

DIGITAL STRAIN GAUGE

ZET 7010 DS, ZET 7110 DS

USER MANUAL

LLC "ETMS"

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1 Designation and technical specifications

1.1. Designation of digital transducers

ZET 7x10 DS is a digital deformation transducer (with an integrated strain gauge), which is intended for monitoring of concrete or steel structures and their tensile/ compression state. These transducers are used within the framework of structural health monitoring systems (also referred to as SHM). Besides, these sensors are also used for evaluation of the stress-strain state and allow to produce alarm notification in the case if non-reversible deformation state is reached. These sensors can be implemented both in stationary and portable structural health monitoring systems.

Digital deformation transducers can be easily installed at the controlled facility (the sensors have integrated strain gauges with bridge connection, thus, there is no need to connect any external primary transducers). Strain gauges of ZET 7x10 DS series are placed into industrial packages with dust- and moist protection, and high shock resistance.

1.2. Operational environment

Digital transducers of ZET 7x10 DS series are manufactured in industrial version and can be used in adverse operational environments. This allows to use them in adverse conditions of operational environment with high mechanical and vibrational load. Digital transducers of ZET 7x10 DS series can also be used in explosion-hazard environments and have the marking *0ExiaIICT6X* on their package.



It is allowed to use the digital transducers in explosion-hazard operational environments in accordance with explosion-proof marking 0ExiaIICT6 X.

Operational environment conditions of the digital transducers are specified in Table 1.1.

Table 1.1 ZET 7x10 DS: operational environment conditions

| Parameter | Value |
|-----------------------------|-------------------------------|
| Ambient air temperature, °C | -40...100 |
| Relative air humidity, % | Not more than 98 ¹ |
| Atmospheric pressure, mmHg | 495-800 |

¹ at the ambient air temperature of 35 °C.

1.3. Technical specifications

Basic technical specifications of the digital transducers are specified in Table 1.2.

Table 1.2 ZET 7x10 DS: Technical specifications

| Parameter | | Value | |
|---|--------------|--|-------------|
| | | ZET 7010 DS | ZET 7110 DS |
| Measured parameter | | Deformation Strain | |
| Type of the integrated primary transducer | | Strain-gauge bridge | |
| Measurement range, $\mu\text{m/m}$ | | -1800...1800 | |
| Measurement range (without the use of mounting plates), $\mu\text{m/m}$ | | -300...300 | |
| Measurement range (with the use of mounting plates), $\mu\text{m/m}$ | | -450...450 -600...600 -1800...1800 | |
| Sensitivity thresholds (depending on the particular range), $\mu\text{m/m}$ | -300...300 | 2 | |
| | -450...450 | 3 | |
| | -600...600 | 4 | |
| | -1800...1800 | 12 | |
| Failure strain (without the use of mounting plates), $\mu\text{m/m}$ | | 500 | |
| Restoring force, N | | 1000 | |
| Temperature influence on sensitivity, by 10°C (from measuring range), % | | 2 | |
| Zero drift for 24 hrs, % | | 0,5 | |
| Data rate, Hz | | 1 | |
| Data interface | | RS-485 | CAN 2.0 |
| Voltage range, V | | 9...24 | |
| Consumed power, W | | 0,5 | |
| Dimensions, mm | | 197x56x30 | |
| Weight, gr | | 300 | |
| Protection class | | IP67 | |

2 External view, contacts labelling, connection diagram

2.1. Digital transducers: external view

Figure 2.1 shows external view of digital transducer ZET 7x10 DS.



Figure 2.1 External view of digital transducer ZET 7x10 DS

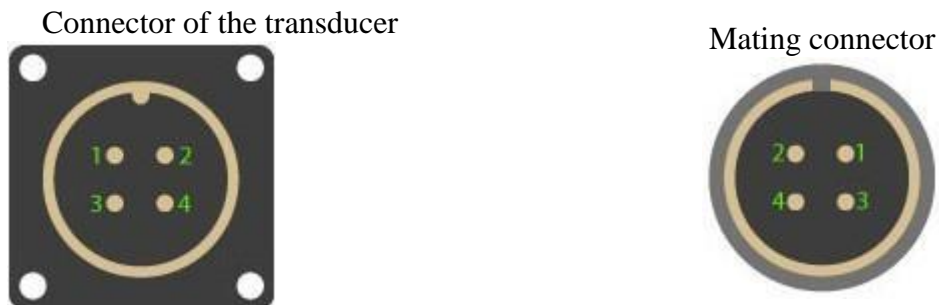


It is allowed to use the digital transducers in explosion-hazard operational environments in accordance with explosion-proof marking 0ExiaIICT6 X.

2.2. Digital transducers: contacts labelling

Digital transducers of ZET 7x10 DS series have 2 4-contact connectors FQ14-4ZK-S for connection to the measuring network.

Figure 2.2 shows contacts labelling of the connector FQ14-4ZK-S, which are used for connection of the digital transducers to measuring network.



| Contact number | Connection to measuring network | |
|----------------|---------------------------------|------------------|
| | ZET 7010 DS | ZET 7110 DS |
| 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 2.2 Contacts labelling for connection to the measuring network

2.3. Connection diagram for establishing measuring network

In the course of the measuring network deployment, digital transducers ZET 7x10 DS are connected to each other with serial connection. The resulting measuring chain is connected to the PC by means of interface converter (see Table 4.1). Figure 2.3 shows measurement network based on the use of measurement transducers ZET 7010 DS.

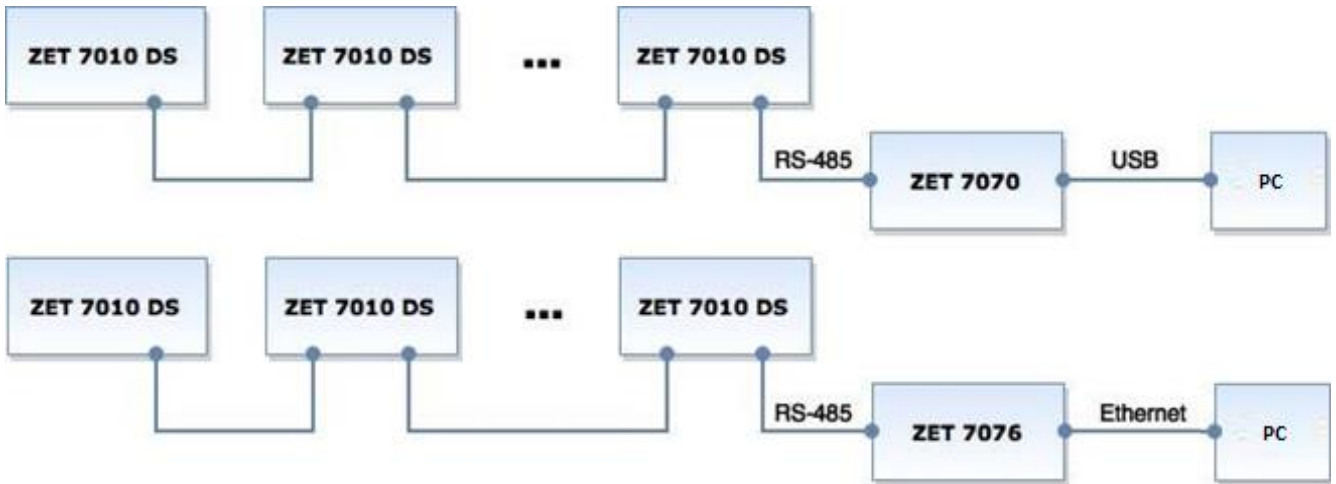


Figure 2.3 Connection diagram

At the last digital transducer ZET 7x10 DS (i.e., at the end of the measuring network) it is necessary to install a terminal plug 120 Ohm. The plug is mounted at free (vacant) connector FQ14-4ZK-S of the last digital transducer ZET 7x10 DS.

3 Digital transducers: mounting options

In order to measure deformation of the controlled object, it is necessary to mount digital transducer ZET 7x10 DS in such a way, so that the mounting axis of the transducer would be aligned with the deformation direction. The digital transducer is mounted on the controlled structure at two points: $\varnothing 6,2$ mm hole and a groove with the length of 6.2 mm. Thus, the baseline distance for mounting of digital transducer ZET 7x10 DS is 180 ± 5 mm (see Figure 3.1).

For mounting of the digital transducers on a concrete surface, you can use tie bolts or anchor bolts with M6 inner thread. Weld studs or M6 bolts (to be used with mounting holes) are used when it is necessary to mount the transducers on a steel surface. It is necessary to provide secure fixation in the course of digital transducers ZET 7x10 DS mounting, thus, it is recommended to use external toothed lock washer DIN 6798 “M6”.

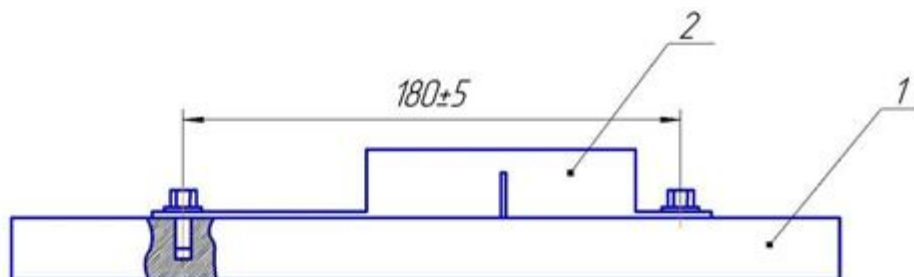


Figure 3.1 Deformation direction and baseline distance

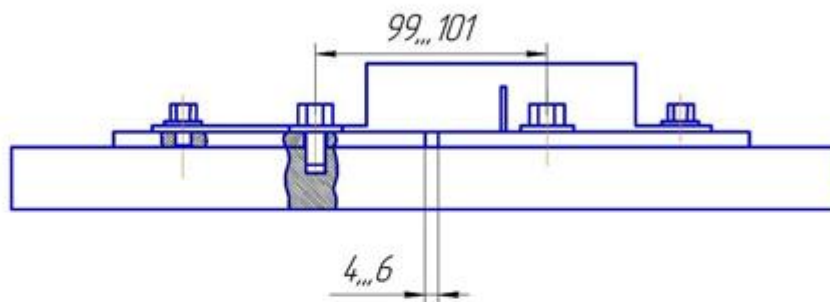
Relative deformation measurement range depends on the particular mounting option of digital transducer ZET 7x10 DS:

- mounting without the use of mounting plates, Figure 3.2 (option A) – compression: up to $-300 \mu\text{m/m}$, tension: up to $300 \mu\text{m/m}$ (force transmission ratio to sensing element $N=9$);
- mounting with the use of mounting plates, Figure 3.2 (option B) – compression up to $-450 \mu\text{m/m}$, tension up to $450 \mu\text{m/m}$ (force transmission ratio to sensing element $N=6$);
- mounting with the use of mounting plates, Figure 3.2 (option C) – compression up to $-600 \mu\text{m/m}$, tension up to $600 \mu\text{m/m}$ (force transmission ratio to sensing element $N=4$);
- mounting with the use of mounting plates, Figure 3.2 (option D) – compression up to $-1800 \mu\text{m/m}$, tension up to $1800 \mu\text{m/m}$ (force transmission ratio to sensing element $N=1.5$);

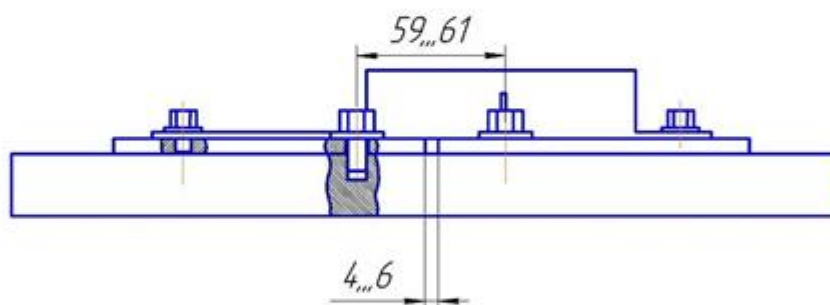
Option A



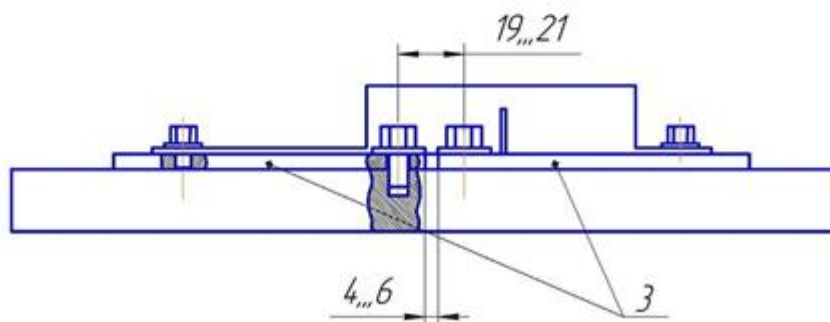
Option B



Option C



Option D



- 1 - Controlled element of the structure
- 2 - Digital transducer ZET 7010 DS
- 3 - Mounting plates

Figure 3.2 Digital transducers: mounting options

4 Configuration: preparation

4.1. Connecting the digital transducers

Before using the digital transducers, it is necessary to connect them to PC by means of interface converter – see Table 4.1.

Note: in order to provide operation with the corresponding modules, it is necessary to configure parameters of the interface converters (see the Manual «ZET7070: configuration», «ZET7076: configuration»).

Table 4.1 Connection of ZET 7x10 DS to interface converters

| Type of digital transducer | Interface converter | PC port |
|----------------------------|---------------------|----------|
| ZET 7010 DS | ZET7070 | USB 2.0 |
| | ZET7076 | Ethernet |
| ZET 7110 DS | ZET7174 | USB 2.0 |
| | ZET7176 | Ethernet |

The PC to be used for digital transducers configuration should have Windows OS and ZETLAB software.

4.2. “Device manager” program

Configuration of digital transducers parameters is conducted in the program “Device manager” available in the tab “Service” of ZETLAB control panel (Figure 4.1).

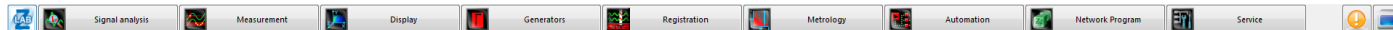


Figure 4.1 ZETLAB control panel

The left section of the program interface contains a hierarchy tree of the devices connected to the PC. The top level of the hierarchy tree contains interface converters and the devices, which are directly connected to the PC. The second hierarchy level displays digital transducers connected to the selected interface converter.

In the detailed view mode, the right section of the program window displays a chart with basic parameter of the measuring channels.

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

5 Configuration of digital transducers

Attention! The Manufacturer reserves the right to change the software version of the digital transducer.

5.1. Configuration of interface part of the digital transducers

Configuration of interface part of the transducers is performed in accordance with the algorithm described in the document “Configuring interface part of digital transducers of ZET 7xxx series”.

Please note that it is necessary to set the unique address of each digital transducer of the measurement network in the field “Address (node) form 2 to 63” of the “Information” tab. In order to secure normal operation of the measurement network, make sure that all the devices within the scope of measurement system have different addresses. The addresses of the instruments should be set in the range from 3 up to 63.

5.2. Functions and description of the tabs used for configuration of measurement part of the digital transducers

5.2.1. “Measurement” tab

The “Measurement” tab contains information about the parameters specified in the Table 5.1.

Table 5.1 Parameters of the “Measurements” tab

| Parameters | Possibility of configuration | Acceptable values | Description |
|---|------------------------------|-----------------------------------|--|
| Current measured value of the transducer (in measurement units) | – | Within the measurement range | As the tab is opened, the parameter displays the current measured value of the channel. |
| Refresh rate, Hz | – | – | Corresponds to the current sampling frequency. |
| Measurement unit | – | – | Corresponds to the current measurement unit set in the parameter “Measurement unit” of the “Settings” tab. |
| Name of the transducer | – | Any sequence of symbols (max. 32) | The parameter is randomly set. |
| Minimal value (in measurement units) | – | – | The section displays the minimal value, that can be measured by the digital transducer. |
| Maximal value (in measurement units) | – | – | The section displays the maximal value, that can be measured by the digital transducer. |
| Reference value for calculations, dB | – | – | The parameter displays the reference value necessary for calculation of the measured value in dB (this parameter is not applicable for digital transducers ZET 7x10 DS). |
| Sensitivity (in measurement units) | – | – | The parameter displays sensitivity value. |
| Sensitivity threshold (in measurement units) | – | – | The parameter identifies measurements precision. |

Figure 5.1 shows an example of “Measurements” tab.

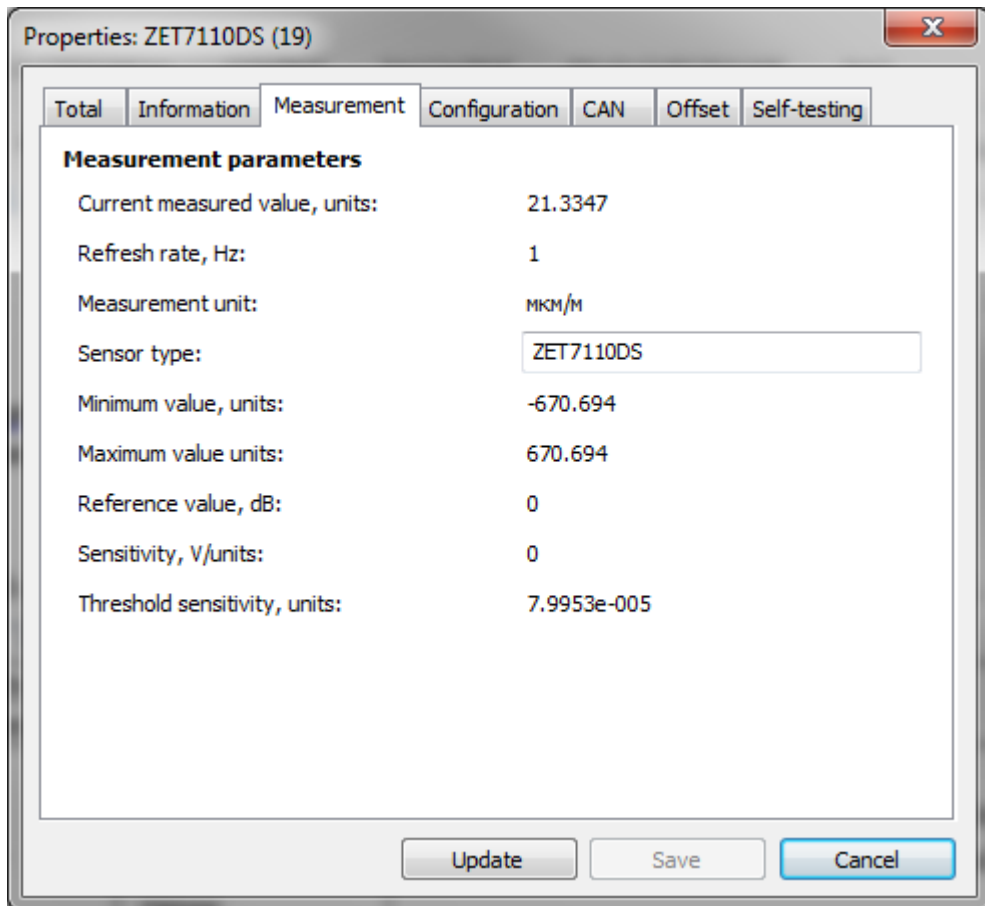


Figure 5.1 “Measurements” tab

5.2.2. “Settings” tab

The “Settings” tab contains information about the parameters specified in Table 5.2.

Table 5.2 Parameters of the “Settings” tab

| Parameters | Possibility of configuration | Acceptable values | Description |
|----------------------|------------------------------|---|---|
| Refresh rate, Hz | – | 1 | Sampling frequency (for digital transducers ZET7010 DS). |
| | Yes | 1 5 25 125 | Sampling frequency (for digital transducers ZET7110 DS). |
| Measurement | Yes | Deformation Strain | The parameter “Deformation” is selected when it is necessary to measure relative deformation. The parameter “Strain” is selected when it is necessary to measure strain and the Young’s modulus for the controlled material is available. |
| Measurement unit | Yes | µm/m mm/m cm/m m/m % Pa kPa MPa | The measurement units identify the physical values to be used for measurements performance. The measurement units µm/m, m/m, cm/m, m/m, % are used for the “Deformation” parameter. The measurement units Pa, kPa, MPa are used for the “Strain” parameter. |
| Young’s modulus, GPa | Yes | – | Young’s modulus (elasticity modulus) – is a physical value, which characterizes the resistance of the material to strain impact. This parameter is set only in the case if the “Strain” parameter is selected. |
| Mounting option | Yes | A (±300 µm/m) B (±450 µm/m) C (±600 µm/m) D (±1800 µm/m) | The measurements range depends on the particular mounting option of the digital transducer. Figure 3.2 shows mounting options of digital transducer ZET 7x10 DS. |

Figure 5.2 shows an example of “Settings” tab.

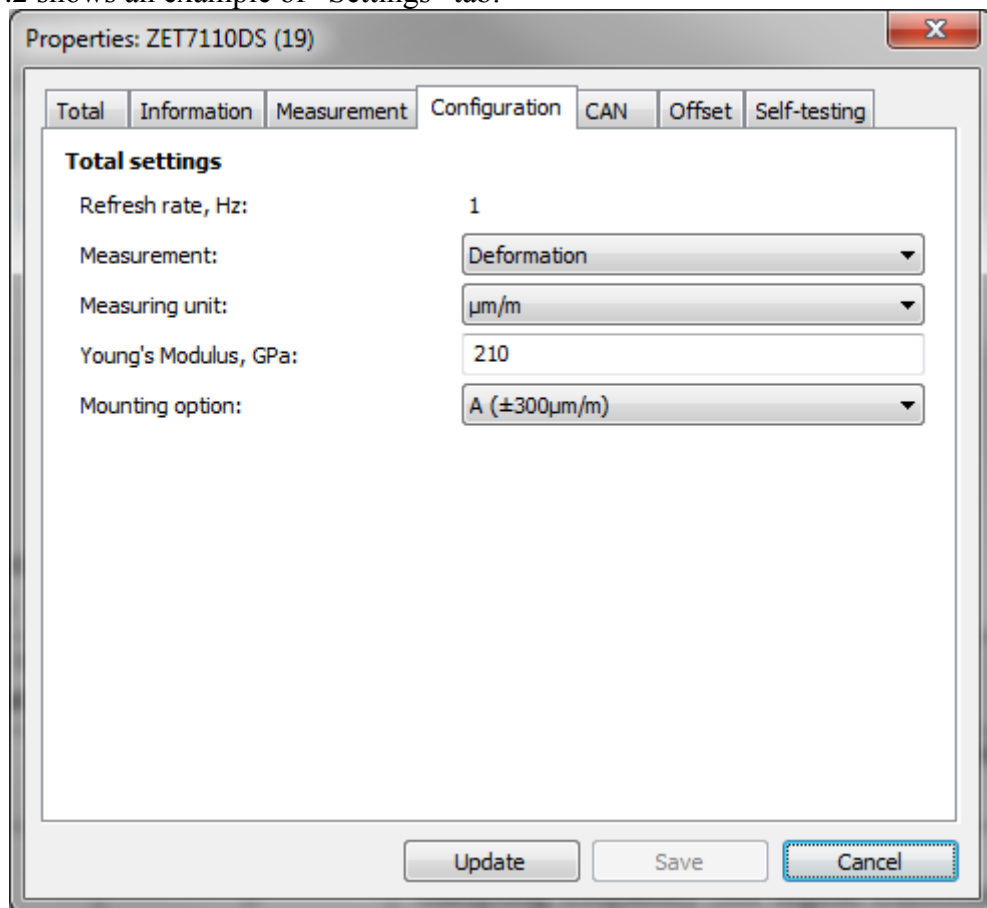


Figure 5.2 “Settings” tab

5.2.3. “Offset” tab

The “Offset” tab contains information about the parameters specified in Table.

Table 5.3 Parameters of the “Offset” tab

| Parameters | Possibility of configuration | Acceptable values | Description |
|-----------------------------|------------------------------|-------------------|---|
| Offset status | Yes | off on | Allows to enable /disable recalculation of the measured value in relation to the value specified in the parameter “Offset, units” |
| Offset in measurement units | Yes | – | The parameter specifies the value to be used as a current reading of the digital transducer. Further changes of the readings will be calculated in relation to the specified value. |

Figure 5.3 shows an example of “Offset” tab.

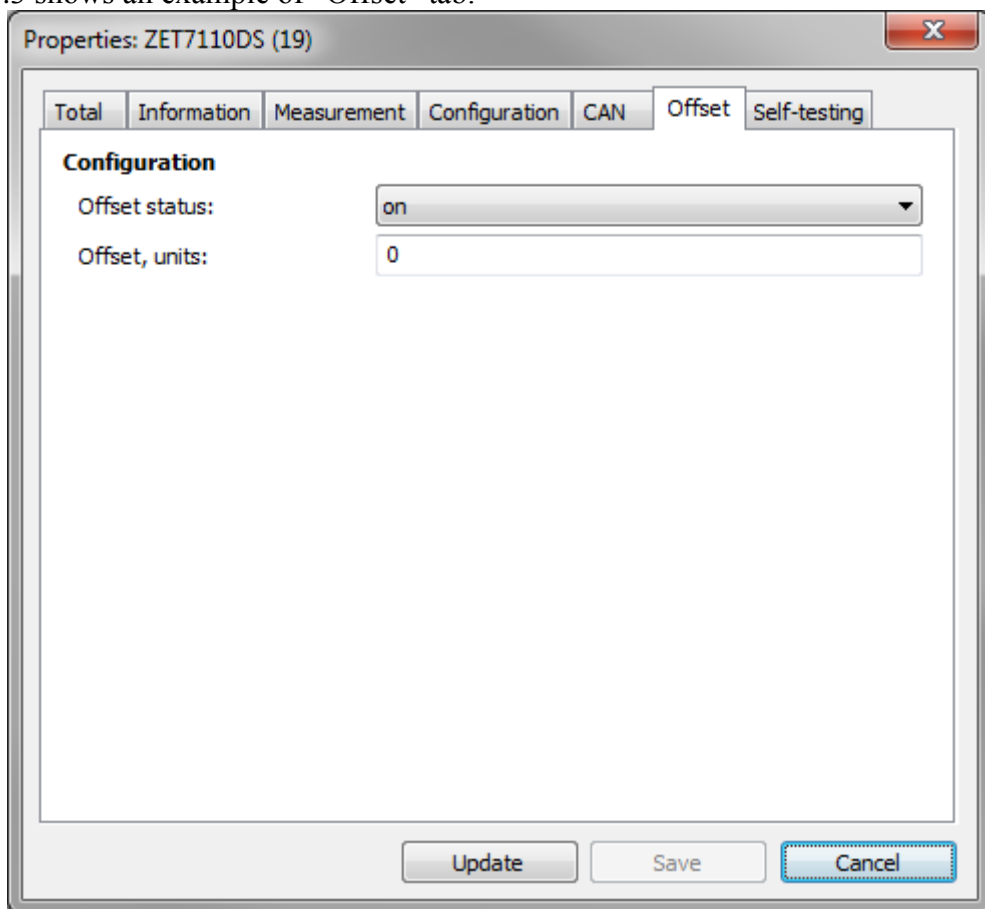


Figure 5.3 “Offset” tab

Note! It is possible to set a new value in the section “Offset” only as the previously assigned value is reset. To do that, select “Off” option in the parameter “Offset status”.

Below you can see several examples of the “Offset” function use for operation of the digital transducers:

Example №1:

It is known, that a structural element has been exposed to the load of 500 MPa prior to mounting of the digital transducer. In order to take into consideration the pre-stressed state of the structural element, set the value “500” in the field “Offset, units”, select the option “On” for the parameter “Offset status”, and click the key “Save”. The digital transducer will start measuring the strain of the controlled object in relation to the pre-stress state of 500 MPa.

Example №2:

Upon completion of digital transducers mounting, the controlled element of the structure is located in the position, in relation to which the deformation value should be measured. Set the value “0” in the section “Offset, units”, select the option “On” for the parameter “Offset status”, and click the key “Save”. The digital transducer will start measuring the deformation of the controlled structural element in relation to the set zero value.

5.3. Configuration of digital transducers of ZET 7x10 DS series

Digital transducer ZET 7x10 DS has an integrated strain gauge with bridge connection.

Configuration of digital transducer ZET 7x10 DS parameters is described below:

- To measure the relative deformation, set the following parameters in the “Settings” tab:
 - *Physical value* – “Deformation”;
 - *Measurement unit* – set the required measurement units (« $\mu\text{m}/\text{m}$ », « mm/m », « cm/m », « m/m », «%»);
 - *Young’s modulus, GPa* – the assigned value is of no relevance. This coefficient is not used by the digital transducer for any calculations in the course of deformation level measurements;
 - *Mounting options* – select the mounting option of the digital transducer ZET 7x10 DS («A ($\pm 300 \mu\text{m}/\text{m}$)», «B ($\pm 450 \mu\text{m}/\text{m}$)», «C ($\pm 600 \mu\text{m}/\text{m}$)», «D ($\pm 1800 \mu\text{m}/\text{m}$)»). See Figure 3.2.

- To measure strain of the material, set the following parameters in the “Settings” tab:
 - *Physical value*– «Strain»;
 - *Measurement unit*– set the required measurement unit («Pa», «kPa», «MPa»).
 - *Young’s modulus GPa* – set the elasticity module of the controlled structural element (the elasticity modulus values for some of the materials are available in Table 5.4);
 - *Mounting options* – select the mounting option of the digital transducer ZET 7x10 DS («A ($\pm 300 \mu\text{m}/\text{m}$)», «B ($\pm 450 \mu\text{m}/\text{m}$)», «C ($\pm 600 \mu\text{m}/\text{m}$)», «D ($\pm 1800 \mu\text{m}/\text{m}$)»). Mounting options of digital transducer ZET 7x10 DS are shown in Figure 3.2.

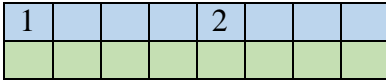
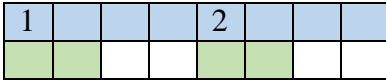
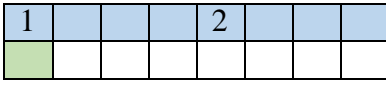
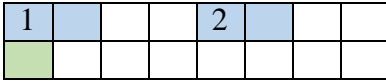
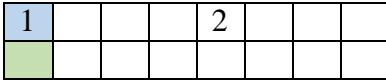
Table 5.4 Elasticity modulus value

| Material | Elasticity modulus value E (GPa) |
|----------|----------------------------------|
| Al | 69 |
| Cu | 100 |
| Steel | 210 |
| Glass | 60 |
| Concrete | 20 |

6 LED indication operation modes

Table 6.1 displays information about operation modes of LED indication integrated into the top part of digital transducer's package. Depending on combination of blue and green LEDs indication, it is possible to control operation of the device and to perform diagnostics.

Table 6.1 LED indication status

| Indication state | Indication during 2 seconds | Description of LED indication type |
|--|--|---|
| Selection of a device or data saving |  | Blue – constant indication Green – constant indication |
| Error (communication failure or fault of the transducer) |  | Blue – constant indication Green - indication 500 ms per 1 second |
| Settings by default (address 2) |  | Blue – constant indication Green – indication 100 ms per 2 seconds |
| Concealed protocol (only for RS- 485) |  | Blue – indication 500 ms per 1 second Green – indication 100 ms per 2 seconds |
| Normal mode of operation |  | Blue – indication 100 ms per 2 seconds Green – indication 100 ms per 2 seconds |