

LLC

“Electronic Technologies and Metrological Systems”

“Fundamental Tone”

Operator’s manual

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1. Functions

The «Fundamental Tone» software is a set of programs, which are used for determination of free oscillations period and logarithmic decrement in accordance with the applicable standards.

Period and decrement of free oscillations' fundamental tone is an important parameter, which is used for analysis of building's stress-strain state changes as well as in the course of building's technical condition control.

2. Fundamental principles

For the purpose of fundamental tone period evaluation an indirect measurements method is used. The essence of this method is that the fundamental tone period for each of the axes is determined by means of building's oscillations spectrum analysis.

The decrement value for each of the mutually transverse axes is calculated by means of the same method, which is used for fundamental tone period calculations.

Building's oscillations are represented by a composition of free and forced oscillations, caused by inner and external impacts. Industrial buildings normally have a lot of manufacturing machinery inside (which is on and moves around the building). In this case, one should perform measurements when the manufacturing process is stopped, or when the manufacturing machinery is stable.

Among the factors that may distort the period measurements results one should mention the snow load stress – hence, this factor is to be taken into consideration during measurements performance.

3. Setting-up procedures

3.1 Installation of ZETLAB Software

Install ZETLab Software (if it hasn't been previously installed) from the CD to your PC, which is going to be used for further operation, then run ZETLab.msi installation file. Follow instructions of set-up wizard and install ZETLab to the directory C:\ZETLab.

3.2 Installation of ZETVIEW Software

Run the installation file ZETView.msi. Follow instructions of set-up wizard and install ZETVIEW software to the directory C:\ZETLab.

3.3 Installation of «Fundamental Tone» Software

In order to use “Fundamental Tone” software it is necessary to copy the folder “Buildings, structures and environment monitoring system” to your PC.

To begin working with “Fundamental tone” software, run the file «Fundamental tone.exe». For more convenience, one can place the shortcut for the file «Fundamental tone.exe» on the desktop.

4. Operation of Fundamental Tone software

4.1 Starting the Software

In order to start «Fundamental Tone» software, double click the «Fundamental tone.exe» to run it (Figure 4.1)

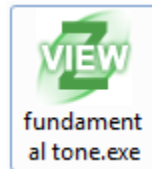


Figure 4.1 «Fundamental tone.exe» file

You will see the window of «Fundamental Tone» program (Figure 4.2).

SCADA-system ZETVIEW c:\users\user\desktop\eng\fundamental tone_eng.exe

Spectrum Result Additional settings Configuration

Determination of the parameters of the fundamental tone of free oscillations of buildings

Information about the investigated object

Address of the object Object purpose

☒ Set limits for fundamental tone calculation from table

Type of building Number of floors

☐ Set limits for fundamental tone calculation by period:

Natural oscillations period range limits for the major axis (X): T1, s T2, s

Natural oscillations period range limits for the minor axis (Y): T1, s T2, s

Natural oscillations period range limits for the vertical axis (Z): T1, s T2, s

☐ Set the limits of fundamental tone calculation by frequency

Natural oscillations frequency range limits for the major axis (X): F1, Hz F2, Hz

Natural oscillations frequency range limits for the minor axis (Y): F1, Hz F2, Hz

Natural oscillations frequency range limits for the vertical axis (Z): F1, Hz F2, Hz

Information about the contractor and the customer

Organization performing the measurements Customer of measurements

Measurement parameter

Number of averages Confidence interval

Duration of one measurement, s Uncertainty coefficient

Frequency resolution, Hz Smoothing ratio

Object major axis: measuring channel

Object minor axis: measuring channel

Object vertical axis: measuring channel

Figure 4.2 «Fundamental tone» program window

The program has several tabs:

- Configuration;
- Spectrum;
- Result;
- Additional settings.

4.2 Tabs description

4.2.1 «Configuration» tab

«Configuration» tab (Figure 4.3) allows you to complete informational fields as well as to change settings.

The screenshot shows the 'Configuration' tab of the SCADA-system ZETVIEW. The window title is 'SCADA-system ZETVIEW c:\users\user\desktop\eng\fundamental tone_eng.exe'. The main title of the tab is 'Determination of the parameters of the fundamental tone of free oscillations of buildings'. The form is divided into several sections:

- Information about the investigated object:**
 - Address of the object: Moscow Zelenograd ELMA corpus 4
 - Object purpose: electronic plant
 - ☐ Set limits for fundamental tone calculation from table
 - Type of building: Large-panel (dropdown menu)
 - Number of floors: 001
 - ☐ Set limits for fundamental tone calculation by period:
 - Natural oscillations period range limits for the major axis (X): T1, s 0.25; T2, s 1.00
 - Natural oscillations period range limits for the minor axis (Y): T1, s 0.25; T2, s 1.00
 - Natural oscillations period range limits for the vertical axis (Z): T1, s 0.50; T2, s 2.00
 - ☒ Set the limits of fundamental tone calculation by frequency
 - Natural oscillations frequency range limits for the major axis (X): F1, Hz 01.00; F2, Hz 04.00
 - Natural oscillations frequency range limits for the minor axis (Y): F1, Hz 01.00; F2, Hz 04.00
 - Natural oscillations frequency range limits for the vertical axis (Z): F1, Hz 00.50; F2, Hz 02.00
- Information about the contractor and the customer:**
 - Organization performing the measurements: ZETLAB
 - Customer of measurements: ZETLAB
- Measurement parameter:**
 - Number of averages: 0100
 - Confidence interval: 0.90 (dropdown)
 - Object major axis: measuring channel: ZET048E_712_1X
 - Duration of one measurement, s: 010
 - Uncertainty coefficient: 0.10
 - Object minor axis: measuring channel: ZET048E_712_1Y
 - Frequency resolution, Hz: 0.01
 - Smoothing ratio: 10.0
 - Object vertical axis: measuring channel: ZET048E_712_1Z

Figure 4.3 «Configuration» tab

The fields «Address of the object», «Object purpose», «Organization performing the measurements», «Customer of measurements» serve for informational purposes only and are used for report creation.

In the «Configuration» tab there is a section «Information about the investigated object» in which you should choose one of the three ways to set limits for fundamental tone calculation:

- 1) «Set limits for fundamental tone calculation from table»

This option is selected if the building has a standard structure. The pop-up list (Figure 4.4) allows you to select corresponding type of the building as well as to set the number of floors.

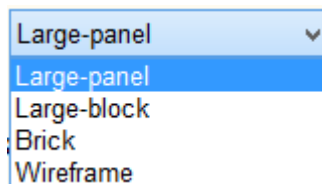


Figure 4.4 Building's structure type - selection menu

- 2) «Set limits for fundamental tone calculation by period»

This option is selected in the case if the building's structure is not typical, but the natural oscillations limits are known. In this case, one have to set oscillations limit values for X, Y, Z axes in corresponding fields (Figure 4.5).

T1, s	0.25	T2, s	1.00
T1, s	0.25	T2, s	1.00
T1, s	0.50	T2, s	2.00

Figure 4.5 Free oscillations period: range limits

3) «Set the limits of fundamental tone calculation by frequency»

This option is selected in the case if the building's structure is not typical, but free oscillations frequency limits are known. In this case, one have to set oscillations frequency limit values for X, Y, Z axes in corresponding fields.

F1, Hz	01.00	F2, Hz	04.00
F1, Hz	01.00	F2, Hz	04.00
F1, Hz	00.50	F2, Hz	02.00

Figure 4.6 Free oscillations frequency: range limits

In the «Configuration» tab, there is a «Measurement parameter» section, where the following parameters are to be set:

- Frequency resolution – spectrum band density in the frequency axis. The lower is the frequency resolution value, the more bands there are.
- Duration of one measurement – the time for a single spectrum values averaging.
- Number of averages – the amount of recorded spectra, which is going to be used for values averaging.
- Confidence interval – confidence interval value stands for probability of the parameter in question being within the set interval. Confidence interval value is a number from 0 to 1 showing the probability of the measured variable being within the specified range. The more is the confidence interval, the higher is the probability that the actual value falls into particular interval.
- Uncertainty coefficient – is a ratio, which is equal to the product of frequency resolution by measurements duration. It corresponds to the amount of noise in the spectrum chart. High value of uncertainty coefficient leads to stable measurements performance and decrease of noise impact. In order to consider the measurements results to be reliable, the uncertainty coefficient value should be ≥ 1 .
- Smoothing ratio – is a value, which is equal to the product of uncertainty coefficient by the number of averages. It correlates to the noise suppression degree. In order to consider the measurements results to be reliable, the smoothing ratio value should be ≥ 100 .
- Object major axis: measuring channel – in this section one should set the measuring channel to be used for oscillations control along major axis (X).

- Object minor axis: measuring channel – in this section one should set the measuring channel to be used for oscillations control along minor axis (Y).

- Object vertical axis: measuring channel – in this section one should set the measuring channel to be used for oscillations control along vertical axis (ось Z).

4.2.2 «Spectrum» tab

«Spectrum» tab (Figure 4.7) shows spectra charts for X, Y and Z measuring channels within the set measurements range. The obtained spectra charts depend on the values set for the parameters «Frequency resolution», «Duration of one measurement», «Number of averages» in the «Configuration» tab.

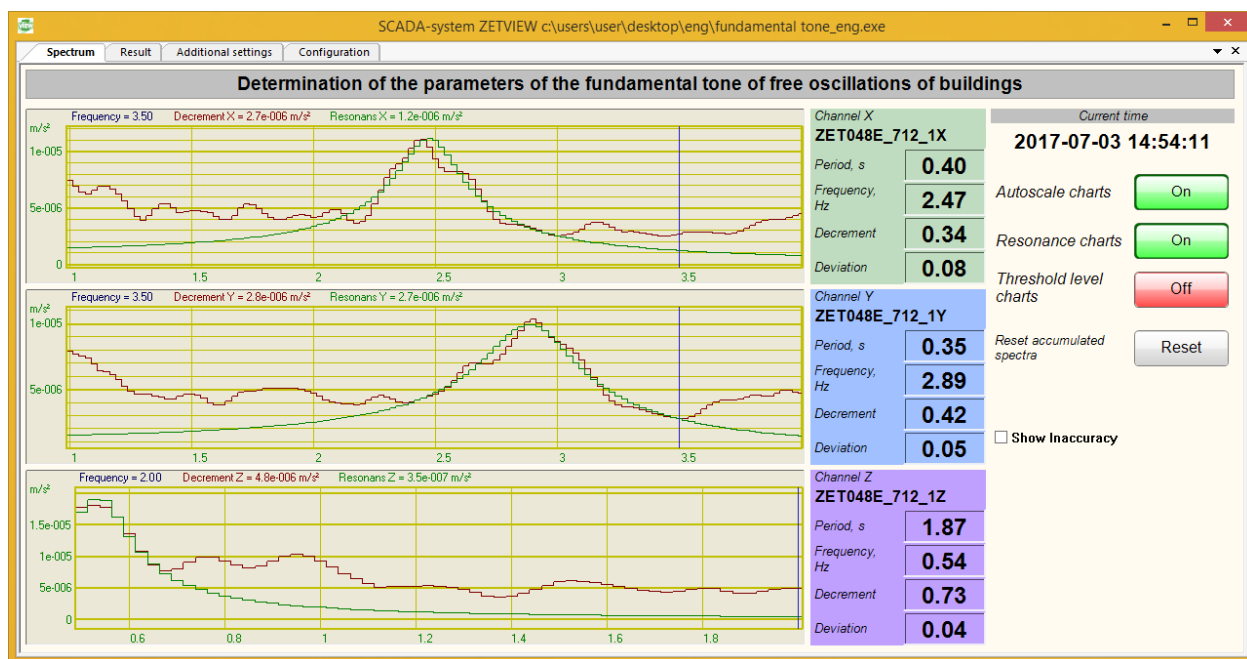


Figure 4.7 «Spectrum» tab

In order to depict resonance charts one should enable corresponding option (Figure 4.8)

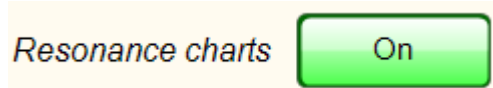


Figure 4.8 Key for resonance charts representation

Threshold level chart is a horizontal line shown in the spectrum chart. The spectrum chart section, which is located above the threshold level line, is used for further calculations. To depict the threshold level line one should enable corresponding option (Figure 4.9).

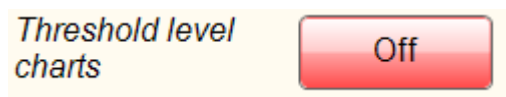


Figure 4.9 Key for threshold level charts representation

Digital indicator «Period, s» stands for average period value of building's natural oscillations period for a set time span.

Digital indicator «Frequency, Hz» stands for average value of building's natural oscillations for a set time span.

Digital indicator «Decrement» stands for average value of building's natural oscillations decrement for a set time span.

Digital indicator «Deviation» stands for spectrum chart deviation from the resonance chart. The higher the «Deviation» indicator value is, the more reliable the measurements results are.

In order to reset the accumulated spectra and related parameters, one should use «Reset accumulated spectra» key (Figure 4.10).

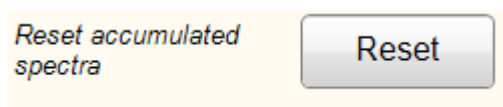


Figure 4.10 Key used to reset the accumulated spectra

4.2.3 «Result» tab

The «Result» tab (Figure 4.11) shows dependence charts of frequency, period and decrement values from the set point (measurement number).

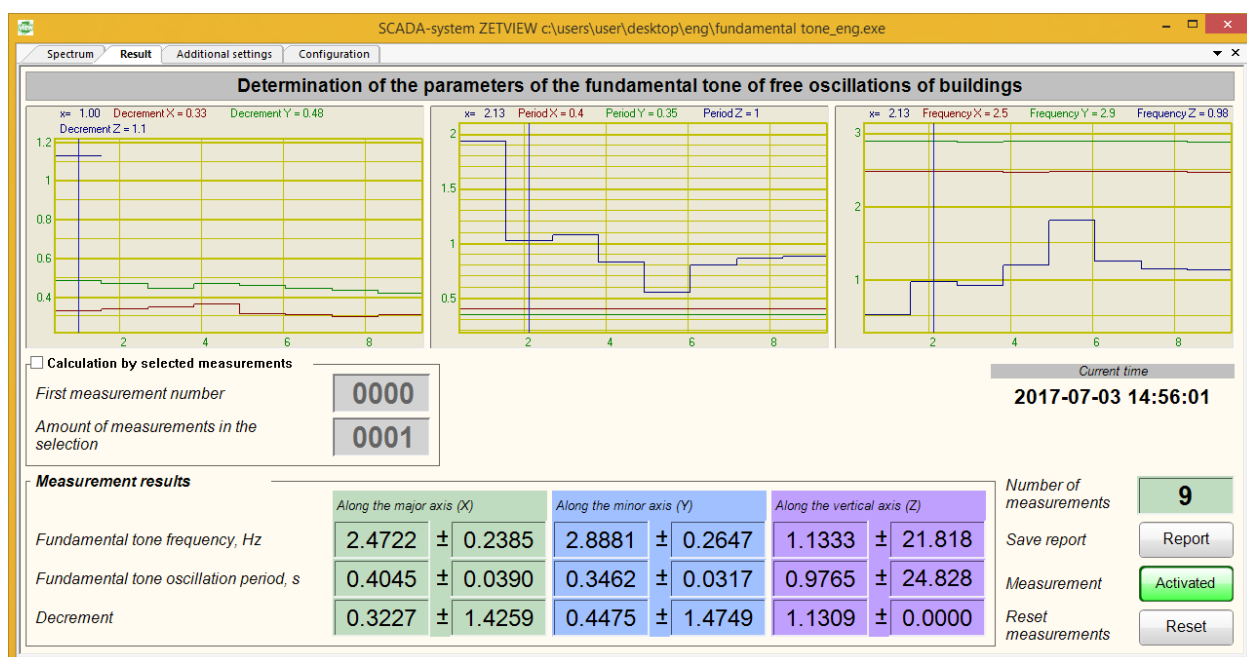


Figure 4.11 «Result» tab

The charts are depicted for each of the three measuring axes for the period from “Measurement” key activation (Figure 4.12) until the current moment or de-activation of the “Measurement” key.

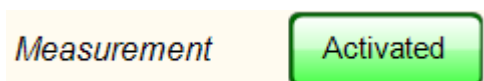


Figure 4.12 «Measurement» activation key

It is also possible to display selected chart section – in order to do that it is necessary to enable the function “Calculation by selected measurements” (Figure 4.13) by selecting corresponding checkbox.

☒ Calculation by selected measurements

First measurement number

Amount of measurements in the selection

Figure 4.13 «Calculation by selected measurements» option

In order to set the limits of the displayed chart section one have to enter the required values in the fields «First measurement number» and «Amount of measurements in the selection». After that, there will be displayed charts with set limits (Figure 4.14).

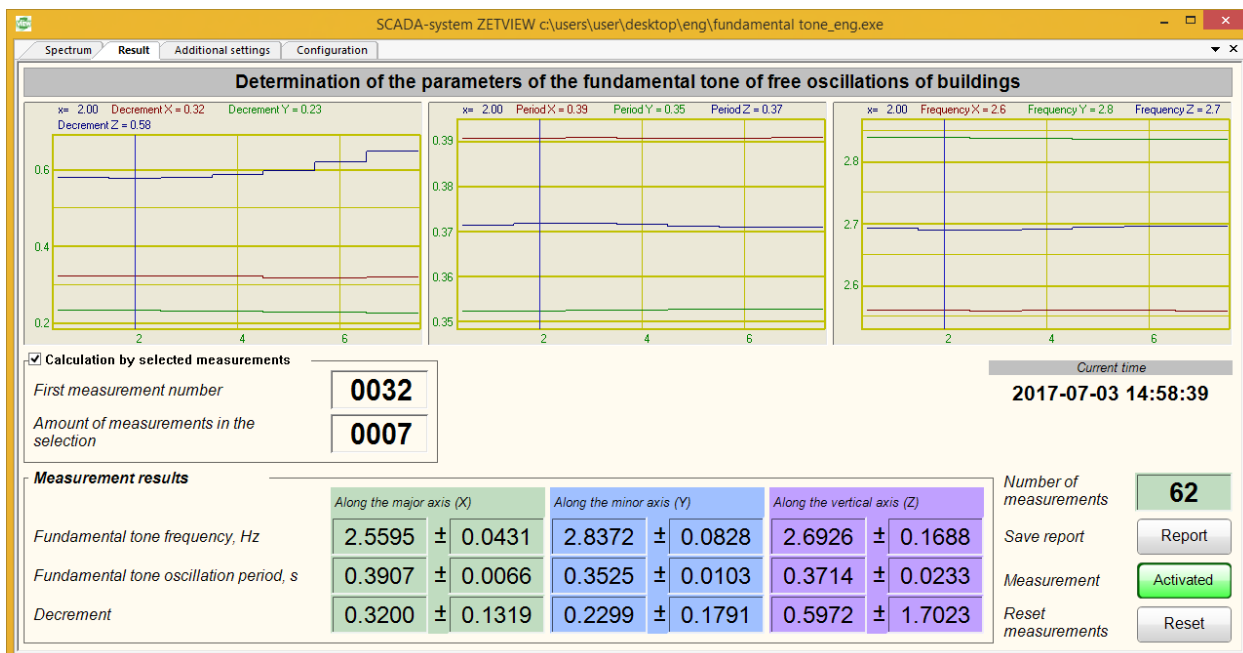


Figure 4.14 Calculation by selected measurements

Digital indicators “Fundamental tone frequency”, “Fundamental tone oscillation period” and “Decrement” depict averaged values of the corresponding parameters, calculated for the period from “Measurement” (Figure 4.12) key activation until the current moment or de-activation of the “Measurement” key.

In order to reset the accumulated data, click “Reset measurements” key (Figure 4.15).

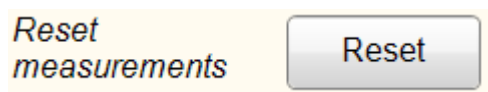


Figure 4.15 “Reset measurements” key

The program also has an option of saving measurements results to a report file using “Save report” key (Figure 4.16).



Figure 4.16 “Save report” key

The results are saved in «docx» file. Figure 4.17 shows an example of a saved report file.

Measurements protocol

Natural oscillations period and decrement of building

1	Address of the object	Moscow Zelenograd ELMA corpus 4
2	Object purpose	electronic plant
3	Organization performing the measurements	ZETLAB
4	Customer of measurements	ZETLAB
5	Time of measurements	2017-07-03 14:59:14
6	Natural oscillations period for the major axis (X), s	0.391 ± 0.007
7	Natural oscillations period for the minor axis (Y), s	0.352 ± 0.010
8	Natural oscillations period for the vertical axis (Z), s	0.371 ± 0.023
9	Natural oscillations decrement for the major axis (X), s	0.320 ± 0.132
10	Natural oscillations decrement for the minor axis (Y), s	0.230 ± 0.179
11	Natural oscillations decrement for the vertical axis (Z), s	0.597 ± 1.702

Figure 4.17 Report file

4.2.4 «Additional settings» tab

«Additional settings» tab (Figure 4.18) allows to change algorithm of decrement calculation. By adjusting such parameters as “Threshold coefficient relative to amplitude”, “Maximum number of points in the calculation” and “Coefficient of culling points after the approximation” one should try to get minimal possible value of “Deviation” parameter in the “Spectrum” tab.

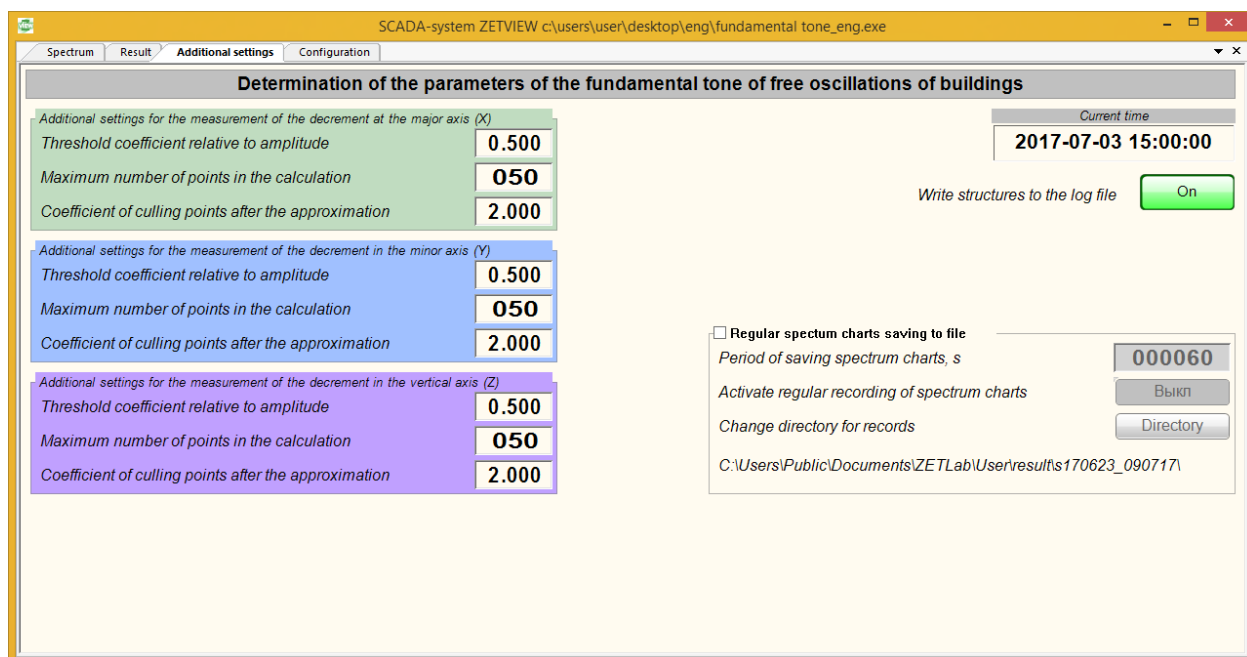


Figure 4.18 Additional settings tab

For periodical saving of spectra charts it is necessary to enable the function “Regular spectrum charts saving to a file” (Figure 4.19) by selecting corresponding check-box.

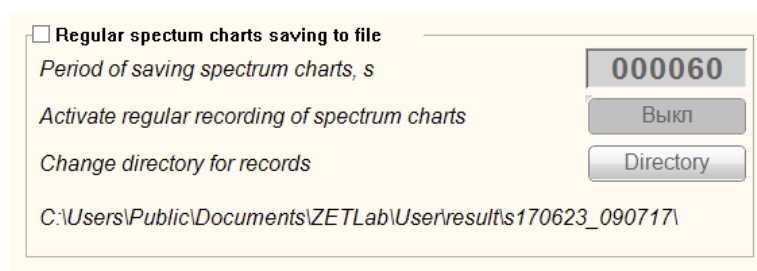


Рис. 4.19 «Regular spectrum charts saving to a file» function

The parameter «Period of saving spectrum charts» determines how often the spectrum charts will be saved. The parameter «Change directory for records» allows to choose records directory. In order to start spectrum charts recording one should enable the «Activate regular recording of spectrum charts» option.