

## **DIGITAL INCLINOMETER**

**ZET 7054, ZET 7154**

**USER MANUAL**

## TABLE OF CONTENTS

1 DESIGNATION AND TECHNICAL SPECIFICATIONS .....	3
1.1 Introduction .....	3
1.2 Designation of inclinometers .....	4
1.3 Operational environment .....	4
1.4 Technical specifications .....	5
1.5 Delivery scope.....	6
2 EXTERNAL VIEW, CONTACTS LABELLING AND CONNECTION DIAGRAM .....	7
2.1 External view of inclinometers (industrial version).....	7
2.2 External view of inclinometers (explosion-proof version) .....	8
2.3 Digital inclinometers: contacts labelling.....	9
2.4 Digital inclinometers: mounting .....	10
2.5 Establishing measuring network: connection diagram.....	11
3 PARAMETERS CONFIGURATION: PREPARATION .....	12
3.1 Connection of digital inclinometers .....	12
3.2 The program "Device manager" .....	12
4 DIGITAL INCLINOMETERS: PARAMETERS CONFIGURATION .....	13
4.1 Configuration of interface part of the digital inclinometers.....	13
4.2 Functions and composition of the tabs used for configuration of measuring part of the digital inclinometers .....	14
5 CONTROL OF DIGITAL INCLINOMETERS .....	20
5.1 Checksum control .....	20
5.2 Constant control .....	21
5.3 Metrological self-check of the inclinometers .....	22

# **1 Designation and technical specifications**

## **1.1 Introduction**

The present User manual describes structure and operating principles of digital inclinometers of ZET 7x54 series (hereinafter referred to as “inclinometers”). The document contains general rules of inclinometers operation as well as instructions concerning installation, start-up and maintenance activities.

Prior to using the inclinometers, it is necessary to study the present User manual and to visit the safety meeting.

Unboxing, installation, start-up and pre-starting procedure can be conducted by the User or by a representative of the organization performing technical maintenance of the equipment as per provisions of the Agreement relating to purchase of the inclinometer.

The Manufacturer reserves the right to introduce minor changes in structure and construction of the inclinometers, which do not affect the technical characteristics, without making any changes in operational and technical documentation.

At all stages of inclinometers operation it is necessary to observe provisions of the present User manual as well as instructions specified in other documents supplied together with the inclinometers.

## 1.2 Designation of inclinometers

Inclinometers are used for measurement (by two mutually transverse axes X and Y) of tilt angle of buildings, structures or controlled structural elements.

The most popular spheres of use of inclinometers are as follows:

1. Platforms position and alignment control;
2. Position and movement parameters monitoring of the controlled object;
3. Alarm notification in the case of critical change of the controlled object's position;
4. Security systems;
5. Navigation.

The inclinometers can be used separately or in the structure of a distributed measurement system used for control of tilt angle of industrial, residential and municipal facilities. The inclinometers can be easily installed on the controlled facility without the need to connect any external primary transducers.

## 1.3 Operational environment

The inclinometers have industrial version available and can be used in adverse operational environments. This allows to use them in hostile environments with high mechanical and vibrational load. It is allowed to use the inclinometers with labelling *0ExiaIICT6X* in explosion-hazard areas.

Operational conditions of inclinometers ZET 7x54 are specified in Table 1.1.

*Table 1.1 Operational conditions of ZET 7x54*

Parameter	Industrial version
Ambient air temperature, °C	-40...80
Relative air humidity, %	Not more than 98 <sup>1</sup>
Atmospheric pressure, mmHg	495-800

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<sup>1</sup> at the ambient air temperature of 35 °C.

## 1.4 Technical specifications

Basic technical characteristics of the inclinometers are specified in *Table 1.2*

*Table 1.2 Technical specifications of ZET 7x54*

Parameter	Value	
	ZET 7054	ZET 7154
Measured physical value	Tilt angle	
Number of measurement axes	2 (X and Y)	
Measurement range, °	From -15 up to +15	
Primary transducer type	Integrated capacitance transducer	
Data refresh rate, Hz	1	
Data interface	RS-485	CAN 2.0
Power supply voltage, V	9...24	
Consumed power, W	0,5	
Protections class - Industrial version: - Explosion-proof version:	IP65 IP67	
Dimensions, mm - Industrial version: - Explosion-proof version:	98x105x28 180x120x77	
Weight, gr - Industrial version: - Explosion-proof version:	300 1400	

Basic metrological specifications of the inclinometers are specified in *Table 1.3*.

*Table 1.3 Metrological characteristics of ZET 7x54*

Parameter	Value	
	ZET 7054	ZET 7154
Limits of absolute admissible error of tilt angle measurements, °	$\pm (0,045^\circ + 0,045 \times \varphi)$ , where $\varphi$ is the measured value of the tilt angle	
Zero setting error, °	$\pm 0,045$	
Zero drift per 100 hrs in relation to tilt angle measurement range under normal conditions, not more than, °	$\pm 0,045$	
Limits of admissible additional error attributed to temperature change of 10°C, °	$\pm 0,05$	

## 1.5 Delivery scope

Delivery scope of digital inclinometers is specified in *Table 1.4*.

*Table 1.4 Delivery scope of ZET 7x54*

#	Item	Quantity
1	Tiltmeter ZET 7x54	1 pc
2	Adjusting plate for ZET 7x54	1 pc
3	Plug for the cable FQ14-4TJ-7	2 pcs
4	CD with ZETLAB SENSOR software	1 pc
5	Product certificate	1 pc
6	User manual <sup>2</sup>	1 pc

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<sup>2</sup> a set of Products can be provided with a single copy of the Document

## 2 External view, contacts labelling and connection scheme

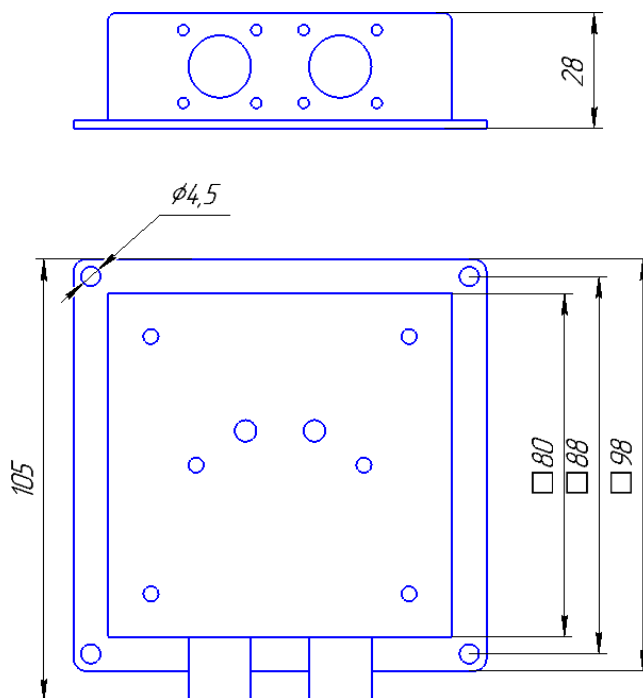
### 2.1 External view of inclinometers (industrial version)

External view of inclinometers (industrial version) is shown in *Figure 2.1*.



*Figure 2.1* External view of digital inclinometer (industrial version)

General dimensions and mounting dimensions of inclinometer (industrial version) are specified in *Figure 2.2*.



*Figure 2.2* Mounting dimensions of digital inclinometers

Four holes with 4,5 mm diameter placed at the corners of the inclinometer are used for attaching the inclinometer to adjustment plate or for mounting of the inclinometer to the surface of the controlled object.

## 2.2 External view of the inclinometers (explosion-proof version)

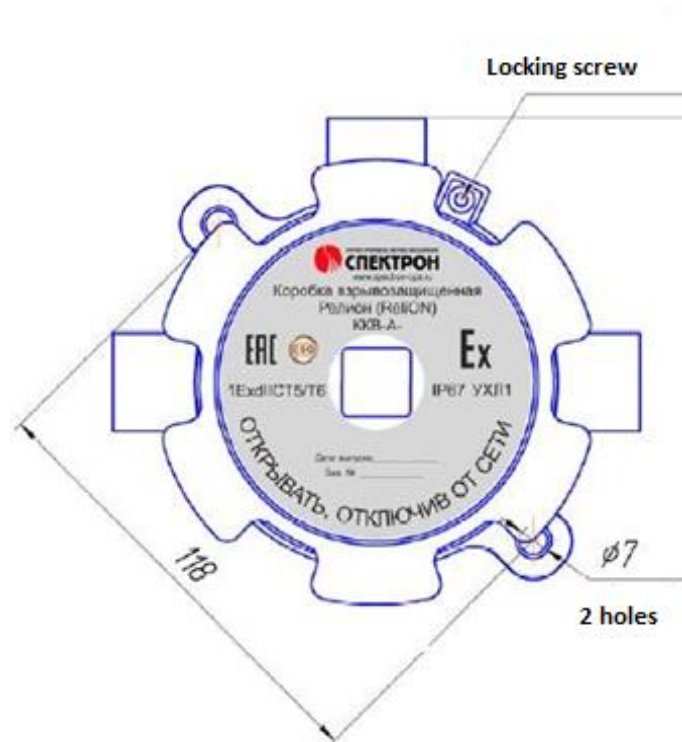
Explosion-proof product version of the inclinometer (1ExdIICT5/T6).

External view of explosion-proof product version of the inclinometer is shown in *Figure 2.3*.



*Figure 2.3* External view of explosion-proof product version of the inclinometer

Mounting dimensions of the inclinometer (explosion-proof version) are specified in *Figure 2.4*.



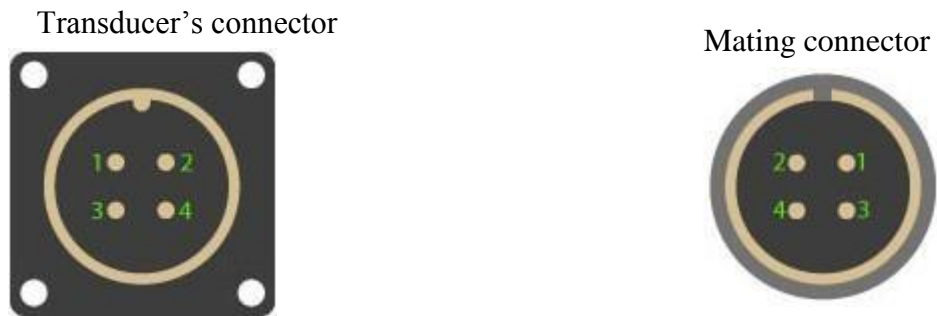
*Figure 2.4* Mounting dimensions of the inclinometer (explosion-proof version)



### 2.3 Digital inclinometers: contacts labelling

The inclinometers have two 4-contact connectors FQ14-4ZK-S used for connection to the measuring line.

*Figure 2.5* displays contacts labelling of connectors FQ14-4ZK-S. Both connectors of the digital inclinometer are fully identical and are used for connection of the inclinometer (depending on its product version) to the measuring line by means of RS-485 or CAN interface.



Contact number	Connection to the measuring network	
	ZET 7054	ZET 7154
1	9...24 V	
2	RS-485 line B or «DATA-»	CAN 2.0 line «H»
3	RS-485 line A or «DATA+»	CAN 2.0 line «L»
4	GND	

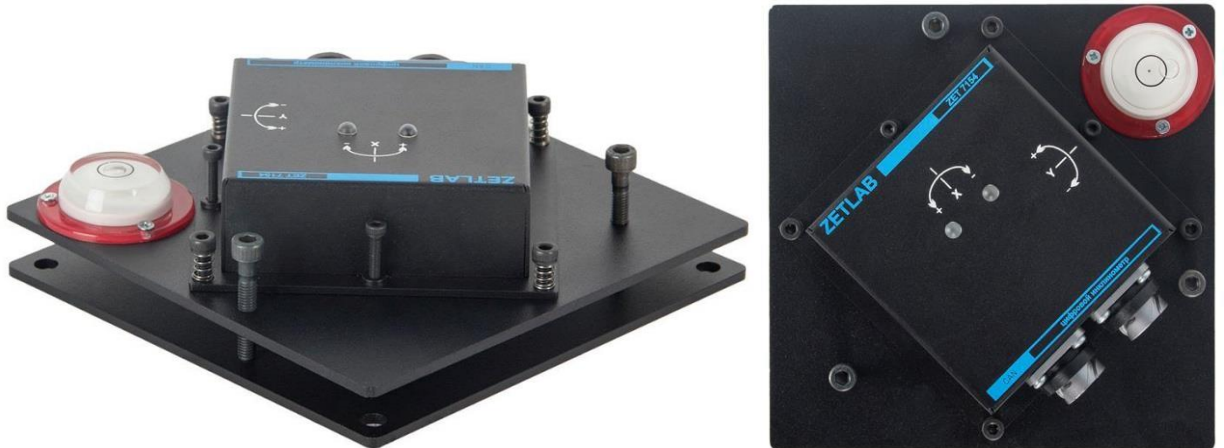
*Figure 2.5 Contacts labelling for connection to measuring network*

Connectors FQ14-4ZK-S are intended for connection of the digital inclinometer to the connecting cables of the measuring line. The connecting cable from the side of measuring line is connected to the connector via interface converter, while the other connector (if necessary) is connected to the connecting cable, thus allowing to increase the measuring line length up to the next inclinometer. Thus, there is formed a sequential structure of the inclinometers (connections of “wye” or “star” type are not allowed) with parallel connection to the electrical circuits of the measuring line.

## 2.4 Digital inclinometers: mounting

It is possible to mount the inclinometers directly to the controlled surface (the inclinometer package has 4 mounting holes with 4,5 mm diameter).

In order to provide the possibility of inclinometer adjustment by azimuth and horizon, one can use the adjustment plate for mounting of the inclinometer (*Figure 2.6*). The adjustment plate has four holes with 5.5 mm diameter for mounting on the controlled surface.



*Figure 2.6 Mounting of ZET7x54 with the use of adjustment plate*

The selected range of tilt angle measurements for measuring axes of the inclinometer is valid only in the case if the zero values of both measuring axes of the inclinometer correspond to its horizontal position.

*Note: during mounting of the inclinometer one should observe the directions of the measuring axes specified on the package of the device – it is necessary to secure correct alignment of the inclinometer by azimuth.*

## 2.5 Establishing measuring network: connection diagram

In the course of measuring network development, digital transducers ZET 7x54 are connected sequentially. The resulting measuring network of digital transducers is further connected to the PC by means of interface converter (*Table 3.1*).

*Figure 2.7* displays the measuring network based on digital transducers ZET 7154.



*Figure 2.7 Variants of establishing measuring lines with CAN interface*

It is necessary to install 120 Ohm terminal plug at the last digital transducer ZET 7x54. The terminal plug is mounted on free (vacant) plug FQ14-4ZK-S of the last digital transducer ZET 7x54 in the measuring line.

### 3 Parameters configuration: preparation

#### 3.1 Connection of digital inclinometers

Prior to using the digital transducers, it is necessary to connect them to the PC by means of the interface converters – see *Table 3.1*.

*Note: the interface converter should be configured in a particular mode, so that to provide their use with digital transducers (see the documents «Configuration of ZET7070: User manual», and «Configuration of ZET 7076: user manual»).*

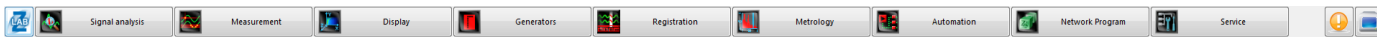
*Table 3.1 Connection of ZET 7x54 to interface converters*

Type of the digital transducer	Interface converter	PC port
ZET 7054	ZET7070	USB 2.0
	ZET7076	Ethernet
ZET 7154	ZET7174	USB 2.0
	ZET7176	Ethernet

The PC to be used for configuration of the digital transducers should have Windows OS and ZETLAB Software installed.

#### 3.2 The program “Device manager”

Configuration of digital transducers is conducted in the program “Device manager” available in the “Service” menu of ZETLAB control panel (Figure3.1).



*Figure 3.1 ZETLAB panel*

The left section of the program contains hierarchy tree of the devices connected to the PC. The top level of the hierarchy is represented by interface converters and by the devices connected to the PC directly. The second level of the hierarchy displays the digital transducers, that are connected to the particular interface converter.

When the detailed view mode is enabled, the right section of the interface will display a chart with basic parameters of the measuring channels.

To select the digital transducer to be configured, double-click its name. (Additional information is available in the document “ZETLAB Software. User manual”).

The program “Device manager” available in the “Service” menu of ZETLAB control panel is used for adjustment and configuration of the inclinometers.

## **4 Digital inclinometers: parameters configuration**

*Note! The Manufacturer reserves the right to change the version of digital transducer's software version. The sequence of software version updates up to the current version is described in the document «Software\_Service work with ZET7xxx.pdf».*

### **4.1 Configuration of interface part of the digital inclinometers**

Configuration of interface part should be performed in accordance with the instructions specified in the document «Configuration of interface part of the intellectual modules of ZET7xxx series».

Please note that it is necessary to set unique address for every device in the measuring network in the section «Address (node) from 2 up to 63» of the “Information” tab. In order to secure normal operation of the measuring network, it is necessary to make sure that all the devices of the measuring network have unique addresses. The addresses are set in the range from 3 up to 63.

*Note: digital transducers ZET 7x54 consist of two channels (channels names by default are as follows: «Axis X», «Axis Y»), corresponding to the two measuring axes. When assigning the addresses, please note that the channels of digital transducers ZET 7154 have two addresses in the measuring network, while the channels of digital transducers ZET 7054 are assigned a common address.*

## 4.2 Functions and composition of the tabs used for configuration of measuring part of the digital inclinometers

Digital transducer consists of two channels (by default, the names of the channels are: “Axis X” and “Axis Y”). It is possible to configure parameters of the digital transducer only in the tab of the channel “Axis X”. As the parameters of the channel “Axis X” are changed, the system automatically applies the corresponding changes to all other channels.

### 4.2.1 The tabs «Axis X» and «Axis Y»

Digital inclinometer ZET7x54 contains two mutually transverse channels X and Y. The tabs “Axis X” and “Axis Y” contain information of the channel parameters, that are further specified in

Table 4.1.

Table 4.1 Parameters of the tab “Axis X”

Parameter	Possibility of configuration	Admissible values	Description
Current value of the channel (in measurement unit)	–	Within the measurement range	Displays the measured value of the channel (at the moment of tab activation)
Refresh rate, Hz	–	–	Depends on the value selected for the parameter «Conversion frequency» of the «Sensor» tab
Measurement unit	–	–	Corresponds to the current measurement unit
Name of the channel for axis X (or Y)	Yes	Any sequence of symbols (max 32)	The parameter is set arbitrary. For the first channel it is recommended to use a name with the symbol “X” (and with the symbol “Y” for the second channel respectively)
Minimal value (in measurement unit)	–	–	The section contains the minimal possible value that can be measured by the digital inclinometer.
Maximal value (in measurement unit)	–	–	The section contains the maximal possible value that can be measured by the digital inclinometer.
Reference value for calculations, dB	–	–	Displays the reference value used for calculation of the measured values in dB
Sensitivity (in measurement unit)	–	–	Displays the sensitivity value (the parameter is not applicable for inclinometers of ZET 7x54 series)
Sensitivity threshold (in measurement units)	–	–	The parameter specifies measurements precision

Figure 4.1 shows an example of the tab «Axis X».

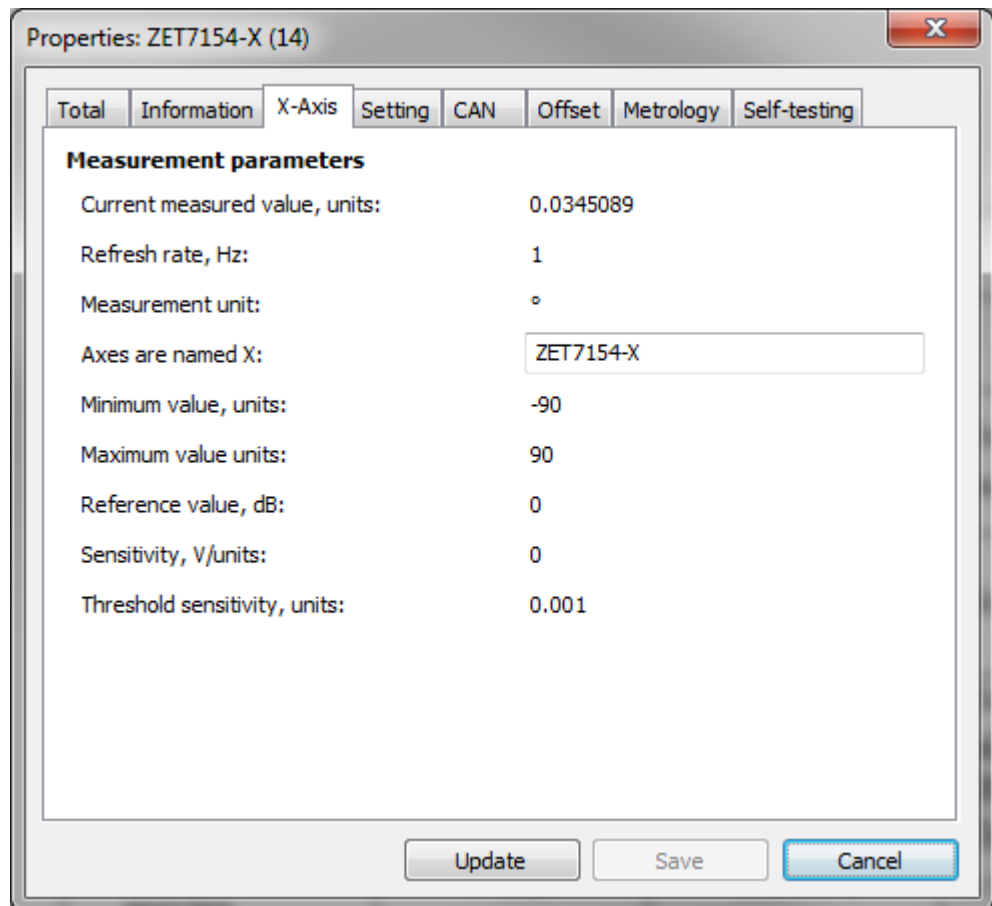


Figure 4.1 The tab «Axis X»

#### 4.2.2 “Settings” tab

The tab “Settings” contains information of the parameters specified in *Table 4.2*.

*Table 4.2 Parameters of the “Settings” tab*

<b>Parameter</b>	<b>Possibility of configuration</b>	<b>Admissible values</b>	<b>Description</b>
Data refresh rate, Hz	No	1	Frequency of data registration by the inclinometer
Exponential moving average order	No	256	Number of averaged counts
Exponential moving average	Yes	0.001...1	Ratio $\alpha$ for EMA filter, which is calculated by the formula: $DMA_t = \alpha * EMA_t + (1-\alpha) * DMA_{t-1}$ The more is the value of $\alpha$ , the higher is the averaging, and the slower is the response to parameters change. For slow processes it is recommended to set the value 0.005, for fast processes - 0.1
Offset by Axis X, °	No	-90...90	The current “zero” offset for axes. For more details, see the tab “Offset”.
Offset by Axis Y, °	No	-90...90	



Figure 4.2 shows an example of “Settings” tab.

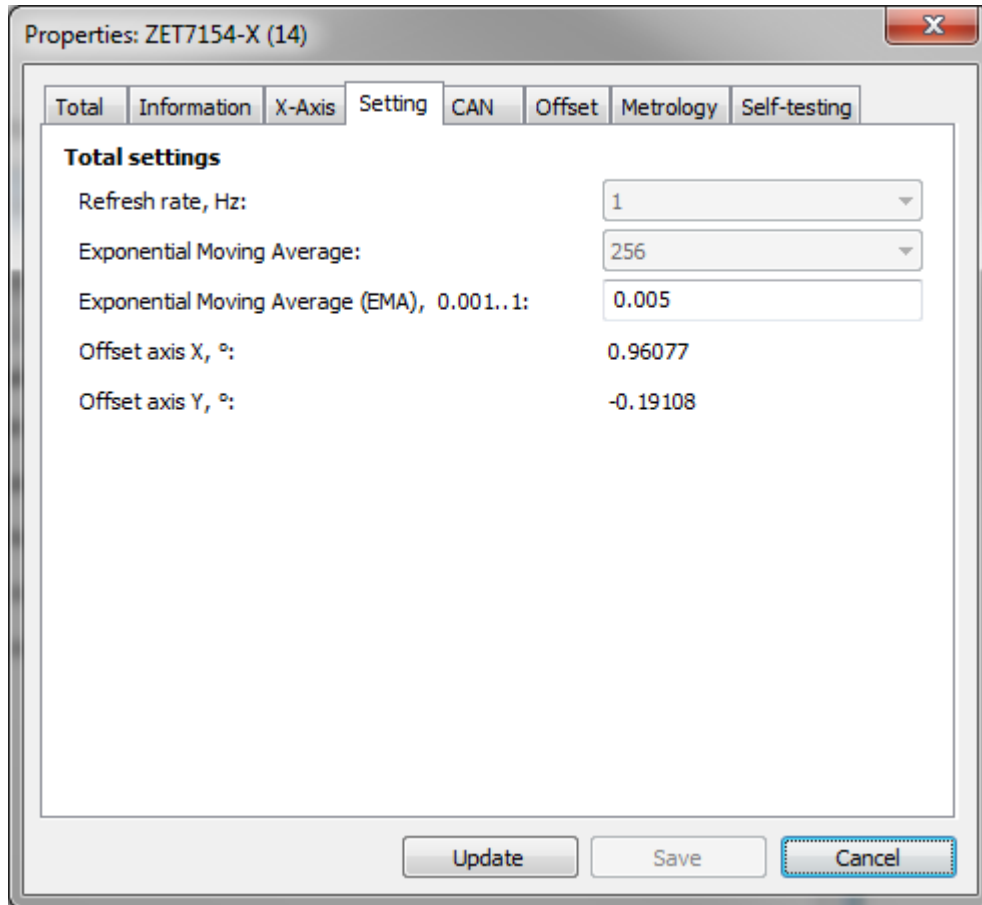


Figure 4.2 “Settings” tab

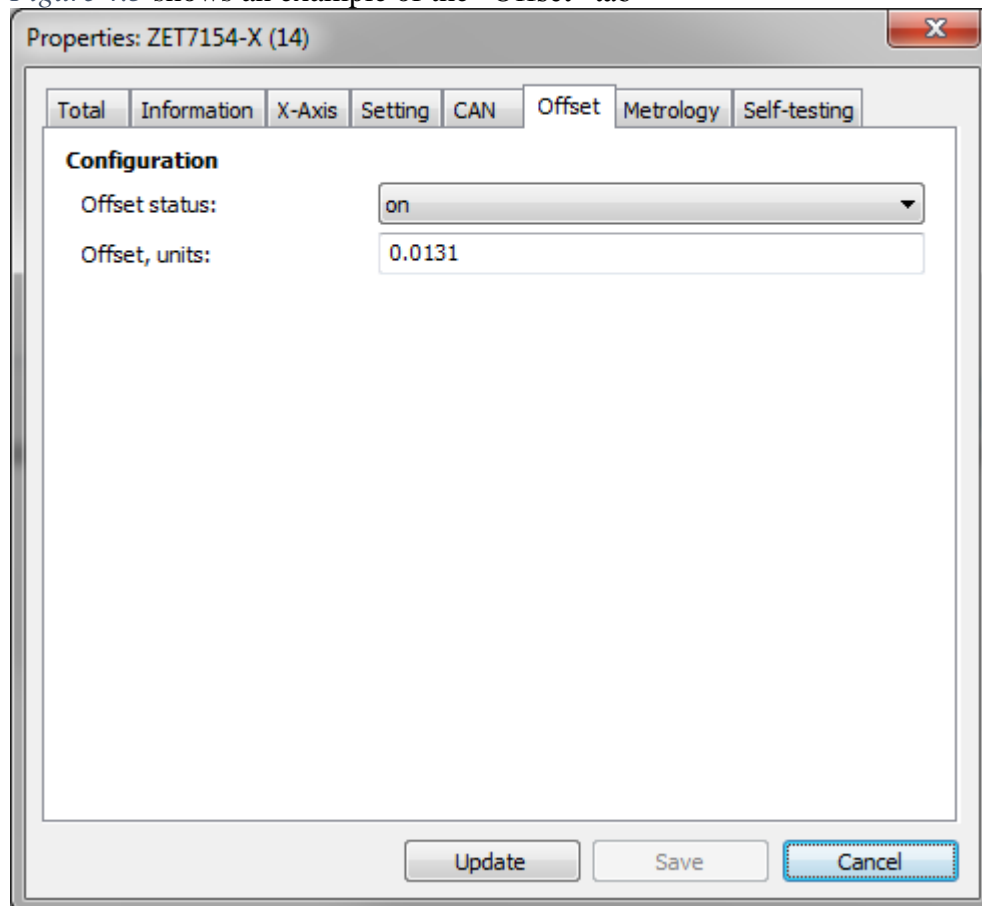
### 4.2.3 “Offset” tab

The ”Offset” tab contains information of the parameters specified in *Table 4.3*

*Table 4.3 Parameters of the “Offset” tab.*

Parameter	Possibility of configuration	Admissible values	Description
Offset status	Yes	off on	If the “Offset” option is disabled, the values by X and Y axes are set to zero. The offset value is displayed in the field “Displacement by axis” of the “Settings” tab. As the “Offset” function is disabled, the values remain unchanged.
Offset (in measurement units)	No	–	The value to be used for modulus in the case of offset option activation.

*Figure 4.3* shows an example of the “Offset” tab



*Figure 4.3 “Offset” tab*

Example №1: The digital inclinometer is mounted at the controlled element of a structure, which is located in position, in relation to which it is necessary to control the tilt angle. Select the option “Off” in the field “Offset”, save the settings, wait for stabilization of digital inclinometer readings (for ratio  $\alpha=0.005$  the stabilization time is approximately 15 minutes – you can visually control the stabilization process with the use of the program “multichannel oscilloscope” from the scope of ZETLab software). Then select the option “On” and save the settings again. The digital inclinometer will start recording the change of the tilt angle in relation to the set zero value.

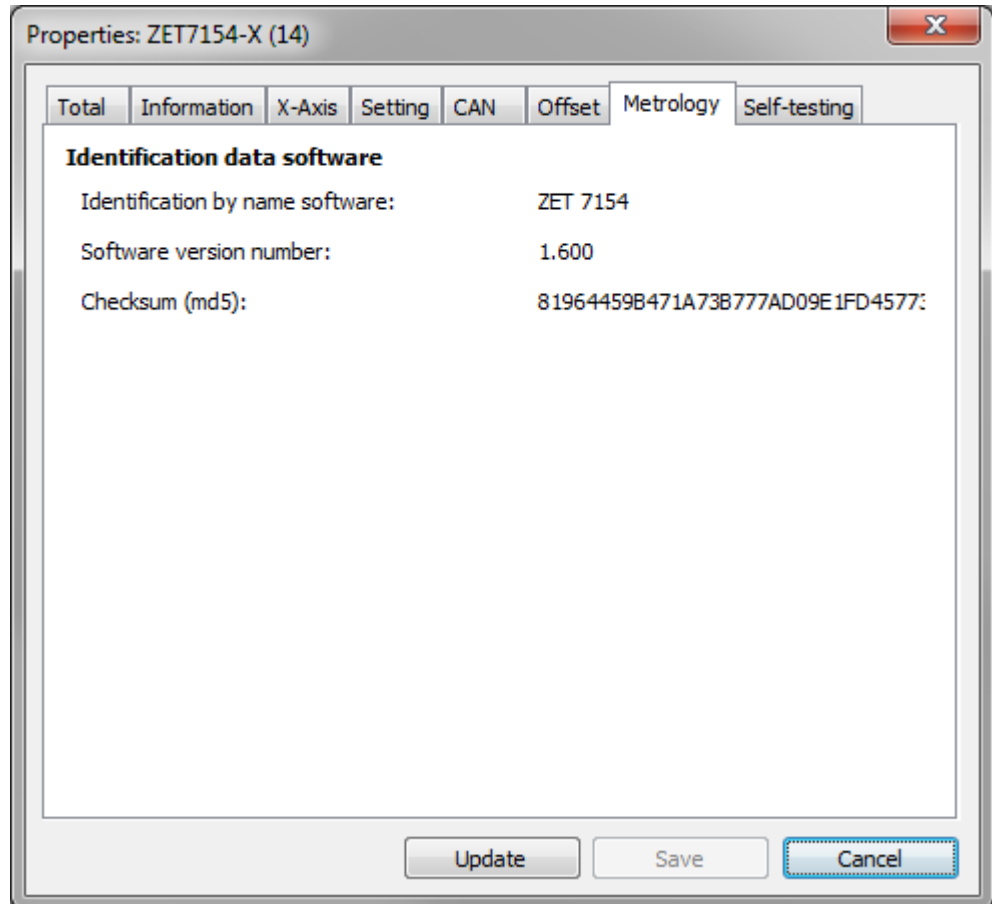
Example №2: In order to measure the absolute angle, set the digital inclinometer at even horizontal surface, configure the settings so that to take the offset into consideration (see Example #1), then place the inclinometer at the controlled surface and measure the angle.

## 5 Control of digital inclinometers

### 5.1 Checksum control

The “Metrology” tab contains digital ID of the software. The field “Digital ID” should have the value «81964459B471A73B777AD09E1FD45773».

*Figure 5.1* shows an example of “Metrology” tab.



*Figure 5.1* “Metrology” tab

## 5.2 Constant control

The inclinometers have the function of constant control of their operation. To view the results of the constant control function, start the exe-file of the program “Synchronization control” available at the directory: C:\ZETLab\SynchronizationControl.exe”. The results of the constant control function operation can be viewed not earlier, than after 5 minutes of program operation.

For inclinometers ZET 7154, it is possible to control the data quality and the synchronization quality, while inclinometers ZET 7054 have only the function of data quality control.

Figure 5.2 shows an example of the program “Synchronization control”.

Каналы	Время	Качество данных	Качество питания	Качество синхр.	Качество резерв
Мой компьютер					
zet7174 363					
ZET7154-X (33)	10.06.2016 08:51:05	Отлично	Не поддерж.	Отлично	3
ZET7154-Y (34)	10.06.2016 08:51:05	Отлично	Не поддерж.	Отлично	3
ZET7154-X (39)	10.06.2016 08:51:05	Отлично	Не поддерж.	Отлично	3
ZET7154-Y (40)	10.06.2016 08:51:05	Отлично	Не поддерж.	Отлично	3
ZET7154-X (42)	10.06.2016 08:51:06	Отлично	Не поддерж.	Отлично	3
ZET7154-Y (43)	10.06.2016 08:51:06	Отлично	Не поддерж.	Отлично	3
ZET7154-X (45)	10.06.2016 08:51:05	Отлично	Не поддерж.	Отлично	3
ZET7154-Y (46)	10.06.2016 08:51:05	Отлично	Не поддерж.	Отлично	3
ZET7120 (63)	10.06.2016 08:51:05	Не поддерж.	Не поддерж.	Отлично	3
zet7070 1685					
ZET7054-X (36)	10.06.2016 08:51:06	Отлично	Не поддерж.	Не поддерж.	3
ZET7054-Y (36)	10.06.2016 08:51:11	Отлично	Не поддерж.	Не поддерж.	3
ZET7054-X (43)	10.06.2016 08:51:11	Отлично	Не поддерж.	Не поддерж.	3
ZET7054-Y (43)	10.06.2016 08:51:05	Отлично	Не поддерж.	Не поддерж.	3

№	Время	Событие
141	10-06-2016 08:50:52.693	ZET7154-Y (34): качество синхронизации изменилось на "Отлично"
142	10-06-2016 08:50:52.842	ZET7154-Y (46): качество данных изменилось на "Отлично"
143	10-06-2016 08:50:52.846	ZET7154-Y (46): качество синхронизации изменилось на "Отлично"
144	10-06-2016 08:50:53.041	ZET7120 (63): качество синхронизации изменилось на "Отлично"

Figure 5.2 Example of the program “Synchronization control”

Interpretation of the “Data quality” parameter:

- Fine – values in the range from - 15° up to +15°;
- Good – values in the range from ± 15° up to ± 80°;
- Bad – values in the range from ± 80° up to ± 90°
- Not supported – this type of control is not supported.

Interpretation of the “synchronization quality” parameter:

- Fine – the tilt meter is synchronized with the interface converter;
- Good – synchronization process is active;
- Bad – no synchronization;
- Not supported – this type of control is not supported.

### 5.3 Metrological self-check

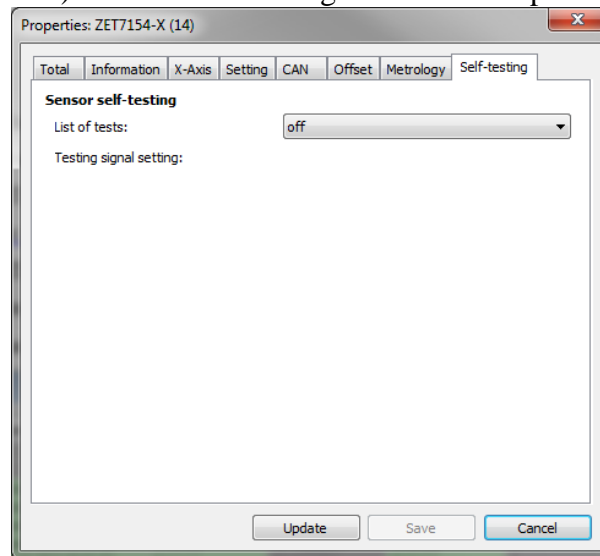
Inclinometers ZET 7154 have a function of metrological self-check.

A reference signal is applied to the sensing element of the inclinometer in order to imitate the change of tilt angle at a particular value.

The deviation of the measured value from the reference one is used to evaluate the metrological reliability of the inclinometer.

In the case of regular metrological self-check of the inclinometers (at least once per 12 month) it is possible to increase the calibration interval in 5 times.

The tab “Testing” (*Figure 5.3*) is used for metrological self-check performance.



*Figure 5.3 “Testing” tab*

Self-check procedure: sequence:

1. Mount the inclinometer at a horizontal surface.
2. Enter the measured value in the Tabs “Axis X” and “Axis Y” (initial readings).
3. Enter the tab “Testing”, select “Measurement” in the list of tests and save the measurement results.
4. Check the current measured value in the tabs “Axis X” and “Axis Y”. The new readings should more than the initial readings by 17-30 degrees – in this case, the metrological self-check shall be considered to be passed.
5. To disable the self-check mode, select the “off” option in the list of tests in the “Testing” tab, or switch-off the power supply of the inclinometer.