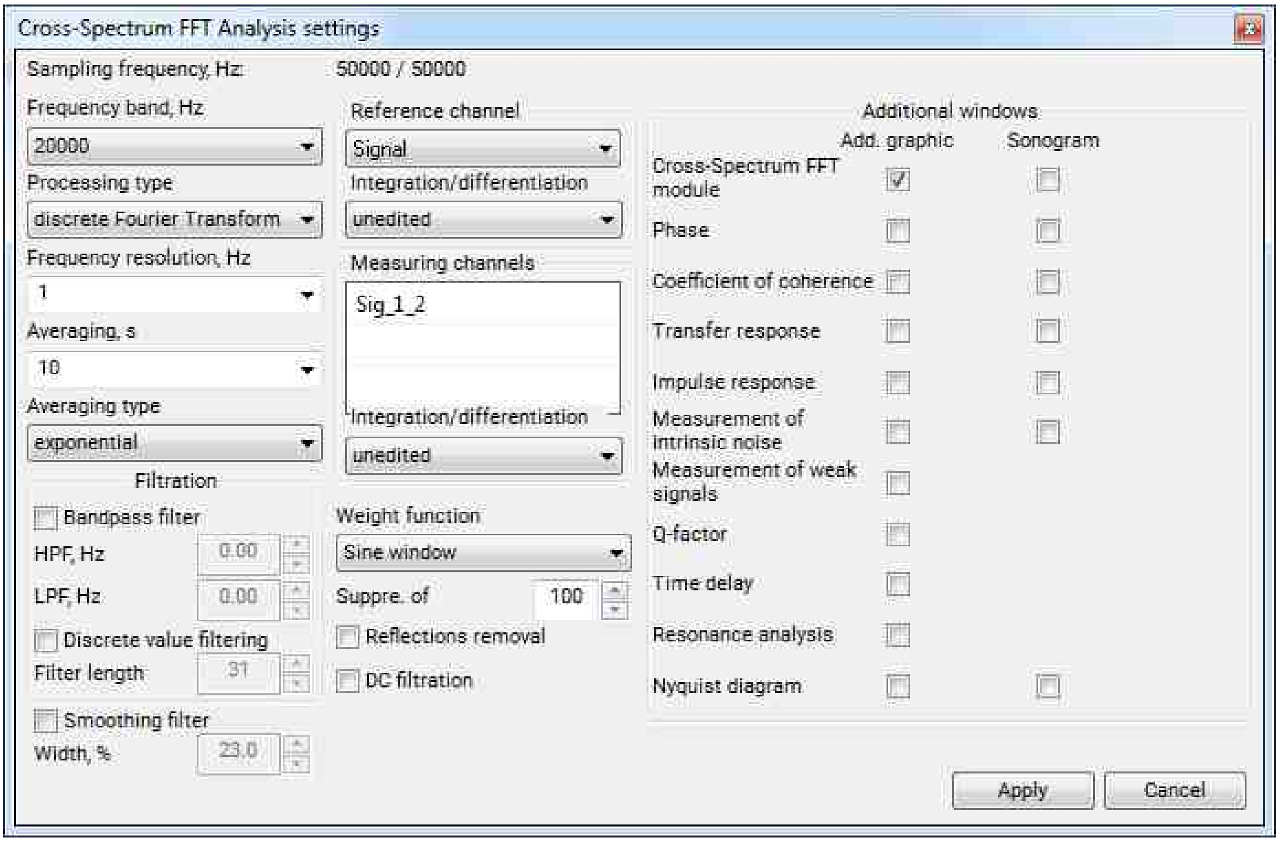


Fig. 3.2

The list below the line "**Averaging, s**" is used for setting spectra averaging duration in seconds. The averaging values can be selected from the list or be entered from the keyboard. The maximum averaging value is 100 s, the minimum possible – 0,1 s.

The list below the line "**Weight function**" allows to select the type of the weighting function to be used for spectral analysis. The list shows possible types of the weighting functions:

rectangular;

- Hann;
- Hanning;
- Hamming;
- Blackman;
- Bartlett;

- Kaiser;
- Reef-Vincent (4);
- Blackman-Harris (3);
- Blackman-Harris (4);
- Natalla;
- Blackman-Natalla;
- A window with flat top;
- Window-sine

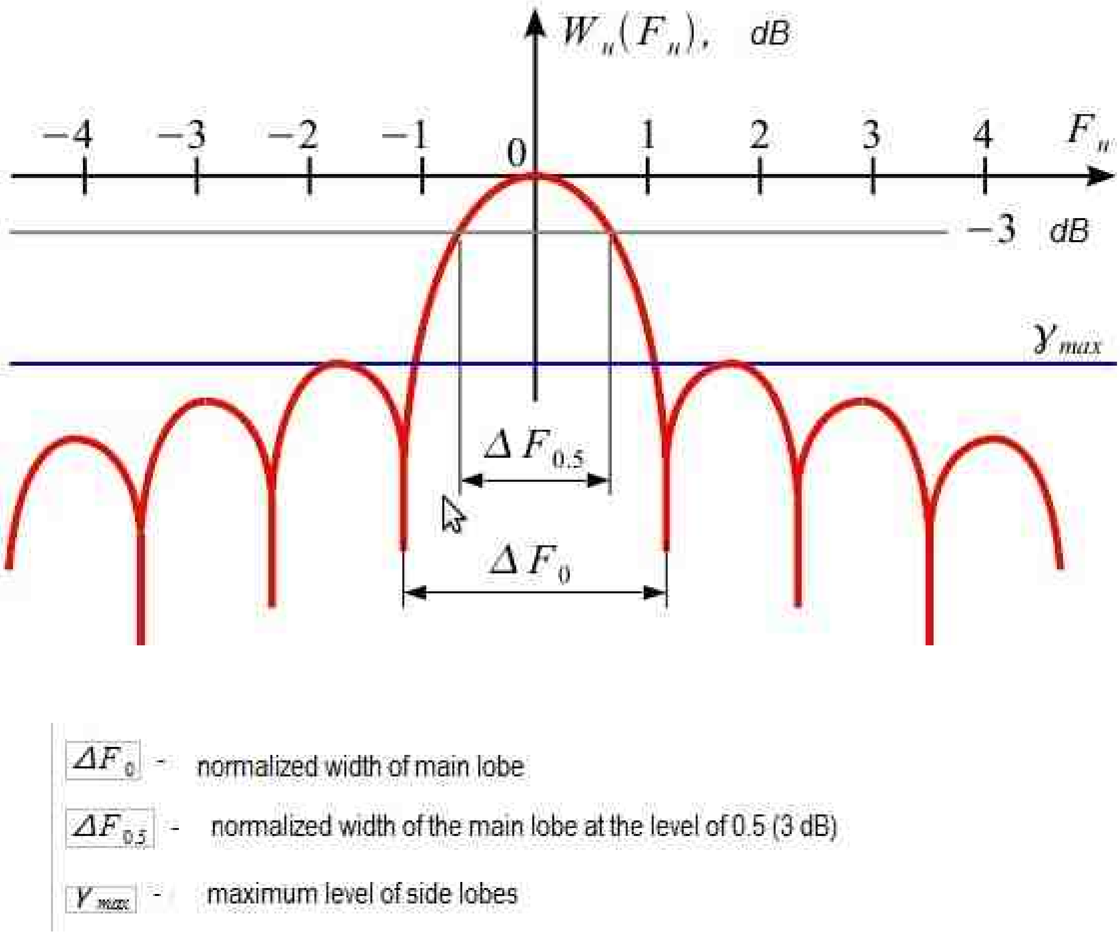


Fig. 1. Normalized FR characteristics of the window function

The basic parameters of the weighting functions are shown in the table below:

Weighting function name	Admissible deviation of average filter frequency 1000 Hz, %	Equivalent noise band, Hz	Band by level 3 dB,	Deviation of filter band width, Hz

			Hz	
Rectangular	1,00	0,89	-13	Rectangular
Hann	2,00	1,50	-31,5	Hann
Hamming	2,00	1,33	-42	Hamming
Blackmann	3,00	1,70	-58	Blackmann
Bartlett	2,00	1,33	-26,5	Bartlett
Kaiser	1,50	1,43	-45,9	Kaiser
Reef-Vincent	-	-	-84	Reef-Vincent
Blackman-Harris	4,00	1,97	-92	Blackman-Harris
Natalla	4,00	1,98	-93	Natalla
Balckman-Natalla	4,00	1,94	-98	Balckman-Natalla
A window with flat top	5,00	3,86	-69	A window with flat top

The list below the title "**Averaging type**" allows to select the mode of spectra accumulation and averaging (i.e. the averaging type): linear or exponential.

The list below the title "**Integration/differentiation**" allows to select the signal processing type: differentiation, double differentiation, unedited, integration, double integration. These options may prove to be useful for operations with velocity and acceleration transducers.

The field under the title "**Processing type**" is used for activation of fast or discrete Fourier transform.

The Cross-Spectrum FFT Analysis is calculated by means of Fourier transform with the use of weight functions.

By discrete Fourier transform there are meant two biunique transforms:

direct transform

$$X(k)=\sum_{n=0}^{N-1}x(n)e^{-j\frac{2\pi}{N}nk}$$, k = 0, 1, …, N-1;

reverse transform

$$x(n)=\frac{1}{N}\sum_{k=0}^{N-1}X(k)e^{j\frac{2\pi}{N}nk}$$, n = 0, 1, …, N-1.

where:

x(n), n=0, 1, …, N-1 – sequence in time domain (material or complex);

X(k), k=0, 1, …, N-1 – discrete Fourier ratios (material or complex) – a single sequential period in frequency domain;

k – sequence counting number X(k), corresponding to the frequency $k\Delta\omega$;

$e^{-j\frac{2\pi}{N}nk}$ - twiddle factor showing the rotation angle at a circle unit of a complex Z-plane.

By the Fast Fourier transform there is meant a set of algorithms intended for fast calculation of the Discrete Fourier transform. For the Fast Fourier transform the length N of the source sequence should be equal to N=2v, where v – is an integer positive number.

The number of filters in the narrow-band analysis can be equal to 2n or (1, 2, 4, 5, 8)*10n. The central frequencies of the narrow-band filters are calculated as follows:

$fm = f_{sample} m/N/2$

where f_{sample} – is the sampling frequency, m – the number of filter, N – the number of analysis bands.

The field under the line "**Comments for record**" is used for any necessary information. This information will be represented as a comment in the file with the signal processing results. .
The checkboxes below the menu "Additional windows" are used for a more detailed analysis of the signal spectrum. The additional windows are used for analysis of the following signal characteristics: actual and virtual signal components, phase, coherence ratio, Nyquist diagram.

The set of sequentially accumulated spectra is available for viewing as a spectrogram. The checkboxes under the "**Spectrograms**" menu are used for displaying of module, real part, imaginary part and coherence ratio spectrograms.

The key "**Apply**" is used for entering the data to the program and for closing the settings window.

The key "**Cancel**" is used to cancel the parameters configuration and to close the settings window. The parameters setting window can also be closed using the key in the top right section of the window.

Recording results to a file .....

The program ***Cross-Spectrum FFT Analysis*** allows to record the instant values of the displayed spectrum to a text file with *.dtx extension. When you click The Recording button in the program window of the ***Cross-Spectrum FFT Analysis,*** there appears a standard dialog box offering you to specify a directory to save the file and the file name. The directory by default is – C:\ZETLab\result.

Note:

When using Excel for opening the dtx file (these files have UTF-8 format), make sure that the right file format (UTF-8) and the separator (tab) are selected. The default settings for opening the file seem to have other parameters.

An example file is shown in the Fig. below.

```
vspectr_2.dtx — Блокнот
Файл Правка Формат Вид Справка
<?xml version="1.0"?><Config version="1"><MaxNumber>240</MaxNumber>	<MaxTextLengthInByte>200</MaxTextLengthInByte>
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<mouse_x>25</mouse_x>	<mouse_y>30</mouse_y>	<timer>0</timer>	<update>0</update> <spectr>1</spectr>	<osc>0</osc>
<font_size>12</font_size>	<make_upor>0</make_upor>	<number>1</number>	<ind>0</ind>	<num_visible_points>-
1</num_visible_points>	<position_of_cursor>11</position_of_cursor>	<size>1251</size>	<GridDimensions left_x="75" right_x="0"
top_y="18" bottom_y="32" width_x="608" height_y="306" />	<GridSetup type_line="0" type_abs="0" type_x_axis="1" type_y_axis="1"
type_y_data="0" log="0" alt_lin="0" show_scale_prop_page="1" alt_coords="0" power_coeff="0" />	<GridMathData
math_width_x="2.0038814616530716" math_width_y="3.4088602066040039" math_min_x="1" math_min_y="-9.2850253582000732"
upor_delta="9.9999999999999995e-007" upor_down="-100000000" upor_up="100000000" x_first="0" x_end="1250"
reference="9.9999999999999995e-007" />	<GridColors cursor_color="16711680" digits_color="5921370" fon_color="15790320"
grid_color="12632256" legend_color="12591136" />	<GridText frm1="Frequency = %.0f Hz" caption="" text_x_axis="Frequency, Hz" font_name="MS
Shell Dlg" />	<GraphSettings>	<Graph number="0" type_grf="0" type_fill="1" valid="1" line_width="2" graph_axis="0"
frm2="Level (RMS) = %.3g мВ×мВ" graph_text="сигнал 0" graph_color="8802382" />	</GraphSettings>	<AxisInfo>	<Axis number="0"
Side="0" UseAxis="1" Multiplicative="1" Additive="0" Color="12632256" Text="Level (RMS), мВ×мВ" />	</AxisInfo>
<AdditionalWindows />	<Comments>	<Comment_1></Comment_1>	<Comment_2></Comment_2>
<Comment_3></Comment_3>	<Comment_4></Comment_4>	<Comment_5></Comment_5>
<Comment_6></Comment_6>	<Comment_7></Comment_7>	<Comment_8></Comment_8>
<Comment_9></Comment_9>	</Comments></Config>
Frequency =	Level (RMS) =
Hz	мВ×мВ
0,000000	7,78429
1,000000	5,93009e-007
2,000000	6,93809e-007
3,000000	3,66324e-007
4,000000	4,44249e-007
5,000000	3,96301e-007
```


Results file recorded with the program "Cross-Spectrum FFT Analysis"

Examples for the section .....

Contents

Method for determining the tensile force in cable-stayed .....

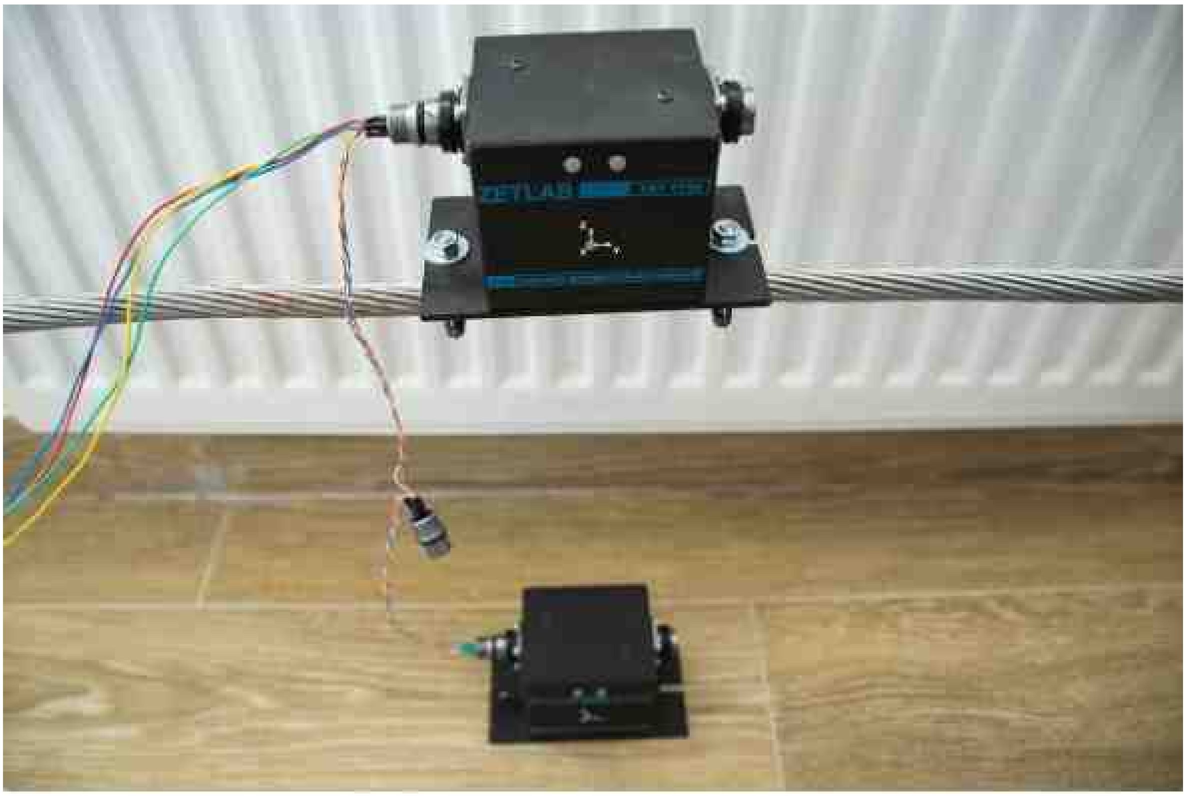
Example Method for determining the tension force in the cable-stayed

Cable-stayed structures have become widespread in construction today due to their advantages:

- economic efficiency;
- high reliability;
- low material consumption during construction;
- designing complex engineering solutions;
- organization of flexible building layout, etc.

Due to the fact that the cable-stayed structures are assembled from individual elements, the pre-tension of each element is carried out individually during installation. At the same time, it is necessary to ensure a symmetrical distribution of efforts. But how to understand how great is the tension force of the cable-stayed element?

This article describes a method for determining the tension force of a cable-stayed element through its own vibrations of the structure.



The proposed method for determining the tension force of a cable-stayed element consists in analyzing the frequency characteristics of the Cross-Spectrum of two vibration sensors and then calculating the longitudinal force according to known formulas.

A low—frequency vibrometer is installed on the structure - in our experiment we used Digital sensor ZET 7156, another ZET 7156 vibrometer is installed on the foundation base.

The measurement of natural oscillation frequencies is performed in the program "Cross-Spectrum FFT Analysis":

As a reference channel, a signal from a low-frequency vibration transducer installed on the foundation is installed, the measuring channel is a sensor installed on the structure.

For a more accurate calculation, it is recommended to set a sufficiently long averaging time in the program settings.

The calculation and display of natural vibration frequencies of the cable-stayed element is carried out in the program [Resonance analysis"](), therefore, in the parameter settings window, you need to activate this function by setting the flag next to the corresponding option.

The program will calculate and display in graphical and tabular form all the available resonant frequencies of the cable-stayed element, as well as their contribution to the energy of the overall resonance of the system. When the cursor is set to a certain frequency, a series will be displayed on the graphic showing the presence of harmonics of the selected frequency.

According to the regulatory documentation for the design of hanging (cable-stayed) structures, it is necessary to fix at least three times the natural vibration frequencies of the cable-stayed element, and determine for each of the first three times the fixed frequencies the tension force of the cable-stayed element according to the formula:

$$Nn = ((m + M/Lp)\ \text{Ч}\ (2Lpfn)2)/n2,$$

where N — longitudinal force in the cable-stayed element, N;

m — linear mass of the cable-stayed element, kg/m;

M — weight of anti-vandal shell, kg;

fn — own frequency of oscillations of the cable-stayed element, Hz;

n — ordinal number of the form of vibrations of the cable-stayed element;

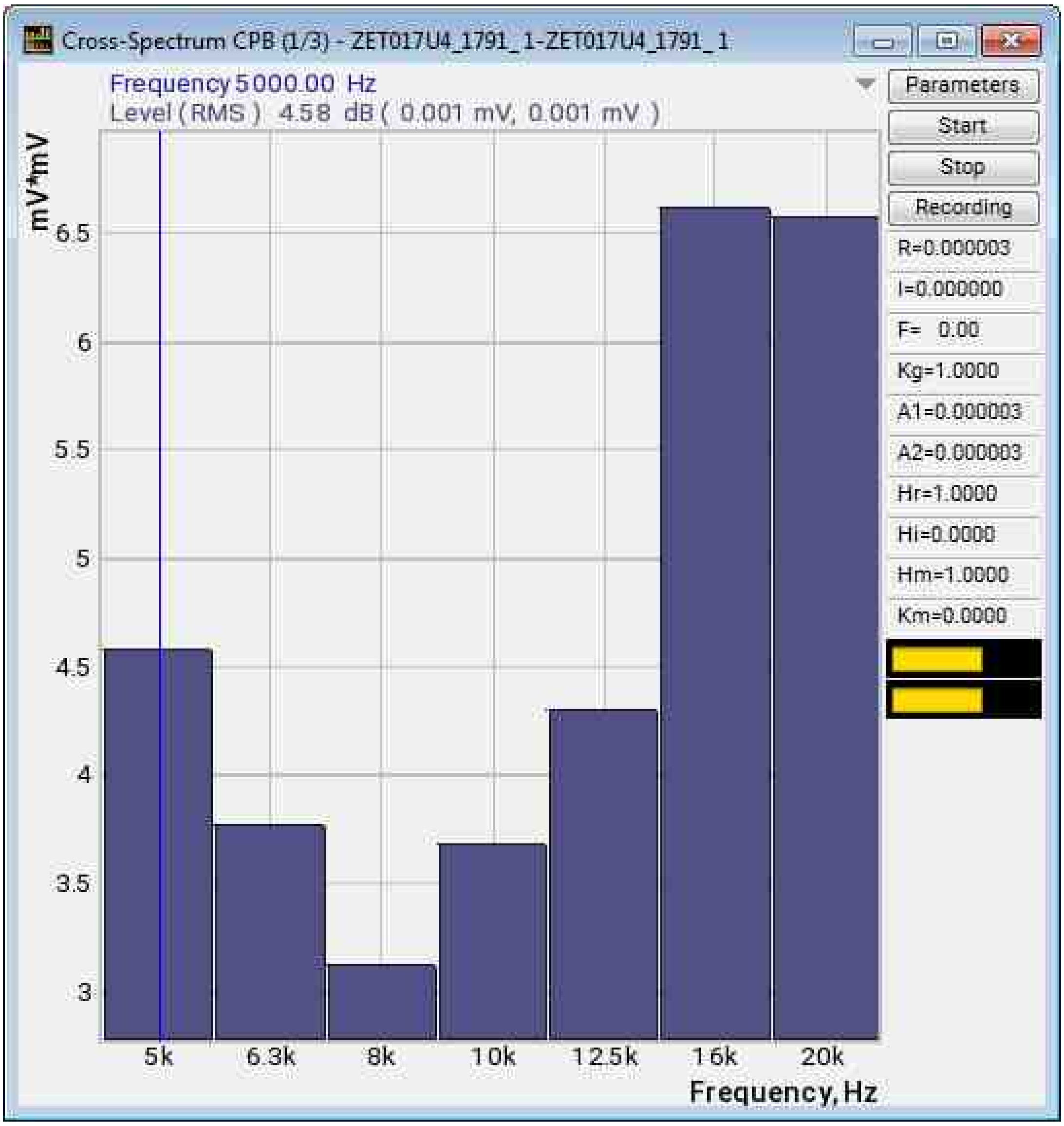
Lp — estimated length of the cable-stayed element, m, equal to the sum of the lengths of the cable-stayed element itself and the estimated length of the anchor device.

The tension force of the cable-stayed element is judged by the average value of the values obtained.

Cross-Spectrum CPB (Constant Percentage Bandwidth) Analysis .....

The program is intended for cross fractional-octave (1/1-, 1/3-, 1/12- and 1/24-octave) analysis of the signal received from the input channels of the FFT Spectrum Analyzers (in real-time or post-processing mode) as well as for analysis of signal's various spectral characteristics.

The program has an integrated control and automation module from the scope of ZETLab-Studio software package. The module enables easy creation of individual software measurement suites.



Main Software Features

- measurement of signal level in octave, 1/3-, 1/12-, 1/24-octave spectral bands. The number of bands: 17, 51, 204, 406 respectively. General technical requirements and methods of testing" for the first accuracy class. Octave-band and fractional-octave-band filters. Technical requirements and test methods";
- measurement and display of signal's fractional octave characteristics with various averaging types (linear, exponential), processing (integration, differentiation) and display (RMS or peak) options;
- measurement and display of signal's valid and virtual parts, phase difference and coherence ratio;
- measurement and display of cross-spectrum module;
- measurement of complex frequency response and coherent power of the spectral component.

Supported Hardware .....

Input data program **Cross-Spectrum CPB (Constant Percentage Bandwidth) Analysis** are digital data channel server **ZETLAB**, which are output signals of the sensors of linear and angular displacements.

For the purpose of analog signals digital processing, it is possible to use *FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01* and *seismic recorder ZET 048*.

Settings of measurement channels are specified in the program "Device Manager".

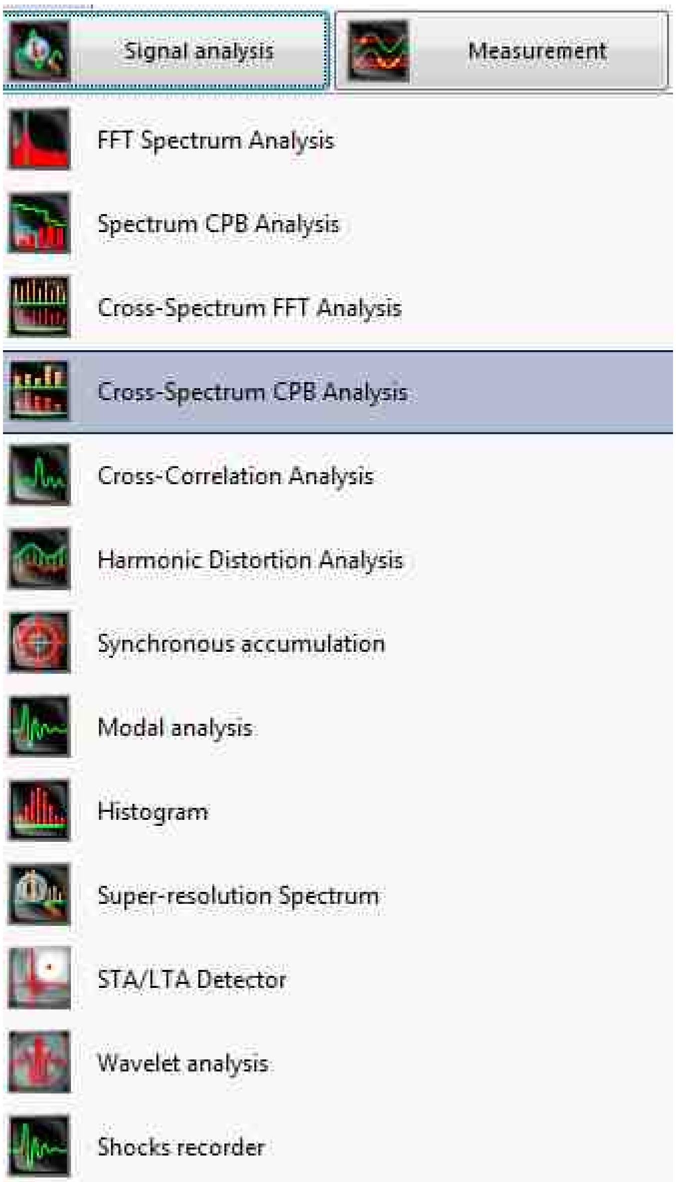
The software **Cross-Spectrum CPB (Constant Percentage Bandwidth) Analysis** is included with the following software:

- ZETLAB ANALIZ – FFT Spectrum software
- ZETLAB VIBRO – Shaker controllers systems software
- ZETLAB SEISMO - seismic station software,

Cross-spectrum CPB analysis is included in the **Signal analysis** software group.

Program description .....

To start the "**Cross-Spectrum CPB**" program, select the corresponding program in the "Signal analysis" menu of ZETLAB panel. You will see the main window of the program "**Cross-Spectrum CPB**" (Fig. 2). The title of the program displays program name. Below you can see oscilloscope graphics (time realizations) of the signals from selected channels. Below each oscilloscope graphic there is a name of the selected channels and the measurement units (time in seconds and amplitude in corresponding measurement units) in relation to the position of graphic cursor.



Starting the "Cross-spectrum CPB analysis"

Note: the program "**Cross-Spectrum CPB**" can be started from ZETLAB directory (by default: c:\ZETLab\). The name of the file: dvspectr.exe.exe. The instant cross-spectrum is calculated by multiplying the spectra of two channels (the spectra values are obtained based on Fourier transform).

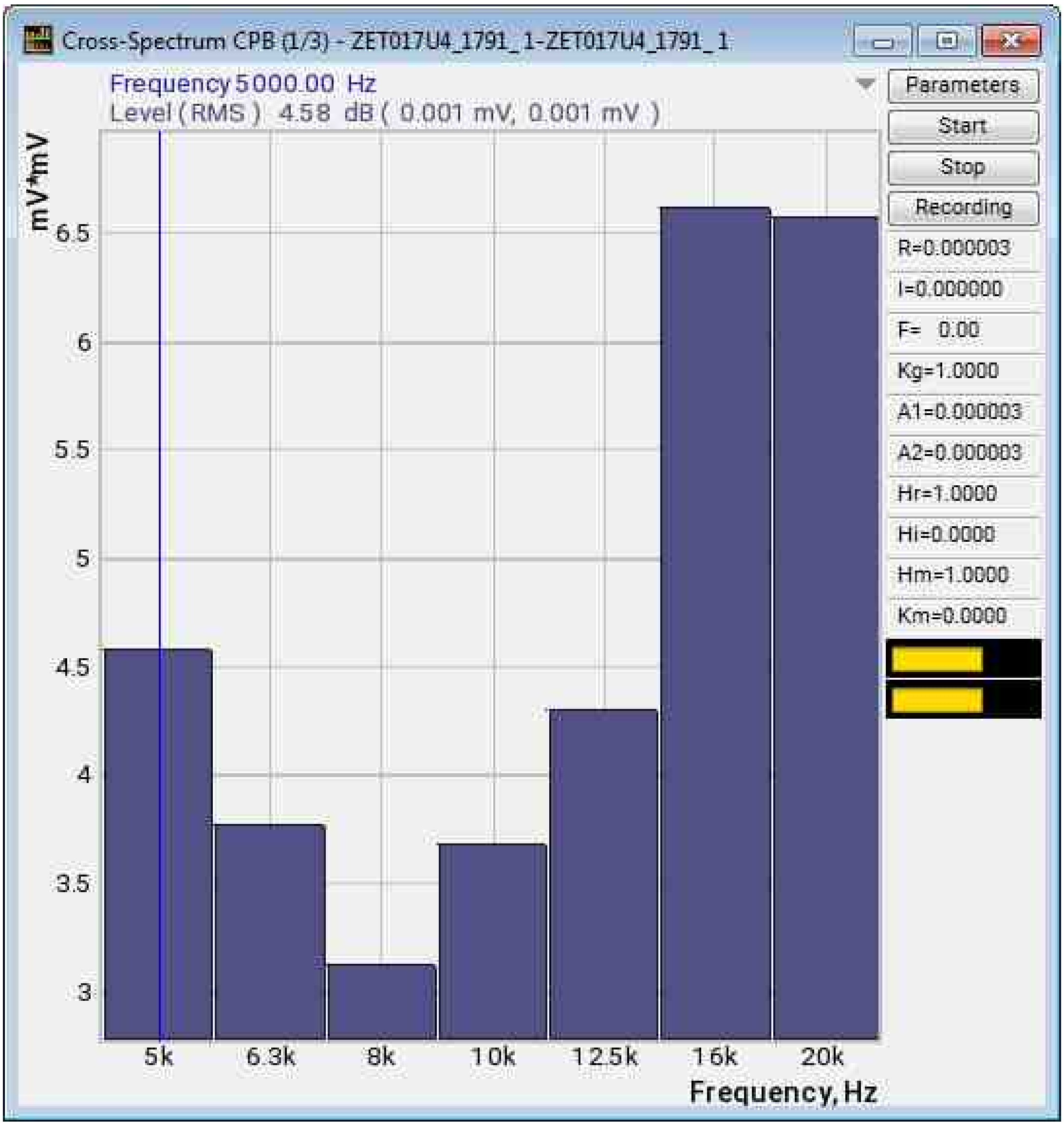


Fig. 2

The title of the window shows the name of the spectrum and the names of the displayed channels. Below you can see the measured parameters (frequency, signal level (RMS)), cursor values and measurement units.

"Cross-Spectrum CPB" program: control

"**Parameters**" key allows to activate the window "**Cross-Spectrum CPB setting**".

The "**Start**" key is used to display the signal. Upon activation of the program "Harmonic Distortion Analysis", the "Start" key is active by default.

The "**Stop**" key allows to suspend both signal displaying process and data update. However, the server continues data accumulation process and all other programs continue their operation.
The "**Recording**" key activates a standard dialog window "Recording the results in a file", allowing the user to select the file name as well as to assign the directory for saving the file (directory by default - C:\ZetLab\result\). The file is saved with *.dtx extension. The file contains information description, data in floating point format (a point is used for separation between fractional and integer numbers).
The indicator depicts integral level of the signal and overloading. In the case, if the signal exceeds the maximal acceptable level, the indicator turns completely red without any black section at the right part. The right section of the indicator will remain red until the user left-clicks it.

In order to exit the program "**Cross-Spectrum CPB**", click the corresponding key in the top right section of the program interface.

See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Setting parameters of display
- Using signal level indicators
- Adjustment of the color scheme used for displaying of the registered signal amplitude values
- Graphical and numerical data transfer to text editors
- Setting GridGl grid functionality

Program settings .....

The key [**Parameters**] is located in the top right section of the program interface. The [**Parameters**] key or right-clicking the program interface are used to activate the configuration window (*Fig. 2.2*). This window can be also activated with <Esc> key when the program "**Cross-Spectrum CPB**" is active.

The top section depicts sampling frequency value (in Hz).

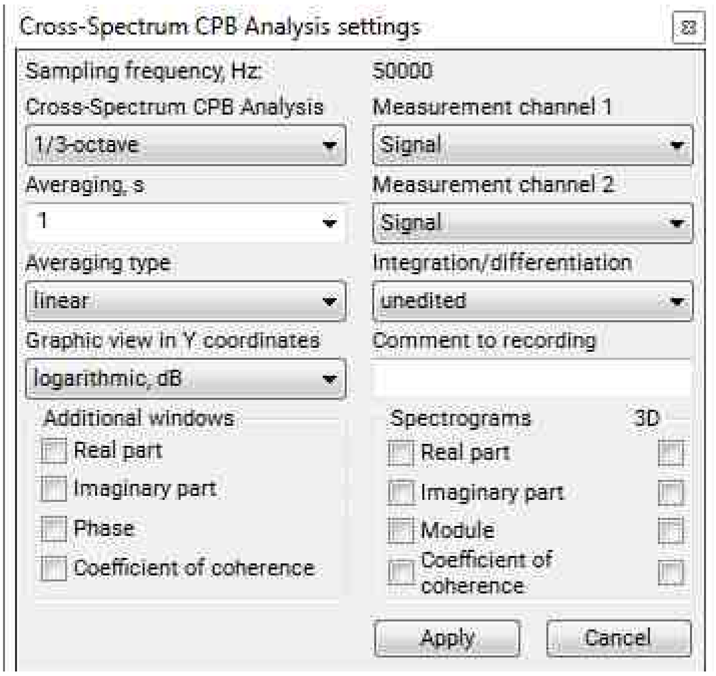


Fig. 2.2 Cross-Spectrum SPB Analysis settings

There are two ways of selecting values in the fields with drop-down lists  Click at the drop down list, select the required element from the appearing list, or use the scroll wheel to select it.

The list under the line [**Cross-Spectrum CPB Analysis**] allows to select various types of cross-spectrum analysis: octave, 1/3-octave, 1/12- and 1/24-octave.

The list under the line [**Averaging, s**] allows to set spectra averaging duration. The duration value can be selected from the drop-down list or be selected from the keyboard. Maximal averaging value is 100 seconds, minimal – 0,1 second.

The list under the line [**Channel measurement 1**] is used for selecting the module's channel. For cross-spectrum calculation, it is necessary to select two different channels.

The list under the line [**Channel measurement 2**] is used for selecting the module's channel. For cross-spectrum calculation, it is necessary to select two different channels.

The list under the line [**Averaging type**] allows to select the accumulation mode and spectra averaging type (linear or exponential).

The list under the line [**Integration / differentiation**] allows to select signal processing type: double differentiation, differentiation, unedited, integration, double integration. These functions are useful for various operations with velocity and acceleration transducers.

The menu under the section [**Graphic view in Y coordinates**] activates logarithmic scale (in dB, in relation to the reference value used for calculations) or linear scale (in measuring units) of the spectrum representation. The reference value for calculations in dB is set in the program "Editing file parameters".

The field under the menu [**Comments for record**] is used for entering relevant information. It will be added to the signal processing results file as a text comment.

The checkboxes under the heading [**Additional windows**] enable performance of spectrum's comprehensive analysis (its Real and Imaginary part, Phase, Coefficient of coherence).

It is possible to view the subsequently accumulated spectra as a spectrogram. The checkboxes under the line [**Spectrograms**] allow to display signal's Real part, Imaginary part, Module and Coefficient of coherence.

The [**3-D**] checkbox is used to enable 3-dimensional representation of signal's time-frequency distribution.

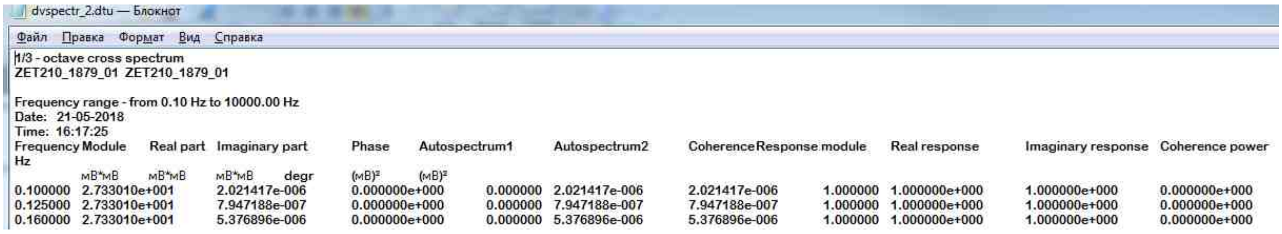
Recording results to a file .....

The program **Cross-Spectrum CPB *a*nalysis** allows to record the instant values of the displayed spectrum to a text file with *.dtu extension. When you click The Recording button in the program window of the **Cross-Spectrum CPB Analysis,** there appears a standard dialog box offering you to specify a directory to save the file and the file name. The directory by default is – C:\ZETLab\result.

Note:

When using Excel for opening the dtu file (these files have UTF-8 format), make sure that the right file format (UTF-8) and the separator (tab) are selected. The default settings for opening the file seem to have other parameters.

An example file is shown in the Fig. below.



Results file recorded with the program " Cross-spectrum CPB analysis"

Cross-Correlation Analysis .....

The program is intended for **Cross-Correlation Analysis** of the signals received from the input channels of the FFT Spectrum Analyzers in real-time or post-processing mode as well as for the analysis of various correlational characteristics of the signals.

Correlation analysis is represented by a set of analytical methods used for the analysis of correlational dependence between two factors (these analytical methods are based on various mathematical theories).

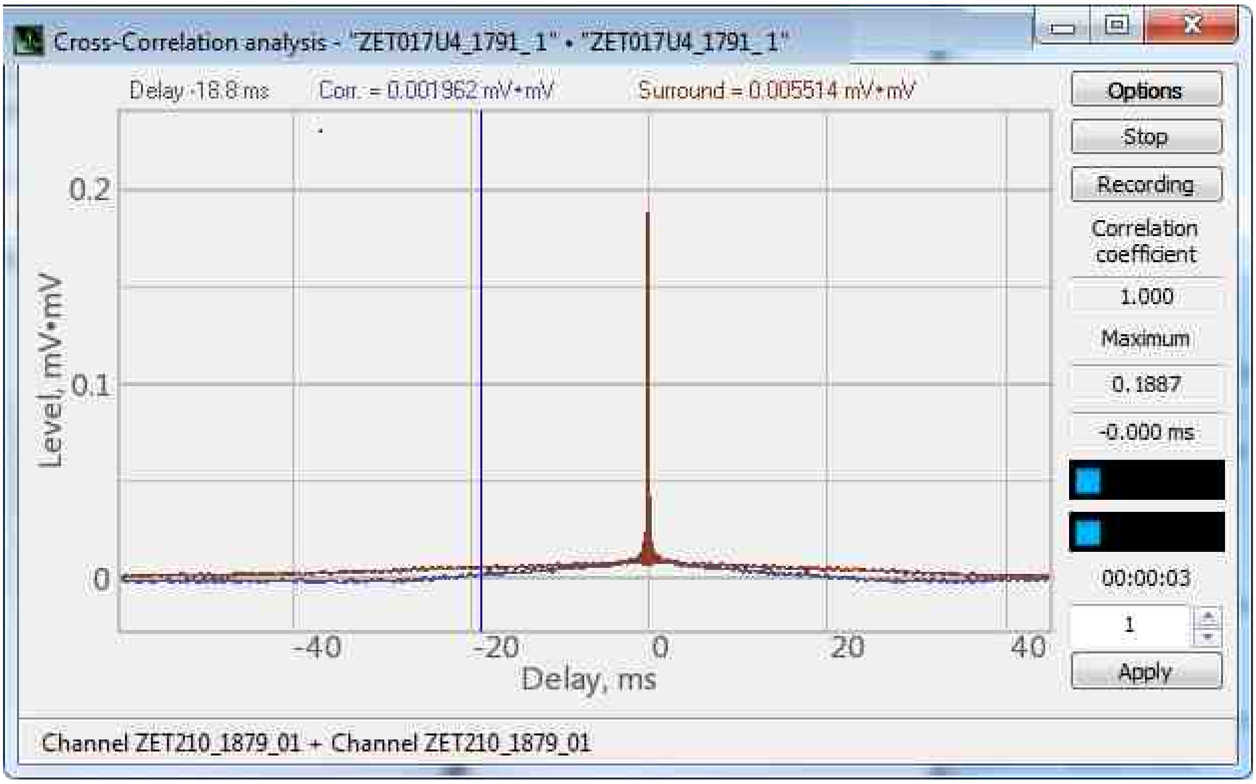
Correlation analysis of signals in two or more control points is implemented for a number of diagnostics purposes. The cross-correlation function is shown below:

$$R_{x_1 x_2} = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \mathbf{x}_1(t)\,\mathbf{x}_2(t+\tau)\,p\{\mathbf{x}_1(t)\,\mathbf{x}_2(t+\tau),t,\tau\}d\,\mathbf{x}_1(t)\,d\,\mathbf{x}_2(t+\tau)$$

where $\mathbf{x}_1(t)\ \mathbf{x}_2(t+\tau)$ - stands for signal values in various points at different periods of time.

The correlation function for two independent signals is 0. However, in the case if there is a common periodical or stationary component, the correlation function value is determined by the rate of this component and by the shift of these two signals between the control points.

Cross-Correlation Analysis is often used for detecting a weak signal against strong static independent interferences as well as for localization of their source coordinates based on the time shift value. It allows to detect both narrow-band and Random signals. Thus, this analysis is effectively used for pipelines leak detection (based on the noise occurring at the leak area and propagating in the flow of gas or liquid).



However, it should be noted, that for the task of leak detection the spectral analysis methods are used much more often that the correlation methods. It is attributed to the fact that the spectral analysis of stationary processes normally allows to obtain more data (see the causes "**Cross-Spectrum FFT Analysis**" and "**Cross spectrum octave**"). Nevertheless, the Cross-Correlation Analysis proves to be more effective for detection of non-stationary and impulse processes and can be used for detection and localization of acoustic emission sources in homogenous loaded metal structures.

Integrated control and automation module from the scope of ZETLab Studio can be used for the creation of software measurement systems.

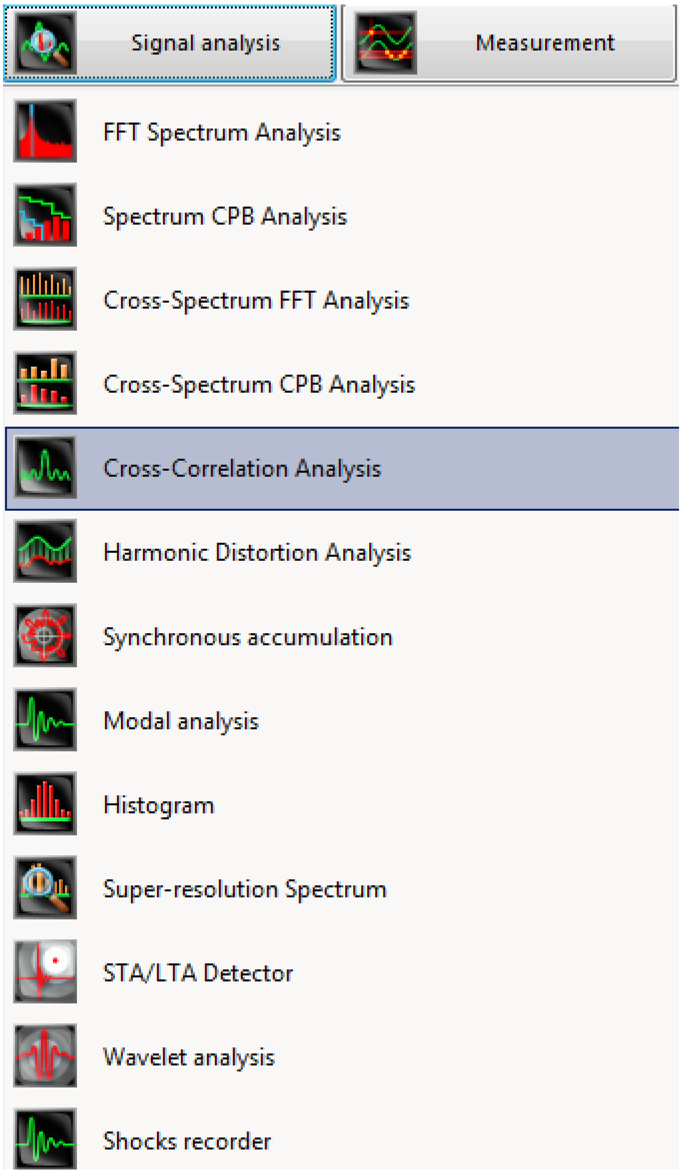
Basic functions and parameters of the program:

- frequency analysis range: 0...1, 0...10, 0...100, 0...1 000, 0...10 000 Hz;
- analysis duration: from 5 ms up to 10,5 s;
- averaging time: from 0,1 up to 10 s;
- Cross-Correlation Analysis in various frequency ranges;
- digital filtration of the signals;

- measurement and displaying of maximum and average values graphics and the envelope graphs;
- measurement and display of 2-/3-dimensional correlation graphs;
- calculation of distance based on signal delay value;
- saving program settings for the subsequent program start.
- new types of the results (+ update of the corresponding SCADA-components):
  - correlation coefficient;
  - noise suppression;
  - noise suppression by channel 2;
- two types of averaging - linear and exponential;
- optional use of time window in the course of calculations;
- selection of filter length for removal of discrete components from the results obtained.

Cross-Correlation Analysis – new functions.

The new version of the program "**Cross-Correlation Analysis**" has a function of calculating both cross-correlational function and likelihood function, as well as normalized and differential correlation functions. The normalized correlation function NC x, y of the signals x (t) and y (t) and differential correlation function SC x of the same signals is calculated by the formula:



Starting the "Cross-Correlation Analysis"

where : XC - is the Cross-Correlation function;;

AC - auto-correlation function with a time delay equal to the delay of the cross-correlation function peak value.

From the definitions of these functions it follows that if y(t) is the delayed function x(t), then $NC_{x,y} \equiv 1$ and $SC_{x, y} \equiv 0$.

These features represent additional functions for signal source detection, which can be useful for various leak detection systems, e.g., for pipelines leak detection.

The 2-D correlation graphic has a function of displaying Additional graphics: correlation graphic cross-section in time domain and by time delay, i.e. the graphics of:

- cross-correlation function dependence on time at a particular time delay value;

- dependence of the Cross-Correlation function value on the delay time at a particular time moment of the correlation graphic.

New program version has a multi-channel function, i.e. it is possible to calculate several correlation functions in a single program window. The number of correlation functions is to be set in the program by means of additional control elements of the main program window – see *Fig. 1*.

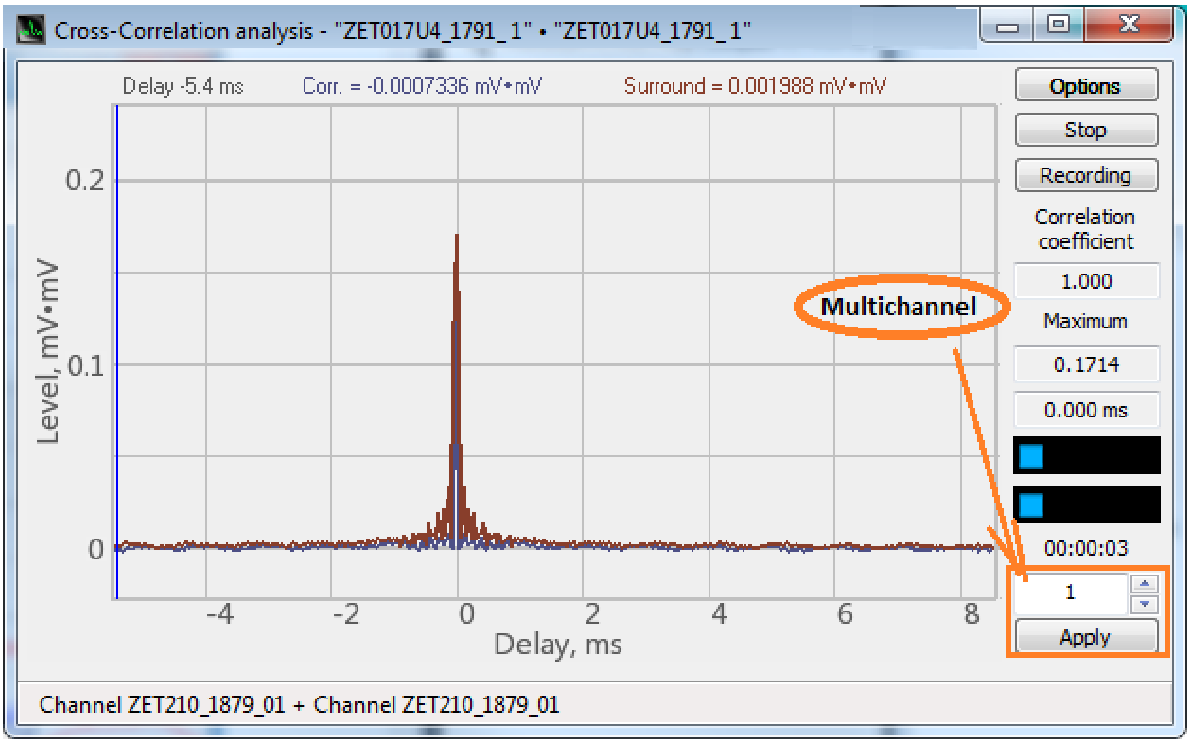


Fig. 1 – Main window of the program. The elements used for setting the number of the correlation functions are underlined with red.

Additional windows of 2- and 3-dimensional correlation functions are not depicted in the multichannel operation mode of the program. In these window the displayed parameters values shall not exceed those of the current correlation function. The current correlator has value 1, however, it is possible to assign a different value – see *Fig. 2*.

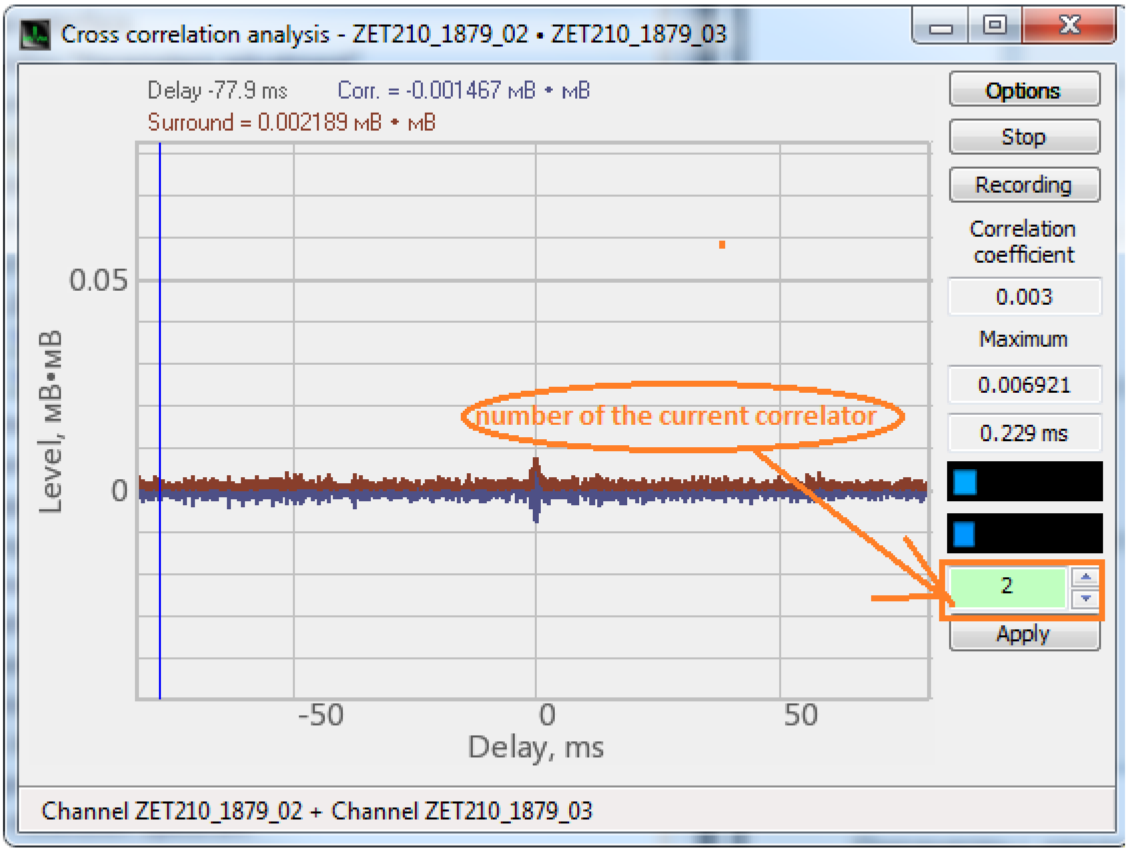


Fig. 2. Main program window – correlator selection – no channels assigned.

Thee Correlation parameters can be individual or common. As the number of correlators is increased, the new correlators are not active since there are no channels assigned for them. The "Parameters" key becomes red (see *Fig. 2*), which means that it is necessary to set the parameters for the correlator operation. Click the "Parameters" key – you will see a window similar to that shown in *Fig. 3*.

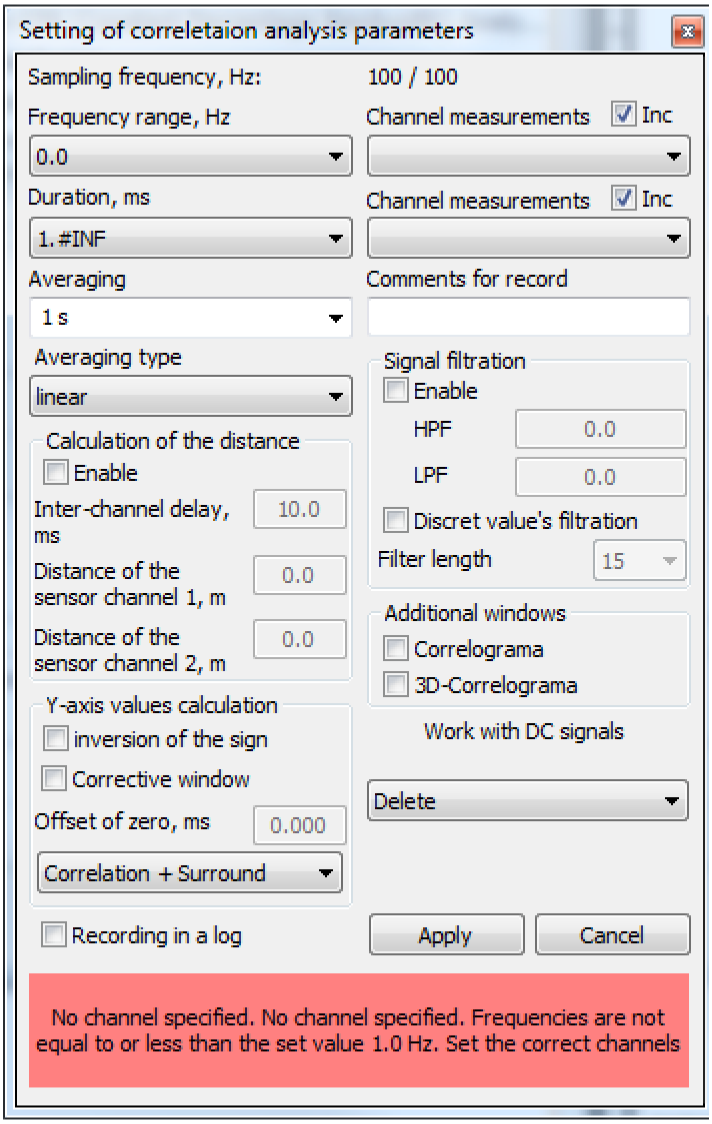


Fig. 3. Parameters window: the channels parameters are not set properly

As you can see from Fig. 3, the bottom part of "Parameters" window contains a notification of wrong parameters on a red background (the red background informs the user of program operation failure).

If a wrong value is set for a particular parameter, there appears a notification on yellow background (Fig. 4).

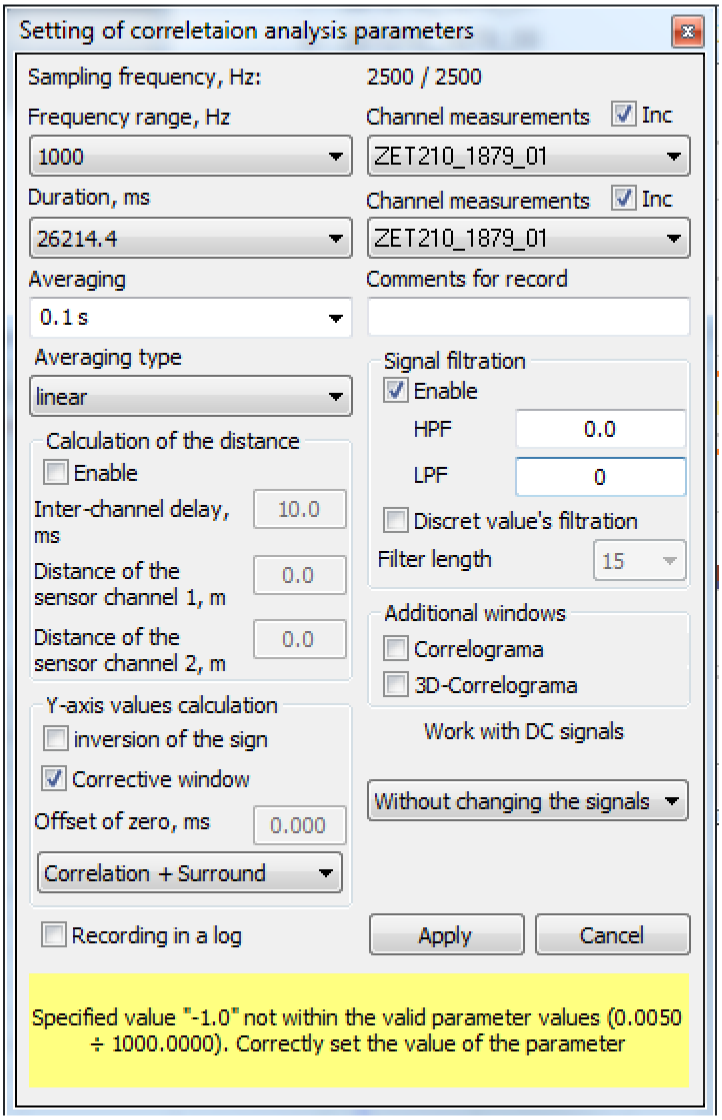


Fig. 4. "Parameters" window: setting Specified value "-1.0" not within the valid parameter values

The updated program version has a new operating mode – operations with a constant component of the source signal "Mode DC" (see Fig.s 3 and 4). It is possible to select one of the following modes: "Remove DC", "Filtering DC" and "With DC".

The mode "Remove DC" allows to remove the DC component from the source signal prior to calculation of the correlation function.

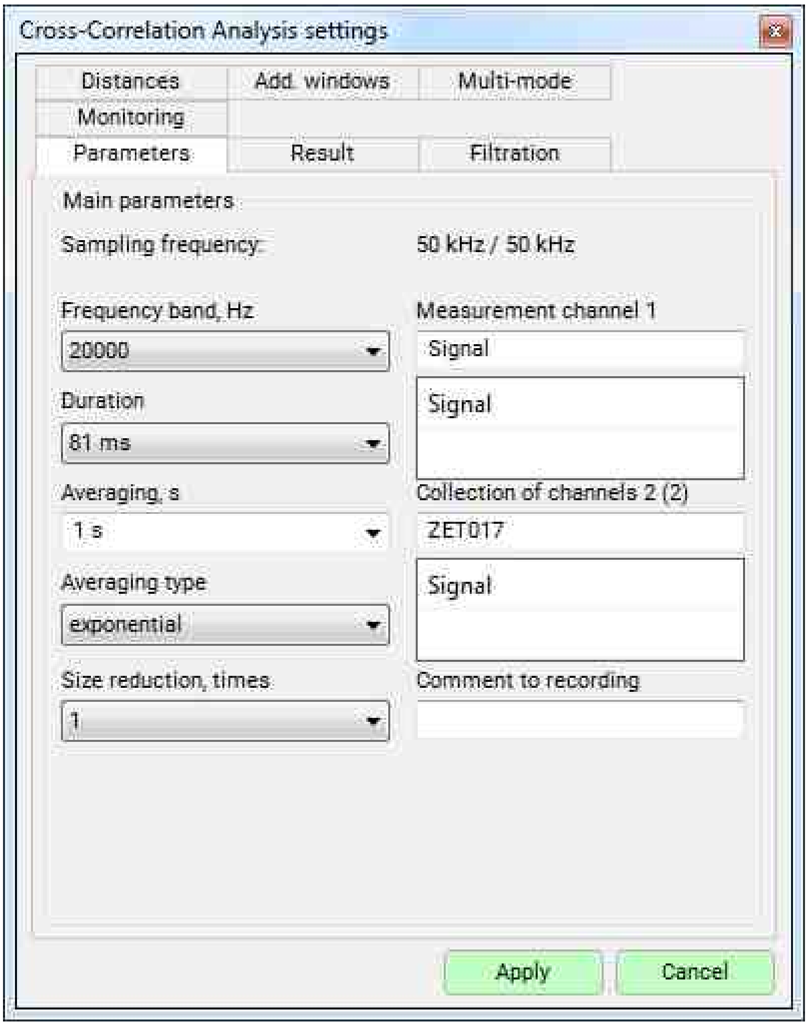
The mode "Remove DC" allows to expose the source signal to LPF filtration (the cutoff frequency is equal to the correlation duration) prior to the calculation.

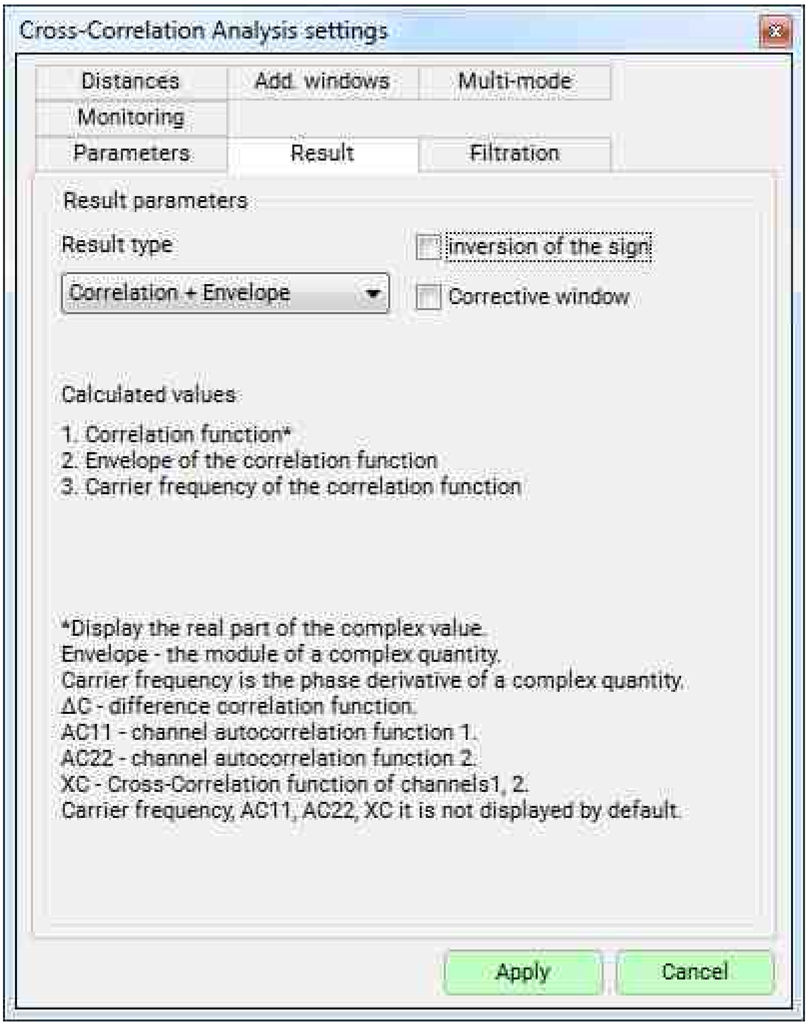
The "With DC" mode is used for calculations without excluding the DC component of the source signals.

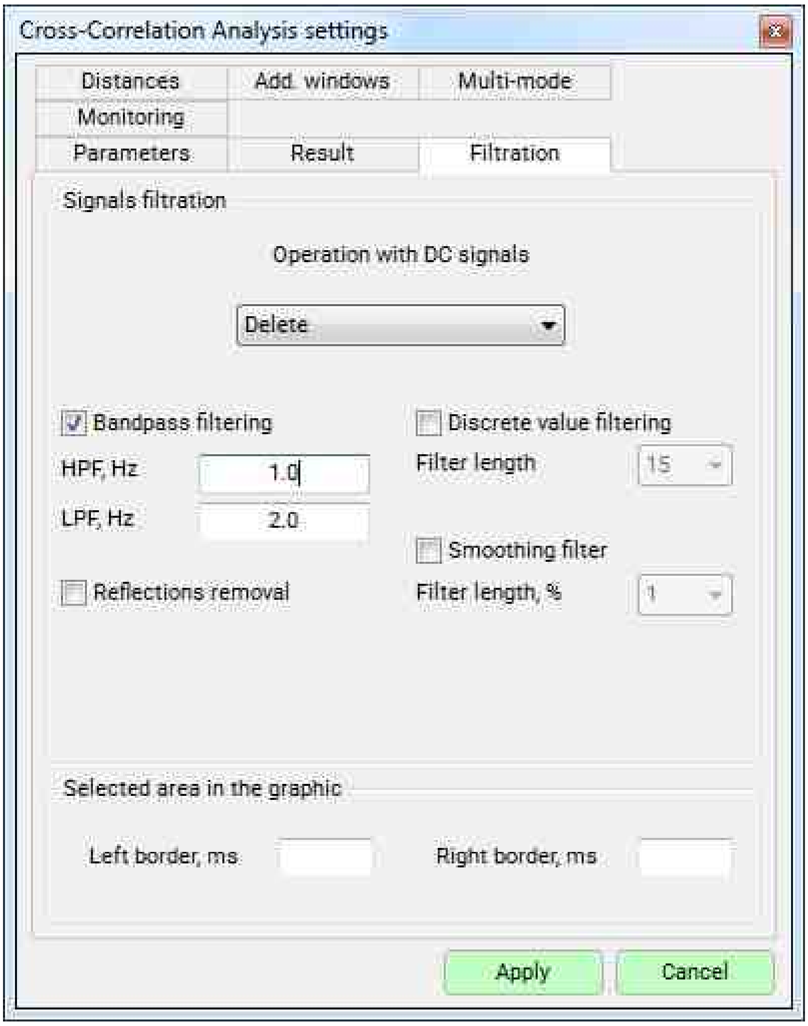
By default, the "Mode DC" is set as "With DC".

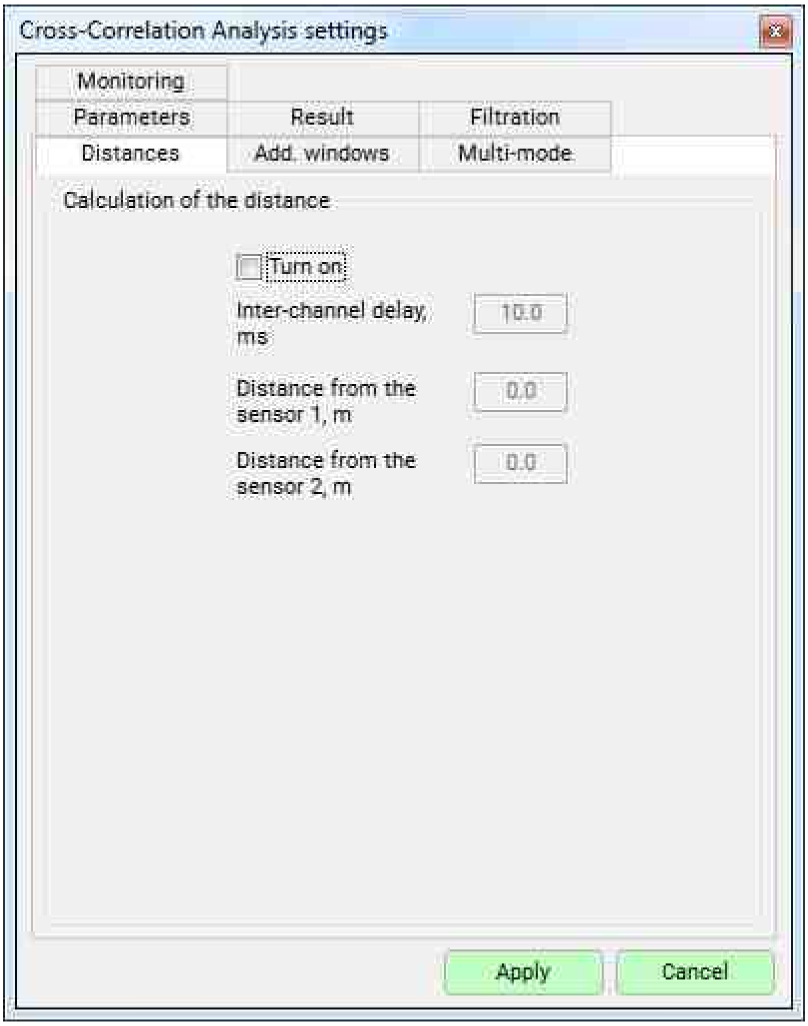
Additional features of Cross-Correlation Analysis

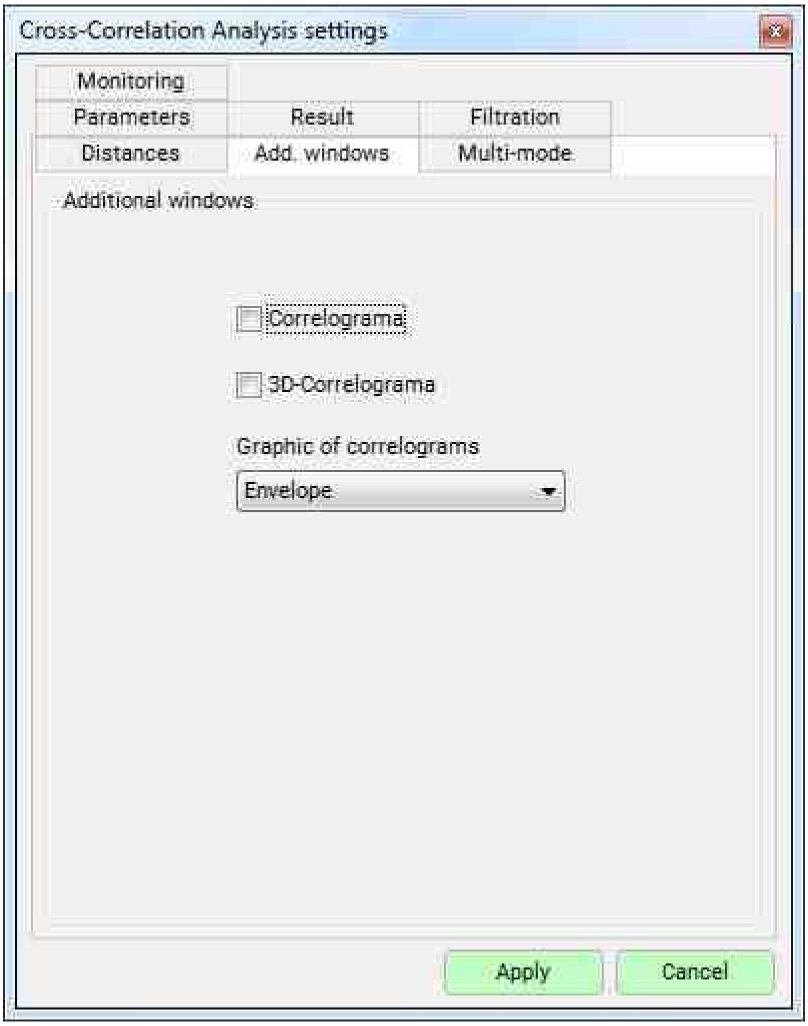
1. The window for set the program "Cross-correlation analysis" consists of a set of tabs shown in the figures.

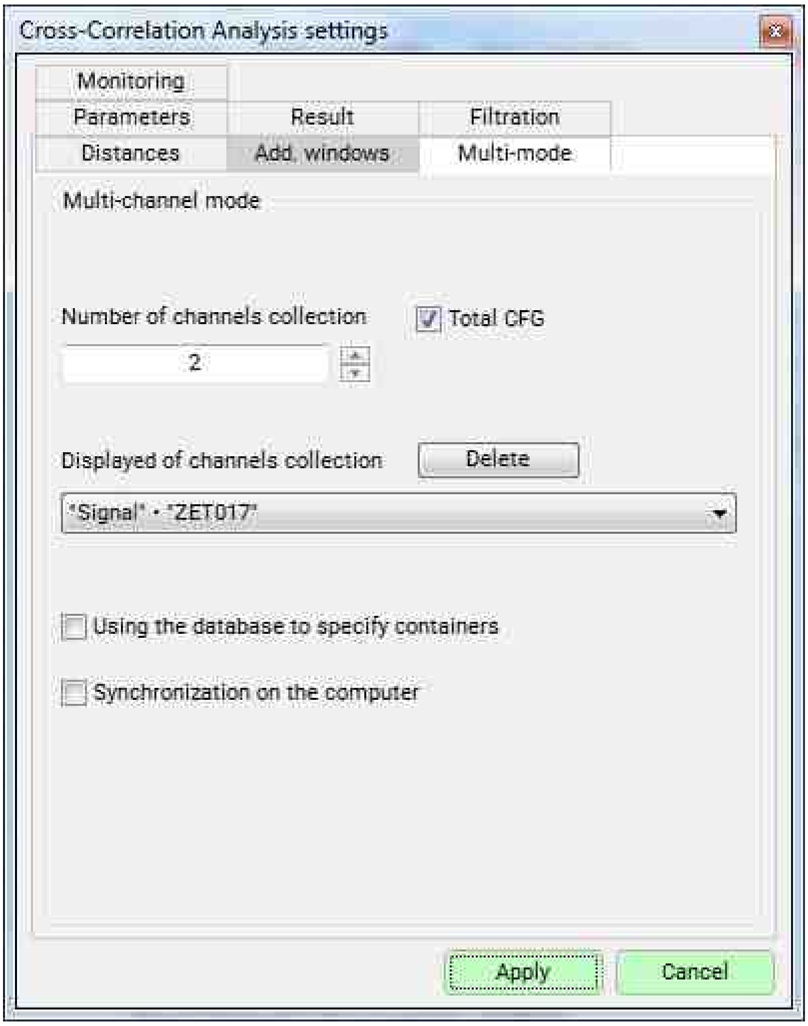

Cross-Correlation Analysis settings
Distances
Add. windows
Multi-mode
Monitoring
Parameters
Result
Filtration
Main parameters
Sampling frequency:
50 kHz / 50 kHz
Frequency band, Hz
20000
Measurement channel 1
Signal
Signal
Duration
81 ms
Averaging, s
1 s
Collection of channels 2 (2)
ZET017
Signal
Averaging type
exponential
Size reduction, times
1
Comment to recording
Apply
Cancel


Cross-Correlation Analysis settings
Distances
Add. windows
Multi-mode
Monitoring
Parameters
Result
Filtration
Result parameters
Result type
Correlation + Envelope
inversion of the sign
Corrective window
Calculated values
1. Correlation function*
2. Envelope of the correlation function
3. Carrier frequency of the correlation function
*Display the real part of the complex value.
Envelope - the module of a complex quantity.
Carrier frequency is the phase derivative of a complex quantity.
ΔC - difference correlation function.
AC11 - channel autocorrelation function 1.
AC22 - channel autocorrelation function 2.
XC - Cross-Correlation function of channels1, 2.
Carrier frequency, AC11, AC22, XC it is not displayed by default.
Apply
Cancel

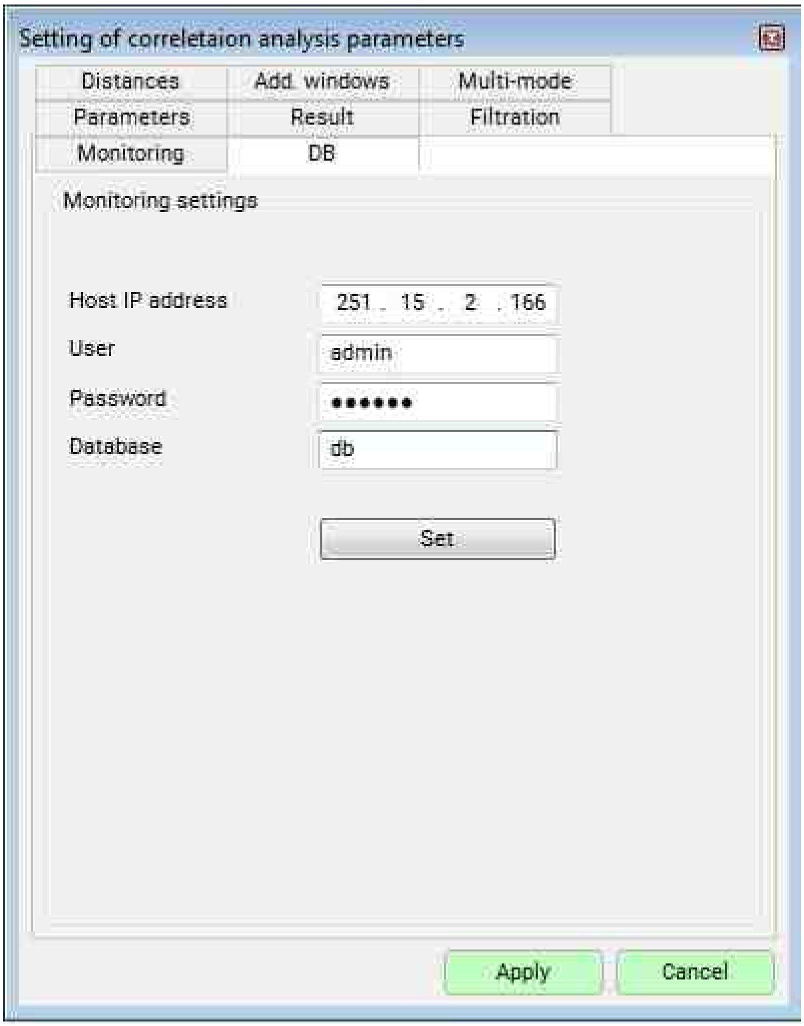

Cross-Correlation Analysis settings
Distances
Add. windows
Multi-mode
Monitoring
Parameters
Result
Filtration
Signals filtration
Operation with DC signals
Delete
Bandpass filtering
HPF, Hz
1.0
LPF, Hz
2.0
Reflections removal
Discrete value filtering
Filter length
15
Smoothing filter
Filter length, %
1
Selected area in the graphic
Left border, ms
Right border, ms
Apply
Cancel

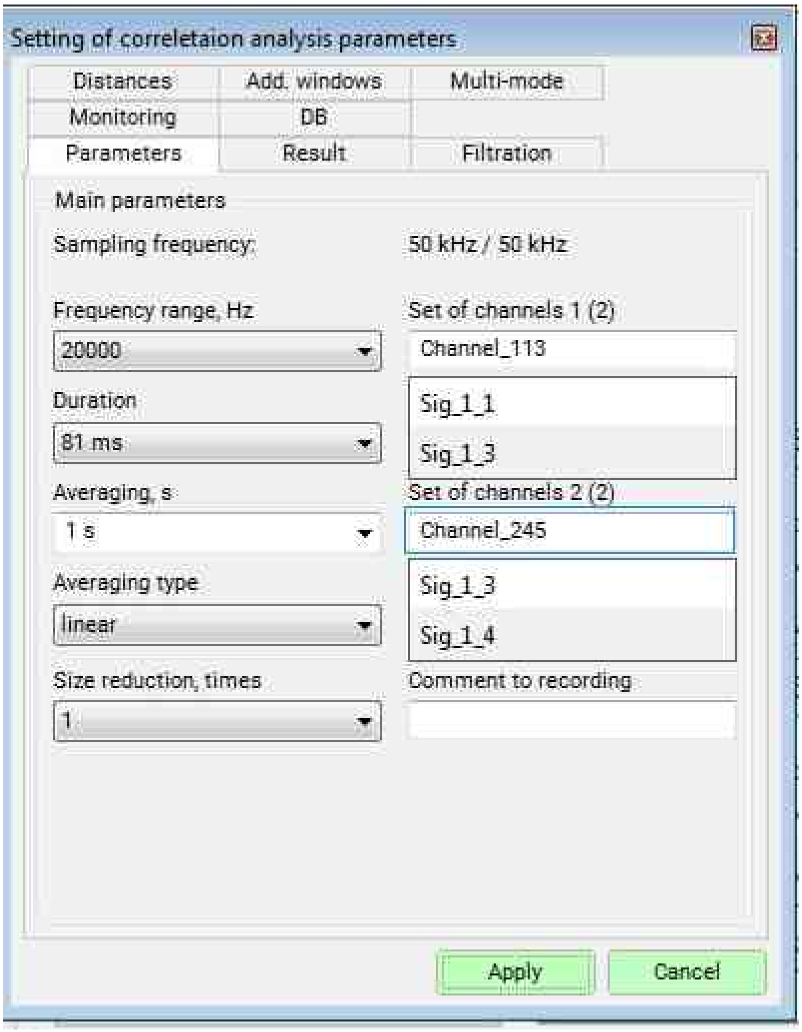

Cross-Correlation Analysis settings
Monitoring
Parameters
Result
Filtration
Distances
Add. windows
Multi-mode
Calculation of the distance
Turn on
Inter-channel delay, ms
10.0
Distance from the sensor 1, m
0.0
Distance from the sensor 2, m
0.0
Apply
Cancel


Cross-Correlation Analysis settings
Monitoring
Parameters
Result
Filtration
Distances
Add. windows
Multi-mode
Additional windows
Correlograma
3D-Correlograma
Graphic of correlograms
Envelope
Apply
Cancel



2. In the new version of the program, calculations can be made not only according to the channel data, but also according to the total energy of several channels. To do this, in the "Parameters" tab of the program settings window, select several channels and set the name of the set. The component for selecting multiple channels in the program is used in the same way as in the "FFT Spectrum Analysis" program.


Setting of correletaion analysis parameters
Distances
Add. windows
Multi-mode
Parameters
Result
Filtration
Monitoring
DB
Monitoring settings
Host IP address
251 . 15 . 2 . 166
User
admin
Password
Database
db
Set
Apply
Cancel



Supported Hardware .....

Input data program Cross-Correlation analysis are digital data channel server **ZETLAB**, which are output signals of the sensors of linear and angular displacements.

For the purpose of analog signals digital processing, it is possible to use *FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01* and *seismic recorder ZET 048*.

Settings of measurement channels are specified in the program "Device Manager".

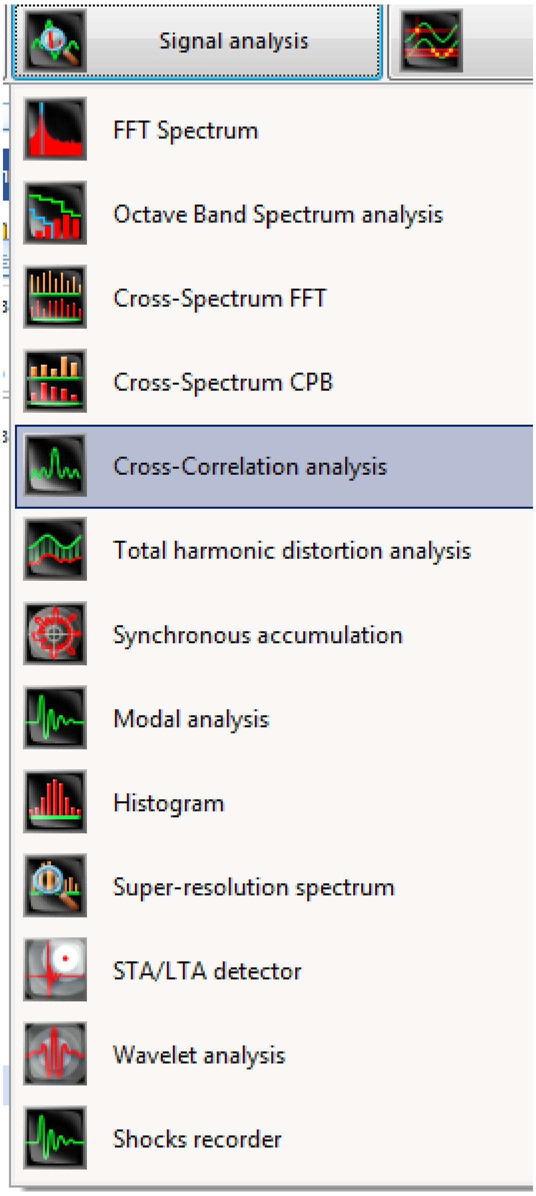
The software Cross-Correlation analysis is included with the following software:

- ZETLAB ANALIZ – FFT Spectrum software
- ZETLAB VIBRO – Shaker controllers systems software
- ZETLAB SEISMO - seismic station software,

Cross-Correlation analysis is included in the **Signal analysis** software group.

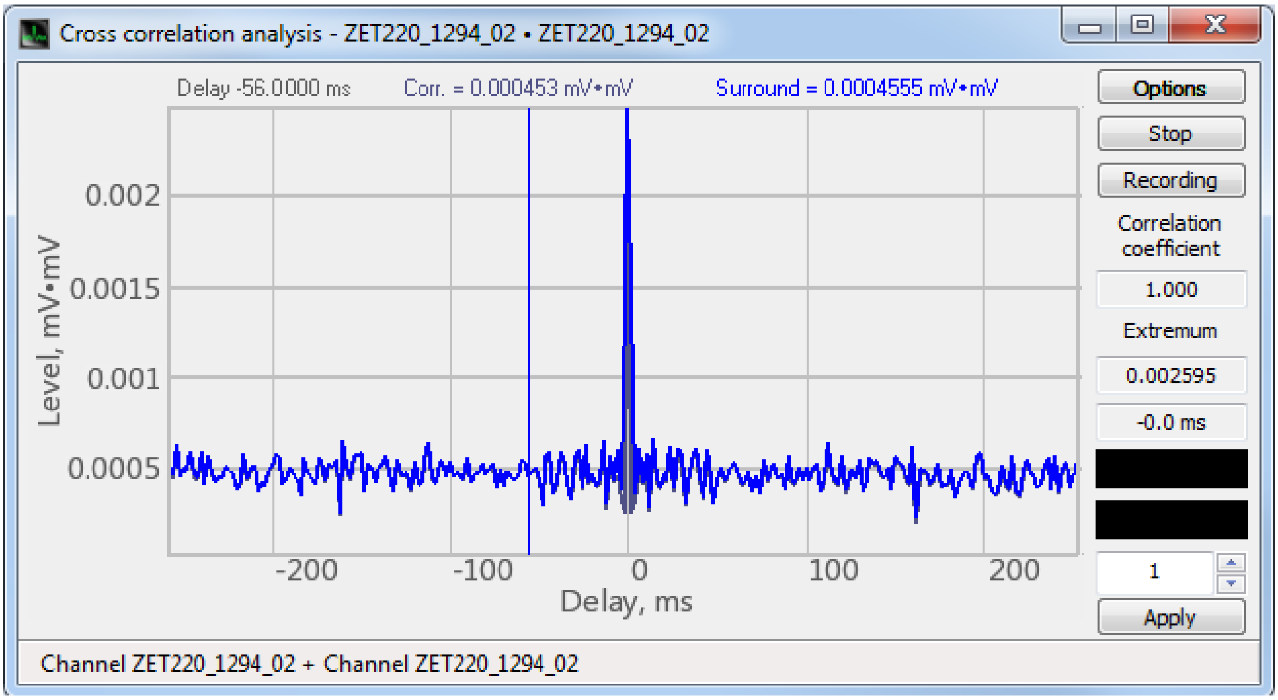
Program description .....

The program "**Cross-Correlation analysis**" is available in the Analysis menu of ZETLAB panel.



Starting the "Cross-Correlation Analysis"

The top section of the program shows the name of the program and the name of the channel selected for the analysis. Above the spectrum graphic one can see the controlled values (delay, signal level), corresponding to the particular cursor position.



The window of "Cross-Correlation analysis" program

Note: the program can be started from ZETLAB directory: (by default: C:\ZETLAB\). The name of the file: corr.exe

The main section of the "***Cross-Correlation analysis***" program is represented by a field for measurements result display and the fields with Additional graphics. The indicator to the right from the graphic shows integral levels of the signals along with their linear-frequency characteristics (to the left) and frequency characteristics of A-D type (to the right).

The type of frequency characteristics is selected in the Options menu under the Integral level menu. It is possible to enable/ disable the indicator options menu with the checkbox integral level.

The right part of the program window contains control keys and indicators:

- *Parameters* – the key activates program parameters window: measuring channel, analysis parameters, etc.

- *Start/Stops* – the key is used for analysis process control. At the first start of the program, the "*Start*" key is active by default. In the case if the interval for Additional graphics calculation has been set, then, upon activation of the key, the interval will be set to zero and the calculations will be started again.
- *Recording* – saving the measurements results to a file, the file structure is described in the clause Saving the results to a file.
- *In=... s* – the time interval from the beginning of the test performance. This parameter is applicable only to the calculation of the Additional graphics. In the setting of the program "*Cross-Correlation analysis*" it is possible to set the time parameters for the calculation of Additional graphics. Upon completion of the set time period the calculation of the graphics will be finalized, the graphics flow will be stopped and the set calculation interval (duration) will be displayed in the corresponding field.
- In the fields below the "*Extremum*" section there are displayed frequency and the current value of the current spectrum extremum.
- The indicator "*Level*" depicts ratio of the current signal value to the maximum value of the measurement range. It enables fast evaluation of the signal level along with control of the channel overloading.

See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Setting parameters of display
- Using signal level indicators
- Adjustment of the color scheme used for displaying of the registered signal amplitude values
- Graphical and numerical data transfer to text editors
- Setting GridGl grid functionality

Program settings .....

In order to set the program "***Cross-Correlation analysis***", left-click the ***"Parameters***" key at the top right section of the program window – you will see the window "***Cross-Correlation analysis setting***" (*Fig. 8*).

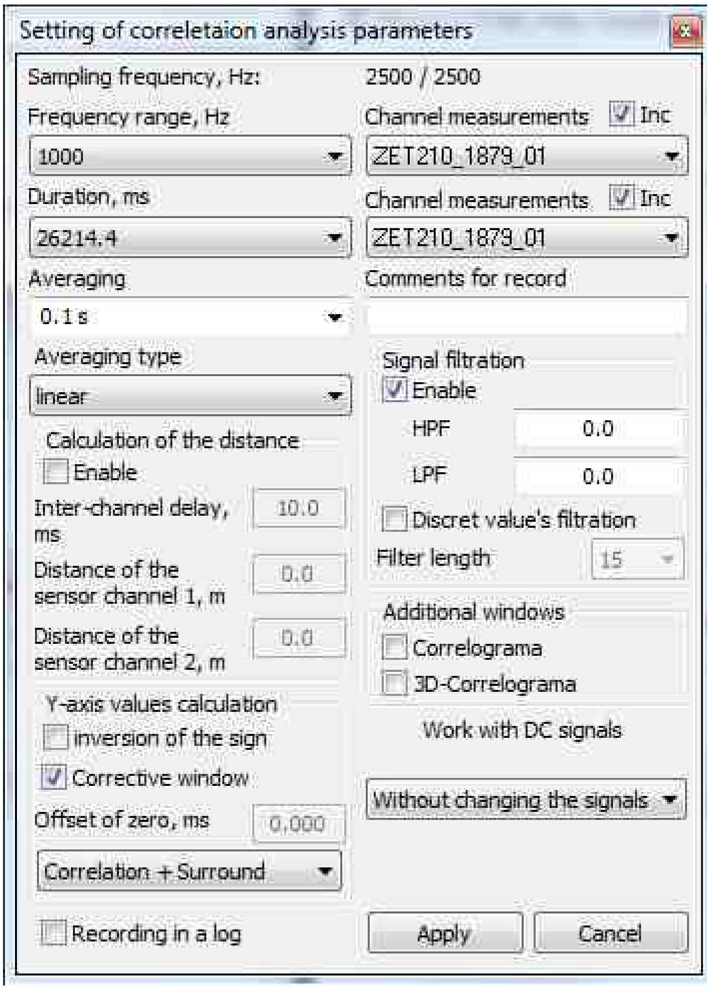


Fig. 8

The top section of the window shows the set Frequency range value in Hz (see the clause *Setting parameters* in the program "Device Manager").

The drop-down lists allow the user to set the parameters in two ways:

- click the field and select the necessary value from the drop-down list;

- left-click the field and use the keyboard keys <> and <Ï > to select the necessary element.

The list ***Frequency range, Hz*** – allows to select the frequency range (analysis bandwidth) for the signal analysis.

List ***Channel measurements*** – is used for selecting physical or virtual channel for the program *Cross-Correlation analysis*.

The list ***Averaging*** is used to set the averaging value of the instant signal spectra in seconds.

In the section ***Additional windows*** you can control the display of additional windows:

- **Correlogram**;
- **3D-correlogram**;

The **Additional graphics** section is used for the display of **Cross-Correlation analysis**, maximum and average spectra and the envelope.

How to turn the measurement data in user-friendly information thus making an animated object from ordinary graphs? For this purpose there has been developed the program "*View historical events*". This program is included into the scope of ZETLAB Software and it is used for display and analysis of the historical events recorded with the use of ZETLAB software for a long period of time.

Questions and answers:
Question: Could you please clarify the features of "*Recording in a log - correlation*" function?

Answer: this option allows to record the spectrum in the format of events, that can be viewed and analyzed by means of the program "*View historical events*" from the "*Registration*" tab. A detailed description of the program is available by the link below:

https://zetlab.com/en/shop/virtual-devices/functions-zetlab/register/view-of-historical-events/

The *Apply* key is used for saving the settings configuration in the program *Cross-Correlation analysis* and for exiting the "*Cross-Correlation analysis setting*" window.

The *Cancel* key is used for exiting the "*Cross-Correlation analysis setting*" window without saving the settings of the program Cross-Correlation analysis.

The window "*Cross-Correlation analysis setting*" can be closed without configuring the settings of Cross-Correlation analysis program. To do that, you can also click  at the top right section of the window.

Additional windows .....

The program **Cross-Correlation analysis** has the following additional functions:

- Correlogram
- 3D-correlogram

Correlogram .....

As the checkbox "*Correlogram*" is set in the "*Additional windows*" menu of the "*Cross-Correlation analysis setting*" window, there appears and additional window of Cross-Correlation analysis – the *Correlogram* (see *Fig. 10*).

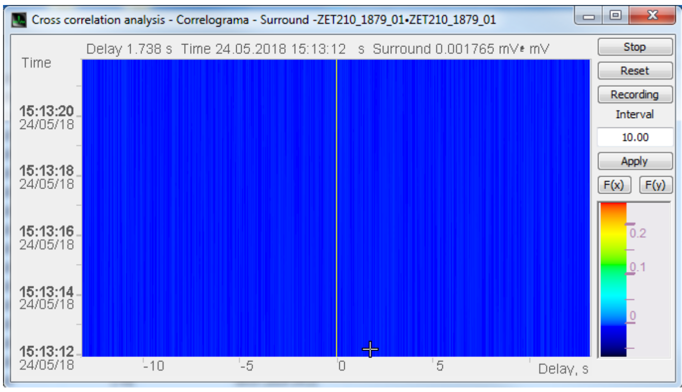


Fig. 10

The name of the window depicts the name of the spectrum (Correlogram) and the names of the two channels (e.g., Generator1*Signal2). The correlogram is a graphic of autocorrelation function τ_h dependence on time delay (time lag) h

.

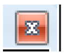
The ***Start*** key begins the display of correlogram graphic.

The key ***Stop*** (***Pause***) is used to suspend the display of the correlogram. To resume the display of the graphic, click the *Start* key described above.

The ***Recording*** key allows to record instant values of the display correlogram to a text file with *.dtx extension. Upon activation of the key, there appears a standard dialog window offering to set the directory for saving the file and the file name. The directory by default is: C:\ZetLab\result\.

Table 1

Line number	Line	**Description**
1	Correlogram	The name of the additional window
2	Signal 3	Name of signal input channel
3	Sensor at point #2	The line contains user’s comments. The comment is entered in the section **"Comments for record"** of the **"Cross-Correlation analysis setting"** window.
4	Frequency range – from 9,104 Hz up to 12500,00 Hz. Frequency step – 6,104 Hz. Analysis bandwidth – 11,871	Correlogram parameters of the **Cross-Correlation**.
5	Date: 10-05-2018	File recording date
6	Time: 20:02:47	File recording time
7	Time Level	Names of the data columns
8	Seconds dB (0,001 mV)	Measurement units (by columns)
9-th and the following lines		Numerical data values with floating point. The point is used for the separation of integral and fractional parts.

To close the **correlogram** window, uncheck the **correlogram** option in the "***Cross-Correlation analysis setting***", or click the key  at the top right section of the window. The **Correlogram** option will be switched off automatically.

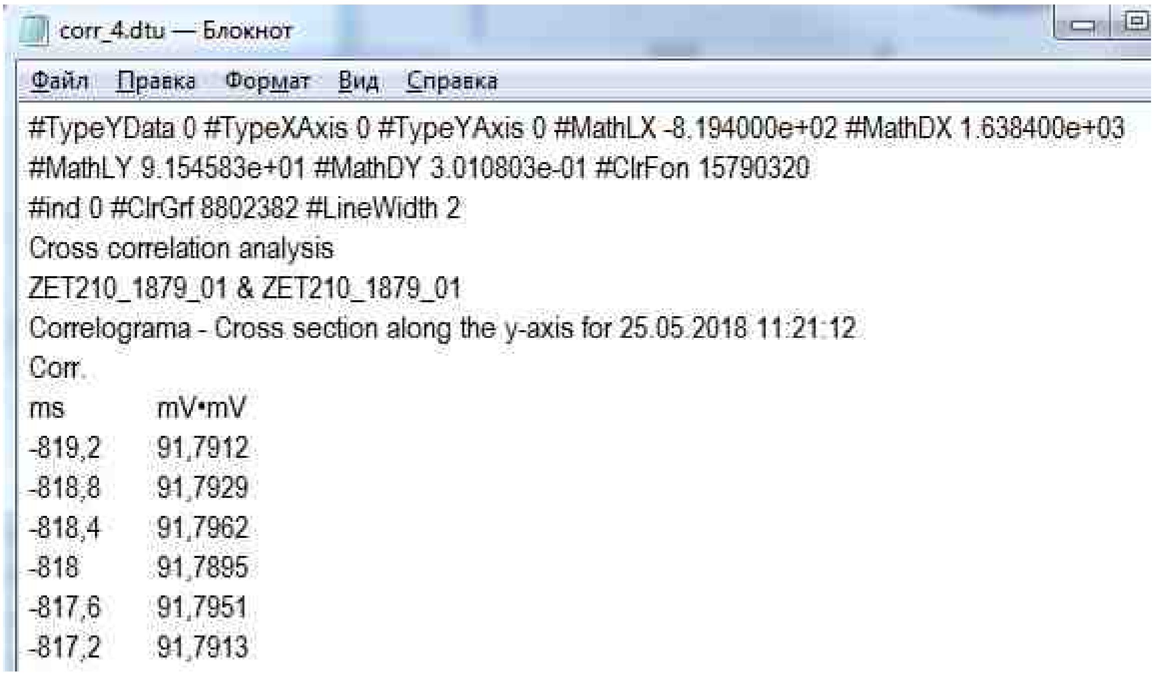
Upon activation of the key F(x) in the window **"Cross-correlation analysis - Correlogram"** there appears the window **"Cross-section along y-axis"**, i.e. the signal graphic displays dependence of the displayed function on the delay (in seconds). The displayed value depends on the cursor position at the correlogram graphic (see the Fig.).

Cross-Correlation analysis- Correlogram - Cross-section along y-axis

By moving the cursor along the graphic section of the program "**Cross-Correlation analysis - Correlogram"**, it is possible to analyze the spectrum characteristics at any particular time point. By setting the cursor at the required time point, it is possible to view the required section of frequency characteristics of the accumulated correlogram. Cursor control and graphics scaling, as well as transfer of graphical and numerical data are implemented in the same way, as in the main window of "**Cross-Correlation analysis"** program (see the clause "Program description – Cursor control and graphics scaling" – "Transfer of graphical and numerical data to text editors").

The "**Recording**" key allows to record the instant values of the displayed frequency cross-section to a text file with *.dtx extension. Activation of the key starts a standard dialog window allowing the user to set file name and directory. The directory by default is C:\ZetLab\result\. The file structure is shown in the graphic.

To close the window "Cross-section along x-axis", click the F(y) key in the window **"Cross-Correlation analysis - Correlogram"** again or use the key in the top right section of the program interface.



corr_4.dtu — Блокнот

Файл Правка Формат Вид Справка

#TypeYData 0 #TypeXAxis 0 #TypeYAxis 0 #MathLX -8.194000e+02 #MathDX 1.638400e+03
#MathLY 9.154583e+01 #MathDY 3.010803e-01 #ClrFon 15790320
#ind 0 #ClrGrf 8802382 #LineWidth 2
Cross correlation analysis
ZET210_1879_01 & ZET210_1879_01
Correlograma - Cross section along the y-axis for 25.05.2018 11:21:12
Corr.

ms	mV•mV
-819,2	91,7912
-818,8	91,7929
-818,4	91,7962
-818	91,7895
-817,6	91,7951
-817,2	91,7913

Results file recorded with the program "Cross-Correlation analysis- Correlogram - Cross-section along y-axis"

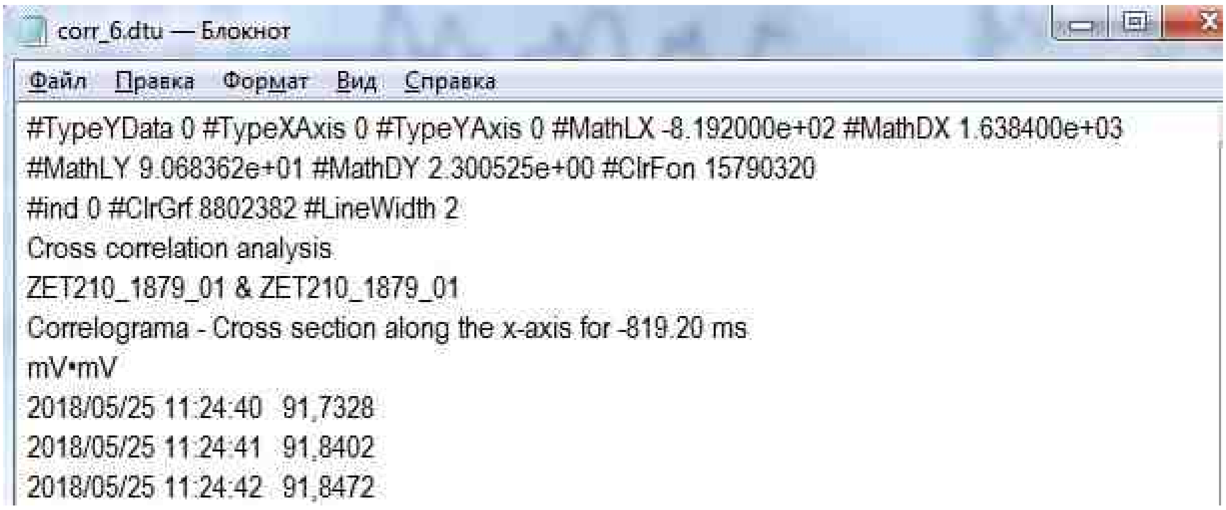
Upon activation of the key F(y) in the window "**Cross-Correlation analysis - Correlogram"** there appears the window "**Cross-section along x-axis"**, i.e. the signal graphic displays dependence of the displayed function on the absolute time of the delay (in seconds). The displayed value depends on the cursor position at the correlogram graphic (see the *Fig.)*.

Cross-Correlation analysis - Correlogram - Cross-section along x-axis

By moving the cursor along the graphic section of the program "**Cross-Correlation analysis-Correlogram"**, it is possible to analyze the spectrum characteristics at any particular time point. By setting the cursor at the required time point, it is possible to view the required section of frequency characteristics of the accumulated correlogram. Cursor control and graphics scaling, as well as transfer of graphical and numerical data are implemented in the same way, as in the main window of "**Cross-Correlation analysis"** program (see the clause "Program description – Cursor control and graphics scaling" – "Transfer of graphical and numerical data to text editors").

The "**Recording**" key allows to record the instant values of the displayed frequency cross-section to a text file with *.dtx extension. Activation of the key starts a standard dialog window allowing the user to set file name and directory. The directory by default is C:\ZetLab\result\. The file structure is shown in the graphic.

To close the window "**Cross-section along x-axis"**, click the F(x) key in the window **"Cross-Correlation analysis- Correlogram"** again or use the key in the top right section of the program interface.


corr_6.dtu — Блокнот
Файл Правка Формат Вид Справка
#TypeYData 0 #TypeXAxis 0 #TypeYAxis 0 #MathLX -8.192000e+02 #MathDX 1.638400e+03
#MathLY 9.068362e+01 #MathDY 2.300525e+00 #ClrFon 15790320
#ind 0 #ClrGrf 8802382 #LineWidth 2
Cross correlation analysis
ZET210_1879_01 & ZET210_1879_01
Correlograma - Cross section along the x-axis for -819.20 ms
mV•mV
2018/05/25 11:24:40 91,7328
2018/05/25 11:24:41 91,8402
2018/05/25 11:24:42 91,8472

Results file recorded with the program "Cross-Correlation Analysis - Correlogram - Cross-section along x-axis"

3D-correlogram .....

Upon activation of the 3D-correlogram option in the window "Cross-Correlation analysis setting" there appears an additional window of the time-frequency distribution of the signal – the 3-D Correlogram (*Fig. 11*). This window depicts 3-dimensional time-frequency distribution of the signal. The 3-D Correlogram allows to estimate the signal level based on the color representation of the diagram.

The title of the window contains the name of spectrum (3D-correlogram) and the channel name (e.g. Signal1*BC-202).

The color stands for the spectrum level. Low levels are marked with black and the high levels – with red respectively.

The scaling by level in the 3-D correlogram is performed by left-clicking the corresponding icons appearing at the vertical scale of the 3D spectrogram located under the *Apply* key.

By default, the 3D Correlogram is black. By double-clicking the graphical section of the 3D-correlogram, it is possible to change its color for white and vice versa.

It is possible to view the 3D Correlogram from any side by rotating it around three mutually transverse axes. To rotate the 3D correlogram around the axes, press and hold the mouse key and move it along the graphic of the 3D-correlogram, thus rotating it around X and Y axes. The right mouse key is used in the same manner for rotating the 3D correlogram around Z axis.

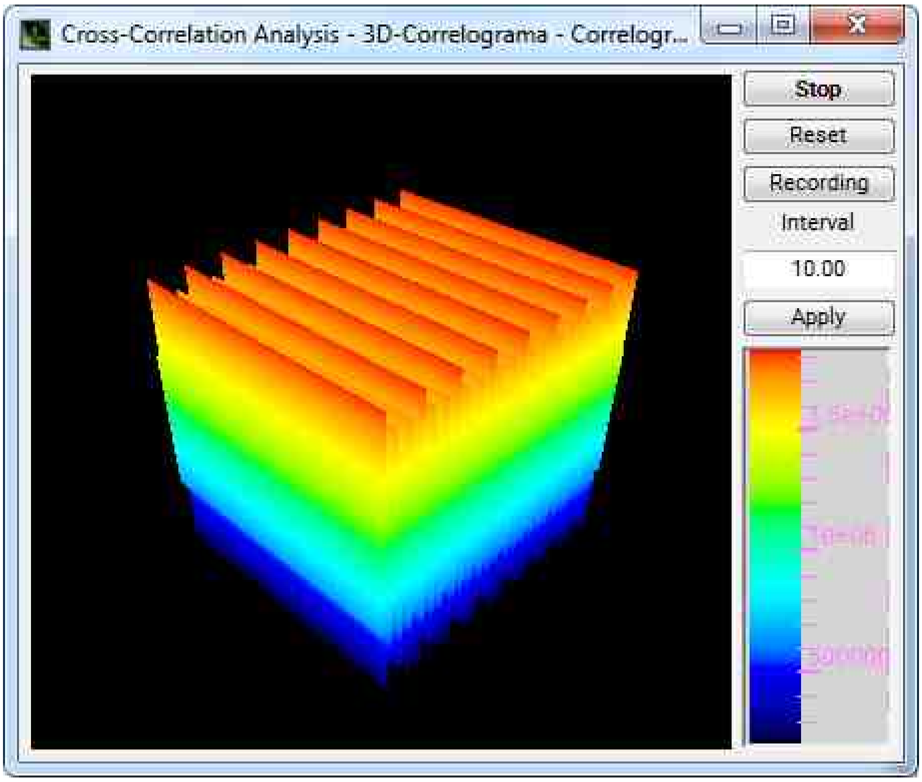


Fig. 11

Use the scroll to increase or decrease the size of the **3D-correlogram**.

Double clicking the **3D correlogram** allows to put the **3D correlogram** into initial position in relation to the axes as well as to bring it into initial scale.

The ***Start*** key starts data accumulation into **3D-correlogram** and resets the previously accumulated data.

The ***Stop*** (***Pause***) key is used to suspend the process of data accumulation to the **3D correlogram**. Further accumulation of spectra is controlled by the *Start* key described above.

The ***Recording*** key allows to save the values of the accumulated data to a text file with *.gru extension. Click the key – you will see a standard dialog window allowing you to choose the directory for saving the file as well as to name the file. These data can be further used for 3D-representation of the accumulated information by means of task-specific software. The directory by default is C:\ZetLab\result\.

The field under the Interval section allows to set the time interval for data accumulation in the **correlogram**. The interval is set in seconds. Interval values are entered from the keyboard. To save the entered interval value, click Apply or use the key <Enter>.

The vertical axis of the **correlogram** located under the *Apply* key shows the relation between **correlogram** color and its level.

In order to close the **3D-correlogram** window, uncheck the option **3D Correlogram** in the window "***Cross-Correlation analysis setting***", or use the key  at the top right section of the window (the **3D-Correlogram** option will be switched-off automatically).

Recording results to a file .....

Cross-Correlation analysis: recording

The program **Cross-Correlation analysis** has a function of recording the instant values of the displayed spectrum to a text file with *.dtx extension. Upon activation of the Recording key there appears a standard dialog window allowing to set the directory for saving the file as well as to assign the file name. The directory by default is C:\ZETLab\Result\.

An example of the file is shown in the Fig. below.

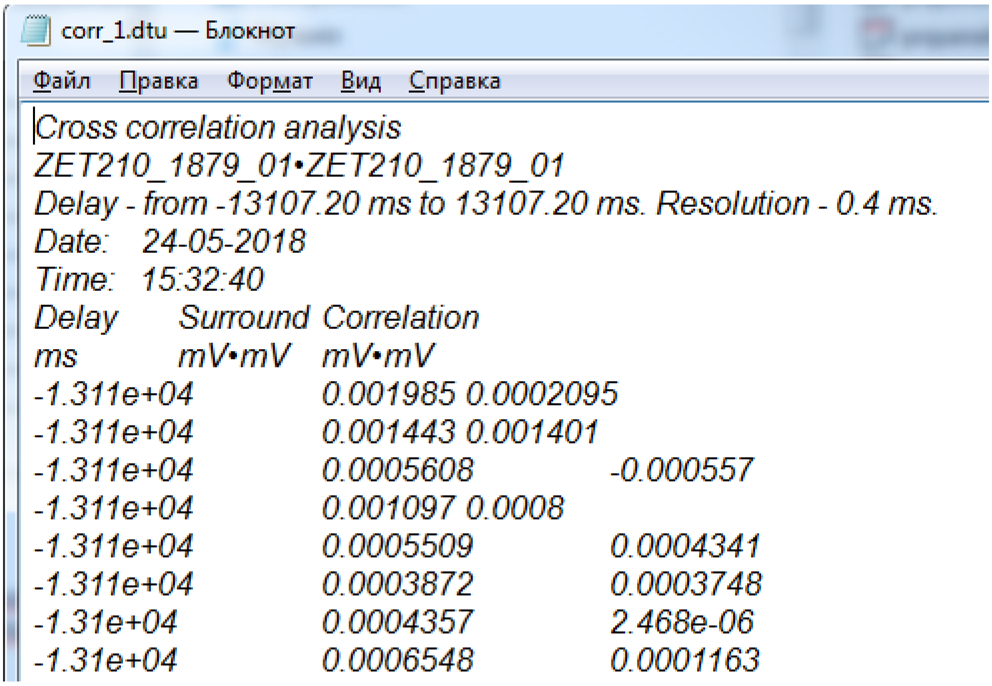
Correlogram: recording

Values of the accumulated spectra are recorded to a text file with *.gru extension. Upon activation of the *Recording* key there appears a standard dialog window allowing to select the directory for saving the file as well as file name. the directory by default:
C:\ZETLab\Result\.

3D-correlogram: recording.

Values of the accumulated spectra are recorded to a text file with *.gru extension. Upon activation of the recording key in the ***Correlogram*** window of the ***Cross-Correlation analysis*** program, there appears a standard dialog window allowing to choose the directory for saving the file as well as to assign file name. The directory by default is: C:\ZETLab\Result\.

An example file is shown in the Fig. below.


corr_1.dtu — Блокнот
Файл Правка Формат Вид Справка

Cross correlation analysis
ZET210_1879_01•ZET210_1879_01
Delay - from -13107.20 ms to 13107.20 ms. Resolution - 0.4 ms.
Date: 24-05-2018
Time: 15:32:40
Delay Surround Correlation
ms mV•mV mV•mV
-1.311e+04 0.001985 0.0002095
-1.311e+04 0.001443 0.001401
-1.311e+04 0.0005608 -0.000557
-1.311e+04 0.001097 0.0008
-1.311e+04 0.0005509 0.0004341
-1.311e+04 0.0003872 0.0003748
-1.31e+04 0.0004357 2.468e-06
-1.31e+04 0.0006548 0.0001163

Results file recorded with the program "Cross-Correlation Analysis"

Monitoring of objects in the Cross-Correlation Analysis .....

Cross-Correlation Analysis settings

From the directory "C:\ZETLab" run the program "corr.exe" and in the window that opens (*Fig. 1*) activate the "Parameters" button.

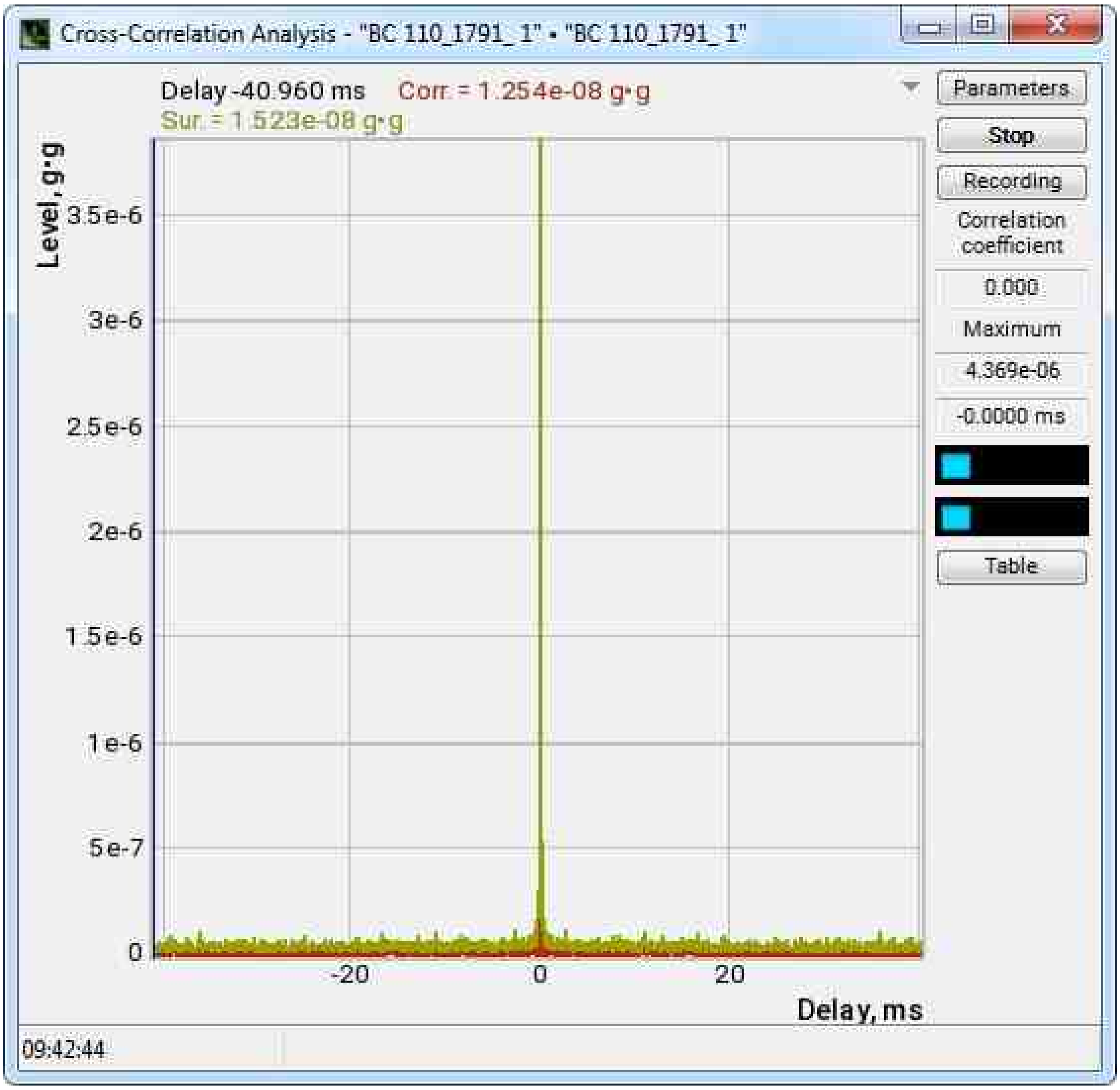


Fig. 1. Corr.exe program window

In the settings window that opens, in the "Parameters" tab, make the settings in accordance with (*Fig. 2)*

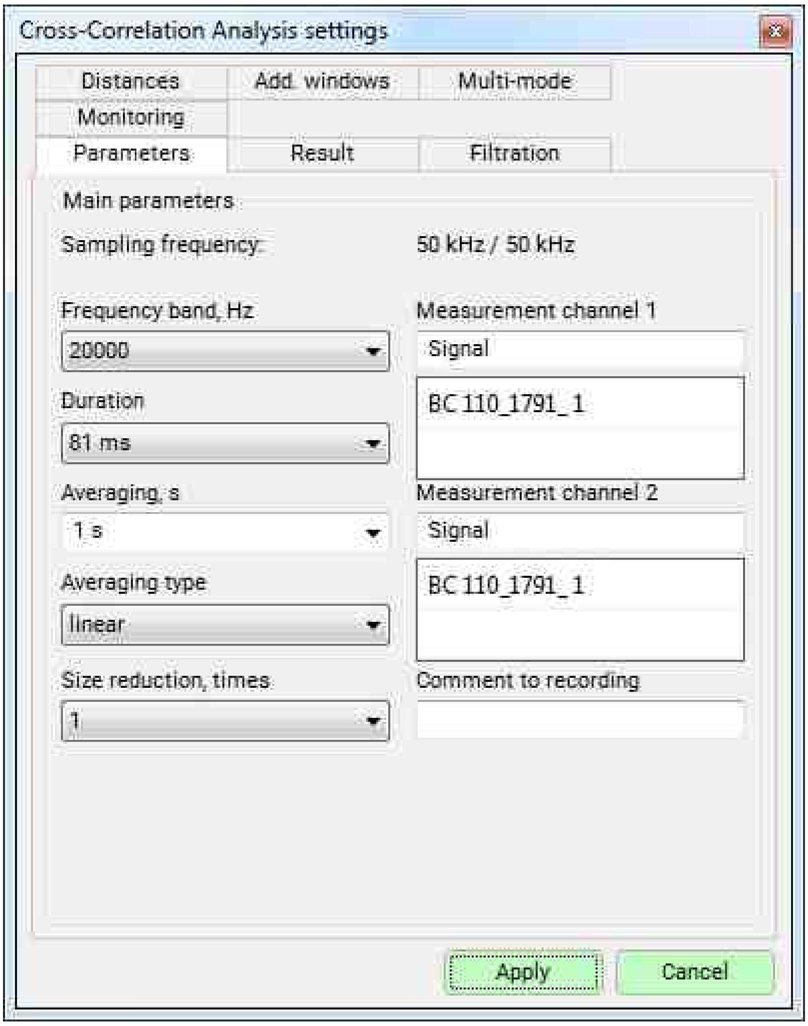


Fig. 2. The settings window of the corr.exe program. Parameters tab..

In the "Monitoring" tab (*Fig. 3)* check the "Monitoring object" checkbox. In the "Object name" field, enter "Tower" and click the "Edit descriptor" button. The Monitor Settings Editor window opens. In the window with a proposal to create a Tower object, activate the Yes button. Next, create a set for monitoring, as shown in (*Fig. 4*) and click Save and Exit.

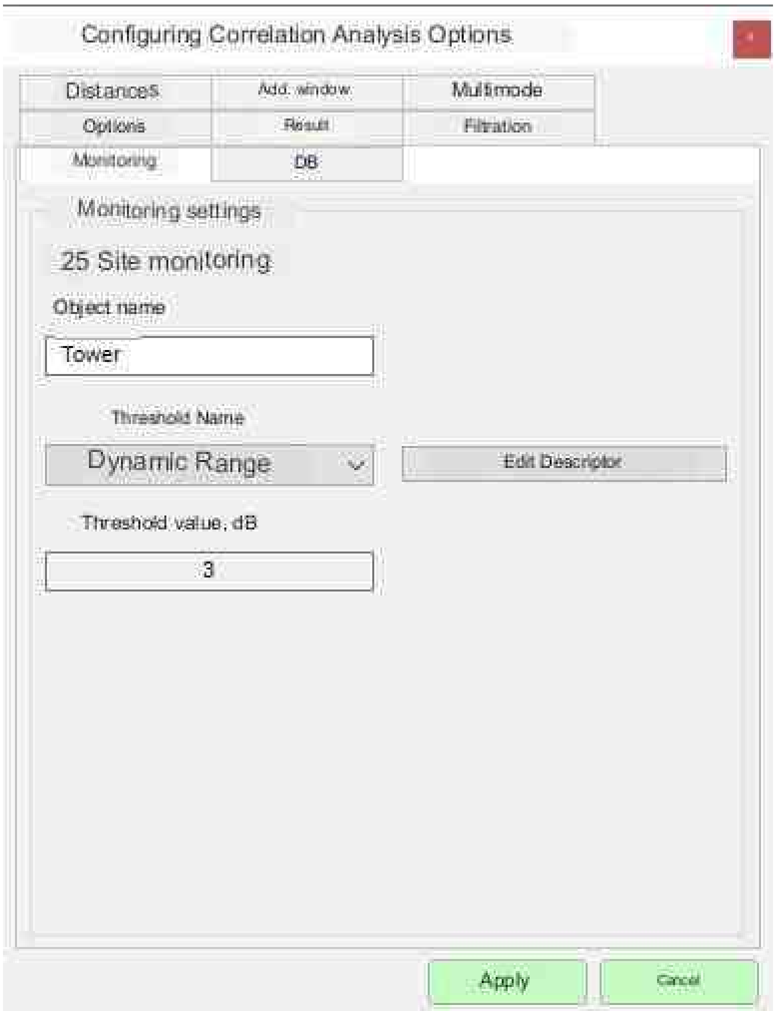


Fig. 3. The settings window of the corr.exe program. Monitoring tab.

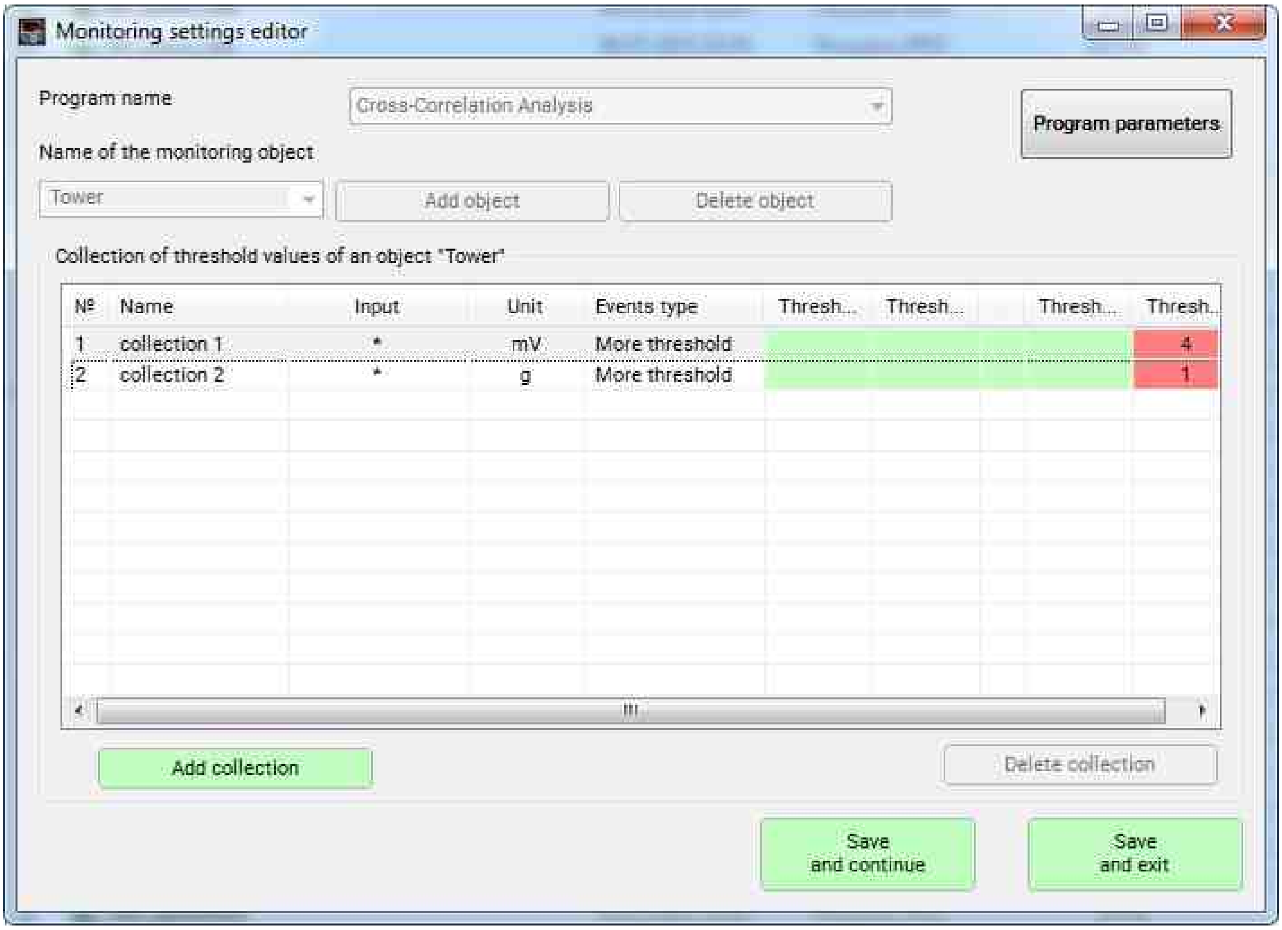


Fig. 4. The window of the monitoring parameters editor.

In the "Multi-mode" tab. (*Fig. 5*) check the box "Use database to specify containers".

In the settings window, click "Apply" and close the program.

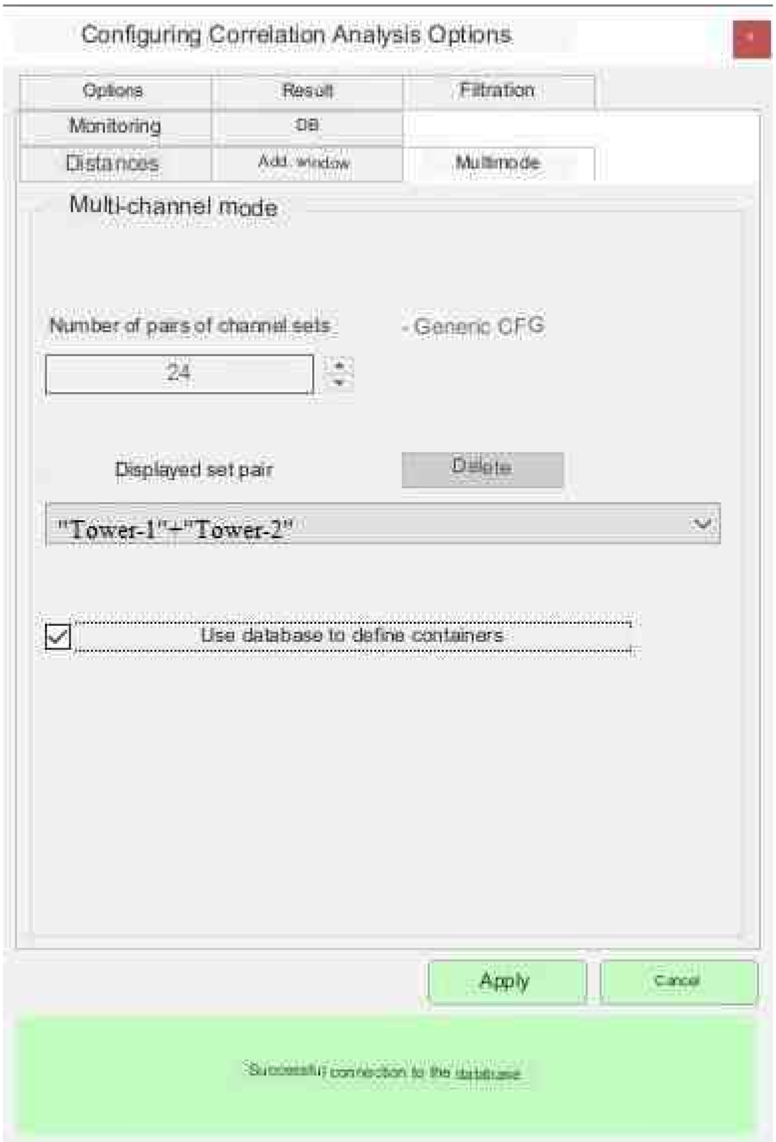


Fig. 5. Program settings window corr.exe. The "Multi-mode" tab.

Go to the directory C:\ZETLab\config \, rename the car01.cfg file to corr.cfg.

If you need to configure the program, you need to go to the directory C:\ZETLab\config \, rename the file corr.cfg to corr01.cfg, open the program, change the settings and perform the reverse rename.

Example for a section .....

Table of contents

Application in practice .....

Application in practice

To demonstrate the operation of monitoring events, consider the operation of a car with an internal combustion engine.

Real monitoring software uses a 20% hysteresis when determining whether an event has ended in order to prevent "bounce" of operation.

So, with the type of events “More than threshold”, the event P4 ends at (**TP** < P4m), provided that the event was observed, where P4m = 0.8 * P4. If the same condition is met with the type of events "More than 2 thresholds", the event P4 ends. But the P3 event will end at (TZP < P3m) provided that the event was observed, where P3m = 0.8 * P3. For event types “Less than threshold” and “Less than 2 thresholds”, event P1 ends at (P1p < TST) provided that the event was observed, where P1p = 1.2 * P1. In this case, the P2 event ends at (P2p < **TP**) provided that the event was observed, where P2p = 1.2 * P2. Similarly, for event types "Out of interval" and "Out of 2 intervals":

- the event P1 ends at (P1m < **TP**) provided that the event was observed;
- the P2 event ends at (P2m < **TP**) provided that the event was observed;
- the P3 event ends at (**TP** < P3p) provided that the event was observed;
- the P4 event ends at (**TP** < P4p) provided that the event was observed.

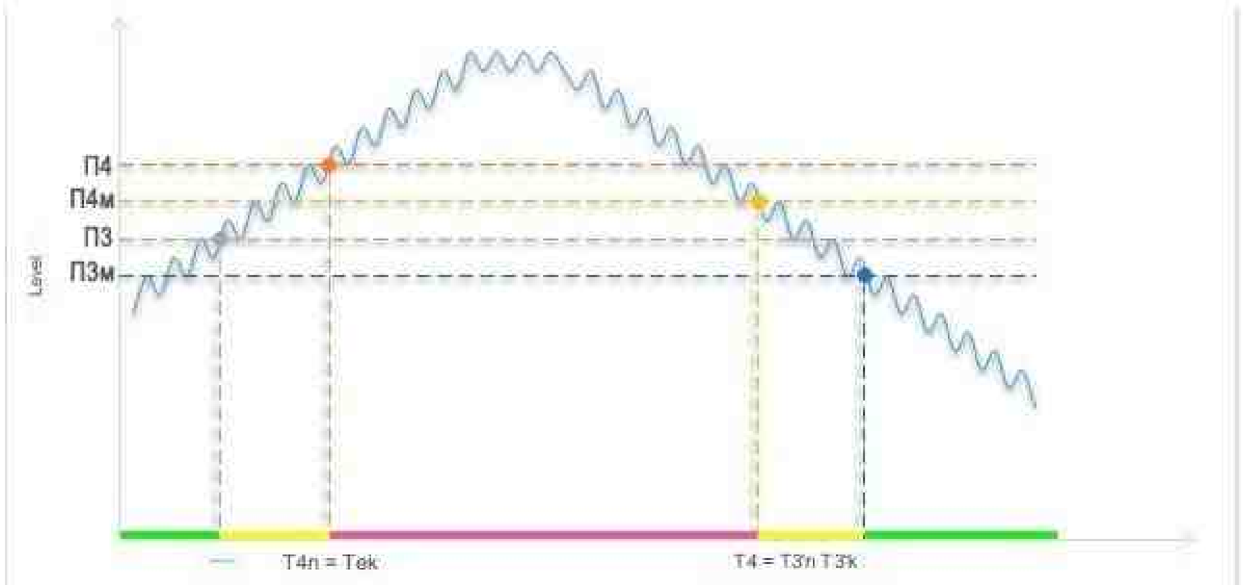
For clarity, the examples in the images show color indication of zones where:

- green zone — no monitoring event;
- yellow zone - an event of the "Warning" type is observed, i.e. P2 or P3;
- red zone - an event of the "Danger" type is observed, i.e. P1 or P4.

Event type "More than threshold"

The "Over Threshold" event type is suitable for monitoring engine temperature. At P4 = 105 °C, the "Danger" event indicates a malfunction in the cooling system and, as a result, the impossibility of continuing the operation of the engine due to the high risk of its failure (jamming).

More than threshold



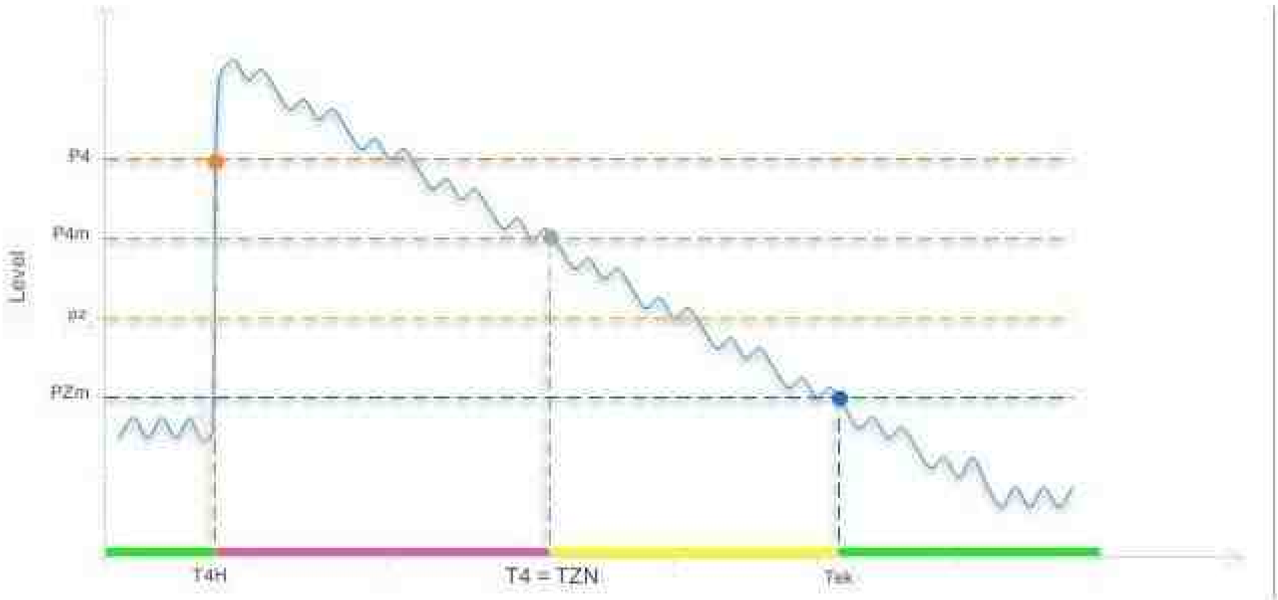
Time

T4n— start time of event P4;
T4k— end time of event P4.

Event type "More than 2 thresholds"

Using the event type "More than 2 thresholds" in this case may additionally issue a preliminary event of the type "Warning". At P3 = 100 °C, this event indicates the beginning of problems.

More than 2 thresholds



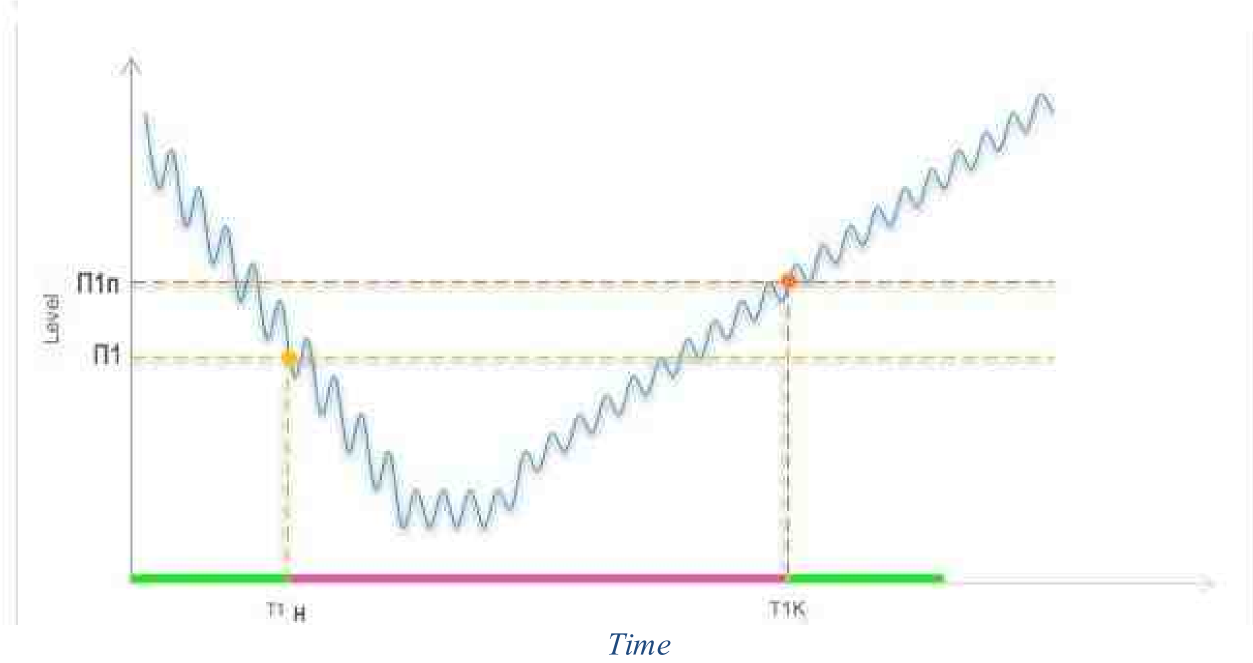
Time

In this case, the P4 event was observed from T4n to T4k, and the P3 event was observed 2 times: from T3n to T3k and from T3n to T3k, while T4n = T3k and T4k = T3n.

Event type "Less than threshold"

The "Less than threshold" event type is suitable for monitoring the amount of fuel in a car's tank. At P1 = 2 liters, the “Danger” event indicates a critical fuel level and, as a result, the impossibility of continuing engine operation due to the high risk of failure of the high-pressure submersible fuel pump.

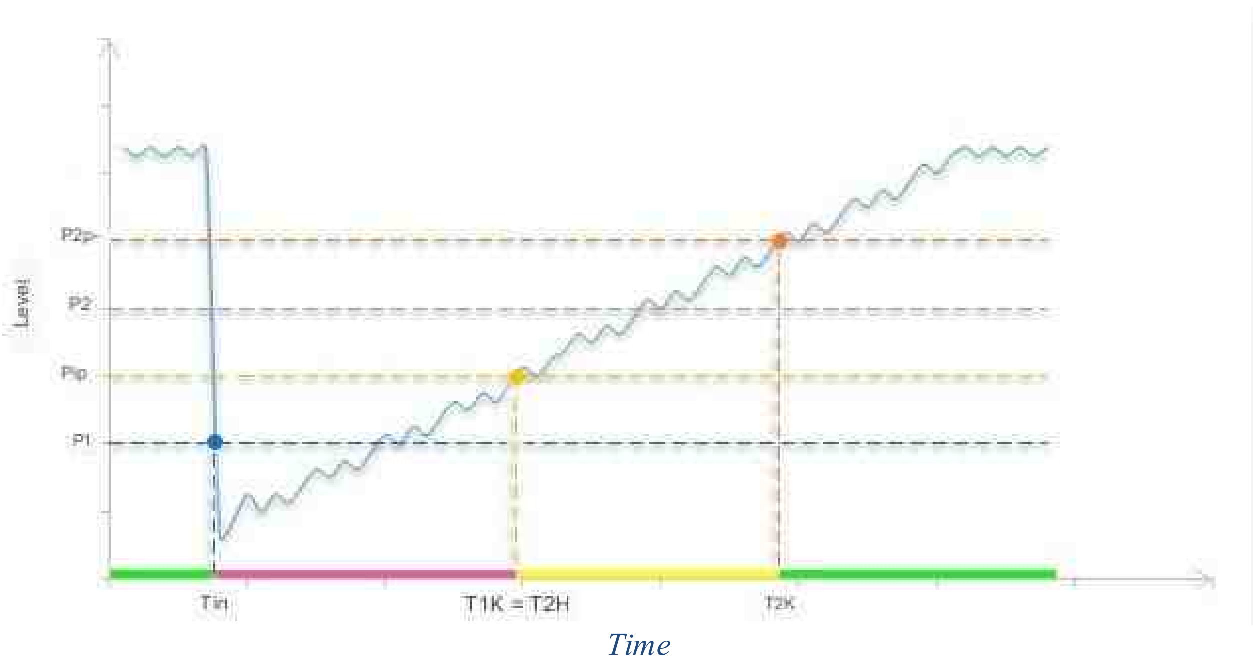
Less than threshold



Event type "Less than 2 thresholds"

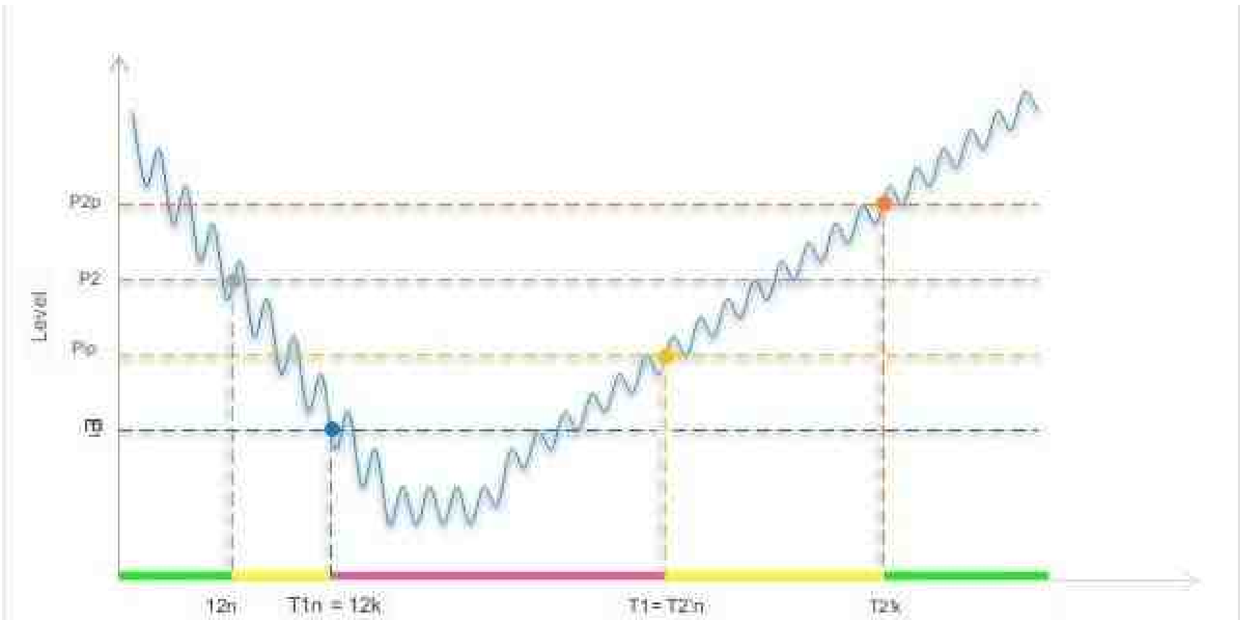
Using the event type "Less than 2 thresholds" in this case may additionally issue a preliminary event of the type "Warning". With P2 = 5 liters, this event indicates the need for refueling.

Less than 2 thresholds



In this example, the P1 event was observed from T1n to T1k, and the P2 event was observed from T2n to T2k.
In this case, T1k = T2n.

Less than 2 thresholds



Time

In this example, event P1 was observed from T1n to T1k, and event P2 was observed twice: from T2n to T2k and from T2'n to T2'k.
In this case, T1n = T2k and T1k = T2'n.

The Out of Range event type is suitable for monitoring engine speed. At P1 = 500 rpm, the “Danger” event indicates that there are problems in the engine power supply system and that the engine can stall at any second. At P4 = 7000 rpm, the "Danger" event indicates that the engine is experiencing heavy loads, the long-term impact of which greatly reduces the engine's service life, and engine failure is also possible.

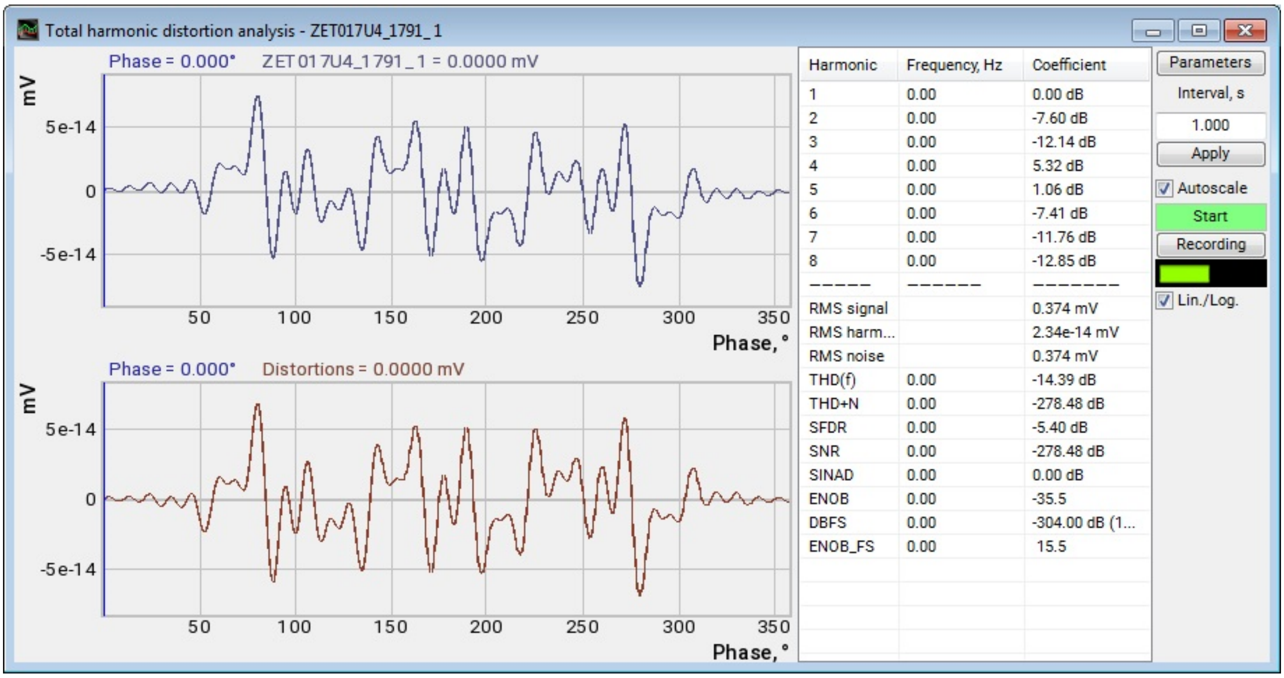
Using the event type "Out of 2 intervals" in this case may additionally generate pre-events of the "Warning" type. At P2 = 700 rpm, the "Warning" event indicates the beginning of problems in the power system. At P3 = 5000 rpm, the "Warning" event indicates the beginning of heavy loads on the engine.

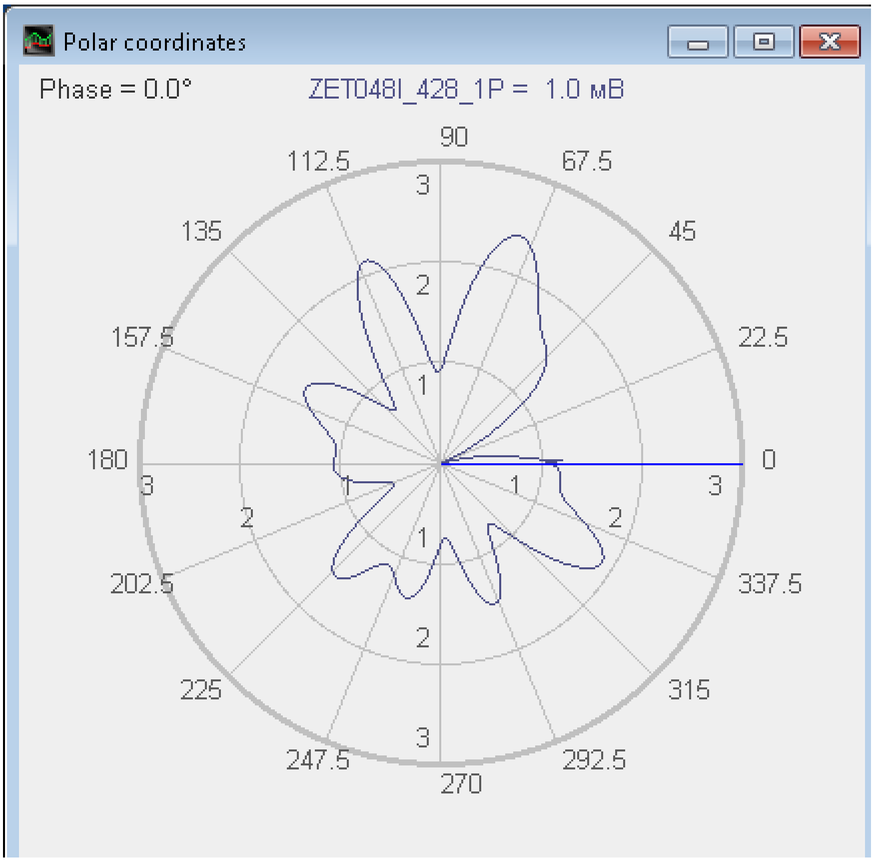
Harmonic Distortion Analysis .....

The program Harmonic Distortion Analysis is intended for automated measurement of non-linear distortion parameters and analysis of the form of the signals sent to the input channels of FFT Spectrum Analyzers. The frequency of the fundamental harmonic is detected automatically. Operating principle of the program is based on measurement of upper harmonics' RMS voltage value under external or internal reference signal.

The program has an integrated control and automation module from the scope of ZETLab-Studio software package. The module enables easy creation of individual software measurement suites.

The window of the program Harmonic Distortion Analysis depicts the graphic of the controlled signal and corresponding non-linear distortion form. The program also depicts frequency value of the fundamental harmonic and non-linear distortions measured parameters (in % or dB). The form of the non-linear distortions curve allows to evaluate deviation of the real signal from the theoretical sinusoidal curve.





Harmonic Distortion Analysis: functions of the program

The program is intended for automated measurement of non-linear distortion parameters and analysis of the form of the signals sent to the input channels of FFT Spectrum Analyzers. The frequency of the fundamental harmonic is detected automatically. Operating principle of the program is based on measurement of upper harmonics' RMS voltage value under external or internal reference signal.

The window of the program depicts the graphic of the controlled signal and corresponding non-linear distortion form. The program also depicts frequency value of the fundamental harmonic and non-linear distortions measured parameters (in % or dB). The form of the non-linear distortions curve allows to evaluate deviation of the real signal from the theoretical sinusoidal curve.

Theory

By non-linear distortions, we mean the distortions that occur in output signal frequency spectrum of the components, that are not present in the input signal. Total harmonic distortions are represented by changes in the fluctuation pattern of the signal in the electrical circuit (e.g., in amplifier or converter). These changes are attributed to imbalance between voltage instant values at input and output of the circuit. This process takes place when the output voltage parameters have non-linear dependence on the input voltage parameters. Quantitative evaluation of non-linear distortions is based on non-linear distortions ratio or harmonic ratio.

Total harmonic distortions ratio is a value that is used for non-linear distortions quantitative evaluation. Total harmonic distortions ratio is calculated as a ratio of RMS sum of output channels spectral components to the RMS sum of input channels spectral components.

$$K_{\text{H}} = \frac{\sqrt{U_2^2 + U_3^2 + U_4^2 + \ldots + U_n^2 + \ldots}}{\sqrt{U_1^2 + U_2^2 + U_3^2 + \ldots + U_n^2 + \ldots}}$$

Total harmonic distortion (also referred to as THD) is a value corresponding to the degree of non-linear distortion ratio of a device. The THD is calculated as a ratio of RMS voltage of upper harmonics to the voltage value of the first harmonic when a sine signal is sent to the input of the device.

$$K_{\Gamma} = \frac{\sqrt{U_2^2 + U_3^2 + U_4^2 + \ldots + U_n^2 + \ldots}}{U_1}$$

THD and non-linear distortion ratio can be represented in % or dB.

THD and non-linear distortion ratio have the following interrelation:

$$K_{\Gamma} = \frac{K_{\text{H}}}{\sqrt{1 - K_{\text{H}}^2}}$$

The program "Harmonic Distortion Analysis" is used for measurement of deviation of real signal form from the ideal sine signal. The program creates a virtual channel with a current non-linear distortion analysis, which can be used for further analysis in the programs from the scope of ZETLab software package, e.g., in the program "FR measurement" it is possible to evaluate the dependence of THD on the frequency value.

The program "Harmonic Distortion Analysis" provides data processing results in the format of the following characteristics:

1. THD - (Total Harmonic Distortion) is a value for harmonic distortion quantitative evaluation that is equal to rms output spectral components absent in the spectrum of the input signal to the RMS sum of all the spectral components of the input signal.
2. SNR - (Signal-to-Noise Ratio) is a dimensionless ratio, equal to the ratio of the desired signal power capacity to the noise power capacity.
3. THD+N - (Total Harmonic Distortion with Noise) is a dimensionless quantity, equal to the ratio of signal power capacity to the sum of distortion and noise power capacity.
4. SFDR - (Spurious-Free Dynamic Range) is a dimensionless quantity, equal to the ratio of useful narrowband signal power capacity (carrier) to the power capacity of the most powerful parasitic frequency component (harmonic).
5. SINAD - (Signal-to-Noise And Distortion ratio) is a dimensionless quantity, equal to the ratio of signal power amount of distortion and noise to the sum of distortion and noise power capacity.
6. ENOB - (Effective Number Of Bits) is a real number of different output levels, which can be achieved in this ADC/DAC.

The program is set up that the input signal is a stationary sine signal. The program determines the fundamental frequency and harmonic frequency. The amplitudes of all harmonics are determined by means of selective voltmeter algorithm. All signals minus harmonic signals are considered noise.

To estimate calculation errors parameters the following approach is used: signal with known parameters is simulated, this signal is fed to the input of THDA program, parameters are calculated and then specified and calculated parameters are compared. Simulation of signals can be performed by “Signals generator” program: the amount of reference signals with specified characteristics is set up by means of the program, and these parameters are defined by means of THDA program. Each ratio of preset parameters can have its own deviations from the expected values and therefore its own errors. By means of the generator program, it is possible to select a sum of the signals for two sinusoids, white noise signal, triangle-shaped signal, square wave signal, etc. This makes it possible to estimate a dispersion of calculated parameters and their deviation from the expected values.

See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Setting parameters of display
- Using signal level indicators
- Adjustment of the color scheme used for displaying of the registered signal amplitude values
- Graphical and numerical data transfer to text editors
- Setting GridGl grid functionality

Supported Hardware .....

Input data program **Harmonic Distortion Analysis** are digital data channel server **ZETLAB**, which are output signals of the sensors of linear and angular displacements.

For the purpose of analog signals digital processing, it is possible to use *FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01, noise- and vibration-meters ZET 110* and *seismic recorder ZET 048*.

Settings of measurement channels are specified in the program "Device Manager".

The software **Harmonic Distortion Analysis** is included with the following software:

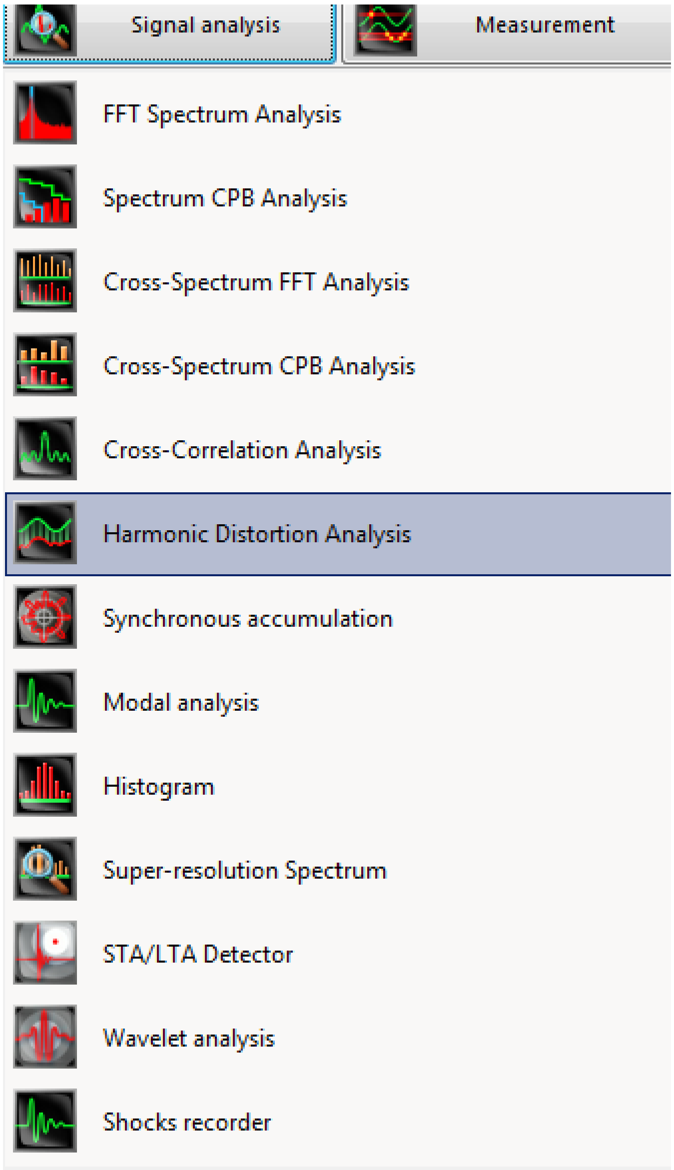
- ZETLAB ANALIZ – FFT Spectrum software
- ZETLAB VIBRO – Shaker controllers systems software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software.

Harmonic Distortion Analysis is included in the **Signal Analysis** software group.

Program description .....

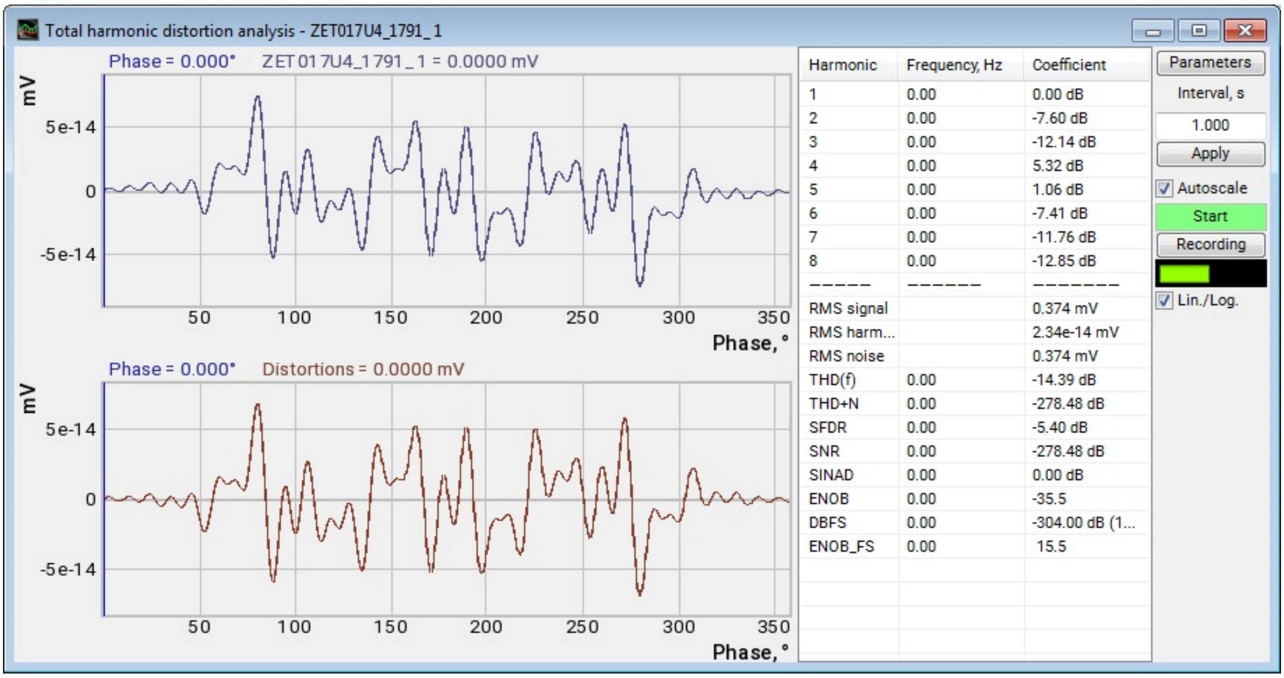
To start the program "**Harmonic Distortion Analysis**", select the corresponding option in the "Signal analysis" menu of ZETLab panel. You will see the program window. The top section of the window displays the name of the program and the name of the channel used for analysis.

Note: the program "Harmonic Distortion Analysis" can be also started from ZETLab directory (by default: c:\ZetLab\). The name of the file to be started: harmdist.exe



Starting the "Harmonic Distortion Analysis"

The title of the window will display the name of the program itself and the name of the selected channel.



Window "Harmonic Distortion Analysis"

The program "Harmonic Distortion Analysis": control

The key **"Parameters"** activates the window "Parameter adjustment". The field "Interval" allows to set time interval of graphics representation. To change the interval, left-click the section and enter corresponding values from the keyboard, click "Apply" option or "Enter" key. The key "Start" enables display of the graphs. When the program is started, the key "Start" is active by default. The "**Stop**" key suspends the process of signal displaying and numerical data updating. However, the data accumulation process at the server continues and other programs are still active.

Upon activation of the "**Recording**" key there appears a standard dialog window, offering the user to select the directory for saving the file and the file directory (by default: C:\ZetLab\result\). The file is saved with *.dtx extension. The file contains data description, and the data in floating point format (the point is used as a separator between the integral and fractional parts). The "**Indicator**" displays the signal’s integral level and overloading. The indicator field is filled with red color in the case if the signal level exceeds the set threshold level. The indicator field remains red until the user left-clicks it.

The checkbox "**Autoscale**" key is used for automated scaling of both graphics by signal level.

The checkbox "**Lin./Log.**" Allows to switch between harmonics representation in dB (checked) and % (unchecked).

To exit the program "**Harmonic Distortion Analysis**", left-click the corresponding icon in the top right section of the program interface.

See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Setting parameters of display
- Using signal level indicators
- Adjustment of the color scheme used for displaying of the registered signal amplitude values
- Graphical and numerical data transfer to text editors
- Setting GridGl grid functionality

Program settings .....

The "**Parameters**" key (located in the top right section of the program interface) activates the window "**Settings**" .

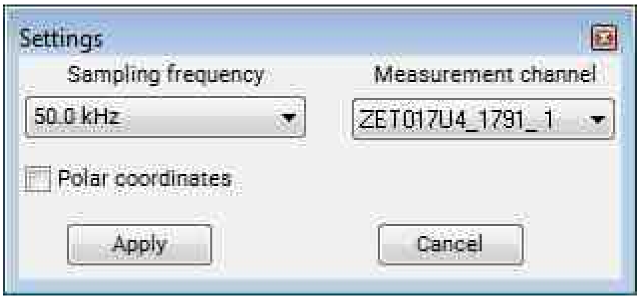
In the top section of the window, you can see sampling frequency value in Hz.

The fields  allow to assign values in two ways. You can select the necessary value in the dropdown list or enter the value using the scroll wheel.

The list "**Sampling frequency**, Hz" allows to set various frequency resolution values (in Hz).

The list "**Measurement channel**" allows to select module channels.

The checkbox "**Polar coordinates**" allows to enable additional representation type.



The "**Apply**" key saves the parameters configuration and closes the configuration window.

The "**Cancel**" key cancels the parameters configuration process and closes the configuration window. The configuration window can also be closed with the corresponding icon at the top right section of the program interface.

Conditions for carrying out signal simulation .....

Function.

The program "Harmonic Distortion Analysis" is used for calculation of non-linear distortions ratio, THD, signal-to-noise ratio (SNR), effective number of bits of ADC converter.

.

The program "Harmonic Distortion Analysis" is used for calculation of the following parameters:

Total harmonic distortion (THD) – this parameter is used for quantitative evaluation of device's (e.g., amplifier) non-linear distortions. This parameter is calculated as a ratio between voltage RMS of upper harmonics (except for the first one) to the voltage of the first harmonics when a sine signal is applied to the input of the device.

Signal-to-noise ratio (SNR) is a dimensionless quantity, which is calculated as a ratio of useful signal to noise power.

Total harmonic distortion + noise (THD+N) – a dimensionless quantity, that is calculated as a ratio of signal power to the sum of distortion and noise power.

Spurious-free dynamic range (SFDR) – a dimensionless quantity, which is calculated as a ratio of useful narrow-band signal power to the power of the major distortion component (harmonic).

Signal-to-noise and distortion (SINAD) – a dimensionless quantity, which is calculated as a ratio of signal power, distortion and noise to the total power of distortion and noise.

Effective number of bits (ENOB) – a real amount of various output signal levels available for a particular ADC/DAC.

The program takes a stationary sine signal as an input signal. The program determines its carrier frequency and harmonics frequencies. Amplitude values of the harmonics are calculated based on selective voltmeter algorithm. The signal without harmonic signals is considered to be the noise signal.

For the purpose of parameters calculation accuracy evaluation, there is used the following approach: a signal with pre-set parameters is sent to the input of "Harmonic Distortion Analysis" program. The program calculates the necessary parameters and then the obtained parameters are compared with the pre-set parameters. The signal with the pre-set parameters can be generated by means of the program "Signals generator". This program generates a sum of reference signals with pre-set characteristics, then the program "Harmonic Distortion Analysis" is used for calculation of the corresponding parameters. Each of the set parameters can have deviation from the calculated values and the corresponding tolerance. Using the program "Signals generator", the user can generate a sum of two sine signals, white noise, triangular, and rectangular signal, etc. It allows to evaluate the resulting dispersion of the calculated parameters and their deviation from the pre-set parameters.

Signals generation guide.

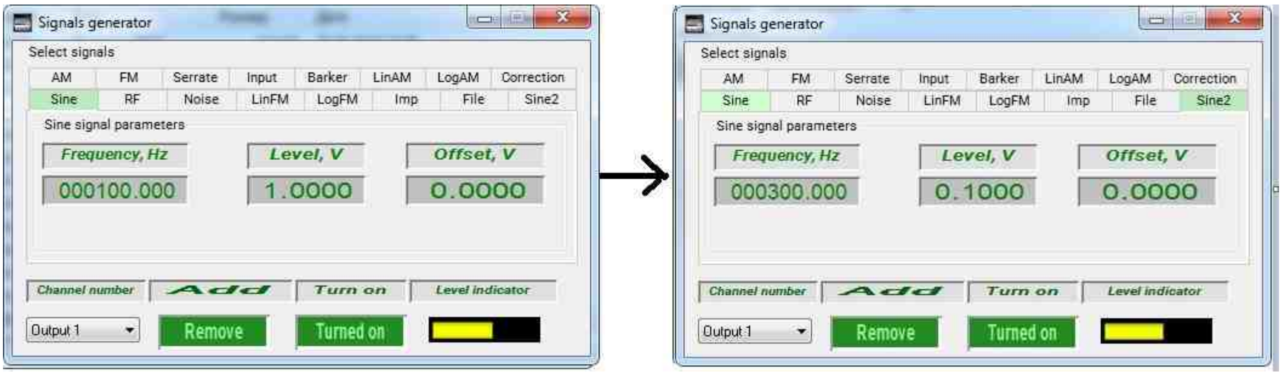
For the purpose of program performance evaluation, it is necessary to set the device in such a way, so that it would have the same value of ADC and DAC sampling frequency – 25 kHz.

Start the program "Signals generator" (hereinafter referred to as "generator").

Start the program "AC Voltmeter" (hereinafter referred to as "voltmeter") and set it for RMS measurement in slow mode (1 second) by generator's channel ("Generator 1").

For illustrative purposes, it is also necessary to start the programs "Multi-channel oscilloscope" and "FFT Spectrum Analysis".

THD (total harmonic distortion) evaluation:
The "THDA" program calculates total harmonic distortion coefficient (hereinafter referred to as THD). THD is a value expressing the degree of harmonic distortion of a device (amplifier, etc.). It is equal to the ratio of rms voltage of the sum of high-order harmonic signal (except for the first one) to the first harmonic voltage when device input is affected by sine signal.
First example
Add "sine" signal in the "Generator" program and set frequency to 100 Hz and level to 1 V.



It is necessary to measure the generator signal level with "Voltmeter" program – it must be equal to 1,000 mV.

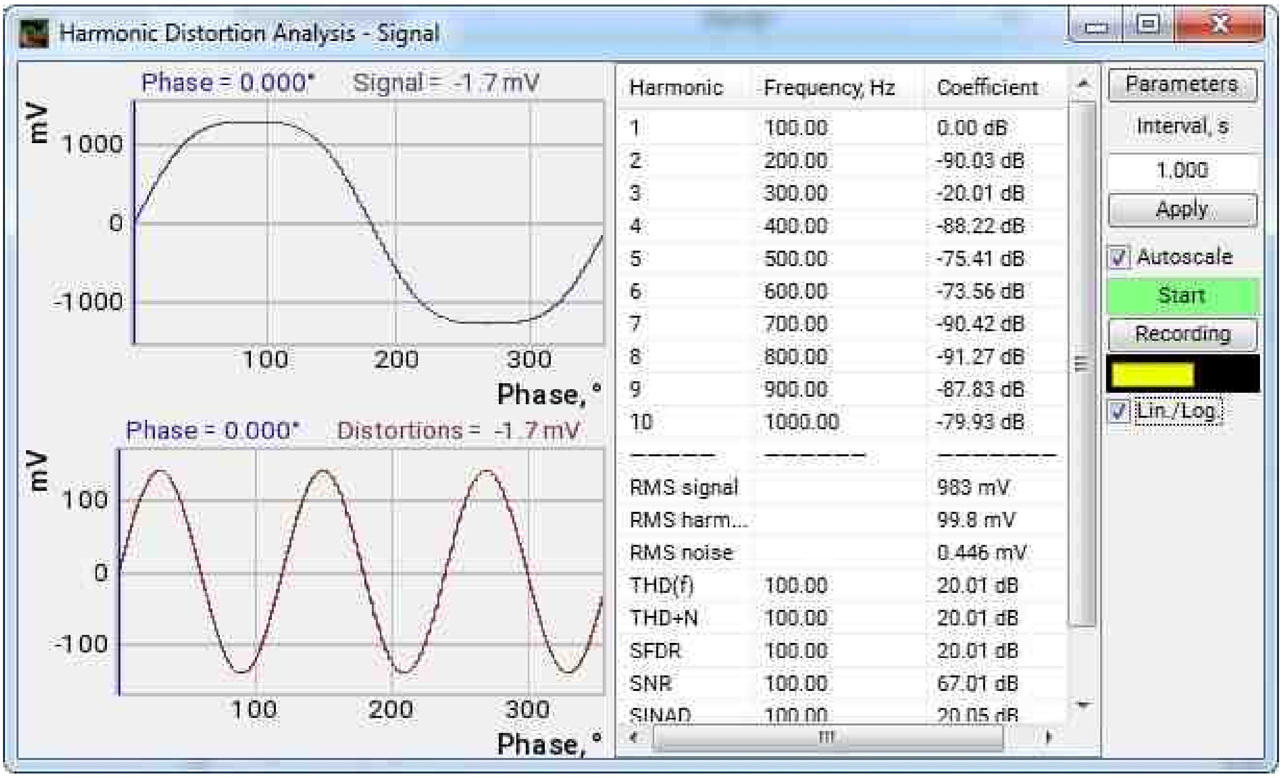
Add "sine2" signal ("sine" signal should be temporarily removed) in the "Generator" program and set frequency to 300 Hz and a level to 0.1 V.

It is necessary to measure the generator signal level with “Voltmeter” program – it must be equal to 100 mV.

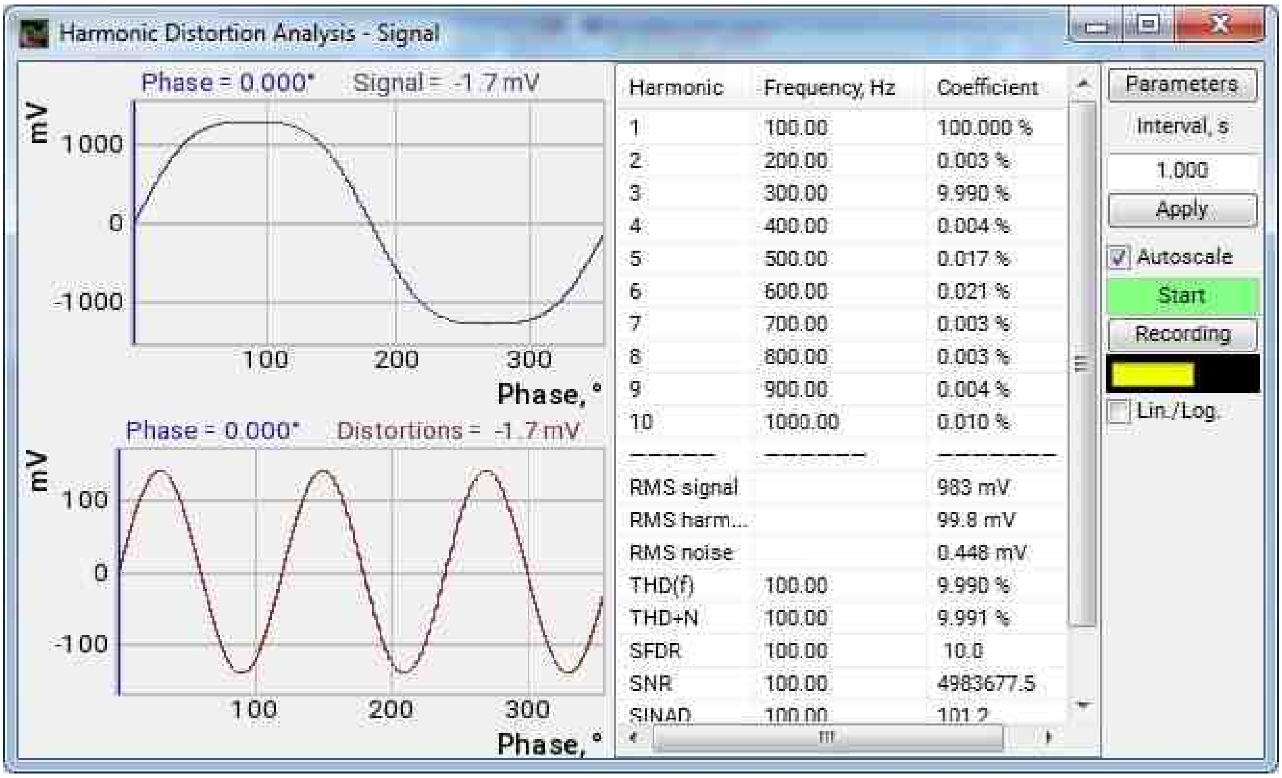
Next, add “sine” signal again in order to measure the THD in “THDA” program. The measurement results must be compared with the results of THD calculations according to a formula:

$$THD(f) = \frac{\sqrt{U_2^2+U_3^2+...+U_n^2}}{U_1} \cdot 100\%$$

In the example set above, THD should result 10% or 20 dB (you can switch between the calculation results indicated in percentage or decibels by ticking “lin/log” boxes).



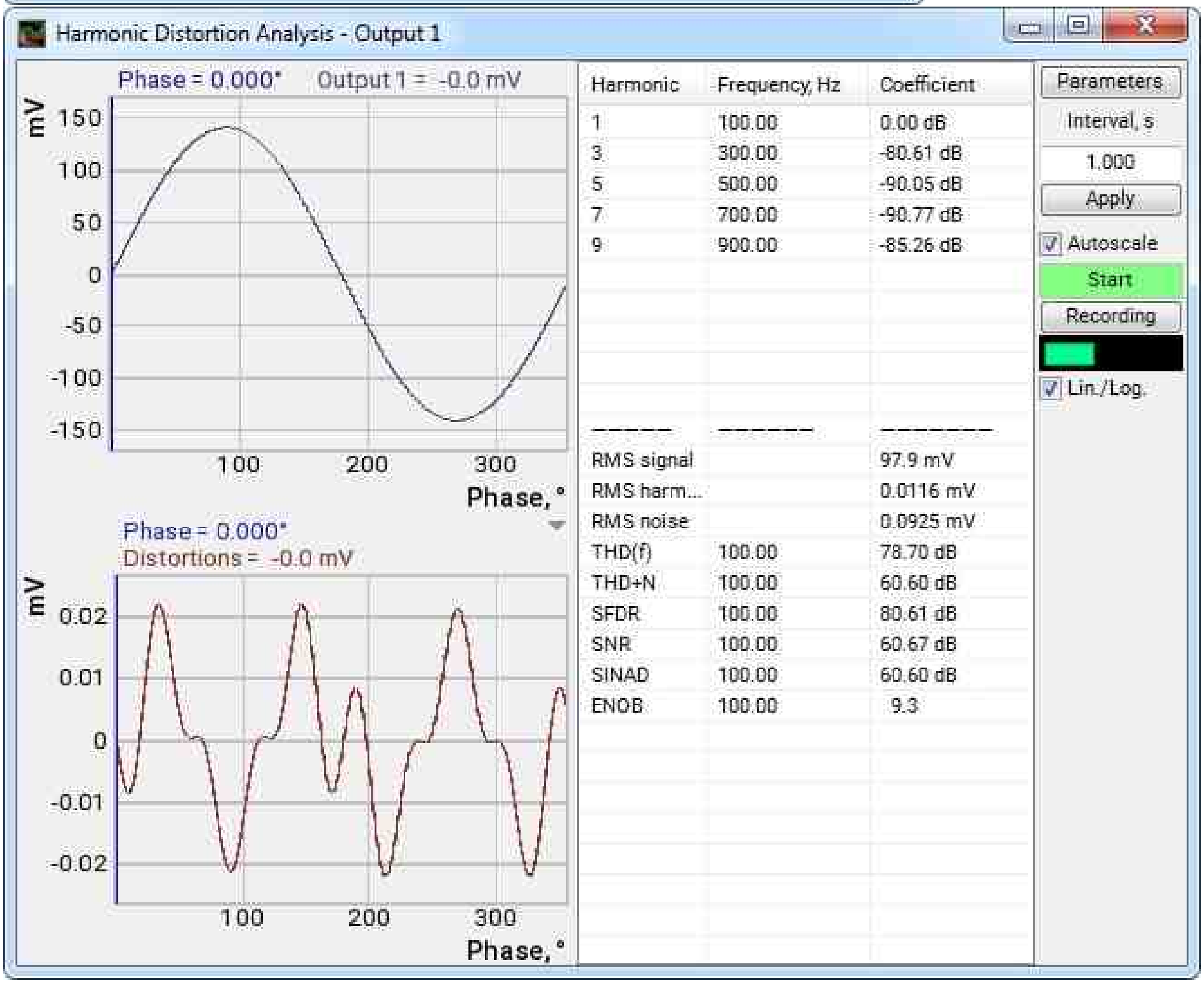
Click the checkbox "lin/log" get the coefficient in dB.



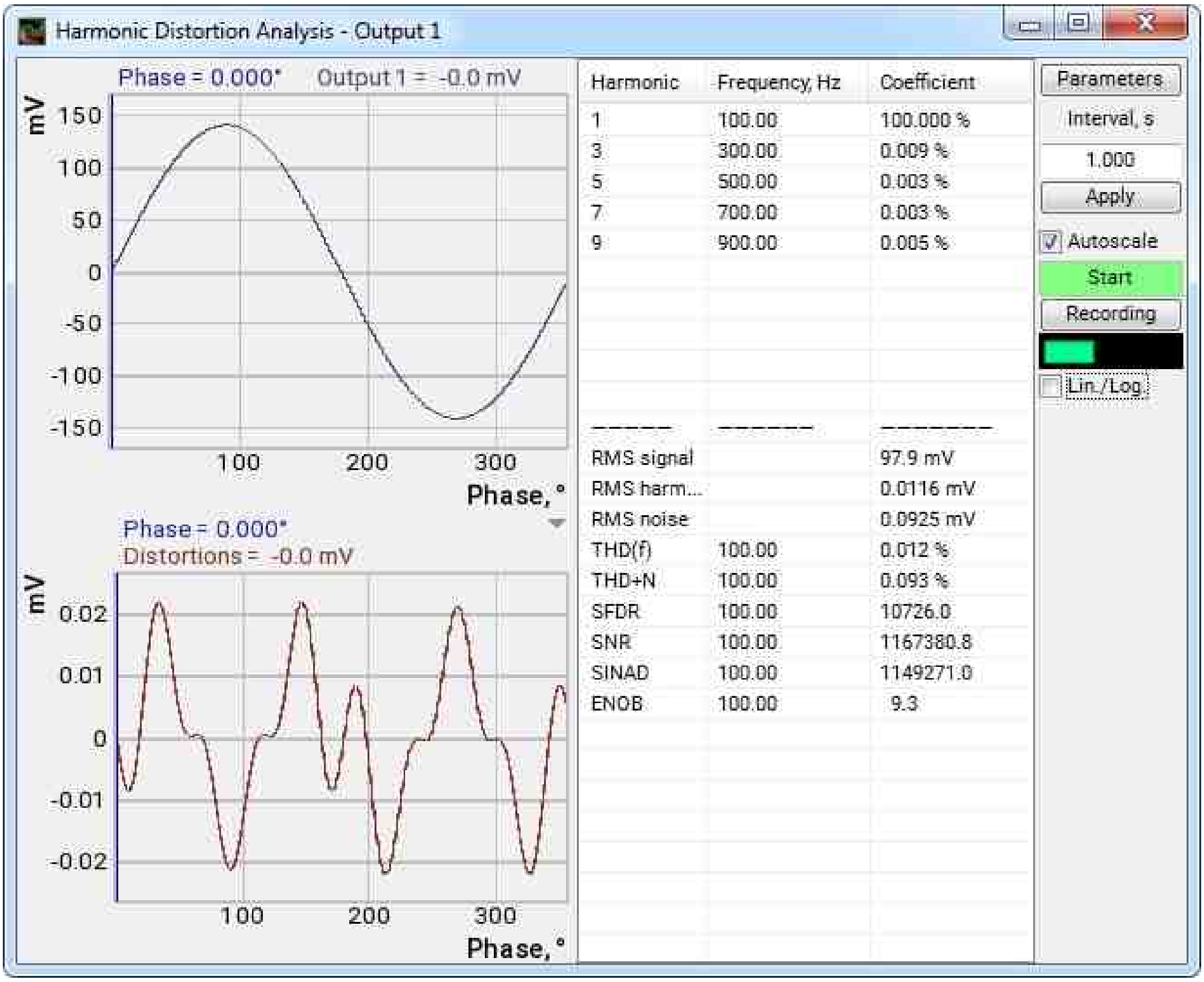
Without the "lin / log" checkbox, the coefficient will be in %.

The range of measurement error must be at 0.1% or 0.01 dB.
Due to limited number of ADC and DAC bits (ADC – measuring channels, DAC – generators) the accuracy of measurement results will increase with a decrease in signal power capacity. Spectrum analyzer digital resolution is approximately 0.3 mV. Furthermore, RMS value of measuring channels nonremovable noise is approximately 0.25 mV.

For example, for a sine signal of 1 mV rms, and the level of the third harmonic of 0.1 mV the results are as follows.



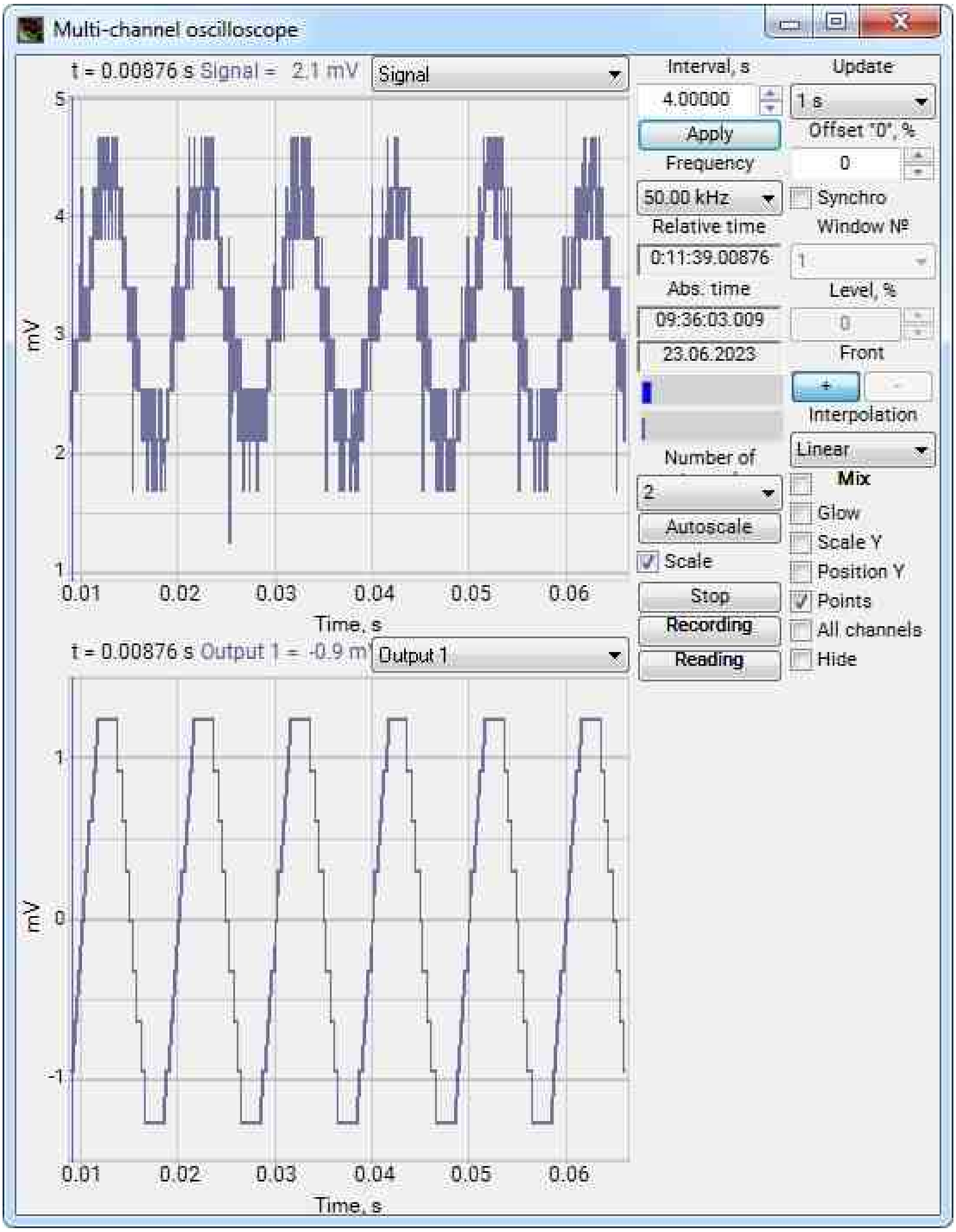
Click the checkbox "lin/log" get the coefficient in dB.



without ticking “lin/log” boxes coefficient in %.

Thus, you can make the following conclusion: the higher is the signal power, the higher is the measurement inaccuracy .


Signals generator
Select signals
AM
FM
Serrate
Input
Barker
LinAM
LogAM
Correction
Sine
RF
Noise
LinFM
LogFM
Imp
File
Sine2
Sine signal parameters
Frequency, Hz
000100.000
Level, V
0.0010
Offset, V
0.0000
Channel number
Add
Turn on
Level indicator
Output 1
Remove
Turned on

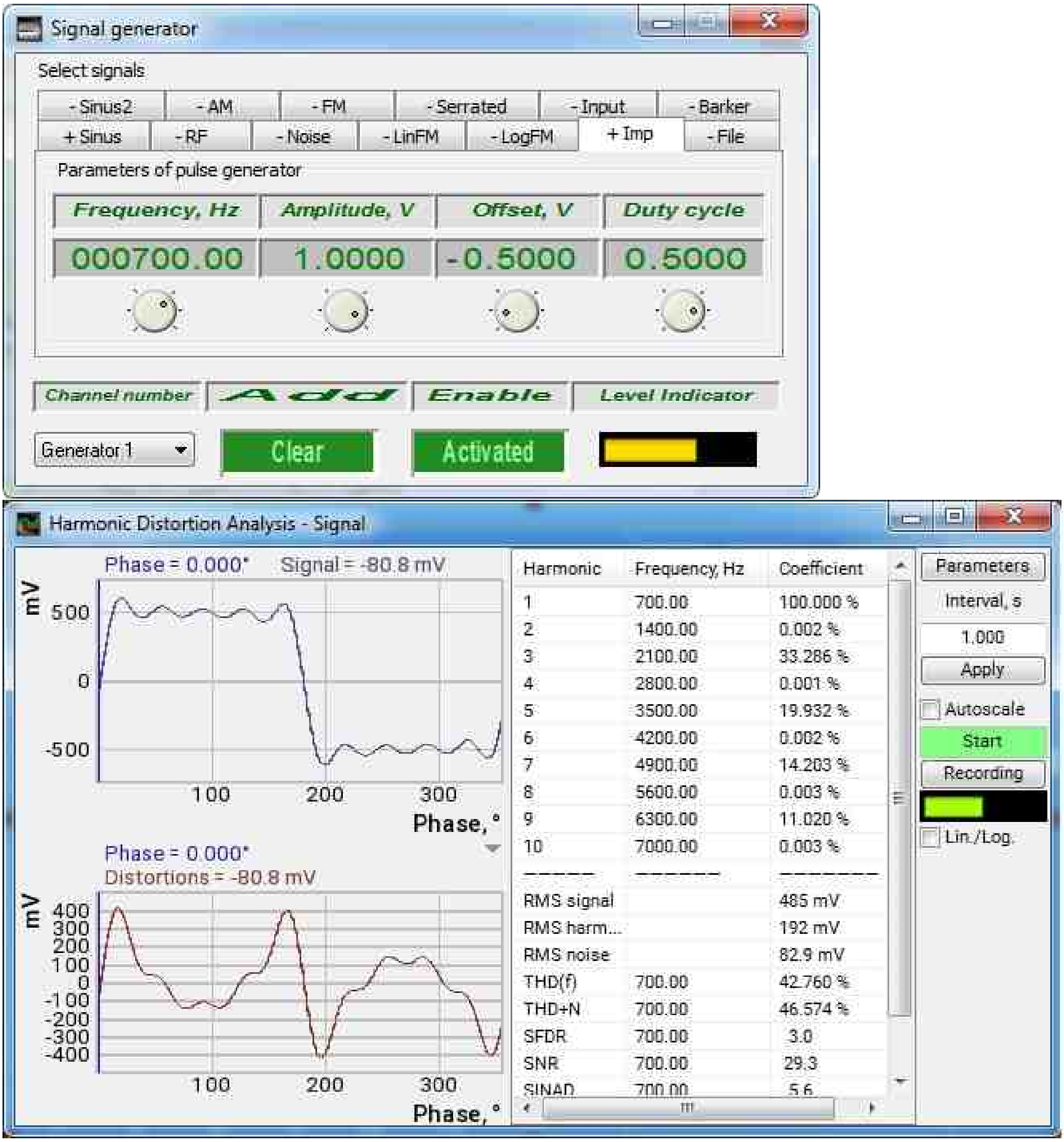


Second example

In the case of standard signals, the THD can be calculated in analytical way. Thus, using the generator program, it is possible to set standards signals and to compare the measurements results obtained with the calculation results.

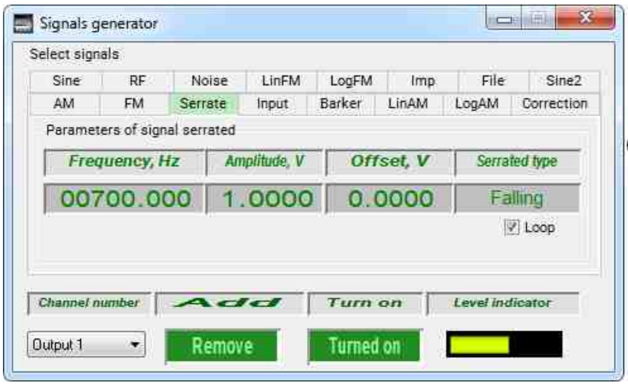
Symmetrical meander signal has the THD of 48.3 %.

In order to create a symmetrical rectangular signal, start the generator program, add the "Imp" signal, set the frequency of 700 Hz, amplitude of 1 V, displacement of 0 V, and duty ratio of 0,5.

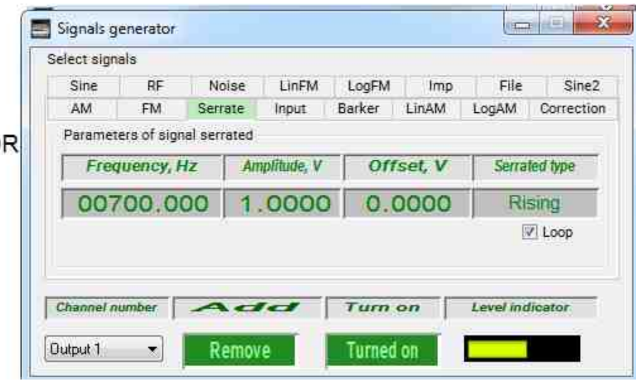


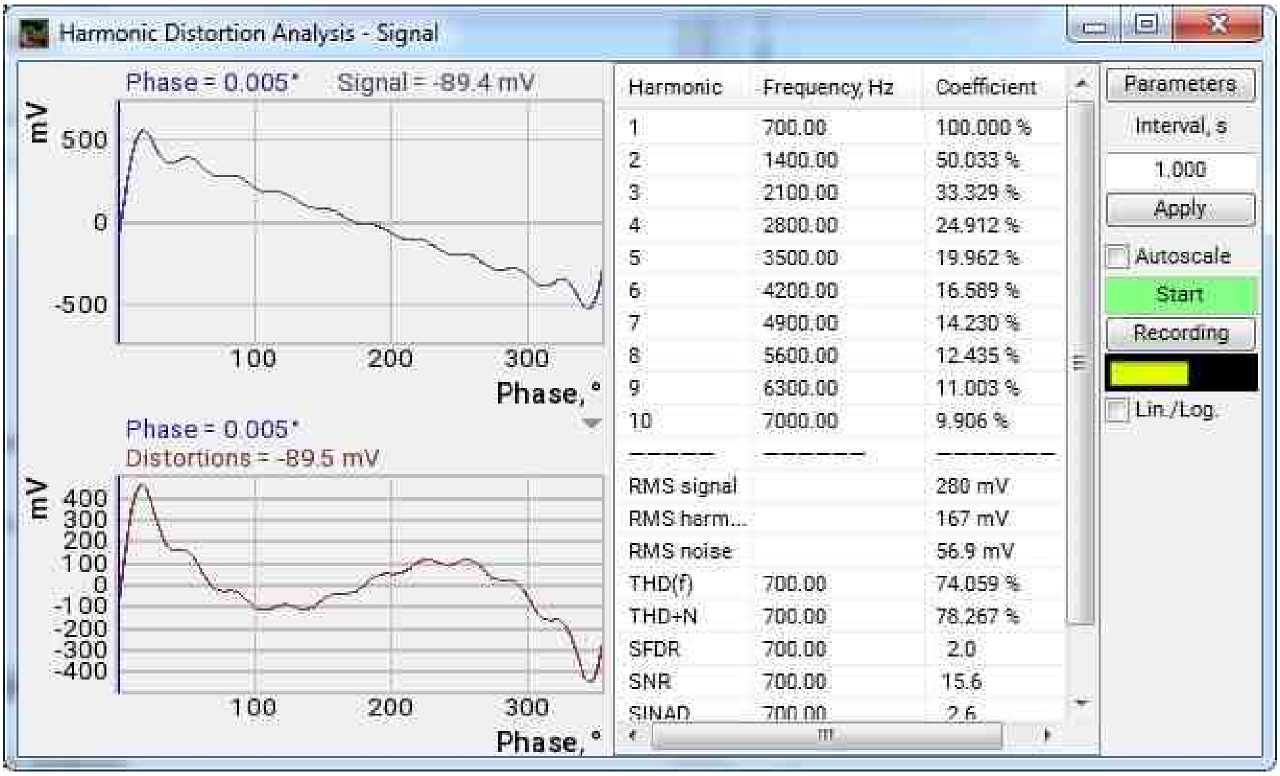
An ideal saw-shaped signal has the THD of 80.3%.

To generate an ideal serrate signal, start the generator program, add "Serrated" signal, set the frequency of 700 Hz, amplitude of 1 V, displacement of 0 V and Falling / Rising type.

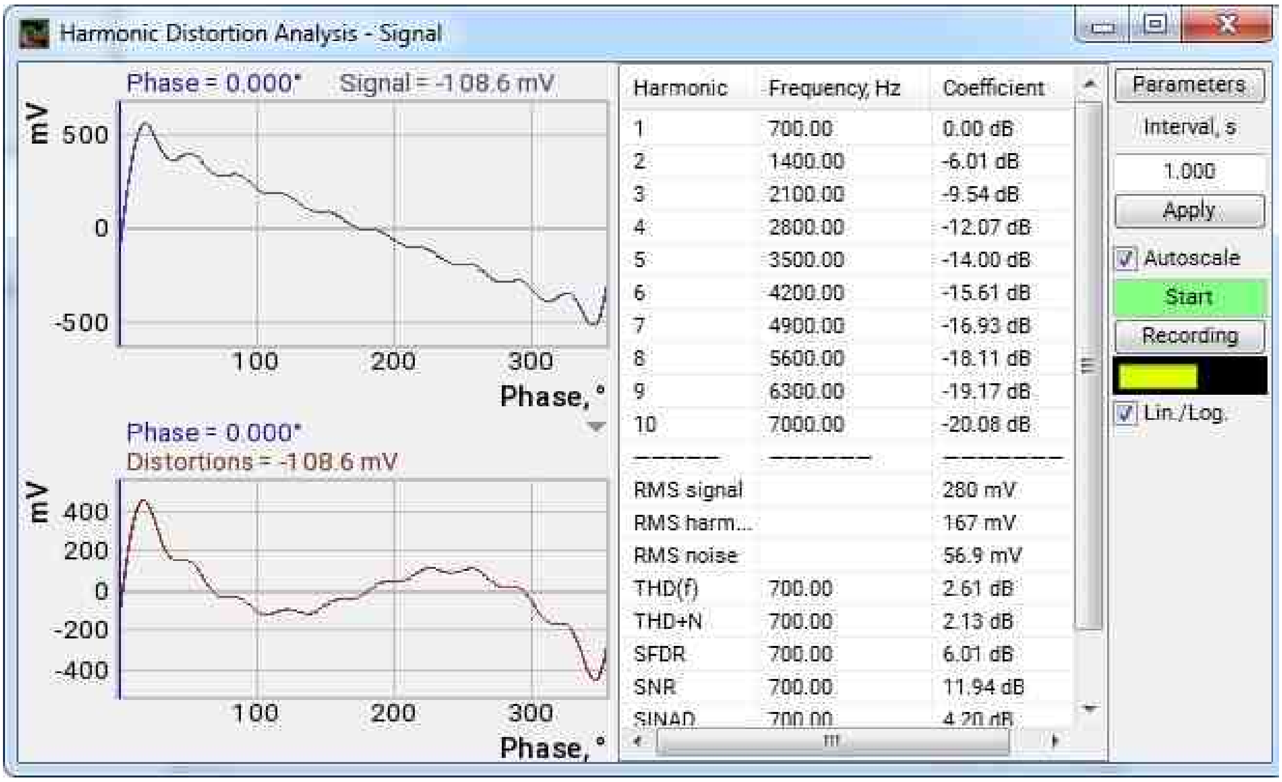


OR





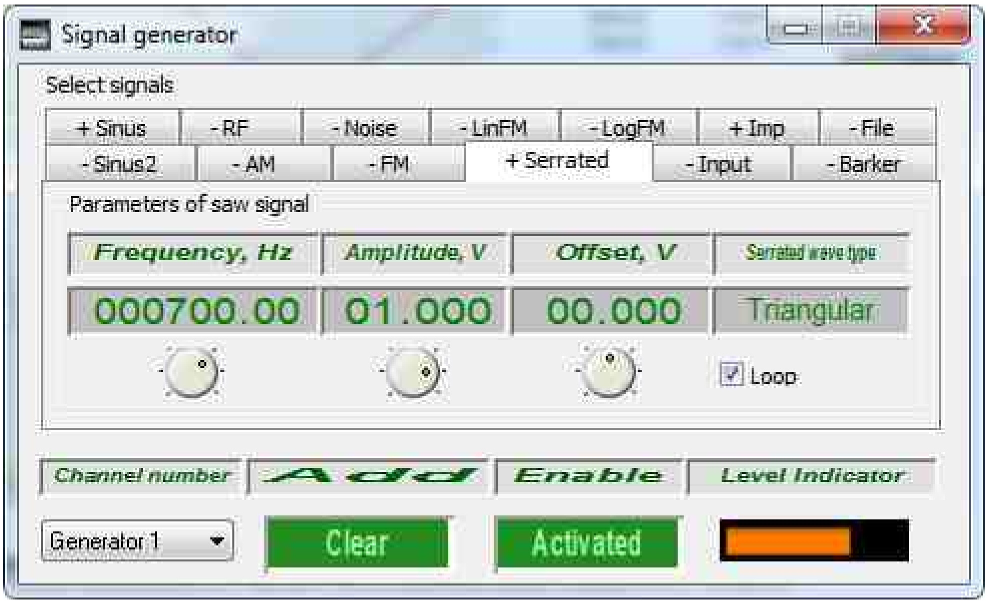
"Serrated" signal falling type.

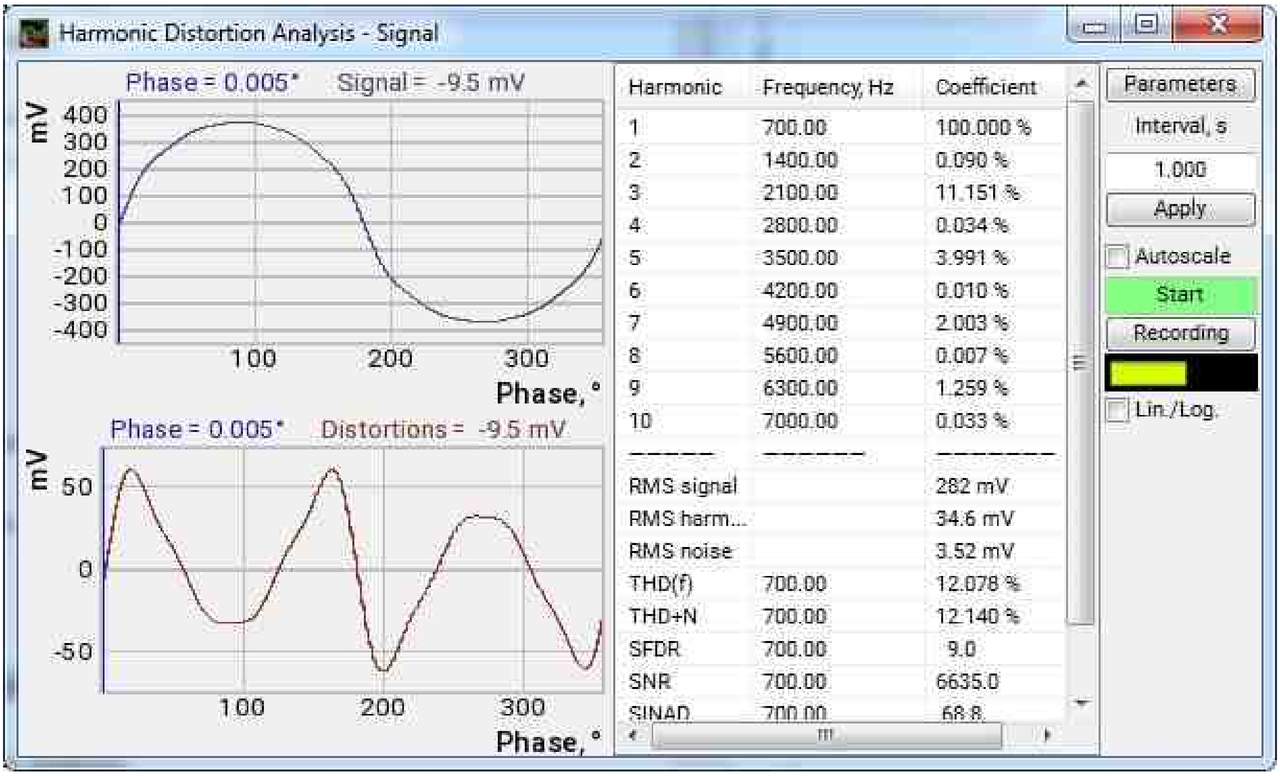


"Serrated" signal rising type.

A symmetrical triangular signal has the THD of 12,1%.

In order to generate a symmetrical triangular signal, start the generator, add "Serrated" signal, set the frequency of 700 Hz, amplitude of 1 V, displacement of 0 V and triangular type.





SNR (Signal-to-noise ratio) evaluation:

Start the generator, add the sine signal, set the frequency of 100 Hz, level of 1 V. The voltmeter reading should be 1000 mV. This will be the signal value – S.

Then remove the sine signal and add the noise signal. Set the level of 0,1 V and the "noise" type. The voltmeter reading should be about 100 mV. This will be the noise value – N.

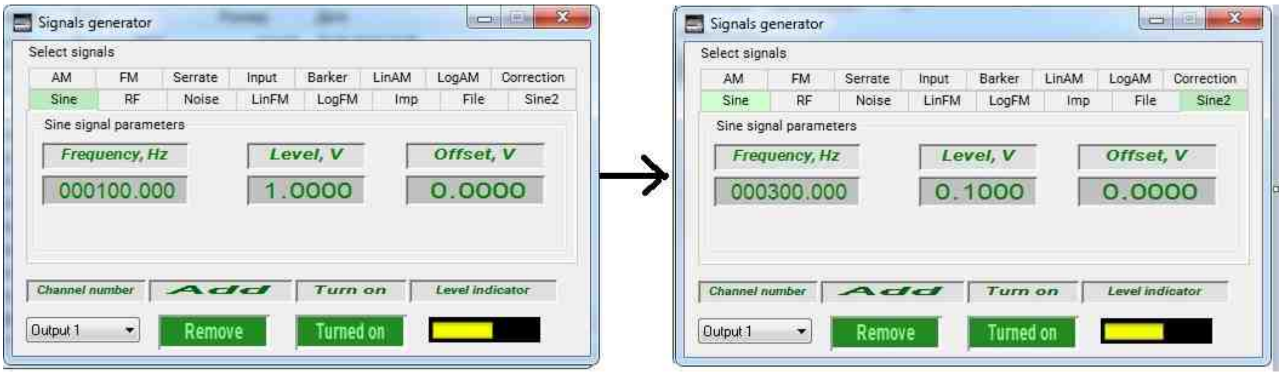
Then add the sine signal again, measure the resulting signal with the "Harmonic Distortion Analysis" program. Compare the measurement results obtained with the use of "Harmonic Distortion Analysis program" to the SNR calculation results obtained by means of the formula.

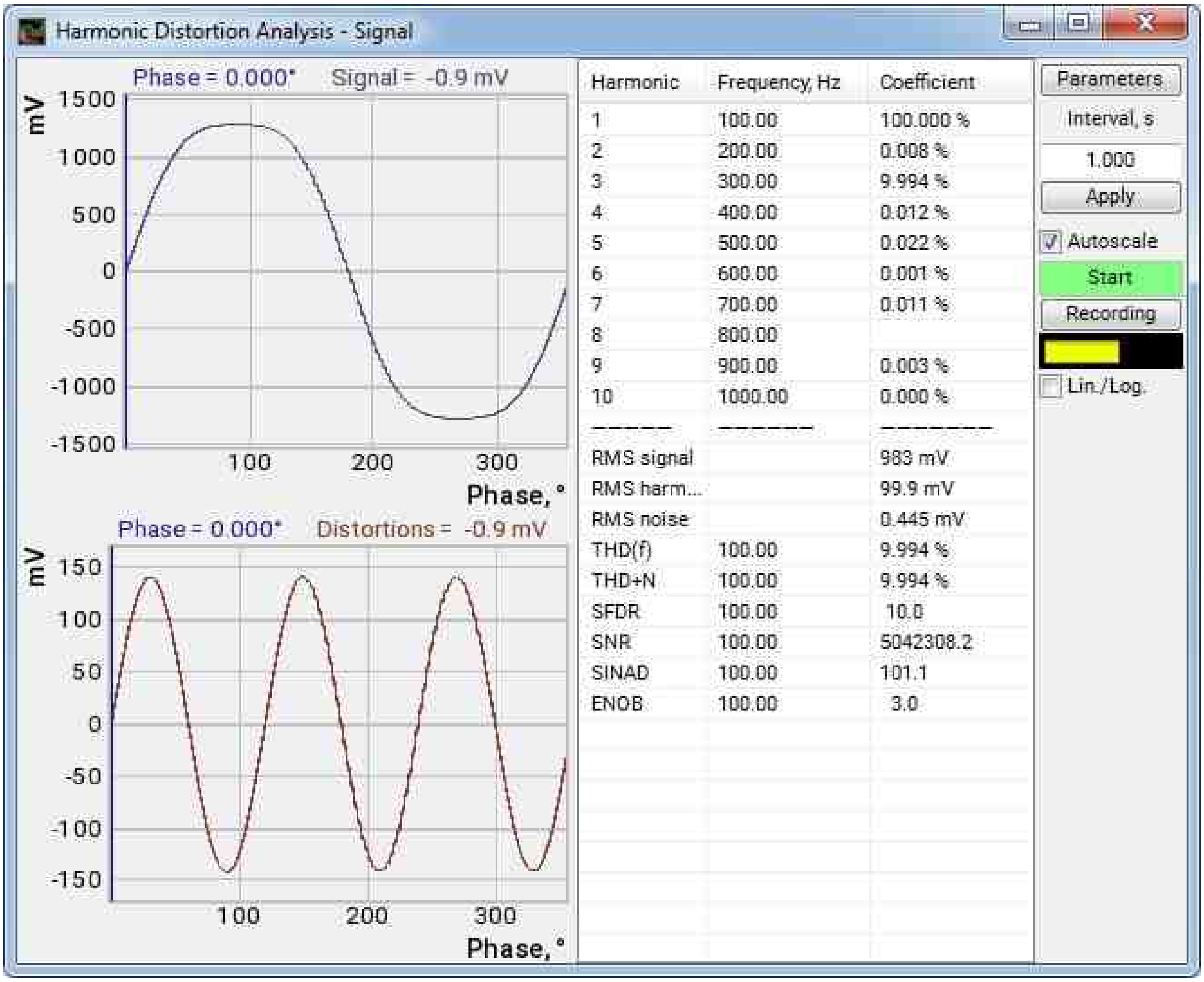
$$SNR = 10lg\frac{P_S}{P_N}$$

.

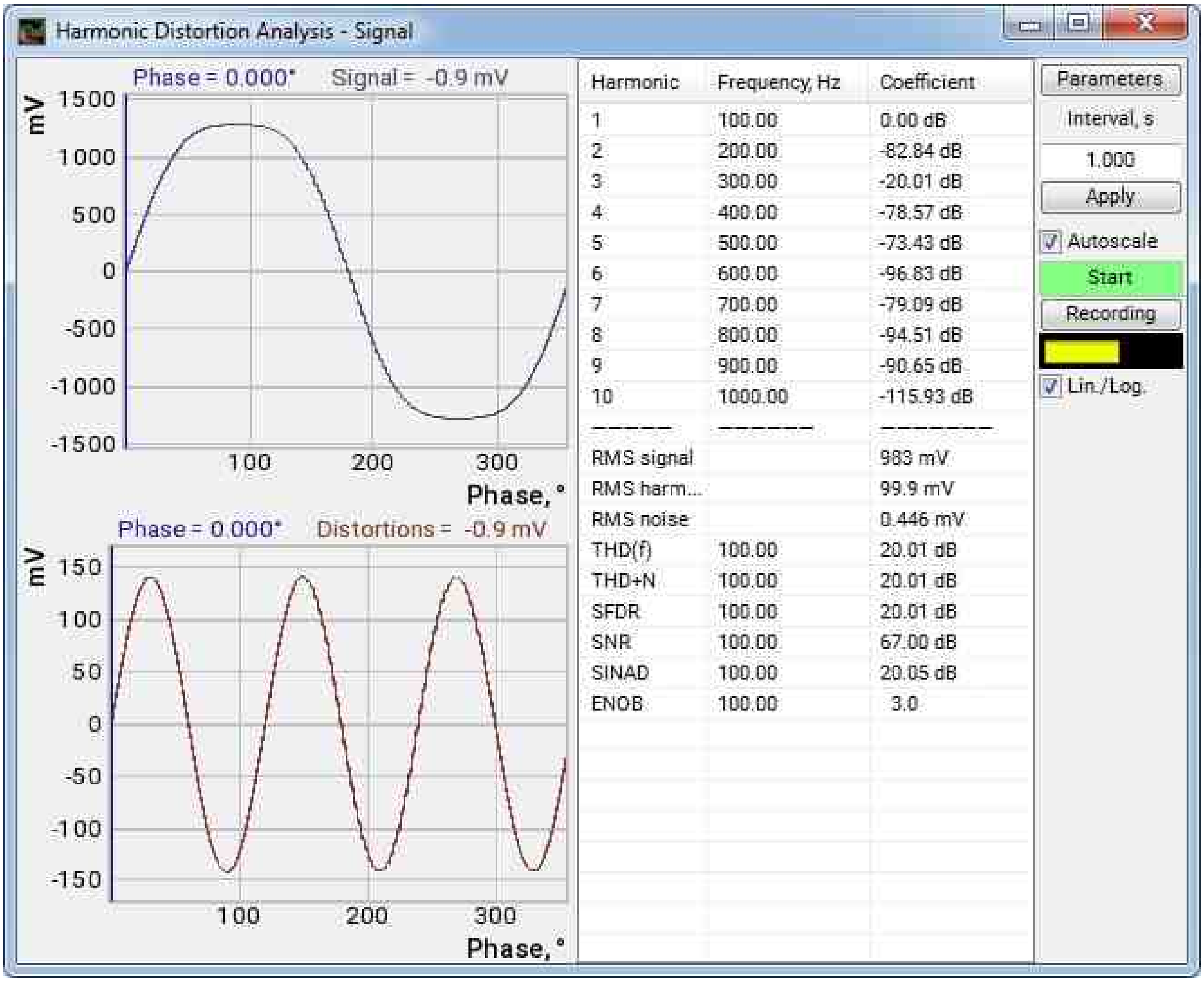
Based on the above mentioned parameters, the SNR should be 20 dB or 100 (thus, signal energy is 100 times bigger than the noise energy value).

The difference of the measurements results attributed to the noise distortion should not exceed 0,5 dB or 5 times.





Click the checkbox "lin/log" get the coefficient in dB.



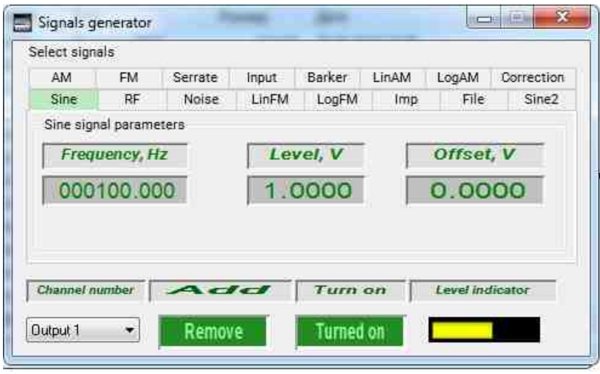
without ticking "lin/log" boxes coefficient in %.

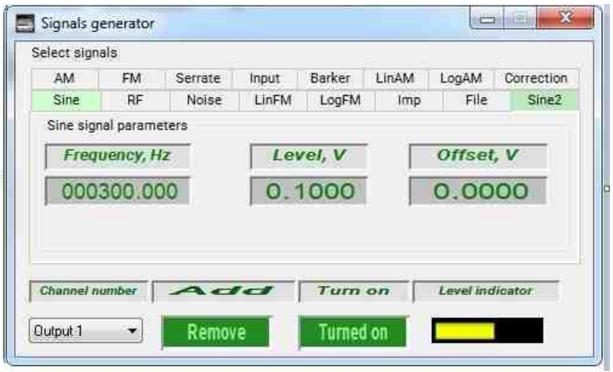
THD+N (Total Harmonic Distortion and Noise) evaluation:

Add "sine" in the generator, set frequency to 100 Hz, level to 1 V and turn on the generator. The voltmeter should read 1,000 mV. This will be the signal value — S.
Then, remove the "sine" and add "sine2", set frequency to 300 Hz, level to 0.1 V, set the type of noise to "white." The voltmeter should read approximately 100 mV. This will be the value of distortion — D.
Finally, it is necessary to remove the "sine2" and add "noise", set level to 0.1 V, set the type of noise to "white." The voltmeter should read approximately 100 mV. This will be the value of the noise — N.
Next, re-enable "sine" and "sine2" and measure the total signal in the "THDA" program. The measurement results obtained from the "THDA" program must be compared with the results of THD + N calculations according to a formula

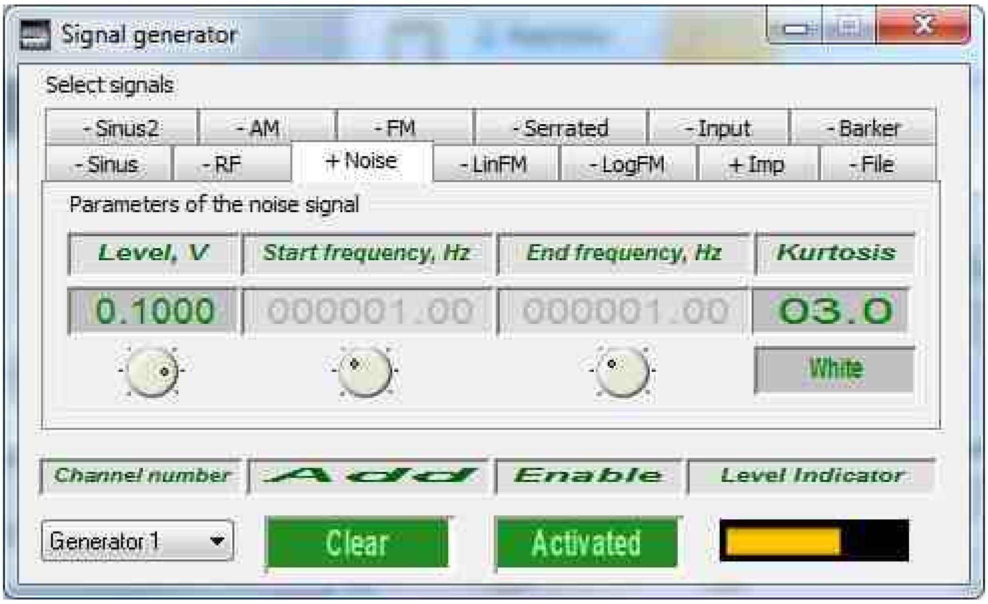
$$THD + N = 10lg\frac{P_S}{P_D+P_N}$$

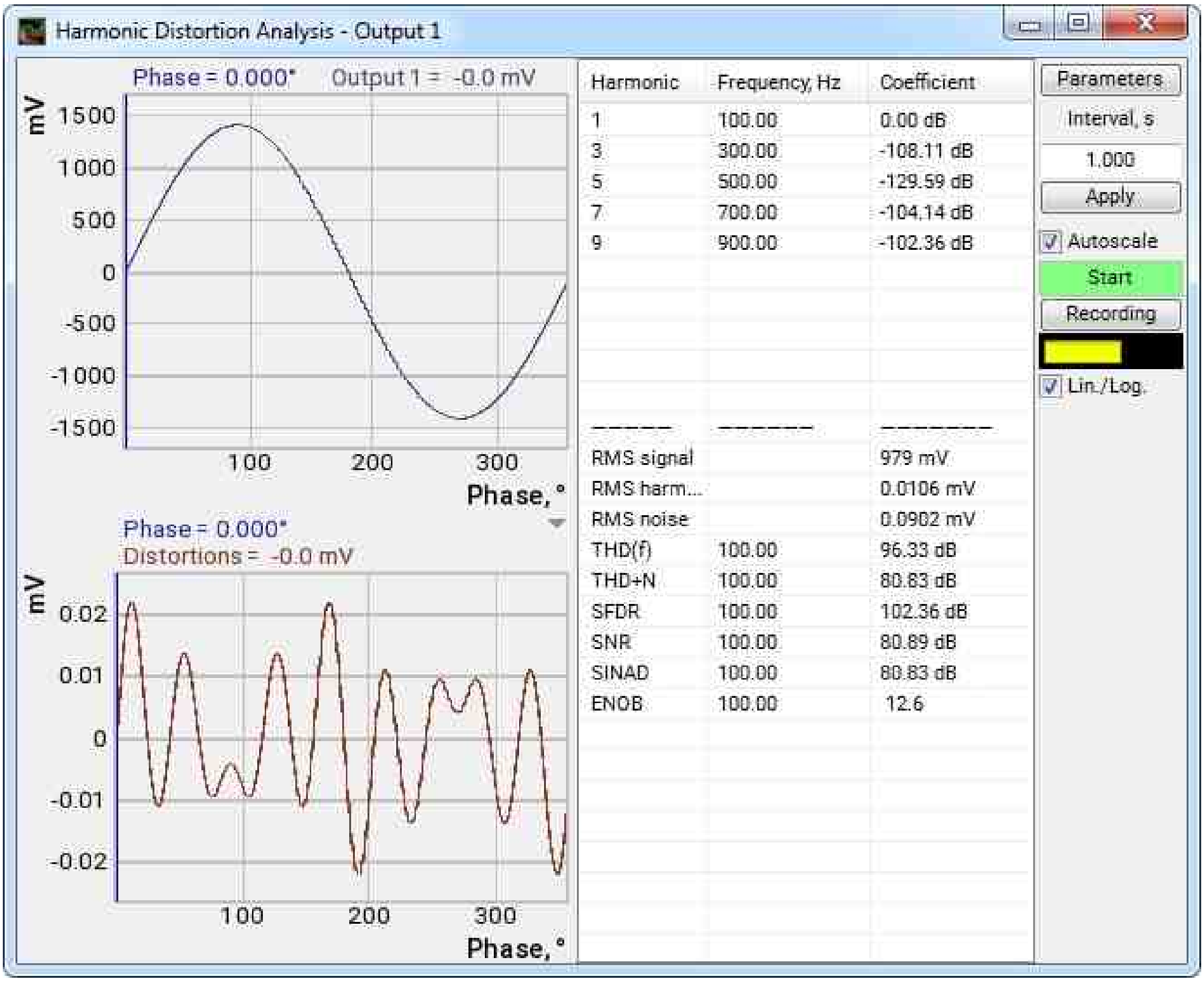
For the signal parameters indicated above, THD + N should be equal to 17 dB, or 14%.
Variations of the measurements caused by randomness in the noise should not exceed 0.5 dB, or 0.5%.
THD and SNR should be equal to 20 dB or 10%.


Signals generator
Select signals
AM FM Serrate Input Barker LinAM LogAM Correction
Sine RF Noise LinFM LogFM Imp File Sine2
Sine signal parameters
Frequency, Hz
Level, V
Offset, V
000100.000
1.0000
0.0000
Channel number
Add
Turn on
Level indicator
Output 1
Remove
Turned on

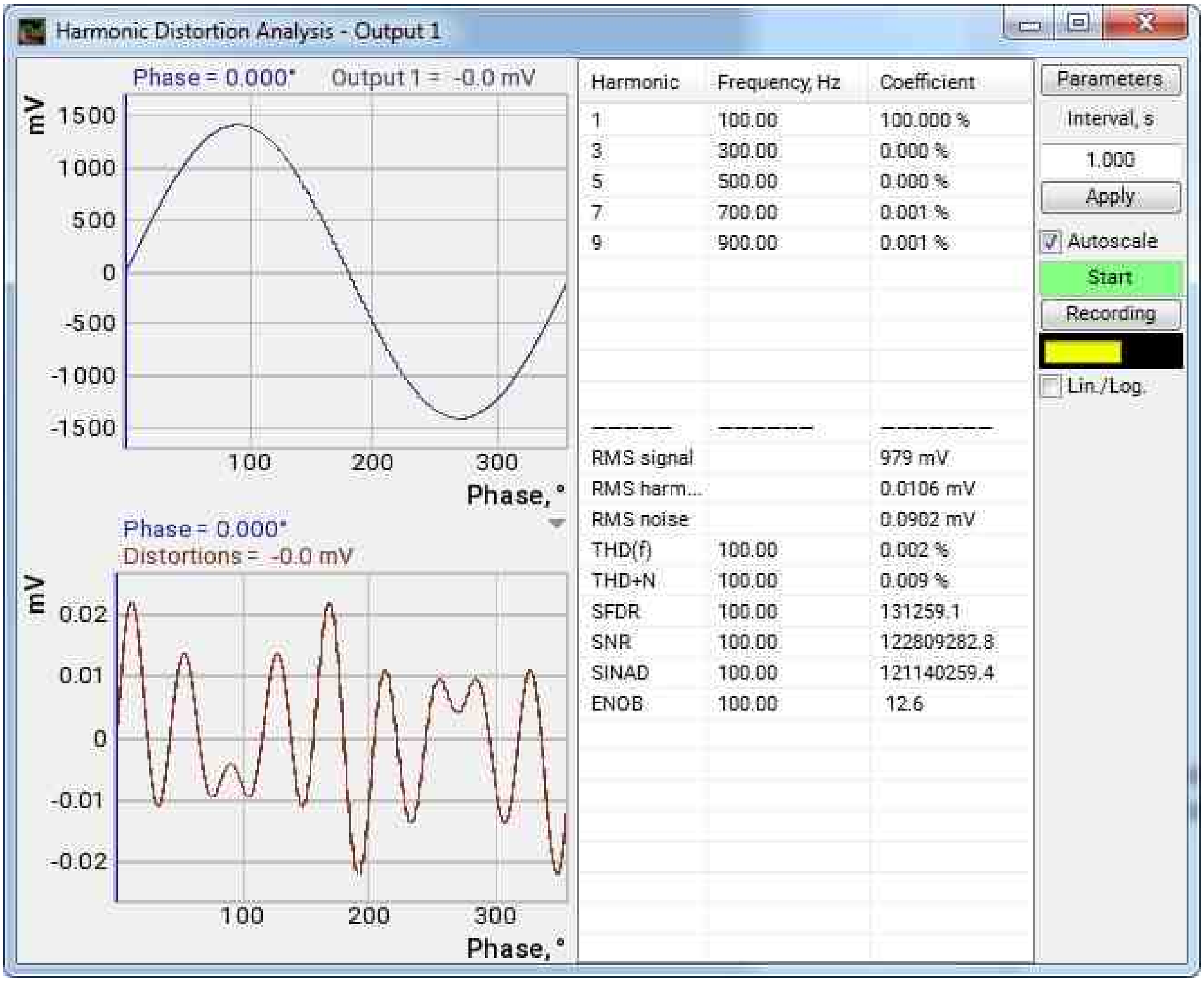

Signals generator
Select signals
AM FM Serrate Input Barker LinAM LogAM Correction
Sine RF Noise LinFM LogFM Imp File Sine2
Sine signal parameters
Frequency, Hz
Level, V
Offset, V
000300.000
0.1000
0.0000
Channel number
Add
Turn on
Level indicator
Output 1
Remove
Turned on

+


Signal generator
Select signals
- Sinus2 - AM - FM - Serrated - Input - Barker
- Sinus - RF + Noise - LinFM - LogFM + Imp - File
Parameters of the noise signal
Level, V
Start frequency, Hz
End frequency, Hz
Kurtosis
0.1000
000001.00
000001.00
03.0
White
Channel number
Add
Enable
Level Indicator
Generator 1
Clear
Activated



Click the checkbox "lin/log" get the coefficient in dB.



without ticking “lin/log” boxes coefficient in %.

SFDR (of spurious free dynamic range) evaluation:

Start the generator, add "sine" signal, set the frequency of 100 Hz, level of 1 V, and activate the generator. The voltmeter reading should be 1000 mV. This will be the signal value – S.

Then remove the "sine" signal, and add the "sine 2" signal, set the frequency of 300 Hz, and level of 0,1 V. The voltmeter reading should be about 100 mV. This will be the value of the third harmonic – U3 (this signal will be the only harmonic).

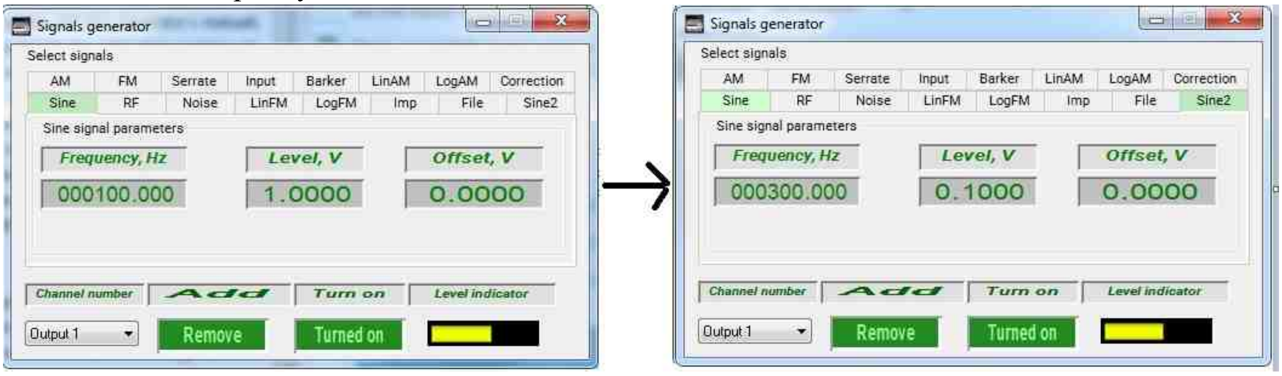
Then, enable the "sine" signal again measure the resulting signal using the program "Harmonic Distortion Analysis". The measurement results obtained should be compared with the SFDR calculation based on the use of the formula:

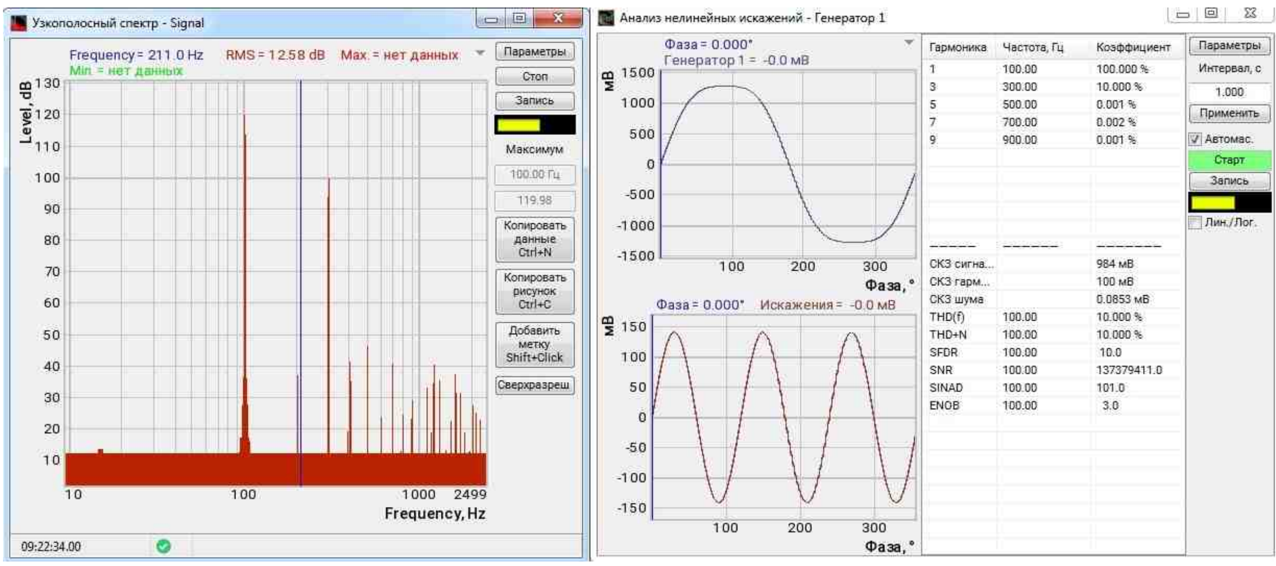
$$SFDR = 20\,lg\frac{S}{U_k}$$

Based on the above listed signal parameters, the SFDR should be 20 dB or 10 (i.e., the main harmonic should be 10 times more than the maximum distortion harmonics).

The measurement Inaccuracy should not exceed 0,01 dB or 0,1.

For visual representation of SFDR calculation results, start the program "FFT Spectrum Analysis", set the parameters "Calculation by Y" in the menu "Logarithmic, dB". In this case, the value of SFDR can be easily calculated as a difference between the peak value at the carrier frequency and the highest peak value at the harmonic frequency.





SINAD (Signal-to-noise ratio and distortion) evaluation:

Start the generator, add "sine" signal, set the frequency of 100 Hz, the level of 1 V, and activate the generator. The voltmeter reading should be 1000 mV. This will be the signal value – S.

Then, remove the "sine" signal and add "sine 2" signal, set the level of 0,1 V, set "white" noise type. The voltmeter reading should be about 100 mV. This will be the distortion value – D.

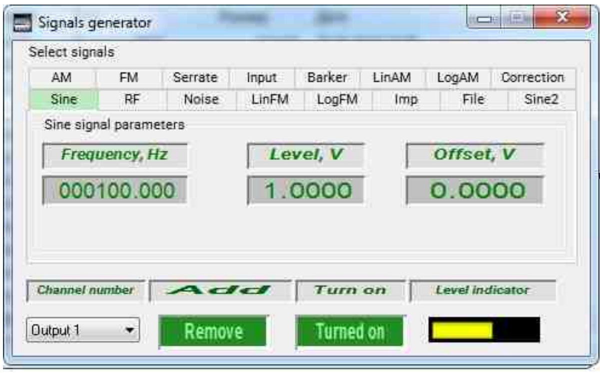
After that, remove the "sine 2" signal and add the "noise" signal, set the level of 0,1 V, and "white" type of noise. The voltmeter reading should be about 100 mV. This will be the noise value – N.

Then enable the "sine" and "sine 2" signals again, and measure the resulting signal using the program "Harmonic Distortion Analysis". The SINAD measurement results obtained with the use of "Harmonic Distortion Analysis" program should be compared with those obtained with the use of the formula:

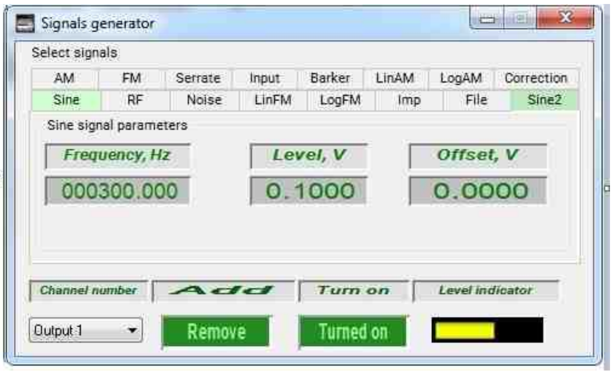
$$SINAD = 10lg\frac{P_S+P_D+P_N}{P_D+P_N}$$

Based on the above listed signal parameters, the SINAD value should be about 17 dB or 50 times.

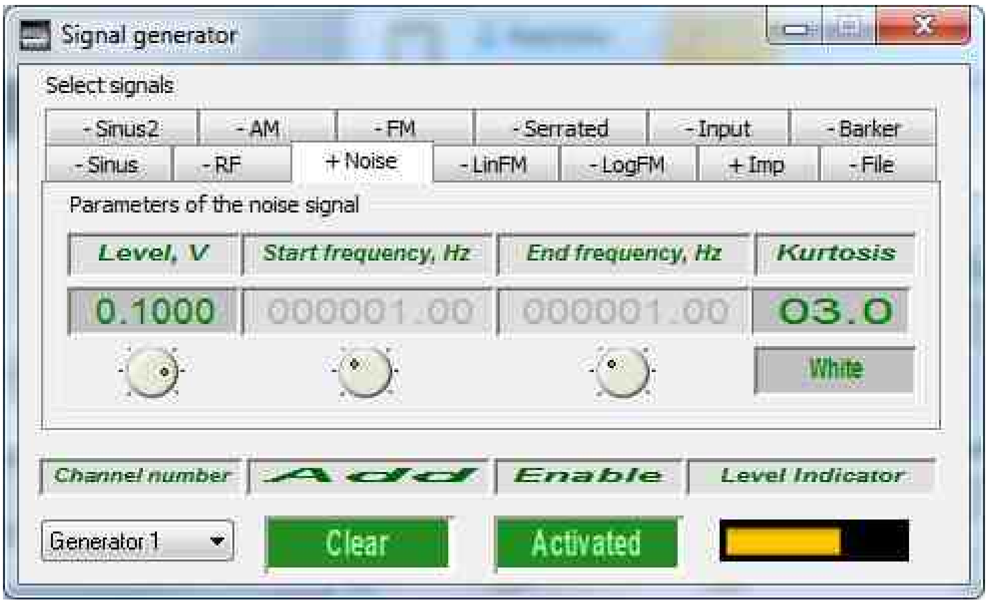
Measurement results fluctuations attributed to the presence of distortion noise, should not exceed 0,5 dB or 2 times.

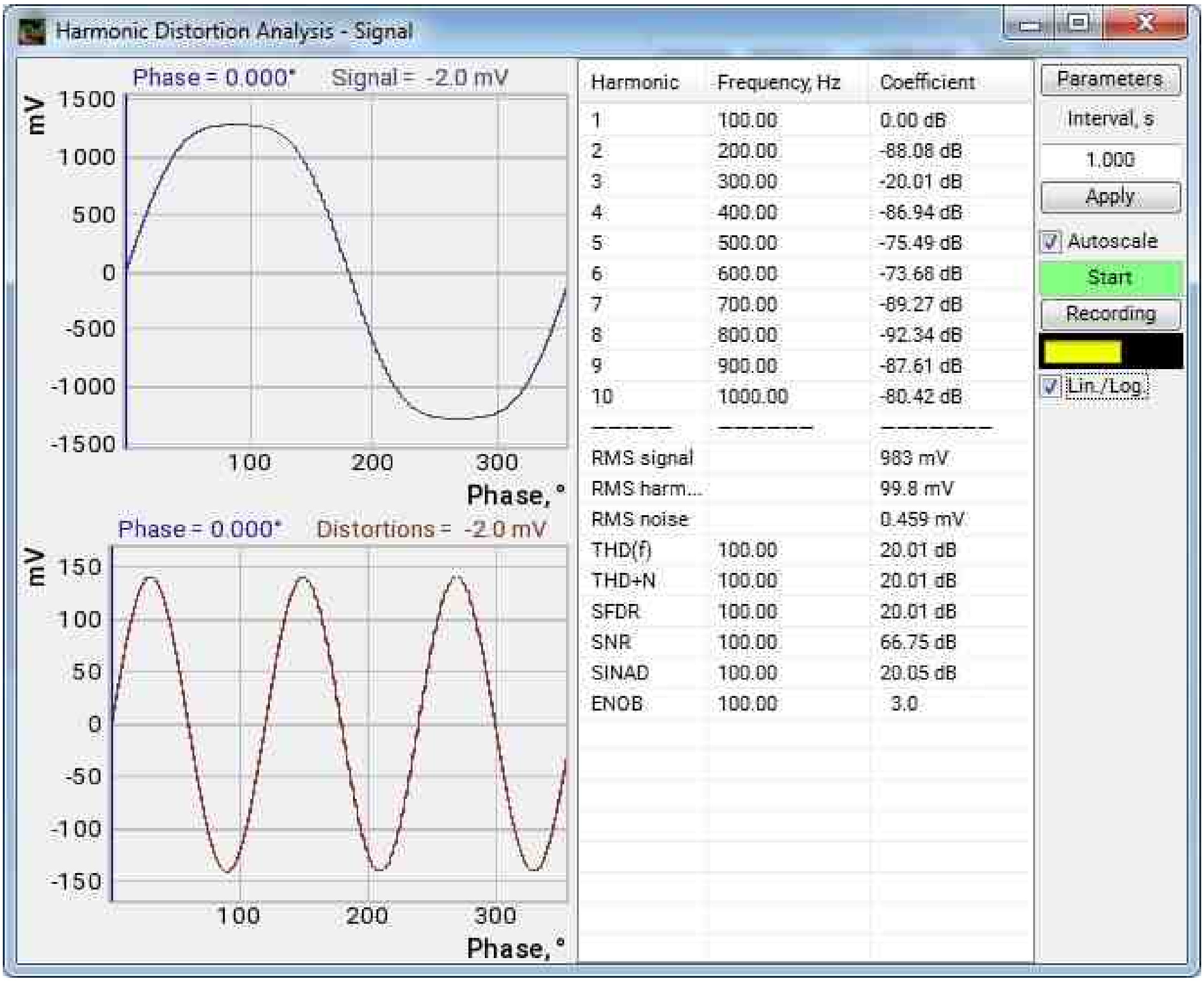


→

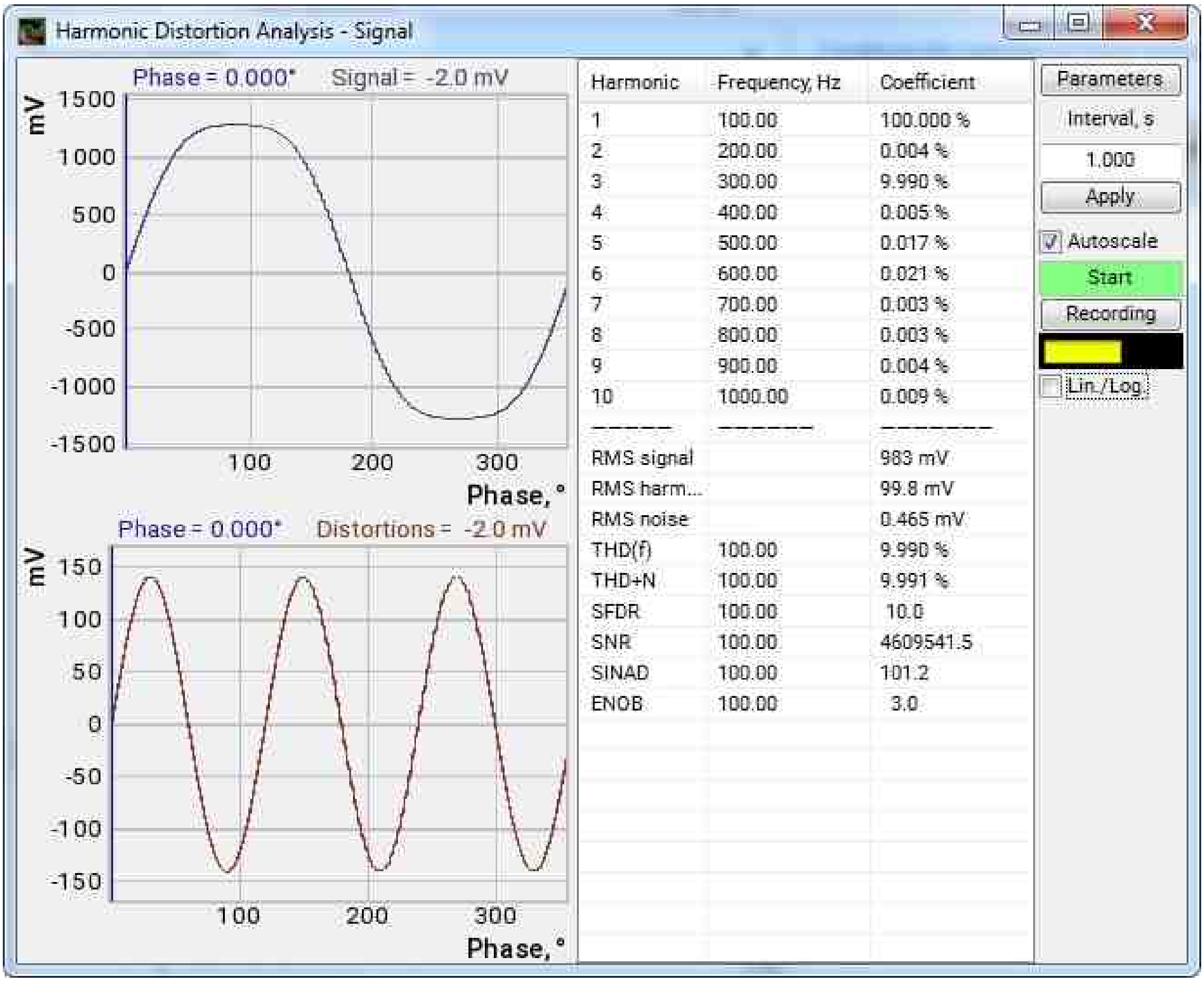


+





Click the checkbox "lin/log" get the coefficient in dB.



without ticking "lin/log" boxes coefficient in %.

ENOB (effective number of bits) evaluation:

Start the generator program, add "sine" signal, set the frequency of 100 Hz, level of 6,0 V, activate the generator. The voltmeter reading should be 6000 mV.

Then it is necessary to measure the signal in the program "Harmonic Distortion Analysis". The ENOB measurement results obtained with the use of the program "Harmonic Distortion Analysis" should be compared with those obtained by means of the formula:

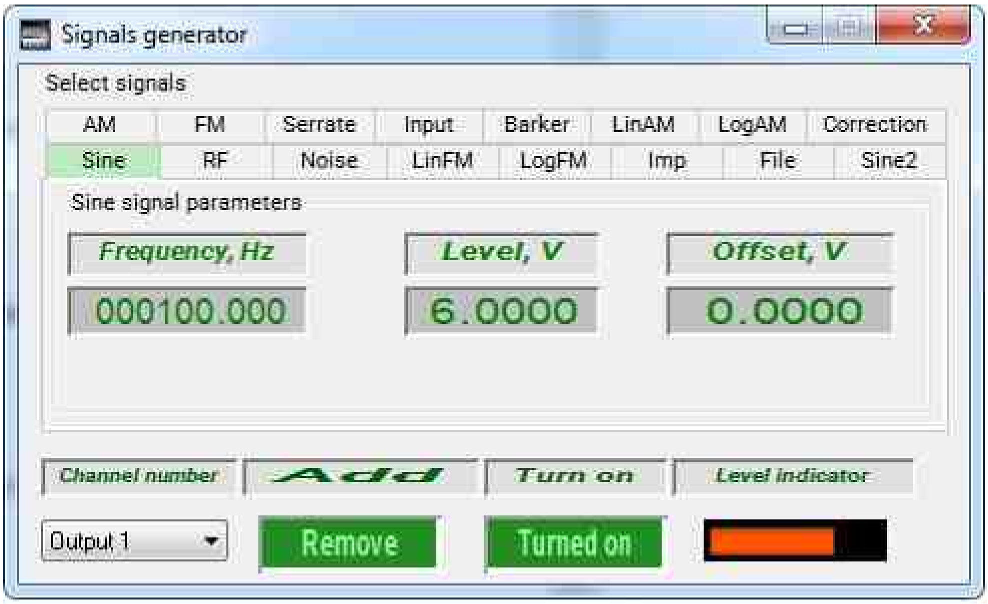
$$ENOB = \frac{SINAD - 1.76}{6.02}$$

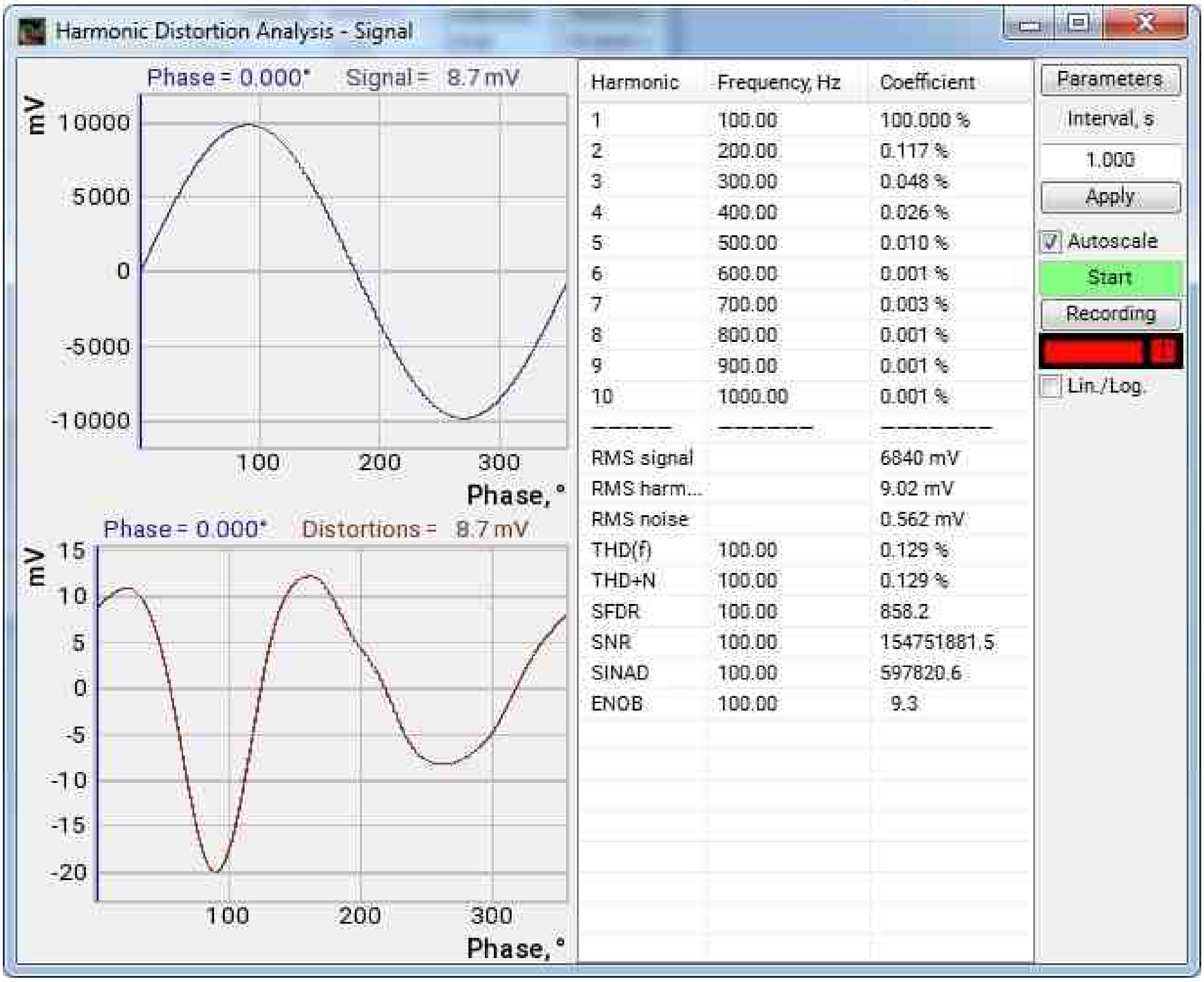
Since the digit capacity of ZET 017 FFT spectrum analyzer is 16 bit, it means that the ENOB cannot be more than 16. Based on the above mentioned parameters, the ENOB calculation result with the use of calibrated ZET 017 FFT spectrum analyzer should be 15.5.

The ENOB characteristics also includes digit bit (just like a usual data bit, it increases the range in two times) and sampling error of an "ideal" ADC.

Since in the calculation of ENOB there is used the SINAD value, the ENOB value of measuring channels will be lower due to the presence of distortions.
The formula for ENOB is reverse to the one used for calculation of the dynamic range:

$$DR = 20lg\left(2^n\sqrt{\tfrac{3}{2}}\right) \approx 6.0206 \cdot n + 1.761$$





Conclusion.

In conclusion, it is necessary to point out that in some cases the above listed parameters can be measured with a different reference level of the signal. In this case, it may be necessary to use reference literature.

dB full scale (dBFS) is a reference voltage corresponding to the full range of the device. E.g., "the recording level is 6 dBFS". In the case of linear digital code, each digit corresponds to 6 dB, and the maximal possible recording level is 0 dBFS.

dBc – the reference value is the emission level at the carrier frequency or the level of basic harmonic in the signal spectrum. Examples of use: "spurious emission level of radio transmitter at the frequency of the second harmonics is 60 dBs (i.e., the power of this spurious emission 1 million times smaller than the power of the carrier frequency), or "distortions level is 60 dBs"".
Since the input signal does not always cover the entire available dynamic range, it was necessary to add a parameter (or several parameters) that would reveal the functional range of the ADC.

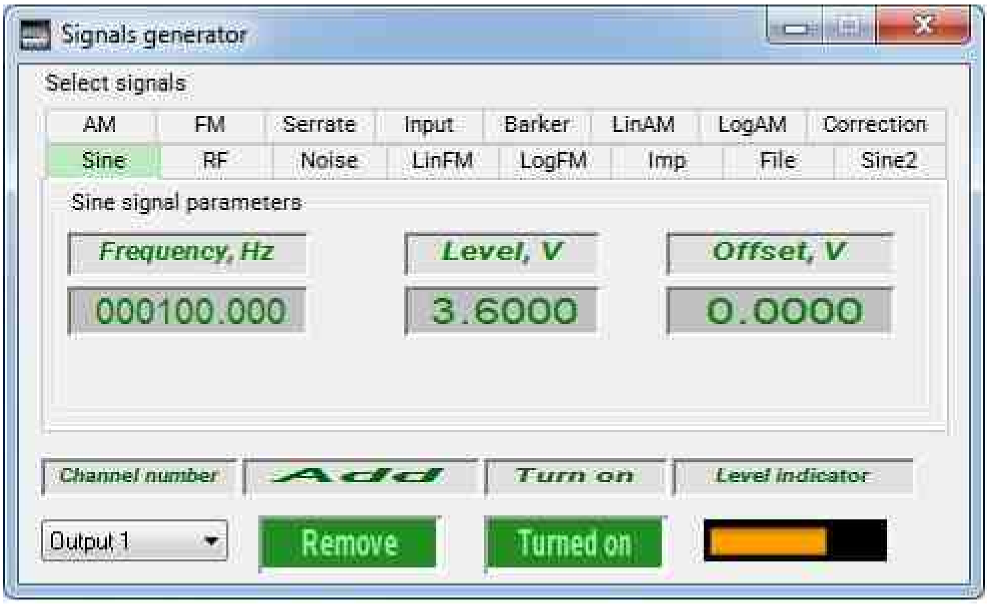
DBFS is a dimensionless quantity, which is calculated as a ratio of major harmonic amplitude (S) to the maximum measurement level of the ADC (M). It is necessary to point out that this value is always less than 0. It is equal to 0 only in the case if signal amplitude covers the entire dynamic range of the device.

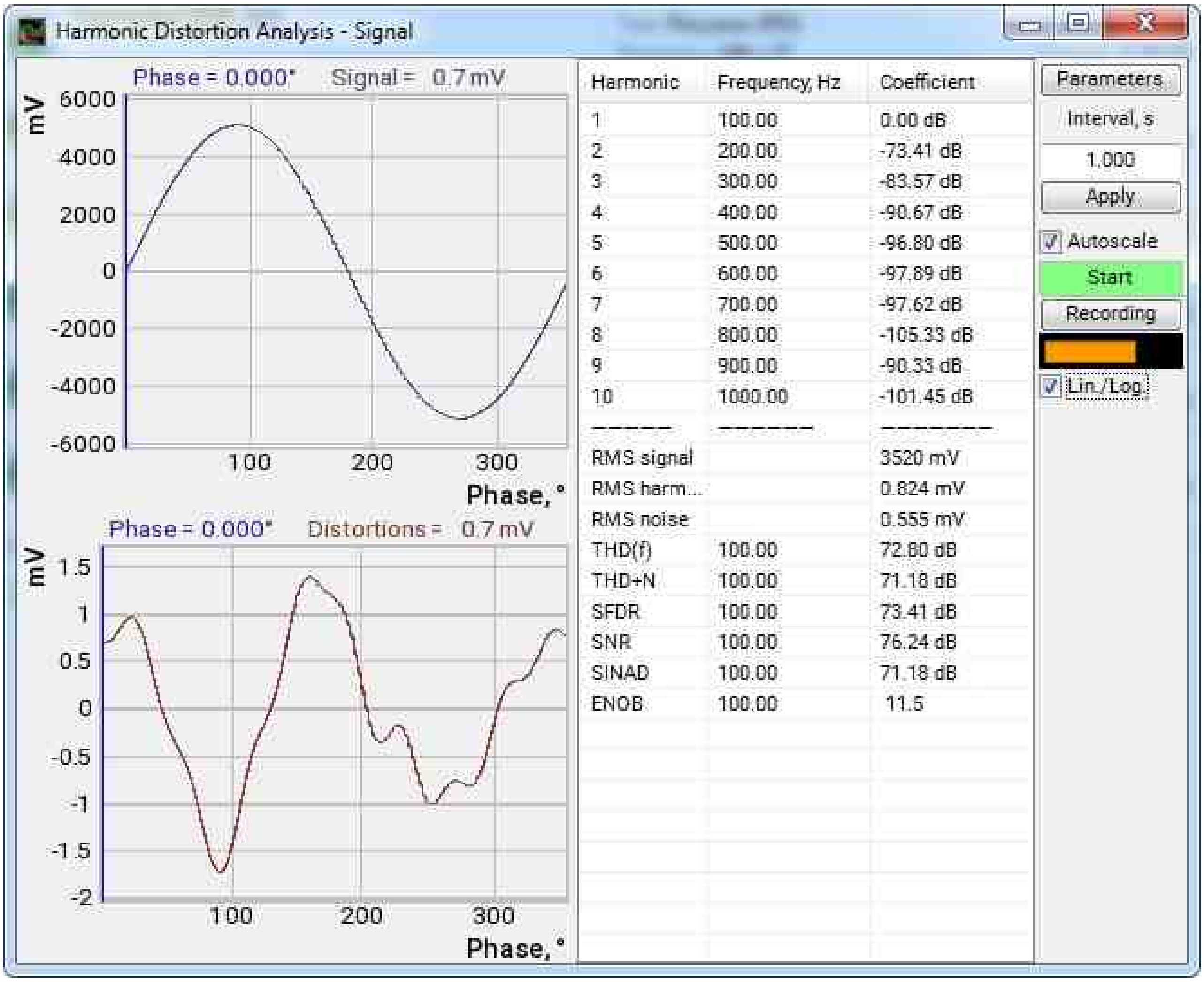
$$DBFS = 20 lg \frac{S}{M}$$

ENOBFS - – is the maximum possible digit number that can be used by ADC/ DAC. This characteristic represents a value, that is close to the real digit capacity of the ADC/ DAC irrespective of the signal power level.

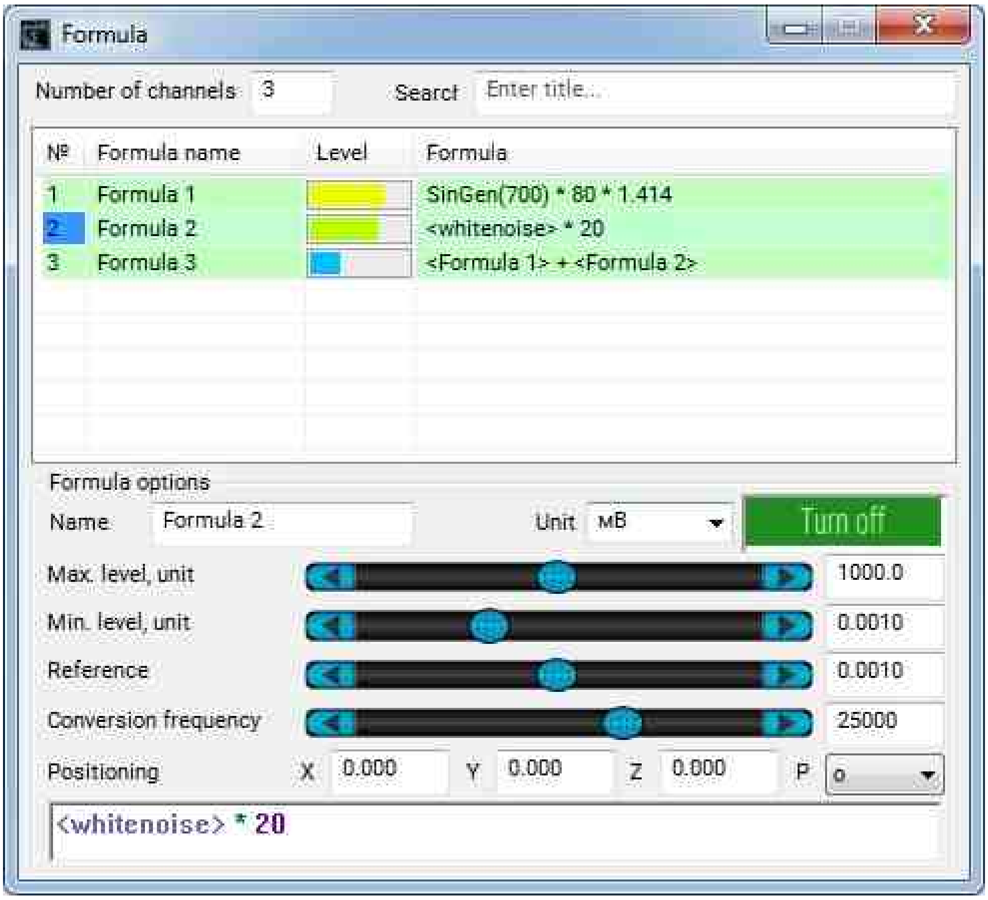
$$ENOBFS = \frac{SINAD - DBFS - 1{,}76}{6.02}$$

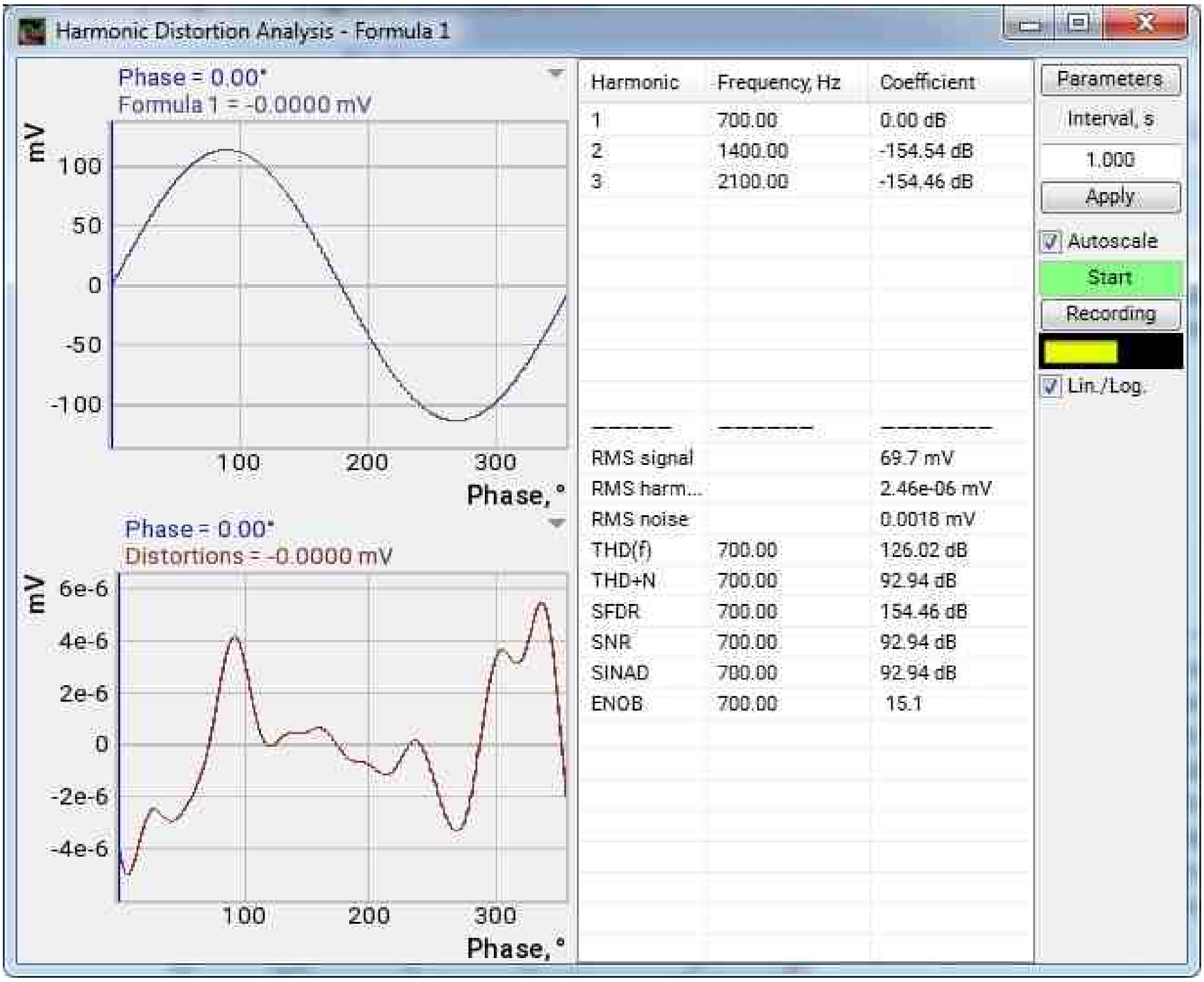
Check example.
In the generator, you need to add a "sine", set the frequency to 100 Hz, the level to 3.6 V and turn on the generator. The voltmeter should show 3600 mV RMS and 5091 mV amplitude.
The DBFS characteristic should be -6 dB.
The ENOBFS characteristic must be exactly 1 greater than the ENOB characteristic.



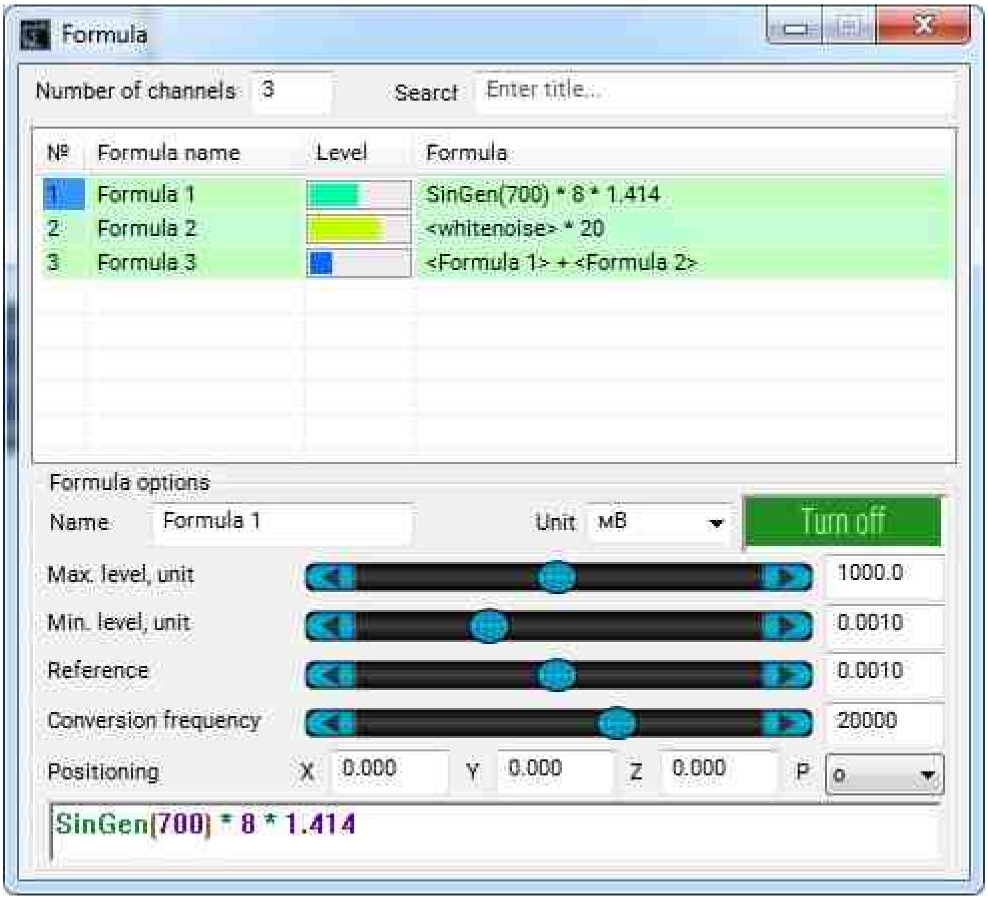


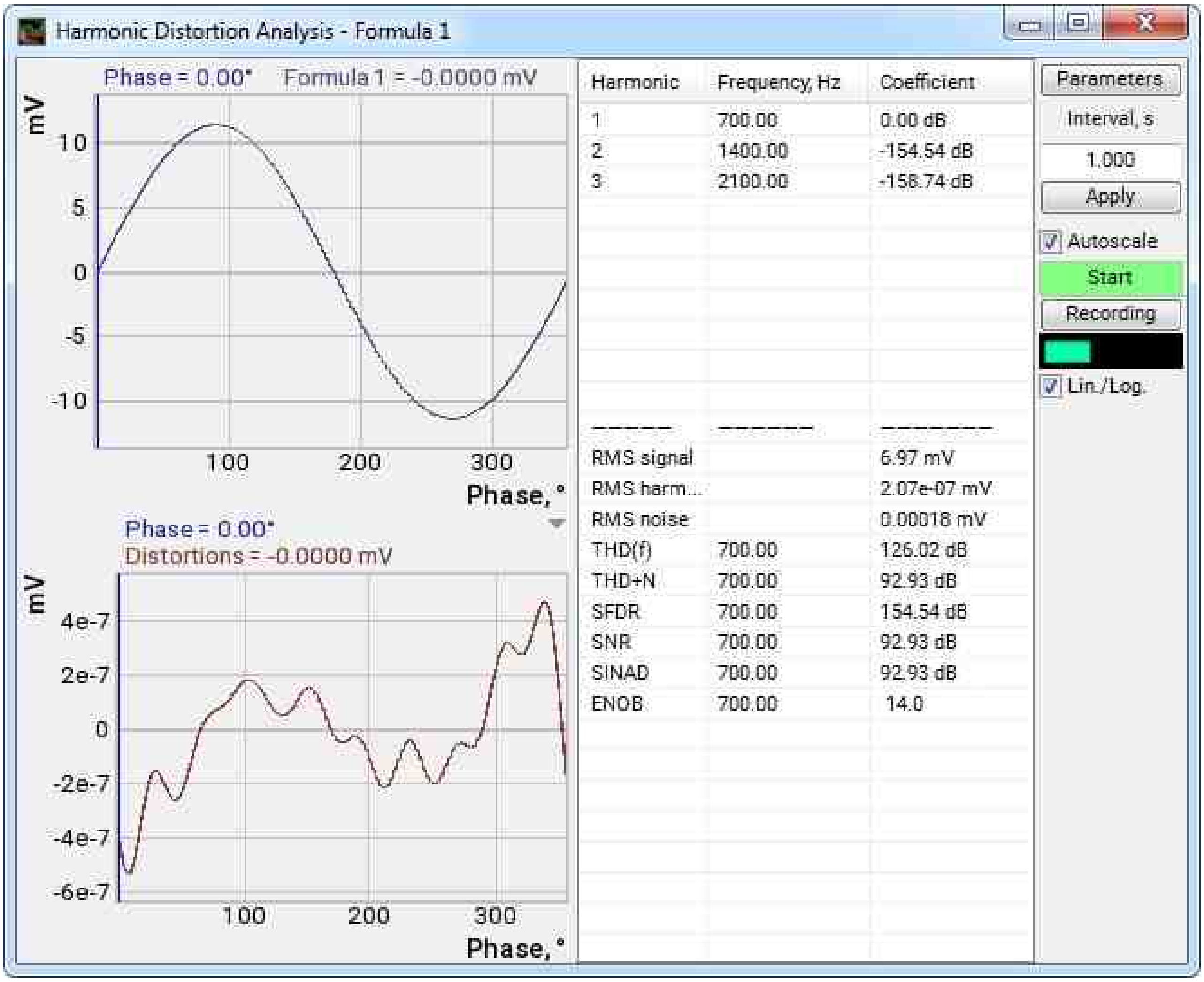
ZETLAB software has the “Formula” program, intended for data processing in accordance with given formulas (including signal generation). Virtual channels created by the “Formula” program (as well as other virtual channels), transmit data in FLOAT-format (32-bit fractional number with floating point according to IEEE 754 standard), which allocated 22 bits to the mantissa. Therefore, for the "Formula" program channels the ENOB value will not exceed 22. The maximum value for ENOB and ENOBFS in "THDA" program is limited to 32.





If the "Formula" channel is set with parameters significantly corresponding to a small dynamic range, then the values of the ENOB and ENOBFS characteristics will be limited by the channel parameters. For example, for a channel with a minimum level of 1 mV (lower bit weight) and a maximum level of 1000 mV (maximum amplitude), the number of valid values will be 2000 and 11 bits will be enough to encode it.


Formula
Number of channels 3
Search Enter title...
№ Formula name Level Formula
1 Formula 1 SinGen(700) * 8 * 1.414
2 Formula 2 <whitenoise> * 20
3 Formula 3 <Formula 1> + <Formula 2>
Formula options
Name Formula 1
Unit мВ
Turn off
Max. level, unit 1000.0
Min. level, unit 0.0010
Reference 0.0010
Conversion frequency 20000
Positioning X 0.000 Y 0.000 Z 0.000 P o
SinGen(700) * 8 * 1.414



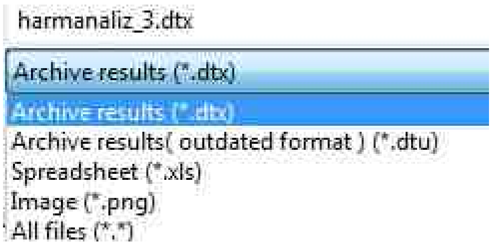
Links:

https://en.wikipedia.org/wiki/Decibel
https://en.wikipedia.org/wiki/Total_harmonic_distortion

Recording results to a file .....

The program **Harmonic Distortion Analysis** allows to record the instant values of the displayed spectrum to a text file with *.dtx extension. When you click The Recording button in the program window of the **Harmonic Distortion Analysis,** there appears a standard dialog box offering you to specify a directory to save the file and the file name. The directory by default is – C:\ZETLab\result.

Note:



When using Excel for opening the dtx file (these files have UTF-8 format), make sure that the right file format (UTF-8) and the separator (tab) are selected. The default settings for opening the file seem to have other parameters.

An example file is shown in the Fig. below.

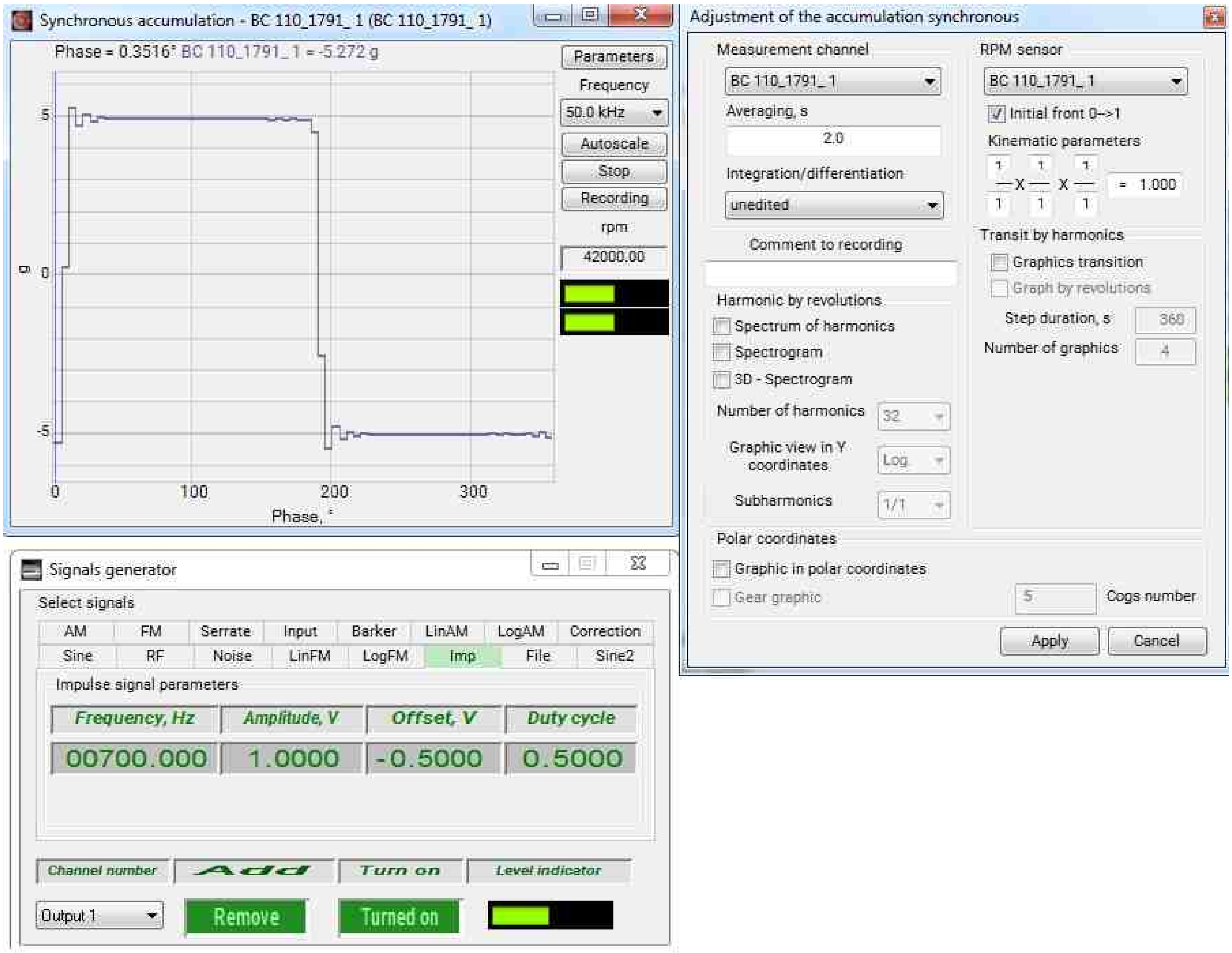

<?xml version="1.0"?><Config version="1"> <MaxNumber>240</MaxNumber> <MaxTextLengthInByte>200</MaxTextLengthInByte> <sizeofgrid>294816</sizeof
_down="-100000000" upor_up="100000000" x_first="0" x_end="360" /> <GridColors cursor_color="16711680" digits_color="0" fon_color="15790320" grid_color="1263225
: 06-05-2021 Time: 15:23:31</Comment_2> <Comment_3></Comment_3> <Comment_4><Harmonic 1 - 3599.46Hz - 100.000 %><Harmonic 2 - 719
Phase ZET017U4_1791_ 1Distortions
degr mV mV
0 -0,00438309 -0,00438309
0,00549325 -0,00438356 -0,00438361
0,0109865 -0,00438403 -0,00438413
0,0164797 -0,0043845 -0,00438465
0,021973 -0,00438497 -0,00438517
0,0274662 -0,00438544 -0,00438568
0,0329595 -0,00438591 -0,0043862
0,0384527 -0,00438637 -0,00438672
0,043946 -0,00438684 -0,00438724

Results file recorded with the program " Harmonic Distortion Analysis"

Synchronous Accumulation (Order Analysis) .....

Order analysis is one of the most convenient and efficient methods for diagnostics and balancing of rotating mechanisms and transmission gears. Using the RPM sensor and a vibration transducer, it is possible to study the time characteristics of gear vibration signals. It is a well-known fact that a signal from a vibration sensor is affected by signals from other sources. To tune out from the disturbing signals, the synchronous signal accumulation method is used. For each shaft rotation, the RPM sensor provides a rotation mark. This signal serves as a triggering strobe for the vibration sensor signal sweeping. The obtained signal sweeps are combined. All the sources of the signals related to the shaft frequency (frequency of rotation) are accumulated and increased in the accumulator linearly proportionally to the N number of rotations. All other signals that are not correlated with the shaft frequency are accumulated proportionally to N1/2 and in case of a greater number of averagings, the useful signal exceeds the interference level.

The program has an integrated control and automation module from the scope of ZETLab-Studio software package. The module enables easy creation of individual software measurement suites.



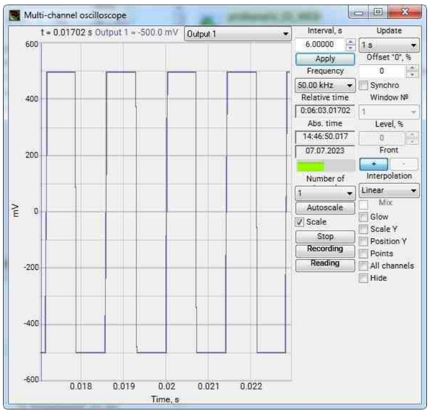


Fig. 1

Fig. 2

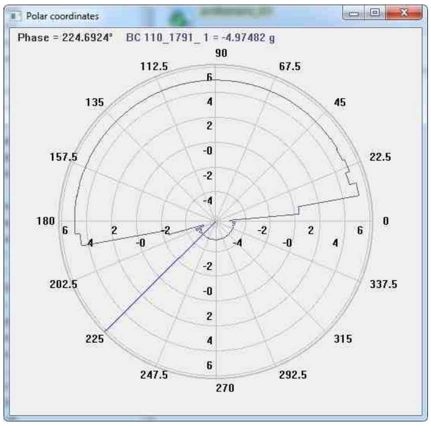


Fig. 3

E.g., *Fig. 1* shows vibrational acceleration – a result of vibration transducers signal accumulation in the frequency range up to 10 kHz. *Fig. 2* shows vibrational acceleration graphic in polar coordinates against the drawing of a gear unit (in grey color). Such graphical representation allows to understand at which particular rotation phase there occurs blocking or declutching between the cogs. At the rotation phase from 90 up to 280 degrees, you can see vibration occurring during clutching while in the remaining sector there is vibration in the declutching phase. In order to understand the reasons for the vibration occurrence, let us analyze the Displacement parameters (see *Fig. 3*) in polar coordinates. From Fig. 3, you can observe an unbalance of the driving shaft and evaluate the parameters of its balance.

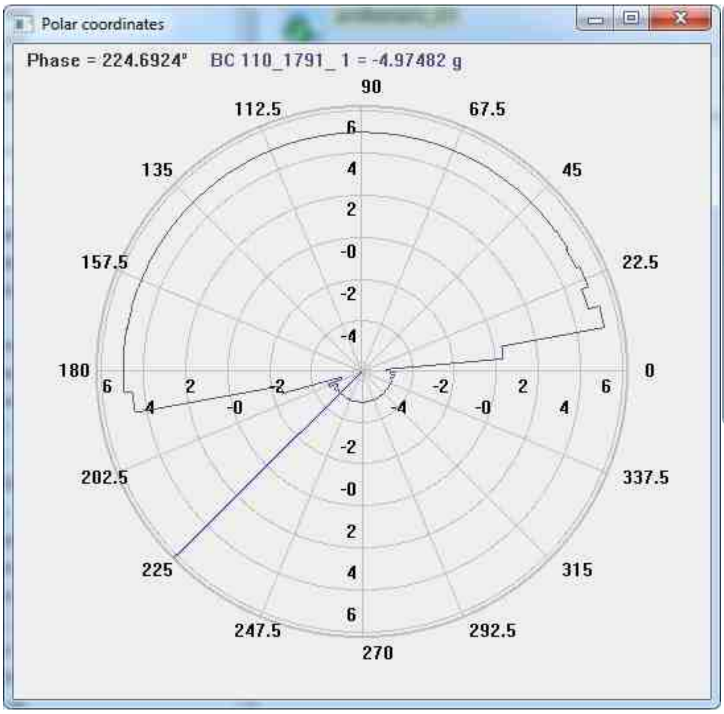


Fig. 4

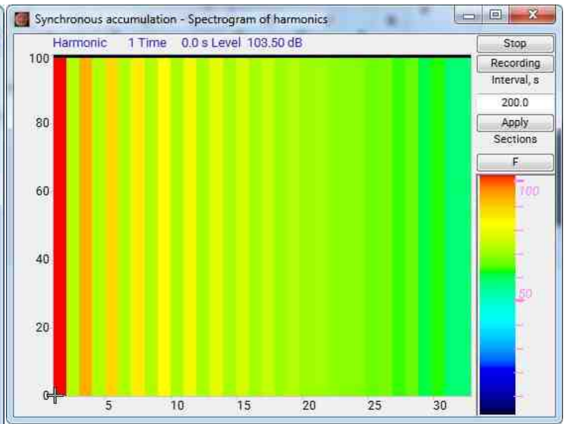


Fig. 5

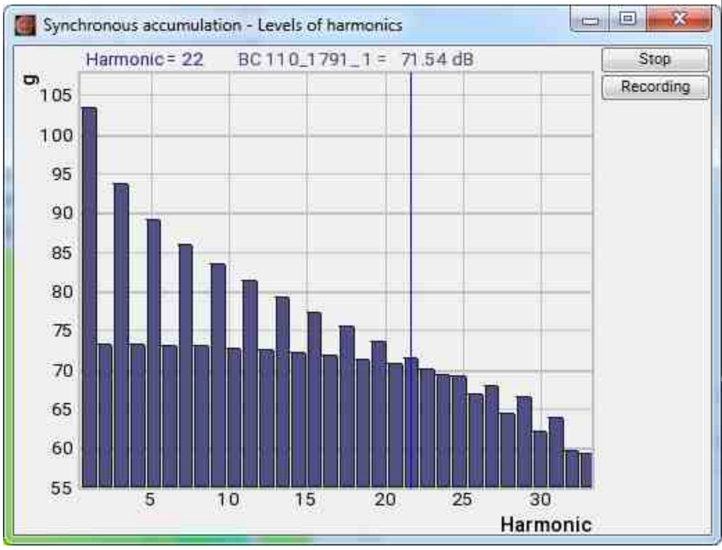


Fig. 6

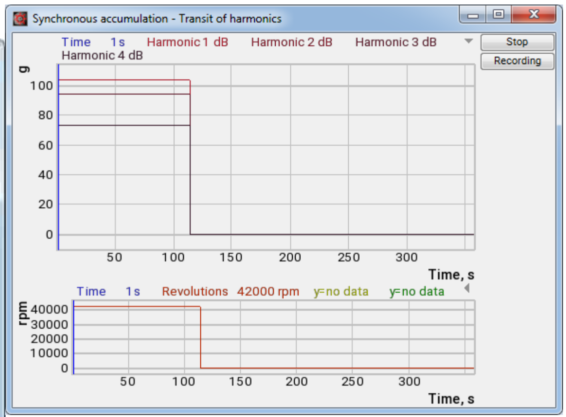


Fig. 7

Fourier transform applied to the signal accumulated after a single rotation cycle reveals harmonics of each rotation frequency of the shaft. *Fig. 4* shows the signals spectrum for the 120-th harmonics. Gear units harmonics can be clearly seen in the spectrum. The first harmonic stands for the number of cogs. Spectra representation in time domain as a spectrogram (*Fig. 5*) allows to track harmonics dynamics.

Display of the selected Levels of harmonics (transient characteristics – see *Fig. 6*) and Display of the selected Transit ofharmonics (transient characteristics – see *Fig. 7*)

Supported Hardware .....

For the purpose of analog signals digital processing, it is possible to use *FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01* and *seismic recorder ZET 048*.

Settings of measurement channels are specified in the program "Device Manager".

Synchronous Accumulation is a part of the following software:

- ZETLAB ANALIZ – FFT Spectrum Analyzers software,
- ZETLAB VIBRO – Shaker controllers software,
- ZETLAB TENZO – Strain-gauge station software,
- ZETLAB SEISMO – Seismic recorder software.

Synchronous Accumulation is included in the **Signal Analysis** software group.

Program description .....

In order to start the program "**Synchronous accumulation**", select the corresponding item in the "**Signal analysis**" section of ZETLab panel. You will see the program interface (Fig. 8). The top section of the program depicts program name, and name of the channel used for analysis. Note: the program "**Synchronous accumulation**" can be started from ZETLab directory (by default: c:\ZetLab\). The name of the file to be started: PrdkAnaliz.exe

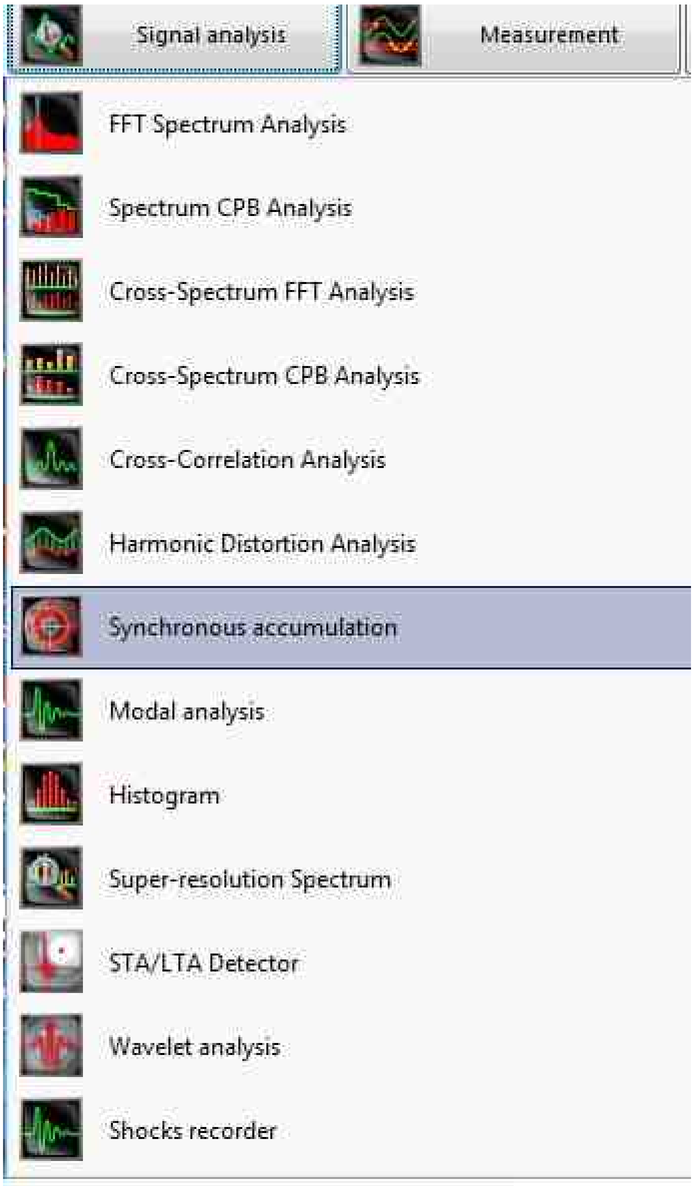


Fig. 7 Starting the "Synchronous accumulation"

Fig. 8 You will see the program interface

"Synchronous accumulation" program: control

"Parameters" key allows to activate the window "Parameters adjustment".

The "**Autoscale**" key allows to align both graphics by the signal level.

The "**Start**" key is used to display the signal. Upon activation of the program "Harmonic Distortion Analysis", the "Start" key is active by default.

The "**Stop**" key allows to suspend both signal displaying process and data update. However, the server continues data accumulation process and all other programs continue their operation.

The "**Recording**" key activates a standard dialog window "Recording the results in a file", allowing the user to select the file name as well as to assign the directory for saving the file (directory by default - C:

\ZetLab\result\). The file is saved with *.dtu extension. The file contains information description, data in floating point format (a point is used for separation between fractional and integer numbers).

The **integral level** indicator is used for the display of the signal's integral level and overloading (in the case, if the acceptable signal level is exceeded by a particular channel). Two thirds of the indicator stand for a signal within the acceptable level range. The higher is the signal level, the bigger part of the indicator section is used for the color indication. As the maximal acceptable level of the signal is exceeded, the indicator turns red. The right part of the indicator will remain red until the channel overloading is eliminated and the user right-clicks the indicator area. The number of indicators depends on the amount of simultaneously displayed oscillographic graphics.

In order to exit the program "**Synchronous accumulation**", click the corresponding key in the top right section of the program interface.

See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Setting parameters of display
- Using signal level indicators
- Adjustment of the color scheme used for displaying of the registered signal amplitude values
- Graphical and numerical data transfer to text editors
- Setting GridGl grid functionality

Program settings .....

The key **"Parameters"** is located at the top right section of the "**Synchronous accumulation**" program. Upon activation of the key **"Parameters"** (or upon right-clicking the window) there appears the window "Setting synchronous accumulation" (Fig. 9).

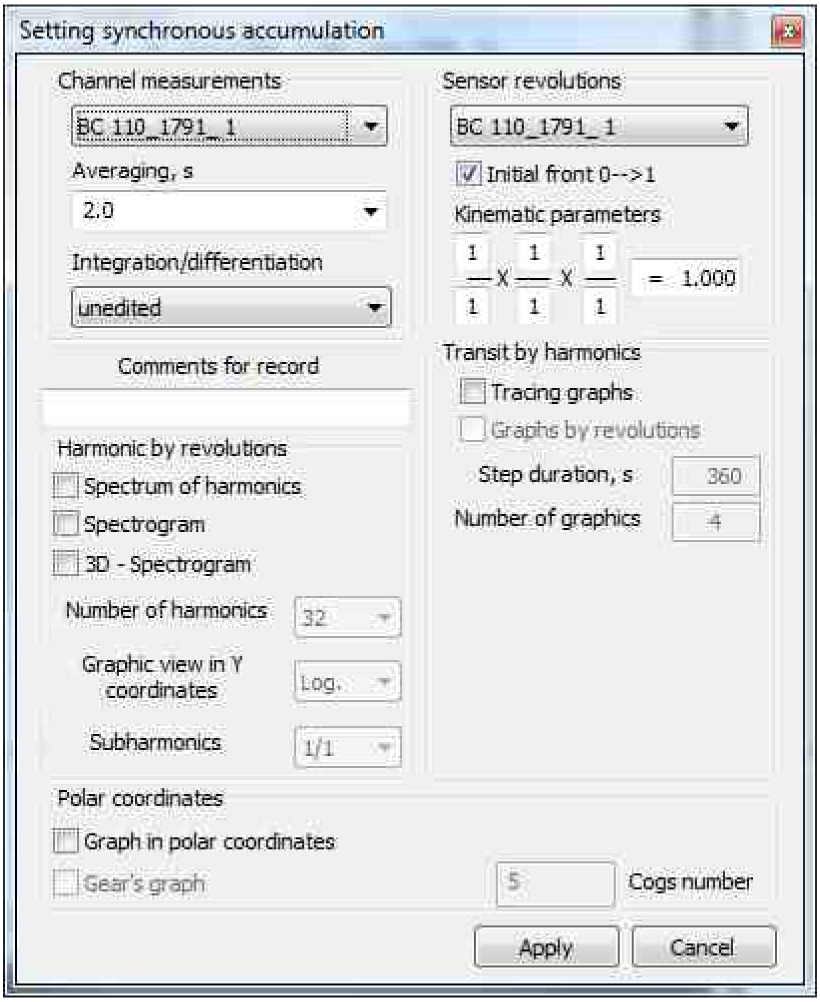


Fig. 9 Setting synchronous accumulation

The key "**Apply**" is used to apply he set program settings and to close the program settings window.

The key "**Cancel**" stops parameters configuration and closes the window "Setting synchronous accumulation". It is also possible to close this window by clicking the corresponding icon at the top right section of the program interface.

Recording results to a file .....

The program **Synchronous Accumulation** allows to record the instant values of the displayed spectrum to a text file with *.dtu extension. When you click The Recording button in the program window of the **Synchronous Accumulation,** there appears a standard dialog box offering you to specify a directory to save the file and the file name. The directory by default is – C:\ZETLab\result.

Note:

When using Excel for opening the dtu file (these files have UTF-8 format), make sure that the right file format (UTF-8) and the separator (tab) are selected. The default settings for opening the file seem to have other parameters.

An example file is shown in the Fig. below.

Results file recorded with the program "Synchronous Accumulation"

Modal Analysis .....

The program "**Modal analysis**" is intended for the analysis of impulse and transient characteristics of signals received from the input channels of FFT Spectrum Analyzers and seismic recorders in real-time or post-processing mode. The program interface is shown in (*Fig. 1*) .

The program has an integrated control and automation module from the scope of ZETLab-Studio software package. The module enables easy creation of individual software measurement suites.

The program allows to determine natural oscillations and damping ratios of mechanisms and structures based on shock excitation method. Additional window "Spectrum" (*Fig. 2*) displays the spectral characteristics of signals from reference and measurement channels as a shock spectrum or a spectrum based on Laplace transform. Thus, the "Modal analysis" program can be used for building structures control, shock spectrum analysis and calculation of natural oscillations and damping ratio.

The program is intended for processing and visual representation of vibration signal, its spectrum, automated calculation of natural oscillations, phase, and relation between peak amplitudes and damping ratio of various mechanisms, parts, structures, and other objects based on measurement of natural oscillations level in the shock excitation mode.

The program can be used for the following purposes:

- Shock impact testing;
- Reduction of the vibration level attributed to structural elements resonance;
- Critical equipment manufacturing and assembly,
- Structural health monitoring systems;
- For scientific and research purposes.

"Energy" checkbox allows to display Additional graphics.

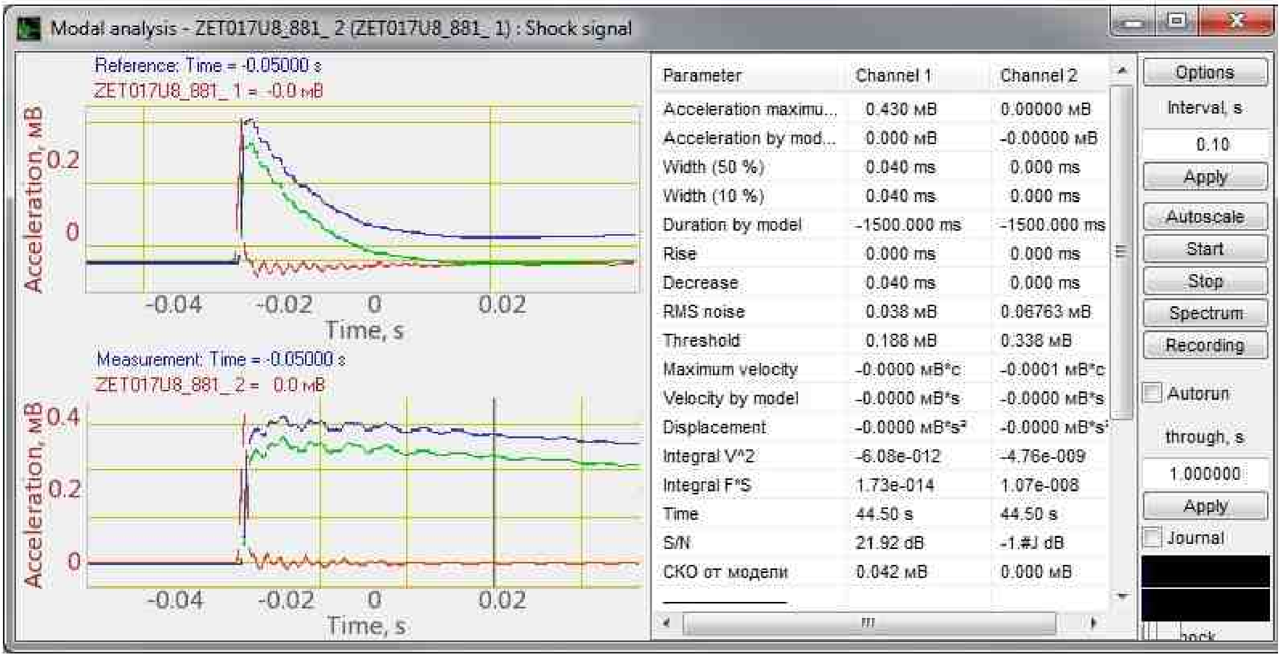


Fig. 1

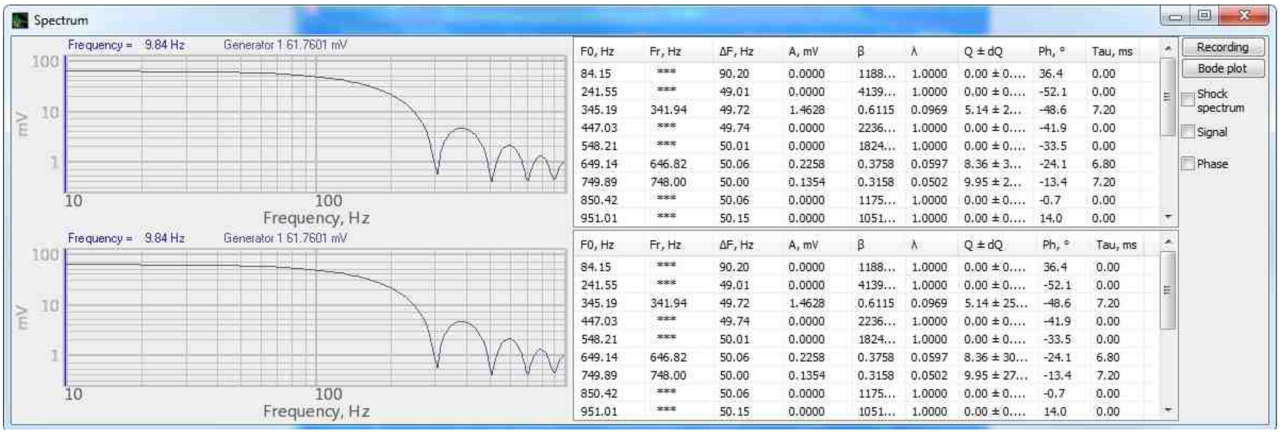
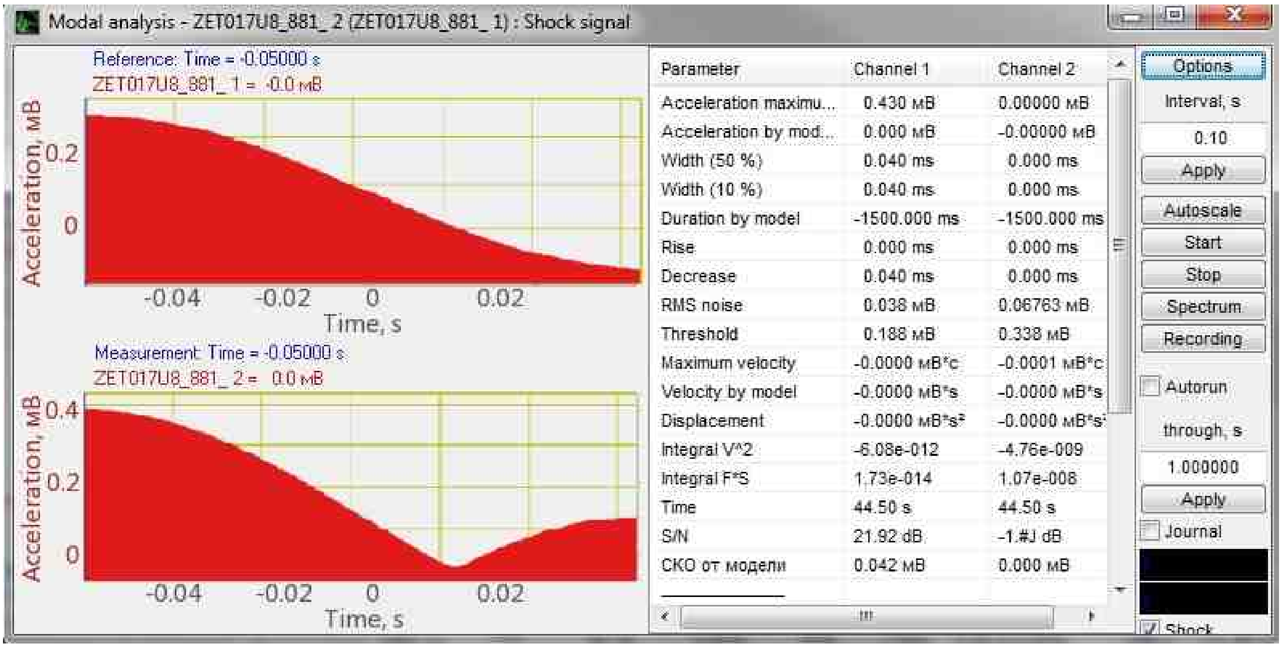


Fig. 2

The program helps to determine the natural frequencies and logarithmic decrements of free vibrations of mechanisms and structures by means of impact excitation. The additional window Spectrum displays the spectral characteristics of signals from reference and measuring channels as an impact spectrum or a spectrum based on Laplace transform. Thus, Modal Analysis can be used for inspection of building structures according to IEC 60068-2-81:2003 "Environmental testing – Part 2-81: Tests – Test Ei: Shock – Shock response spectrum synthesis" to obtain impact spectra and calculate the main tone of natural vibrations and logarithmic decrement of the main tone of natural vibrations.



Modal Analysis is used for processing and visualization of a vibrational signal and its spectra, automatic determination of natural frequencies, phases, ratios of peak amplitudes of two signals and damping decrement of various mechanisms, parts, structures, and other items by measuring free vibrations by impact excitation.

The function of calculating the frequency and quality factor is represented by two algorithms: Fast Fourier Transform without window function, and using a selective filter that selects the signal based on its intrinsic frequency, determined by the damping factor of the signal.
Using the program Modal Analysis, it is possible to precisely determine the natural frequencies of the object under study and damping ratio for each frequency.

For different signal patterns in the program Modal Analysis it is necessary to use different spectra, so that they could be properly compared and analyzed:

- acceleration power spectral density, g2/Hz;
- spectral density measured, g/Hz1/2;
- power spectrum, g2;
- amplitude spectrum, g.

Specific Features of ZETLAB Modal Analysis:

- Flexibility. There are no requirements for the vibration exciter, which significantly simplifies the system composition and reduces its cost.
- Capabilities. Simple and fast determination of natural frequencies and various vibration modes.
- IEC 60088-2-81:2003. Calculation of shock response spectrum according to IEC 60088-2-81:2003 (Environmental testing – Part2-81: Tests – Test Ei: Shock – Shock response spectrum synthesis).
- Products selection. The program is supplied with FFT Spectrum Analyzers, seismic stations, and strain-gauge stations.
- Recording of the results obtained. Saving measurement results to a file supported by Word, Excel, or Notepad.

Modal Analysis: Application:

Reduction of vibration caused by the structural resonance. Detection of specimen damage

1. Single-impact tests are used to determine the quality of the specimen and to evaluate its structural strength. Tests are carried out by exerting single impacts on the specimen placed on the vibration bench with standard impulse forms of a certain duration and peak acceleration value. The most important test parameters are the impact strength and speed change. Acceleration impact spectra usually provide detailed information about the potential damage during operation.

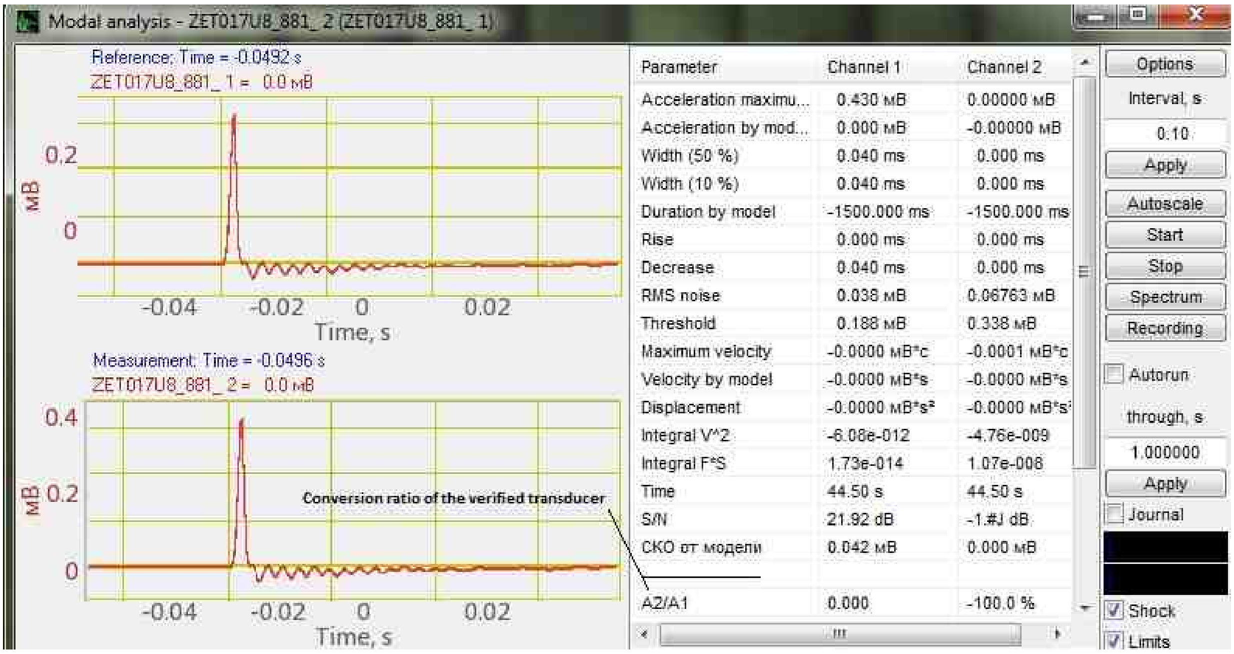
Critical equipment production and assembly control. Scheduled maintenance planning

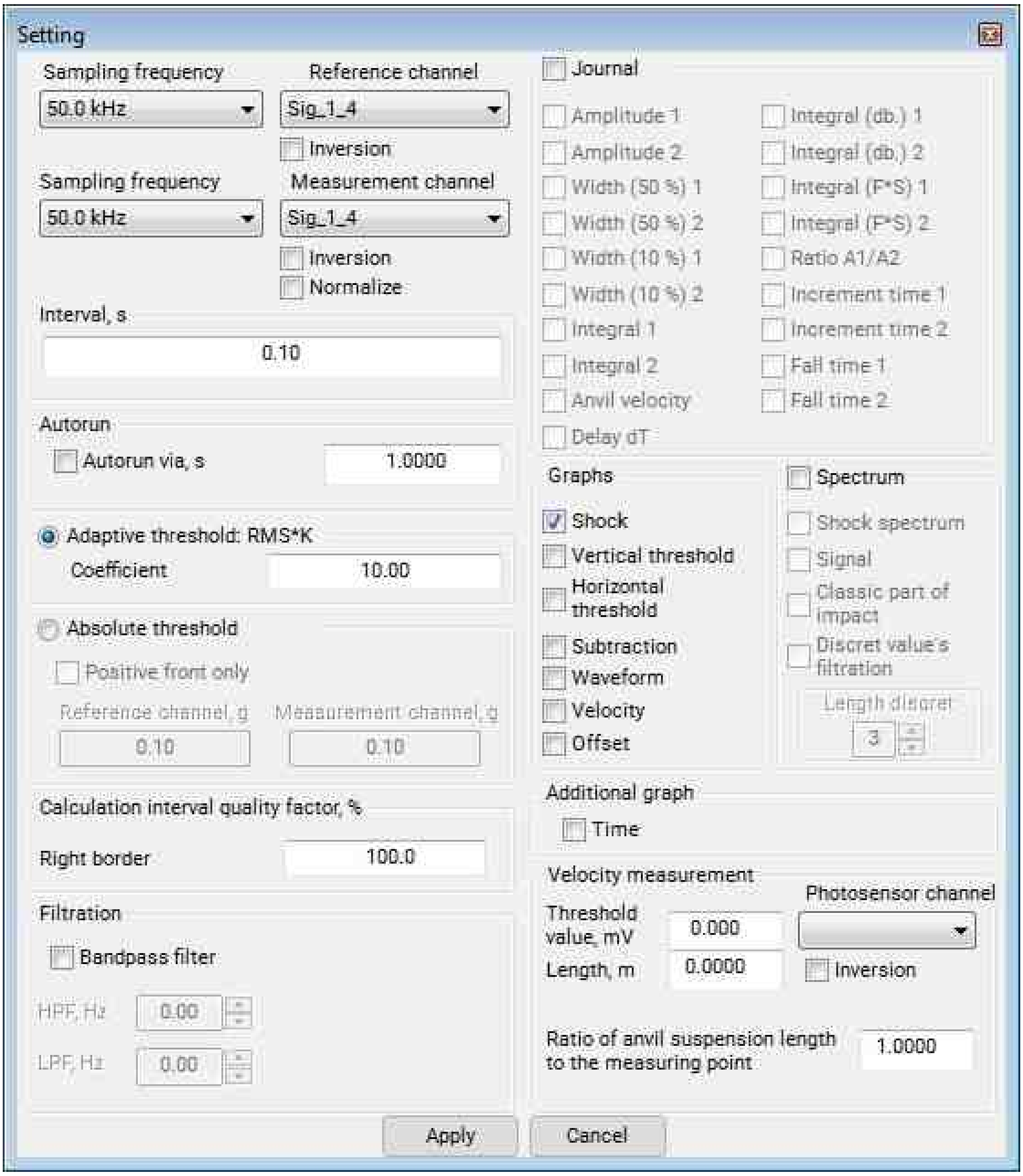
2. In the course of its operation, the specimen can be exposed to fatigue deformations, microcracks in joints which do not cause the product geometry to change, but affect its dynamic characteristics. Analyzing such changes allows for predicting routine maintenance.

Experimental research for scientific purposes. Sensor verification.

3. Sensors are verified on a vibration bench by comparing the sensitivity of the test and reference vibration sensors. Verification is performed with single impacts with different durations and peak accelerations. The program calculates the duration of amplitudes, impulses, amplitude ratios,

wavefront steepness, and impact acceleration impulse. These parameters serve as primary data for verification.





Measured Parameters:

- **pulse amplitude** is the amplitude (pulse crest factor value) of the reference and measuring channels, in units of measurement;
- **noise RMS** is the root-mean-square value (RMS) of the signal noise in the reference and measuring channels before the impulse (in units of measurement);
- **lower and upper limits** of the reference and measuring channels, in units of measurement;
- **amplitude/interference ratio** of the reference and measuring channels, in units of measurement;
- **amplitude ratio** between the measuring and reference channels;
- **pulse width** in the reference and measuring channels, in milliseconds;
- **pulse arrival time** in the reference and measuring channels, in milliseconds;

- **pulse arrival time** difference, in milliseconds;
- **impact spectrum**;
- **frequency spectrum** based on Laplace transformation;
- **free vibration frequencies** and **logarithmic damping decrements** of impulses in the reference and measuring channels;
- **signal phase** in the reference and measuring channels;

The shock spectrum is calculated in accordance with IEC 60068-2-81:2003 (Environmental testing - Part 2-81: Tests - Test Ei: Shock - Shock response spectrum synthesis).

The shock spectrum (also referred to as shock response spectrum or SRS) is represented by a graphic showing the dependence of maximum response (displacement, velocity or acceleration) on the input impact of the oscillators with a set Q-factor based on their natural oscillations without regard to damping factor. Unless otherwise specified, linear SDOF systems with viscous damping should be used in the course of calculations.

Integrated control and automation module from the scope of ZETLab Studio ensures simple creation of software measurement suites.

Q-factor in the program "Modal analysis":
The Q-factor is calculated in the following way:

1. Find local maximum point on the graphic, assign its frequency value and the resonance frequency.

2. Find adjacent points with a 3 dB less value, save their frequency values.

3. Calculate the Q-factor as a ratio of resonance frequency to the difference of adjacent frequencies.

In our case, it is necessary to bear in mind that the adjacent frequencies do not always depend on the source resonance. That is exactly why we have to use the two points next to the maximum location. Then these points are further used for the resonance curve interpolation and subsequent calculation of the resonance frequency. Based on this signal, it is possible to calculate the signal damping and then – the Q-factor. The formula used for this purpose is rather complicated and will not be considered in this manual. Besides, solving of such tasks for digital signals is a know-how.

Supported Hardware .....

For the purpose of analog signals digital processing, it is possible to use *FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01* and *seismic recorder ZET 048*.

Settings of measurement channels are specified in the program "Device Manager".

Modal Analysis is a part of the following software:

- ZETLAB ANALIZ – FFT Spectrum Analyzers software;
- ZETLAB VIBRO – Shaker controllers software;
- ZETLAB TENZO – Strain-gauge station software;
- ZETLAB SEISMO – Seismic station software;;
- ZETLAB NOISE – Vibration meter-noise meter software.

Modal Analysis is included in the **Signal Analysis** software group.

Program description .....

To start the program "**Modal analysis**", use the "**Signal analysis**" menu in ZETLab panel (*Fig. 3*). You will see the main program window (*Fig. 4*). The top section of the program window shows the name of the program and the name of the channel used for the analysis. Note: the program "**Modal analysis**" can be started directly from
ZETLab directory (by default: c:\ZetLab\). The name of the file to be started: PrdqAnaliz.exe

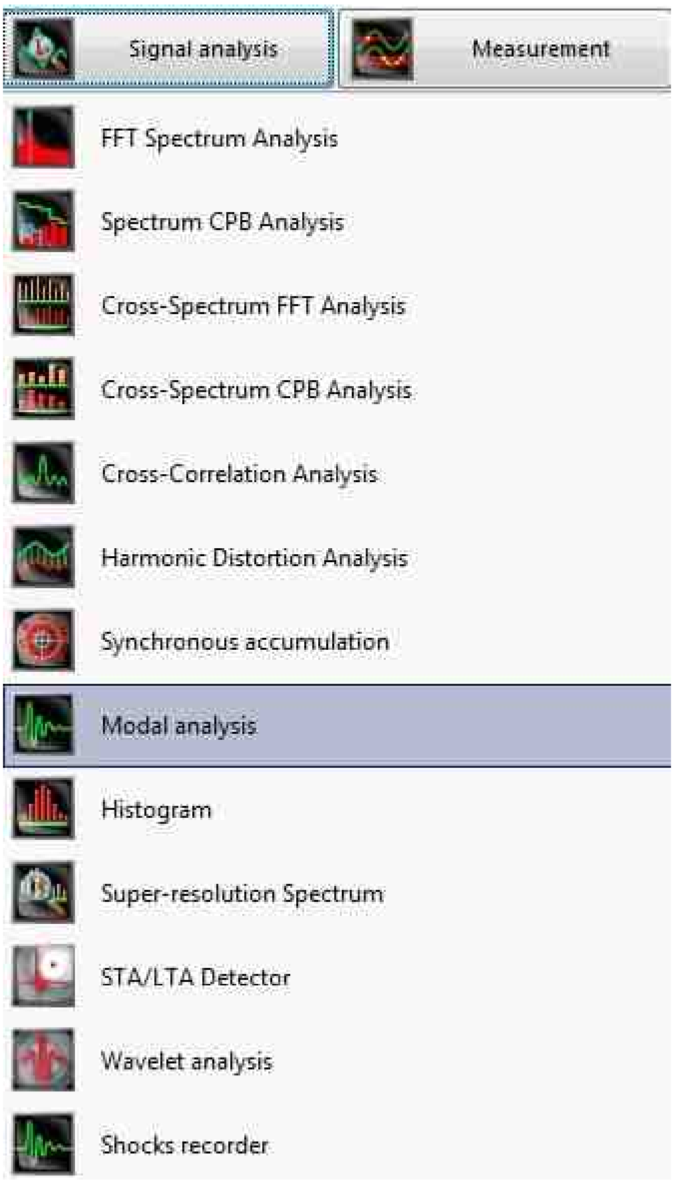


Fig. 3 Starting the "Modal analysis"

The title of the window shows the name of the spectrum and the names of the displayed channels. Below you can see the measured parameters, cursor values and measurement units.

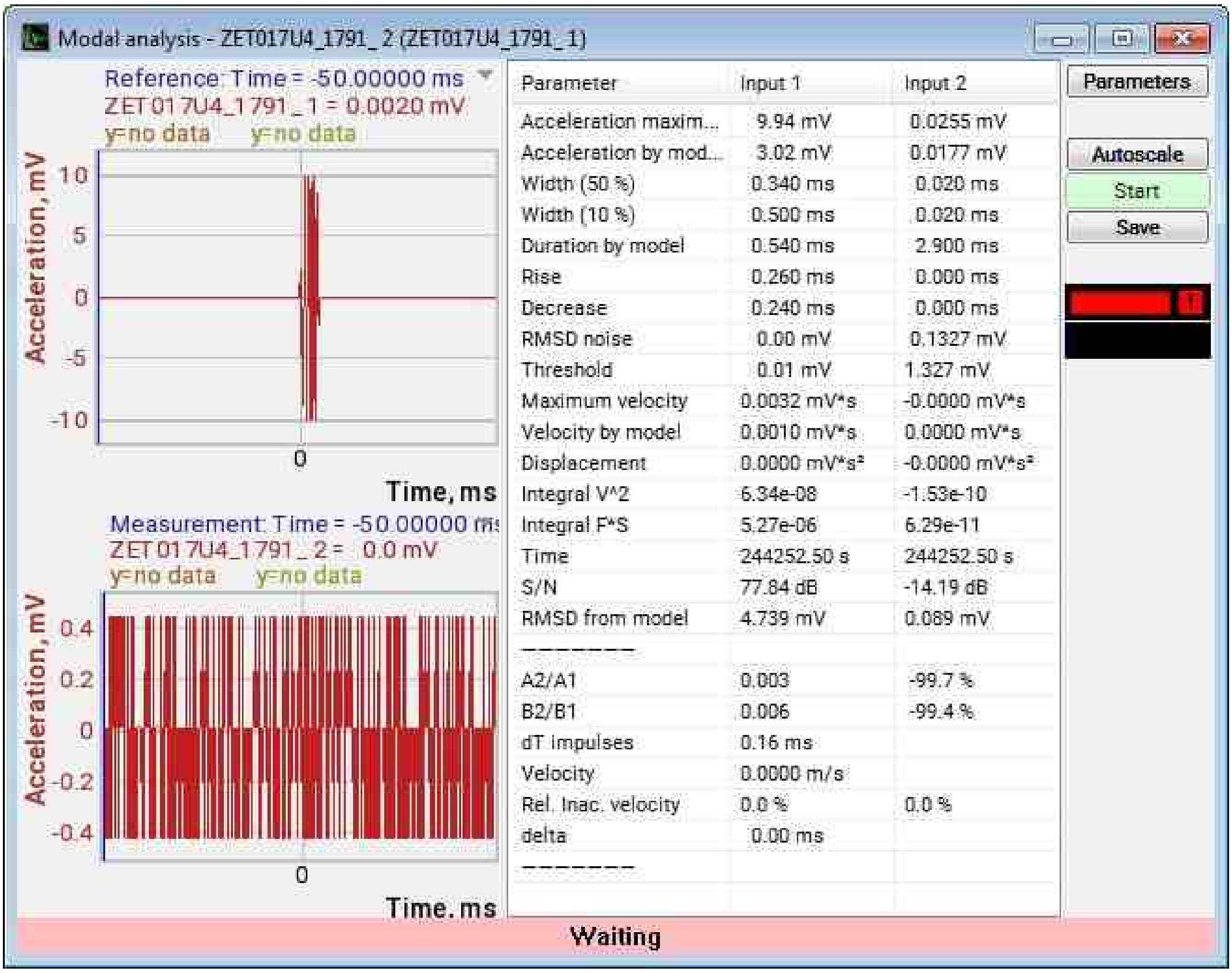


Fig. 4 You will see the program interface

"Modal analysis" program: control

"**Parameters**" key allows to activate the window "Parameters adjustment".

The "**Autoscale**" key allows to align both graphics by the signal level.

The "**Start**" key is used to display the signal. Upon activation of the program "Harmonic Distortion Analysis", the "Start" key is active by default.

The "**Stop**" key allows to suspend both signal displaying process and data update. However, the server continues data accumulation process and all other programs continue their operation.

The "**Recording**" key activates a standard dialog window "Recording the results in a file", allowing the user to select the file name as well as to assign the directory for saving the file (directory by default - C:

\ZetLab\result\). The file is saved with *.dtx extension. The file contains information description, data in floating point format (a point is used for separation between fractional and integer numbers).
The indicator depicts integral level of the signal and overloading. In the case, if the signal exceeds the maximal acceptable level, the indicator turns completely red without any black section at the right part. The right section of the indicator will remain red until the user left-clicks it.

In order to exit the program "**Modal analysis**", click the corresponding key in the top right section of the program interface.

See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Setting parameters of display
- Using signal level indicators
- Adjustment of the color scheme used for displaying of the registered signal amplitude values
- Graphical and numerical data transfer to text editors
- Setting GridGl grid functionality

Program settings .....

The **"Parameters"** key is located in the top right section of the **Modal analysis** program. Upon activation of the **"Parameters"** key there will be displayed the window "**Setting**"

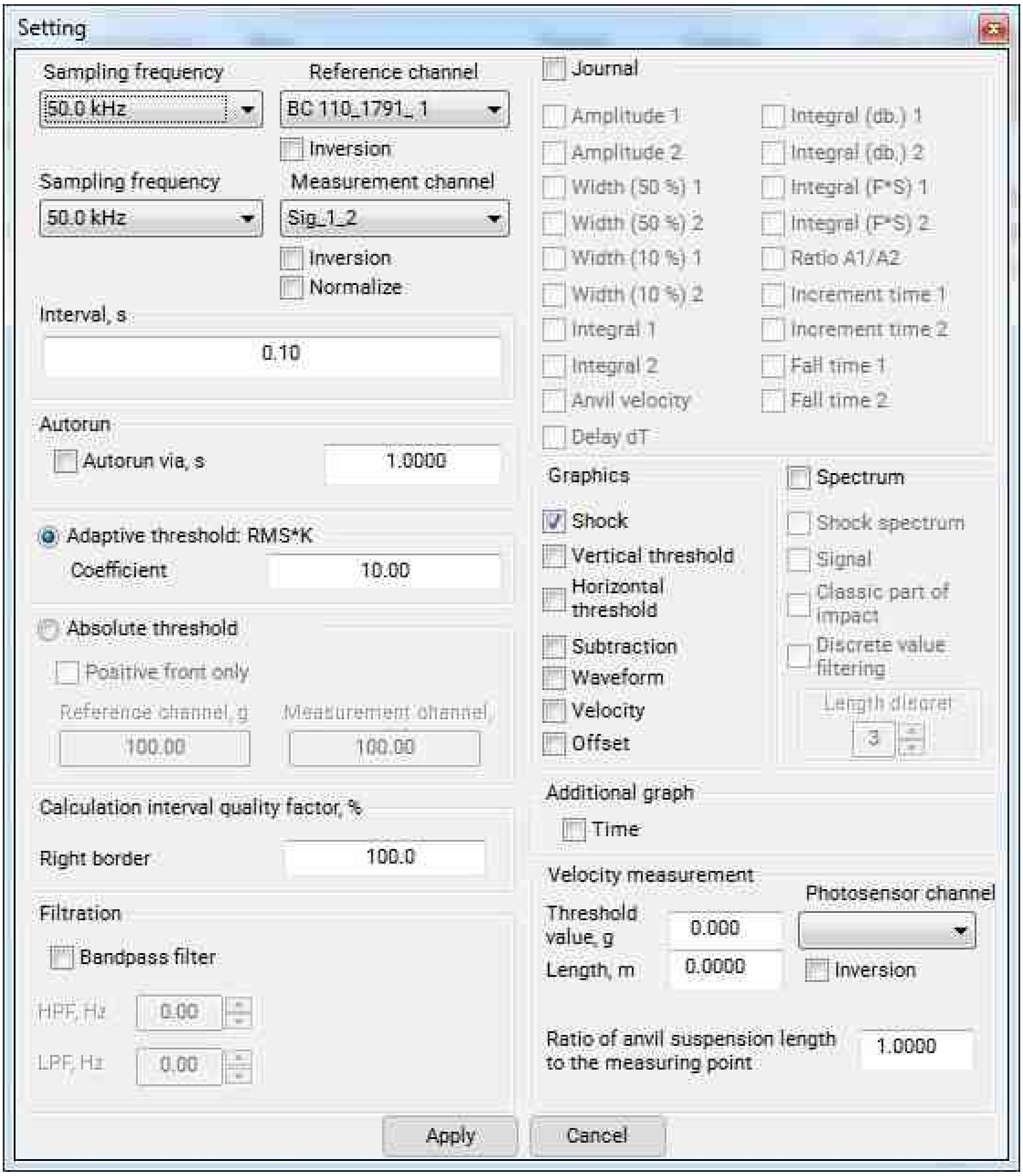


Fig. 5 Setting Modal analysis program

The section below the field "**Interval, s**" depicts the time interval of graphic display. To change the time interval, left-click the section, enter new value and click the "Apply" button or use "Enter" key.

The key "**Apply**" enters the new parameters into the program and closes the parameters adjustment window.

The key "**Cancel**" is used to cancel the parameters saving and closes the parameters configuration window. The parameters adjustment window can also be closed with the corresponding key at the top right section of the window.

Check of main calculating functions .....

The program "**Modal analysis**" is used for analysis of impulse and transient characteristics of the signals received from the input channels of FFT Spectrum Analyzers and seismic recorders in real-time or post-processing mode. For the purpose of checking the major calculating functions of the program it is possible to use the signal from the generator of FFT spectrum analyzer ZET 017. The sampling frequency of ADC channels is 25 kHz, DAC – 200 kHz.

1) Checking the parameters calculating function:

Start the program "Signal generator, enter the RF" tab (*Fig. 1*).

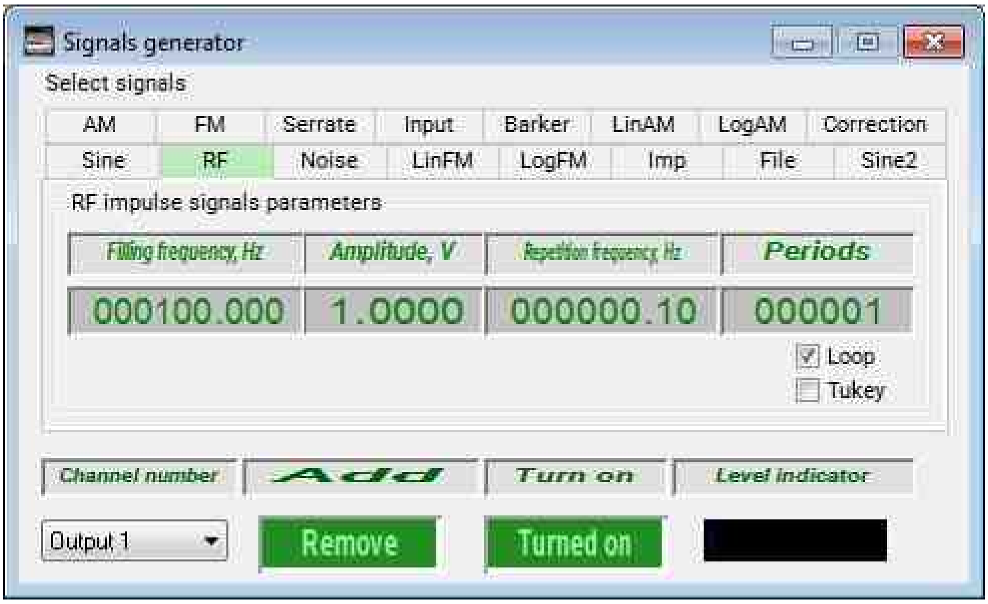


Fig. 1

Start the program "**Modal analysis**" (*Fig. 2*), set the program parameters as it is shown in *Fig. 3*.

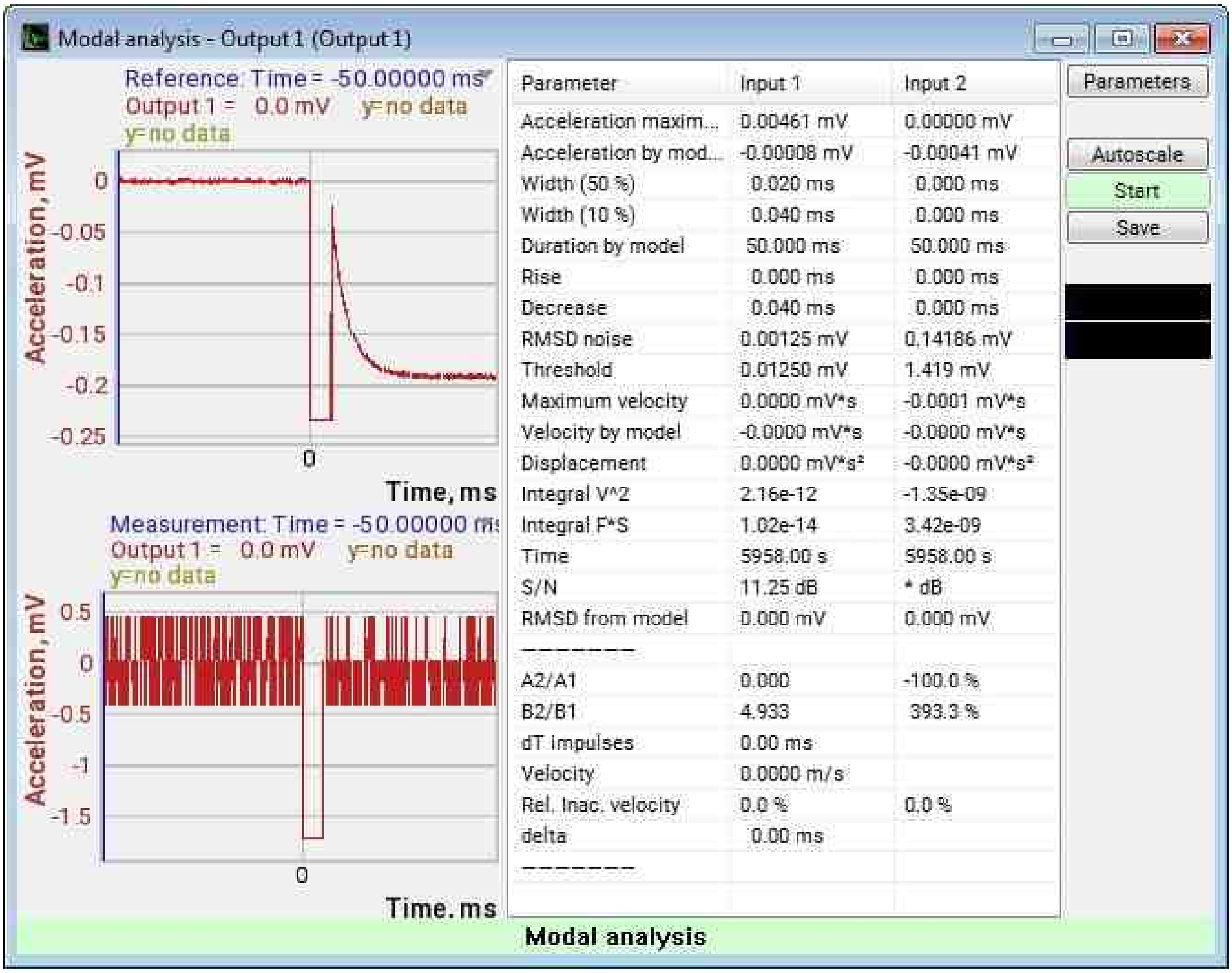


Fig 2 You will see the program interface

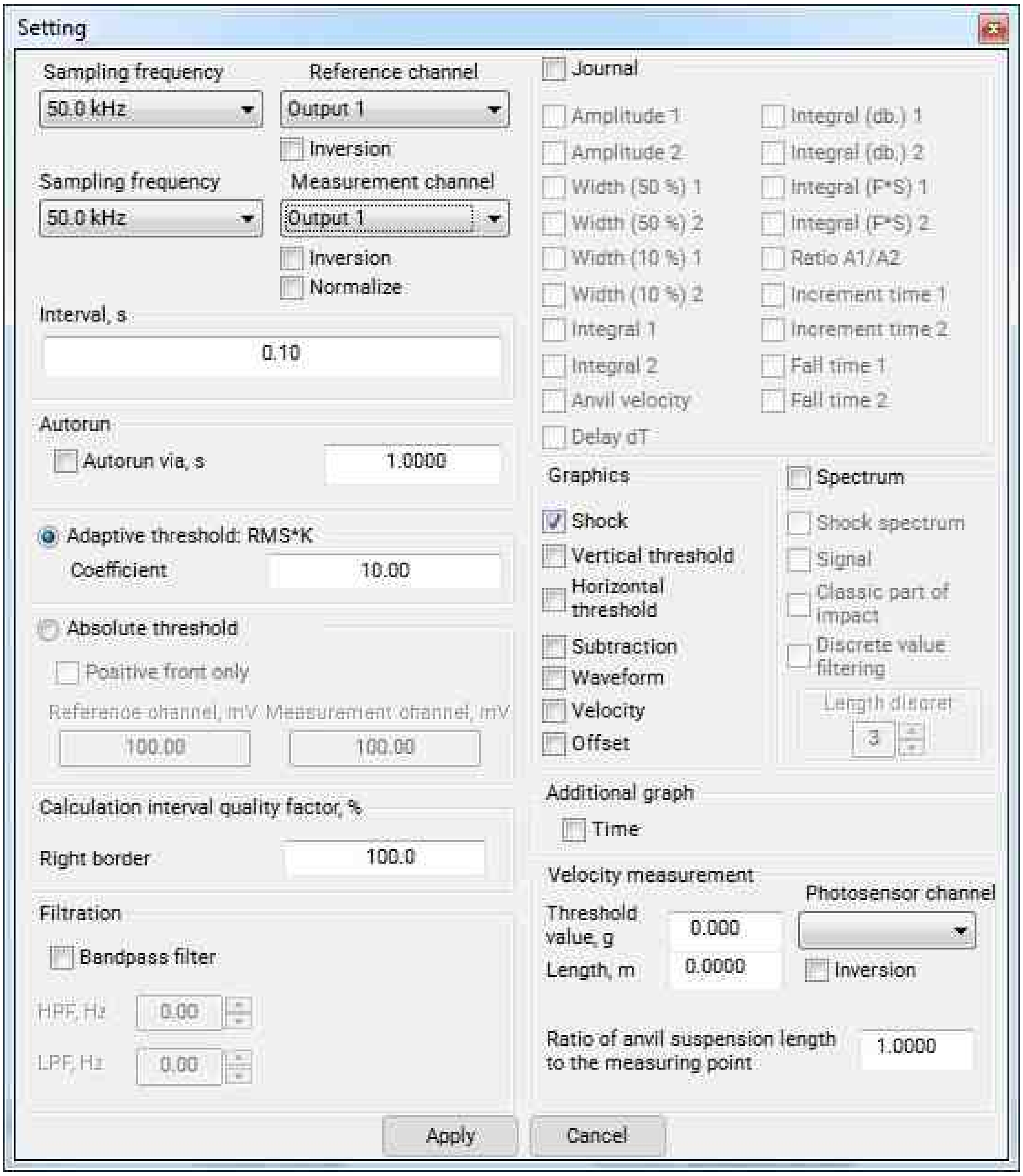


Fig. 3 Setting program "Modal analysis"

In the course of checking process it will be necessary to change the generated signal parameters in the program "**Signals generator**" and to compare the obtained calculated parameters with those specified in the graphic of the program "**Modal analysis**" (*Fig. 4*)

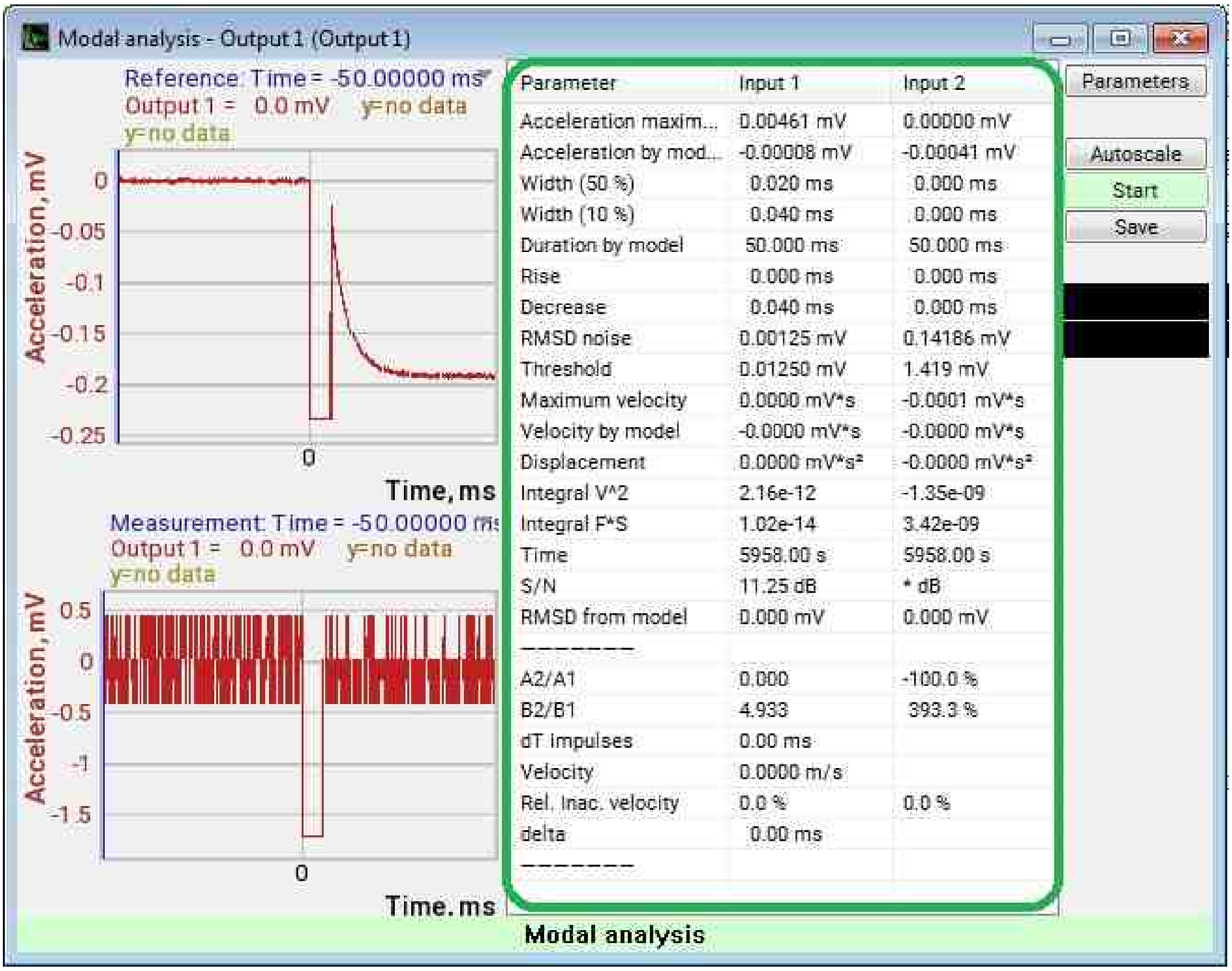


Fig. 4 Compare the obtained calculated parameters

a) Impulse amplitude, Noise RMS, Threshold, S/N

In order to verify the calculation impulse amplitude, noise RMS, threshold level and signal-to-noise ratio (S/N), it is necessary to set the following parameters of the generator: Filling frequency – 100 Hz, Repetition frequency – 0,1 Hz, Number of periods – 1, then click the keys "Remove" and "Turn On" (*Fig. 5*).

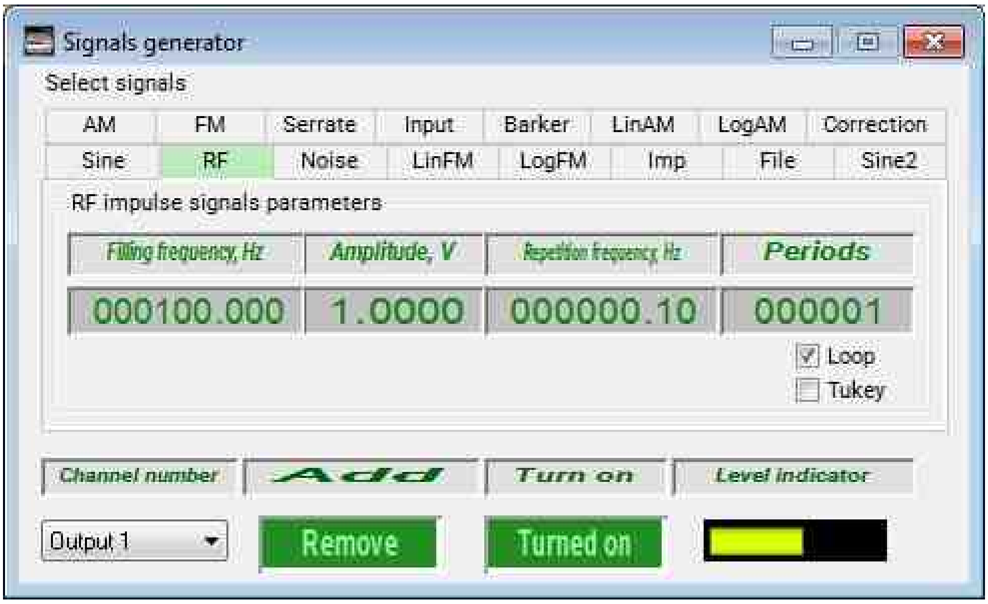


Fig. 5 Click the keys "Remove" and "Turn On"

Alternating parameters of the signal, admissible values of the impulse amplitude, noise RMS, activation threshold, signal-to-noise ratio (S/N) measured with the use of the program "Modal analysis" are shown in *Table 1*.

	Radio impulse amplitude in the program "Signals generator", V	Parameter value in the program "Modal analysis"			
		Pulse amplitude, mV	Noise RMS, mV	Threshold, mV	S/N, dB
	0.01	10±0.2	0	0	*≈60*
	0.05	50±0.2	0	0	*≈44*
	0.1	100±0.2	0	0	*≈50*
	0.25	250±0.2	0	0	*≈58*
	0.5	500±0.2	0	0	*≈64*
	1	1000±0.2	0	0	*≈70*
	5	5000±0.2	0	0	*≈84*

Table 1

Then it is necessary to set radio impulse amplitude value 1 V in the program "Signals generator" and switch over to the "Noise" tab. Set the following noise parameters: noise type – white. Click "Add" key. (*Fig. 6*)

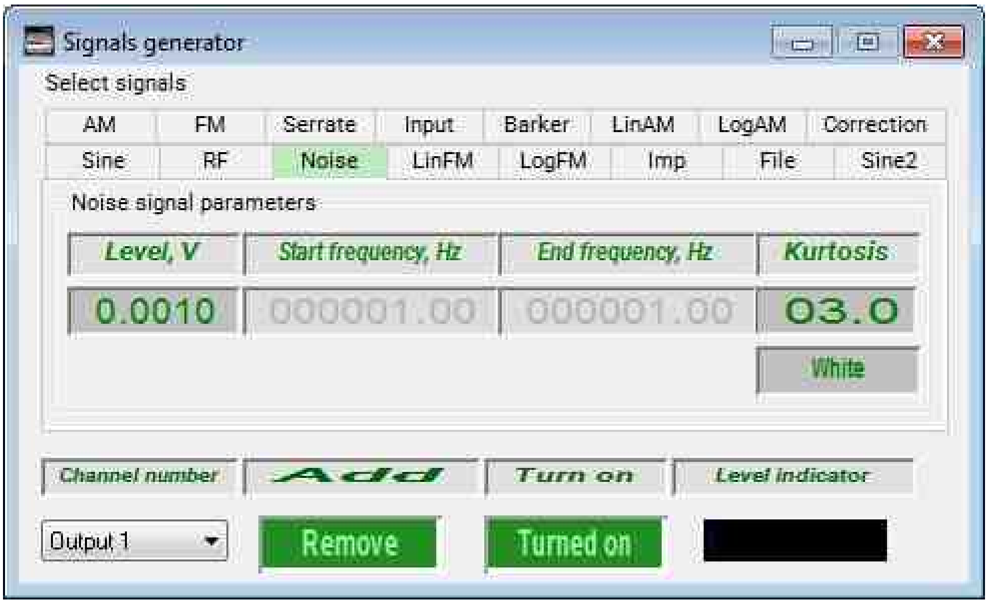


Fig. 6

Thus, there will be formed a radio impulse signal mixed with random noise.

Alternating parameters of the signal, acceptable values of impulse amplitude, noise RMS, activation threshold, signal-to-noise ratio (S/N) measured with the use of the program "**Modal analysis**" are shown in *Table 2*.

	Radio impulse amplitude in the program "Signals generator", V	Parameter value in the program "Modal analysis"			
		Pulse amplitude, mV	Noise RMS, mV	Threshold, mV	S/N, dB
	0.001	1000±3	1±0.1	10±1	*≈60*
	0.005	1000±15	5±0.1	50±1	*≈46*
	0.01	1000±30	10±0.1	100±1	*≈40*
	0.025	1000±75	25±0.2	250±2	*≈32*
	0.05	1000±150	50±0.5	500±5	*≈26*
	0.1	1000±300	100±1	1000±10	*≈20*

Table 2

Based on the procedure of amplitude calculation verification, it is possible to check calculation of the remaining parameters using radio impulse signal together with other signals.

b) Dip

Radio impulse signal parameters: filling frequency – 100 Hz, amplitude – 1 V, Repetition frequency – 0.1 Hz, Periods number – 1.

Additional signal parameters: type – sine signal ("Sinus" tab), frequency – 10 Hz, offset – 0 V.

Measured signal parameters, and acceptable dip value provided by the program "Modal analysis", are shown in *Table 3*.

	Sine signal level in the program "Signals generator", V	Dip parameter value in the program "Modal analysis", mV
	0.001	-1.41±0.2
	0.005	-7.07±0.2
	0.01	-14.1±0.2
	0.025	-35.3±0.2
	0.05	-70.7±0.2
	0.1	-141.4±0.2

Table 3

c) Width (50 %), Width (10 %), Width (0 %)

Radio impulse signal parameters: amplitude 1 V, filling frequency 0,1 Hz, number of periods – 1.

Measured signal parameters and acceptable values of impulse width, measured by means of the program "Modal analysis" are shown in *Table 4*.

	Filling frequency of RF impulse signals, Hz	Parameter value in the program "Modal analysis", ms				
		Width (50%)	Width (10%)	Width (0%)	Rise	Decrease
1	10	33.33±0.1	46.82±0.1	50±0.1	24.5±0.2	24.5±0.2
2	25	13.33±0.05	18.73±0.05	20±0.05	9.8±0.2	9.8±0.2
3	100	3.33±0.05	4.68±0.05	5±0.05	2.45±0.05	2.45±0.05
4	500	0.67±0.05	0.94±0.05	1±0.05	0.49±0.05	0.49±0.05
5	1000	0.34±0.05	0.47±0.05	0.5±0.05	0.25±0.05	0.25±0.05

Table 4

Note: width of the radio impulse signal at the level of 50% of the amplitude (i.e. one sinusoidal period) should be calculated as a difference between the moments at which the sinusoidal value is 0,5, i.e. between the moments π/6 and 5π/6. Thus, the width (50%) is equal to 2π/3, i.e. to 1/3 of the signal period.

Note: the width at the level of 10% of the radio impulse signal (a single sinusoidal period) should be calculated as a difference between the moments, where the sine value is 0,1, i.e. between the moments arcsin(0.1) and (π - arcsin(0.1)). arcsin(0.1)≈0.1.Thus, the width (10%) is equal to (π-0.2)/2π, i.e. to 0.468 of the signal period.

Note: the width (0%) for radio impulse signal (a single sine period is equal to 1/2 of the signal period.

Note: impulse rise is calculated as the difference between the maximum impulse value and the moment of maximal impulse value and the moment at which the pre-pulse value exceeds 0,03 from the impulse amplitude value. For radio impulse signal (a single sinusoidal period) the rise is calculated between the moment arcsin(0.03) and π/2. arcsin(0.03)≈0.03 Thus, the rise is equal to (π/2-0.03)/2π, i.e. to 0.245 of the signal period.

Note: impulse decrease is calculated as a difference between the moment at which the after-pulse value is below 0.03 of the impulse amplitude and the moment at which the impulse has the maximal possible value. For radio impulse signal (a single sinusoidal period) the decrease is calculated between the moment π/2 and (π-arcsin(0.03)). arcsin(0.03)≈0.03 Thus, the increase is equal to (π-0.03- π/2)/2π, i.e. to 0.245 of the signal period value.

Recording results to a file .....

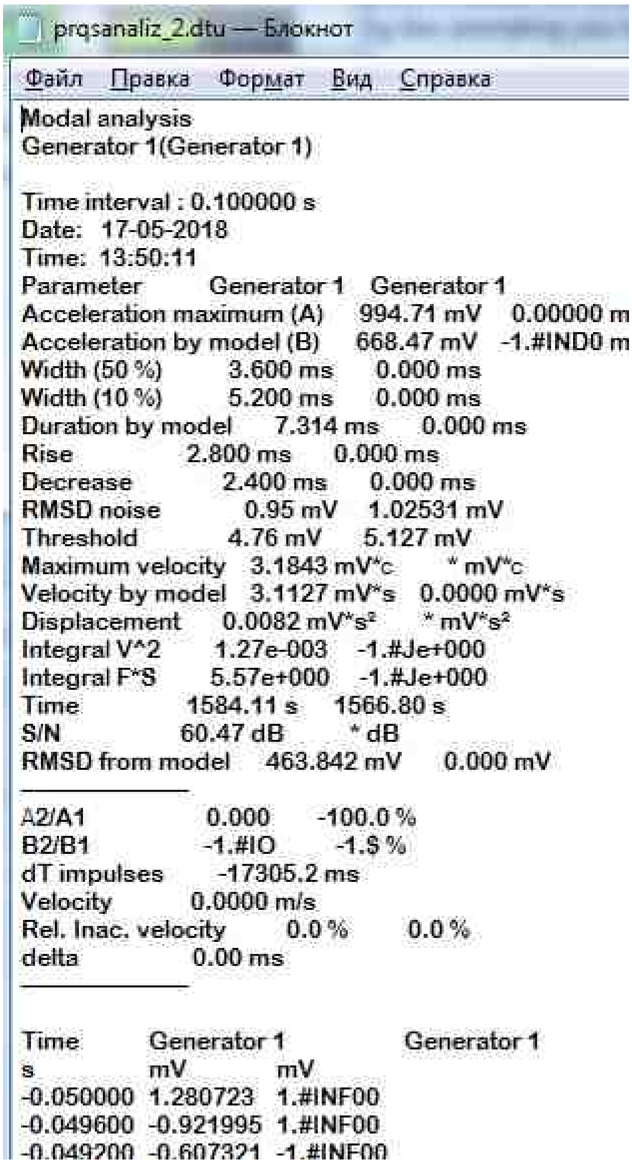
The program **Modal Analysis** allows to record the instant values of the displayed spectrum to a text file with *.dtx extension. When you click The Recording button in the program window of the **Modal**

Analysis, there appears a standard dialog box offering you to specify a directory to save the file and the file name. The directory by default is – C:\ZETLab\result.

Note:

When using Excel for opening the dtx file (these files have UTF-8 format), make sure that the right file format (UTF-8) and the separator (tab) are selected. The default settings for opening the file seem to have other parameters.

An example file is shown in the Fig. below.



```
prqsanaliz_2.dtu — Блокнот
Файл  Правка  Формат  Вид  Справка
Modal analysis
Generator 1(Generator 1)

Time interval : 0.100000 s
Date:  17-05-2018
Time:  13:50:11
Parameter        Generator 1   Generator 1
Acceleration maximum (A)   994.71 mV   0.00000 m
Acceleration by model (B)   668.47 mV   -1.#IND0 m
Width (50 %)      3.600 ms     0.000 ms
Width (10 %)      5.200 ms     0.000 ms
Duration by model     7.314 ms     0.000 ms
Rise          2.800 ms     0.000 ms
Decrease         2.400 ms     0.000 ms
RMSD noise        0.95 mV    1.02531 mV
Threshold         4.76 mV    5.127 mV
Maximum velocity   3.1843 mV*c      * mV*c
Velocity by model   3.1127 mV*s   0.0000 mV*s
Displacement     0.0082 mV*s²     * mV*s²
Integral V^2      1.27e-003    -1.#Je+000
Integral F*S      5.57e+000    -1.#Je+000
Time          1584.11 s    1566.80 s
S/N           60.47 dB       * dB
RMSD from model    463.842 mV     0.000 mV
______________
A2/A1          0.000     -100.0 %
B2/B1          -1.#IO      -1.$ %
dT impulses      -17305.2 ms
Velocity        0.0000 m/s
Rel. Inac. velocity     0.0 %       0.0 %
delta          0.00 ms
______________

Time      Generator 1            Generator 1
s         mV         mV
-0.050000  1.280723   1.#INF00
-0.049600  -0.921995  1.#INF00
-0.049200  -0.607321  -1.#INF00
```

Results file recorded with the program "Modal Analysis"

Areas of application of the modal analysis program .....

Reduced vibration associated with structural resonance

Specimen damage detection

Single impact testing is used as a way to determine the quality of a sample design and assess its structural strength. The test is carried out by exposing the sample to single impacts on an impact shaker with standard impulse shapes of a certain duration and peak acceleration. Important parameters for this type of test are: the degree of impact hardness and change in speed. In many practical cases, shock acceleration spectra provide complete information about the potential damage that has occurred during operation.

Reduced vibration associated with structural resonance

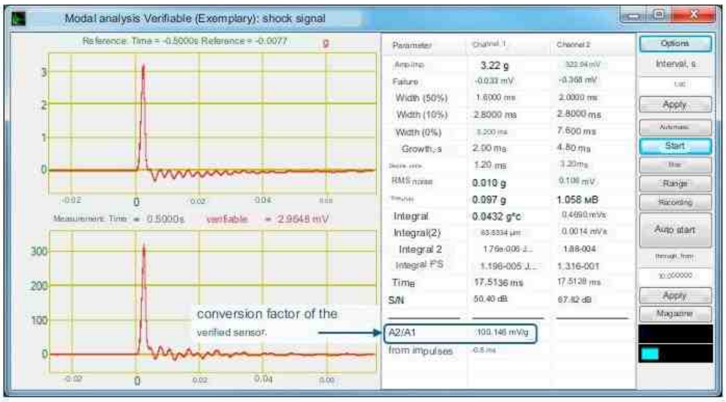
Specimen damage detection

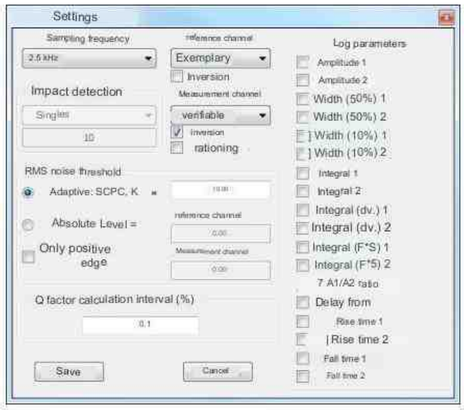
As a result of operation, fatigue deformations, microcracks in the connecting seams can occur in the product, which do not lead to changes in the geometric dimensions of the product, but lead to a change in the dynamic characteristics of the structure. The analysis of these changes makes it possible to predict the performance of routine maintenance work.

Conducting experimental research for scientific purposes

Checking sensors

Checking sensors on an impact vibration stand is carried out by comparing the sensitivity of the verified and exemplary vibration sensors. Checking is performed by single blows with different durations and peak accelerations. The program calculates the duration of amplitudes, impulses, amplitude ratios, steepness of fronts, shock acceleration impulse. These parameters are the primary data for checkup.





Distinctive features of ZETLAB modal analysis

VERSATILITY

No requirements for a vibration exciter, which simplifies the system and reduces its cost

possibilities

Simple and fast determination of natural frequencies and various oscillation mode

GOST 31937-2011

Determination of natural frequency and decrement when examining the state of building structures

SELECTION OF EQUIPMENT

The program comes with spectrum analyzers, seismic stations, strain gauges

IMPACT SPECTRUM CALCULATION

in accordance with GOST 31418-2010 (IEC 60068-2-81:2003) and GOST R 53190-2008 (MЭK 60088-2-81:2003)

RECORDING THE RESULTS

Saving measurement results to a file opened by word, excel, notepad editors

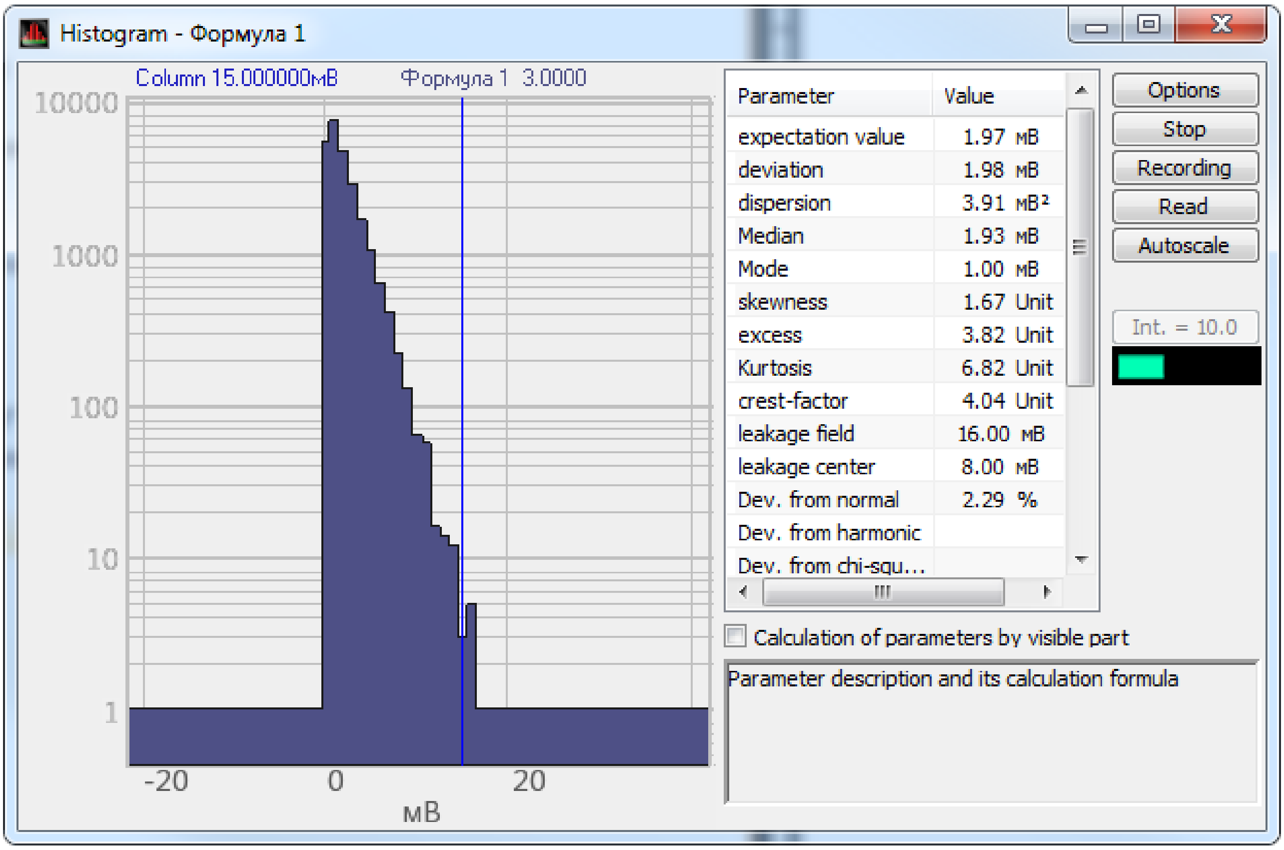
Histograph .....

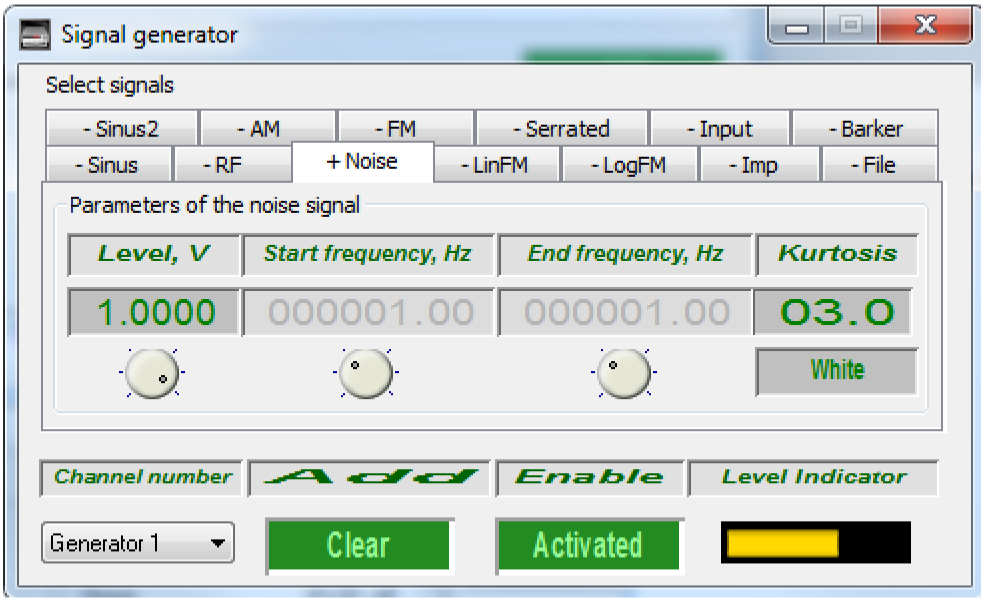
The **Histograph** software is used for statistical signal analysis: finding the statistical values characterizing the signal and building the theoretic histograms based on the data obtained.
The software allows to build the following diagrams:

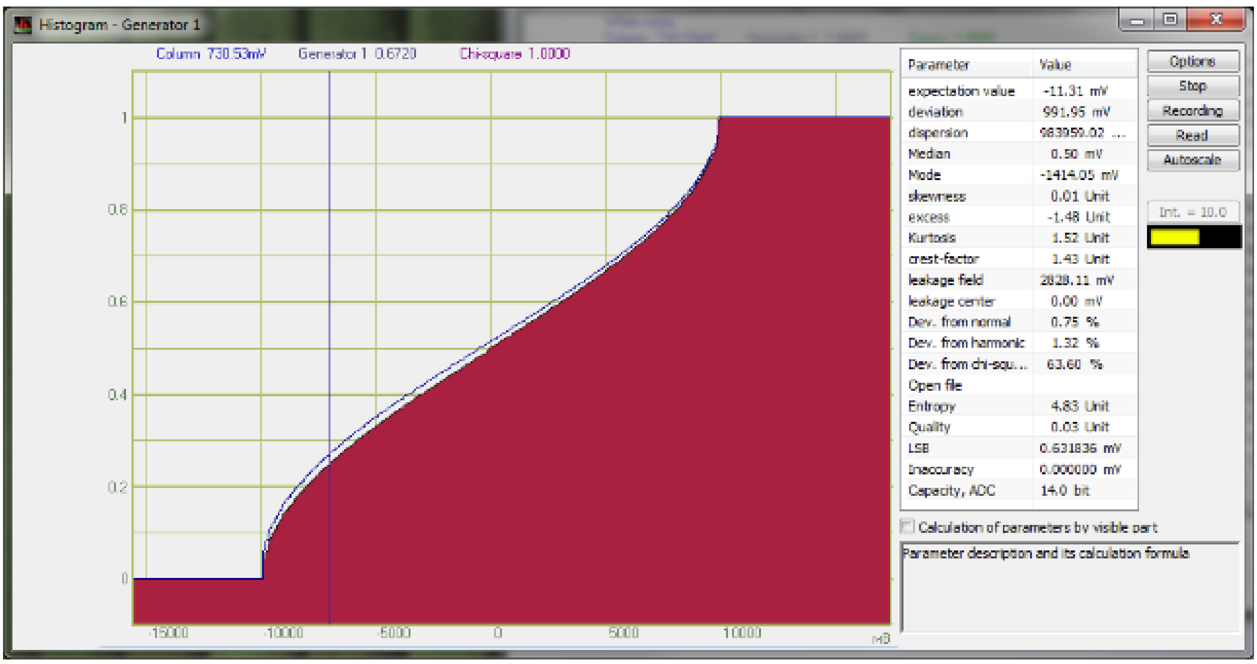
- Histogram
- Probability
- Probability density function

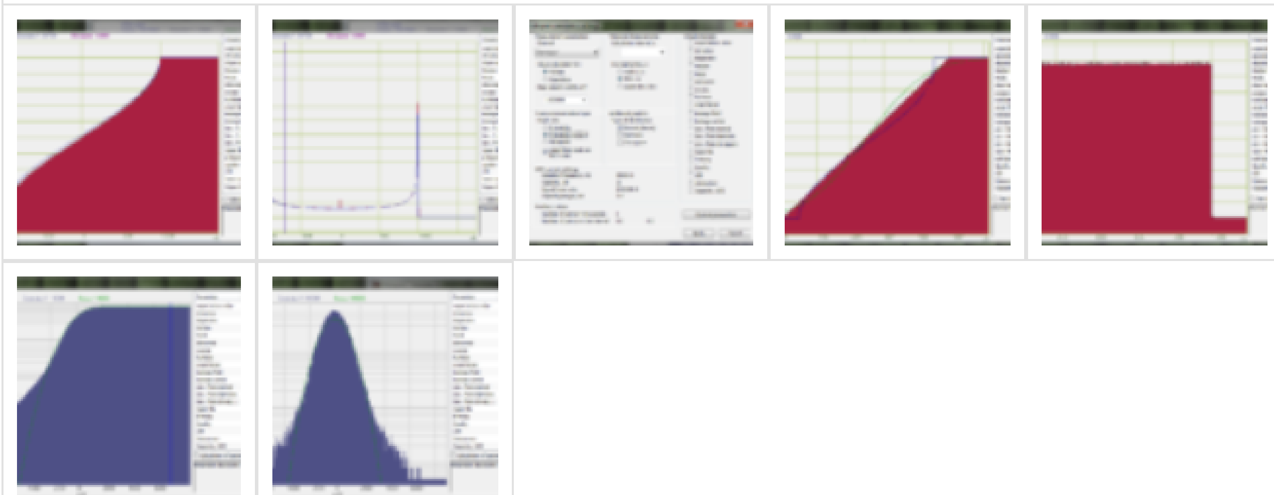
The program has an integrated control and automation module from the scope of ZETLab-Studio software package. The module enables easy creation of individual software measurement suites.

Input data for **Histogram** includes digital data of the ZETLAB server channel (signals registered by a FFT spectrum analyzer, a strain-gauge station, or a seismic station).




Signal generator
Select signals
- Sinus2
- AM
- FM
- Serrated
- Input
- Barker
- Sinus
- RF
+ Noise
- LinFM
- LogFM
- Imp
- File
Parameters of the noise signal
Level, V
Start frequency, Hz
End frequency, Hz
Kurtosis
1.0000
000001.00
000001.00
03.0
White
Channel number
Add
Enable
Level Indicator
Generator 1
Clear
Activated


Histogram - Generator 1
Column 730.53mV
Generator 1 0.6720
Chi-square 1.0000
Parameter
Value
expectation value
-11.31 mV
deviation
991.95 mV
dispersion
983959.02 ...
Median
0.50 mV
Mode
-1414.05 mV
skewness
0.01 Unit
excess
-1.48 Unit
Kurtosis
1.52 Unit
crest-factor
1.43 Unit
leakage field
2828.11 mV
leakage center
0.00 mV
Dev. from normal
0.75 %
Dev. from harmonic
1.32 %
Dev. from chi-squ...
63.60 %
Open file
Entropy
4.83 Unit
Quality
0.03 Unit
LSB
0.631836 mV
Inaccuracy
0.000000 mV
Capacity, ADC
14.0 bit
Options
Stop
Recording
Read
Autoscale
Int. = 10.0
Calculation of parameters by visible part
Parameter description and its calculation formula
1
0.8
0.6
0.4
0.2
0
-15000
-10000
-5000
0
5000
10000
mB



Supported Hardware .....

For the purpose of analog signals digital processing, it is possible to use *FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01* and *seismic recorder ZET 048*.

Settings of measurement channels are specified in the program "Device Manager".

Histogram is a part of the following software:

- ZETLAB ANALIZ – FFT Spectrum Analyzers software;
- ZETLAB VIBRO – Shaker controllers software;
- ZETLAB TENZO – Strain-gauge station software;
- ZETLAB SEISMO – Seismic station software;;
- ZETLAB SENSOR – digital ZETSENSOR sensor software

Histogram is included in the **Signal Analysis** software group.

Program description .....

In order to start "**Histogram**" program, select the corresponding command from "**Signal analysis**" menu (Fig. 1) of ZETLAB panel. You will see the main window of the "**Histogram**" program (*Fig. 1*). The title of the window depicts the name of the program, and the name of the program selected for analysis. Above the graphic, you can see the measured parameters values (frequency, signal level), corresponding to the position of graphic cursor. The right part of the window shows the distribution parameters: expectation value, dispersion, RMS deviation, leakage and leakage center.

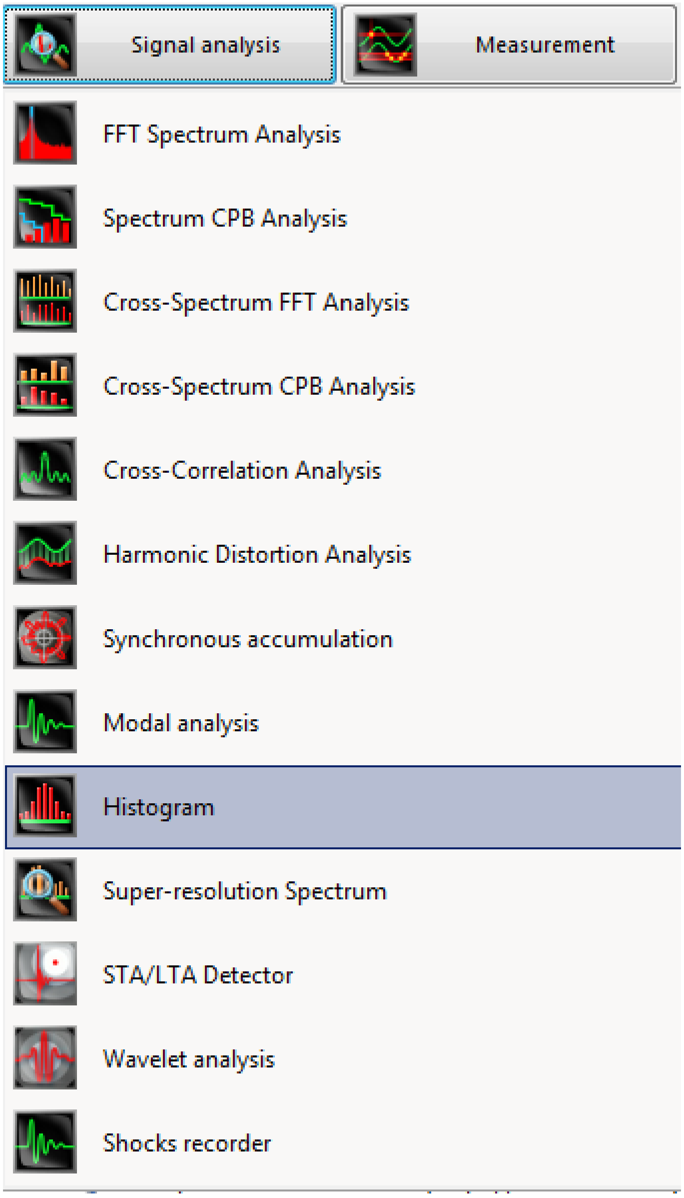
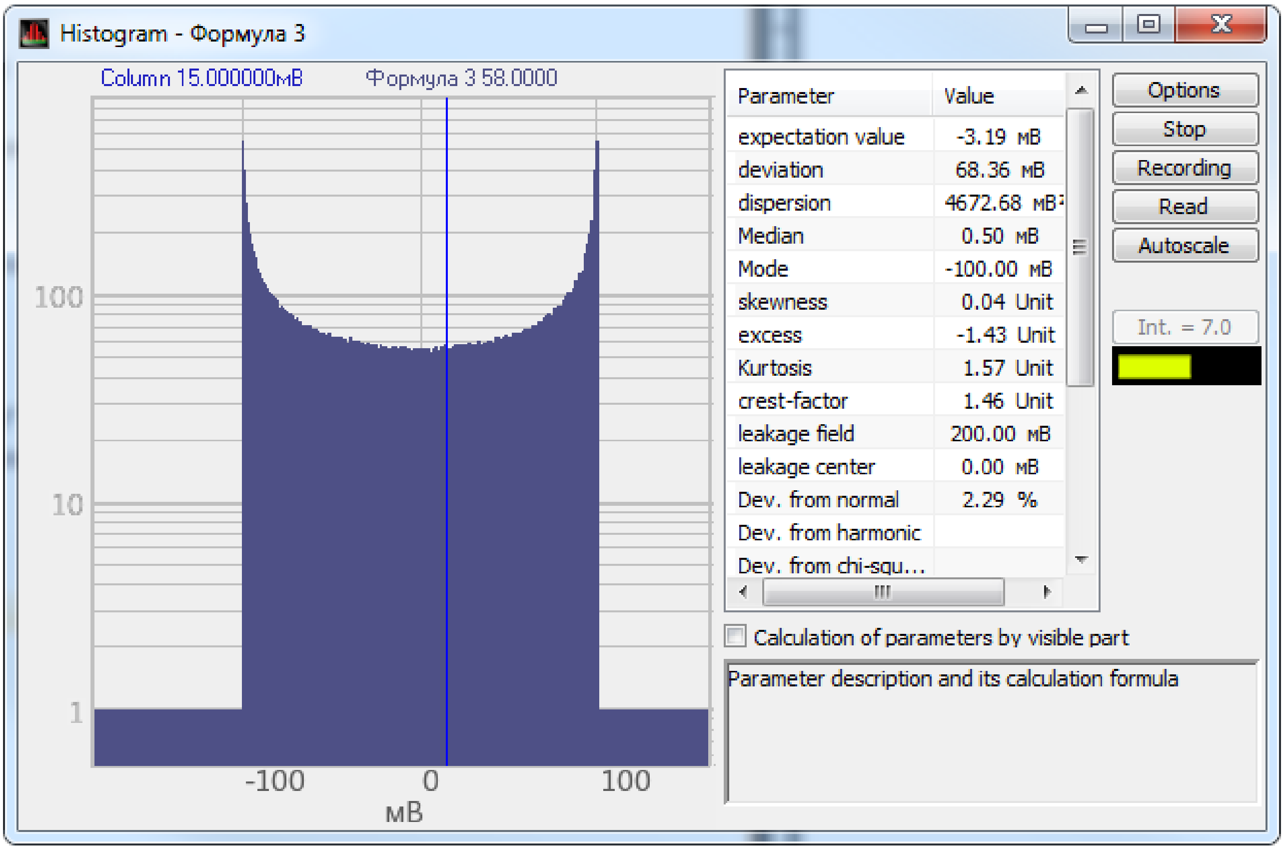


Fig. 1. Starting the "Histogram"



"Histogram" program: control

"Parameters" key allows to activate the window "Parameters adjustment".

The **"Autoscale"** key allows to align both graphics by the signal level.

The **"Start"** key is used to display the signal. Upon activation of the program "Harmonic Distortion Analysis", the "Start" key is active by default.

The **"Stop"** key allows to suspend both signal displaying process and data update. However, the server continues data accumulation process and all other programs continue their operation.

The **"Recording"** key activates a standard dialog window "Recording the results in a file", allowing the user to select the file name as well as to assign the directory for saving the file (directory by default - C:\ZetLab\result\). The file is saved with *.dtu extension. The file contains information description, data in floating point format (a point is used for separation between fractional and integer numbers).

The **"Read"** key is used for loading of the results data from a file.

The indicator depicts integral level of the signal and overloading. In the case, if the signal exceeds the maximal acceptable level, the indicator turns completely red without any black section at the right part. The right section of the indicator will remain red until the user left-clicks it.

In order to exit the program "**Histogram**", click the corresponding key in the top right section of the program interface.

See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Setting parameters of display
- Using signal level indicators
- Adjustment of the color scheme used for displaying of the registered signal amplitude values
- Graphical and numerical data transfer to text editors
- Setting GridGl grid functionality

Program settings .....

To set parameters of "**Histogram**" program, click "Parameters" key at the top right section of the program. The general view of the "Histogram settings" is shown in Fig. 2.

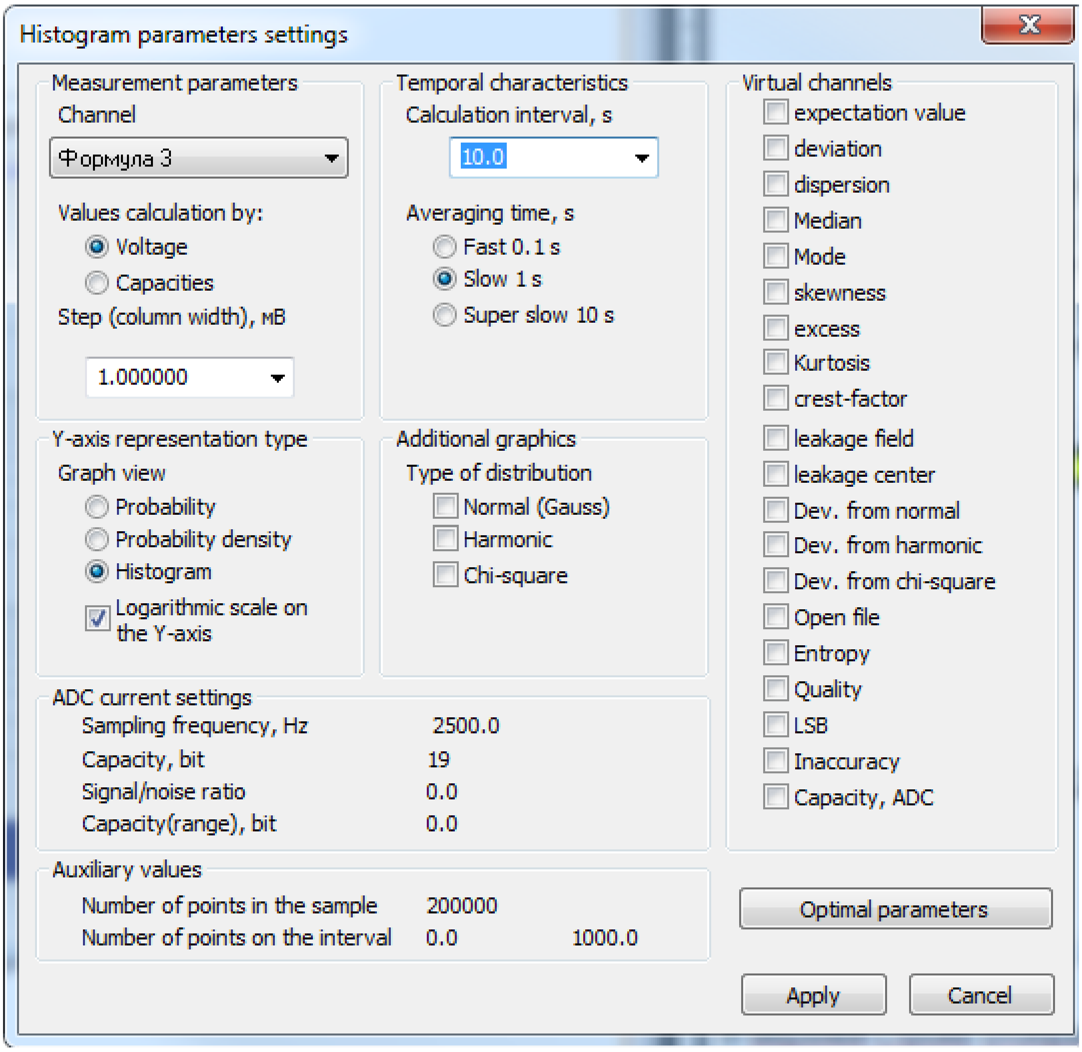


Fig. 2 Histogram parameters setting

The upper line depicts sampling frequency value of the measurement channel.

The top left section of the window interface is used for setting the **"Measurement parameters"** and "**Step (column width)**". The menu "**Values calculation by:**" allows to set voltage or ADC capacity parameter. By measurement limit there is meant the maximal possible value of the channel or the maximal expected value. The measurement step is the width of histogram column. Note: if the parameter **"Calculation by voltage"** is selected, then the measurement step shall be calculated as (3*log(N) +6)/step, where N is the number of counts in a single cycle of the histogram.

The bottom left section of the program allows to set the values of the "**Calculation interval"** and "**Averaging**" parameters. The calculation interval is the memory buffer duration (in seconds). The "Averaging" parameter stands for the polling rate of the program.

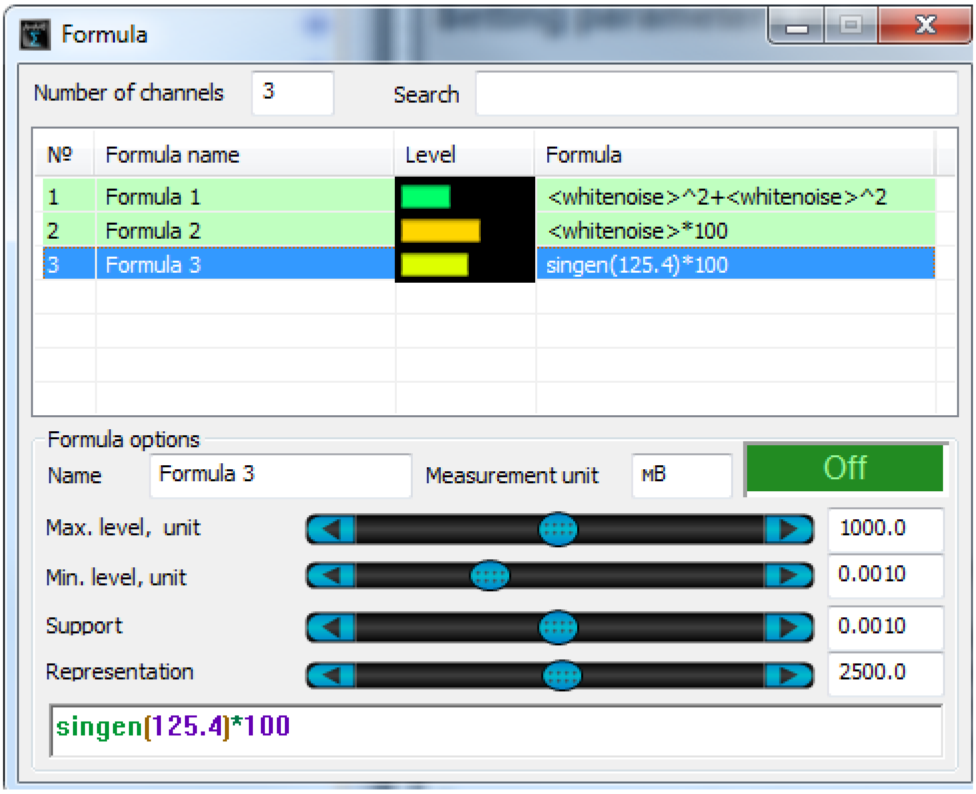
In the upper right section of the program, it is possible to set the name of the measurement channel used for parameters calculation and the representation type. The **"Representation type"** menu has the options "**Probability**" and **"Probability density"** (by "**Probability**" there is meant the integrated density value). The checkbox "**Normalization**" allows to normalize the obtained measurement values.

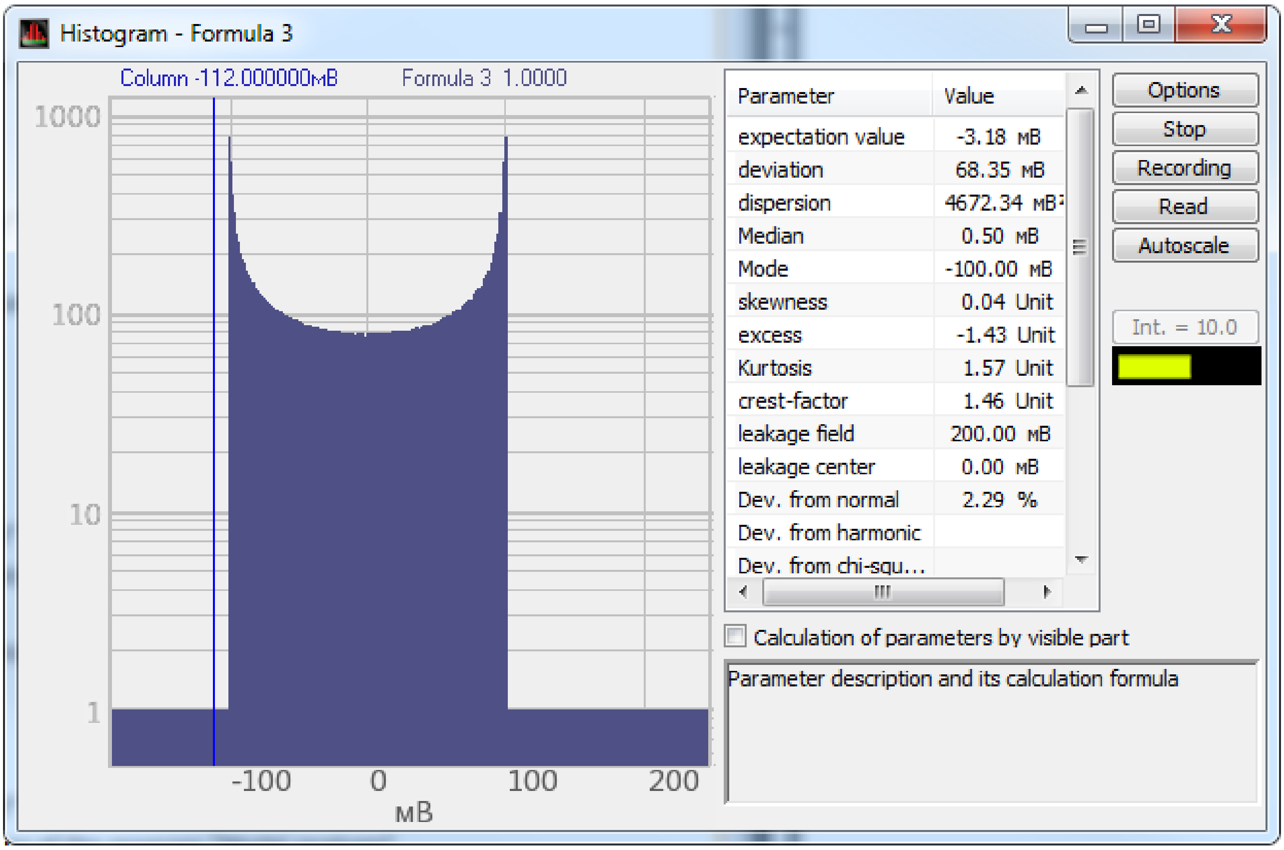
In the bottom right section of the program, it is possible to set representation of Additional graphics (theoretical distributions with the same parameters configuration).

The "**Normal (Gauss)**" distribution has the same expectation and dispersion value as the real distribution.

"**Harmonic**" distribution has the same dispersion field.

"Chi-square" option has the same DOF. By DOF there is meant the sum of the squares of independent random values, the sum of which stands for Chi-square distribution.
The examples are shown in the Fig.s below:


Formula
Number of channels 3
Search
№ Formula name Level Formula
1 Formula 1 <whitenoise>^2+<whitenoise>^2
2 Formula 2 <whitenoise>*100
3 Formula 3 singen(125.4)*100
Formula options
Name Formula 3
Measurement unit мВ
Off
Max. level, unit 1000.0
Min. level, unit 0.0010
Support 0.0010
Representation 2500.0
singen(125.4)*100


Histogram - Formula 3
Column -112.000000мВ
Formula 3 1.0000
1000
100
10
1
-100 0 100 200
мВ
Parameter Value
expectation value -3.18 мВ
deviation 68.35 мВ
dispersion 4672.34 мВ
Median 0.50 мВ
Mode -100.00 мВ
skewness 0.04 Unit
excess -1.43 Unit
Kurtosis 1.57 Unit
crest-factor 1.46 Unit
leakage field 200.00 мВ
leakage center 0.00 мВ
Dev. from normal 2.29 %
Dev. from harmonic
Dev. from chi-squ...
Options
Stop
Recording
Read
Autoscale
Int. = 10.0
Calculation of parameters by visible part
Parameter description and its calculation formula

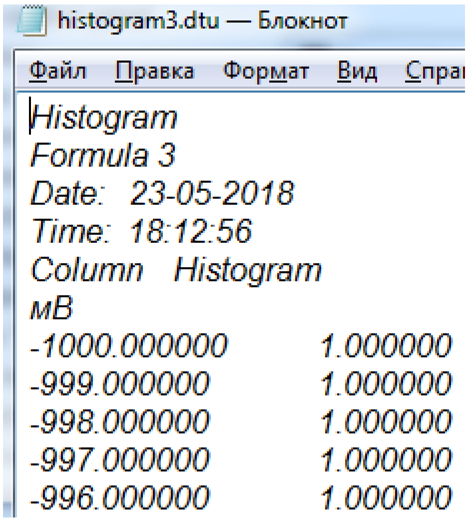
Recording results to a file .....

The program **Histograph** allows to record the instant values of the displayed spectrum to a text file with *.dtu extension. When you click The Recording button in the program window of the **Histograph,** there appears a standard dialog box offering you to specify a directory to save the file and the file name. The directory by default is – C:\ZETLab\result.

Note:

When using Excel for opening the dtu file (these files have UTF-8 format), make sure that the right file format (UTF-8) and the separator (tab) are selected. The default settings for opening the file seem to have other parameters.

An example file is shown in the Fig. below.



Results file recorded with the program "Histograph"

Super-Resolution Spectrum .....

The program "**Super-Resolution Spectrum**" (further referred to as the "program") is intended for solving the following tasks:

- analysis of long-term dependencies of FFT Spectrum signals parameters;
- spectral separation of signal’s harmonic components having similar frequency range.

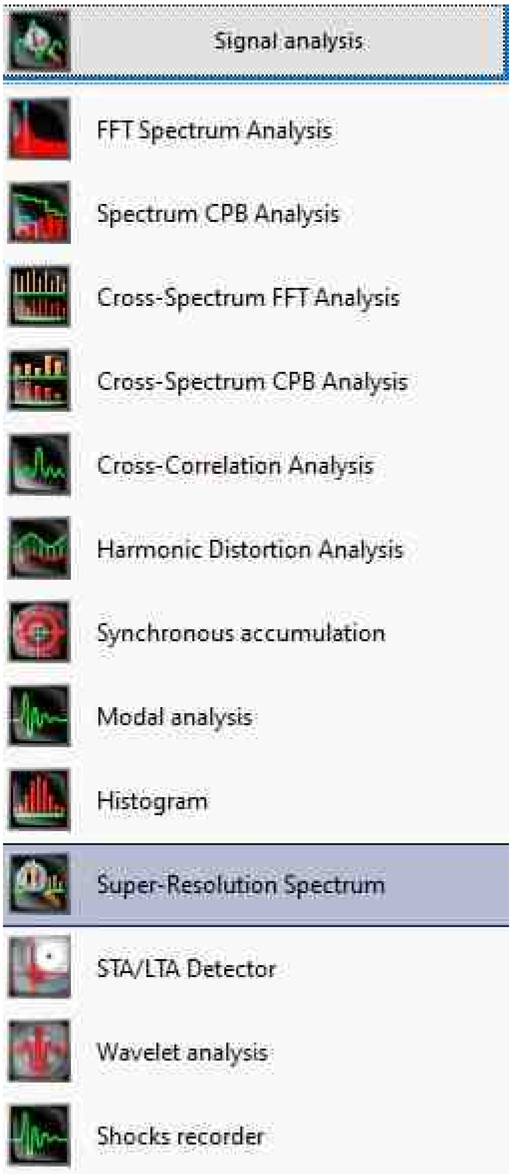


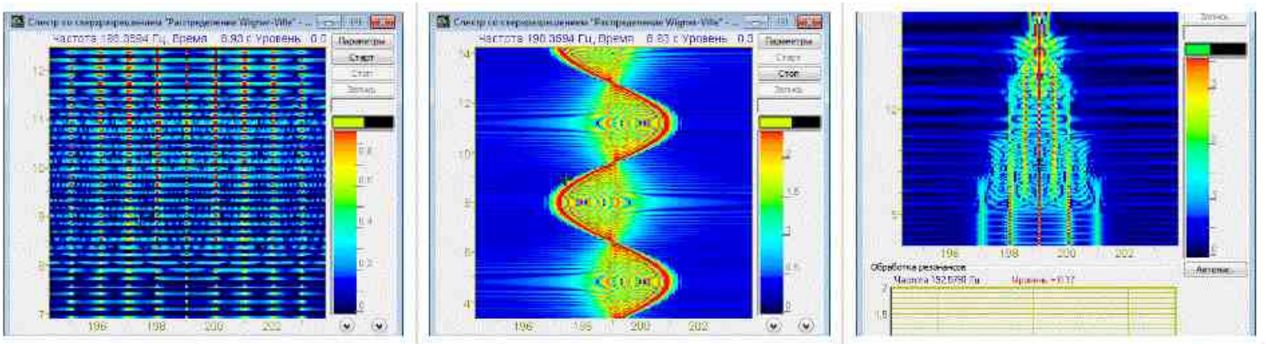
Fig. 1. Starting the "Super-resolution Spectrum"

The program does not serve as a substitution for "**FFT Spectrum Analysis**" software which is used to determine primary signal frequency band in the case of **FFT Spectrum Analysis**.

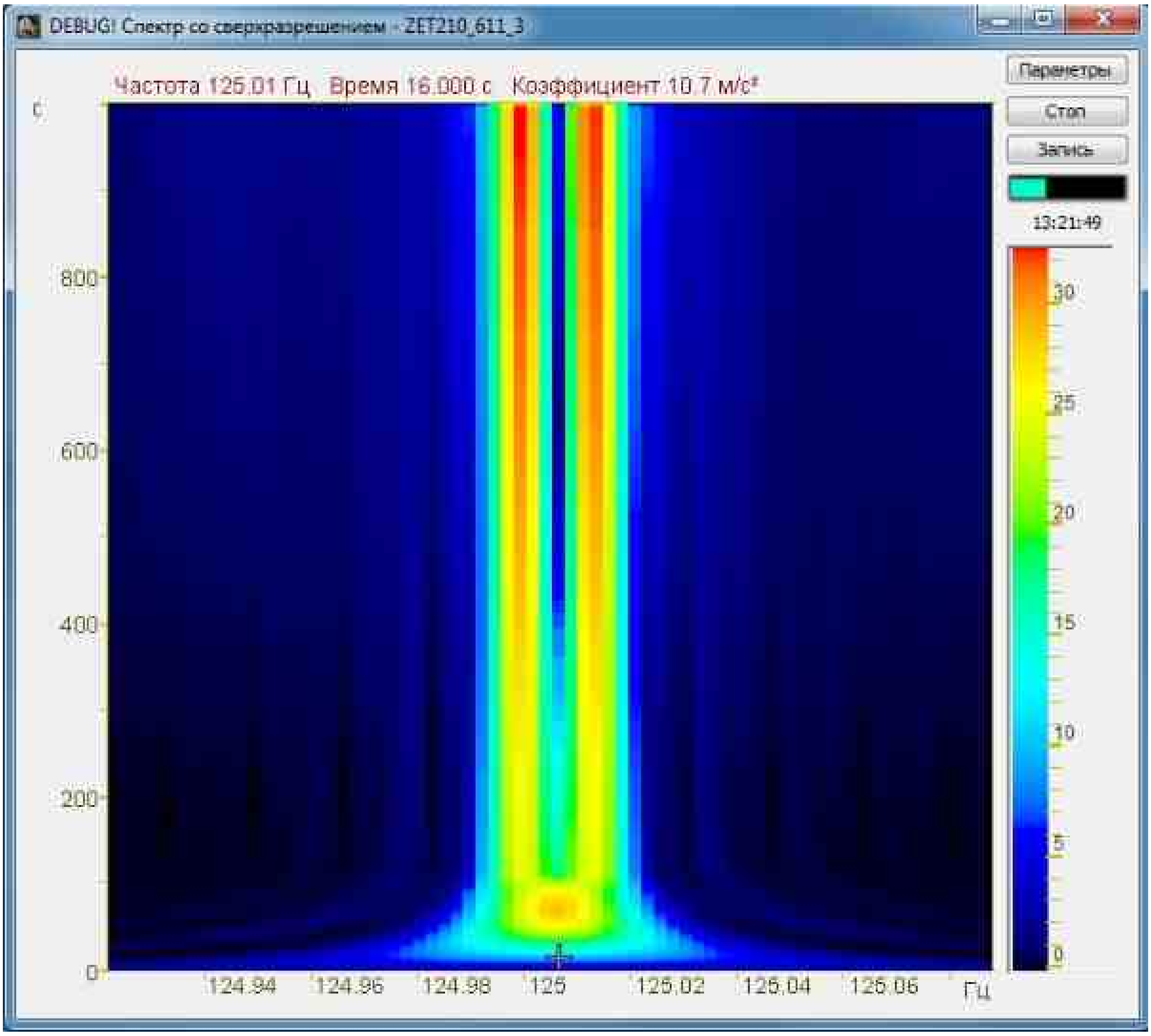
Then the "Super-resolution spectrum" program enables perfomance of spectral analysis with a maximum resolution value available in the "**FFT Spectrum Analysis**" software.

The program creates a two-dimensional sonogram of the selected signal. Horizontal axis represents the frequency value of the selected band and the vertical axis shows the time (time value maximum limit is up to 83 hours).

The sonogram has a color representation of spectral density power. The color sonogram allows the operator to easily determine the maximum value change nature, which (depending on the particular task) can be a resonance, intrinsic frequency or other parameter of the researched **FFT Spectrum Analysis**.



Below you can see a Fig. showing a sonogram of the program for the first 1000 seconds of signal processing process. It is represented by a sum of two harmonic signals with frequencies of 125,00 and 125,01 Hz. Amplitudes of both harmonic components are equal. Signal sampling frequency is 10 kHz. In this case, the program "**FFT Spectrum Analysis**" does not allow to reveal presence of two harmonics with a frequency difference of 0,008%. However, amplitude fluctuations displayed at the oscilloscope inform us of signal's complex structure, which is also proved by the sonogram.



Program sonogram: processing of the signal represented by two harmonic signals with frequencies of 125,00 Hz and 125,01 Hz.

Supported Hardware .....

For the purpose of analog signals digital processing, it is possible to use *FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01 seismic recorder ZET 048*.

Settings of measurement channels are specified in the program "Device Manager".

Super-resolution Spectrum is a part of the following software:

- ZETLAB ANALIZ – FFT Spectrum Analyzers software;
- ZETLAB VIBRO – Shaker controllers software;
- ZETLAB TENZO – Strain-gauge station software;
- ZETLAB SEISMO – Seismic station software;;

- ZETLAB SENSOR – digital ZETSENSOR sensor software

Super-resolution Spectrum is included in the **Signal Analysis** software group.

Functions of the program .....

The program "**Super-Resolution Spectrum**" (further referred to as the "program") is intended for solving the following tasks:

- analysis of long-term dependencies of FFT Spectrum signals parameters;
- spectral separation of signal's harmonic components having similar frequency range.

The program can be used when it is necessary to analyze the influence of the external factors upon natural frequencies and resonance characteristics of various technical facilities (bridges, buildings, structures, etc.). The program calculates and displays spectrum of the controlled signal with the set parameters of frequency resolution.

The program should not be considered to be a substitution of "**FFT Spectrum Analysis**" program, which is used in the course of **FFT Spectrum Analysis** for primary estimation of signal's frequency bandwidth.
After that, using the program "**Super-Resolution Spectrum**", it is possible to implement spectral analysis with the maximum resolution level available in the program "**FFT Spectrum Analysis**".

When the program is started, it depicts a 2-dimensional sonogram of the selected signal. The horizontal axis corresponds to frequency of the selected bandwidth, the vertical axis indicates time (max. value – up to 83 hours). The color indication of the sonogram corresponds to the power spectral density. The color representation of the sonogram allows the operator to evaluate the dynamics of the maximal value, which, depending on the particular task, can be resonance, natural frequency, or any other parameter of the analyzed narrow-band signal.

For calculation of the spectral power density, it is possible to use one of the following algorithms: fast Fourier transform (FFT) or pseudo Wigner-Ville distribution (PWV). The values of power spectral density displayed by the program are normalized in reference to the amplitude value. It means, that if the input signal of the program is represented by a harmonic signal, then the value of power spectral density displayed by the program at the frequency of this harmonic signal, should almost coincide with the amplitude value of this signal, measured with the program "DC Voltmeter".

Below you can find description of the program use with a sine signal (frequency - 12,5 Hz, amplitude – 100 mV, digitized at the sampling frequency of 100 Hz) used as an input signal.

The program has several windows: the main window, the parameters setting window (further referred to as "parameters window"), the window displaying time correlation between the parameters of central frequency and the window for representation of averaged signal spectrum.

Program description .....

Main program window

If a sine signal (12,5 Hz frequency and 100 mV amplitude) is applied to the channel input, and the program parameters are set in accordance with *Fig. 2*, then, approximately after 100 seconds, the main program window will contain the same information, as is shown in *Fig. 4*. The title of the window will depict the name of the program "Super-Resolution Spectrum" and the name of the analyzed channel.

X axis depicts frequency value in the range from 12,45 up to 12,55 Hz, i.e. from (F0 – ΔF/2) up to (F0 + ΔF/2). Y axis depicts time values from 0 up to 100 seconds, i.e. from "0" up to the value of the displayed interval. The highlighted coefficient is equal to the value of the calculated power spectral density of the signal in relation to the amplitude of the sine signal. The degree of this ratio corresponds to that of the selected channel. Correlation between the color and the coefficient value is shown in the color diagram in the right part of the program interface.

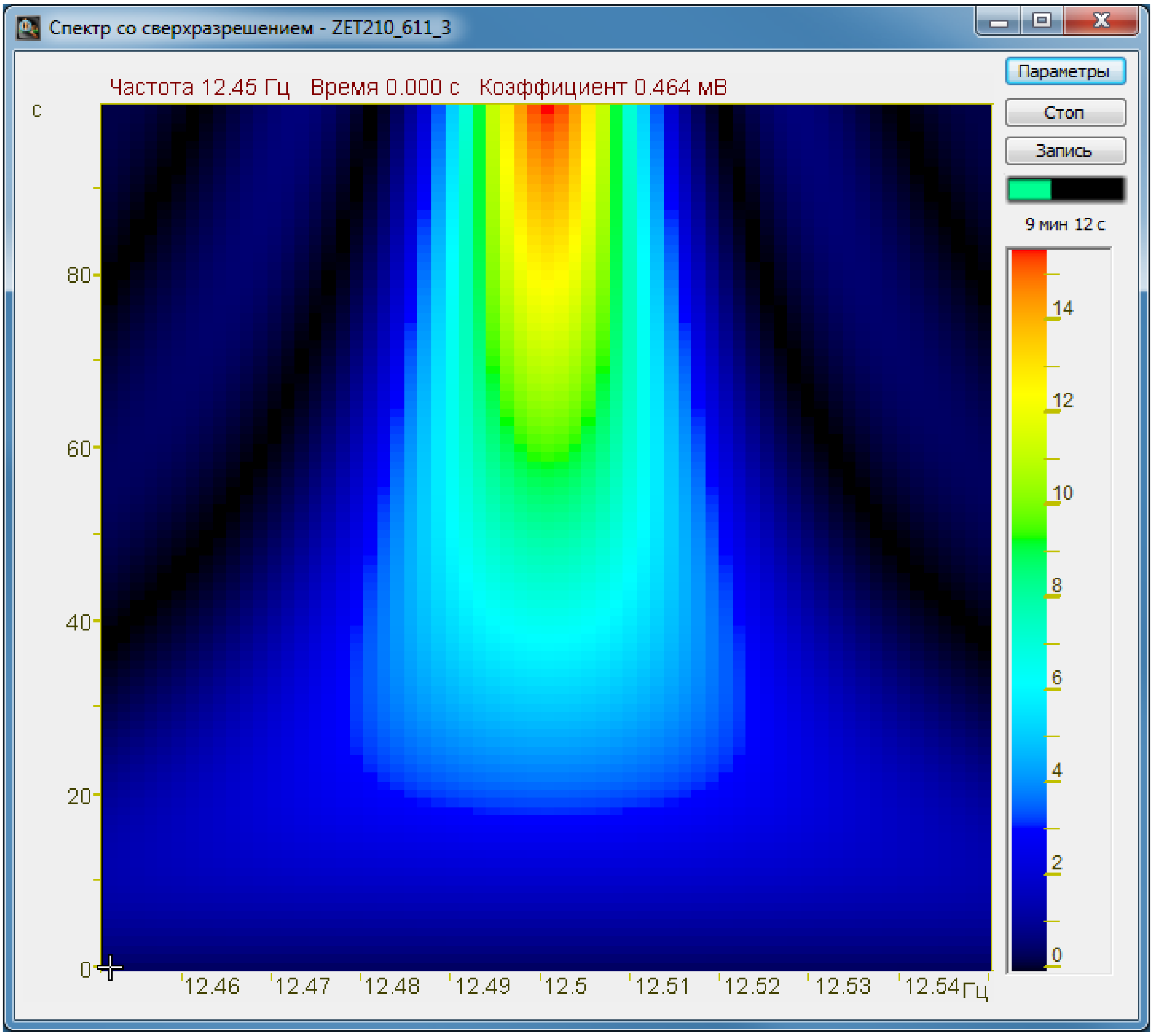


Fig. 4 — Main program window – beginning of operation.

When the user left-clicks the graphic area, the top section of the window will depict the values of time, frequency and coefficient, corresponding to this particular point of the graphic (the point will be highlighted with plus mark). In order to move the selected point along the graphic, use the control keys: A — to the left, S — down, D — to the right, W — up (the keyboard case is of no relevance). To move the selected point to the left / to the right, it is also possible to use the scroll wheel.

Each point of the graphic stands for the value of a single calculated spectrum. The time interval between the adjacent lines is the data update interval. The time interval displayed by Y axis stands for the time interval of the displayed data.

The upper right section of the window contains the control elements of the program.

The **"Parameters"** key is used for activation of the parameters configuration window. The display of the parameters configuration window can be enabled / disabled with "Esc" key. The parameters configuration window is a modal one, i.e. it is impossible to access the main window while the parameters configuration window is active, even though the program continues its operation.

The "**Stop**" key is used to suspend operation of the program. As the key is activated, it changes its name for "**Start**". As the key is used again, its title changes for the initial one and the program resumes its operation.

The "**Recording**" key is used for saving the graphic to a gru file, which can be viewed in the program "Results view". If the program is running, then in the folder with measurements results there appears a new folder with a file "UltaZoom.gru". Upon completion of file recording, the program produces a sound signal. As the program operation is suspended, there appears a dialog window allowing to select directory and name of the gru file.

Below the control keys, there is an indicator of the controlled channel data loading. Further below you can see time indication that has two modes of operation. In the beginning of the calculation process, the counter has the format "hh:mm:ss" and displays the remaining time of the program's transient processes. Upon completion of the transient processes, the counter displays the time interval of the previous spectrum calculation. If the update interval is 0,1 sec, the counter shall have corresponding format.

In the course of program operation based on PWV algorithm, the program may depict zero values during half of the transient process duration.

The graphic shown in *Fig. 4* is symmetrical because the sampling frequency of the signal is divisible by the signal frequency level.

See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Using signal level indicators

Program settings .....

Parameters configuration window

When the program is started, it depicts the main program window. This section contains description of parameters configuration, that allows to obtain physically correct results. Fig. 1 shows parameters configuration window, which appears during the first start of the program with connected ADC FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23 with serial number 611.

By default, the first server channel is used (in our case the channel has the name "ZET210_611_1"). To the right from it you can see the sampling frequency value (in this example – 100 Hz). The central frequency value is set as the sampling frequency value divided by 100 (in our case – 1 Hz). The frequency band value is set as the central frequency value divided by 10 (in our case – 0,1 Hz). The value of the parameter "Type of frequency resolution" is set as 0,1 (the available values of frequency resolution type are as follows: 0,1; 0,05; 0,02; 0,01; 0,005; 0,002; 0,001); we will consider this parameter later.

To the right from the program parameters values section, you can see corresponding admissible values, that are calculated with the use of the formulas:

$$2 \cdot \Delta F \le F_0 - \frac{\Delta F}{2} < F_0 + \frac{\Delta F}{2} \le a \cdot 0.45 \cdot F_{adc},$$

$$\frac{F_{adc}/2}{2000} \le \Delta F \le \frac{a \cdot F_{adc}/2}{20}$$

where:: F0 – is the central frequency, Hz;

ΔF – width of the displayed frequency band, Hz;
Fadc – sampling frequency of the selected channel, Hz;
a – is a ratio, that is equal to "1" for the FFT algorithm and to "0,5" - for PWV algorithm.

Fig. 1 — Parameters configuration window – first start of the program.

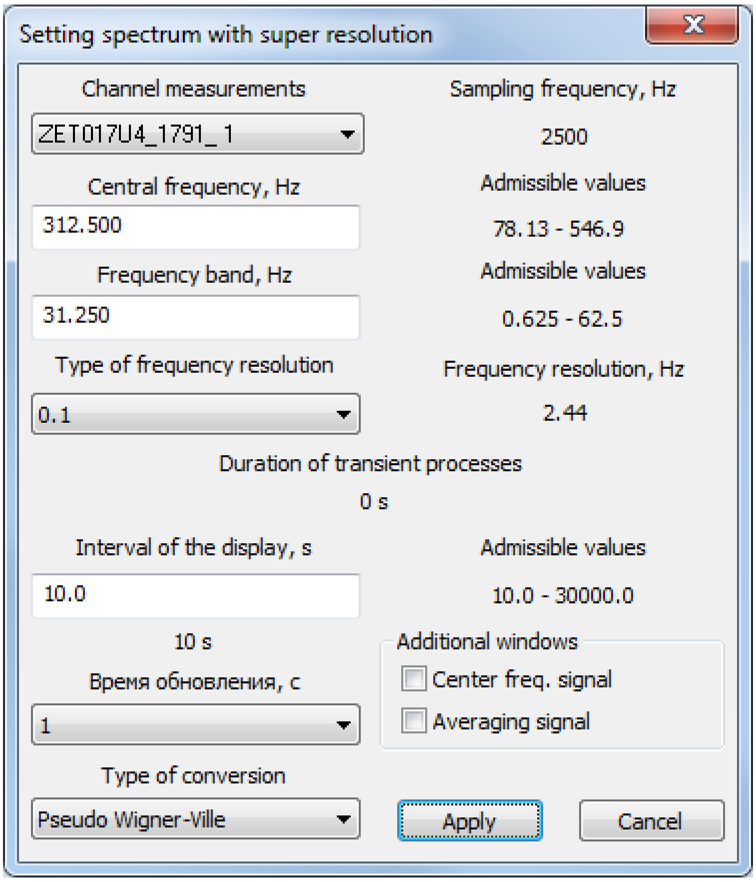


Fig. 1 — Parameters configuration window – first start of the program

First of all, it is necessary to select server channel. Then the user has to assign the central frequency value and controlled frequency bandwidth. If the user assigns a parameter value, that does not comply with the previously mentioned formulas, then the parameters changes will not be saved.

The parameter "**Type of frequency resolution**" is represented by a number, which determines the maximum possible resolution value for calculation of the dFmax spectrum. If the frequency resolution type is "0,1", then the dFmax = 0.1 * ΔF. Actual frequency resolution will be determined as the maximum possible value.

$$dF = \frac{F_{adc}}{2^n} \le dF_{max} = \frac{\Delta F}{type\, dF}, n \subset \mathbb{N}$$

In the right section, you will see the dF parameter value in Hz.

The general empirical rule used for spectral analysis says that the spectral resolution (in Hz) is approximately equal to a value, which is reverse to the time interval of the controlled signal (in seconds). This means that with dF = 0,001 Hz, the minimum signal time (and, hence, the duration of program's transient processes) is approximately 1000 seconds, i.e. 16 min 40 seconds. The duration of transient processes calculated based on this algorithm is displayed in the program configuration window.

In addition to the above listed parameters, you can also set the interval of signal representation in seconds (the default value is 10 seconds) and data update rate (the value by default is 1 second, the available values are as follows: 0,1 s; 1 s; 10 s). The data update rate parameter determines the admissible display intervals values. If the data update rate is 0,1 s, then the display interval is from 1,0 up to 3000,0 s (i.e., 50 minutes), for 1s – from 10,0 s up to 30000,0 s (8 hours 20 minutes), for 10 seconds – from 100,0 s up to 300000,0 s (83 hours 20 minutes). The admissible values of this parameter correspond to the sampling frequency of the channel and are also displayed in the program configuration window.
The bottom left section of the program configuration window allows to select the type of the algorithm to be used for calculation of the power spectral density (FFT or PWV). With the same duration of the controlled signal, the PWV algorithm allows to obtain more accurate results if compared to FFT algorithm (that is exactly why the PWV algorithm is set by default). Another advantage of this algorithm is that at the same resolution value of transient processes, their duration is two times shorter, however, it leads to a smaller frequency range of the admissible central frequency values.

The right bottom section of the parameters window contains the menu "Additional windows", allowing to set the options of additional windows displaying.

For operations with the signal 12,5 Hz there are used parameters shown in *Fig. 2* or *3* (the parameters are set depending on the type of algorithm selected).

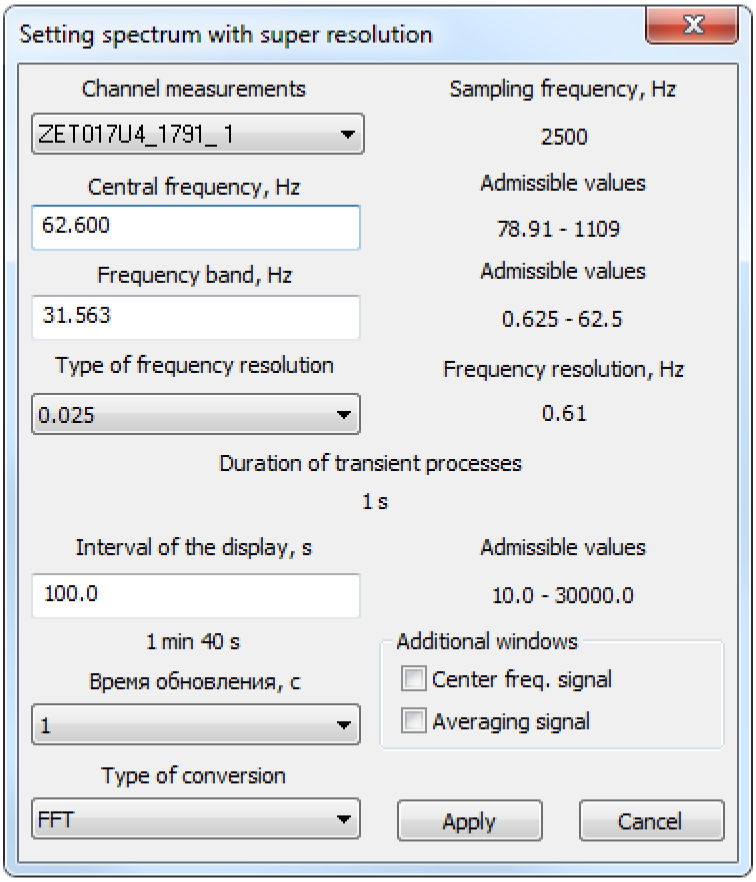


Fig. 2 – Parameters configuration window: sine signal, frequency 12,5 Hz, FFT analysis algorithm.

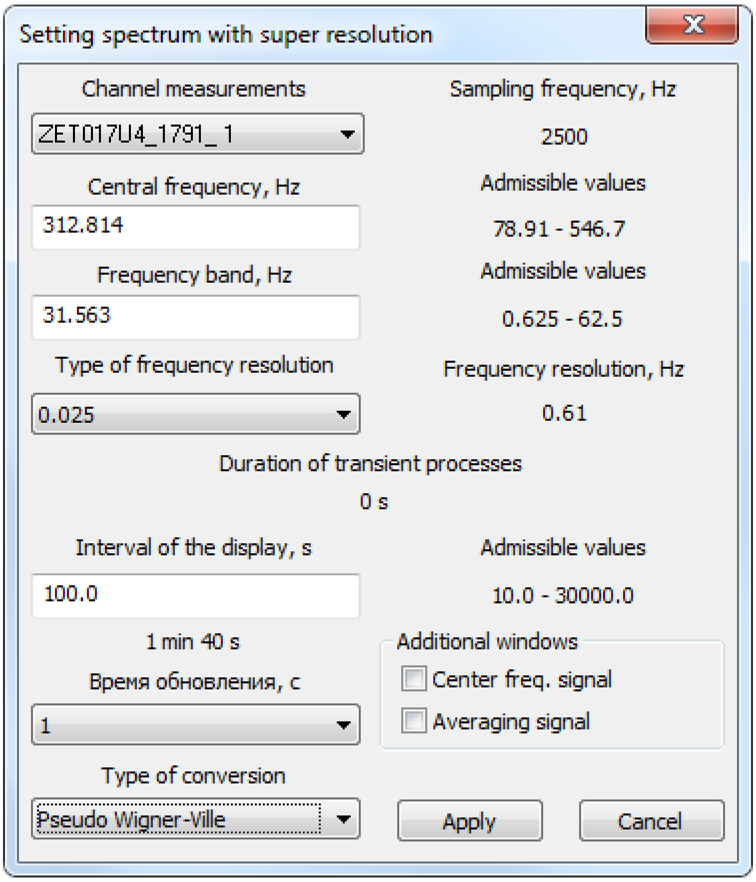


Fig. 3 — Parameters configuration window: sine signal, frequency value: 12,5 Hz, type of analysis algorithm used: PWV.

STA/LTA Detector .....

The STA/LTA Detector program is a detector of various events in triaxial or single-component time signals. The software is based on one of the STA/LTA detector types.

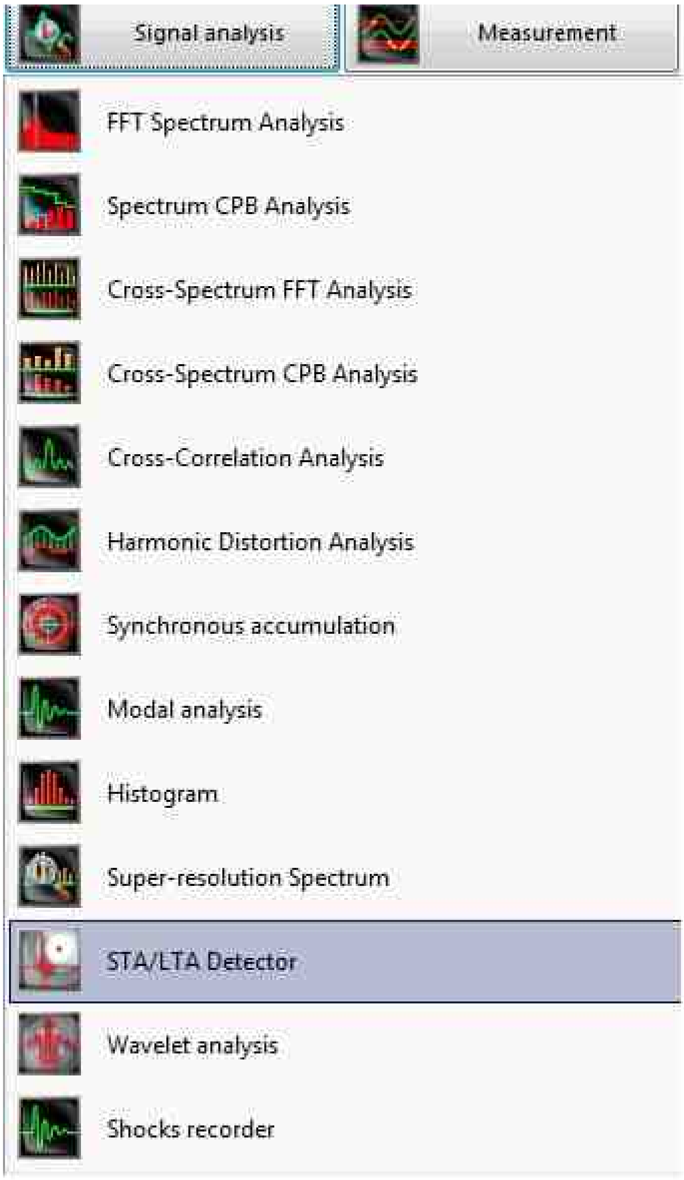


Fig. 1. Starting the "STA/LTA Detector "

About the program .....

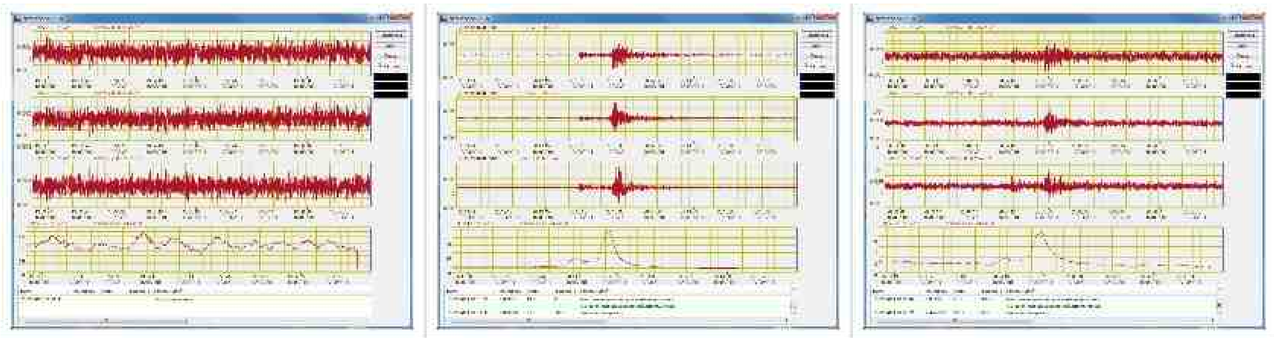
The STA/LTA Detector program is a representation of a detector of various events in triaxial or single-component time signals. The software is based on one of the STA/LTA detector types.
STA/LTA Detector can be used for detecting any events accompanied by a short-term increase in the input signal amplitude, e.g.:

- seismic events;

- explosions of various nature;
- events expected during safeguarding activities;
- various structures initial defects detection (using acoustic emission).

The Fig.s below show the results of the STA/LTA Detector software operation when reproducing the signals of the 5.0 magnitude earthquake which took place on March 16, 2011. The earthquake was registered by the **BC 1313 sensor** located approximately at a distance of 210 km from the earthquake focus.

The program has an integrated control and automation module from the scope of ZETLab-Studio software package. The module enables easy creation of individual software measurement suites.



Supported Hardware .....

For the purpose of analog signals digital processing, it is possible to use *FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01* and *seismic recorder ZET 048*.

Settings of measurement channels are specified in the program "Device Manager".

STA/LTA Detector is specialized software, an event detection tool which is included into the following software packages:

- ZETLAB ANALIZ – FFT Spectrum Analyzers software;
- ZETLAB VIBRO – Shaker controllers software;
- ZETLAB TENZO – strain-gauge station software;
- ZETLAB SEISMO – seismic station software;
- ZETLAB SENSOR – digital ZETSENSOR sensor software

STA/LTA Detector is included in the **Signal Analysis** software group.

Program functions and application spheres .....

The program "Detector STA/ LTA" (further referred to as the "program") supplied as executable file "STA_LTA.exe", is a realization of events detector in three-component and single-component signals. Operation of the program is based on one of the STA/ LTA detector types.

The program can be used for detection of any events, that are accompanied by short-term increase of the input signal amplitude, e.g.:

- seismic events;
- explosions of various types;
- processes, related to security control;
- defects of various structures at the initial stage of their development (based on the use of acoustic emission sensors).

The program is intended for PC use (PC parameters should meet the requirements specified in the technical documentation of LLC "ETMS" # 00068-01 34 "ZETLab software. Operator manual"). The PC should have installed ZETLab software package and ADC compatible with ZETLab software package.

The program may undergo minor updates, that are not described in the present manual.

Input signals .....

Input channels of the program are represented by the digital data from ZETLab data server channels. The data is formed by single- or three-component digitized signal.

For the purpose of analog signals digital processing one can use FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01, noise- and vibration meters ZET 110 and seismic recorders ZET 048.

As a source of analog signals one can use a wide range of sensors and transducers:

- single-axial accelerometers BC 110, BC 111, BC 201, BC 202;

- single-axial seismic recorders BC 120, BC 130, BC 1311;
- triaxial accelerometers BC 1313;
- low-frequency explosion-proof vibration sensors VPN-1, VPN-2;
- microphones BC-501;
- hydrophones BC 312;
- acoustic emission transducers GT200, GT200B, GT205, GT300, GT301, GT200U, GT250, GT350, GT400.

Sampling frequency of the signals used in the program should not exceed 1,0 MHz.

Operating principles .....

Detector STA/LTA averages the signal amplitude for two time intervals: short (Short Time Average) and long (Long Time Average). The end of the LTA interval coincides with the beginning of the STA interval. As the values of these two average amplitudes are obtained, it is necessary to calculate their ratio - STA/LTA. In the case of discrete signal the following formula is used:

$$d(t_i) \equiv d_i = \frac{\frac{1}{N_{\mathrm{STA}}} \sum_{n=i}^{i+N_{\mathrm{STA}}} \mathrm{Ampl}_n}{\frac{1}{N_{\mathrm{LTA}}} \sum_{n=i-N_{\mathrm{LTA}}}^{i} \mathrm{Ampl}_n}$$

where; d – ratio of amplitudes STA/LTA;

ti – time point corresponding to the calculated value;

NSTA – number of ADC counts in short interval;

NLTA - number of ADC counts in long interval;

Ampln – signal amplitude at the time point *tn*.

For proper operation of the detector, the following condition should be observed:

$$N_{LTA} >> N_{STA}.$$

In the case of single-component signals, by "amplitude", we mean an absolute instant value. Presence of DC components implies that the ratio of amplitudes STA/ LTA will always slightly differ from "1". Hence, prior to the beginning of the calculations, it is necessary to remove the DC component from all the signal components, for instance, using the HPF. However, in most cases, there is used the voice filtration. It allows to considerably improve the SNR of the source signal. It is attributed to the removal of non-informative frequency components from the signal. However, in the case if this approach is implemented, it is necessary to know the frequency range of the expected signal.

It is a common knowledge that the digital filters with cut-of frequencies less than 0,0001 from the ADC sampling frequency (fadc) may have unstable operation. Hence, for the purpose of remote earthquakes detection (containing the frequencies below 0,02 Hz) it is better to use digital deduction of the known DC component from the signal counts instead of HPF.
The program implements band pass signal filtration or LPF with the removal of signal’s DC components. It is also possible to remove the DC component without any preliminary filtration.

Time-series analysis *di* allows to detect the events as well as to outline their beginning and end. Detection of the event’s beginning is based on the amplitude detection of STA/LTA ratio. The detection threshold value is selected depending on the power range of the expected event. As the end of the event, we may consider the moment when the detection value (after passing the maximum point) is less than "1".

The physical essence of Detector STA/LTA operation as well as the capacity of digital filters impose the following limitations on the program's parameters values:

- filter bottom frequency (f_{min}) for HPF cannot be less than 0,0001 from f_{adc};
- when it is necessary to remove the DC signal components, the filter bottom frequency is set as "0", i.e. HPF is not used;
- filter top frequency (f_{max}) of the LPF cannot be less than 50% from f_{adc};
- ratio of STA/STA durations cannot be less than 10;
- detection threshold - from 3,0 up to 60,0.

Program description .....

The program has two Table of contents: the main section and the parameters section. As the program is started, there appears the main program window displaying oscilloscope graphics of the signal components (1 or 3) and the signal of the detector. The program begins immediate operation based on the parameters saved in the course of the previous program session. The program allows to record signal components counts during observation period to a text file with dtu extension, which is used in ZETLab software. The program enables creation of a virtual channel containing the calculated values of the time series *di*, that are further forwarded to ZETLab data server. This data can used by other programs from the scope of ZETLab software package (e.g., Multi-channel oscilloscope).

In the case, if the program is started at the PC for the first time, the default parameters are applied. The default parameters are as follows:

- signal dimensionality - 3D (if the server has more than 2 channels), otherwise - 1D;

- channels numbers for 3D signal: component X - channel 0, component Y - channel 1, component Z - channel 2;
- channels numbers for 1D signal: component Z - channel 0;
- signal filtration with LPF;
- DC components removal;
- f_{min} of the filter - 0;
- f_{max} of the filter - 0,2 from f_{adc};
- time interval of oscilloscope patterns displaying in the main window - 200,0 s, but not more than 500000/f_{adc};
- oscilloscope pattern update rate - 0,1 s, but not less than 10/f_{adc} and not more than 50000/f_{adc};
- STA time - 20 periods of 0,5 f_{max} frequency;
- LTA time - STA time multiplied by 20;
- Detection threshold - 3,0;
- Virtual channel creation is required;
- Events saving to a dtu-file is required.

Upon completion of its operation cycle (which is set by the operator), the program saves its current parameters to a configuration file STA_LTAxx.cfg, (where *xx* – is the number of program's active copy). The file is saved to a folder (folder directory is assigned in the register of the OS).

In the case if, due to some reasons, the server suspends its operation, the program will be closed as well (the configuration file will not be updated).

The program can be used within the scope of the project based on the components available in ZETLab control panel. In this case, the program will operate in parallel with other ZETLab programs. Parameters of these programs will be saved in the configuration file of this project.

Quality of program operation (e.g., the possibility of the event non-detection) generally depends on the configuration of program's parameters (STA and LTA duration, filter f_{min} and f_{max} limit frequencies). In many cases, for the purpose of the event beginning detection, it is better to implement STA duration from 50% to 100% from the expected event duration. It is also useful to implement signal filtration, since it allows to remove non-informative frequency components of the input signal.

Main program window .....

As the program is started, there is displayed the main program window shown in **Fig. 1** (it is used for band filtration of the signals).

In the case of three-component signal analysis, the window in the left part of the program has 4 oscilloscope graphs: x, y, z components of the signal, and the detector signal. The name of the displayed oscilloscope graphic is displayed in the following format: "Fn – Channel name", where "F" is the information of the filter used; "n" – number of program copy, "Channel name" – name of the channel used by the data server. X axis of the oscilloscope graphics shows absolute time, which is identical for all the graphs. The time (in the top left part of each section) stands for the graphic cursor time (the blue vertical line at oscilloscope graphs). This time is synchronized for all the graphs. In the beginning of the operation the cursor is set in the right part of the window section, i.e. its time is the same as that of the PC.

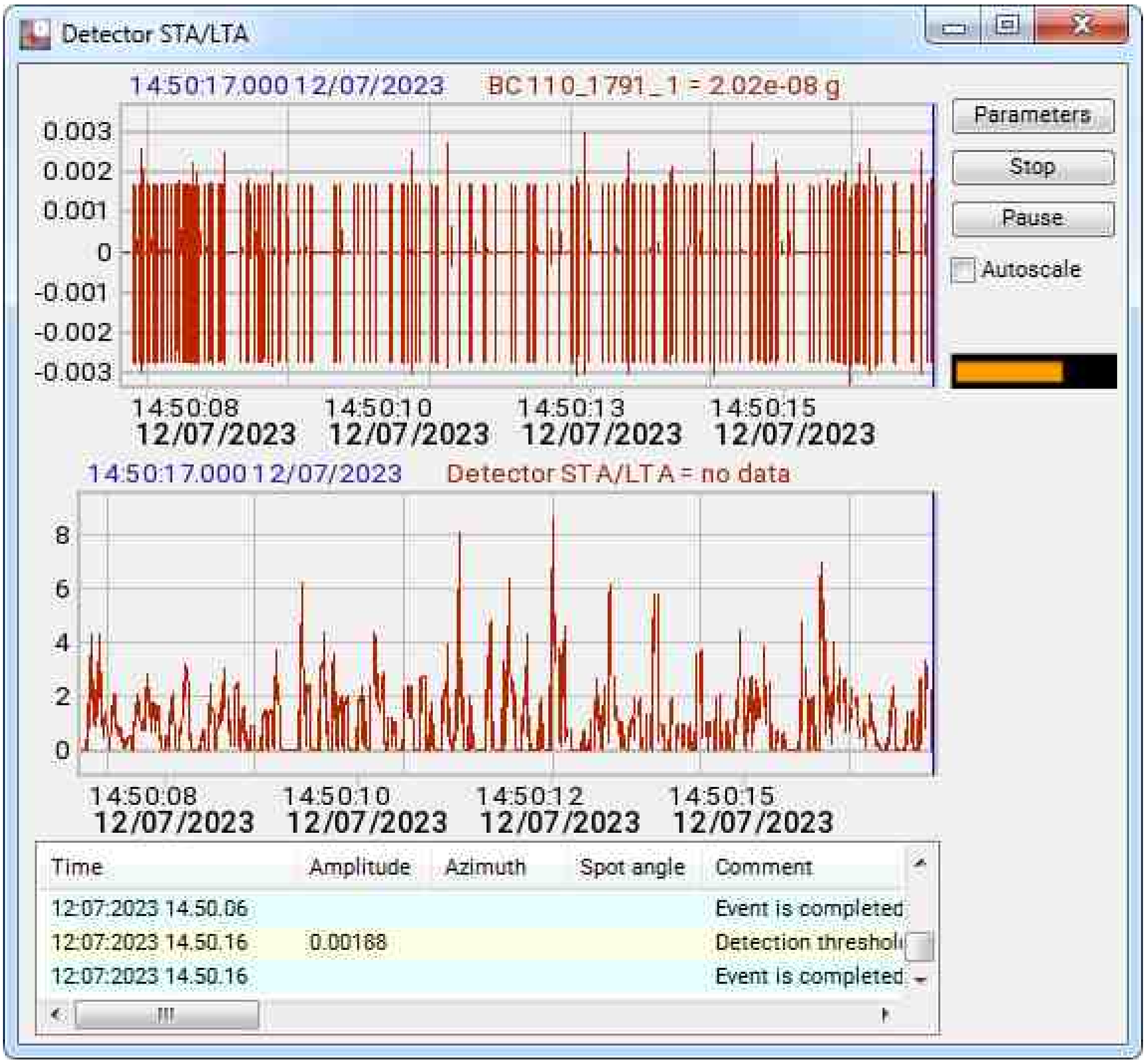


Fig. 1. Main program window – beginning of operation

Oscilloscope graphics shown in Fig. 1 clearly display the transient processes occurring in the analog circuits of the ADC used. Duration of these events is in reverse proportion to f_{min} parameter of the filter. The signal detector oscilloscope graphic depicts a signal with "1" value. The process will continue until the detector's operational cycle is suspended. The cycle duration is determined by the sum of STA and LTA durations. Besides, it is necessary to bear in mind that the signal of the detector is a suspended signal in relation to the source signal. Duration of the delay is the duration of STA (during this process, the value of detector's signal is set to zero).

To the right from the oscilloscope graphics you can see the control elements of the program. Let us list them in descending order.

The key "Parameters" allows to activate parameters adjustment window.

The "Stop" key allows to suspend or to restart program operation.

The "Pause" key suspends updating of the oscilloscope graphs. As the key is activated, the name of the window changes for "Detector STA/ LTA - pause". To resume the process, click the same key again. Beginning off the event to be detected also disables the "Pause" function.

The switchbox "Autoscale" allows to enable / disable the automated scaling of all the oscilloscope graphs.

The key "Exit" closes the program.

Below you can see the indicator displaying the reverse time count in seconds until the completion of detector's initialization. As the count reaches zero, it is not displayed.

And the last element is "The number of event channels". It is set to zero every time the program is activated.

The program window unidades can be changed. The program can be displayed in full-screen mode. The control elements will not change their positioning in relation to the top right section of the program, while the oscilloscope graphics will be changed in proportion to the size of the program window.

Fig. 2 shows the window of the program with a registered event. As the event, there was used a radio impulse applied to channel 1 (i.e., to Z channel of the signal). Radio impulse signal has the amplitude of 3 mV at the noise level of 0,5 mV. In this case, the maximum detector signal level was approximately 8,5. Thus, the detector threshold was 3, and the event has been registered by the recorder counter reading has changed from 0 to 1.

Fig. 2 Main program window showing a registered event

Fig. 3 shows the main program window and processing of a single-component signal. There are only two oscilloscope graphics displayed: source signal Z channel and detector signal. Fig. 3 shows radio-pulse signal with the same parameters as in the radio-pulse shown in Fig. 2.

When **operating** with low-frequency signals, HPF is not used. In this case, the DC components are removed from all the components of the signal. DC components are revealed in the course of detector's evaluation, i.e. in the beginning of the program operation during a period equal to the durations of STA and LTA. Upon completion of the initialization time, the data arrays saved in the program undergo processing and are displayed at the oscilloscope graphics as centralized time series.

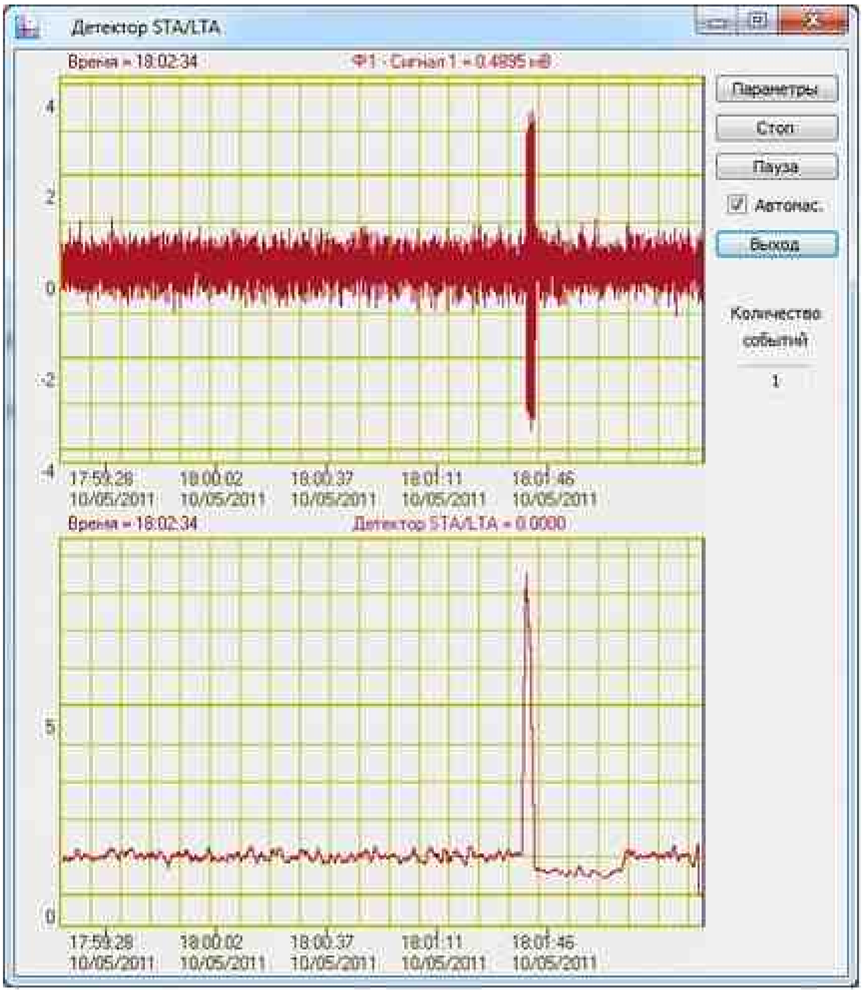


Fig. 3 Main program window – single-component signal

Program settings .....

Upon activation of the "Parameters" key of the main program window there appears the "Parameter adjustment" window shown in Fig. 4. The "Parameter adjustment" window has four titled panels and two keys – "Apply" and "Cancel". The "Parameter adjustment" window is used for configuration of program’s operation and displaying of the current parameters. The "Parameter adjustment" window is used for configuration of the program operation as well as for configuration of control parameters representation. The control elements of the main panel become unavailable when the "Parameter adjustment" window is active.

The panel "Source signal" allows to select the source signal type – "Scalar" (single-component) or Vectorial 3D (three-component). The panel also contains data server channels selection menu for X, Y and Z components of the signal. X and Y components are displayed only in the case of vector signal processing. The channel selection elements are located under the "Signal" element. The panel also depicts ADC sampling frequency value, that cannot be changed by the program and the value of time interval specified by the oscilloscope graphics in the main window.

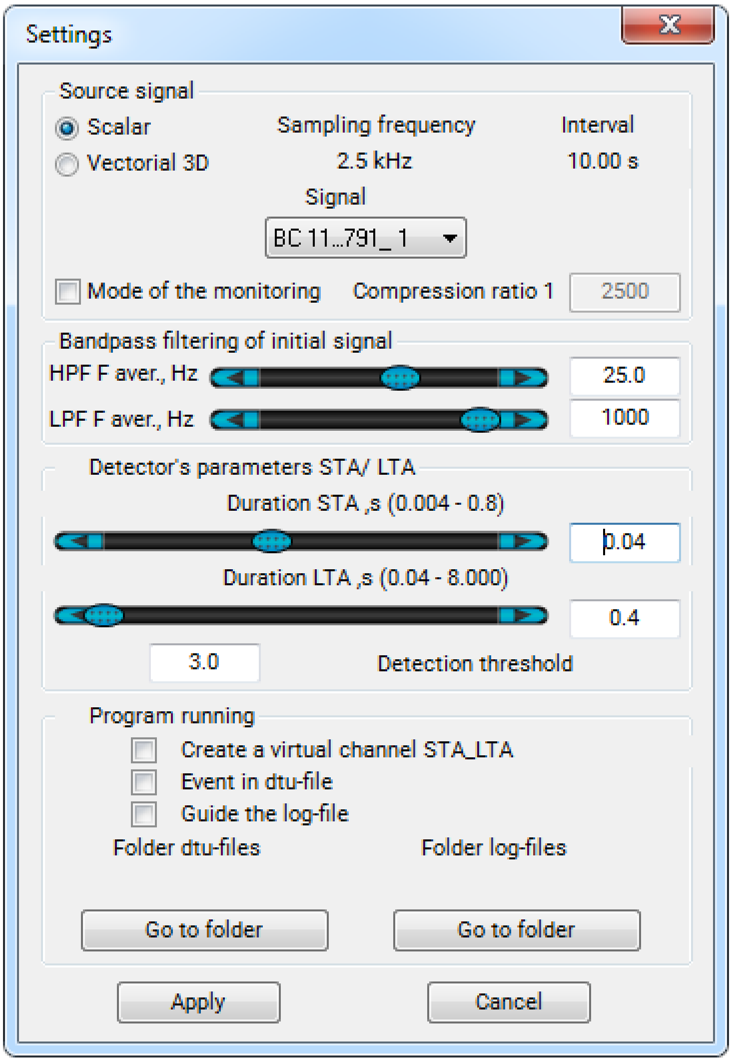


Fig. 4. Parameters adjustment window

The panel "Detector's parameters STA/LTA" contains three elements for adjustment of STA and LTA durations and the detection threshold. As the new parameters are entered, the corresponding limitations are applied automatically (these limitations are listed in the clause "Operating principles").

The panel "Program running" contains three checkboxes and text fields specifying the directories for saving the dtu-files (these files contain time realization of the signal in the course of the events). The checkbox "Create a virtual channel STA_LTA" enables / disables creation of the virtual channel by the program.

The checkbox "Event in dtu-file" enables / disables creation of text files continuing time realization of the signal in the course of the event. The names of the text files have the following format:

STA_LTAxx_yy.dtu,

where xx – number of running program copy;

yy – file number in the folder.

New parameters will be applied as the "Parameters adjustment" key is closed with the "Apply" key. The program will restart automatically with new parameters. The "Cancel" key closes the "Parameters adjustment" window without saving the set parameters. The new parameters configuration will not be saved if the window is closed with the key at the top right section of the window.

Upon activation of the "Parameters adjustment" window, operation of the program will be suspended.

The signal selected for the components X, Y and Z should have sampling frequency of more than 100 Hz.

Note:

It is also possible to display the measured data in user-friendly format together with additional information, thus turning the usual graphics into an animated object. For this purpose, there has been developed the program "View historical events". This program is included into the basic scope of ZETLAB software package and allows to view and analyze historical events recorded by means of ZETLAB programs for a long-tern time period.

View detailed information about the program "View historical events" from the "Registration" menu.

View additional information on ZETLAB Company website.

https://zetlab.com/en/shop/software/functions-zetlab/register/view-of-historical-events/

Program messages .....

The program can function without participation of the operator (i.e. the program saves the messages into a log). The log records can be viewed in "ZETLAB Error journal" from the "Service" tab of the program panel.

The messages recorded by ZETLab Software in the log have the following format:

"Name of the program No.xx. Text of the message",

In this case "Name of the program" is "Detector STA/LTA";

xx – running program copy number.

The program records to the system log the error messages as well as parameters configuration information. These messages allow to reproduce the sequence of program operation (which is often useful for analysis of errors). The table below displays the program messages and other notifications.

When the control panel is active, all error notifications of ZETLab software are duplicated in pop-up messages in the system tray (notifications area – or in the task panel of Windows OS).

Table

Text of the message	Category
Connection error to the data server	Error
Error of retrieving the data from the register	Error
Configuration file is not available in the folder DirConfig	Error

Help file does not exist	Error
Help file loading error	Error
Folder DirHelp is not available	Error
Folder DirSignal is not available	Error
Folder DirResult is not available	Error
Folder InstallLocation is not available	Message
Program has started	Message
ADC sampling frequency = xxx.xx Hz	Message
Working channels of the data server not found. Program is not loading	Error
Starting error of the parameters processing program	Error
Virtual channel parameters setting error	Error
Switch over to signal 1D	Message
Switch over to signal 3D	Message
3D-signal processing is not possible since the server has less than 3 channels	Message
Signals filtering started	Message

Signals filtering finished	Message
New value Fmin = xxx.xx Hz	Message
New value Fmax = xxx.xx Hz	Message
New channel for X - Signal x	Message
New channel for Y - Signal x	Message
New channel for Z - Signal x	Message
New value STA = xxx sec	Message
New value LTA = xxx sec	Message
New detection threshold value = xxx	Message
Server stream is not responding the queries. The program will be closed	Error
dtu-files recording stream does not respond the queries. The program will be closed	Error
Event file "file_name.dtu" has been recorded	Message
Error has occurred while creating the dtu-file	Error
The program has been closed	Message

Application examples .....

Fig. 5 shows an example of program operation with a real signal. This signal is an aftershock of the earthquake that occurred at the Eastern coast of Honshu island on March 11, 2011. The signal has been registered in Eastern Siberia at the distance of more than 2000 km from the earthquake focus. As a source signal for the program, there were used output signals of a 3-component accelerometer. The signal has been registered by Moscow time. Program parameters in the course of signal detection were as follows: DC components removal, LPF with cutoff frequency f_{max} = 10,0 Hz.

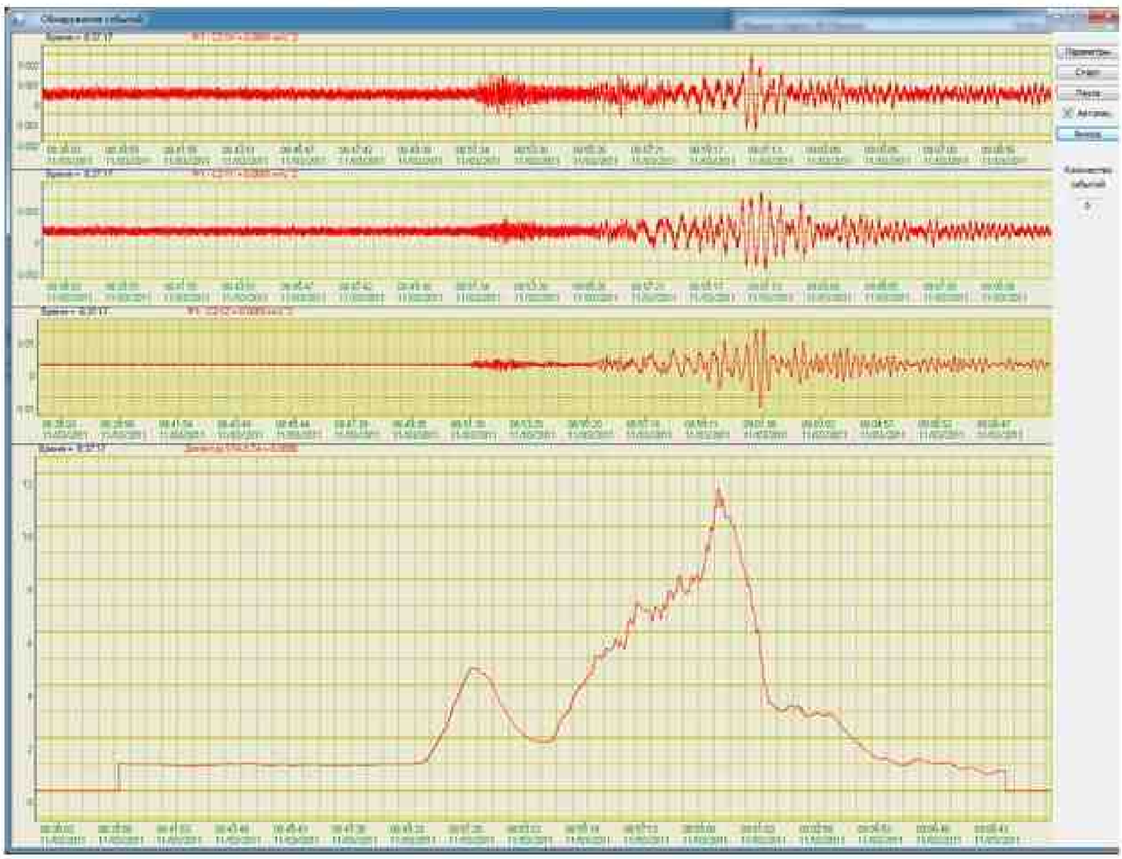


Fig. 5 Shows an example of program operation with a real signal

From the oscilloscope graphic of STA/LTA detector, it is clear that the detector's signal level "3" (i.e., beginning of the event at the "3" threshold) corresponds to the time 08:50:30. The signal level of the detector has decreased to "1" (after having passed through the maximal level) at 09:06:50. This very time interval contains P and S phases of the earthquake and their maximum acceleration values. The maximal detector signal value during the P-phase was around 5, and 11,5 in the course of S-phase duration. During the maximum of S-phase, ground acceleration value by Z-axis has exceeded 0,01 m/s^2 or 0,1 g, which indicates high level of the signal.

This example clearly shows that reliable detection of an earthquake in teleseismic area implies the use of DC components removal of the signal.

"STA/ LTA detection" program: testing procedure .....

1. Set-up activities

1.1. Remove the file "STA_LTA01.cfg" from the configuration folder.

1.2. Device No. 1, connected to the PC, i.e. the device with the channel No. 0, should have at least 3 channels.

1.3. Set the sampling frequency of 2,5 kHz.

1.4. Start the "Signal generator" program, set the following parameters:

Radio impulse signal;
Filling frequency - 100 Hz:
Amplitude – any value of at least 200 % of channel No.0 noise level;
Repetition frequency – any value;
Number of periods - 4;
Uncheck the "Loop" option;
Add the signal, but do not enable it.

1.5. Apply the signal of the Generator to any channel of the device No. 1. Let us use the channel Sig_1_3.

1.6. Start the program "ZETServer time". Make sure that the time count for the channels of device No. 1 is enabled.

1.7. Start the program "Multi-channel oscilloscope".

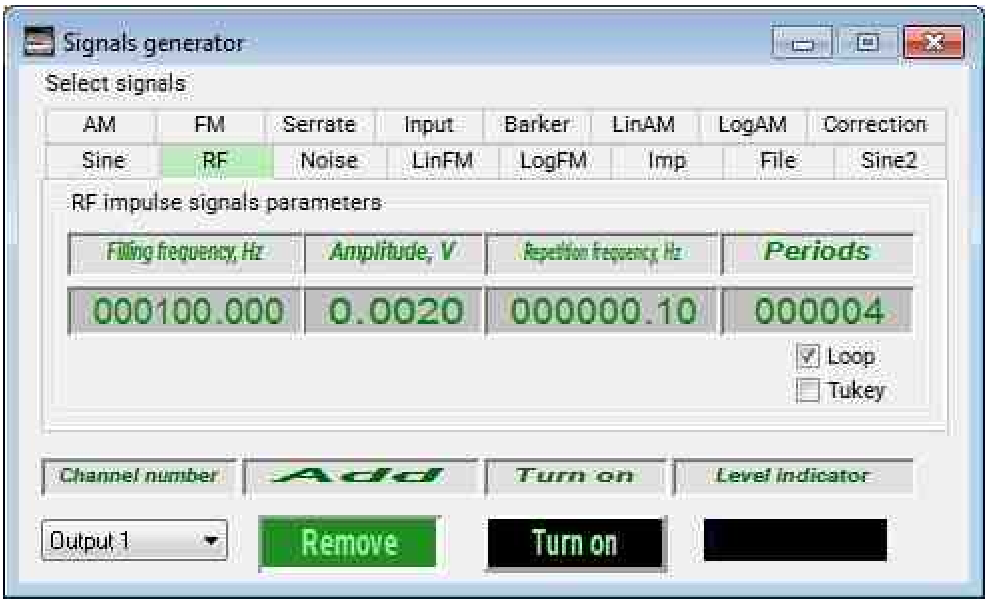


Fig. Apply the signal of the Generator to any channel of the device No. 1

2. Checking operational capacity of the program

2.1. Open "Parameter adjustment" window, select the channel No. 3. Exit the program by clicking "Apply" key.

2.2. Open the window of the generator, add the signal, as the signal is produced, click "Enable".

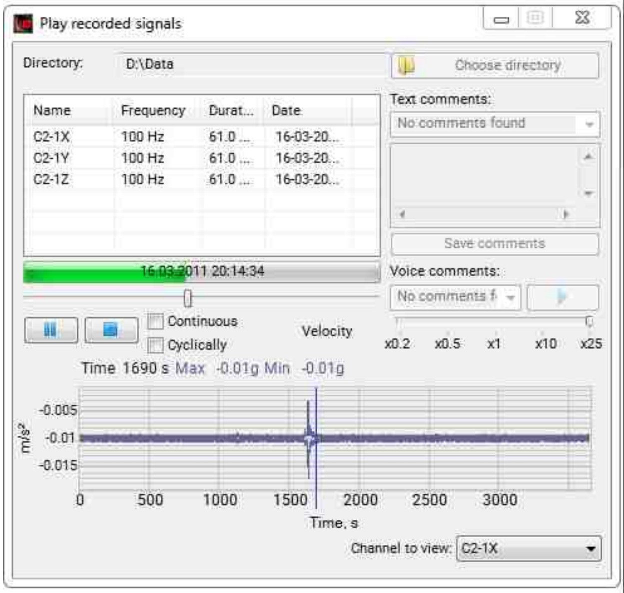
2.3. Oscilloscope graphics of the program should display patterns similar to those shown in Fig. 2.

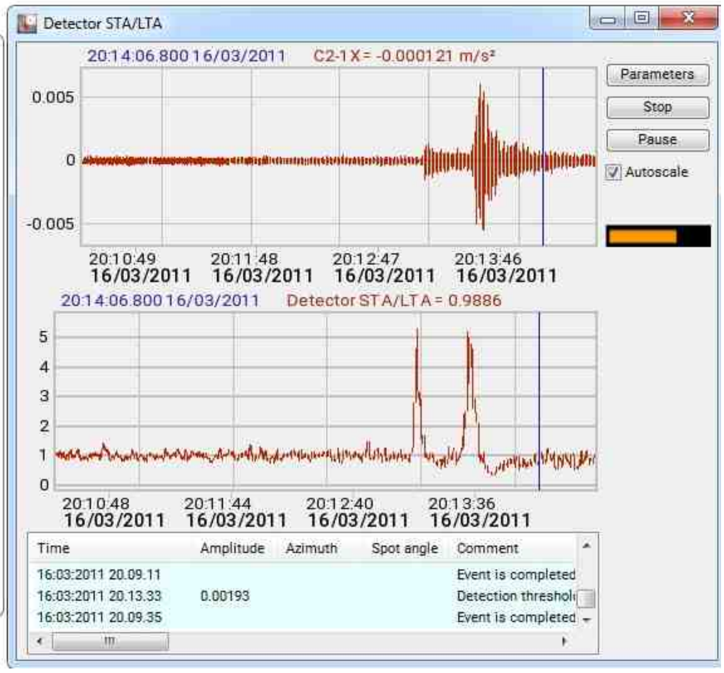
2.4. The program log (component ListCtrl at the bottom part of the program) should display the data of the beginning / end of the event.

2.5. In the "Parameter adjustment" window, select "vectorial" signal, and the channel No. 3. Exit the parameters adjustment window by clicking "Apply" key.

2.6. Repeat the actions specified in Clauses 2.2. and 2.3.

2.7. The verification is considered to be successfully completed if similar results are obtained in both cases.





3. Virtual channel check

3.1. In the "Parameter adjustment" window, select the option "Create a virtual channel". Exit the parameters adjustment window by clicking "Apply" key.

3.2. Make sure that the program "ZETServer time" displays a new virtual channel "STA_LTA 1".

3.3. Select this channel in the program "Multi-channel oscilloscope". The oscilloscope graphic of the virtual channel should correspond to the oscilloscope pattern displayed at the bottom section of the program.

3.4. Uncheck the option "Create a virtual channel". Exit the parameters adjustment window by clicking "Apply" key.

3.5. Make sure that the program "ZetServer time" does not depict the virtual channel "STA_LTA 1".

3.6. The verification process is considered to be finalized in the case if the operations specified in Clauses have been successfully performed.

4. Check of dtu-files

4.1. In the parameters adjustment window, select the option "Event in dtu-file". Exit the parameters configuration window by clicking the "Apply" key.

4.2. Perform the operations specified in Clause 2.2. After a while in the program log there will appear a notification informing the user that the file has been successfully recorded.
In the folder "DirResult", there appears a new file "sta_lta_N.dtu", where there is N or 1 (depending on the ordinary number of the file in the folder). You can enter the folder "DirResult" by clicking the key "Go to folder" in the parameters adjustment window.

4.3. you can open the file from the folder "DirResult" using the program "Results view". The oscilloscope graphic of the signal from the file should correspond to the upper oscilloscope pattern shown in Fig. 2. The registered event should be placed in the middle of the oscilloscope graphic.

4.4. The verification is considered to be passed in the case if the actions specified in Clauses. 4.2 and 4.3 have been completed successfully.

4.5. In the parameters adjustment window, uncheck the option "Even in dtu-file". Exit the program using the "Apply" key.

5. Testing of the log-file

5.1. In the parameters adjustment window, select the option "Guide the log-file". Exit the program by clicking the "Apply" key.

5.2. Perform the actions specified in Clause 2.2. Upon completion of the program operation, enter the folder "Config" and open the file "STA_LTA01.log". Check the presence of the corresponding entry of the generated event. Enter the folder "DirResult" by clicking the right key "Go to folder".

5.3. In the parameters adjustment window, uncheck the option "Guide the log-file". Exit the parameters configuration window using the "Apply" key.

5.4. The verification procedure is considered to be passed if positive results have been obtained according to the Clause 5.2.

6. Check of the parameters saving

6.1. Set arbitrary parameters in the "Parameters adjustment" window. Exit the window by clicking "Apply" key.

6.2. Uncheck the option "Autoscaling". Set and save arbitrary parameters of windows display by Y axis.

6.3. Close the program.

6.4. Start the program.

6.5. Check the set parameters of the windows display.

6.6. Open the parameters options and check that the set parameters are saved.

6.7. The verification is considered to be passed based on the results of the procedures described in Clauses 6.5 and 6.6.

7. Check of parameters saving in the project of Zet-panel

7.1. Create a Zet-panel project using the program "Detector STA/LTA".

7.2. Perform the actions described in the sections 6.1 and 6.2.

7.3. Close the project.

7.4. Open the project.

7.5. Perform the actions described in Clauses 6.5 and 6.6.

7.6. The check is considered to be successful in the case of positive results for each of the Clauses.

8. Durability testing

8.1. Start the program.

8.2. Set arbitrary parameters in the "Parameters configuration" window. Exit the parameters window using the "Apply" key. To save the memory space, uncheck the options "Event in dtu-file" and "Guide the log-file".

8.3. Let the program run for necessary time period.

8.4. Close the program.

8.5. Set ADC sampling frequency of 25 kHz. Repeat the steps described in Clauses 8.1 - 8.4.

8.6. If the program continues its operation upon completion of the specified time period in both cases, the testing may be considered to be successfully passed.

8.7. Possible durations of the interval are as follows: 30 minutes, 1 hour, several hours, 24 hours, several days, a week, several weeks, a month, several months.

9. Start testing using the UNIT interface

9.1. Start the program using the program "TestUNIT".

9.2. In the panel "Testing with arbitrary parameters", set the parameters interval in the range from 0 up to 18.

9.3. Select the testing time interval from the options listed in Clause 8.7.

9.4. Start the testing process.

9.5. The testing is considered to be successfully passed in the case if the program continues its operation upon completion of the testing time interval.

9.6. Close the program "TestUNIT".

10. Testing of the program together with the component ZETSTA_LTA

10.1. Start the SCADA project.

10.2. In the components list "Signal analysis", select the component "Events detector" and place it in the working area.

10.3. Assign arbitrary values to several parameters of the component. Make sure that the component has reacted to the set parameters (saved the new values or has corrected them in the case if they were inappropriate).

10.4. Remove the component from the working area.

10.5. Start the project "Test_3_STA_LTA.zvx" (or any project that has the components "Events detector").

10.6. Wait until the time period completion (see the possible interval durations in Clause 8.7).

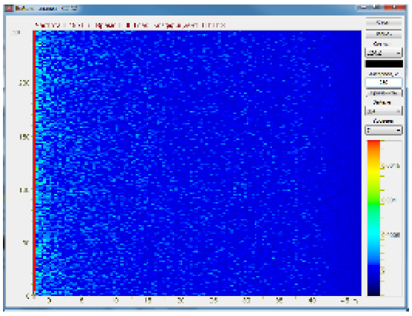
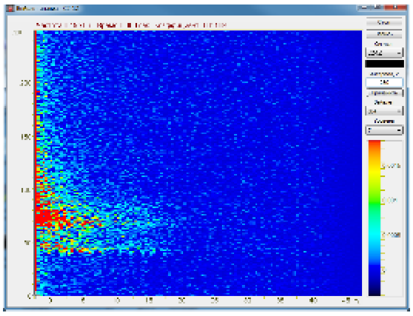
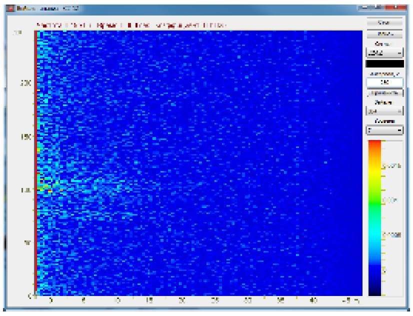
10.7. The testing shall be considered to be successful depending on the results of the processes described in Clauses 10.2 - 10.6.

Wavelet analysis .....

Wavelet analysis is perfect for non-stationary signals analysis. The properties of theses signals change in time and space domain. Besides, the program "**Wavelet analysis**" is also a powerful tool for system dynamics analysis.

The Fig.s below show the results of **Wavelet analysis** when reproducing the signals of the 5.0 magnitude earthquake which took place on March 16, 2011. The earthquake was registered by BC 1313 sensor located at the distance of approximately 210 km from the earthquake focus.

The program has an integrated control and automation module from the scope of ZETLab-Studio software package. The module enables easy creation of individual software measurement suites.

Supported Hardware .....

For the purpose of analog signals digital processing, it is possible to use *FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01* and *seismic recorder ZET 048*.

Settings of measurement channels are specified in the program "Device Manager".

Wavelet analysis is a part of the following software:

- ZETLAB ANALIZ – FFT Spectrum Analyzers software;
- ZETLAB VIBRO – Shaker controller software;
- ZETLAB TENZO – Strain-gauge station software;
- ZETLAB SEISMO – Seismic station software;
- ZETLAB SENSOR – Digital ZETSENSOR sensor software.

Wavelet analysis is included in the **Signal Analysis** software group.

Functions of the program .....

Nowadays the wavelet-transform is widely applicable for digital processing of the signal in various scientific and technological spheres. Since the wavelet transform is a 2-parameter conversion, and one of the parameters is time, it follows that the main use of this transform is the analysis of non-stationary signals. The program "**Wavelet analysis**" is intended for calculation and visual representation of discrete wavelet transform of time series. The calculations are performed in real-time mode based on the algorithm of batch transformation. The second parameter of the wavelet transform is the scale, which is in reverse proportion to the frequency value. Hence, the coefficient value is proportional to the total energy level of the signal at a particular time point, and in the frequency band, corresponding to this coefficient.

The software developers constantly improve the software programs, hence, this description may not fully correspond to your particular program. The developers hereby reserve to themselves the right to change this manual without notification to the Customer.

Program description .....

To start the program "Wavelet analysis", select it from the menu "Signal analysis" (*Fig. 1*) of ZETLab panel. You will see the main window of the "Wavelet analysis"program (*Fig. 2*). The title of the window depicts the name of the program. Above the spectrum graphic you can see the values of the measured parameters (frequency, signal level), that correspond to the location of the graphic cursor.

Note: the program "Wavelet analysis" can be also started from ZETLab working directory (by default: c:\ZetLab\). The name of the executable file: FDWT.exe

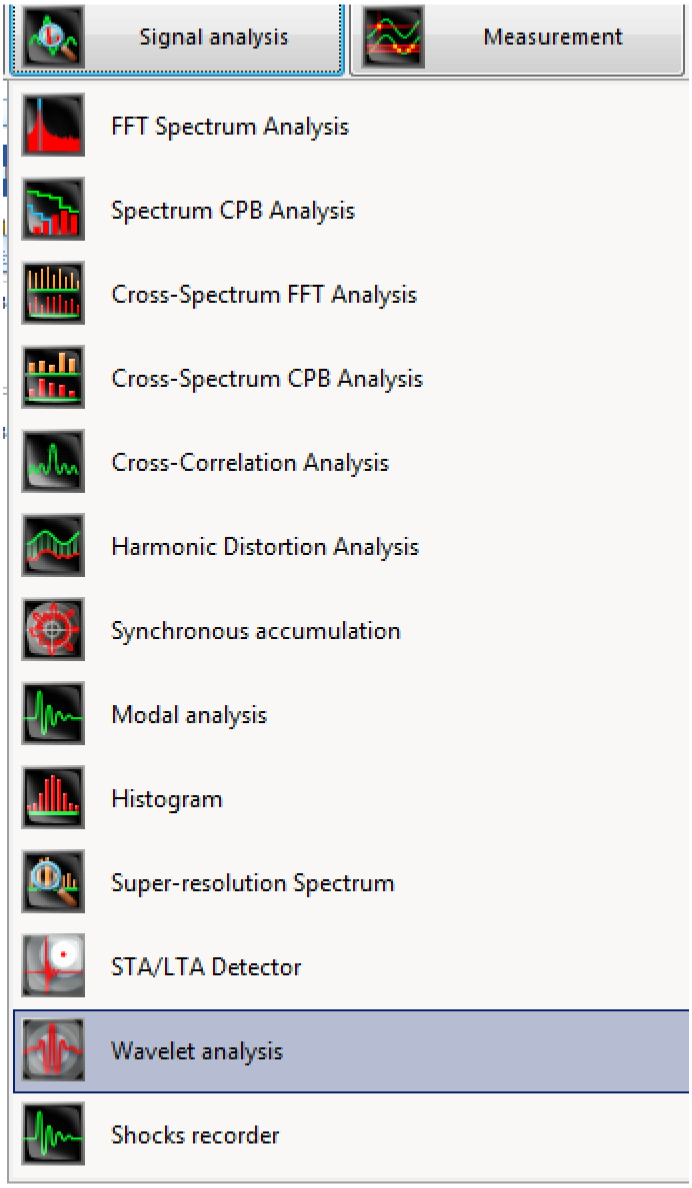


Fig. 1 Starting the "Wavelet analysis"

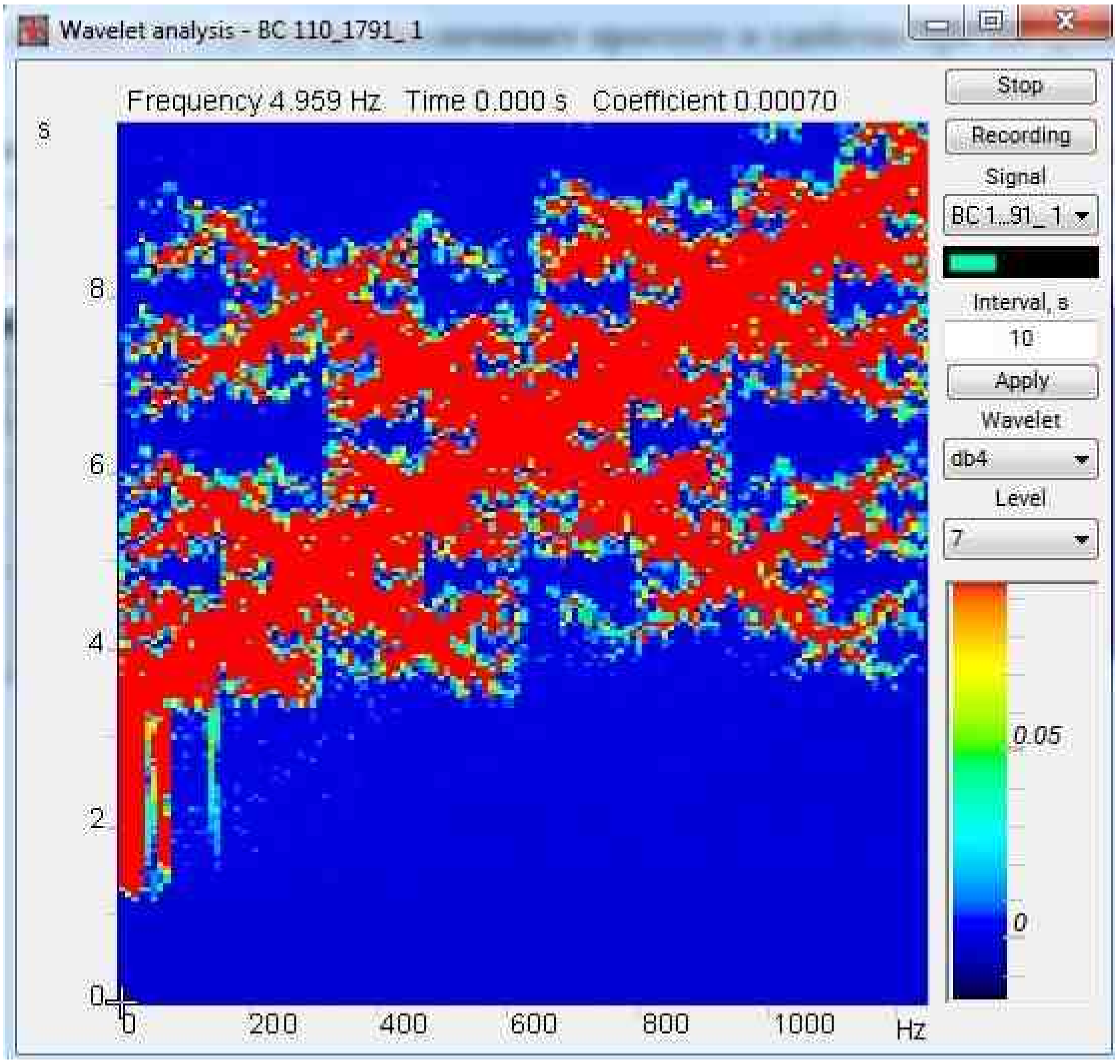


Fig. 2 Main window of the "Wavelet analysis" program

See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Using signal level indicators

Operating principles .....

The main window of the program **"Wavelet analysis"** contains signal graphic and the control elements (see the Fig.3). The signal graphic represents the calculated coefficients. Horizontal axis shows frequency value in Hz, the vertical axis depicts time in seconds. The color indication is used to show the coefficient level. The calculated coefficients for the new time interval are shown in the upper color line of the graphic. That is exactly why upon filling of the graphic window it seems that the graphic moves downwards, though the time axis has upwards direction.

Control elements of the program:

- the key "Start / Stop" is used to start or suspend the calculation process;
- the "Recording" key is used for recording of the current signal in a file;
- element for selecting the signal to be used for wavelet transform;
- element for setting the duration of the displayed signal;
- key is used for creating a new graphic with a new duration value of the displayed signal;
- element for selection of the source wavelet used for the wavelet transform process;
- element for selection of the decomposition level for the wavelet transform;
- element for configuration of the color indication for the calculated coefficients.

To record the current signal in a file, click "Apply" key. The program will produce a sound signal and create a folder with date and time data and "fdwt.gru" file in it. This file will contain the current coefficients of the wavelet transform based on the set parameters. The file can be viewed in the program "Results view".

The Fig. shows "Wavelet analysis" program window during conversion of vertical accelerometer signal recorded in the course of the earthquake that occurred in Western Siberia on March 16, 2011. The graphic clearly shows P- and S- phases of the earthquake. If compared to the P-phase, the S-phase contains more powerful and low-frequency components, which is quite typical for the earthquakes.

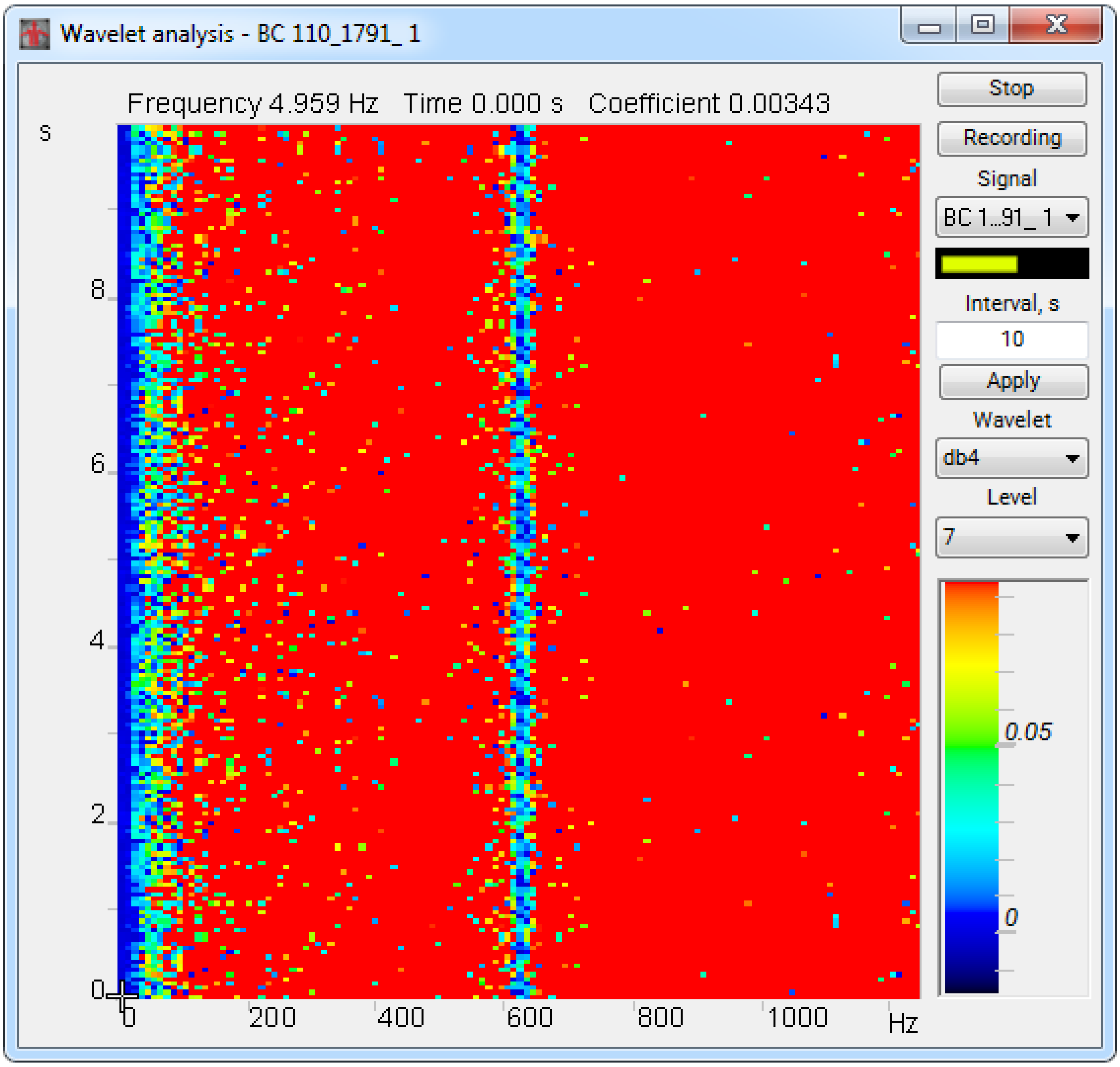


Fig 3 "Wavelet analysis" contains signal graphic and the control elements

Shocks recorder .....

Purpose of the program

The Shocks recorder program is intended for processing, visualization of a vibration signal, vibration signal spectrum, automatic determination of natural frequencies, phases, the ratio of peak amplitudes of two signals and the damping decrement of various mechanisms, parts, structures and other objects by measuring the frequencies of free vibrations, in shock excitation mode.

This program can be used for impact testing; in the field of vibration associated with the resonance of structures; to control the manufacture and assembly of critical equipment; in systems for monitoring the technical condition of buildings and structures; as well as for scientific purposes when conducting experimental studies.

The composition of the necessary equipment

For testing you will need:

- Impact stand;
- Controller series ZET02x or ZET03x;
- Accelerometer model BC111 (or equivalent);
- Computer (laptop).

Fix the sample on the shock stand in accordance with the requirements of GOST 28231-89.

Connect an accelerometer to the controller input.

Install (if not installed) software according to section 2.1 And activate the ZETLAB control panel (section2.2).

Guided by the section 3.1 connect the controller to the computer.

The monitor screen will display the Shocks recorder program window (*Fig.13.2*) which includes five areas: the “Reference” graphic, the “Measuring” graphic, the table of registered values, the control panel and the events journal.

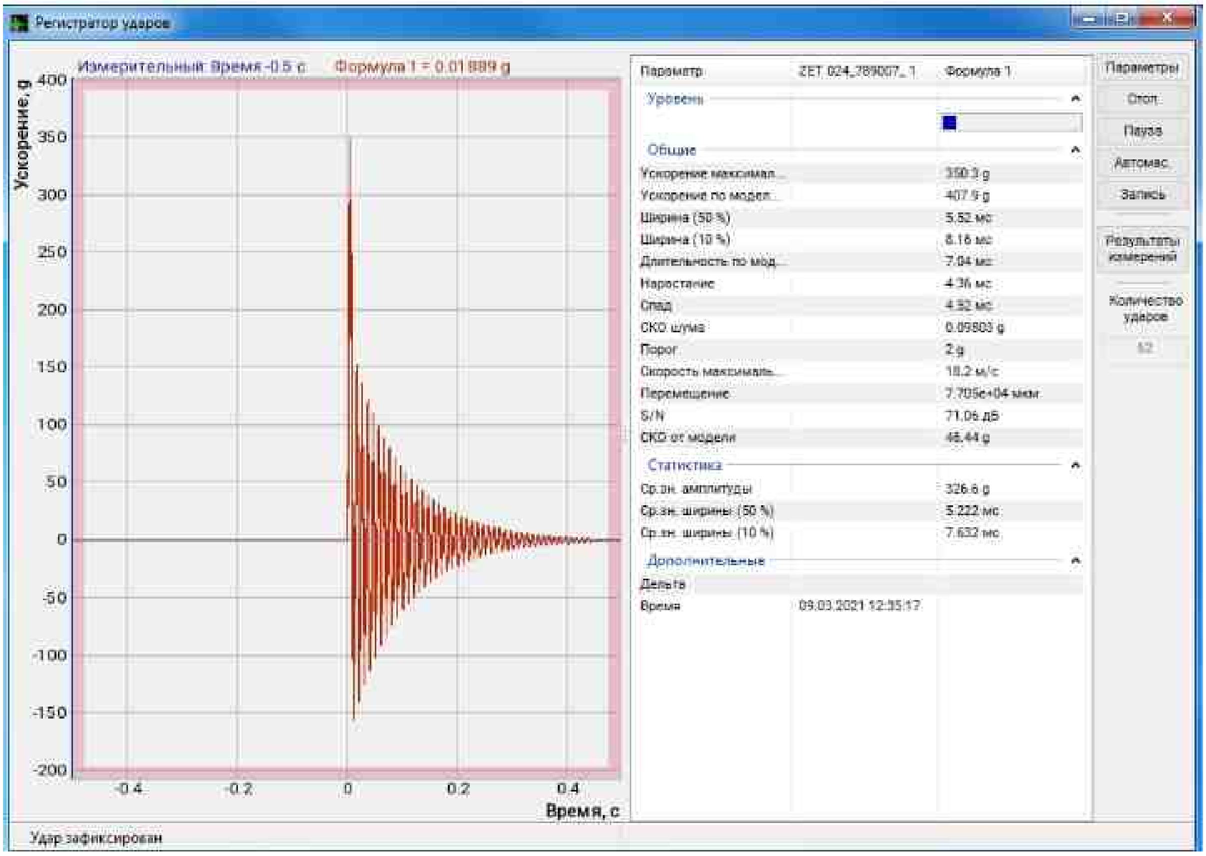


Fig. 2 Main window of the "Shocks recorder" program

In the "Reference" and "Measuring" areas of the graphs, the forms of registered shock impulses along the measuring channels with the corresponding statuses are displayed.

The table of recorded values displays the parameters calculated from the last recorded stroke.

The control field includes the following buttons:

- "Parameters" - causes a transition to the parameter settings window;
- "Start" - launches the impact registration mode (changes its name to "Stop" after activation);
- "Pause" - serves to pause the registration of strikes for subsequent continuation;
- "Autoscale" - designed to bring the graph of the registered impulse to the window scale vertically;
- "Record" - calls a window for saving the registered impact graphs to a file;
- "Measurement results" - calls the window with the directory in which automatic registration was performed;
- "Device Manager" - calls the appropriate window for setting the parameters of the controller and measuring channels.

In the event log area (at the bottom of the Shock Recorder window) are displayed as a list *registered hits as they are registered.*

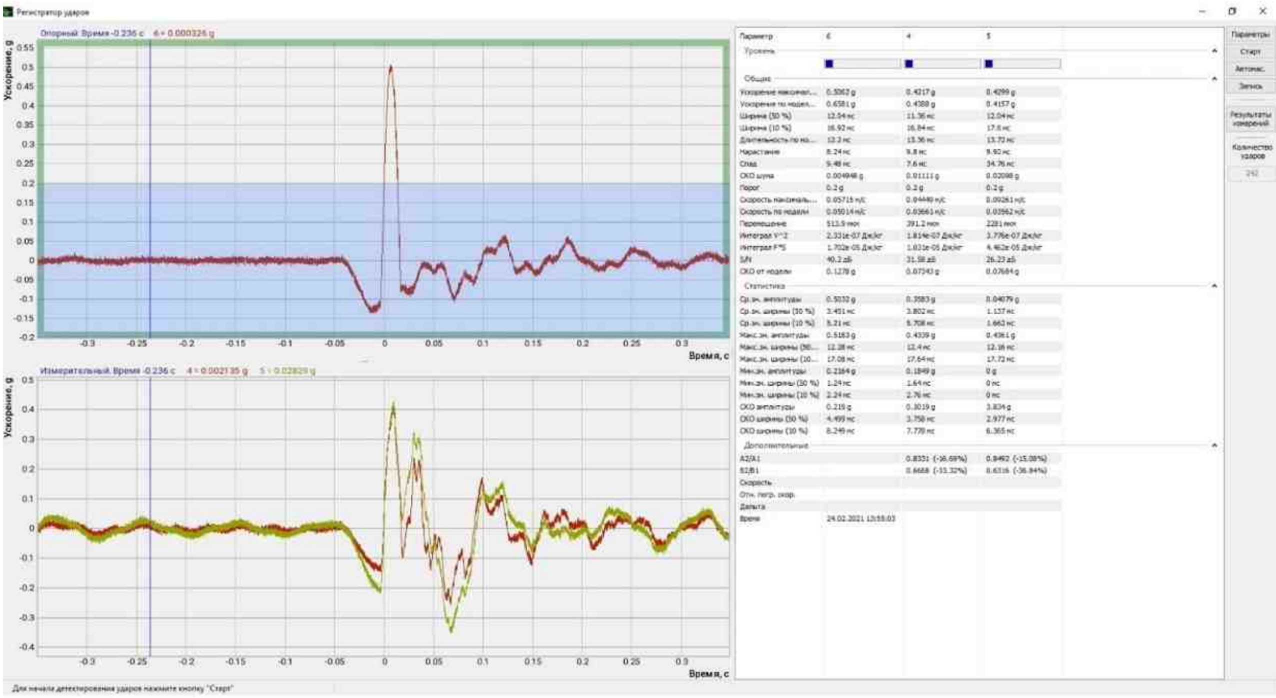


Fig. 2 Registered hits are displayed as they are registered.

Supported Hardware .....

For the purpose of analog signals digital processing, it is possible to use *FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01* and *seismic recorder ZET 048*.

Settings of measurement channels are specified in the program "Device Manager".

Shocks recorder is included in the following software as an additional option:

- ZETLAB ANALIZ – FFT Spectrum Analyzers software;
- ZETLAB VIBRO – Shaker controller software;
- ZETLAB TENZO – Strain-gauge station software;
- ZETLAB SEISMO – Seismic station software;
- ZETLAB SENSOR – Digital ZETSENSOR sensor software.

Shocks recorder is included in the **Signal Analysis** software group.

Functions of the program .....

To launch the **Shocks recorder** program, in the Signal Analysis menu of the ZETLab panel, select the Shock Recorder command (*Fig. 3*). The working window of the program will be displayed on the monitor screen (*Fig. 4*). At the top, in the title of the window, the name of the program and the name of the channel through which the analysis is carried out are displayed. **Note:** The Shock Recorder program can be launched directly from the ZETLab working directory (by default: c:\ZETLab\). Executable file name: NewModalAnalysis.exe

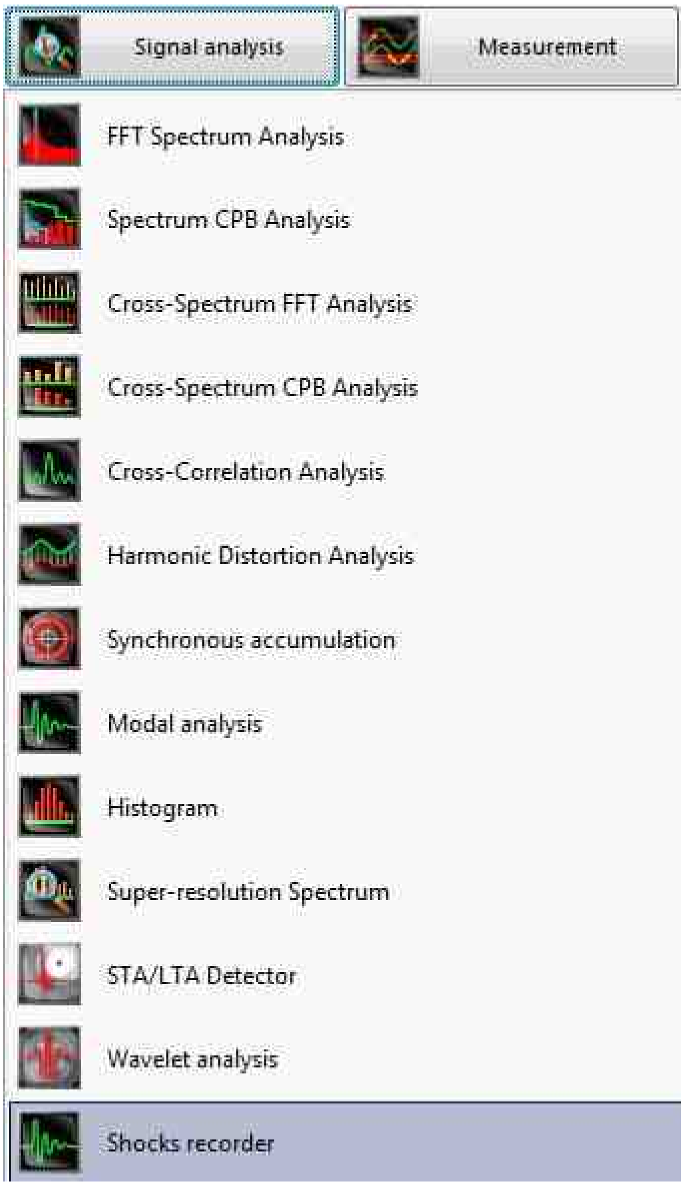


Fig. 3 Starting the "Shocks recorder"

The monitor screen will display the Shock Recorder program window (*Fig. 4*) which includes five areas: the “Reference” graph, the “Measuring” graph, the table of registered values, the control panel and the event journal.

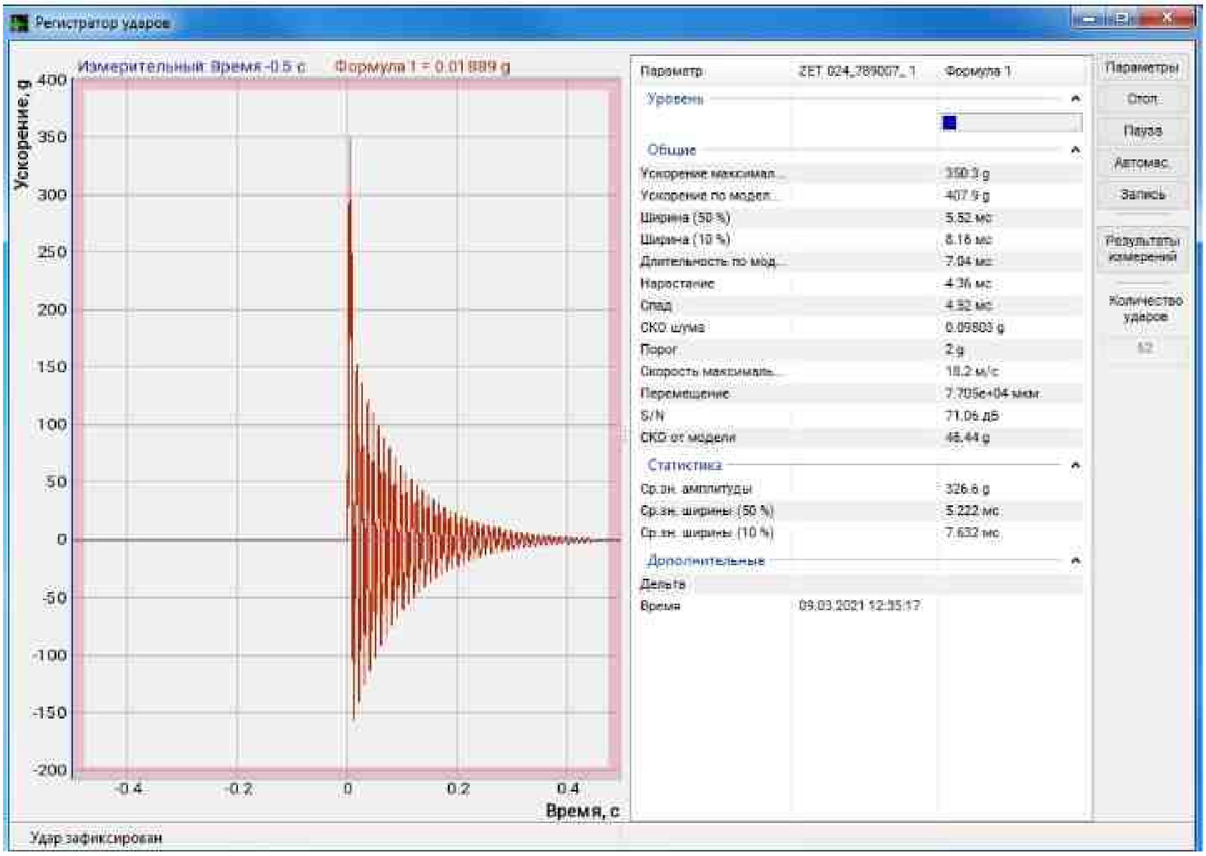


Fig. 2 Main window of the "Shocks recorder" program

In the "Reference" and "Measuring" areas of the graphs, the forms of registered shock impulses along the measuring channels with the corresponding statuses are displayed.

The table of recorded values displays the parameters calculated from the last recorded stroke.

The control field includes the following buttons:

- "Parameters" - causes a transition to the parameter settings window;
- "Start" - launches the impact registration mode (changes its name to "Stop" after activation);
- "Pause" - serves to pause the registration of strikes for subsequent continuation;
- "Autoscale" - designed to bring the graph of the registered impulse to the window scale vertically;
- "Record" - calls a window for saving the registered impact graphs to a file;

- "Measurement results" - calls the window with the directory in which automatic registration was performed;
- "Device Manager" - calls the appropriate window? intended for setting the parameters of the controller and measuring channels.

The event log area (at the bottom of the Stroke Recorder window) lists recorded strikes as they are recorded.

See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Setting parameters of display
- Using signal level indicators
- Adjustment of the color scheme used for displaying of the registered signal amplitude values
- Graphical and numerical data transfer to text editors
- Setting GridGl grid functionality

Program description .....

The program operation mode is configured in the program window “Settings” (*Fig. 5*), to switch to which in the window of the program "Shock Recorder" (*Fig. 4*) should  activate the "Setting" button.

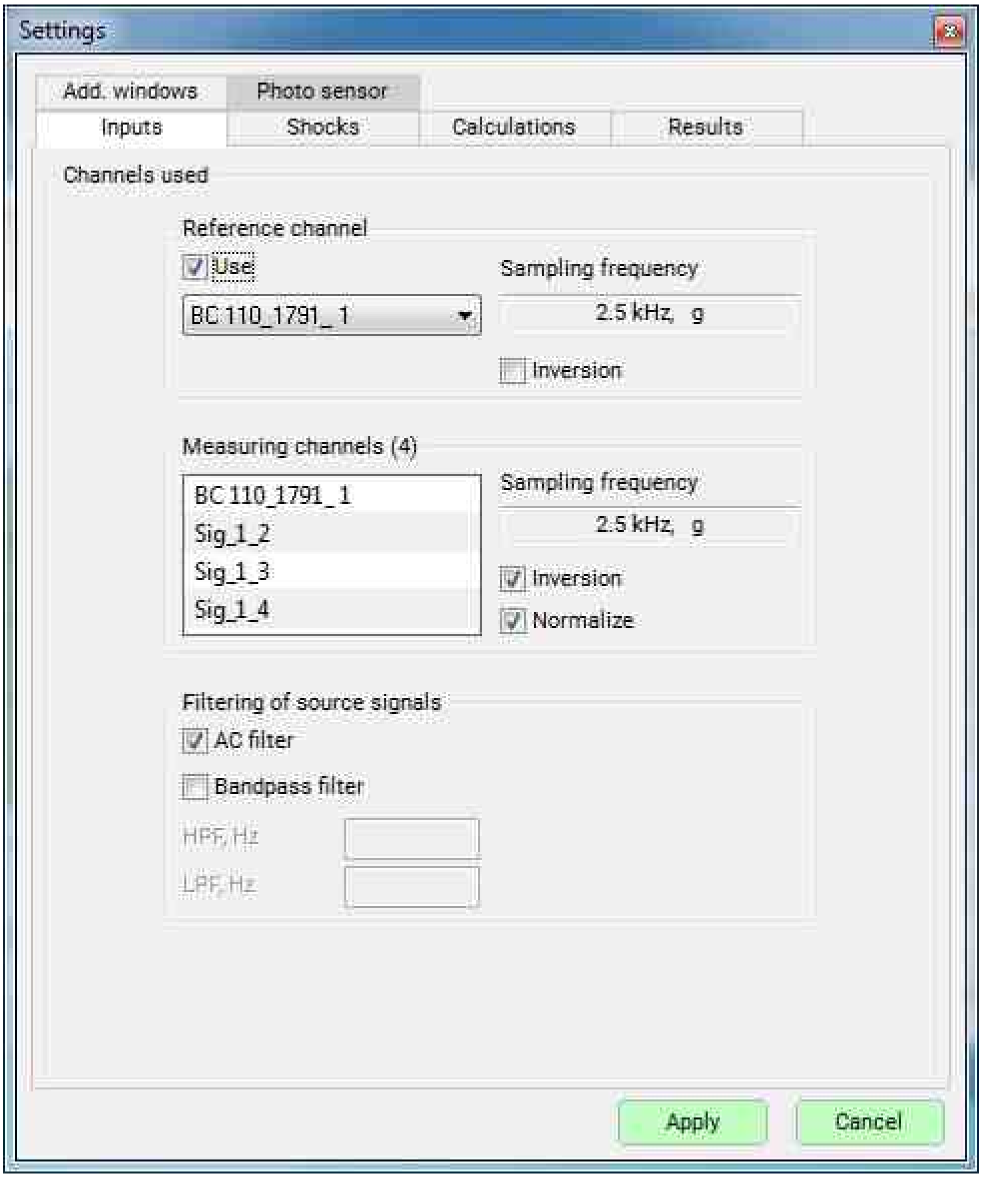


Fig. 5 Window "Setting parameters" section "Input"

The "Reference channel" parameter allows you to specify the measurement channel that will be used by the program as a reference. In this case, the detection of the impact fact will be carried out only on it, while the impact parameters will be calculated for all selected channels, including those indicated as measuring ones. In the window of the "Shock Recorder" program, the reference channel will be displayed in the graph field of the reference channel.

Activating the "Measuring channels" window will open the "Channels selection" window (*Fig. 6*) in which you can add or exclude (if necessary) certain measuring channels from the program. In the window of the "Shock Recorder" program, the measuring channels will be displayed in the graph field of the measuring channels.

If the checkbox for the “Invert” parameter is activated, then in the window corresponding to this checkbox, the displayed chart will be inverted (flipping about the horizontal axis).

The "Photosensor channel" parameter allows you to use the measuring channel of the photosensor as a reference. In this case, relative to the photo sensor channel, the parameters of impacts along the measuring channels will be calculated.

The corresponding fields "Sampling rate" display the sampling rates of the reference and measurement channels.

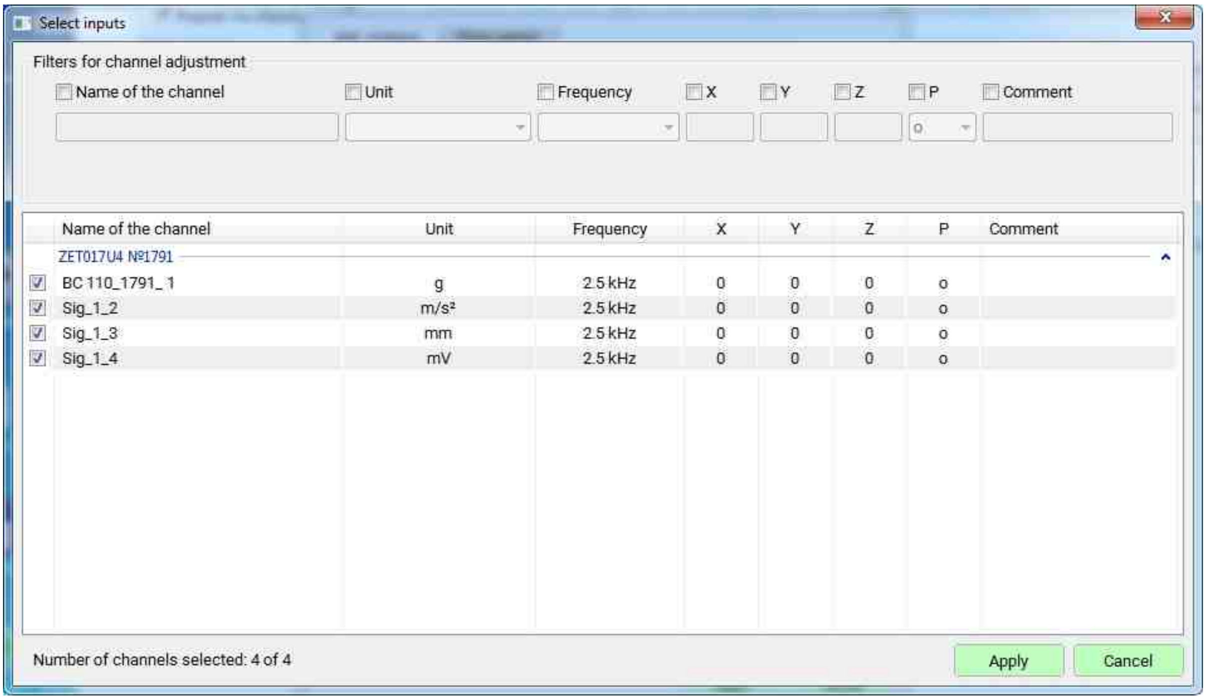


Fig. 6 Channel selection window

The "Time interval" parameter sets the time interval for displaying the graph along the X axis in the main program window (the time value of the rightmost point of the X axis minus the time value of the leftmost point of the X axis).

The Auto Trigger option enables the Shock Pulse Trigger to fire automatically after the amount of time (in seconds) set for the Auto Trigger After option.

If the "Autostart after" parameter is disabled, then for each activation of the "Start" button in the "Shock Recorder" program window, only the first of the shocks will be registered.

The Thresholds parameter (per reference channel) sets the threshold for triggering a hit. The threshold can be adaptive or absolute.

- The adaptive threshold sets the trigger at a level equal to the product of the noise on the reference channel and the coefficient specified in the settings.
- An absolute threshold sets the trigger at a given level in absolute terms. For the absolute threshold, you can also specify that the trigger fires only on the positive edge of the shock pulse.

The "Filtering" parameter imposes a band-pass filter on the signal of the fixed shock pulse. Bandpass filter boundaries are set in the "HPF" and "LPF" fields.

The “Show Event journal” option in the “Shock recorder” area is used to open an additional field at the bottom of the “Shock recorder” program window (*Fig. 7*) in which information on each of the recorded strikes is displayed in order of priority.

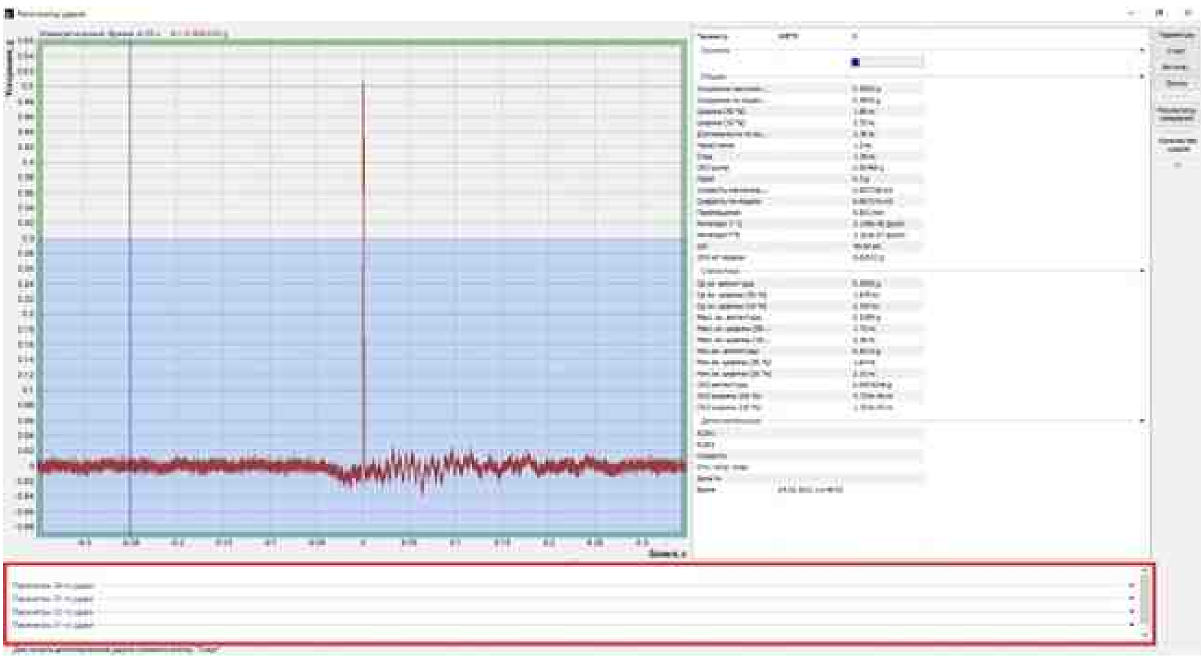


Fig. 7 The "Event journal" field in the "Impact Logger" window

The “Save parameters of shocks” parameter in the “Shock recorder” area is used to activate the saving of information on registered strikes to the directory specified in the “Save parameters” window (*Fig. 8*).

To call the program window "Save options" it is necessary in the window "Settings" (*Fig. 5*) activate the "Save options" button.

The "Save Options" window allows you to specify the folder for saving the test results, the name of the report file, and also specify whether or not to save graphs during testing to text (*.dtx) and graphic (*.png) files.

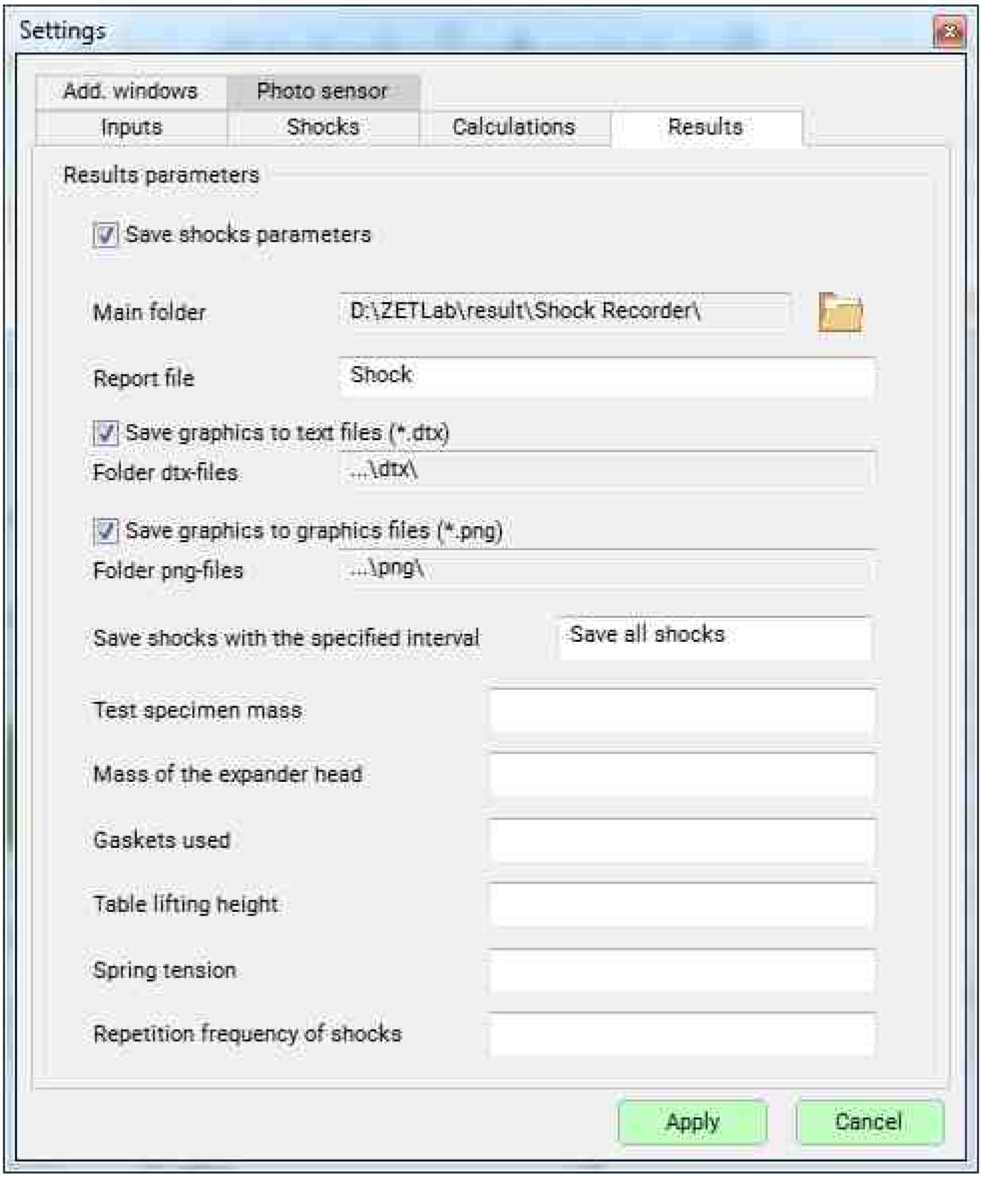


Fig. 8 The "Setting" window

The "Save beats at a specified interval" option in the "Save shocks with the specified interval" window determines the step when saving beats: "1" - every beat is saved, "2" - every second beat, "3" - every third beat, etc.

The "Save Options" window provides fields for entering test information, which provides information about the mass of the tested product, the mass of the expander table, the type of gasket, etc. The information entered in these fields is then automatically entered into the test report file.

Activating the Select Display Parameters button in the "Settings" window (*Fig. 5*) calls the corresponding window (*Fig. 9*) in which you can define the parameters that need to be displayed in the "Shock Recorder" window.

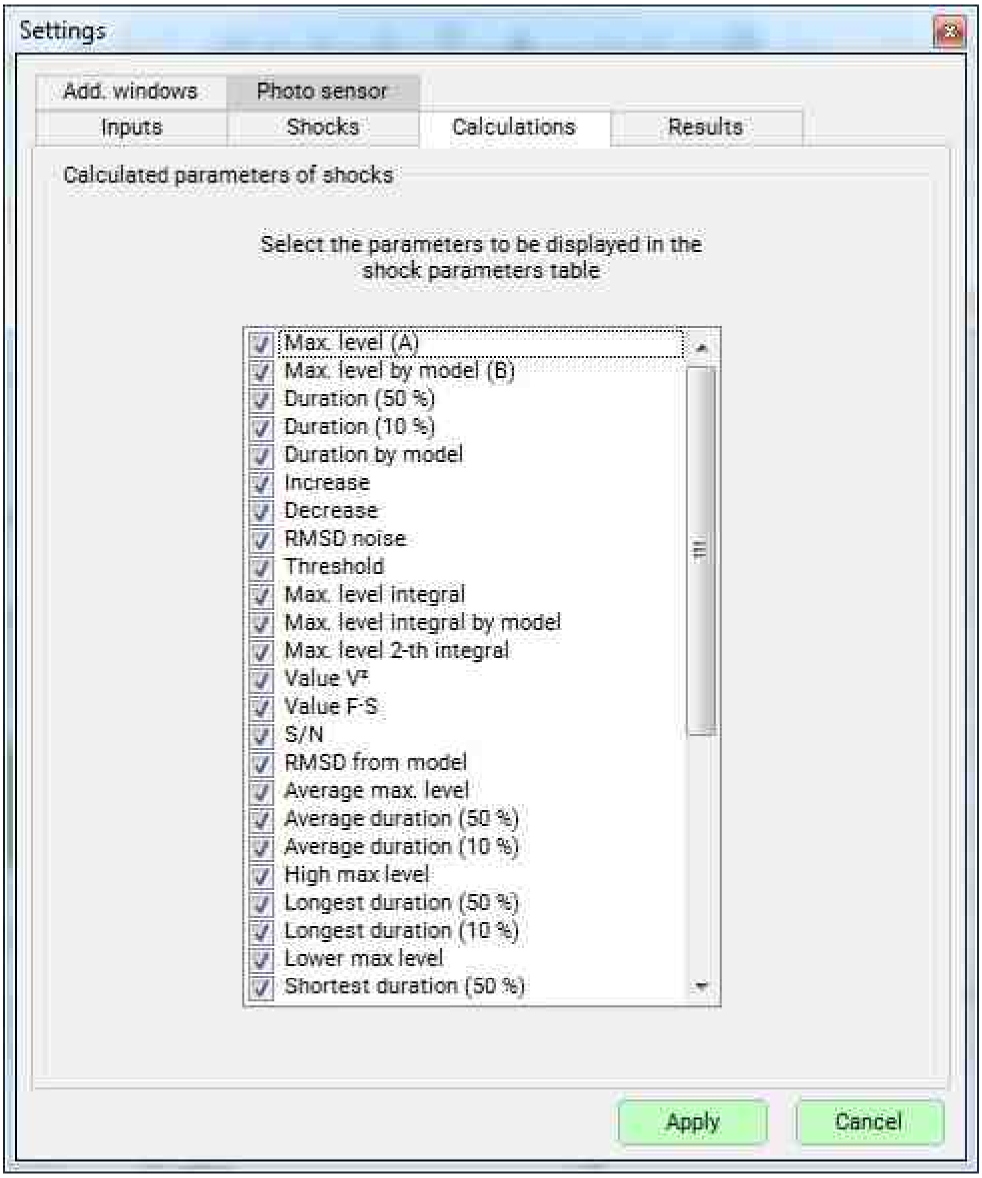


Fig. 9 Window "Select displayed parameters"

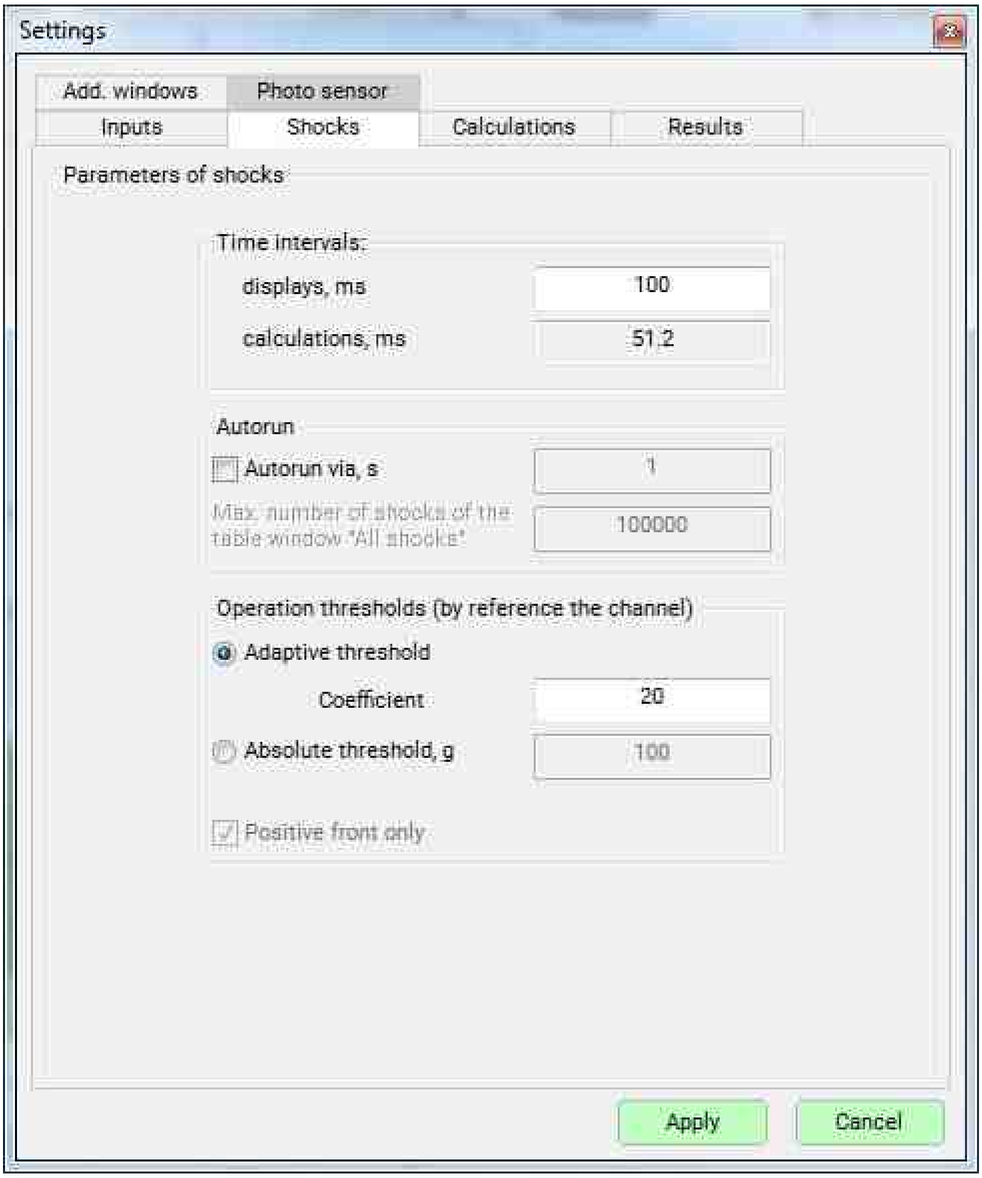


Fig. 9 Window "Photo sensor"

Operating principles .....

Make sure that the measuring equipment (analyzer, VCS controller, etc.) is connected, and that the measuring channels necessary for recording shocks are configured and activated.

Guided by the section (*Fig. 7)* configure the parameters of the "Shock recorder" program.

Then activate the "Start" button in the "Shock recorder" program window, after which the program will switch to the shock registration mode.

After detecting a shock whose amplitude exceeds the threshold level, its registration will be performed.

If the registration mode is selected by the reference channel (the "Reference channel" parameter is activated), the window of the "Shock recorder" program includes two graphs (*Fig. 10*), the upper one for displaying the reference channel, and the lower one for other active measurement channels.

If the reference channel mode is deactivated, then all active measuring channels are displayed in the window of the “Shock recorder” program on one graphic (*Fig. 11*).

If necessary, save the results recorded on the screen to the report. activate the "Record" button.

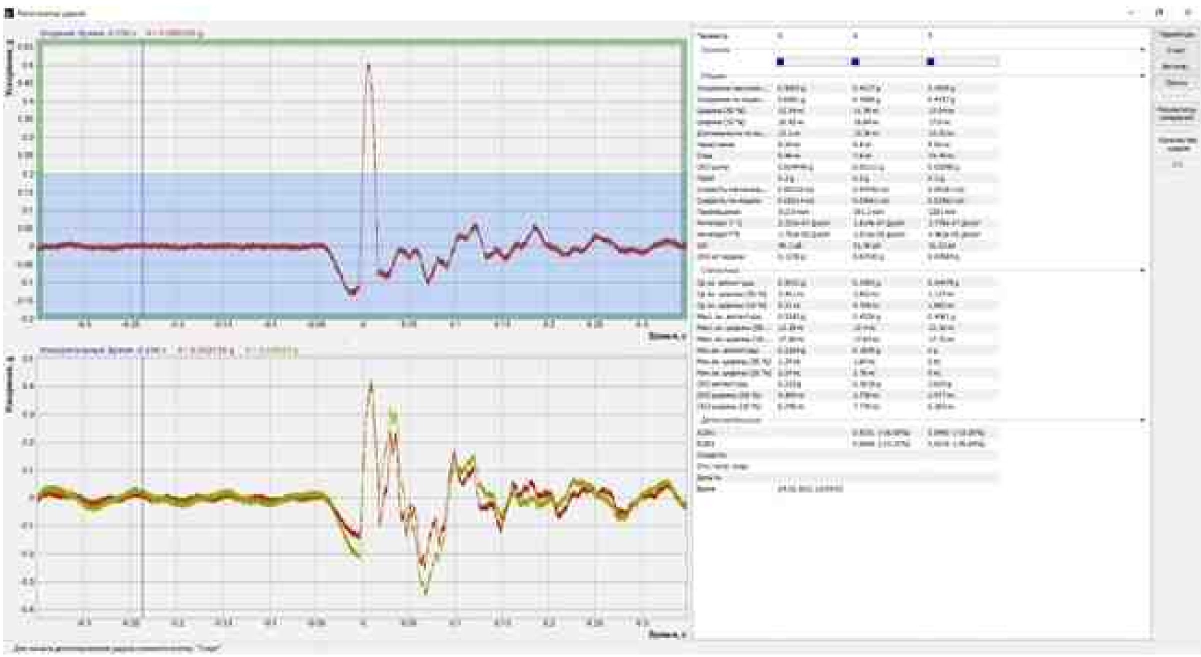


Fig. 10 “Shock recorder” window when registering with a reference channel

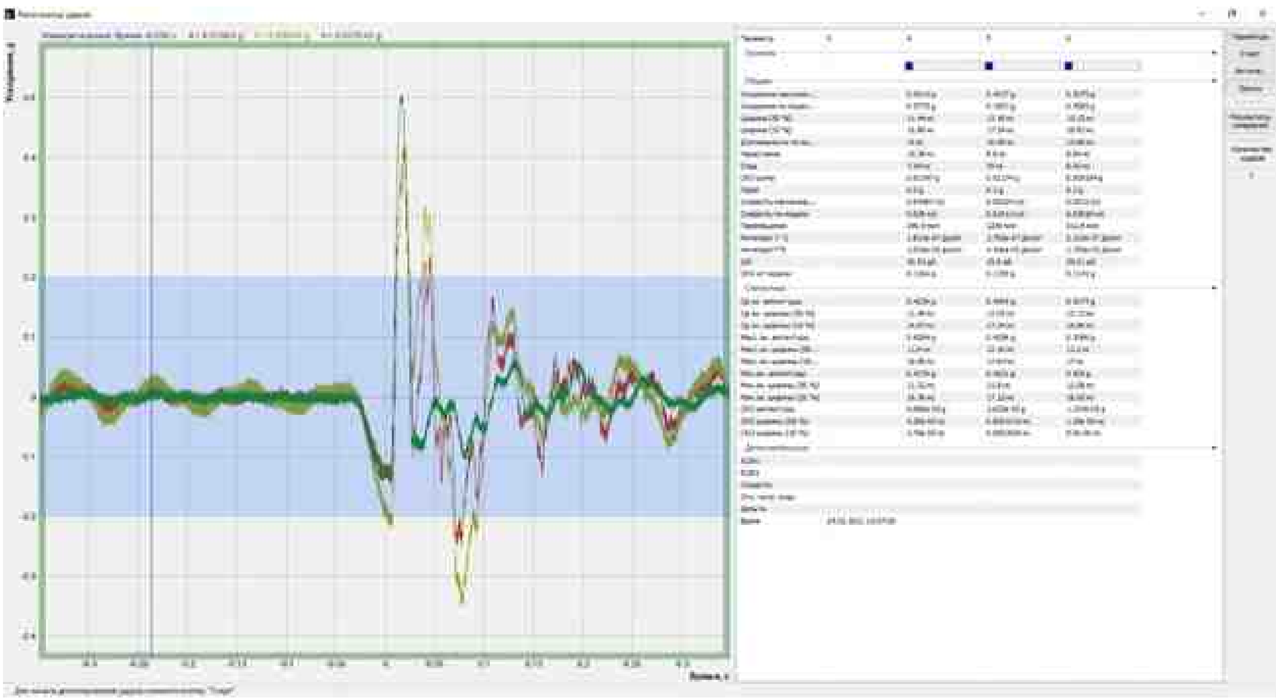


Fig. 11 “Shock recorder” window when registering without a reference channel

Measurement

Program section "Measurement" is designed to measure various signal parameters.

Voltmeters are universal measuring devices and expect constant and variable signal levels (RMS, Standard deviation may be abbreviated **SD**, amplitude, peak etc.). When connecting the vibration sensor, the AC voltmeter will show the level of vibration (acceleration), when connecting current sensors - switches ammeter, etc.

Such programs as "strain-gauge", "Vibrometer", "Thermometer" are specialized and designed to measure parameters when connecting the sensors of a specific type using the appropriate equipment (strain test station, spectrum analyzer).

Program "Encoder", "Torygraph", "Tachometer" is intended for measurements of parameters related to rotation: the rotation angle, rotation speed, rotation irregularity, etc.

All programs section "Measurement" displays the measurement result on the digital display. Specialized programs (i.e. all except voltmeters) create virtual channels with the results of processing which are accessible to other ZETLAB programs. This allows, for example, to record temperature Multichannel recorder, build mutual dependence of the tension from the applied force to XYZ-oscilloscope, to obtain the spectrum of vibration, etc.

AC voltmeter .....

The program **"AC voltmeter"** is supplied as an executable file "VoltMeter.exe", and is used for measuring parameters of alternating signals. The measured parameters are as follows: amplitude, peak value and RMS value of the signal components.

The program **AC voltmeter** can be used in various spheres of science and technology.

The program AC Voltmeter is intended for PC use (see the "Hardware requirements" in boxed the present Manual). The PC should have ZETLAB software installed. Then it is necessary to connect ADC to the PC (the ADC should be compatible with ZETLAB software).

The program **"AC Voltmeter"** can differ from the description specified in the present Manual.

Supported Hardware .....

The input data of the **AC Voltmeter** program is the digital data of the ZETLAB server channel, which is a digitized arbitrary variable signal. In this case, a variable signal is understood as a signal whose instantaneous values depend on time. First of all, the **AC Voltmeter** program is focused on working with harmonic signals that have a non-zero constant component.

For the purpose of analog signals digital processing, it is possible to use FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01, noise- and vibration-meters ZET 110 and seismic recorder ZET 048.

Parameters of measurement channels are specified in the program "Device Manager".

For digital processing of the analog signals it is possible to use the following programs:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT spectrum analyzer software
- ZETLAB VIBRO – Shaker controllers software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software (option).

AC voltmeter is included into the **Measurement** software group.

Operating principles .....

In the course of input signal parameters measurements, the program implements the following operations:

· the data of the selected channel is retrieved from ZETLAB server;

· from the accumulated data there is produced a selection of data arrays containing a whole number of periods;

· based on this data array, there is calculated an average value;

· the data arrays are aligned;

· based on the centralized arrays, there is calculated RMS value and amplitude of signal's DC (it is calculated as a half of signal's amplitude).

From ZETLAB server there is retrieved certain number of counts (N)

$$N = time * Freq_{ADC}$$

where: $time$ – averaging time, $Freq_{ADC}$ – ADC sampling frequency. Averaging time can be set as follows: 0,1 s; 1 s; 10 s.

Based on the accumulated data, it is possible to calculate the average value (it is calculated as an average between the minimal and the maximal values). Then it is necessary to calculate the first transition of the signal through the average value. Let us consider this count number as n_1. Then it is necessary to calculate the last transition of the signal through the average value (n_2). Then:

$$\bar{x} = \frac{1}{n_2 - n_1} \sum_{n=n_1}^{n_2-1} x_n ,$$

$$RMS = \sqrt{\frac{1}{n_2 - n_1} \sum_{n=n_1}^{n_2-1} (x_n - \bar{x})^2} ,$$

$$A_{peak} = \max(\max(\sum_{n=n_1}^{n_2-1} (x_n - \bar{x})), -\min(\sum_{n=n_1}^{n_2-1} (x_n - \bar{x}))) ,$$

$$A = [\max(\sum_{n=n_1}^{n_2-1} (x_n - \bar{x})) - \min(\sum_{n=n_1}^{n_2-1} (x_n - \bar{x}))] * 0.5 .$$

where: X- calculated signal value, x_n - n-input signal count. A_{peak} – peak value of signal's alternating component, A – amplitude of signal's alternating component.

In order to optimize the program resources used in the course of data acquisition from ADC, we always set the interval of 0,1 s. Then, using particular operations with the data, we implement calculations using the above listed formulas. It is also desirable to avoid using ADC sampling frequencies, for which the result of formula

$$0{,}1 * Freq_{ADC}$$

is not represented by an integral value.

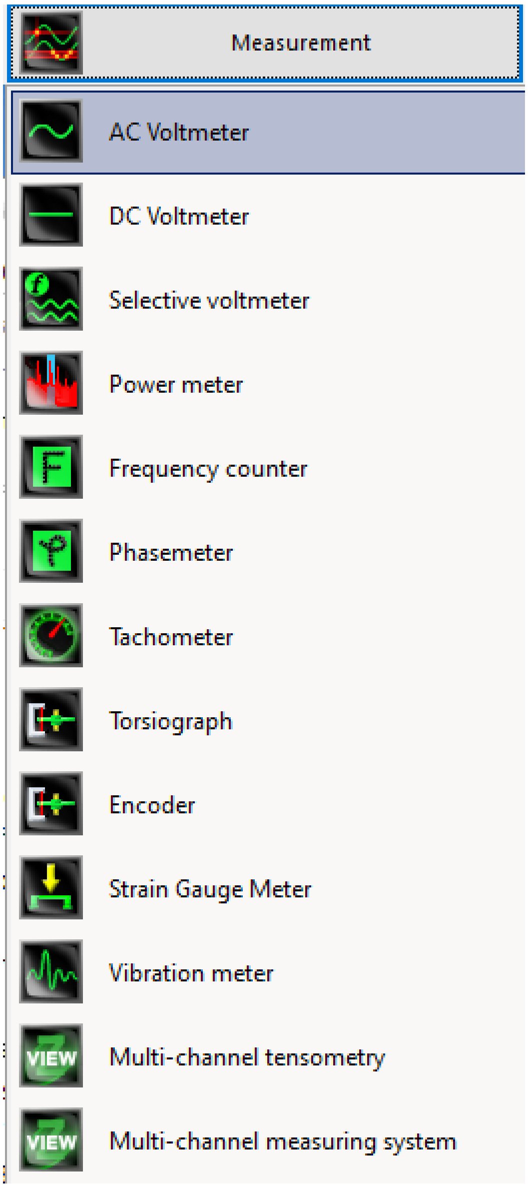
For averaging time of 0,1 s and 1 s, acquisition of the data used for further calculations is conducted sequentially, without any data omission. The calculated values that are displayed in the program window, are updated with the interval of 0,1 s or 1 s respectively.

For the averaging time of 10 seconds for both measured parameters there is used a moving average with data overlapping of 90%. In this case, the measurement data displayed in the program window are updated with the interval of 1 second.

The program begins its operation upon downloading completion.

Program description .....

The AC voltmeter program can be started from "Measurement" section of ZETLAB panel.



Starting the program AC voltmeter

Note: the program AC voltmeter can be also started from ZETLAB directory (by default: C:\ZETLAB\).

The name of the file to be started: VoltMeter.exe.

The title of the window displays the name of the program and the name of the measurement channel.

The name of the program changes depending on the measurement unit selected for a particular channel. When a current transducer (with accordingly set parameters set in ZET Device manager program) is connected, the name of the program changes for AC ammeter. In this case, the program will display the AC values.

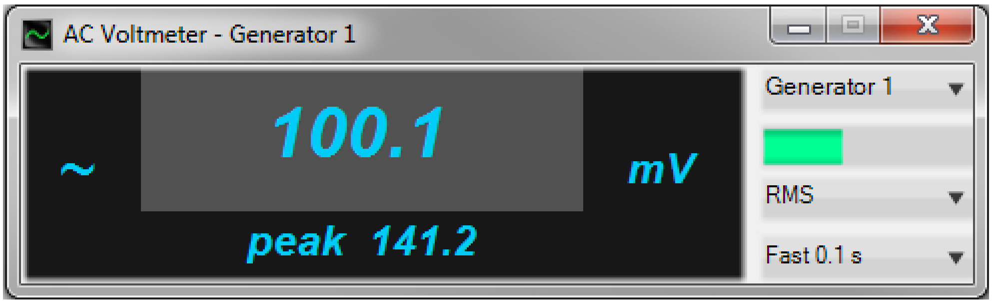
If a vibration transducer (with accordingly set parameters set in ZET Device manager program) is connected, the name of the program changes for AC Voltmeter and displays Acceleration values:.

The graphic displays all possible variants of program window titles.

Title	Measurement unit of the channel
AC voltmeter	V, mV or µV
AC current meter	A, mA or µA
Temperature	Degrees or C
DC measurements	other

The left section of the program window contains 4 indicators depicting measurement data in blue font against black background. The left indicator always depicts "twiddle" – a symbol that stands for alternating current. The right indicator depicts the measurement units of the selected channel, which may change in the case if another channel is selected. The upper indicator depicts amplitude value and RMS value of the signal’s alternating component. Precision of the displayed data is determined by the minimal parameter value set for the channel (the user can view or set this value using the program ZET device manager from Service menu of ZETLAB panel). The bottom indicator displays the word "peak" and the corresponding value of signal's alternating component.

As the mouse pointer is placed at the top or bottom indicator, the mouse pointer changes its appearance and the background changes its color from black to grey (see the Fig. below). As the indicator is selected, left-click it to copy its readings to the clipboard. The data is copied in text format, which allows to use the copied data in other programs, e.g., in Word or Excel. The combination "Ctrl+C" allows to copy the displayed readings of the top indicator.

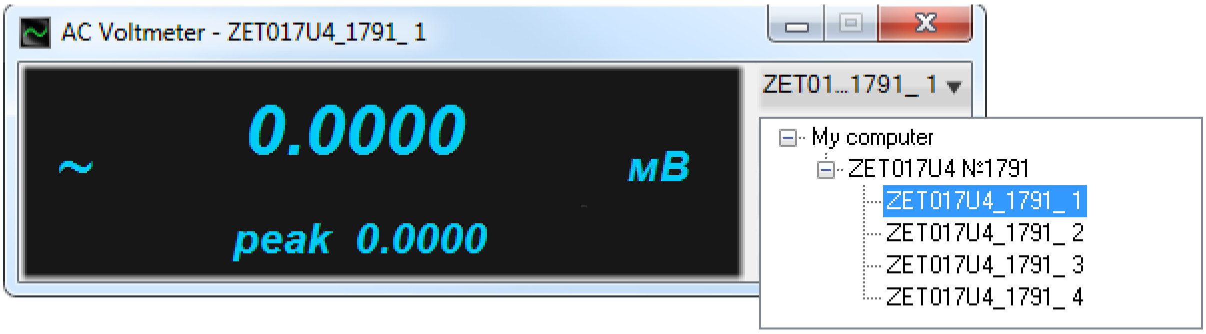


The right section of the program contains four elements: the first one (at the top) is used for selection of the measurement channel, the second one displays the integral level of the channel, the third one is used to select the measurement unit to be displayed at the top indicator, the fourth one allows to select the averaging type. As the mouse pointer is aligned with the indicator area, the mouse pointer changes its appearance. The background color of the indicator also changes from black into grey (see the Fig. "Copying measurement results to the Clipboard"). As the indicator is selected, left-click it to copy the displayed value to the clipboard. The data is copied in text format, which allows to use the copied data in Word or Excel document. The combination "Ctrl+C" also allows to copy indicator readings to the clipboard.

As the readings of the indicator are copied to the clipboard, the point that separates integral and fractional parts of the number, changes into another symbol that has been selected in user profile (see the control panel – "Language and regional standards – Additional parameters – Separator of integer and fractional parts"). By default, if Russian language menu is used, the separator is represented by the symbol ",". Changing the separator symbol allows such programs as Excel to recognized the copied text as a number.

Left-click the upper control element to activate the drop-down list of ZETLAB server available channels (see the Fig. below). The channel selection is performed by right-clicking a particular channel. As the channel is selected, the drop-down list will be closed. Then the window title displays the name of the selected channel and the indicator – the measurement units used. It is also possible to change the title based on the parameters specified in the table about.

As the measurement channel is assigned, or the program is started, the top and the bottom indicators do not display any readings, since the signal parameters have not yet been measured. The first measured parameters will be displayed upon completion of the first averaging period.



The channel selection is performed by right-clicking a particular channel

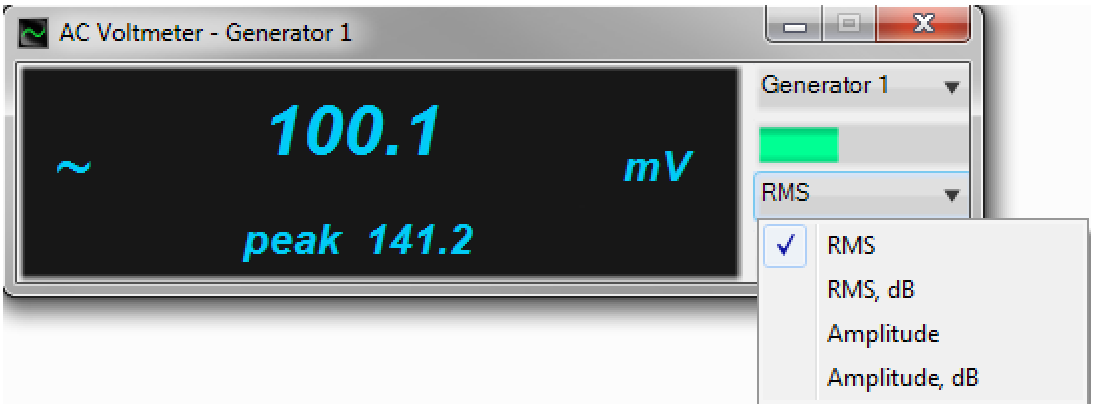
Note:

If the Voltmeter program is used with a virtual channel (generator's channel or a channel of "Formula" and "Signal filtration" programs), it is possible that the operator can close the program, that produces the virtual channel. The virtual channel will be disabled, and the program will switch over to the mode of channel substitution. In this mode, the program starts processing another channel (in most cases – channel with "0" number). If a virtual channel is activated, the program will switch over to it. If the program that operates in channel substitution mode is closed, the program will save the information of the previously used virtual channel. As the program is started again, the program will try to establish connection with this virtual channel. The program exits the channel substitution mode as the operator selects a different channel.

For ZetView projects, the channel substitution mode is not available (as the channel is disabled, the program suspends its operation until the channel restores its operation or a new channel is assigned).

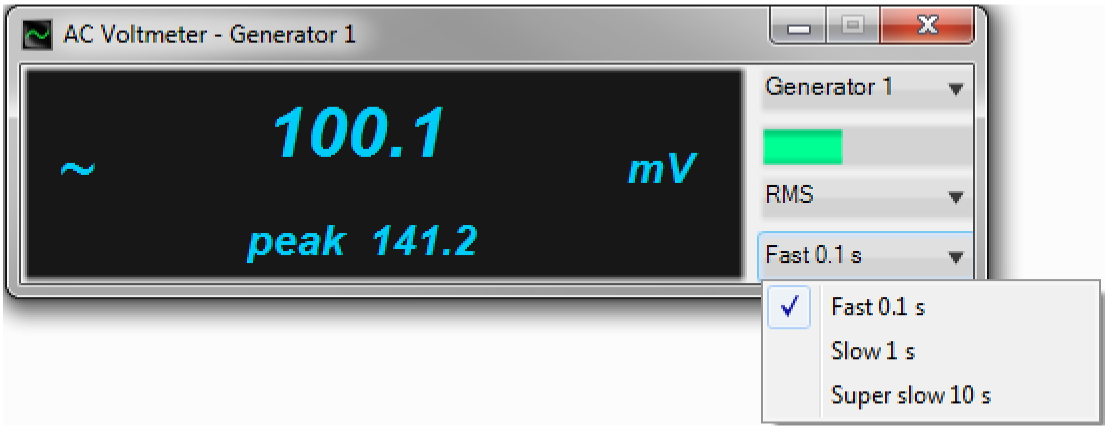
The second element displays the integral level of the signal. The integral level is displayed by means of color indication and width of the color indication field, that may occupy up to 2/3 of the section. As the channel level changes to the maximal level, the color changes from blue to red. The higher is the signal level, the larger part of the indicator is occupied with red indication. The right section of the indicator will remain red until the overloading is eliminated or the user left-clicks the indicator. As the maximal admissible level is exceeded, the indicator is filled with red color. The right section of the indicator remains red until the overloading of the channel is eliminated, and the user left-clicks the indicator.

The third element allows to select the parameter to be depicted in the upper indicator. Left-click this element to activate drop-list with the available parameters (see the Fig. below). To select the parameter to be depicted, use the checkbox. Select another checkbox to switch to a different parameter.



It is possible to display the measured parameters in dB. The reference value used for calculation of decimal logarithm is represented by the parameter of the selected channel, that can be displayed or set by means of the program ZET Device manager ("Service" tab in ZETLAB panel). In the case of the channels used for voltage measurements, this value is 1 μV. If the parameters are displayed in dB, the peak value at the bottom indicator will also be displayed in dB.

The bottom element is used for selection of averaging time interval. Left-click this element to display the drop-down list of options (see the Fig. below). Use the checkbox to select the averaging time interval. To set the interval, left-click another averaging time option.



Notifications of the program .....

Notifications of the program

The program can operate without participation of the operator. The notifications of the program are displayed as dialog windows and are saved to the system log. The log can be viewed in the program ZETLAB Error journal (in the "Service" tab of the control panel).

The notifications that are recorded to the log by ZETLAB software, have the following format:

"Name of the program No.xx. Text of the message",

The name of the program in this case is "DC Voltmeter"; xx – is the number of active program copy.

The program records error notifications, as well as information of the set parameters to the log. These messages allow to reproduce the sequence of program operations, which may be useful when it is necessary to analyze errors that occurred in the course of program operation. In the table below, you can see the program notification messages.

Text of the message	Category
Connection to data server: error	error
An error has occurred when reading the data from the register	error
Configuration file in the folder DirConfig is not available	error
Help file loading error	error
Folder DirSignal not available	error
Folder DirResult not available	error
The program is running	message
ADC sampling frequency = xxx.xx Hz	message
Work channels of data server not found. Program is not loading	error
Data server has too many channels or large sampling frequency. Not enough memory to run the program in this mode. The program will be closed	error
Go to the channel - Signal x	message
Go to the averaging - code x	message
Server stream does not respond to the queries. The program will be closed	error

The program has completed its operation	message

If the program operates with active control panel, then the notifications of ZETLAB programs will be duplicated with pop-up messages in the system tray (i.e., in the notifications area or Windows task panel, that are used for the control of running programs).

The message "Data server has too many channels or large sampling frequency. Not enough memory to run the program in this mode. The program will be closed." means that there are too many programs that operate with ZETLAB data server or that RAM volume is insufficient. In the first case, it is necessary to close the programs that are not used and to restart the program. In the second case, the user can use other PC, or increase the RAM volume.

DC voltmeter .....

The program "**DC Voltmeter**" is supplied as an executable file "VoltMeterDC.exe", and is intended for measurement of signal's various parameters. The measured parameters are the magnitude of the signal and its standard deviation (Standard deviation may be abbreviated RMSD).

The program can be used in various scientific and technological spheres.

The program is intended for PC use. The PC should have characteristics specified in the section "Hardware requirements". The PC should also have ZETLAB software package. The ADC used for measurements should be compatible with ZETLAB Software.

The program may undergo updates that are not specified in the present manual.

Supported Hardware .....

The input data of the **DC Voltmeter** program is the digital data of the ZETLAB server channel, which is a digitized arbitrary constant signal. In this case, a constant signal is understood as a signal whose instantaneous values in a statistical sense either do not depend on time, or whose changes during measurement can be neglected.

Examples of acceptable parameters measured by the program: current strength and DC voltage, temperature of slowly changing processes.

An example of an invalid parameter measured by the program: a constant component of an alternating current with a non-zero amplitude. In this case, the instantaneous value of the voltage and current will change according to some time function. For a periodic signal, this function will be periodic, for example, for a harmonic signal, the time function will have a "Sine" form.

For the purpose of analog signals digital processing, it is possible to use FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01, noise- and vibration-meters ZET 110 and seismic recorder ZET 048.

Parametrs of measurement channels are specified in the program "Device Manager".

For digital processing of the analog signals it is possible to use the following programs:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT spectrum analyzer software
- ZETLAB VIBRO – Shaker controllers software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software (option).

DC voltmeter is included into the **Measurement** software group.

Operating principles .....

The value of constant input signal is calculated using the formula:

$$\bar{x} = \frac{1}{N}\sum_{n=0}^{N-1} x_n$$

$$N = time * Freq_{ADC}$$

where: $\bar{x}$ – calculated value of the signal, N – the number of counts, x_n – number of input signal count.

$time$ – averaging time, $Freq_{ADC}$ – ADC sampling frequency.

The averaging time interval may have the following values: 0,1 s; 1 s; 10 s. In order to optimize the resources of the program, it is recommended to use the interval of 0,1 s for data acquisition from ADC. Then, using obvious operations, the accumulated data undergoes processing in accordance with the above-mentioned formula. It is recommended to avoid using the ADC sampling frequencies, at which the result of the formula:

$0{,}1 * Freq_{ADC}$

is not represented by integral number.

When selecting an alternating signal, the calculated value will be shifted in relation to the actual value. Thus, for a harmonic signal, the value calculated by the program, will be equal to the DC component of harmonic signal only in the case if the averaging interval is equal to the duration of several periods of the signal. Otherwise, there occurs a displacement that is proportional to the relation of signal frequency and ADC sampling frequency. It is noteworthy that increase of input signal frequency leads to a decrease of the calculated signal shift.

The RMS value of constant input signal **s** is calculated by the program in accordance with the formula:

$$\sigma = \sqrt{\frac{1}{N-1}\sum_{n=0}^{N-1}(x_n - \bar{x})^2}$$

If an alternating signal is used as an input signal, the calculated RMS deviation (at N>>1) will be equal to the RMS value of the centralized signal.

Even though the signal will be processed with intervals of 0,1 s (no matter what averaging time is selected), the displayed RMS value will be calculated in compliance with the above-mentioned formula.

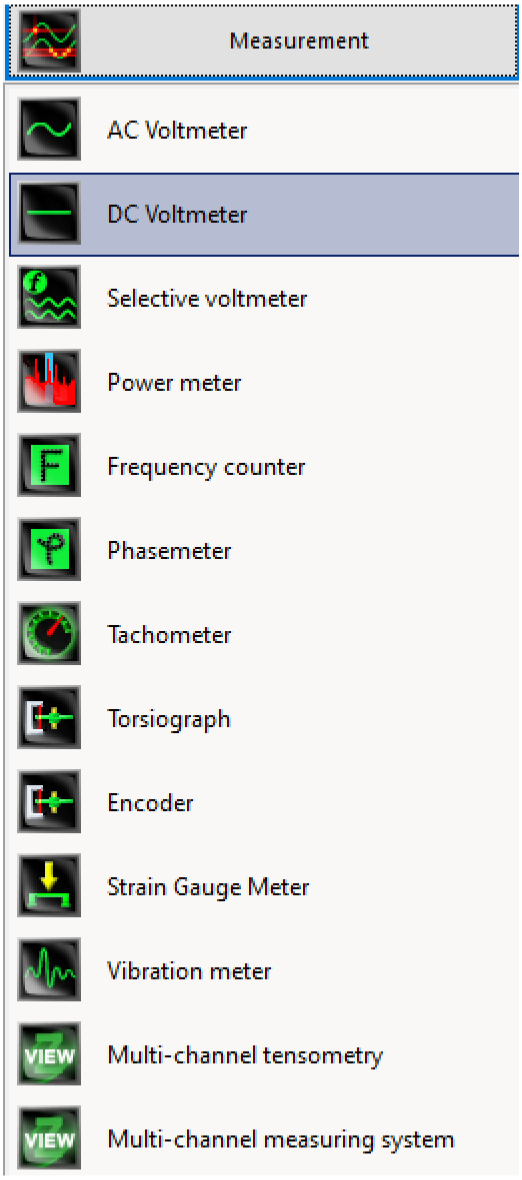
For averaging intervals of 0,1 s and 1 s, the signal arrays used for calculations are sequential (they do not overlap, thus preventing data loss). The calculated values displayed at the indicators are updated with the interval of 0,1 s or 1 s respectively.

For averaging interval of 10 seconds, for both controlled parameters, there is used a moving average with 90% overlapping. In this case, the displayed measurement data is updated with the interval of 1 second.

As the program is started, it begins operating immediately.

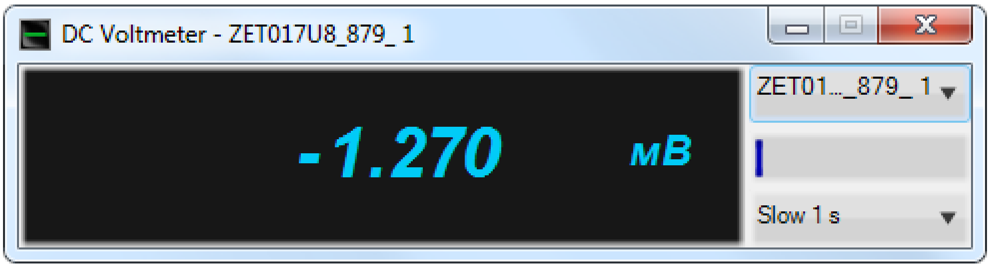
Program description .....

The program "**DC Voltmeter**" can be started from "Measurement" section of ZETLAB panel.



Starting the program DC Voltmeter

The Fig. below shows the program window. The top section of the window has a title and functional keys. The left section of the interface contains indicators, the right one – control elements.

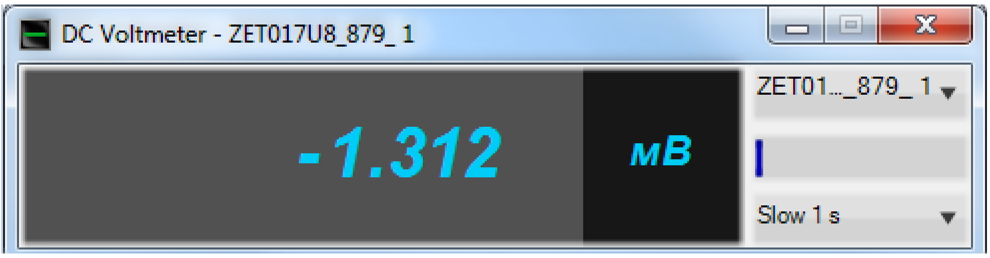


The title of the window contains the title of the program and the name of the measurement channel. The title changes depending on measurement units of a particular measurement channel. The table below contains all possible titles of the program.

Title	Measurement unit of the channel
DC Voltmeter	V, mV or µV
DC current meter	A, mA or µA
Temperature	Degrees or C
DC Voltmeter	other

The left section of the program contains two indicators displaying the measurement data (blue font against black background). The right indicator displays the measurement unit of the selected channel. The precision of measurement data is determined by the minimal parameter value of the channel – it can be viewed or set using the program ZET Device manager ("Service" section of ZETLAB panel).

As the text is copied from the indicator to the clipboard, the symbol ".", that is used for separation of integral and fractional part, changes for a different symbol selected in the profile of a particular user (Control panel – Language and regional parameters – Additional parameters – The separator of integer and fractional parts). For Russian language of the menu, the separator by default is ",". The use of separator allows such programs as Excel to recognized the copied text as a number.



As the mouse pointer is aligned with the indicator displaying the measurement values, the cursor changes its appearance. The indicator also changes the background color from black to grey (see the Fig. "Copying measurement results to the clipboard"). As the indicator is selected, left-click it to copy the displayed value of the indicator to the clipboard. The data is copied in text format, which allows to use the copied data in such programs as Word or Excel. The combination "Ctrl+C" can also be used to copy the indicator readings to the clipboard.

The right section of program interface contains three elements: the top one is used to select the measurement channel, the medium one displays signal integral level and the bottom element is used for select ion of averaging interval.

As the mouse pointer is aligned with the top or bottom indicator, it changes its appearance.

Left-click the upper element to activate the drop-down list of the available channels of ZETLAB server (see the example in the Fig. below). To select the channel, left-click it – the channel list will disappear, the title of the window will display the name of the selected channel. The right indicator will display the measurement unit of the new channel. It is also possible to change the title of the program (see the graphic above).

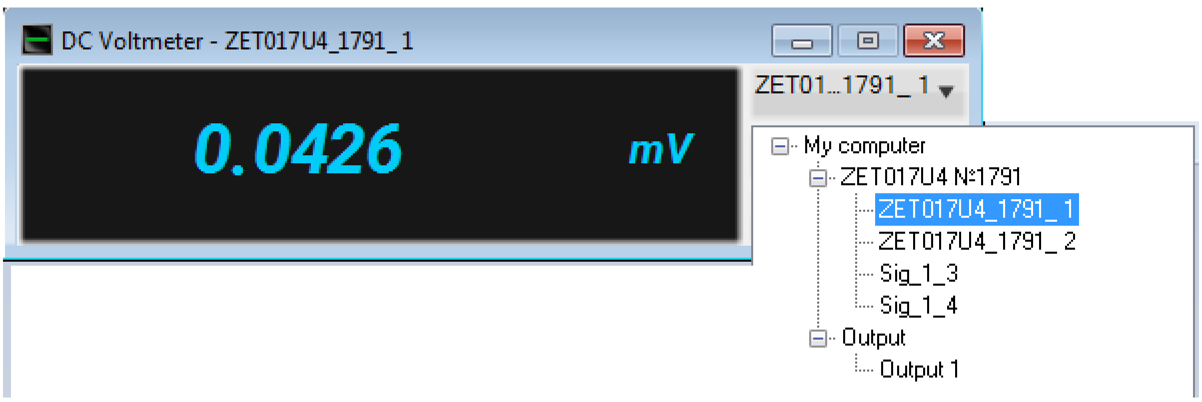
Note:

When the program "DC Voltmeter" is used with a virtual channel (generator channel, or the channel of the program "Formula", "Signals filtration", etc.). It is also possible, that the operator may close the program used for generation of the virtual channel. Thus, as the channel is disabled, the program switches over to the channel substitution mode. In this mode, the program starts operating with a different channel (in most cases, with a channel having "0" number). As the virtual channel appears again, the program switches over to it automatically. If the program that operates in channel substitution mode is closed, the program saves the data of the previously used virtual channel. As the program is started again, it will try to resume operation with this virtual channel. The channel substitution mode is disabled as the operator selects a different channel.

For the projects created in ZetView environment the channel substitution mode is not used. In the case if a channel disabled, the program suspends its operation until the channel is enabled or another channel is selected.

The medium element displays the integral level of the signal. The indication is performed with red color and the width of the highlighted section of the indicator (it may reach up to 2/3 of the indicator field). As the signal level changes from minimal to the maximal, the color of the indication changes from blue to red. The higher is the signal level, the wider is the color section of the indicator. As the maximum admissible level is exceeded, the indicator section becomes completely red. The right section of the indicator remains red until the channel overloading is eliminated and the user left-clicks the indicator.

The bottom element is used for selection of averaging time. Left-clicking this element activates a drop-down list shown in the Fig. below.



The channel selection is performed by right-clicking a particular channel

The active checkbox corresponds to the current averaging time. To change it, left-click the corresponding value of averaging time.

Notifications of the program .....

Notification messages of the program

The program can operate without participation of the operator. The notifications are not displayed as dialog windows – the notifications are saved to the system log, which can be viewed by means of the program ZETLAB Error journal from the "Service" tab of ZETLAB control panel.

The messages recorded by ZETLAB programs to the log have the following format:

"Name of the program No.xx. Text of the message", the name of the program in this case is "**DC Voltmeter**"; xx – the number of the program copy used.

The program records notification messages as well as information of parameters configuration to the system log. The recorded notification messages allow to reproduce the sequence of program operations, which is often useful when it is necessary to analyze program errors. The table below specifies notification messages of the program.

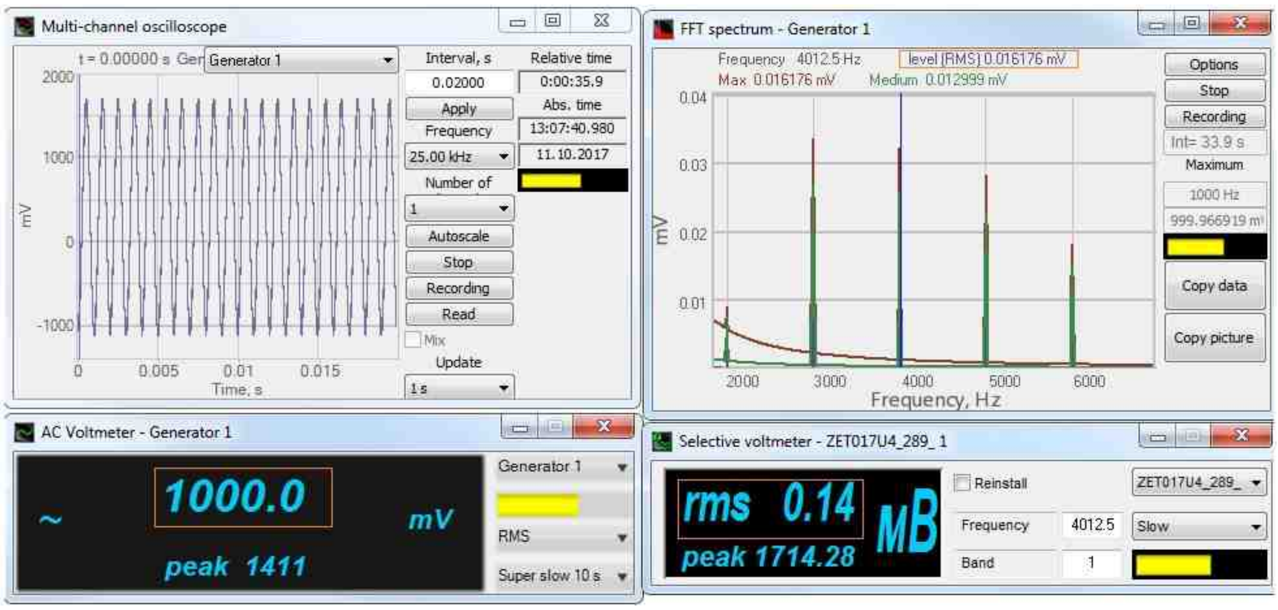
Text of the message	**Category**
Connection to data server: error	error
Error has occurred when reading the data from the register	error
Configuration file in the folder DirConfig is not available	error
Help file downloading error	error
The folder DirSignal is not available	error
The folder DirResult is not available	error
The program is running	message

ADC sampling frequency = xxx.xx Hz	message
Data server operating channels not found. The program will not be started	error
The data server has too many channels. Not enough memory for program operation in the selected mode. The program will be closed	error
Go to channel - Signal x	message
Go to averaging - code x	message
The server does not respond to the queries. The program will be closed	error
The program has completed its operation	message

When the program is running, the notification messages of ZETLAB programs are duplicated with pop-up messages in the system tray (i.e., in the notification area of the instrument panel or in Windows task manager).
The notification message "The data server has too many channels. Not enough memory for program operation in the selected mode. The program will be closed." means that there are too many active programs operating with ZETLAB server, or that the PC used does not have enough RAM volume. In the first case, it is recommended to close some of the programs used and to restart the program. In the second case, it is necessary to use another PC or to increase the RAM volume.

Selective voltmeter program .....

The program "***Selective voltmeter***" is intended for measurement of RMS (True RMS) and peak (peak-to-peak) value of AC voltage at the basic (carrier frequency) of the signal. A special feature of "***Selective voltmeter***" program is that the harmonic components of the signal do not affect the measurement results. Below you can see an example of signal analysis with the use of various programs from the scope of ZETLAB software. The *Oscilloscope* depicts the form of the signal, and the ***FFT Spectrum*** displays operation of frequency filters. DC voltmeter displays RMS of the signal throughout the controlled frequency range. The *Selective voltmeter* displays signal RMS in the controlled frequency band (1±0,01) Hz.



Comparison of ordinary and selective voltmeter

This example clearly illustrates operating principle of selective voltmeter: measurement of signal's RMS within the set frequency range. This allows to conduct accurate measurements in the environment with strong distortions and interference.

Supported Hardware .....

The Selective Voltmeter program is designed to measure the RMS (True RMS) and peak (peak-peak) values of the AC voltage at the main (carrier) frequency of the signal. A feature of the selective voltmeter is the exclusion of the influence of harmonics on the readings.

The following is an example of signal analysis by various ZETLAB programs: the waveform is displayed on the oscilloscope, the FFT Spectrum Analysis program shows responses to a set of frequency filters, on an AC voltmeter - the RMS of the signal in the entire measured frequency range, on a selective voltmeter - the RMS of the signal in the band (1 ± 0.01) Hz.

For the purpose of analog signals digital processing, it is possible to use FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01, noise- and vibration-meters ZET 110 and seismic recorder ZET 048.

Parameters of measurement channels can be set in the program "Device Manager".

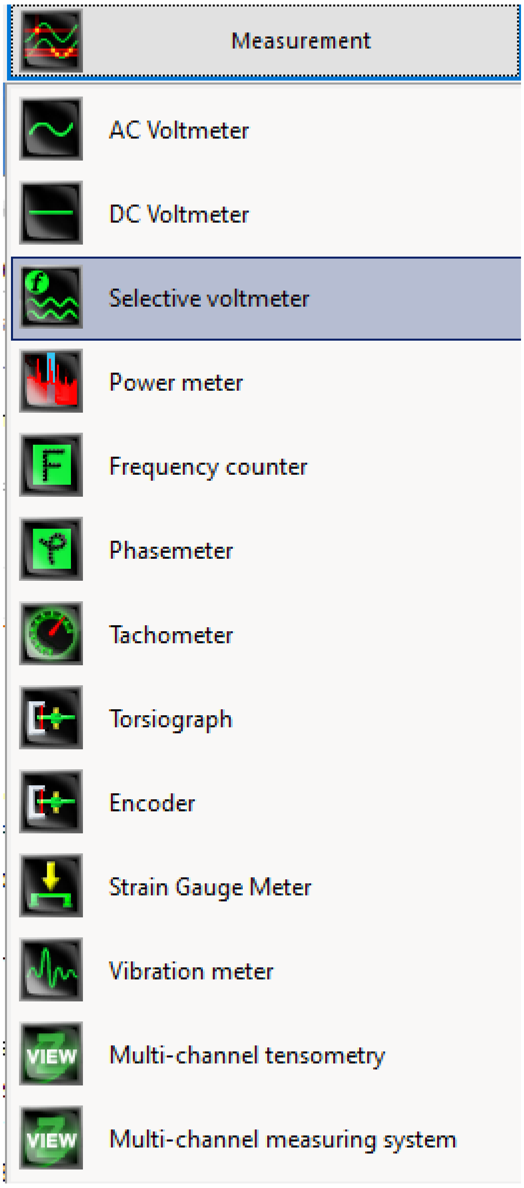
The program "***Selective voltmeter***" is included into the scope of the following software packages:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT spectrum analyzer software
- ZETLAB VIBRO – Shaker controller software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software (option).

Selective voltmeter is included into the **Measurement** software group.

Program description .....

The program **Selective voltmeter** can be started from "***Measurement***" section of *ZETLAB panel*.

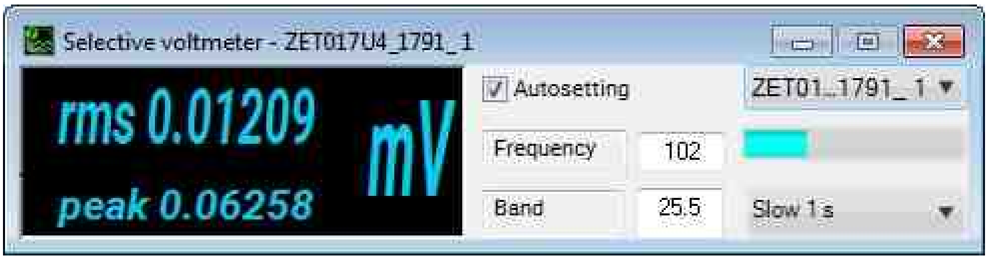


Starting the program Selective voltmeter

Note: the program Selective voltmeter can be started from ZETLAB directory (by default: C:\ZETLAB\).

The name of the file to be started: VoltMeterSel.exe.

The top section of the window displays the name of the program and the name of the channel used for measurements.



The left section of the program interface contains an indicator displaying RMS value (true RMS) and peak value of the selected channel's signal at the carrying frequency with the set filter bandwidth. The measurement units are set in the program *ZET Device manager*.

he checkbox "*Autosetting*" allows to enable /disable automated setting of carrier frequency, and filter bandwidth. When the option "*Autosetting*" is selected, the program automatically sets the carrier frequency and filter bandwidth. The carrier frequency and filter bandwidth are set in Hz. If the option "*Autosetting*" is disabled, the carrier frequency and filter bandwidth are to be set in manual mode.

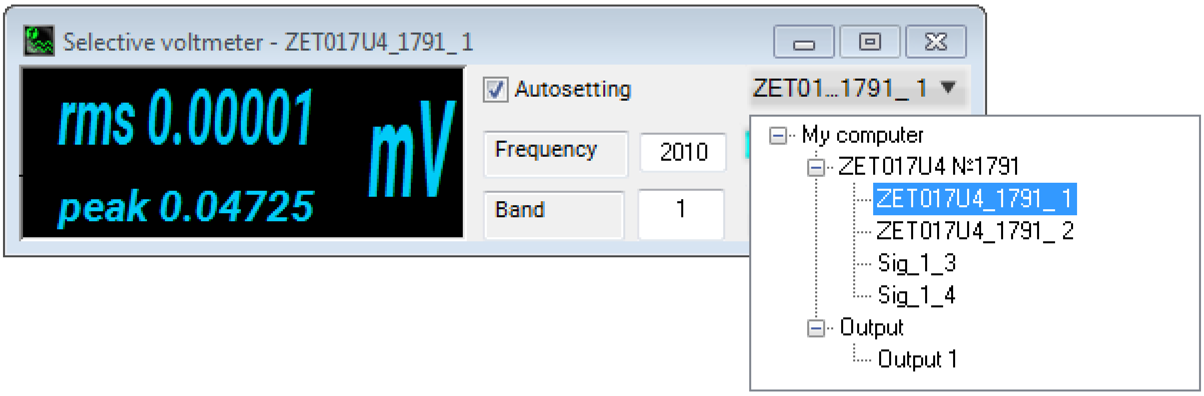
The field to the right from "*Frequency*" section is used for setting the carrier frequency in manual mode. In the case if the "*Autosetting*" option is selected, the same field displays the automatically set carrier frequency. In manual mode, the value of the carrying frequency is entered from the keyboard (left-click the section to enter the frequency value). As the carrier frequency value is set, click <*Enter*> to calculate the RMS value for this frequency.

he field to the right from "*Bandwidth*" section is used for setting the filter bandwidth in manual mode. In the case if the "*Autosetting*" option is selected, the same field displays the automatically set filter bandwidth value. In manual mode, the value of the filter bandwidth is entered from the keyboard (left-click the section to enter the frequency value). As the filter bandwidth value is set, click <*Enter*> to calculate the RMS value for this frequency band.

In order to measure RMS and peak values of a particular physical or virtual channel, select the corresponding channel in the drop-down menu to the right from the "*Autosetting*" section. After that, the graphical indicator will display the signal level in the measurement units, which have been set for this particular channel. There are two ways of selecting a channel:

· click the dropdown menu and select the channel from the list;

· left-click the section and use the scroll wheel or keyboard keys to select the channel.

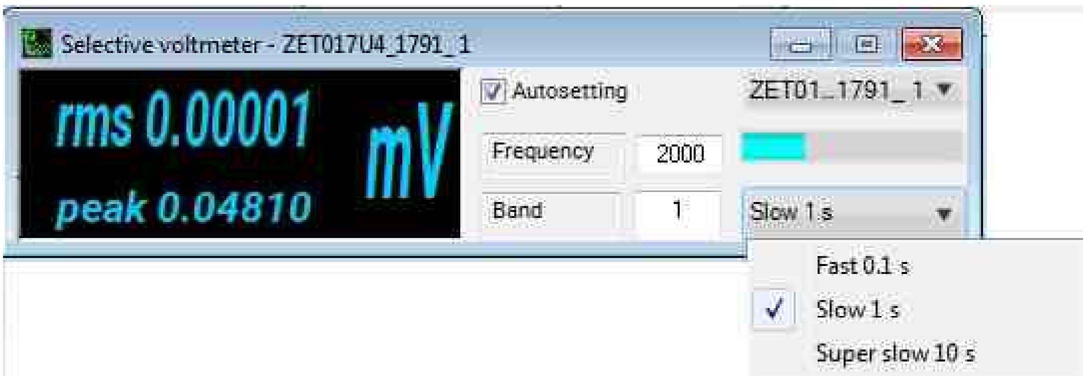


Selective voltmeter - select measurement channel

The drop-down list to the right from the carrier frequency section is used for setting the averaging time. The "*Fast*" option sets the value of 0,1 s. In this case, it is possible to obtain correct RMS for the signal with frequency over 20 Hz. The "*Slow*" option sets the averaging time of 1 second. In this case, it is possible to obtain correct RMS for the signal with frequency over 2 Hz. The "*Super-slow*" option sets the averaging time of 10 second. In this case, it is possible to obtain correct RMS for the signal with frequency over 0,2 Hz. There are two ways of selecting the necessary averaging time:

· left-click the section and select the necessary channel from the drop-down list;

· left-click the section and use the scroll wheel or keyboard keys to select the necessary channel.



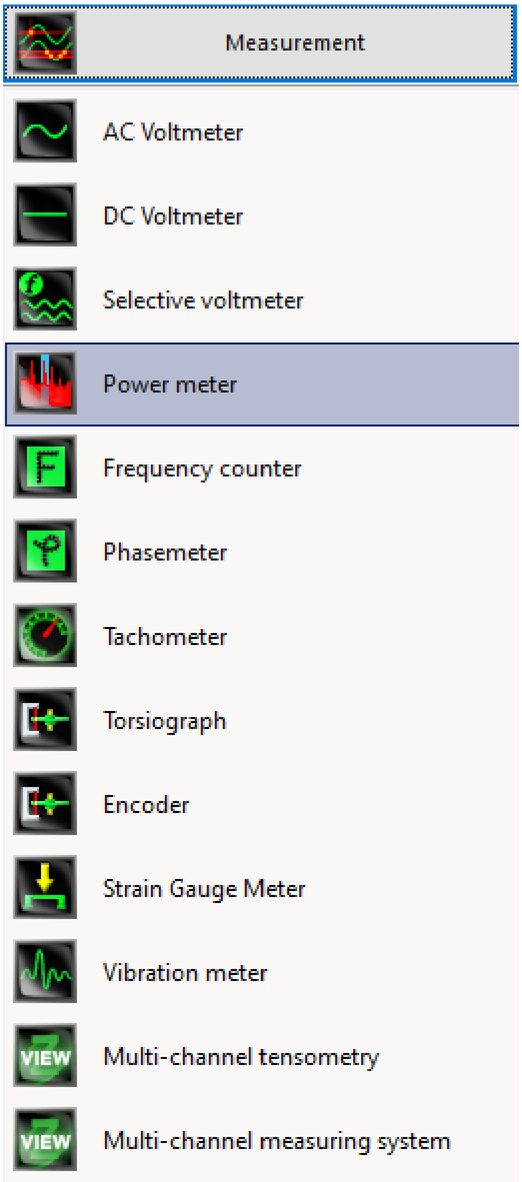
Selective voltmeter - averaging time selection

The indicator "*Integral level*" displays integral level of the signal and channel overloading (in the case if the threshold value is exceeded). 2/3 of the section are used for indication of the signal level that is within the admissible range. The higher is the level, the bigger part of the indicator is used. As the maximum allowable level is exceeded, the indicator becomes red. The right section of the indicator will remain red until the channel overloading is eliminated and the user left-clicks the indicator area.

Power meter .....

Power meter

The program ***Power meter*** is intended for measurement of electrical current power (or electromagnetic signal) applied to the input channels of ADC modules and FFT Spectrum Analyzers. The indicator displays active power (P), full power (S), and reactive power (Q) measured by the selected channels. It is also possible to apply averaging to the displayed value (0,1 s or 1.0 s), to select the required channels of ADC module and the type of data representation.



Power meter program interface

Measured parameters

· **ACTIVE POWER: (W)**

Average value of instant power for the period T is referred to as the power. For single-phase sine current circuits:

P=U·I·cos φ, where U and I — RMS values of voltage and current, φ — phase angle between them

· **REACTIVE POWER: (VAR)**

The value that characterizes the loads occurring in electrotechnical devices and attributed to electromagnetic field energy in sine alternating current circuits, is equal to the product of RMS voltage values U and I, multiplied by sine value of phase shift φ between them: Q=U·I·sin φ, where U and I — RMS values of voltage and current, φ — phase shift between them

· **FULL POWER: (V·A)**

The value that is equal to the product of periodical current value I (in the circuit) and U (at the contacts): S=U·I, where U and I — RMS values of voltage and current

Supported Hardware .....

The source data of the program "***Power meter***" is represented by digital data from ZETLAB data server channels. The server data is represented by digitized random alternating signal. By alternating signal, we mean a signal, instant values of which have dependence on time parameter.

For the purpose of analog signals digital processing, it is possible to use FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01, noise- and vibration-meters ZET 110 and seismic recorder ZET 048.

Parameters of measurement channels can be set in the program "Device Manager".

Program ***Power meter*** is included into the following software packages:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT spectrum analyzer software
- ZETLAB VIBRO – Shaker controller software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,

Power meter is included into the **Measurement** software group.

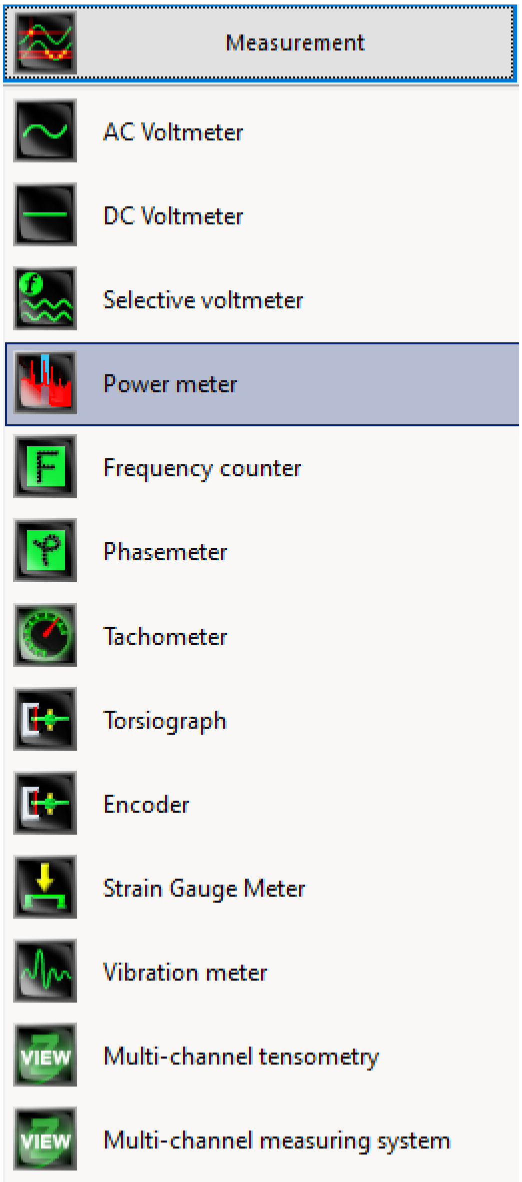
Program description .....

Functions of the program

The program "***Power meter***" is intended for evaluation of electrical current or electromagnetic signal.

The program "***Power meter***" can be started from "*Measurement*" section of *ZETLAB control panel*.

Note: the program can be started from ZETLAB directory (by default: C:\ZETLab\). The name of the file to be started: WattMeter.exe.



Starting the program Power meter

Program description.

To start the program "***Power meter***", select the corresponding option from the "*Measurement*" section of ZETLAB panel (see the Fig. "Starting the program "***Power meter***"). As the program is started, there appears the window of the "***Power meter***" program. The title of the program displays the name of the program and the name of the channels used for power measurements.

Power meter.

The program "***Power meter***" is intended for evaluation of the current power (and electromagnetic signal) applied to the input channels of ADC modules and FFT Spectrum Analyzers. The indicator displays active power (P), full power (S), and reactance power (Q) measured by the selected channels. It is also possible to set averaging interval of the displayed value (0,1 or 1.0 s), select the channels of ADC modules and data display type.

Active power: (W);

Active power – is the average value of instant power values for the period T, also referred to as the power. For single-phase sine current:

$P=U \cdot I \cdot \cos\varphi$

, where U and I – the RMS values of voltage and current

φ — phase angle between them.

Reactance power: (var);

Reactance power is a value that characterizes the load of electrotechnical devices, which is attributed to oscillation of electromagnetic field in sine alternating current circuits. It is equal to the product of RMS voltage values U and I multiplied by phase angle φ between them:

$Q = U \cdot I \cdot \sin\varphi$

, where U and I are the RMS values of voltage and current

φ — phase angle between them.

Full power: (V· A);

Full power is a value equal to the product of periodical current value I in the circuit and U voltage at the contacts:

$$S = U \cdot I$$

, where U and I – the RMS values of voltage and current.

Program description.

The left section of the program "***Power meter***" contains graphical indicator displaying the values of active power (P), full power (S), and reactive power (Q) of the selected channels in corresponding measurement units.

To set the averaging interval, left-click the averaging time switch and select the required value from the dropdown list.

To change the data representation type, left-click the switch and select the required data display type from the dropdown list (*View 1* or *View 2*).

Indicator "***Integral level***" displays the signal level and channel overloading (in the case if the set threshold value is exceeded). 2/3 of the indicator area display the signal level, that is within the allowable range. The higher is the level, the bigger part of the indicator is filled with color. As the maximal allowable limit is exceeded, the indicator will be completely filled with red color. The right section of the indicator will remain red until the channel overloading is eliminated and the user left-clicks the indicator. To exit the program, use the corresponding icon in the top right section of the program interface.

Frequency counter .....

The program "***Frequency counter***" is used for measurement of frequency of the signal applied to the input channels of ADC modules and FFT Spectrum Analyzers.

The indicator displays the measured frequency value (frequencies of periodical oscillations) and the time period of the signal, corresponding to a particular frequency. It is also possible to set the averaging time (0,1; 1 or 10 s), to select the required channel of ADC module or a virtual channel.

Note:

The *Frequency counter* can be used for measurements in the range from 0,5 Hz up to 50 kHz (depending on the sampling frequency of the device).

Supported Hardware .....

The source data of the program "**Frequency counter**" is represented by digital data of ZETLAB data server channels. This data is represented by digital alternating random signal. By alternating signal in this case there is meant a signal, instant values of which depend on the time parameter.

For the purpose of analog signals digital processing, it is possible to use FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01, noise- and vibration-meters ZET 110 and seismic recorder ZET 048.

Parameters of measurement channels can be set in the program "Device Manager".

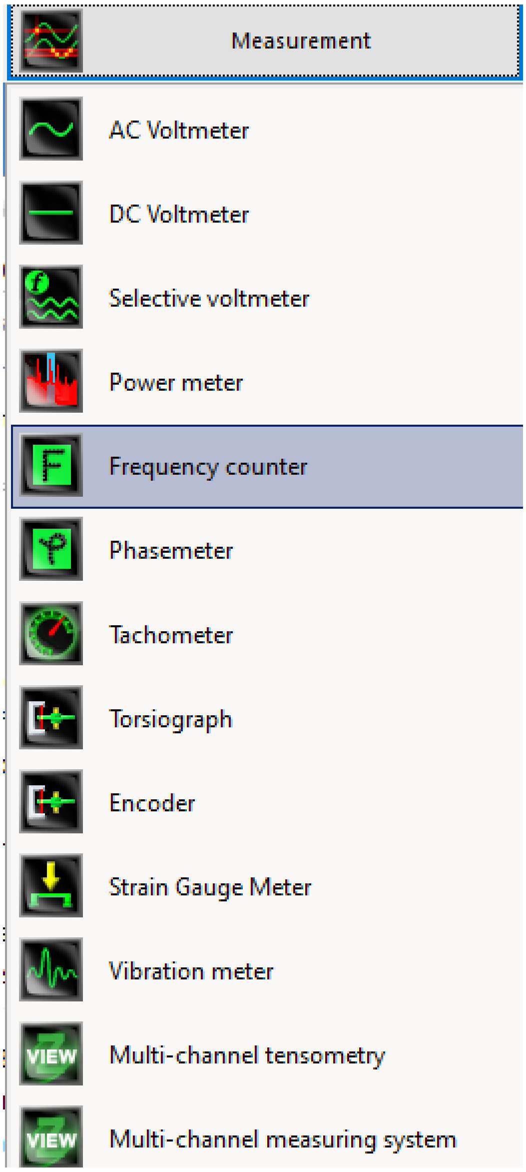
The program "Frequency counter" is included into the scope of the following software packages:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT spectrum analyzer software
- ZETLAB VIBRO – Shaker controller software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software (option).

Frequency counter is included into the **Measurement** software group.

Program description .....

The program "***Frequency counter***" is started from "***Measurement***" section of ZETLAB control panel.



Starting the program Frequency counter

Note: the program "Frequency counter" can also be started from ZETLAB directory (the directory by default: C:\ZETLAB\). The name of the file to be started: FreqMeter.exe.

The title of the window displays the name of the program and the name of the channel selected for measurements performance.

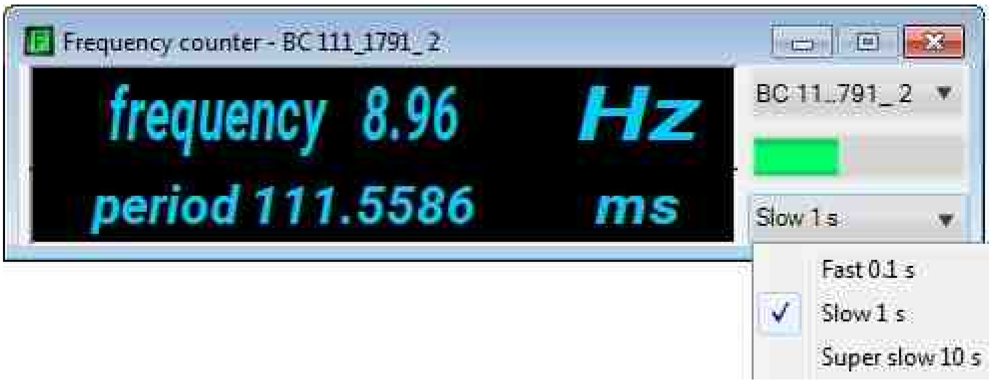
Frequency counter - program interface

The left section of the "Frequency counter" interface contains a digital indicator displaying signal frequency and signal period duration of the selected channel. The frequency is displayed in Hz, the duration – in ms.

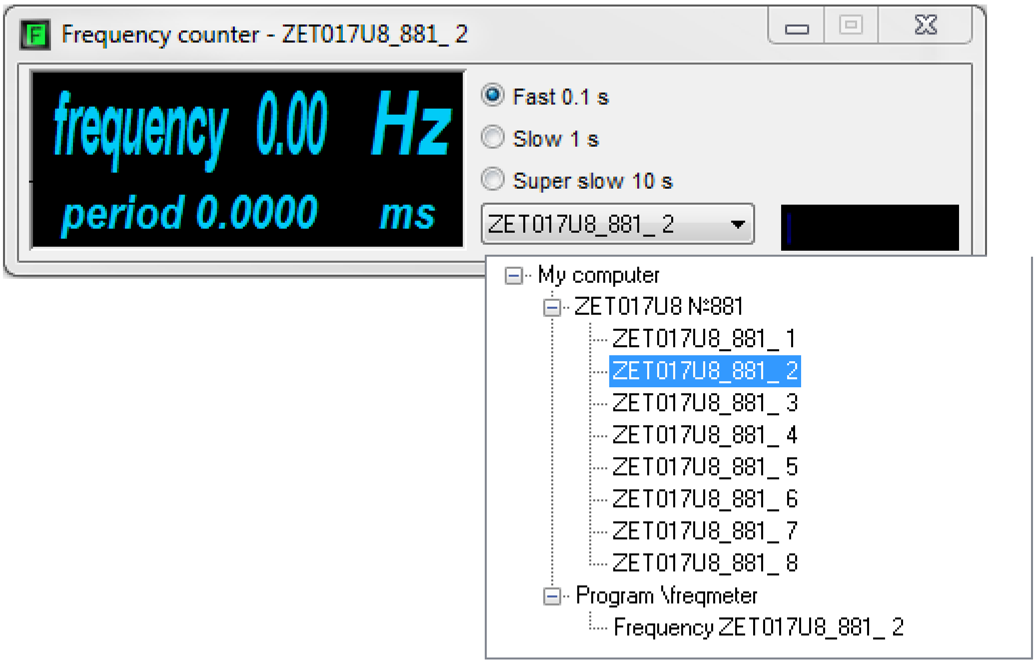
To set the averaging period, left-click the corresponding switch. The option "Fast 0,1 s" sets the averaging time of 0,1 s (accurate measurements of frequency and period duration are only possible for a signal with the frequency >20 Hz). The option "Slow 1 s" sets the averaging time of 1 s (accurate measurements of frequency and period duration are only possible for a signal with the frequency >2 Hz). The option "Super-slow 10 s" sets the averaging time of 10 s (accurate measurements of frequency and period duration are only possible for a signal with the frequency >0,2 Hz).

In order to measure frequency and period duration of physical or virtual channel, select the corresponding channel from the drop-down list. The are two ways of selecting the required channels:

· click the corresponding section and select the channel from the drop-down list;
· left-click the corresponding section and select the channel using the scroll wheel or keyboard keys.



Frequency counter - averaging time selection



Frequency counter - measurement channel selection.

The indicator "Integral level" displays the integral level of the signal and the overloading of the channel in the case if the maximum admissible level of the signal is exceeded. 2/3 of the indicator section are used for the signal level, that is within the acceptable level. The higher is the level, the bigger section of the indicator is filled with color indication. As the maximal admissible level is exceeded, the indicator is completely filled with red color. The right section of the indicator will remain red until the channel overloading is eliminated and the user left-clicks the indicator section.

Phasemeter program .....

The **Phasometer program** is designed to measure the phase difference of two signals entering the input channels of spectrum analyzers. The current value of the phase difference in degrees is displayed in the upper line of the indicator, and the phase difference in radians is displayed in the lower line. It is possible to change the averaging of the displayed value (0.1 or 1 s) and select the necessary channels of spectrum analyzers.

Supported Hardware .....

The source data of the ***Phasemeter*** program is represented by digital channels of ZETLAB data server.

The program ***Phasemeter*** is included into the scope of the following software packages:

For the purpose of analog signals digital processing, it is possible to use FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01, noise- and vibration-meters ZET 110 and seismic recorder ZET 048.

The measuring channels parameters of the program are set in the program "Device Manager".

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT spectrum analyzer software
- ZETLAB VIBRO – Shaker controller software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software.

Phasemeter is included into the **Measurement** software group.

It is necessary to bear in mind the following aspects:

1. ADC/DAC modules use FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01, noise- and seismic recorder ZET 048. have a single integrated ADC/DAC converter, that is used for digital processing of all the connected channels. Multichannel multiplexer enables connection of module input channels to the input of ADC circuit. In order to measure the phase difference using ADC/DAC

module with compensation of phase delay between the channels, one can use the program *Phasemeter* in *SCADA ZETVIEW environment*.

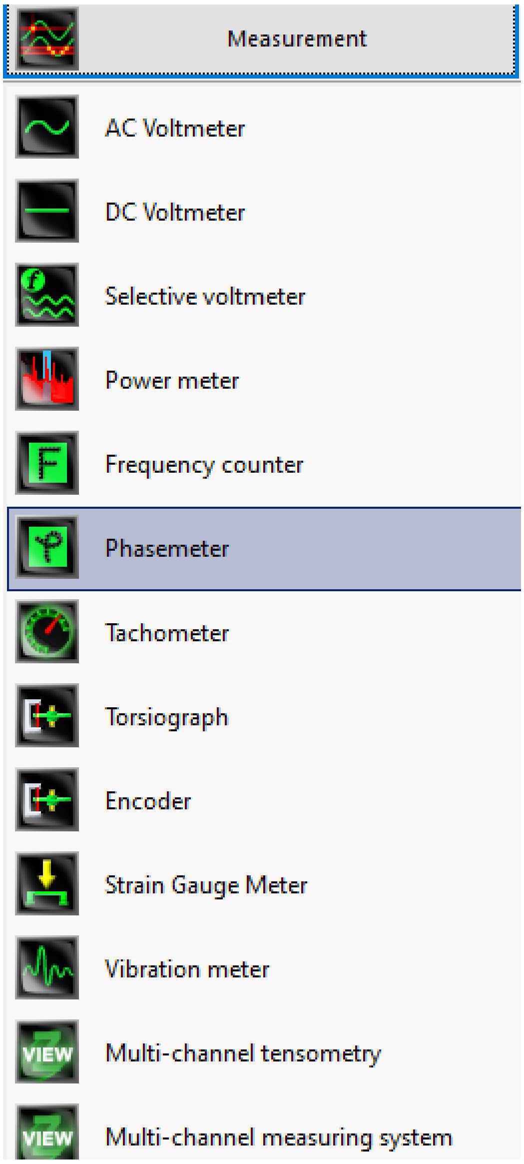
2. Noise- and vibration meters ZET 110 have a single measurement channel and are not used for measurement of the phase difference.

3. Synchronous operation of intelligent transducers of *ZETSENSOR* series is possible only for measuring networks with CAN interface.

4. In order to measure the phase difference of the signals applied to the input channels of several instruments of the same type (e.g., to the remote seismic recorders of a distributed network), it is necessary to implement synchronization of the instruments.

Program description .....

The program ***Phasemeter*** can be started from "***Measurement***" section of ZETLAB panel.



Starting the program Phasemeter

Note: the program ***Phasemeter*** can be started from ZETLAB directory (the directory by default: C:\ZETLAB\). The name of the file to be started: Phasemeter.exe.

The title of the window depicts the name of the program and the names of the two channels used for measurements of the phase difference.

Phasemeter program interface

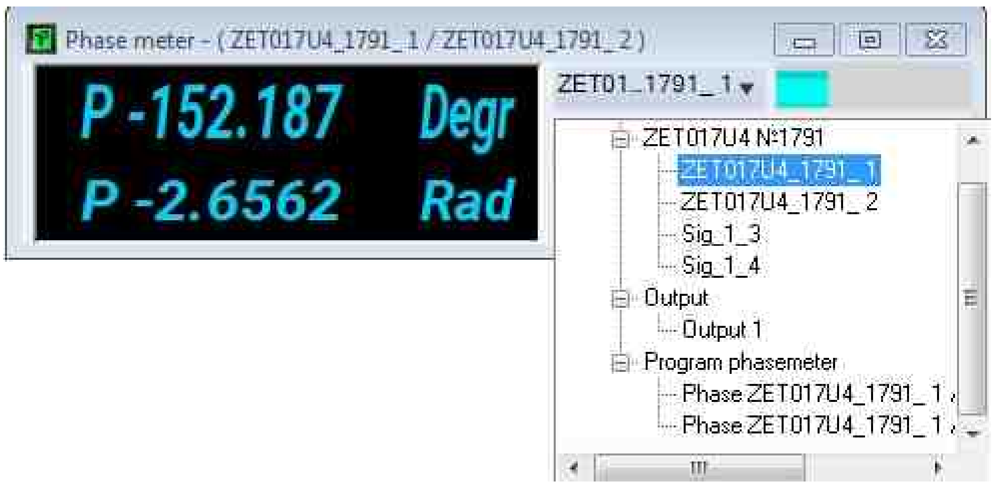
The left section of the program interface contains a graphical indicator displaying the value of the phase difference of the two signals of the selected channels. The phase is displayed in degrees and radians.

In order to set the averaging interval, left-click the corresponding menu. The option "*Fast 0,1 s*" sets the averaging period of 0,1 s – in this case, accurate measurement of the phase is possible for signals with the frequency value > 20 Hz. The option "*Slow 1 s*" sets the averaging period of 1 s – in this case, accurate measurement of the phase is possible for signals with the frequency value > 2 Hz.

In order to measure the phase difference of two channels (physical or virtual), select the names of these channels in the drop-down lists. There are two ways of selecting the channel:

· left-click the corresponding key and select the channel from the drop-down list;

· left-click the corresponding section and use the scroll wheel or keyboard keys to select the channel.



Phasemeter - measurement channel selection

Phasemeter - averaging time selection

The indicator "*Integral level*" displays the integral level of the controlled signal and channel overloading (in the case if the set threshold value is exceeded). Each of the selected channels has a separate indicator located to the right from the channels list. 2/3 of the indicator section are used for displaying of the signal that is within the admissible level. The higher is the level, the bigger part of the indicator is filled with color. As the threshold value is exceeded, the indicator fills with red color completely. The right section of the indicator remains red until the channel overloading is eliminated and the user left-clicks the indicator section.

Tachometer .....

The program "***Tachometer***" is intended for measurement of rotation frequency of various mechanisms as well as for calculation of complete rotations number.

For complex mechanisms, e.g., for gearboxes, it is necessary to set the gear ratio value.

The parameters of tachometer's signal are quite useful for diagnostics and research of internal combustion engines and various rotary mechanisms (turbines, compressors, pumps, fans, etc.).

For research, diagnostics and balancing of various rotary mechanisms there is used the program "***Synchronous accumulation***".

For research and diagnostics of non-stationary processes there is used the program "***Angular displacement indicator***".

When the program "***Multi-channel oscilloscope***" is used in the mode of displaying the signal frequency, the user can obtain the RPM value (frequency*60=RPM). Based on the graphic parameter, it is possible to obtain the values of acceleration and deceleration time of the engine. These parameters also allow to evaluate the damping of the system for the purpose of further analysis.

If the mechanism operates with stable rotation frequency, then the graphic can be used for the analysis of the following factors:

· RPM governor operation (maintenance of the set rpm level) when a power consumer is connected or set;

· evaluation of rotation unevenness at constant load (especially for internal combustion engines).

The instant values of angular velocity can be used for evaluation of shaft rotary oscillations in radians or degrees.

Measurement of instant velocity values difference (at two cross-sections of the shaft) allows to evaluate twist angle of the shaft (constant or alternating) and to calculate such parameters as shaft tension and mechanism power.

Note:

The "***Tachometer***" program conducts measurements in the range from 0,5 RPS up to 1500 RPS, or from 30 RPM up to 100000 RPM (depending on the sampling frequency of the device).

Supported Hardware .....

The source data of the **Tachometer** program is represented by digital channels of ZETLAB data server. As a rule, optical or inductive transducers (e.g., BC 401) are used for rotation frequency measurements. Parameters of measurement channels (transducer parameters) are set in the program ZET device manager.

The program is intended for PC use. The PC configuration should comply with the characteristics, specified in the clause "Hardware requirements" of the present manual. The PC should also have ZETLAB software installed. It is also necessary to connect ADC to the PC (the ADC should be compatible with ZETLAB software).

The source data of the "***Tachometer***" program is represented by digital data of ZETLAB data server channel.

For the purpose of analog signals digital processing, it is possible to use FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01, noise- and vibration-meters ZET 110 and seismic recorder ZET 048.

The measuring channels parameters of the program are set in the program "Device Manager".

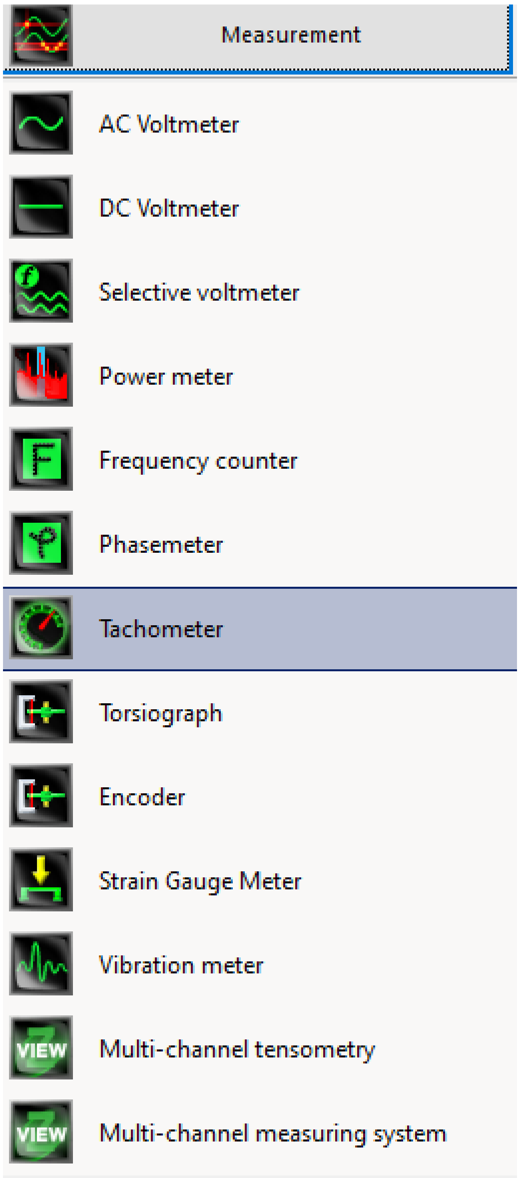
The program "***Tachometer***" is included into the scope of the following software packages:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT spectrum analyzer software
- ZETLAB VIBRO – Shaker controllers software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software (option).

Tachometer is included into the **Measurement** software group.

Program description .....

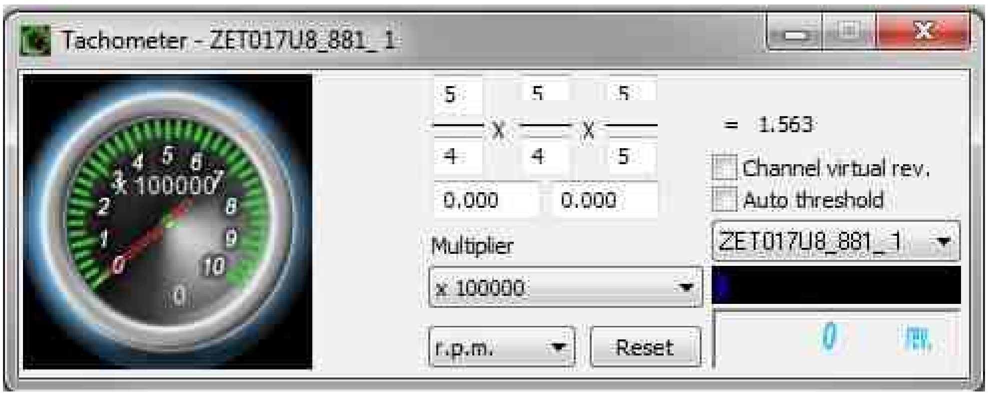
The program "***Tachometer***" can be started from "***Measurement***" section of ZETLAB panel.



Starting the program Tachometer

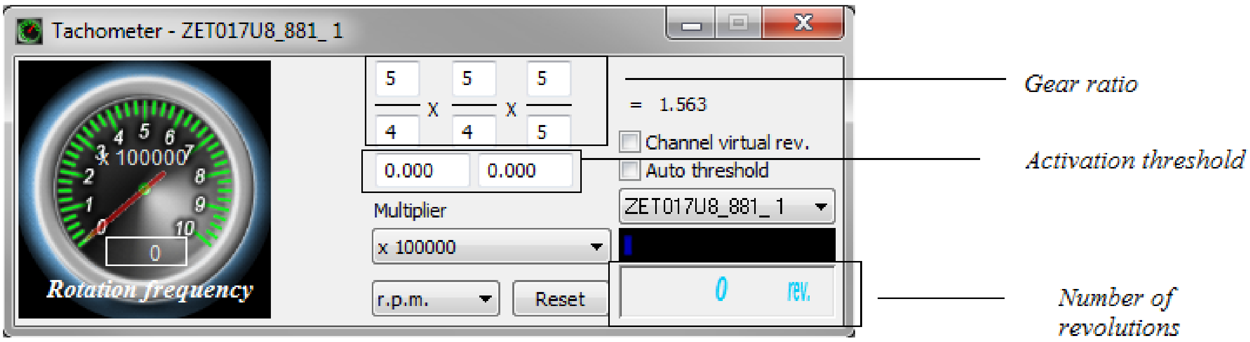
Note: the program "***Tachometer***" can also be started from ZETLAB directory (the directory by default: C:\ZETLAB\). The name of the file to be started: TahoMeter.exe.

The title of the window displays the name of the program and the names of the channels, the phase difference between which is to be measured.



Tachometer program interface

The left section of the program "***Tachometer***" contains graphical indicator displaying the rotation frequency. In the right section of the program interface, you can see the control elements: gear ratio, threshold values, multiplier, measurement units, generation of virtual channel, list of measurement channels, key for reset of rotation number, indicator of total rotations number.



Tachometer - indicators layout

There are two ways of selecting parameters from the list:

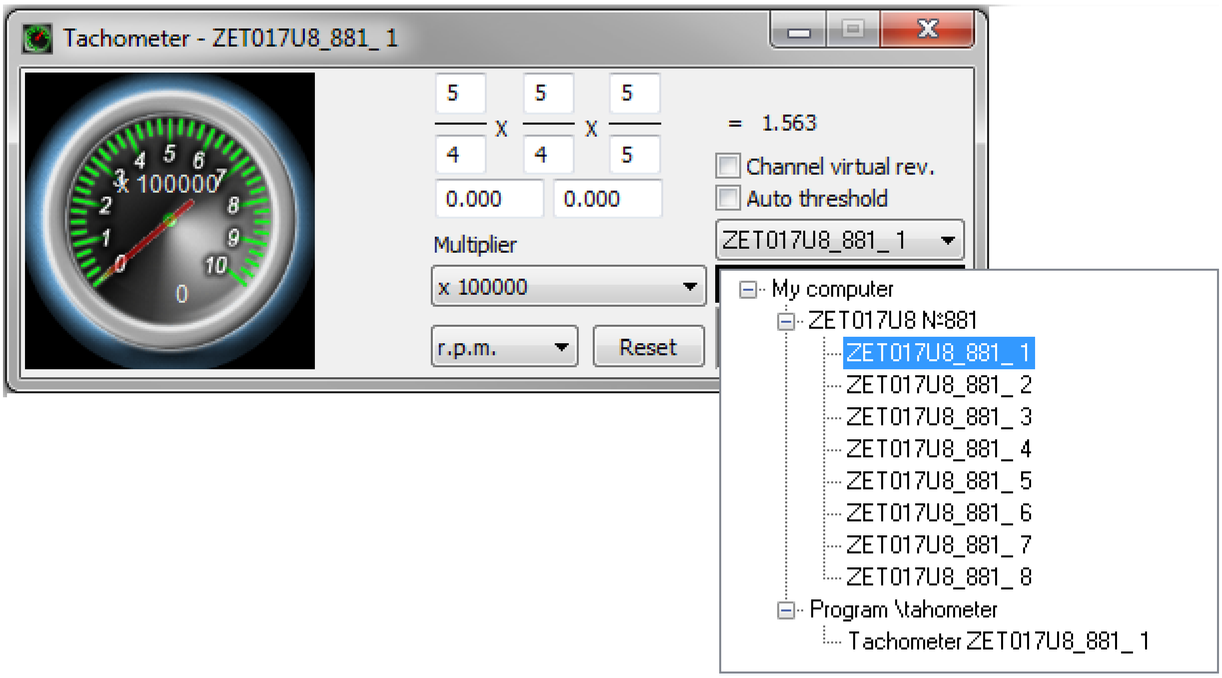
· left-click the section and select the required parameter from the drop-down menu;

· left-click the section and select the required parameter using scroll wheel or keyboard keys.

The keyboard is used for entering the value to the input boxes.

Measurement channel

The measurement channel is selected from the list:



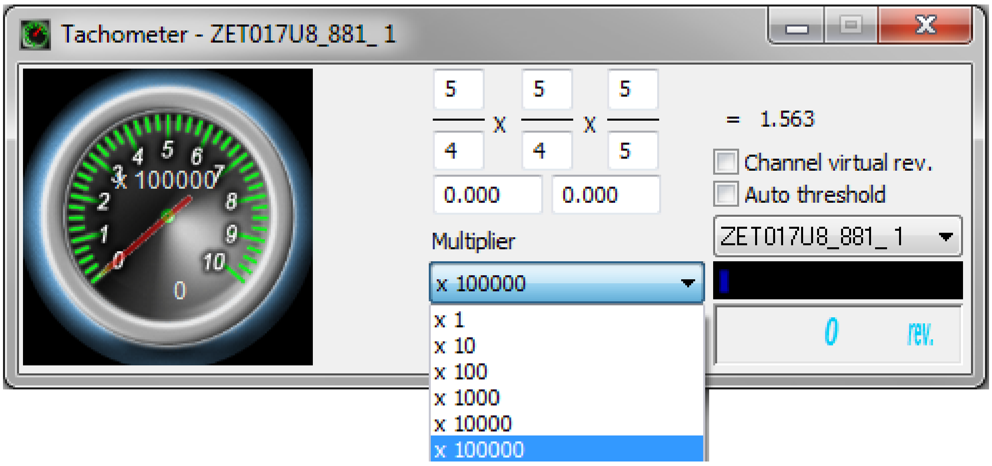
Tachometer program - measurement channel selection

If it is necessary, the user can implement filtration or any other preliminary processing of the signal prior to using the program "***Tachometer***". Such programs as "***Signal filtration***" are used to create virtual channels.

Below the section used for selection of measurement channel, you can see the indicator if integral level. The indicator displays the integral level of the signal and overloading of the selected channel (in the case if the threshold value is exceeded). 2/3 of the indicator section are used for displaying the signal level that is within the acceptable limit. As the set threshold level of the signal is exceeded, the indicator section is filled with red color. The right section of the indicator remains red until the channel overloading is eliminated and the user left-clicks the indicator.

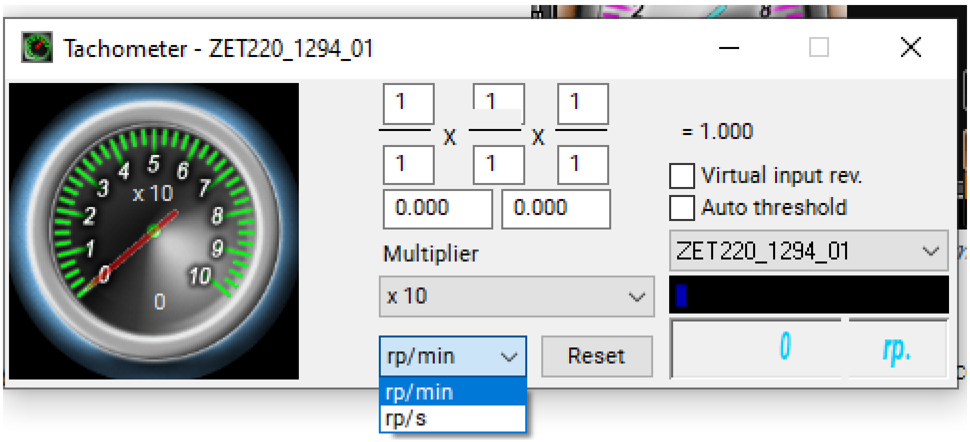
Results indication

The dial gauge displays the ratio, which is selected in the "***Multiplier***" section. The bottom part of the indicator displays the rotation frequency value without the ratio.



Tachometer program - dial gauge multiplier selection

The rotation frequency is displayed in RPM or RPS. The measurement units are selected from the list:



Tachometer program - measurement units selection

The number of full rotations is displayed at the indicator located in the right bottom section of the program interface. To the left from the rotation number indicator you can see the "***Reset***" key allowing to set to the zero the number of rotations.

Generation of the results

The "***Tachometer***" program generates a signal of rotation frequency in the selected measurement units (RPS or RPM). The virtual channel has the name "***Tachometer – The name of the channel***".
In order to generate a signal of rotations number, select the check-box "V***irtual input rotations***.". The virtual channel has the name "***Tachometer of rotations – Name of the channel***".

Activation thresholds

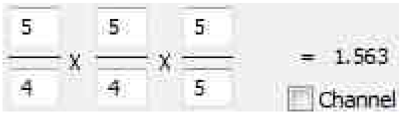
The checkbox "***Auto threshold***" allows to enable/disable automated/manual adjustment of upper and bottom threshold of input signal level used for rotation velocity measurements. When the checkbox is active, the program automatically sets upper and bottom threshold levels of the signal.

The input boxes located to the right from "***Auto threshold***" option are used for setting upper and bottom threshold values (when the "***Auto threshold***" option is disabled). The top section is used for setting the upper threshold, the one below allows to set the bottom threshold. Upper and bottom threshold values are entered from the keyboard. As the value is set, click <**Enter**> key. When the option "***Auto threshold***" is active, the input boxes of top and bottom values will not be available. The top and bottom thresholds are used to exclude false activation of the program in the course of rotation frequency measurements. For accurate measurements performance, the maximal level of the signal should not exceed the top threshold value of the channel and the minimal level of the signal should not be below the bottom threshold. In order to evaluate the minimal and the maximal levels of the signals of the channel with RPM transducer connected to it, one can use the program "***Multi-channel oscilloscope***" (open the corresponding channel in the program to determine the values of these levels).

Gear ratio

The Fig. below displays a section of tachometer program with input boxes (3 columns with 2 input boxes each) indicating the number of teeth in the gear (as a driving gear we shall consider the rotating gear with

RPM transducer attached to it), and the number of driven gears. The number of gear teeth for the input box is from 1 up to 99. The values are entered with a keyboard. As the value is entered, use <***Enter***> key or left-click another input box to include the new value into calculations. To the right from the input boxes there is a section displaying the calculated gear ratio.



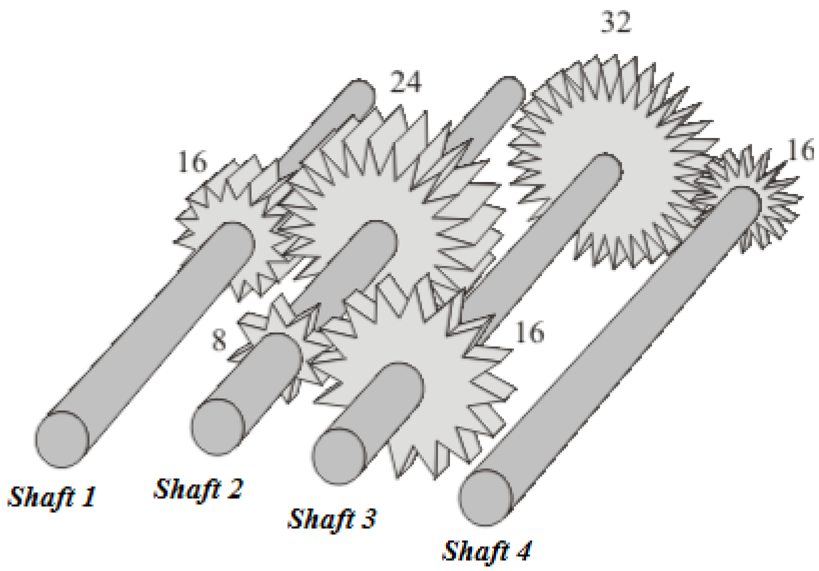
Tachometer program - gear ratio calculation section

If it is necessary to measure the rotation velocity of rotating mechanisms with access for mounting of RPM transducers, then the user should specify identical values in all the sections displaying the number of gear teeth. In this case, the gear ratio will be "1", and the graphical indicator will display the rotation velocity and the number of rotations of the rotary mechanism (at which the RPM transducer is mounted).

In the case of complex kinematic systems, where it is possible to attach the rpm transducer only to one of the rotary mechanisms, while it is necessary to measure the rotation frequency at the other rotary element of the system, then, knowing the number of gear teeth and gears, the user can set corresponding number of teeth in the program. The gear ratio will be calculated in accordance with the set number of gear teeth. The graphical indicator will display the rotation frequency and the number of full rotations of the controlled mechanism. Below you can see examples of measuring the rotation velocity of a mechanism, where it is impossible to install the RPM transducer.

Examples .....

The Fig. below shows a kinematic scheme displaying the algorithm of filling the gear teeth numbers. Each shaft in scheme has a number. The Fig. next to the number displays the number of corresponding gear cogs.



Tachometer program - kinematic scheme

1. The RPM transducer is mounted on the shaft 1 (it shall be considered to be the driving gear, since the transducer is mounted on it). It is necessary to measure rotation velocity at the shaft number 3. Hence, the user has to enter the following number of gear teeth in the input boxes:

· enter "16" in the numerator of the first column, the number of teeth of the driving gear – "1";

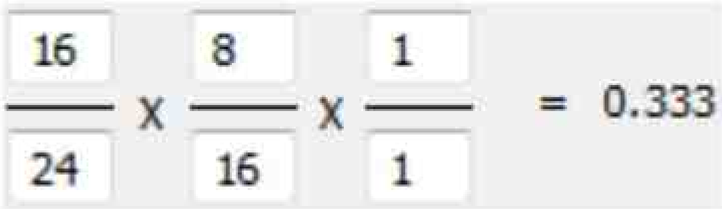
· enter "24" in the nominator of the first column, the number of teeth of the driven gear – "2" (relation of driven gear to the shaft is "1");

· enter "8" in the numerator of the second column, the number of teeth of the driving gear – "2" (relation of driving gear to the shaft is "3");

· enter "16" in the denominator of the second column, the number of teeth of the driving gear – "16" (relation of driven gear to the shaft is "2");

· nominator and denominator of the third column contain identical values.

The Fig. below shows input boxes for gear teeth number and the field of gear ratio with corresponding values.



Tachometer program - gear ratio calculation

As the required values are entered, the graphical display will depict the calculated value of rotation frequency and the number of full rotations – "3".

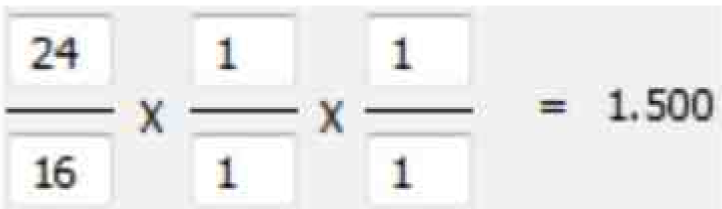
2. The RPM transducer is mounted on the shaft#2 (it is a driving shaft, since the transducer is mounted on it). Hence, we should set the following numbers of gear teeth:

· set "24" in the numerator of the first column, the number of gear teeth of the driving shaft – "2";

· set "16" in the nominator of the first column, the number of gear teeth of the driven shaft – "1" (the relation of driven gear to the shaft is "2");

· set identical values for numerator and nominator of the third column.

The Fig. below shows the input boxes of the program with the set values of gear teeth units and gear ratio for this example.



Tachometer program - gear ratio calculation

As the necessary values are set, the graphical indicator will display the calculated value of the rotation velocity and number of full rotations – "1".

3. The RPM transducer is mounted on the shaft #4 (it shall be considered to be the driving one, since the transducer is attached to it). It is necessary to measure the rotation velocity of the shaft#1. Hence, it is necessary to set the following values of gear teeth:

· set "16" in the numerator of the first column, the number of the gear teeth of the driving shaft – "4";

· set "32" in the nominator of the first column, the number of the gear teeth of the driven shaft – "3" (relation of driven gear to the shaft is "4");

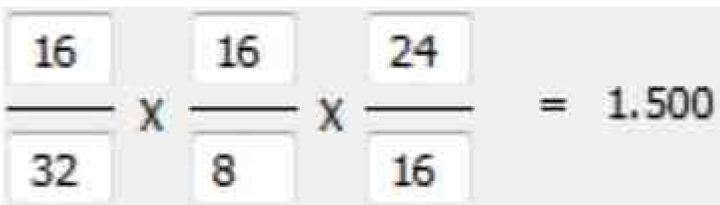
· set "16" in the numerator of the second column, the number of gear teeth of the driving shaft – "3" (relation of driving gear to the shaft is "2");

· set "8 " in the nominator of the second column, the number of gear teeth of the driven shaft is "2" (the relation of the driven gear to the shaft is "3");

· set "24" in the numerator of the third column, the amount of the gear teeth of the driving shaft – "2" (relation of the driving gear to the shaft is "1");

· set "16" in the nominator of the third column, the number of gear teeth of the driven shaft is "1" (relation of driven gear to the shaft is "2").

The Fig. below shows the input boxes for the gear teeth numbers with the values specified in this example.



Tachometer program - gear ratio calculation

As the required values are set in the program, the graphical indicator will display the calculated value of rotational velocity and the number of full rotations of the shaft#1.

Torsiograph .....

The program "***Torsiograph***" is intended for measurement of rotation unevenness of rotary parts of various mechanisms. The program "***Torsiograph***" creates virtual channel of displacement and displacement velocity. These channels can be analyzed using the other programs from the scope of ZETLAB software package (e.g., the measurement data can be displayed in the program "***Multi-channel oscilloscope***").

Supported Hardware .....

The source data of the program ***"Torsiograph"*** is represented by digital data of ZETLAB server channels.

The program is intended for PC use. Parameters of the PC should comply with the characteristics specified in the clause ***"***Hardware requirements***"*** of the present user manual. The PC should also have ZETLAB software installed. It is also necessary to connect ADC to the PC (the ADC should be compatible with ZETLAB Software).

For the purpose of analog signals digital processing, it is possible to use FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01, noise- and vibration-meters ZET 110 and seismic recorder ZET 048.

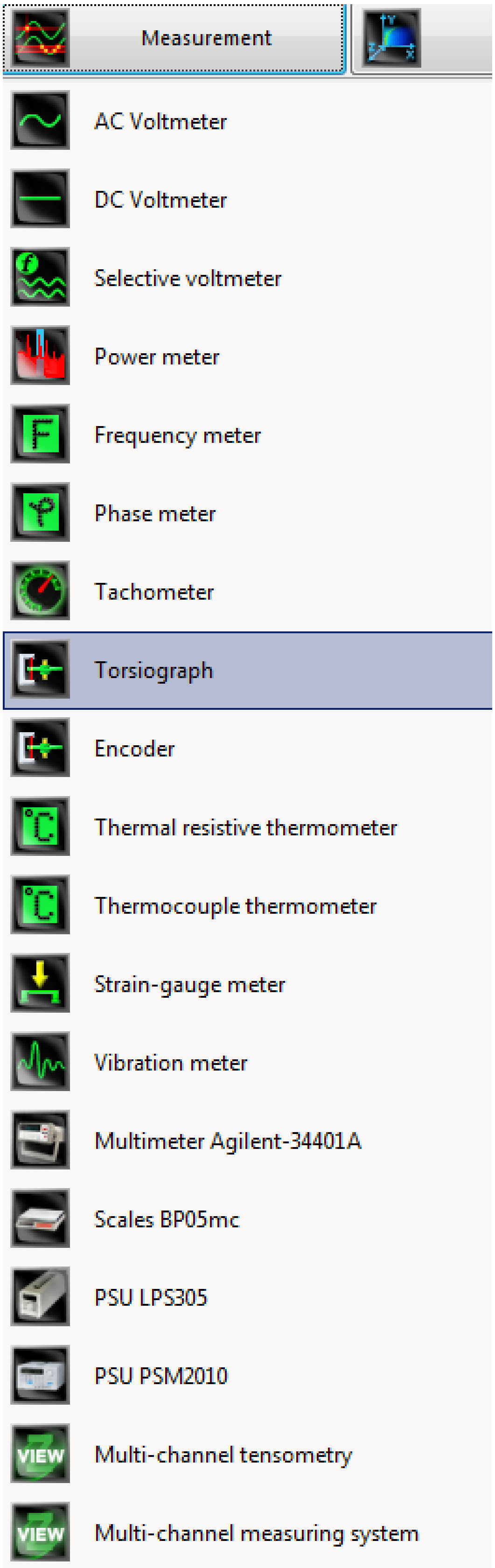
The measuring channels parameters of the program are set in the program "Device Manager".

- ZETLAB ANALIZ – FFT spectrum analyzer software
- ZETLAB VIBRO – Shaker controller software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,

The program "***Torsiograph***" is included into the scope of the following software groups:

Program description .....

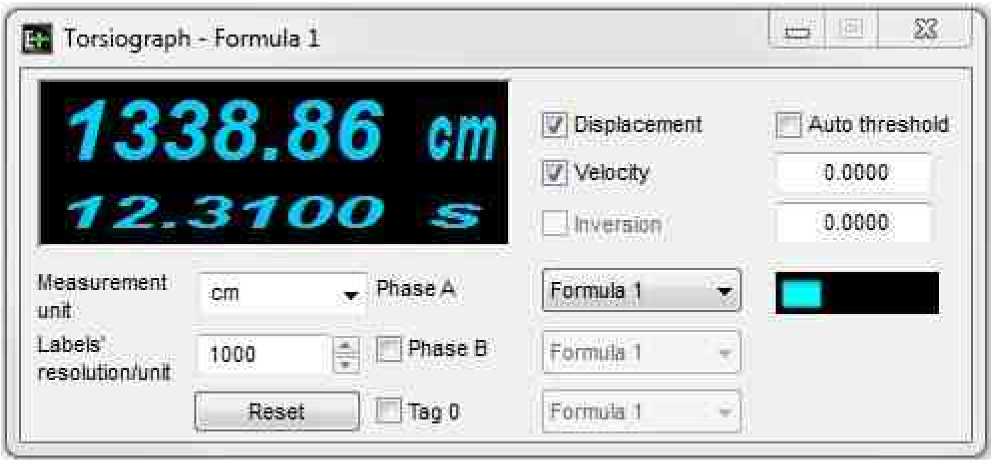
The program "***Torsiograph***" can be started from "***Measurement***" menu of ZETLAB control panel.



Starting the program "Torsiograph"

Note: the program "***Torsiograph***" can be started from ZETLAB directory (by default: C:\ZETLAB\). The name of the file to be started: Torsiographic.exe.

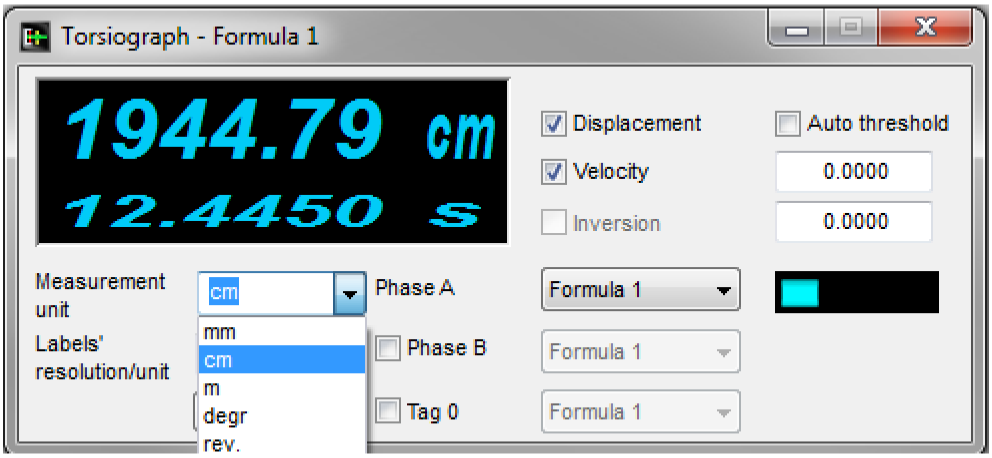
The title of the program window displays the name of the program and the name of measurement channel.



"Torsiograph" program interface

The left section of the "***Torsiograph***" program window contains graphical indicator displaying the values of angular or linear displacement (position) and displacement speed. This information is accumulated from the selected channel(s). Depending on the task to be solved, the displacement value can be measured in various measurement units; and the displacement speed is measured in measurement units per second. E.g., to measure the displacement value in millimeters, it is necessary to select corresponding unit in the menu "***Measurement unit***". As the measurement value is set, the displacement value will be displayed in *mm*, and the displacement speed – in *mm/s*.

The menu to the right from the "***Measurement unit***" section allows to select the measurement unit to be used for the signal of the selected channel (the user can select the measurement unit from the list, or enter it from the keyboard). To select the measurement unit, left-click the menu, and choose the required measurement unit from the drop-down list. In the case, if the drop-down list does not contain the required measurement unit, left-click the text area and enter the required measurement unit from the keyboard.



"Torsiograph" program - measurement unit selection

Resolution of the torsiographic is determined by the amount of impulses per revolution (ppr). In the field to the right from the title "***Label's resolution/unit***" the user can select the required amount of labels for the set measurement unit. E.g., the torsiographic has 1080 labels per one revolution, which means 3 labels per degree. It is necessary to control the position of the transducer in degrees with accuracy up to one degree. To do this, select "***degr***" option in the menu "***Measurement unit***" and set "3" in the menu "***Label's resolution/unit***" (i.e., 3 labels per one degree of transducer's rotation). The required resolution value is set with arrow keys or using the scroll wheel. It is also possible to set the required value from the keyboard (to apply the new parameter, click <***Enter***> key). Under the section "***Label's resolution/unit***" there is the "***Reset***" key, which is used to set to zero the value of displacement (position).

The check-boxes "***Displacement***" and "***Velocity***" located to the right from the graphical display, are used to enable/disable the virtual channels of "***Displacement***" and "***Velocity***", created by the program "***Torsiograph***". These channels can be analyzed by other programs from the scope of ZETLAB Software. The check-boxes are used to enable/ disable the virtual channels.

The "***Inversion***" option becomes available as the option "***Phase B***" is selected. It allows to invert the displacement signal direction.

The measurement channel can be selected from the list to the right from "***Phase A***" option.

To use the channel "***B***", select the corresponding option and choose the required physical channel from the list to the right from the checkbox. As the option "***Phase B***" is unchecked, the list of channels and "***Inversion***" option become unavailable.

If it is necessary to calculate absolute position, activate the option "***Label 0***". In the list of available channels, select the required physical channel, to which the zero channel of the torsiographic is connected. Every time as the transducer passes the zero mark, the graphical indicator sets to zero the measured displacement value. It is convenient for the control of linear displacement accompanied by piston-wise motion. By setting the zero label in the middle of the controlled object, it becomes possible to measure the displacement in both directions from the label.

The option "***Auto threshold***" is used to enable / disable automated / manual setting of upper and bottom threshold of the input signal level, which is to be used for displacement measurements. When this option is active, the program automatically sets the upper and bottom threshold of the signal level. As this option is disabled, the top and bottom threshold values of the signal level are to be set manually.

The input boxes located under the section "***Auto threshold***" are used for entering the signal threshold level in manual mode (when the option "***Auto threshold***" is disabled). The upper section is used to set the top threshold value, the section below allows to set the bottom threshold. As the value is set, click <***Enter***> key. As the option "***Auto threshold***" is enabled, the input sections of top and bottom threshold levels become unavailable. The upper and bottom threshold levels are set in order to eliminate false activations in the course of displacement measurements. In order to secure accurate measurements results, the upper threshold value should not exceed the maximal level of the signal, and the bottom level should be more than the minimal level of the signal. It is possible to evaluate the maximal and the minimal signal level of the channel, to which the recorder is connected, with the use of the program "***Multi-channel oscilloscope***". Start the program, connect to the required channel, and evaluate the maximal and minimal signal levels using the oscilloscope graphic.

The indicator "***Integral level***" displays integral level of the signal and the channel overloading (in the case if the set threshold value is exceeded). As the options "***Phase B***" and "***Label 0***" are enabled/disabled, the corresponding indicators are displayed or hidden. 2/3 of the indicator section are used for displaying of the signal, that is within the admissible level. The higher is the signal level, the bigger section of the indicator is filled with color. As the maximal threshold level of the signal is exceeded, the indicator becomes completely red. The right section of the indicator will remain red until the overloading is eliminated and the user left-clicks the indicator section.

Encoder .....

Encoder

The program "**Encoder**" is used for measurement of relative position (displacement), velocity, and displacement direction evaluation by means of optical transducers of angular and linear displacement (encoders), connected to the input channels of ADC. The program "**Encoder**" creates virtual displacement channels of displacement and displacement velocity. These channels are available for further analysis with the use of other programs from the scope of ZETLAB software package.

Functions of the program "*Encoder*"

· **Measurement of displacement unevenness and velocity**

The program "**Encoder**" can create virtual channels (velocity and displacement signals) for further analysis in other programs from the scope of ZETLAB software package. For instance, these channels can be viewed in the program "**Multi-channel oscilloscope**". The data of virtual channel is displayed in real-time mode of each impulse processing without averaging. It allows to control displacement, displacement velocity as well as displacement unevenness. If the encoders are used with other transducers (e.g., with pressure or temperature transducers), then the pressure and temperature data together with encoders data are accumulated synchronously with each impulse of the encoder.

· **Calculation of absolute position**

As the zero label of the encoder is connected to the channel of the measurement instrument, the program allows to calculate absolute position. Every time as the zero label is passed, the graphical indicator of the measured displacement value is set to zero. It is convenient for measurements of linear displacement accompanied by piston-wise displacement. By setting the label into central position, it is possible to measure the displacement value in both directions from the set zero label.

· **Torsional oscillations analysis**

When the program "**Encoder**" is used together with the programs from the scope of ZETLAB software package and angular displacement transducers, it is possible to perform analysis of torsional oscillations and to use these instruments instead of torsiographs.

Program description of the program *"Encoder"*

The indicator of the "**Encoder**" program displays the measured values of angular and linear displacement (position) and displacement velocity. Depending on the task to be solved, the displacement is measured in various measurement units and the displacement velocity is displayed in measuring units per second.
The resolution of incremental encoders is determined by the amount of impulses per single revolution (ppr). The program allows to select the required amount of labels for a particular measurement unit. For instance, the incremental encoder has 1080 labels per single revolution, i.e., approximately 3 labels per single rotation degree. It is necessary to measure the encoder position with the precision up to one degree.

To do that, select the measurement unit – degrees (degr), and set "3" in the section "**Label's resolution/unit**" (i.e., 3 labels per a single degree of the encoder's revolution).

The program "**Encoder**" allows to set upper and bottom threshold values of the signal (in manual or automated mode). Upper and bottom threshold levels are set in order to exclude false activations in the course of displacement measurement. It is possible to evaluate maximal and minimal signal level of the channel with the connected recorder by means of "**Multi-channel oscilloscope**" program. Start the program "**Multi-channel oscilloscope**", select the channel, and evaluate the signal level using the oscilloscope graphic.
The program also has a graphical indicator displaying the integral level of the signal and channel overloading (in the case if the set threshold level is exceeded).

Supported Hardware .....

The source information of the program "**Encoder**" is represented by digital data of ZETLAB data server channels. This data consists of output signals of linear and angular displacement transducers.

The program "**Encoder**" is intended for PC use. The PC parameters should comply with the characteristics specified in the clause "Hardware requirements" of the present user manual. The PC should have ZETLAB software installed. It is also necessary to connect ADC to the PC (the ADC should be compatible with ZETLAB software).

For the purpose of analog signals digital processing, it is possible to use FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01, noise- and vibration-meters ZET 110 and seismic recorder ZET 048.

The measuring channels parameters of the program are set in the program "Device Manager".

The program "**Encoder**" is included into the scope of the following software packages:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT spectrum analyzer software
- ZETLAB VIBRO – Shaker controller software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,

Encoder is included into the **Measurement** software group.

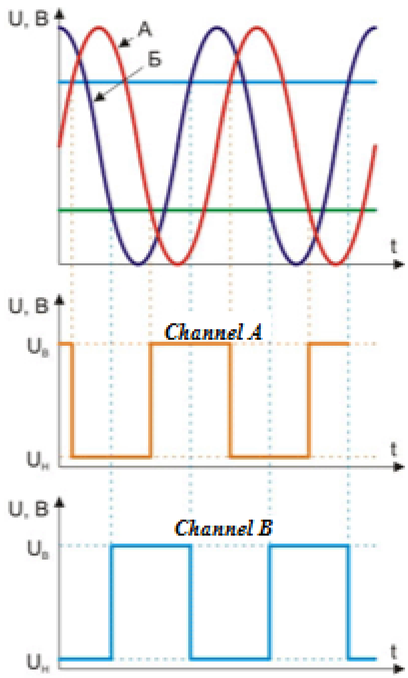
Connection of the transducers .....

The program "**Encoder**" is intended for operations with the channels represented by output channels of linear and angular displacement transducers.

Linear and angular displacement transducers are based on optical sensors. Accuracy of these transducers is from 1 μm up to 1 mm (the gauge length is from 8 mm up to 3 m). Angular displacement transducers may have from 100 up to 10000 labels per revolution, i.e. the resolution value is from several degrees up to 5 minutes.

Optical technologies offer several standard ways of creating an encoder – a transducer controlling motion, location or direction in digital format (absolute encoders), or as a sequence of impulses (incremental encoders).

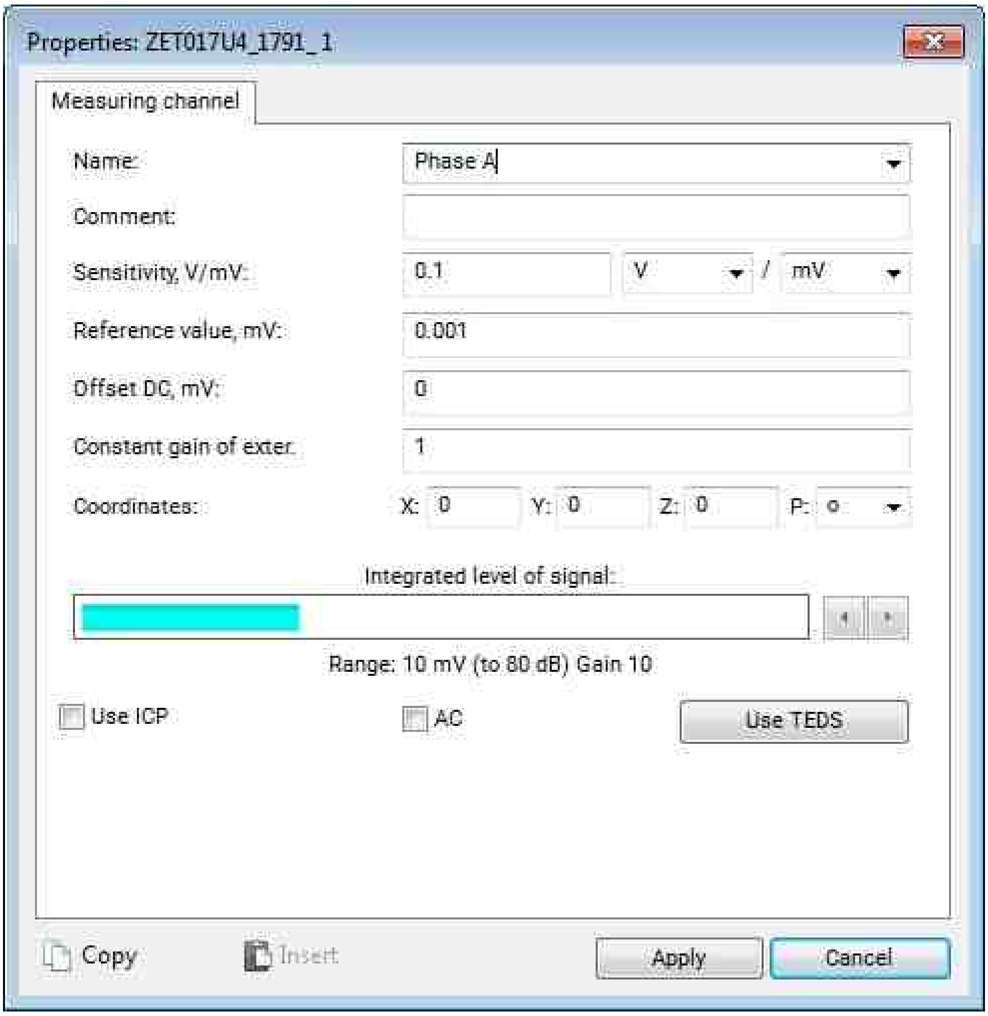
Further description of "**Encoder**" program is to deal with incremental encoders, since the program "**Encoder**" is intended for operations with this particular type of the transducers. Program description of incremental encoders are shown in the Fig.s below. Optical encoder consists of a thin optical disk or a stationary module – a measuring probe including light source and a photo-cell. The optical disk contains a surface with transparent and non-transparent areas. The labels may be represented by openings in metal foil or by markings at the glass disk. As the disk rotates, the labels transmit or block the beam of light (depending on the type of the disk) coming from the light source to the photo-sensor.



Encoder - Channel A, Channel B

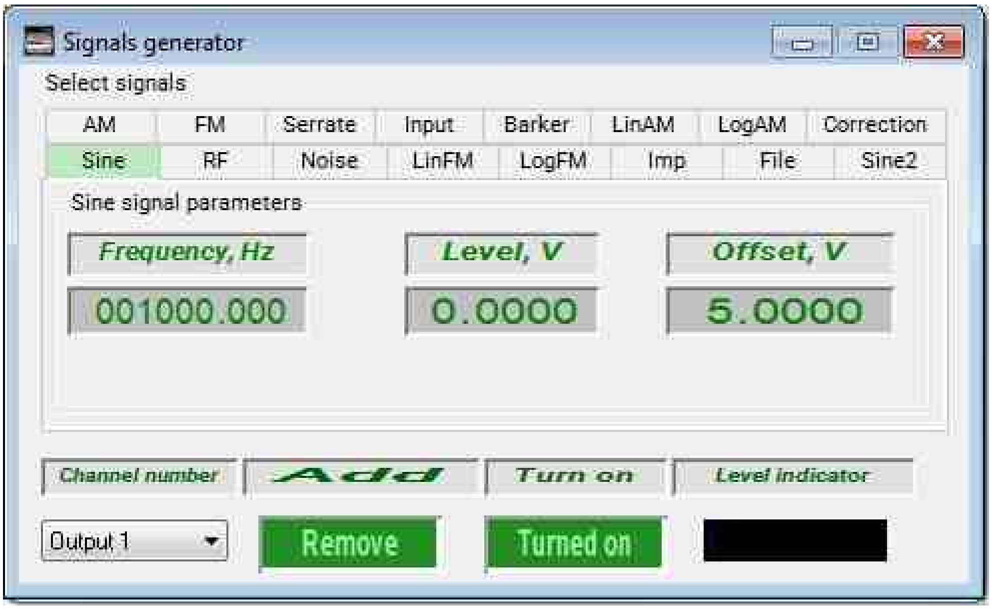
The photo-cell generates a signal with a frequency level equal to that of the code elements. The signal can be produced in digital or analog format (the analog signal can be further amplified and undergo digital processing). If we add another pair of LED and photo-cell with angular displacement in relation to the first pair (1/4 of the signal period), then it is possible to obtain a second sequence of impulses – channel B (having phase displacement of 90° in relation to the channel A). Incremental encoder using two optical channels allows to duplicate the resolution of location and velocity evaluation and to determine the direction. The third channel is used as a reference of the zero label (label "0").

In order to measure displacement (location) and displacement velocity, it is necessary to set the channels parameters, to which the recorder is connected, in the program ZET Device manager. The measurement channels parameters should be set in relation to the voltage measurements as it is shown in the Fig. below (the names of the channels can be set arbitrary by the user):



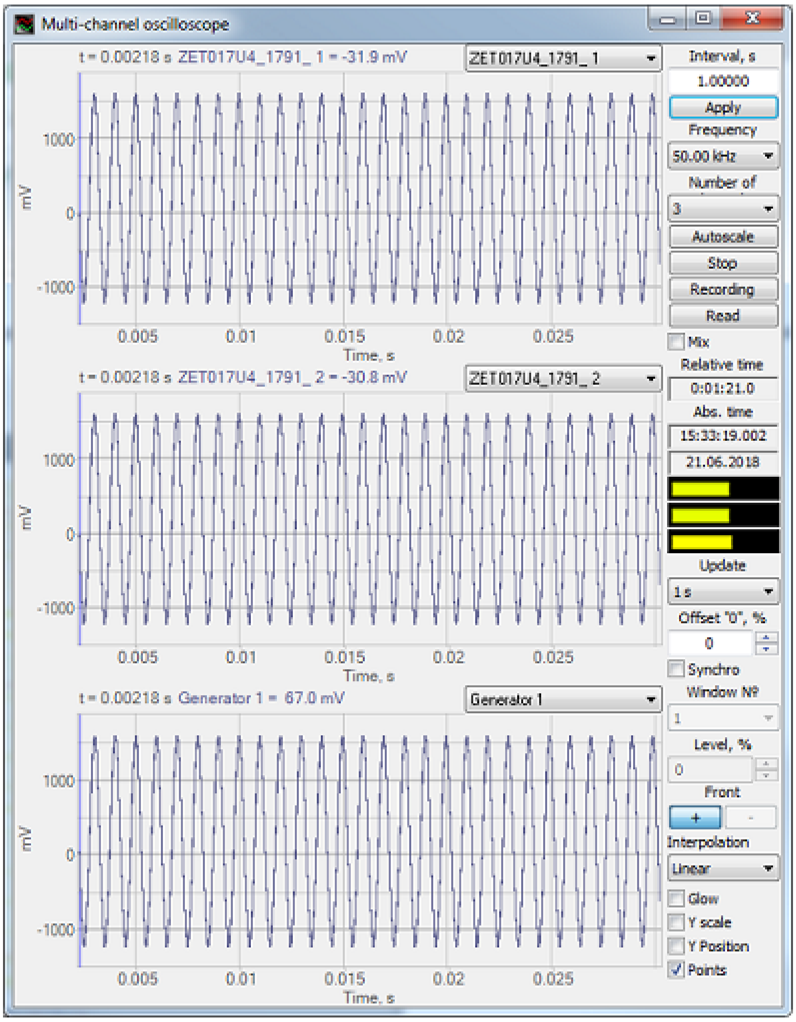
Encoder - Properties - Phase A

For power supply of the transducers it is possible to use the output of the integrated generator (if it is available) in the mode of sine signal generation (see the Fig.) with constant zero shift of 5 V, or an external 5 V power supply module.



Encoder - Generator parameters configuration for power supply of the transducers

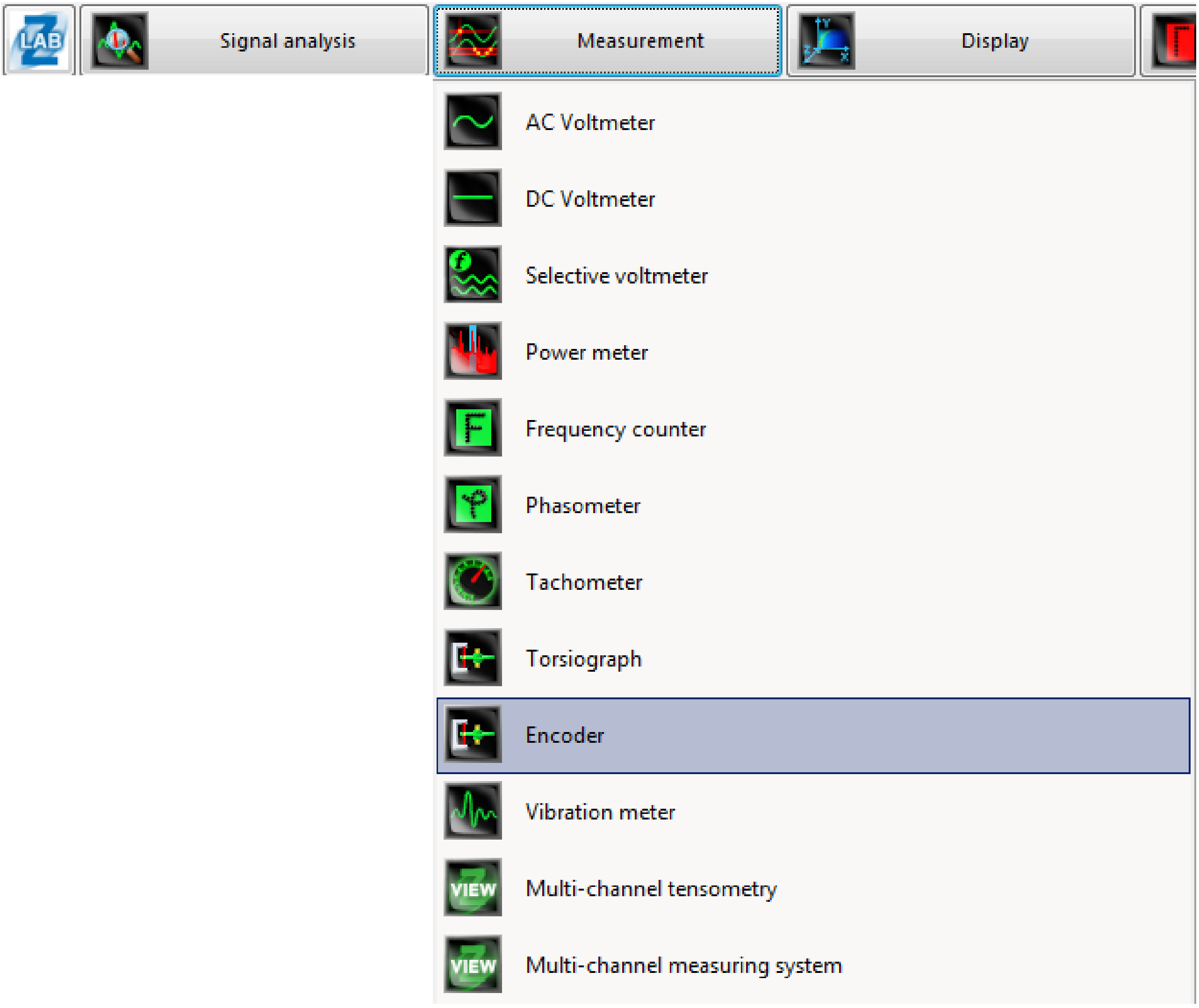
The Fig. below shows oscilloscope graphics of the signals received from angular displacement transducer. The upper oscilloscope graphic shows the signal of channel A (phase A), the central Fig. depicts channel B (phase B), the third Fig. shows the signal of zero label (label 0).



Encoder- signal analysis - three channels

Program description .....

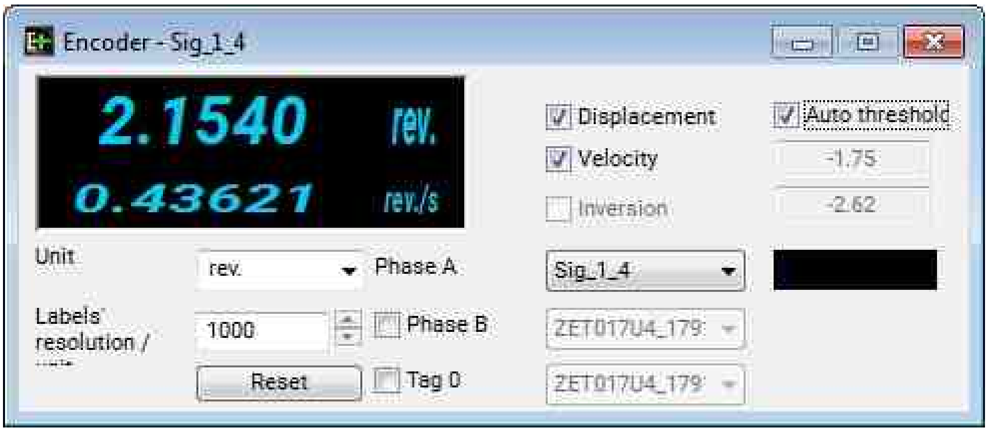
The program "***Encoder***" can be started from "***Measurement***" section of ZETLAB control panel.



Starting the program Encoder

Note: the program "***Encoder***" can be started from ZETLAB directory (the directory by default: C:\ZETLAB\). The name of the file to be started: Encoder.exe.

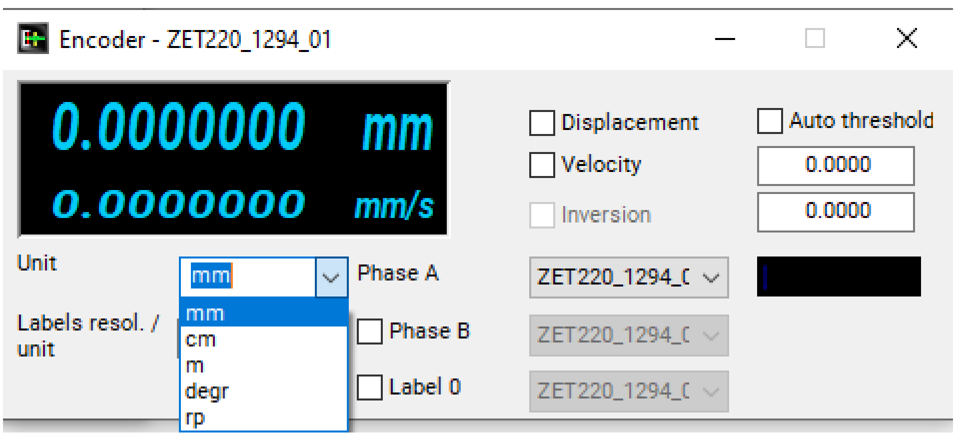
The title of the program window contains the name of the program and the name of measurement channel.



Encoder program interface

The left section of "***Encoder***" program interface contains a graphical indicator displaying the values of angular or linear displacement (position) and displacement velocity, information of which is acquired from the selected channel(-s). Depending on the task to be solved, the displacement is measured in the specified measurement units. The displacement velocity is measured in corresponding measurement units per second. In order to measure the displacement value in millimeters, select "mm" in the menu "***Measurement unit***" (the menu is described below). Then the displacement value will be displayed in mm, and the displacement velocity in mm/s.

The list to the right from the "***Measurement unit***" section allows to select the measurement unit (the measurement unit can be selected in the menu or entered from the keyboard) to be used for the signal of the selected channel. If the list does not contain the required measurement unit, right-click the input box and enter the value from the keyboard.



Encoder program - measurement unit selection

The resolution of incremental encoders is determined by the number of impulses per one revolution (ppr). The list to the right from the section "***Label's resolution/unit***" allows to select the required number of labels for the set measurement unit. For instance, incremental encoder of angular displacement has 1080 labels per one revolution, i.e., 3 labels per one degree. It is necessary to measure the position of the encoder with accuracy up to one degree. To do that, select the measurement unit – degrees (dgr.), and set "3" in the menu "***Label's resolution/unit***" (3 labels per one degree of encoder's revolution). The required resolution is set by left-clicking the necessary resolution value, selecting it with a scroll wheel, or by left-clicking the input box and entering the required value from the keyboard.

Under the section "***Label's resolution/unit***" there is a "***Reset***" key. Left-click it to set to zero the displacement (position) value.

The check-boxes "***Displacement***" and "***Velocity***" located to the right from the graphical indicator allow to enable/ disable the virtual channels "***Displacement***" and "***Velocity***", formed by the program "***Encoder***". These channels can be used for further analysis in other programs. As these options are enabled, the virtual channels will be active, and vice versa. The data of these virtual channels is accumulated along with the processing of each impulse (without averaging). This allows to control displacement, displacement velocity, as well as displacement unevenness. As the encoder is used together with other transducers (e.g., pressure or temperature transducers), the data from these transducers and displacement / displacement velocity values are accumulated synchronously with accuracy up to a single impulse of the encoder.

The "***Inversion***" option becomes available for use, as the "***Phase B***" option is selected. Selecting this option allows to implement inversion and vice versa.

In order to measure the displacement and displacement velocity by physical channel, to which the Channel A of the encoder is connected, select the name of the corresponding channel in the menu to the right from the "***Phase A***" section.

If it is necessary to use the channel B, select the corresponding option and choose the required physical channel to which the channel B of the recorder is connected. If the "***Phase B***" option is unchecked, selection of channel B and inversion option will be disabled.

If it is necessary to calculate absolute position value, set the corres

ponding option to the right from the option "***Label 0***". Select the name of active physical channel, to which the zero label of the encoder is connected. Every time as the zero label is passed by the photo-cell, the measured displacement values displayed at the indicator are set to zero. This may be useful, for instance, when it is necessary to measure linear displacement accompanied by piston-wise motion. If the label is placed in the central position, it becomes possible to measure the displacement in both directions from the set zero label.

The "***Auto threshold***" option allows to enable/disable automated/ manual adjustment of upper and bottom thresholds of input signals, used for measurements of the displacement. When this option is active, the program automatically sets upper and bottom threshold of the signal. If the option is disabled, the values of upper and bottom signal threshold should be set manually.

The input boxes located under the section "***Auto threshold***" allow to set upper and bottom threshold levels of the threshold in manual mode (when the "***Auto threshold***" option is disabled). The top section allows to set upper threshold, the lower one is used to enter the value of bottom threshold (the values are entered from the keyboard). As the values are set, click <***Enter***> key. When the option "***Auto threshold***" is active, the input boxes for setting the threshold values are not available. Upper and bottom threshold values are used to exclude false activations in the course of displacement measurements. For correct displacement measurements, the upper threshold should not exceed the maximal level of the signal by the channel. The same applies equally to the bottom threshold value. The user can evaluate maximal and minimal signal level of the channel, to which the recorder is connected, using the program "***Multi-channel oscilloscope***". Start the program, set the required channel, use the oscilloscope graphic to evaluate the corresponding levels. To exit the program, click the key at the top right section of the program window.

The "***Auto threshold***" option allows to enable/ disable automated/ manual setting of upper and bottom threshold of the input signal level of the channel that is used for measurements. When the option is enabled, the program automatically sets upper and bottom threshold levels for the signal. If the option is disabled, the user can enter the values of signal thresholds in manual mode.

The input boxes located under the section "***Auto threshold***" allow to set upper and bottom threshold values in manual mode (if the option "***Auto threshold***" is disabled). The upper section allows to set the top threshold value, the section below is used for setting the bottom threshold value. The threshold values are entered from the keyboard. As the values are set, click <***Enter***> key. When the option "***Auto threshold***" is active, the sections for entering the values of upper and bottom threshold values are not available. The upper and bottom thresholds are set in order to exclude false activations in the course of displacement measurements. For accurate measurements of the displacement values, the upper threshold should not exceed the maximal level of the signal, and the bottom threshold should not be less than the minimal level of the signal. It is possible to evaluate maximal and minimal level of the signal of the channel, to which the encoder is connected, using the program "***Multi-channel oscilloscope***". Start the program, select the required channel, and use the oscilloscope graphic for evaluation of the signal levels.

The indicator "***Integral level***" displays the integral level of the signal and overloading of the channel (in the case if the maximum threshold level is exceeded). Activation of the options "***Phase B***" and "***Label 0***" allows to display the corresponding indicators (and vice versa). 2/3 of the indicator area are used to display the signal, which is within the allowable limit. The higher is the signal level, the bigger part of the indicator area is filled with the color. As the maximal threshold level is exceeded, the indicator is filled with red color. The right section of the indicator remains red until the channel overloading is eliminated and the user left-clicks the indicator area.

If the program "***Encoder***" is used together with the programs from the scope of ZETLAB software package and angular displacement transducers, the user can perform analysis of torsional oscillations and use these instruments instead of torsiographs.

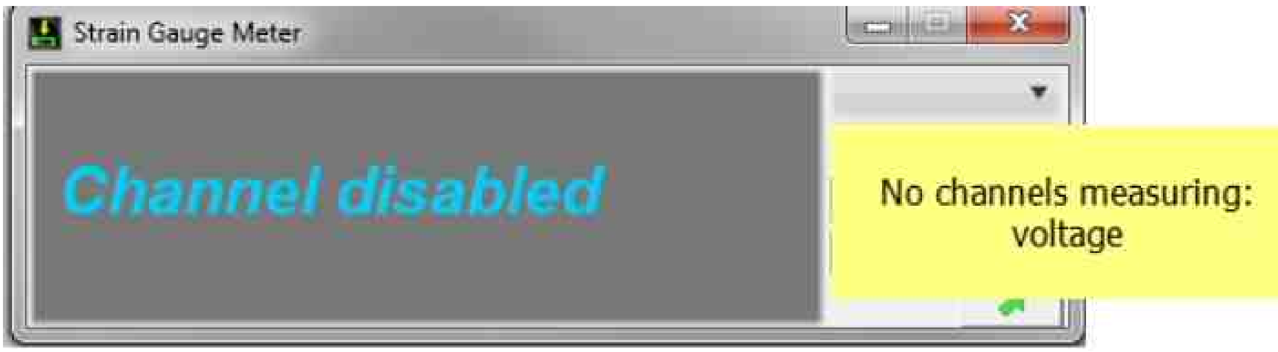
Strain Gauge Meter .....

The program ***Strain Gauge Meter*** is intended for various strain-gauge measurements with the use of strain-gauge transducers (e.g., force and torque transducers, RPM sensors, bridge and half-bridge circuits based on strain gauges, etc.) and a measurement module for strain gauges ZET 017-T.

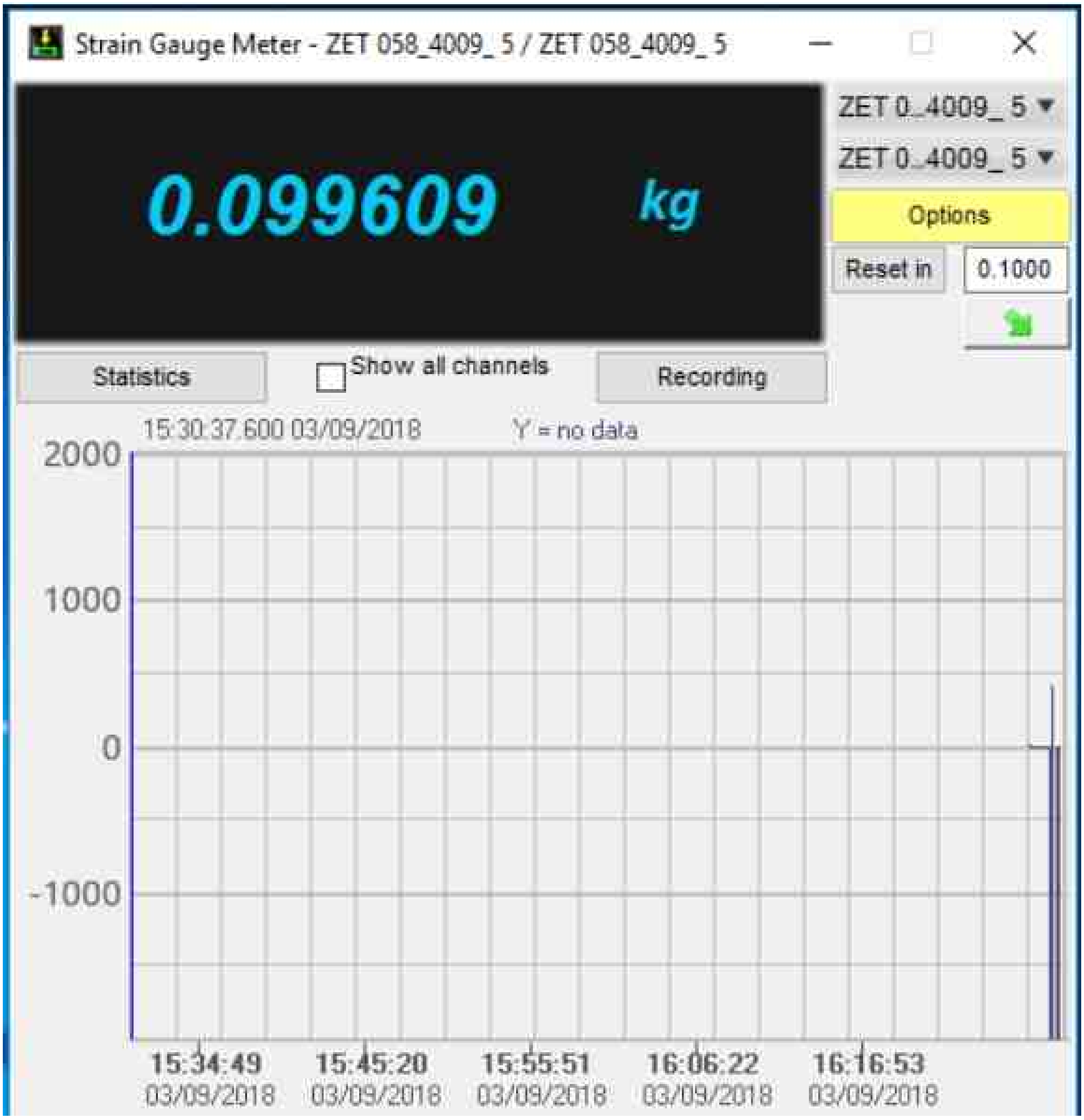
Depending on the parameters configuration of the *Strain Gauge Meter* program, the measurements results can be represented as force, weight, displacement, torque and other parameters. Integrated generator of the measurement module can be used for power supply of the transducers..

Start Strain gauge meter

The program ***Strain Gauge Meter*** is compatible only with the input channels, which are used for voltage measurements. The measurement unit by default is *V*, or its derivatives. In the case, if the corresponding channels are not found, the drop-down list becomes unavailable and there appears the following notification:



The program ***Strain Gauge Meter*** has an integrated signals recorder, which is used for displaying of the recorded data for the period of 60 minutes. It is also possible for the user to save the signals displayed on the graphic to a file with *.dtx extension. If the program is used in multi-channel mode, then in order to display all the channels on the graphic, it is necessary to enable the option *Show all channels*. For more convenience, the channels data is also available in graphic form (the displayed parameters are as follows: max. and min. value, amplitude, average value and RMS value).



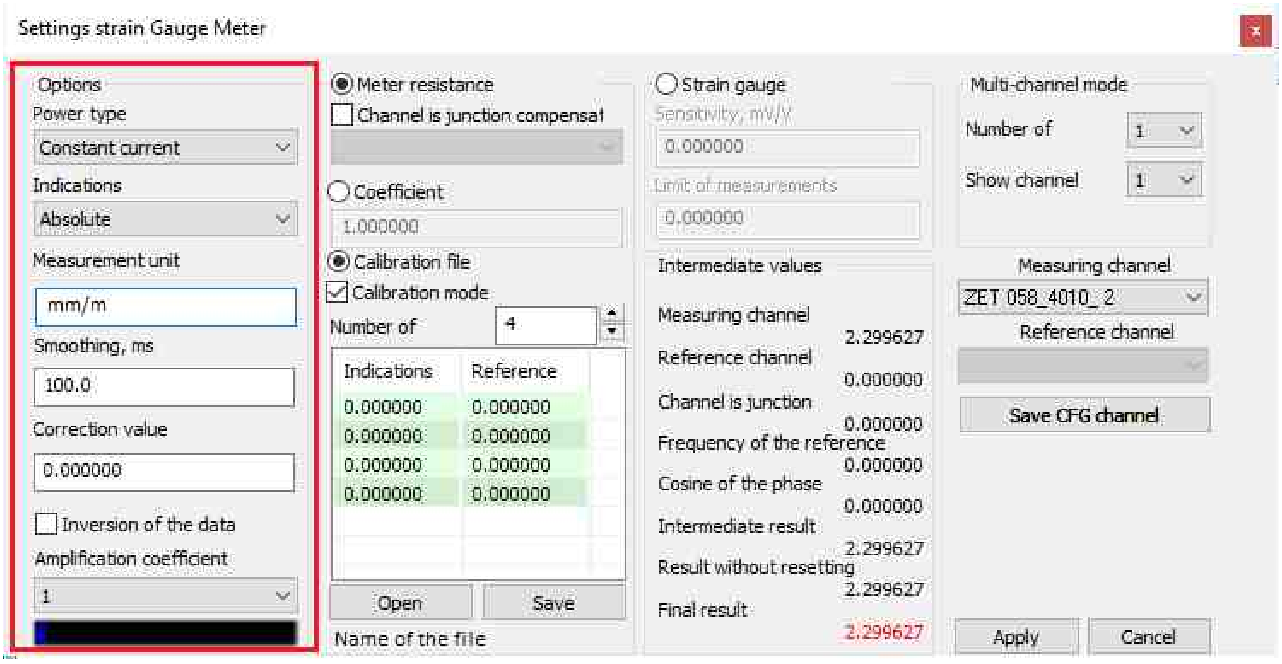
Strain Gauge Meter program: parameters configuration

Configuration of the measurement channels parameters is performed in the dialog window *"Settings Strain Gauge Meter"*, which is activated with the key *"Parameters"* in the main window of the *Strain Gauge Meter* program.
The window *"Settings Strain Gauge Meter"* is separated into several sections, which are also available for configuration: *"Parameters", "Strain gauge", "Intermediate values", "Multi-channel mode"* and the section displaying the channels used for configuration.

Parameters

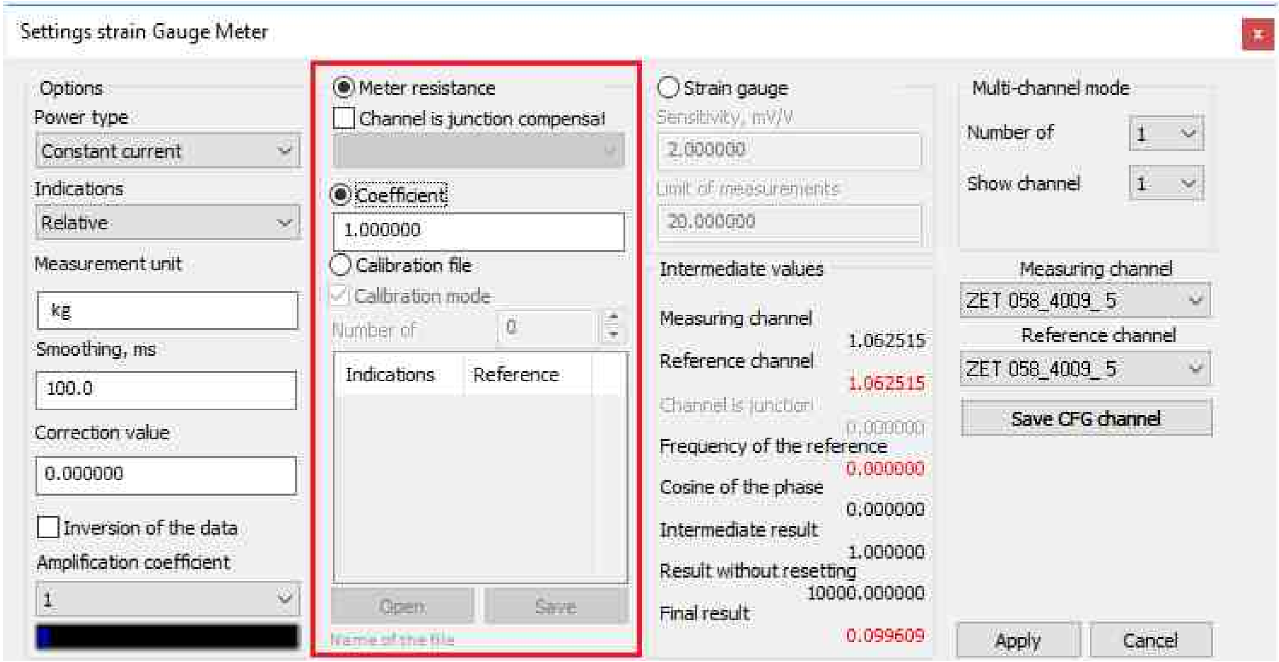
The section "Parameters" is used for configuration of general parameters of the measurement suite:

- *Power type* – variants of power supply for the transducers from the integrated generator of the measurement module (constant or alternating current);
- *Indications* – absolute or relative. If the relative readings are selected, it is necessary to assign two channels: measuring channel and reference channel. In the case, if absolute readings are selected, the section "Reference channel" becomes unavailable;
- *Measurement unit* – the measurement unit to be displayed next to the numerical value. This parameter does not convert the measurement units and is used for informational purposes only;
- *Smoothing, ms* – the period in ms to be used for averaging of the measured values. The interval of a single measurement is 100 ms, hence, the averaging interval should be divisible by 100 ms;
- *Correction value* – the value, which is not to be taken into consideration in the case, is the key *"Reset in"* is active. This section displays the difference between the value specified in the filed *"Reset in"* and the current measurements results (i.e., if we set the reset value as *"0"* when the current measurement value is *"3"*, then the correction value will be *"-3"*);
- *Inversion of the data* – this option is used when it is necessary to obtain the results with opposite value;
- *Amplification coefficient* – amplification of the measurement channel in 1, 10, 100 or 1000 times. As the amplification coefficient value is changed, the signal integral level indicator will display the ratio of the input signal to the available measurement range of the strain-gauge module.

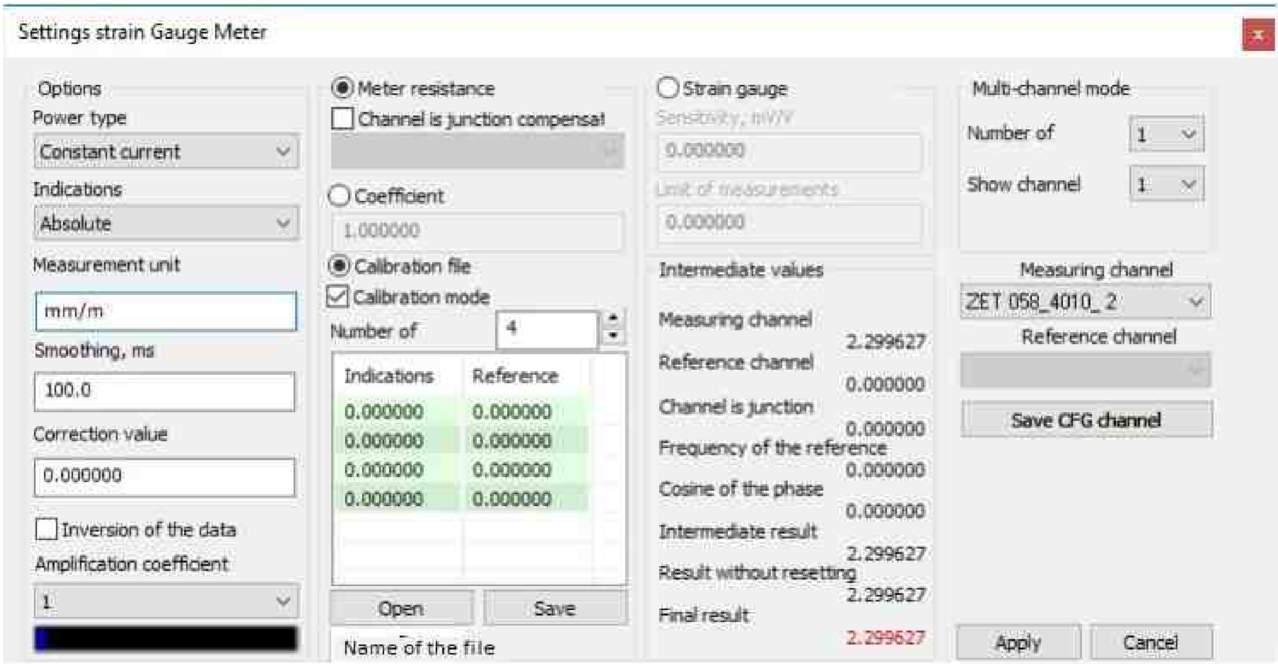


Meter resistance

When a load-indicating resistor is used as a sensing element, the section *"Meter resistance"* is used for configuration of the corresponding parameters, and the *"Strain gauge"* section becomes unavailable.



The parameters also allow to assign the channel to be used for thermal compensation (i.e., to select the strain-gauge to be used for temperature coefficient evaluation). The set value will be taken into consideration in the course of measurements performance.
For the load-indicating sensors, it is necessary to select the algorithm of the measurement process (i.e., to select *Coefficient* or *Calibration file*).
If there is a need to measure relative deformation, strain, or any other values having linear relation to the load-indicating sensors measurements, it is necessary to assign the Coefficient of load-indicating sensor sensitivity (the coefficient is calculated individually for each particular circuit).
In the case, if it is necessary to measure weight, force, and other physical values, which have non-linear dependence on the load-indicating sensor value, or it is difficult to calculate the sensitivity value, then it is possible to use the calibration graphic for the conversion purpose. To do it, enable the option *"Calibration file"*. Then it is necessary to enter the load value and *Strain Gauge Meter* value into the calibration file, or use already existing file with the calibration graphic.
Upon activation of the "Calibration file" option, the user can switch over into *Calibration mode* by activation the corresponding option. The calibration mode implies the use of absolute values.
As the calibration mode is enabled, the indication color of the *Strain Gauge Meter* program changes (from blue to red).
The registered values correspond to the voltage level at the output of the strain-gauge transducer. Thus, it is possible to conduct calibration of the sensing element by applying the reference value and recording the corresponding voltage level at the indicator of the *Strain Gauge Meter*.



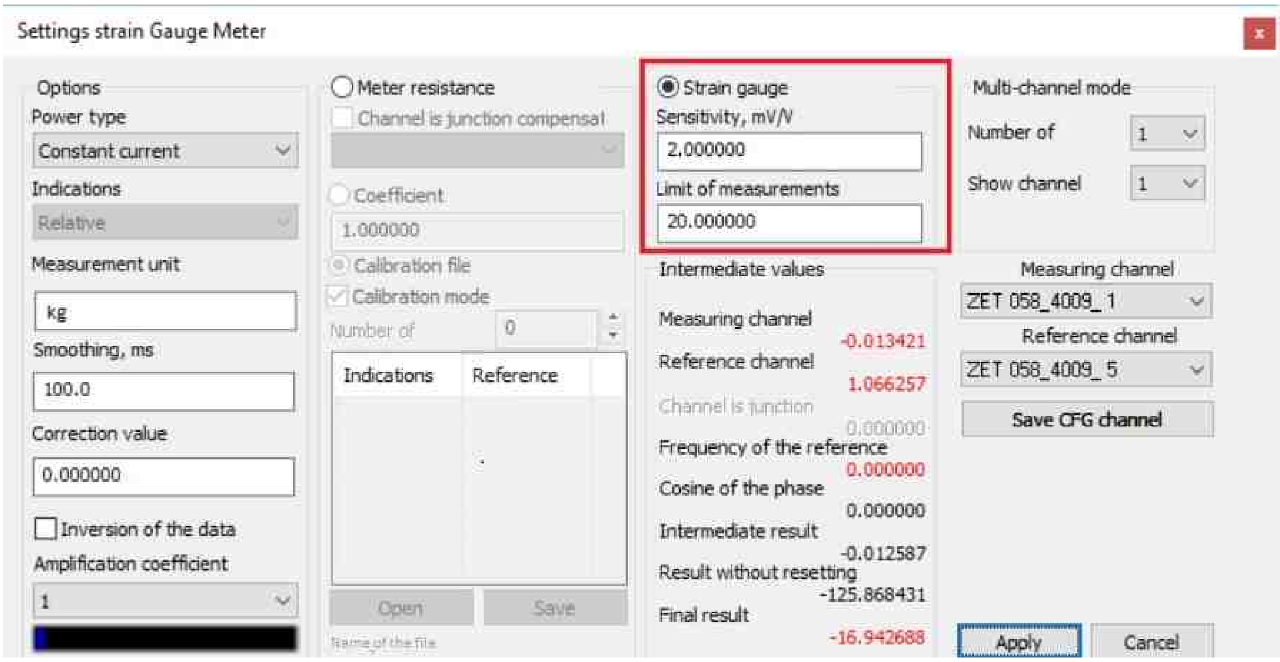
The section *Indications* of the calibration chat can be filled automatically: right-click on the reference value and select the option "Use the indicator value".
It is also possible to save the calibration graphic for further use.
Upon completion of the calibration process, uncheck the option *Calibration mode* and save the changes by clicking *Apply* key.

Strain Gauge

If a strain-gauge transducer is used as a sensing element, the parameters configuration is conducted in the corresponding section *"Strain gauge"*. In this case, the section *"Meter resistance"* becomes unavailable.
It is possible to use two parameters for configuration of the strain-gauge transducers:

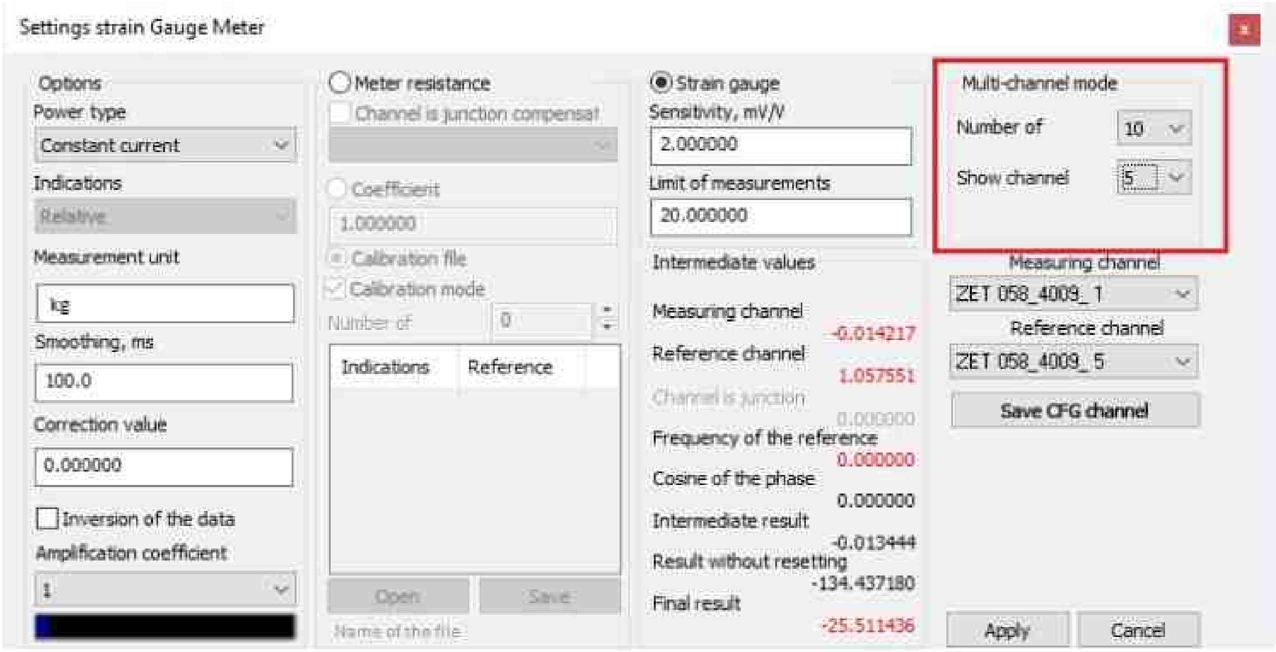
- *Sensitivity, mV/V*;
- *Limit of measurements* – the maximal value of the deformation, which can be registered by the transducer.

When the strain-gauge sensor is used as a primary transducer, it is possible to calculate only relative values of the strain-gauge meter.
Hence, it is necessary to use a reference channel in addition to the measurement channel.



Multi-channel mode

New version of the *Strain Gauge Meter* program has a function of *Multi-channel mode*.
If there is a need to implement a great number of primary transducers, it becomes necessary to control each of the channels simultaneously. Previously it was possible to do it by running several copies of the "*Strain Gauge Meter*" program, which was not always convenient. Now it is possible to display several channels by using a single copy of the program and by activating the *Multi-channel mode*.

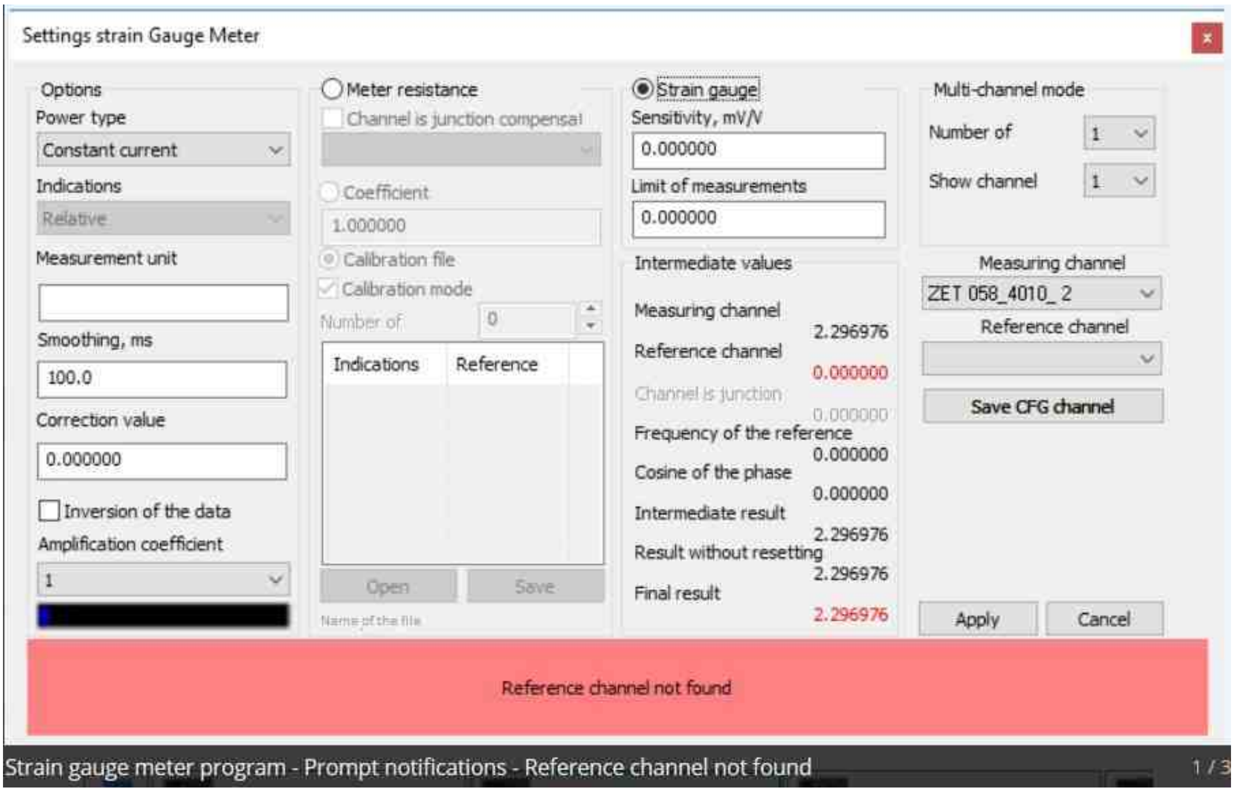


Strain Gauge Meter program: prompt messages

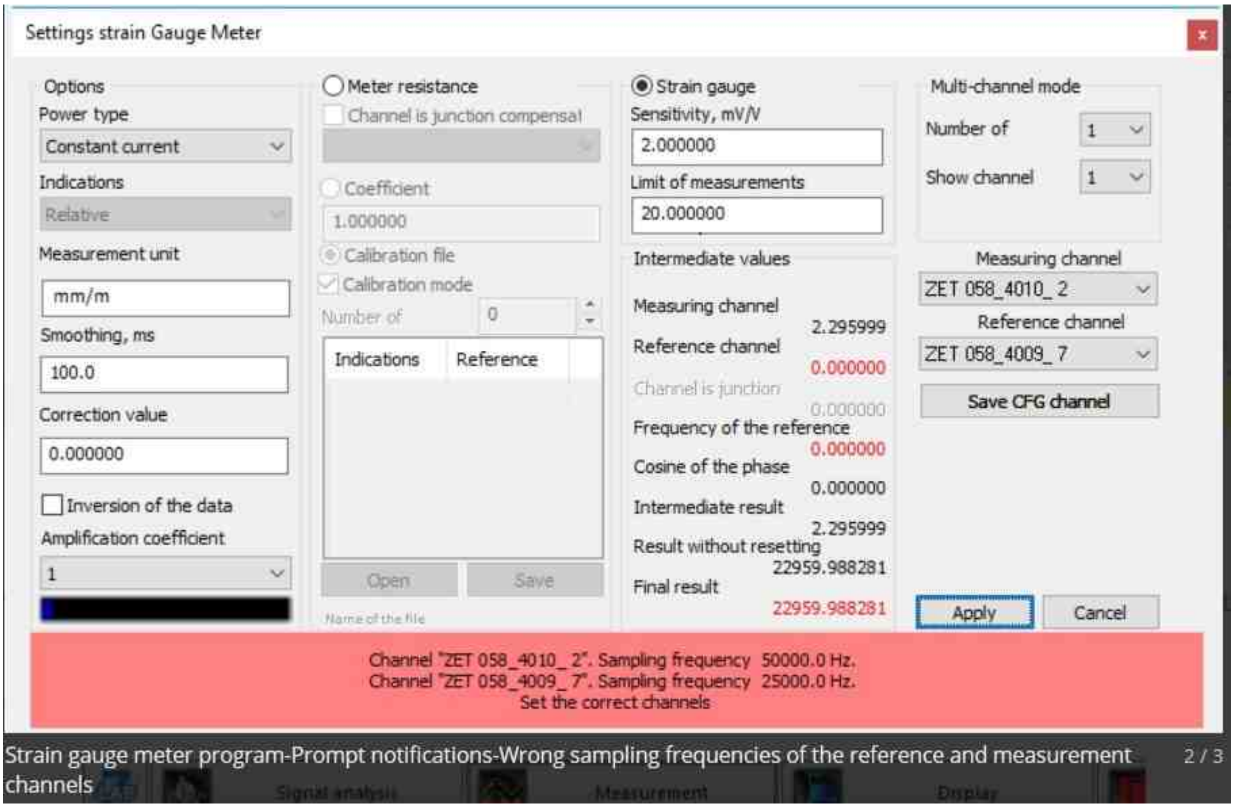
In order to secure correct operation of the "Strain gauge meter" program, the system produces a number of prompt messages informing the user of the wrong parameters values. The developers of the program have conducted comprehensive analysis of the most frequent mistakes in the course of program operation. As a result, the program has the following notification messages:

- *Reference channel not found* – the message is formed in the case if relative indications are selected, but the reference channel is not assigned;
- *Set the correct channels* – the program produces this message in the case if measurement and reference channels have different sampling frequencies;

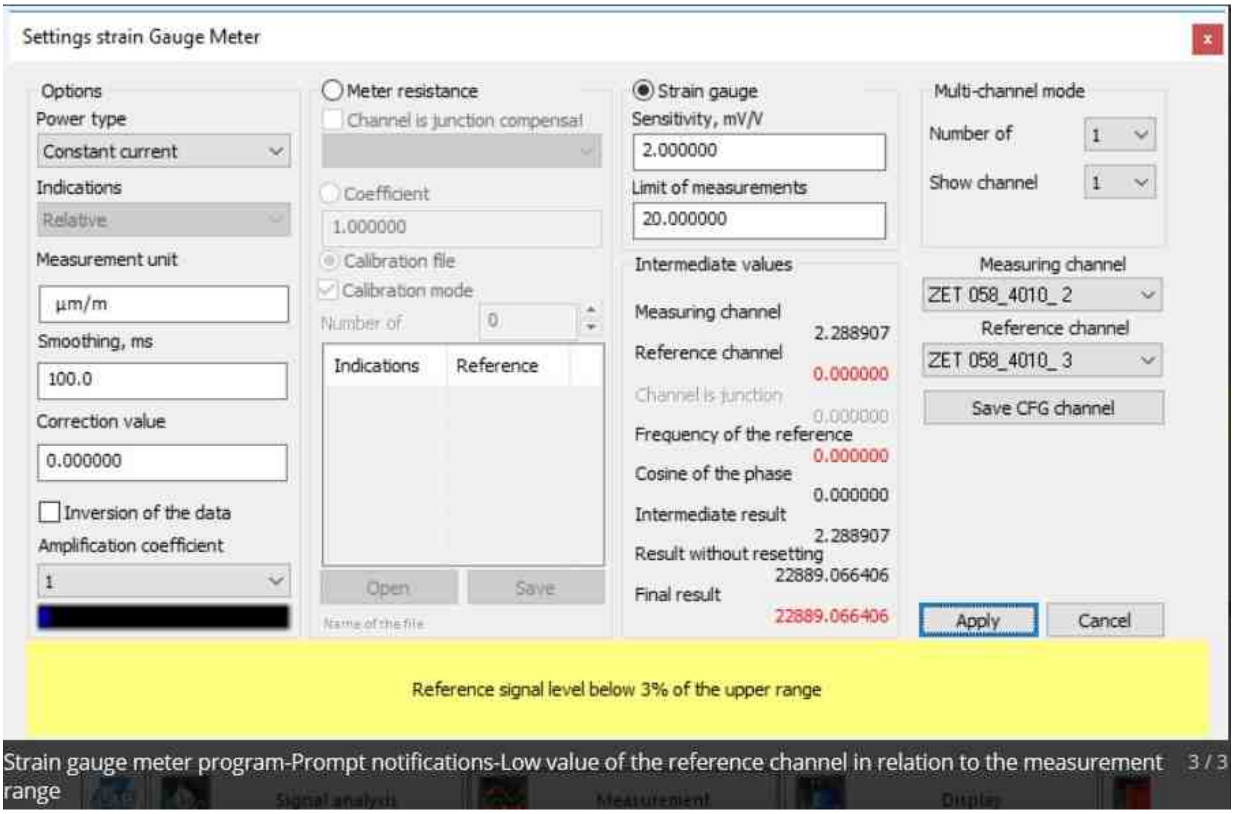
- *Reference signal level below 3% of the upper range* – the message recommends to select suitable reference channel.



Strain gauge meter program - Prompt notifications - Reference channel not found 1 / 3



Strain gauge meter program-Prompt notifications-Wrong sampling frequencies of the reference and measurement channels 2 / 3



Supported Hardware .....

The input data of the program **Strain Gauge Meter** is represented by digital channels of **ZETLAB server**. This data contains output signal that is used for Acceleration measurements (i.e., the measured values are displayed in "*mV*" or "*V*").

For the purpose of analog signals digital processing, it is possible to use FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01, noise- and vibration-meters ZET 110 and seismic recorder ZET 048.

The measuring channels parameters of the program are set in the program "Device Manager".

The program **Strain Gauge Meter** is included into the scope of the following software packages:

- ZETLAB TENZO – Strain-gauge station software,

Strain Gauge Meter is included into the **Measurement** software group.

Tensometry .....

This section describes the operation of strain-gauge modules and sensors.

Design and connection options for strain-gauge modules, use cases, and turnkey solutions based on strain-gauge modules.

General information on strain-gauge sensors, their connection and establishment of bridge circuits, practical application.

Strain-gauge modules

Design and Connection Options for Strain-gauge modules
Available modifications of strain-gauge modules for addressing the tasks of any complexity.
Methods for connecting bridge circuits to strain-gauge modules.

Practical Application of Strain-gauge modules

Managing the processes in test chambers, measuring dynamic voltage-strain status of structures, and controlling the power quality using the measuring system based on a strain-gauge module.

Reference Information

Concept and theory of strain-gauge measurements. General specifications and connection layouts of resistive strain sensors. Strain-gauge sensors.

Connecting and Establishing Bridge Circuits

Variety of strain-gauge bridges and establishment of bridge circuits. Testing the operation capacity of strain-gauge bridges.
Connection of strain-gauge sensing element to strain-gauge module.

Practical Application

Specifics of resistive strain sensor application, pressure sensors on resistive strain sensors, and application of resistive strain sensors for measuring physical values

The basics of tensometry .....

Website on the Internet: https://zetlab.com/en/theory-of-strain-gauge-measurements/

A Little Bit of Physics

Let us Let us consider a cylindrical conductor (wire), which is stretched at *F* force. The wire volume *v* remains constant, while the cross-section is reduced and the length increases. Conductor resistance can be presented as:

$$R = \rho\frac{l^2}{\upsilon}$$

where ρ is resistivity of the material.
After differentiation, we obtain a formula for determining the sensitivity of resistance to wire stretching:

$$\frac{dR}{dl} = 2\frac{\rho}{\upsilon}l$$

The sensitivity increases with growing length and resistivity of the wire, and decreases with increasing cross-section of the wire. The relative change of wire resistance against the relative strain can be presented as:

where S_k is strain-gauge sensitivity coefficient. For metal wires it makes 2 to 6, and for semiconductors – 20 to 200.

$$\frac{dR}{R} = S_k e$$

where S_k is strain-gauge sensitivity coefficient. For metal wires it makes 2 to 6, and for semiconductors – 20 to 200.

Let us consider, for instance, the strain-gauge resistance with the following characteristics:

Sensitivity (S_k)	2.0
Bed material	Polyamide
Measuring grid	Constantan foil
Base (measuring grid length), mm	20; 50; 100; 150
Temperature coefficient of sensitivity, 1/K	$115 * 10^{-6}$
Transverse sensitivity, %	0,1
Operating temperature range, °C	-70 to +200 for static measurements -200 to +200 for dynamic measurements
Rated resistance, Ohm	120; 350; 700; 1000

Let us consider the strain-gauge balance based on the measurement of bending deflection of the beam located on two supports (Fig. 1).

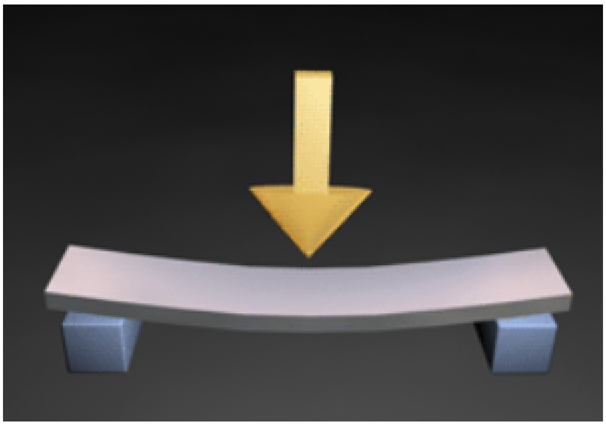


Fig. 1

Bending deflection is:

$$\lambda = Fl^3/(48EI)$$

where F is the applied force in the middle of the beam, l is the beam length, I is moment of inertia of the beam cross-section. If the beam cross-section is rectangular with width a and height b, then

$$I = 1/12ab^3$$

For circular cross-section with radius r:

$$I = 1/4\pi r^4$$

Bending radius of the beam will be:

$$R = \frac{4EI}{Fl}$$

If a resistive strain sensor is attached to the bottom of the rectangular beam, the relative strain of the sensor will be:

$$e = \frac{3Fl}{2Eab^2}$$

Let us assume that the steel beam has cross-section $a = b = 1$ cm $= 10^{-2}$ m and length $l = 10$ cm $= 10^{-1}$ m, then force $F = 8{,}000$ N will correspond to bending deflection $\lambda = 1$ mm, which corresponds to 800 kg weight. The relative strain of the resistive strain sensor attached to bottom of the beam will be 0.006 with 0.012 relative change of resistance. To establish the balance with definition of 1 kg, we need to record the relative change of resistance up to 10^{-5}.

The following table presents the Young's modulus and strength limit for some materials.

Material	**Young's Modulus, 10^9 N/m^2**	**Strength Limit, 10^7 N/m^2**
Steel	196	127

Iron	186	33
Copper	120	24
Brass	102	35
Aluminum	68	7.8
Lead	1.7	1.5

Measuring Circuit

Usually, there are three circuits for connecting resistive sensors. The first circuit (Fig. 2) is full-bridge, the second (Fig. 3) and third (Fig. 4) are half-bridge. The first and second circuits control the supplied voltage and measure the relative voltage drop V_1/V_2. The third circuit measures V_1 voltage relative to the supplied voltage.

As resistances R_1-R_3, the resistive strain sensor identical to the measuring ones are typically used, but attached to the beam in transverse direction, which is not sensitive to strain. This is primarily due to the high temperature coefficient of resistance of the resistive strain sensor. When using as R_1-R_3 the same strain-gauge sensors under the same conditions as the measuring resistive strain sensor, it becomes much easier to ensure temperature compensation of the bridge circuit. To facilitate that, a six-wire measuring circuit is required. One wire pair powers the bridge, another wire pair measures the supplied voltage, the third wire pair measures the electric potential difference within the bridge circuit.

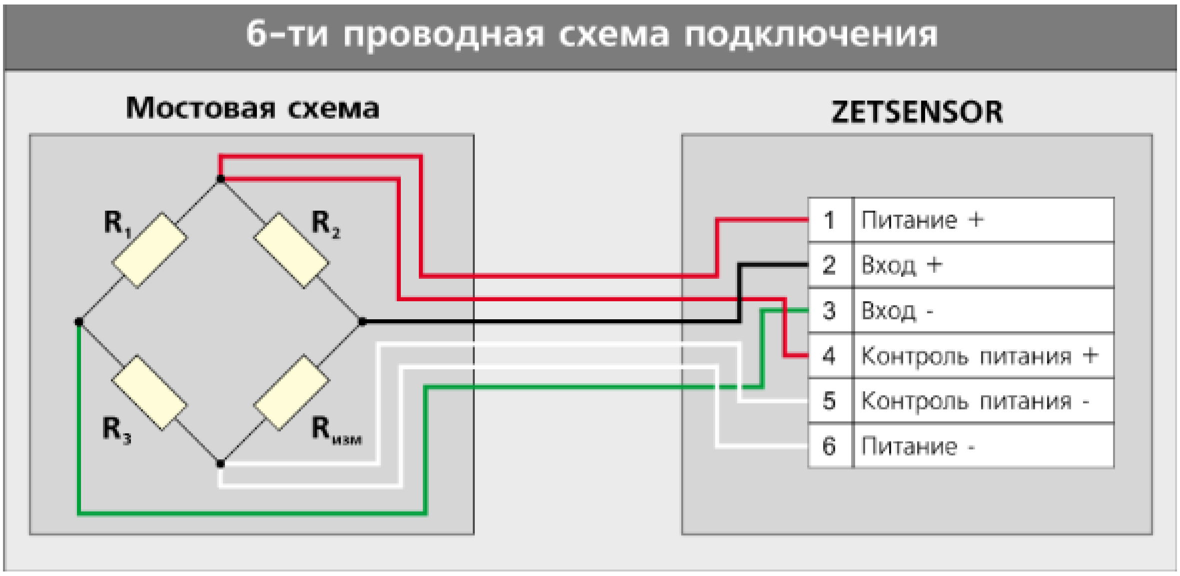


Fig. 2

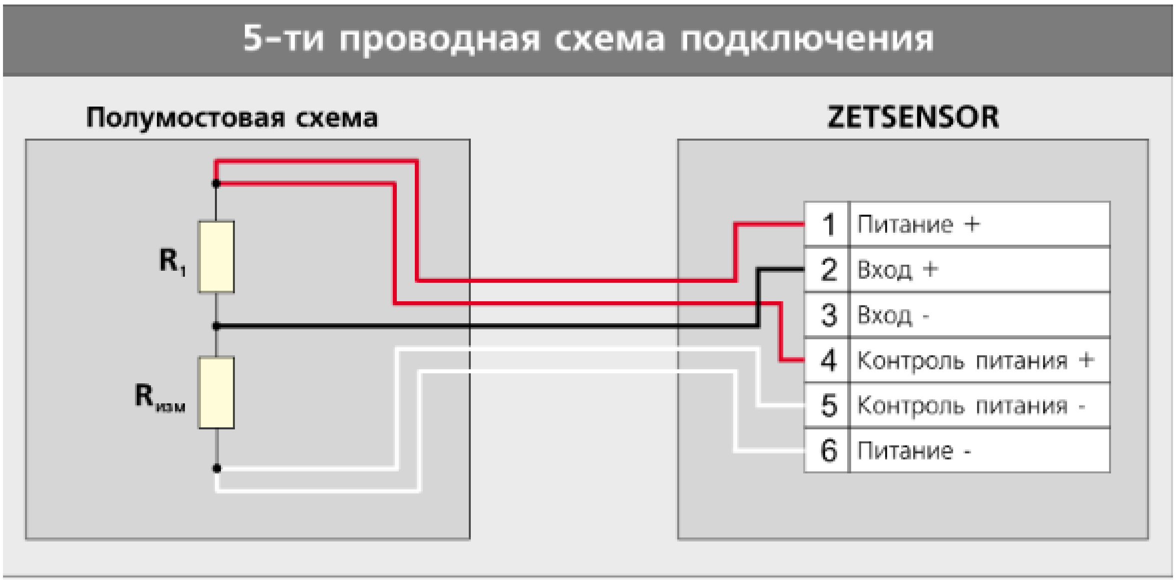


Fig. 3

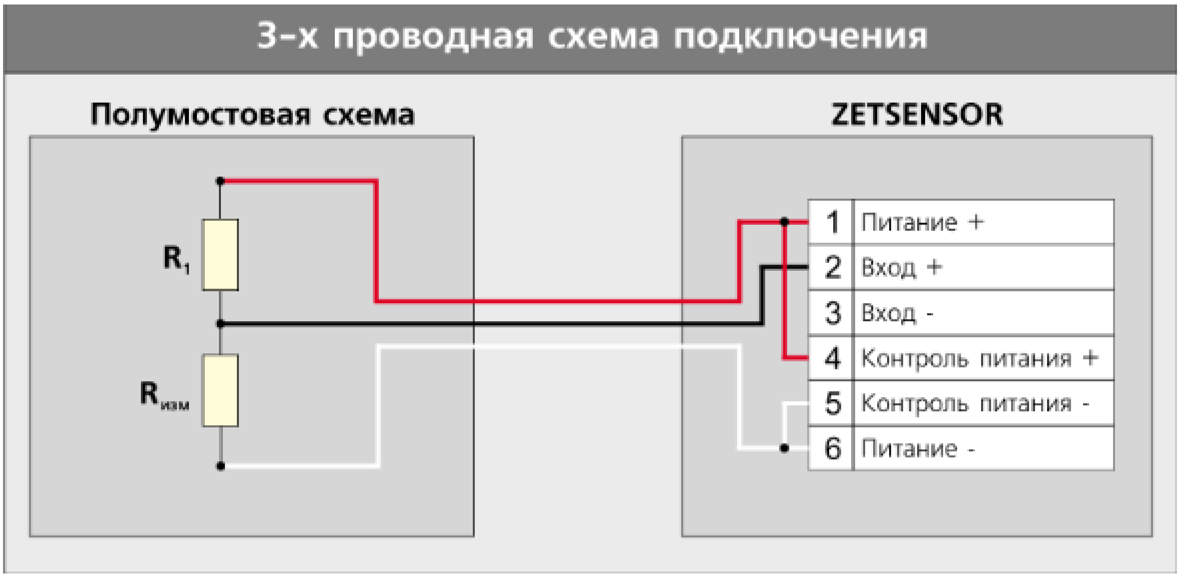


Fig. 4

The application of six-wire sensor connection circuit excludes error of voltage drop on leads and the voltage drop changes on leads caused by the temperature dependence of resistance. Another source of error is the noise pickup from from other circuits. The most relevant is the network interference of 50 Hz. The longer the leads, the higher the noise pickup. To reduce the pickup, the twisted-pair screened wires shall be used.
During measurements within the bridge circuit, the output signal is:

$$V_1/V_2 = \frac{R_{изм}}{R_2 + R_{изм}} - \frac{R_3}{R_1 + R_3}$$

If resistances $R_1 = R_2 = R_3 = R$, then:

$$V_1/V_2 = \frac{1}{2}\frac{R_{изм} - R}{R + R_{изм}}$$

For half-bridge circuit:

$$V_1/V_2 = \frac{R_{изм}}{R + R_{изм}}$$

Another source of interference is non-linear dependence of the voltage drop on the measured value of resistance.

Meter resistances sensors

The Meter resistance principle allows to manufacture the ***pressure sensors*** with internal bridge circuit.

Photoresistance sensors are sensors, the resistance of which varies depending on the ambient light. In the dark, this sensor demonstrates high resistance, and when lighted, the resistance

decreases. This sensor has a non-linear characteristic.
There is also a wide variety of ***potentiometric sensors*** – position sensors, rate-of-turn sensors. The principle of measurement of resistance of such sensors is similar to measuring the resistance of temperature-sensitive resistor.

The ***capacitive*** and ***induction sensors*** have similar function. For example, the induction sensor of linear displacement is based on the half-bridge circuit with 350 Ohm input resistance. A carrier frequency of 5 kHz is required for powering the sensor. The sensor consists of two transformer windings. One transformer winding is supplied with AC voltage, the other winding delivers the output signal. Retractable probe is made of ferromagnetic material. Depending on the position of the probe, the transformation coefficient between windings changes along with the corresponding change of the output signal amplitude. The output signal amplitude determines the probe displacement. The linearity of such sensor does not exceed 1-2%.

ZETLAB offers **ZETSENSOR** series measuring modules for each sensor type. Specifically designed to address a particular measuring task, **ZETSENSOR** modules allow to connect primary transducers directly, i.e. bypassing the matching, amplifying circuits and power circuits. The power is supplied from measuring module in form of AC (static measurements) or DC (dynamic measurements). The sensor signals are processed directly by the measuring module, and the measurement results are transmitted in digital form via RS-485 or CAN interface using the Modbus protocol. The measurement results can be displayed on a digital indicator or PC. **ZETSENSOR** control modules implement the control and management systems, both on PC and offline.

Strain-gauge measurement .....

The choice of a primary transducer is crucial for any task in computer automation of measurements, testing and control of technological production. The primary converters of external impact signals into an electric signal are based on different physical effects and have different types and designs. Let us consider one of the common transducer types – resistive transducers.

Resistive sensors are widely used in tensometry. Tensometry (Lat. tensus – stressed, tense and Gr. metréō – measure) (strain-gauge measurement) implies experimental determination of voltage status of structures based on the measurement of local strains. Mechanical strain of material changes its electric resistance. This effect is called Meter resistance. This effect is a basis for strain-gauge sensors, which respond to mechanical voltage σ:

$$\sigma = \frac{F}{a} = E\frac{dl}{l}$$

where E is Young's modulus of the material, F is the applied force, dl/l = e – relative strain of the material. Strain-gauge measurements are conducted using ZET 7010 Tensometer-485, ZET 7110 Tensometer-CAN, ZET 7111 Tensometer-CAN measuring modules, or ZET 017-T8 strain-gauge module with Strain Gauge Sensor software facility. The strain-gauge sensors or resistive strain sensors of different design can serve as sensing elements. Meter resistance is utilized for measuring various physical values: weight, pressure, mechanical voltage, etc. Fig. 1 shows the forms of measuring grids of resistive strain sensors manufactured by Messtechnik HBM. Fig. 2 shows a typical pressure sensor manufactured by Metronik LLC.

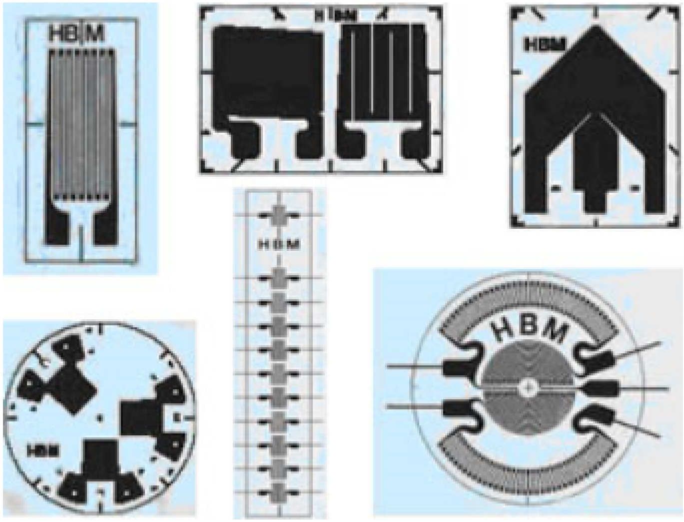


Fig. 1

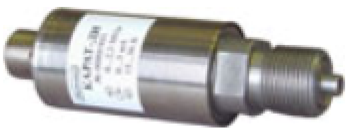


Fig. 2

For building the multi-channel control and measuring systems of process automation, several ZET 017-T8 strain-gauge modules are used, facilitating the establishment of up to 128 measuring channels. For connecting so many sensors, the terminal modules are applied (Fig.s 3 and 4). The modules can be installed on a DIN bar in order to integrate the strain-gauge measuring system into the existing process. For building a distributed strain-gauge measuring system, ZET 7010 Tensometer-485, ZET 7110 Tensometer-CAN, ZET 7111 Tensometer-CAN modules are utilized.

Fig. 3

Fig. 4

The digital input/output of ZET 017-T8 strain-gauge module or the control module ZET 7060 Digital-485 or ZET 7160 Digital-CAN is used to monitor and manage processes. For example, when the pressure at a monitored point of the analyzed object is exceeded, the digital output transmits a signal to the actuator, which triggers it to, for example, open the bleed valve. Once the pressure is back to normal, the digital output signal turns off and the system continues to run normally. Thresholds (setpoints) of digital input/output trigger are set by the operator. The measured parameters control and trigger algorithms of setpoints may vary. The whole process of parameter measurements, setpoint triggering, and occurrence of irregular situations is displayed on the screen in real time and logged for further analysis and storage.

See also

- Theory of Strain Gauge Measurements, Layouts of Resistive Strain Sensor Connection to ZETSENSOR
- Layouts of Resistive Strain Sensor Connection to ZET 017-T8 Strain Gauge Module
- DIY Strain Gauge Weigher
- Establishment of Strain Gauge Bridge Circuits for Measuring Various Parameters
- Application of Resistive Strain Sensors for Measurement of Physical Values
- ZET 7010 Tensometer-485, a smart strain-gauge sensor with RS-485 interface (static measurements)
- ZET 7110 Tensometer-CAN, a smart strain-gauge sensor with CAN interface (static measurements)
- ZET 7111 Tensometer-CAN, a smart strain-gauge sensor with CAN interface for dynamic measurements

General characteristics of meter resistances .....

There is a wide range of resistive strain sensors for optimal solution of the set tasks. Each resistive strain sensor has precision resistive foil grids, which are mounted on a bed of organic material.
Each series of resistive strain sensors is unique, having its own design, construction features, and a specific combination of alloy and bed material. The descriptions of resistive strain sensors contain details on unidades, operational characteristics, and application notes, as well as information of the alloy and bed material.

Main Specifications of Resistive Strain Sensors

Series	**EA**	**EP**

<table>
<tr><td>Application</td><td>Foil constantan combined with durable, pliable polyimide bed.
Wide selection of available options.
Originally designed for general static and dynamic analysis of strain.
Not recommended for high-frequency transducers</td><td colspan="2">Special annealed constantan alloy with durable, highly elastic polyimide bed.
Mainly used for measuring large strains.
Available with options E, L, and LE (may limit the extensibility parameters)</td></tr>
<tr><td>Temperature range, °C</td><td>Operating: -75 to 175
Short-term: -195 to 205</td><td colspan="2">−75…205</td></tr>
<tr><td>Measuring range (the range of elastic strain against grid length), %</td><td>± 3% for sensors with up to 3.2 mm measuring grid
± 5% for sensors with at least 3.2 mm measuring grid</td><td colspan="2">± 10% for sensors with up to 3.2 mm measuring grid
± 20% for sensors with at least 3.2 mm measuring grid</td></tr>
<tr><td rowspan="3">Strain level, µm/m</td><td>±1800</td><td rowspan="3">±1000</td><td rowspan="6">EP series sensors demonstrate zero offset during highly cyclic strains</td></tr>
<tr><td>±1500</td></tr>
<tr><td>±1200</td></tr>
<tr><td rowspan="3">Number of cycles</td><td>10^5</td><td rowspan="3">10^4</td></tr>
<tr><td>10^6</td></tr>
<tr><td>10^8</td></tr>
</table>

Strain and Temperature Range

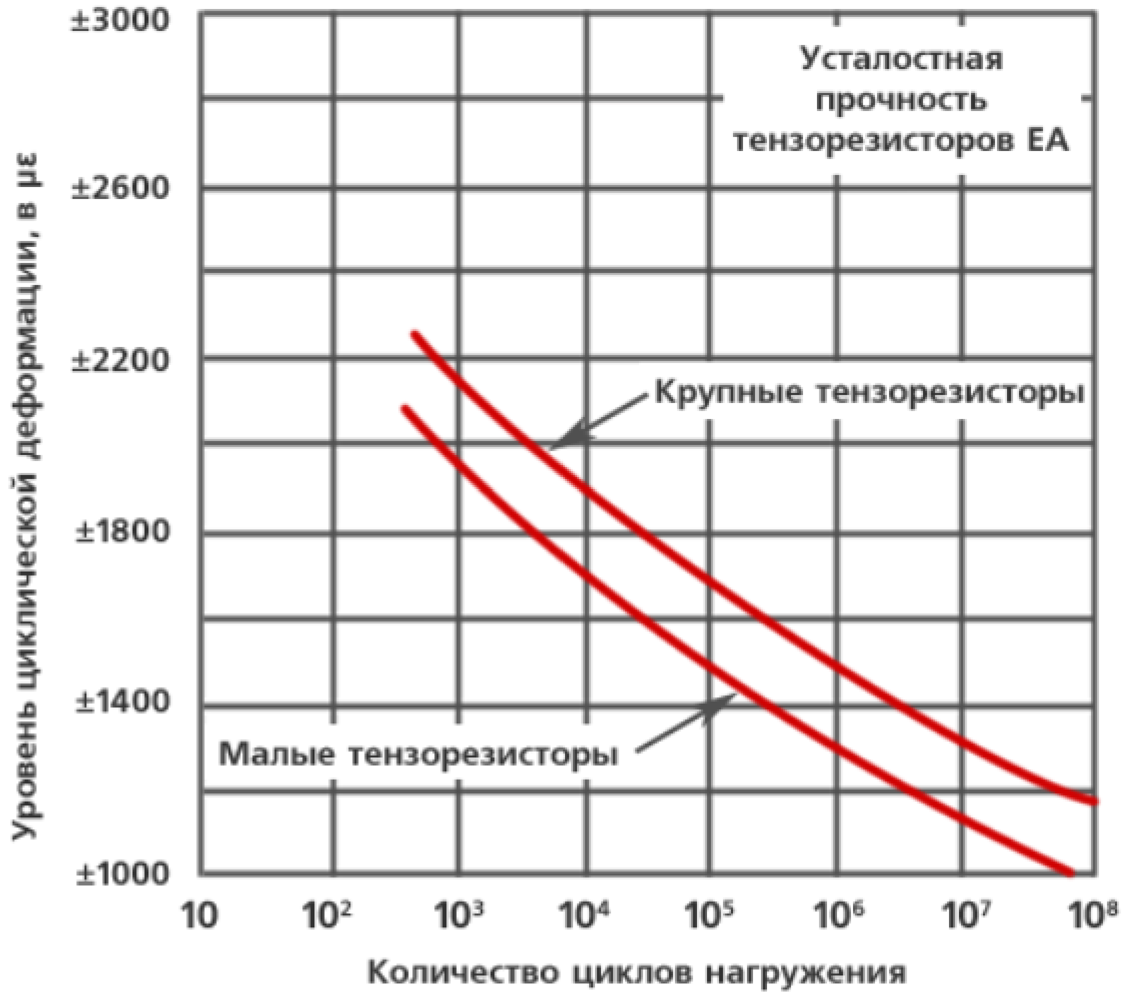
The permissible strain range is defined with indication of the recommended operating temperature for various applications. Cyclic strain level graphics, depending on the number of cycles, are specified for all series and show the overall norm for nominal fatigue performance. As fatigue performance of resistive strain sensors depends on various conditions, the relevant instructions shall be learned.
The below fatigue strength curves of strain sensors match the reversible strain levels. They can also apply to unidirectional strain subject to amplitude peaks reduction by 10%. For instance, the fully reversible strain range of ± 1,500 µm/m is approximately equal to the fatigue damage of resistive strain sensor with strain levels:

- 0 to + 2,700 µm/m,
- 0 to – 2,700 µm/m,
- – 200 to + 2,500 µm/m.

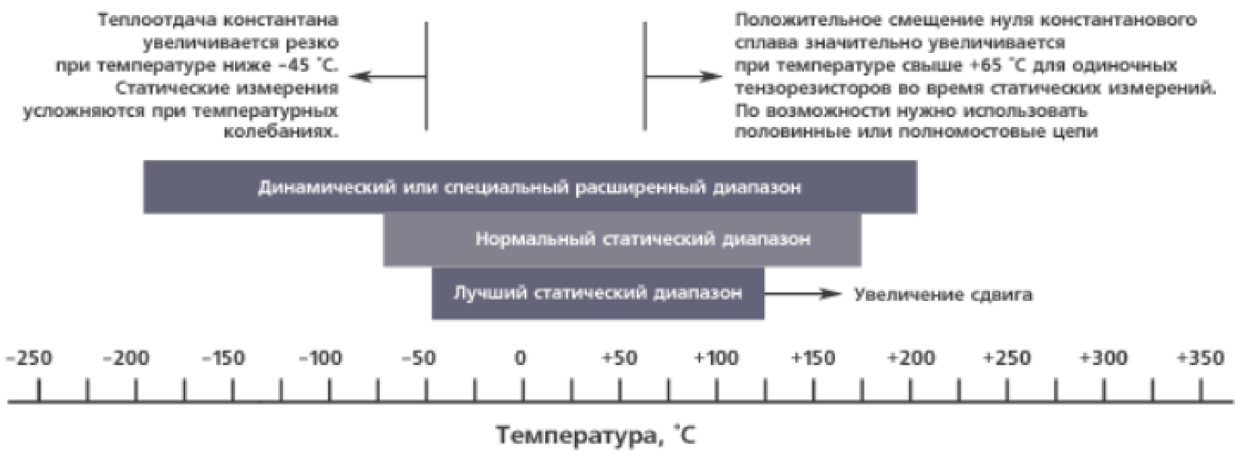
However, the average strain value increased in the direction of stretching during the cycle leads to earlier breakdown. It should be noted that all the operational characteristics of resistive strain sensors are nominal, because behavior of an individual sensor may change during installation or under the environmental conditions. In addition, these parameters apply to resistive strain sensors without accessories, having active length of 3 mm or more, unless otherwise specified.

EA Series

EA series resistive strain sensors made of constantan are widely used for general purpose experimental analysis of voltage. A basic model has an open design with 0.025 mm durable elastic bed of cast polyimide. This series offers a wide range of models and is usually cheaper. This series has many optional features, such as different form of lead bonding cover and protective encapsulation. The bed is prepared for solid fixation by all standard glues for resistive strain sensors. The range of elastic strain against the the grid length for resistive strain sensors with at least 3 mm grid: ± 5%; for sensors with shorter grid: 3%.



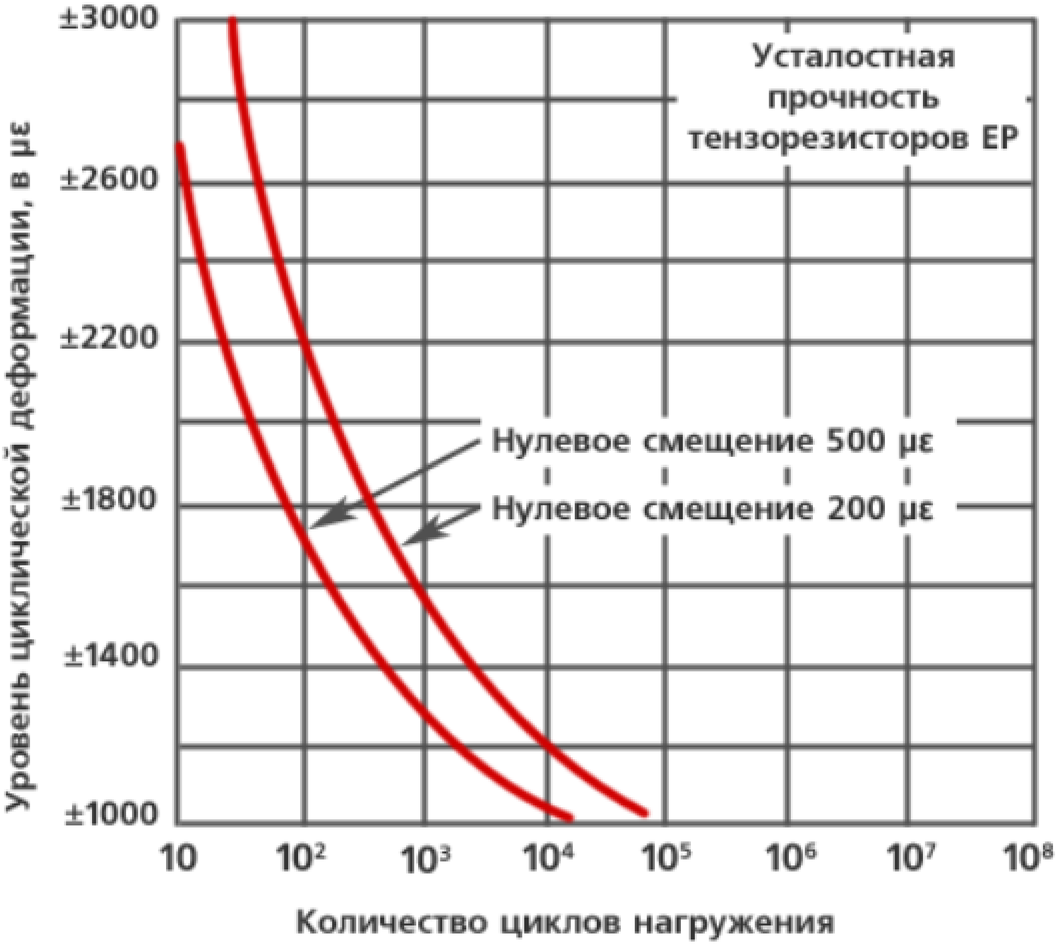
Fatigue strength of EA series resistive strain sensors



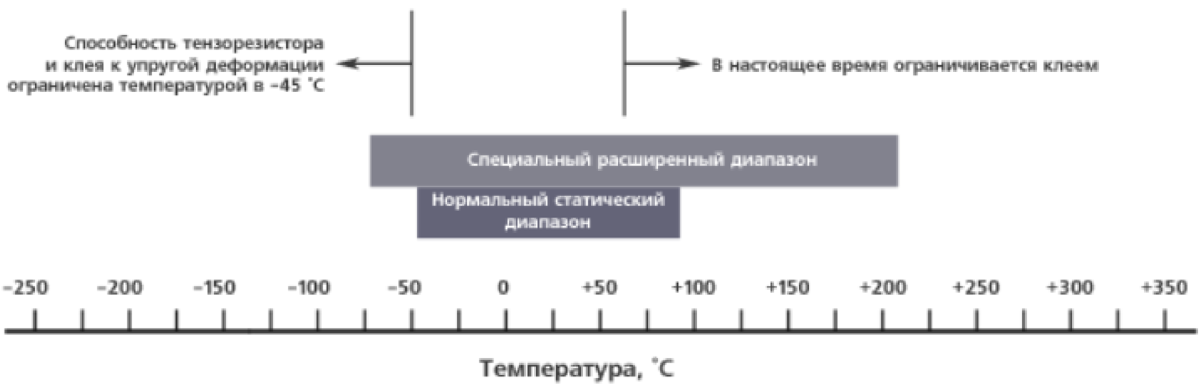
Operating temperature of EA series resistive strain sensors

EP Series

EP series resistive strain sensors are specifically designed for large strain measurements, > 3-5%. A basic model has an open design with 0.025 mm durable elastic bed of highly elastic cast polyimide. Measuring grid is made of the special grade annealed constantan foil for maximum plasticity. The series offers 08 and 40 compensation for application on metals and plastic, respectively. The precise values of temperature self-compensation are typically irrelevant for operation in plastic status, because the temperature error is very small compared to the measured high levels of strain. The strain limit for EP series resistive strain sensors with at least 3 mm grid: ± 20%; for sensors with shorter grid: 10%. The optional designs mainly reduce the extensibility. EP series resistive strain sensors can be purchased by special order with all options available for EA series.



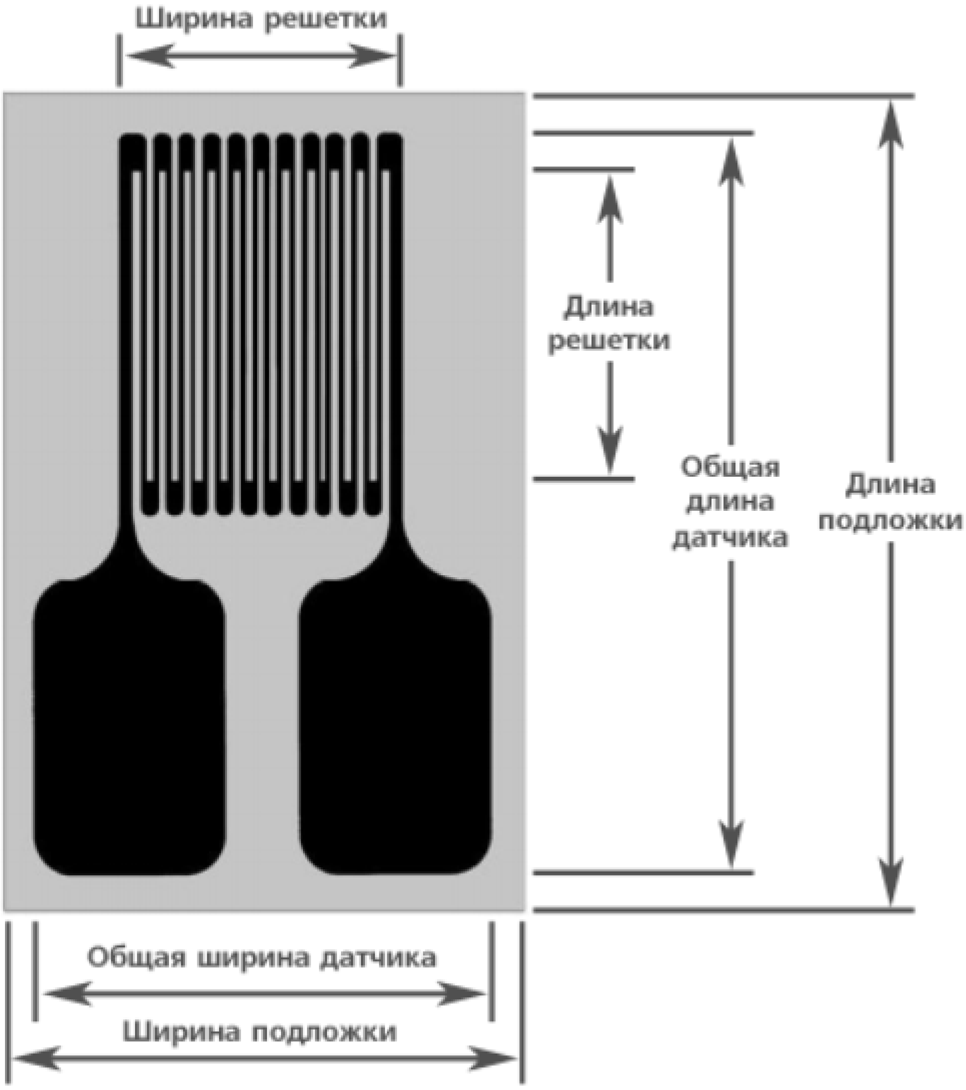
Fatigue strength of EP series resistive strain sensors



Operating temperature of EP series resistive strain sensors

Unidades of Resistive Strain Sensors

Measuring grid length is an important parameter for selection of a resistive strain sensor, and usually it becomes a decisive factor. The unidades specified for length and width refer to the active size of measuring grid. The overall length and width of a resistive strain sensor refer to actual size along the grid edges, not including the alignment marks or bed. The bed unidades are nominal with up to ± 0.4 mm tolerable deviation. If the sensors are encapsulated, the bed can be downsized, but no more than by 0.25 mm to the edge of grid pattern, with no loss of sensor performance quality. For these purposes, the majority of models also include trim marks for use in confined spaces.



Designations of dimension parameters

Self-Temperature-Compensation (S-T-C)

All resistive strain sensors with "XX" in third part of sensor designation code (for example, MT-EA-XX-0.38DJ-120) have self-temperature-compensation for application on structures made of materials with a certain thermal expansion coefficient.

When selecting a resistive strain sensor, replace the XX code part with the desired S-T-C number, which represents the thermal expansion coefficient of the construction material. The table of resistive strain sensor labels contains the available S-T-C numbers for grid alloys. The 06 and 13 values available for alloy A are typical for general-purpose resistive strain sensors. If there are no special requirements, the 06 value is the most suitable.

S-T-C Number	**Linear Expansion Coefficient of Material**	Material
00	1.4	Invar alloy (FeNi)
	0.5	Quartz, molten
	1.4	Titanium silicate*
03	5.4	Burnt alumina (aluminum)
	4.9	Molybdenum*
	4.3	Tungsten
	5.6	Zirconium
05	9.2	Silicate glass
	9.9	Ferritic stainless steel
	8.6	Titanium, pure
	8.8	Titanium alloy, 6 AL-4V*
06	11.5	Beryllium
	10.8	Gray cast iron
	12.6	Inconel, Ni-Ct-Fe alloy
	12.1	Inconel X, Ni-Cr-Fe alloy
	13.5	Monel, Ni-Cu alloy
	11.9	Nickel, Cu-Zn-Ni alloy
	11.3	4340 steel
	12.1	Carbon steel, 1008, 1018*
	10.8	Stainless steel, hardened-
	10.3	Stainless steel, hardened-
	9.0	Stainless steel, hardened-
09	16.7	Beryllium-copper, Cu25, BE25
	18.4	Phosphor-bronze, Cu90, Sn10
	16.6	Copper; 99.9%+
	17.3	Austenitic stainless steel
	17.4	Austenitic stainless steel
	16.0	Stainless steel
13	23.2	Aluminum alloy 2024-T4*
	20.0	7075 T6; brass
	22.7	Cu70 Zn30; pure tin
15	26.1	Magnesium alloy, AZ-318*
18, 30, 40		Plastics and composites

* the material used for determining the thermal output signal

Strain-gauge sensors .....

Strain-gauge sensor (resistive strain sensor, strain-gauge) is a device for measuring the voltage condition of metal. It is designed as a special form conductor that is connected to the measured product.

Knowing the sensor resistance in the non-strained status, it is possible to determine the strain degree based on resistance change.
Before invention of strain-gauge sensors, the industry mostly used mechanical lever scales for weighing. Mechanical scales offered two methods of weighing: a balancing mechanism or a mechanism for measuring force based on mechanical levers. The very first strain gauges for weighing, developed before the strain-gauge sensors, were hydraulic or pneumatic. In 1843, an English physicist Charles Wheatstone invented a bridge for measuring the electric resistance of conductors. Wheatstone bridge became an ideal instrument for measuring the resistance changes occurring in the strain-gauge sensors.
Despite the fact that the first strain-gauge sensor was invented in the 40-s of the last century, its production became economically and technically feasible only when electronics advanced enough. Ever since, the strain-gauge sensors became integral components of mechanical scales and independent load sensors. Simplicity of sensor connection to a strain-gauge module allows to assemble the entire measuring complexes. Smart strain-gauge sensors allow to directly obtain the measured value, thus eliminating the need to set the measuring channels.
Nowadays, the strain-gauge sensors predominate in the weight measuring equipment industry. However, some laboratories still use the precise balancing scales.

Modification of strain-gauge bridges .....

Why should one use a bridge instead of a divider?
It might seem that a voltage divider consisting of a resistive strain sensor and a fixed resistor (see Fig. 1) would be sufficient for measuring the strain by means of resistive strain sensor.
R1 – fixed resistor, R2 – resistive strain sensor, R1=R2.

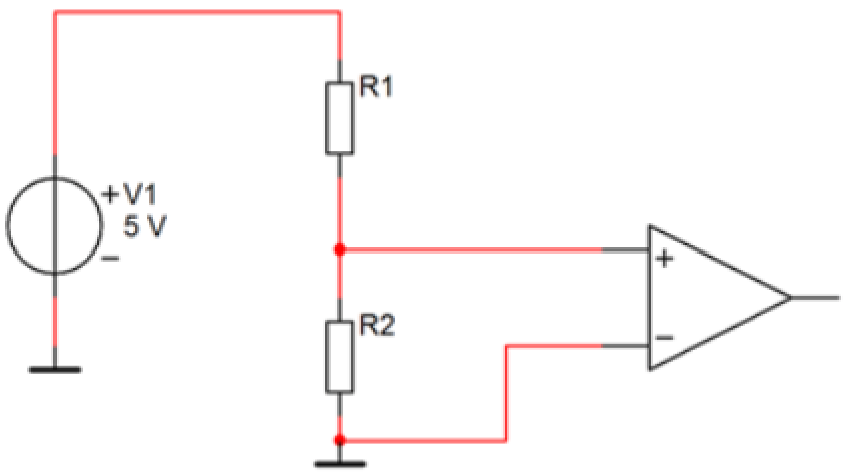


Fig. 1. Divider with resistive strain sensor

Everything seems to be simple: strain causes the resistance, for example, to increase, and voltage at the midpoint also increases. However, if you actually assemble such circuit, you will face a few problems that will hinder the measurements or even lead to experiment failure.
The main disadvantage of this circuit is that the bias (rest) voltage considerably differs from voltage changes due to change in resistance of the resistive strain sensor. In other words, this circuit sets unreasonably strict requirements to the dynamic range of the measuring amplifier. For instance, when the divider is powered with 5.0 V DC voltage, it is necessary to measure at the 2.5 V level the voltages of mV units with precision of tens of µV, and this is at least 20 log2,5/10-6 ≈ 100 dB! It means that you need a fairly expensive amplifier with a wide input dynamic range.

However, there is a simple solution: adding one more divider to this circuit and measuring the signal between two midpoints which seems to be a quite elegant solution to the problem. Let us consider this circuit in Fig. 2. R1 and R2 resistors have a purpose similar to the previously considered circuit. R3 and R4 resistors act as fixed resistors. R1=R2=R3=R4.

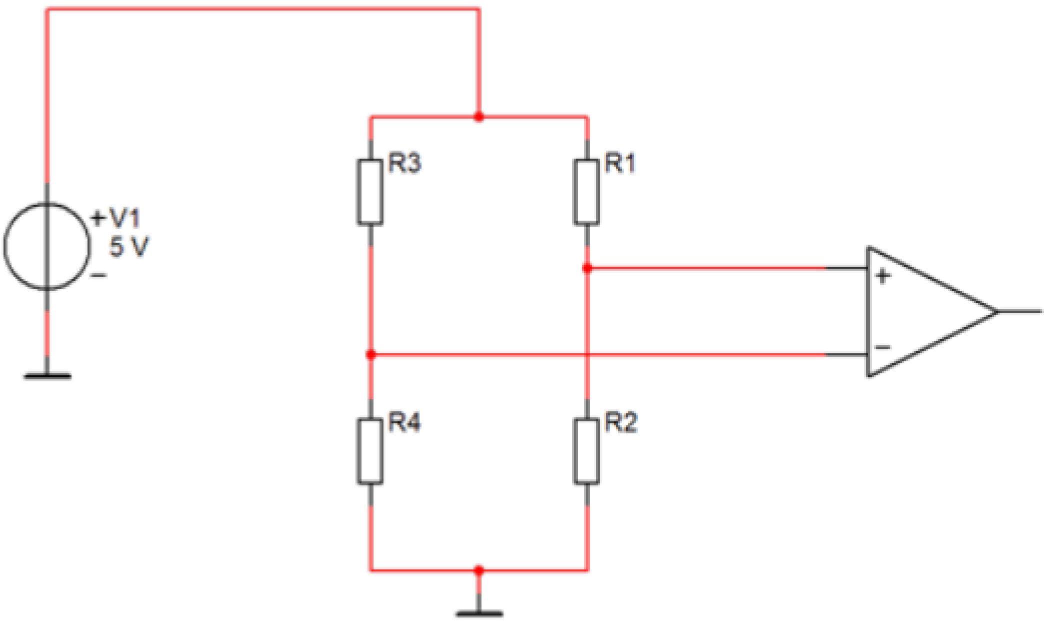


Fig. 2. Strain gauge bridge

In an ideal scenario both inputs of differential amplifier with the unloaded resistive strain sensor should have the same voltage. In reality, there is a small voltage on the bridge, which is caused by resistances mismatching, also called the bridge unbalance. This voltage can be excluded by replacing one of the fixed resistors with a potentiometer or by deducting it from the result obtained.
Now we can perform measurements using the amplifier with a relatively narrow dynamic range, i.e. we can simplify the requirements for measuring amplifier.
If classifying this circuit according to the number of required connection wires, this circuit will be called a four-wired measuring circuit.
But this circuit is not perfect as well. The power supply voltage may change under the influence of different factors, which introduces errors to measurements. Besides, the wires from measuring bridge to the amplifier tend to be very long, and hence have some resistance that causes certain decline in power supply voltage. These factors must be taken into account in order to ensure more precise measurements. To compensate for these factors, it is sufficient to measure the actual voltage on the strain-gauge bridge. To do this one has to add another differential amplifier to the circuit for measuring the bridge power voltage directly on the strain-gauge bridge (see Fig. 3). This amplifier has a wider absolute range of measurements than the measuring amplifier. If we calculate the number of wires coming from the measuring circuit to the strain-gauge bridge, it will be clear why this circuit is called a six-wire measuring circuit.
However, that is still not as good as it gets. There is a following way to ensure even greater accuracy of measurements. All previous circuits utilized the strain-gauge bridge power with DC voltage. But, as is well known, low-frequency part of spectrum contains considerable amount of thermal and other noise. By powering the strain-gauge bridge with AC current, while shifting the operating frequency range to high frequencies, you can increase the signal-to-noise ratio, thus enhancing the measurements accuracy. To do this, select the spectrum window with low noise.

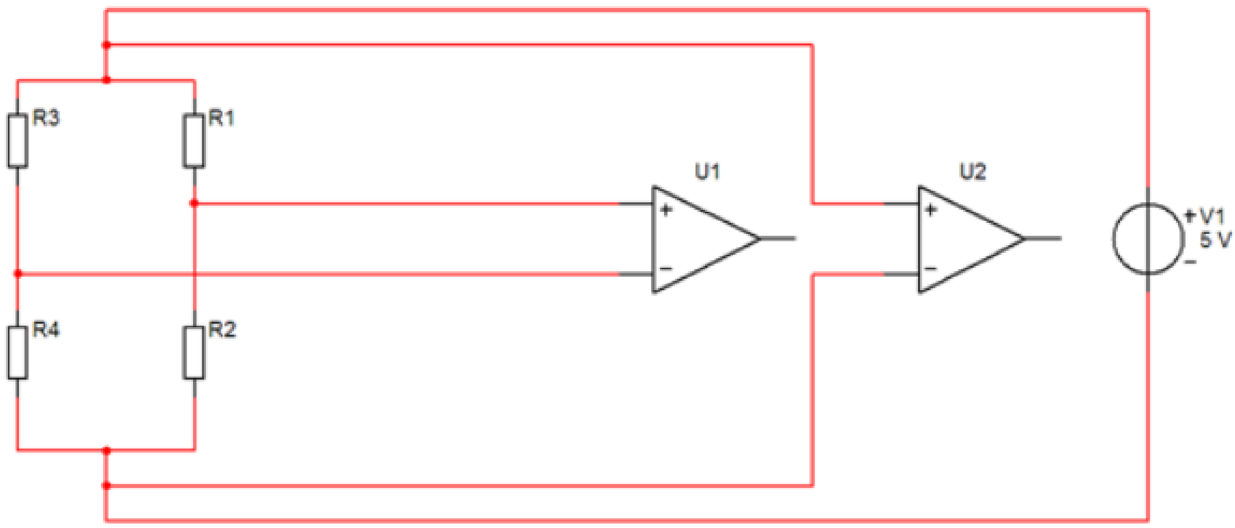


Fig. 3

These circuits have both advantages and disadvantages. The table below demonstrates them. We excluded the voltage divider circuit due to its incapacity.

Circuit Type	Power Type	Accuracy	Frequency Range	Cost
Four-wire	DC	—	+	++
	AC	—	—	+
Six-wire	DC	+	+	—
	AC	++	—	—

See also

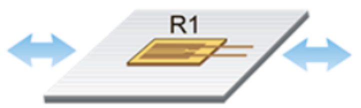
- Strain Gauge Measurements
- Theory of Strain Gauge Measurements, Layouts of Resistive Strain Sensor Connection to ZETSENSOR
- Layouts of Resistive Strain Sensor Connection to ZET 017-T8 Strain Gauge Module
- DIY Strain Gauge Weigher
- Establishment of Strain Gauge Bridge Circuits for Measuring Various Parameters
- Application of Resistive Strain Sensors for Measurement of Physical Values
- ZET 7010 Tensometer-485, a smart strain-gauge sensor with RS-485 interface (static measurements)
- ZET 7110 Tensometer-CAN, a smart strain-gauge sensor with CAN interface (static measurements)
- ZET 7111 Tensometer-CAN, a smart strain-gauge sensor with CAN interface for dynamic measurements

Connecting bridge circuits to the measuring modules ZETSENSOR .....

The resistive strain sensors are designed for measuring the voltage on surface of different elements. They can be used to measure compression and stretch, twisting, bending, and calculate the force applied to an object.
Below you can find various connection pattern options for connecting the resistive strain sensors to ZETSENSOR measuring modules, as well as instruction on module configuration.

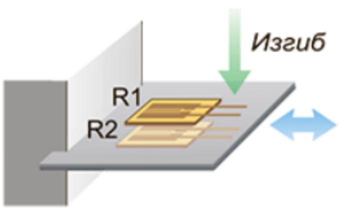
Table 1

1. Uniaxial Strain.1 resistive strain sensor, 1 resistance, R≈R1. Temperature compensation — no. Bending compensation — no.



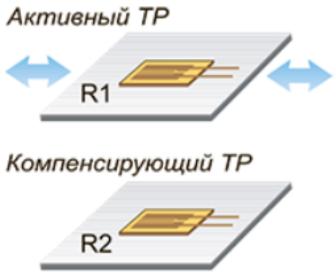
Configuration:
Settings/Circuit: Half-Bridge.
Settings/Method: Transfer factor.
Resistive Strain Sensor/Status: On.
Resistive Strain Sensor/Sensitivity: S=4/K.

2. Uniaxial Strain.2 resistive strain sensors, 1 resistance, R≈R1+R2. Temperature compensation — no. Bending compensation — yes.



Configuration:
Settings/Circuit: Half-Bridge.
Settings/Method: Transfer factor.
Resistive Strain Sensor/ Status: On.
Resistive Strain Sensor/ Sensitivity: S=4/(2*K).

3. Uniaxial Strain.2 resistive strain sensors, R2≈R1. Temperature compensation — yes. Bending compensation — no.

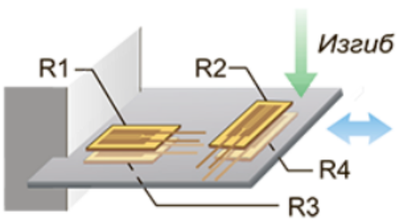


Configuration:
Settings/Circuit: Half-Bridge.
Settings/Method: Transfer factor.
Resistive Strain Sensor/ Status: On.
Resistive Strain Sensor/ Sensitivity: S=4/K.

4. Uniaxial Strain.2 resistive strain sensors, R2≈R1. Temperature compensation — yes. Bending compensation — no.

Configuration:
Settings/Circuit: Half-Bridge.
Settings/Method: Transfer factor.
Resistive Strain Sensor/ Status: On.
Resistive Strain Sensor/ Sensitivity: S=4/((1+ν)*K).
ν – Poison's ratio

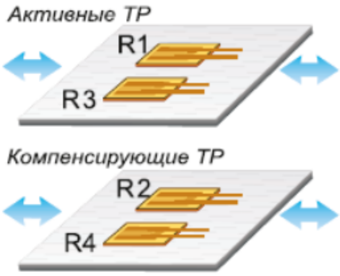
5. Uniaxial Strain. 4 resistive strain sensors, R4≈R3≈R2≈R1. Temperature compensation — yes. Bending compensation — no.



Configuration:
Settings/Circuit: Bridge.
Settings/Method: Transfer factor.

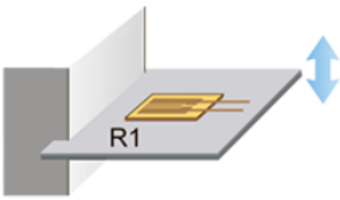
Resistive Strain Sensor/ Status: On.
Resistive Strain Sensor/ Sensitivity: S=4/((1+ν)*2*K).

6. Uniaxial Strain. 4 resistive strain sensors, R4≈R3≈R2≈R1. Temperature compensation — yes. Bending compensation — no.



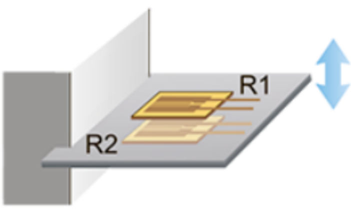
Configuration:
Settings/Circuit: Bridge.
Settings/Method: Transfer factor.
Resistive Strain Sensor/ Status: On.
Resistive Strain Sensor/ Sensitivity: S=4/(2*K).

7. Bending Strain. 1 resistive strain sensor, 1 resistance, R≈R1. Temperature compensation — yes.



Configuration:
Settings/Circuit: Bridge.
Settings/Method: Transfer factor.
Resistive Strain Sensor/ Status: On.
Resistive Strain Sensor/ Sensitivity: S=4/K.

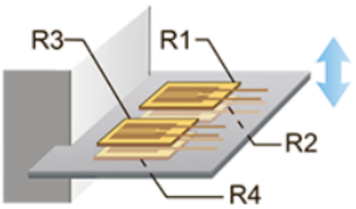
8. Bending Strain. 2 resistive strain sensors, R2≈R1. Temperature compensation — yes.



Configuration:
Settings/Circuit: Bridge.
Settings/Method: Transfer factor.

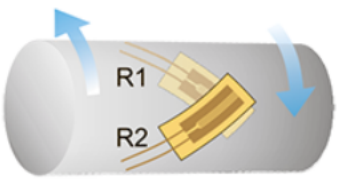
Resistive Strain Sensor/ Status: On.
Resistive Strain Sensor/ Sensitivity: S=4/(2*K).

9. Bending Strain. 4 resistive strain sensors, R4≈R3≈R2≈R1. Temperature compensation — yes.



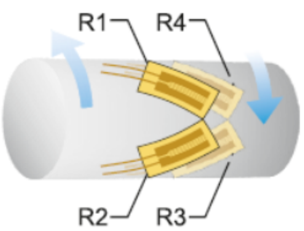
Configuration:
Settings/Circuit: Bridge.
Settings/Method: Transfer factor.
Resistive Strain Sensor/ Status: On.
Resistive Strain Sensor/ Sensitivity: S=4/(4*K).

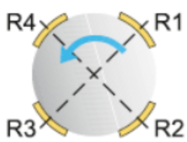
10. Twisting Strain. 2 resistive strain sensors, R2≈R1. Temperature compensation — yes.



Configuration:
Settings/Circuit: Bridge.
Settings/Method: Transfer factor.
Resistive Strain Sensor/ Status: On.
Resistive Strain Sensor/ Sensitivity: S=4/(2*K).

11. Twisting Strain. 4 resistive strain sensors, R4≈R3≈R2≈R1. Temperature compensation — yes.





Configuration:
Settings/Circuit: Bridge.

Settings/Method: Transfer factor.
Resistive Strain Sensor/ Status: On.
Resistive Strain Sensor/ Sensitivity: S=4/(4*K).

K – sensitivity of resistive strain sensor (datasheet value).

Relative Strain Measurement with ZETSENSOR

The strain of the analyzed object leads to a relative change in output voltage from strain-gauge half-bridge (or full-bridge) circuits. The relative change of the output voltage is described by formula $\Delta U = e_0/U$ (mV/V),

where e_0 is the change in output voltage of strain-gauge circuit

U is power voltages of strain-gauge circuit

The calculated relative strain ε_0 (mm/m) is correlated to recorded value of the relative change in the output voltage of strain-gauge circuit according to the formula:

$$\varepsilon_0 = \Delta U * S$$

where **S** is the sensitivity of the applied strain-gauge connection circuit (the formula for calculation is shown in table 1 and depends on the selected connection circuit)

When recording the relative strain with ZETSENSOR modules, **Relative strain** should be selected as measuring type in the Device Manager, and the adjusted (depending on the required strain measurement units) value of the sensitivity coefficient in accordance with Table 2 shall be set.

Table 2

Strain measurement units	Adjustment of sensitivity set for ZETSENSOR
mm/m	S
µm/m	S*1000
m/m	S/1000
%	S/10

Material voltage measurement with ZETSENSOR

The voltage occurring in the material can be calculated within its elastic strain according to the strain of the analyzed object, which is associated with the recorded (using ZETSENSOR) relative change in the output voltage of the half-bridge or full-bridge circuit according to the formula: $\varepsilon_0 = \Delta U * S$,

where **S** is the sensitivity of the applied strain-gauge connection circuit (the formula for calculation is shown in Table 1 and depends on the selected connection circuit)
Note: When measuring the voltage, the sensitivity ratio should be adjusted according to the formula S/10
Material voltage is related to its relative strain according to the formula:

$$\sigma = \varepsilon_0 * E = \Delta U * S * E$$

where **E** is the modulus of elasticity of the material of the analyzed object (values for the modulus of elasticity of certain materials are provided in Table 3)

Table *3*

Material	Value of the Modulus of Elasticity E (MPa)
Aluminum	69000
Copper	100000
Steel	210000
Glass	60000
Concrete	20000

When recording the material voltage change with ZETSENSOR modules, **Stress** should be selected as measuring type in the Device Manager, and the adjusted for % units (see Table 2) value of the sensitivity coefficient, along with the material-specific modulus of elasticity **E,** shall be set for the analyzed object.

Torque Measurement with ZETSENSOR

The torque causes strain of the shaft, which is recorded on its surface as the relative change in output voltage from the strain-gauge half-bridge (full-bridge) circuits **ΔU =** e_0**/U** (mV/V). The torque **M** (Nm) is measured according to the formula:

M= ΔU*Stq

where ***Stq*** is sensitivity for torque measurement

The formula for **Stq** calculation for solid shafts:

$$Stq=S*E*\pi*D^3/(1000*16*(1+v))$$

where **S** is the sensitivity of the applied strain-gauge connection circuit (the formula for calculation is shown in Table 1 and depends on the selected connection circuit)

E is the modulus of elasticity of the shaft material

D is shaft diameter

v is Poisson's ratio for the shaft material (the ratio values for certain materials are provided in Table 4)

The formula for **Stq** calculation for hollow shafts:

$$Stq=S*E*\pi*D^3*(1-d^4/D^4)/(1000*16*(1+v))$$

where **d** is the internal diameter of the hollow shaft

When recording the torque with ZETSENSOR modules, **Relative Strain** should be selected as measuring type in the Device Manager, and the calculated sensitivity value **Stq** shall be specified.

Table *4*

Material	Value of Poisson's Ratio
Aluminum	0,34
Copper	0,35
Steel	0,28

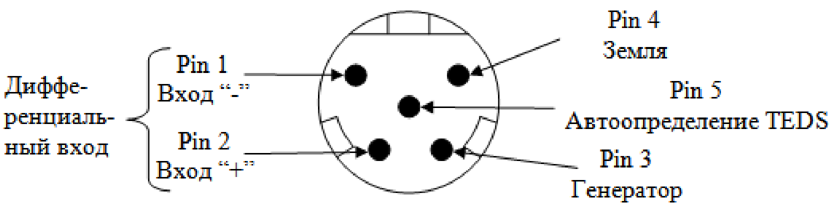
Connecting bridge circuits to the strain measurement data acquisition modules .....

Connecting Strain Gauge Sensing Elements to ZET-017-T8 Strain Gauge Module

This section describes the layouts of resistive strain sensor connection to ZET 017-T8 strain-gauge module and issues of measurements using ZETLAB TENZO software supplied with strain-gauge modules.

ZET 017-T8 strain-gauge module has miniXLR 92M-502 input channels and is supplied with cables for connection of strain-gauge sensing elements and resistive strain sensors for each channel.

Strain Gauge Module inputs



Strain Gauge Module inputs

Input Channel Connector of Strain Gauge Module	Cable Terminals
Input -	Sig -
Input +	Sig +
Generator	EXC +
Ground	EXC -
TEDS Autodetect	—

Input- and Input+ contact points form the differential input of the strain-gauge module which receives the signal from sensor (strain-gauge bridge).
Generator contact point is designed for supplying the power to sensor from an integrated generator of strain-gauge module. The generator is controlled via Signals generator software, and the signal is forwarded to all strain-gauge module channels.

Note: *The generator also has a BNC output on the rear panel of strain-gauge module.*

Measurements are performed via Strain Gauge software. There is a separate software facility for each of the channels. One can use several software facilities for a single measuring channel and adjust them for measurement of various parameters according to the relevant calibration graphics. All settings are made in the Options window "Configuring the strain Gauge Meter" . Besides the "Device Manager" software application allows to assign signal conversion frequencies and measuring channels names.

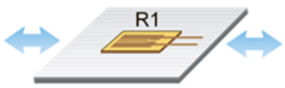
The signal at the strain-gauge sensor output is proportional to the supplied power and applied load, thus, in order to obtain the measured values it is necessary to perform relative measurements, i.e. take into account the circuit power. For this purpose one can use generator virtual channel or strain-gauge module input channel.
The Strain Gauge program displays the current measured value as well as creates a virtual channel available for display on a multi-channel oscillographic, signal parameters recorder, and in other ZETLAB TENZO software facilities.

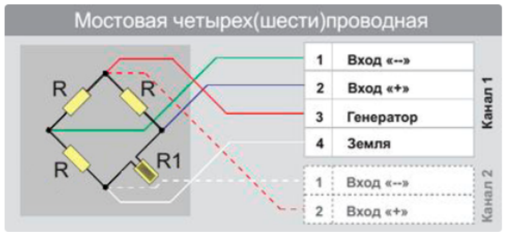
The resistive strain sensors are designed for measuring the voltage on surface of different elements. They can be used to measure compression and stretch, twisting, bending, and calculate the force applied to an object.
Below you can find various connection pattern options for connecting the resistive strain sensors to Strain-gauge station , as well as instruction on module configuration.

Note: Formula for calculating the sensitivity coefficient S is given for units of measure mm/m, *KR* – sensitivity of resistive strain sensor (datasheet value), *ν – Poison's ratio*.

Table 1

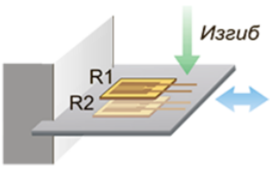
1. Uniaxial Strain. 1 resistive strain sensors, 3 resistance, R≈R1. Temperature compensation — no. Bending compensation — no.

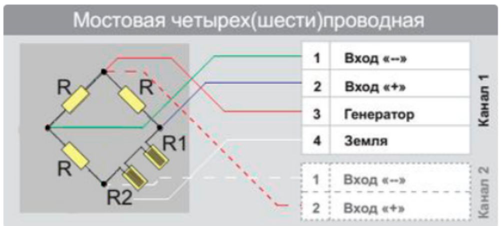




	Four-wire circuit	Six-wire circuit
Parameters/Measurement	*Relative*	Relative, or Relative + Alternating current
Measurement channel		Channel 1
Reference channel	Generator 1	Channel 2
Parameters/Coefficient		S=4/KR

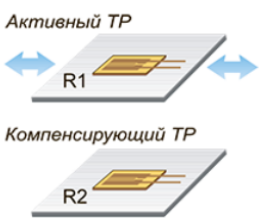
2. Uniaxial Strain. 2 resistive strain sensors, 3 resistance, R≈R1+R2. Temperature compensation — no. Bending compensation — yes.

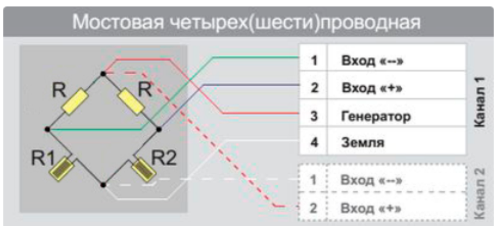




	Four-wire circuit	Six-wire circuit
Parameters/Measurement	*Relative*	Relative, or Relative + Alternating current
Measurement channel		Channel 1
Reference channel	Generator 1	Channel 2
Parameters/Coefficient		S=4/(2·KR)

3. Uniaxial Strain. 2 resistive strain sensors, 2 resistance, R≈R1≈R2. Temperature compensation — yes. Bending compensation — no.

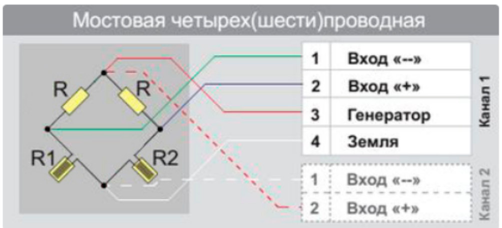




	Four-wire circuit	Six-wire circuit
Parameters/Measurement	*Relative*	Relative, or Relative + Alternating current

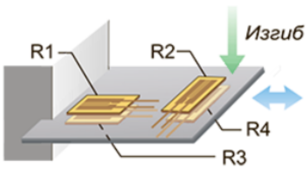
Measurement channel		Channel 1
Reference channel	Generator 1	Channel 2
Parameters/Coefficient		S=4/KR

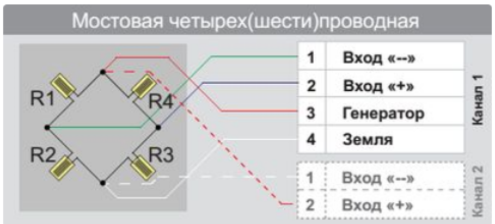
4. Uniaxial Strain. 2 resistive strain sensors, 2 resistance, R≈R1≈R2. Temperature compensation — yes. Bending compensation — no.



	Four-wire circuit	**Six-wire circuit**
Parameters/Measurement	*Relative*	Relative, or Relative + Alternating current
Measurement channel		Channel 1
Reference channel	Generator 1	Channel 2
Parameters/Coefficient		S=4/((1+ν)·KR)

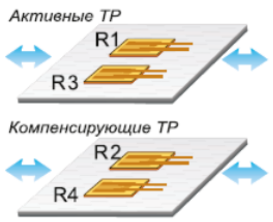
5. Uniaxial Strain. 4 resistive strain sensors, R4≈R3≈R2≈R1. Temperature compensation — yes. Bending compensation — yes.

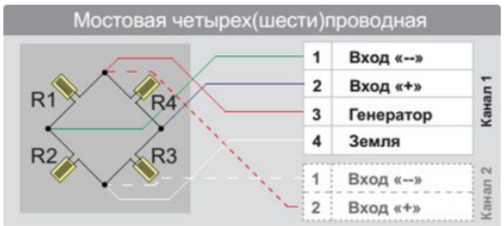




	Four-wire circuit	**Six-wire circuit**
Parameters/Measurement	*Relative*	Relative, or Relative + Alternating current
Measurement channel		Channel 1
Reference channel	Generator 1	Channel 2
Parameters/Coefficient		S=4/((1+ν)·2·KR)

6. Uniaxial Strain. 4 resistive strain sensors, R4≈R3≈R2≈R1. Temperature compensation — yes. Bending compensation — no.

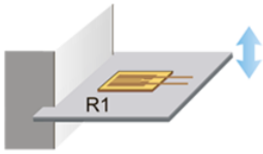


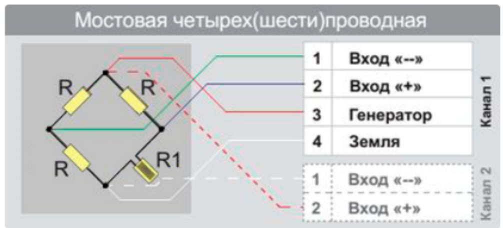


	Four-wire circuit	**Six-wire circuit**
Parameters/Measurement	*Relative*	Relative, or Relative + Alternating current

Measurement channel		Channel 1
Reference channel	Generator 1	Channel 2
Parameters/Coefficient		S=4/(2·KR)

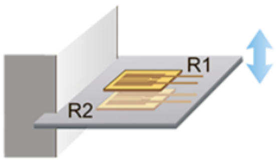
7. Bending Strain. 1 resistive strain sensors, 3 resistance, R≈R1. Temperature compensation — no.

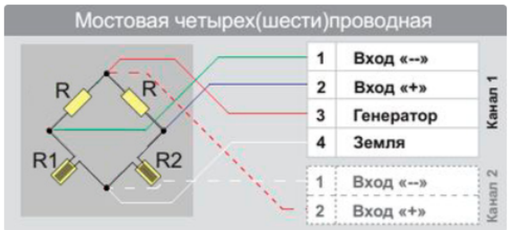




	Four-wire circuit	**Six-wire circuit**
Parameters/Measurement	*Relative*	Relative, or Relative + Alternating current
Measurement channel		Channel 1
Reference channel	Generator 1	Channel 2
Parameters/Coefficient		S=4/KR

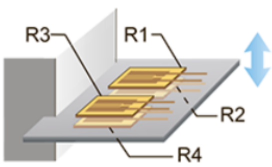
8. Bending Strain. 2 resistive strain sensors, 2 resistance, R≈R2≈R1. Temperature compensation — yes.

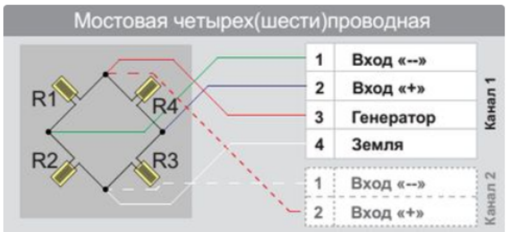




	Four-wire circuit	**Six-wire circuit**
Parameters/Measurement	*Relative*	Relative, or Relative + Alternating current
Measurement channel		Channel 1
Reference channel	Generator 1	Channel 2
Parameters/Coefficient		S=4/(2·KR)

9. Bending Strain. 4 resistive strain sensors, R4≈R3≈R2≈R1. Temperature compensation — yes.

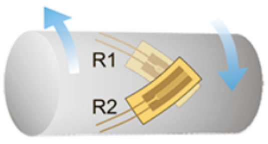


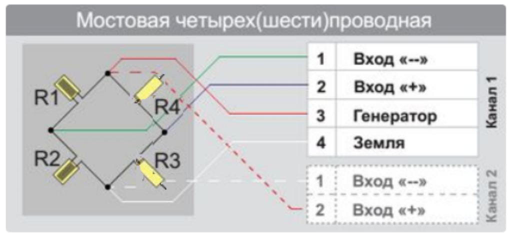


	Four-wire circuit	**Six-wire circuit**
Parameters/Measurement	*Relative*	Relative, or Relative + Alternating current
Measurement channel		Channel 1
Reference channel	Generator 1	Channel 2

Parameters/Coefficient	S=4/(4·KR)

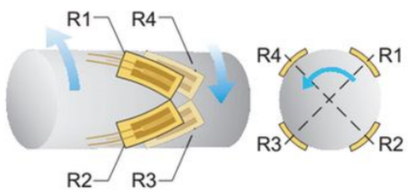
10. Twisting Strain. 2 resistive strain sensors, 2 resistance, R≈R2≈R1. Temperature compensation — yes.

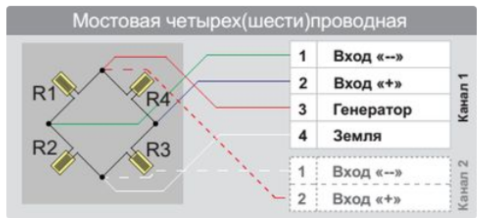




	Four-wire circuit	Six-wire circuit
Parameters/Measurement	*Relative*	Relative, or Relative + Alternating current
Measurement channel	Channel 1	
Reference channel	Generator 1	Channel 2
Parameters/Coefficient	S=4/(2·KR)	

11. Twisting Strain. 4 resistive strain sensors, R4≈R3≈R2≈R1. Temperature compensation — yes.





	Four-wire circuit	Six-wire circuit
Parameters/Measurement	*Relative*	Relative, or Relative + Alternating current
Measurement channel	Channel 1	
Reference channel	Generator 1	Channel 2
Parameters/Coefficient	S=4/(4·KR)	

K – sensitivity of resistive strain sensor (datasheet value).

Relative Strain Measurement with ZETSENSOR

The strain of the analyzed object leads to a relative change in output voltage from strain-gauge half-bridge (or full-bridge) circuits. The relative change of the output voltage is described by formula $\Delta U = e_0 / U$ (mV/V),
where e_0 is the change in output voltage of strain-gauge circuit
U is power voltages of strain-gauge circuit
The calculated relative strain ε_0 (mm/m) is correlated to recorded value of the relative change in the output voltage of strain-gauge circuit according to the formula:

ε_0 = ΔU*S

where **S** is the sensitivity of the applied strain-gauge connection circuit (the formula for calculation is shown in Table 1 and depends on the selected connection circuit)
When recording the relative strain with ZETSENSOR modules, **Relative Strain** should be selected as measuring type in the Device Manager, and the adjusted (depending on the required strain measurement units) value of the sensitivity coefficient in accordance with Table 2 shall be set.

Table 2

Strain measurement units	Adjustment of sensitivity set for ZETSENSOR
mm/m	S
µm/m	S*1000
m/m	S/1000
%	S/10

Material voltage measurement with ZETSENSOR

The voltage occurring in the material can be calculated within its elastic strain according to the strain of the analyzed object, which is associated with the recorded (using ZETSENSOR) relative change in the output voltage of the half-bridge or full-bridge circuit according to the formula: **ε_0 = ΔU*S**,

where **S** is the sensitivity of the applied strain-gauge connection circuit (the formula for calculation is shown in Table 1 and depends on the selected connection circuit)
Note: When measuring the voltage, the sensitivity ratio should be adjusted according to the formula S/10
Material voltage is related to its relative strain according to the formula:
$\sigma=\varepsilon_0$*E= ΔU*S*E

where **E** is the modulus of elasticity of the material of the analyzed object (values for the modulus of elasticity of certain materials are provided in Table 3)

Table 3

Material	Value of the Modulus of Elasticity E (MPa)
Aluminum	69,000
Copper	100,000
Steel	210,000
Glass	60,000
Concrete	20,000

When recording the material voltage change with ZETSENSOR modules, **Stress** should be selected as measuring type in the Device Manager, and the adjusted for % units (see Table 2) value of the sensitivity coefficient, along with the material-specific modulus of elasticity **E,** shall be set for the analyzed object.

Torque Measurement with ZETSENSOR

The torque causes strain of the shaft, which is recorded on its surface as the relative change in output voltage from the strain-gauge half-bridge (full-bridge) circuits **ΔU = e_0/U** (mV/V). The torque **M** (Nm) is measured according to the formula:
where ***Stq*** is sensitivity for torque measurement
The formula for **Stq** calculation for solid shafts:

Stq=S*E*π*D^3/(1000*16*(1+ν))
where **S** is the sensitivity of the applied strain-gauge connection circuit (the formula for calculation is shown in Table 1 and depends on the selected connection circuit)
E is the modulus of elasticity of the shaft material
D is shaft diameter
ν is Poisson's ratio for the shaft material (the ratio values for certain materials are provided in Table 4)
The formula for **Stq** calculation for hollow shafts:
Stq=S*E*π*D^3*(1-d^4/D^4)/(1000*16*(1+ν))
where **d** is the internal diameter of the hollow shaft
When recording the torque with ZETSENSOR modules, **Relative Strain** should be selected as measuring type in the Device Manager, and the calculated sensitivity value **Stq** shall be specified.

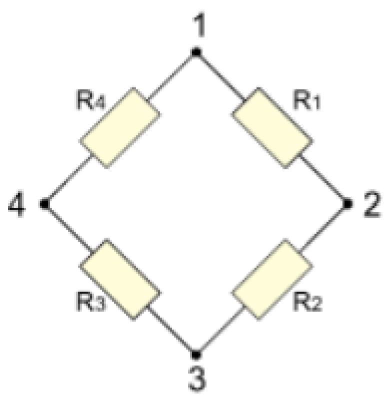
Table *4*

Material	Value of Poisson's Ratio
Aluminum	0,34
Copper	0,35
Steel	0,28

Strain-gauge bridge testing .....

This section addresses the issue of strain-gauge bridge testing.
To test the operation capacity of a strain-gauge bridge, make sure that all the resistive strain sensors are functioning properly and the circuit is powered.

Testing without load



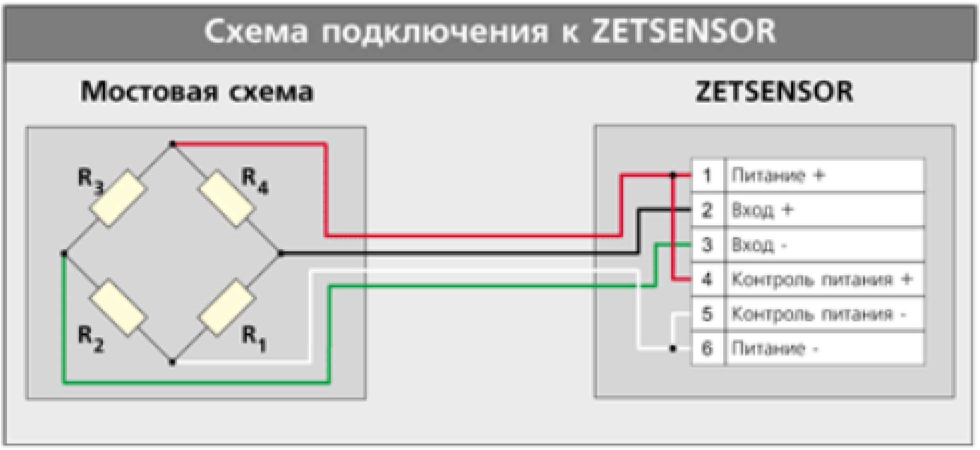
In order to test the operability of all resistive strain sensors of the strain-gauge bridge, the resistance of diagonals and sides of circuit shall be tested without any load.
Let us consider a case with 200 Ohm resistance of R1, R2, R3, and R4 resistive strain sensors. In this case:

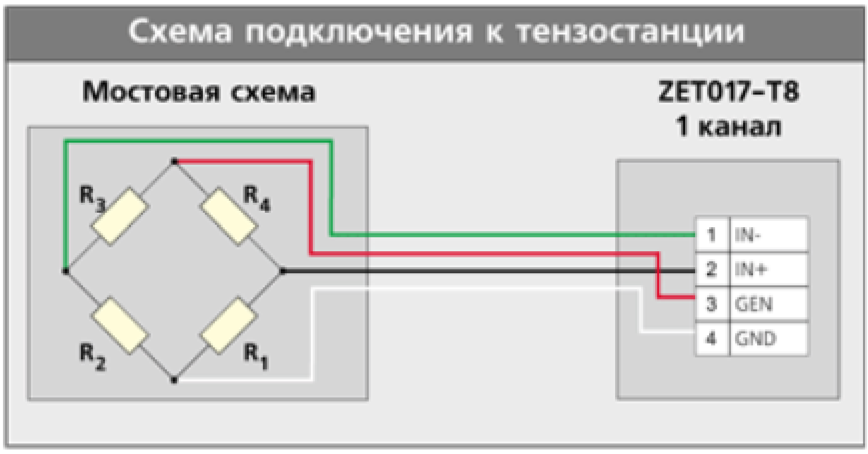
- the resistance of diagonals (i.e. resistance between points 1 and 3 and between points 2 and 4) shall be 200 Ohm,
- the resistance of sides (i.e. resistance between pairs of points 1-2, 2-3, 3-4, 4-1) shall be 150 Ohm (i.e. 3/4 of 200 Ohm).

Load Testing

The circuit shall be powered, for example, from ZET 017-T8 strain-gauge module or ZET 7010 or ZET 7110 module with DC voltage of U V.

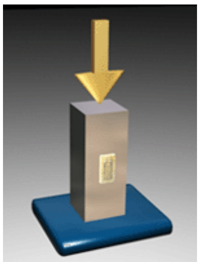
1. Measure the power voltage between GND and GEN points in case of connection to strain-gauge module, and between Power+ and Power- in the case of connection to ZETSENSOR module. It shall be U V.
2. Measure the voltage between GND and IN+ points in case of connection to strain-gauge module, and between Input+ and Power- in case of connection to ZETSENSOR module. It shall be 0.5ЧU V.
3. Measure the voltage between GND and IN- points in case of connection to a strain-gauge module, and between Input- and Power- in case of connection to ZETSENSOR module. It shall be 0.5ЧU V.





Application of meter resistances for measuring physical quantities .....

The required physical values can be estimated by measuring the strain of working medium caused by force, pressure, displacement, etc. The strain is measured by resistive strain sensors. The Fig.s below depict examples of various parameter measurements using resistive strain sensors:



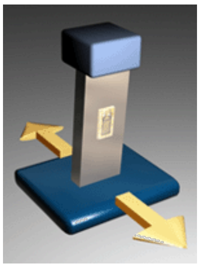
Force Measurement

Force Measurement

A resistive strain sensor attached to the working medium of the sensor, which serves as support for weight or applied effort, can measure the force directed at this support or the weight lying on it.

The sensors can be selected in the following Table of contents:

- Force sensors
- Strain-gauge sensors
- Resistive strain sensors



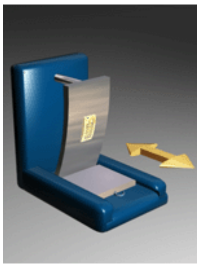
Vibration /Acceleration Measurement

Vibration /Acceleration Measurement

A resistive strain sensor attached to a thin elastic plate allows to measure the frequency and the amplitude of the vibration and acceleration affecting this plate.

The sensors can be selected in the following Table of contents:

- Accelerometers
- Resistive strain sensors



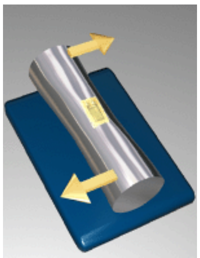
Measurement of displacement

Measurement of displacement

A resistive strain sensor attached to an elastic element allows to determine the bending force on this elastic element, thus allowing to measure the displacement causing this bending force.

The sensors can be selected in the following Table of contents:

- Displacement sensors
- Resistive strain sensors



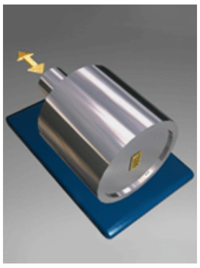
Torque measurement

Torque Measurement

A resistive strain sensor attached to a drive shaft of car engine or a torsion shaft of drilling machine allows to measure the transmission force, i.e. the torque of this shaft.

The sensors are available in the following Table of contents:

- Torque sensors
- Resistive strain sensors



Pressure Measurement

Pressure Measurement

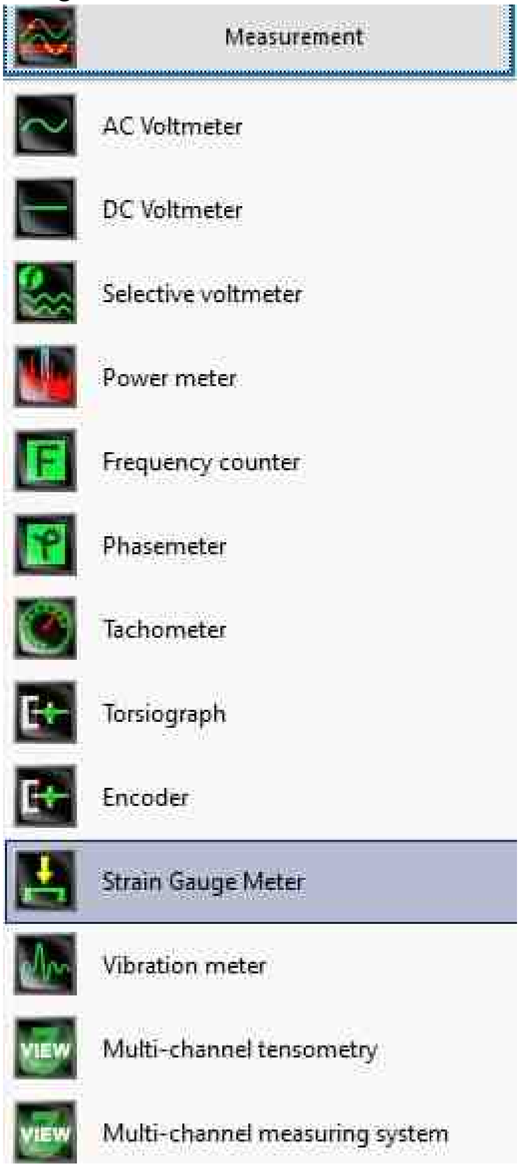
A resistive strain sensor attached to a diaphragm (membrane) allows to determine the air or liquid pressure on this diaphragm. The resistive strain sensor is typically attached to the back of the diaphragm to avoid sensor damage due to direct pressure of air or liquid.

The sensors can be selected in the following Table of contents:

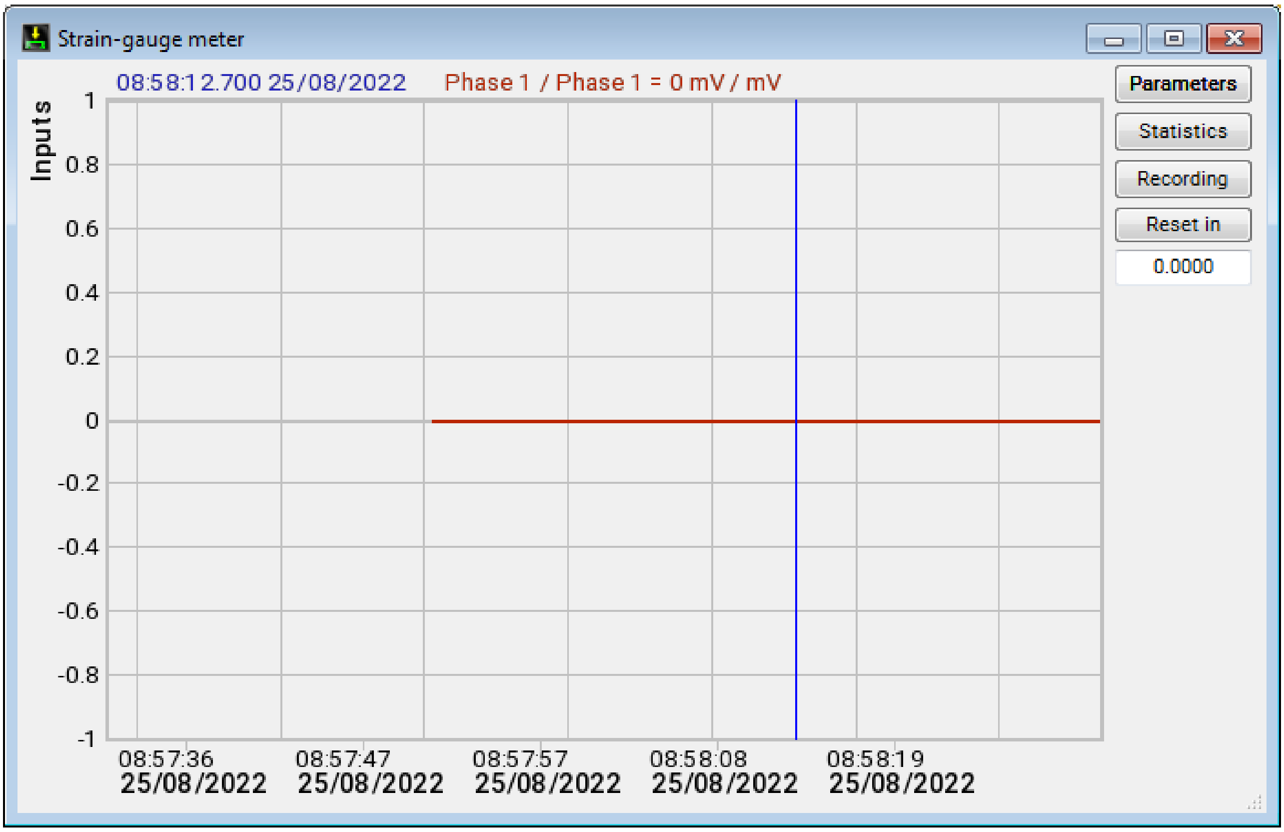
- Pressure sensors
- Resistive strain sensors

Program description .....

To launch the **Strain Gauge Meter** program, select the **Strain Gauge Meter** command from the **Measurement** menu on the ***ZETLab*** panel. The **Strain Gauge Meter** program working window will be displayed. The heading of the program window will contain the program name and the name of the channel used for frequency measuring.



Starting of a Strain Gauge Meter

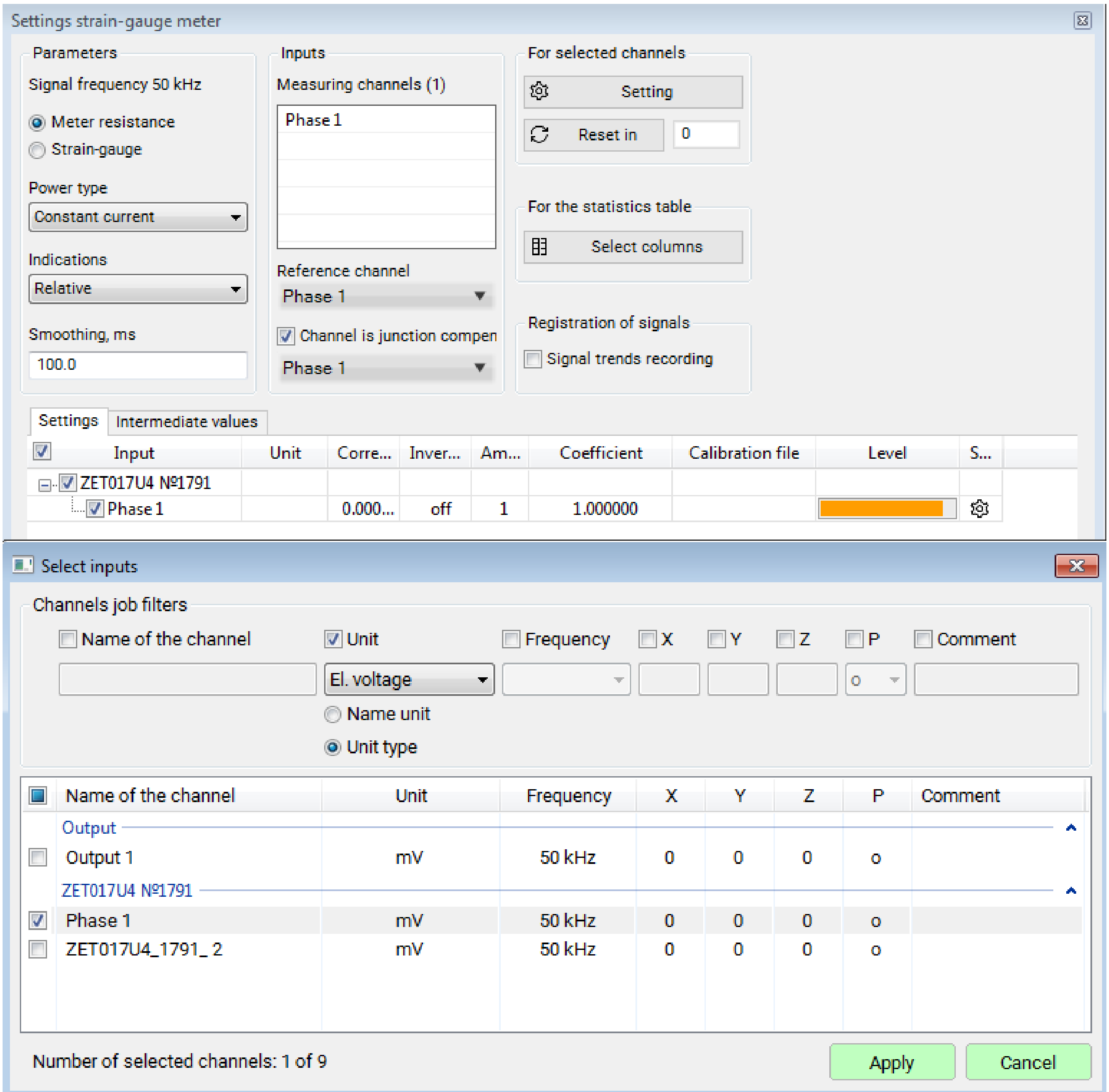


Strain Gauge Meter

Note: The program can also be launched directly from the ***ZETLab*** working directory (by default: C:\ZETLab\). Executable file name: TenzoMeter.exe.exe

In the left part of the main window of the strain-gauge is a graphical indicator that displays the measured force value. Force is measured in Newtons (N) or kilogram-force (kgf). Extras can be measured by various values that are used when measuring with the use of piezoresistive sensors. The units are installed in the window Configuring the strain Gauge Meter.

To the right of the indicator measurement results are the selection fields of the measuring and reference channels in the form of lists:



Select of the reference channel

As the measuring channel select the enabled physical channel that is connected to the strain gauge. As a channel you can also select virtual channel, for example, after filtering of the signal. The reference channel used when performing relative measurements. List box, select the reference channel will be available to select a channel only when the flag is relative to the settings window strain gauge (see the description in section Configuring the Strain Gauge Meter).

To select the required channel in two ways:

- click on the arrow field and "mouse" choose from the expanded list channel;
- click the left button of "mouse" on the field and use the roller mouse, or the keyboard up and down arrows to select a channel.

In the box to the right of the Reset button in exposed balance value in the specified units of measurement. If there is an imbalance of the device and in the absence of the effort meter shows a value in the field is necessary to set the value to 0 and click on the Reset button in, while further measurements are made with respect to balancing.

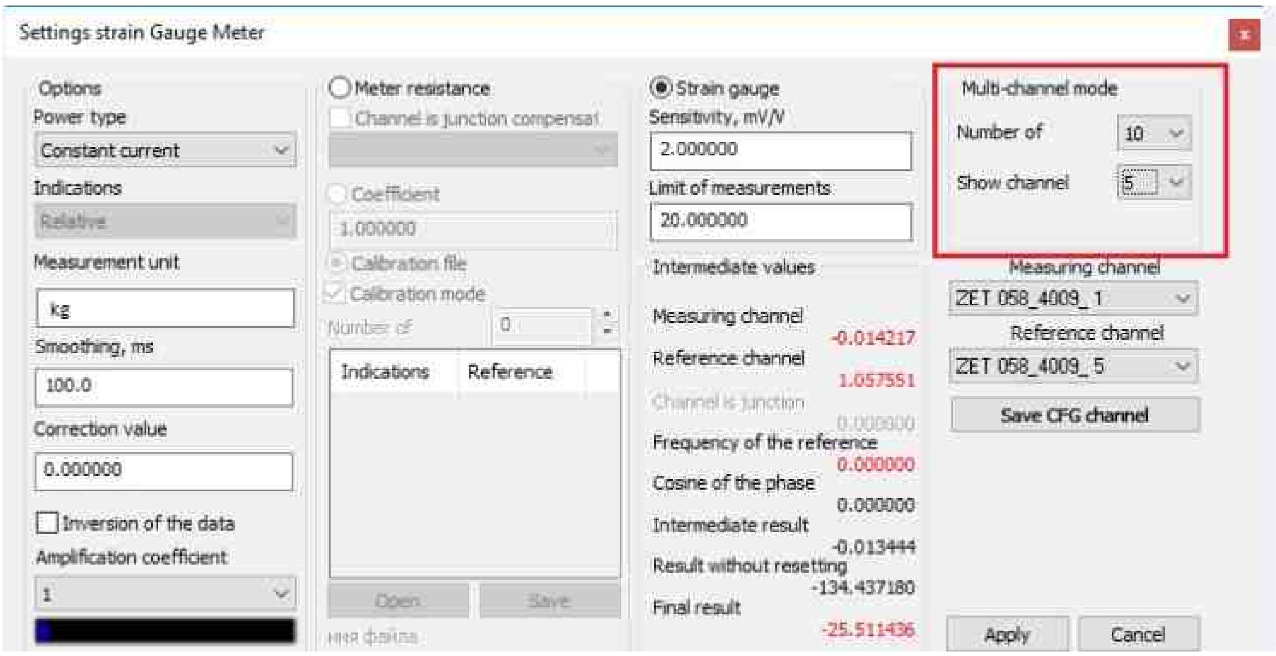
The **Options** button is used to open the window **Setting of meter parameters** (setting the program parameters **Strain Gauge Meter**).

Attention

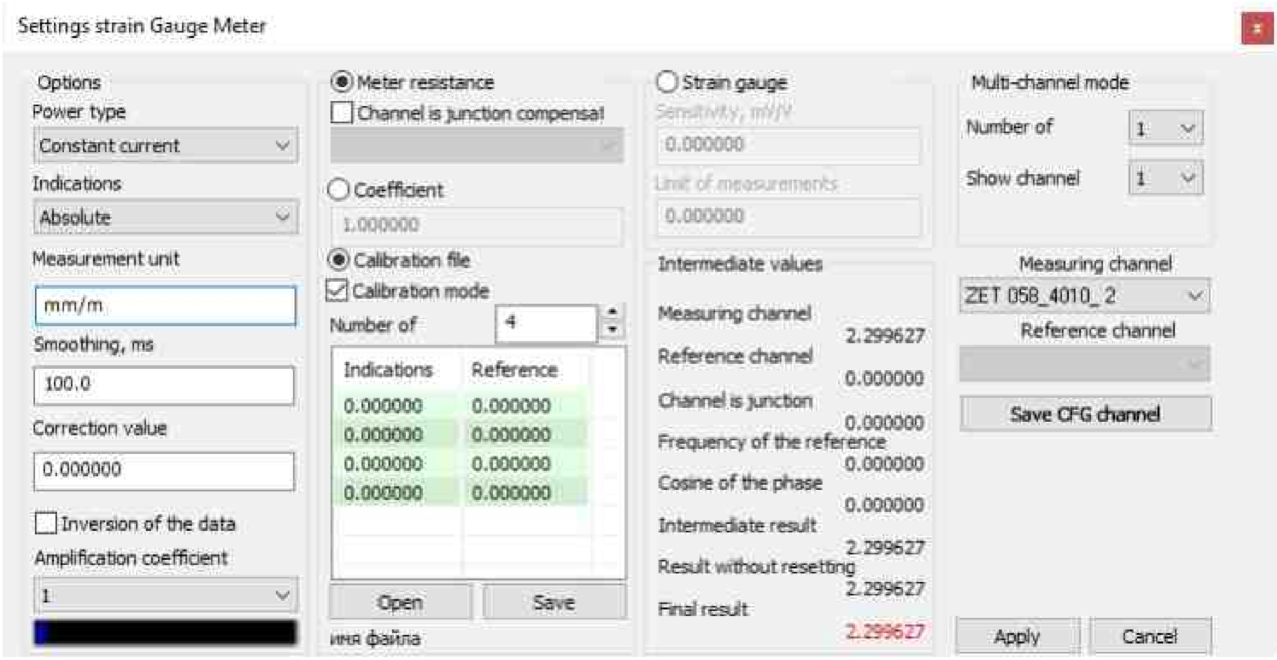
Failure of the programs included into the scope of ZETLAB Software package may be attributed to electrical crosstalk. In order to check operational capacity of the device, establish Ethernet connection and start the corresponding programs. Detailed description of establishing Ethernet connection is available in user manual (to enter the user manual section, start ZETLAB control panel, press F1 key and select the clause "Connection via Ethernet").
If the device and the program operate in normal mode, you can continue using Ethernet connection.

Strain-gauge meter setting .....

When you press the left button of the mouse on the **Options** button located in the right part of the main window of the strain-gauge logger, the view settings of the **Strain Gauge Meter** .



Setup of Strain Gauge Meter when connecting the strain gauge

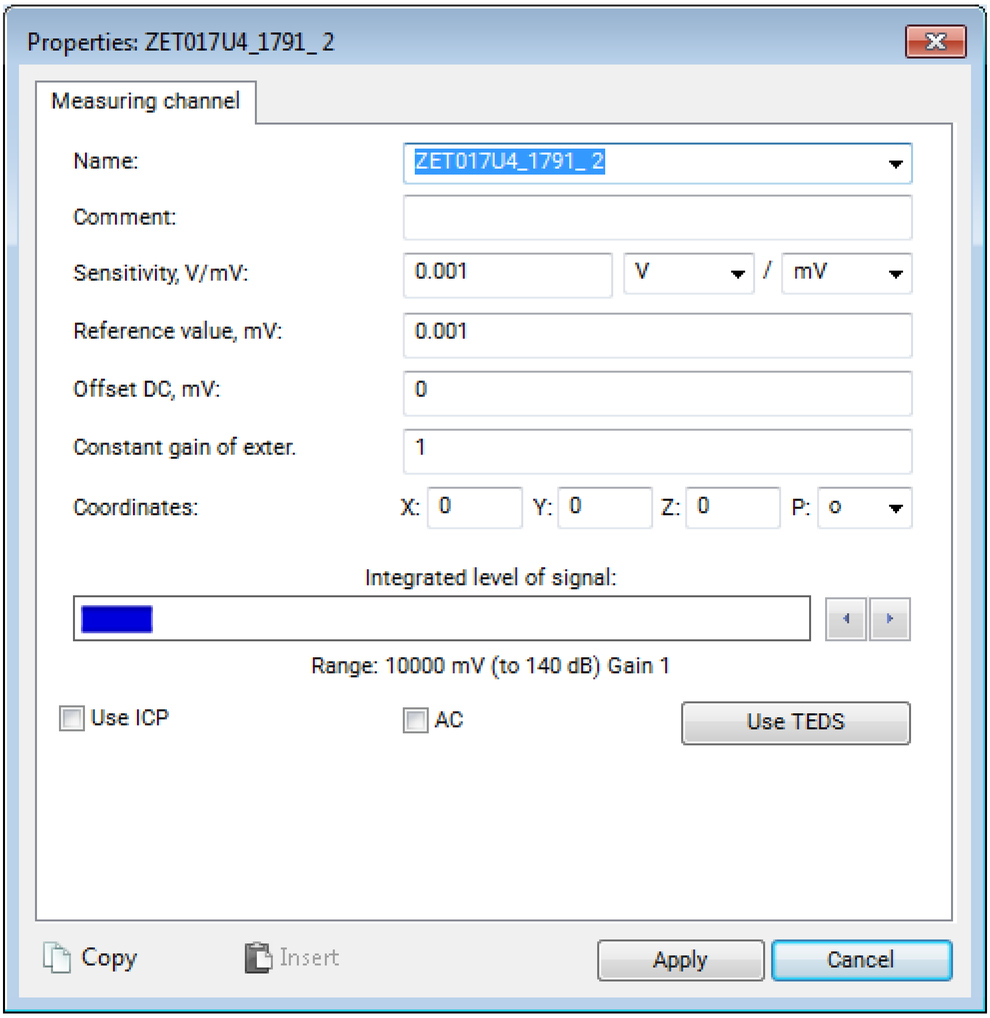


Setup of Strain Gauge Meter when select the columns to be displyed

Carry out the settings necessary to program the strain-gauge correctly display the measured value relative to the calibration table or the strain-gauge parameters in the measurement units that will be specified in the settings window of the meter. Otherwise, in the absence of calibration tables or parameters of the strain gauge, the program will show the ratio of the signal levels of the measuring and reference channels.

The channels parameters

Note: the measuring and reference channels should have the default settings (set in program "Device Manager"):



Settings of the measuring channel

Units

In the input field of the frame Unit is entered the unit of measure (for example N, kgf, kg, times, etc.) against which you will measure. When you connect the force sensors and strain-gauges in the Unit field indicates the unit of measurement according to the passport on the sensor.

Measurement

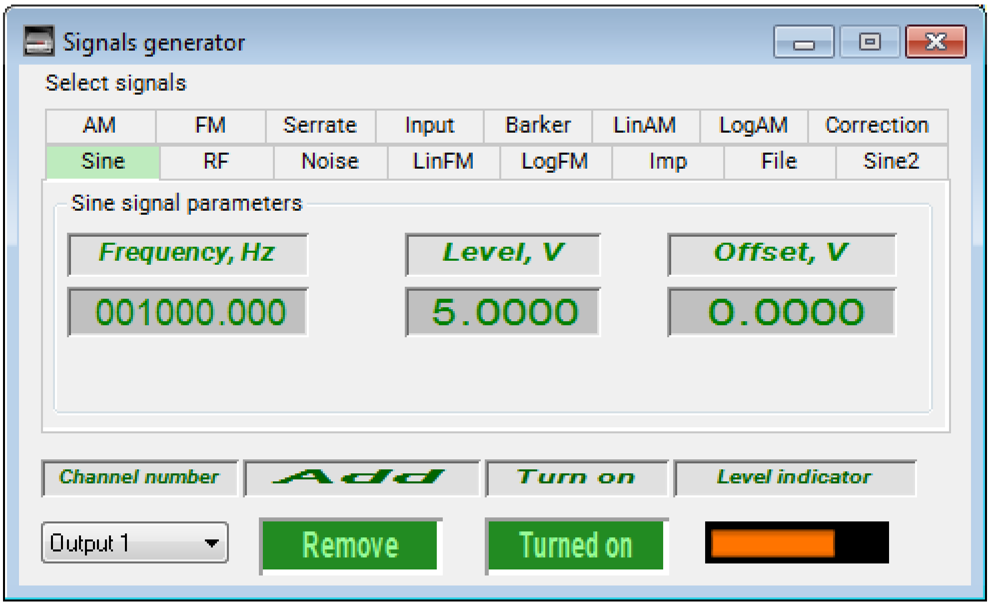
If the flag is Relative to the frame Measurements will be relative measurements (calculated the ratio of the signal level of the measuring channel to the signal level of the reference channel).

When removing the flag Relative will be absolute measurements (returns the value of the signal level of the measuring channel), the reference channel in the program the strain gauge is not available.

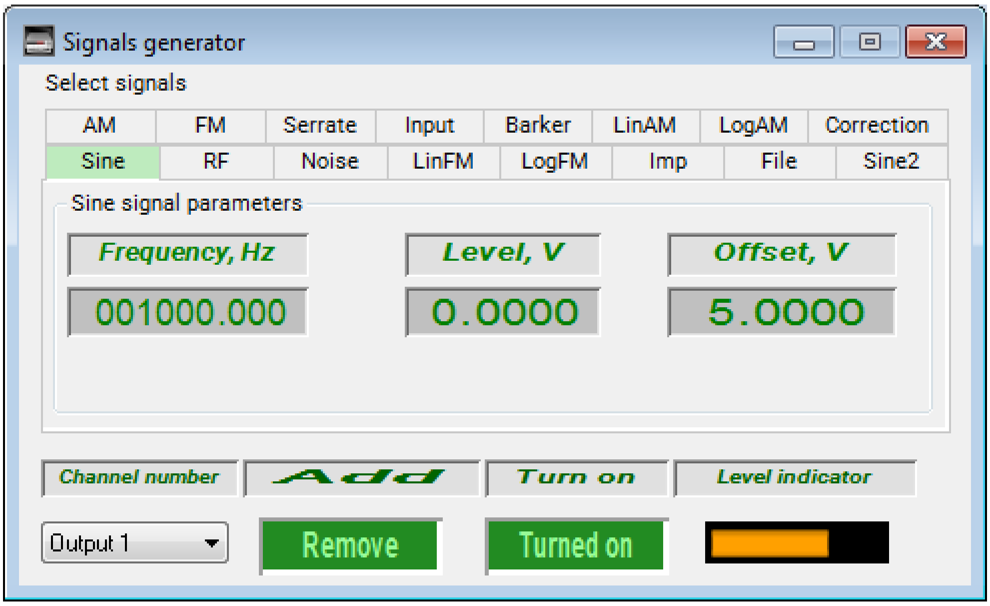
Power supply of the sensors

If the flag is Alternating current in the Measurement calculation will be performed according to the algorithm of the selective voltmeter, and, accordingly, the measuring scheme (transducer) needs to be powered with alternating current. When removing the flag Alternating current calculation will be carried out according to the algorithm of the DC voltmeter, and, accordingly, the measuring scheme (transducer) needs to be powered with constant current.

Note: the power supply of the sensors and bridge circuits can be powered from the integrated generator of the strain-gauge station, the power settings are set in the program signal Generator:



Power sensors AC 5 V



Power sensor DC 5 V

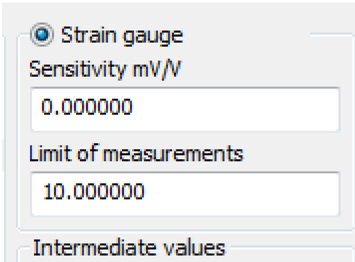
Recommended frequency power supply of strain gauges ranges from 80 - 1500 Hz (it is not recommended to choose a frequency of 50 Hz). At check melanoprotein processes choose the minimum frequency signal to energize the strain gauge. For measuring the parameters of fast processes require high frequency power to the sensor. The sample rate generator must be several times higher than the required sampling frequency of the sensor signal, and the frequency power sensor - frequency range of the signal..Recommended frequency power supply of strain gauges ranges from 80 - 1500 Hz (it is not recommended to choose a frequency of 50 Hz). At check melanoprotein processes choose the minimum frequency signal to energize the strain gauge. For measuring the parameters of fast processes require high frequency power to the sensor. The sample rate generator must be several times higher than the required sampling frequency of the sensor signal, and the frequency power sensor - frequency range of the signal.

Smoothing

In the field sets the Smoothing time averaging of data in microseconds. For fast processes, this parameter indicates the minimum for slow-moving - higher. The higher the time of smoothing, the less the readings affected by random components. The Smoothing parameter is similar to parameter Averaging time.

Setting the strain-gauge (force sensor)

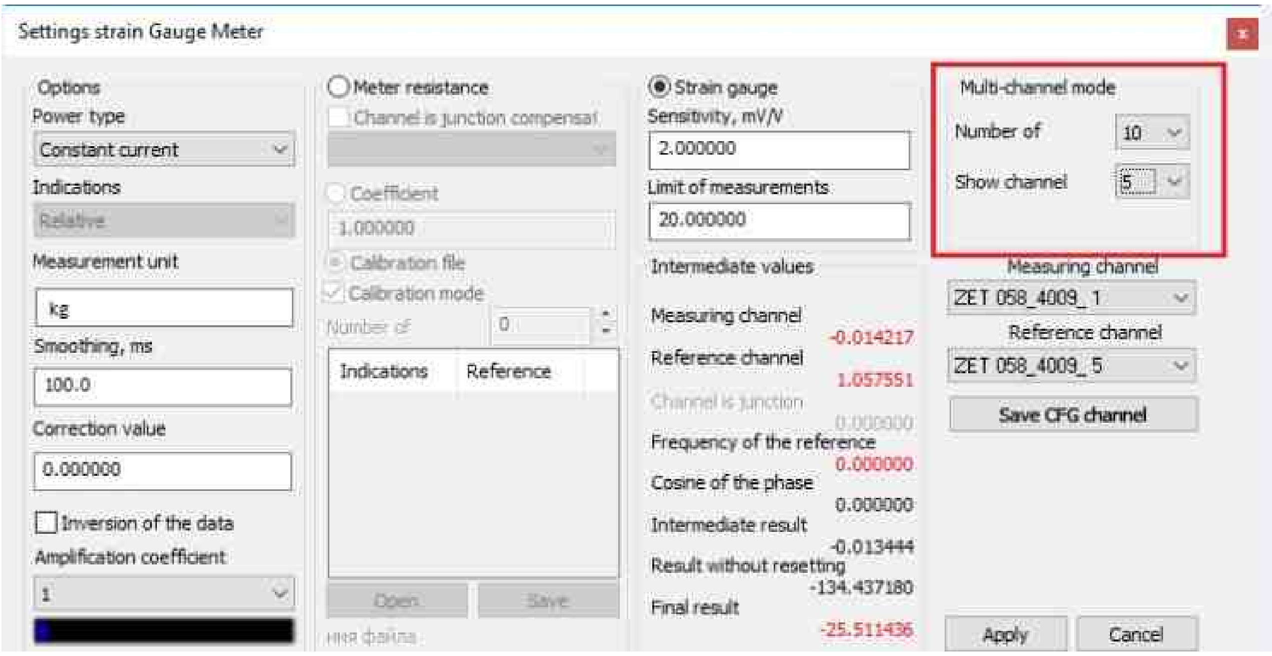
In the case of using a force sensor (strain gauge) is sufficient to indicate its sensitivity (conversion factor) and the limit of measurement specified in the passport of the sensor..In the case of using a force sensor (strain gauge) is sufficient to indicate its sensitivity (conversion factor) and the limit of measurement specified in the passport of the sensor.



Setting of force sensor

Configuration of the bridge circuit

When using strain gauges, it is necessary to fill the calibration table.

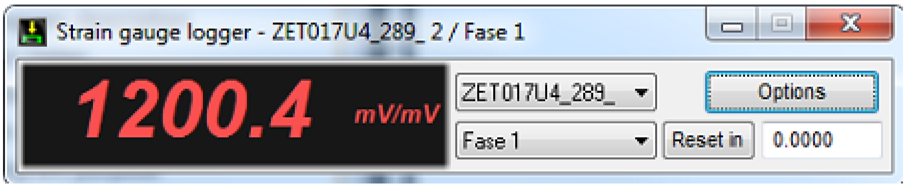


Settings of the strain-gauge circuit

Field calibration File enter the path to the file with saved settings and calibration tables. By clicking on the button located to the right of the entry field path, opens the standard window file open. In this window, specify the path and filename of the calibration file. The directory where you stored calibration files, default C:\ZETLab\config\. Calibration files have the extension *.clb.

In the framework of the Calibration table are the elements to create, edit and save calibrations.

The Calibration checkbox is used to select the display mode. If the flag is set the program **Strain Gauge Meter** will display a direct relationship of the signal levels of the measuring and reference channels without units and without taking into account the calibration table (see Fig. below). When removing the flag in the selected units, and in accordance with the calibration table.



Strain gauge, the calibration mode

In the list located to the right of the Number of points selects the required number of points for calibration of the transducer. The minimum number of points – 2, maximum – 15. To select the required number of points need to press the left button of the mouse on the list button and in the drop-down list, select the desired number of points.

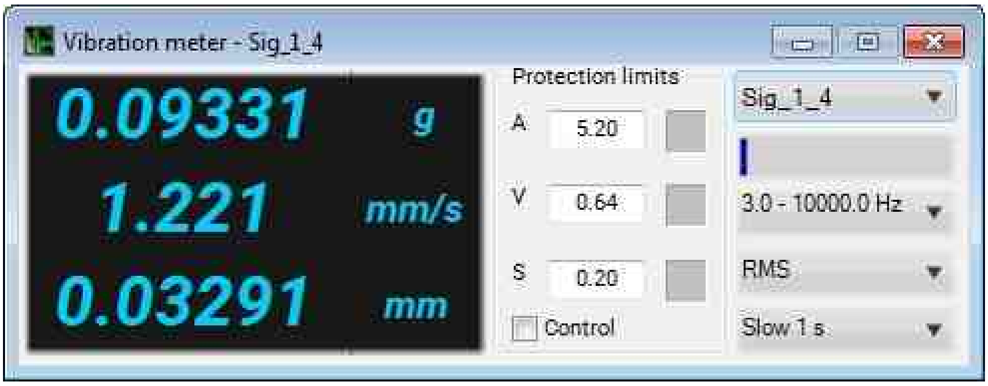
After selecting the number of points for calibration in the table below list the number of points that will display as many rows as you selected the number of points. In the left column of the calibration tables in the specified cells quantified in established units (attached load), in the right are indicated the numerical values of the signal levels corresponding quantitative expression. Numerical values are the values of the program the strain gauge in the calibration mode, ie with the flag set to Calibration.

Button to Save the calibration file is used to save calibration parameters in file. After pressing the button opens a standard dialog box to save the file. In this window you must specify the path and file name. The directory where to save the calibration file, the default C:\ZETLab\config\. Calibration files have the extension *.clb.

Program the **Strain Gauge Meter** does not hold data extrapolation, only interpolation. I.e. the interval of the displayed values is given in the calibration table as the maximum and minimum values.

Vibration meter .....

The input signal of the Vibration meter software, which is the output signal of the accelerometer, i.e. the vibrational acceleration signal, is filtered by means of one of four possible digital band filters. Then, based on this signal, vibrational velocity and displacement signals are calculated by means of integrating filters. Thus, the software generates three signals which are transferred to the ZETLAB data server virtual channels created by the program and having the word "Acceleration", "Speed" or "Displacement" in their names, respectively.
Signals are averaged for a selected time interval (0.1 s, 1 s, or 10 s), after which the obtained values are displayed in the dialog box elements of the Vibration meter program. It is possible to display a root-mean-square (RMS), average amplitude or peak value.



The program can be used within the scope of various vibration parameters control systems, e.g., in Shaker controllers.
The program is intended for PC use. The PC parameters should comply with those specified in the section "Hardware requirements" of the present user manual. The PC should have ZETLAB software installed and the ADC used should be compatible with ZETLAB Software.
The program may contain updates, that are not described in the present User manual.

If the threshold control option is used, the Operator should set the threshold values of Acceleration, vibration velocity and Displacement and then enable the threshold control option. In the case, if any of the specified threshold values is exceeded:

· the value indicator is highlighted with red color;
· ZETLAB generators receive a command to disable the output signal;
· It is also possible to produce signals of "dry contact" type – logical level "1" for a particular virtual channel and / or for the selected digital bit (in the case of their presence in the ADC used).
The duration of maintaining high logical level upon activation of the threshold control option can be set by the operator (in the range from 1 up to 100 seconds with 1 s interval).

Supported Hardware .....

The input data of the program **Vibration meter** is represented by digital channels of **ZETLAB server**.

This data contains output signal that is used for Acceleration measurements (i.e., the measured values are displayed in "*g*" or "m/s^2").

For the purpose of analog signals digital processing, it is possible to use *FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23, BK-01, noise- and vibration-meters ZET 110* and *seismic recorder ZET 048*.

The measuring channels parameters of the program are set in the program "Device Manager".

As a source of analog signal, it is possible to use the following accelerometers:

· *single-axial accelerometer BC 110, BC 111, BC 201, BC 202*;

· *single-axial seismic recorders BC 120, BC 130, BC 1311*;

· *three-axial seismic recorders BC 1313*.

The program **Vibration meter** is included into the scope of the following software packages:

- ZETLAB ANALIZ – FFT spectrum analyzer software;
- ZETLAB VIBRO – Shaker controller software;
- ZETLAB SEISMO - seismic station software;
- ZETLAB NOISE - vibration meter-noise meter software.

The program **Vibration meter** is included into the scope of the following software groups:

Operating principles .....

The input signal of the **Vibration meter** program is represented by the accelerometer output signal (i.e., by the Acceleration signal). The signal can further be processed by one of the four available digital band pass filters. Then, based on the resulting signal and with the use of integrating filters, it is possible to calculate Acceleration and Displacement values. Thus, the program generates three signals, that are further transferred to the virtual channels of ZETLAB data server. The names of the channels begin with the words "**Acceleration**", "**Velocity**" or "**Displacement**" respectively.

The signals undergo averaging for a particular time interval (0,1 s, 1 s, or 10 s). Then the accumulated values are displayed in the elements of the **Vibration meter** program dialog windows. It is also possible to display the RMS value of average amplitude or peak value.

If the threshold control option is used, the operator should set the threshold values of Acceleration, vibration velocity and Displacement and then enable the threshold control option. In the case if any of the specified threshold values is exceeded:

· *the value indicator is highlighted with red color;*

· *ZETLAB generators receive a command to disable the output signal;*

· *It is also possible to produce signals of "dry contact" type – logical level "1" for a particular virtual channel and / or for the selected digital bit (in the case of their presence in the ADC used).*

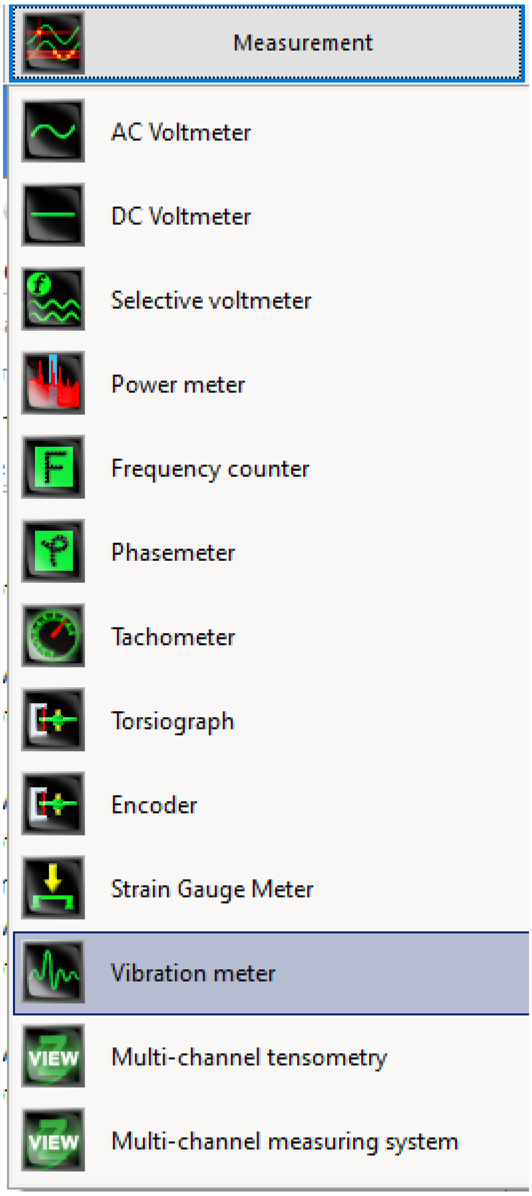
The duration of maintaining high logical level upon activation of the threshold control option can be set by the operator (in the range from 1 up to 100 seconds with 1 s interval).

The program "**Vibration meter**" begins its operation immediately upon loading completion.

During operation of the program, it is not recommended to change the sampling frequency of the ADC used and amplification ratios of the measurement channels.

Program description .....

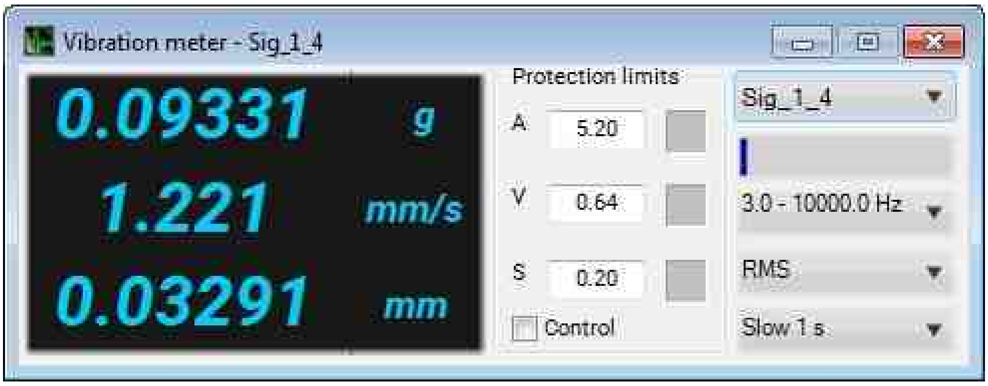
The program "***Vibration meter***" can be started from "***Measurement***" section of ZETLAB control panel. The title of the window depicts the name of the program and the name of the measurement channel used.



Starting the program Vibration meter

Note: the program "***Vibration meter***" can be started from ZETLAB directory (the directory by default: C:\ZETLAB\). The name of the file to be started: VibroMeter.exe.

The program "***Vibration meter***" has two types of dialog window: with the elements displaying the threshold level control and without them.



Vibration meter program without threshold level control elements

The left section of the program interface (green font against black background) depicts the following values:

· "**A**" – average values of Acceleration and corresponding measurement unit ("*g*" – free fall acceleration or "m/s^2");

· "**V**" – average vibration velocity value and corresponding measurement unit "*mm/s*";

· "**S**" – average Displacement value in "*mm*".

The middle section of the window ("**Protection limits**" column) contains the menu for entering the threshold values (for Acceleration, vibration velocity and Displacement – "**A**", "**V**", and "**S**" respectively). The color indicators of this section can be filled with green or red color. The red color indicates excess of the average value, the green color stands for normal level. This interface section also contains "**Control**" switch, allowing to enable/ disable the threshold control option.

The upper right section of the program contains the following control elements (in downwards order):

· the list used for ZETLAB server channel selection (to be further used as data source). This element displays the channels, that correspond to the acceleration values: "g" or "m/s^2";

· horizontal indicator of the selected signal level;

· the list for selection of band-pass filter to be used for signal filtration;

· the list for selection of values to be displayed in the left section of program window;

· signal averaging time selection menu.

The program has a set filters for the following frequency bands (the limit values of the filters correspond to filter's cutoff frequencies):

· *from 1,0 up to 200,0 Hz;*

· *from 10,0 up to 1000,0 Hz;*

· *from 3,0 up to 10000,0 Hz;*

· *from 1,0 up to 10,0 Hz.*

The specified values of filter's cutoff frequencies correspond to the sampling frequency of the 25 kHz ADC used. If the ADC used has a different sampling frequency, these values will be automatically changed by the program in accordance with digital signal processing requirements (in particular, the cutoff frequency should not be too low or to exceed 50% of the ADC's sampling frequency).

In order to use threshold level control, the operator should set the required threshold levels for all the three signals and enable the "*Control*" option. After that, the program window will increase and the section "*Dry contact's output*" will be displayed.

Vibration meter program - Threshold level control elements

As the "*Control*" option is enabled, it becomes impossible to change the threshold values, measurement units and averaging time options.

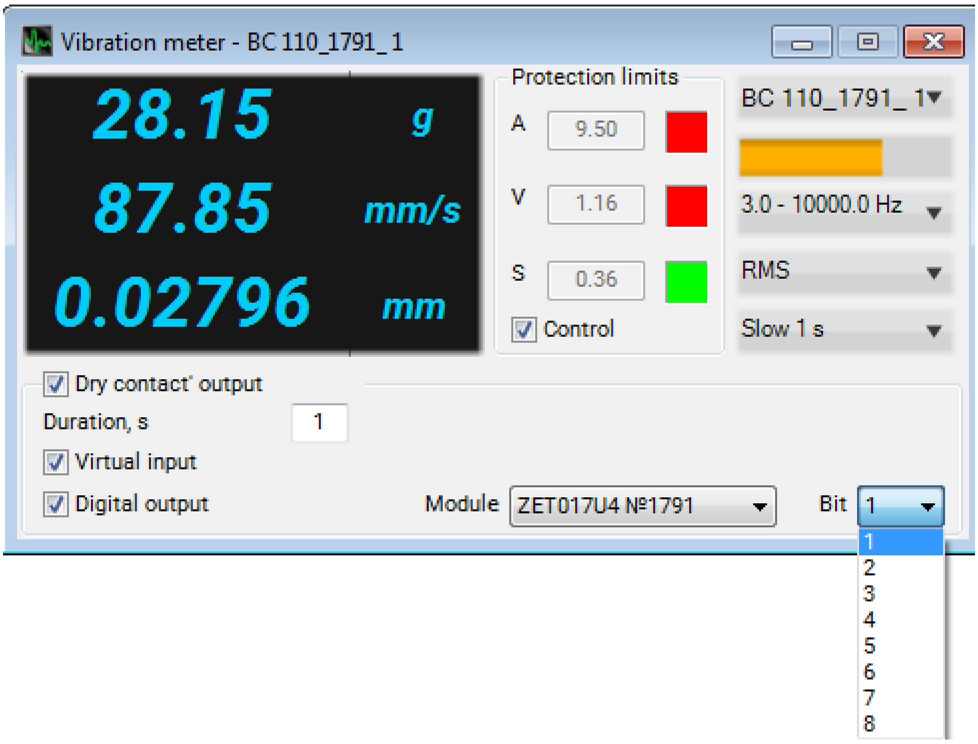
Next to the title "*Dry contact's output*" there is a switch allowing to use the signals of "dry contact" type. In the case if this option is unchecked, all the control elements of this section become unavailable.

The program allows to set "dry contact" signals of two types:

· *virtual data server channel (the name of the channel begins with "DC");*

· *digital output to one of the digital bits (in the case if they are available in ZET-device).*

The use of any of these two signals is controlled by corresponding check-boxes in the "Dry contact's output" menu. The duration of logical unit signal maintenance for these signals can be set by the operator in the range from 1 up to 100 seconds.



Vibration meter program - Dry contact output selection

Notifications of the program .....

Notifications of the program

The program can operate without participation of the operator – in this case, the messages of the program are saved to a log instead of being displayed as dialog windows. To view these messages, you can use **ZETLAB Error journal** from the "**Service**" section of ZETLAB control panel. The messages recorded by ZETLAB Software have the following format: "*Name of the program #xx. Text of the message*". In this case the name of the program is "*Vibration meter*"; xx – number of active program copy. The program saves error messages as well as parameters changes to the system log. The recorded messages allow to reproduce the sequence of program operation. It can be quite useful for the analysis of program operation errors. The table below shows the notifications of the program (the program can also produce other messages).

Text of the message	Category
Error has occurred while connecting to data server	error
Error has occurred	error
Configuration file in the folder DirConfig is not available	error
Help file does not exist	error
Help file loading error	error
Folder DirHelp is not available	error
Folder DirSignal is not available	error

Folder DirResult is not available	error
Folder InstallLocation is not available	message
Program has been started	message
ADC sampling frequency = xxx.xx Hz	message
Work channels of data server not found. The program will not be loaded	error
Data server has too many channels or large sampling frequency. Not enough memory to run the program in this mode.	error
Go to channel - Signal x	message
Go to band pass filter No. x	message
Go to averaging code x	message
Go to RMS value	message
Go to amplitude value	message
Go to peak value	message
Allow threshold control	message
Do not allow threshold control	message
New acceleration threshold value = x,xx	message

New velocity threshold value = x.xx	message
New displacement threshold value = x.xx	message
Allow dry contact	message
Do not allow dry contact	message
New event maintenance duration = xx sec	message
Enable the data transmission to virtual channel of dry contact	message
Disable the data transmission to virtual channel of dry contact	message
Enable digital bit of dry contact	message
Disable digital bit of dry contact	message
New module for digital output= x	message
New bit for digital output = x	message
Server stream is not responding the queries. The program will be closed	error
The program has been closed	message

In the case if the control panel is active, the error notifications are duplicated by pop-up windows in the system tray (i.e., in the notifications area or Windows task panel). The message "*Data server has too many channels or large sampling frequency. Not enough memory to run the program in this mode. The program will be closed*" means that there are too many programs operating with ZETLAB data server, or that the PC used does not have enough RAM. In the first case, it is necessary to close the programs that are not used and to restart the program, or to increase the RAM volume.

Display

This section describes examples of signals graphical representation (in 2- and 3-dimensional format) and data processing with the use of the programs from the scope of ZETLAB software as well as processing of the recorded signals data.

Universal oscilloscope .....

Universal oscilloscope

The program "**Universal oscilloscope**" is intended for visual representation of constant data flow from a big number of channels in universal scale. The program is used for timely evaluation of the processes occurring within the controlled system.

Main application spheres of the program:

· strain-gauge measurements (displaying of signals from a great number of strain-gauge transducers – this function can be used for structural health assessment);

· displaying of signals obtained from several tilt meters – this function can be used for structural health assessment).

The program "**Universal oscilloscope**" can be started from "**Display**" menu of ZETLAB control panel.

Note: the program "**Universal oscilloscope**" can be started from ZETLAB directory (the directory by default: C:\ZETLab\). The name of the file to be started: ZetSeismographic.exe.

Supported Hardware .....

Input data of the program "**Universal oscilloscope**" consists of digital signals of ZETLAB server channels. These signals are represented by digitized arbitrary alternating signal. In this case, by alternating signal we mean a signal, instant values of which depend on time parameter.

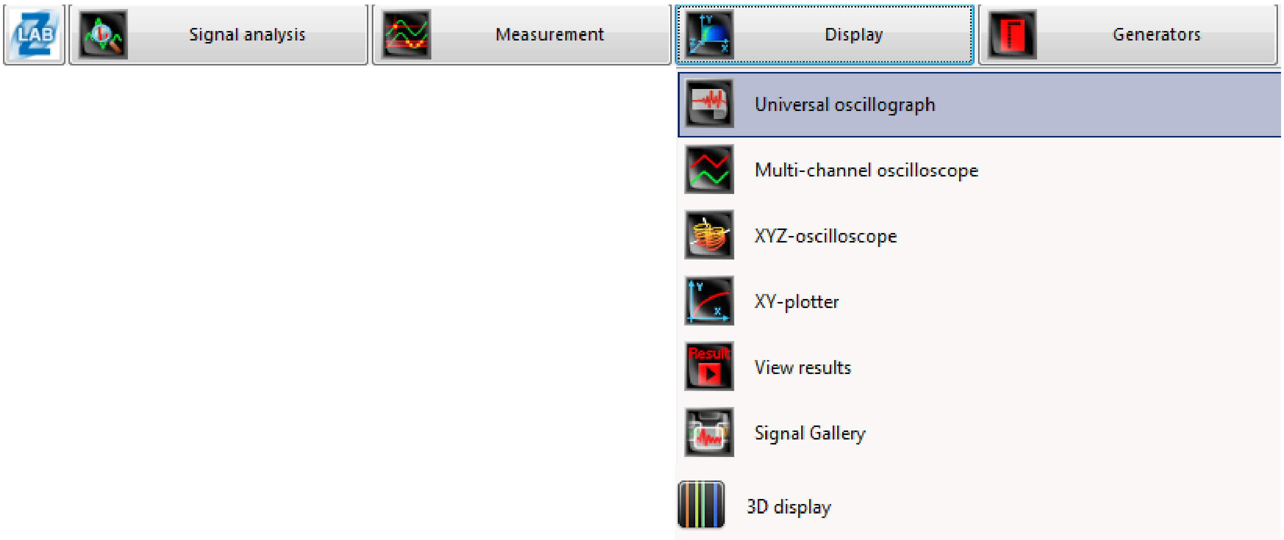
The program "**Universal oscilloscope**" is included into the scope of the following software packages:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT Spectrum Analyzers software
- ZETLAB VIBRO – Shaker controllers systems software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software (option).

The program "**Universal oscilloscope**" is located in the *Display* software section.

Program description .....

The program "**Universal oscilloscope/ seismograph**" is used for visual representation of constant data flow by several channels simultaneously. This program enables prompt evaluation of the processes occurring in the controlled system. In the case of *ZETLAB Seismo* Software package, the program can be found in the "*Seismic monitoring*" tab. In all other cases, the program can be found in the "**Display**" tab. The program "**Universal oscilloscope**" changes its title for "**Seismograph**" if a corresponding device is detected by *ZETLAB software.*

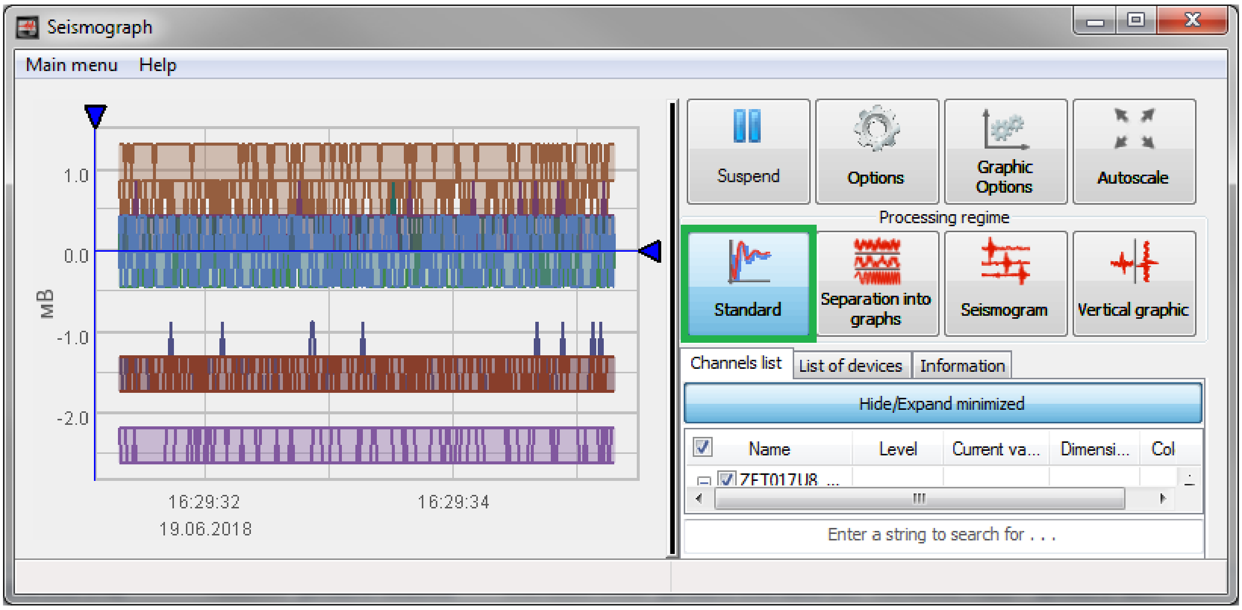


Universal oscilloscope - starting the program

*Note: the program "**Universal oscilloscope**" can also be started from ZETLAB directory (the directory by default: C:\ZETLab\). The name of the file to be started: ZetSeismographic.exe.*

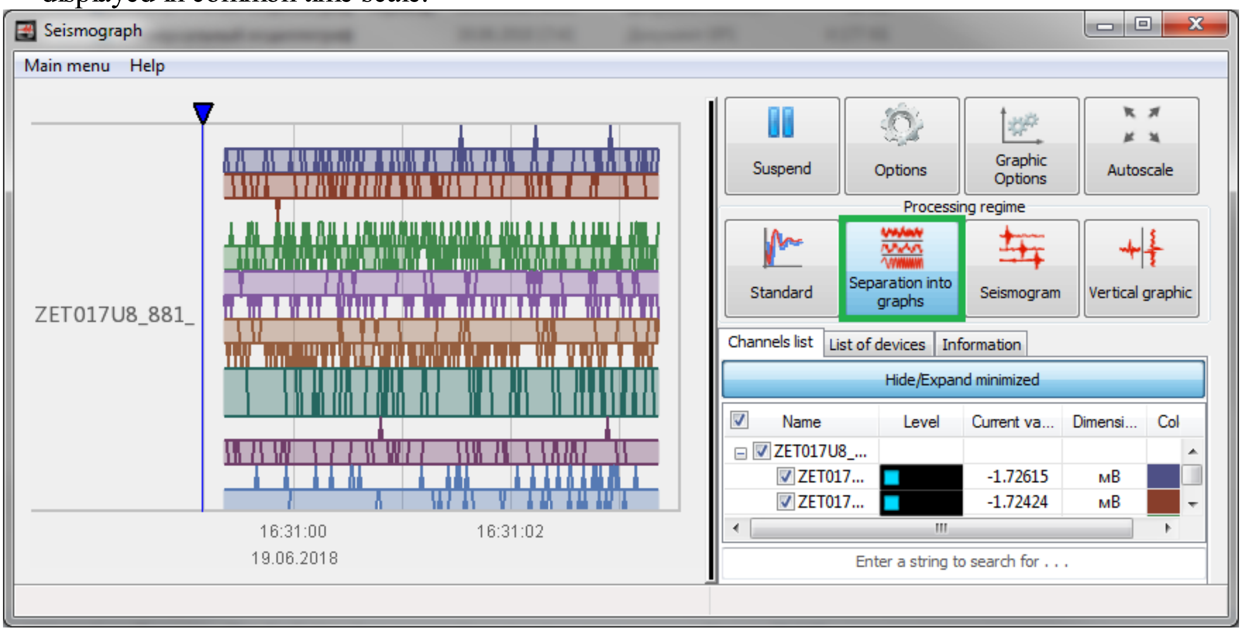
The program has several modes of data representation:

- ***Standard*** – all graphics are displayed in common scale.



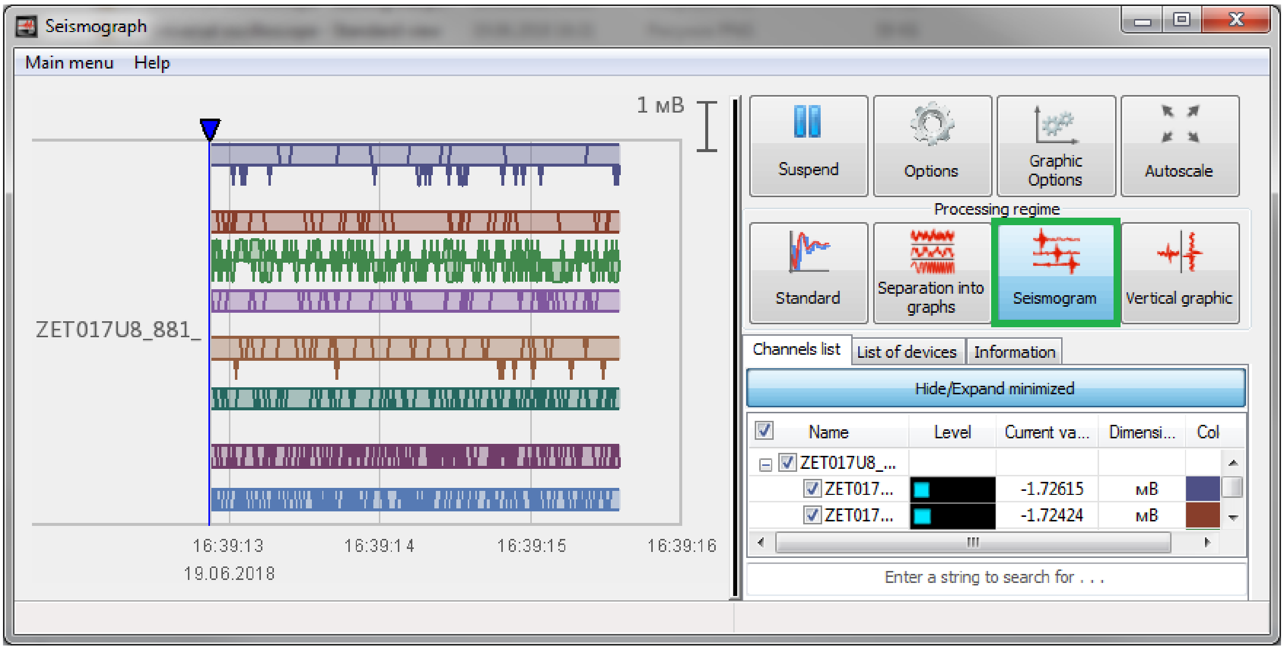
Universal oscilloscope - Standard view

- ***Separation into graphics*** – each channel has a separate area in the graphic, all the graphics are displayed in common time scale.



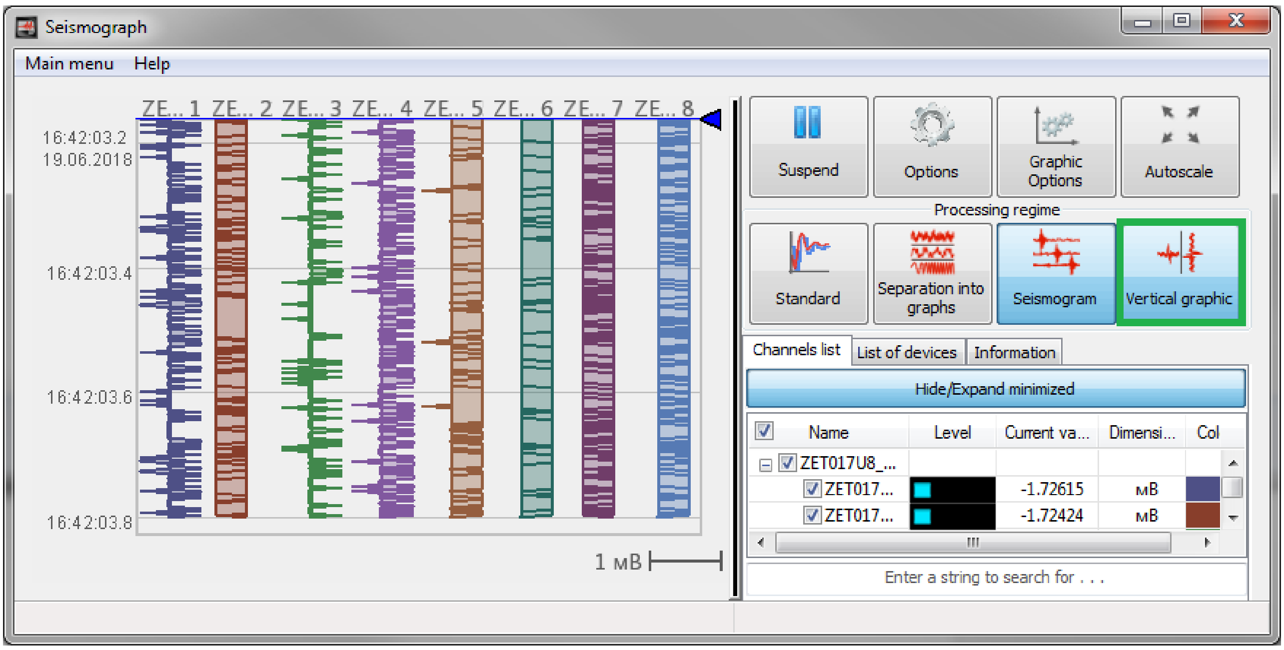
Universal oscilloscope - Separation into graphics

- ***Seismic*** – seismogram mode. It allows to evaluate signal form and to compare the data of the channels.



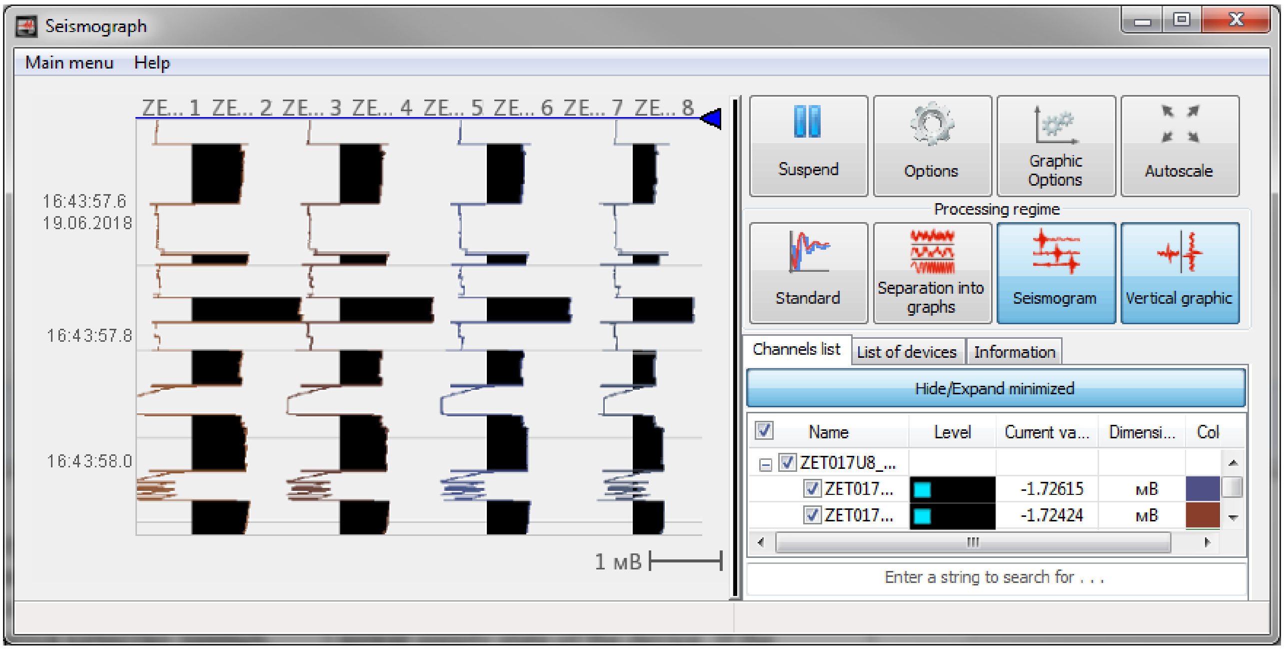
Universal oscilloscope - Seismogram mode

Vertical graphic – it allows to display graphics in vertical format, which can be useful for visual representation of the relation between various processes.



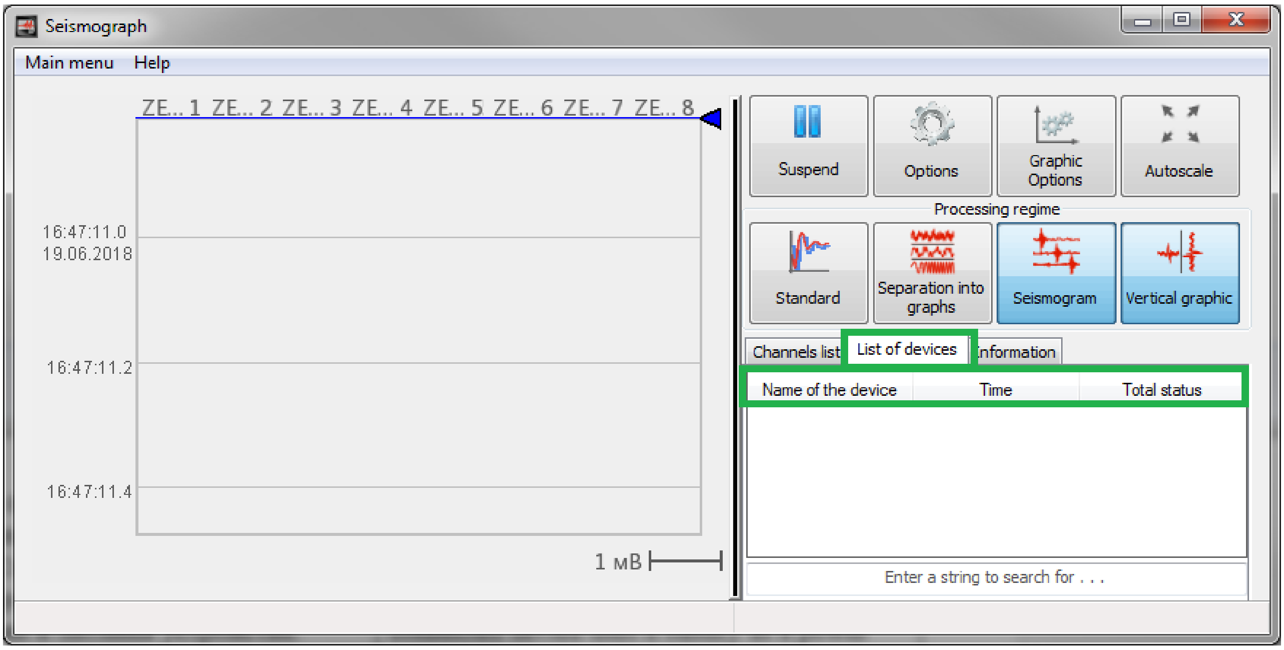
Universal oscilloscope - Vertical graphic

Graphic filling with color – this function is intended for visual representation of active processes. It is available in the modes **"Separation into graphics"** and **"Seismogram"**.



Universal oscilloscope - Graphic filling with color

The tab "***List of devices***" allows to display the current status of the connected device. This tab displays data quality, synchronization and power supply status of the device. If the connected device uses a battery as a power supply source, this tab will depict its charge level. In the case, if the connected device has an integrated memory card, then this tab will depict the amount of free space left. This tab can also display GPS coordinates and the number of active satellites detected by the device (upon activation of the corresponding option, it becomes possible to view current location of the device). Please, note, that only some of ZETLAB devices have the above listed functions.



Universal oscilloscope - Devices list tab

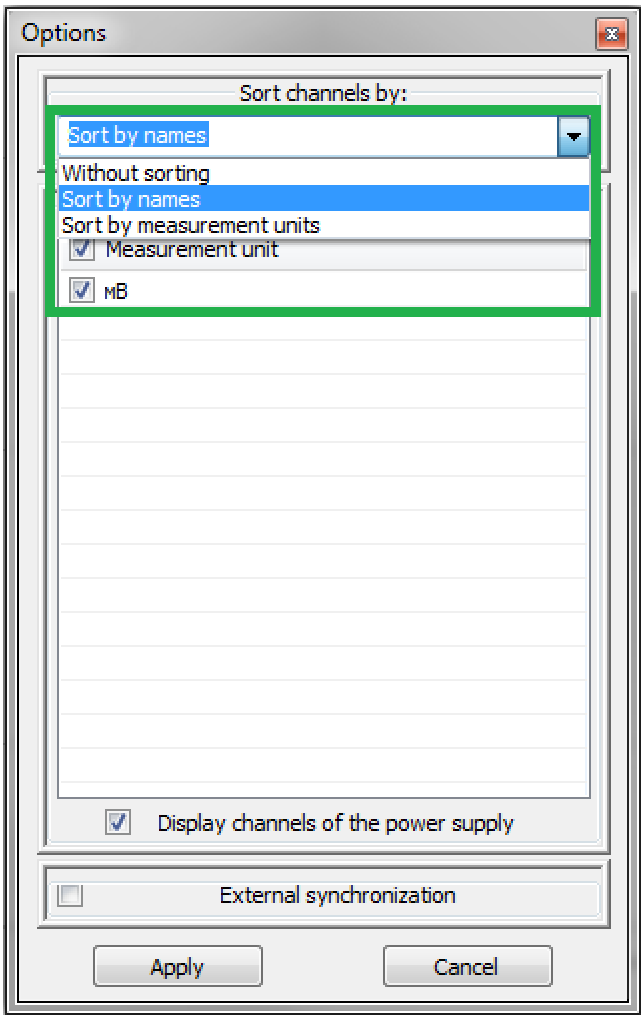
The program also has a separate mode for operation with the events generated by ZETLAB programs or various instruments (see the clause "*Kit for seismic research performance: software*").

https://zetlab.com/en/theory-of-strain-gauge-measurements/

The main program window allows to set the graphics display mode: standard or seismic, to activate "***auto-scale***" option, to suspend program operation and to set program parameters and to display the data as separate graphs. It is also possible to change the view of channels list. To do that, use the key .

In this mode, the graphic displays the current channel time, the number of active satellites and the battery level. It is also possible to display the current location of the device.

The parameters window also allows to sort the channels and to disable the channels with particular measurement units.

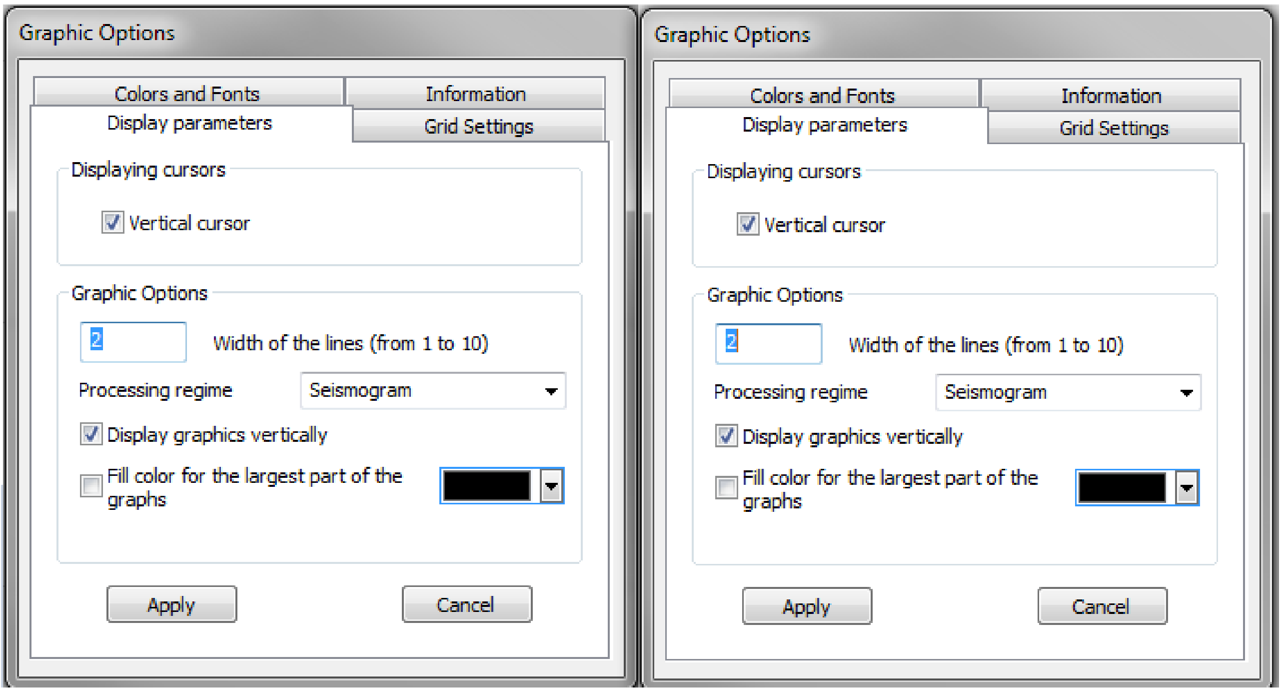


Universal oscilloscope - Channels sorting option

Graphic display settings .....

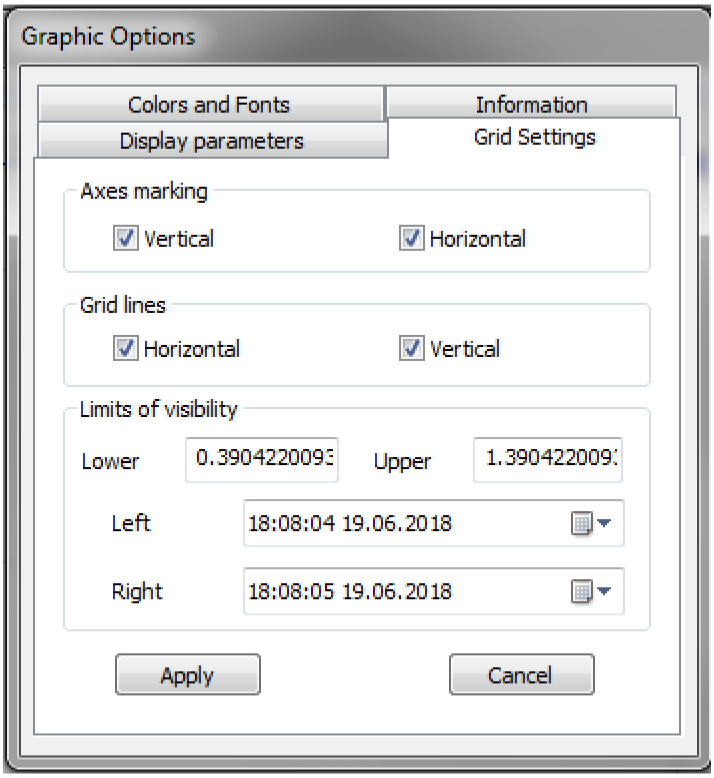
Right-click the graphic area of the "***Trends view***" program to activate parameters configuration window.

Graphic settings



Universal oscilloscope - Graphic display parameters

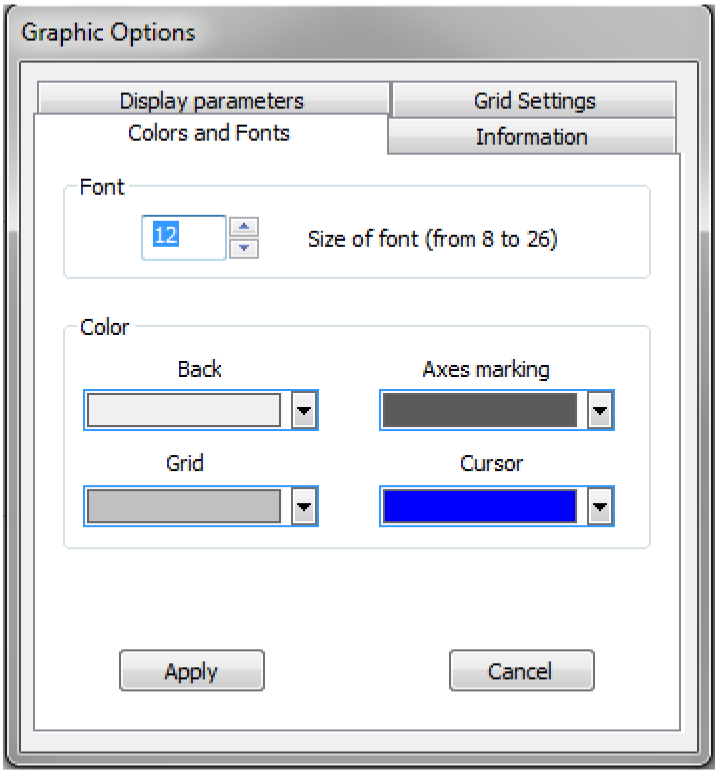
Grid settings



Universal oscilloscope - Grid settings

This tab allows to set visibility limits and to enable/ disable axes marking and grid lines.

Colors and fonts

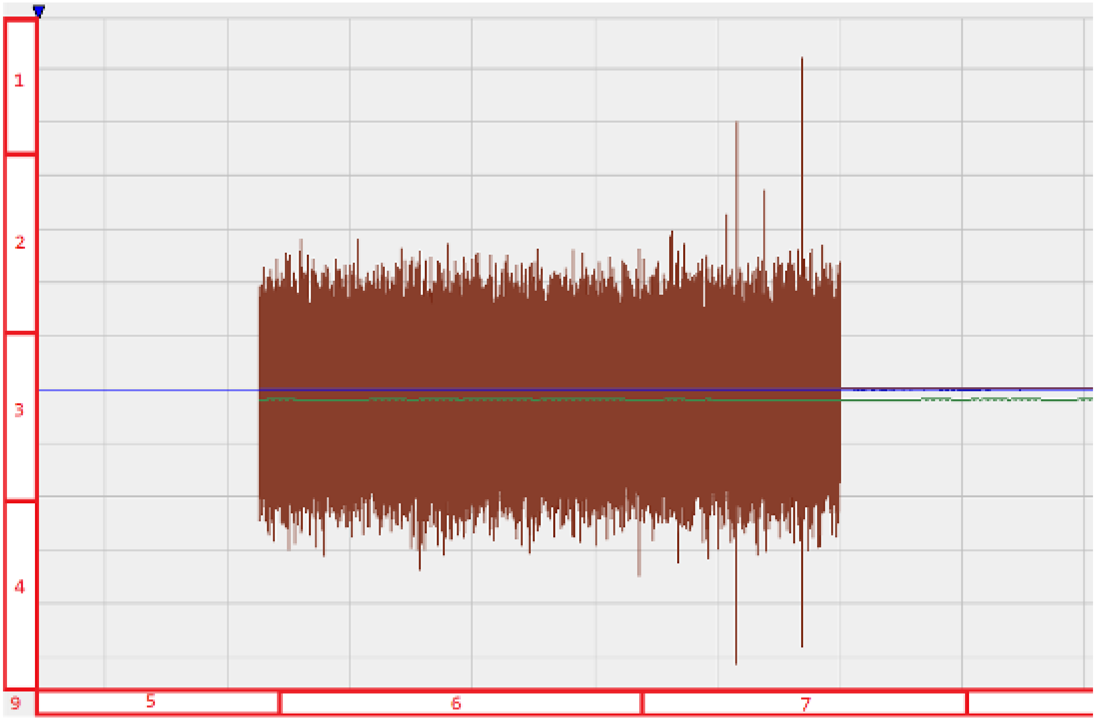


Universal oscilloscope - Colors and fonts

This tab allows to select font size and graphic color.

Scaling

Working areas:



Universal oscilloscope - Graphic scaling elements

The graphic is separated into working areas (see the Fig.). Right-click them or use the scroll wheel to change the current displayed range.

1. Changing vertical scale, moving the graphic up.

2. Vertical scale increase.

3. Vertical scale decrease.

4. Changing vertical scale, moving the graphic down.

5. Changing horizontal scale, moving the graphic to the left.

6. Horizontal scale decrease.

7. Horizontal scale increase.

8. Changing horizontal scale, moving the graphic to the right.

9. Auto-scaling of the graphic.

Right-click the graphic to scale its visible part. If nothing is depicted, then all the graphic undergoes auto-scaling.

Hold the "Shift" key and right-click the graphic to auto-scale it by vertical graphic. Hold the Ctrl key and right-click the graphic to scale the loaded data by vertical and horizontal axes.

The upper and the right section of the graphic is used for moving the cursor.

Hot keys:

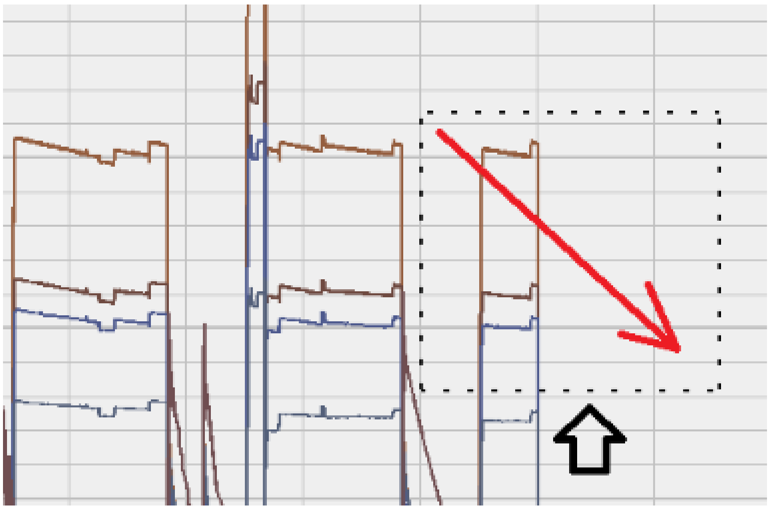
"Shift + scroll" – fast scaling by vertical axis;

"Ctrl + scroll" – fast scaling by horizontal axis.

Changing the scale using the mouse

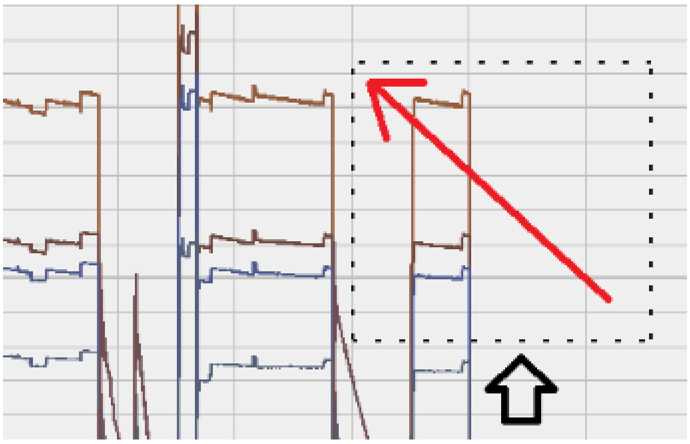
Right-click the graphic area and use the mouse pointer to move the graphic.

"Ctrl+RMB" – the combination allows to select a particular range of the graphic. There appears a frame specifying the area to be scaled.



Universal oscilloscope - Scaling

There appears a frame around the selected graphic are (see the Fig.). Release the RMB to scale the graphic within the highlighted area.



Universal oscilloscope - Scaling

Multi-channel oscilloscope .....

The program "**Multi-channel oscilloscope**" is intended for signal's form evaluation and measurements of instant values. The program allows to display several signals from a particular time span simultaneously (each signal can be displayed in different measurement units). For the purpose of signals comparison, it is possible to display their oscilloscope graphics in the same coordinate network. Simple and user-friendly system of cursor control and graphics scaling enables comprehensive evaluation of a particular process.

Main functions of the program:

- Displaying of form and amplitude of the signals received from the input channels of the system;
- Setting the time interval for displaying of the signals;
- Frequency range selection for the displayed signals;
- Flexible adjustment of the displayed channels number;
- Auto-scaling option that can be applied to an individual channel or to a group of channels;
- Synchronization by the selected channel;
- Frame-by-frame viewing option;
- Dynamic display of signal's integral levels, overloading evaluation for each particular channel, overloading status parameters analysis;
- Viewing each graphic in individual section or a combined representation of several graphs;

- Displaying absolute time from the moment of previous start of the ADC or from the beginning of signals Play recorded signals from a file;

- Synchronous cursor positioning at the oscilloscope patterns allows to simultaneously evaluate the amplitude of several signals at a particular time point;

- Saving of graphical and numerical data to the clipboard for further use in text editing program;

- Measurement of time (frequency) for updating of the data displayed in the program (0,1 s or 1 s) ;

- Zero time label adjustment (moving "0" label along the horizontal graph);

- Channel synchronization with the displaying of signal level and synchronization front (positive or negative);

- In order to display the signal form in the set frequency band, it is possible to use the program "**Signals filtration**". This program allows to set the cutoff frequencies for the high-pass and low-pass filters as well as to enable integration or differentiation of the filters.

- Graphic smoothing (*Linear, Spline, WKS*);

- Glowing of the graphic (on/ off);

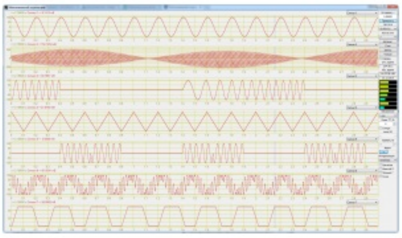
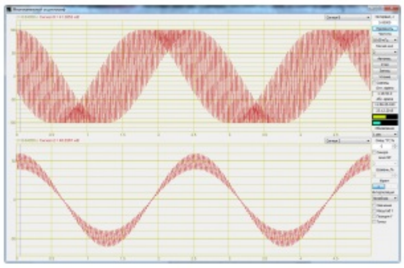
- Enable auto-scaling by Y (on/ off);

- Set position by Y (on/ off);

- Labels of non-interpolated points (hide/ show).

Special features of the program

The program "**Multi-channel oscilloscope**" updates measurement data based on the time of measurement device (the real-time data update is not used). Data update rate depends on the set sampling frequency value of the device.

Multi-channel oscilloscope - program interface

The field " *Interval, s"* is intended for entering the time interval for displaying the signal (horizontal scale). The maximum and minimum values depend on the selected frequency range of the displayed signals. The larger the frequency range, the larger the amount of processed data and the shorter the time interval for displaying the signal, respectively, the smaller the frequency range, the smaller the amount of processed data and the longer the interval for displaying the signal. The interval values are entered from the keyboard, having previously placed the cursor in the interval input field. To set the entered time interval, press the *Apply button* located under the interval entry field, or press the keyboard key.

Frequency drop-down list allows the program to work with different data streams implemented in the ZETLAB software. The main data stream is its source data, i.e. instantaneous signal values that follow with the channel sample rate. The main data stream corresponds to the top line of the list, which displays the channel sampling rate (set in the **ZET Device Manager** *program*). Data can also be resampled at a ratio of 1:10; 1:100; 1:1000 and 1:1000 of the original sample rate. When resampling , an appropriate low-pass filter is used.

The drop-down list Quantity (*Number of channels)* allows the user to customize the display of the required number of waveforms in the program window. The maximum number of waveforms in one running program is 8.

Automask button . is used for automatic scaling (reducing the scale of the graph to the signal level) of all oscillograms simultaneously along the level axis. Automatic scaling can be done for each individual waveform.

When you start the *Multi-channel oscilloscope software*, the waveform display starts immediately. To stop (pause) the process of displaying a signal, you must activate the *Stop button* , while the name of the button changes to *Start* . To start the stopped process of displaying the signal, it is necessary to activate the button *Start*, in this case the recorded data is reset, and the name of the button changes to *Stop* .

Recording and *Reading* buttons are used to write waveforms to a file and display the recorded data.

If you set the *Combine flag*, the signals of all included waveforms will be displayed in the same coordinate grid on one waveform. This option is useful when comparing signals of the same type. To exit the combination mode, uncheck the *Combine flag* . In this case, the signals displayed on the combined waveform will be distributed to separate waveforms. As many waveforms will be displayed as there are channels selected in the Number of channels list for *display* .

Note: when the checkbox is set, Combine you cannot select the displayed channels.

Field *Rel. time* displays the time in seconds, counted from the moment the ADC was last started or from the moment the signals from the file started playing. In the fields under the inscription *Abs . time* displays the current time and date.

Refresh drop-down list allows the user to set the interval for updating program charts in seconds. When you select a value of *0.1 s,* the graphs change more smoothly, which is more like analog oscilloscopes, however, in this mode, the load on the processor of the computer used is greater.

DATA UPDATE IN THE MULTI-CHANNEL OSCILLOSCOPE IS DEVICE TIME, NOT REAL TIME. THE UPDATE RATE IN THE SERVER DEPENDS ON THE SAMPLING RATE SET IN THE DEVICE.

Supported Hardware .....

Supported hardware

The program "**Multi-channel oscilloscope**" is intended for evaluation of signal form and measurement of instant values. It is possible to display several signals simultaneously and in corresponding measurement units. To compare the signals, it is possible to display them in universal coordinate axes. Simple and user-friendly cursor control and graphic scaling system enables comprehensive research of process dynamics.

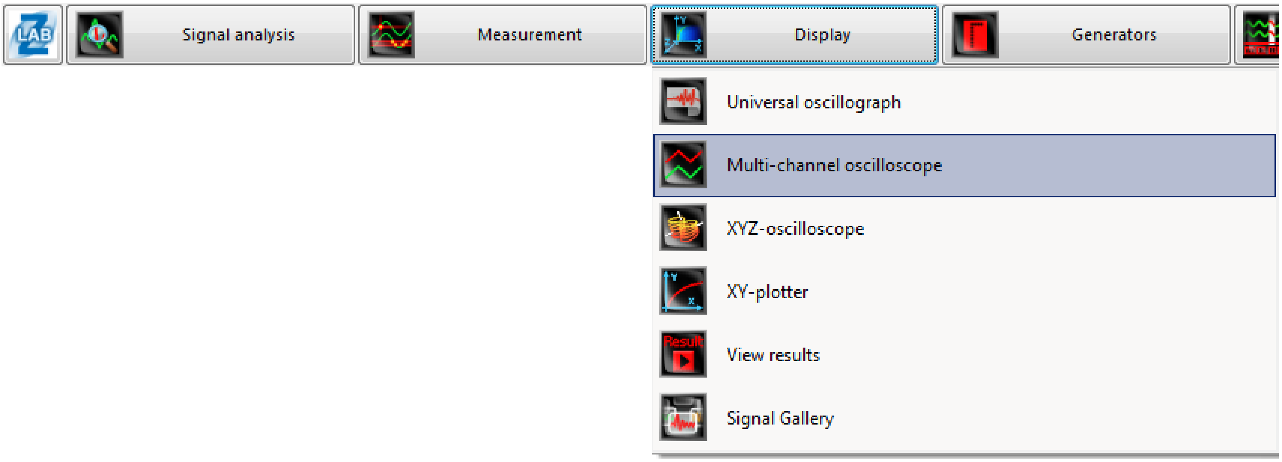
The program "**Multi-channel oscilloscope**" is included into the scope of the following software packages:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT Spectrum Analyzers software
- ZETLAB VIBRO – Shaker controllers software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software (option).

The program "**Multi-channel oscilloscope**" is located in the "**Display**" program section.

Program description .....

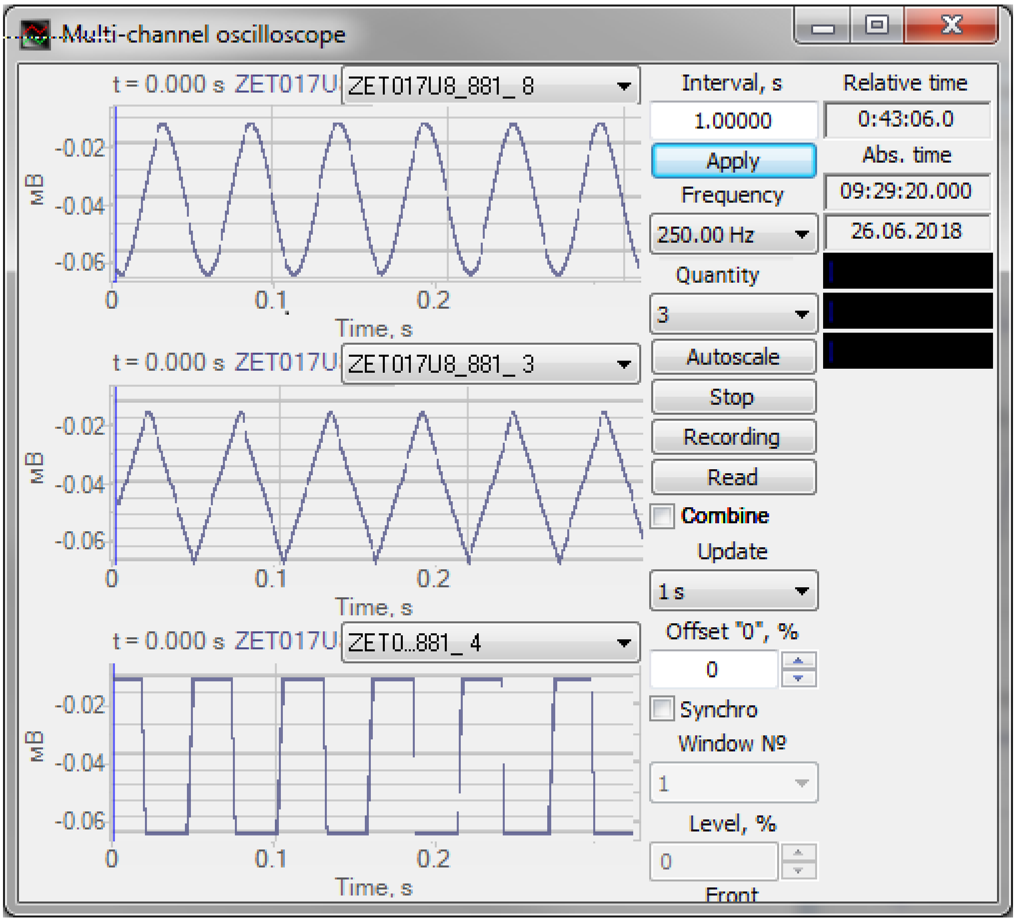
The program "**Multi-channel oscilloscope**" can be started from "**Display**" section of ZETLAB panel.



Starting the program Multi-channel oscilloscope

Note: the program "**Multi-channel oscilloscope**" can also be started from ZETLAB directory (the directory by default: C:\ZETLab\). The name of the file to be started: Oscgraphic.exe.

The title of the window displays the name of the program. Below you can see the oscilloscope graphics (time realizations) of the signals from the selected channels. The section above each oscilloscope graphic contains the name of the channel and the measurement units used (time is measured in seconds and amplitude value is displayed in corresponding measurement units). The values are displayed depending on cursor position and selected measurement channel.



Multi-channel oscilloscope - parallel displaying of three signals

Control keys and control elements are located at the right section of the program interface.

Display interval and data update rate

The field under the section "**Interval, s**" is used to set the time interval for displaying of the signals (horizontal sweep). The maximal and minimal values of the time interval depend on the selected frequency range of the displayed signals. The higher is the frequency range, the more data will be processed and the less will be the time interval for displaying the signal, and vice versa. The values of the interval are entered from the keyboard. To set the interval value, click the key "*Apply*" located under the section for entering the value of the interval, or use the <*Enter*> key.

The "*Apply*" key allows to set the time interval as well as to set the source scale of the displayed data by time axis.

The drop-down list under the "**Frequency**" title allows the program to process various data flows available in ZETLAB software.

The main data flow of a channel is represented by its source data, i.e. by the instant values of the signal, which depend on the sampling frequency of the channel. The main data flow of the channel corresponds to the top line of the list with the sampling frequency value of the channel.

The next data flow of the channel is represented by down-converted (1:10) values. These values have a sampling frequency, which is 10 times lower than the source one.

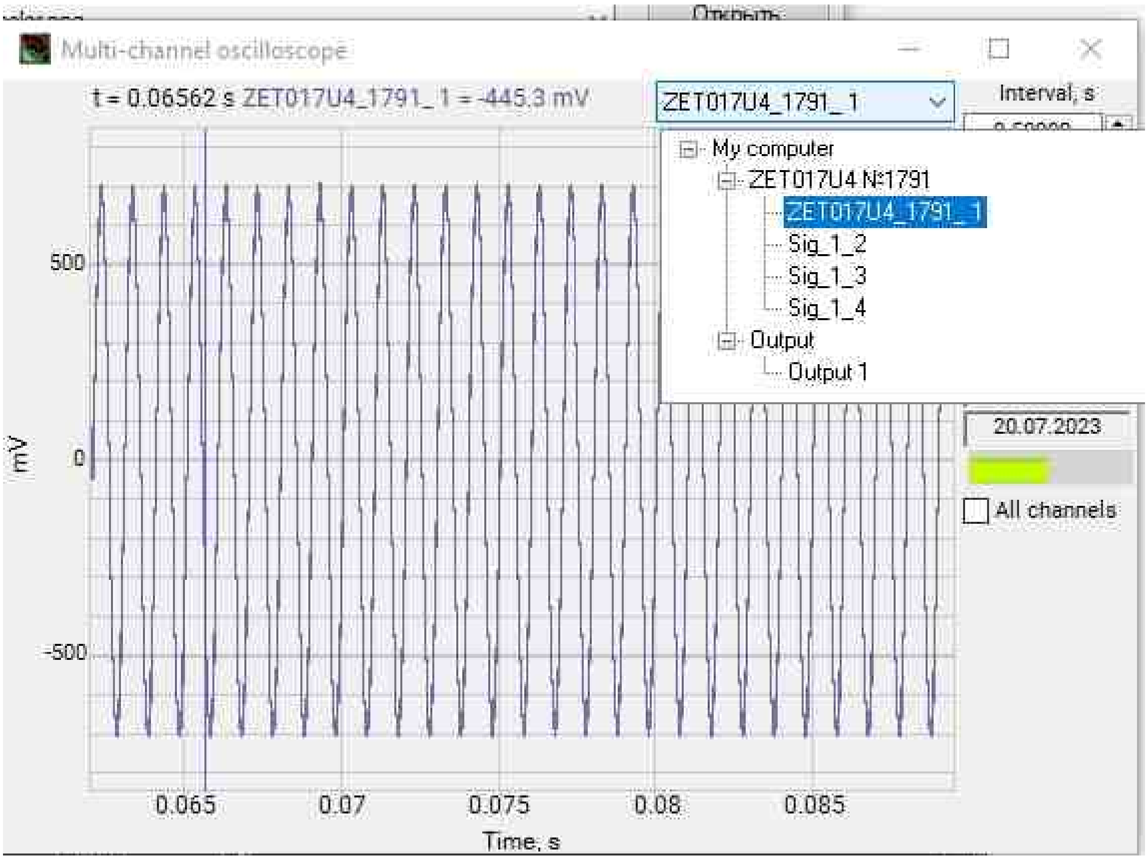
In order to down-convert the signal, there is used a low-pass filter. This data flow is represented by the second line of the list – this line displays the sampling frequency value of the channel reduced in 10 times.

The next lines display the down-converted values (1 : 100, 1 : 1000, and 1 : 10000), which have been produced in the same way.

Channels of the displayed signals

The list under the section "**Quantity** (Number of channels)" allows to set the required number of channels to be displayed in the program "**Multi-channel oscilloscope**". The maximum possible number of the oscilloscope graphics to be simultaneously displayed in the program is 8.

Each of the active oscilloscope graphics used for displaying of the signals should be assigned with a physical channel or with a virtual one. The virtual channels are produced by the corresponding programs (e.g., by the programs used for signals filtration and generation, strain-gauge measurements, etc.). The list for channels selection is located in the top right section of each oscilloscope graph:



Multi-channel oscilloscope - measurement channel selection

The "**Auto-scale**" key is used for automated scaling (changing the graphic scale depending on the signal level) of all the oscilloscope graphics by the level axis.

In the case if it is necessary to auto-scale a particular graphic, place the mouse pointer at the left bottom section of the graphic area and left-click as the mouse pointer changes for the symbol  .

Signal display: start/ stop

The key "**Start**" begins the process of constant displaying of the signal (upon activation of the key, the previously accumulated data is set to zero and the name of the key changes for "**Stop**").

As the "**Multi-channel oscilloscope**" program is started, the program already displays a signal. The "**Start**" key is used to resume the signal display process after it has been suspended.

The key "**Stop/ pause**" suspends the process of constant signal displaying. As the key is activated, it changes its name for "**Start**".

Results recording and representation

The keys "**Recording**" and "**Reading**" are used for saving the oscilloscope graphics to a file and for representation of the recorded data. The following section contains a detailed description of oscilloscope graphics recording and reading.

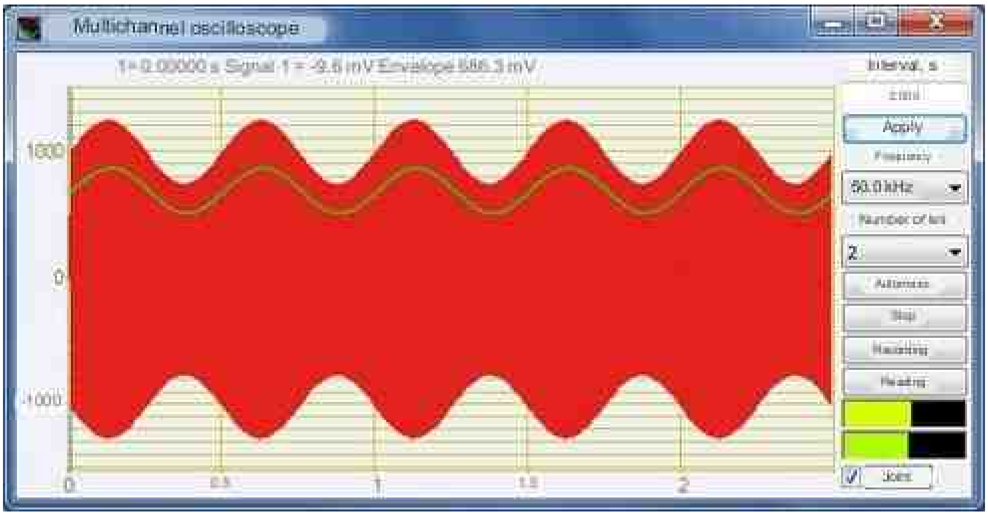
Signal level indicators

Indicator "**Integral level**" displays the integral level of the signal and overloading of the channel in the case if the threshold value is exceeded. Two thirds of the indicator section are used for displaying of the signal level, that is within the admissible range. The higher is the level, the bigger section of the indicator is filled with color. As the maximum admissible level is reached, the entire indicator area is filled with red color. The right section of the indicator remains red until the overloading of the channel is eliminated and the user right-clicks the indicator area. The number of the indicators is equal to that of the oscilloscope graphics used.

"***Combine***" mode

Upon activation of the "***Combine***" mode, the signals of the oscilloscope graphics will be displayed in universal coordinate network at one oscilloscope graphic section. This option is convenient for comparing the signals of similar type.

The Fig. below shows an example of amplitude-frequency modulated signal and its envelope curve in the "**mix**" mode.



Multi-channel oscilloscope - signals displayed in Combine mode

To exit the "**mix**" mode, uncheck the corresponding option. As the "**mix**" mode is switched off, the signals displayed in the combined diagram will be distributed into separate oscilloscope graphs. The number of the oscilloscope graphics sections will be equal to the number specified in the "**Quantity** (Number of channels)" section.

Note: if the "**mix**" mode is active, it is impossible to select the channels to be displayed.

Time and date

The field under the section "**Relative time**" displays the time from the previous activation of the ADC or the duration of signal Play recorded signals from a file. The field under the section "**Abs. time**" displays the current date and time.

The list under the section "**Update**" has two options: "**1 s**" and "**0,1 s**". This section allows to set update time for the graphics (the update time is set in seconds). If the option "**0,1 s**" is selected, the graphics are displayed more smoothly (the displayed graphics are similar to those of analog oscilloscopes). However, in this mode the processor load is rather high.

Positioning of signals in axes of the graphs

The list under the section **"Offset "0", %"** allows to set the horizontal displacement of the signal (displacement along the time axis). The horizontal displacement value is set in percentage form. By adjusting the displacement value, it is possible to set the signal in the best possible position at the oscilloscope graphic for further analysis. It is possible to set the required displacement value by left-clicking the corresponding options from the list, or by setting the displacement value from the keyboard and clicking the <*Enter*> key.

The "**Synchro**" option allows to enable synchronization mode. The "**Synchro**" mode allows to obtain a stabilized image of the signal at the oscilloscope graphic. The synchronization is implemented based on the set threshold value and signal front of one of the channels. Positioning of the displayed signals in relation to the synchronization point is set in the section **"Offset "0", %".** To disable the "**Synchro**" mode, uncheck the corresponding option.

The list under the section "**Window No.**" allows to select the oscilloscope graphic to be used as a reference one for the synchronization process. The oscilloscope graphics (windows) are assigned a number in downwards order. This list is not available for the user in the case if the "**Synchro**" option is switched off. In order to select the required oscilloscope graphic to be used as a reference one for the synchronization procedure, left-click the drop-down list and select the required oscilloscope graphic number. The list under the section **"Level, %"** allows to set synchronization threshold level. The threshold level is set in percentage rate from the displayed signal level range. Synchronization threshold level is displayed as a horizontal green line at the graphic section. This option is not available for the user in the case if the "**Syncro**" mode is switched off. It is possible to set the required threshold level by left-clicking the required option in the drop-down list, by using the scroll wheel, or by entering the required value from the keyboard and clicking the <*Enter*> key.
The keys under the "**Front**" section allow to select synchronization mode based on increasing (the key "+") or decreasing (the key "-") the front of the signal. These keys are not available for the user in the case if the "**Synchro**" option is switched off.

The list under the "**Interpolation**" section allows to select the type of graphic smoothing (*linear, spline, WKS*);

The option "**Glow**" allows to enable/ disable glowing of the graphic;

The option "**Y scale**" allows to enable/ disable the scaling by Y axis, i.e. the range of graphic displaying;

The option "**Y position**" allows to enable / disable primary positioning of Y value;

The option "**Points**" allows to show/ hide the labels of non-interpolated points;

The option "**All channels**" allows you to enable or disable the display of all channels up to 8 channels;

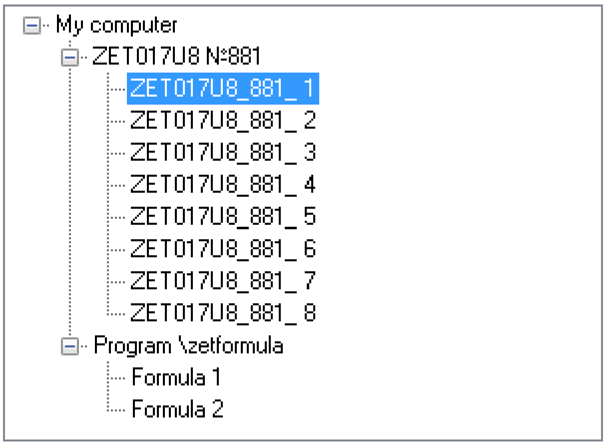
The option "**Hide**" allows you to enable or disable the mode of hiding or revealing the options of the Multi-channel oscilloscope to increase the size of the graphic display area;

When decreasing the size of the program along the Vertical axis, the chart options are divided into 2 or 3 columns if the Hide option is not selected.

Note:

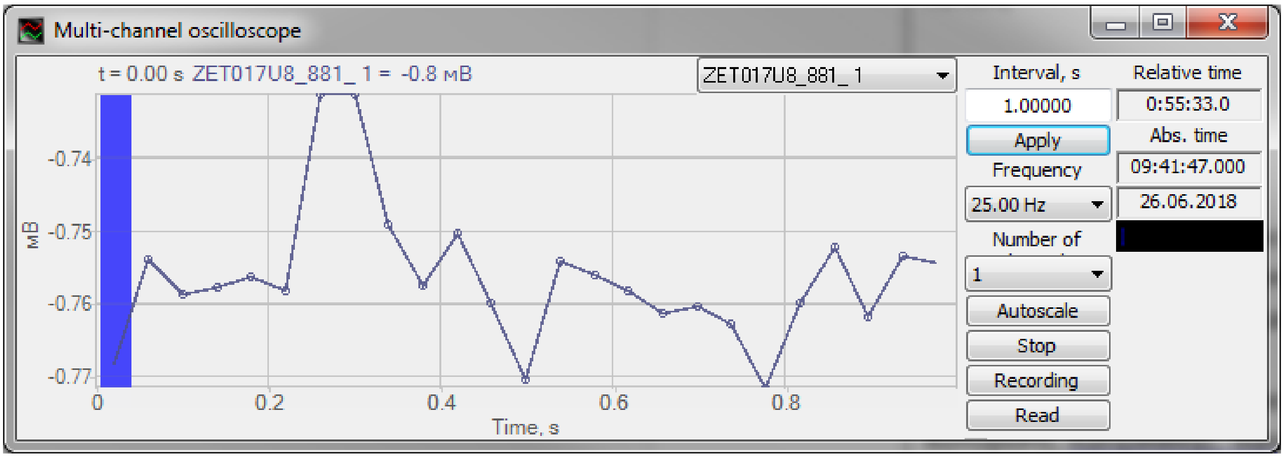
The "**Multi-channel oscilloscope**" program allows to set identical parameters for several channels:

1) Set the name of the channel, e.g., Sig_1_9, to be used as a reference channel for the other oscilloscope graphs.



Multi-channel oscilloscope - setting the required parameters of the first channel

2) Set the other required parameters for the first channel



Multi-channel oscilloscope - configuration of the reference channel parameters

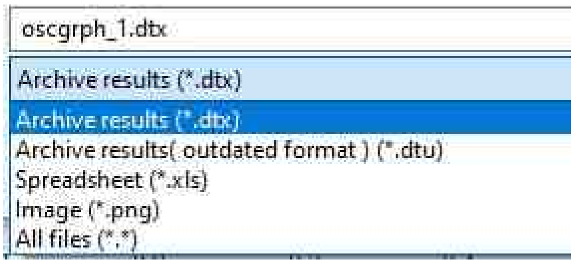
3) Set the required number of oscilloscope graphics in the section "**Number of channels**". All the parameters of the first channel will be applied to the oscilloscope graphs.

See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Using signal level indicators

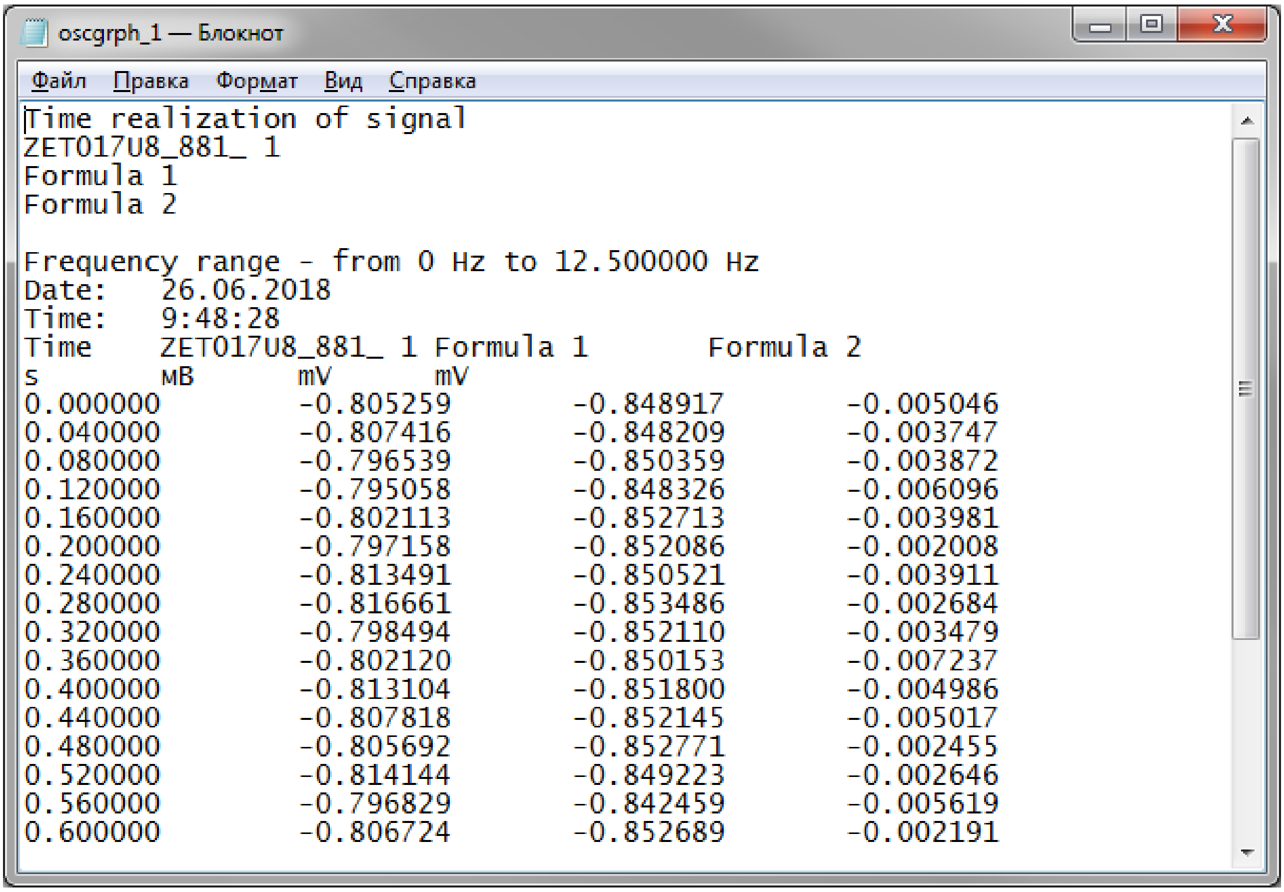
Data recording and reading .....

The "**Recording**" key allows to record the accumulated data by several channels for a particular time interval to a text file with *.*dtu* and *.*dtx* extension. Upon activation of the key, there appears a standard dialog window allowing the user to set the file name and the directory for saving the file. The directory by default: C:\ZETLab\Result\.



Select a text file recording with extensions.

An example of the file **.dtu* is shown in the Fig. below.




```
Time realization of signal
ZET017U8_881_ 1
Formula 1
Formula 2

Frequency range - from 0 Hz to 12.500000 Hz
Date:   26.06.2018
Time:   9:48:28
Time    ZET017U8_881_ 1 Formula 1       Formula 2
s       мВ      mV      mV
0.000000        -0.805259       -0.848917       -0.005046
0.040000        -0.807416       -0.848209       -0.003747
0.080000        -0.796539       -0.850359       -0.003872
0.120000        -0.795058       -0.848326       -0.006096
0.160000        -0.802113       -0.852713       -0.003981
0.200000        -0.797158       -0.852086       -0.002008
0.240000        -0.813491       -0.850521       -0.003911
0.280000        -0.816661       -0.853486       -0.002684
0.320000        -0.798494       -0.852110       -0.003479
0.360000        -0.802120       -0.850153       -0.007237
0.400000        -0.813104       -0.851800       -0.004986
0.440000        -0.807818       -0.852145       -0.005017
0.480000        -0.805692       -0.852771       -0.002455
0.520000        -0.814144       -0.849223       -0.002646
0.560000        -0.796829       -0.842459       -0.005619
0.600000        -0.806724       -0.852689       -0.002191
```

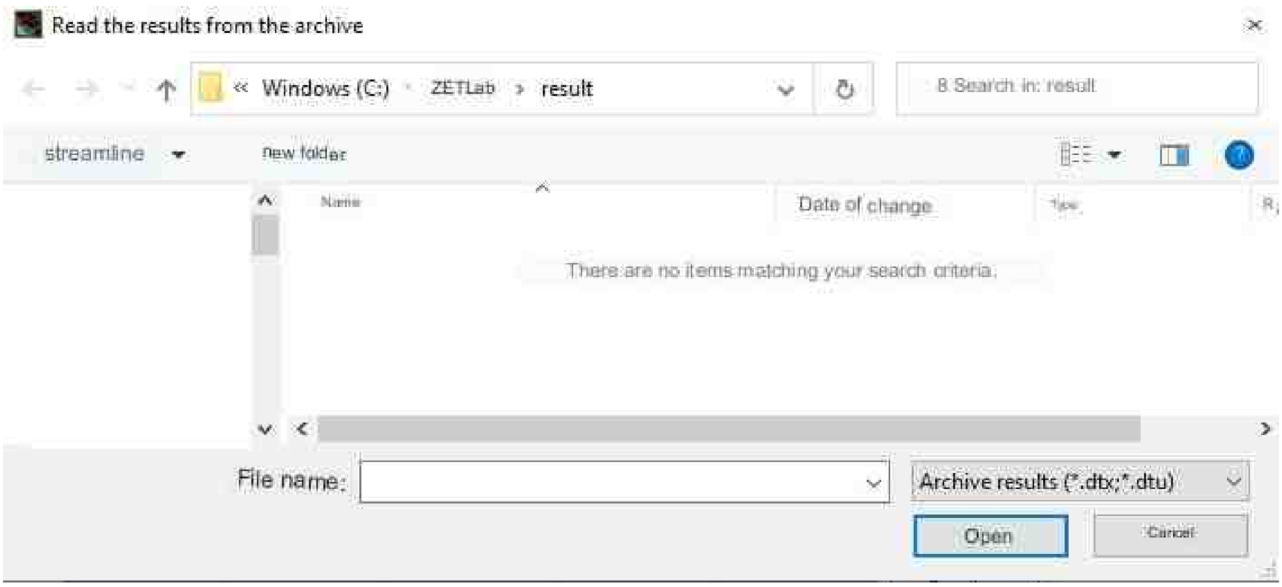
*Multi-channel oscilloscope - measurement results recorded to a file *.dtu for further analysis*

The file *.dtu structure is described in the graphic.

Line #	Lines	Description

1	Time realization of the signals	Data description
2	Signals 1	Name of the first channel
3		The line for user's comments. This line is not used by the program "**Multi-channel oscilloscope**" in the course of data recording
4	Frequency range: from 0 Hz up to 25000.00 Hz	Frequency range of the recorded signals
5	Date: 25-09-2012	File recording date
6	Time: 13:45:51	File recording time
7	Time Signal 1 Signal 2	Titles of data columns
8	s mV mV	Measurement units by columns
9-th and the following lines	0 0.0617873 3.2976	Numerical data values represented in floating comma format. The symbol **"."** is used as a separator between integral and fractional parts of the signals

The "**Reading**" key allows to view the previously recorded oscilloscope graphic files with **.dtu and *.dtx* extension. Upon activation of "**Reading**" key there appears a standard dialog window allowing the user to select the file to be opened. As the file is selected, the program will display the data from the file (including the parameters of corresponding channels). In order to switch over to standard mode (the real-time mode), click the "**Reading**" key again.



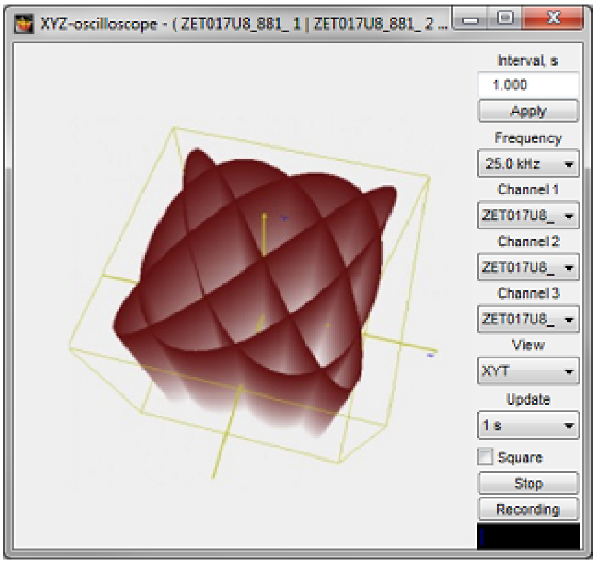
Select a text file reading with extensions.

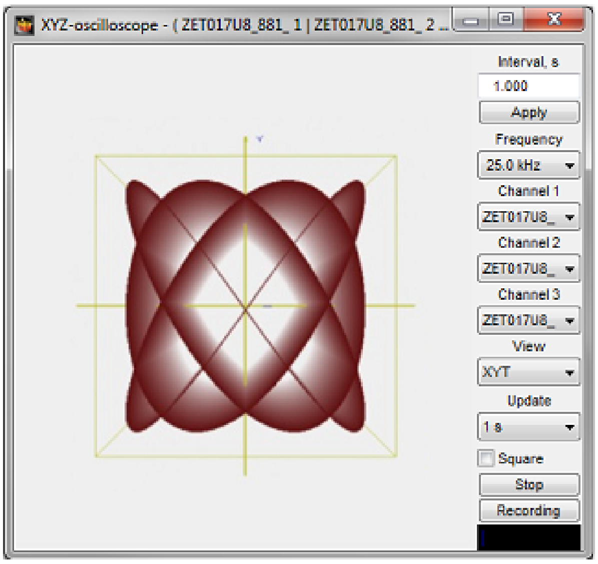
XYZ-Oscilloscope .....

The program **XYZ-Oscilloscope** is intended for signal form evaluation and displaying the parametric dependence of the controlled signals.

There are three sequences with time dependence: X(t), Y(t) and Z(t). Based on these sequences, the user can obtain:

- time realization in the plane (x,t), (y,t) or (z,t);
- parametric curve (x,y), where x=X(t), y=Y(t), $T<t<(T+\Delta T)$ in the plane XY;
- parametric curve (x,z), where x=X(t), z=Z(t), $T<t<(T+\Delta T)$ in the plane XZ;
- parametric curve (z,y), where z=Z(t), y=Y(t), $T<t<(T+\Delta T)$ in the plane YZ;
- parametric curve (x,y,t), where x=X(t), y=Y(t), $T<t<(T+\Delta T)$ in 3D format in the unidad XYT;
- parametric curve (x,z,t), where x=X(t), z=Z(t), $T<t<(T+\Delta T)$ in 3D format in the unidad XZT;
- parametric curve (z,y,t), where z=z(t), y=Y(t), $T<t<(T+\Delta T)$ in 3D format in the unidad YZT;
- parametric curve (x,y,z), where x=X(t), y=Y(t), z=Z(t), $T<t<(T+\Delta T)$ in 3D format in the unidad XYZ.





XYZ-Oscilloscope - 3D view of the signals

Supported Hardware .....

The source information of the **XYZ-oscilloscope** program is represented by the data received from digital channels of ZETLAB server.

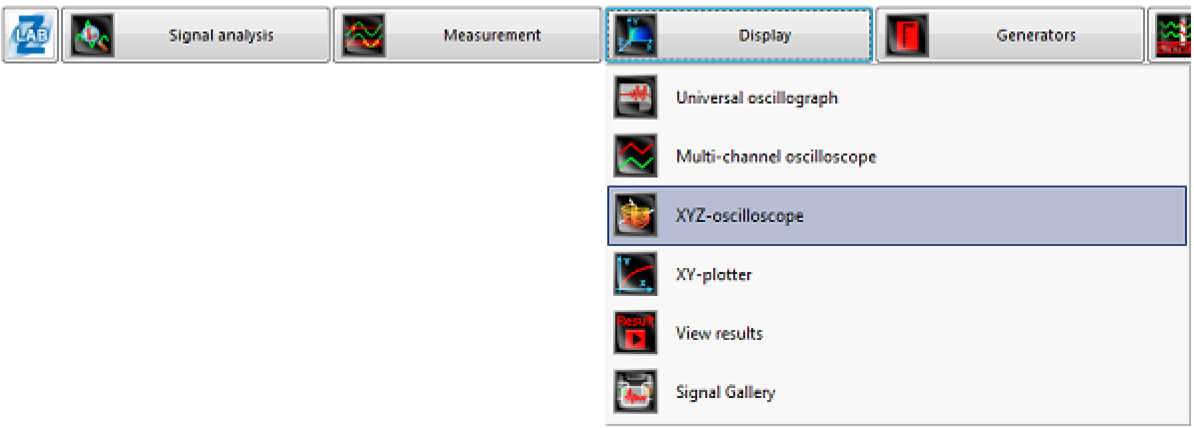
The program **XYZ-Oscilloscope** is included into the scope of the following software packages:

- ZETLAB BASE — ADC/DAC board software;
- ZETLAB ANALIZ — FFT spectrum analyzer software;
- ZETLAB VIBRO — Shaker controller software;
- ZETLAB TENZO — strain-gauge station software;
- ZETLAB SEISMO — seismic station software;
- ZETLAB NOISE — vibration meter-noise meter software;
- ZETLAB SENSOR — digital ZETSENSOR sensor software.

The program **XYZ-Oscilloscope** is located in the "**Display**" software group.

Program description .....

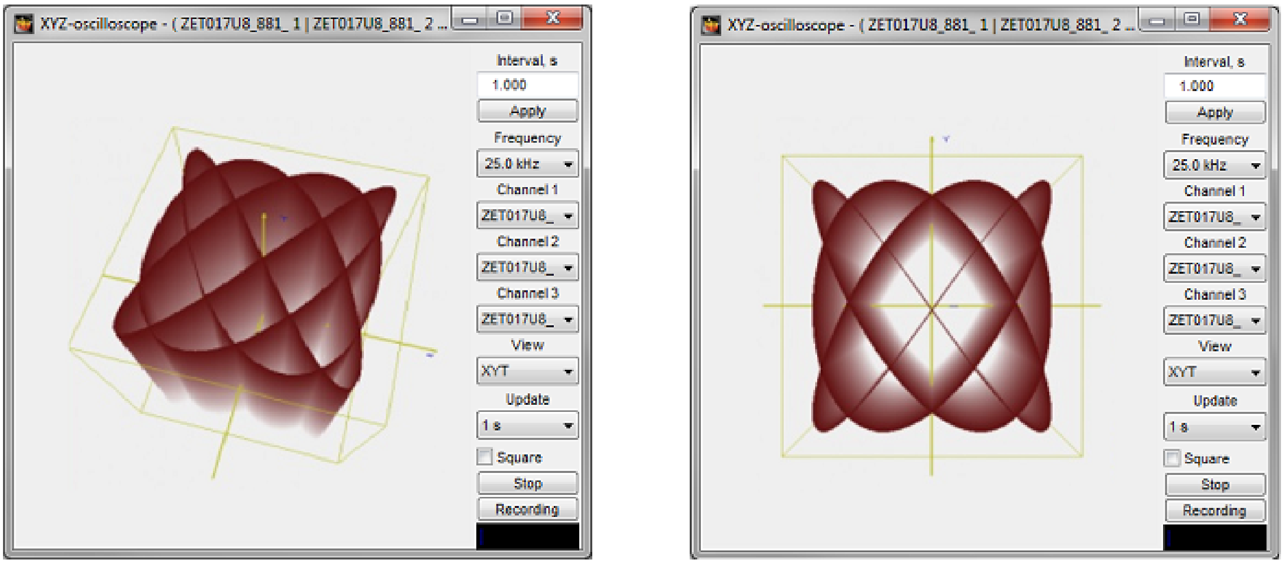
The program **XYZ-Oscilloscope** can be started from **Display** menu of ZETLAB panel.



XYZ-Oscilloscope - starting the program

*Note: the program **XYZ-oscilloscope** can also be started from ZETLAB directory (the directory by default: C:\ZETLab\). The name of the file to be started: XYOscgraphic.exe.*

The title of the window displays the name of the program and the name of the channel (channels) used.



XYZ-Oscilloscope

The control elements are located in the right section of program interface.

Data display interval and sampling frequency

The field under the section "**Interval, s**" allows to set the time interval for signals ratio display (horizontal sweep). The maximal and minimal values of the interval depend on the selected frequency range of the displayed signals. The more the frequency range is, the more data it is possible to process, and vice versa. To set the new interval value, click the "**Apply**" key located under the section for entering the interval value, or use <**Enter**> key.

The **Apply** key is used for setting the time interval, besides, this key also restores the scale of the data by time axis.

The list under the section "**Frequency, Hz**" allows to select the frequency range for the selected signals. To select the required frequency range, left-click the corresponding symbol and select the required frequency range from the dropdown list. The frequency range depends on the sampling frequency value set in the program "**ZET device manager**".

Measurement channels selection

The list under the title **Channel 1** allows to select the channel to be displayed in **X** plane.

The list under the title **Channel 2** allows to select the channel to be displayed in **Y** plane.

The list under the title **Channel 3** allows to select the channel to be displayed in **Z** plane.

Display options

The list under the section "**View**" is used to select the display option: **XT, YT, ZT, XY, YZ, XZ, XYT, YZT, XZT, XYZ**.

· The graphics **XT, YT, ZT** – time realizations (oscilloscope graphs) of channel 1, channel 2 and channel 3 respectively.

· graphic of **XY** type – parametric curve, where $x=X(t)$ and $y=Y(t)$, $T<t<(T+\Delta T)$ in the plane **XY** – Lissajous pattern.

· graphic of **XZ** type – parametric curve, where $x=X(t)$ and $z=Z(t)$, $T<t<(T+\Delta T)$ in the plane **XZ** – Lissajous pattern.

· graphic of **YZ** type – parametric curve, where $z=Z(t)$ and $y=Y(t)$, $T<t<(T+\Delta T)$ in the plane **YZ** – Lissajous pattern.

· graphic of **XYT** type – parametric curve, where $x=X(t)$, $y=Y(t)$, $T<t<(T+\Delta T)$ in 3D format in **XYT** unidad – 3D Lissajous Fig..

· graphic of **XZT** type – parametric curve, where $x=X(t)$, $z=Z(t)$, $T<t<(T+\Delta T)$ in 3D format in **XZT** dimension– 3D Lissajous Fig..

· graphic of **YZT** type – parametric curve, where z=Z(t), y=Y(t), T<t<(T+ΔT) in 3D format in **YZT** unidad – 3D Lissajous Fig..

· graphic of **XYZ** type – parametric curve, where x=X(t), y=Y(t), z=Z(t), T<t<(T+ΔT) in 3D format in **XYZ** unidad – Lissajous pattern in dynamics.

The checkbox "**Square**" allows to align the scale by axes X and Y. Activation of this option allows to align the scale.

Data representation: start/ stop

The key "**Start**" activates the process of constant signal displaying. As this option is enabled, the previously accumulated data is set to zero and the key changes its name for "**Stop**".

The key "**Stop (pause)**" allows to suspend the process of constant signal displaying. As this option is activated, the name of the key changes for "**Start**".

Results recording

The key "**Recording**" allows to record the data accumulated for a particular period to a text file with ***.dtu** extension. Detailed description of the file structure is available in the Section "**Results recording**".

Indicators of signal level

The indicator "**Integral level**" displays the integral level of the signal for each of the channels. As the set threshold level is exceeded, the indicator displays overloading of the corresponding channel. Two-thirds of the indicator section are used for displaying the signals that are within the admissible range. The higher is the level of the signal, the bigger part of the indicator section is filled with color. As the maximal set threshold value is exceeded, the indicator is completely filled with red color. The right section of the indicator remains red until the user right-clicks it or the channel overloading is eliminated. The number of the indicators is determined by the number of the oscilloscope graphics used.

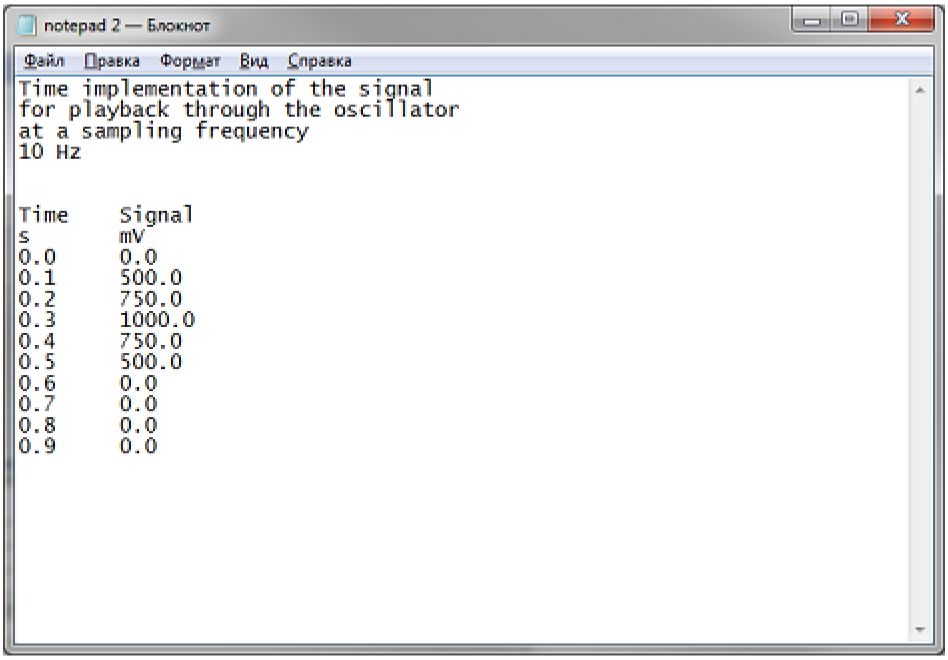
See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Using signal level indicators

Results recording .....

Upon activation of the "**Recording**" key in the program **XYZ-oscilloscope**, there appears a standard dialog window allowing the user to select file name and directory for saving the file. The directory by default C:\ZETLab\Result\. The file contains the data that has been accumulated during the set time interval. The data is recorded to a text file with ***.dtu** extension.

The Fig. below shows an example of this file.



XYZ-Oscilloscope - Time implementation of the signal

The file structure is described in the Fig. below.

Line number	Lines	Description
1	Time realization of the signal	Data description
2	Signal 1+ Signal 2+ Signal 3	Names of the channels
3		The line for comments. It is not used in the course of file recording by the program **XYZ-oscilloscope**
4	Frequency range - from 0 Hz up to 25000.00 Hz	Frequency range of the recorded signals
5	Date: 25-09-2012	File recording date
6	Time: 13:45:51	File recording time
7	Time Signal 1 Signal 2 Signal 3	Data columns titles
8	s mV mV mV	Measurement units (by the columns)
9^{-th} and the following lines	0 0.0617873 3.2976 0.599203	Numerical data values represented in floating comma format. The symbol "." is used as a separator between integral and fractional parts.

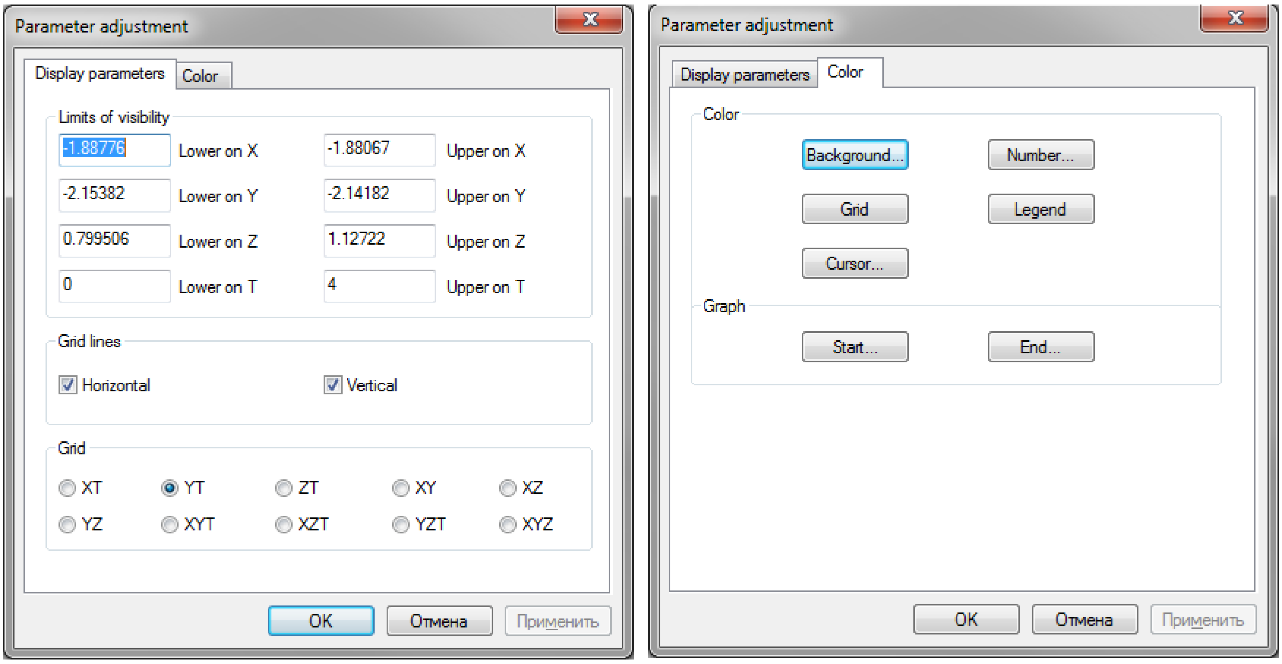
Text editor, "**Results view**" and "**Signal gallery**" programs can be used for viewing the files recorded with the use of the "**XYZ-Oscilloscope program**".

Graphic display settings .....

Graphic display parameters configuration

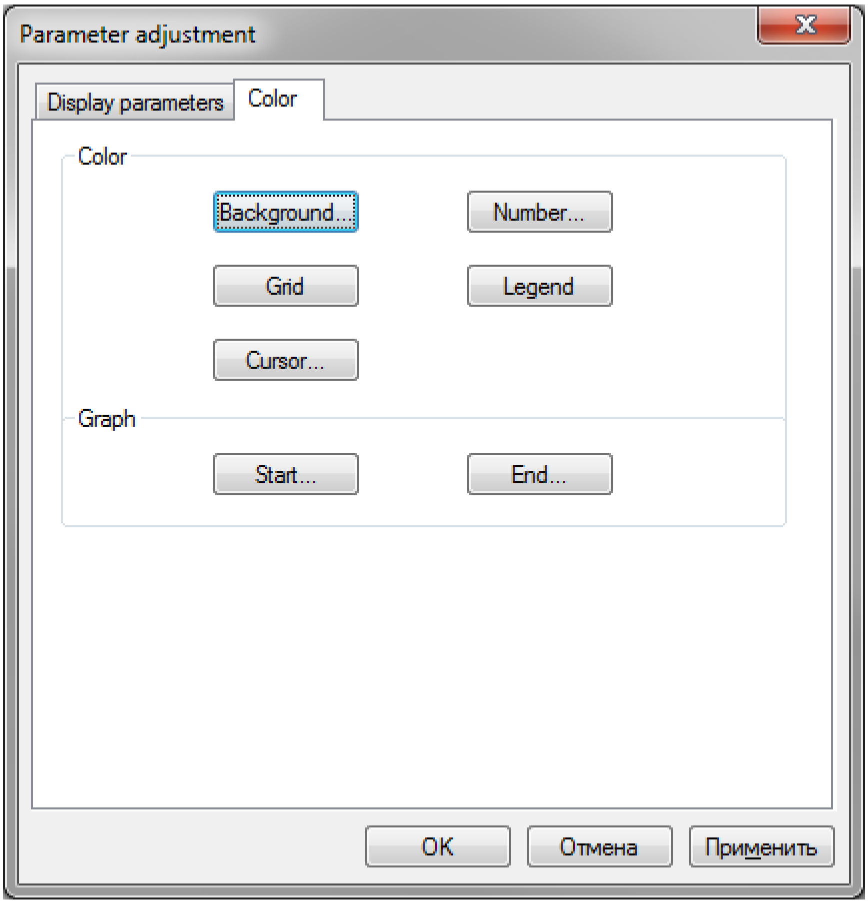
Right-click the graphic area of **XYZ-Oscilloscope** program to activate display parameters configuration window.

The display parameters tab allows to set visibility limits and grid lines type (i.e., the type of data representation):



XYZ-Oscilloscope - Graphic display parameters adjustment

The "**Color**" section allows to select colors for background, grids, cursor, etc.



XYZ-Oscilloscope - display parameters adjustment

Click one of the color setting options to activate color selection window allowing to set a color for a particular element of the graphic.

XYZ-Oscilloscope - background color parameters

XY Plotter .....

XY-Plotter

The program **XY-Plotter** is intended for visual representation (shape evaluation) of mutual characteristics of the two controlled parameters.

For the purpose of mutual characteristics analysis, it is possible to use the following instruments: **DC voltmeters, AC voltmeters, selective AC voltmeters, Frequency counter** and **Phasemeter**. The characteristics can be displayed in three planes (XY, XT and YT), as well as in 3D format.

Functions of the program:

· selection of signals representation type (planes XY, XT, YT) or 3-D view;

· selection of instruments type to be used for graphics plotting;

· display form and amplitude of the signals received by input channels of **ADC DAC modules** and **FFT Spectrum Analyzers**;

·automated scaling of the displayed information;

· suspending signal form representation at a particular moment of time (still-frame playback mode);

· saving instant values of the displayed signals to a file;

· saving screenshot to the clipboard to be further used in reports or measurement protocols in Microsoft Word or Excel format;

· saving numerical data to the clipboard to be further used in text or table editors.

Supported Hardware .....

The source information of the program **XY-Plotter** is represented by digital data of ZETLAB server channels.

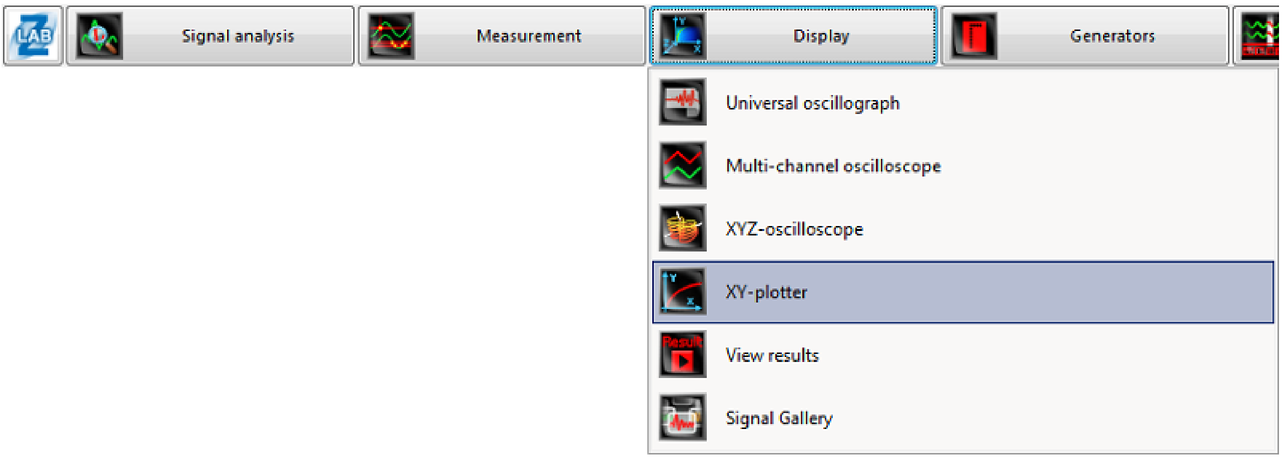
The program **XY-Plotter** is included into the scope of the following software groups:

- ZETLAB BASE – ADC/DAC board software;
- ZETLAB ANALIZ – FFT spectrum analyzer software;
- ZETLAB VIBRO – Shaker controller software;
- ZETLAB TENZO – strain-gauge station software;
- ZETLAB SEISMO – seismic station software;
- ZETLAB NOISE – vibration meter-noise meter software;
- ZETLAB SENSOR – digital ZETSENSOR sensor software;

XY-Plotter is located in the **Display** program group

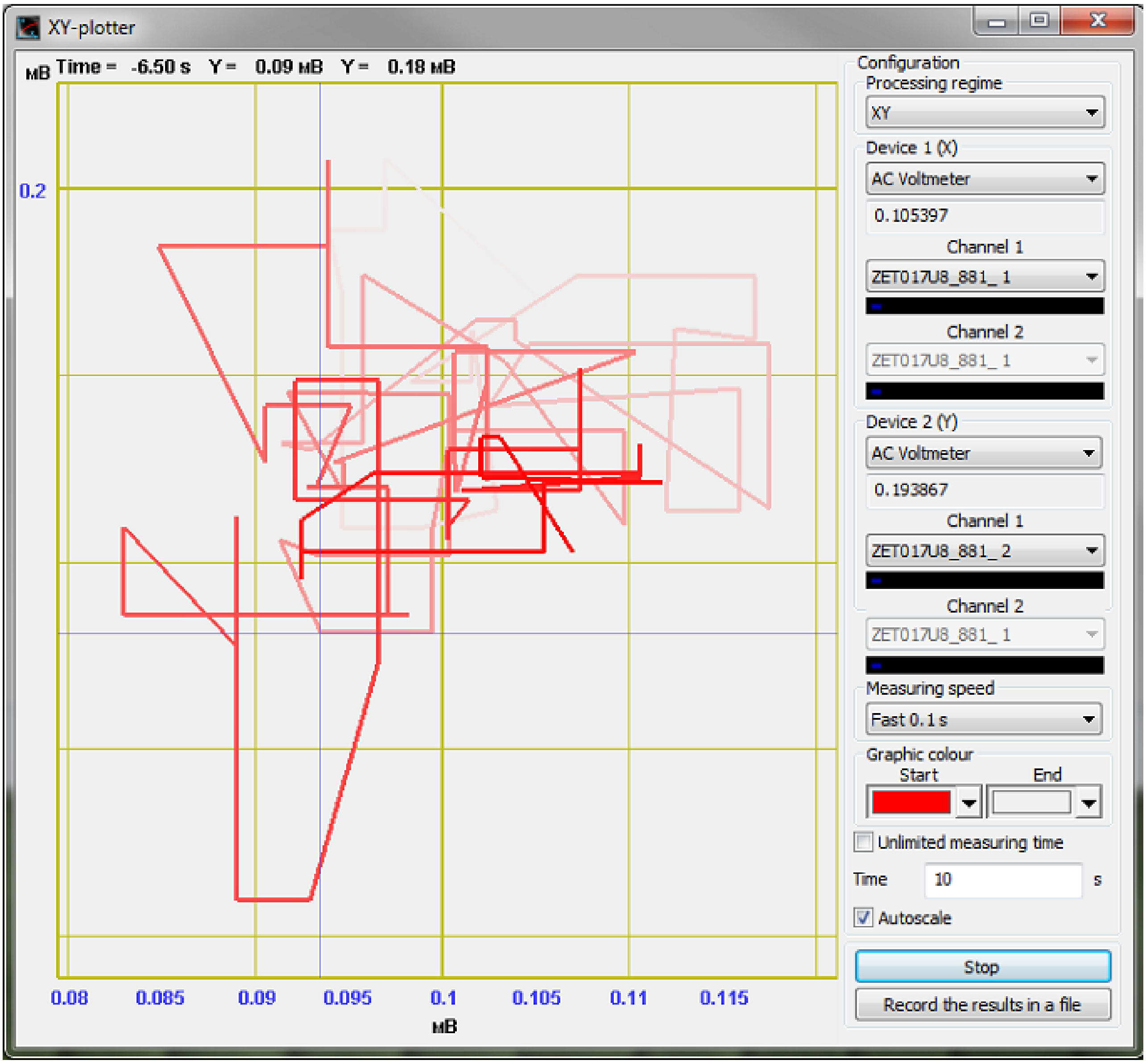
Program description .....

The program XY-Plotter can be started from the Display section of ZETLAB control panel.



XY-plotter - starting the program

Note: the program **XY-Plotter** can also be started from ZETLAB directory (the directory by default: C:\ZETLab\). The name of the file to be started: *XYPlotter.exe*.



XY-plotter - program interface

The list "**Processing regime**" allows to select the type of results representation. The option "**XYT**" enables displaying of the mutual characteristics from the two measured values in three-dimensional environment. The option "**XT**" enables displaying of the controlled value by the first device (see the frame "**Device 1 (X)**"). The "**YT**" option enables displaying of the measured values by the second device (see the frame "**Device 2 (X)**"). The option "**XY**" enables displaying of mutual characteristics of the two measured values in two-dimensional plane.

It is possible to select the devices to be used for displaying the mutual characteristics in the lists located under the names of the corresponding devices ("**Device 1 (X)**" and "**Device 2 (X)**" respectively). It is possible to select the following devices: **AC** and **DC voltmeters, AC selective voltmeter, Frequency counter** and **Phasemeter**.

The lists under the devices section allow to select the measuring channels.

If a Phasemeter is selected as the measuring device, then there will be two sections for selection of measuring channels. It is attributed to the fact that the "**Phasemeter**" program is used for phase difference measurement between two channels.

The list under the section "**Measuring speed**" allows to select the update rate of the graphs: **slow (1 s)** and **fast (0,1 s)**.

The menu under the section "**Graphic color**" allows to select the graphic color. The graphic can be displayed in two colors (one color for the beginning of the graphic and the other – for the end of the graphic with gradual shading-off to the end of the graph).

The check-box to the left from the "**Unlimited measuring time option**" enables the function of constant data accumulation for the graphs. Click this checkbox to enable this option.

The field to the right from "**Time**" section allows to set the time interval for data representation (for horizontal signal sweep). This section will be disabled if the option "**Unlimited measuring time**" is selected.

The check-box "**Autoscale**" is used for automated scaling of the graphic (the graphic is scaled in relation to the displayed data). Click the check-box to enable automated scaling of the graphic.

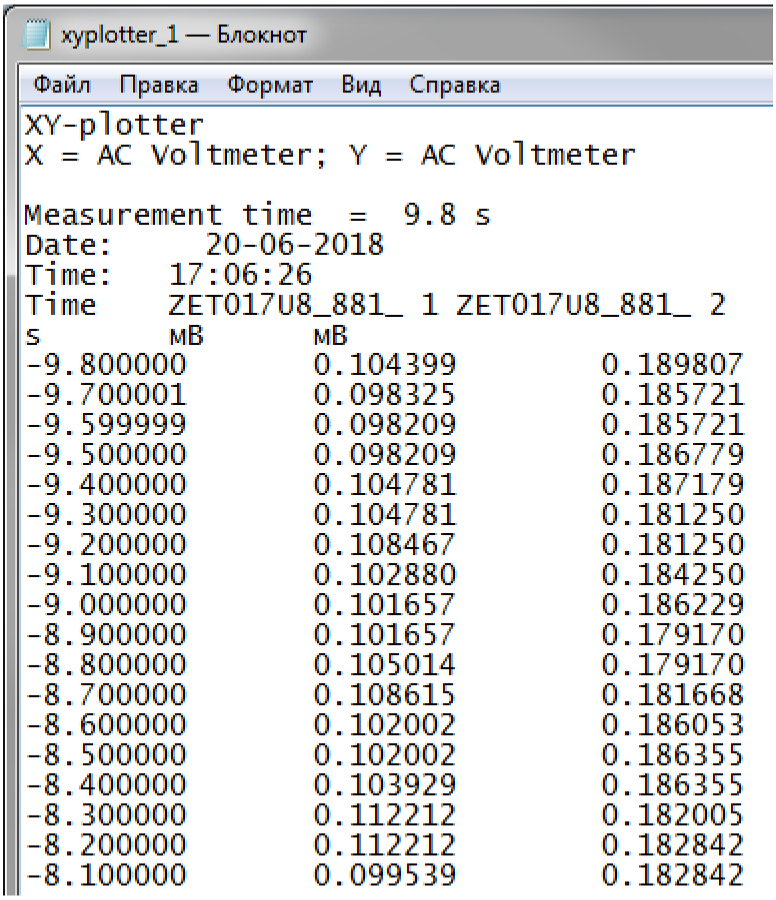
The key "**Start**" begins the process of constant data displaying (upon activation of the "**Start**" key the previously accumulated data is set to zero).

The key "**Start/ stop**" suspends the process of data representation. To resume the process, click the "**Start**" key. The option "**Record the results to a file**" allows to save the data accumulated for a particular interval to a text file with ***.dtu** extension.

Results recording .....

Upon activation of the "Recording" key in the program "XY-plotter" there appears a standard dialog window allowing to select the file name and the directory for saving the file. The directory by default: C:\ZETLab\Result\. The file contains measurement data, which has been accumulated during the set time interval. The data is recorded to a file with ***.dtu** extension.

An example of the file is shown in the Figure.



```
xyplotter_1 — Блокнот
Файл  Правка  Формат  Вид  Справка
XY-plotter
X = AC Voltmeter; Y = AC Voltmeter

Measurement time  =  9.8 s
Date:      20-06-2018
Time:    17:06:26
Time     ZET017U8_881_ 1 ZET017U8_881_ 2
s        мВ      мВ
-9.800000       0.104399        0.189807
-9.700001       0.098325        0.185721
-9.599999       0.098209        0.185721
-9.500000       0.098209        0.186779
-9.400000       0.104781        0.187179
-9.300000       0.104781        0.181250
-9.200000       0.108467        0.181250
-9.100000       0.102880        0.184250
-9.000000       0.101657        0.186229
-8.900000       0.101657        0.179170
-8.800000       0.105014        0.179170
-8.700000       0.108615        0.181668
-8.600000       0.102002        0.186053
-8.500000       0.102002        0.186355
-8.400000       0.103929        0.186355
-8.300000       0.112212        0.182005
-8.200000       0.112212        0.182842
-8.100000       0.099539        0.182842
```

XY-plotter - recording measurement data to a file

The file structure is described in the graphic below.

Line number	**Lines**	**Description**
1	XY - Plotter	Data description
2	X=Voltmeter DC Y=Voltmeter DC	Names of the devices used in the program
3		Line for user's comment (this line is not used by the program **XY-plotter** in the course of files recording)

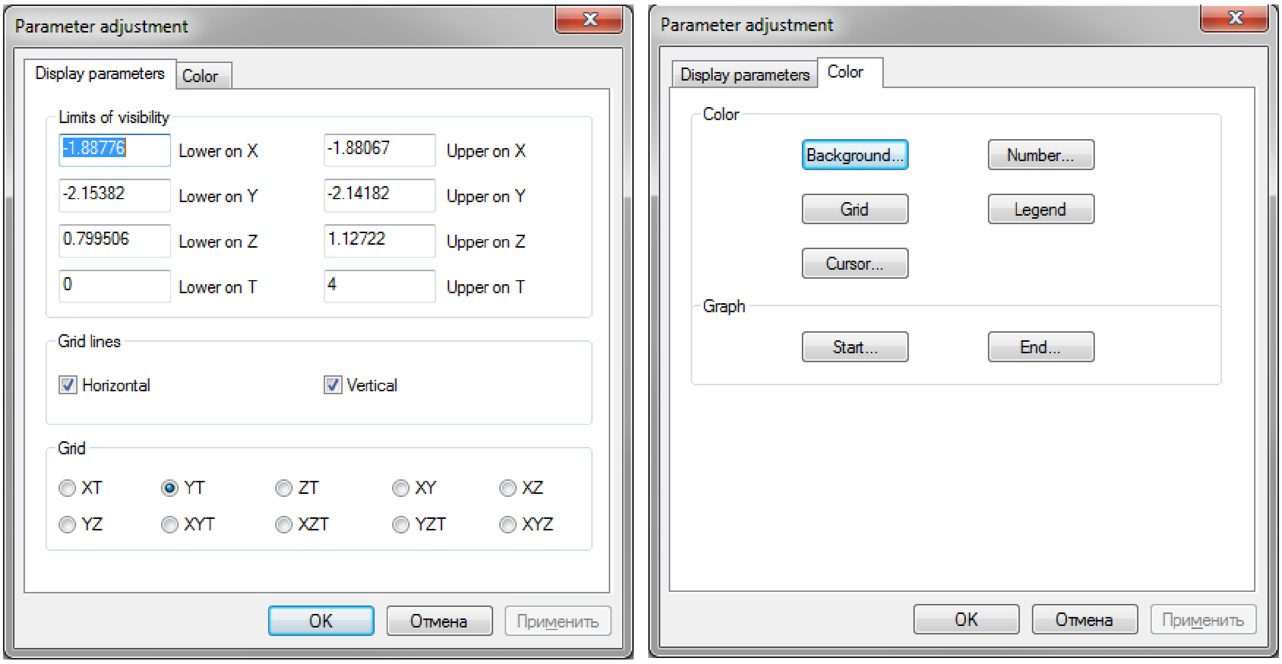
4	Measurement time (in seconds): 20	The set display interval
5	Date: 25-05-2018	File recording date
6	Time: 13:45:51	File recording time
7	Time Signal 1 Signal 2	Data columns titles
8	S mV mV mV	Measurement units (by the columns)
9-th and the following lines	0 0.0617873 3.2976 0.599203	Numerical data values represented in floating comma format. The **"."** symbol is used as a separator between the integral and fractional parts.

The files recorded by the program **XY-Plotter** can be viewed in text editors or in the programs "**Results view**" and "**Signals gallery**".

Graphic display settings .....

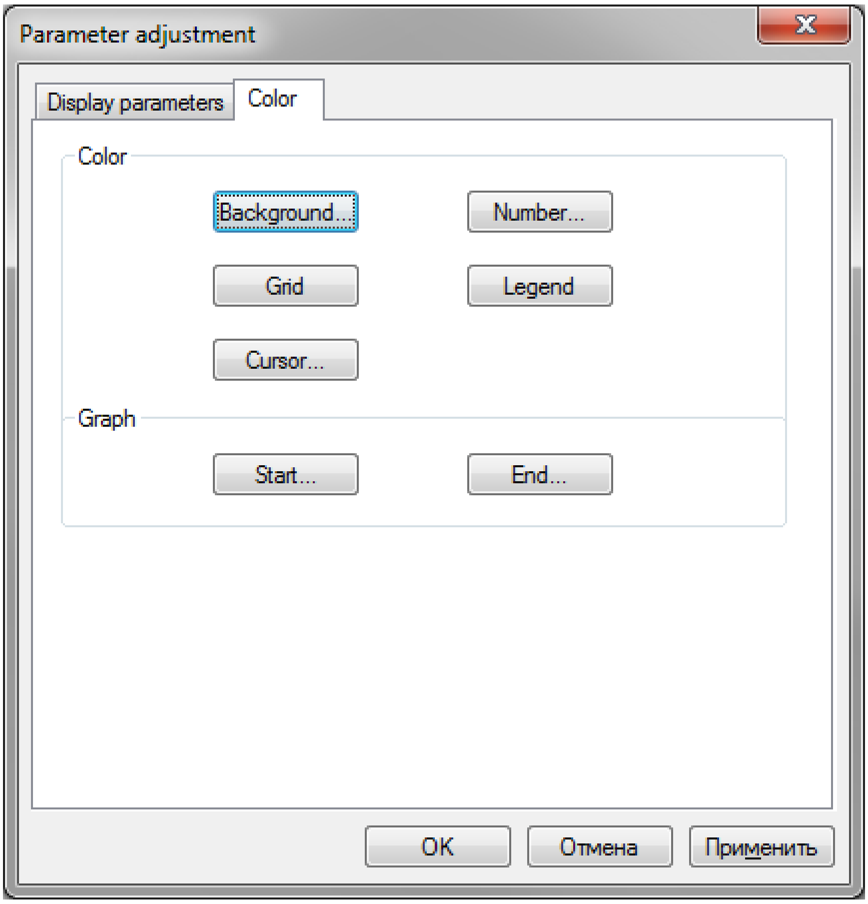
Graphic display parameters configuration

Right-click the graphic area of **XY-Plotter** program to activate display parameters configuration window. The display parameters tab allows to set visibility limits and grid lines type (i.e., the type of data representation):



XY-Plotter- Graphic display parameters adjustment

The "**Color**" section allows to select colors for background, grids, cursor, etc.



XY-Plotter- display parameters adjustment

Click one of the color setting options to activate color selection window allowing to set a color for a particular element of the graphic.

XY-Plotter- background color parameters

Results viewing .....

The program allows to simultaneously download several data files obtained with the use of ZETLAB programs, as well as to view and edit this data in graphical and spreadsheet format.

Main functions of the program:

The program "**Results viewing**" allows:

- To simultaneously download several data files recorded with the use of ZETLAB software;
- To download data files from different directories or PC-s and to unite them into a common data base, which considerably simplifies operations with the files;
- To conduct automated search of files;
- The program also has user-friendly interface;
- To copy the data from ZETLAB programs used in real-time mode;
- To view the data in graphical format;
- To edit data in spreadsheet format;
- To combine graphics and to recalculate their scale in frequency and time domain;
- To save the statistical data to *Report1.xlsx*;
- To conduct various operations with data columns (addition, subtraction, smoothing), including math operations and calculation of various parameters;
- To preview the signals. All the files are displayed in preview format;
- To compare several signals within a single coordinate network;
- To view signal trends for a particular period of time.

Supported Hardware .....

Supported hardware

The program allows to simultaneously download several data files, which have been recorded with the use of ZETLAB software.

The program **"Results viewing"** is included into the scope of the following software packages:

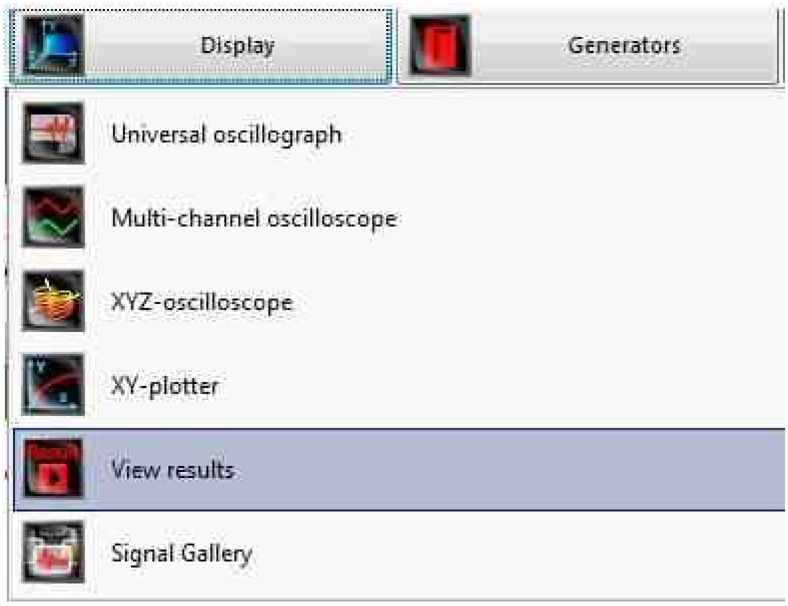
- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT spectrum analyzer software

- ZETLAB VIBRO – Vibration controllers software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software.
-

Results viewing is included into **Display** software group.

Program description .....

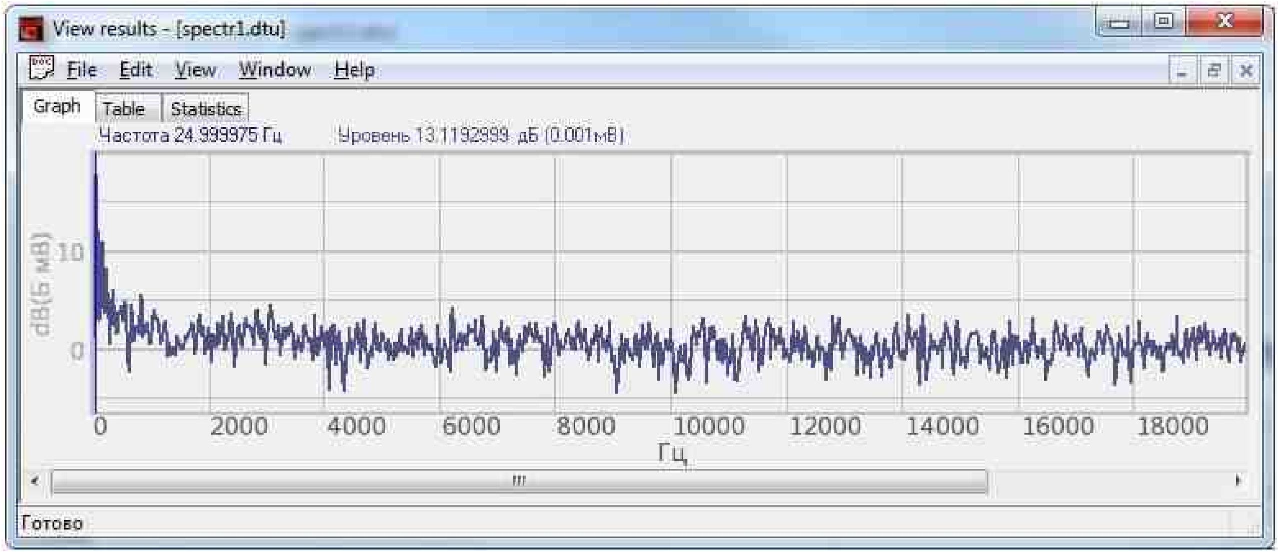
The program "**Results viewing and processing**" is started from the Display section of ZETLAB panel.



Starting the Results viewing program

Starting the program "Results viewing and processing"

Note: the program "**Results viewing**" can also be started from ZETLAB directory (the directory by default: C:\ZETLab\). The name of the file to be started: ResultViewer.exe.

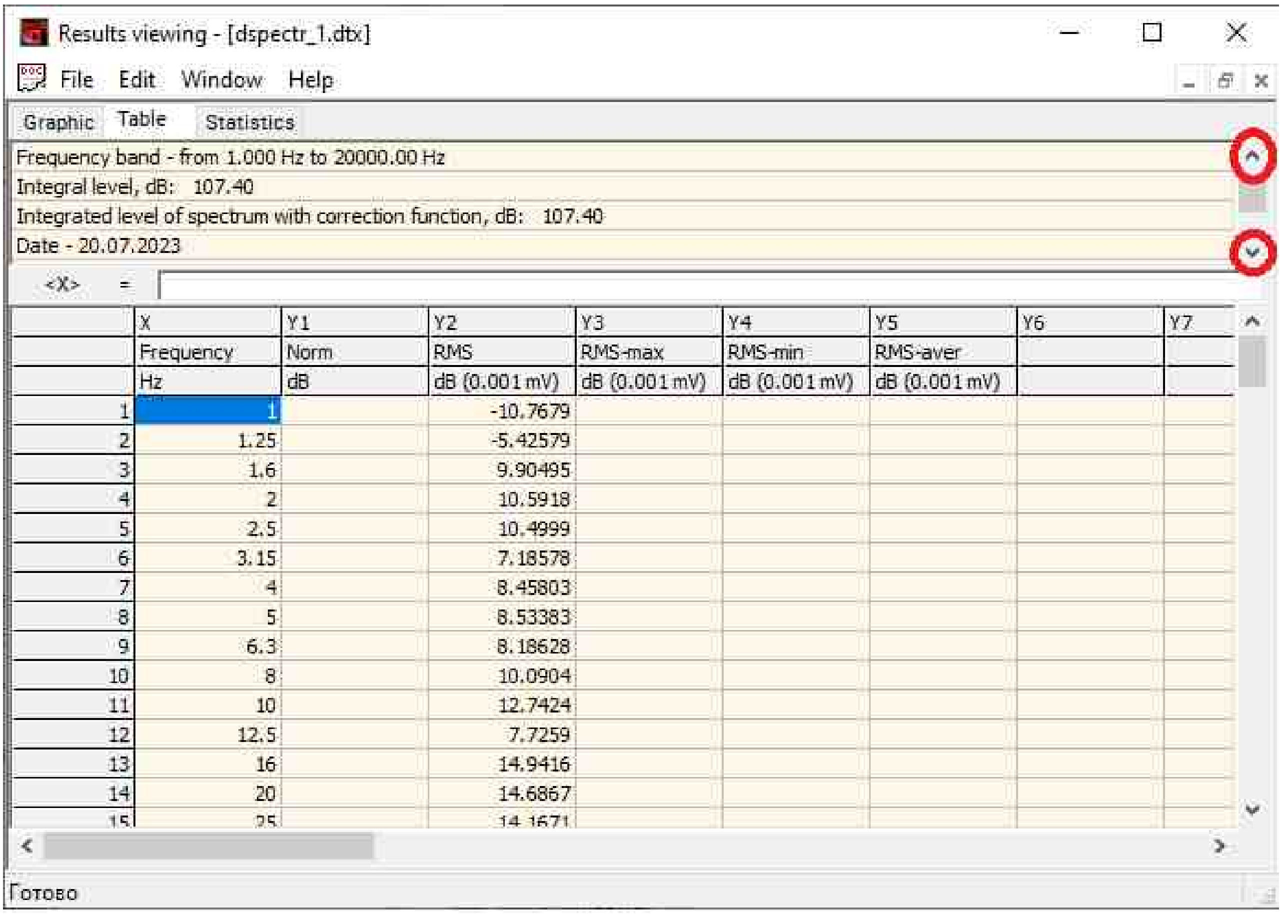


Interface of the Results view program

Question and answer:

Question: How to find the values of integral levels in the dtx file of the "**Spectrum CPB Analysis**"?
Answer: Data on integral levels in the latest versions of the program are recorded in a dtx file. There are two ways to get this information:
- open the file with a text editor and find the <Comments> section, see the example below;
- open the file with the program "**Results viewing**", click on the word "Table", then scroll the top table to the words "Integral level", see the attached file "example.png".

Example of the <Comments> section of the dtx file:
<Comments>
<Comment_1>Spectrum CPB Analysis</Comment_1>
<Comment_2>KP_2293_4-1Z</Comment_2>
<Comment_3></Comment_3>
<Comment_4>Frequency range - from 1.000 Hz to 40.00 Hz</Comment_4>
<Comment_5>Integral level, dB - -13.43</Comment_5>
<Comment_6>Integral level of the spectrum taking into account the correction function, dB - -13.43</Comment_6>
<Comment_7>Date - 27.05.2022</Comment_7>
<Comment_8>Time - 11:18:37</Comment_8>
<Comment_9></Comment_9>
</Comments>



See also:

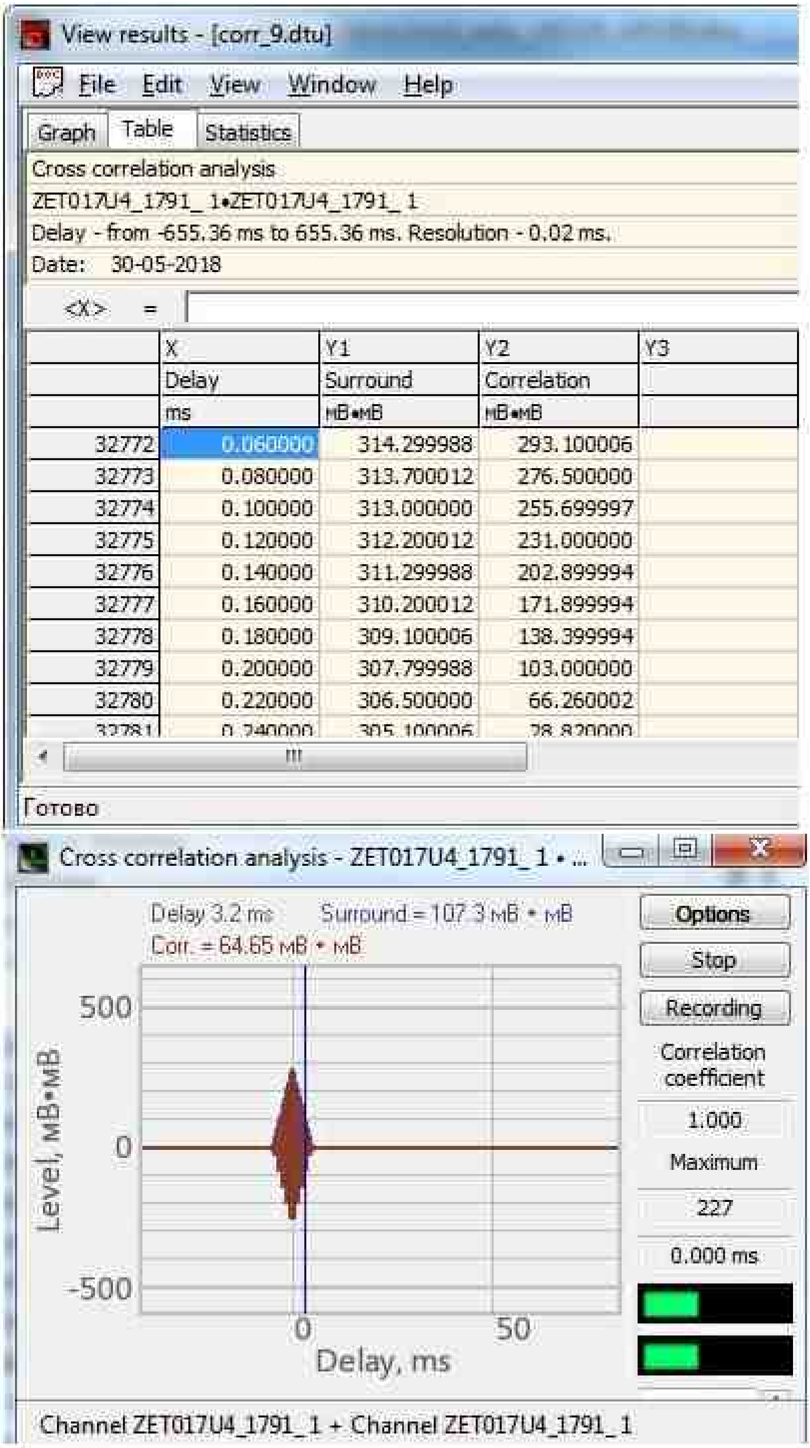
- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Setting parameters of display
- Using signal level indicators
- Adjustment of the color scheme used for displaying of the registered signal amplitude values
- Graphical and numerical data transfer to text editors
- Setting GridGl grid functionality

The main window of the program .....

To start the program from ZETLAB panel, go to "*Display*" section and select the option "**Results view**".

Note: it is also possible to start the program using the command line: C:\Zetlab\ResultViewer.exe

Program description – general view:



Main window of the program Results view

Upon activation of the command "**Open**" there appears a window for file section. The files to be view should have extensions **.dtu* or **.gru*

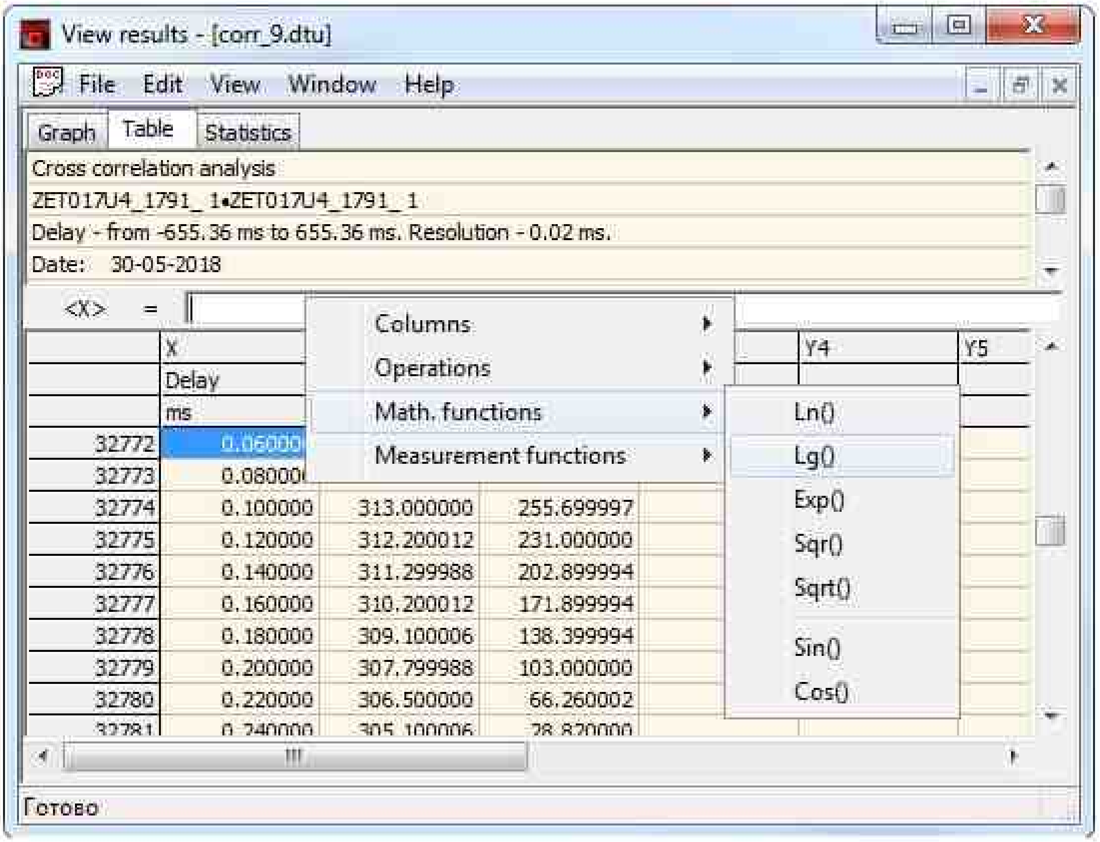
It is also possible to start several files simultaneously. The files can be viewed in graphical and spreadsheet format.

To close the program, use the command "**Exit**" or click the corresponding icon at the top right section of the program interface.

Above the graphic, you can see the type of analysis used, the number (name) o the channel, date and time of recording.

The keys "**Open**", "**Save**", and "**Save as**" activate dialog windows allowing to open and to save the file. These functions are described in the following clauses.

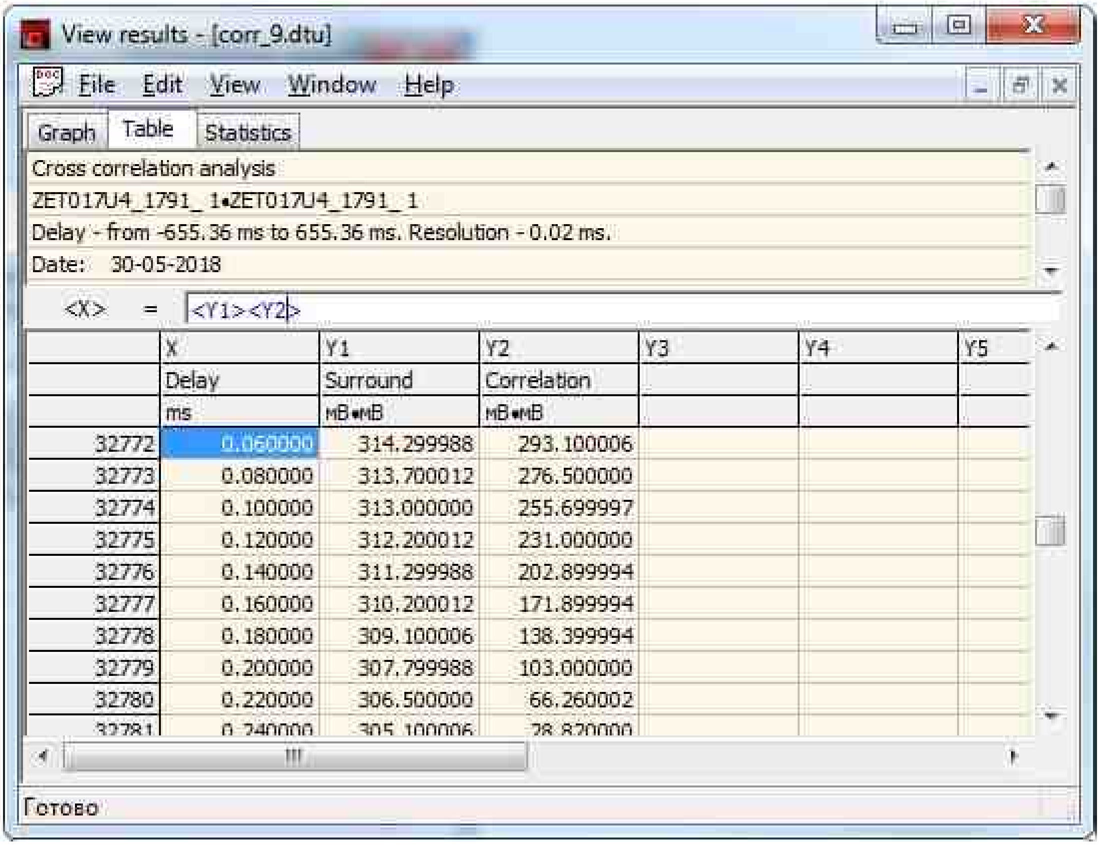
The "**Help**" key provides access to additional information about the program.



Results view - list of available math functions

It is also possible to perform various math operations with the data columns (addition, subtraction, calculation of various parameters).

To do that, select the data column, set the mathematical expression for the particular column and click "**Enter**" key.



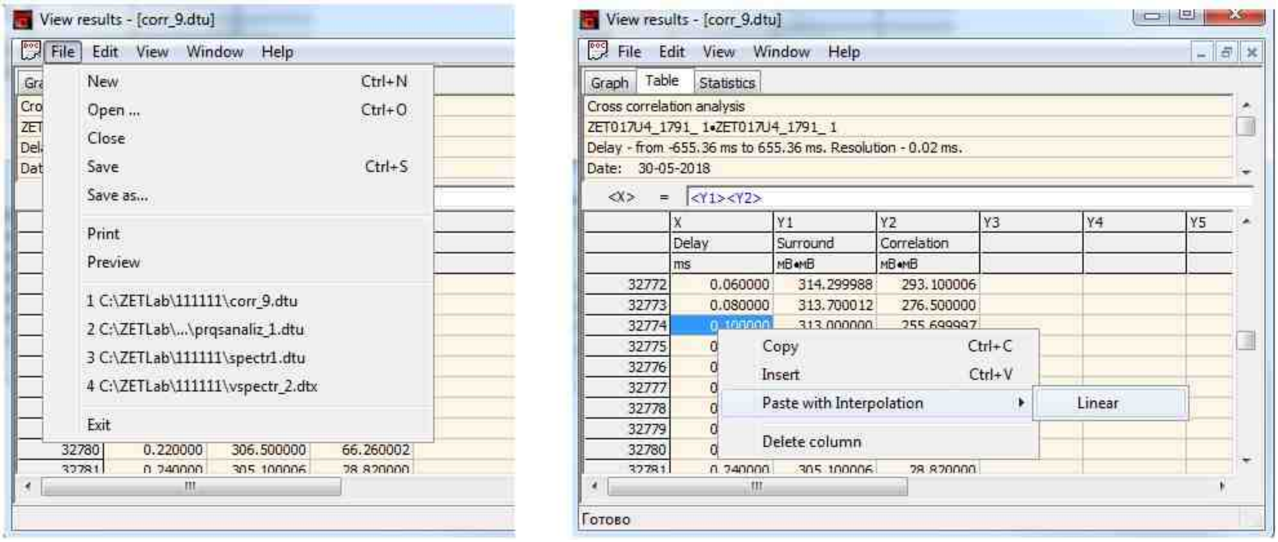
Results view program - using the math functions for calculations

Click the **Expression** at the "**Math. Function**" section to view the available functions (mathematical and measurement operations).

Menu structure .....

The menu section is located at the top part of the main program window. It displays the titles of all command sections.

To select a particular command, left-click the corresponding menu section and select the required command in the drop-down list. It is also possible to switch between the commands using the arrow keys of the keyboard and to use the <*Enter*> key to select the required command. Some of the commands may have quick access keys – in this case, the quick access combination will be displayed next to the title of the command. The symbol "+" in the combination means that it is necessary to press and hold the first key and then to press the second key. For example, to copy the data, it is necessary to use <Ctrl>+<C> combination.



Results view program - menu functions

File menu .....

The File menu contains the following commands:

• New;

• Open...;

• Close;

• Save;

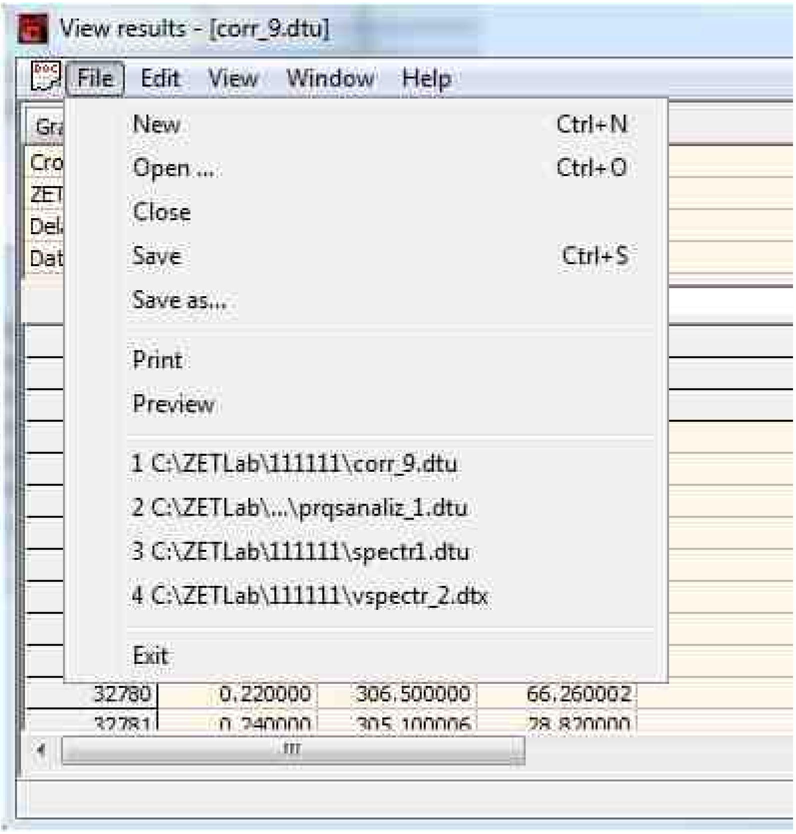
• Save as...;

• Print;

• Preview ;

• Recent documents ;

• Exit.



Results view program - File section menu

New

The command is used to create a new file with **.dtu* extension. It is also possible to create a new file using the combination <Ctrl>+<N>. Upon activation of this command, the previously opened files will not be closed.

Open…

Upon activation of the "**Open…**" command there appears a window for file selection. The files to be opened should have the extension **.dtu* or **.gru*. The combination <Ctrl>+<O> also allows to open a file. Upon activation of this command, the previously opened files will not be closed.

Close

Allows to close active window (file). It is also possible to close the file by clicking the key , at the top right section of the window.

Save

The command allows to save the changes introduced in the particular file. The combination <Ctrl>+<S> also allows to save the changes.

Save as

The command allows to save the changes and starts a standard dialog window for saving the file.

Print

The command allows to print the accumulated signals data. All the files are saved as images of the signal graph;

Preview

The command enables signals preview, all the files are displayed in preview mode;

Exit

The command allows to exit the "**Results view**" program. To exit the program, click the key at the top right section of program interface.

The "**File**" menu section also displays the list of recent files.

Edit menu .....

"**Edit**" menu contains the following commands:

• Copy;

• Update;

• Undo update.

Window Menu .....

The "**Window**" menu contains the following commands:

• New window;

• Arrange windows as cascade;

• Arrange windows as table;

• Align icons of all windows.

"New window" command

The command creates a new file with *.dtu extension. It is also possible to create a new file using the combination <Ctrl>+<N> or the icon in the tool panel. Upon activation of this command, the previously opened files will not be closed.

Arrange windows as cascade

The command aligns all active windows and unifies their size.

Arrange windows as table

The command arranges all active windows as table, unifies their size, and evenly distributes them along the working area of the "**Results viewing**" program.

Align icons of all windows

The command allows to align icons of all windows.

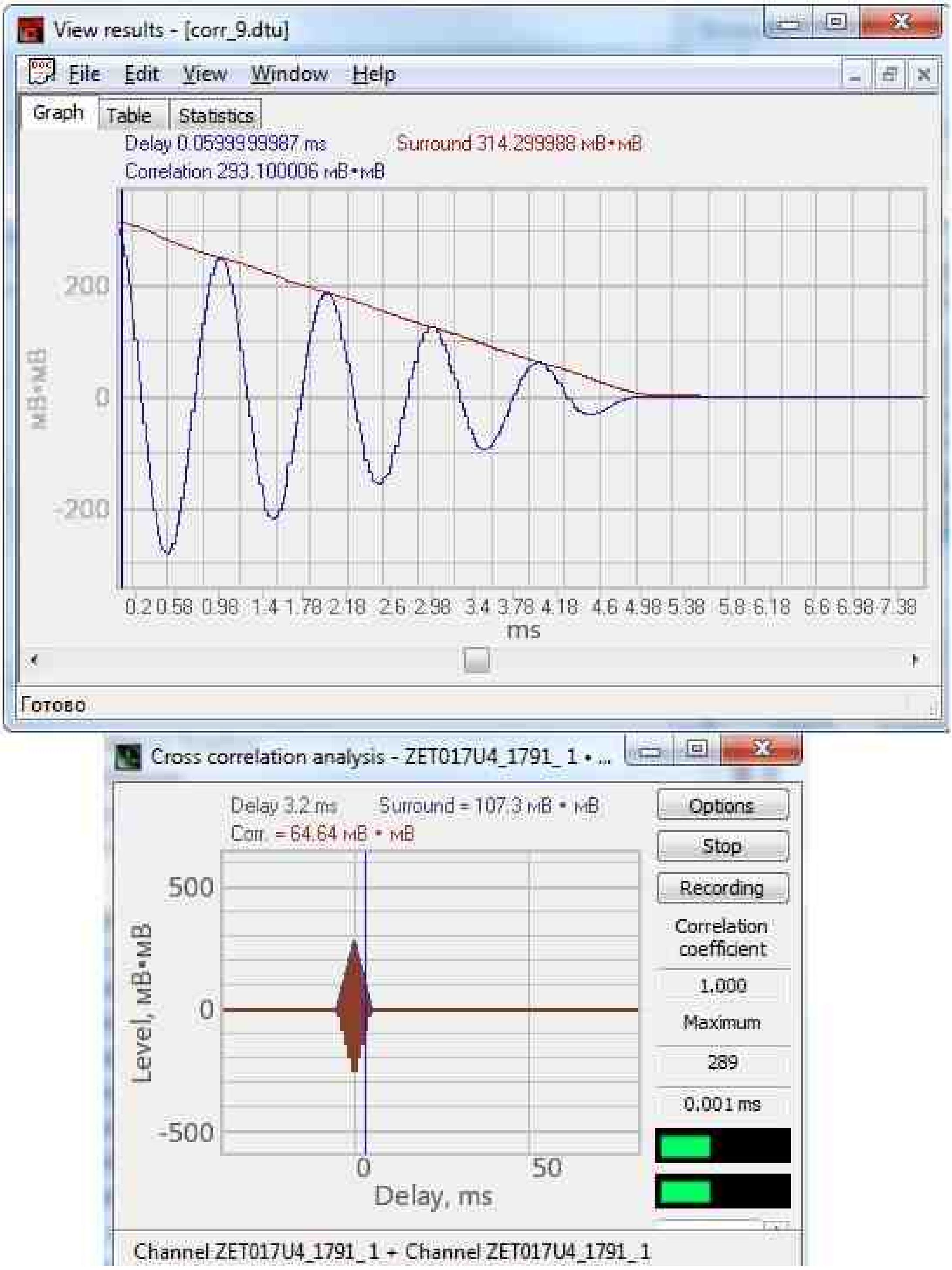
In the "**Windows**" menu, under the list of available commands, there is also a list of recent. files. The file, that is currently used for data viewing or editing has a checkmark. The window of the active file is located above the other windows.

Help menu .....

The "**Help**" menu contains the command "**About the program**".

Upon activation of this command, there appears informational window "**About the program**", which can also be opened with <F1> key.

Using the program .....



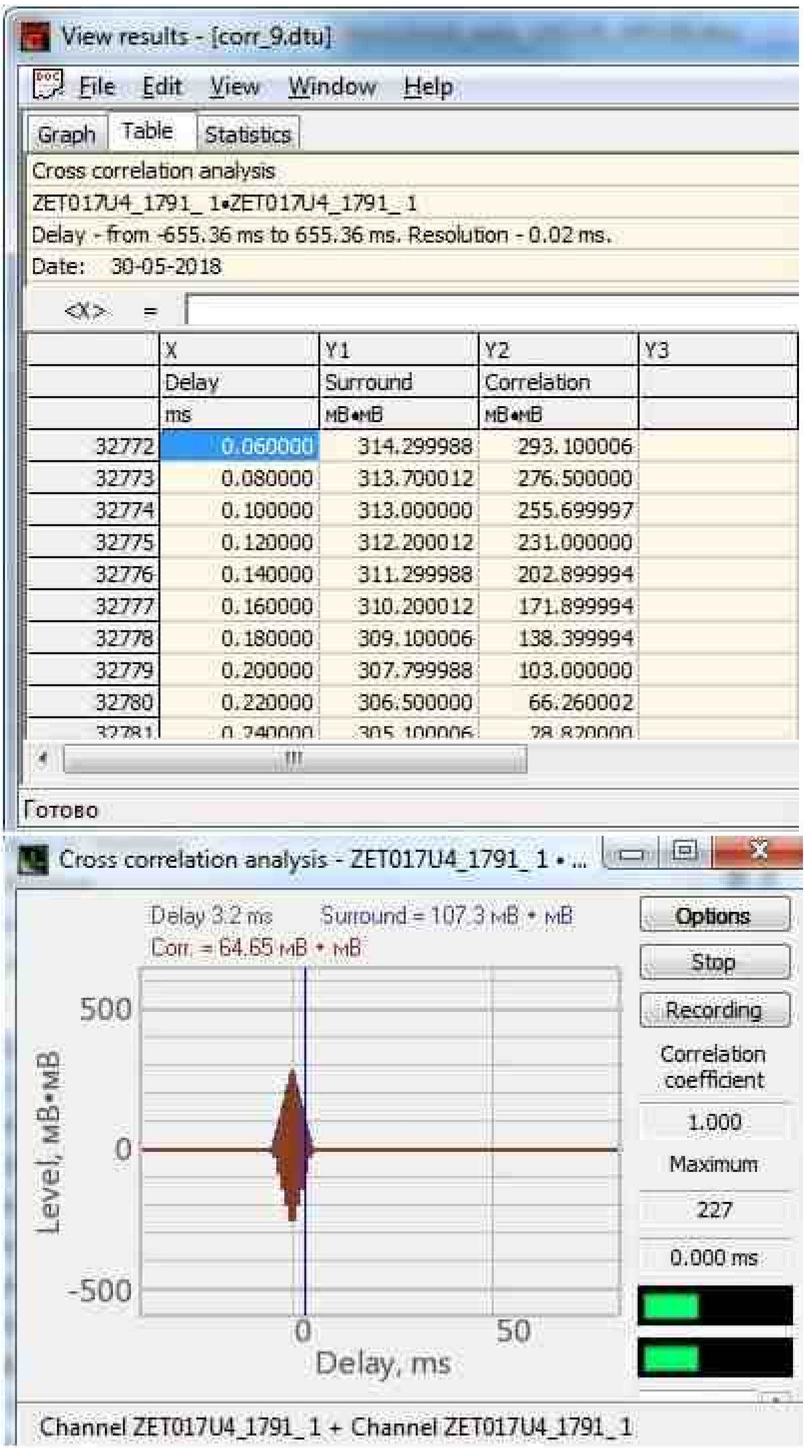
Using the Results view program

Tabs .....

Each window, containing a new document or a file, has two tabs. The first tab contains graphical representation of the data. The second tab displays the same data in spreadsheet format (it is possible to edit this data). All the changes, that were introduced in the spreadsheet format, are further displayed in graphical view.

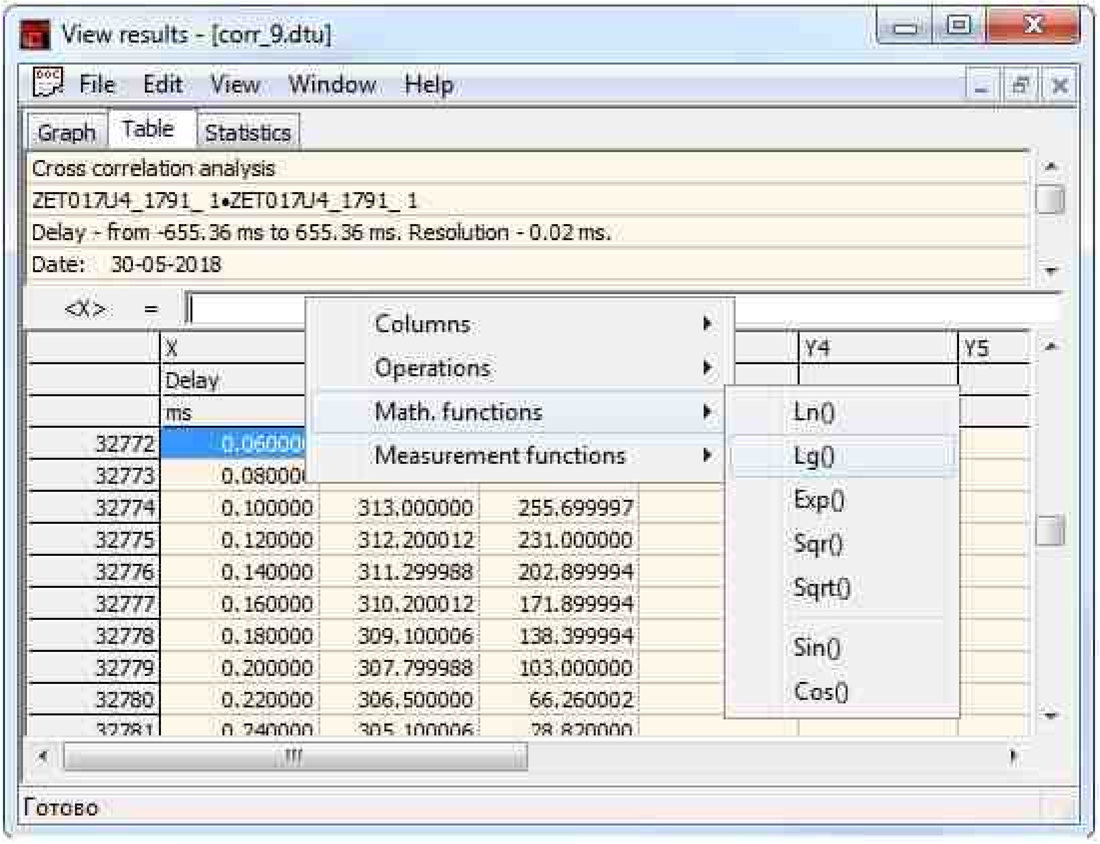
Syntax .....

Instead of using error notifications, the program highlights the title of the column containing wrong expression with red color. For the columns with correct expressions, the color of the highlighting is blue. The mistakes in the expression are also highlighted with red color.



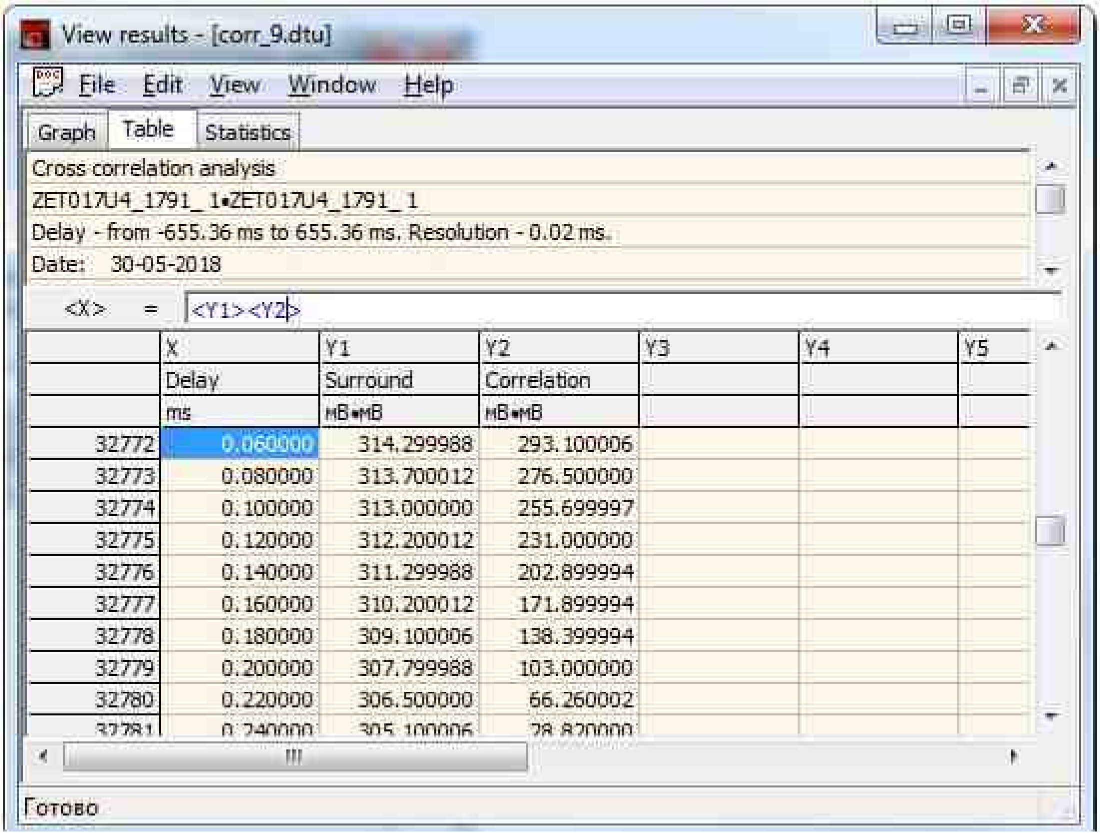
Syntax of the Results view program

In this example, everything is correct



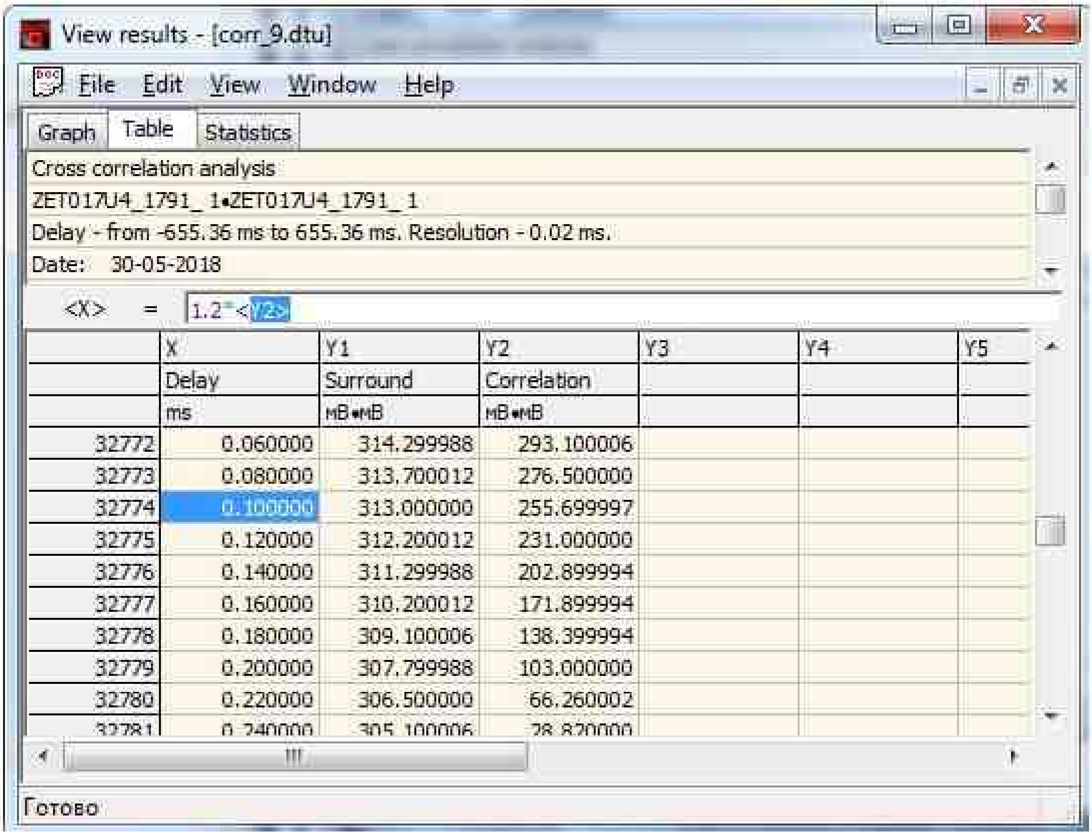
Syntax of the Results view program - wrong name of the function

In this case, a wrong function name is specified – there is no such function.



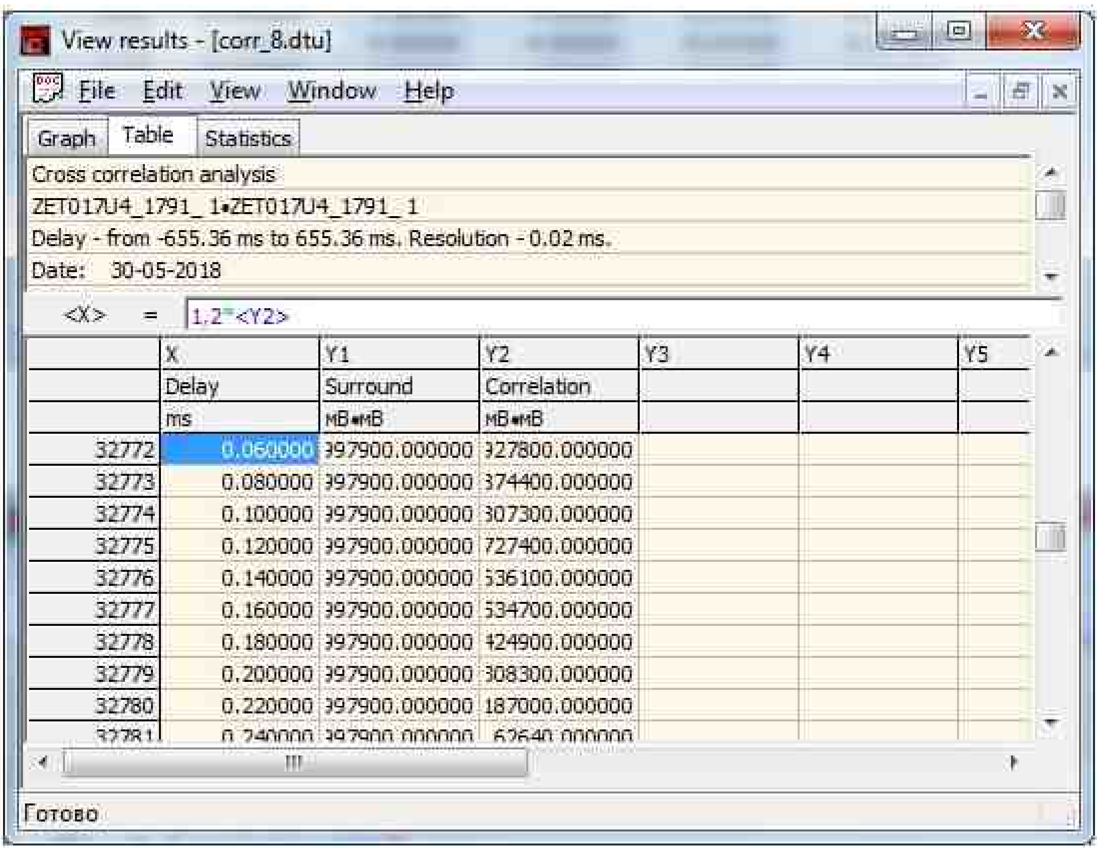
Syntax of the Results view program - non-existing column specified

In this case, a non-existing column is specified. The names of the columns are enclosed in parentheses <>.



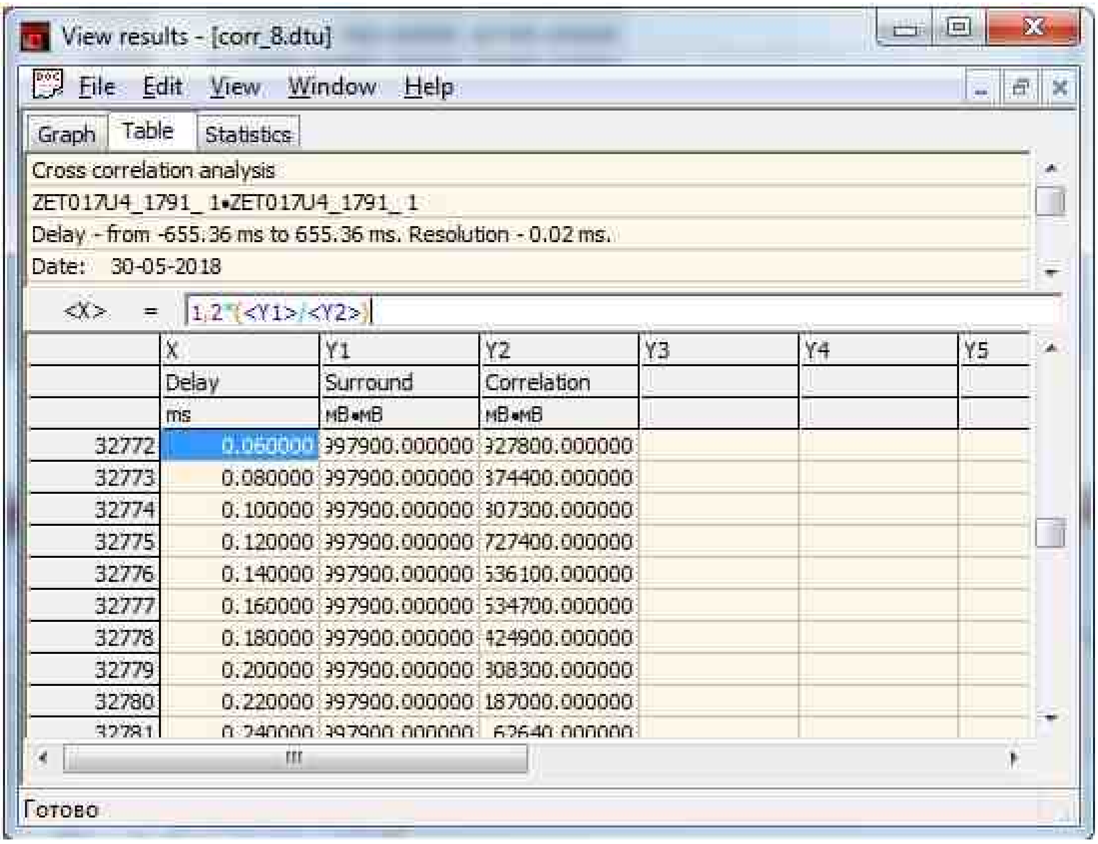
Syntax of the Results view program - constant expressions

Constant expressions are highlighted in violet color. The symbol "." is used as a decimal separator.



Syntax of the Results view program - wrong use of comma symbol

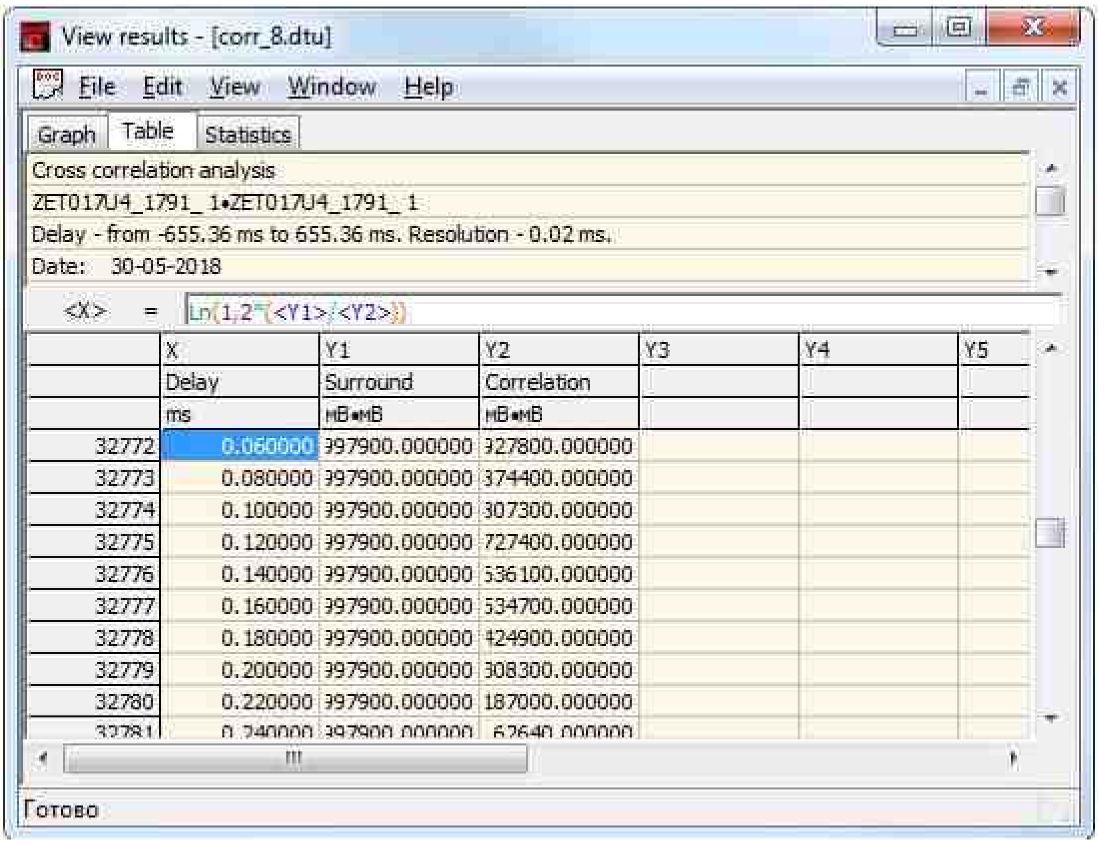
The mistake in the second example is attributed to the wrong use of "," symbol.



Syntax of the Results view program - operational signs

Arithmetical operators are shown in blue color.

The brackets are highlighted with brown color.



Syntax of the Results view program - functions names

The names of the functions are shown in dark-green color. In the case if the function has several variables, the variables are separated with "," symbol.

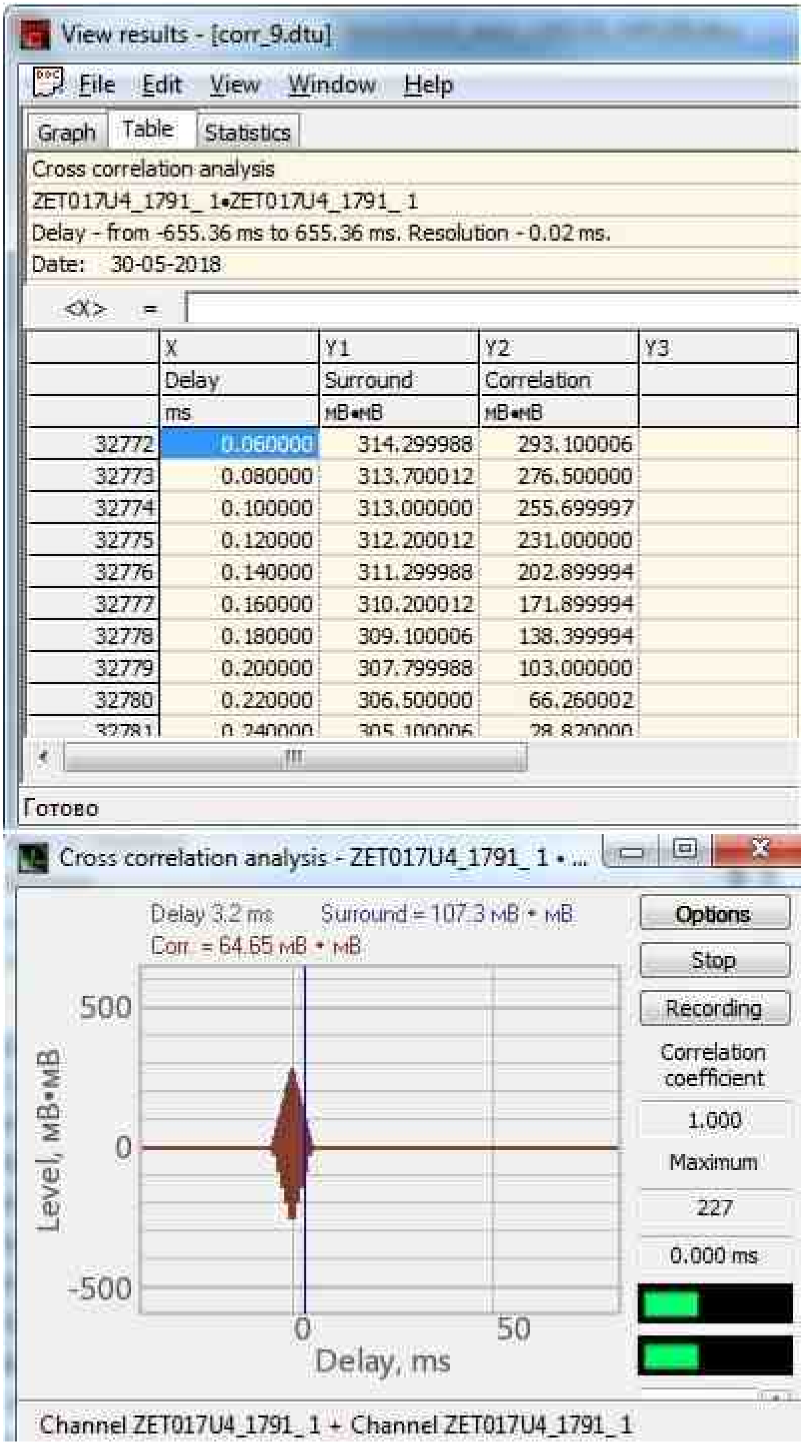
Operations .....

"+" – addition of columns, constant values, calculations results;

"-" – subtraction of columns, constant values, calculations results;

"*" – multiplication of columns, constant values, calculations results;

"/" – division of columns, constant values, calculations results.



Syntax of the Results view program - operations

Mathematical functions .....

Ln(<Y1>) – natural logarithm calculation for a column. It can be used for calculation of the measured values in dB;

Lg(<Y1>) – decimal logarithm calculation for a column. It can be used for calculation of the measured values in dB;

Exp(<Y1>) – exponential value calculation for a column;

Sqr(<Y1>) – calculation of squared value for a column;

Sqrt(<Y1>) – calculation of square root for a column;

Sin(<Y1>) - sine value calculation for a column;

Cos(<Y1>) – cosine value calculation for a column.

Measuring functions .....

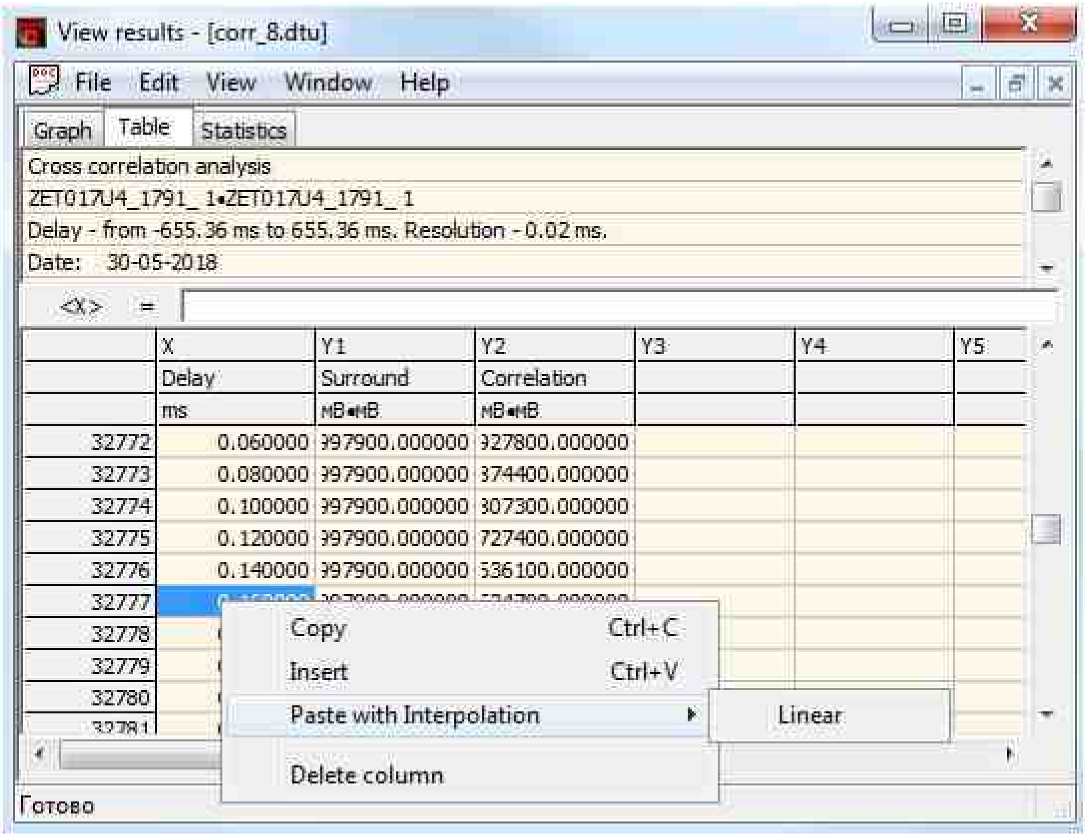
Min (<Y1>) – the function is used to find the minimal value of a channel;

Max (<Y1>) - the function is used to find the maximal value of a channel.

Editing the data .....

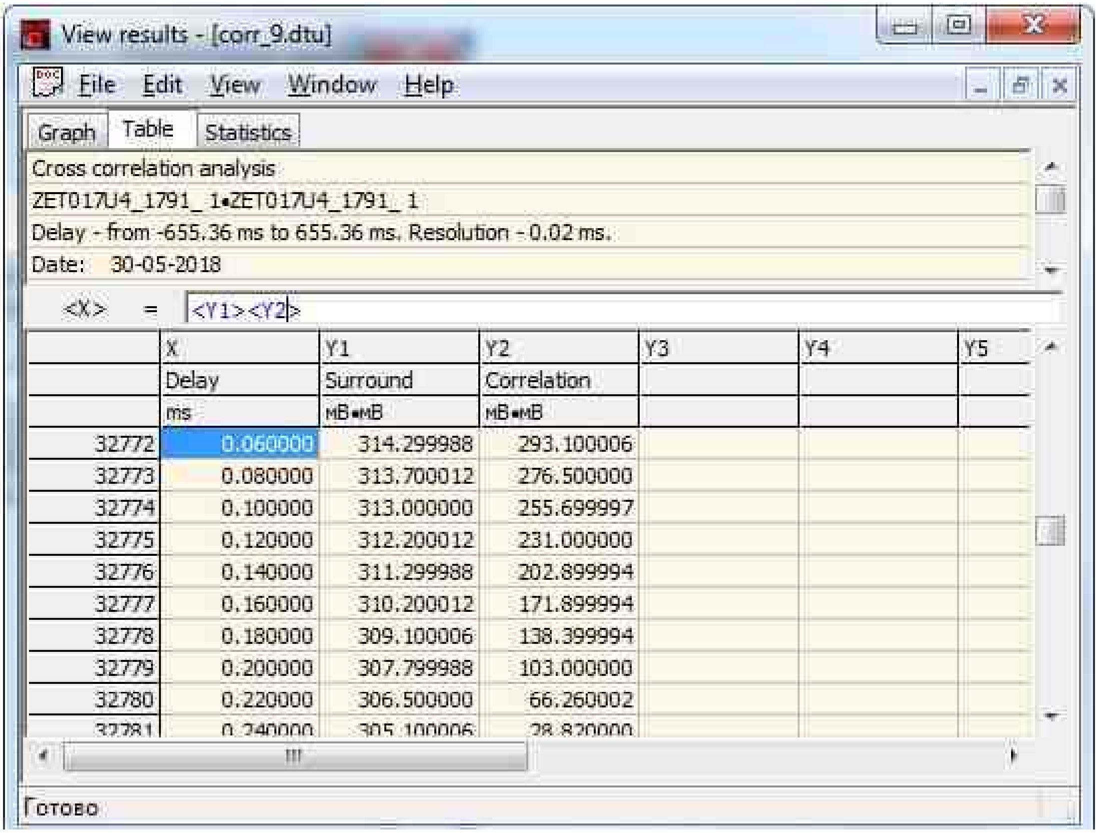
As the file is opened, it becomes possible to edit the data

It is possible to copy a column or any other section of the file.



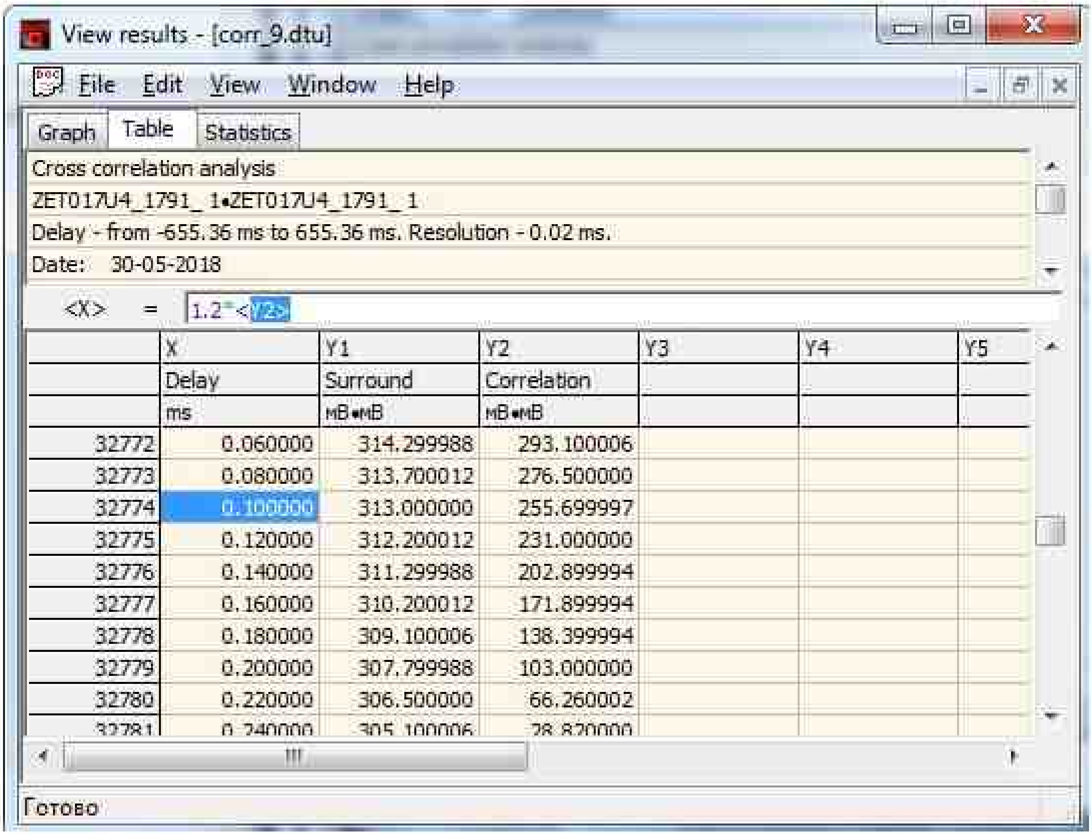
Syntax of the Results view program - Editing

And to paste it into the second file.



Syntax of the Results view program - Editing

In the case if <X> resolution value of the first file does not comply with <X> resolution value of the second one, you can use the function "Paste with interpolation". The Y value will be recalculated with reference to the new frequency or time scale.



Syntax of the Results view program - Editing

It is also possible to edit the contents of cells. Double-click a cell. If the column does not exist yet, the program will create it. If you have selected a position different from "0" value, all the previous positions will be filled with "0" values.

Signals gallery .....

The "Signals gallery" program is intended for viewing and analysis of the recorded signals (the records can be stored on the hard disk or be available via remote access).

Special features and advantages of the program "Signals gallery":

• The files of the recorded signals (that are located in various directories of a hard disk or stored in the memory of several PC-s within a single network) are combined into a single database, which considerably simplifies analysis performance;
• Automated files search;
• User-friendly interface;
• Function of signals preview: all the files are displayed in preview mode;
• Convenient comparison of several signals within a single coordinate network;
• Possibility of analyzing signal trends for a particular measurement period.

Supported Hardware .....

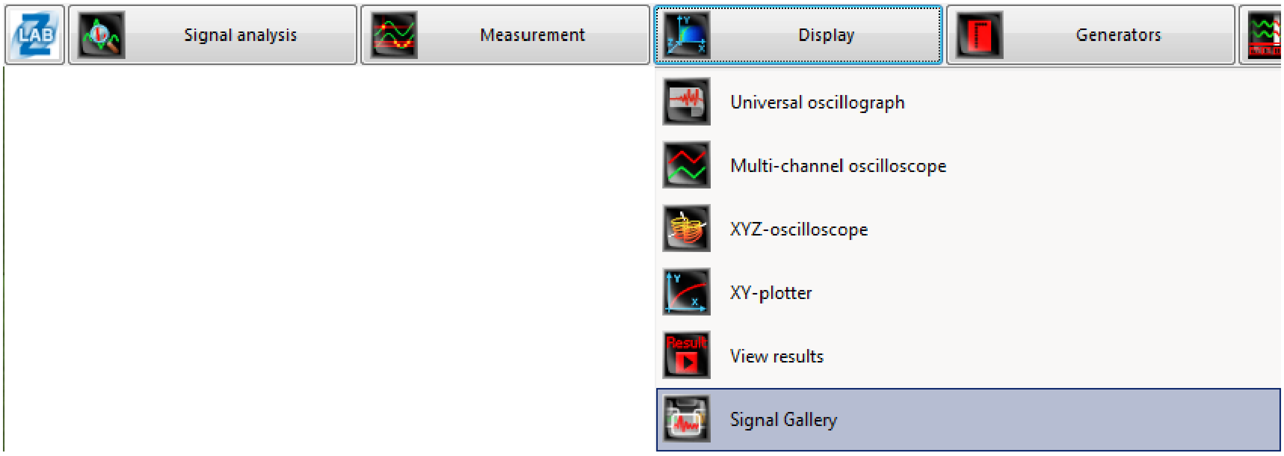
The input data of the "Signals gallery" program are represented by digital channels of *ZETLAB* data server.
The "Signal gallery" program is included into the scope of the following software packages:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT spectrum analyzer software
- ZETLAB VIBRO – Shaker controllers systems software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration and noise meter software,
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software.

The "Signal gallery" program is located in the "Display" software section.

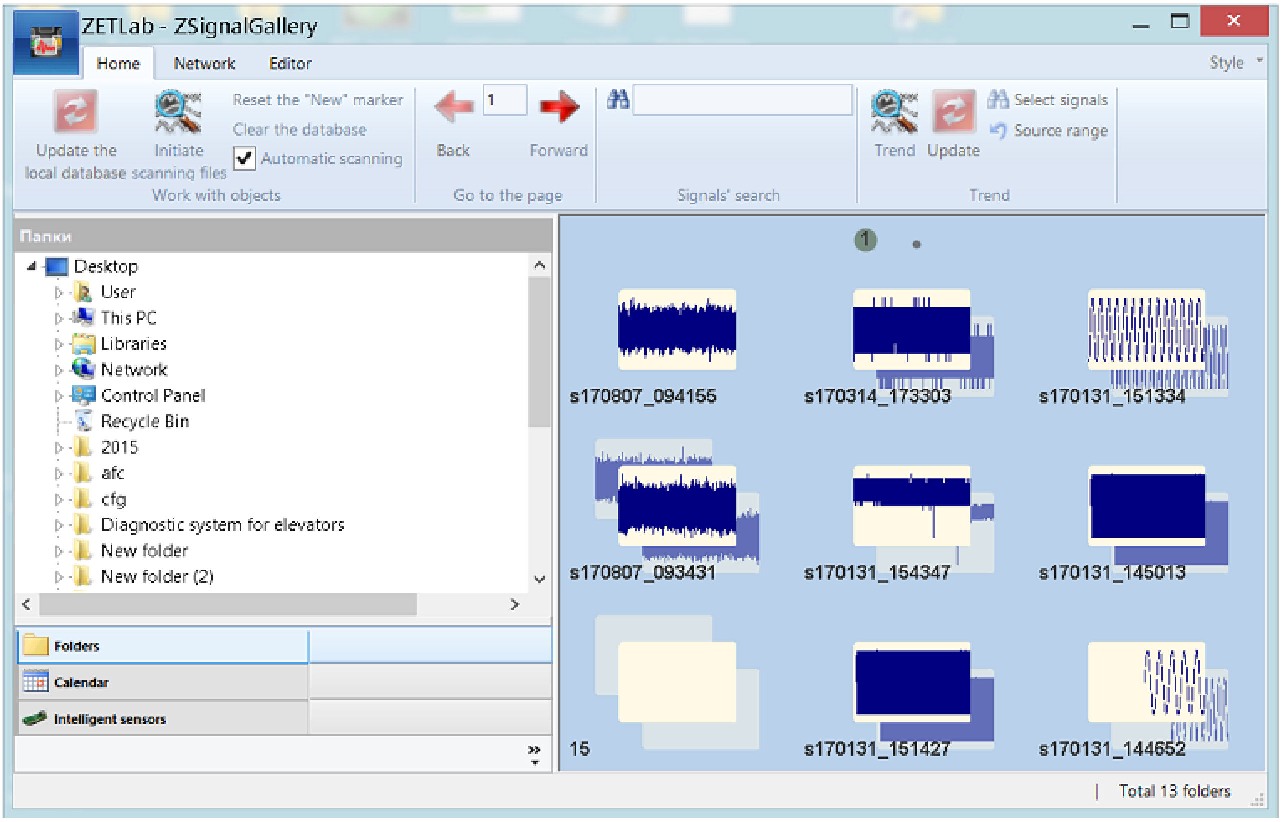
Program description .....

In order to start the program **"Signals gallery"**, select the corresponding program from the display section of *ZETLAB* Control panel. You will see the main working window of the program.



Starting the program Signals gallery

Note: the program **"Signals gallery"** can also be started from *ZETLAB* directory (the directory by default: C:\ZETLab\). The name of the file to be started: ZETSignalGallery.exe.



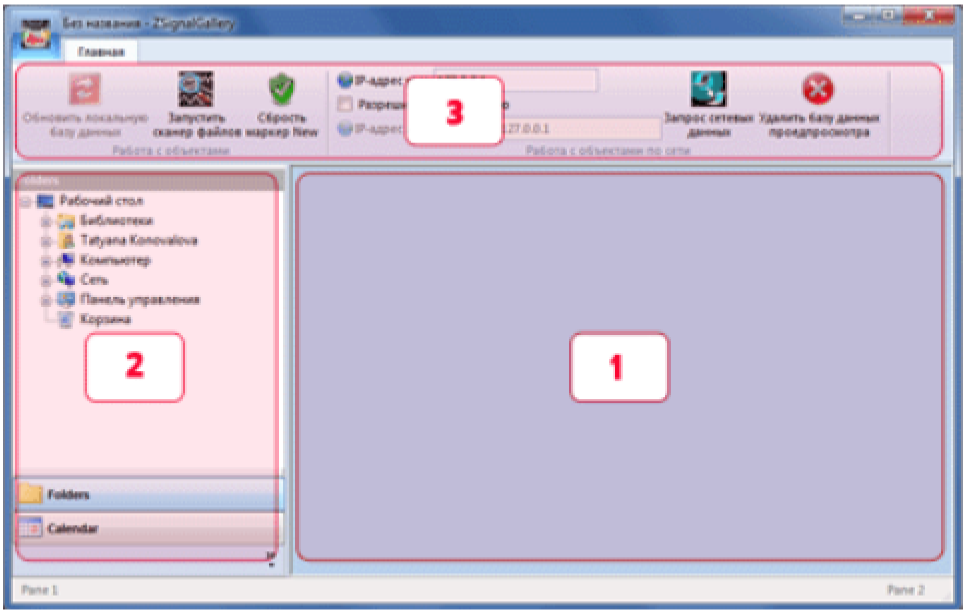
Interface of the program Signals gallery

The program consists of the main window containing all necessary tools:

• Work environment section. Display section for files and folders

• Side panel. Menu "*File manager*" and "*Calendar*".

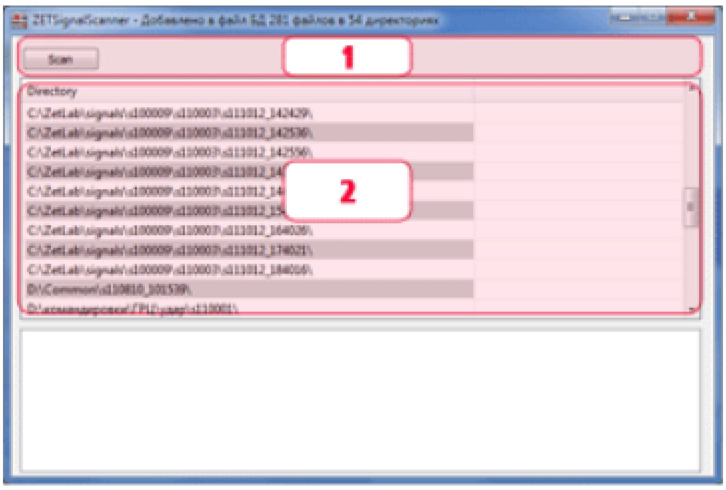
• Instruments panel.



Signals gallery program - interface layout

To start operation of the program, click the key "*Initiate scanning files*", you will see *Signals scanner* window with the following elements:

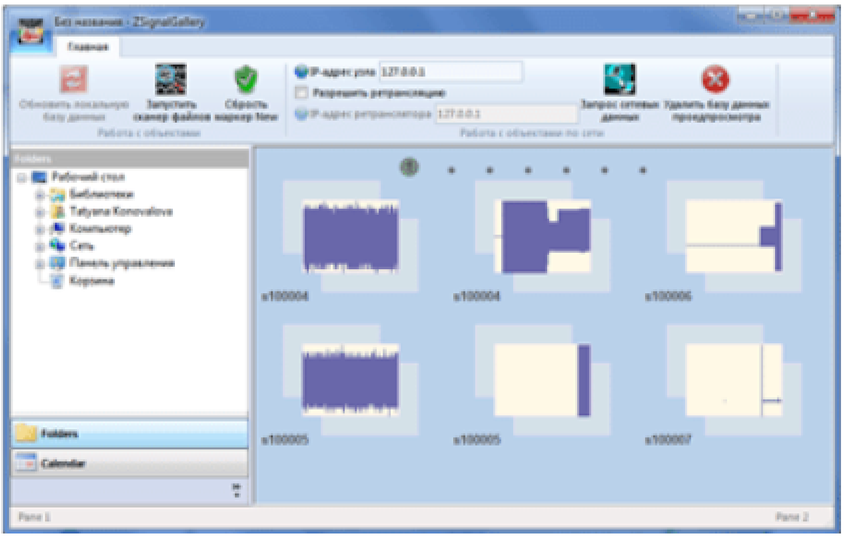
• Section with a key used for scanning PC directories and detection of signal files, and a progress bar.
• Graphic with the names of the detected directories.



Signals gallery program - files search - scanning of directories

Starting the scanning process

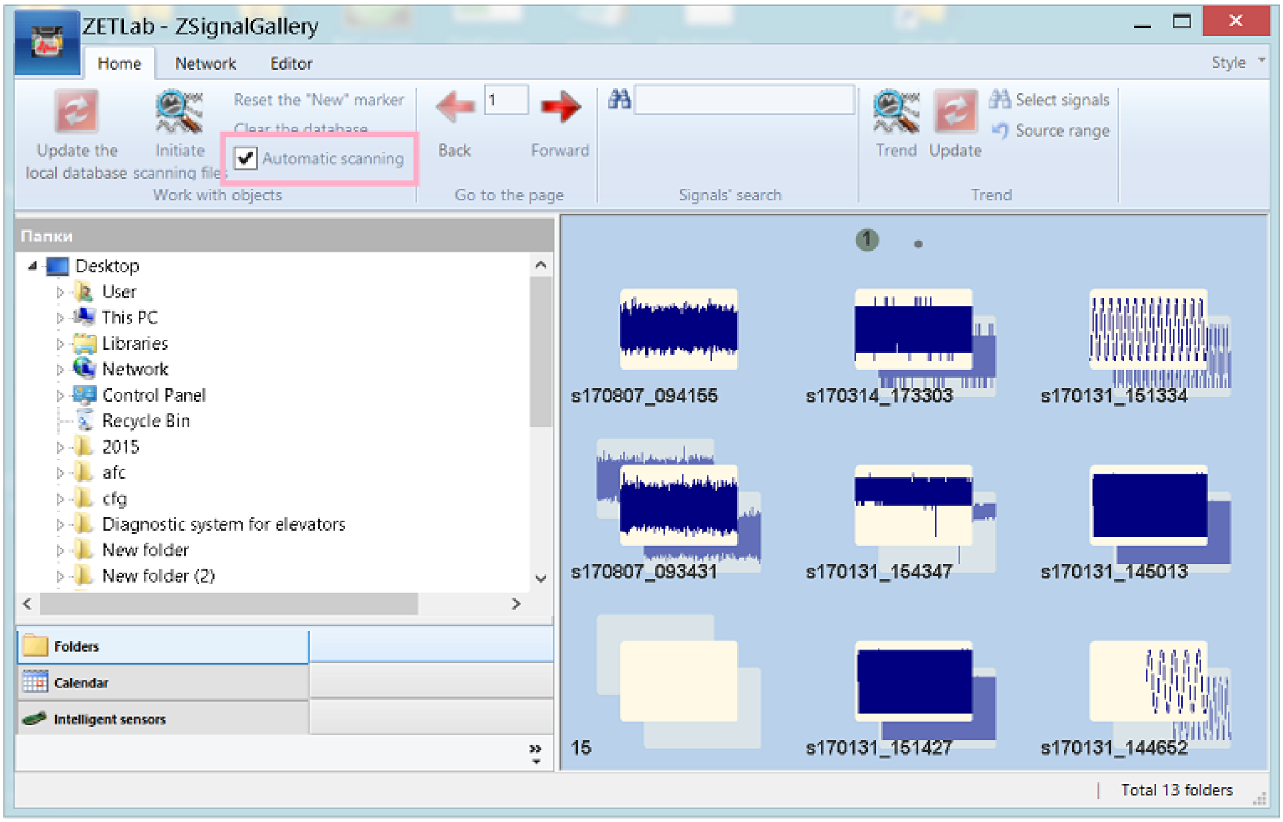
Upon completion of the scanning procedure, all the detected directories will be displayed in the main program window with the label "*New*" (to remove it, click the key "*Remove New label*"). The working area of the program now displays the previews of the folders containing the signals. The search data is then saved and the detected directories will be displayed upon the next start of the program.



Signals gallery program - automated scanning of the files

Automated scanning of the signals

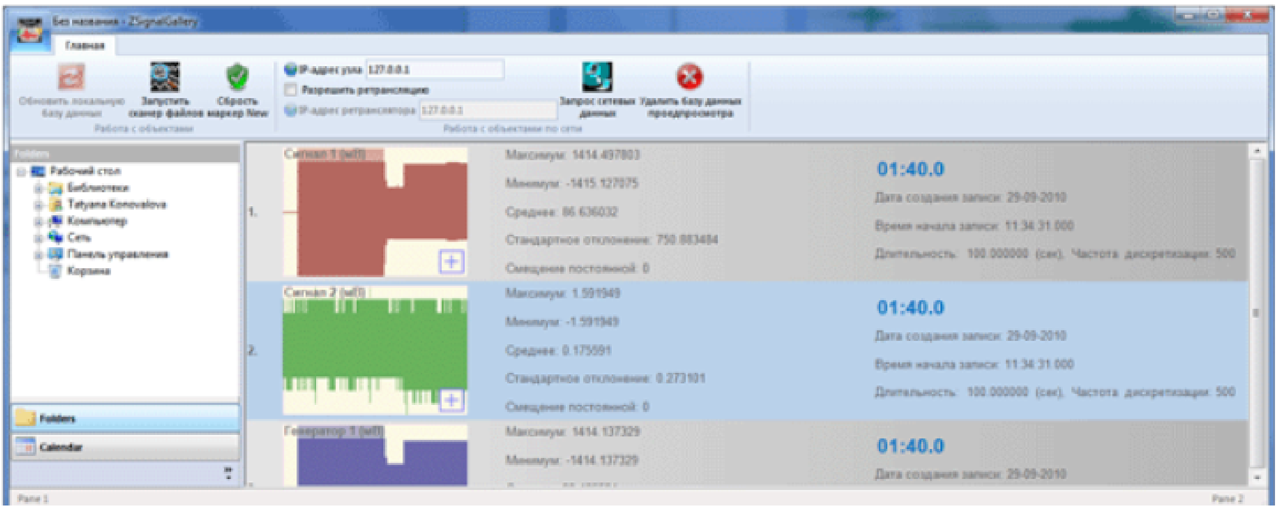
If the option *"Auto-scanning"* is enabled, then the program automatically displays the selected directories and the recent files of the recoded signals.



Signals gallery program - automated scanning of the files

Files viewing

By clicking a preview, the user gets access to the list of the files contained in the corresponding directory. The contents of the directory is represented by a numbered list of previews with the following characteristics: "*Max*", "*Min*", "*Average*", "*Standard deviation*", "*Offset DC*", duration of the recording, "*Recording date*", "*Recording start time*", "*Duration*", "*Sampling frequency*".

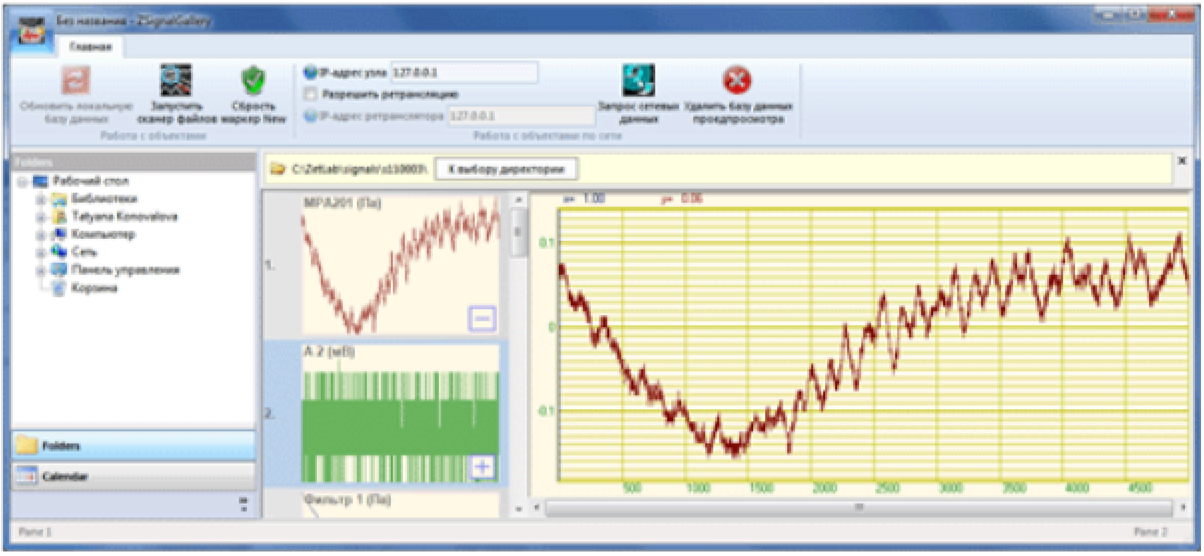


Signals gallery program - Viewing the signals

Viewing file parameters

As the user clicks the required signal, the field containing signal description disappears – instead of it, the program displays a section with signal graphic.

The number of the selected channels is not limited – the displayed channels will be simply placed on each other. The graphical display system allows to zoom-in/-out, to move along the displayed section of the signal and to evaluate the instant values of the signal. To close the display of signal's graphic, click its preview again.

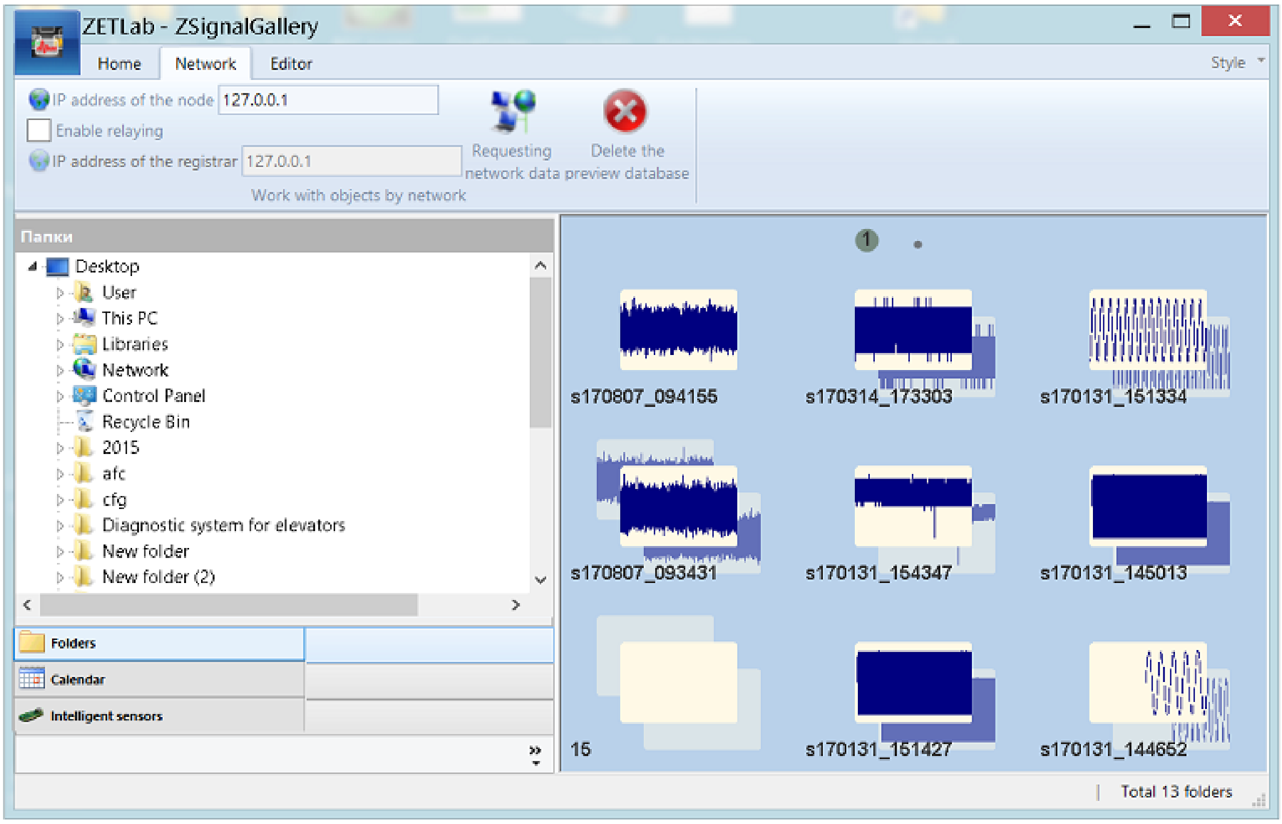


Signals gallery program - Signal preview

Viewing the signals

In order to obtain data from a PC, Enter its IP-address in the corresponding section. If a proxy-server is used, activate the option "*Enable relaying*" and enter the IP address of the registrar into the corresponding section. Then click the key "*Request network data*".

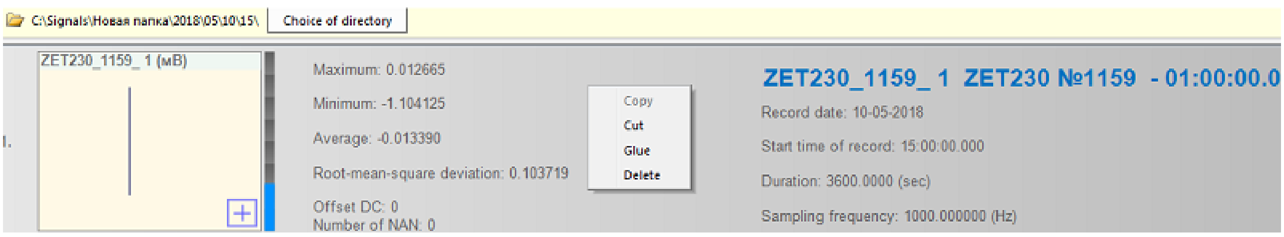
In order to enable displaying of recently recorded signals, click the key "*Update local database*". In the case if you are using remote access data, establish the connection with the necessary PC and then click the key "*Clear the database*".



Signals gallery program - Network tab

Network

The "*View*" option in the "*Editor*" section allows to view the previously recorded signal. The "*Option*" function is necessary for group operations with the signals. The "*Cut*" function is used to separate the signal into parts. The "*Glue*" function allows to combine the signals. The "*Delete*" key is used for removal of the signals.



Signals gallery program - Editor tab options

The program "**Signals gallery**" has additional functions used for cutting parts of the signal.

The "*Cut*" window has the following options:

1. From beginning;

2. From the end of;

3. Everything up to the cursor;

4. All after the cursor;

5. Interval before the cursor;

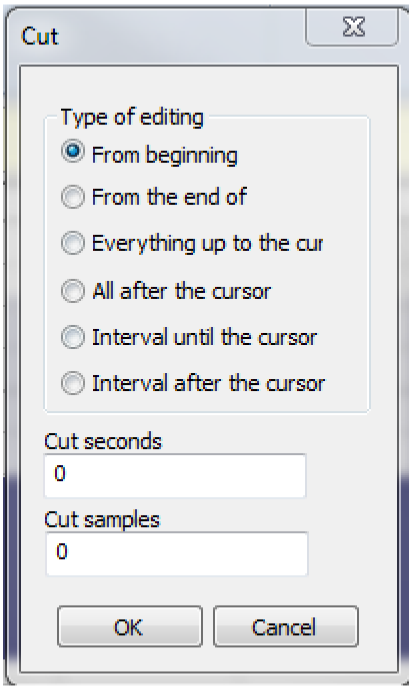
6. Interval after the cursor.

Below you can see the sections for setting the number of seconds and samples. When this dialog window is started, these fields display the values corresponding to the current position of the cursor. These values can be set by the user. The number displayed in the second section is calculated automatically based on the sampling frequency of the recorded signal.

The options "*From the beginning*" or '"*From the end of*" allow to copy the data interval, that begins with the first data element or ends with the last one.

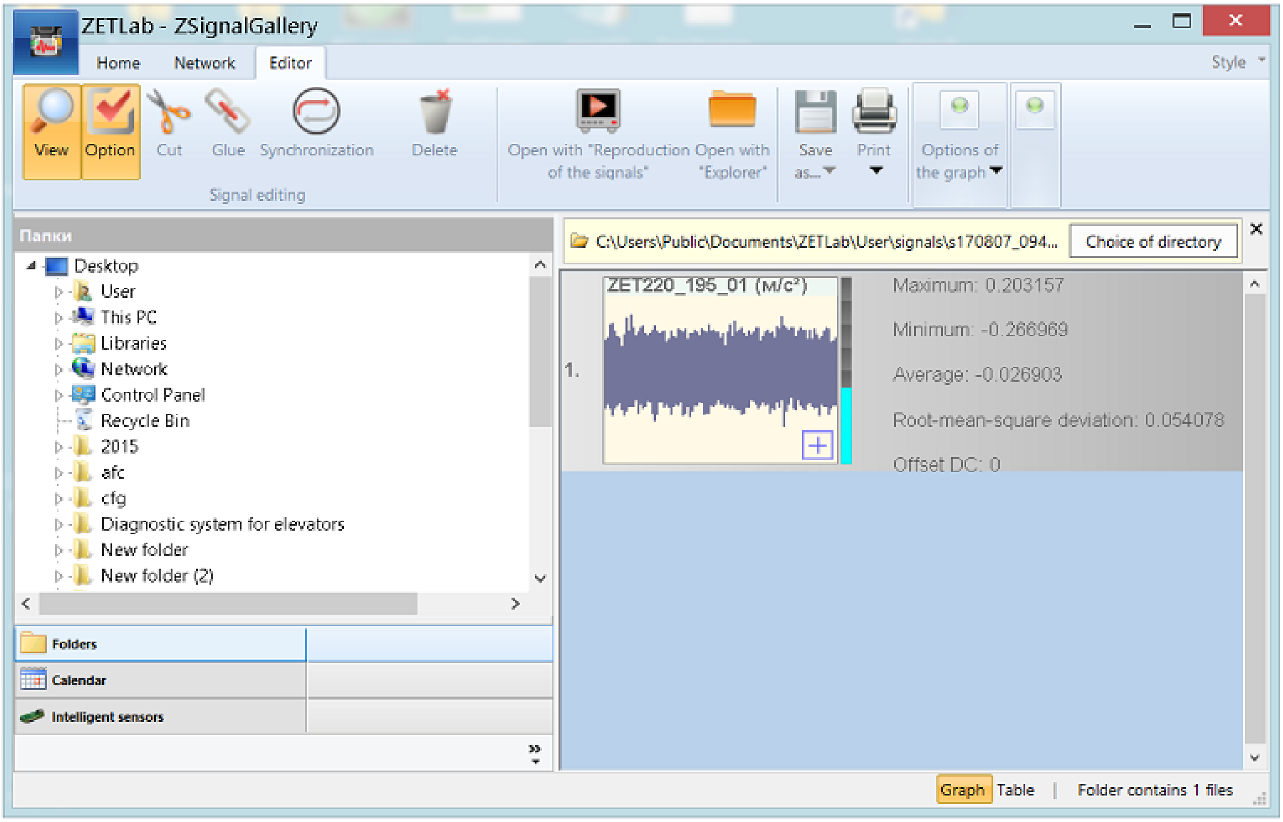
The option "*Everything after the cursor*" copies the data interval from the current position of the cursor to the end of the file. The option "*Everything up to the cursor*" allows to copy data interval from the beginning of the file and up to the current position of the cursor.

The options "*Interval before the cursor*" and "*Interval after the cursor*" allow to copy the intervals that begin with the cursor position or end with it.



Signals gallery program - Cut - available options for selection of signal part

The signals can also be viewed using the function "*Play recorded signals*". To find the required file, you can use the file manager. The signals can also be saved in different formats: binary (*.ana/*.anp), text *.dtu, Seg-Y, Wave (*.wav). The program also has a function of signal graphic printing and preview. It is possible to display graphic in different measurement units by X axis (in samples, seconds, or data/time format). The program also has auto-scaling option and possibility of downloading all files from the selected folder.



Signals gallery program - Signal Editor tab

Signals Editor

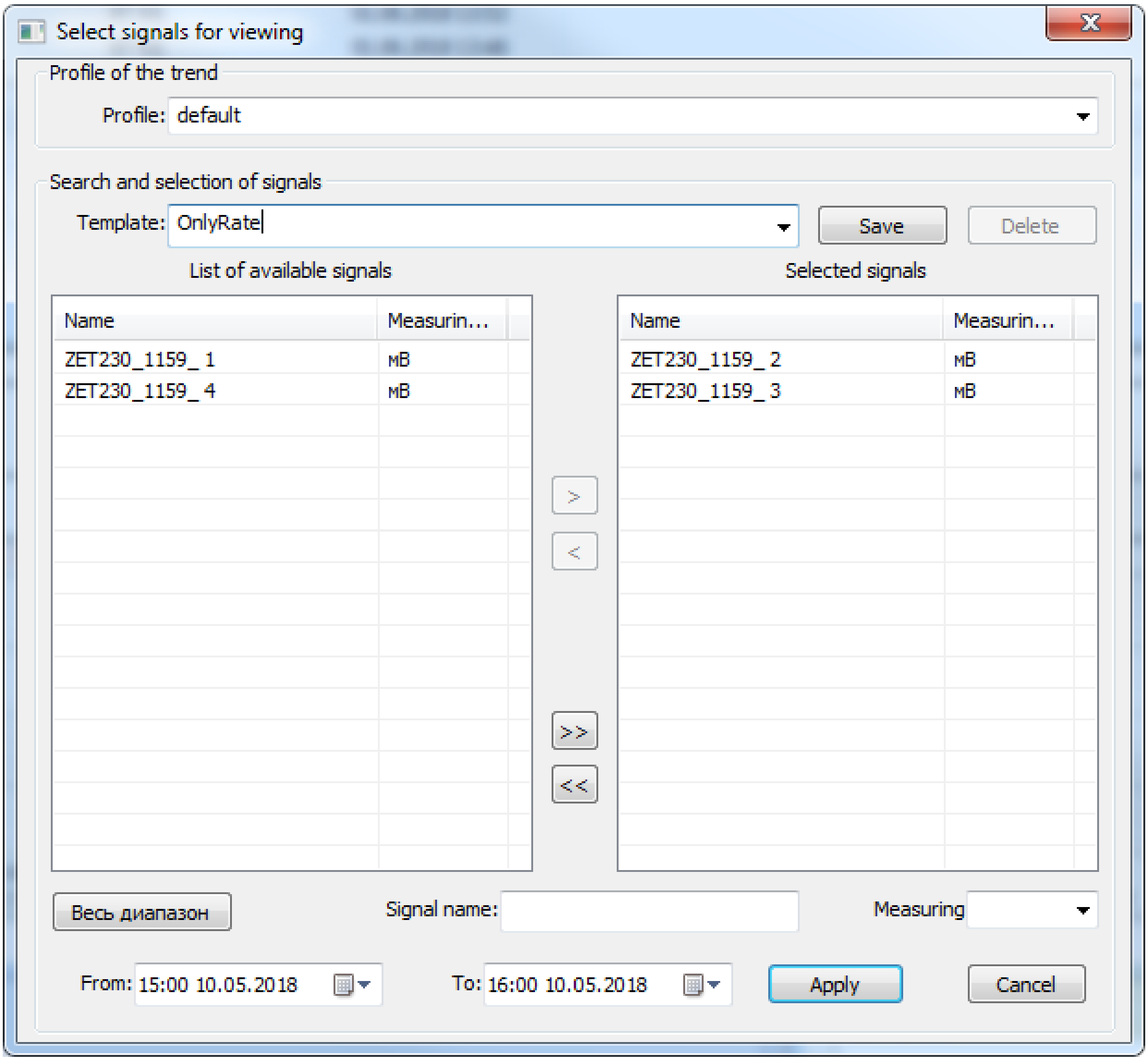
Signals gallery program - Graphics trends

Trends graph

To view signal trends, use the "*Trends*" function. Upon activation of this function, there appears a trends graphic corresponding to a particular measurement interval and a graphic with the channels of the signals.

In the beginning of trends data representation, it will take the program some time to download and to process the trend data. This process will be accompanied by displaying of downloading process progress. It is also recommended to wait until completions of this process.

Using the mouse pointer, it is possible to change the graphic scale and to view the trend graphic in more details. The channels table allows to enable/ disable displaying of particular signal channels in the graphic.



Signals gallery program - Dialog window used for signals selection

List of available signals – list of all available channels.

Selected signals – the signals that are currently displayed.

It is also possible to set the time interval for data representation.

The program also has a search function. It is possible to perform the search by template, by name, or by measurement units. The search template may contain the following symbols:

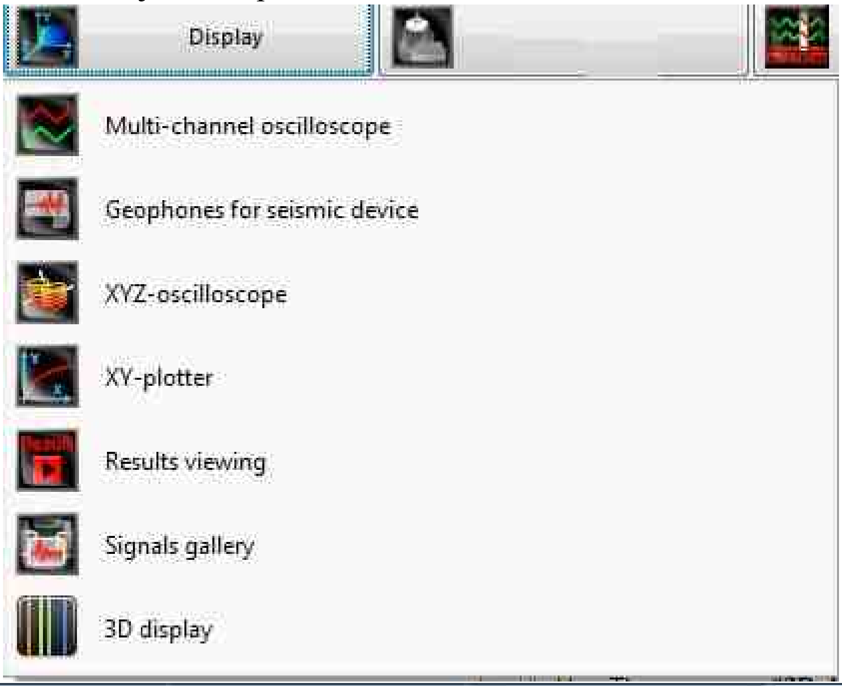
? – any symbol;

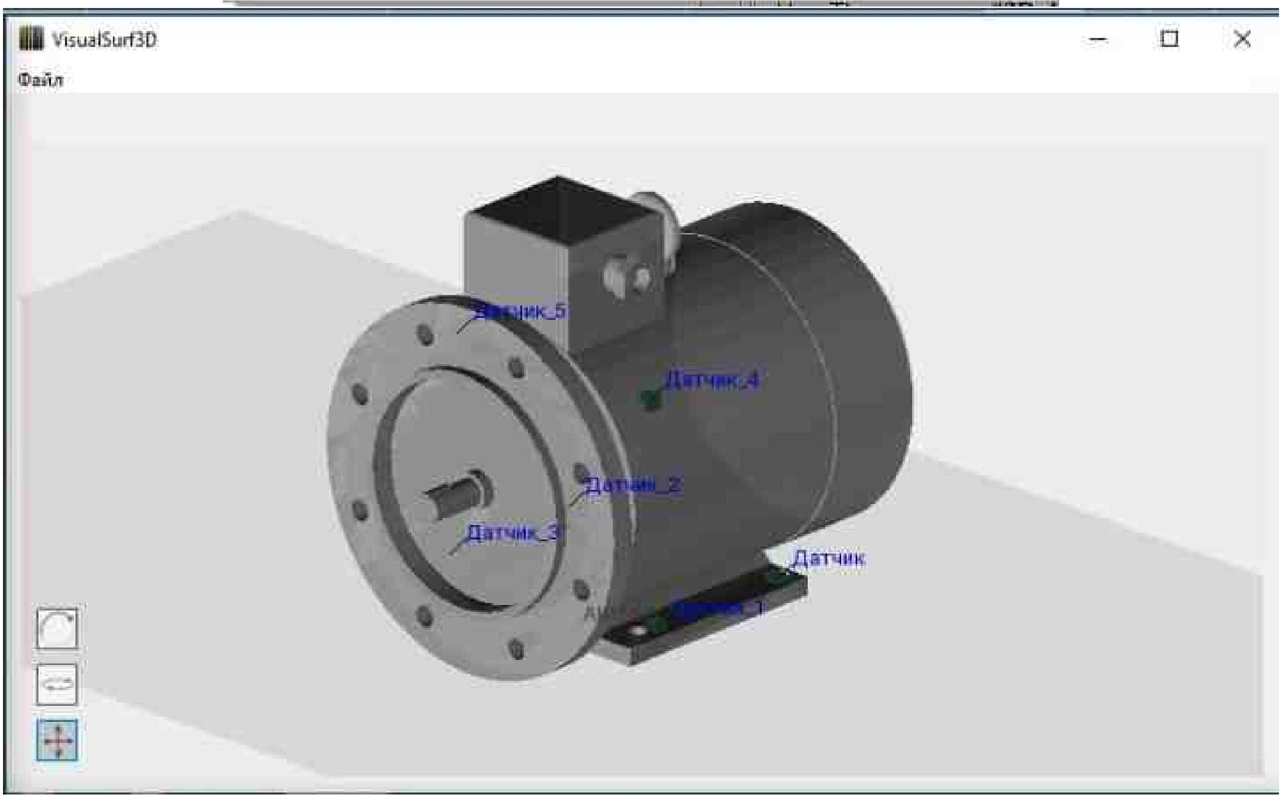
***** - arbitrary number of any symbols;

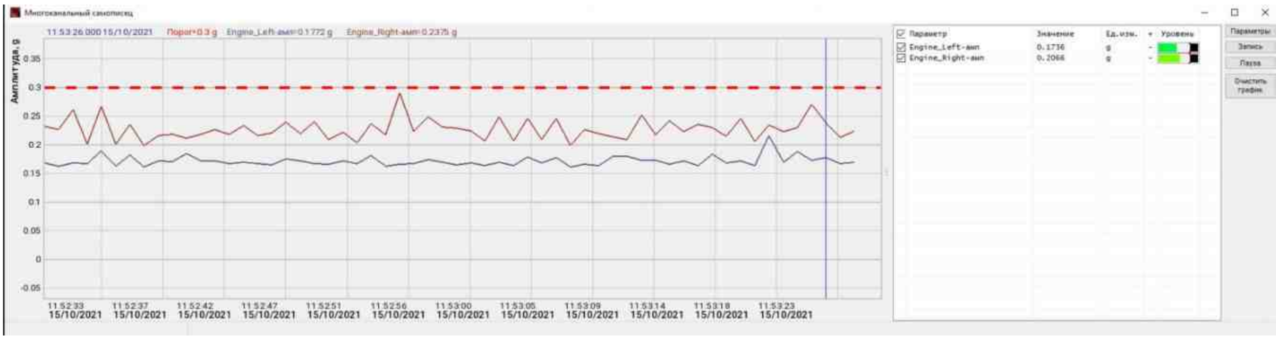
; - separator between various templates.

3D display .....

A wide range of software products for vibration monitoring with the ability to display problem areas on a 3D model of an object will optimize the workflow.







Supported Hardware .....

Supported hardware

The program allows to simultaneously download several data files, which have been recorded with the use of ZETLAB software.

The program **"3D display"** is included into the scope of the following software packages:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT spectrum analyzer software
- ZETLAB VIBRO – Vibration controllers software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software.

3D display is included into **Display** software group.

Program description .....

The program "3D display" is started from the Display section of ZETLAB panel (*fig. 6.1*). The program is launched through the "Specimen parameters" program from the VCS program group from the "**3D display**" field; its launch through ZETPanel is not used.

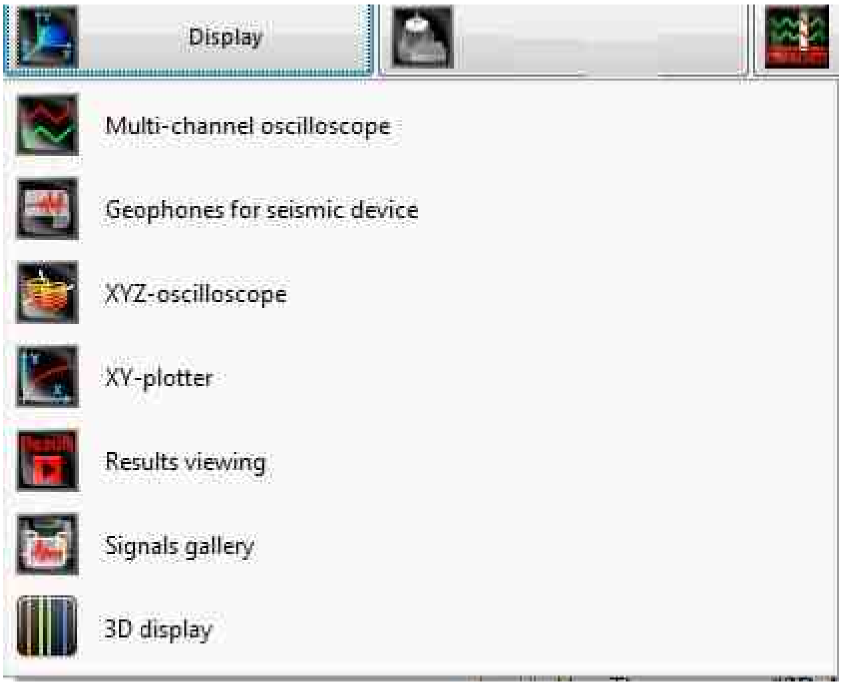


Fig. 6.1 Start 3D display

The "Model display" field located in the "Specimen mass" window allows the software to specify a link to a configuration file prepared in the "*.xml" format. The information in the file indicates to the system the layout of the sensors on specimen to be tested, which allows 3d visualization of its waveforms based on the results of the conducted Pre-Test.

Note: *detailed information on the principle of control over the waveforms is given in the section 8.3.2.*

The area [...] in the "Model display" field allows you to select the directory where the prepared configuration file is located, and the area allows you to open the "Configuration editor" window (Fig. 6.2).

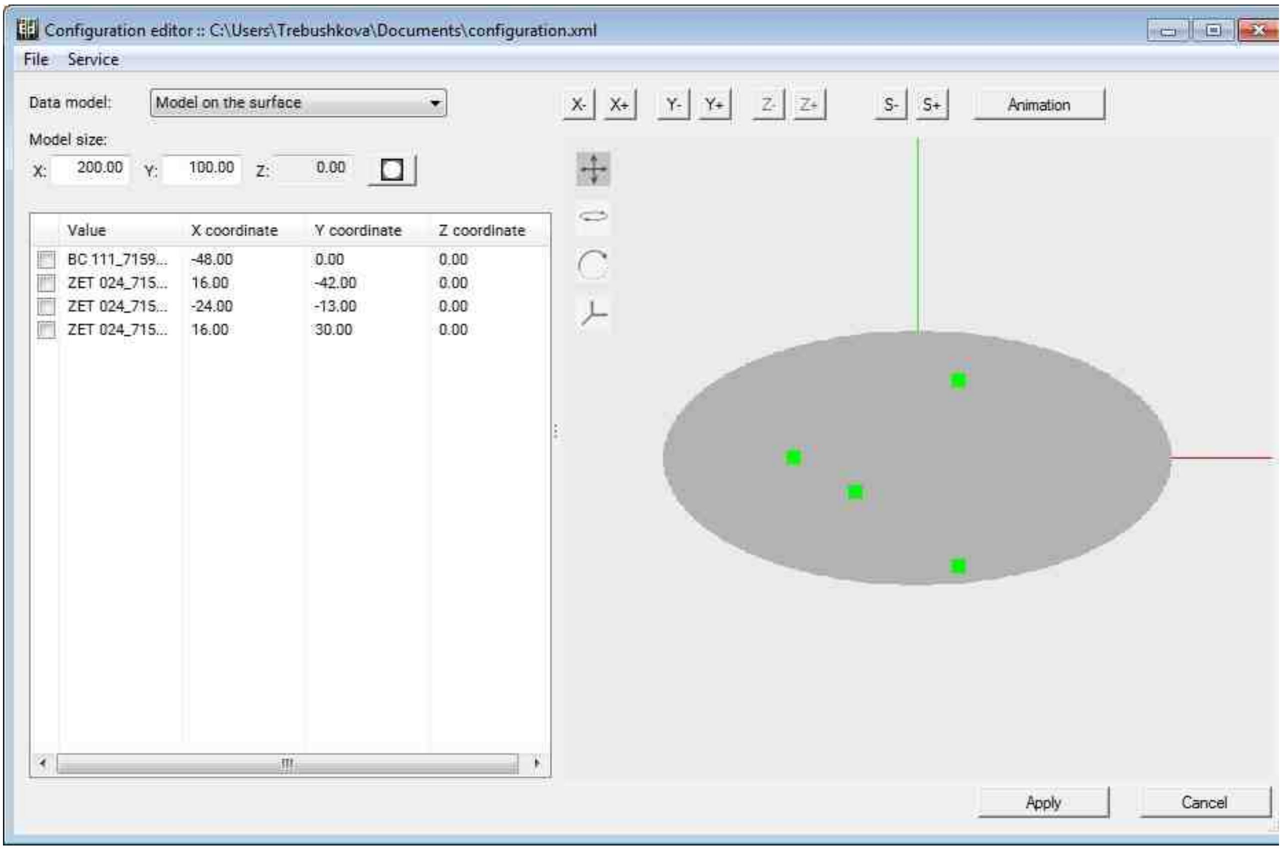


Fig. 6.2 "Configuration editor" window

For the "Data model" parameter in the "Configuration editor" window (*Fig. 6.2*) one of two values can be set: "Model on the pivot", which implies the location of the sensors in the same plane with the setting of the values of the coordinates "X" and "Y" (the Z coordinates are zero) for each sensor and "Model on the rod", which implies the location of the sensors in the nodes of the grid with the setting for each of sensors for the values of the coordinates "X", "Y" and "Z".

By the "Model size" parameter in the "Configuration Editor" window (*Fig. 6.2*) the required size of the area for the placement of sensors is determined.

Note: *when setting the size of an area, it should be taken into account that the zero coordinates are always located in its center.*

If you need to edit a previously created configuration file, activate the "File" menu in the "Configuration editor" window (*Fig. 6.3*) and then "Load configuration", then in the "Open" window (*Fig. 6.4*) specify the configuration file to be edited after which activate the "Open" button.

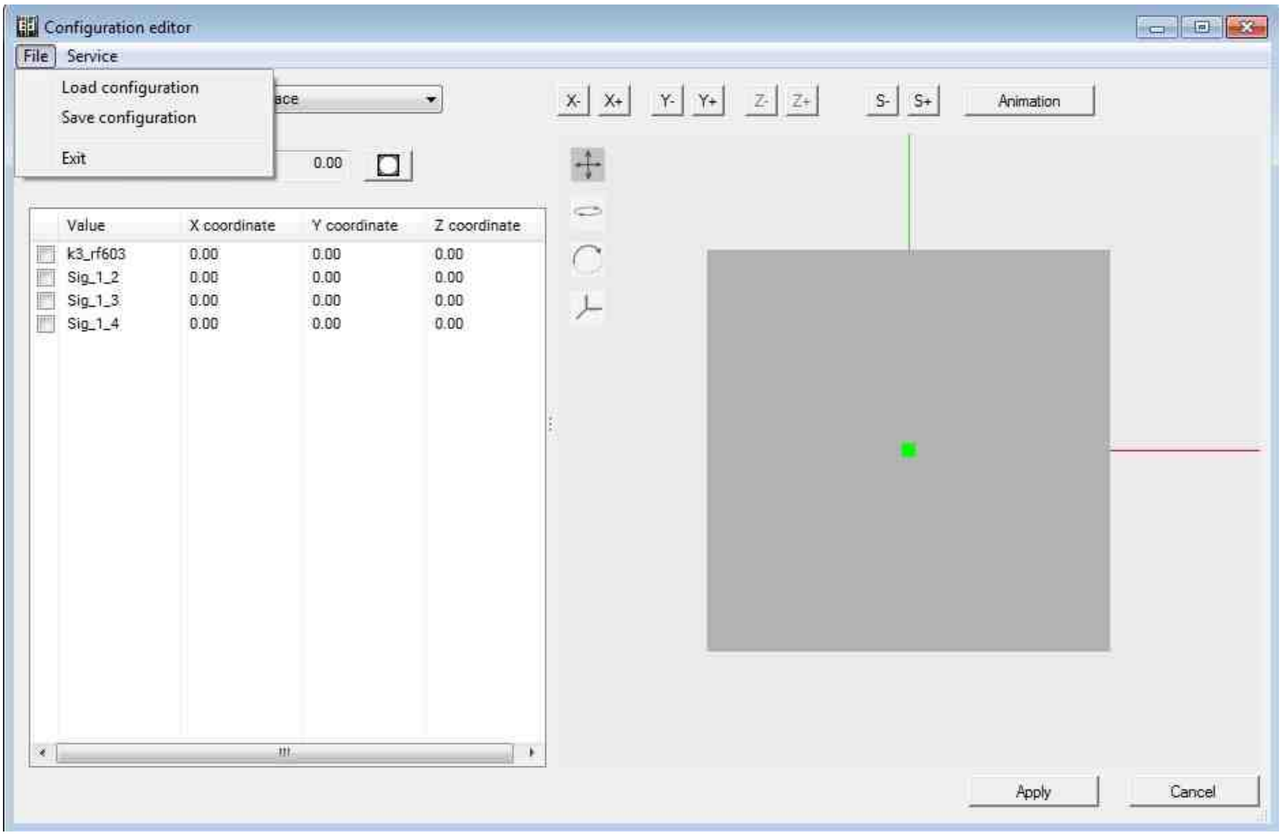


Fig. 6.3 "Configuration editor" window, "File" menu

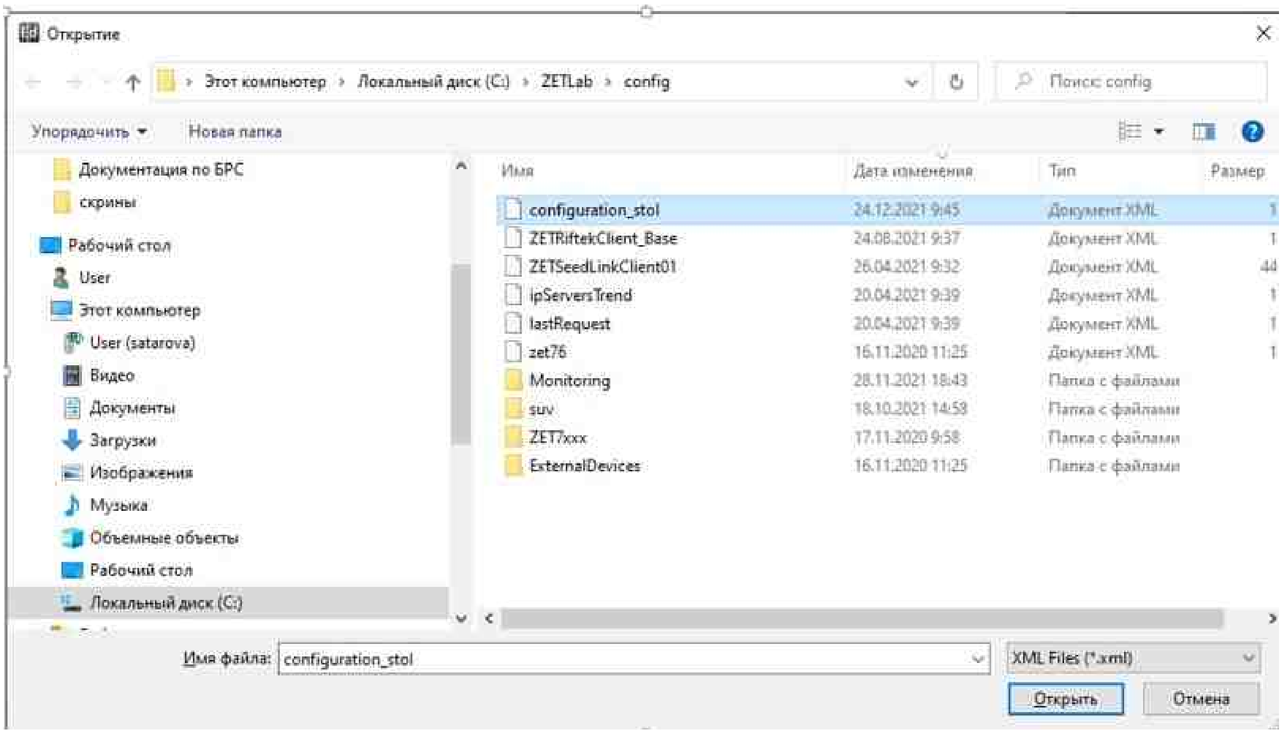


Fig. 6.4 The "Open" window

To save the configuration file in the "File" menu of the "Configuration editor" window (*Fig. 6.4*) than activate "Save configuration" and in the "Save" window (*Fig. 6.5*) specify the path and name to be assigned to the saved file.

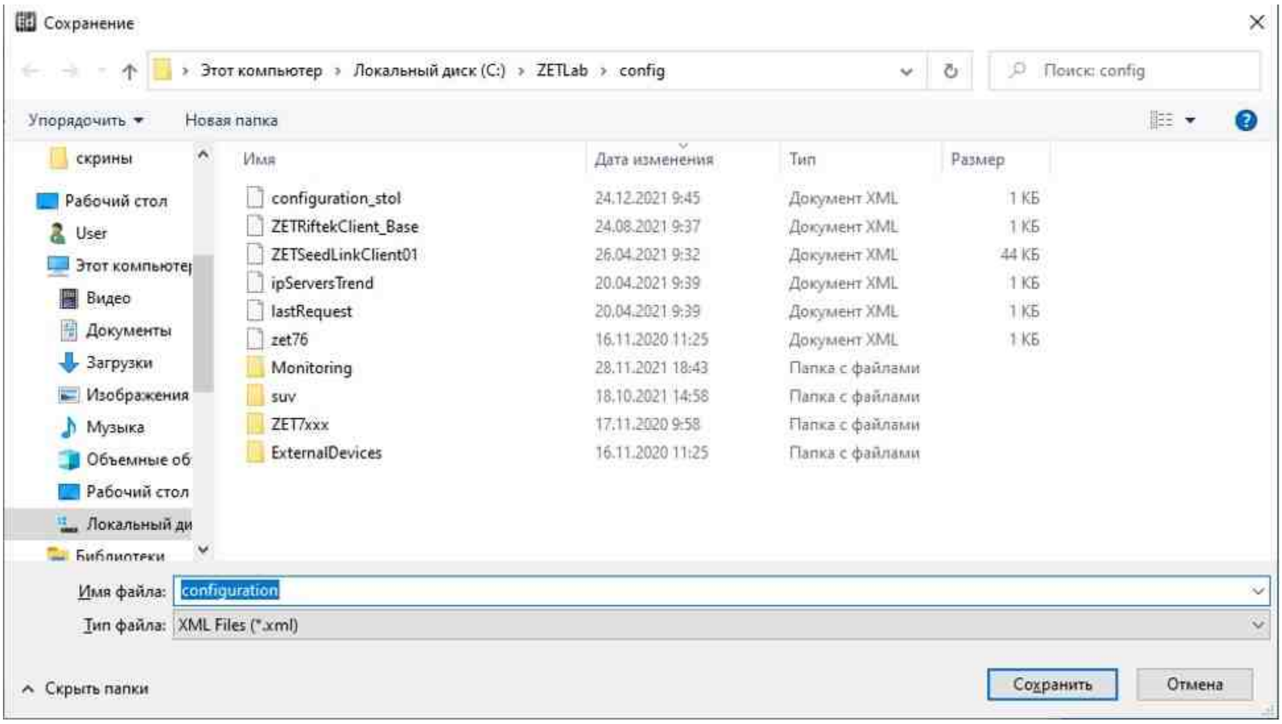


Fig. 6.5 The "Save" window

To edit the list of measuring channels that will be used to control the form of the oscillations, go to the "File" menu of the "Configuration Editor" window (*Fig. 6.6*) activate the "Channel filter" and in the window that opens (*Fig. 6.5*) in the checkboxes, mark the channels involved in the control.

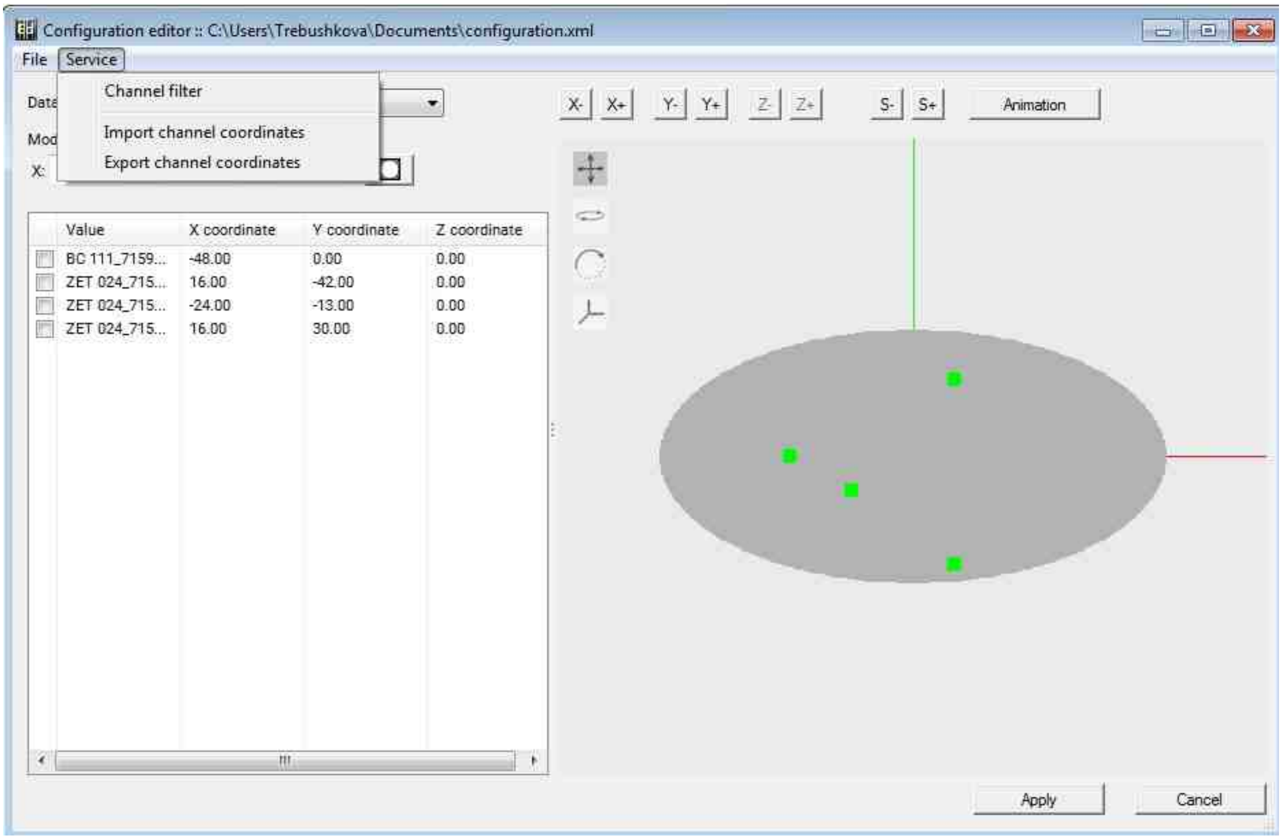


Fig. 6.6 "Configuration Editor" menu "Service" The "Save" window

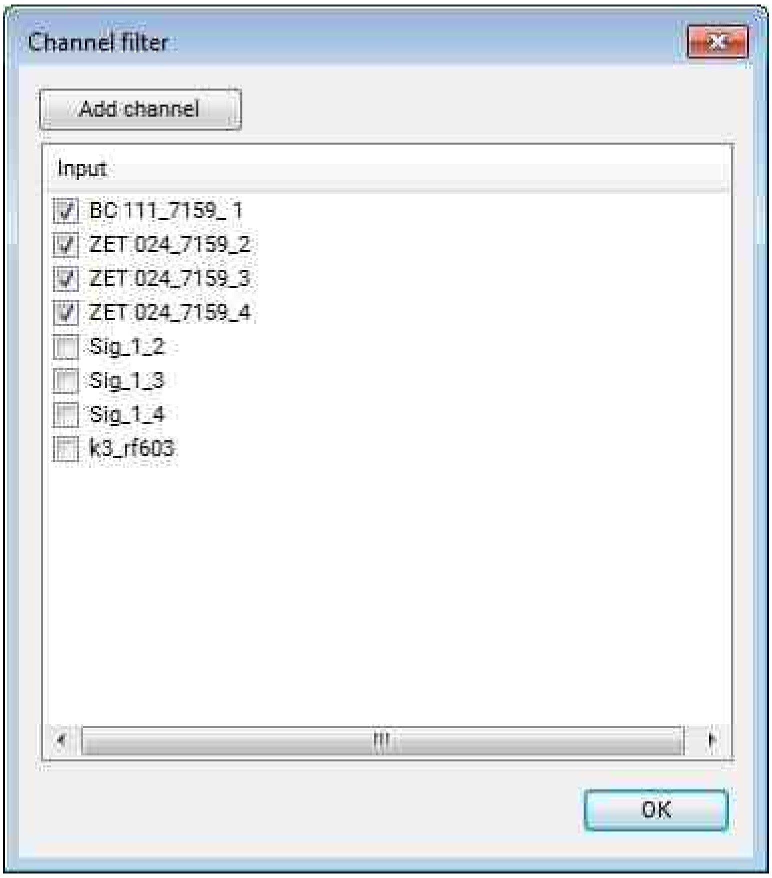


Fig. 6.7 "Channel filter" window

Information from the "Specimen parameters" window (*Fig. 6.1*) it is indicated in the test report. In the "Specimen parameters" window, parameter fields with information about the Customer and the Test Performer are provided by default. If parameters that are not present in the default form are required for saving to the report, then they should be added manually using the "Additional Parameters" area. In this case, in the "Specimen parameters" window (*Fig. 6.8*) necessary  activate the "Edit" button, after which each activation of the "Add" button will add one field, in each of which you should then specify the information required to save in the report file.

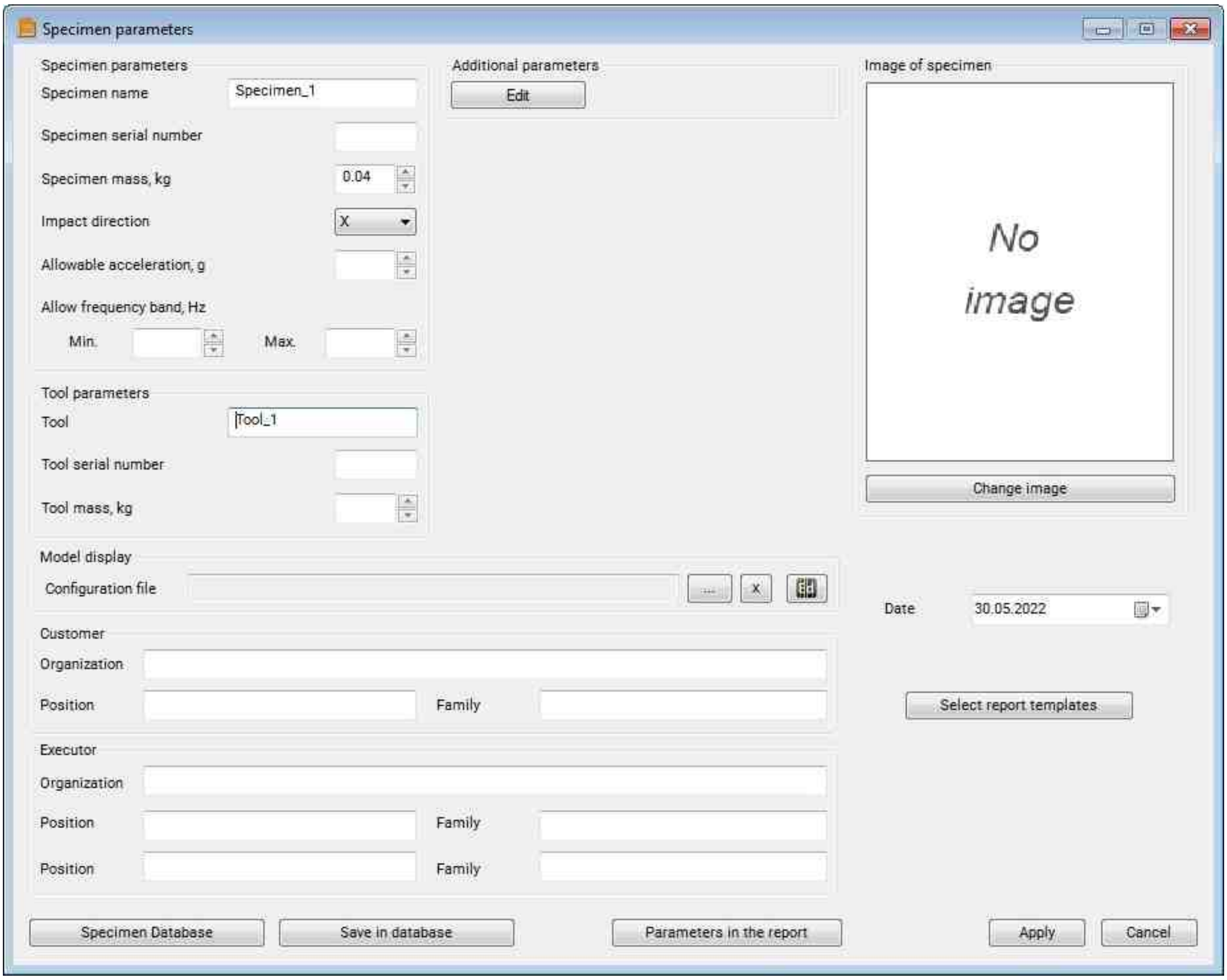


Fig. 6.8 The "Specimen parameters" window with additional parameters

To visualize the names of parameter labels, it is necessary activate the "Parameters in the report" button. Parameter labels (*Fig. 6.9*) provide binding of parameter values to the places in the report to which they will be displayed

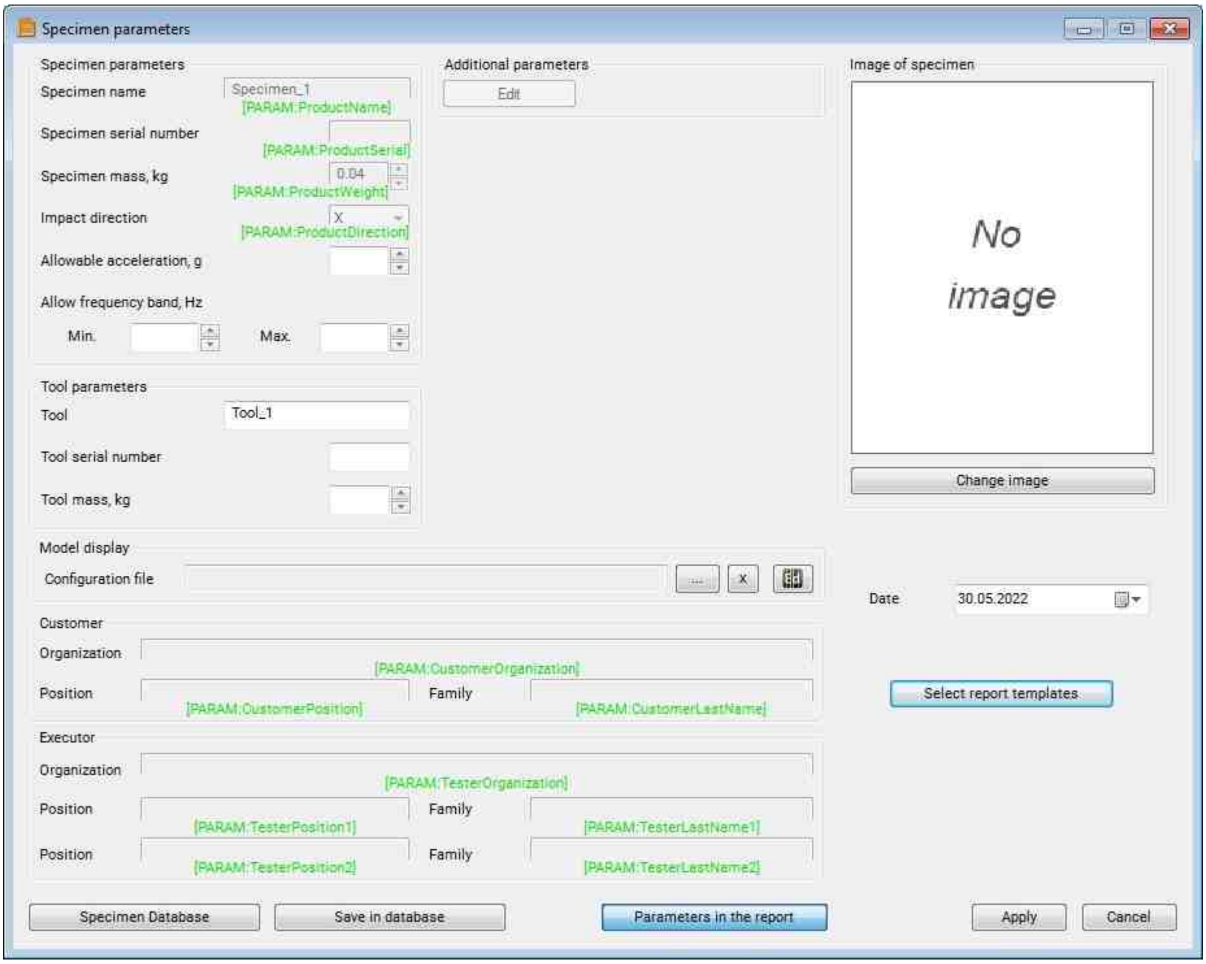


Fig. 6.9 The "Specimen parameters" window with the names of parameter labels

The "Select report template" button is designed to activate the program window (*Fig. 6.10*) which specifies the location directories and file names of report templates for various types of tests.

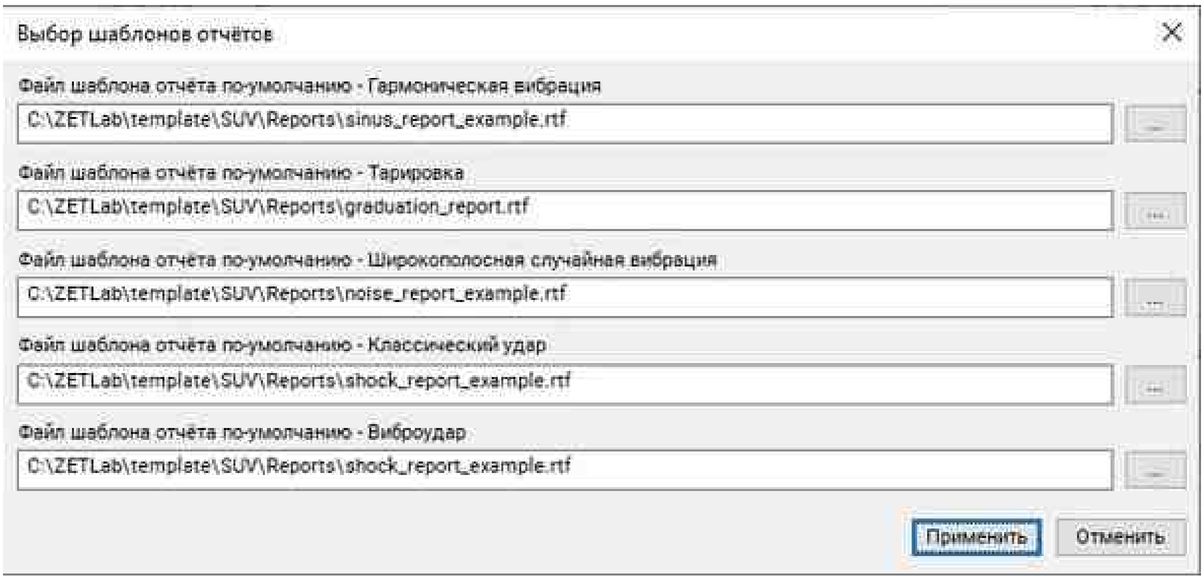


Fig. 6.10 "Select report templates" window

Note: *for more information about the rules for generating reports, see the section [13](#).*

To add a specimen to the database, press the *Save in database* button. The ***Specimen parameters*** will be saved in the database.

In the subsequent testing of specimens added to the database, select the desired specimen type from the database window (*Fig. 6.11*), and use the *Specimen Database button* in the ***Specimen parameters*** window to go to it.

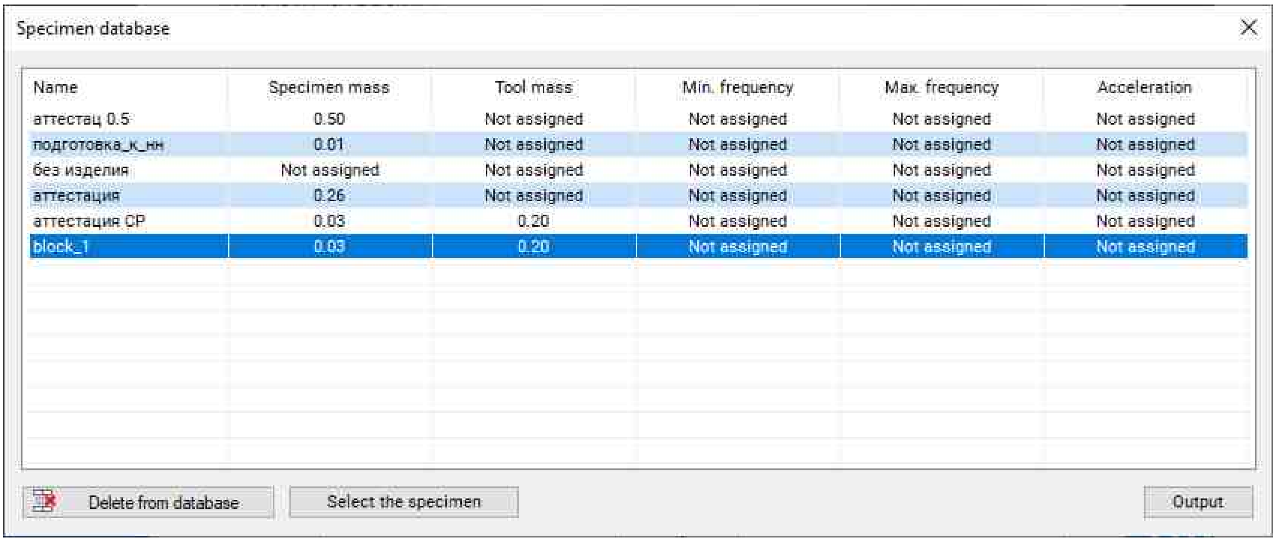


Fig. 6.11 "Specimen Database" window

Press the *Change the image* button to add a specimen photo to the ***Specimen parameters*** window. The photo in the ***Specimen parameters*** window provides an additional specimen identification in the database.

Note: *The specimen photo to be added in the* ***Specimen parameters*** *window should be in any graphic format with 2/3 (width/height) aspect ratio and in any available directory.*

Generators

This section describes the programs used for generation of the signals at the output of *ADC/DAC modules*, *FFT Spectrum Analyzers* and *strain-gauge stations*. These programs include **Signals generator** and **Synchronous generator**.

Note: the **Generator with feedback** programs supplied together with *Shaker controllers* are described in the corresponding User manuals.

Signals generator .....

The program **Signals generator** is used for producing signals of various form, amplitude and frequency at the output channels of ZET devices.

From the functional point of view, the signals generators represent a substitution for stationary generators used in laboratory conditions.

The **Signals generator** program produces a virtual channel, which is further displayed in the list of available channels as **Generator N**. The data of this virtual channel is represented by the information from the output of ADC converter (generator output), which further becomes available for the analysis with the use of other programs from the scope of **ZETLAB software package**.

The program **Signals generator** also has a function of producing complex signals by means of mixing various types of generated signals.

Note! The program **Signals generator** is supplied only with the devices equipped with integrated DAC converter.

Types of the Generated signals by the Signal generator program:

- sine signal;
- RF impulse signal;
- white, band-pass, pink, red, deterministic, semi-white and colored noise;
- amplitude-modulated signal with linear frequency sweep (LinAM);
- frequency-modulated signal with linear frequency sweep (LinFM);
- amplitude modulated signal with logarithmic frequency sweep (LogAM);
- frequency modulated signal with logarithmic frequency sweep (LogFM);
- impulse signal;
- signals file;
- sine signal2;
- amplitude-modulated signal (AM);
- frequency-modulated signal (FM);
- serrate signal;
- Input channels;
- Barker codes;
- Correction.

One copy of **Signals generator** program allows to control one generator (DAC output of ZET device). In order to generate signals using several generators, it is necessary to start several copies of the program **Signals generator** and to choose the generator for each copy of the programs used.

The program "**Signals generator**" also has the function "**Kurtosis**" available for white and band-pass noise.

The program "**Synchronous generator**" allows to generate synchronous signals.

Supported Hardware .....

The program "**Signals generator**" is included into the scope of the following software packages:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT Spectrum software
- ZETLAB VIBRO – Shaker control systems software
- ZETLAB TENZO – strain-gauge station software

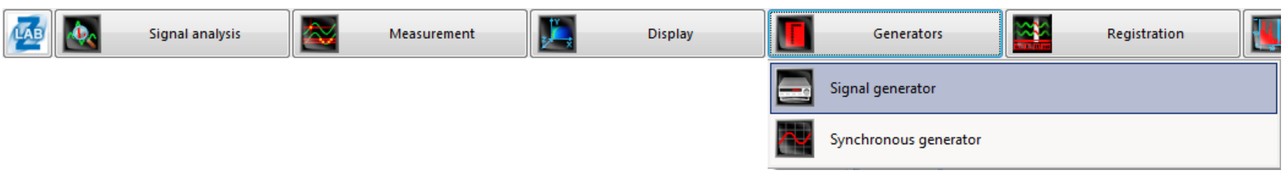
The "**Signals generator**" program is located in the "**Generators**" software section

Note 1. In the case, if the difference between sampling frequency of ADC and DAC of the device, that is used for generation of the signal, is more than 10 times, there occurs a loss of one data point from ZETLAB virtual signal. However, the generated signal still fully complies with the set parameters. Hence, with these parameters applied, the virtual channel cannot be used for calculations (e.g., with the use of "***Arithmometer***" program), or as a reference channel of the "*Strain Gauge Meter*" program. In the case if it is necessary to use the virtual channel, the user should decrease the DAC sampling frequency or increase the ADC sampling frequency.

Note 2. When a device is connected to PC via Ethernet network, the DAC sampling frequency should not be more than 100 kHz. If a device has several DAC outputs, the DAC should not be more than 100/N kHz, where "*N*" stands for the number of the generators used.

Program description .....

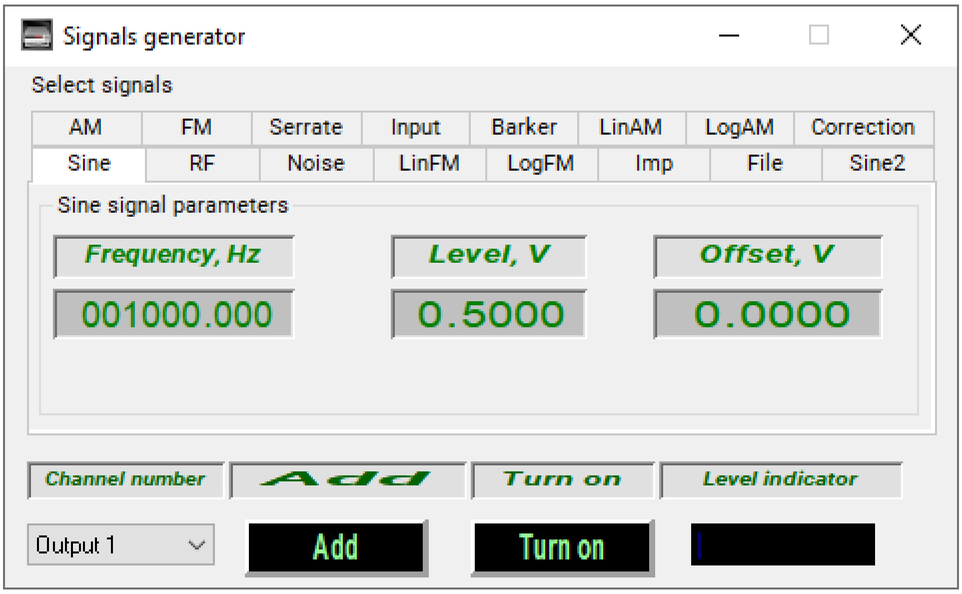
The program "**Signals generator**" can be started from "**Generators**" section of **ZETLAB** control panel.



Signals generator - starting the program

Note: it is also possible to start the program "**Signals generator**" from ZETLAB directory (the directory by default: C:\ZETLAB\). The name of the file to be started: DAC_OCX.exe.

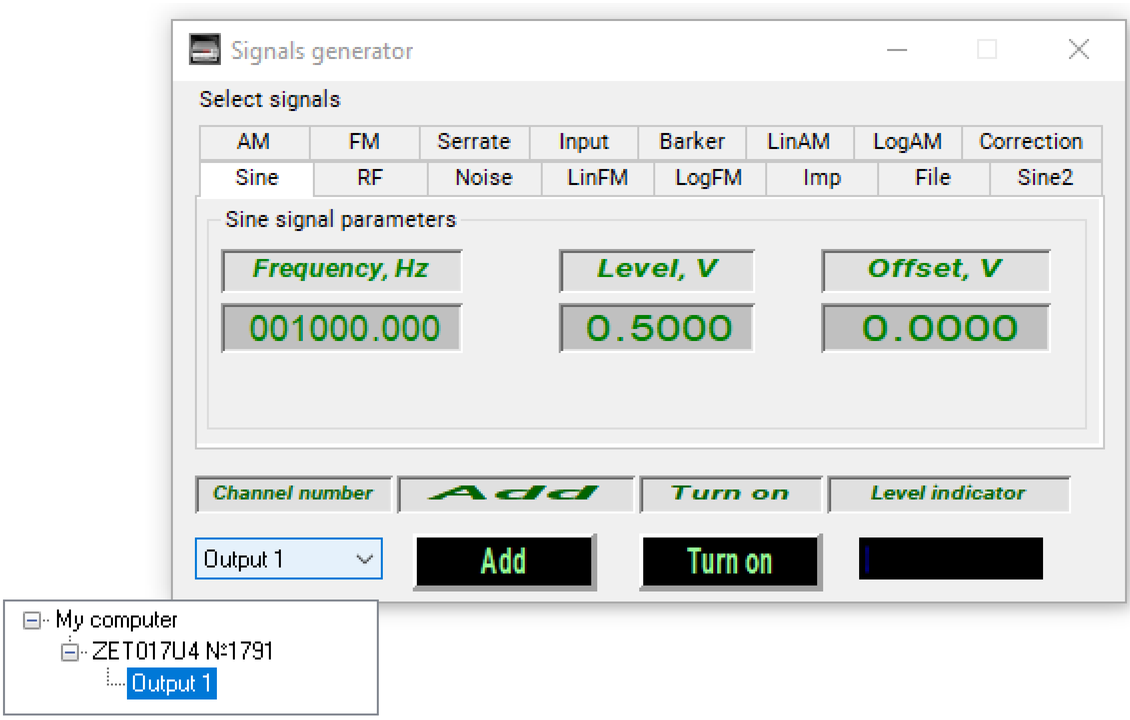
The title of the program interface displays its name ("**Signals generator**").



Signals generator - program interface

The main part of the program interface area is occupied by the configuration options of the generated signals (the configuration options will be described later).

The bottom left section of the program interface is used for selection of generator channel.



Signals generator - generator channel selection

The "**Add**" key is used for preliminary activation of the signal, which is selected for further generation. Upon activation of this option, the signal is not yet applied to the output of the generator (the signal at the output of the generator is activated with the use of "**Turne on**" key). The key "**Add**" is available for every type of the signal (i.e., for each tab of the program interface). The program allows to enable several types of the signals simultaneously, thus generating a signal with complex (mixed) form. Upon activation of the "**Add**" key, it will be highlighted and it will change its name for "**Remove**". The name of the tab will then display the symbol "+", which means that the signal is applied to the generator output. The "**Add**" key allows to disable the signal. Upon activation of the key, the backlighting of the key will be **Turned on** and the tab will display the symbol "-".

The "**Turned on**" key is used to start the process of signals generation with the signal parameters, that are specified in the corresponding tabs with the "**Add**" option enabled.

The bottom right section of the program interface contains an indicator of signal's integral level.

Amplitude-modulated (AM) .....

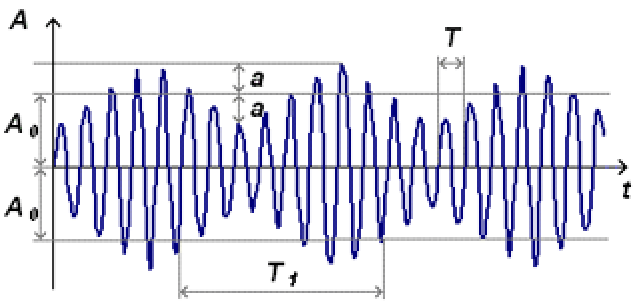
An amplitude modulated signal is a signal in which the change in the amplitude of oscillations occurs at a frequency much lower than the frequency of the oscillations themselves.

The level of the amplitude modulated signal is calculated by the formula:

$A=(A_0+a\sin\omega_1 t)\sin\omega t$

where $A_0 = 2V_{rms}/\sqrt{2}$ –

where is the signal amplitude, $\omega = 2\pi f$ is the signal phase (f is the signal frequency, related to its period T by the dependence $f=1/T$), $\omega_1 = 2\pi f_1$ is the signal phase (f_1 is the signal frequency, related to its period T_1 by the dependence $f_1=1/T_1$), t - the current time, a is the modulation amplitude.



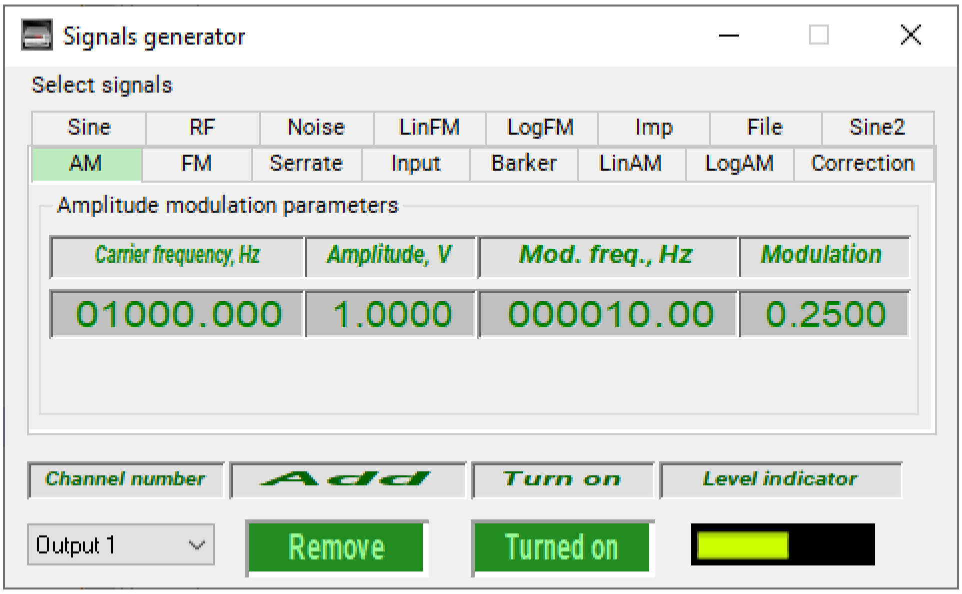
Signals generator - Amplitude-modulated signal form

To generate an amplitude modulated signal, go to the -AM tab in the **Signals generator** program, after which the elements for setting the parameters of an amplitude modulated signal will be displayed in the program window:

- *Carrier frequency, Hz* – carrier frequency with which the signal will be generated. It is connected with its period *T* (Fig. above) by dependence $f=1/T$. The duty cycle is specified in hertz (Hz).
- *Amplitude, V* - the peak value of the signal with which the signal will be generated. The amplitude is given in volts (V). In the figure above, the amplitude is labeled A0.
- *Modulation frequency, Hz* – modulation frequency with which the signal will be generated. It is connected with its period T_1 (Fig. above) by dependence $f_1=1/T_1$. The modulation frequency is specified in hertz (Hz).
- *Modulation* - the modulation depth with which the signal will be generated. Specified as a percentage of the signal amplitude. In the figure above, the amount of modulation is indicated as a/A_0..

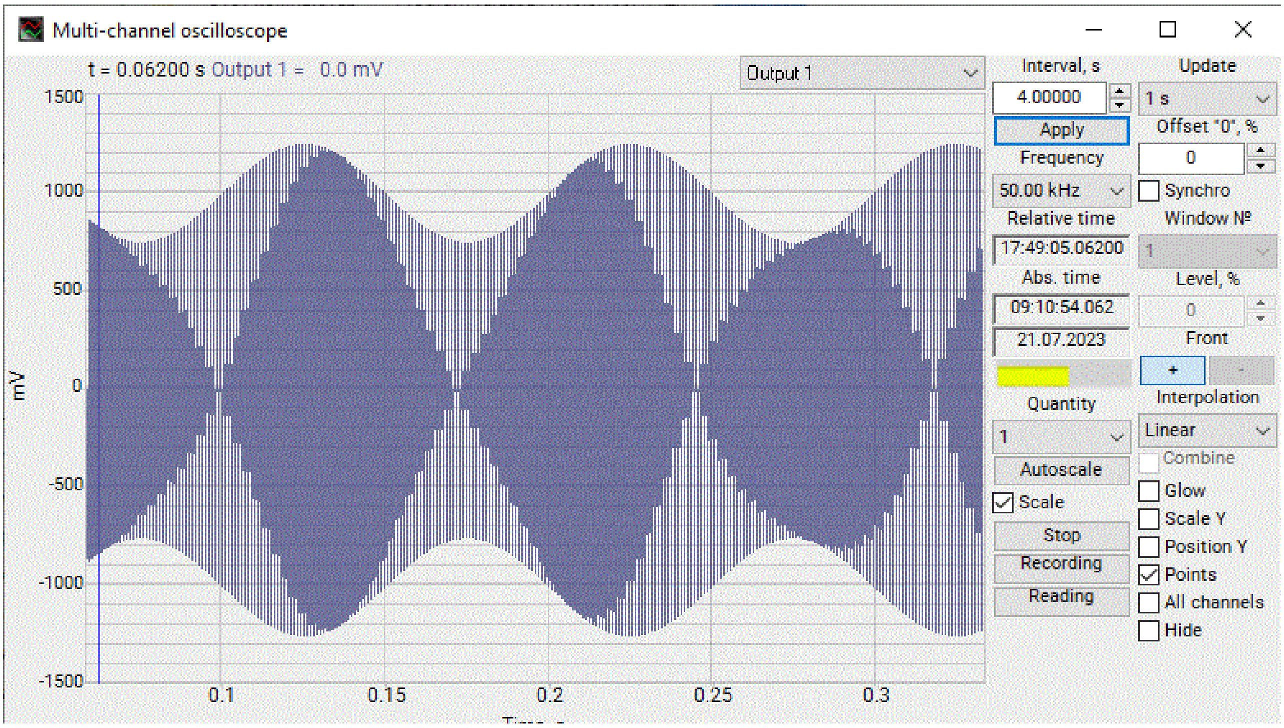
After setting the required parameters of the amplitude-modulated signal and starting generation (generation starts after successively pressing the **Add** Signal button and the **Turne on** All Signals button), the program window will look as shown in the figure below.

.



Signals generator - Amplitude-modulated signal - signal parameters

The figure below shows the corresponding waveform obtained using the Multi-channel oscilloscope software.



Signals generator - Amplitude-modulated signal - oscilloscope graphic

Generating signal from a file .....

The function of generating a signal from a file allows to reproduce previously recorded signals at the output of the generator. This allows, for instance, to conduct tests of hardware and software components, to reproduce earthquake signals in the seismic impact control systems (in order to check the seismic event detection function, to evaluate earthquake parameters and to produce dry contact, etc.).

The program "**Signals generator**" allows to generate signals from binary and text files at the outputs of the connected ADC-s.

In order to generate a previously recorded signal, enter the "**-File**" tab of the "**Signals generator**" program – you will see the control elements that are used for signal's parameters configuration:

· **File name** – allows to select file name and corresponding directory. The selected file will be reproduced at the ADC output with the set ratio one or several times. The "**Option**" key is used for selection of the file. The files can have the following extensions:

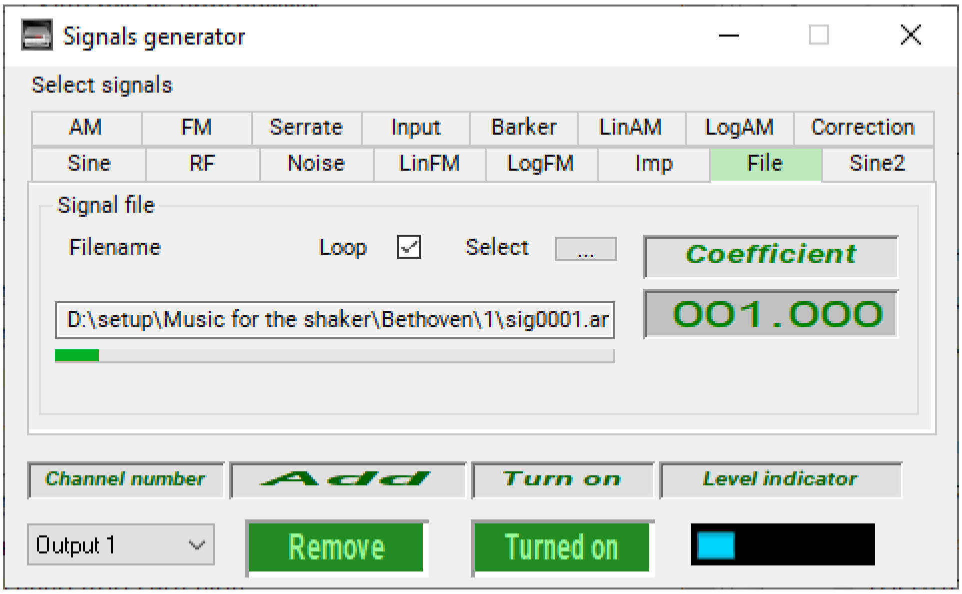
*.anp and *.ana – binary files created with the program "**Signals recording**".

*.dtu – text files recorded with the use of the program "**Multi-channel oscilloscope**" (previously these files used to have *.dtn format).

*.dat – text files created by the user.

· **Coefficient** – amplification / attenuation coefficient of the signal produced at the generator’s output. If the coefficient is more than "1", the signal is amplified, and if the coefficient is less than "1", the signal is attenuated. For instance, the level of the recorded time realization of the signal from ADC/DAC modules ZET FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23 is up to 7,5V, while at the generator’s output it is possible to produce a signal with level up to 1,5 V. Hence, in order to generate this time realization of the signal from a file, it is necessary to lower the signal level at least 5 times.

· The "**Loop**" checkbox allows to set single or multiple repetition of signal generation from a file. It is possible to enable/ disable this option both before and in the course of signal generation process.



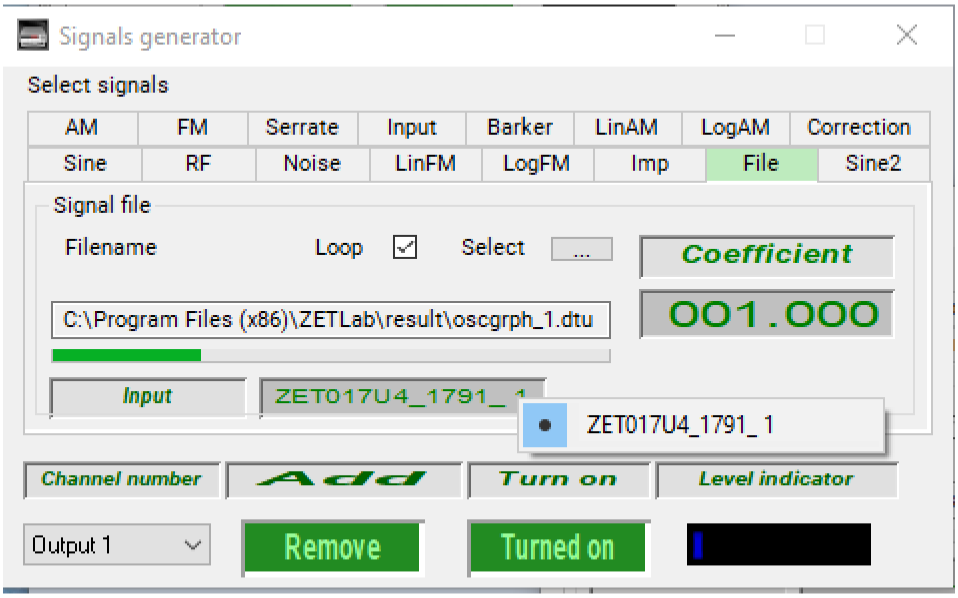
Signals generator - Generation of signals from a file - signal parameters

The generation process is started upon activation of the keys "**Add**" and "**Turn On**".

The binary files (with *.anp and *.ana extension) are created by means of ZETLAB software programs (e.g., "**Signals recording**" program), that are used for recording of the data received from primary transducers. As the signal is generated from a binary file, the signal formed at the generator’s output has the same structure and form, as the signal received from the primary transducer.

Note: ZETLAB software may be supplied as an additional option for some of ZET instruments used for signals recording and Play recorded signals.

The text files with *.dtu extension are produced in the course of "**Multi-channel oscilloscope**" program operation. When such file is selected in the "**-File**" tab of the "**Signals generator**" program, there appears additional configuration parameter – selection of the channel to be used for signal Play recorded signals (see the Fig. below). When the program "**Multi-channel oscilloscope**" has several channels for data representation (i.e., several oscilloscope graphs), then the measurement data of all the channels will be recorded into a single file with *.dtu extension. When a file with several recorded oscilloscope graphics is selected in the program "**Signals generator**", the channel selection menu located to the right from "**Channel**" section will allow the user to select any of the channels that have been recorded to this file. To do that, right-click the channel selection section and choose the required channel.



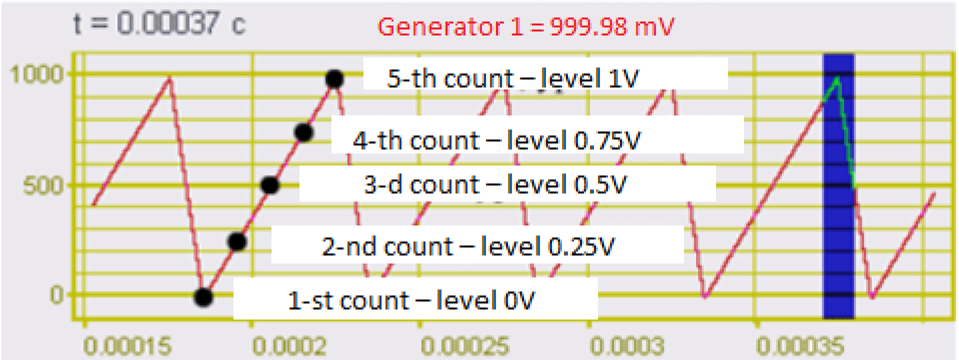
Signals generator - Generation of signals from a file - signal parameters

Note! When operating in the mode of processing *.dtn text files, the program "**Signals generator**" will process data and generate signals only from the files recorded with the program "**Multi-channel oscilloscope**". If the files with this extension have been recorded in other programs from the scope of ZETLAB software, then the program "**Signals generator**" will not be able to generate a signal with sufficient accuracy.

It is possible to create files with *.dat extension in any text editor. It should contain the lines specifying the required signal levels. The signal levels are specified in Volts (V). The symbol "." should be used as a separator between integral and fractional parts. The time interval between the counts is determined by the ADC sampling frequency (it is set in the program "**ZET Device manager**").

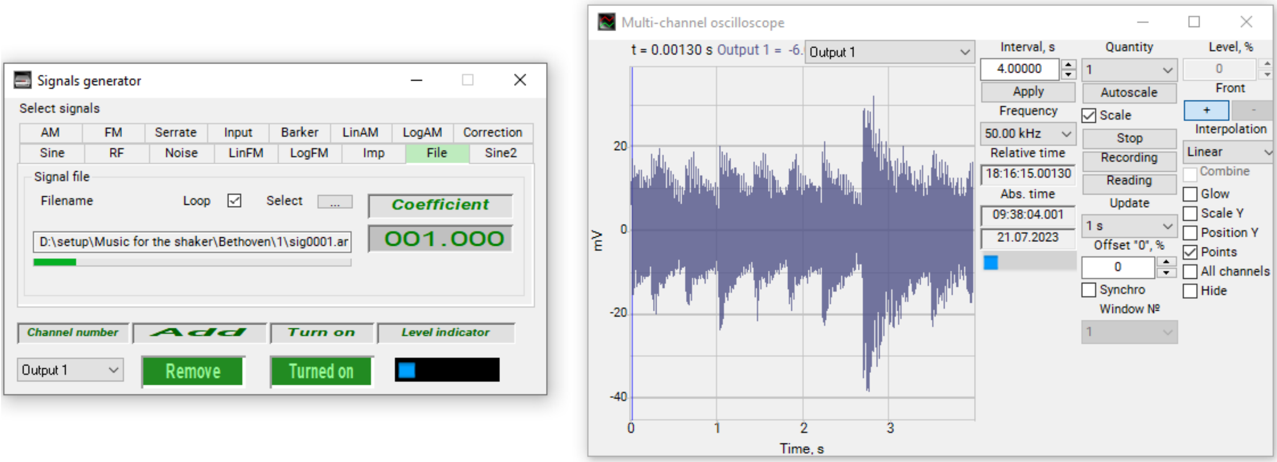
The table below shows an example of a text with the set signal levels and the Fig. displays the oscilloscope graphic of the signal, which has been generated from this file. The labels on the oscilloscope graphic are used to highlight the counts. The signal from this file is generated in cycle mode, hence, the signal has saw-shape form.

Line number	Set level	Description
1	0	1-st count – level 0V
2	0.25	2-nd count – level 0.25V
3	0.5	3-d count – level 0.5V
4	0.75	4-th count – level 0.75V
5	1	5-th count – level 1V



Signals generator - Generation of signals from text file - example

Application examples



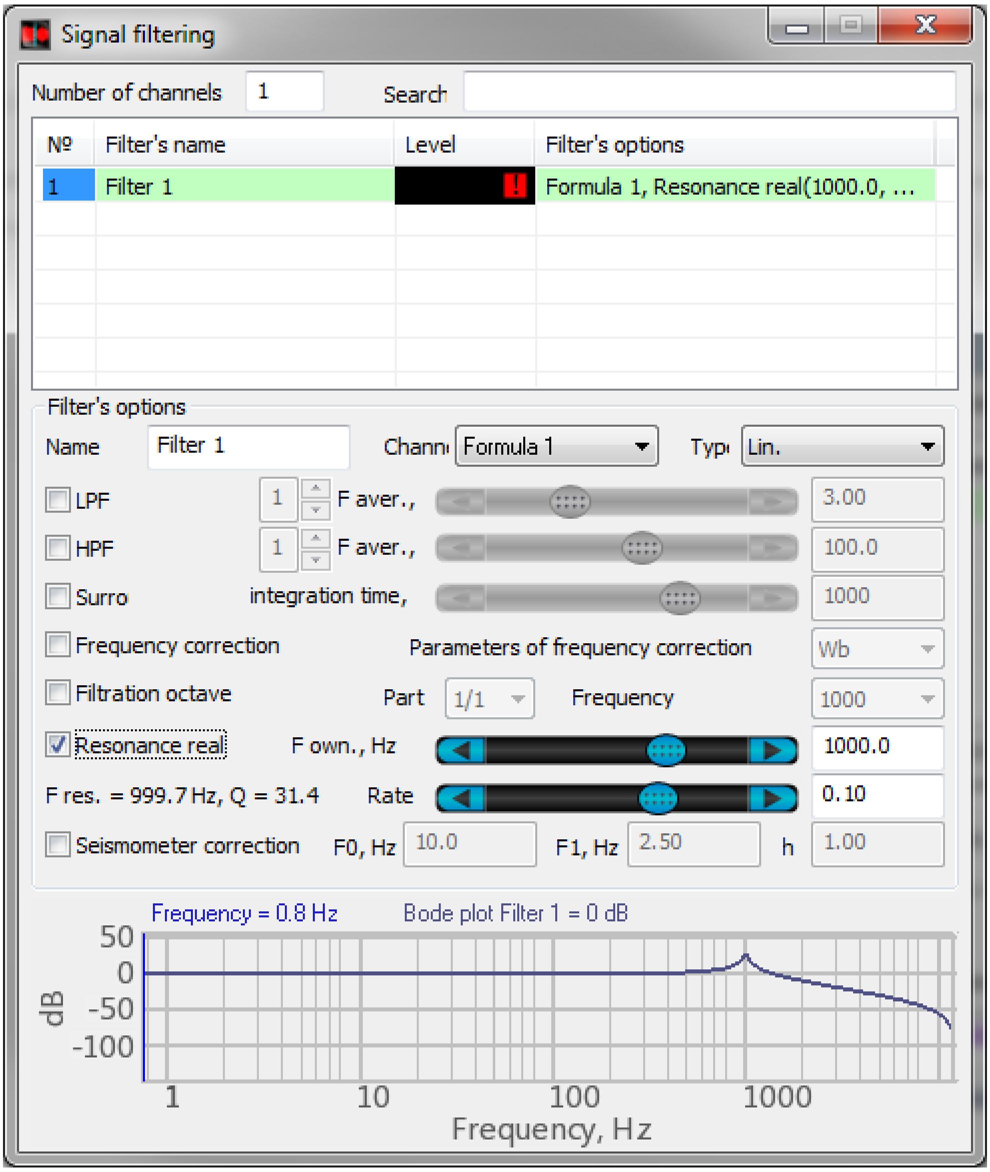
Signals generator - Generation of signals from text file - application example

The function "**Signal generation from a file**" is used when it is necessary to reproduce certain conditions, which have been previously recorded in the format of binary signals. This function is also extremely useful in the case if a signal is recorded as a text file. This allows to use the ADC outputs to generate both standard and specific signals as well as to produce signals of any form!

In the case if there is no recorded signal, it is possible to modulate it using ZETLAB software programs.

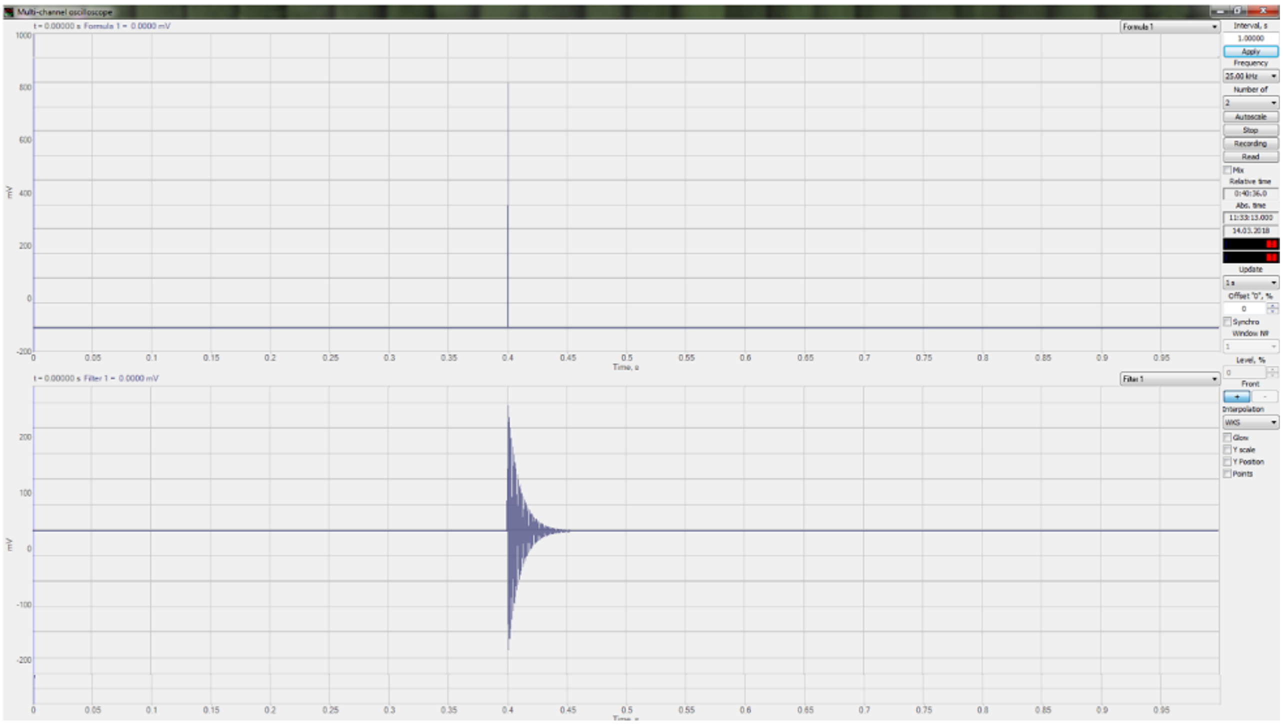
· The "**Formula**" program allows to produce signals with various forms (the list of the available signal forms is displayed in the section "**Deterministic signals**"). In our particular example, we were using multistage signal *StepGen* (with the frequency of 25000 kHz and delta-function)

· Start the program "**Signal filtering**", create real resonance filter with 1000 Hz sampling frequency and "0.1" damping ratio for the channel "*Formula 1*" (this channel has previously been created with the use of "**Formula**" program). Now we have the channel "*Filter 1*".



Signals generator - Generation of signals from text file - Signals filtering program

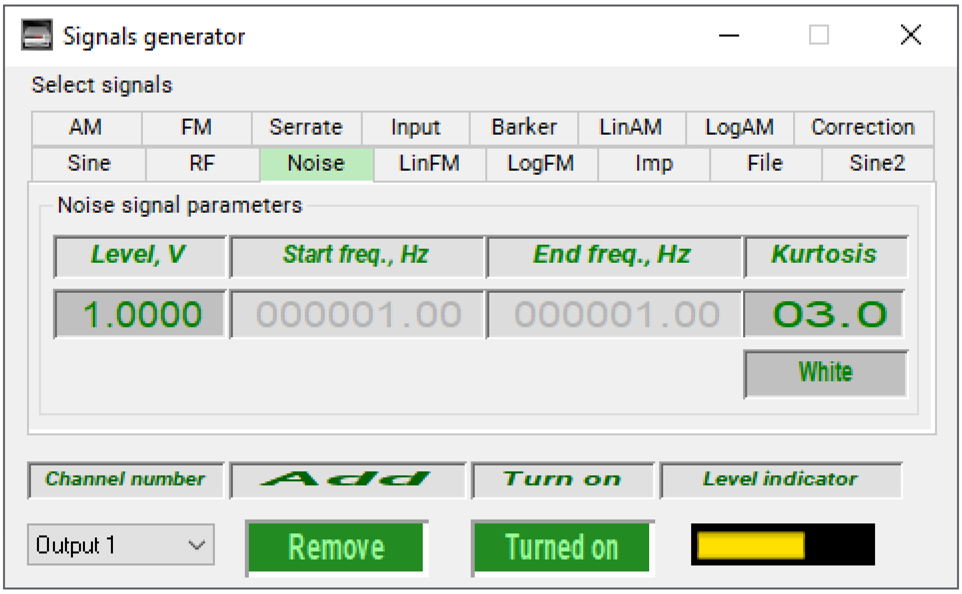
· in order to record the produced signals, start the program "**Multi-channel oscilloscope**", set the program for displaying of two channels (*Formula 1* and *Filter 1*) with signal sweep duration of 1 second. Click the "**Recording**" key to produce a text file and save it as "File.dtu".



Signals generator - Generation of signals from text file - Multi-channel oscilloscope program

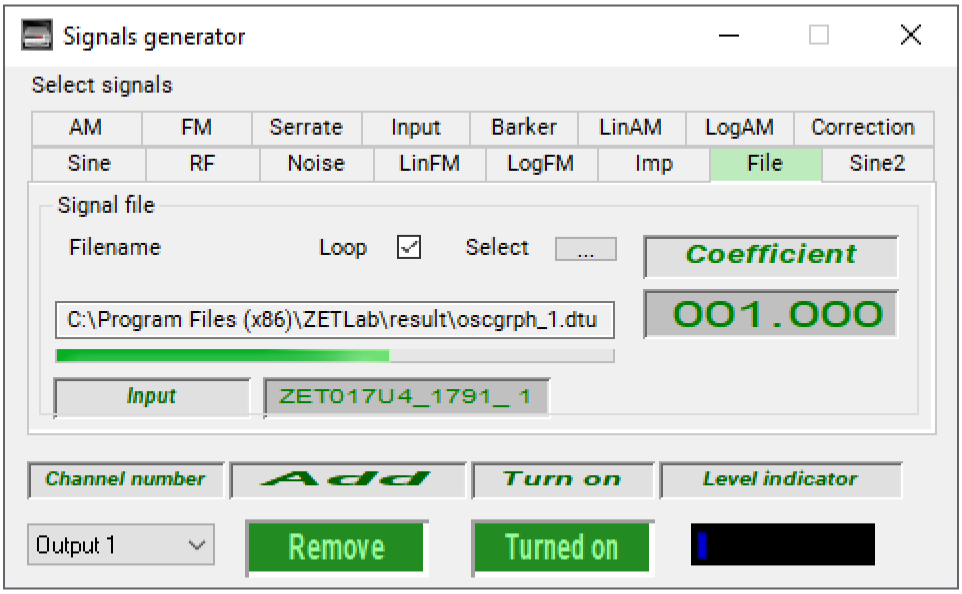
In order to view the recorded text file using the program "**Signals generator**", it is necessary to edit its contents using a text editor (e.g., Notepad++).

It is necessary to introduce **8** additional lines prior to the data array. The lines **1, 2, 3, 5** and **6** may contain arbitrary information, while the line **4** should specify the sampling frequency (in this case: 25 000 Hz), the line number **7** contains names of the data columns (separated by tab character), the line number **8** specifies the measurement units (also separated with the tab character).



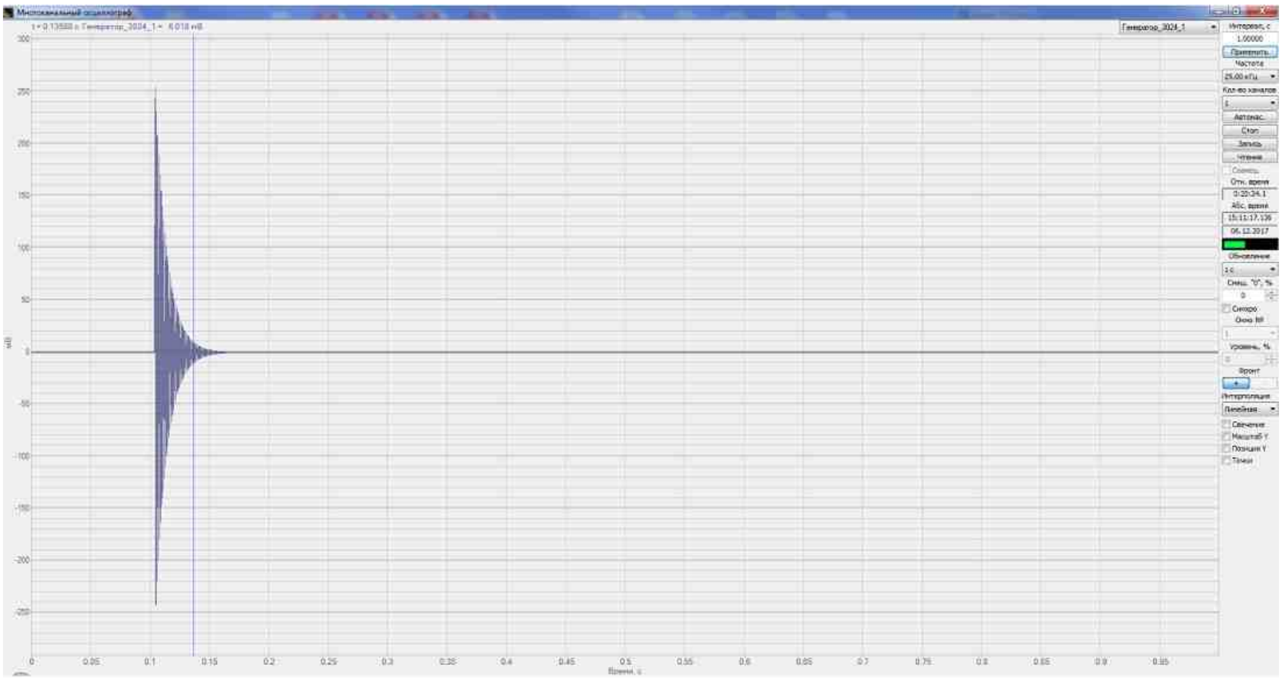
Signals generator Reproduction of a signal from a text file

Start the program "**Signals generator**", enter the "**File**" tab, select .dtu file, select the channel to be used for data Play recorded signals (in this case – *Formula 1* or *Filter 1*), enable the option "**Loop**" and start the generator.



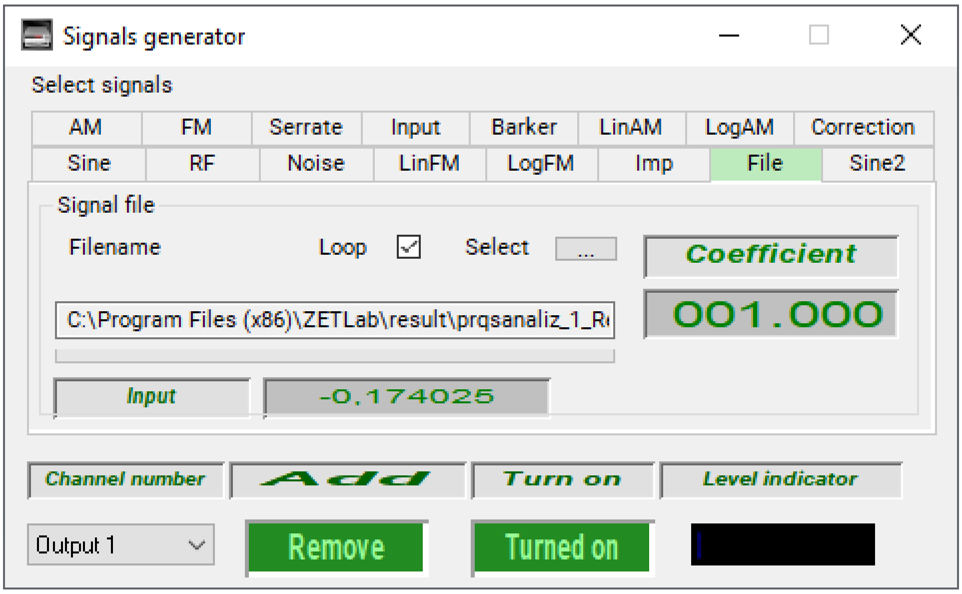
Signals generator - Generation of signals from text file - Starting the dtu file

Using the program "**Multi-channel oscilloscope**", it is possible to view the reproduced signal of the required form.



Signals generator - Generation of signals from text file - Multi-channel oscilloscope program

This signal can also be processed with the use of other programs from the scope of ZETLAB Software package. For instance, you can use the "**Modal analysis**" program available in the section "**Signal analysis**".



Signals generator - Play recorded signals of the recorded signals - Starting the dtu file

It is also possible to create the *.dtu files to be reproduced in the program "**Signals generator**" using a text editor.

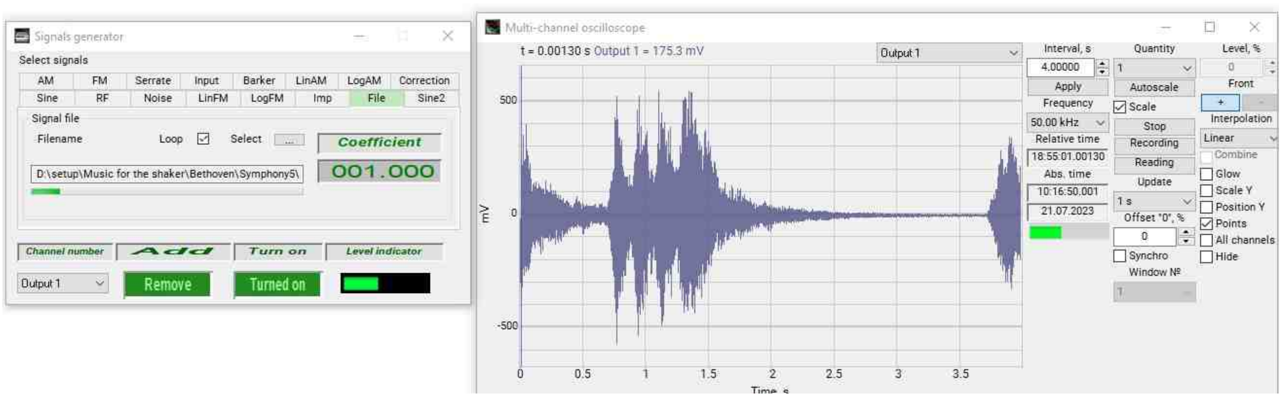
dspectr_1.dtu – Блокнот

Файл Правка Формат Вид Справка

```
Spectrum CPB Analysis
ZET017U4_1791_ 1
Frequency band - from 1.000 Hz to 20000.00 Hz
Integral level, dB:   103.54
Integrated level of spectrum with correction function, dB:   103.54
Date - 21.07.2023
Time - 9:57:37
Frequency         Norm    RMS       RMS-max RMS-min RMS-aver
Hz       dB       dB (0.001 mV)     dB (0.001 mV)   dB (0.001 mV)    dB (0.001 mV)
1        No data -0,333285          No data No data No data
1,25     No data 1,27567 No data No data No data
1,6      No data 16,4761 No data No data No data
2        No data 3,18735 No data No data No data
2,5      No data 4,17559 No data No data No data
3,15     No data 12,3883 No data No data No data
4        No data 5,37572 No data No data No data
5        No data 11,5888 No data No data No data
6,3      No data 8,68316 No data No data No data
8        No data 14,9063 No data No data No data
10       No data 13,2769 No data No data No data
12,5     No data 12,0592 No data No data No data
16       No data 11,2074 No data No data No data
20       No data 12,3303 No data No data No data
25       No data 12,7356 No data No data No data
31,5     No data 13,548  No data No data No data
40       No data 14,8555 No data No data No data
50       No data 15,8915 No data No data No data
63       No data 15,679  No data No data No data
```

Signals generator - viewing the signal parameters in the NotePad prgram

The sequence of starting the recorded signal from a file is similar to the one described above: enter the "**File**" tab of the "**Signals generator**" program, select the file to be reproduced and start the generator. The results of program operation can also be viewed in the program "**Multi-channel oscilloscope**".



Example of the recorded signals Play recorded signals

An example of Play recorded signals of the recorded signal can be viewed in the video-lesson "Music for the shaker". In this video, a piece of music is Play recorded signals at the output of **FFT Spectrum Analyzer**, which is connected to a vibration exciter.

Play recorded signals applied to the input channels .....

The function of input channel generation considerably increases the functional scope of "**Signals generator**" program. For instance, if it is necessary to generate a complex signal at the input of a device, and this signal is not available in the program "**Signals generator**", then it is possible to use the program "**Formula**". This program allows to produce signals with various profiles as well as to perform a variety of mathematical operations with them.

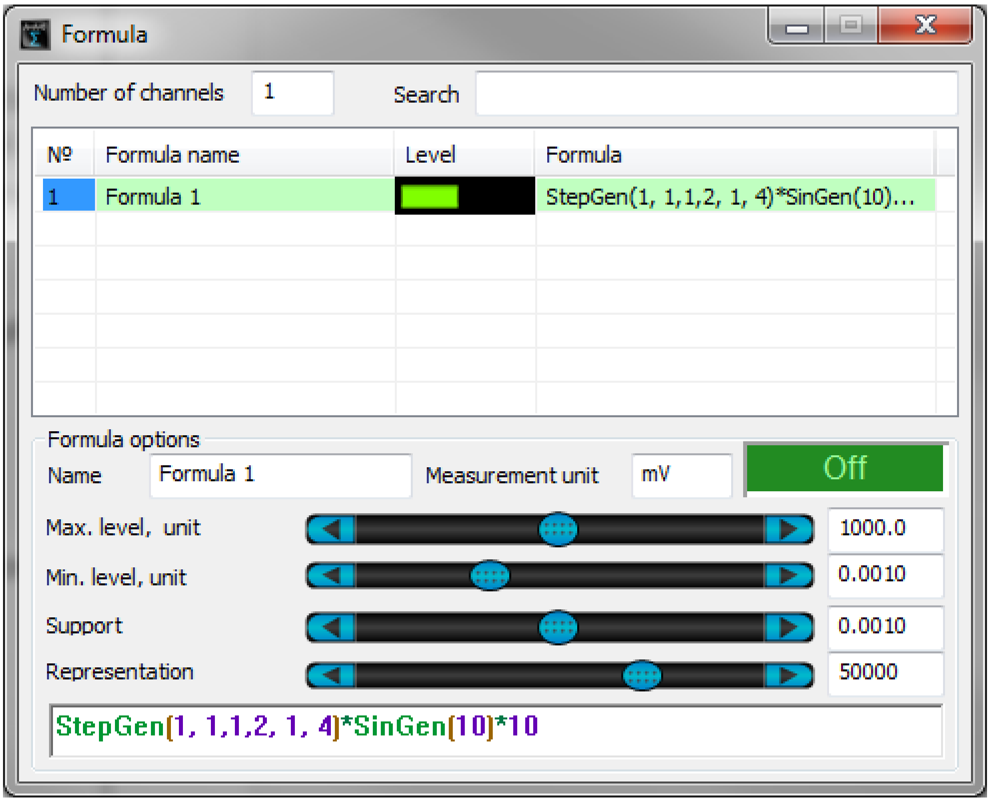
In order to produce a signal at the output of the generator to be further applied to the input of a device, enter the tab "**-Input**" of the "**Signals generator**" program – you will see the control elements used for configuration of signal parameters.

· **Input channel** – input channel of ZET device or a virtual channel created by the programs from ZETLAB software package. The selected channel will be reproduced at the output of the generator.

· **Coefficient** – amplification / attenuation ratio of the signal transferred from the input channel of ADC or virtual channel to the generator output.

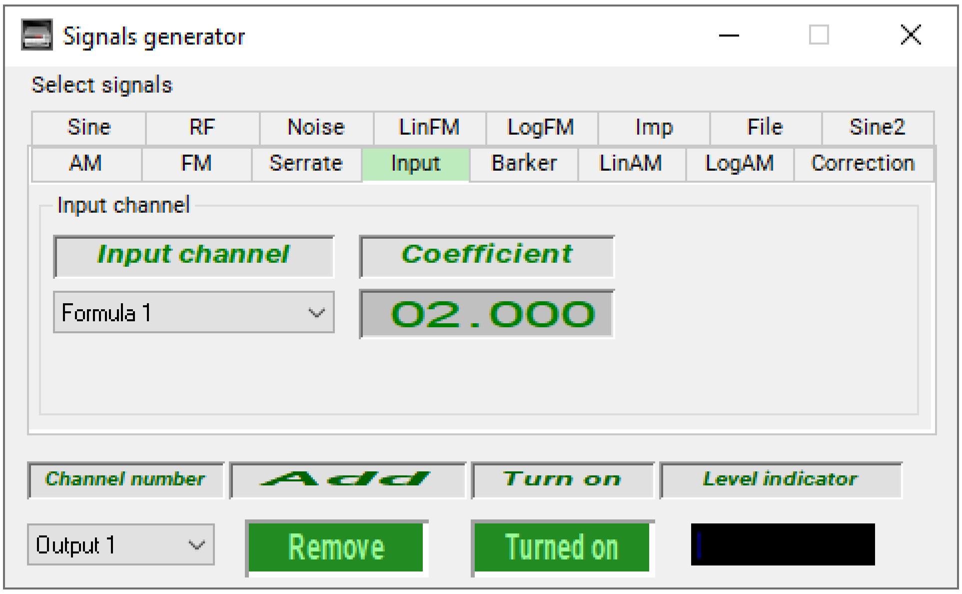
Signal generation is started upon activation of the keys "**Add**" and "**Enable**".

The Fig. below shows interface of the "**Formula**" program that is used for generation of a signal consisting of two different signals.



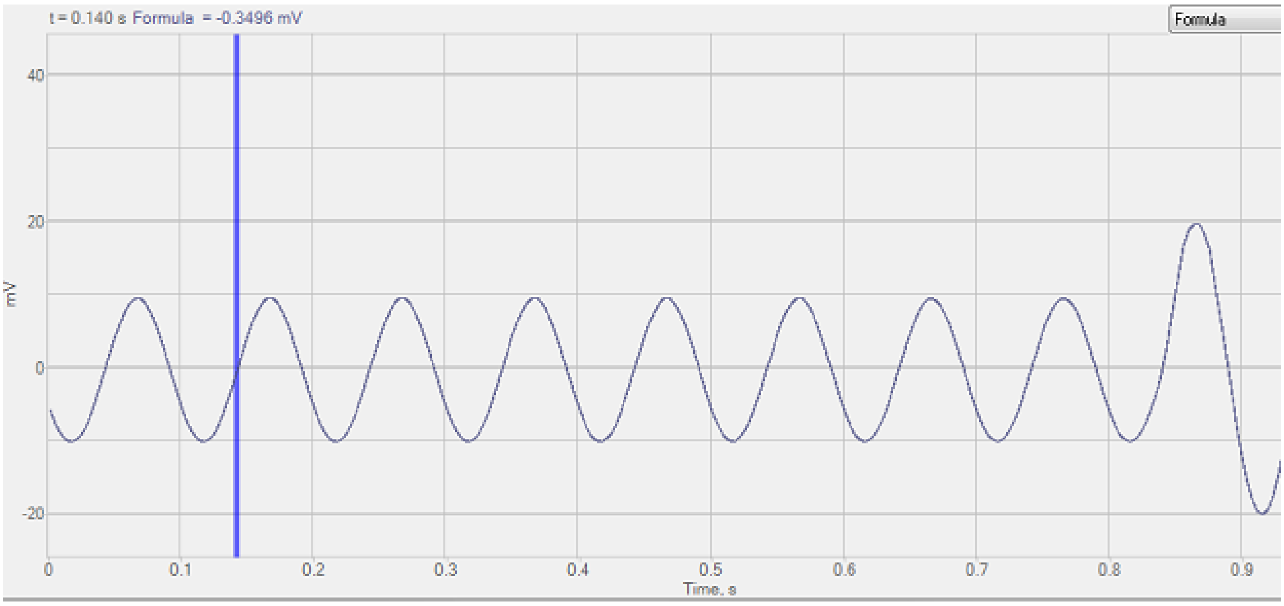
Signals generator - Input - generation of signal using the program Formula

This signal is transferred from generator output with amplification ratio "2".

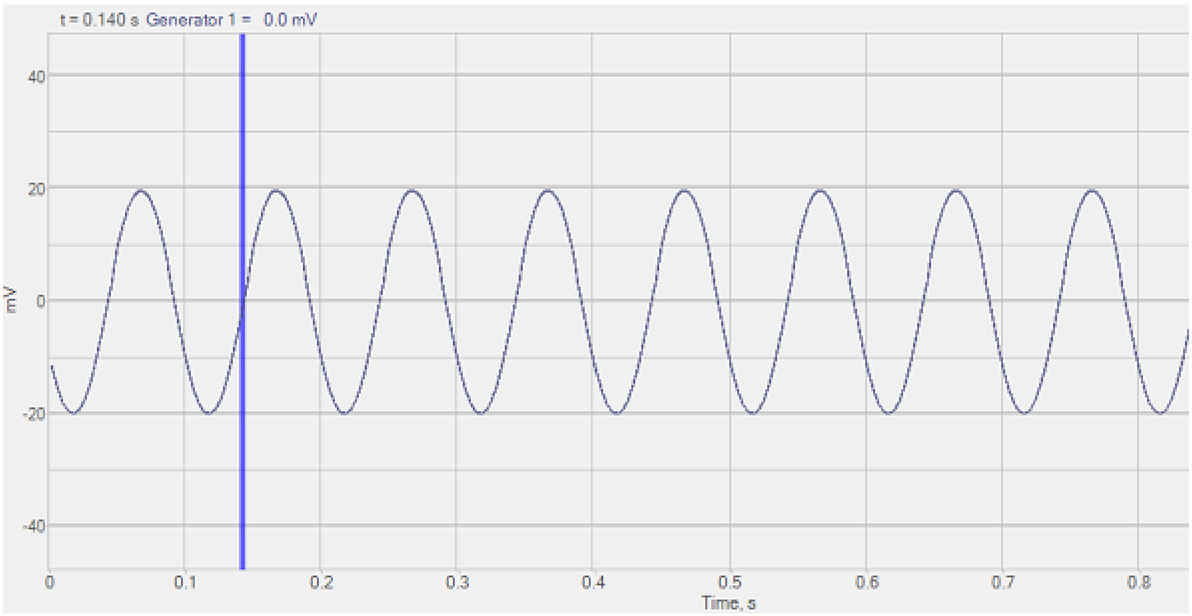


Signals generator - Input - Signal generator settings

The Fig.s below display oscilloscope graphics of the signals produced by the programs "**Formula**" and "**Signals generator**":



Signals generator - Input - oscilloscope graphic of the program Formula



Signals generator - Input - oscilloscope graphic of the program Signals generator

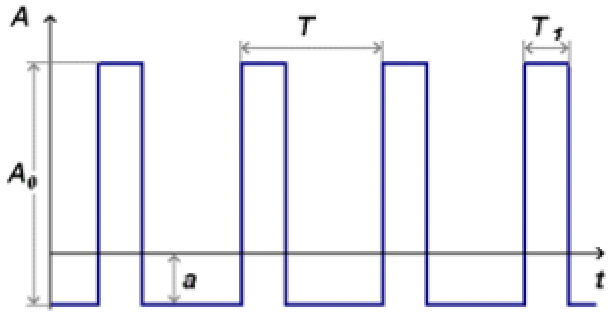
Impulse signal .....

The **Impulse signal** is represented by a signal with short-term change of the stabilized status, which is also characterized by small interval if compared to overall period of the stabilized process.

The **Impulse signal** is calculated by the formula:

$$A = \begin{cases} 1, & if \quad \omega t < 2\pi \cdot S \\ 0, & if \quad \omega t > 2\pi \cdot S \end{cases}$$

Signals generator - Impulse signal - formula for calculations where $\omega = 2\pi f$ – signal phase $(f=1/T)$, t – current time, S – filling ratio.



Signals generator - Impulse signal - form of the signal

In order to produce a impulse signal with pre-set values of frequency, amplitude, DC offset and duty cycle, enter the tab "**-Imp**" of the "**Signals generator**" program – there you can find the control elements used for setting the impulse signal parameters:

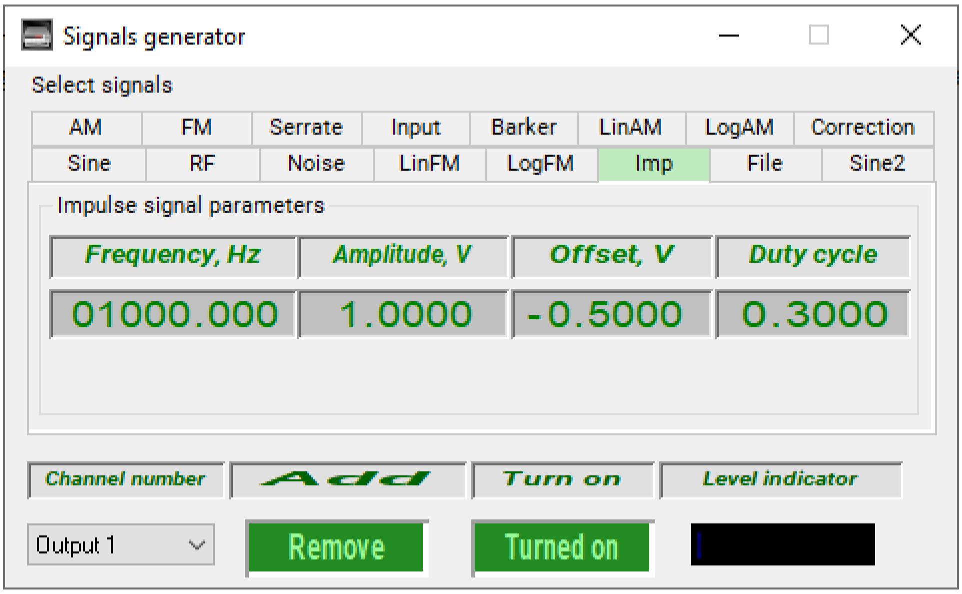
· **Freqency, Hz**– the carrier frequency of the produced signal. The signal frequency value f has the following relation to its period T (see the Fig. above): $f = 1/T$.

· **Amplitude** – the peak value of the signal to be used for impulse generation (this value is set in Volts). In the Fig. above, the amplitude level is specified as A.

· **Offset, V** – the value of DC offset to be used for signal generation. This value is set in Volts. In the Fig. above, the offset value is specified as a.

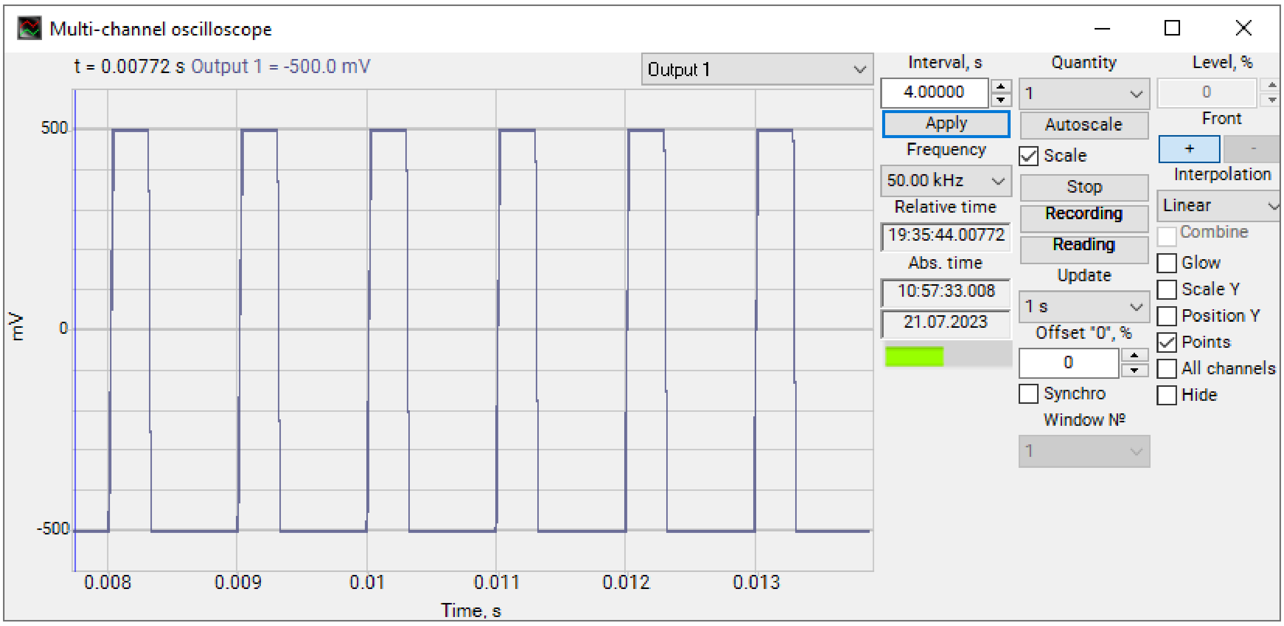
· **Duty cycle** – also referred to as *filling ratio* – relation of impulse duration to the impulse repetition cycle, i.e. T_1/T. The duty cycle is set in fractions of period: from 0,01 up to 0,99.

As the required parameters are set, and impulse generation is started (the keys "**Add**" and "**Turne on**" are used to start the generation process), the program interface will look as it is shown in the Fig. below:



Signals generator - Impulse signal - Generation parameters

The Fig. below displays the corresponding form of the impulse signal obtained with the use of the program "**Multi - channel oscilloscope**".



Signals generator - Impulse signal - oscilloscope graphic of the generated signal

Barker code generation .....

Barker code signals are represented by signals with phase modulation, that are described by the formula:

$$s(t) = \sum_{k=0}^{N-1} q_k f_k(t)$$

Signals generator - Barker code - formula for signal parameters calculation

· $q_k = \pm 1$ (if k is from 0 up to $N-1$),

· $f_k(t) = A_0 \sin(\omega t)$

· $\omega = 2\pi f$ – signal phase (f – signal phase, which is related to the period as $f=1/T$),

· A_0 – signal amplitude

Barker signals have power spectra with minimum possible deviation (in square terms) from the single discrete spectrum. Auto-correlational functions of **Barker signal** are quite similar to discrete auto-correlational functions. The lateral peaks (sidelobes) of Barker signal auto-correlational function do not exceed the value of $1/N$. These codes are available for $N \le 13$. Below you can see the graphic with available Barker codes:

N	k												
	0	1	2	3	4	5	6	7	8	9	10	11	12
2	+1	-1											
3	+1	+1	-1										
4	+1	+1	-1	+1									
5	+1	+1	+1	-1	+1								
7	+1	+1	+1	-1	-1	+1	-1						
11	+1	+1	+1	-1	-1	-1	+1	-1	-1	+1	-1		
13	+1	+1	+1	+1	+1	-1	-1	+1	+1	-1	+1	-1	+1

Signals generator - Barker code - Barker codes table

In order to produce Barker code signal with the set frequency, level and period, enter the **"-Barker"** tab of the "**Signals generator**" program – you will see the control elements used for Barker code signal parameters.

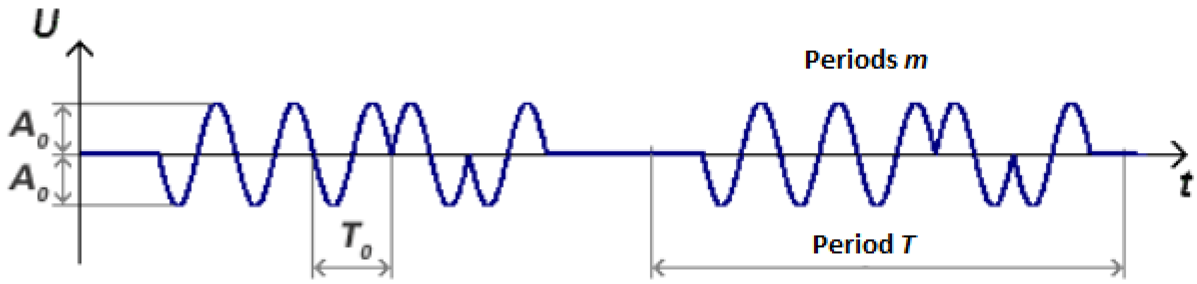
· **Frequency, Hz** – generated signal impulse frequency (in Hz). Signal frequency f is related to its period T_0 (see the Fig. below) as $f=1/T0$.

· **Periods** – the number of impulses within a single discrete component. This parameter will be further described in more details.

· **Amplitude, V** – the amplitude to be used for signal generation. This value is set in Volts. In the Fig. below, this value is specified as A_0.

· **Period, Hz** – the number of discrete components generated per second, i.e. Barker code repetition frequency (discrete components repetition frequency).

· **Code** – Barker code.



Signals generator - Barker code - Barker code signal form

Periods

In a simple case, when the number of periods in the program ("**Periods**" parameter) is "1", the impulse sequence in a single discrete component of the generated signal corresponds to the value, which is specified in the graphic above. If the number of periods is m, it leads to the increase of impulses number within a discrete component (instead of increase of discrete components number per second). For instance, for Barker signal with code "5", the sequence q_k for the number of periods m will be:

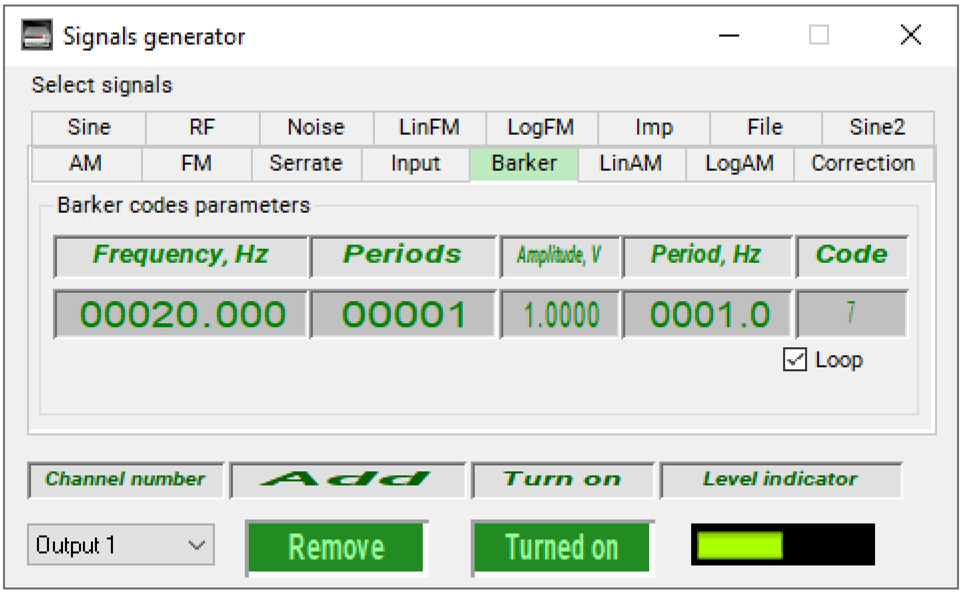
·m=1: {+1; +1; +1; -1; +1};

·m=2: {+1; +1; +1; +1; +1; +1; -1; -1; +1; +1};

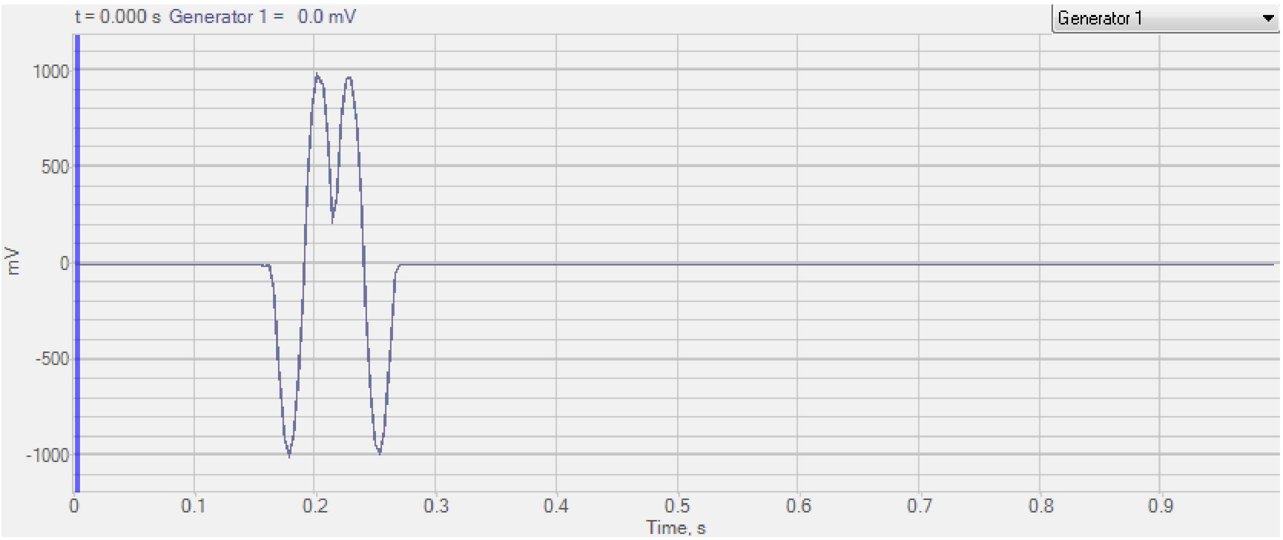
·m=3: {+1; +1; +1; +1; +1; +1; +1; +1; +1; -1; -1; -1; +1; +1; +1}

·and so on.

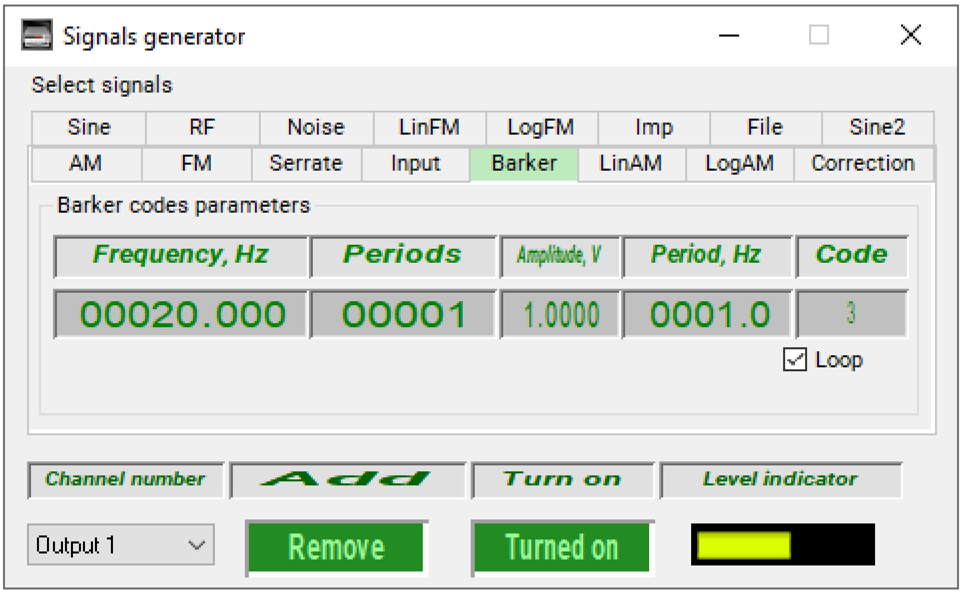
That means, that the number of impulses with the same sign within a single discrete component increases in the number of times, which is set for "**Periods**" parameter. The generation process begins upon activation of the keys "**Add**" and "**Enable**". The Fig.s below show the parameters used for Barker codes generation and corresponding signal forms, as well as auto-correlational function for code "13":



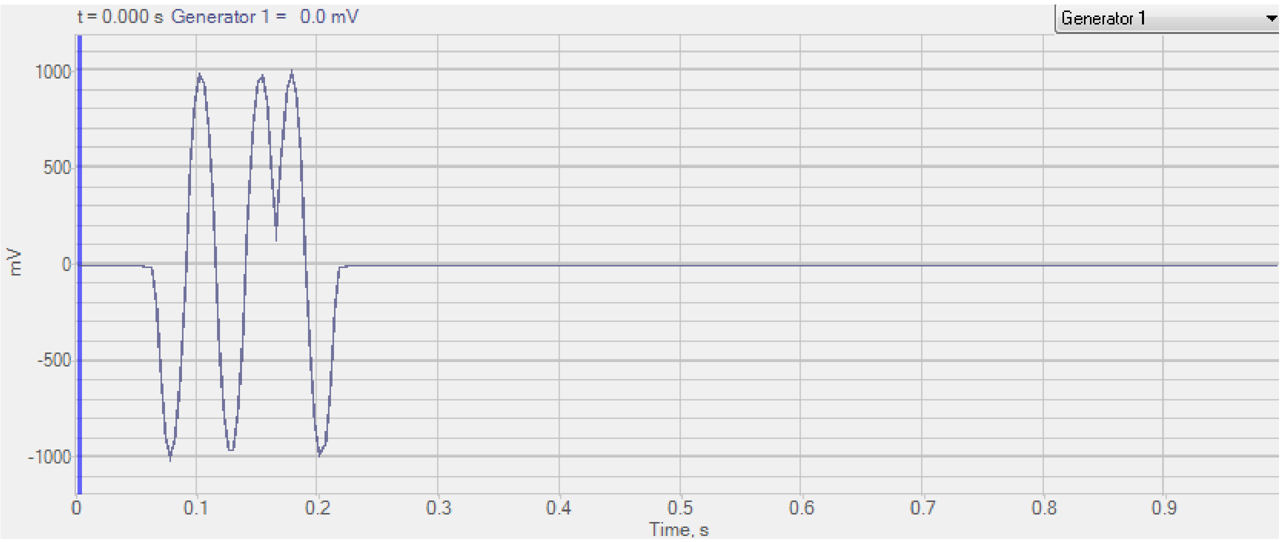
Signals generator - Barker code - signal parameters



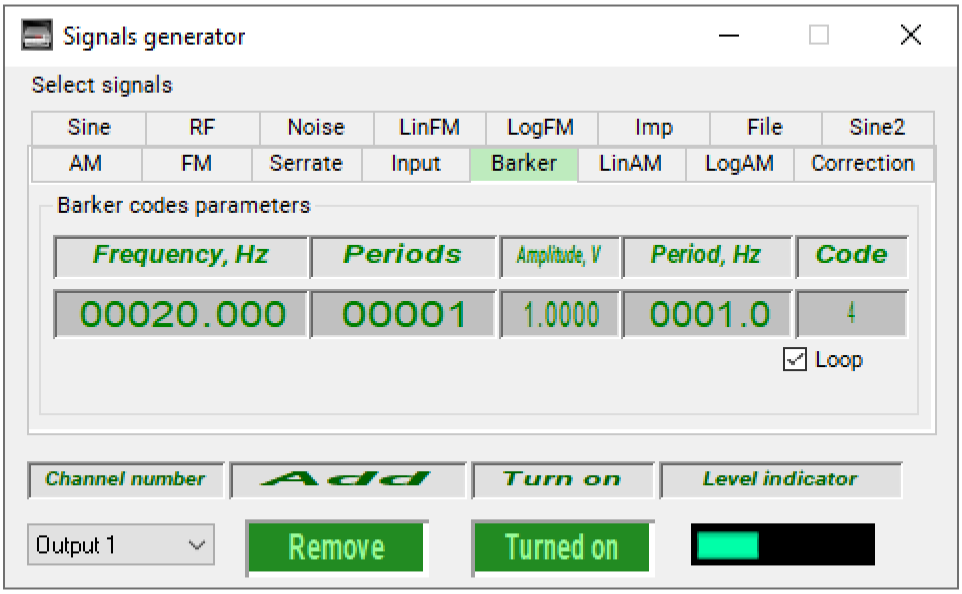
Signals generator - Barker code - oscilloscope graphic



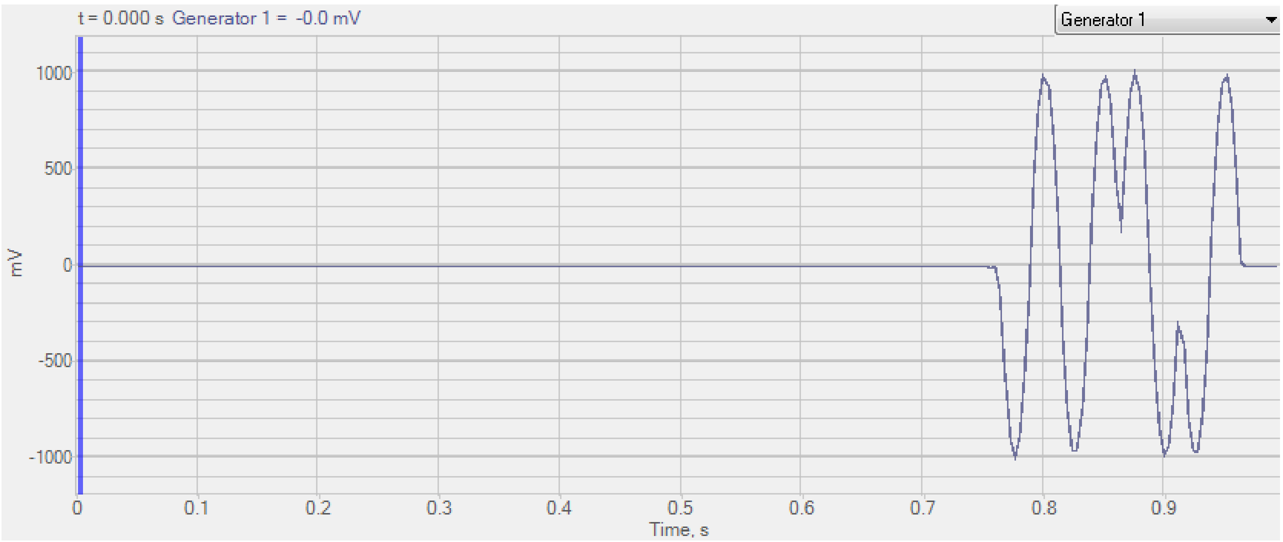
Signals generator - Barker code - signal parameters



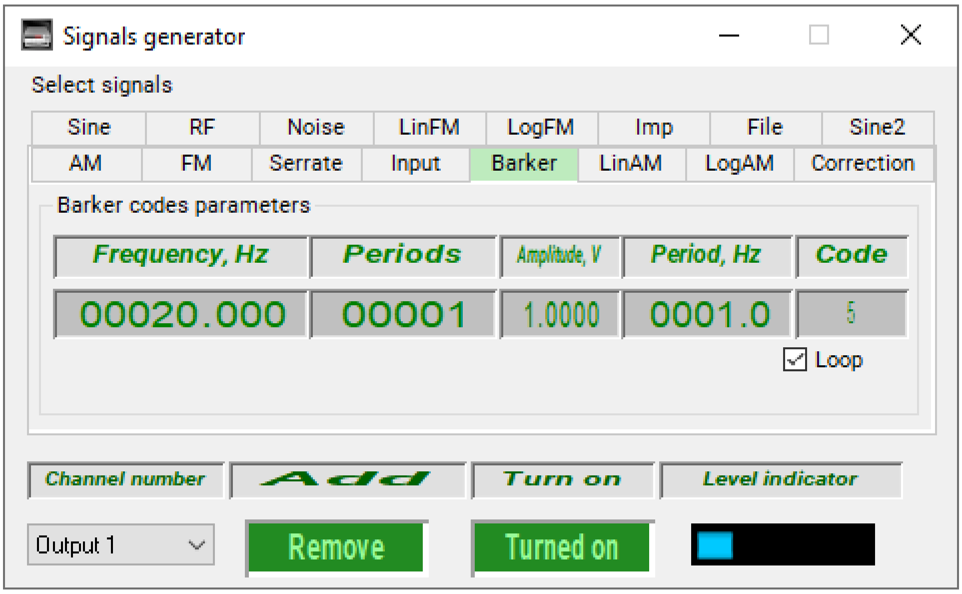
Signals generator - Barker code - oscilloscope graphic



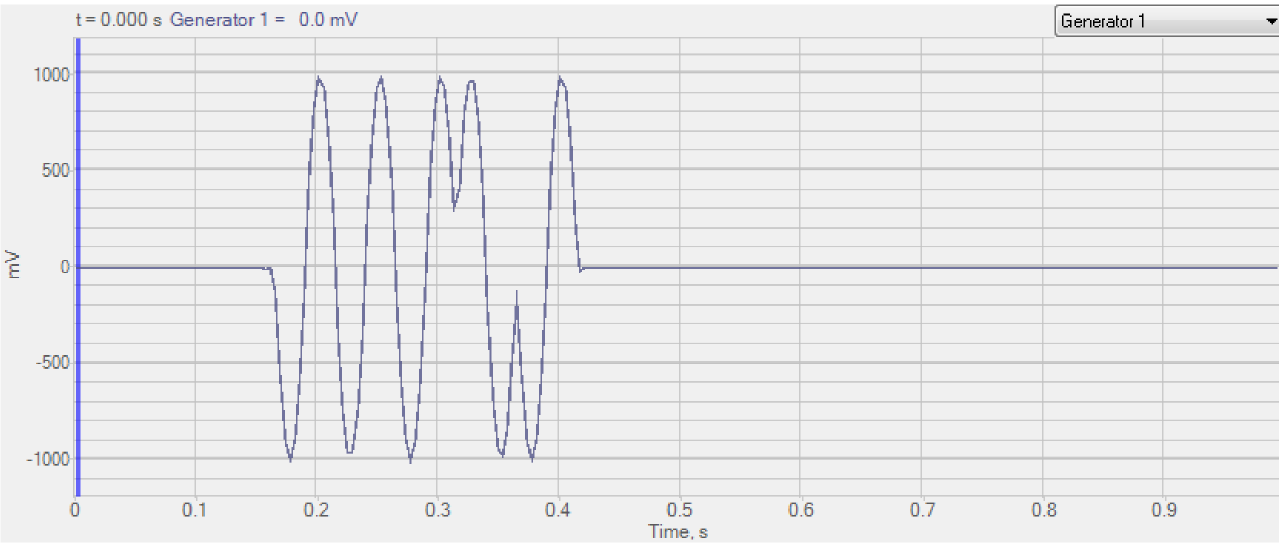
Signals generator - Barker code - signal parameters



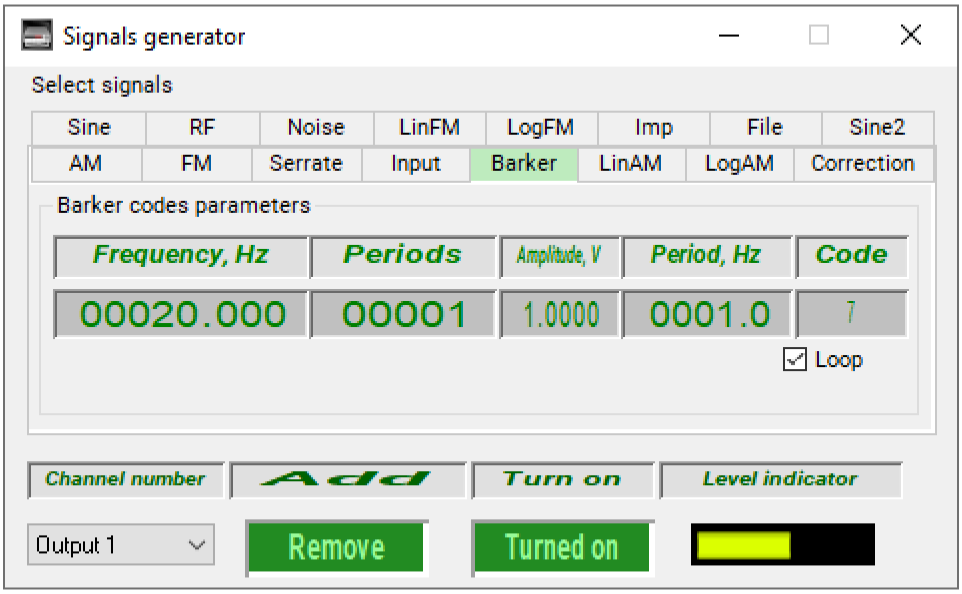
Signals generator - Barker code - oscilloscope graphic



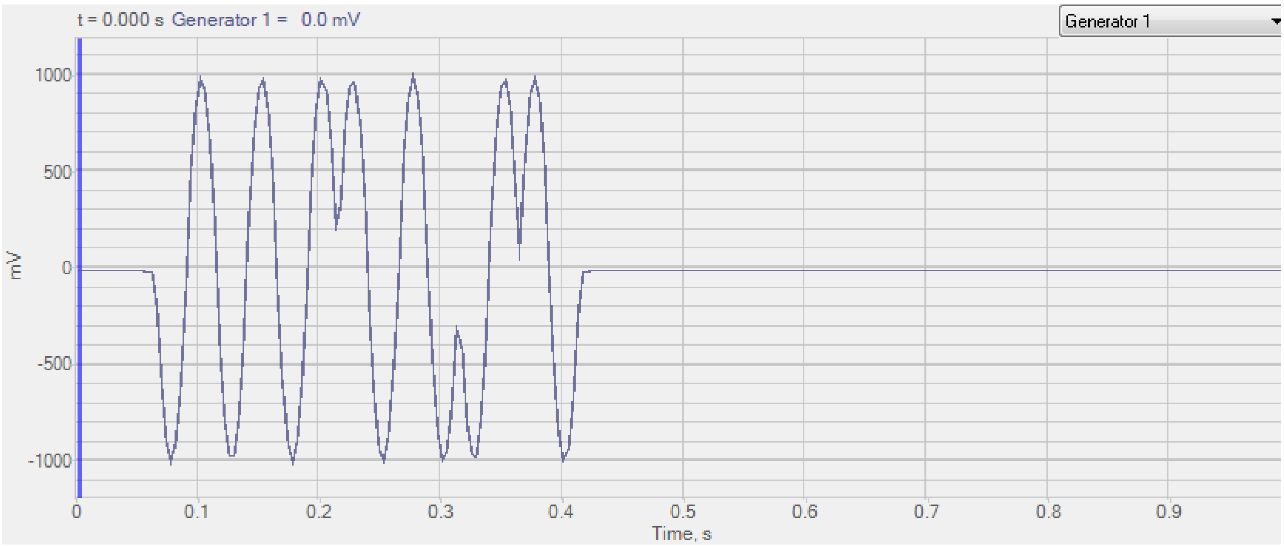
Signals generator - Barker code - signal parameters



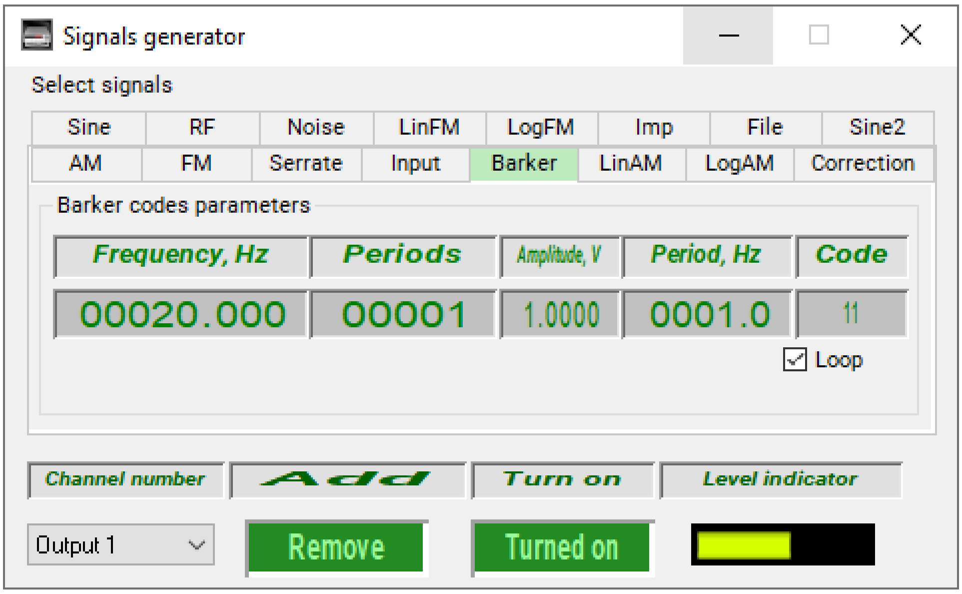
Signals generator - Barker code - oscilloscope graphic



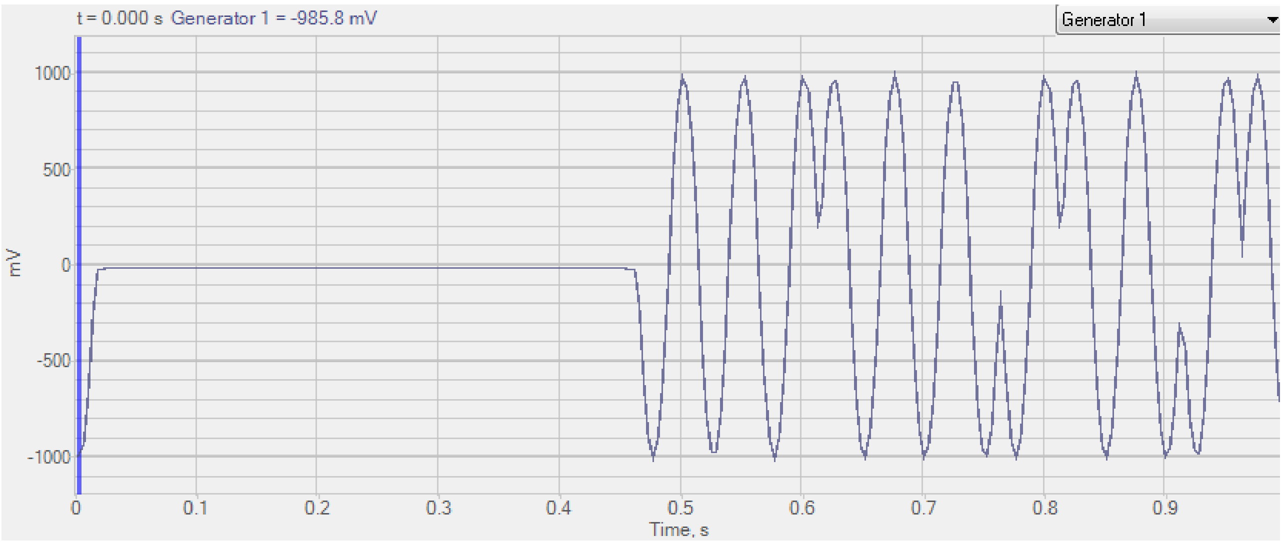
Signals generator - Barker code - signal parameters



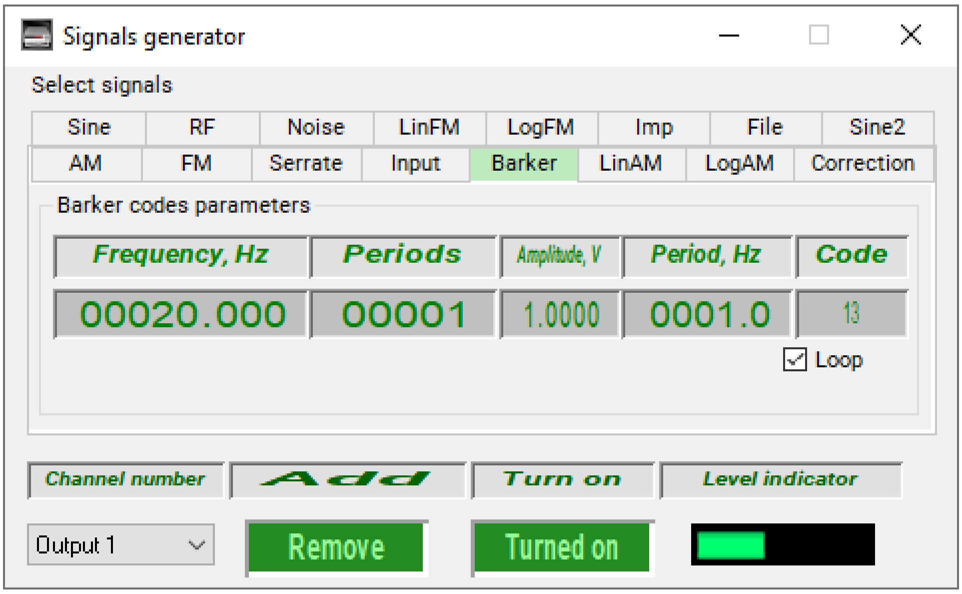
Signals generator - Barker code - oscilloscope graphic



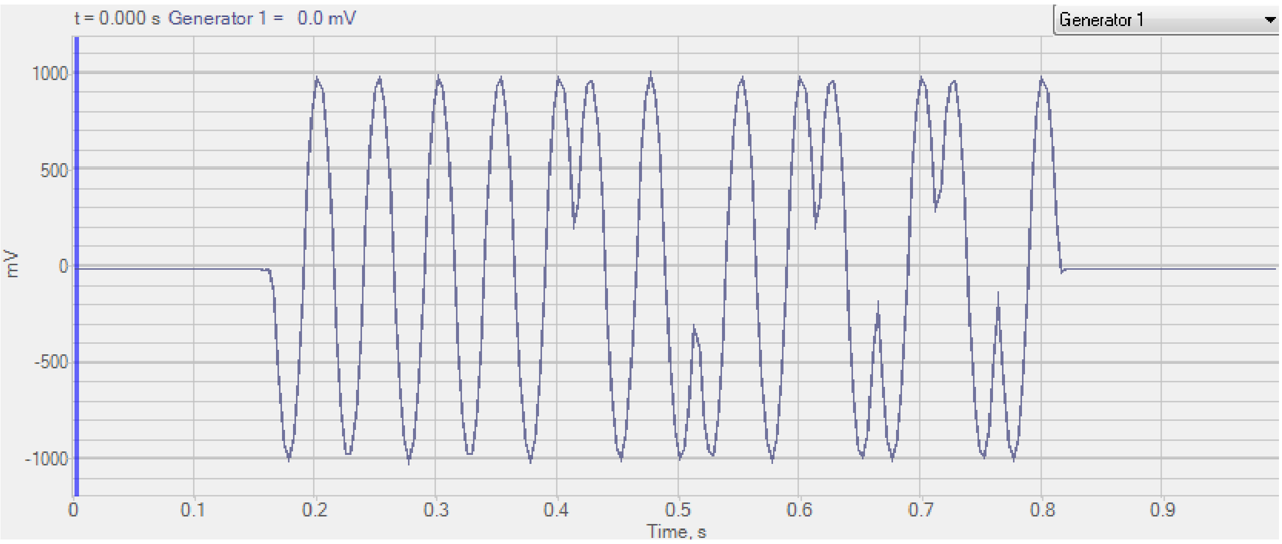
Signals generator - Barker code - signal parameters



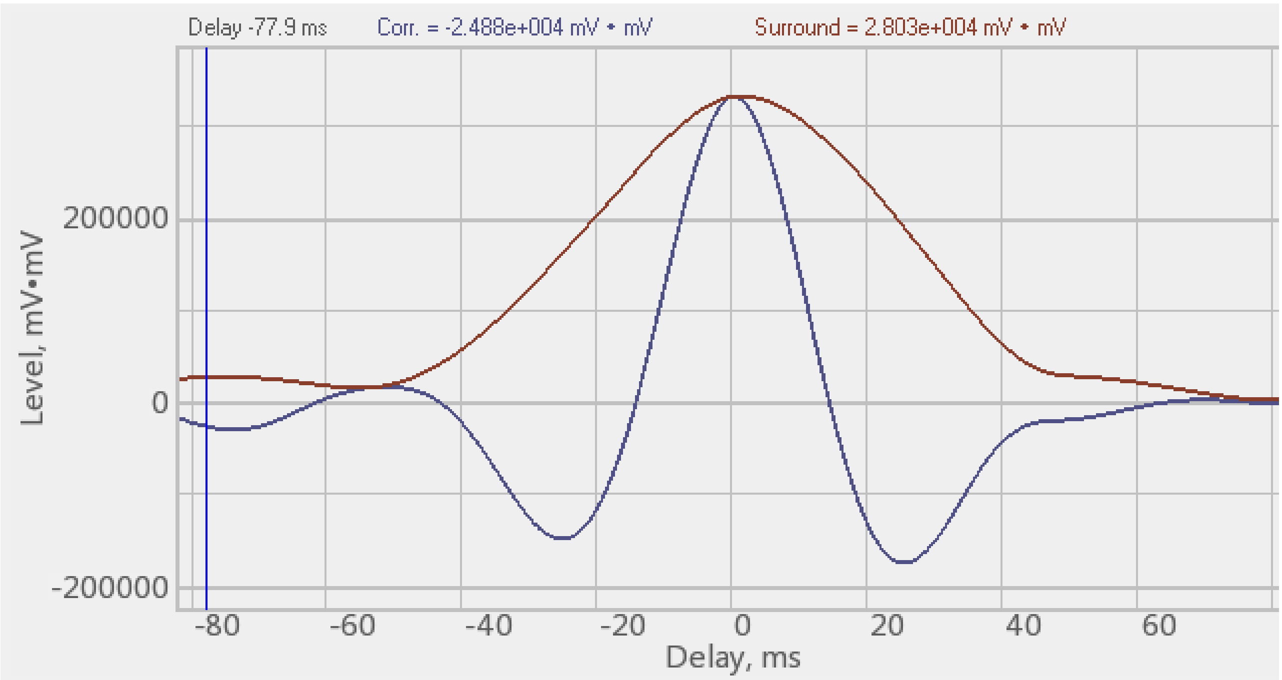
Signals generator - Barker code - oscilloscope graphic



Signals generator - Barker code - signal parameters



Signals generator - Barker code - oscilloscope graphic



Signals generator - Barker code - Auto-correlational function of the signal

Correction .....

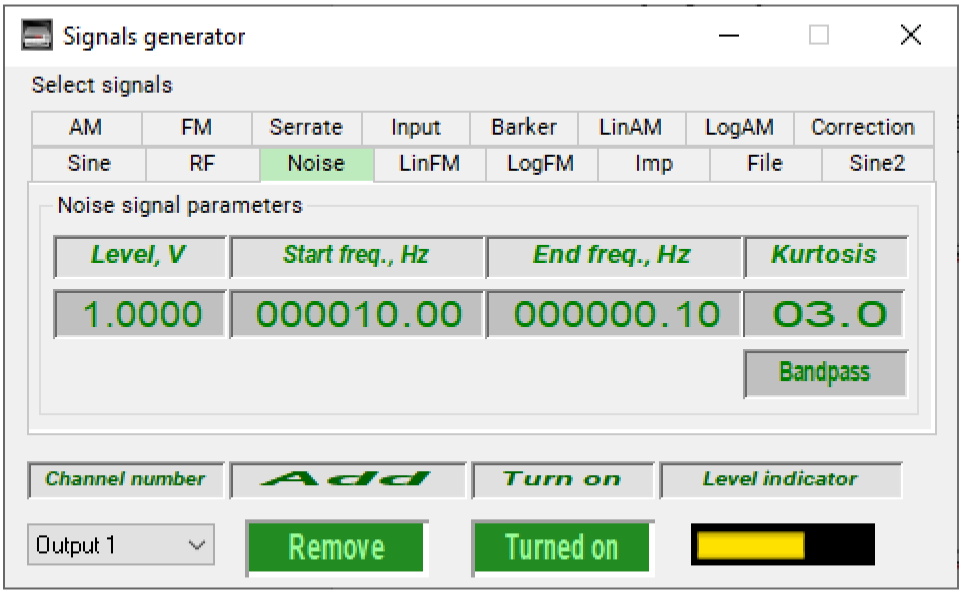
Frequency correction of the oscillator signal is necessary to set the oscillator signal with such an amplitude in order to obtain the desired result on the selected channel.

to go to the tab - **Correction** in the **Signals generator** program , after which the elements for setting the **Correction** parameters will be displayed in the program window:

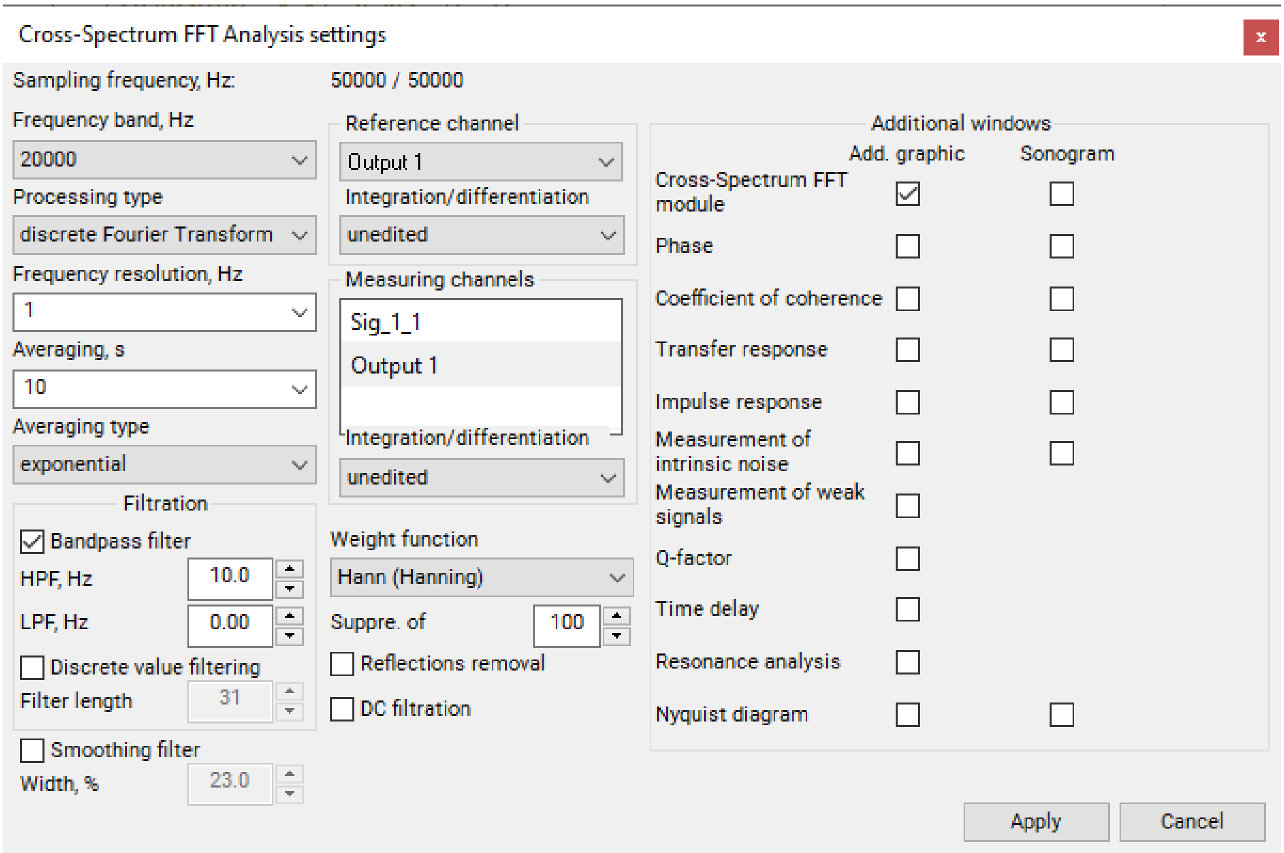
- *Level. V* is the root mean square value (RMS) of the level with which the Correction will be generated. The level is set in volts. Note that the RMS value is set as the level. The peak value (denoted as A_0 *in the figure above*) is related to RMS by the relationship A_0 = RMS * √2.
- *Start frequency, Hz* – initial frequency of the frequency range in which the Correction will be generated. It is related to the period *Tn* in the figure above by the relation $f_H = 1/T_H$. The start frequency is given in hertz.
- *End frequency, Hz* – end frequency of the frequency range in which the Correction will be generated. It is related to the period Tk in the figure above by the ratio $f_k = 1/Tk$. The end frequency is specified in hertz.
- *Level. V* is the root mean square value (RMS) of the level with which LogFM will be generated . The level is set in volts. Note that the RMS value is set as the level. The peak value (denoted as A_0 *in the figure above*) is related to RMS by the relationship A_0 = RMS * √2.
- Kurtosis.

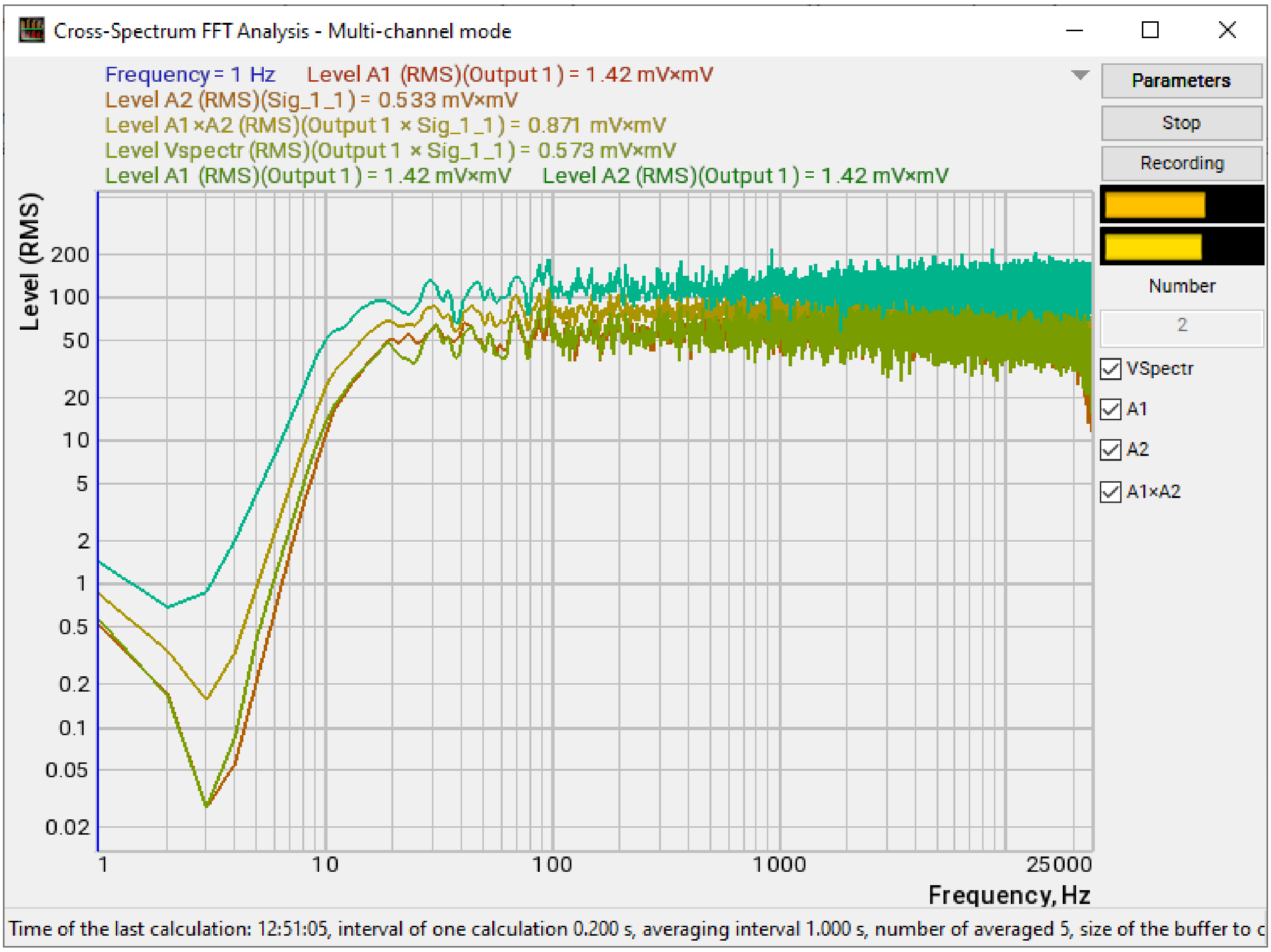
- The program "**Signals generator**" has 7 available noise types:
  - · W*hite,*
  - · *Bandpass,*
  - · *Pink,*
  - · *Red,*
  - · *Determinate,*
  - · Semi-w*hite,*
  - · *Colored.*

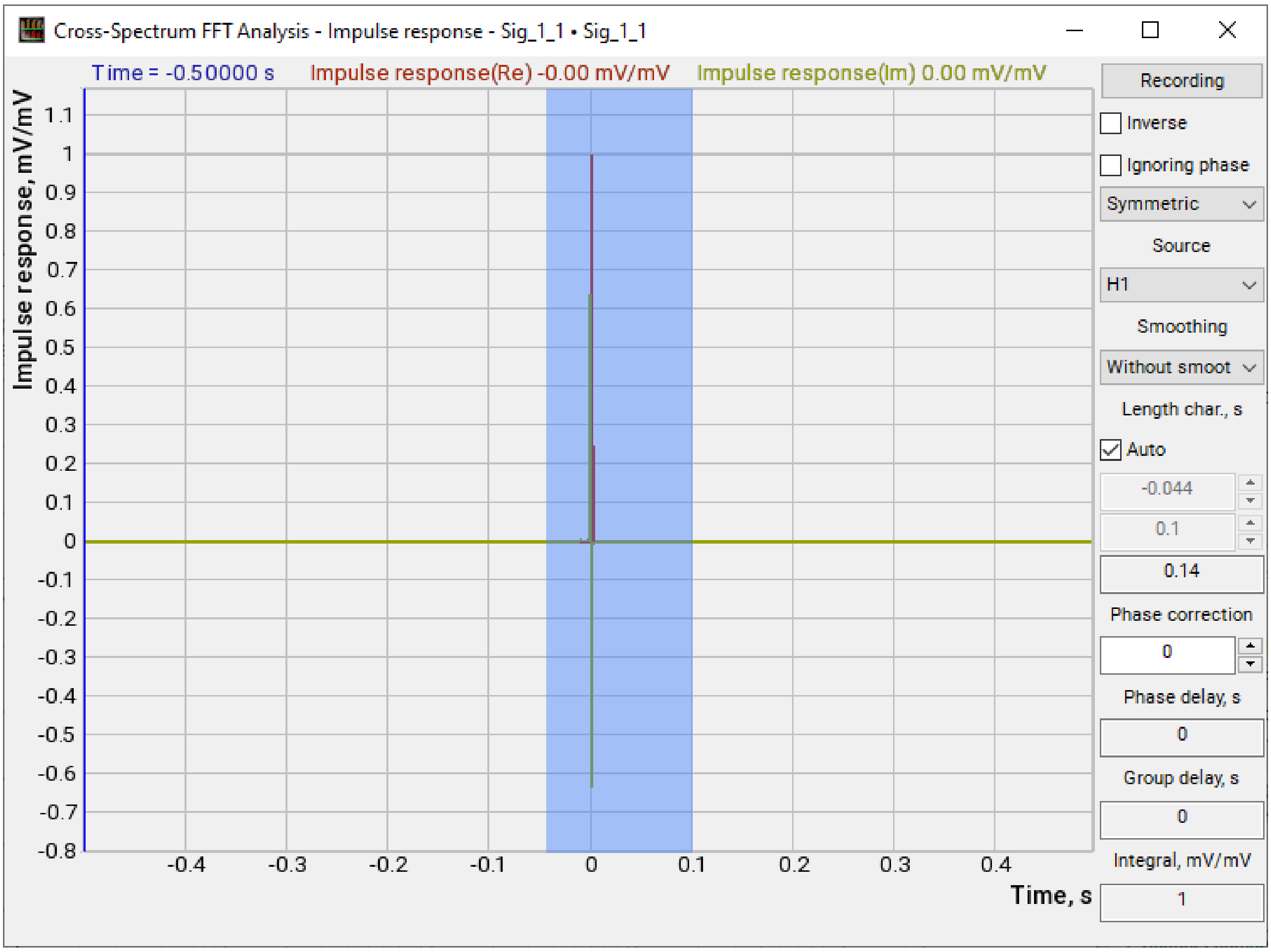
Launch the **Signals generator** program. Select the "Noise" tab on it. In the noise signal parameters, select "*Bandpass*" noise. Specify the frequency range not less than the operating frequency range. Set the signal level to be sufficient to get a noticeable response on the measuring sensor.



Run the program “Cross-Spectrum FFT Analysis”. Select the generator channel in the reference channels, and the channel on which you want to get the specified result as the measuring channel. Turn on the bandpass filter and set the filter frequencies to match the frequency band in the oscillator. Set the averaging to at least 10 seconds. You can set the processing type and frequency resolution as you wish. Here it is necessary to clarify that the smaller the frequency resolution, the more accurate the result will be, but the larger the file with the impulse response will be and the more computer resources the “Signal Generator” program will need for calculations. Do not set the frequency resolution higher than the lower frequency of the operating range (and, accordingly, the frequency of the HPF). In the "Additional windows" section, check the box next to the "Impulse response" line.

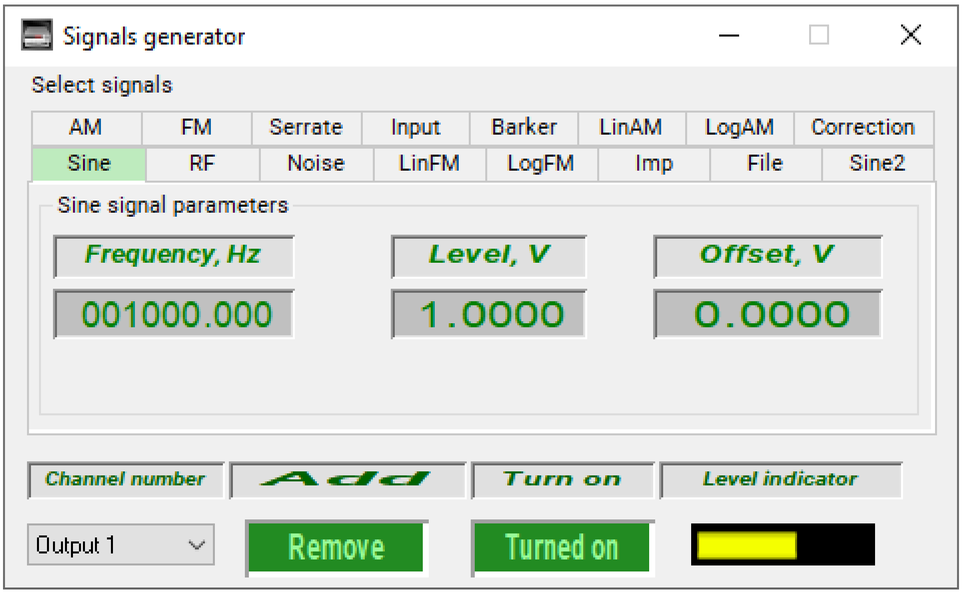

Cross-Spectrum FFT Analysis settings
Sampling frequency, Hz:
50000 / 50000
Frequency band, Hz
20000
Processing type
discrete Fourier Transform
Frequency resolution, Hz
1
Averaging, s
10
Averaging type
exponential
Filtration
Bandpass filter
HPF, Hz
10.0
LPF, Hz
0.00
Discrete value filtering
Filter length
31
Smoothing filter
Width, %
23.0
Reference channel
Output 1
Integration/differentiation
unedited
Measuring channels
Sig_1_1
Output 1
Integration/differentiation
unedited
Weight function
Hann (Hanning)
Suppre. of
100
Reflections removal
DC filtration
Additional windows
Add. graphic
Sonogram
Cross-Spectrum FFT module
Phase
Coefficient of coherence
Transfer response
Impulse response
Measurement of intrinsic noise
Measurement of weak signals
Q-factor
Time delay
Resonance analysis
Nyquist diagram
Apply
Cancel

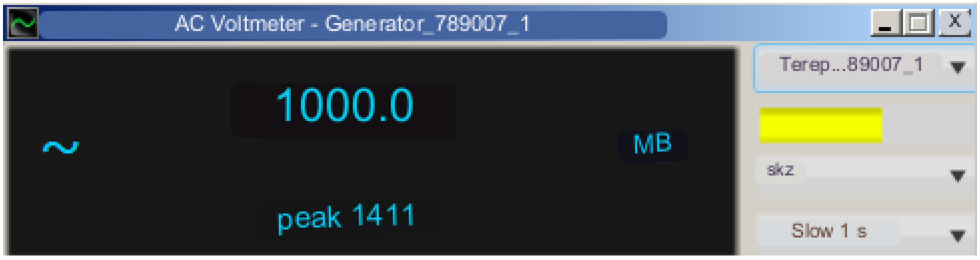

Cross-Spectrum FFT Analysis - Multi-channel mode
Frequency = 1 Hz
Level A1 (RMS)(Output 1) = 1.42 mV×mV
Level A2 (RMS)(Sig_1_1) = 0.533 mV×mV
Level A1×A2 (RMS)(Output 1 × Sig_1_1) = 0.871 mV×mV
Level Vspectr (RMS)(Output 1 × Sig_1_1) = 0.573 mV×mV
Level A1 (RMS)(Output 1) = 1.42 mV×mV
Level A2 (RMS)(Output 1) = 1.42 mV×mV
Parameters
Stop
Recording
Number
2
VSpectr
A1
A2
A1×A2
Level (RMS)
200
100
50
20
10
5
2
1
0.5
0.2
0.1
0.05
0.02
1
10
100
1000
25000
Frequency, Hz
Time of the last calculation: 12:51:05, interval of one calculation 0.200 s, averaging interval 1.000 s, number of averaged 5, size of the buffer to c



In the Impulse response window, check the “Inverse” checkbox. In the drop-down list "Source" select the option "H1". Click the "Record" button and set the file name for saving the impulse response.

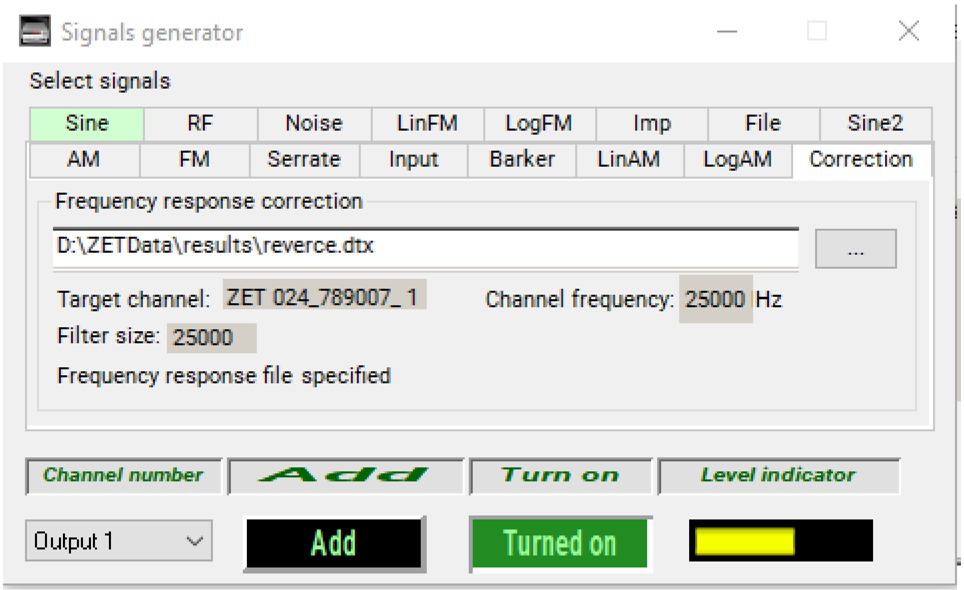
Return to the "**Signals generator**" program and turn off the noise generation. Select the signal you need and turn it on. For example, we have included a sinusoidal signal with a frequency of 1000 Hz and a rms level of 1 V. Run two programs “DC Voltmeter”, in the first select the generator channel, and here is the second measurement channel.

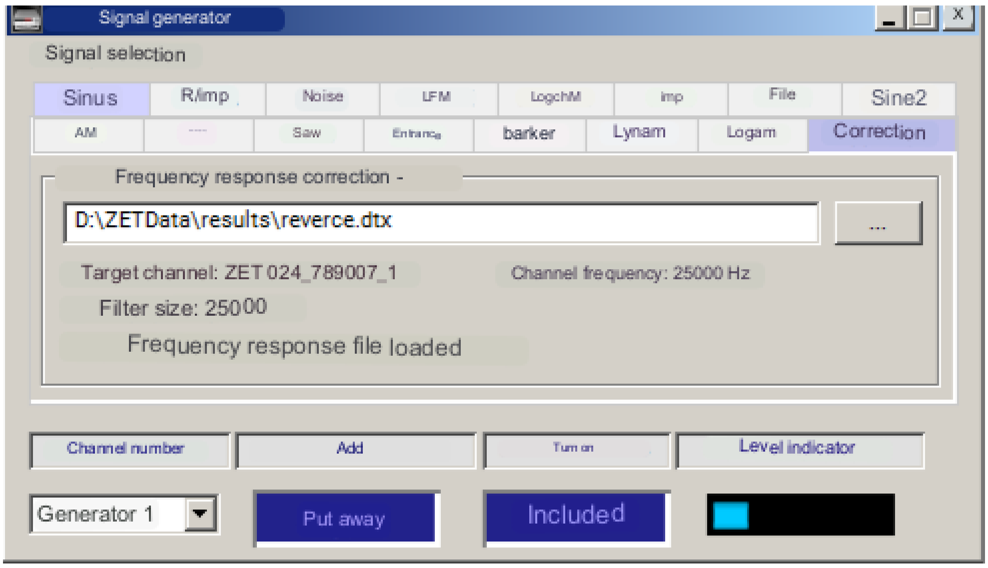


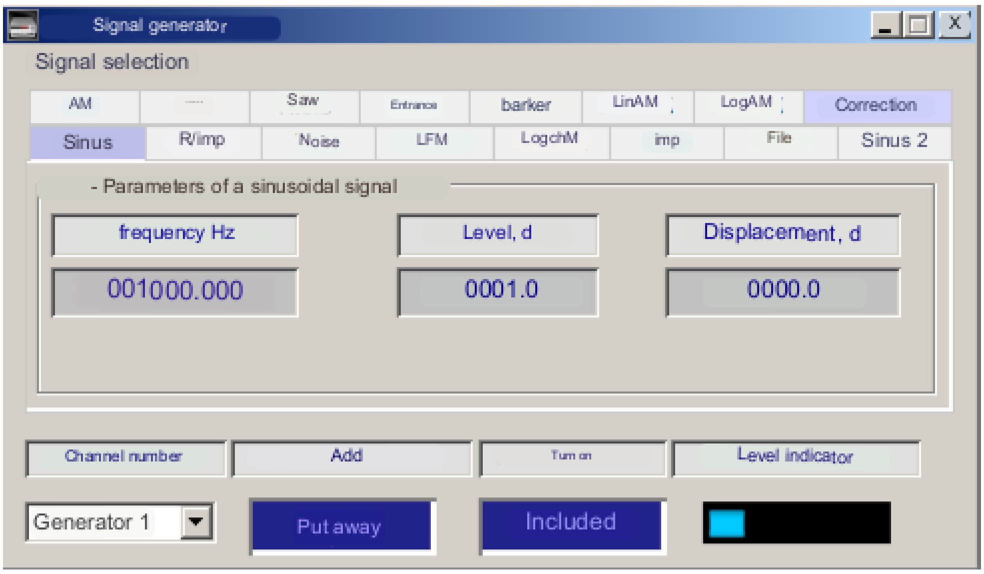


The measurement channel voltmeter shows approximately 50 g, which corresponds to a conversion factor of 0.02 V/g.

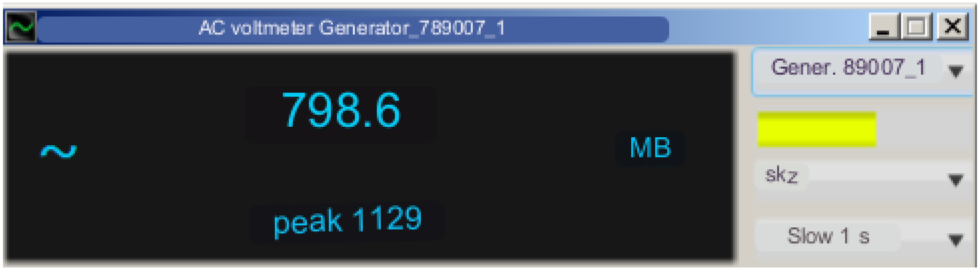
In the "**Signals generator**" program, switch to the "Correction" tab. Click on the button with three dots and select the recently saved impulse response file. Click the Add button. The color of buttons and labels will change to blue. Return to the “Sine” tab and set the required acceleration value.

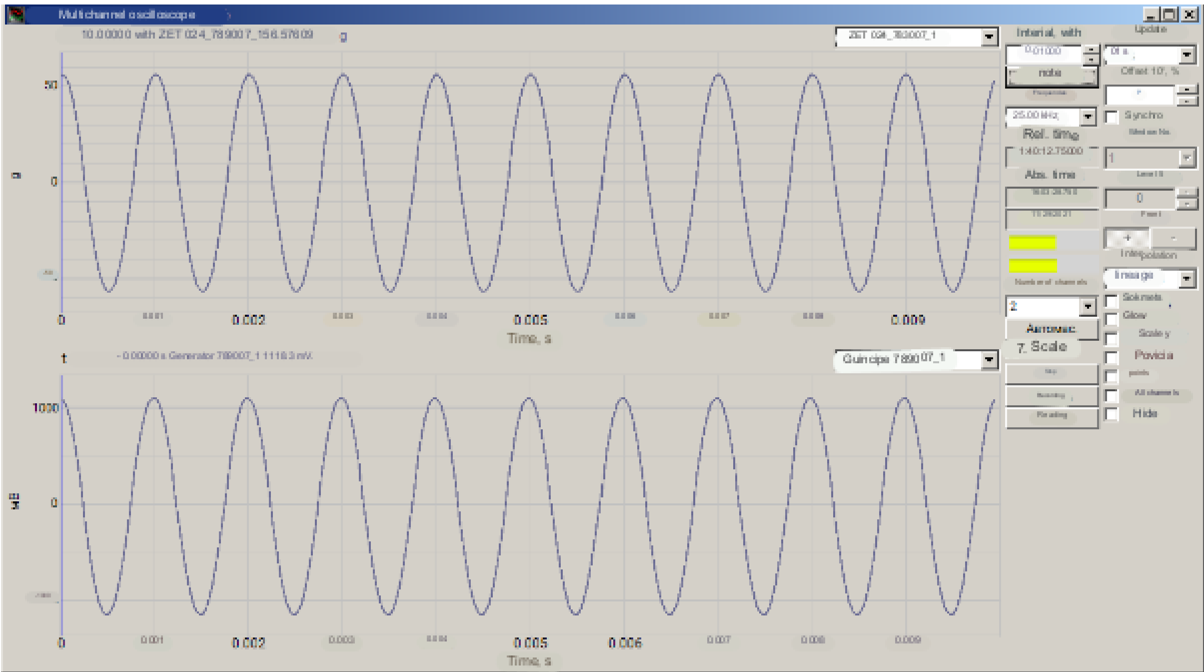

Signals generator
Select signals
Sine
RF
Noise
LinFM
LogFM
Imp
File
Sine2
AM
FM
Serrate
Input
Barker
LinAM
LogAM
Correction
Frequency response correction
D:\ZETData\results\reverce.dtx
...
Target channel: ZET 024_789007_1
Channel frequency: 25000 Hz
Filter size: 25000
Frequency response file specified
Channel number
Add
Turn on
Level indicator
Output 1
Add
Turned on


Signal generator
Signal selection
Sinus
R/imp
Noise
Sine2
barker
Lynam
Logam
Correction
Frequency response correction -
D:\ZETData\results\reverce.dtx
...
Target channel: ZET 024_789007_1
Channel frequency: 25000 Hz
Filter size: 25000
Frequency response file loaded
Channel number
Add
Level indicator
Generator 1
Put away
Included


Signal generator
Signal selection
AM
Saw
barker
LinAM
LogAM
Correction
Sinus
R/imp
Noise
LFM
imp
File
Sinus 2
- Parameters of a sinusoidal signal
frequency Hz
Level, d
Displacement, d
001000.000
0001.0
0000.0
Channel number
Add
Level indicator
Generator 1
Put away
Included

Check the readings with a voltmeter. Run the Multi-channel oscilloscope software to check the signal form.





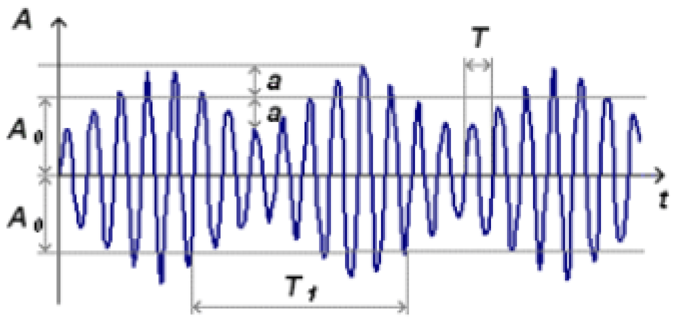
Amplitude-modulated signal generator (LinAM) .....

Amplitude-modulated signal is represented by a signal with oscillation amplitude fluctuations exceeding those of the oscillations.

The level of amplitude-modulated signal is calculated by the formula:

$$A=(A_0+a\sin\omega_1 t)\sin\omega t$$

Signals generator - Amplitude-modulated signal generator (LinAM) - formula for signal parameters calculation where $A_0=2V_{rms}/\sqrt{2}$ is the signal amplitude, $\omega = 2\pi f$ – signal phase (f – signal frequency, which is related to its period (T) as $f=1/T$), $\omega_1 = 2\pi f_1$ – signal phase (f_1 – signal frequency, which is related to its period (T_1) as $f_1=1/T_1$), t – current time, a – modulation amplitude.



Signals generator - Amplitude-modulated signal generator (LinAM) - formula for signal parameters calculation

In order to produce amplitude-modulated signal, enter the tab **"-AM"** of the "**Signals generator**" program – you will see the control elements used for configuration of **amplitude-modulated signal** parameters:

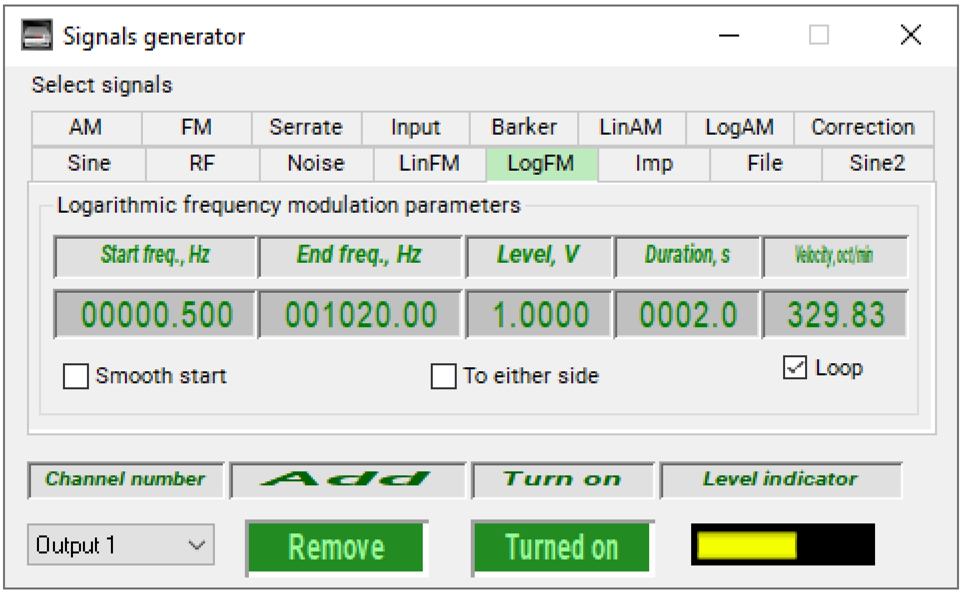
· **Carrier's frequency** – carrier frequency to be used for signal generation. It is related to the period T (see the Fig. above) as $f=1/T$. the filling frequency value is set in Hz.

· **Amplitude** – peak value of the signal to be used for signal generation. The amplitude is set in Volts. In the Fig. above, the amplitude is specified as A_0.

· **Modes frequency** – modulation frequency to be used for signal generation. It is related to the period T_1 (see the Fig. above) as $f_1=1/T_1$. The modes frequency is set in Hz.

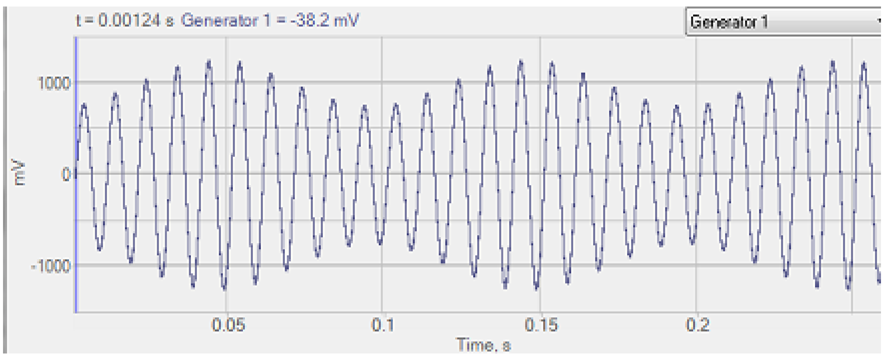
· **Modulation** – modulation depth to be used for signal generation. It is set in percentage rate from the signal amplitude. In the above Fig., the modulation value is specified as a/A_0.

As the required parameters of **AM-signal** are set and generation process is started (the generation process is started with the keys "**Add**" and "**Turne on**"), the program will look as it is shown in the Fig. below.



Signals generator - Amplitude-modulated signal generator (LinAM) - signal parameters

The Fig. below shows a signal form obtained with the use of the program "**Multi-channel oscilloscope**".



Signals generator - Amplitude-modulated signal generator (LinAM) - oscilloscope graphic of the generated signal

Frequency-modulated signal generator (LinFM) .....

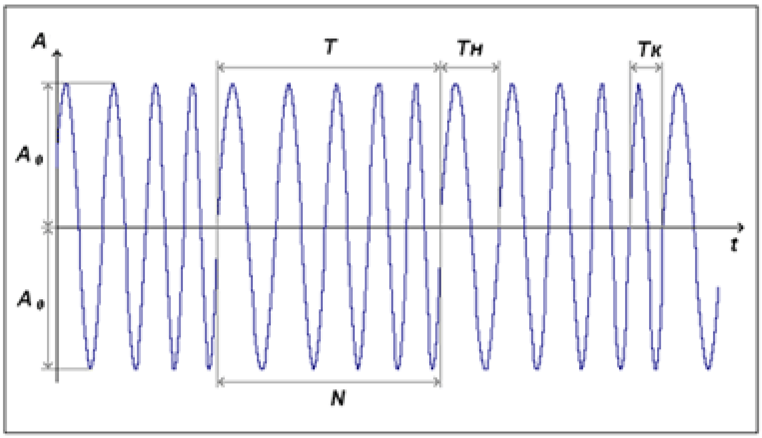
Frequency modulated signal with linear frequency sweep (**LinFM**) is represented by a Sine signal with evenly increasing frequency value.

The **LinFM** is calculated by the formula:

$$A(t) = A_0 \cdot \sin\left(\omega t + \frac{\mu t^2}{2} + \varphi_0\right)$$

Signals generator - Amplitude-modulated signal generator (LinFM) - formula for signal parameters calculation

, where $A_0=2V_{rms}/\sqrt{2}$ – is the signal amplitude, $\omega = 2\pi f$ – signal phase ($f=1/T$, T – signal period), t – current time, $\mu=\Delta f/T$ – signal dynamics rate, φ_0 – initial phase of the signal.



Signals generator - Amplitude-modulated signal generator (LinFM) - formula for signal parameters calculation

In order to generate **LinFM** signal with pre-set parameters, enter the tab **LinFM** of the "**Signals generator**" program – you will see the elements to be used for setting the **LinFM** signal parameters:

· **Start frequency, Hz** – the initial frequency of the frequency range used for generation of **LinFM** signal. It is correlated to the period "*Tn*" in the Fig. as $fn = 1/Tn$. The initial frequency value is set in Hz.

· **End frequency, Hz** – the end frequency of the frequency range used for generation of **LinFM** signal. It is correlated to the period "T_k" in Fig. 1 as $f_k = 1/T_k$. The end frequency value is set in Hz.

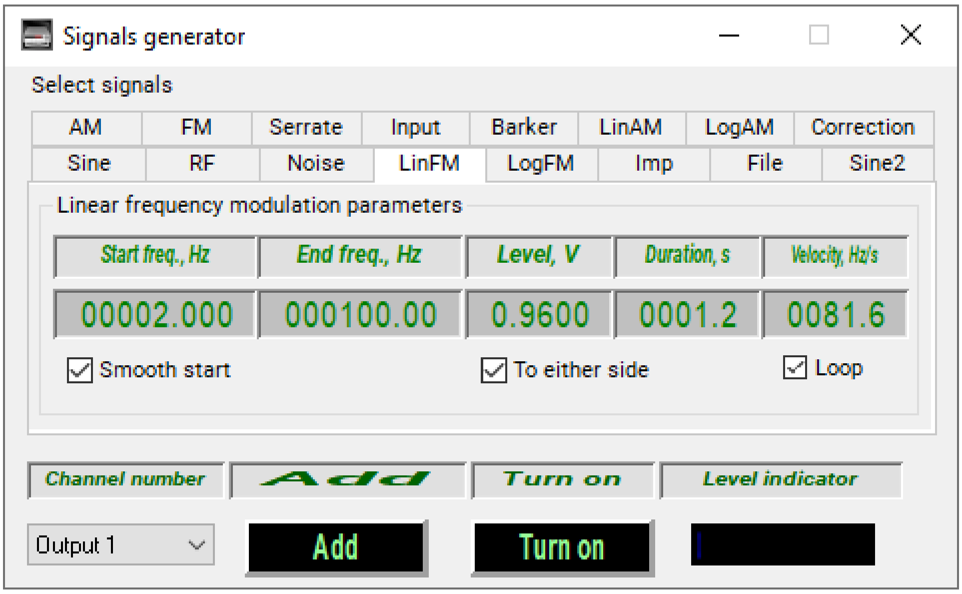
· **Level, V** – the root-mean-square value (RMS) of the level to be used for **LinFM** signal generation. The level value is set in Volts. Please, note, that in this parameter there is used the RMS value. The peak value ("A_0" in the Fig.) is correlated to the RMS value.

· **Duration, s** – duration of the cycle used for **LinFM** signal generation. The duration is set in seconds. In the Fig., the cycle duration is specified as "*T*".

· **Velocity, Hz/s** – frequency dynamics in relation to Hz/s to be used for **LinFM** signal generation. It is calculated automatically based on the values of duration, start frequency and end frequency.

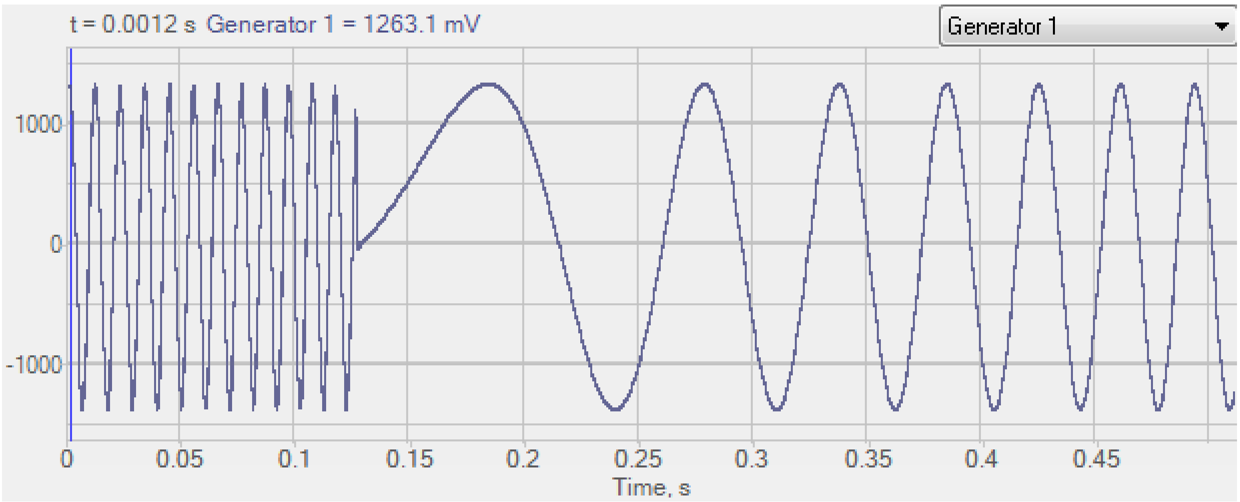
· **Loop** – the checkbox allows to set single or multiple repletion of the cycle.

As the necessary parameters of **LinFM** signal are set and the signal generation process is started (to start the generation process, use the keys "**Add**" and "**Turn on**"), the program interface will look as follows:



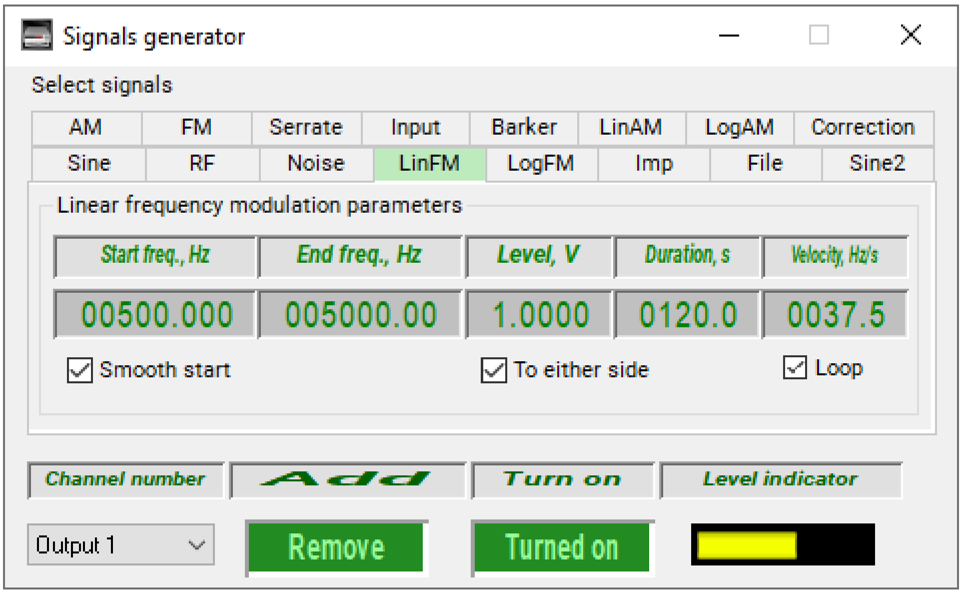
Signals generator - LinFM - parameters configuration

Form of the signal with pre-set parameters:

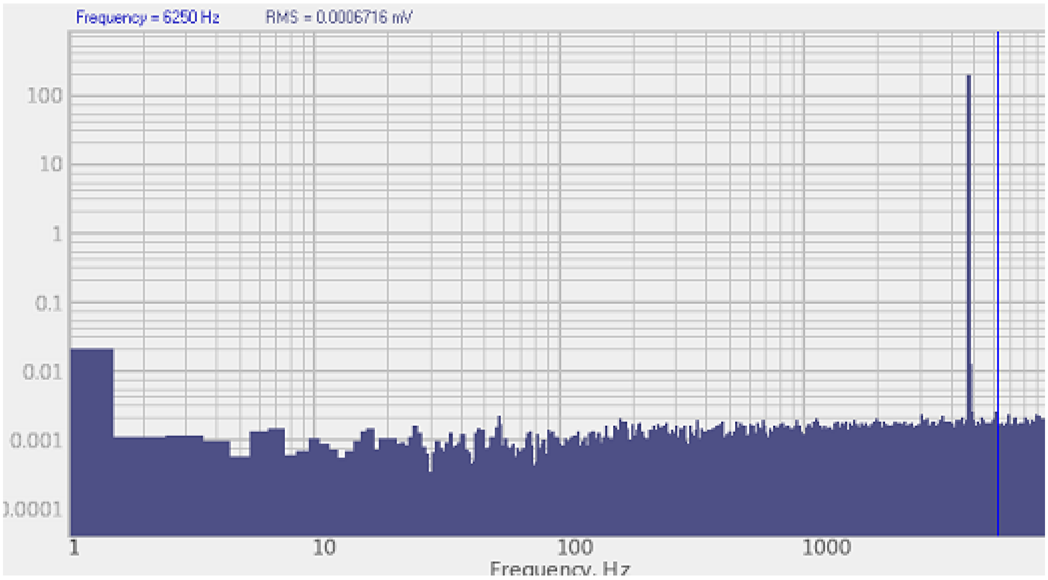


Signals generator - LinFM - oscilloscope graphic of the generated signal

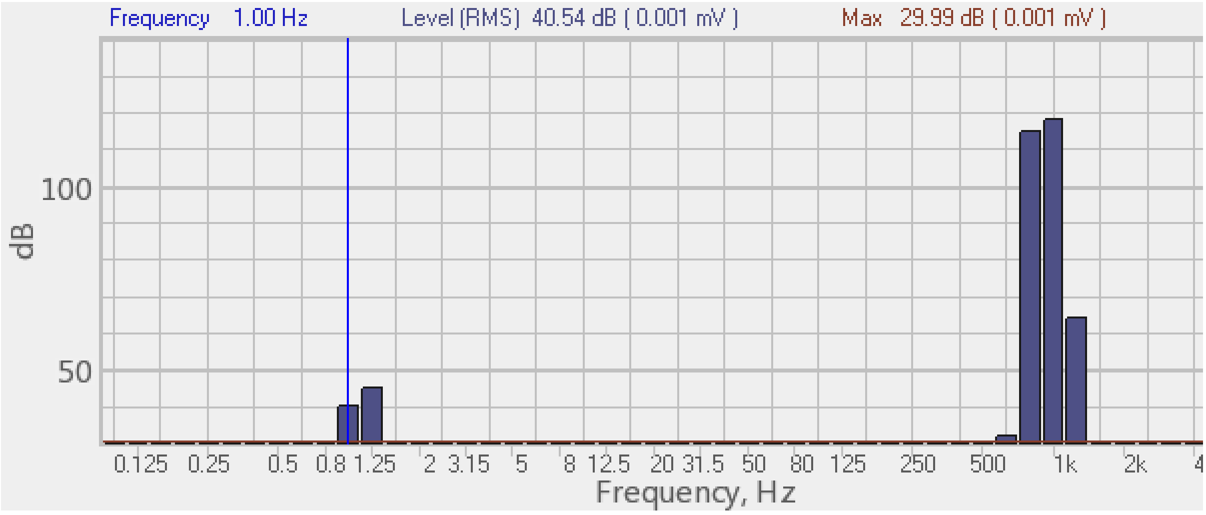
The Fig.s below show *narrow-band* and 1/3-*octave spectra* with maximal accumulated values in the set frequency range of the **LinFM** signal:



Signals generator - LinFM - generated signal parameters



Signals generator - LinFM - FFT Spectrum Analysis of the generated signal



Signals generator - LinFM - Spectrum CPB analysis (Constant Percentage Bandwidth) Analysis

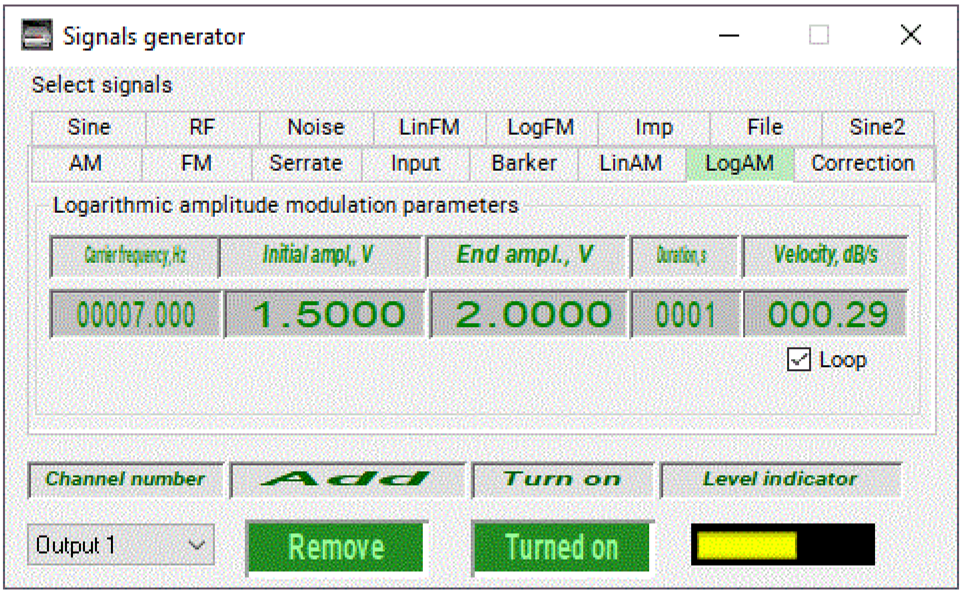
Amplitude-modulated signal generator (LogAM) .....

An amplitude-modulated signal with a logarithmic frequency sweep (**LogAM**) is a sinusoid with a frequency that varies according to a logarithmic law.

To generate **LogAM** with the given parameters, it is necessary to go to the tab - **LogAM** in the **Signals generator** program, after which the elements for setting the LogAM parameters will be displayed in the program window:

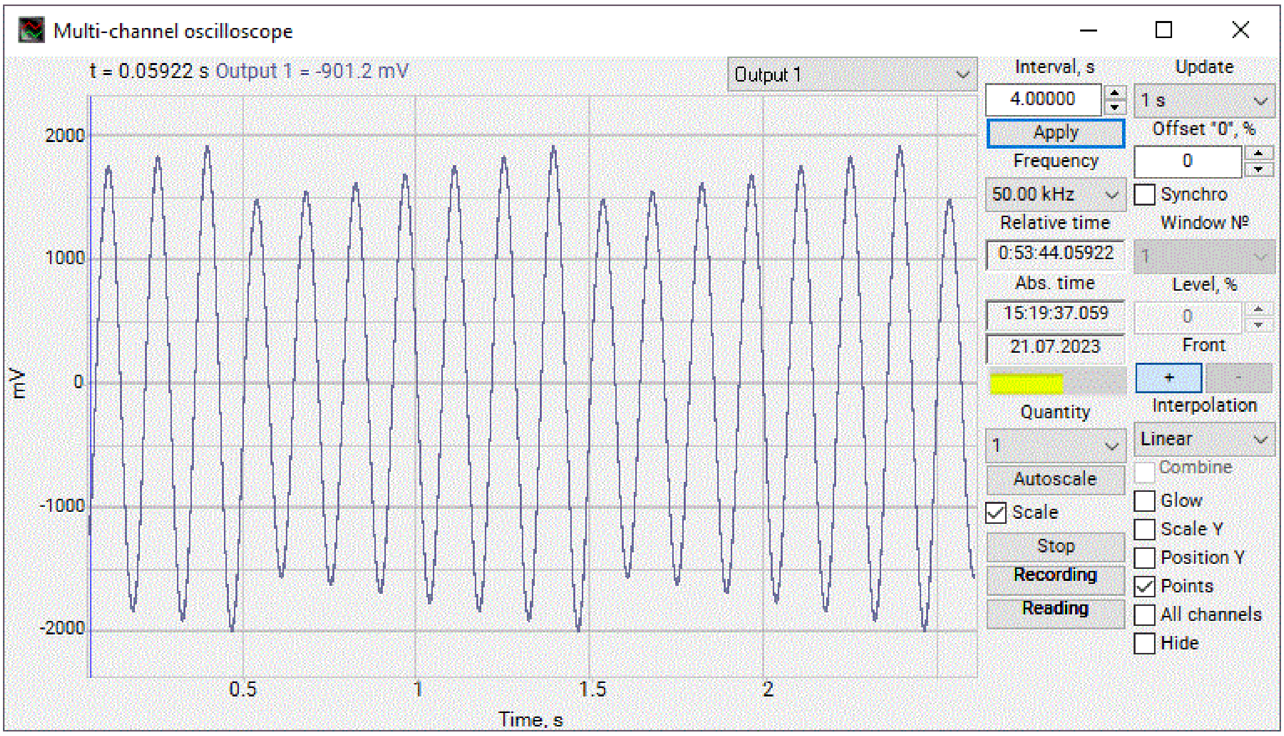
- **Carrier frequency, Hz** – carrier frequency in which **LogAM** will be generated. The carrier frequency is specified in hertz.
- **Start amplitude**S, **V** - start level with which the signal will be generated. Specified in volts.
- **End amplitude, V** - end level with which the signal will be generated. Specified in volts.
- ·**Duration, s** – duration of the cycle used for **LogFM** signal generation. The duration is set in seconds. In the Fig., the cycle duration is specified as "*T*".
- **Velocity, dB/s** – frequency dynamics in relation to dB/s to be used for **LogFM** signal generation. It is calculated automatically based on the values of duration, start amplitude and end amplitude.
- **Loop** – the checkbox allows to set single or multiple repletion of the cycle.

After setting the necessary parameters of the **LogFM** signal and starting generation (generation starts after successively pressing the ***Add*** signal button and the ***Turne on*** all signals button), the program window will look like the one shown in the figure below.



Signals generator - LogFM - parameters configuration

Form of the signal with Generation parameters:



Signals generator - Amplitude-modulated signal generator (LogAM) - oscilloscope graphic of the generated signal

Frequency-modulated signal generator (LogFM) .....

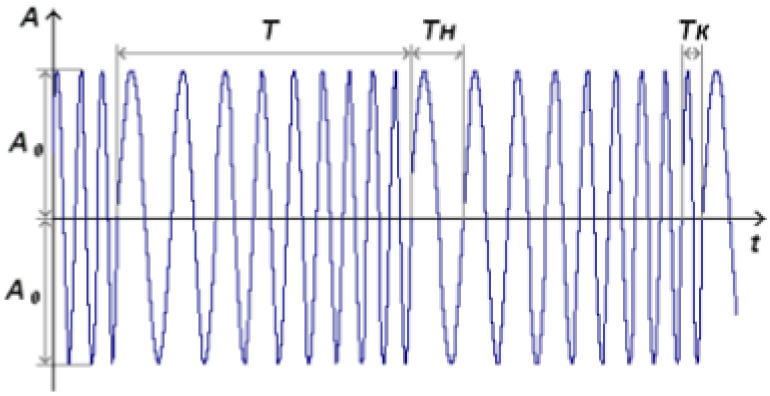
Frequency-modulated signal with logarithmic frequency sweep (**LogFM**) is represented by a Sine signal with frequency changing in accordance with the logarithmic law.

LogFM is calculated with the use of the formula:

$$A = A_0 \cdot \sin\left(\frac{\omega \cdot T}{\ln\left(\frac{f_k}{f_0}\right)} \cdot \left(\frac{f_k}{f_0}\right)^{t/T} + \varphi_0\right)$$

Signals generator - Amplitude-modulated signal generator (LogFM) - formula for signal parameters calculation

Where: $A_0=2V_{rms}/\sqrt{2}$ – the signal amplitude, $\omega = 2\pi f$ – signal phase ($f=1/T$), T – time of frequency change, f_0 – start frequency of the signal, f_k – end frequency of the signal, t – current time, φ_0 – initial phase of the signal.



Signals generator - Amplitude-modulated signal generator (LogFM) - formula for signal parameters calculation

In order to produce **LogFM** signal with pre-set parameters, enter the "**LogFM**" tab of the program containing the control elements for **LogFM** signal parameters configuration:

· **Start frequency, Hz** – start frequency of the frequency range to be used for **LogFM** signal generation. It is related to the period *Tn* in the following way: $fn = 1/Tn$. The initial frequency value is set in Hz.

· **End frequency, Hz** – the end frequency of the frequency range to be used for **LogFM** signal generation. This value is related to the period Tk in the following way: $fk = 1/Tk$. The end frequency is set in Hz.

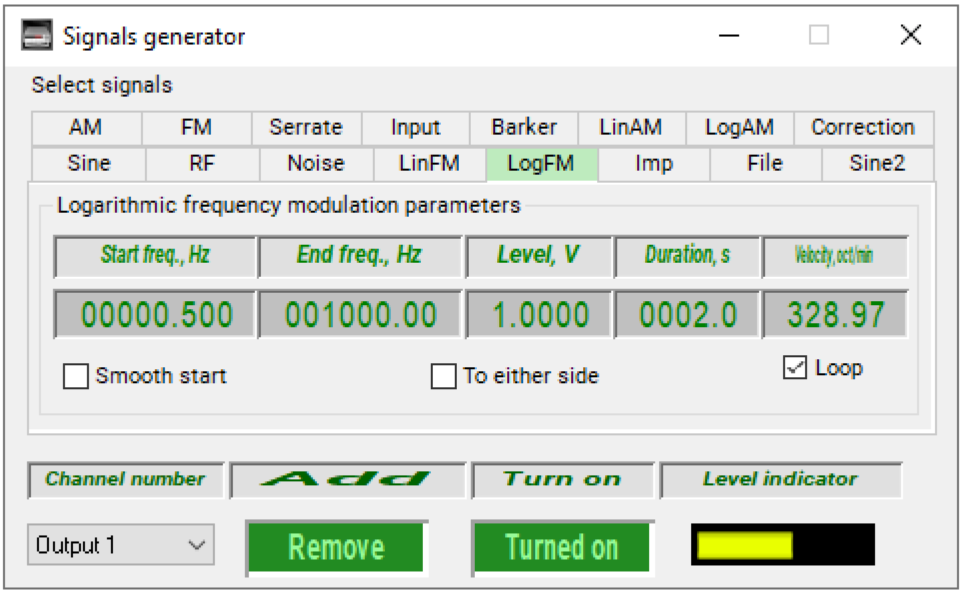
· **Level, V** – root-mean-square value of the level to be used for **LogFM** signal generation. The level is set in Volts. Please, note, that in this case there is used the RMS value. The peak value (shown in the Fig. as A_0) is related to the RMS value as: $A_0 = RMS * \sqrt{2}$.

· **Duration, s** – duration of **LogFM** generation cycle. The duration is set in seconds. The cycle duration is specified in the Fig. as *T*.

· **Velocity, octave/min** – the velocity of frequency change in relation to octaves per minute to be used for **LogFM** signal generation. This value is calculated automatically based on the values of duration, start and end frequencies.

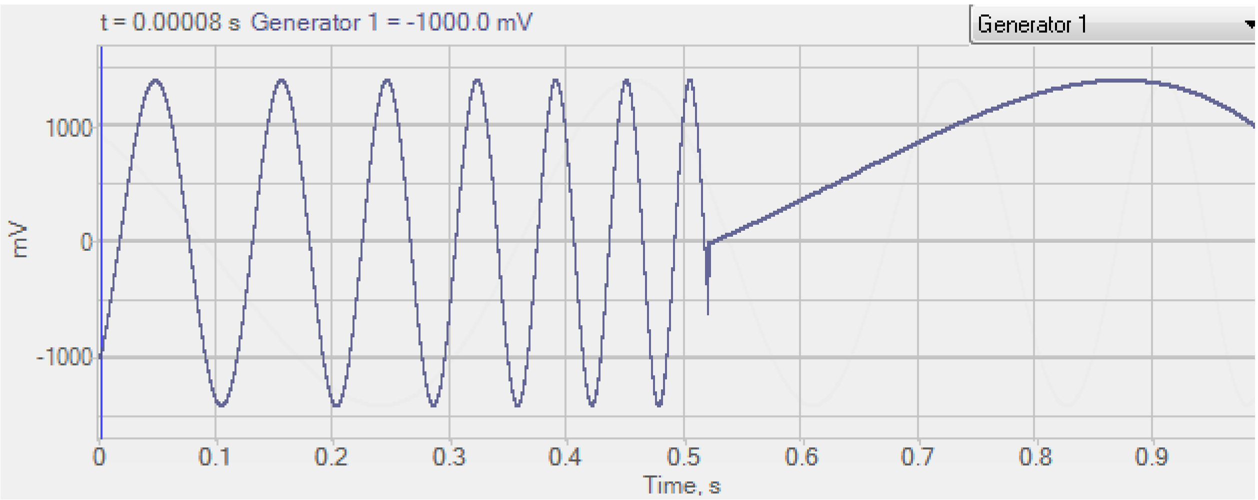
· **Loop** – the checkbox allowing to set single or multiple Play recorded signals of the cycle.

As the necessary **LogFM** signal parameters are set and the signal generation process is started (generation starts after successively pressing the Add Signal button and the Turne on All Signals button), the program interface will look as it is shown in the Fig. below:



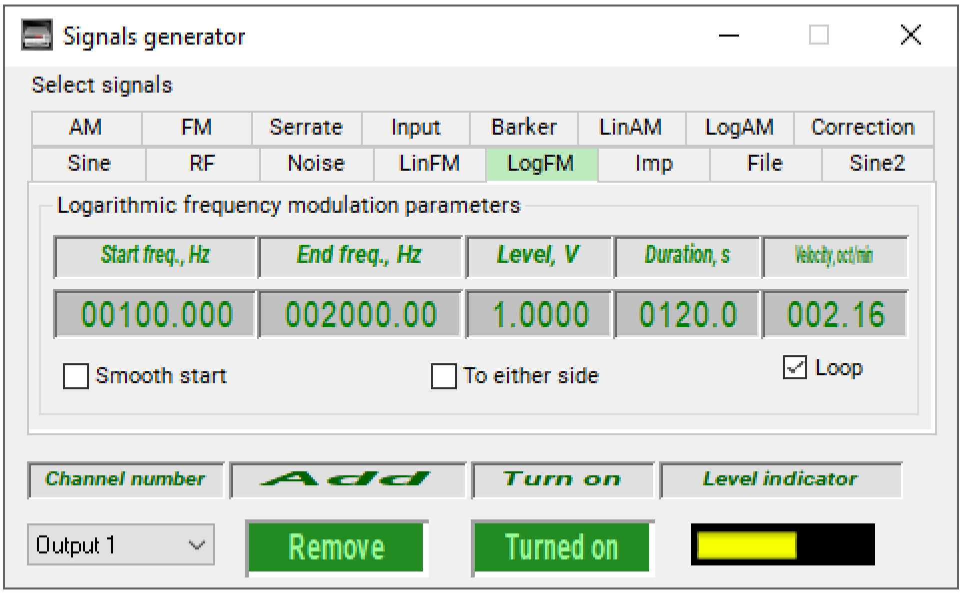
Signals generator - Amplitude-modulated signal generator (LogFM) - Generation parameters

Form of the signal with Generation parameters:

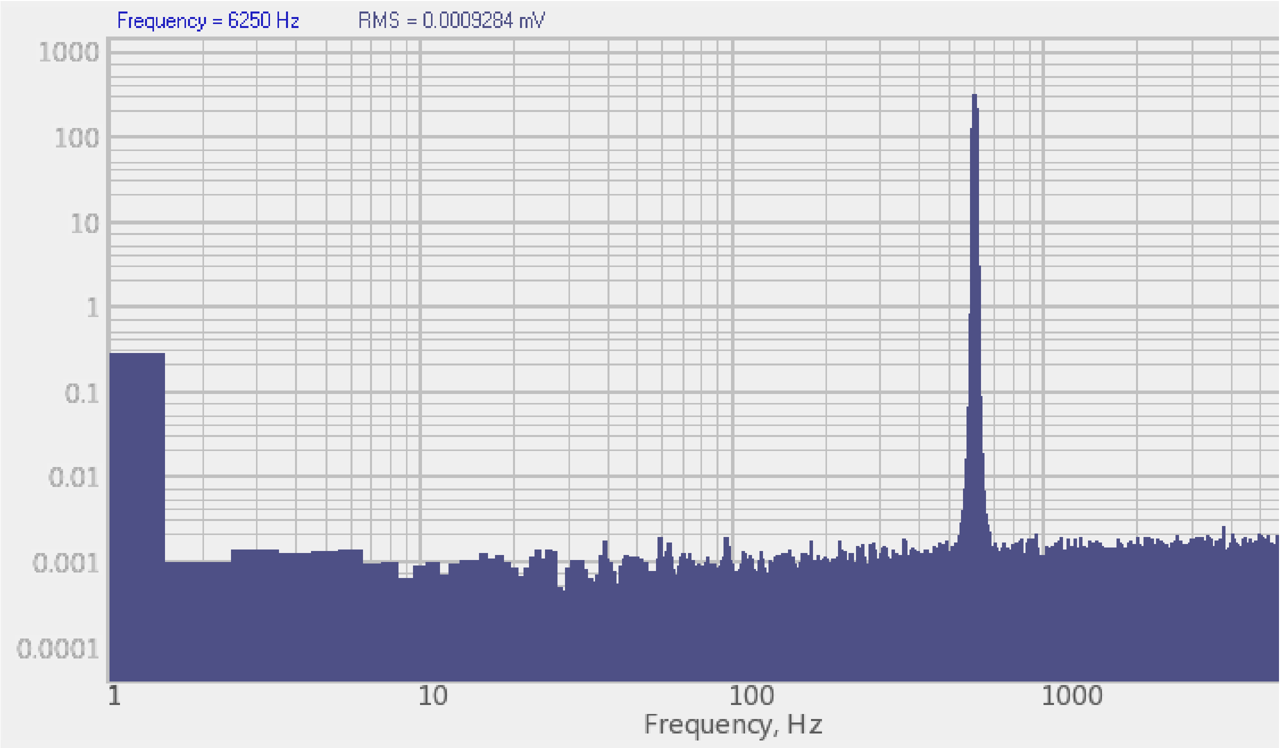


Signals generator - LogFM - oscilloscope graphic of the signal

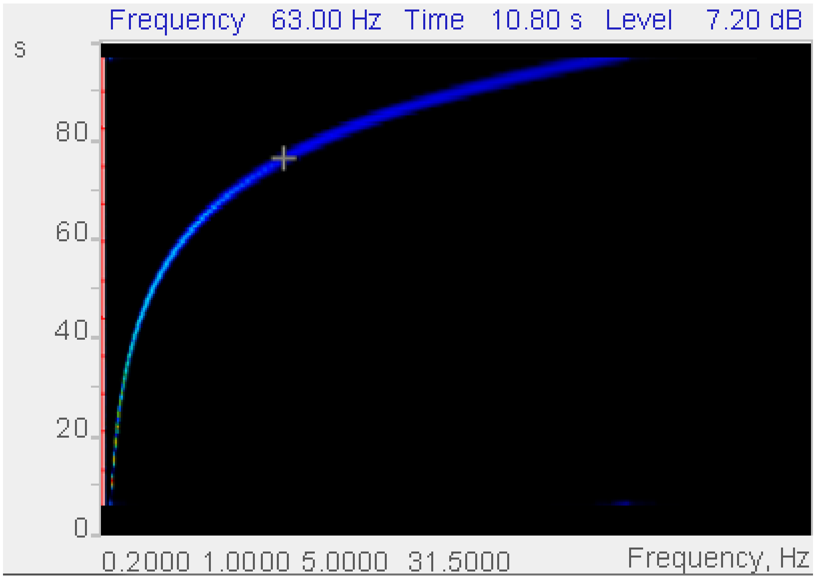
The Fig.s below show *Spectrum CPB analysis (Constant Percentage Bandwidth) Analysis*, *spectral graphic* and *1/3-Octave Band Spectrum* with the maximal accumulated values for the set frequency range of **LogFM** signal:



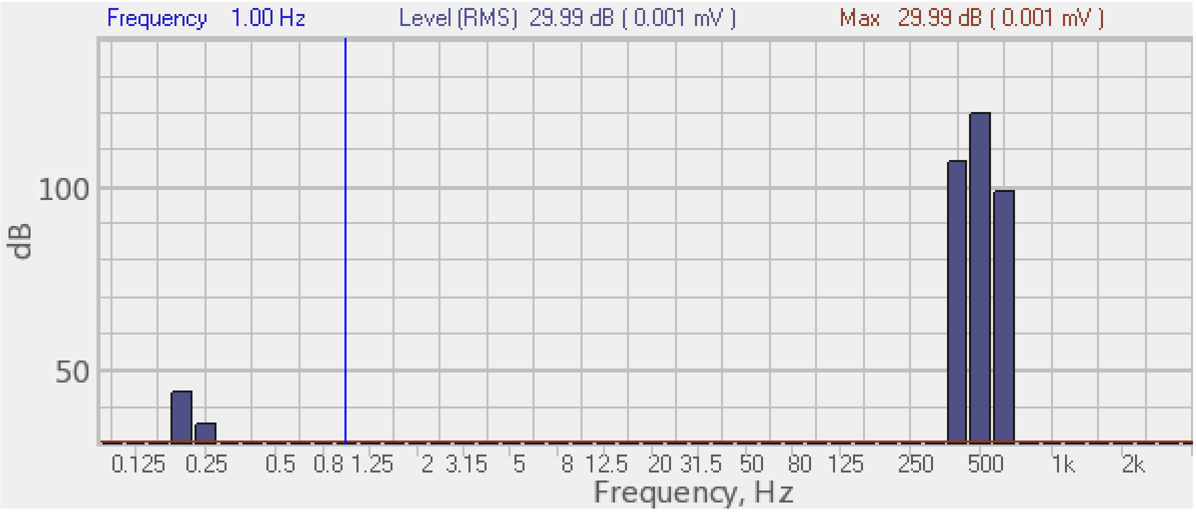
Signals generator - LogFM - parameters of the generated signal



Signals generator - LogFM - FFT Spectrum Analysis of the generated signal



Signals generator - LogFM - spectral graphic of the generated signal



Signals generator - LogFM - Spectrum CPB analysis (Constant Percentage Bandwidth) Analysis of the generated signal

Serrated signal .....

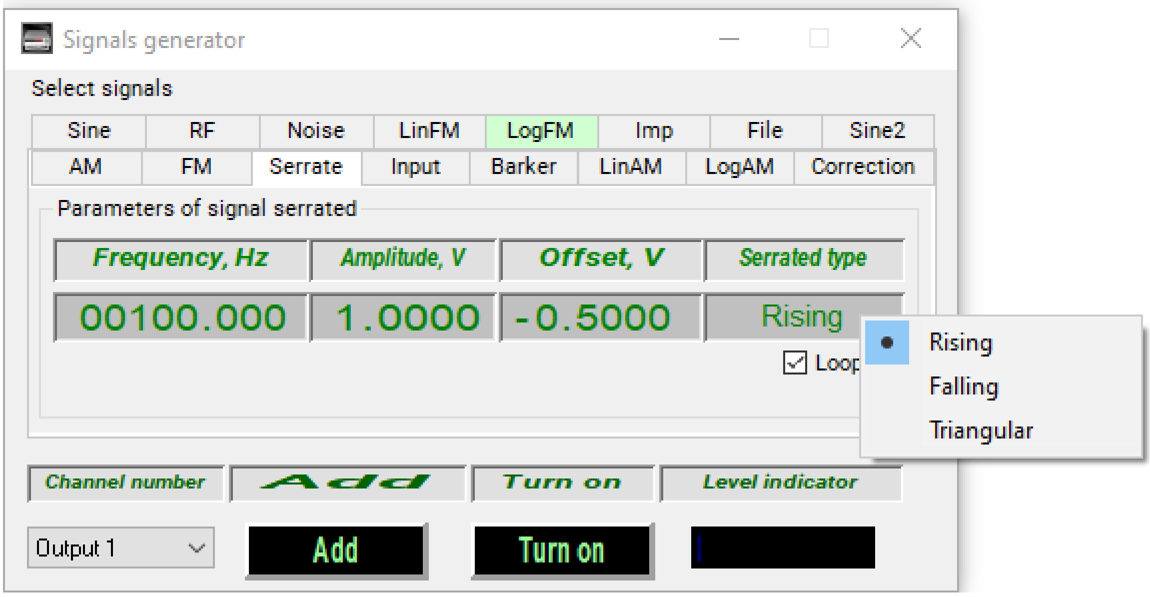
To produce serrate signal, enter the tab "**Serrated**" of the "**Signals generator**" program – you will see the control elements to be used for configuration of the serrate signal parameters:

· **Frequency, Hz** – frequency of the generated signal. Signal frequency *f* is related to its period *T* as *f=1/T*.

· **Amplitude, V** – the level to be used for signal generation. The level value is set in Volts.

· **Offset, V** – DC offset value to be used for signal generation. The offset value is set in Volts.

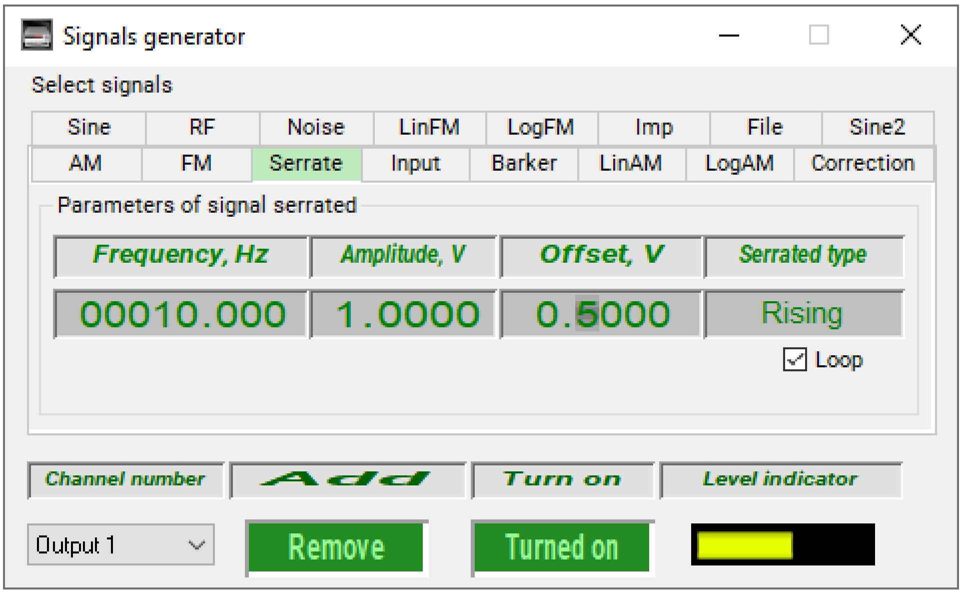
· **Serrated type** – *growing, downward,* or *triangular*. Right-click the corresponding section to activate the drop-down menu for wave type selection.



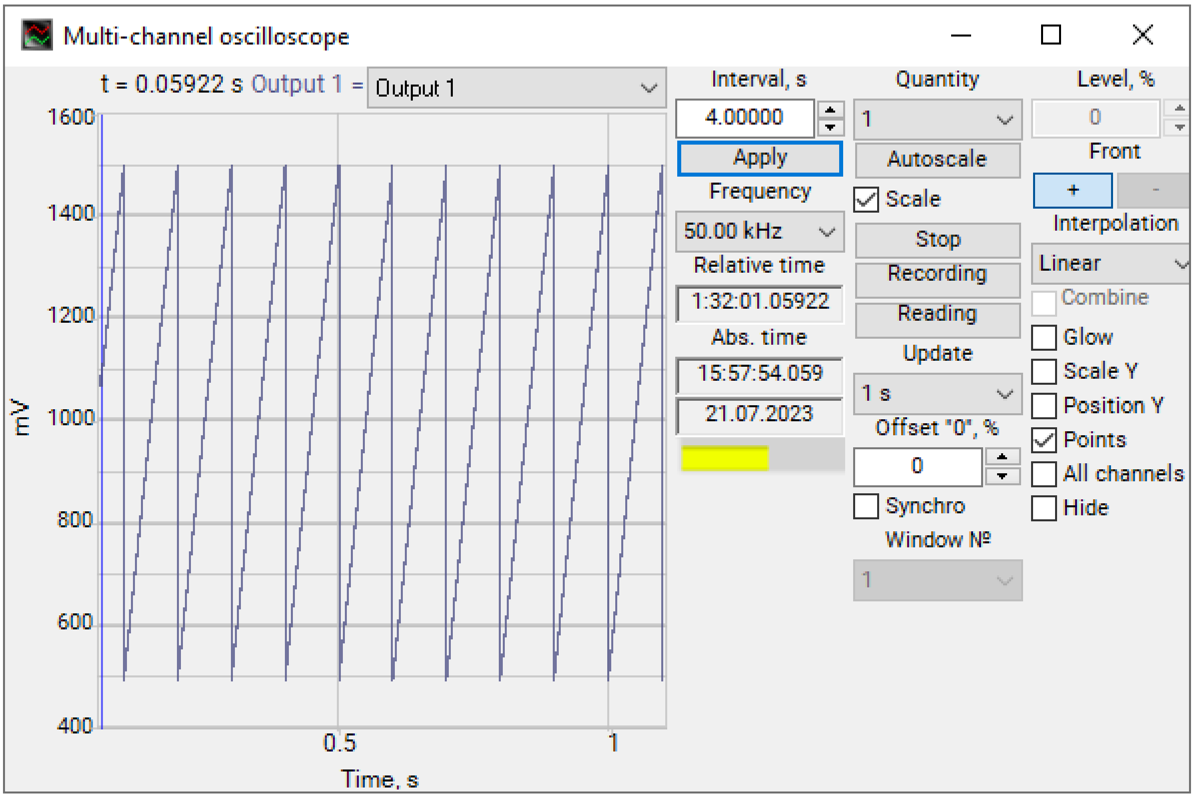
Signals generator - Serrated signal - Generation parameters

The keys "**Add**" and "**Turn on**" are used to start the signal generation process.

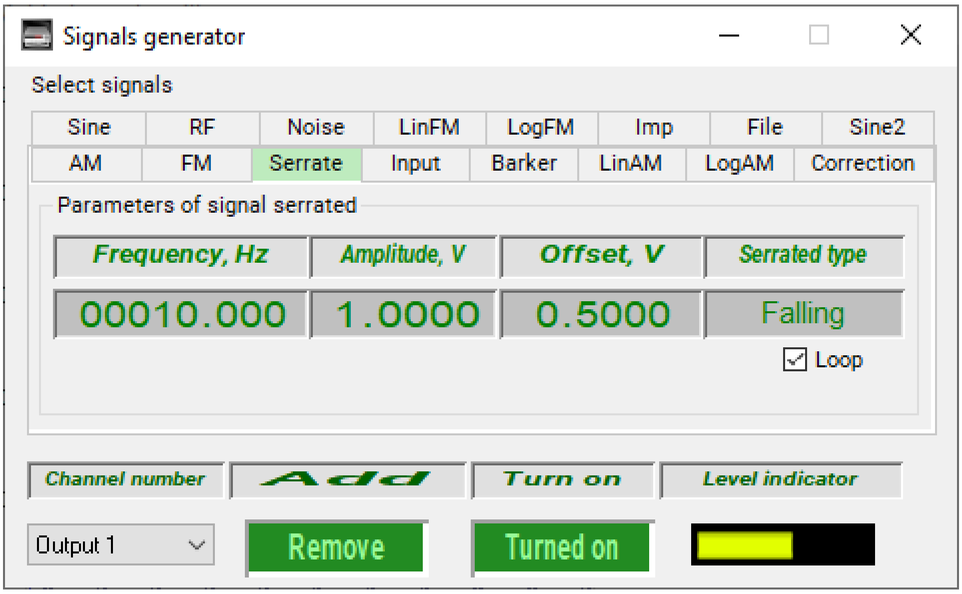
The Fig.s below show signal parameters and corresponding signal forms for triangular, growing and downwards signals.



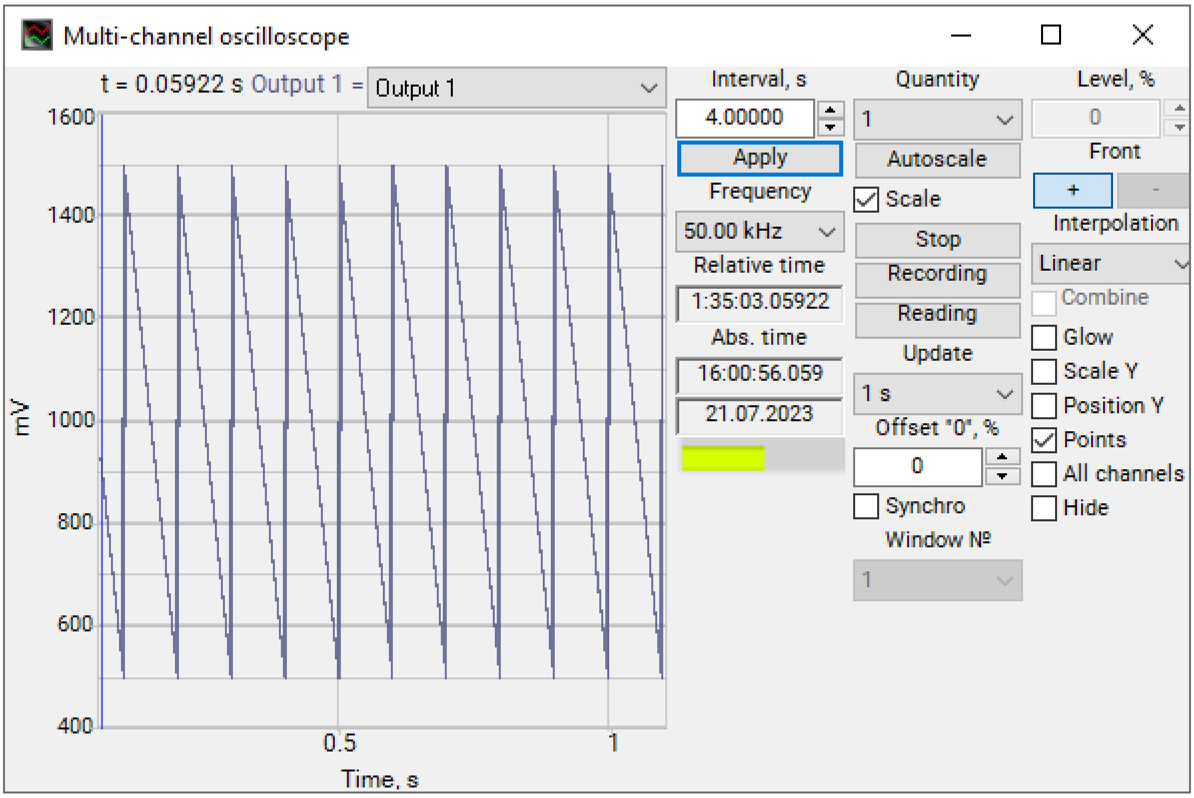
Signals generator - Serrated signal - Rising



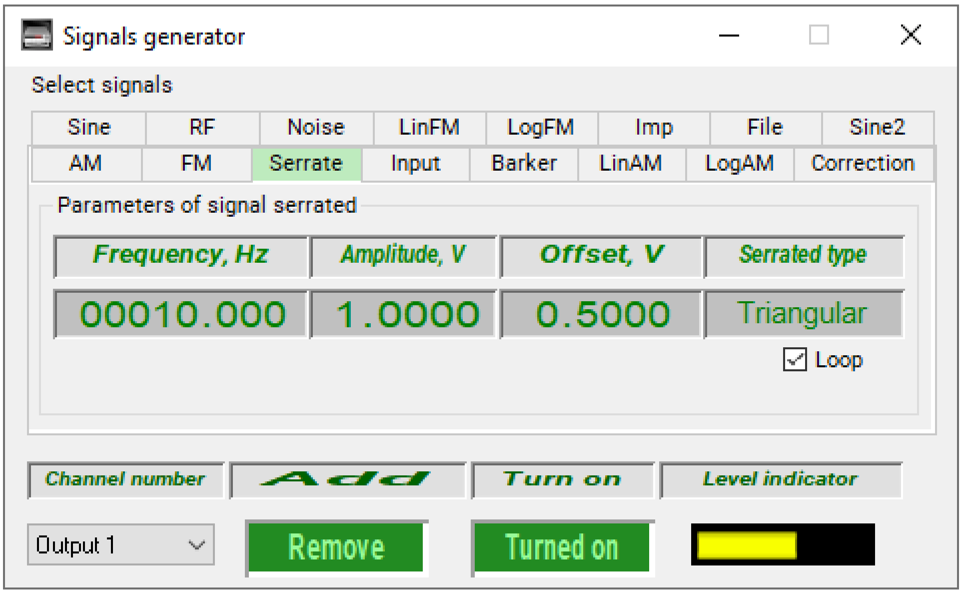
Signals generator - Serrated signal - oscilloscope graphic of the generated signal



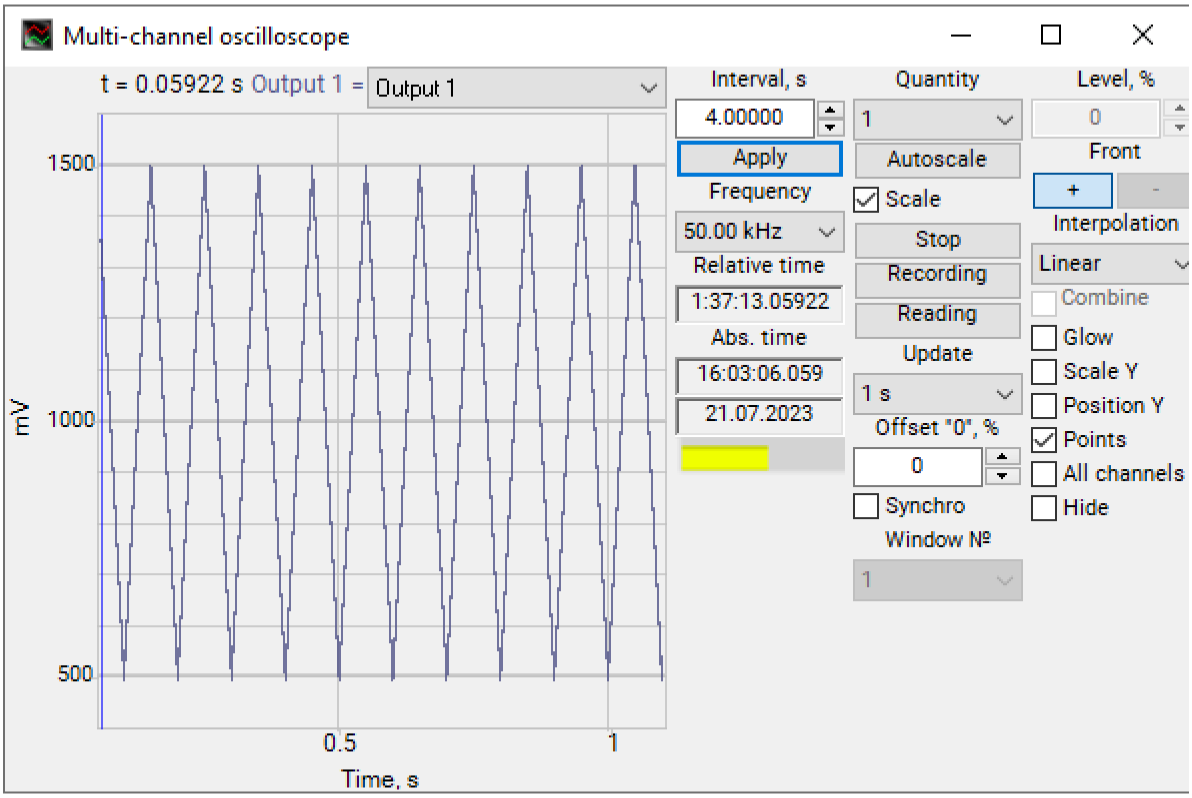
Signals generator - Serrated signal - Falling



Signals generator - Serrated signal - oscilloscope graphic of the generated signal



Signals generator - Serrated signal - Triangular



Signals generator - Serrated signal - oscilloscope graphic of the generated signal

RF impulse signal .....

RF impulse signal is a signal with short-term change of stable status that is characterized by a short time interval if compared to the time characteristics of the stabilized process.

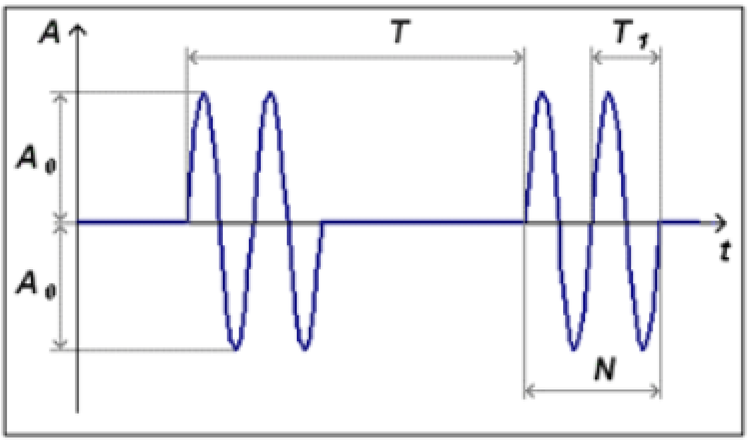
The level of **RF impulse signal** at a particular moment is calculated by the formula:

$$A = \begin{cases} A_0 \sin \omega_1 N t, & \text{if} \quad \omega_1 N t < \omega t \\ 0 & \text{if} \quad \omega_1 N t > \omega t \end{cases}$$

Signals generator - formula for RF impulse level calculation

where: $A_0 = 2V_{rms}/\sqrt{2}$ – signal amplitude,

$\omega = 2\pi f$ – signal phase, f – signal frequency, that is related to its period (T) as $f=1/T$, t – current time, N – duty factor.



Signals generator - RF impulse signal form

In order to generate **RF impulse signal** (intermittent oscillations), enter the tab "**-RF**", you will see the control elements for setting the parameters of **RF impulse signal**:

· **Filling frequency** – also referred to as carrier frequency – the frequency of **RF impulses** generation. The filling frequency is set in Hz. The value of filling frequency is correlated with the signal period (*T1*).

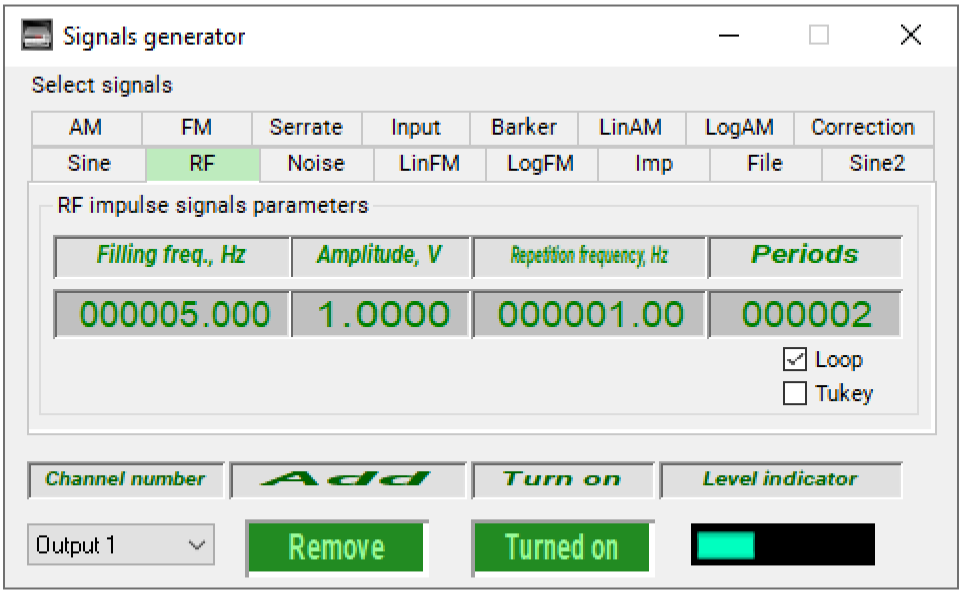
· **Amplitude** – peak value of the signal to be used for **RF** impulse generation. The amplitude value is set in V. In the Fig. above, the amplitude is specified as A_0.

· **Repetition frequency** – frequency of RF impulses generation (modulation frequency). The repetition frequency is set in Hz and has a relation with signal period parameter (*T*).

· **Periods** – bandwidth of signals generation – the number of impulses "*N*" with the duration "T_1" within a single period "*T*".

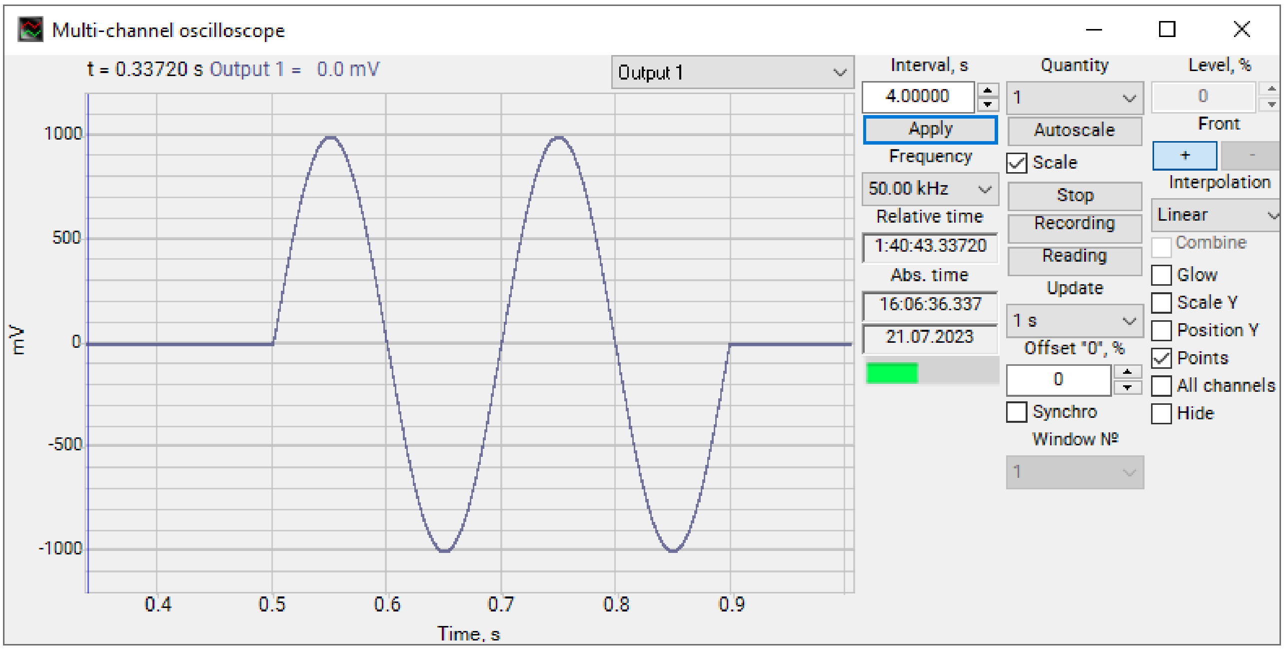
· The checkbox "**Loop**" allows to set single or multiple repetition of the **RF** impulse generation cycle.

As the required parameters of the **RF** impulse are set and signal generation process is started (the signal generation process is started with the keys "**Add**" and "**Enable**"), the program interface will look as follows:



Signals generator - RF impulse signal - signal parameters

The Fig. below shows the form of the signal, obtained with the use of the program "**Multi-channel oscilloscope**".



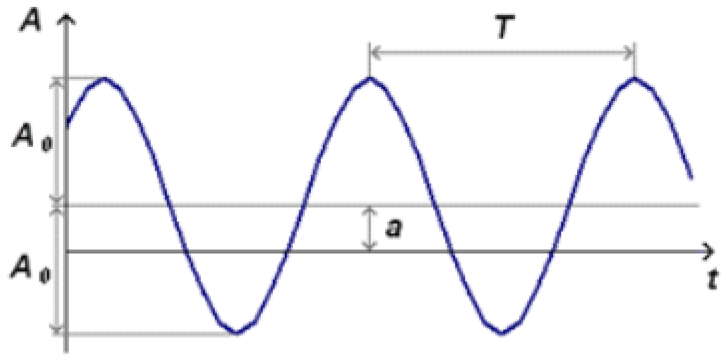
Signals generator - RF impulse signal - oscilloscope graphic of the generated signal

Sine signal .....

Sine wave amplitude is calculated by the formula:

$$A(t) = A_0 \cdot \sin(\omega t + \varphi_0),$$

Where: $A_o=2V_{rms}/\sqrt{2}$ is the amplitude of the signal, $\omega = 2\pi f$ – signal phase ($f=1/T$, T – signal period), t – current time, φ_0 – initial phase of the signal.



Signals generator - Sine signal - formula for signal parameters calculation

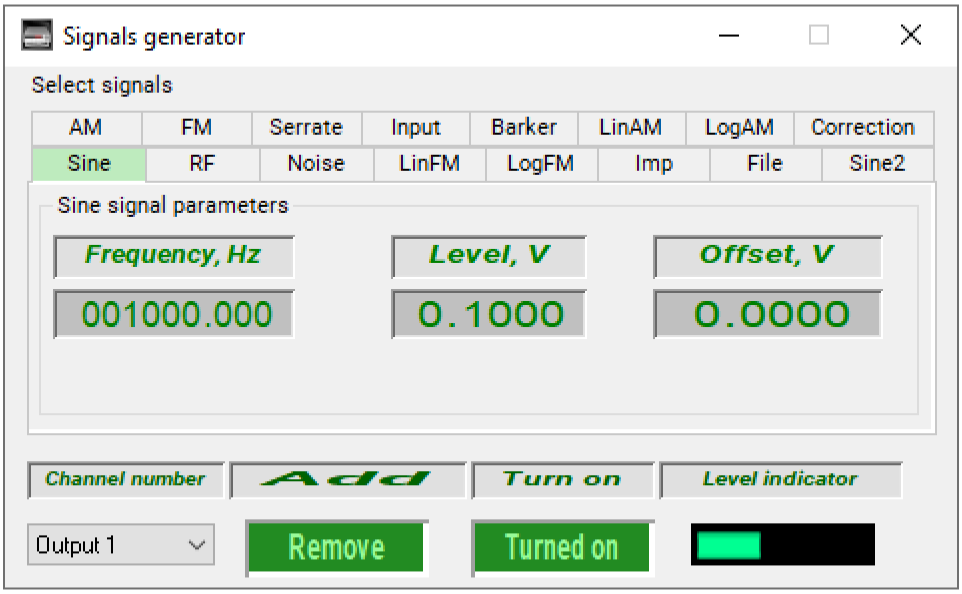
In order to produce sine wave with the set frequency, level and DC offset, enter the tab "-*Sinus*" or "-*Sinus2*". You will see the elements for sine wave parameters configuration:

· **Frequency, Hz** – frequency of generated signal (in Hz). The signal frequency "*f*" is correlated to its period "*T*" (see the above Fig.) in accordance with the formula: $f=1/T$.

· **Level, V** – the root-mean-square value of the generated signal's level (in V). In the above formula, it is specified as A_0.

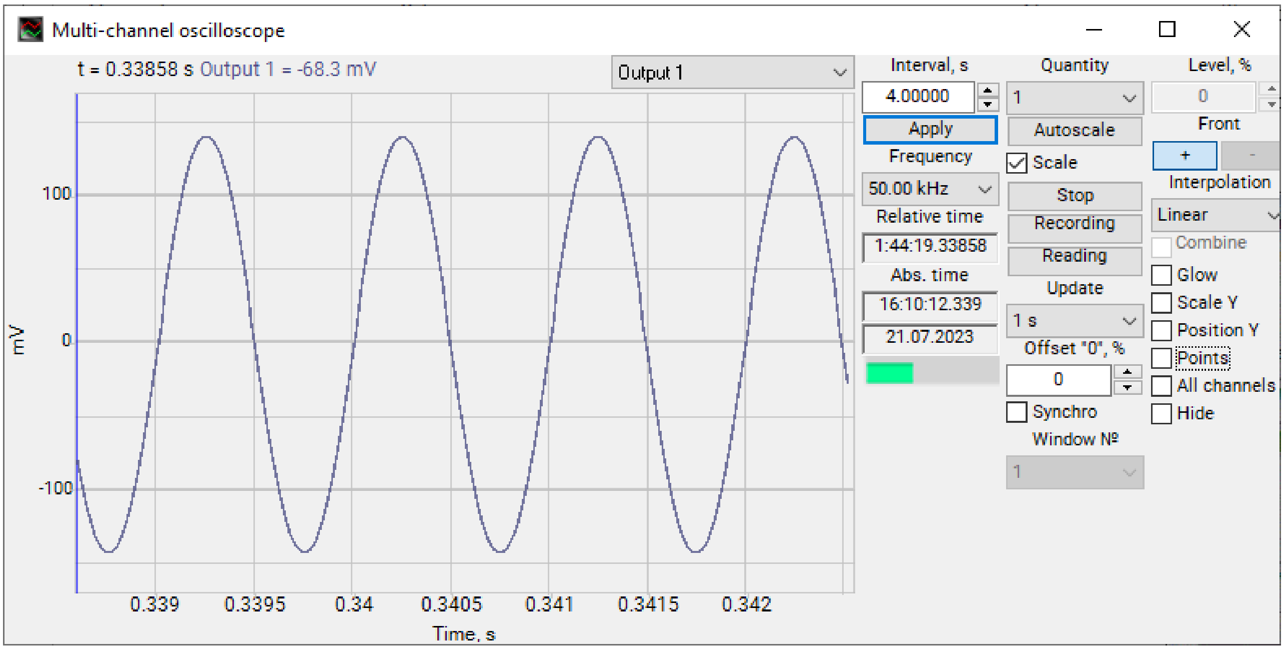
· **Displacement, V** – value of DC offset to be used for generation of the signal (in V) In the above formula it is specified as "*a*".

As the required parameters are set and signal generation is started (the signal generation begins upon activation of the keys "**Add**" and "**Enable**"), the program interface will look as it is shown in the Fig. below:



Signals generator - parameters of sine signal

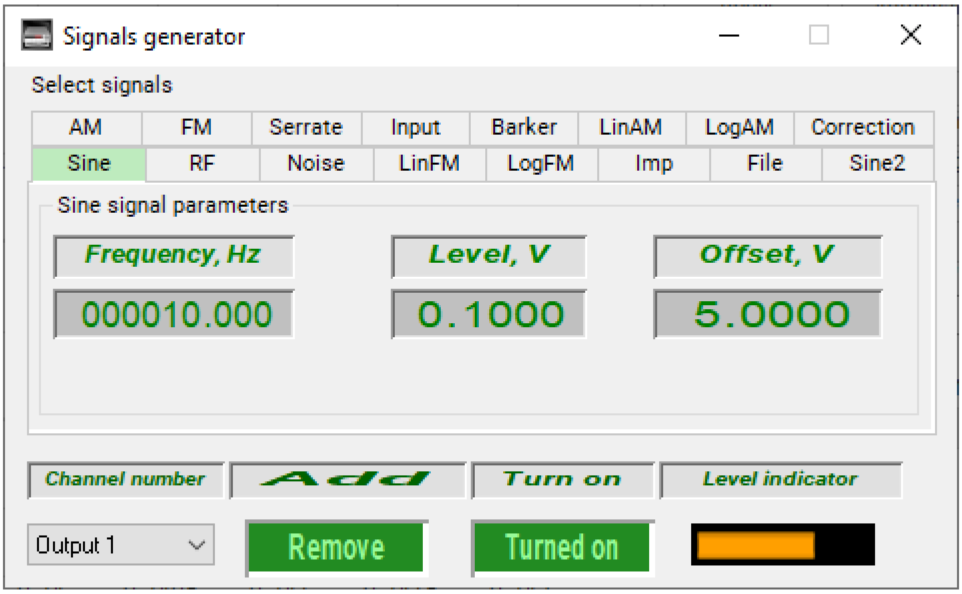
The Fig. below shows the form of the signal obtained with the use of "**Multi-channel oscilloscope**" program.



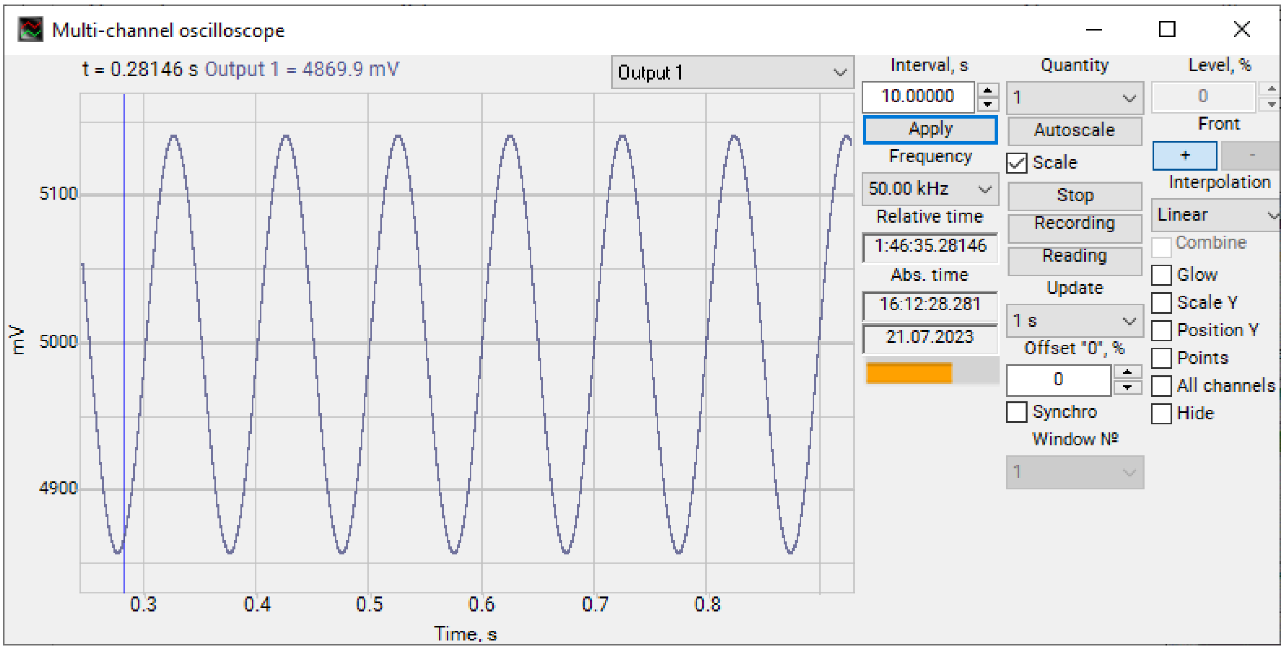
Signals generator - oscilloscope graphic of the generated sinusoidal signal

Please note, that we use the RMS value of the signal as its level. In this case, the maximum amplitude (the peak value) is $RMS * \sqrt{2}$.

If the generator is used for DC power supply of the transducers, it is also possible to use the "**Sinus**" tab. However, in this case, we use the "**Offset, V**" function instead of "**Level**".



Signals generator - parameters of the generated signal



Signals generator - oscilloscope graphic of the generated signal

Frequency-modulated (FM) .....

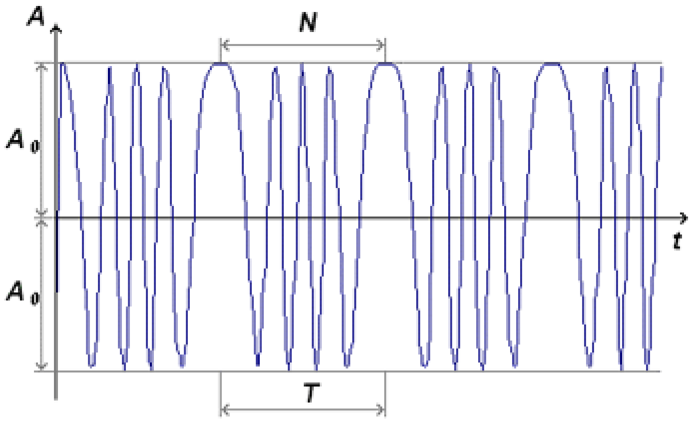
Frequency modulated signal with linear frequency sweep (**FM**) is represented by a Sine signal with evenly increasing frequency value.

The **FM** is calculated by the formula:

$$A=A_0\sin[\omega t+\Delta\omega\sin\omega_1 t+\varphi_0]$$

Signals generator - Frequency-modulated (FM) - formula for signal parameters calculation

where $A_0 = 2V_{rms}/\sqrt{2}$ – is the signal amplitude, $\omega = 2\pi f$ – signal phase (f - signal carrier frequency), $\omega_1 = 2\pi f_1$ – signal phase (f_1 - signal modulation frequency), $\Delta\omega$ – frequency deviation (modulation), t – current time, φ_0 – initial phase of the signal.



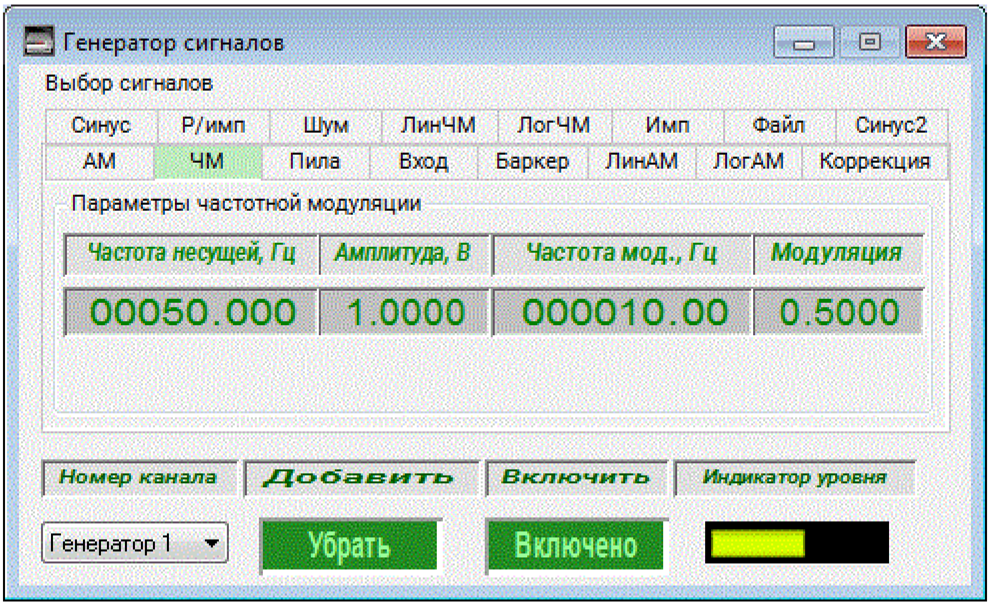
Signals generator - Frequency-modulated (FM) - formula for signal parameters calculation

The number of impulses N in one period T (see figure) is equal to the ratio of the carrier frequency to the modulation frequency.

To generate a frequency-modulated signal, it is necessary to go to the *-FM tab in the* **Signals generator program**, after which the elements for setting the parameters of a frequency-modulated signal will be displayed in the program window:

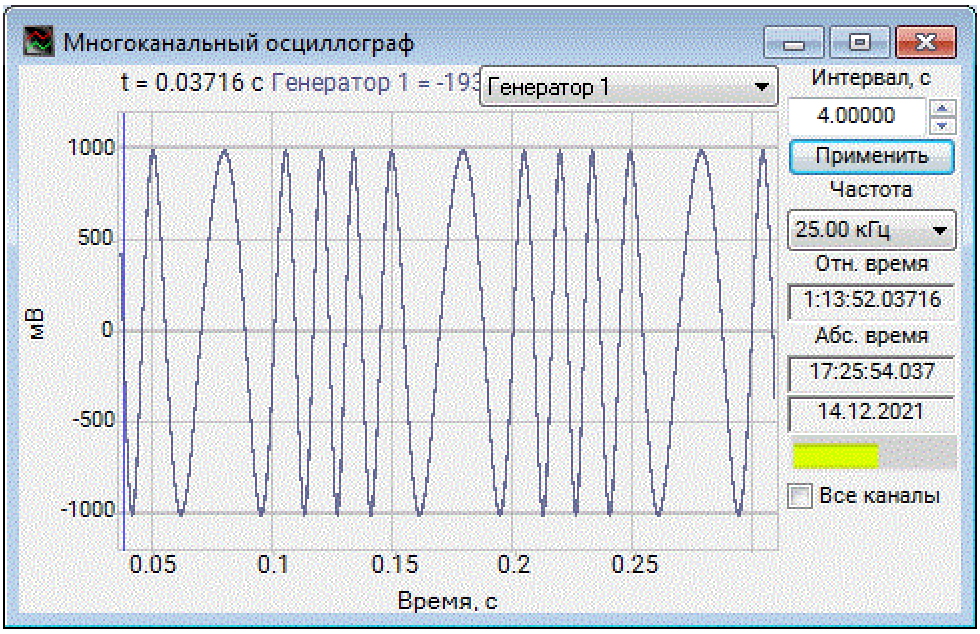
- *Carrier frequency, Hz* – carrier frequency with which the signal will be generated. The duty cycle is specified in hertz (Hz).
- *Amplitude, V* - the peak value of the signal with which the signal will be generated. The amplitude is given in volts (V). In the figure above, the amplitude is labeled A_0.
- *Modulation frequency, Hz* – modulation frequency with which the signal will be generated. The modulation frequency is specified in hertz (Hz).
- *Modulation* - the modulation depth with which the signal will be generated. Specified as a percentage of the signal frequency.

After setting the necessary parameters of the frequency-modulated signal and starting generation (generation starts after successively pressing the *Add* signal button and the *Turne on* all signals button), the program window will look like the one shown in the figure below.



Signals generator - Frequency-modulated (FM) - signal parameters

The Fig. below shows the form of the signal obtained with the use of Multi-channel oscilloscope program.



Signals generator - Frequency-modulated (FM) - oscilloscope graphic of the generated signal

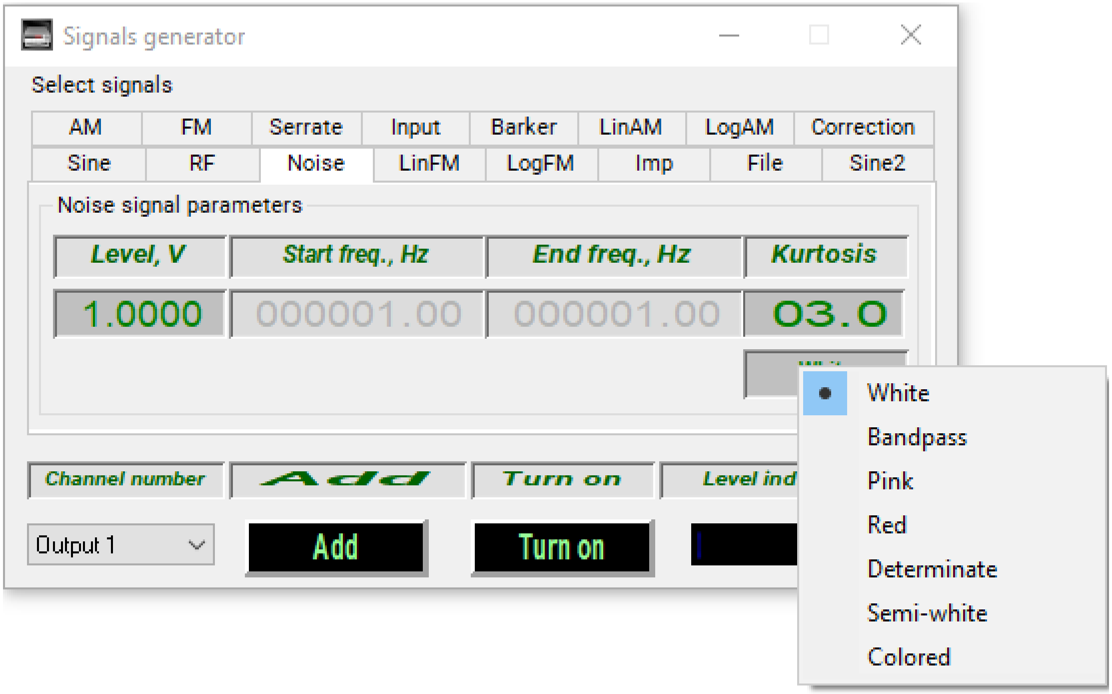
Noise signal .....

The program "**Signals generator**" has 7 available noise types:

- · *White,*
- · *Bandpass,*
- · *Pink,*

- · *Red,*
- · *Determinate,*
- · Semi-*white,*
- · *Colored.*

The noise type is selected from the context menu: right-click the corresponding section and select the required noise type from the drop-down menu.



Signals generator - Noise - Selection of the noise type to be generated

For *band-pass*, *pink* and *deterministic noise* it is necessary to set the frequency range for noise generation. The white noise is generated throughout the complete generator frequency range (which depends on DAC sampling frequency).

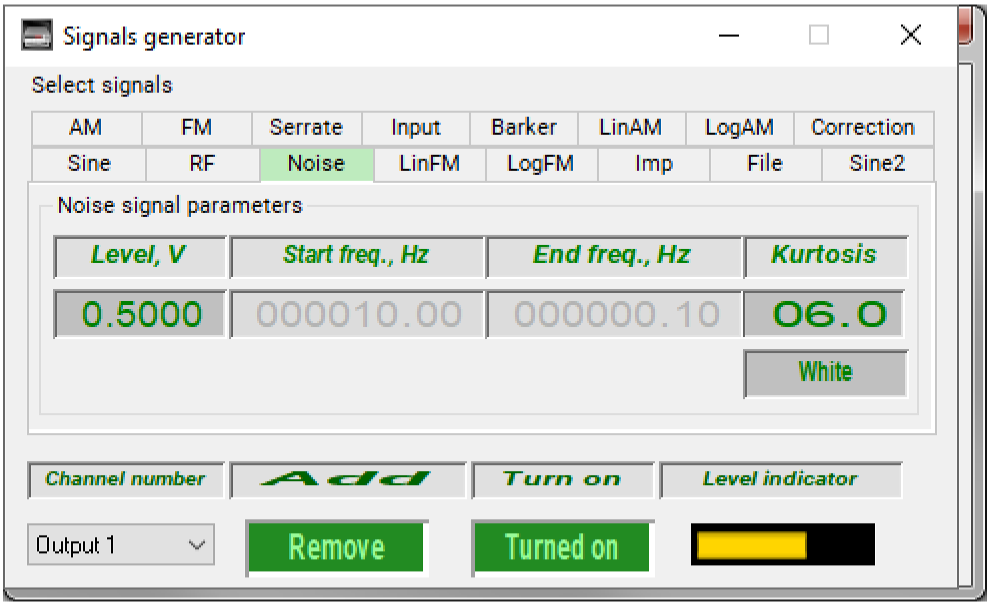
The section "**Level, V**" allows to set the noise level.

White noise – stationary noise with signal components evenly distributed along the frequency range used. The white noise is calculated by the formula:

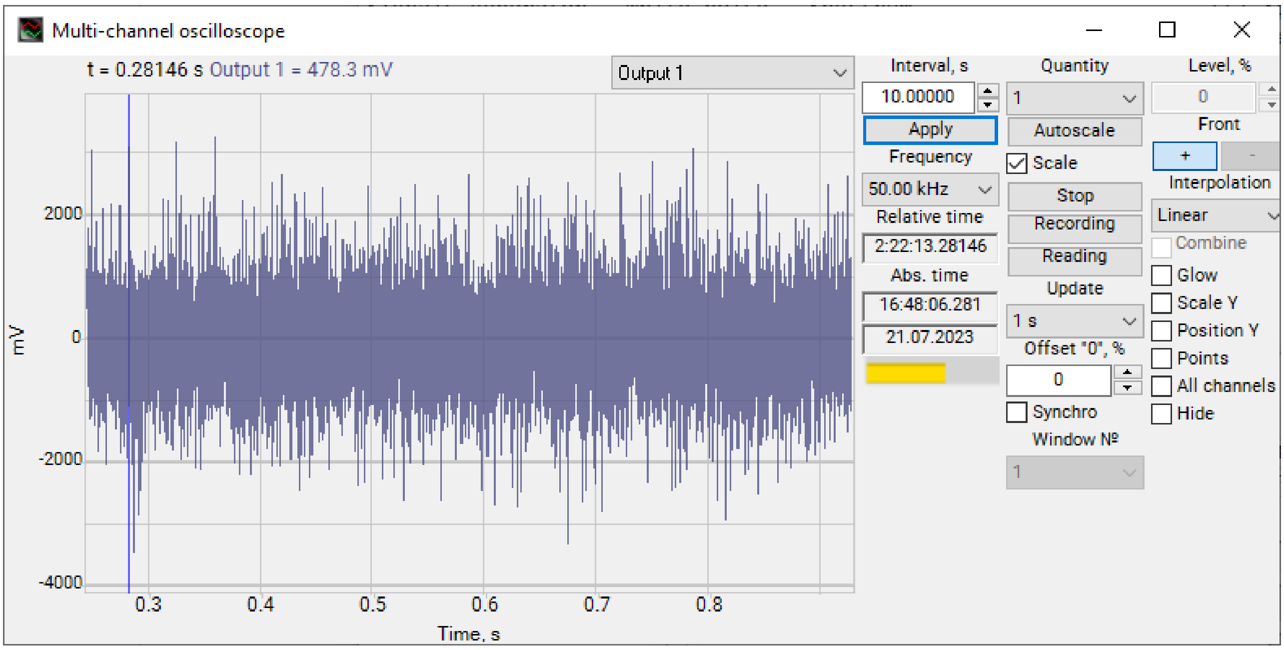
$$A = A_0 \cdot \left(\sum_{1}^{12} rand() - 6 \right),$$

Signals generator - Noise - Formula for white noise parameters calculation

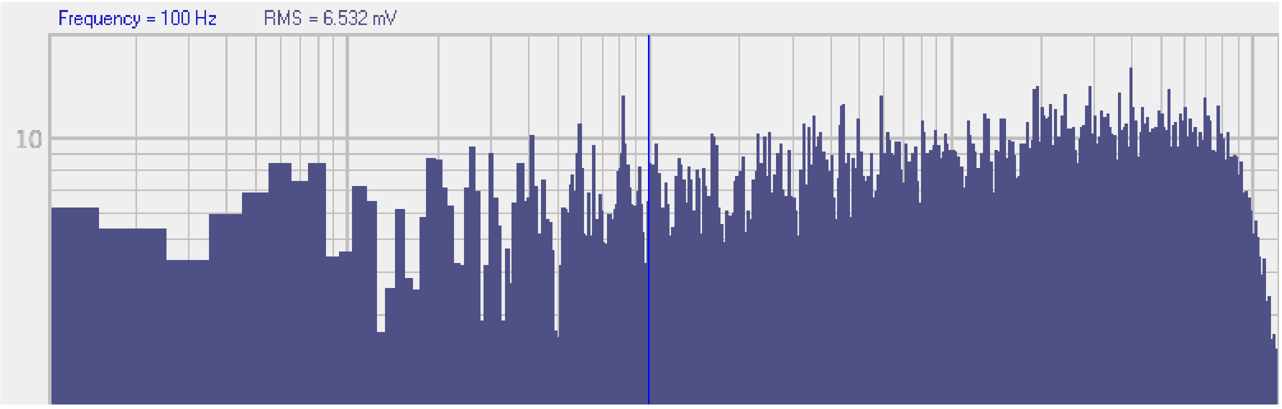
Where: $A_0=2V_{rms}/\sqrt{2}$ – primary amplitude of the signal, *rand()* – function for random number calculation, where $0<rand()<1$.



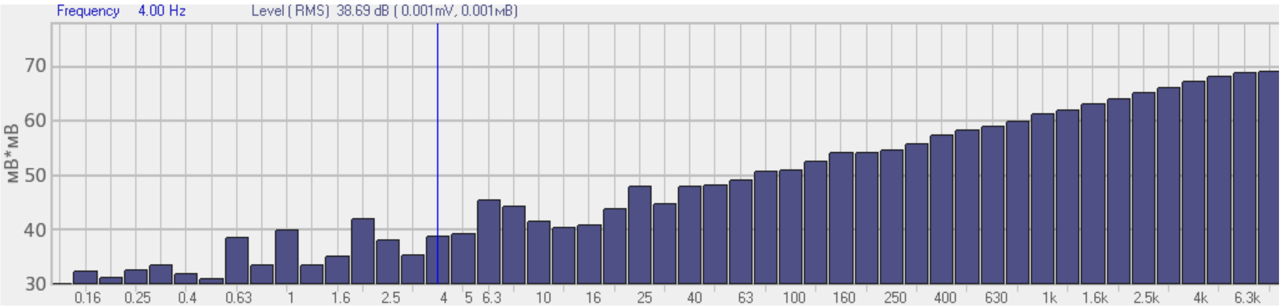
Signals generator - White noise - Generation parameters



Signals generator - White noise - Oscilloscope graphic

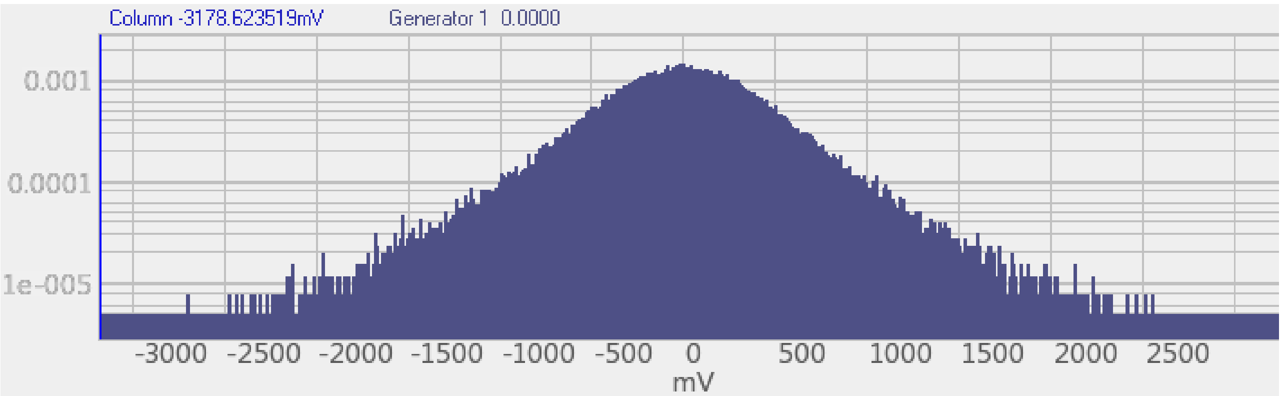


Signals generator - White noise - FFT Spectrum Analysis



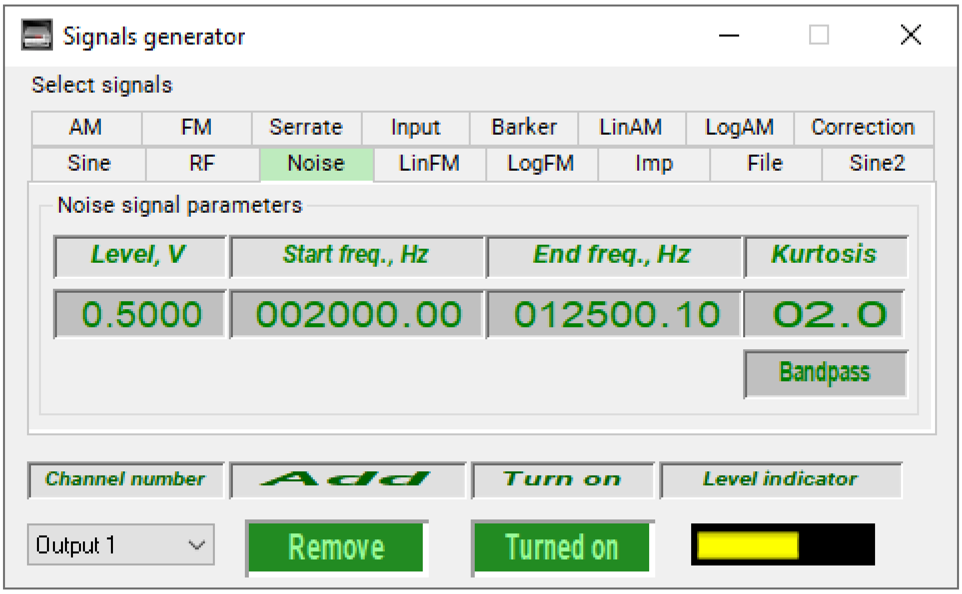
Signals generator - White noise - Spectrum CPB analysis (Constant Percentage Bandwidth) Analysis

Deviation of **white noise** from the normal distribution is <20 %.

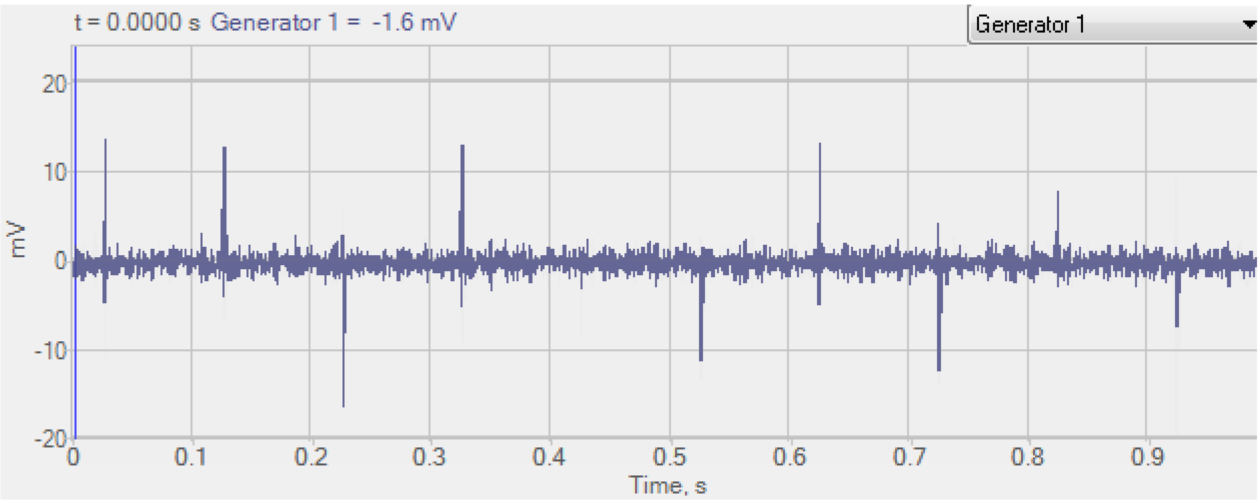


Signals generator - White noise - Histogram

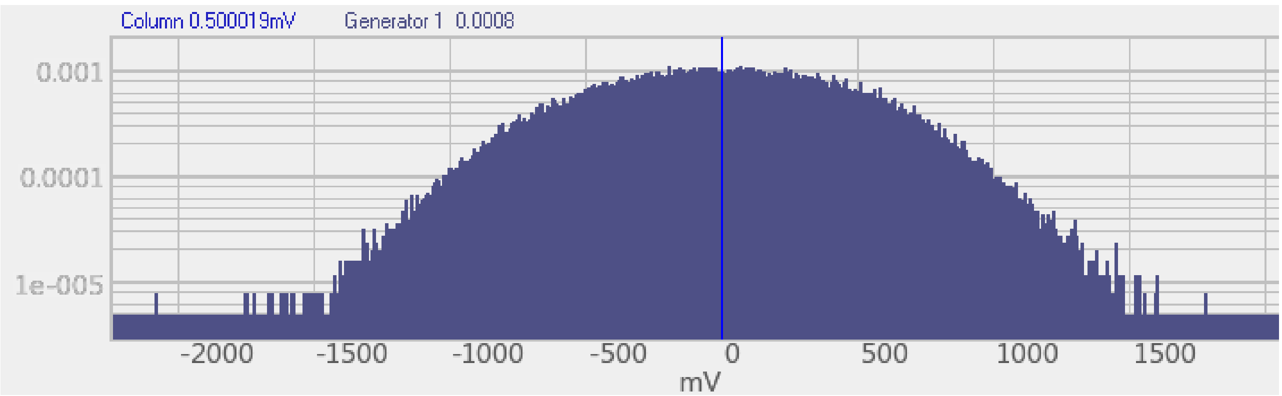
Band-pass noise – is a noise signal with limited frequency range.



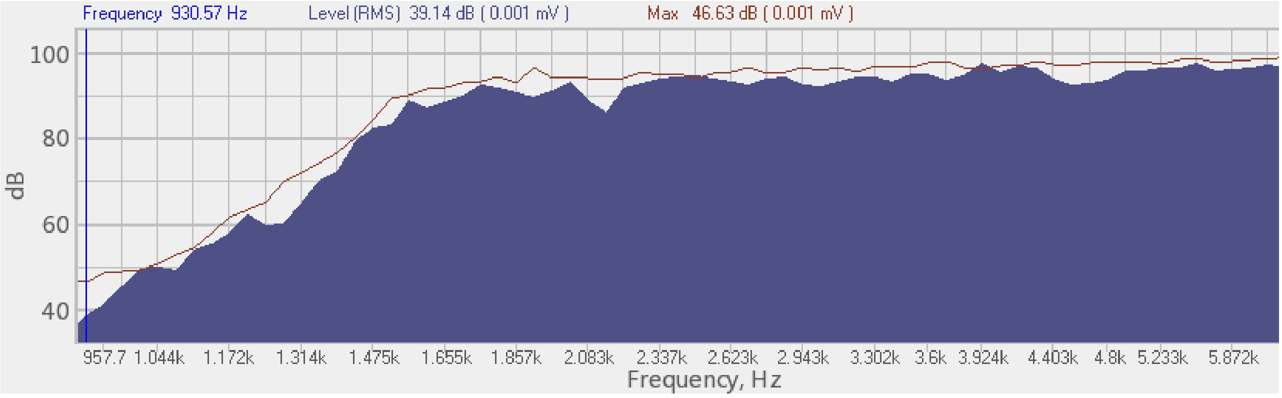
Signals generator - Bandpass noise - Generation parameter



Signals generator - Bandpass noise - oscilloscope graphic of the generated signal

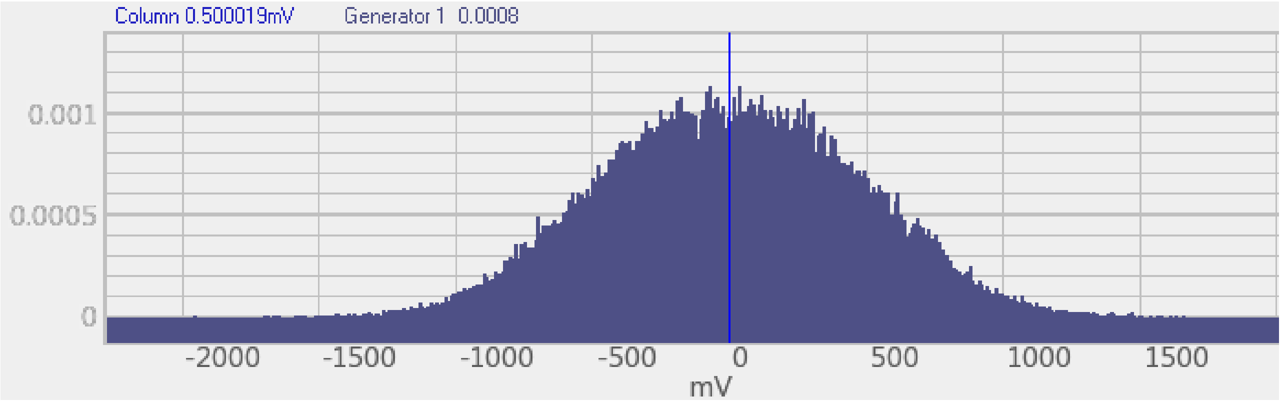


Signals generator - Bandpass noise - FFT Spectrum Analysis



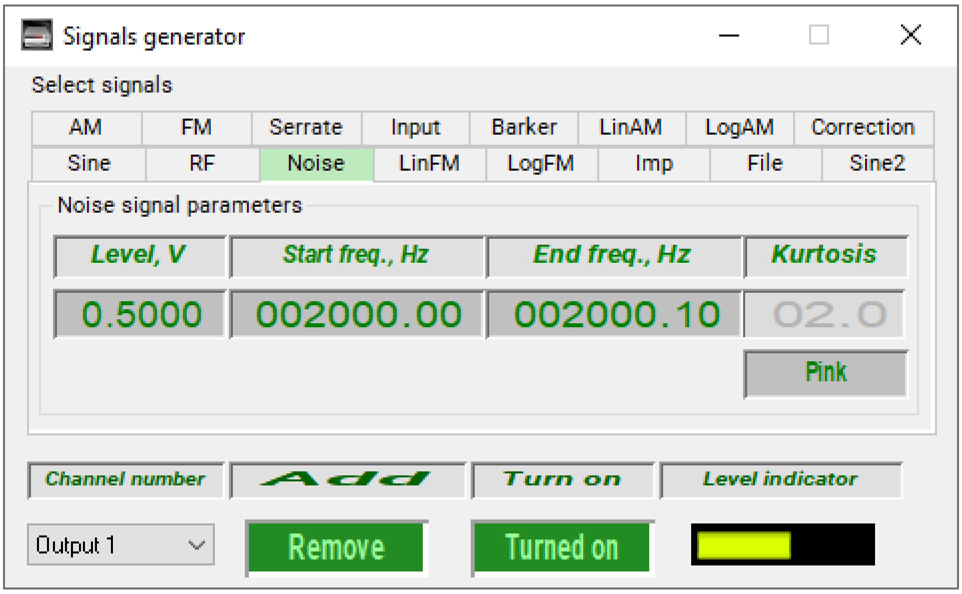
Signals generator - Bandpass noise - Spectrum CPB analysis (Constant Percentage Bandwidth) Analysis

Deviation of **band-pass noise** from the normal distribution is <15 %

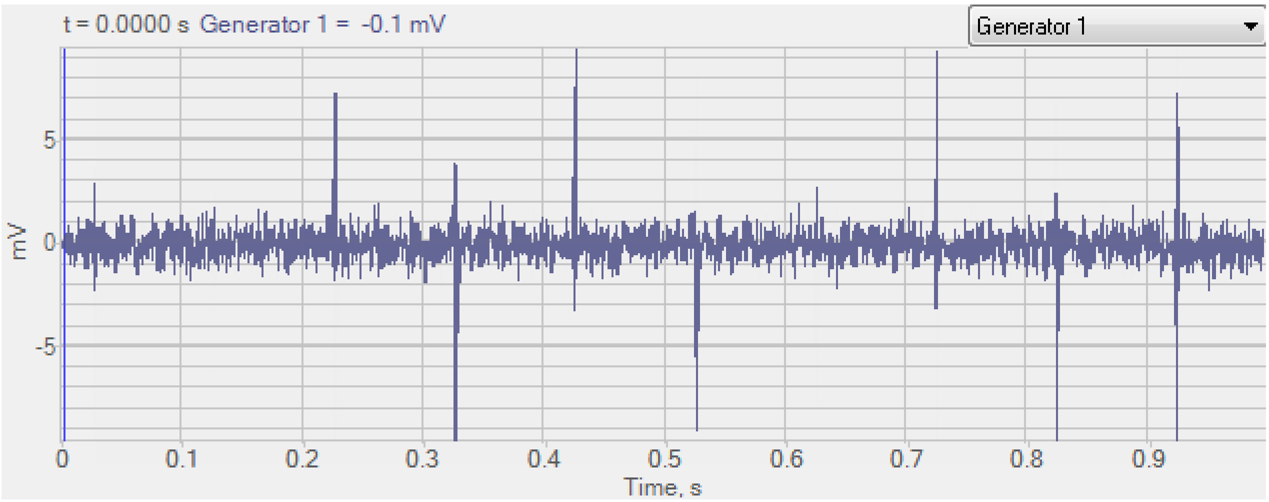


Signals generator - Bandpass noise - Histogram

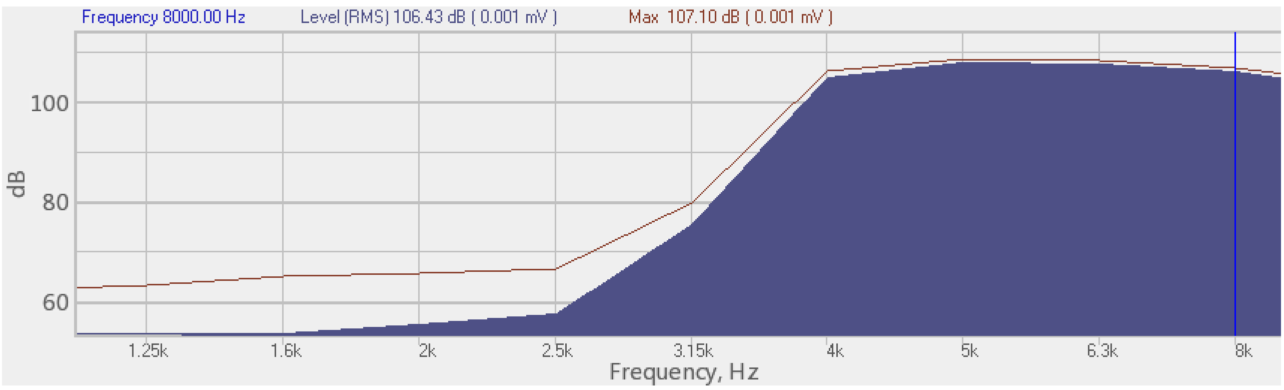
Pink noise – is a noise signal, spectral level of which decreases along with the increase of frequency level (the decline rate is 3 dB per octave).



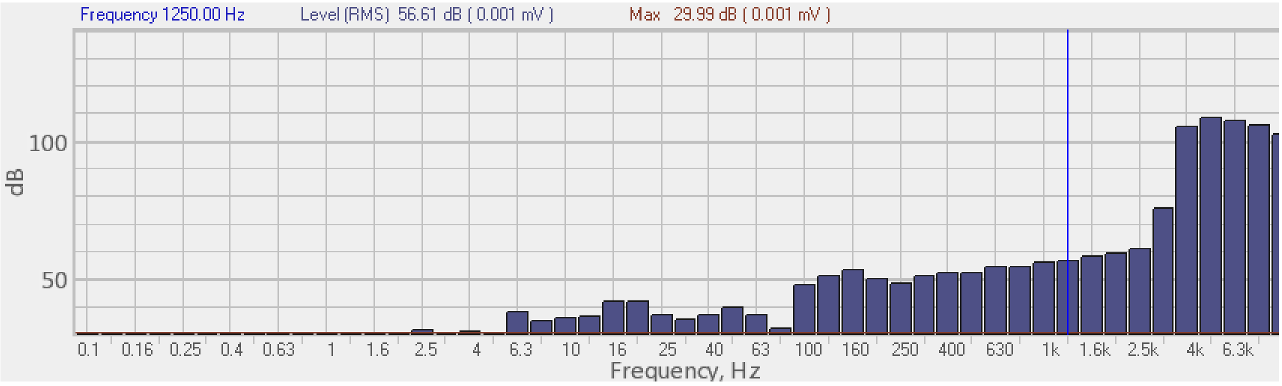
Signals generator - Pink noise - Generation parameters



Signals generator - Pink noise - oscilloscope graphic of the generated signal

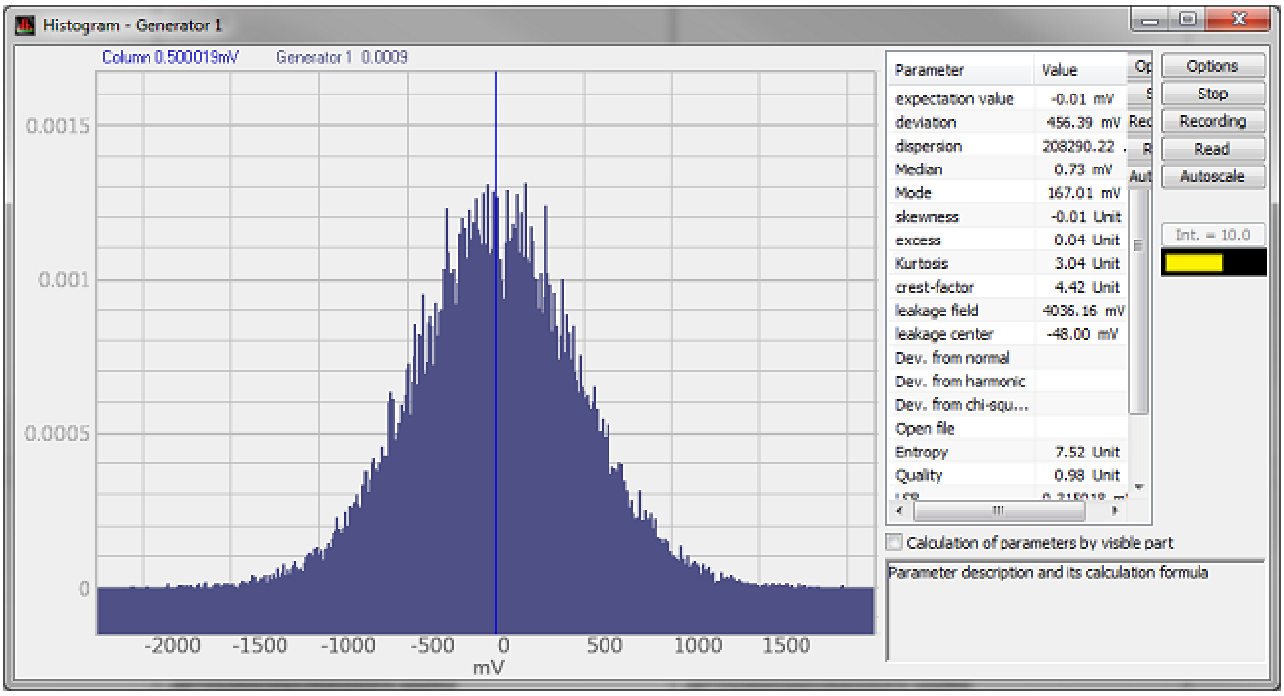


Signals generator - Pink noise - FFT Spectrum Analysis



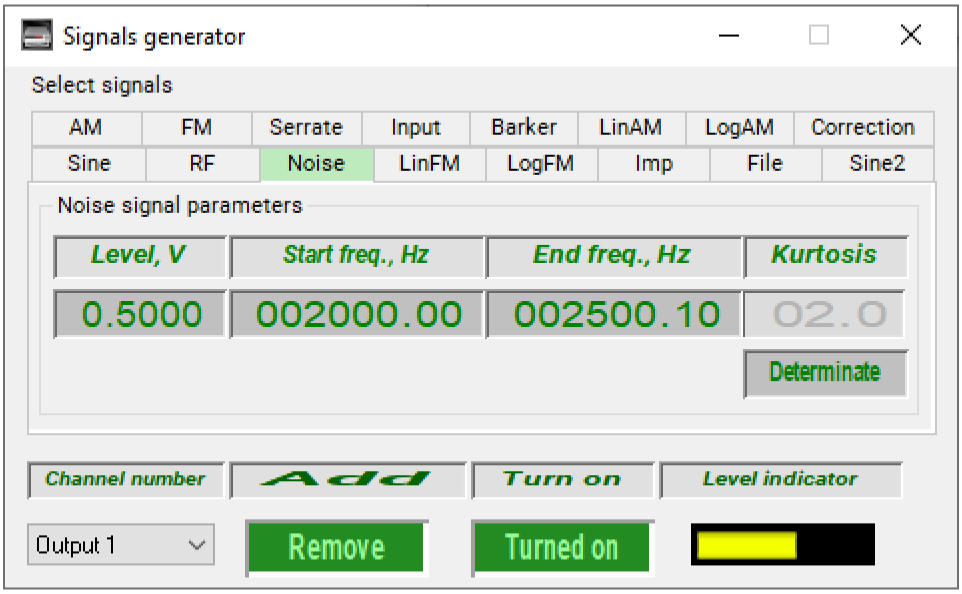
Signals generator - Pink noise - Spectrum CPB analysis (Constant Percentage Bandwidth) Analysis

Deviation of **pink noise** from normal distribution is about 50%.

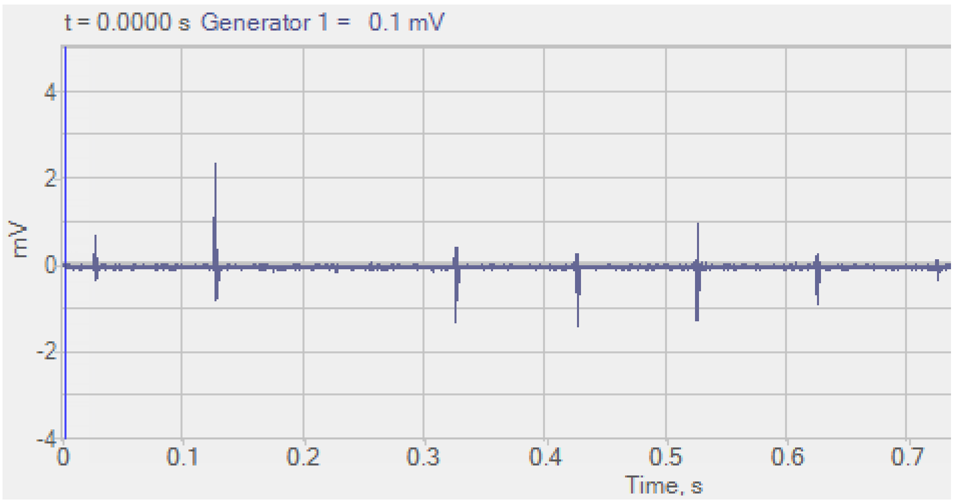


Signals generator - Pink noise - Histogram

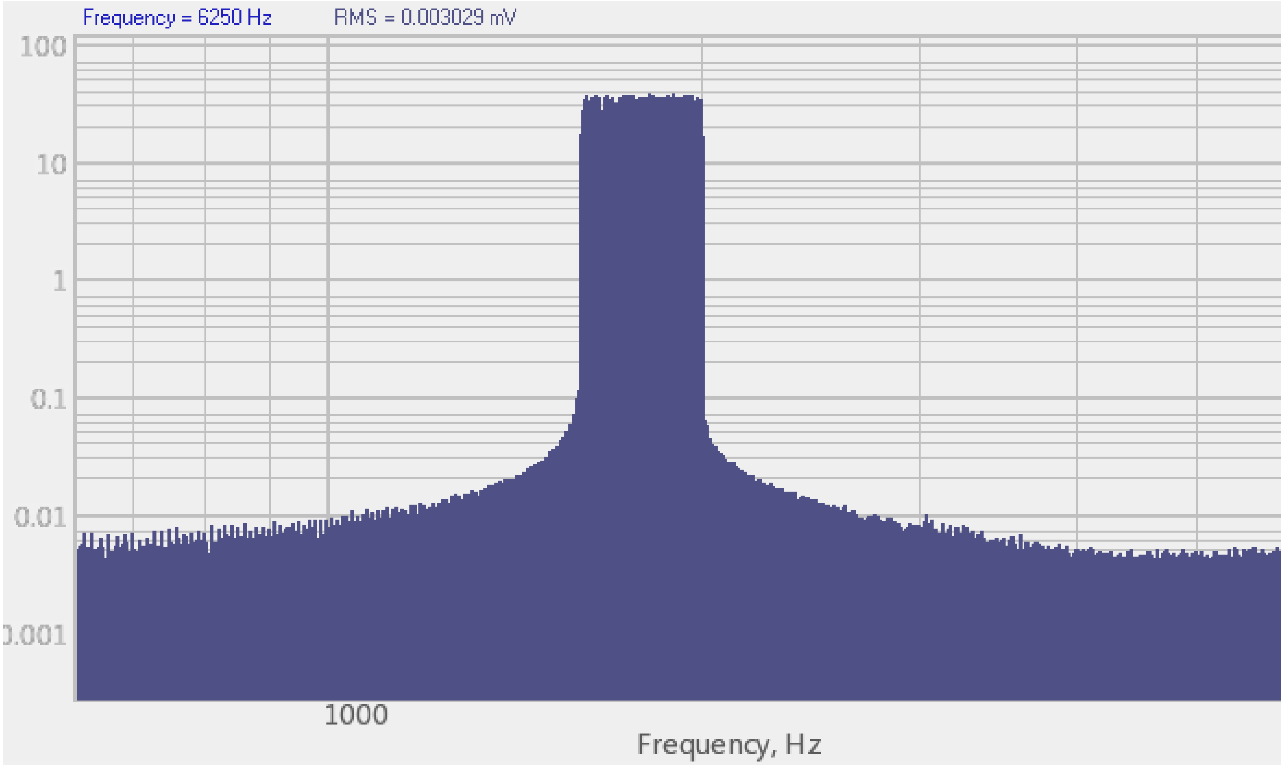
Deterministic noise – is a white noise with limited frequency range.



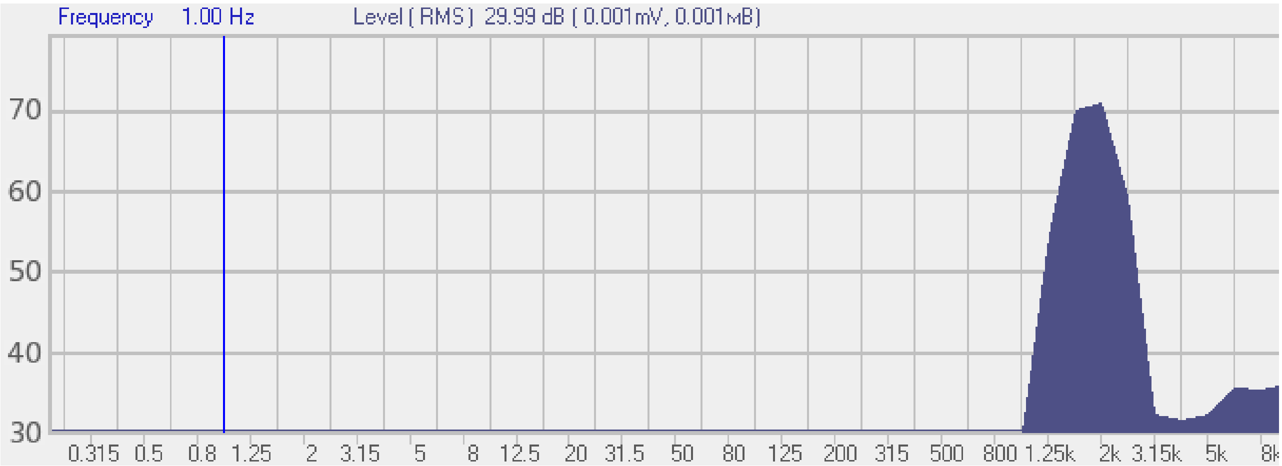
Signals generator - Deterministic noise - Generation parameters



Signals generator - Deterministic noise - oscilloscope graphic of the generated signal

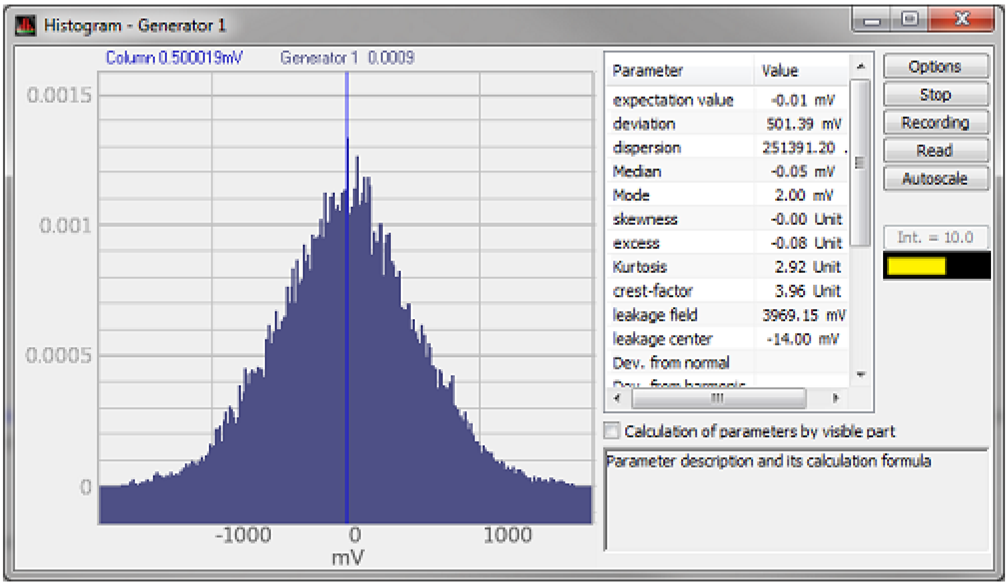


Signals generator - Deterministic noise - FFT Spectrum Analysis



Signals generator - Deterministic noise - Spectrum CPB analysis (Constant Percentage Bandwidth) Analysis

Deterministic noise has the maximal deviation from normal distribution if compared to other types of noise generated by the program.



Signals generator - Deterministic noise - Histogram

Synchronous generator .....

The program "**Synchronous generator**" is used to produce signals at the output channels of devices, manufactured by **LLC "Electronic technologies and metrological systems"**. The types of generated signals are as follows: sine wave and meander. The maximum number of channels is equal to the number of DAC-s in the connected devices. A special feature of this program is the function of synchronization between the generated signals.

The program "**Synchronous generator**" allows to create virtual channels (these channels are displayed in the lists used for the selection of the channels as "*Generator 1*", "*Generator 2*", etc.). The data of these virtual channels is represented by the information from DAC output of the generator. This information is available for further analysis with the use of other programs from the scope of *ZETLAB software package*.

The program enables simultaneous control over several outputs of the signal generator (i.e., DAC converters) for a single or several connected devices.

Note! The program "**Synchronous generator**" is supplied only with the devices equipped with integrated DAC-s.

Supported hardware .....

The program "**Synchronous generator**" allows to produce signals at the output channels of *ZETLAB* instruments. The types of the generated signals are as follows: sine wave and meander. The maximal number of channels is equal to the number of DAC outputs of all the connected devices. A special feature of the program is the function of synchronization between the generated signals.

The program "**Synchronous generator**" is included into the scope of the following software packages:

The "**Synchronous generator program**" is located in the "**Generators**" program section.

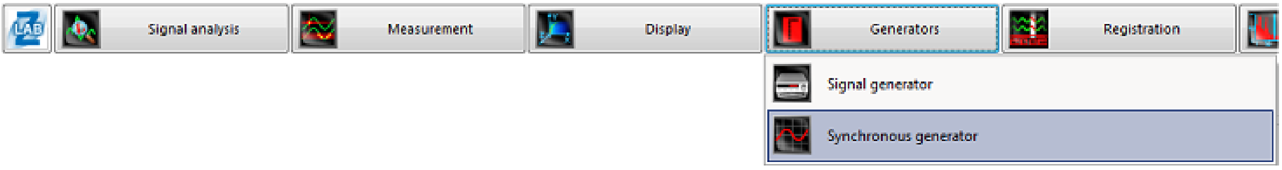
- ZETLAB BASE – ADC/DAC module software;
- ZETLAB ANALIZ – FFT Spectrum software;
- ZETLAB VIBRO – Shaker control systems software;
- ZETLAB TENZO – strain-gauge station software;

Note 1. In the case, if the difference between sampling frequency of ADC and DAC of the device used for signal generation process is more than 10 times, there occurs a loss of one data point from the ZETLAB virtual channel. However, the generated signal still fully complies with set parameters. Hence, with these settings applied, the virtual channel cannot be used for calculations (e.g., with the use of arithmometer) or as a reference channel to be used in the "**Strain Gauge Meter**" program. If it is still necessary to use this virtual channel, one should decrease the DAC sampling frequency or increase the ADC sampling frequency.

Note 2. If a device is connected to PC via Ethernet, the DAC sampling frequency should not exceed 100 kHz. If a device has several DAC outputs, then the DAC sampling frequency should not exceed *100/N kHz*, where *N* is the number of generators used.

Program description .....

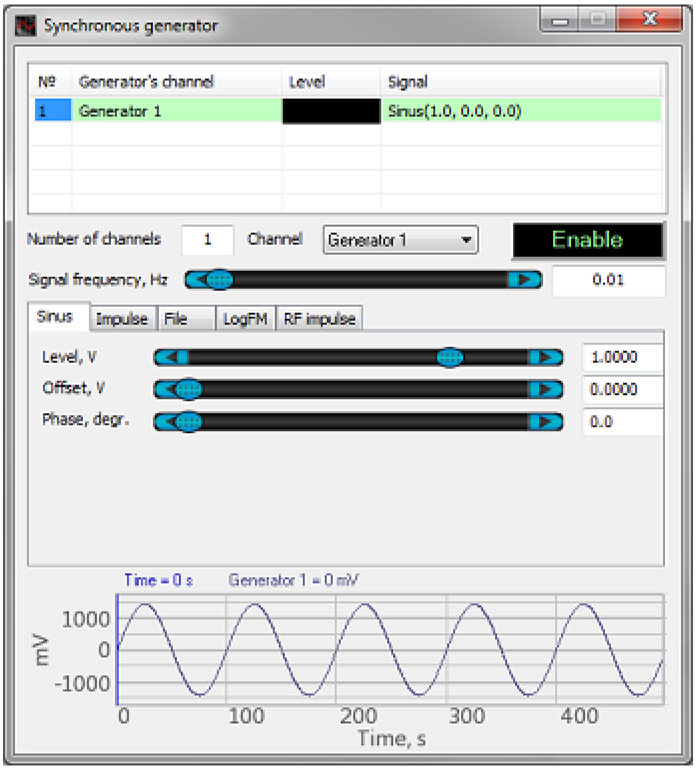
The program "**Synchronous generator**" is started from the "**Generators**" program section of ZETLAB panel.



Synchronous generator - starting the program

Note: the program "**Synchronous generator**" can also be started from ZETLAB directory (the directory by default: C:\ZETLAB\). The name of the file to be started: SynchroChanDac.exe.

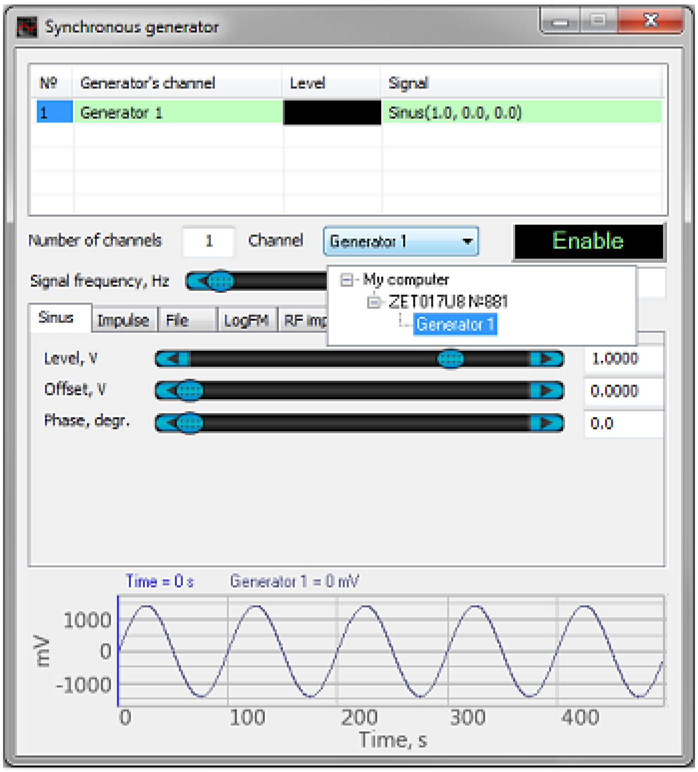
The title of the program interface displays the name of the program – "**Synchronous generator**".



Synchronous generator - Program interface

The upper section of the program interface contains the list of the generators. The middle section displays parameters of the generated signal, and the bottom section of the program interface contains oscilloscope graphic of the generated signal.

The section "**Number of channels**" allows to set the number of the generated signals. To the right from this section there is a list displaying the name of the generator to be used for the signal:



Synchronous generator - Selection of the generator

The key "**Enable/ Off**" allows to enable/ disable generation of the signals.

The field "**Signal frequency, Hz**" allows to set the frequency value of sinusoidal and impulse signals.

The program "**Synchronous generator**" allows to produce the following types of the signals:

- Sine signal
- Impulse signal
- Signal from a file
- Frequency-modulated signal (log.)
- RF impulse signal

The parameters of these signals are further described in more details.

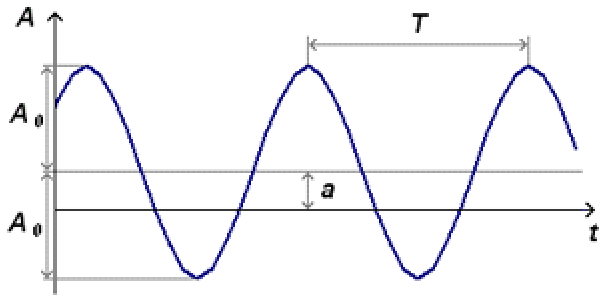
Sine signal .....

Amplitude of sine wave is calculated by the formula:

$$A(t)= A_0 \cdot sin(\omega t+\varphi_0),$$

Synchronous generator - Formula for Sine signal parameters calculation

where: $A_0=2V_{rms}/\sqrt{2}$ – is the signal amplitude, $\omega = 2\pi f$ – signal phase (f – signal frequency, $f=1/T$, T – signal period), t – current time, φ_0 – start phase of the signal.

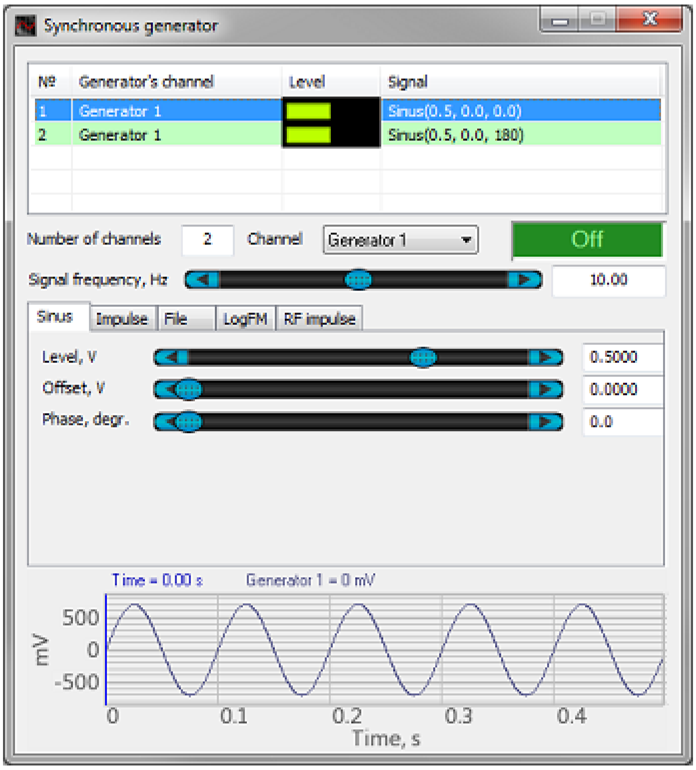


Synchronous generator - Sine signal form

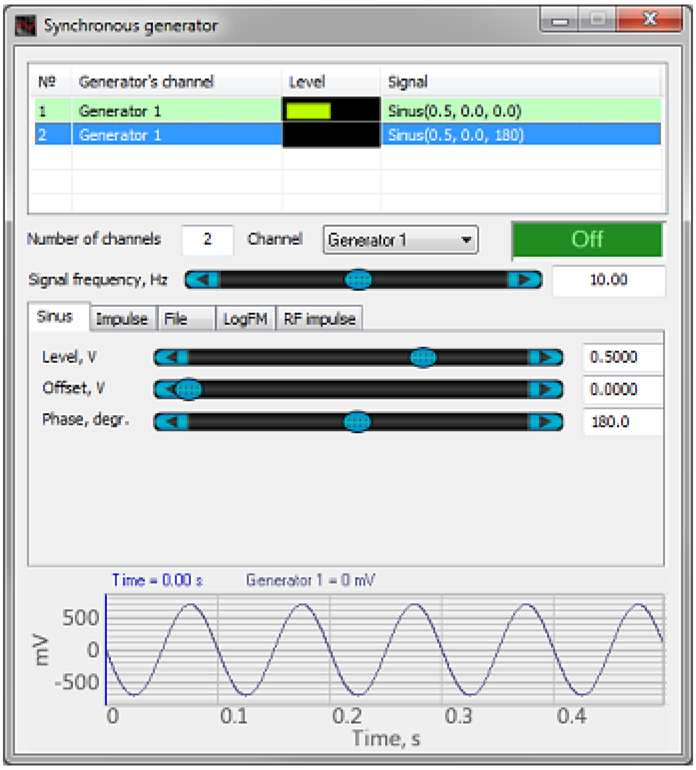
In the program "**Synchronous generator**" the frequency of the generated sine waves is set in the section "**Signal frequency, Hz**", which is located above the signal tab. The horizontal cursor is used to change the frequency level.

The field "**Level, V**" allows to set the RMS value of the generated signal. The section "**Offset, V**" allows to set the DC component of the signal (it is specified as "*a*" in the formula). The section "**Phase, degr.**" Allows to set the initial phase of the signal (φ_0).

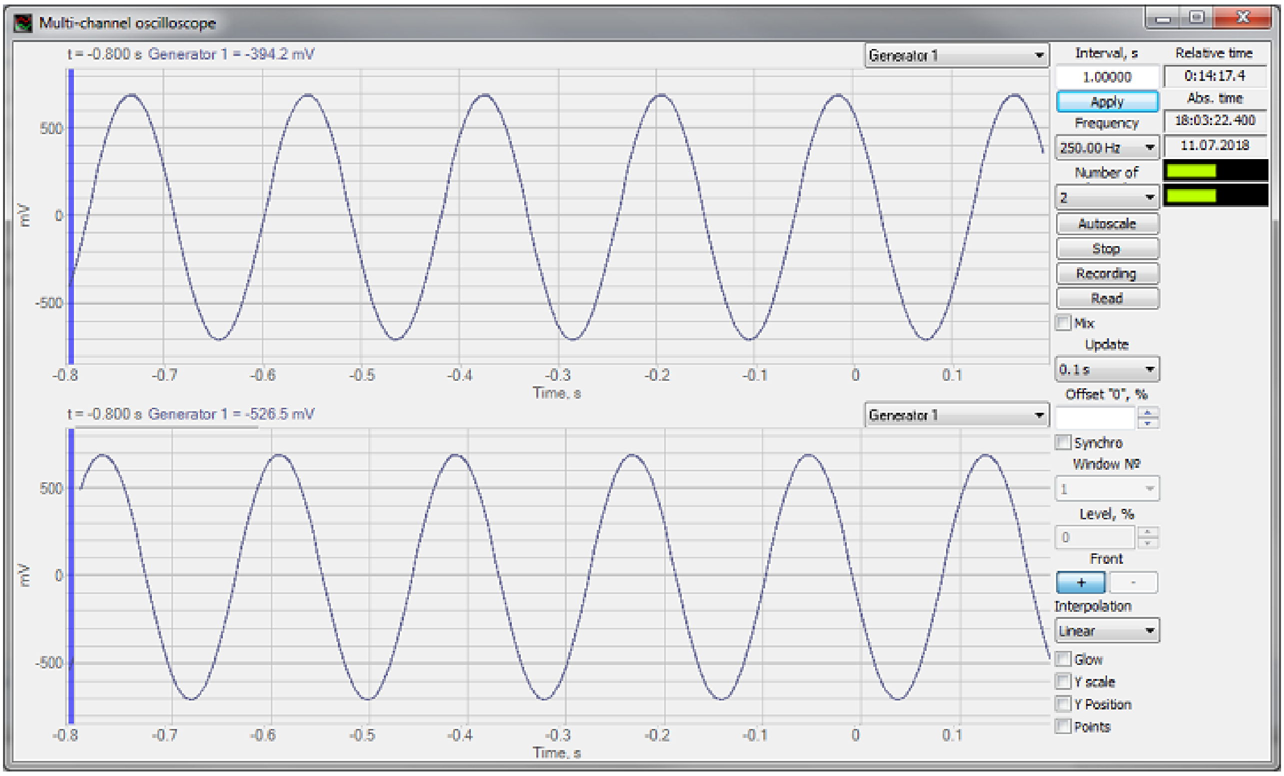
The Fig.s below display an example of generating two signals in phase opposition.



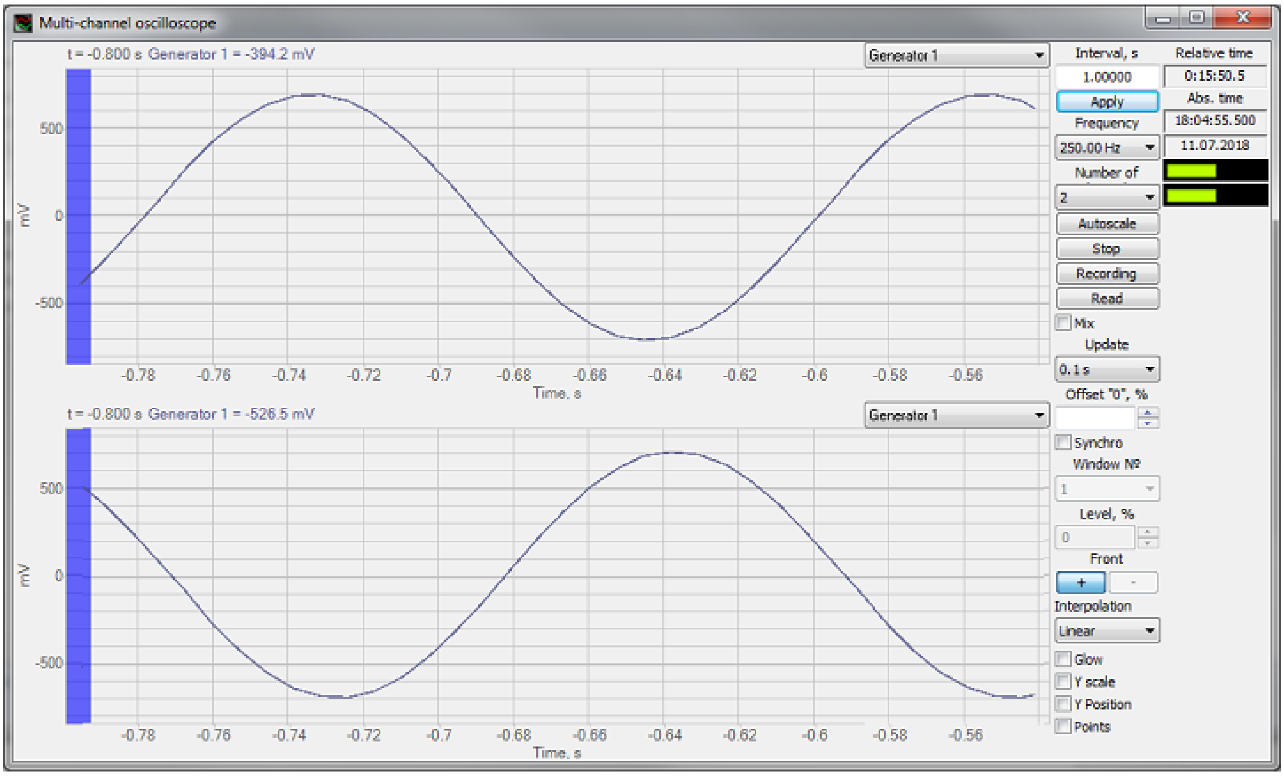
Synchronous generator - Generation parameters of the first generated channel



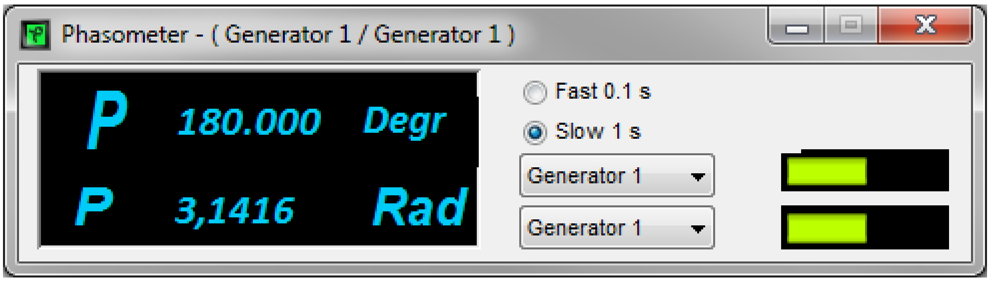
Synchronous generator - Generation parameters of the second generated channel



Synchronous generator - Oscilloscope graphics of the generated signals-1



Synchronous generator - Oscilloscope graphics of the generated signals-2



Synchronous generator - Generation phase difference between the two generated signals

Impulse signal .....

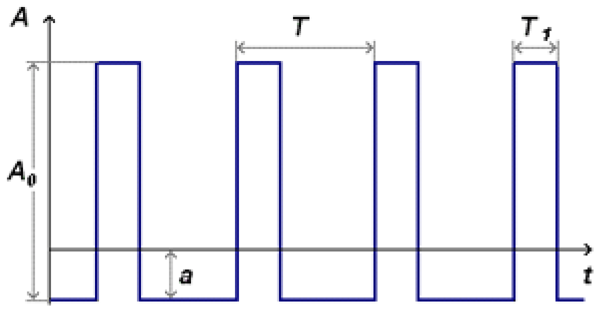
The **pulse signal** is represented by a signal with a short-term change of the stabilized status, which is characterized by a minor interval if compared to the time characteristics of the stabilized process.

The **pulse signal** is calculated by the formula:

$$A = \begin{cases} 1, & \text{if} \quad \omega t < 2\pi \cdot S \\ 0, & \text{if} \quad \omega t > 2\pi \cdot S \end{cases}$$

Synchronous generator - Formula for impulse signal parameters calculation

where $\omega = 2\pi f$ – is the signal phase (f – signal frequency, $f=1/T$, T – signal period), t – current time, S – filling ratio (duty cycle, $T1/T$).

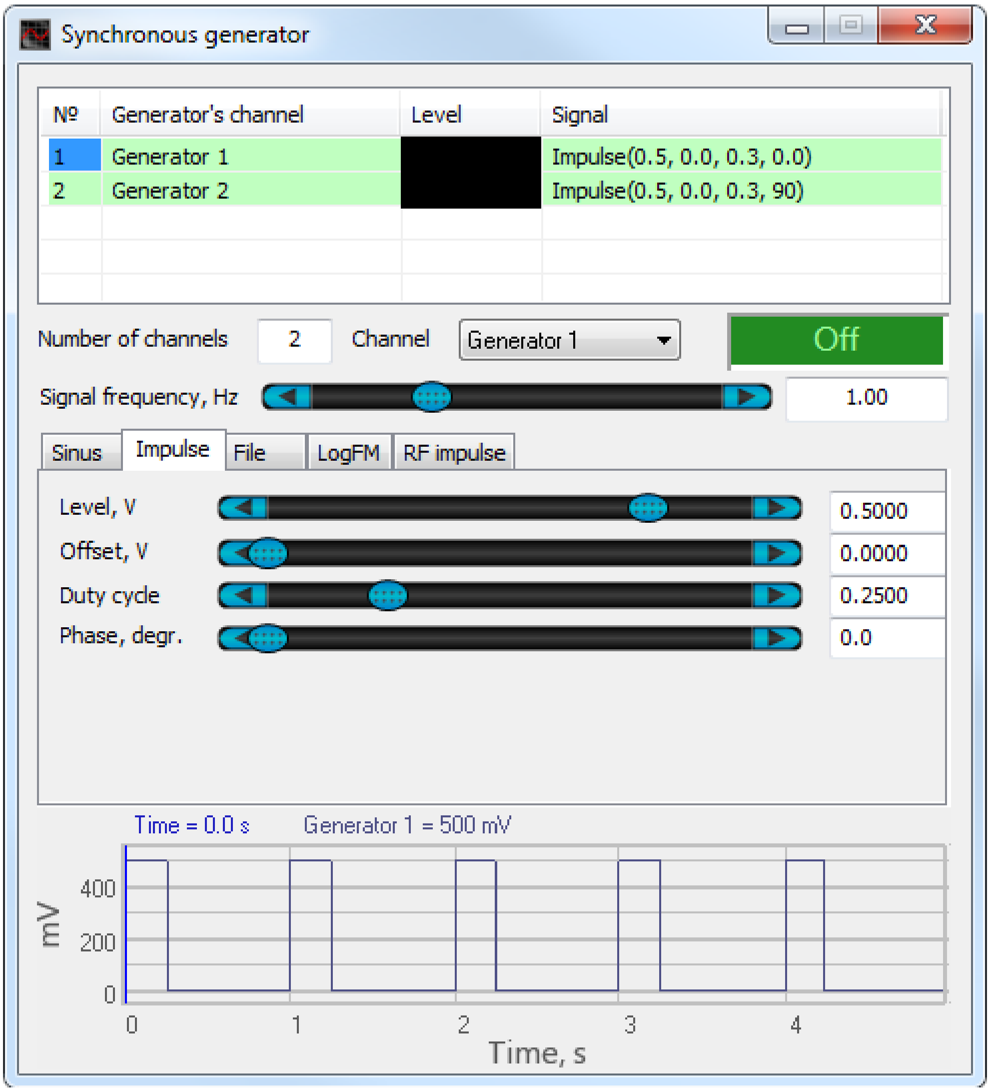


Synchronous generator - Impulse signal form

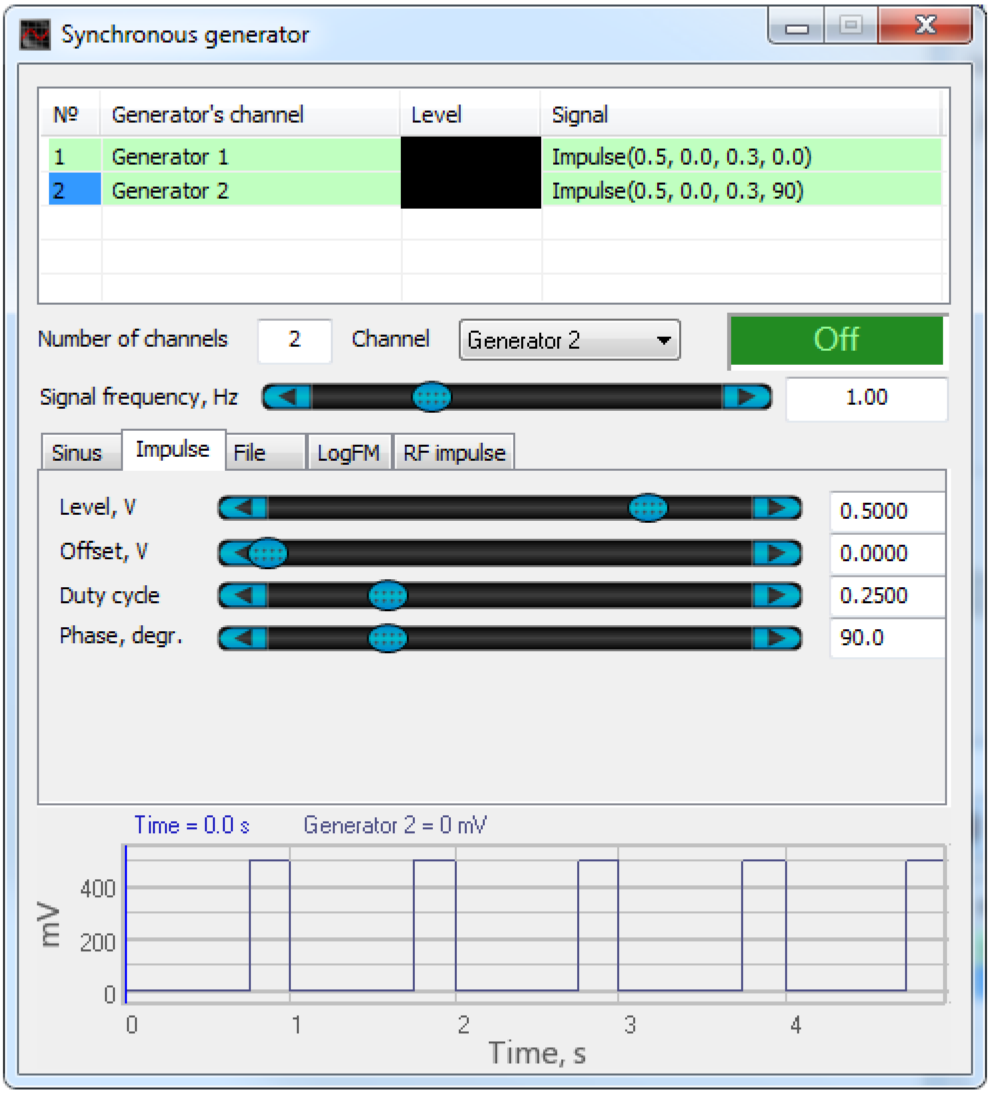
In the "**Synchronous generator**" program, the frequency of the generated signals is set in the section "**Signal frequency, Hz**", which is located above the signal tab. The horizontal cursor allows to change the frequency level.

The field "**Level, V**" allows to set the RMS value of the generated signal. The section "**Offset, V**" allows to set the DC component of the signal (it is specified as "a" in the formula). The field "**Duty cycle**" allows to set filling ratio as a relation of impulse duration to its period. The section "**Phase, degr.**" allows to set the start phase of the signal (φ_0).

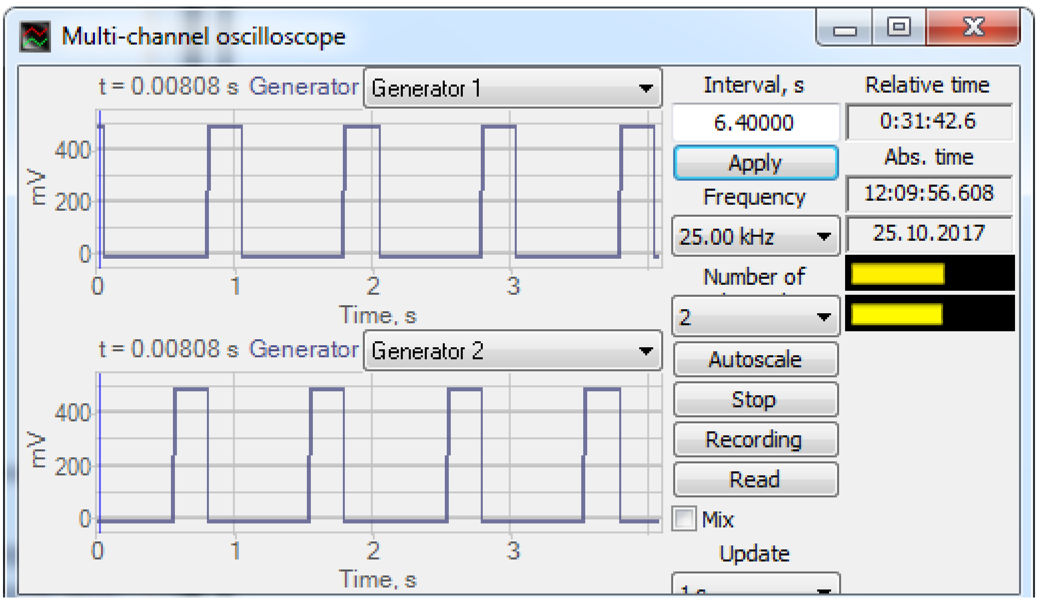
The Fig.s below show an example of two impulses generation with a shift of 24% of the period.



Synchronous generator - Impulse signal - generation parameters of Channel 1



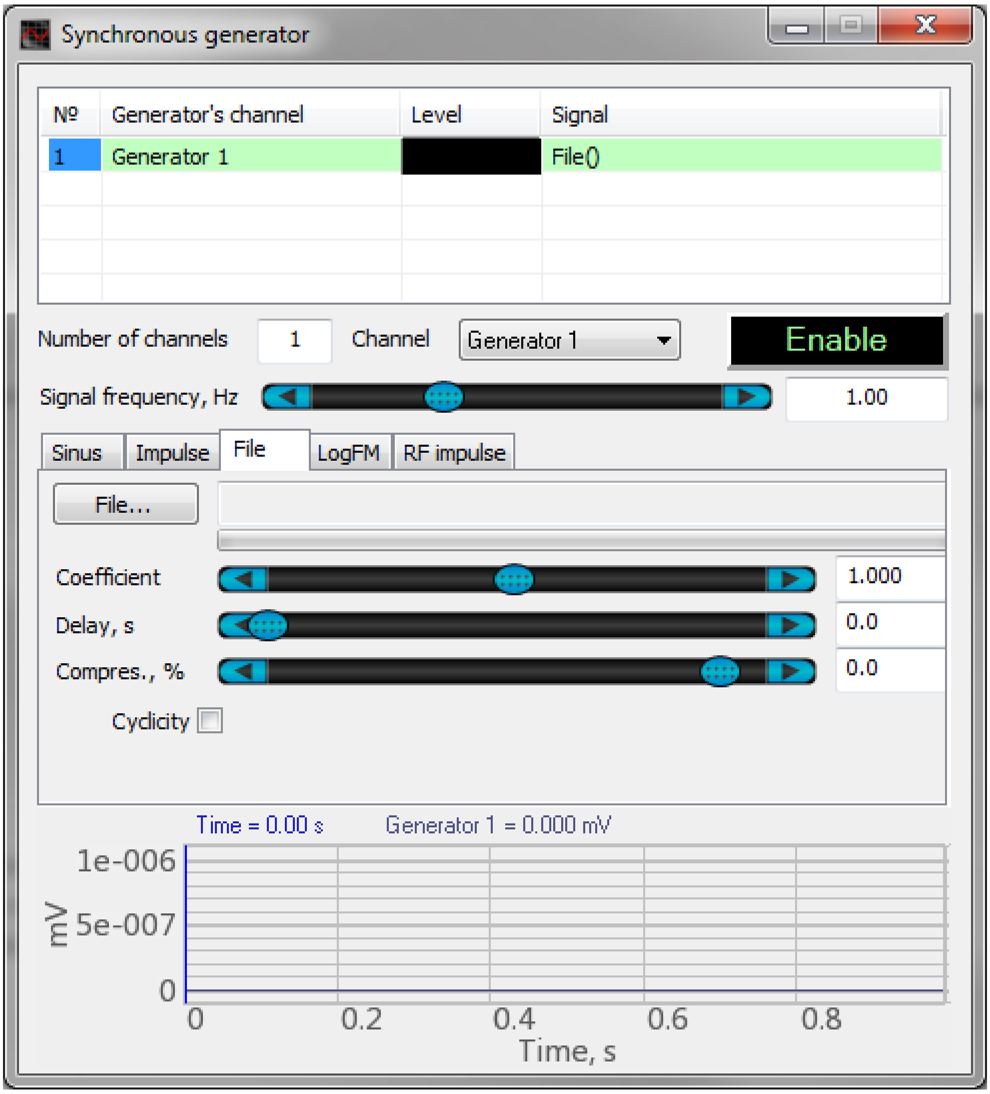
Synchronous generator - Impulse signal - generation parameters of Channel 2



Synchronous generator - Impulse signal - oscilloscope graphics of the generated signals

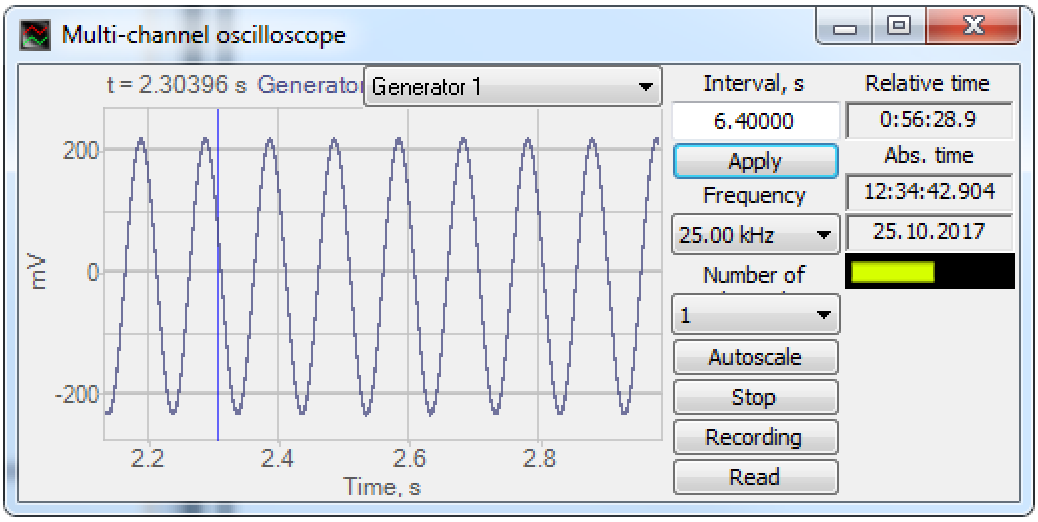
Generation of signal from a file .....

The function "***Generation of signal from a file***" in the program "**Synchronous generator**" is used for parallel Play recorded signals of the recorded signals.



Synchronous generator - File tab - Generation parameters of the recorded file generation

The key "**File**" activates the window used for the selection of the file to be produced at the output of the generator with a corresponding amplification/ attenuation ratio (section "**Coefficient**"), and compression in time domain (the section "**Compres., %**"). The key "**Enable**" is used to start Play recorded signals of the signal upon completion of the delay period (see the section "**Delay, s**"). The "**Cyclicity**" option allows to enable/ disable the cyclic Play recorded signals of the selected signal.



Synchronous generator - File tab -oscilloscope graphic of the generated signal

LogFM .....

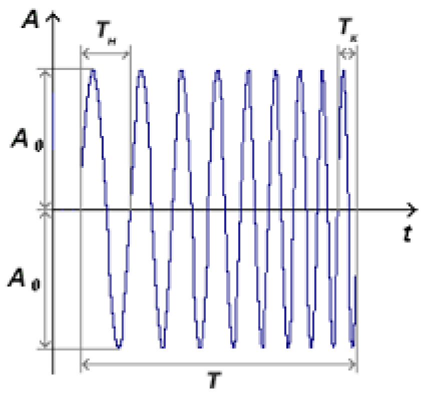
Frequency-modulated signal with logarithmic frequency sweep (**LogFM**) is represented by a sine wave with frequency level changing in accordance with logarithmic law.

The **LogFM signal** parameters are calculated by the formula:

$$A = A_0 \cdot \sin\left(\frac{\omega \cdot T}{\ln\left(\frac{f_k}{f_0}\right)} \cdot \left(\frac{f_k}{f_0}\right)^{t/T} + \varphi_0 \right)$$

Synchronous generator - LogFM - Formula for LogFM signal parameters calculation

where $A_0 = 2V_{rms}/\sqrt{2}$ – signal amplitude, $\omega = 2\pi f$ – signal phase $(f=1/T)$, T – frequency change time, f_0 – start frequency of the signal, f_k – end frequency of the signal, t – current time, φ_0 – start frequency of the signal.



Synchronous generator - LogFM - Signal form

In order to produce LogFM signal with pre-set parameters, enter the tab "**LogFM**" of the "**Synchronous generator program**" – you will see the control elements used for configuring the **LogFM signal** parameters:

· **Level** – the root-mean square value (RMS) of the signal to be used for generation of **LogFM signal**. The level of the signal is set in Volts. Please, note, that the RMS value is used as the level of the signal. The peak value (specified as A_0 in the above Fig.) is related to the RMS value as $A_0 = RMS * \sqrt{2}$.

· **Freq. Initial, Hz** – start frequency of the frequency range to be used for generation of the **LogFM signal**. It is related to the period *Tn* in the Fig. above as $fn = 1/Tn$. The initial frequency value is set in Hz.

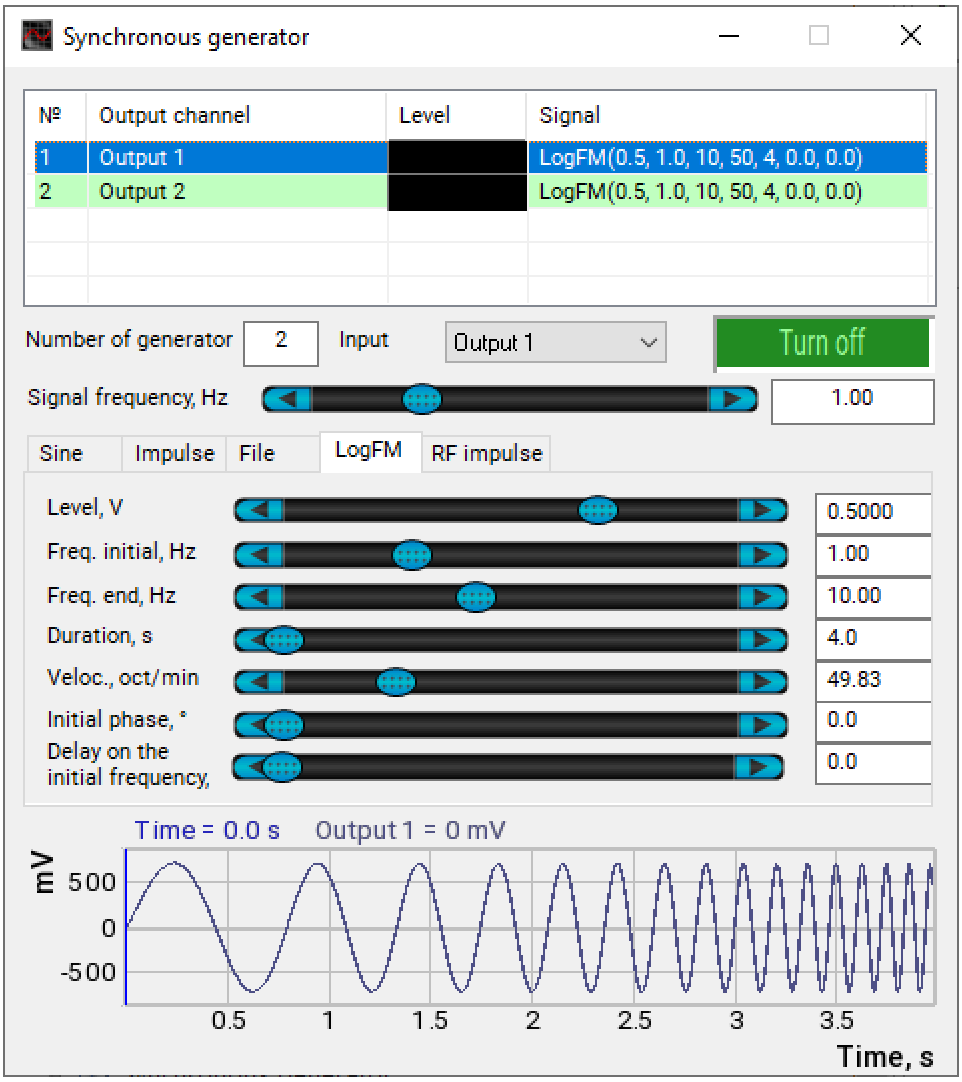
· **Freq. End, Hz** – the end frequency of the frequency range used for generation of **LogFM signal**. It is related to the period *Tk* in the above Fig. as $fk = 1/Tk$. The end frequency is set in Hz.

· **Duration, s** – duration of the cycle to be used for generation of the **LogFM signal**. The duration is set in seconds. In the above Fig., the duration is specified as *T*.

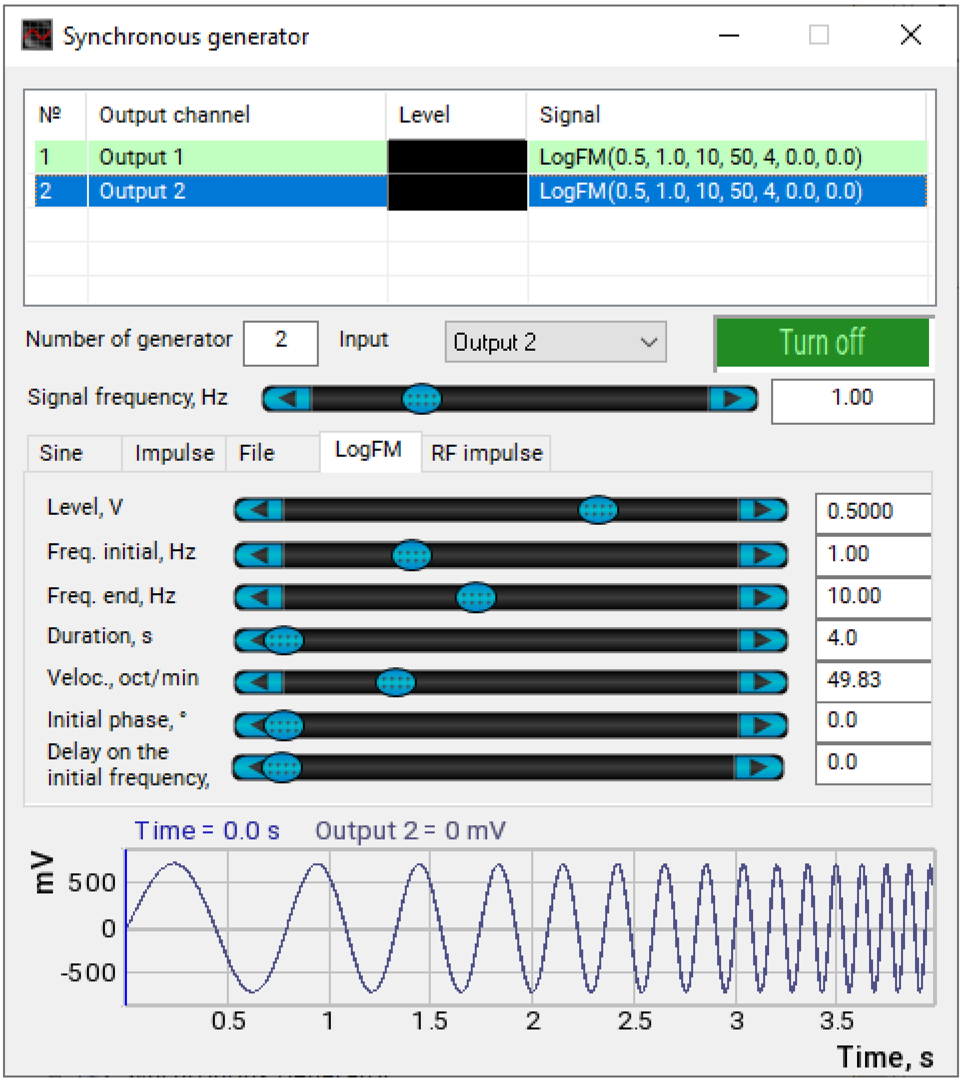
· **Veloc., oct/min** – velocity of frequency change in relation to octaves per minute (*oct/min*) to be used for generation of the **LogFM signal**. It is calculated automatically based on the duration of start and end frequencies.

· **Initial phase, degr** – initial phase of the signal ($\varphi 0$).

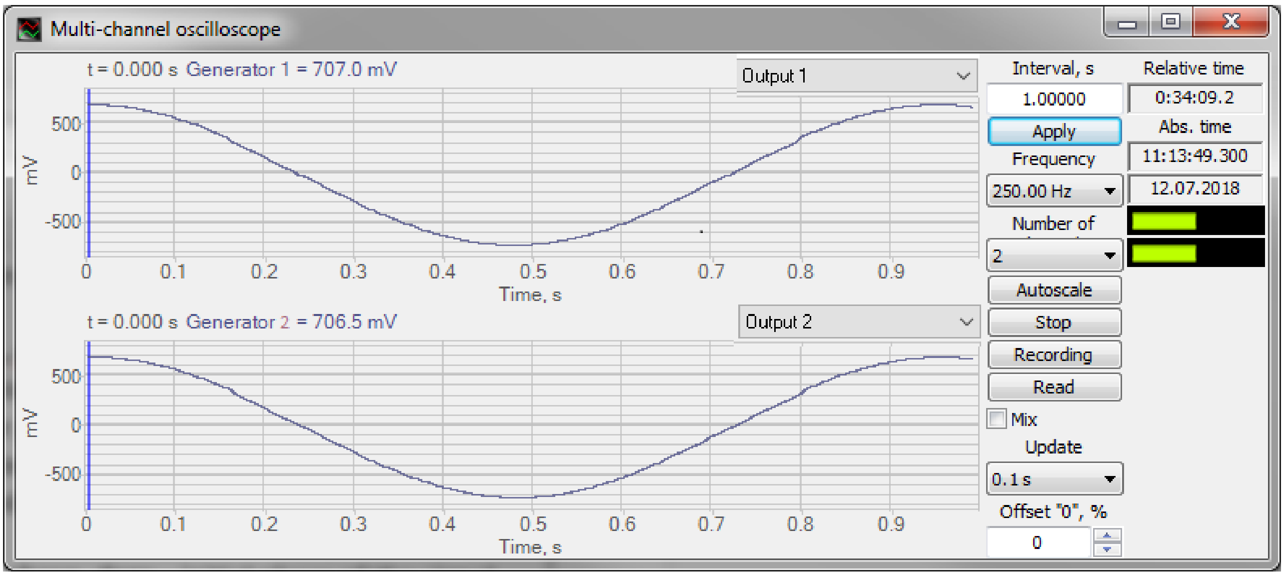
The Fig.s below display an example of generation of two frequency-modulated signals in opposite phases:



Synchronous generator - LogFM - parameters of the first generated signal



Synchronous generator - LogFM - parameters of the second generated signal



Synchronous generator - LogFM - oscilloscope graphics of the generated signals

RF impulse signal .....

RF impulse signal is represented by a signal with a short-term change of the stabilized status, which is characterized by a short time interval if compared to the time characteristics of the stabilized process.

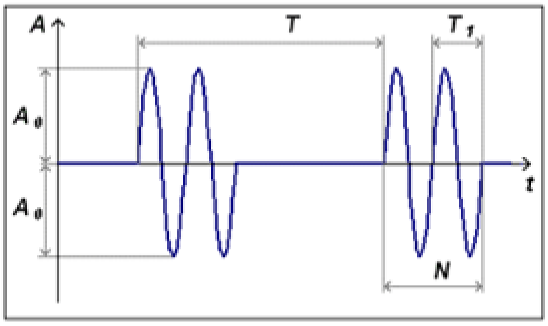
The level of **RF impulse signal** at each particular moment of time can be calculated with the formula:

$$A = \begin{cases} A_0 \sin \omega_1 N t, & \text{if} \quad \omega_1 N t < \omega t \\ 0 & \text{if} \quad \omega_1 N t > \omega t \end{cases}$$

Synchronous generator - RF impulse signal - Formula for calculation of the RF impulse signal parameters

where: $A_0=2V_{rms}/\sqrt{2}$– is the signal amplitude, $\omega = 2\pi f$ – signal phase, f – signal frequency (carrier frequency), which is related to its period T as $f=1/T$, t – current time, N – filling ratio (relation of the carrier frequency and repetition frequency).

Note: in the Fig. below "*N*" stands for the number of impulses within a single period.



Synchronous generator - RF impulse signal - Generation parameters RF impulse signal

In order to produce RF impulse signal (intermittent oscillations), enter the tab **"-RF impulse signal"** of the "**Synchronous generator**" program – you will see the control elements used for configuration of the **RF impulse signal** parameters:

· **Level, v** – root-mean-square value (RMS) of the level to be used for signal generation. The level is set in Volts. Please, note, that the RMS value is used as the level of the signal. The peak value (specified as A_0 in the Fig.) is related to the RMS value as $A_0 = RMS * \sqrt{2}$

· **Freq. Fil. Hz** – filling frequency (the carrier frequency) to be used for RF impulses generation. The filling frequency value is set in Hz. The filling frequency is related to the period *T1* shown in the Fig..

· **Freq. Repet., Hz** – repetition frequency (modulation frequency), to be used for RF impulses generation. The repetition frequency value is set in Hz. This parameter is related to the period "*T*"shown in the Fig. above.

· **Offset, V** – DC offset value to be used for generation of the signal. The offset value is set in Volts.

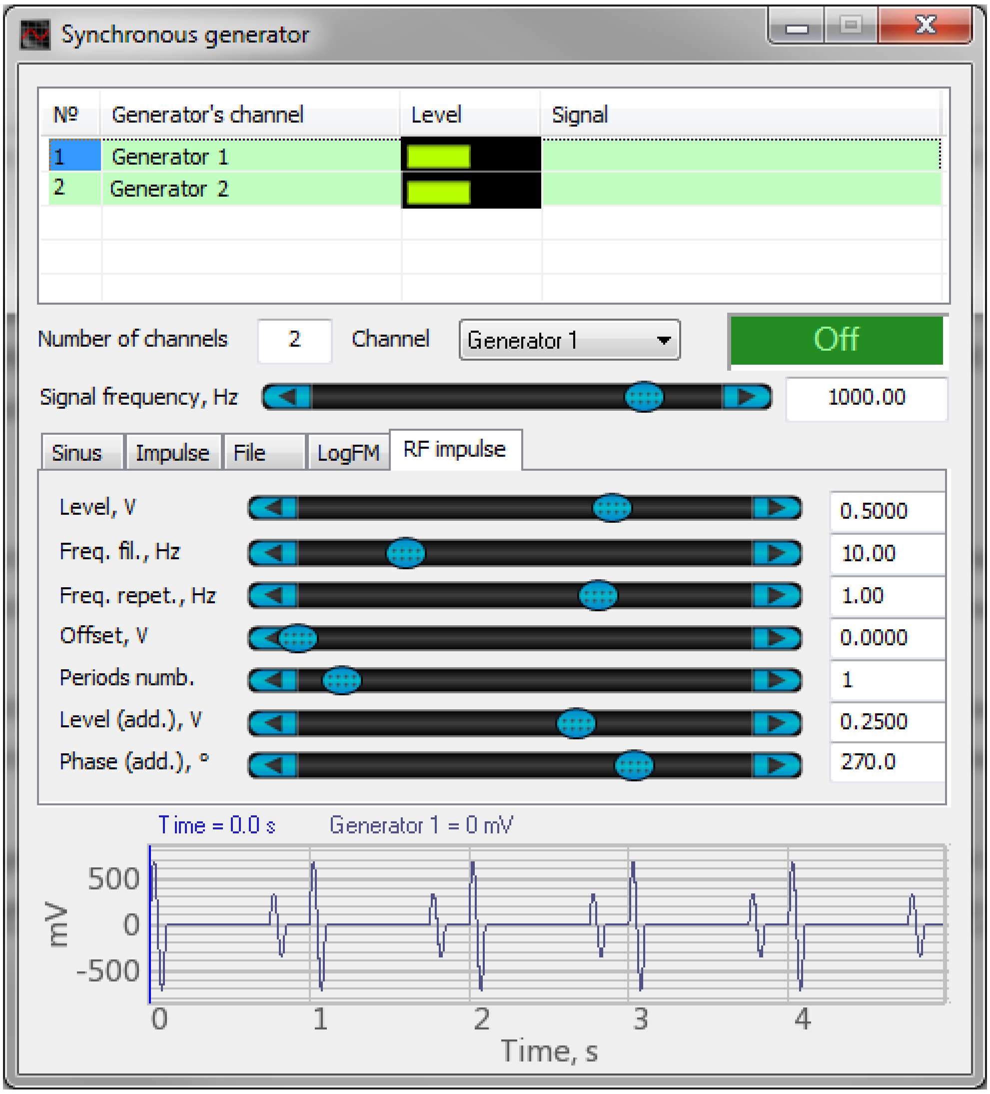
· **Periods numb.** – the bandwidth to be used for signal generation – the number of impulses *N* with the duration *T1* within the period *T*.

· **Level (add.), V** – the RMS value of additional impulse.

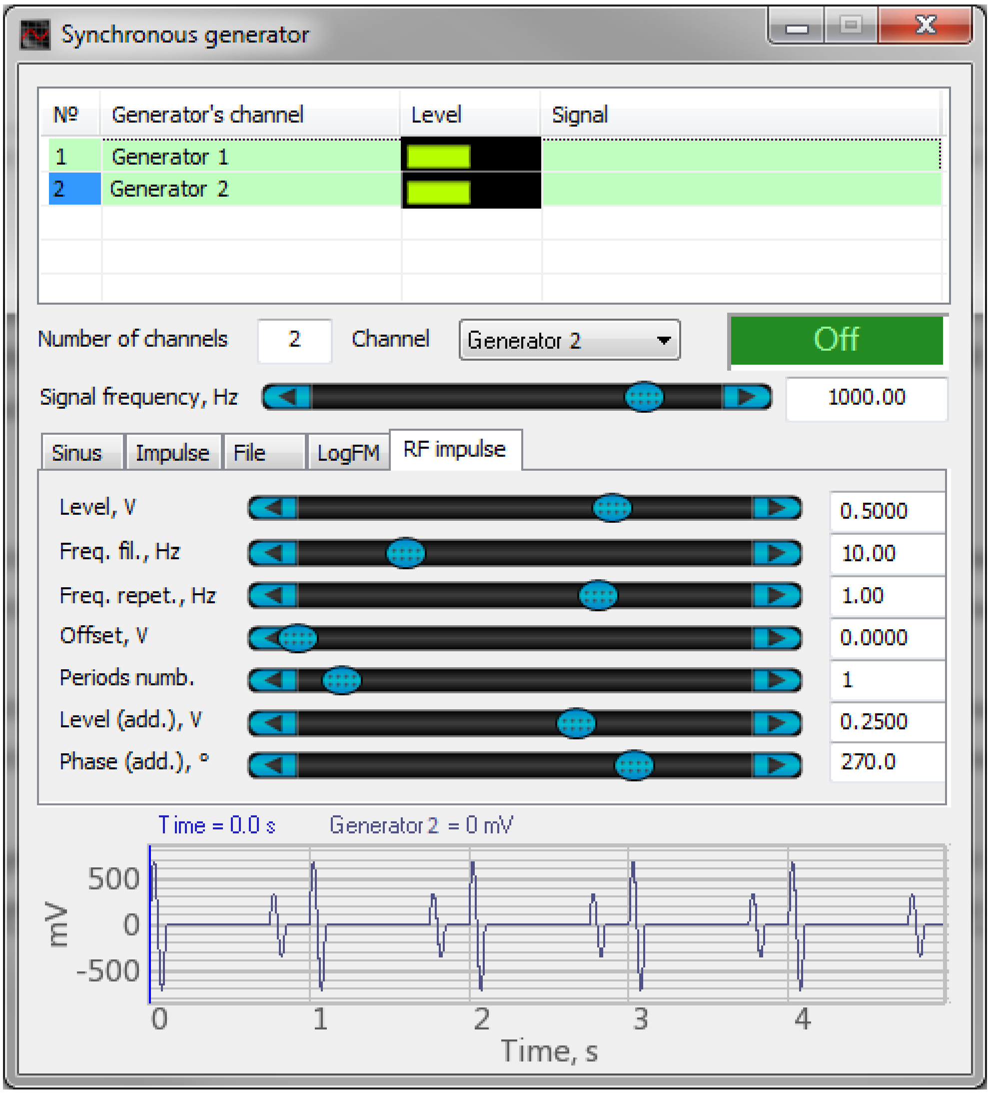
· **Phase (add.), °** – the phase shift of the additional impulse in relation to the main impulse.

The RF impulse signal is produced in cycle format.

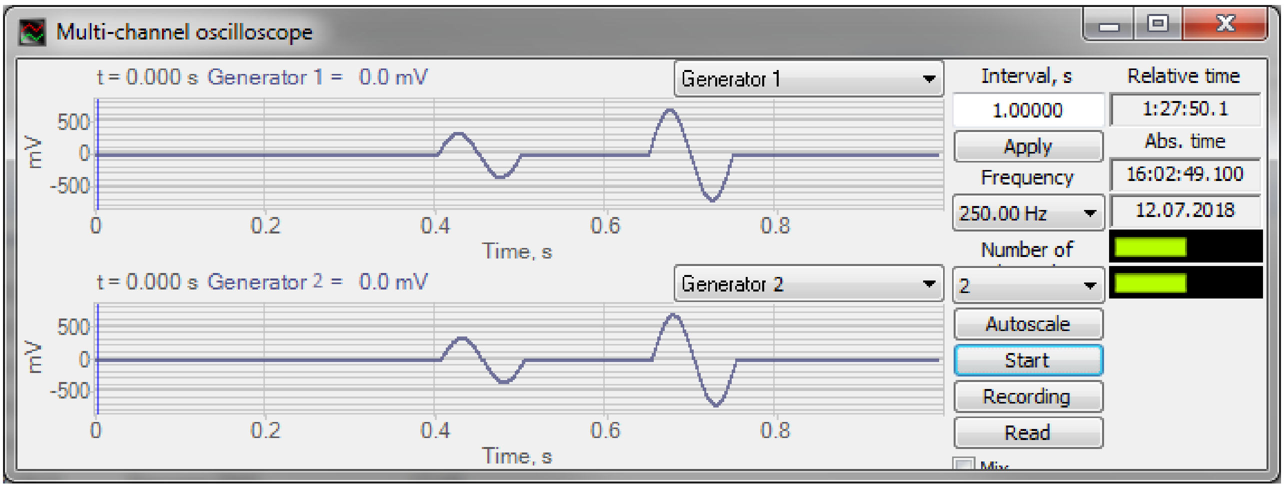
The below Fig.s display an example of RF impulse signal generation with a different phase shift:



Synchronous generator - RF impulse signal - Generation parameters RF impulse signal - Channel 1



Synchronous generator - RF impulse signal - Generation parameters RF impulse signal - Channel 1



Synchronous generator - RF impulse signal - oscilloscope graphic of the generated signal

Registration

The Registration section contains ZETLAB setting and auxiliary tools.

The **Signal recording** is designed for continuous recording of signals in real time coming to the input channels of measuring instruments. For the convenience of subsequent signal processing, the possibility of an unlimited number of recordings of text and voice comments is provided. The signals can be recorded in a ring or direct buffer of RAM, followed by overwriting to the drive. Recording in this mode allows you to register any previously unknown event with a background.

The **Signals conversion** is designed to convert ZETLab's recorded signals of the format - ana/anp into compressed data, and from seismic devices
into the format: MiniSEED.

The **Play recorded** signals is designed to reproduce signals recorded using the **Signal recording** program. When playback is turned on, the played signals become available for analysis and measurements in all ZETLAB programs.

The **Signals trends viewing** is a graph that allows you to analyze long-term records of measured values from sensors (for hours, days, months, years). Depending on the sampling frequency, the nth number of samples per second is performed, and in a year their number is 31,556,926 *n. If the user needs to evaluate the short-term moments of the original signal, then there are no difficulties. But it is much more difficult when the task is to evaluate the parameters for the whole year or even several years, there is not enough monitor size or patience. It is in such situations that trend building helps out.

The **View historical events** allows you to view and analyze historical events recorded using the ZETLAB software over a long period of time.

The **Multi-channel recorder** is designed for long-term registration and display of signal parameters entering the input channels of controllers, spectrum analyzers (included in the package), digital sensors and ADC/DAC modules (optional).

The **Group multi-channel recorder** is designed for long-term registration and display of signal parameters entering the input channels of controllers, spectrum analyzers (included in the delivery package), digital sensors and ADC/DAC modules (optional).

Signals recording .....

The program "**Signals recording**" is intended for constant real-time recording of the signals applied to the input channels of measurement instruments. To make further signals processing more convenient, there has been implemented a function of recording unlimited number of comments files in text format. It is possible to record the data both in direct and loop mode to the RAM with a subsequent recording to a data storage device. In this operation mode, it is possible to record any unknown event together with its pre-history.

Additional functions of the "**Signals recording**" program:

- Adding text comments to the recorded data. It is possible to add several text comments to the record file.

About the program .....

The program "**Signals recording**" is intended for constant real-time recording of the signals applied to the input channels of the measurement instruments. To make further signals processing more convenient, there has been implemented a function of recording unlimited number of comments files in text format. It is possible to record the data both in direct and loop mode to the RAM with a subsequent recording to a data storage device. In this operation mode, it is possible to record any unknown event together with its pre-history.

Note: the program "**Signals recording**" is included into ZETLAB software package supplied with **FFT Spectrum Analyzers** and **ZETLAB Registration** software package (used for recording and Play recorded signals of measurement data).

It is possible to start / suspend the process of signals and comments recording both automatically and in manual mode. There are three ways to start / suspend the recording process: use the control keys available in the program interface, enter the hotkeys combination, or start / suspend the data recording process using the local data-processing network. In the latter case (when there is used a remote station and a terminal), it is possible to used wired or wireless connection with the local data-processing network. The terminal starts a program, which is used for the control of the recorder. The operator can change the directories used for signals recording, record the signals, text and voice comments. The remote station is used for keeping the log of all the commands received from the terminal.

The recorded files can be viewed with the use of the program "**Play recorded signals**" and undergo processing with other programs from *ZETLAB software* scope. Besides, it is possible to convert the files to a text format and to open them with the "**View and results processing**" program.

It is possible to view the trends only for the signals which have been recorded in continuous way.

***Note*:** simultaneous operation of the programs "**Signals recording**" and "**Play recorded signals**" is impossible.

The program also has an integrated control and automation module from the scope of *ZETLAB Studio* software, which simplifies the process of software measurement systems development.

The recorder is a virtual measurement instrument supplied together with *strain-gauge stations* and *FFT Spectrum Analyzers*. It is used for data acquisition and subsequent processing.

Supported Hardware .....

The source information of the program "**Signals recording**" is represented by digital channels of *ZETLAB server*.

The program "**Signals recording**" is included into the scope of the following software packages:

- ZETLAB ANALIZ – FFT spectrum analyzer software;
- ZETLAB VIBRO – vibration control systems software;
- ZETLAB TENZO – strain-gauge station software;
- ZETLAB SEISMO – seismic station software;
- ZETLAB NOISE – vibration meter-noise meter software;

Signals recording *is included in the* ***Registration*** *software group:*

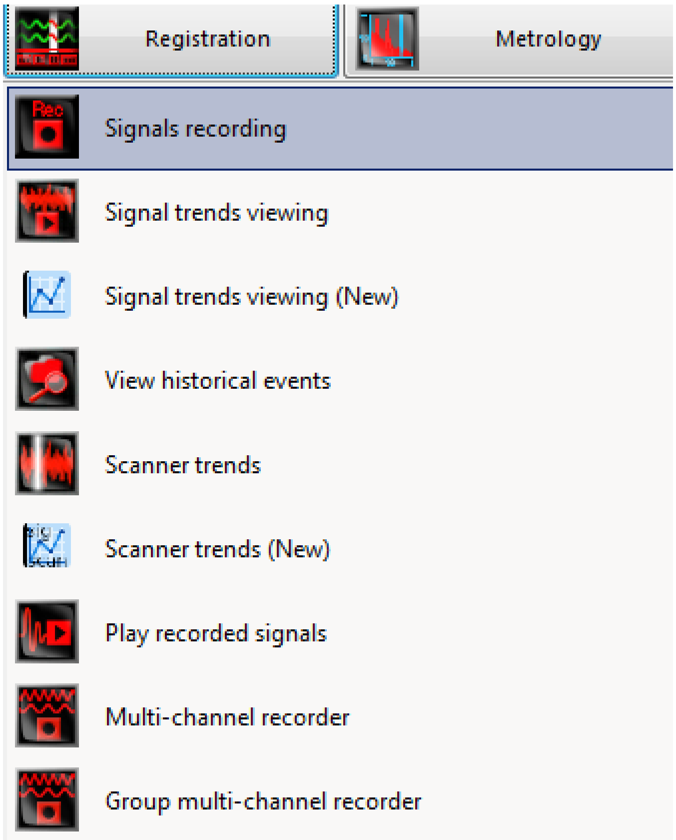
For *ADC-DAC modules* and *digital transducers of ZETSENSOR series*, the program is available with the option "**Signals recording and Play recorded signals**".

Program description .....

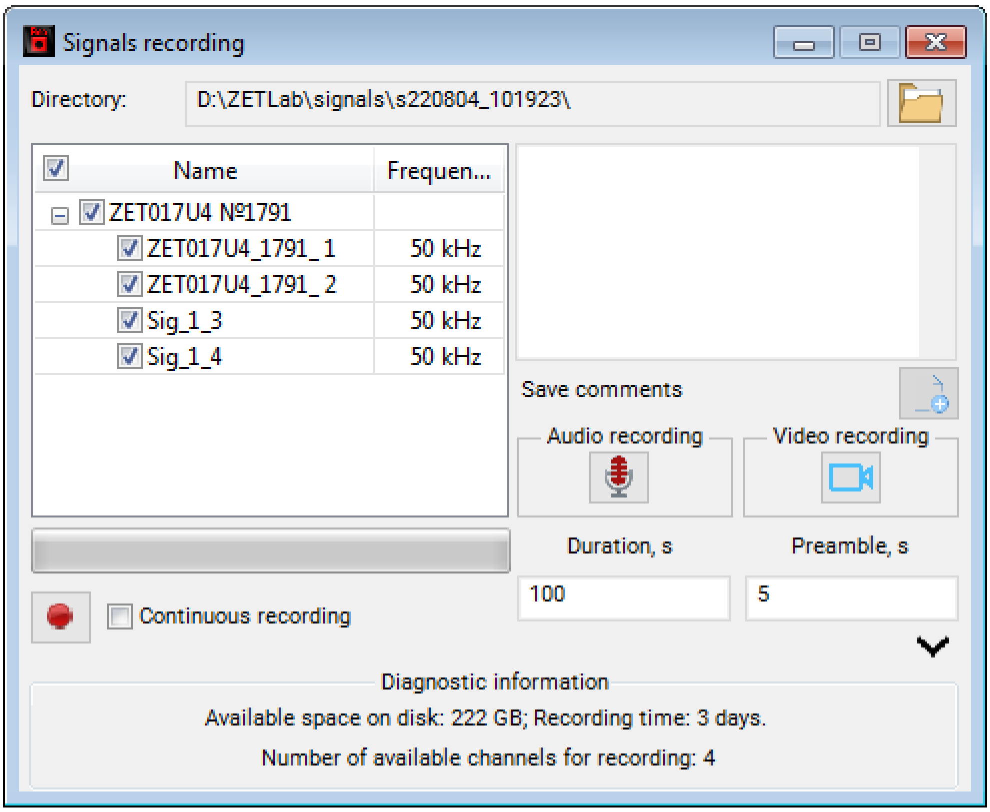
To start the program "**Signals recording**", select it in the "**Registration**" section of *ZETLAB panel*.

You will see the main interface of the program *Signals recording*. The top section of the interface displays the name of the program.

Note: the program "**Signals recording**" can also be started from ZETLAB directory (the directory by default: c:\ZETLab\). The name of the file to be started: SignalWriter.exe.



Starting the program Signals recording



Interface of the Signals recording program

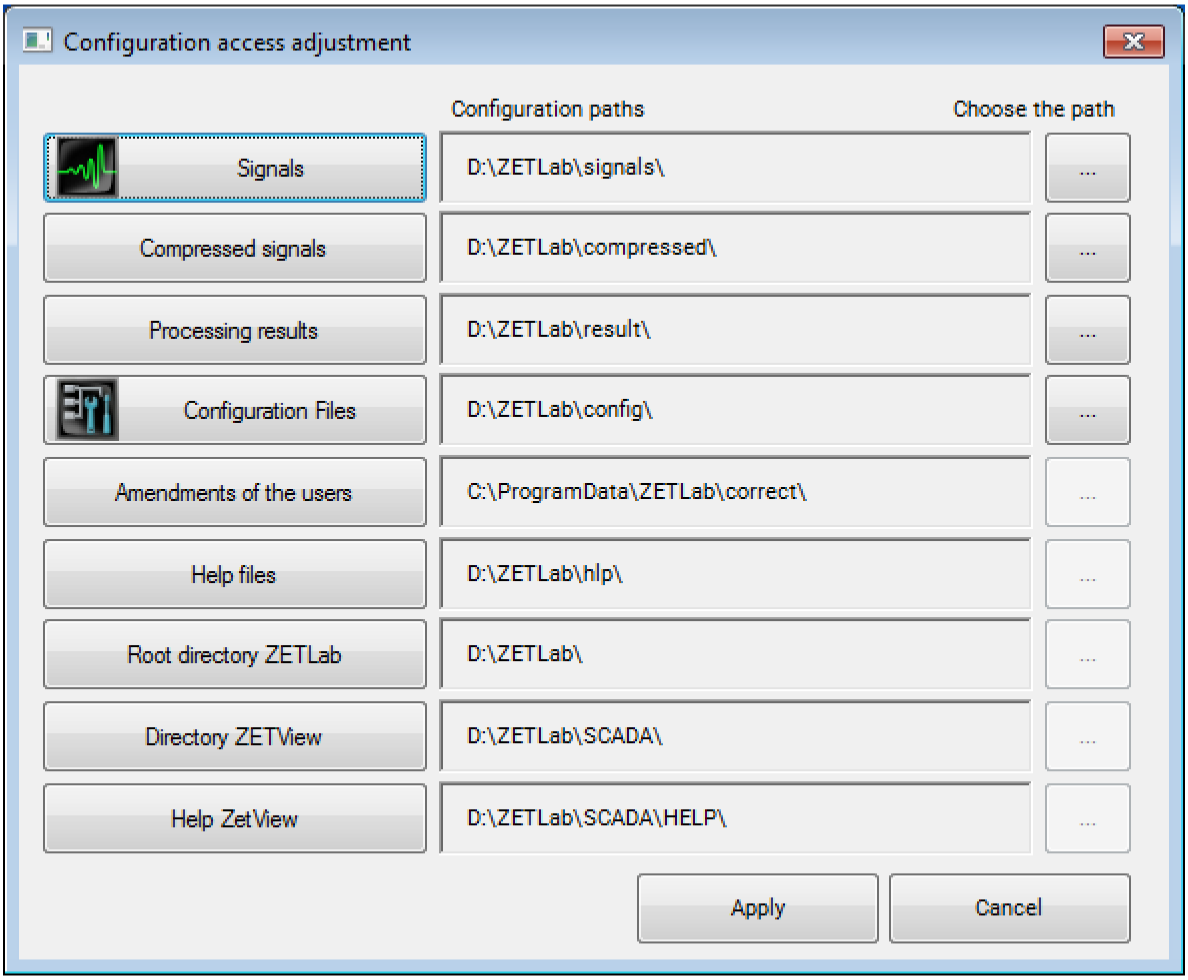
The program interface has the following control elements:

"**Directory**" – the current directory used for recording of the signals.

The key "**Current directory**" allows to enter the current directory used for recoding of the signals. It is also possible to set another directory for recording of the signals by changing the configuration path in **ZETLAB software**.

User configuration files in ZETLAB programs

User configuration files are displayed in the window "**Configuration access adjustment**", which can be started with the key "**User's path configuration**" available in the main menu of *ZETLAB panel*. The file directory is displayed in the section "**Configuration paths**". To the left from this section there is a key allowing to change the directory (i.e., to select another folder).



User configuration files in ZETLAB programs

User's path configuration menu

The "**Signals**" section is intended for saving the files, that were recorded with the use of the "**Signals recording**" program. The signals are saved in binary format (as a file in "*ana*" format) together with the file containing description (the file in "*anp*" format).

The directory "**Compressed files**" is intended for saving the compressed trends files to be further processed with *ZETLAB software*.

The directory "**Processing results**" is used for saving the files containing the results of *ZETLAB programs* operation. The files are saved in "*dtu*" format and can be viewed in such programs as "**Signals gallery**" and "**Results viewing**", as well as in any text editor.

The "**Configuration files**" directory is used for storage of the files containing configuration settings of *ZETLAB programs*. It considerably simplifies the use of *ZETLAB programs*, since there is no need for the user to adjust program parameters every time the program is used. Even if several program copies are started simultaneously, each of the program copies uses a configuration of its own.

The "**Amendments of the users**" directory contains configuration channels of the measurement channels and generator channels of ZET instruments.

The "**Help files**" directory contains a help file (operator's manual in "*chm*" format) for *ZETLAB software* and examples of programs operation.

The "**Root directory ZETLab**" section contains all *ZETLAB programs* and their software components.

The "**Directory ZETView**" contains files related to *ZETView software* and examples of program operation.

The "**Help ZETView**" directory contains help file (*ZETView* operator's manual in "*chm*" format) and examples of program operation.

Note! The changes in path configuration parameters are saved only upon activation of the "**Apply**" key.

The graphic contains the following Table of contents:

Selection – allows to enable/ disable the channel used for recording using the corresponding check-box;

Channel – ordinal number of the ADC channel;

Channel name - text name of the ADC channel (or a comment to it);

The key "**Save comments**" allows to add a text comment to a file. The "**Text comment**" section allows to leave a comment, that describes the recorded signal. It is possible to make several comments.

The **"Voice comment"** field - enables/disables recording a voice comment on a microphone connected to the spectrum analyzer sound card. There may be several such comments.

The "**Video Recording**" field - enables/disables video recording on a camera connected to a computer. There may be several such records.

The "**Duration, s**" section displays the duration of signals recording (in seconds). The duration of signals recording can be changed by using "up" and "down" keys (the interval length can also be set from the keyboard). As the recording interval is changed, the size of the file used for storage of the signal data will be extended automatically. As the certain threshold is exceeded (i.e., 50% of the disc space), the recording process is suspended and the "**Recording**" key becomes unavailable. As the program is started, the recording duration is set based on the data from the file*SignalWriter01.cfg*, which is located in the configuration files directory.

To the right from the key "**Duration, s**" there are the keys, which allow to start/ suspend the recording process. As the program is started, the keys are not active. As the recording process is enabled, the appearance of the keys will be changed.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Signals recording program - main control keys

The program also has a number of pop-up tooltips. i.e., as the mouse pointer is located above a particular element, there appears a tooltip describing this element, its properties and function.

If the option "**Continuous recording**" is enabled, the program will perform a single recording of the set duration.

The checkbox "**Continuous recording**" also saves the registered parameters for the set interval of trends recording.

In the *ZETLAB software* package the function of trends recording is available in the programs "**Signals recorder**" and "**Multi-channel recorder**". Both programs record the source signals with a particular sampling frequency and represent the information with a set compression degree. In addition to that, the program "**Multi-channel recorder**" also allows to view the dynamics of signal’s RMS, frequency, etc.

Each of the channels used in the program "**Signals recording**" has two corresponding files: one with "*ANP*" extension (name, sampling frequency, code of the device, sensitivity ratio, offset, etc.), and the other with "*ANA*" extension (this file contains ADC data in binary format). All the ADC counts contain 32 bits or 4 bytes. Hence, the recording process for 200-channel system at the sampling frequency of 10 Hz requires the following free disc space volumes depending on the duration of the recording:

1 second	20Ч10Ч4=8000=8 kb
1 hour	20Ч10Ч4Ч3600=28800000=28 Mb

1 day	20Ч10Ч4Ч3600Ч24=691200000=690 Mb

Thus, prior to the recording process, it is necessary to make sure, that there is enough free disk space available.

Note:

1. In the case, if there is no free disk space available(or it is less than 10%), the recordings will be started anew in accordance with their chronological sequence.

2. The comments are saved to the corresponding folder in the ***SignalWriter*** directory only in the case if the key "**Save comment**" is used, and the comment is displayed in the corresponding section of the program window. If a comment is entered when the recording process is not yet started, then upon activation of the "**Save**" key, the comment will not be saved either.

Additional Information .....

Additional information:

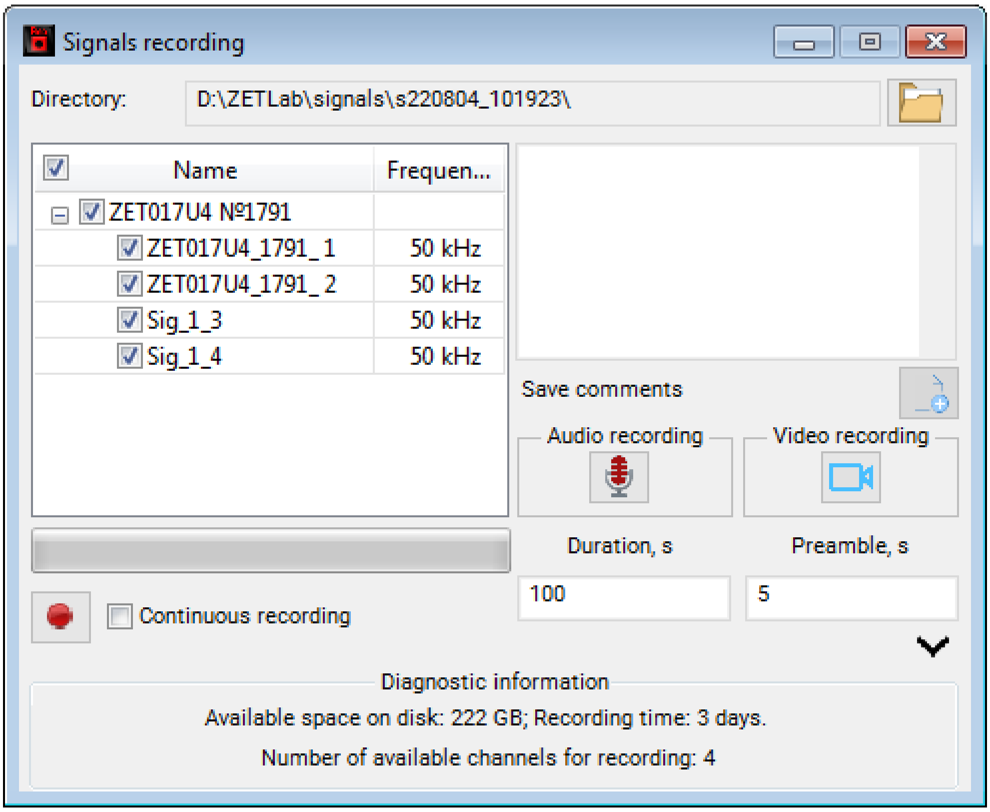
·additional information on using the option "**Continuous recording**",

·additional information on using the *signal trends.*

Additional information on using the option "Continuous recording" .....

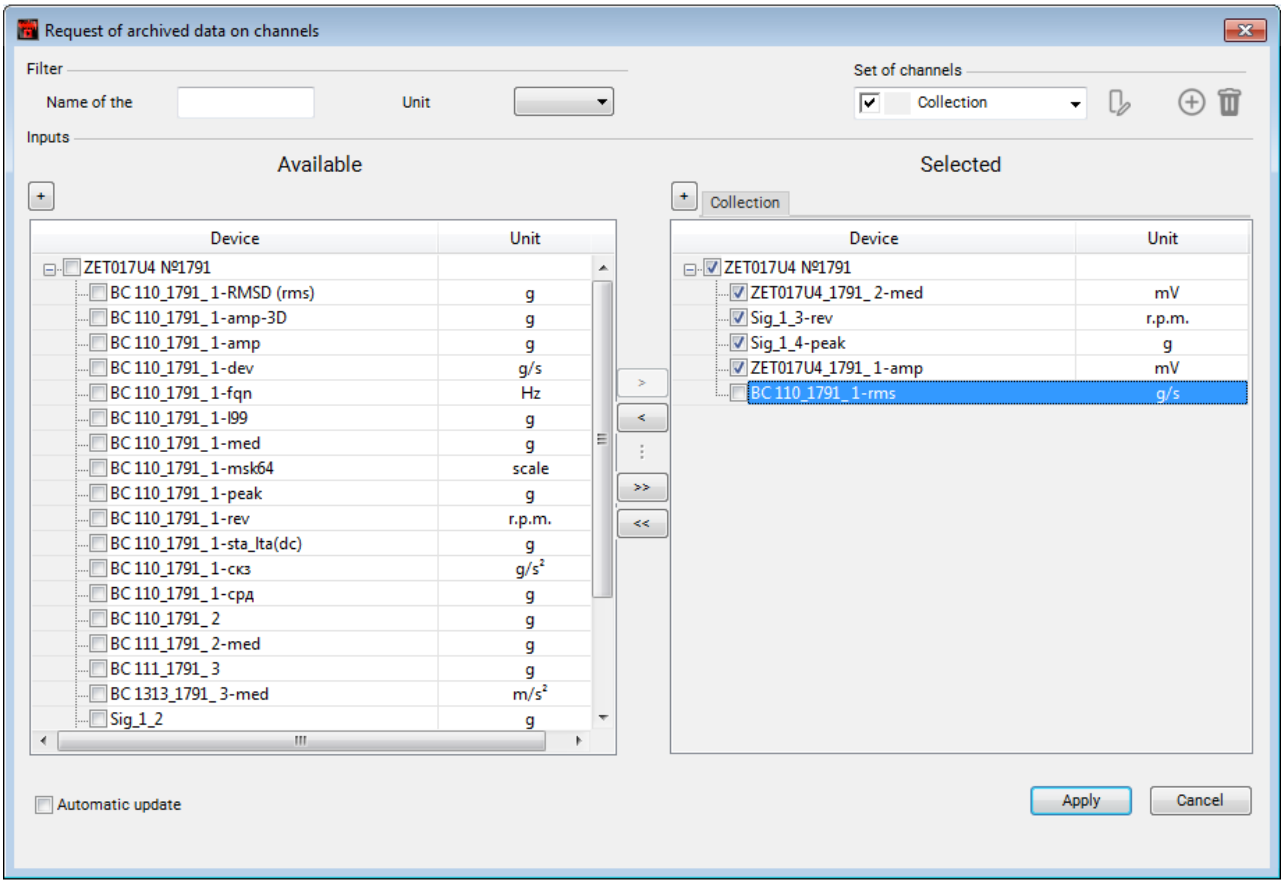
Additional information on using the option "**Continuous recording**":

Enter the tab "**Registration**"-> start the program "**Signals recording**", enable the option "**Continuous recording**" (see the Fig.) and start the recording of the signal with the specified duration. Upon completion of the signal recording, click the "**Stop**" key.

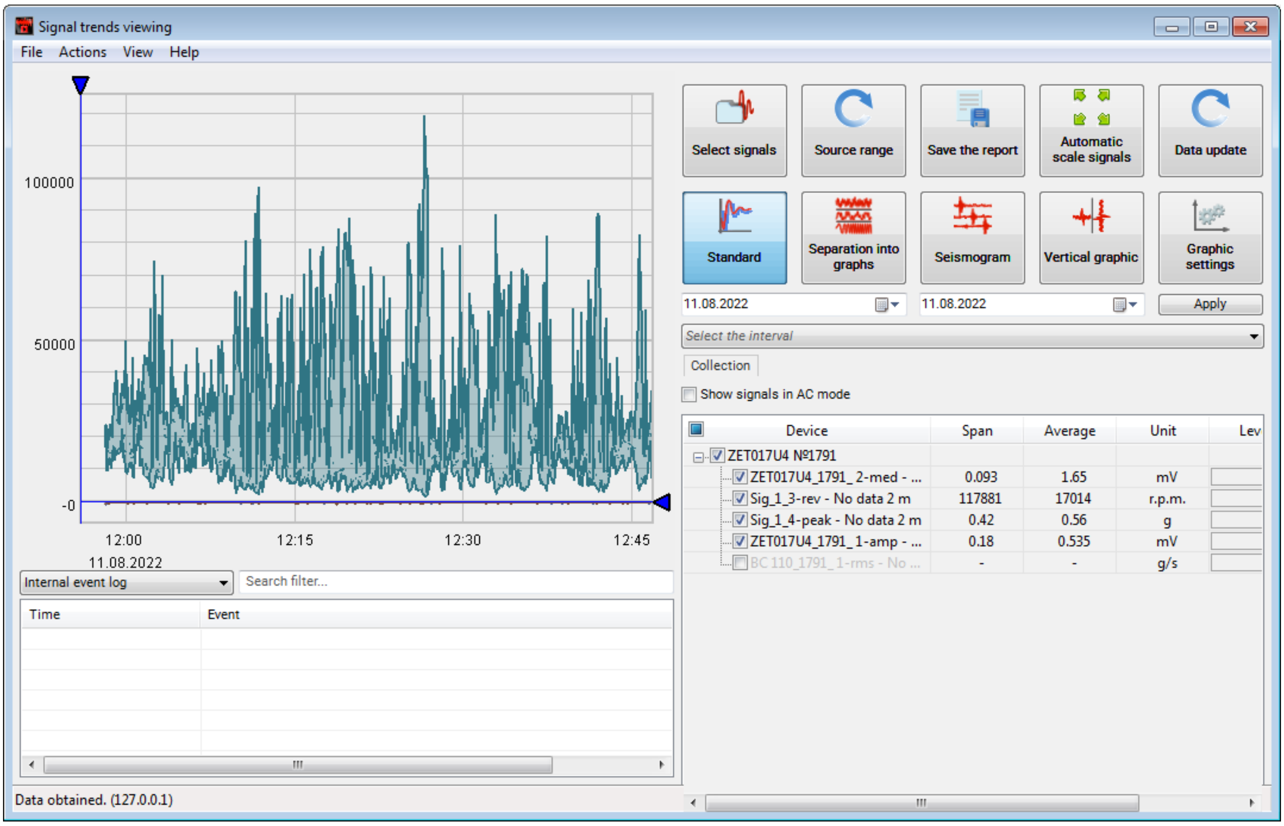


***Signals recording** - Continuous recording option*

As the data recording process is complete, start the program "**Signal trends viewing**", select the required time interval (see the Fig.). Click the key "**Select signal**" and choose the required file from the list.



Signals recording - selecting the file to be Play recorded signals



***Signals recording - Signal trends viewing** program interface*

Then select the option "**Actions**"->"**Play recorded signals**". Click the key "**play**" in the program "**Play recorded signals**" (please note, that it is necessary to close the program "**Signals recording**").

Start the program "**Signals recording**" located in the "**Display**" section of *ZETLAB panel*, then click the keys "**Stop**" and "**Recording**" (see the Fig. below).

Open the saved file using the program "**Results viewing**".

In order to enable parallel representation of the signal graphics, paste the data from the other recorded file (see the Fig. below).

Additional information on using the signal trends .....

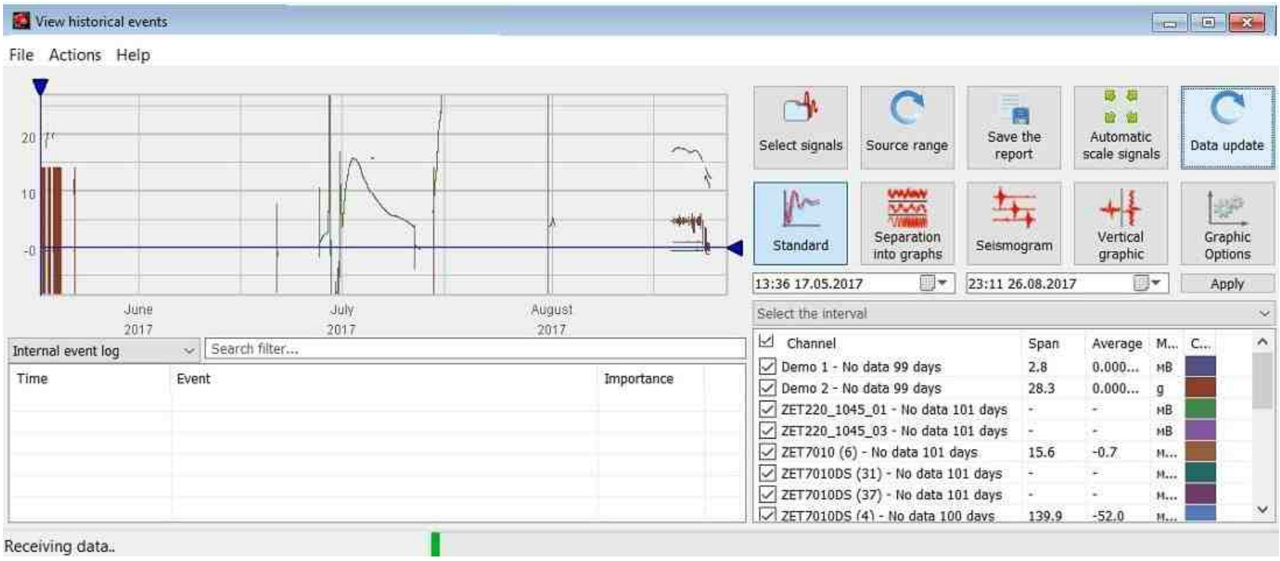
Additional information on using the signal trends:

There are several available compression degrees that can be used for creating the signal trends: *1 second, 10 seconds, 1 minute, 10 minutes*, etc. Depending on the duration of the selected signal, it is possible to use various compression degrees. For instance, in order to view a signal trend for 1 year, the compression degree of 10 minutes can be used, while for the period of 1 day the compression degree can be up to 1 second. The program also has zeroing option, which allows to measure relative values.

The recorded data is arranged into folders: by year, month, day, hour. A special feature of hour records is their synchronization with the time of the PC. Compressed (i.e., averaged) signals are recorded to a different directory with the folders arranged by months and years. These values stand for the period of 1 month and have various compression degrees: 1 s, 10 s, 1 min, 10 min, 1 hour, 4 hours, etc.

The functions of signal trends viewing and representation are implemented in various applications, since in most cases, the information is stored at a data server, while the trends analysis is normally conducted at automated workstations. The application used for analysis, processing and sending of the data is started at the server, while the work station is used for receiving of the processed data and trends representation.

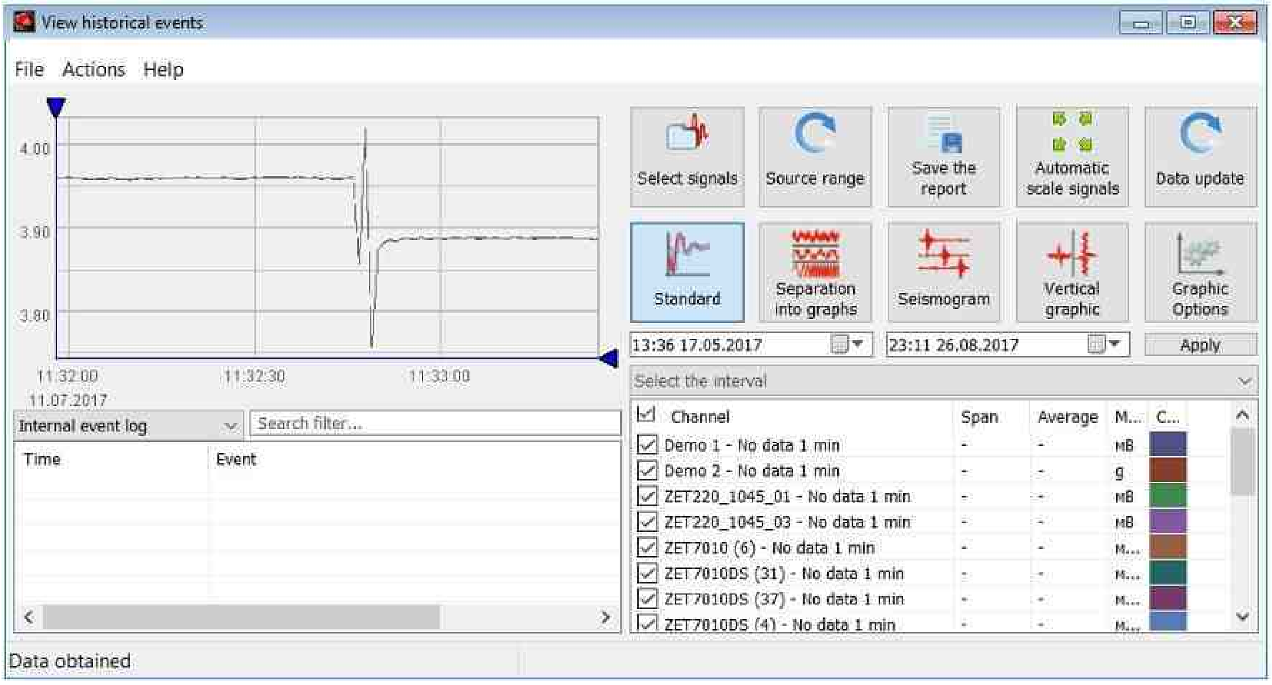
In order to establish connection with the server, start the application used for displaying of the trends, and enter the corresponding IP address of the server. In the case, if the data server and the workstation are represented by one and the same PC, it is necessary to enter the local host: 127.0.0.1. As the connection is established, the program will automatically display the signal trends for the entire period of measurements (see the Fig. below).



***Signals recording** - signal trends representation for the entire period of measurements*

For a more detailed data representation (see the Fig.), it is also possible to select the time interval, particular type of the signals, or the measurement units to be used for data representation purposes.

In the course of trends viewing, it is possible to change the scale of the displayed graphic (as the scale is changed, the program automatically calculates the required data volume and compression ratio to be used for data representation).



Signals recording - Additional options of trends representation parameters

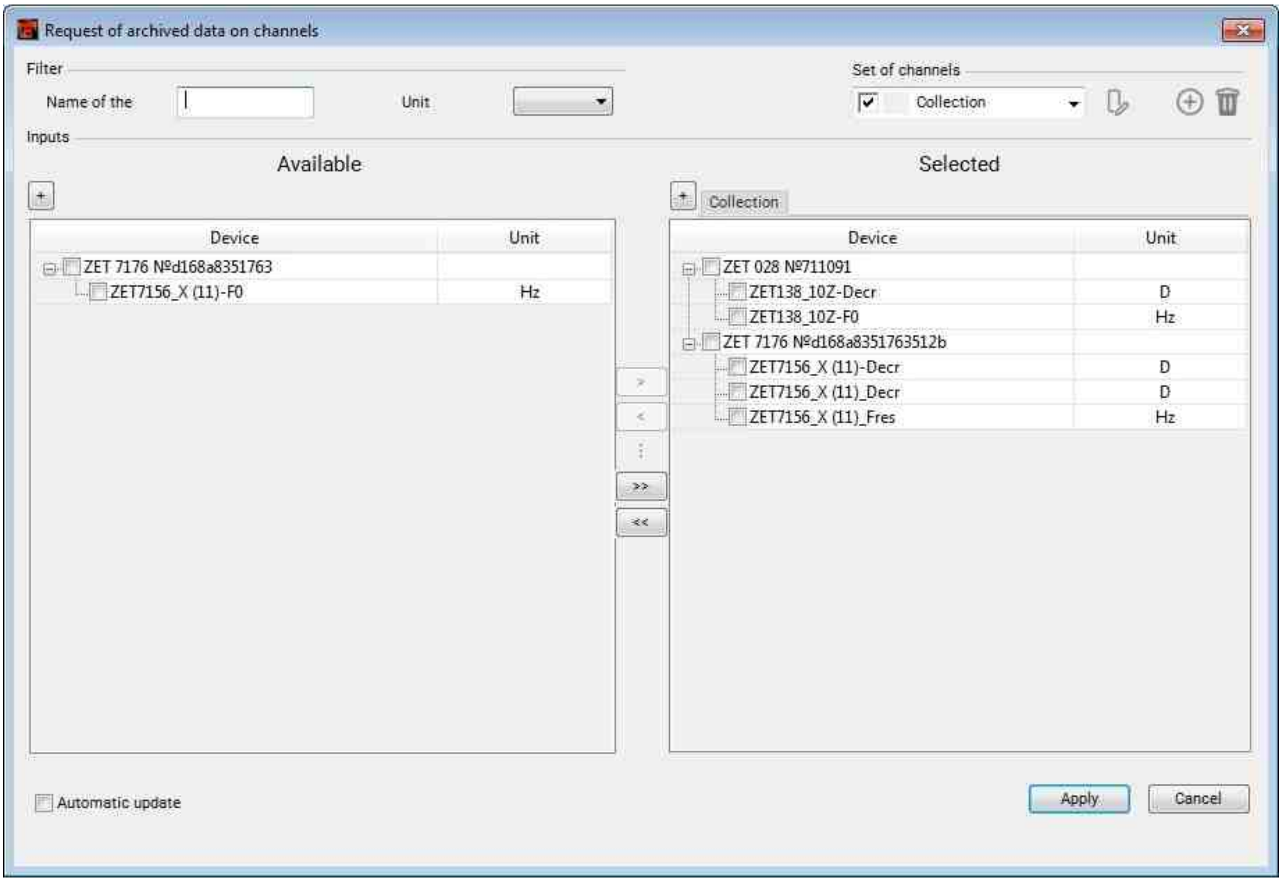
The program also allows to arrange absolute and relative measurement data, to go back to the initial range (i.e., to the initial trends view format), to save the reports in *.csv* format, to print the measurement data, to view the events database as well as to view the historical events.

The signal trend allows to view short-term as well as long-term registered values, and the values of a particular parameter. The variable signals compression rate allows to view the registered values for a long period of measurements performance, to analyze signal's form/ envelope. The program has a user-friendly interface, which enables comprehensive analysis of signal parameters.

The signal trends option is useful for many application spheres (including temperature measurements, fracture openings control, etc.). The program also simplifies tensile and compression measurements with the use of strain gauges (the measurement process is rather long, and depends on temperature fluctuations): the use of signals trend option makes the analysis of the results more comprehensive.

If you are using one of the previous software versions of ZETLAB software, which does not have the function of trends recording and representation, you can still use the option of converting the previously recorded files for the purpose of subsequent signals trends viewing.

The program dialog for selection of the signals:



Signals recording - Program dialog used for selection of a particular channel

The **list of available signals** contains all the channels available in the database.

The **list of the selected channels** displays the channels that are currently displayed in the program.

It is also possible to set the time interval for data representation.

The program also has a quick search function. It is possible to conduct search by name of the signal and the measurement units. For the search purposes the following symbols can be used:

? – any symbol

***** - arbitrary number of any symbols

; - separator between different masks

Questions and answers:

Question: I have failed to view any information in the functions "*Viewing of trends and historical events*". The program does not seem to operate properly – I cannot select a folder with files or to set the date for files search.

Answer: The program *Trends viewing* is used for analysis of the signals recorded in constant mode. If you record the data as a range of separate entries, it will be impossible to view anything with the use of this program. The signal trends are normally used in the case of constant monitoring purposes. It is also possible to edit the records in the program Signals gallery.

Signals recording process .....

Before starting the process of signals recording, it is necessary to set parameters of the program.

The section "**Directory**" displays the current directory used for signals files recording.

Upon activation of the "**Recording**" key, the program creates a directory for saving the file (the directory contains current date and time). The directory address as well as the folder used for signals recording can be viewed and set in the main menu of the program. This menu also allows to save/ open projects, to activate *ZETLAB task manager* program, and to view configuration path of the current user.

Then it is necessary to assign the channels to be used for data recording and to select the recording duration. As a new recording duration is set, the size of the file to be used for saving of the recorded signal will be changed by the program automatically. As a certain threshold value is exceeded (i.e., 50% of the free disc space available), it becomes impossible to conduct the recording (the respective keys become unavailable as it is shown in *Fig. 3* below).

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Signals recording - control keys used in the program

It is also possible to enter a common text comment for the signal files as well as to create several text comments. To do that, click the key "**Write comments**", enter the comment and click the "**Enter**" key.

In order to start the recording process, click the corresponding key (see *Fig. 1* above). As the recording process is started, the section above the key "**Recording**" serves as a status bar indicating the recording process progress as well as the current duration of the recording process.

Note:

1. Upon activation of any key used for the beginning of recording process, the program displays the corresponding directory used for saving the file. In the case if the directory is not assigned, the program will offer the user to create it prior to the beginning of signals recording.

2. The text comments to the signal files are stored in the same directory with signal files and have "*txt*" extension. The text comments can be viewed in any text-editing program.

3. The text comments to the signal file can be created before/ after/ and in the course of signals recording.

Format of signal files and description files .....

Upon activation of the signals recording process, the program creates a set of *SIGXXXX.ANA* and *SIGXXXX.ANP* files in the directory *s130425_094633*. The section *XXXX* changes for *0001, 0002, 0003*, etc.

The name of the directory - *s130425_094633* contains information about the time and date of the recording process.

SIGXXXX.ANA is a file containing digitized data. The data is represented by 16-digit integral numbers in complement numbers. These numbers stand for sequential digitized signal counts by a particular channel of ADC module.

SIGXXXX.ANP is a file containing description of the recorded files. The structure of such file is described below:

----- beginning -----

Line of the file	Description
BC 201	- name of the signal input channel
COMMENT Point 5 in the Black Sea water zone	- comment
GAIN 1.000000	- amplification ratio of the programmable amplifiers and filters
ABSVOLT 0.000318757	- ADC's LSB in Volts
FRQ 50000.000000	- signal'sampling frequency in Hz
TMI 0	- initial time shift of the signal
FRL 0.00	- LPF cutoff frequency
FRH 25000.00	- HPF cutoff frequency
FORMAT f2	- data representation format – integral number, 16 bits
START 9:41:38.000	- time of signal recording
DATE 25-04-2013	- data of signal recording

CHANNEL 1 TypeAdc 16 **NumberAdc 0 Serial 428** **GroupName ZET048I No.428**	- input channel number, device type, serial number of the device, name of the device series
MAXLEVEL 23.3298	- maximal admissible level of the signal.
SENSE 0.5	- sensitivity of the primary transducer used for conversion of the physical value into voltage
CONVERT m/s^2	- name of the measurement unit used
AMPL 0.003162	- amplification ratio of pre-amplifier or intermediate amplifier
REFER 0.02	- threshold value for calculations in dB. For electricity this value is 1 mkV, for hydroacoustics – 20 μPa, for vibration - 300 μm /s^2
AFCH g26	- file with AFR corrections of the measuring lines
DC 0	- DC offset in the signal

----- the end of the file -----

Examples for the section .....

Table of contents

The "Short recording" scenario .....

The "**Short recording**" scenario is recommended for registration of short-term fast processes. As a rule, for this scenario of operation, the duration of the recorded signals should not exceed 5-10 minutes, which makes it possible to easily analyze the recorded signals. When working according to the "**Short recording**" scenario, the following sequence of actions is performed:

1. Start the "**Signals recording**" program from the "Registration" menu of the ZETLAB panel.
2. In the opened window of the "**Signals recording**" program (*Fig. 1.1*):
   - ✍ Select the measuring channels whose signals you want to register;
   - ✍ In the "Duration" field, set the duration of the «**Signals recording**»;

✍ Press the button to start recording «».

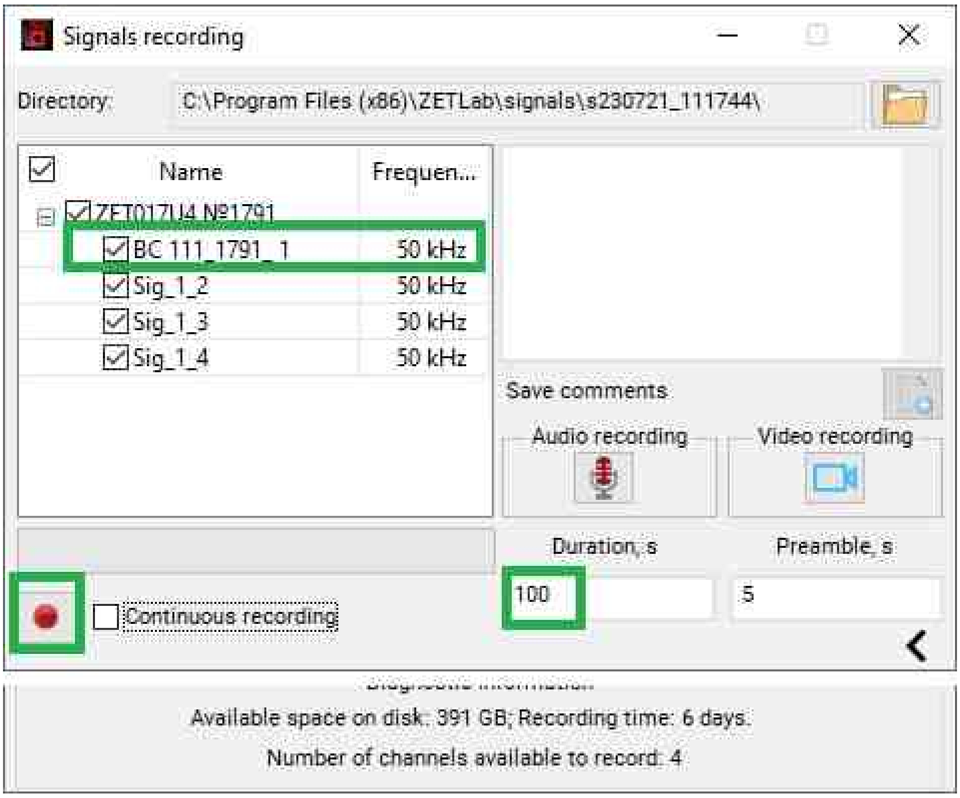


Fig. 1.1 "Signals recording" program

3. Wait for the Signals recording to finish. To view the recording results, open the folder with registered signals in the "**Signals recording**" program window by pressing the " " button. From the directory that opens, open a file with the extension *". ana "* by the "Signals gallery" program from the "Display" menu of the ZETLAB panel (*Fig. 1.2*).

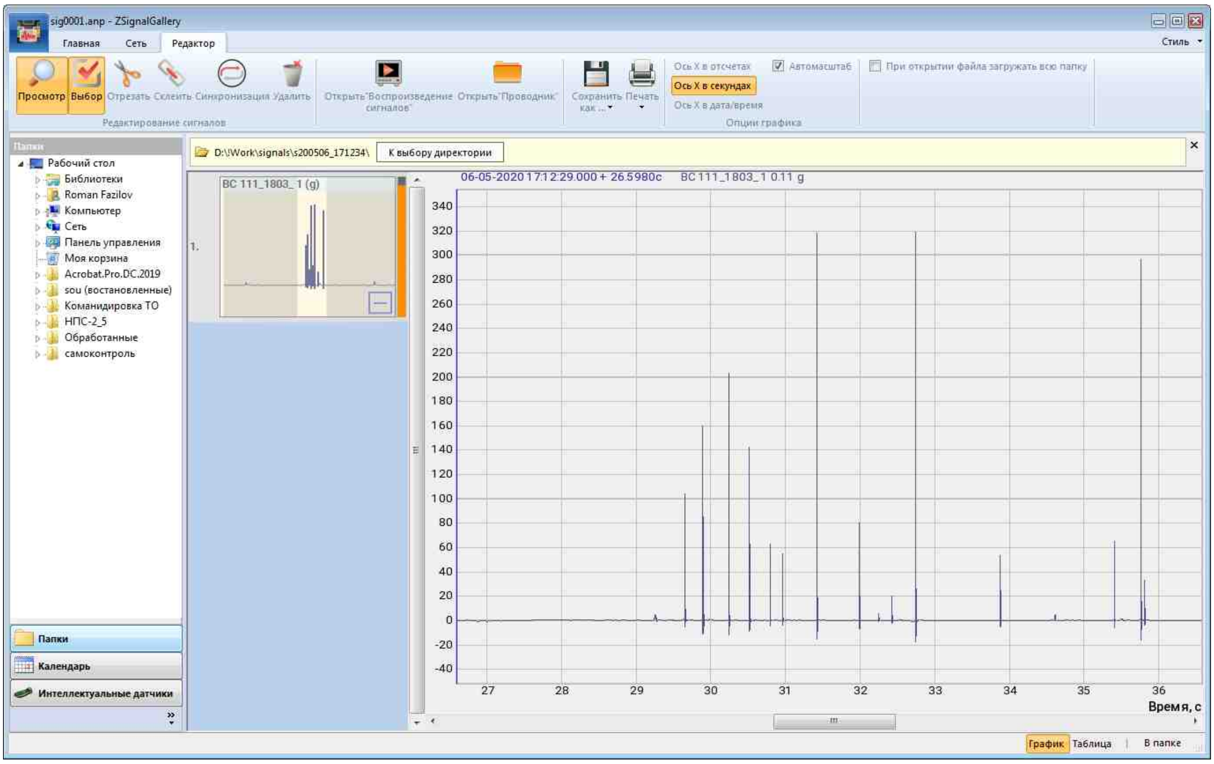


Fig. 1.2 Signals gallery program

4. If it is necessary to analyze and process the temporal realizations of the registered signals in real time, open the "Play recorded signals" program from the "Registration" menu of the ZETLAB panel. In the program window "Signal playback" (*Fig. 1.3*):

- Press the "Select directory" button and select the directory of registered signals in the window that opens;
- If it is necessary to play back a Signals recording from a certain point in time, place the cursor on the corresponding time mark on the preview graph;
- To auto-repeat playback of the recorded signal, check the box "Cyclic";
- Press the " " button to start playback .

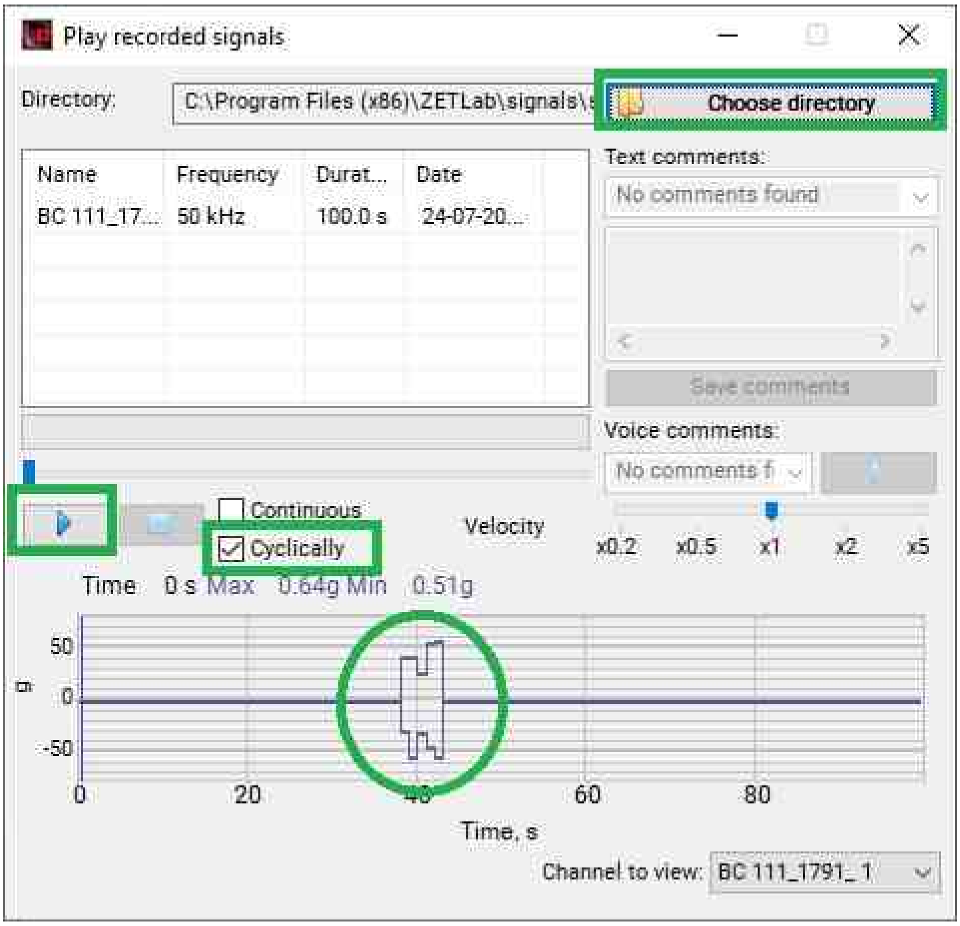


Fig. 1.3 «Play recorded signals» program

5. After starting program "Play recorded signals", the recorded signals become available for programs from the ZETLAB software used for signal processing. Most requested programs:

- "Multichannel oscilloscope" (ZETLAB panel, section "Display");
- "Narrow-band spectrum" (ZETLAB panel, section "Signal analysis");
- “Mutual narrow-band spectrum” (ZETLAB panel, section “Signal analysis”);
- “Modal analysis” (ZETLAB panel, section “Signal analysis”);
- "Cross-correlation analysis" (ZETLAB panel, “Signal analysis”), etc.

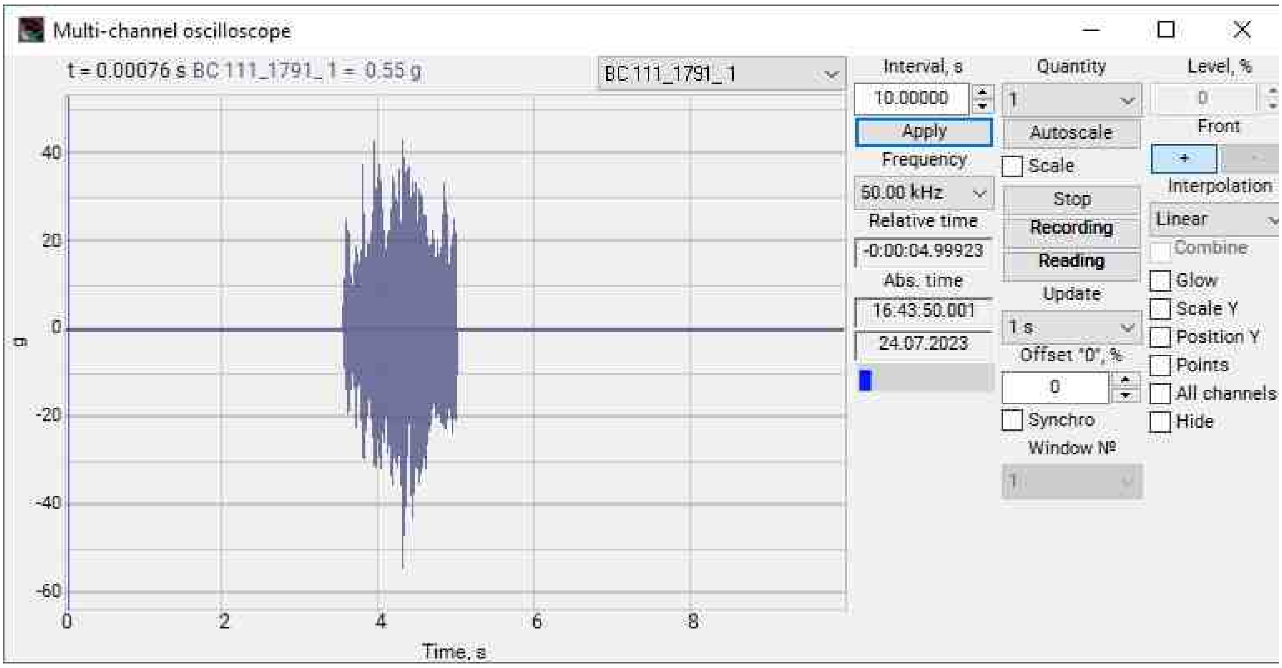


Fig. 1.4 Program "Multi-channel oscilloscope"

The «Continuous recording» scenario .....

The scenario "**Continuous recording**" is recommended to be used in cases of registration of long-term processes, when C**ontinuous recording** of signals is performed (up to continuous monitoring), followed by analysis of the registered signals in the time domains corresponding to the registered events.

When working with the "**Continuous recording**" scenario, the following sequence of actions is performed:

1. Launch the "**Signals recording**" program from the «Registration» menu of the ZETLAB panel.
2. In the opened window of the "**Signals recording**" program (*Fig. 2.1*):
   - ✍ Select the measuring channels whose signals you want to register;
   - ✍ Check the box " **Continuous recording**";
   - ✍ Press the “ ” button to start recording .

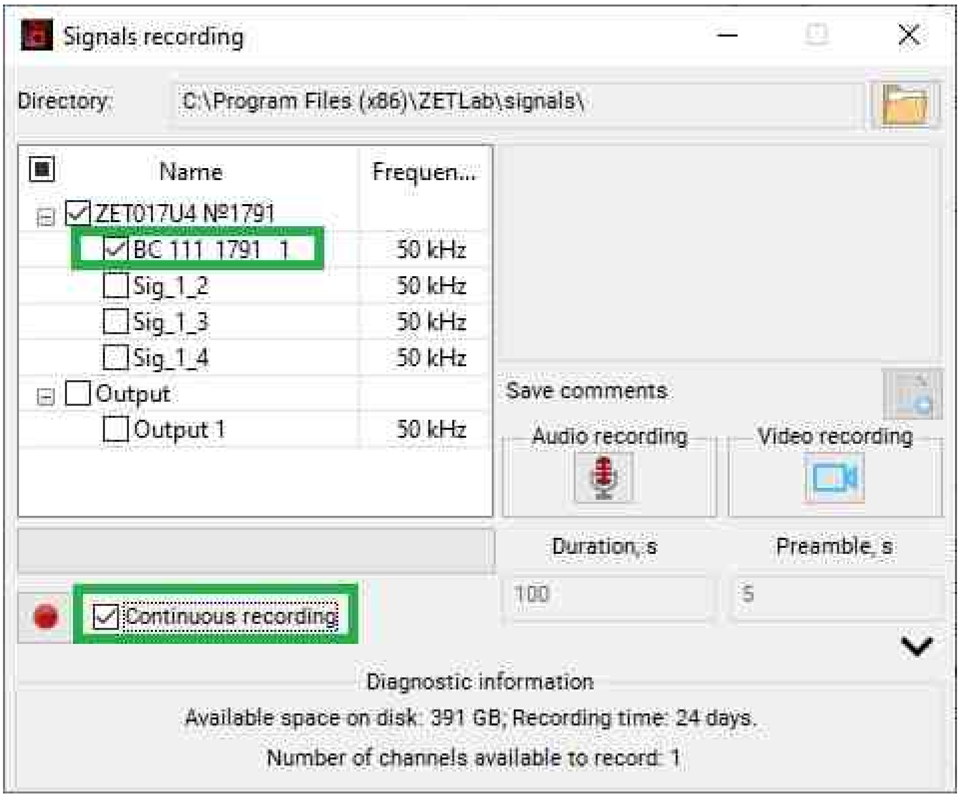


Fig. 2.1 "Signals recording" program

3. When working in the continuous recording mode, the **Signals recording** program creates hourly duration files along the hour boundary. Even if the recording starts and ends at an arbitrary time, the time of the hour at which the recording was not performed is supplemented in the file with a code indicating the absence of data. This approach makes it possible to link both continuously recorded signals and periodically recorded signals from common sources (from unchanging identifiers of measuring channels) into single long-term trends.

4. It is convenient to view the signals registered in the continuous recording mode using the "**Signal trends viewing**" program (*Fig. 2.2*), which is launched from the "Registration" menu of the ZETLAB panel.

5. To view the signals in the "**Signal trends viewing**", connect to the data server and select the measurement channels to display the corresponding signals on the graphic. When viewing graphics, you can zoom in or zoom out the display area (scale), which allows you to view the signal fragment of interest in detail.

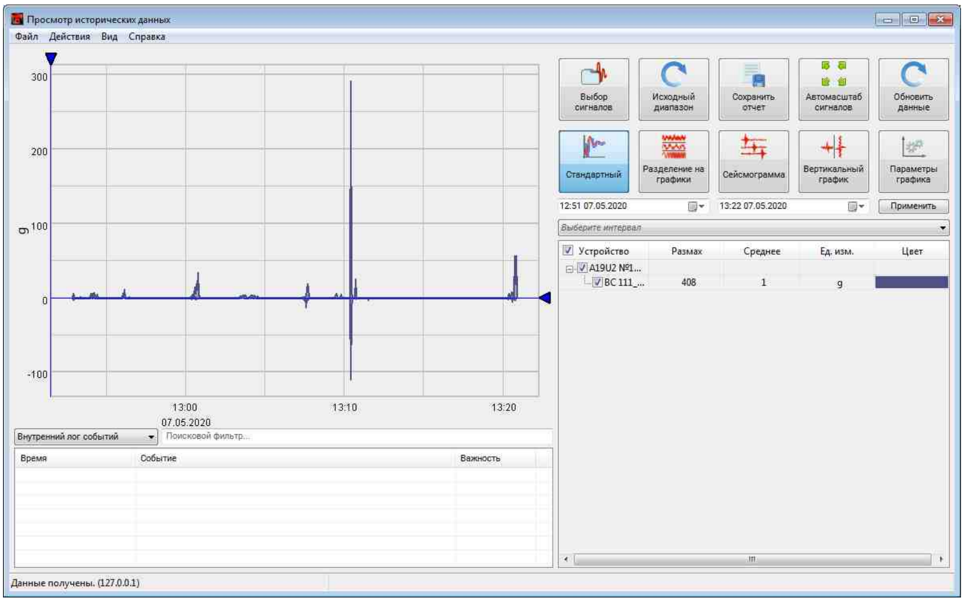


Fig. 2.2 Signal trends viewing

6. If it is necessary to analyze and process the temporal realizations of the registered signals, zoom in on the area of interest on the chart and start the "**Play recorded signals**" program from the "Actions" menu (*Fig. 2.3*) of the " **Signal trends viewing** " program.

Fig. 2.3 Menu "Actions"

7. In the opened window of the " Play recorded signals" program (*Fig. 2.4*) a directory with an hourly record containing the area of interest will automatically open. To play back a Signals recording from a certain point in time on the preview graphic, place the cursor on the corresponding time mark. If you need to play a recording lasting more than 1 hour, then you should check the box "Continuously Press the button to start playback. «».

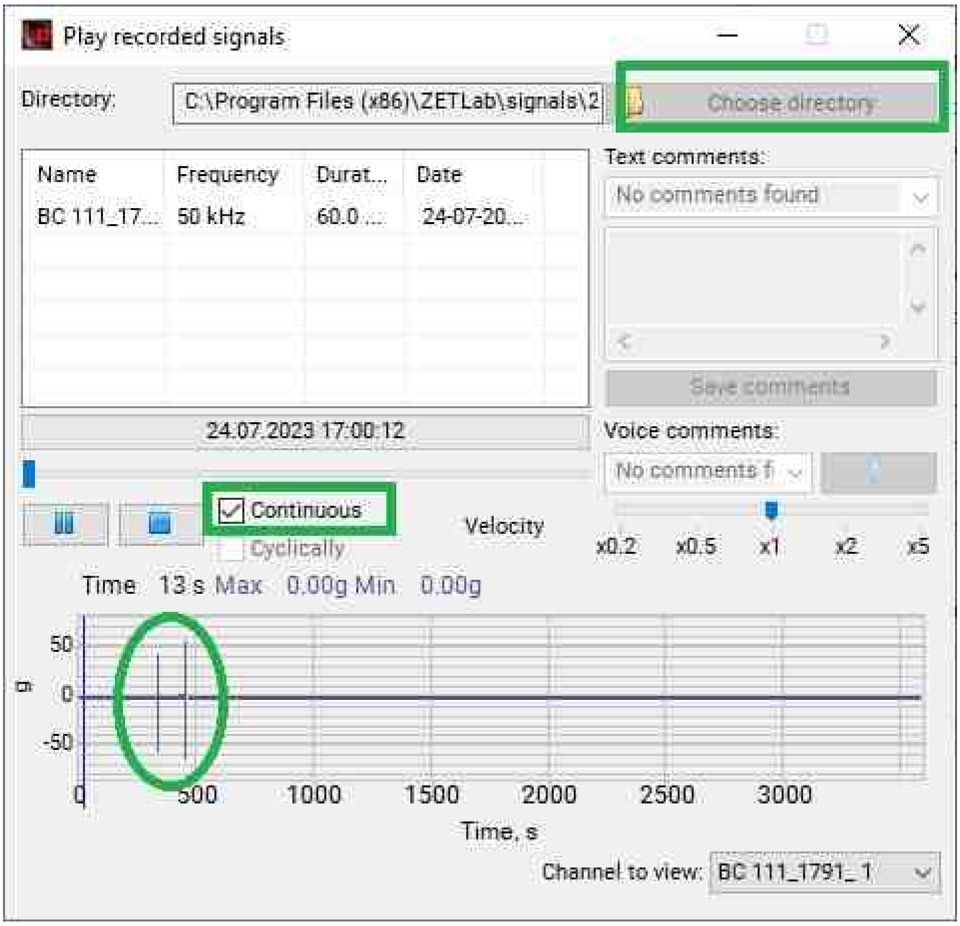


Fig. 2.4 «Play recorded signals» program

8. After starting the Play recorded signals, the recorded signals become available to the programs from the ZETLAB software used for signal processing. Most requested programs:

- "Multichannel oscilloscope" (ZETLAB panel, section "Display");
- "Narrow-band spectrum" (ZETLAB panel, section "Signal analysis");
- “Mutual narrow-band spectrum” (ZETLAB panel, section “Signal analysis”);
- “Modal analysis” (ZETLAB panel, section “Signal analysis”);
- “Cross-correlation analysis“ (ZETLAB panel, “Signal Analysis”), etc.

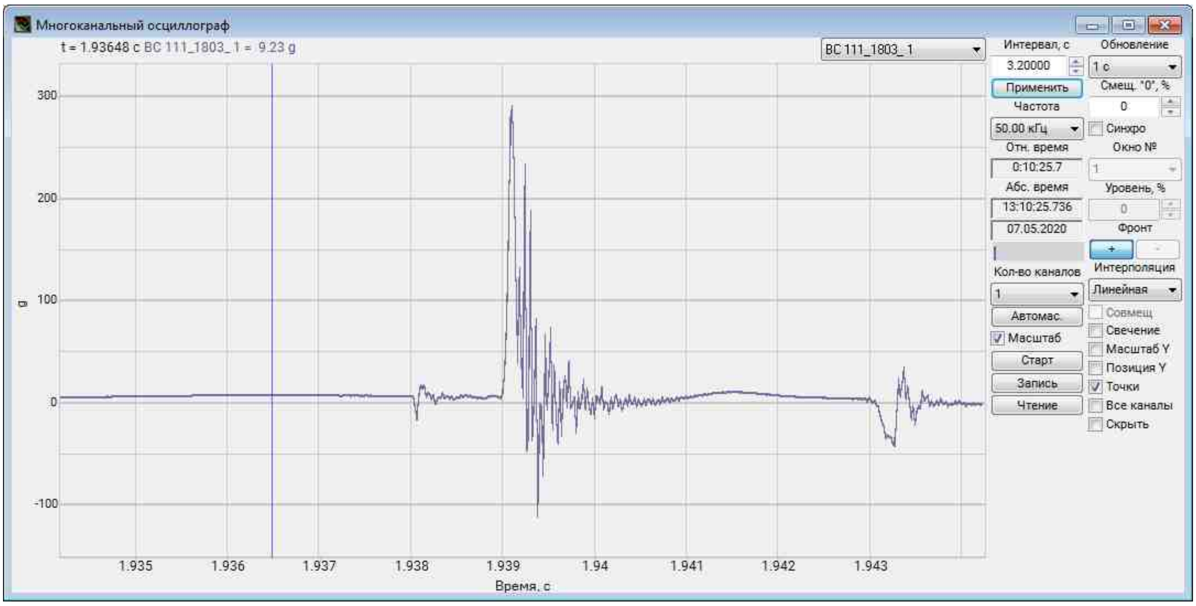


Fig. 2.5 Program "Multi-channel oscilloscope"

Signals conversion .....

The program **Signals archive converter** is intended for conversion of the recorded signals saved in the formats typically used in ZETLAB Company (ana/ anp) into compressed data. The data from the devices used for seismic research performance are in the MiniSEED format.

Additional functions of the program Signals archive converter:

- Combine the channels without the reference to the device
- Combine the channels without reference to the names of the channels.

Data conversion into MiniSEED format .....

Start the program Signals archive converter: "*My Computer*" - > "Local disk" -> "ZETLab" -> "SignalConverter.exe"

The dialog window of the program is shown in Fig. 1.

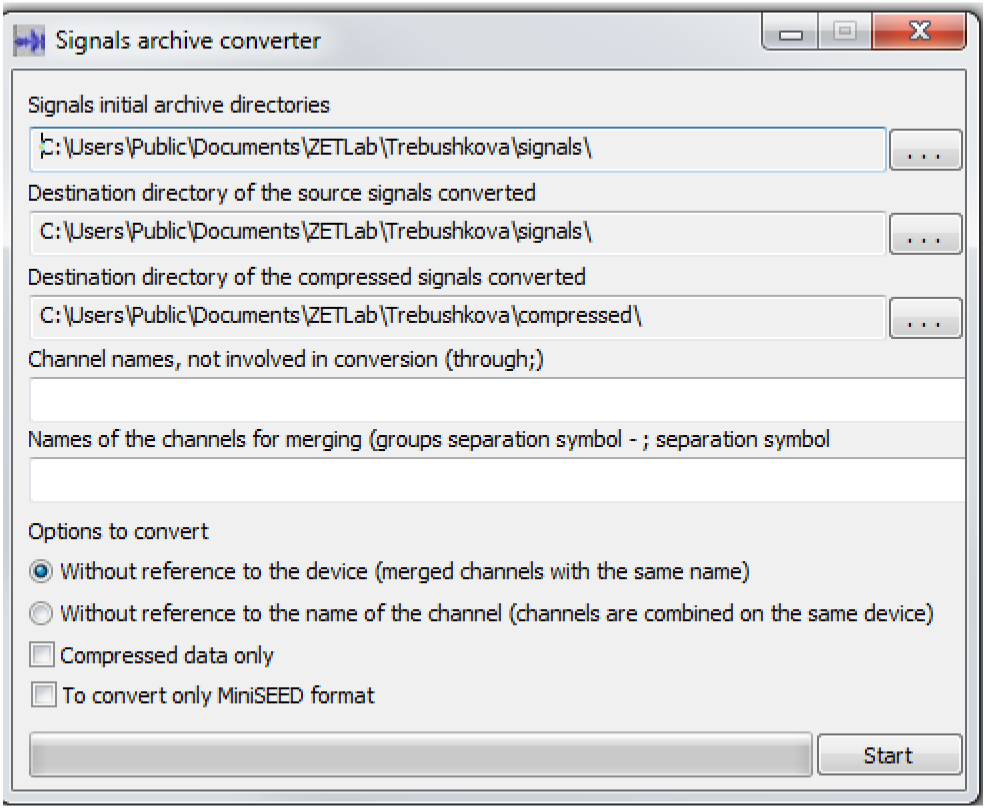


Fig. 1 Dialog window of the program SignalConverter

For data conversion into MiniSEED format, mark the checkbox "Convert into MiniSEED only", as it is shown in Fig. 2

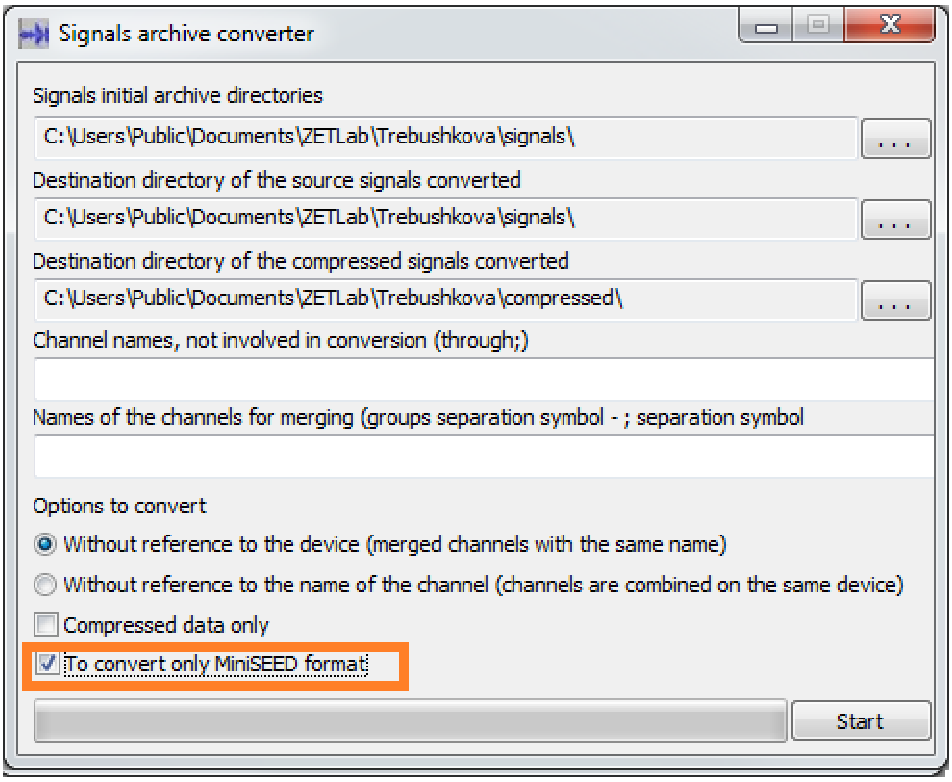


Fig. 2 Select of the MiniSEED format option

The next important step is the selection of the data for further conversion. Choose the directory with data in ana/anp format.

note:

- The device used for recording of the data should be represented by **SEISMIC RECORDER.**
- Sampling frequency should be less then 1kHz.
- Measurement units by the channels:
    1. Velocity
    2. Acceleration
    3. Displacement.

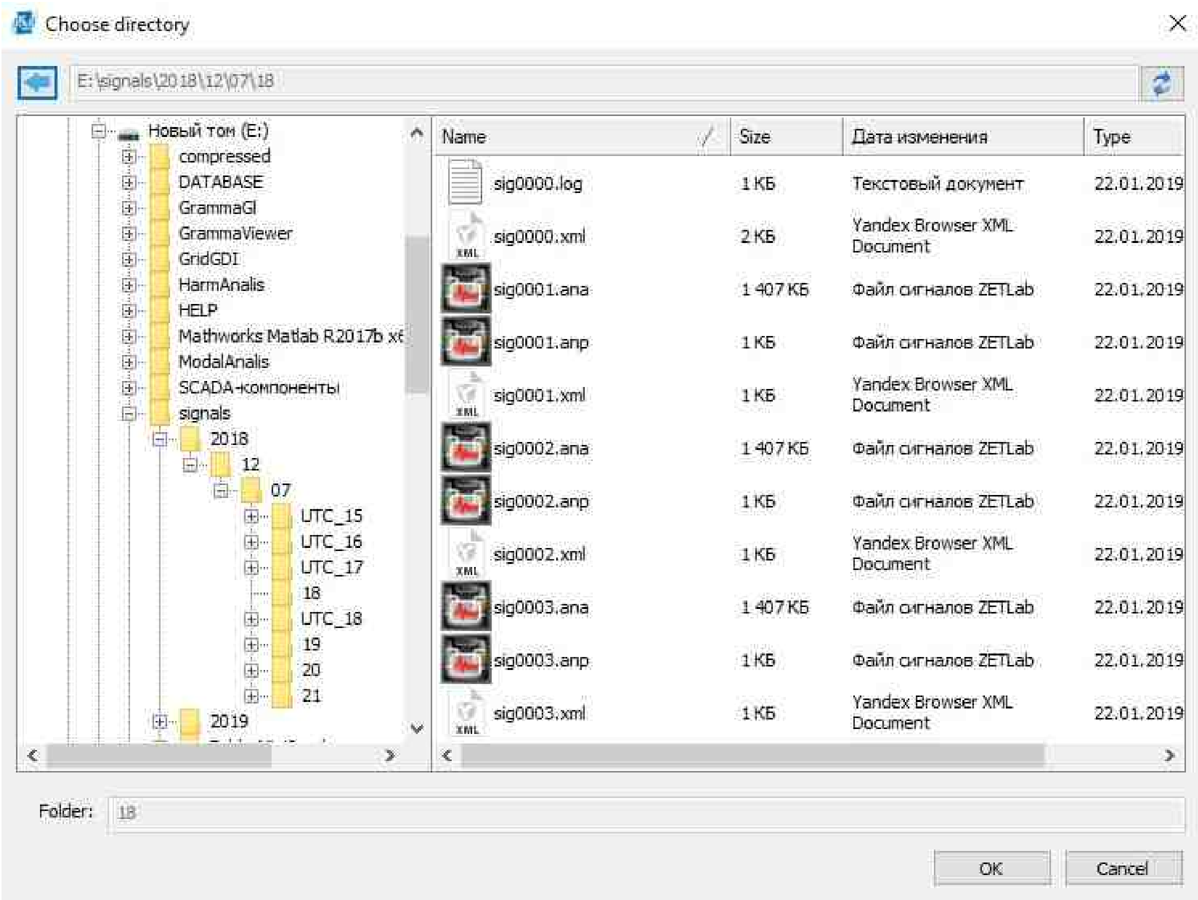


Fig. 3 Select of the signals archive directory

It is also important to assign the directory for storage of the converted signals.

<u>Notes</u>:

- Do not use the "space" symbol in the name of the folder.
- The converter will create the following folders in the specified directory: yyyy\mm\dd\hh (in the UTC format)\Device type _Serial number _ recording date.

Then click the "Start" key and wait for the completion of the conversion process (Fig. 4).

Note: the channels are combined into groups - 3 ana/anp files are combined into a single MiniSEED file.

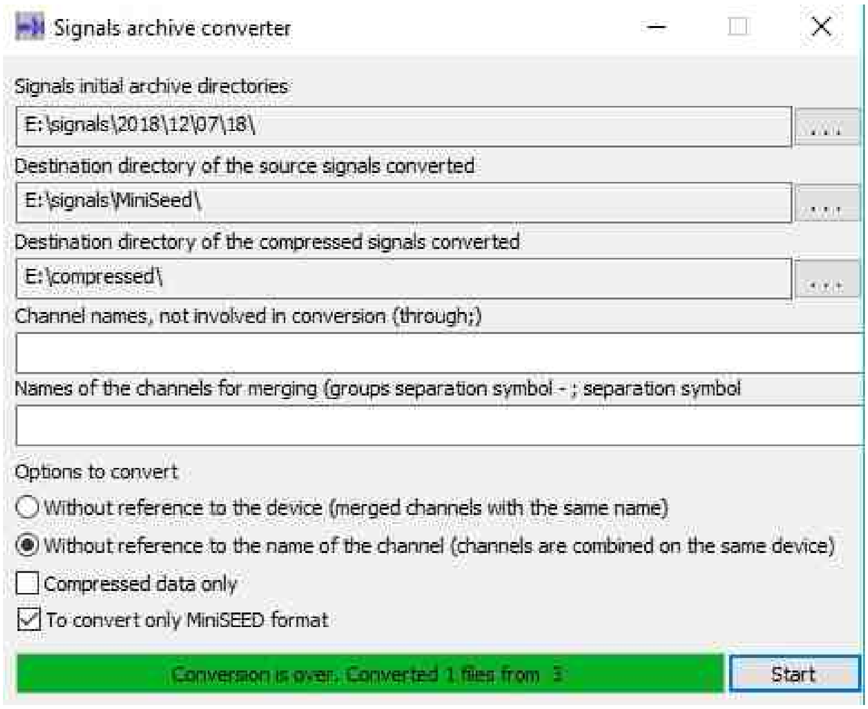


Fig. 4 The end of conversion process

The contents of the directory with the source files is shown in Fig. 5.

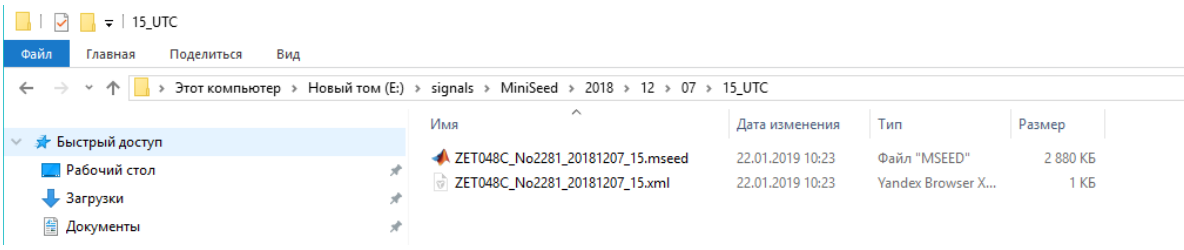


Fig. 5 Results of data conversion into MiniSEED format

Below you can see the source data and the results of their conversion into MiniSEED format.

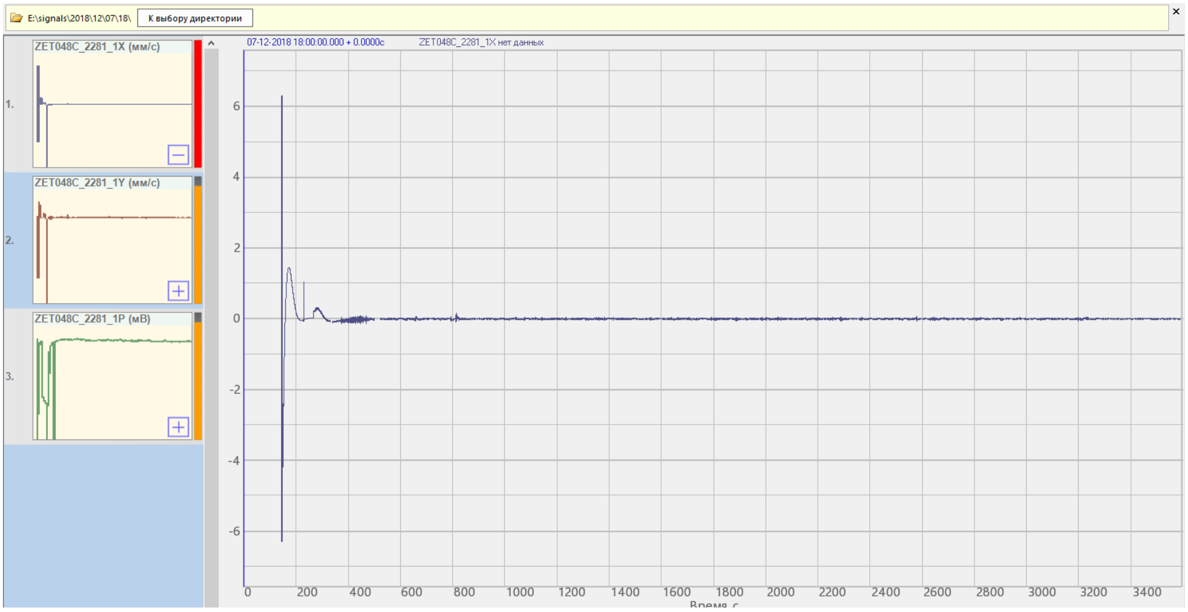


Fig. 6 The source data in ana/anp

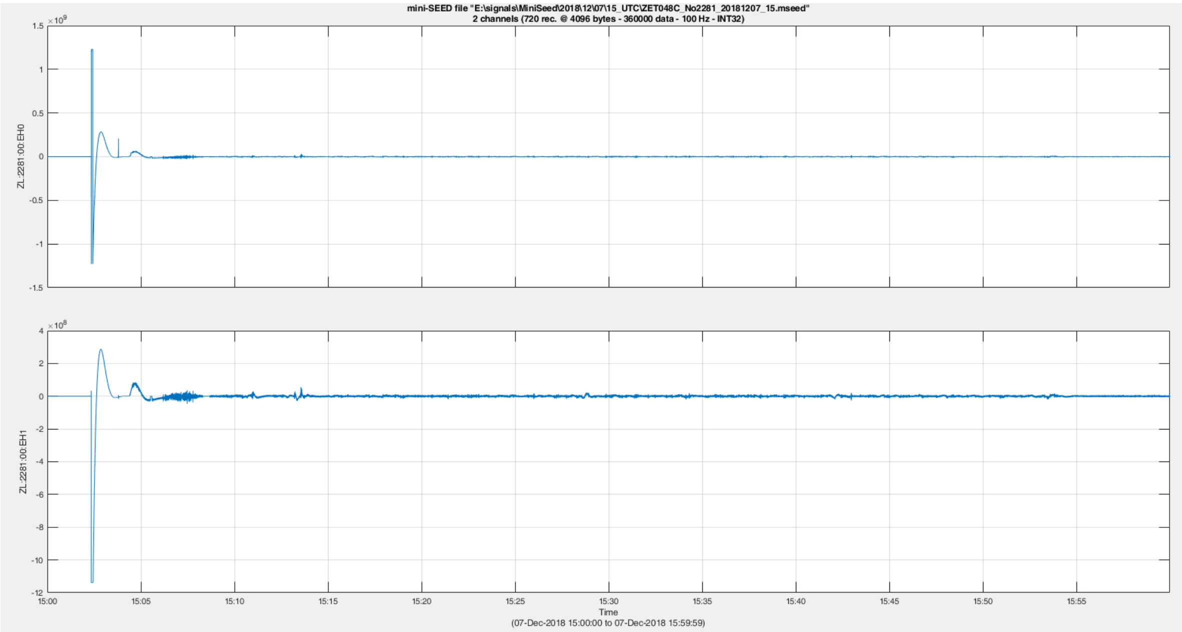


Fig. 7 Results of data conversion.

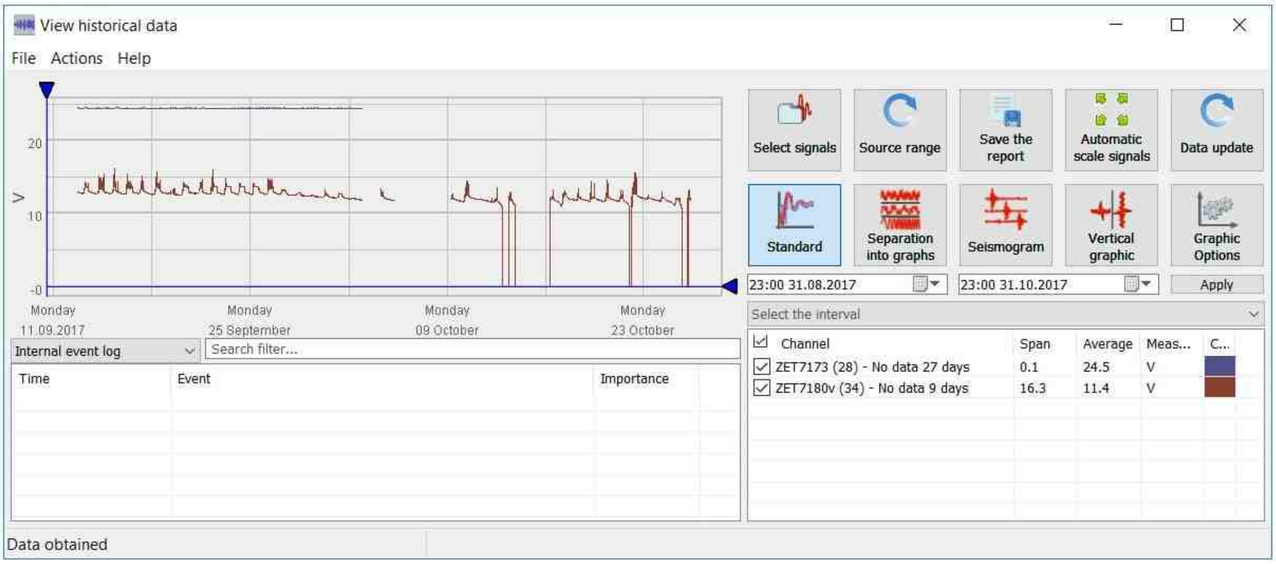
Signal trends viewing .....

A signal trend is represented by a graphic, which is used for analysis of long-term records of the data received from measurement transducers (e.g., for the period of several hours, days, months, years). Depending on the set sampling frequency, the program makes "*n*" counts per second, which means that for the period on one year the number of counts will be 31 556 926**n*. If the user wants to conduct analysis of short-term periods of the source signal, there should be no difficulties. However, the situation is much more complicated in the case if it is necessary to evaluate several parameters for the period of one year or even several years. In this case, it is necessary to have a really long signal graphic and a great deal of patience. Thus, this is exactly the case, when the use of signal trends is an especially good solution.
The signal trend can be described as a compressed envelope curve of the source signal, which is obtained based on the measurement data with the use of several compression degrees. A single trend point contains minimal and maximal number of counts per second. The main task of building the signal envelope curve is to analyze the overall dynamics of the registered parameters for a considerable duration of measurements period (e.g., to zoom-in for a particular data / minute of the signal graph).

ZETLAB software package has the function of signal trends recording available in the programs **Signals recording,** **Multi-channel recorder** Both of these programs are used for recording of the source signal with a set sampling frequency and allow to obtain the required data with a particular compression degree. In addition to that, the program **"Multi-channel recorder"** also allows to view the dynamics of signal's RMS and frequency, etc.

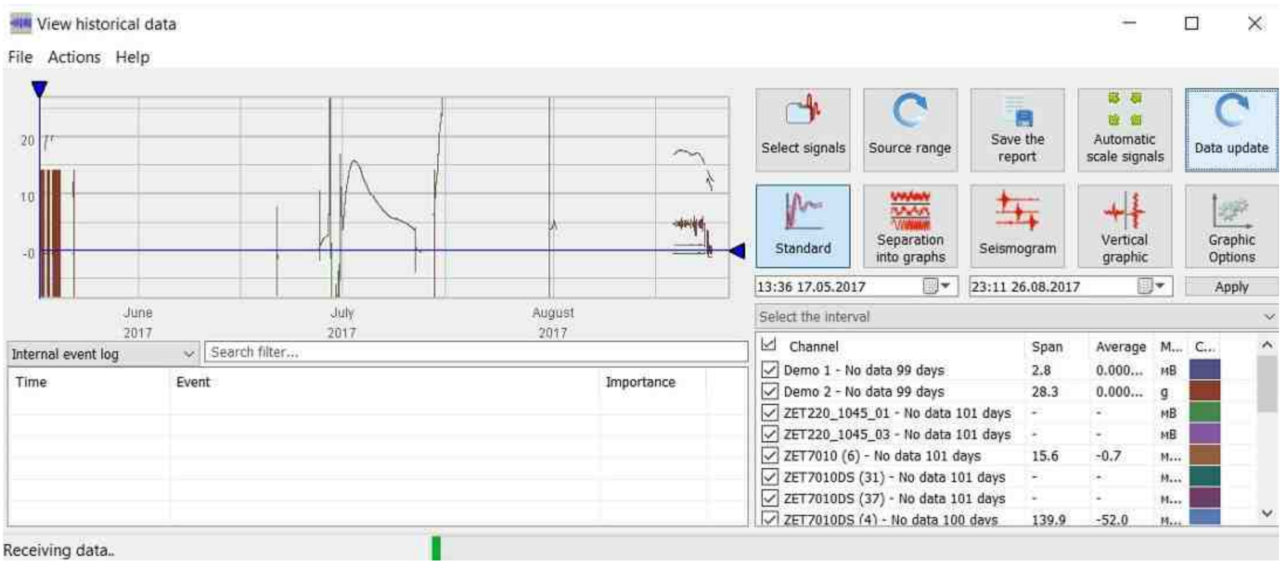
The functions of trends analysis and displaying are available in various applications, since, in most cases, the information is available at data server, while signal analysis is conducted at the automated workstations. The application used for signal analysis, scans the data, processes it, and starts at the server, while the automated workstation is used for receiving of the data and visual representation of the signal trends.

In order to connect to the data server, enter the IP – address in the application used for trends representation. In the case, if the server and the automated workstation are represented by one and the same PC, enter the local host: 127.0.0.1. As the connection is established, the program will automatically display the signal trends for the entire period of data acquisition process from the measurement transducers.



Signal trends viewing - measurement data for a long period of measurements

For a more detailed representation of the signals trends, it is possible to select the particular time interval and several channels depending on their name and measurement unit. When viewing the trends, it is possible to change the scale of signal trends representation (the program will automatically calculate the required data volume, compression degree, etc.).



Signal trends viewing - detailed view of signal trends depending on the particular selected parameters

The program also allows to arrange absolute and relative measurement values, to go back to the source range (i.e., to the initial scale of representation), to save the reports in .csv format, to print various measurement data, to conduct search in the data base as well as to view historical data.

The signal trends allow to view both short-term and long-term registered values and to display the measurements results of a particular parameter. The degree of signal compression allows to view the registered signals for a large time interval, to analyze approximate form/ envelope of the signal. The program also has a user-friendly interface enabling comprehensive analysis of the signal parameters.

Implementation of signals trends analysis is quite useful in many spheres of application (e.g., temperature measurements, crack extension control). The tensile-compression measurements used for cracks extension control purposes take a lot of time and depend on temperature fluctuations. The use of signal trends analysis allows to simplify the measurement process as well as to conduct more comprehensive analysis of the results obtained.

If you are using one of the previous versions of ZETLAB software package, where the functions of signal trends recording and displaying are not available, you can still convert the previously recorded signals and then view the signal trends.

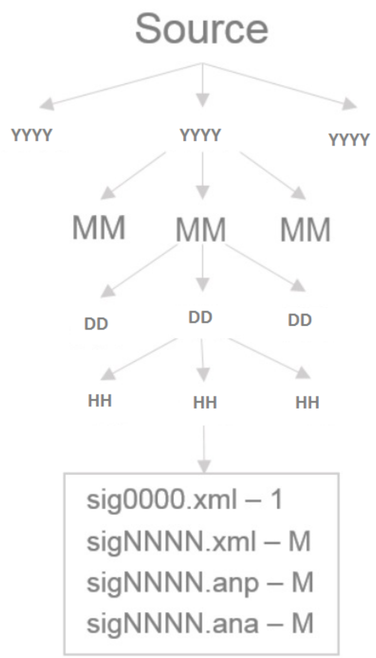
Data structure

There are several compression degrees used for plotting a signal trend: 1 second, 10 seconds, 1 minute, 10 minutes, etc. Depending on the duration of the signal to be analyzed, it is possible to use different degrees of signal compression. For instance, if you have to conduct analysis of the signal trends for the period of one year or more, you can use the compression degree of 10 minutes, while for a signal with the duration of one day, the compression degree can be 1 second. The program also has zeroing option, which allows to conduct measurements of relative values.

The recorded data is arranged into folders: years, months, days, hours. A special feature of hourly recordings is their synchronization with the time of the PC.

Averaged (i.e., compressed signals) are recorded to a different directory with the folders which correspond to a particular month and year. These values are saved for the period of one month. The files have various compression degrees: 1 second, 10 seconds, 1 minute, 10 minutes, 1 hour, 6 hours, etc.

The Fig.s below contain schematic structure of the recorded and compressed data.



Structure of the recorded data

Structure of the compressed data

Trends viewing - Scematic structure of the recorded and compressed data

N — name of the channel;

M — number of the recorded signals for each of the channels.

Supported Hardware .....

The source data of the program **Signal trends viewing** is represented by digital data from **ZETLAB server** channels.

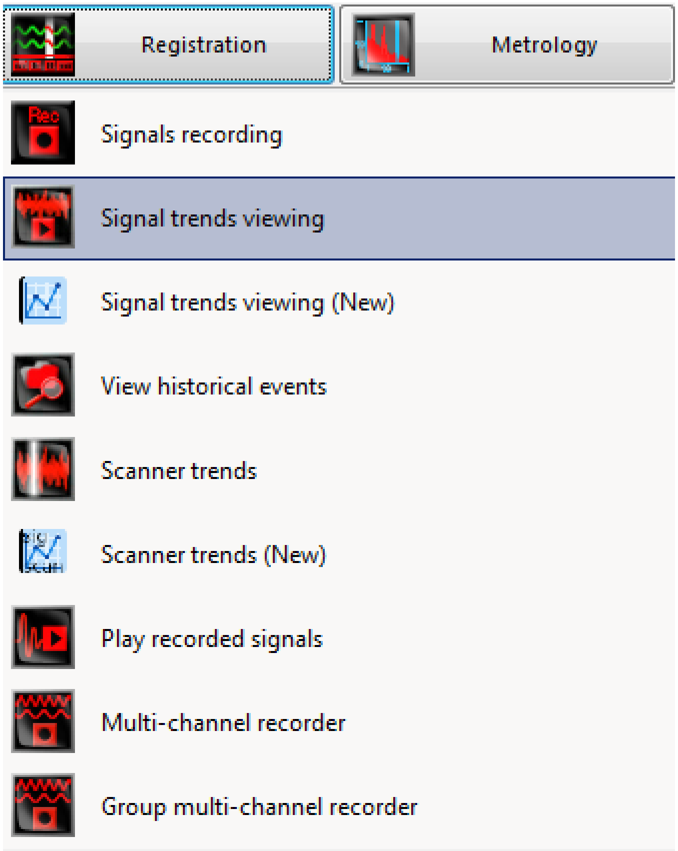
The program **Signal trends viewing** is included into the following software packages:

- ZETLAB BASE – ADC/DAC module software;
- ZETLAB ANALIZ – FFT spectrum analyzer software;
- ZETLAB VIBRO – vibration control systems software;
- ZETLAB TENZO – strain-gauge station software;
- ZETLAB SEISMO - seismic station software;
- ZETLAB NOISE - vibration meter-noise meter software;
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software (option).

Signal trends viewing is included in the program group **Registration.**

Program description .....

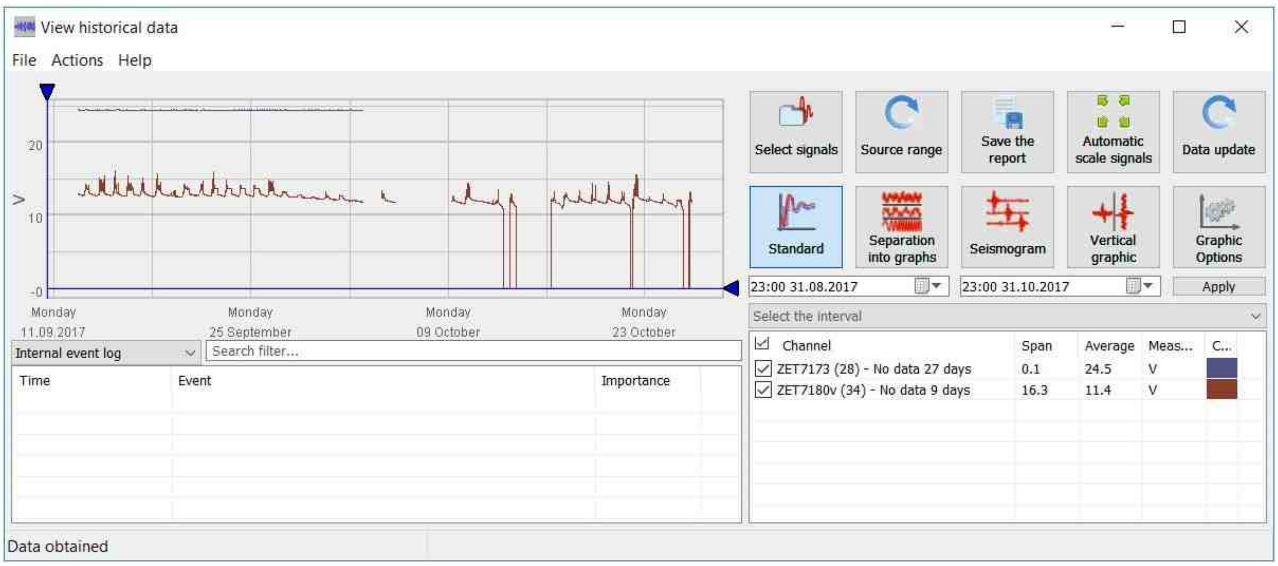
The program "**Signal trends viewing**" can be started from the **Registration** section of *ZETLAB control panel*.



Starting the program Signal trends viewing

Note: the program **Signal trends viewing** can also be started from *ZETLAB directory* (the directory by default: C:\ZETLab\). The name of the file to be started: *ZETTrends.exe.*

The title of the program interface *is "View historical events"*.



Signal trends viewing - main interface of the program

Control keys and elements are located in the right part of the program interface.

Description:

- analysis of the registered parameters dynamics for a long period of measurements;
- evaluation of signal's dynamics;
- possibility of analysis of a particular date / time section of the graphic.

Operating principle:

A *signal trend* is represented by a graphic, which is used for analysis of long-term records of the measurement data obtained from the transducers (for the period of several hours, days, months, years). Depending on the set value of sampling frequency, the program makes "*n*" counts per seconds, thus, for the period of one year the number of counts will be: *31 556 926*n*. In the case, if the user wants to evaluate short-term sections of the source signal, there should be no difficulties. However, the task becomes much more complicated when it is necessary to conduct analysis of the data accumulated for the period of one or even several years. This is exactly the case, when using the signal trends is especially useful.

The signal trend is represented by a compressed envelope curve, which is created based on the measurement data with several compression degrees used. Each signal trend point contains minimal and maximal number of counts per second. The main task of building an envelope curve is the overall control of the registered parameters dynamics for a long period of measurements performance, analysis of signal dynamics with a possibility of investigating a particular time point of the graphic.

In the *ZETLAB software*, the function of signal trends recording is implemented in the programs "***Signals recording***" and "***Multi-channel recorder***". Both of the programs allow to register the source signal with a particular sampling frequency and to produce signal fragments with the required compression degrees. In addition to that, the "**Multi-channel recorder**" program also allows to track the dynamics of signal's RMS, frequency and other parameters.

In order to produce a signal trend, it is possible to use several degrees of compression: 1 second, 10 seconds, 1 minute, 10 minutes, etc. Depending on the duration of the signal fragment to be analyzed, it is possible to use different compression degrees. For instance, for the analysis of signal trends for the period of one year, it is possible to use the compression up to 10 minutes, while for the signal trend of one day one can use compression up to 1 second. The program also has zeroing option, which allows to measure relative values.

The recorded data is arranged into folders: by years, months, days, hours. A special feature of hourly records is their synchronization with the time of the PC.

The functions of reading and viewing of signal trends are available in various programs, since it is often the case, that the information is located at a data server, while the signals processing is conducted at automated workstations. Hence, the application used for scanning, processing and transfer of the signal records is located at the server. The automated workstation is used for receiving of the processed data and displaying of signal trend.

In order to establish connection to the server in the application used for viewing the trends, set the IP address of the server. In the case if the server and the automated workstation are represented by one and the same PC, it is necessary to set the local host: 127.0.0.1. As the connection is established, the program will automatically download the signals trends for the entire period of measurement data acquisition by the transducers.

For a more detailed representation of signal trends, it is possible to select a particular time interval, signal type (by name or measurement unit). When viewing the signal trends, it is also possible to change the scale of signal trend representation (the program will automatically calculate the required data volume and compression degree, etc.).

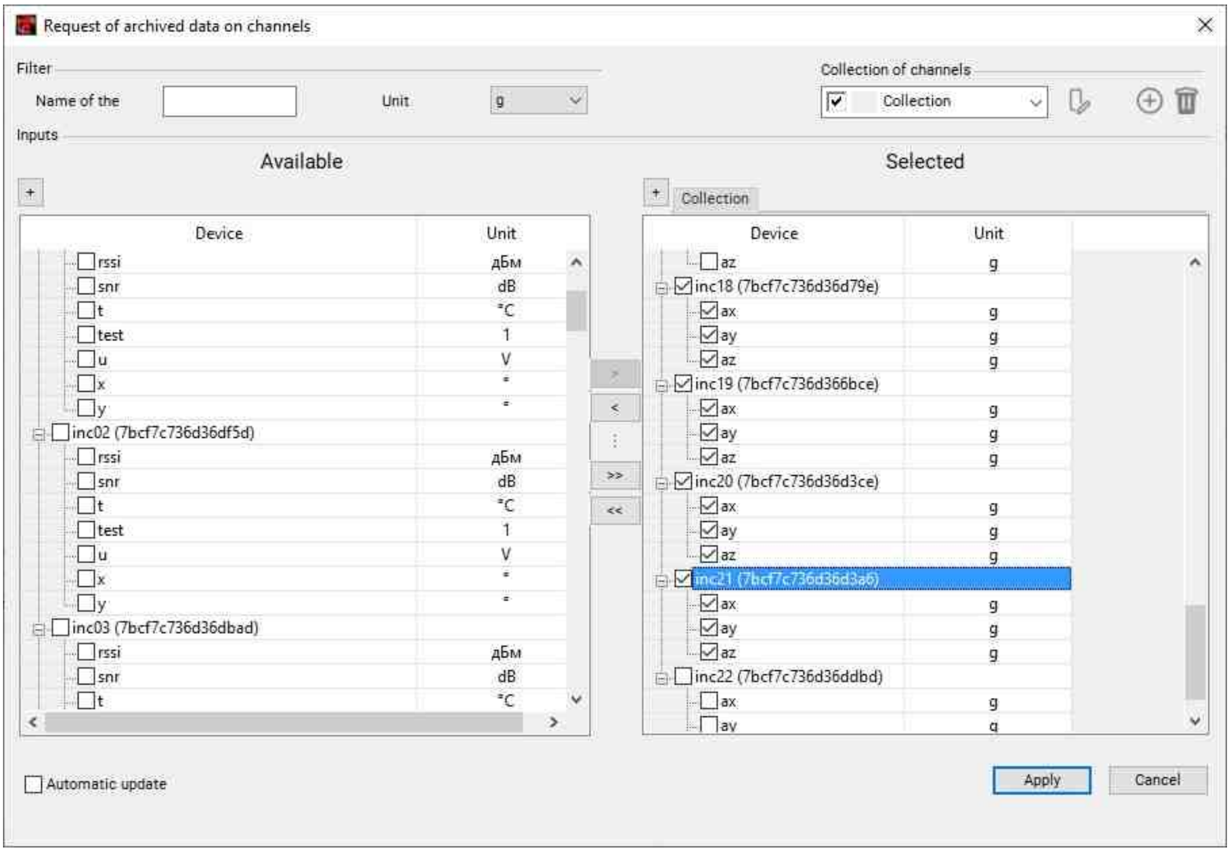
The program also allows to arrange absolute and relative measured values, go back to the source scale (i.e., to the initial display form), save the reports in .csv format, print them, access the database, and to view the historical data.

The signal trends allow to view both short-term and long-term registered values as well as to display measured values of a particular controlled parameter. The compression degree of a signal allows to view the registered values for a considerable period of time, to analyze signal's form/ envelope. The program also has user-friendly interface for comprehensive analysis of the signal.

Implementation of signals trends analysis is quite useful in many spheres of application (e.g., temperature measurements, crack extension control). The tensile-compression measurements used for cracks extension control purposes take a lot of time and depend on temperature fluctuations. The use of signal trends analysis allows to simplify the measurement process as well as to conduct more comprehensive analysis of the results obtained.

If you are using one of the previous versions of *ZETLAB software* package, where the function of trends recording and reading is not available, it is still possible to convert previously recorded signals for the purpose of further signal trends analysis.

Program dialog for selection of the signals:



Signal trends viewing - program dialogue for the selection of the signals

List of available channels – this list contains full list of signals available in the database.

List of selected channels – this list displays the channels, that are currently viewed in the program.

It is also possible to set the time interval for data representation.

In addition to that, the program also has a quick search function (it is possible to conduct search by name or by measurement units). The following symbols can be used for quick search purposes:

? – any single symbol

* - arbitrary number of any symbols

; - separator

Type of data presentation:

- Standard;

- Separation into graphs;

- Seismogram;

- Multiple axes.

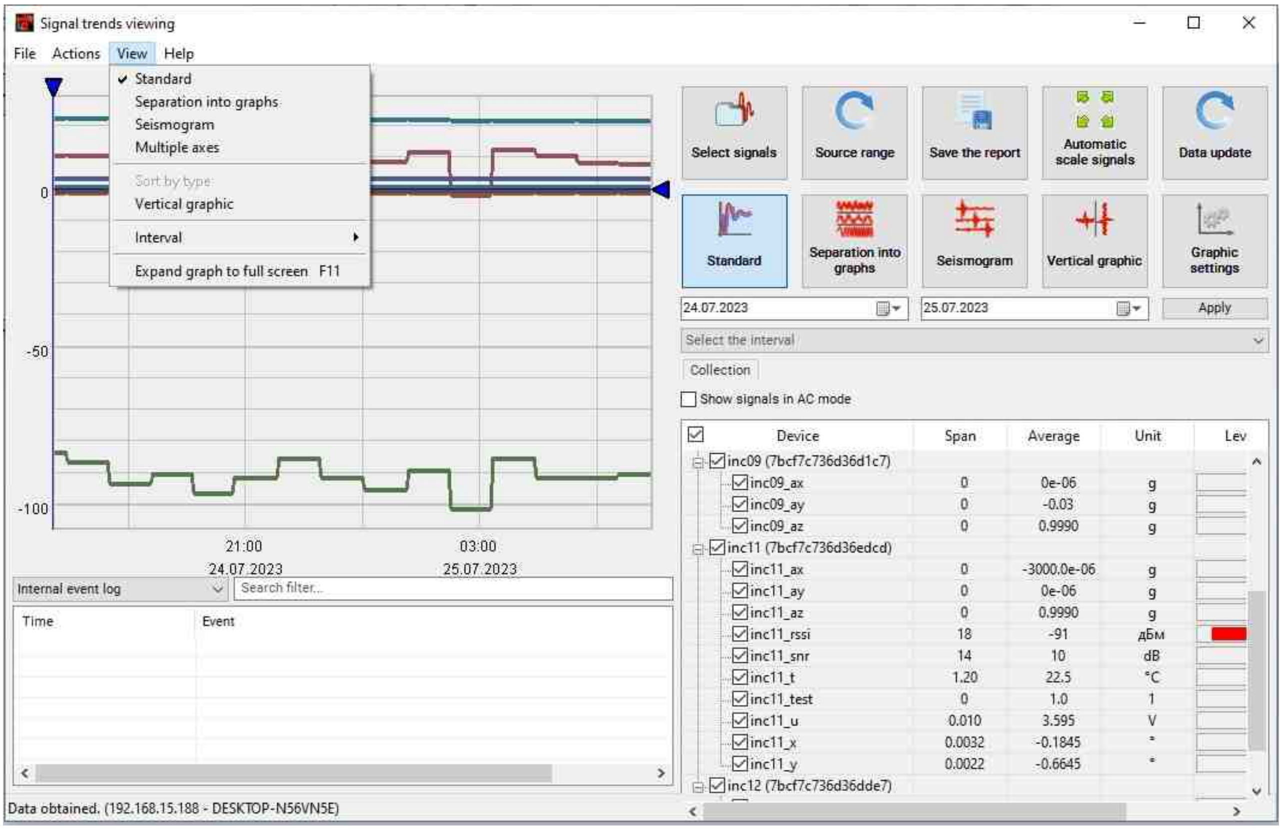
"Multiple axes" mode allows to display up to 6 graphics in various measurement units (V, Pa, kPa, Pcs, °C and Mv). Each graphic has the maximal possible scale, which allows to analyze correlation between parameters, e.g., between temperature (°C) and pressure (Pa). The graphic is not displayed in the case if it belongs to the group #7 or higher.

Additional display modes*:*

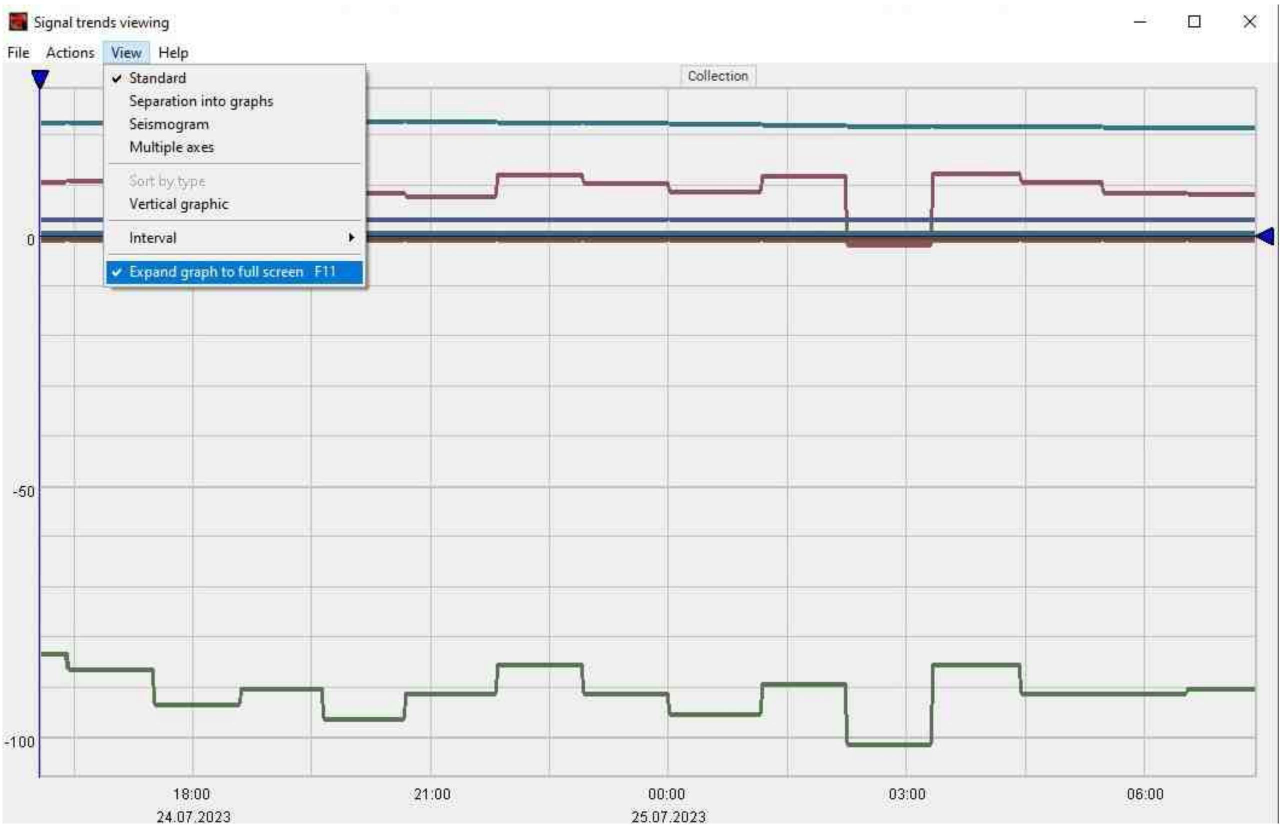
- sort by type (available in the mode "Separation into graphs");

- vertical graphic;

- expand graphic to full screen F11.



6 - View trends - Menu "View"



7 - View trends - Menu "View" Expand graph to full screen

Questions and answers:

Question: I have tried to use the function of viewing signal trends and historical data, but I failed to obtain any data or to view any kind of information.

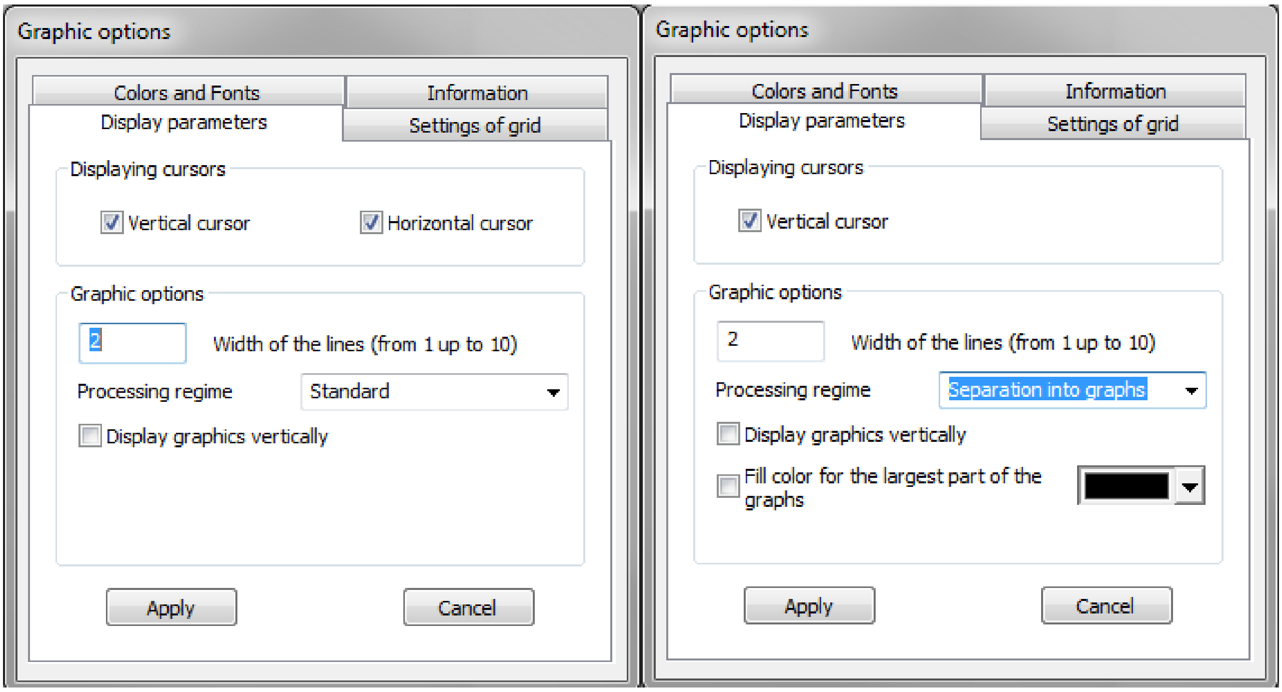
The program does not seem to operate properly; selection of folders with files and the search by date are not available.

Answer: The function of viewing the signal trends is to be used with the signals, which have been recorded in a constant mode. If you have a number of separate entries, it would be impossible to use this program. Normally the signal trends are used when there is a need of constant monitoring of a controlled object. The possibility of editing the signal records is available in the program "**Signals gallery**".

Graphic display options .....

Right-click the graphic area of the program **"Signal trends viewing"** to activate the window of graphic display configuration.

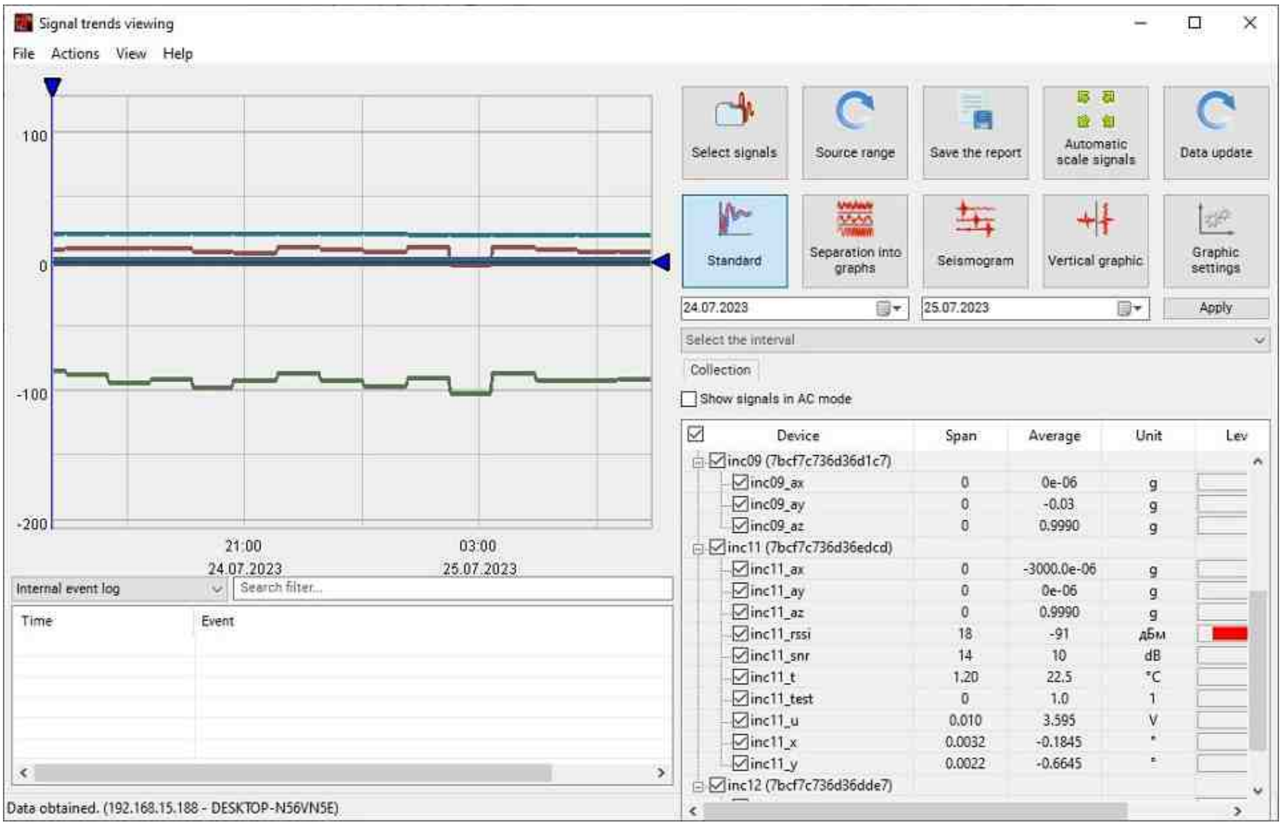
Configuration of graphic display parameters



Signal trends viewing - configuration of display limits of the graphic

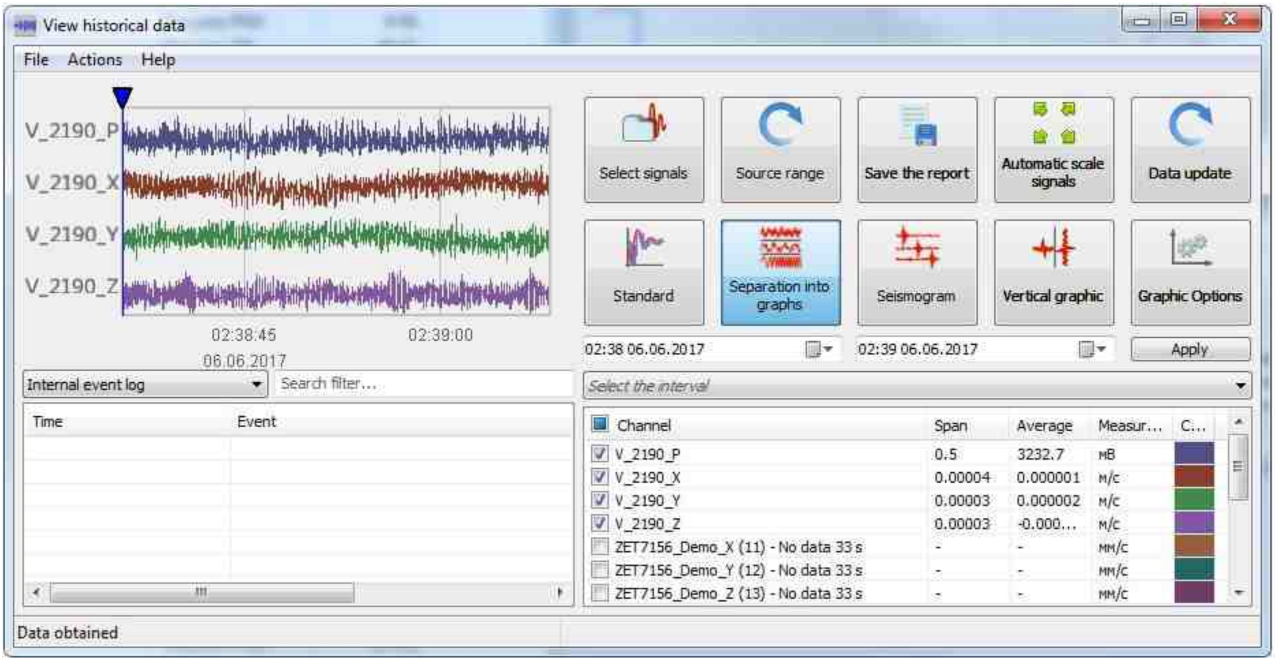
Display modes:

1. **Standard** – all the graphics are displayed in the same scale.



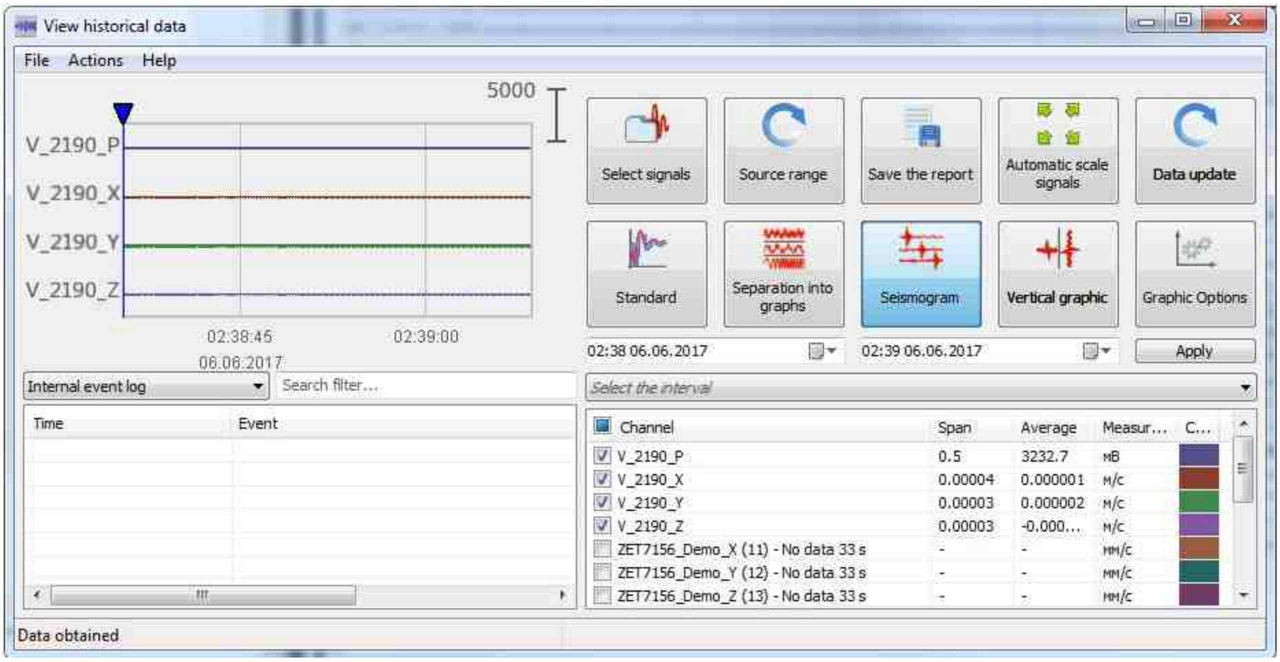
Signal trends viewing - standard display mode - the same scale for all the graphics

2. **Separation into graphics** – each of the channels has a separate area in the graphic, all the graphics have the same time scale. The graphics undergo automated scaling in vertical direction.



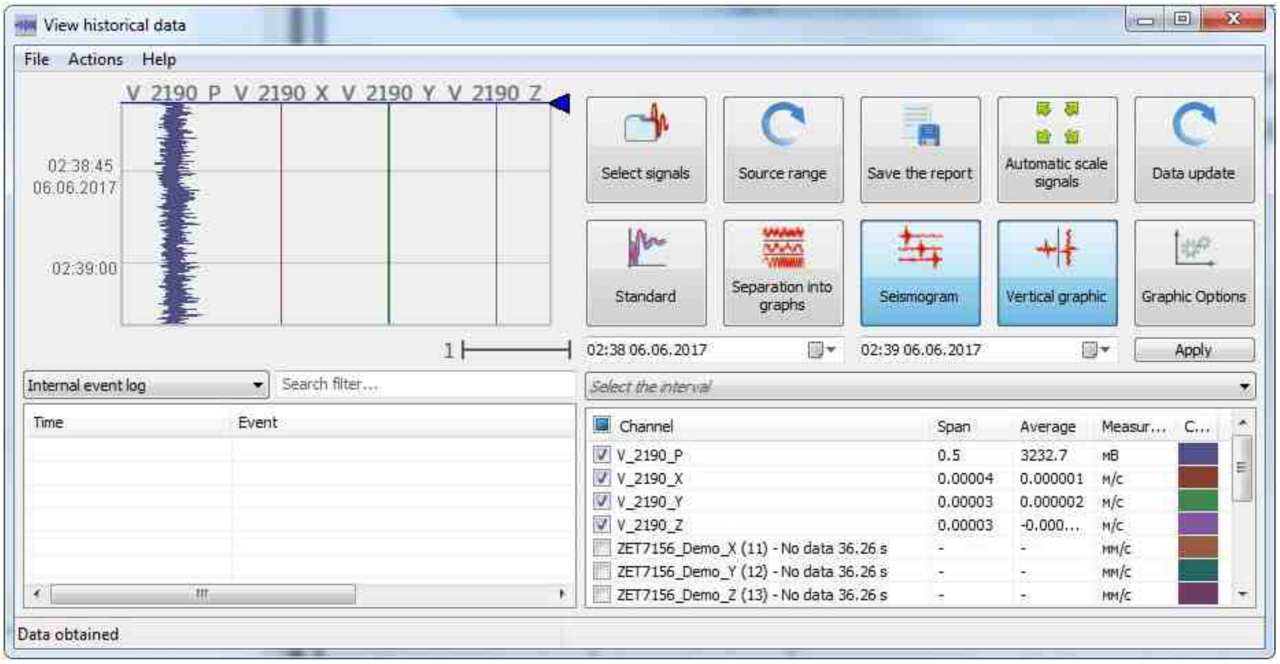
Trends view - graphic display modes - separation into graphics

3) **Seismogram** – allows to evaluate signal form and general differences of the channels' data.



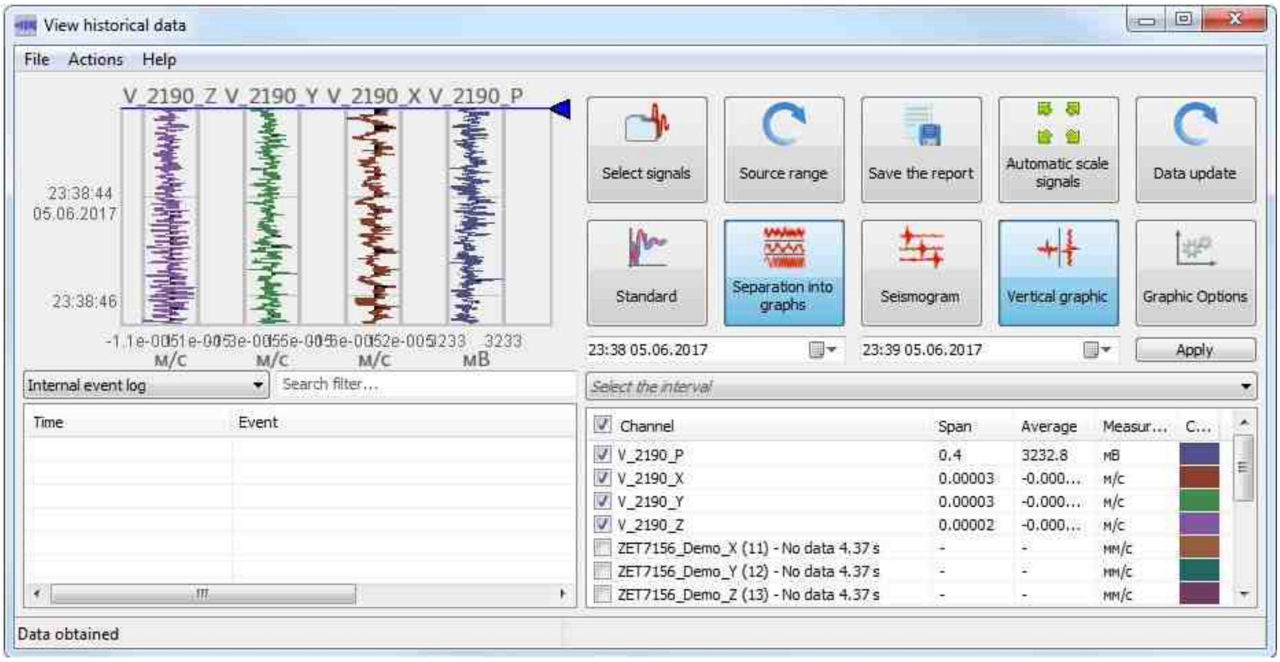
Signal trends viewing - graphic display modes - Seismogram

Display graphics vertically – this function allows to display graphics in vertical direction, which can be useful for visual representation of various processes interdependence.



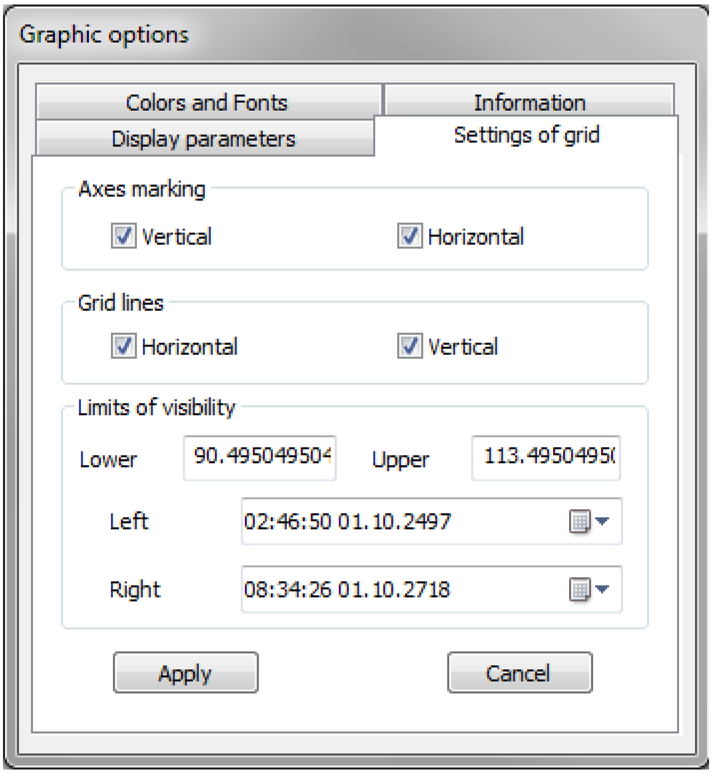
Signal trends viewing - Vertical displaying of the graphics

Color filling of the biggest part of the graphic – this function is intended for visual representation of the active processes (this function is available in the modes "*separation into graphs*" and "*seismogram*").



Signal trends viewing - color filling of the graphic

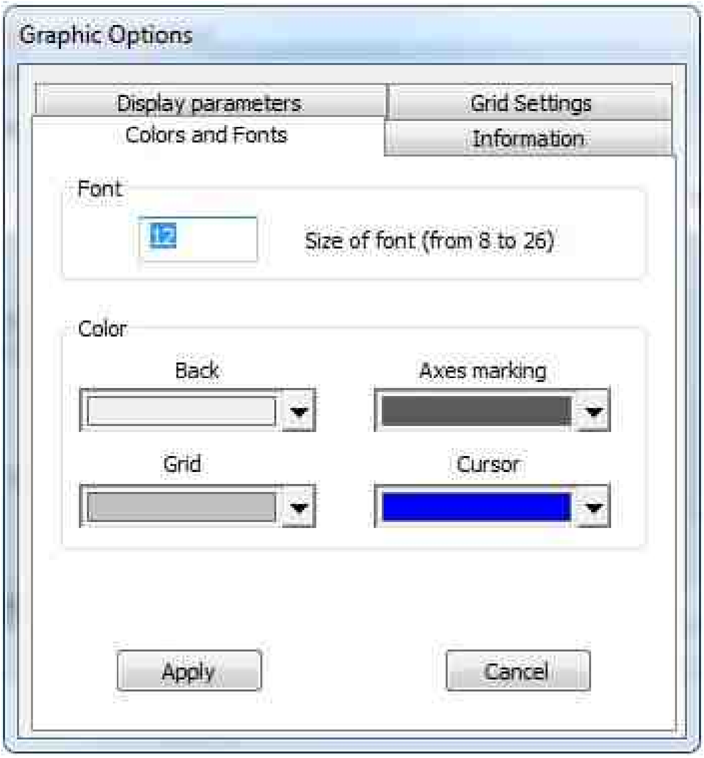
Grid parameters setting



Signal trends viewing - grid settings for Play recorded signals

This tab allows to set the current display limits, enable/ disable indexing of axes and grid.

Colors and fonts

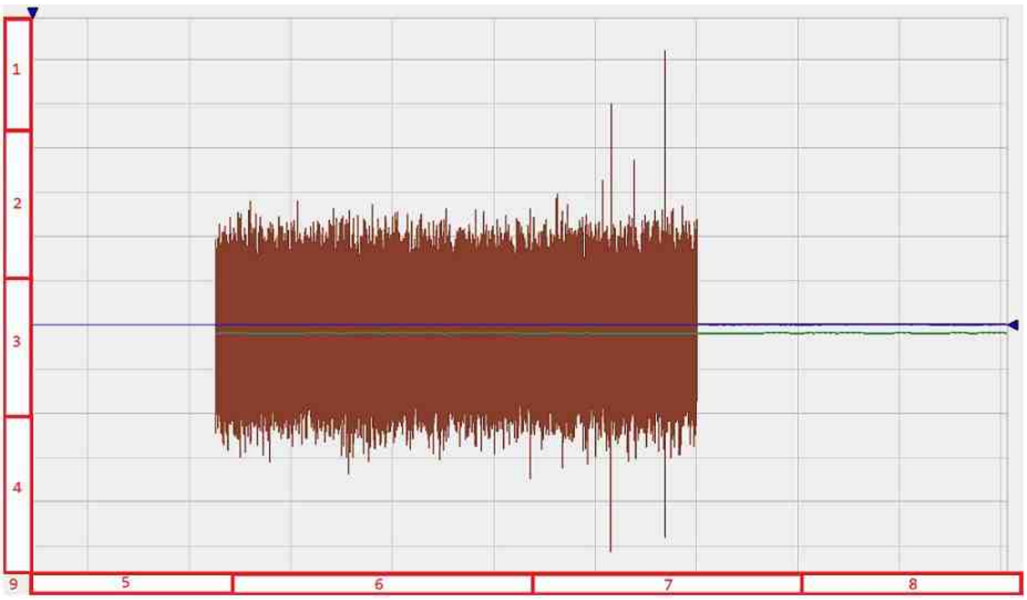


Signal trends viewing - colors and fonts

This tab allows to set the font size and to select the color of the graphic.

Scaling

Working areas:



Signal trends viewing - scaling - working areas

As it is shown in the Fig., the graphic is separated into working areas. In order to change the displayed range of the graphic, right-click the graphic area or use the scroll wheel.

1. Change of the vertical scale – the graphic is moved upwards.

2. Increase of vertical scale.

3. Decrease of vertical scale.

4. Change of the vertical scale – the graphic is moved downwards.

5. Change of the horizontal scale – the graphic is moved to the left.

6. Decrease of horizontal scale.

7. Increase of horizontal scale.

8. Change of the horizontal scale – the graphic is moved to the right.

9. Auto-scaling of the graphic. Right-click to auto-scale the visible part of the graphic. If there is no graphical data available, the program will conduct auto-scaling of the entire graphic area. Use the combination *"LMB+Shift"* to auto-scale the graphic along the vertical axis. The combination *"LMB+Ctrl"* is used to auto-scale the graphical data along both vertical and horizontal axes.

Upper and right section of the graphic is intended for moving the cursor.

Hot-keys:

"Shift + scroll" – accelerated scaling along vertical axis.

"Ctrl + scroll" – accelerated scaling along horizontal axis.

"Ctrl + C" – saving the currently displayed graphical data to the clipboard.

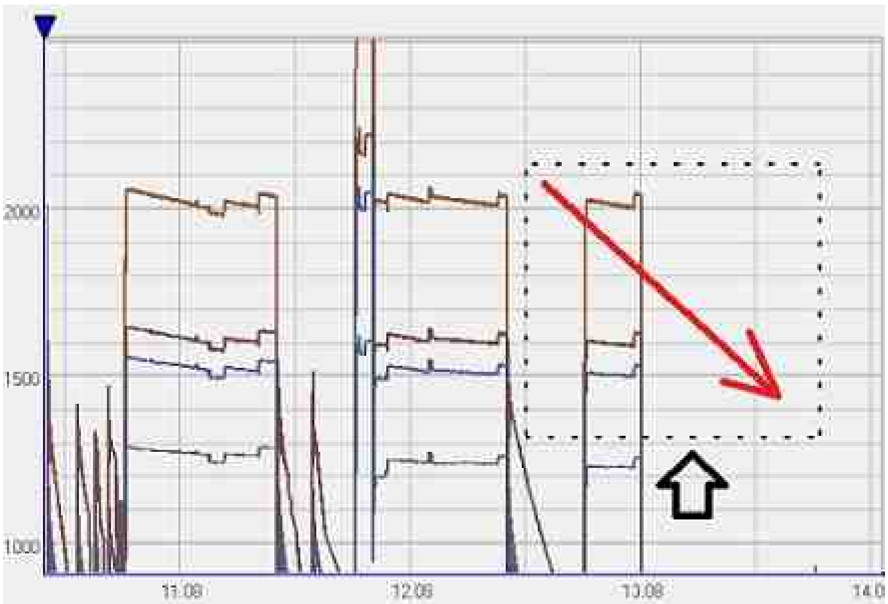
"Ctrl + N" – saving the data of all the displayed graphics to the clipboard (the format used by the program allows to paste the accumulated data to Excel document).

"Ctrl + F" – saving the graphic plot as an image in *png.* format. The file is saved to the directory of the program (by default, it is the *ZETLAB* directory).

Using the mouse to change the scale

Hold *LMB* in the working area of the graphic, move the mouse to shift along the graphic plot.

Combination *"Ctrl+LMB"* allows the user to highlight a particular area in the graphic. There will appear a frame, which encompasses the area to be scaled.



Signal trends viewing - scaling of a particular graphic area

As the user releases the *LMB*, the program will auto-scale the area selected by the user.

In the case, if the frame is created in the direction specified in the Fig. below, then, as the left mouse key is released, the signal graphic will go back to the initial scale.

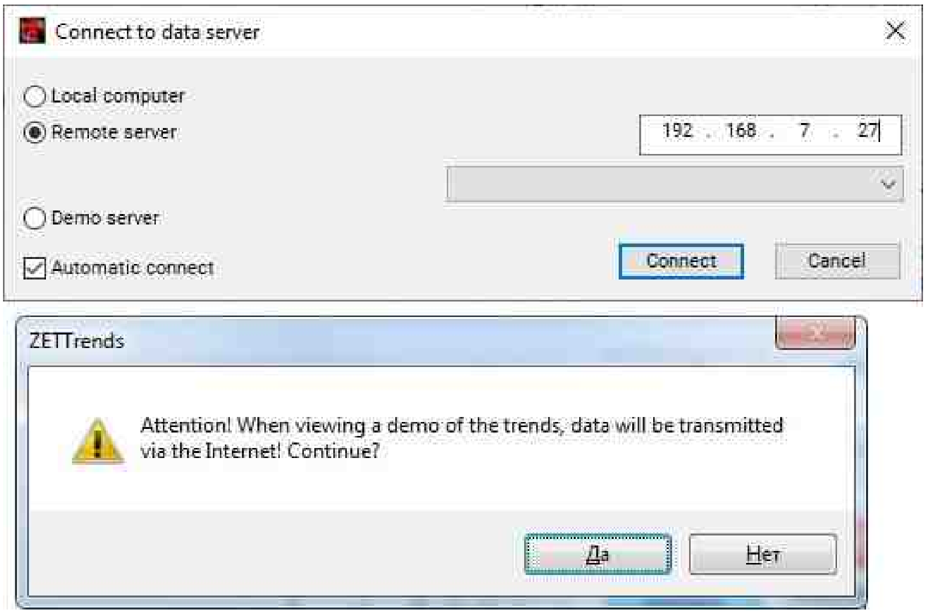
Viewing demo-trends and demo-events, multi-user access to trends .....

Is it possible to evaluate the functional features of viewing *signal trends* and events, if there is no device or software key available? All you need to have is the Internet connection in order to get access to demo-server containing the information about signals and events. The server operates in online mode and is available 24 hours a day. It is very easy to establish connection with the demo-server:

a) start the program of viewing trends or historical events

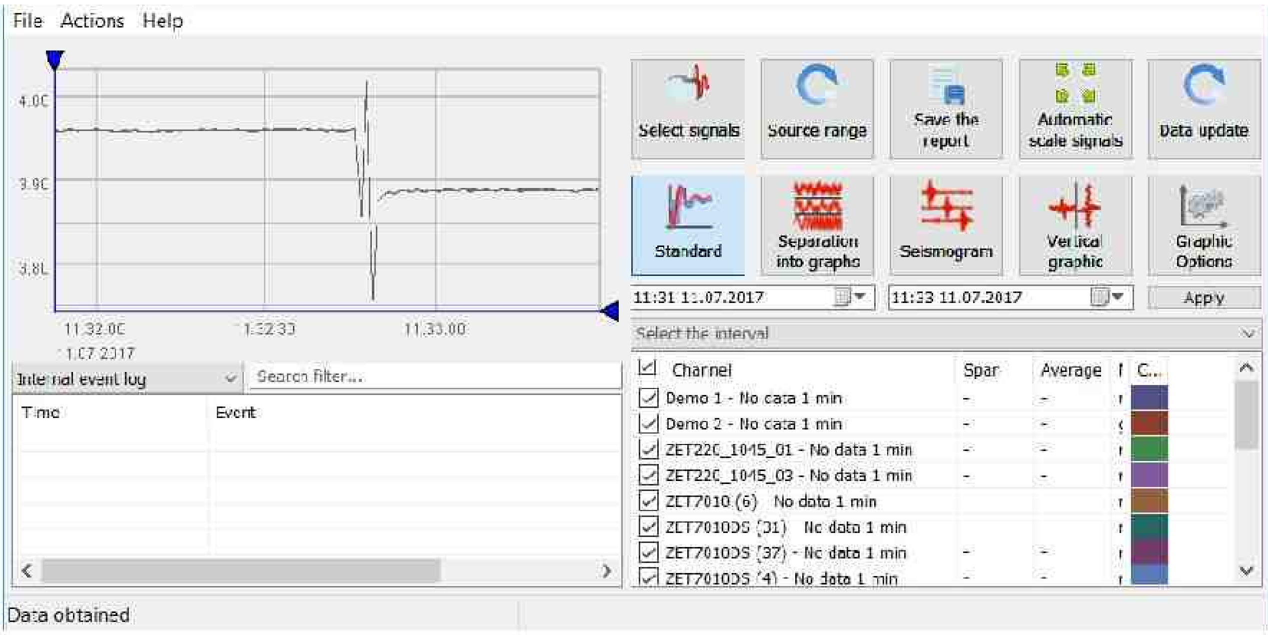
Starting the program for viewing trends of historical events

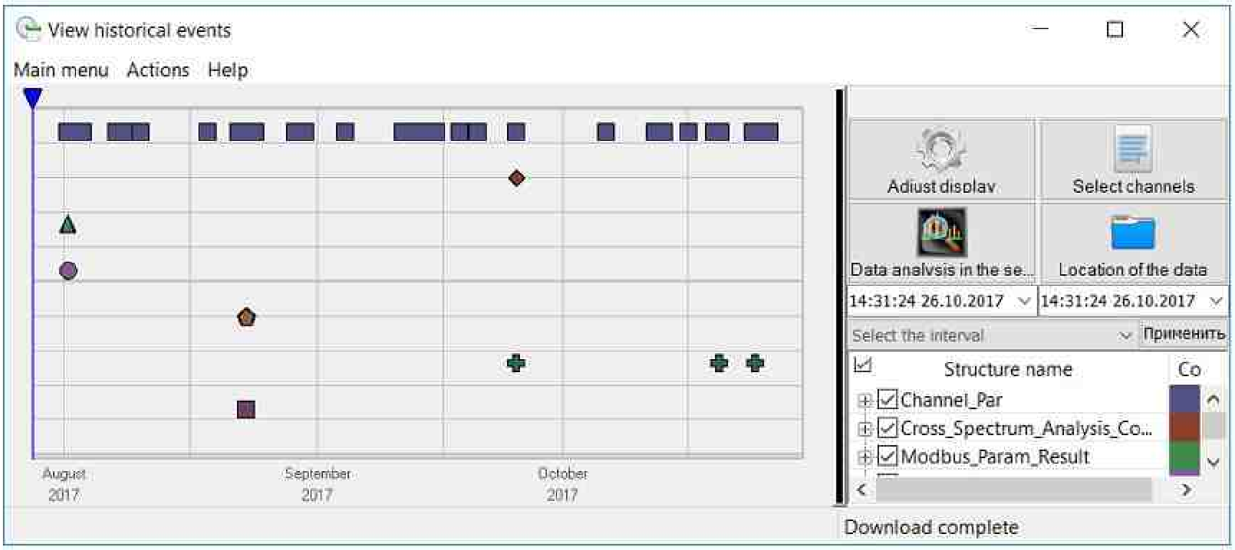
b) select the connection to demo-server,



Signal trends viewing - Establishing the connection to demo-server

c) view signals or events

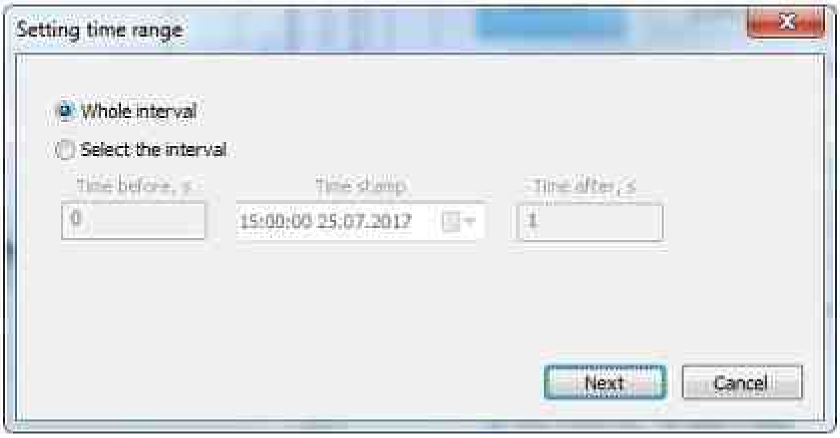




Signal trends viewing - analysis of the data obtained from the demo-server via remote connection

Saving reports of the program .....

Select "*Save*" option in the "*File*" menu of the "*View historical events*" program. In the new window select the option "*The entire interval*" and click "*Next*"

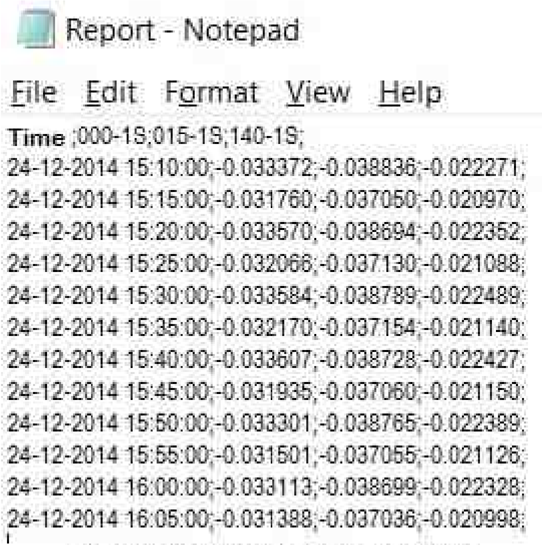


Signal trends viewing - selection of the time interval for saving the data for the report

In the new window "*Save as*" select the directory for saving the file and assign the file name, and the file extension type (for instance, *.csv*), then click the key "*Save*". In the specified directory there will appear a file with the information from the selected channels for a particular time period in tabular format (the file contains vertical columns).

The key "*Save*" activates standard dialog window allowing the user to specify the directory for saving the file and the name of the file. The directory by default is *Libraries\Documents\Report.csv*.

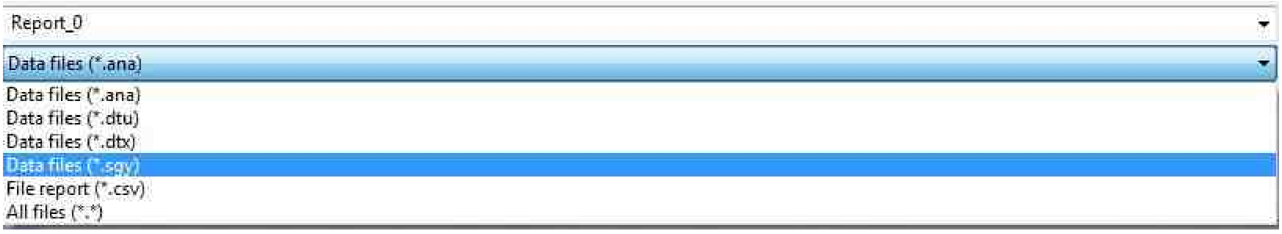
An example of the file is shown in the Fig. below.


Report - Notepad
File Edit Format View Help
Time ;000-1S;015-1S;140-1S;
24-12-2014 15:10:00;-0.033372;-0.038836;-0.022271;
24-12-2014 15:15:00;-0.031760;-0.037050;-0.020970;
24-12-2014 15:20:00;-0.033570;-0.038694;-0.022352;
24-12-2014 15:25:00;-0.032066;-0.037130;-0.021088;
24-12-2014 15:30:00;-0.033584;-0.038789;-0.022489;
24-12-2014 15:35:00;-0.032170;-0.037154;-0.021140;
24-12-2014 15:40:00;-0.033607;-0.038728;-0.022427;
24-12-2014 15:45:00;-0.031935;-0.037060;-0.021150;
24-12-2014 15:50:00;-0.033301;-0.038765;-0.022389;
24-12-2014 15:55:00;-0.031501;-0.037055;-0.021126;
24-12-2014 16:00:00;-0.033113;-0.038699;-0.022328;
24-12-2014 16:05:00;-0.031388;-0.037036;-0.020998;

The report file of recorded Trend signals

Signal trends viewing - example of the report file contents

In this example, we consider the function of saving the data obtained from the channels used for pressure measurements with the source sampling frequency. If it is necessary to save the data of the pressure measurement channel at the frequency of 1 Hz, then place the mouse pointer at the graphic section in the program "*View historical events*", press the hot-keys combination "*Ctrl+N*" (thus copying the data to the clipboard), create a new Excel document and use the command "*Ctrl+V*".



Signal trends viewing - list of available formats to be used for saving the report

The key "*Save the report*" allows to save the data obtained with the use of the program "*Signal trends viewing*" for a particular period of time to a text file with one of the following extension formats:

- **.ana/anp* (source data – max. 500 000 values per channel);
- **.sgy* (source data);
- **.csv* (the source data are saved with the same compression degree, that is used for viewing the data);
- **.dtu;*
- **.dtx;*
- **.sgy.*

Signal trends viewing (New) .....

Supported Hardware .....

The source data of the program **Signal trends viewing (New)** is represented by digital data from **ZETLAB server** channels.
The program **Signal trends viewing (New)** is included into the following software packages:

- ZETLAB BASE – ADC/DAC module software;
- ZETLAB ANALIZ – FFT spectrum analyzer software;
- ZETLAB VIBRO – vibration control systems software;
- ZETLAB TENZO – strain-gauge station software;
- ZETLAB SEISMO - seismic station software;
- ZETLAB NOISE - vibration meter-noise meter software;
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software (option).

Signal trends viewing (New) is included in the program group **Registration.**

Program purposes and total information .....

Introduction

This user's guide is intended to study the principles of working with the software (hereinafter referred to as the software) "Signal trends viewing", contains general rules of operation, as well as instructions for installation and launch. When working with the "Signal trends viewing" program, you should follow this document. The developer reserves the right to make changes to the software that do not impair its functionality, without correcting the operational and technical documentation. If you have any questions about working with the software "Signal trends viewing", please contact the technical support service of ZETLAB by e-mail: info@zetlab.com.

1 Program purposes and total information

1.1. The purpose of the application

The "Signal trends viewing" software is included in the ZETLAB software and is a set of software tools designed to graphically display historical data registered on a computer by data collection devices for an arbitrary period of time (hours, days, months, years) and subsequent analysis of the data obtained.

The "Signal trends viewing"software has a user-friendly graphical interface that provides the user with the ability to fully navigate through the registered sensor signals. The program allows you to access the event database, view historical data, change the scale of the graph display along two axes, return to the original range (i.e. to the original view), save the report.

1.2. The principle of operation

The graphic implemented in the "Signal trends viewing" software is a kind of compressed envelope of the original signal, built on the basis of measured data, with several degrees of compression. One point includes the minimum and maximum values of the counts per second. The main task of drawing the envelope is to generally view the changes in the registered parameters over a long period of time, evaluate the dynamics of the signal, with the ability to approximate the graph to a specific date, a specific minute. Several degrees of compression are used to plot graphs: 1 second, 10 seconds, 1 minute, 10 minutes, etc. Depending on the duration of the sample, different degrees of compaction are possible, for example, when viewing a graphic for a year or more, compaction takes 10 minutes, while compression can reach up to 1 second per day. The recorded data is structured by folders: years, months, days, hours. A distinctive feature of hourly recordings is the time binding on the PC, i.e. at any time the recording starts, an hourly recording is still started, in which the first minutes of data will be missing (they simply do not exist), and then the signal will be recorded. The averaged, i.e. compressed, signals are recorded in another directory, there are only folders for the Year and Month. Such values are recorded immediately for a whole month, different files have different degrees of compaction: 1c, 10c, 1 min, 10 min, 1 hour, 4 hours, etc.

1.3. ZETLAB software is developed to be used on PC-s of IBM PC Intel® Pentium®/Celeron®/ type or any other compatible russified or localized OS versions:

- Microsoft® Windows® 10 64 bit.
- Microsoft® Windows® Server 2016 64 bit;
- Microsoft® Windows® Server 2019 64 bit;
- Microsoft® Windows® Server 2022 64 bit.

PC configuration for installation and start of ZETLAB software and devices drivers:

- Dual or more core processor;
- Processor speed - over 1,6 GHz;
- HighSpeed USB 2.0* interface;
- RAM – more than 8 Gb;
- Hard disk free space – more than 20 Gb;
- videocard with 3D-graphical acceleration, support of OrenGL, DirectX, memory - over 1 GB;

- display resolution 1280Ч1024;
- mouse or any other pointing device (touch screen, track ball, TouchPad, graphic pad);
- standard keyboard or any other input device (sensor screen, graphic pad);
- CD-ROM for software installation.

ZET devices support HighSpeed USB 2.0 interface only. However, it is possible to connect ZET device to PC via USB 3.0, in the case if controller bus is compatible with USB 2.0 interface (e.g., NEC controllers).
Note: currently there may occur mistakes in the course of Asmedia USB 3.0 controllers use (during driver installation error message "10" is displayed). In this case, it is recommended to use USB 2.0 bus for connection to PC.

In the case if industrial PC-s are used for operation on ZETLAB and ZETVIEW software, we recommend to use 64-bit OS Windows.

When using industrial computers to work on them in ZETLAB and ZETVIEW, we recommend you to use the 64-bit version of Windows.*Equipment ZET interface only supports USB 2.0 HighSpeed. But ZET devices can be connected to a PC via USB 3.0, if the controller of this bus is backward compatible with USB 2.0 interface, such as controllers NEC.
Note: at the moment when working with USB 3.0 controllers Asmedia production problems can occur (if the driver installation, an error occurs with the code "10"). In this case, we recommend to use for PC connection USB 2.0.

When using industrial computers to work on them in ZETLAB and ZETVIEW, we recommend you to use the 64-bit version of Windows

Preparation for work .....

2.1. Installing the ZETLAB software

To install the ZETLAB software, run the ZETLAB.msi installer file on your computer (supplied on a USB flash drive) and follow the instructions to install the ZETLAB software in the directory C:\ZETLab .

2.2. Launching the ZETLAB Control Panel

To launch the ZETLAB control panel, you need to activate the ZETLAB "shortcut" (*Fig. 2.1*), located on the Windows desktop.

Fig. 2.1 The appearance of the ZETLAB "icon"

At the top section of the screen there will appear *ZETLAB* panel (*Fig. 2.2*).

Fig. 2.2 ZETLAB Control Panel

The ZETLAB control panel is divided into sections, which allows you to quickly select the required programs. To select a program, activate the name of the corresponding section of the ZETLAB control panel and select the desired program from the expanded list. In the list, next to the program names, there are graphical icons that simplify the search for the desired program. To work with the programs included in the ZETLAB software, you must insert a ZETKey hardware key with the appropriate software license into any unused USB port of the computer.

2.3. Getting background information

At any time when working with the ZETLAB software, you can use the help information on working with it. Access to the reference information is organized by the type of tree structure.

To access the reference information (being in the window of the program for which you want to get reference information), you should  activate the key on the keyboard <F1>.

2.4. User directories configuration

ZETLAB software needs several directories on the PC for proper operation. Some directories are created by the software and cannot be changed, while the other can be set by the user.

The directories containing signals, compressed signals, processing results and configuration files can be set by the user.

To assign user directories, it is necessary to create them (in the case, if they do not exist), and then set user path configuration for them.

To set user path configuration, go to "ZETLAB control panel" (*Fig. 2.2*), click *ZETLAB* icon, and enable the panel "User path configuration" in the window "Main menu of the control panel" (*Fig. 2.3*).

Fig. 2.3 Main menu of ZETLAB control panel

In the window "Adjusting configuration access" (*Fig. 2.4*), activate the panel "" for each user directory, which corresponds to the data type to be stored in them (signals, compressed signals, processing results, configuration files). In the window "Choose directory" set the required configuration path, and click "Select folder".

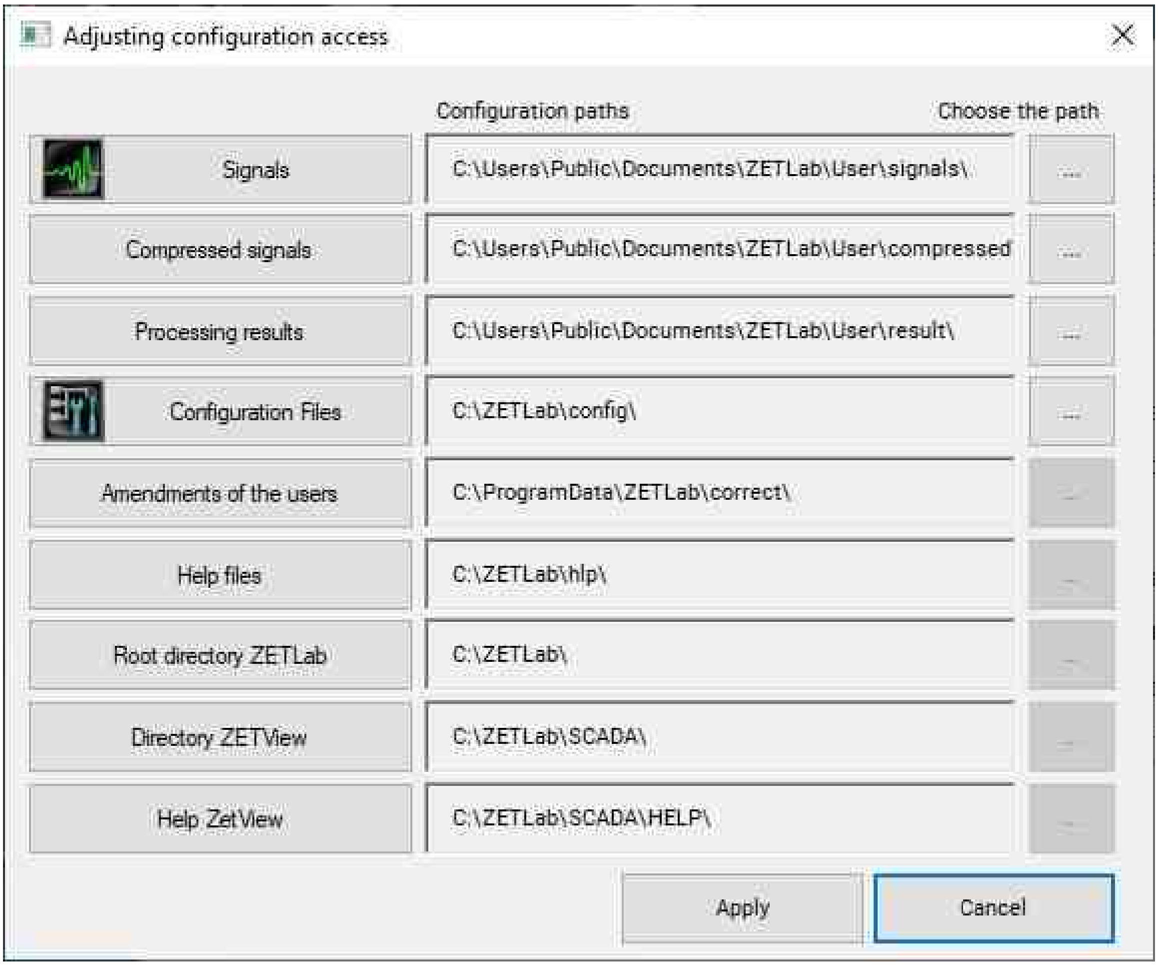


Fig. 2.4 Window "Adjusting configuration access"

2.5. Signals recording

To record signals in the "Signal trends viewing (New)" software format, it is necessary:

- Open the program "**Signals recording**" from the "Registration" menu of the ZETLAB panel.
- Select the channels whose signals should be registered by activating the corresponding cells (*Fig. 2.5*).

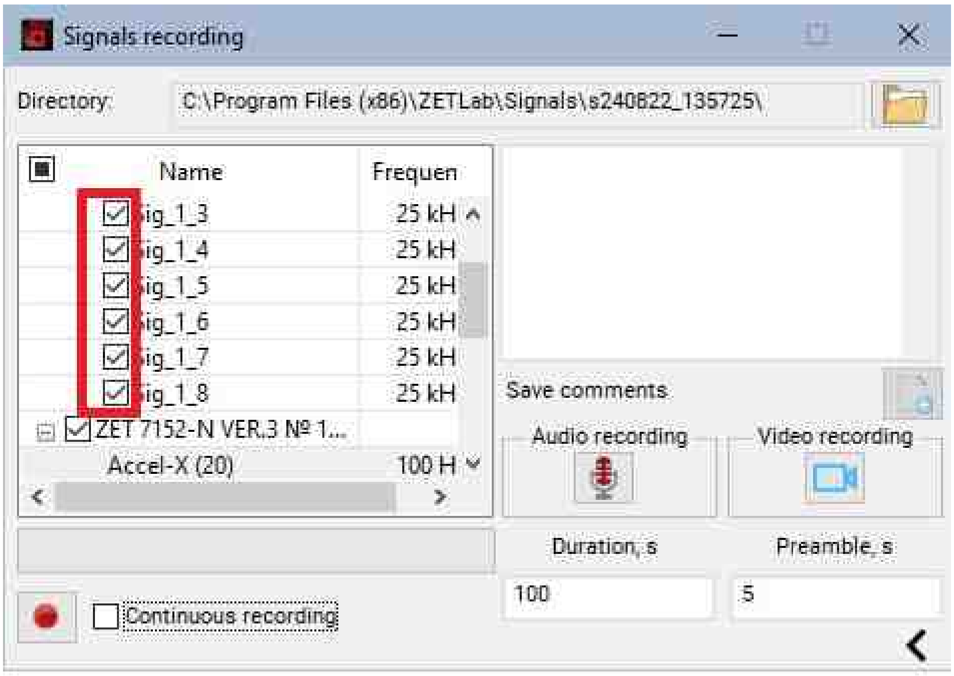


Fig. 2.5 Select channels for recording

- Activate the field in the "Continuous recording" cell (*Fig. 2.6*), then press the button .

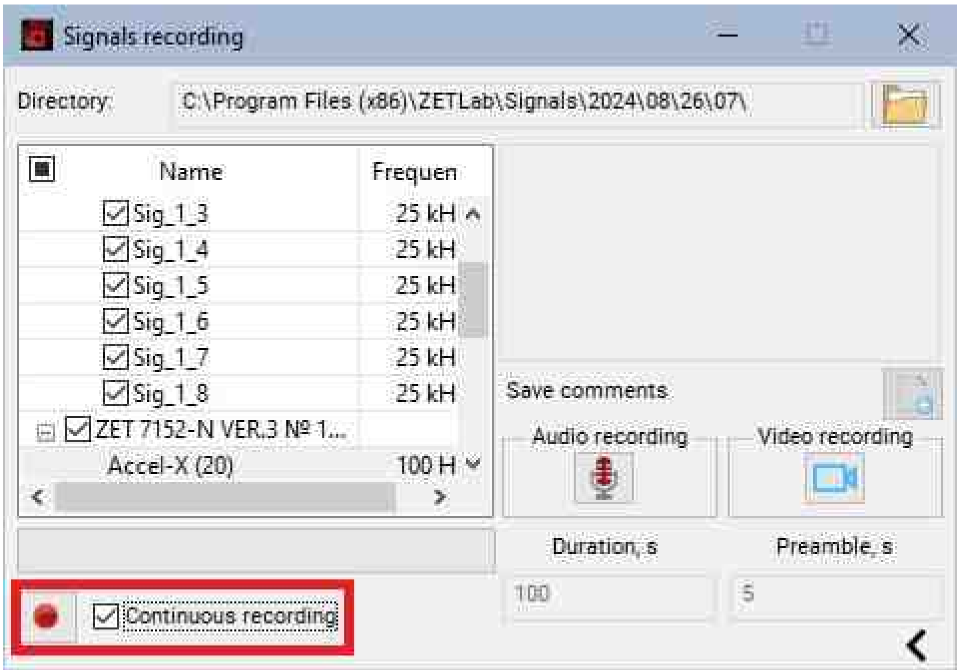


Fig. 2.6 Continuous recording in the program "Signals recording"

2.6. Starting ZETLAB "Signal trends viewing (New)" software

The "Signal trends viewing (New) software is launched from the "Registration" menu of the ZETLAB panel (*Fig. 2.7*).

Fig. 2.7 Starting the "Signal trends viewing (New)" program

Working with software .....

3.1. Description of the program interface

The "Signal trends viewing (New)" software consists of several workspaces: a control panel, a graphical area and a list of channels (*Fig. 3.1*).

1. The Control panel;
2. Graphic area;
3. The list of channels.

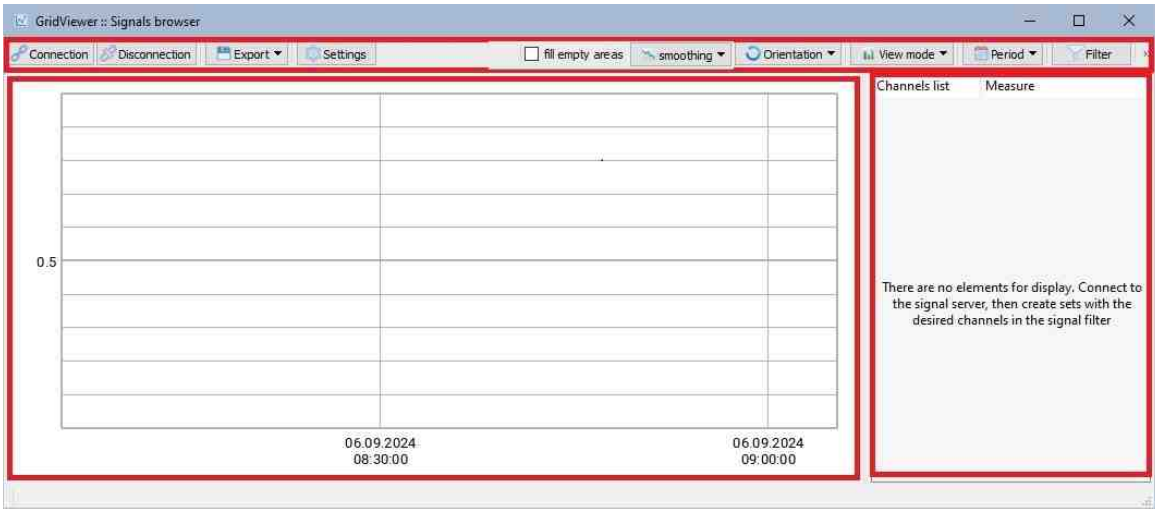


Fig. 3.1 The window of the program "Signal trends viewing (New)"

3.1.1. *The Control panel*

The control panel is located at the top of the program and is a set of tools designed to control the parameters of the "Signal trends viewing (New)" program. The control panel consists of the following menu items: "Connect", "Disconnect", "Export", "Settings", "Anti-Aliasing", "Orientation", "Viewing Mode", "Period", "Filter", "Automatic update".

The "Connect..." and "Disconnect..." menu (*Fig. 3.2*) are designed to connect and disconnect the "Signal trends viewing (New)" program from the data server where signal recordings are stored.

Fig. 3.2 The "Connection" and "Disconnection" menu

The Export tab consists of two menu items: "Data export" and "Snapshot of the area" (*Fig. 3.3*).

The "Export Data" menu is designed to export the data displayed on the graphic to formats: ANA/ANP, CSV, XLSX, DTU, MSEED, SEGY.

The "Snapshot of the area" menu allows you to take a picture of the graphic area in PNG format.

Fig. 3.3 Вкладка «Экспорт»

"Settings" menu (*Fig. 3.4*) is intended for setting the parameters for the design of graphic elements.

Fig. 3.4 The "Settings" menu

The parameters of the "Settings" window are shown in *Fig. 3.5*.

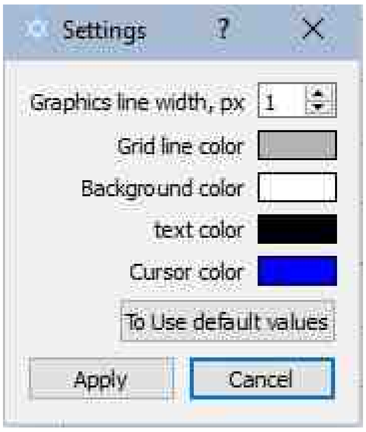


Fig. 3.5 The "Settings" menu

The "Smoothing" menu (*Fig. 3.6*) It is intended to eliminate the gradation in the graphics of signal parameters. To enable smoothing, activate the "Use smoothing" cell and set the time period.

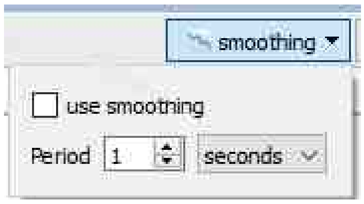


Fig. 3.6 The "Smoothing" menu

The "Orientation" menu (*Fig. 3.7*) designed to change the graph view to horizontal (*Fig. 3.8*) or vertical position (*Fig. 3.9*).

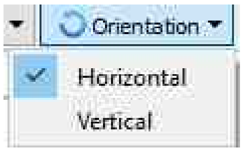


Fig 3.7 The "Orientation" menu

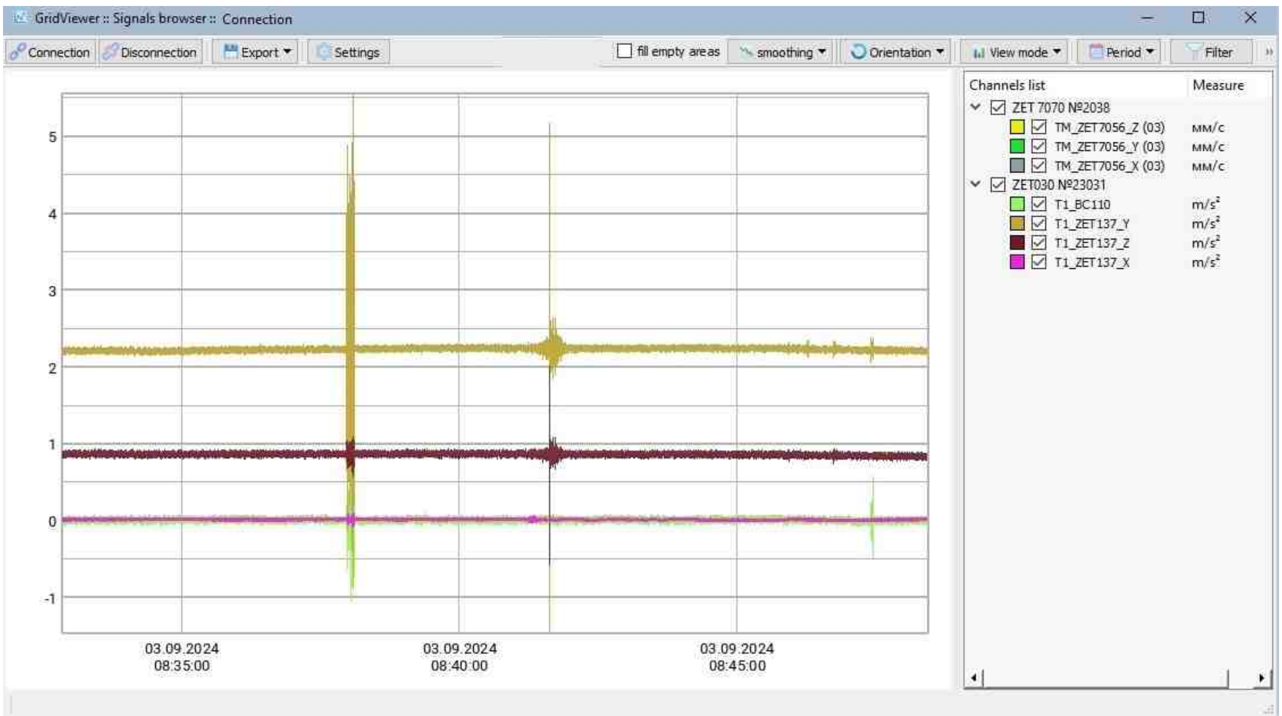


Fig. 3.8 Graphic orientation – "Horizontal"

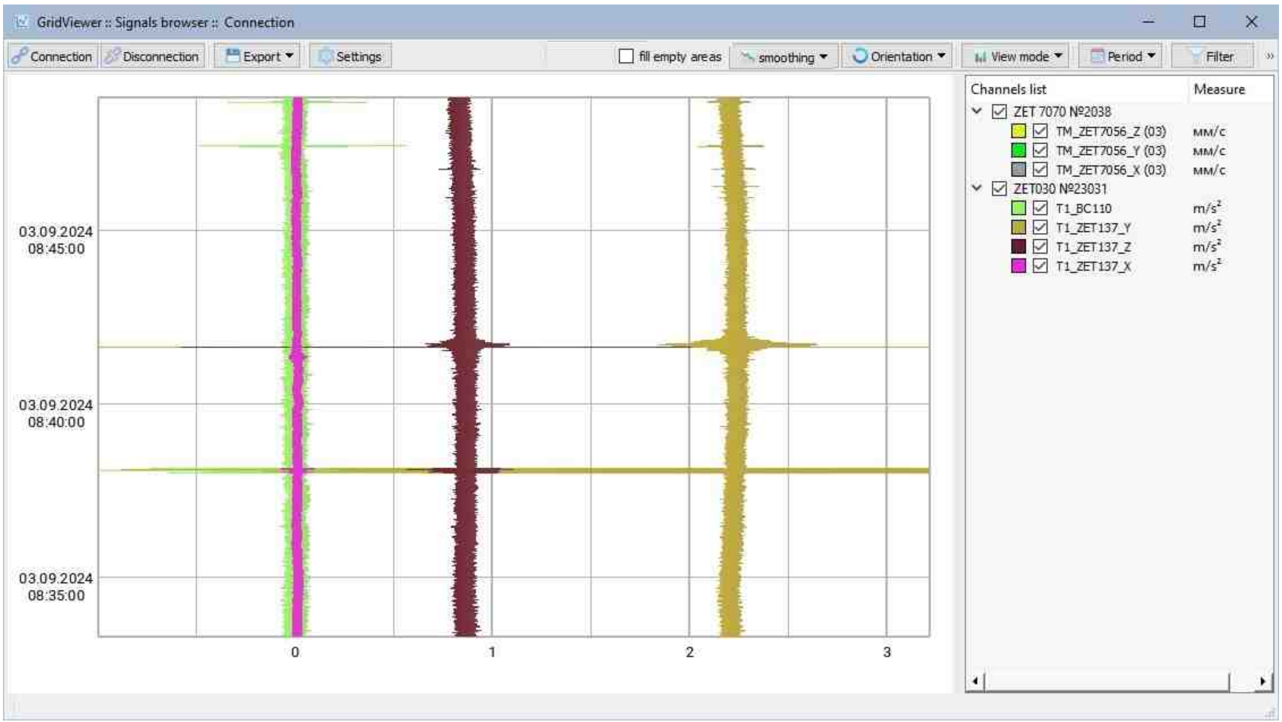


Fig. 3.9 Graphic orientation – "Vertical"

"View mode" tab (*Fig. 3.10*) is used to select the graphic display mode: standard, split, seismogram. When selecting the "Standard" mode, (*Fig. 3.11*) graphics are displayed in one window. When selecting the "Separation" and "Seismogram" modes (*Fig. 3.12*) each graph is displayed individually in its own window.

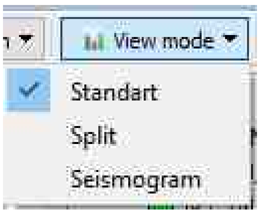


Fig. 3.10 "View mode" tab

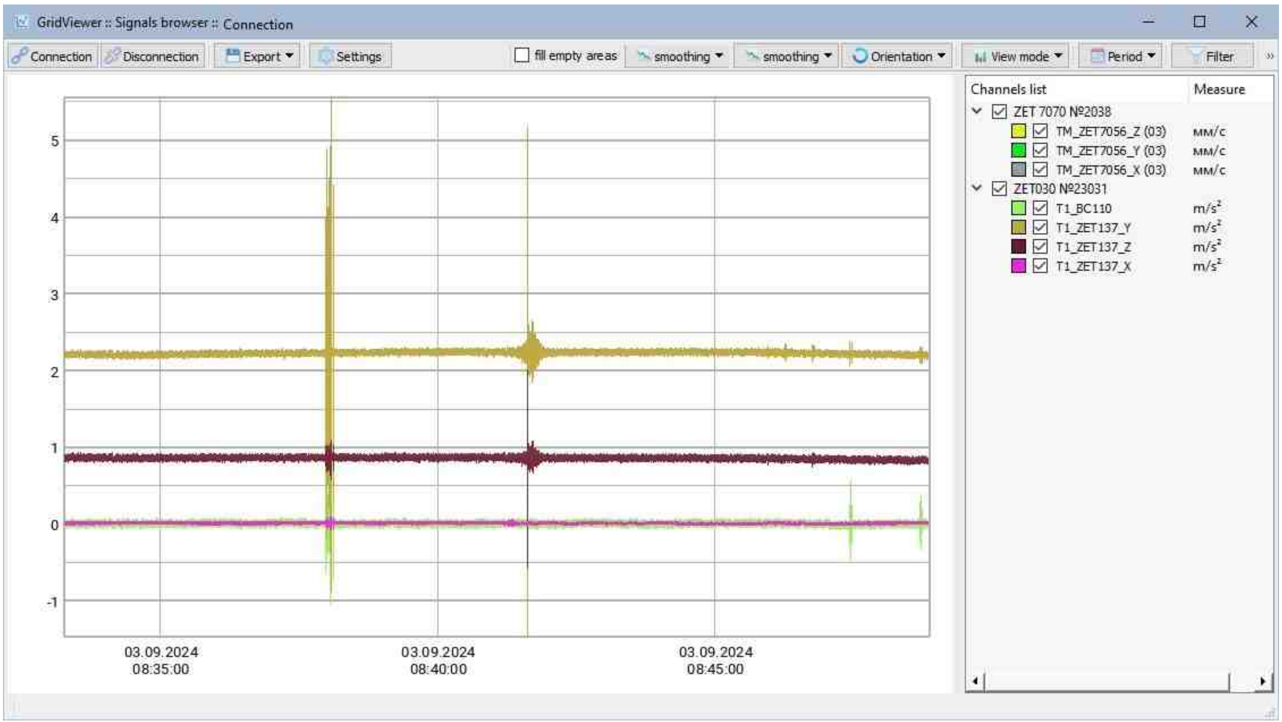


Fig. 3.11 View mode "Standard"

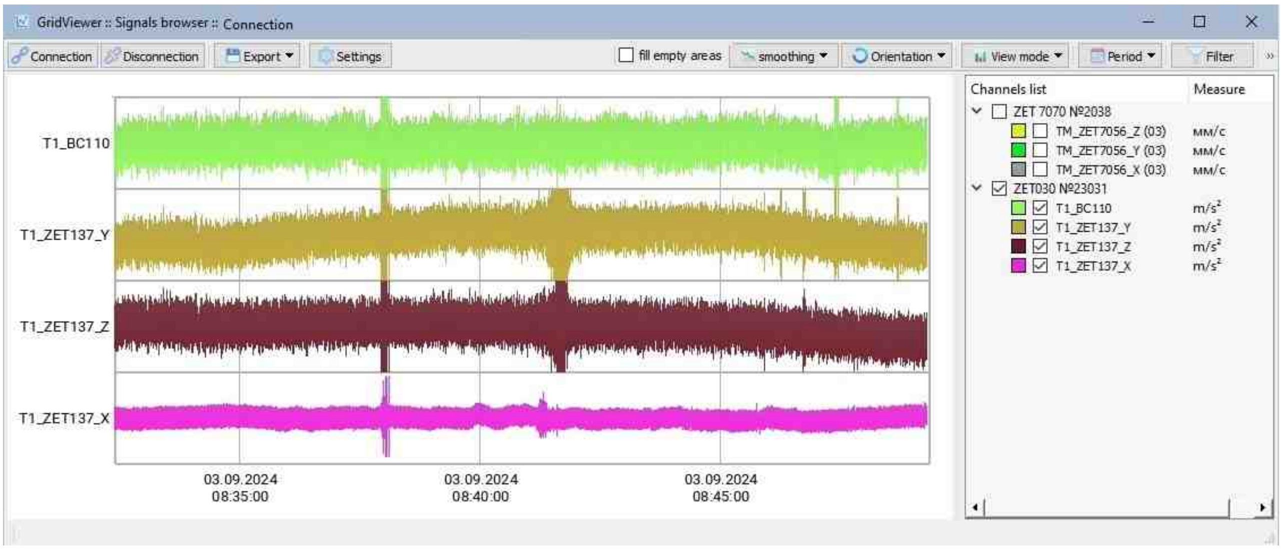


Fig. 3.12 View mode "Seismogram"

The "Period" tab (*Fig. 3.13*) is designed to select the boundaries of the data displayed on the graph along the X axis. To select the boundaries from the pop-up list, select the period of the data displayed: for the last hour, last day, last week, last month, last year.

Fig. 3.13 The "Period" tab

It is also possible to independently set the period of the displayed range by clicking the "Choose..." button and in the "Display period" window that opens, set the values of the beginning and end of the period (*Fig. 3.14*).

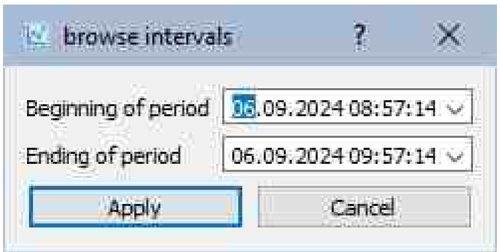


Fig. 3.14 Window "Display period"

The "Filter" menu (*Fig. 3.15*) is intended for adding measuring channels from the database of requested data to the list of channels. To the right of the Filter menu there is a field for selecting groups of measuring channels.

Fig. 3.15 The "Filter" menu

Activating the "Autoupdate" option (*Fig. 3.16*) automatically updates the data displayed on the graphic.

Fig. 3.16 The "Autoupdate" parameter

3.1.2 C*hannels list*

The channel list is used to select measuring channels, the recording of signals for which should be displayed on the graphic (*Fig. 3.17*). To select a measuring channel, activate the cell in the field corresponding to the measuring channel. Also, the corresponding unit of measurement is displayed opposite each measuring channel.

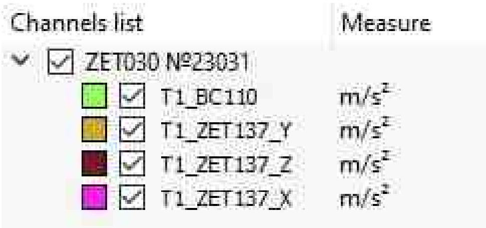


Fig. 3.17 The list of channels of the program "Signal trends viewing (New)"

Note: the measuring channels will be displayed in the list only after selecting a group of measuring channels from the "Filter" field *(Fig. 3.30)*.

A cell filled with an arbitrary color is designed to highlight the signal line on the graphic with a unique color. To set the color of the signal line display, left-click on the cell with the color corresponding to the measuring channel. In the "Select color" window that opens, set the desired color and click "Ok" (*Fig. 3.18*).

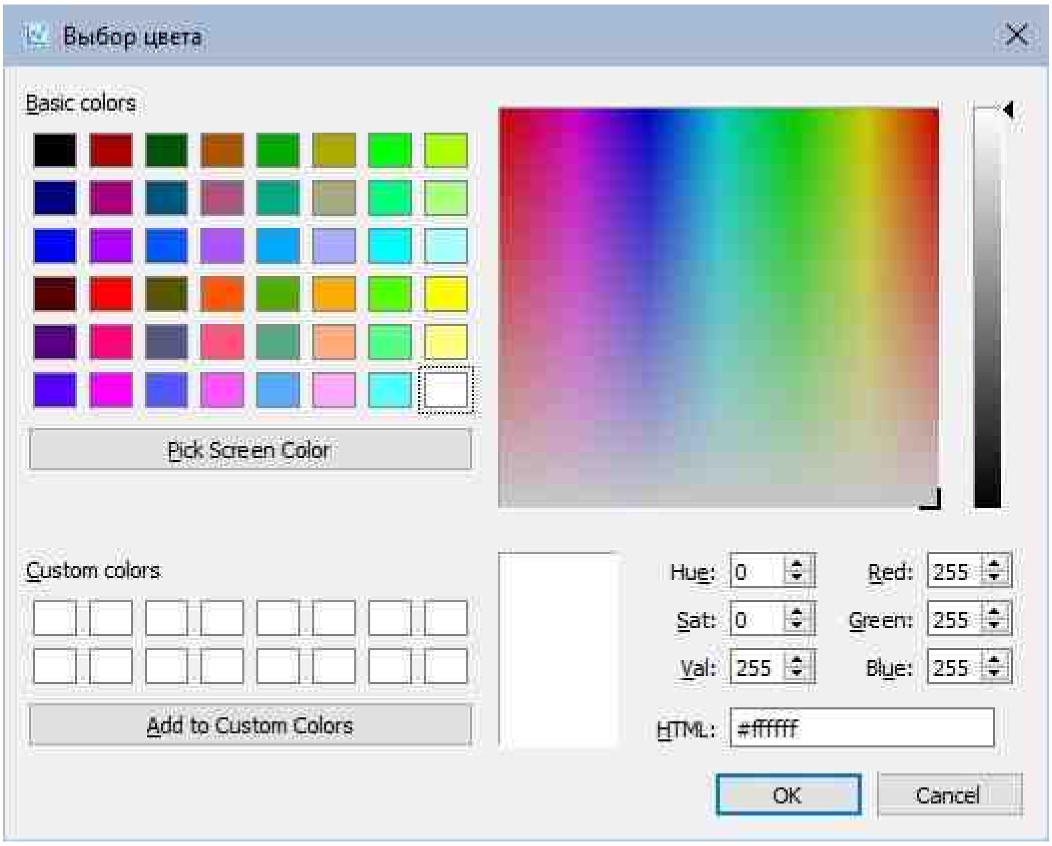


Fig. 3.18 The "Select color" window

3.1.3 ***Graphic area***

The area is designed to graphically display changes in the registered parameters of the measurement channel signals activated in the "Channels list" area (*Fig. 3.19*).

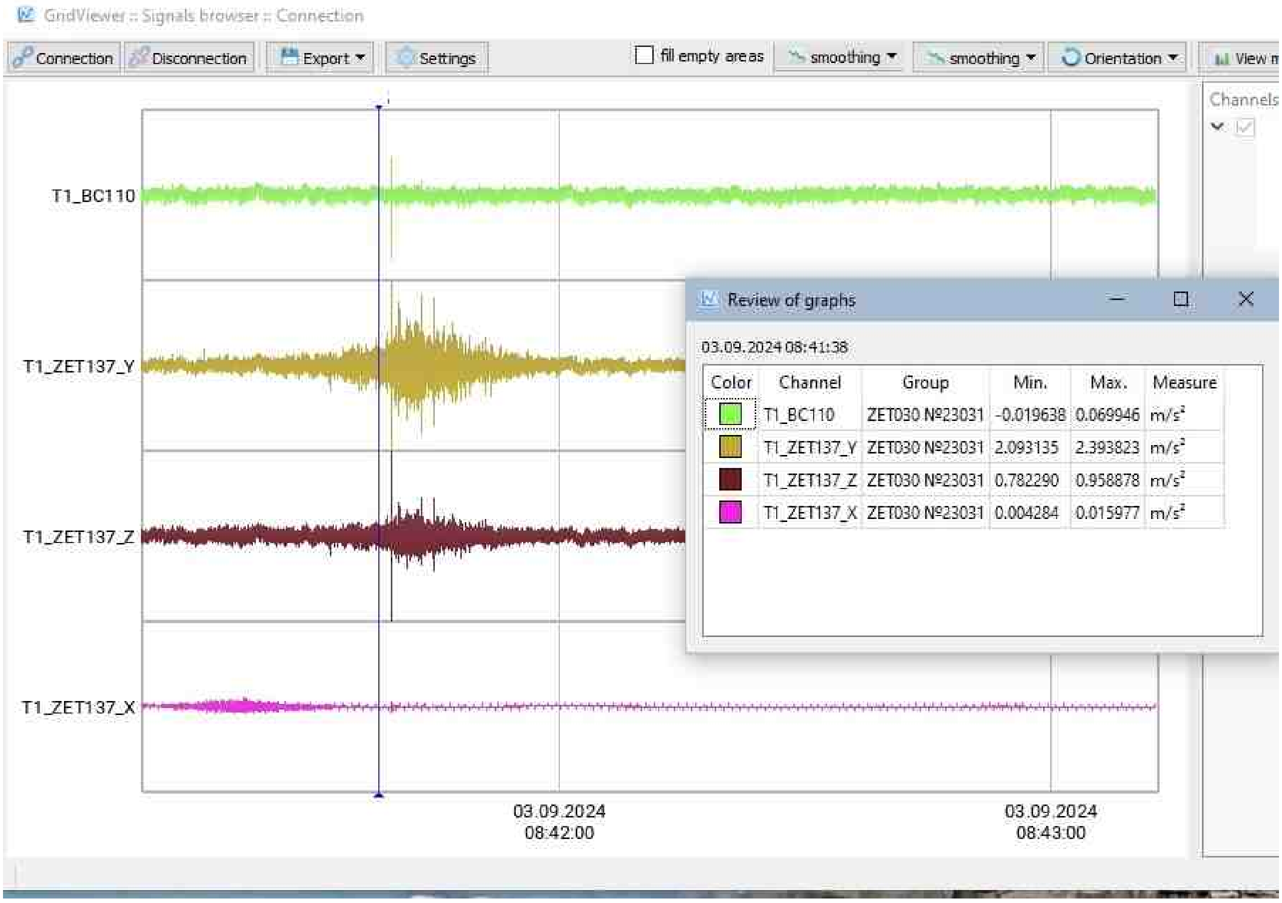


Fig. 3.19 The graphical area of the "Signal trends viewing (New)" program

The horizontal scale is the time scale corresponding to the period of the displayed data on the graph along the X axis.

The vertical scale is the amplitude scale, corresponding to the units of measurement along the measuring channels.

The marker is a vertical thin line in the display area. When you hover the cursor over an arbitrary area of the graphic and then press the left mouse button, a marker will be displayed and the "Overview of graphics" window opens, containing information about the time, minimum and maximum amplitude of the signal at the intersection point of the marker with the

signals of the measuring channels (*Fig. 3.20*).

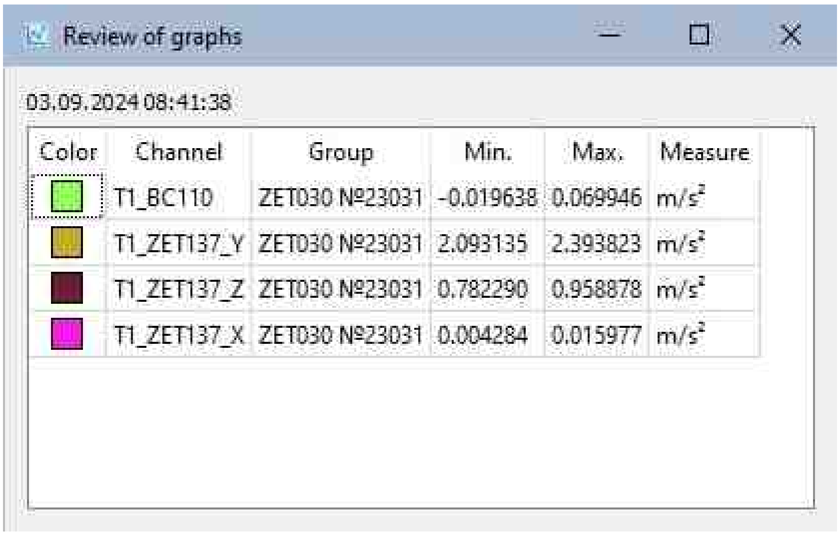


Fig. 3.20 "Overview of graphics" window

When viewing a graph, you can increase or decrease the display area (scale) of the graphic, change the boundaries of the displayed data using the mouse pointer, while the program automatically calculates how much data needs to be requested to build a detailed display and with what compaction.

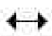
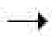
To change the scale along the time axis, you need to move the mouse cursor to a point on the graph, the scale of which needs to be changed, and rotate the mouse wheel back and forth to increase or decrease the scale of the signal display along the time axis.

To change the scale along the amplitude axis, move the mouse cursor to the vertical scale area until the expansion icon appears and rotate the mouse wheel forward/backward to increase or decrease the scale of the signal display along the amplitude axis.

Note: Scaling along the amplitude axis is only available in the viewing modes – standard and seismogram.

You can scale the numerical axes using mouse.

To scale the numerical axes, place the mouse cursor to the scale axis of the graphic. The cursor will change its appearance depending on its position on the numerical axis:

- For horizontal axes: , , , ;
- For vertical axes: , , , .

Symbols ↔ and ↕ stand for extension, and symbols →← and ↓↑ - for compression of the graphic scale by the corresponding axis. Symbols ← and → stand for moving to the left and to the right by the horizontal axis, and symbols ↑ , ↓ stand for moving up and down by the vertical axis.

As you select the required action for scaling by numerical axis and the cursor changes its appearance, you can scale the graphic by using the left mouse key, or by using the scroll key.

For auto-scaling of the vertical axis in the registered range of values (which is displayed in horizontal axis of the graph), place the cursor at the crossing of the numerical axes, so that the cursor icon would change for and left-click it.

3.2. *Connect to data server*

Activate the Connection menu from the control panel of the "Signal trends viewing (New)" program. The Connection Manager window that opens is designed to connect the "Signal trends viewing (New)" program to the data server where signal recordings are stored (*Fig. 3.21*).

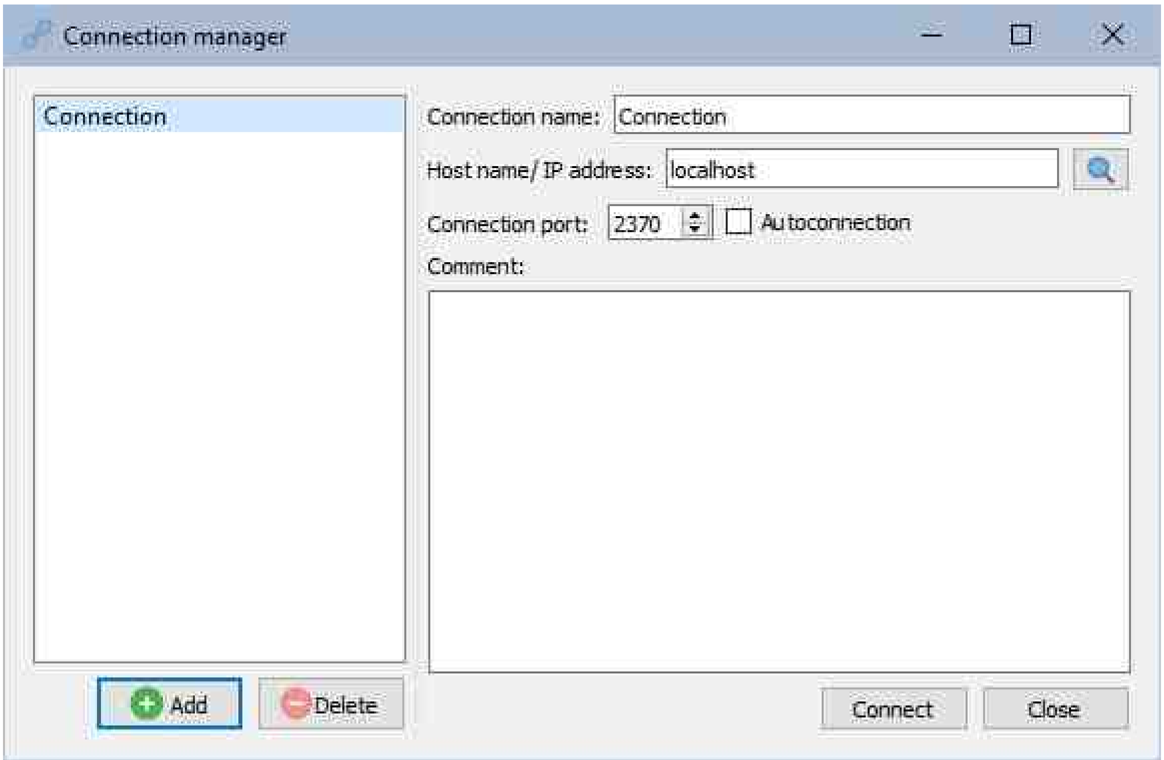


Fig. 3.21 "Connection manager" window

In the "Connection Manager" window, in the Host name/IP address field, enter the host name or IP address of the signal server. If the signals are located on the same computer from which the "Signal trends viewing (New)" is running, you must specify the value "localhost" in the Host name field and set the connection port to "2370".

In the Connection name field, enter the name of the data server.

The checkbox in the Auto connection field activates the automatic download of trends from the specified data server when the "Signal trends viewing (New)" is launched.

In the Comment field, you can enter additional information about the data server, such as information identifying its purpose, location, etc.

To search for available data servers, click the button with the image . In the opened window "Autodiscovery" click the button "Search". After the search is complete, a list of available servers will be displayed. To select a specific server, click the button "Use" in the corresponding line (*Fig. 3.22*).

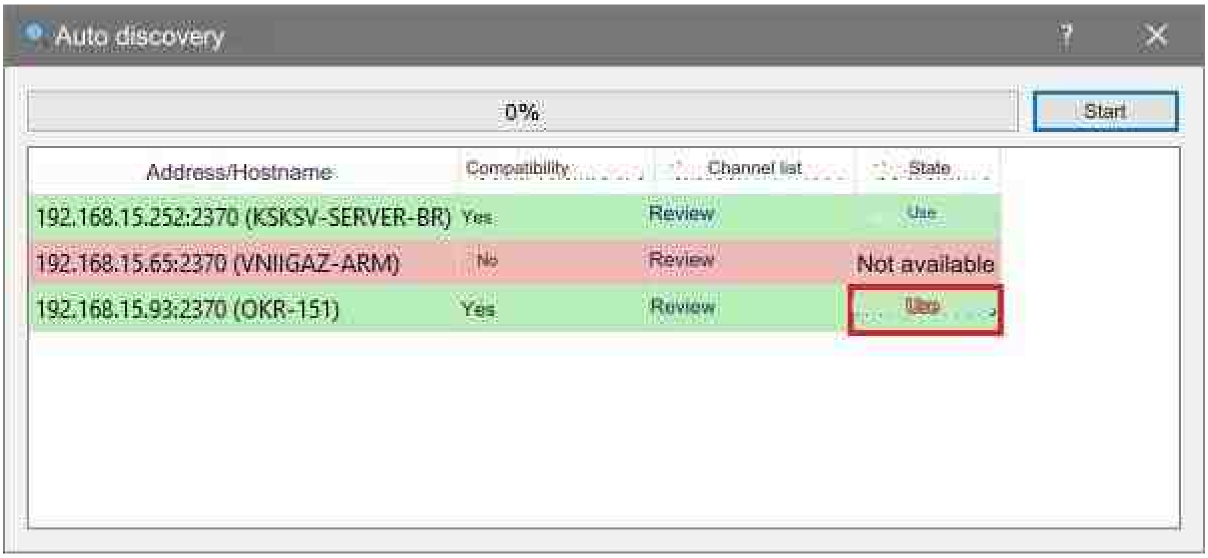


Fig. 3.22 The "Auto-detection" window

The "Connection manager" program provides the ability to add multiple connection templates to data servers. To add a template, you must first set the parameters of the data server, and then click the "Add" button (*Fig. 3.23*).

Fig. 3.23 The "Add" button

The created server will be displayed in the list of data servers. (*Fig. 3.24*).

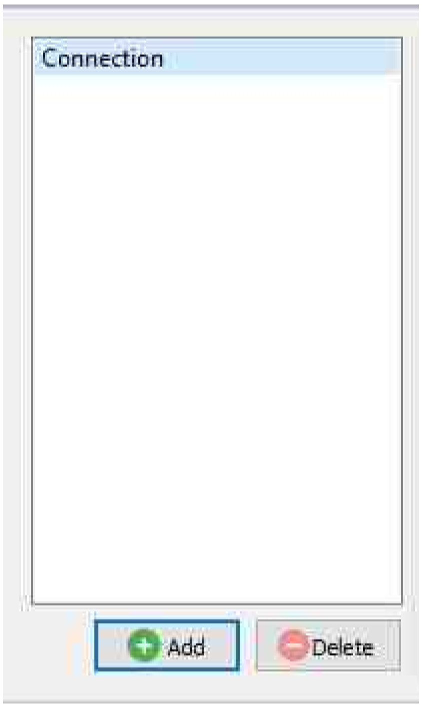


Fig. 3.24 List of data servers

To connect to a data server, select the desired server from the list and click the "Connect" button.

After connecting to the data server, the "Signals server" window opens, in which, upon successful connection, information about the client connection should be displayed (*Fig. 3.25*)

Fig. 3.25 The "Signals server" window

Press the "Channels filter" button to set up the list of measuring channels. In the "List of channels" window that opens, activate the necessary measuring channels and click "Ok" (*Fig. 3.26*). In the future, the measurement channels involved will be available for selection in the channel list of the "Channels filter" window (*Fig. 3.28*).

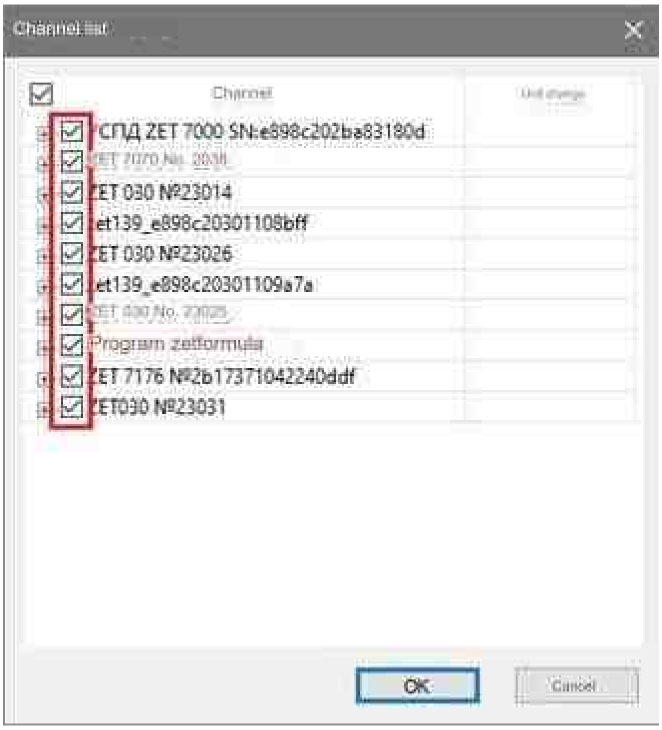


Fig. 3.26 List of channels

Minimize the "Signals server" window by clicking .

3.3. *Working with software*

After connecting to the data server, in the main menu of the program "Signal trends viewing (New)" click the menu "Filter" (*Fig. 3.27*).

Fig. 3.27 The menu "Filter"

The “Channels filter” window that opens will display a list of available measurement channels (*Fig. 3.28*).

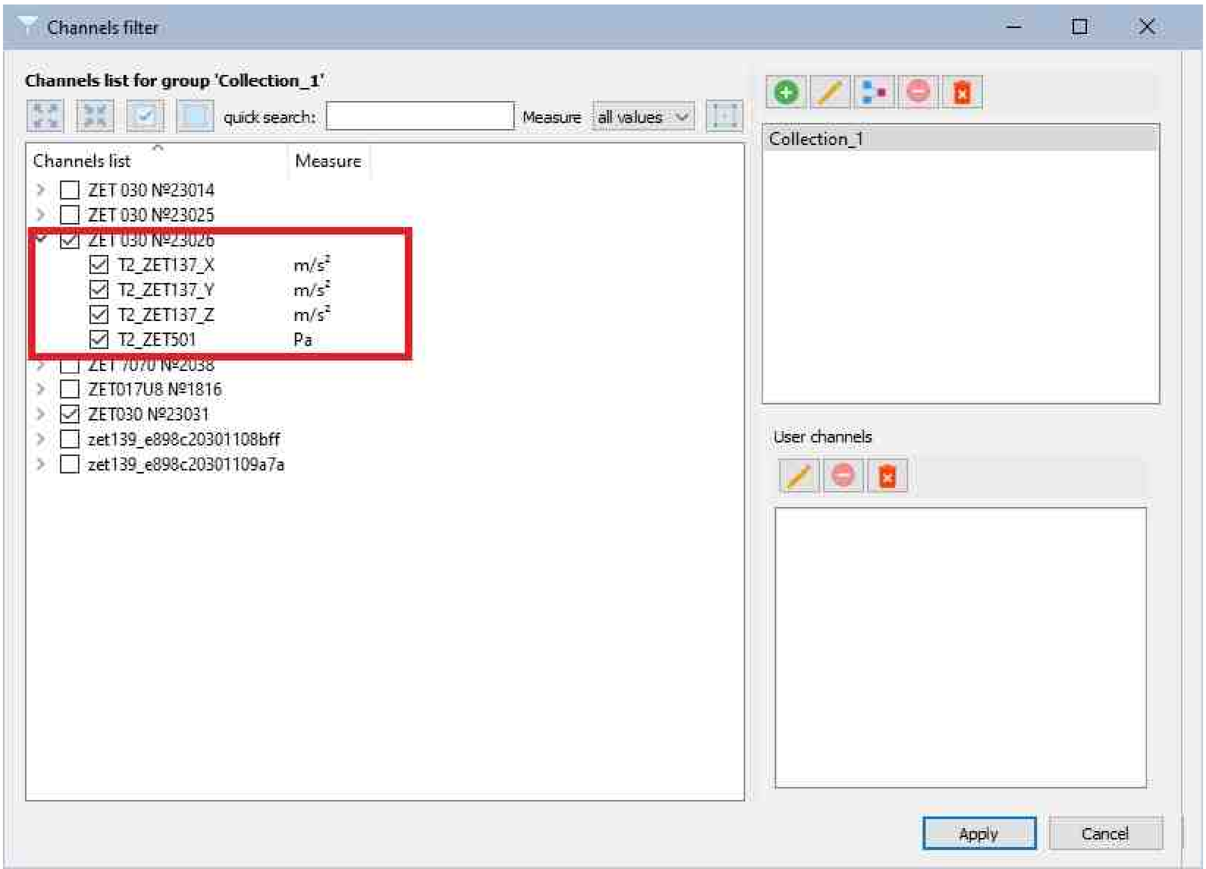


Fig. 3.28 The "Channels filter" window

In the "Channels filter" window, click the "Add group" button (*Fig. 3.29*).

Fig. 3.29 The "Add Group" button

In the "Add a group" window that opens, enter the name of the channel group and click "Ok" (*Fig. 3.30*).

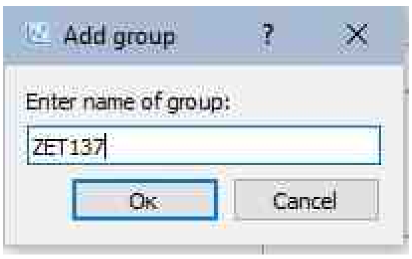


Fig. 3.30 The "Add a group" window

In the window with the list of groups, select the previously created group, then activate the necessary measuring channels from the list of available measuring channels and click the "Apply" button (*Fig. 3.31*).

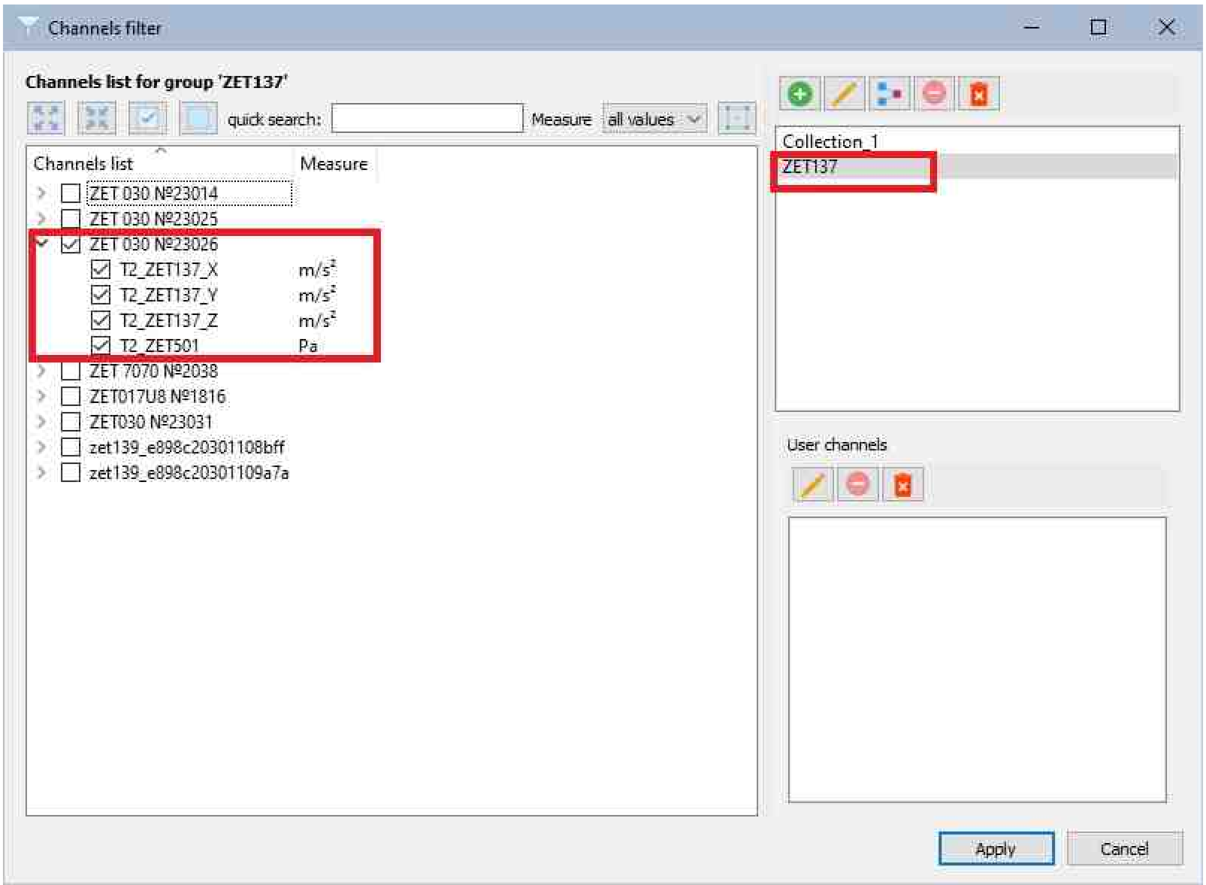


Fig. 3.31 "Channels filter" window

In the main menu of the "Signal trends viewing (New)" program, click the field with the list of available groups and select a previously created group or several groups from the list (*Fig. 3.32*).

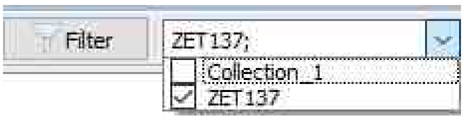


Fig. 3.32 Select a channel group

The measurement channels of the selected group will be displayed in the channel list. Activate cells in the fields of measuring channels, the data for which you want to display on the graphic (*Fig. 3.33*).

Fig. 3.33 Select channels from the list

The graphic shows the recorded data for the selected measurement channels (*Fig. 3.34*).

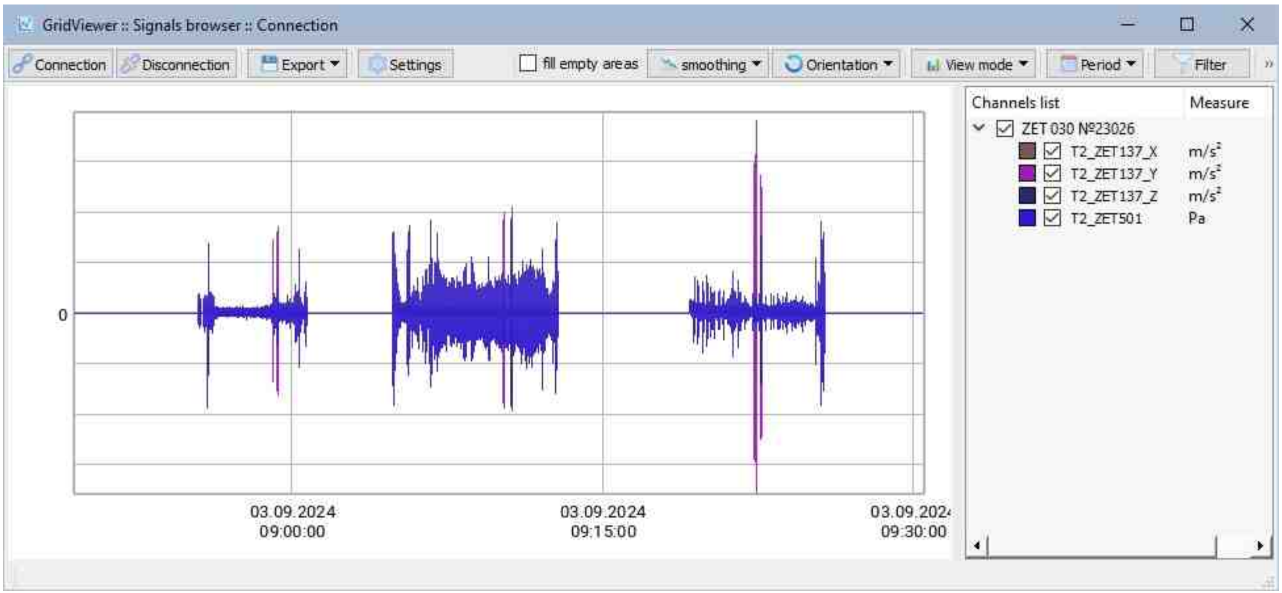


Fig. 3.34 The window of the program "Signal trends viewing (New)"

In the main menu of the "Signal trends viewing (New)" program, click the "Period" tab and select the boundaries of the displayed data on the chart along the X axis. You should also use the graphic controls to scale and detail the required signal fragment. (*Fig. 3.35*).

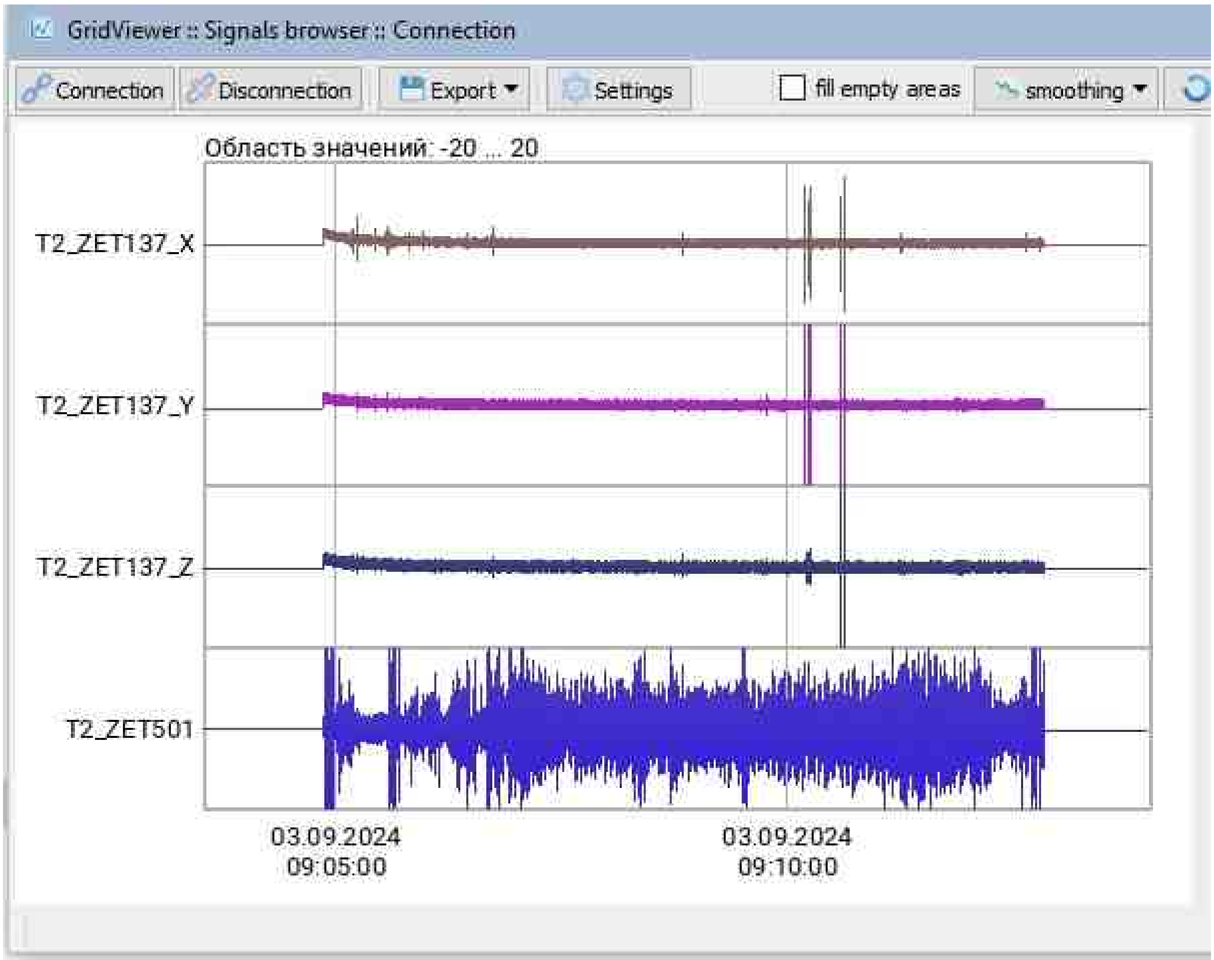


Fig. 3.35 The window of the program "Signal trends viewing (New)" - scaling

If necessary, you can change the graphic display mode (*Fig. 3.36*), by selecting the desired mode from the "Viewing mode" tab of the main menu of the "Signal trends viewing (New)" program.

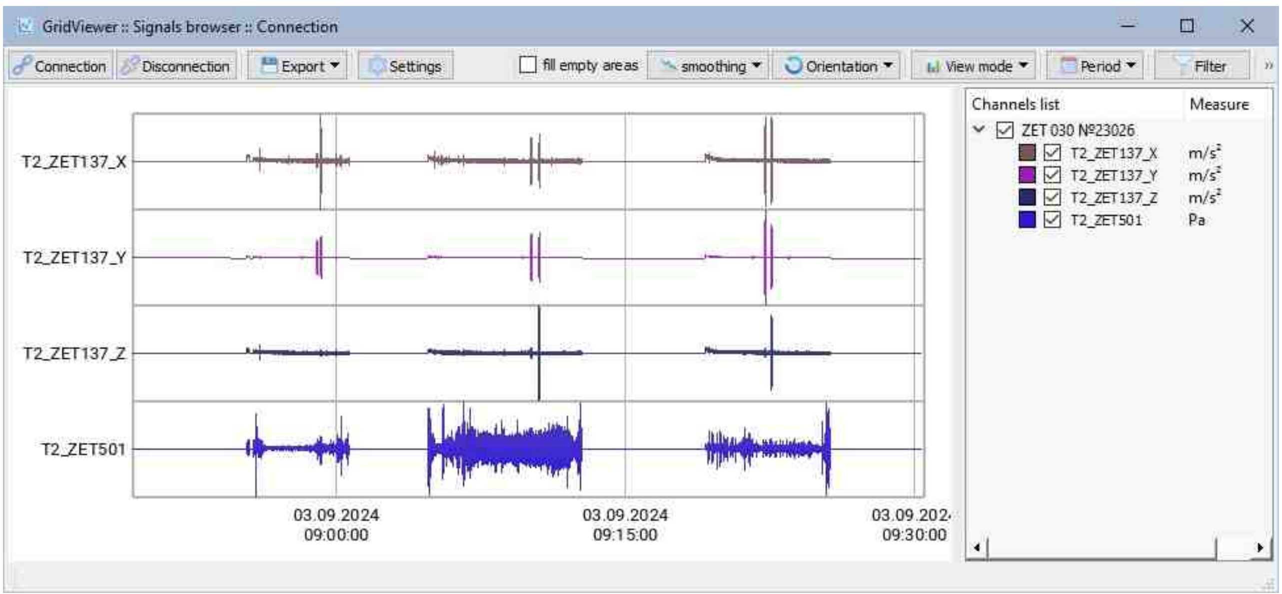


Fig. 3.36 The window of the "Signal trends viewing (New)" program is the "Seismogram" viewing mode

To save the viewing results, open the Export tab from the main menu of the "Signal trends viewing (New)" program and use one of the suggested options for saving the results in formats: ANA/ANP, CSV, XLSX, DTU, MSEED, SEGY, PNG.

View historical events .....

A **View historical events** is a diagram facilitating analysis of long records of measured sensor values (for hours, days, months, years). Based on the sampling frequency, an *n* number of counts per second are performed, and their yearly number equals to 31,556,926*n.

View historical events is included in the **Recording** software group.

Supported Hardware .....

Input data program **View historical events** are digital data channel server **ZETLAB**.

The software **View historical events** is included with the following software:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT Spectrum software
- ZETLAB VIBRO – Shaker control systems software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software (option).

View historical events is included in the program group **Registration**

Program description .....

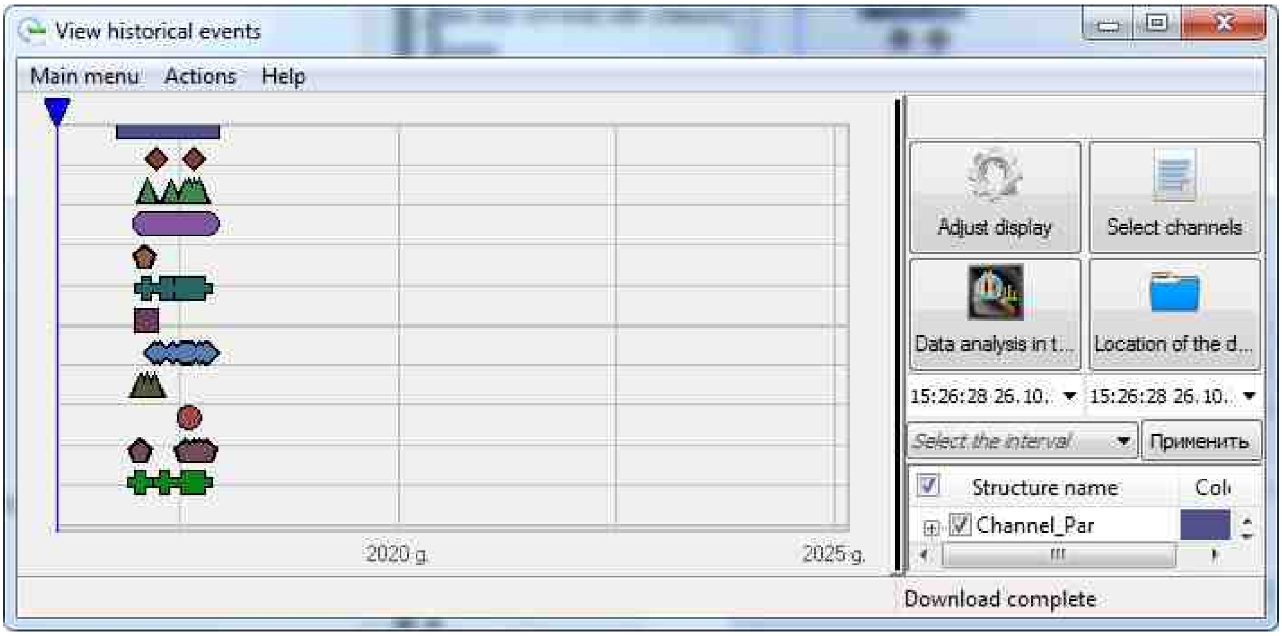
The program **View historical events** is started from the **Registeration** menu of the **ZETLAB** panel.

Start View historical events.

This program **View historical events** is included into basic **ZETLAB** software set and enables representation and analysis of historical events registered by means of **ZETLAB** sotware for a long-term time span.
Note: the **View historical events** can be run directly from the working directory **ZETLAB** (default: C:\ZETLAB\). The name of the startup file: TrendViewer.exe.

"**View historical events** has several sub-clauses:

- Quick access menu;
- A graphic with selection of the recorded structures;
- Coordinates for graphical representation of the events.



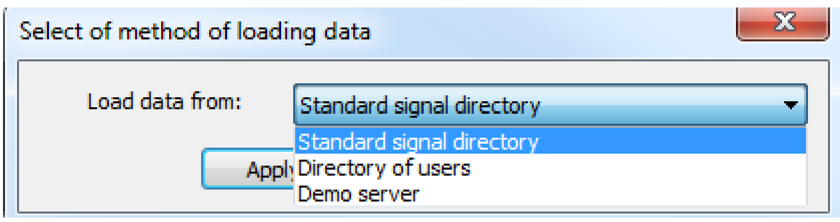
.Quick access menu

The menu contains a set of "hot keys" used for fast adjustment of "View historical events" program settings. In the Fig. below you can see the image of quick access menu.

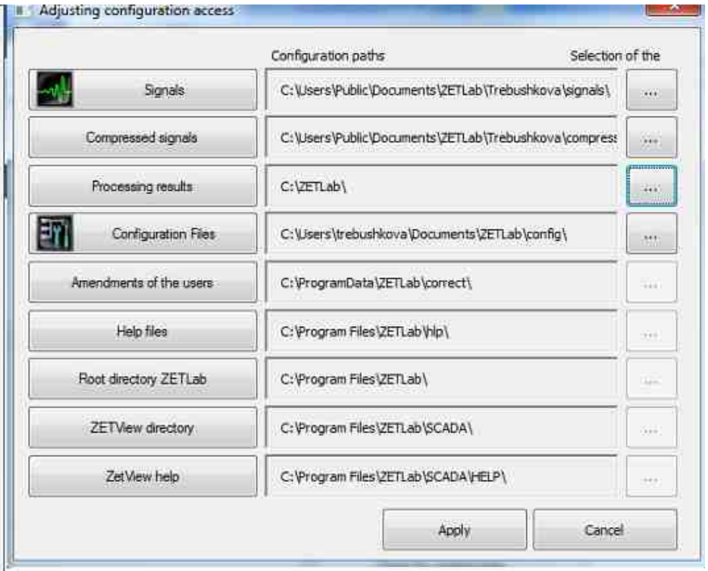
Data location

The key "Data location" allows you to select the directory to be used for storage of the recorded data. There are three options available:

- Standard signals directory
- User directory
- Demo-server

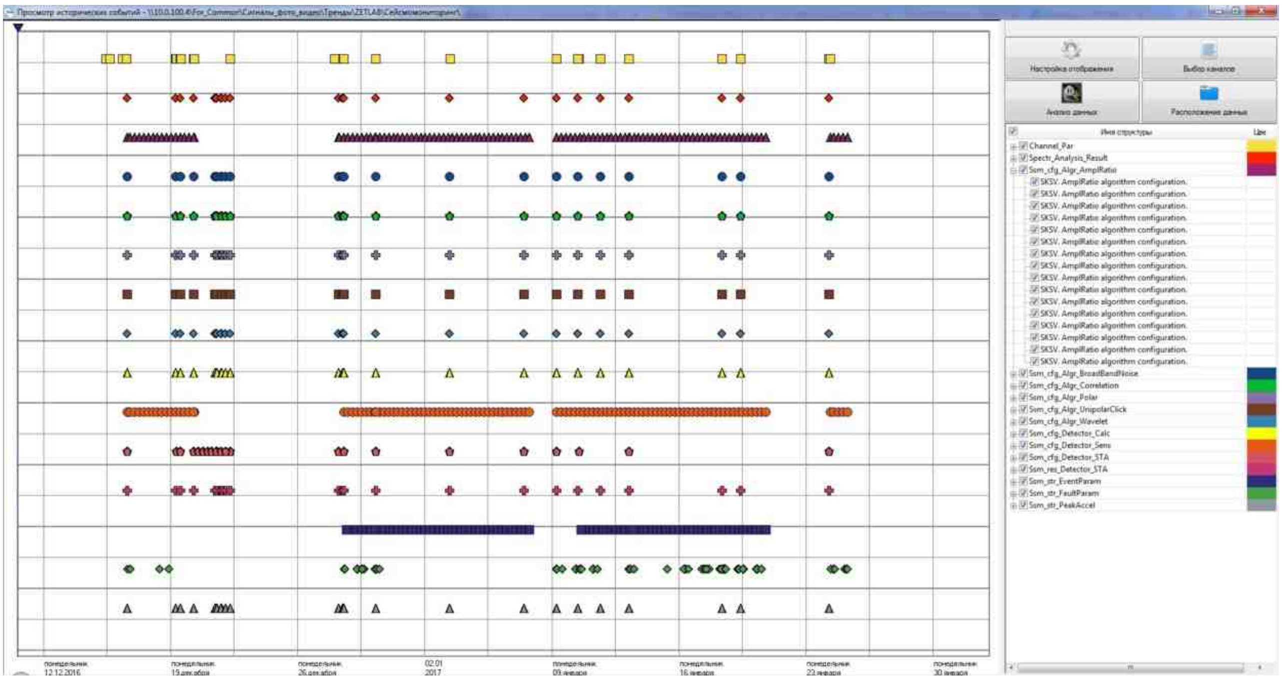


Standard directory is set in the main menu of ZETPanel upon activation of the key "User configuration".



In the case if "DEMO-Server" directory is selected, the data will be downloaded from **ZETLAB** server (this data has been recorded in the Company's headquarters).

Upon selection of files directory there will appear a graphic listing all the recorded data. The coordinates will depict the graphical data relating to corresponding signals.

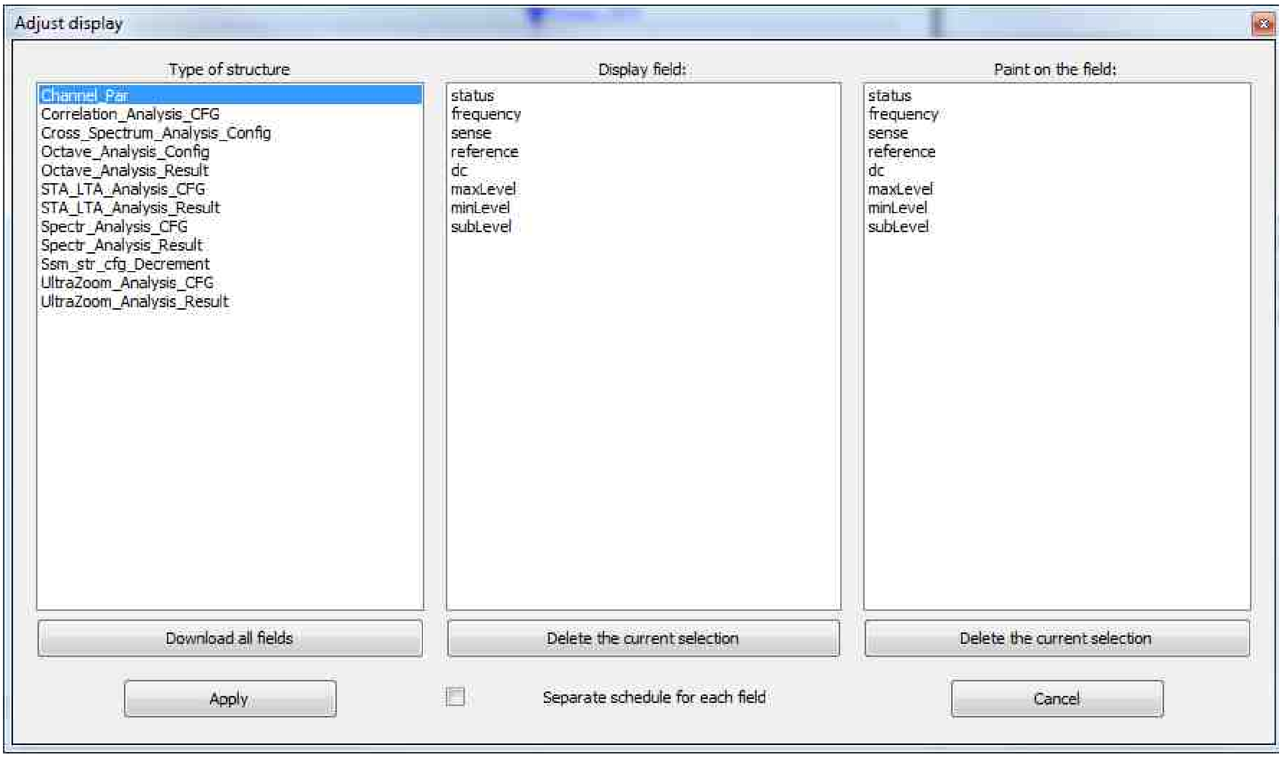


Channels selection

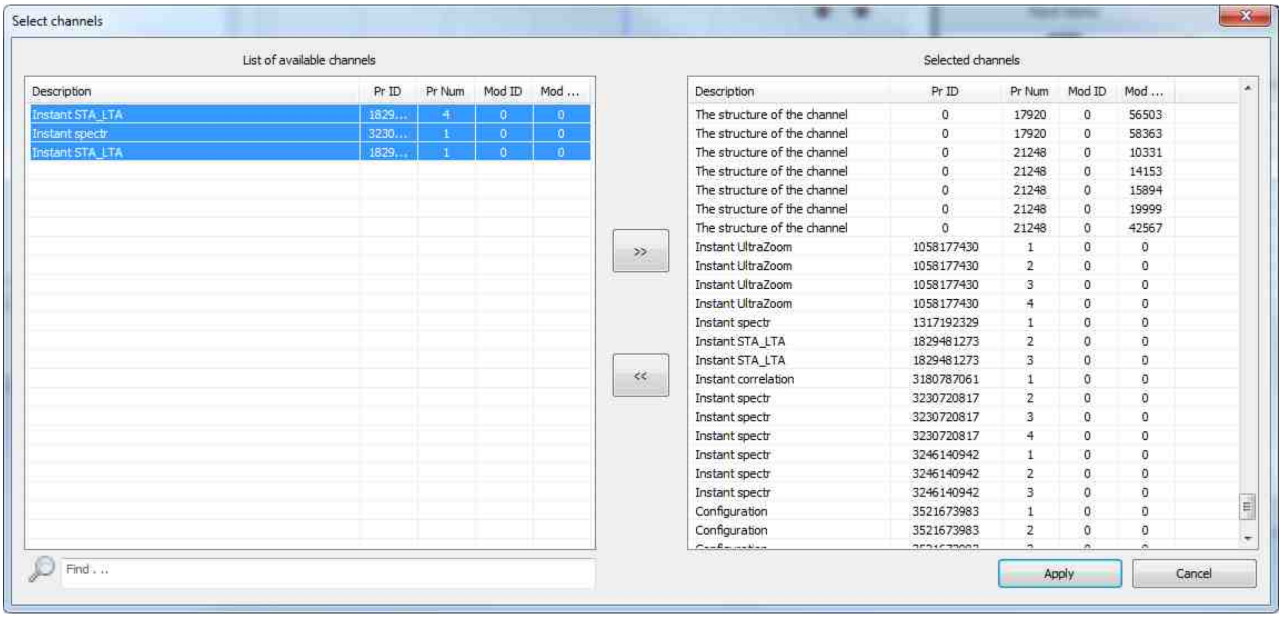
In order to select the data to be represented on the coordinates, one should enable "Select signals" option. Upon activation of the key you will see "Signals selection" window consisting of:

- graphics with available and selected signals;
- channels search field.

The selected channels will be depicted in the "Selection graphic of the recorded signal" section of the program.



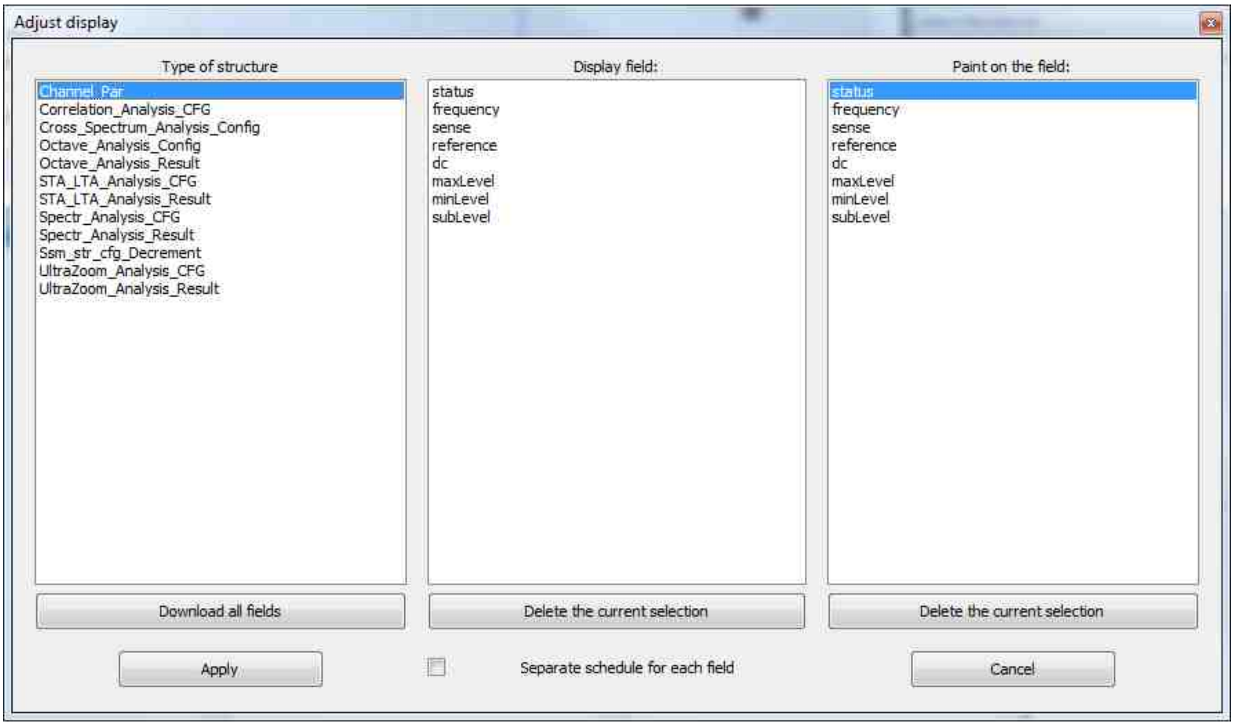
The table "Selected channels" depicts the channels that are selected by the user for further analysis in the coordinate network. The table "Available channels" depicts full range of channels, requested from the data server. For switching between the channels one can use the keys: "" and "". In order to relocate the channel one should highlight it in the list and press corresponding key. To relocate several channels at once one can use "Ctrl" or "Shift" and the corresponding key.
The search field allows to find and highlight a channel or a group of channels in accordance with the particular request.



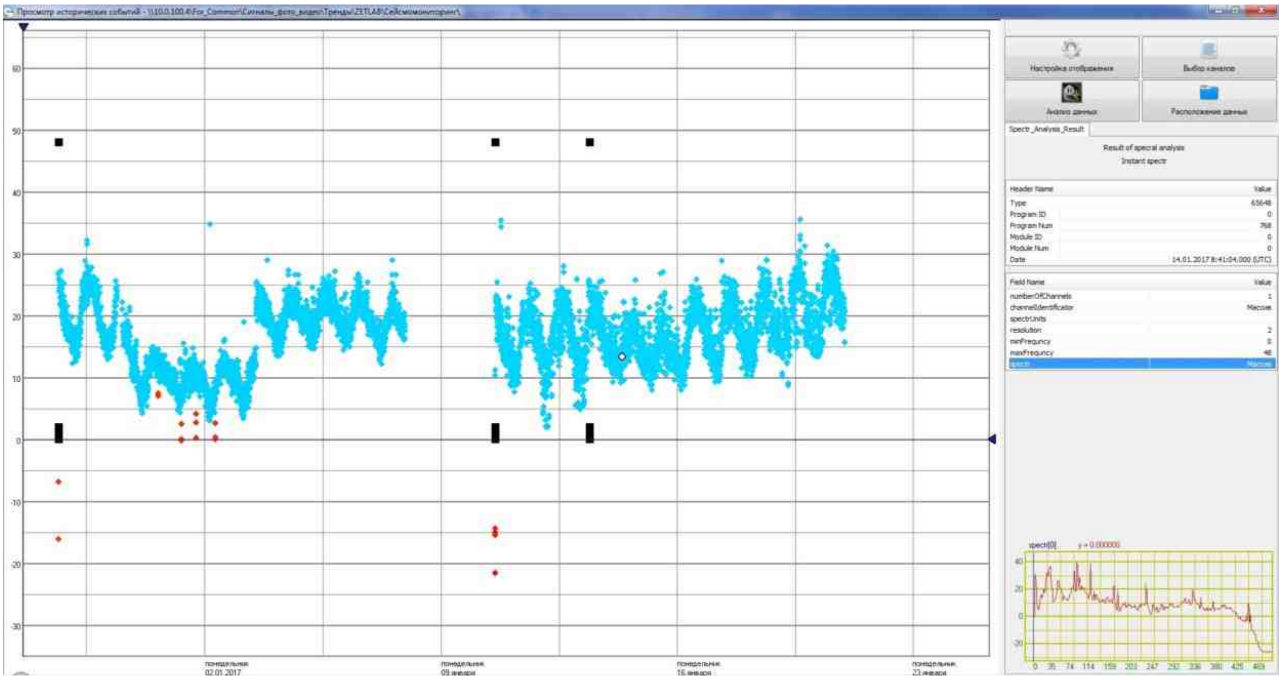
Display settings

The "Display settings" key activates the settings tab, in which it is possible to set the parameters of structures representation. It has several active Table of contents:

- Structures type – selection of particular structures to be represented on the coordinate network for further analysis;
- Description by field – selection of value for Y axis (axis X always stands for the date of the recorded structure);
- Highlight a field – selection of the field to be highlighted with color indication.

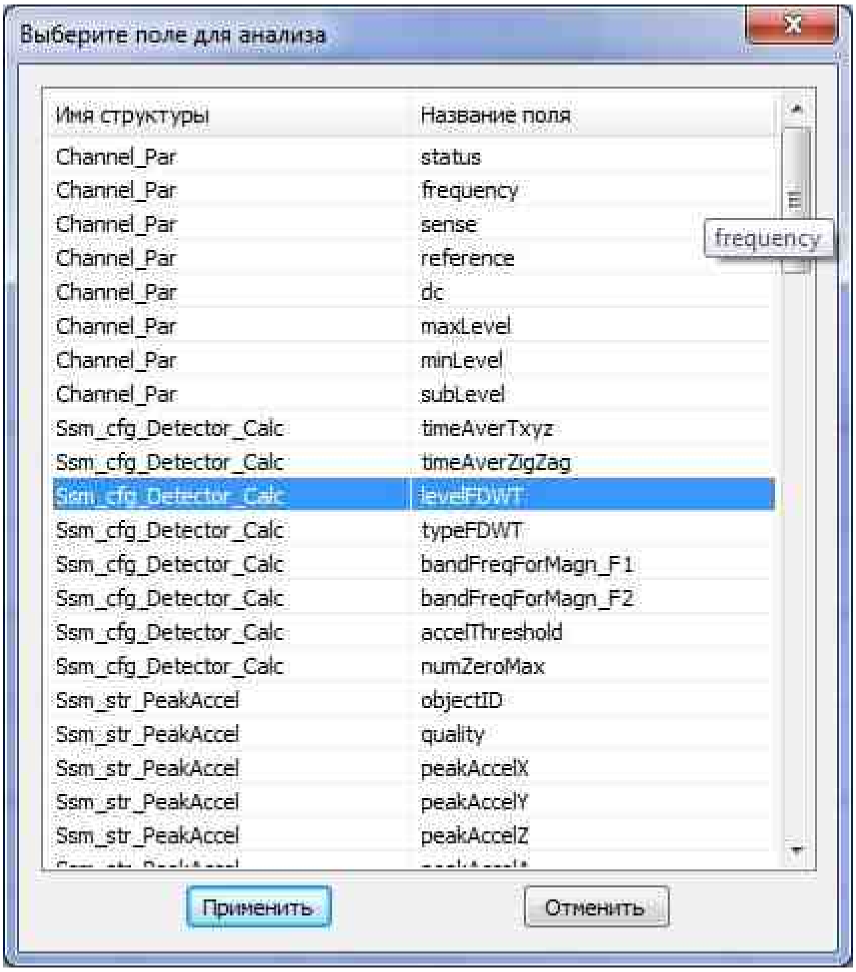


In the case if it is necessary to depict a graphic for each of the fields, one should check the "Separate graphic for every field" check-box. As the settings changes are saved, the coordinate network and available channels section will depict a more detailed information of the selected data structure.

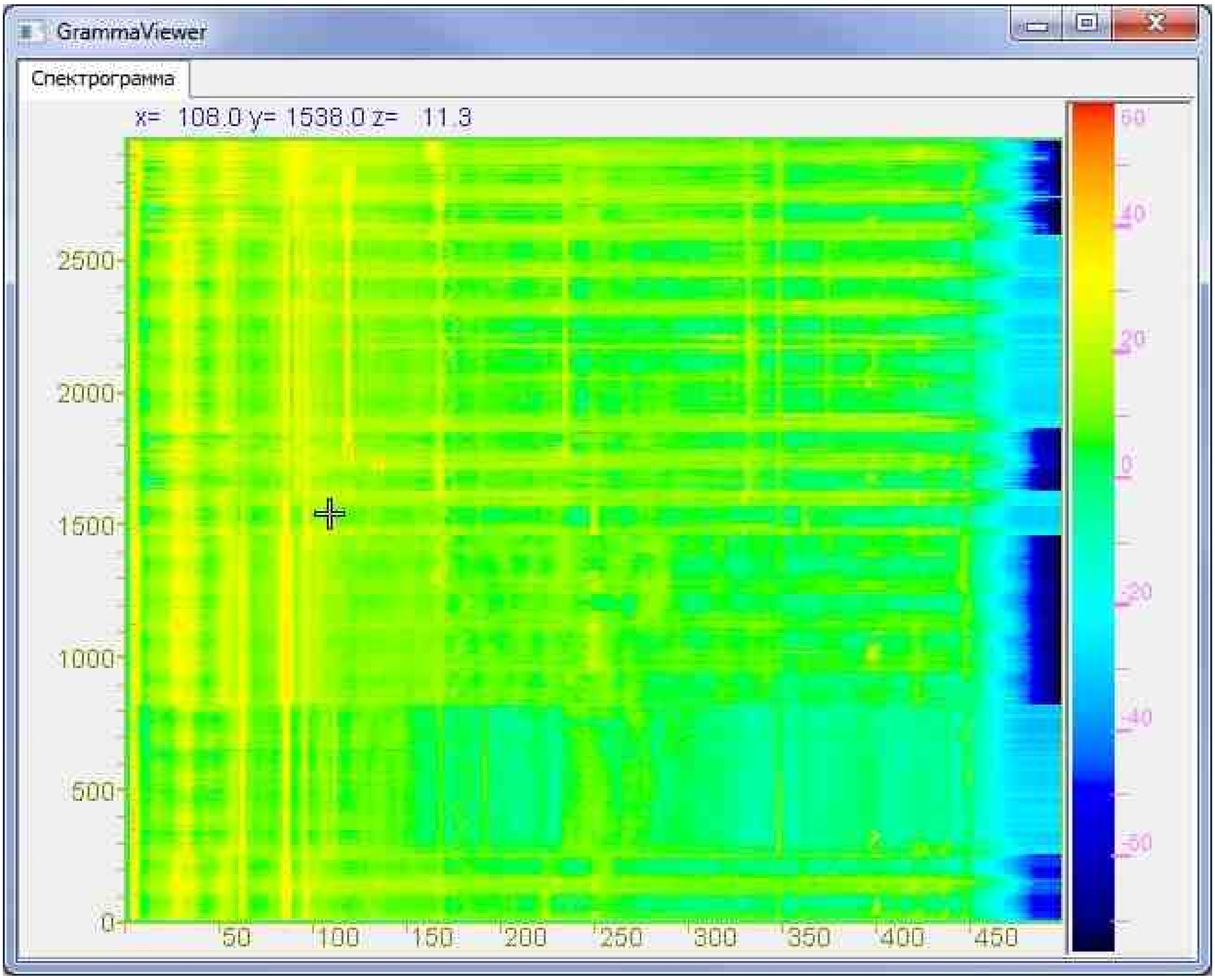


Data analysis

"Data analysis" key activates a window for selection of the field to be analyzed.

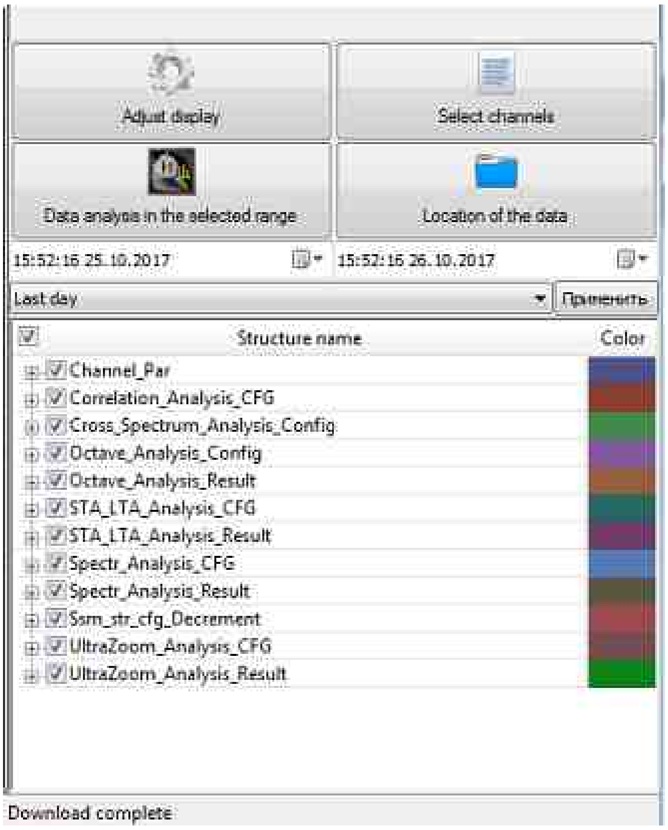


Upon activation of "Apply" key there appears a new window with graphical representation of the selected structure's analysis results. Depending on the structure's type there will be different graphical representation (e.g. a spectral pattern for a spectrum).



Recorded structures table

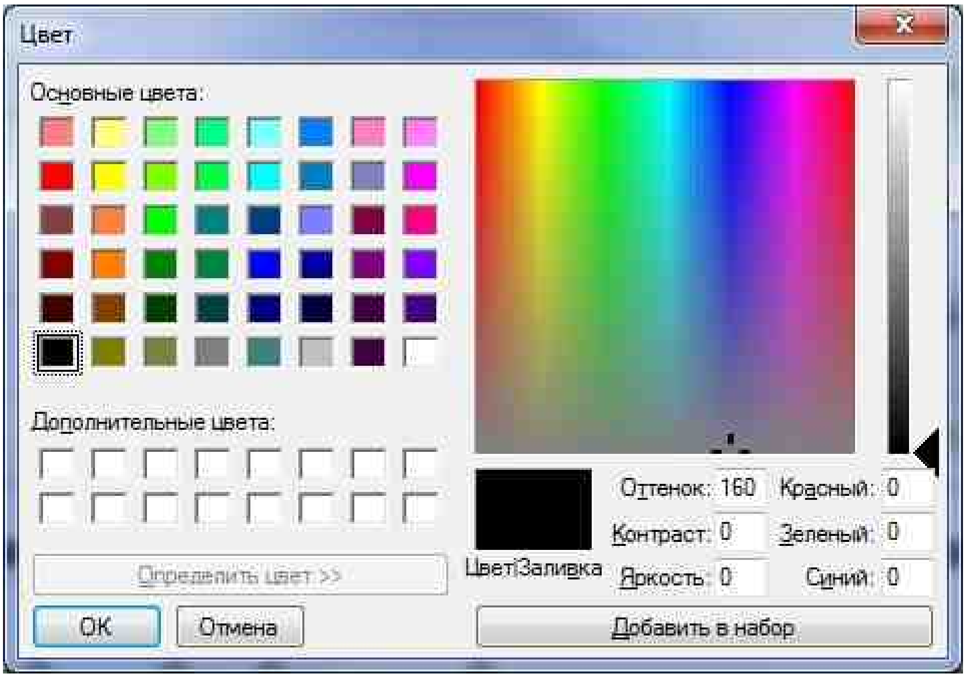
The table is used for selecting the particular structures, signals records of which are to be depicted at the coordinate network. In addition to that, the table may also contain additional information of the selected structures.



In order to select a particular structure to be depicted at the signals record coordinate network, it is necessary to check the box located to the left from the structure’s name.In order to disable representation of a paticular structure, un-check the corresponding box.

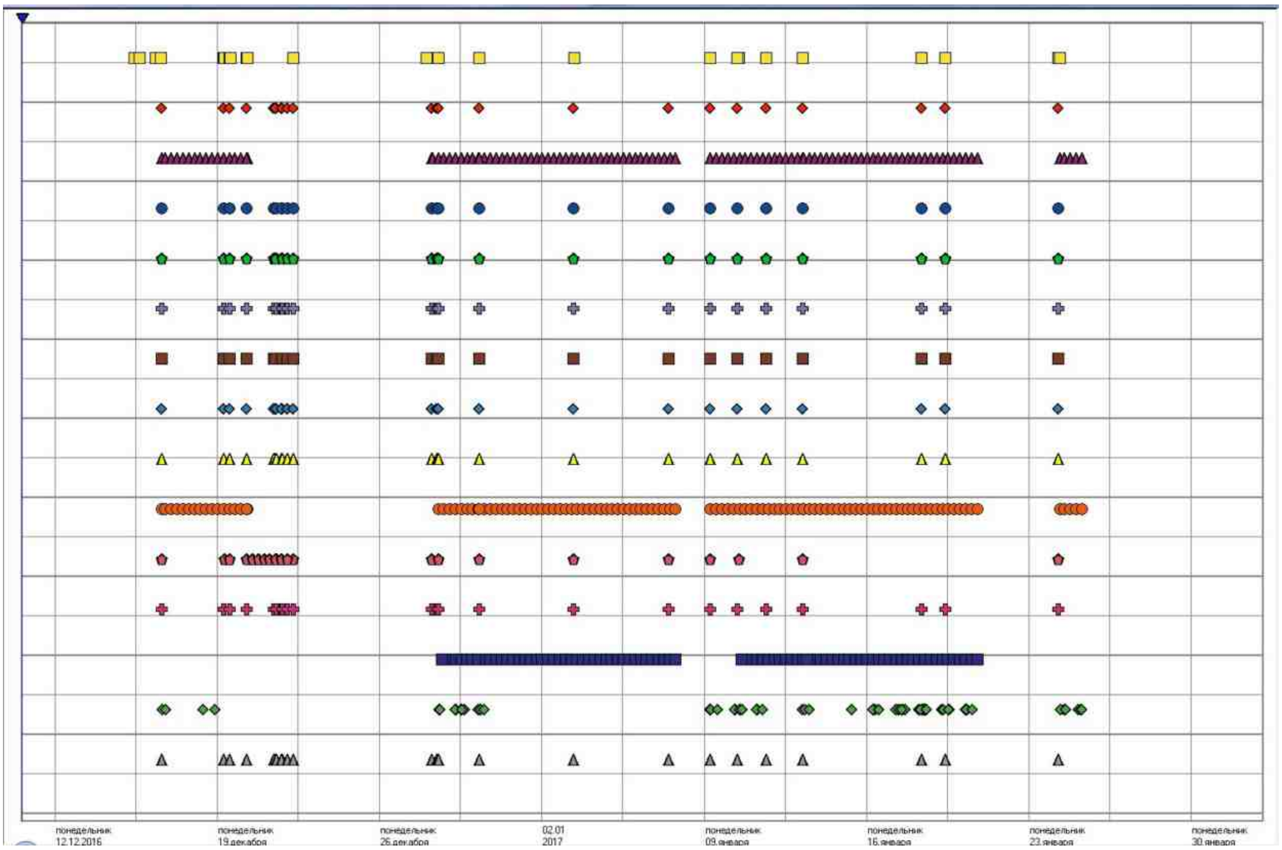
In the case if it is necessary to depict all the structures at once, check the box to the left from "Structure name" section. Un-check the box to disable the function.

The "Color" tab is used to highlight the recorded signals structures in the coordinate network. Double-click the "Color" key next to corresponding structure. It will activate the "Color" window allowing the user to set the selected color by clicking "OK" key.

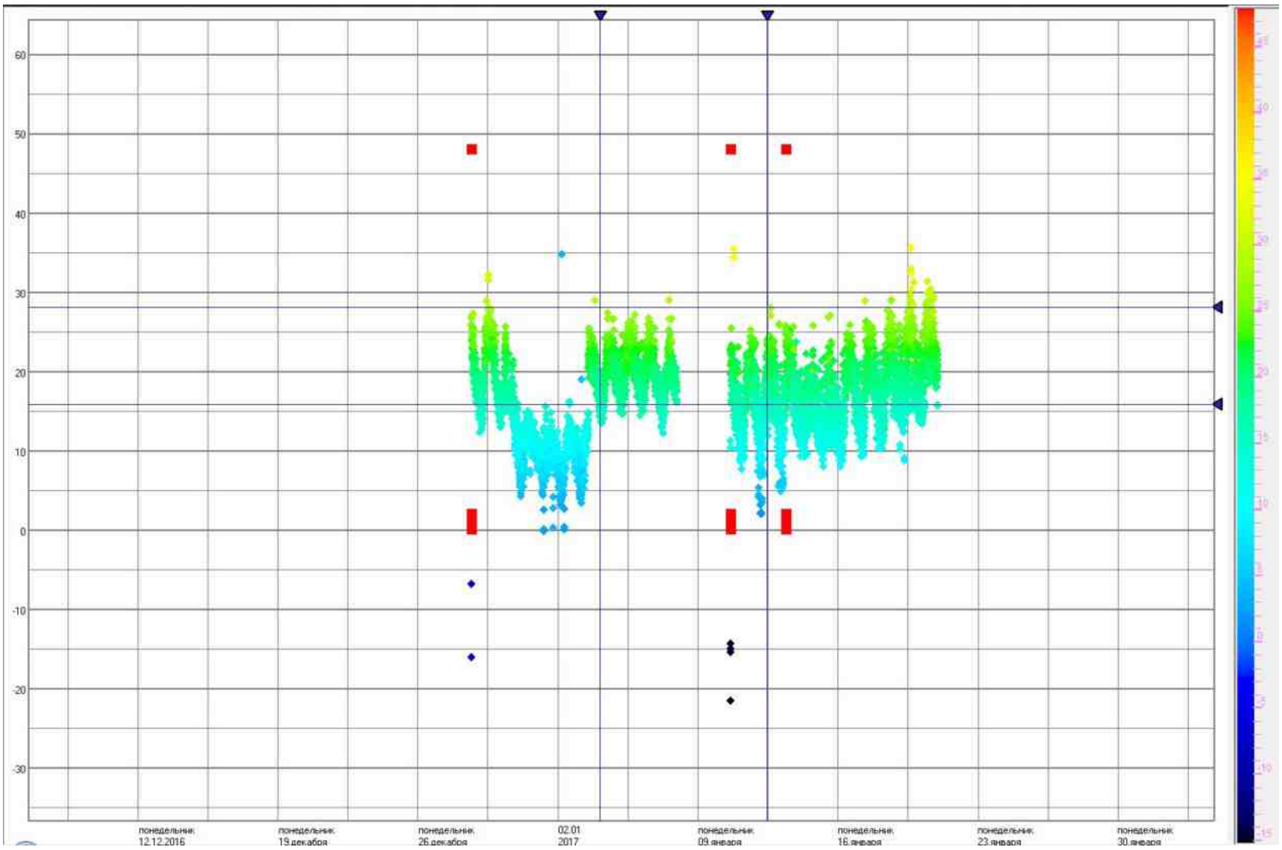


Coordinate network

As the active structures have been selected, the coordinate network depicts corresponding data types. Each data type is displayed by a certain Fig.. The Fig. color is assigned by the user.

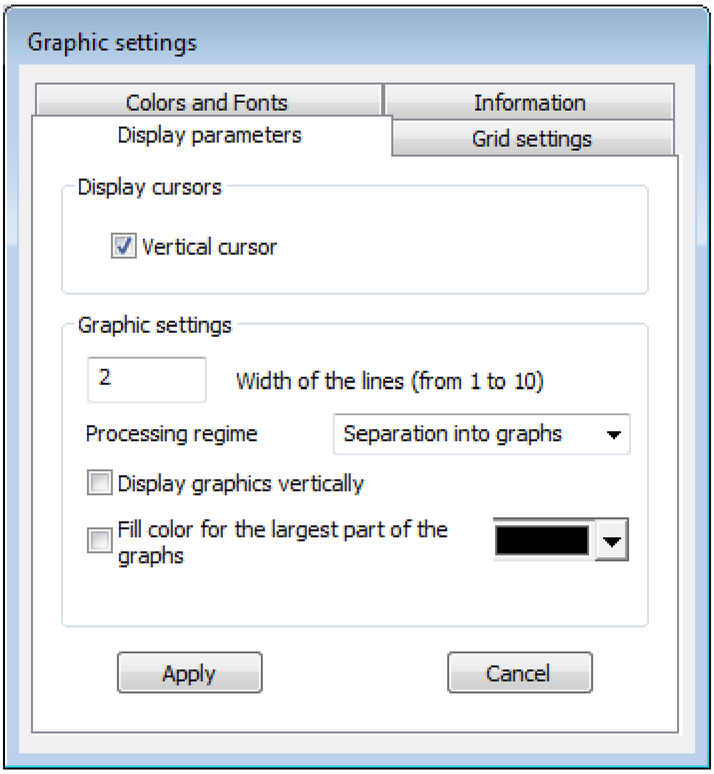


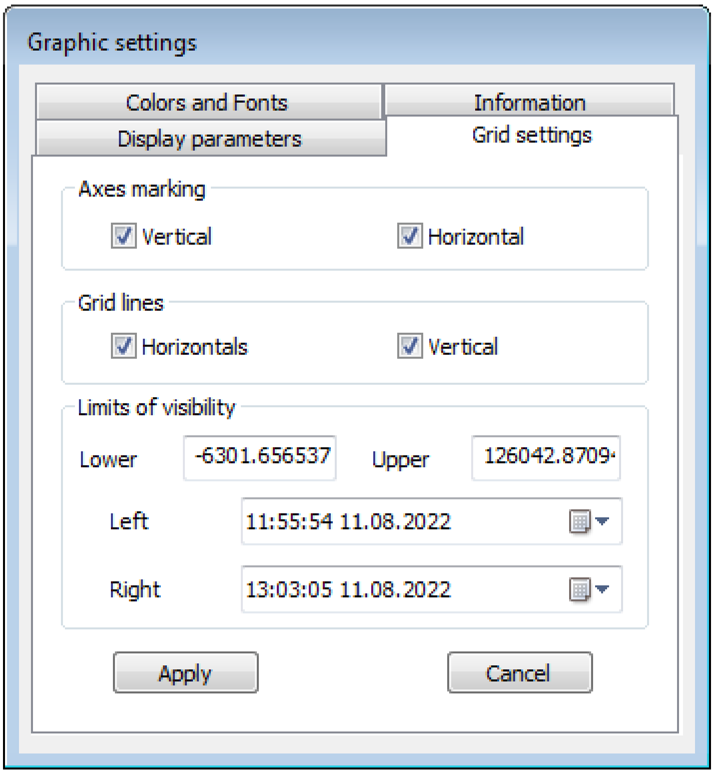
Display area – is an area for active structures signals representation.
Horizontal scale – is a time scale depicting the time period during which active structures signals have been recorded. Vertical scale – is an amplitude scale of the value set in the "Display settings" option. In the mode of displaying all the events the vertical scale does not represent any values.
4 lines in the display area (2 horizontal and 2 vertical) are called markers. Marker can be moved around the display with the left mouse key. The horizontal markers are available only for viewing the selected records with pre-set values of vertical scale.

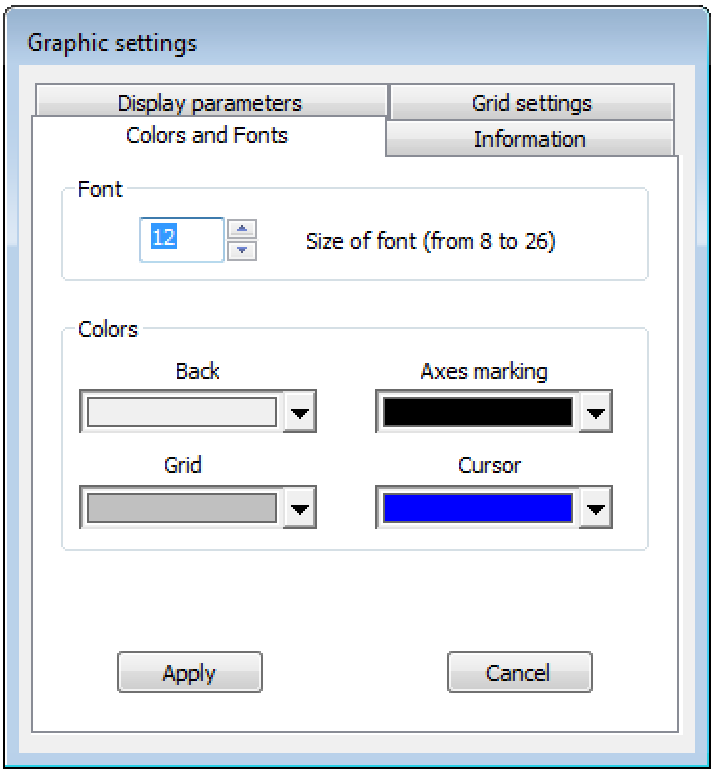


Amplitude and time information in the area of markers overlapping is displayed in the quick access menu.

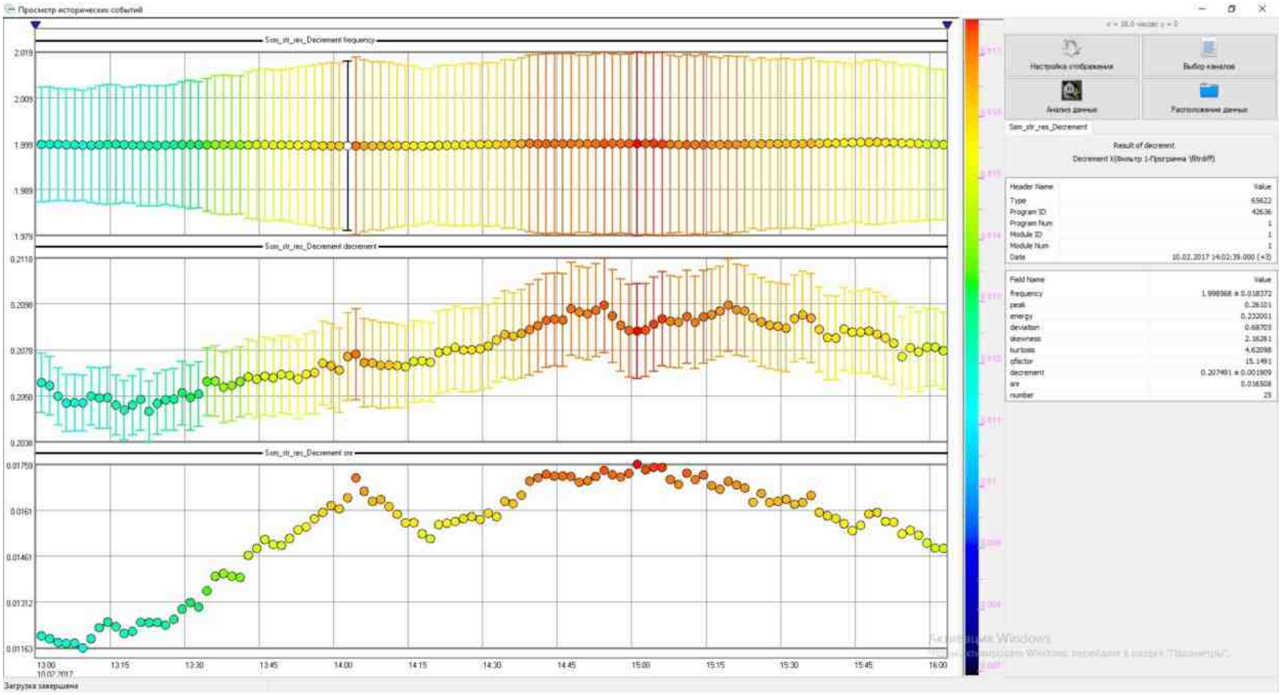
If you want to change the data display in the coordinate network, right-click the display window – this will activate the dialogue window with available settings.

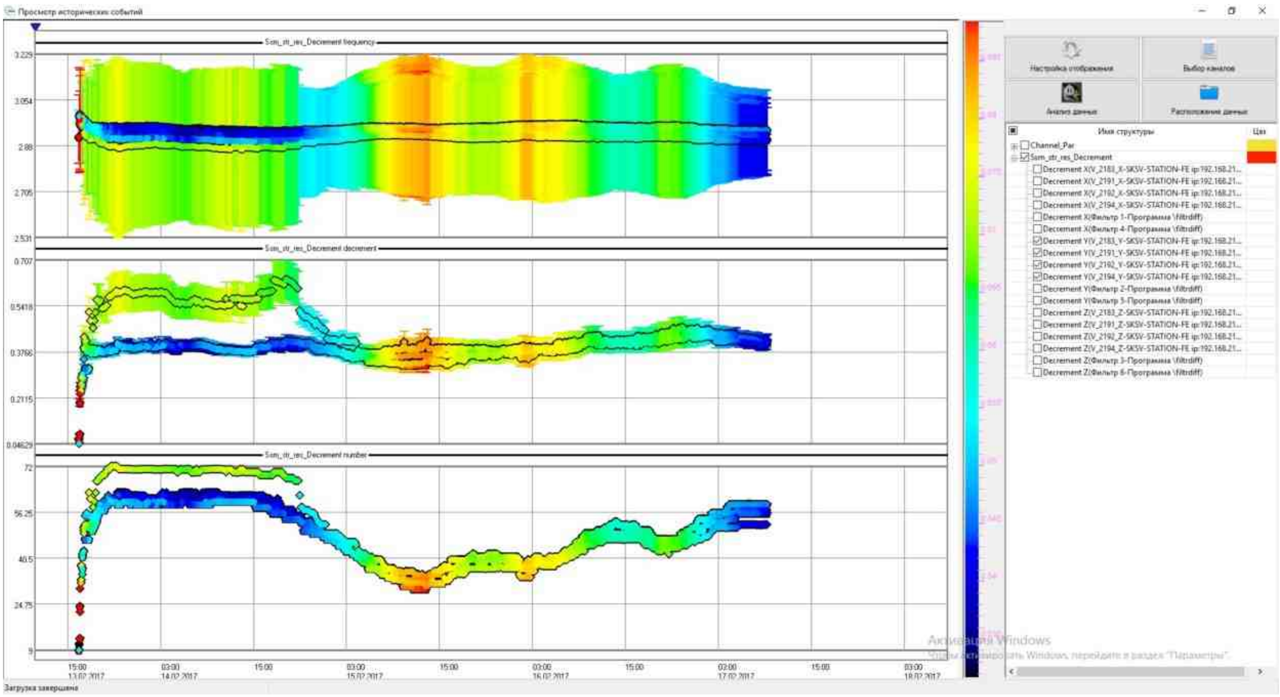

Graphic settings
Colors and Fonts
Information
Display parameters
Grid settings
Display cursors
Vertical cursor
Graphic settings
2
Width of the lines (from 1 to 10)
Processing regime
Separation into graphs
Display graphics vertically
Fill color for the largest part of the graphs
Apply
Cancel


Graphic settings
Colors and Fonts
Information
Display parameters
Grid settings
Axes marking
Vertical
Horizontal
Grid lines
Horizontals
Vertical
Limits of visibility
Lower
-6301.656537
Upper
Left
11:55:54 11.08.2022
Right
13:03:05 11.08.2022
Apply
Cancel



One more special feature of "Historical data viewer" is the possibility of representing the measured values with absolute tolerance in visual format, which, in some cases, is easier to analyse than textual or digital information.
The graphics represent the measured value with tolerance limits for a given time span as well as dependence of the measured value on the selected parameter. The dependence is determined by color indication (its measuring scale is placed to the right from the diagram).
For instance, in the course of temperature measurements it is possible to see the value tolerance dynamics as well as humidity impact on temperature meters readings.
This option allows to display a 4-dimensional diagram in a common coordinate network.





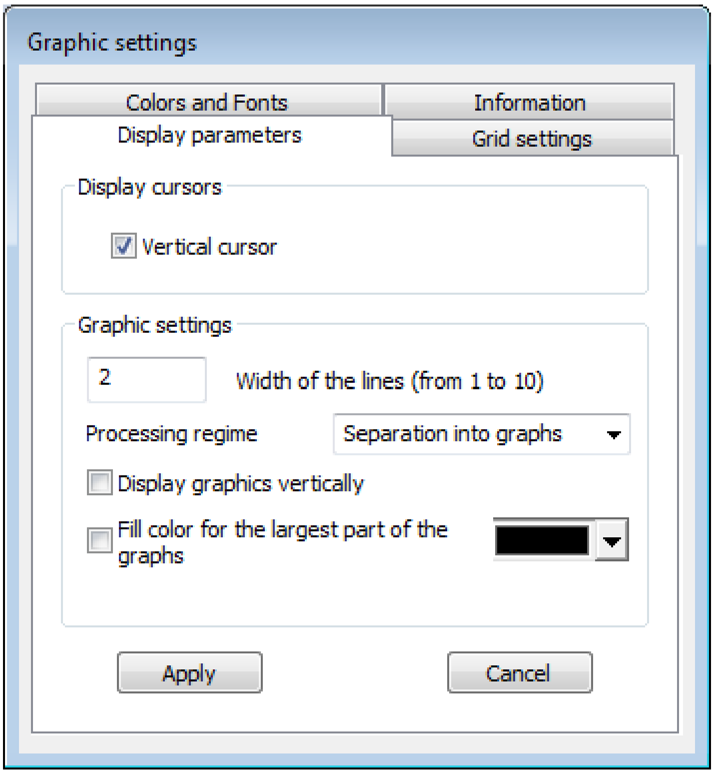
See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics

Possible graphics .....

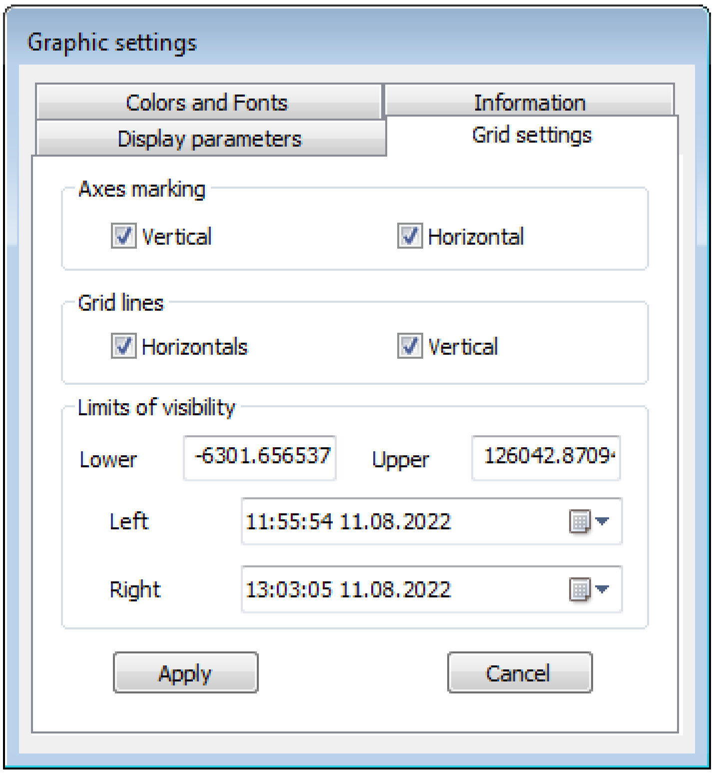
When you right-click in the workspace graphic program **View historical events** window opens the display settings where you can change the configuration..When you right-click in the workspace graphic View trending window opens the display settings where you can change the configuration.

Graphics settings



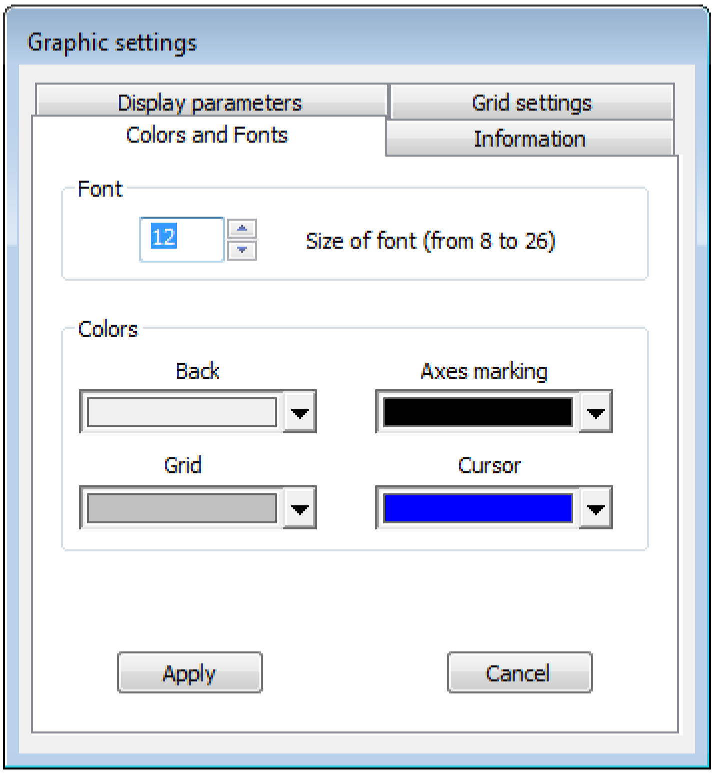
Setting the boundaries of the display

Grid settings



This tab allows you to adjust the current displayed borders and enable / disable the marking of the axes and grid lines.

Colors and fonts



This tab allows you to adjust the size of the text and change the color of the graphic.

Autoscale

Work areas:

The graphic is divided into workspaces, which are marked in the Fig.. Press ***SMW*** (or scrolling mouse wheel) it changes the current displayed range.

1. Change the vertical scale by moving the graphic up.
2. Increase in the vertical scale.
3. Decrease in the vertical scale.
4. Changing the vertical scale, shifting the graphic down.
5. Zooming horizontally shifting the graphic to the left.
6. Zoom out horizontally.
7. Zoom in horizontally.
8. Zooming horizontally shifting the graphic to the right.
9. Autoscale the graphics. Press ***SMW*** – scales the visible part of the graphic, if nothing is displayed, applies the auto-scale of the entire graphic. Press ***SMW*** with the Shift key pressed - auto-scales the graphics only on the vertical axis. Press ***SMW*** – with the Ctrl key pressed - auto-scales with respect to all data loaded in the graphic along the vertical and horizontal axis.

The upper and right part of the graphic is intended for moving cursors.

Hotkeys:

"Shift + scrolling mouse wheel" – accelerated scaling on the vertical axis.

"Ctrl + scrolling mouse wheel" – accelerated scaling on the horizontal axis.

"Ctrl + C" – saves the current graphic image to the clipboard.

"Ctrl + N" – saves data for all displayed graphics to the clipboard with formatting that allows you to insert the obtained data in Excel

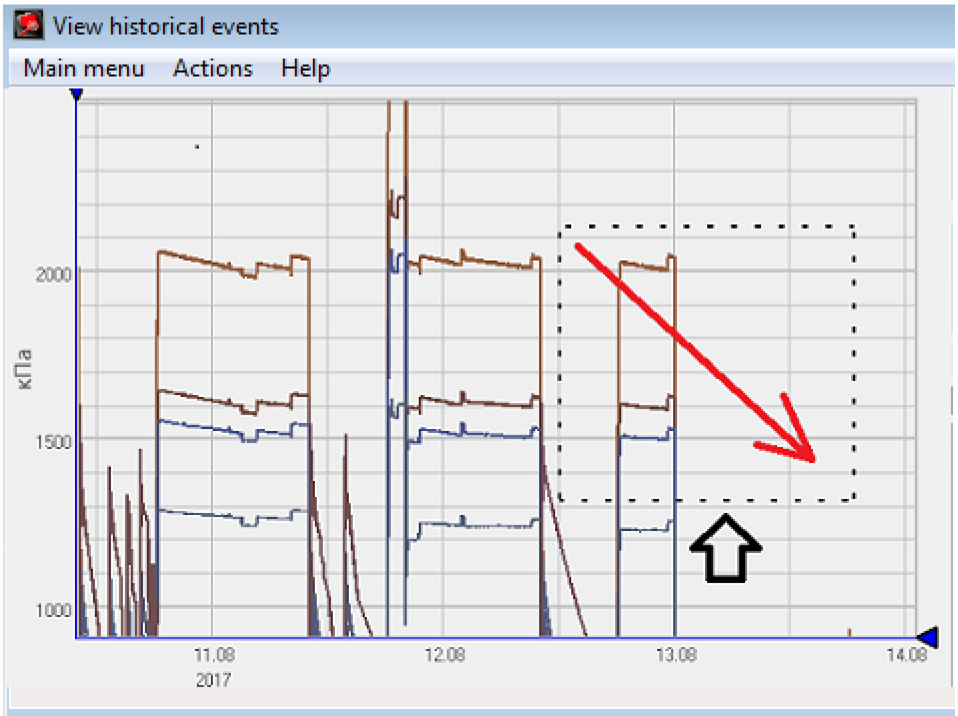
"Ctrl + F" – save graphic as image in png format.. the File is saved in the place where the program is running, which by default is the install location of the software ZETLab.

Zooming with the mouse

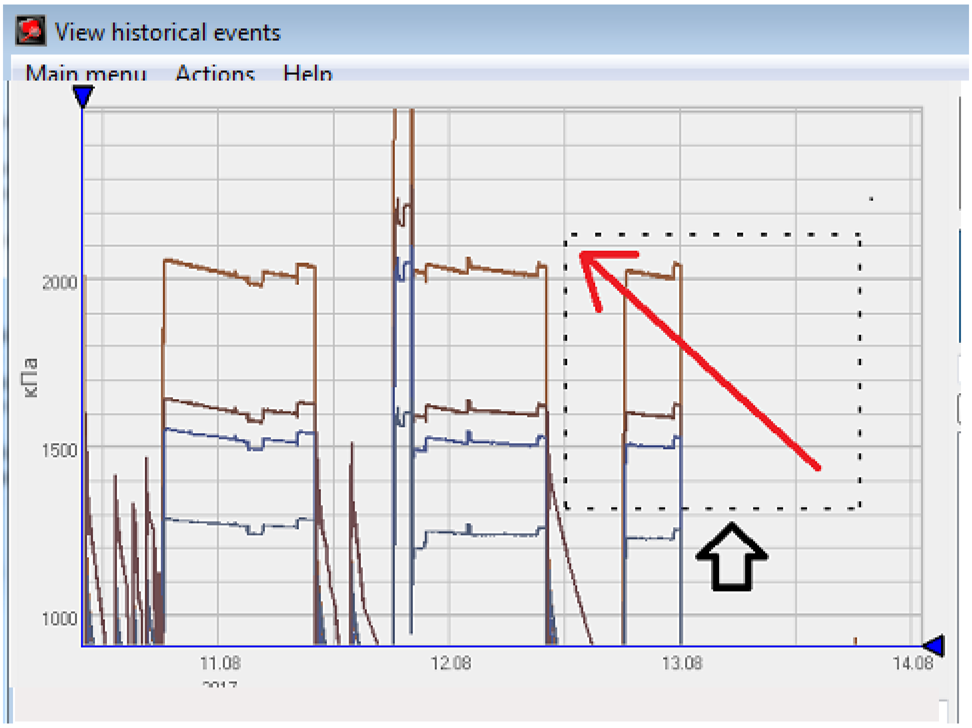
Pressing the ***SMW*** in the working area of the graphic and moving the mouse, you can move the graphic.

"Clicking Ctrl + clicking ***SMW***" - allows the user to select a range on the graphic. There will be a special frame that displays the region to be scaled.

allows the user to select a range on the graphic. There will be a special frame that displays the region to be scaled.



When creating a frame as shown in the Fig., after the user presses the ***SMW*** the graphic is scaled to the user-selected area.



With this creation of the frame, after the user presses the ***SMW*** the graphic will return to the status preceding the previous frame scaling.

Play recorded signals .....

The **Play recorded signals** program is designed to play recorded signals using the **Signals recording** program. When **Play recorded signals** is enabled, the play recorded signals become available for analysis and measurements in all ZETLAB programs.

Determination of the quality factor of the recorded signal

In order to determine the quality factor of the recorded signal, you need to start **Play recorded signals**, select the folder with the previously recorded signal and press the Play button to start playing the recording. In this mode, you can process the signal using the **Modal analysis** program

Features of Signals recording and Play recorded signals in ZETLAB

The ZETLAB software offers various options for saving data:

- **Signals recording**

  — initial data coming to the input channels of measuring devices (**Signals recording**)
- **Signals recording parameters**

  — e.g. constant level values with specified averaging (**Multi-channel recorder**)
- **Recording current results**

  — in analysis and display programs (Recording button in the program interface).
  Depending on what data was written and how, the following programs are used for reading:
- **Play recorded signals**

  — for Play recorded signals (directly temporary realizations) and their processing by ZETLAB programs
- **Signal trends viewing**

  — to study trends of long-term implementations (recorded by **Multi-channel recorder** or **Signals recording**)
- **Results viewing**
  — to display recorded measurement results

Program purpose .....

the program "**Play recorded signals**", intended to be read from the data files of temporary records to process, study and analysis, for example, when it was impossible to do in conditions of the measurement. Provided for Play recorded signals of the signals recorded in text or binary form, as well as play text and voice comments.

Note: the program "**Play recorded signals**" is part of software for ZETLab and ZETLab spectrum analyzers Registration (means of registration and Play recorded signals).

In read mode, signals from a file, program, instruments of composition ZETLab working in the processing mode of the Play recorded signals of the signals, with the signals coming to the inputs of connected devices that are excluded from the list of channels.

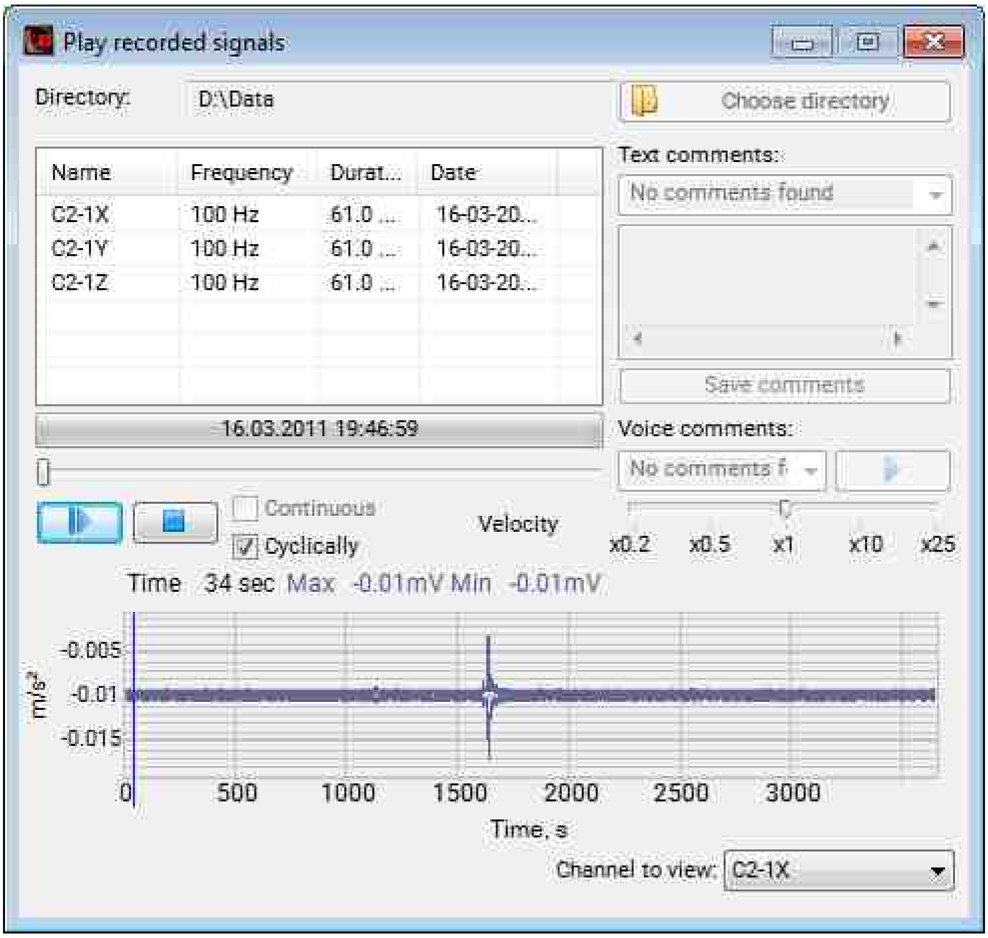
The principle of the program is similar to analog tape - the user after selecting the appropriate directory where the files of Play recorded signals of the signals, can play, (when)to stop, rewind and fast forward the selected signals.

When you expand the player window appears below a graphic showing the maximum and minimum values of the signal on the selected channel.

Rewinding can be done 5 ways:

- set the time to start playback from the keyboard;
- scrolling the mouse roller forward/backward;
- pressing the up/down arrows on the keyboard;
- the positioning of the position marker to a specified position;
- positioning the cursor on the graphic minimum and maximum values.

When the program player program listen to the channels of the ADC switches to the playback of the files, so the operator may listen to the Play recorded signals of the signals through the speakers connected to the sound card of the computer. In parallel, you can listen to voice comments.



Note: simultaneous operation of programs **Signals recording** and the **Play recorded signals** impossible.

The built-in application control module and automation of the composition ZETLab Studio provides the ease and convenience when you build your own software of measuring complexes.

Supported Hardware .....

In **Play recorded signals**, it is possible to view and listen to the comments made during signal recording. It is possible to switch on continuous signal Play recorded signals, which is convenient, if the signal recording was divided into parts (e.g. during long measurements or continuous monitoring).

Play recorded signals is a part of the following software:

- ZETLAB ANALIZ – FFT Spectrum software;
- ZETLAB VIBRO – Shaker control systems software;
- ZETLAB TENZO – strain-gauge station software;

- ZETLAB SEISMO – seismic station software;
- ZETLAB NOISE – vibration meter-noise meter software;

***Play recorded signals** is included in the **Registration** software group:*

For ADC-DAC and ZETSENSOR digital sensors, the program can be available as part of the **Signals recording** and **Play recorded signals** option.

Program description .....

For ADC-DAC and ZETSENSORS digital sensors, the program can be available as part of the recording and **Play recorded** signals signal option.

Play recorded signals is included in the **Registration** software group:

The **Play recorded signals** program signals intended for Play recorded signals of signals recorded by the program **Signals recording**. When I start playback of the Play recorded signals are available for analysis and measurements in all the ZETLAB programs.

On the monitor screen displays the working window of the program **Play recorded signals** (*Fig. 2*). From the top, the title bar displays the name of the program.

Note: program **Play recorded signals** can be run directly from the working directory **ZETLab** (default: c:\ZETLab\). The name of the startup file: reader.exe.

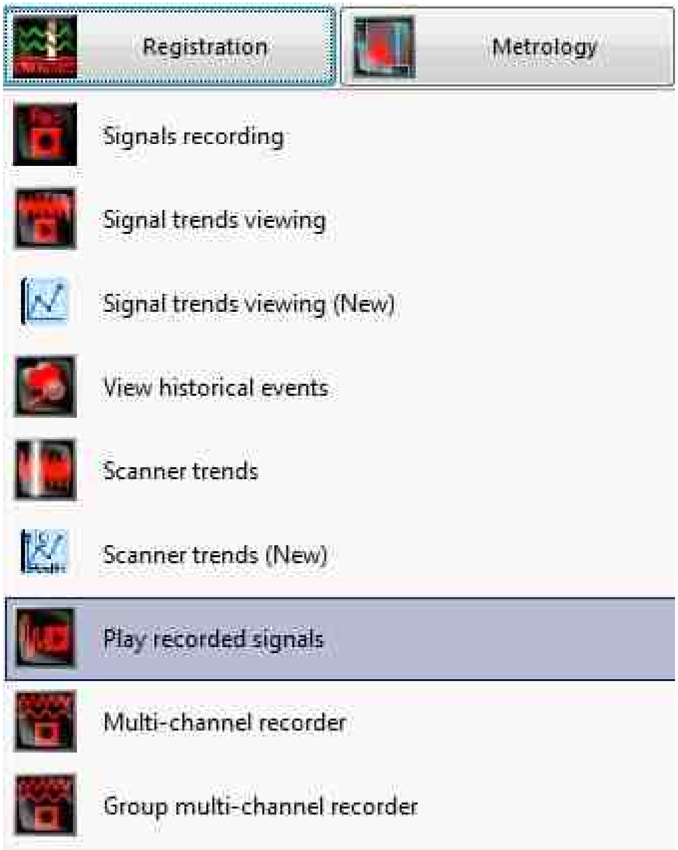


Fig. 1 Starting the program Play recorded signals

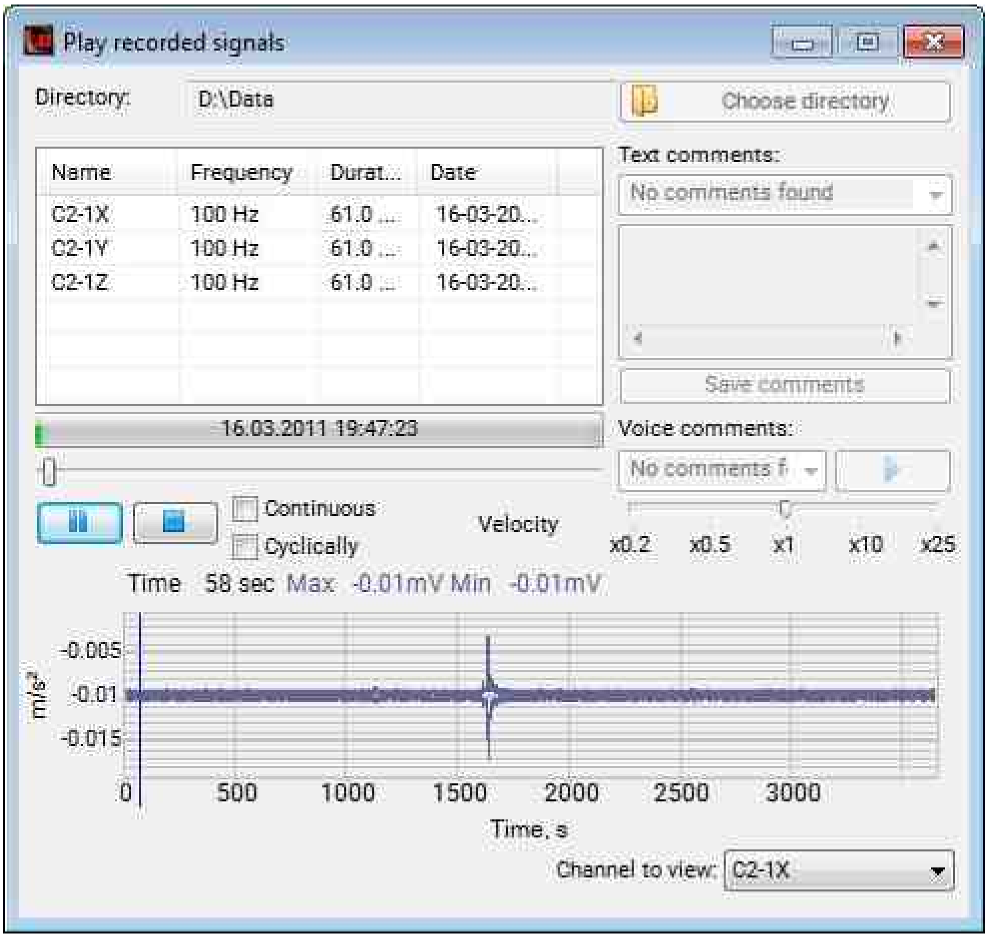


Fig. 2 Interface of the Play recorded signals program

When you click on [**Choose directory**] dialog select the folder signals, files which must be read (*Fig. 3*). After pressing the button "**Select the folder**" window will close and the program "**Play recorded signals**" file they upload in a list.

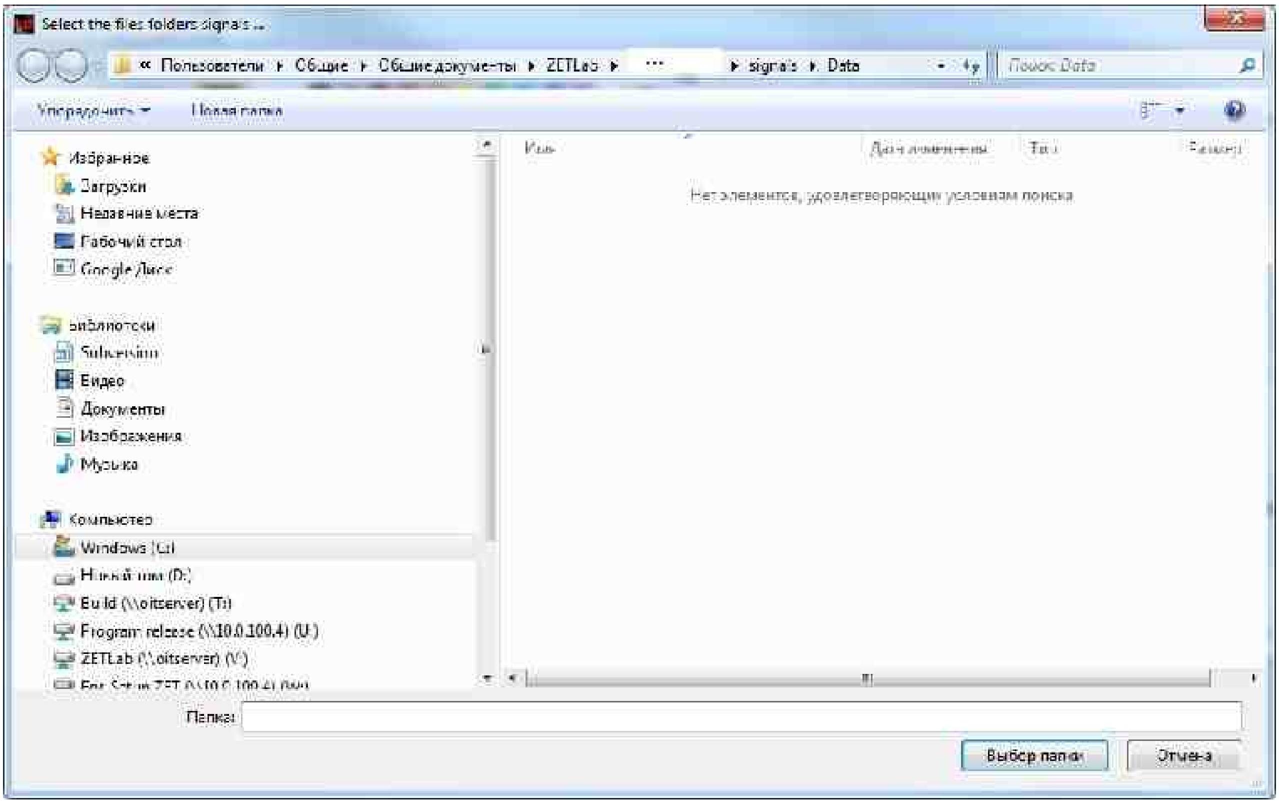
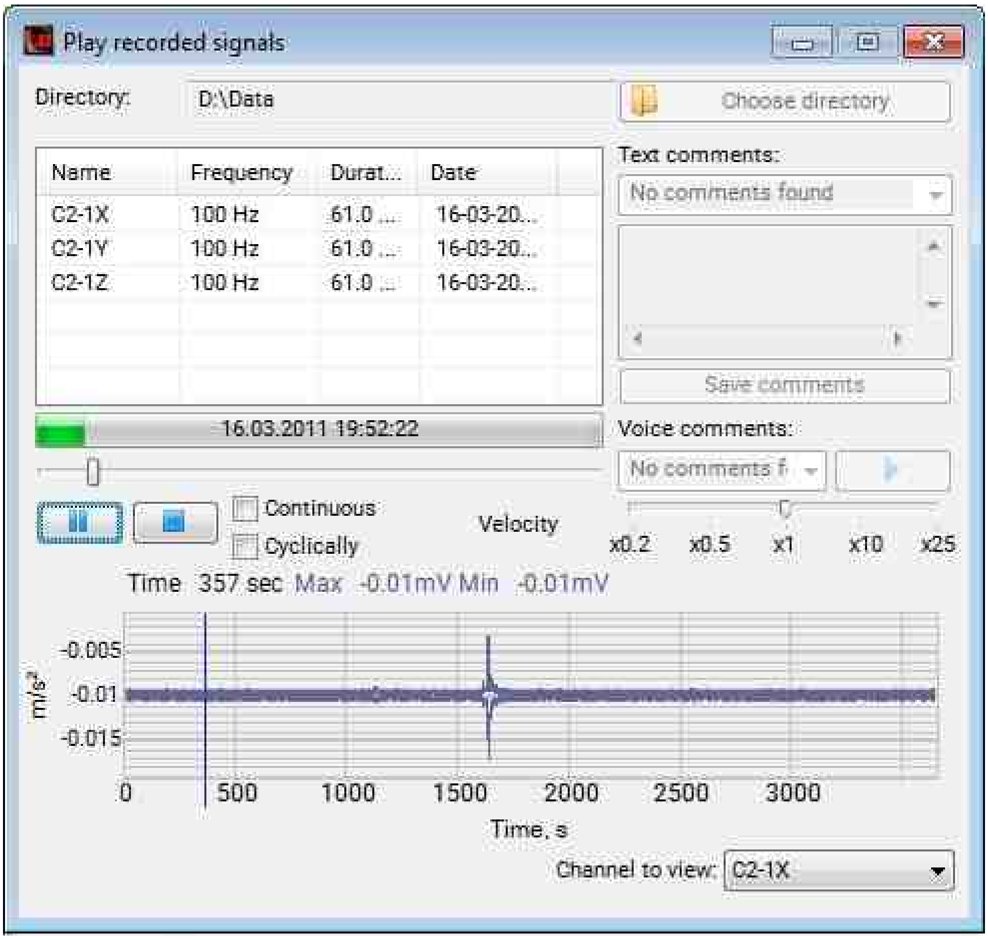


Fig. 3 Choice directory of a folder signals

Back to the program "**Play recorded signals**".

Under [Directory] is the table. It has five columns: the name of the channel, the sampling frequency of the ADC in Hertz, duration in seconds, the date and time to start recording.

Below is a progress bar reading.



Button  starts **Play recorded signals**. Button pause **Play recorded signals**. Button  stops process of the **Play recorded signals**.

In the field 

we see, time **Play recorded signals**, and the indicator of how much has been played.

You can start **Play recorded signals** not from the beginning, and since some seconds. To do this, we set the desired time in the window with the arrow keys, or by moving the slider on the progress bar reading.

Close program cross in the upper right corner of the window.

Below, in the box with the arrow (a list) select the number of text comments to the recorded signals. In the field below the list displays the comment text.

In the list on the left lists all channels that have been saved in the specified directory. To change the directory using the button "Choose directory" in the upper right corner. Bottom left is a button playback. Next are two checkboxes to select the **Play recorded signals** mode.

"Velocity" - allows you to select the **Play recorded signals** velocity of the signals (x0.2, x0.5, x1, x10, x25). In brackets are the coefficients relative to real time, which allows you to **Play recorded signals** as faster and slower.

"Continuous" - upon completion of the **Play recorded signals** of the selected directory, the program "**Play recorded signals**" go to parent directory and look for a directory with the next name and Play recorded signals a recording from it.

"Voice comments:" - You can leave a comment for this entry.

Play recorded signals to work with treatment programs and measurement can be just as if these data come with real devices.

Example for the section .....

Determination of the Q-factor of the oscillatory system

Determination of the Q-factor of the oscillatory system .....

In order to determine the Q-factor of the oscillatory system, it is necessary to measure and record the signal using vibration sensors, run the **Play recorded signals** program, select the folder with the previously recorded signal and press the Play button to start playing the recording. In this mode, the signal can be processed using the Modal Analysis program.
The quality factor is calculated as follows:
1. A local maximum point is determined on the graphic of the recorded signal, its frequency is selected as the resonant frequency of the system.
2. The nearest points are determined, with a value 3 dB less than at the maximum point, their frequencies are fixed.
3. The Q-factor of the system is defined as the ratio of the resonant frequency to the difference of neighboring frequencies.

Multi-channel recorder .....

Multi-channel recorder is used for long recording and display of signal parameters coming to the input signals of spectrum analyzers (included in the supply package) and ADC/DAC modules (optional).

The Recorder facilitates continuous recording of selected signal parameters in a file. The program is used in continuous monitoring and control systems, in various testing systems for documenting Tests results. For instance, when carrying out vibration resistance tests, the operator must record the vibration levels at reference and control points and the frequency of the excitation signal. Tests can be carried out during several work shifts. When carrying out vibration tests for three axes, it is necessary to rearrange the sample. When rearranging the sample, it is possible to stop the recorder and then restart the recording, when necessary. The number of simultaneously recorded signals can be up to 60.

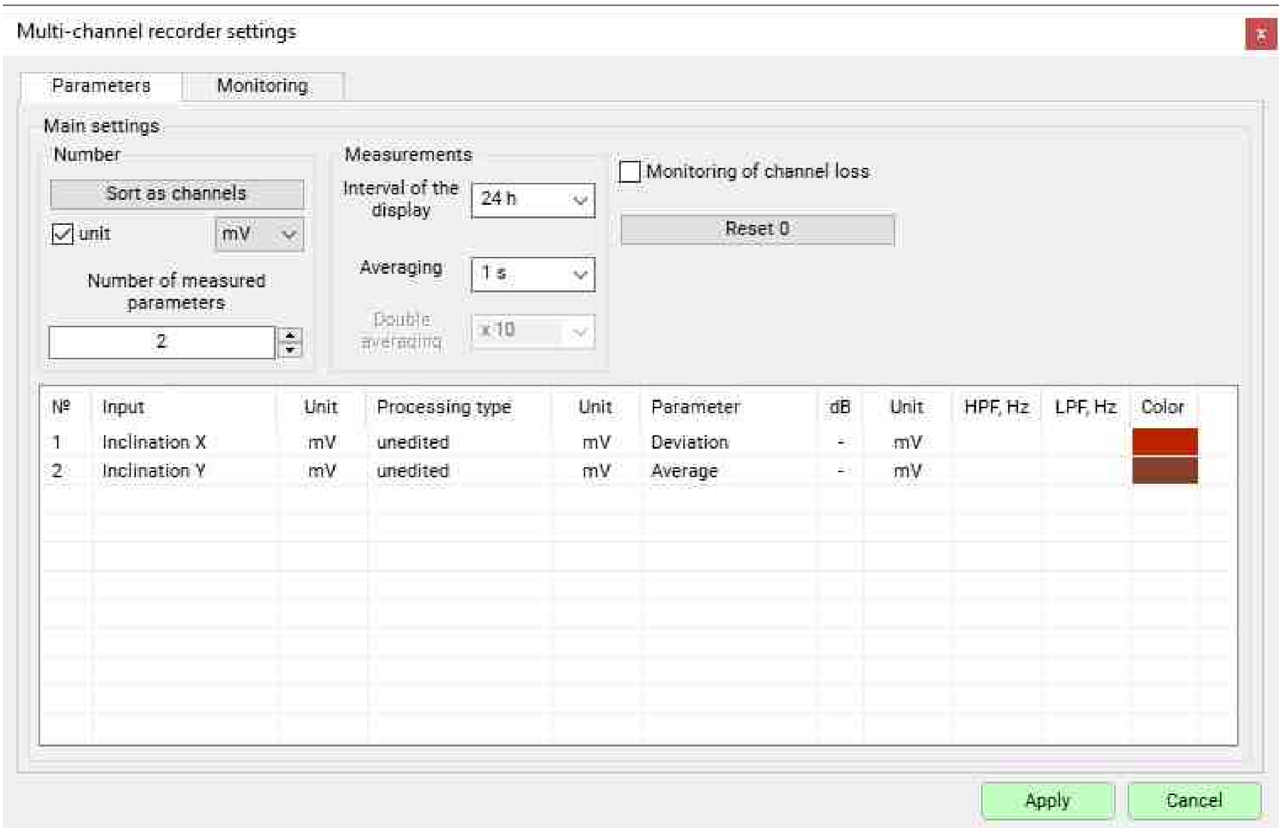
It is possible to simultaneously record the constant, variable, and peak value, peak-to-peak value and frequency for several channels. If accelerometers, i.e. acceleration sensors, are used, the recorder allows to record the vibrational acceleration, velocity, and displacement for the set channel. It is possible to simultaneously start several recorders. In automated process equipment control systems, it is necessary to perform continuous control and recording of process parameters – pressure, temperature, load. In this case, the recorder is switched to continuous recording mode. Annual, weekly or daily reports are archived by the operator as necessary.

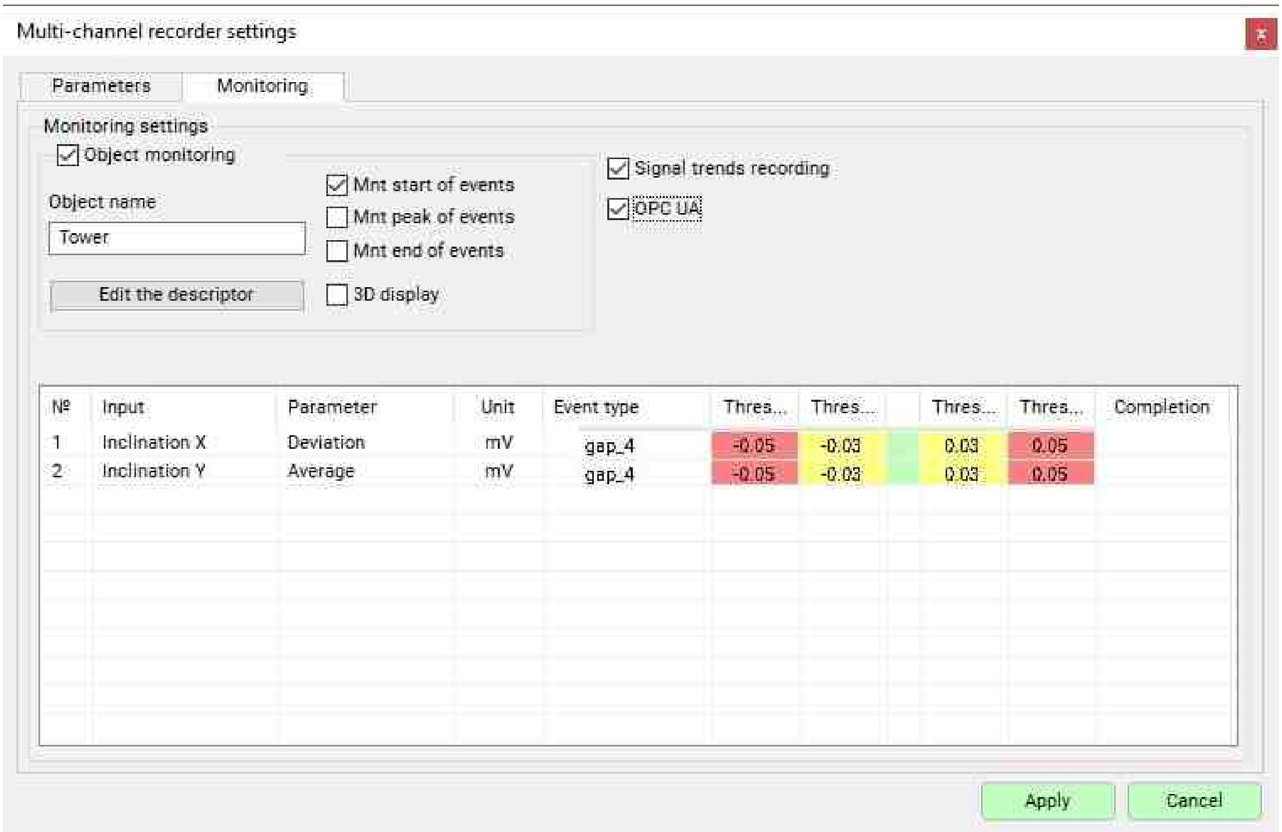
Main Features and Parameters

The program settings window is made in an easy-to-understand and use form:

the upper part of the window contains several areas for configuring the overall display of information: the number of channels displayed, the display interval and averaging, the ability to configure object monitoring and recording signal trends;

the lower part of the window is made in the form of a table, where each measurement channel is individually configured.


Multi-channel recorder settings
Parameters
Monitoring
Main settings
Number
Sort as channels
unit
mV
Number of measured parameters
2
Measurements
Interval of the display
24 h
Averaging
1 s
Double averaging
x 10
Monitoring of channel loss
Reset 0
№
Input
Unit
Processing type
Unit
Parameter
dB
Unit
HPF, Hz
LPF, Hz
Color
1
Inclination X
mV
unedited
mV
Deviation
-
mV
2
Inclination Y
mV
unedited
mV
Average
-
mV
Apply
Cancel


Multi-channel recorder settings
Parameters
Monitoring
Monitoring settings
Object monitoring
Object name
Tower
Edit the descriptor
Mnt start of events
Mnt peak of events
Mnt end of events
3D display
Signal trends recording
OPC UA
№
Input
Parameter
Unit
Event type
Thres...
Thres...
Thres...
Thres...
Completion
1
Inclination X
Deviation
mV
gap_4
-0.05
-0.03
0.03
0.05
2
Inclination Y
Average
mV
gap_4
-0.05
-0.03
0.03
0.05
Apply
Cancel

Configurable signal processing and presentation parameters include:

Processing type - differentiation, db. differentiation, integration, db integration.

Parameter — value by which the signal will be displayed on the graphic.

Constant signal;

- Average;
- Average (Reset to 0).

Variable signal:

- Root mean square (RMS) value (with linear or logarithmic (dB) calculation of Y values);
- Amplitude (with linear or logarithmic (dB) calculation of Y values);
- Peak (with linear or logarithmic (dB) calculation of Y values);
- Span;
- Deviation;
- Kurtosis.

Vibro-statistics:

- Square RMSD;
- coefficient of the impulse;
- Form factor;
- CSM-5;
- CSM-6;
- CSM-7;
- CSM-8;
- CSM-9.

Frequency:

- Frequency;
- Revolution.

Double averaging:

- Kurtosis (RMS);
- RMSD (root-mean-square deviation) (RMS);
- STA/LTA (DC);
- STA/LTA (AC);
- L99.

Constant signal-3D:

- Average-3D;
- InclinationDC-3D;
- AzimuthDC-3D.

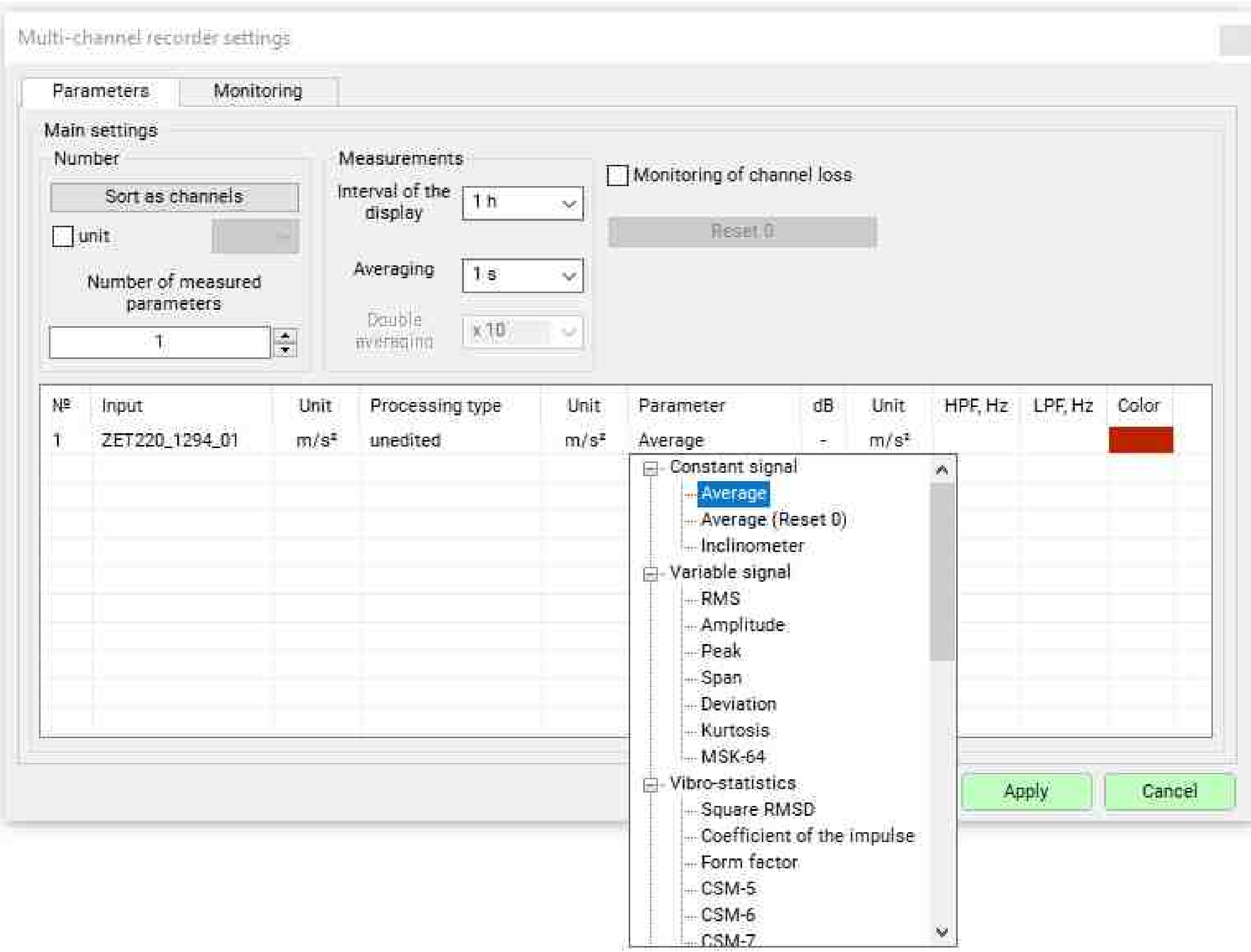
Variable signal-3D:

- Amplitude-3D;
- Peak-3D;
- PeakXYZ-3D;
- Inclination-3D;
- Azimuth-3D;
- STA/LTA-3D.

Additional Features of the Multi-channel recorder

1. Added 3D parameters, the values of which are calculated from the data of three channels, i.e. the initial data can now be the data of real 3-component sensors (accelerometers, velocimeters, inclinometers, …). In this case, the name of the first channel (X component of the 3-dimensional vector) is displayed in the “Channel” column. It is assumed that the next Zet-server channels are the Y and Z components of this 3D vector.

2. The list of valid parameters in the settings window (“Parameters” tab) is separated into a separate window, in which the parameters are presented in a tree structure grouped by the properties of the original signals.



The parameter tree structure contains the following sections

Constant signal:
- Average;
- Average (Reset 0);
- Inclinometer.

Variable signal:
- RMS (root mean square);
- Amplitude;
- Peak;
- Span;
- Deviation;
- Kurtosis;
- MSK-64.

Vibration-statistics:

- Square RMSD (root-mean-square deviation);
- Coefficient of the impulse;
- Form factor;
- SCM-5;
- SCM-6;
- SCM-7;
- SCM-8;
- SCM-9,

Frequency:
- Frequency;
- Revolutions.

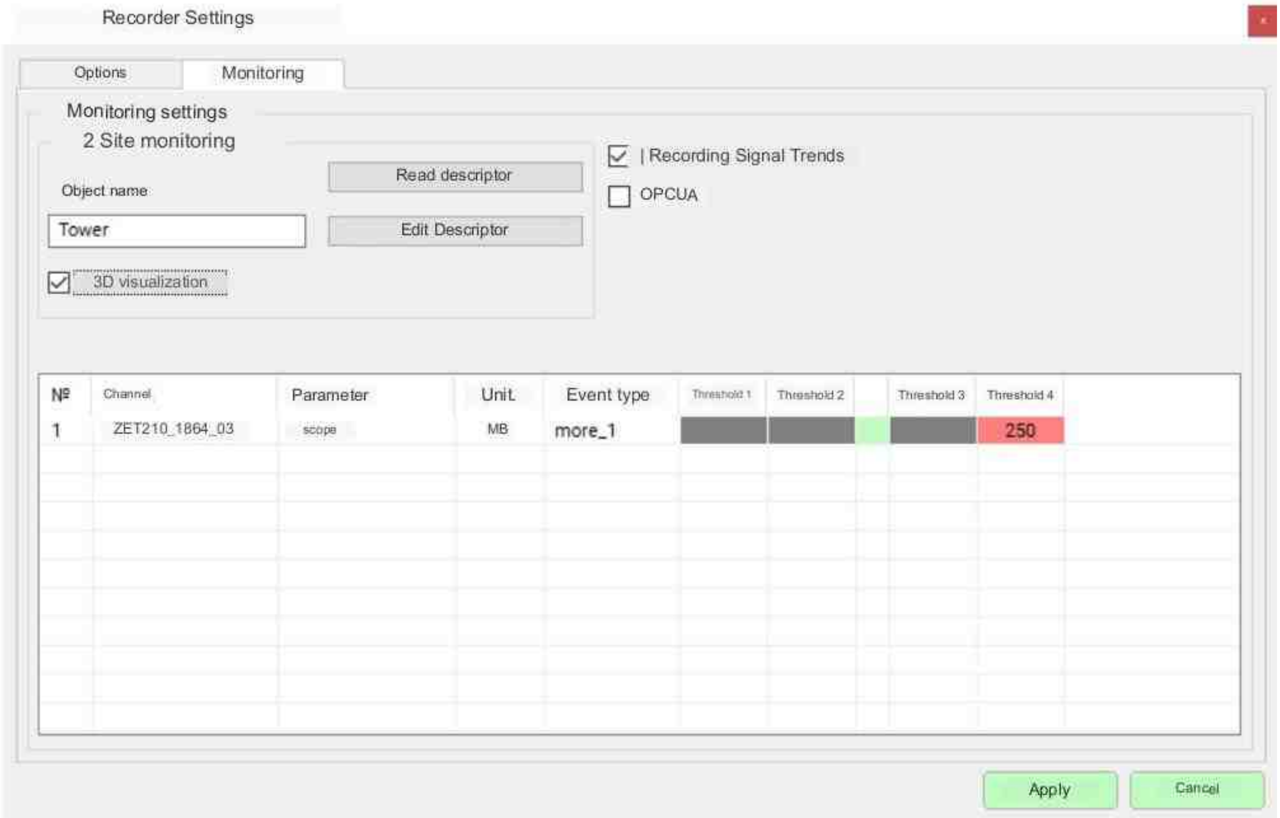
Double averaging::
- Kurtosis (RMS);
- RMSD (RMS);
- STA/LTA(AC);
- STA/LTA(DC);
- L99.

Constant signal-3D:
- Average-3D;
- InclinationDC-3D;
- AzimuthDC-3D;
- Inclinometer-3D-Average.

Variable signal-3D:
- Amplitude-3D;
- Peak-3D;
- PeakXYZ-3D;
- Inclination-3D;
- Azimuth-3D;
- STA/LTA-3D;
- MSK-64-3D;
- Inclinometer-3D-Amplitude.

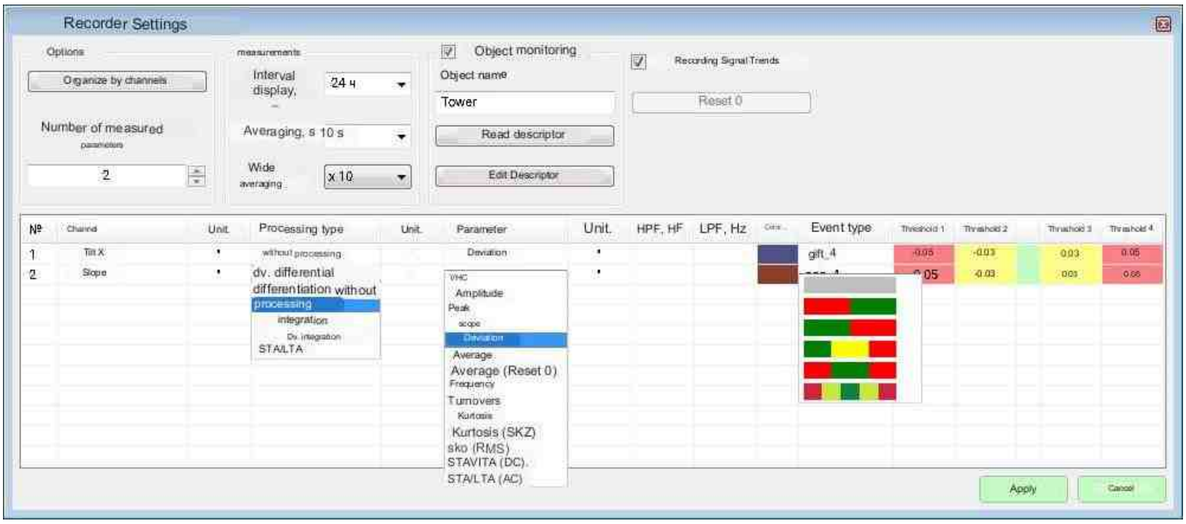
When working with variable signals, the DC component is preliminarily excluded from the channel data.

3. When working in the monitoring mode, it became possible to display the calculated values of some parameters on a previously created STL model, i.e. 3D visualization. For this, a new program “3D Visualization” is used, which is located in the “Display” tab in the Zet-panel. In this case, the excess of the calculated values over the specified threshold values is displayed in color.



For channels that measure acceleration, the values Inclinometer (calculation of the angle of deviation from the normal) and MSK-64 (calculation according to the algorithm of seismic intensity in points) are additionally available.

Event type - this parameter becomes available only after setting the flag in the "Object monitoring" field. Allows you to set the thresholds and control the output of the signal beyond the specified thresholds. For clarity, the type of logs is presented in color combinations.



Setting and setting of threshold values is carried out in the xml-file "Monitoring.xml", which is opened using the "Edit descriptor" button in the "Object monitoring" field. For the parameters specified in the descriptor to take effect, you must activate the "Edit the descriptor" button.

```
<?xml version="1.0"?>
<root version="5">
    <program name="multiSWvm">
        <object name="СМИК">
            <tag name="Отклонение" Channels="ZET7110 (11)" Unit="мкм/м" TypeEvent="gap_4" Threshold_1="-1" Threshold_2="-0.5" Threshold_3="0.5" Threshold_4="1" />
            <tag name="Отклонение" Channels="ZET7154-X (22)" Unit="°" TypeEvent="gap_4" Threshold_1="-1" Threshold_2="-0.5" Threshold_3="0.5" Threshold_4="1" />
            <tag name="Отклонение" Channels="ZET7154-Y (23)" Unit="°" TypeEvent="gap_4" Threshold_1="-1" Threshold_2="-0.5" Threshold_3="0.5" Threshold_4="1" />
            <tag name="СКЗ" Channels="ZET7152N_X (31)" Unit="g" TypeEvent="more_2" Threshold_1="0.5" Threshold_2="1" Threshold_3="" Threshold_4="" />
            <tag name="СКЗ" Channels="ZET7152N_Y (32)" Unit="g" TypeEvent="more_2" Threshold_1="0.5" Threshold_2="1" Threshold_3="" Threshold_4="" />
            <tag name="СКЗ" Channels="ZET7152N_Z (33)" Unit="g" TypeEvent="more_2" Threshold_1="0.5" Threshold_2="1" Threshold_3="" Threshold_4="" />
        </object>
    </program>
</root>
```

The number of monitoring and recording channels in one program window: up to 60. To increase the monitoring channels, you just need to run one more Multi-channel recorder program.

Signal parameters display time: from 1 second to 24 hours.

Units of time intervals of display: second, minute, hour.

Dynamic display of integrated signal levels, overload detection for each channel and storage of overload status.

The entire temporal implementation of the signal can be written to the result file for further processing in the display and processing program.

Supported Hardware .....

Input data program **Multi-channel recorder** are digital data channel server **ZETLAB**.

The software **Multi-channel recorder** is included with the following software:

- ZETLAB BASE – ADC/DAC module software (option).
- ZETLAB ANALIZ – FFT Spectrum software
- ZETLAB VIBRO – Shaker control systems software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software (option).

Multi-channel recorder is included in the program group **Registration**

Program description .....

The program **Multi-channel recorder** is started from the **Registeration** menu of the **ZETLAB** panel.

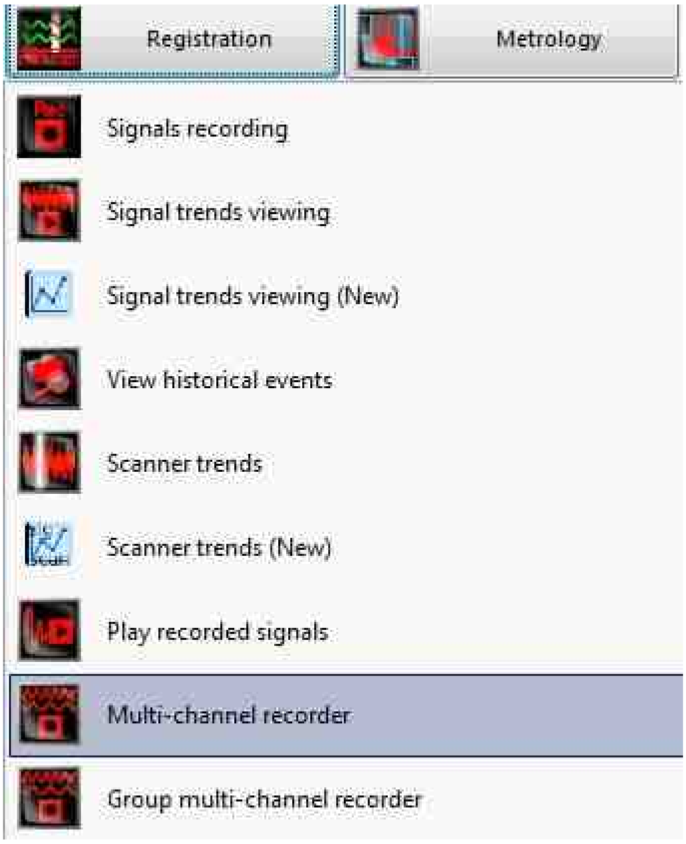


Fig. 1 Start Multi-channel recorder

This program **Multi-channel recorder** is included into basic **ZETLAB** software set and enables representation and analysis of historical events registered by means of **ZETLAB** sotware for a long-term time span.
Note: the **Multi-channel recorder** can be run directly from the working directory **ZETLAB** (default: C:\ZETLAB\). The name of the startup file: multiSWvm.exe .

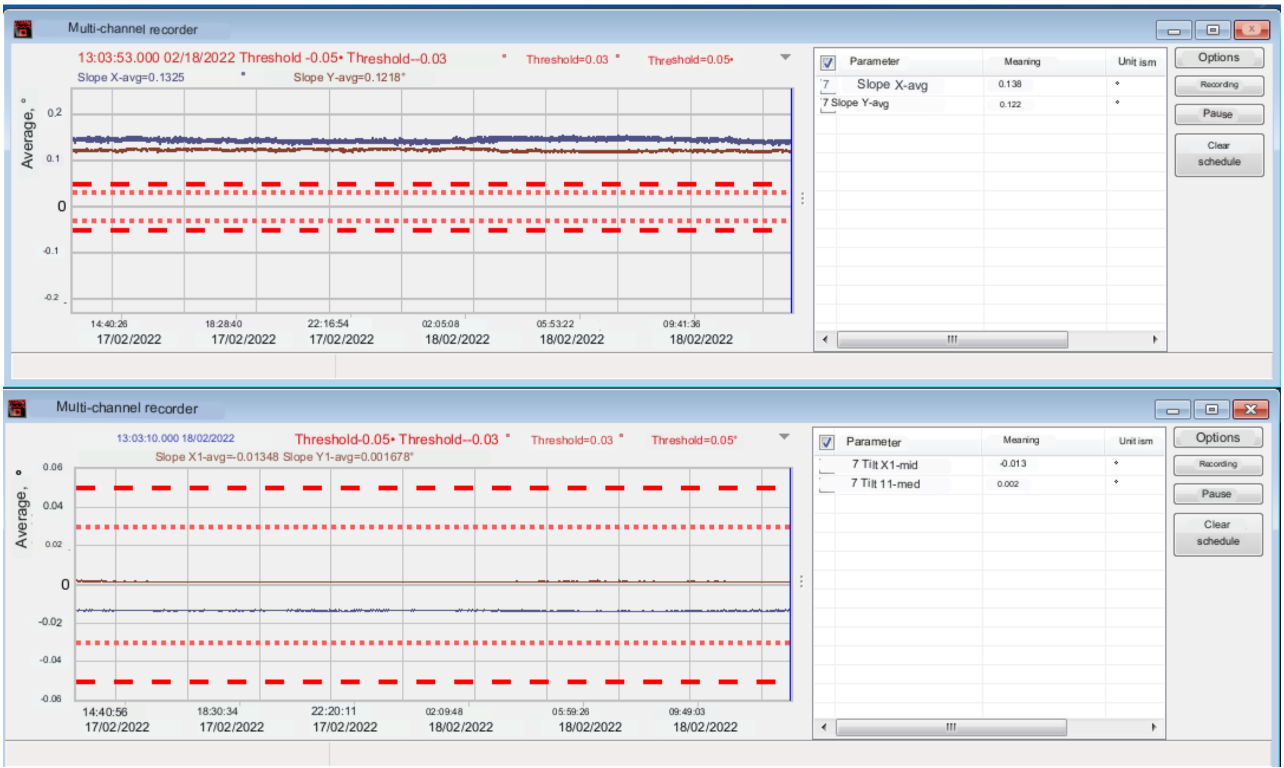


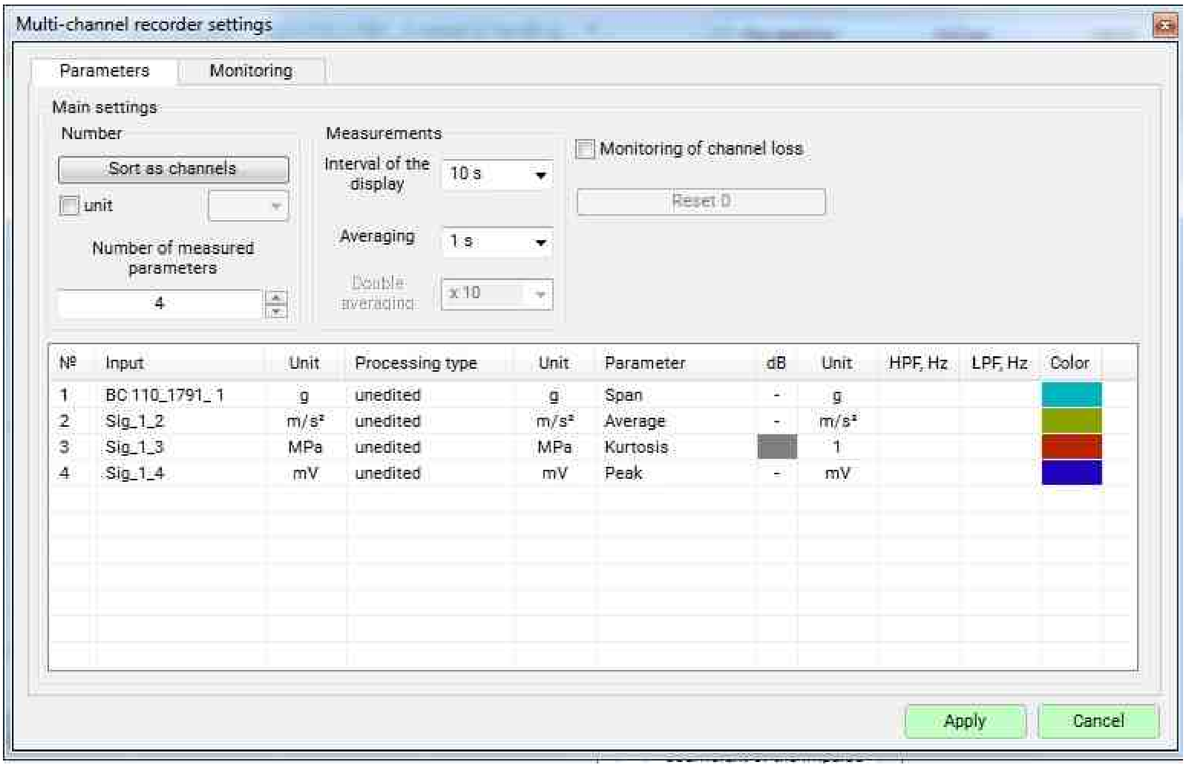
Fig. 2 The program window "Multi-channel recorder" with signals exceeding the thresholds and within the range

See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists
- Setting parameters of display
- Using signal level indicators
- Adjustment of the color scheme used for displaying of the registered signal amplitude values
- Graphical and numerical data transfer to text editors
- Setting GridGl grid functionality

Multi-channel recorder setting .....

Button **[Parameters]** located at the top right of the working window of the program **Multi-channel recorder**. By pressing the button **[Parameters]** or the right mouse button in the working window of the **Multi-channel recorder** program, the window "**Multi-channel recorder setting**" is displayed. The "**Multi-channel recorder setting**" window can also be called up by pressing the "Esc" button on the keyboard while the **Multi-channel recorder** window is active.



Set the number of measured parameters using the "Sort as channels" button

In this case, the number of parameters (and, accordingly, the number of lines in the table of the parameters window) is set equal to the number of ZETServer channels. At the same time, channel data processing options and result presentation options (processing type, calculation type, presentation in dB, bandpass filter cutoff frequencies, monitoring parameters) are copied to all parameters from the first (topmost) row of the table. The channels of all parameters will be set in accordance with the sequence of ZETServer channels, which can be found in the **ZETServer time** program.

Setting the number of measured parameters using the input field "Number of measured parameters"

In this case, only numbers can be entered in the input field, the program will not skip other characters.

If the entered number is less than the already specified number of parameters, then the entered number will be applied with a corresponding decrease in the number of rows in the table.

If the entered number is greater than the number of parameters already set, then the number of rows in the table will increase accordingly, and the options for processing channel data and presenting the result for new parameters will be copied from the last row of the table. The maximum number of parameters is 400. At the same time, the ZETServer channel of the new parameter is the next channel compared to the channel of the previous parameter. The next channel for the last ZETServer channel is its first channel. The sequence of ZETServer channels is the sequence of channels in the **ZETServer time** program.

***Setting the number of measured parameters using the buttons "▲" and "▼"* to the right of the input field "Number of measured parameters"**

In this case, clicking on the button "▲" increases the number of parameters by 1, and clicking on the button "▼" reduces the number of parameters by 1. The ZETServer channel and data processing options for the new channel will be determined in accordance with the rule for entering the number of measured parameters using the "Number of measured channels" input field.

Interval of the display parameter sets the time interval for displaying the graph along the X axis in the main program window (the time value of the rightmost point of the X axis minus the time value of the leftmost point of the X axis).

On the right, under the inscription "**Averaging**" sets the duration of the interval for averaging the values on the graphic (*Fig. 3*). Thus, the graphic displays the average values for a set period of time.

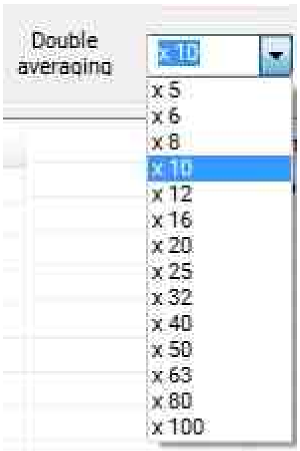


Fig. 3 "Averaging" parameter window

Under the inscription "Double averaging", allows you to increase the selected averaging by the number of times (*Fig. 4*). Only with certain parameters in the table (for example, Kurtosis (RMS).

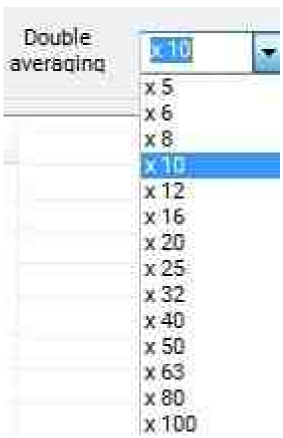


Fig. 4 Parameter window "Double averaging"

Function activation "**Object monitoring**" adds the ability to set control over the output of the signal beyond the specified thresholds. After activating the "**Object monitoring**" function, you need to specify the name of the object (*Fig. 5*).

The set flag "**Signal trends recording**" allows to record the trends of signal files to the hard disk, both in original and in compressed form. They can be viewed using the "**View historical events**" program from the ZETLab working directory (by default: c:\ZETLab\). Executable file name: ZETTrends.exe. The cleared flag "**Signal trends recording**" does not record in the trend.

Button "**Apply**" - entering data into the program and exiting the window "**Multi-channel recorder setting**".

The "**Cancel**" button cancels the settings and closes the "**Multi-channel recorder setting**" window. You can also close the window with a cross located in the upper right corner of the window.

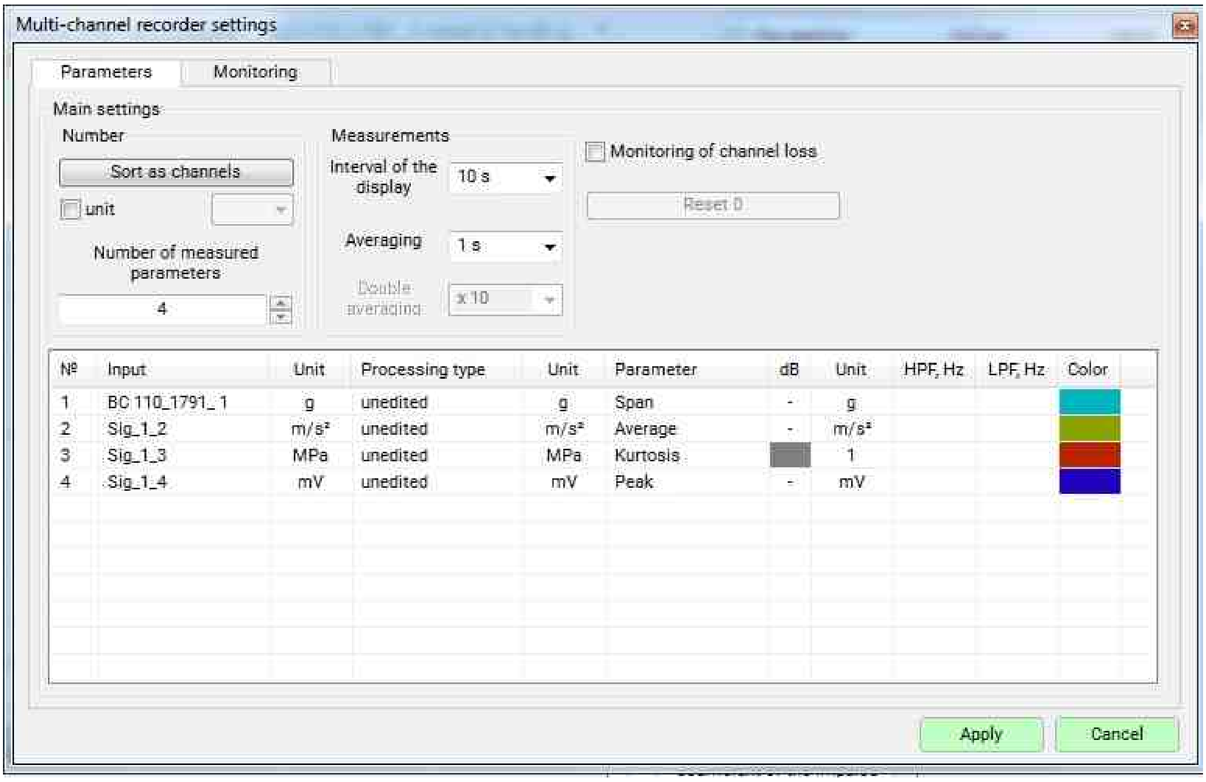


Fig. 5 Parameters window

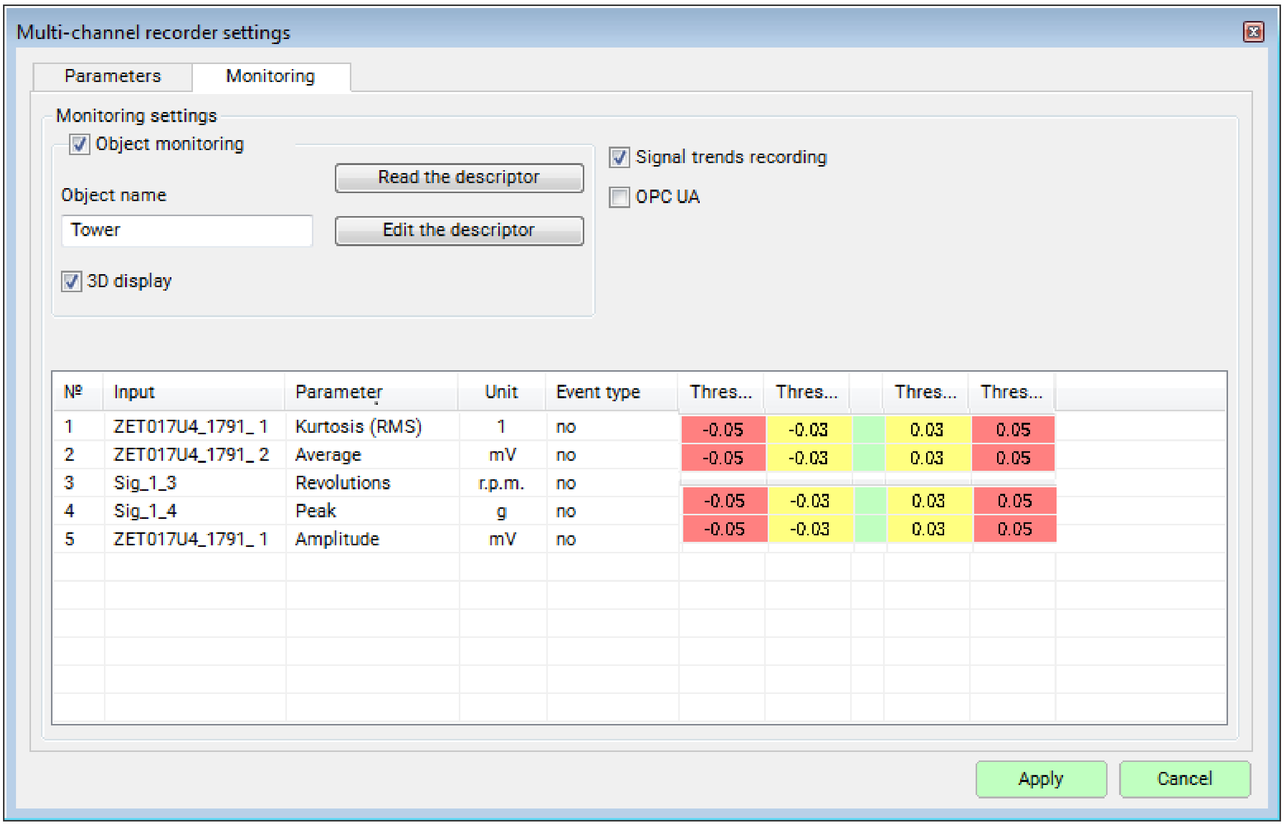


Fig. 5a "Object monitoring" parameter window

The list under the inscription "Measurement channel" select the channel of the module to be displayed.

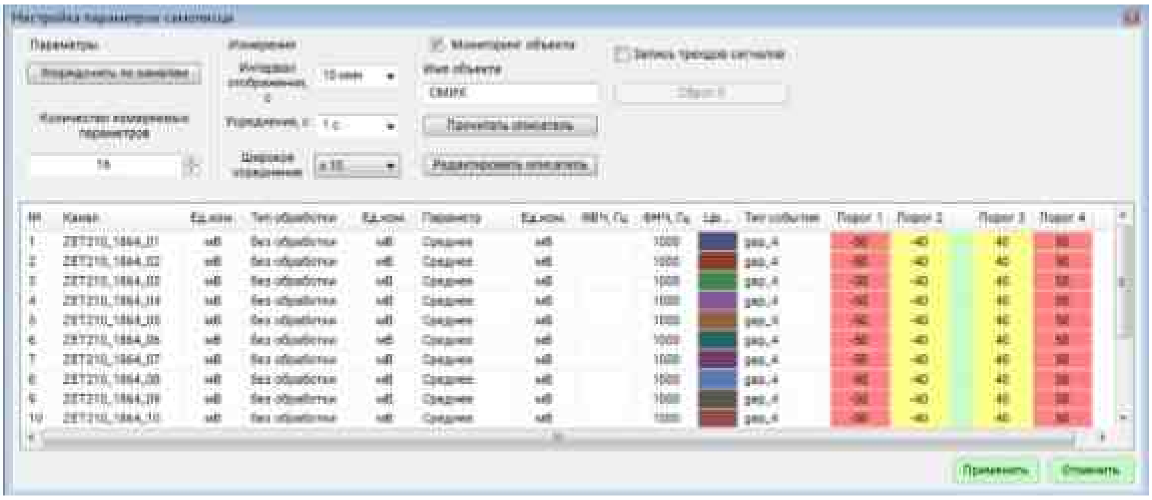


Fig. 6 Settings window for the case of choosing 16 parameters calculated from the channels of the ADC FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23

Settings window for the case of choosing 16 parameters calculated by the channels of the ADC ZET 210, serial number 1864. One parameter - one channel. For all parameters - a channel without processing, with a low-pass filter, whose cutoff frequency is set to 1000 Hz and monitored by 4 settings (setting values on a red background are settings of the "Danger" type, setting values on a yellow background are settings of the "Warning" type).

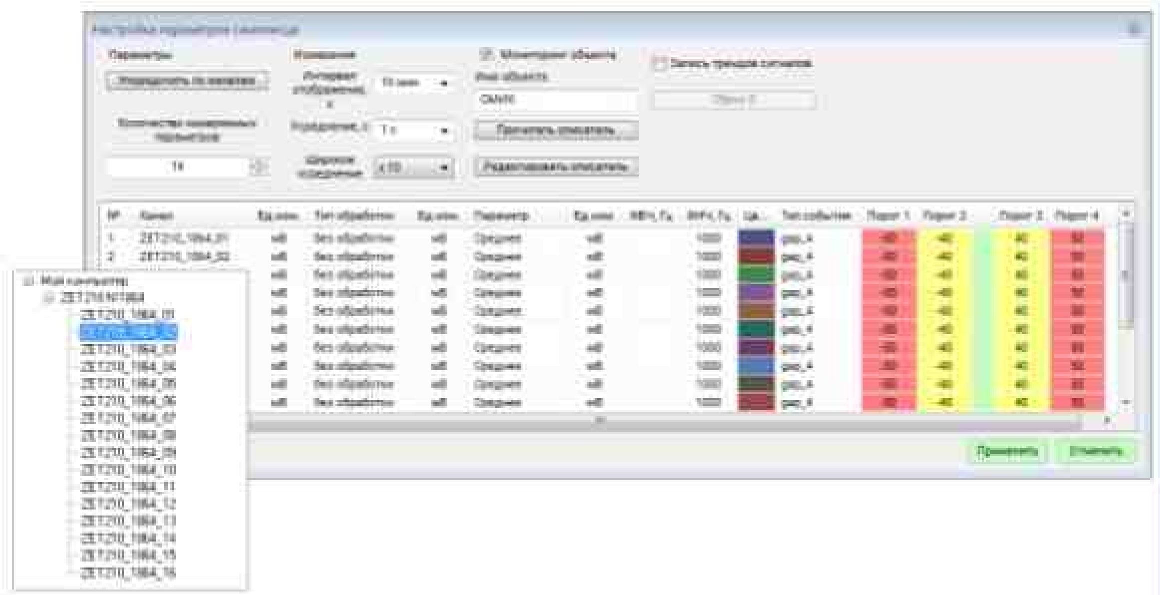


Fig. 7 Settings window, in which the source channel is selected for parameter No. 2 (click on the cell with row 2 and the "Channel" column)

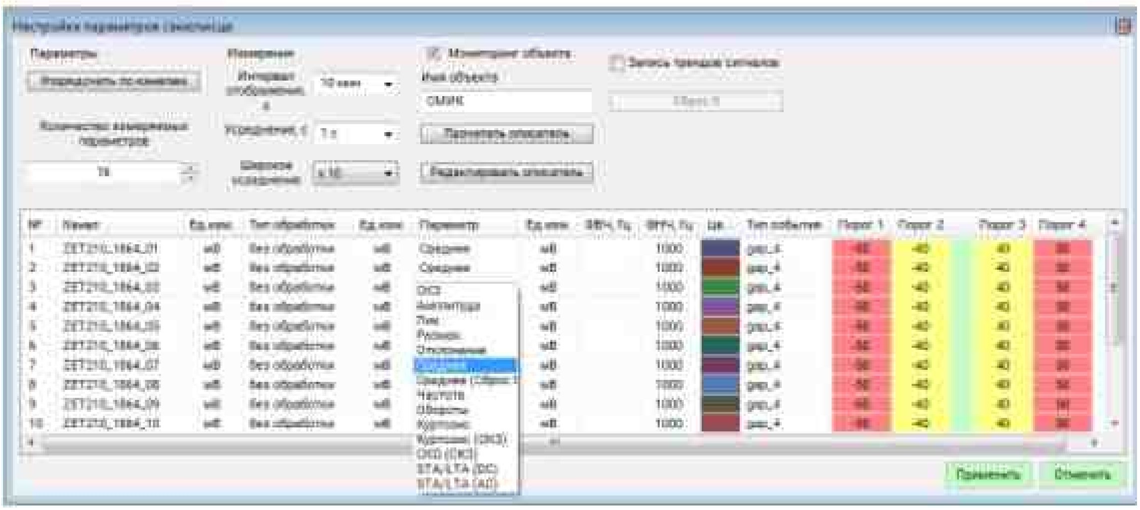


Fig. 8 Settings window, in which for parameter No. 2 the type of calculated parameter is selected (click on the cell with row 2 and the "Parameter" column)

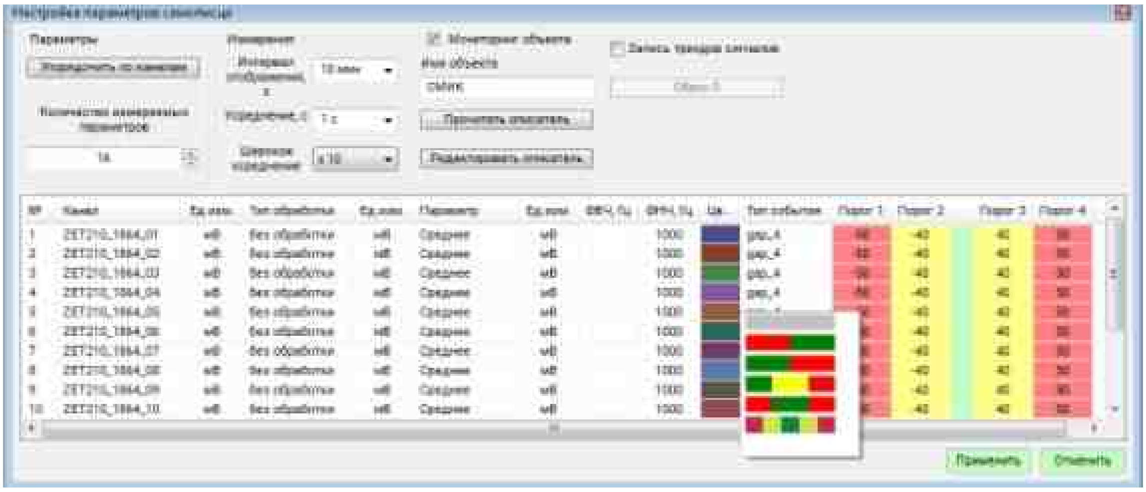


Fig. 9 Settings window, in which for parameter No. 4 the type of monitoring events is selected (type of RAV parameters) (click on the cell with line 4 and the column "Event type"), where The range of acceptable values (RAV)

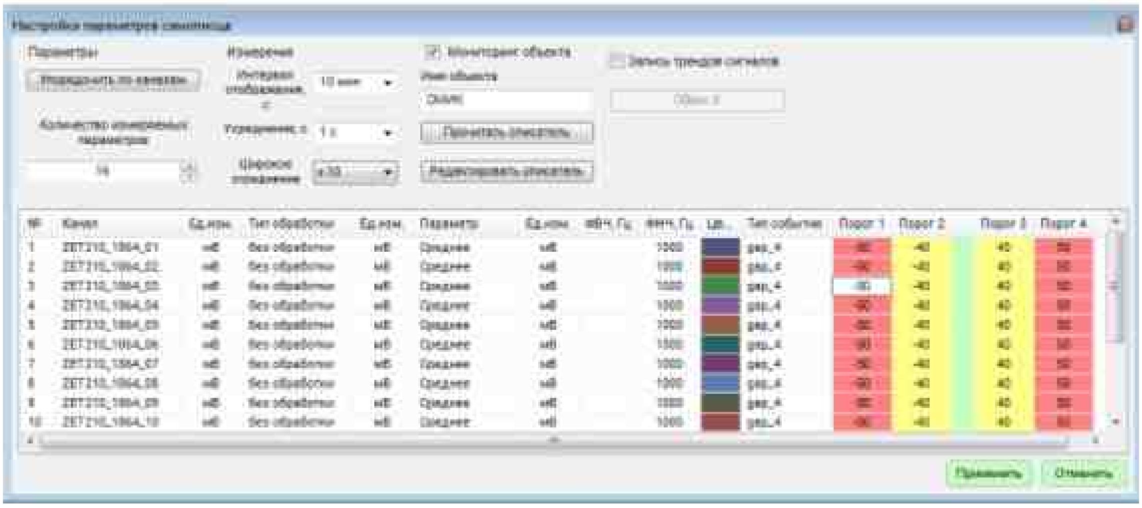


Fig. 10 Window setting, in which for parameter No. 3 an input window is opened (by mouse click) for setting/editing the value of the lower setting of the "Danger" type (threshold value 1). The values of the remaining settings and the values of the cutoff frequencies of the HPF and LPF are set in a similar way.

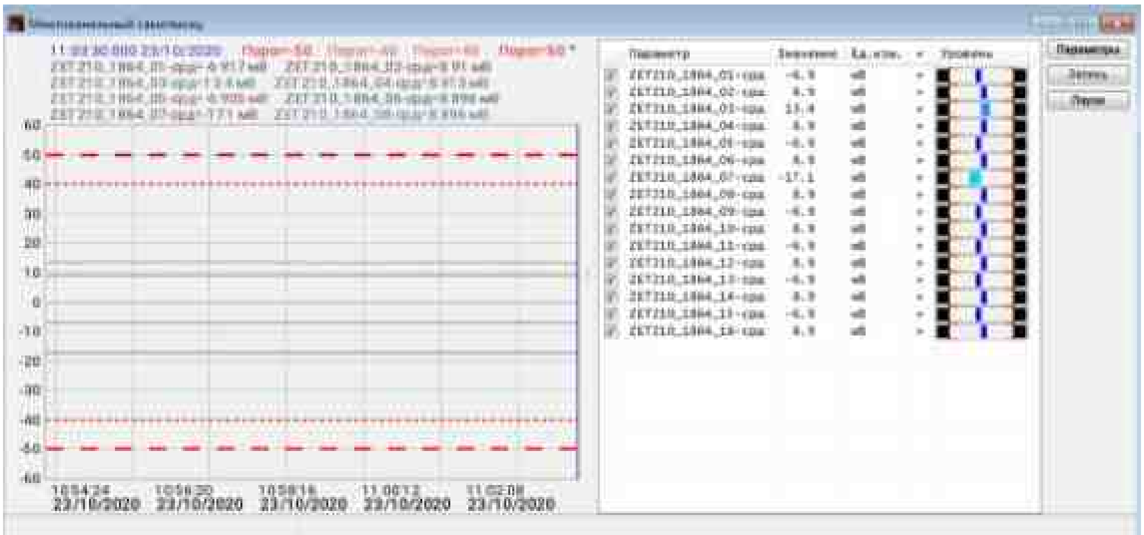


Fig. 11. The main window of the program for the parameters set in accordance with Fig.1.

In the graphic, the horizontal dashed lines are the lines with the setting value of the "Danger" type, the horizontal dotted lines are the lines with the setting values of the "Warning" type. The level indicators in the table have risks according to the setting values. The right and left squares of the indicators change color when the calculated parameter values exceed the values of the corresponding settings. Only the operator can transfer the color of these squares from the original (black) by clicking on the square with the mouse. The "+" sign in the "+" column means that the parameter value in the table will be aligned by the position of the decimal point character.

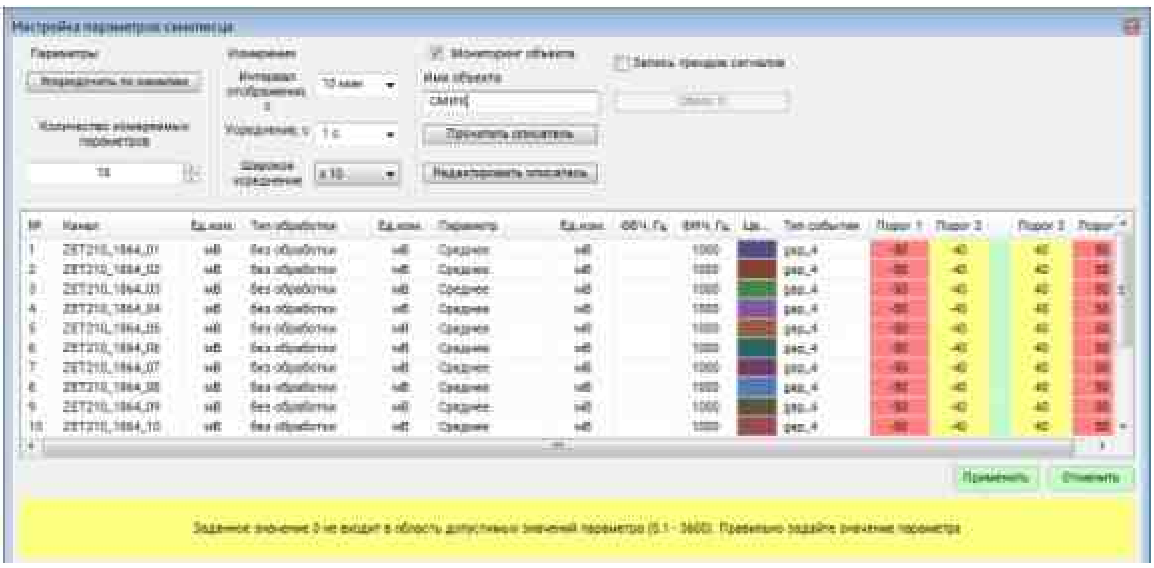


Fig. 12. Setting window, if you enter an invalid value for the averaging time equal to 0 sec.

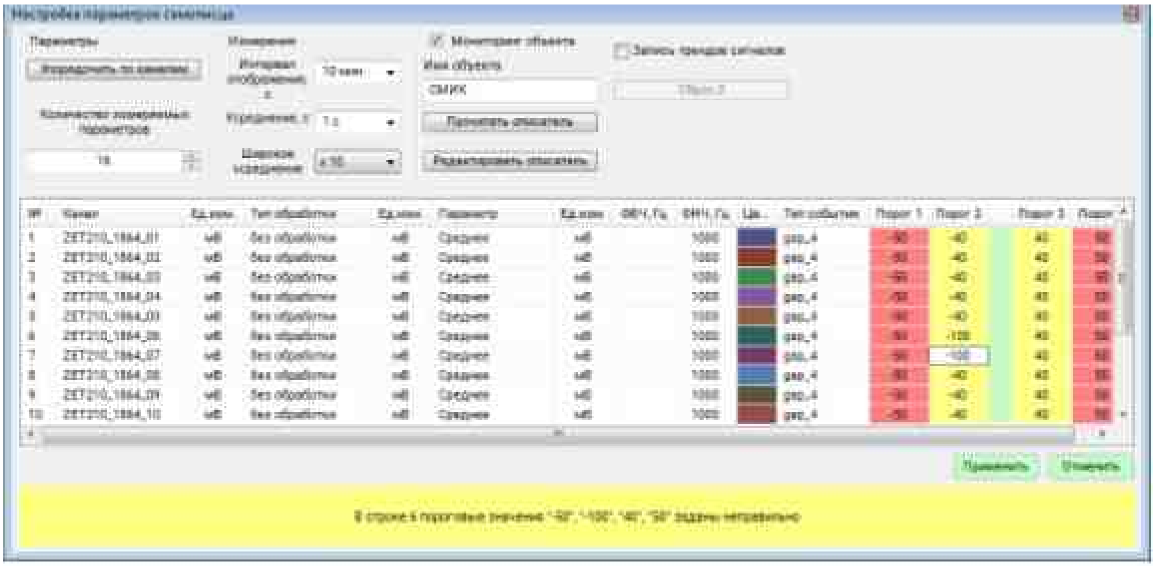


Fig. 13 Window setting, when entering an invalid value for one of the setting values

A description of the type of threshold events and the conditions for their formation are presented in Table 4.1, where the variable val contains the current value of the parameter, and the variables Threshold_1, Threshold_2, Threshold_3, Threshold_4 contain the values of thresholds 1, 2, 3, 4, respectively.

Table 4.1 Event type description

No.	Threshold type	Color combination	Formation condition	Description
1	no		–	There is no threshold.
2	less_1		val < Threshold_1	The event "Danger" occurs if the measured parameter value is less than the set threshold value 1.
3	more_1		Threshold_4 < val	The event "Danger" occurs if the measured parameter value is greater than the set threshold value 4.
4	more_2		**Warning** Threshold_3 ≤ val & val < Threshold_4 **Danger** Threshold_4 ≤ val	The "Warning" event occurs if the measured parameter value is greater than the set value of threshold 3 and less than the set value of threshold 4. The "Danger" event occurs if the measured parameter value is greater than the set threshold value 4.

5	gap_2		val < Threshold_1 || Threshold_4 < val	The event "Danger" occurs if the measured parameter value is less than the set value of threshold 1 or greater than the set value of threshold 4.
6	gap_4		**Warning** Threshold_1 < val < Threshold_2 || Threshold_3 < val < Threshold_4 **Danger** val < Threshold_1 || Threshold_4 < val	The "Warning" event occurs if the measured parameter value is greater than the set value of threshold 1, but less than the set value of threshold 2 or greater than the set value of threshold 3, but less than the set value of threshold 4. The "Danger" event occurs if the measured parameter value is less than the set value of threshold 1 or greater than the set value of threshold 4.

After selecting the event type in the **Multi-channel recorder setting** window, click the descriptor edit button. In the opened file "Monitoring.xml" in the lines "tag" for the attributes "Threshold_1", "Threshold_2", "Threshold_3", "Threshold_4" the values of thresholds 1, 2, 3 and 4 respectively are set.

14. After making changes in the "Monitoring.xml" file, save the changes: "File→Save" and close this file.

```
<?xml version="1.0"?>
<root version="5">
    <program name="multiSWvm">
        <object name="СМИК">
            <tag name="Отклонение" Channels="ZET7110 (11)" Unit="мкм/м" TypeEvent="gap_4" Threshold_1="-1" Threshold_2="-0.5" Threshold_3="0.5" Threshold_4="1" />
            <tag name="Отклонение" Channels="ZET7154-X (22)" Unit="°" TypeEvent="gap_4" Threshold_1="-1" Threshold_2="-0.5" Threshold_3="0.5" Threshold_4="1" />
            <tag name="Отклонение" Channels="ZET7154-Y (23)" Unit="°" TypeEvent="gap_4" Threshold_1="-1" Threshold_2="-0.5" Threshold_3="0.5" Threshold_4="1" />
            <tag name="СКЗ" Channels="ZET7152N_X (31)" Unit="g" TypeEvent="more_2" Threshold_1="0.5" Threshold_2="1" Threshold_3="" Threshold_4="" />
            <tag name="СКЗ" Channels="ZET7152N_Y (32)" Unit="g" TypeEvent="more_2" Threshold_1="0.5" Threshold_2="1" Threshold_3="" Threshold_4="" />
            <tag name="СКЗ" Channels="ZET7152N_Z (33)" Unit="g" TypeEvent="more_2" Threshold_1="0.5" Threshold_2="1" Threshold_3="" Threshold_4="" />
        </object>
    </program>
</root>
```

Fig. 14 Setting thresholds in the "Monitoring.xml" file

In the program "**Multi-channel recorder setting**" press the button "Read the descriptor" and make sure that the table displays the specified threshold values, then click the "Apply" button (*Fig. 15*).

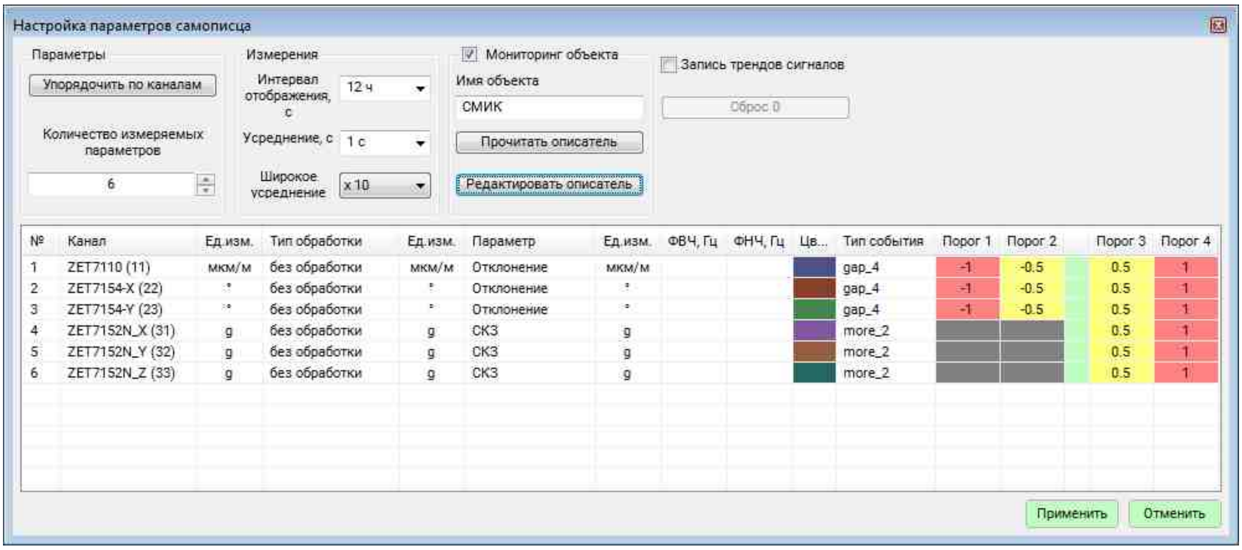


Fig. 15 Multi-channel recorder setting

The program window "Multichannel recorder" will display the graphics of the selected measuring channels, as well as the threshold levels set for them *Fig. 16*.

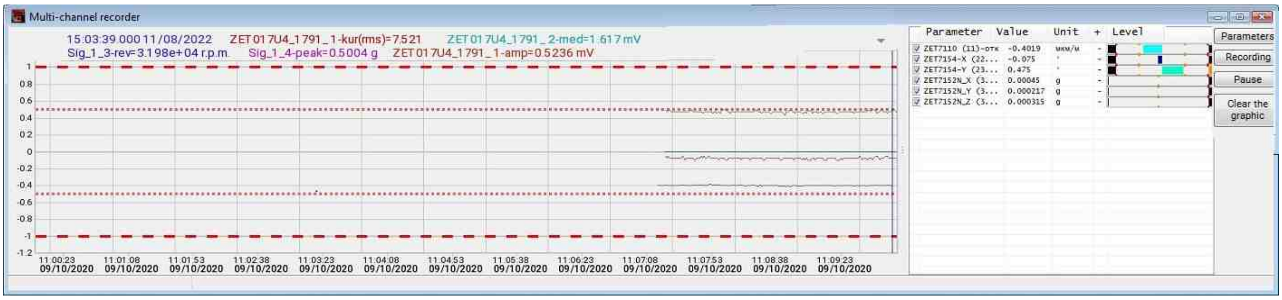


Fig. 16 Program window "Multichannel recorder"

For the convenience of perceiving the information displayed on the graph, it is recommended to launch several windows of the "Multi-channel recorder" program, grouping the graphs by types of digital sensors, for example:

- Window No. 1 displays the deformation values of ZET digital sensors ZET 7110-DS in unit "µm/m";
- Window No. 2 displays the values of the angle of inclination of digital sensors ZET 7154 in unit "º";
- Window No. 3 displays the acceleration values of ZET digital sensors 7152-N in unit "g".

In the settings of the parameters of each of the running programs "**Multi-channel recorder**", select the necessary measuring channels, enable the "Object monitoring" function, specify the previously created name in the "Object name" field and click the "Read the descriptor" button, then click the "Apply" button.

The windows of the "**Multi-channel recorder**" program will display the graphs of the selected measuring channels, as well as the threshold levels set for them (*Fig. 17*).

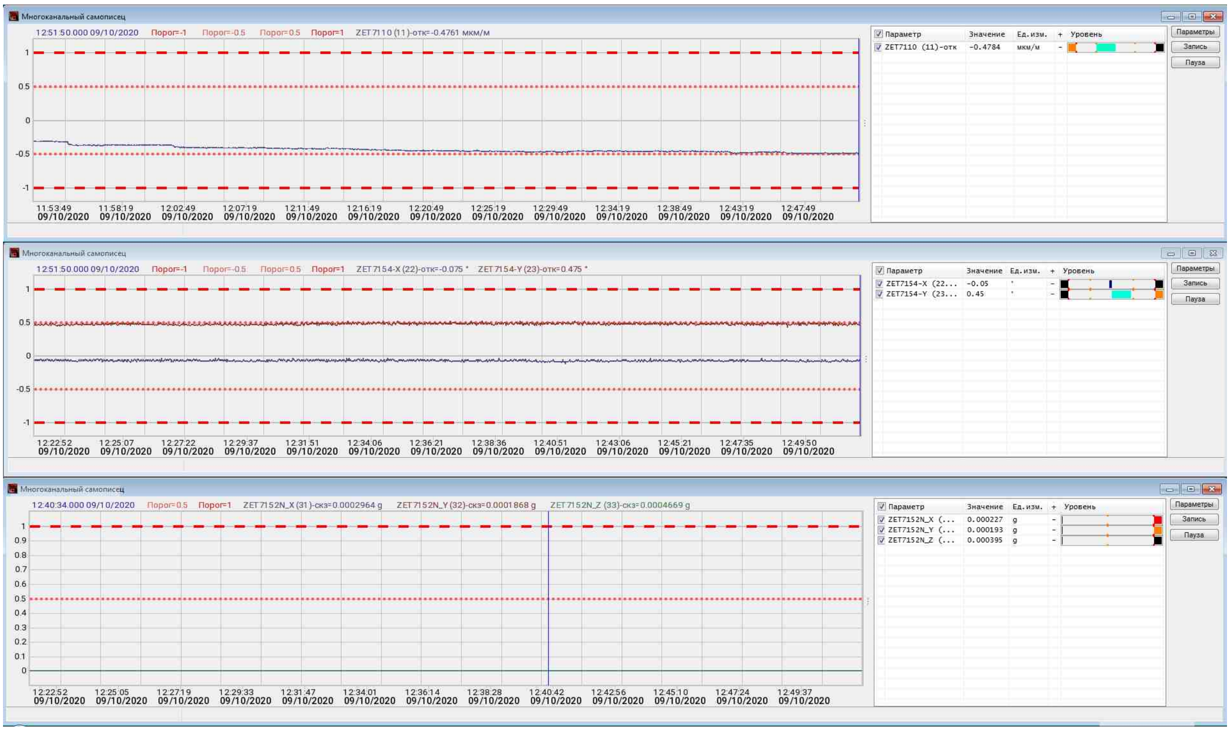
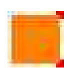


Fig. 17 Program "Multi-channel recorder" in multi-window mode

Depending on the type of the set threshold, the graphs of the "Multi-channel recorder" program can display two types of lines, which are threshold levels, the excess of which leads to the formation of the "Warning" or "Danger" event and the setting of the signal flag on the level indicator (*Table 4.2*).

Table 4.2 Description of threshold levels

	Line type	Event type	Description	Flag
1		Warning	This type of line displays the threshold level on the graphics of the "Multi-channel recorder" program, when it is exceeded, the "Warning" event is generated, and the corresponding flag is set on the level indicator.	
2		Danger	This type of line displays on the graphs of the "Multi-channel recorder" the threshold level, when it is exceeded, the "Danger" event is generated, and the corresponding flag is set on the level indicator.	

The level indicator is a scale that displays the current integrated level of loading on the measuring channel. Depending on the type of threshold event set, the zero load level for the measuring channel can be in the center of the scale or on the edge. On *Fig. 18* shows an example of different types of level indicator.

Fig. 18 Level meters

Along the edges of the level indicator there are fields where a signal flag is raised, indicating that the threshold level has been exceeded. In the normal status - when there is no excess of any threshold, the field has a black background. When the "Warning" event occurs, the background of the corresponding field turns orange, when the "Danger" event occurs, it turns red (*Table 4.2*). Also on the scale of the level indicator are orange and red marks indicating the location of the corresponding threshold levels. On *Fig. 19* shows an example of the formation of the "Warning" and "Danger" events in the "Multichannel recorder" program.

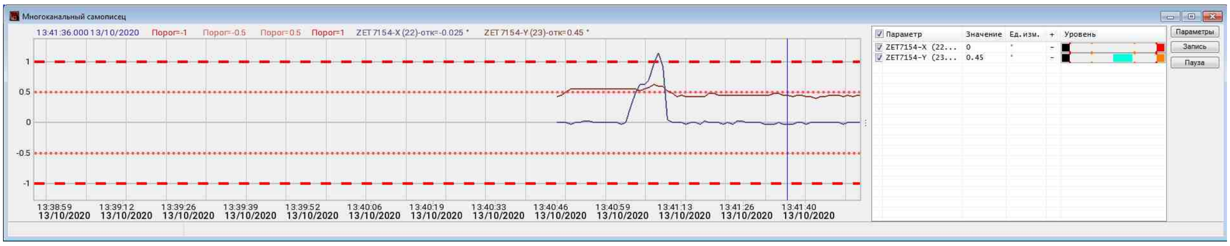


Fig. 19 Formation of events "Warning" and "Danger" in the program "Multi-channel recorder"

To remove the cocked "Warning" or "Danger" flag, use the "mouse" pointer to click on the field with the corresponding flag. But it should be understood that the flag will be removed only if the event that triggered this flag has already stopped. More detailed information about the fact of exceeding the threshold levels is contained in the program "Event Journal".

Monitoring of objects in the Multi-channel recorder .....

In the “Monitoring” tab (*Fig. 4*) check the box “Object monitoring”. In the "Object name" field, enter " Tower " and click the "Edit descriptor" button.

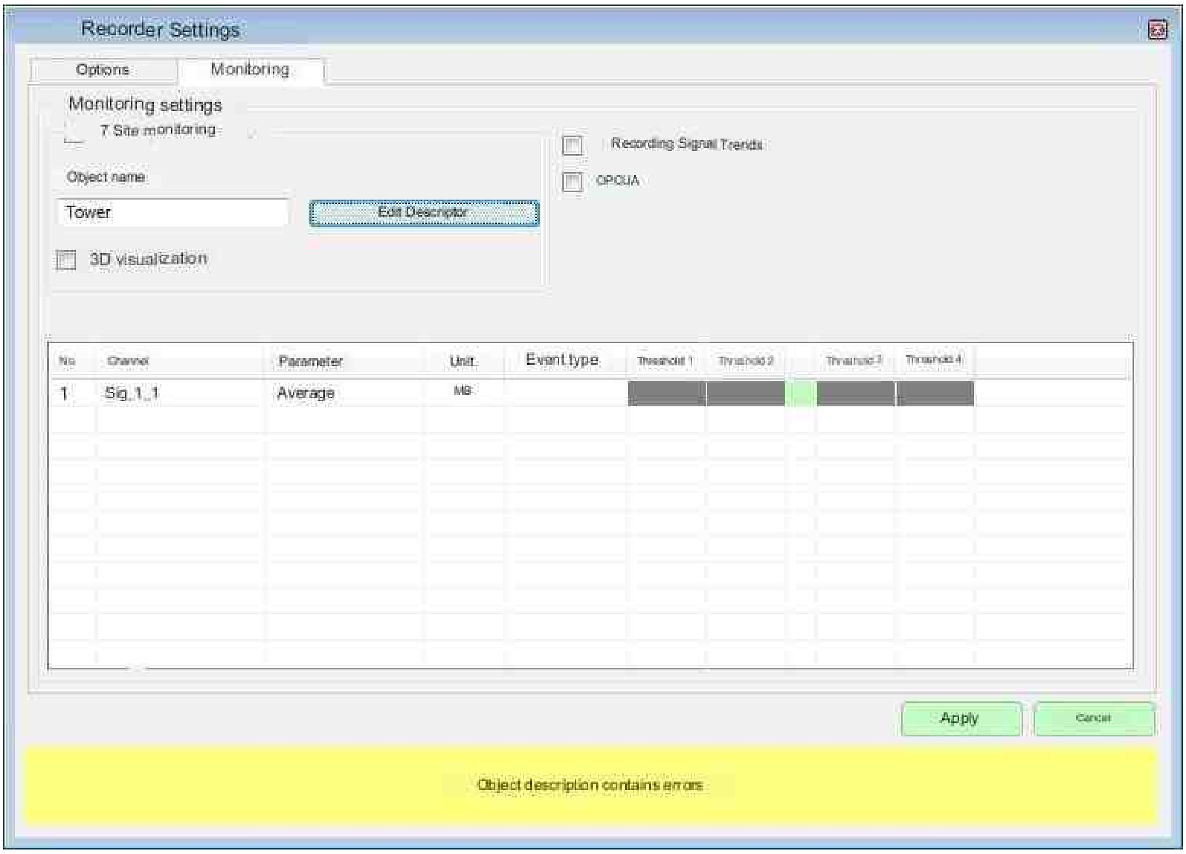


Fig. 4. Program settings window Multichannel recorder “Monitoring” tab

The "Editor of monitoring parameters" window will open (Fig. 5). In the window with the offer to create the Tower object,  activate the Yes button.

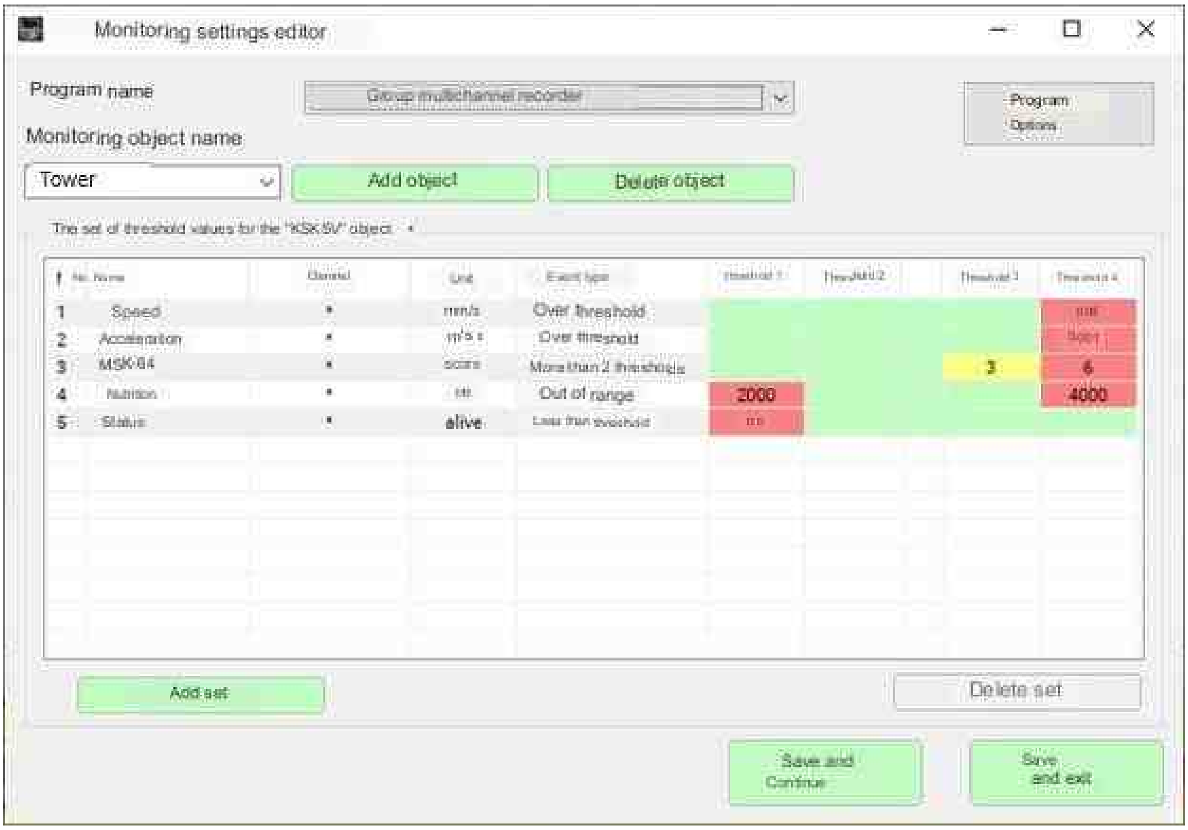


Fig. 5. Window of the monitoring parameters editor.

Next, in the "Monitoring Settings Editor" window, click the "Save and Exit" button.

Setting up a Multi-channel recorder for measuring accelerations

Setting up a Multi-channel recorder for measuring accelerations is performed according to the procedure given in the previous section. At the same time, in the "Measured parameters" panel, select "Acceleration" in the drop-down list, and the monitoring set is created in accordance with the second line of the table (*Fig. 5*).

To create a monitoring set for the "Acceleration" parameter, click the "Add set" button. In the opened window "Edit threshold values" enter the parameter values in accordance with *Fig. 6*, then click the "Apply" button.

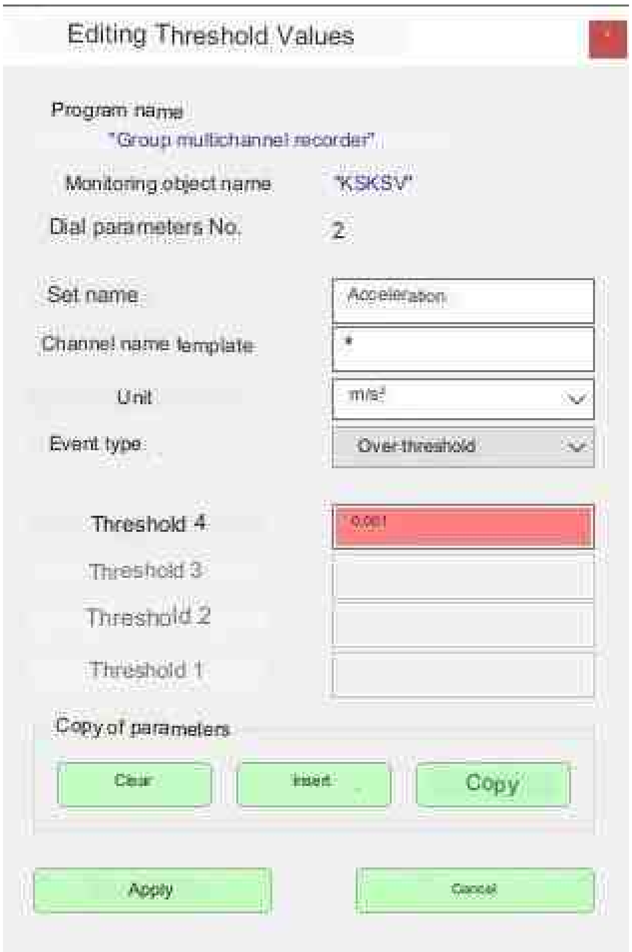


Fig. 6. Window "Editing threshold values" of the "Acceleration" set

When renaming a configuration file, use the file name swmchan _ accel.cfg.

Setting up a Multi-channel recorder for measuring the ball

Setting up a Multi-channel recorder for measuring the scoring is performed according to the method given in the section above. At the same time, in the "Measured parameters" panel, select " MSK - 64" in the drop-down list, and the monitoring set is created in accordance with the third line of the table (Fig. 5).

To create a monitoring set for the " MSK -64" parameter, click the "Add set" button. In the opened window "Edit threshold values" enter the parameter values in accordance with Fig. 7 , then click the "Apply" button.

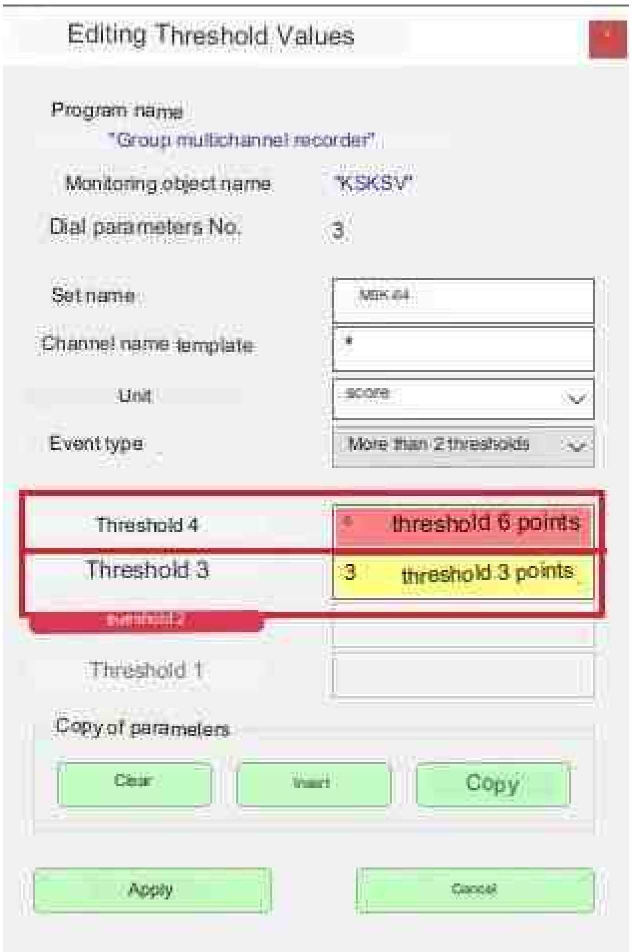


Fig. 7. Window "Editing threshold values" of the " MSK -64" set

the configuration file, use the file name swmchan _ msk 64.cfg .

Setting up the Multi-channel recorder to measure the power of seismic receivers

Setting up the Multi-channel recorder for measuring the power of seismic receivers is performed according to the procedure given in the section. At the same time, in the "Measured parameters" panel, select "Power" in the drop-down list, and the monitoring set is created in accordance with the fourth line of the table (Fig. 5).

To create a monitoring set for the “Power” parameter, click the “Add set” button. In the opened window "Edit threshold values" enter the parameter values in accordance with Fig. 8 , then click the "Apply" button.

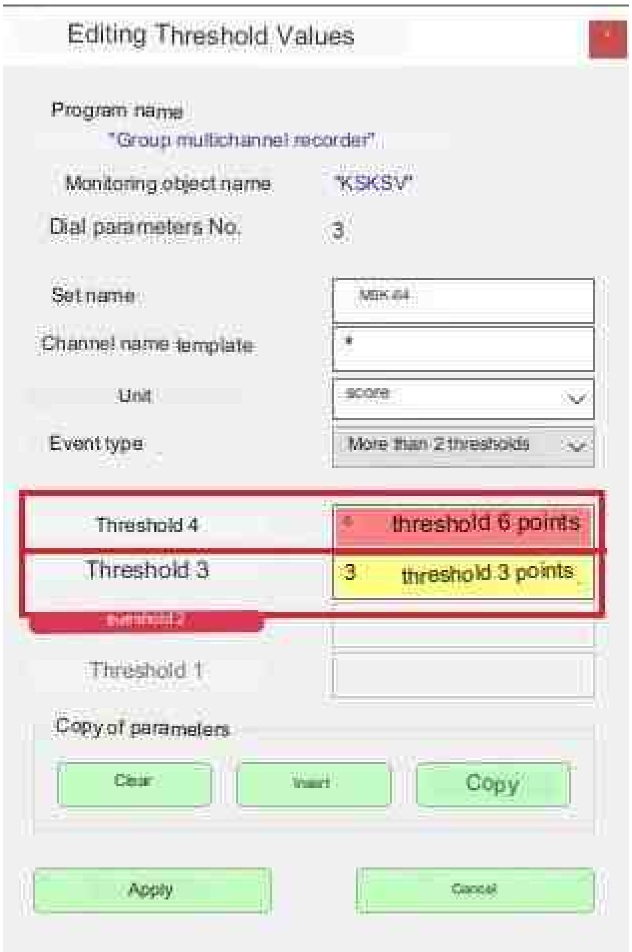


Fig. 8. Window "Editing threshold values" of the "Power supply" set

When renaming a configuration file, use the file name swmchan _ power . cfg .

The remaining lines in the table are configured in the same way as described above.

Note: In the table (*Fig. 5)* of the "Monitoring parameters editor" window, sets with different units of measurement are configured to display different types of thresholds. If two or more rows are configured with the same unit of measure, then the thresholds will be applied to the unit of measure above.

Examples for the section .....

Contents

[Application in practice](#)

[Mechanical reliability tests of soldered connections of printed circuit boards](#)

Application in practice .....

Application in practice

To demonstrate the operation of monitoring events, consider the operation of a car with an internal combustion engine.

Real monitoring software uses a 20% hysteresis when determining whether an event has ended in order to prevent "bounce" of operation.

So, with the type of events “More than threshold”, the event P4 ends at (**TP** < P4m), provided that the event was observed, where P4m = 0.8 * P4. If the same condition is met with the type of events "More than 2 thresholds", the event P4 ends. But the P3 event will end at (TZP < P3m) provided that the event was observed, where P3m = 0.8 * P3. For event types “Less than threshold” and “Less than 2 thresholds”, event P1 ends at (P1p < TST) provided that the event was observed, where P1p = 1.2 * P1. In this case, the P2 event ends at (P2p < **TP**) provided that the event was observed, where P2p = 1.2 * P2. Similarly, for event types "Out of interval" and "Out of 2 intervals":

- the event P1 ends at (P1m < **TP**) provided that the event was observed;
- the P2 event ends at (P2m < **TP**) provided that the event was observed;
- the P3 event ends at (**TP** < P3p) provided that the event was observed;
- the P4 event ends at (**TP** < P4p) provided that the event was observed.

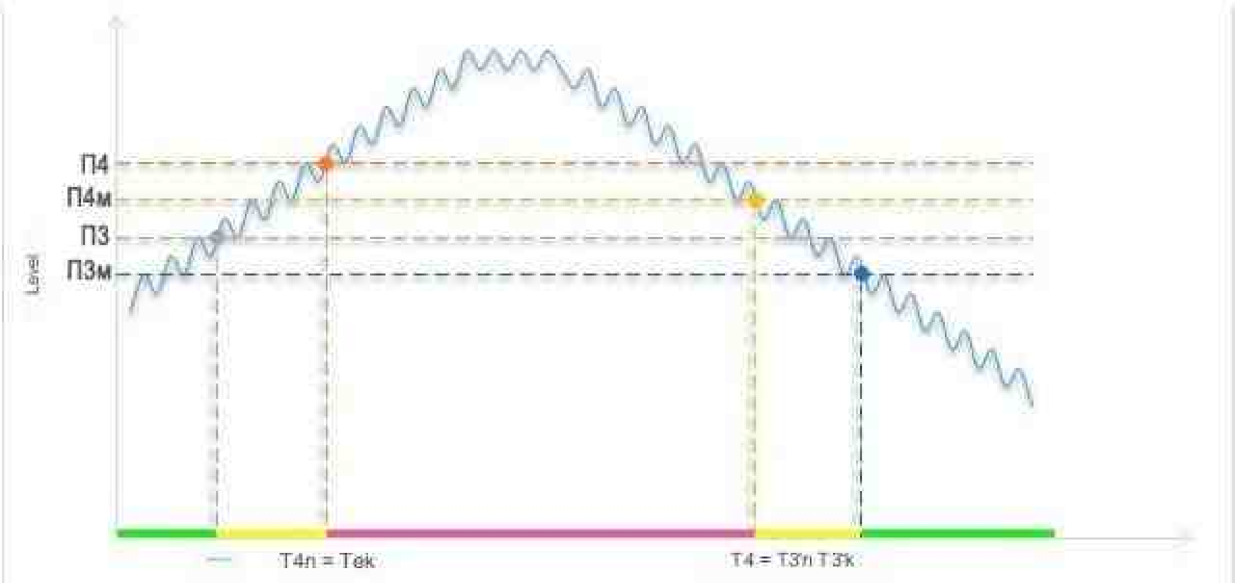
For clarity, the examples in the images show color indication of zones where:

- green zone — no monitoring event;
- yellow zone - an event of the "Warning" type is observed, i.e. P2 or P3;
- red zone - an event of the "Danger" type is observed, i.e. P1 or P4.

Event type "More than threshold"

The "Over Threshold" event type is suitable for monitoring engine temperature. At P4 = 105 °C, the "Danger" event indicates a malfunction in the cooling system and, as a result, the impossibility of continuing the operation of the engine due to the high risk of its failure (jamming).

More than threshold



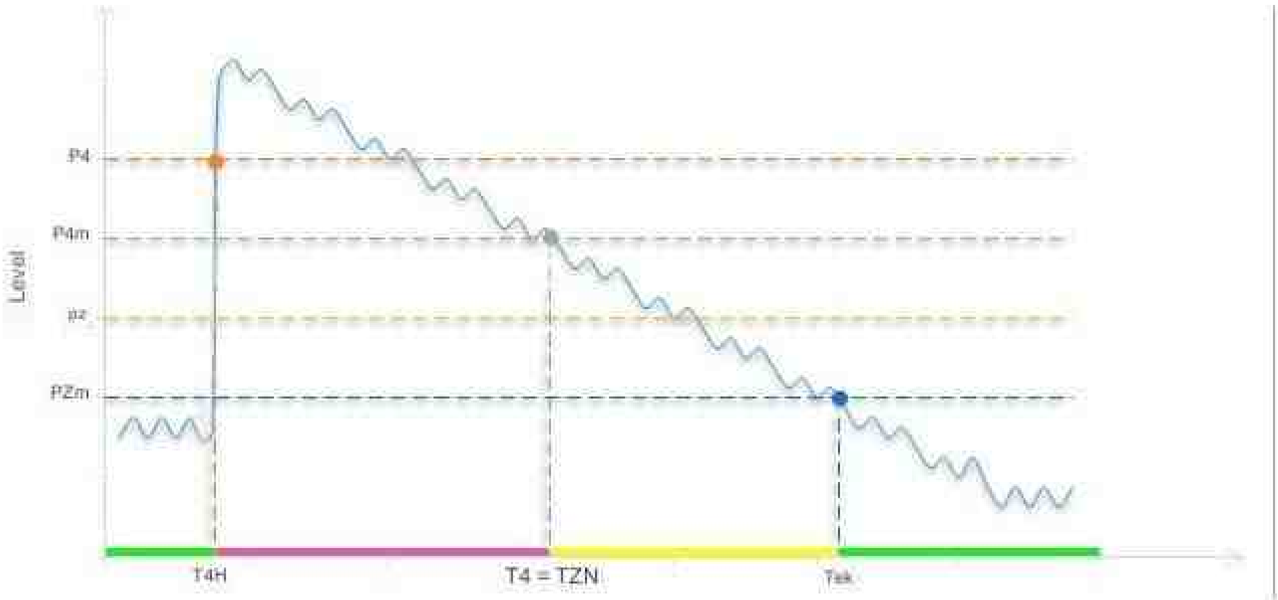
Time

T4n— start time of event P4;
T4k— end time of event P4.

Event type "More than 2 thresholds"

Using the event type "More than 2 thresholds" in this case may additionally issue a preliminary event of the type "Warning". At P3 = 100 °C, this event indicates the beginning of problems.

More than 2 thresholds



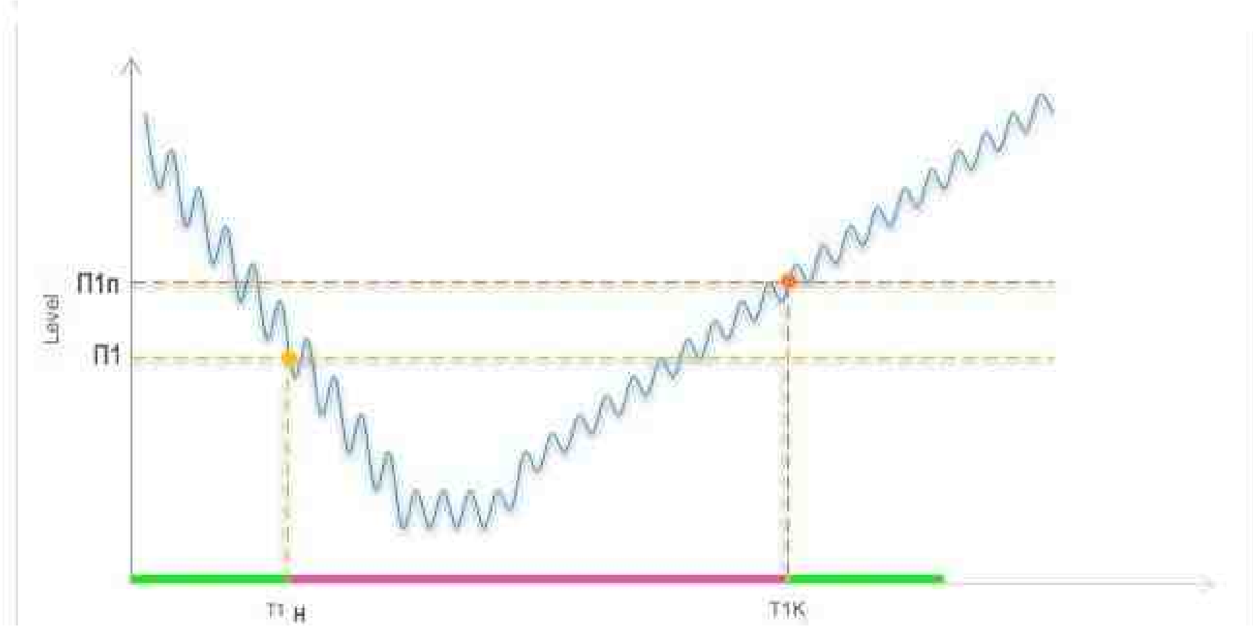
Time

In this case, the P4 event was observed from T4n to T4k, and the P3 event was observed 2 times: from T3n to T3k and from T3n to T3k, while T4n = T3k and T4k = T3n.

Event type "Less than threshold"

The "Less than threshold" event type is suitable for monitoring the amount of fuel in a car's tank. At P1 = 2 liters, the “Danger” event indicates a critical fuel level and, as a result, the impossibility of continuing engine operation due to the high risk of failure of the high-pressure submersible fuel pump.

Less than threshold

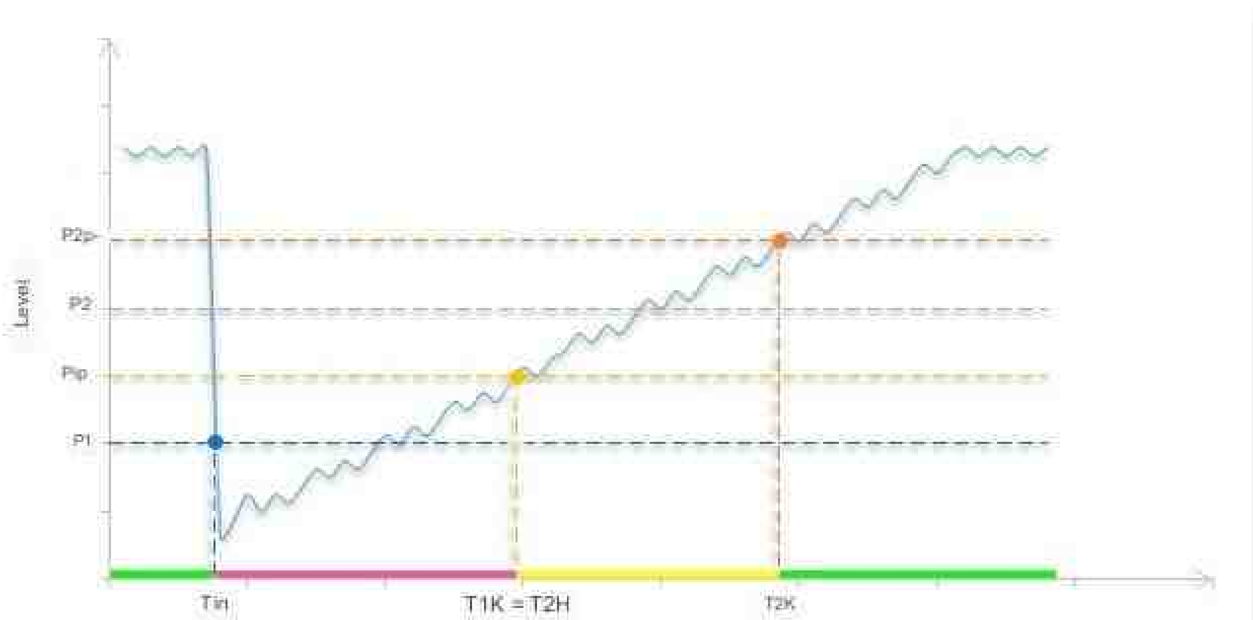


Time

Event type "Less than 2 thresholds"

Using the event type "Less than 2 thresholds" in this case may additionally issue a preliminary event of the type "Warning". With P2 = 5 liters, this event indicates the need for refueling.

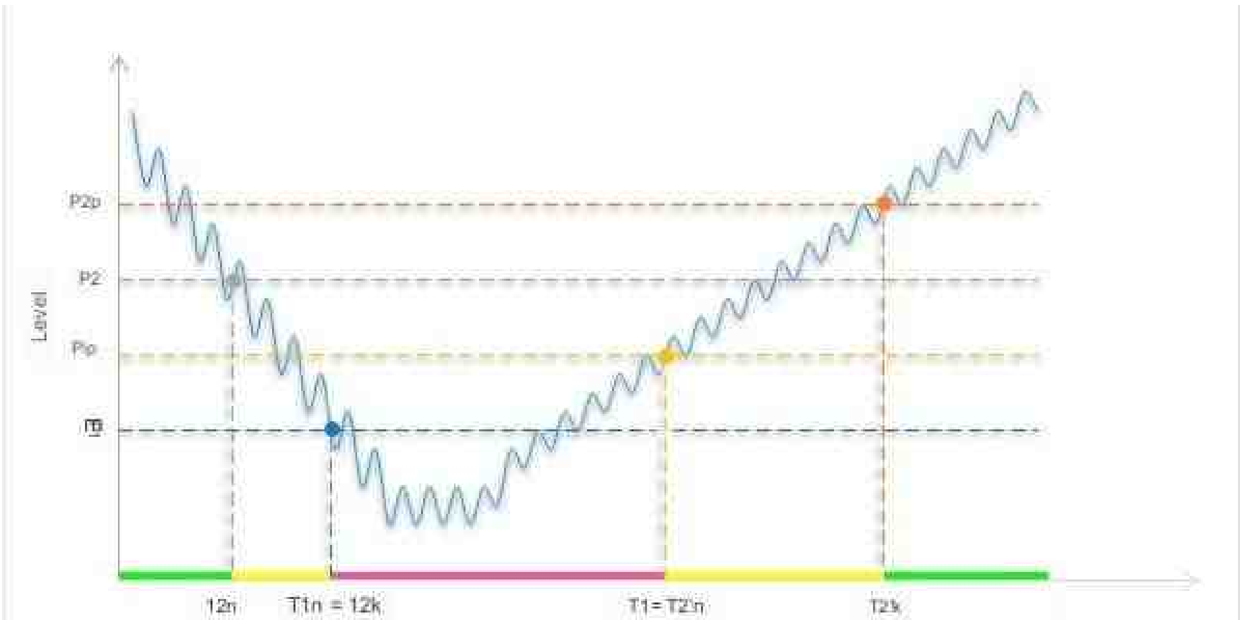
Less than 2 thresholds



Time

In this example, the P1 event was observed from T1n to T1k, and the P2 event was observed from T2n to T2k.
In this case, T1k = T2n.

Less than 2 thresholds



Time

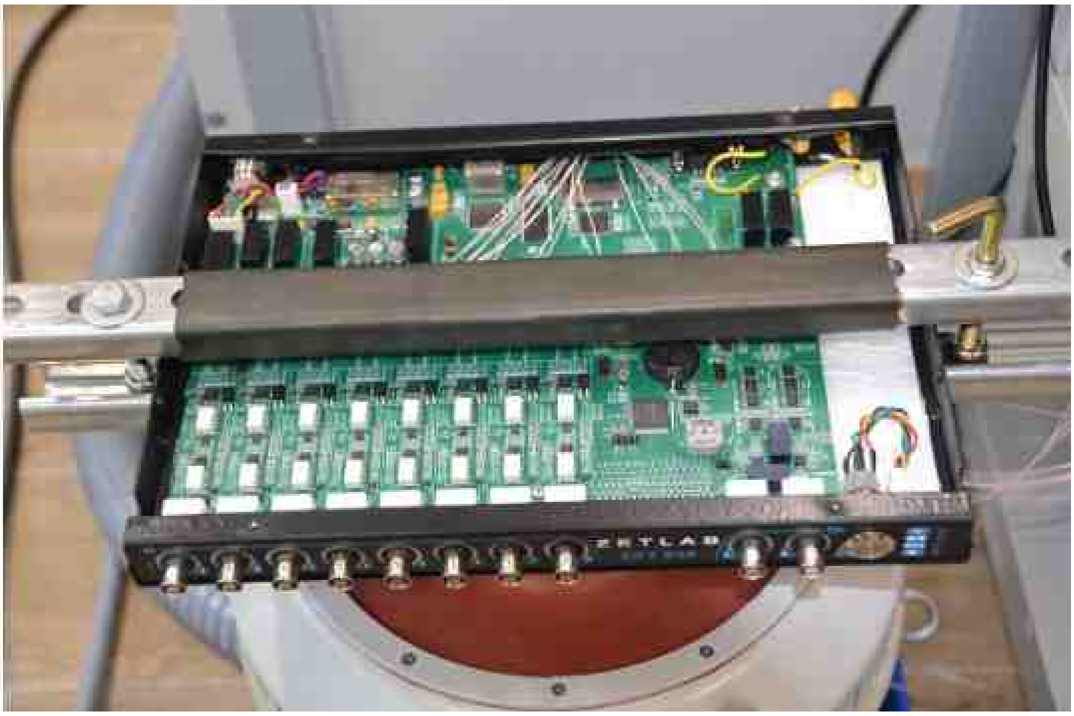
In this example, event P1 was observed from T1n to T1k, and event P2 was observed twice: from T2n to T2k and from T2'n to T2'k.
In this case, T1n = T2k and T1k = T2'n.

The Out of Range event type is suitable for monitoring engine speed. At P1 = 500 rpm, the “Danger” event indicates that there are problems in the engine power supply system and that the engine can stall at any second. At P4 = 7000 rpm, the "Danger" event indicates that the engine is experiencing heavy loads, the long-term impact of which greatly reduces the engine's service life, and engine failure is also possible.

Using the event type "Out of 2 intervals" in this case may additionally generate pre-events of the "Warning" type. At P2 = 700 rpm, the "Warning" event indicates the beginning of problems in the power system. At P3 = 5000 rpm, the "Warning" event indicates the beginning of heavy loads on the engine.

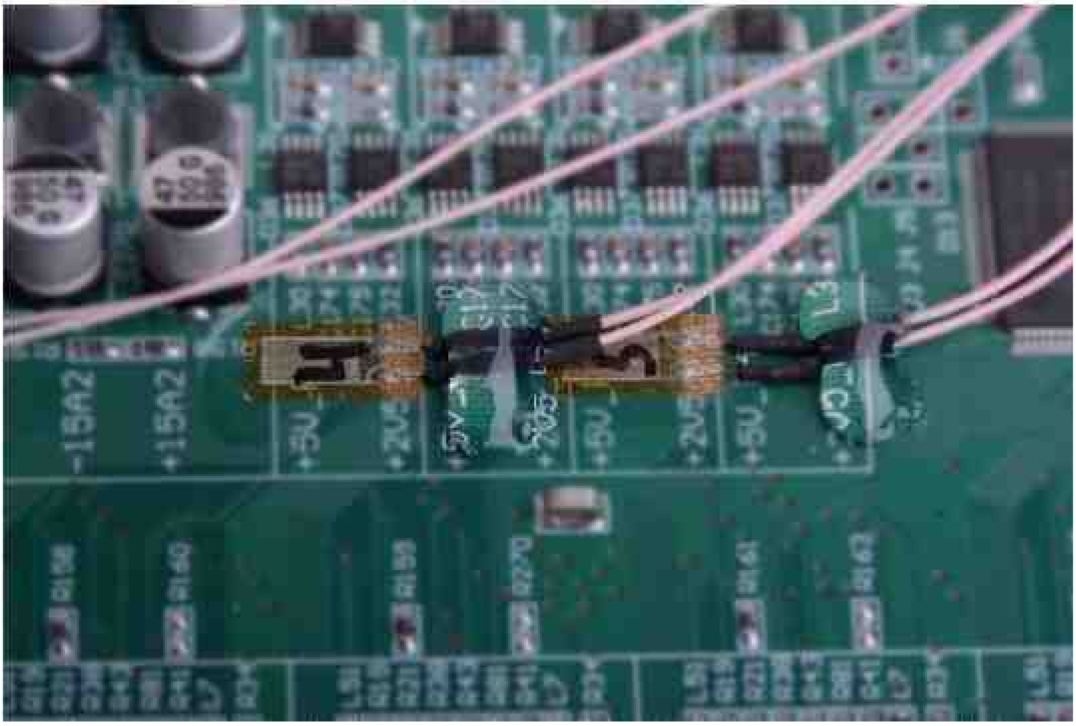
Mechanical reliability tests of soldered connections of printed circuit boards .....

Mechanical reliability tests of soldered connections of printed circuit boards are carried out by the strain-gauge method. This type of testing allows for an objective analysis of the levels of deformation and the rate of deformation to which the printed circuit board is subjected during assembly, testing and operation. Recommendations for conducting tests are given in the Manual for Mechanical Shock Tests to assess the reliability of soldered joints IPC-JEDEC-9703.



Due to the susceptibility of soldered connections of printed circuit board components to failures caused by deformation, the parameters of the maximum allowable voltage-strain status is crucial during operation. Excessive deformation can lead to damage to the solder joints for all coatings of the housing substrate. Such failures include cracking of solder balls, damage to the track, separation of the contact pad and cracking of the substrate during the manufacture of the board and during testing.

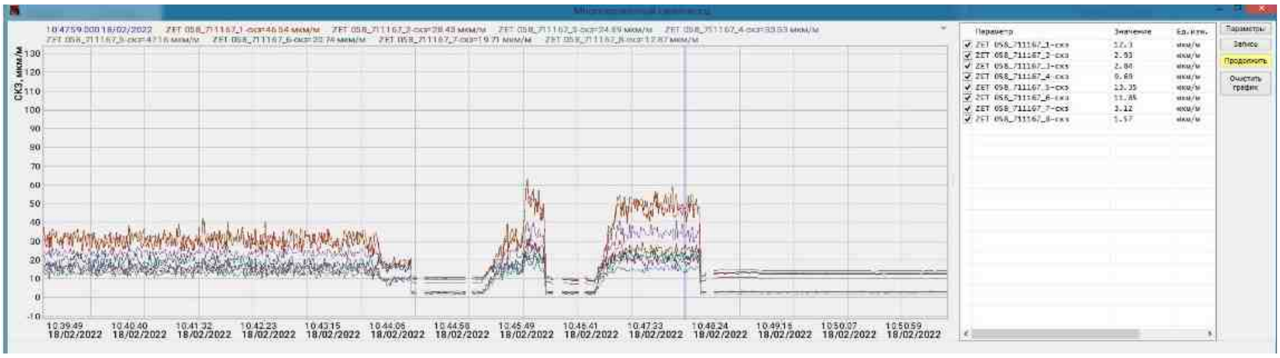
In this article, we will consider the basic procedure for conducting mechanical tests of a printed circuit board, using the example of transport vibration.



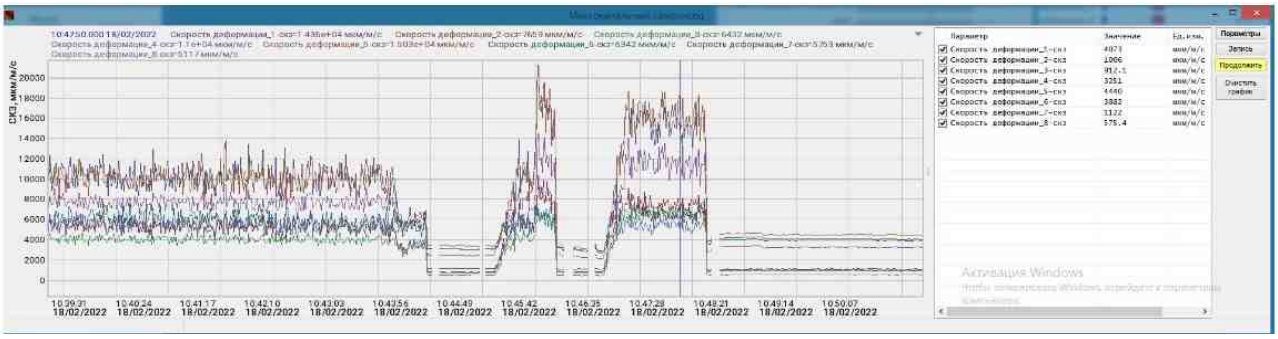
The measurement of the voltage-strain status of the printed circuit board includes the installation of meter resistances in places most exposed to load, and then testing the board for the effects of Random

In the process of testing, data on the value of deformation and the rate of deformation of the printed circuit board are recorded in the program "Multi-channel recorder".

Test steps that exceed the strain limits are considered excessive and identified so that corrective action can be taken. Strain limits may be determined by the customer, component supplier, or best practice.

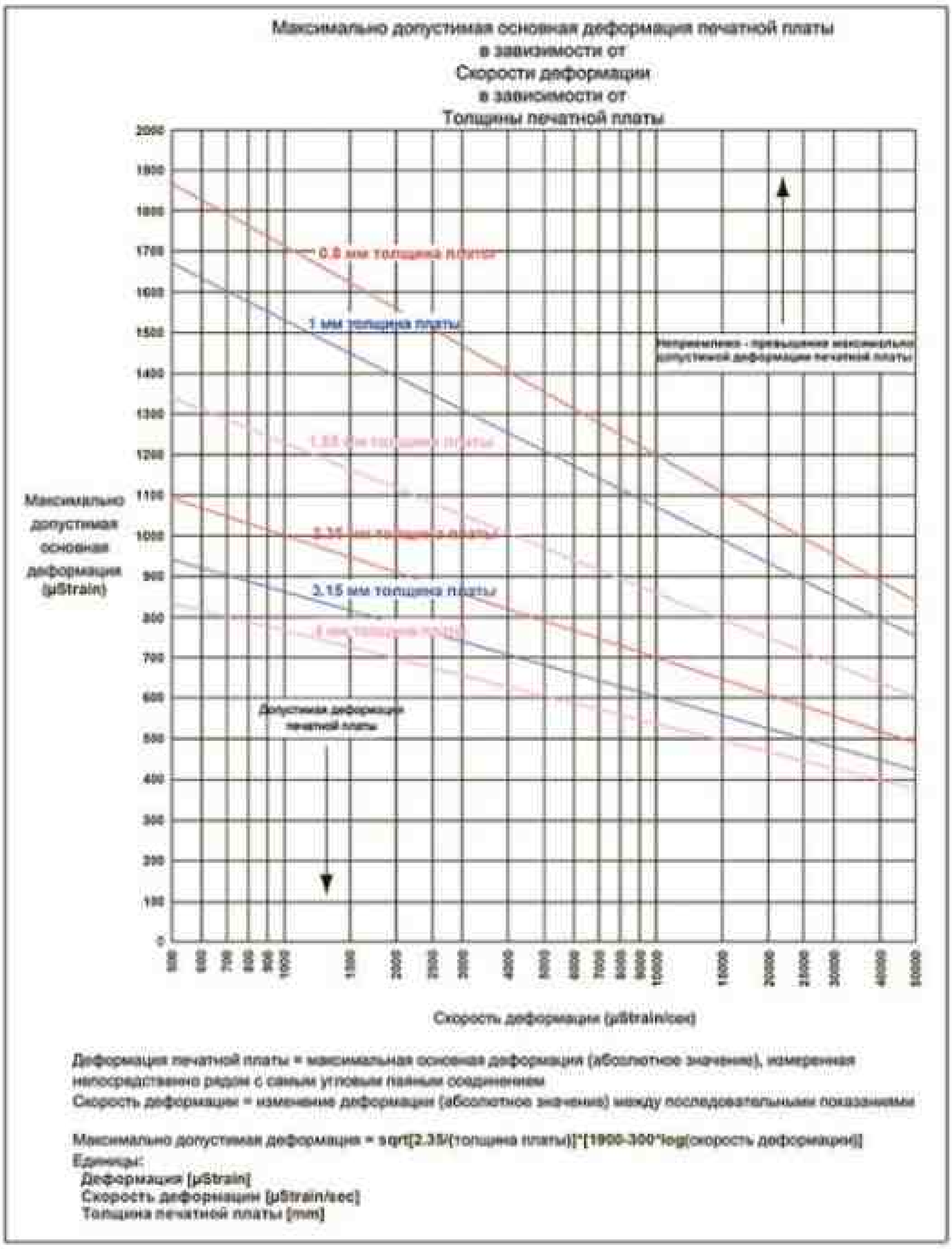


Deformation of printed circuit boards during testing



Deformation rate of printed circuit boards during testing

Examples of deformation measurement criteria in accordance with the IPC/JEDEC-9703 standard are shown on the nomogram of the maximum permissible main deformation of the printed circuit board, depending on the deformation rate and the thickness of the board:



The control of the bending of boards using meter resistance has proved to be very useful for the electronics industry and continues to be recognized as a method of detecting harmful production processes.

However, this method has a number of disadvantages that do not allow its use in some cases:

- the small size of the printed circuit board, and as a result, the impossibility of mounting meter resistance;
- the possibility of only one-time use;
- the need to compensate for temperature effects.

Group multi-channel recorder .....

Group multi-channel recorder program is designed for long-term recording and displaying the parameters of signals received on the input channels of controllers, spectrum analyzers (included in the delivery package), digital sensors and ADC / DAC modules (optional).

The recorder allows continuous recording of selected signal parameters to a file. The program is used in systems of continuous monitoring and control, in systems for conducting various types of tests for recording test results. For example, when conducting vibration tests, the operator needs to record the vibration levels at the reference and control points and the frequency of the excited signal. Tests can be carried out over several work shifts. When conducting vibration tests along three axes, it is necessary to rearrange the sample. During the reset, the recorder can be stopped and then continue recording as needed. The number of simultaneously registered channels can be up to 60.

Group multi-channel recorder program displays the measured signal values as well as the results of signal data processing. The **Group multi-channel recorder** program provides the ability to set thresholds, the signal going beyond the boundaries of which leads to an alarm. Several recorders can be run at the same time. In automated control systems for technological equipment, it is necessary to continuously monitor and record technological parameters - pressure, temperature, load. In this case, the recorder switches to continuous recording mode. Annual, weekly or daily protocols are archived by the operator as needed.

The “ **Group multi-channel recorder** ” program is launched from the “Registration” menu of the ZETLAB panel (*Fig. 1*). The program window " **Group multi-channel recorder** " will be displayed on the monitor screen (*Fig. 2*). From the directory " C :\ ZETLab " run the program " swmchan . exe " and in the opened window activate the "Parameters" button.

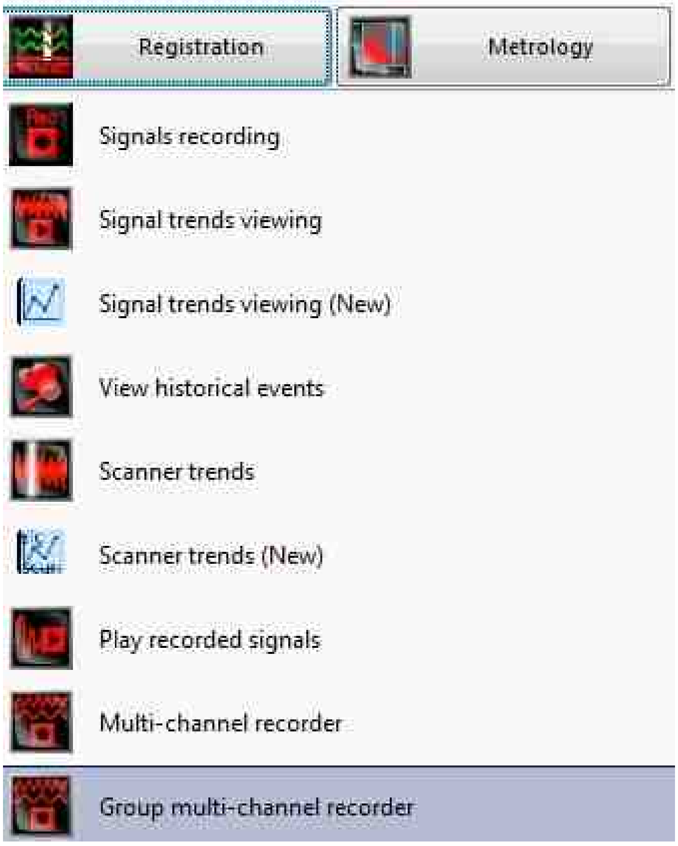


Fig. 1 Starting the Group multi-channel recorder program from the "Registration" tab

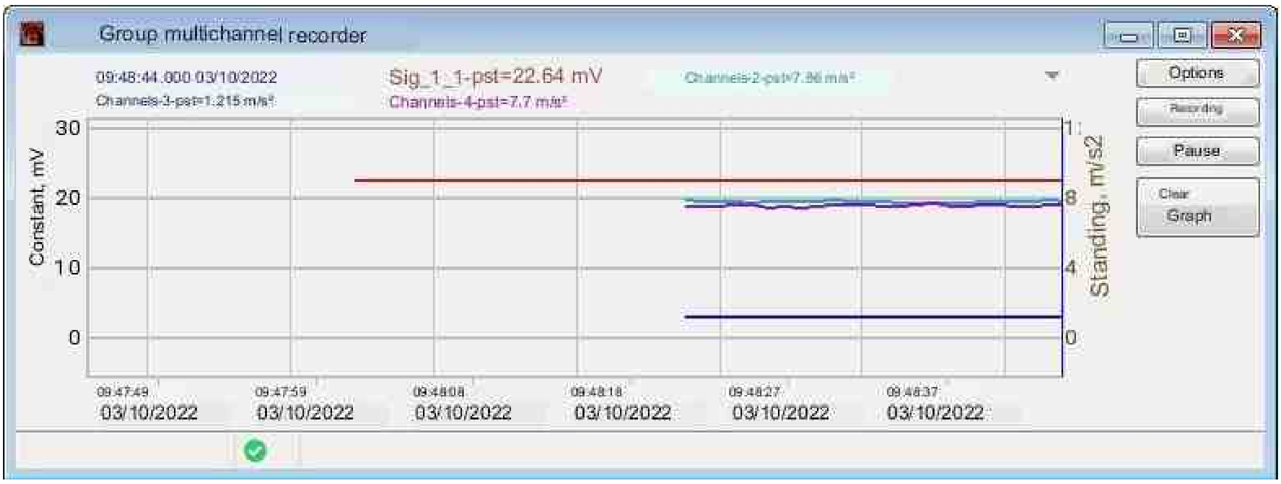


Fig. 2 "Group multi-channel recorder" program window

Supported Hardware .....

The input data of **the Group multi-channel recorder program** are the digital data of the **ZETLAB server channel**.

Group multi-channel recorder program is included in the following software:

- ZETLAB BASE - software supplied with ADC / DAC modules (optional);
- ZETLAB ANALIZ - software supplied with spectrum analyzers ;
- ZETLAB VIBRO - software supplied with the shaker control system ;
- ZETLAB TENZO - software supplied with strain gauges ;
- ZETLAB SEISMO - software supplied with seismic stations ;
- ZETLAB NOISE is the software supplied with the vibration sound level meter .
- ZETLAB SENSOR — software supplied with ZETSENSOR digital sensors (optional).

Group multi-channel recorder is included in the program group **Registration**

Program description .....

The " **Group multi-channel recorder** " program is launched from the "Registration" menu of the ZETLAB panel (*Fig. 1*). The program window " **Group multi-channel recorder** " will be displayed on the monitor screen (*Fig. 2*). From the directory " C :\ ZETLab " run the program " swmchan . exe " and in the window that opens,  activate the "Settings" button.

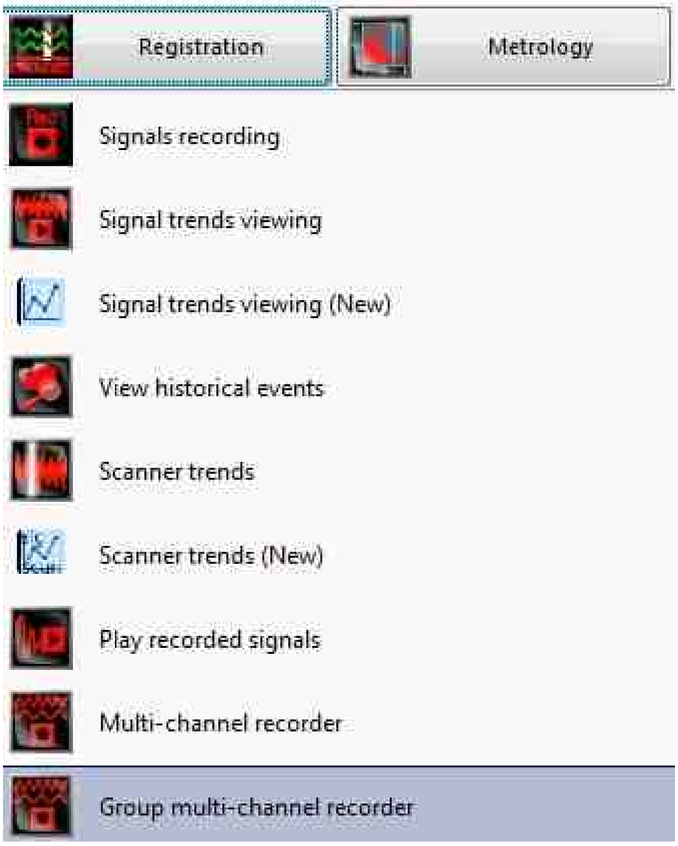


Fig. 1 Starting the multi-channel recorder program from the "Registration" tab

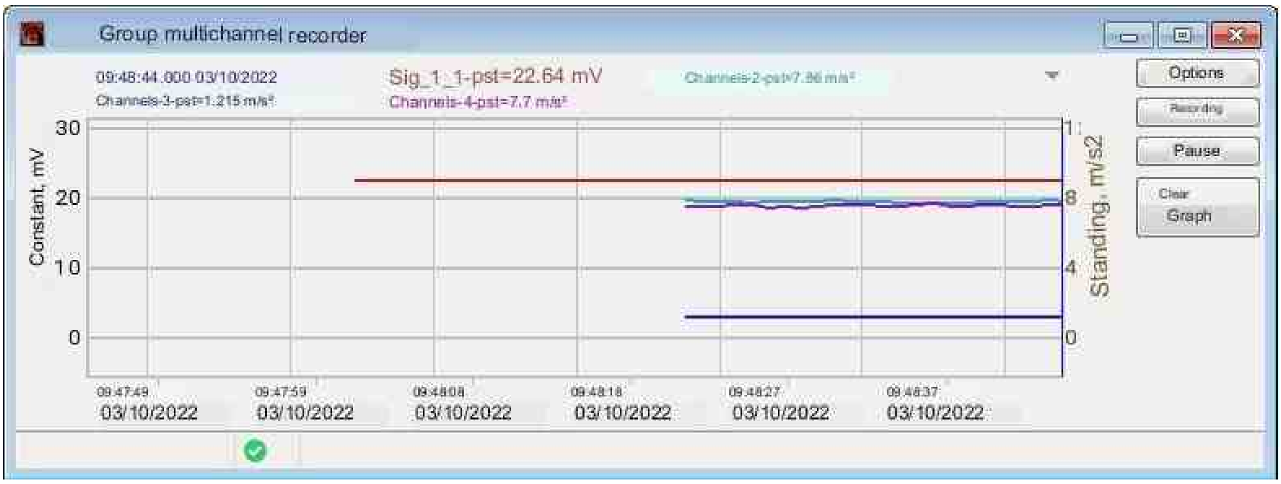


Fig. 2 “Group multi-channel recorder” program window

See also:

- Cursor control in graphics
- Scaling the numerical axes of graphics
- Selection from the lists

Group multi-channel recorder .....

BASIC FUNCTIONS AND PARAMETERS OF THE PROGRAM

In the settings window that opens, in the "Parameters" tab (Fig. 3), configure the following parameters:

1) In the panel "Measured parameters" in the drop-down list, select "Velocity"
2) Click the "Set channels" button
3) In the "Measurements" panel, in the "Display interval" field, set 24 hours
4) In the "Measurements" panel, in the "Averaging" field, set 10 s.

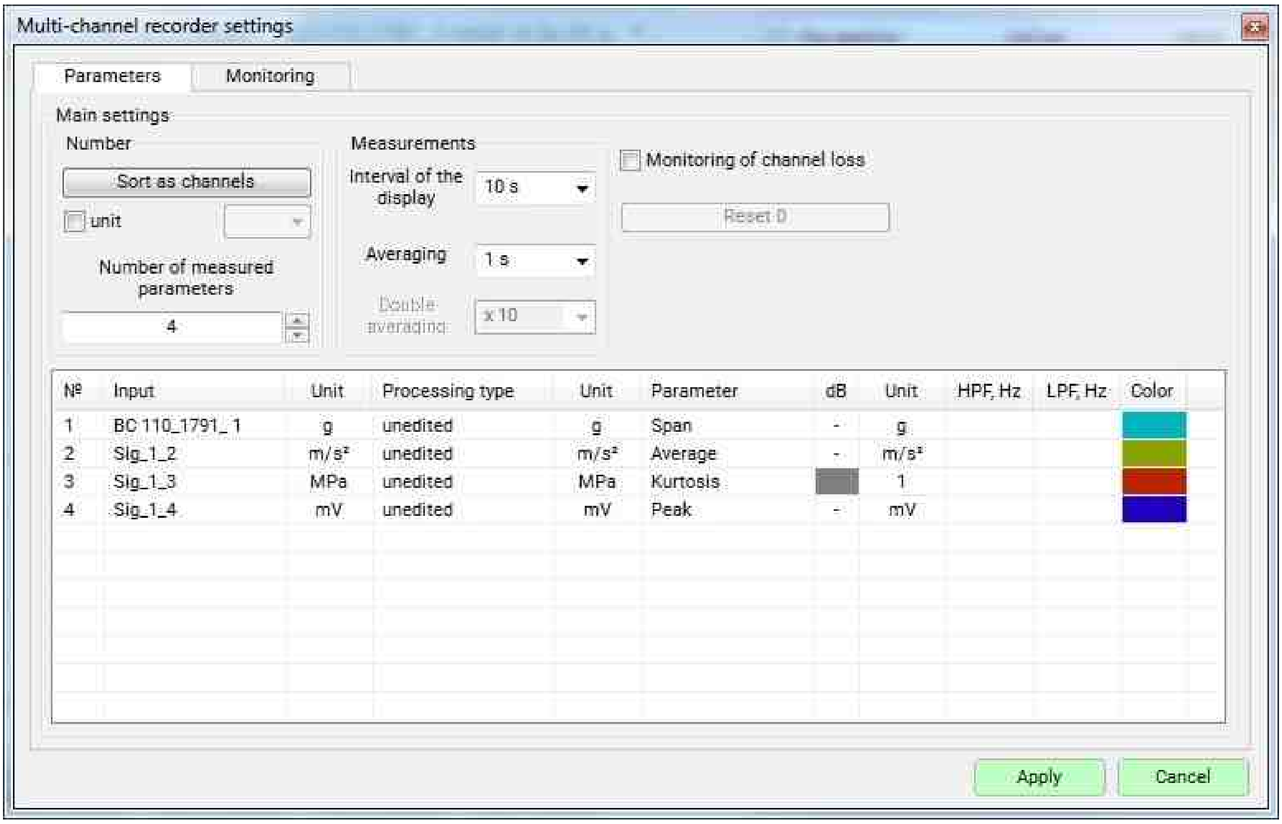


Fig. 3. Settings window of the program swmchan.exe. Parameters tab

Configurable signal processing and presentation parameters include:

Processing type - signal processing in the form of differentiation, double differentiation, integration, double integration or STA / LTA algorithm is available if necessary .

Parameter - the value by which the signal will be displayed on the chart (*Fig. 3a*) :

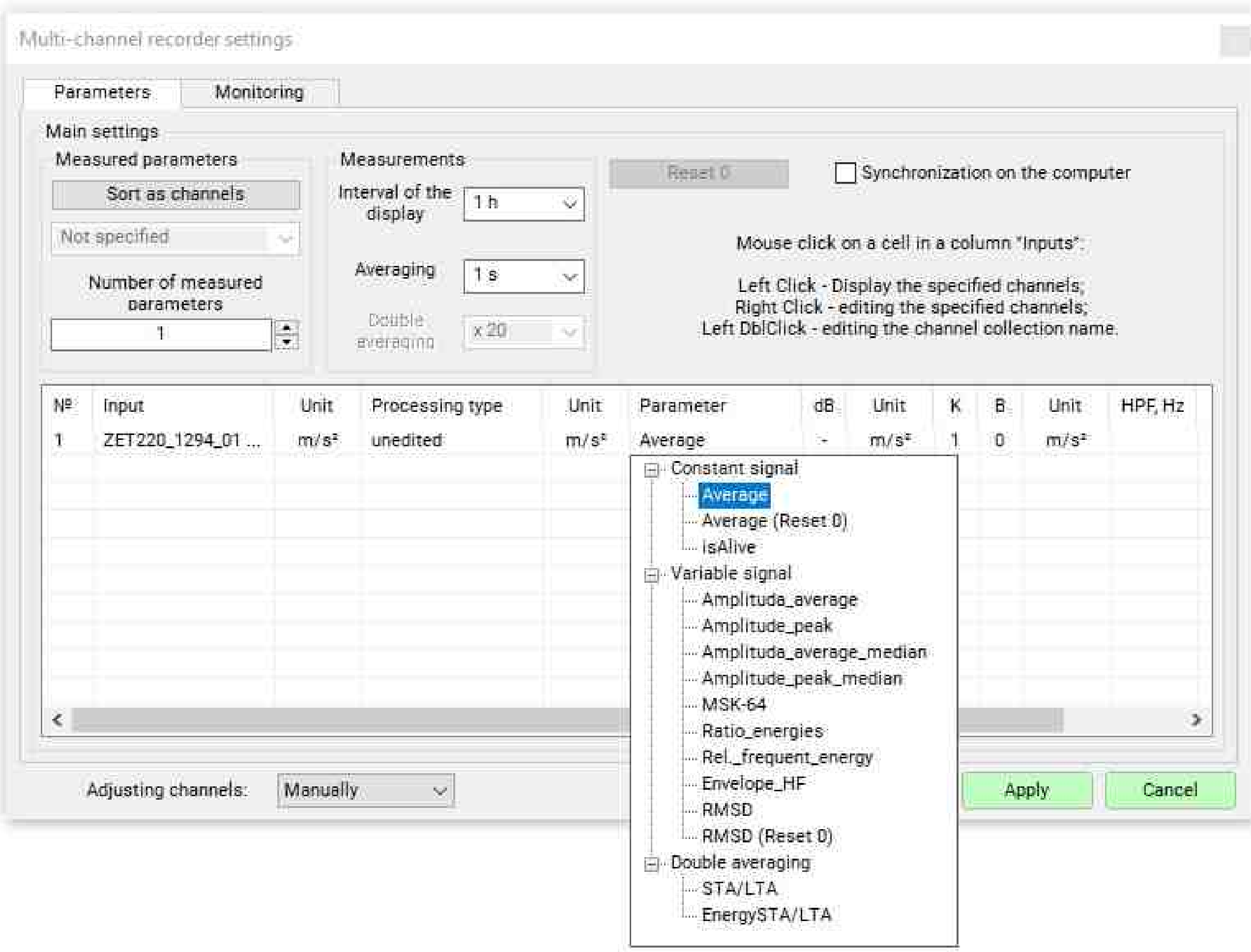


Fig. 3a. Program settings window Group multi-channel recorder. Options tab Options column

The parameter tree structure contains the following sections

Constant signal:

- Offset DC;
- Offset DC (Reset to 0);
- isAlive;

Variable signal:

- Amplitude_average;
- Amplitude_peak;
- Amplitude_average_median;
- Amplitude_peak_median;
- MSK-64.This parameter is available only for channels whose unit of measurement is acceleration g; m/s^2;
- Ratio energies;
- Rel_of_frequent_energies;
- Envelope_RF.This parameter is available only for channels whose unit of measurement is acceleration g; m/s^2;
- RMSD;
- RMSD (Reset 0).

Double averaging:

- STA/LTA;
- EnergeSTA/LTA.

"Mathematical description "The parameter tree structure contains the following sections"

Formulas for calculating program parameter values "Group multi-channel recorder"

Let the container contain N Zet-server channels having the same sampling rate Fadc and the same dimension.

Let us designate the values of the time series of the i-th channel as xij = xi(tj), where tj = dt * j is the j-th time count, i = 1,…, N, dt = 1 / Fadc, j = 1, …, M , dt * M is equal to the averaging time.

Average value of the 1st channel $\bar{x}_i = \frac{1}{M}\cdot\sum_j x_{ij}$

Centered time series of the 1st channel $z_{ij} = x_{ij} - \bar{x}_i$

Average energy of the 1st channel $E_i = \frac{1}{M}\cdot\sum_j (z_{ij})^2$

Total energy of the 1st channel E. _ 7̄ (z)?

Огибающая временного ряда $Env_{ij} = \sqrt{x_{ij}^2+y_{ij}^2}$, где y_{ij} – это аналитическое дополнение временного сигнала x_{ij}, рассчитанное с помощью преобразования Гильберта по временному ряду x_{ij}.

The parameter "Average" parameter

$$P_{dc} = \frac{1}{N}\sum_i \bar{x}_i$$

The parameter "Average (Reset 0)"

Raco=Ras-Ro

Ro is initially equal to 0. Clicking on the "Reset 0" button in the "Parameters" tab of the recorder's parameters settings window sets the value of Ro, so that at the moment of clicking, the value of P is equal to zero.

The parameter "isAlive" This parameter is very different from the other parameters, because its value is formed by analyzing the current statuses of the container channel and analyzing the passage of time through these channels. If the status of all channels is good and the time on all channels is running, then the parameter value is 1, otherwise the value is 0. When working with this parameter, time series of channels are not required, so it is strongly NOT RECOMMENDED to use this parameter when working with other parameters in other containers.

The parameter "Average amplitude"

$$P_{ampl\_aver} = \sqrt{\frac{1}{N}\cdot\sum_i \bar{E}_i}$$

The parameter "Peak amplitude"

The maximum amplitude (peak) is the maximum deviation from the zero point, or from the equilibrium position. The range (peak-peak) is the difference between the amplitudes of the positive and negative peaks. For a sinusoidal oscillation, the amplitude is exactly equal to twice the peak amplitude, since the temporal implementation in this case is symmetrical.

The parameter "Amplituda_average_median"

The parameter "Amplitude_peak_median"

The parameter "MSK-64"

Pmsk64=msk64(Pampl_peak), where msk64(...) is a function for calculating the seismic impact in points, in accordance with the "Methodology for measuring the level of seismic impact. CJSC "ETMS", 2013", developed on the basis of GOST R 53166-2008 "Earthquakes".

This parameter is available only for channels whose unit of measurement is acceleration g; m/s^2.

The parameter "STA/LTA"

Psta_ta=short/long, where

$$short = \sqrt{\frac{3}{N}\cdot\sum_i \tilde{E}_i(j=1, M)}$$

$$long = \sqrt{\frac{3}{N}\cdot\sum_i \tilde{E}_i(j=-(M*DM-1), 0)}$$

DM - double averaging factor, which is set in the drop-down list of the <<Parameters> tab of the recorder settings window.

The parameter "Frequency energy ratio"

P_{ratio_freq} = low / high, где

low = $\sqrt{\frac{3}{N}\sum E}$, the energy is calculated from the signal in the frequency band from 10 to f1,

high = $\sqrt{\frac{3}{N}\sum E}$, = energy is calculated from the signal in the frequency band above f1,

Where: f0=0.0004 * Fadc, but not more than 10 Hz.
f1=0.05 * Fade, but not more than 1 kHz.

The parameter "High frequency envelope"

$$P_{envelope\_high} = \sqrt{\frac{3}{N}\cdot\sum_i\left(\frac{1}{M}\sum_j Env_{ij}\right)}$$

energy is calculated from the signal in the frequency band above f1 = 0.05 * Fadc, but not more than 1 kHz.

This parameter is available only for channels whose unit of measurement is acceleration g; m/s².

The parameter "RMSD" (root-mean-square deviation)

Standard deviation (standard deviation, standard deviation)— the most common indicator of the dispersion of the values of a random variable relative to its mathematical expectation (an analogue of the arithmetic mean with an infinite number of outcomes). Usually means the square root of the variance of a random variable, but sometimes it can mean one or another way of estimating this value.

Functionality:

std = sqrt(sum((x[n] - mean(x))^2, n=0..len-1) / (len-1)

The parameter "RMSD (Reset 0)" (root-mean-square deviation)

Standard deviation (standard deviation, standard deviation)— the most common indicator of the dispersion of the values of a random variable relative to its mathematical expectation (an analogue of the arithmetic mean with an infinite number of outcomes). Usually means the square root of the variance of a random variable, but sometimes it can mean one or another way of estimating this value.

Functionality:

std = sqrt(sum((x[n] - mean(x))^2, n=0..len-1) / (len-1)

The parameter "Energy ratio"

P_{energy_ratio} = curent / previous, где

$$curent = \sqrt{\frac{3}{N}\sum_i E(j=1, M)}$$

$$previous = \sqrt{\frac{3}{N}\cdot\sum_i \bar{E}_i(j=-(M-1),0)}$$

The parameter «Energy STA/LTA»

$P_{energy\_sta\_lta}$ = curent/previous

$$curent = \sqrt{\frac{3}{N}\cdot\sum \tilde{E}_i(j=1,M)}$$

$$previous = \sqrt{\frac{3}{N}\cdot\sum_i \equiv (j=-(M-1),0)}$$

thus this parameter differs from the "STA/LTA" parameter in that the durations i energy sums for numerator and denominator are equal.

Monitoring of objects in the Group multi-channel recorder .....

In the “Monitoring” tab (*Fig. 4*) check the box “Object monitoring”. In the "Object name" field, enter " Tower " and click the "Edit descriptor" button.

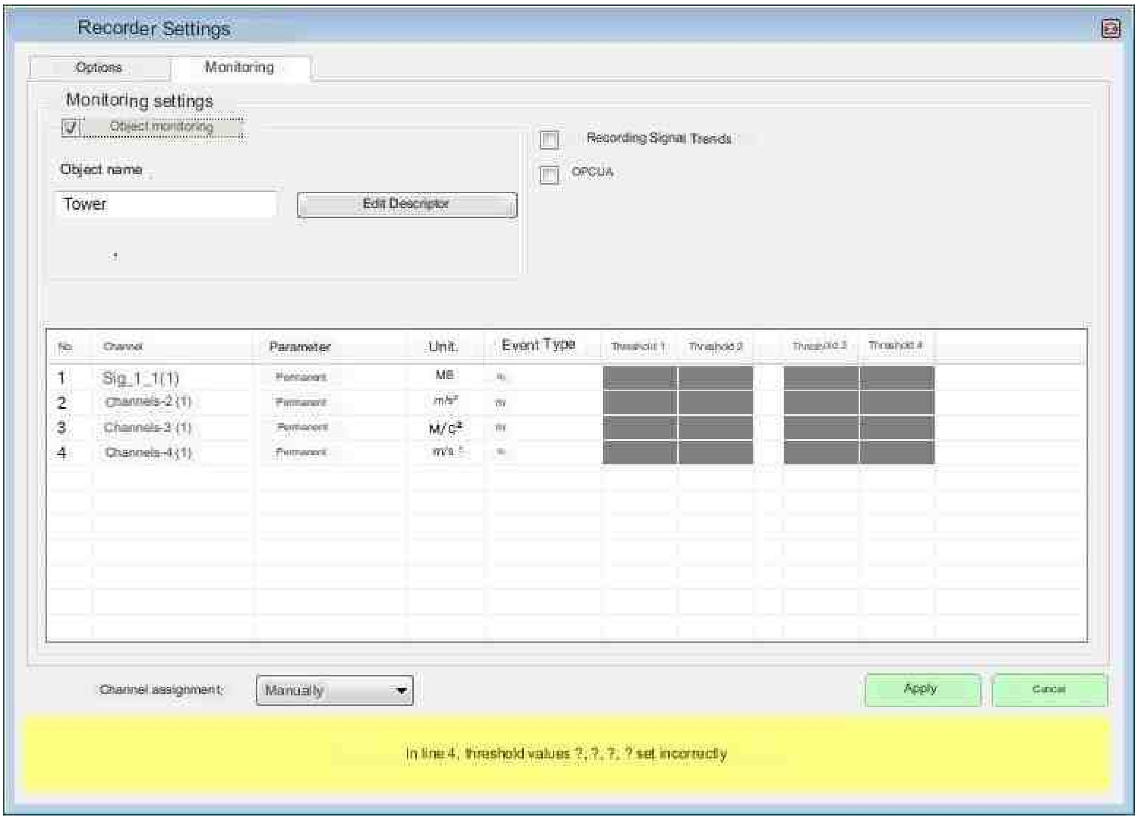


Fig. 4. Settings window of the Group multi-channel recorder program. Monitoring tab

The "Editor of monitoring parameters" window will open (*Fig. 5*). In the window with the offer to create the Tower object,  activate the Yes button.

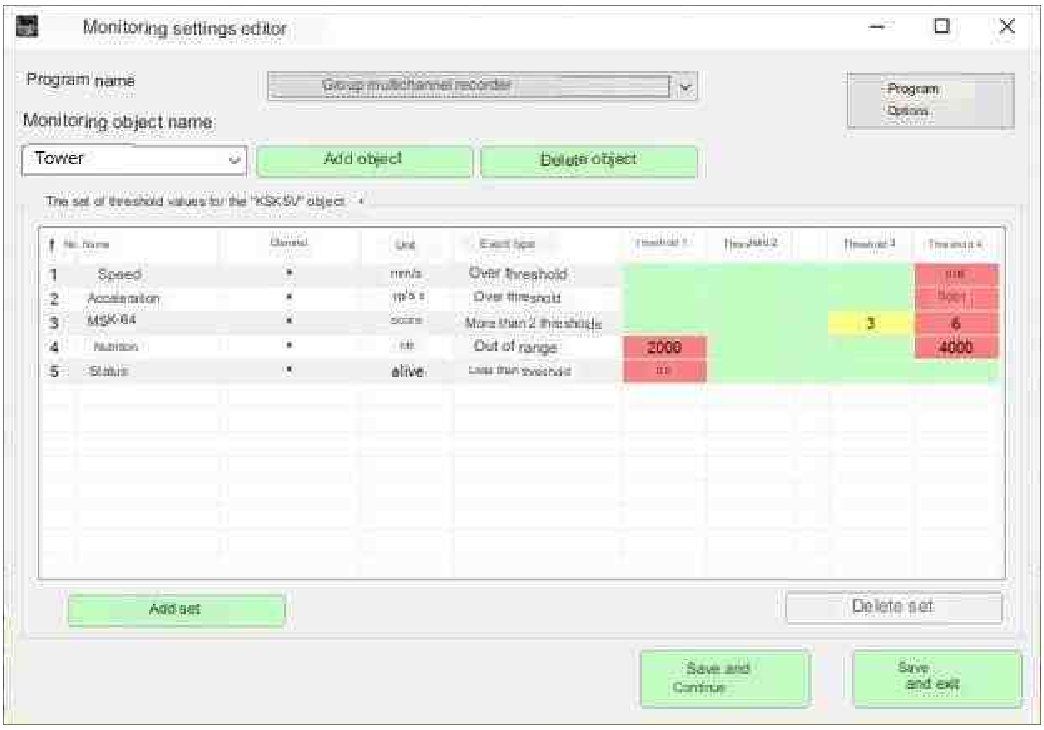


Fig. 5. Window of the monitoring parameters editor.

Next, in the "Monitoring Settings Editor" window, click the "Save and Exit" button.

Go to directory C : \ ZETLab \ config \ , rename swmchan 01.cfg file to swmchan_velocity . cfg .

the program, you need to go to the directory C :\ ZETLab \ config \, rename the file swmchan_velocity . cfg to swmchan 01. cfg , open the program, change the settings and rename it back.

Setting up a Group multi-channel recorder to measure accelerations

Setting up a Group multi-channel recorder for measuring accelerations is performed according to the procedure given in the previous section. At the same time, in the "Measured parameters" panel, select "Acceleration" in the drop-down list, and the monitoring set is created in accordance with the second line of the table (*Fig. 5*).

To create a monitoring set for the “Acceleration” parameter, click the “Add set” button. In the opened window "Edit threshold values" enter the parameter values in accordance with Fig. 6 , then click the "Apply" button.

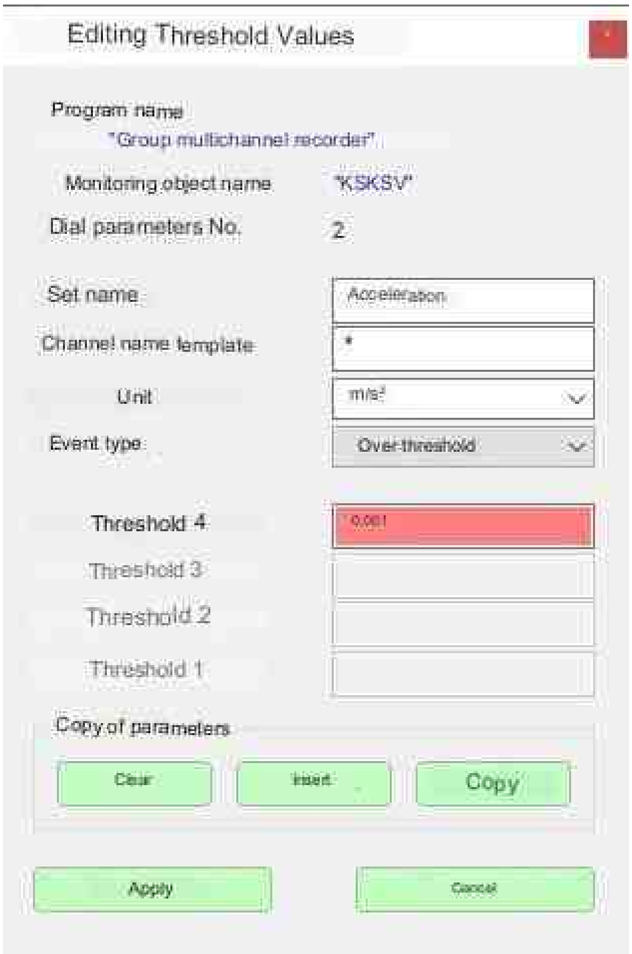


Fig. 6. Window "Editing threshold values" of the "Acceleration" set

When renaming a configuration file, use the file name swmchan _ accel . cfg .

Setting up a Group multi-channel recorder to measure the ball

Setting up a Group multi-channel recorder for measuring the scoring is performed according to the method given in the section above. At the same time, in the "Measured parameters" panel, select " MSK -64" in the drop-down list, and the monitoring set is created in accordance with the third line of the table (Fig. 5).

To create a monitoring set for the " MSK -64" parameter, click the "Add set" button. In the opened window "Edit threshold values" enter the parameter values in accordance with (Fig. 7), then click the "Apply" button.

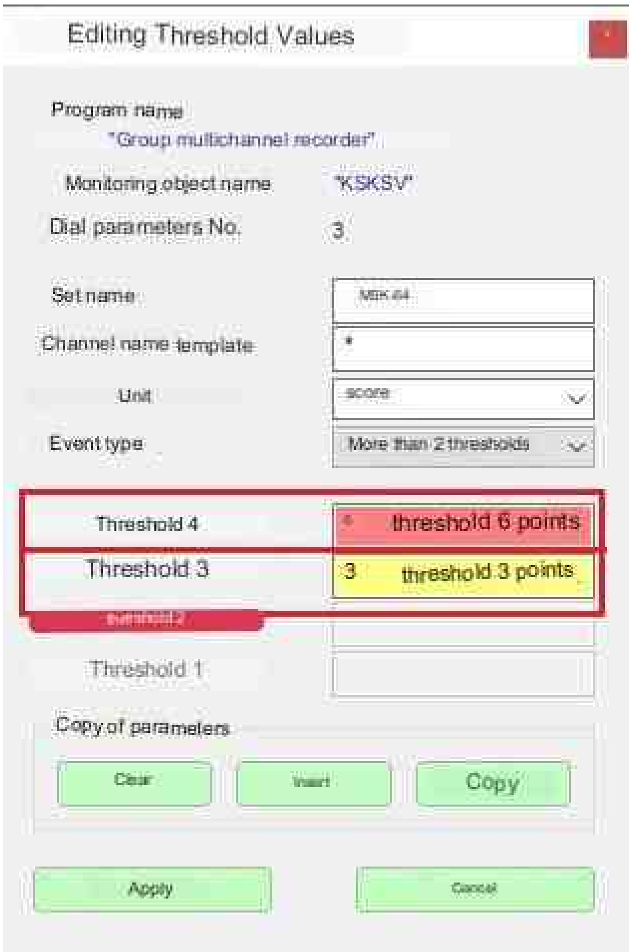


Fig. 7. Window "Editing threshold values" of the " MSK -64" set

When renaming the configuration file, use the file name swmchan_msk 64.cfg.

Setting up a Group multi-channel recorder to measure the power of seismic receivers

Setting up the array recorder to measure the power of seismic receivers is performed according to the procedure given in the section. At the same time, in the "Measured parameters" panel, select "Power" in the drop-down list, and the monitoring set is created in accordance with the fourth line of the table (*Fig. 5*).

To create a monitoring set for the “Power” parameter, click the “Add set” button. In the opened window "Edit threshold values" enter the parameter values in accordance with *Fig. 8* , then click the "Apply" button.

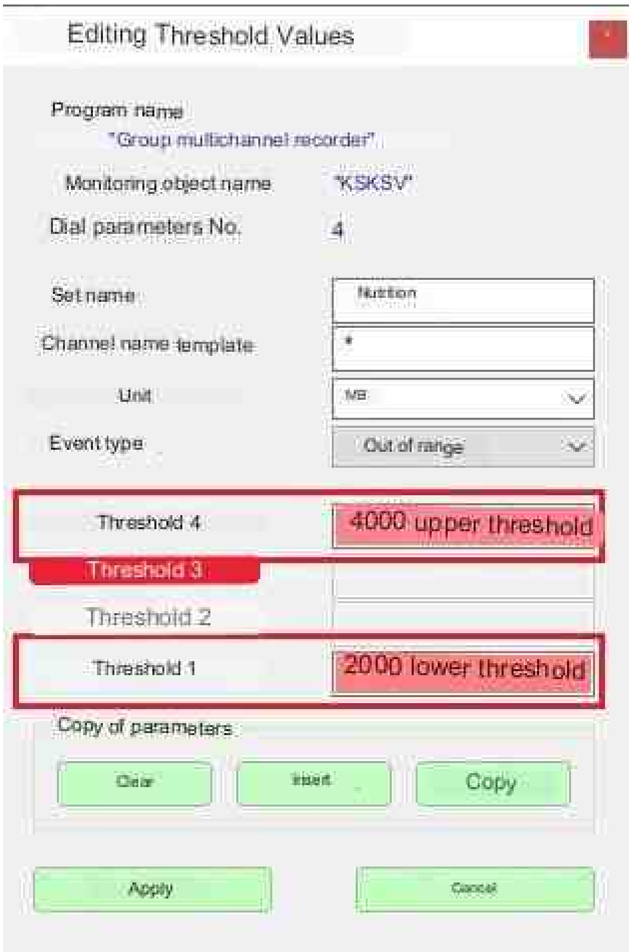


Fig. 8. Window "Editing threshold values" of the "Power supply" set

When renaming the configuration file, use the file name swmchan_power.cfg.

The remaining lines in the table are configured in the same way as described above.

Note: In the table (*Fig. 5)* of the "Monitoring parameters editor" window, sets with different units of measurement are configured to display different types of thresholds. If two or more rows are configured with the same unit of measure, then the thresholds will be applied to the unit of measure above.

Examples for the section .....

Table of contents

Application in practice .....

Application in practice

To demonstrate the operation of monitoring events, consider the operation of a car with an internal combustion engine.

Real monitoring software uses a 20% hysteresis when determining whether an event has ended in order to prevent "bounce" of operation.

So, with the type of events "More than threshold", the event P4 ends at (**TP** < P4m), provided that the event was observed, where P4m = 0.8 * P4. If the same condition is met with the type of events "More than 2 thresholds", the event P4 ends. But the P3 event will end at (TZP < P3m) provided that the event was observed, where P3m = 0.8 * P3. For event types "Less than threshold" and "Less than 2 thresholds", event P1 ends at (P1p < TST) provided that the event was observed, where P1p = 1.2 * P1. In this case, the P2 event ends at (P2p < **TP**) provided that the event was observed, where P2p = 1.2 * P2. Similarly, for event types "Out of interval" and "Out of 2 intervals":

- the event P1 ends at (P1m < **TP**) provided that the event was observed;
- the P2 event ends at (P2m < **TP**) provided that the event was observed;
- the P3 event ends at (**TP** < P3p) provided that the event was observed;
- the P4 event ends at (**TP** < P4p) provided that the event was observed.

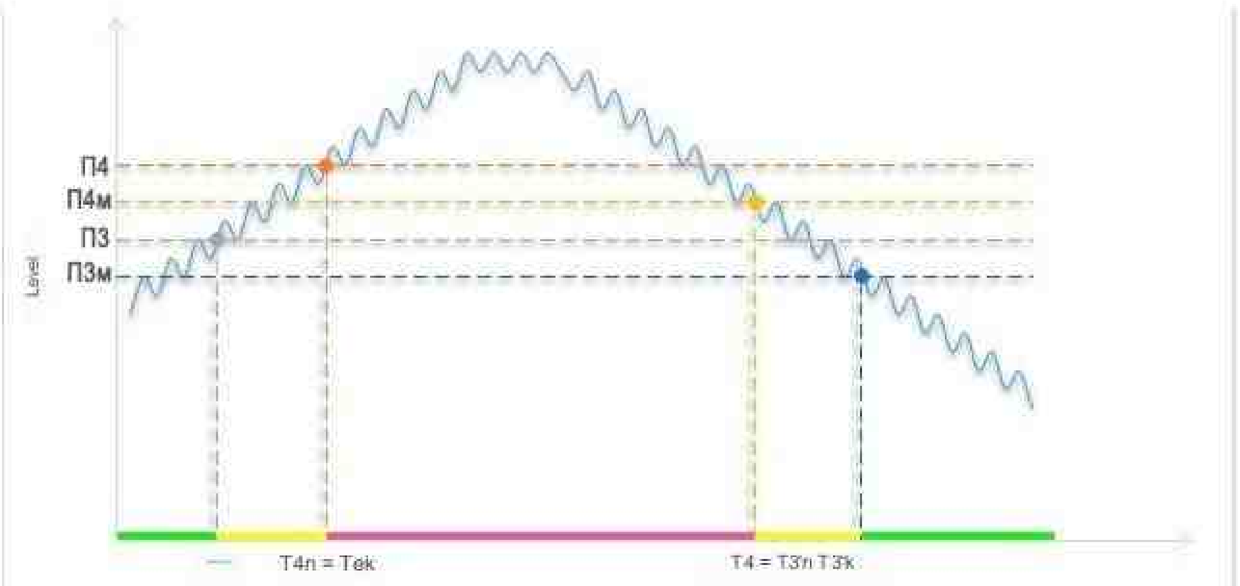
For clarity, the examples in the images show color indication of zones where:

- green zone — no monitoring event;
- yellow zone - an event of the "Warning" type is observed, i.e. P2 or P3;
- red zone - an event of the "Danger" type is observed, i.e. P1 or P4.

Event type "More than threshold"

The "Over Threshold" event type is suitable for monitoring engine temperature. At P4 = 105 °C, the "Danger" event indicates a malfunction in the cooling system and, as a result, the impossibility of continuing the operation of the engine due to the high risk of its failure (jamming).

More than threshold



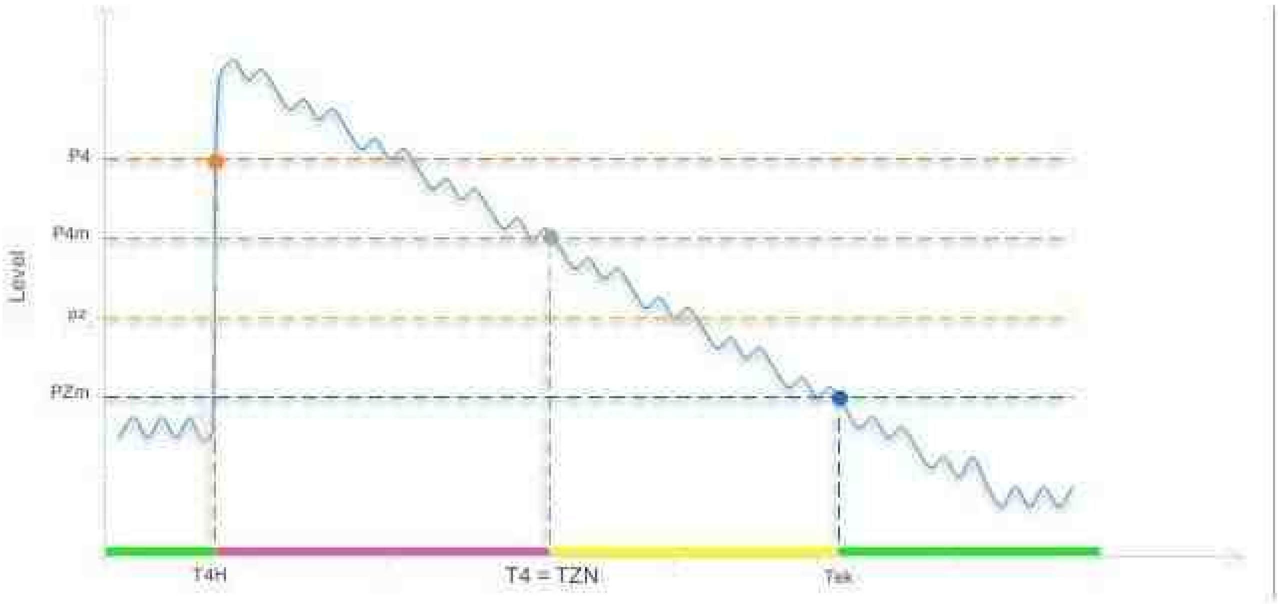
Time

T4n— start time of event P4;
T4k— end time of event P4.

Event type "More than 2 thresholds"

Using the event type "More than 2 thresholds" in this case may additionally issue a preliminary event of the type "Warning". At P3 = 100 °C, this event indicates the beginning of problems.

More than 2 thresholds



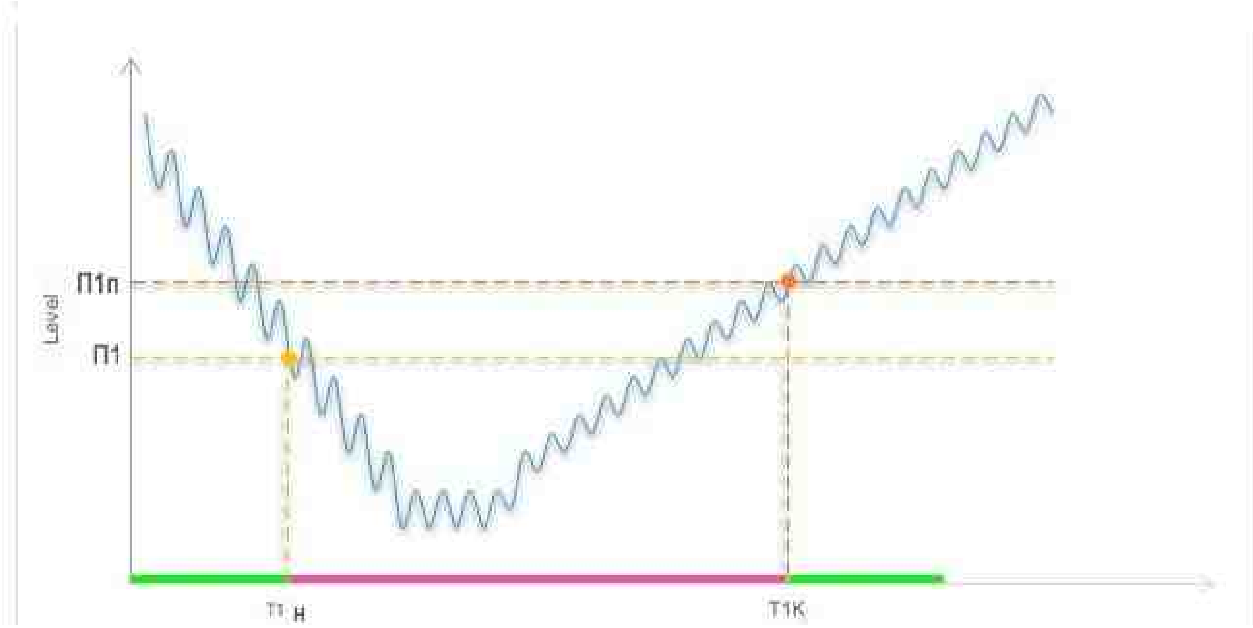
Time

In this case, the P4 event was observed from T4n to T4k, and the P3 event was observed 2 times: from T3n to T3k and from T3n to T3k, while T4n = T3k and T4k = T3n.

Event type "Less than threshold"

The "Less than threshold" event type is suitable for monitoring the amount of fuel in a car's tank. At P1 = 2 liters, the "Danger" event indicates a critical fuel level and, as a result, the impossibility of continuing engine operation due to the high risk of failure of the high-pressure submersible fuel pump.

Less than threshold

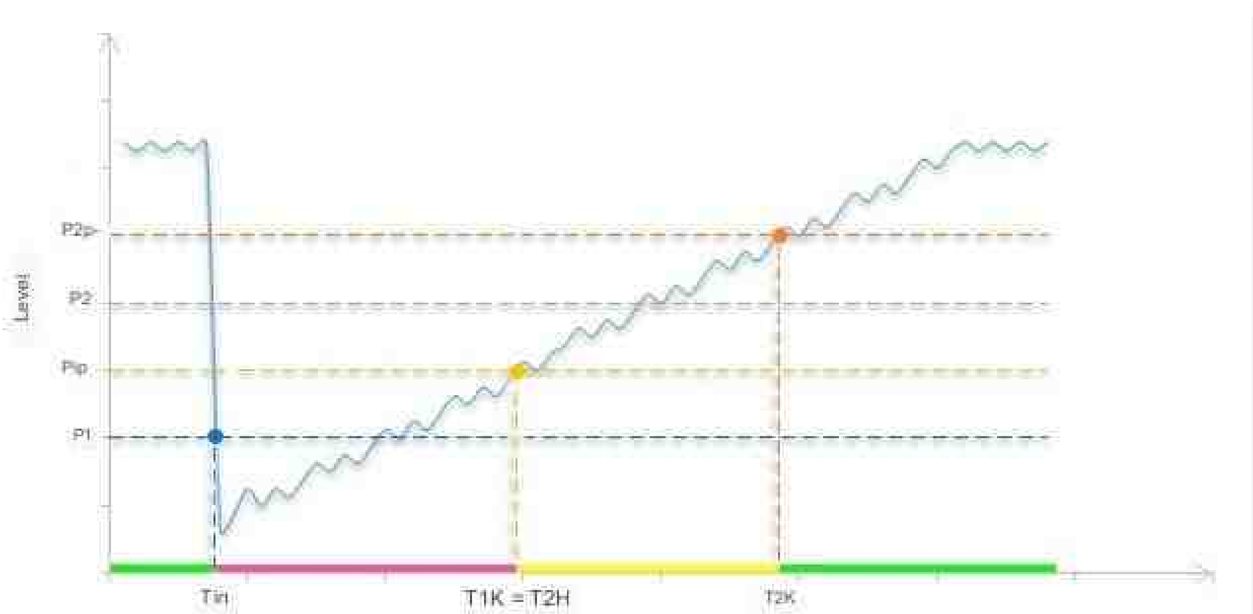


Time

Event type "Less than 2 thresholds"

Using the event type "Less than 2 thresholds" in this case may additionally issue a preliminary event of the type "Warning". With P2 = 5 liters, this event indicates the need for refueling.

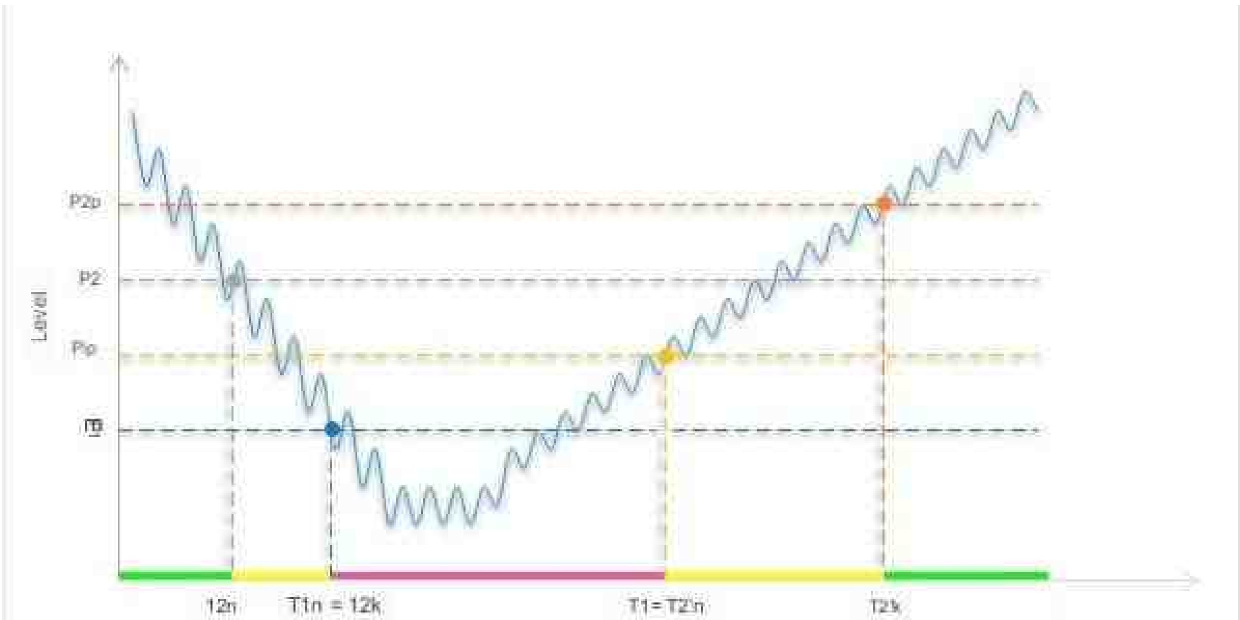
Less than 2 thresholds



Time

In this example, the P1 event was observed from T1n to T1k, and the P2 event was observed from T2n to T2k.
In this case, T1k = T2n.

Less than 2 thresholds



Time

In this example, event P1 was observed from T1n to T1k, and event P2 was observed twice: from T2n to T2k and from T2'n to T2'k.
In this case, T1n = T2k and T1k = T2'n.

The Out of Range event type is suitable for monitoring engine speed. At P1 = 500 rpm, the “Danger” event indicates that there are problems in the engine power supply system and that the engine can stall at any second. At P4 = 7000 rpm, the "Danger" event indicates that the engine is experiencing heavy loads, the long-term impact of which greatly reduces the engine's service life, and engine failure is also possible.

Using the event type "Out of 2 intervals" in this case may additionally generate pre-events of the "Warning" type. At P2 = 700 rpm, the "Warning" event indicates the beginning of problems in the power system. At P3 = 5000 rpm, the "Warning" event indicates the beginning of heavy loads on the engine.

Metrology

Section Metrology ZETLAB auxiliary tools.

Automation

This section describes operation of various programs used for automation purposes (control of switching unit, feedback channel, signal processing: preliminary filtration of the signal, signals processing, etc.).

Controller, PID Controller .....

The ***Regulator*** is used on PC-s, that are connected to ***FFT Spectrum Analyzers***, *strain-gauge* modules or a *seismic recorder* with analog and digital inputs/ outputs.

The program *Regulator* implements the functions of two-position controller and proportional-integral differential controller (*PID*), which are used for control and adjustment of the parameters used in technological and industrial processes at various facilities. The input signal can be applied in the format of *pulse width modulation (PWM)*.

During the *PWM* adjustment, the control signal depends on the difference between the measured value and the set value, on the difference integral, and parameters change dynamics. As a result, the *PID-controller* provides a status of the executive device (which is intermediate between the "*On*" and "*Off*" statuses), under which the measured parameter is equal to the set one. Since the status of the executive device undergoes stabilization, the precision of parameters maintenance increases drastically. Thus, the control law secures the required degree of precision.

The control signal of *PID-controller* is determined by three components: *proportional, integral and differential*. The control signal produced by regulator depends on the misalignment degree (proportional component), misalignment duration (integral component) and the misalignment duration (differential component).

The *Regulator* can maintain the set level or operate in accordance with the set profile. In addition to that, the program also allows to obtain visual representation of the set profile, level, current parameter value, and output signal.

About the program .....

The *Regulator* is used on PC-s, that are connected to *ADC/DAC boards*, *FFT Spectrum Analyzers* with analog and digital inputs/ outputs.

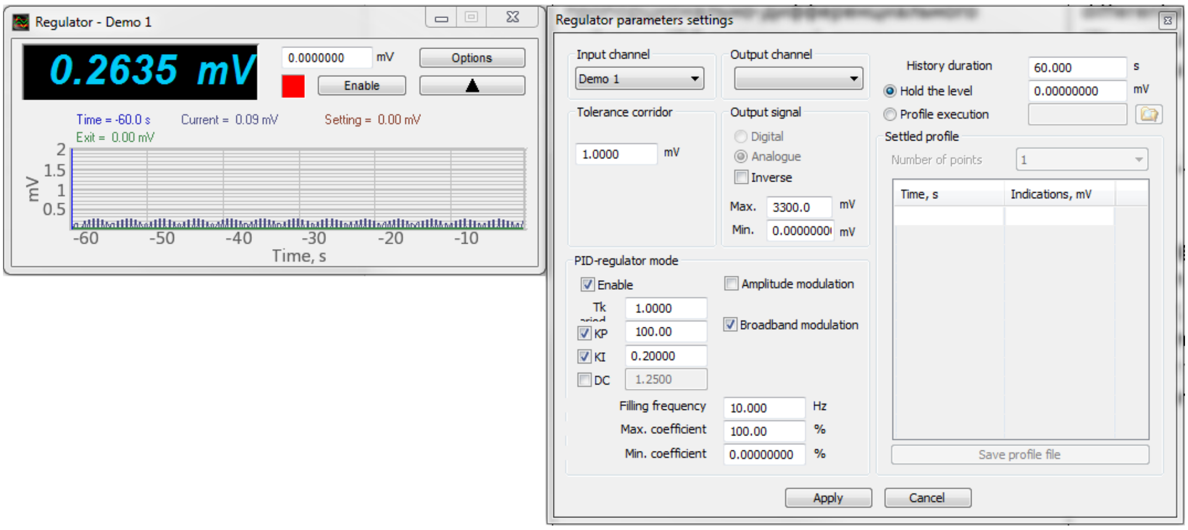
The program *Regulator* implements the functions of two-position controller and proportional-integral differential controller (*PID*), which are used for control and adjustment of the parameters used in technological and industrial processes at various facilities. The input signal can be represented in the format of impulse width modulation (*PWM*).

During *PWM* adjustment, the control signal depends on the difference between the measured value and the set value, on the difference integral, and parameters change dynamics. As a result, the *PID-controller* provides a status of the executive device (which is intermediate between the "*On*" and "*Off*" statuses), under which the measured parameter is equal to the set one. Since the status of the executive device undergoes stabilization, the precision of parameters maintenance increases drastically. Thus, the control law secures the required degree of precision.

The control signal of *PID-controller* is determined by three components: proportional, integral and differential. The control signal produced by regulator depends on the misalignment degree (proportional component), misalignment duration (integral component) and the misalignment duration (differential component).

The regulator can maintain the set level or operate in accordance with the set profile. In addition to that, the program also allows to obtain visual representation of the set profile, level, current parameter value, and output signal.

The program has an integrated control and automation module from the scope *of ZETLAB Studio software*, which allows to simplify development of unique software and hardware suites.



Regulator - program interface

Functions of the program

The industrial processes are characterized by a variety of controlled values: temperature, pressure, flow, concentration, etc., which are also referred to as process parameters. In order to secure operation of the industrial machinery in the required mode, i.e., with the required efficiency, output, product quality, and reliability, it is necessary to ensure stability of the process-related parameters. This task is solved by automated systems used for control and stabilization of the technological processes.

The program *Regulator* is intended for development of automated control systems based on *ADC/ DAC modules* (e.g., *ZET2XX* modules), used for maintenance of the controlled value in accordance with the reference one.

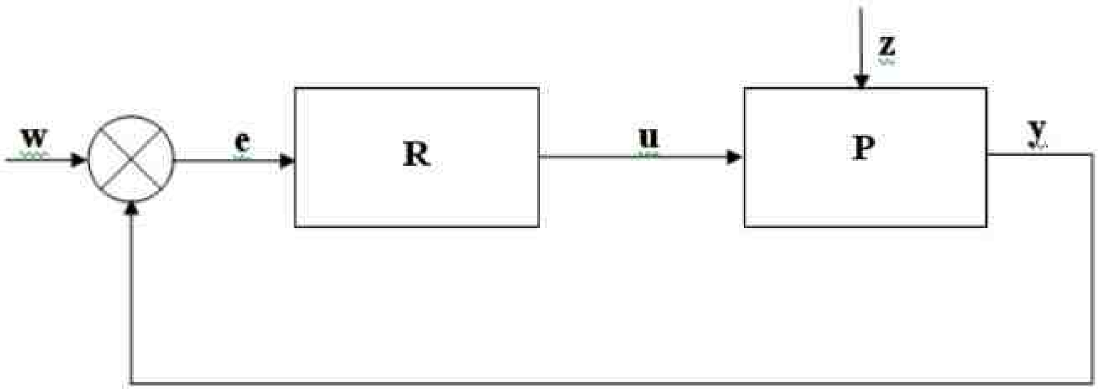
The program *Regulator* implements the functions of two-positional and ***PID-controller*** with feedback.

Two-positional regulator can be described as a regulator with a control unit, which, depending on the signal received from the transducer, can be in one of the two extreme positions: "open" or "close". Hence, the energy or material flow to the controlled object can be whether maximal or minimal. This type of regulator determines constant oscillations of process variable close to the set value. This regulator is quite popular because it is simple to use and it provides good control quality. Depending on the set value *u* and the error limit *u*, in the case if the controlled value is exceeded *u+*, *u* controller is switched off. If the value goes below *u-*, *u* controller is switched on. As a rule, two-positional controllers are used in simple systems (e.g., temperature control systems and parameter level control systems).

In order to secure the required level of control system precision and optimal elimination of interference, it is necessary to consider the transfer characteristic of the process. For this purpose, there are used feedback systems with *PID-controllers*.

PID-controller can be described as a controller with a control element, which, depending on the signal received from the transducer, can be placed in any position between "*open*" and "*close*". The position of the control element is determined by the PID ratio of the controlled process. The PID controller was invented in 1910. In 1942 Ziegler and Nichols developed a tuning method for it. 2/3 of the controllers are represented by single-loop controllers and 1/3 is classified as multi-loop controllers. A simple scheme of automated control with feedback is shown in the Fig. below. The "R" unit is referred to as regulator, P – controlled object, u – control value or set-point, e – error value, y – output variable, w – required value of the output variable, z – external interference impact.

The PID controllers are further classified into: proportional (P-controllers), proportional – differential (PD-controllers), proportional-integral (PI-controllers), and proportional-integral-differential (PID-controllers).



Regulator - general scheme of operation

Depending on the type of the controlled object, it is often enough to use a more simple P-controller, PI-controller, or PD-controller, which can be considered to be a particular case of PID-controller with a task-specific combination of integration and differentiation constants.

In practice, PI-controller is the most widely spread one, since it guarantees zero statical error of tuning, it is also easy to set (there are only two parameters to be set). This controller also provides the possibility of optimization, which allows to implement control functions with the minimum possible error. Besides, it also has low sensitivity to the noise present in the measurement channel

In the case of most critical loops, it is recommended to use a PID-controller, since it enables high-speed performance of the system. It is necessary to bear in mind, that these properties can be only achieved in the case of optimal configuration of the three parameters. The PID-controller should be selected for the systems, which have low noise and delay level.

Supported Hardware .....

The source information of the ***Regulator*** program is represented by digital data of *ZETLAB* server.

The program ***Regulator*** is included into the scope of the following software packages:

- ZETLAB BASE – ADC/DAC board software (option);
- ZETLAB ANALIZ – FFT Spectrum Analyzers software;
- ZETLAB VIBRO – Shaker control systems software;
- ZETLAB TENZO – strain-gauge station software;
- ZETLAB SEISMO – seismic recorder software;
- ZETLAB SENSOR – digital ZETSENSOR sensor software.

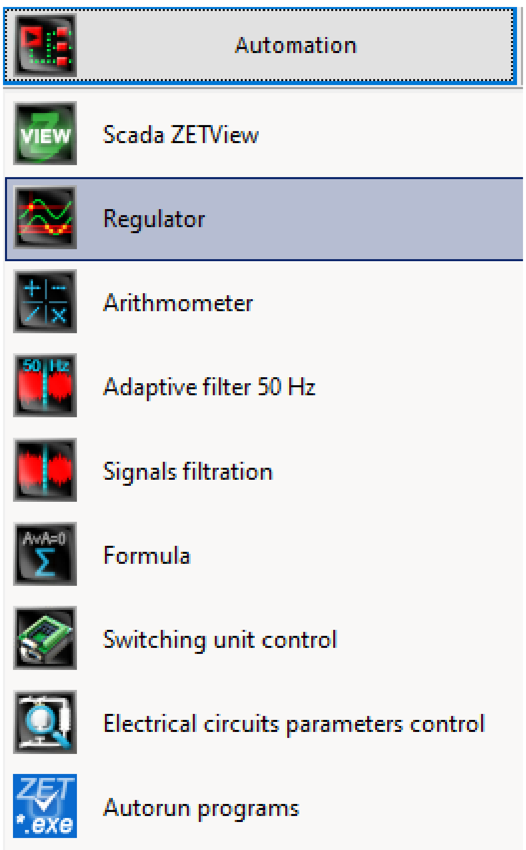
The *Regulator* program is included into **Automation** software section.

Program description .....

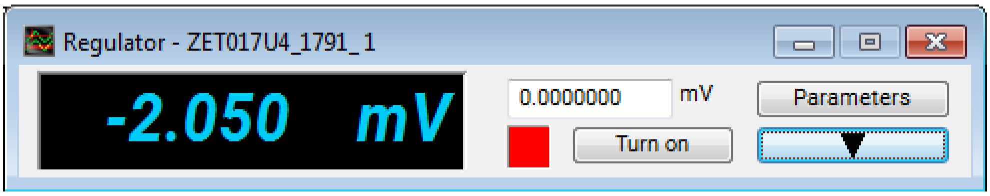
To start the program, enter *Automation* section of *ZETLAB* panel and select the *Regulator* program (see the Fig. below).

You will see the main window of the program. The top section of the program interface depicts the title of the program and the name of the selected channel.

Note: the program can also be started from *ZETLAB* directory (the directory by default: *c:\ZETLab\)*. The name of the file to be selected: Regulator.exe.



Starting the program Regulator



Interface of Reguator program

The left section of the program interface contains graphical indicator displaying the signal level for the selected channel in corresponding measurement units.

The measurement units are to be selected in properties of the channels in *ZET device manager* program.

To the right from the graphical indicator there is a text field, that is used for setting the level to be maintained (the set-point).

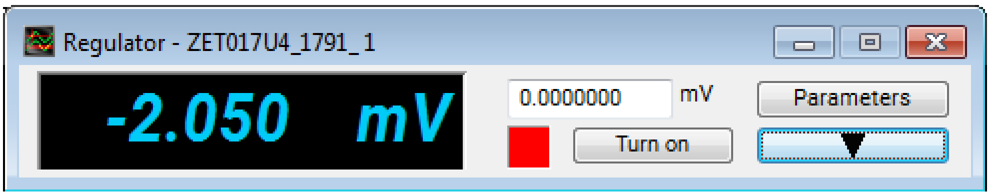
Below the set-point section, there is an indicator of on/off status of the *Regulator* program. Green or alternating green and red indication means, that the program is operating and that the set regulation mode is on. Red indication means that the program is off, or that regulation parameters have not been assigned properly.

The key **Enable** starts the process of the controlled value regulation. Upon activation of the "*Enable*" key, it changes its name for "*Off*". The "*Off*" key allows to disable the regulation process.

The key *Options* allows to start the window used for configuration of the Regulator program parameters.

The key  located under the Options key allows to enable/disable graphical representation of the set and actual profile. Upon activation of the key, the program interface will change – see the Fig. below. The key allowing to enable/ disable graphical representation will change: , hence, now it will be used to disable the graphical representation of the program data.

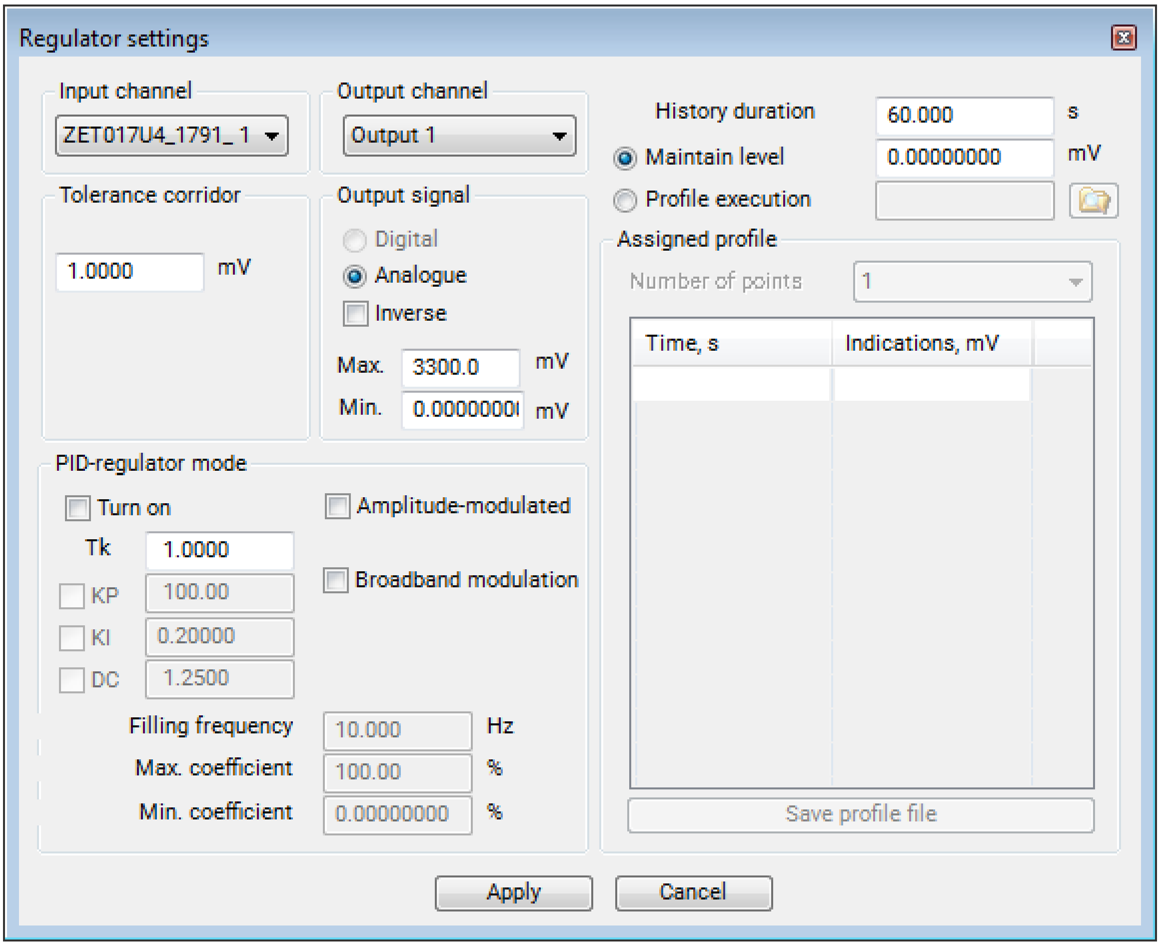
To exit the program, click the key  at the top right section of the program interface.



Regulator program - general view of program interface

Regulator settings .....

Left-click the *"**Parameters**"* key at the right section of "*Regulator*" program window to enter the menu used for configuration of ***Regulator*** parameters (see the Fig. below).



Regulator program settings

The section "*Input channel*" allows to select feedback channel (the measurement channel, at which it is necessary to maintain the set level).

The "*Output channel*" section is used to assign a channel to be used for control of the actuating device.

The control channel can be represented by generator's analog output or a channel of digital port. Control of the actuating device with the use of analog port is conducted by means of DC voltage. It is necessary to set minimal and maximal value of the output level. In order to select analog output (generator output) as a control channel, left-click the "*Analog*" option.

If analog output is selected as the control channel, it will be possible to assign an integrated generator to be further used for control of the actuating mechanism. If the user selects the integrated generator, it is necessary to specify the maximal output voltage value at the output of the generator, or the value of input voltage of the actuating mechanism, which is below the output voltage of the generator. As a rule, in the text field "*Min*" it is necessary to set whether zero value, or a value, that is different from the one specified in the field "*Max*". If the user sets identical or similar values for maximal and minimal threshold voltage, then the actuating mechanism will not operate properly.

The "*Inverse*" option in the "*Output signal*" section is used for inversion of the output signal, i.e., the controlled signal.

The text field "*Tolerance corridor*" allows to set tolerance threshold for two-positional controller to be used for feedback channel measurement data adjustment (i.e., input variable adjustment).

The "*PID-regulator mode*" section also contains configuration and control elements for P-, PI-, PD-, and PID-controllers and PWM (pulse width modulation) control.

The program "*Regulator*" can be switched over to the mode of P-, PI-, PD-, or PID-controller by selecting the "Enable" option in the corresponding section. As this option is disabled, the program will switch over to the mode of two-positional controller. Configuration of program parameters for operation in P-, PI-, PD-, or PID-controller mode is further described in the corresponding sections of this manual.

It is possible to activate the PWM operation mode by selecting the option "*Broadband modulation*" in the parameters menu of Regulator program. Uncheck this option to disable the PWM mode. Configuration of the Regulator program for operation in PWM mode is further described in the corresponding clause.

In the top right section of the program interface, it is possible to set "*History duration*" for displaying graphical data in seconds.

If the option "*Hold the level*" is enabled, it is possible to enter the required set-point value to be maintained by the program. As the set point value is enabled, the option "*Profile execution*" will not be available as well as the key for directory selection, and the elements of the "*Set profile*" program section.

If the option "*Profile execution*" is enabled, the program will operate in accordance with the set profile. Selection of this option activates the key for directory selection, and the control elements in the section "*Set profile*", while the option "*Hold the level*" will not be available.

To run the program *Regulator* in accordance with the set profile, it is necessary to do the following:

1. Enable the check-box "*Hold the level*";

2. Click the key for selection of the file directory – you will see a standard menu for selection of the file. The directory by default is C:\ZetLab\config\. The profile files have **.pfl* extension. As the file is opened, the program will extract the profile data from the file and display them in the "*Set profile*" section;

3. In the case if the profile file has not been previously created, then it is necessary to select the required amount of points to be used for profile configuration using the drop-down list of the "*Set profile*" menu. The minimal possible number of points is 2, the maximal one – 15. As the number of points is selected, the field below the drop-down list will display corresponding number of lines.

4. The left column of the profile is used for setting the time interval in seconds, the right one is used to set the level by input channel (i.e., the set-point) for each particular interval;

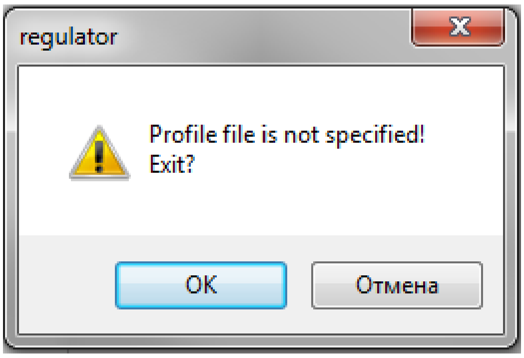
5. As all the levels and intervals are set, click the key "*Save profile file*". You will see a standard dialog window for saving the file. Enter the name of the file and select the corresponding directory. By default, the directory for saving the profile file is as follows: C:\ZetLab\config\. The profile files have *.*pfl* extension;

6. As the profile file is saved, open it using the instructions specified in *Section 2* of the present manual.

To save the set parameters of the *Regulator*, click the *Apply* key. The parameters configuration window will be closed, and the program will display the measured values based on recently set parameters of the *Regulator* program.

If the option "*Profile execution*" is enabled, and the profile file is not selected, then upon activation of the *Apply* key the program will produce a notification message (see the Fig. below). In this case, you should whether specify the profile file or enable the option "*Hold the level*".

To exit the parameters configuration menu without saving the changes, click "*Cancel*" or the corresponding key at the top right section of the program interface.



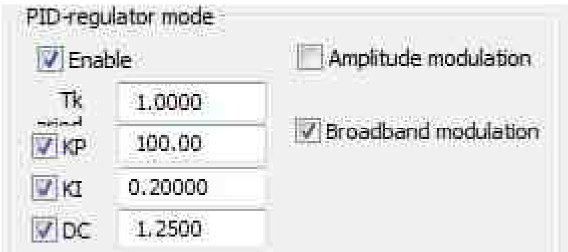
Regulator program - notification message - profile channel is not assigned

Setting of P-, PI-, PD-, and PID-controllers parameters .....

Selection of the controller type and its parameters depends on type and properties of the controlled object. In order to select the controller type and its parameters, it is necessary to be aware of statical and dynamic properties of the controlled object, requirements to the process control quality, and the process control interference type.

Proper configuration of PID-controllers parameters enables high quality of control for most of the industrial processes.

As the "Enable" mode is activated in the section "PID-regulator mode", it becomes possible to set additional parameters. The parameters of PID-controller are located in the corresponding section of the program interface: *TK* – quantization period, *KP* – proportional ratio, *KI* – integral ratio, and *DC* – differential coefficient. The Fig. below shows a section of PID – controller parameters configuration window.



Regulator program - PID controller settings

The text field "Tk" allows to set quantization period. The quantization period is an obligatory parameter for any type of PID-controllers. The period is set in the range from 0,1 up to 1000 seconds. The quantization period is determined by the time of system's response to a stepwise impact.

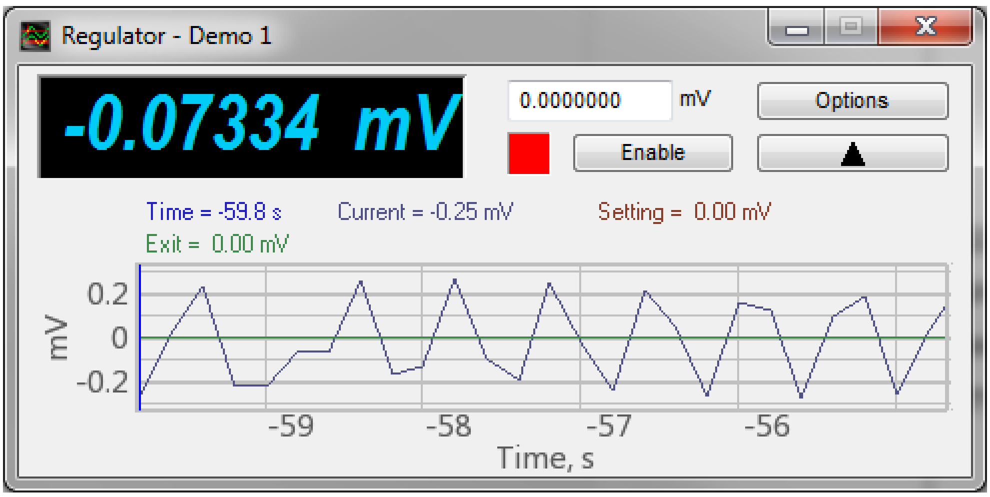
In order to reduce quantization effect impact on the dynamics of the control system, the quantization period is selected based on the following ratio:

$$\frac{T95}{15} < Tk < \frac{T95}{5}$$

Regulator program - formula used for calculation of the PID controller parameters calculation

where: - *T95* is the time required for the output signal to reach 95% of the set value when a stepwise impact is applied to the input of the controlled object.

In the Fig. below, the blue graphic stands for the set-point impact, green graphic – for stepwise impact, and red graphic – for system response. The duration of impulse rise time up to the level of 95% is approximately 10 seconds. The quantization period for this process can be set in the range from 1 up to 2 seconds.



Regulator program - displaying of the setpoint value

In practice, for the inertial processes control the quantization period value varies from 1 second to several minutes. In the case of fast-response processes (e.g., flow rate control), the quantization period value can be set as several tenths of a second. It is not recommended to set higher values of the quantization period, especially for critical processes, since in the case of alarm notification it takes a long time to eliminate the emergency situation. Too low quantization frequency may also lead to increased noise interference.

Enable the "KP" option to activate the field used for setting the proportionality factor.

The proportionality factor is calculated based on the following correlations:

For P-controller: KP=Tg/Tu*Ks

For PI-controller: KP=0,8(Tg/Tu*Ks)

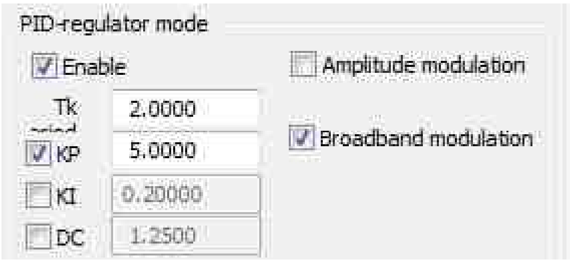
For PID-controller: KP=1,2(Tg/Tu*Ks)

where: Tg – alignment time, Tu – delay time, Ks – transmission ratio of the controlled object.

The higher is the value of proportionality factor, the higher is the frequency change dynamics.

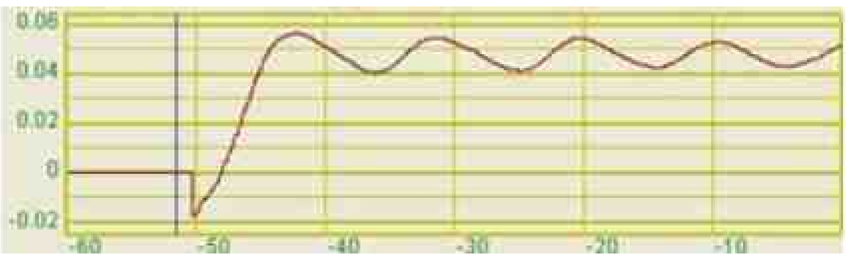
If only the "KP" option is active ("KI" and "DC" options are unchecked) as it is shown in the Fig. below, then the program *Regulator* will operate in the *P-controller* mode.

Prior to configuration of the proportionality ratio "KP", it is necessary to disable "KI" and "DC" options.



Regulator program - PID-controller settings

In the Fig. below, the proportionality factor is too high. Thus, in this mode, there occur undamped oscillations.



Regulator program - presence of undamped oscillations in the signal

The following Fig. shows a process with optimal proportionality factor.

Regulator program - optimal proportionality ratio

The next Fig. displays a process, where the set proportionality factor is too low.

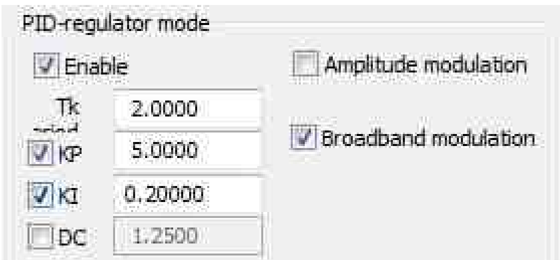
Regulator program - low proportionality factor

Activation of the "KI" option unlocks the field used for setting the integral coefficient.

The integral coefficient can be described as a time interval used for averaging of the actual value deviation from the set one. This coefficient also determines the speed of system response. Selection of the integral component is conducted in order to minimize the misalignment between the set-point value and the actual value.

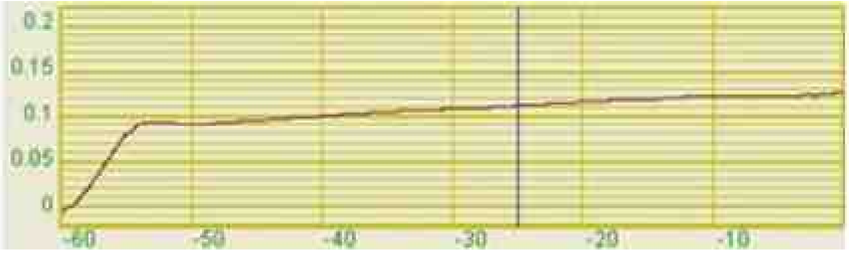
In the case of Ziegler-Nichols algorithm, the integral coefficient is "0,2".

Upon activation of the "KP" and "KI" options (as it is shown in the below Fig.), the program Regulator will operate in PI-controller mode.



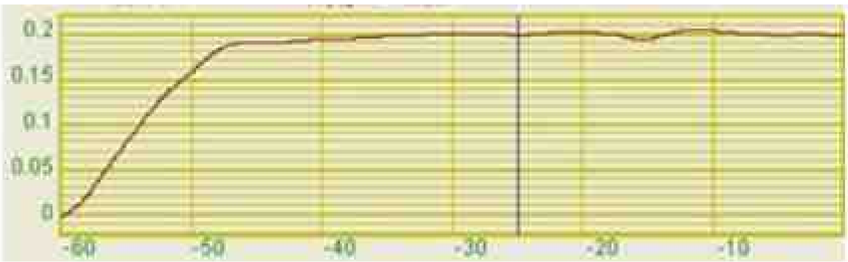
Regulator program - operation in the PI-controller mode

The next Fig. displays a process with low integral coefficient: the signal does not reach the required level.



Regulator program - low integral ratio - the signal does not reach the required level

The following Fig. shows a process with optimal integration ratio.



Regulator program - optimal integral factor

The below Fig. displays a process where the set integral coefficient is too high – there occurs the self-oscillations process.

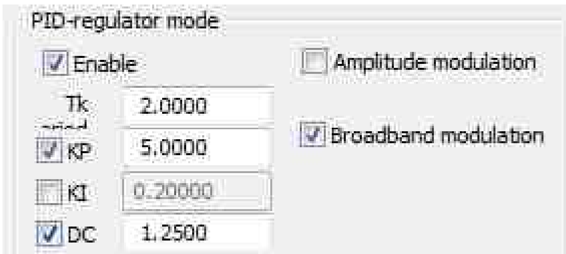
Regulator program - the integral ratio is too high - the signal reaches the self-oscillations mode

Activation of the "DC" option unlocks the field used for setting the differential coefficient.

Configuration of differential component.

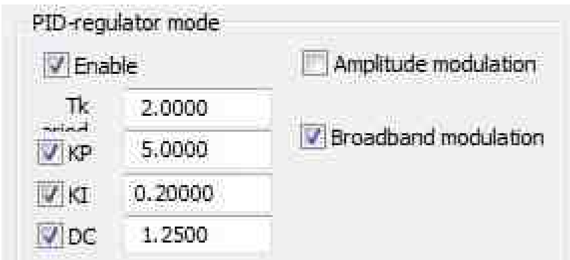
This process is obligatory for establishing a fully-functional PID-controller.

If the options "KP" (proportionality factor) and "DC" (differentiation constant) are both enabled as it is shown in the Fig. below, then the *Regulator* program will operate in *PD-controller* mode.



Regulator program - operation in the PD-controller mode

In the case, if all the options are selected (proportionality ratio "KP", integration ratio "KI" and differential component "DC"), the program Regulator will operate in the mode of fully-functional PID-controller.

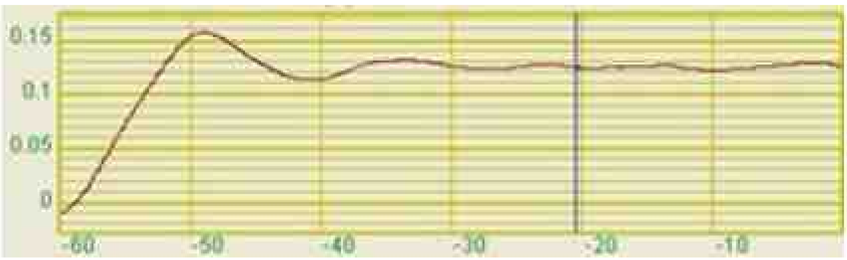


Regulator program - configuration for operation in the mode of fully-functional controller mode

Differential transfer coefficient can be described as a relation of the measured output value to the speed of the input value change.

In accordance with Ziegler-Nichols algorithm, the differential ratio is "1,25".

The Fig. below shows a process with a low differential ratio.

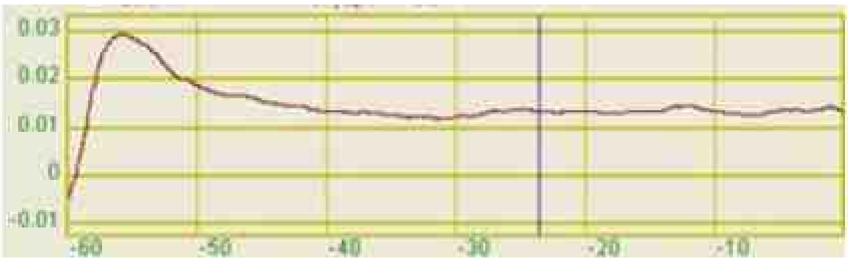


Regulator program - the differential ratio is too low

The next Fig. displays a process with optimal differential ratio.

Regulator program - process with optimal differential ratio

The below Fig. shows a process with a high differential ratio.



Regulator program - process with too high differential ratio

Setting of PWM parameters .....

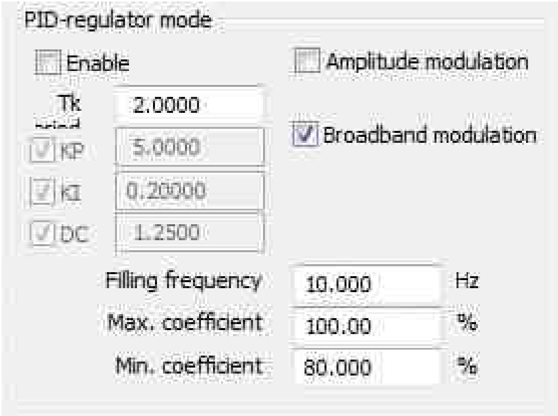
Pulse-width modulation (PWM) is the alignment of the target signal (multi-level or constant) with the actual binary signal (with two levels – on/off) aimed at equalization of their average value for a particular time interval.

PWM is a impulse signal with constant frequency and alternating Q-factor. By setting the Q-factor value, it is possible to adjust the average voltage level at the output of the generator.

It is possible to use various circuits, solid-status relays, or IGBT-keys as actuating devices. The actuating devices can be whether in fully-opened or fully-closed condition. For smooth operation of these instruments, there is used the PWM method. The program sets the carrier frequency of the modulation in Hz, min. and max., and the Q-factor in %. A standard example of PWM is shown in the Fig. below.

Regulator program - Standard example of PWM application

Upon activation of the PWM option of the *Regulator* program, additional parameters of the PWM mode will become available for configuration. PWM parameters are located in the PWM modulation section of the program interface. PWM parameters are as follows: *filling frequency, max.* and *min. coefficient*, and possibility of *three-channel PWM mode* activation. The Fig. below shows a section of parameters configuration window with PWM options.



Regulator program - PWM parameters

In the text field "*Filling frequency*" the user can set the PWM carrier frequency in Hz.

The text fields "*Max. coefficient*" and "*Min. coefficient*" are used to assign top and bottom limits of the duty cycle. The duty cycle ratio determines the relation of impulse repetition cycle to the duration of the impulses.

In the case if the three-phased PWM option is enabled, the program activates the mode of 3-phase PWM.

If for the control of the actuating mechanism the user selects the digital port in the section Output signal, enables PWM option and disables the 3-phase PWM option, then it would be possible to select any of the 14 channels of the digital port in the Output signal section.

If for the control of the actuating mechanism the user selects the digital port in the section Output signal, enables PWM option and the 3-phase PWM option, then, as the control channels by default the program will select channels 12, 13, and 14 of the digital port. Channel 12 of the digital port will be used as the first control channel of the actuating mechanism (channels 13 and 14 will be used as the 2-nd and the 3-d respectively). Hence, in the section Digital input-output it is necessary to select channels # 12, 13, and 14.

Note! 3-channel PWM option operates only in the case if the digital port is used for the control of the actuating mechanism.

Arithmometer .....

The program "***Arithmometer***" is intended for the performance of arithmetic operations on instant values of the signals, which are applied to the input channels of *ADC modules* and *FFT Spectrum Analyzers*. The indicator displays current value of the selected arithmetic operation. Upon activation of the program, the system creates additional virtual channel (the values of this channel can be used in all programs from the scope of *ZETLAB Software* package).

About the program .....

The program "***Arithmometer***" is intended for the performance of arithmetic operations on the instant values of signals, which are applied to the input channels of *ADC modules* and *FFT Spectrum Analyzers*.
As the program is started, the system creates a new virtual channel, values of which can be used in all programs from the scope of *ZETLAB software* package.

List of available arithmetic operations:

·*addition;*

·*subtraction;*

·*multiplication;*

·*division;*

·*max. value;*

·*min. value;*

· *arithmetic mean;*

·*geometric mean;*

·*modulus;*

·*multiplication by constant;*

·*adding a constant.*

Integrated software control and automation module from the scope of *ZETLab-Studio* software package enables simple deployment of software measurement suites.

It is also possible to create band-rejection and comb filters with the use of the programs "***Signals filtration***" and "***Arithmometer***".

Supported Hardware .....

The source information of the "***Arithmometer***" program is represented by the digital data of *ZETLAB* server channels.

The program "***Arithmometer***" is included into the scope of the following software packages:

- ZETLAB BASE – ADC/DAC board software;
- ZETLAB ANALIZ – FFT Spectrum Analyzers software;
- ZETLAB VIBRO – Shaker control systems software;
- ZETLAB TENZO – strain-gauge station software;
- ZETLAB SEISMO – seismic station software;
- ZETLAB NOISE – vibration meter-noise meter software;
- ZETLAB SENSOR – digital ZETSENSOR sensor software.

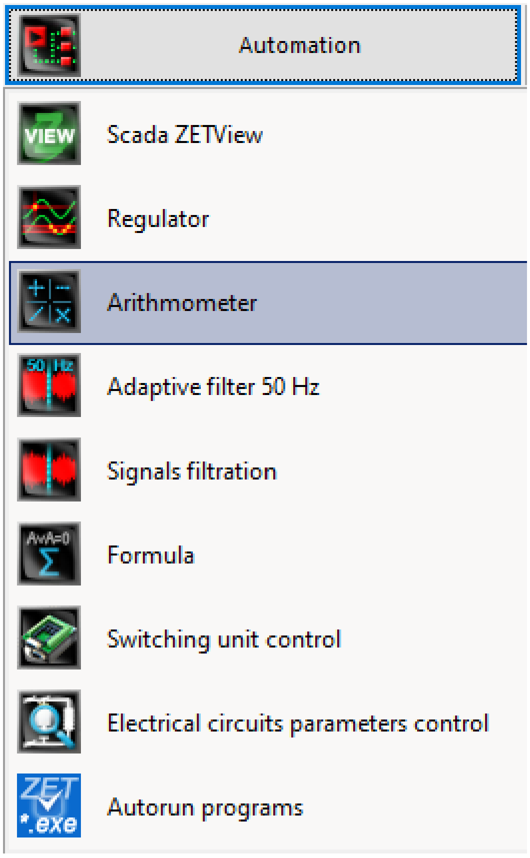
The program "***Arithmometer***" is located in the "***Automation***" software section.

Program description .....

The program "***Arithmometer***" can be started from "***Automation***" section of *ZETLab software* panel (see the Fig. below). You will see the main window of the "***Arithmometer***" program. The title of the program displays the name of the program.

Note: the program can also be started from ZETLAB directory (the directory by default:

\ZETLab\). The name of the file to be started: ArithmoMeter.exe.



Starting the program Arithmometer

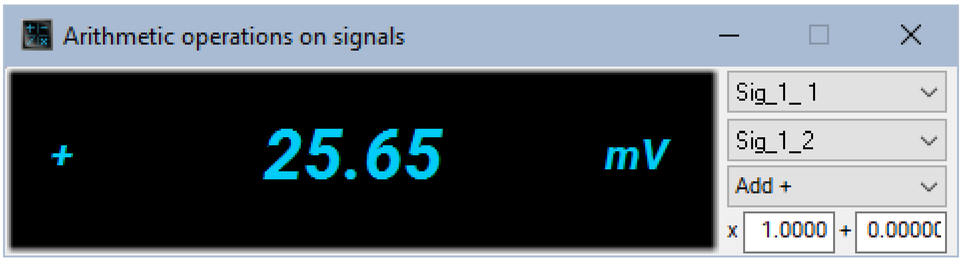
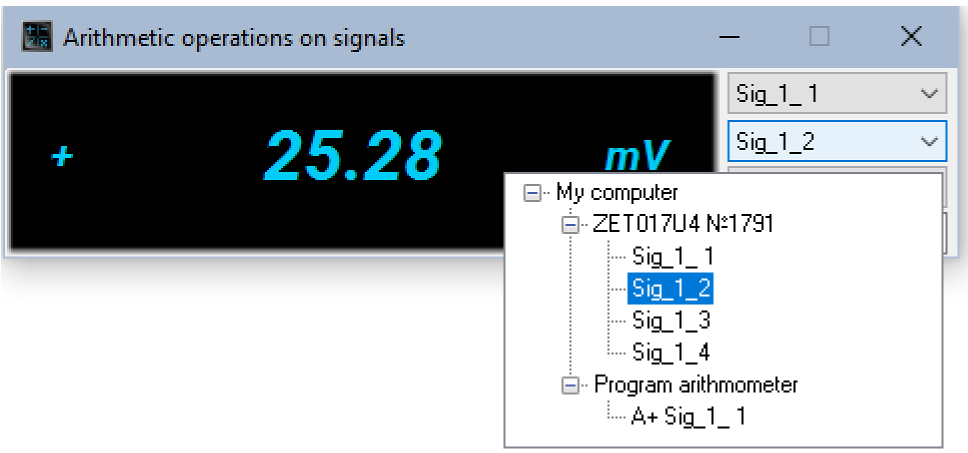


Fig. 2 The sum of the values of the two signals

Fig. 3 Values of constant signals intended for summation

The left section of the program interface contains a graphical indicator displaying the result of the arithmetic operation with the signals of the selected channels. The result of the arithmetic operation is displayed in corresponding measurement units of the first channel selected in the program. The measuring units are set in the program "*ZET device manager*".

In order to calculate and display the result of arithmetic operation with the two signals (of physical or virtual channels), select the names of the channels in the corresponding sections of the program interface.



The list of channels is available to the right from the graphical indicator. The top list is used for selection of the first channel to be used for the arithmetic operation (the bottom list is used for selection of the second channel respectively). There are several ways of selecting a channel from the list:

- click the channel selection area and use the mouse to select the channel;
- left-click the section and use the scroll wheel or keys <> and <↓> to select the channel.

The section in the right part of the program interface allows to select a particular arithmetic operation to be used.

Below the section used for selection of arithmetic operation, there are two additional sections used for setting the constant values. The section x 1.0000 allows to set the constant value to be used for multiplication result, while the next section + 0.00000 is used for setting the addition constant.

The sequence of operations in the program "***Arithmometer***" is as follows:

1. operation with two signals;
2. multiplication by constant;
3. adding a constant.

To exit the program, use the key X at the top right section of the program interface.

Questions and answers:

Topic. Summing up the channels of ZETLAB software.

Question: I have recorded the data from current probes by 6 channels with the use of *ZET 017-U8*. Upon implementation of signals processing, I need to obtain the total value for all the 6 channels. However, the program "*Arithmometer*" allows to conduct arithmetic operations only with two channels. Could you please provide me with a solution for this task?

Answer: you can use several "***Arithmometer***" programs or the "***Formula***" program available in the "***Automation***" section.

50 Hz Adaptive Filter .....

One of the main factors, which negatively affect the precision of low-frequency signals parameters measurements is the effect of electromagnetic interference of natural and man-made origin on the channels of the measuring instruments. The main interference in laboratory, industrial and natural environments is the 50 Hz interference.

Supported Hardware .....

The source information of the "***Adaptive filter 50 Hz***" program is represented by digital data of ZETLAB server channels.

The program "***Adaptive filter 50 Hz***" is included into the scope of the following software packages:

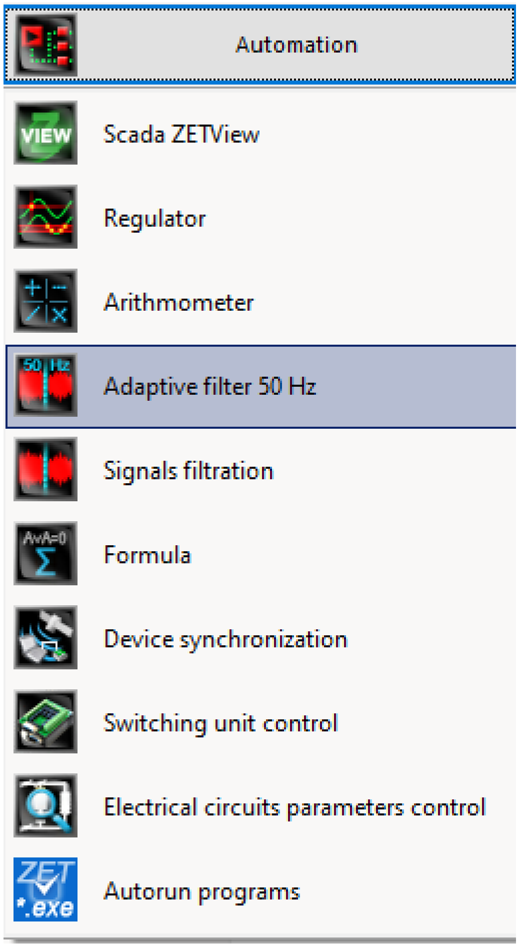
- ZETLAB BASE – ADC/DAC module software (option).
- ZETLAB ANALIZ – FFT Spectrum Analyzers software;
- ZETLAB VIBRO – Shaker controllers software;
- ZETLAB TENZO – Strain-gauge station software;
- ZETLAB SEISMO – Seismic station software;
- ZETLAB NOISE - vibration meter-noise meter software;
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software.

The program "***Adaptive filter 50 Hz***" is located in the ***Automation*** software section.

Program description .....

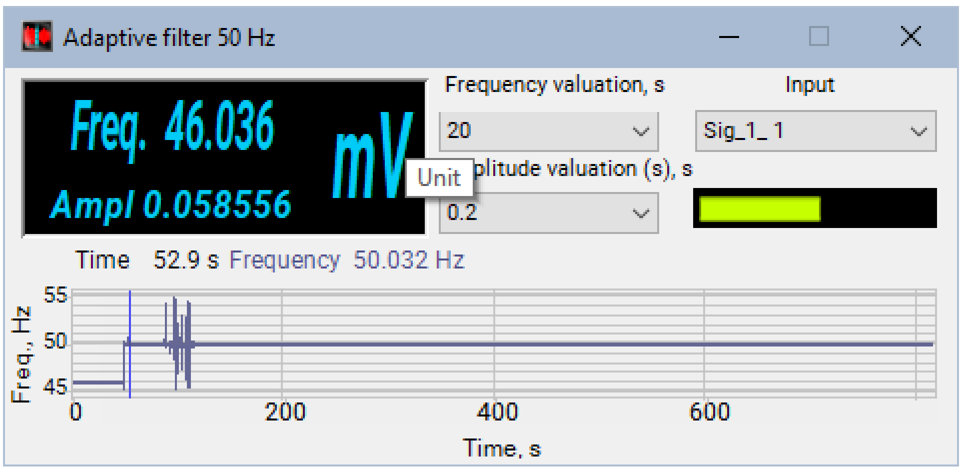
In order to start the program "***Adaptive filter 50 Hz***", activate it in the "***Automation***" section of ZETLAB panel. Then you will see the main interface of the program.

Note: the program can also be started from ZETLAB directory (the directory by default: c:\ZETLab\). The name of the file to be started: filtr50.exe.



Starting the program Adaptive filter 50 Hz

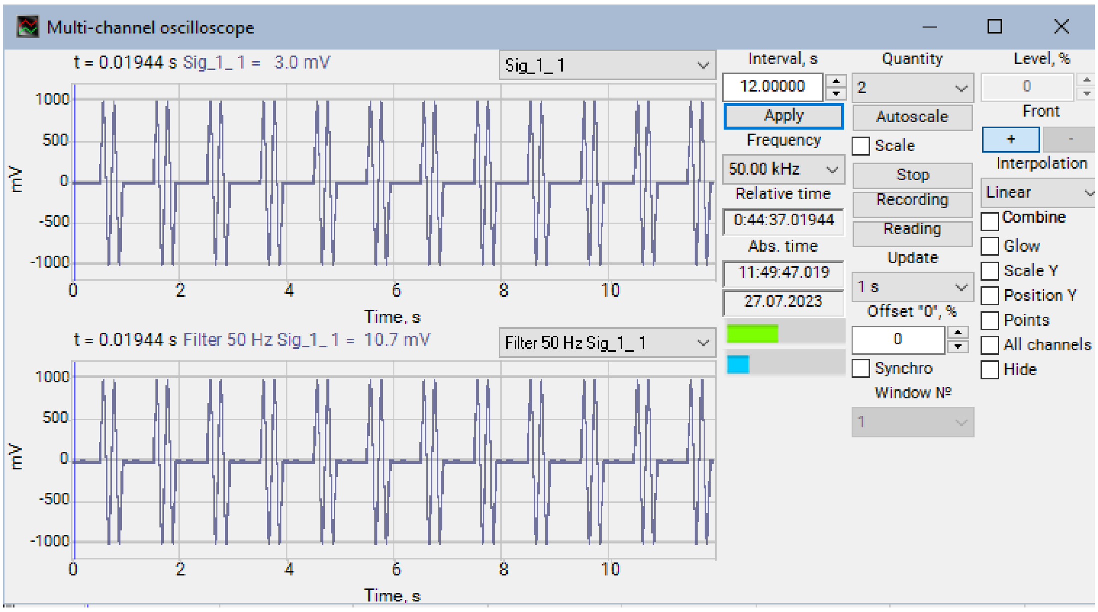
As the program is started, there appears a window displaying the following parameters: precise value of the 50 Hz interference, interference amplitude in the measuring units, graphic of interference dynamics in time domain (sec.). The program parameters include: interval of frequency calculation and interval of frequency interference calculation. It is also necessary to assign the number of the measurement channel to be used for displaying of channel's integral level. The program creates additional virtual channel, in which the 50 Hz interference and corresponding harmonics are eliminated.



Adaptive filter 50 Hz - main interface of the program

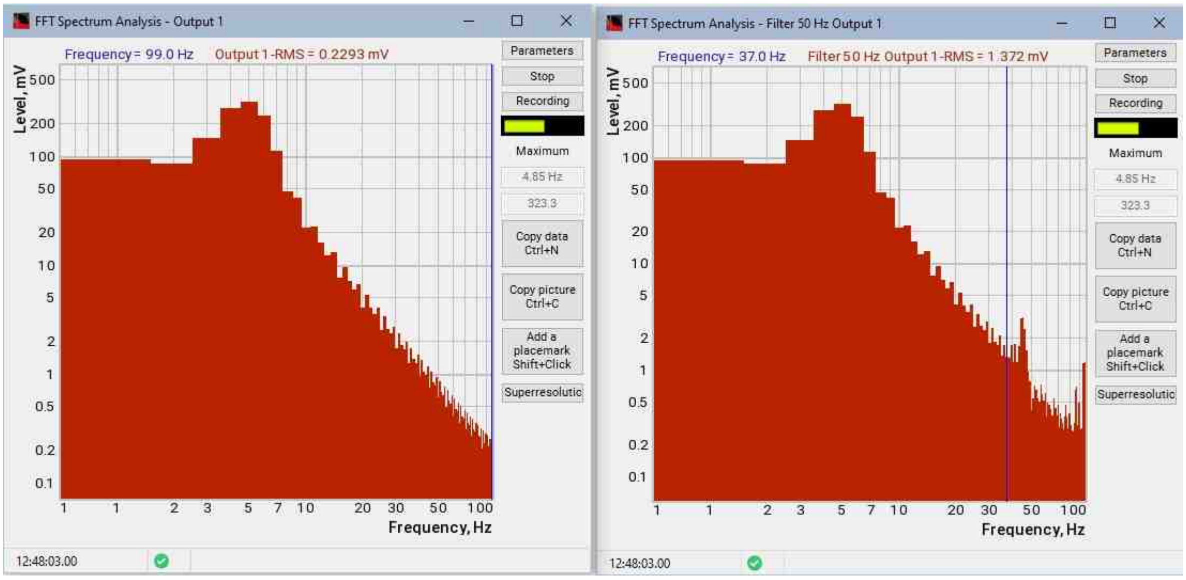
Operation of the program can be shown graphically with the use of the program "*Multi-channel oscilloscope*" available in the *Display* section of *ZETLAB* panel. The top section of the *Multi-channel oscilloscope* program displays a signal with 50 Hz interference, and the bottom section displays a signal, where the interference has been cleared.

Adaptive filter 50 Hz - Signals generator



Example of the Adaptive filter 50 Hz implementation

Another considerable advantage of the "***Adaptive filter 50 Hz***" program is the fact, that the program filters both the 50 Hz interference and the corresponding harmonics. This feature is based on implementation of Walsh transform, which allows to suppress the harmonics and does not distort the useful part of the signal.



Example of Adaptive filter implementation in the program FFT Spectrum Analysis

Upon activation of the program "***Adaptive filter 50 Hz***" **there appears a virtual channel (in addition to the channels, which are already present in the system). Thus, if you need to implement filtration for 8 channels, you need to use 8 copies of the "*Adaptive filter 50 Hz*"** program. In this case, the program will produce 8 additional virtual channels for 8 physical channels. Operation of the virtual channels is similar to that of usual channels: these channels allow to view signal form, spectra, correlational functions, etc.

The program also has an integrated control and automation module from the scope of *ZETLAB STUDIO* software package, which contributes to easy deployment of task-specific software measurement suites.

Signals filtration .....

The *Signals filtration* program is intended for filtering of the signals applied to the input channels of ***FFT Spectrum analyzers***, ***Strain-gauge station modules*** and ***Seismic recorders*** for further processing with the use of *ZETLAB software* programs. The program can also be used for processing of virtual channels (e.g., channels, created in such programs as ***Vibration meter***, ***Strain gauge***, etc.). The *Signals filtration* program can be used both for processing of the signals in real-time mode and for ***Play recorded signals*** of the recorded signals.

In the course of various tests, measurements, diagnostic procedures and speech recognition process, which are affected by strong interference, it is often necessary to evaluate a particular parameter of the signal (e.g., its level, frequency, correlation ratio with another signal). If the useful signal and interference signal have a common frequency domain, then it is necessary to use signals filtration method.

About the program .....

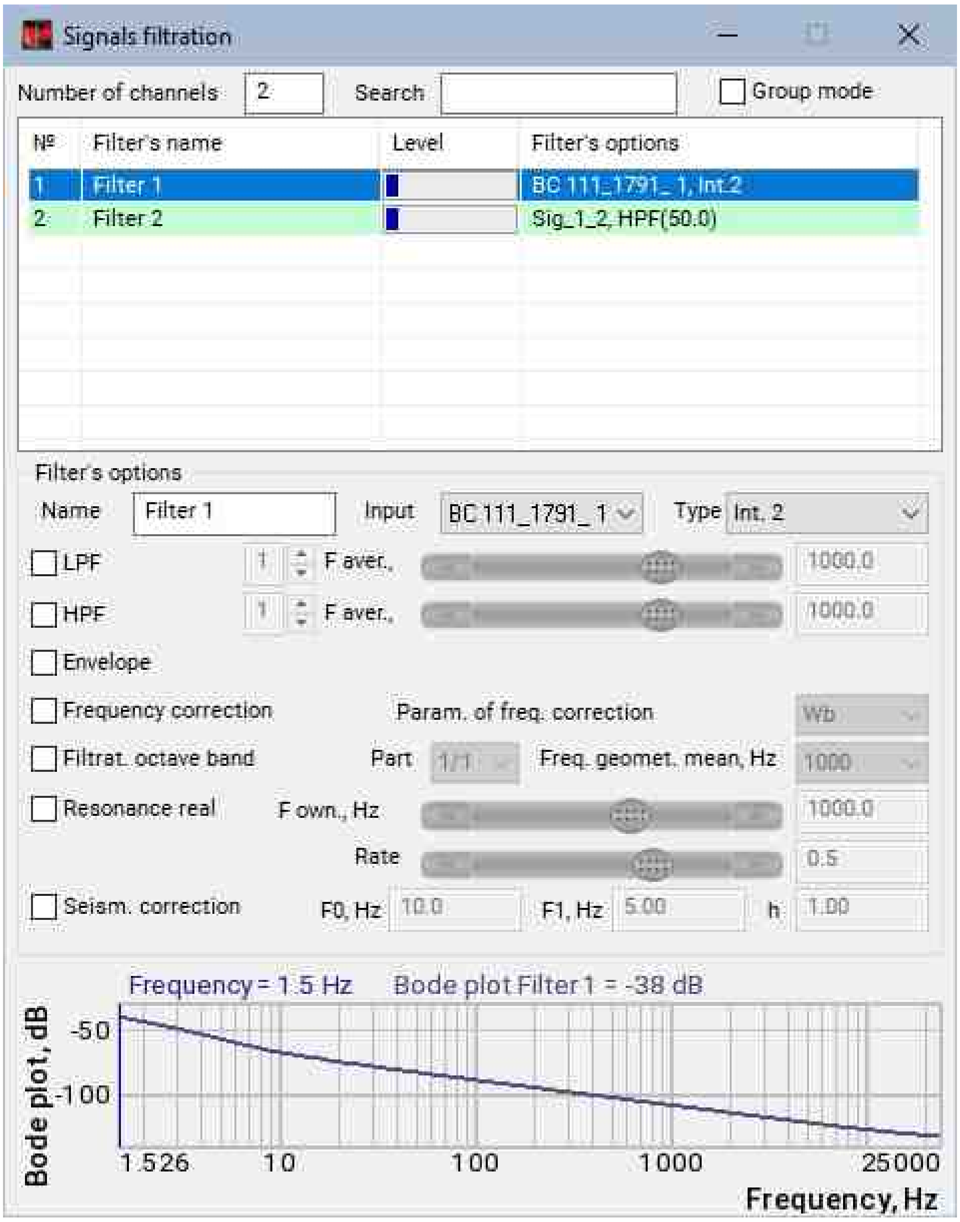
The program *Signals filtration* is used for filtration of the signals, applied to the input channels of *FFT Spectrum Analyzers, strain-gauge modules*, and *seismic recorders* for the purpose of further processing with the programs from *ZETLAB* software suite. The program *Signals filtration* can also be used for processing of virtual channels, which have been created in such programs as *Vibration meter*, *Strain-gauge module*, etc. The *Signals filtration* program can be used both for processing of the signals in real-time mode and for Play recorded signals of the previously recorded signals.

In the course of various tests, measurements, diagnostic procedures and speech recognition process, which are affected by strong interference, it is often necessary to evaluate a particular parameter of the signal (e.g., its level, frequency, correlation ratio with another signal). If the useful signal and interference signal have a common frequency domain, then it is necessary to use signals filtration method.

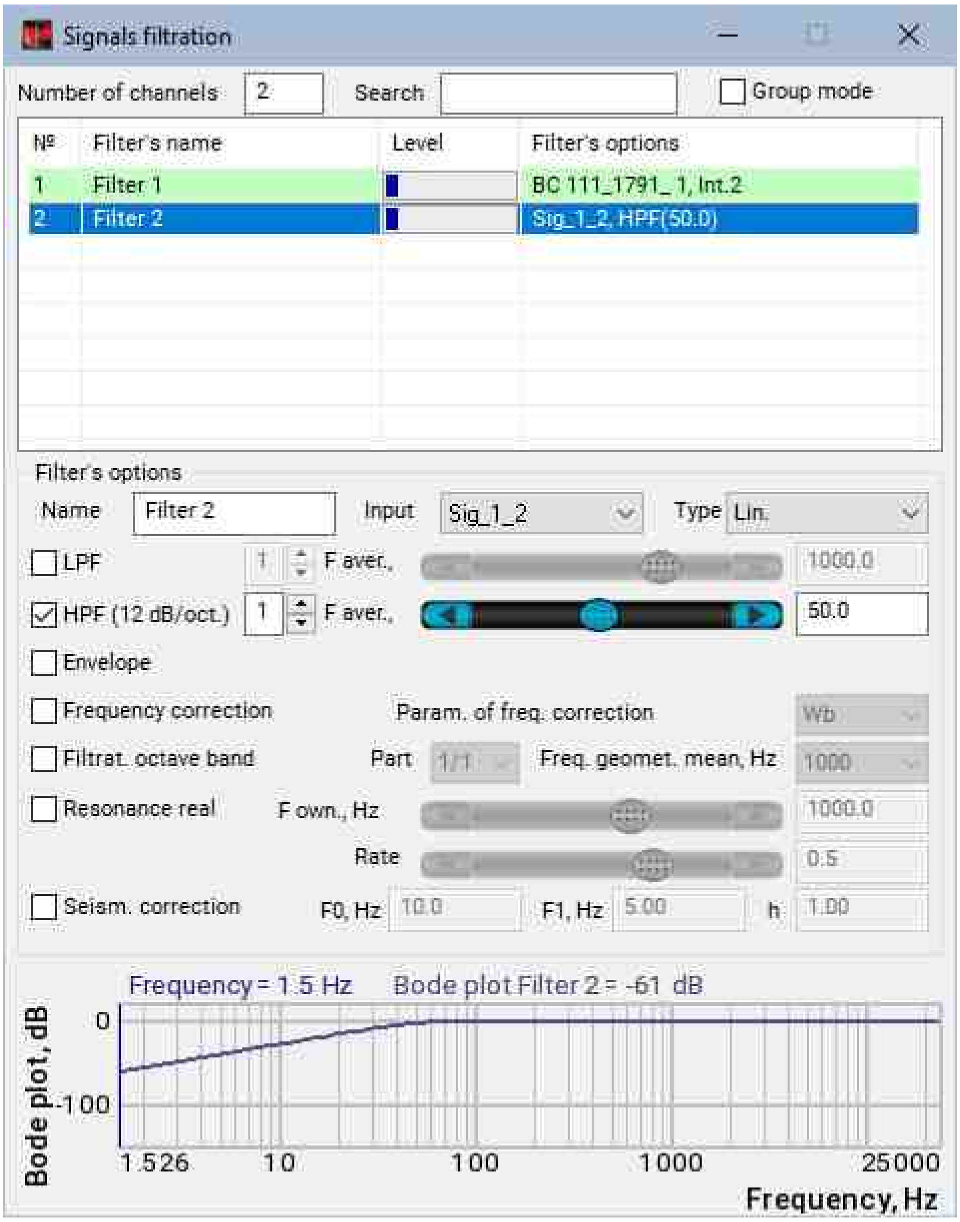
Below you can see a flow graphic of signal filtration process. It is possible to enable/ disable any element of the process. The filters can be connected to each other sequentially.

Signals filtration program – flow graphic of program operation

The Fig.s below show interface of the Signals filtration program ("*Int.2*" function – double integration of the signal and "*HPF*"-high-pass filter).

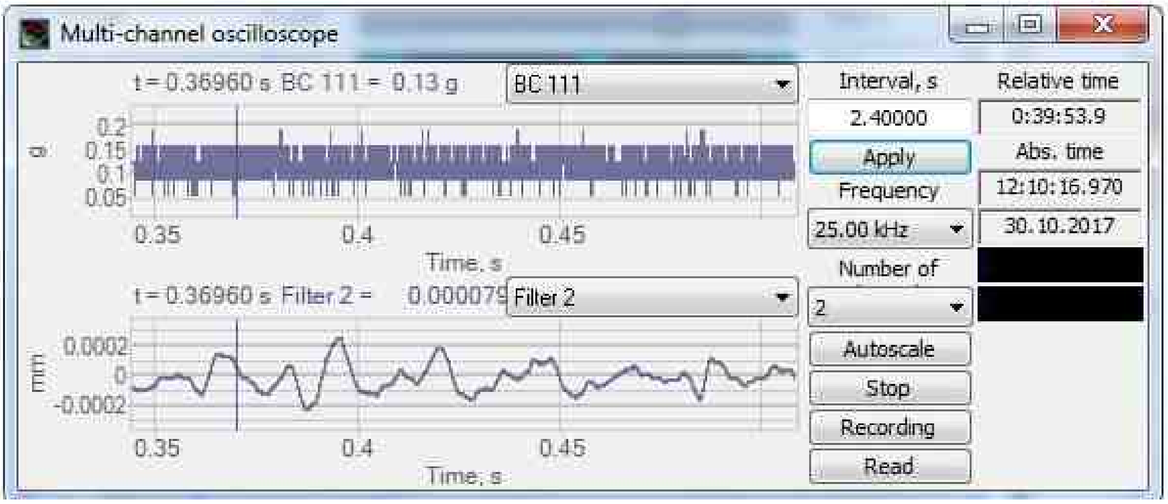


Signals filtration - double integration function



Signals filtration - HPF filter

The below Fig. displays the interface of the ***Multi-channel oscilloscope*** program. The upper graphic shows time realization of the source signal, the below graphic displays the result of double integration and HPF functions implementation. In this example, we were processing the signal from accelerometer mounted on a stable surface. The double integration is used in order to obtain displacement signal from acceleration signal, while the HPF is used to compensate for the DC component of the signal.



Signals filtration program - source and processed signal

The program creates additional virtual channels used for processing of the signals. All the signals (both real and virtual) have inner synchronization function, which allows to conduct their parallel processing (e.g., with the use of *Cross-Correlation analysis* program). The source signals used for the filtration remain unchanged. All the programs from the scope of ZETLAB software suite allow to conduct parallel processing of the real signals and to implement filtration of virtual channels.

The program *Signals filtration* has the following additional options:

·*Selection of channels number to used for filtration*

·*Filter type selection (integral and differential filter of 1-st and 2-nd order)*

·*Selection of HPF and LPF filters*

·*Frequency correction function selection*

·*Signal envelope function*

The ***Signals filtration*** program is part of:

- *ZETLAB ANALIZ (supplied with spectrum analyzers ZET 017-U8, ZET 017-U2, A19-U2, A 23 and VK-01);*
- *ZETLAB TENZO (supplied with ZET017-T8 strain stations),*
- *ZETLAB SEISMO (supplied with ZET048-E, ZET048-I, ZET048-C seismic stations),*
- *ZETLAB NOISE (supplied with a ZET 110 vibration meter).*

Selection of channels number to be used for filtration

The program allows to conduct parallel filtration of several different channels (including the virtual channels).

Selection of filter type

Differentiation and integration of signals is widely used for vibration and acoustic research purposes. Most of the transducers used for vibration research purposes are represented by piezo-electric accelerometers, which means that the transducers produce a signal, which is proportional to the acceleration value. Many controlled vibrational parameters of mechanisms are set as vibration velocity levels. E.g., for balancing of rotary mechanisms, it is necessary to know the vibration velocity value at the point of vibration transducer mounting. In order to obtain vibration velocity value from the vibrational acceleration value, it is necessary to implement integration of the signal. If it is required to obtain the Displacement value, it is necessary to conduct double integration of the signal. Thus, the signal of the linear displacement transducer can be used for obtaining vibrational displacement and acceleration signals.

Integrating filters allow to use the *FFT Spectrum analyzer* as the vibration meter of the first precision class.

Differentiation of the signal is also useful for vibroacoustic monitoring of various systems. One of the key monitoring parameters is the process trend, i.e. the long-term dynamics of the control signal in time domain (e.g., integral vibration level or band-pass noise level). In order to track dynamics of the signal, one can use differentiation of the signal (the derivative value obtained is further used for the control of signal level).

In the case, if the input signal is represented by Acceleration signal (i.e., the measurement unit is "*g*" or "m/s^2"), then, after integration, the measurement value of the output channel will be represented by vibration velocity – "*m/s*". After double integration, the value of output channel will be represented by Displacement value – "*m*". The reference values for calculations in "*dB*" also undergo changes. If the reference value "*dB*" of the input channel is assigned in accordance with ISO requirements, then the reference channels of the output channels used for integration and double integration should also be selected in compliance with ISO requirements. Otherwise, upon completion of the integration, the measured value of the output channel will be accompanied by symbol "**s*", and with "$*s^2$" – in the case of double integration. The reference values in "*dB*" will not be changed. The linear filter does not make any changes.

Setting top and bottom frequencies.

HPF and LPF filters can be used for each channel of the *Signals filtration* program. These filters are implemented as Butterworth filters of 2-nd, 4-th, 6-th, 8-th or 10-th order with unlimited impulse characteristics. The sequence of filters application depends on the ratio of cutoff frequency to the sampling frequency of the channel used for filtration. The higher is the ratio, the higher is the order of the filter. The cutoff frequency of the filter is set in Hz at the minimal level of -3 dB.

Frequency correction

The *Signals filtration program* has several frequency correction filters:

·A, C, Z – "Sound",

·G – "Infrasonic sound",

·Wd, Wk Wb, Wc, We, Wj, Wm, Fk (Lin 0,4–100 Hz), Fm (lin 0,8–100 Hz) – general vibration,

·Wh, Fh (lin 6,3 – 1286 Hz) – local vibration.

The Correction filters A, B, C, D are used for measurements of the airborne noise level. These filters allow to use *FFT spectrum analyzer ZET 017-U2, ZET 017-U8* and *A19-U2* as first-class precision noise meters.

Signal envelope

The *Signals filtration* program can be used for calculation of the signal's envelope. The signal envelope is calculated as a smoothed RMS value of the signal. The envelope function parameter is represented by smoothing time, which is set in *ms*. For vibration – and noise-meters there are two standard averaging periods: "*Fast*" (125 ms) and "*Slow*" (1000 ms).

Additional information

Frequency weighing: corrective filters Wb, Wc, Wd, We, Wf, Wh,Wj, Wk, Wm, Fh, Fk, Fm, A, B, C, D

The program has an integrated control and automation module from the scope of *ZETLAB Studio* software, which enables simple deployment of individual software measurement suites.

It is also possible to obtain AFR and PFR characteristic of filters with the use of the program "*AFR and PFR measurement*".

With the use of the *Arithmometer* program it is also possible to implement band-rejection filters.

Supported hardware .....

The source information of the ***Signals filtration*** program is represented by digital data of *ZETLAB* server channels.

The ***Signals filtration*** program is included into the scope of the following software packages:

- ZETLAB ANALIZ – FFT Spectrum software;
- ZETLAB VIBRO – Shaker controllers systems software;
- ZETLAB TENZO – strain-gauge station software;
- ZETLAB SEISMO - seismic station software.

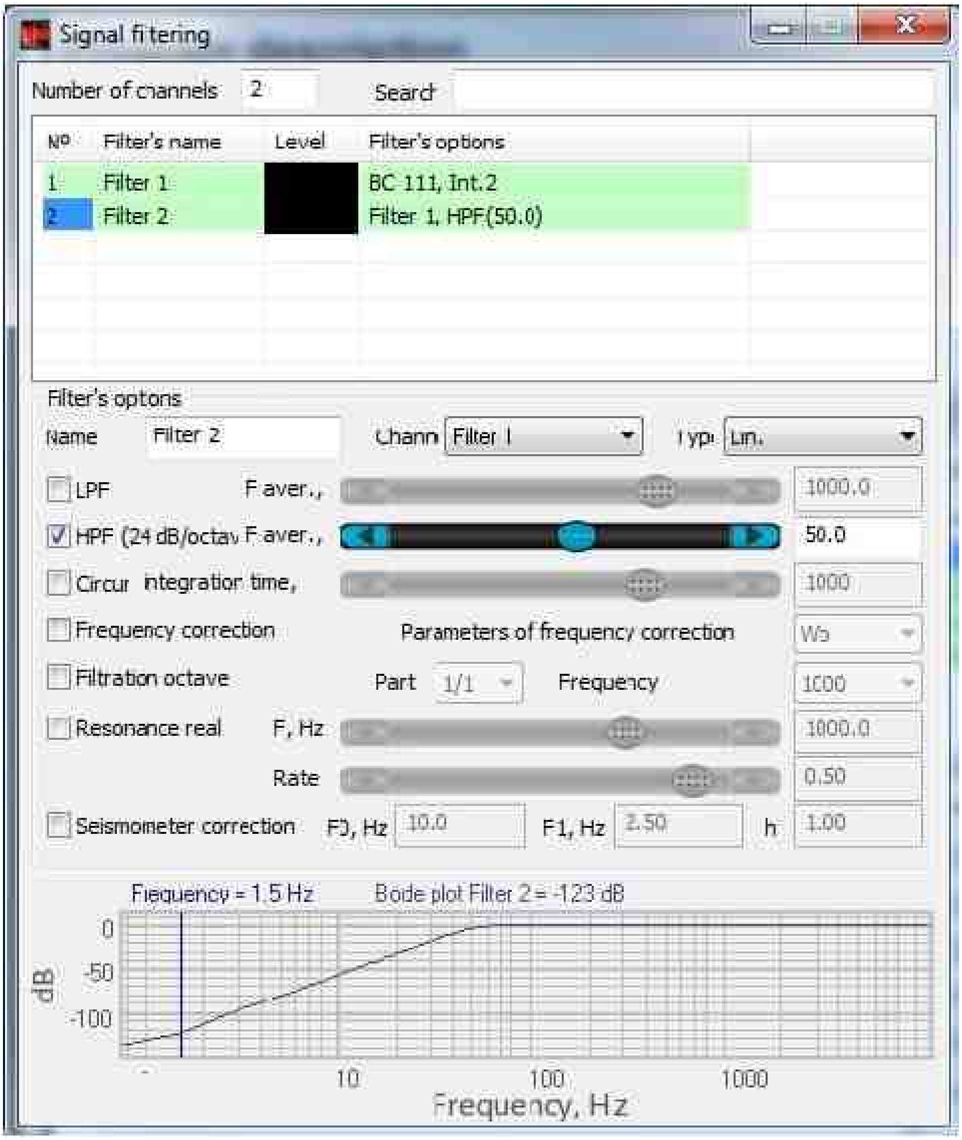
The program "***Signals filtration***" is located in the "***Automation***" software section.

Description of the program .....

To start the ***Signals filtration*** program, find it in the *Automation* section of *ZETLAB* control panel (see the Fig. below). You will see the main window of the program interface. The top section of the program window displays the name of the program.

Note: the program can also be started form ZETLAB directory (the directory by default: c:\ZETLab\). The name of the file to be started: filtrdiff.exe.

Starting the Signals filtration program



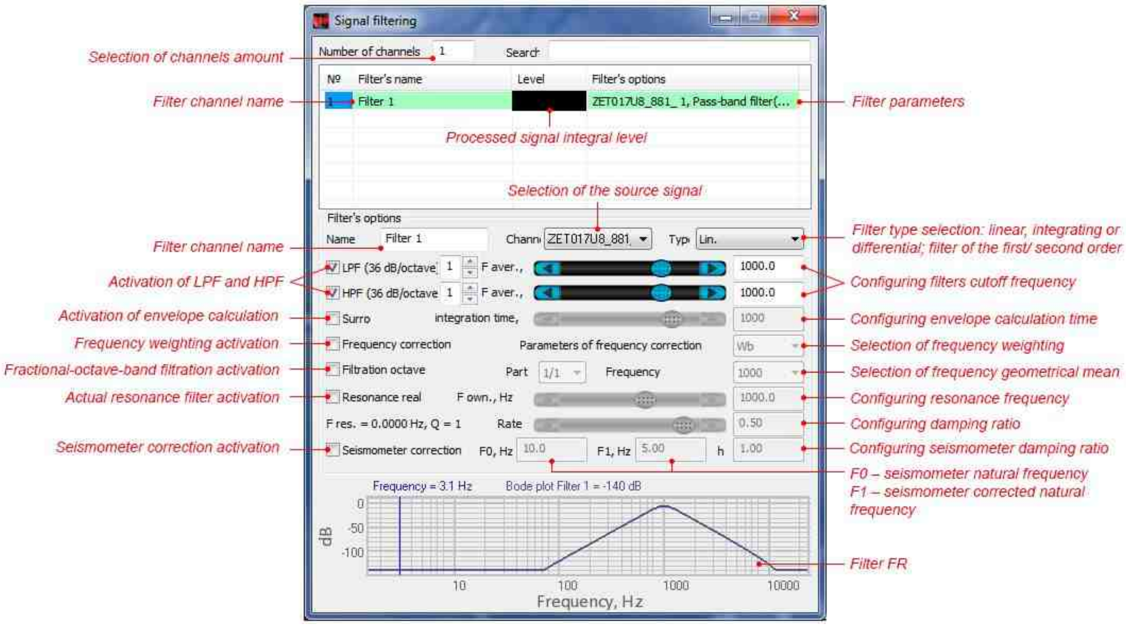
Interface of the Signals filtration program

The program ***Signals filtration*** is included into the following software suites:

- ZETLAB ANALIZ – FFT Spectrum software (supplied together with *FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19-U2, A23* and *BK-01*);
- ZETLAB VIBRO – Shaker controllers systems software (supplied together with *FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19-U2, A23* and *BK-01*);
- ZETLAB TENZO – strain-gauge station software (supplied together *with strain-gauge modules ZET017-T8*),
- ZETLAB SEISMO - seismic station software (supplied together with *seismic recorders ZET048-E, ZET048-I, ZET048-C*),

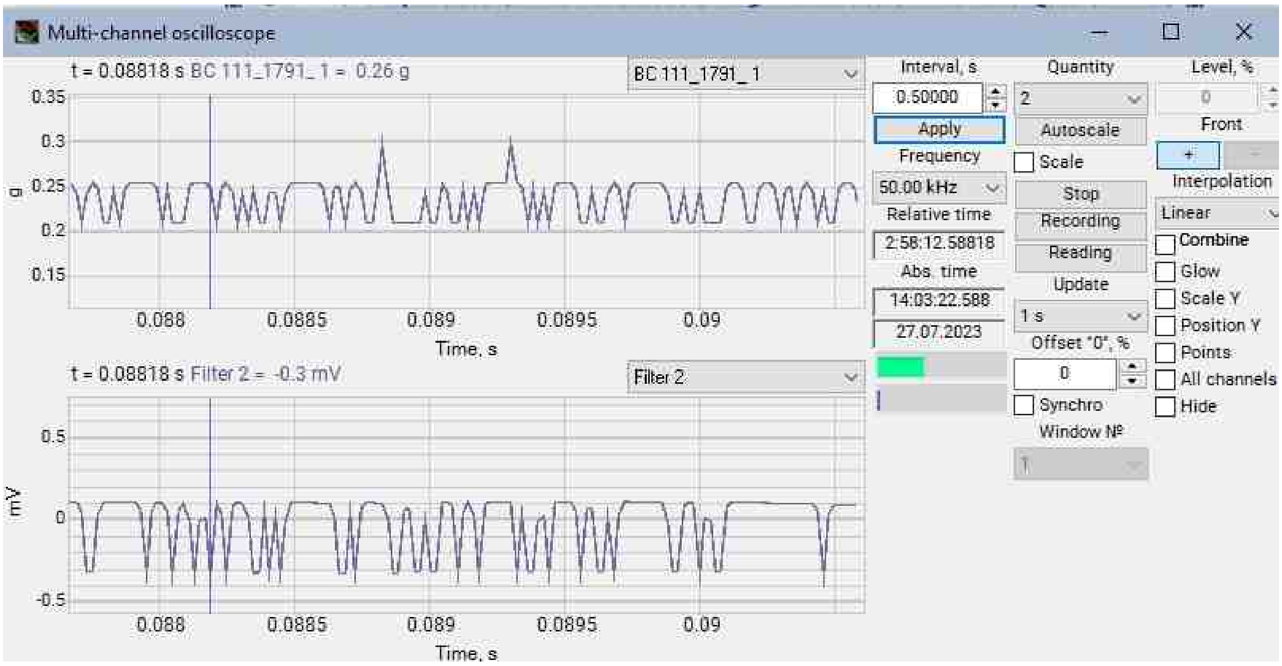
- [ZETLAB NOISE – vibration meter-noise meter](#) software (supplied together with *noise- and Vibration meter ZET 110*);

The ***Signals filtration*** program can be started from ***Automation*** section of *ZETLAB* control panel. The below Fig. shows control elements of the *Signals filtration* program.



Signals filtration - control elements of the program

It is possible to view the results of filters operation from "**Signal filtration**" program using the ["Multi-channel oscilloscope"](#) program. The upper diagram shows the time realization of the source signal, the bottom diagram shows the result of double integer function implementation and HPF of the **Signal filtration** program. The below example shows the accelerometer signal processing (the accelerometer is attached to the casing of the controlled device). Double integer function is used is implemented in order to turn acceleration signal into displacement signal, HPF is used to compensate for the drift of the received signal's constant component.



The **Signal filtration** program creates additional virtual channels that are used for signal processing. All the signals – both real and virtual – have inner synchronization, allowing to process them simultaneously, for instance, with the program "**FFT and DFT (Fast and Discrete Fourier Transform) Analysis (FFT Spectrum)**". The source signals for filtration remain unchanged. All the programs from the scope of ZETLab software package allow to process the real signals and the filtered virtual signals simultaneously.

Select of the channels number for filtration.

The program allows to conduct filtration by several channels simultaneously. This function is available both for identical and different measuring channels, including the virtual channels.

The Signals filtration program has the functions of integration and differentiation filters of first and second order. Description of filters operation is available in the corresponding sections of the user manual.

Choosing the filter type

Differentiation and **integration** of the signals are widely used for vibration and acoustics studies. Most of the transducers used in vibration studies are represented by piezoelectric accelerometers, i.e. the sensors produce a signal, that is proportional to the acceleration value. A lot of controlled vibrational parameters of various mechanisms are set depending on particular acceleration level. For balancing of the rotational mechanisms, it is necessary to know the value of vibration displacement at the point of vibration transducer mounting. In order to obtain vibration velocity signal from vibration acceleration value, it is necessary to obtain first-order integer value of the signal. To get the vibration displacement value, it is necessary to double-integer the vibration acceleration value. In a similar way, it is also possible to obtain displacement velocity and acceleration signal from the linear displacement sensor using the signal differentiation function.

Implementation of **integrating filters** allows to use the analyzer as a high-precision vibration meter.

Signal differentiation is also very useful for the purposes of various systems vibration and acoustic monitoring. Among the key monitoring parameters, one should mention the process trend, i.e. long-term change of the controlled signal level in the time domain (e.g., integral vibration level or noise level). To control the change of the signal, it is possible to perform differentiation of the signal and to control the level of its derivative, i.e. the signal change degree.

In the case, if the input signal is represented by vibration acceleration signal (i.e. the measuring unit is “g” or “m/s^2”), then, upon integration of the signal, the measurement unit for the output channel value will be vibration displacement – “m”. In the case of double integration of vibration acceleration signal the measuring unit of the output channel value will be vibration displacement – “m”. If the reference value “dB” of the input channel has been selected based on the ISO system requirements, then the ISO instructions should also be used for the output channels reference values of both integer and double integer functions. If the dB reference values have been selected based on GOST requirements, then the output channels reference values should be also assigned based on GOST system. Otherwise, it is necessary to add to the input channel measurement unit: “*s” for integer, “$*s^2$” for double integer, “/s” for differentiation, “$/s^2$” for double differentiation. In this case, the calculation reference value “dB” is not to be changed.

The **Linear filter** does not perform any operations.

Integration and differentiation filters

HPF, LPF, BPF and BSP

The *Signals filtration* program has the functions of HPF (high-pass filter), and LPF (low-pass filter). Using a combination of HPF and LPF, it is possible to implement band-pass filter (BPF) or band-stop filter (BSP). The cutoff frequency is set in Hz at the level of -3 dB. The minimal possible value of the cutoff frequency is 0,5 Hz, while the maximal possible value depends on the connected device and the sampling frequency used. The decline rate of the filter can be controlled with the use of cascade signal filtration. The order of the filter is determined by the ratio of filter sampling frequency and frequency of signal’s digital processing (channel sampling frequency). Examples of filters implementation are described in the corresponding sections of the User manual.

Signal envelope

The *Signals filtration* program also allows to calculate the signal envelope (i.e., smoothed RMS value of the signal). The envelope function parameter is represented by smoothed RMS value of the signal, which is set in *ms*. An example of this function operation is available in the corresponding section of the present User manual.

Frequency correction

The ***Signals filtration*** program has a set of frequency correction filters available: Wb, Wc, Wd, We, Wf, Wh,Wj, Wk, Wm, Fh, Fk, Fm, A, B, C, D. Examples of filters implementation are described in the *Frequency correction* section.

Other parameters

The name of filter channel is assigned by the user. The channel’s measurement unit is selected based on the measurement unit of the source signal and the filtration type used. The reference value for calculation of signal level in dB is set automatically depending on the measurement units used.

In the course of ***Signals filtration*** program operation, the program creates additional virtual channels, which are displayed in all the programs from *ZETLAB* measurement suite. The below Fig. shows interface of *ZETServer* program, displaying the time of physical and virtual channels. In this example the first four channels are represented by measurement channels of *FFT Spectrum analyzer ZET017-U4*, the 5-th channel is a virtual channel of the generator (the ***Signals generator*** program). The channels #6 and #7 were created in the *Signals filtration* program (see the above example).

The program also has an integrated control and automation module from the scope of *ZETLAB Studio* software suite, which contributes to easy deployment of individual software measurement systems.

AFR and phase frequency characterisitcs can be obtained with the use of the programs "*AFR and phase frequency response*".

It is also possible to implement band-stop filters with the use of the *Arithmometer* program.

FUNCTIONS

of "Signal filtration" program

- BANDPASS FILTERS

Selection of LPF and HPF

- SIGNAL ENVELOPE

signal envelope

- FREQUENCY WEIGHTING

selection of frequency weighting type

- OCTAVE-BAND FILTER

octave-band and 1/3 fractional-octave-band filters of high-precision

- ACTUAL RESONATOR

oscillatory link

- SEISMOMETER CORRECTION

for the extension of frequency range

The program has an integrated *control and automation module* from the scope of *ZETLab Studio*, which makes it easy for the user to establish software measurement systems of his own design.

Frequency response and amplitude response characteristics of the filters can be obtained using the programs "Frequency response measurement" and "Lin. phase – frequency response measurement".

"Aritmometer" program also enables implementation of the band-stop filter.

Questions and answers:

Question: In the attached file there is a 60-seconds recording from two channels, which was registered in January 2016 with the use of *ADC ZET 230* and amplifier *ZET 410*. The signals from two coils of the seismic transducer are received from the depth of 1000 meters via two pairs of shielded wires. The system does not have any additional electronic components. As we visited the facility in May 2016, it turned out, that the signal of the second channel has shifted beyond the limit of the set range. After having changed the amplification ratio from 1000 to 100, we managed to put the signal into the required limit. We thought that the problem was caused by the amplifier. However, as we switched it off, the signal shift preserved. The issue was not solved by connection amplifier to the ADC via capacitors. So, this is our problem. We have not switched the program into Russian language, thus, I do not think it is the reason of the problem. We shall be glad to know whether you have any solution for us.

Can the "zero drift" be attributed to the English version of the software? If so, how can we solve the problem?

Which key should we buy for ADC 230, and what are the limits for zero drift? And one more question – should the key be connected to the PC all the time, or only during loading of the program?

Answers:

1. It is possible to eliminate zero drift by configuring the properties of the channel (it is necessary to set the value to subtracted from the channel signal value).

2. You can use the program "***Signals filtration***" (*Automation -> Signals filtration*). Set the HPF at the level of 1 Hz or below.

These actions will help you in the case if the signal is within the ADC's measurement range. Thus, the amplification ratio of ZET 410 should be selected in such a way, so that to keep the signal within the specified range.

3. English language of the program used for data acquisition should not cause zero drift.

4. It seems likely, that the specified option (signals filtration) is not available in your system. In this case, it is necessary whether to purchase the key, or to change the firmware of the system.

5. When using the program, it is necessary to have the key connected to the PC, otherwise the program will not be displayed.

Actual resonator .....

Analysis and deployment of digital filters

Let us consider and IIR filter of the second order with two complex conjugated poles:

$$p_1 = re^{j\omega_0},\ p_1^* = re^{-j\omega_0}$$

$$H(z) = \frac{1}{2}\left[\frac{1}{1-re^{j\omega_0}z^{-1}} + \frac{1}{1-re^{-j\omega_0}z^{-1}}\right] = \frac{1-(r\cos\omega_0)z^{-1}}{1-2(r\cos\omega_0)z^{-1}+r^2z^{-2}} = \frac{1+b(1)z^{-1}}{1+a(1)z^{-1}+a(2)z^{-2}}$$

The transfer function has a zero $z_1 = r\cos\omega_0$, position of which is related to that of the poles. The differential equation of the filter is as follows:

$$y(n) = -a(1)y(n-1) - a(2)y(n-2) + x(n) + b(1)x(n-1)$$

AFR of this actual resonator is characterized by aggregation of AFR of two complex resonators with the resonance frequencies ω_0 and $(-\omega_0)$ for the frequency range $(-\pi \le \omega \le \pi)$.

The Fig. below shows a possible variant of actual resonator's structural scheme, while the next Fig. displays AFR graphic at $r=0.95$ and $\omega_0=\pi/2$.

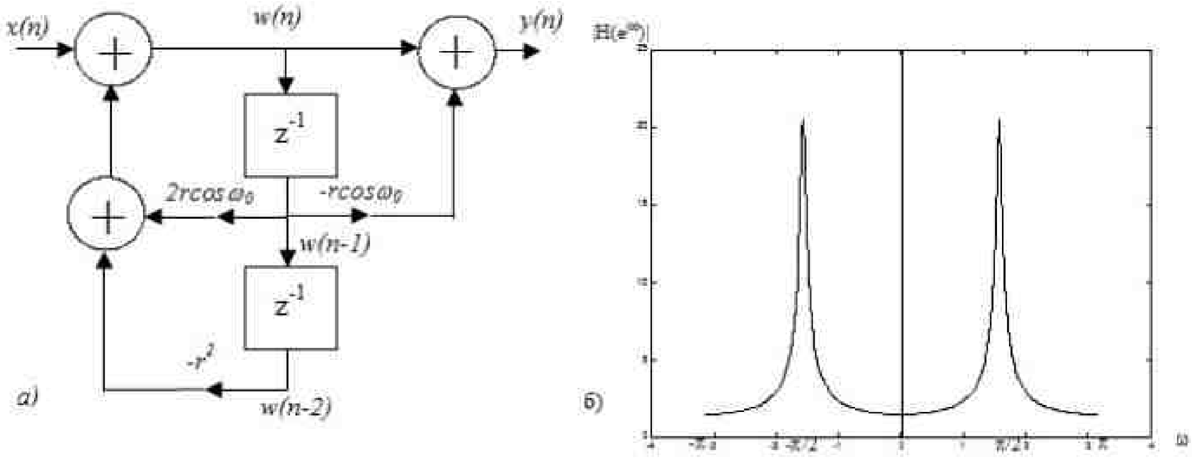
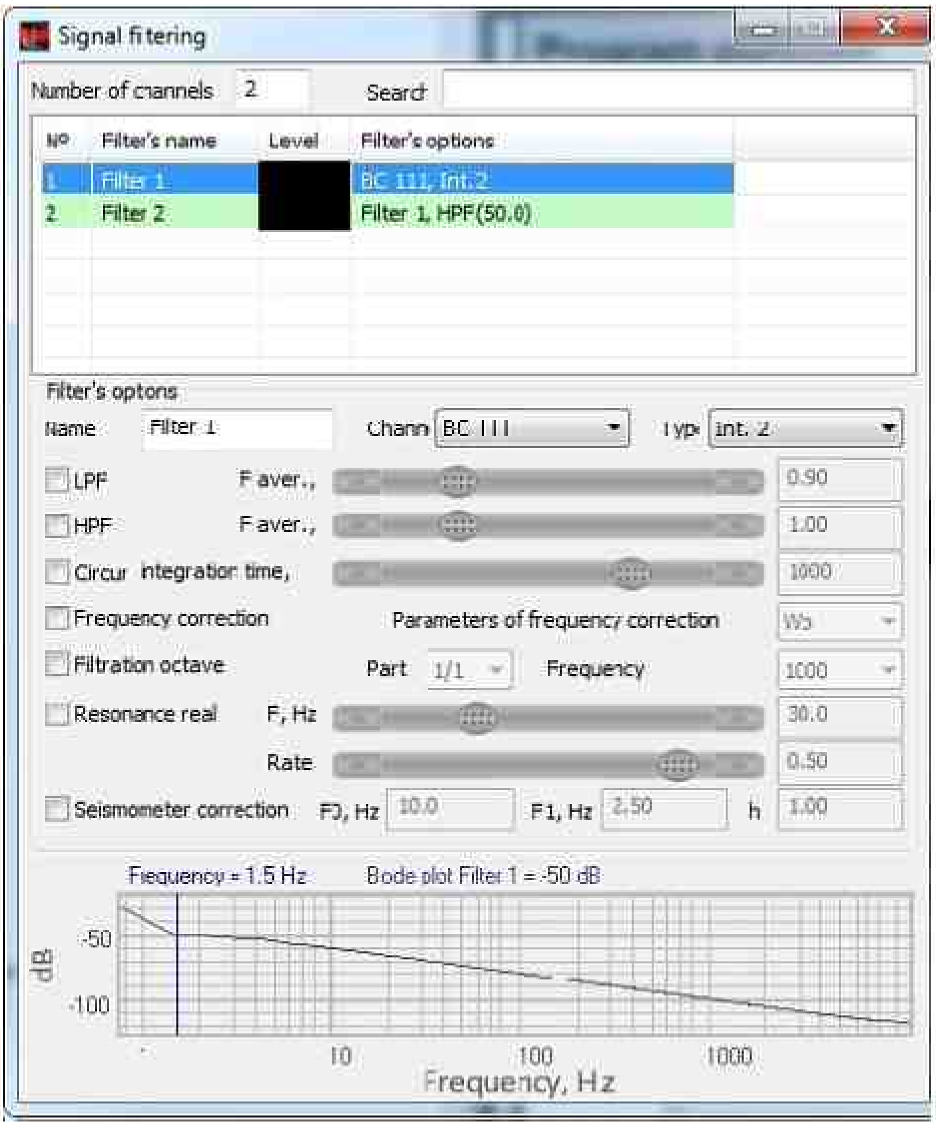


Fig. a) Structural scheme and AFR of actual resonator b) Structural scheme and AFR of actual resonator

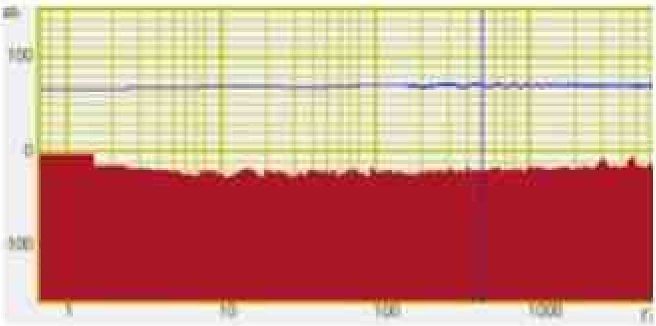
Integrating and differentiating filters .....

The *Signals filtration* program has a set of integration and differentiation filters of the 1-st and the 2-nd order.

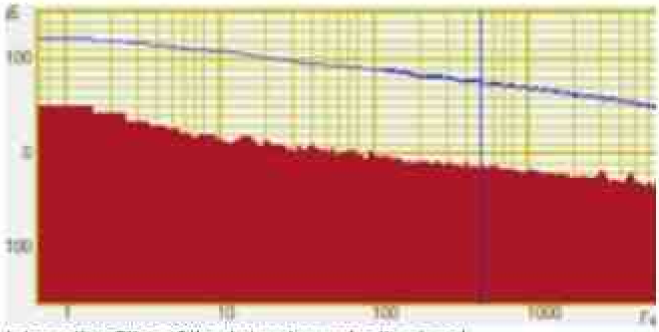


Integration filters allow to obtain vibration velocity and displacement value from the Acceleration signal. This allows, for instance, to implement control of vibration-related characteristics of the facility (frequency, acceleration, velocity and displacement). Integration of acceleration signal is used in inertial measurement systems: rail gauge control system, elevator positioning system, etc. Integration filters are used for balancing of rotary elements, since in order to evaluate the imbalance parameters, it is necessary to have the value of the control point, which cannot be obtained with the use of displacement transducers, especially at high rotation speed.

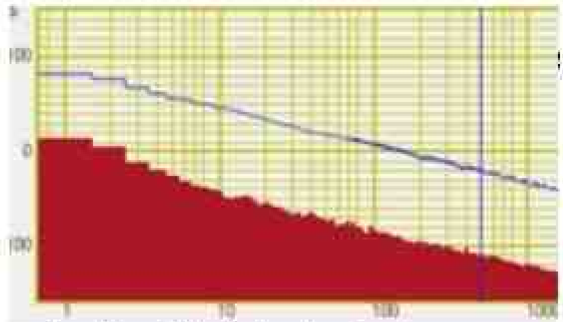
The below Fig.s display operation of integration filters of the 1-st and the 2-nd order. The first Fig. shows the spectrum of the source acceleration signal. The other Fig. displays a signal spectrum, which has been processed with integration filter of the first order (which allowed us to obtain the velocity signal). The third Fig. shows the displacement signal, which has been obtained after double integration of the acceleration signal.



Linear filter - signal of acceleration



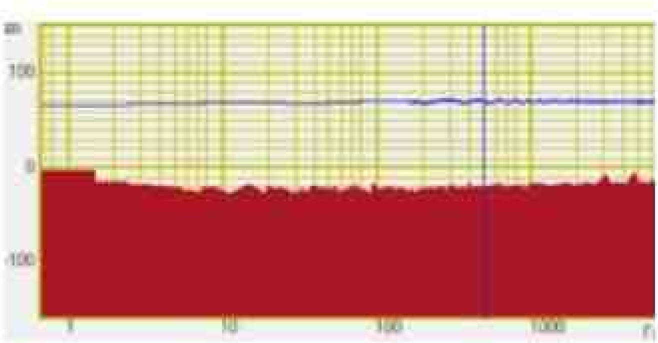
Integrating filter of the 1st order- velocity signal



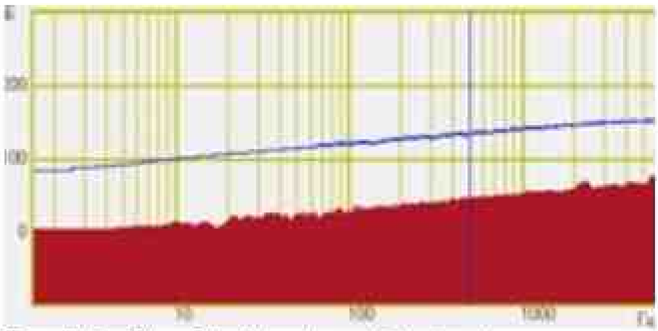
Integrating filter of the 2nd order - signal displacement

Differentiation filters are used in order to obtain velocity and acceleration signals from displacement signals produced, for instance, by optical or eddy-current displacement transducers. This method is often used for low-frequency signals. It is attributed to the fact, that in the low-frequency domain the readings of vibration sensors are affected by intrinsic noise of the transducer and electronic noise of the measuring instruments, while the displacement transducers ensure higher measurement accuracy.

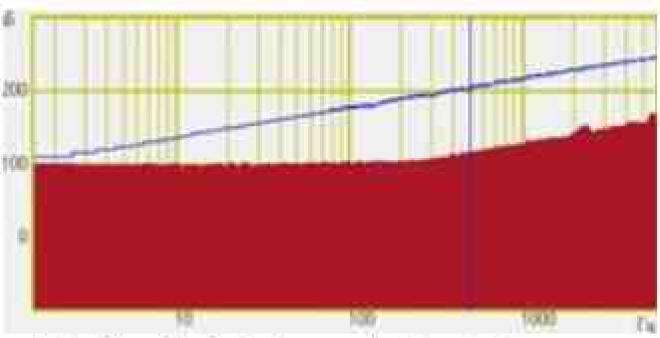
The below Fig.s display operation of differentiating filters of the first and the second order. The first Fig. shows the spectrum of the source displacement signal. The second Fig. displays the spectrum of the signal, which has been processed by differentiating Fig. of the first order (thus, we have obtained the vibration velocity signal). The third Fig. contains the acceleration signal, which has been obtained with the use of double integration applied to the displacement signal.



Linear filter- signal displacement



Differentiating filter of the 1st order- velocity signal



Differentiating filter of the 2nd order - acceleration signal

If the source signal is represented by the Acceleration signal (i.e., it is measured in "*g*" or "m/s^2"), then, after integration, the measurement value of the output channel will be represented by vibration velocity – "*m/s*". After double integration of the Acceleration signal, the output channel will produce the value of Displacement (measured in "*mm*").

The reference values for calculations in *dB* also udergo changes. In the case if the reference values "*dB*" of the input channel have been selected in compliance with ISO standards, then the reference values of the output channels used for integration and double integration should be also selected in accordance with ISO principles.

Otherwise, upon integration of the input channel measurement value, the program will add the symbol "**s*" in the case of double integration, and "$/s^2$" – for double integration respectively.

The Fig.s below have been obtained with the use of "*sine scan*" signal processing algorithm and the program "FFT Spectrum Analysis" was used for displaying the maximum value of the accumulated signal spectrum.

Band-pass filters .....

The following filters are available for the user in the *Signals filtration* program:

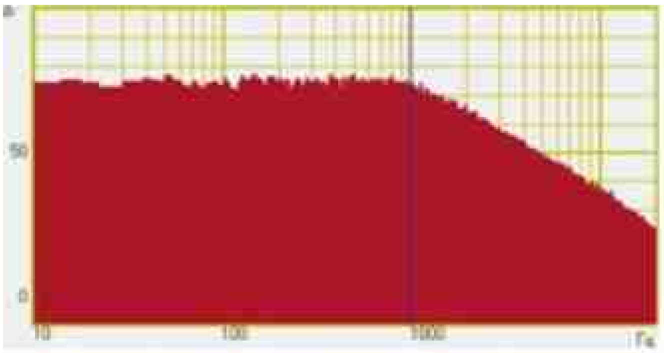
·*LPF (low-pass filter)* – the filter passes frequencies up to F_{cutoff},

·*HPF (high-pass filter)* – the filter passes frequencies starting from F_{cutoff},

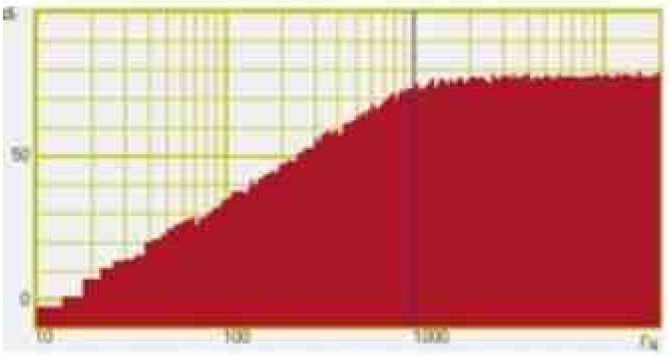
·*BPF (band-pass filter)* – the filter passes the frequencies within the set band width,

·*BSF (band-stop filter)* – the filter passes all the frequencies outside of the set band width.

In the Fig.s below, you can see two spectra, which have been processed with LPF and HPF filters at the cutoff frequency of 1000 Hz.



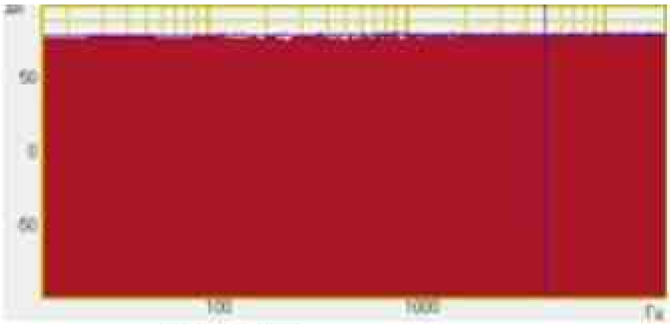
Low-pass filter Fc = 1000 Hz



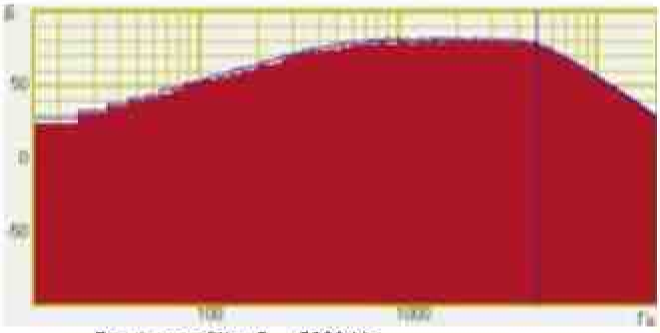
High-pass filter Fc = 1000 Hz

HPF and LPF are implemented as Butterworth filters of 2-nd, 4-th, 6-th, 8-th, or 10-th order with IIR. The coefficients of the filters are calculated in compliance with standard methods described in the corresponding literature (Richard Lyons, "*Understanding Digital Signal Processing*", Chapter 6). The sequence of filters use depends on the ratio of filter's cutoff frequency to the sampling frequency of the channel: the higher is the ratio, the higher is filter's order.

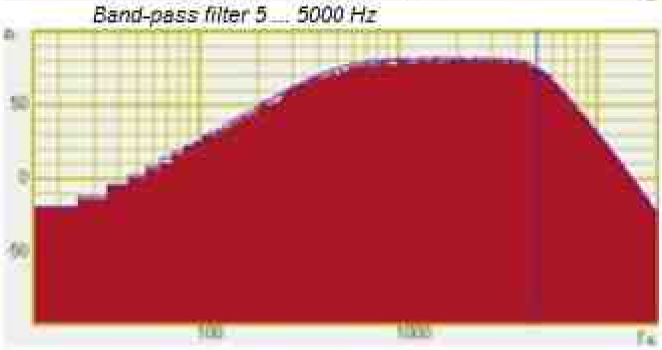
The filters' cutoff frequencies F_{cutoff} are set in Hz at the level of -3dB. The filter discrimination can be estimated with the use of cascade filtration. The Fig.s below show spectra of the white noise signal, which have been processed with a band-pass filter at the cutoff frequencies of 500 Hz and 5000 Hz at different stages: without processing, one cycle, two cycles, three cycles:



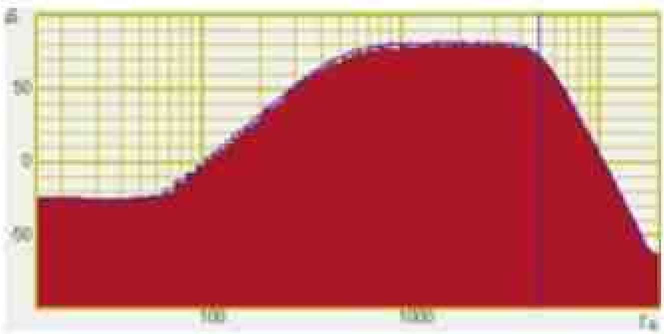
Source signal



Band-pass filter 5 .... 5000 Hz



Band-pass filter 5...5000 Hz, applied twice



Bandpass filter 5...5000 Hz, applied three times

The cascade filtration algorithm is described below: at first, it is necessary to create several channels in the *Signals filtration* program:

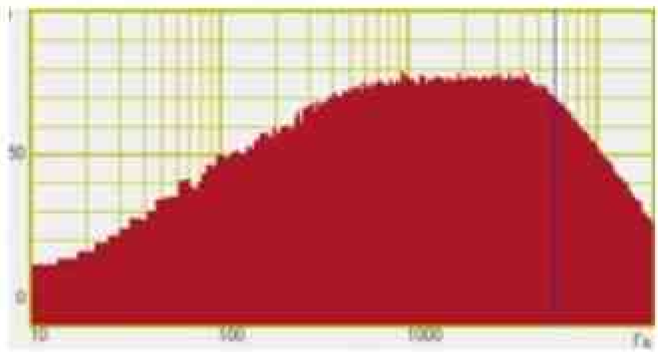
·1-st channel of the program: the filter is applied to the source signal

·2-nd channel of the program: the filter is applied to the processed signal, i.e., to the first channel of the program,

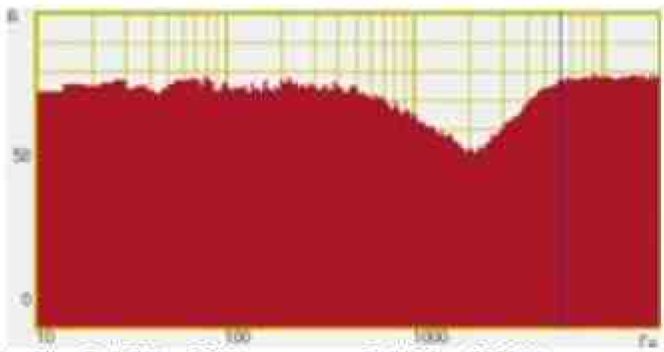
·3-d channel of the program: the filter is applied to the processed signal, i.e., to the second channel of the program,

·and so on, depending on the required number of cycles

The band-pass and band-stop filters are implemented as a combination of HPF and LPF. The band-pass filter is implemented as a combination of HPF and LPF with the following cutoff frequencies ratio: $F_{cutoffLPF} > F_{cutoff}$HPF. The following ratio: FF_{cutoff}LPF < FF_{cutoff}HPF allows to obtain band-stop filter. The Fig.s below show examples of band-pass and band-stop filters with cutoff frequencies 500 Hz and 5000 Hz respectively.

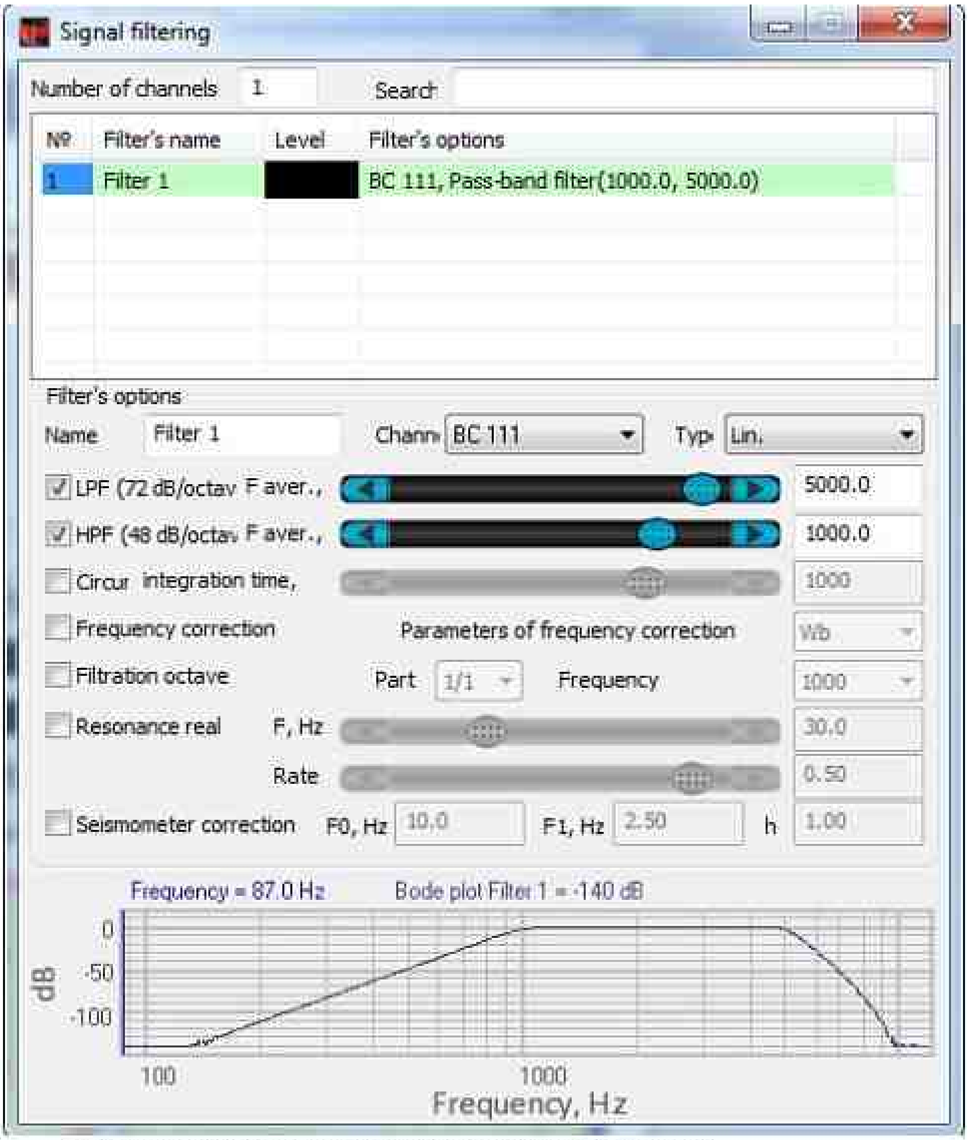


Band-pass filter Fc(HPF) = 500 Hz Fc (LPF) = 5000 Hz

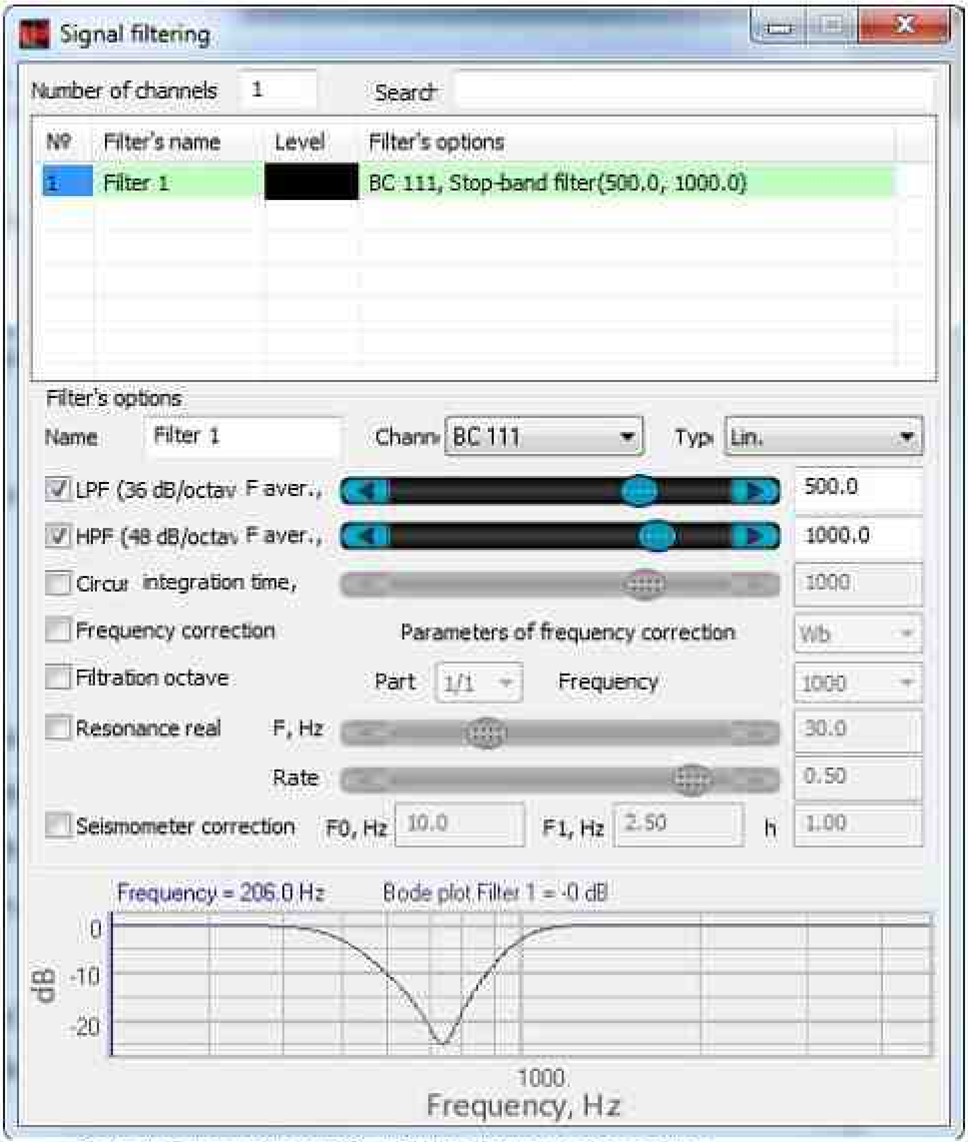


Band-stop filter Fc(LPF) = 500 Hz Fc(HPF) = 5000 Hz

These Fig.s show parameters configuration of the Signals filtration program for implementation of band-pass and band-stop filters.



Band-pass filter with band 1000...5000 Hz. Setting band-pass filter

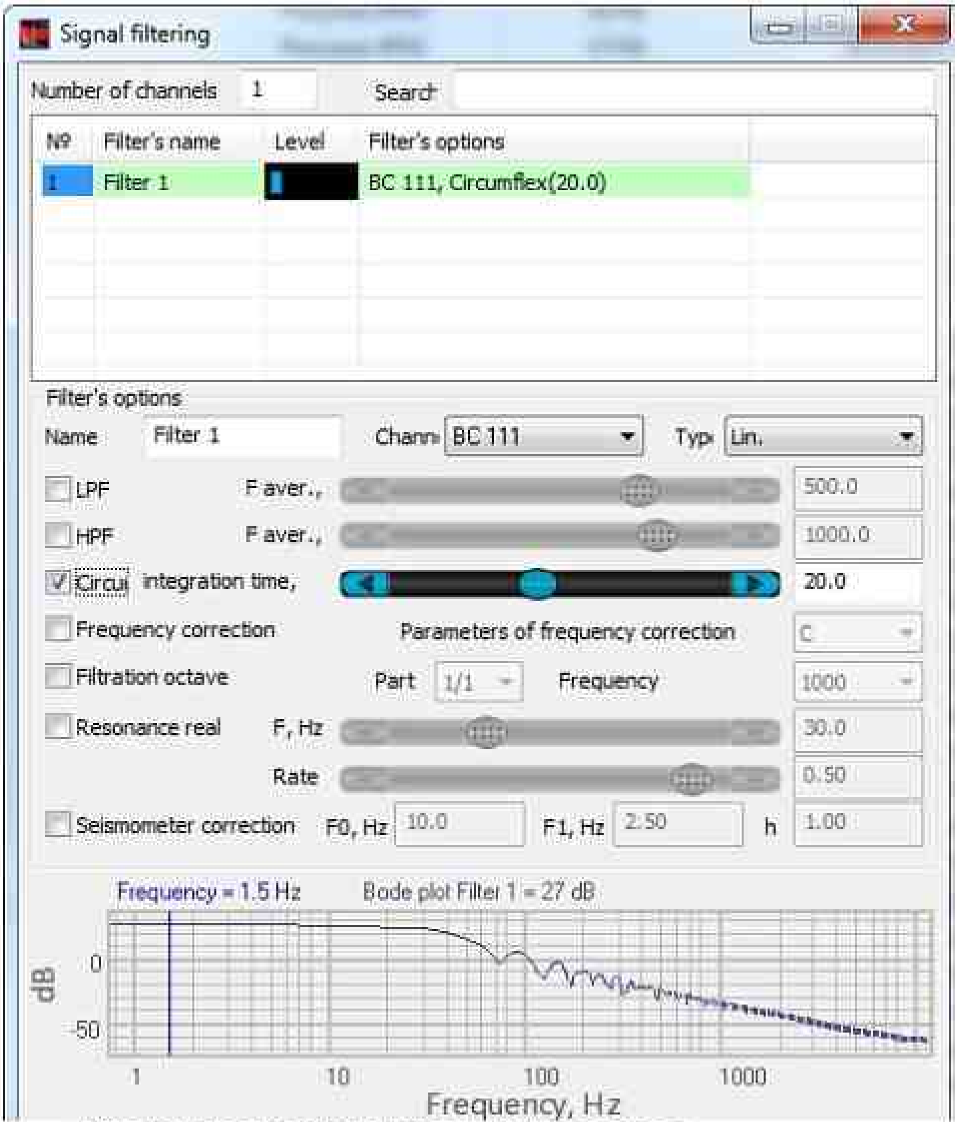


Band-stop filter with band 500...1000 Hz. Setting band-stop filter

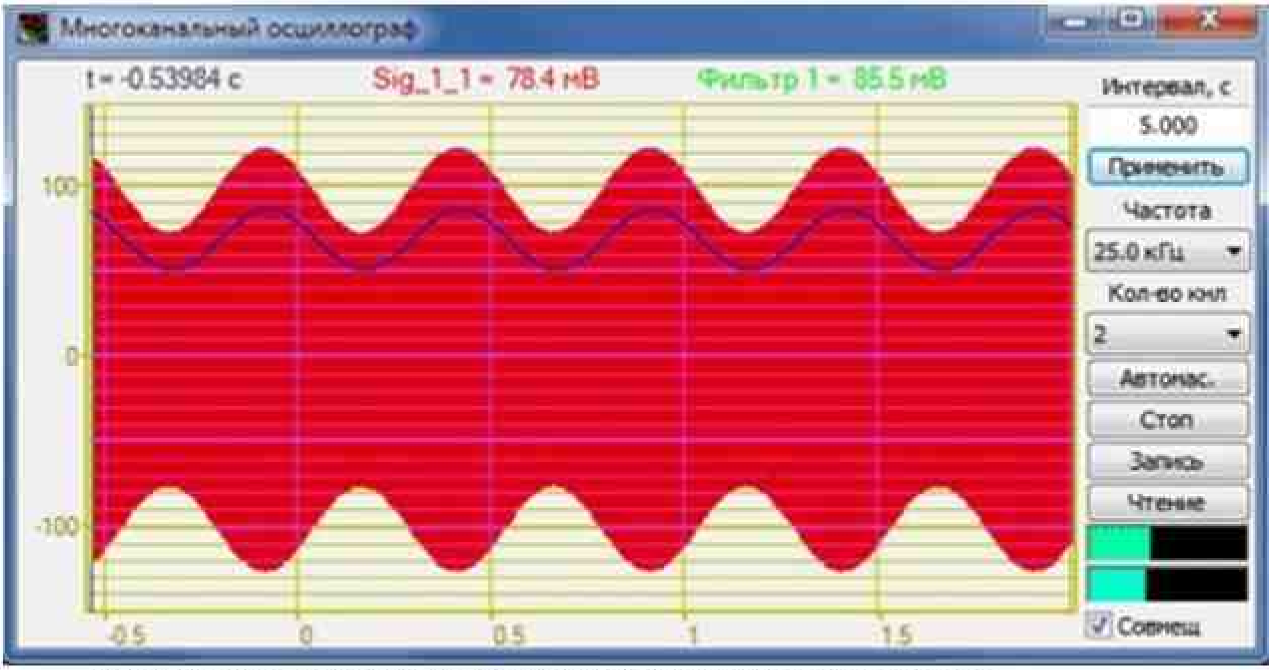
Signal envelope .....

The program ***Signals filtration*** allows to calculate the signal's envelope curve. The signal envelope is calculated as the smoothed RMS value of the signal. The envelope curve parameter is represented by the smoothing time, which is set in *ms*. For vibration- and noise-meters there are two standard averaging periods: "*Fast*" (125 ms) "*Slow*" (1000 ms).

The Fig.s below show an example of calculating the envelope curve of the amplitude-modulated signal in the *Signals filtration* program.



The calculation of the signal envelope in the "Signal Filtering"



The original signal and envelope (the "Multi-channel oscilloscope, the concurrency mode")

Frequency correction .....

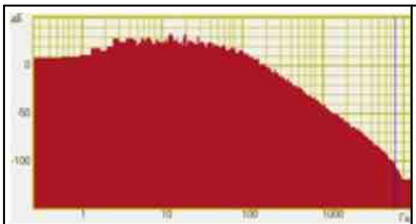
The program **Signals filtration** has filters with frequency correction: Wb, Wc, Wd, We, Wf, Wh, Wj, Wk, Wm, Fh, Fk, Fm, A, B, C, D.

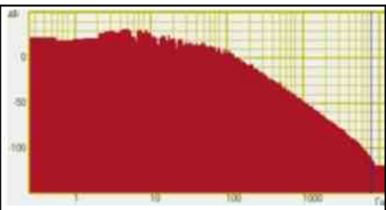
Frequency correction W

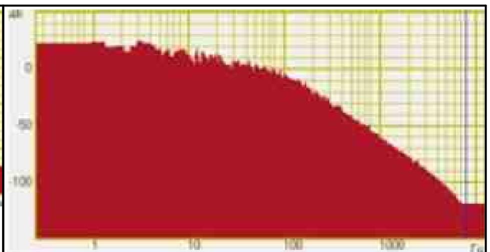
In the program **Signal Filtering**, the following filters with frequency corrections are available: Wb, Wc, Wd, We, Wf, Wh,Wj, Wk, Wm in accordance with ISO 8041-2006:

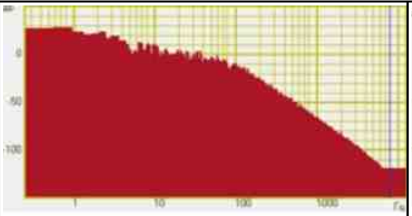
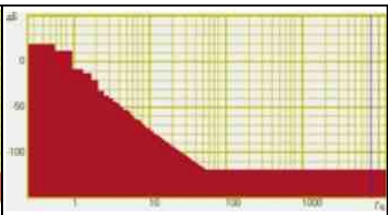
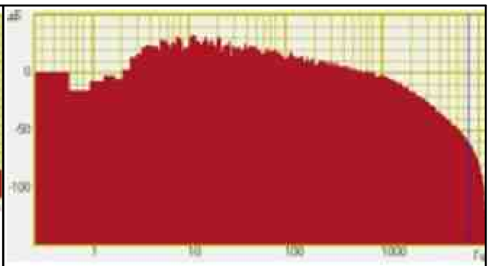
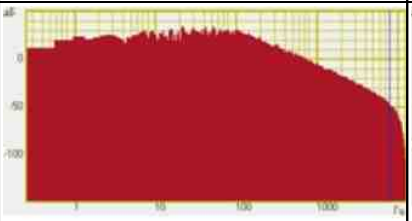
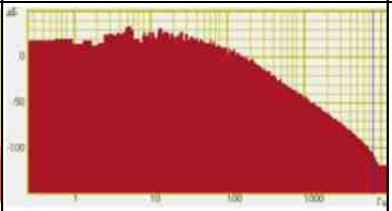
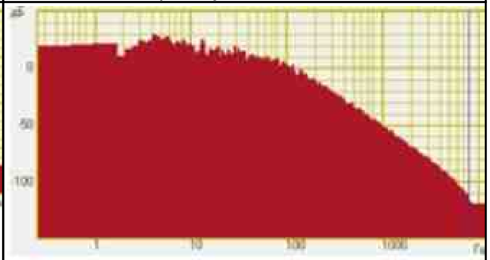
Frequency correction function	Designation	Nominal frequency range, Hz	Reference frequency, rad/s, Hz	The value of the frequency correction function on the reference frequency
Wh	The function of frequency correction Wh for measuring local vibration in all directions (based on ISO 5349-1)	8...1000	79,58	0,2020
Wb	The frequency correction function Wb for measuring the total vibration in the vertical direction (z axis) affecting a person in a sitting, standing or lying position (based on ISO 2631-4)	0,5...80	15,915	0,8126
Wc	The frequency correction function Wc for measuring the overall vibration in the horizontal direction (x-axis) affecting the person in the	0,5...80	15,915	0,5145

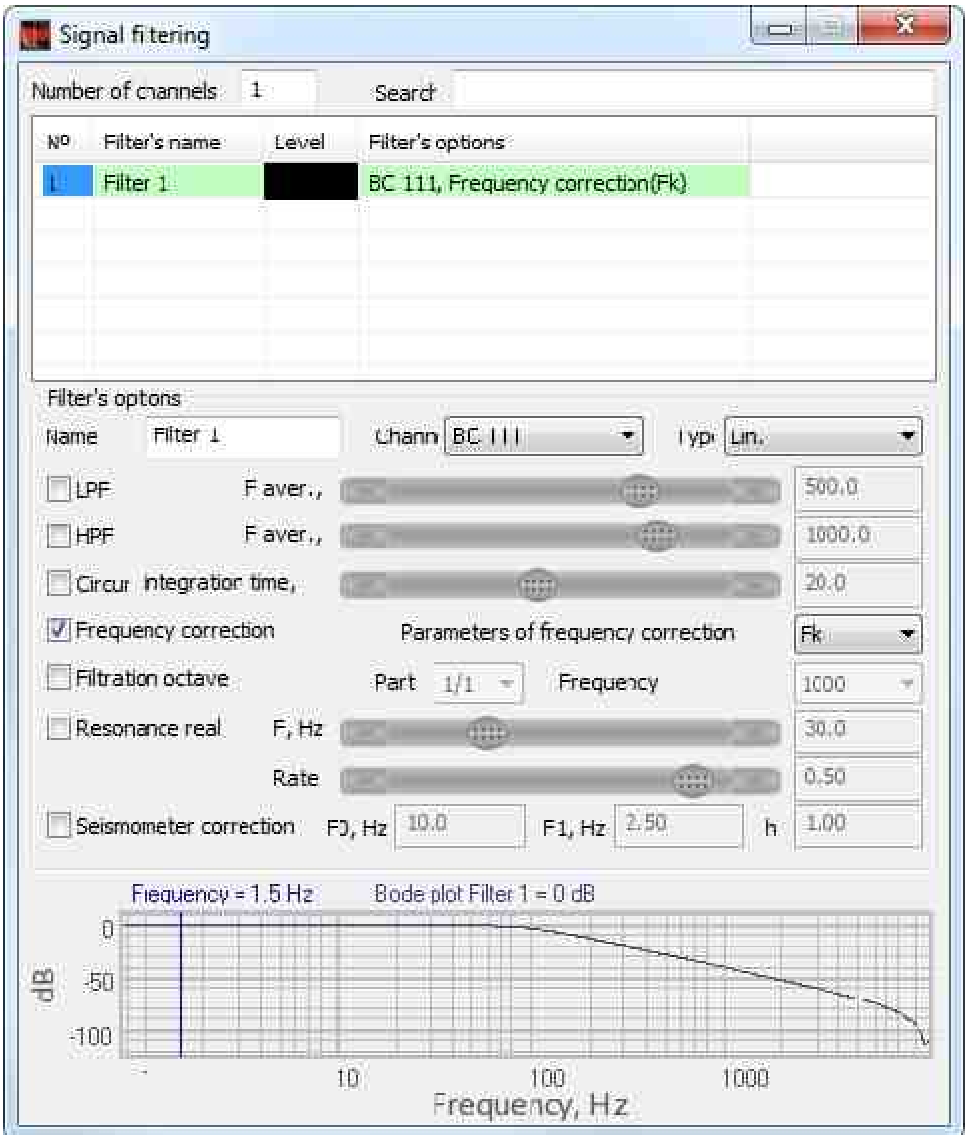
	sitting position, the seat back (based on ISO 2631-1)			
Wd	The frequency correction function Wd for measuring the total vibration in the horizontal direction (x-axis or y-axis) affecting the person in the sitting, standing or lying position (based on ISO 2631-1)	0,5...80	15,915	0,1261
We	The function of frequency correction We to measure the total angular vibration in all directions affecting the person in the sitting position (based on ISO 2631-1)	0,5...80	15,915	0,06287
Wj	The frequency correction function Wj for measuring vibration in the vertical direction (x-axis) acting on the head of a lying person (based on ISO 2631-1)	0,5...80	15,915	1,019
Wk	The frequency correction function Wk for measuring the total vibration in the vertical direction (z axis) affecting the person in the sitting, standing or lying position (based on ISO 2631-1)	0,5...80	15,915	0,7718
Wm	The function of frequency correction Wm for measurement of general vibration in buildings in all directions (based on ISO 2631-2)	1...80	15,915	0,3362
Wf	The frequency correction function Wf for measuring the overall low-frequency vibration in the vertical direction (z-axis) affecting the person in a sitting or standing position (based on ISO 2631-1)	0,1...0,5	0,3979	0,3888


Frequency correction Wb


Frequency correction Wc


Frequency correction Wd

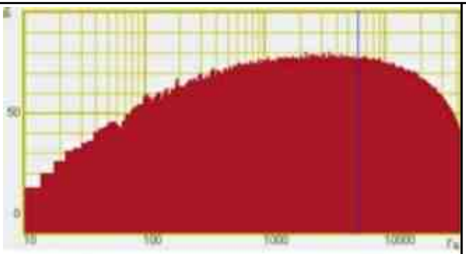
 *Frequency correction We*	 *Frequency correction Wf*	 *Frequency correction Wh*
 *Frequency correction Wj*	 *Frequency correction Wk*	 *Frequency correction Wm*



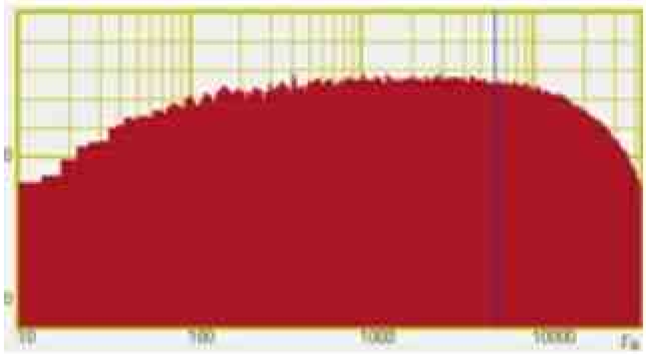
Frequency correction Wk

Frequency correction: A, B, C and D

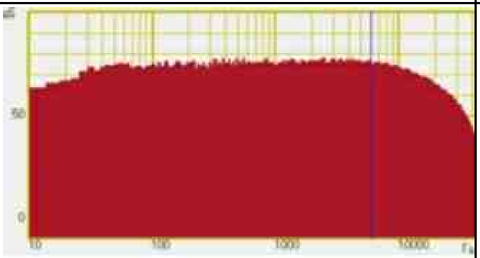
Filters with frequency corrections A, B, C and D are used for noise level measurements. This allows the ZET 017-U2, ZET 017-U8 and A19-U2 analyzers to be used as a first-class accuracy audio-noise meters.
The following Fig.s show the spectra of signals processed by filters with frequency corrections A, B, C and D implemented in the **Signal Filtering** program.



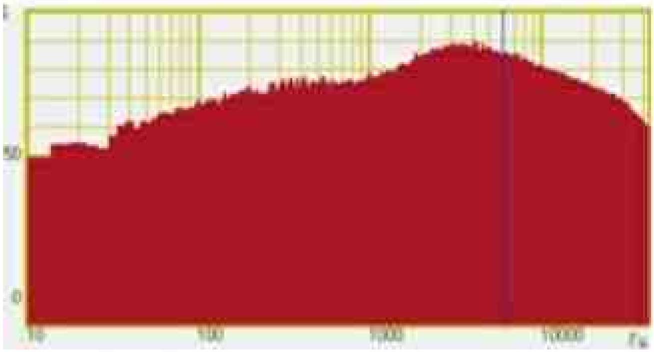
Frequency correction A



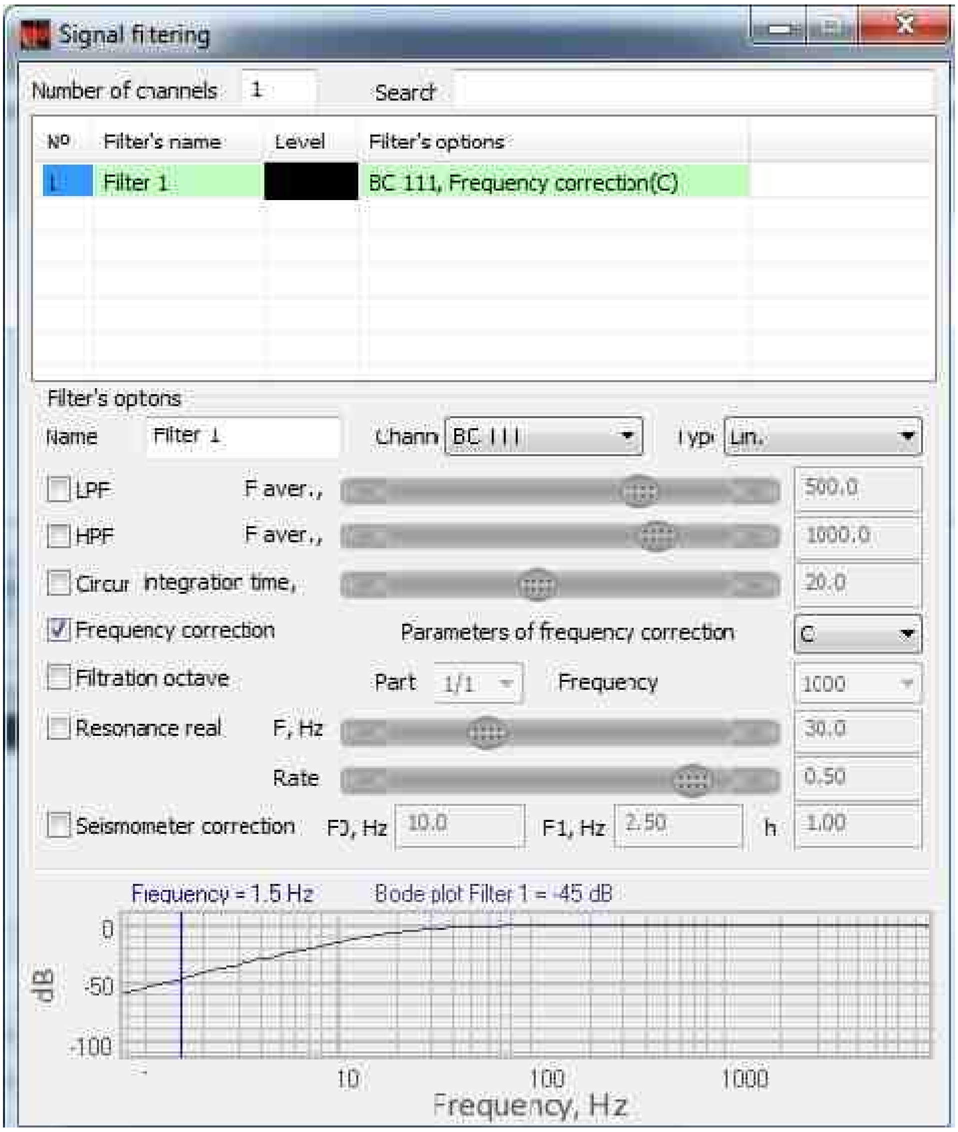
Frequency correction B



Frequency correction C



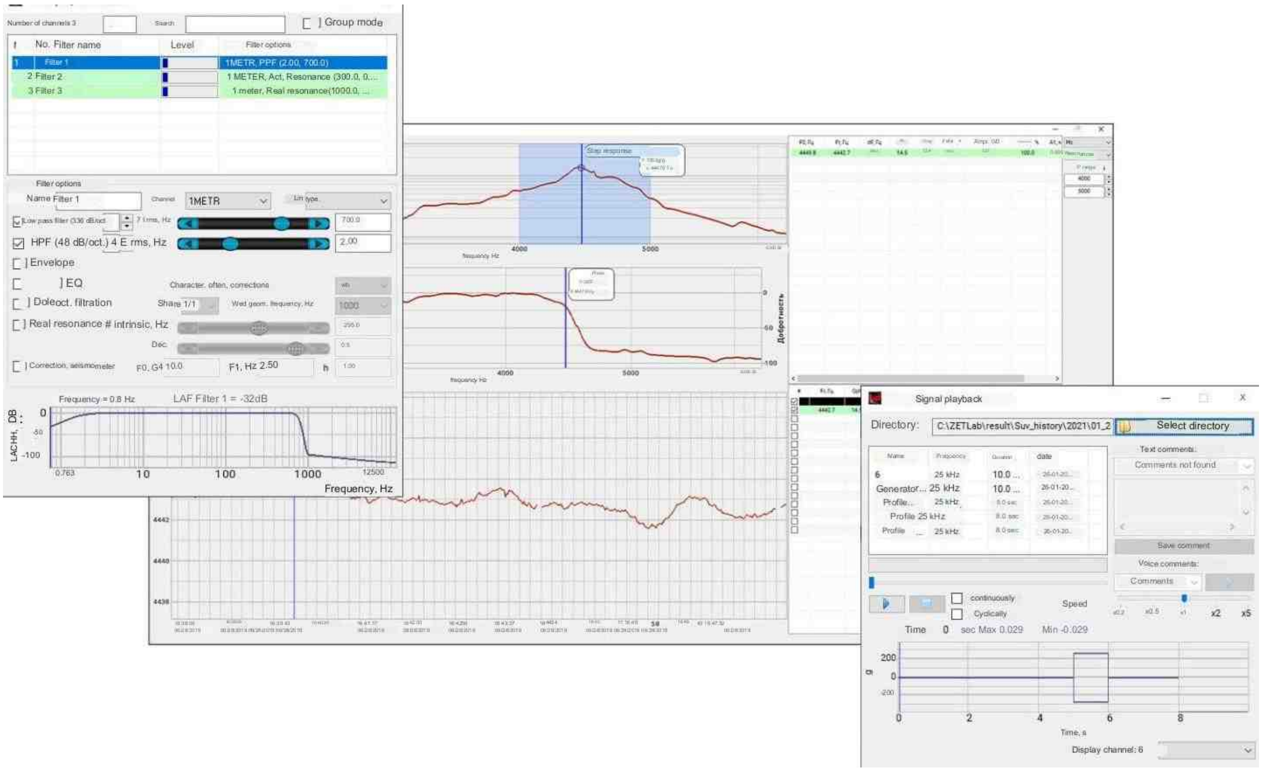
Frequency correction D



Frequency correction C

Post-processing of signals .....

In-depth analysis of experimental data



Under the conditions of testing objects for resistance to mechanical external influencing factors, it is not always possible to conduct an in-depth analysis of instantly received signals. This may be due to both complex processing algorithms and the speed of the tests themselves.

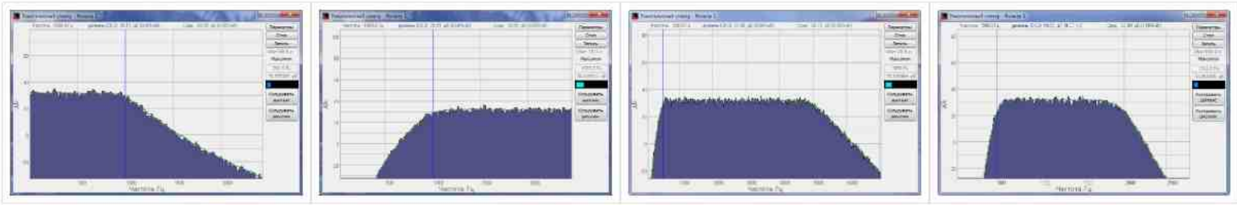
Recording and subsequent processing of signals in more comfortable conditions allows you to study the behavior of the sample in detail and identify all defects, including minor ones, that have arisen as a result of testing.

Signal post-processing programs included in the ZETLAB VIBRO software package allow you to work in the following main modes:

- play recorded signals - the program "**Play recorded signals**";
- band-pass filtering of signals - the program "**Signals filtration**";
- spectral analysis - program "**FFT Spectrum Analysis**";
- cross-Spectrum FFT Analysis - program **" Cross-Spectrum FFT Analysis**".

Signals filtration

The "**Signals filtration**" program allows you to perform band-pass filtering, which is used for preliminary analysis of signals, as well as for extracting informative frequency ranges.



Cross-Spectrum analysis

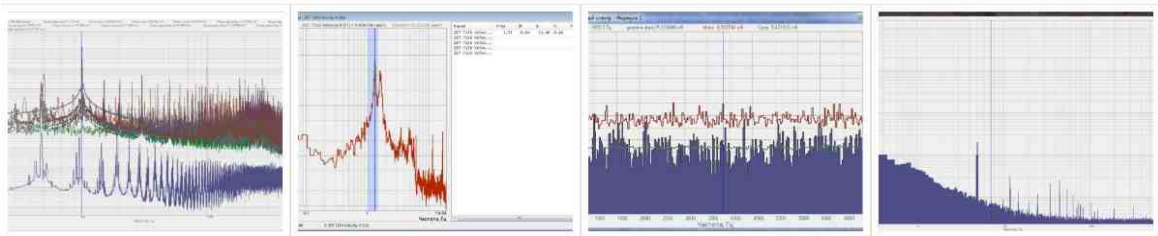
Spectral analysis is used to study the frequency composition of the measured signal. This is due to both its physical clarity and the possibility of meaningful interpretation of the results obtained. In the Narrowband Spectrum program, the user can determine the presence of tonal signals (discrete components) and noise components in the measuring channel by the graphic of the spectrum.

The use of **FFT Spectrum Analysis** in the processing of recorded signals will allow you to easily:

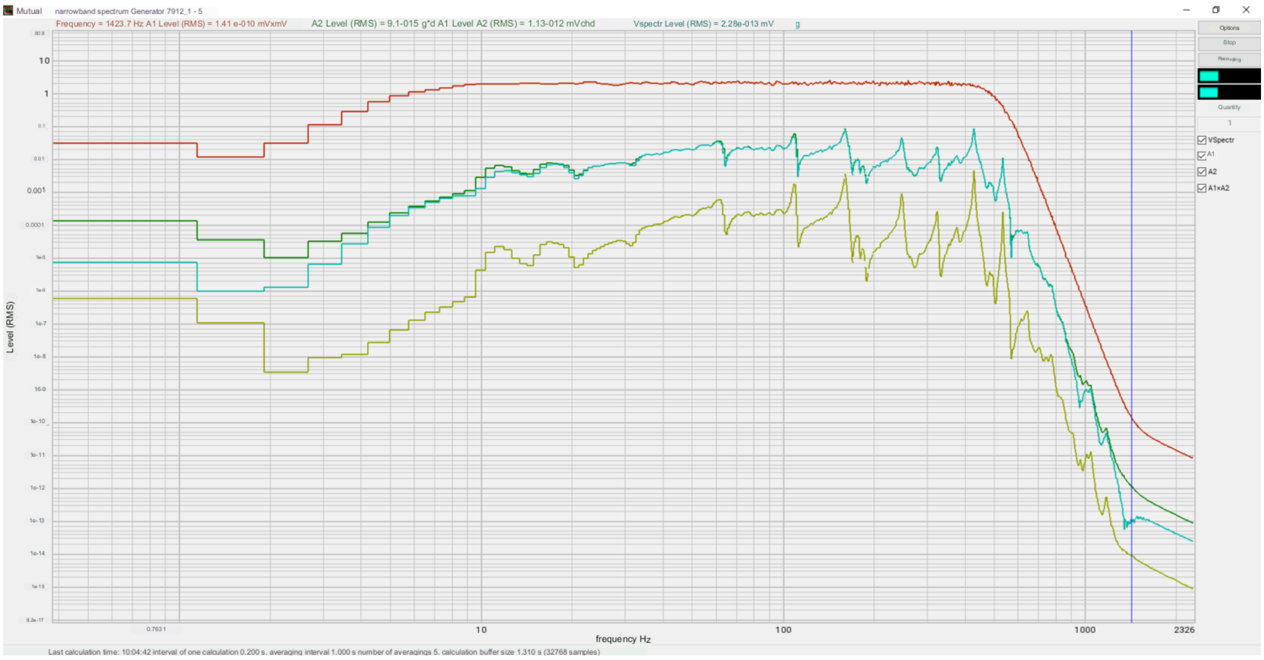
carry out narrow-band spectral analysis of vibration in extended frequency ranges;

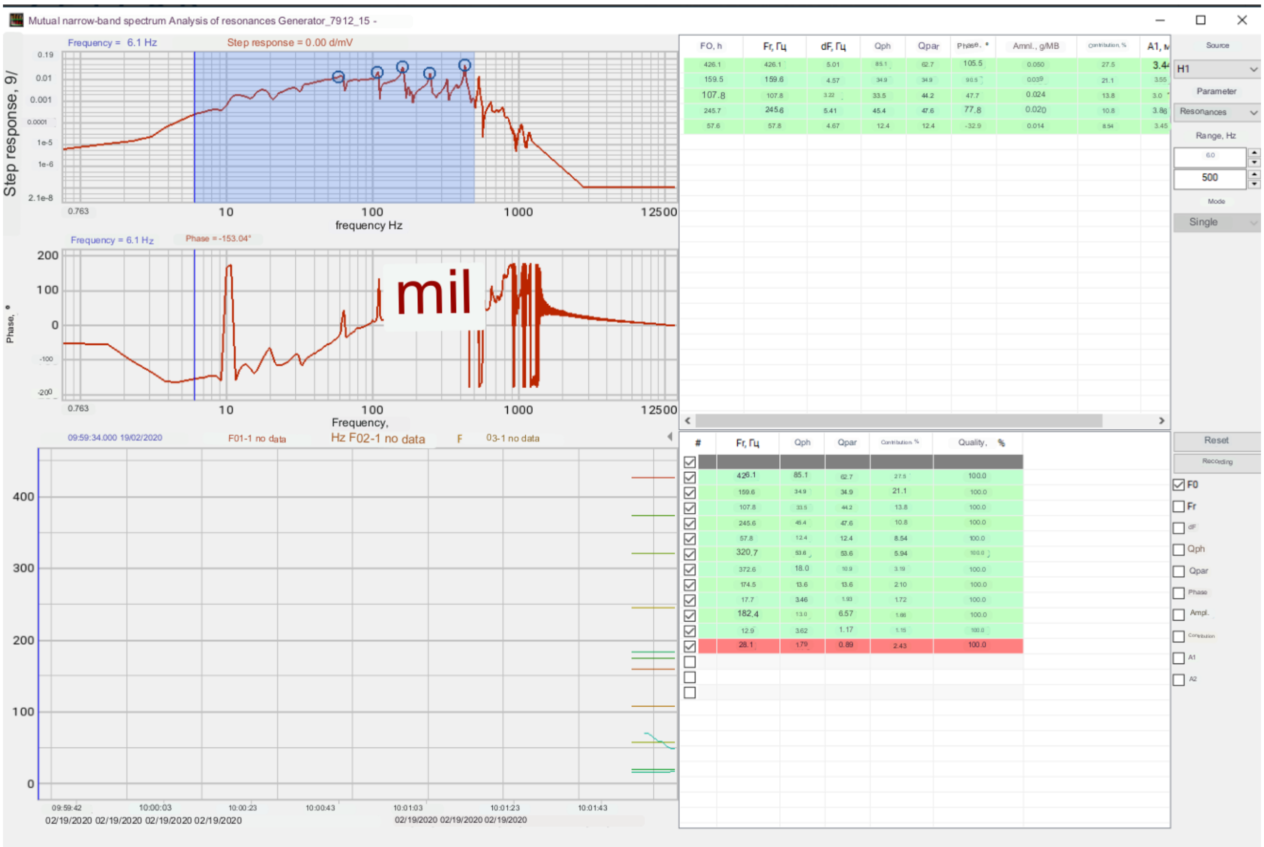
obtain the main spectral characteristics of the signal;

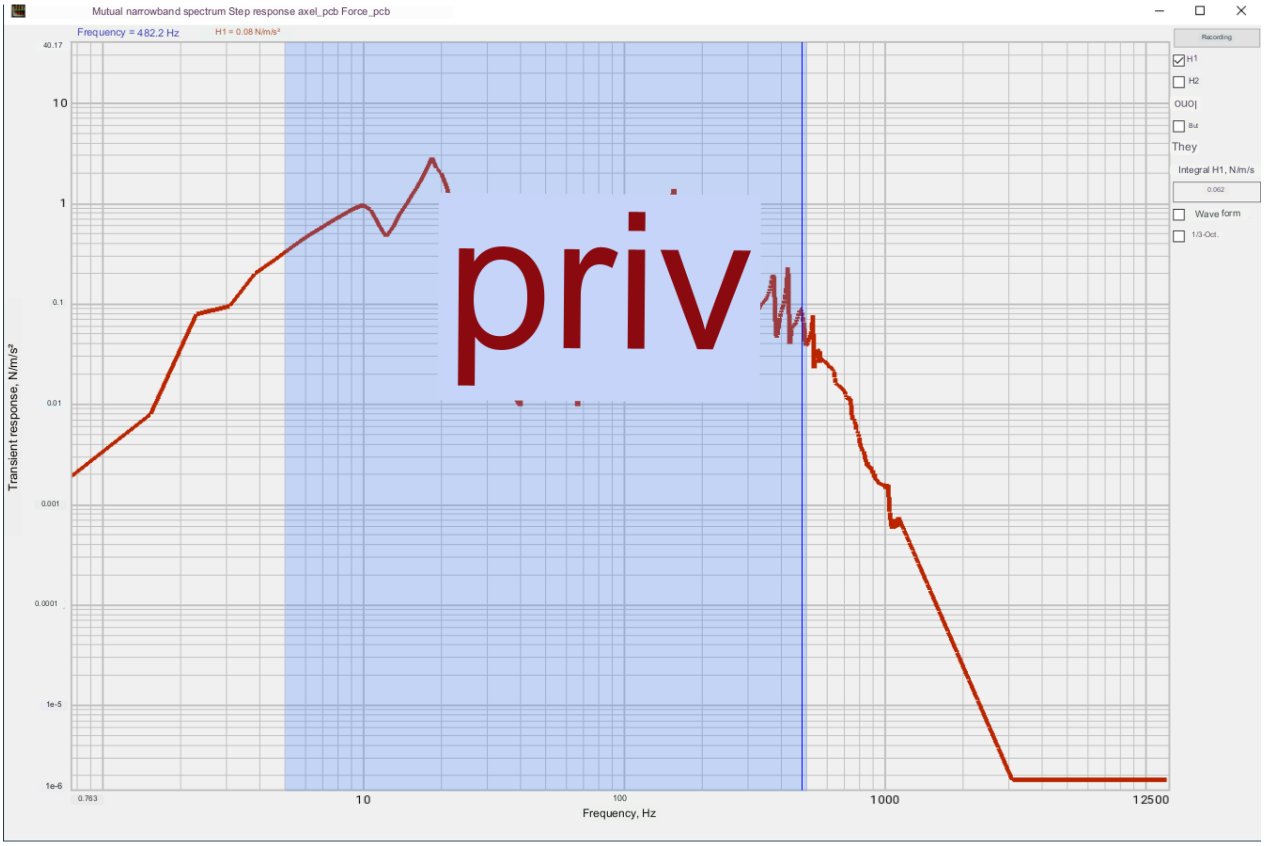
determine the natural frequencies of the object under study.



Cross-Spectrum FFT Analysis







Possibilities .....

Built-in control and automation module from ZETLab Studio provides simplicity and convenience when building your own software and measuring systems,
The amplitude-frequency and phase -frequency characteristics of filters can be obtained using the programs "AFR measurement or Ph.- freq. response".
Using the Arithmometer program, it is also possible to implement notch filters.

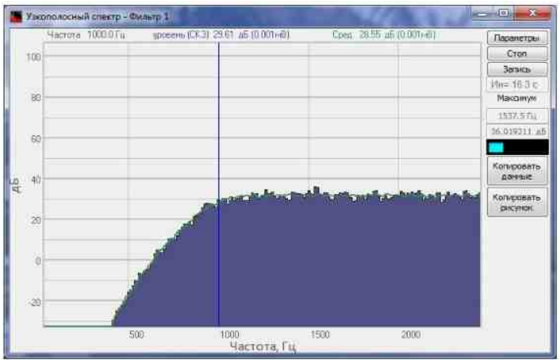
Bandpass filters .....

Band pass filters Selectable high and low pass filters (LPF, HPF)

in the **Signals filtration program**:

- cutoff (low pass filter) - passes frequencies up to F_{cutoff},
- HPF (high pass filter) - passes frequencies from F_{cutoff},
- BPF (bandpass filter) - passes frequencies in a given band,
- BPF (band-stop filter) - passes frequencies outside the specified band.

The figures below show the spectra of the "white noise" signal processed by a low-pass filter with a cutoff frequency of 1000 Hz and a low-pass filter with a cutoff frequency of 1000 Hz

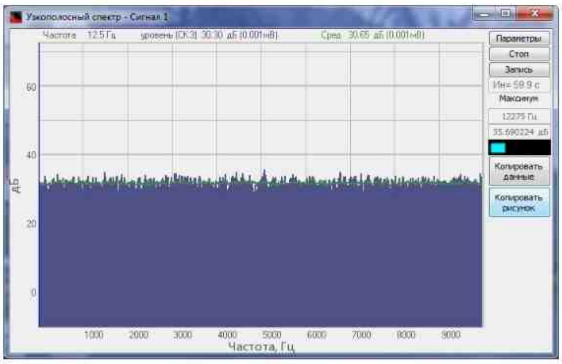


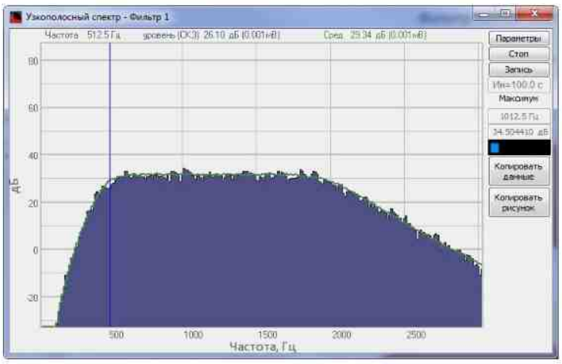
Low pass filter F_{cutoff} = 1000 Hz

High pass filter F_{cutoff} = 1000 Hz

High-frequency and low-frequency filters are implemented as Butterworth filters of 2, 4, 6, 8 or 10 orders with infinite impulse response. The filter coefficients are calculated according to standard techniques found in the literature (eg Richard Lyons , Digital Signal Processing, Chapter 6). The order of the filters depends on the ratio of the filter cutoff frequency to the sampling frequency of the filtered channel: the larger this ratio, the higher the filter order.

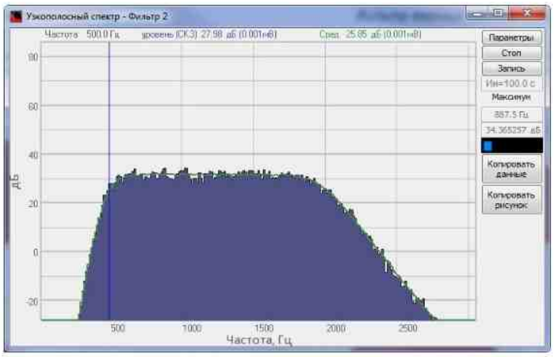
Filter cutoff frequencies F_{cutoff} are specified in Hz and set at minus 3 dB. You can change the slope of the filter by applying cascaded filtering. The figures below show the spectrum of the "white noise" signal processed by a band-pass filter with cutoff frequencies of 500 Hz and 5000 Hz, at various stages: without processing, one iteration, two iterations, three iterations:

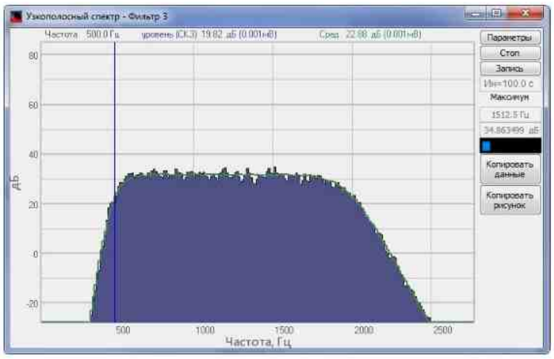




Low pass filter F_{cutoff} = 1000 Hz High pass filter F_{cutoff} = 1000 Hz

Spectrum of the original signal (white noise) Band pass filter 500...2000 Hz



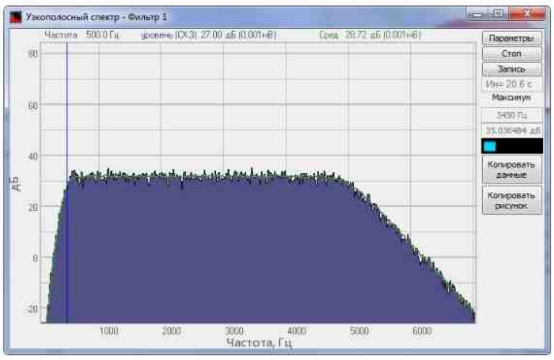


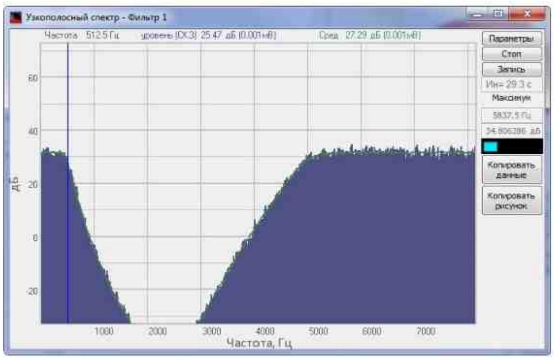
Bandpass filter 500...2000 Hz applied twice
Bandpass filter 500...2000 Hz applied three times

Cascade filtering is carried out as follows: several channels are created in the "Signal filtering" program:

- 1st channel of the program: first the filter is applied to the original signal
- 2nd channel of the program: the filter is applied to the processed signal, i.e. to the 1st channel of the program,
- 3rd channel of the program: the filter is applied to the processed signal, i.e. to the 2nd channel of the program,
- etc. required number of times

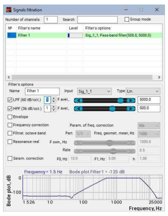
Bandpass and band-stop filters are created by combining high and low pass filters. The Bandpass filter is implemented by a combination of low-pass filter and high-pass filter with cutoff frequencies $F_{cutoff}LPF > F_{Cutoff}HPF$. When the LPF cutoff frequency is lower than the HPF cutoff frequency ($F_{cutoff}LPF < F_{cutoff}HPF$), a band-stop filter (BSF) is implemented. The figures below show examples of bandpass and band-stop filters with cutoff frequencies of 500 Hz and 5000 Hz.

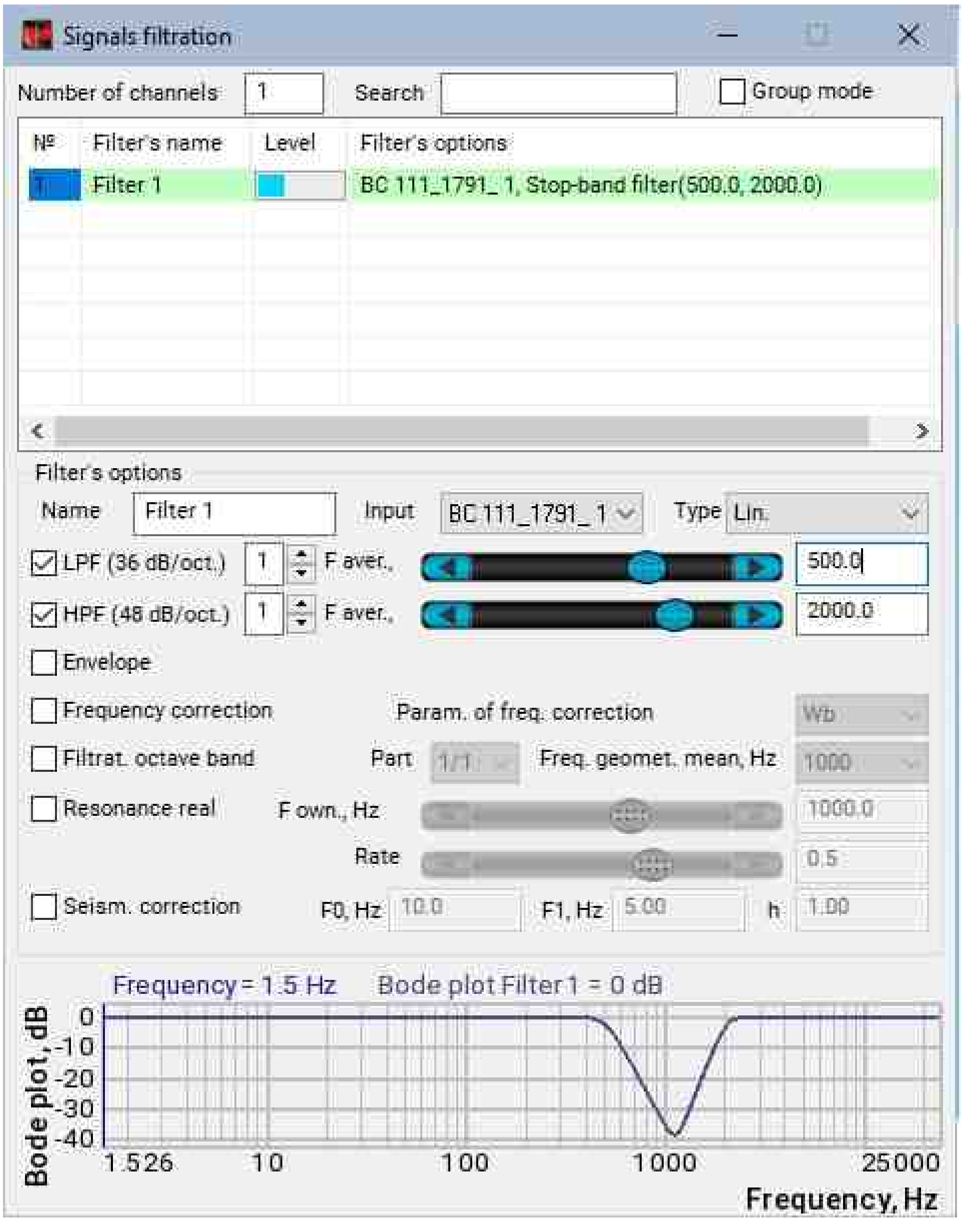




Bandpass filter $F_{cutoff}HPF = 500$ Hz; $F_{cutoff}LPF = 5000$ Hz *Band-stop filter $F_{cutoff}LPF = 500$ Hz; $F_{cutoff}HPF = 5000$ Hz*

The figures below show examples of setting up the **Signals filtration** program to implement bandpass and band-stop filters.





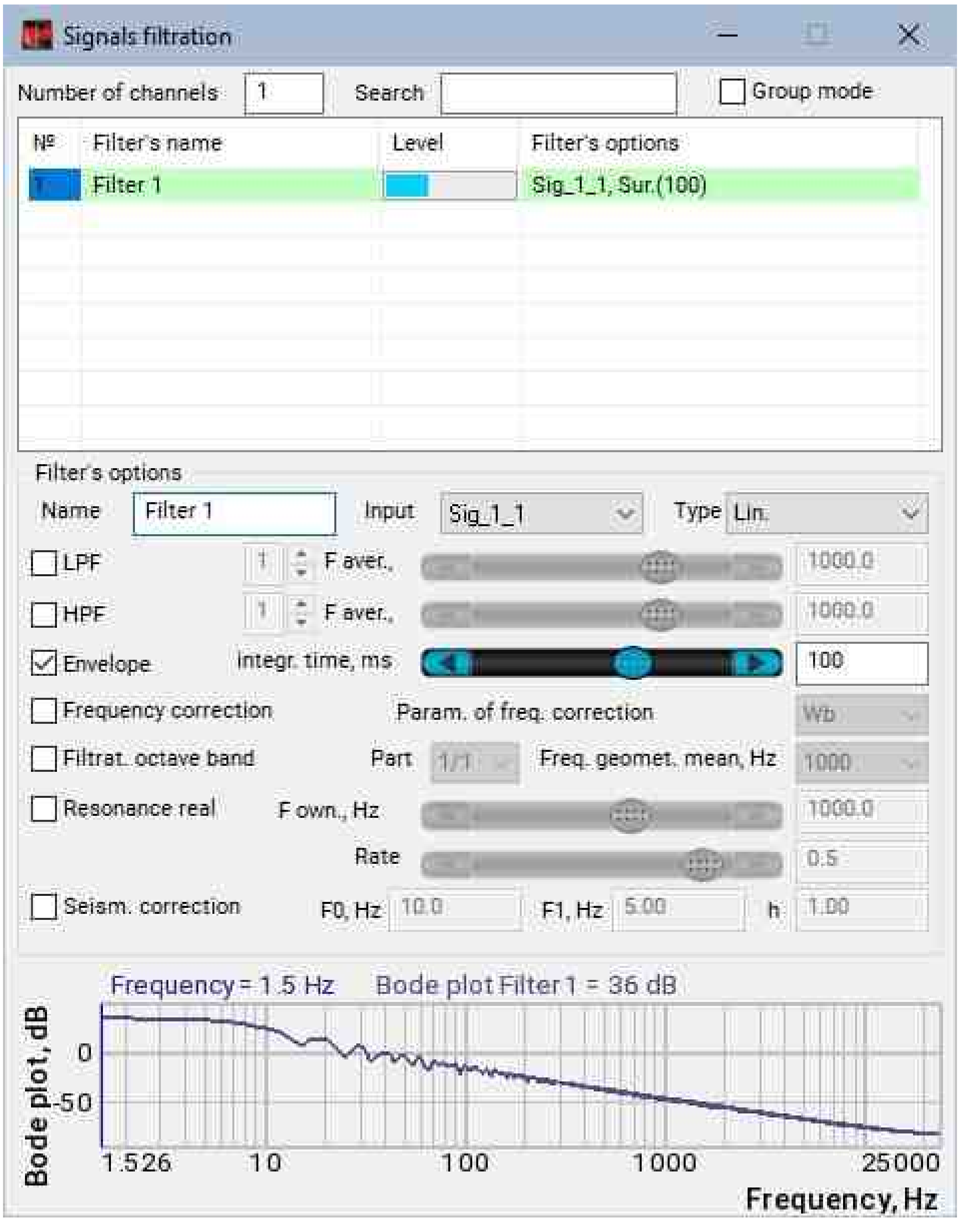
Bandpass filter with a band of 1000...5000 Hz. Bandpass filter setting

Band-stop filter with a band of 500...1000 Hz. Setting the band-stop filter

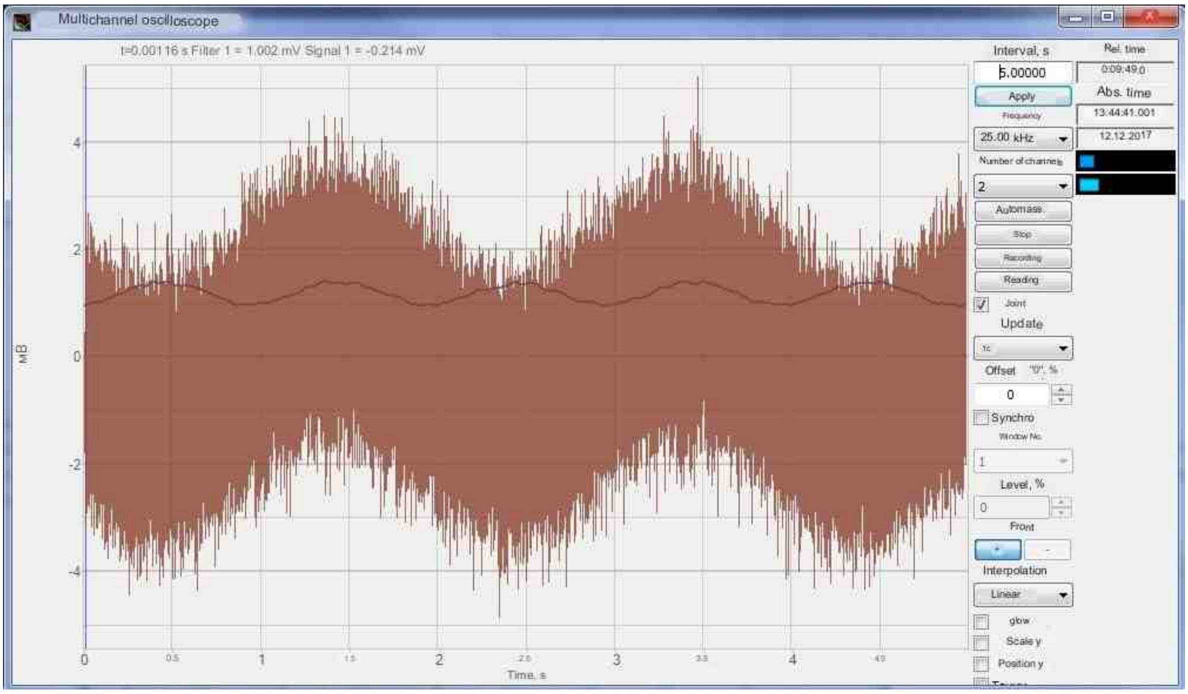
Signal envelope .....

Signals filtration program allows you to calculate the signal envelope. The level envelope is calculated as the smoothed RMS value of the signal. The parameter for the envelope function is the smoothing time, which is specified in ms . For vibrometers and sound level meters two averaging times are standardized "Fast" (125 ms) "Slow" (1000 ms).

The figures below show an example of calculating the envelope of an amplitude-modulated signal in the "**Signals filtration**" program



Calculation of the signal envelope in the "Signals filtration" program



Source signal and Envelope (Multi- channel oscilloscope, Combien mode)

Frequency correction .....

In the **Signals filtration** program , filters with frequency corrections are implemented:

- Wb , Wc , Wd , We , Wf , Wh , Wj , Wk , Wm , Fh , Fk , Fm (according to **GOST ISO 8041**);
- A, B, C, D (in accordance with **GOST 17187 (IEC 61672-1)**);
- CFC 60, CFC 180, CFC 600, CFC 1000 (according to **ISO 6487**).

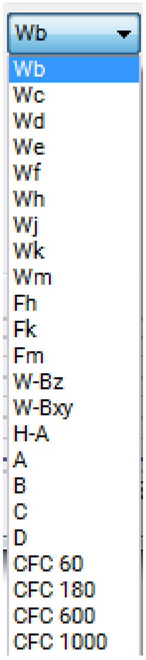


Fig. 1 List of corrective filters used in the program

Frequency correction

To measure the vibration action on the human body, it is possible to use frequency-correcting filters:

- **W- Bz** - to measure the total vibration (corrected vibration acceleration) in the vertical plane of the Z axis (in accordance with ISO 8041 and CH 2.2.4 / 2.1.8.566-96);
- **W- Bxy** - to measure the total vibration (corrected vibration acceleration) in the horizontal plane along the XY axes (in accordance with ISO 8041 and CH 2.2.4 / 2.1.8.566-96);
- **W- Bc** - to assess the impact of vibration on a person on the back of the seats (according to ISO 2631 and ISO 8041); (In developing)
- **Wk** - to measure the total vibration affecting a person along the Z axis (in accordance with ISO 8041, ISO 2631-1 and GOST 12.1.012) (currently not used in Russia);
- **Wd** - to measure the total transport vibration affecting a person along the XY axes (in accordance with ISO 8041, ISO 2631-1 and GOST 12.1.012) (currently not used in Russia);
- **Wh** - for measuring the general vibration affecting a person (in accordance with ISO 8041, ISO 2631-1 and GOST 12.1.012);
- **Wc** - to assess the impact of vibration on a person through the seat back (in accordance with ISO 8041, ISO 2631-1 and GOST 12.1.012) (currently not used in Russia);
- **Wj** - to assess the impact of vibration on the head of a lying person (in accordance with ISO 8041, ISO 2631-1 and GOST 12.1.012) (currently not used in Russia);
- **HA** - for measuring local vibration (corrected vibration acceleration) acting on parts of the human body along the three XYZ axes (in accordance with ISO 5349 and CH 2.2.4 / 2.1.8.566-96);
- **KB** - for measuring the general vibration on sea and river vessels (CV = W- Bc + 28.9 dB). (In developing)

Frequency correction W .....

The **Signals filtration** program implements filters with frequency corrections Wb , Wc , Wd , We , Wf , Wh , Wj , Wk , Wm in accordance with GOST ISO 8041-2006 and ISO 2631-4:

Note - In this annex, the values of the frequency correction function, its phases and the true geometric mean values of the frequencies of one-third octave bands are presented with an accuracy of four significant digits for absolute values and with an accuracy of two decimal places for relative values (in dB). This should not be interpreted as an accuracy required from a measuring instrument.

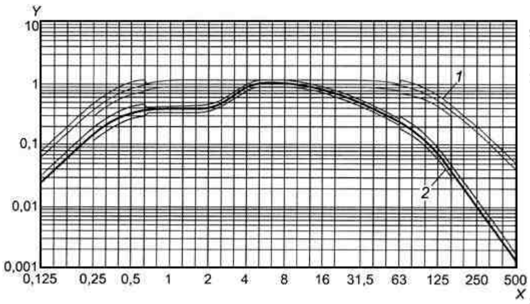
Table 1 - Frequency correction function Wb for total vibration in the vertical direction (z-axis),

affecting a person in a sitting, standing or lying position (based on ISO 2631-4)

n	Geometric mean frequency, Hz		Bandpass filter characteristic			Frequency equalization function Wb			Tolerance		
	Nominal	True	Module, %	dB	Phase, °	Module, %	dB	Phase, °	Module, %	dB	$\Delta\varphi_0$, °
-10	0.1	0.1000	0.06238	-24.10	159.3	0.02494	-32.06	160.0	+26/-100	+2/-∞	+∞/-∞
-9	0.125	0.1259	0.09857	-20.12	153.6	0.03941	-28.09	154.5	+26/-100	+2/-∞	+∞/-∞
-8	0.16	0.1585	0.1551	-16.19	146.3	0.06198	-24.15	147.4	+26/-100	+2/-∞	+∞/-∞
-7	0.2	0.1995	0.2415	-12.34	136.6	0.09645	-20.31	138.1	+26/-100	+2/-∞	+∞/-∞
-6	0.25	0.2512	0.3669	-8.71	124.1	0.1464	-16.69	126.0	+26/-100	+2/-∞	+∞/-∞
-5	0.315	0.3162	0.5300	-5.51	108.3	0.2113	-13.50	110.7	+26/-21	+2/-2	+12/-12
-4	0.4	0.3981	0.7037	-3.05	90.06	0.2800	-11.06	93.14	+26/-21	+2/-2	+12/-12

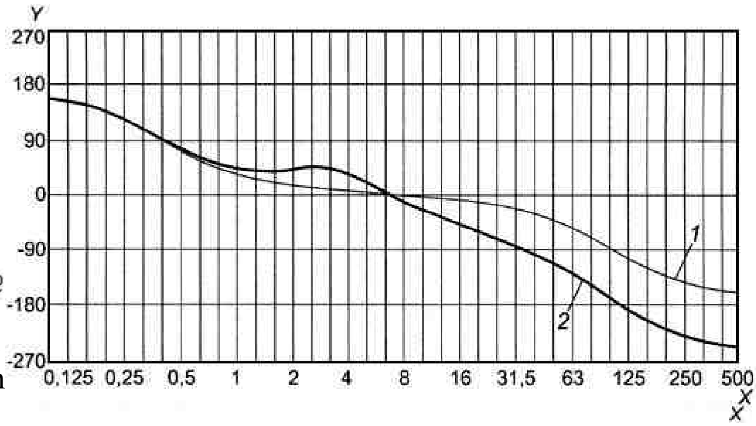
-3	0.5	0.5012	0.8434	-1.48	71.76	0.3347	-9.51	75.73	+26/-21	+2/-2	+12/-12
-2	0.63	0.6310	0.9279	-0.65	55.78	0.3666	-8.72	60.94	+12/-11	+1/-1	+6/-6
-1	0.8	0.7943	0.9693	-0.27	43.01	0.3808	-8.39	49.84	+12/-11	+1/-1	+6/-6
0	1	1.000	0.9874	-0.11	33.15	0.3853	-8.29	42.42	+12/-11	+1/-1	+6/-6
1	1.25	1.259	0.9949	-0.04	25.54	0.3864	-8.26	38.51	+12/-11	+1/-1	+6/-6
2	1.6	1.585	0.9980	-0.02	19.58	0.3916	-8.14	38.27	+12/-11	+1/-1	+6/-6
3	2	1.995	0.9992	-0.01	14.84	0.4168	-7.60	41.76	+12/-11	+1/-1	+6/-6
4	2.5	2.512	0.9997	0.00	10.97	0.4960	-6.09	46.57	+12/-11	+1/-1	+6/-6
5	3.15	3.162	0.9999	0.00	7.740	0.6653	-3.54	45.79	+12/-11	+1/-1	+6/-6
6	4	3.981	0.9999	0.00	4.941	0.8850	-1.06	34.64	+12/-11	+1/-1	+6/-6
7	5	5.012	1.0000	0.00	2.416	1.026	0.22	17.75	+12/-11	+1/-1	+6/-6
8	6.3	6.310	1.0000	0.00	0.0244	1.054	0.46	1.770	+12/-11	+1/-1	+6/-6
9	8	7.943	1.0000	0.00	-2.366	1.026	0.23	-11.94	+12/-11	+1/-1	+6/-6
10	10	10.00	0.9999	0.00	-4.887	0.9745	-0.22	-24.56	+12/-11	+1/-1	+6/-6
11	12.5	12.59	0.9999	0.00	-7.679	0.9042	-0.87	-37.10	+12/-11	+1/-1	+6/-6

12	16	15.85	0.9997	0.00	-10.90	0.8144	-1.78	-49.93	+12/-11	+1/-1	+6/-6
13	20	19.95	0.9992	-0.01	-14.75	0.7088	-2.99	-62.89	+12/-11	+1/-1	+6/-6
14	25	25.12	0.9980	-0.02	-19.47	0.5973	-4.48	-75.75	+12/-11	+1/-1	+6/-6
15	31.5	31.62	0.9950	-0.04	-25.40	0.4906	-6.18	-88.55	+12/-11	+1/-1	+6/-6
16	40	39.81	0.9877	-0.11	-32.97	0.3950	-8.07	-101.7	+12/-11	+1/-1	+6/-6
17	50	50.12	0.9699	-0.27	-42.78	0.3118	-10.12	-116.0	+12/-11	+1/-1	+6/-6
18	63	63.10	0.9291	-0.64	-55.49	0.2389	-12.44	-132.2	+12/-11	+1/-1	+6/-6
19	80	79.43	0.8457	-1.46	-71.41	0.1734	-15.22	-150.9	+26/-21	+2/-2	+12/-12
20	100	100.0	0.7071	-3.01	-89.68	0.1154	-18.75	-171.3	+26/-21	+2/-2	+12/-12
21	125	125.9	0.5336	-5.46	-107.9	0.06929	-23.19	-191.3	+26/-21	+2/-2	+12/-12
22	160	158.5	0.3699	-8.64	-123.8	0.03818	-28.36	-208.5	+26/-100	+2/-∞	+∞/-∞
23	200	199.5	0.2436	-12.27	-136.4	0.01999	-33.98	-222.2	+26/-100	+2/-∞	+∞/-∞
24	250	251.2	0.1565	-16.11	-146.1	0.01020	-39.82	-232.8	+26/-100	+2/-∞	+∞/-∞
25	315	316.2	0.09950	-20.04	-153.5	0.005154	-45.76	-240.8	+26/-100	+2/-∞	+∞/-∞
26	400	398.1	0.06297	-24.02	-159.2	0.002591	-51.73	-247.1	+26/-100	+2/-∞	+∞/-∞



X - frequency, Hz; Y - weighting factor; *1* - bandpass filter; *2* - frequency correction **function** Wb

Fig. 1 - Frequency correction function module Wb



X - frequency. Hz; Y - phase, °; *1* - bandpass filter; *2* - frequency correction **function** Wb

Fig. 2 - Phase of the frequency correction function Wb,

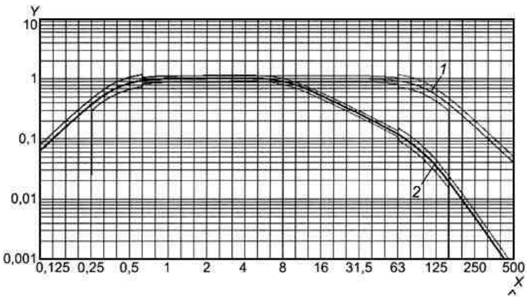
Table 2 - Frequency correction function **Wc** for total vibration in the horizontal direction (x-axis), acting on a person in a sitting position, seatback (based on ISO 2631-1)

n	Geometric mean frequency, Hz		Bandpass filter characteristic			Frequency equalization function Wb			Tolerance		
	Nominal	True	Module, %	dB	Phase, °	Module, %	dB	Phase, °	Module, %	dB	$\Delta\varphi_0$, °
-10	0.1	0.1000	0.06238	-24.10	159.3	0.06238	-24.10	158.8	+26/-100	+2/-∞	+∞/-∞
-9	0.125	0.1259	0.09857	-20.12	153.6	0.09858	-20.12	153.1	+26/-100	+2/-∞	+∞/-∞
-8	0.16	0.1585	0.1551	-16.19	146.3	0.1551	-16.19	145.6	+26/-100	+2/-∞	+∞/-∞
-7	0.2	0.1995	0.2415	-12.34	136.6	0.2415	-12.34	135.8	+26/-100	+2/-∞	+∞/-∞

-6	0.25	0.2512	0.3669	-8.71	124.1	0.3669	-8.71	123.0	+26/-100	+2/-∞	+∞/-∞
-5	0.315	0.3162	0.5300	-5.51	108.3	0.5302	-5.51	107.0	+26/-21	+2/-2	+12/-12
-4	0.4	0.3981	0.7037	-3.05	90.06	0.7042	-3.05	88.38	+26/-21	+2/-2	+12/-12
-3	0.5	0.5012	0.8434	-1.48	71.76	0.8442	-1.47	69.65	+26/-21	+2/-2	+12/-12
-2	0.63	0.6310	0.9279	-0.65	55.78	0.9292	-0.64	53.11	+12/-11	+1/-1	+6/-6
-1	0.8	0.7943	0.9693	-0.27	43.01	0.9716	-0.25	39.64	+12/-11	+1/-1	+6/-6
0	1	1.000	0.9874	-0.11	33.15	0.9910	-0.08	28.88	+12/-11	+1/-1	+6/-6
1	1.25	1.259	0.9949	-0.04	25.54	1.000	0.00	20.11	+12/-11	+1/-1	+6/-6
2	1.6	1.585	0.9980	-0.02	19.58	1.006	0.06	12.66	+12/-11	+1/-1	+6/-6
3	2	1.995	0.9992	-0.01	14.84	1.012	0.10	5.957	+12/-11	+1/-1	+6/-6
4	2.5	2.512	0.9997	0.00	10.97	1.017	0.15	-0.5318	+12/-11	+1/-1	+6/-6
5	3.15	3.162	0.9999	0.00	7.740	1.023	0.19	-7.327	+12/-11	+1/-1	+6/-6
6	4	3.981	0.9999	0.00	4.941	1.024	0.21	-15.00	+12/-11	+1/-1	+6/-6
7	5	5.012	1.0000	0.00	2.416	1.013	0.11	-24.10	+12/-11	+1/-1	+6/-6
8	6.3	6.310	1.0000	0.00	0.0244	0.9739	-0.23	-34.91	+12/-11	+1/-1	+6/-6

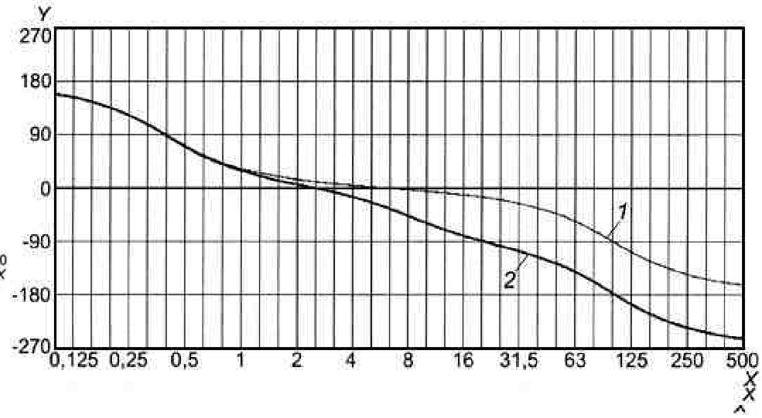
9	8	7.943	1.0000	0.00	-2.366	0.8941	-0.97	-47.06	+12/-11	+1/-1	+6/-6
10	10	10.00	0.9999	0.00	-4.887	0.7762	-2.20	-59.37	+12/-11	+1/-1	+6/-6
11	12.5	12.59	0.9999	0.00	-7.679	0.6425	-3.84	-70.70	+12/-11	+1/-1	+6/-6
12	16	15.85	0.9997	0.00	-10.90	0.5166	-5.74	-80.61	+12/-11	+1/-1	+6/-6
13	20	19.95	0.9992	-0.01	-14.75	0.4098	-7.75	-89.43	+12/-11	+1/-1	+6/-6
14	25	25.12	0.9980	-0.02	-19.47	0.3236	-9.80	-97.78	+12/-11	+1/-1	+6/-6
15	31.5	31.62	0.9950	-0.04	-25.40	0.2549	-11.87	-106.4	+12/-11	+1/-1	+6/-6
16	40	39.81	0.9877	-0.11	-32.97	0.2002	-13.97	-115.9	+12/-11	+1/-1	+6/-6
17	50	50.12	0.9699	-0.27	-42.78	0.1557	-16.15	-127.3	+12/-11	+1/-1	+6/-6
18	63	63.10	0.9291	-0.64	-55.49	0.1182	-18.55	-141.2	+12/-11	+1/-1	+6/-6
19	80	79.43	0.8457	-1.46	-71.41	0.08538	-21.37	-158.0	+26/-21	+2/-2	+12/-12
20	100	100.0	0.7071	-3.01	-89.68	0.05665	-24.94	-177.0	+26/-21	+2/-2	+12/-12
21	125	125.9	0.5336	-5.46	-107.9	0.03394	-29.39	-195.8	+26/-21	+2/-2	+12/-12
22	160	158.5	0.3699	-8.64	-123.8	0.01868	-34.57	-212.1	+26/-100	+2/-∞	+∞/-∞
23	200	199.5	0.2436	-12.27	-136.4	0.009772	-40.20	-225.1	+26/-100	+2/-∞	+∞/-∞

24	250	251.2	0.1565	-16.11	-146.1	0.004987	-46.04	-235.0	+26/-100	+2/-∞	+∞/-∞
25	315	316.2	0.09950	-20.04	-153.5	0.002518	-51.98	-242.6	+26/-100	+2/-∞	+∞/-∞
26	400	398.1	0.06297	-24.02	-159.2	0.001266	-57.95	-248.5	+26/-100	+2/-∞	+∞/-∞



X - frequency, Hz; Y - weighting factor; *1* - bandpass filter; *2* - frequency correction **function** Wc

Fig. 3 - Frequency correction function module Wc



X - frequency. Hz; Y - phase. °; *1* - bandpass filter; *2* - frequency correction **function** Wc

Fig. 4 - Phase of the frequency correction function Wc.

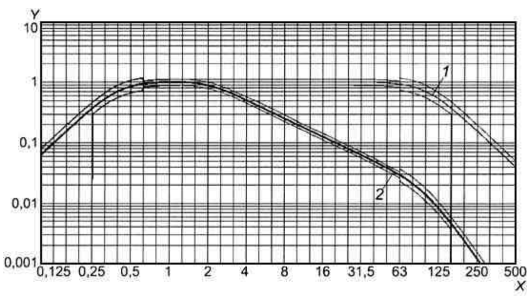
Table 3 - Frequency correction function **Wd** for total vibration in the horizontal direction (x or y axis), affecting a person in a sitting, standing or lying position (based on ISO 2631-1)

n	Geometric mean frequency, Hz		Bandpass filter characteristic			Frequency equalization function Wb			Tolerance		
	Nominal	True	Module, %	dB	Phase, °	Module, %	dB	Phase, °	Module, %	dB	$\Delta\varphi_0$, °

-10	0.1	0.1000	0.06238	-24.10	159.3	0.06242	-24.09	157.6	+26/-100	+2/-∞	+∞/-∞
-9	0.125	0.1259	0.09857	-20.12	153.6	0.09867	-20.12	151.5	+26/-100	+2/-∞	+∞/-∞
-8	0.16	0.1585	0.1551	-16.19	146.3	0.1553	-16.18	143.6	+26/-100	+2/-∞	+∞/-∞
-7	0.2	0.1995	0.2415	-12.34	136.6	0.2420	-12.32	133.2	+26/-100	+2/-∞	+∞/-∞
-6	0.25	0.2512	0.3669	-8.71	124.1	0.3862	-8.68	119.8	+26/-100	+2/-∞	+∞/-∞
-5	0.315	0.3162	0.5300	-5.51	108.3	0.5330	-5.47	102.8	+26/-21	+2/-2	+12/-12
-4	0.4	0.3981	0.7037	-3.05	90.06	0.7097	-2.98	83.11	+26/-21	+2/-2	+12/-12
-3	0.5	0.5012	0.8434	-1.48	71.76	0.8540	-1.37	62.84	+26/-21	+2/-2	+12/-12
-2	0.63	0.6310	0.9279	-0.65	55.78	0.9443	-0.50	44.21	+12/-11	+1/-1	+6/-6
-1	0.8	0.7943	0.9693	-0.27	43.01	0.9914	-0.08	27.86	+12/-11	+1/-1	+6/-6
0	1	1.000	0.9874	-0.11	33.15	1.011	0.10	13.09	+12/-11	+1/-1	+6/-6
1	1.25	1.259	0.9949	-0.04	25.54	1.007	0.06	-1.131	+12/-11	+1/-1	+6/-6
2	1.6	1.585	0.9980	-0.02	19.58	0.9707	-0.26	-15.55	+12/-11	+1/-1	+6/-6
3	2	1.995	0.9992	-0.01	14.84	0.8913	-1.00	-30.06	+12/-11	+1/-1	+6/-6

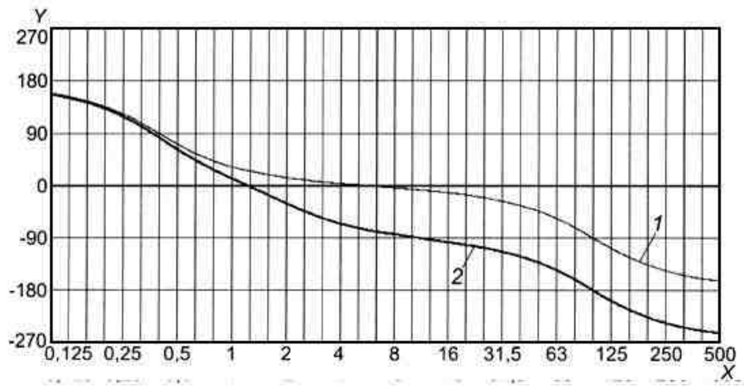
4	2.5	2.512	0.9997	0.00	10.97	0.7733	-2.23	-43.71	+12/-11	+1/-1	+6/-6
5	3.15	3.162	0.9999	0.00	7.740	0.6398	-3.88	-55.44	+12/-11	+1/-1	+6/-6
6	4	3.981	0.9999	0.00	4.941	0.5143	-5.78	-64.89	+12/-11	+1/-1	+6/-6
7	5	5.012	1.0000	0.00	2.416	0.4081	-7.78	-72.34	+12/-11	+1/-1	+6/-6
8	6.3	6.310	1.0000	0.00	0.0244	0.3226	-9.83	-78.34	+12/-11	+1/-1	+6/-6
9	8	7.943	1.0000	0.00	-2.366	0.2550	-11.87	-83.39	+12/-11	+1/-1	+6/-6
10	10	10.00	0.9999	0.00	-4.887	0.2017	-13.91	-87.90	+12/-11	+1/-1	+6/-6
11	12.5	12.59	0.9999	0.00	-7.679	0.1597	-15.93	-92.20	+12/-11	+1/-1	+6/-6
12	16	15.85	0.9997	0.00	-10.90	0.1266	-17.95	-96.59	+12/-11	+1/-1	+6/-6
13	20	19.95	0.9992	-0.01	-14.75	0.1004	-19.97	-101.3	+12/-11	+1/-1	+6/-6
14	25	25.12	0.9980	-0.02	-19.47	0.07958	-21.98	-106.8	+12/-11	+1/-1	+6/-6
15	31.5	31.62	0.9950	-0.04	-25.40	0.06299	-24.01	-113.3	+12/-11	+1/-1	+6/-6
16	40	39.81	0.9877	-0.11	-32.97	0.04965	-26.08	-121.3	+12/-11	+1/-1	+6/-6
17	50	50.12	0.9699	-0.27	-42.78	0.03872	-28.24	-131.4	+12/-11	+1/-1	+6/-6
18	63	63.10	0.9291	-0.64	-55.49	0.02946	-30.62	-144.4	+12/-11	+1/-1	+6/-6

19	80	79.43	0.8457	-1.46	-71.41	0.02130	-33.43	-160.6	+26/-21	+2/-2	+12/-12
20	100	100.0	0.7071	-3.01	-89.68	0.01414	-36.99	-179.0	+26/-21	+2/-2	+12/-12
21	125	125.9	0.5336	-5.46	-107.9	0.008478	-41.43	-197.4	+26/-21	+2/-2	+12/-12
22	160	158.5	0.3699	-8.64	-123.8	0.004668	-46.62	-213.4	+26/-100	+2/-∞	+∞/-∞
23	200	199.5	0.2436	-12.27	-136.4	0.002442	-52.24	-226.1	+26/-100	+2/-∞	+∞/-∞
24	250	251.2	0.1565	-16.11	-146.1	0.001246	-58.09	-235.8	+26/-100	+2/-∞	+∞/-∞
25	315	316.2	0.09950	-20.04	-153.5	0.000629	-64.02	-243.3	+26/-100	+2/-∞	+∞/-∞
26	400	398.1	0.06297	-24.02	-159.2	0.000316	-70.00	-249.0	+26/-100	+2/-∞	+∞/-∞



X - frequency, Hz; Y - weighting factor; *1* - bandpass filter; *2* - frequency correction **function** Wd

Fig. 5 - Frequency correction function module Wd



X - frequency. Hz; Y - phase, °; *1* - bandpass filter; *2* - frequency correction **function** Wd

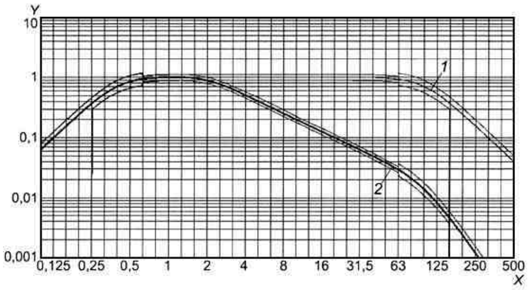
Fig. 6 - Phase of the frequency correction function Wd

Table 4 - Frequency correction function We for total angular vibration in all directions, affecting a person in a sitting position (based on ISO 2631-1)

n	Geometric mean frequency, Hz		Bandpass filter characteristic			Frequency equalization function Wb			Tolerance		
	Nominal	True	Module, %	dB	Phase, °	Module, %	dB	Phase, °	Module, %	dB	$\Delta\varphi_0$, °
-10	0.1	0.1000	0.06238	-24.10	159.3	0.06252	-24.08	155.9	+26/-100	+2/-∞	+∞/-∞
-9	0.125	0.1259	0.09857	-20.12	153.6	0.09893	-20.09	149.3	+26/-100	+2/-∞	+∞/-∞
-8	0.16	0.1585	0.1551	-16.19	146.3	0.1560	-16.14	140.8	+26/-100	+2/-∞	+∞/-∞
-7	0.2	0.1995	0.2415	-12.34	136.6	0.2435	-12.27	129.7	+26/-100	+2/-∞	+∞/-∞
-6	0.25	0.2512	0.3669	-8.71	124.1	0.3715	-8.60	115.1	+26/-100	+2/-∞	+∞/-∞
-5	0.315	0.3162	0.5300	-5.51	108.3	0.5394	-5.36	96.68	+26/-21	+2/-2	+12/-12
-4	0.4	0.3981	0.7037	-3.05	90.06	0.7198	-2.86	74.87	+26/-21	+2/-2	+12/-12
-3	0.5	0.5012	0.8434	-1.48	71.76	0.8635	-1.27	51.65	+26/-21	+2/-2	+12/-12
-2	0.63	0.6310	0.9279	-0.65	55.78	0.9389	-0.55	29.04	+12/-11	+1/-1	+6/-6

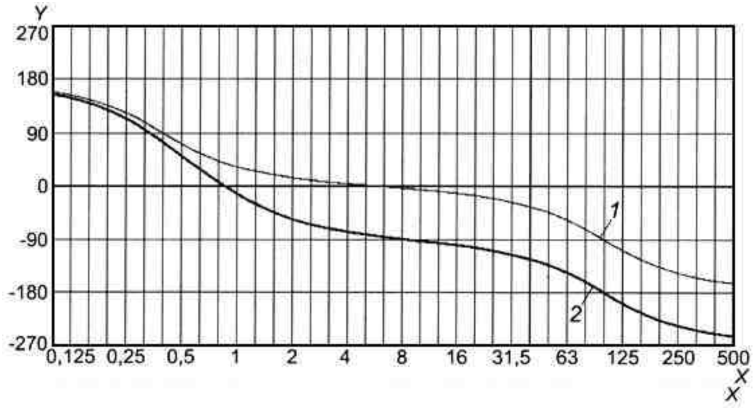
-1	0.8	0.7943	0.9693	-0.27	43.01	0.9423	-0.52	7.786	+12/-11	+1/-1	+6/-6
0	1	1.000	0.9874	-0.11	33.15	0.8798	-1.11	-11.85	+12/-11	+1/-1	+6/-6
1	1.25	1.259	0.9949	-0.04	25.54	0.7683	-2.29	-29.24	+12/-11	+1/-1	+6/-6
2	1.6	1.585	0.9980	-0.02	19.58	0.6372	-3.91	-43.67	+12/-11	+1/-1	+6/-6
3	2	1.995	0.9992	-0.01	14.84	0.5127	-5.80	-55.05	+12/-11	+1/-1	+6/-6
4	2.5	2.512	0.9997	0.00	10.97	0.4070	-7.81	-63.83	+12/-11	+1/-1	+6/-6
5	3.15	3.162	0.9999	0.00	7.740	0.3218	-9.85	-70.66	+12/-11	+1/-1	+6/-6
6	4	3.981	0.9999	0.00	4.941	0.2543	-11.89	-76.11	+12/-11	+1/-1	+6/-6
7	5	5.012	1.0000	0.00	2.416	0.2012	-13.93	-80.61	+12/-11	+1/-1	+6/-6
8	6.3	6.310	1.0000	0.00	0.0244	0.1594	-15.95	-84.51	+12/-11	+1/-1	+6/-6
9	8	7.943	1.0000	0.00	-2.366	0.1263	-17.97	-88.06	+12/-11	+1/-1	+6/-6
10	10	10.00	0.9999	0.00	-4.887	0.1002	-19.98	-91.49	+12/-11	+1/-1	+6/-6
11	12.5	12.59	0.9999	0.00	-7.679	0.07954	-21.99	-94.99	+12/-11	+1/-1	+6/-6
12	16	15.85	0.9997	0.00	-10.90	0.06314	-23.99	-98.77	+12/-11	+1/-1	+6/-6
13	20	19.95	0.9992	-0.01	-14.75	0.05011	-26.00	-103.1	+12/-11	+1/-1	+6/-6

14	25	25.12	0.9980	-0.02	-19.47	0.03975	-28.01	-108.1	+12/-11	+1/-1	+6/-6
15	31.5	31.62	0.9950	-0.04	-25.40	0.03147	-30.04	-114.3	+12/-11	+1/-1	+6/-6
16	40	39.81	0.9877	-0.11	-32.97	0.02481	-32.11	-122.1	+12/-11	+1/-1	+6/-6
17	50	50.12	0.9699	-0.27	-42.78	0.01935	-34.26	-132.1	+12/-11	+1/-1	+6/-6
18	63	63.10	0.9291	-0.64	-55.49	0.01473	-36.64	-145.0	+12/-11	+1/-1	+6/-6
19	80	79.43	0.8457	-1.46	-71.41	0.01065	-39.46	-161.0	+26/-21	+2/-2	+12/-12
20	100	100.0	0.7071	-3.01	-89.68	0.007071	-43.01	-179.3	+26/-21	+2/-2	+12/-12
21	125	125.9	0.5336	-5.46	-107.9	0.004239	-47.46	-197.7	+26/-21	+2/-2	+12/-12
22	160	158.5	0.3699	-8.64	-123.8	0.002334	-52.64	-213.6	+26/-100	+2/-∞	+∞/-∞
23	200	199.5	0.2436	-12.27	-136.4	0.001221	-58.27	-226.2	+26/-100	+2/-∞	+∞/-∞
24	250	251.2	0.1565	-16.11	-146.1	0.0006232	-64.11	-236.0	+26/-100	+2/-∞	+∞/-∞
25	315	316.2	0.09950	-20.04	-153.5	0.0003147	-70.04	-243.4	+26/-100	+2/-∞	+∞/-∞
26	400	398.1	0.06297	-24.02	-159.2	0.0001528	-76.02	-249.1	+26/-100	+2/-∞	+∞/-∞



X is the frequency. Hz; Y - weighting factor; *1* - bandpass filter; *2* - frequency correction **function** We

Fig. 7 - Frequency correction function module We



X - frequency, Hz; Y - phase, °; *1* - bandpass filter; *2* - frequency correction **function** We

Fig. 8 - Phase of the frequency correction function We ,

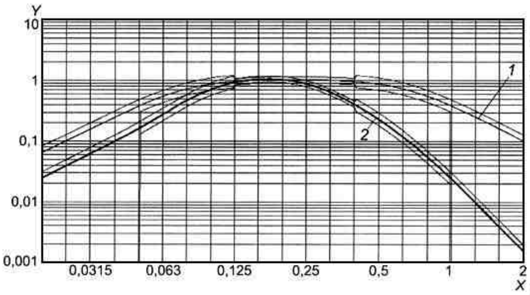
Table **5** - Frequency correction function **Wf** for general low-frequency vibration in the vertical direction (z-axis),

affecting a person in a sitting or standing position (based on ISO 2631-1)

n	Geometric mean frequency, Hz		Bandpass filter characteristic			Frequency equalization function Wb			Tolerance		
	Nominal	True	Module, %	dB	Phase, °	Module, %	dB	Phase, °	Module, %	dB	$\Delta\varphi_0$, °
-17	0.02	0.01995	0.06208	-24.14	156.8	0.02407	-32.37	160.9	+26/-100	+2/-∞	+∞/-∞
-16	0.025	0.02512	0.09811	-20.17	150.5	0.03803	-28.40	156.2	+26/-100	+2/-∞	+∞/-∞
-15	0.0315	0.03162	0.1544	-16.23	142.4	0.06021	-24.41	150.6	+26/-100	+2/-∞	+∞/-∞

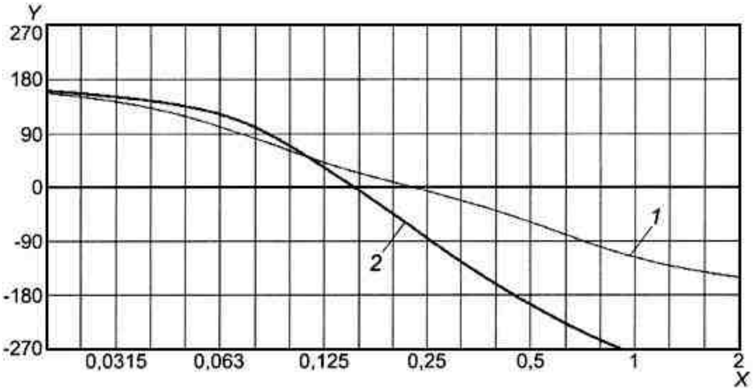
-14	0.04	0.03981	0.2404	-12.38	131.8	0.09619	-20.34	143.7	+26/-100	+2/-∞	+∞/-∞
-13	0.05	0.05012	0.3653	-8.75	118.0	0.1575	-16.06	134.8	+26/-100	+2/-∞	+∞/-∞
-12	0.063	0.06310	0.5282	-5.54	100.6	0.2675	-11.45	121.4	+26/-21	+2/-2	+12/-12
-11	0.08	0.07943	0.7020	-3.07	80.31	0.4537	-6.86	99.53	+26/-21	+2/-2	+12/-12
-10	0.1	0.1000	0.8420	-1.49	59.38	0.6951	-3.16	68.36	+26/-21	+2/-2	+12/-12
-9	0.125	0.1259	0.9265	-0.66	40.04	0.9000	-0.92	32.06	+12/-11	+1/-1	+6/-6
-8	0.16	0.1585	0.9671	-0.29	22.97	1.004	0.04	-5.596	+12/-11	+1/-1	+6/-6
-7	0.2	0.1995	0.9824	-0.15	7.579	0.9928	-0.06	-44.61	+12/-11	+1/-1	+6/-6
-6	0.25	0.2512	0.9826	-0.15	-7.217	0.8501	-1.41	-85.43	+12/-11	+1/-1	+6/-6
-5	0.315	0.3162	0.9677	-0.29	-22.58	0.6149	-4.22	-125.5	+12/-11	+1/-1	+6/-6
-4	0.4	0.3981	0.9279	-0.65	-39.60	0.3884	-8.22	-162.1	+12/-11	+1/-1	+6/-6
-3	0.5	0.5012	0.8447	-1.47	-58.89	0.2225	-13.05	-195.6	+26/-21	+2/-2	+12/-12
-2	0.63	0.6310	0.7059	-3.02	-79.79	0.1157	-18.73	-226.8	+26/-21	+2/-2	+12/-12
-1	0.8	0.7943	0.5324	-5.47	-100.1	0.05434	-25.30	-254.6	+26/-21	+2/-2	+12/-12
0	1	1	0.3689	-8.66	-117.6	0.02352	-32.57	-277.7	+26/-100	+2/-∞	+∞/-∞

1	1.25	1.259	0.2429	-12.29	-131.5	0.00971	-40.26	-295.8	+26/-100	+2/-∞	+∞/-∞
2	1.6	1.585	0.1561	-16.13	-142.2	0.00392	-48.14	-309.8	+26/-100	+2/-∞	+∞/-∞
3	2	1.995	0.0992	-20.07	-150.4	0.00157	-56.11	-320.6	+26/-100	+2/-∞	+∞/-∞



X is the frequency. Hz; Y - weighting factor; *1* - bandpass filter; *2* - frequency correction **function** Wf

Fig. 9 - Frequency correction function module Wf



X - frequency, Hz; Y - phase, °; *1* - bandpass filter; *2* - frequency correction **function** Wf

Fig. 8 - Phase of the frequency correction function Wf,

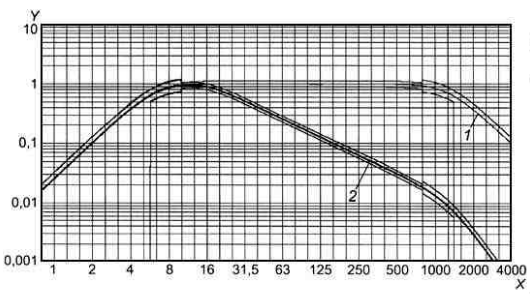
Table 6 - Wh frequency correction function for local vibration in all directions (based on ISO 5349-1)

n	Geometric mean frequency, Hz		Bandpass filter characteristic			Frequency equalization function Wb			Tolerance		
	Nominal	True	Module, %	dB	Phase, °	Module, %	dB	Phase, °	Module, %	dB	$\Delta\varphi_0$, °

-1	0.8	0.7943	0.01585	-36.00	169.7	0.01586	-36.00	168.1	+26/-100	+2/-∞	+∞/-∞
0	1	1.000	0.02511	-32.00	167.0	0.02514	-31.99	165.0	+26/-100	+2/-∞	+∞/-∞
1	1.25	1.259	0.03978	-28.01	163.5	0.03985	-27.99	161.0	+26/-100	+2/-∞	+∞/-∞
2	1.6	1.585	0.06297	-24.02	159.1	0.06314	-23.99	155.9	+26/-100	+2/-∞	+∞/-∞
3	2	1.995	0.09950	-20.04	153.4	0.09992	-20.01	149.3	+26/-100	+2/-∞	+∞/-∞
4	2.5	2.512	0.1565	-16.11	146.1	0.1576	-16.05	140.8	+26/-100	+2/-∞	+∞/-∞
5	3.15	3.162	0.2436	-12.27	136.4	0.2461	-12.18	129.7	+26/-100	+2/-∞	+∞/-∞
6	4	3.981	0.3699	-8.64	123.7	0.3754	-8.51	115.2	+26/-100	+2/-∞	+∞/-∞
7	5	5.012	0.5336	-5.46	107.9	0.5450	-5.27	96.70	+26/-21	+2/-2	+12/-12
8	6.3	6.310	0.7071	-3.01	89.59	0.7272	-2.77	74.91	+26/-21	+2/-2	+12/-12
9	8	7.943	0.8457	-1.46	71.30	0.8731	-1.18	51.74	+26/-21	+2/-2	+12/-12
10	10	10.00	0.9291	-0.64	55.36	0.9514	-0.43	29.15	+12/-11	+1/-1	+6/-6
11	12.5	12.59	0.9699	-0.27	42.62	0.9576	-0.38	7.810	+12/-11	+1/-1	+6/-6

12	16	15.85	0.9877	-0.11	32.76	0.8958	-0.96	-12.05	+12/-11	+1/-1	+6/-6
13	20	19.95	0.9950	-0.04	25.14	0.7820	-2.14	-29.71	+12/-11	+1/-1	+6/-6
14	25	25.12	0.9980	-0.02	19.15	0.6471	-3.78	-44.37	+12/-11	+1/-1	+6/-6
15	31.5	31.62	0.9992	-0.01	14.34	0.5192	-5.69	-55.89	+12/-11	+1/-1	+6/-6
16	40	39.81	0.9997	0.00	10.38	0.4111	-7.72	-64.78	+12/-11	+1/-1	+6/-6
17	50	50.12	0.9999	0.00	7.027	0.3244	-9.78	-71.70	+12/-11	+1/-1	+6/-6
18	63	63.10	0.9999	0.00	4.065	0.2560	-11.83	-77.27	+12/-11	+1/-1	+6/-6
19	80	79.43	1.000	0.00	1.330	0.2024	-13.88	-81.94	+12/-11	+1/-1	+6/-6
20	100	100.0	1.000	0.00	-1.330	0.1602	-15.91	-86.06	+ 12/-11	+ 1/-1	+ 6/-6
21	125	125.9	0.9999	0.00	-4.065	0.1270	-17.93	-88.92	+ 12/-11	+ 1/-1	+ 6/-6
22	160	158.5	0.9999	0.00	-7.027	0.1007	-19.94	-93.75	+ 12/-11	+ 1/-1	+ 6/-6
23	200	199.5	0.9997	0.00	-10.38	0.07988	-21.95	-97.80	+ 12/-11	+ 1/-1	+ 6/-6
24	250	251.2	0.9992	-0.01	-14.34	0.06338	-23.96	-102.3	+ 12/-11	+ 1/-1	+ 6/-6
25	315	316.2	0.9980	-0.02	-19.15	0.05026	-25.97	-107.5	+ 12/-11	+ 1/-1	+ 6/-6
26	400	398.1	0.9950	-0.04	-25.14	0.03980	-28.00	-113.8	+ 12/-11	+ 1/-1	+ 6/-6

27	500	501.2	0.9877	-0.11	-32.76	0.03137	-30.07	-121.7	+ 12/-11	+ 1/-1	+ 6/-6
28	630	631.0	0.9699	-0.27	-42.62	0.02447	-32.23	-131.8	+ 12/-11	+ 1/-1	+ 6/-6
29	800	794.3	0.9291	-0.64	-55.36	0.01862	-34.60	-144.7	+ 12/-11	+ 1/-1	+ 6/-6
30	1000	1000	0.8457	-1.46	-71.30	0.01346	-37.42	-160.8	+ 26/-21	+ 2/-2	+12/-12
31	1250	1259	0.7071	-3.01	-89.59	0.008940	-40.97	-179.2	+ 26/-21	+ 2/-2	+12/-12
32	1600	1585	0.5336	-5.46	-107.9	0.005359	-45.42	-197.5	+ 26/-21	+ 2/-2	+12/-12
33	2000	1995	0.3699	-8.64	-123.7	0.002950	-50.60	-213.5	+ 26/-100	+2/- ∞	+∞ /- ∞
34	2500	2512	0.2436	-12.27	-136.4	0.001544	-56.23	-226.2	+ 26/-100	+2/- ∞	+∞ /- ∞
35	3150	3162	0.1565	-16.11	-146.1	0.0007878	-62.07	-235.9	+ 26/-100	+2/- ∞	+∞ /- ∞
36	4000	3981	0.09950	-20.04	-153.4	0.0003978	-68.01	-243.3	+ 26/-100	+2/- ∞	+∞ /- ∞



X is the frequency. Hz; Y- weighting factor; 1 - bandpass filter; 2 - frequency correction function Wh

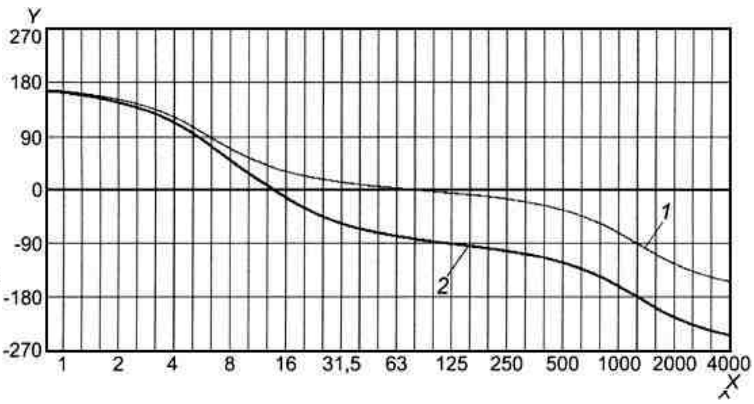


Fig. 11 - Wh equalization function module

X - frequency, Hz; Y - phase, °; *1* - bandpass filter; *2* - function of frequency correction Wh

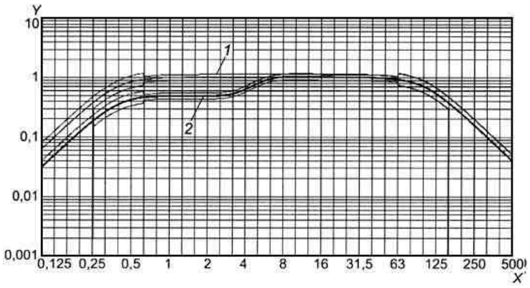
Fig. 12 - Phase of the frequency correction function Wh ,

Table 7 - Frequency correction function **Wj** for vibration in the vertical direction (X-axis) acting on the head of a lying person (based on ISO 2631-1)

n	Geometric mean frequency, Hz		Bandpass filter characteristic			Frequency equalization function Wb			Tolerance		
	Nominal	True	Module, %	dB	Phase, °	Module, %	dB	Phase, °	Module, %	dB	$\Delta\varphi_0$, °
-10	0.1	0.1000	0.06238	-24.10	159.3	0.03099	-30.18	159.8	+26/-100	+2/-∞	+∞/-∞
-9	0.125	0.1259	0.09857	-20.12	153.6	0.04897	-26.20	154.2	+26/-100	+2/-∞	+∞/-∞
-8	0.16	0.1585	0.1551	-16.19	146.3	0.07703	-22.27	147.0	+26/-100	+2/-∞	+∞/-∞
-7	0.2	0.1995	0.2415	-12.34	136.6	0.1199	-18.42	137.6	+26/-100	+2/-∞	+∞/-∞
-6	0.25	0.2512	0.3669	-8.71	124.1	0.1821	-14.79	125.3	+26/-100	+2/-∞	+∞/-∞
-5	0.315	0.3162	0.5300	-5.51	108.3	0.2630	-11.60	109.9	+26/-21	+2/-2	+12/-12
-4	0.4	0.3981	0.7037	-3.05	90.06	0.3489	-9.15	92.06	+26/-21	+2/-2	+12/-12
-3	0.5	0.5012	0.8434	-1.48	71.76	0.4176	-7.58	74.31	+26/-21	+2/-2	+12/-12

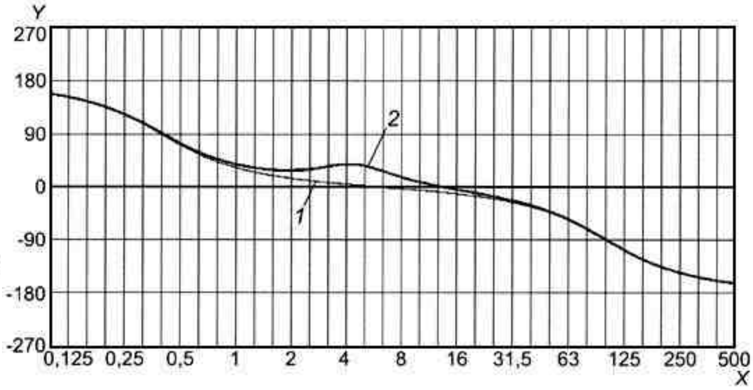
-2	0.63	0.6310	0.9279	-0.65	55.78	0.4585	-6.77	59.02	+12/-11	+1/-1	+6/-6
-1	0.8	0.7943	0.9693	-0.27	43.01	0.4776	-6.42	47.18	+12/-11	+1/-1	+6/-6
0	1	1.000	0.9874	-0.11	33.15	0.4844	-6.30	38.57	+12/-11	+1/-1	+6/-6
1	1.25	1.259	0.9949	-0.04	25.54	0.4851	-6.28	32.71	+12/-11	+1/-1	+6/-6
2	1.6	1.585	0.9980	-0.02	19.58	0.4832	-6.32	29.31	+12/-11	+1/-1	+6/-6
3	2	1.995	0.9992	-0.01	14.84	0.4819	-6.34	28.42	+12/-11	+1/-1	+6/-6
4	2.5	2.512	0.9997	0.00	10.97	0.4889	-6.22	30.41	+12/-11	+1/-1	+6/-6
5	3.15	3.162	0.9999	0.00	7.740	0.5246	-5.60	35.14	+12/-11	+1/-1	+6/-6
6	4	3.981	0.9999	0.00	4.941	0.6251	-4.08	39.31	+12/-11	+1/-1	+6/-6
7	5	5.012	1.0000	0.00	2.416	0.7948	-1.99	36.78	+12/-11	+1/-1	+6/-6
8	6.3	6.310	1.0000	0.00	0.0244	0.9470	-0.47	27.42	+12/-11	+1/-1	+6/-6
9	8	7.943	1.0000	0.00	-2.366	1.016	0.14	17.07	+12/-11	+1/-1	+6/-6
10	10	10.00	0.9999	0.00	-4.887	1.030	0.26	8.688	+12/-11	+1/-1	+6/-6
11	12.5	12.59	0.9999	0.00	-7.679	1.026	0.22	2.043	+12/-11	+1/-1	+6/-6
12	16	15.85	0.9997	0.00	-10.90	1.019	0.16	-3.729	+12/-11	+1/-1	+6/-6

13	20	19.95	0.9992	-0.01	-14.75	1.012	0.10	-9.330	+12/-11	+1/-1	+6/-6
14	25	25.12	0.9980	-0.02	-19.47	1.006	0.06	-15.31	+12/-11	+1/-1	+6/-6
15	31.5	31.62	0.9950	-0.04	-25.40	1.000	0.00	-22.16	+12/-11	+1/-1	+6/-6
16	40	39.81	0.9877	-0.11	-32.97	0.9911	-0.08	-30.43	+12/-11	+1/-1	+6/-6
17	50	50.12	0.9699	-0.27	-42.78	0.9720	-0.25	-40.78	+12/-11	+1/-1	+6/-6
18	63	63.10	0.9291	-0.64	-55.49	0.9304	-0.63	-53.90	+12/-11	+1/-1	+6/-6
19	80	79.43	0.8457	-1.46	-71.41	0.8465	-1.45	-70.15	+26/-21	+2/-2	+12/-12
20	100	100.0	0.7071	-3.01	-89.68	0.7075	-3.01	-88.68	+26/-21	+2/-2	+12/-12
21	125	125.9	0.5336	-5.46	-107.9	0.5338	-5.45	-107.1	+26/-21	+2/-2	+12/-12
22	160	158.5	0.3699	-8.64	-123.8	0.3700	-8.64	-123.2	+26/-100	+2/-∞	+∞/-∞
23	200	199.5	0.2436	-12.27	-136.4	0.2437	-12.26	-135.9	+26/-100	+2/-∞	+∞/-∞
24	250	251.2	0.1565	-16.11	-146.1	0.1565	-16.11	-145.7	+26/-100	+2/-∞	+∞/-∞
25	315	316.2	0.09950	-20.04	-153.5	0.09951	-20.04	-153.2	+26/-100	+2/-∞	+∞/-∞
26	400	398.1	0.06297	-24.02	-159.2	0.06297	-24.02	-158.9	+26/-100	+2/-∞	+∞/-∞



X - frequency, Hz; Y - weighting factor; *1* - bandpass filter; *2* - frequency correction **function** Wj

Fig. 13 - Frequency correction function module Wj



X - frequency, Hz; Y - phase, °; *1* - bandpass filter; *2* - frequency correction **function** Wj

Fig. 14 - Phase of the frequency correction function Wj

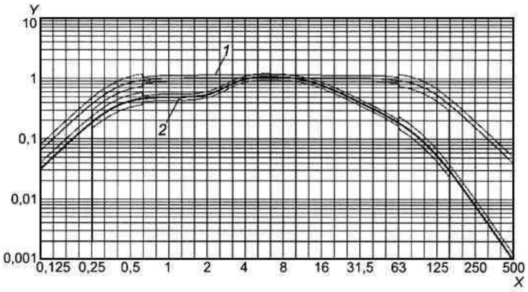
Table 8 - Frequency correction function Wk for total vibration in the vertical direction (z-axis), affecting a person in a sitting, standing or lying position (based on ISO 2631-1)

n	Geometric mean frequency, Hz		Bandpass filter characteristic			Frequency equalization function Wb			Tolerance		
	Nominal	True	Module, %	dB	Phase, °	Module, %	dB	Phase, °	Module, %	dB	$\Delta\varphi_0$, °
-10	0.1	0.1000	0.06238	-24.10	159.3	0.03121	-30.11	159.8	+26/-100	+2/-∞	+∞/-∞
-9	0.125	0.1259	0.09857	-20.12	153.6	0.04931	-26.14	154.3	+26/-100	+2/-∞	+∞/-∞
-8	0.16	0.1585	0.1551	-16.19	146.3	0.07756	-22.21	147.1	+26/-100	+2/-∞	+∞/-∞
-7	0.2	0.1995	0.2415	-12.3	136.6	0.1207	-18.37	137.7	+26/-100	+2/-∞	+∞/-∞

				4							
-6	0.25	0.2512	0.3669	-8.71	124.1	0.1832	-14.74	125.4	+26/-100	+2/-∞	+∞/-∞
-5	0.315	0.3162	0.5300	-5.51	108.3	0.2644	-11.55	109.9	+26/-21	+2/-2	+12/-12
-4	0.4	0.3981	0.7037	-3.05	90.06	0.3504	-9.11	92.20	+26/-21	+2/-2	+12/-12
-3	0.5	0.5012	0.8434	-1.48	71.76	0.4188	-7.56	74.54	+26/-21	+2/-2	+12/-12
-2	0.63	0.6310	0.9279	-0.65	55.78	0.4588	-6.77	59.44	+12/-11	+1/-1	+6/-6
-1	0.8	0.7943	0.9693	-0.27	43.01	0.4767	-6.44	47.96	+12/-11	+1/-1	+6/-6
0	1	1.000	0.9874	-0.11	33.15	0.4825	-6.33	40.06	+12/-11	+1/-1	+6/-6
1	1.25	1.259	0.9949	-0.04	25.54	0.4846	-6.29	35.55	+12/-11	+1/-1	+6/-6
2	1.6	1.585	0.9980	-0.02	19.58	0.4935	-6.13	34.48	+12/-11	+1/-1	+6/-6
3	2	1.995	0.9992	-0.01	14.84	0.5308	-5.50	36.45	+12/-11	+1/-1	+6/-6
4	2.5	2.512	0.9997	0.00	10.97	0.6335	-3.97	37.98	+12/-11	+1/-1	+6/-6
5	3.15	3.162	0.9999	0.00	7.740	0.8071	-1.86	32.73	+12/-11	+1/-1	+6/-6
6	4	3.981	0.9999	0.00	4.941	0.9648	-0.31	20.35	+12/-11	+1/-1	+6/-6
7	5	5.012	1.0000	0.00	2.416	1.039	0.33	6.309	+12/-11	+1/-1	+6/-6
8	6.3	6.310	1.0000	0.00	0.0244	1.054	0.46	-6.841	+12/-11	+1/-1	+6/-6

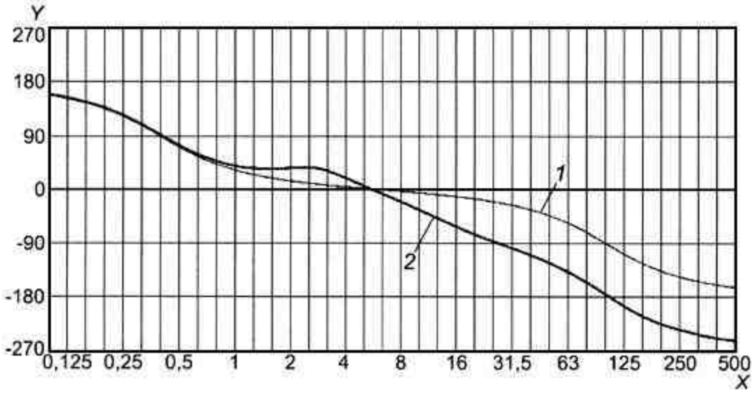
9	8	7.943	1.0000	0.00	-2.366	1.037	0.32	-19.73	+12/-11	+1/-1	+6/-6
10	10	10.00	0.9999	0.00	-4.887	0.9884	-0.10	-33.30	+12/-11	+1/-1	+6/-6
11	12.5	12.59	0.9999	0.00	-7.679	0.8989	-0.93	-47.62	+12/-11	+1/-1	+6/-6
12	16	15.85	0.9997	0.00	-10.90	0.7743	-2.22	-61.84	+12/-11	+1/-1	+6/-6
13	20	19.95	0.9992	-0.01	-14.75	0.6373	-3.91	-75.03	+12/-11	+1/-1	+6/-6
14	25	25.12	0.9980	-0.02	-19.47	0.5103	-5.84	-87.02	+12/-11	+1/-1	+6/-6
15	31.5	31.62	0.9950	-0.04	-25.40	0.4031	-7.89	-98.35	+12/-11	+1/-1	+6/-6
16	40	39.81	0.9877	-0.11	-32.97	0.3160	-10.01	-109.9	+12/-11	+1/-1	+6/-6
17	50	50.12	0.9699	-0.27	-42.78	0.2451	-12.21	-122.7	+12/-11	+1/-1	+6/-6
18	63	63.10	0.9291	-0.64	-55.49	0.1857	-14.62	-137.6	+12/-11	+1/-1	+6/-6
19	80	79.43	0.8457	-1.46	-71.41	0.1339	-17.47	-155.2	+26/-21	+2/-2	+12/-12
20	100	100.0	0.7071	-3.01	-89.68	0.08873	-21.04	-174.8	+26/-21	+2/-2	+12/-12
21	125	125.9	0.5336	-5.46	-107.9	0.05311	-25.50	-194.1	+26/-21	+2/-2	+12/-12
22	160	158.5	0.3699	-8.64	-123.8	0.02922	-30.69	-210.7	+26/-100	+2/-∞	+∞/-∞
23	200	199.5	0.2436	-12.27	-136.4	0.01528	-36.32	-224.0	+26/-100	+2/-∞	+∞/-∞

24	250	251.2	0.1565	-16.11	-146.1	0.007795	-42.16	-234.2	+26/-100	+2/-∞	+∞/-∞
25	315	316.2	0.09950	-20.04	-153.5	0.003935	-48.10	-241.9	+26/-100	+2/-∞	+∞/-∞
26	400	398.1	0.06297	-24.02	-159.2	0.001978	-54.08	-247.9	+26/-100	+2/-∞	+∞/-∞



X - frequency, Hz; Y - weighting factor; *1* - bandpass filter; *2* - frequency correction function Wk

Fig. 15 Frequency correction function module Wk



X - frequency, Hz; Y - phase, °; *1* - bandpass filter; *2* - frequency correction function Wk

Fig. 16 - Phase of the frequency correction function Wk

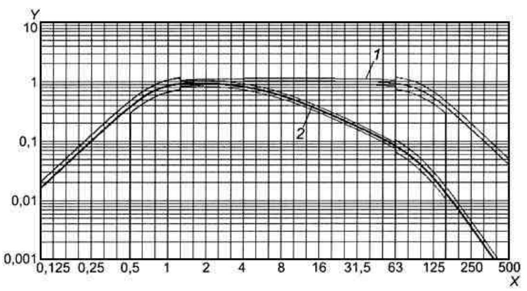
Table 9 — Frequency correction function Wm for general building vibration in all directions (based on ISO 2631-2)

n	Geometric mean frequency, Hz		Bandpass filter characteristic			Frequency equalization function Wb			Tolerance		
	Nominal	True	Module, %	dB	Phase, °	Module, %	dB	Phase, °	Module, %	dB	$\Delta\varphi_0$, °

-10	0.1	0.1000	0.01585	-36.00	169.7	0.01584	-36.00	168.7	+26/-100	+2/-∞	+∞/-∞
-9	0.125	0.1259	0.02511	-32.00	166.9	0.02510	-32.00	165.7	+26/-100	+2/-∞	+∞/-∞
-8	0.16	0.1585	0.03978	-28.01	163.5	0.03976	-28.01	161.9	+26/-100	+2/-∞	+∞/-∞
-7	0.2	0.1995	0.06297	-24.02	159.1	0.06293	-24.02	157.1	+26/-100	+2/-∞	+∞/-∞
-6	0.25	0.2512	0.0995	-20.04	153.4	0.09941	-20.05	150.8	+26/-100	+2/-∞	+∞/-∞
-5	0.315	0.3162	0.1565	-16.11	146.0	0.1563	-16.12	142.8	+26/-100	+2/-∞	+∞/-∞
-4	0.4	0.3981	0.2436	-12.27	136.3	0.2430	-12.29	132.2	+26/-100	+2/-∞	+∞/-∞
-3	0.5	0.5012	0.3699	-8.64	123.6	0.3684	-8.67	118.6	+26/-100	+2/-∞	+∞/-∞
-2	0.63	0.6310	0.5336	-5.45	107.7	0.5304	-5.51	101.3	+26/-21	+2/-2	+12/-12
-1	0.8	0.7943	0.7071	-3.01	89.36	0.7003	-3.09	81.40	+26/-21	+2/-2	+12/-12
0	1	1.000	0.8457	-1.46	71.00	0.8329	-1.59	42.49	+26/-21	+2/-2	+12/-12
1	1.25	1.259	0.9291	-0.64	54.98	0.9071	-0.85	26.56	+12/-11	+1/-1	+6/-6
2	1.6	1.585	0.9699	-0.27	42.14	0.9342	-0.59	12.83	+12/-11	+1/-1	+6/-6

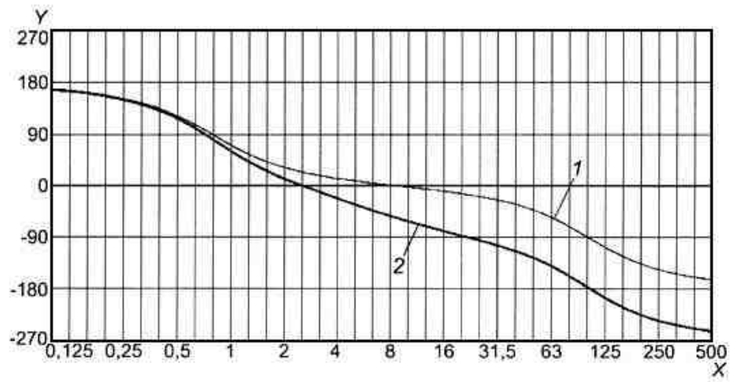
3	2	1.995	0.9877	-0.11	32.17	0.9319	-0.61	0.5459	+12/-11	+1/-1	+6/-6	
4	2.5	2.512	0.9950	-0.04	24.39	0.9101	-0.82	-10.89	+12/-11	+1/-1	+6/-6	
5	3.15	3.162	0.9980	-0.02	18.20	0.8721	-1.19	-21.86	+12/-11	+1/-1	+6/-6	
6	4	3.981	0.9992	-0.01	13.15	0.8184	-1.74	-32.52	+12/-11	+1/-1	+6/-6	
7	5	5.012	0.9997	0.00	8.884	0.7498	-2.50	-42.85	+12/-11	+1/-1	+6/-6	
8	6.3	6.310	0.9999	0.00	5.135	0.6692	-3.49	-52.73	+12/-11	+1/-1	+6/-6	
9	8	7.943	0.9999	0.00	1.680	0.5819	-4.70	-62.07	+12/-11	+1/-1	+6/-6	
10	10	10.00	0.9999	0.00	-1.680	0.4941	-6.12	-70.84	+12/-11	+1/-1	+6/-6	
11	12.5	12.59	0.9999	0.00	-5.135	0.4114	-7.71	-79.15	+12/-11	+1/-1	+6/-6	
12	16	15.85	0.9997	0.00	-8.884	0.3375	-9.44	-87.25	+12/-11	+1/-1	+6/-6	
13	20	19.95	0.9992	-0.01	-13.15	0.2738	-11.25	-95.45	+12/-11	+1/-1	+6/-6	
14	25	25.12	0.9980	-0.02	-18.20	0.2203	-13.14	-104.2	+12/-11	+1/-1	+6/-6	
15	31.5	31.62	0.9950	-0.04	-24.39	0.1760	-15.09	-114.0	+12/-11	+1/-1	+6/-6	
16	40	39.81	0.9877	-0.11	-32.17	0.1396	-17.10	-125.7	+12/-11	+1/-1	+6/-6	
17	50	50.12	0.9699	-0.27	-42.14	0.1093	-19.23	-139.8	+12/-11	+1/-1	+6/-6	

18	63	63.10	0.9291	-0.64	-54.98	0.08336	-21.58	-156.9	+12/-11	+1/-1	+6/-6
19	80	79.43	0.8457	-1.46	-71.00	0.06036	-24.38	-176.1	+26/-21	+2/-2	+12/-12
20	100	100.0	0.7071	-3.01	-89.36	0.04013	-27.93	-195.1	+26/-21	+2/-2	+12/-12
21	125	125.9	0.5336	-5.46	-107.7	0.02407	-32.37	-211.5	+26/-21	+2/-2	+12/-12
22	160	158.5	0.3699	-8.64	-123.6	0.01326	-37.55	-224.6	+26/-100	+2/-∞	+∞/-∞
23	200	199.5	0.2436	-12.27	-136.3	0.006937	-43.18	-234.7	+26/-100	+2/-∞	+∞/-∞
24	250	251.2	0.1565	-16.11	-146.0	0.003541	-49.02	-242.3	+26/-100	+2/-∞	+∞/-∞
25	315	316.2	0.09950	-20.04	-153.4	0.001788	-54.95	-248.3	+26/-100	+2/-∞	+∞/-∞
26	400	398.1	0.06297	-24.02	-159.1	0.000899	-60.92	-252.8	+26/-100	+2/-∞	+∞/-∞



X - frequency, Hz; Y - weighting factor; *1* - bandpass filter; *2* - frequency correction **function** Wm

Fig. 17 - Frequency correction function module Wm



X - frequency, Hz; Y - phase, °; *1* - bandpass filter; *2* - frequency correction **function** Wm

Fig. 18 - Phase of the frequency correction function Wm

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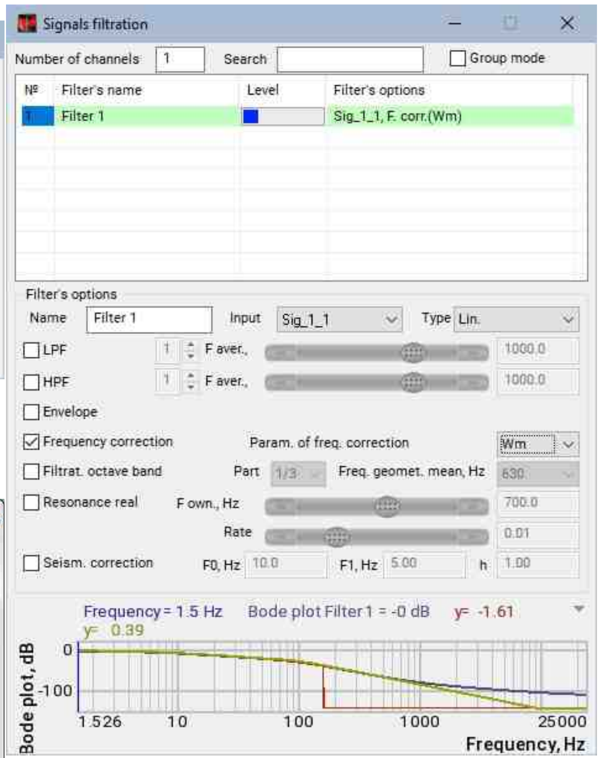
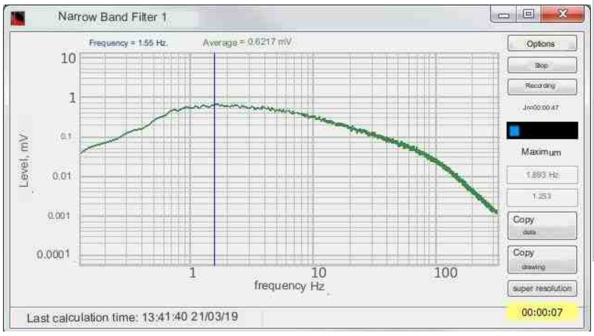
Examples of filters using ZETLAB programs

Setting "Signals generator"

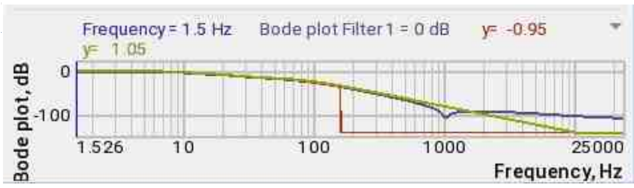


Setting "Signals filtration"

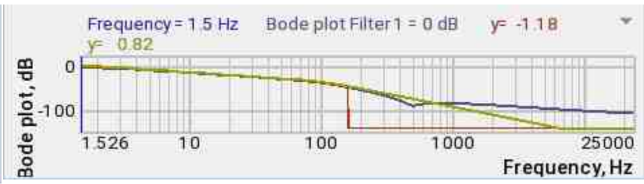


Setting "FFT Spectrum Analysis"

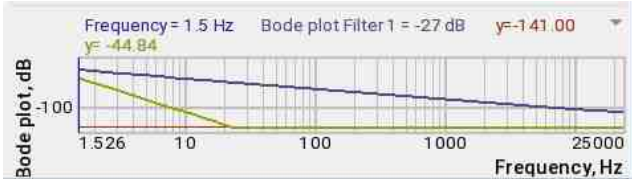
Examples of frequency filters in "Signals filtration"



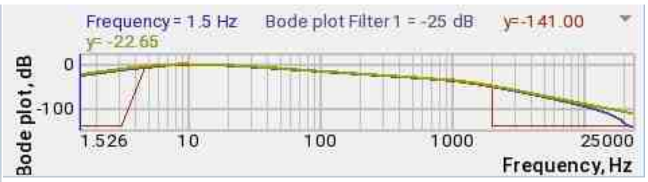
Frequency correction Wc



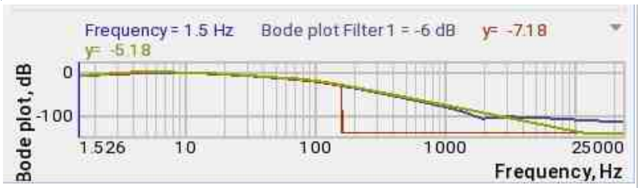
Frequency correction Wd



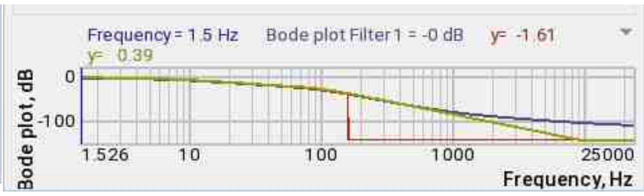
Frequency correction Wf



Frequency correction Wh

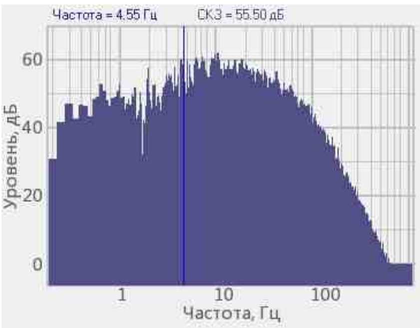


Frequency correction Wk

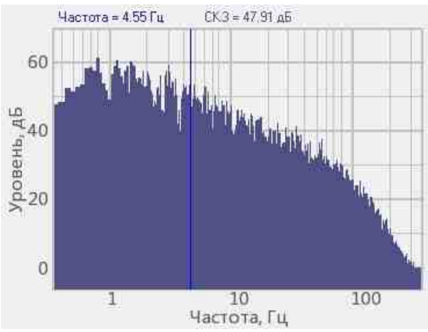


Frequency correction Wm

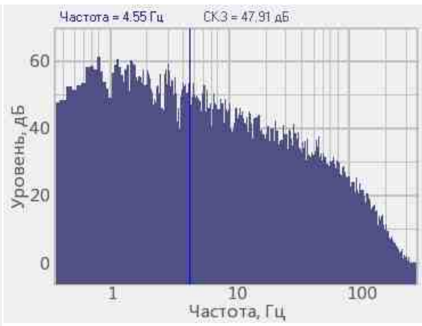
Examples of frequency filters in "FFT Spectrum Analysis"



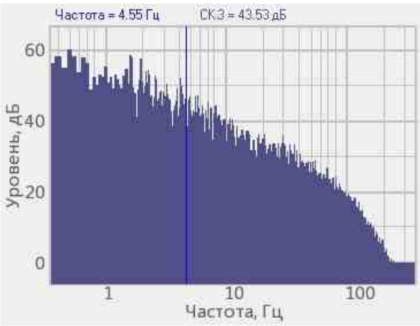
Frequency correction Wb



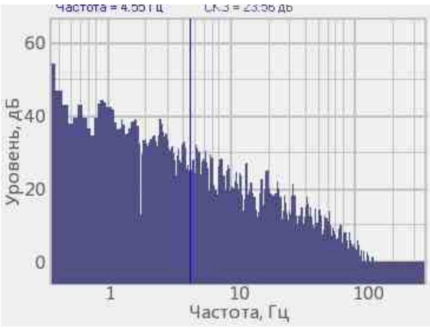
Frequency correction Wc



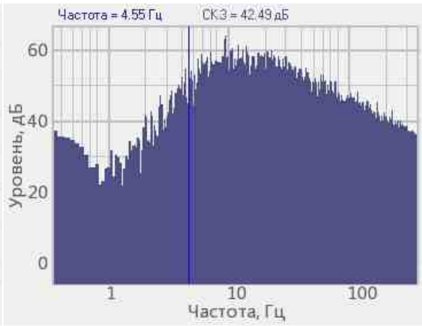
Frequency correction Wd



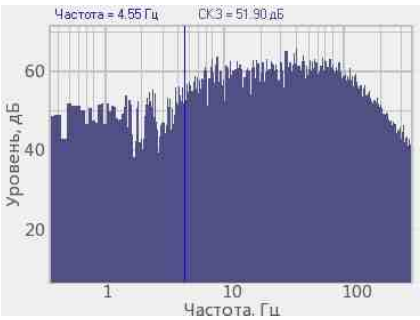
Frequency correction We



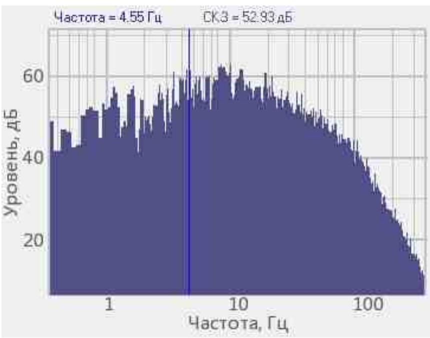
Frequency correction Wf



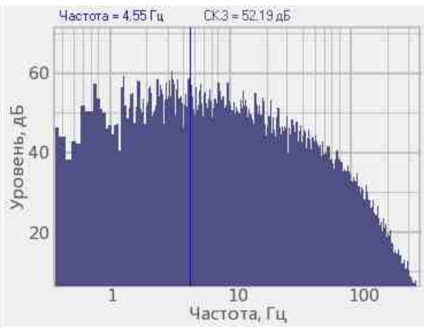
Frequency correction Wh



Frequency correction Wj



Frequency correction Wk



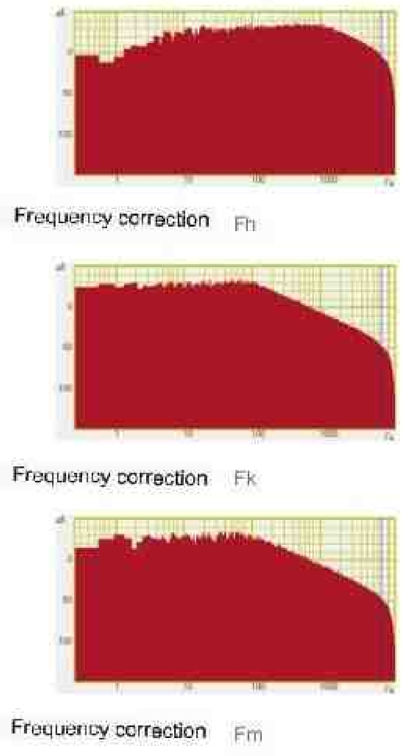
Frequency correction Wm

Linear filters .....

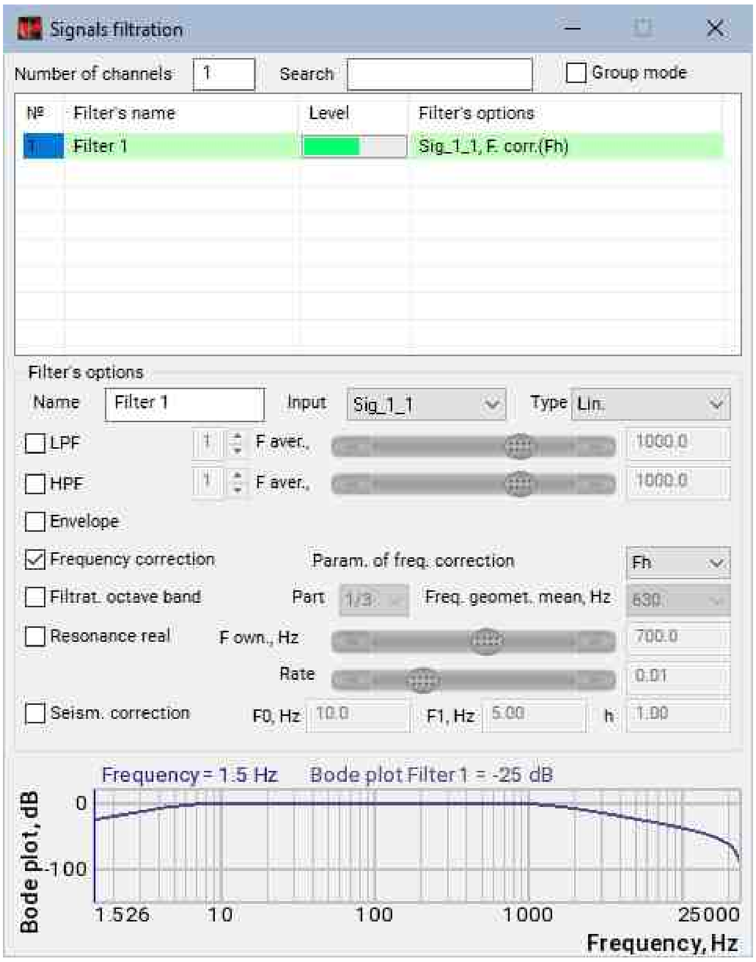
Signals filtration program implements linear filters with frequency corrections:

- ***Fh*** - linear BPF (bandpass filter) with a band of 6.8 ... 1286 Hz,
- ***Fk*** - linear BPF (bandpass filter) with a band of 0.4 ... 100 Hz,
- ***Fm*** - linear BPF (bandpass filter) with a band of 0.8 ... 100 Hz.

The results of the filters are shown below - the spectra of the signal processed by filters with frequency correction Fh, Fk, Fm.



Spectras of the signal processed by filters with frequency correction Fh , Fk , Fm

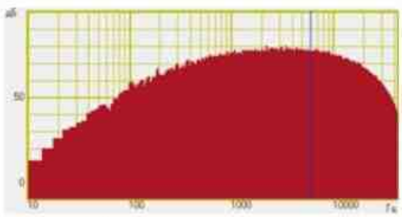


Filter with frequency correction Fh

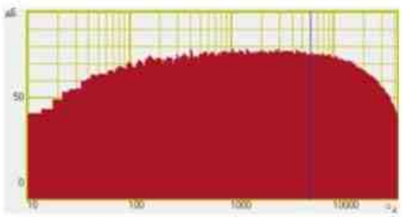
Frequency equalization filters A, B, C and D

Frequency equalization filters A, B, C and D are used in noise measurements. The filters are made in accordance with GOST 17187 "Sound level meters, general technical requirements and test methods". This makes it possible to use ZET 017-U2, ZET 017-U8 and A19-U2 analyzers as a sound level meter of the first accuracy class.

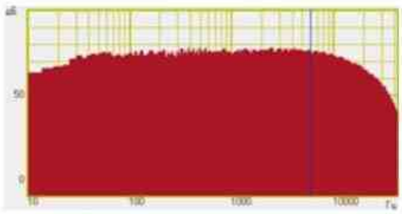
The figures below show the spectra of signals processed by filters with frequency corrections A, B, C and D, implemented in the Signals filtration program.



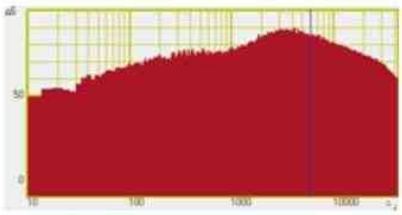
Frequency correction A



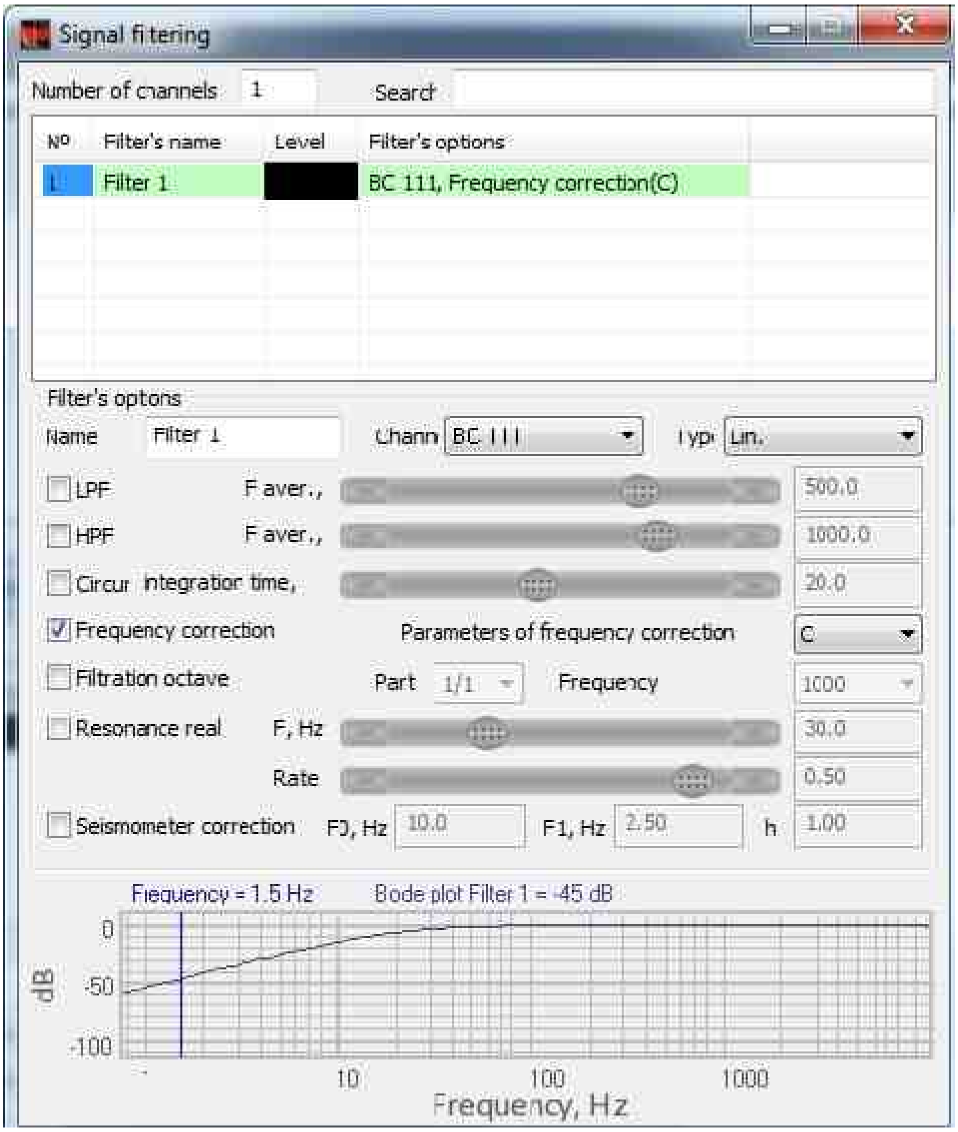
Frequency correction B



Frequency correction C

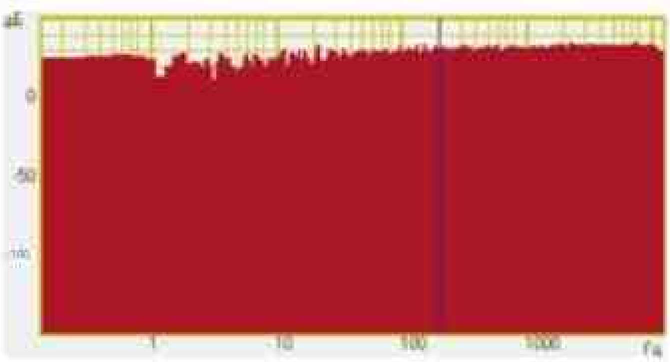


Frequency equalization D



Filter with frequency correction C

In all the examples discussed above, white noise was used as the source signal to demonstrate the operation of filters. The white noise spectrum is shown in the figure below.



Spectrum of the original signal

Filters according to ISO 6487-2015 .....

ISO 6487-2015(E)

Road transport. Measurement methods for shock tests.

Filters according to ISO 6487-2015

CFC

the frequency class of the channel is indicated by a number indicating that the frequency response of the channel lies within certain limits

Note 1 to entry: CFC XXXX defines a frequency class with XXX = Frequency, Fh , Hz

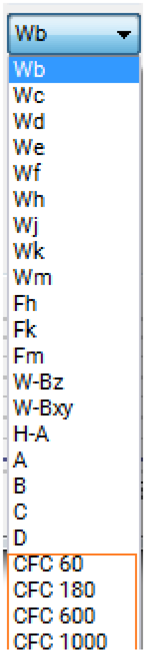


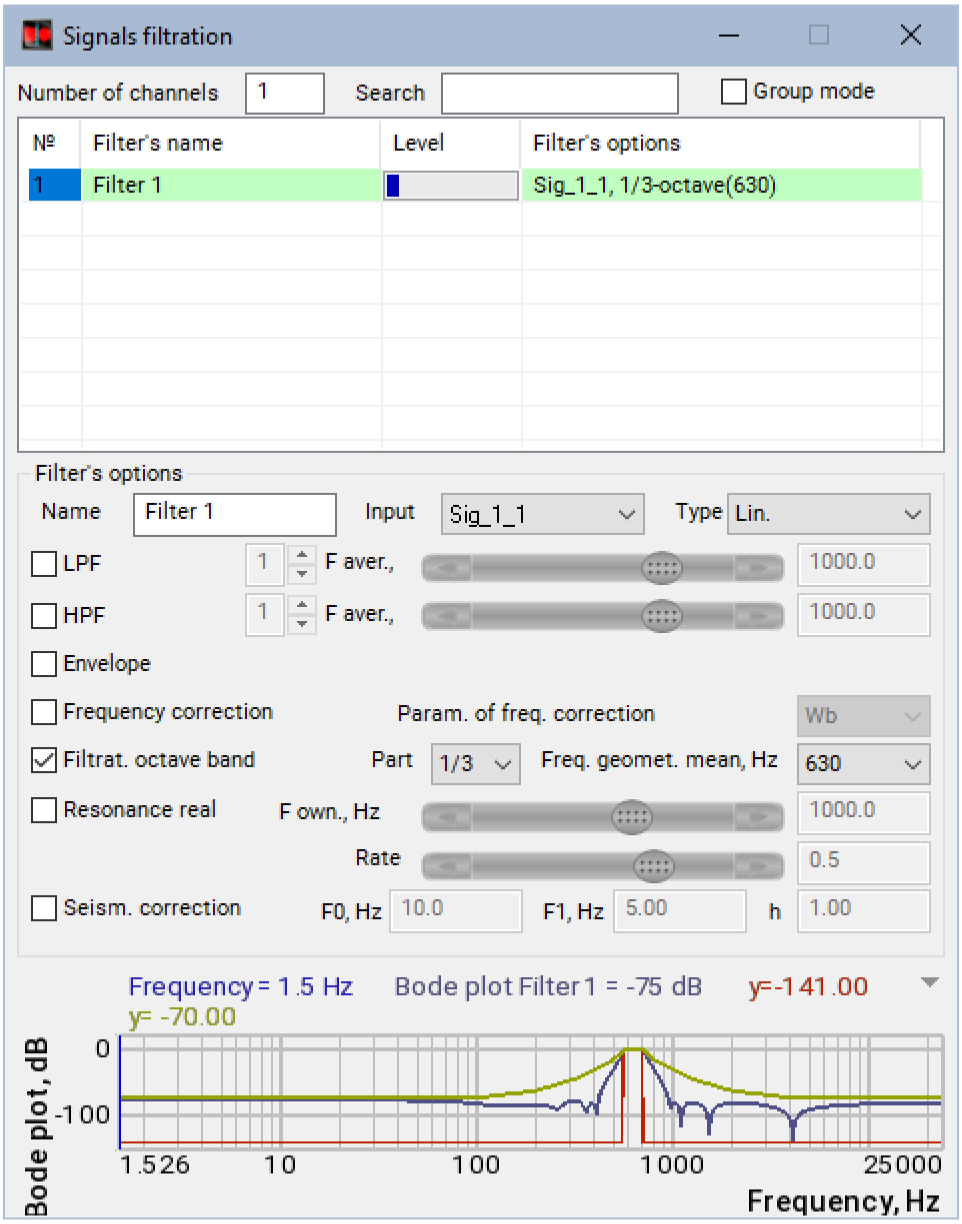
Fig. 2 List of corrective filters used in the program

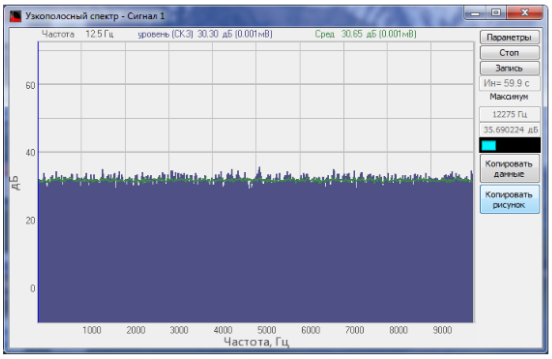
Filtration octave band .....

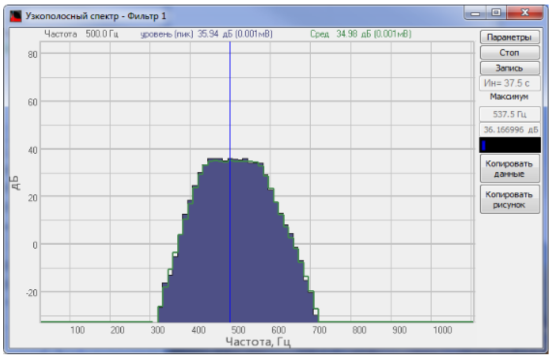
In each channel of the **Signals filtration** program, octave or sub-octave filters can be turned on. The filters are implemented in accordance with GOST R 8.714-2010 (IEC 61260:1995) "Octave bandpass and fractional octave filters. Technical requirements and test methods" for the 1st accuracy class.
The essence of octave filtering is to divide the signal under study into octave frequency bands. Octave frequency band (octave) - a frequency band in which the ratio of the upper cutoff frequency to the lower

one is 2. Accordingly, the entire frequency range under study is divided into a certain number of octaves using octave filters, which is necessary for further processing.
The **Signals filtration** program implements:

- notch filter with accurate center frequencies: 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, 8000 Hz;
- 1/3 octave filter with precise center frequencies: 315Hz, 400Hz, 500Hz, 630Hz, 800Hz, 1000Hz, 1250Hz, 1600Hz, 2000Hz, 2500Hz, 3150Hz, 4000Hz, 5000Hz, 6300Hz, 8000Hz, 10000Hz.







Spectrum of the original signal (white noise
Signal spectrum after 1/3-octave filtering at the center frequency of 500 Hz

Resonator real. .....

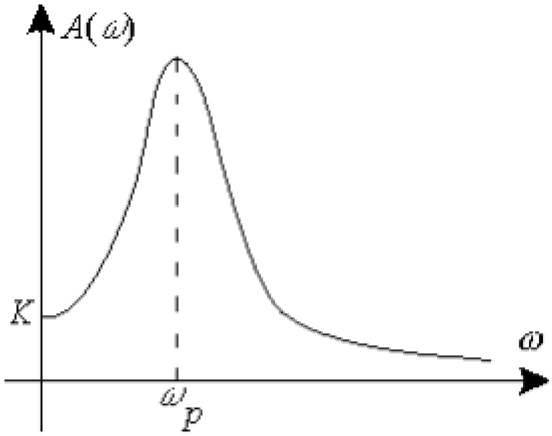
Signals filtration program allows you to set resonance at a frequency set by the user and with a set damping factor.

Resonance generation in the program **Signals filtration** is carried out using an oscillatory link. An oscillatory link is called a second-order link, in which, upon receiving a step action at the input, the output value tends to a new steady value, making damped oscillations.

The equation of motion of an oscillatory link has the form:

$$T^2 \frac{d^2 y(t)}{dt^2} + 2\xi T \frac{dy(t)}{dt} + y(t) = KX(t)$$

The amplitude-frequency characteristic of the oscillatory link is shown in the graphic:

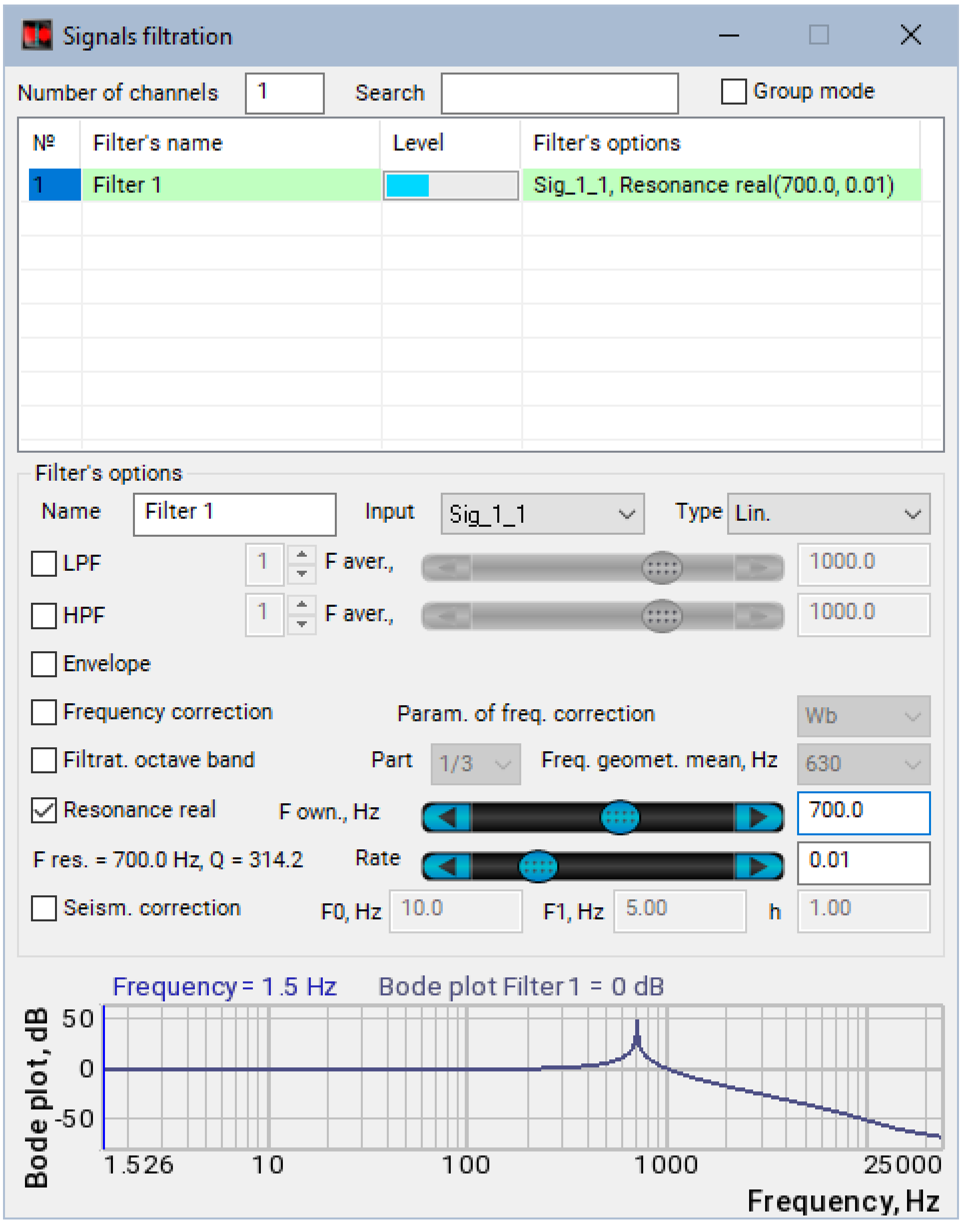


A(w) has a maximum corresponding to the resonance condition. The resonant frequency can be determined from the condition $\frac{dA(w)}{dw} = 0$, How.

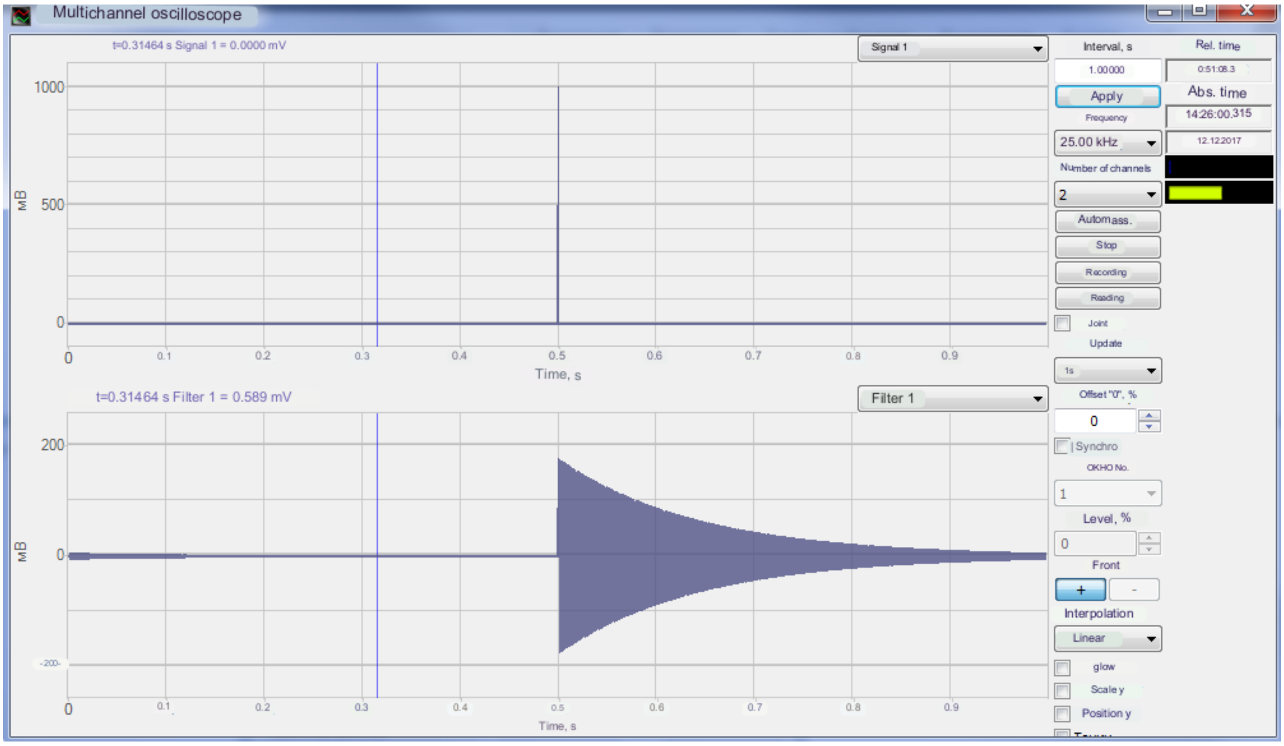
$$w_p = \frac{1}{T}\sqrt{1-2\xi^2}$$

An example of an oscillatory link is any RLC circuit.

The figures below show an example of resonance formation in the Signals filtration program.



Program window Filtering signals with resonance parameters



Program window Multi-channel oscilloscope. Display of the original signal and the signal with the filter applied (sweep duration 1 s)

Mathematical description
Analysis and design of digital filters

Consider ***a real second-order IIR filter*** whose transfer function has two complex conjugate poles:

$$p_1 = re^{j\omega_0}, \quad p_1^* = re^{-j\omega_0}$$

$$H(z) = \frac{1}{2}\left[\frac{1}{1 - re^{j\omega_0} z^{-1}} + \frac{1}{1 - re^{-j\omega_0} z^{-1}}\right] = \frac{1 - (r\cos\omega_0)z^{-1}}{1 - 2(r\cos\omega_0)z^{-1} + r^2 z^{-2}} = \frac{1 + b(1)z^{-1}}{1 + a(1)z^{-1} + a(2)z^{-2}}$$

The transfer function also has one zero $z_1 = r\cos\omega_0$, the position of which is rigidly connected with the position of the poles. The difference equation of the filter has the form:

$$y(n) = -a(1)y(n-1) - a(2)y(n-2) + x(n) + b(1)x(n-1)$$

The frequency response of such a real resonator is formed by the combination of the frequency response of two complex resonators with resonant frequencies ω_0 and $(-\omega_0)$ for the frequency range $(-\pi \leq \omega \leq \pi)$.
(Fig.1a shows one of the variants of the block diagram of a real resonator, and (Fig.1b - a graphic of its Amplitude-frequency response at $r=0.95$ and $\omega_0=\pi/2$.

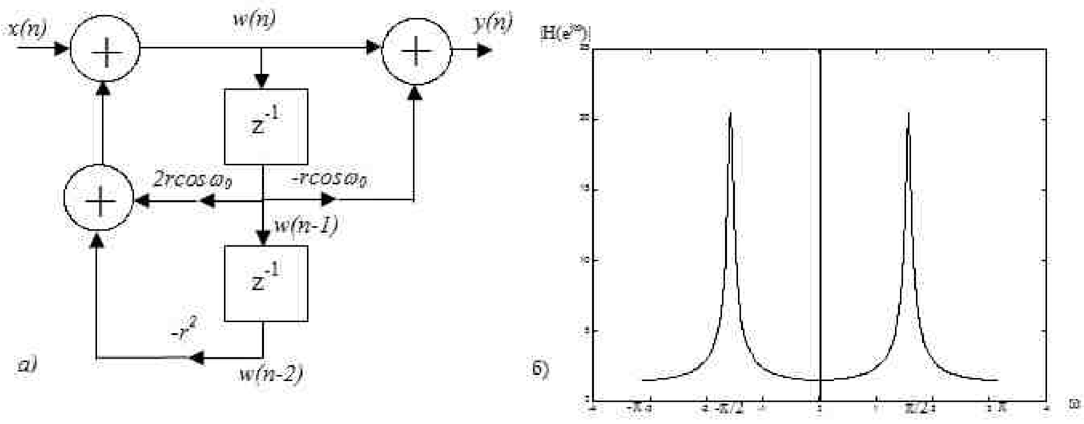
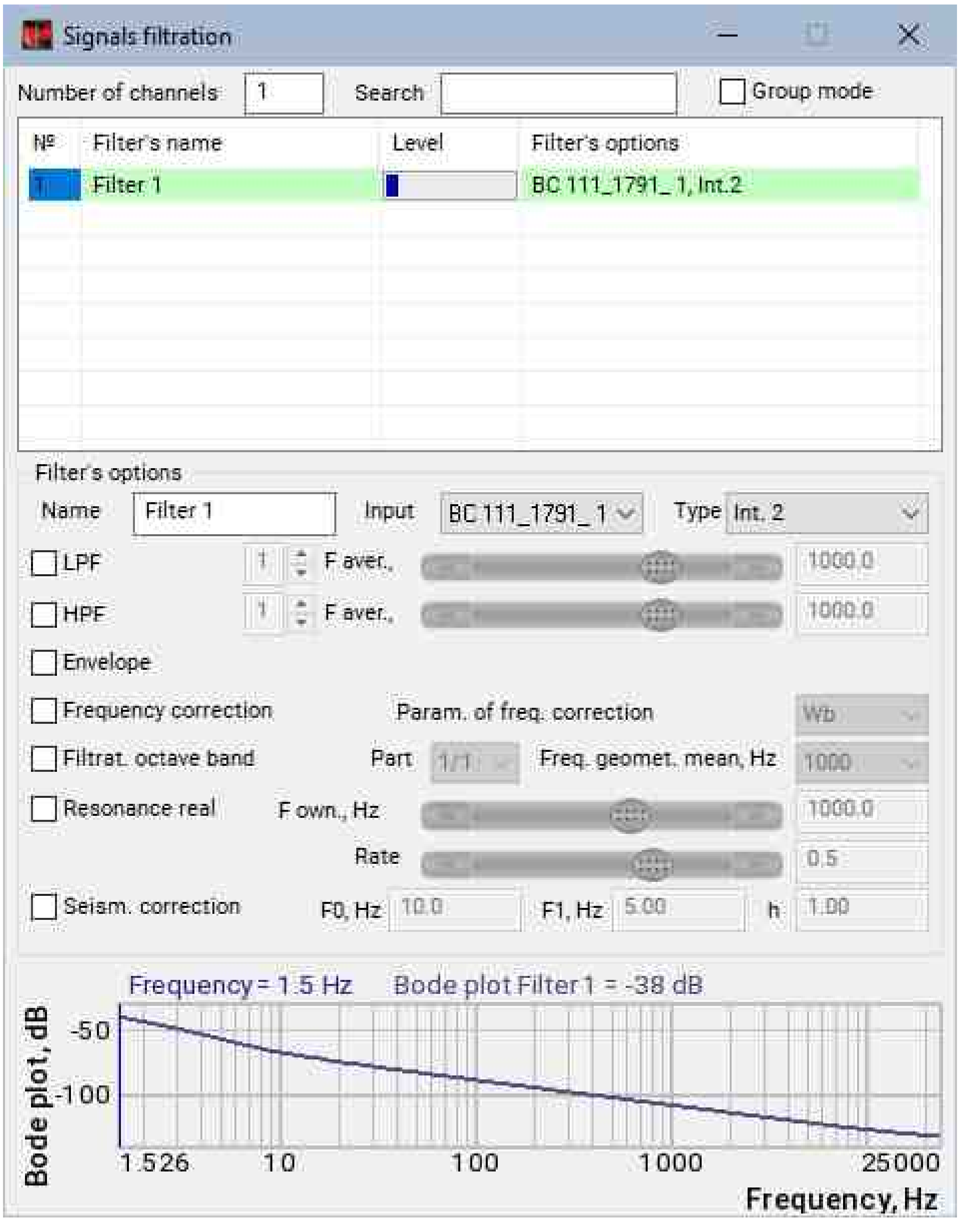


Fig. a) Structural diagram and frequency response of a real resonator b) Structural diagram and frequency response of a real resonator

Fig. 1. Structural diagram (a) and frequency response of a real resonator (b)

Integrating and differentiating filters .....

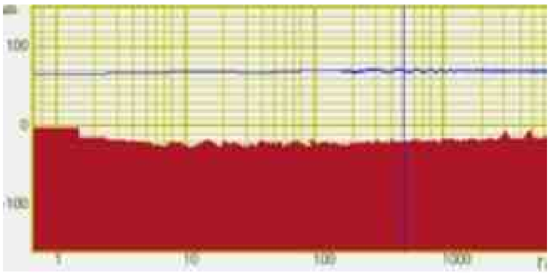
In the **Signals filtration program** , integrating and differentiating filters of the first and second order are implemented.



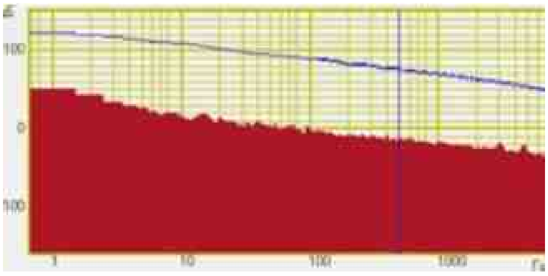
Program "Signals filtration" Second-order integrating filter

Integrating filters make it possible to obtain a speed signal and a displacement signal from the acceleration signal. This will allow, for example, to control all the vibrational characteristics of an object (frequency, acceleration, speed and displacement) using the signal of one sensor - an accelerometer. Acceleration signal integration is used in inertial measurement systems: railway track gauge monitoring system, elevator position and movement parameters detection system, etc. Integrating filters are used for balancing rotating products, since unbalance determination requires a reference point displacement value, which cannot be obtained using displacement sensors at high rotational speeds.

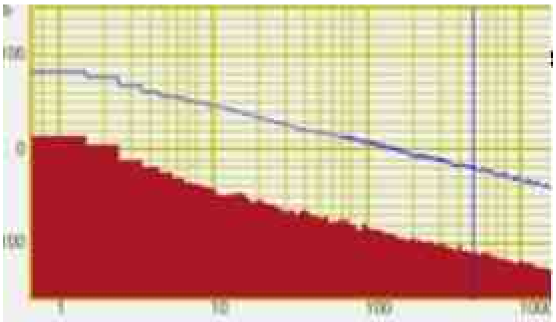
The figures below demonstrate the operation of integrating filters of the 1st and 2nd orders. The first figure shows the spectrum of the original acceleration signal. The second figure shows the spectrum of the signal that passed the first-order integrating filter, resulting in a speed signal. The third figure shows the displacement signal - the result of double integration of the acceleration signal.



Line filter - acceleration signal



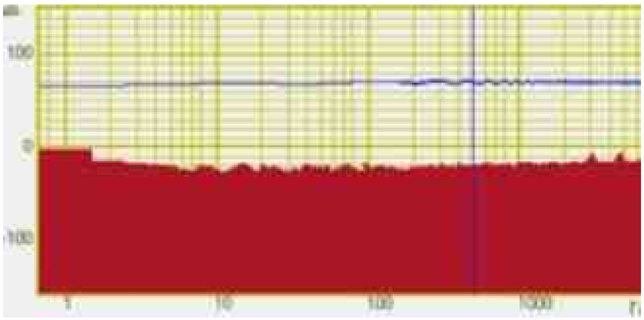
1st order integrating filter - velocity



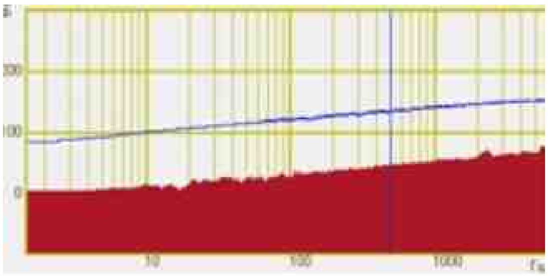
2nd order integrating filter - displacement signal

Differentiating filters are used to obtain speed and acceleration signals from displacement signals given, for example, by optical displacement sensors, eddy current displacement sensors, etc. This method is often used for low-frequency signals, since in the low-frequency region, the vibration sensors readings are strongly influenced by the intrinsic noise of the sensor and electronic noise of measuring equipment, while displacement sensors provide high measurement accuracy.

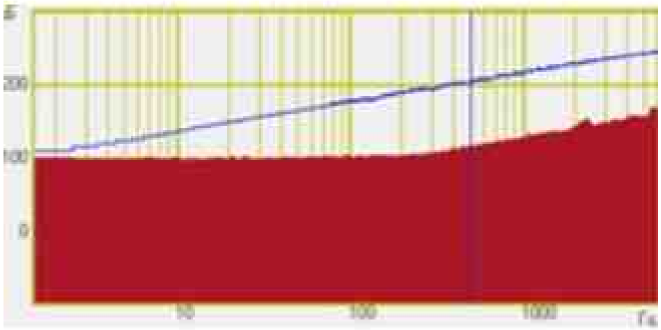
The figures below demonstrate the operation of differentiating filters of the 1st and 2nd orders. The first figure shows the spectrum of the original displacement signal. The second figure shows the spectrum of the signal that passed the first-order differentiating filter, resulting in a speed signal. The third figure shows the acceleration signal - the result of double differentiation of the displacement signal.



Line filter - displacement signal



1st Order Differential Filter - velocity signal



2nd Order Differential Filter - acceleration signal

If the input signal is a vibration acceleration signal (i.e. the unit of measurement is "g" or "m/s2"), then during integration the unit of measurement of the output channel becomes the unit of measurement of vibration velocity - "m/s". With double integration of the vibration acceleration signal , the unit of measurement of the output channel becomes the unit of vibration displacement - "mm".

The reference values for calculating "dB" are also subject to change. If the input channel reference values "dB" were selected according to the ISO system, then the reference values of the output channels for integration and double integration are also taken according to the ISO system. If the reference dB values are selected according to GOST, then the reference values of the output channels are also set according to GOST.

Otherwise, "*s" is added to the unit of measurement of the input channel during integration, and "*s ^{2} " for double integration, "/s" for differentiation, and "/s ^{2} " for double differentiation. The calculation reference values "dB" remain unchanged.

The figures were obtained by processing the signal "scanning sine" (a sinusoidal signal with a time-varying frequency). The program "Narrow-band spectral analysis" was used for displaying in the mode of accumulation of the maximum value of the signal spectrum.

Seismometer correction .....

In the **Signals filtration** program, the function of correcting the frequency response of seismometers with an inverse filter is implemented to reduce the lower cutoff frequency of the sensor.

Mathematically, the correction process in the frequency domain is described as follows:

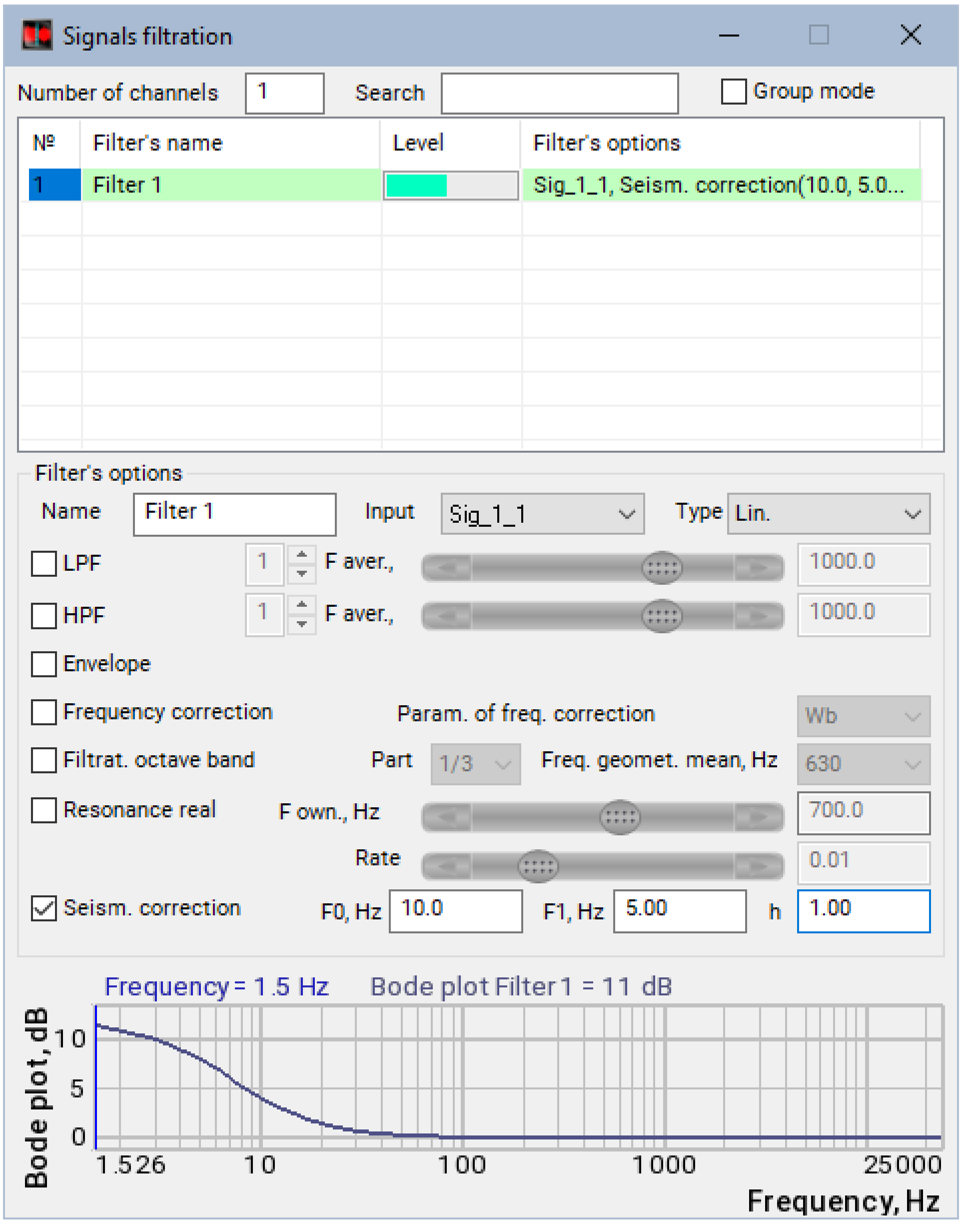
$$F_0 \square F_k = F_1,$$

where F_0 is the frequency response of the corrected sensor;

Fk is the frequency response of the corrective circuit ;

F_1 - frequency response for the sensor, obtained as a result of correction.

The program **Signals filtration** thanks to the inverse filter allows you to reduce the lower cutoff frequency of the seismometer by 10-20 times. The only disadvantage of such filtering is the increase in the intrinsic noise of the seismometer. The dependence of such parameters as the intrinsic noise of the seismometer, attenuation and inertial mass was established by the American seismologists Aki K. and Richards P. and described in their book “Quantitative Seismology: Theory and Methods.”: the intrinsic noise of the seismometer is directly proportional to the attenuation and inversely proportional to the inertial mass of the seismometer.



Inverse filter settings window in the Signals filtration program

Formula .....

The **Formula** program allows the user to simulate signals of any complexity online. All you need is to enter the appropriate code into the command line or select the desired one from the list of available commands, and immediately a virtual channel with a simulated signal is formed at the output, which can be studied and analyzed using any programs from the ZETLAB software. The **Formula** program is a kind of universal programming environment for any user, ranging from a perfect person far from programming, to a professional in his field!

The **Formula** is a program for performing mathematical operations with signals, filtering signals, measuring signal parameters and generating various signals. The **Formula** program is a virtual measuring device. The **Formula** program is designed to perform arithmetic, algebraic and logical operations and filtering over continuous data streams coming from ADC and DAC modules, virtual channels in real time. In post-processing mode, you can perform various operations from previously recorded files by the **Signals recording** program.

The **Formula** program creates from 1 to 100 virtual channels. You can run multiple instances of the **Formula** program at the same time.

Supported Hardware .....

Input of the program "**Formula**" is a digital data channel server **ZETLAB**, which is a digitized arbitrary variable signal. Under a variable signal in this case refers to a signal, the instantaneous magnitude of which depend on time. Settings of measurement channels are specified in the program "Device Manager".

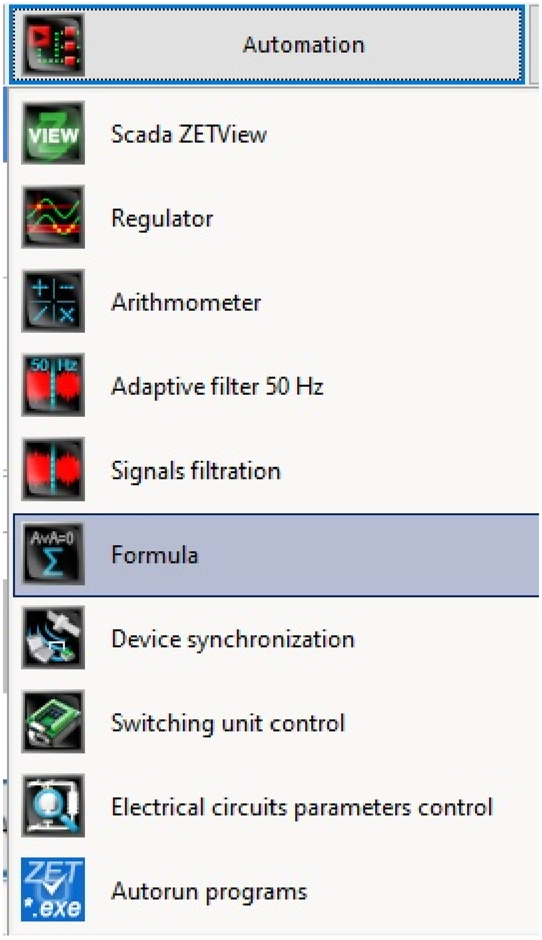
Program the **Formula** is included with the following:

- ZETLAB ANALIZ – FFT Spectrum software;
- ZETLAB VIBRO – Shaker control systems software;
- ZETLAB TENZO – strain-gauge station software;
- ZETLAB SEISMO - seismic station software.

The program "**Formula**" is located in the "***Automation***" software section.

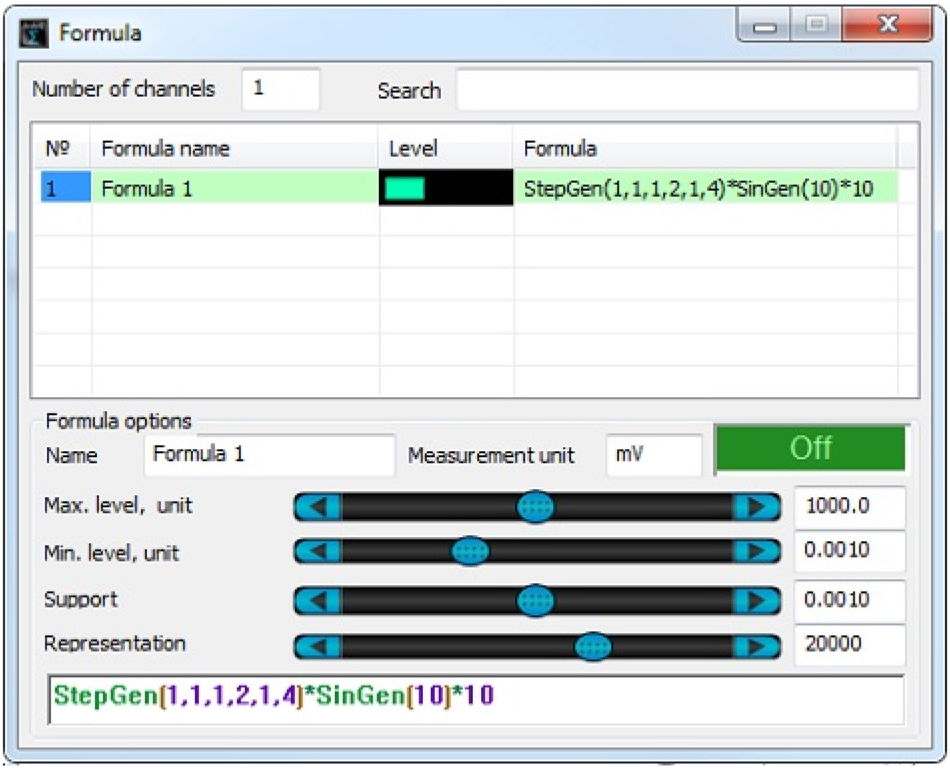
Program description .....

The program **Formula** is run from the menu automation **ZETLAB** panel.



Starting the Formula program

The program header displays the name of the **Formula**.



Interface of the Formula program

Formula is a program for mathematical operations with signals, signal filtration, signal parameter measurement, and formation of various signals. **Formula** is a virtual measuring instrument. It is designed to perform arithmetic, algebraic, and logic operations and filtration for continuous data flows coming from ADC and DAC modules or virtual channels in real time. In post-processing mode, one can perform various operations with the files recorded by the program Signals recording.

Formula creates from 1 to 100 virtual channels. It is possible to simultaneously launch several instances of **Formula**.

The middle part of the program is a table of the created channels. Simultaneously displays 7 rows of the table, while creating a greater number of channels, and a scrollbar appears. Quick links to the line for the desired channel is a search (box on the right above the table).

In the channels table displays the ordinal channel number, the name of the generated signal, its integral and formula. if the formula is used to calculate the signal, there is no error, the line is displayed in green. Lines with errors in the formulas are displayed in red.

The lower part of the program **Formula** is the editing area of the created channel. Each channel **Formula** are edited individually, but the button to Enable/Disable enables/disables the creation of all the channels **Formula**. To edit channel **Formula**, select it in the table (click the left button of "mouse" in the line of the channel).

Formula parameters

Each signal is generated by the Formula enters the data server **ZETLAB** and thus become available to all the **ZETLAB** programs. Channels **Formula** that have the name specified in the *Name* field.

In the Unit field specifies the *unit of measurement* according to the created channel. For example, if the program **Formula** is used to calculate secondary parameters of voltage-strain status of the signal from the strain Gauge Meter, the signal will have units of the calculated parameter.

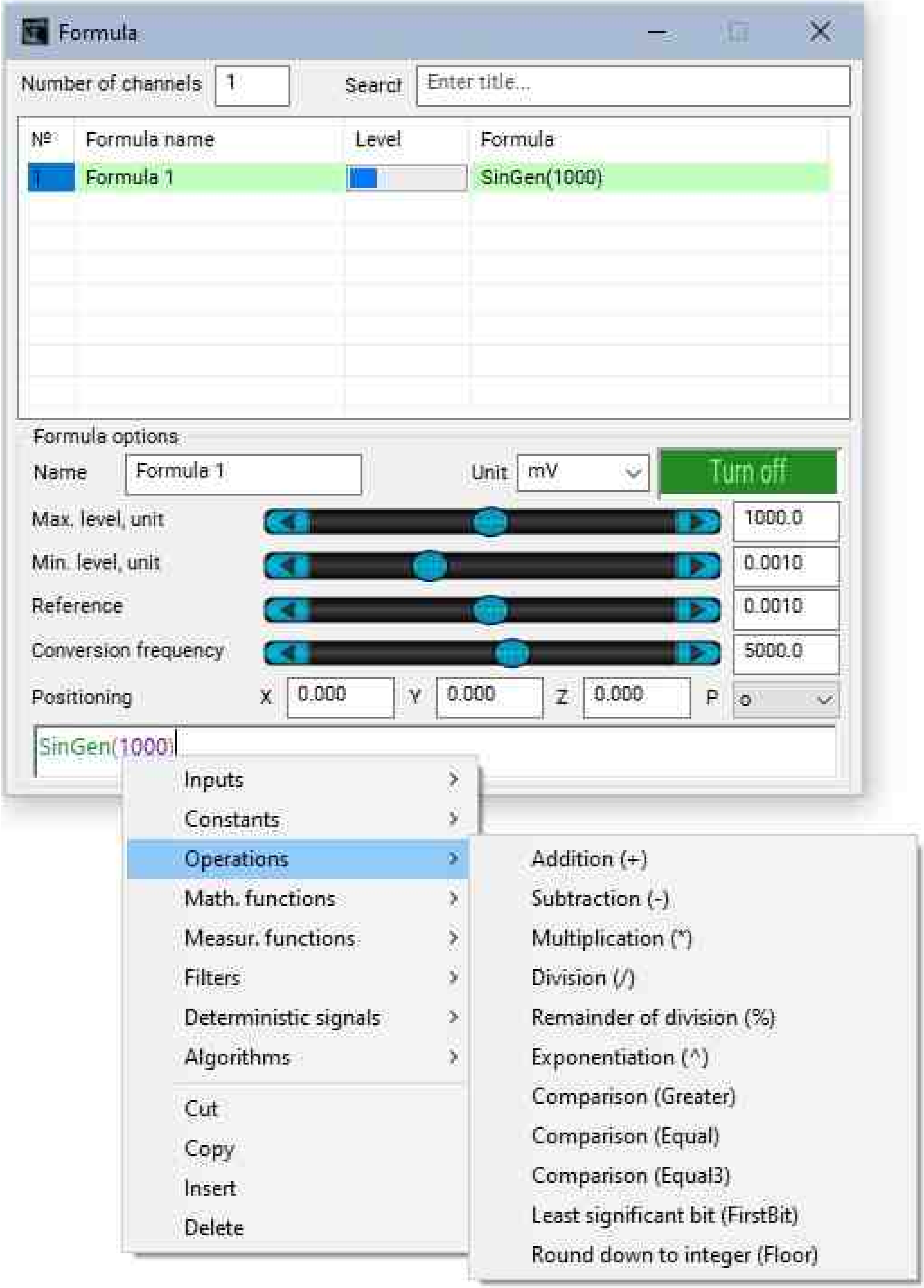
Button to *Enable/Disable* enables/disables the creation of all the channels **Formula**.

In the fields *Max. level, unit*, and *Min. level, unit*, specifies the level range of the generated signal in the unit of measure to calculate the relative level displayed on the level indicators of the Integral. The set values do not affect the level of the generated signal, the calculation is made according to laid down formula.

In the *Support* provide a value for the calculation of the signal level in dB, which is used by programs such as **Alternating current voltage meter**, **FFT Spectrum Analysis program** etc. to display the measurement results in dB.

In the *Frequency representation* field of view is set to the sampling frequency of the generated signal is the number of points in the waveform in one second.

In the lower part of the program is the field specify the formula by which we calculate the signal. The **Formula** can be entered from the keyboard and use the context menu which is invoked by pressing the right button of "mouse" on the field:

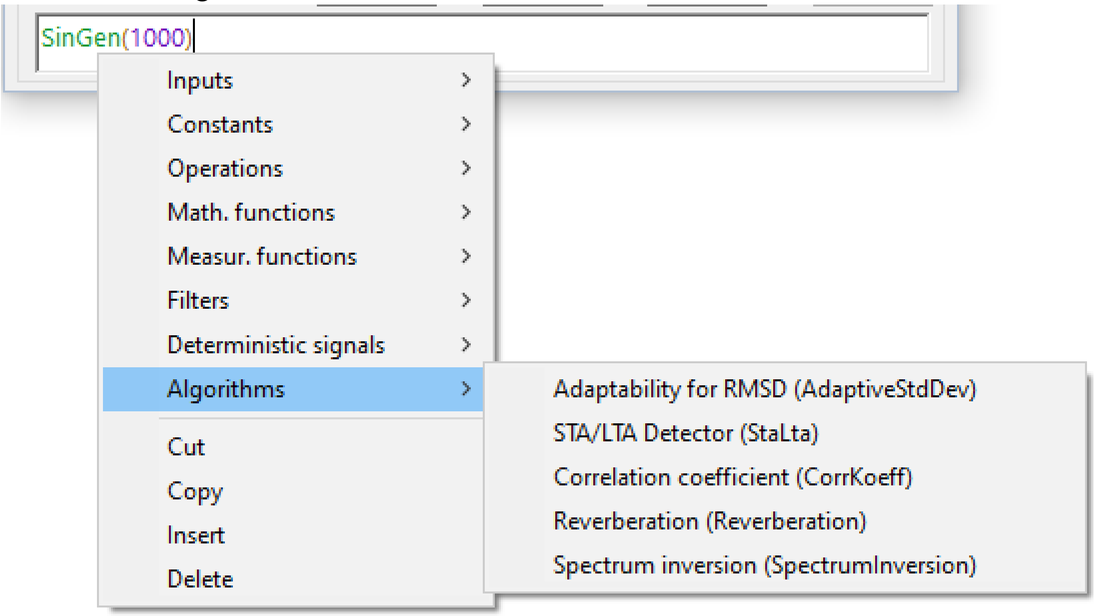


Context menu field create a formula

The context menu contains the following options:

- Channels - list of channels ZET-server,
- Constants - list of constants,
- Operations - list of mathematical operations,
- Mathematical functions - list of mathematical functions,
- Measurement functions - list of measurement functions,
- Filters - list of filters,

- Deterministic signals - list of deterministic signals;
- Algorithms - list of algorithms;

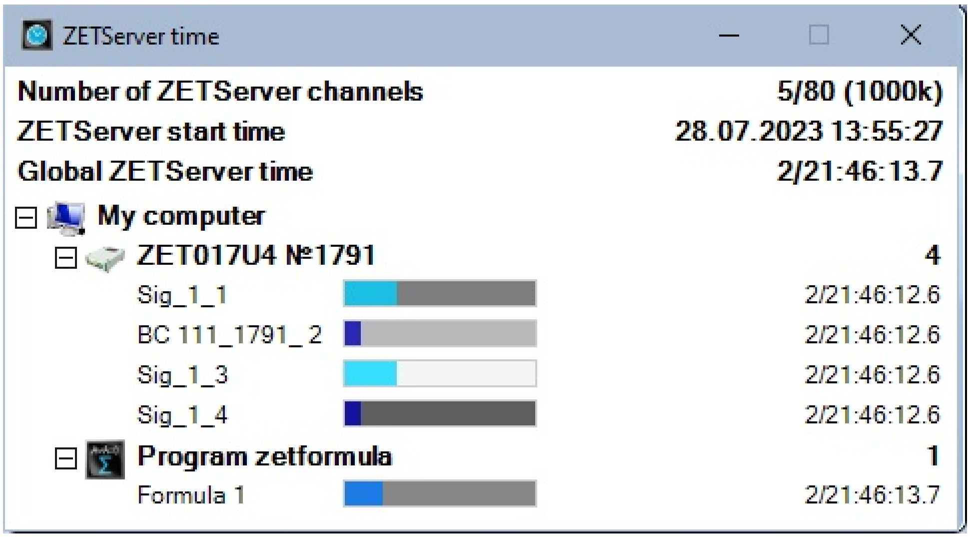


Formula: Algorithms

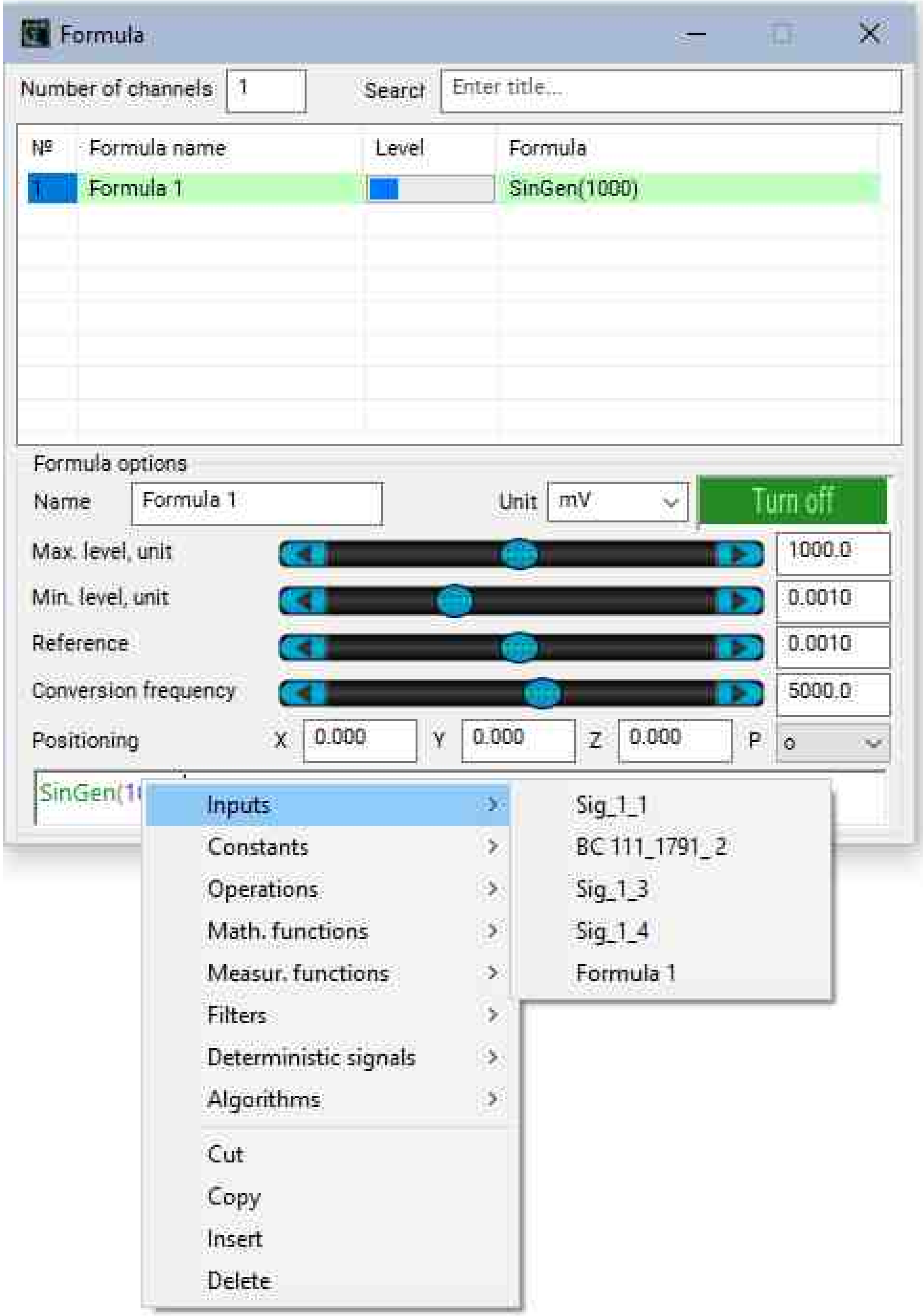
As well as the standard commands *Cut*, *Copy*, *Paste*, and *Delete*, which produce corresponding actions on the selected portion of the formula.

Channels .....

In the ***Channels*** menu displays the available channels. In the pictures below is a sample list of channels in the **ZETSERVER Time** and in the context menu of the **Formula**.



List of channels ZET server



Formula: Inputs list

When you select a channel, its name will appear in the formula bar in angle brackets.

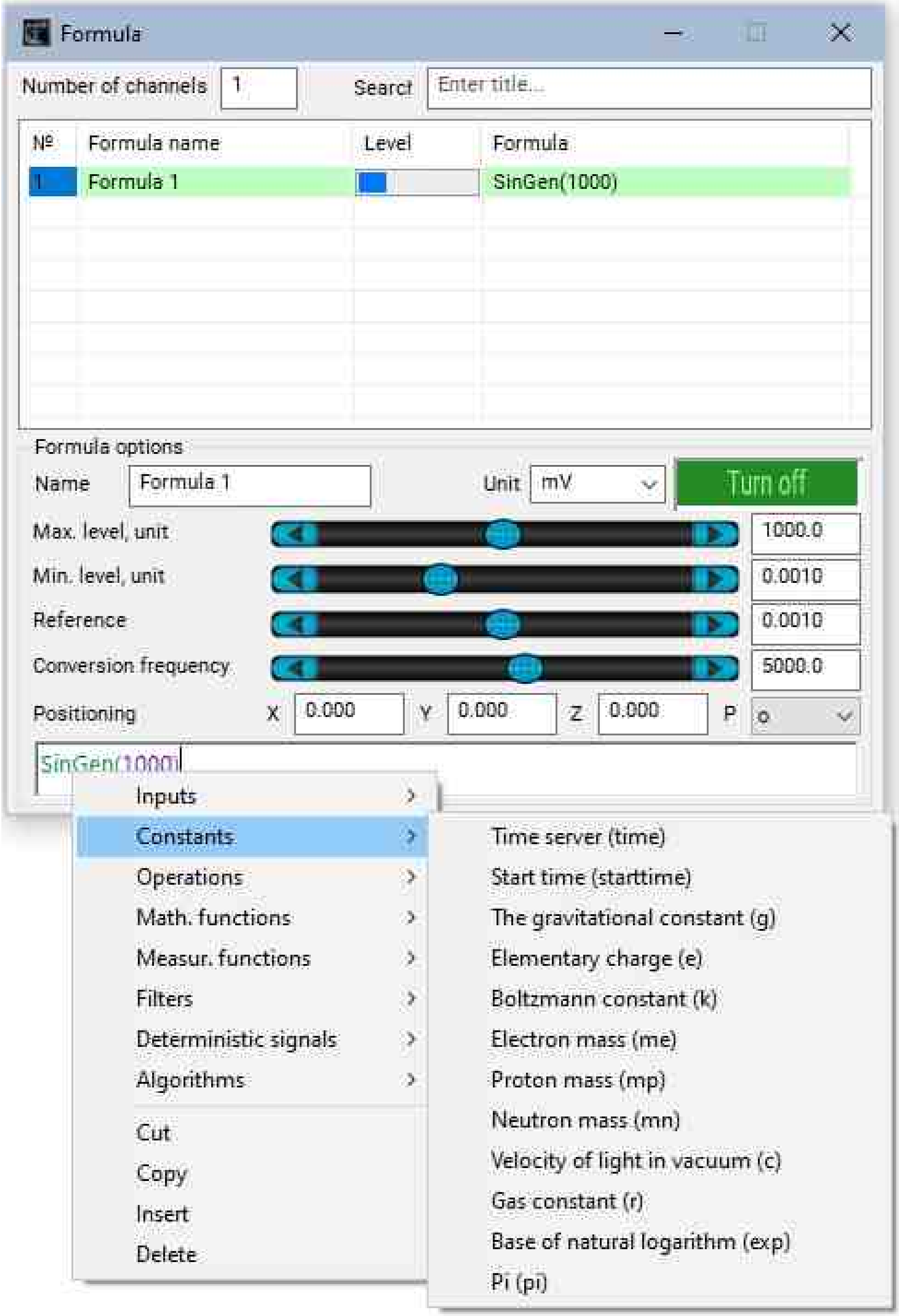
If your computer is connected to multiple devices ZET, and sampling frequencys for them are different, then the channels with lower sample rates to be piecewise-linear interpolation and increase the sampling frequency to the highest in the system.

On some devices ZET, has one chip ADC making alternate sampling between channels, which causes a phase delay. Program **Formula** synchronizes those channels in the background.

The intermediate results of calculations are the same channels, but they are not displayed in the system **ZETLAB**. That is, in functions that require the argument channel, it is possible to use expressions as a parameter

Constants .....

For the convenience of the user in the program **Formula** of some mathematical and physical constants.



Formula: Constants

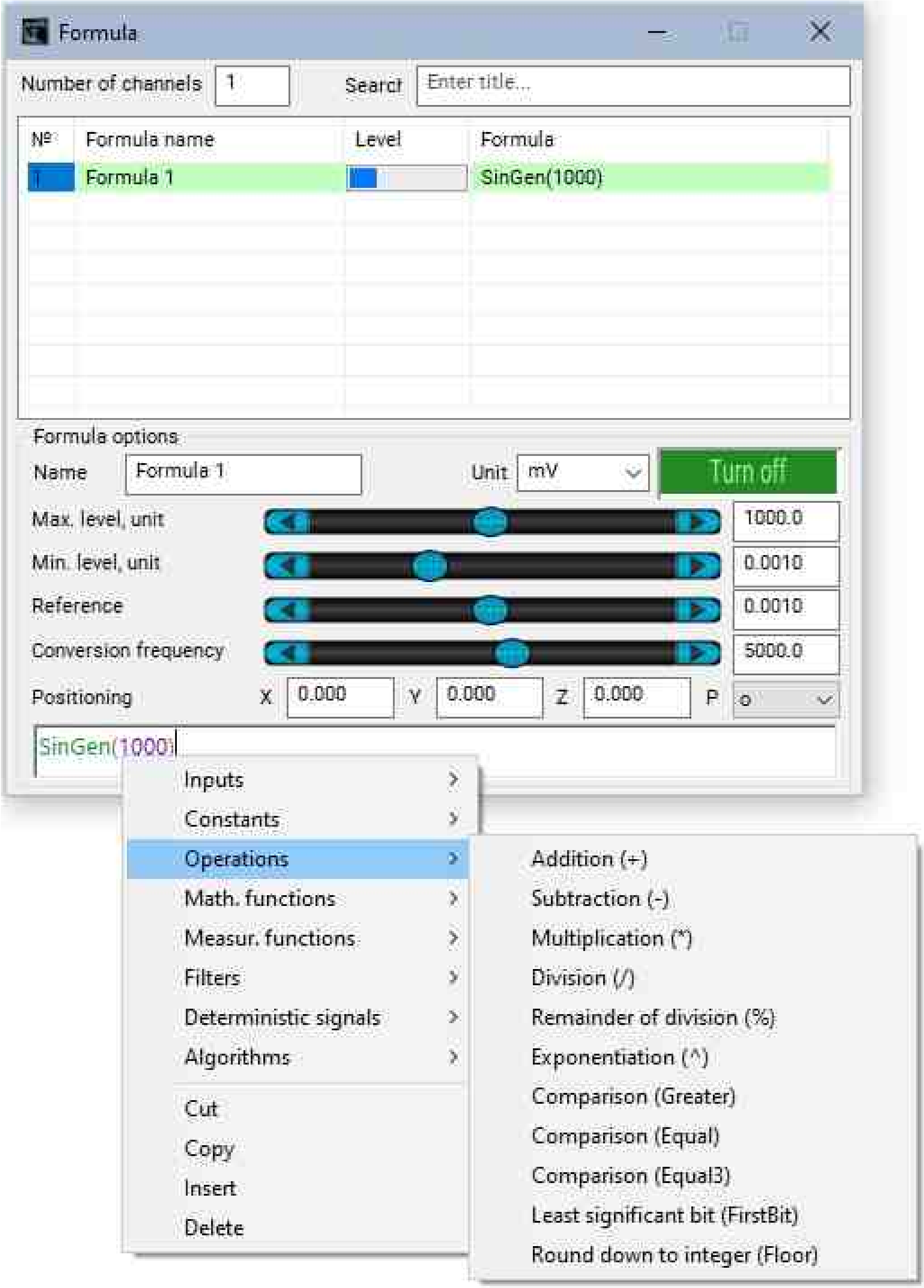
The table below shows the values of the constants.

The name in the menu	Display in the formula bar	Name of the	Value of the	The unit of measurement
Time server (time)	<time>	server time	**time ZET server**	s
Start time (starttime)	<starttime>	the program start time **Formula**		s
The gravitational constant (g)	<g>	gravitational constant	6,67Ч10^{-11}	$m^3/(kg \cdot s^2)$
Elementary charge (e)	<e>	elementary charge	1,602Ч10^{-19}	cgs
Boltzmann constant (K)	<k>	Boltzmann constant	1,380Ч10^{-23}	J/K
Mass of the electrons (me)	< me >	electron mass	9,10938291(40) Ч10^{-31}	kg
Mass of the proton (mp)	<mp>	proton mass	1,672621777(74) Ч10^{-27}	kg
Mass of the neutron (mn)	<mn>	neutron mass	1,674927351(74) Ч10^{-27}	kg
Velocity of light in vacuum (s)	<c>	Velocity of light in vacuum	299 792 458	m/s
Gas constant (R)	<r>	Gas constant	8,314	J/(K·mol)
Base of the natural logarithm (exp)	<exp>	Euler's constant	2,718…	
PI (pi)	<pi>	the number PI	3.14….	

In the formula bar constants appear in brackets in purple

Operations .....

The Fig. below shows the *Operations* menu of the program **Formula**.

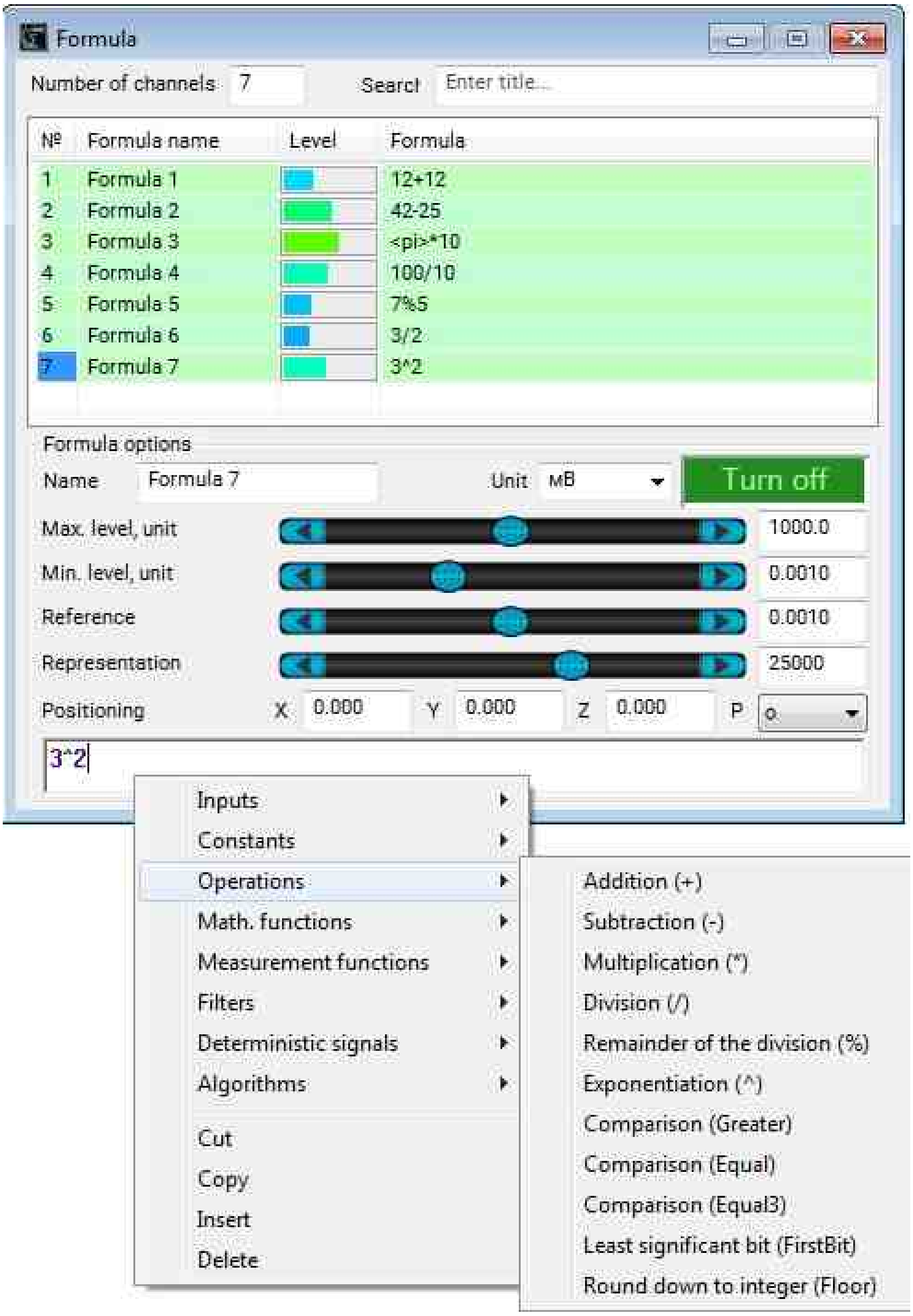


Formula: Operation

"Addition (+)" – addition of channels, constants, results of expressions are evaluated.
"Subtraction (–)" – the difference between the channels, constants, results of expressions are evaluated.
"Multiplication (*)" the product of channels, constants, results of expressions are evaluated.
"Divide (/)," are private channels, constants, results of expressions are evaluated.

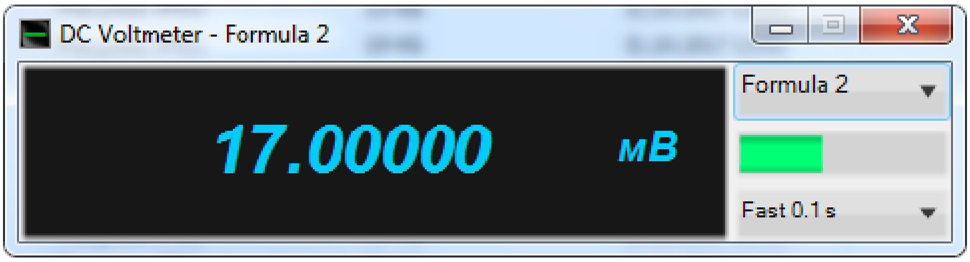
"Residue of division (%)" is the remainder of division of channels, constants, results of expressions are evaluated.
"Exponentiation (^)" – exponentiation channels, constants, results of expressions are evaluated.
"Inversion (!)", "Module (|)", "Comparison (Greater)", "Comparison (Equal), "Comparison (Equal3)", "Junior bit (FirstBit)" - is described below in the examples.

The Fig.s below show the operation of the basic mathematical operations "+", "-", "*", "/", "%" and "^". For clarity, the work is done with numbers (constants), however, these operations can be applied to channels (use instantaneous values of the signals) and the results of evaluation of the expressions. Values through the program **Formula** are measured by the DC voltmeter, as in this example, the result of evaluating a mathematical expression is a constant.

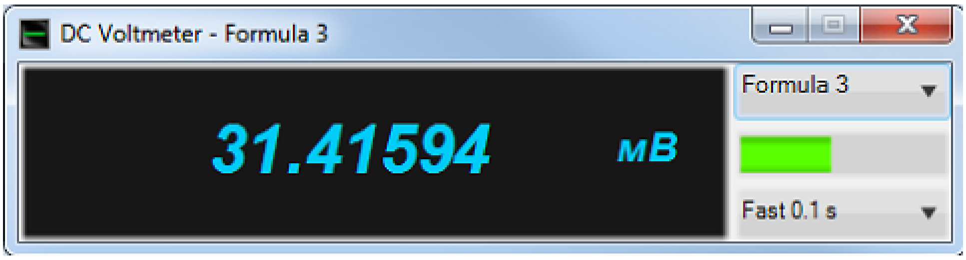


Formula: operation "+", "-", "", "/", "%" and "^" constant.*

The result of the operation "+"

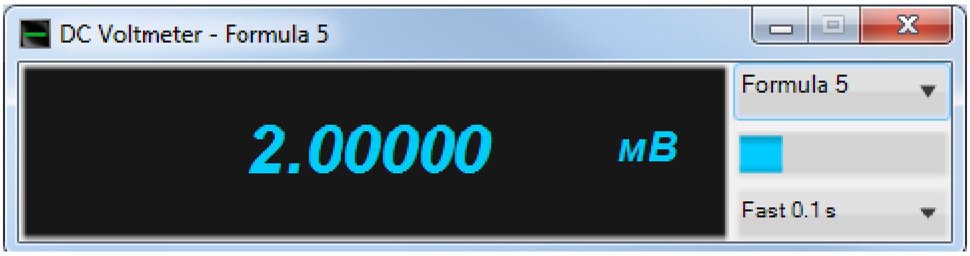


The result of the operation "-"

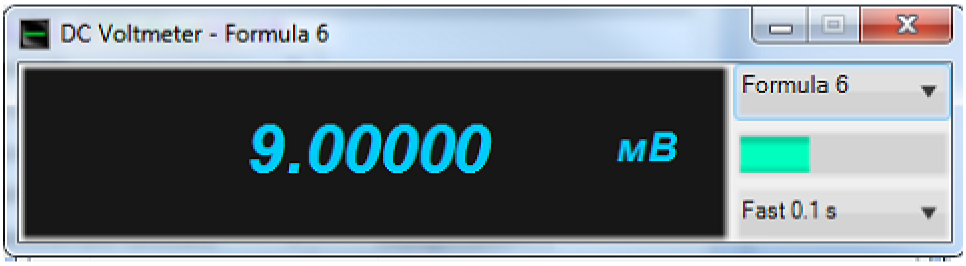


The result of the operation ""*

The result of the operation "/"



The result of the operation "%"

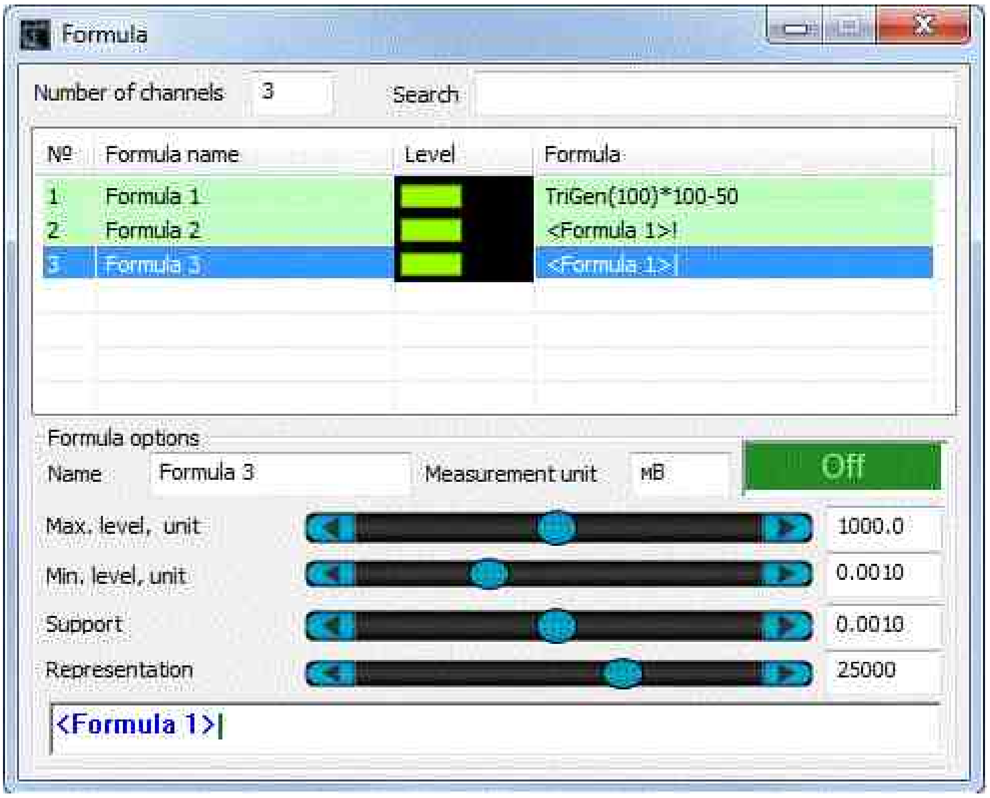


The result of the operation "^"

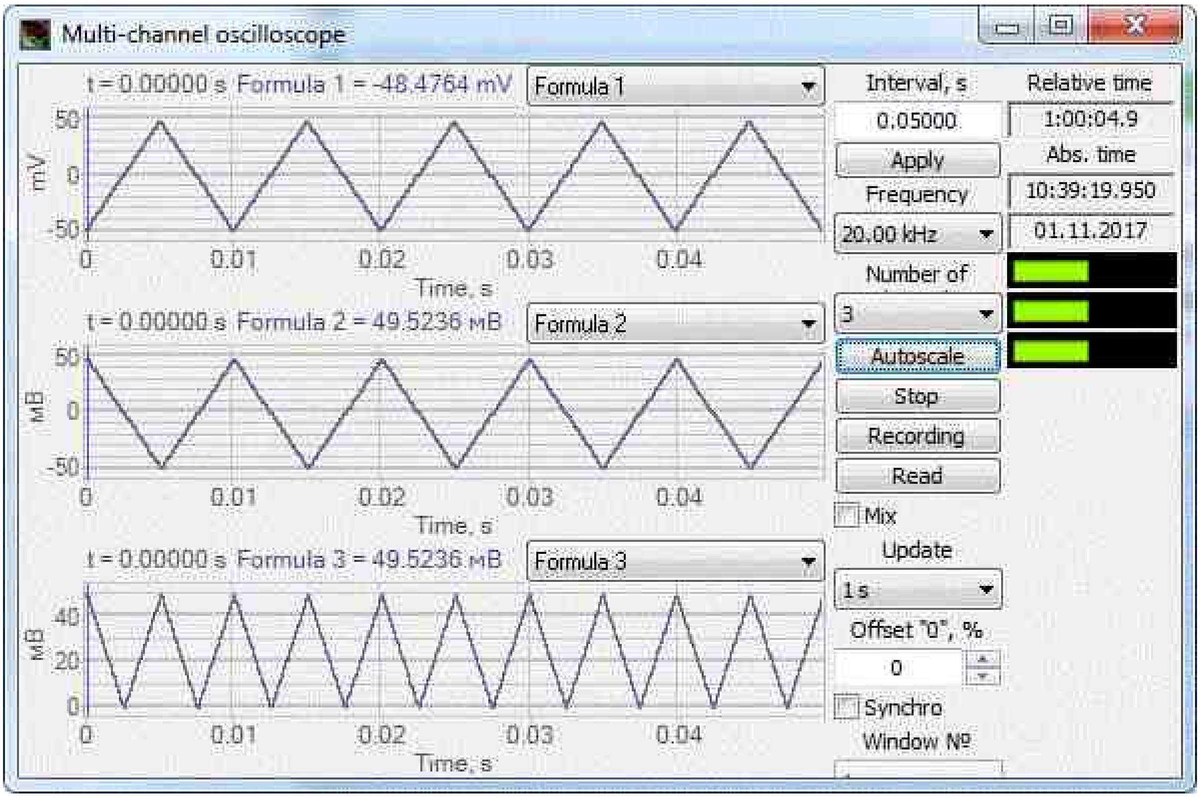
"Inversion (!)" – a unary Postfix operator inversion is equivalent to multiplying by (-1).

"Module (|)" - a unary Postfix operator module: sets the positive sign for all values.

In the example the Fig. below shows the operators inversion and module. As the basis taken the *TriGen* function (Serrated signal). On the oscilloscope showing the original signal (Formula 1), the inverse signal (Formula 2) and the signal modulo (Formula 3).



Formula: operation "!" and "|"



The result of the operations". " and "|"

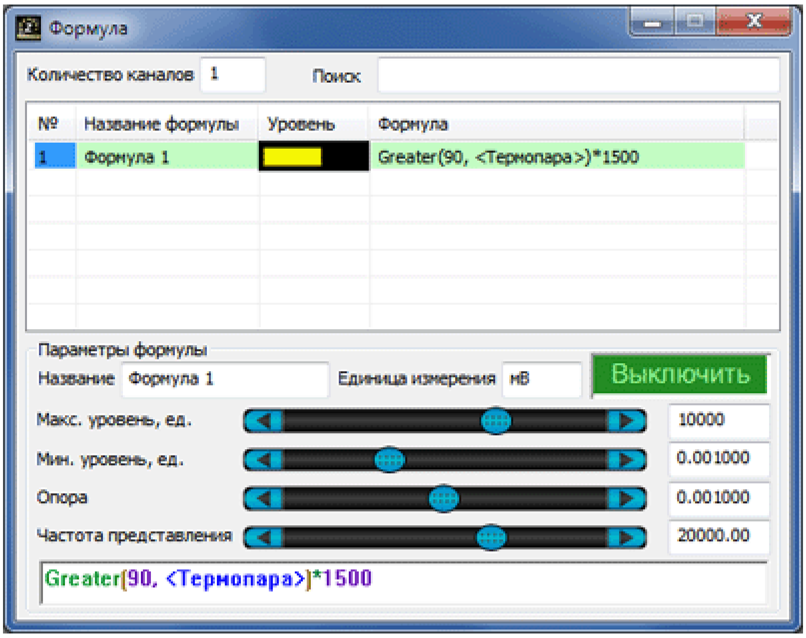
Greater (a1, a2) - is the comparison operation returns a one if the value of the first operand greater than the second value, otherwise returns zero.

Equal (*a1, a2, const*) – equality comparisons, if the difference between the values of the first and second operands modulo is less than the value of the const, returns one, otherwise - zero.

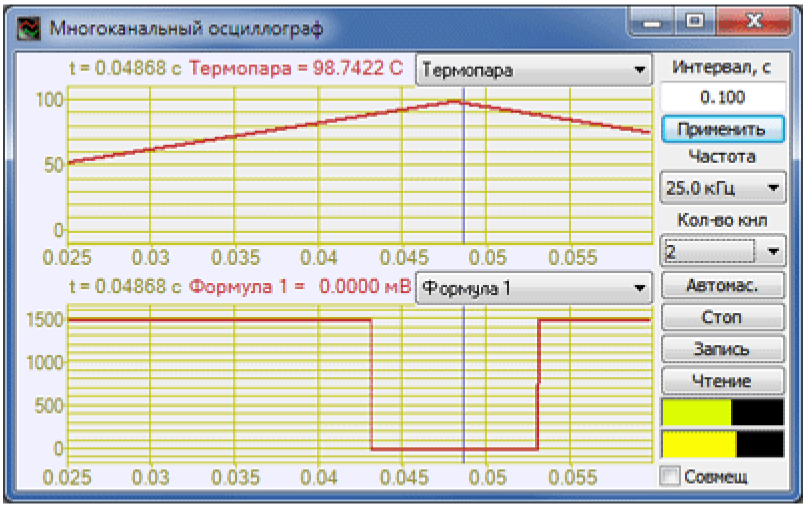
Equal3 (*a1, a2, const*) – equality comparisons, if the difference between the values of the first and second operands is greater than the value const, it returns a unit less than -const - minus one, otherwise - zero.

Operations *Greter*, *Equal*, *Equal3* convenient to write functions threshold detection and the creation of various regulators. As operands you can use channels (transactions are instantaneous values of the signals), constants, and expressions (operations with the results of the calculation).

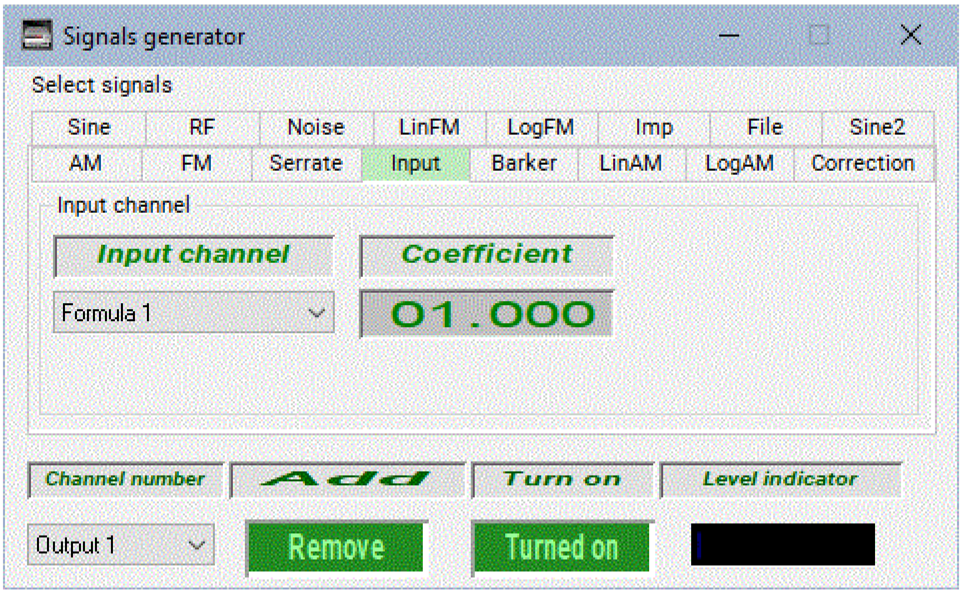
In the example the Fig. below shows a work function *Greater*. The value of the signal "Channel 1" is equal to 1.5 V, if the sensor "Thermocouple1". less than 90. You can organize a system for maintaining a constant temperature, if the DAC output to connect a relay that controls current to the heating element and start the program Signal generator set to generate the signal "Channel 1".



Formula: operation "Greater"

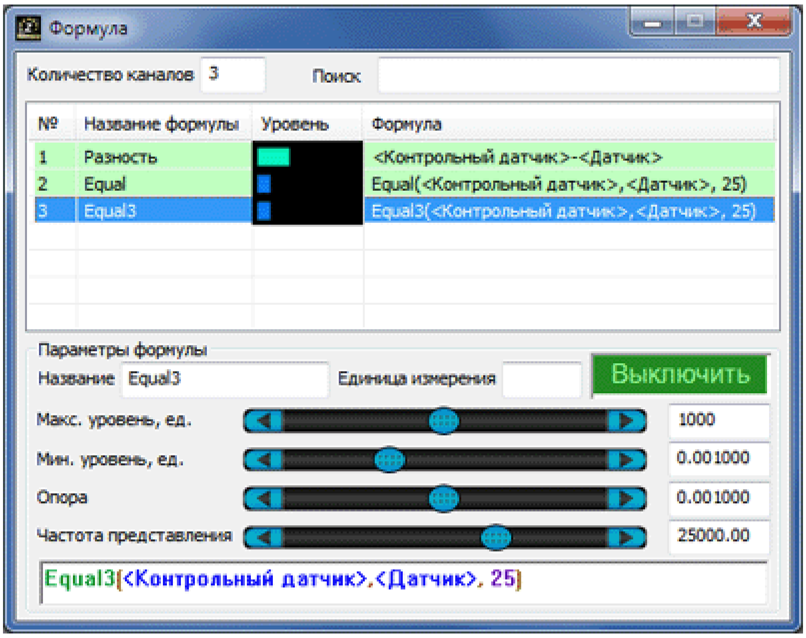


The result of the operation "Greater"

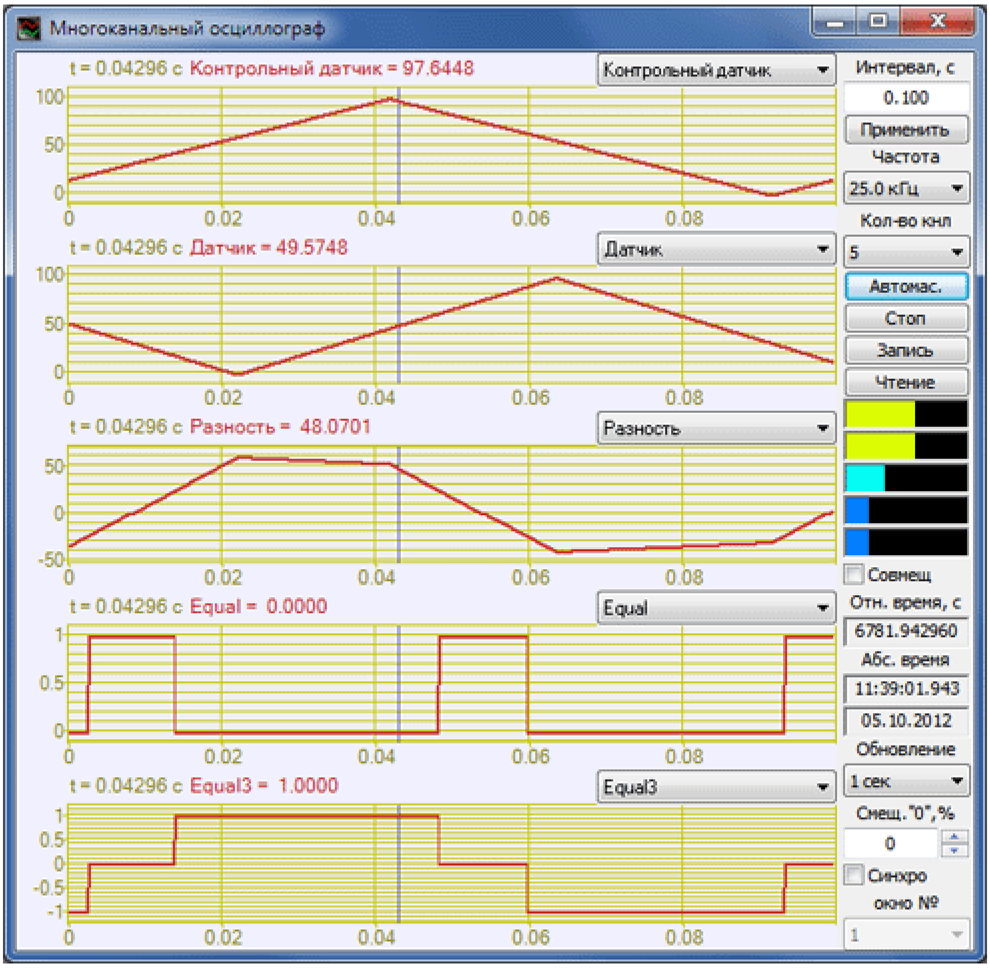


Using the results of the operation of the formula for controlling a generator

The Fig. below shows an example of a program **Formula**, showing the work of the operations Equal and Equal3. For ease of demonstration created 3 channels. The first channel, the Difference - calculates the difference between the instantaneous values of the measurement channel's "Control sensor" and "Sensor". The second channel is the result of the operation Equal, the third channel is the result of the operation Equal3.



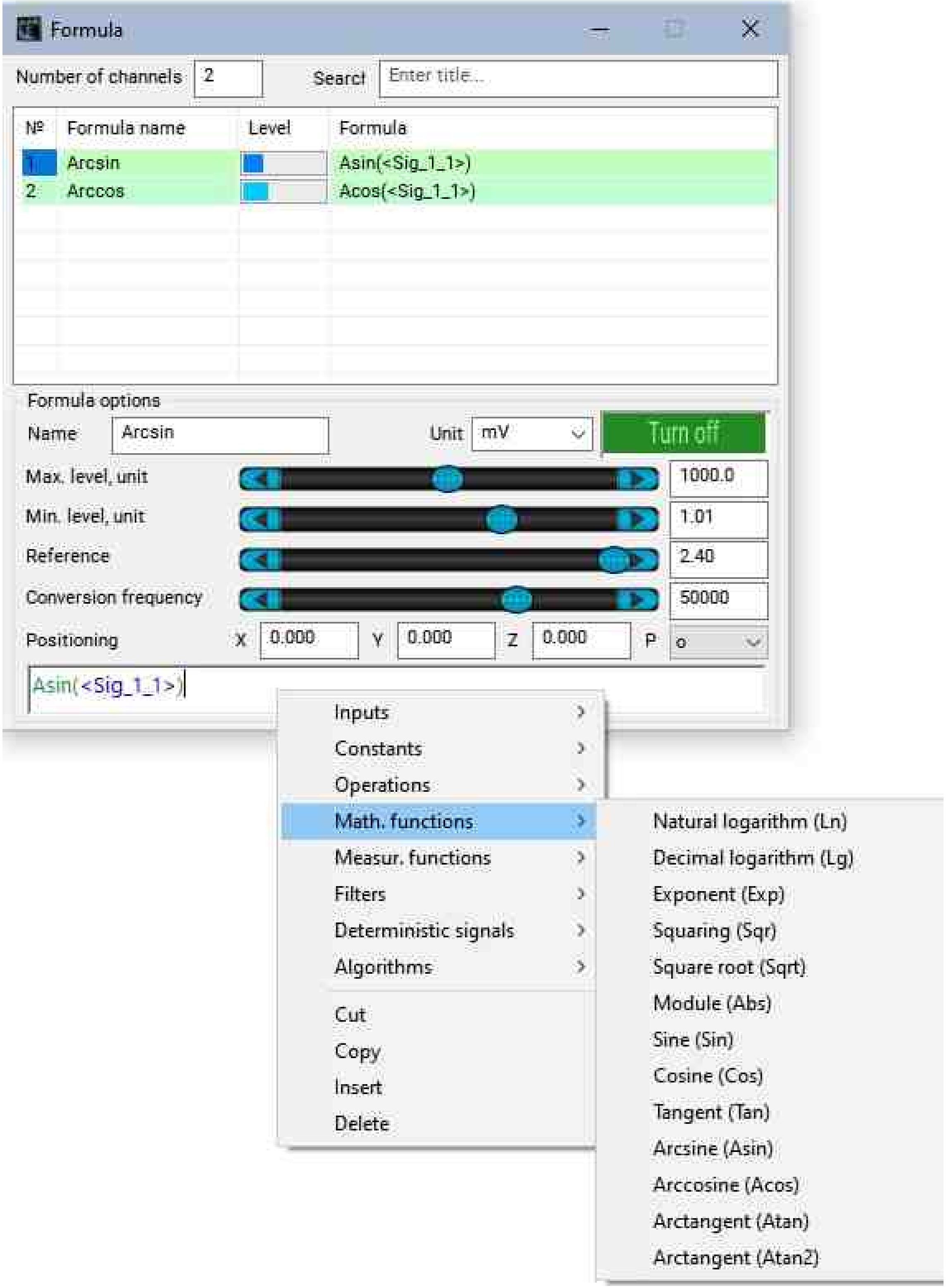
Formula: the operation "Equal" and "Equal3"



The result of the operations of "Equal" and "Equal3"

Mathematical functions .....

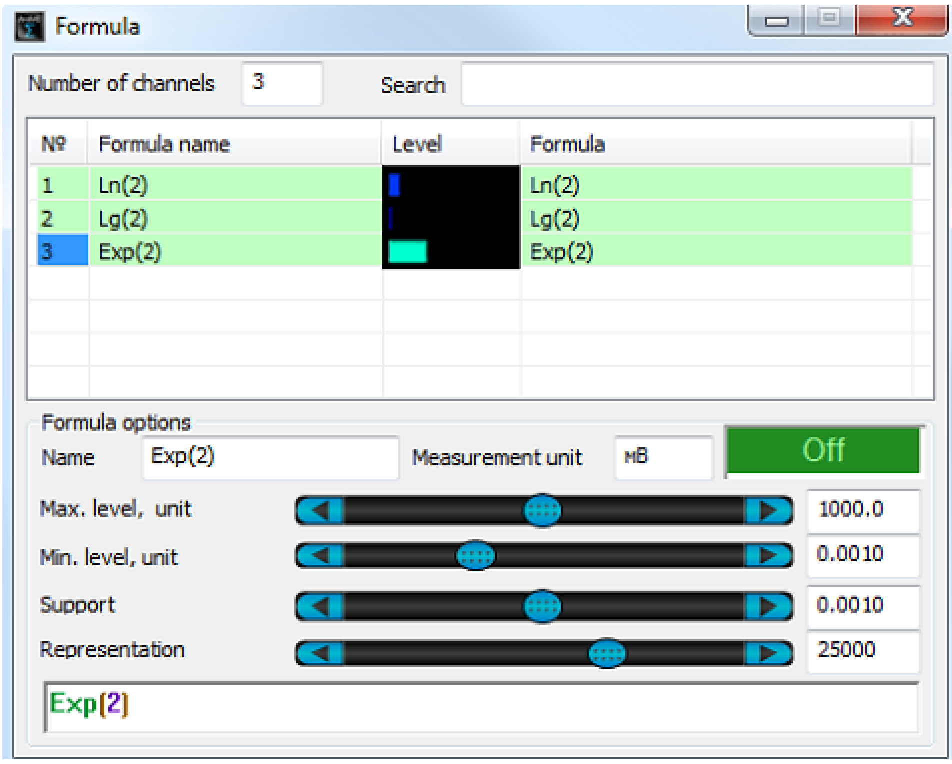
Mathematical function is designed for executing mathematical operations – computing logarithms, exponentiation, etc., as arguments of mathematical functions can be used the channels (operations are performed on the instantaneous values of the signals), constants, and expressions..Mathematical function is designed for executing mathematical operations – computing logarithms, exponentiation, etc., as arguments of mathematical functions can be used the channels (operations are performed on the instantaneous values of the signals), constants, and expressions.



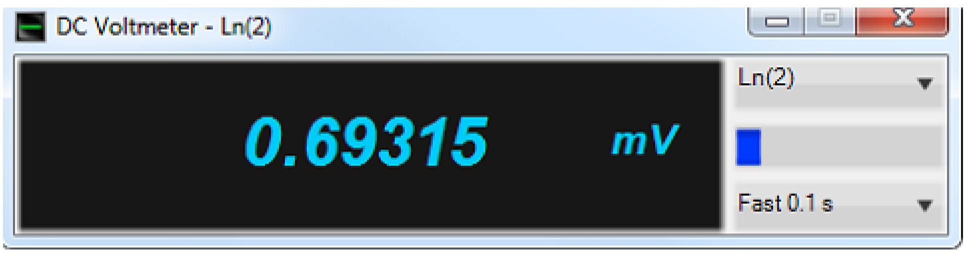
Formula: math functions

The Natural logarithm (Ln) – calculate natural logarithm of argument (constant, channel, expression).
The Decimal logarithm (Lg) – computation of decimal logarithm of the argument (constant, channel, expression).
The Exponent (Exp) – calculates the exponent of the argument (constant, channel, expression).

The Fig. below shows an example of calculating natural and decimal logarithms and exponents. For clarity, the work is done with numbers (constants), however, these operations can be applied to channels (use instantaneous values of the signals) and the results of evaluation of the expressions. Values through the program Formula are measured by the DC voltmeter, as in this example, the result of evaluating a mathematical expression is a constant..The Fig. below shows an example of calculating natural and decimal logarithms and exponents. For clarity, the work is done with numbers (constants), however, these operations can be applied to channels (use instantaneous values of the signals) and the results of evaluation of the expressions. Values through the program **Formula** are measured by the DC voltmeter, as in this example, the result of evaluating a mathematical expression is a constant.



The formula is: Mat. the function "Ln", "Lg" and "Exp".



The result of the work Mat. the function "Ln"

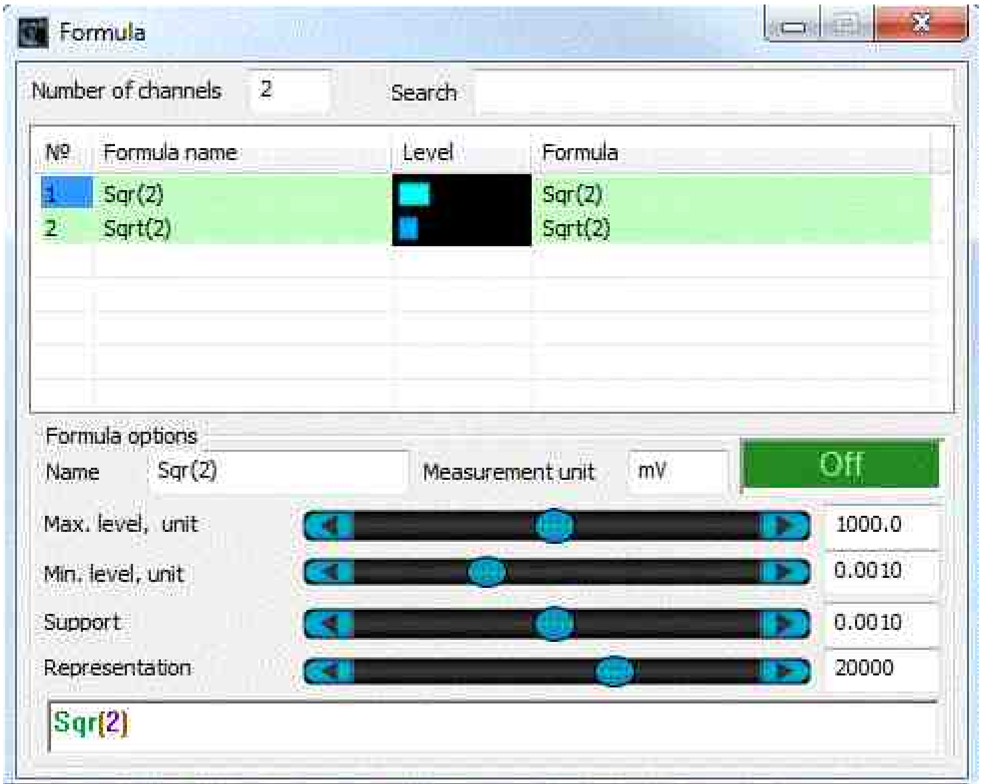
The result of the work Mat. the function "Lg"

The result of the work Mat. the function "Exp"

Squaring (Sqr) - calculation of the square of the argument.

Square root (Sqrt) - calculation of the square root of the argument.

The Fig. below shows an example of squaring and computing a square root. For clarity, the work is done with numbers (constants), however, these operations can be applied to channels (use instantaneous values of the signals) and the results of evaluation of the expressions. Values through the program **Formula** are measured by the DC voltmeter, as in this example, the result of evaluating a mathematical expression is a constant.



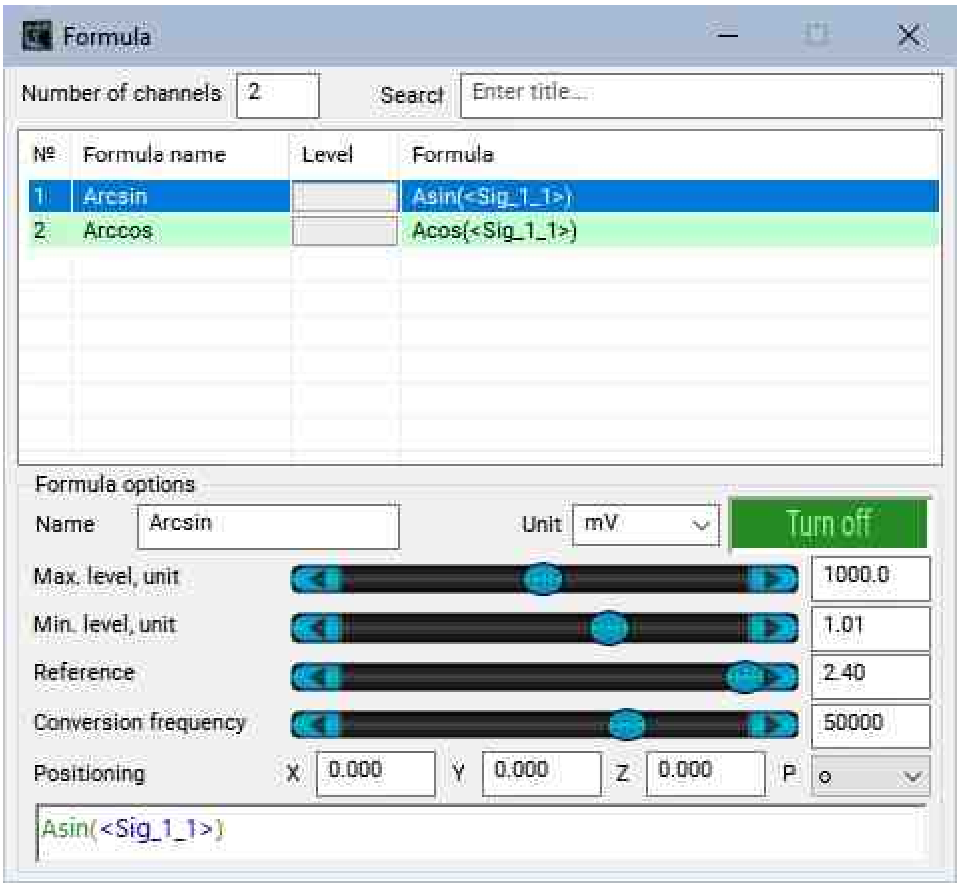
Formula: team "Sqr" and "Sqrt"

The result of the command "Sqr"

The result of the command "Sqrt"

The sine (Sin) – calculate sine of argument (assumes it is radians).
The cosine (Cos) – calculates cosine of the argument (assumes it is radians).

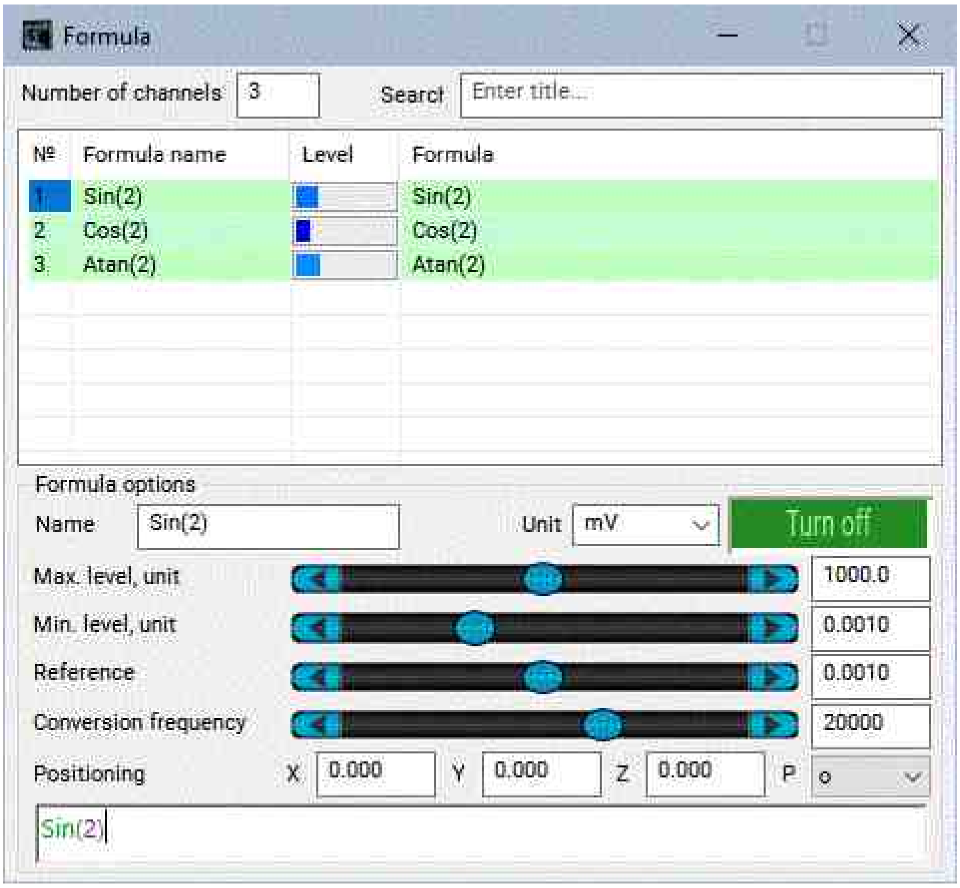
The arcsin (ASin) – calculate sine of argument (assumes it is radians). The input value can be arccos x: $-1 \le x \le 1$.
The Arccosine (ACos) – calculate sine of argument (assumes it is radians). The input value can be arcsin x: $-1 \le x \le 1$.



Formula: parameters "Asin", "Acos"

The tangent (Tan) – calculates the tangent of the argument (assumes it is radians).
The arctangent (Atan) – calculate the arctangent of the argument (assumes it is radians).

The Fig. below shows an example where in the program the **Formula** to calculate sine, cosine, and tangent. For clarity, the work is done with numbers (constants), however, these operations can be applied to channels (use instantaneous values of the signals) and the results of evaluation of the expressions. Values through the program Formula are measured by the DC voltmeter, as in this example, the result of evaluating a mathematical expression is a constant..The Fig. below shows an example where in the program the **Formula** to calculate sine, cosine, and tangent. For clarity, the work is done with numbers (constants), however, these operations can be applied to channels (use instantaneous values of the signals) and the results of evaluation of the expressions. Values through the program **Formula** are measured by the DC voltmeter, as in this example, the result of evaluating a mathematical expression is a constant.



Formula: parameters are "Sin", "Cos", "Atan"

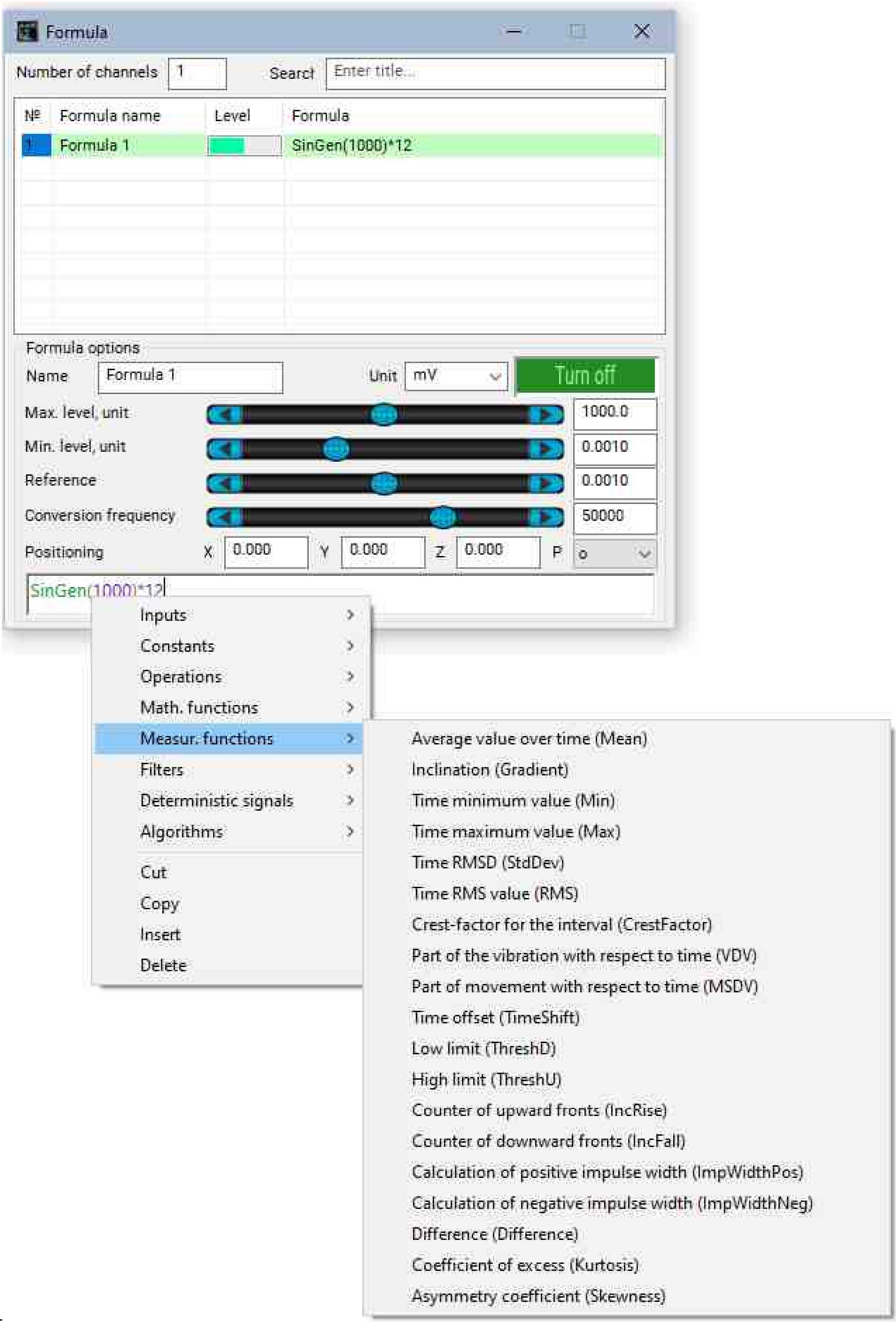
The calculation result of the function "Sin"

The calculation result of the function "Cos"

The result of calculating the function "Atan"

Measurement functions .....

Measuring functions are designed to measure various signal parameters. Like for other functions of the Formula program, arguments can be specified as an expression.

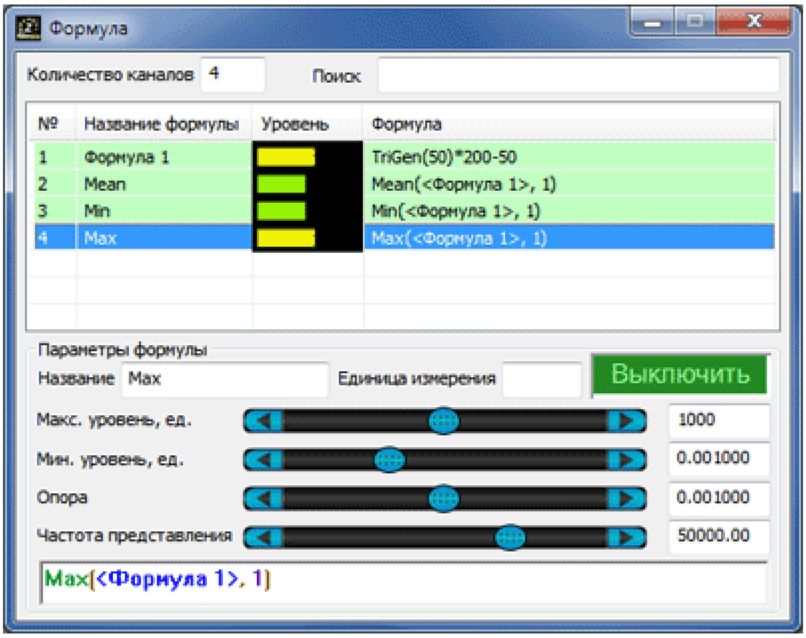

Formula
Number of channels
1
Search
Enter title...
№
Formula name
Level
Formula
1
Formula 1
SinGen(1000)*12
Formula options
Name
Formula 1
Unit
mV
Turn off
Max. level, unit
1000.0
Min. level, unit
0.0010
Reference
0.0010
Conversion frequency
50000
Positioning
X
0.000
Y
0.000
Z
0.000
P
o
SinGen(1000)*12
Inputs
Constants
Operations
Math. functions
Measur. functions
Filters
Deterministic signals
Algorithms
Cut
Copy
Insert
Delete
Average value over time (Mean)
Inclination (Gradient)
Time minimum value (Min)
Time maximum value (Max)
Time RMSD (StdDev)
Time RMS value (RMS)
Crest-factor for the interval (CrestFactor)
Part of the vibration with respect to time (VDV)
Part of movement with respect to time (MSDV)
Time offset (TimeShift)
Low limit (ThreshD)
High limit (ThreshU)
Counter of upward fronts (IncRise)
Counter of downward fronts (IncFall)
Calculation of positive impulse width (ImpWidthPos)
Calculation of negative impulse width (ImpWidthNeg)
Difference (Difference)
Coefficient of excess (Kurtosis)
Asymmetry coefficient (Skewness)

Formula: measuring functions

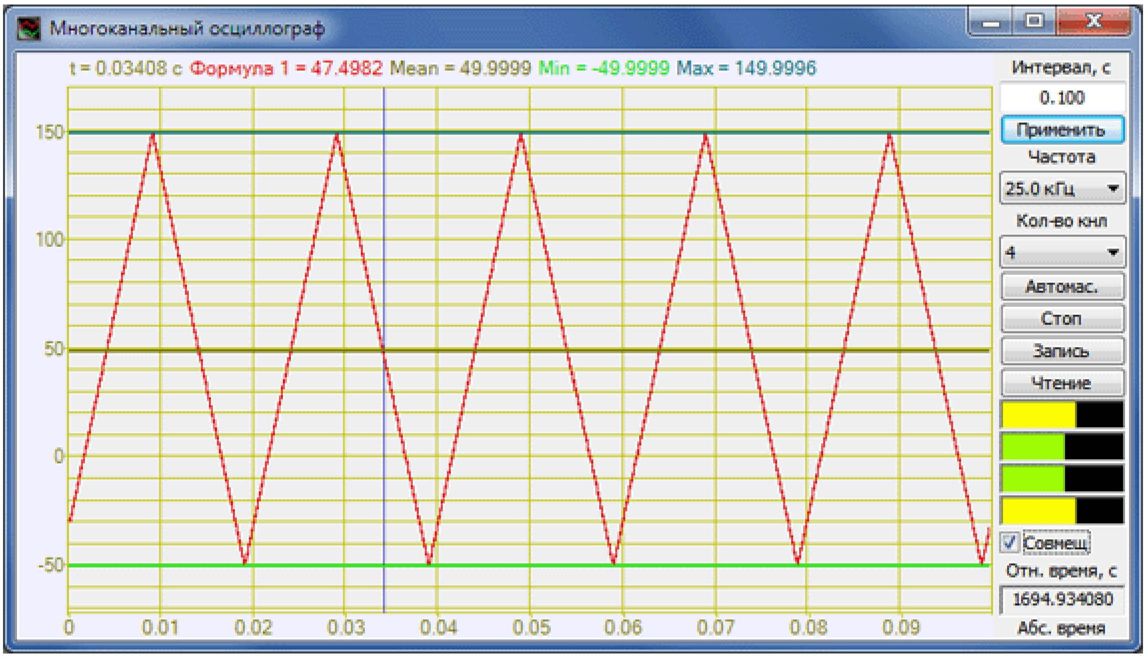
Mean*(*<channel>*, t)* – finds the average value over the channel after t preceding seconds.
Min*(*<channel>*, t)* – finds the minimum value over the channel after t preceding seconds.
Max*(*<channel>*, t)* – finds the maximum value on the channel after t preceding seconds.

These functions are inherently filters, The AFC of which looks like a function sin(x)/x, where x is the inverse of the entered time interval. For values of the time interval above 0.1 s, these values are rounded off with an accuracy of 0.1 s to the nearest larger, in order to speed up the work and save memory by the program.

The Fig. below shows the calculation of the minimum, maximum and average values for the channel. As the analyzed signal is given a triangular form. The results of the calculation are displayed on the oscilloscope in the mode of registration:



Formula: the functions "Min", "Max", "Mean"

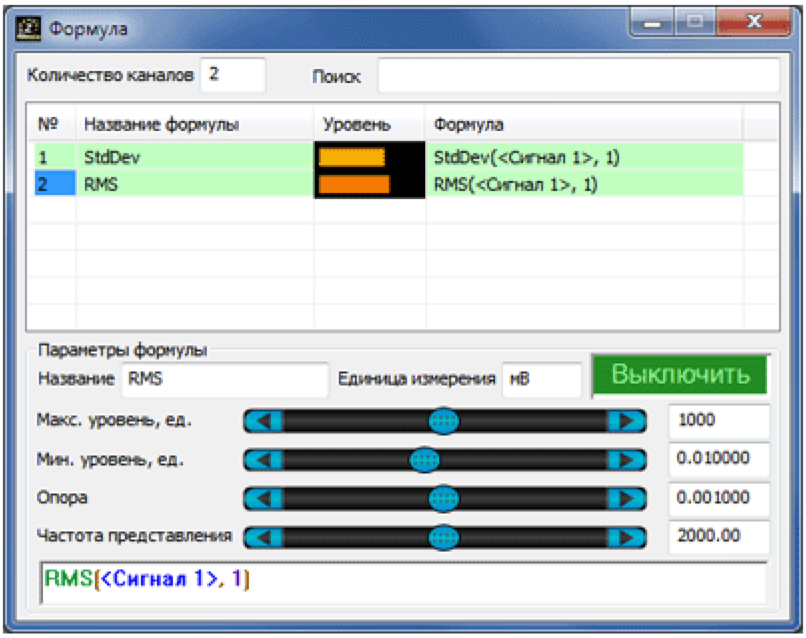


The result of the "Min", "Max", "Mean"

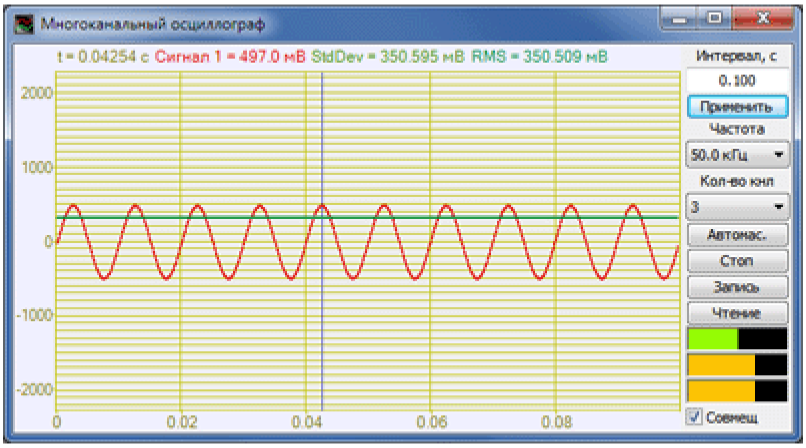
StdDev(<channel>, *t*) – finding the standard deviation (Standard deviation may be abbreviated RMSD) from. expectation (the square root of the variance) along the channel after t preceding seconds. For periodic signals is essentially an AC voltmeter.

RMS(<channel>, *t*) – rms signal level for a time t.

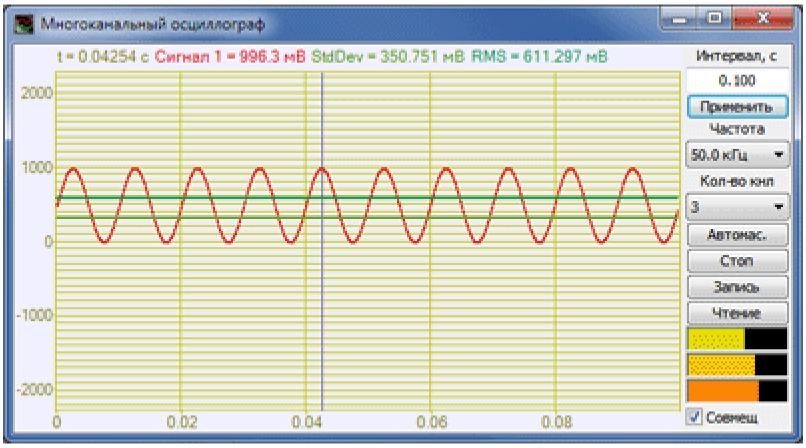
The Fig. below shows the result of the functions ***StdDev*** and ***RMS***, as an argument a signal of the same amplitude is used, but having a different level of the constant component.



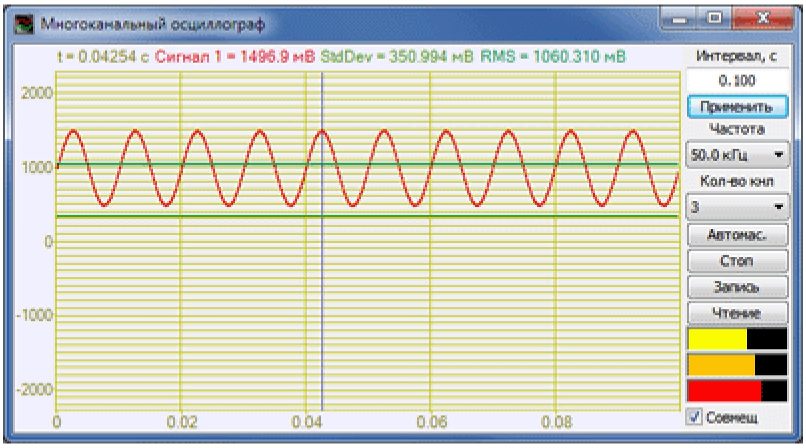
Formula: the functions "StdDev" and "RMS"



The result of the "StdDev" and "RMS" functions, the centered signal



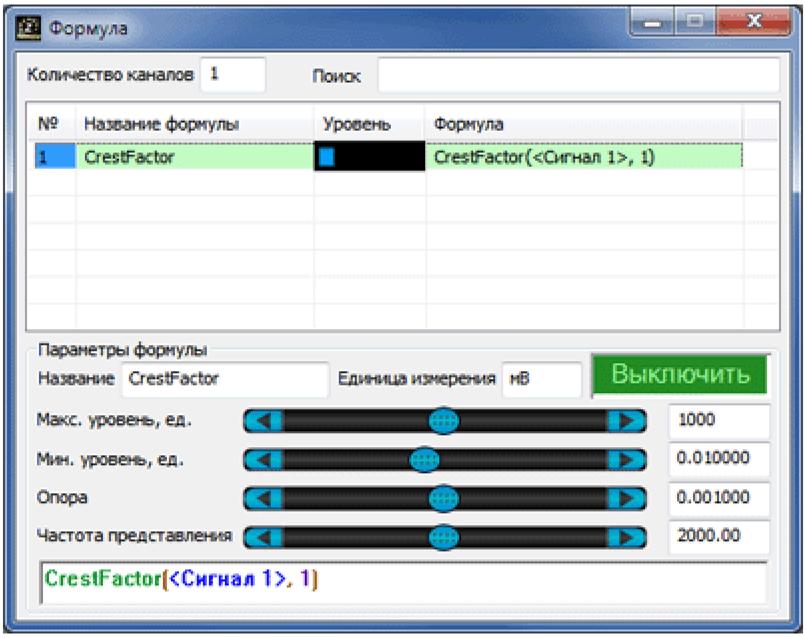
The result of the "StdDev" and "RMS" functions, the offset signal



The result of the "StdDev" and "RMS" functions, the offset signal

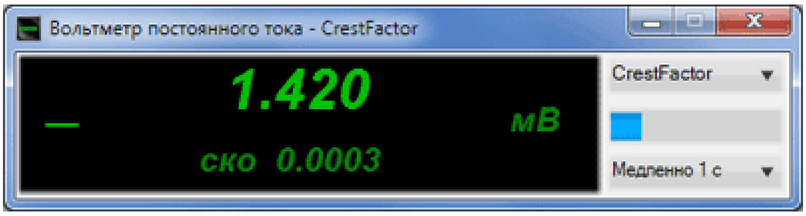
CrestFactor(<channel>, *t*) – peak factor, calculates the ratio of the amplitude value (peak) of the signal to the rms value with averaging over t preceding seconds.

The Fig. below shows the result of the function ***CrestFactor***, the sine wave is used as an argument whose parameters (RMS and peak) are measured by an AC voltmeter. The result of the function ***CrestFactor*** is displayed by a DC voltmeter.



Formula: "CrestFactor" function

Signal parameters: RMS and Peak



The result of the "CrestFactor" function

VDV(<channel>, *t*) – dose of vibration in time t.
MSDV(<channel>, *t*) – dose of motion sickness in time t.

The peak factor (***CrestFactor***), dose of vibration (***VDV***) and dose of motion sickness (***MSDV***) are the parameters of the corrected acceleration and are performed in accordance with GOST ISO 8041-2006: *rms value of the corrected acceleration* a_w: Averaged over time, translational or angular vibration, defined by the formula:

$$a_w = \left(\frac{1}{T} \int_0^T a_w^2(\xi) d\xi \right)^{1/2},$$

- $a_w(\xi)$ - the current value of the corrected acceleration (translational or angular) as a function of time ξ;
- *T* - measurement period.

corrected acceleration level L_w: The rms level of the corrected acceleration, dB, defined by the formula:

$$L_w = 20 \lg \frac{a_w}{a_0},$$

- a_w - rms value of the corrected acceleration, m/sI;
- a_0 - acceleration reference value equal to 10^{-6} m/sI.

the current rms value of the corrected acceleration $a_{w,\theta}(t)$: The root-mean-square value of the corrected acceleration at time t, defined by the formula:

$$a_{w,\theta}(t) = \left(\frac{1}{\theta} \int_{t-\theta}^{t} a_w^2(\xi) d\xi \right)^{1/2},$$

- $a_w(\xi)$ - the current value of the corrected acceleration at the time point ξ;
- *θ* - period of integration;
- *t* - current time.

Note - as an approximation of linear averaging, exponential averaging can be used, defined by the formula:

$$a_{w,\tau}(t) = \left(\frac{1}{\tau} \int_{-\infty}^{t} a_w^2(\xi) \exp\left(\frac{\xi - t}{\tau} \right) d\xi \right)^{1/2},$$

- *τ* - time constant of exponential averaging.

maximum short-time rms value (corrected acceleration) ***MTVV***: The maximum value of the current rms value of the corrected acceleration for the integration period θ equal to 1 s.

dose of motion sickness ***MSDV***: The value representing the integral of the square of the corrected acceleration $a_w(t)$, expressed in m/s$^{1.5}$ and defined by the formula:

$$MSDV = \left(\int_0^{\Phi} a_w^2(\xi) d\xi \right)^{1/2},$$

where Φ - the common period of time during which low-frequency oscillations that cause motion sickness (motion sickness) are observed.

Notes:

1. The lactation dose can be obtained from the rms value of the corrected acceleration by multiplying by a factor $\Phi^{1/2}$.
2. Unless otherwise specified, the exposure time Φ is assumed to be equal to the measurement period T.

dose of vibration ***VDV***: The value representing the integral of the fourth power of the corrected acceleration $a_w(t)$, expressed in m/s$^{1.75}$ and defined by the formula:

$$VDV = \left(\int_0^{\Phi} a_w^4(t) dt \right)^{1/4},$$

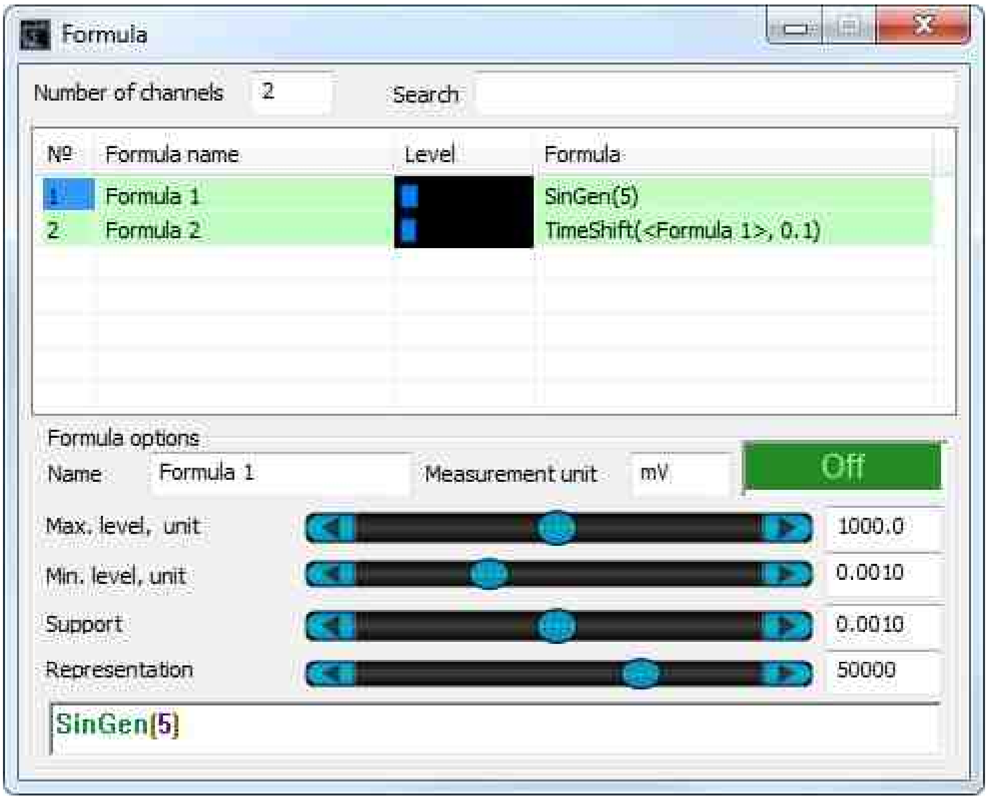
where Φ is the total time of exposure to vibration

Notes:

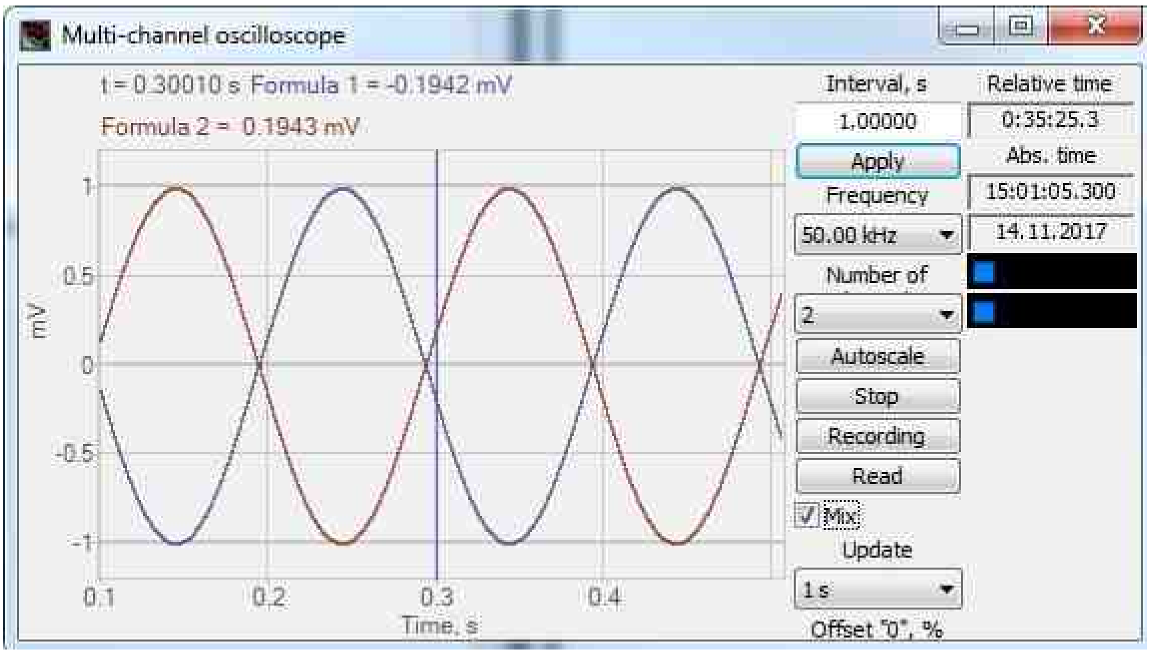
1 The vibration dose is more sensitive to peak acceleration values than the rms value.

2 Unless otherwise specified, the exposure time Φ is assumed to be equal to the measurement period T.

TimeShift (<channel>, *t*) – The time shift of values over the channel, for a specified number of seconds. The Fig. below demonstrates the operation of the function ***TimeShift***. The initial function is given by the function ***SinGen*** (Formula 1). The time shift is carried out by 0.1 s (Formula 2).



Formula: the function "TimeShift"



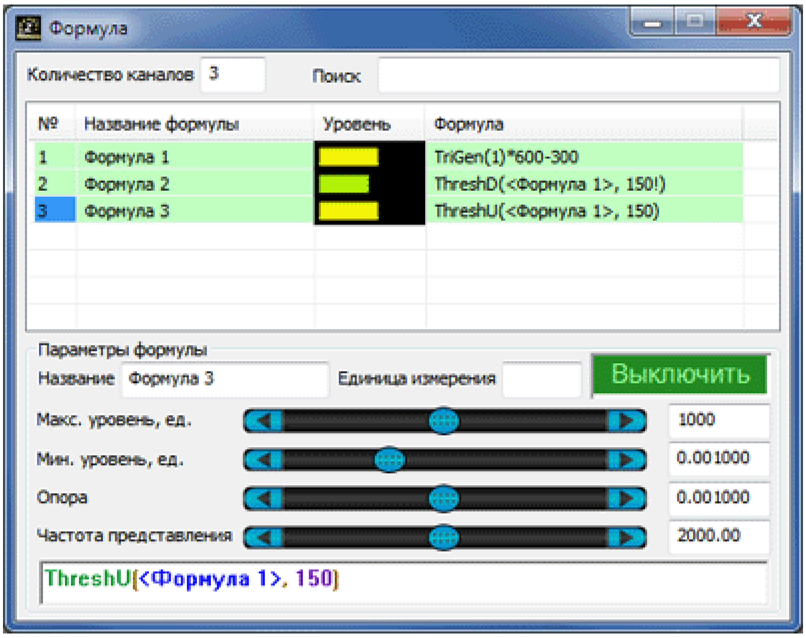
The result of the "TimeShift" function

ThreshD (<channel>, *const*) – restriction from below values on a constant channel. That is, all values, smaller constants are replaced by it.

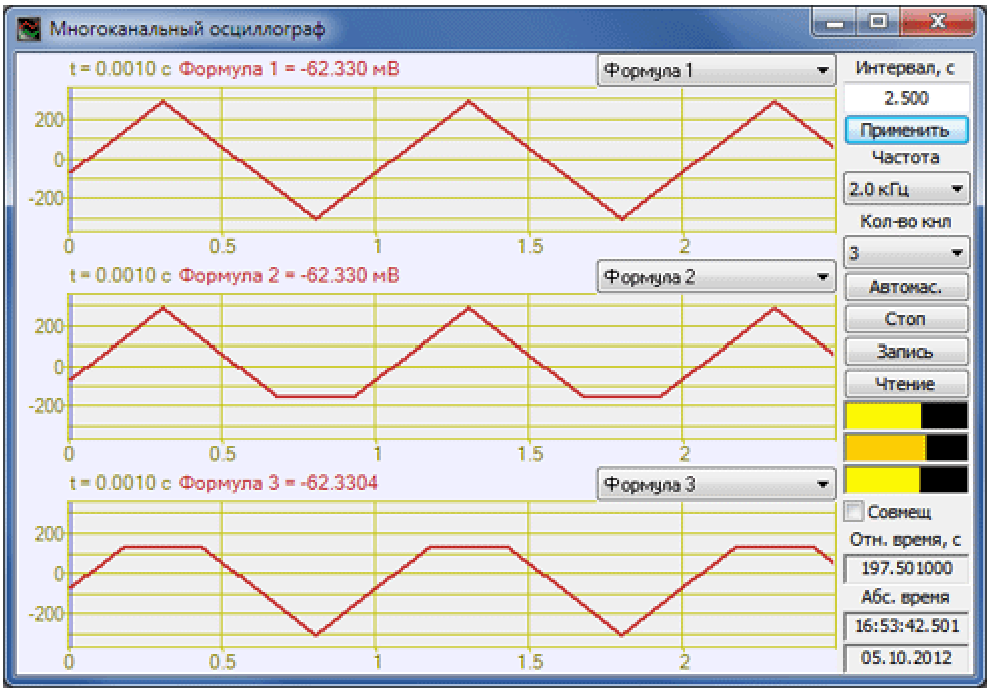
ThreshU (<channel>, *const*) – restriction on top of values on a constant channel. That is, all values, large constants are replaced by it.

To specify a negative value as a constant, use the postfix inversion operator.

The Fig. below shows the result of the functions ***ThreshD*** or ***ThreshU.*** As a source, we used a triangular waveform with an amplitude of ± 300 mV (Formula 1). Limitation from below is carried out by the value -150 (Formula 2), from above - value 150 (Formula 3).



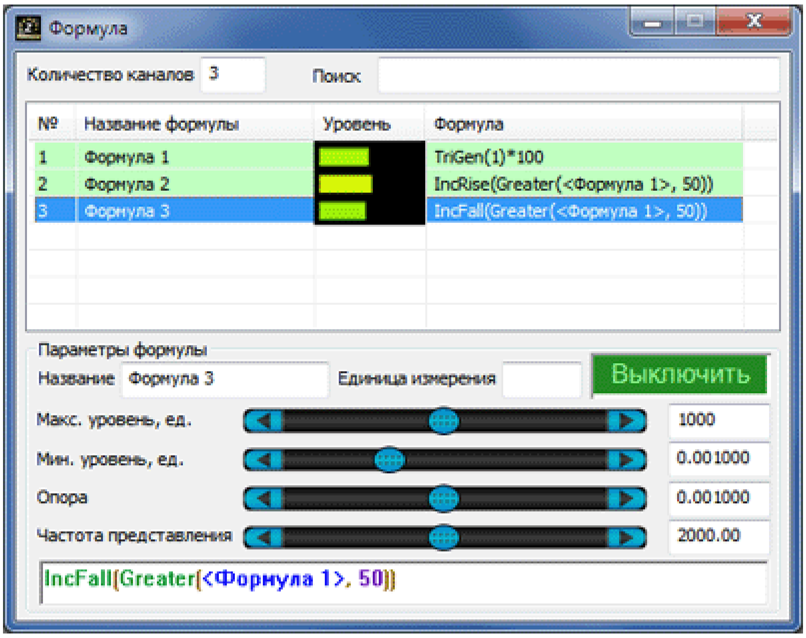
Formula: "ThreshD" and "ThreshU" functions



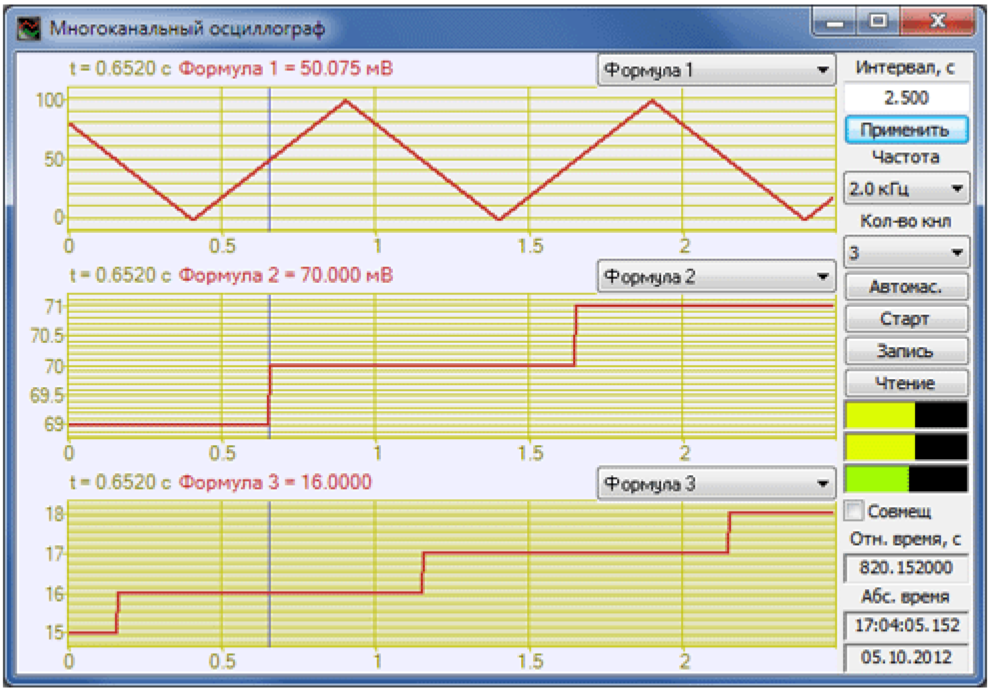
The result of the "ThreshD" and "ThreshU" functions

- ***IncRise*** (<channel>) – counter of fronts (transitions from 0 to 1).
- ***IncFall*** (<channel>) – counter of slices (transitions from 1 to 0).

Should be used with logical functions ***Equal*** or ***Greater***. The following Fig. shows an example of the operation of the counters. The sawtooth signal is taken as a basis ***TriGen***.



Formula: conversion counters



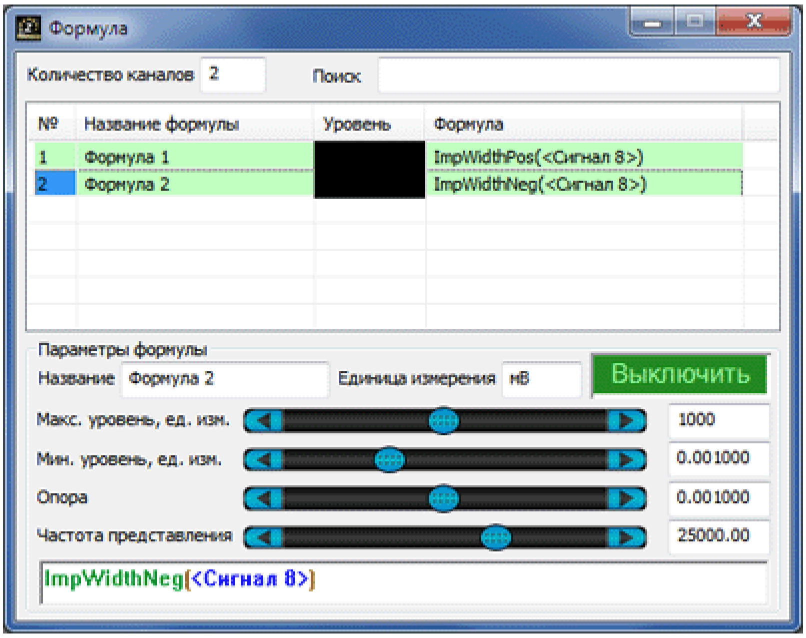
The results of the counters of the transitions

ImpWidthPos(<channel>) – width of positive impulse in seconds.

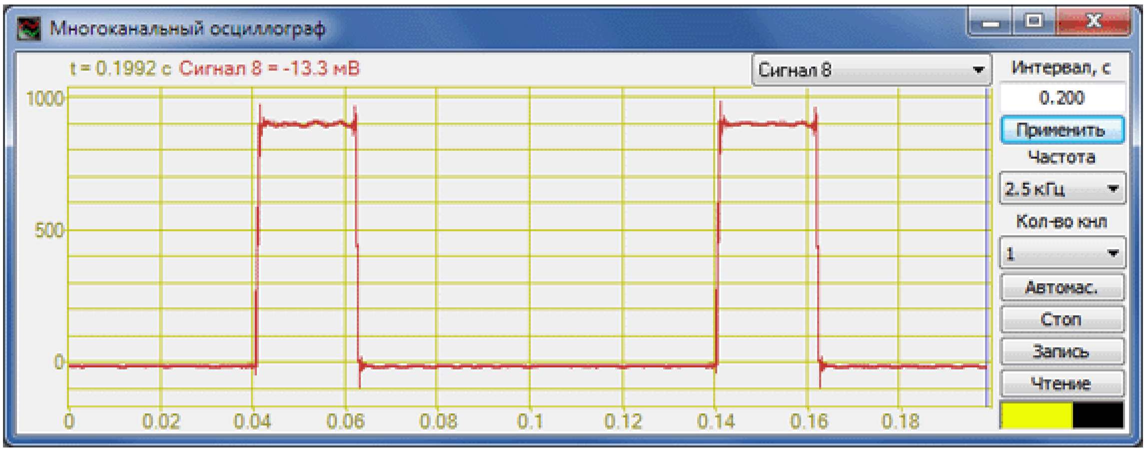
ImpWidthNeg(<channel>) – width negative impulse width in seconds.

Should be used logical functions ***Equal*** and ***Greater***.

The Fig.s below demonstrate how to work functions ***ImpWidthPos*** or ***ImpWidthNeg***.



Formula function "ImpWidthPos" and "ImpWidthNeg"



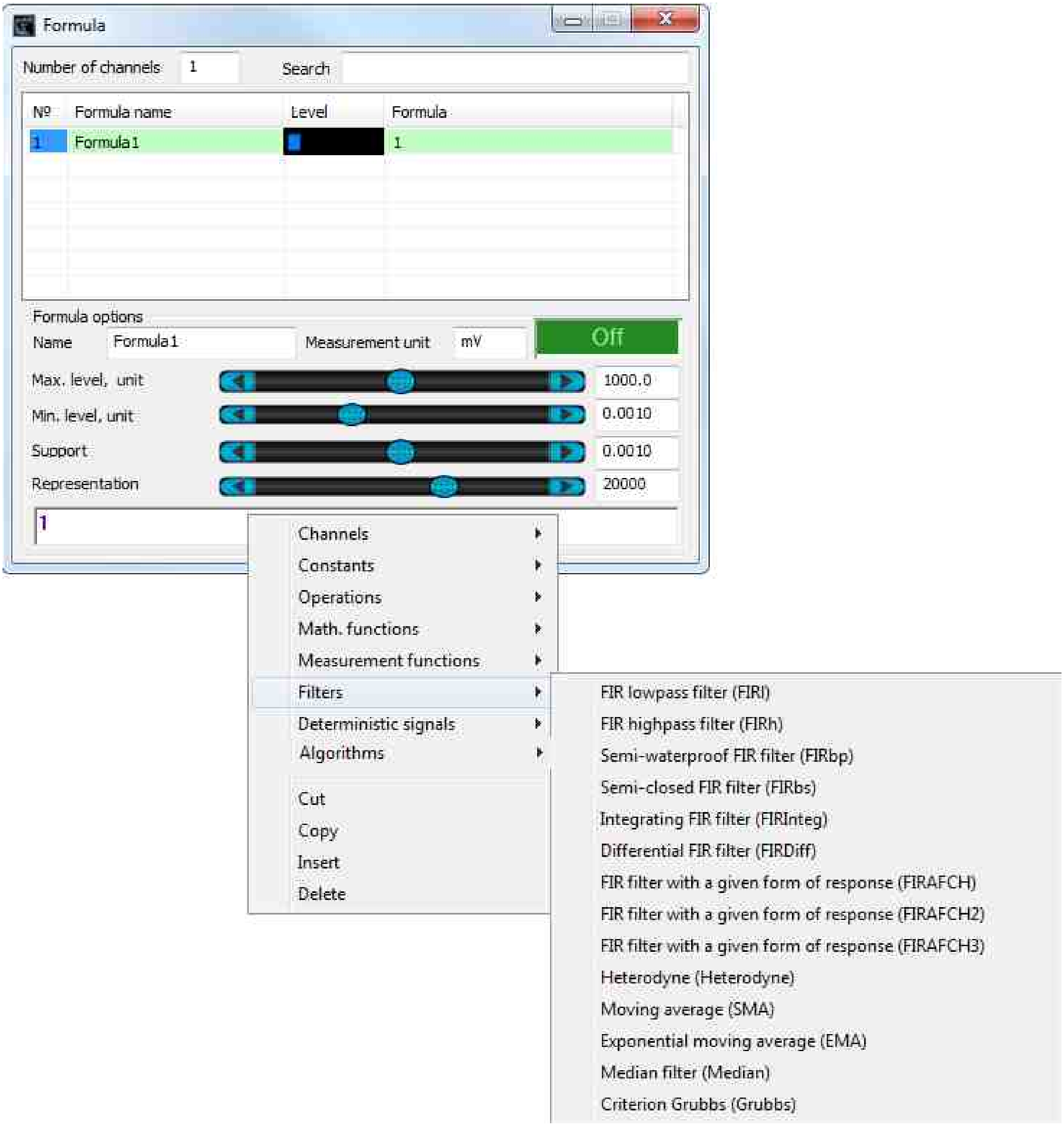
The oscillogram of the signal

The result of the function "ImpWidthPos"

The result of the function "ImpWidthNeg"

Filters .....

The **Filters** menu contains functions that impose a variety of filters:



Formula: filters

A few words about using FIR filters

Filters with finite impulse response (FIR filters) have a delay determined by the number of coefficients. And the delay is always equal to the number of filter coefficients. Also, the number of coefficients serves as a measure of the accuracy of the filter: the ratio of the sampling frequency per channel, referred to the number of filter coefficients, is half the frequency band in which the filter meets the requirements. Generally speaking, for the digital filter in the overwhelming number of cases, the number of coefficients is better to increase. But there is one important limitation: with a large number of coefficients, filtering the signal takes too much CPU time. In this connection, in the program "Formula":

1) determines the clock speed of the installed processor, and the number of coefficients is calculated so that the loading of one processor core is 3%. Formula for calculation:tapslen = CPUSPEED*2%/ADC_FREQUENCY, where tapslen is the number of filter coefficients, **CPUSPEED** - processor clock speed, Hz, ADC_FREQUENCY - frequency of sampling over the filtered channel.
2) If the result obtained exceeds the rationally admissible number of coefficients (2000), then the number of coefficients is equated to it.
3) If the result is less than the minimum acceptable (20), then the number of coefficients is equal to it.
4) If the result obtained does not allow the calculation of the result with the required frequency accuracy, then the formula is used: tapslen = 1/(0.5 * NORM_FREQ), where NORM_FREQ is the normalized frequency, that is the entered frequency is related to the sampling frequency.
5) If the result is too expensive for computing power (loads more than 30% of one processor core), the final result will be calculated using the formula: tapslen = CPUSPEED * 30% / ADC_FREQUENCY.

Example:
Let it be necessary to calculate the time delay on a channel with a sampling frequency of 500 kHz on a dual-core 2.5 GHz processor, with a low-pass filter at 300 Hz.
We use the algorithm for steps:

1) tapslen = 2.5e+9 * 2e-2 / 5e+5 = 100 - - a variant in which the processor load will be 2% divided by the number of cores, that is 1%.

2), 3) - do not influence the result.

4) tapslen = 1 / (5e-1 * 3e+2 / 5e+5) = 3.3e+3 - such an amount of coefficients is necessary to satisfy the task.

5) tapslen = 2.5e+9 * 3e-1/ 5e+5 = 1500 - such an amount of coefficients we can afford under the given conditions.

Now that the number of filter coefficients tapslen = 1500 is obtained, we estimate the time delay and how far the required filter meets our accuracy requirements.
Temporary delay dt = tapslen/ADC_FREQUENCY = 1.5e+2 / 5e+5 = 3e-4 (seconds), or 300 µs.
The cutoff frequency of the filter is: Fc = ADC_FREQUENCY/(0.5e-1 * tapslen) = 5e+5 / (0.5e-1 * 1.5e+3) = 6.7e+3 (Hertz), i.e. two times more than was required.

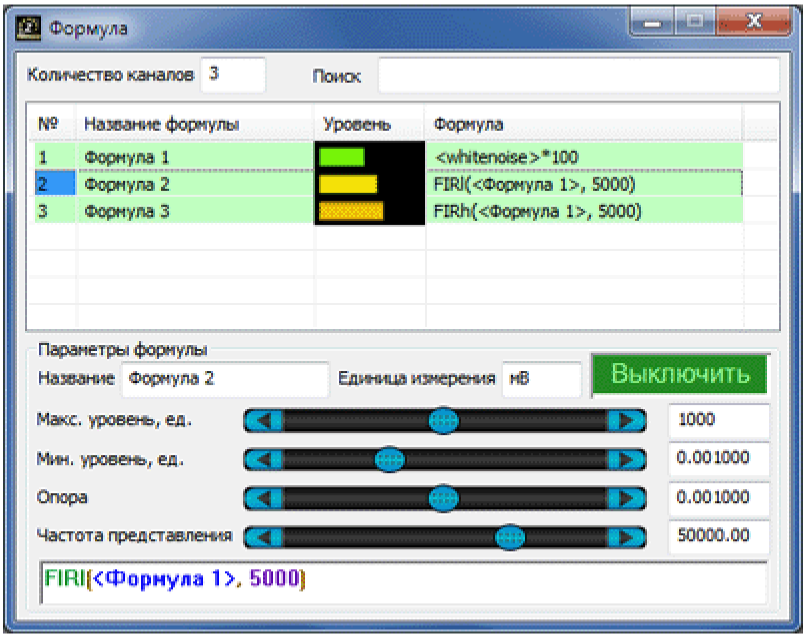
Be careful! At high sampling frequencys, you do not need to adjust the filters with very high accuracy - you will load the processor, but the result will not be achieved. Try to choose the most optimal frequency range for measurements. If you need to investigate the HF signal, then we recommend using a hardware

heterodyne.
Note: the filtering program uses "Signal Filtering" with infinite impulse response. When describing the filters of the "Formula", the results of the filters of the program "Signal Filtering" - for comparison will be given.

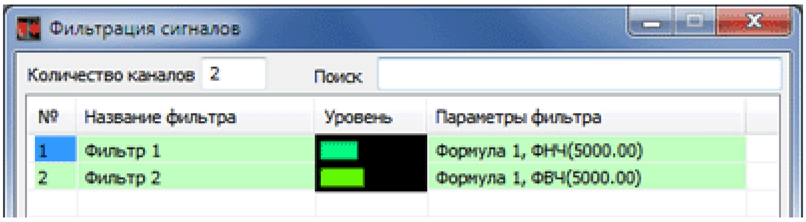
Description of filters

FIRl(<channel>, const) – low-pass filter with boundary frequency equal to const. The frequency can not be less than zero and more than half the sampling frequency. This type of filter should be used to cut off unwanted high-frequency components, for example - in the task of identifying the movement of a person or car on the ground, where the signal of interest to us lies in the low frequency region.
FIRh(<channel>, const) – high-pass filter with boundary frequency equal to const. The frequency can not be less than zero and more than half the sampling frequency. This type of filter should be used to cut off the constant and low-frequency components of the signal. Example usage: output of audio information with clipping of the inaudible part and a constant component.

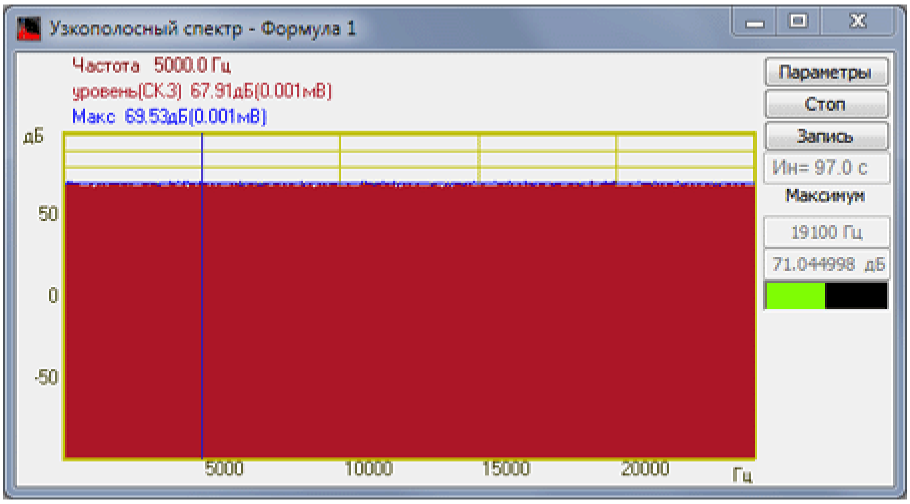
The pictures below show an example of noise filter filtering (the function of the <whitenoise> formula is used) by the low-pass filter and the high-pass filter in the "Formula" program and the "Signal Filtering" program.



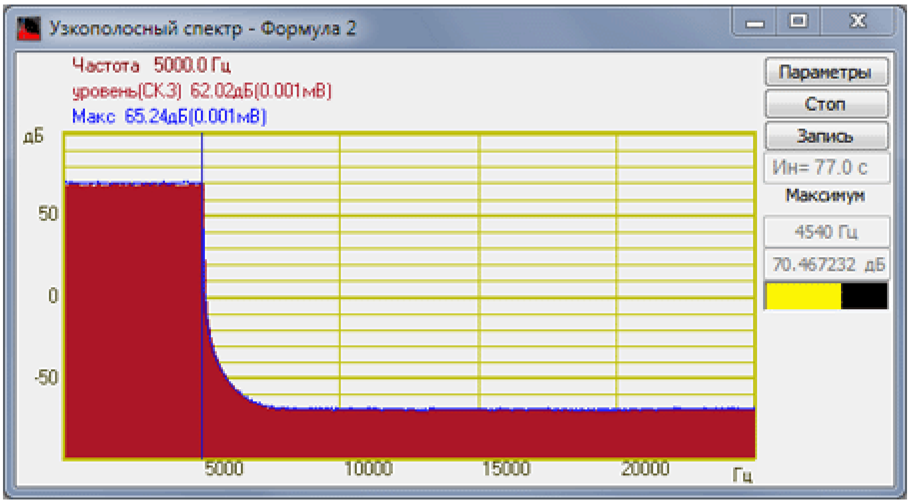
Filter parameters in the program "Formula"



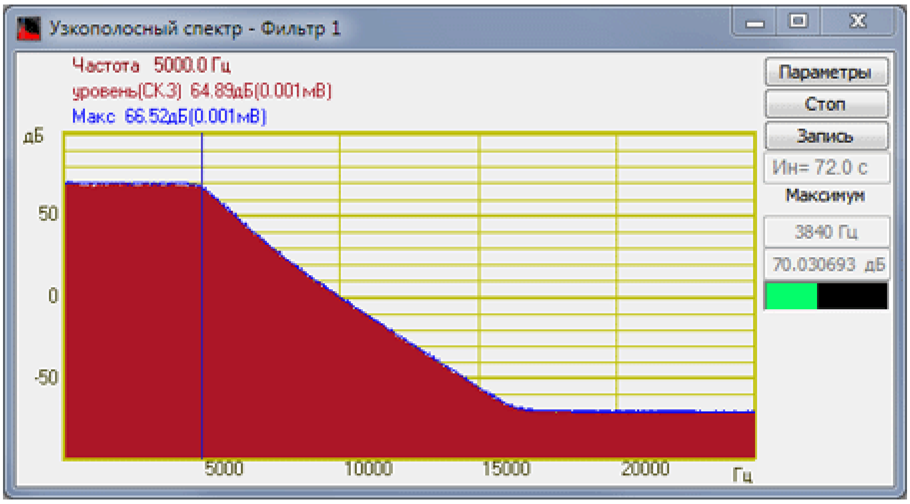
Filtering parameters in the program "Signals filtering"



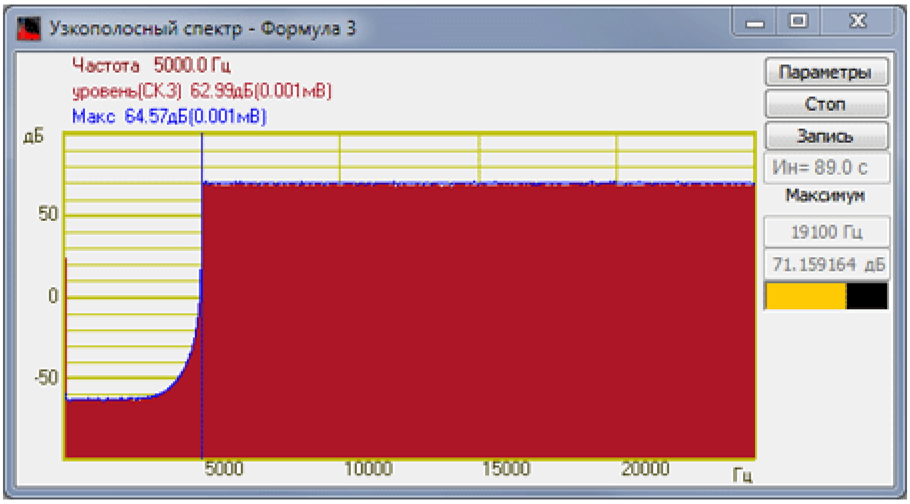
The spectrum of the initial signal



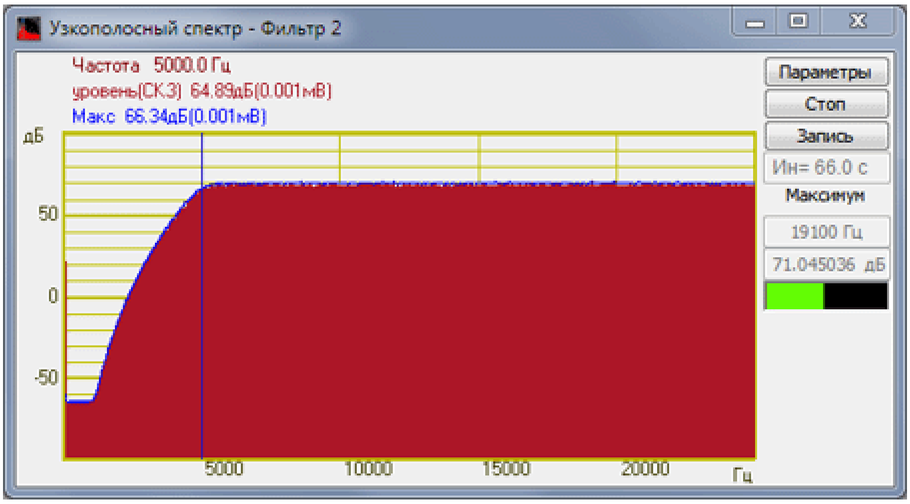
The spectrum of the signal processed by the LPF of the program "Formula"



The spectrum of the signal processed by the LPF of the program "Signals filtering"



The spectrum of the signal processed by the HPF program "Formula"

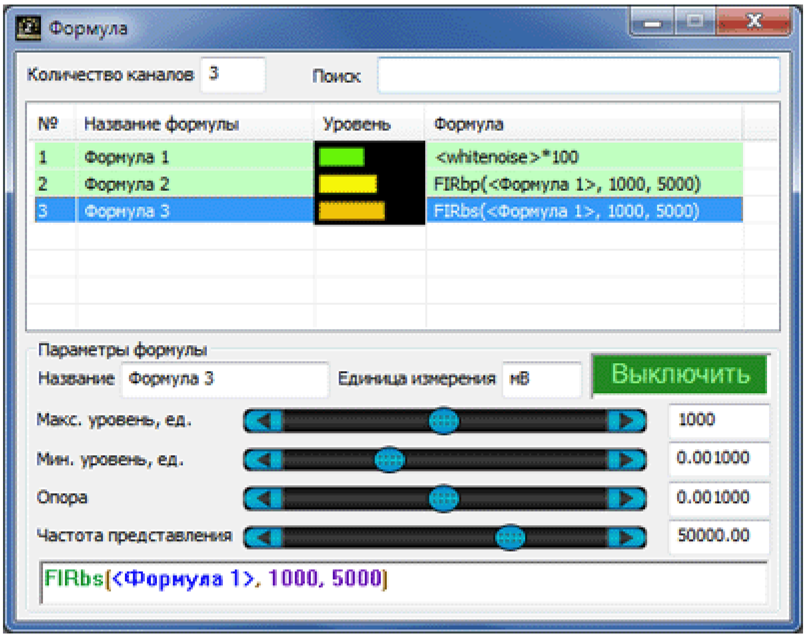


The spectrum of the signal processed by the HPF program "Signals filtering"

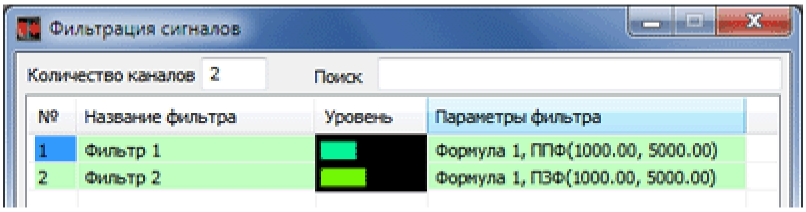
FIRbp(<channel>, const 1, const 2) – Bandpass filter that passes frequencies from the first to the second. The frequency values can not be less than zero and more than half the sampling frequency. If such values are entered, then the filter in their place substitutes the maximum permissible. The filter can be used to cut frequencies corresponding to the human voice.

FIRbs(<channel>, const 1, const 2) – Bandpass filter that cuts frequencies from the first to the second. The frequency values can not be less than zero and more than half the sampling frequency. If such values are entered, then the filter in their place substitutes the maximum permissible. The differences in the order of the frequencies in the expression are not present.

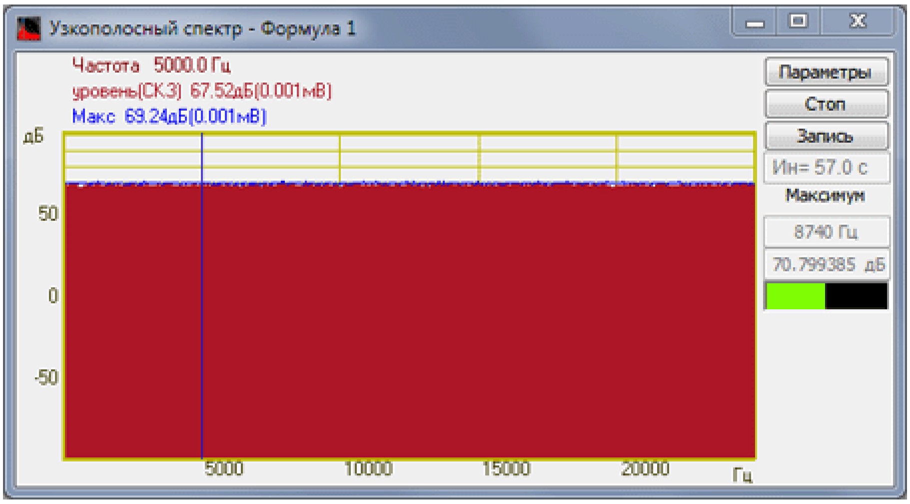
The following Fig.s show an example of filtering a noise signal (using the function of the <whitenoise> formula) with a bandpass filter (PPF) and a bandpass filter (BPF) in the "Formula" program and the Filter "Signal Filtering".



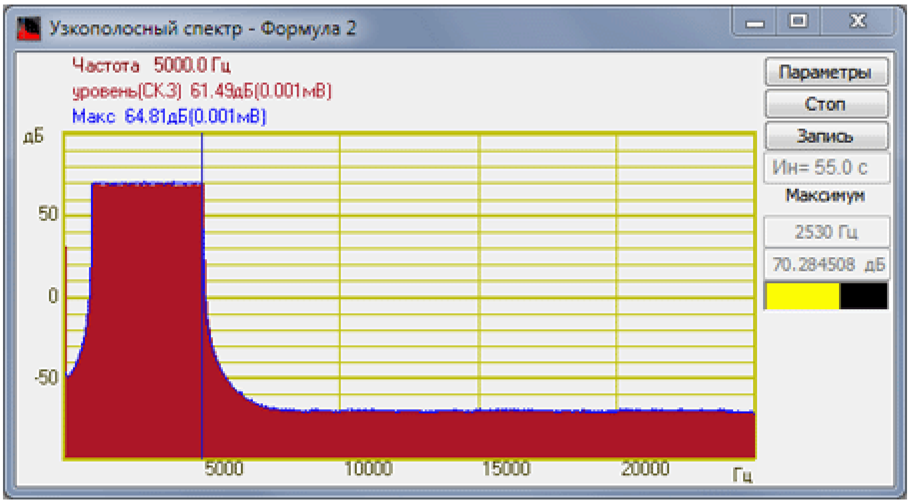
Filter parameters in the program "Formula"



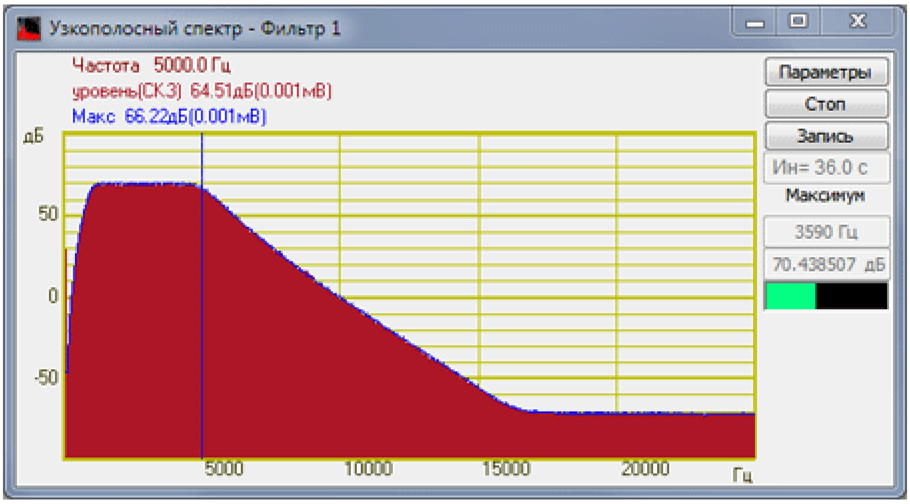
Filtering parameters in the program "Signals filtering"



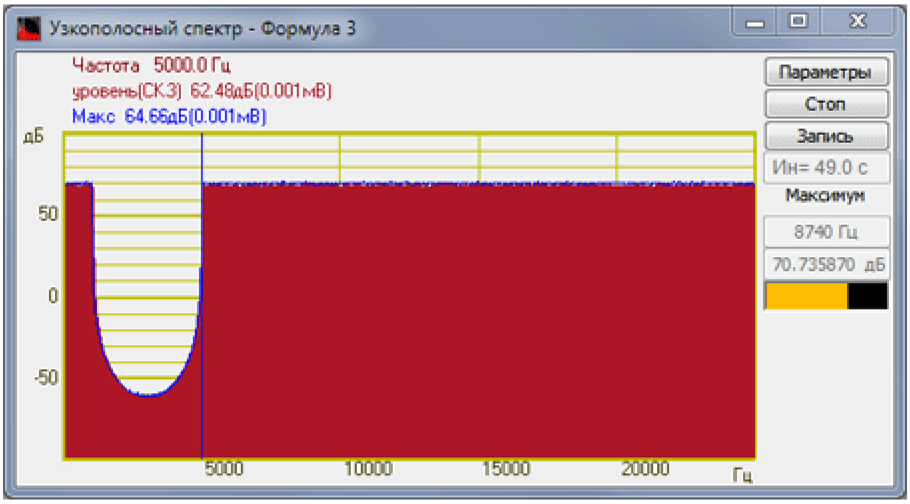
The spectrum of the initial signal



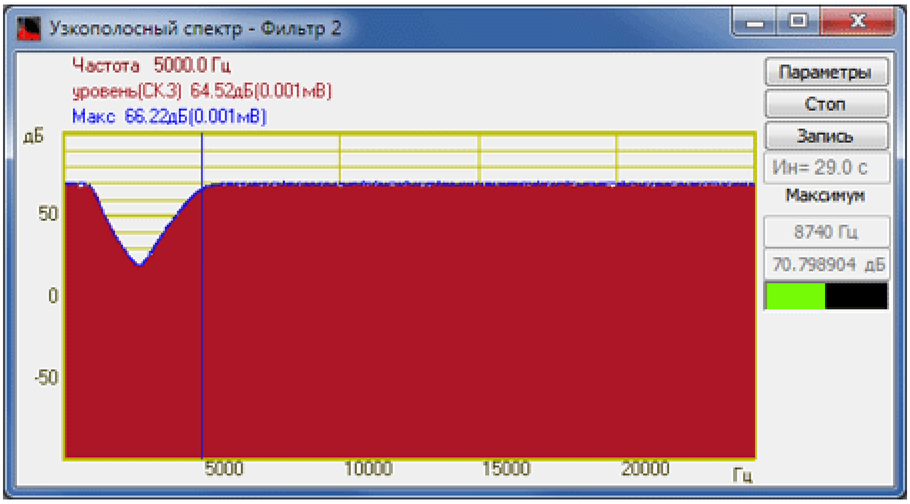
The spectrum of the signal processed PPF program "Formula"



The spectrum of the signal processed PPF program "Signals filtering"



The spectrum of the signal processed by the BPF program "Formula"



The spectrum of the signal processed by the BPF program "Signals filtering"

FIRInteg(<channel>) – the integrating FIR filter is potentially unstable, so a high-pass filter must be placed before using it.

FIRDiff(<channel>) - differential FIR filter.

FIRAFCH(<channel1>, <channel2>) – FIR filter with a given form of AFC.

Heterodyne(<channel>, frequency, band) – heterodyne. Cut out from the signal spectrum a band with Frequency Hz and Band Band Hz. Then shifts it to the low frequency region. The main use of the local oscillator is the frequency demodulation of the signal - the process of transferring part of the spectrum from the high-frequency region to the low-frequency region. It is used in radio engineering tasks.

SMA *(*<channel>, time) - filters the moving average of which at each point of the definition is equal to the average value of the original function for the previous period. Moving averages are usually used with time series data to smooth short-term fluctuations. A mathematically moving average is one of the types of convolution, and therefore it can be considered as a low-pass filter used in signal processing. Since the value of the function is calculated every time anew in the calculation of the moving average, taking into account the finite significant set of previous values, the moving average "moves" (moves), as it were, "sliding" along the time series.

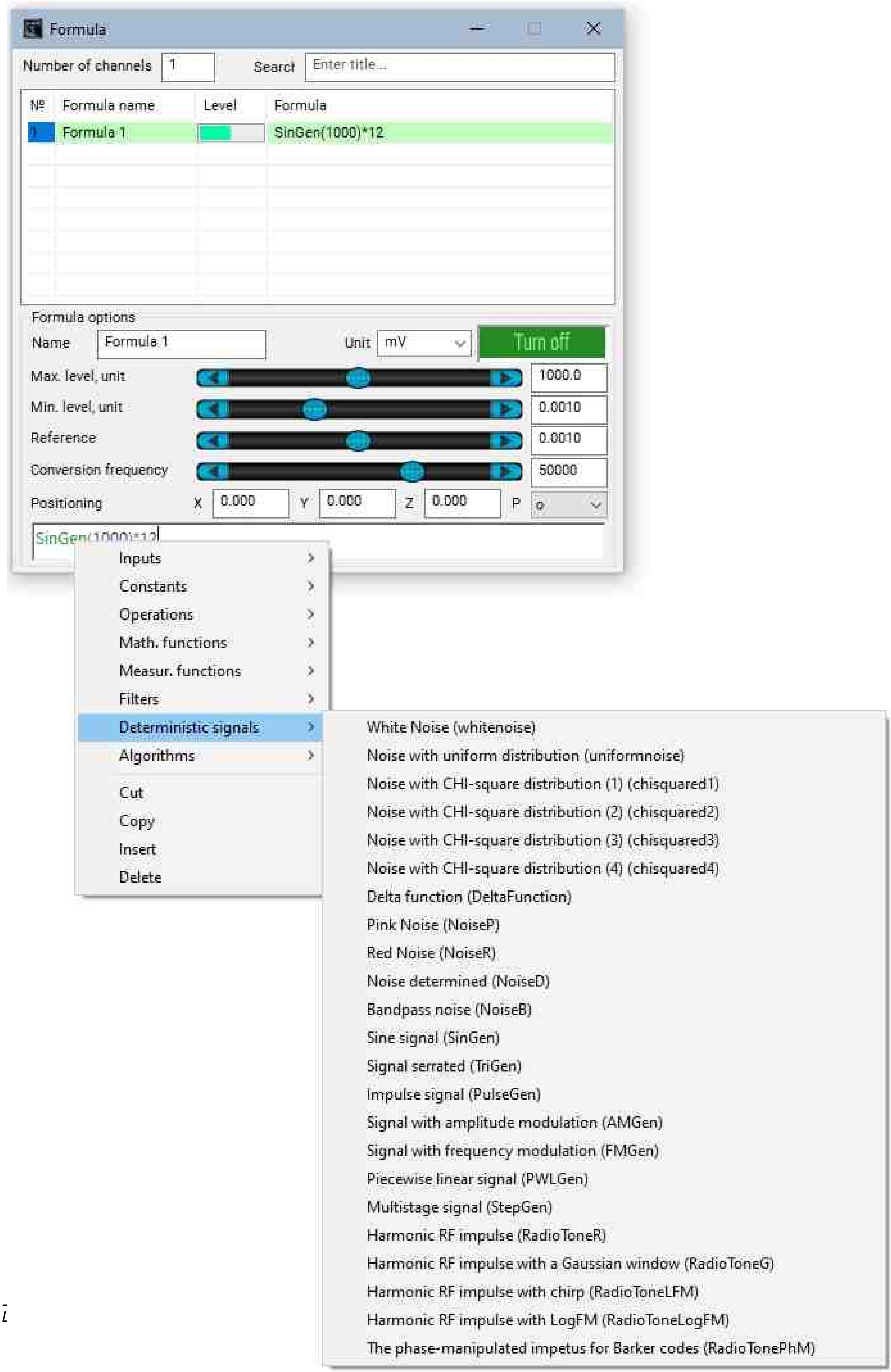
EMA(<channel>, const) - filters the exponential mean. In the ordinary exponential moving average, the values of the original function are subjected to the smoothening, however, the values of the resulting function can be smoothed out. The value "Constant" must vary from 0 to 1, the smaller it is, the larger the exponential value becomes.

Median(<channel>, Time) - an efficient procedure for processing signals subjected to impulse noise. It is a type of digital filter, widely used in digital signal processing and image processing to reduce noise levels. The median filter is a nonlinear FIR filter. The values of the readings inside the filter window are sorted in ascending order (decreasing); and the value in the middle of the ordered list goes to the output of the filter. In the case of an even number of samples in the window, the output value of the filter is equal to the average of the two samples in the middle of the ordered list. The window moves along the filtered signal and the calculations are repeated.

Grubbs(<channel>, Time, Q) - eliminates gross errors. To eliminate gross errors, the Grubbs criterion is used. Grubbs statistical criterion for the elimination of gross errors is based on the assumption that the group of measurement results belongs to the normal distribution. Implemented in accordance with GOST R 8.736-2011 GSI. Direct measurements are multiple. Methods for processing the results of measurements..

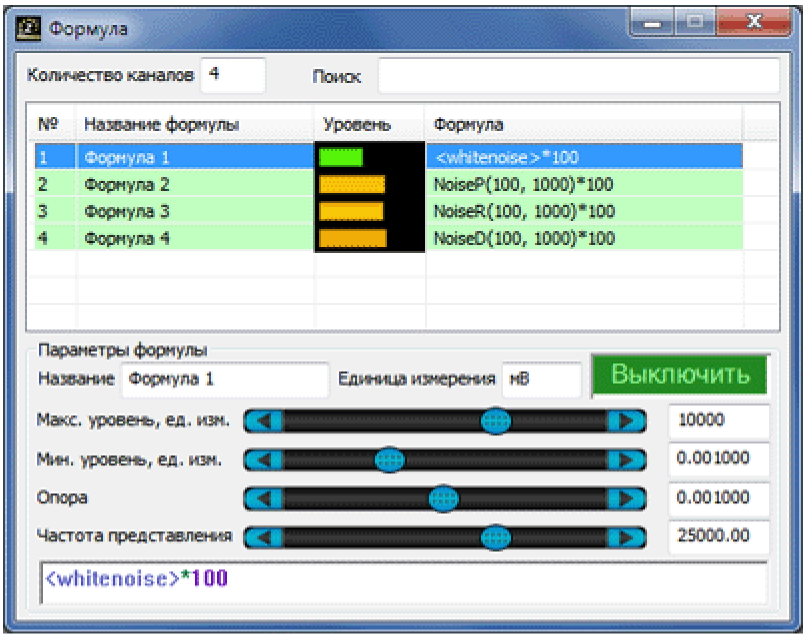
Deterministic signals .....

Section "Deterministic signals" of the program functions menu The "Formula" contains functions for generating signals.

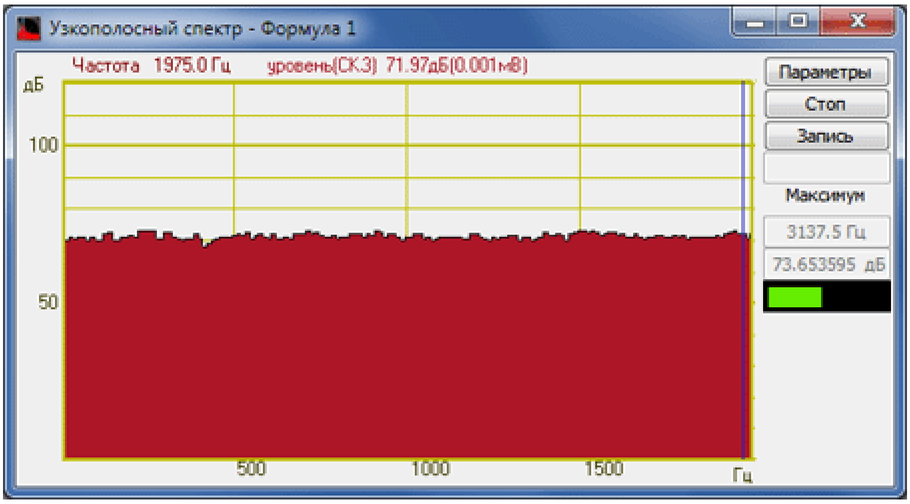

Formula
Number of channels 1
Search Enter title...
№ Formula name Level Formula
Formula 1 SinGen(1000)*12
Formula options
Name Formula 1
Unit mV
Turn off
Max. level, unit 1000.0
Min. level, unit 0.0010
Reference 0.0010
Conversion frequency 50000
Positioning X 0.000 Y 0.000 Z 0.000 P o
SinGen(1000)*12
Inputs
Constants
Operations
Math. functions
Measur. functions
Filters
Deterministic signals
Algorithms
Cut
Copy
Insert
Delete
White Noise (whitenoise)
Noise with uniform distribution (uniformnoise)
Noise with CHI-square distribution (1) (chisquared1)
Noise with CHI-square distribution (2) (chisquared2)
Noise with CHI-square distribution (3) (chisquared3)
Noise with CHI-square distribution (4) (chisquared4)
Delta function (DeltaFunction)
Pink Noise (NoiseP)
Red Noise (NoiseR)
Noise determined (NoiseD)
Bandpass noise (NoiseB)
Sine signal (SinGen)
Signal serrated (TriGen)
Impulse signal (PulseGen)
Signal with amplitude modulation (AMGen)
Signal with frequency modulation (FMGen)
Piecewise linear signal (PWLGen)
Multistage signal (StepGen)
Harmonic RF impulse (RadioToneR)
Harmonic RF impulse with a Gaussian window (RadioToneG)
Harmonic RF impulse with chirp (RadioToneLFM)
Harmonic RF impulse with LogFM (RadioToneLogFM)
The phase-manipulated impetus for Barker codes (RadioTonePhM)

Menu "Deterministic signals" of the program "Formula"

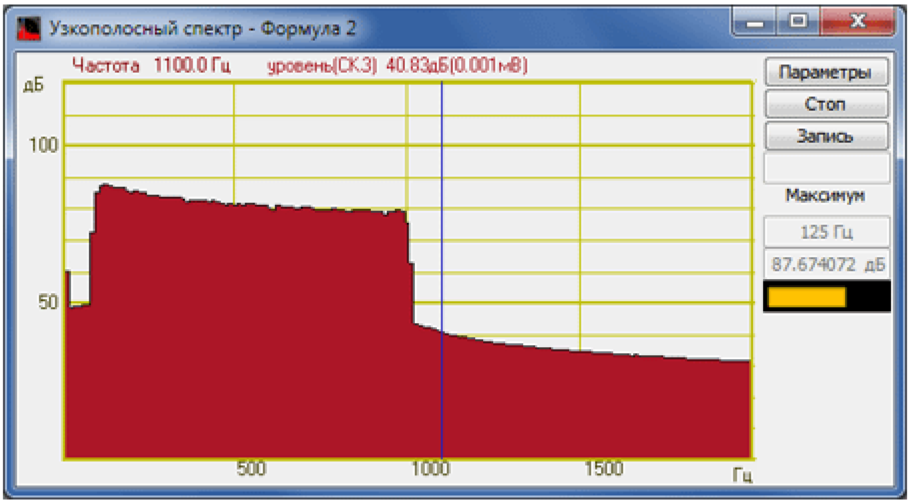
Functions **<whitenoise>**, **NoiseP(Frequency1, Frequency2)**, **NoiseR(Frequency1, Frequency2)**, **NoiseD(Frequency1, Frequency2)**, **NoiseB(Frequency1, Frequency2)** are designed to generate noise signals: white, pink, red and deterministic, band respectively. The noise frequency band is set from the lower frequency (**Frequency1**) to the upper frequency (**Frequency2**). The following Fig. shows an example of generation of virtual noise signals by the program "Formula" - signal parameters and corresponding spectra.
Function **<uniformnoise>** is designed to generate noise signals: noise with uniform distribution.
Functions **<chisquared1>, <chisquared2>, <chisquared3>, <chisquared4>** are designed to generate noise signals with n degrees of freedom: noise with chi-square distribution (1), noise with chi-square distribution (2), noise with chi-square distribution (3), noise with chi-square distribution (4).
Signal functions **PulseGen(RiseTime, FallTime, WidthTime, PeriodTime)** - impulse, **SinGen(Frequency)** - sinusoidal, **TriGen(Frequency)** - serrated, **AMGen(Frequency1, Frequency2, Depth)** - with amplitude modulation, **FMGen(Frequency1, Frequency2, Depth)** - with frequency modulation, **PWLGen(Time1, Level1, Time2, Level2, ...)** - piecewise linear, **StepGen(Time1, Level1, Time2, Level2, ...)** - multistage.
Harmonic radio impulse function **RadioToneR(Time, Period, Frequency).**
Harmonic radio impulse function with a Gauss window **RadioToneG(Time, Period, Frequency).**
Harmonic radio impulse function with Linear Frequency Modulation (LFM) **RadioToneLFM(Time, Period, Frequency1, Frequency2).**
Harmonic radio impulse function with Logarithmic Frequency Modulation (LogFM) **RadioToneLogFM(Time, Period, Frequency1, Frequency2).**
Function of the phase-manipulated impulse according to the codes of Barker **RadioTonePhM(Frequency, Period, NumPeriods, NumDiscretes).**



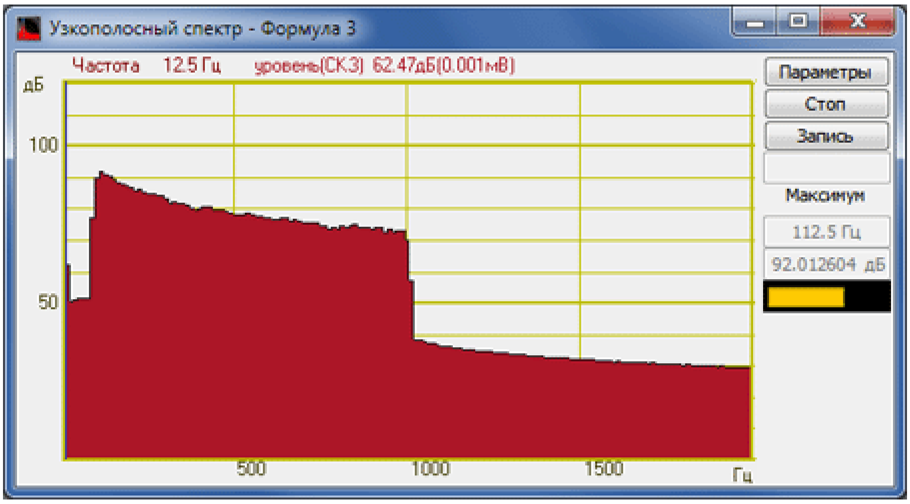
Formula: generation of noise signals



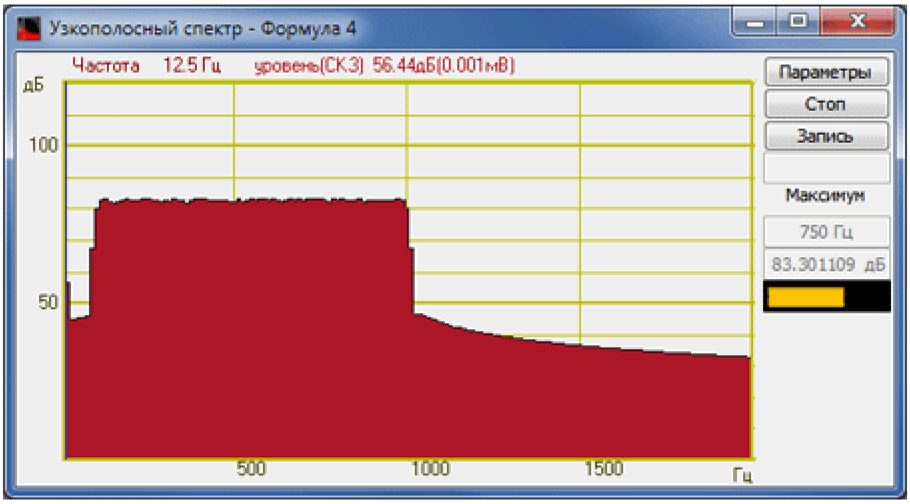
Spectrum of white noise generated by the program "Formula"



Spectrum of pink noise generated by the program "Formula"



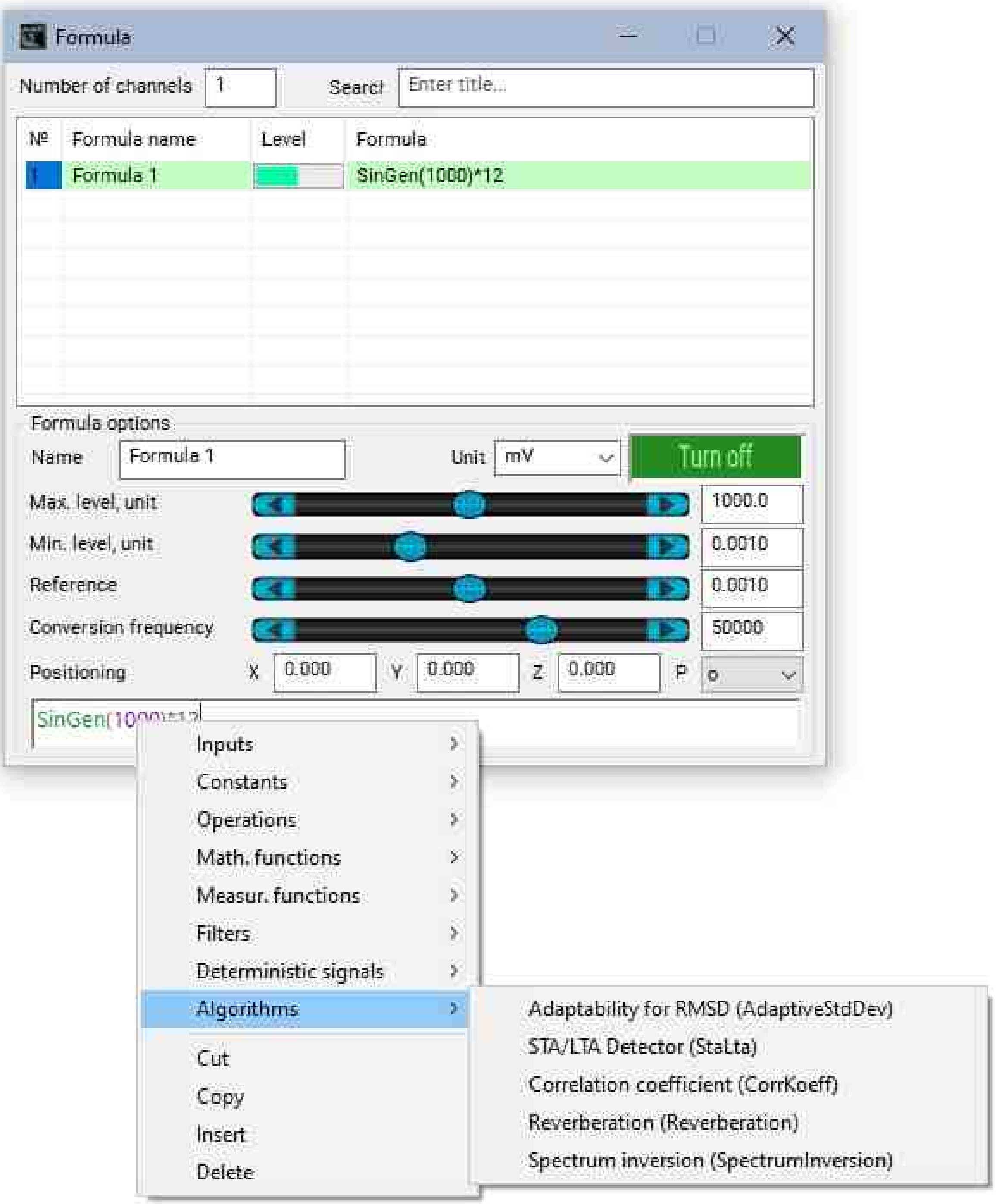
Spectrum of red noise generated by the program "Formula"



The spectrum of the deterministic noise generated by the program "Formula"

Algorithms .....

Section "Algorithms" menu of the program functions "Formula" contains functions of algorithms.



Menu "Algorithms" programs "Formula"

Device synchronization .....

Displaying and recording the current coordinates and the velocity of the object during the registration of signals coming to the input channels of the modules "ZET 2XX".

- Recreating experiment parameters during playback of recorded signals.
- The program works according to the NMEA 183 protocol.

Supported Hardware .....

The software **Device synchronization** is included with the following software:

- ZETLAB BASE – ADC/DAC module software;
- ZETLAB SEISMO - seismic station software.

Device synchronization is included in the **Automation** software group.

Program description .....

To launch the Device **Synchronization** program, select the Device Synchronization command in the Automation menu of the ZETLab panel (*Fig. 1*). The operating window of the Device **Synchronization** program will be displayed on the monitor screen (*Fig. 2*). Note: the program can be launched directly from the ZETLab working directory (by default: c:\ZETLab\). Executable file name: Synchronization.exe.

Fig. 1 Starting the program Synchronization

The main part of the program window is occupied by a graphic indicator, which displays:

- date and time (first line);
- coordinates (second line);
- object movement rate; the number of observed satellites for which all parameters are calculated; time offset in seconds between the internal time and the exact time determined by the satellite system (third line).

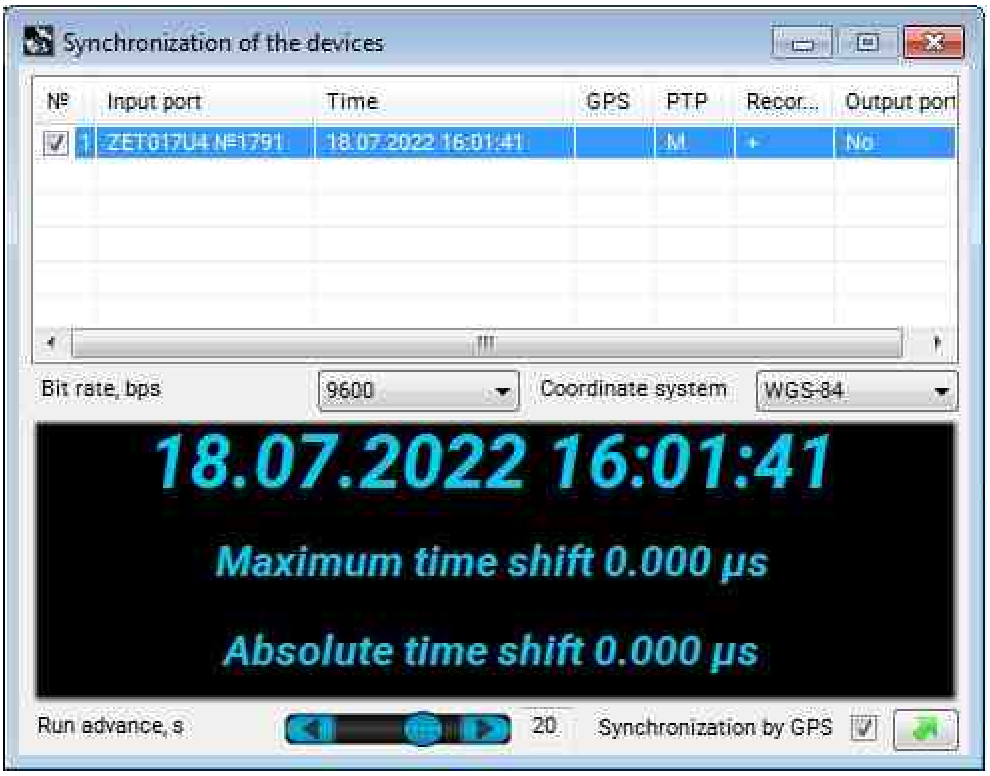


Fig. 2 Synchronization program will be displayed on the monitor screen

In the right part of the program window there are fields with a list of input and output ports of the ADC-DAC module (spectrum analyzer, strain gauge, seismic stations).

Input port - the port to which the GPS is connected.

Output port - the port to which the device is connected, to which data is transmitted during the playback of the recorded parameters of the experiment.

Bit rate on the port of the receiving device, bit/s - bit rate.

Launch advance, s - determines the time after which synchronization should occur relative to the current instantaneous time (1-20).

Synchronization of devices - allows you to enable Synchronization by devices through the lead time.

If the Device Synchronization program is launched together with the **Signal recording** program, then in addition to signal recording, the NMEA stream is recorded to the GPSData.log file in the file recording directory.
All parameters of the experiment are recorded in this file (date and time, speed and coordinates at each moment of time, number of observed satellites and time shift).

When the **Play recorded signals** program is launched, the Device Synchronization program window displays the recorded parameters of the experiment, which are transmitted to devices connected to the output port. When using cartography programs, it is possible to recreate the trajectory of the object during the experiment, simultaneously observing the position of the object and its parameters at each moment of time.

On the Oscillogram, you can see the operation of device **Synchronization** (*Fig. 3*).

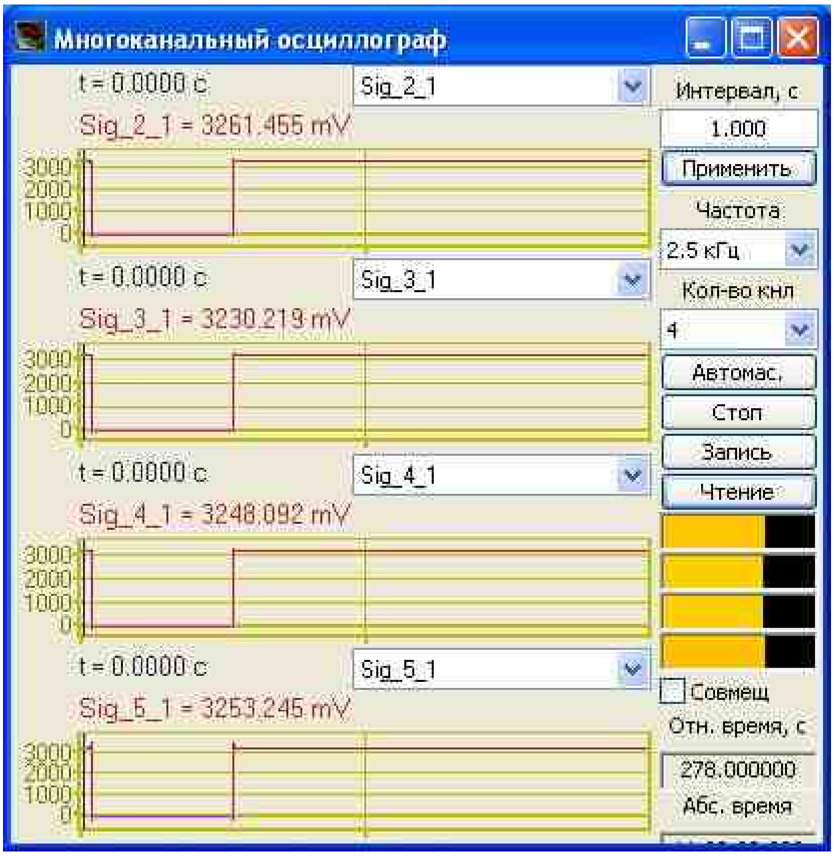


Fig. 3 Multi-channel oscilloscope program will be displayed

In the ZETServer Time program, you can see the time elapsed since synchronization (*Fig. 4*)

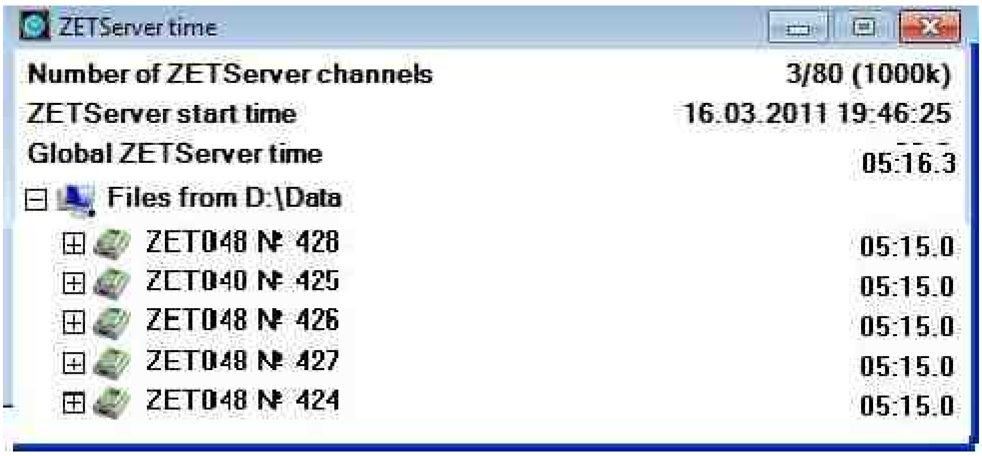


Fig. 4 ZETServer time

The instruments are connected via Ethernet (*Fig. 5*).

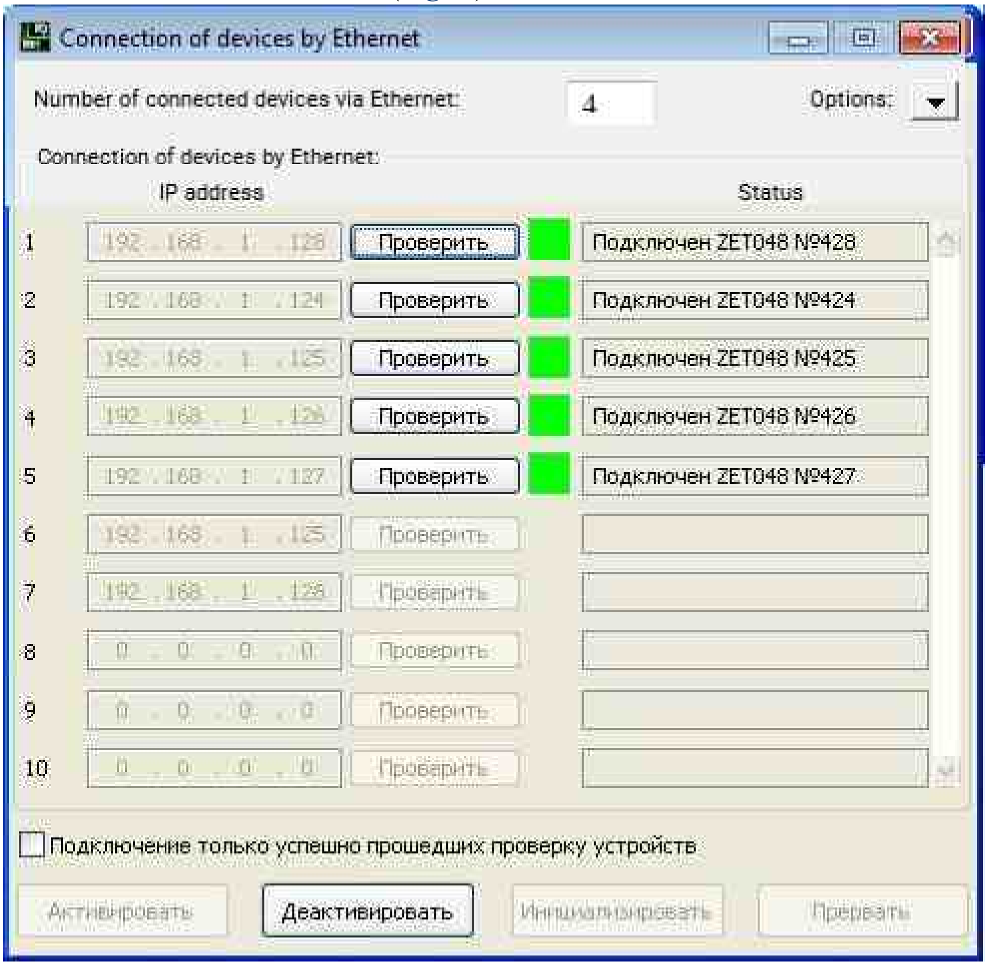


Fig. 5 Connection of devices by Ethernet

Switching unit control .....

The program is designed to control the status of relays located on the switching block using the digital port of the APC-DAC modules ZET 210, ZET 220, ZET 230.

Supported Hardware .....

The software **Switching unit control** is included with the following software:

- ZETLAB BASE – ADC/DAC module software;
- ZETLAB SEISMO - seismic station software.

Switching unit control is included in the **Automation** software group.

Program description .....

To start the **Switching Unit Management** program, select the Switching Unit Management command from the Automation menu (*Fig. 1*) of the ZETLab panel. The operating window of the **Switching Unit Control** program will be displayed on the monitor screen (*Fig. 2*). The title of the program window will display the name of the program.

Note: the program can be run directly from the working directory of ***ZETLab*** (by default: c:\ZETLab \). The name of the file to run: RelayCommutation.exe .

Fig. 1 The program "Control of the switching unit" from the menu "Automation"

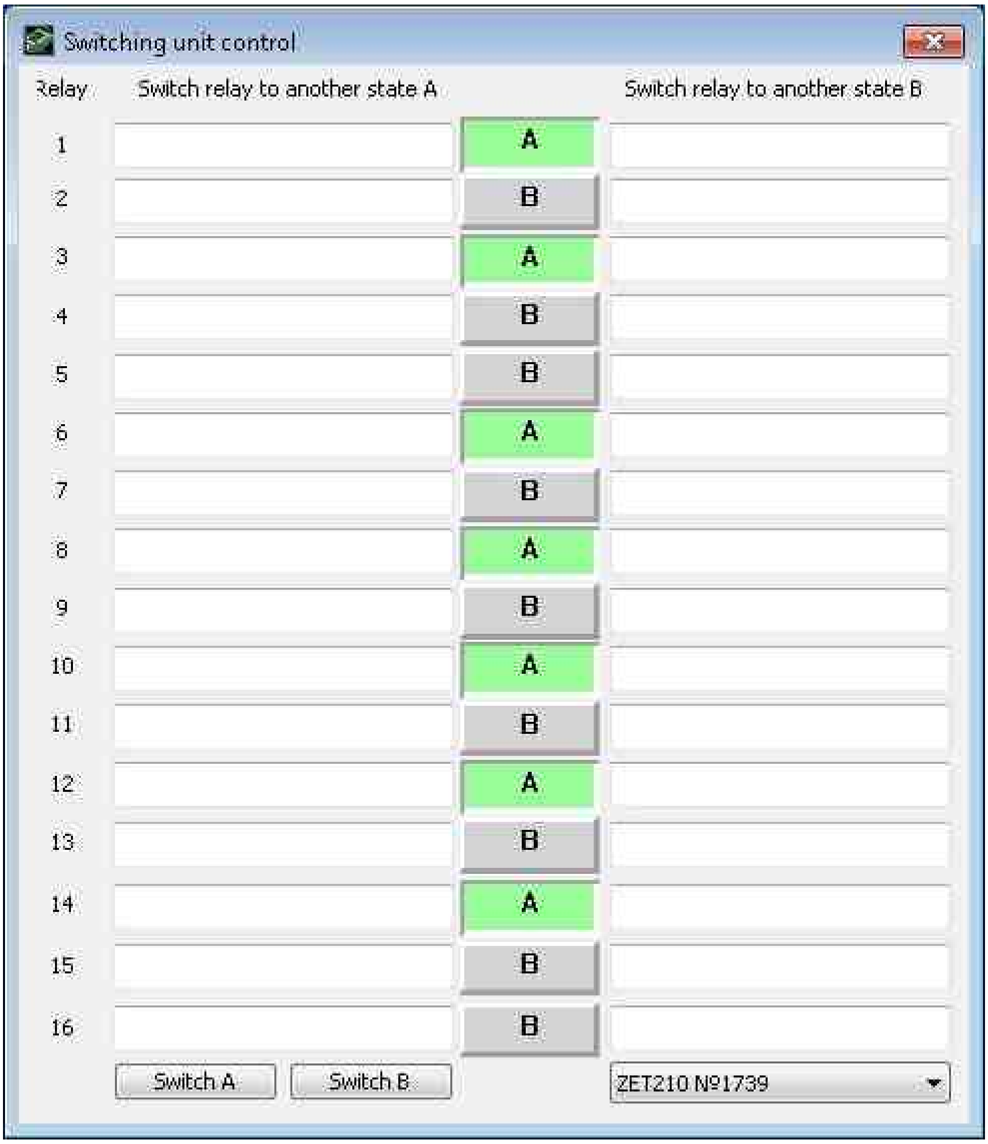


Fig. 2 Program description

The switching block consists of 16 signal relays and is connected to the digital port of the ADC-DAC module "ZET 2XX" by means of a cable through which voltage is applied to the relay contacts. For each relay of the switching block, there are two options for closing contacts: INx – xA, or INx – xB, where x is the relay number. It is assumed that the relay is turned off when the relay input (INx) is closed to output "B" (xB), and turned on when the relay input (INx) is closed to output "A". This correspondence is emphasized by the color design of the program (green color corresponds to the on status of the relay ("A"), red color corresponds to the off status of the relay ("B"). In order to switch the relay from one status to another, press the button in the corresponding line. When switching the relay from status "A" to status "B", it will turn red, and when switching from status "B" to status "A", it will turn green. There are two comment fields for each relay: one for the on status of the relay, the other for the off status. In order to enter a comment, you need to left-click on the desired field and enter a comment from the keyboard. For the group transfer of relays from one status to another, there are buttons "Turn everything on" (transfer of all relays to the "A" status) and "Turn everything off" (transfer of all relays to the "B" status). It is also possible to select the "ZET 2XX" module, with the help of a digital port of which the relay of the switching pad will be controlled.

Electrical circuits parameters control .....

The "Electrical circuits parameters control" software is designed to control the ZET 452 device and process digitized signals, as well as calculate and display the results of these signals.

Supported Hardware .....

The software **Electrical circuits parameters control** is included with the following software:

- ZETLAB BASE – ADC/DAC module software;
- ZETLAB SEISMO - seismic station software.

The "Electrical circuits parameters control" software is designed to control the ZET 452 device and process digitized signals, as well as calculate and display the results of these signals.

Electrical circuits parameters control is included in the **Automation** software group.

Program description .....

The program "**Electrical circuits parameters control**" can be started from "Automation" section of ZETLab software panel (see the *Fig. 1*). You will see the main window of the "**Electrical circuits parameters control**" program. The title of the program displays the name of the program.

Note: the program can also be started from ZETLAB directory (the directory by default:

\ZETLab\). The name of the file to be started: CableTest.exe.

The program starts only when the ZET 452 device is connected.

Fig. 1 Program "Electrical circuit parameters control" from the "Automation" menu

The "Electrical circuits parameters control" program is launched from the "Automation" menu of the "Electrical circuits parameters control" program. Start the taskbar of the Windows operating system.

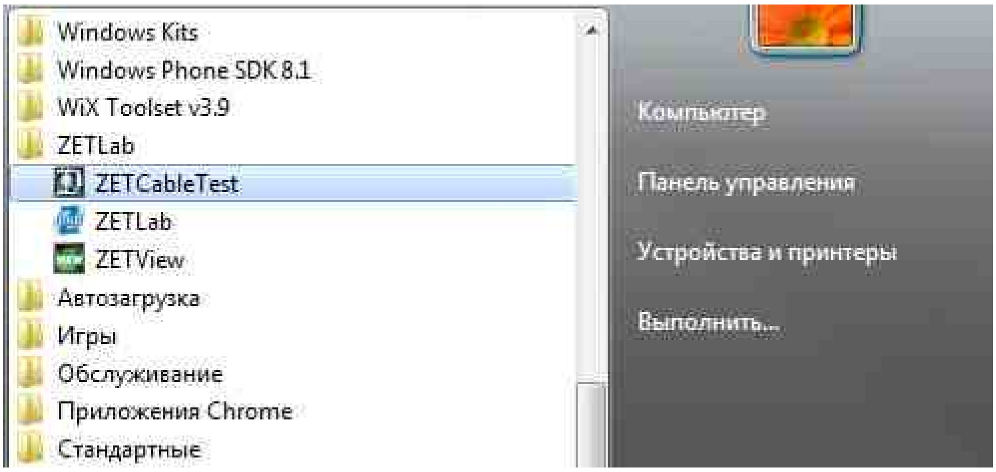


Fig. 2. Windows taskbar start

The program window "Electrical circuits parameters control" is presented (*Fig. 3.1*).

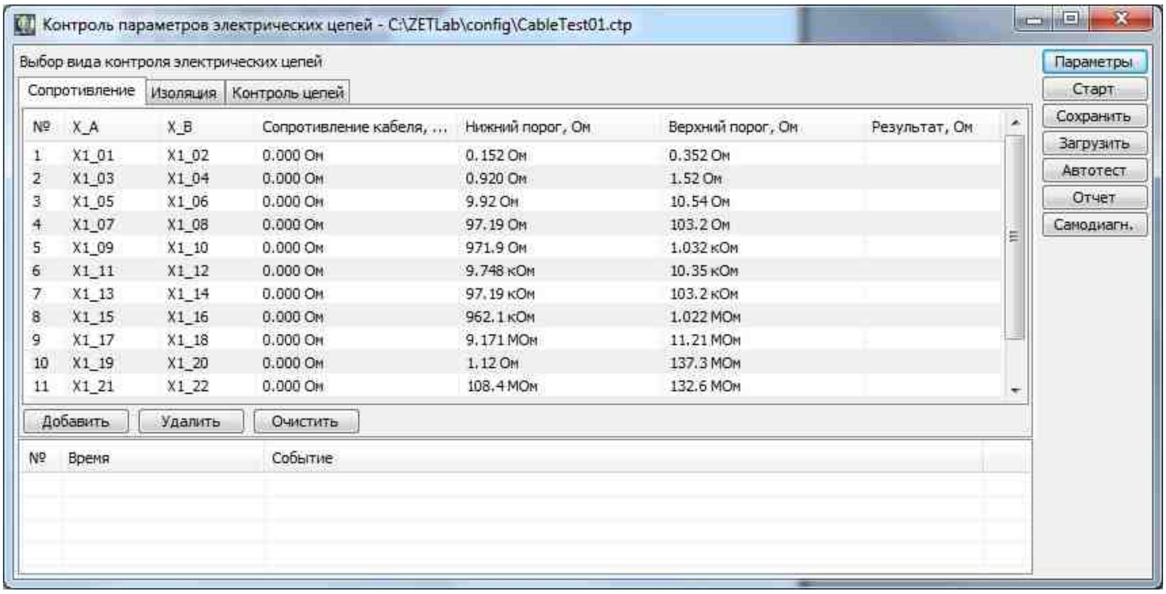


Fig. 3.1 for the "Resistance" tab

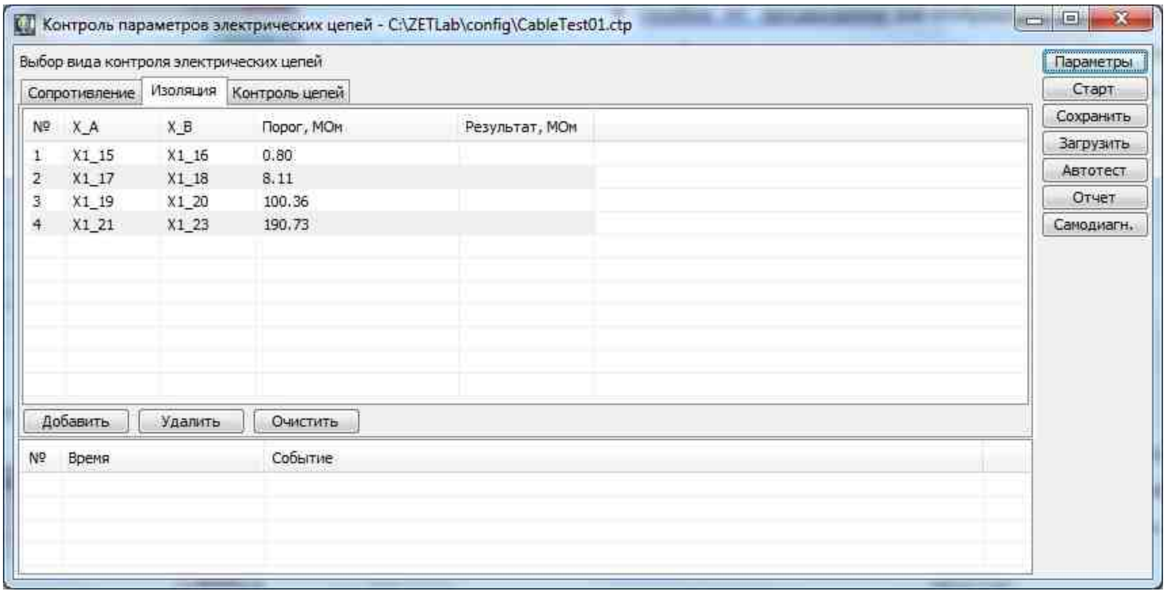


Fig. 3.2 for the "Insulation" tab

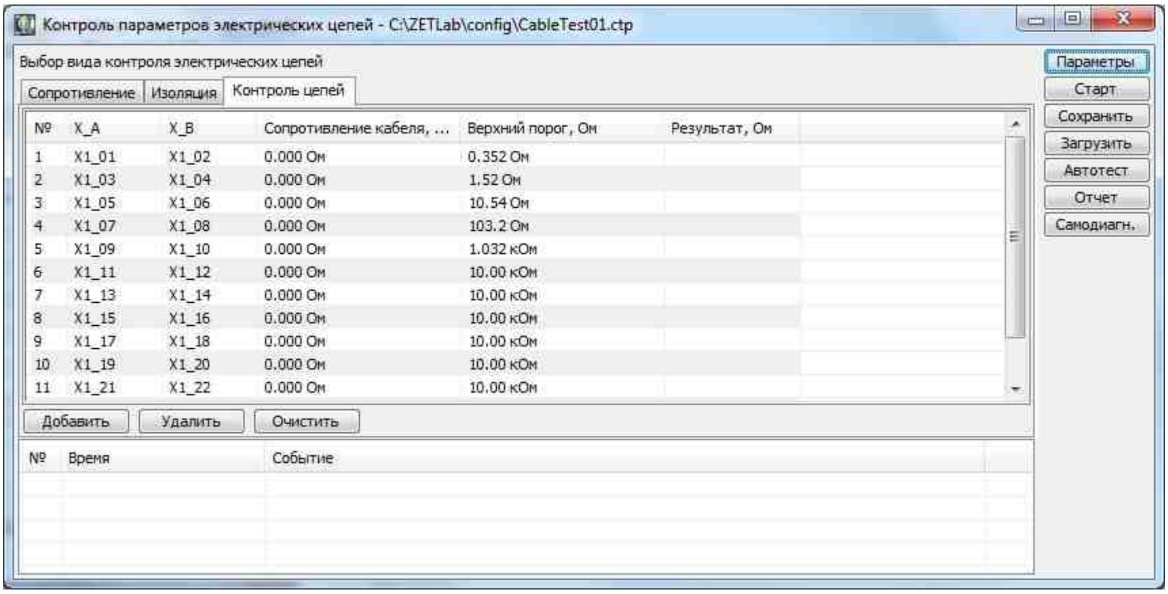


Fig. 3.3 for the "Control circuits" tab

Program management "Electrical circuits parameters control"

In the upper part of the program window there are tabs for selecting the type of control of electrical circuits. When measuring resistances, select the "Resistance" tab, when measuring insulation resistances – the "Insulation" tab, when monitoring circuits for integrity – the "*Control circuits*" tab.

In the selected tab, you need to fill in the table:

· column No. is used to display the sequence number of the row;

· column X_A designed to select the beginning of the tested electrical circuit;

click on a cell X1_1 allows you to select from the drop-down menu X1_1 the necessary circuit (*Fig. 3.4*);

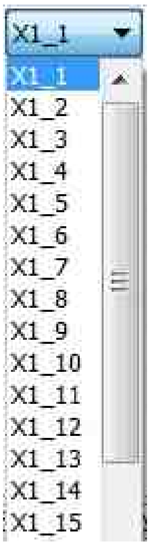


Fig. 3.4 List for selecting the necessary chain

click on an empty field allows you not to select a chain.

· column X_B designed to select the end of the tested electrical circuit;

click on a cell X1_1 allows you to select from the drop-down menu X1_1 the necessary circuit (*Fig. 3.5*);

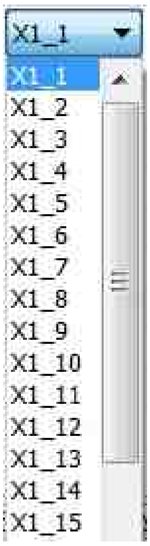
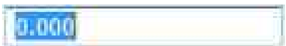


Fig. 3.5 List for select the necessary chain

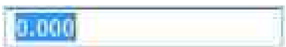
 click on an empty field allows you not to select a chain.

 the column "Cable resistance, Ω" (for the tabs "Resistance" and "*Control circuits*") is designed to record the resistance value of the cable with which the test product is connected to the ZET452.

 click on a cell  allows you to manually change the cable resistance values in this cell;

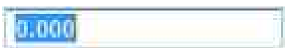
 click on an empty field allows you not to change the values in this cell.

 the column "Lower threshold, Ω" (for the "Resistance" tab) is intended for recording the value of the permissible lower threshold of the measured resistance;

 click on a cell  allows you to manually change the cable resistance values in this cell;

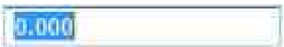
 click on an empty field allows you not to change the values in this cell.

 the column "Upper threshold, Ω" (for the tabs "Resistance" and "*Control circuits*") is intended for recording the upper threshold;

 click on a cell  allows you to manually change the cable resistance values in this cell;

 click on an empty field allows you not to change the values in this cell.

□ the "Threshold, MΩ" column (for the "Insulation" tab) is intended for recording the value of the permissible lower threshold of the measured resistance;

- click on a cell 

allows you to manually change the cable resistance values in this cell;

- click on an empty field allows you not to change the values in this cell.

□ the column "Result, Ω" ("Result, MΩ" for the "Insulation" tab) is designed to display the values of the measured resistance (insulation) on the screen.

In the lower part of the program window "Electrical circuits parameters control" there are buttons:

· "Add" (used to add a line);

When the button is pressed, a line with "default" settings is added (*Fig. 3.6*).

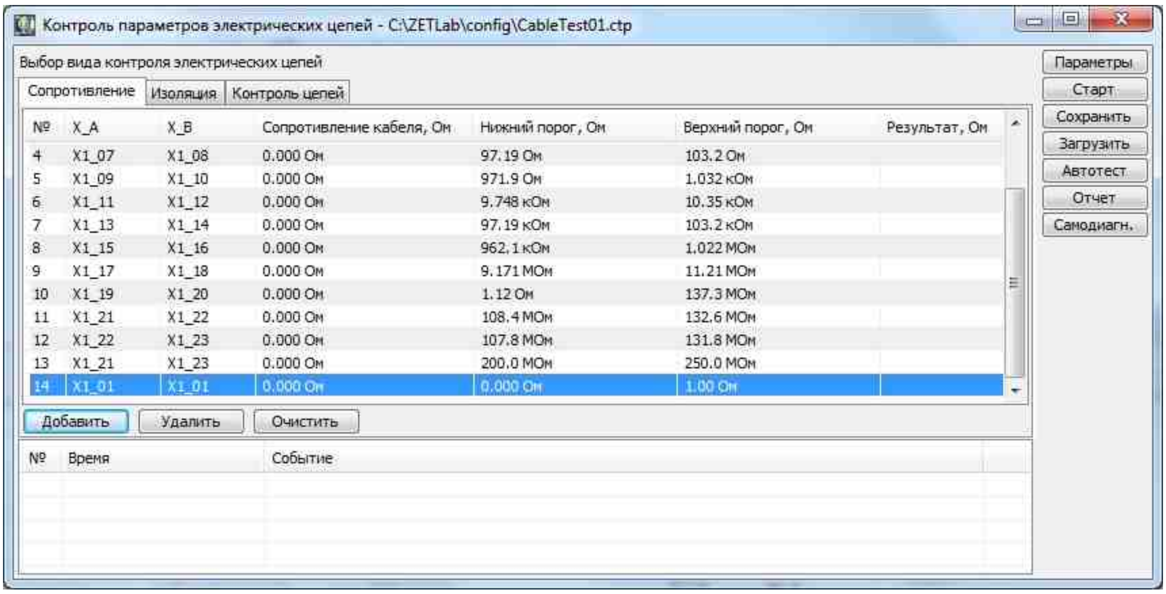


Fig. 3.6 When you click on the button, a line with the "default" settings is added

· "Delete" (used to delete a line);

When you click on the button, the line is deleted.

· "Clear" (used to delete all values entered in the table).

In the right part of the "Electrical circuits parameters control" program window there are buttons:

Parameters button

Used to setting circuit parameters;

Clicking on the button opens a window for setting parameters (*Fig. 3.7*). The description of the "Setting parameters" window is given below.

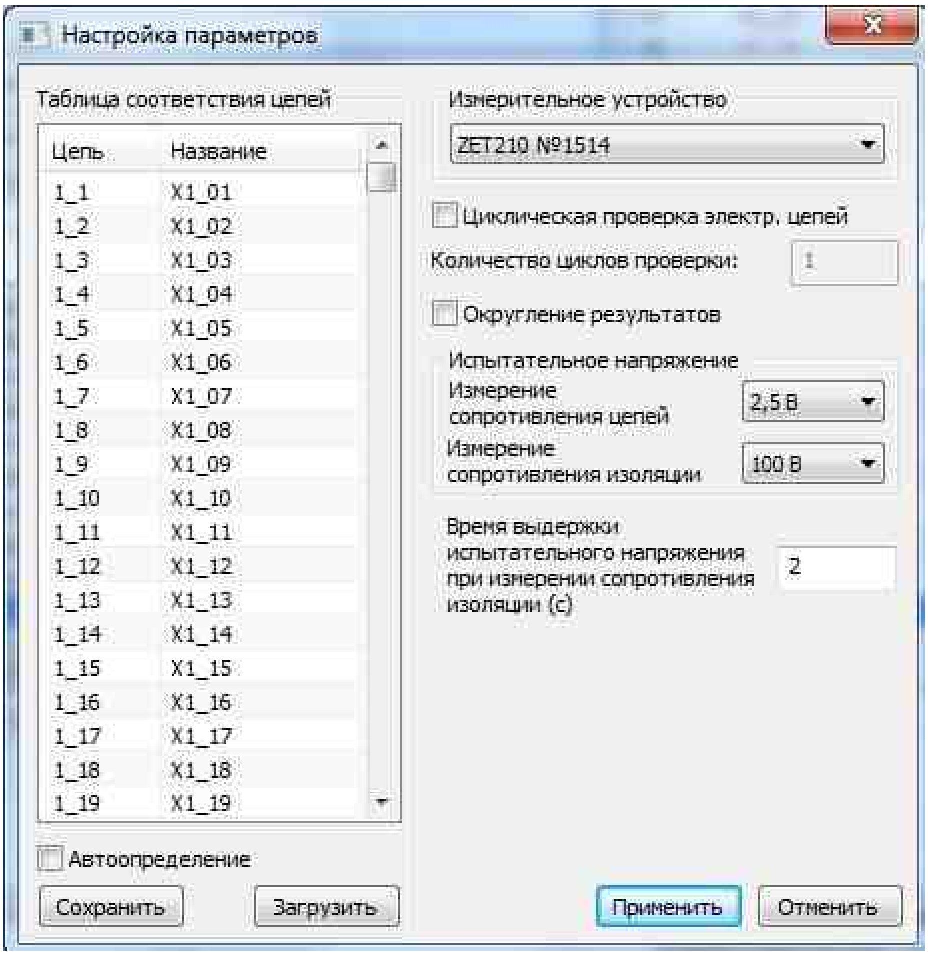


Fig. 3.7 Description of the "Setting parameters" window

*The "*Setting parameters*" window*

the "Circuit matching table" is designed to assign names to the contacts of the "Input" connector of the ZET452 device. To change the name of a contact, you need to hover the mouse cursor over the corresponding cell, select it with one click of the left mouse button and edit the value in accordance with the electrical circuit of the technological cable;

the "Auto-detection" function is designed to automatically detect the device being tested by special sealing of the process cable. After all the required data is entered into the "Circuit matching table", setting the "Auto-detection" line and pressing the "Save" button saves all the entered parameters for the monitored device and helps to automatically load the "Circuit matching table" for subsequent connections of the monitored device;

click on the "Save" button allows you to save the created table as a file with the extension «*.cbl» (*Fig. 3.8*);

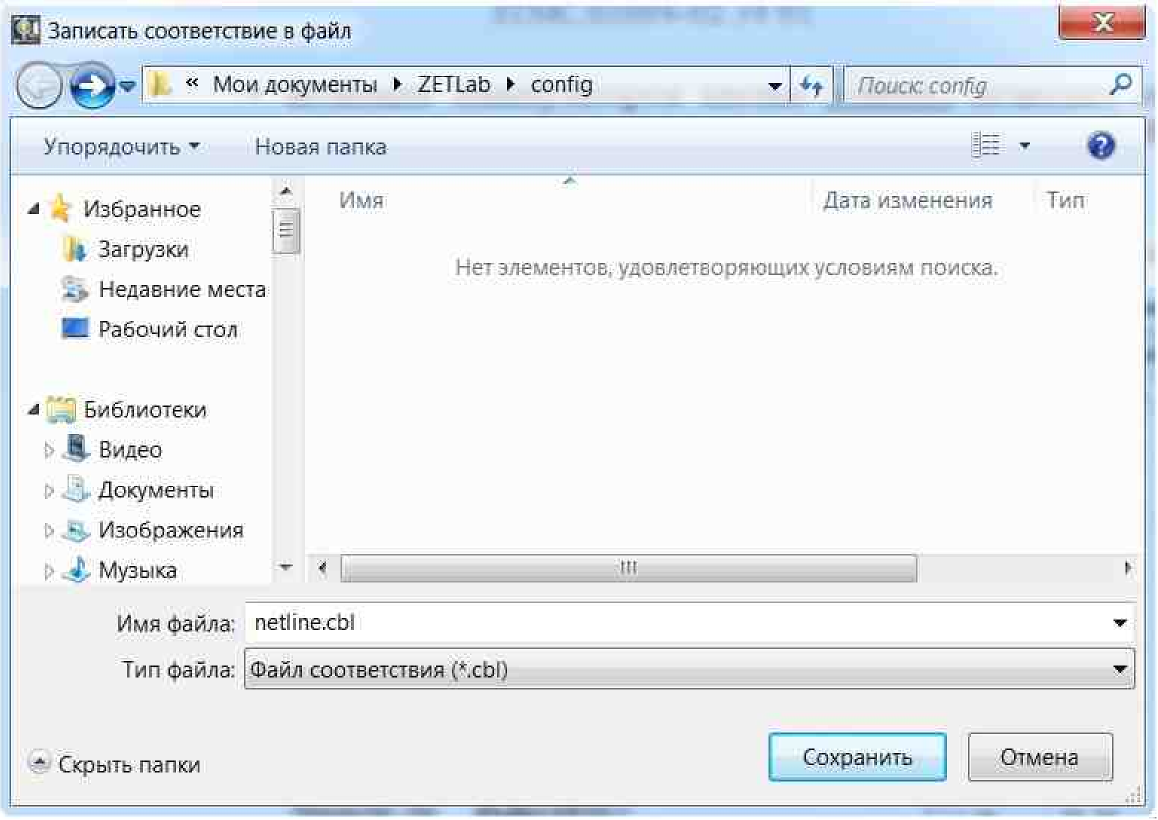


Fig. 3.8 Click on the "Save" button allows you to save the created table as a file with the extension ".cbl"*

clicking on the "Cancel" button allows you not to save the table;

click on the "Download" button allows you to download the previously created file (*Fig. 3.9*). To do this, in the "Read match from file" window.

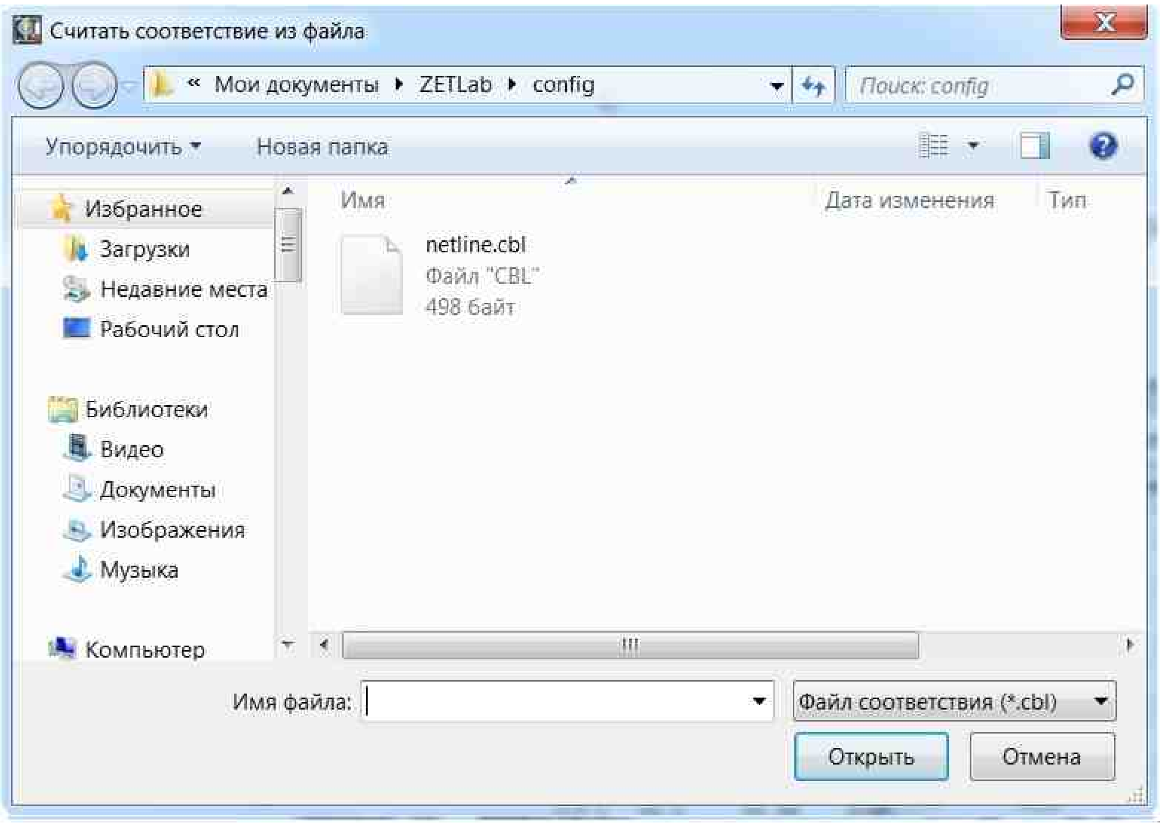


Fig. 3.9 You must select a file and click on the "Open" button;

click on the "Cancel" button allows you not to download the file;

- when you click on the drop-down menu "Measuring device", the serial number of the ZET210 device, which is part of the ZET452 device, is displayed *(Fig. 3.10*);

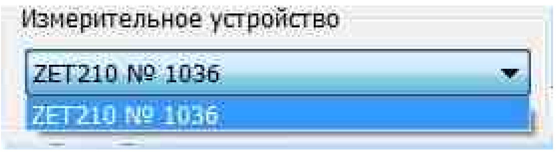


Fig. 3.10 The serial number of the device is displayed

- When the option “Cyclic check of electr. circuits", the entry of the number of test cycles will become available. This option allows testing multiple times.

- If you select the "Rounding results" option, the results will be rounded depending on the denomination of the received value.

- The "Test voltage" group is designed to select the nominal value of the test voltages used in the test. The choice is made from the available values, depending on the optional capabilities of the ZET452 device.

- The parameter "Test voltage exposure time when measuring insulation resistance" allows you to set the indicated time from 2 to 60 seconds.

click on the "Apply" button allows you to save the changes;

click on the "Cancel" button allows you not to save the changes made;

using the function "Cyclic check of electr. circuits" allows you to perform the specified number of checks in a row when you press the "Start" button, while all events for each measurement cycle will be displayed in the event journal.

The "Start" button

used to start the measurement

pressing the "Start" button starts the measurement of resistances (insulation) according to the specified profile and the "Start" button changes the name to "Stop".

at the end of the measurements, the "Stop" button changes its name to "Start", and the column "Result, Ω" ("Result, MΩ" for the "Insulation" tab) displays the values of the measured resistances (*Fig. 3.11*) or insulation resistances (*Fig. 3.12*).

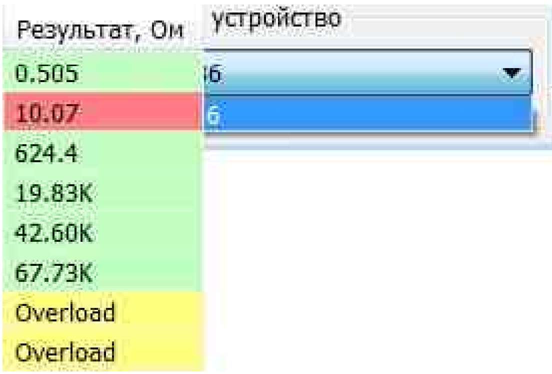


Fig. 3.11 Measured resistance values are displayed

Insulation resistance values are displayed

Notes .....

Notes 1:

For resistance measurement:

Шline colored in color – indicates that the measured values are within the allowed range between the Lower and Upper thresholds.

Шline colored in color - indicates that the measured values are not within the allowed range between the Lower and Upper thresholds.

Шline colored in color - indicates that the measured values exceed the upper measurement threshold of 200 MΩ).

To measure insulation resistance:

Шline colored in color – indicates that the measured values are above the Threshold.

Шline colored in color - indicates that the measured values are below the Threshold.

Notes 2:

Шif the measurement results of the resistance value (insulation resistance) exceed values equal to 200 MΩ (100 MΩ), respectively, the message Overload (*Fig. 3.13*) or Open (*Fig. 3.14*) is displayed instead of the measured value.

№	X_A	X_B	Нижний порог, Ом	Верхний порог, Ом	Результат, Ом
31	X1_62	X1_63	446.5M	493.5M	Overload

Fig. 3.13

№	X_A	X_B	Порог, МОм	Результат, МОм Эм	Результат, Ом
1	X1_62	X1_66	10.000000	Open	Overload

Fig. 3.14

Шfor the case of insulation resistance measurement, Shorting is displayed on the screen if the value of the measured insulation resistance is less than 1 MΩ (*Fig. 3.15*).

№	X_A	X_B	Порог, МОм	Результат, МОм
8	X1_1	X1_8	1	Shorting

Fig. 3.15

· "Save" (used to save the test profile);

Pressing the button opens a window for saving the test profile as a file with the extension "*.ctp" (*Fig. 3.16*). The description of how the "Save" button works is given below.

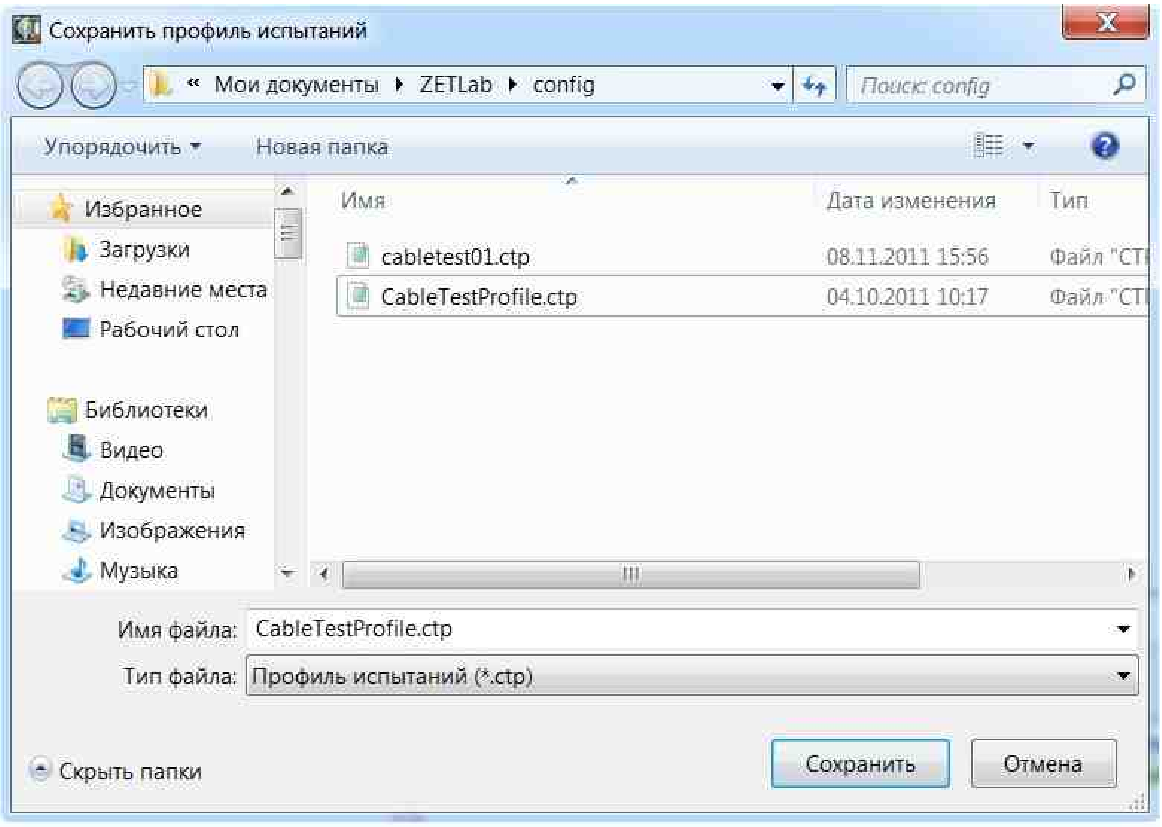


Fig. 3.16 The description of how the "Save" button works

"Save" button

click on the button allows you to save the test profile; for this, in the "Save test profile" window in the "File name" line, you must enter the file name (by hovering the "mouse" cursor over the line and entering the file name);

click on the "Save" button allows you to save the test profile as a file with the extension "*.ctp";

click on the "Cancel" button allows you not to save the changes made.

· "Download" (used to download the test profile created earlier);

Press the button opens a window for downloading a test profile (*Fig. 3.17*). The description of the "Load test profile" window is given below.

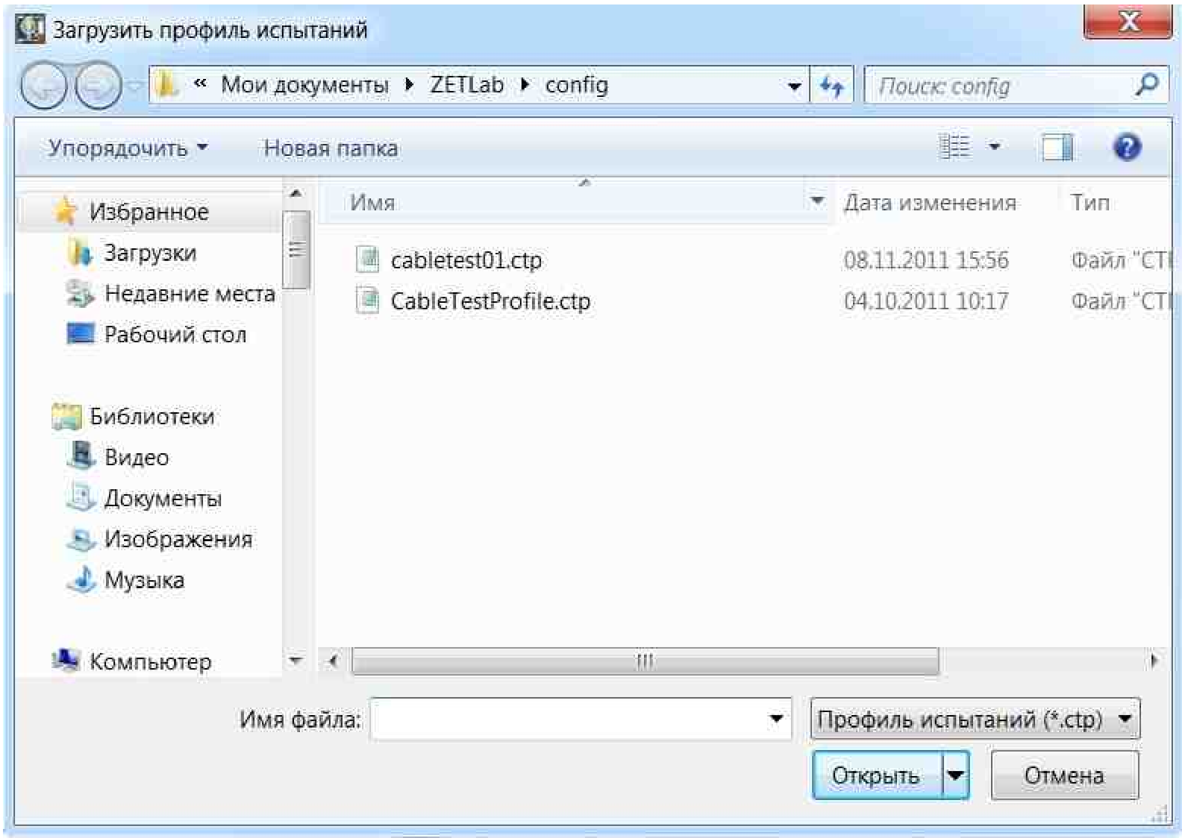


Fig. 3.17 Window for downloading a test profile

"Download" button

click on the button allows you to load the test profile created earlier, for this, in the "Load test profile" window, you must select the file (by hovering the mouse cursor over the required file and selecting it with one click of the left mouse button) and click the "Open" button;

click on the "Cancel" button allows you not to download the test profile file.

"Autotest" button

used to account for the resistance of switching circuits (both internal and external);

Note 3:

ШThe button can only be used when the "Resistance" and "Network control" tabs are selected.

When plugging ZERO is connected to the "Input" connector (or when a specially made technological plug is connected to a switching device or a technological cable, if it is necessary to take into account their resistance) and pressing the button, the measurement of the switching circuits resistance starts. More detailed information about the autotest function is given in paragraph 2.4.1 of the ETMS.0029.00.000RE Operation Manual. Description of the principle of operation of the button "Autotest." below.

- press the button allows you to start automatic accounting of resistances, connecting circuits and the button "Autotest" changes its name to "Stop"
- at the end of the accounting, the “Stop” button changes its name to “Autotest” and a window for saving the test profile opens (*Fig. 3.18*);
- click on the "Save" button allows you to save the test profile taking into account the resistance of the connecting circuits as a file with the "*.ctp" extension. Each new test profile is autotested once after it is created. With further use of the profile, re-autotesting, as a rule, is not required.
- click on the "Cancel" button allows you not to save the test profile file.

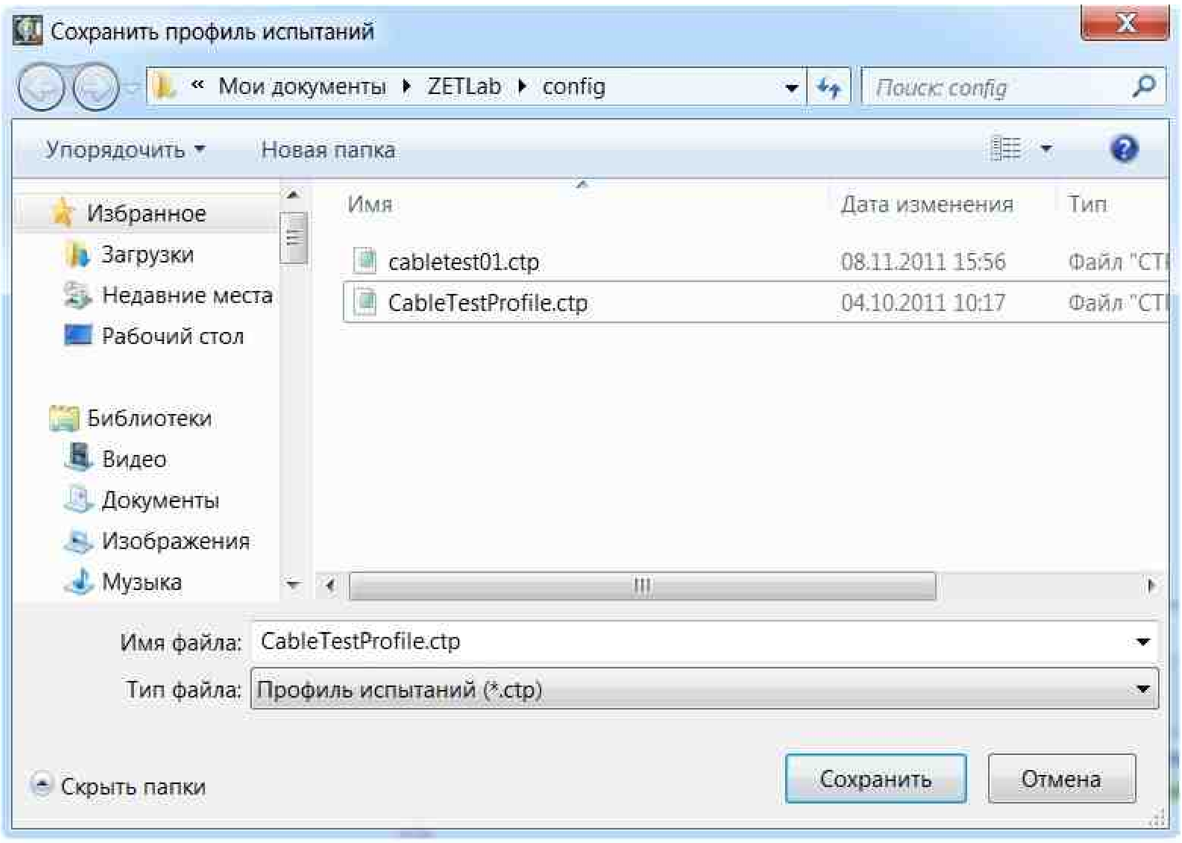


Fig. 3.18 Save the test profile file

· "Report" (used to save a table with the results of monitoring the parameters of electrical circuits in the form of a file with the extension "*.xls");

Press the button opens a window for saving a table with the results of monitoring the parameters of electrical circuits in the form of a file with the extension "*.xls" (*Fig. 3.19*). The description of how the Report button works is given below.

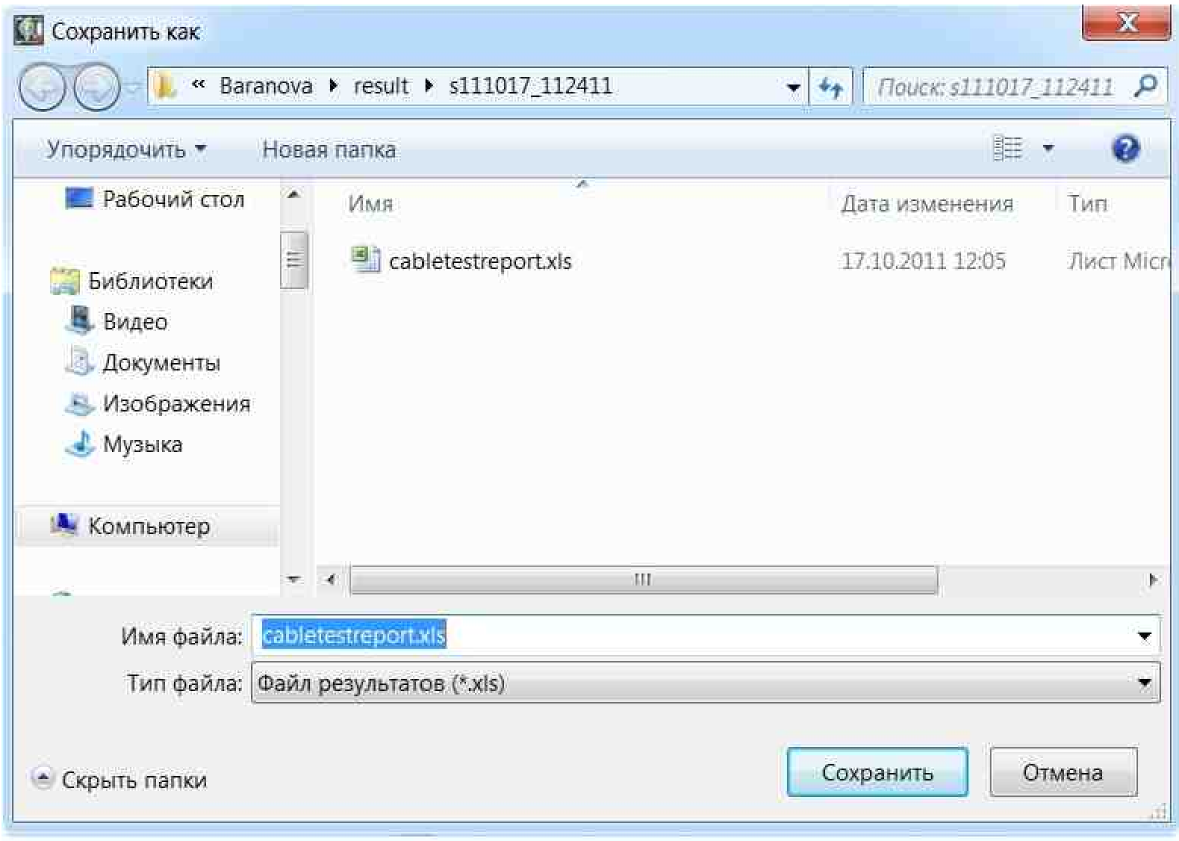


Fig. 3.19 Form of a file with the extension ".xls"*

"Report" button

- click on the button allows you to save the table with the results, for this, in the "Save as" window, in the "File name" line, you must enter the file name (by hovering the "mouse" cursor over the line and entering the file name);

- press a button Сохранить allows you to save the test profile as a file with the extension "*.xls" (*Fig. 3.20* - Sample report);

- press a button Отменить allows you not to save the test profile file.

	A	B	C	D	E	F
1			Протокол проверки цепей			
2						
3	Номер цепи	Начало цепи	Конец цепи	Нижний порог, Ом	Верхний порог, Ом	Результат, Ом
4	1	X1_1	X1_1	0	1	0,351
5	2	X1_3	X1_4	0,09	0,29	0,208
6	3	X1_5	X1_6	0,39	0,59	0,503
7	4	X1_7	X1_8	0,88	1,08	1,01
8	5	X1_9	X1_10	2,56	2,76	2,68
9	6	X1_23	X1_24	614,8	627,7	624,5
10	7	X1_25	X1_26	990	1.010K	1.005K
11	8	X1_27	X1_28	1.782K	1.818K	1.809K
12	9	X1_29	X1_30	3.227K	3.293K	3.274K
13	10	X1_42	X1_43	97.02K	102.0K	99.87K
14	11	X1_44	X1_45	174.4K	181.6K	179.0K
15	12	X1_46	X1_47	290.1K	301.9K	295.0K
16	13	X1_48	X1_49	457.7K	476.3K	467.0K
17	14	X1_50	X1_51	950.0K	1.050M	1.000M
18	15	X1_52	X1_53	2.090M	2.330M	2.228M
19	16	X1_54	X1_55	5.311M	5.870M	5.789M
20	17	X1_56	X1_57	9.500M	10.50M	10.13M
21	18	X1_58	X1_59	43.60M	48.20M	46.07M
22	19	X1_60	X1_61	109.3M	120.8M	115.7M
23	20	X1_62	X1_63	446.5M	493.5M	466.9M
24	21	X1_64	X1_65	950.0M	1050.0M	967.7M
25	22	X1_66	X1_67	0	0,1	0,028
26	23	X1_67	X1_68	0	0,1	0,013
27	24	X1_68	X1_69	0	0,1	0,025
28	25	X1_69	X1_70	0	0,1	0,02
29	26	X1_70	X1_71	0	0,1	0,013
30	27	X1_71	X1_72	0	0,1	0,001
31	28	X1_39	X1_39	0	0,1	0
32						
33					Дата	17 октября 2011г.
34					Исполнитель	Антонов А.Ю.
35					Подпись	

Fig. 3.20 - Report example

After finish work in the “Electrical circuits parameters control” program, it is necessary to close it by activating the button in the upper right corner with the manipulator .

"Self-diagnosis" button

pressing the button opens the window of the self-diagnostics mode intended for check the ZET452. (*Fig. 3.21*)

Attention! Disconnect all process cables from the "Input" connector before performing the self-diagnosis.

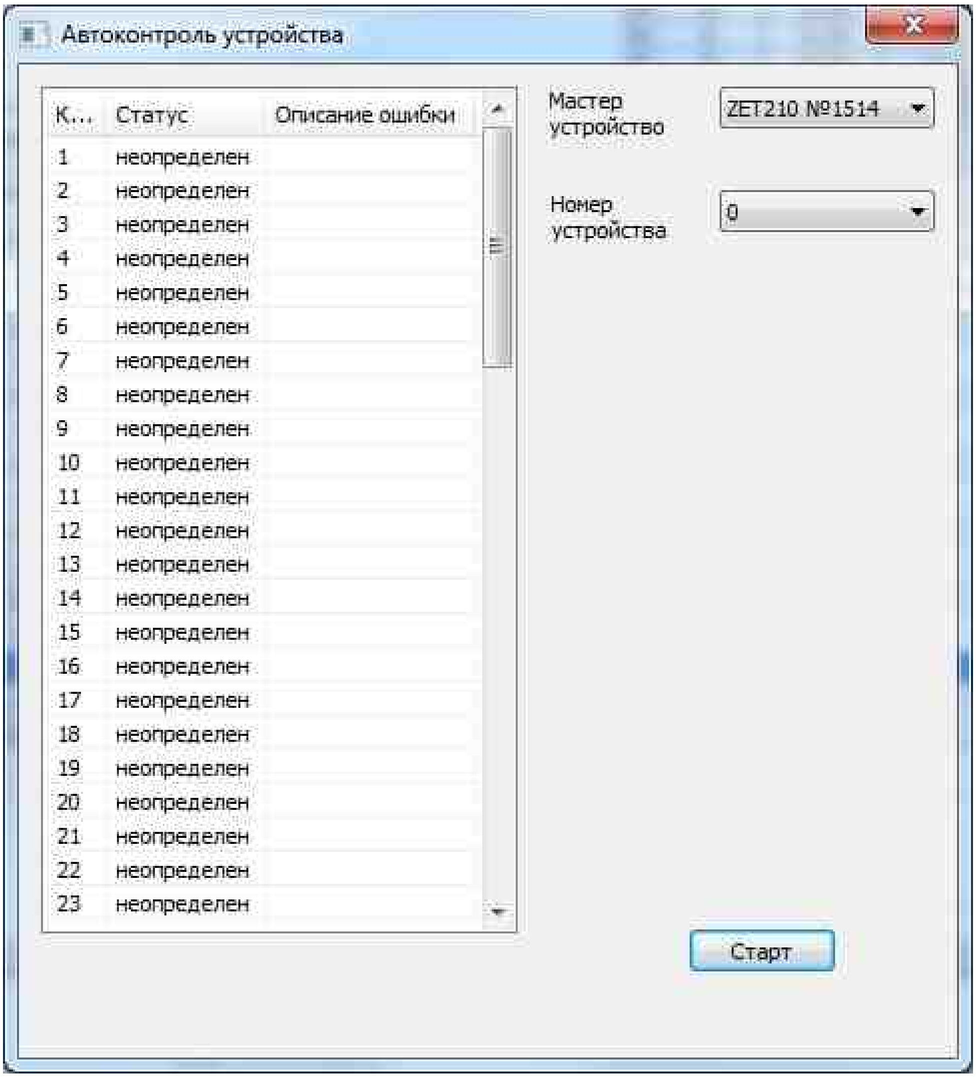


Fig. 3.21 The self-diagnostics mode intended for check the ZET452

- Before performing self-diagnostics, it is necessary to select a master device (main module ZET 452) from the list.

- Then you need to select the device number: 0 - main module, 1 ... 7 expansion modules (if available)

- To start self-diagnostics, you must press the start button and wait for the end. If the device is working, all rows of the table in the left part of the "Device Auto Control" window will be highlighted in green (*Fig. 3.22*)

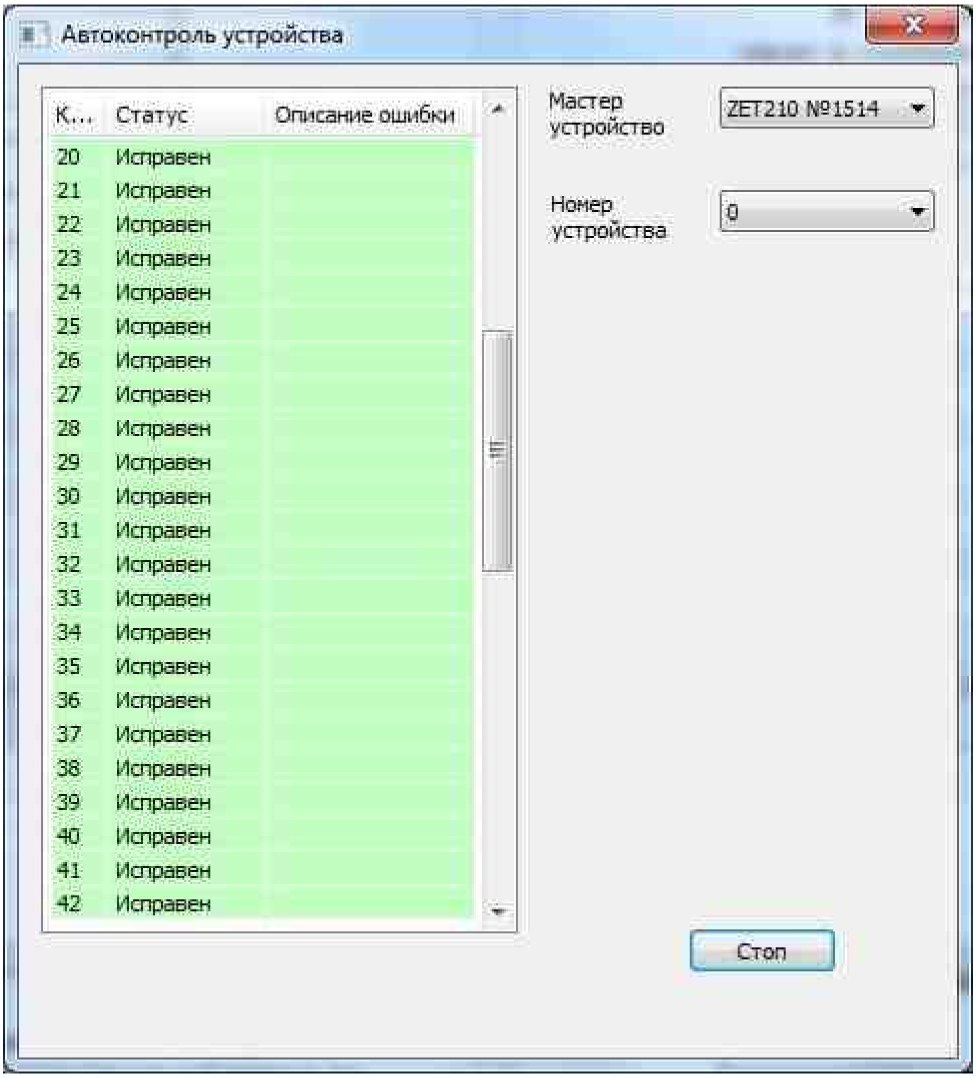
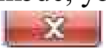


Fig. 3.22 "Device Auto Control" window

To exit the self-diagnosis mode, you must close the window by clicking the left mouse button in the upper right corner of the button 

Program messages .....

The program has the ability to work without operator intervention, so the program does not display its messages in the form of dialog boxes, but writes them to the system application log, which can be viewed using the **ZETLAB Error journal** program from the **ZETLAB** "Service" from **ZETLab control panel** tab.

The format of messages recorded by **ZETLAB** programs in the journal is as follows:

"Program name No. xx. Message text",

where xx is the number of the running copy of the program.

The program writes to the system log not only error messages, but also messages about changes in its parameters. Recorded messages allow you to restore the sequence of program actions, which is often useful when analyzing errors that occur during program operation. The table below shows the program messages.

Table 5.1

Message text	**Category**
Messages from the ZETLAB Error journal	
101 Error connecting to the data server	error
102 Error when reading data from the registry	error
103 The configuration file in the Dir Config folder is not available	error
104 The help file is missing	error
105 DirHelp folder is unavailable	error
106 DirSignal folder is unavailable	error
107 DirResult folder is unavailable	error
108 DirCorrect folder is unavailable	error
109 InstallLocation folder is unavailable	error
110 Error creating an instance of the CAutoScaleXY class	error
111 Error connecting to Unit	error
112 The program is launched via Unit	error
113 The program is launched from the Z-panel	error
114 The program has started working	error
115 ADC sampling frequency, Hz	error
116 Error code	error
117 There are no working channels of the data server. The program will not load	error
118 Error when calling program help	error
119 The program has completed its work	error
120 An error occurred while reading data from the channel	error
121 An error occurred while processing data	error
122 No data server	error
123 Program will close	error
124 Error when starting parameter processing program	error
Messages from ZETServer	
There was no connection to the server	error
The server is not loaded on the computer	error
Too many programs connected to the server	error
The server does not boot on the computer	error
Low RAM or disk space	error
Channel number less than zero	error
Channel number is greater than the maximum possible value	error
Unable to instantiate the Server component	error

When working with a running control panel, **ZETLAB** program error messages are duplicated by temporary pop-up texts in the system tray (the notification area is an element of the desktop toolbar or "Taskbar" in Windows, used for the needs of constantly used programs).

Receiving the message "The data server has too many channels. There is not enough memory for the program to work in this mode. The program will be closed" indicates that too many programs are currently loaded that work with the **ZETLAB** data server, or that the used The computer does not have enough RAM. In the first case, close unused programs and restart the program. In the second case, you must either notice the computer, or increase the amount of RAM in the one used.

Autorun programs .....

The **ExeStarter** program is designed to batch launch a certain set of programs with the possibility of a software Watch Dog to execute running programs.

It is not recommended to use programs in this set that can be run in a single instance and that are launched by other programs, for example: NetSrv.exe, which is launched by the server. In this case, the work of the Watch Dog can be unpredictable.

The **ExeStarter** program works in two modes: program launch mode and running program monitoring mode. In the first mode, the title of the program window is "Autorun programs" and in the table the lines of all programs are white. In the second mode, the title of the window is "Autorun programs - monitoring mode" and the lines of programs in the table are colored (see the "Program colors" section). Running programs are not monitored in run mode. If a monitored program hangs or closes while in watch mode, it will be restarted.

You can run only one copy of the program. The program reads the **ExeStarter**.xml file from the %DirConfig folder, in which you must first specify the list of programs to be launched and their properties. Below is an example of an ExeStarter.xml file.

```
//////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
<?xml version="1.0" encoding="UTF-8"?>
<Lib name = "Program tree" autostart="+" topmost="+" reverseClose="+">
	<Program name="Copy the directory">
		<Property StartingFlag="+" Path="c:\windows\system32\cmd.exe" Params=" /c copy /y c:
\zetlab\configarh\*.* c:\zetlab\config\" Sleep="5000"/>
	</Program>
	<Program name="Time by channels">
		<Property StartingFlag="+" Path="c:\ZETLab\zetservertime.exe" Params=""
TimeForStart="2500" NeedWD="+"/>
	</Program>
	<Program name="GPS Sync">
		<Property StartingFlag="+" Path="c:\ZETLab\Synchronization.exe" Params=""
TimeForStart="5000" NeedWD="+"/>
	</Program>
	<Program name="SCADA project">
		<Property StartingFlag="+" Path="c:\ZETLab\seismo.exe" Params=""
TimeForStart="5000"  NeedWD="+"/>
	</Program>
	<Program name="Oscilloscope">
		<Property StartingFlag="-" Path="c:\ZETLab\Oscgraphic.exe" Params=""/>
	</Program>
	<Program name="Voltmeter">
		<Property StartingFlag="+" Path="c:\ZETLab\VoltMeterDC.exe" Params=""
NeedWD="1"/>
	</Program>
</Lib>
//////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
```

In this file, the parameters of the program itself are written in the first line ExeStarter.exe , then the parameters of the programs being run. The order in which programs are started corresponds to the order in which programs are written to the file ExeStarter.xml . For a list of parameters, see tables 1 and 2.

Table 1. Parameters of the program itself

Parameter	Description	Type	Default value
autostart	running programs after starting **ExeStarter**	flag	false
topmost	The **ExeStarter** window is always in the foreground	flag	false
reverseClose	reverse order of closing programs	flag	true
needLogFile	log file maintenance is required	flag	false
HangTimeOut_mSec	waiting time when checking programs for hang, ms	number	3000
MinTimeJob_mSec	minimum program running time that does not cause a restart, ms	number	10000
NumReStart	the number of allowed restarts, if this number is exceeded, **ExeStarter** stops with the output of MessageBox	number	3
DownTime_mSec	Downtime before restart when NumReStart is exceeded	number	60000

Table 2. Parameters of running programs

Parameter	Description	Type	Default value
name	arbitrary description of the program	text	-
Path	the full name of the file to run (with the path)	text	-
Params	command line	text	-
StartingFlag	to run the program or not	flag	false
NeedWD	the program requires Watch Dogs, acceptable options: "-", "+", "1","name of the Watch Dogs group" (not implemented in the current version)	text	"-"
TimeForStart	maximum program start time, ms	number	100000
VisibleType	the type of initial display of the program window, acceptable options: "Visible", "Turn", "Hide", "AsParent"	text	"Visible"

The execution of programs with the NeedWD parameter "+" or "1" is monitored by software. If such a program in watch mode hangs or closes, then **ExeStarter** will restart such a program.

Programs with the NeedWD = "+" parameter form a group of programs. If any program from this group freezes and/or closes, all programs in the group will be restarted with **ExeStarter** switching to run mode. Group programs are closed according to the "reverseClose" parameter, launched - in accordance with the order in the xml file. The formation of such a group is expedient when joint processing of data received by the programs of the group is required.

Programs with the NeedWD = "1" parameter do not form a group. If such a program hangs or terminates, **ExeStarter** will simply restart this program without exiting monitoring mode.

It is possible to launch in hidden mode (without displaying windows and a shortcut) both Autorun programs and the ExeStarter.exe program. The VisibleType = "AsParent" parameter means that the program window display mode will correspond to the window display mode of ExeStarter.exe itself.

Running the "ExeStarter.exe /hide" command loads the program in hidden mode. In this case, the program (and child programs running as "Hide" or "AsParent") can only be closed using the task manager.

When running child programs in the "Hide" option, the windows of the programs being launched are displayed on the desktop for a moment.

Program colors

In the ExeStarter.exe program window, running programs will be listed in a table and highlighted in different colors. Below is a breakdown of the colors.

White - start mode.
Brown - no such program.
Blue - the program does not require launching.
Red - the program is working with problems (more often it has no windows found).
Green - the program is running with some Watch Dogs.
Yellow - program without Watch Dogs.
Blue - the program is selected with the mouse.

Recommendations

The local policy of the computer on which you intend to run programs using ExeStarter.exe must be configured accordingly. To do this, you need to run the local group policy editor under the administrator account, for example: by executing "gpedit.msc" in the command line. In the "Computer configuration" section, select in sequence: "Administrative templates", "Windows components", "Windows error report". Then, in the right pane of the editor window, switch the "Disable Windows error reporting" and "Do not send additional data" elements to the "Enabled" status, see *Fig. 1*.

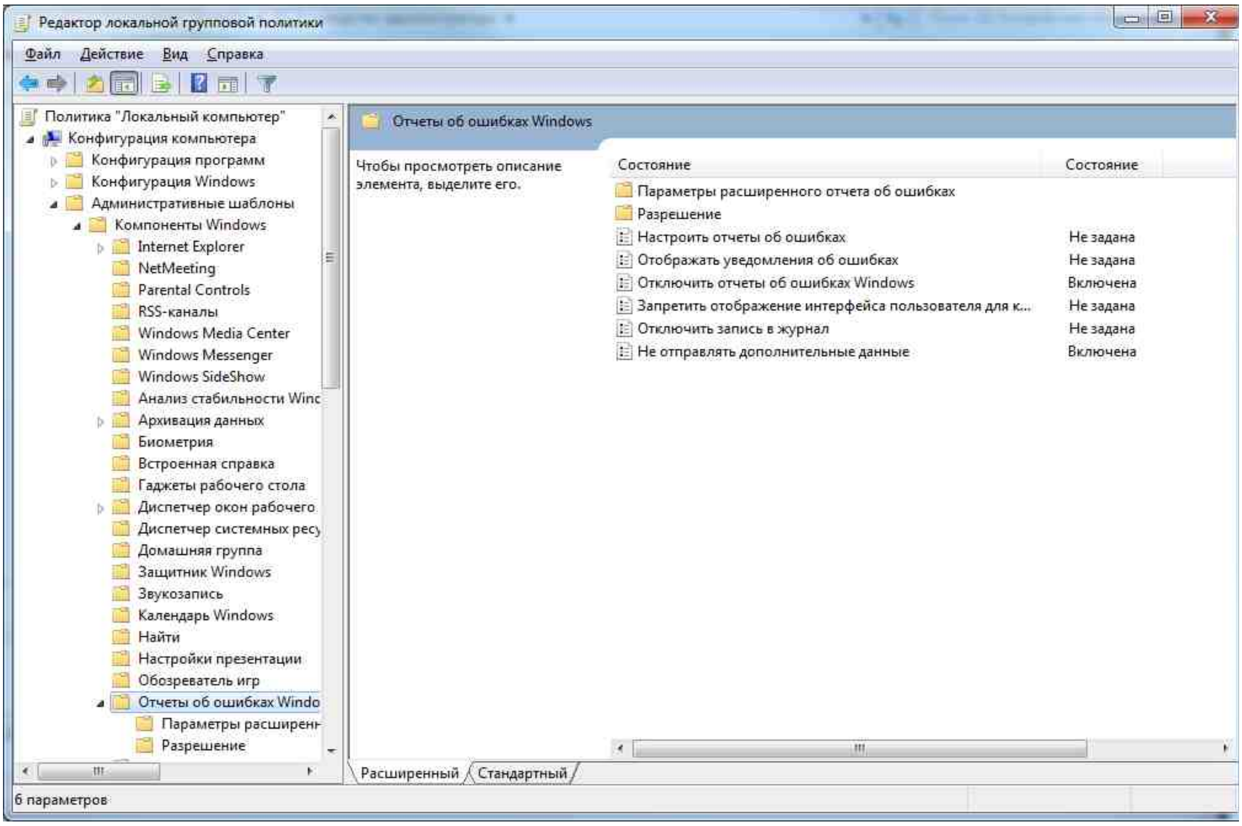


Fig. 1

Supported Hardware .....

Autorun programs is a part of the following software:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT Spectrum Analyzers software;
- ZETLAB VIBRO – Shaker control systems software;
- ZETLAB TENZO – strain-gauge station software;
- ZETLAB SEISMO – seismic station software;
- ZETLAB NOISE – vibration meter-noise meter software
- ZETLAB SENSOR – digital ZETSENSOR sensor software

Autorun programs is included in the **Automation** software group.

Program description .....

To start the program **Autorun programs** must be launched directly from the ZETLab working directory (by default: c:\ZETLab\). Executable file name: ExeStarter.exe.

The main part of the program window is occupied by a field that displays:

- job number (first column). Job sequence number.
- Start flag (second column). The start flag can be "+", i.e. the program will run, and "-" the program will not run and will be skipped.
- program name (third column). The name of the program is indicated for the convenience of the user.
- path to the program (fourth column). The name of the program being launched is filled in.
- launch options (fifth column). Description is below.

The buttons on the right side of the program window are:

- Run (upper button). Allows you to run the program.
- Stop (middle button). Allows you to stop the program.
- Restart (bottom button). Restart stops all programs, unloads all programs and memory, and restarts the program.

The following buttons are located at the bottom of the program window:

- Collapse all (left button). Allows all programs to be minimized.
- Show all (right button). Expands all programs previously minimized.

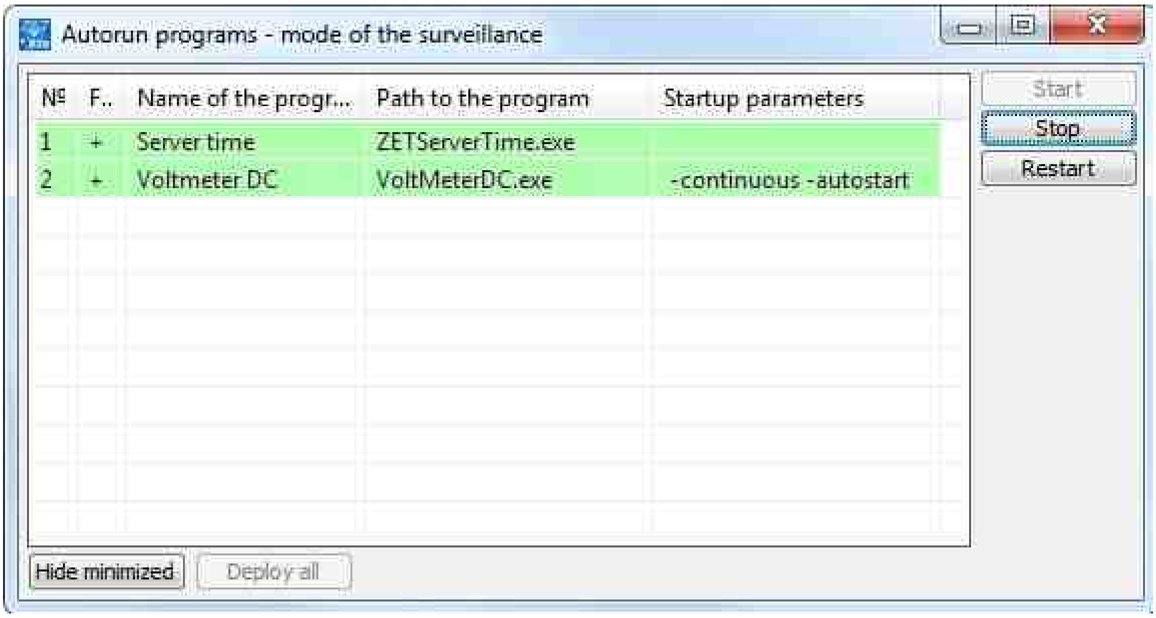


Fig. 2

The program "ZETServer Time" allows to display current time of server channels as well as to control the time of ADC channels (including network channels). The program periodically checks the time of these channels and compares the obtained value with the value of previous check. In the case if the new value has not increased, then ZETLAB Error journal saves the message "Channel time stop Channel_name".

The check periodicity is about 60 seconds. The program checks active ADC channels (except for idle channels and channels of disabled devices). The time of virtual channels is not checked.

Besides, the program also generates a broadcast message of ADC channel time stop. Currently this message can only be received by the program ExeStarter.exe (as the program receives this message, it closes active programs and stops its operation saving the text "Command CommonEvent_StopTimeSRV" to its log).

Network Program

The programs are designed to transmit and receive digitized **ZETLAB** signals over a network.

Signal Transmitter (Data Server) .....

The program is used for transferring **ZETLAB** digitized signals through the network.

As soon as the data server is turned on, any computer in the same subnetwork can connect to it via the program **Signal Receiver (Data Client)** – and all signals of the server computer appear in its channel list. Then, it does not matter whether these signals are processed by the server computer or a computer to which they are coming via the Data server → Data client system.

Signal Transmitter Application

One of our latest developments – a virtual laboratory – is based on Data Client and Data Server. It may seem a simple circuit (one computer transfers the data, and the other receives it), but in fact it brings quite a range of possibilities! Among them – innovative distributed data collection systems, virtual laboratories, and final division of "responsibilities": it is hard to make data collection and data processing blocks more independent.

Classrooms

The data server facilitates creation of entire classrooms based on one ZET device. The FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23 ADC/DAC modules is designed right for such purposes. The teacher connects the module with his/her computer and starts **Signal Transmitter (Data Server)**. The students start **Signal Receiver (Data Client)** on their computers. Thus, signals digitized by the same ADC/DAC module can be processed by each student separately. Since the data server can transfer not only digitized signals of ADC physical channels, but also channels created by ZETLAB virtual devices, each student can compare his/her result with the source signal processing result obtained by the teacher. For instance, lower and upper frequency filters change the signal dramatically, outlining the useful signal among noises.

Virtual Laboratories

Laboratory benches are created not only at technical and research institutes. Since studying is an interesting activity, and visual demonstration brings more results than long narration of physical laws and principles. The office at our enterprise houses all kinds of benches: "Vibration", "Strain-Gauge", "Thermo", etc. To get to know ZETLAB software, you can install its demo version, connect to one or several data servers, and proceed with measurements.

Distributed Data Collection Systems

The **Data server → Data client** system is used not only in education. The transfer of already digitized signals is required in distributed data collection systems with preliminary processing. Currently, connection of data collectors to the computer via Ethernet is also widely used. Thus, signals from all analyzers/ADC-DAC modules come to the computer where they are processed. But the more distant the data collectors are from each other, the more ramified the system becomes, and the more complicated the system structure becomes. In this case, several data collectors (or even each separately) are connected to the industrial computer where preliminary data processing takes place. Signals from local computers are transferred to the server from which they are passed to the control station in a single flow.

Supported Hardware .....

Signal Transmitter (Data Server) is a part of the following software:

- ZETLAB BASE – ADC/DAC board software;

- ZETLAB ANALIZ – FFT Spectrum Analyzers software;
- ZETLAB VIBRO – Shaker control systems software;
- ZETLAB TENZO – strain-gauge station software;
- ZETLAB SEISMO – seismic station software;
- ZETLAB NOISE – vibration meter-noise meter software;
- ZETLAB SENSOR – digital ZETSENSOR sensors software.

Signal Transmitter (Data Server) is included in the **Network program** software group**.**

Program description .....

To run the program, the **Signal Transmitter (Data Server)** required in the Network program (*Fig. 1*) **ZETLab** panel choose **Signal Transmitter (Data Server)**. On the monitor screen displays the working window of the program, the **Signal Transmitter (Data Server)** (*Fig. 2*). From the top, the title bar displays the name of the program

Note: the **ZETLab** program (default: c: \ ZETLab \). The name of the startup file: NetSrv.exe.

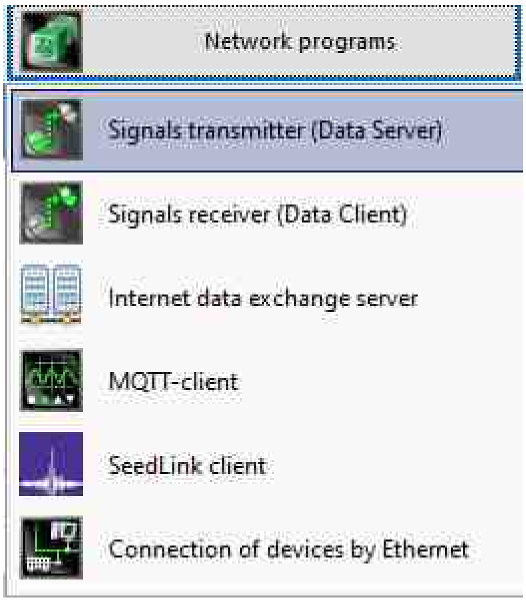


Fig. 1 Starting the program Signal Transmitter (Data Server)

From the moment the **Signal Transmitter (Data Server)** is turned on, any computer on the same subnet can connect to it using the Connect to the **Signal Transmitter (Data Server)** program and all the signals from the server computer appear in its channel list. Further, it does not matter whether these signals are processed by the server computer or the computer to which they are received via the system Turn on **Signal Transmitter (Data Server)** → Connect to the **Signal Receiver (Data Client)**.

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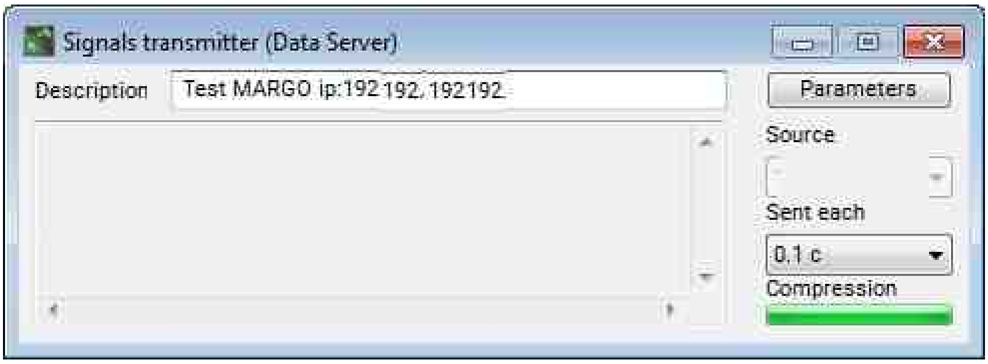


Fig. 2 Connect to the Signal Receiver (Data Client)

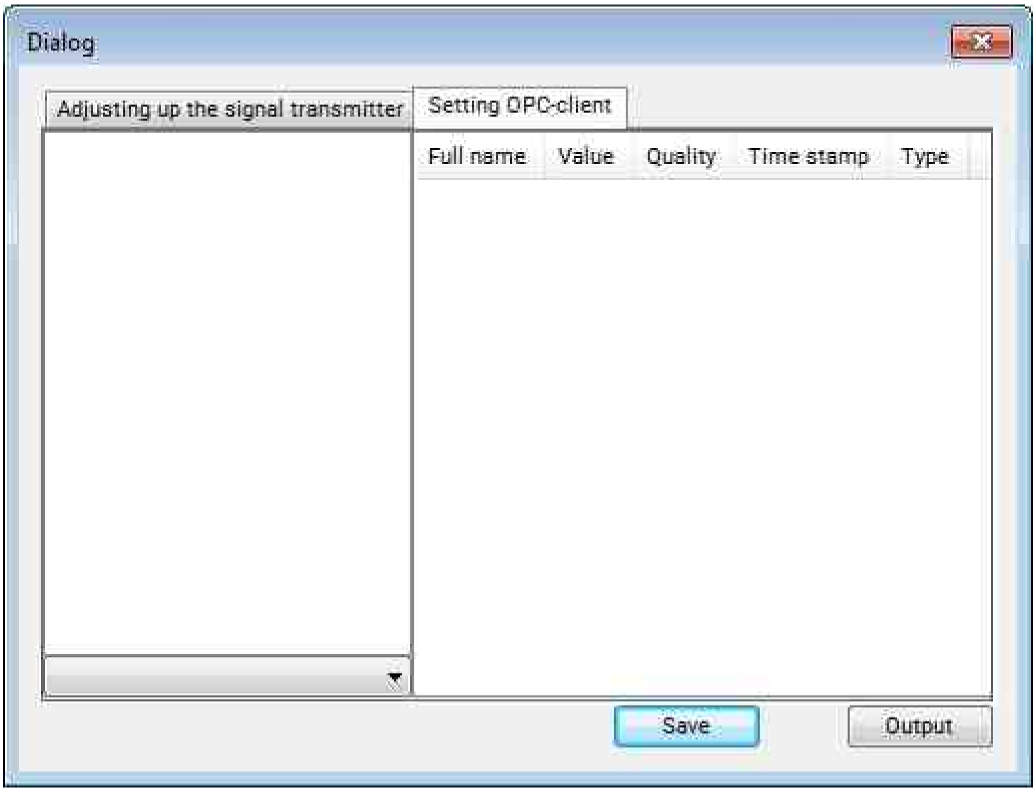


Fig. 3 Setting OPC-client

In the Connect to **Signal Transmitter (Data Server)** window, information about connecting data clients (the date and time of connection) is displayed. If there are several network cards in the computer, in order to ensure the security of connections in the Enable **Adjusting up the signal transmitter(cliente de datos)** window, the IP field of the network card that will be broadcasting the data becomes active.

OPC server data transfer

Functional range of the program now includes the function of OPC server data transfer. The parameters window has a new tab "Setting OPC-Client". Upon activation of the tab, there appears a window used for configuration of the tags to be transferred. The window has three working areas (Fig. 3).

(1 – selection of OPC server;

2 – area of displaying OPC server structure (OPC tag tree);

3 – graphic with information of the selected tags.)

As the OPC server is selected and the connection is established, OPC server tree will be displayed in area 2 (*Fig. 4*).

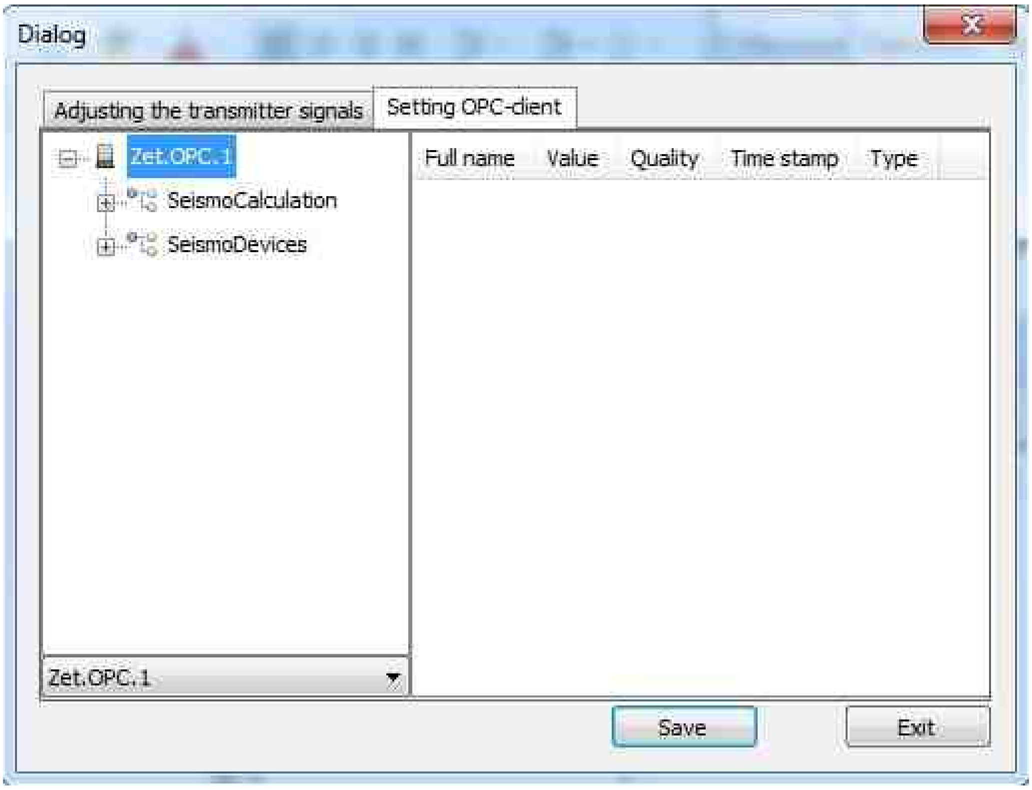


Fig. 4 OPC server tree will be displayed

Right-click the tag tree element to activate the context menu (*Fig. 5*).

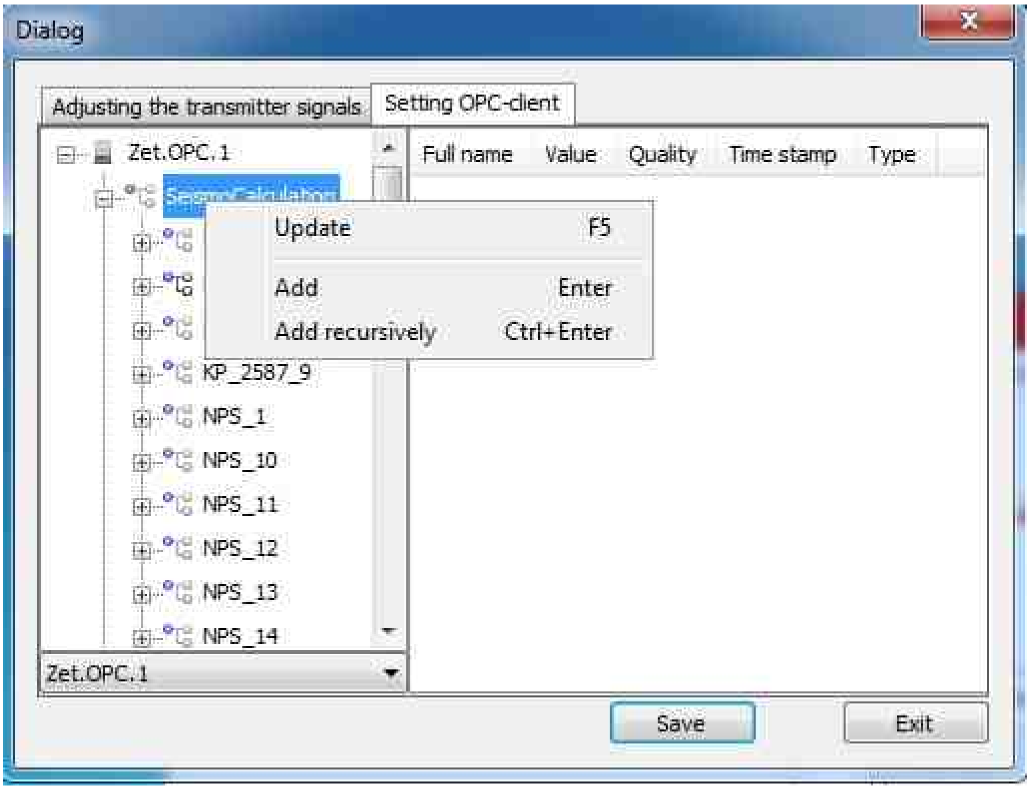


Fig. 5 Tag tree element to activate the context menu

Context menu:

1)"Update" – the option is used if the OPC server tree has been changed.

2)"Add" – the option allows to add a tag to a leaf or a leaf node.

3)"Add recursively" – the option allows to add tags to a node, which contains other nodes.

For user convenience, the program allows the use of hotkeys, besides, it is possible to add a tag by double-clicking a leaf node .

Upon completion of tags adding, they will be displayed in area #3. These tags are trackable, and it is these tags, that are sent to NetClient. Right-click the graphic element to activate the context menu (it is also possible to use the hotkeys). In this menu, the user can copy tag name or delete a tag (see *Fig. 6*).

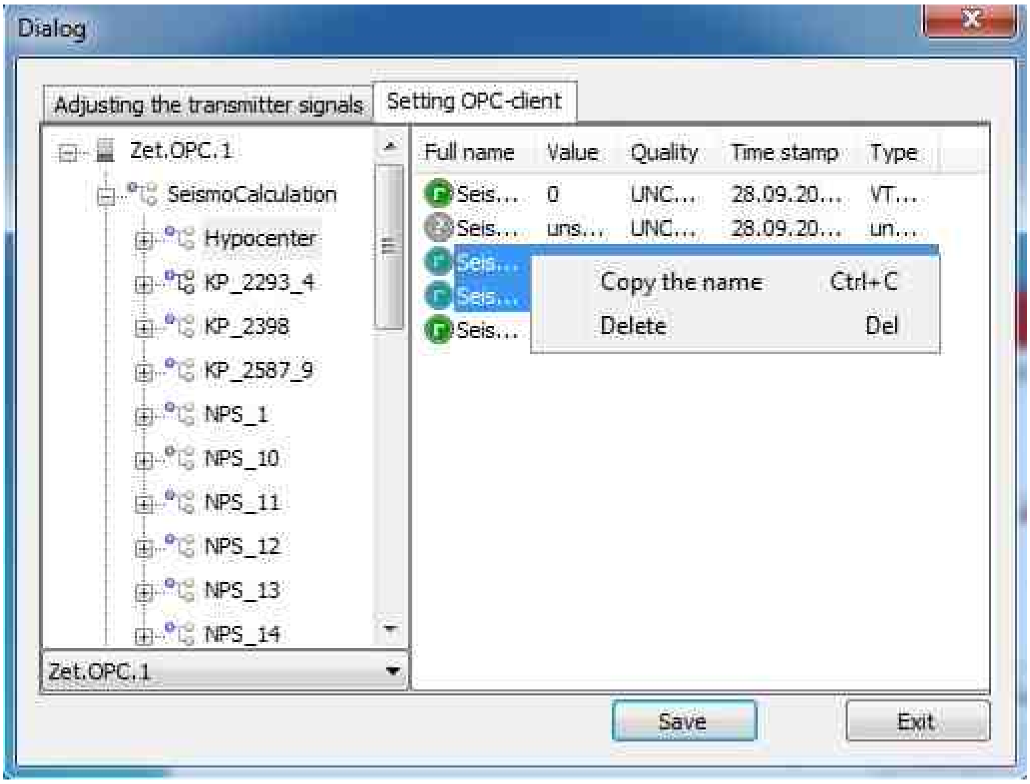


Fig. 6 The user can copy tag name or delete a tag

To the left from the tag name you can see an indicator displaying status of the tag.

Black indicator informs the user of the fact that the tag is no longer available, but since it has been previously used, it will be still displayed in the graphic until it is deleted by the user (*Fig. 7*).

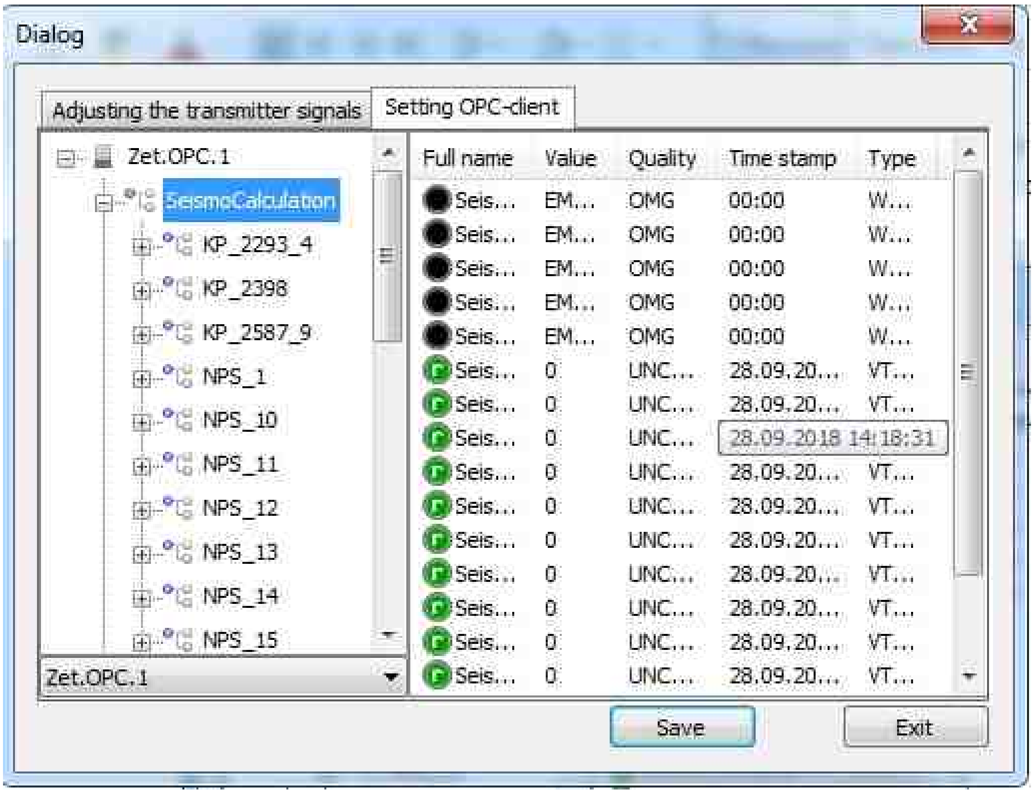


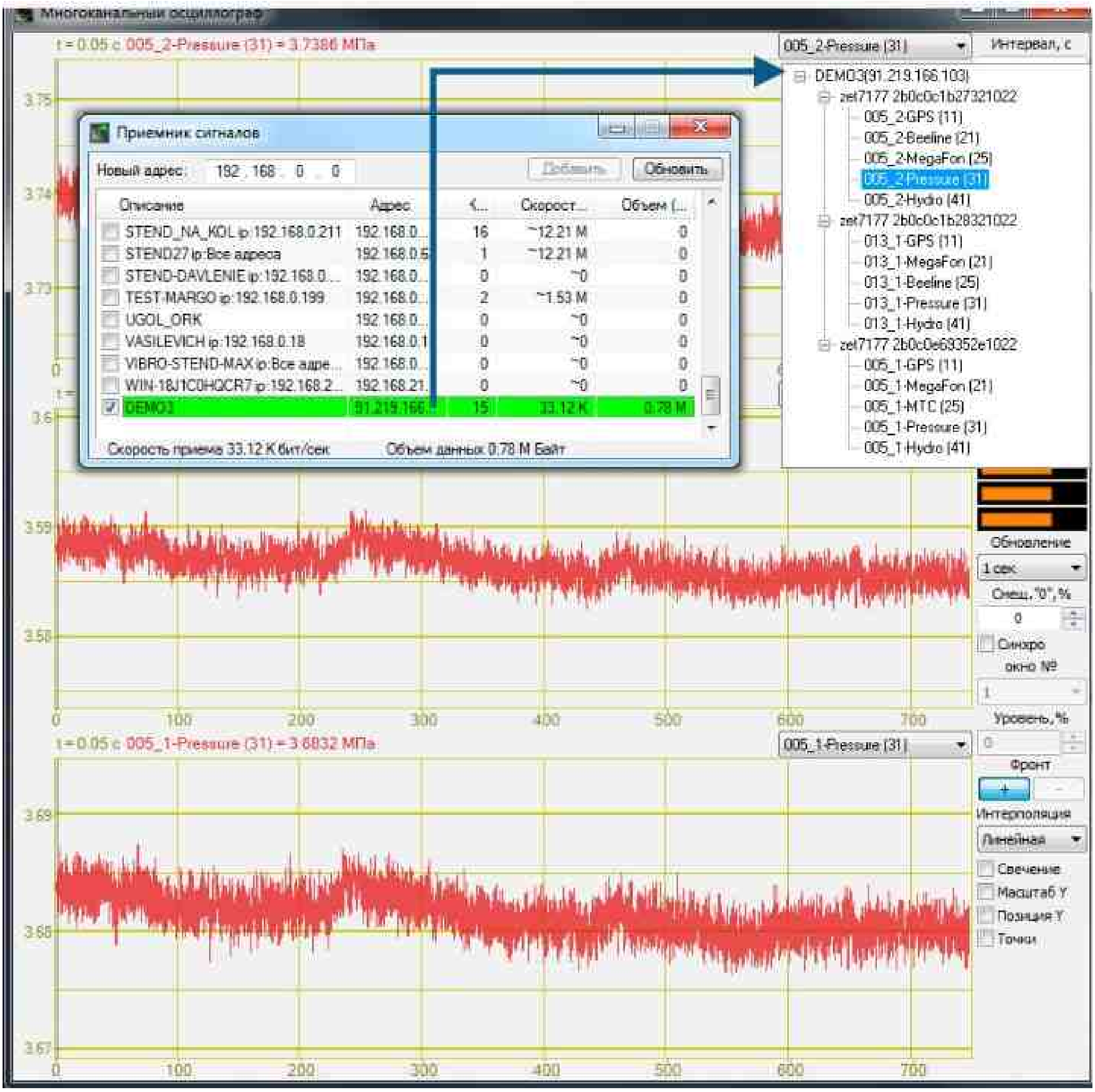
Fig. 7 It will be still displayed in the graphic

Data recording to the configuration file takes place as the parameters window is closed.

As the program NetSrv is started again, the program automatically establishes connection to the OPC server, while the "Setting OPC-Client" tab is filled with the data of the tags, which have been previously used.

Signal Receiver (Data Client) .....

The program is used for receiving digitized signals from server computers. Network data transfer is highly required in distributed measuring systems as well as educational laboratories.
The Fig. below shows **Data Client** and **Multichannel Oscillograph** windows. The data client can be used for connecting the ZETLAB DEMO server. The DEMO server channels will appear in the oscillographic signal list.



In the **Signal Receiver (Data Client)** window specify the IP address of the computer which serves as the data server. If the connection is successful, the digitized signal speed and volume of the received data are displayed.

ZETLAB Signal Transmitting and Receiving

ZETLAB software is a set of virtual instruments working with signals of the ZET server. The list of ZET server signals can differ by the number and type of connected devices, presence of programs generating virtual channels, etc. All ZET server signals can be roughly divided into 4 types:

- digitized signals of switched-on channels of ZET devices connected to the computer;
- demo channels (in case there are no ZET devices connected);
- virtual channels created by programs such as **Signals generator**, **Strain-Gauge Sensor**, **Vibration Meter**, etc.;
- signals received from data servers.

As soon as the signal transmitter turns on, any computer located on the same subnetwork can connected to it via the program **Signal Receiver (Data Client)** – and all signals of the server computer appear in its channel list. Then it does not matter whether these signals are processed by the server computer or a computer to which they are coming via the **Signal Transmitter (Data Server)→ Signal Receiver (Data Client)** system.

Supported Hardware .....

Signal Receiver (Data Client) is a part of the following software:

- ZETLAB BASE – ADC/DAC board software;
- ZETLAB ANALIZ – spectrum analyzer software;
- ZETLAB VIBRO – vibration control system software;
- ZETLAB TENZO – strain-gauge station software;
- ZETLAB SEISMO – seismic station software;
- ZETLAB NOISE – vibration meter-noise meter software;
- ZETLAB SENSOR – digital ZETSENSOR sensors software;

Signal Receiver (Data Client) is included in the Network program software group**.**

Program description .....

To run the program, the **Signal Receiver (Data Client)** required in the Network program (*Fig. 1*) **ZETLab** panel choose **Signal Receiver (Data Client)**. On the monitor screen displays the working window of the program, the **Signal Transmitter (Data Server)** (*Fig. 2*). From the top, the title bar displays the name of the program

Note: the **ZETLab** program (default: c: \ ZETLab \). The name of the startup file: NetClt.exe

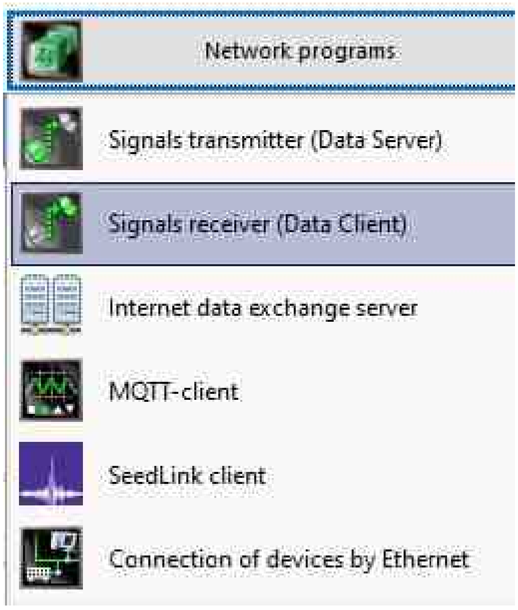


Fig. 1 Signal Receiver (Data Client)

From the moment the **Signal Receiver (Data Client)** is turned on, any computer on the same subnet can connect to it using the Connect to the **Signal Receiver (Data Client)** program and all the signals from the server computer appear in its channel list. Further, it does not matter whether these signals are processed by the server computer or the computer to which they are received via the system Turn on the **Signal Receiver (Data Client)** → Connect to the **Signal Transmitter (Data Server)**.

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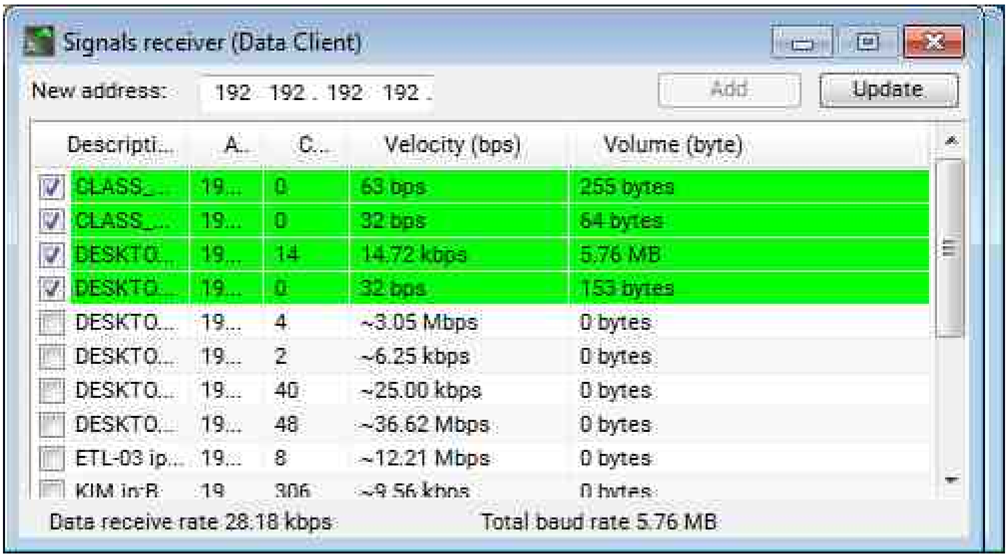


Fig. 2 Connect to the Signal Receiver (Data Client)

In the Connect to **Signal Receiver (Data Client)** window, information about connecting data clients (the date and time of connection) is displayed. If there are several network cards in the computer, in order to ensure the security of connections in the Enable **Signal Transmitter (Data Server)** window, the IP field of the network card that will be broadcasting the data becomes active.

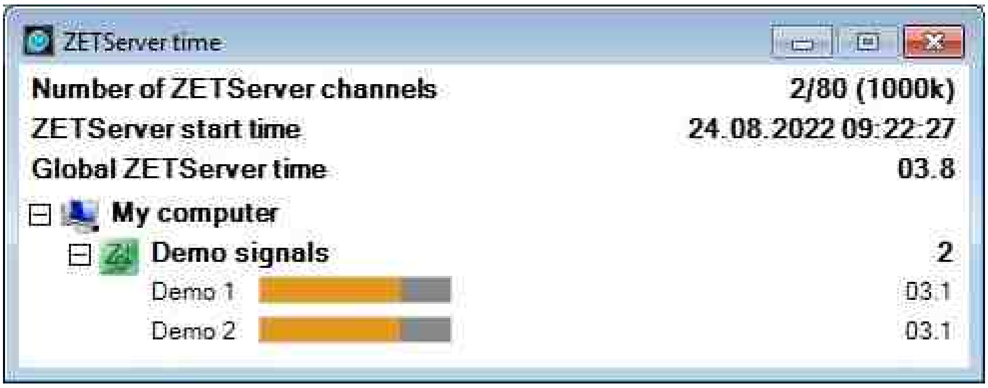


Fig. 3 List of channels of the demo version of ZETLab

Fig. 3 shows the ZETServer Time window for the case when no ZET devices are connected to the computer: the ZET server contains only two demo signals. When a ZET device is connected to the computer, digitized signals of the included ADC channels get to the list of channels of the ZET server (Fig. 2 - includes all 16 channels of the FFT spectrum analyzer ZET 017-U8, ZET 017-U2, A19, A19-U2, A23 modules).

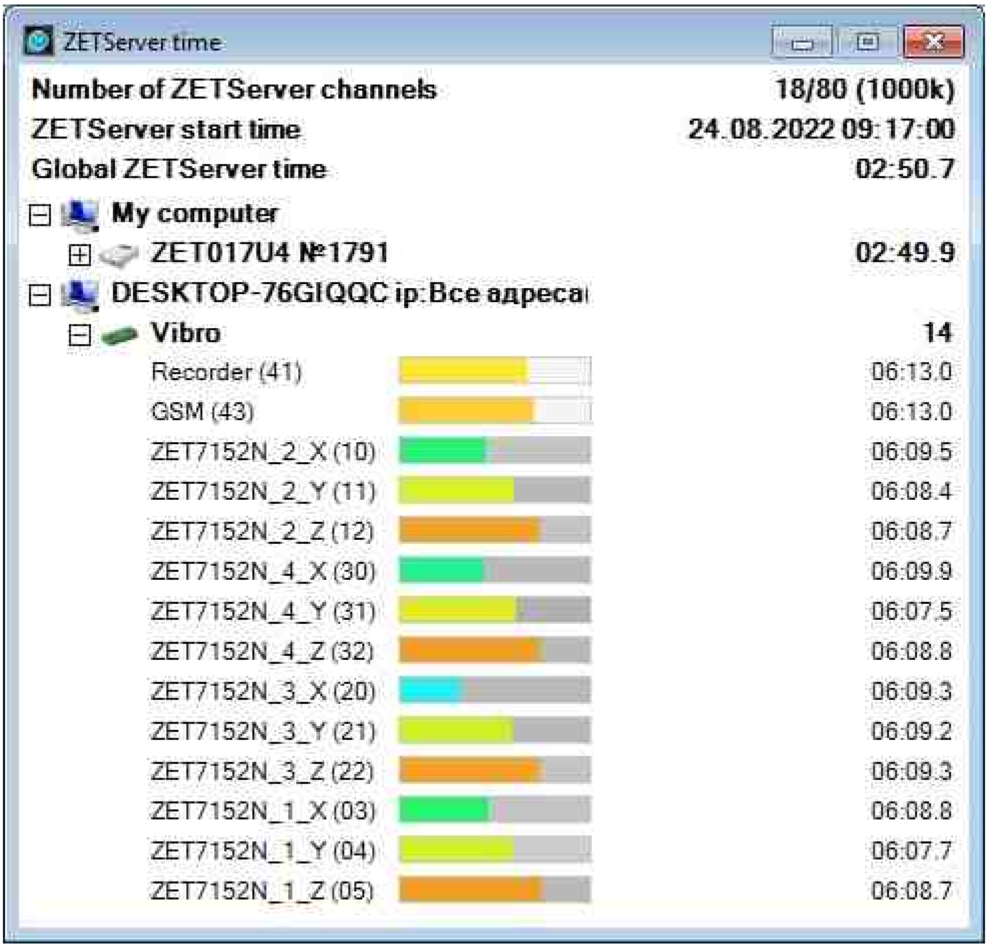


Fig. 4 List of channels of the ZET 210 ADC / DAC module (basic package ZETLab)

For cases where a ZET device that digitizes signals is connected to a single computer and the received data is to be processed on another computer, a pair of programs is activated, Turn on the **Signal Transmitter (Data Server)** and Connect to the **Signal Receiver (Data Client)**.

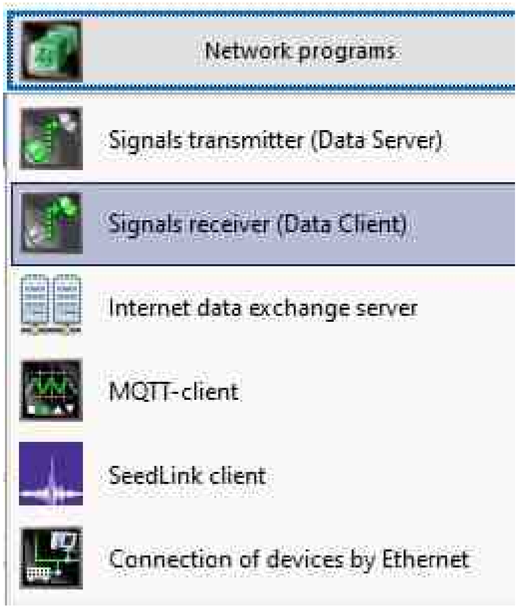


Fig. 5

The program Connect to the **Signal Receiver (Data Client)** is designed to receive digitized signals from the server computers. The program is shown in Fig. 7.

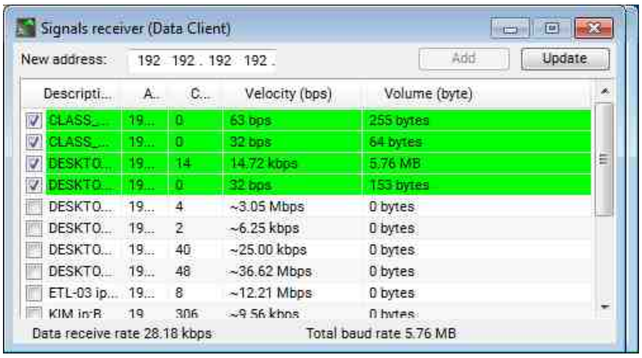


Fig. 6 Program Signal Receiver (Data Client)

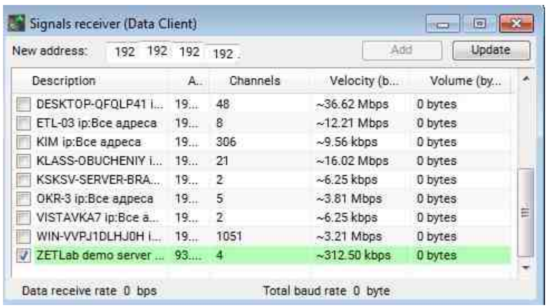


Fig. 7 Program Signal Receiver (Data Client)

The program window specifies the IP address of the computer that is the data server (*Fig. 4*). If the connection is successful, the reception speed of the digitized signals and the amount of data received are indicated (Fig. 7). The lower part of the program window Connect to the **Signal Receiver (Data Client)** is reserved for messages to the operator: the date and time of connection, the number of channels (in addition to digitized signals, the data servers can transmit virtual channels created during signal processing by **ZETLab** programs), the date and time of shutdown.

Fig. 8 shows the **ZETServer time** window for the case when the ZET 210 ADC/DAC module is connected to the computer and, in addition, data is received from the server.

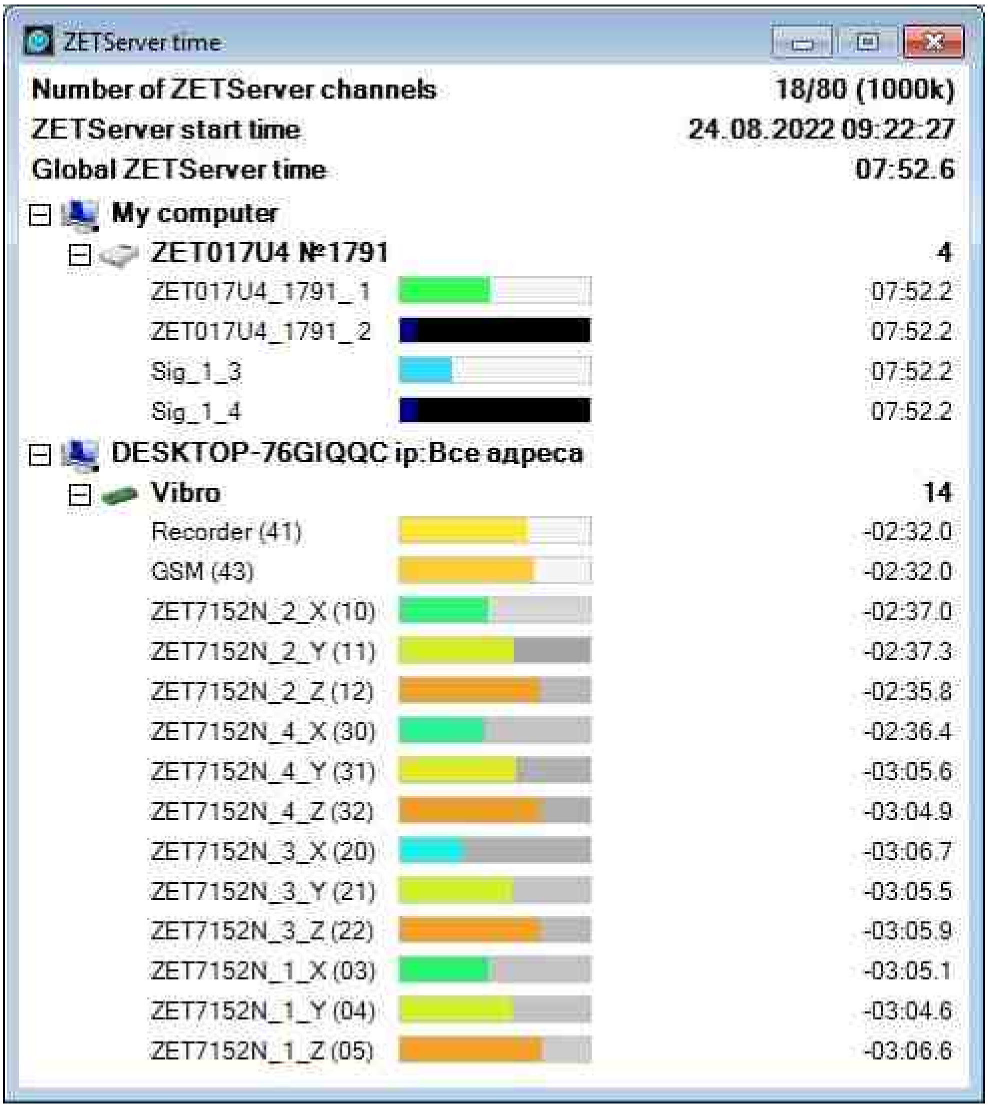


Fig. 8 ZETServer time and connected channels

When the ZETLab program activates the **Signal Transmitter (Data Server)**, the signals received by the Connect to the **Signal Receiver (Data Client)** become available. In addition, if such programs as the Signals generator or Seismic Monitoring are running on the data server, the virtual channels generated by these programs will also be received. Connect to the **Signal Receiver (Data Client)**.

New features of data transmission programs over the network .....

Improving the stability of programs. Added the functionality of resuming data when the connection is broken.

Let's consider a simple example. There are three computers. The first ones are servers (the "Signal Transmitter (Data Server)" program is running on them). The third computer is a client that receives signals from two servers (the "Signal Receiver (Data Client)" program is running on it) (*Fig. 1*). Using the ZETServer Time program (*Fig. 2*), we see that the client receives two channels from each server.

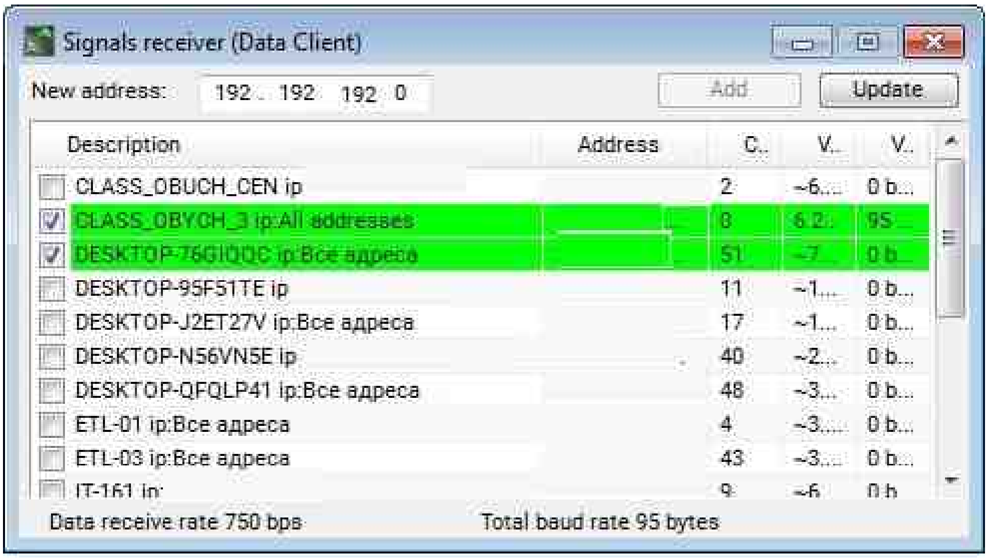


Fig. 1 Program "Signal Receiver (Data Client)"

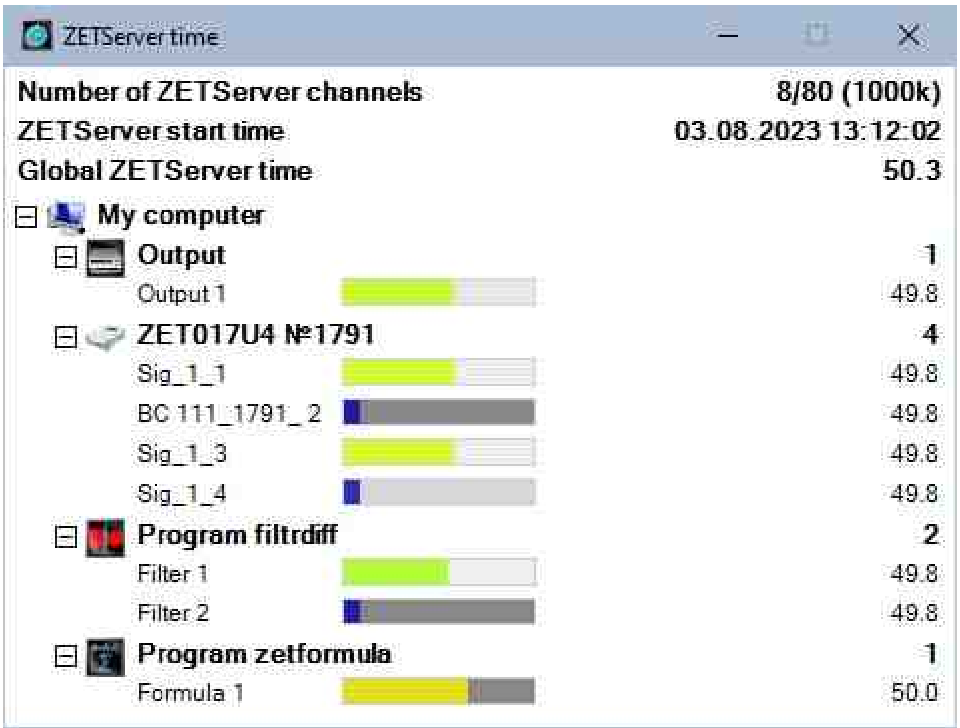


Fig. 2 "ZetServer Time" program

For clarity, we will continuously record channel data using the “Signals recording” program (*Fig. 3*) and view them with the “Signal trends viewing” program (*Fig. 4*).

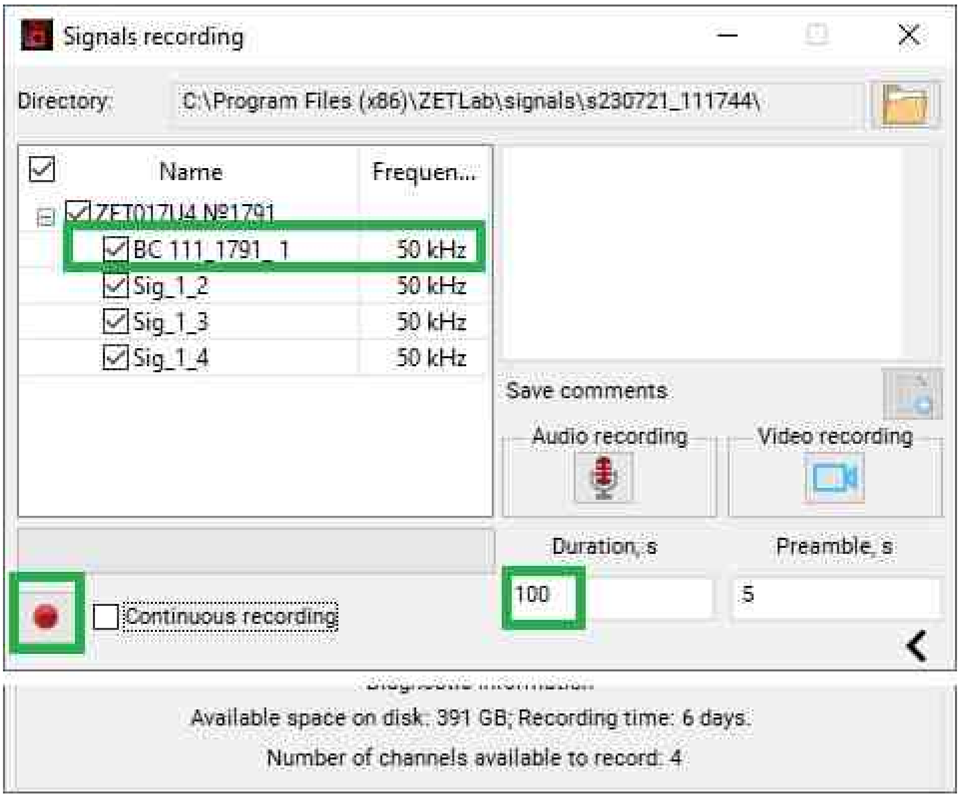


Fig. 3 "Signals recording" program

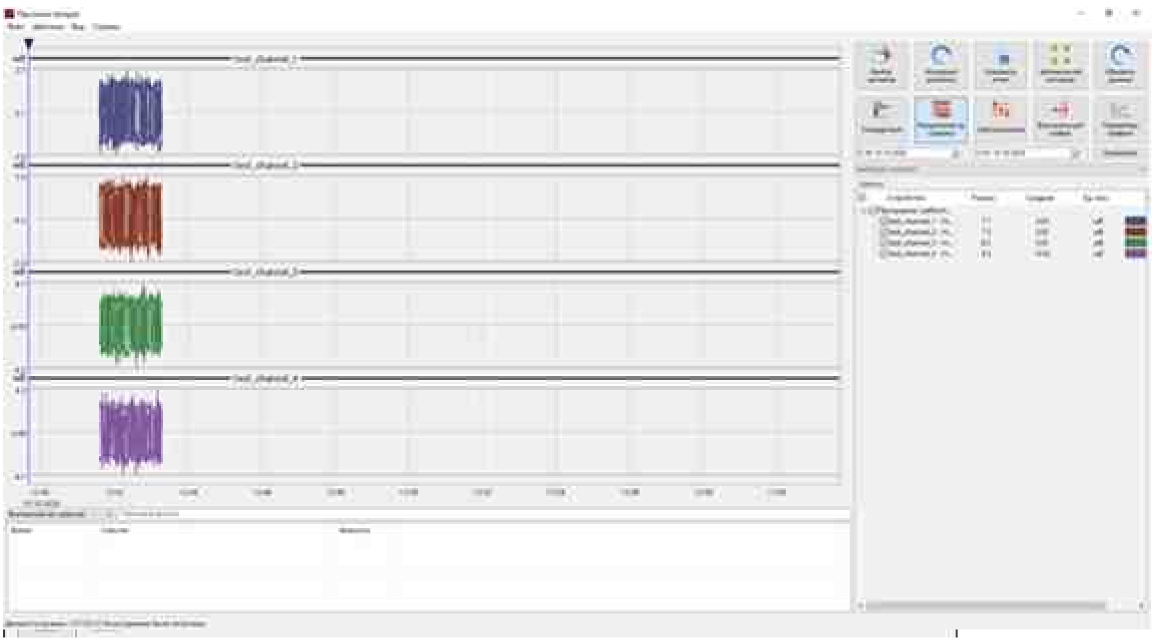


Fig. 4 "Signal trends viewing" program

Let's simulate a network break with the second PC (in this case, just turn off the Ethernet communication channel). The data client highlighted the connection string to the second PC in red, and the time ZETServer displays the corresponding channels as inactive (*Fig. 5*).

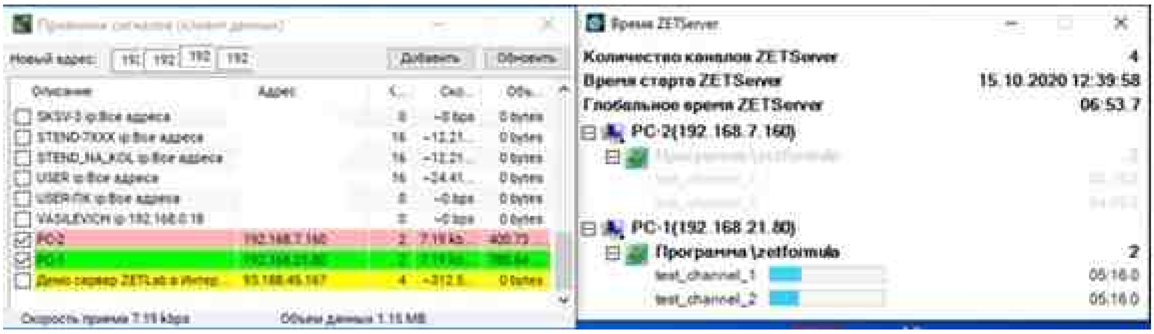


Fig. 5 Time ZetServer displays corresponding channels as inactive

Let's wait about five minutes. In the "Signal trends viewing" program, we see that the channels from the first PC continue to be recorded, which cannot be said about the channels of the lost connection (*Fig. 6*).

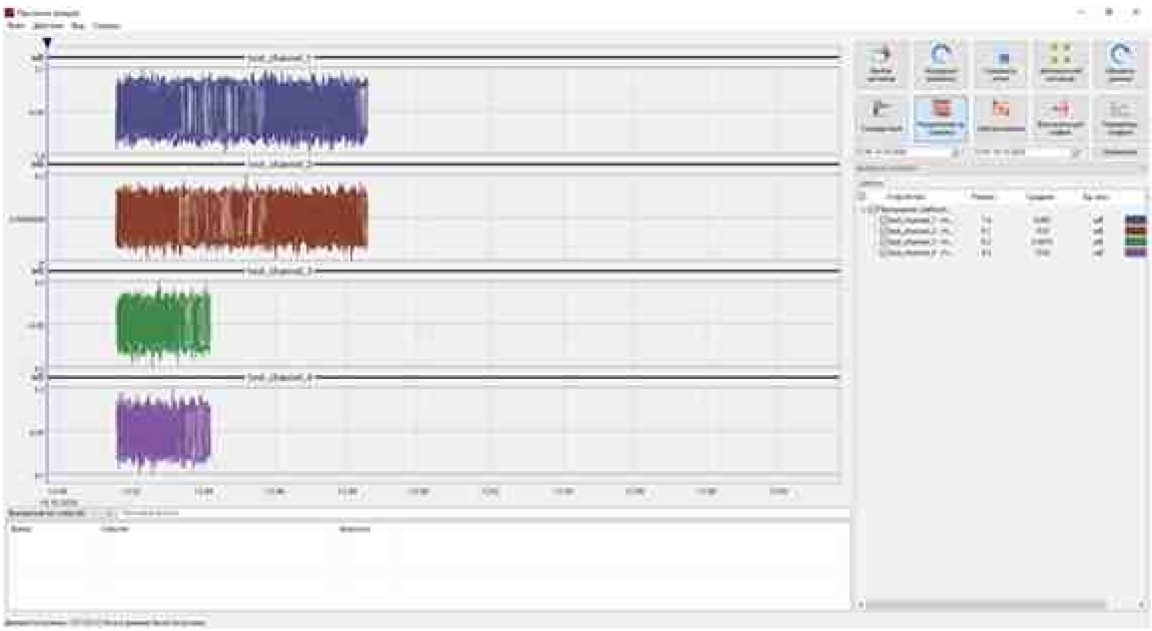


Fig. 6 In the "Signal trends viewing" program, we see that the channels from the first PC continue to be recorded, but there are no lost ones

Let's restore the connection with the second PC. After a short period of time, we see that the data has been downloaded, there are no gaps (*Fig. 7*)

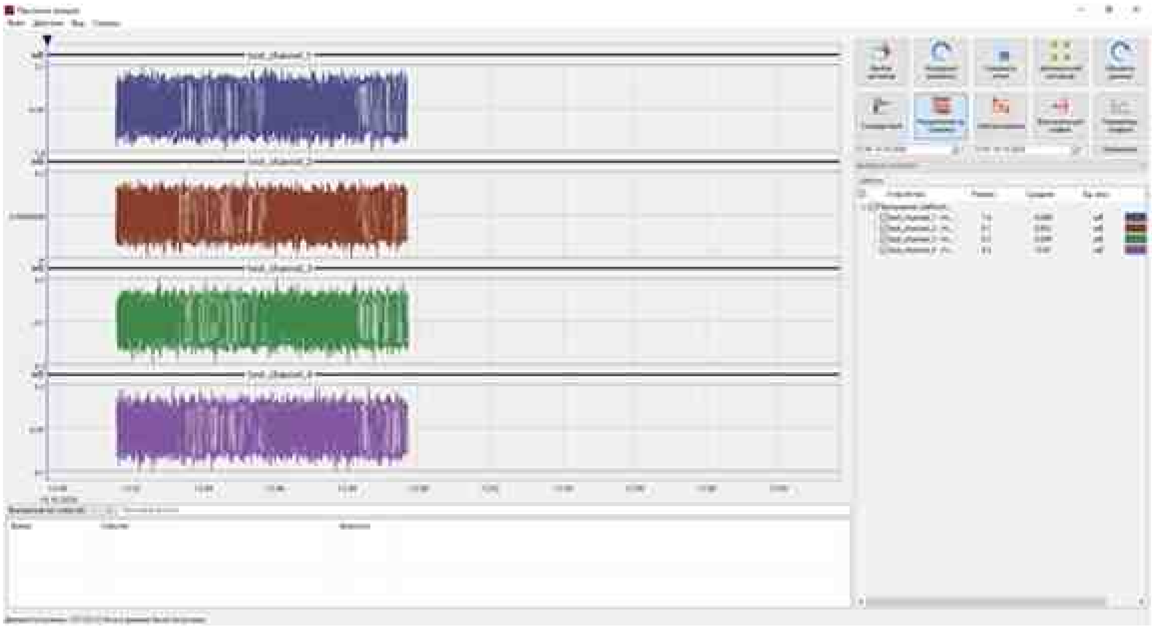


Fig. 7 After a short period of time, we see that the data has been downloaded, there are no gaps.

SeedLink client .....

The program allows you to add and configure data between stations. which contain a group of channels (*Fig. 1*).

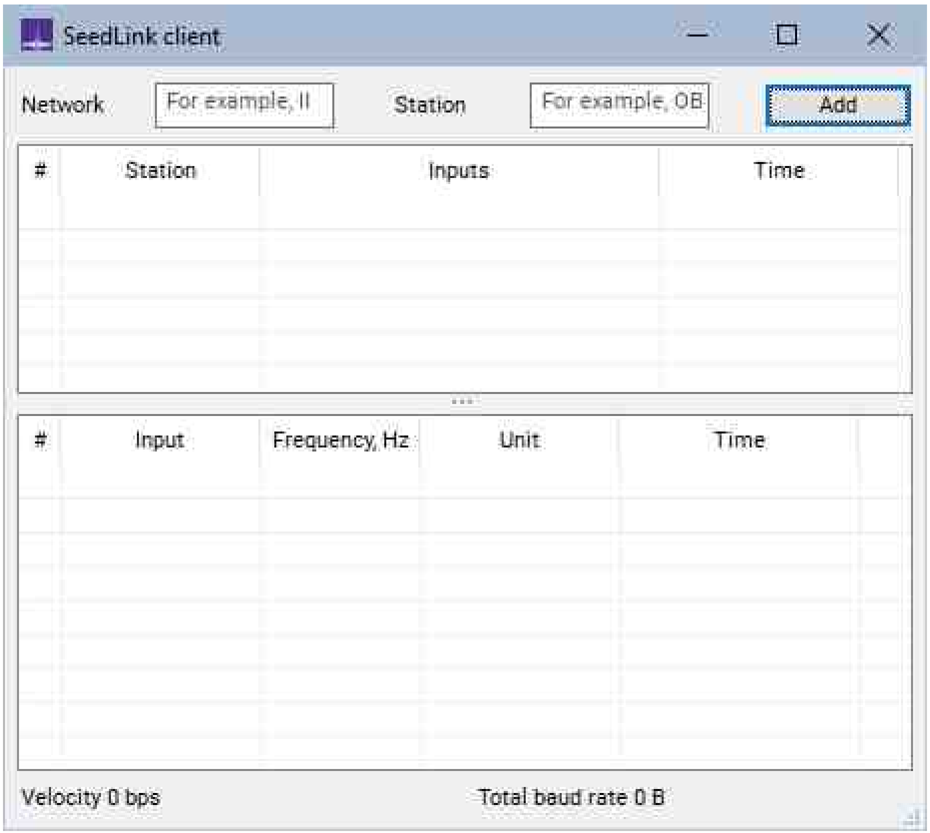


Fig. 1

Supported Hardware .....

The **Speedlink** client program is part of the following software:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT Spectrum Analyzers software
- ZETLAB VIBRO – Shaker controllers systems software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software (option).

The program **Speedlink** is included in the Network program software group**.**

Program description .....

To start the program, select the Network Programs menu in the control panel and select the Speedlink client program. The working window of the program is displayed on the monitor screen (*Fig. 1*).
Note: the program can be run directly from the working directory of ZETLab (by default: c:\ZETLab \). The name of the file to run: ZETSeedLinkClient.exe

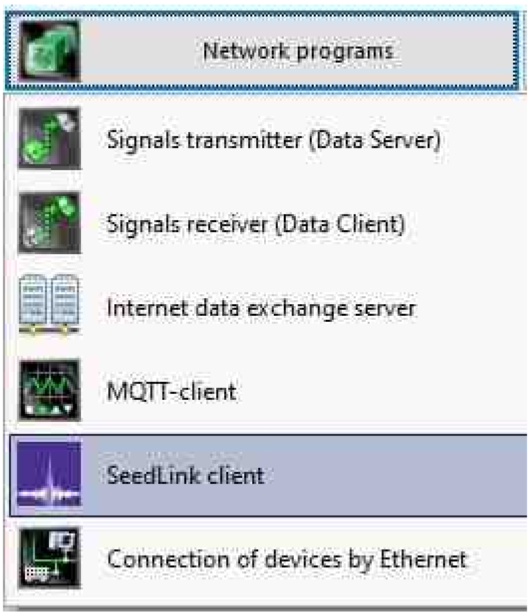


Fig. 1 Starting the program Speedlink client

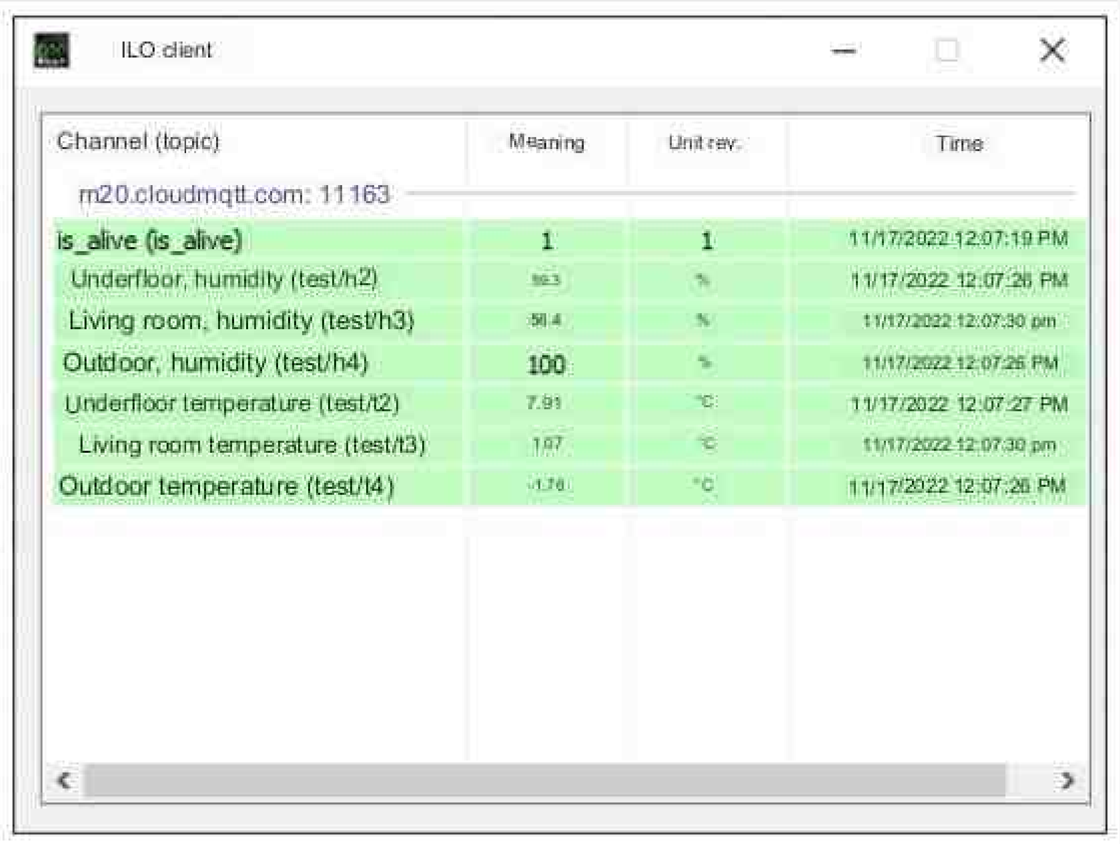
A real-time signal server implementing the Speedlink protocol.

Description

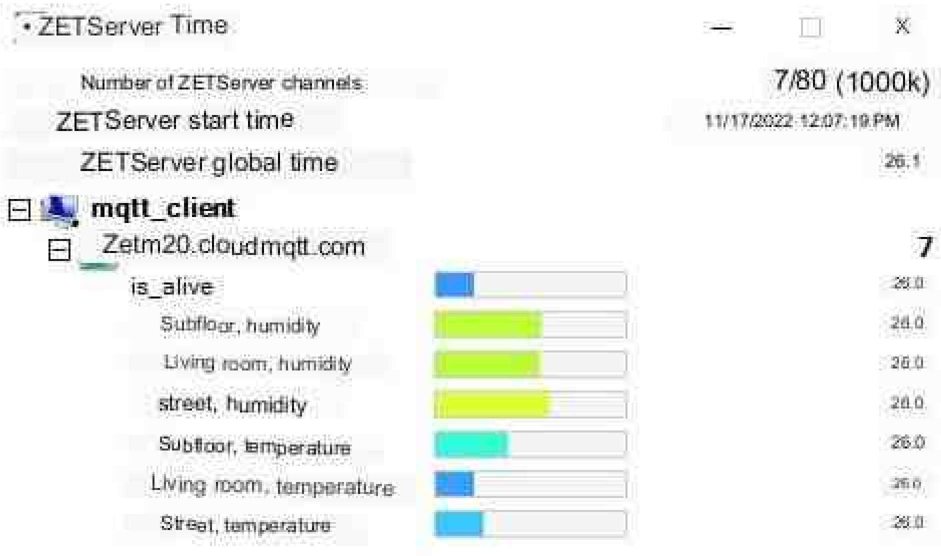
SeedLink is a real-time data acquisition protocol and client-server software implementing this protocol. The SeedLink protocol is based on TCP. All connections are initiated by the client. At the stage of establishing a connection, the client can subscribe to certain stations and streams using simple ASCII-encoded commands. When the handshake is completed, a stream of "packets" of the initial link, consisting of an 8-byte header of the initial link (containing the sequence number), followed by a 512-byte record of the mini-transmission, is sent to the client. The packets of each individual station are always transmitted in a timely manner (FIFO).

MQTT-client .....

The MQTT client program allows the user to configure interaction between devices at remote locations using the MQTT (Message Queue Telemetry Transport) data exchange protocol.
The MQTT protocol has recently become widespread in industry and IoT, this is due to the stability of message delivery for unstable Internet channels and low-power devices.
With the rapid development of the IoT industry, the MQTT protocol is being used by an increasing number of companies and developers, and our company is no exception.



Program MQTT-client interface



An example of the MQTT client program

So what are the main advantages of using the MQTT protocol?

MQTT is an asynchronous protocol, thanks to which data can be transmitted at any time.

Information is exchanged using compact messages.

It continues to work even in conditions of unstable communication on the data transmission line.

Supports multiple levels of quality of service (QoS).

It mainly has easy integration of new devices into the existing network.

The principle of operation

In the process of messaging in the MQTT protocol, three communication nodes participate: the publisher, the broker, and the subscriber.

The scheme of interaction between them is as follows:

the publisher connects to the message broker and publishes data to the topic on the broker;

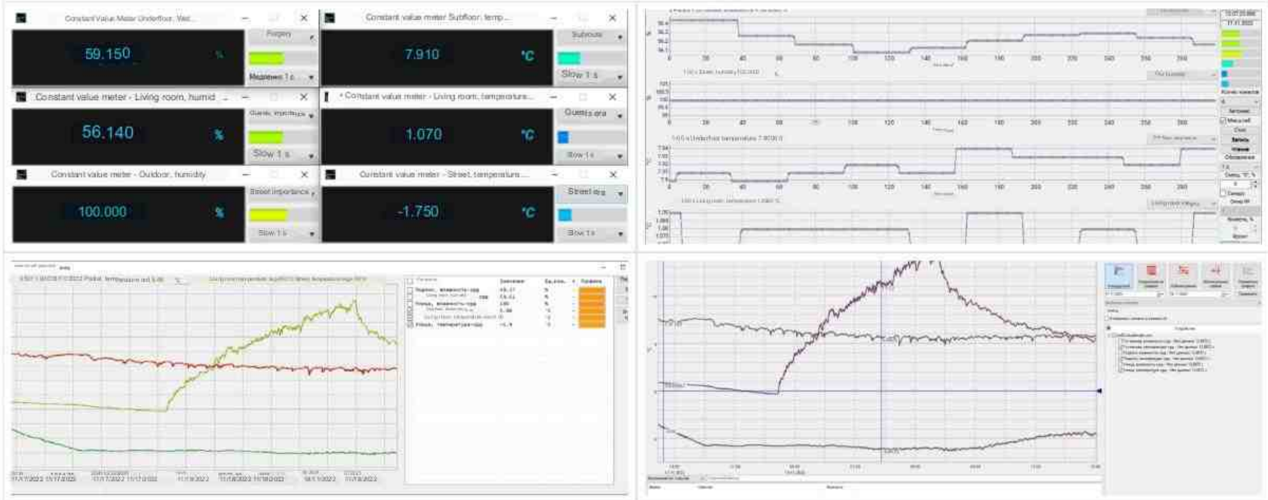
the subscriber connects to the broker and subscribes to the necessary broker topics;

the broker, when publishing data from the publisher, sends data to the subscriber from the topics for which the subscription is made.

The MQTT protocol has a fairly simple structure for understanding and configuring even by non-advanced users. An additional advantage is the availability of libraries for various programming languages and a guarantee of message delivery.

As a demonstration of the work of the MQTT client program in combination with other programs from the ZETLAB software, we will give an example of climate monitoring of a country house.

Temperature and humidity sensors are installed in three monitoring zones: street, utility room and residential area. Through the MQTT client program, we will connect to a broker where sensors publish data and subscribe to the necessary topics.



Long-term monitoring with trend recording is carried out only in the Multi-channel recorder program or in the Signal trends viewing program, other programs allow you to register only instantaneous values. Additionally, in the Multi-channel recorder program, the user has the ability to adjust the thresholds of values for each parameter and alarm when the value exceeds the specified limits.

Supported Hardware .....

The **MQTT-client** client program is part of the following software:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT Spectrum Analyzers software
- ZETLAB VIBRO – Shaker controllers systems software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software (option).

The program **MQTT-client** is included in the Network program software group**.**

Program description .....

To start the program, select the **Network programs** menu in the control panel and select the **MQTT client** program. The working window of the program is displayed on the monitor screen (*Fig. 1*).
Note: the program can be run directly from the working directory of ZETLab (by default: c:\ZETLab \).
The name of the file to run: ZETMQTTClient.exe

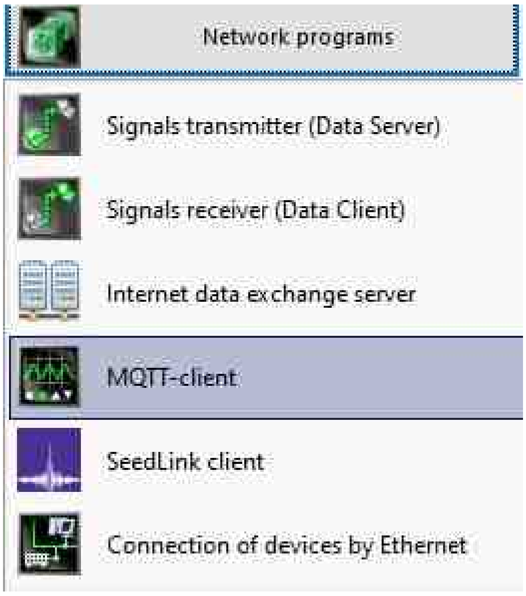


Fig. 1 Starting the program MQTT-client

The theoretical part

Total data

MQTT (Message Queue Telemetry Transport) is a network protocol that usually works on top of TCP/IP, oriented for exchanging messages between devices on the publisher-subscriber principle.
This protocol is not so old, it appeared in 1999, it was standardized in 2014, and MQTT v5 was released in April 2019.0

Main features of the MQTT protocol:

- Asynchronous protocol
- Compact messages
- Work in conditions of unstable communication on the data line
- Support of several levels of quality of service (QoS)
- Easy integration of new devices

- MQTT Protocol devices

The client (client), which is divided into:

  - Publisher (publisher)
  - Subscriber (subscriber)

- Broker (broker) or server
- Among other things, the concept of topic is used. this message
- Here is a diagram of how it all looks.

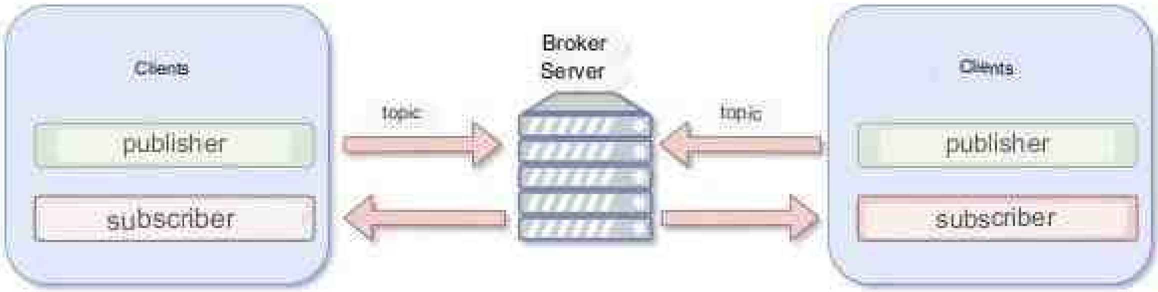


Fig. 2

MQTT

The MQTT protocol works at the application layer on top of TCP/IP and uses ports:
1883 by default
8883 when connected via SSL

In addition, there are some other terms that you need to know about:

QoS (Quality of Service) – this indicator indicates the probability of a packet passing between two network points.

QoS happens:

- QoS 0 - no more than once, the server sends and forgets. Messages can be lost or duplicated, this level is the fastest, but unreliable;
- QoS 1 - At least once, the recipient confirms the delivery. Messages may be duplicated, but delivery is guaranteed. This level is used by default.
- QoS 2 - exactly once, the server provides delivery. Messages arrive exactly once without loss or duplication. This is the most reliable level, but the slowest.

MQTT devices use certain types of messages to interact with the broker, the main ones are presented below (in reality there are more of them):

- Connect – establish a connection with a broker.
- Disconnect – disconnect the connection with the broker.
- Publish – publish data to topic.
- Subscribe – subscribe to the topic.
- Unsubscribe – unsubscribe from the topic.

INTERFACE CONVERTER ZET 7176 .....

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Designation and technical specifications .....

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Purpose of interface converters .....

Interface converters ZET 7176 are intended for connection of measuring networks based on digital transducers with CAN interface to PC via Ethernet network. The throughput capacity of Ethernet network allows to send commands and large data volumes without delay.

The ZETLAB package includes drivers for ZET 7176 modules. ZETLAB data server automatically detects devices in CAN line, reads the name of the measurement channel, the measurement unit, top and bottom range of the admissible parameters values, processes the data of measurement channel, and produces constant synchronized data stream in ZETLAB environment

The ZETLAB data server scans the line for all available addresses and, in the event of a new device, dynamically connects a new channel to the system. When a new ZET 7176 device is detected, the ZETLAB data server also connects all channels on the go. Thus, the line can be serviced without interrupting the work process through other channels, i.e. the system allows "hot" replacement of elements.

Operational environment .....

Depending on designation and intended use, interface converters ZET 7176 have two product versions available:

1. Laboratory version – for use of the digital transducers in mild operational environment.
2. Industrial version – for use of the digital transducers in adverse operational environment.

Operational environment conditions of the digital transducers are specified in Table 1.1.

Table 1.1 Operational environment of ZET 7176

Parameter	Laboratory	Industrial

	version	version
Ambient air temperature, єC	5…40	-40…80
Relative air humidity, %	Max 90	Max 98
Atmospheric pressure, mmHg	630-800	495-800

at an air temperature of 25 єC without moisture condensation.

at an air temperature of 35 єC.

Scope of delivery ZET 7176 .....

The scope of delivery of the interface converter ZET 7176 is given in Table 1.2.

Table 1.2 Scope of delivery ZET 7176

No.	Title	Quantity	Note
1	ZET 7176 interface converter	1 piece	
2	Ethernet cable (patch cord)	1 piece	2 meters
3	Power supply 220V → +24V	1 piece	
4	220V mains cable "plug without grounding" with free terminals	1 piece	1.7 meters
5	ZET 7001 measuring line connector	1 piece	
6	DIN rail 300 mm, 2 stoppers per DIN rail for plastic modules (dimensions 71Ч39 mm and 87Ч50 mm)	1 piece	
7	0.2 meter cable (two red/blue conductors), connecting cable with free terminals for assembling ZET 7xxx on a rail, length 10 m.p.	1 piece.	
8	ZETKEY — USB device (key for ZETLAB activation)	1 piece	
9	Terminating resistance 120 Ω	1 piece	
10	USB flash drive with ZETLAB SENSOR software	1 piece	
11	Set of documentation	1 set	

In the case of delivery of an interface converter with digital sensors in industrial design, the composition is additionally equipped with a connection cable for connecting ZET 7xxx in industrial design, 2 meters long with connectors FQ14-4TJ-7 ↔ FQ14-4TJ-7, as well as a connection cable for connecting the interface module to the interface line ZET 7xxx 2 meters long with connectors free outlet ↔ connector FQ14-4TJ-7.

External view and contacts designation .....

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External view of interface converters .....

External view of interface converters

Fig. 2.1 displays external view of interface converters ZET 7176 (laboratory version). Inside of the transducer (at its bottom surface), there is a magnet, which allows to mount the transducer at steel surface.

Fig. 2.1 External view of the interface converter (laboratory version)

Fig. 2.2 displays external view of interface converter ZET 7176 (laboratory version).

Fig. 2.2 External view of the interface converter (laboratory version)

Interface converters: contacts labellings .....

Interface converters: contacts labellings

Interface converters ZET 7176 (laboratory product version) have 4 contacts for the connection of digital transducers and connector RJ-45, which is used for connection of the interface converters to PC via Ethernet interface.

Fig. 2.3 shows contacts labelling of interface converter ZET 7176.

Fig. 2.3 Contacts labelling of ZET 7176 (laboratory version)

Table 2.1 ZET 7176: contacts designation for connection of digital transducers

Table 2.1 ZET 7176: contacts designation for connection of digital transducers

Contact #	Designation	Labelling
1	(9…24) V	Orange
2	CAN 2.0 line "H"	Blue
3	CAN 2.0 line "L"	White-blue
4	GND	White-orange

Establishing measuring network: connection diagram .....

Establishing measuring network: connection diagram

In the course of measuring network deployment, digital transducers with CAN 2.0 interface are connected sequentially. The resulting measuring network consisting of digital transducers is connected to the PC by means of interface converter ZET 7176. Fig. 2.4 shows a measuring network with interface converter ZET 7176.

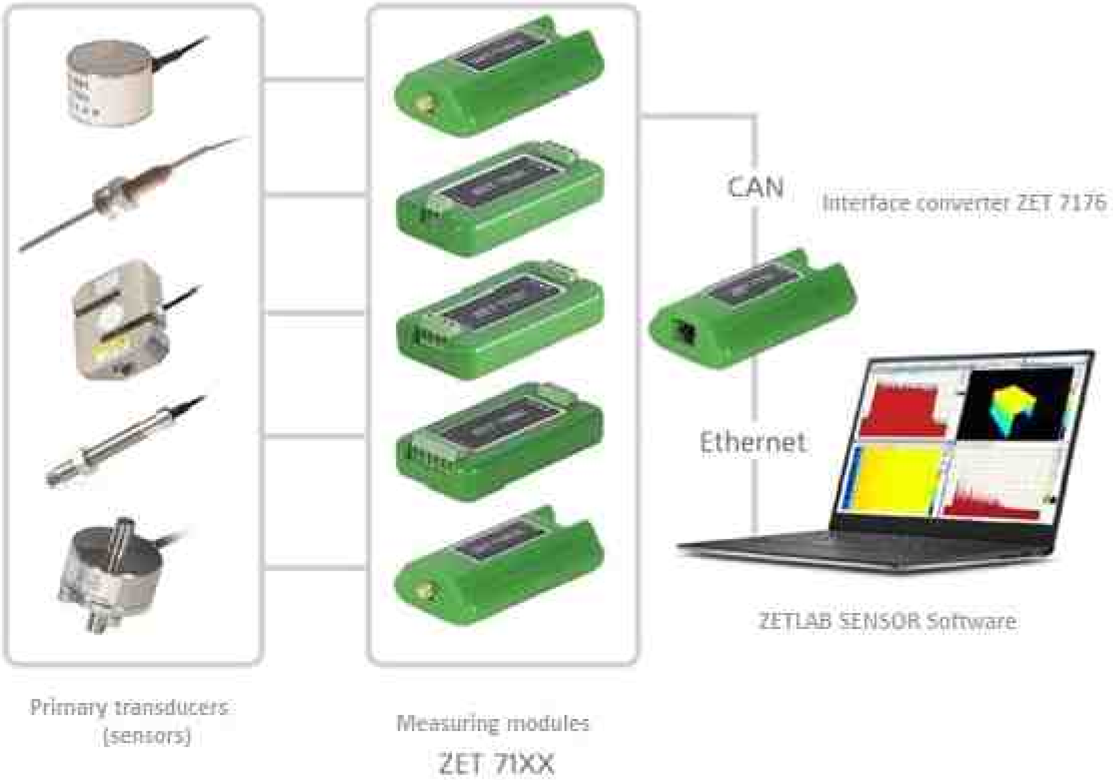

Fig. 2.4 Connection diagram

<u>Note!</u> The addresses (nodes) of the transducers within a measuring network should be different from each other. Identical addresses of digital transducers in a measuring network may negatively affect the validity of data received from the digital transducers.

Connection of interface converters .....

To work with ZET 7176 interface converters, you should connect them to an Ethernet local network or directly to a computer. It is also necessary to supply voltage of 9…24 V.

On the computer, which will be used to conFig. the interface converters, the Windows operating system must be installed, and the ZETLAB software must be installed and launched. It is also necessary to connect the ZETKEY dongle supplied with the interface converter to the USB connector of the computer.

Connection order .....

Connection order

When connecting the interface converter for the first time, it is necessary to conFig. the Ethernet ports on the computer and the interface converter in such a way that the values of IP addresses and masks determine their relation to a single subnet. To do this, either the IP address of the Ethernet port of the interface converter is reconfigured to the subnet of the port of the computer, or the IP address of the Ethernet port of the computer to the subnet of the port of the interface converter.

Note: *If necessary, check the IP address of the interface converter according to section* *3.1.3*.

The Ethernet IP address of the interface converter port must be configured in accordance with section 3.1.4.

Setting the IP address of the Ethernet port of the computer should be done in accordance with Section 3.1.5.

After the IP addresses of the Ethernet ports of the computer and the interface converter are located in a single subnet, it is necessary, guided by the section 3.1.6, perform the activation of the Ethernet channel of the interface converter, after which the interface converter will be completely ready for operation.

Note: *When using several interface converters at the same time, it is necessary to use an Ethernet switch that provides the required number of Ethernet ports for connection. In this case, the connected Ethernet ports of the interface converters and the computer must belong to the same subnet and not have the same IP addresses.*

Setting by default of the IP address .....

Setting by default for the interface converter is an IP address of 192.168.1.76 with a subnet mask of 255.255.255.0.

Checking the IP address of the interface converter .....

To check the IP address of the interface converter on the ZETLAB panel, in the "Network programs" menu, activate the program "Connecting devices via Ethernet", this will open the program window (*Fig. 3.1*).

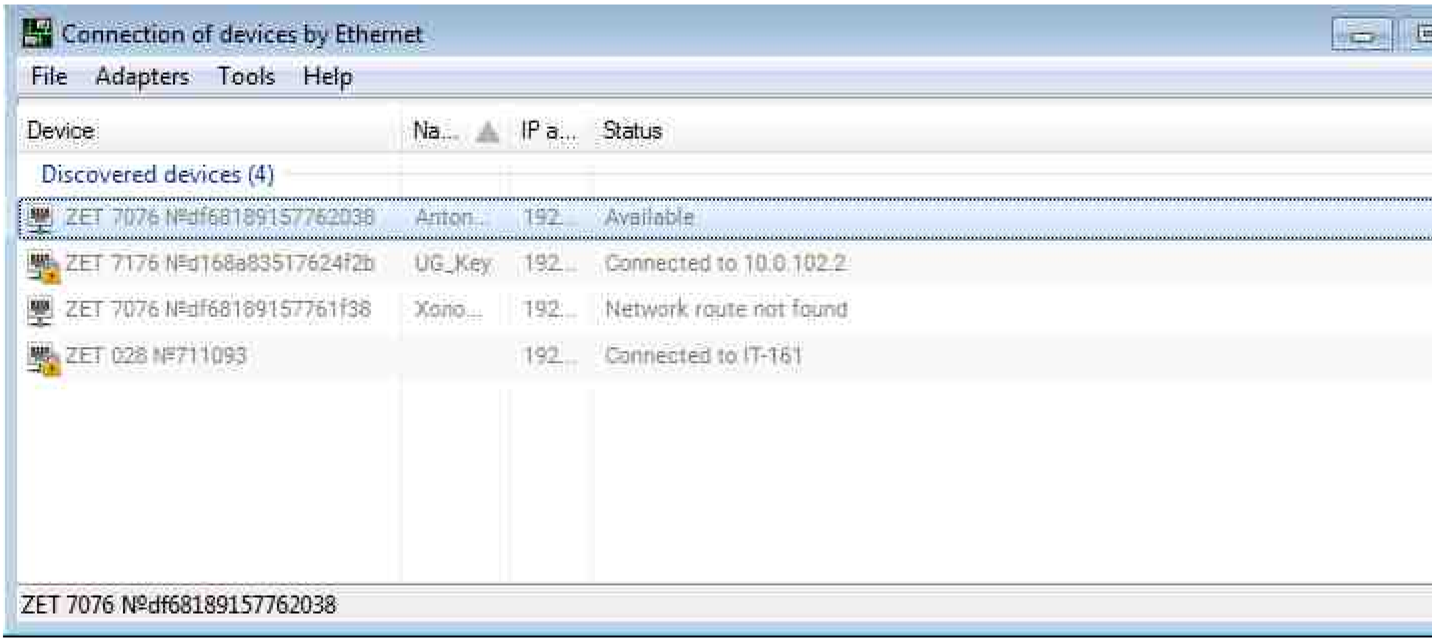

Fig. 3.1 Connection of device by Ethernet window

To view the current IP address of the interface converter, move the mouse cursor over the name of the interface converter and read the value of the IP address (*Fig. 3.2*).

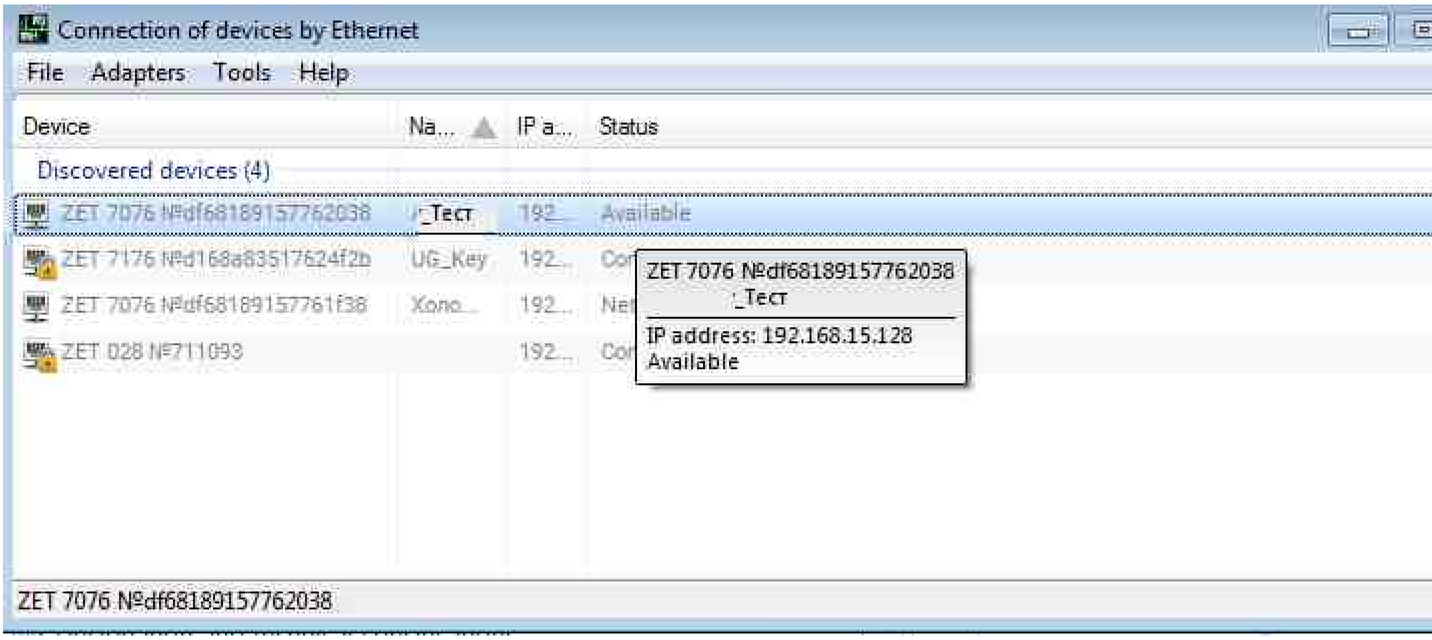

Fig. 3.2 Viewing the IP address of the interface converter

Setting the IP address of the interface converter .....

To change the IP address of the interface converter, in the window of the program "Connecting devices via Ethernet" by right-clicking on the name of the interface converter, open the context menu and select the function "Change IP address" (*Fig. 3.3*).

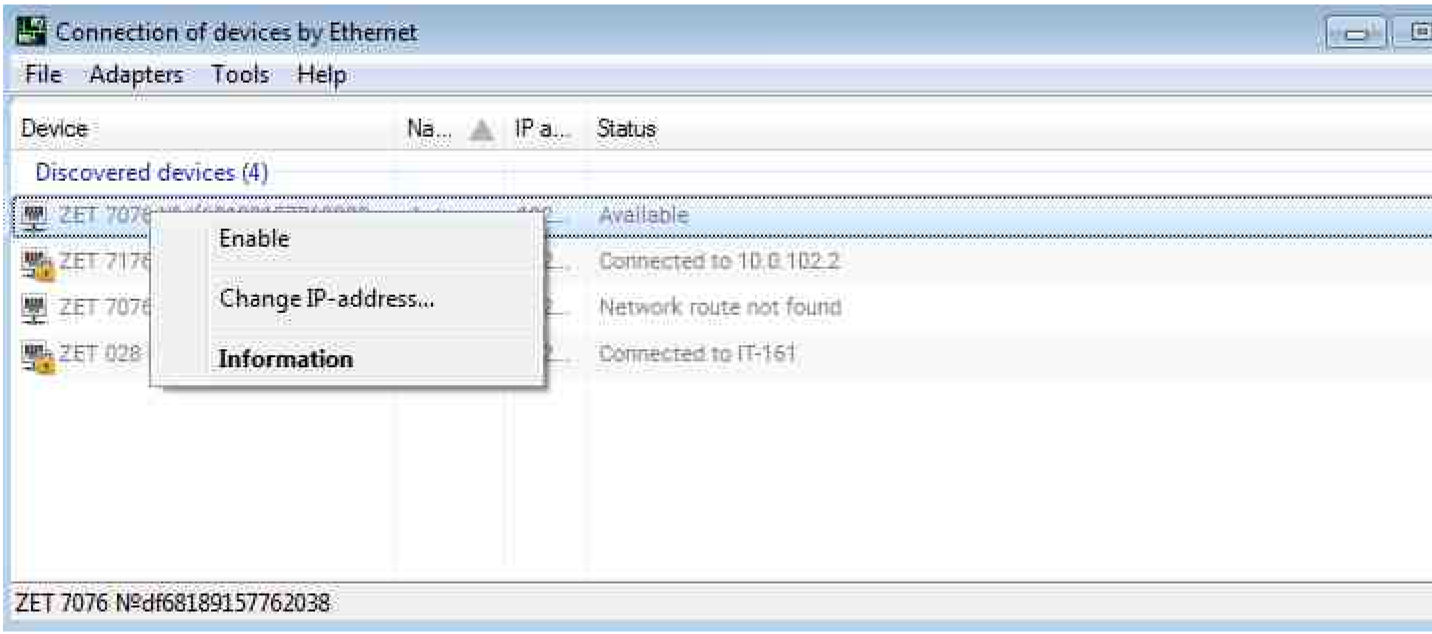

Fig. 3.3 Calling the function to change the IP address of the interface converter

In the "Change IP address" window that opens, in the "New IP address" line, set a new network address and subnet mask of the interface converter, and then click the "OK" button (*Fig. 3.4*).

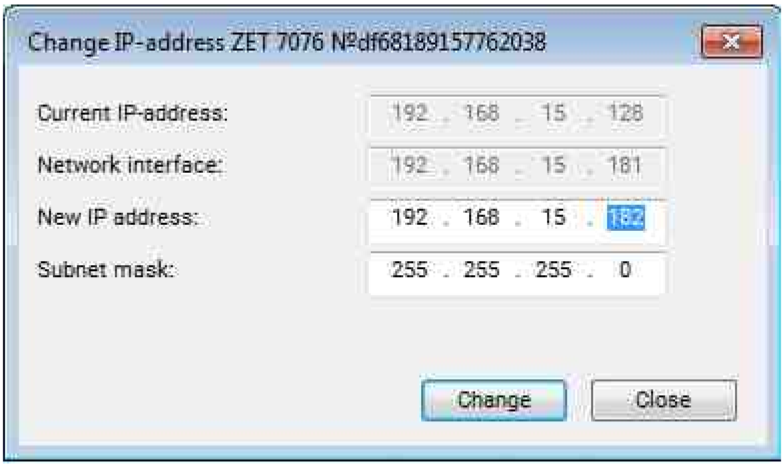

Fig. 3.4 Chang the IP address of the interface converter

Setting the computer's IP address .....

To conFig. the IP address of the Ethernet port of the computer, open the "Network connections" window from the programs of the Windows operating system and then activate double-click the icon corresponding to the Ethernet network port configured on the computer, and the "Ethernet status" window will open (*Fig. 3.5*) selected port.

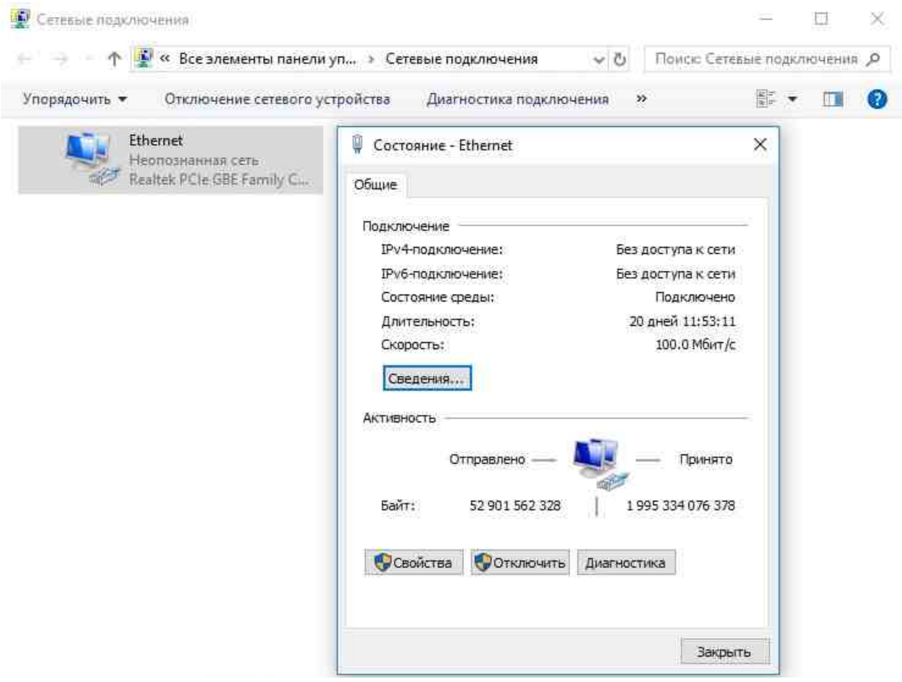

Fig. 3.5 "Ethernet status" Window

In the "Ethernet status" window, activate the panel "Properties" and in the opened window "Ethernet properties" (*Fig. 3.6*) "highlighting" the line "IP version 4 (TCP / IPv4)" (as shown in the figure) activate the "Properties" panel.

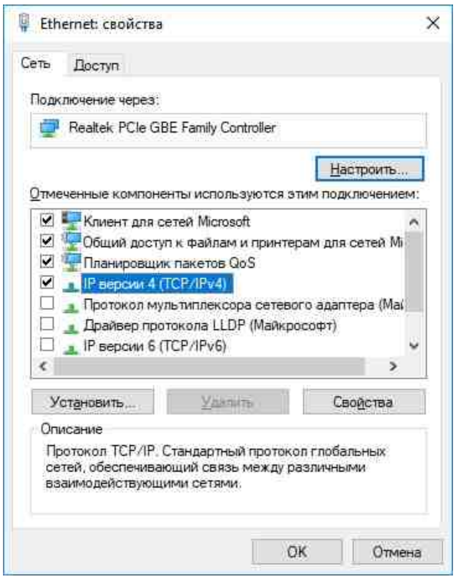

Fig. 3.6 "Properties" window

In the opened window "Properties: IP version 4 (TCP/IPv4)" assign the IP address and Ethernet mask of the computer port (*Fig. 3.7*).

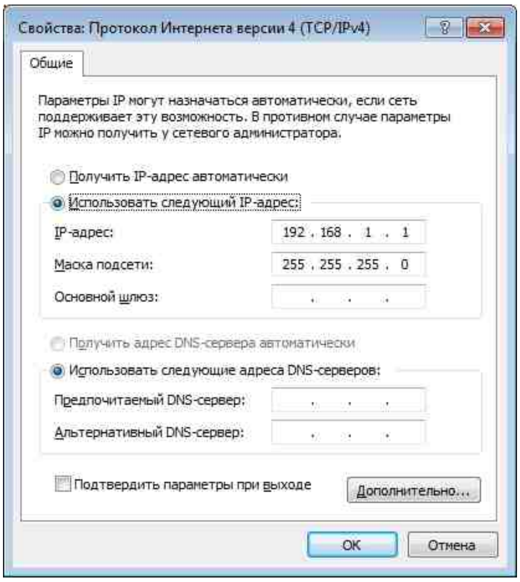

Fig. 3.7 "Properties: IP version 4 (TCP/IPv4)" window

Note: *By default, the interface converters use the "255.255.255.0" mask, which defines the class C subnet (in the example, the network address is 192.168.1.xxx, where xxx is the IP addresses of the nodes in the range from 1 to at the computer port 1).*

Activating an Ethernet connection .....

To enable the device to connect via Ethernet, it is necessary that the Ethernet IP addresses of the interface converter and computer ports belong to the same subnet. If necessary, reconFig. the IP address of the port of the interface converter or computer, according to the sections 3.1.4 or 3.1.5.

To connect the interface converter to the computer, in the program "Connecting devices via Ethernet" by right-clicking on the name of the device, open the context menu and select the "Enable" function (*Fig. 3.8*).

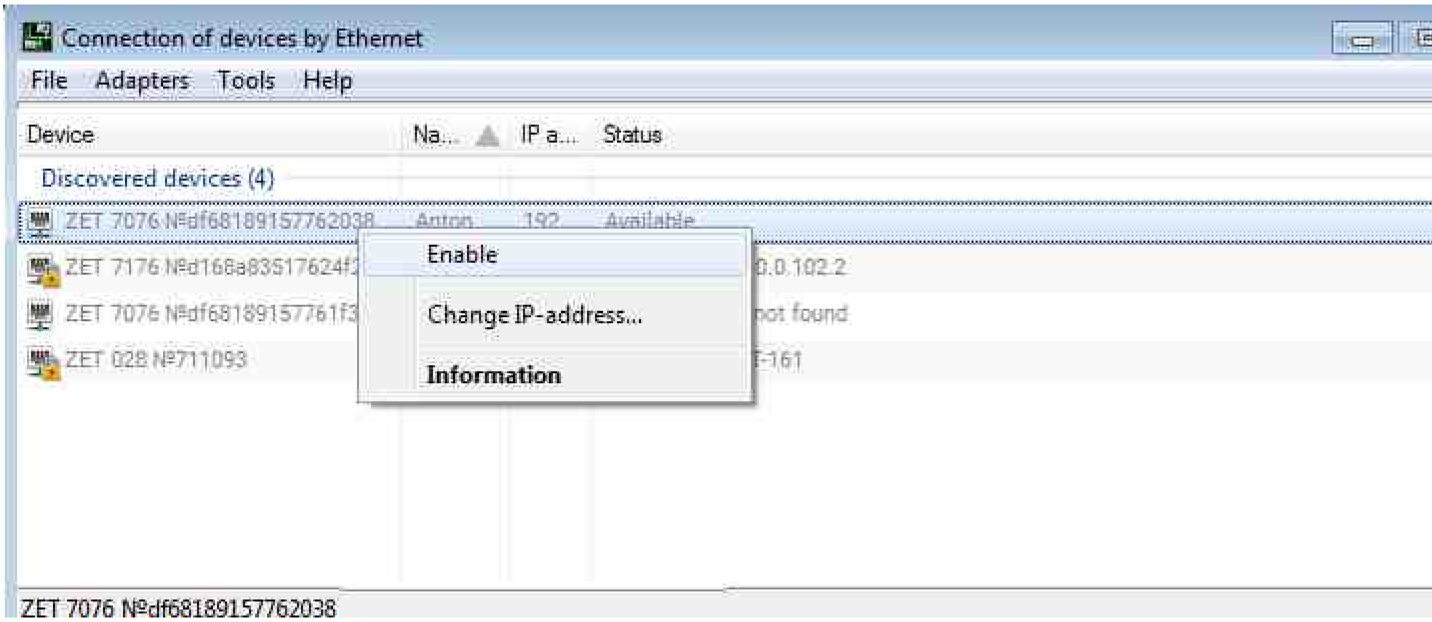

Fig. 3.8 Activating the interface converter

In the "Connect devices via Ethernet" window, make sure that the status of the involved interface converter has changed to "Device connected" (*Fig. 3.9*).

Fig. 3.9 Status "Device connected"

Configuration of interface converters .....

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Purpose and composition of tabs .....

To set parameters of the interface converters, right-click its name and enter the "Properties" menu – you will see the "General" properties tab.

The "Total properties" tab contains information of the interface converter type and its serial number. Fig. 4.1 shows an example of "Total properties" tab.

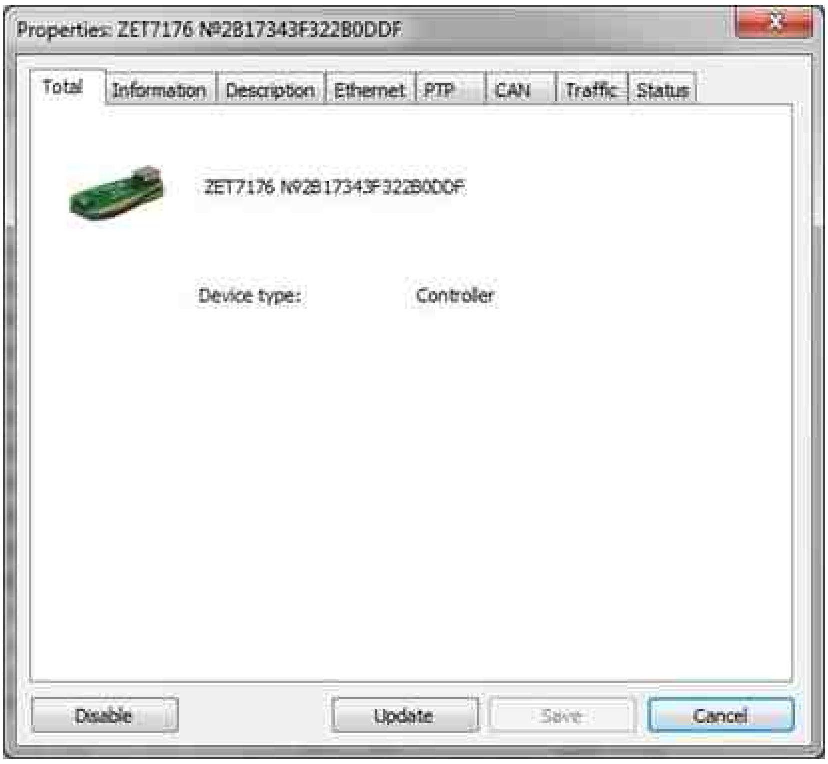


Fig. 4.1 "Total properties" tab

The tab “Information” .....

Designation and contents of the tabs used for configuration of interface converters

The tab "Information"

The tab "Information" contains information of the parameters specified in Table 4.1.

Table 4.1 Parameters of the "Information" tab

Parameter	Possibility of configuration	Admissible values	Description
Digital measurement module	–	ZET 7176	–
Serial number	–	–	The parameter is displayed in hexadecimal format (the serial number is assigned by manufacturer).
Date of software	–	–	Data of interface converter’s firmware

version			version.
Change of configuration	–	–	Date of the last change of interface converter configuration.
Address (node)	–	1	Interface converter address in the measuring network.

Fig. 4.2 shows an example of "Information" tab

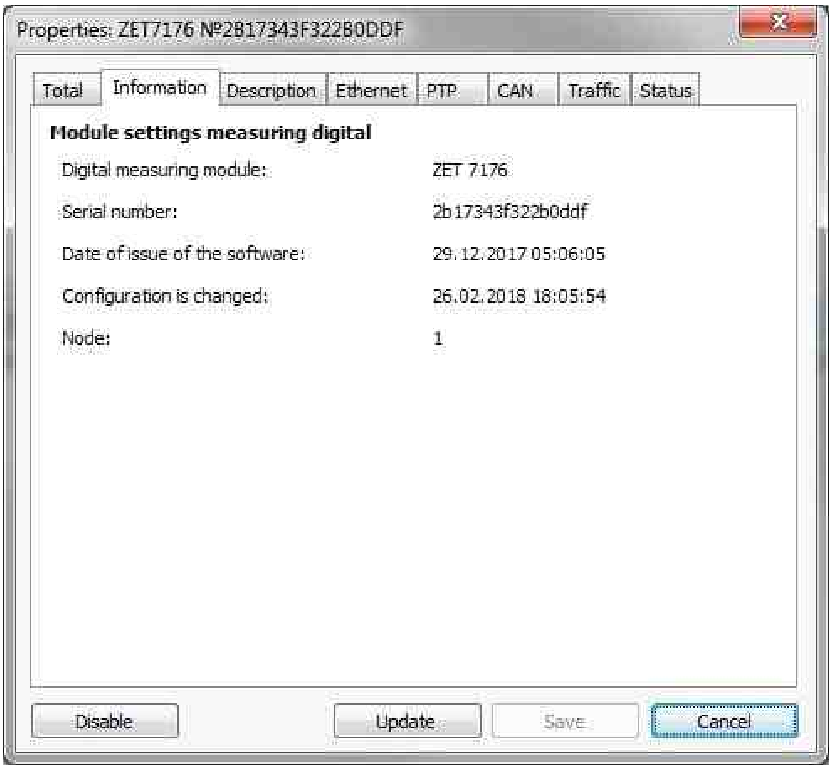


Fig. 4.2 "Information" tab

The tab «Ethernet» .....

The tab "Ethernet" contains information of the parameters specified in Table 4.2.

Parameter	Possibility of configuration	Admissible values	Description
Address IPv4	Yes	–	IP-address of the interface converter.

Subnet mask	Yes	–	Subnet mask of the interface converter.
Gateway by default	Yes	–	IP-address of the gateway in the local subnet.
TCP/IP port	Yes	1…64000	Number of the port used for the connection to interface converter.
Physical address of the device in Ethernet network	–	–	MAC-address of the device.

Fig. 4.3 shows an example of the "Ethernet" tab.

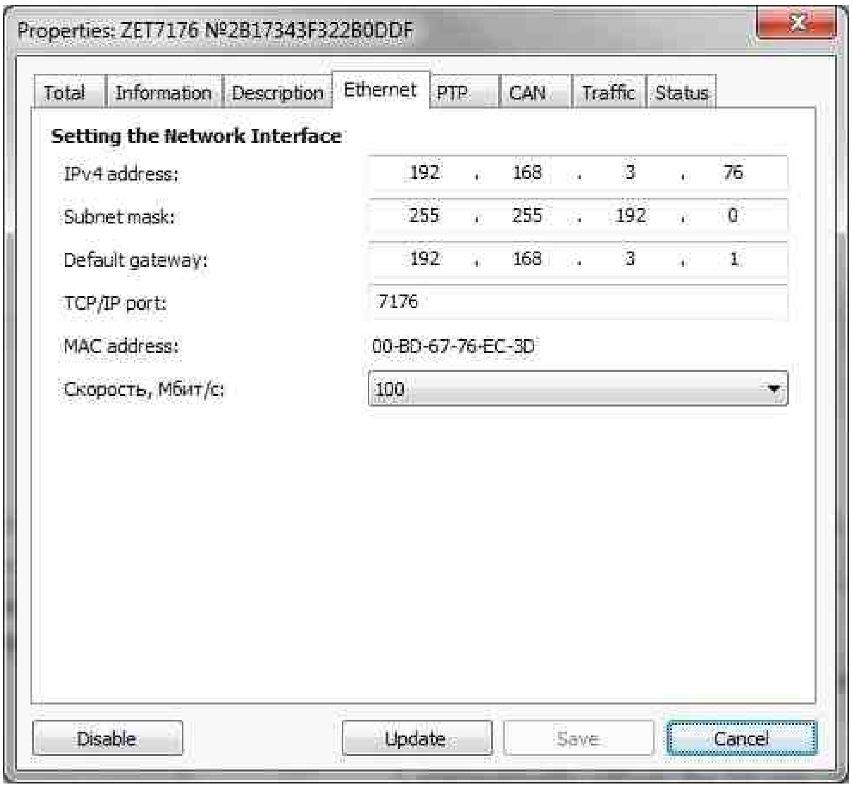


Fig. 4.3 "Ethernet" tab

The tab «PTP» .....

The tab "PTP" contains information of the parameters specified in Table 4.3.

Table 4.3 Parameters of the "PTP" tab

Parameter	Possibility of configuration	Admissible values	Description
Network level	No	–	The parameter displays the network protocol of interface converter connection to PC.
Master clock mode	Yes	Deny / Allow	Allows the interface converter to operate as master clock for other devices.
Slave clock mode	Yes	Deny / Allow	Allows the interface converter to operate as slave clock in the case if the Ethernet network has a master clock.
Domain number 0ч127	Yes	0…127	Master clock and slave clock interact with each other only in the case if they are in the same domain.
Absolute priority 0 ч 255	Yes	0…255	The value is used for selection from several master clocks. The more is the value, the higher is the priority.
Relative priority 0 ч 255	Yes	0…255	The value is taken into consideration if it is necessary to select from several master clocks with the same absolute priority and clock parameters. The lower is the value, the higher is the priority.

Fig. 4.4 shows an example of the "PTP" tab.

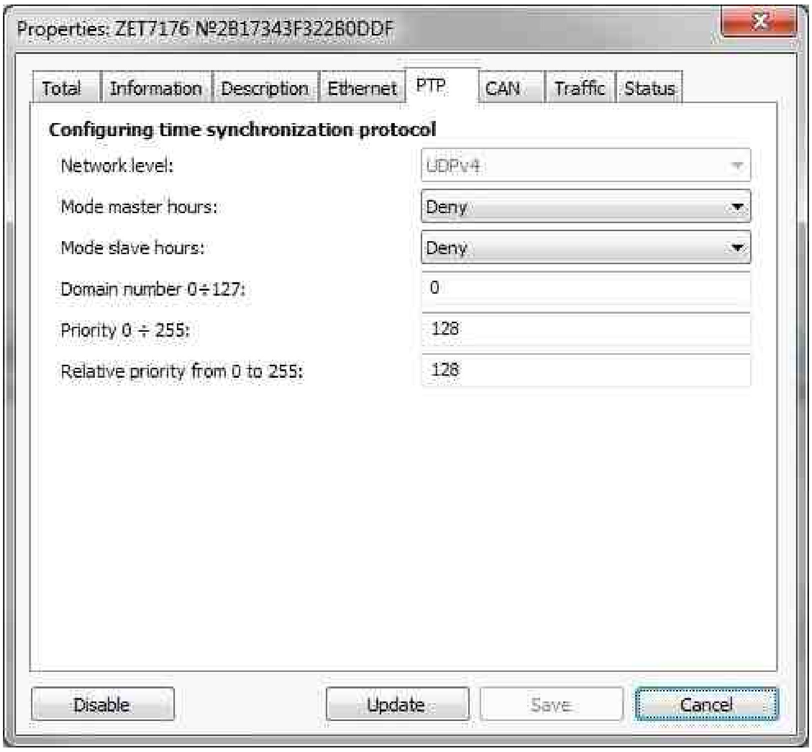


Fig. 4.4 "PTP" tab

The tab «Connection» .....

In the interface converter, it is possible to activate the data transfer mode, in which the module does not wait for connection from the PC, but, on the contrary, it tries to connect to the selected server in the local or global network. In this mode, the main focus is on the continuity of data transmission and saving traffic, so it is suitable for situations where data transmission over the Internet or just continuous data acquisition is required. In this mode of data transmission, in order to ensure security, there is no possibility of changing the settings, so you should make the necessary settings in advance.

The Connection tab contains information about the parameters given in Table 4.5.

Table 4.5 Parameters of the "Connection" tab

Parameter	Possibility of change	Acceptable values	Description
Connection to the server	Yes	Forbidden Allowed	Enable/disable the connection mode of the interface converter to the server in the local network.
Name of the server to connect to	Yes	–	The name of the server on the network to which the interface converter should

			connect.
TCP port number for connection	Yes	80…64000	The TCP port number of the server through which the interface converter connection is available.
Current status	No	Not connected Connection Connected Data transmission Time error Node 2 address No data available Traffic exceeded	Current connection status: • Not connected – connection is prohibited by the settings; • Connection – an attempt to connect to the server; • Connected – connection is made, but data transfer is not activated on the server side; • Data transfer – data is being transferred to the connected server, it can be suspended if any problem is detected; • Time error – transmission is suspended because the time is not set (for example, from a PC or via GPS): you need to connect to the converter in normal mode or use an external time source (for example, GPS via ZET 7175); • Node 2 address – transmission is suspended because a node with address 2 is detected in the CAN line (it is assumed that this is a module with reset settings): you need to change the node address to 3 or higher; • No data – transmission is suspended because there is no data from other sensors in the CAN line: you need to add sensors and check the quality of the line itself; • Traffic exceeded – transmission is suspended because the CAN line is overloaded: it is necessary to reduce the frequency of data output in the sensors or increase (if possible) can speed.
Number of connections	No	–	The number of connections of the interface converter to the server.
Last connection time	No	–	The time of the last connection of the interface converter to the server.

Transfer rate, kbps	No	–	Current data transfer rate to the server
Transmitted from the last connection, bytes	No		The amount of data transferred from the interface converter to the server since the last connection..
Total transmitted, bytes	No	–	The total amount of data transferred from the interface converter to the server.

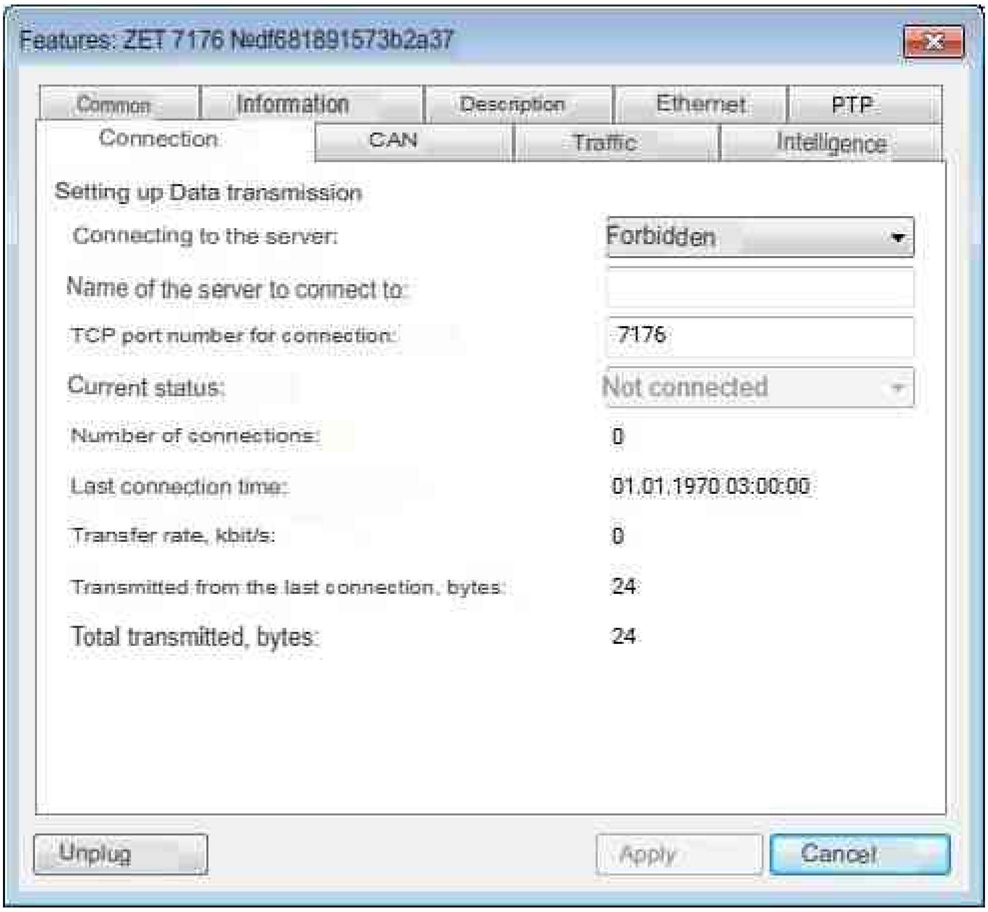


Fig. 4.9 shows an example of the "Connection" tab.

The tab «CAN» .....

The tab "CAN" contains information about the parameters specified in Table 4.4.

Table 4.4 Parameters of the "CAN" tab

Parameter	Possibility of configuration	Admissible values	Description
Bit rate, kbps	Yes	100 300 1000	Data bit rate between the digital transducer and interface converter. As the bit rate is changed, the system automatically adjusts the bit rate of the digital transducers connected to the interface converter.
Current time	–	–	Displays the current time of the device at the moment of tab activation.
Time delay of master clock, ns	–	–	The current measured value of the integrated clock delay in relation to the master clock (in the case if the interface converter operates in slave clock mode via CAN interface)
Sync status	–	Master clock	Current status of time synchronization via CAN interface.

Fig. 4.5 shows an example of "CAN" tab.

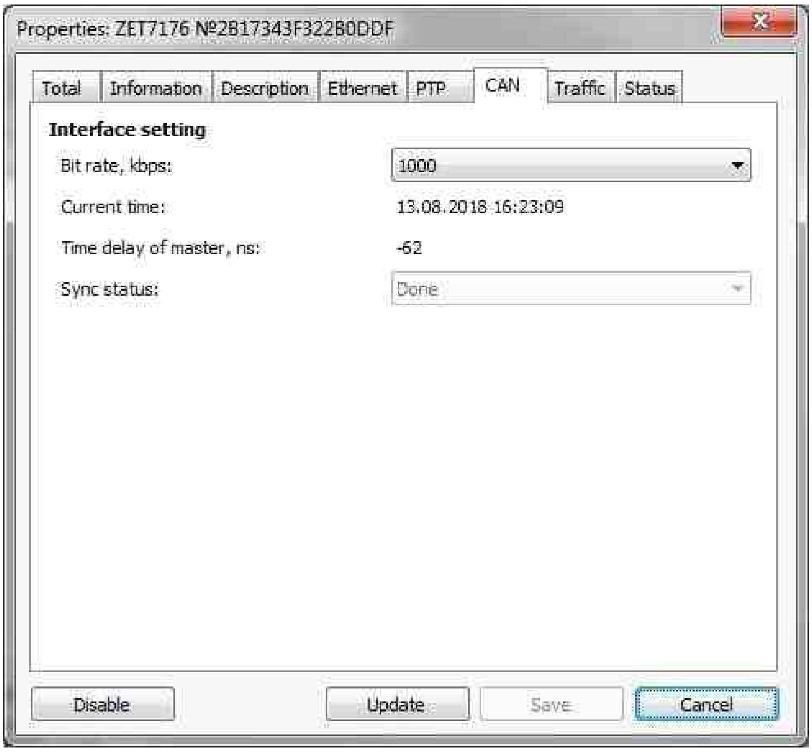


Fig. 4.5 "CAN" tab

The tab «Traffic» .....

The tab "Traffic" contains information of the parameters specified in Table 4.5.

Table 4.5 Parameters of the "Traffic" tab

Parameter	Possibility of configuration	Admissible values	Description
CAN bus load, %	–	0-100	The parameter displays percentage rate of CAN line current load. For normal operation of the CAN line, the CAN bus load should not exceed 90%.
CAN packages per second	–	–	The parameter displays the number of measuring line CAN packages per second.
Total throughput, kbps	–	–	The parameter displays total speed of CAN packets transfer in the measuring line.

Data throughput, kbps	–	–	The parameter displays data stream transfer speed of the CAN line.
Active addresses on bus	–	–	The parameter displays the number of active addresses of the CAN line.
List of active addresses	–	–	The parameter displays addresses numbers (nodes) of active digital transducers in CAN line.

Fig. 4.6 shows an example of "Traffic" tab

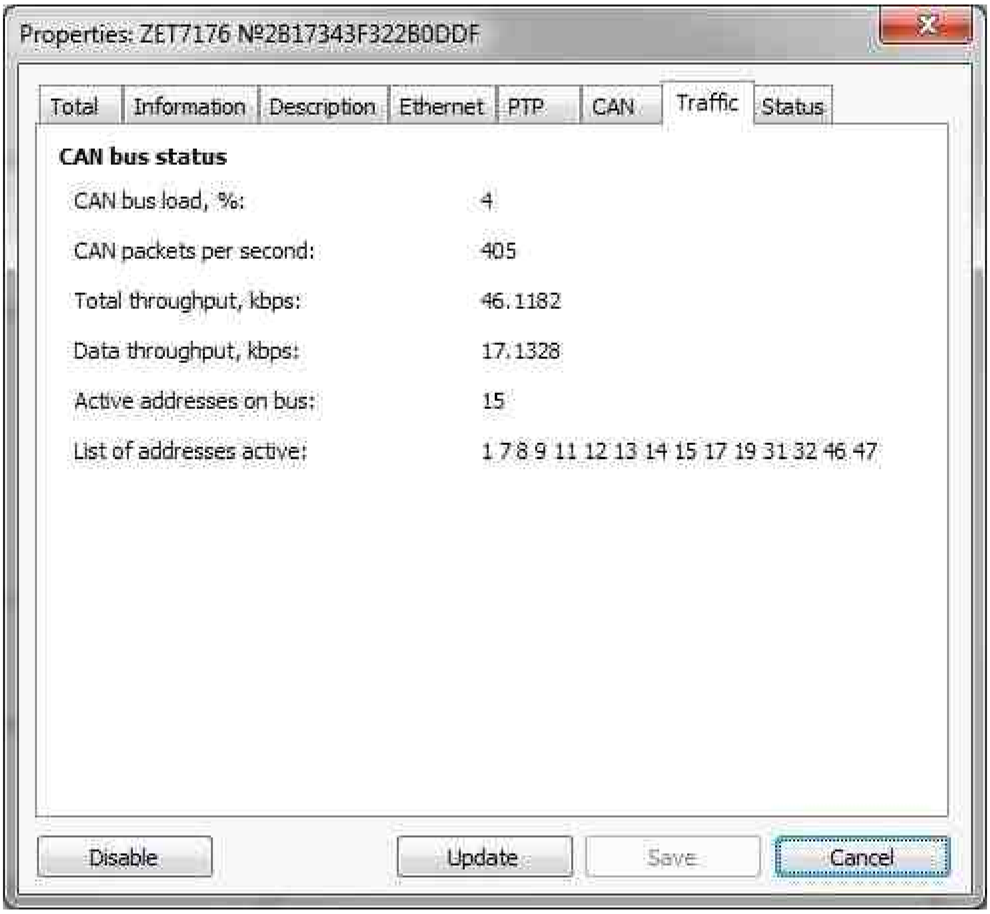


Fig. 4.6 "Traffic" tab

The tab «Status» .....

The "Status" tab contains information of the parameters specified in Table 4.6.

Table 4.6 Parameters of the "Status" tab

Parameter	Possibility of configuration	Admissible values	Description
PTP sensor status	–	Initialization Disabled Waiting Master clock Passive Slave clock	Current status of PTP sensor: • Initialization – activation of the PTP sensor; • Disabled –PTP is switched off in the settings; • Waiting –PTP is in the slave clock mode and is waiting for synchronization wizard (master clock; • Master clock – PTP operating in master clock mode (sets the time); • Passive –PTP in slave clock mode, but the network already has a synchronization wizard with higher priority; • Slave clock – the module operates in slave clock mode.
Current time	–	–	Current time of PTP module
Time delay master-slave	–	–	Calculated time difference between the internal clock of the module and the master clock (in the case if the module operates in slave mode). If the value is more than 0, it means that the system clock are ahead of master clock, and vice versa.
Synch status	–	Missing In progress Complete	Current status of the synchronization is displayed in slave clock mode: • Missing – synchronization process is disabled, since the device is not operating in the slave clock mode; • In progress – time synchronization is in progress; • Complete – synchronization is

		Via CAN	complete (smooth synchronization mode); • Via CAN – the module is synchronized via CAN bus (e.g., with the use of GPS synchronization module ZET 7175), the PTP protocol is not used.
Average network time delay, ns	–	–	Calculated time of package route from module up to synchronization wizard via Ethernet network (including all switching devices). The parameter is calculated only in slave clock mode.

Fig. 4.7 shows an example of "Status" tab.

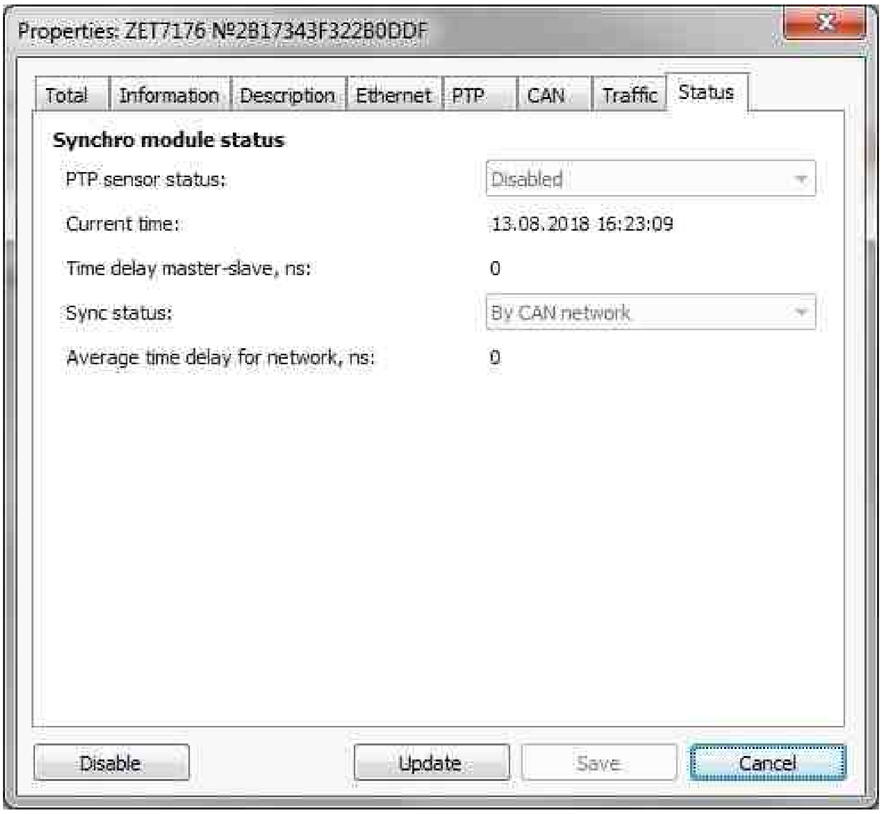
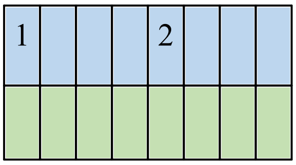
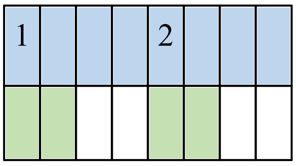
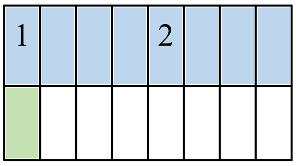
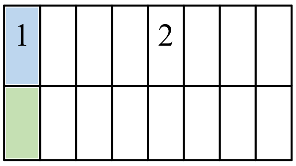


Fig. 4.7 "Status" tab

LED indication: operation modes .....

In .Table. 5.1 contains information about the operating modes of the LED indication located on the top panel of the digital sensor housing. Depending on the combined operating modes of the blue and green LEDs, it is possible to monitor the status of the device and diagnose malfunctions.

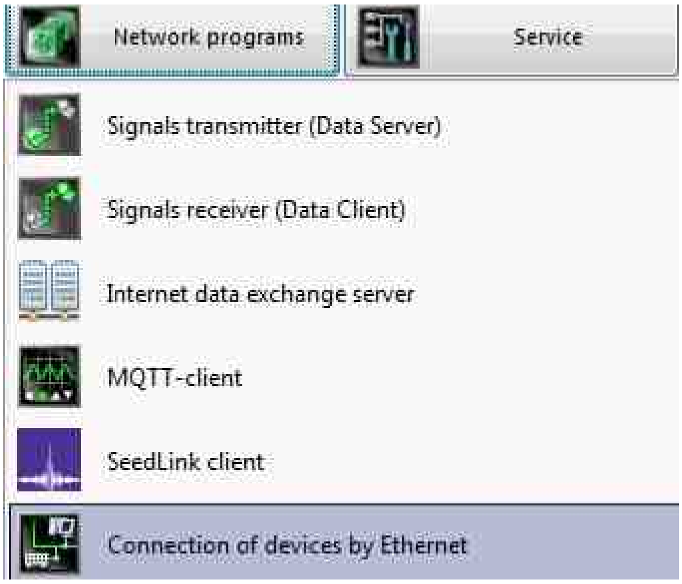
Table 5.1 LED indication status

Indication status	Indication during 2 seconds	Discription of LED indication operation mode
Selection of a device of data saving		Blue – constant indication Green – constant indication
Error (lost connection or defect of the transducer)		Blue – constant indication Green – indication 500 ms per 1 second
Setting by default (address 2)		Blue – constant indication Green – indication 100 ms per 2 seconds
Normal operation mode		Blue – indication 100 ms per 2 seconds Green – indication 100 ms per 2 seconds

Connection of VCS controller to PC by Ethernet .....

The program **Connection of devices by Ethernet** is available in the **Network programs** menu of ZETLAB software.

Note: the **ZETLab** program (default: c: \ ZETLab \). The name of the startup file: NetWizardNew or NetWizard.exe



Starting the "Connection of devices by Ethernet"

Note: The window of the "Connecting Ethernet devices" program has two types: "connecting by IP addresses" and "new interface". To change the window view, you need to open a drop-down menu in the window name area and activate "Switch to a new interface" or "Connection by IP addresses" depending on the transition

Connection of controllers of the ZET 02x, ZET 03x and ZET05x series to the computer .....

1. Connection sequence

During the first connection of the VCS controller to PC, it is necessary to set Ethernet ports of the controller and PC, so that their network masks and IP-addresses would correspond to a single subnetwork. In order to do that, you can set IP-address of Ethernet port of the PC to the subnetwork of the VCS controller port, or vice versa.

Note: *You can check IP-address of the VCS controller using the instructions specified in section 4.1.3.*

Attention! *The connection of the computer to the controllers involved in working with the UH must be organized in an isolated local network via physical wired cable connections*

(UTP twisted pair). The use of wireless connections (using WiFi, WiMAX, etc.) is not allowed.

In the case, if you need to set the IP-address of Ethernet port of the PC to the subnetwork of the VCS controller, follow the instructions specified in section 4.4.

In the case, if you need to set the IP-address of VCS controller Ethernet port to the subnetwork of the PC, follow the instructions specified in section 4.4 to Reset. the initial IP-address of the PC to the subnetwork of the VCS controller, then follow the instructions specified in section 4.5 to Reset. the IP-address of VCS controller to the initial subnetwork of the PC, then restore the value of the PC port IP-address to the initial one.

When the IP-addresses of Ethernet ports of PC and VCS controller are located in the same subnetwork, activate Ethernet channel of the VCS controller. After that the VCS controller will be ready for use.

Note: *If you use several VCS controllers, it is necessary to use Ethernet switch to have the required number of Ethernet ports for connection. The connected ports of VCS controller and PC should belong to the same subnetwork, and there should be no identical IP-addresses.*

2. *Factory setting of the IP address*

The factory setting for the controller is the IP address - 192.168.0.100 with a subnet mask of 255.255.255.0.

Pressing and holding the "Reset" button on the back of the controller for at least 10 seconds will reset the IP address of the controller to the factory setting.

3. *Checking the IP address of the controller*

To check the IP address of the controller on the ZETLAB panel in the "Network programs" menu, activate the "Connecting devices via Ethernet" program and the program window will open (Fig. 4.1).

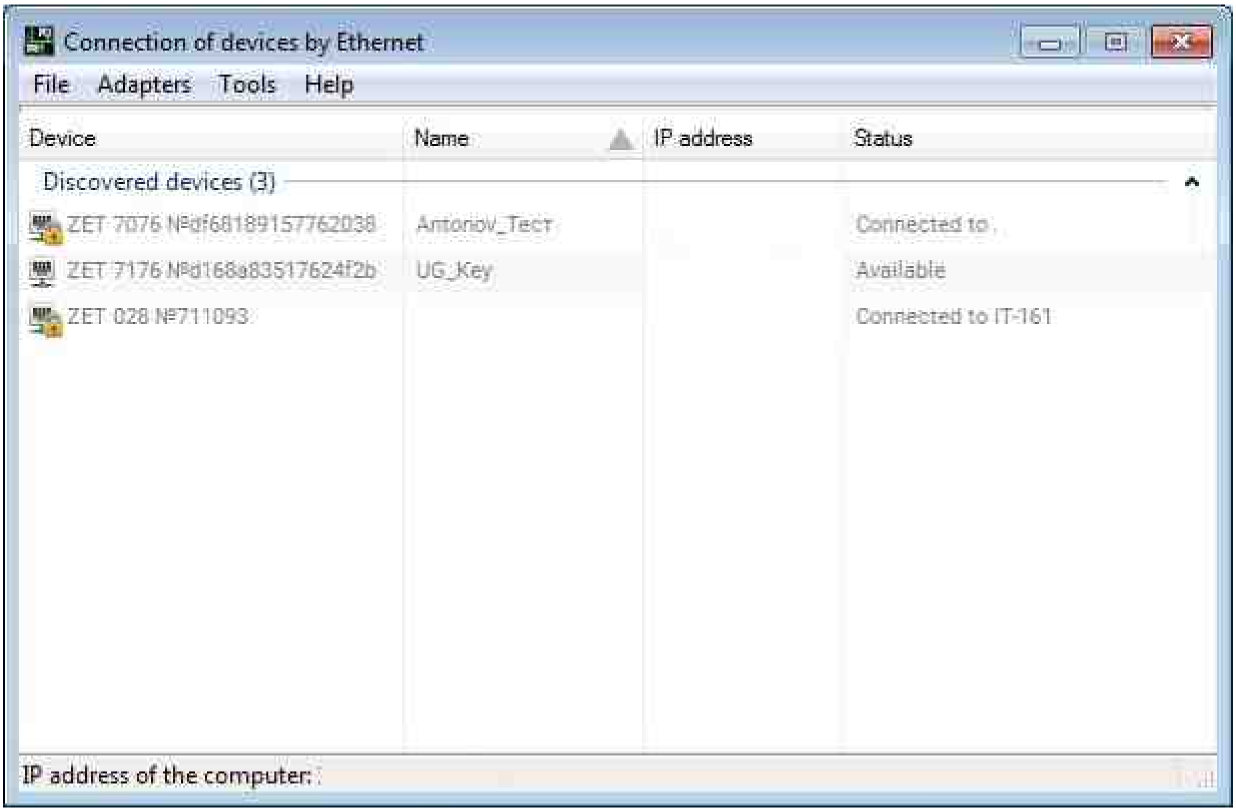


Fig. 4.1 The "Connecting devices via Ethernet" window

If there are several network adapters in the computer to which the controller is connected, then through the "Adapters" menu you can select a specific network adapter to which the controller is connected (*Fig 4.2*).

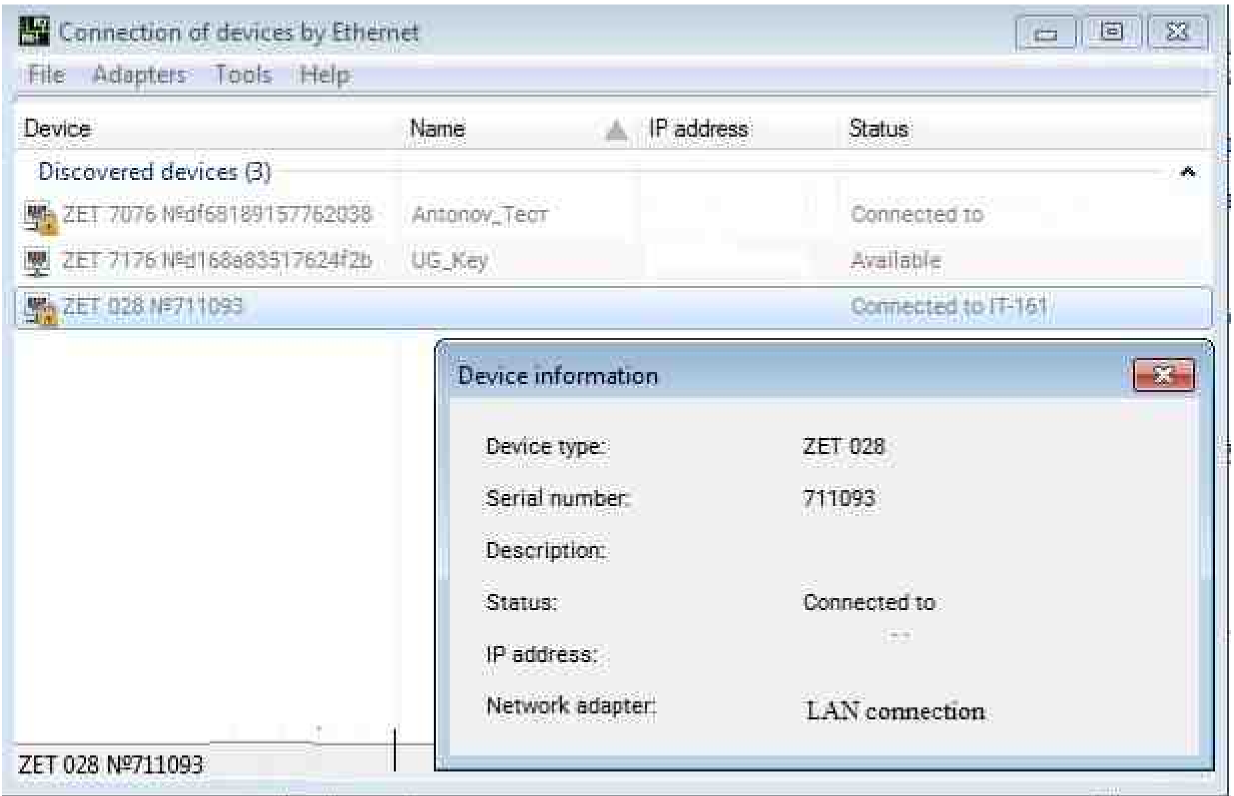


Fig. 4.2 Viewing the IP address of the controller

4. Setting the IP address of the controller

To view the current IP address of the controller, hover the mouse cursor over the name of the controller and read the value of the IP address of the controller (*Fig. 4.3*).

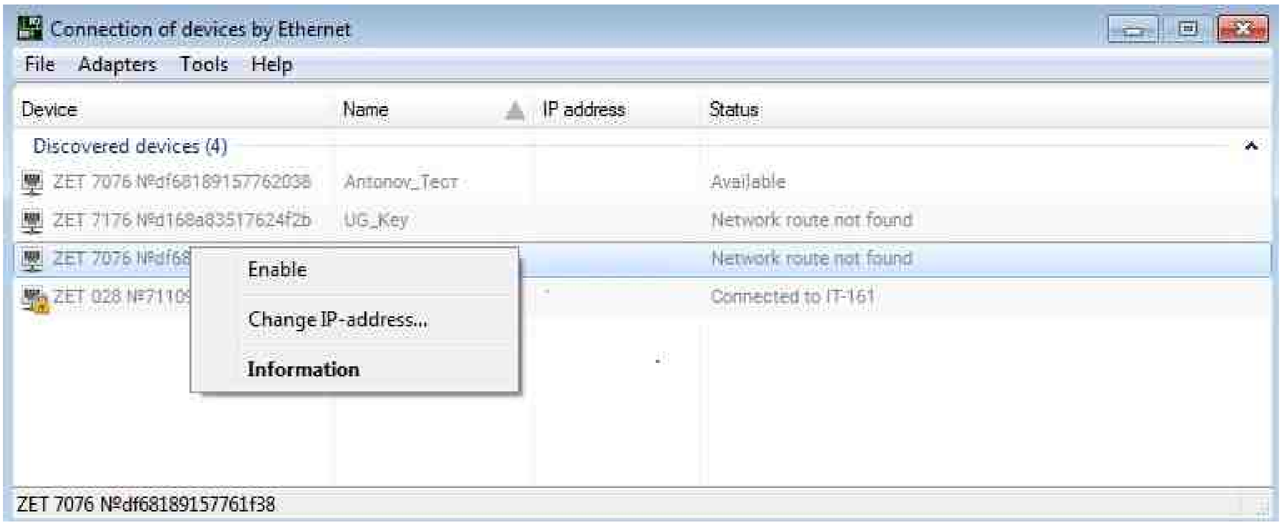


Fig. 4.3 Viewing the IP address of the controller

In the "Change IP address" window that opens, in the "New IP address" line, set the new network address and subnet mask of the controller, and then activate the "Ok" button (*Fig. 4.4*).

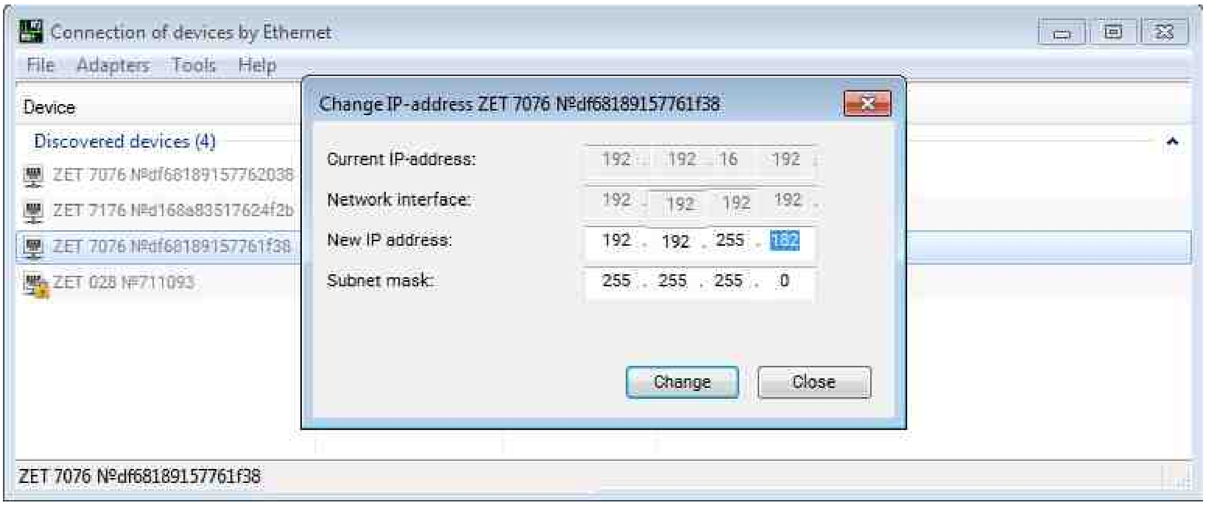


Fig. 4.4 Change IP address

5. Setting the IP address of the controller

To set the IP address of the Ethernet port of the computer, open the "Network Connections" window from the Windows operating system programs and double-click the icon corresponding to the

Ethernet network port set on the computer, and the "Status-Ethernet" window opens (*Fig. 4.5*) the selected port.

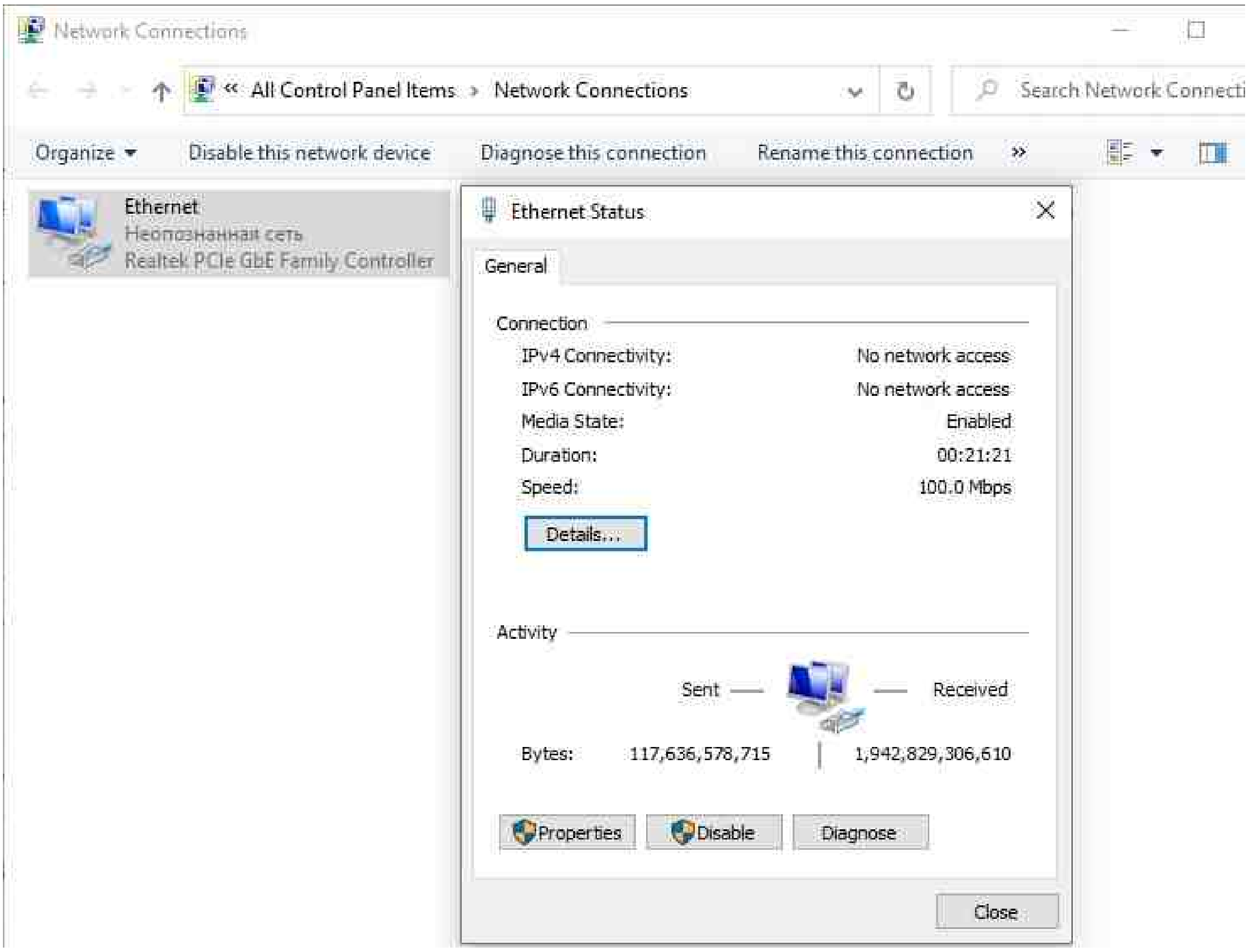


Fig. 4.5 The "Ethernet Status" window

In the "Status-Ethernet" window, activate the "Properties" panel and in the "Ethernet Properties" window that opens (Fig. 4.6), "highlighting" the line "IP version 4(TCP/IPv4)" (as shown in the Fig.) activate the "Properties" panel.

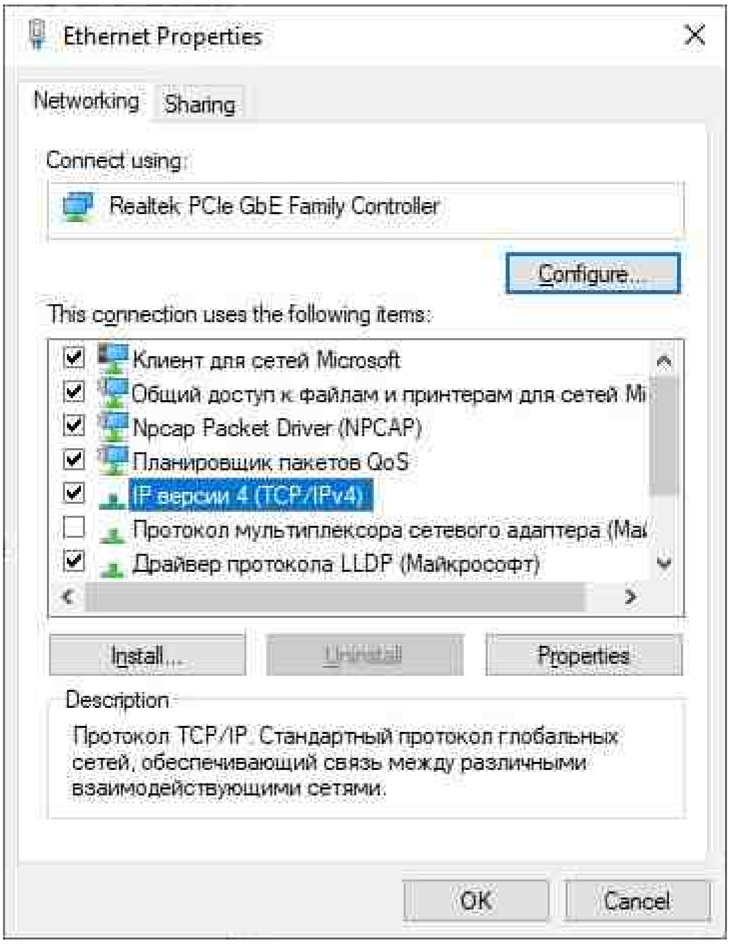


Fig. 4.6 Window "Properties"

In the "Status-Ethernet" window, activate the "Properties" panel and in the "Ethernet Properties" window that opens(*Fig. 4.7*) , "highlighting" the line "IP version 4(TCP/IPv4)" (as shown in the Fig.) activate the "Properties" panel.

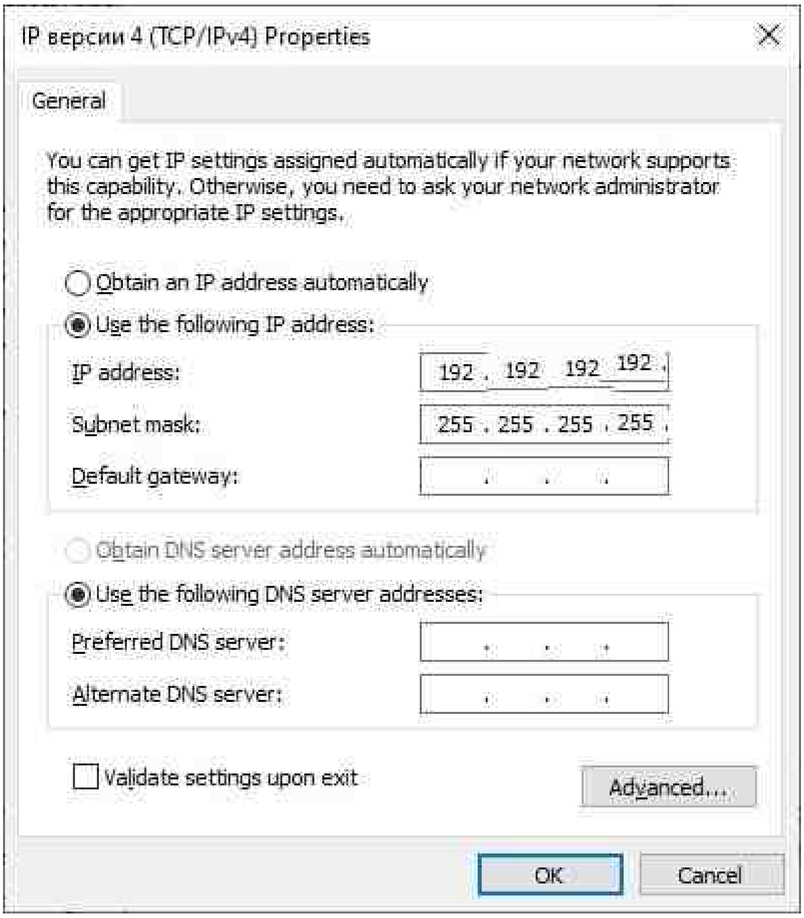


Fig. 4.7 "Properties" window: IP version 4 (TCP/IPv4)"

Note: *Controllers use the mask "255.255.255.0" by default, which defines a class C subnet (in the example, the network address is 192.168.0.xxx, where xxx is the IP addresses of nodes in the range from 1 to 254 (in this example, the controller port 100 and the computer port 29).*

6. Activating an Ethernet connection

To activate an Ethernet connection, it is necessary that the IP addresses of the Ethernet ports of the controller and the computer belong to a single subnet. If necessary, Reset the IP address of the controller or computer port, according to the sections 4.1.4 or 4.1.5.

To connect the controller to the computer, in the "Connecting devices via Ethernet" program, right-click on the name of the controller to open the context menu and select the "Activate" function (*Fig. 4.8*).

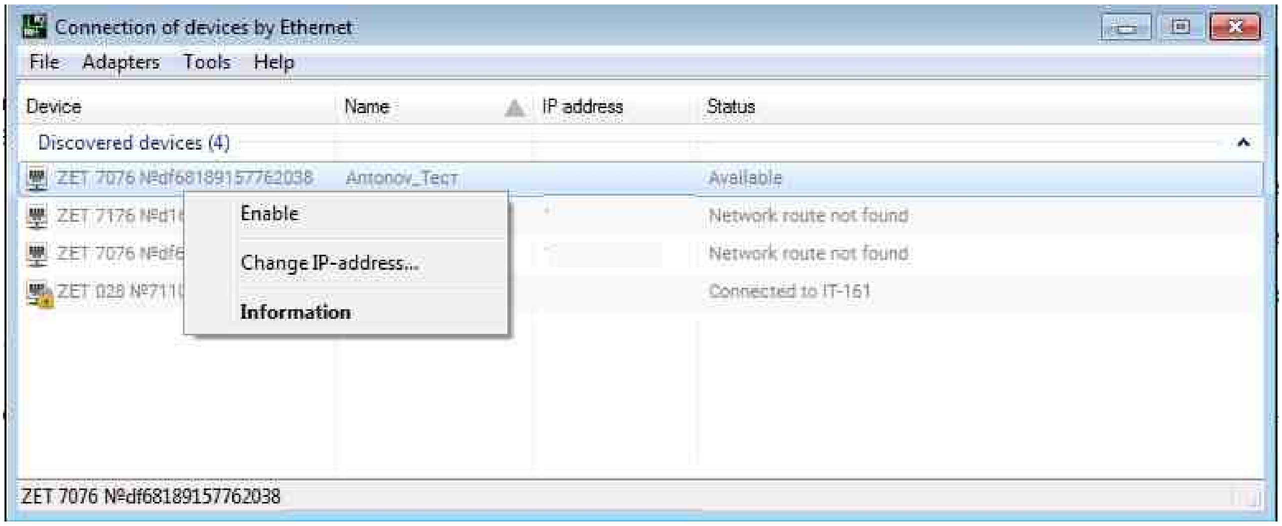


Fig 4.8 Activating the controller

In the "Connecting devices via Ethernet" window, make sure that the status of the involved controller has changed to "Device connected" (*Fig. 4.9*).

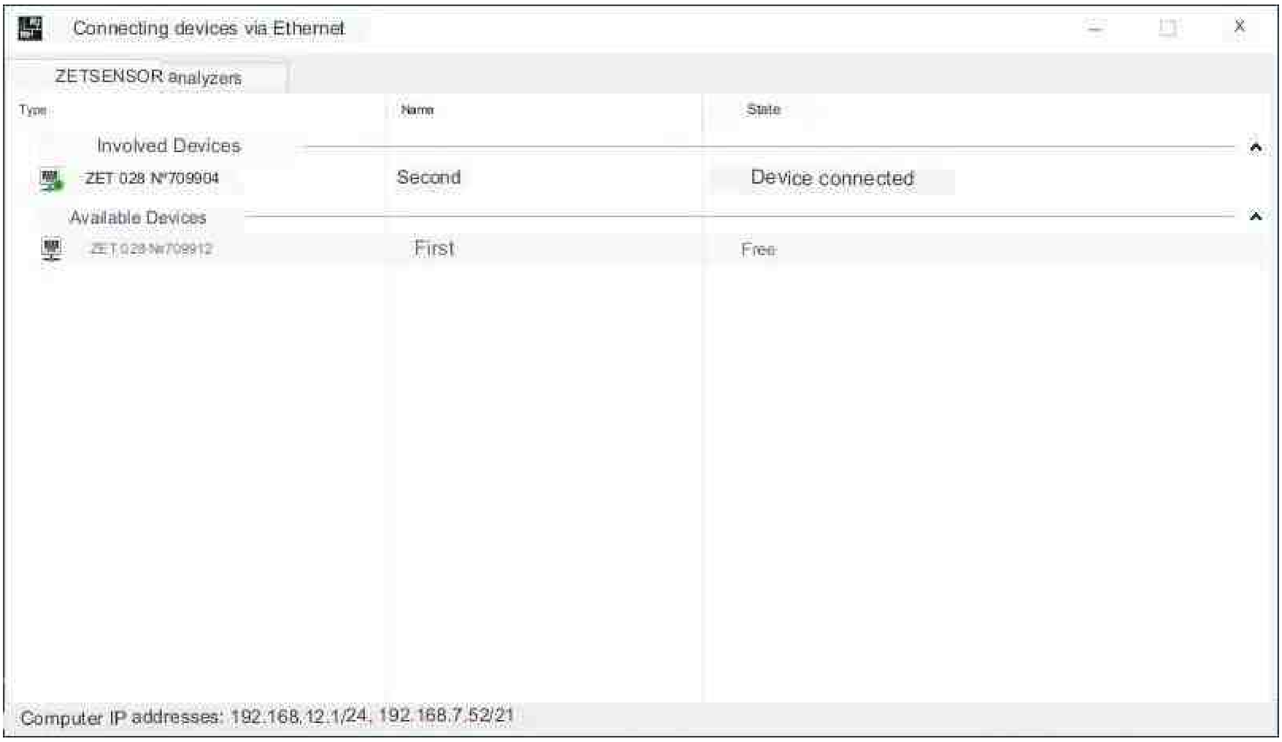


Fig. 4.9 The "Device is connected" status

Connection of ZET 017, A19 series controllers .....

1. Connection sequence

During the first connection of the VCS controller to PC, it is necessary to set Ethernet ports of the controller and PC, so that their network masks and IP-addresses would correspond to a single

subnetwork. In order to do that, you can set IP-address of Ethernet port of the PC to the subnetwork of the VCS controller port, or vice versa.

Note: *You can check IP-address of the VCS controller using the instructions specified in section 4.1.3.*

Attention! *The connection of the computer to the controllers involved in working with the UH must be organized in an isolated local network via physical wired cable connections (UTP twisted pair). The use of wireless connections (using WiFi, WiMAX, etc.) is not allowed.*

In the case, if you need to set the IP-address of Ethernet port of the PC to the subnetwork of the VCS controller, follow the instructions specified in section 4.4.

In the case, if you need to set the IP-address of VCS controller Ethernet port to the subnetwork of the PC, follow the instructions specified in section 4.4 to Reset. the initial IP-address of the PC to the subnetwork of the VCS controller, then follow the instructions specified in section 4.5 to Reset. the IP-address of VCS controller to the initial subnetwork of the PC, then restore the value of the PC port IP-address to the initial one.

When the IP-addresses of Ethernet ports of PC and VCS controller are located in the same subnetwork, activate Ethernet channel of the VCS controller. After that the VCS controller will be ready for use.

Note: *If you use several VCS controllers, it is necessary to use Ethernet switch to have the required number of Ethernet ports for connection. The connected ports of VCS controller and PC should belong to the same subnetwork, and there should be no identical IP-addresses.*

2. Factory setting of the IP address

The factory setting for the controller is the IP address - 192.168.0.100 with a subnet mask of 255.255.255.0.

Pressing and holding the "Reset" button on the back of the controller for at least 10 seconds will reset the IP address of the controller to the factory setting.

3. Checking the IP address of the controller

To check (clarify) the IP address installed in the VCS controller, it is not required that the IP addresses of the Ethernet ports of the VCS controller and the computer belong to a single subnet.

To check the IP address of the VCS controller on the ZETLAB panel in the "Network programs" menu, activate the "Connecting devices via Ethernet" program and the program window will open (*Fig. 4.10*).

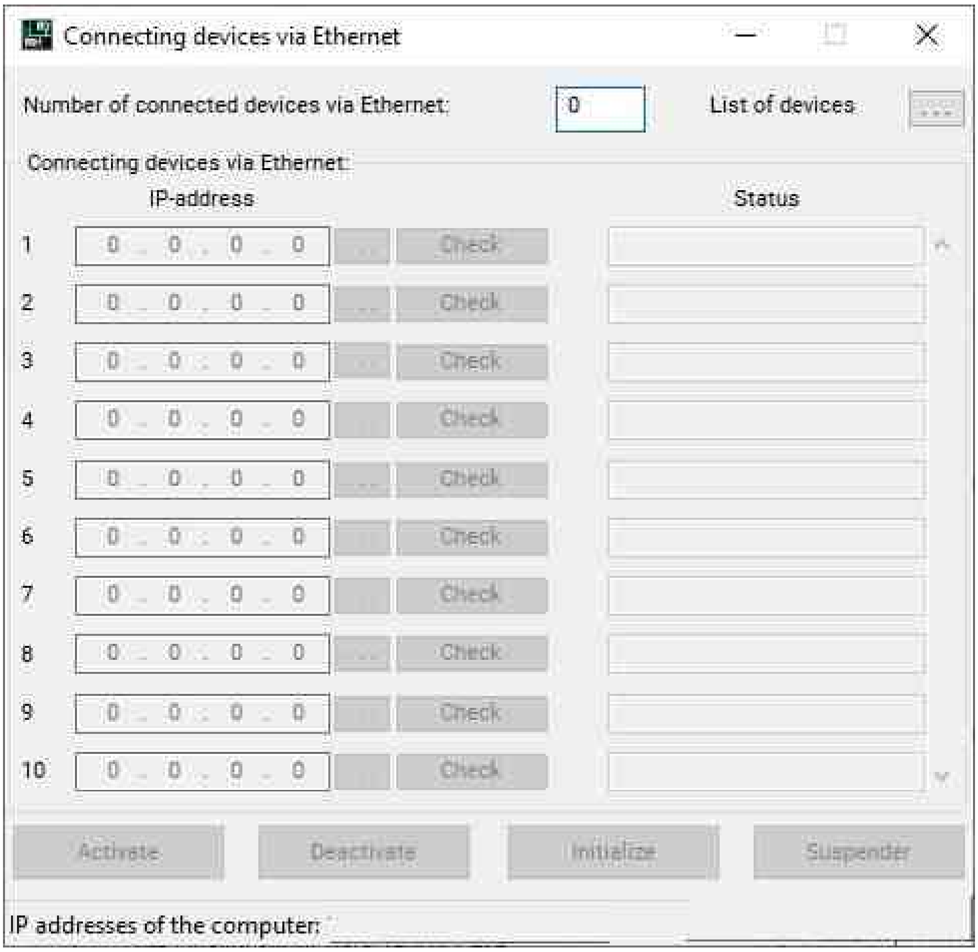


Fig. 4.10 " Connecting devices via Ethernet "

Click the key "..." (List of devices). In the window "List of available devices" (*Fig. 4.11*), you will see the IP-address of the VCS controller.

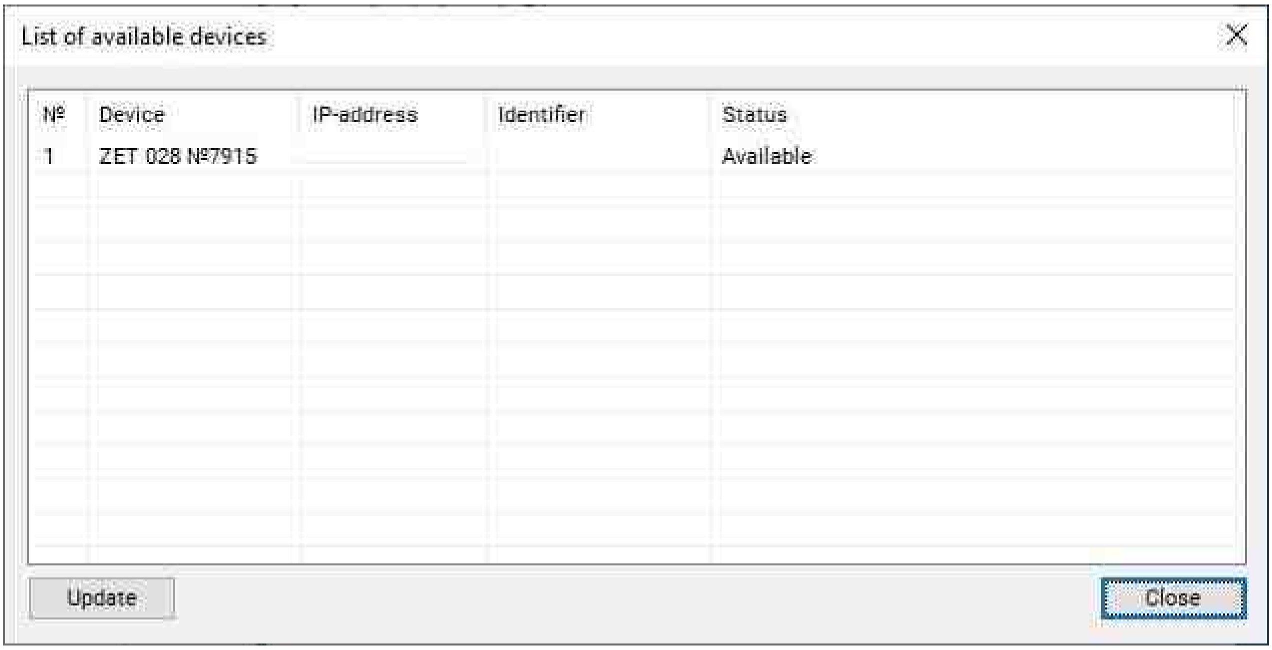


Fig. 4.11 "List of available devices"

4. Setting the IP address of the controller

In order to set the IP-address of the PC port, go to "Network connections" (*Fig. 4.12*) and double-click the icon corresponding to the relevant Ethernet port. You will see the window "Ethernet Status" (*Fig. 4.12*) of the selected port.

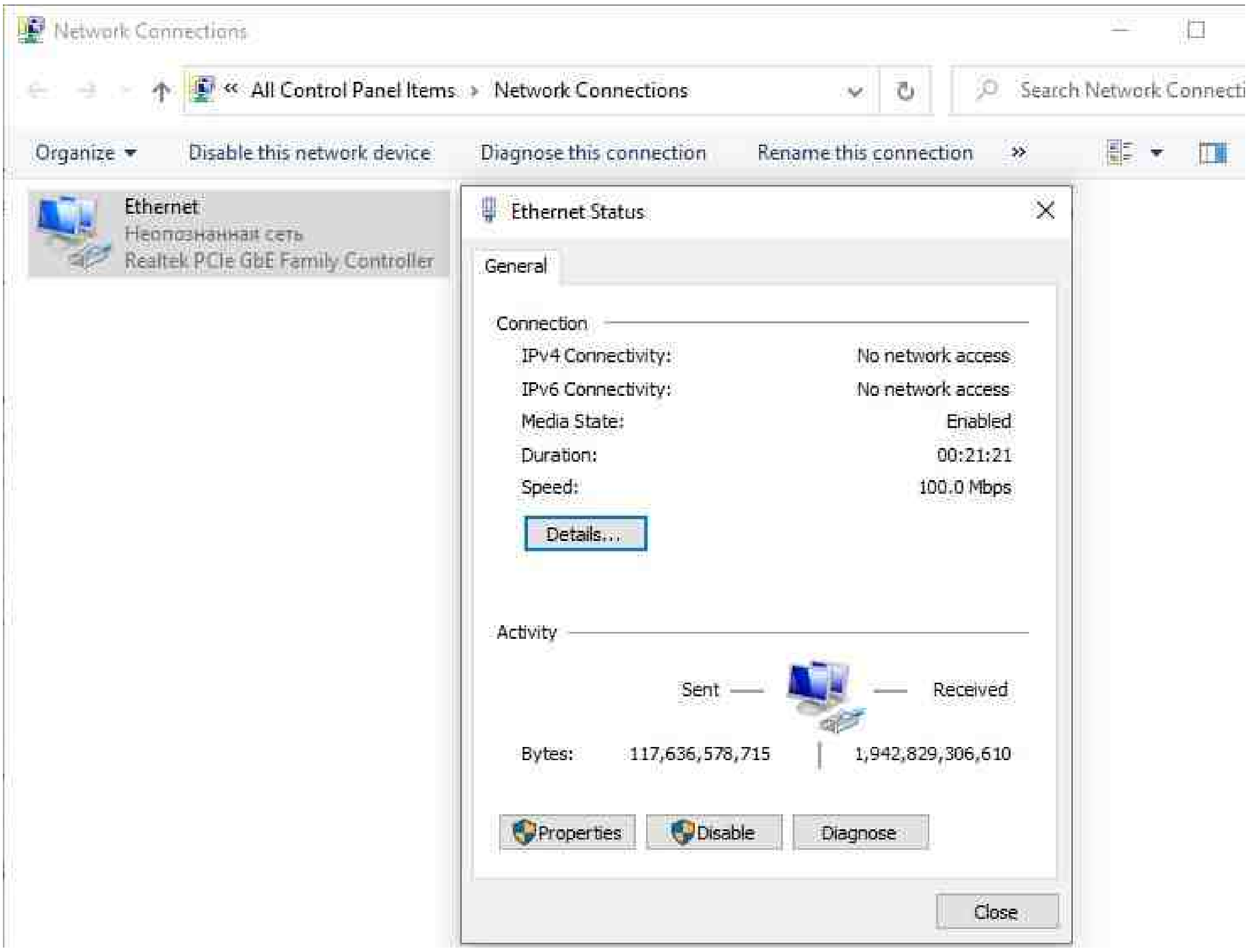


Fig. 4.12 "Status - Ethernet"

In the window " Ethernet Status " activate the panel *"Properties"*. In the window "Ethernet Properties" (Fig. 4.13) select the line "IP version 4(TCP/IPv4)" (as it is shown in the Fig.) and click the panel "Properties".

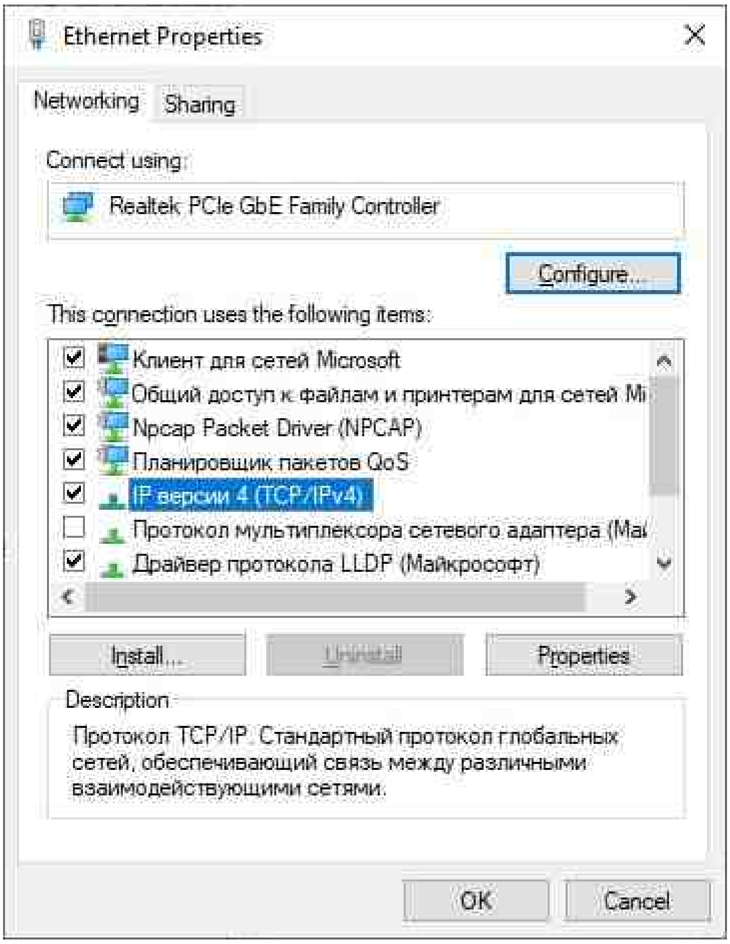


Fig. 4.13 "Properties"

In the window "IP version 4 (TCP/IPv4) Properties" assign IP-address and mask of Ethernet port of the PC (*Fig. 4.14*).

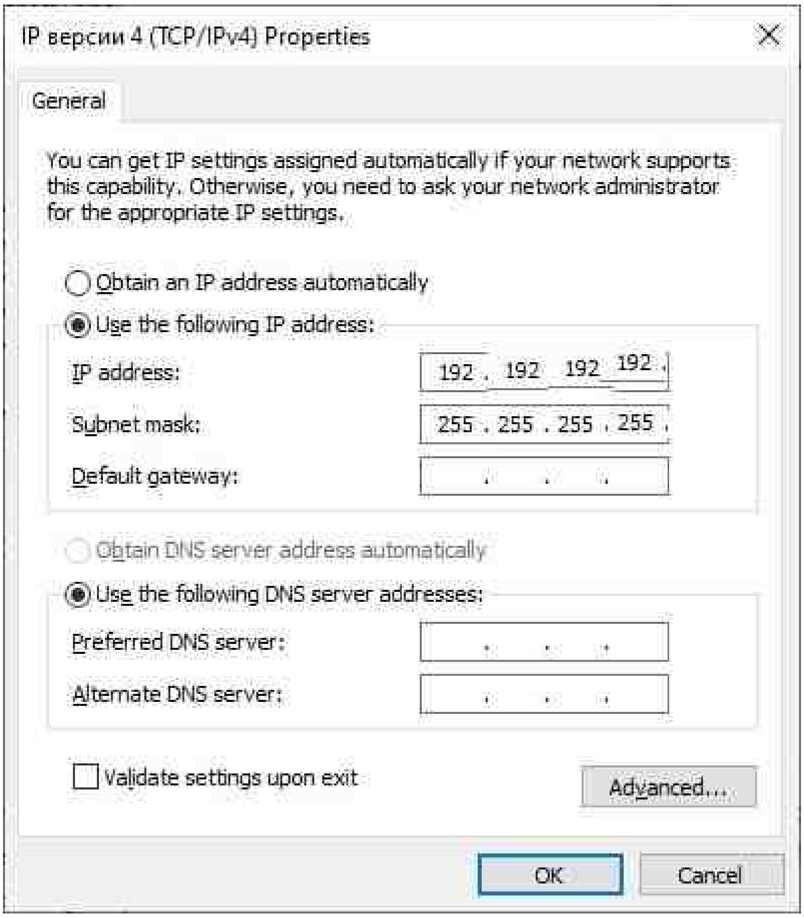


Fig. 4.14 "Properties: IP version 4 (TCP/IPv4)"

Note: *by default, VCS controllers use the mask "255.255.255.0", that corresponds to the sub-net of C-class (in this example, the IP-address is 192.168.12.xxx, where xxx stand for IP-addresses in the range from 1 up to 254 (in this example: 108 for controller port, and 10 for the PC port).*

5. Setting up the IP address of the controller

In order to set IP-address of the VCS controller, enable Ethernet channel of the VCS controller following the instructions specified in section 4.6.

As the connection to the VCS controller is established, enable the program, "Device Manager" in the "Service" section of ZETLAB panel (*Fig. 4.15*)

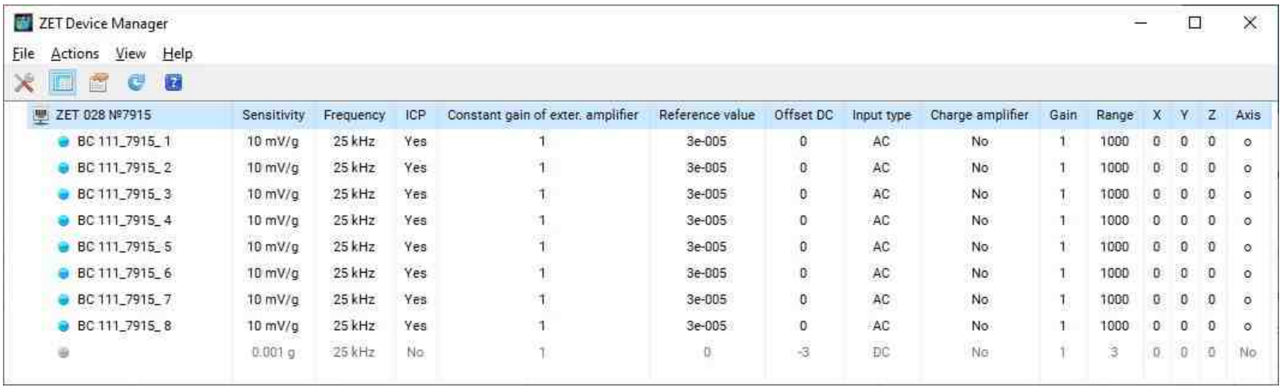


Fig. 4.15 "ZET Device Manager"

In the window of the program "ZET Device Manager" double-click the icon of the VCS controller. In the "Properties" window (*Fig. 4.16*) set the required IP-address and mask of VCS controller subnet (in this example: IP-address 192.168.12.108, mask 255.255.255.0).

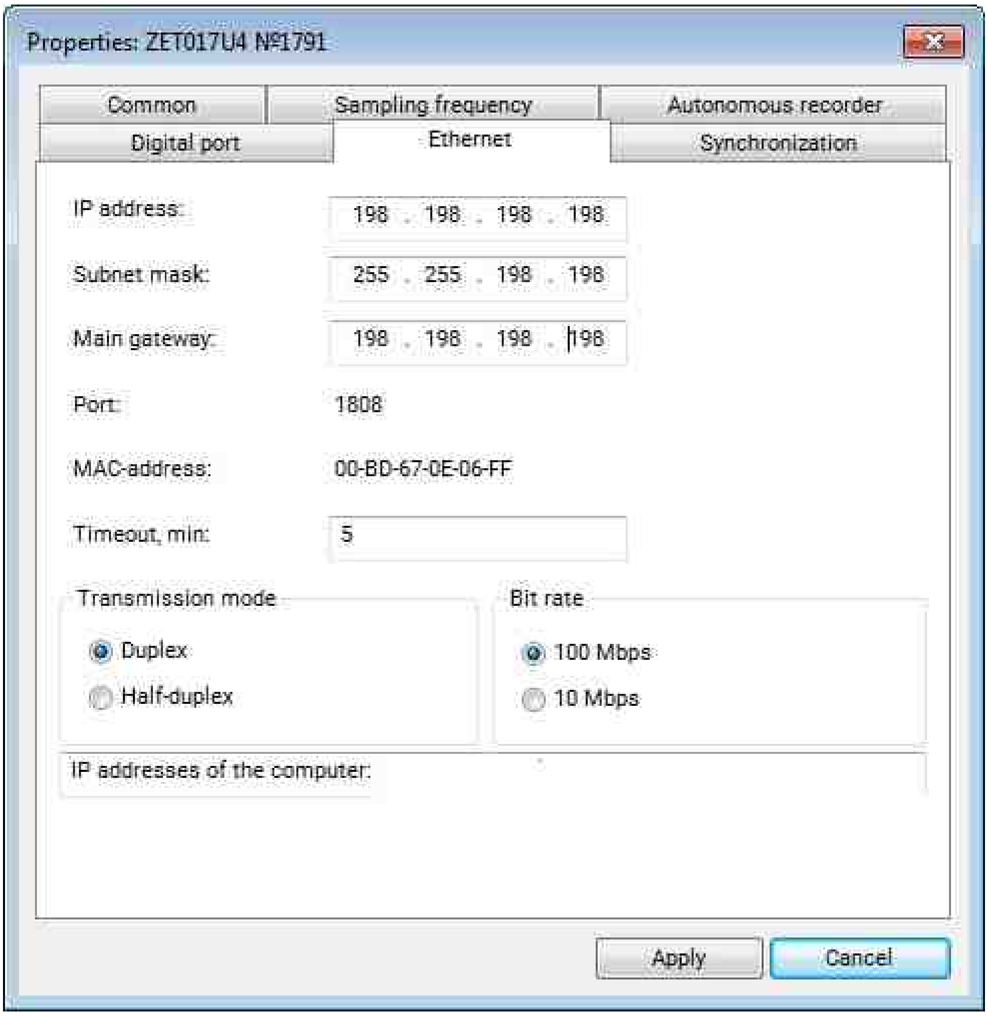


Fig. 4.16 "Ethernet" tab of the window "ZET properties"

Note! *As the IP-address of the controller is changed, its Ethernet channel will be disabled. For further activation, Reset. the IP-address of the PC following the instructions specified in section 4.4, so that it would correspond to the sub-net containing the IP-address of the VCS controller, then activate the Ethernet channel following the instructions specified in section 4.6*

6. Activation of VCS controller Ethernet channel

In order to activate Ethernet channel of VCS controller, make sure, that IP-addresses of VCS controller Ethernet ports and PC belong to the same subnetwork. If necessary, follow the instructions specified in section 4.2.4 to Reset. IP-address of PC Ethernet port to VCS controller subnetwork.

To enable Ethernet channel of VCS controller, go to "Network programs" of ZETLAB panel, and start the program "Connecting devices via Ethernet" (*Fig. 4.17*).

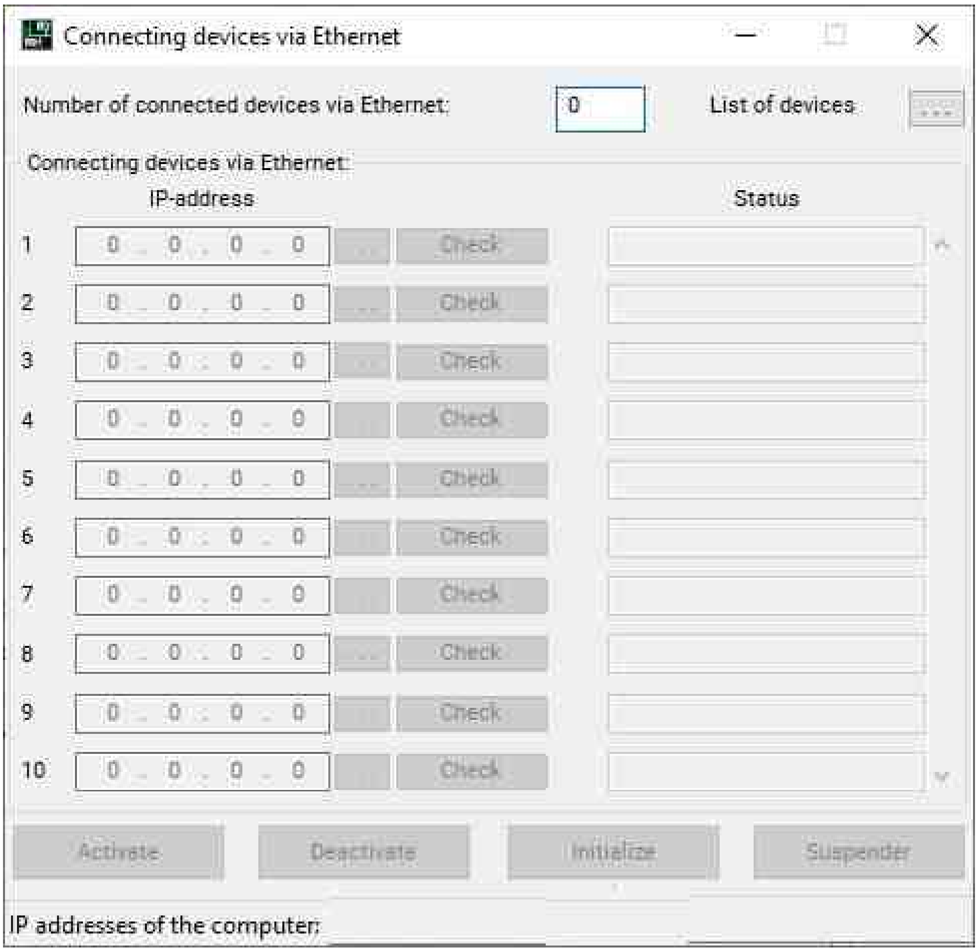


Fig. 4.17 "Connecting devices via Ethernet"

In the field "Number of connected devices via Ethernet" set the value equal to the number of VCS controllers used for vibration testing performance (in this example- "1"). As a result, you will be able to edit the first line of the IP-addresses list (*Fig. 4.18*).

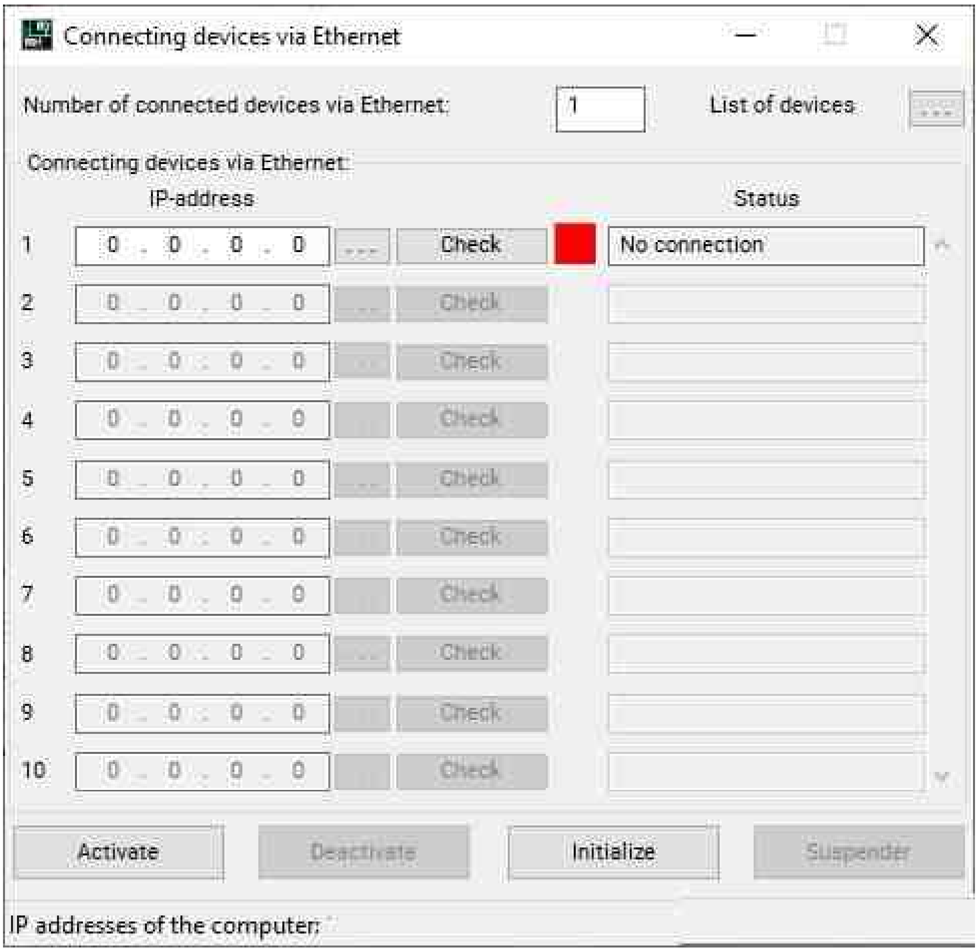


Fig. 4.18 "Connecting devices via Ethernet"

Enter the IP-address of the VCS controller to be activated (in this example - 192.168.12.108) (*Fig. 4.19*). If necessary, check the IP-address of VCS controller following the instructions specified in section *4.3.2*

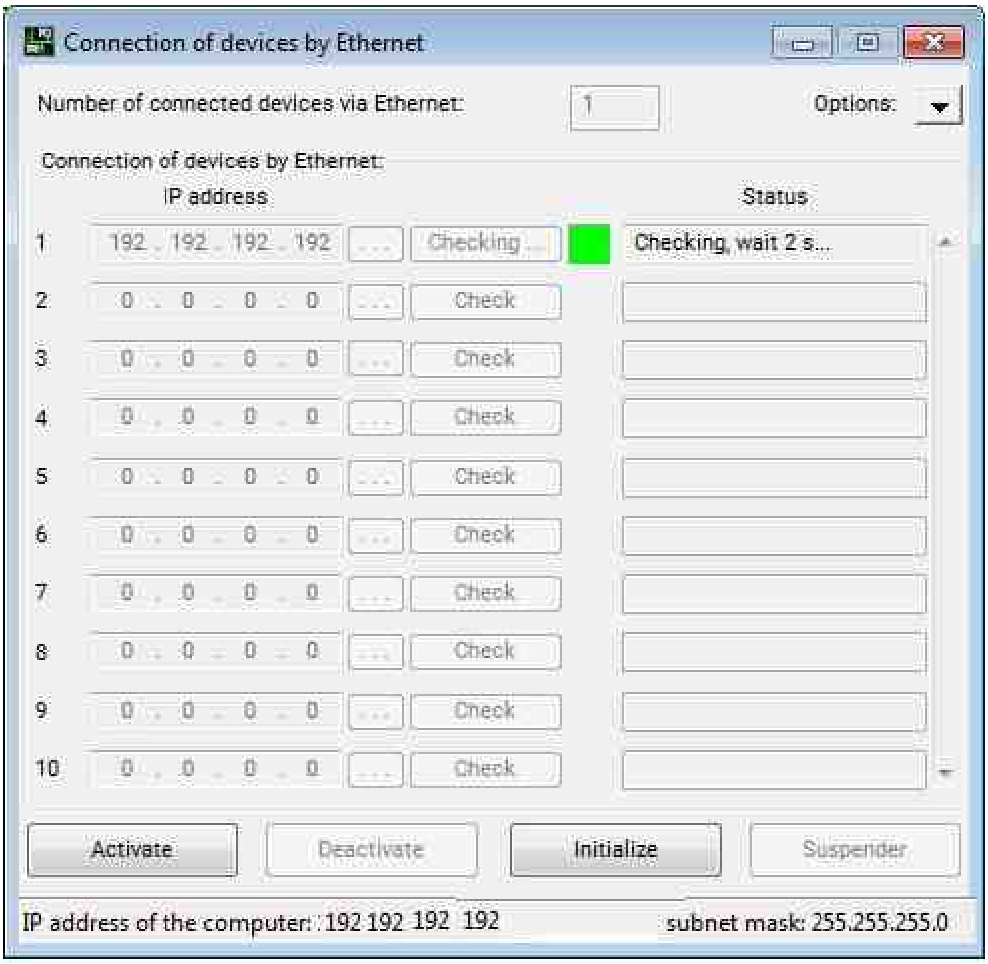


Fig. 4.19 "Connecting devices via Ethernet"

Click the key "Activate". If the VCS controller is successfully connected to the PC, its status in the program "Connecting devices via Ethernet" will change for "Connected" (*Fig. 4.20*).

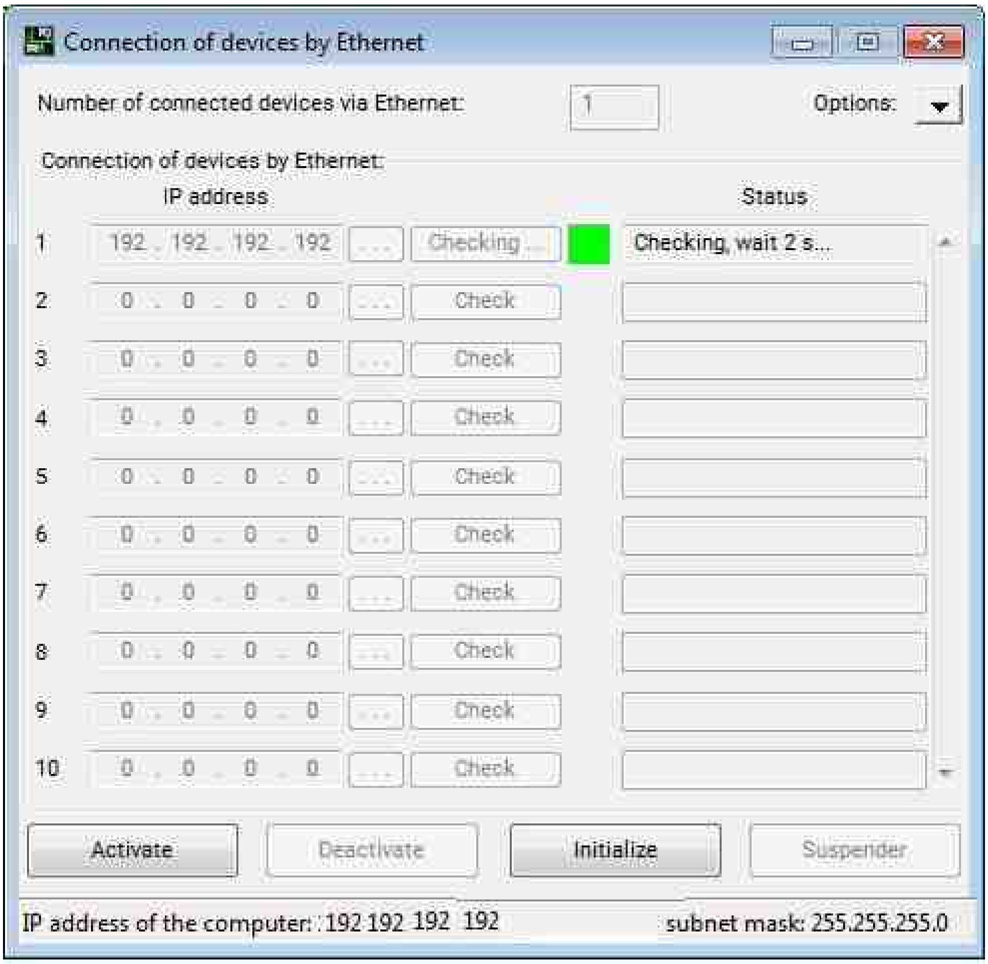


Fig. 4.20 "Connecting devices via Ethernet"

Service

The **Service** section contains ZETLAB configuration and auxiliary Table of contents:

The device manager is designed to setting the parameters of connected ZET devices (frequency of digitization of signals, parameters of connected sensors, etc.)

Time ZETSERVER - the data server of the channels of the ZETLAB system. The program interface provides the user with information on all channels of the ZETLAB system on this computer:

- measuring channels of connected ZET devices,
- channels of generators of connected ZET devices,
- virtual channels created by ZETLAB programs,
- signals transmitted over the network,
- demo signals (in demo mode).

The **Channel listening** program is designed to play signals through the computer's sound card.

The ZETLAB Error journal contains information about the operation of programs.

Device Manager .....

ZETDeviceManager - a program for configuring connected ZET-devices: ADC and DAC parameters, network settings, synchronization, measuring channels, digital lines, smart sensors and ZETSENSOR control devices. Information about device parameters is saved to the file "devices.cfg" in the directory "C:\ZETLab\Config" (the directory can be changed through the main menu of the ZETLAB panel - see section ZETLAB Control Panel - Main Menu of the ZETLAB panel). The **ZET Device Manager** program allows you to view file data and change device parameters in a convenient interface.

The ZET Device Manager program has been included in the ZETLAB software since version 05/12 and combines the functions of the programs:

Setting up ADC / DAC;

Editing parameter files (setting parameters of measuring channels);

Range setting;

Digital input/output (digital port setting);

Setting the device IP addresses.

Added TEDS technology to device manager.

Note 1: When ZETLAB is launched for the first time, ZET Device Manager may not save the changes made by the user - this is because the first time the program is launched, a file with device data is created, but information about this file is not yet saved in the ZETLAB configuration file database. To work with the device manager, you need to make changes to the program, for example, change the channel name, and save them with the "OK" button, then restart the ZETLAB panel and restart the ZET Device Manager program (full-functional work with the device parameters file "devices.cfg" will be carried out at the second and subsequent launches of the program after the first reboot of the ZETLAB panel).

Note 2: complete information on connection, configuration and operation of digital sensors of the ZETSENSOR family

Our company is committed to making the setup of measuring equipment for testing easier and more understandable. This time we have simplified the work of setting up channels for strain measurement. Now, when using the new Strain-gauge stations ZET 058, setting up the connection of strain gauges using a j -bridge scheme is reduced to performing simple and understandable actions. In addition, the software allows you to take into account the imbalance of the measuring circuit, when the resistance of the measuring strain gauge is very different from the resistance of the reference resistor. In this case, software balancing will help you choose the most optimal parameters for measurements.

Supported Hardware .....

Device Manager - program is included in the following software:

- ZETLAB BASE – ADC/DAC module software;

- ZETLAB ANALIZ – FFT spectrum analyzer software;
- ZETLAB VIBRO – vibration control systems software;
- ZETLAB TENZO – strain-gauge station software;
- ZETLAB SEISMO - seismic station software;
- ZETLAB NOISE - vibration meter-noise meter software;
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software (option).

ZET Device Manager is included in the **Service** group of programs

Program interface .....

The ZETLAB control panel will open at the top of the screen (*Fig. 2.1*).

Fig. 2.1 ZETLAB control panel

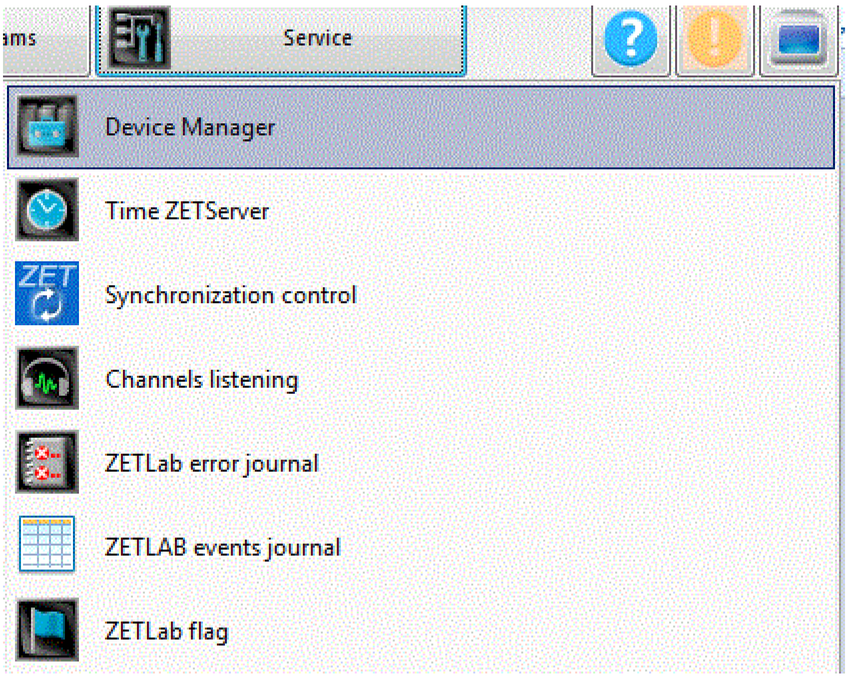
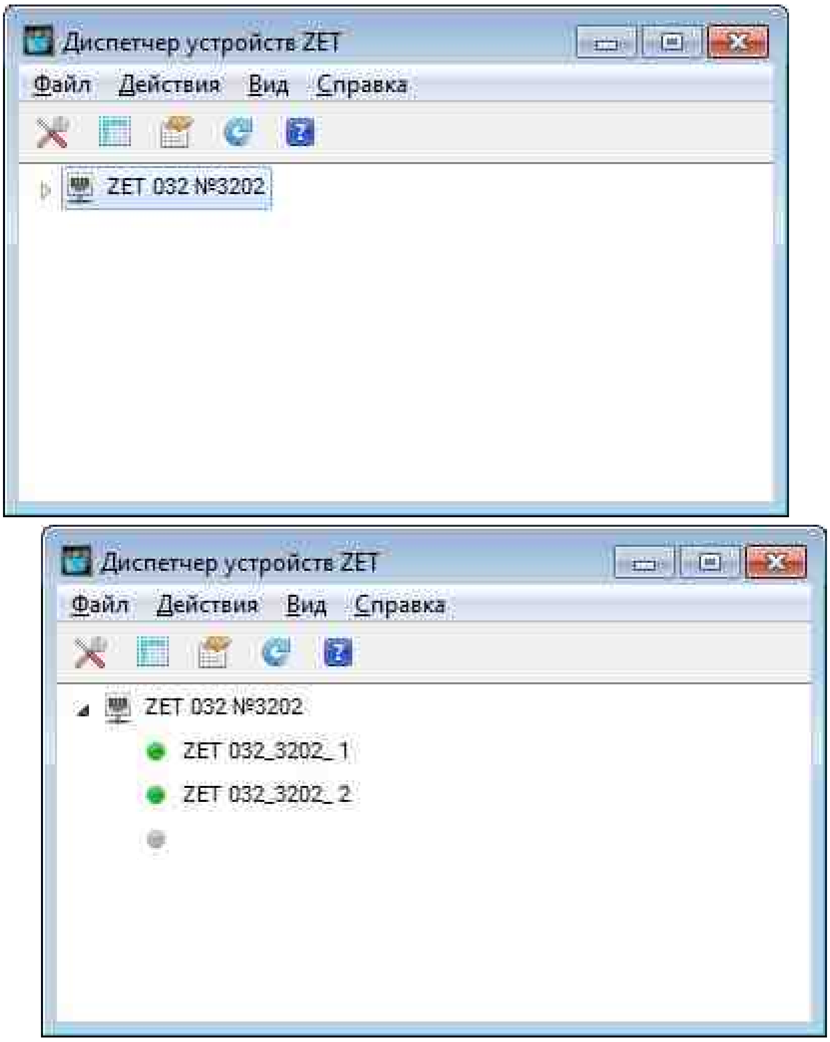


Fig. 2.2 Starting ZET Device manager

To switch to the program, in the "Service" section located on the ZETLAB panel (*Fig. 2.2*), select the "Device Manager" program (*Fig. 2.3*).



Channel list is hidden *Channel list revealed*

Fig. 2.3 Device Manager window

Revealing and hiding of measuring channels from the list is performed by activating the symbols " " and " " respectively.

If necessary, you can switch the "Device Manager" window to the mode of detailed viewing of channel properties (*Fig. 2.4*) by activating the symbol " ".

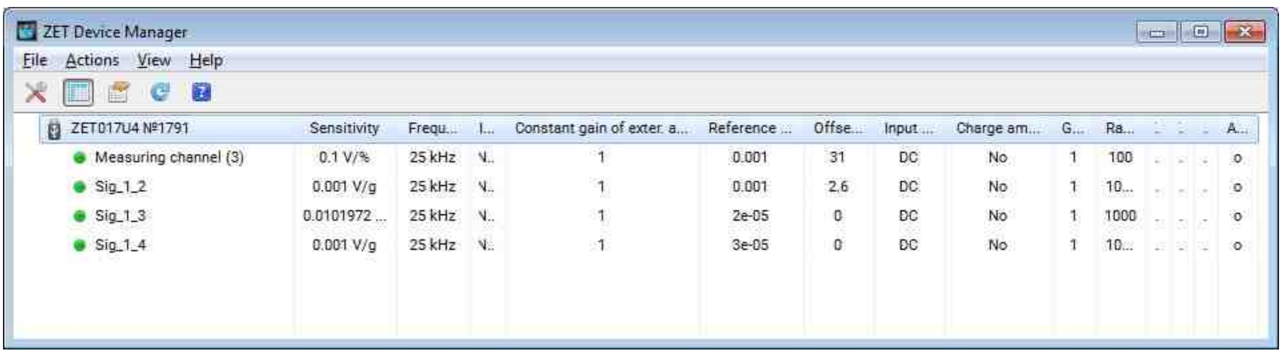


Fig. 2.4 Device Manager window

Setting the sampling frequency .....

To set the sampling frequency in the "**Service**" section located on the ZETLAB panel (*Fig. 2.2*), select the "Device Manager" program (*Fig. 2.3*).

Double-click on the controller ID in the Device Manager program window to activate the Properties window, in which select the **Sampling frequency** tab (*Fig. 2.5*).

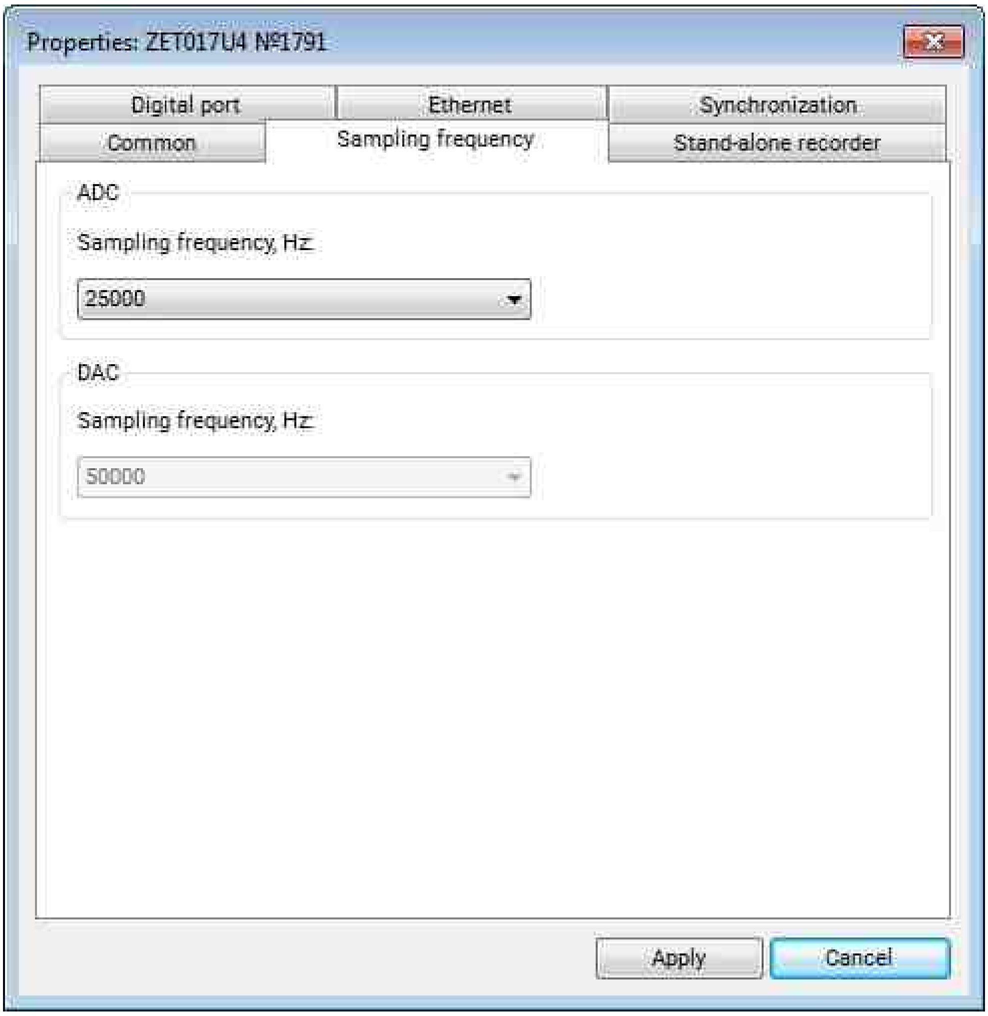


Fig. 2.5 Sampling frequency tab of the Properties window

Set the sampling frequency for the controller inputs, for which, in the "ADC" field, activate the pointer to the drop-down list and select the required sampling frequency value from the list .

Set the sampling frequency for the output of the controller oscillator, for which, in the "DAC" field, activate the pointer to the drop-down list and select the required sampling frequency value from the list.

To save the changes, activate the "Apply" button, to exit the window without making changes, activate the "Cancel" button.

Set up synchronization over the PTP protocol .....

This setting is performed for those cases when it is necessary to provide simultaneous synchronous operation for several controllers.

In the "Service" section located on the ZETLAB panel (*Fig. 2.2*), select the "Device Manager" program (*Fig. 2.3*).

Double-click on the controller ID in the "Device Manager" program window to activate the "Properties" window, in which select the "Synchronization" tab (*Fig. 2.6*).

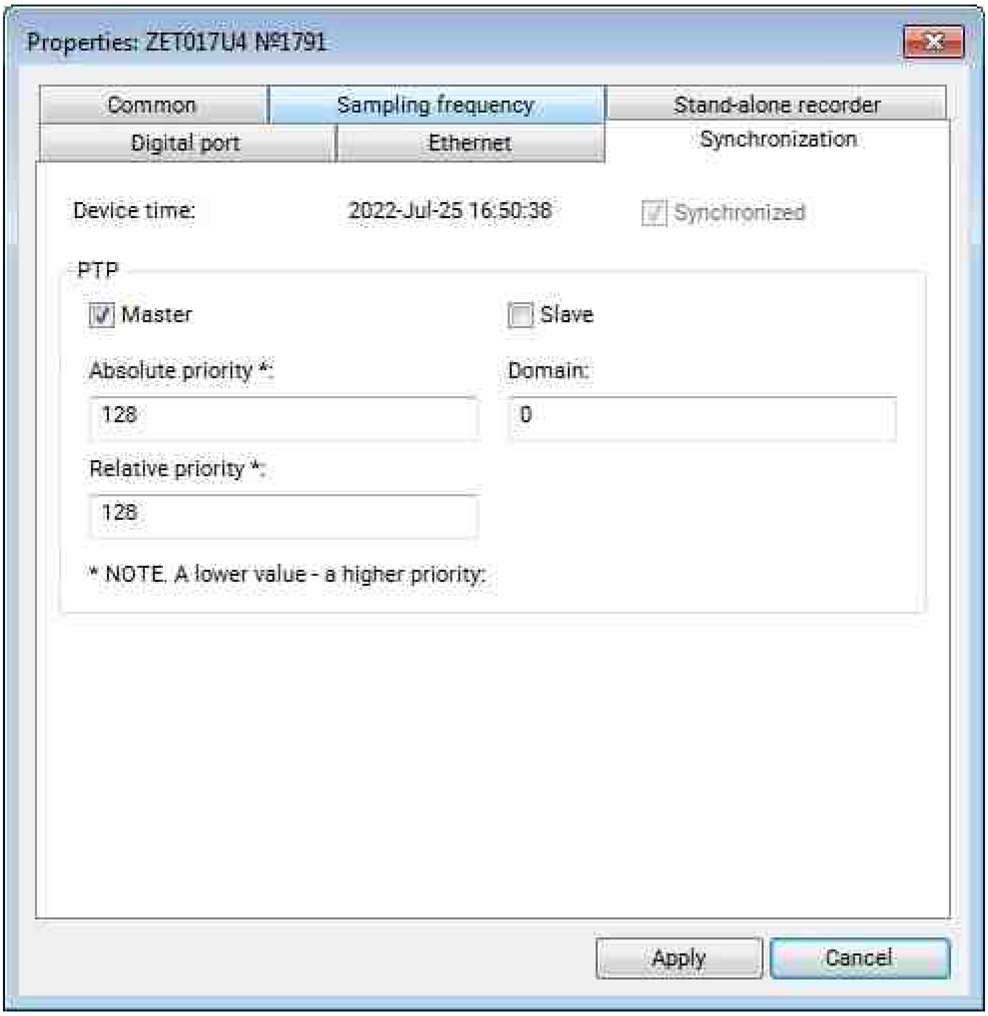


Fig. 2.6 "Synchronization" tab of the Properties window

Set the "Master" flag for the controller that will be used as a synchronization wizard using the PTP protocol, and set the "Slave" flag for controllers that will adapt to the synchronization wizard..

Note: *The synchronization source in the controllers selected as synchronization masters is the built-in quartz oscillator.*

In the "Domain" field (valid value from 0 to 127), specify the number of the group for which (in the Ethernet subnet) synchronization via the PTP protocol between devices will be organized. In this way, it is possible to organize several independently synchronized groups in an Ethernet subnet.

Attention! Specify the same values in the "Domain" field for devices that are combined into a common synchronization group using the PTP protocol

In the "Absolute Priority" and "Relative Priority" fields, if necessary, set priorities (a valid value from 0 to 255), which will be taken into account by the PTP protocol when choosing a synchronization wizard if there are several wizards.

Note 3

PTP synchronization is provided for devices configured to work in a single Ethernet subnet

Stand-alone recorder .....

Management of information Autonomous recorder operation mode is performed through the "Autonomous recorder" tab.

To go to the "Autonomous recorder" tab in the "Service" section located on the ZETLAB panel (*Fig. 2.2*), you must select the "Device Manager" program (*Fig. 2.3*).

By double-clicking on the device ID in the "Device Manager" program window, activate the "Properties" window, in which select the "Autonomous recorder" tab (*Fig. 2.7*).

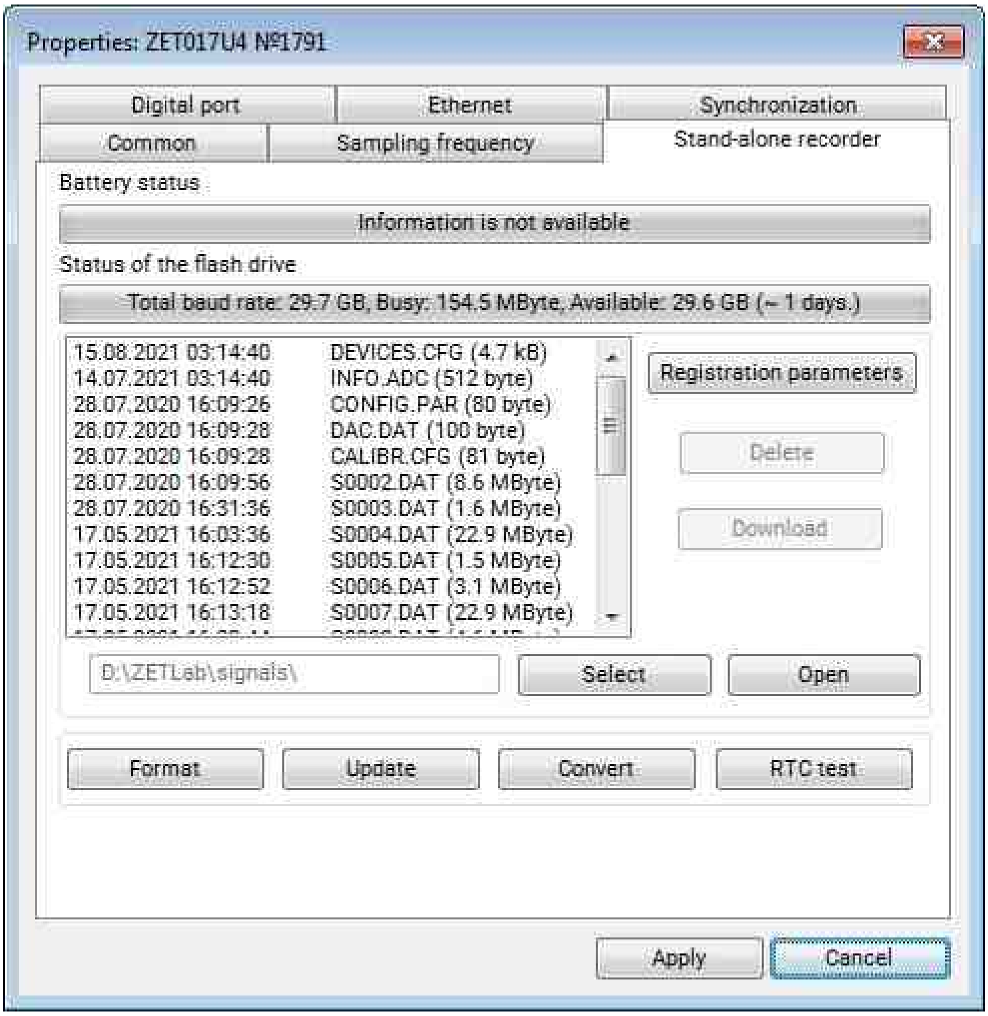


Fig. 2.7 Autonomous recorder tab of the Properties window

The "Delete" button is intended for selective deletion of files from the memory card. To delete a file, select it in the list, and then activate the "Delete" button.

Attention! *Delete files from the non-volatile memory (SD) of the controller in a timely manner to ensure sufficient Autonomous recorder.*

Note: *At each Stand-alone recording session, signals are recorded to files with a size not exceeding 128 MB, while the number of files created during the offline recording session is determined by the duration of the Stand-alone recording, as well as the ADC conversion frequency and the number of simultaneously recorded (enabled) controller channels*

The "Download" button is intended for selective downloading of text ("*.log") files from a memory card.

Note 4

This option is available only for controllers equipped with non-volatile SD memory, as well as licensed "SD non-volatile memory"

The "Select" button is designed to select the directory for saving downloaded files, and the "Open" button to go to the directory.

The "Format" button is designed to format the memory card.

The "Update" button allows you to update the list of registered files without leaving the "Offline Registrar" tab

The "Convert" button activates the program for converting and saving the registered signals in the memory (on the hard disk) of the computer.

The "RTC Test" button checks the health of the built-in battery.

__Attention!__ If the RTC test fails, the controller must be sent to the factory for battery replacement.

Note 5 and 6

- Only for downloading files with the extension "*.log"
- Save directories are defined in accordance with section 3.8

Check available memory and registration time .....

To check the available memory and registration time in the "Service" section located on the ZETLAB panel (*Fig. 2.2*), select the "Device Manager" program (*Fig. 2.3*).

By double-clicking on the device ID in the "Device Manager" program window, activate the "Properties" window in which select the "Common" tab (*Fig. 2.7*).

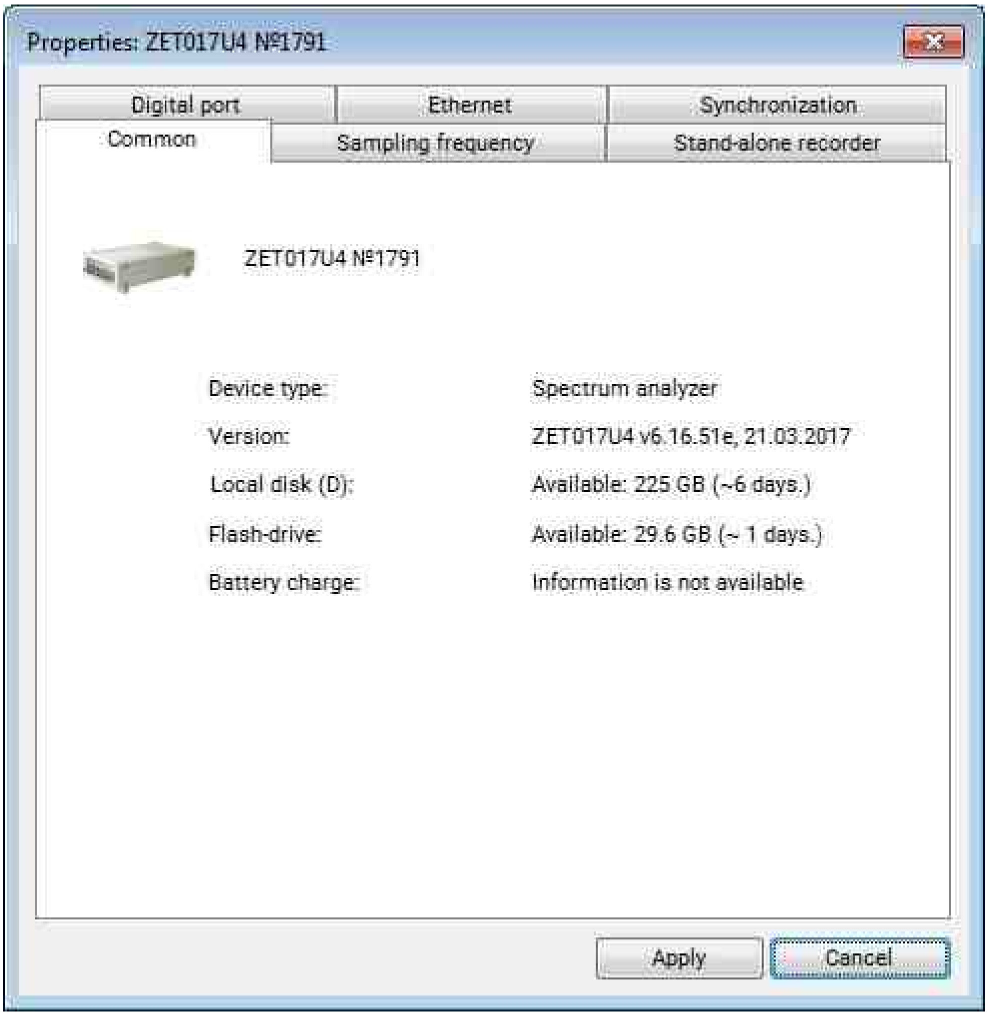


Fig. 2.7 Common tab of the Properties window

The lines "Autonomous recorder" show the available volume and time of continuous recording for Autonomous recorder mode, and the line "Local disk x. Flash-drive x:" - for stationary mode.

Note: *The recording time is determined by the amount of available memory and the amount of information recorded per unit of time, which in turn depends on the sampling frequency, as well as the number of included (registered) measurement channels.*

Adjustment measurement channels .....

Used for multi-channel devices, the Device Manager program provides a function for individual adjustment of the measuring channel. For example, for the ADC channel of a spectrum analyzer of type A19, the following parameters can be set:

The name of the measuring channel, as well as, if necessary, comments on it;

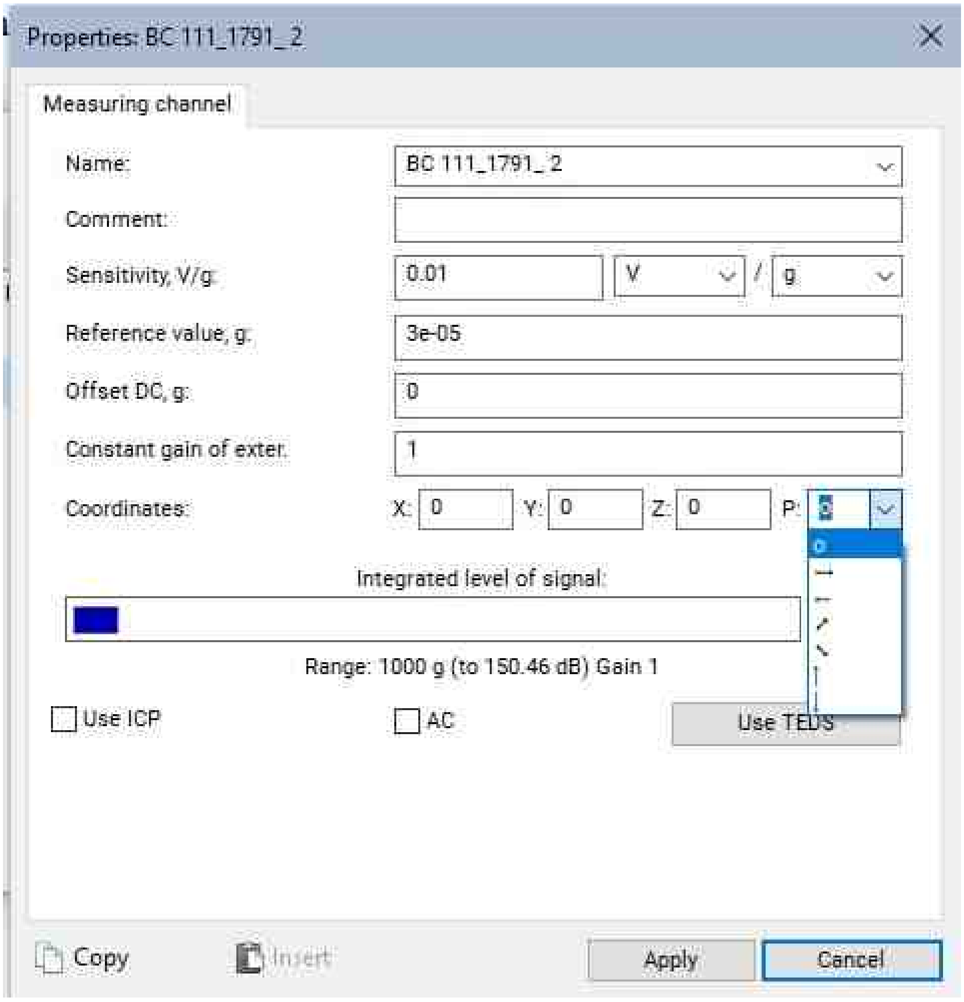
Sensitivity in the required units of measurement;

Reference value;

External amplifier ratio;

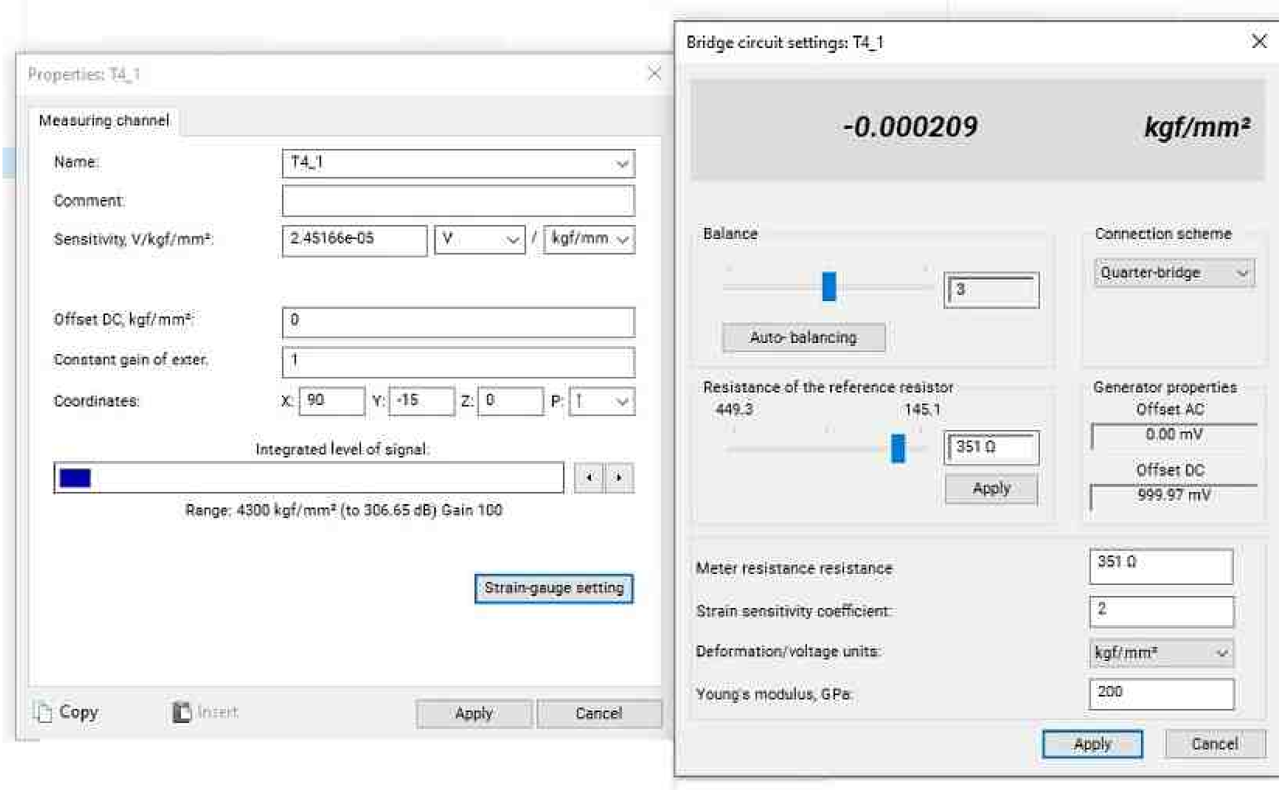
Displacement of the constant component;

The coordinates of the location (relative) of the measuring transducer in space and its orientation.

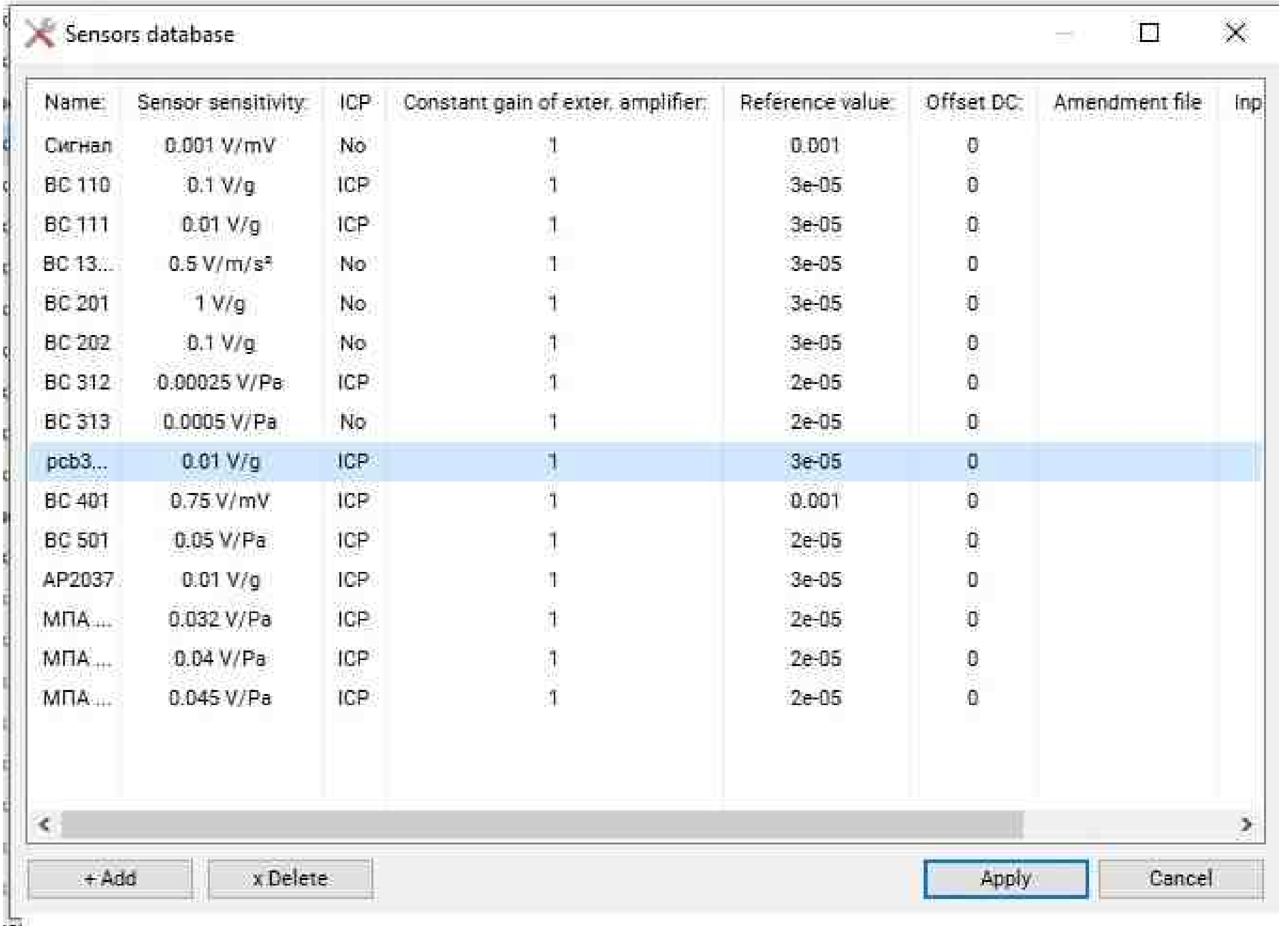


Used for the new generation controllers ZET 024, ZET 028, ZET 032, ZET 034, ZET 038, the Device Manager program provides a function for connecting strain-resistant sensors. To work with such sensors, it is necessary to use the option "1/4-bridge circuit" by checking the appropriate box. At the same time, new parameters will appear in the settings of the measuring channel:

The measuring channel at the software level will switch to the appropriate operating mode;
Measuring resistor — the nominal resistance of the connected strain gauge in Ω;
The reference value and the displacement of the constant component will have a unit of measurement of deformation — µm/m.



Used for quick setup of measuring channels, the **Device Manager** program has a sensor database that can be manually supplemented with sensor data used in operation. When connecting a sensor from the base to the measuring channel, to configure the measuring channel, it is enough to select the type of sensor from the base — and the conversion coefficient, units of measurement and support for calculating the level in dB, the optimal measurement range will be recorded in the settings, the ICP preamplifier will turn on for ICP sensors.



Name	Sensor sensitivity	ICP	Constant gain of exter. amplifier	Reference value	Offset DC	Amendment file	Inp
Сигнал	0.001 V/mV	No	1	0.001	0		
BC 110	0.1 V/g	ICP	1	3e-05	0		
BC 111	0.01 V/g	ICP	1	3e-05	0		
BC 13...	0.5 V/m/s²	No	1	3e-05	0		
BC 201	1 V/g	No	1	3e-05	0		
BC 202	0.1 V/g	No	1	3e-05	0		
BC 312	0.00025 V/Pa	ICP	1	2e-05	0		
BC 313	0.0005 V/Pa	No	1	2e-05	0		
pcb3...	0.01 V/g	ICP	1	3e-05	0		
BC 401	0.75 V/mV	ICP	1	0.001	0		
BC 501	0.05 V/Pa	ICP	1	2e-05	0		
AP2037	0.01 V/g	ICP	1	3e-05	0		
МПА ...	0.032 V/Pa	ICP	1	2e-05	0		
МПА ...	0.04 V/Pa	ICP	1	2e-05	0		
МПА ...	0.045 V/Pa	ICP	1	2e-05	0		

Enabling and disabling measuring channels .....

To enable and disable measuring channels in the "Service" section located on the ZETLAB panel (*Fig. 2.2*), select the "Device Manager" program (*Fig. 2.3*) and open the list of measuring channels.

Symbols of green (voltage input), red (ICP mode) and white (charge input) indicate the enabled status of the measuring channel, and the gray symbol means the disabled status.

To disable the measuring channel, highlight the identifier of the enabled measuring channel, and then, by pressing the right mouse button, open the drop-down window (*Fig. 2.8*), in which activate the "Disable" field.

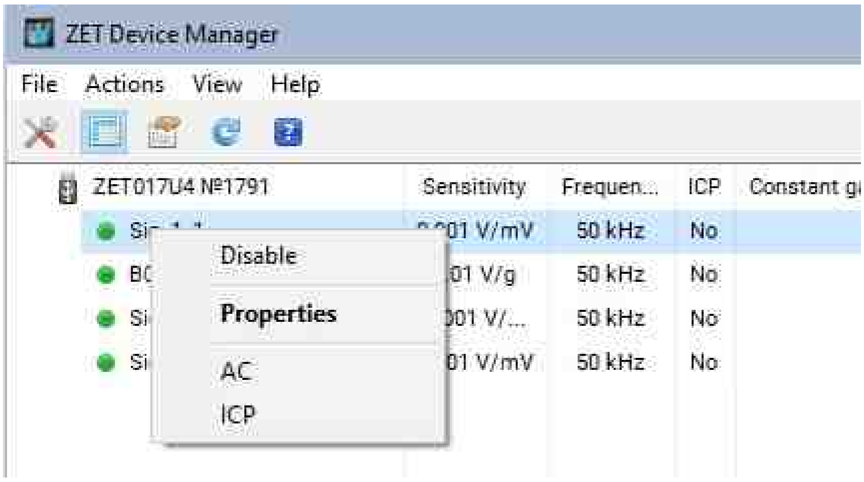


Fig. 2.8 Device Manager window with a drop-down window for the selected measurement channel

Enabling a measuring channel is performed in the same way as disabling it, but when switching it on, select the identifier of the disabled channel and activate the "Enable" field in the drop-down window (*Fig. 2.8*).

Note 7 and 8

- Only available for model 032
- Switching the measuring channel on and off can also be done by checking and unchecking the box in the "Status" field of the "Property" window (*Fig. 2.9*)

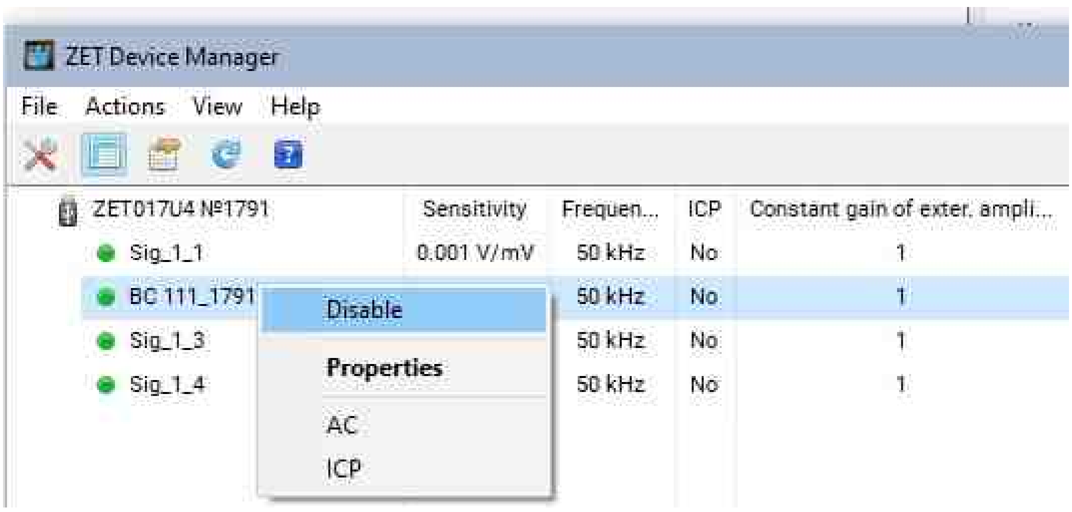


Fig. 2.9

"Properties" window .....

In the "Service" section, located on the **ZETLAB** panel, select the "Device Manager" program (*Fig. 2.2*) and open the list of measuring channels.

To open the "Properties" window (*Fig. 2.11*), select the identifier of the measuring channel and then, by pressing the right mouse button, open the drop-down window (*Fig. 2.10*), in which activate the "Properties" field.

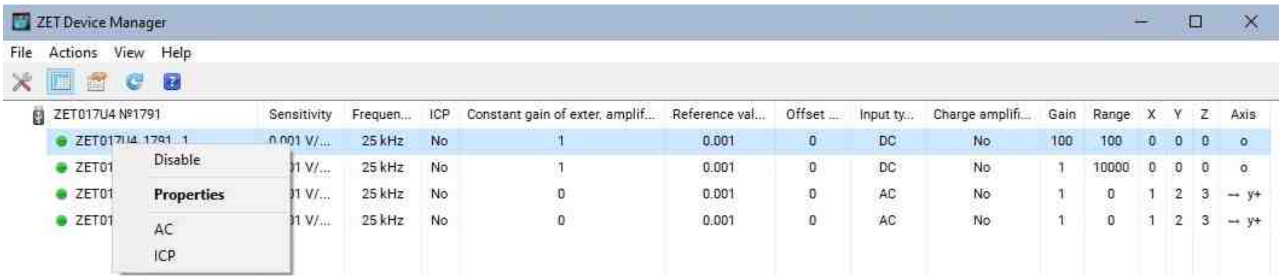


fig. 2.10 Device Manager window with a drop-down window for the selected measurement channel

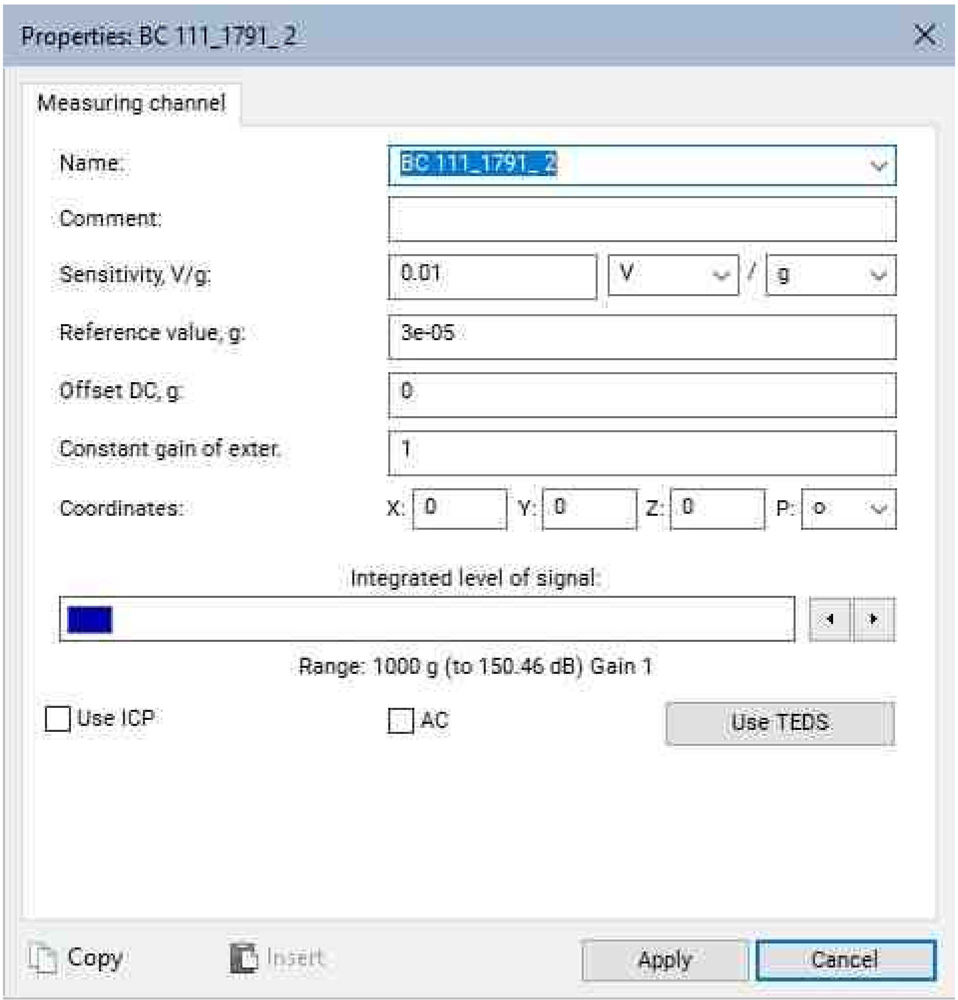


Fig. 2.11 Properties window

Note: *Measurement channels parameters are configured individually for each measurement channel*

Attention! *Measurement channel parameter settings are stored in the controller memory. When the controller is connected to the computer for the first time, the parameters of the measuring channels are determined by the factory (initializing) settings*

Note 9

- An alternative way to open the "Properties" window is to double-click on the identifier of the enabled measurement channel

Additional channel settings.

When you click on the channel name, a selection menu appears (Fig. 2.12).

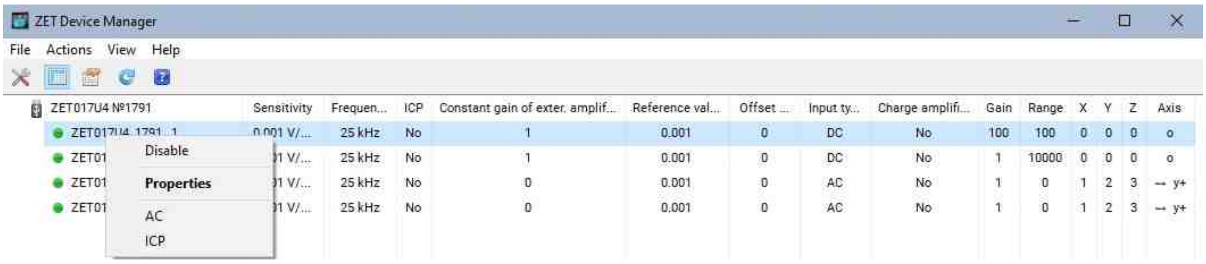


fig. 2.12 Device Manager change settings menu, click on the channel name, a selection menu appears

When you click on the device name, a selection menu appears (Fig. 2.13).

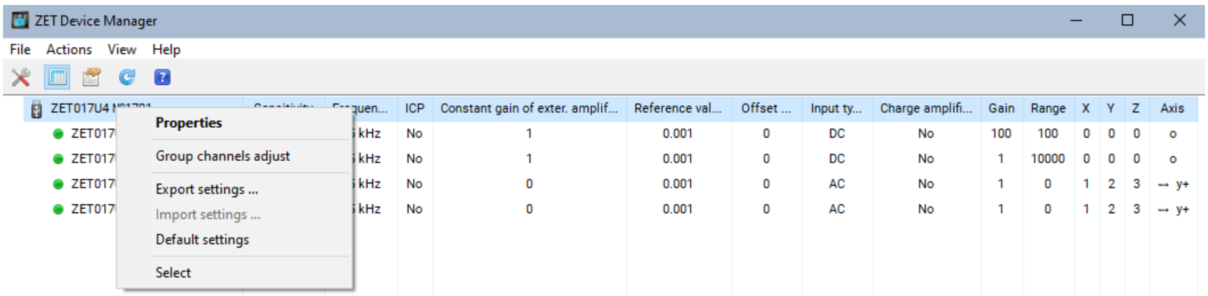


fig. 2.13 Device Manager cchange settings menu, click on the device name selection menu appears

- Group channel setup - setup of dedicated channels (ICP, AC, channel dimensions):
- Export settings allows you to save the settings state on your computer.
- Import settings allows you to import previously saved settings.
- Default settings reset all channel settings in the device to the initial setting.

- Select allows you to detect the device by a special flashing signal if many of them are used at the same time.

In addition, there is an option in the "Device Manager" to simultaneously enable or disable channels (Fig. 2.14).

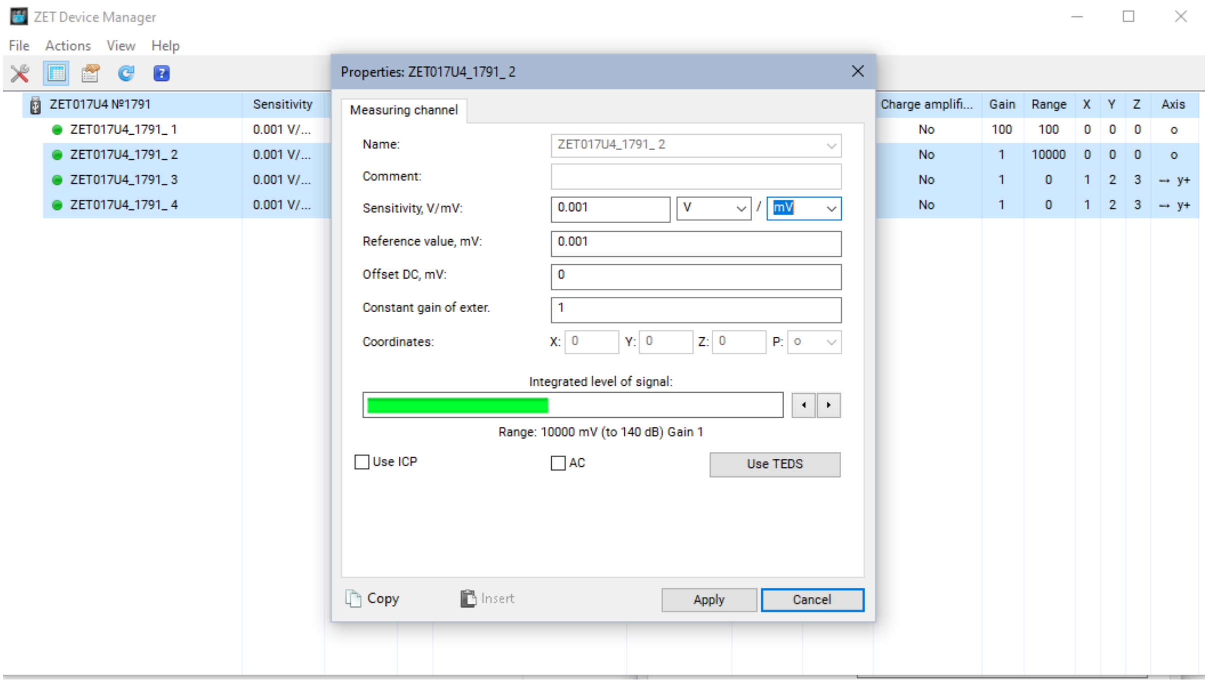


fig. 2.14 Menu for changing all channel settings at once in the "Device Manager"

<u>Selecting channels:</u>
- **Ctrl + LMB** (left mouse button), on selected channels RMB (right mouse button) and a group menu of channels appears
- **Shift** + down arrow, then as above

If there is at least 1 disabled channel, the menu will only Enable

AC - brings the selected channels to AC
ICP - brings the selected channels to ICP or removes the selection

Disable - disables and enables the selected channels. **Channel 1 on the device is always enabled. Do not apply to generators**

Assigning a name to the measuring channel .....

The ZET03X controller is a universal measuring device and allows you to connect sensors of various types to its inputs that measure various physical quantities, which makes it necessary to identify the measuring channels.

Note: *the assignment of unique names to the measuring channels, characterizing, among other things, the types of primary transducers, ensures the convenience of identifying the measuring channels during subsequent measurements using the ZETLAB software*

To assign a name to the measurement channel, go to the "Properties" window.

If a sensor is connected to the measuring channel of the controller, information about which has already been added to the database, go to the "Name" field and, by activating the pointer to the drop-down list (*Fig. 2.12*), select the type of sensor to be connected from the list, while the parameter fields of the window " Properties" will be automatically filled in.

Attention! *When filling in the "Sensitivity" field, the average value for this type of sensors is entered as. You should manually correct the value of the parameter in the "Sensitivity" field so that it corresponds to the passport (or verification certificate) for the sensor.*

If desired, change (by entering from the keyboard) the name of the measuring channel to whatever suits you.

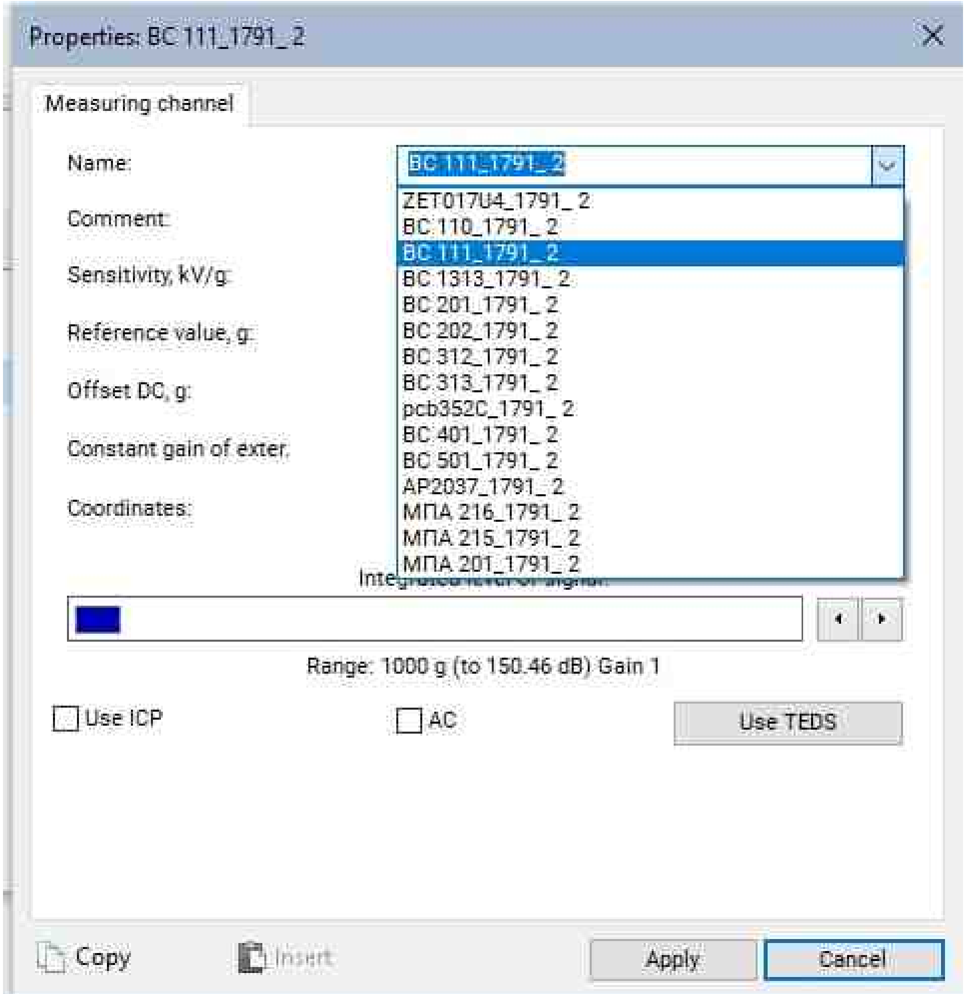


Fig. 2.12 "Properties" window with a list of sensors from the database

Attention! *The ZETLAB software allows assigning the same names to the measuring channels, however, their further identification when working with the software becomes difficult.*

If a sensor is connected to the measuring channel of the controller, the type of which is not in the drop-down list, it is necessary to enter the required name of the measuring channel from the keyboard.

Attention! *In the case when you need access to arbitrary settings for all parameters in the "Properties" window in the "Name" field, select the top line with the identifier "ZET xxxxx" from the list (Fig. 2.12).*

To save the changes in the "Properties" window, activate the "Apply" button.

Setting units of measurement .....

The ZET 03X controller is a universal measuring device and allows you to connect to its inputs sensors of various types that measure various physical quantities such as: acceleration (g, m/s^2), displacement (mm), speed (m/s, mm/s), temperature (°C), voltage (V), current (A, mA), etc., which makes it necessary to set the correct units of measurement for the measuring channel.

To set the units of measurement on the measuring channel, go to the "Properties" window.

The most commonly used units of measurement can be selected from the drop-down list (*Fig. 2.13*) by activating the symbol in the "Unit of measurement" field.

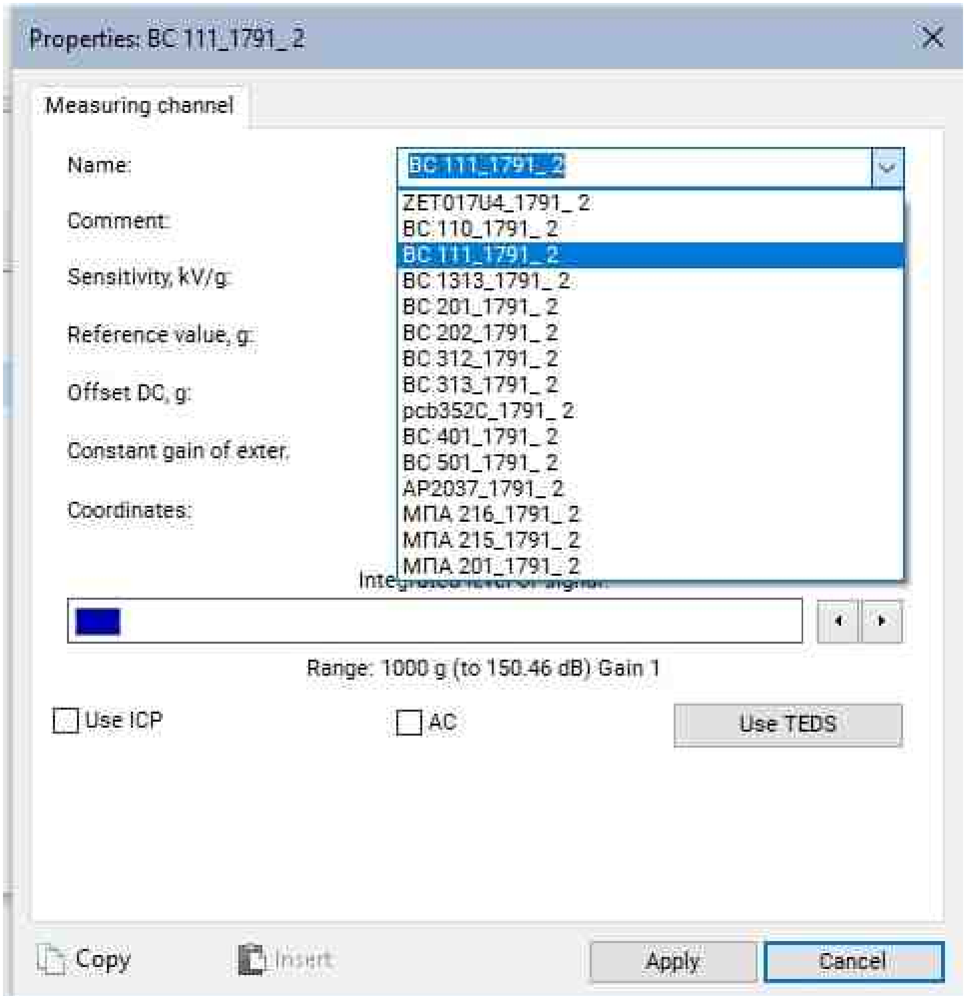


Fig. 2.13 Properties window with list of units of change

Note: *if you need to clarify the units of measurement, refer to the information provided in the passports for the connected sensor.*

To save the changes in the "Properties" window, activate the "Apply" button.

Setting the sensitivity .....

The sensitivity of the measuring channel determines the binding of the recorded values to the absolute (certified) values, taking into account the units of measurement.

To set the sensitivity of the measuring channel, go to the "Properties" window.

Using the keyboard in the "Sensitivity" field of the "Properties" window (*Fig. 2.14*) set the required sensitivity value for the measuring channel.

When sensors are connected to the measuring channel of the device, as a rule, the value of the sensor sensitivity is set as the sensitivity value.

Note: For information about the sensitivity values of connected sensors, refer to the information provided in their passports or verification certificates.

To save the changes in the "Properties" window, activate the "Apply" button.

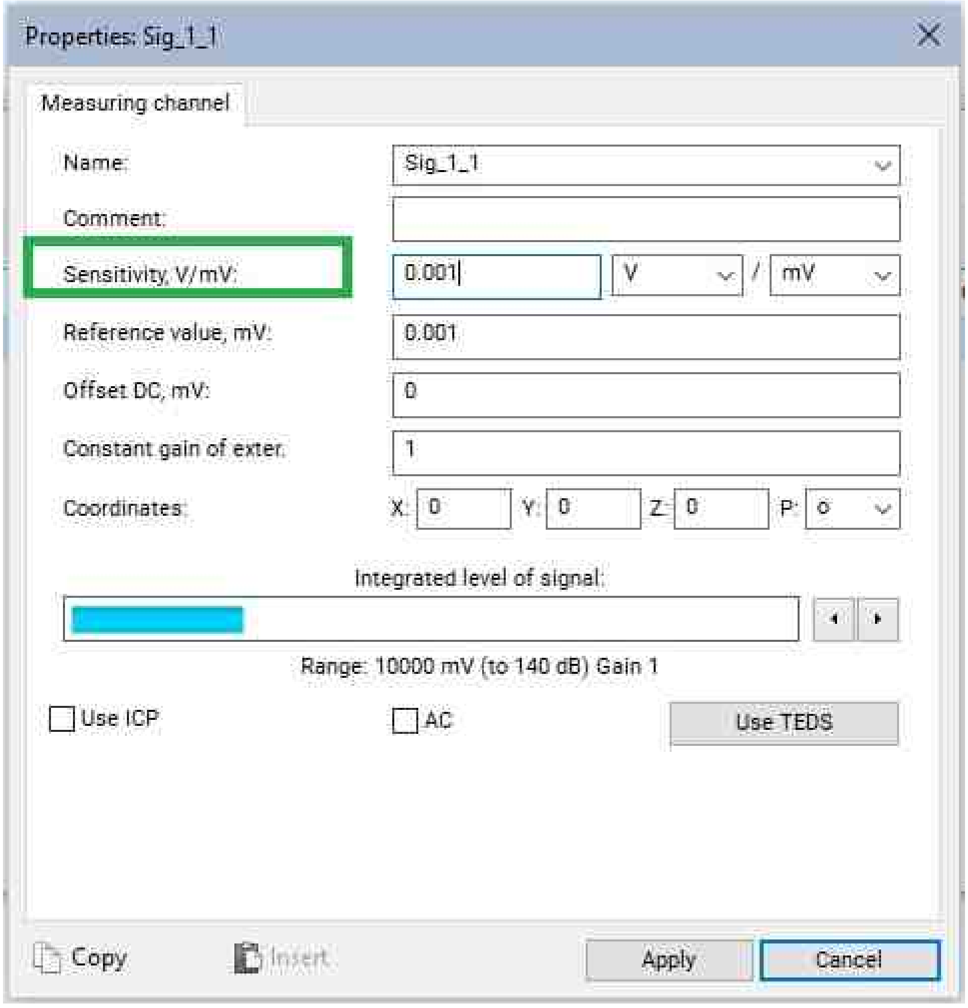


Fig. 2.14 Properties window with sensitivity

Setting the reference value .....

The reference value is used to recalculate the values recorded in the measurement channel to the dB scale.

To set the reference value of the measuring channel, go to the "Properties" window.

Using the keyboard in the "Reference value" field of the "Properties" window (*Fig. 2.15*), set the required reference value for the measuring channel.

To save the change in the "Properties" window, activate the "Apply" button.

Note: when selecting units from the drop-down list, the corresponding reference value will be set automatically.

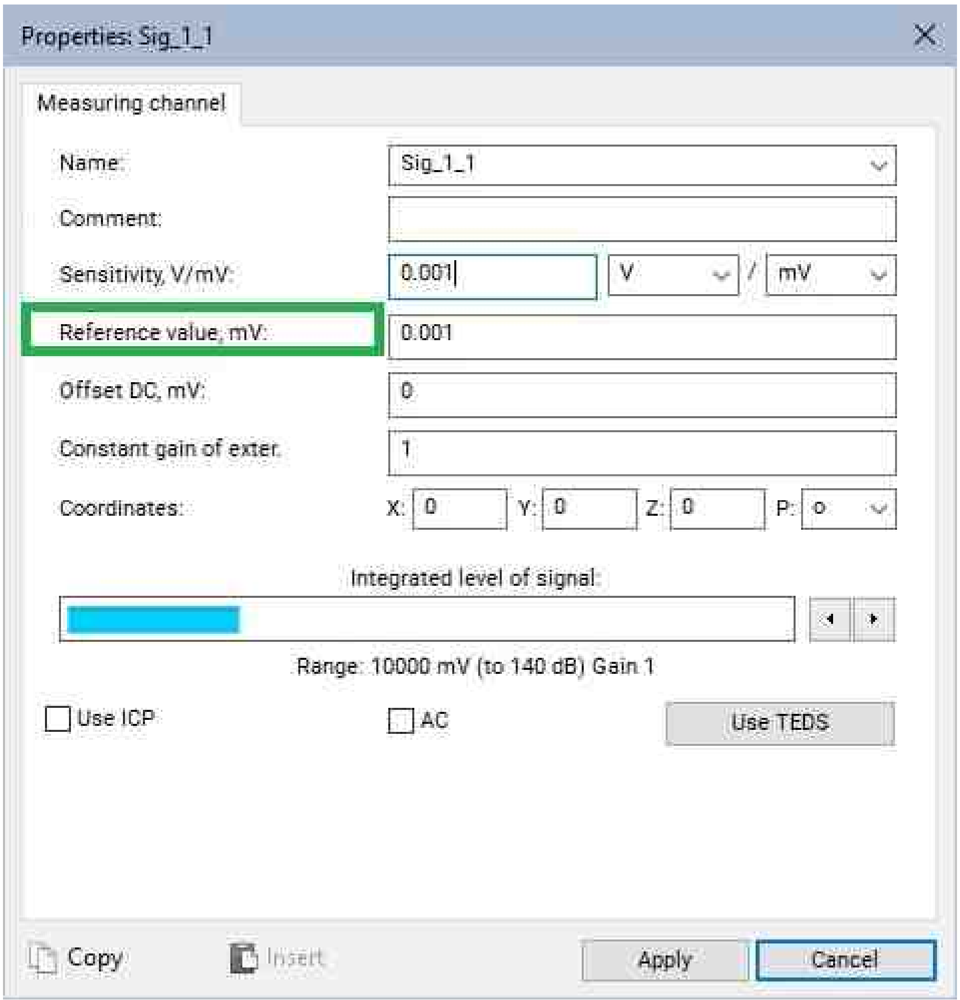


Fig. 2.15 Properties window with reference value

Setting the offset DC .....

If it is necessary to shift the constant component of the measuring channel, go to the "Properties" window.

Using the keyboard in the "Offset DC" of the Properties window (*Fig. 2.16*), set the required offset value for the measuring channel.

To save the change in the "Properties" window, activate the "Apply" button.

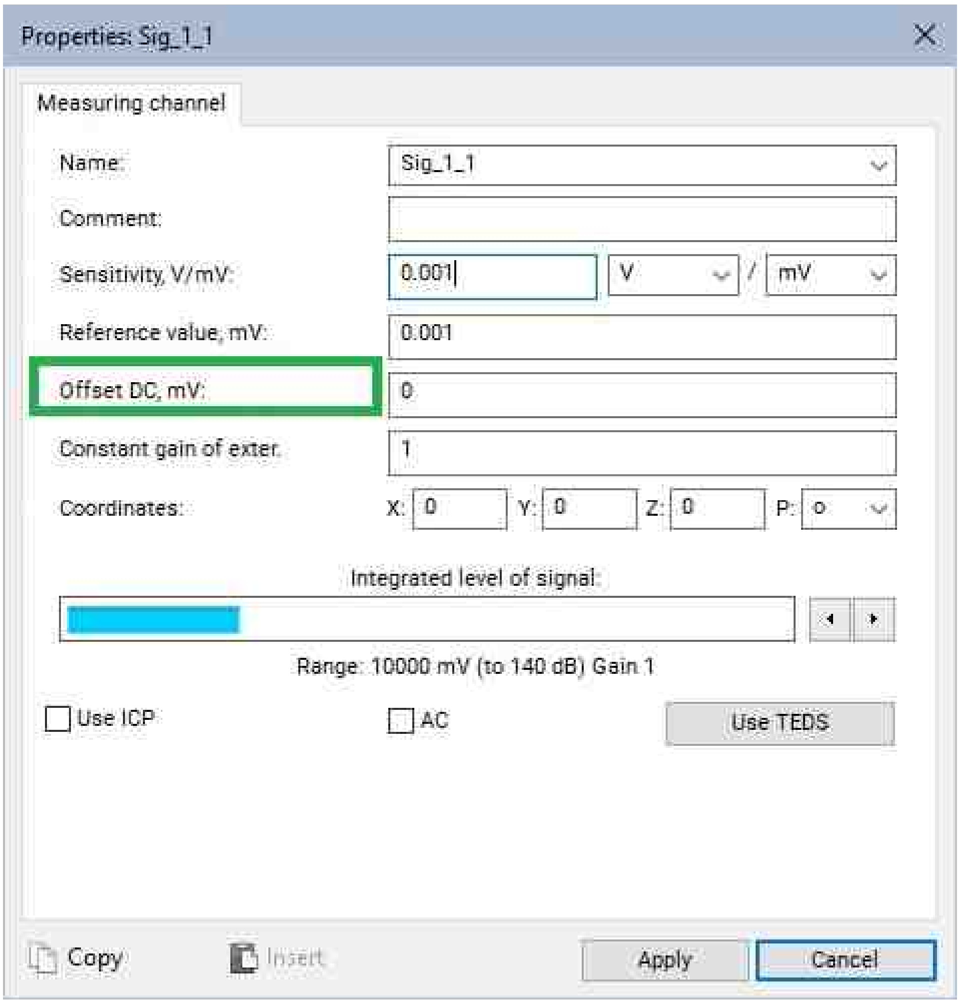


Fig. 2.16 Properties window with offset DC

Setting the gain of external amplifier .....

When connecting sensors using matching amplifiers, their gains must be taken into account.

To take into account the gain of an external amplifier, go to the "Properties" window.

Using the keyboard, in the "External amplifier gain" field of the "Properties" window (*Fig. 2.17*), set the gain of the external amplifier.

Note: *in the absence of external amplifiers, the field "KU of external amplifier" is set to "1"*

To save the changes in the "Properties" window, activate the "Apply" button.

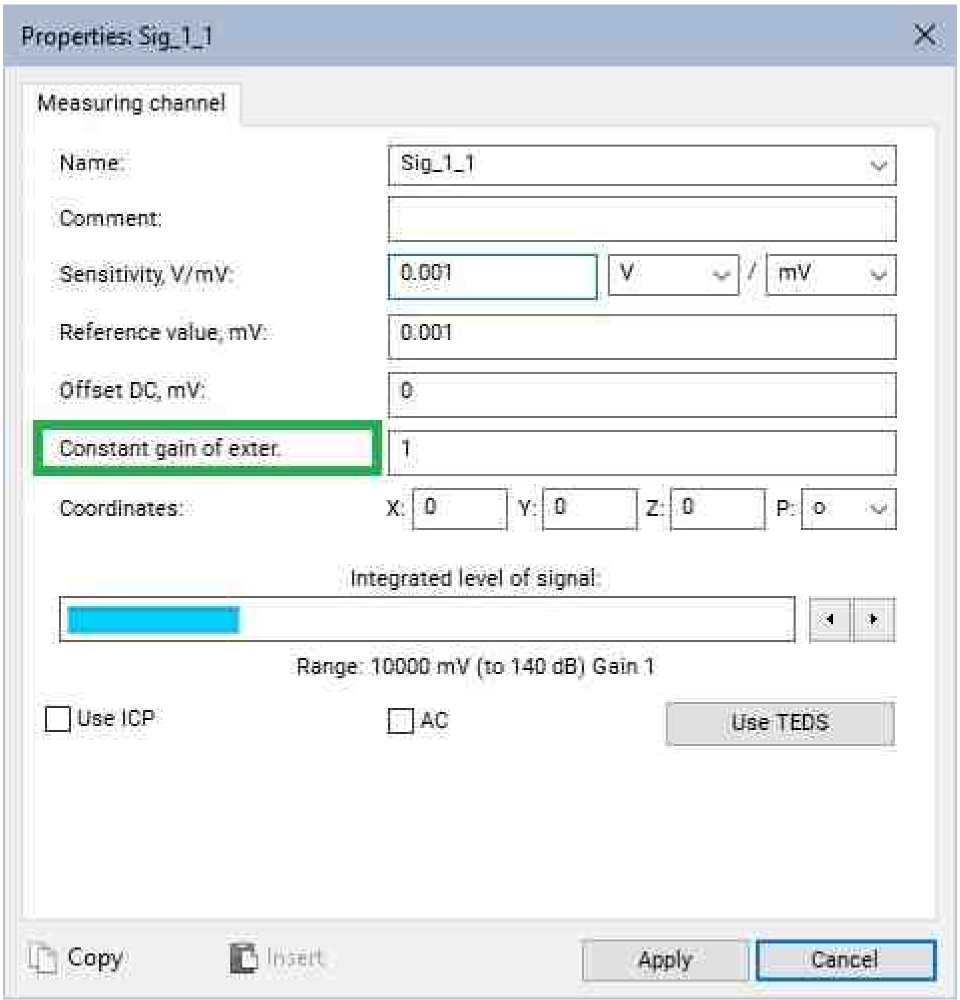


Fig. 2.17 Properties window with offset DC

Integral level indicator and gain setting .....

The indicator of the integral signal level of the Properties window (*Fig. 2.11*) allows you to estimate the recorded signal level through the measuring channel (*Fig. 2.18*). The more the indicator scale is shaded (colored from left to right) the higher the level of the recorded values of the signal through the measuring channel.

Attention! *It is necessary to avoid complete coloring of the indicator scale (Fig. 4.12), which means an overload of the measuring channel, the consequence of which is the occurrence of nonlinear signal distortions, leading to unreliable measurement results.*

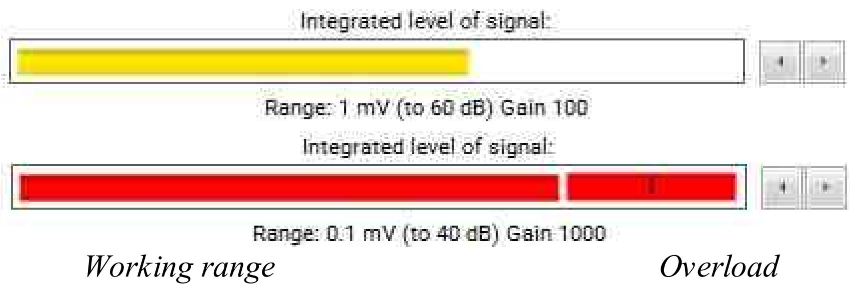


Fig. 2.18 Integral signal level indicator

The following gain values can be set individually in the controller for each measuring channel: 1; 10; 100.

If necessary, use the symbols in the "Integral signal level" field to set the desired gain level..

Note: *In the case of a recorded overload on the measuring channel, the gain should be reduced, in the case of a small signal level, it should be increased.*

To save the changes in the Properties window, activate the Apply button.

Setting the operation mode of the measuring channel .....

The parameters "Use ICP", "Charge amplifier" and "AC" in the "Properties" window (*Fig. 2.11*) are used to assign the appropriate operating mode to the measuring channel.

If the parameters "Use ICP" and "Charge amplifier" are deactivated, then the measuring input is in the "ICP input" operation mode, which corresponds to the green color of the indicator at the input.

When the "Use ICP" parameter is activated, the measuring channel is switched to the "ICP Input" operation mode, which corresponds to the blue color of the indicator at the input. In this mode, the power supply of the sensor (primary converter) is carried out from the input of the measuring channel of the controller.

Attention! *Avoid switching on ICP mode on the measuring channel to which a sensor that does not support ICP mode is connected due to possible damage to the sensor.*

When the "Charge amplifier" parameter is activated, the measuring channel is switched to the "Charge input" operating mode, which corresponds to the white color of the indicator at the input.

Activation of the "AC" parameter for all operating modes imposes a high-pass filter on the signal recorded from the measuring channel at the software level to exclude the constant component from the signal.

Attention! *If you turn on the "AC" parameter on one of the channels of the device, then on this channel there is a phase shift of the signal relative to other channels of the device, where this parameter is turned off, since a high-pass filter with a cutoff frequency of 0.5 Hz is used. In cases where several measuring channels are involved, it is recommended to set the same values of the "AC" parameter for these channels.*

Setting the parameters of the measuring channel using TEDS .....

If the sensor is equipped with the TEDS function, when setting the parameters of the measuring channel, you can use this functionality, for this you should go to the "Properties" window (*Fig. 2.19*).

In the "Properties" window, activate the "Use TEDS" button; in this case, the fields of the properties window will be filled with the information necessary for setting up the measuring channel.

Enter in the "Name" field the name of the measuring channel that is convenient for you, and then activate the "Apply" button to save the settings.

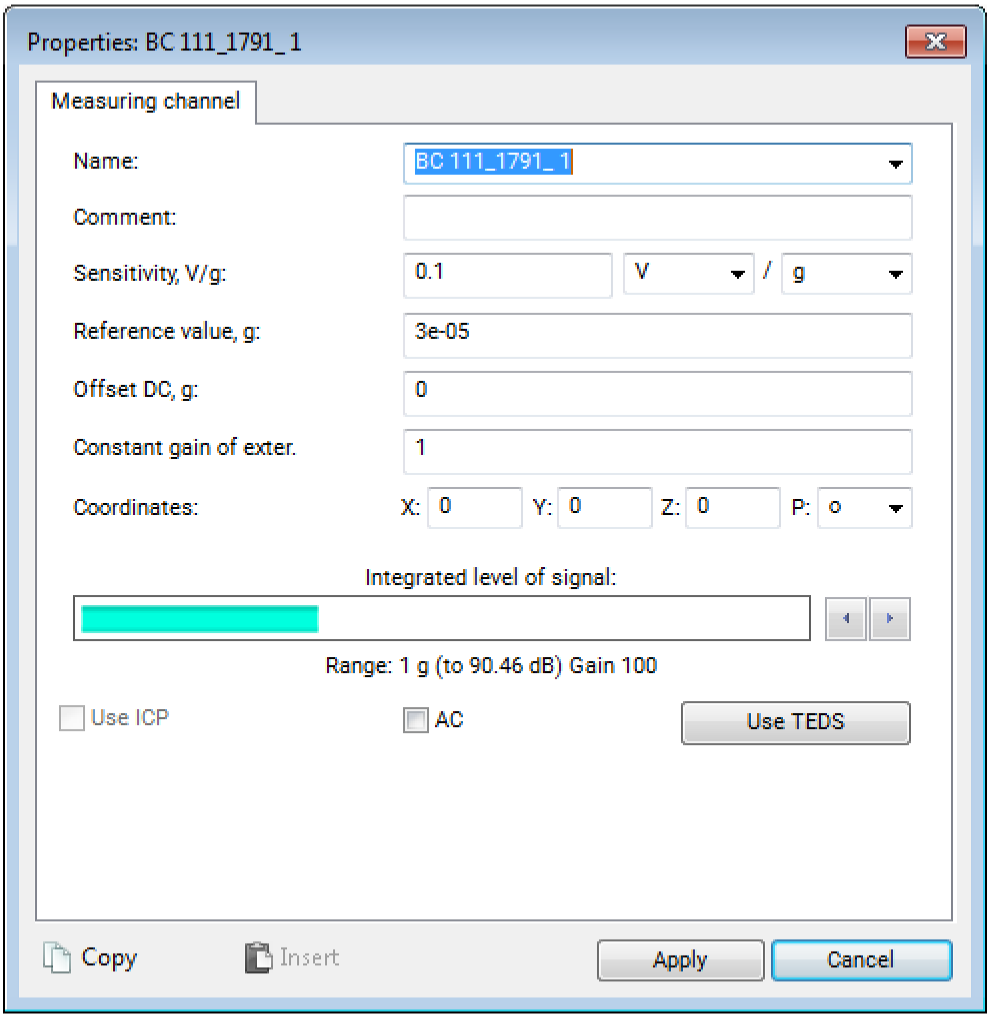


Fig. 2.19 In the "Properties" window, activate the "Use TEDS" button

Setting up channels for strain measurement .....

Our company is committed to making the setup of measuring equipment for testing easier and more understandable. This time we have simplified the work of setting up channels for strain measurement. Now, when using the new ZET 058 Strain-gauge stations, setting up the connection of strain gauges using a j - bridge scheme is reduced to performing simple and understandable actions. In addition, the software allows you to take into account the imbalance of the measuring circuit, when the resistance of the measuring strain gauge is very different from the resistance of the reference resistor. In this case, software balancing will help you choose the most optimal parameters for measurements.

Set up the measuring channels of controllers of the ZET 058 series

In the **"Device Manager" program** window (*Fig. 7.1*) activate the ID corresponding to the controller. In the Properties window, set the parameters of the measuring channel according to the datasheet for the primary converter and the current test conditions (*Fig. 7.8*).

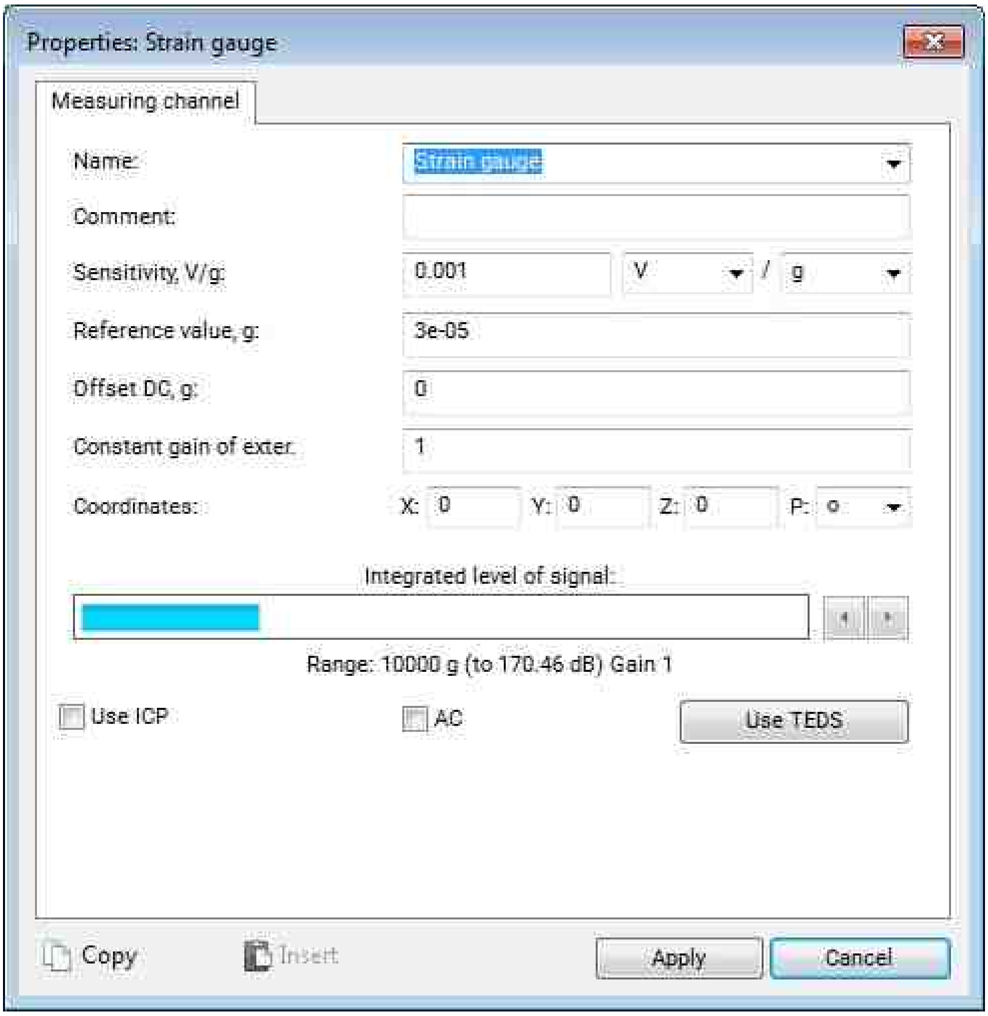


Fig. 7.8 Measuring channel tab of the "Properties" window

Note: *The parameters of the measuring channels are adjusted individually for each measuring channel*

Attention! *The settings of the parameters of the measuring channels are stored in the memory of the strain station. When first connected to a computer, the parameters of the measuring channels are determined by the factory (initializing) settings*

Note: *Assigning unique names to measuring channels, including the types of primary converters, provides convenience of identifying measuring channels during subsequent* *measurements using the ZETLAB software.*

If a sensor is connected to the measuring channel of the controller, information about which has already been added to the database, go to the "Name" field and activate the pointer to the drop-down list (*Fig. 7.9*), select the type of sensor to be connected from the list, and the parameter fields of the "Properties" window will be automatically filled in.

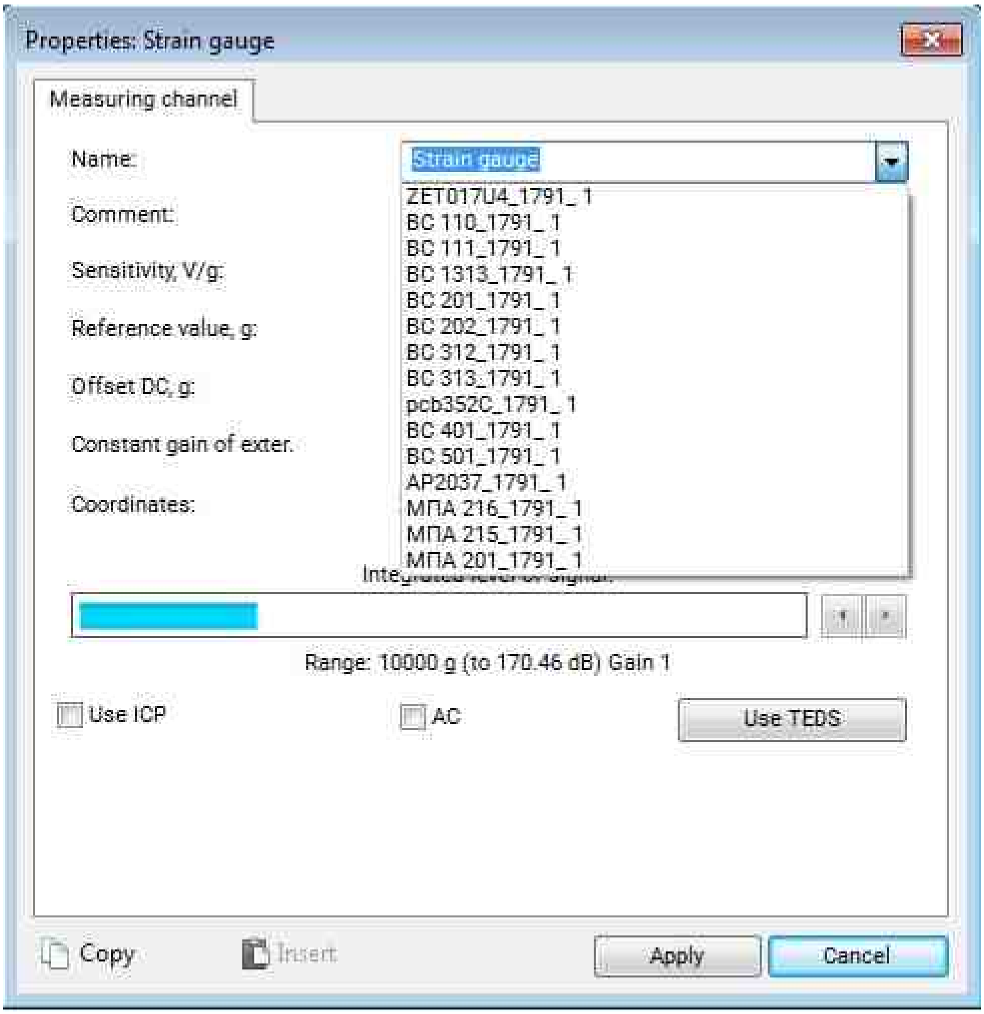


Fig. 7.9 "Properties" window with a list of sensors from the database

Attention! *When selecting the type of sensor to be connected from the "Name" list, the average value for this type of sensors is set in the "Sensitivity" field. It is necessary to manually adjust the value in the "Sensitivity" field so that it corresponds to the value specified in the passport or in the certificate of verification for the sensor.*

If desired, change (by entering from the keyboard) the name of the measuring channel to a convenient one for you.

Attention! *The ZETLAB software allows the assignment of identical names to measuring channels, but their further identification becomes difficult when working with the software*

If a sensor is connected to the measuring channel of the strain station, the type of which is not in the drop-down list, it is necessary to enter the required name of the measuring channel from the keyboard.

Attention! *In the case when you need access to an arbitrary setting for all parameters in the Properties window, in the Name field, select the top row with the identifier "ZET xxxxx" from the list (Fig. 7.9)*

The sensitivity of the measuring channel determines the binding of the recorded values to absolute (certified) values, taking into account the units of measurement. To set the sensitivity of the measuring channel, go to the Properties window.

Using the keyboard in the "Sensitivity" field of the "Properties" window (*Fig. 7.8*) set the required sensitivity value for the measuring channel.

When connecting sensors to the measuring channel of the device, as a rule, the sensitivity value of the sensor is set as the sensitivity value.

Note: *for information about the sensitivity values of the connected sensors, refer to the information provided in the passports or verification certificates.*

To save changes in the "Properties" window, you should activate the "Apply" button.

The most commonly used units of measurement can be selected from the drop-down list (*Fig. 7.10*), by activating the symbol opposite the "Sensitivity" parameter, or manually register the necessary unit of measurement from the keyboard.

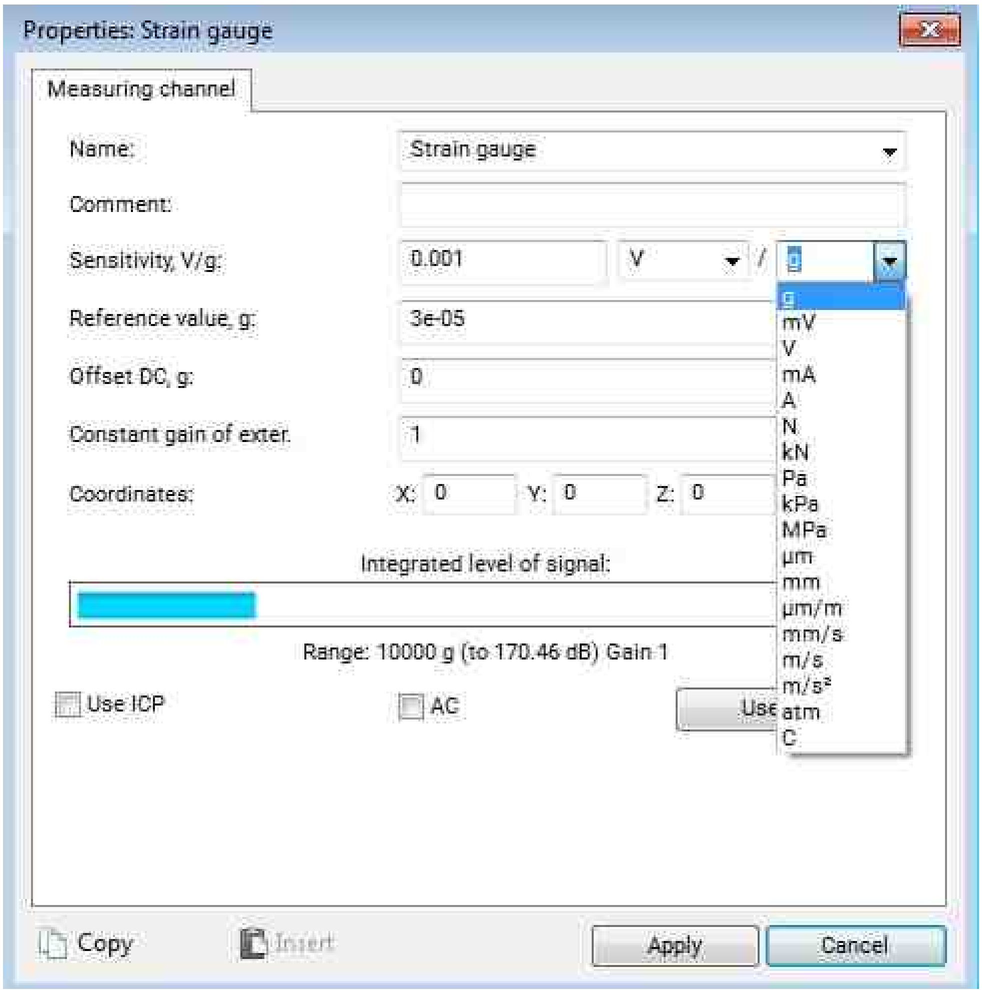


Fig. 7.10 "Properties" window with a list of units of change

Note: *if you need to specify the units of measurement, refer to the information provided in the passport for the connected sensor.*

The reference value is used to recalculate the values recorded in the measuring channel to the dB scale.

Using the keyboard in the "Reference value" field of the "Properties" window (*Fig. 7.8*), set the required reference value for the measuring channel.

Note: *when selecting units of measurement from the drop-down list, the corresponding reference value will be set automatically.*

Using the keyboard in the "Offset field. comp." windows "Properties" (*Fig. 7.8*), set the required offset value for the measuring channel.

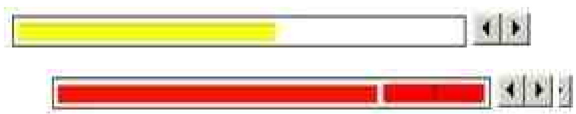
When connecting sensors using matching amplifiers, their gain factors must be taken into account.

Using the keyboard in the "Constant gain of exter. amplifier" field of the "Properties" window (*Fig. 7.8*), set the values of the constant gain of exter. amplifier.

Note: *in the absence of external amplifiers in the field "Constant gain of exter. amplifier" the value "1" is set.*

Integral signal level indicator of the "Properties" window (*Fig. 7.8*), allows you to estimate the recorded signal level via the measuring channel (*Fig. 7.11*), . The more the indicator scale is painted over (it is painted from left to right) the higher the level of the recorded values of the signal through the measuring channel.

Attention! *Complete coloring of the indicator scale should be avoided (Fig. 7.11), which means an overload of the measuring channel, the consequence of which is the occurrence of non-linear distortion, leading to unreliable measurement results.*



Operating range Overload

Fig. 7.11 Integral signal level indicator

In the Strain-gauge station, individually for each measuring channel, the following amplification-attenuation coefficient values can be set: 1; 10; 100.

If necessary, using symbols in the "Integral signal level" field, set the desired gain level.

Note: *In the case of a recorded overload on the measuring channel, the gain should be reduced; in the case of a low signal level, it should be increased.*

By activating the *AC* parameter, you apply a high-pass filter to the signal recorded in the measuring channel at the software level in all operation modes, in order to exclude the constant component from the signal.

To balance the strain gauge of the controller connected to the measuring channel in the "Properties" window (*Fig. 7.8*) necessary activate the "Tenso settings" button, this will open the "Bridge settings" window (*Fig. 7.12*).

Attention! *Each of the strain-gauge connection schemes requires power supply, therefore, before balancing, the corresponding adjustment of the built-in generator used to power the primary converters must be performed. Rules for setting up the generator are given later in this chapter.*

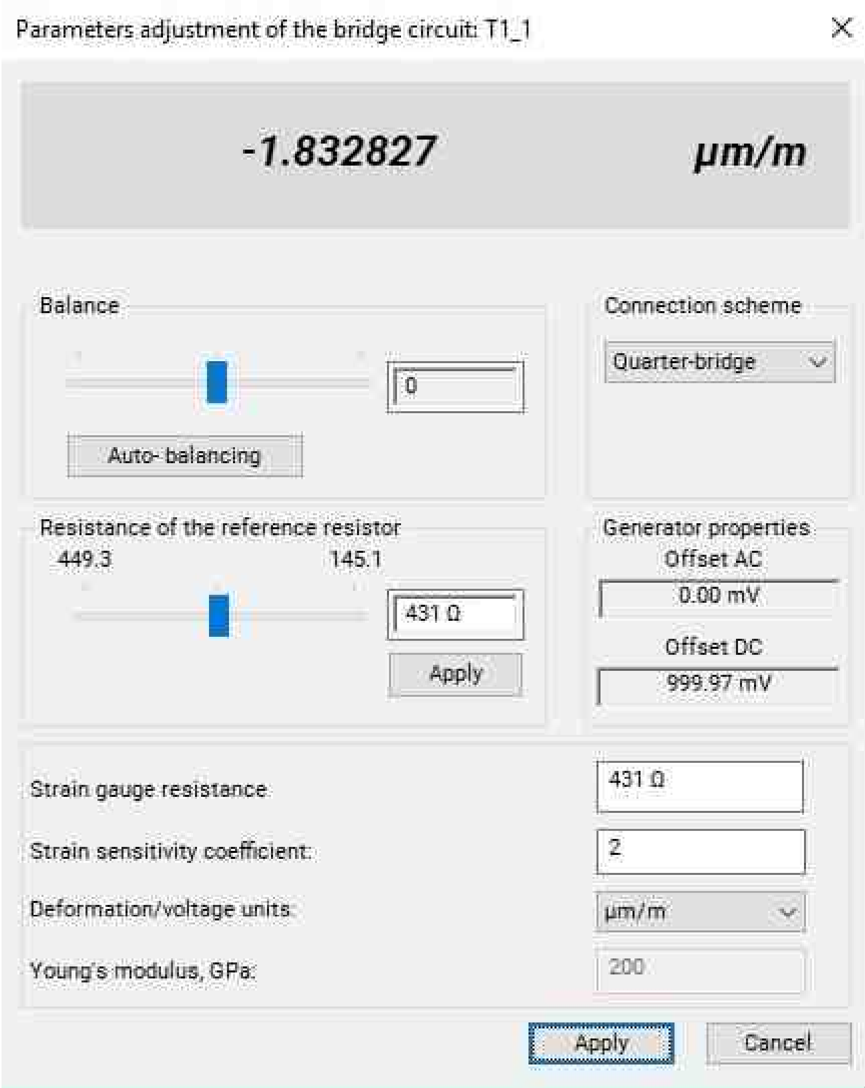


Fig. 7.12 The window "Adjustment bridge circuit parameters"

From the "Connection scheme" drop-down list (*Fig. 7.13*) select the appropriate connection diagram for the strain gauge:

- Bridge;
- Half-bridge;

- Quarter-bridge.

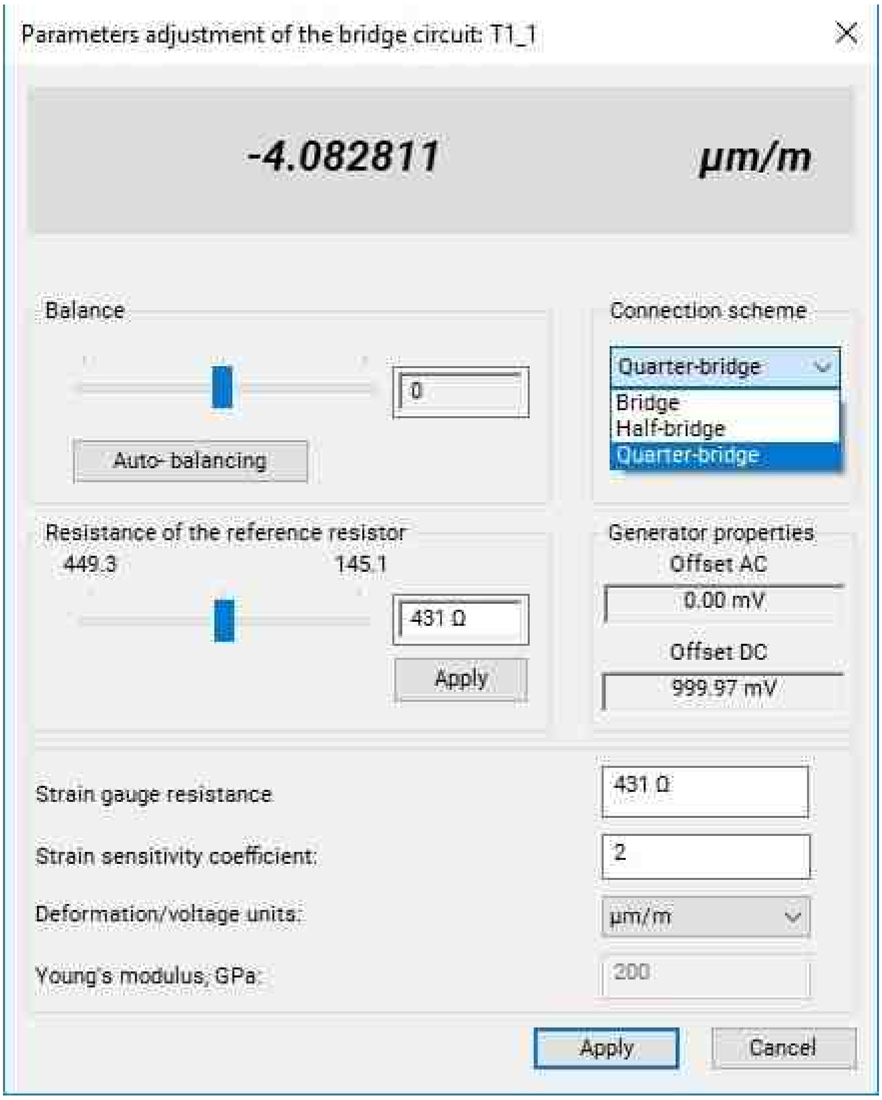


Fig. 7.12 The window "Adjustment bridge circuit parameters"

Note: *if the connection scheme "Quarter-bridge" is selected, it is necessary to set the resistance value of the connected strain gauge in the "Resistance of the quarter-bridge sensor" field (according to the passport data) and activate the "Apply" button.*

To balance the strain gauge , it is necessary activate the "Auto-balancing" button and wait for the end of the balancing process, after which you should apply the changes by activating the "OK" button.

Note: *when changing the value or sign of the supply voltage, it is necessary to perform auto-balancing.*

The units of measurement of the strain-gauge scheme are selected from the drop-down list in the "Settings of parameters of the bridge scheme" window (*Fig. 7.14*).

Note: *when selecting units of measurement other than "µm/m" in the "Young's Modulus" field, it is required to specify the value corresponding to the Young's modulus of the material on which the strain-gauge is glued.*

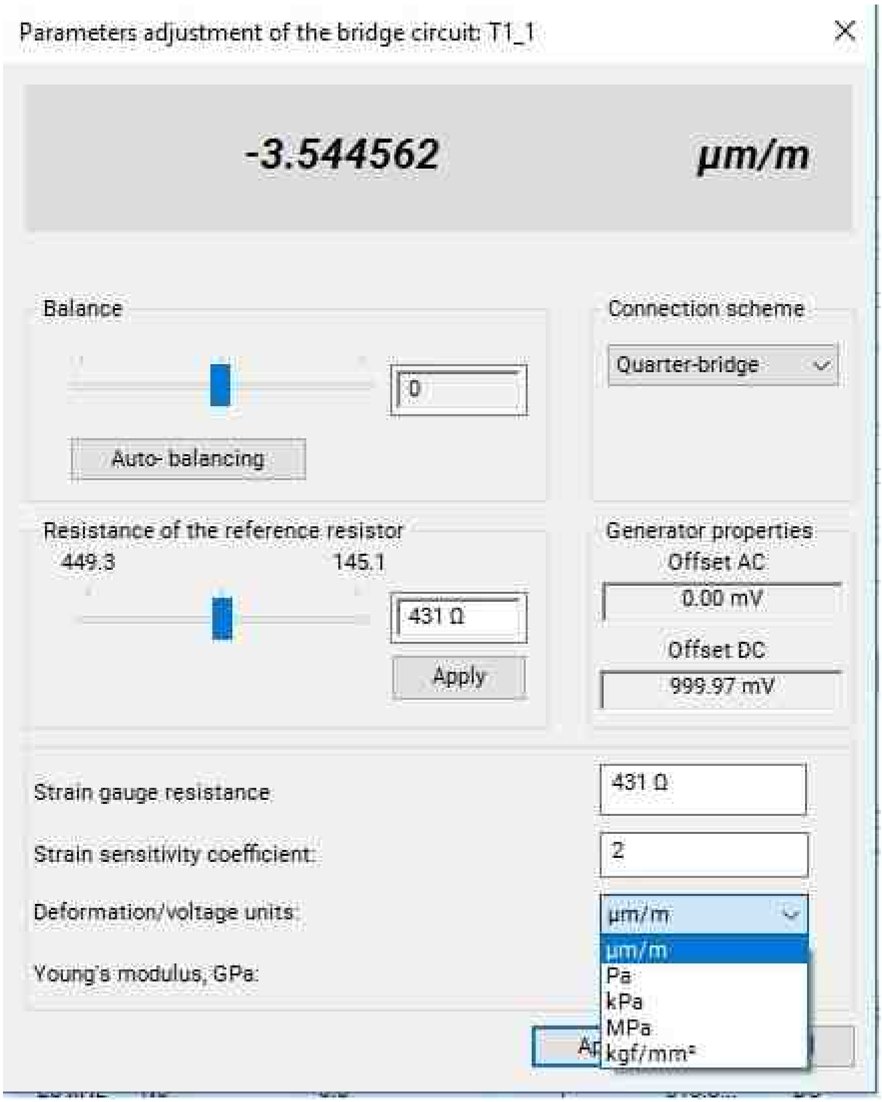


Fig. 7.14 The window "Adjustment bridge circuit parameters"

The ZET 058 controllers provide power to the primary converters with both constant and alternating voltage, due to which they can be used to collect and process signals during static or dynamic measurements.

To turn on the power of the primary converter, it is necessary to open the "Properties" window of the generator channel from the **"Device Manager"** (*Fig. 7.15*).

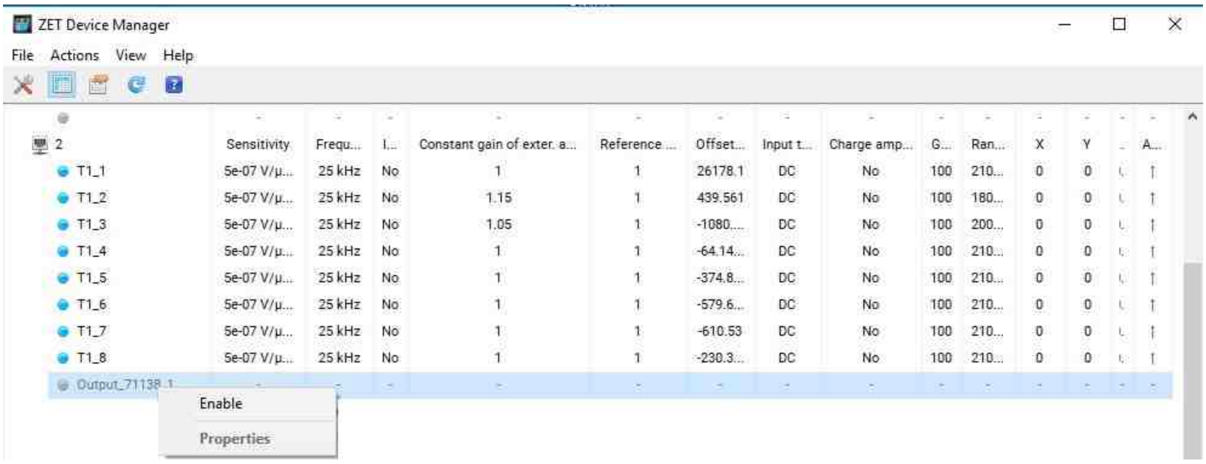


Fig. 7.15 The "Device Manager" window with a drop-down window on a dedicated channel generator

In the "Properties" window that opens, go to the "Sine" tab and set the appropriate power parameters of the primary converter (*Fig. 7.16*).

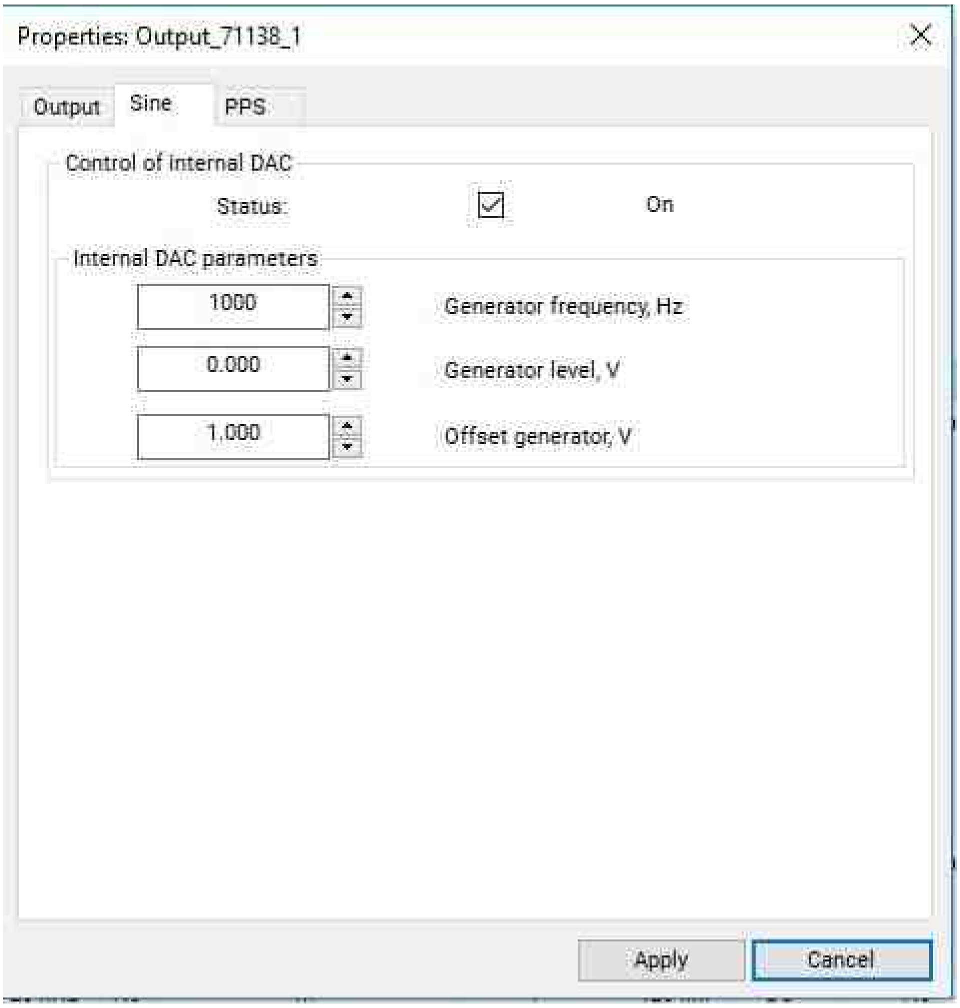


Fig. 7.16 The "Sine" tab of the generator channel

Attention! *It is forbidden to use an alternating voltage to power the j bridge circuit. The RMS value of the current flowing through the resistor should not exceed 5 mA.*

Go to the "Generator" tab and set the "Status" parameter to "Enabled"

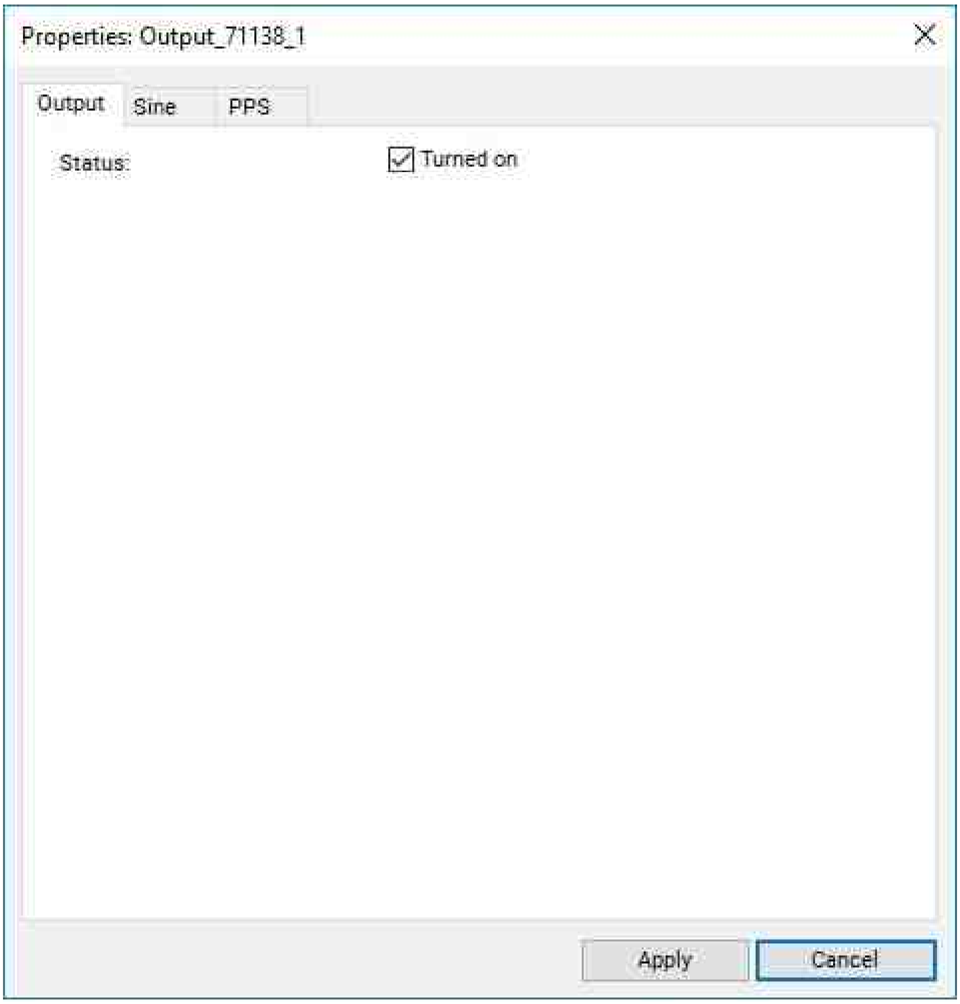


Fig. 7.17 The "Generator" tab of the generator channel

After powering up the primary converters in the "Device Manager" program, the symbol before the name of the generator channel should change color to blue (*Fig. 7.18*).

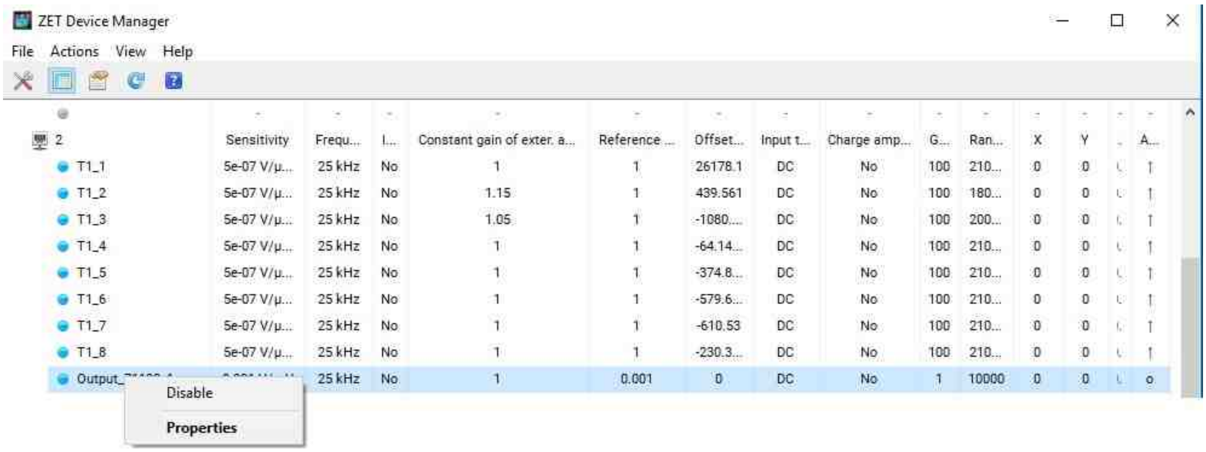


Fig. 7.18 The "Device Manager" program

Work in stationary registration mode .....

Connect the controller to the computer according to section 3 and setting (see section 4.6) the measuring channels of the controller in accordance with the types of connected sensors (primary converters),

Check available check-in times according to section 4.5.

Connect sensors (primary converters) or other sources of recorded signals to the controller inputs.

You can enable and disable the registration (recording) of signals either by hardware launch (using the "Start / Stop recording" button on the controller panel), or by software launch (using the "**Signals recording**" program).

In case of hardware start of registration, move the "Start/Stop recording" button (pos. 3 Fig. 1.4) to the "Pressed" position, while the "Signal Recording" program (Fig. 4.13) will be launched on the computer, which starts recording the recorded signals. To stop the recording, press the "Start / Stop recording" button again to transfer it to the "Pressed" position.

Attention! *If there is not enough memory on the computer disk to save the recorded data for at least three hours, then the message "Free disk space is not enough for recording" will be displayed in the program window (Fig. 4.14), and the signal recording will not be produced.*

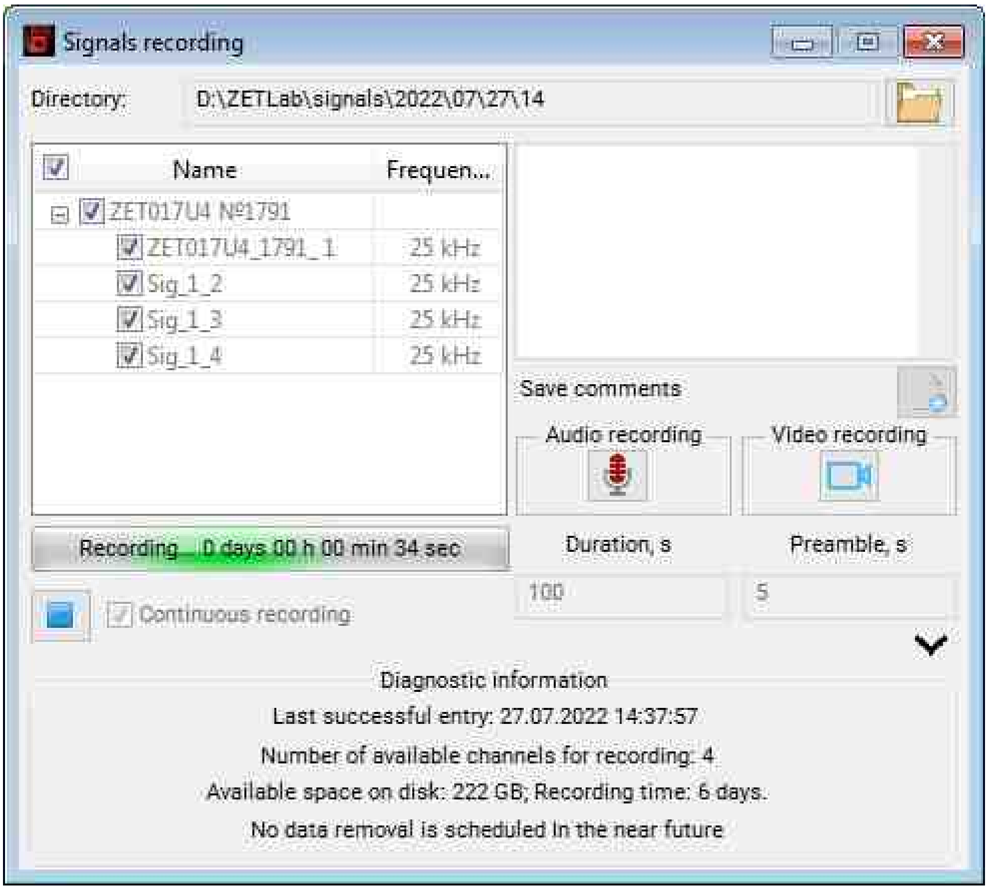


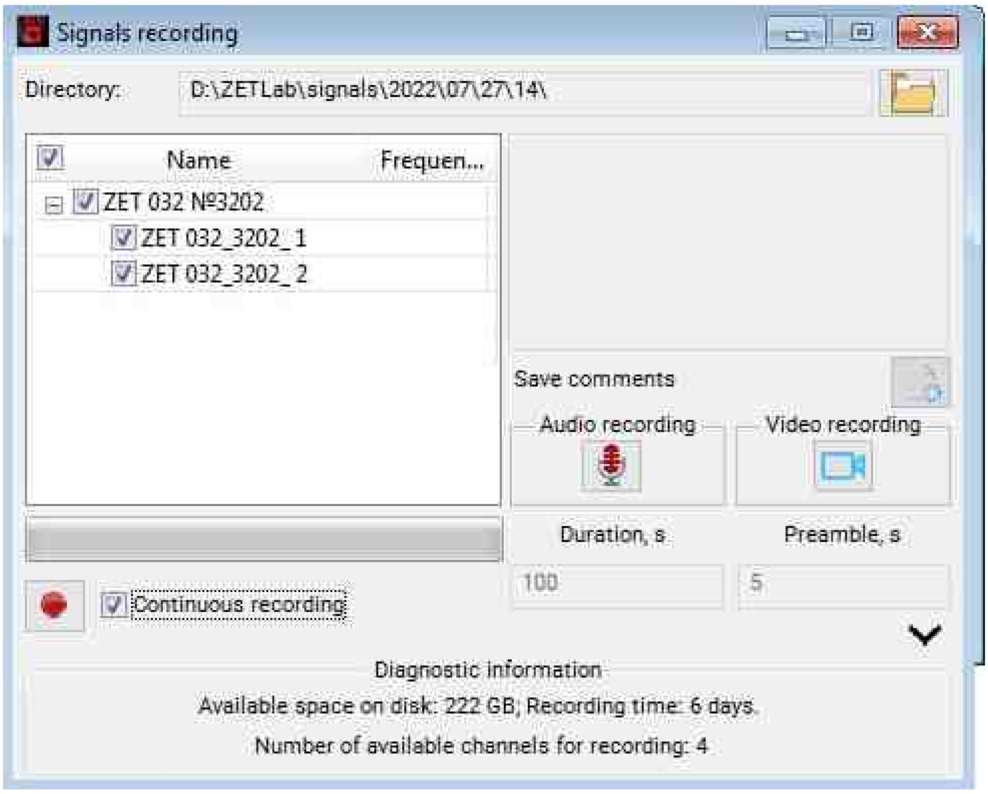
Fig. 4.13 "Signal recording" program window at hardware launch (from the controller panel)

Note 10

Available only for model ZET 032

*Rice. 4.14 "**Signal recording**" program window in case of insufficient free memory*

During program launch, in the "Registration" section located on the ZETLAB panel, select the "**Signal recording**" program (Fig. 4.1).



*. 4.15 Program window **Signal recording***

Then activate (if not activated) the parameter "Continuous recording"

Start recording by clicking on the button .

Click the button to end the recording. .

Note: *Paths to computer directories, which will be used for saving signals and compressed signals, are determined by the program "Configuration access adjustment" (see section 2.8).*

Work in stand-alone registration mode .....

Install (if not installed) a SecureDigital (SD) memory card into the slot located on the back of the controller.

If necessary, connect the controller to a computer in accordance with Section 3 to conFig. (see Section 4.6) the measuring channels of the controller in accordance with the types of connected sensors (primary converters), as well as to check the available memory card space and available offline registration time (see Section 4.5) .

Set up the controller at the offline recording location.

Connect sensors (primary converters) to controller inputs.

Apply power to the controller using one of the following options:

- from AC 220 V using the power supply included in the delivery;
- from a 12V battery using a cable with a soldered Mini-XLR 92M-502(3P) connector in accordance with the information given in section 1.6.2..

On the rear panel of the controller, move the "On/Off" button (pos. 7 of Fig. 1.6) to the "On" position (button "Pressed"). At the same time, the indicators on the front panel should light up in green: the operation status (pos. 4 of Fig. 1.4), as well as the indicator of the first measuring channel, which means that the controller is ready for operation.

To start recording, switch the "Start/Stop recording" button (pos. 3 Fig. 1.4) to the "On" position (the button is recessed), while the operating mode indicator starts flashing blue with a frequency of 1 second, informing about the recording of signals.

To stop recording, press the "Start / Stop recording" button again, moving it to the "Disabled" position (the button is released).

After carrying out the necessary stand-alone recording sessions, turn off the controller and disconnect the primary converters from the controller inputs.

Attention! *Do not turn off the power of the controller during stand-alone recording, as this may result in the loss of recorded information.*

For further work with the signals registered offline, you should connect the controller to the computer according to section 3. And copy the data to the computer disk according to section 4.9.

Note. *To view the recorded signals, use the program "View historical events" (Signal trends viewing) from the ZETLAB software (see ZETLAB Software. Operator's Manual*

Controller panel markings

1.4.1 Appearance of two-channel controllers ZET 032

On Fig. 1.1 shows the appearance of two-channel controllers ZET 032.

Fig. 1.1 Appearance of two-channel controllers ZET 032

1.4.2 Appearance of four-channel controllers ZET 034

On Fig. 1.2 shows the appearance of four-channel controllers ZET 034.

Fig. 1.2 Appearance of four-channel controllers ZET 034

1.4.3 Appearance of eight-channel controllers ZET 038

On Fig. 1.3 shows the appearance of eight-channel controllers ZET 038.

Fig. 1.3 Appearance of eight-channel controllers ZET 038

Note! *By combining controllers, measuring systems with up to 128 channels can be formed*

Controller panel markings

On Fig. 1.4 shows the front panels of the controllers ZET 032, ZET 034 and ZET 038, and in the table Tab. 1.3 shows the purpose of the panel elements.

Fig. 1.4 Front panels of controllers ZET 032, ZET 034 and ZET 038

Tab. 1. Purpose of the front panel elements

No.	Purpose
1	Measuring channel inputs with built-in indicators. Green color of the indicator - the operating mode "Voltage input" is enabled. Blue color of the indicator - the operating mode "ICP input" is enabled White color of the indicator - the "Charge input" operating mode is enabled
2	Generator output with built-in operation indicator. The green color of the indicator is the generator control mode from the computer. Generator blue color - offline generator control
3	Signal recording Start/Stop button
4	Controller operation status indicator (enabled/disabled). When the controller is turned on, the indicator lights up green
5	Controller operating mode indicator. When the controller is connected to a computer (stationary mode), the indicator lights up green. When the controller is operating (recording recorded signals to an SD card) without connecting to a computer (offline mode), the indicator flashes blue
6	Controller sync indicator. When the synchronization mode is "Master", the indicator lights up green. When the synchronization mode is "Slave", the indicator lights up in blue.
7	Error indicator.

	Lights up red when diagnosing an error or exceeding the allowable input voltage level on the measuring channel.

On Fig. 1.5 shows the rear panel of the ZET 032 controllers, in Fig. 1.6 rear panel of controllers ZET 034 and ZET 038, and in the table Tab. 1.4 shows the purpose of the panel elements.

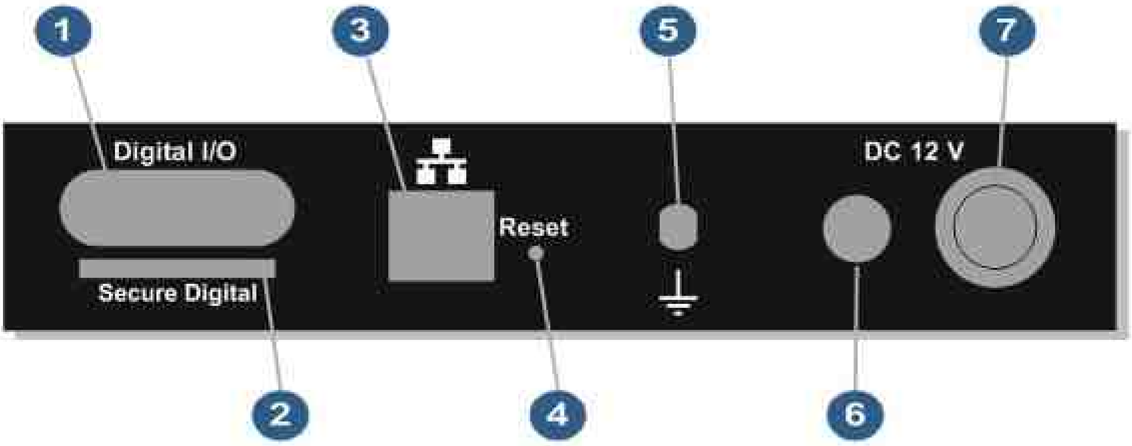


Fig. 1.5 Rear panel of ZET 032 controller

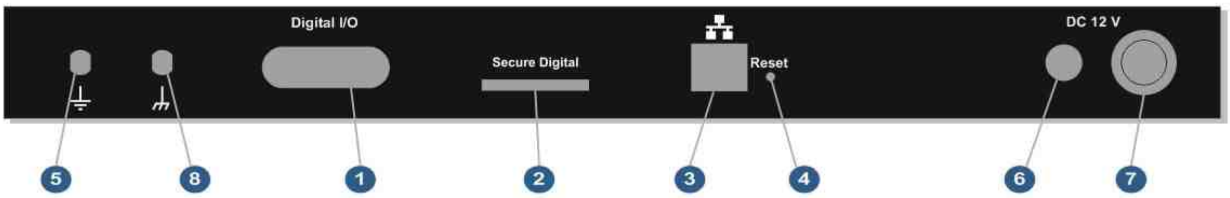


Fig. 1.6 Rear panel of ZET 034 and ZET 038 controllers

Tab. 1. Purpose of the rear panel elements

No.	Purpose
1	Digital input/output
2	SD card slot for recording signals and files with the extension "*.log" offline. Supports SD/SDHC card up to 32GB
3	Connector for connecting the controller to a computer via an interface Ethernet 10/100
4	Button "Reset" the address of the Ethernet port to factory settings.
5	Controller ground terminal
6	12 V power supply connector
7	Controller On/Off button
8	Controller generator ground terminal

Copying and converting data .....

How can one create user-friendly interface for the program used for data conversion? Is it possible not to get lost in large volume of the recorded data and to process only particular intervals of data recording? In order to address this task, we have developed a brand new program for data conversion.

After having thoroughly studied the most popular variants of the off-line recorders operation, we have outlined the following most common scenarios:

a) Conversion of files, which have been recorded for a particular time interval (this option is implemented as "Convert files in the interval");

b) Conversion of new files. This function is implemented as a separate option "Convert only new files";

c) Conversion of all the files. This option is available in the function "Convert all files on the disk".

Thus, the interface of the program used for data conversion has been changed (see Fig. 1). In order to simplify access to the program, we have realized the function of automated start of the program in the case if a new device is detected by ZETLAB software. Thus, the user can implement the required operation with a single click.

Note: the program SilentConverter (conversion of data accumulated by the off-line recorders) can also be started with the use of Device manager program (select the option Offline recorder - Convert).

The signal information registered in the controller's memory in offline mode has a format that requires subsequent conversion, which is performed simultaneously with copying to the computer's memory.

Note: *When converting, signals and compressed signals are created, which are saved on the computer in directories, the paths to which are determined by the "Configuration access adjustment" program (see section 2.8).*

To copy and convert data from the controller memory to computer memory, in the "Autonomous recorder" tab of the "Properties" window (Fig. 4.5), activate the "Convert" button, and the "Closing other programs" window will open with a choice of further actions (Fig. 4.16) .

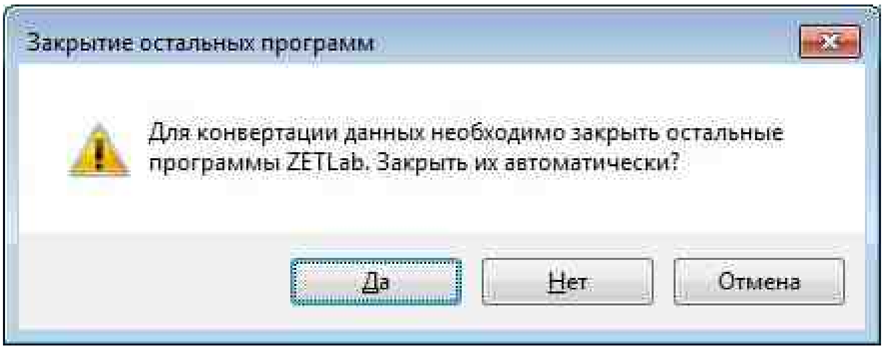


Fig. 4.16 "Closing other programs" window

Than activate the "Yes" button, this will close the open ZETLAB programs, and the window of the program for saving and converting files from the built-in memory of the recorder to the computer memory will open (Fig. 4.17).

Fig. 4.17 Program window "Select files to convert"

Select the desired time range, then activate the "Apply" button, this will start saving and converting files in the directory to the computer disk.

If the "Cancel" button is activated in the "Select files for conversion" window (Fig. 4.17), the corresponding window will be closed and data will not be copied.

Attention! *Premature interruption of the process of copying and converting files may lead to the need to restart the computer and the recorder.*

In the case of the first scenario, the user has to remember the exact time of the measurement performance. Standalone recorders manufactured by ZETLAB Company allow to register such parameters as the exact location of measurements, time, battery level and ambient temperature. The accumulated data is processed and displayed in comprehensive form (Fig. 4.16). Prior to viewing the measurement data, it is necessary to select the time interval of the measurements performance (see Fig. 4.18).

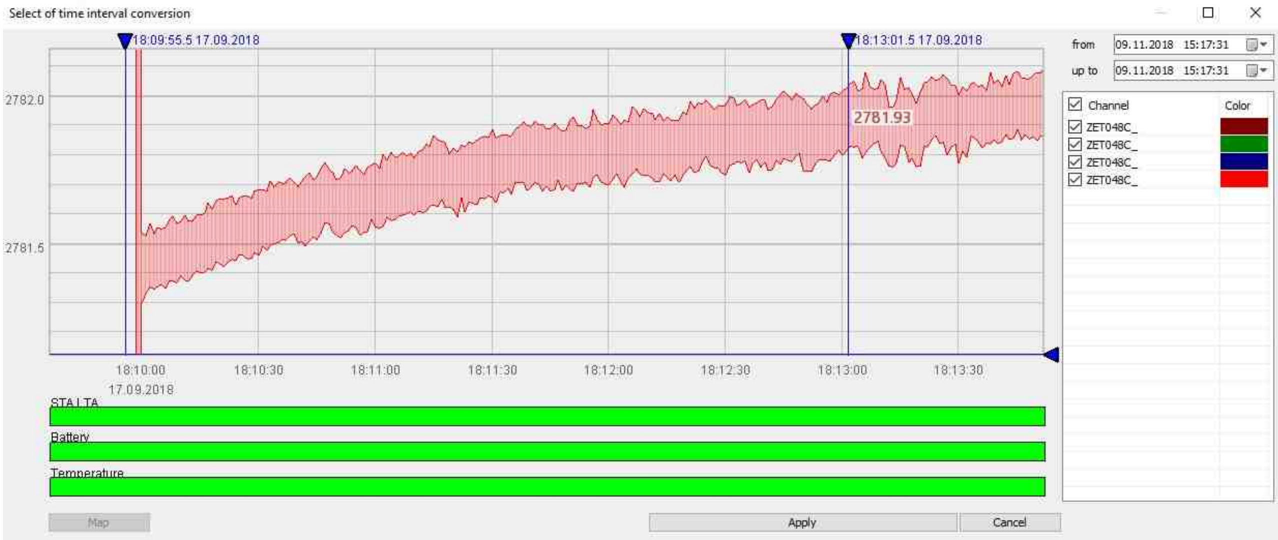


Fig. 4.18 – Selection of the time interval

In this section, we can observe the time of signals recording, view the results of integrated STA/LTA detector operation, view information about location of the device (to do that, click the "Map" key – see Fig. 4.19). It is also possible to control ambient temperature and battery charge level.

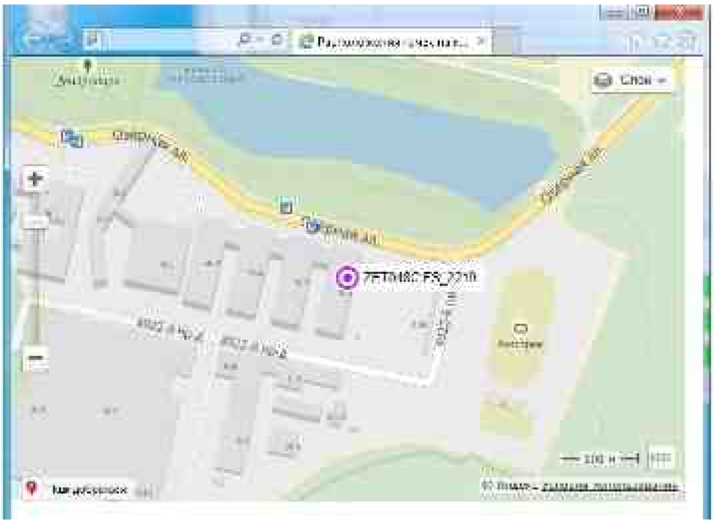


Fig. 4.19 – Displaying location of the instrument

As the files have been copied, the program begins data processing. The time required for copying and processing of the data depends on the file volume (e.g., it will take more than an hour to process 3Gb file).

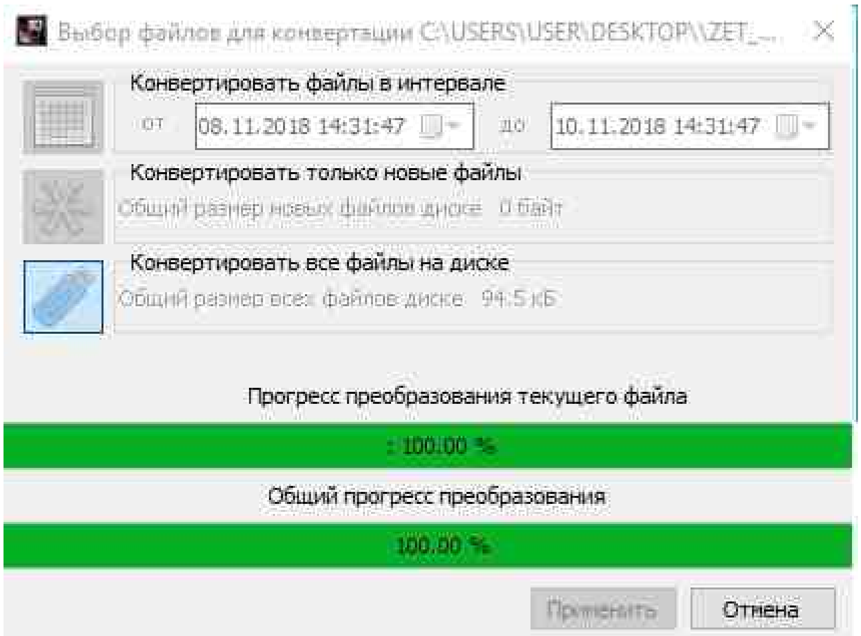


Fig. 4.20 – Data transfer and files conversion

As the data conversion process is complete (Fig. 4.21), the program will offer you to start the program for viewing historical events. The data will be automatically scaled for the required time interval (see Fig. 4.21, 4.22).

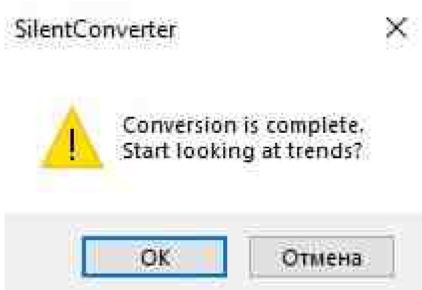


Fig. 4.21 – the program offers to start the program for viewing historical events

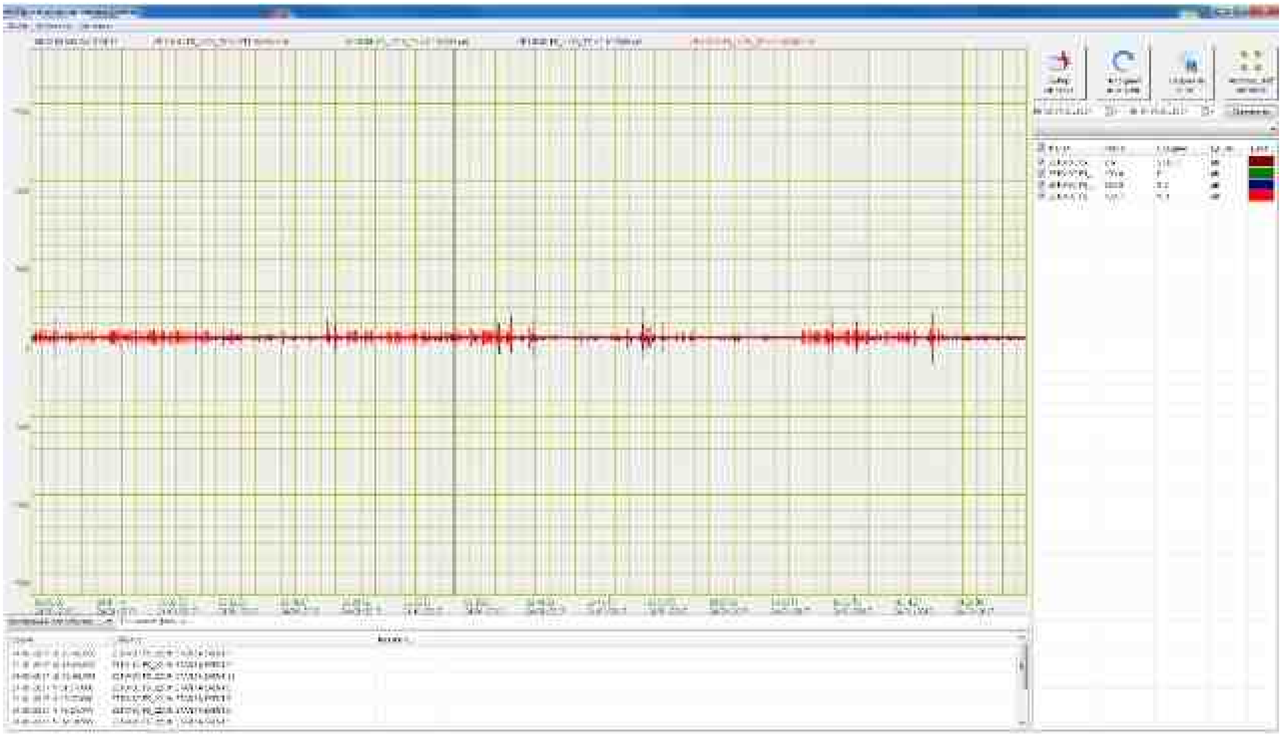


Fig. 4.22 – The program used for viewing historical events

Time ZETServer .....

The software is used for displaying the time after the ADC, **spectrum analyzer** or measuring instrument connected to the computer is started.

The program window will display a table consisting of two columns and rows. The number of rows is determined by the number of enabled physical and virtual channels generated by virtual devices. The physical channels are included in "Device Manager". Virtual channels are generated by such virtual devices as, for example, Signal generator, Signal Filtering, Formula etc.
The names of the channels will be displayed in the lines of the left column, in the lines of the right column the ADC start time for each channel in seconds. The time of the physical channels of one device must be the same. The time of the virtual channels is displayed with a slight delay relative to the time of the physical channels.

Supported Hardware .....

The **ZETServer time** software is a part of the following software:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT Spectrum software
- ZETLAB VIBRO – Shaker control systems software
- ZETLAB TENZO – strain-gauge station software
- ZETLAB SEISMO - seismic station software,
- ZETLAB NOISE - vibration meter-noise meter software,
- ZETLAB SENSOR - digital ZETSENSOR intelligent sensor software.

ZETServer time is a part of **Service** software group.

Program description .....

To run the program, the **ZETServer time** required in the Registration (*Fig. 1*) **ZETLab** panel choose ZETServer time. On the monitor screen displays the working window of the program, the **ZETServer time** (*Fig. 2*). From the top, the title bar displays the name of the program

Note: the **ZETLab** program (default: c: \ ZETLab \). The name of the startup file: ZETServerTime.exe.

Fig. 1 Starting ZETServerTime

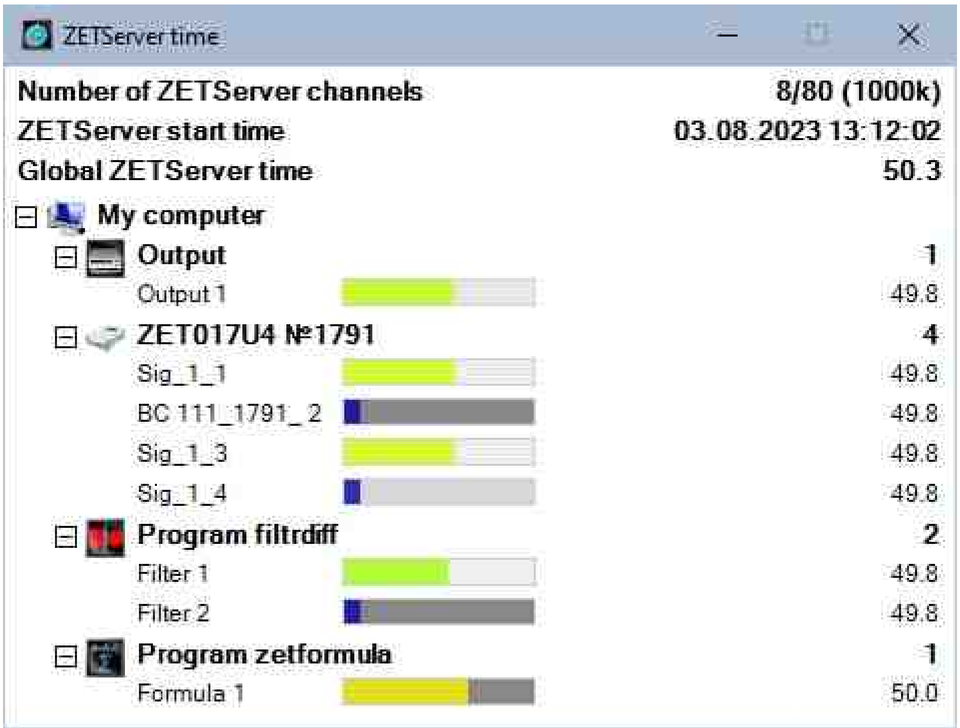


Fig. 2

In the number of channels **ZETServer time** added information about the number of valid channels with the selected device. In this case, we use 4 channels, and each channel is allocated a 1000 kB data buffer from the Server.

Most windows of ZETLAB programs that use recorded signals for processing (on the selected measuring channel) are equipped with a signal level indicator (Fig. 3), which graphically shows the integral level of the signal recorded at the current moment.

Fig.3 View of the indicator of the integral signal level

The signal level indicator allows the user to quickly evaluate the quality of the selection, matching and sensitivity settings of the elements that make up the measuring channel selected in the program and thereby exclude processing both in case of overloads and in the absence of a signal in the selected measuring channel.

Two-thirds of the signal strength indicator field is reserved for a level that does not exceed the maximum allowable level. The color rectangle that fills the background area of the indicator shows with its color and size the ratio of the registered signal (for a period of 0.1 seconds) to the maximum possible. The larger the signal in the channel, the wider the color rectangle and the color shade closer to red. When the maximum allowable signal level is exceeded, the indicator is filled in red. When the overload on the measuring channel ceases to be registered, the indicator area located on the right will remain red until the user resets the overload indication (fixed on the channel) by activating the overload zone of the left mouse button.

The indicators of the **ZETServer time** program window are also equipped with the function of changing the color of the background area of the indicator. This function allows you to perform the statistical quality of the recorded signal in the measurement channel. The more the signal is statistically similar to white noise, the brighter the background area. The less the signal resembles white noise, the darker the background. At rest, a healthy sensor signal should show background noise that is close to white in characteristics. The presence of interference (pulse, harmonic, etc.) or a malfunction in the sensor leads to a change in signal characteristics and darkening of the indicator background area.

The program window will display a table consisting of three columns and rows. The number of rows is determined by the number of enabled physical and child virtual channels. Physical channels are included in the program Device Manager. Virtual channels are generated by such programs as, for example, Generators, Signals filtration , Formula etc.

The lines of the left column will display the names of the channels, the lines of the right column will display the start time of the ADC for each channel, between them the current level of the channel will be displayed. The time of the physical channels of one device must be the same. The time of virtual channels is displayed with a slight delay in relation to the time of physical channels.

By clicking on the selected channel and pressing the right mouse button, you can view the channel settings (*Fig. 4*). And by pressing the left mouse button on the device, you can stop the time going through the channels and the level.

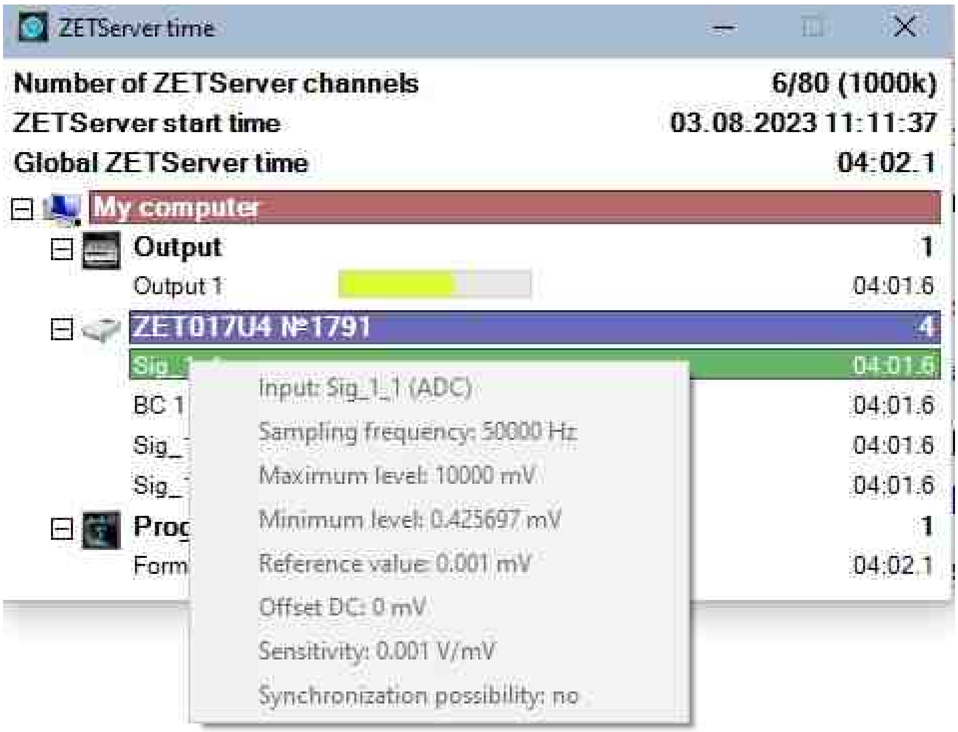


Fig. 4 View the channel settings

Exit the program by pressing a button , located in the upper right corner of the program window.

Synchronization control .....

The program "Synchronization Control" displays detailed information about events in the table (Fig. 1):

Inputs;

Time (ZETServer);

Time (Watermark);

Data quality;

Power supply quality;

Synchro quality;

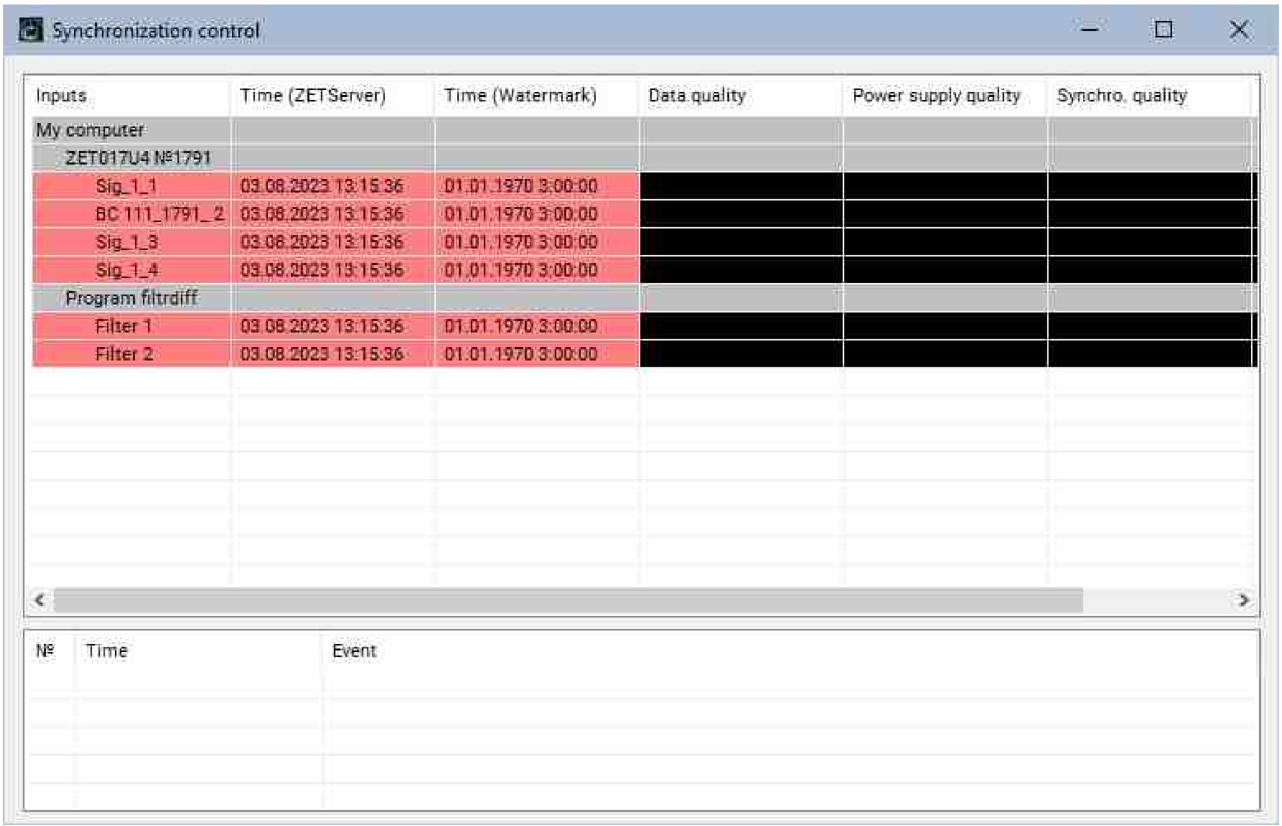


Fig. 1 Synchronization control

The event journal contains the following basic information:

Date and time of the event exceeding the specified parameters.

Supported Hardware .....

The input data of the **Synchronization control** program are the digital data of the following software:

- ZETLAB BASE - software supplied with ADC / DAC modules (optional);
- ZETLAB ANALIZ - software supplied with spectrum analyzers;
- ZETLAB VIBRO - software supplied with the shaker control system;
- ZETLAB TENZO - software supplied with strain gauge;
- ZETLAB SEISMO - software supplied with seismic stations;
- ZETLAB NOISE is the software supplied with the vibration sound level meter;
- ZETLAB SENSOR — software supplied with ZETSENSOR digital sensors (optional).

Synchronization control is included in the program group **Service.**

Program description .....

To start the **Synchronization control** program, it is necessary to select the **Synchronization control** command in the **Service** menu (*Fig. 1*) of the ZETLab panel. The operating window of the Synchronization Control program will be displayed on the monitor screen (*Fig. 2*).

Note: the program can be launched directly from the ZETLab working directory (by default: c:\ZETLab\). Executable file name: SynchronizationControl.exe.

Fig. 1 "Synchronization control" program from the "Service" menu

The **Synchronization control** program displays detailed information about events (*Fig. 2*).

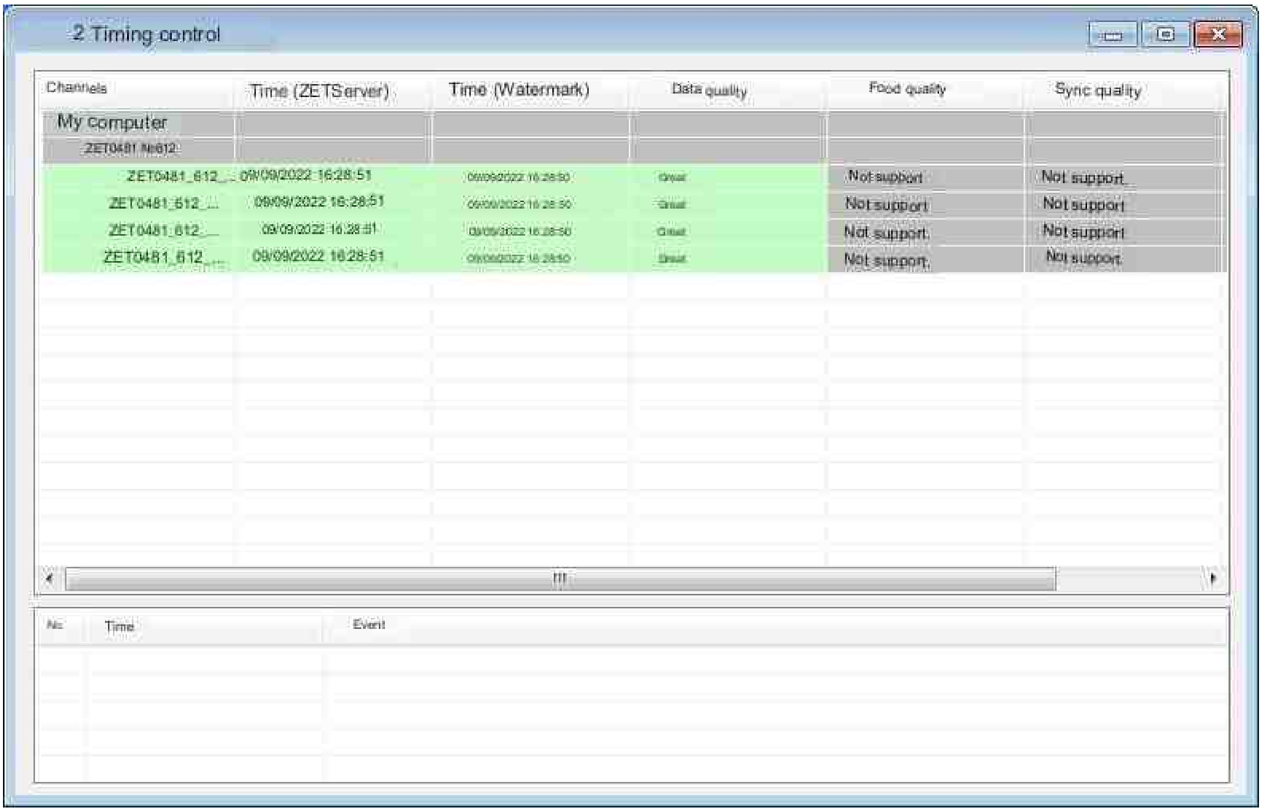


Fig. 2 Event journal

The event journal contains the following basic information:

Date and time of the event.

ADC Channel Listening .....

via a sound card

The program is used for listening to signals coming to the input channels of **ADC modules** and **FFT Spectrum Analyzers**.

When working with measurement objects in real conditions or through **signal Play recorded signals** from the recorded files, the user can listen to the data coming to the input channels of **ADC modules** and **FFT Spectrum Analyzers** via the PC sound card, which can be very useful during signal analysis in an acoustic range, since spectral analysis cannot always provide proper information about the analyzed values. For instance, distortion due to a short-term interference will be well audible for a human, while 1/3-octave analysis will not introduce any noticeable changes in the signal spectrum. This is due to the fact that the human ear, as compared to the analyzing instruments, can identify parasite sound sources much more distinctly.

For further analysis of acoustic information, it is possible to listen to the recorded signal time realizations in the analogue tape recorder mode.

Program purpose .....

via a sound card

The program is intended for listening the signals received at the input channels, and for listening signals of virtual channels and signals generated by the integrated generator.

Listening of signals received at input channels of ADC modules through the PC sound card can be very useful for signal analysis in the audible range since the spectrum analysis cannot always provide the adequate information on the values being analyzed. For instance, a distortion due to a short-time disturbance can be easily detected by ears while the narrow-band analysis will not reflect any significant changes in the signal spectrum. This is due to the fact that human ear, unlike the analyzing equipment, can much more clearly identify the parasite sound sources.

For subsequent analysis of the acoustic information in the analog tape recorder mode, the recorded time realization of signals can be listened to.

Supported Hardware .....

Input of the program "**Channel Listening**" is a digital data channel server **ZETLAB**, which is a digitized arbitrary variable signal. Under a variable signal in this case refers to a signal, the instantaneous magnitude of which depend on time. Settings of measurement channels are specified in the program "**ZET Device Manager**".

Channel Listening is a part of the following software:

- ZETLAB BASE – ADC/DAC module software;
- **ZETLAB ANALIZ** – FFT Spectrum Analyzers software;
- **ZETLAB VIBRO** – Shaker controllers systems software;
- **ZETLAB TENZO** – Strain-gauge station software;

- **ZETLAB SEISMO** – Seismic station software;
- ZETLAB NOISE – vibration meter-noise meter software;
- ZETLAB SENSOR – digital ZETSENSOR sensor software.

Channel Listening is included in the **Service** software group.

Program description .....

To launch the **Channel listening** program, select the **Channel listening** command from the **Service** menu (*Fig. 1*) on the ***ZETLab*** panel. The **Channel listening** program working window will be displayed (*Fig. 2*). The window heading will display the program name and the name of the channel selected for listening.

Note: the program can be started from ZETLAB directory (by default: C:\ZETLAB\). Name of the file: Listener.exe

Fig. 1 Channel listening command from the Service menu

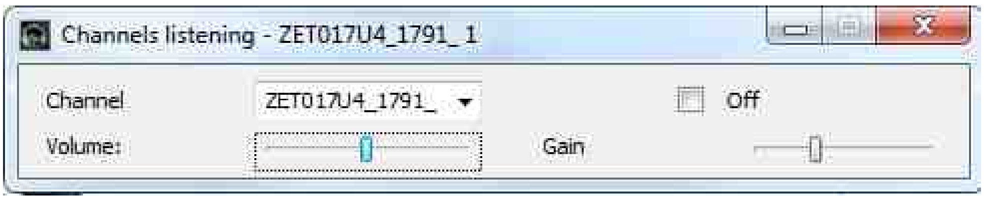
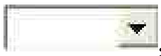


Fig. 2 User interface

The channel for listening is selected in the list field (with an arrow) , in the left part of the program.

On the right from the **Sound level** text, there is the sound volume controller, . The volume is controlled using the roller. To adjust the level, left-click on the roller and, holding the button pressed, move the roller in the desired direction. When the roller is moved to the left, the sound level decreases; to the right, increases. When the sound level is set by the roller, from the beginning point and to the middle point of the sound level controller, sound level is controlled; then, digital signal amplification takes place, which may cause distortions.

The **Off** flag: enables/disables listening to a selected channel.

To exit the program, press ,in the right upper corner of the window.

OPC UA data client .....

A new feature has appeared in the ZETLAB software, namely, to connect to OPC UA data servers, subscribe to their tags and receive data in the form of channels in the ZETLAB system.

ZETLAB Error journal .....

ZETLAB Error journal is used for creating and sending error logs from a spectrum analyzer, strain-gauge station, ADC/DAC module or other measuring instrument to the developer of ZETLAB software (ZETLAB Company).

All errors (lags, glitches, incorrect functioning of programs) in ZETLAB software for ADC/DAC boards, spectrum analyzers, strain-gauge stations, etc. are recorded in a log file. This log file is sent to the software developer (provided there is access to the Internet) via **ZETLAB Error journal**. After receiving the error log file, ZETLAB Company specialists take all necessary measures to eliminate the faults causing failures in ZETLAB software and drivers functioning.

ZETLAB programs can function independently from an operator, which is why the programs present their messages not as dialog boxes, but record them in the application log which can be viewed in **ZETLAB Error journal** via ZETLAB "Service" control panels.

In the log, the programs record not only error messages, but also messages regarding any changes in their parameters. The recorded messages help to trace back the sequence of program actions, which is often useful for analyzing errors occurring during the program operation.

Supported Hardware .....

ZETLAB Error journal is a part of the following software:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT Spectrum Analyzers software;
- ZETLAB VIBRO – Shaker control systems software;
- ZETLAB TENZO – strain-gauge station software;
- ZETLAB SEISMO – seismic station software;
- ZETLAB NOISE – vibration meter-noise meter software
- ZETLAB SENSOR – digital ZETSENSOR sensor software

ZETLAB Error journal is included in the **Service** software group.

Program description .....

To Starting the **ZETLAB Error journal** program, select the **ZETLAB Error journal** command from the **Service** menu (*Fig. 1*) on the ***ZETLab*** panel. The **ZETLAB Error journal** program working window will be displayed (*Fig. 2*). The window heading will display the program name and the name of the channel selected for listening.

Note: the program can be started from ZETLAB directory (by default: C:\ZETLAB\). Name of the file: ZETMessenger.exe.

Fig. 1 ZETLAB Error journal command from the Service menu

ZETLAB Error journal is used for creating and sending error logs from a spectrum analyzer, strain-gauge station, ADC/DAC module or other measuring instrument to the developer of ZETLAB software (ZETLAB Company).

All errors (lags, glitches, incorrect functioning of programs) in ZETLAB software for ADC/DAC boards, spectrum analyzers, strain-gauge stations, etc. are recorded in a log file. This log file is sent to the software developer (provided there is access to the Internet) via **ZETLAB Error journal**. After receiving the error log file, ZETLAB Company specialists take all necessary measures to eliminate the faults causing failures in ZETLAB software and drivers functioning.

ZETLAB programs can function independently from an operator, which is why the programs present their messages not as dialog boxes, but record them in the application log which can be viewed in ZETLAB Error journal via ZETLAB "Service" control panels.

In the log, the programs record not only error messages, but also messages regarding any changes in their parameters. The recorded messages help to trace back the sequence of program actions, which is often useful for analyzing errors occurring during the program operation.

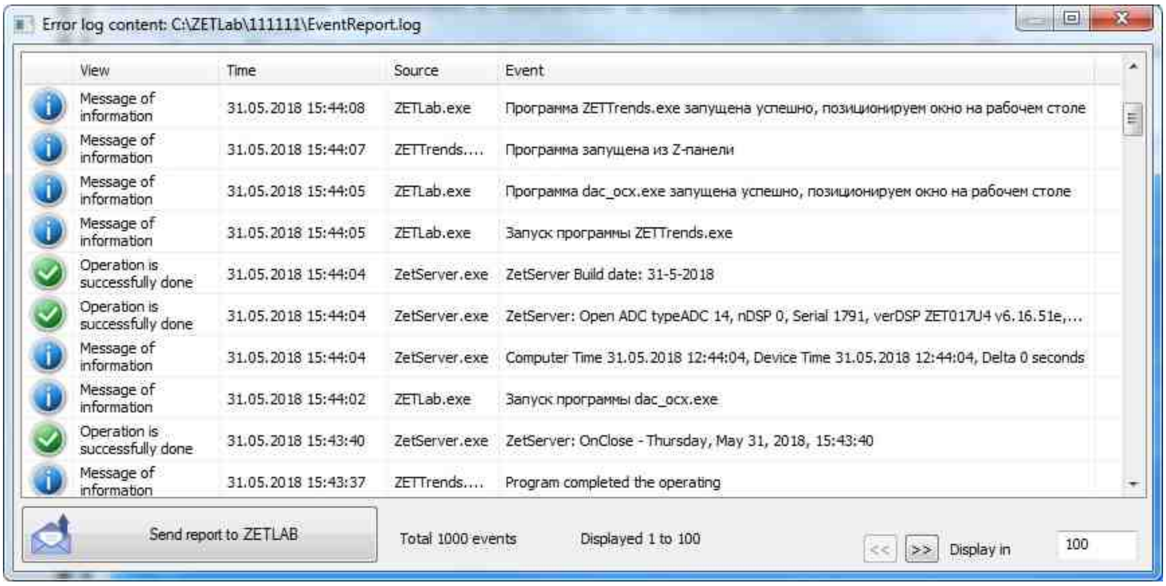


Fig. 2 User interface

To exit the program **ZETLAB Error journal**, press ,in the right upper corner of the window..

ZETLab event journal .....

The **ZETLab event journal** program displays detailed information about cases when the parameters exceed the set thresholds (*Fig. 1*).

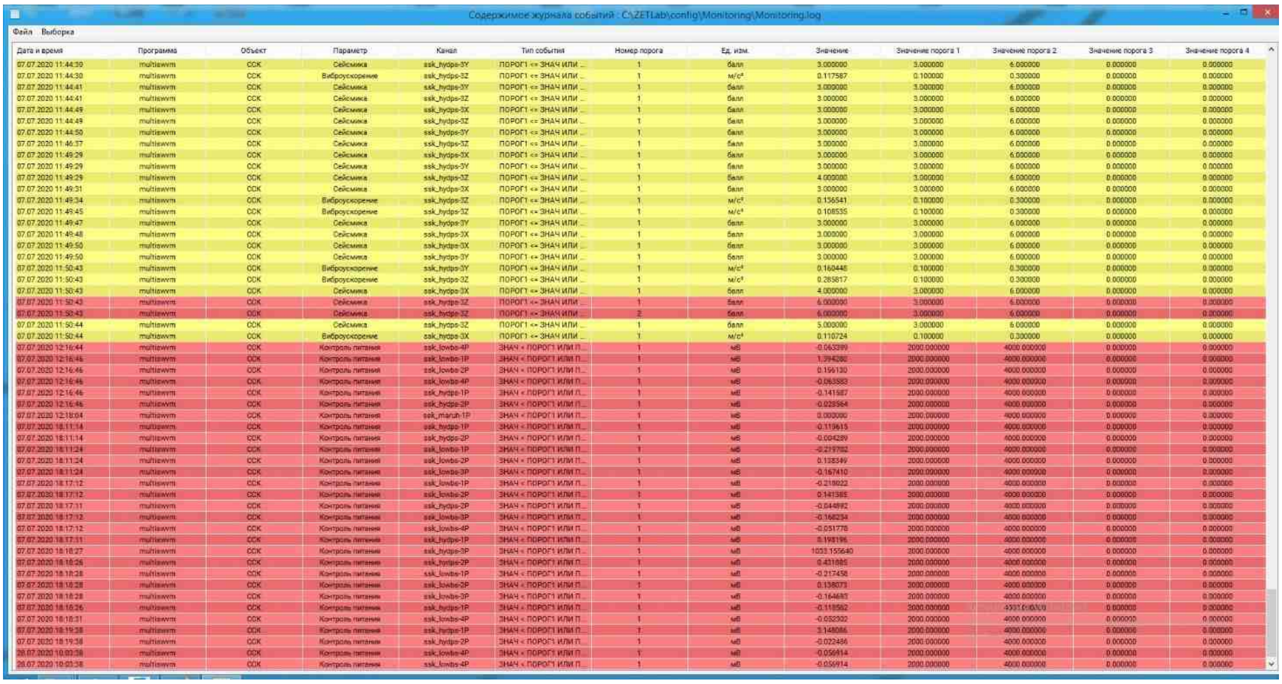


Fig. 1 ***ZETLab event journal***

ZETLab event journal contains the following basic information:

Date and time of the threshold exceeded event.

The parameter for which the threshold was exceeded.

The measured value of the parameter.

If you need to view the registered signals on the graphic, you should use the "Signal trends viewing" program.

Supported Hardware .....

ZETLab event journal is a part of the following software:

- ZETLAB BASE – ADC/DAC module software
- ZETLAB ANALIZ – FFT Spectrum Analyzers software;
- ZETLAB VIBRO – Shaker control systems software;

- ZETLAB TENZO – strain-gauge station software;
- ZETLAB SEISMO – seismic station software;
- ZETLAB NOISE – vibration meter-noise meter software
- ZETLAB SENSOR – digital ZETSENSOR sensor software

ZETLab event journal is included in the **Service** software group.

Program description .....

To Starting the **ZETLAB event journal** program, select the **ZETLAB event journal** command from the **Service** menu (*Fig. 1*) on the ***ZETLab*** panel. The **ZETLAB Error journal** program working window will be displayed (*Fig. 2*). The window heading will display the program name and the name of the channel selected for listening.

Note: the program can be started from ZETLAB directory (by default: C:\ZETLAB\). Name of the file: ZetEventJournal.exe.

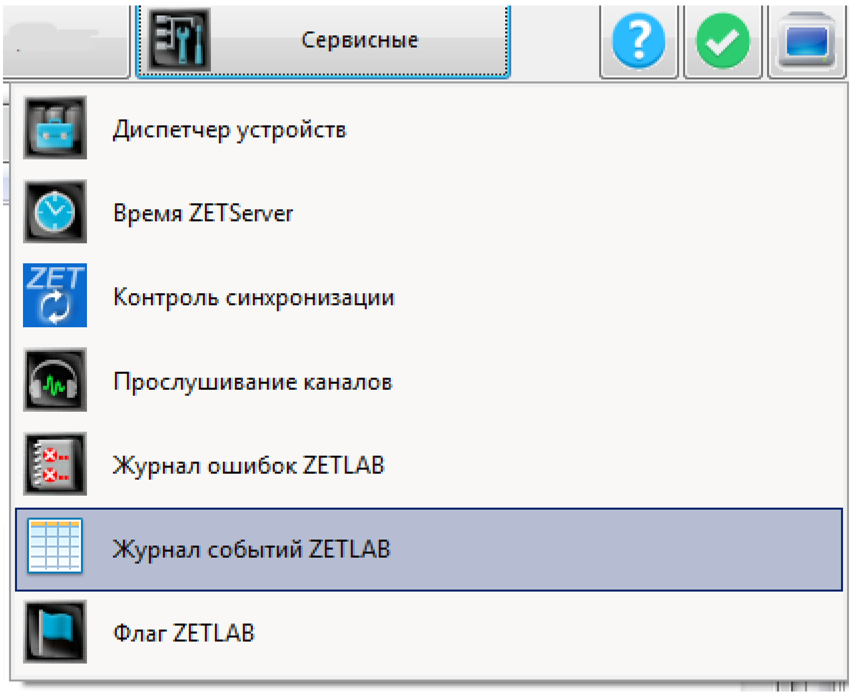


Fig. 1 ZETLab event journal program from the "Service" menu

The **ZETLAB event journal** program displays detailed information about cases when the parameters exceed the set thresholds (Fig. 2).

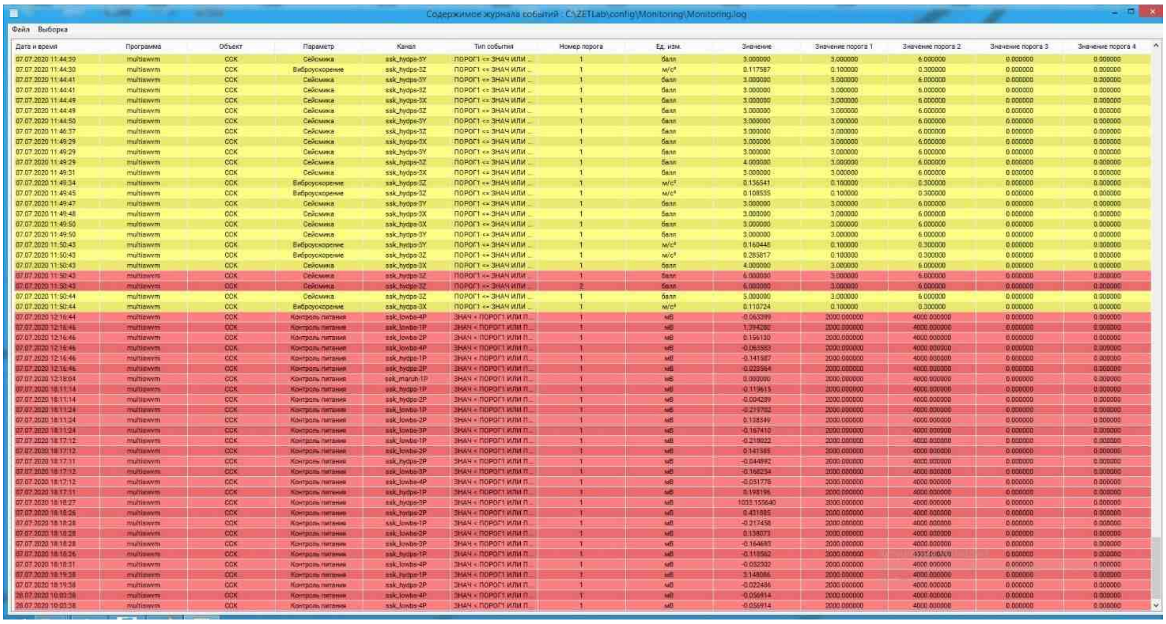


Fig. 2 ZETLAB event journal

The event log contains the following basic information:

1. Date and time of the threshold exceeded event.
2. The parameter for which the threshold was exceeded.
3. The measured value of the parameter.

If you need to view the registered signals on the graphic, you should use the **Signal trends viewing** program.

Monitoring settings editor .....

Object monitoring in the ZETLAB software is designed to collect and process primary information from sensors installed on the object in order to continuously calculate and store object parameters that allow (*Fig. 1*) :

- draw conclusions about the performance of the object;
- generate events both when an object transitions to a different functional status (events of the "Danger" type), and in the event of a situation preceding such a status transition (events of the "Warning" type).

Note: In the "Editor of monitoring parameters" it is necessary to configure a set of channels only one for each unit of measurement, if two are configured, as indicated in (*Fig. 1*), then only one upper set will be used in the program.

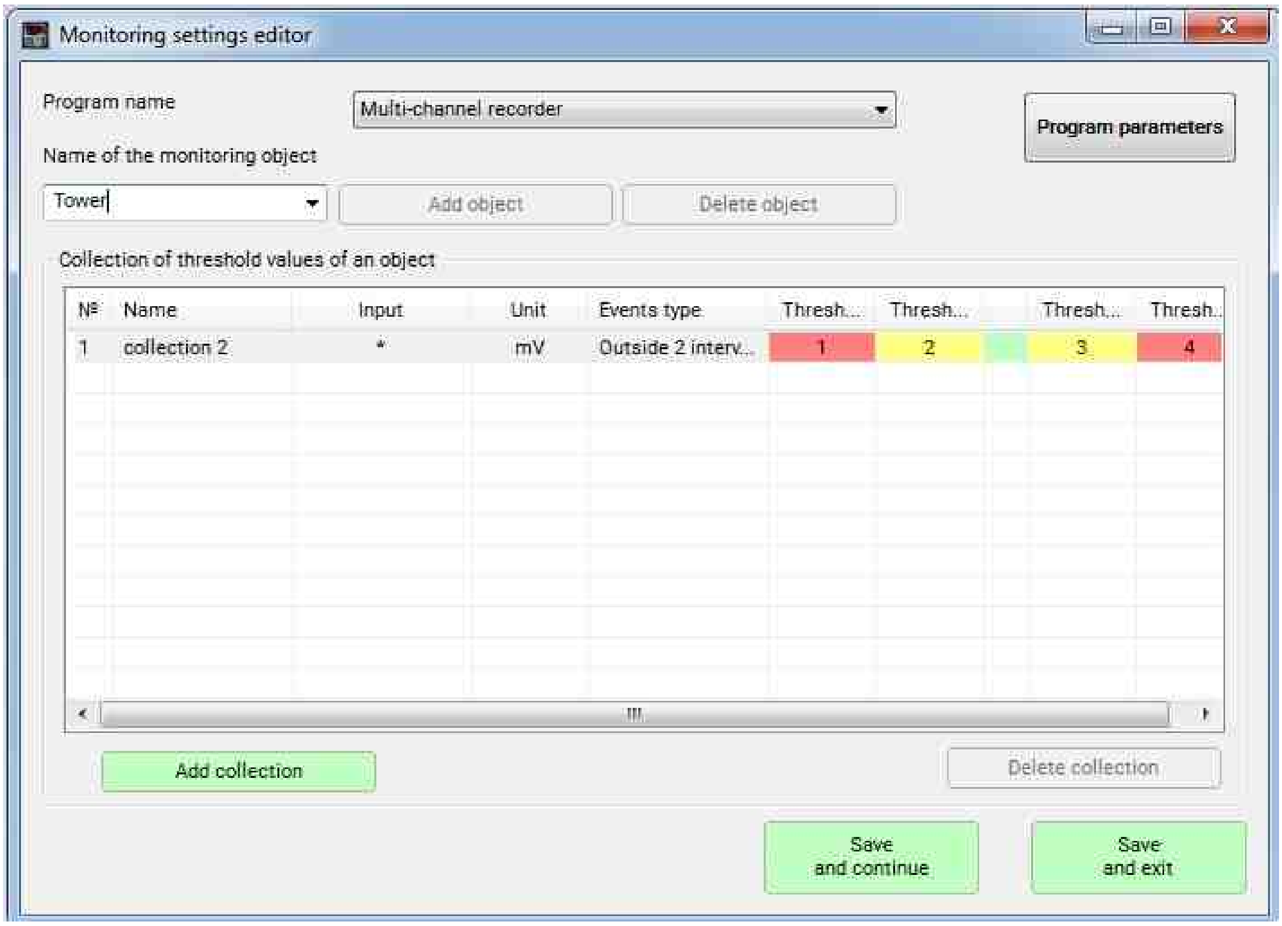


Fig. 1 Program user interface

Monitoring settings editor program provides the user with the ability to set the necessary threshold values in such programs as:

- Multichannel recorder;
- Group multi-channel recorder;

- Cross-Correlation Analysis;
- FFT Spectrum Analysis.

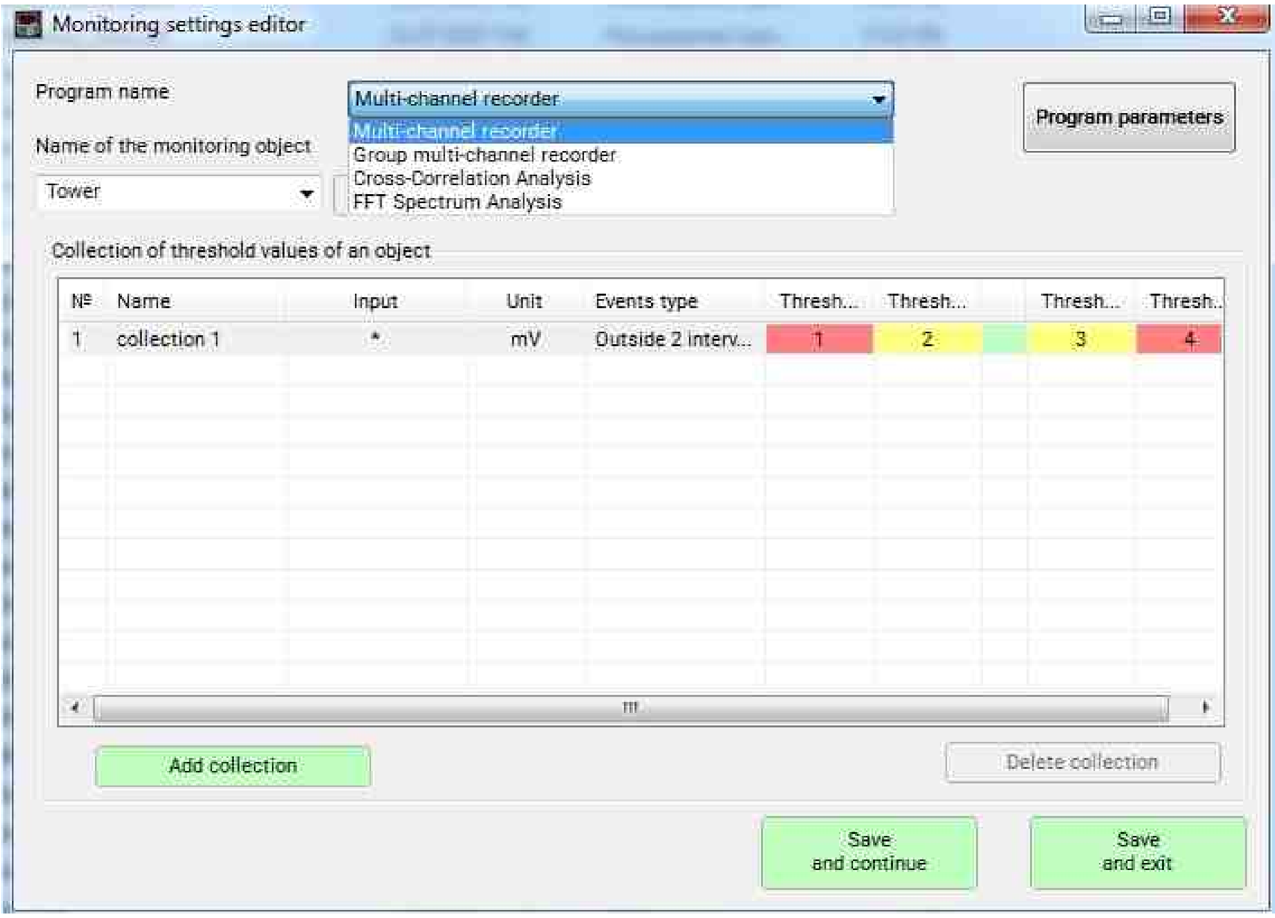


Fig. 2 List of program names

When launched, the "Program Options" button launches an additional window with program settings.

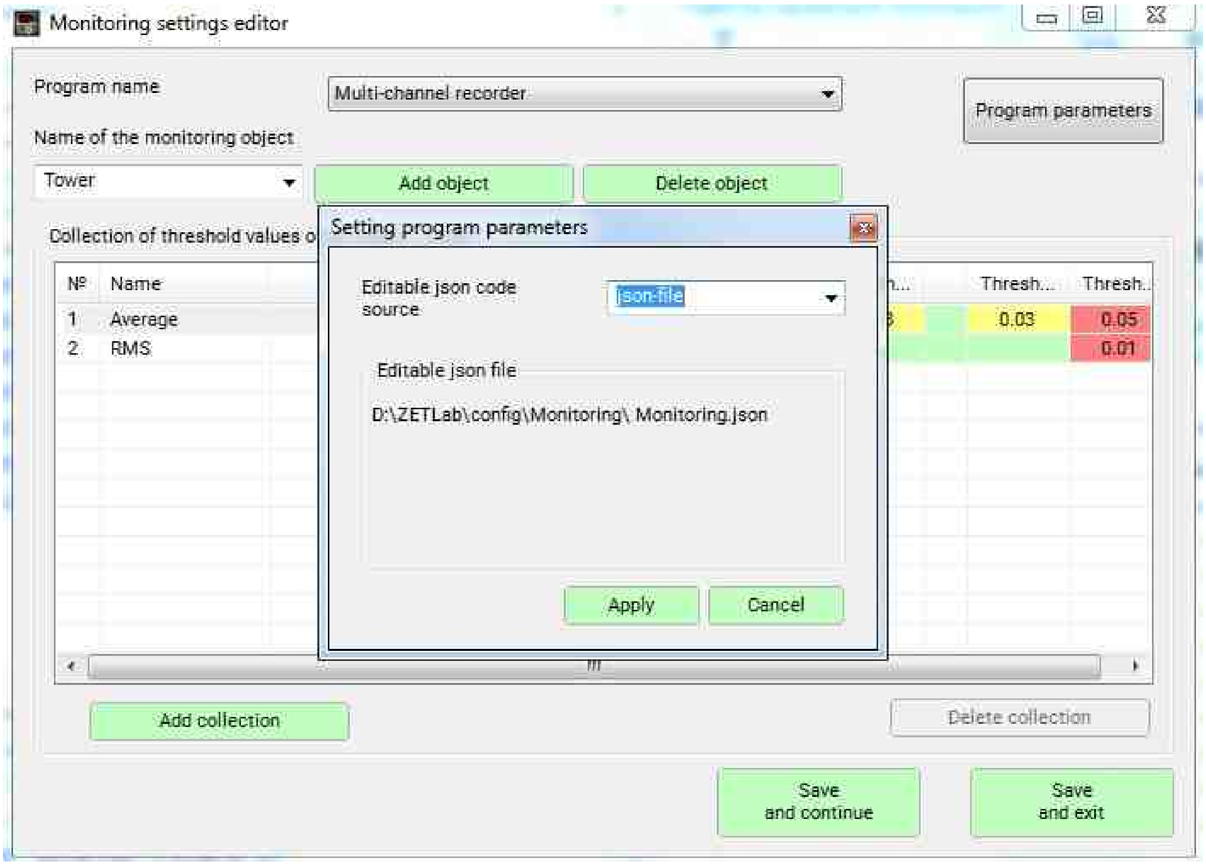


Fig. 3 Additional window with program settings

In the next field, you must select the Name of the monitoring object that the programs will work with after creation and editing. It is allowed to delete unnecessary objects and, if necessary, add new objects.

In the Set of threshold values table of an object, for example, Tower, you can edit the existing sets of channels, but also add a new set. When you click the right mouse button, another window will appear that needs to be fixed.

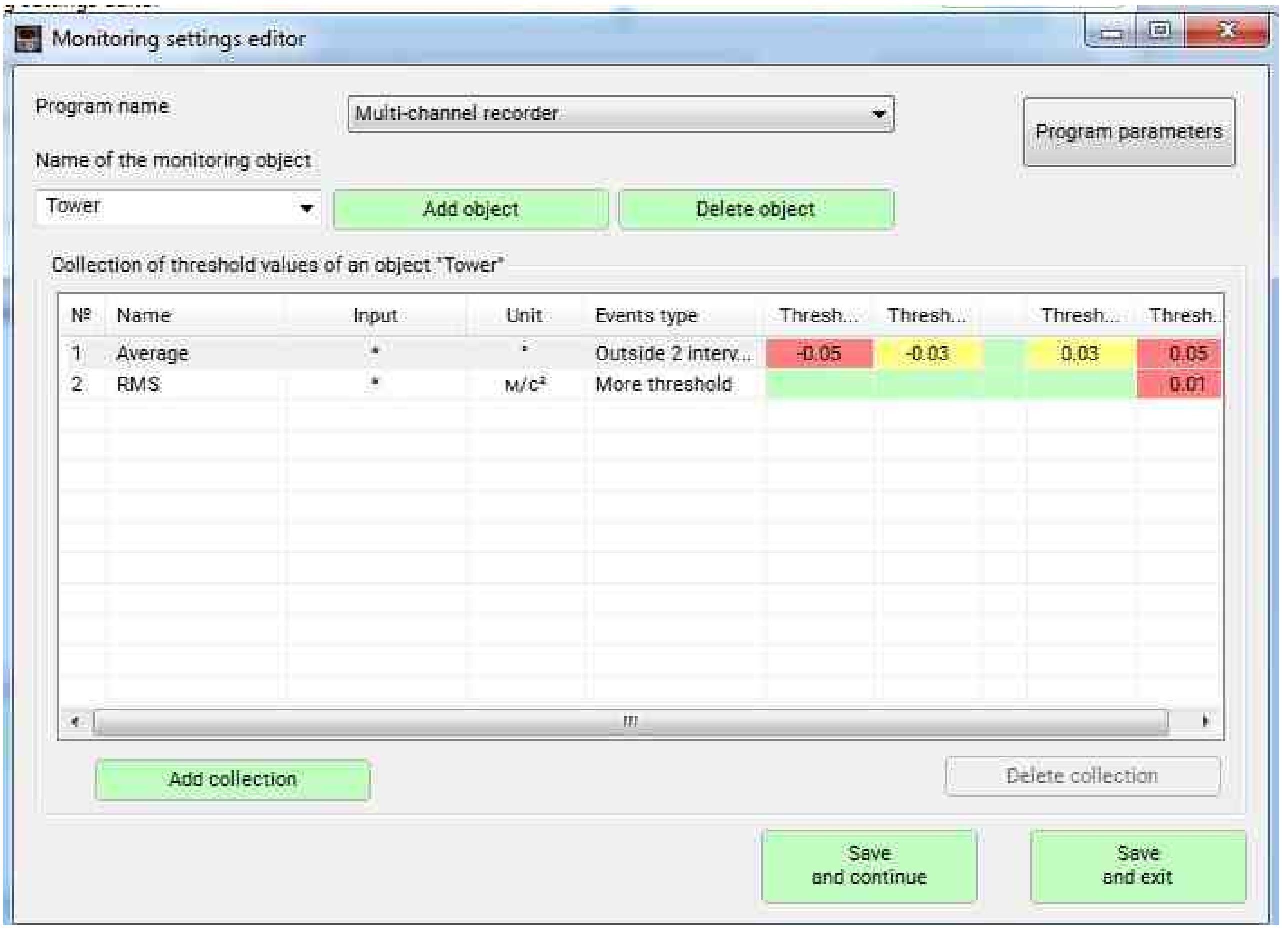


Fig. 4 Adding and editing sets with thresholds

In the "Monitoring settings editor" window, you need to set a unique "set name" and specify which channels this threshold will be applied to. Channels are selected by name and unit of measurement. The channel name must match the specified "channel name pattern". If the "*" character is specified in the text field, all channels will be selected. If you want to select only channels among all channels whose name begins with "Accel", then write "Accel*" in the text field. If you specify a string without special characters in the text field, only one channel will be selected, whose name exactly matches the specified string. It is the same with units of measurement. You can specify the name of the unit of measurement to select only certain channels, or specify the "*" symbol to select channels with any units of measurement. It is undesirable to leave the field empty. Then you need to select the "event type", which will determine which thresholds will be active, and set the threshold values in the active fields. To avoid problems, if the yellow and red fields for setting thresholds are active, "threshold value 4" should be set more than "threshold value 3", and "threshold value 1" is less than "threshold value 2".

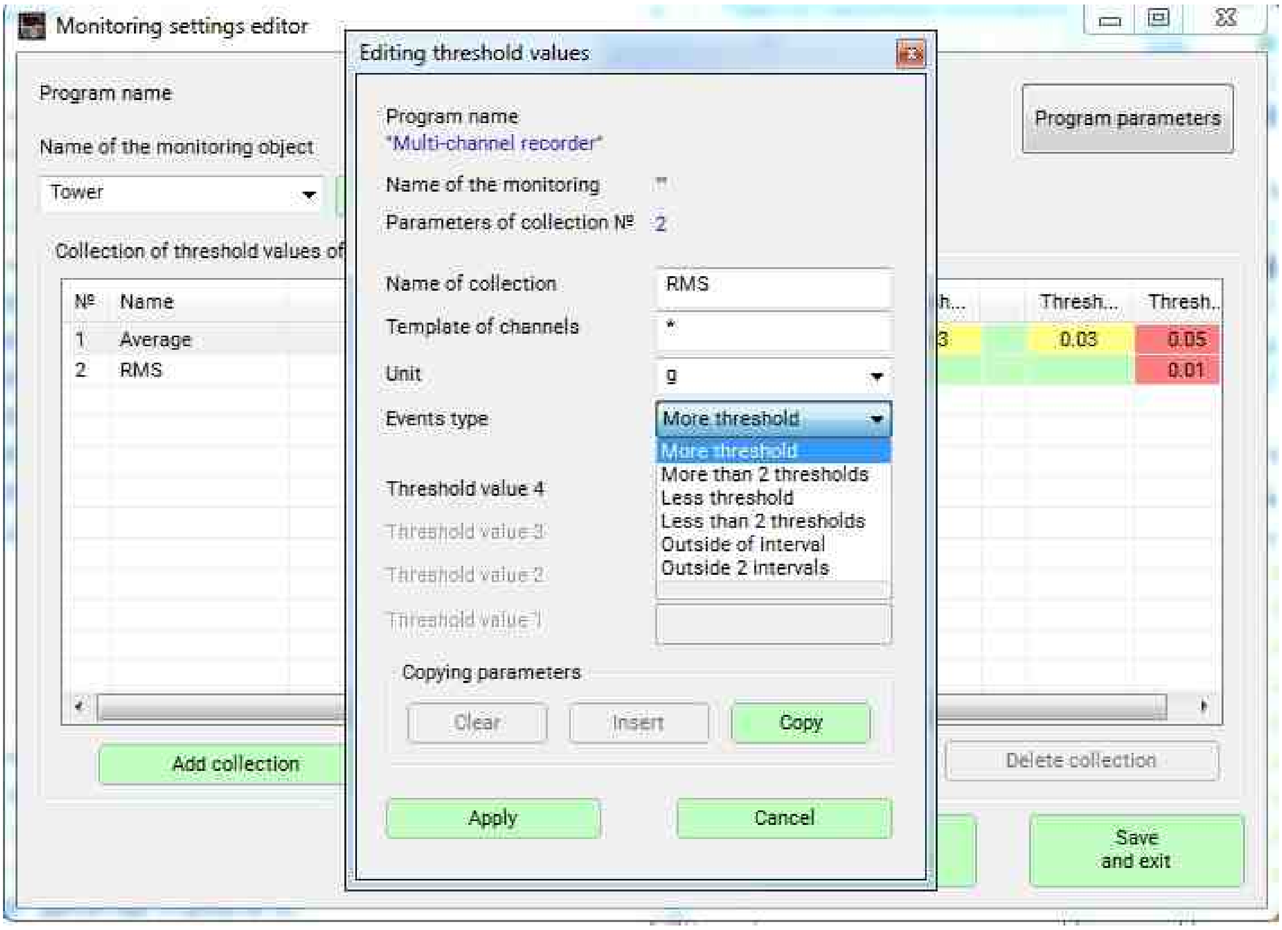


Fig. 5 Editing threshold values in case of error a warning appears

At the end of the program interface, you can save the necessary settings, or you can see how they are applied in another program.

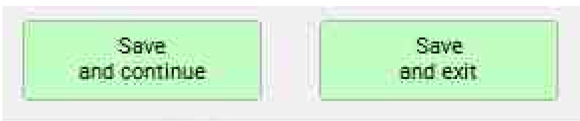


Fig. 6 Types of saving edited settings

Supported Hardware .....

The input data of the **Monitoring settings editor** are the digital data of the **ZETLAB server channel**.

Monitoring settings editor program is included in the following software:

- [ZETLAB BASE](#) - software supplied with [ADC / DAC modules](#) (optional);

- ZETLAB ANALIZ - software supplied with spectrum analyzers ;
- ZETLAB VIBRO - software supplied with the shaker control system ;
- ZETLAB TENZO - software supplied with strain gauges ;
- ZETLAB SEISMO - software supplied with seismic stations ;
- ZETLAB NOISE is the software supplied with the vibration sound level meter .
- ZETLAB SENSOR — software supplied with ZETSENSOR digital sensors (optional).

Monitoring settings editor is included in the program group **Service**

Program description .....

To start the program **"Monitoring settings editor" it is necessary** to select the command **"Monitoring settings editor"** in the menu **Service** (*Fig. 7*) of the ***ZETLab panel*** . The working window of the **Monitoring settings editor** program will be displayed on the **monitor screen** (*Fig. 8*).

Note: the program can be launched directly from the ZETLab working directory (by default: c:\ZETLab\). Executable file name: editMntJson.exe.

Fig. 7 Program " Monitoring settings editor" from the menu "Service"

"Monitoring settings editor" program displays detailed information about the settings of the set thresholds (*Fig. 8*).

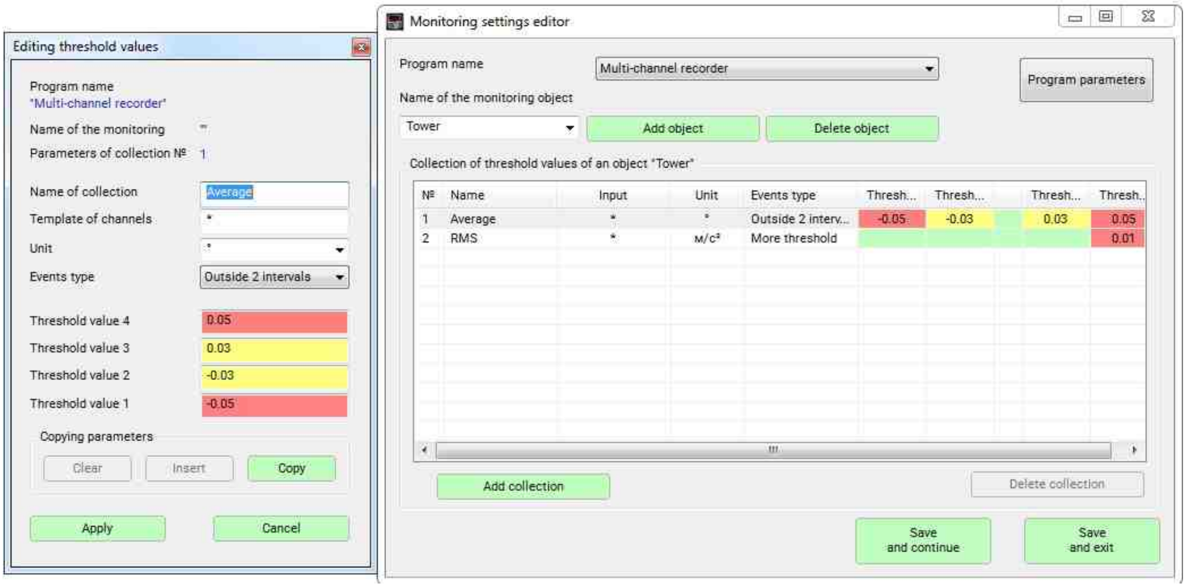


Fig. 8 Program " Monitoring settings editor" from the menu "Service" interface

Monitoring of objects .....

In the "Monitoring" tab (*Fig. 4*) check the box "Object monitoring". In the "Object name" field, enter " Tower " and click the "Edit descriptor" button.

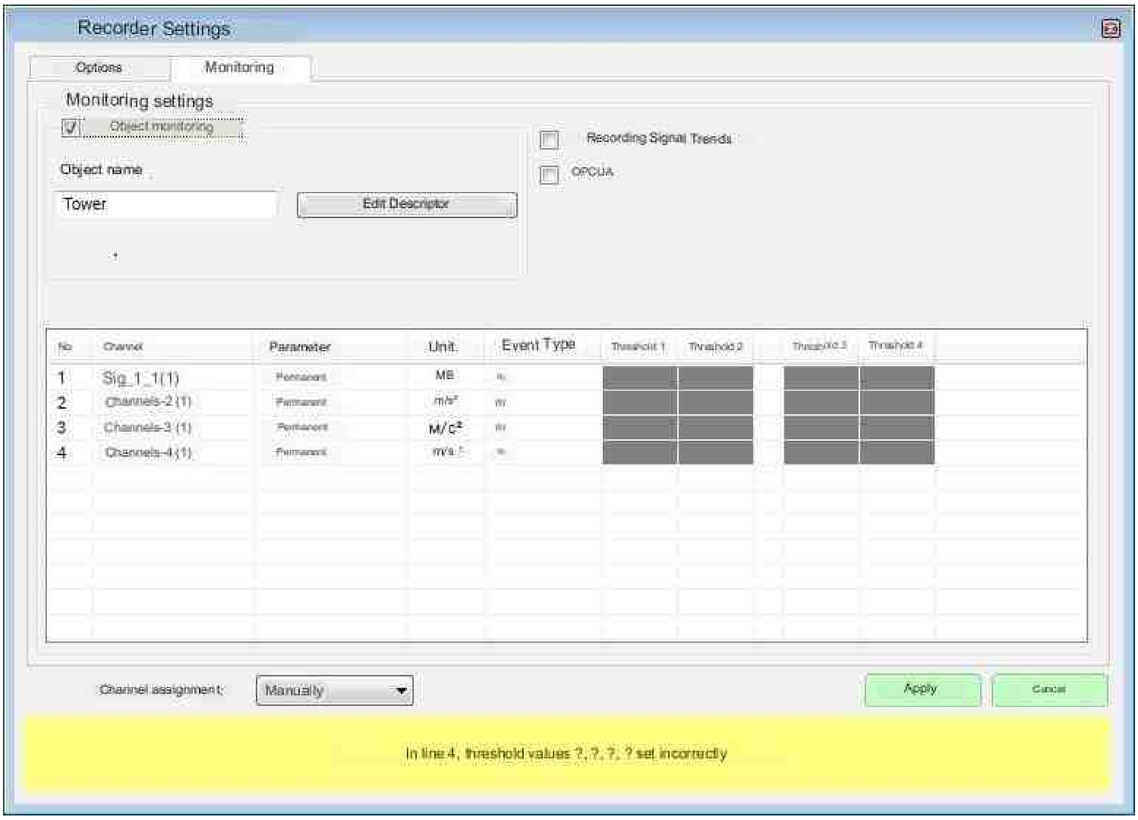


Fig. 4. Settings window of the Monitoring settings editor program. Monitoring tab

The "Editor of monitoring parameters" window will open (Fig. 5). In the window with the offer to create the Tower object,  activate the Yes button.

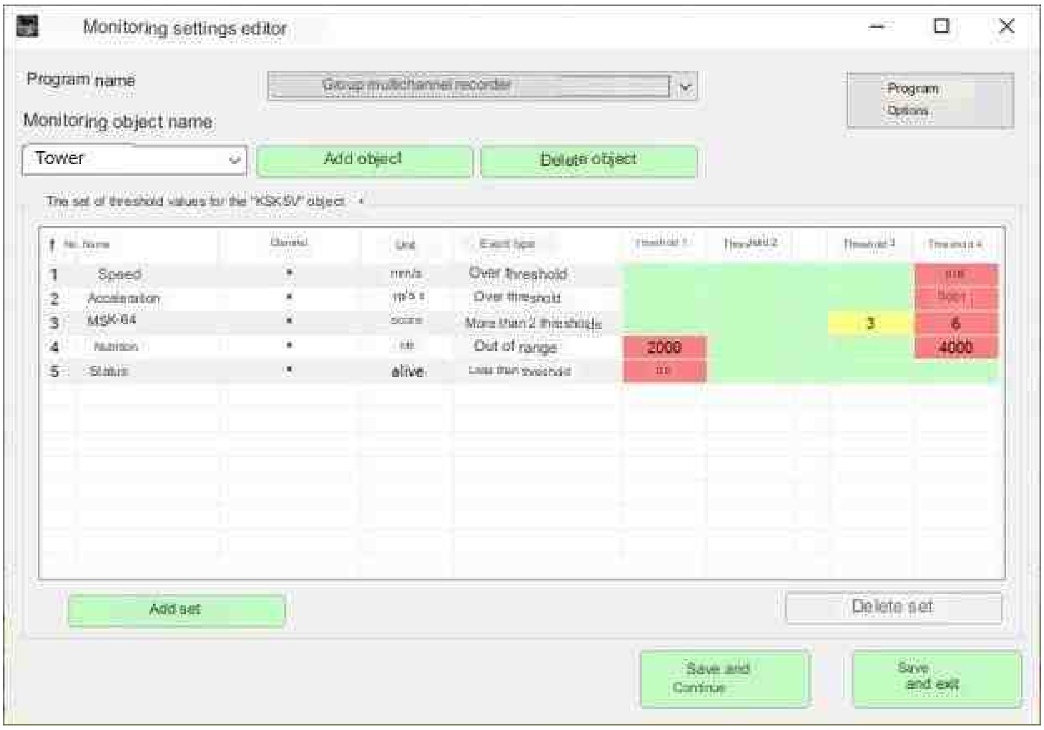


Fig. 5. Window of the monitoring parameters editor.

Next, in the "Monitoring Settings Editor" window, click the "Save and Exit" button.

Go to directory C : \ ZETLab \ config \ , rename swmchan 01.cfg file to editMntJson_velocity . cfg .

the program, you need to go to the directory C :\ ZETLab \ config \, rename the file editMntJson_velocity . cfg to editMntJson 01. cfg , open the program, change the settings and rename it back.

Setting up a Monitoring settings editor to measure accelerations

Setting up a Monitoring settings editor for measuring accelerations is performed according to the procedure given in the previous section. At the same time, in the "Measured parameters" panel, select "Acceleration" in the drop-down list, and the monitoring set is created in accordance with the second line of the table (*Fig. 5*).

To create a monitoring set for the “Acceleration” parameter, click the “Add set” button. In the opened window "Edit threshold values" enter the parameter values in accordance with Fig. 6 , then click the "Apply" button.

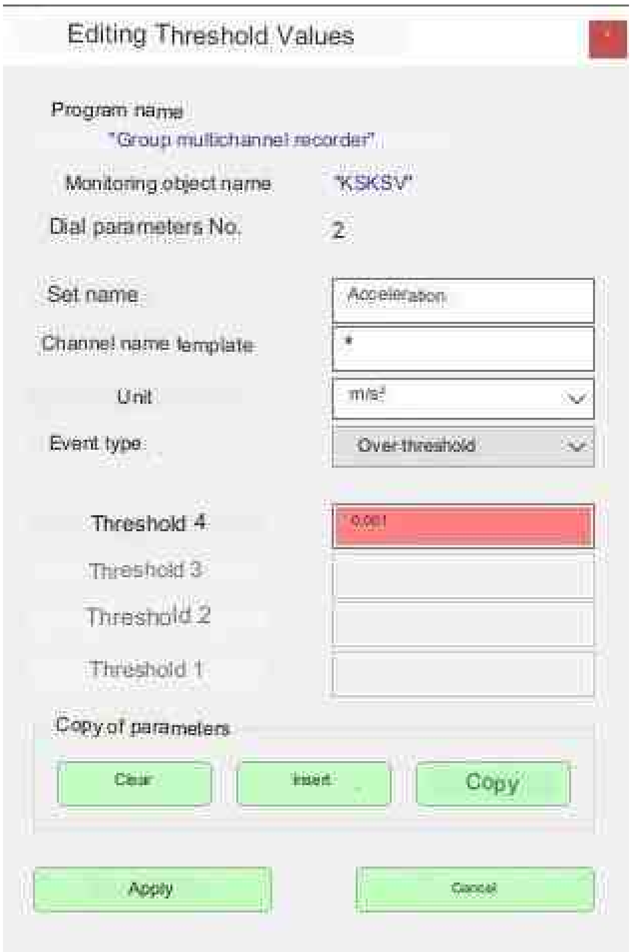


Fig. 6. Window "Editing threshold values" of the "Acceleration" set

When renaming a configuration file, use the file name editMntJson _ accel . cfg .

Setting up a Monitoring settings editor to measure the ball

Setting up a Monitoring settings editor for measuring the scoring is performed according to the method given in the section above. At the same time, in the "Measured parameters" panel, select " MSK -64" in the drop-down list, and the monitoring set is created in accordance with the third line of the table (Fig. 5).

To create a monitoring set for the " MSK -64" parameter, click the "Add set" button. In the opened window "Edit threshold values" enter the parameter values in accordance with (Fig. 7), then click the "Apply" button.

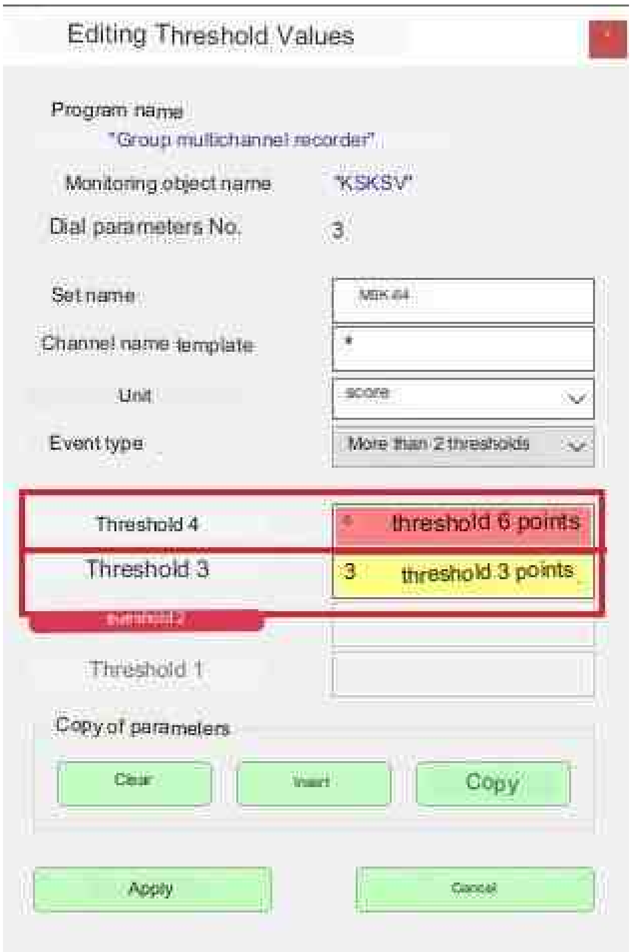


Fig. 7. Window "Editing threshold values" of the " MSK -64" set

When renaming the configuration file, use the file name editMntJson_msk 64.cfg.

Setting up a Monitoring settings editor to measure the power of seismic receivers

Setting up the array recorder to measure the power of seismic receivers is performed according to the procedure given in the section. At the same time, in the "Measured parameters" panel, select "Power" in the drop-down list, and the monitoring set is created in accordance with the fourth line of the table (*Fig. 5*).

To create a monitoring set for the “Power” parameter, click the “Add set” button. In the opened window "Edit threshold values" enter the parameter values in accordance with *Fig. 8* , then click the "Apply" button.

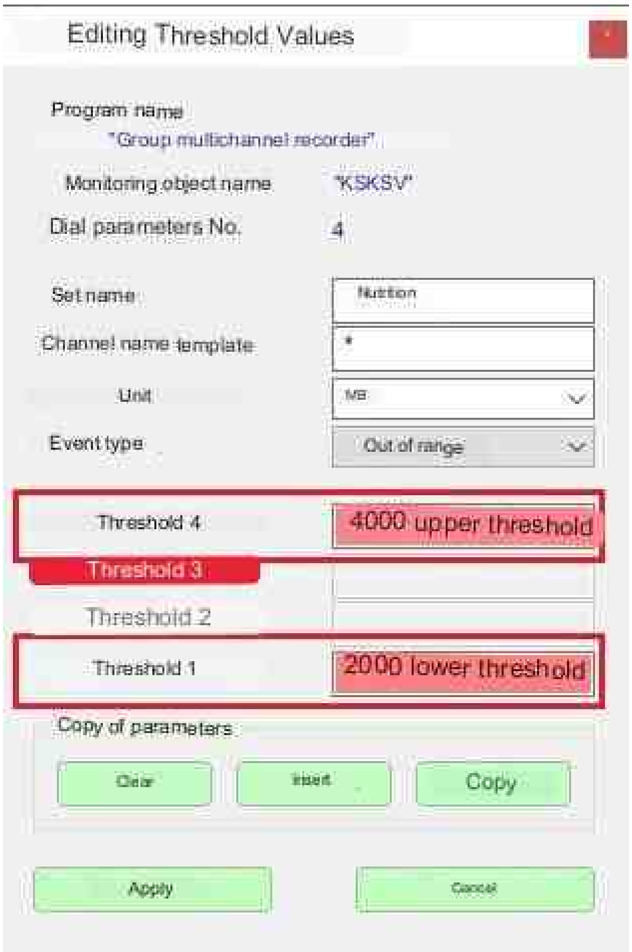


Fig. 8. Window "Editing threshold values" of the "Power supply" set

When renaming the configuration file, use the file name editMntJson_power.cfg.

The remaining lines in the table are configured in the same way as described above.

Note: In the table (*Fig. 5)* of the "Monitoring parameters editor" window, sets with different units of measurement are configured to display different types of thresholds. If two or more rows are configured with the same unit of measure, then the thresholds will be applied to the unit of measure above.

Examples for the section .....

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[Application in practice](#)

Application in practice .....

Application in practice

To demonstrate the operation of monitoring events, consider the operation of a car with an internal combustion engine.

Real monitoring software uses a 20% hysteresis when determining whether an event has ended in order to prevent "bounce" of operation.

So, with the type of events “More than threshold”, the event P4 ends at (**TP** < P4m), provided that the event was observed, where P4m = 0.8 * P4. If the same condition is met with the type of events "More than 2 thresholds", the event P4 ends. But the P3 event will end at (TZP < P3m) provided that the event was observed, where P3m = 0.8 * P3. For event types “Less than threshold” and “Less than 2 thresholds”, event P1 ends at (P1p < TST) provided that the event was observed, where P1p = 1.2 * P1. In this case, the P2 event ends at (P2p < **TP**) provided that the event was observed, where P2p = 1.2 * P2. Similarly, for event types "Out of interval" and "Out of 2 intervals":

- the event P1 ends at (P1m < **TP**) provided that the event was observed;
- the P2 event ends at (P2m < **TP**) provided that the event was observed;
- the P3 event ends at (**TP** < P3p) provided that the event was observed;
- the P4 event ends at (**TP** < P4p) provided that the event was observed.

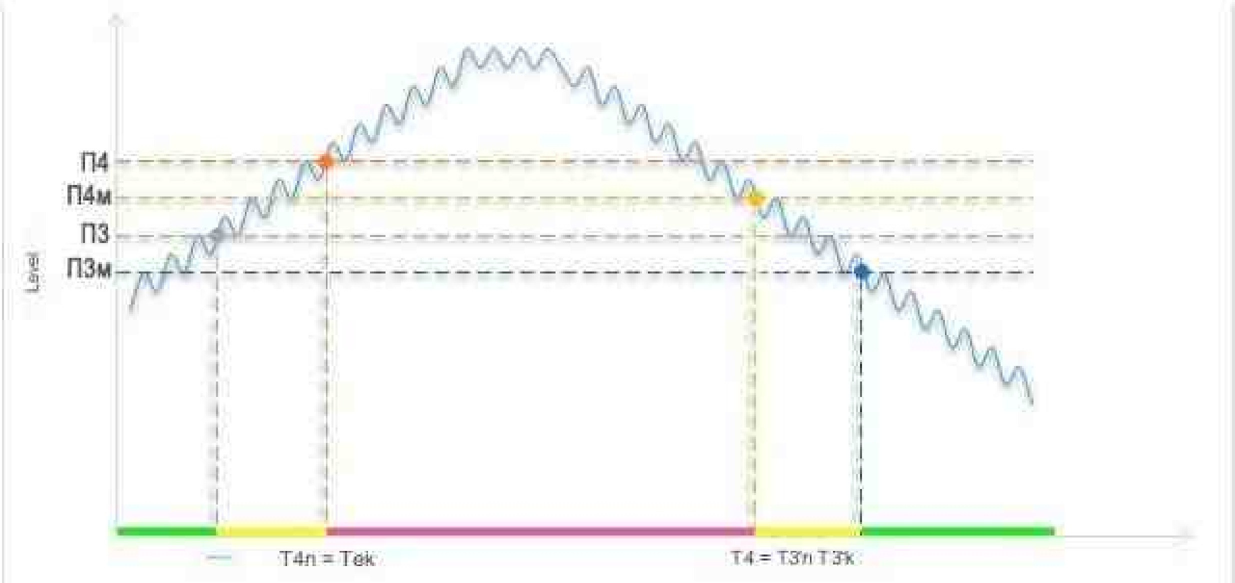
For clarity, the examples in the images show color indication of zones where:

- green zone — no monitoring event;
- yellow zone - an event of the "Warning" type is observed, i.e. P2 or P3;
- red zone - an event of the "Danger" type is observed, i.e. P1 or P4.

Event type "More than threshold"

The "Over Threshold" event type is suitable for monitoring engine temperature. At P4 = 105 °C, the "Danger" event indicates a malfunction in the cooling system and, as a result, the impossibility of continuing the operation of the engine due to the high risk of its failure (jamming).

More than threshold



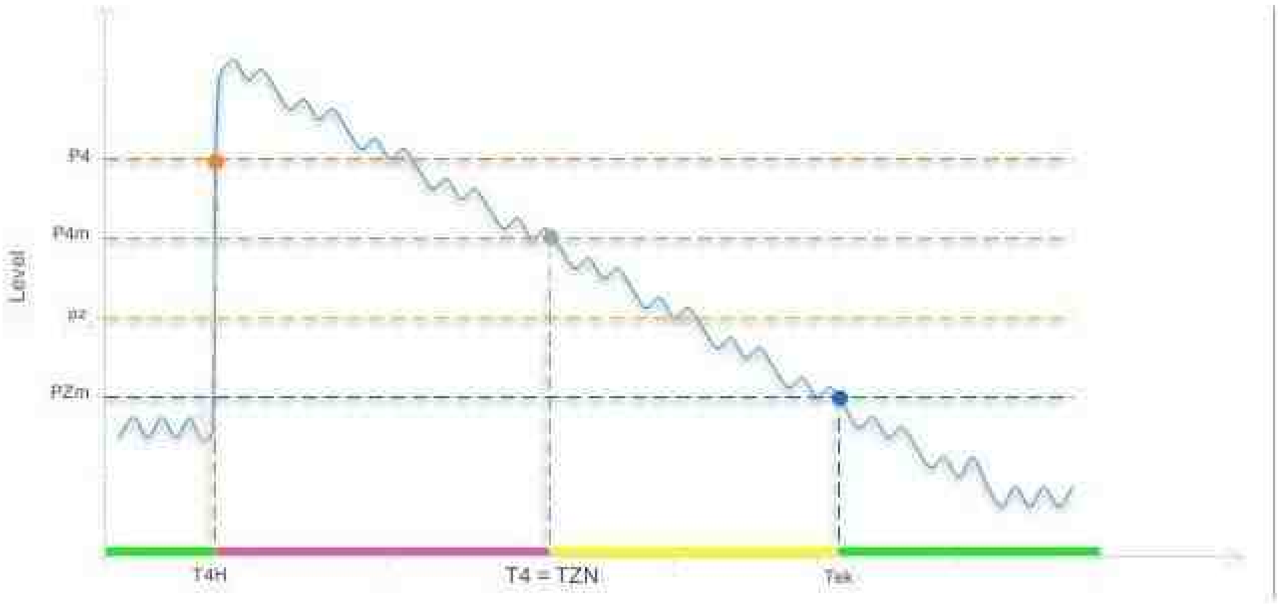
Time

T4n— start time of event P4;
T4k— end time of event P4.

Event type "More than 2 thresholds"

Using the event type "More than 2 thresholds" in this case may additionally issue a preliminary event of the type "Warning". At P3 = 100 °C, this event indicates the beginning of problems.

More than 2 thresholds



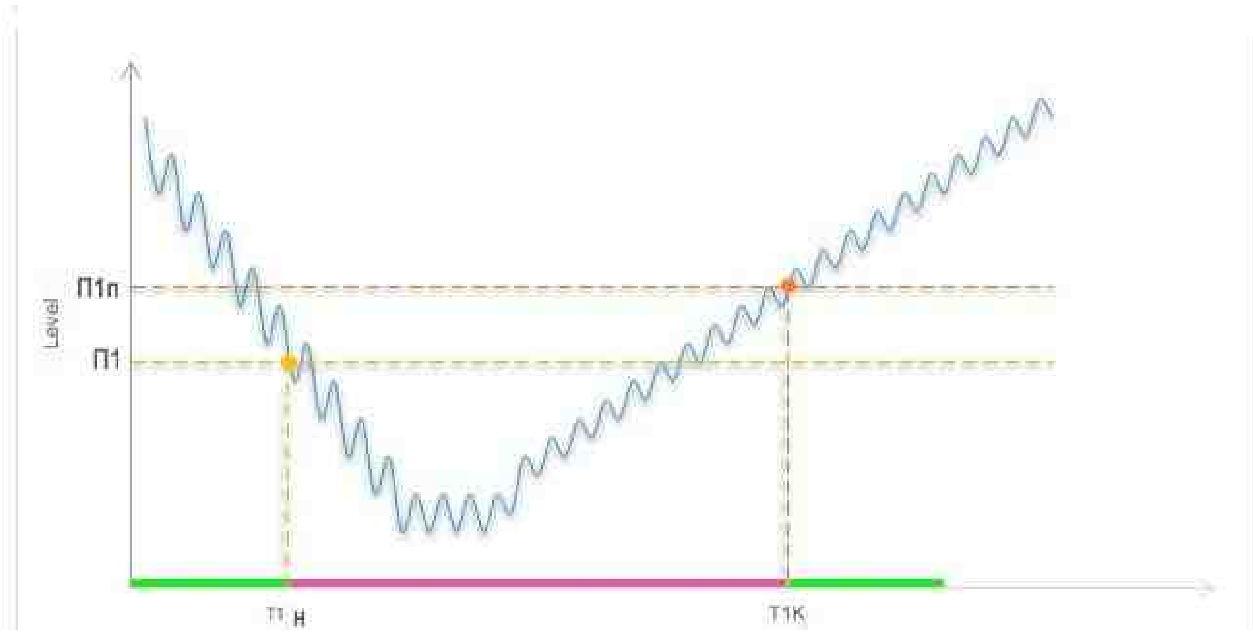
Time

In this case, the P4 event was observed from T4n to T4k, and the P3 event was observed 2 times: from T3n to T3k and from T3n to T3k, while T4n = T3k and T4k = T3n.

Event type "Less than threshold"

The "Less than threshold" event type is suitable for monitoring the amount of fuel in a car's tank. At P1 = 2 liters, the “Danger” event indicates a critical fuel level and, as a result, the impossibility of continuing engine operation due to the high risk of failure of the high-pressure submersible fuel pump.

Less than threshold

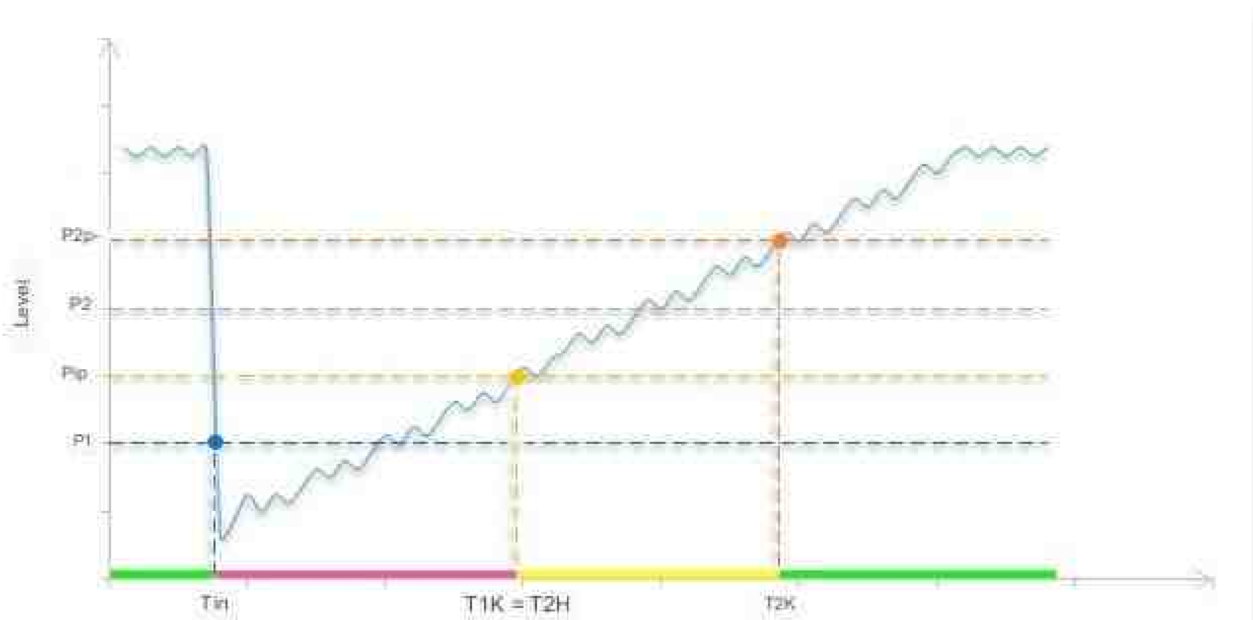


Time

Event type "Less than 2 thresholds"

Using the event type "Less than 2 thresholds" in this case may additionally issue a preliminary event of the type "Warning". With P2 = 5 liters, this event indicates the need for refueling.

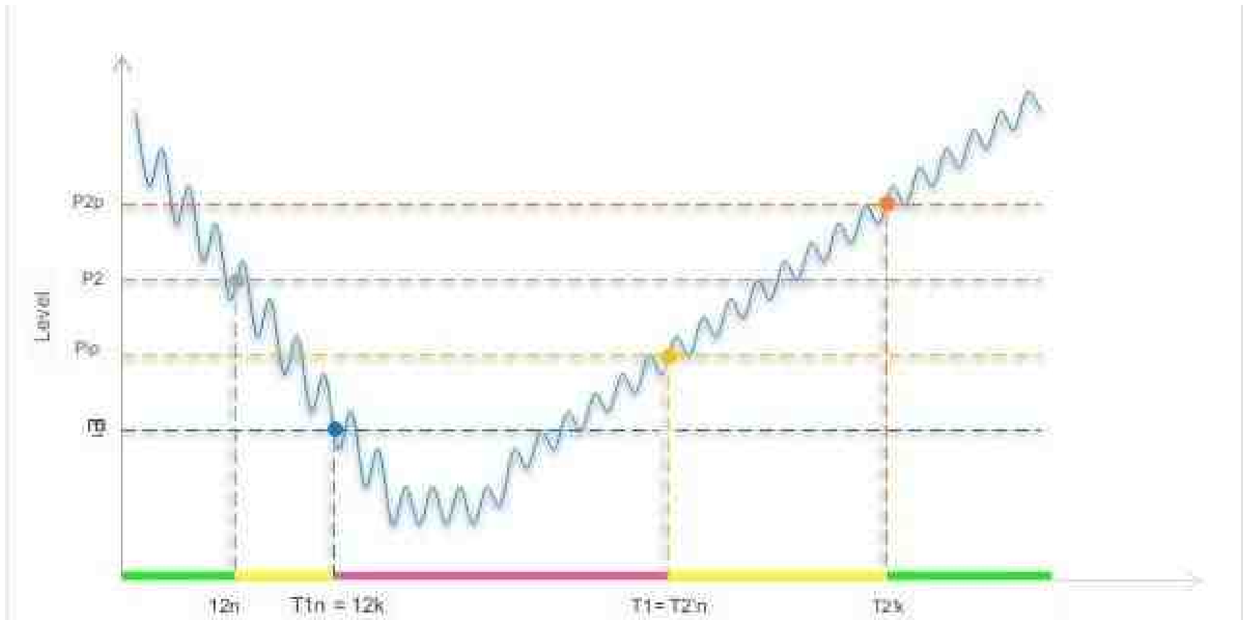
Less than 2 thresholds



Time

In this example, the P1 event was observed from T1n to T1k, and the P2 event was observed from T2n to T2k.
In this case, T1k = T2n.

Less than 2 thresholds



Time

In this example, event P1 was observed from T1n to T1k, and event P2 was observed twice: from T2n to T2k and from T2'n to T2'k.
In this case, T1n = T2k and T1k = T2'n.

The Out of Range event type is suitable for monitoring engine speed. At P1 = 500 rpm, the “Danger” event indicates that there are problems in the engine power supply system and that the engine can stall at any second. At P4 = 7000 rpm, the "Danger" event indicates that the engine is experiencing heavy loads, the long-term impact of which greatly reduces the engine's service life, and engine failure is also possible.

Using the event type "Out of 2 intervals" in this case may additionally generate pre-events of the "Warning" type. At P2 = 700 rpm, the "Warning" event indicates the beginning of problems in the power system. At P3 = 5000 rpm, the "Warning" event indicates the beginning of heavy loads on the engine.

Connecting third-party RS-485 Sensors .....

via Modbus protocol

To connect third-party sensors operating via the Modbus protocol, it is necessary to describe the characteristics of the connected sensors in the configuration file in the ZETLAB software. A simple configurator was created specifically for this purpose:

Configurator .....

The program for configuring third-party MODBUS devices (hereinafter referred to as the **Configurator**) is designed to create configuration files that are further used by the ZETLab software (hereinafter referred to as the ZETLab software). These configuration files are designed for convenient presentation of sensor parameters and measured values in ZETLab software (*Fig 1*).

Note: the **Configurator** program can be launched directly from the ZETLAB working directory (by default: C:\ZETLAB\). Executable file name: ExtModbusDeviceConfig.exe.

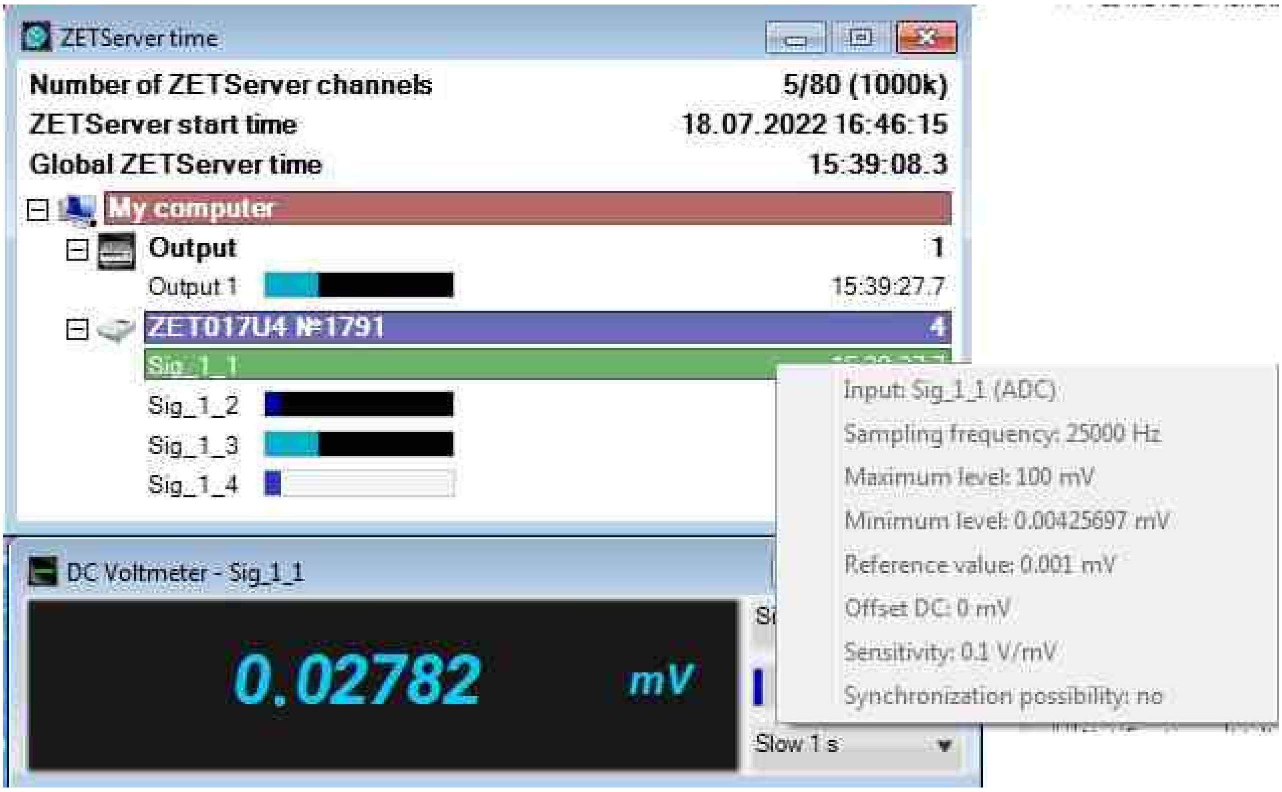


Fig 1 — Data representation in software

The Configurator window has a simple dialog interface (Fig. 2). The main menu of the **Configurator** has only one sub-item "File", which in turn contains the following sub-items: "Open", "Create", "Save", "Save as", "Close" and "Exit".

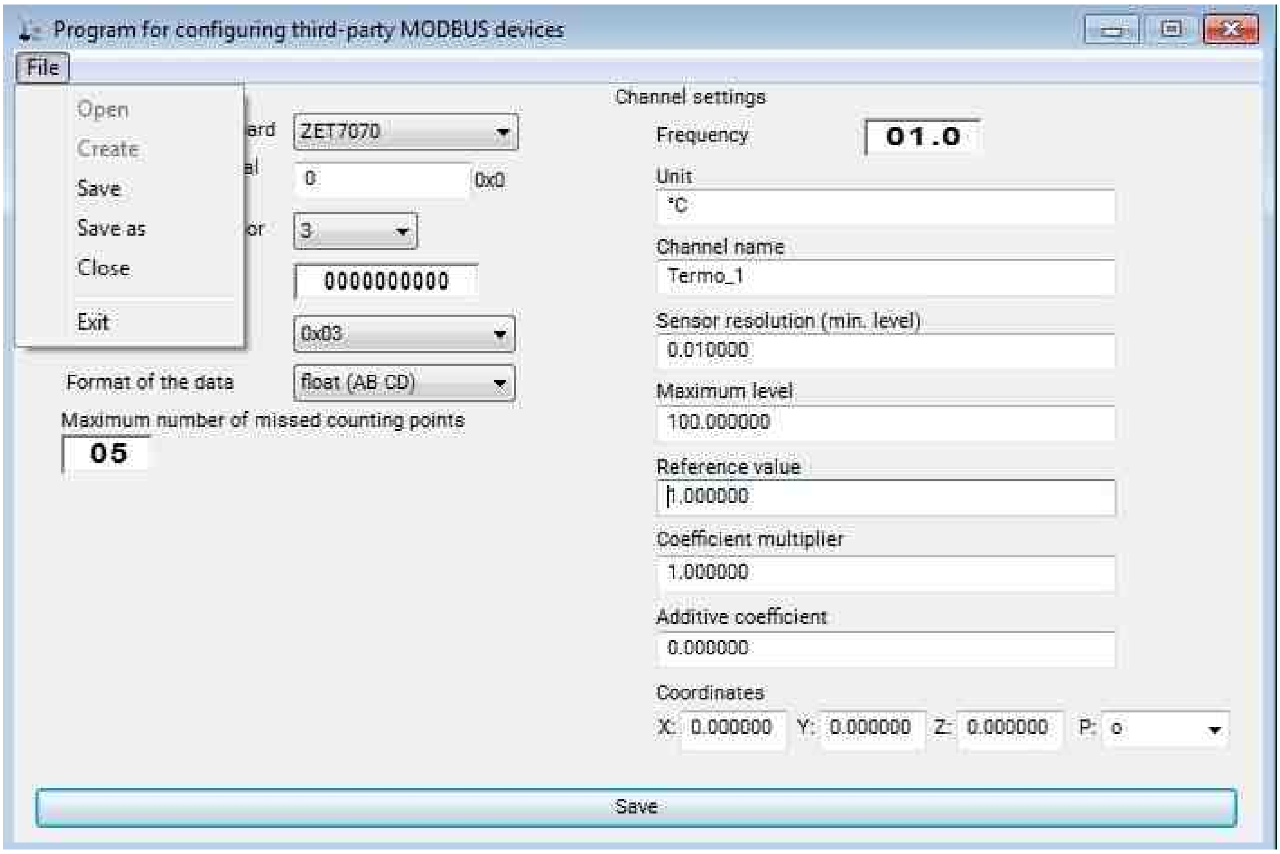


Fig 2 — Main menu of the ***Configurator***

When you click on the "Open" item, a window opens prompting you to select the path to the reconfigurable configuration file (Fig 3). If you select a file and click on the Open button, the Configurator will load and display the parameters from the selected configuration file (Fig 4).

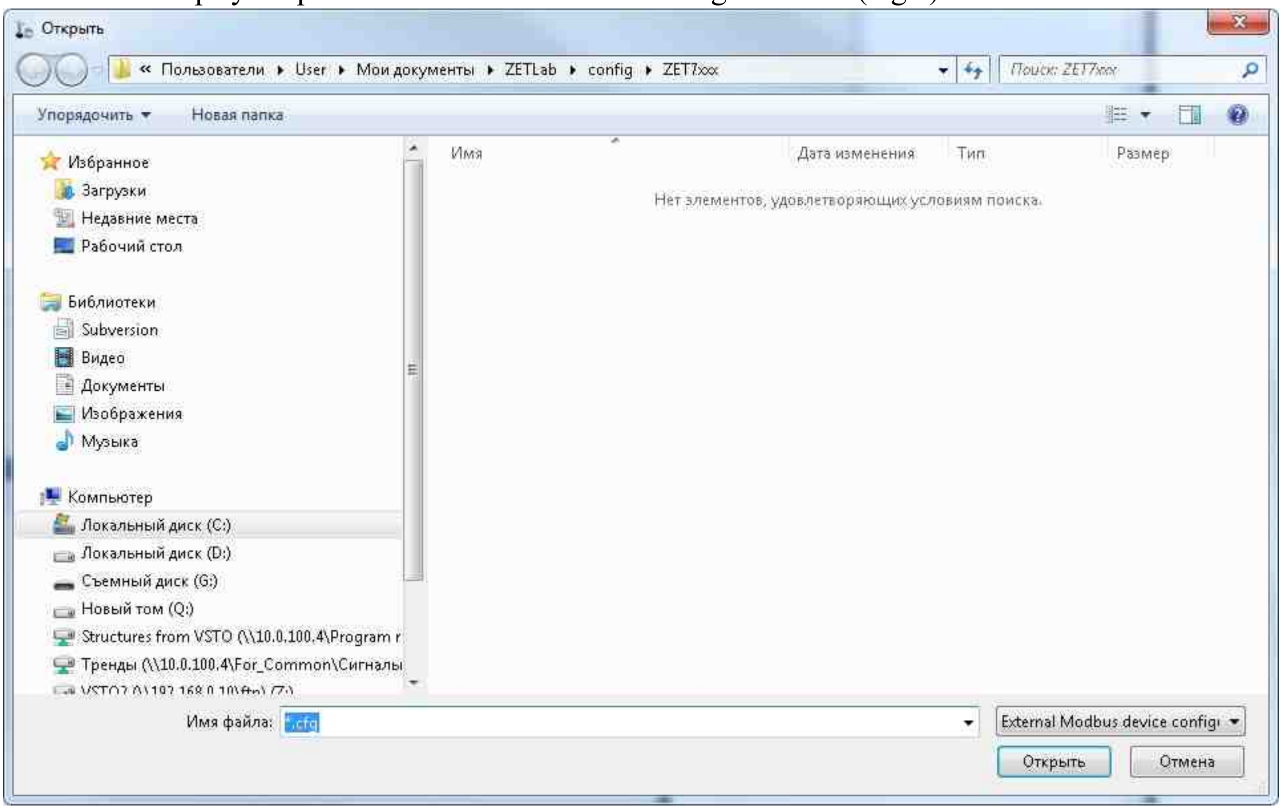


Fig. 3 - Selecting the path of the configuration file

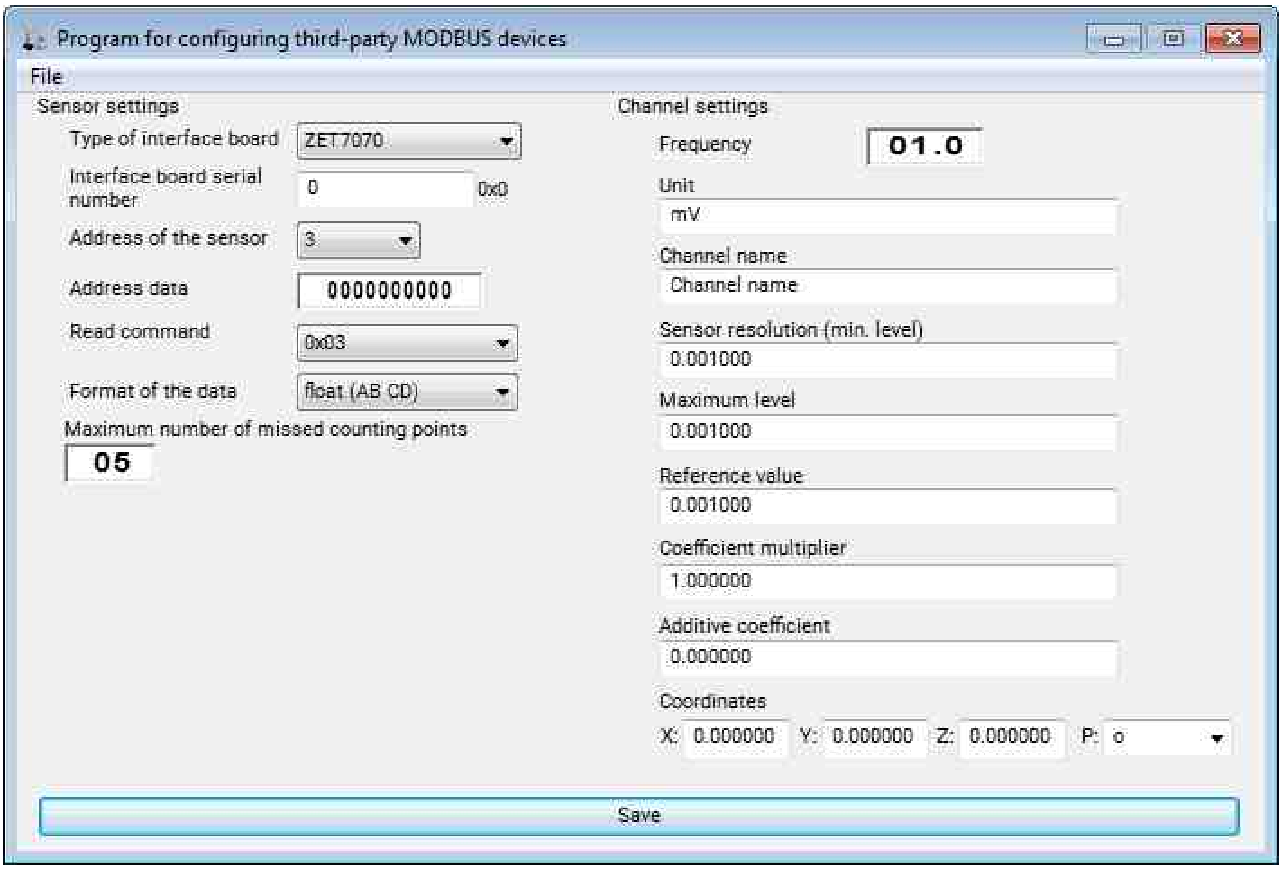


*Fig. 4 — Display of configuration parameters in the **Configurator***

When you click on the "Create" item, the Configurator will display the default parameters (Fig. 5).

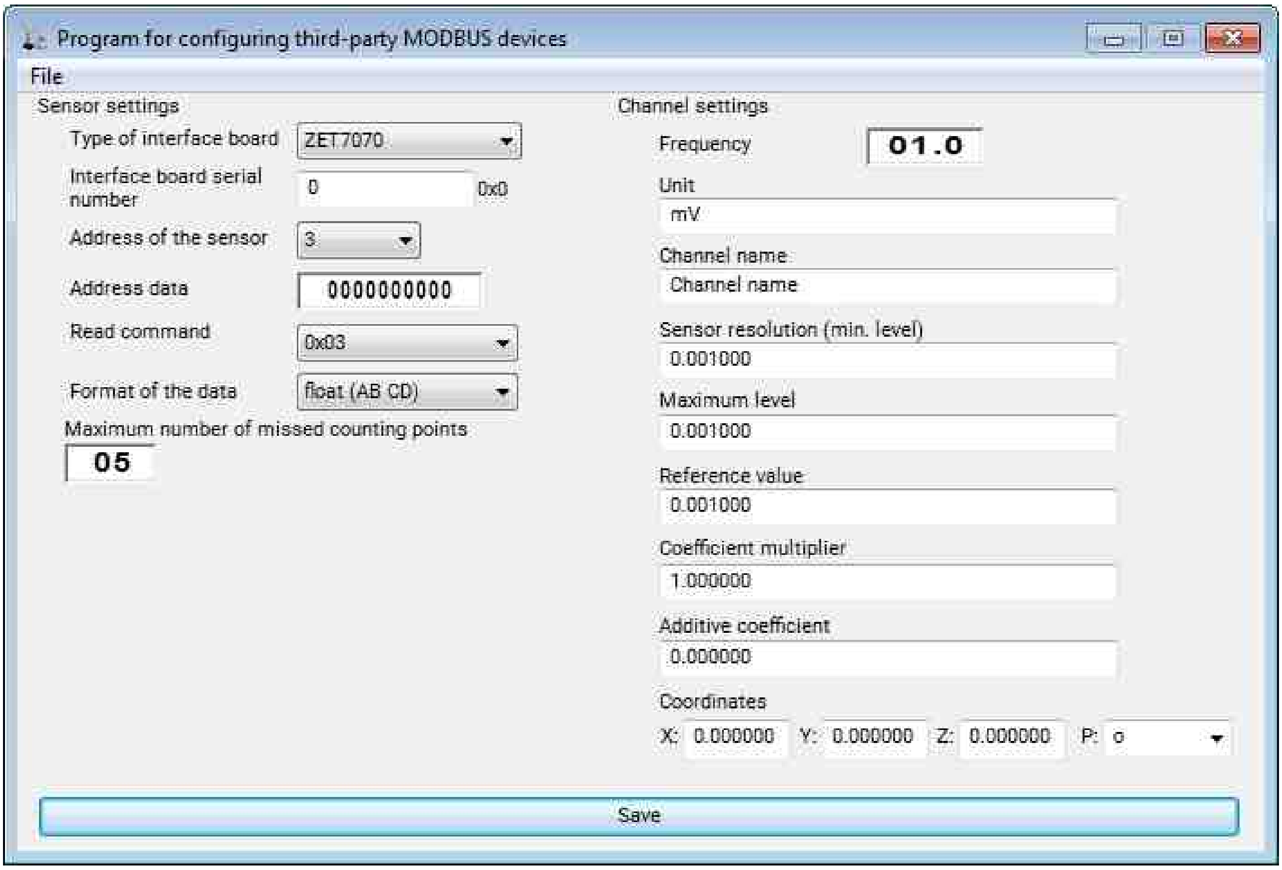


Fig. 5 - Default settings

When you click on the "Save" item, the **Configurator** will overwrite the new parameters in the previously opened configuration file. If the configuration file was created new, then the actions will be similar to clicking the "Save as" item.

When you click on the "Save as" item, the **Configurator** will open a window asking you to select the path for the newly created or overwritten configuration file. After clicking the Recording button, the file will be saved (Fig. 6).

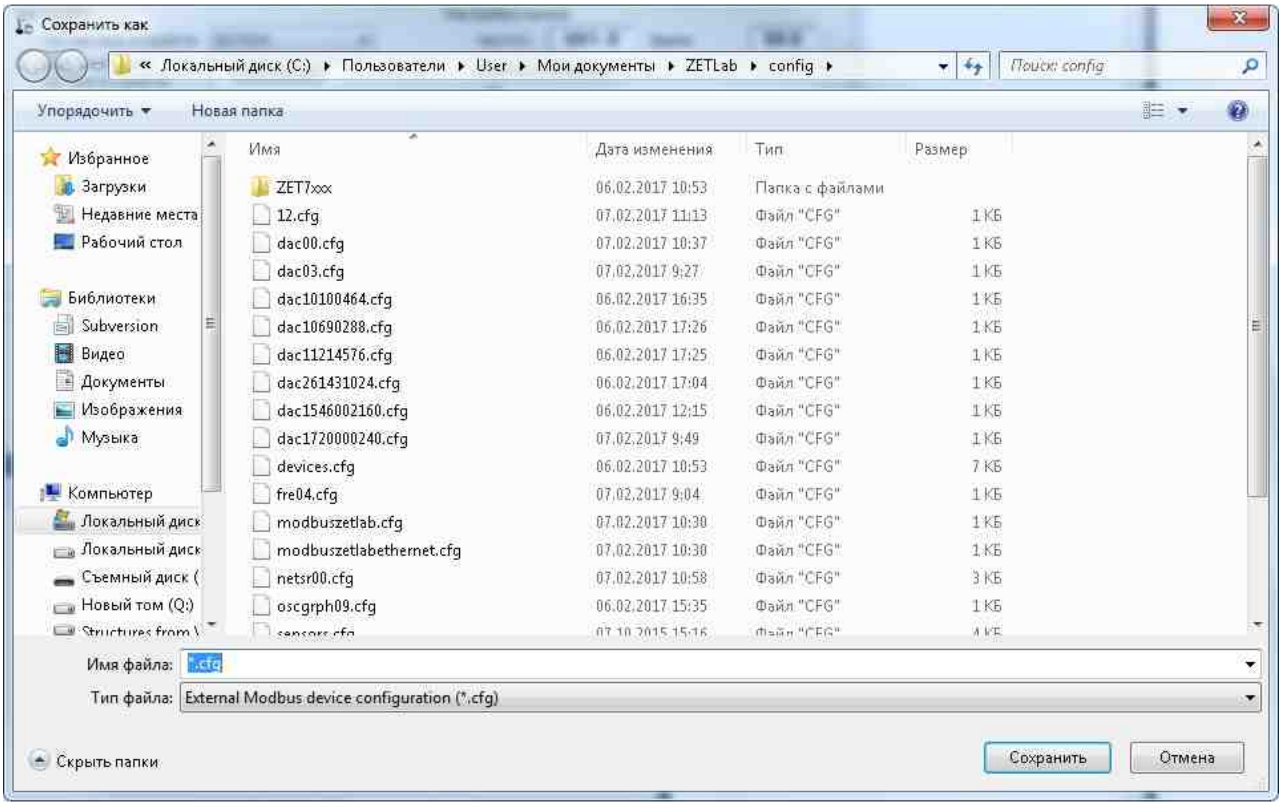


Fig. 6 - Window for choosing the path to save the configuration file

When you click on the "Close" item, the **Configurator** will close the configuration parameters from the currently displayed configuration file (Fig. 2).
When you click on the "Exit" item, the **Configurator** will stop working (Fig. 2).

Setting

The **Configurator** program allows you to set the following parameters of third-party MODBUS devices (Fig. 4):

Configuration parameter	***Description***
Settings	
Interface board type	This field indicates the type of interface board used by ZETLab (hereinafter referred to as the Interface Board)
Interface board serial number	This field specifies the serial number of the Interface Board being used.
Sensor type	This field indicates the type of a third-party sensor operating via the MODBUS protocol and connected to the Interface Board (hereinafter referred to as the Sensor)
Sensor serial number	This field contains the serial number of the Sensor
Sensor name	This field specifies the name of the used Sensor
Sensor address	This field specifies the address assigned to the connected Sensor using the MODBUS protocol

Data address	This field specifies the address in the Sensor's internal memory, from which it is necessary to read data via the MODBUS protocol
Read command	This field indicates the MODBUS command used to read data from the Sensor
Format of data	ofThis field specifies the data format in which data is stored in the Sensor
Maximum waiting time	This field specifies the time after which the Sensor is considered disabled (the option is not available at the moment)
Channel settings	
A sensor can have several measured values. For example, the first value is stored at 0x0000, the second at 0x0002, the third at 0x0004, and so on. The values at each address will be referred to as channels.	
Frequency	This field indicates the frequency of polling data from the Sensor channel described by the configuration file (hereinafter referred to as the Channel)
Unit of measurement	This field specifies the Channel unit in which the data for the current Channel is stored.
Channel name	This field indicates the name of the current Channel
Resolution	This field indicates the resolution specific to the current Channel.
Maximum value	This field specifies the maximum modulo value characteristic of the current Channel
Reference value	This field specifies the reference value of the Channel used for calculations on the current Channel
Multiplicative coefficient	This field specifies the multiplicative value conversion factor for the current Channel
Additive factor	This field specifies the additive value conversion factor for the current Channel
Coordinates	This field specifies the coordinate values for the current Channel.

After completing the configuration and saving the configuration files, you need to make sure that the actions performed are correct. To do this, run the ZetServerTime program (ZETLab → Service → ZetServer Time) and make sure that a new data channel has appeared (Fig. 7, 8). In this example, this channel is named External channel.

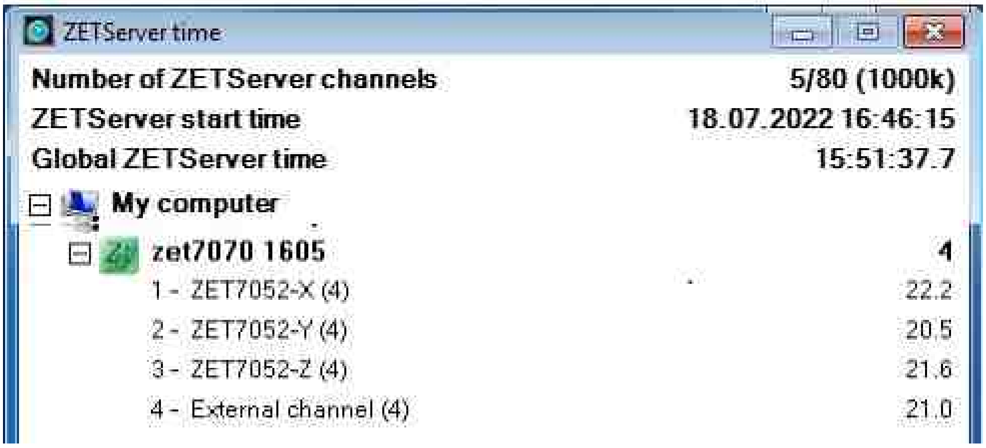


Fig.7 - Displaying a third-party sensor in the ZetServerTime program
(In this example, a third-party sensor is artificially created based on our sensor, your device addresses must be different)

Fig. 8 - Checking the displayed value

To use data from a third-party sensor in the ZETView program, you must use the measurement channel. To do this, it is necessary to place the Measuring channel component in the project (ZETView Components → ADC Input → Measuring Channel), DC Voltmeter (ZETView Components → Measurement (External devices) → DC Voltmeter) (Fig. 9, 10).

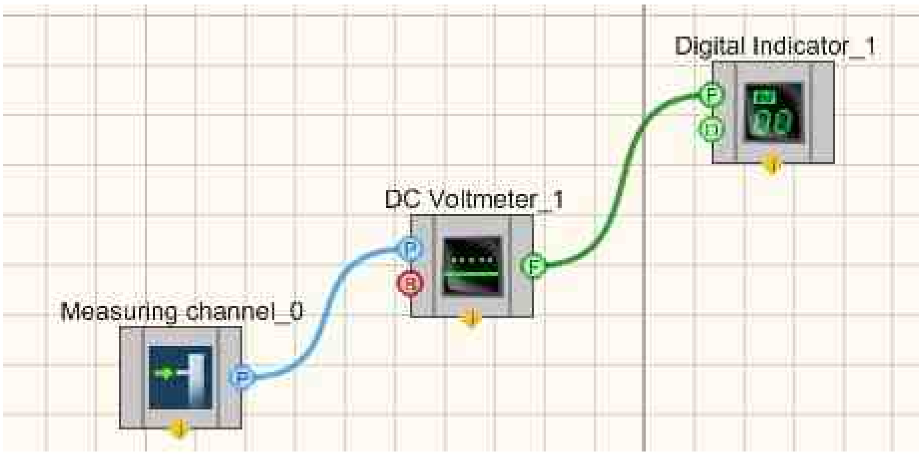


Fig. 9 - Developer View

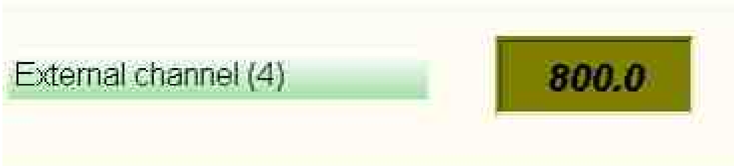


Fig. 10 - View of the operator

Configurator universal third-party devices .....

Abstract module:
Measuring channel. This term refers to the data flow from the measurement module. So, for example, the measuring module of a weather station can contain such measuring channels as: air temperature, ambient humidity, atmospheric pressure, etc.

The configurator program contains a tree of modules (*Fig 1*). This example shows that the interface module "Interface module" contains two measuring modules "Weather station" and "Weather station 2" on its bus. Measuring module "Weather station" includes three measuring channels: "Humidity", "Pressure" and "Temperature". Measuring module "Weather station 2" includes similar channels as the measuring module "Meteo station".

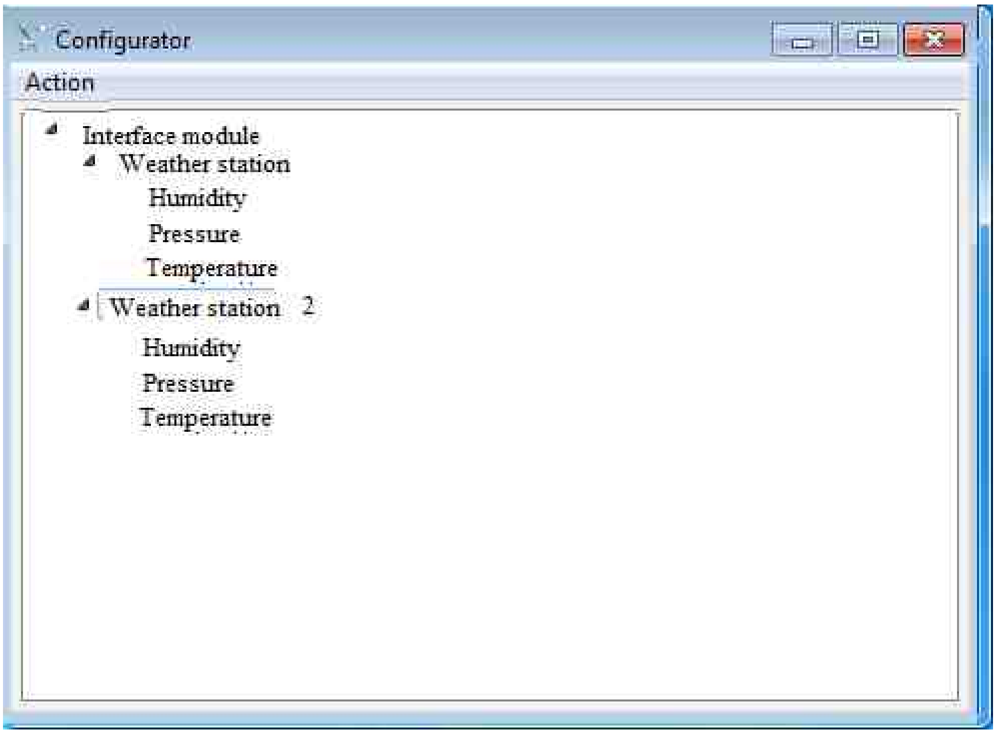


Fig 1 The program Configurator contains a tree of modules

Adding a new interface module .....

To add a new interface module in the main window of the **Configurator** program, press the menu button "Action->Add interface module" (*Fig. 2*).

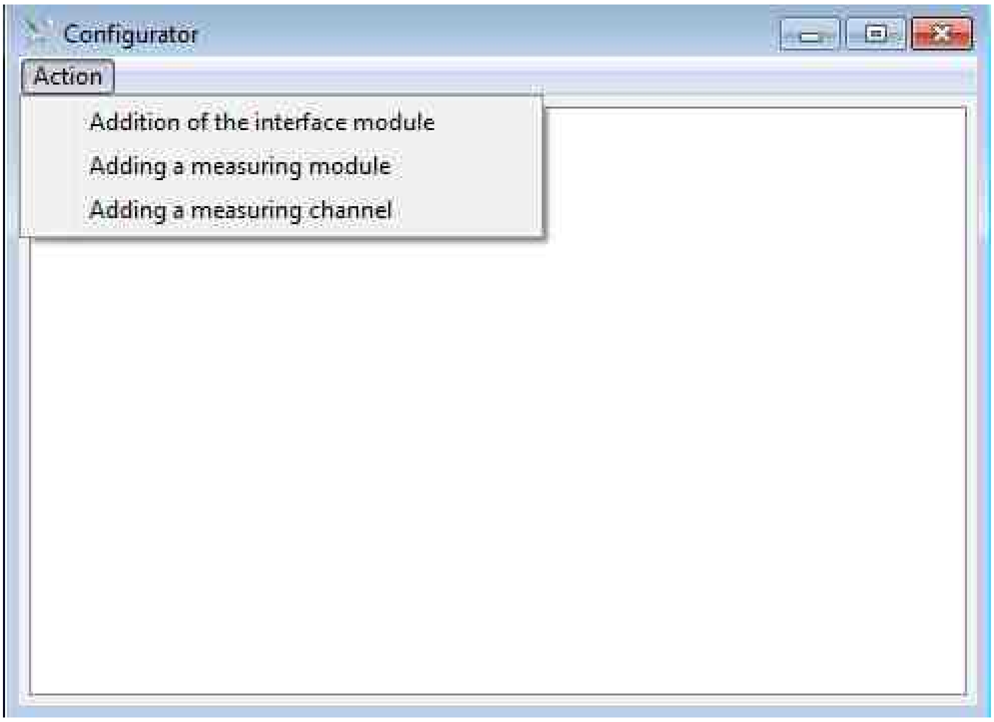


Fig. 2 - Menu "Action"

After calling the menu "Action->Add interface module", a window for adding a new interface module will open (*Fig. 3*).

Adding an interface module occurs in three steps.

The first step is to select a device from those currently connected to the computer (*Fig. 3*).

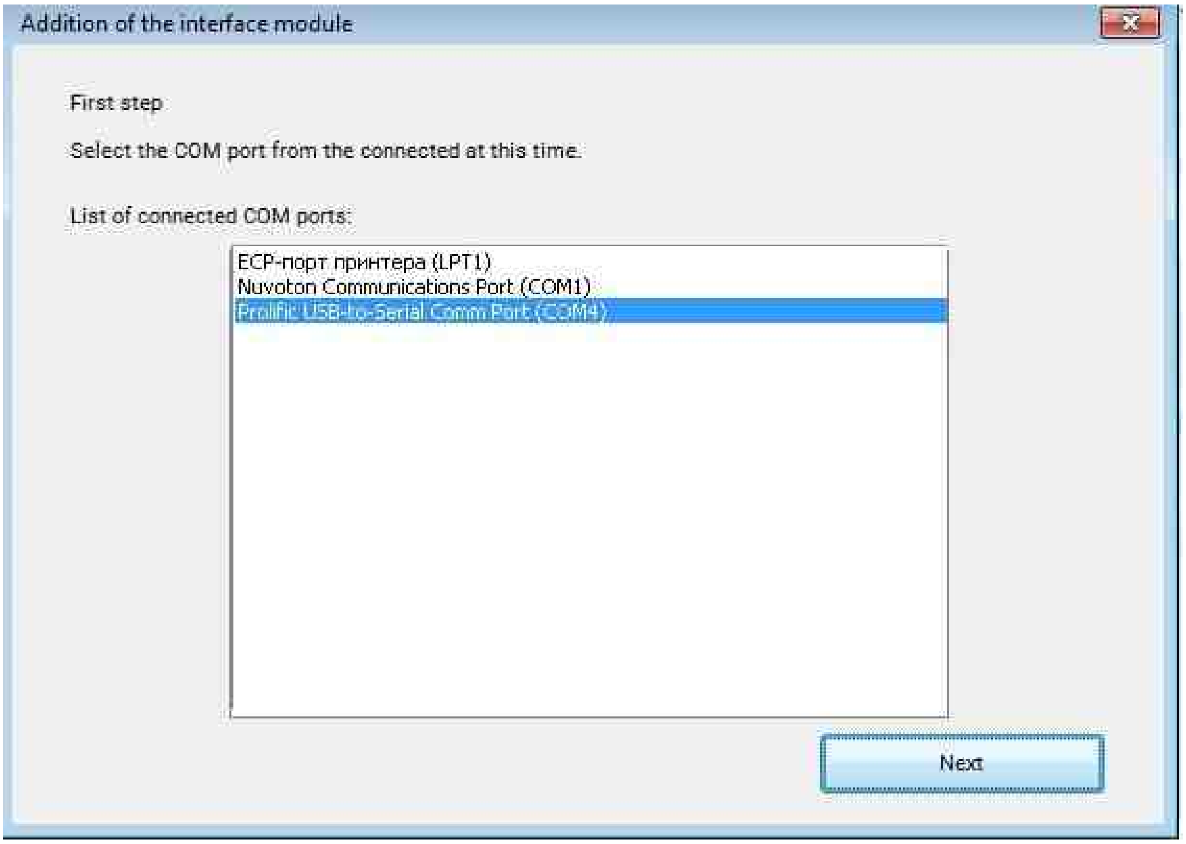


Fig. 3 - Adding an Interface Module (Step 1)

We select the device of interest to us from the list and click the "Next" button.

At the second step, we need to set the name of the interface module, convenient for further perception, it will be used in the future in the ZETLab software (*Fig. 4*).

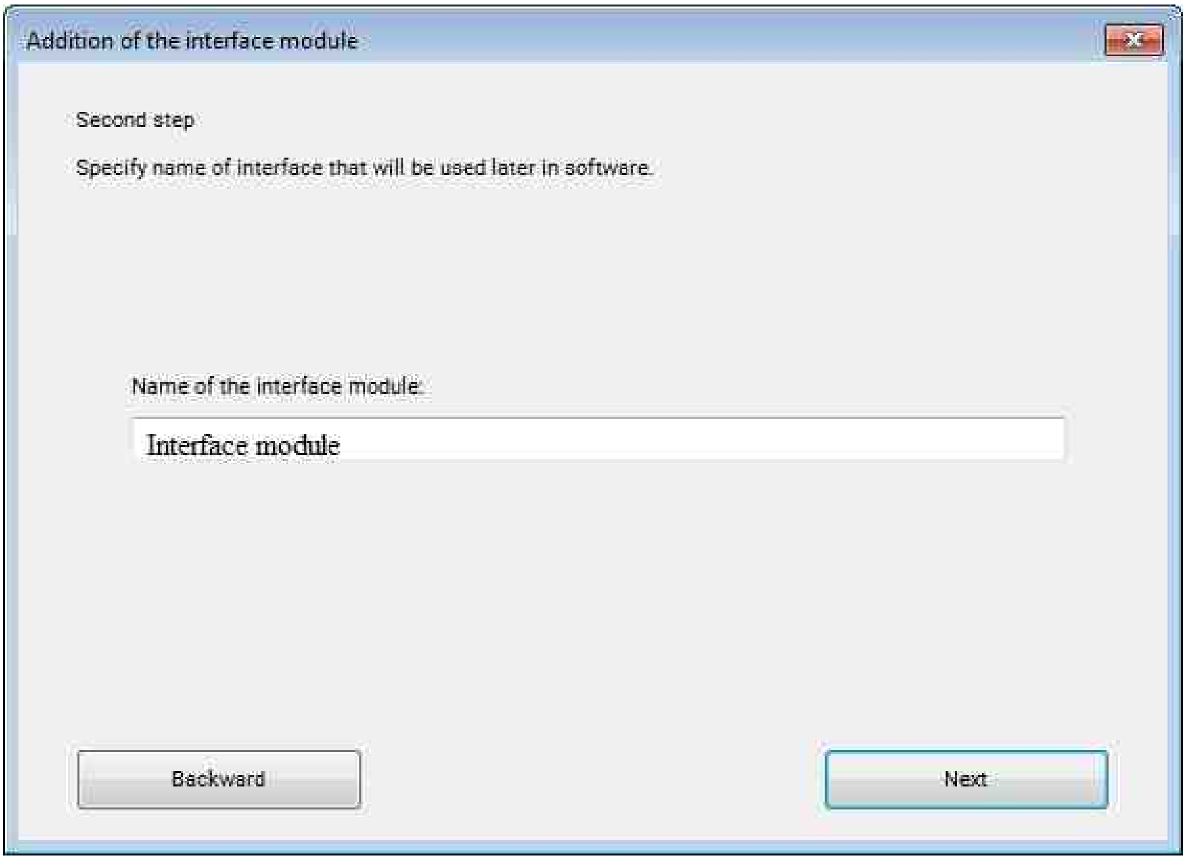


Fig. 4 - Adding an Interface module (Step 2)

Enter a device name and click the Next button.

In the third step, we need to set the data transfer settings (*Fig. 5*).

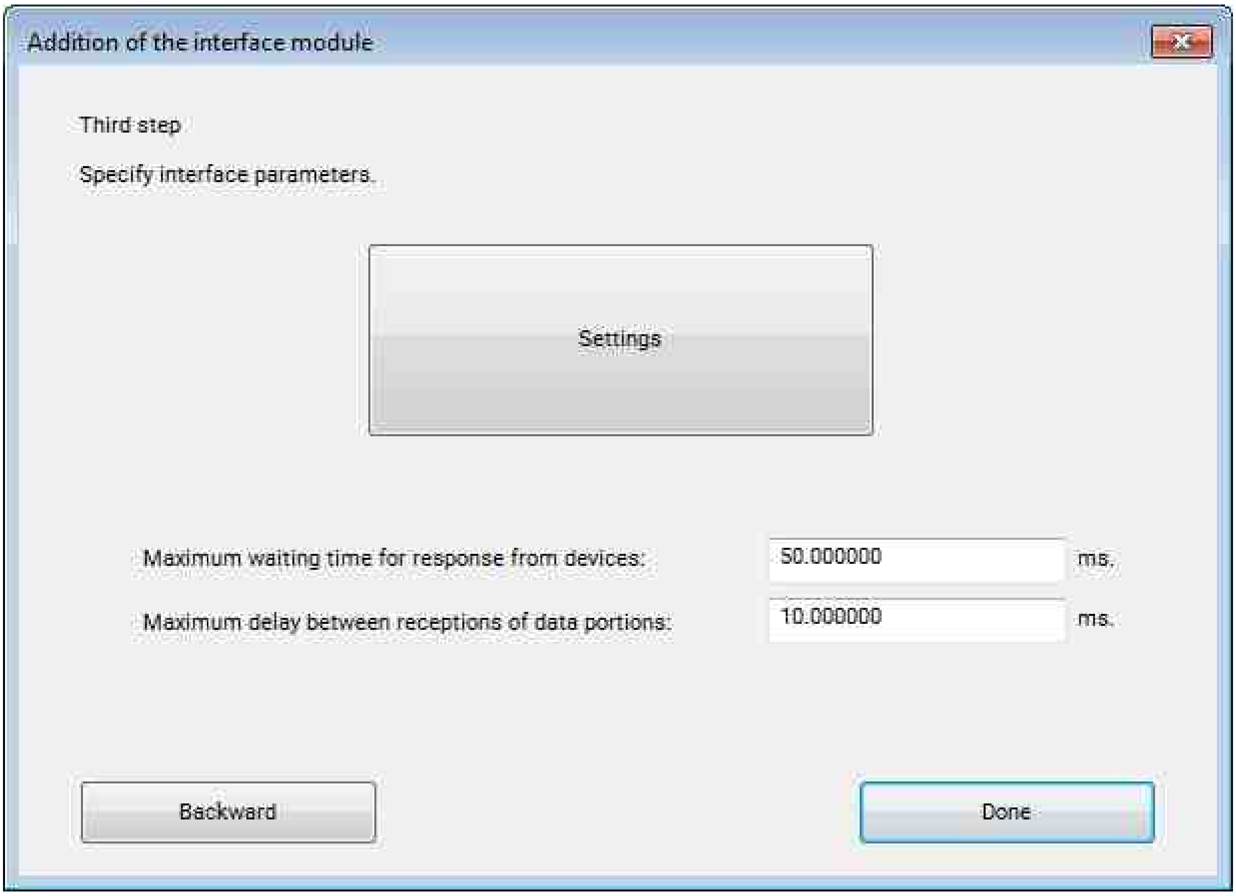


Fig. 5 - Adding an Interface module (Step 3)

To do this, press the "Settings" button and set the data transfer parameters in the standard Windows window (*Fig. 6*).

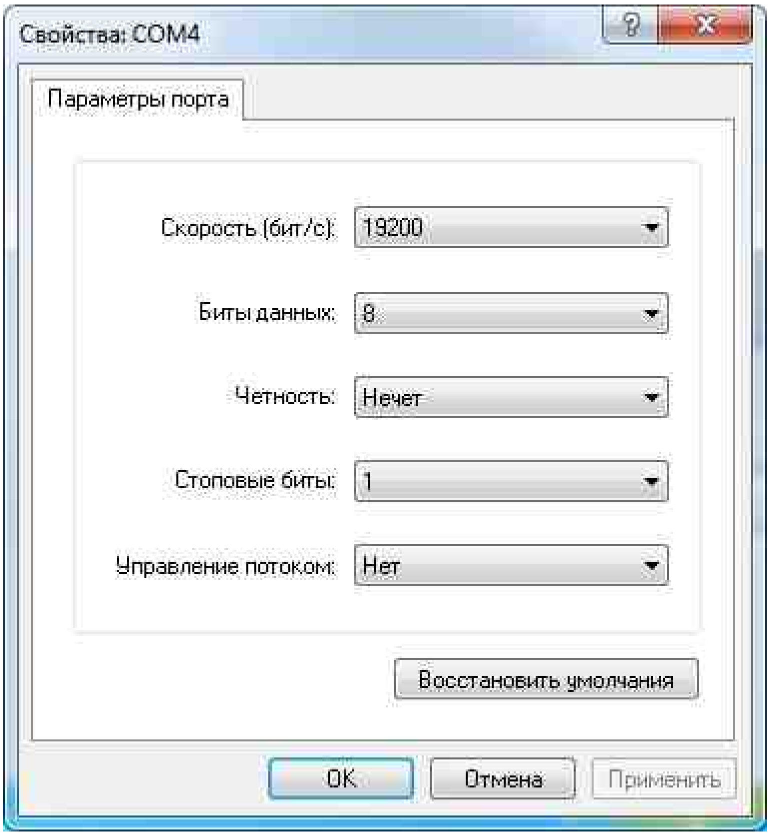


Fig. 6 - Data transfer settings

Additionally, we set the device polling parameters: the maximum waiting time for a response from the device and the maximum delay between successive data portions (for some interface modules, this parameter is set in the device driver). After specifying all the settings of the interface module, click the "Finish" button. Interface module added (*Fig. 7*).

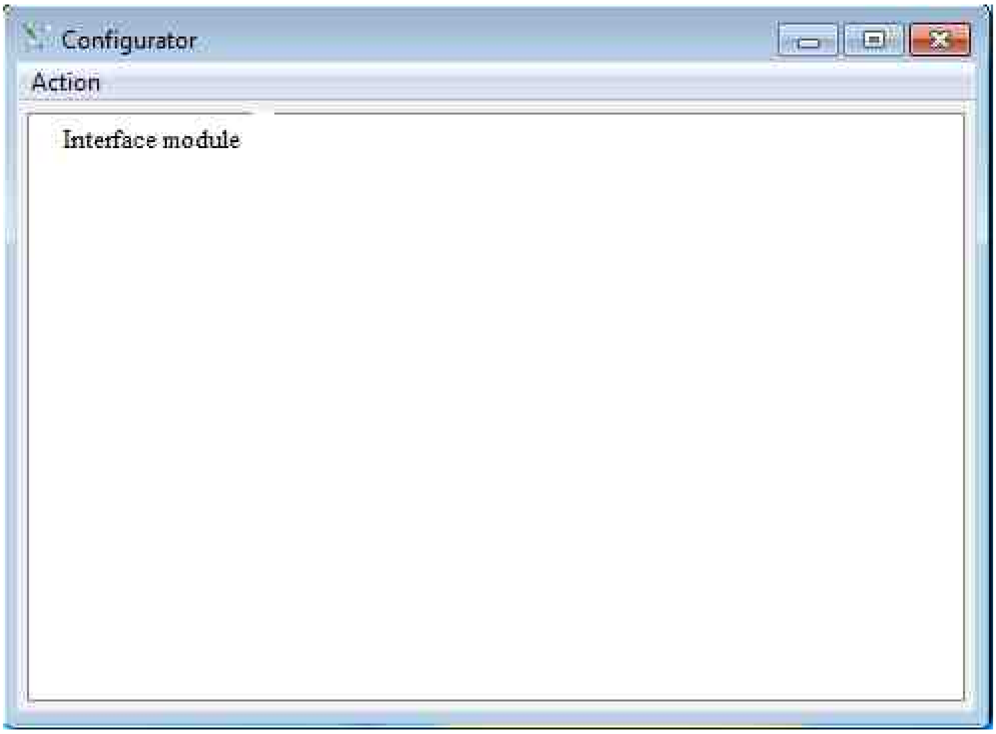


Fig. 7 - New interface module

Adding a new measurement module .....

To add a new measurement channel, in the main window of the "Configurator" program, click the menu "Action->Add measurement module", this menu can also be called by right-clicking on the required interface module (Fig. 8). Adding an interface module occurs in three steps. The first step is to select the interface module on which the measurement module will operate (*Fig. 8*).

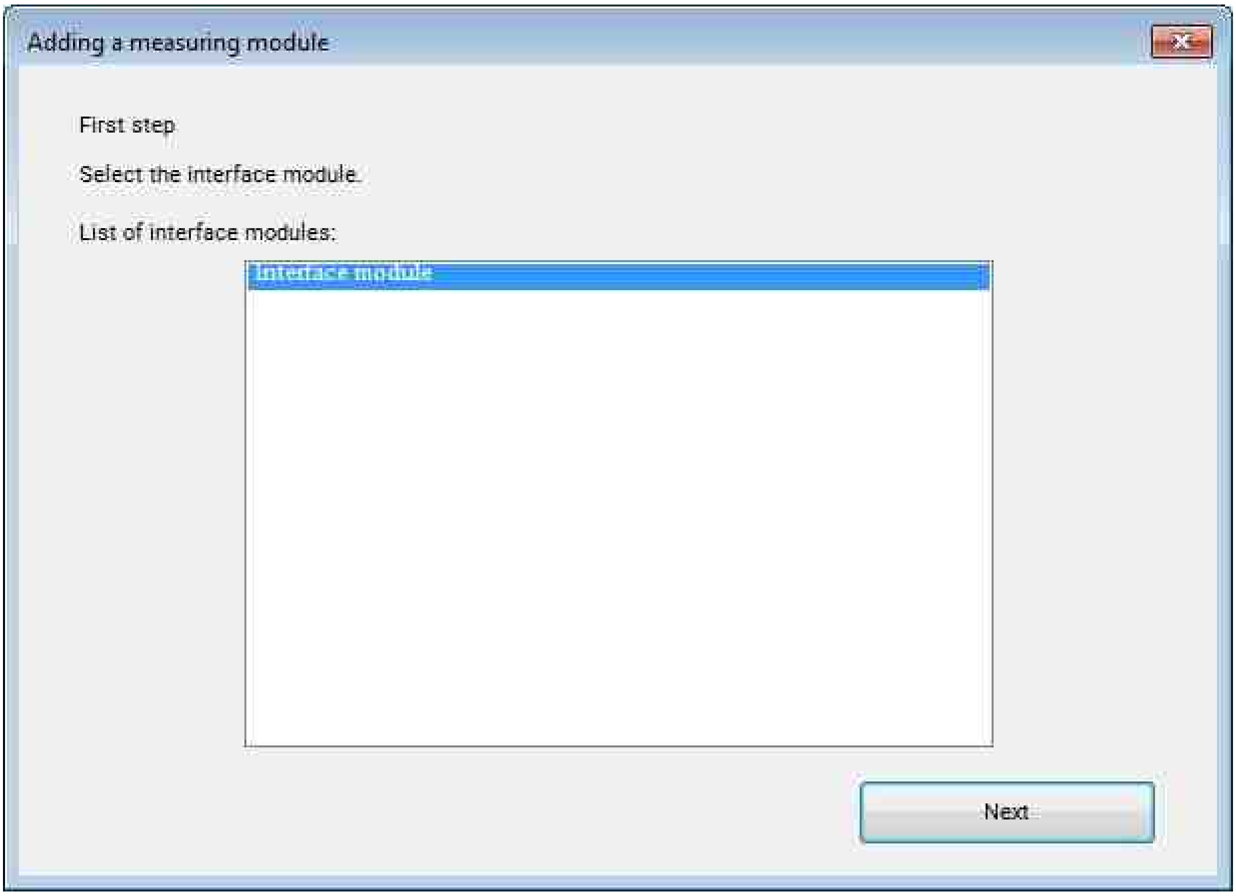


Fig. 8 - Adding a measurement module (Step 1)

After selecting the desired interface module, click the "Next" button. The second step is to set the name of the measuring module, convenient for further perception, this name is necessary for further use in the ZETLab software (*Fig. 9*).

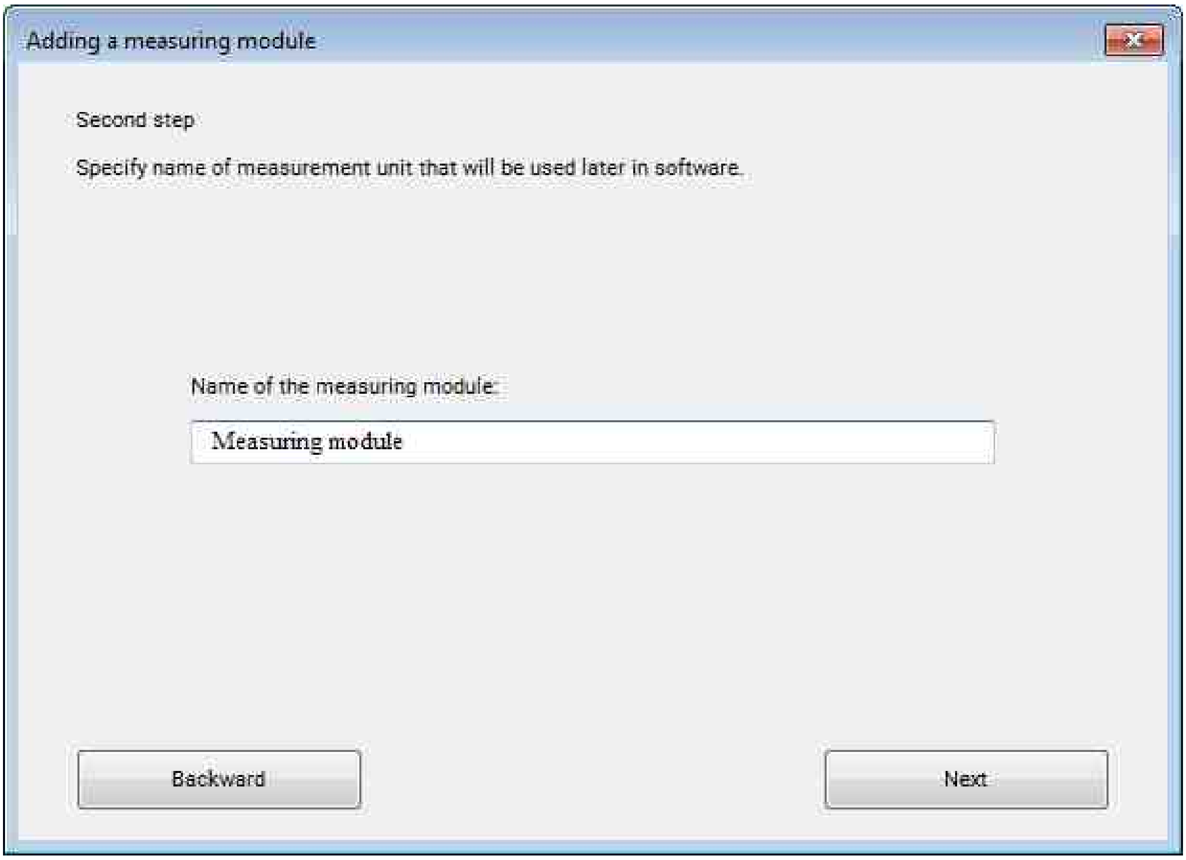


Fig. 9 - Adding a measurement module (Step 2)

After specifying the name of the measuring module, you must click the "Next" button. In the third step, you must specify the address of the measuring module and the type of communication protocol used (*Fig. 10*).

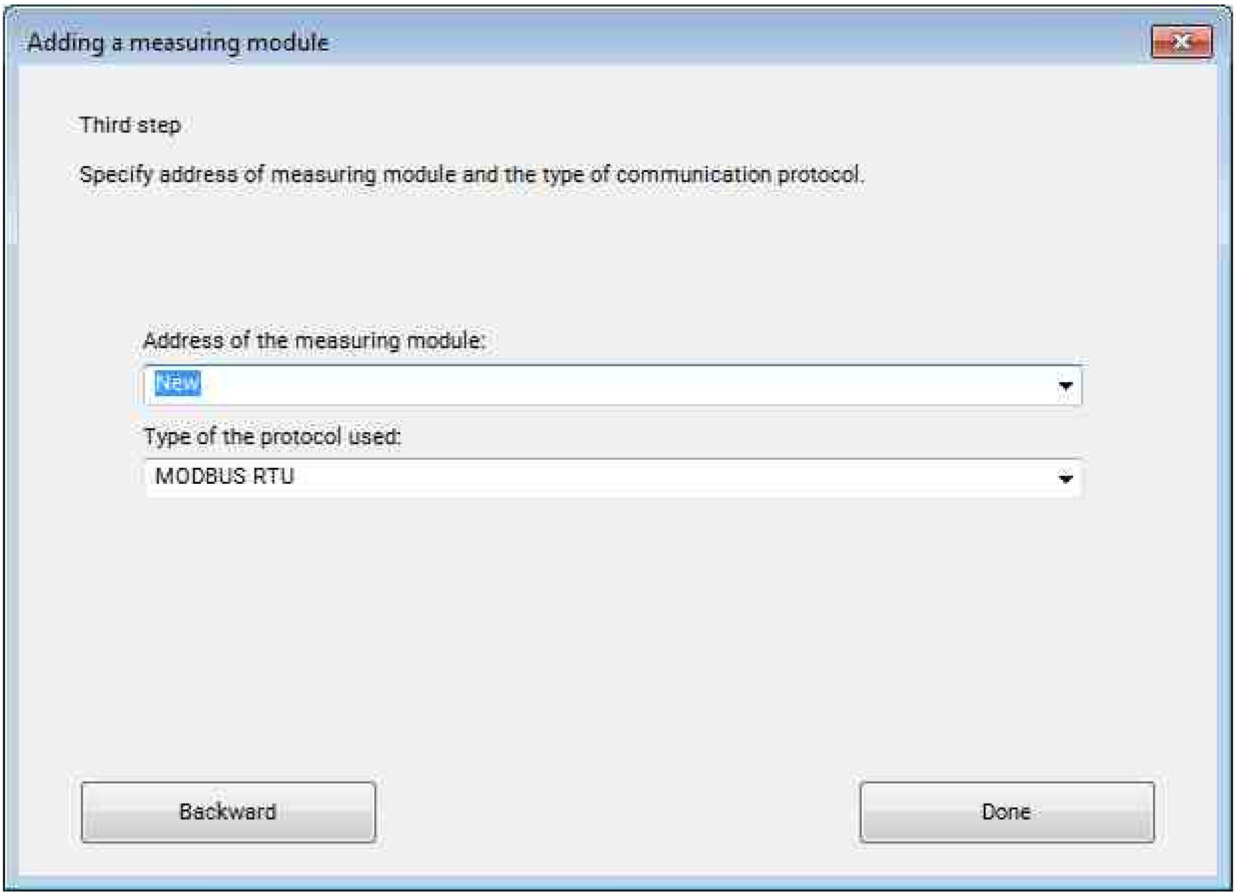


Fig. 10 - Adding a Measurement module (Step 3)

To complete the procedure for adding a new measuring module, click the "Finish" button. The measurement module has been successfully added (*Fig. 11*).

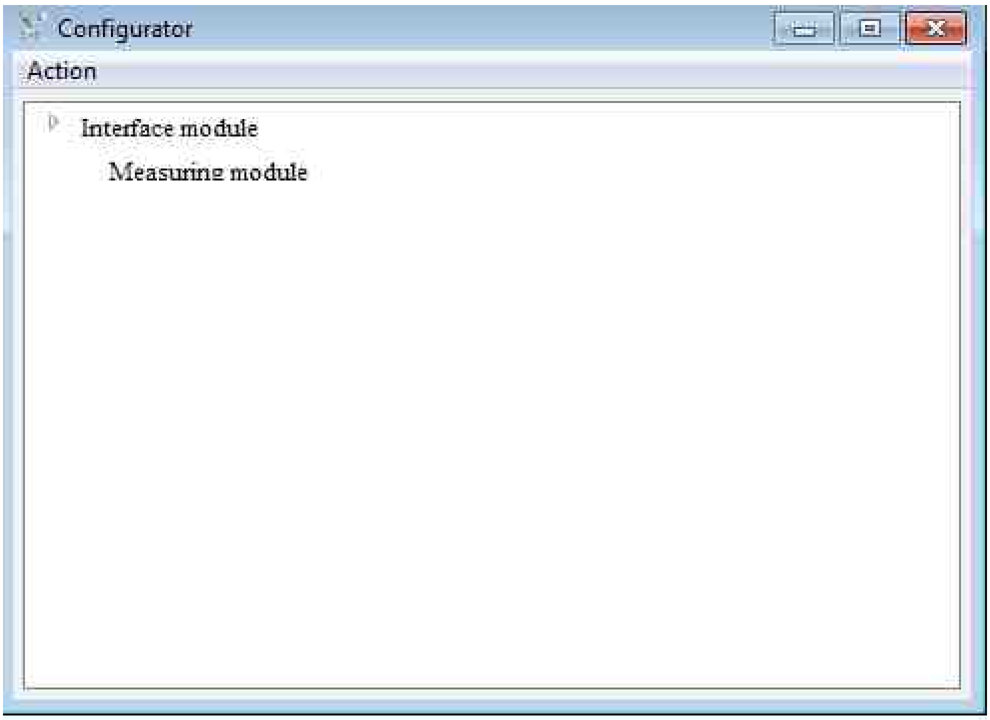


Fig. 11 - New measuring module

Addition of the measuring channel .....

To add a new measuring channel in the main window of the "Configurator" program, press the menu "Action->Add measuring channel", this menu can also be called by right-clicking on the required measuring module (*Fig. 12*).

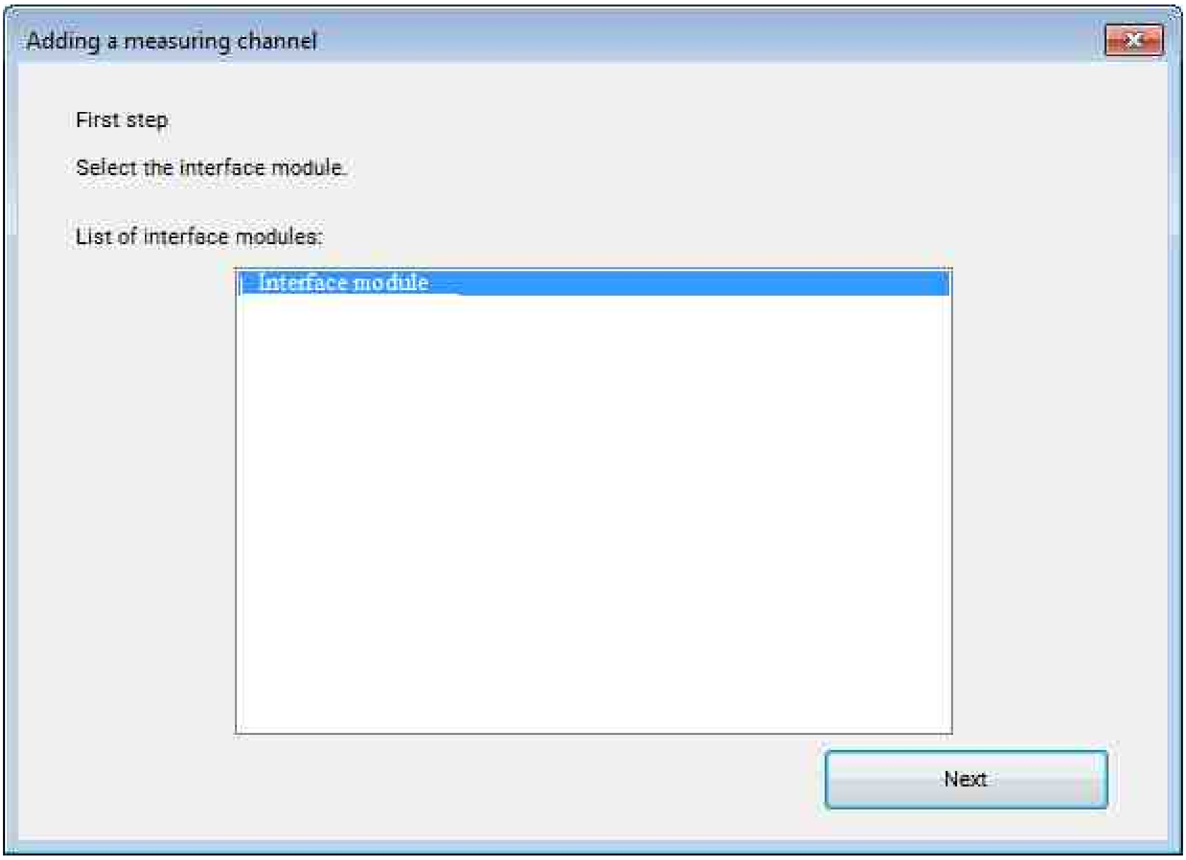


Fig. 12 - Adding a measurement channel (Step 1)

Adding a measuring channel takes place in five steps. The first step is to select the interface module on which the measurement channel will operate (*Fig. 13*).

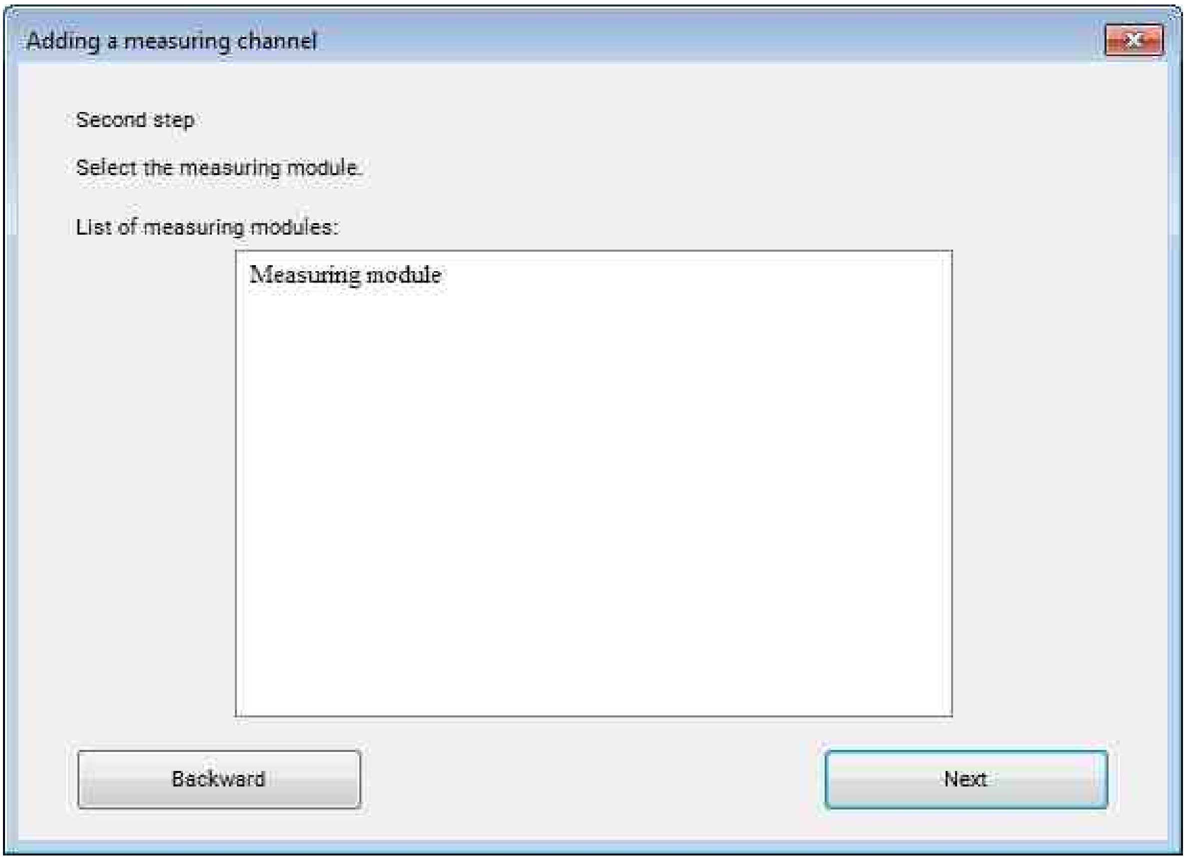


Fig. 13 - Adding a measurement channel (Step 2)

After selecting the desired interface module, click the "Next" button. The second step is to select the name of the measuring module on which the measuring channel will work (*Fig. 14*).

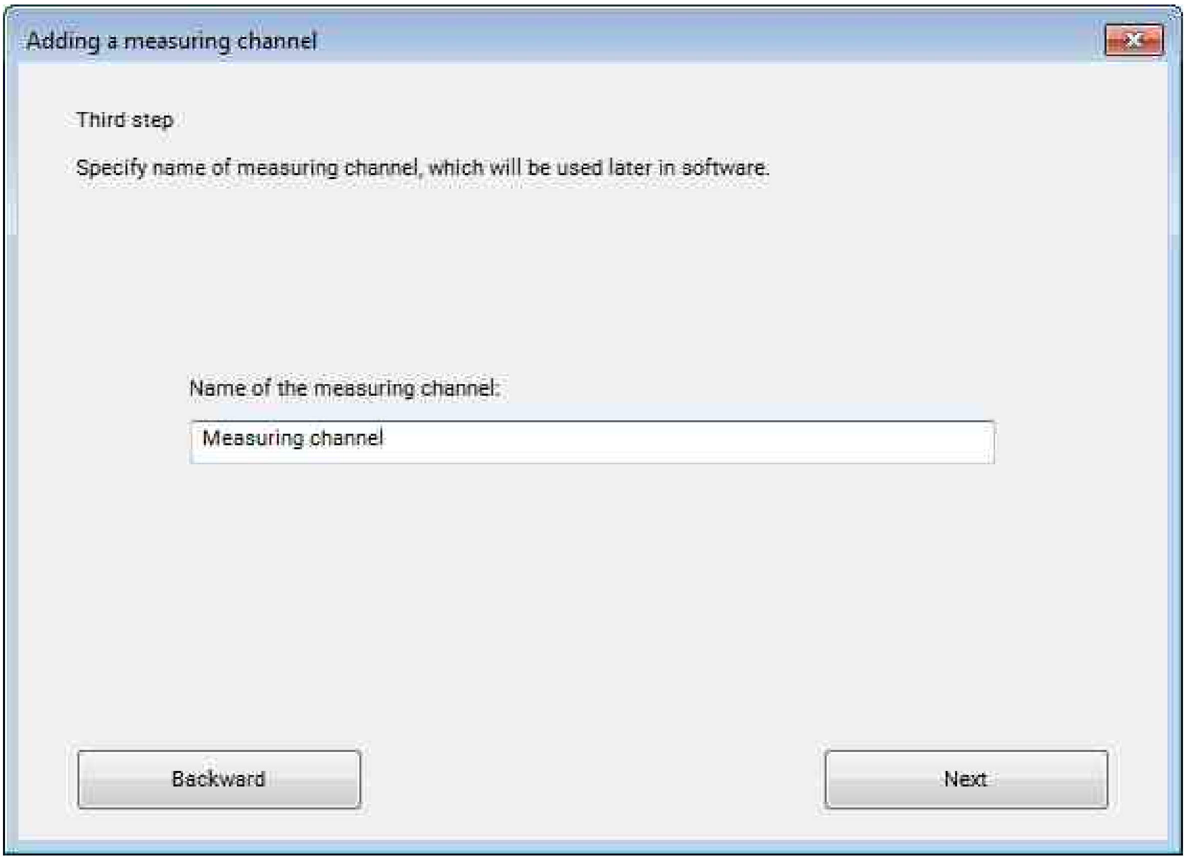


Fig. 14 - Adding a measurement channel (Step 3)

After selecting the measuring module, you must click the "Next" button. At the third step, you must specify the name of the measuring channel, this name is necessary for further use in the ZETLab software (*Fig. 15*).

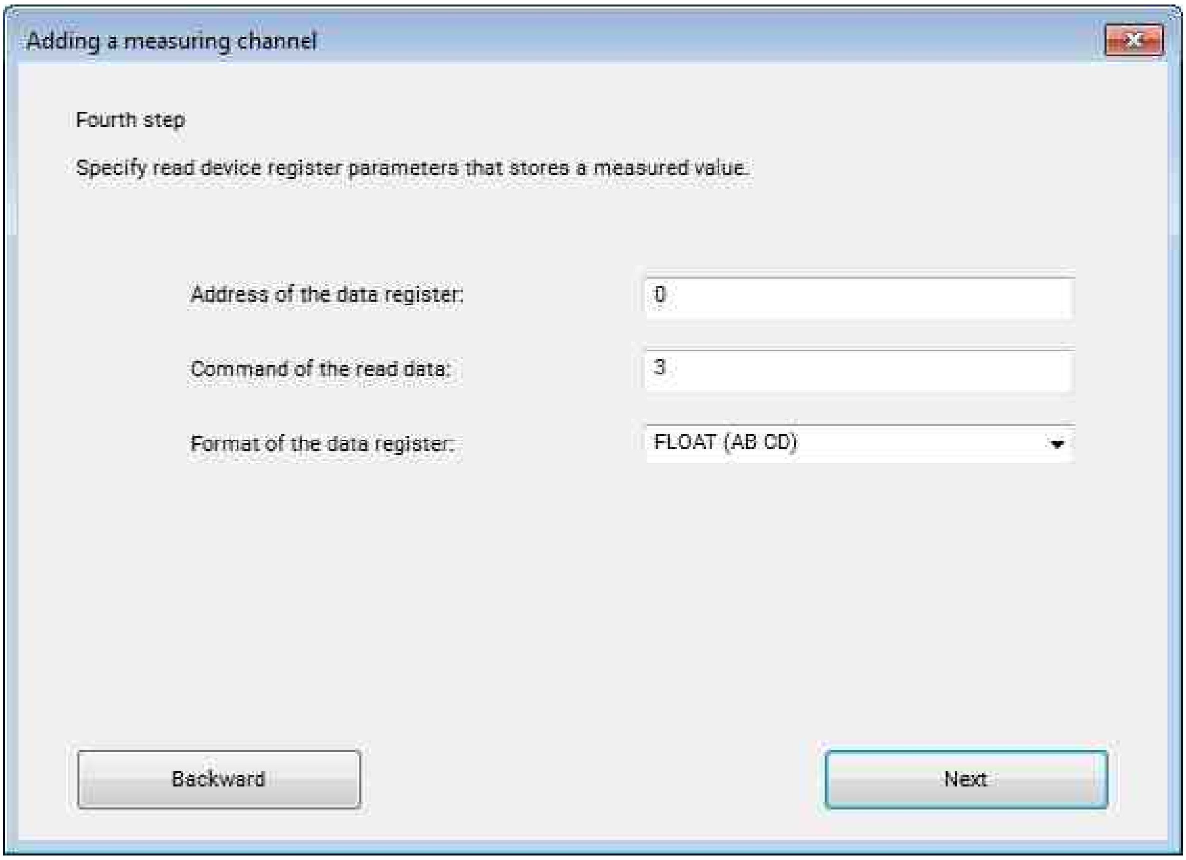


Fig. 15 - Adding a measurement channel (Step 4)

After specifying the name of the measuring channel, click the "Next" button. At the fourth step, you must specify the address of the register of the measuring module from which the data will be read. Specify the command that will be used to read the data and the data format in which the data is in the register (*Fig. 16*).

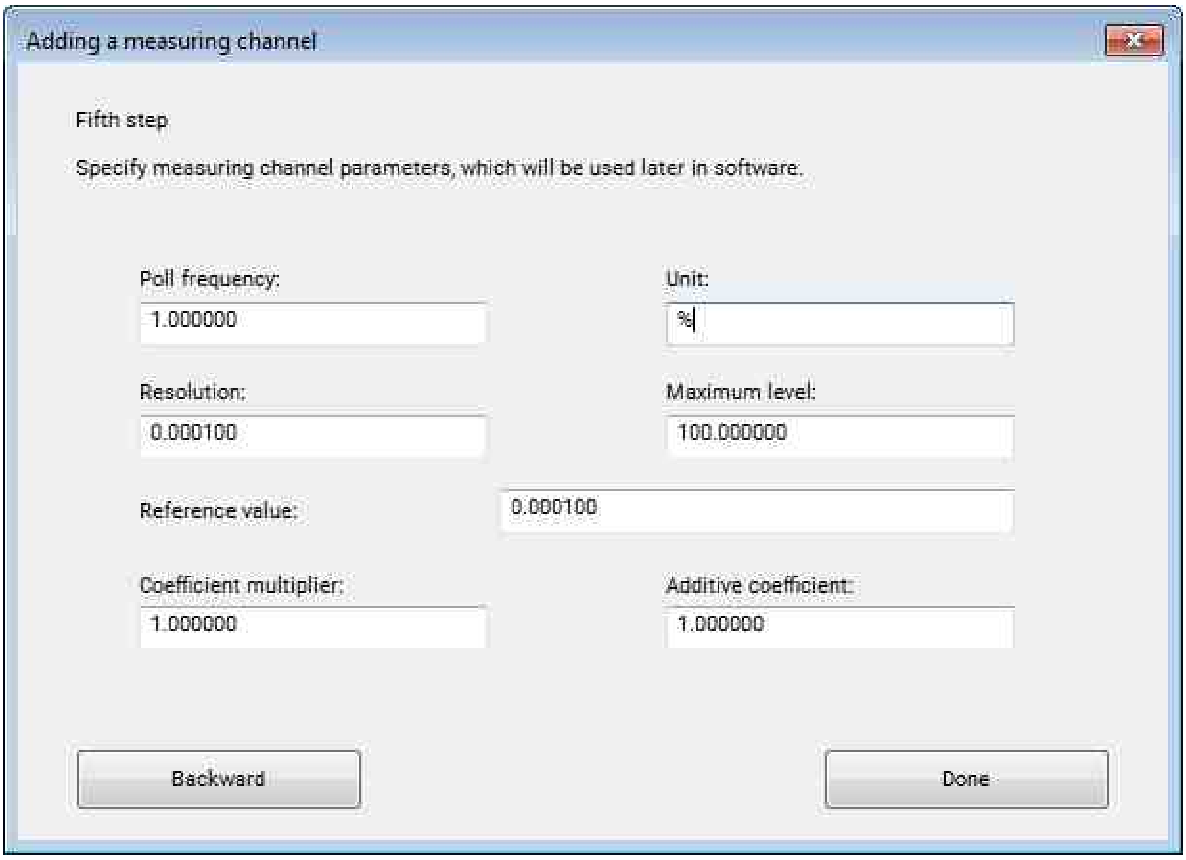


Fig. 16 - Adding a measurement channel (Step 5)

After specifying all the settings, you must click the "Next" button. At the fifth step, it is necessary to set the parameters of the measuring channel: the data polling frequency, the unit of measure, the resolution of the device when measuring this parameter, the maximum value for the measuring channel, the reference value of the measuring channel, the multiplicative and additive components. After all the settings, you must click the "Finish" button. The measurement channel will be added successfully (*Fig. 17*).

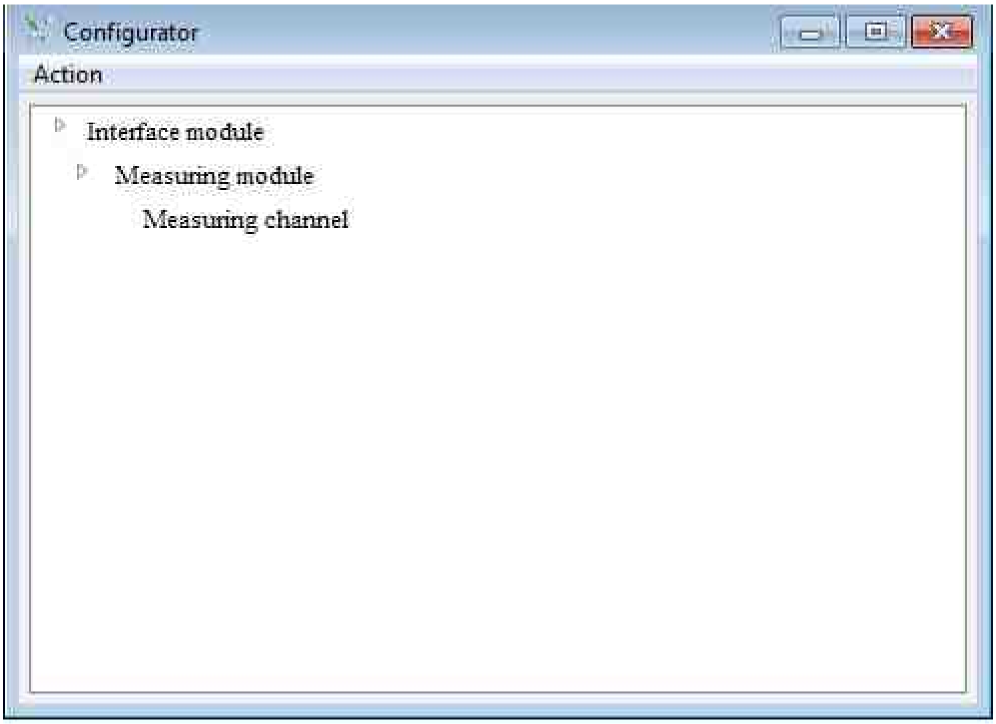


Fig. 17 - New measuring channel

Edit the parameters .....

To edit interface module parameters (*Fig.18*),

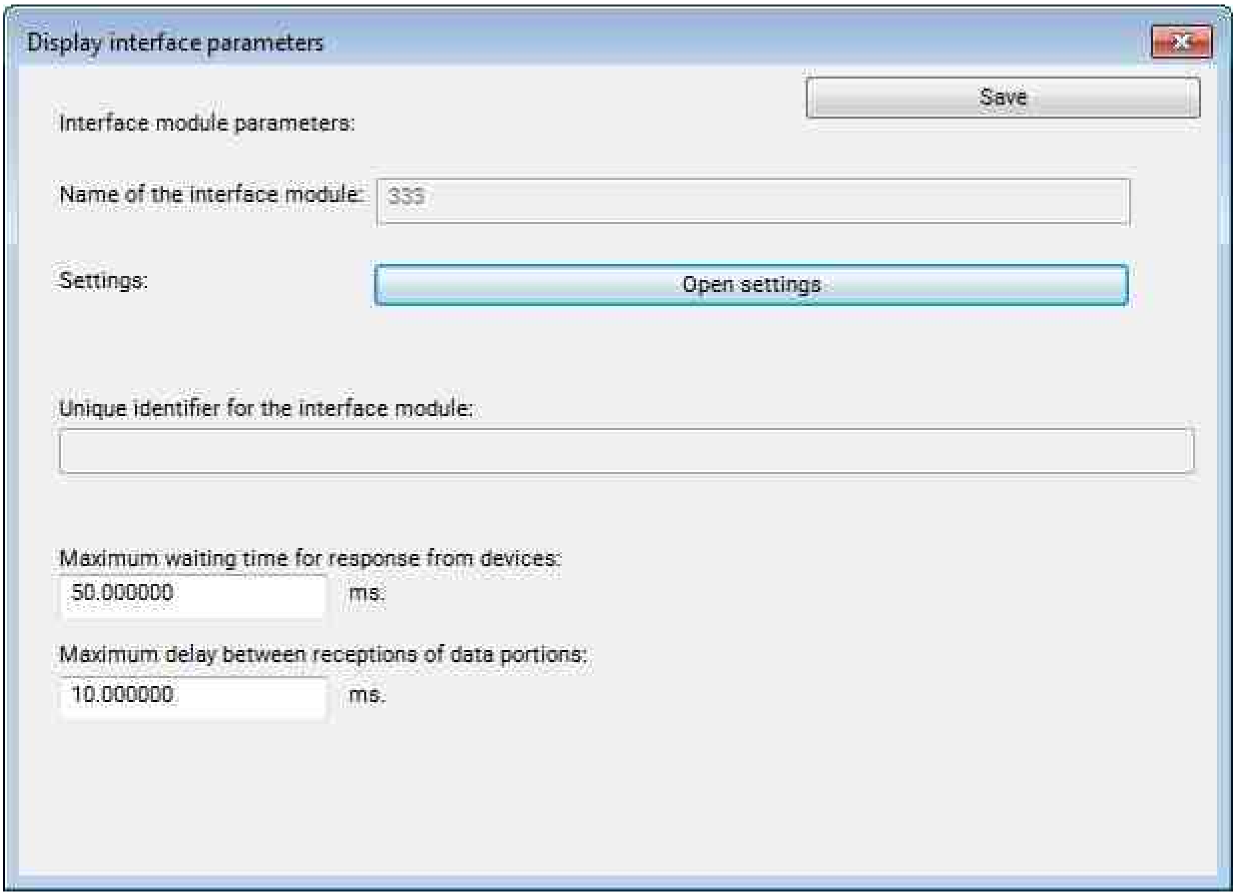


Fig.18 - Editing interface module parameters

measuring module (*Fig. 19*)

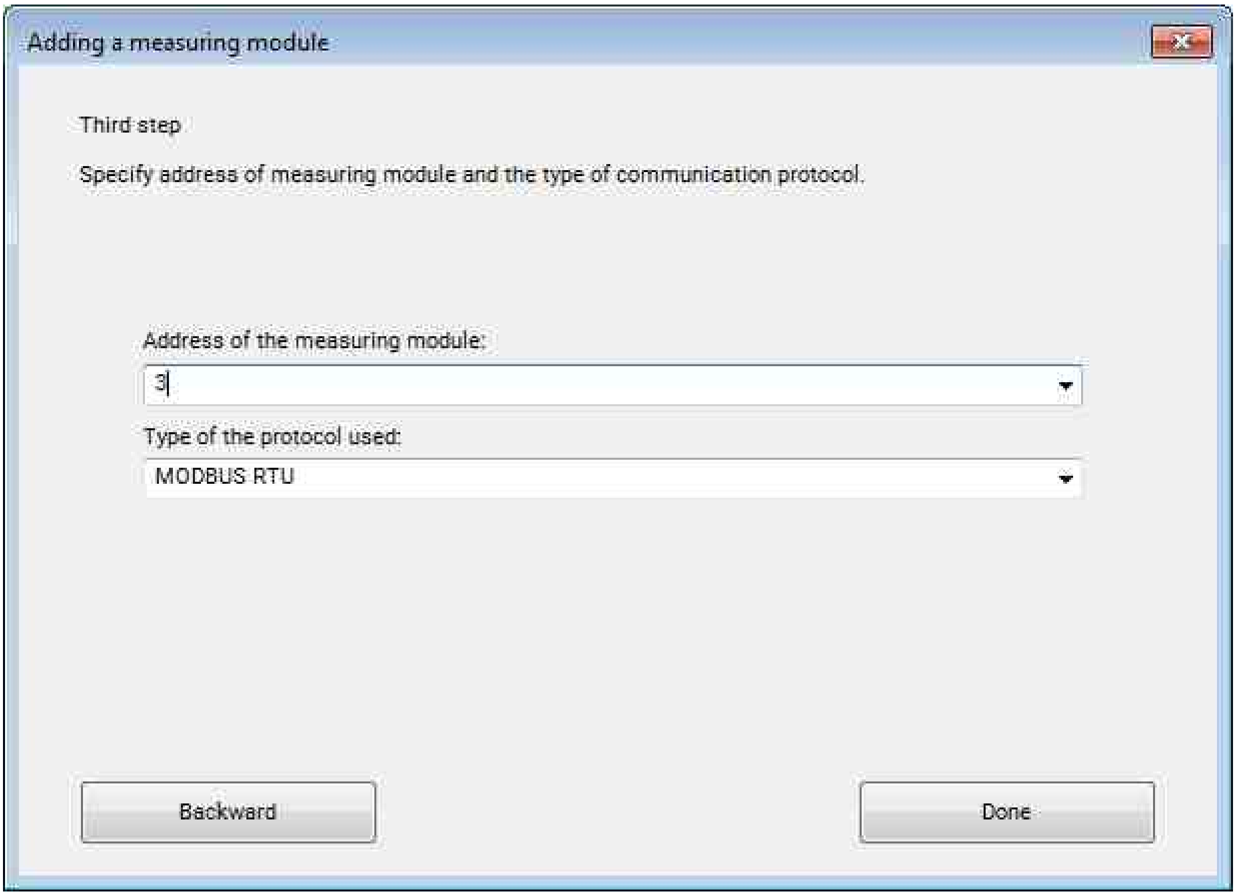


Fig. 19 - Editing the parameters of the measuring module

and the measuring channel (*Fig. 20*), right-click on the desired module and select "Edit ...".

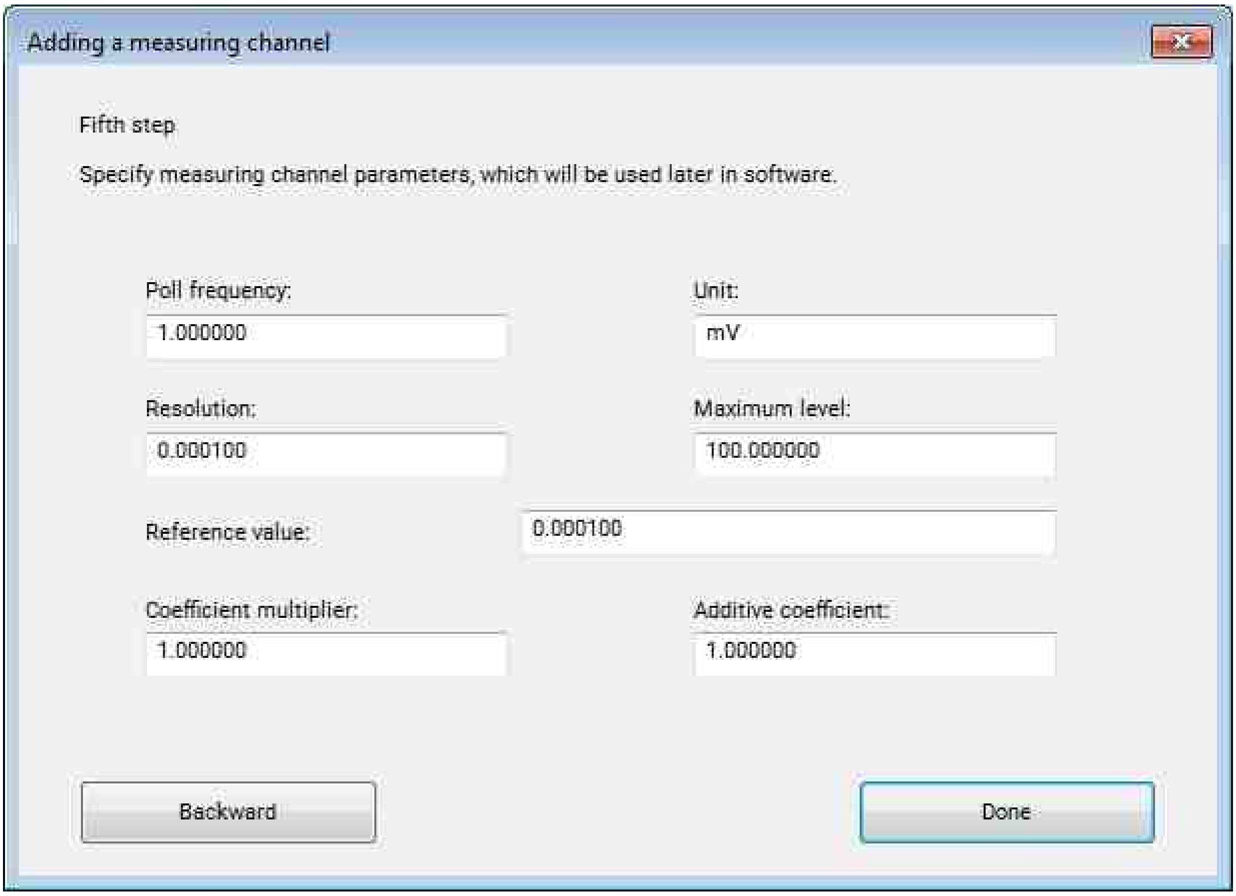


Fig. 20 - Editing the parameters of the measuring channel

Delete .....

To delete an interface module, measuring module or measuring channel (*Fig.21*), right-click on the desired module and select "Delete ..." and confirm the intent of their actions in the window that opens.

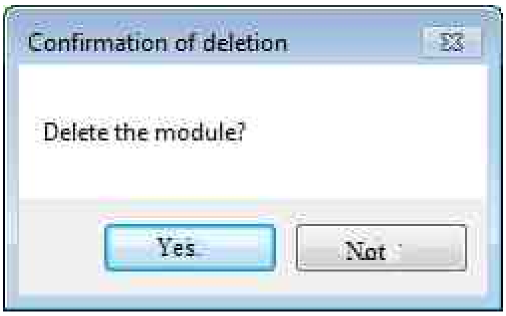


Fig.21 - Confirmation of module deletion

Data processing .....

After setting up the measuring system, it is necessary to launch the program "ZETLab -> Service -> ZETServer time". If the time moves along the configured measuring channel and the channel is not gray (*Fig.22*),

Fig.22 - Correct setting of the measuring system

means the measuring system has been set up correctly. In case the time does not pass (*Fig. 23*),

Fig. 23 - Measuring system configured in error

then it is necessary to adjust the settings of the measuring system. If the measuring channel was created correctly, then the data from it can be processed in any program from the ZETLab and ZETView software (*Fig. 24, 25, 26*).

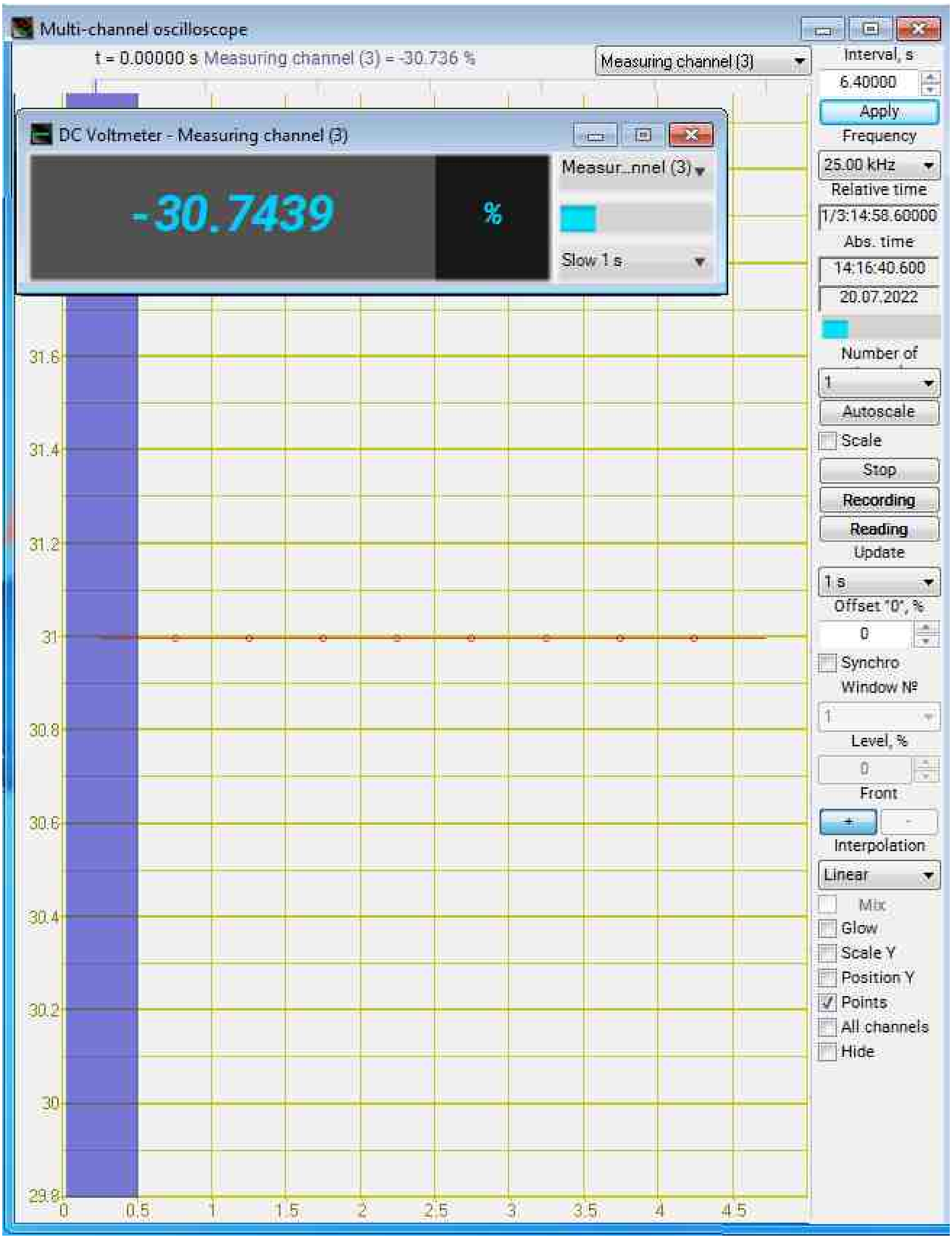


Fig. 24 - Data processing in ZETLab software

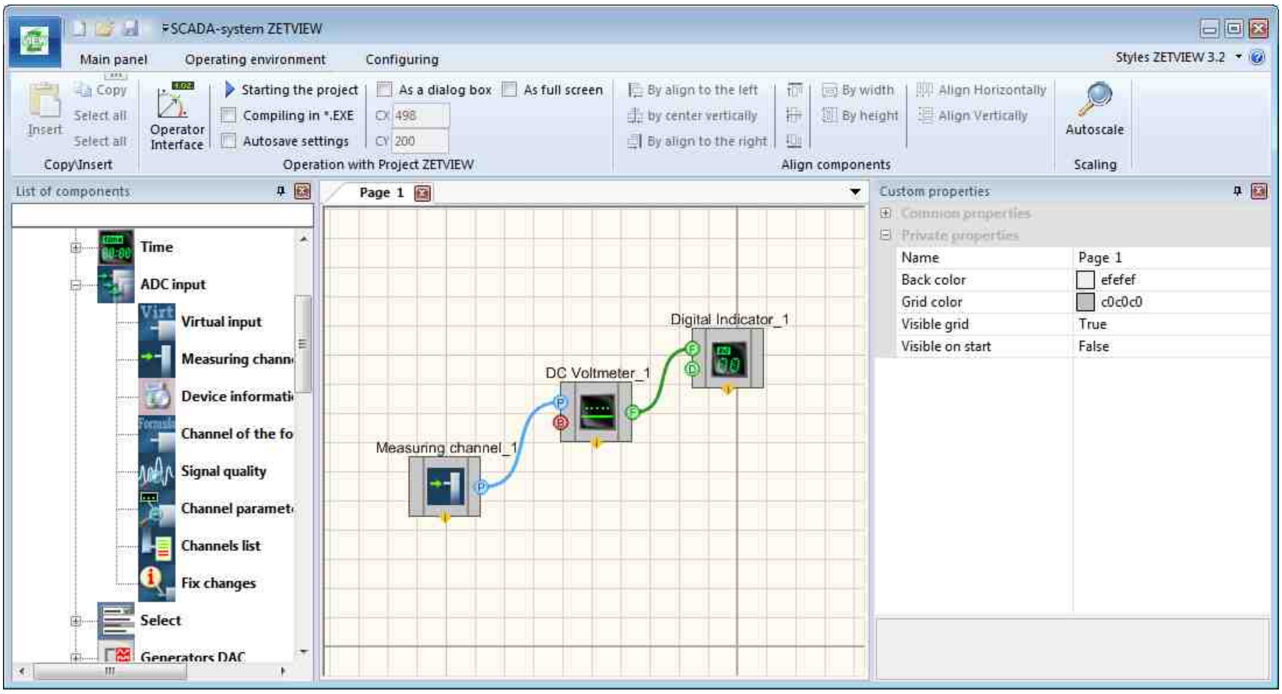


Fig. 25 - Data processing in ZETView software

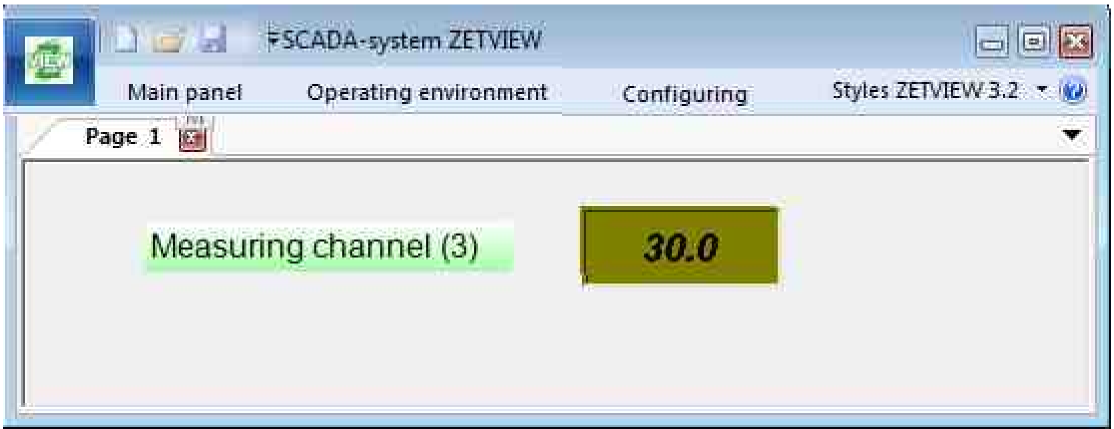


Fig. 26 - Data processing in ZETView software.

The program “Service work with ZET7XXX”: User manual .....

Function

The present user manual is intended for the personnel involved in configuration and maintenance of the measurement systems based on devices of *ZETSENSOR* series. The User Manual covers the following issues:

·updates of integrated software of the digital transducers,

·diagnostics of automated data acquisition systems based on modules of ZET7xxx series,

·configuration of OPC-server parameters (registers of the digital transducers are represented as tags). The configuration is possible both at the stage of system deployment and in the course of its operation.

Preparation for work .....

Install *ZETLAB* Software (in the case if it has not been previously installed) from the CD to the PC which will be used for diagnostic purposes, then start the installation file "*ZETLab.msi*", follow the instructions, and complete the installation process. Additional information regarding the use of *ZETLAB* Software is available in the document "*ZETLAB Software. User manual*". Start *ZETLAB* software using the program icon at the desktop.

Fig.2.1 Service work with ZET7XXX - program icon image

Start the program "*Service work with ZET7XXX*" by selecting the corresponding option in the main menu of *ZETLAB* Software (see the Fig. below).

Note! In order to secure correct operation of the program "*Service work with ZET7XXX*", it is necessary to suspend operation of all the other programs from the scope of *ZETLAB* Software package (e.g., *Device manager, ZETServer time*, etc.).

Note! Before starting the program "*Service work with ZET7XXX*", make sure that the measuring lines, which are subject to diagnostics, are connected with the use of interface converters. Also, it is obligatory, that *ZET7XXX* modules of the measuring line should have identical operational speeds by the digital interface, and that the power supply is available.

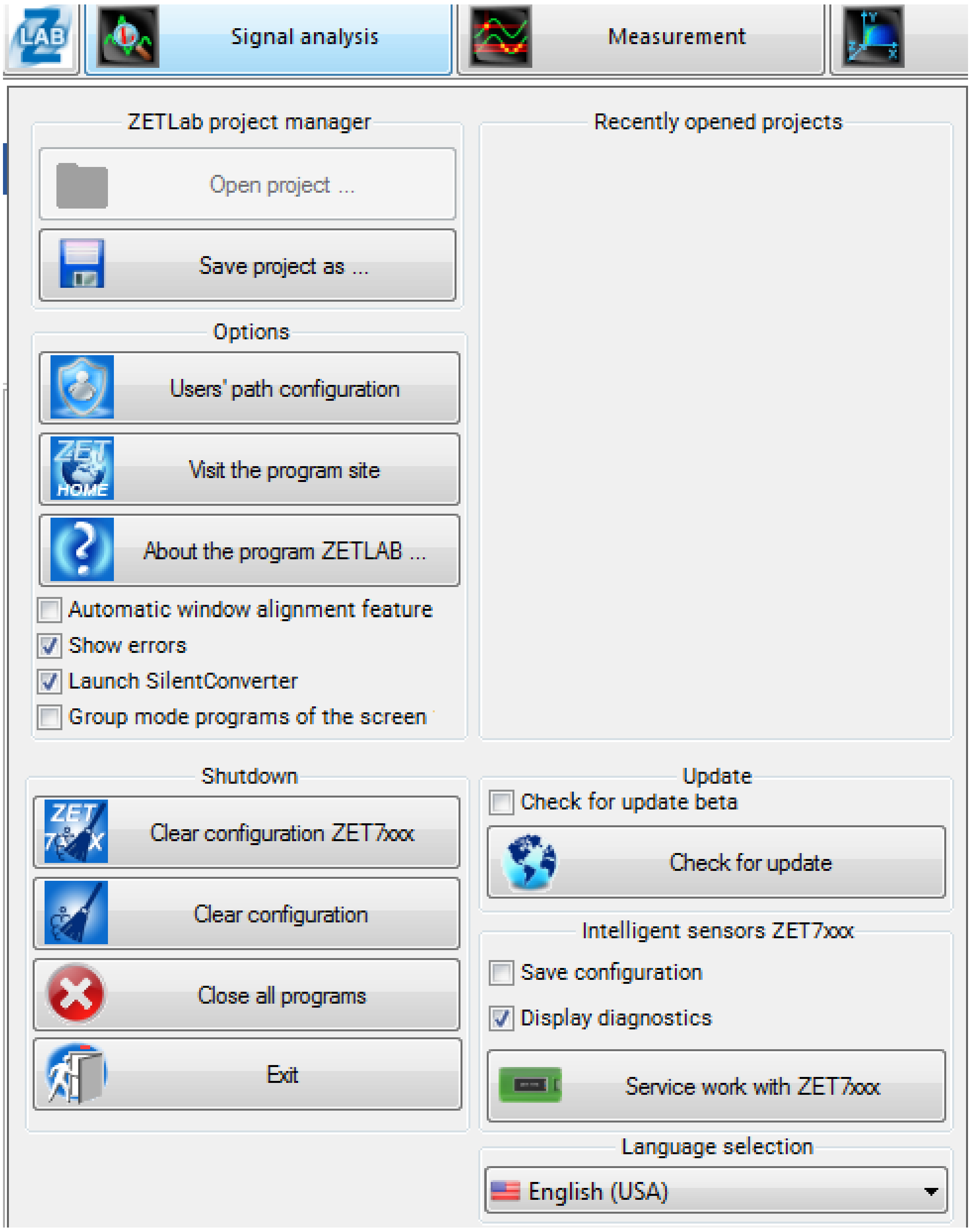


Fig.2.2 Service work with ZET7XXX - Starting the program from the main menu of ZETLAB Software

The main interface of the program "*Service work with ZET7XXX*" contains the first root level, which displays the list of interface converters, that have been detected by the program. The second root level contains the list of digital modules, that are connected to the corresponding interface converters. In order to search for digital modules, use the function of slave devices search (i.e., use the key "*Search for devices in the measuring line*" and wait for completion of the process).

Note: some of the primary transducers require preliminary activation. To do that, right-click the corresponding interface converter and select the option "*Activate*".

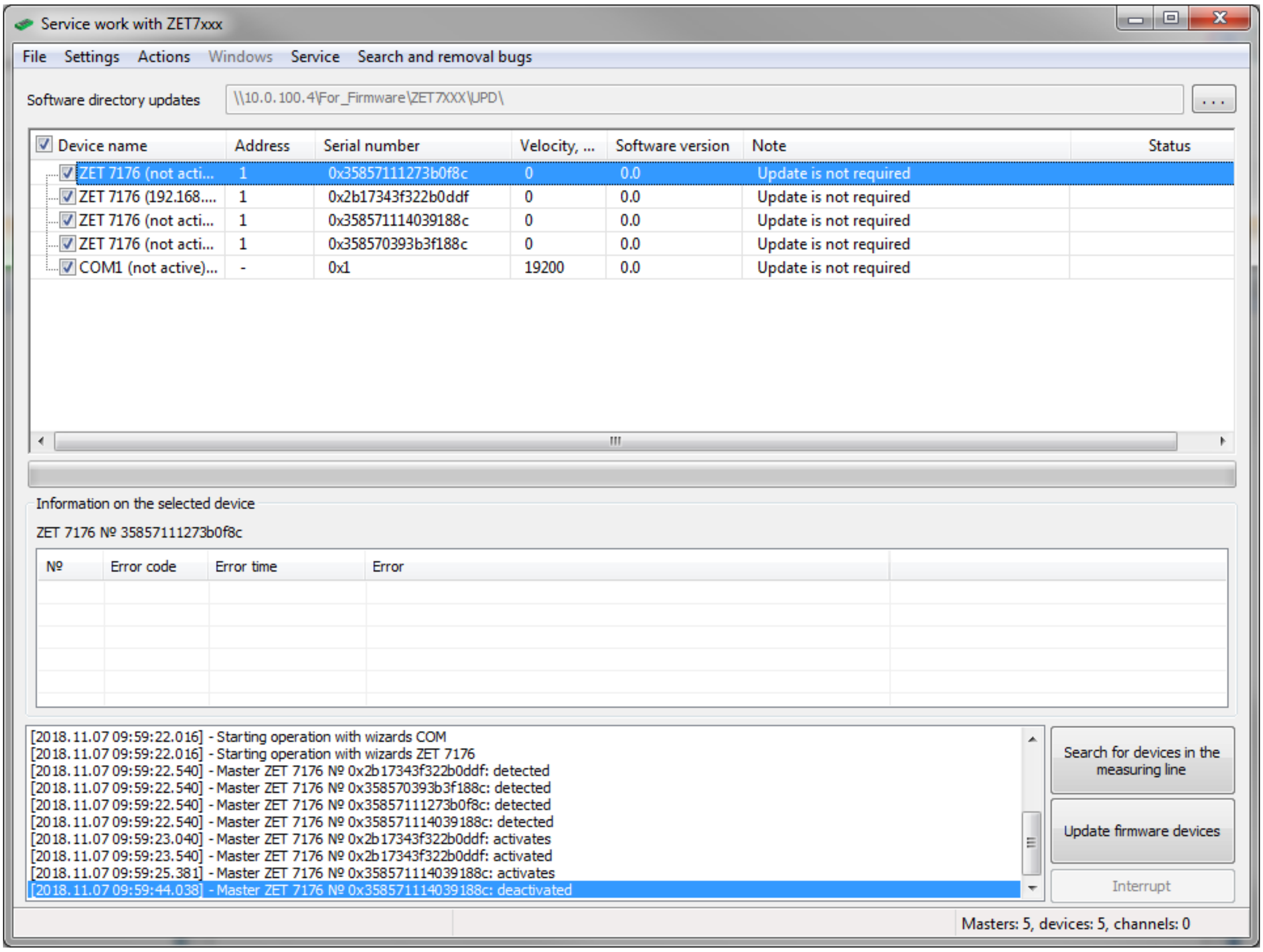


Fig.2.3 Service work with ZET7XXX - Main interface of the program

Getting started with the program "Service work with ZET7xxx" .....

The program "**Service work with ZET7xxx**" is launched from the main menu of ZETLab (*Fig.2.2*) by pressing the button "**Service work with ZET7xxx**" (*Fig.3.1*).

*Fig.3.1 Start button of the program "**Service work with ZET7XX**"*

Schematically, the program window "**Service work with ZET7xxx**" can be divided into several main works areas (*Fig. 3.2*):

- Control panel;
- Table of connected devices;
- Table "Information on the selected device";

- Event log;
- Quick commands;
- Menu for selecting the directory for updating the software firmware of devices.

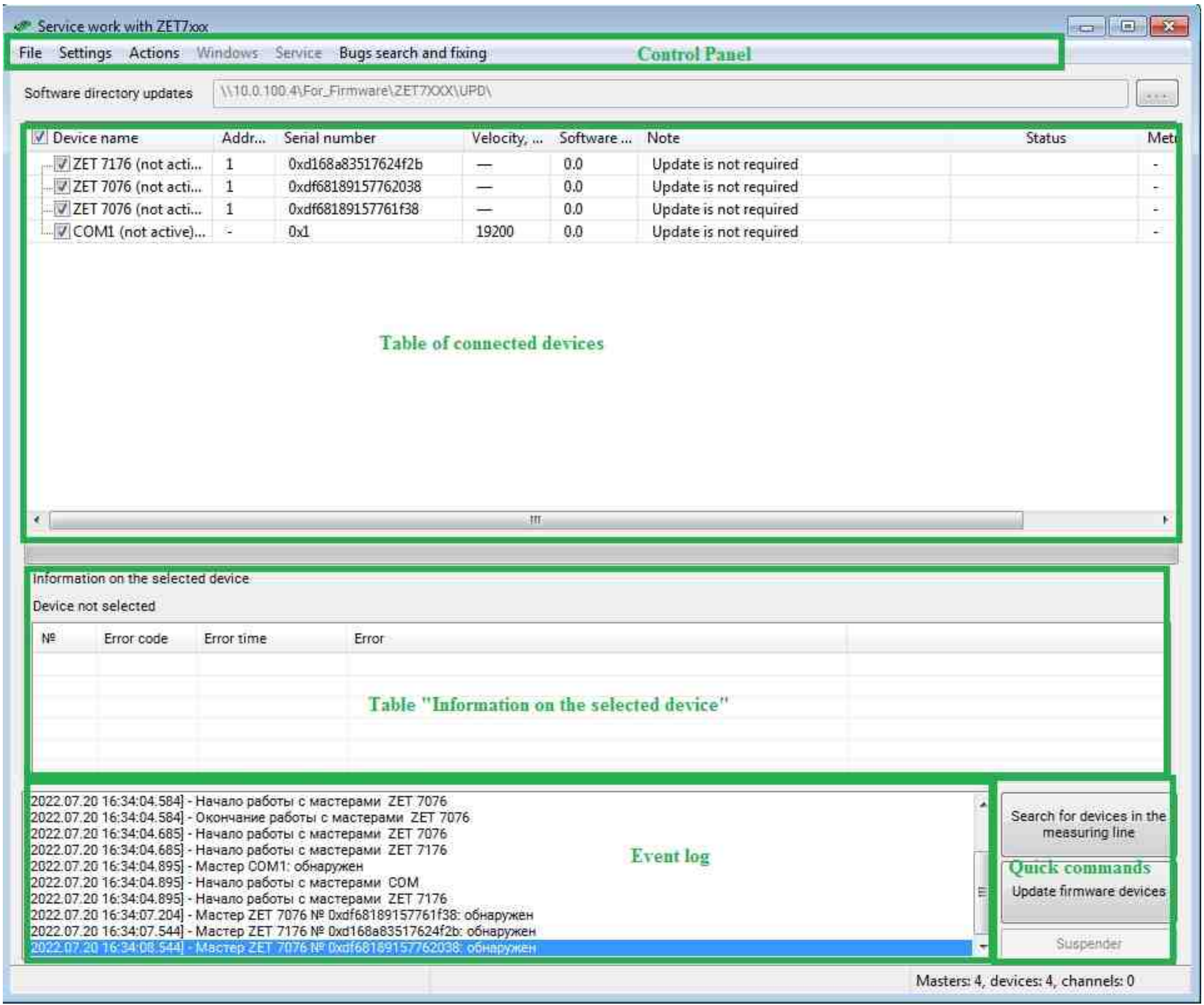


*Fig.3.2 Program window "**Service work with ZET7xxx**"*

The cells of the table of connected devices contain the following information:

- "Device name" – device type;
- "Address" - the address of the device in the measuring circuit;
- "Serial number" - a unique number of the device;
- "Speed, bps" – values of the parameters "Bit rate" and "Parity bit";
- "Software version" – firmware version number;
- "Note" - additional information.

To display specific types of interface converters in the table of connected devices, on the control panel of the program "**Service work with ZET7xxx**" go to the menu "Settings" - "Work with wizards", and select the required types of converters from the pop-up list (*Fig.3.3*).

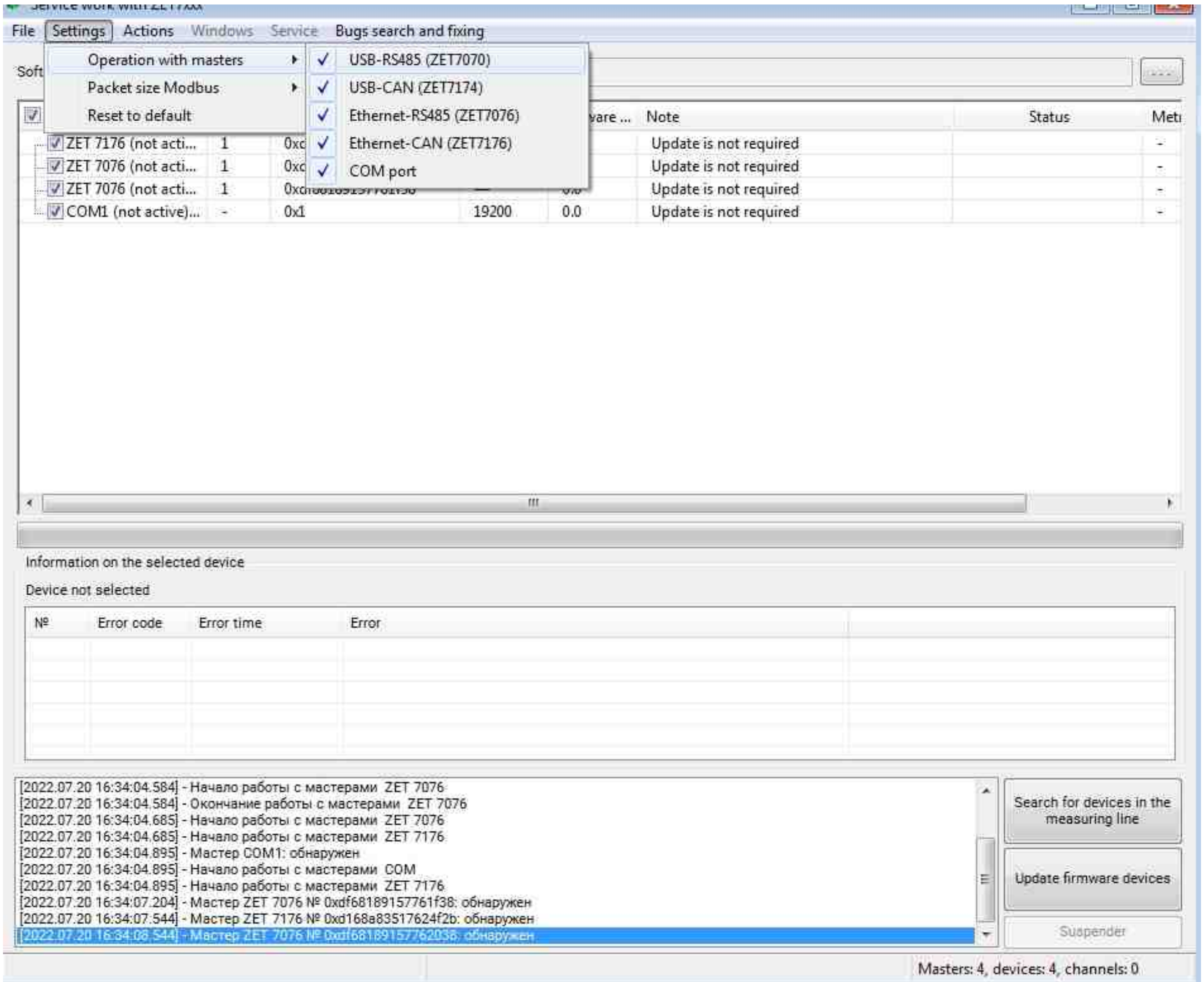


Fig.3.3 Menu "Working with masters"

Note: Some types of interface converters may require activation for their operation. As a rule, such interface converters include – *ZET 7076 (RS-485 ↔ Ethernet) and ZET 7176 (CAN 2.0 ↔ Ethernet)*. In this case, it is necessary to press the right mouse button on the name of the unused interface converter, open the context menu and in the window that opens activate the "Enable" command (*Fig.3.4*).

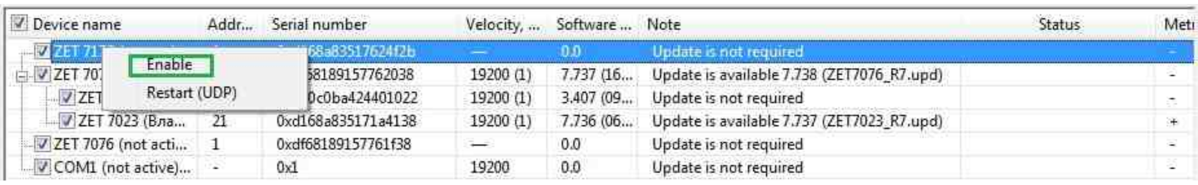
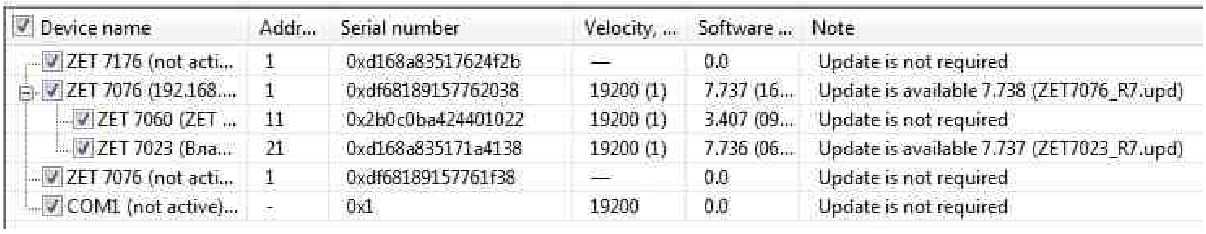


Fig.3.4 The "Enable" command

To display the digital sensors connected to the enabled interface converters, you need to activate the button "Search for devices in the measuring line" (*Fig.3.5*).

Fig.3.5 Button "Search for devices in the measuring line"

After the search for digital sensors is completed, in the table of connected devices in the first root level of the "Device name" cell, a list of interface converters detected by the program connected to this computer should be displayed, and in the second root level - a list of digital sensors connected to the corresponding interface converters (*Fig.3.6*).



Device name	Addr...	Serial number	Velocity, ...	Software ...	Note
ZET 7176 (not acti...	1	0xd168a83517624f2b	—	0.0	Update is not required
ZET 7076 (192.168....	1	0xdf68189157762038	19200 (1)	7.737 (16...	Update is available 7.738 (ZET7076_R7.upd)
ZET 7060 (ZET ...	11	0x2b0c0ba424401022	19200 (1)	3.407 (09...	Update is not required
ZET 7023 (Вла...	21	0xd168a835171a4138	19200 (1)	7.736 (06...	Update is available 7.737 (ZET7023_R7.upd)
ZET 7076 (not acti...	1	0xdf68189157761f38	—	0.0	Update is not required
COM1 (not active)...	-	0x1	19200	0.0	Update is not required

Fig.3.6 Table of connected devices in the program "Service work with ZET7xxx"

Note:

For digital sensors with an RS-485 data transmission interface, the "Search for devices in the measuring line" function is equipped with an additional option - "Auto-tuning of exchange parameters".

For proper operation of digital sensors, the values of the "Baud rate" and "Parity" parameters of digital sensors are set in strict accordance with the set values for the interface converter. The "Auto-configuration of exchange parameters" option is designed to resolve conflicts between digital sensors and the interface converter, in case of mismatch between these parameters.

The option "Auto-configuration of exchange parameters" is called as follows:

1. For the interface converter, set the value "19200" in the "Baud rate" parameter, set the value "1" in the "Parity check" parameter.

2. Turn off the power supply of digital sensors connected to this interface converter.

3. Apply voltage power supply to the digital sensors.

4. Not earlier than 5 seconds after power supply on activate the button "Search for devices in the measuring line" (Fig.3.7).

5. Digital sensors switch to a special mode of operation to set the parameters "Baud rate", "Parity check" of all digital sensors in this measuring circuit, in accordance with similar parameters of the interface converter.

"Search and troubleshooting" menu .....

"**Search and troubleshooting**" menu located on the control panel of the program "Service work with ZET 7xxx" (*Fig.4.1*) and contains the following options:

- "Search devices with enumeration of baud rates and parity bit";
- "Troubleshooting Modbus address conflicts";
- "Reading internal error logs".

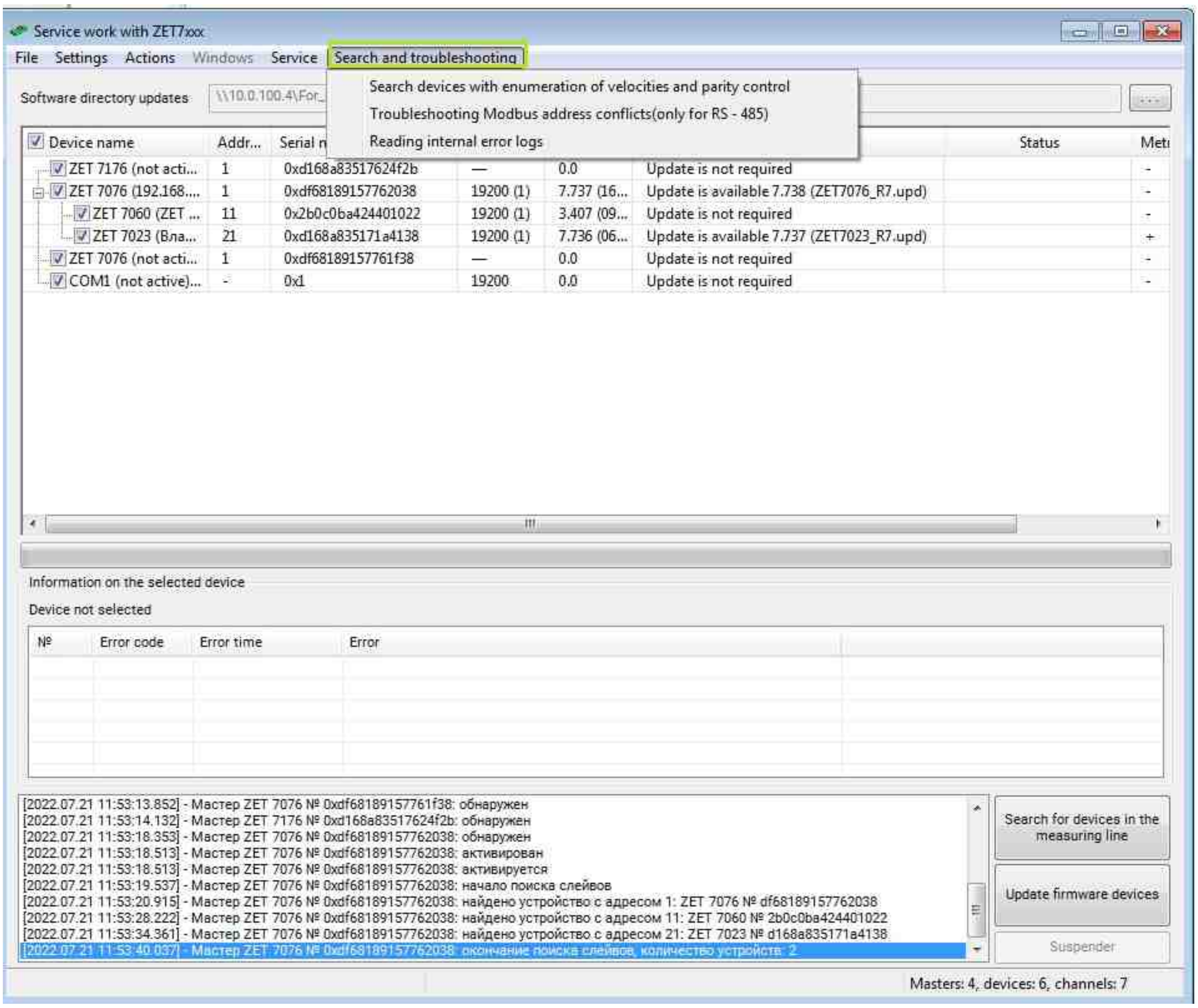


*Fig.4.1 "**Search and troubleshooting**" menu*

Search devices with enumeration of baud rates and parity bit .....

Attention! *The "Search devices with enumeration of baud rates and parity bit" option is intended only for digital sensors with an RS-485 data interface.*

For proper operation of digital sensors, the values of the "Baud rate" and "Parity bit" parameters of digital sensors are set in strict accordance with the set values for the interface converter. In the case when the parameters "Baud rate" and "Parity bit" of digital sensors are unknown (differs from the parameters set for the interface converter), then the following actions should be performed:

In the table of connected devices, select the interface converter to which digital sensors with undefined parameters "Baud rate" and "Parity bit" are connected (Fig. 4.2).

Device name	Addr...	Serial number	Velocity, bps	Software version	Note
ZET 7176 (not acti...	1	0xd168a83517624f2b	—	0.0	Update is not required

Fig. 4.1 Select of the interface converter

2. Then activate the option "Search devices with enumeration of baud rates and parity bit" (Fig.4.3).

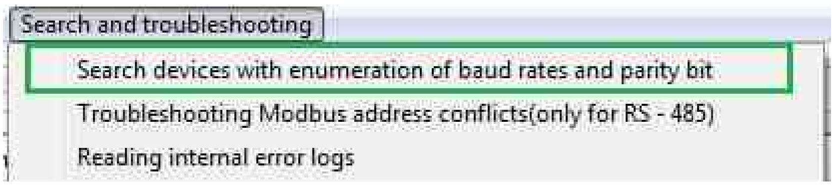
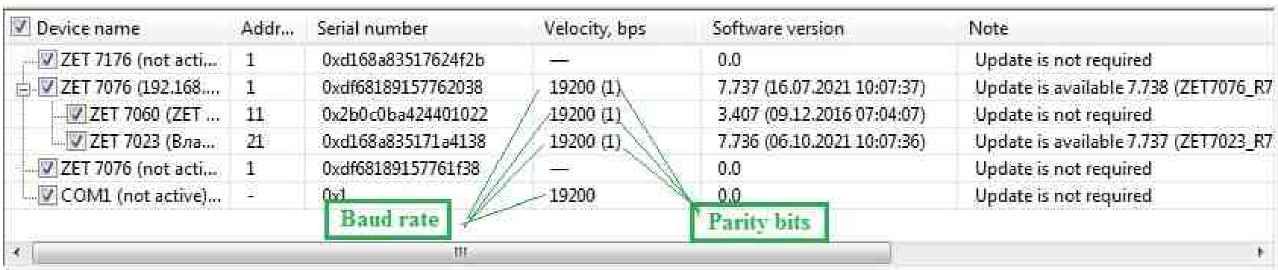


*Fig. 4.2 Option "**Search devices with enumeration of baud rates and parity bit**"*

3. After the search for digital sensors connected to the selected interface converter is completed, the table of connected devices will display information about the parameters "Baud rate" and "Parity bit" (Fig.4.4).



Device name	Addr...	Serial number	Velocity, bps	Software version	Note
ZET 7176 (not acti...	1	0xd168a83517624f2b	—	0.0	Update is not required
ZET 7076 (192.168....	1	0xdf68189157762038	19200 (1)	7.737 (16.07.2021 10:07:37)	Update is available 7.738 (ZET7076_R7
ZET 7060 (ZET ...	11	0x2b0c0ba424401022	19200 (1)	3.407 (09.12.2016 07:04:07)	Update is not required
ZET 7023 (Вла...	21	0xd168a835171a4138	19200 (1)	7.736 (06.10.2021 10:07:36)	Update is available 7.737 (ZET7023_R7
ZET 7076 (not acti...	1	0xdf68189157761f38	—	0.0	Update is not required
COM1 (not active)...	-	0x1	19200	0.0	Update is not required

*Fig. 4.3 The result of the option "**Search devices with enumeration of baud rates and parity bit**"*

Attention! *Option "Search devices with enumeration of baud rates and parity bit" does not change the values of the parameters "Baud rate" and "Parity bit", but only displays these values in the table of connected devices.*

You can change the values of the "Baud rate" and "Parity bit" parameters manually through the device manager, or by using the "Troubleshooting Modbus address conflicts" option in the "Service work with ZET7xxx" program (paragraph 4.2).

It should be noted that if the addresses of digital sensors that are in the same measuring circuit match, these digital sensors will be faulty, and the table of connected devices will not contain information about them. To resolve the conflict of addresses of digital sensors, use the option "Troubleshooting Modbus address conflicts" (paragraph 4.2).

Option "Troubleshooting Modbus address conflicts" .....

Attention! *The option "**Troubleshooting Modbus address conflicts**" is intended only for digital sensors with an RS-485 data interface.*

You should pay special attention to the fact that for all digital sensors located in the same measuring circuit, a unique device address must be set. A prerequisite for the correct operation of the measuring circuit is the presence of different addresses for all devices that are part of this circuit. Device addresses should be set in the range from 3 to 63. If the addresses of several digital sensors that are in the same measuring circuit coincide, address conflicts occur, leading to a communication line failure.

Also, digital sensors will not work properly if the "Baud rate" and "Parity bits" parameters of the digital sensors differ from those of the interface converter.

To resolve the conflict of addresses and the bit rate of digital sensors, do the following:

1. In the table of connected devices, select the interface converter to which the digital sensors are connected (*Fig.4.2*).
2. Then activate the option "**Troubleshooting Modbus address conflicts**" (*Fig.4.5*).

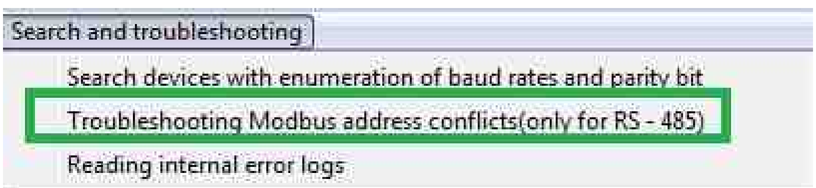


*Fig.4.5 Option "**Troubleshooting Modbus address conflicts**"*

3. Fulfill the requirements of the program by reconnecting the power supply of digital sensors.
4. At the end of the conflict resolution process, the following transformations take place:
   - The parameters "Baud rate", "Parity bits" of all digital sensors in this measuring circuit are set in accordance with similar parameters of the interface converter.
   - In cases where the addresses of several digital sensors that are part of a given measuring circuit coincide, the program will automatically replace the matching addresses with free ones.

Option "Reading internal error logs" .....

Sometimes, during the operation of digital sensors, problems may arise due to incorrect connection, or the occurrence of other internal device errors. To display a list of errors that occurred when working with a digital sensor, do the following:

1. In the table of connected devices, select a digital sensor whose error log should be displayed (*Fig.4.6*).

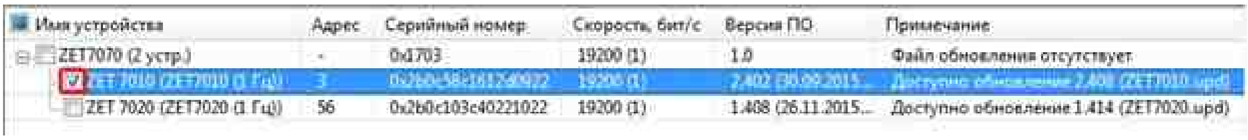


Fig.4.6 Select a digital sensor

2.Then activate the option "Read internal error log from devices" (*Fig.4.7*).

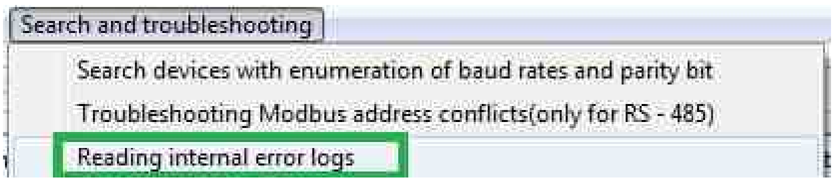


Fig.4.7 Option "Read internal error log from devices"

3. Click on the name of a digital sensor in the table "Information on the selected device" will display information about the errors of this digital sensor (*Fig.4.8*).

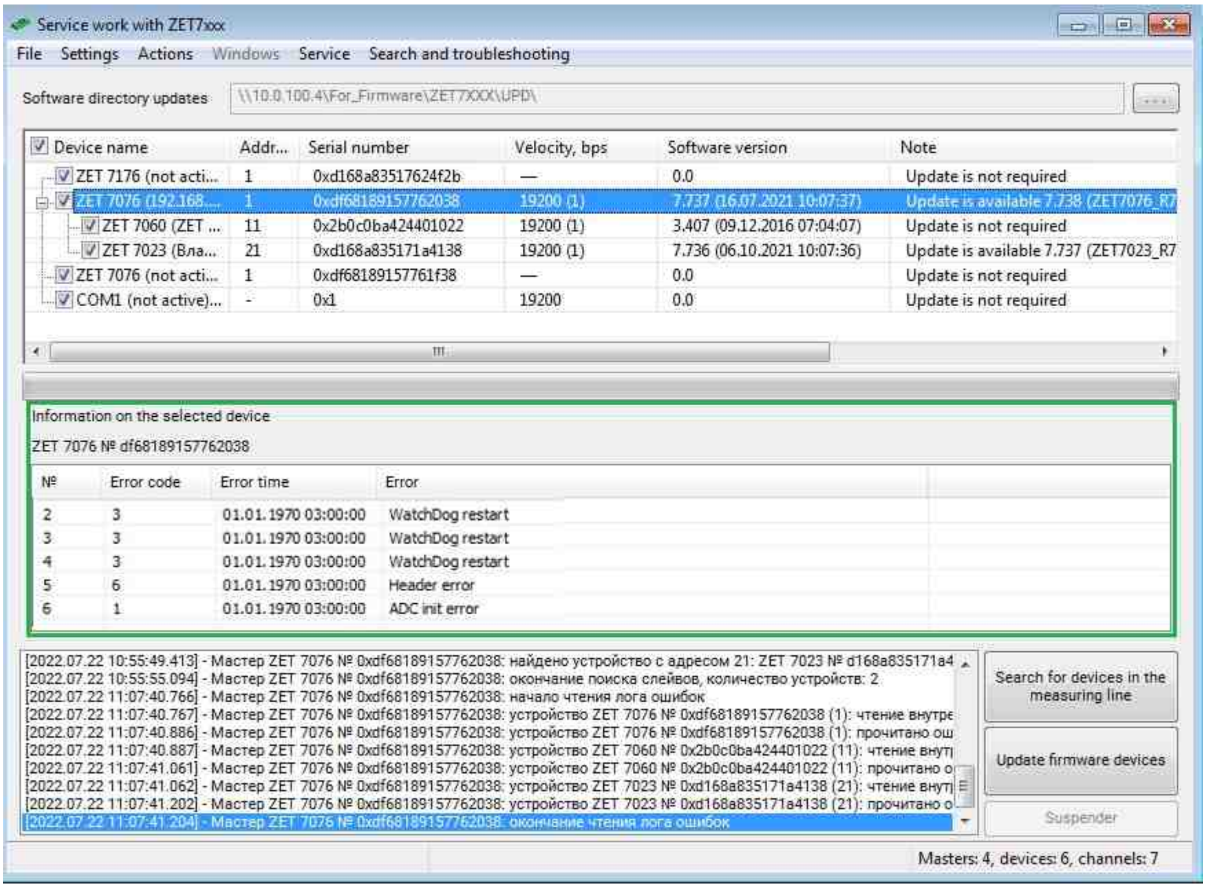


Fig.4.8 Table "Information on the selected device"

Context menu .....

Right-click on a device name brings up a context menu. The context menu is a set of commands. The composition of the context menu commands differs for interface converters and digital sensors.

Context menu of the interface converter ZET 7070 .....

The appearance of the context menu of ZET 7070 interface converters is shown in *Fig.5.1*.

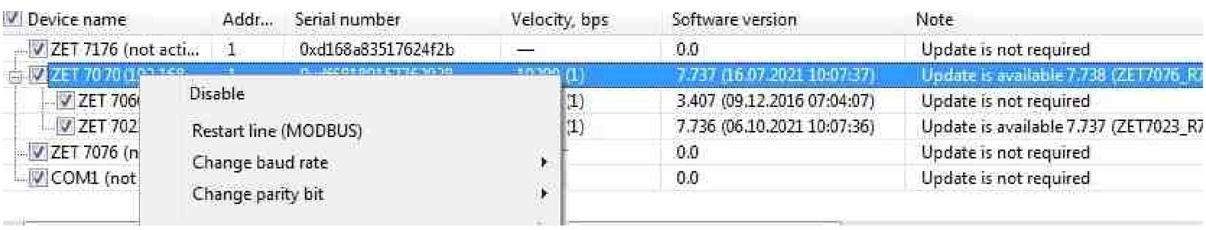


Fig.5.1 Context menu of interface converter ZET 7070

The context menu has the following set of commands:

Disable – deactivation command, switches the interface converter to the "Not used" status.

Restart line (MODBUS) is a Modbus command designed to restart all digital sensors in the given measuring circuit.

Change baud rate – the command sets the "Baud rate" parameter of the devices in the given measuring circuit. The "Change baud rate" command does not apply to digital sensors whose "Baud rate" and "Parity bits" parameters differ from those of the interface converter.

Change parity bit – the command sets the parameter "Parity" of the devices in the given measuring circuit. The "Change parity" command does not apply to digital sensors whose "Baud rate" and "Parity" parameters differ from those of the interface converter.

Context menu of the interface converter ZET 7076 .....

The appearance of the context menu of ZET 7076 interface converters is shown in *Fig.5.2*.

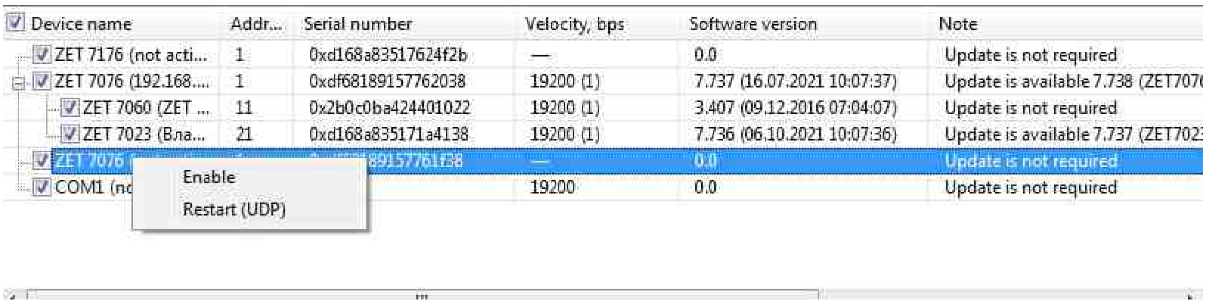


Fig.5.2 Context menu of interface converter ZET 7076

The context menu has the following set of commands:

Disable – deactivation command, switches the interface converter to the "Not used" status.

Restart line (MODBUS) is a Modbus command designed to restart all digital sensors in the given measuring circuit.

Context menu of the interface converter ZET 7174 .....

The appearance of the context menu of interface converters ZET 7174 is shown in *Fig.5.3*.

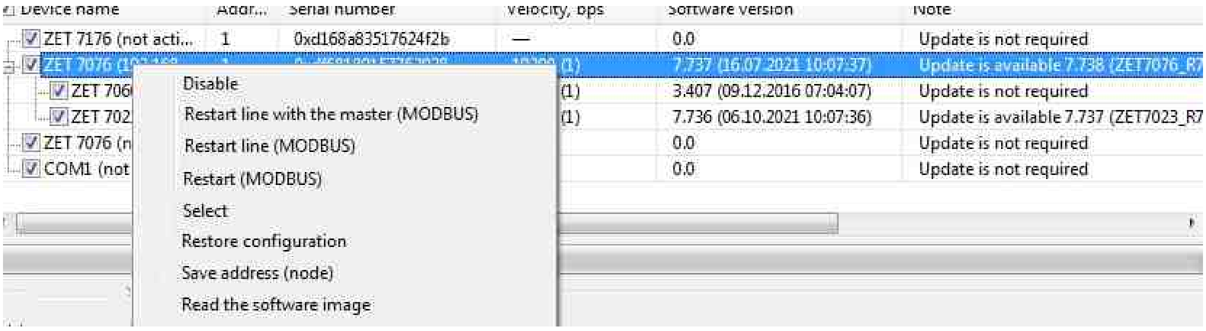


Fig.5.3 Context menu of interface converter ZET 7174

The context menu has the following set of commands:

- *Disable* – deactivation command, switches the interface converter to the "Not used" status.
- *Restart line with master (MODBUS)* is a Modbus command designed to restart the interface converter and all digital sensors in this measuring circuit.
- *Restart line (MODBUS)* is a Modbus command designed to restart all digital sensors in the given measuring circuit.
- *Restart (MODBUS)* – Modbus command to restart the selected device.
- *Select* – the command is designed to select a specific digital sensor in the measuring circuit. When using this command, the LEDs of the digital sensor are switched to the continuous indication mode.
- *Restore configuration* – the command allows you to return to earlier configurations of digital sensors. In the event of a misconfiguration, or loss of important information, such as changing the data in the calibration table, it is possible to restore the previous version of the configuration of the digital sensor. Data files have the extension type "*.DAT" and are saved in the directories:

"C:\ZETLab\SensorWork\ConfigurationBackup",

"C:\ZETLab\config\ZET7xxx".

- *Save address (node) – the command generates a table of Modbus register addresses. For more information on assigning and creating an address table, see* 9.
- *Read the software* – the command saves the current firmware image of the device, thus allowing you to return to the previous firmware version if necessary. Image files have the extension type "*.UPD" and are stored in the directory: "C:\ZETLab\SensorWork\Firmware".

By default, a file with a firmware image is created with a name like "XXX YYY ZZZ.upd" (for example, ZET 7110 No. 0x2b0c58c1612d0922_ver_2_402.upd), where

"XXX" – device name (ZET 7110);

"YYY" – device serial number (No. 0x2b0c58c1612d0922);

"ZZZ" – firmware version of the device (ver_2_402);

".upd" – file name extension.

In order for the program to accept the firmware update file, it must have a name like "XXX.upd" (for example, ZET7110.upd), where

"XXX" – device name without spaces;

".upd" – file name extension.

For more information on updating the firmware of the device, please refer to the section 6.

Context menu of the interface converter ZET 7176 .....

The appearance of the context menu of ZET 7176 interface converters is shown in *Fig.5.4*.

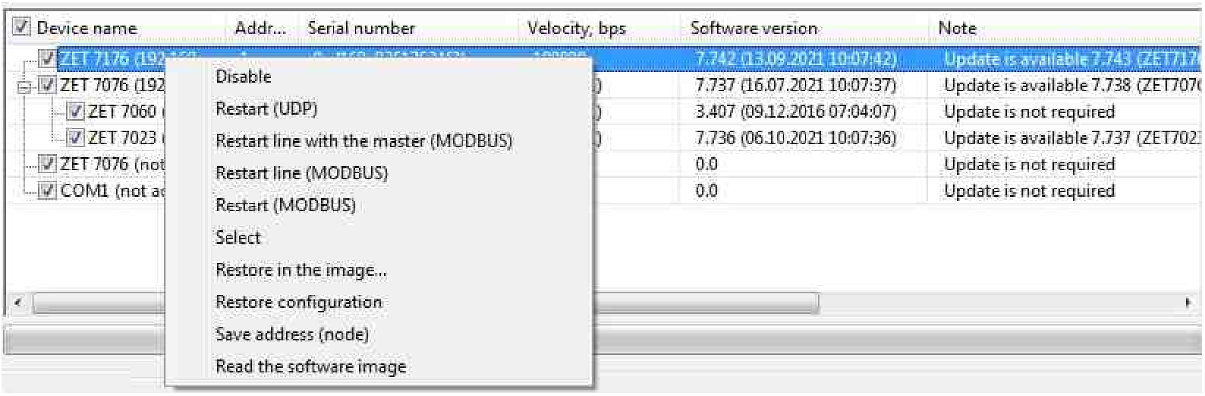


Fig.5.4 Context menu of interface converter ZET 7176

The context menu has the following set of commands:

- *Disable* – deactivation command, switches the interface converter to the "Not used" status.
- *Restart (UDP) – the command is designed to restart the converter via the UDP protocol (the command does not require the interface converter to be enabled).*
- *Restart line with master (MODBUS)* is a Modbus command designed to restart the interface converter and all digital sensors in this measuring circuit.
- *Restart line (MODBUS)* is a Modbus command designed to restart all digital sensors in the given measuring circuit.
- *Restart (MODBUS)* – Modbus command to restart the selected device.

- *Select* – the command is designed to select a specific digital sensor in the measuring circuit. When using this command, the LEDs of the digital sensor are switched to the continuous indication mode.
- *Restore configuration* – the command allows you to return to earlier configurations of digital sensors. In the event of a misconfiguration, or loss of important information, such as changing the data in the calibration table, it is possible to restore the previous version of the configuration of the digital sensor. Data files have the extension type "*.DAT" and are saved in the directories:

"C:\ZETLab\SensorWork\ConfigurationBackup",

"C:\ZETLab\config\ZET7xxx".

- *Save address (node)* – the command generates a table of Modbus register addresses. For more information on assigning and creating an address table, see 9.
- *Read the software* – the command saves the current firmware image of the device, thus allowing you to return to the previous firmware version if necessary. Image files have the extension type "*.UPD" and are stored in the directory: "C:\ZETLab\SensorWork\Firmware".

By default, a file with a firmware image is created with a name like "XXX YYY ZZZ.upd" (for example, ZET 7110 No. 0x2b0c58c1612d0922_ver_2_402.upd), where

"XXX" – device name (ZET 7110);

"YYY" – device serial number (No. 0x2b0c58c1612d0922);

"ZZZ" – firmware version of the device (ver_2_402);

".upd" – file name extension.

In order for the program to accept the firmware update file, it must have a name like "XXX.upd" (for example, ZET7110.upd), where

"XXX" – device name without spaces;

".upd" – file name extension.

For more information on updating the firmware of the device, please refer to the section 6.

Context menu of digital sensors .....

The appearance of the context menu of digital sensors is shown in *Fig.5.5*.

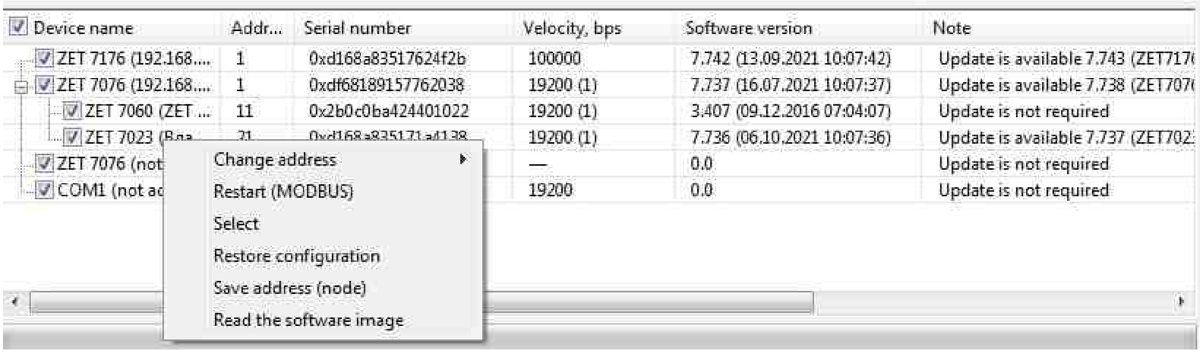


Fig.5.5 Context menu of digital sensors

The context menu has the following set of commands:

* Change address – device addresses should be set in the range from 3 to 63. If the addresses of several digital sensors that are in the same measuring circuit coincide, address conflicts occur, leading to a communication line failure.

- *Restart line (MODBUS)* is a Modbus command designed to restart all digital sensors in the given measuring circuit.
- *Select* – the command is designed to select a specific digital sensor in the measuring circuit. When using this command, the LEDs of the digital sensor are switched to the continuous indication mode.
- *Restore configuration* – the command allows you to return to earlier configurations of digital sensors. In the event of a misconfiguration, or loss of important information, such as changing the data in the calibration table, it is possible to restore the previous version of the configuration of the digital sensor. Data files have the extension type "*.DAT" and are saved in the directories:

"C:\ZETLab\SensorWork\ConfigurationBackup",

"C:\ZETLab\config\ZET7xxx".

- *Restore configuration* – the command allows you to return to earlier configurations of digital sensors. In the event of a misconfiguration, or loss of important information, such as changing the data in the calibration table, it is possible to restore the previous version of the configuration of the digital sensor. Data files have the extension type "*.DAT" and are saved in the directories:

"C:\ZETLab\SensorWork\ConfigurationBackup",

"C:\ZETLab\config\ZET7xxx".

- *Save address (node)* – the command generates a table of Modbus register addresses. For more information on assigning and creating an address table, see 9.

- *Read the software* – the command saves the current firmware image of the device, thus allowing you to return to the previous firmware version if necessary. Image files have the extension type "*.UPD" and are stored in the directory: "C:\ZETLab\SensorWork\Firmware".

By default, a file with a firmware image is created with a name like "XXX YYY ZZZ.upd" (for example, ZET 7110 No. 0x2b0c58c1612d0922_ver_2_402.upd), where

"XXX" – device name (ZET 7110);

"YYY" – device serial number (No. 0x2b0c58c1612d0922);

"ZZZ" – firmware version of the device (ver_2_402);

".upd" – file name extension.

In order for the program to accept the firmware update file, it must have a name like "XXX.upd" (for example, ZET7110.upd), where

"XXX" – device name without spaces;

".upd" – file name extension.

For more information on updating the firmware of the device, please refer to the section 6.

Updating the software firmware of devices .....

Attention! *To update the firmware of digital sensors of the ZETSENSOR family, the computer to which this device is connected must have access to the global Internet.*

To update the firmware of a digital sensor, you must perform the following steps:

Run the ZET7xxx service program and make sure that access to the server with the update files is open. The column "Software update directory" should display the path to the file.zetlab.com server (*Fig.6.1*). If there is no access to the server, then you should check the connection of the computer to the global Internet.

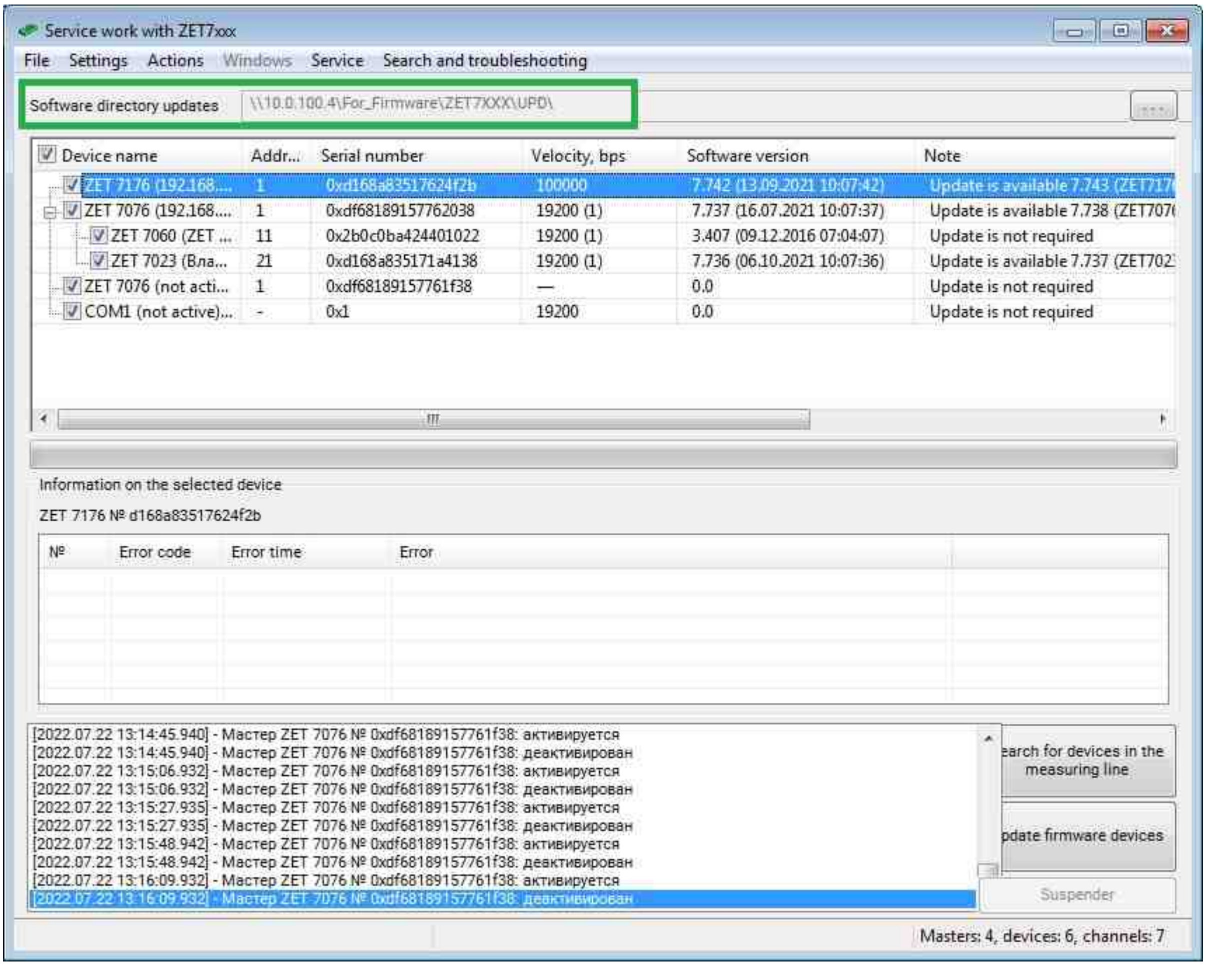


Fig.6.1 Path to the server with firmware update files

2. Make sure you have a newer version of the device firmware. In the table of connected devices, in the line with the name of the digital sensor to be updated, in the "Note" column, the value "X update available" should be displayed, where X is the firmware version number (*Fig.6.2*).

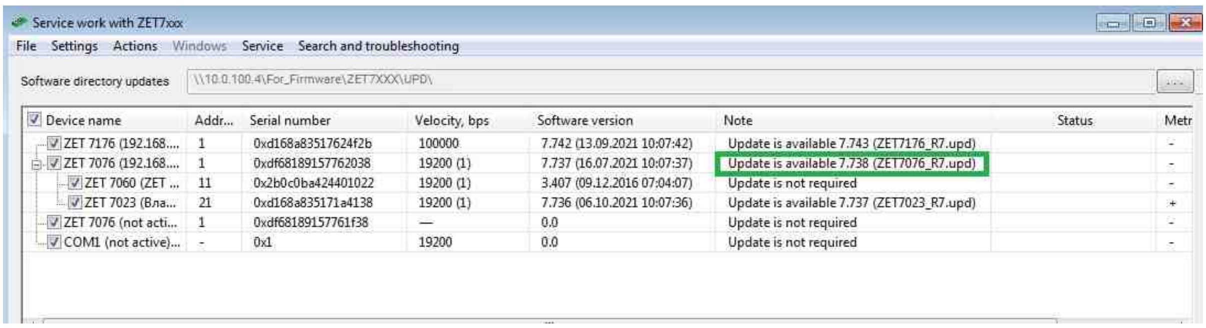


Fig.6.2 Firmware version available for update

3. Select the digital sensor whose firmware needs to be updated (*Fig.6.3*).

Fig.6.3 Selecting a digital sensor for firmware update

4. Then  activate the button "Updating firmware devices" (*Fig.6.4*).

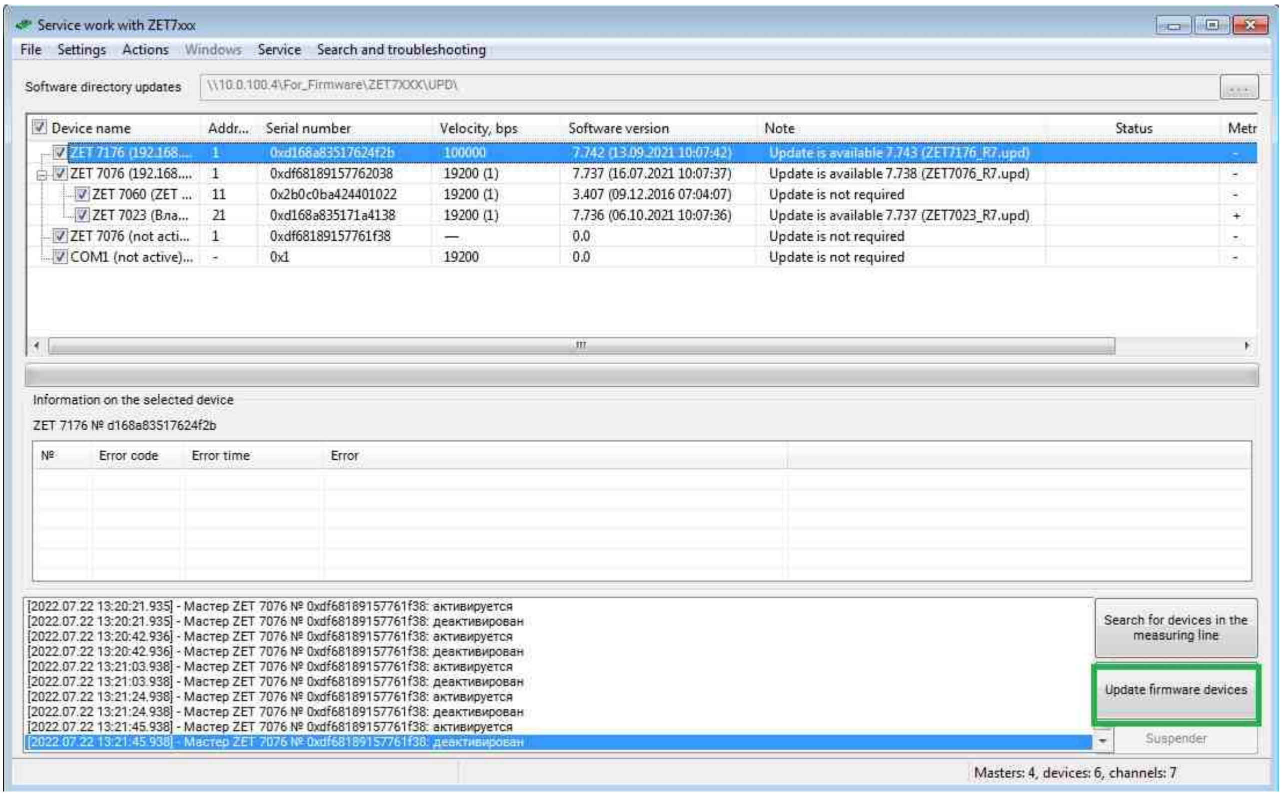


Fig.6.4 Button "Updating firmware devices"

5. The Status column displays the current status of the firmware update process (*Fig.6.5*). You should wait until the software update of the digital sensor is completed, and if necessary, follow the instructions of the program.

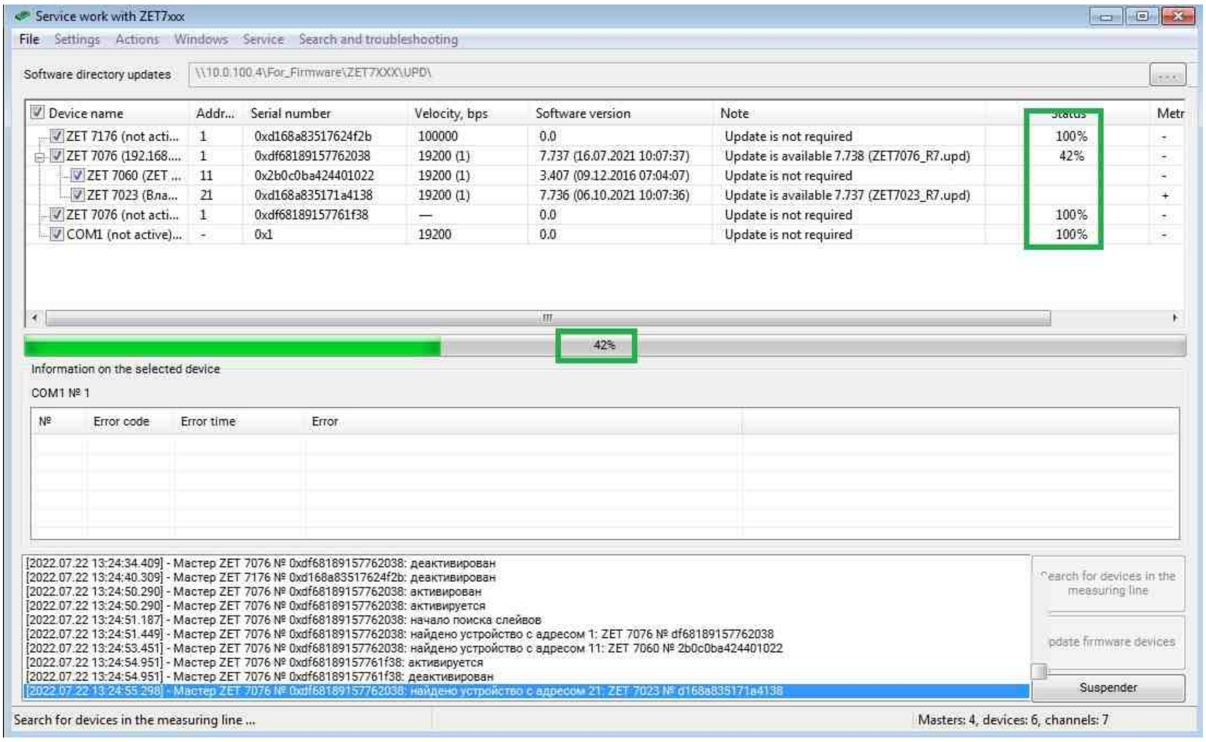


Fig.6.5 Digital sensor firmware update process status

6. After the update is completed, make sure that the latest firmware version has been installed on the digital sensor (*Fig.6.6*).

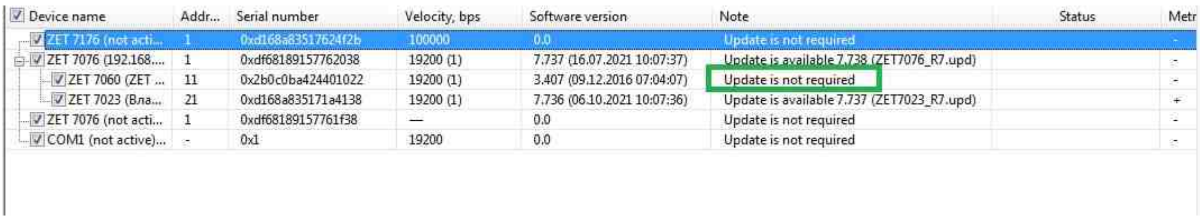


Fig.6.6 The device has the latest firmware version

Diagnostics .....

Before starting the diagnostics, it is necessary to tick off the identifiers of those interface converters for which it is necessary to perform diagnostics of the measuring lines formed by them. In the "Service work with ZET7xxx" program, go to the menu "Actions" - "Diagnostics" (Fig. 7.1) and select "Diagnostics of data quality" from the pop-up list.

The program will start testing the measuring lines, the results of which will be displayed in the program window "Diagnostics of data quality" (*Fig.7.7*).

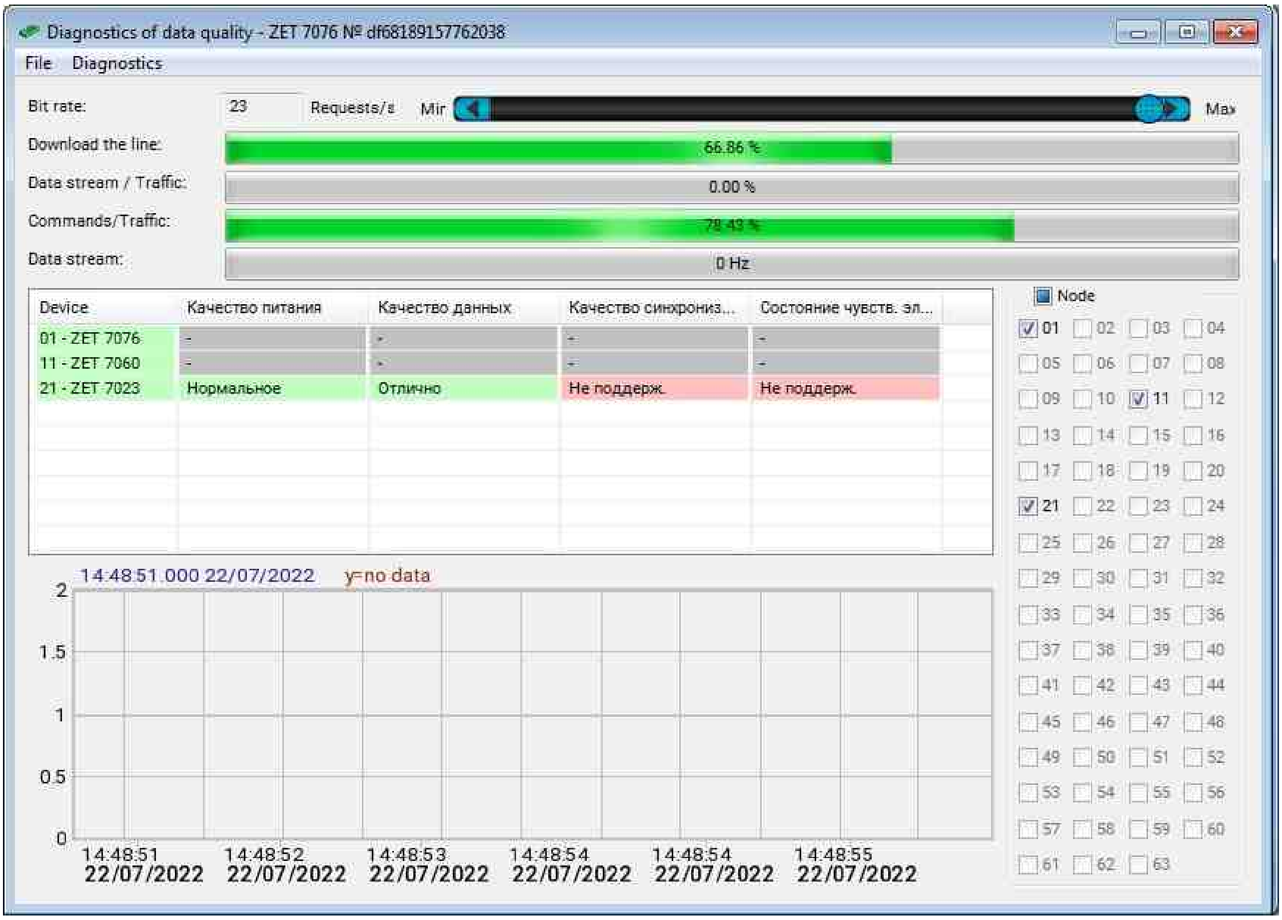


Fig.7.7 The window of the program "Diagnostics of data quality"

Diagnostics of data quality in the measuring line consists in diagnostics of a digital sensor in several parameters:

1. "Power supply quality" parameter

The "Power supply quality" parameter informs about the status of the supply voltage of the digital sensor. There are several indication statuses for the "Power supply quality" parameter:

- Not supported - the digital sensor does not have a power quality control function;
- Low - digital sensor supply voltage is less than 9 V;
- Normal - the supply voltage of the digital sensor is in the range from 9 V to 24 V;
- High - the supply voltage of the digital sensor is more than 24 V;

2. "Data quality" parameter

The "Data quality" parameter informs about problems in the data transmission line of the digital sensor. There are several indication statuses for the "Data quality" parameter:

- Not supported - the digital sensor does not have a data quality control function;

- Bad - there are problems in the data line. The quality of the data is unsatisfactory, the current data cannot be trusted;
- Good - may be there is a problem with the data line. Pay attention to the data;
- Excellent - there are no problems in the data line.

3, "Line synchronization diagnostics" parameter

The "Line synchronization diagnostics" parameter informs about the synchronization status of the digital sensor. The function is valid only for digital sensors operating via the CAN interface. There are several indication statuses for the "Line synchronization diagnostics" parameter:

Not supported - the digital sensor does not have a synchronization quality control function;

Bad - no synchronization. Check GPS antenna or ZET 7175 synchronization module;

Good - may be there is a problem with the data line synchronization. Pay attention to the data line synchronization;

Excellent -there are no problems in the data line synchronization.

4. "Sensing element status" parameter

The "Sensitive element status" parameter informs about the status of the primary transducer connected to a specific digital sensor. There are several indication statuses for the "Sensing element status" parameter:

- Not supported - the digital sensor does not have the function of monitoring the status of the sensitive element;
- Error - the sensitive element is not connected, is not working, or is connected incorrectly;
- Good - the sensing element is connected correctly.

Diagnostics of data exchange .....

Diagnosis of data exchange in the measuring line is performed by sending commands "Read Holding Registers" and/or "Read Input Registers" to the line with subsequent analysis of the response or its absence. By default, requests are sent as often as possible. The purpose of diagnostics is to identify faults and thin spots in the measuring line in terms of data exchange between the transmitter and the digital sensor.

Before starting the diagnostics, it is necessary to tick off the identifiers of those interface converters for which it is necessary to perform diagnostics of the measuring lines formed by them. In the "Service work with ZET7xxx" program, go to the "Actions" - "Diagnostics" menu (Fig. 7.1) and select the "Diagnostics of data exchange" option from the pop-up list.

The program will start testing the measuring lines, the results of which will be displayed in the program window "Diagnostics of data exchange in the line" (*Fig.7.2*).

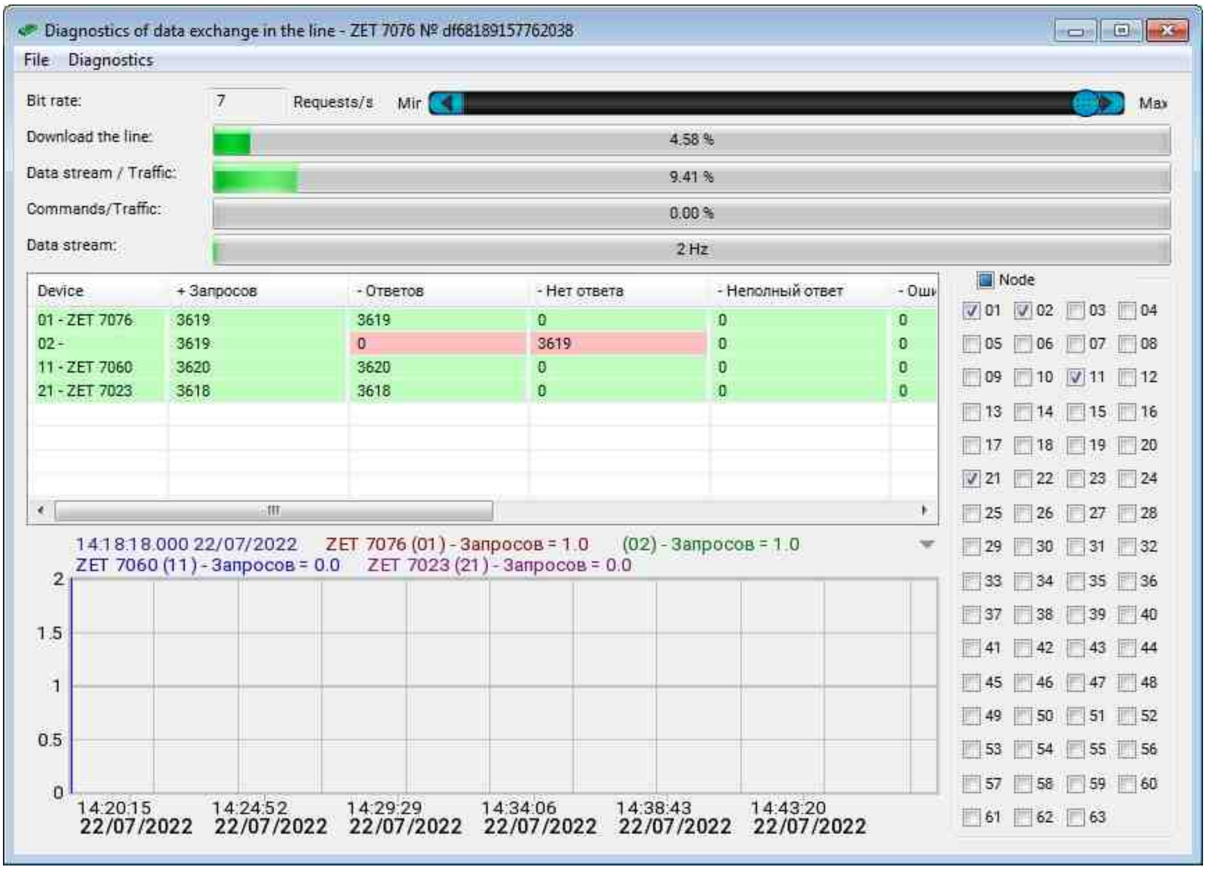


Fig.7.2 The window of the program "Diagnostics of data exchange in the line"

The Line Communications Diagnostics window displays diagnostic information for the meter line related to the first interface converter selected in the list. To view diagnostic information on other measuring lines, it is necessary to select the appropriate identifiers of the interface converter in the "Service work with ZET7xxx" program window in the "Windows" menu (*Fig.7.3*).

Fig.7.3 "Windows" menu

The Diagnostic Information window contains the following areas:

- Bit rate - displays the current bit rate on the digital channel between interface converters and digital sensors;
- Line load - displays the current load of the digital line (as a percentage of the maximum);
- Device list area - displays a list of devices and diagnostic information on them;
- Device address area – displays the addresses at which the program makes diagnostic requests (selected addresses are marked with a "tick").
- *Fig.7.4* illustrates a malfunction diagnosed on the measuring channel, which is associated with duplication of addresses No. 2 assigned to digital modules.

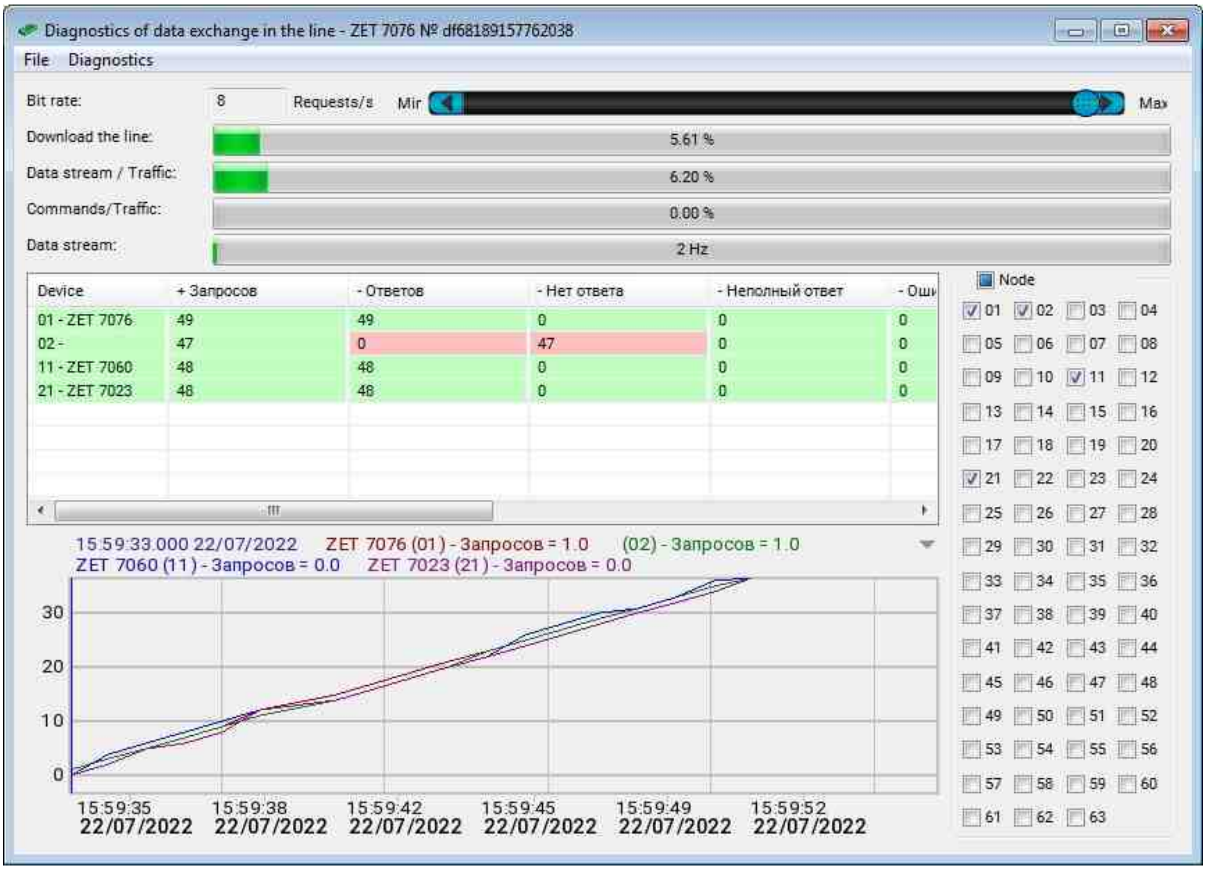


Fig.7.4 Diagnosed malfunction example

When the addresses of devices in the same measuring line match, for each request, devices with the same address respond simultaneously. As a result, collisions are formed during data exchange, and, consequently, incorrect responses to requests occur, and then the values are incremented in the columns "Incomplete response", "Address error", "Command error" and "CRC error". In addition, the overall bit rate in the line drops, and the value displayed in the "Bit rate" field will differ from the normal one for this line.

The normal bit rate in the line is determined by:

- With a maximum load of requests. The bit rate regulator is in the extreme right "maximum" position (*Fig.7.5*).

Fig.7.5 Baud rate controller

- When sending the "Read Holding Registers" command only to devices existing in the line. The data request command – "ReadInputRegisters" should be disabled via the menu "Diagnostics" - "Commands" (*Fig.7.6*).

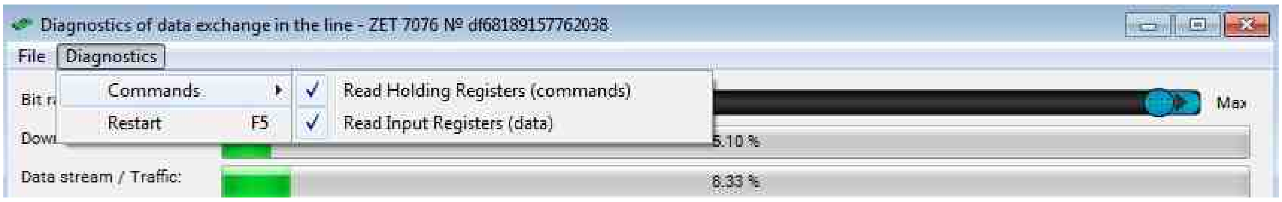


Fig.7.6 "Commands" menu

The normal number of requests depending on the bit rate within the measuring lines is presented in *Table 7.1* and *Table 7.2.*

Table 7.1 Dependence of the number of requests on the bit rate for RS-485

Bit rate	Requests/s	
	ZET 7070	ZET 7076
2400 bps	≈10	Not supported
4800 bps	≈15	≈10
9600 bps	≈30	≈20
14400 bps	≈40	Not supported
19200 bps	≈50	≈30

38400 bps	≈75	≈45
57600 bps	≈90	≈50
115200 bps	≈110	≈55

Table 7.2 *Dependence of the number of requests on the bit rate for CAN 2.0*

Bit rate	Requests/s	
	ZET 7174	ZET 7176
100 kbps	≈175	≈110
300 kbps	≈210	≈140
1 Mbps	≈245	≈180

In some cases, the number of requests per second may not be normal, but it should remain stable. If stability is not observed over time, then there is most likely a problem in the line.

Attention*! For the correct operation of the measuring line, it is strictly forbidden to duplicate the addresses of the digital sensors located on it.*

Note: *The addresses of digital sensors are always related to their measuring channels, so it should be taken into account that some digital sensors such as ZET 7152 or ZET 7154 have more than one measuring channel. When configuring digital sensors with more than one address, only the address of the first of its measuring channels is indicated, however, it should be remembered that the addresses following the list (depending on the number of measuring channels in the sensor) will also be used and should not be assigned to other digital sensors installed on the same measuring line. Example: a digital sensor ZET 7152 configured to address No. 5 is installed on the measuring line. Since the ZET 7152 digital sensor has three measuring channels, addresses No. 6 and No. 7 cannot be assigned to other digital sensors on this measuring line.*

Diagnostics of data quality .....

Before starting the diagnostics, it is necessary to tick off the identifiers of those interface converters for which it is necessary to perform diagnostics of the measuring lines formed by them. In the "Service work with ZET7xxx" program, go to the menu "Actions" - "Diagnostics" (*Fig. 7.1*) and select "Diagnostics of data quality" from the pop-up list.

The program will start testing the measuring lines, the results of which will be displayed in the program window "Diagnostics of data quality" (*Fig.7.7*).

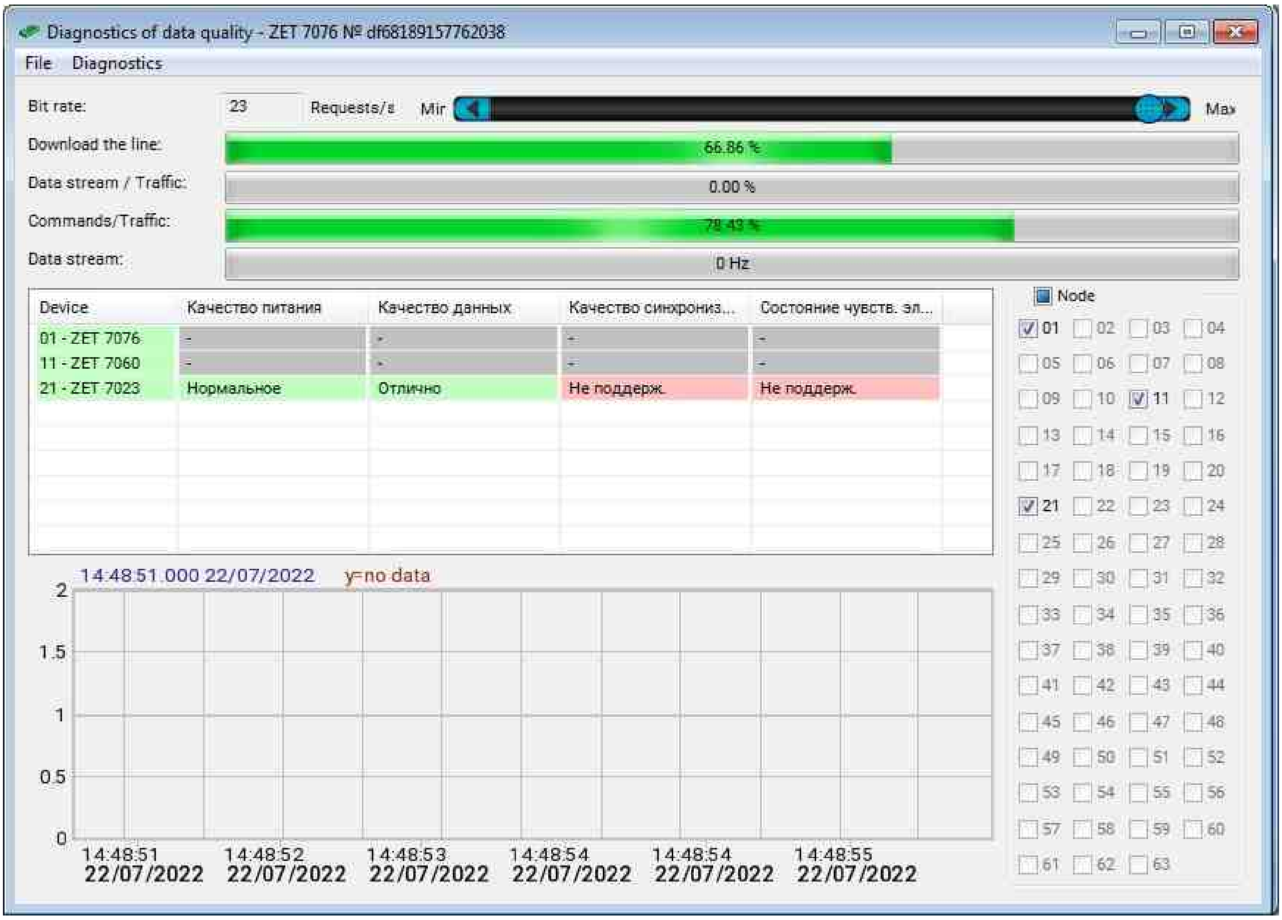


Fig.7.7 The window of the program "Diagnostics of data quality"

Diagnostics of data quality in the measuring line consists in diagnostics of a digital sensor in several parameters:

1. "Power supply quality" parameter

The "Power supply quality" parameter informs about the status of the supply voltage of the digital sensor. There are several indication statuses for the "Power supply quality" parameter:

- Not supported - the digital sensor does not have a power quality control function;
- Low - digital sensor supply voltage is less than 9 V;
- Normal - the supply voltage of the digital sensor is in the range from 9 V to 24 V;
- High - the supply voltage of the digital sensor is more than 24 V;

2. "Data quality" parameter

The "Data quality" parameter informs about problems in the data transmission line of the digital sensor. There are several indication statuses for the "Data quality" parameter:

- Not supported - the digital sensor does not have a data quality control function;
- Bad - there are problems in the data line. The quality of the data is unsatisfactory, the current data cannot be trusted;
- Good - may be there is a problem with the data line. Pay attention to the data;
- Excellent - there are no problems in the data line.

3, "Line synchronization diagnostics" parameter

The "Line synchronization diagnostics" parameter informs about the synchronization status of the digital sensor. The function is valid only for digital sensors operating via the CAN interface. There are several indication statuses for the "Line synchronization diagnostics" parameter:

Not supported - the digital sensor does not have a synchronization quality control function;

Bad - no synchronization. Check GPS antenna or ZET 7175 synchronization module;

Good - may be there is a problem with the data line synchronization. Pay attention to the data line synchronization;

Excellent -there are no problems in the data line synchronization.

4. "Sensing element status" parameter

The "Sensitive element status" parameter informs about the status of the primary transducer connected to a specific digital sensor. There are several indication statuses for the "Sensing element status" parameter:

- Not supported - the digital sensor does not have the function of monitoring the status of the sensitive element;
- Error - the sensitive element is not connected, is not working, or is connected incorrectly;
- Good - the sensing element is connected correctly.

Diagnostics of line synchronization .....

Before starting the diagnostics, it is necessary to tick off the identifiers of those interface converters for which it is necessary to perform diagnostics of the measuring lines formed by them. In the "Service work with ZET7xxx" program, go to the menu "Actions" - "Diagnostics" (*Fig. 7.1*) and select "Diagnostics of line synchronization" from the pop-up list.

The program will start testing the measuring lines, the results of which will be displayed in the program window "Diagnostics of line synchronization" (*Fig.7.8*).

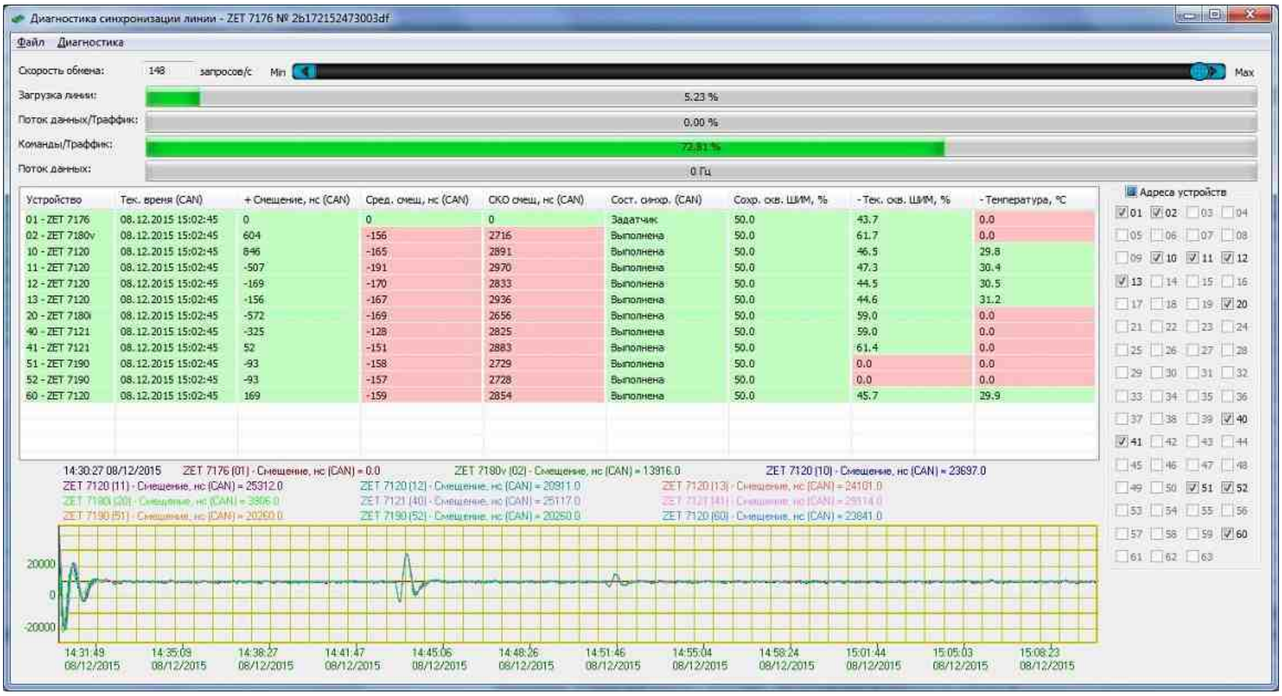


Fig.7.8 The window of the program "Diagnostics of line synchronization"

Measuring line synchronization diagnostics consists in diagnostics by several parameters:

1. Current time

   Digital sensor internal clock

2. Offset, ns

   The instantaneous value of the calculated offset of the internal clock relative to the clock of the master (master).

3. Average displacement, ns

   The average value of the offset for a certain period of time.

4. RMS offset, ns

The standard deviation (Standard deviation may be abbreviated RMSD) of the offset over a specified period of time.

5. Synchronization status

Synchronization status of the digital sensor. There are several statuses:

5. Completed;

Performed.

6. Stored PWM duty cycle, %

The value of the PWM duty cycle, set at the verification stage. Expressed in %.

7. Current PWM duty cycle, %

The current duty cycle of the PWM measured at the present time. The normal value should be in the range of 25-75%.

8. Temperature, °C

9. Board temperature °C.

Diagnostics of network synchronization .....

This diagnostic is intended only for ZET 7176 interface converters and is a network synchronization diagnostic using the PTP protocol. The appearance of the window of the "Network Synchronization Diagnostics" program is shown in *Fig.7.9*.

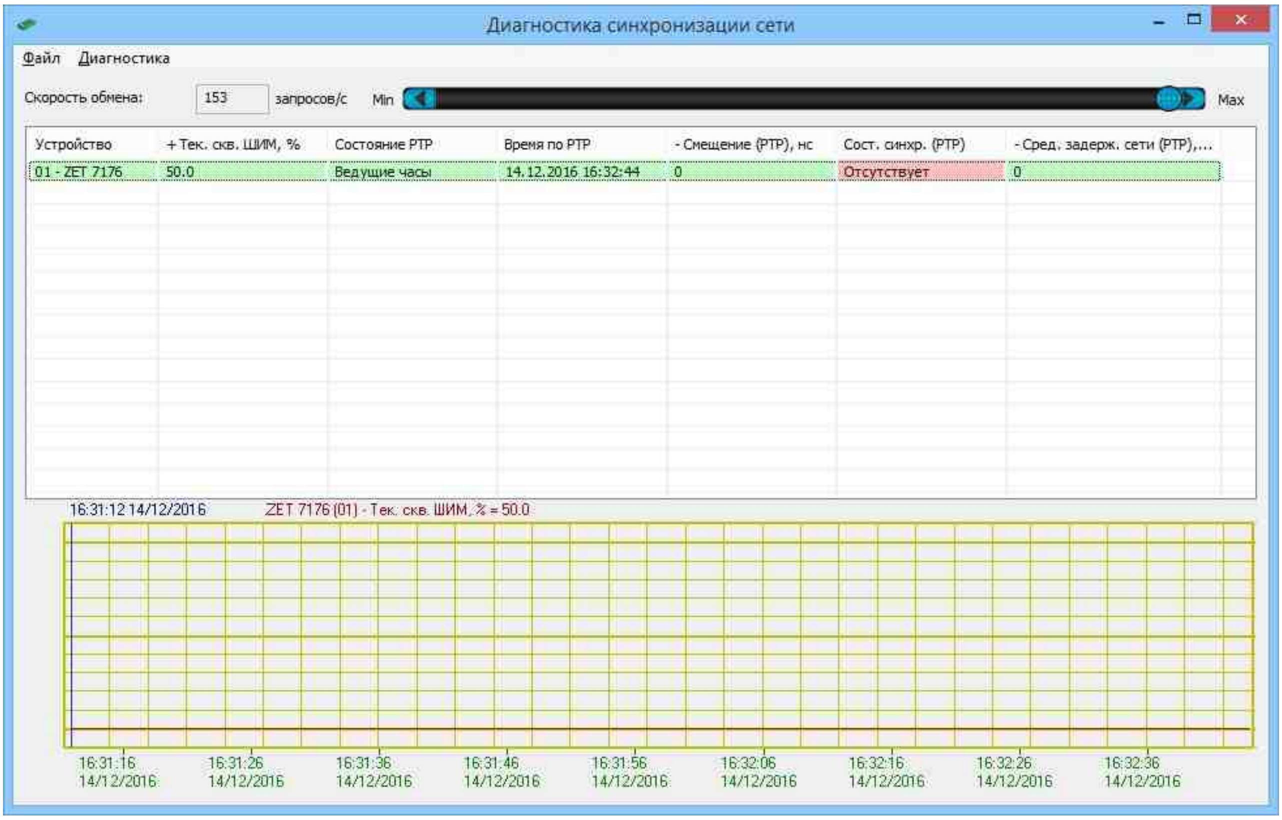


Fig.7.9 The window of the program "Diagnostics of network synchronization"

Save the configuration for the OPC server .....

The program "Service work with ZET7xxx" provides the ability to save the configuration to work in the OPC server mode. When operating in the OPC server mode, the ZET7xxx OPC Server program forms a tag tree based on the devices found in the measuring line and updates the tag value once a second. By default, the tag tree is formed only from the registers of the current value of the measured value. If necessary, you can conFig. the program so that other registers are read from the digital sensor and then written to the corresponding OPC server tag.

To save the configuration required to work with devices in the OPC server mode, do the following:

1. It is necessary to mark with a tick symbol those identifiers of interface converters that should work in this mode (*Fig.8.1*).

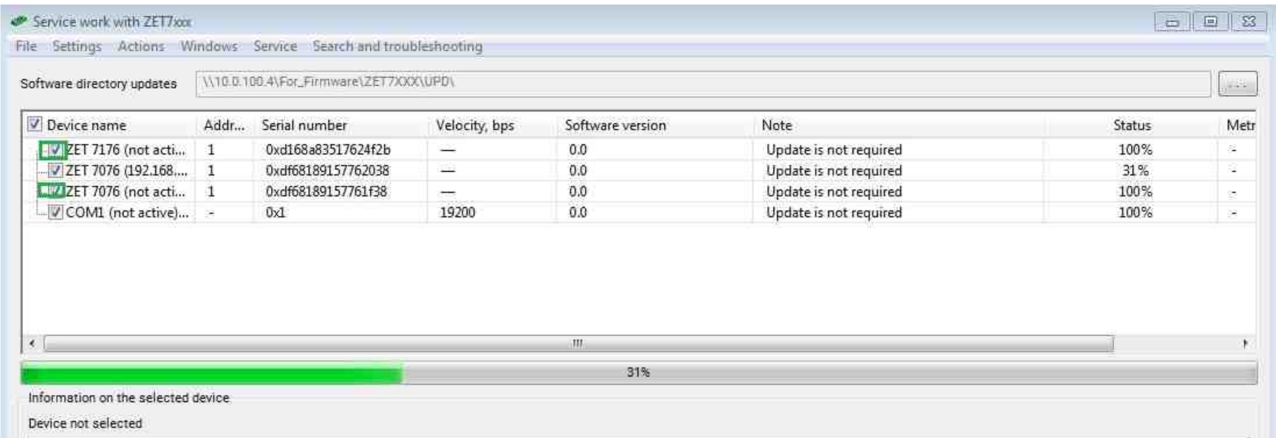


Fig.8.1 Select devices for operation in OPC server mode

2. On the control panel in the menu "Actions" - "Work with OPC" you need to activate the option "Save configuration for OPC DA server…" (*Fig.8.2*).

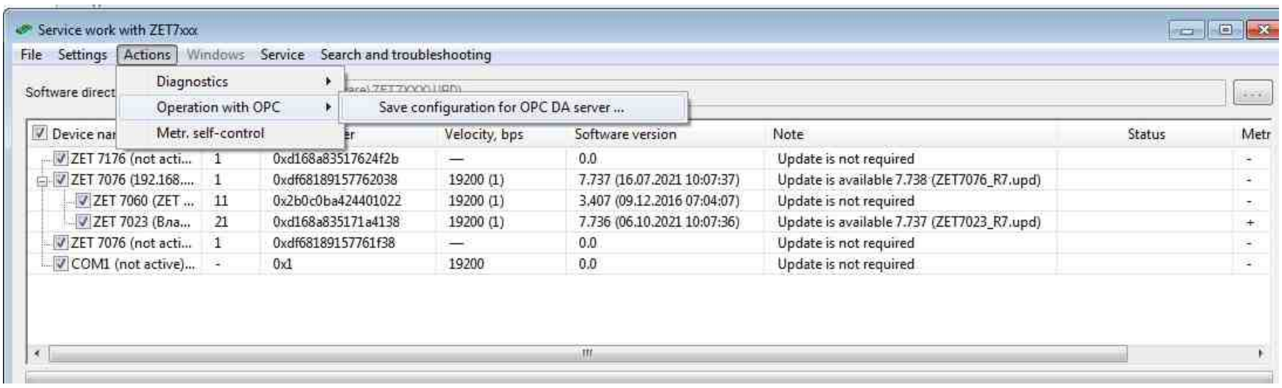


Fig.8.2 "Save configuration for OPC DA server…" option

3. In the "Save as" window that opens, in the "File name" field, set an arbitrary name for the configuration file and activate the "Save" button (*Fig.8.3*). As a result, a configuration file with the extension ".zopc" will be created.

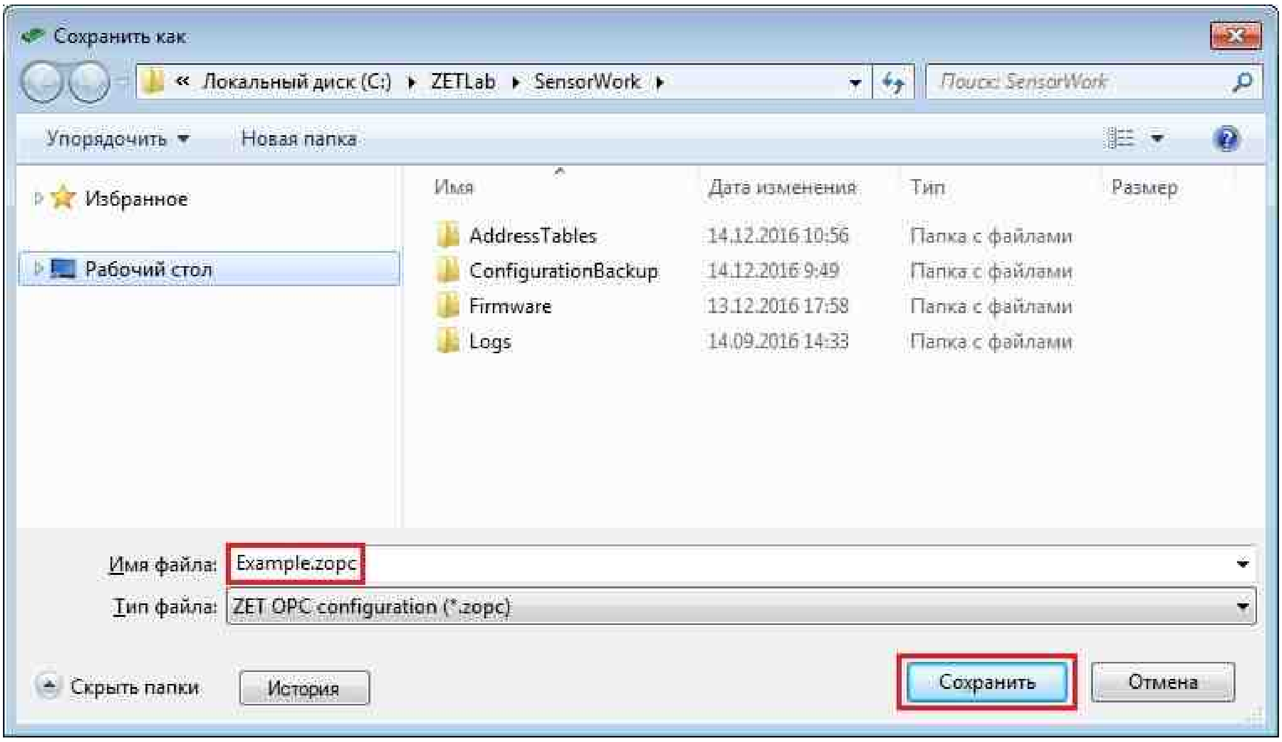


Fig.8.3 "Save as" window

4. Next, you need to close the program window "Service work with ZET7xxx" by pressing the button , located in the upper right corner of the program window.

5. Run the ZET7xxx OPC Server program by activating the ZET7xxxOPCServer.exe executable file located in the directory: C:\ZETLab (*Fig.8.4*).

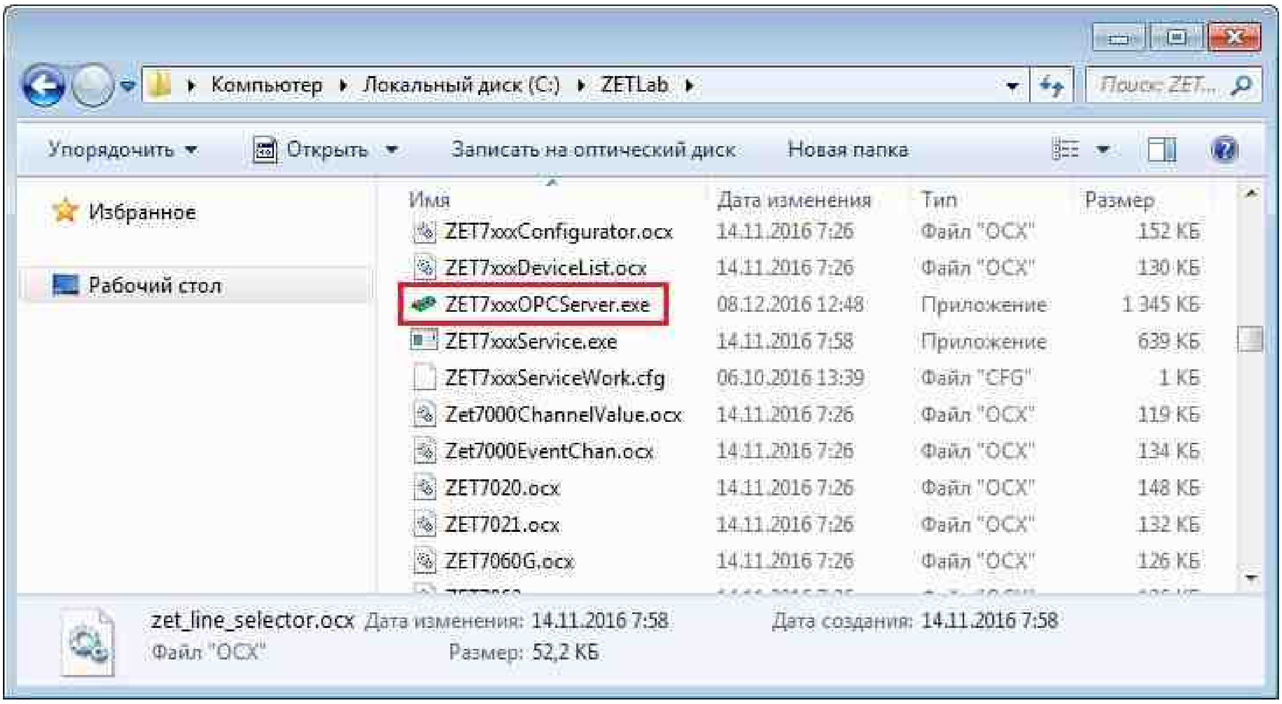


Fig.8.4 Starting the ZET7xxx OPC Server program

6. After launching the program, it will automatically hide in the notification area on the task-bar. By clicking the right mouse button on the program icon "ZET7xxx OPC Server" you should call up the context menu, and then activate the "Configuration ..." option (*Fig.8.5*).

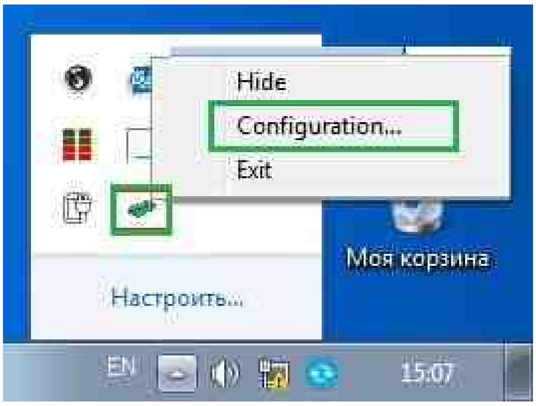


Fig.8.5 Context menu of the program "ZET7xxx OPC Server"

7. In the "Open" window that opens, select the previously created configuration file and activate the "Open" button (*Fig.8.6*).

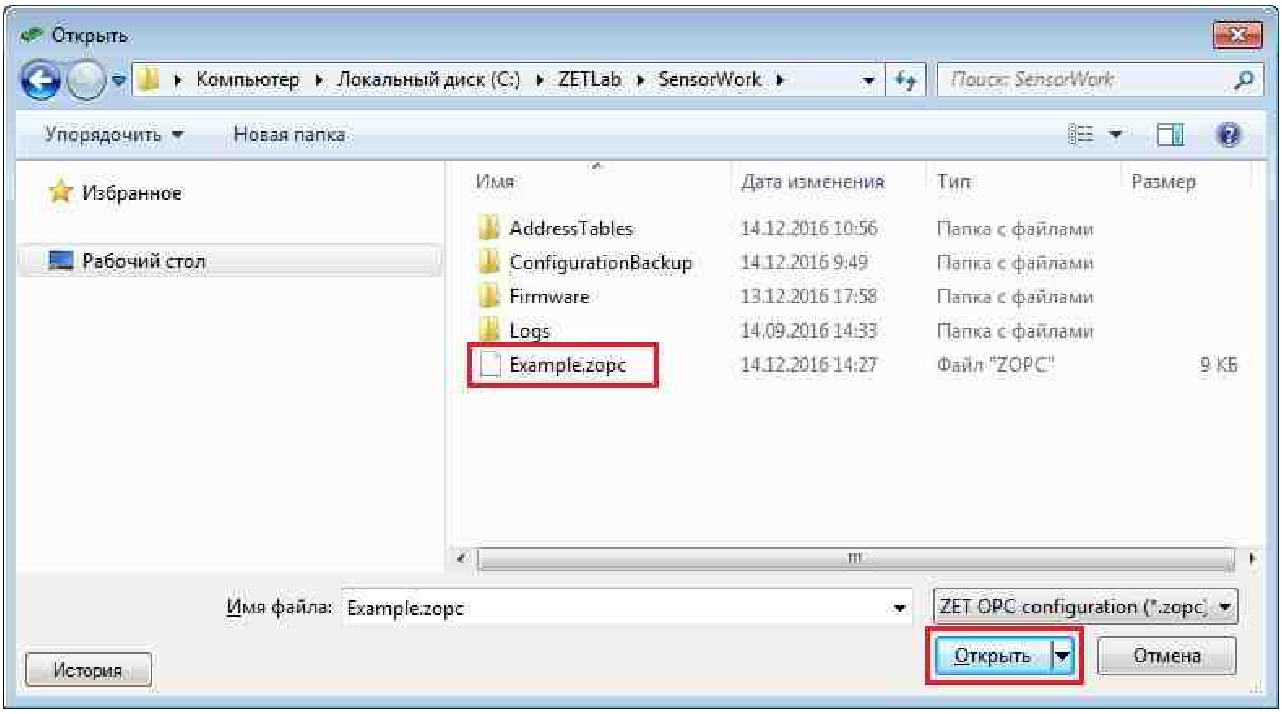


Fig.8.6 "Open" window

8. At the same time, the program will form an OPC tag tree and start reading the necessary registers from the sensors. The process of the OPC server will be displayed in the "ZET7xxx OPC Server" window (*Fig.8.7*).

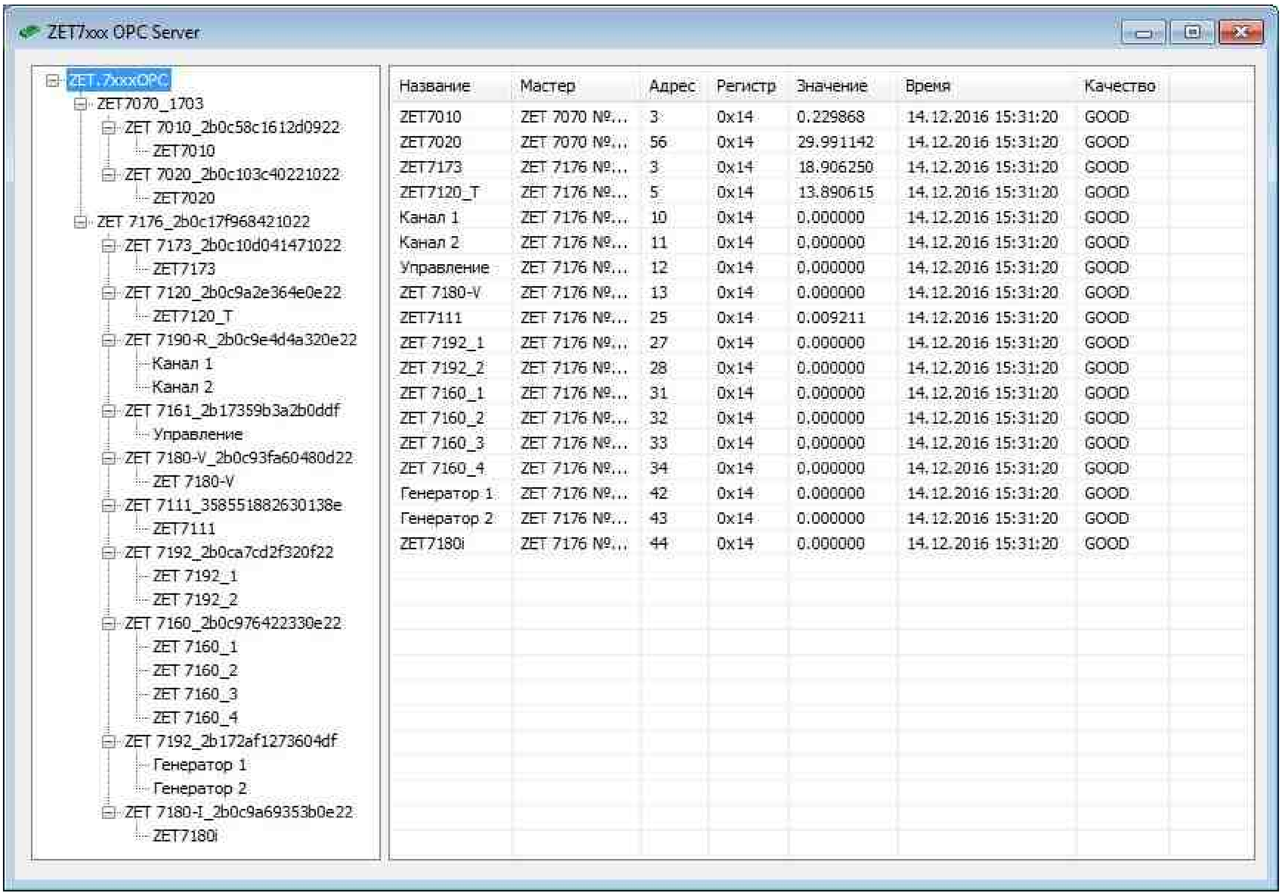


Fig.8.7 "ZET7xxx OPC Server" program window

Create Modbus register address tables .....

The Modbus register address table is designed to communicate digital sensors with third-party interface converters using the Modbus protocol. The table contains information about which address should be contacted to obtain the relevant data. It is possible to create a table of Modbus register addresses for all digital sensors, as well as for interface converters ZET 7174 and ZET 7176.

In order to create a Modbus register address table for a specific device:

Using the right mouse button, open the context menu of the device whose address table is to be created. In the context menu that opens, activate the "Save address (node)sses" command (*Fig.9.1*).

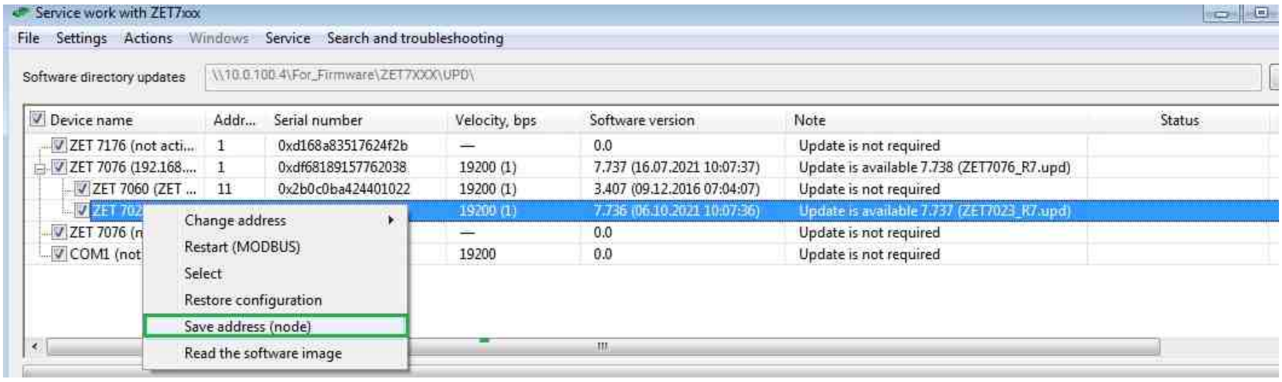


Fig.9.1 "Save address (node)" command from the context menu

1. After executing the "Save address (node)" command, the folder located in the directory: C:\ZETLab\SensorWork\AddressTables will open, in which a file with the extension ".html" will be created for this device (Fig.9.2).

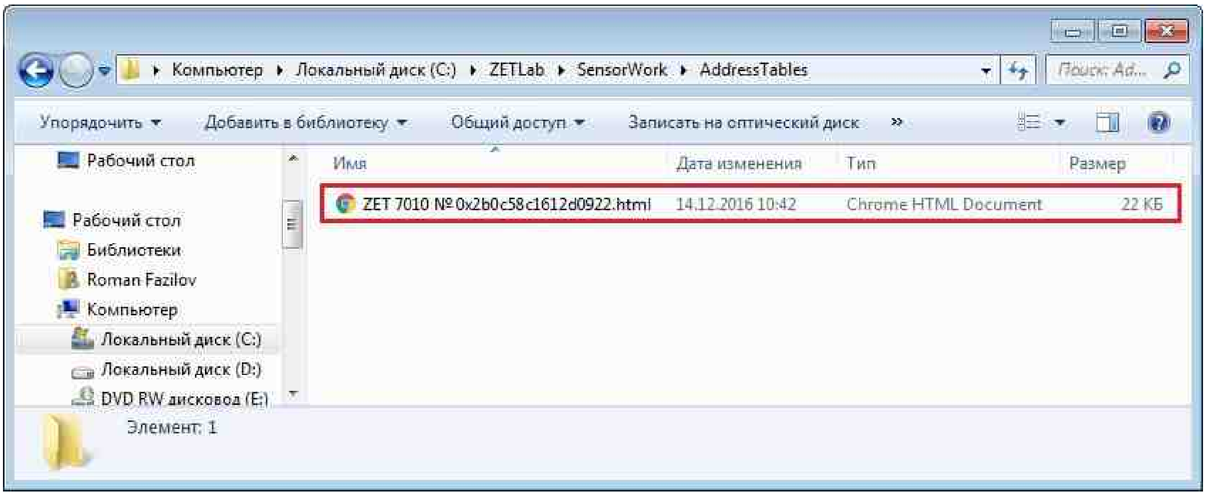


Fig.9.2 File created by the "Save address (node)" command

2. This file contains a table of Modbus register addresses for this device. It is possible to open a file using any Web browser (Chrome, Mozilla, IE, etc.), for this you need to double-click on it with the left mouse button. A page containing a table of Modbus register addresses will open in the browser. Fig. 9.3 shows an example of such a table of addresses.

Register address table MODBUS ZET 7060 No. 0x2b0c0ba424401022

Parameter name	Address, WORD	Structure address,	Data type	Number of	Accepted values

	hex (WORD dec)	WORD hex (WORD dec)		registers (in words)	
Information (Measuring digital module settings), ID = 0x18c, address = 0x00 (00)					
Measuring digital module	0x04 (04)	0x04 (04)	int(type of 17)	2	Arbitrary value(only reading) (only reading)
Serial number	0x06 (06)	0x06 (06)	longlong(type of 14)	4	Arbitrary value(only reading) (only reading)
Software release date	0x0a (10)	0x0a (10)	time(type of 11)	2	Arbitrary value(only reading) (only reading)
Configuration changed	0x0c (12)	0x0c (12)	time(type of 11)	2	Arbitrary value(only reading) (only reading)
Address (node) from 2 to 63	0x0e (14)	0x0e (14)	int(type of3)	2	Arbitrary value(only reading)
Port 1 (Port Settings 1), ID = 0xd0, Address = 0x10 (16)					
Current measured sensor value (in units)	0x14 (20)	0x04 (04)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Data update rate, Hz	0x16 (22)	0x06 (06)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Unit of measurement	0x18 (24)	0x08 (08)	char[8](type of 1)	4	Arbitrary value(only reading) (only reading)
Sensor name	0x1c (28)	0x0c (12)	char[32](type of 1)	16	Arbitrary value(only reading)
Minimum value (in units)	0x2c (44)	0x1c (28)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Maximum value (in units)	0x2e (46)	0x1e (30)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Reference value for calculation in dB	0x30 (48)	0x20 (32)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Sensitivity, V/unit.	0x32 (50)	0x22 (34)	float(type of 6)	2	Arbitrary value(only reading) (only reading)

Sensitivity threshold (in units)	0x34 (52)	0x24 (36)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Port 2 (Port Settings 2), ID = 0xd0, Address = 0x36 (54)					
Current measured sensor value (in units)	0x3a (58)	0x04 (04)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Data update rate, Hz	0x3c (60)	0x06 (06)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Unit of measurement	0x3e (62)	0x08 (08)	char[8](type of 1)	4	Arbitrary value(only reading) (only reading)
Sensor name	0x42 (66)	0x0c (12)	char[32](type of 1)	16	Arbitrary value(only reading)
Minimum value (in units)	0x52 (82)	0x1c (28)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Maximum value (in units)	0x54 (84)	0x1e (30)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Reference value for calculation in dB	0x56 (86)	0x20 (32)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Sensitivity, V/unit.	0x58 (88)	0x22 (34)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Sensitivity threshold (in units)	0x5a (90)	0x24 (36)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Port 3 (Port Settings 3), ID = 0xd0, Address = 0x5c (92)					
Current measured sensor value (in units)	0x60 (96)	0x04 (04)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Data update rate, Hz	0x62 (98)	0x06 (06)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Unit of measurement	0x64 (100)	0x08 (08)	char[8](type of 1)	4	Arbitrary value(only reading) (only reading)
Sensor name	0x68 (104)	0x0c (12)	char[32](type of 1)	16	Arbitrary value(only reading)

Minimum value (in units)	0x78 (120)	0x1c (28)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Maximum value (in units)	0x7a (122)	0x1e (30)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Reference value for calculation in dB	0x7c (124)	0x20 (32)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Sensitivity, V/unit.	0x7e (126)	0x22 (34)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Sensitivity threshold (in units)	0x80 (128)	0x24 (36)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Port 4 (Port Settings 4), ID = 0xd0, Address = 0x82 (130)					
Current measured sensor value (in units)	0x86 (134)	0x04 (04)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Data update rate, Hz	0x88 (136)	0x06 (06)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Unit of measurement	0x8a (138)	0x08 (08)	char[8](type of 1)	4	Arbitrary value(only reading) (only reading)
Sensor name	0x8e (142)	0x0c (12)	char[32](type of 1)	16	Arbitrary value(only reading)
Minimum value (in units)	0x9e (158)	0x1c (28)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Maximum value (in units)	0xa0 (160)	0x1e (30)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Reference value for calculation in dB	0xa2 (162)	0x20 (32)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Sensitivity, V/unit.	0xa4 (164)	0x22 (34)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Sensitivity threshold (in units)	0xa6 (166)	0x24 (36)	float(type of 6)	2	Arbitrary value(only reading) (only reading)
Settings (Digital Port Settings 7060), ID = 0x3e5, Address = 0xa8 (168)					

Sampling frequency	0xac (172)	0x04 (04)	float(type of 7)	2	1 10 50 100 200
Control mask of the port 0	0xae (174)	0x06 (06)	int(type of 10)	2	0 - Output 1 - Input
Control mask of the port 1	0xb0 (176)	0x08 (08)	int(type of 10)	2	0 - Output 1 - Input
Control mask of the port 2	0xb2 (178)	0x0a (10)	int(type of 10)	2	0 - Output 1 - Input
Control mask of the port 3	0xb4 (180)	0x0c (12)	int(type of 10)	2	0 - Output 1 - Input
Value on port 0	0xb6 (182)	0x0e (14)	int(type of 10)	2	0 - 0V 1 - +5V
Value on port 1	0xb8 (184)	0x10 (16)	int(type of 10)	2	0 - 0V 1 - +5V
Value on port 2	0xba (186)	0x12 (18)	int(type of 10)	2	0 - 0V 1 - +5V
Value on port 3	0xbc (188)	0x14 (20)	int(type of 10)	2	0 - 0V 1 - +5V
RS-485 (Serial Port Setting), ID = 0x7a, Address = 0xbe (190)					
Bit rate, bps	0xc2 (194)	0x04 (04)	int(type of 8)	2	2400 4800 9600 14400 19200 38400 57600 115200
Parity bit (0-none/1-odd)	0xc4 (196)	0x06 (06)	int(type of 8)	2	0 1
Current time	0xc6 (198)	0x08 (08)	time(type of 11)	2	Arbitrary value (only reading)
Management (Port Status), ID = 0x28a, Address = 0xde (222)					
Value on port 0	0xe2 (226)	0x04 (04)	int(type of 10)	2	0 - 0B 1 - +5V
Value on port 1	0xe4 (228)	0x06 (06)	int(type of 10)	2	0 - 0B 1 - +5V
Value on port 2	0xe6 (230)	0x08 (08)	int(type of 10)	2	0 - 0B 1 - +5V

Value on port 3	0xe8 (232)	0x0a (10)	int(type of 10)	2	0 - 0B 1 - +5V

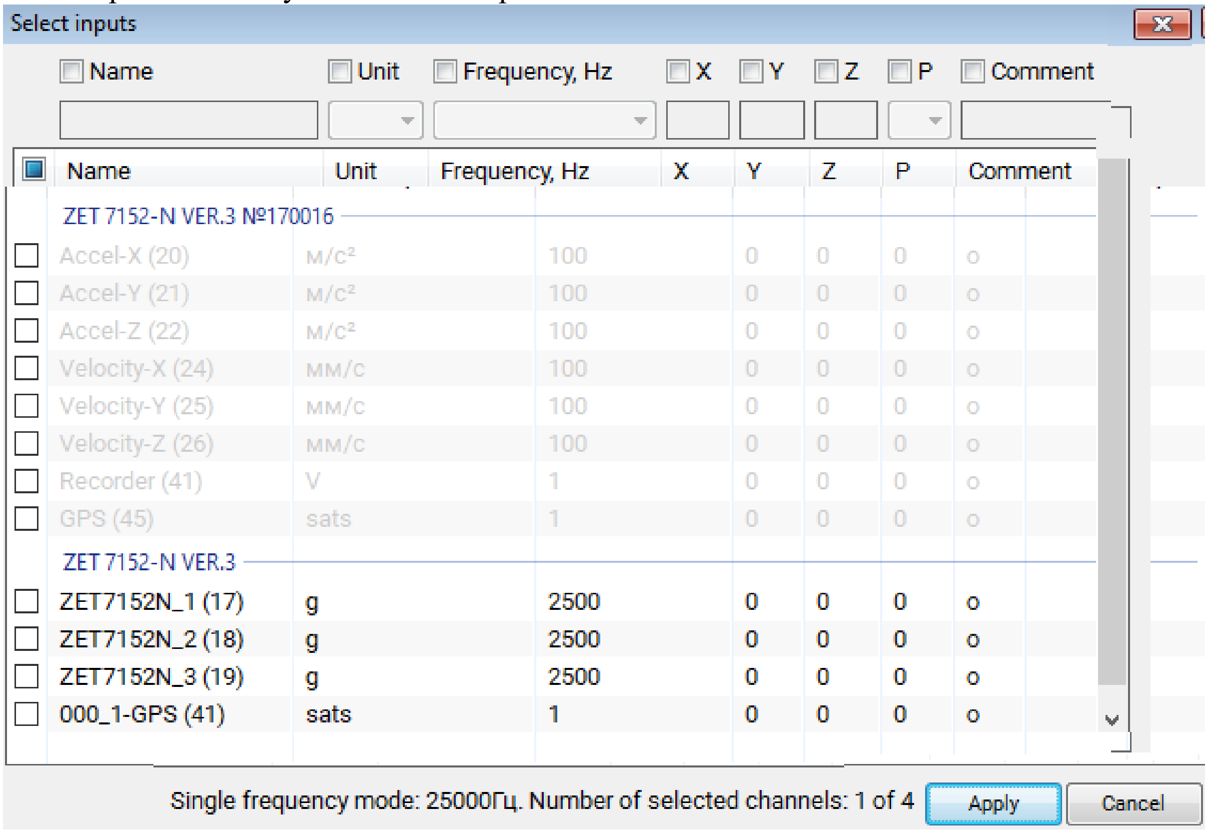
Fig.9.3 Modbus register address table example

This table of MODBUS register addresses was obtained using the SensorWork program

Management to the "Select inputs" component

Purpose

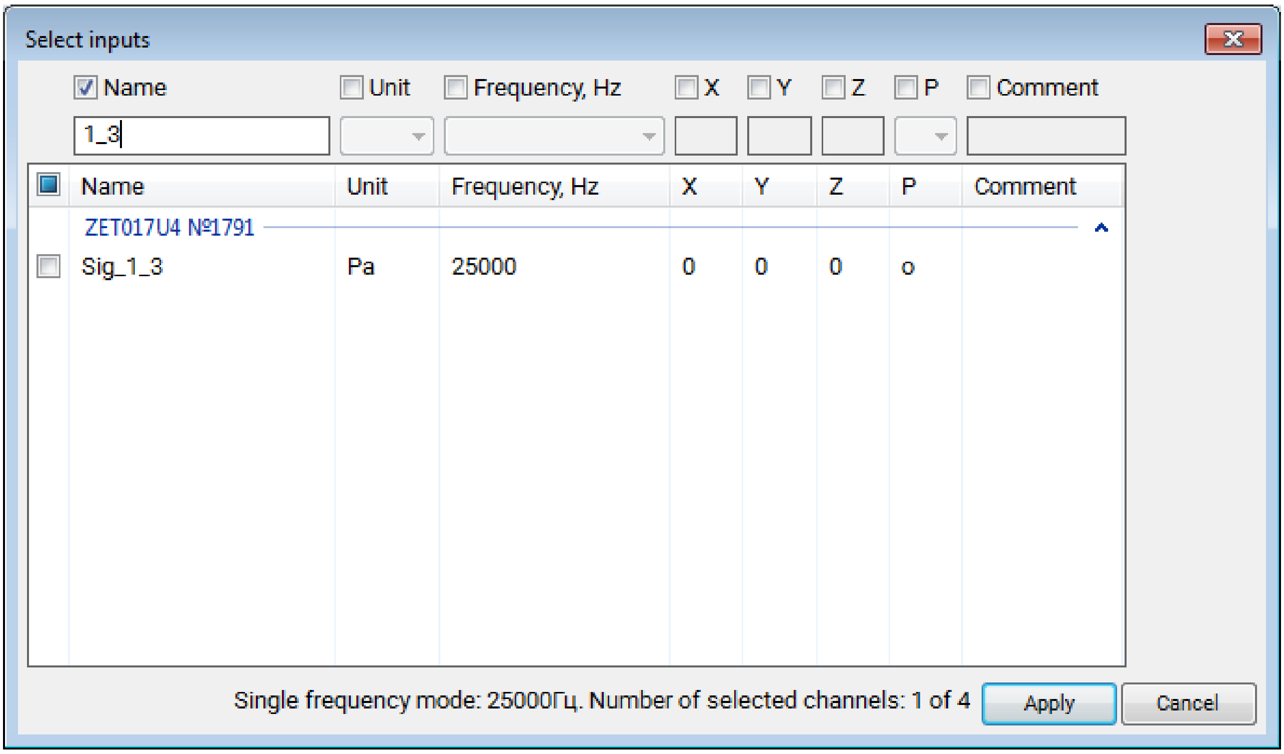
The component allows you to select multiple channels.



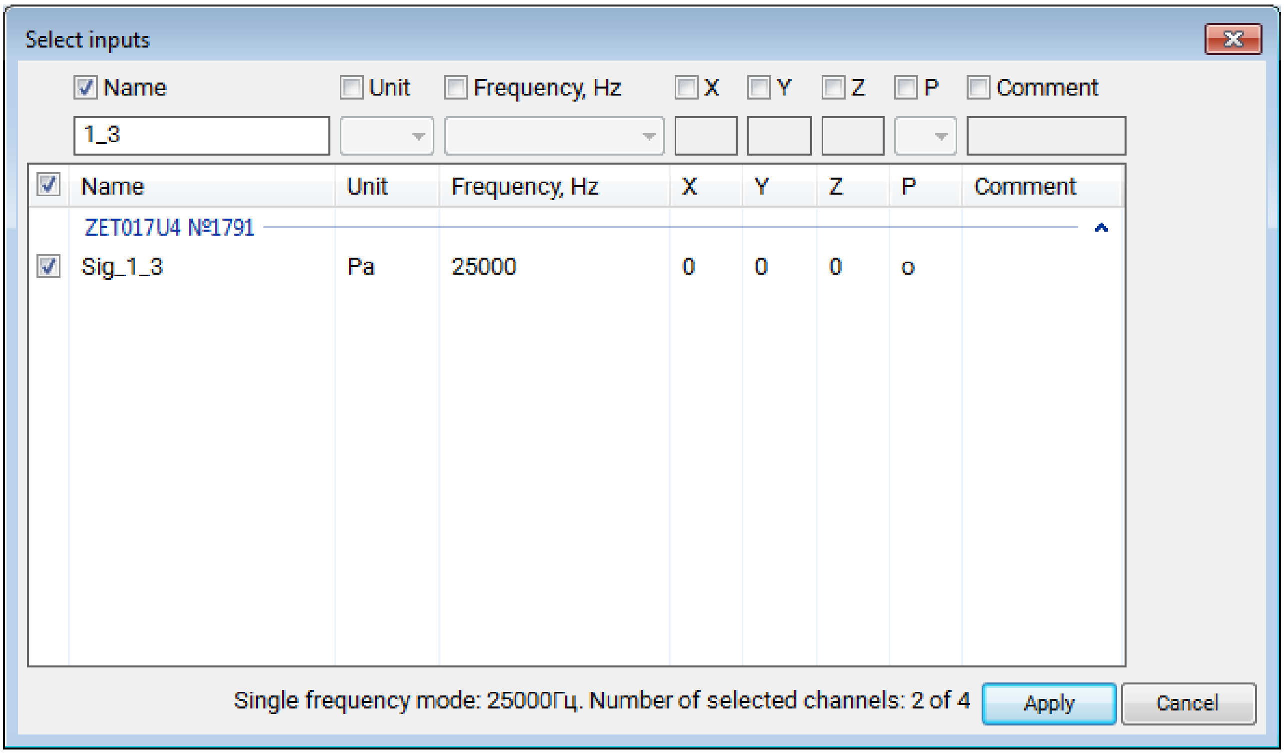
For a more convenient search for the desired channel, you can use sorting:

1. By channel name
2. By unit of measure
3. By frequency
4. By coordinates (X,Y,Z) and orientation P
5. By channel comment

Check the box below the required option and enter a value, or select from the available



After selecting the desired channels, click the "Apply" button



Note:

- Single frequency mode, allows the user to select channels with the same sampling frequency, respectively, the list will be filtered by frequency.
- Single channel selection mode allows the user to select only one channel from the available channels.
- Please note that at least 1 channel must be selected.

Program messages from the error Log and ZETServer

The program has the ability to work without operator intervention, so the program does not display its messages in the form of dialog boxes, but writes them to the system application log, which can be viewed using the **ZETLAB Error journal** program from the **ZETLAB** "Service" from **ZETLab control panel** tab.

The format of messages recorded by **ZETLAB** programs in the journal is as follows:

"Program name No. xx. Message text",

where xx is the number of the running copy of the program.

The program writes to the system log not only error messages, but also messages about changes in its parameters. Recorded messages allow you to restore the sequence of program actions, which is often useful when analyzing errors that occur during program operation. The table below shows the program messages.

Message text	**Category**
Messages from the ZETLAB Error journal	
101 Error connecting to the data server	error
102 Error when reading data from the registry	error
103 The configuration file in the Dir Config folder is not available	error
104 The help file is missing	error
105 DirHelp folder is unavailable	error
106 DirSignal folder is unavailable	error
107 DirResult folder is unavailable	error
108 DirCorrect folder is unavailable	error
109 InstallLocation folder is unavailable	error
110 Error creating an instance of the CAutoScaleXY class	error
111 Error connecting to Unit	error
112 The program is launched via Unit	error
113 The program is launched from the Z-panel	error
114 The program has started working	error
115 ADC sampling frequency, Hz	error
116 Error code	error
117 There are no working channels of the data server. The program will not load	error
118 Error when calling program help	error
119 The program has completed its work	error
120 An error occurred while reading data from the channel	error
121 An error occurred while processing data	error
122 No data server	error
123 Program will close	error

124 Error when starting parameter processing program	error
Messages from ZETServer	
There was no connection to the server	error
The server is not loaded on the computer	error
Too many programs connected to the server	error
The server does not boot on the computer	error
Low RAM or disk space	error
Channel number less than zero	error
Channel number is greater than the maximum possible value	error
Unable to instantiate the Server component	error

When working with a running control panel, **ZETLAB** program error messages are duplicated by temporary pop-up texts in the system tray (the notification area is an element of the desktop toolbar or "Taskbar" in Windows, used for the needs of constantly used programs).

Receiving the message "The data server has too many channels. There is not enough memory for the program to work in this mode. The program will be closed" indicates that too many programs are currently loaded that work with the **ZETLAB** data server, or that the used The computer does not have enough RAM. In the first case, close unused programs and restart the program. In the second case, you must either notice the computer, or increase the amount of RAM in the one used.

Help and technical support

Contact information

LLC "Electronic technologies and metrological systems"

Please notify us using any communication of your convenience on any issues and faults occurring during ZETLab software installation and operation.

Manufacturer's address: 14 Konstruktora Lukina str. build.12, Zelenograd, 124460, Moscow, Russia.

GPS COORDINATES 56.008067, 37.153907

Telephone/fax: +7 (495) 739-39-19 (Multichannel)
Technical support: INFO@ZETLAB.RU for issues relating to purchase of standard products/ SNAB@ZETLAB.COM - on issues of supply, logistics, certification and labor protection..
REKLAMA@ZETLAB.COM - for publications and promotional offers.
Web site: https://www.zetlab.com information on Company products.
Number for WhatsApp correspondence - 8-916-003-63-73.

OFFICE HOURS Mon-Fri: 9 a.m.–6 p.m. (MSK time)

For issues relating to publications and advertising proposals, please, contact: REKLAMA@ZETLAB.COM

Technical support

Should you have any questions regarding equipment selection, use and maintenance, you can contact us by E-mail or in the forum of our website. Our specialist will provide you with informational support.

In order to receive information concerning equipment operation from our specialists, you should prepare a list of the source data. Taking into consideration the source data volume, it is better to send it by E-mail. It is hardly reasonable to try to submit this information over the phone.

We need the following details:

• your name and contacts;

• name and serial number of the instrument;

• information about your PC (processor, memory, video card) and operating system;

• ZETLAB software version and configuration. Date of the previous software update;

• the program settings – sampling frequency, number of channels, amplification ratios, co-phase and differential channels;

• external connection scheme – text description, technical drawing, photo of the connected device or a schematic drawing;

• contact pins numbers, connections length, type of cable used: shielded, twisted pair;

• signal sources used: inner impedance levels;

• Evaluation of signal levels at the device input, signal type used (specific signal parameters (if any) – impulse, sine, random, periodical, frequency band width);

• Operating environment of the instrument (laboratory, manufacturing facility);

• Describe grounding chains of the PC, grounding of signal sources – if they are used, describe them;

• It is also necessary to describe the interference factors – cross-channel mixing or any other negative effects together with some quantitative characteristics! It is also desirable to attach several print-screens.

In the case if you provide our technical specialist with this source information, it will allow us to provide you with the necessary information as soon as possible!

ZETLAB