

TMS-E5-01
(rus. TMC-Э5-01)

OPERATION MANUAL
CVIA.468156.117-01 RE
(rus. ЦВИЯ.468156.117-01 РЭ)

Total pages: 36



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This operation manual gives information on operation of the TMS-E5001 CVIA.468156.117-01 (rus. TMC-Э5-01 ЦВИЯ.468156.117-01) downhole monitoring system surface acquisition unit (hereinafter referred to as TMSE5 Surface Acquisition Unit) to ensure its correct and safe use by the user.

Only technical personnel of at least IV electrical safety qualification level for working with high voltages above 1,000 V who has read this operation manual may operate the TMS-E5 Surface Acquisition Unit.

The list of the documents referred in this operation manual is given in the chapter “Reference Regulatory Documents” herein.

ATTENTION: THERE IS LIFE THREATENING VOLTAGE UP TO 400V IN TMS-E5.

WHEN TMS-E5 IS CONNECTED TO THE POWER NETWORK, DANGEROUS VOLTAGE APPEARS AT PINS OF THE “TELEMETRY” (RUS. «ТЕЛЕМЕТРИЯ») CONNECTORS OF BST-M-01 AND AT PINS OF CONNECTORS OF THE PROTECTION BOARD;

IN CASE OF FAILURE OF THE STEP-UP TRANSFORMER, DANGEROUS VOLTAGE OVER 1,000V MAY APPEAR AT PINS OF THE “TELEMETRY” (RUS. «ТЕЛЕМЕТРИЯ») CONNECTORS OF BST-M-01 AND AT PINS OF CONNECTORS OF THE PROTECTION BOARD.

IF TMS-E5 IS CONNECTED TO THE POWER NETWORK, IT IS PROHIBITED TO REMOVE COVERS FORM BST-M-01 OR PROTECTION BOARD AND TO TOUCH THEIR ELEMENTS AND CONNECTORS CONTACTS.

1 Product Description and Operation

1.1 Product designation

1.1.1 The TMS-E5-01 CVIA. 468156.117-01 (rus. ТМС-Э5-01 ЦВИЯ. 468156.117-01) Surface Acquisition Unit is designed to:

- monitor insulation resistance of the “Step-up Transformer (SUT) - Cable – Submersible Electric Motor (SEM)” system relative to the ground;
- receive and process telemetry information from the BP-103 CVIA.468154.002 (rus. БП-103 ЦВИЯ.468154.002) downhole sensor or its modifications (hereinafter referred to as Downhole Sensor);
- transfer the telemetry information and real-time values of insulation resistance to the control station controller or computer (and then to the external device) via the RS232 or RS485 interface using the MODBUS RTU protocol.

1.1.2 The TMS-E5 Surface Acquisition Unit is manufactured in the climatic category for moderate and frigid climate (rus. УХЛ), placement category 2.1 according to GOST 15150 (rus. ГОСТ 15150) and is designed for operation under the following climatic conditions:

- ambient temperature: from -60°C to +70°C;
- relative air humidity: up to 98% at the temperature of +25°C;
- air pressure: 84-106.7 kPa.

1.2 Specifications

1.2.1 Main parameters of the TMS-E5 Surface Acquisition Unit are given in Table 1.1.

Table 1.1.

| Parameter | Parameter value |
|---|-----------------|
| Supply voltage, V | 170 – 285 |
| Frequency of supply voltage, Hz | 50±1 |
| Power consumption, W, up to | 40 |
| Range of insulation resistance monitoring, kOhm | 10 – 9,999 |
| Relative error of insulation resistance monitoring in the range of 10-350 kOhm, %, up to | ±2 |
| Relative error of insulation resistance monitoring in the range of 0.35-10 MOhm, %, up to | ±5 |
| Insulation resistance between the connectors “220V, 50Hz” (rus. «220В, 50Гц»), “TELEMETRY” (rus. «ТЕЛЕМЕТРИЯ»), “RS232”, and “RS485”, MOhm, not less than | 40 |
| Operation mode | continuous |

1.2.2 Maximum allowable linear operating voltage on secondary windings of SUT is 3,500 V. **If linear voltage of SUT is over 3,500 V, it is prohibited to operate the TMS-E5-01 Surface Acquisition Unit connected to the SUT Zero Point wire at reduction of insulation in the “SUT Zero Point - cable - SEM” system to a level less than 30 kOhm.**

1.3 Product components

1.3.1.1 The TMS-E5-01 CVIA.468156.117-01 (rus. TMC-Э5-01 ЦВИЯ. 468156.117-01) Surface Acquisition Unit consists of a protection board and a BST-M-01 (rus. БСТ-М-01) telemetry interface unit installed on a CVIA.741424.272-02 (rus. ЦВИЯ.741424.272-02) panel.

1.3.2 Overall and installation dimensions of the TMS-E5-01 Surface Acquisition Unit are given in Figure A.1 of Appendix A.

1.4 Description and operation

1.4.1 The following elements are located on the TMS-E5-01 Surface Acquisition Unit panel:

- “220V, 50 Hz” (rus. «220В, 50Гц») terminal block for connection to the power network;
- safety ground terminal indicated by “ \perp ”;
- “RS232” electric connector for connection to an external device; designation of the connector pins is detailed in Table 1.2;
- “RS485” electric connector for connecting to an external device, designation of the connector pins is detailed in Table 1.3;
- switches 1-5 to select the exchange protocol with the control station, switch 6 is not used. The switch positions are detailed in Table 1.4;
- “POWER” light indicator for visual checking of switch on;
- “TM” light indicator for visual checking of receipt of information frames from the Downhole Sensor and for monitoring insulation resistance measured in the “SUT - Cable - SEM” system;
- “TX” light indicator for visual checking of data transfer via the RS232 and RS 485 interfaces;
- “RX” light indicator for visual checking of data receipt via the RS232 and RS 485 interfaces.

Table 1.2.

| Contact No. | Mark | Note |
|-------------|------|------------------|
| 2 | RxD | Received data |
| 3 | TxD | Transferred data |
| 5 | SG | Grounding |

Table 1.3.

| Contact No. | Mark | Note |
|-------------|---------|--------------------------------------|
| 1 | DATA- | B |
| 2 | DATA+ | A |
| 5 | GND_485 | Grounding |
| 8 | 232/485 | Contacts 8 and 9 shall be connected. |
| 9 | GND_INT | |

Table 1.4.

| Switch position | | | | | | Protocol | Note |
|-----------------|---|---|---|---|---|-------------------------------|---|
| 1 | 2 | 3 | 4 | 5 | 6 | | |
| 0 | 0 | 0 | 0 | 0 | 0 | Automatic protocol definition | Standard display of T _{wind} and T _{oil} |
| 1 | 1 | 0 | 0 | 0 | 0 | IRZ TMS-2 (rus. ИПЗ TMC-2) | |
| 1 | 0 | 1 | 0 | 0 | 0 | IRZ TMS-1 (rus. ИПЗ TMC-1) | |
| 1 | 0 | 0 | 1 | 0 | 0 | BORETS SPT (rus. БОРЕЦ СПТ) | |
| 1 | 0 | 0 | 0 | 1 | 0 | ELEKTON (rus. ЭЛЕКТОН) | |

Notes

1. "1" = the switch is on, "0" = the switch is off;
2. After configuring the switch, reset TMS-E5 power.

1.4.2 In 20-25 seconds after switching on, the TMS-E5 Surface Acquisition Unit supplies power to the Downhole Sensor and receives an information frame with real-time values of parameters monitored by the Downhole Sensor, then it measures insulation resistance of the "SUT - Cable - SEM" system. The TMS-E5 Surface Acquisition Unit interacts with the external device via the RS232 or RS485 interface using the MODBUS RTU protocol.

1.4.3 Operation of the TMS-E5 Surface Acquisition Unit using the IRZ TMS-2 (rus. ИПЗ TMC-2) protocol

1.4.3.1 To switch to the IRZ TMS-2 (rus. ИПЗ TMC-2) protocol operation mode, set the switches to positions according to Table 1.4 for the IRZ TMS-2 (rus. ИПЗ TMC-2) protocol.

1.4.3.2 Switch off TMS-E5 Surface Acquisition Unit power supply and wait for at least 1 minute.

1.4.3.3 Supply power to the TMS-E5 Surface Acquisition Unit.

1.4.3.4 The TMS-E5 Surface Acquisition Unit is ready to operate with the IRZ TMS-2 (rus. ИПЗ TMC-2) protocol. IRZ TMS-2 (rus. ИПЗ TMC-2) is used in control stations of DOOO

“IRZ TEK” manufactured since 2011. The IRZ TMS-2 (*rus. ИПЗ TMC-2*) protocol allows transferring high-accuracy telemetry data to the control station. The IRZ TMS-2 (*rus. ИПЗ TMC-2*) protocol is described in Appendix B.

1.4.4 Operation of the TMS-E5 Surface Acquisition Unit using the IRZ TMS-1 (*rus. ИПЗ TMC-1*) protocol

1.4.4.1 To switch to the IRZ TMS-1 (*rus. ИПЗ TMC-1*) protocol operation mode, set the switches to positions according to Table 1.4 for the IRZ TMS-1 (*rus. ИПЗ TMC-1*) protocol.

1.4.4.2 Switch off TMS-E5 Surface Acquisition Unit power supply and wait for at least 1 minute.

1.4.4.3 Supply power to the TMS-E5 Surface Acquisition Unit.

1.4.4.4 The TMS-E5 Surface Acquisition Unit is ready to operate with the IRZ TMS-1 (*rus. ИПЗ TMC-1*) protocol. IRZ TMS-1 (*rus. ИПЗ TMC-1*) is used in control stations of DOOO “IRZ TEK” manufactured before 2011. The IRZ TMS-1 (*rus. ИПЗ TMC-1*) protocol is described in Appendix B.

1.4.5 Operation of the TMS-E5 Surface Acquisition Unit using the BORETS SPT (*rus. БОРЕЦ СПТ*) protocol.

1.4.5.1 To switch to the BORETS SPT (*rus. БОРЕЦ СПТ*) protocol operation mode, set the switches to positions according to Table 1.4 for the BORETS SPT (*rus. БОРЕЦ СПТ*) protocol.

1.4.5.2 Switch off TMS-E5 Surface Acquisition Unit power supply and wait for at least 1 minute.

1.4.5.3 Supply power to the TMS-E5 Surface Acquisition Unit.

1.4.5.4 The TMS-E5 Surface Acquisition Unit is ready to operate with the BORETS SPT (*rus. БОРЕЦ СПТ*) protocol. BORETS SPT (*rus. БОРЕЦ СПТ*) is used in control stations manufactured by BORETS CJSC. The BORETS SPT (*rus. БОРЕЦ СПТ*) protocol is described in Appendix B.

1.4.6 Operation of the TMS-E5 Surface Acquisition Unit using the ELEKTON (*rus. ЭЛЕКТОН*) protocol.

1.4.6.1 To switch to the ELEKTON (*rus. ЭЛЕКТОН*) protocol operation mode, set the switches to positions according to Table 1.4 for the ELEKTON (*rus. ЭЛЕКТОН*) protocol.

1.4.6.2 Switch off TMS-E5 Surface Acquisition Unit power supply and wait for at least 1 minute.

1.4.6.3 Supply power to the TMS-E5 Surface Acquisition Unit.

1.4.6.4 The TMS-E5 Surface Acquisition Unit is ready to operate with the ELEKTON (*rus. ЭЛЕКТОН*) protocol. ELEKTON (*rus. ЭЛЕКТОН*) is used in control stations manufactured by ELEKTON CJSC. The ELEKTON (*rus. ЭЛЕКТОН*) protocol is described in Appendix B.

1.4.7 Operation of the TMS-E5 Surface Acquisition Unit in the Automatic Protocol Definition mode

1.4.7.1 The Automatic Protocol Definition mode allows automatic definition of the exchange protocol between the TMS-E5 Surface Acquisition Unit and the control station. Automatic selection is made among the following protocols: IRZ TMS-2 (rus. ИРЗ TMC-2), IRZ TMS-1 (rus. ИРЗ TMC-1), BORETS SPT (rus. БОРЕЦ СПТ), ELEKTON (rus. ЭЛЕКТОН).

1.4.7.2 To switch to the Automatic Protocol Definition mode, set the switches to positions according to Table 1.4 for automatic protocol definition.

1.4.7.3 Switch off TMS-E5 Surface Acquisition Unit power supply and wait for at least 1 minute.

1.4.7.4 Supply power to the TMS-E5 Surface Acquisition Unit.

1.4.7.5 The TMS-E5 Surface Acquisition Unit is ready to operate in the automatic detection mode.

1.4.7.6 Automatic detection is performed as follows:

- after supplying power to the TMS-E5 Surface Acquisition Unit and the control station, the proper exchange protocol is detected within 5 minutes;

- upon the expiration of 5 minutes, the TMS-E5 Surface Acquisition Unit starts operating using the protocol of the control station.

In case the control station protocol is changed, the TMS-E5 Surface Acquisition Unit shifts to the new protocol within 5 minutes.

1.5 Marking and sealing

1.5.1 The TMS-E5 Surface Acquisition Unit has a sticker with information as follows:

- product name;
- company trademark;
- serial number;
- manufacture date.

1.5.2 The package is marked by a label with the following information:

- product name;
- serial number;
- manufacturer name;
- marking of the manufacturer's Quality Assurance Department;
- month and year of manufacture;
- gross weight;
- warranty storage period;
- manufacturer's address;
- handling symbols "Fragile. Caution", "Keep dry", "Up" and "Limit number of products arranged in a stack" (up to five pcs) as per GOST 14192 (*rus. ГОСТ 14192*).

1.5.3 Connectors are marked by graving.

1.5.4 Components of the TMS-E5 Surface Acquisition Unit are sealed by four paper seals located on the corners where the covers join the lateral sides. Assembled TMS-E5 Surface Acquisition Unit does not need not be sealed.

1.6 Package

1.6.1 The package of the TMS-E5 Surface Acquisition Unit corresponds to requirements of manufacturer's drawings, the package variant is VU5 (*rus. BY5*) according to GOST 9.014 (*rus. ГОСТ 9.014*), the package category is KU1 (*rus. KY1*) according to GOST 23170 (*rus. ГОСТ 23170*).

1.6.2 Operational documents and the packing list are put in individual bags made of polyethylene film as per GOST 10354 (*rus. ГОСТ 10354*).

1.6.3 The packing list of the TMS-E5 Surface Acquisition Unit contains the following information:

– name and reference no. of the TMS-E5 Surface Acquisition Unit and its components supplied;

– packing date;

signature and stamp of the person responsible for packing and the stamp of the quality assurance department of the manufacturer.

1.6.4 The TMS-E5 Surface Acquisition Unit prepared for packing, the associated documentation and package pass through inspection of the quality assurance department of the manufacturer.

2 Intended Use

2.1 Operation Limits

2.1.1 IT IS PROHIBITED TO CONNECT/ DISCONNECT THE CONNECTORS “TELEMETRY” (rus. «ТЕЛЕМЕТРИЯ»), “RS232”, “RS485” AND THE “ \perp ” TERMINAL IF TMS-E5 IS POWERED.

2.1.2 IT IS PROHIBITED TO CONNECT THE POWER NETWORK TO CONTACTS OF THE CONNECTORS “TELEMETRY” (rus. «ТЕЛЕМЕТРИЯ»), “RS232”, “RS485” AND TO THE “ \perp ” TERMINAL.

2.1.3 IT IS PROHIBITED TO USE RS232 AND RS485 PORTS SIMULTANEOUSLY.

2.2 Safety Precautions

2.2.1 While operating the TMS-E5 Surface Acquisition unit, observe the Safety Rules for Operation of Customers’ Electrical Installations and the Rules for Operation of Customers’ Electrical Installations.

2.2.2 Before to connect the TMS-E5 Surface Acquisition Unit to the power network, connect the “ \perp ” terminal to the protective ground loop.

2.2.3 Installation, operation and maintenance of the TMS-E5 Surface Acquisition Unit shall be performed by specially trained personnel.

2.3 Before Operation

2.3.1 All measuring instruments used to tune the product shall have operational documentation and be calibrated according to PR50.2.006 (rus. ПР50.2.006). The control equipment shall be periodically calibrated according to the operational documents.

2.3.2 Read this operation manual and prepare necessary equipment listed in Table C.1 of the Appendix C.

2.3.3 Unpack the TMS-E5 Surface Acquisition Unit and check completeness according to the chapter 2 of the CVIA.468156.117-01 PS (rus. ЦВИЯ.468156.117-01 ПС) Technical Certificate.

2.3.4 Inspect the TMS-E5 Surface Acquisition Unit for absence of mechanical damages of connectors, the “ \perp ” terminal and light indicators.

2.3.5 Installation of the TMS-E5 Surface Acquisition Unit

2.3.5.1 Fix the TMS-E5 Surface Acquisition Unit inside the control station cabinet using the installation kit so as to ensure the possibility of visual monitoring of light indicators condition and availability of free space of at least 10 cm on the side of the connectors to connect external cables.

2.3.5.2 Connect the “ \perp ” terminal and electric connectors as shown in Figure D.1 of Appendix D.

2.4 Use of the TMS-E5 Surface Acquisition Unit

2.4.1 Prepare the unit to operation as specified in clause 2.3.

2.4.2 Supply power to the TMS-E5 Surface Acquisition Unit. In no more than 5 minutes TMS-E5 is ready to transfer data.

2.4.3 Data from the TMS-E5 Surface Acquisition Unit are received via the RS232 or RS485 interface using the MODBUS RTU protocol.

2.5 Troubleshooting

2.5.1 Possible failures while operating TMS-E5, possible causes and the recommendations on their elimination are given in Table 2.1.

Table 2.1.

| Description and signs failure | Possible cause | Elimination methods |
|---|---|---|
| 1 | 2 | 3 |
| TMS-E5 is connected to the power network, the "POWER" light indicator is off. | No power is supplied to TMS-E5 | Check integrity of the power supply circuit of TMS-E5 and eliminate possible breakage |
| | Non-conformity of the voltage supplied to TMS-E5 | Ensure power supply to TMS-E5 from the network with voltage of 170-285V |
| 25 s after switching TMS-E5 on, the "TM" light indicator is not On. | Short circuit in the circuit of TM data reception. | Check the circuit: contact 1 of the Downhole Sensor "TELEMETRY" (rus. «ТЕЛЕМЕТРИЯ») connector – "SUT Zero Point" contact of the TMS-E5-01 Surface Acquisition Unit – SUT Zero Point; eliminate possible short circuits of the circuit to the housing. |
| The "RX" light indicator is flashing, the "TX" indicator is off. | No telemetry is transferred to the external device. | The automatic protocol determination is in process. The determination will be completed in up to 7 min. |
| | | Power TMS-E5-01 off and power it on in at least 60 s. |

Continuation of Table 2.1.

| 1 | 2 | 3 |
|---|---|---|
| 25 s after switching TMS-E5-01 on, the "TM" light indicator is on for 7-8 s and then off for 2s. Then it is on for 7-8 s and off for 15-25 s. The "TM" light indicator is not flickering. | The circuit connecting TMS-E5-01 to SUT is open. | Check the "Downhole Sensor "TELEMETRY" (rus. «ТЕЛЕМЕТРИЯ») connector contact 1 – TMS-E5-01 "SUT Zero Point" contact – SUT Zero Point" circuit; eliminate possible breaking. |
| | The circuit connecting the Downhole Sensor to the SEM Zero Point is open. | Check the "Downhole Sensor "X1" connector – SEM Zero Point" circuit; eliminate possible breaking. |
| | Failure of the Downhole Sensor. | Replace the Downhole Sensor. |
| 25 s after switching TMS-E5-01 on, the "TM" light indicator flickers for 7-8 s at intervals of 1-2 s. | The voltage amplitude in the middle point of SUT exceeds 200 V. | Check the voltage amplitude in the middle point of SUT; if necessary, reduce the voltage amplitude in the middle point of SUT to a level not more than 200V or replace SUT. |
| The pressure reading is 195 or 7.07 kgf/cm ² . Pressure is not measured. | The Downhole Sensor pressure channel failed | Replace the Downhole Sensor |
| The winding temperature reading is 0 – 3°C that is not true | The Downhole Sensor channel for measuring temperature of the SEM winding failed | Replace the Downhole Sensor |
| | The thermal element (of the Downhole Sensor) failed | Replace the thermal element |
| The intake temperature reading is 0 – 3°C that is not true | The Downhole Sensor channel for measuring intake temperature failed | Replace the Downhole Sensor |

2.5.2 If the failure elimination methods specified in Table 2.1 are not effective or if the TMS-E5 failure signs do not correspond to those specified in Table 2.1, TMS-E5 has to be replaced.

3 Maintenance

3.1 General guidelines

3.1.1 Maintenance of the TMS-E5 Surface Acquisition Unit shall be performed by personnel specially trained and admitted to the work.

3.1.2 Do maintenance of the TMS-E5 Surface Acquisition Unit at least once a year.

3.2 Maintenance Procedure

3.2.1 Inspect the TMS-E5 Surface Acquisition Unit visually for mechanical damages according to cl. 2.3.4.

3.2.2 Check operation of the TMS-E5 Surface Acquisition Unit.

3.2.2.1 Assemble the workplace for testing according to Figure E.1 of Appendix E.

3.2.2.2 Switch the computer on and start the "BST.exe" program ref. CVIA.00526-01 (rus. ЦВИЯ.00526-01).

3.2.2.3 Connect the R1* 47 kOhm resistor.

3.2.2.4 Connect the TMS-E5 Surface Acquisition Unit to the power network and make sure that the "POWER" indicator is on.

3.2.2.5 20-25 seconds after switching TMS-E5 on, the "TM" indicator shall start flickering; the flickering shall be 7-8 seconds at intervals of 1-2 seconds.

3.2.2.6 In the "Telemetry Diagnostics" (rus. «Диагностика телеметрии») window of the "BST.exe" program, open the "File" (rus. «Файл») menu and select "Setting COM port" (rus. «Настройка COM порта»). In the window that appears, select the port to which TMS-E5 is connected, then set the rate of 19,200 bit/s.

3.2.2.7 Select the IRZ TMS-1 (rus. ИРЗ TMC-1) protocol (see clause 1.4.4) or the automatic detection mode (see cl. 1.4.7).

3.2.2.8 In the "Telemetry Diagnostics" (rus. «Диагностика телеметрии») window of the "BST.exe" program, enter the "Show" (rus. «Показать») menu and select "TM Data Reception History" (rus. «Хронология приёма ТМИ»). Make sure that in the opened window the data frame number value is increased by one every 8-10 seconds and is in the range of 0-255.

Make sure that the "TX" and "RX" indicators are flashing.

* According to Table C.1 of Appendix C.

3.2.2.9 Wait for at least one minute and then check the following parameters of the current data frame in the “TM Data Reception History” window:

- data frame No;
- insulation resistance $R = (47 \pm 3.3) \text{ kOhm}$;
- intake temperature, T_{intake} (rus. Тос) = 45°C ;
- motor winding temperature T_{win} (rus. Тобм) = 130°C ;
- vibration value Vibr1 (rus. Вибр1) = 20 m/s^2 ;
- vibration value Vibr2 (rus. Вибр2) = 45 m/s^2 ;
- intake pressure P_{intake} (rus. Пос) = 50 kg/cm^2 ;
- pressure of oil in SEM P_{oil} (rus. Рм) = 200 kg/cm^2 .

3.2.2.10 Perform actions described in clauses 3.2.2.3-3.2.2.9 while connecting R1* resistors of 1 MOhm and 5.6 MOhm sizes one at a time. At that, be obtained readings of insulation resistance shall be $R = (1 \pm 0.1) \text{ MOhm}$ and $R = (5.6 \pm 0.6) \text{ MOhm}$ correspondingly.

3.2.2.11 If any failure is detected while performing actions according to cl. 3.2.1 and cl. 3.2.2, TMS-E5 must be repaired at the manufacturing factory.

* According to Table C.1 of Appendix C.

4 Storage

4.1 Storage conditions of the TMS-E5 Surface Acquisition Unit in the package shall correspond to Storage Conditions 2 as per GOST 15150 (*rus. ГОСТ 15150*) with the storage period of 1 year.

4.2 The TMS-E5 Surface Acquisition Unit shall be kept on a shelf in the original package.

4.3 The location of TMS-E5 in the warehouse shall ensure easy handling and free access to it.

5 Transportation

5.1 The TMS-E5 Surface Acquisition Unit may be transported by automotive and railroad transport inside covered cars or containers, by air in pressurized compartments at any distance and at any speed. Appropriate placement and fixing of the transport container in the transport vehicle shall secure its steady position and prevent from drifting during transportation.

5.2 Transportation conditions:

- ambient temperature: from - 60°C to +70°C;
- relative humidity: up to 98% @ +25°C;
- air pressure: from 84 to 106.7 kPa (630-800 mm Hg).

5.3 While loading and transportation, requirements of the warning signs on the package must be observed.

Appendix A

(reference)

Overall and Installation Dimensions

A.1 Overall and installation dimensions of the TMS-E5-01 Surface Acquisition Unit are given in Figure A.1.

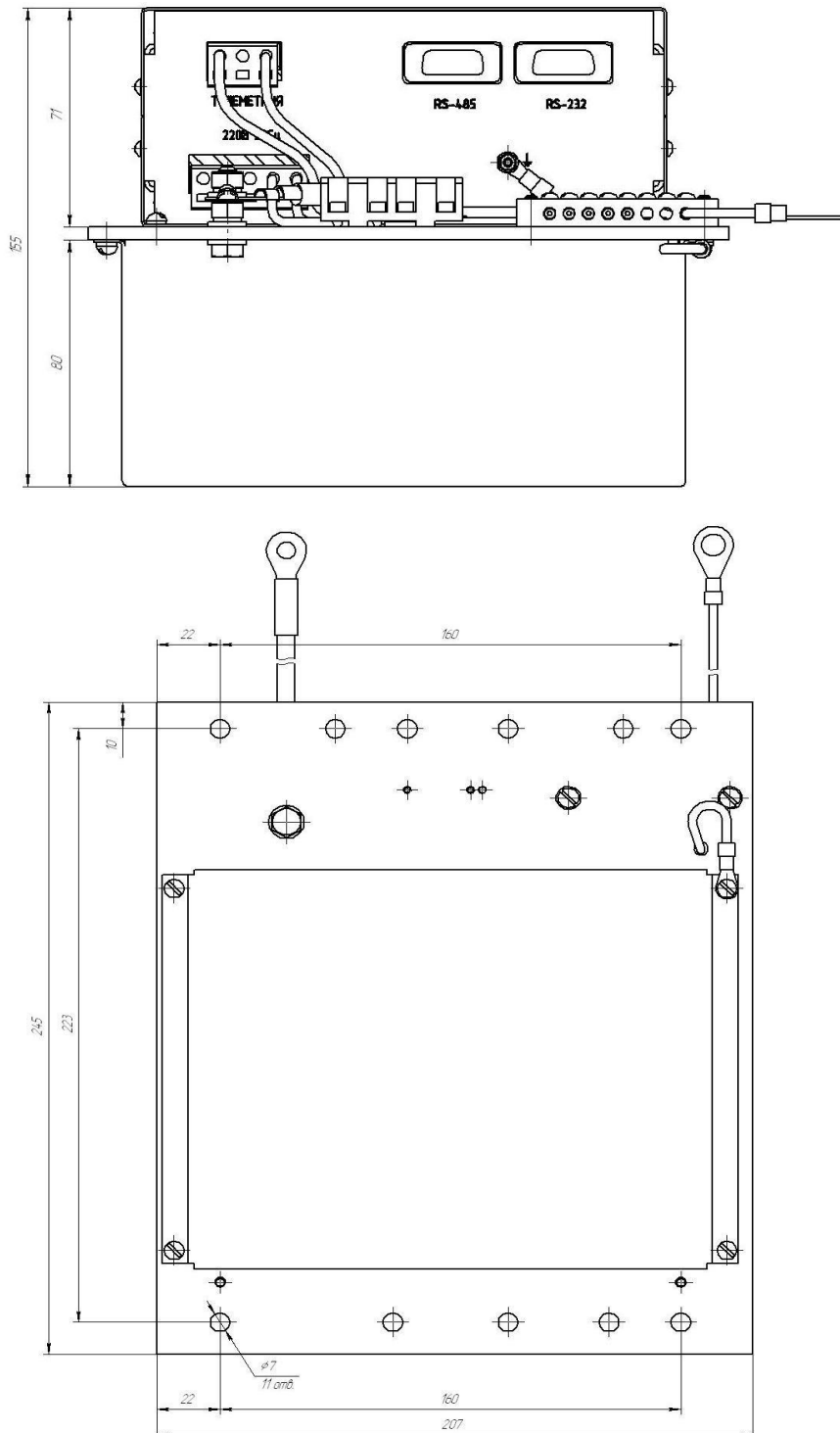


Figure A.1 - Overall and installation dimensions of the TMS-E5-01 Surface Acquisition Unit.

Appendix B
 (mandatory)
Description of Work Protocols

B.1 MODBUS RTU Protocol

B.1.1 Description of the MODBUS RTU protocol

B.1.1.1 The TMS-E5 Surface Acquisition Unit supports the following protocols: IRZ TMS-01 (rus. ИПЗ TMC-1), IRZ TMS-02 (rus. ИПЗ TMC-2), BORETS SPT (rus. БОРЕЦ СПТ), and ELEKTON (rus. ЭЛЕКТОН). Parameters of the protocols are given in Table B.1. These protocols are based on the MODBUS RTU protocol. More precisely, these protocols implement some MODBUS protocol functions. According to this protocol, on the bus there is one unit operating in the Master Mode and one or more units operated in the Slave Mode. For components of the Downhole Monitoring System supplied by other manufacturers, the surface equipment of the Downhole Monitoring System is the unit operating in the Slave Mode.

B.1.1.2 On the physical layer, connection to the Downhole Monitoring System is performed via the RS232 serial interface. Depending on modification of the surface equipment, the Downhole Monitoring System may have the appropriate port and support operation in the RS485 mode as well.

B.1.1.3 The BST Telemetry Interface Unit supports the MODBUS RTU protocol of 8N1 type (8 data bits, without parity, one stop bit) when using the RS232 and RS485 interfaces. The data transfer rate is 19,200 bit/s. Data reliability is checked by calculating the checksum (CRC) transferred at the end of each message sent. To calculate the checksum, the $x^{15}+x^{13}+x^0$ polynomial is used. The time interval between the messages is equal or more than the time of transferring of 3.5 symbols at this transfer rate in the network.

The data link layer parameters are given in Table B.1.

Table B.1 - The parameters of the protocol MODBUS.

| Parameter | Default value |
|---|--------------------------------|
| Address of the slave unit for IRZ TMS-1 | 17 (0x11) |
| Address of the slave unit for IRZ TMS-2 | 15 (0x0f) |
| Address of the slave unit for BORETS | 33 (fixed) |
| Address of the slave unit for ELEKTON | 1-247 (variable, by default 1) |
| First interface bit rate | 19200 |
| Second interface bit rate | 115200 |
| Protocol mode | MODBUS RTU 8N1 |

| | |
|------------------------------|-----|
| Recommended polling interval | 4 s |
|------------------------------|-----|

B.1.2 MODBUS RTU Checksum calculation

B.1.2.1 The checksum consists of two bytes. The checksum is calculated by the transmitter and added at the end of the message. The receiver calculates the checksum at receipt and compares it to the checksum value in the received message.

B.1.2.2 The checksum is preliminary initiated by the 0xFFFF number. To calculate the checksum, 8 data bits are used. The start and stop bits and the parity bit (if used) are not considered for checksum calculation.

B.1.2.3 At calculating the checksum, every byte of the message is added to the current contents of the checksum register using EXCLUSIVE OR. The result is displaced toward the least significant bit, while the most significant bit becomes zero. If the least significant bit is unit, then EXCLUSIVE OR with the contents of the checksum register and the certain number (0xA001) is performed. If the least significant bit is zero, then the EXCLUSIVE OR is not performed. The displacement repeats eight times. After the last (eighth) displacement, the following byte is added to the current value of the checksum register and the displacement repeats eight times as described above. The resulting contents of the register is the checksum.

B.2 Description of IRZ TMS-1 (rus. ИРЗ ТМС-1) protocol operation

B.2.1 Function 04 – Telemetry data reading

B.2.1.1 The format of the TM data reading command is given in Table B.2; the format of the response is given in Table B.3.

Table B.2

| Field designation | Note |
|--|-----------|
| 1 BST Telemetry Interface Unit network address | |
| 2 Function number | |
| 3 Initial address | high byte |
| | low byte |
| 4 Number of words read | high byte |
| | low byte |
| 5 Checksum | low byte |
| | high byte |

Table B.3

| Field designation | Note |
|--|-----------|
| 1 BST Telemetry Interface Unit network | |
| 2 Function number | |
| 3 Byte counter | |
| 4 Data | |
| 5 Checksum | low byte |
| | high byte |

B.2.1.2 Calling the function 04 allows reading the telemetry data the example of which is given in Table B.4.

Table B.4

| Parameter | Address of MODBUS RTU (hex) | Value range |
|--|-----------------------------|-------------|
| 1 Intake temperature, °C | 0806 | 0-150 |
| 2 Motor winding temperature, °C | 0807 | 0-150 |
| 3 X-axis vibration value, m/s ² | 0808 | 0-50 |
| 4 Y-axis vibration value, m/s ² | 0809 | 0-50 |
| 5 Intake pressure, kgf/cm ² | 080A | 0-650 |
| 6 Pressure of oil in SEM, kg/cm ² . | 080B | 0-650 |
| 7 Calibration sensor | 080C | 127-128 |
| 8 Frame Number | 080D | 0-255 |
| 9 Insulation resistance, kOhm | 0101 | 0 – 9,999 |
| 10 Basic version number | 0700 | 0-65535 |
| 11 Software version | 0701 | 0-65535 |

B.2.1.3 Registers containing vibration values have 10 times increased values. That is, vibration of 0.1 g corresponds to 1 and vibration of 5.0 g corresponds to 50.

B.2.1.4 An example of the function 04 for reading TM parameters is given in Table B.5, and an example of the response is given in Table B.6.

Table B.5

| Field designation | Value | Note |
|--|-------|-----------|
| 1 BST Telemetry Interface Unit network address | 0x11 | |
| 2 Function number | 0x04 | |
| 3 Initial address | 0x08 | high byte |
| | 0x06 | low byte |
| 4 Number of words read | 0x00 | high byte |
| | 0x03 | low byte |
| 5 Checksum | 0x50 | low byte |
| | 0xFA | high byte |

Table B.6

| Field designation | Value | Note |
|--|-------|-----------|
| 1 BST Telemetry Interface Unit network address | 0x11 | |
| 2 Function number | 0x04 | |
| 3 Byte counter | 0x06 | |
| 4 Data | 0x00 | high byte |
| | 0x12 | low byte |
| 5 Data | 0x00 | high byte |
| | 0x1F | low byte |
| 6 Data | 0x00 | high byte |
| | 0x02 | low byte |
| 7 Checksum | 0x57 | low byte |
| | 0xA5 | high byte |

Return values:

- intake temperature 18°C;
- motor winding temperature 31°C;
- X-axis vibration X 0.2 m/s².

B.2.2 Error messages

B.2.2.1 If the BST Telemetry Interface Unit cannot perform a request, then an error message in the format specified in Table B.7 is displayed.

Table B.7

| Field designation | Note |
|--|----------------------------------|
| 1 BST Telemetry Interface Unit address | |
| 2 Function number | Most significant bit is set to 1 |
| 3 Error code | |
| 4 Error code extension | low byte |
| | high byte |

B.2.2.2 The list of errors is given in Table B.8.

Table B.8

| Error code | Description |
|------------|--|
| 01 | The received function code cannot be processed by the BST Telemetry Interface Unit. The error code extension bytes are not informative. |
| 02 | The data address specified in the request is not available for the BST Telemetry Interface Unit. The error code extension bytes are not informative. |
| 05 | The BST Telemetry Interface Unit has accepted the request and is processing it, but it requires a lot of time. This response prevents from generating the timeout error. The error code extension bytes are not informative. |

B.2.2.3 An example of referring to an inadmissible address is given in Table B.9, and an example of the error message is given in Table B.10.

Table B.9

| Field designation | Value | Note |
|--|-------|-----------|
| 1 BST Telemetry Interface Unit network address | 0x11 | |
| 2 Function number | 0x04 | |
| 3 Initial address | 0x0C | high byte |
| | 0x01 | low byte |
| 4 Number of words read | 0x00 | high byte |
| | 0x01 | low byte |
| 5 Checksum | 0x61 | low byte |
| | 0xCA | high byte |

Table B.10

| Field designation | Value | Note |
|--|-------|-----------|
| 1 BST Telemetry Interface Unit network address | 0x11 | |
| 2 Function number | 0x84 | |
| 3 Error code | 0x02 | |
| 4 Error code extension | 0x00 | high byte |
| | 0x00 | low byte |
| 5 Checksum | 0x51 | low byte |
| | 0x33 | high byte |

B.3 Description of IRZ TMS-2(rus. ИРЗ TMC-2) protocol operation

B.3.1 This protocol implements application level functions of the MODBUS protocol. These functions have the following numbers and designation:

- 0X04 To read input registers values (Read Input Registers);
- 0X03 To read values of several internal registers (Read Holding Register);
- 0X06 To set a value in an internal register (Write Single Holding Register).

B.3.2 With these functions, access to two register types is allowed: internal (holding) registers and input registers. As a rule, it is not required to provide access for interrogating units to holding registers through the functions 0x03 and 0x06. For external interrogating units it is enough to perform interrogation of the input registers unit through the function 0x04.

B.3.3 Input registers

B.3.3.1 These registers are available only for reading (function 0x04). Each register is of 16 bit size and contains 2 bytes of information in the integer format. The set of registers is given in Table B.11. The registers are applied for reading measurement data and other information.

B.3.3.2 Actual resolution and value range of Downhole Sensors may be less than 16 binary bits of the register data. The capacity and value range are specially increased in this protocol with a view to further improvement of the device.

Table B.11 - Memory Card of Input Registers.

| Address (Hex) | Description | Range | Resolution |
|---|---|-----------------|-------------------------|
| 0x0600 | Insulation resistance | 1 — 65535 | 1 kOhm |
| 0x0601 | Downhole Monitoring System status word | See Table B.12. | |
| 0x0602 | Counter of the last successfully received frame | 0-65535 | - |
| 0x0603 | SUT Zero Point voltage | 0-3276.7 | 0.1 V |
| Telemetry information from the Downhole Sensor | | | |
| Vibration Data | | | |
| 0x0604 | Rotor rotation frequency | 0-655.35 | 0.01 Hz |
| 0x0605 | Vibration amplitude, X-axis | 0-6553.5 | 0.1 m/s ² |
| 0x0606 | Vibration amplitude, Y-axis | 0-6553.5 | 0.1 m/s ² |
| 0x0607 | Vibration amplitude, Z-axis | 0-6553.5 | 0.1 m/s ² |
| Downhole Sensor TM Data | | | |
| 0x0608 | Intake temperature | 0-655.35 | 0.01°C |
| 0x0609 | Motor winding temperature | 0-655.35 | 0.01°C |
| 0x060A | Intake pressure | 0-655.35 | 0.01 kg/cm ² |
| 0x060B | Motor oil pressure | 0-655.35 | 0.01 kg/cm ² |
| 0x060C- 0x061A | Reserved | | |
| 0x061B | Motor oil temperature | 0-655.35 | 0.01°C |
| 0x061C – 0x061F | Calibration information | | |
| Downhole Sensor Specifications | | | |
| 0x0620 | Downhole Sensor serial number | - | - |
| 0x0621 | Downhole Sensor software version | - | - |

Table B.12 – Downhole Monitoring System status word format (holding register 0x0601).

| Bit No | Description |
|--------|--|
| 0-9 | Reserved |
| 10 | Relay status |
| 11 | No signal from the Downhole Sensor |
| 12 | SUT Zero Point voltage is high (over 150V) |
| 13 | No 220V power supply |

| | |
|-------|----------|
| 14.15 | Reserved |
|-------|----------|

B.3.4 Holding registers

B.3.4.1 These registers are available both for reading (function 0x03) and for writing (function 0x06). The set of registers is detailed in Table B.13. Each register is of 16 bits size, the data format is integer.

B.3.4.2 The registers are used mainly to control the unit and contain control information affecting device operation. Some functions are described below.

Table B.13 - Memory Card of Holding Registers.

| Address (Hex) | Description | Value, range |
|---------------|---|---|
| 0x0800 | Address of the slave unit of the TMS-2 protocol | (0x0f by default) 1-247 range |
| 0x0801 | Address of the slave unit of the TMS-1 protocol | (0x11 by default) 1-247 range |
| 0x0802 | Address of the slave unit of the BORETS protocol | (0x33 by default) 1-247 range |
| 0x0803 | Address of the slave unit of the ELEKTON protocol | (0x01 by default) 1-247 range |
| 0x0804-0x0807 | Reserved | |
| 0x0808 | Bit rate of the first serial port RS-232/RS-485 | 2,400;4,800; 9,600;19,200; 38,400; 57,600; 11,520* (19,201 by default) |
| 0x0809 | Bit rate of the second serial port RS-485 | 2,400;4,800; 9,600;19,200; 38,400; 57,600; 11,520 (11,520 by default)* |
| 0x080A-0x080B | Reserved | |
| 0x080C | Threshold value of insulation resistance for NK310 (rus. HK310) relay actuation | 1 kOhm resolution (30 kOhm by default) 1-65534 range 0 - deactivates the function of relay switching for insulation measurement. |
| 0x080D | Reserved | |
| 0x080E | Duration of relay operation in off state | 0.01 s (5.00 s by default) |
| 0x080F | Duration of relay operation in on state | 0.01 s (600.00 s by default) |
| 0x0810 | Upper limit of insulation resistance measuring | 1 kOhm resolution (9,999 kOhm by default) |
| 0x0811-0x0813 | Reserved | |
| 0x0814 | Resetting time if no telemetry is available | 0.1 s (off (0 s) by default) |

* The bit rate of 115,200 is not within the range of 0-65,535, so to change operation till this rate, the value shall be written in the cell 11520.

B.4 Description of BORETS SPT (rus. БОРЕЦ СПТ) protocol operation

B.4.1 Input registers

The memory card of the input registers of the BORETS SPT protocol is given in Table B.14.

Table B.14 - Memory Card of Input Registers.

| Hex | Description | Value |
|--------|---|-----------|
| 0x0240 | Insulation resistance of the "SUT - Cable - SEM - SPT-1BP" line, kOhm | 0 – 9,999 |
| 0x0241 | Formation temperature, °C | 0 – 250 |
| 0x0242 | Temperature of SEM winding, °C | 0 – 250 |
| 0x0243 | Mean square x- and y-axis vibration, g | 0.0 – 9.9 |
| 0x0244 | Z-axis vibration, g | 0.0 – 9.9 |
| 0x0245 | Pressure, atm. | 0 – 350 |

B.5 Description of ELEKTON (rus. ЭЛЕКТОН) protocol operation

B.5.1 The ELEKTON protocol operates at the rate of 9,600 bauds. At activation of the ELEKTON protocol, the dip switch sets the interface speed to 9,600 bauds. In the automatic mode, if there are no correct requests, the device starts automatically switch interface rate between 9,600 bauds and 19,200 bauds, thereby the current exchange rate is searched.

B.5.2 Holding registers

These registers are available for reading only. Their contents can be read using the function 3. In these registers those parameters are available for reading that are measured by TMS2: insulation resistance, temperature, pressure and vibrations.

The memory card of holding registers of the ELEKTON protocol is given in Table B.15.

Table B.15 - Memory Card of Holding Registers.

| Address (Hex) | Register designation |
|---------------|--|
| 0x002D | Insulation resistance, kOhm |
| 0x002E | Pressure, atm. |
| 0x0030 | Remote sensor temperature, °C |
| 0x0031 | Downhole sensor temperature, °C |
| 0x0034 | Vibration in the XY plane, one digit after the decimal point, m/s ² |
| 0x0035 | Vibration in the Z plane, one digit after the decimal point, m/s ² |

Appendix C

(mandatory)

List of measuring instruments, control equipment, devices, materials, purchased products and software for checking

Table C.1

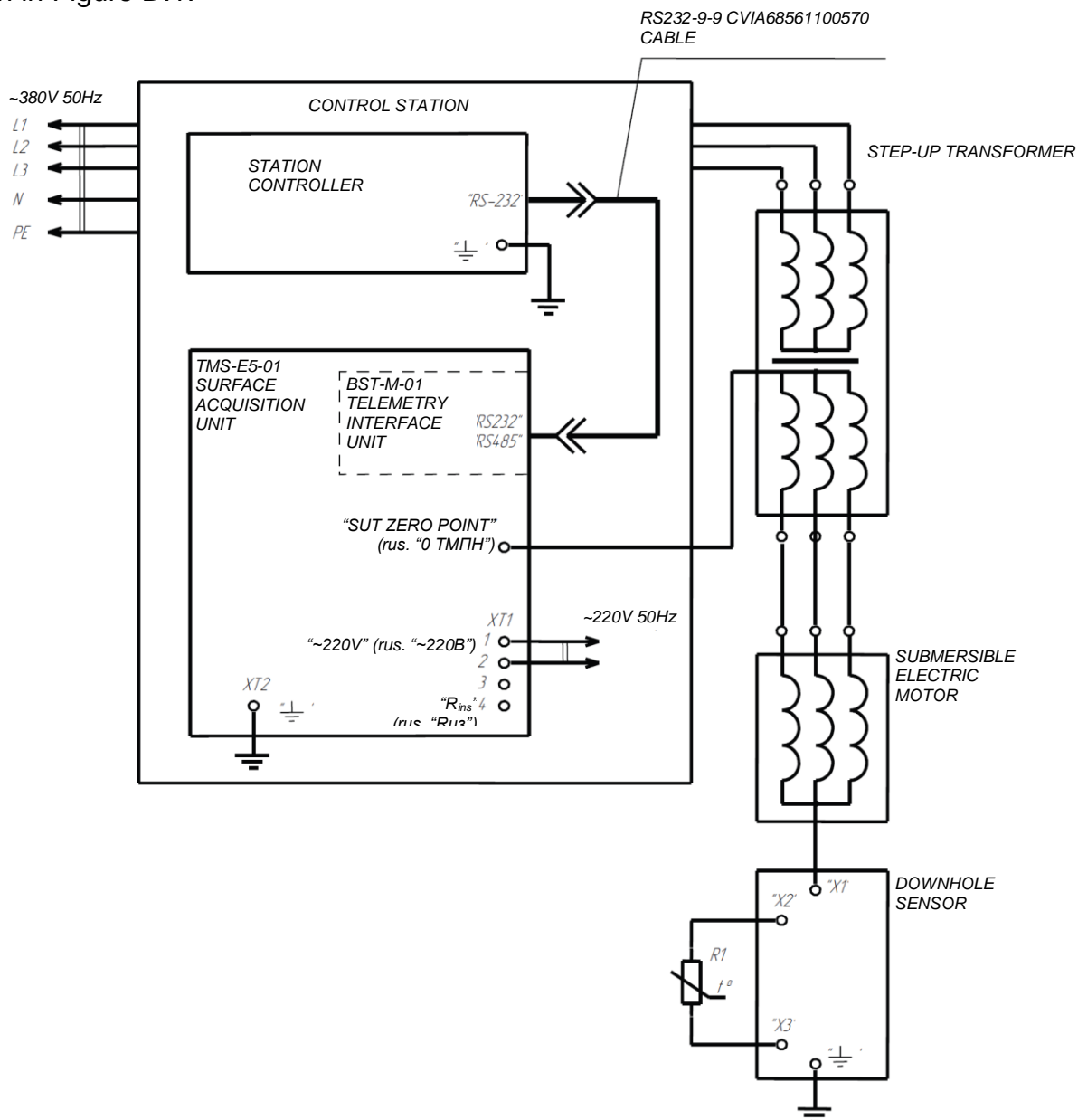
| Name | Reference no. | Qty | Note |
|---|---|-----|---|
| Downhole Sensor simulator | CVIA.468154.004 (rus. ЦВИЯ.468154.004) | 1 | |
| Computer | | 1 | Pentium 1 or higher, Windows 95/98/NT/2000/XP |
| RS232-9-9 Cable | CVIA.685611.005.70 (rus. ЦВИЯ.685611.005.70) | 1 | Supplied under a separate contract |
| "BST.exe" program | CVIA.00526-01 (rus. ЦВИЯ.00526-01) | 1 | Supplied |
| SDSpr-1-2-000 (rus. СДСпр-1-2-000) Timer | - | 1 | Accuracy grade 2 |
| MGShV 0.5 (rus. МГШВ 0,5) Cable | TU16-505.437-82 (rus. ТУ16-505.437-82) | 2 m | |
| 231-203/026-000 WAGO Socket | - | 1 | |
| S2-33-2n-47kOhm±5% (rus. С2-33-2Н 47кОм±5%) Resistor | OZh0.467.093 TU (rus. ОЖ0.467.093 ТУ) | 1 | R1* is the reference resistor, not supplied |
| S2-33-2N-1M0hm±5% (rus. С2-33-2Н-1МОм±5%) Resistor | OZh0.467.093 TU (rus. ОЖ0.467.093 ТУ) | 1 | |
| S2-33-2N-5.6M0hm±5% (rus. С2-33-2Н-5,6МОм±5%) Resistor | OZh0.467.093 TU (rus. ОЖ0.467.093 ТУ) | 1 | |
| Note - it is allowed to replace the measuring instruments by similar ones providing the necessary metrological parameters upon agreement with the chief metrologist of the operating company. | | | |

Appendix D

(reference)

Connection Diagram

D.1 The connection diagram of the TMS-E5-01 Surface Acquisition Unit at the operation site is given in Figure D.1.

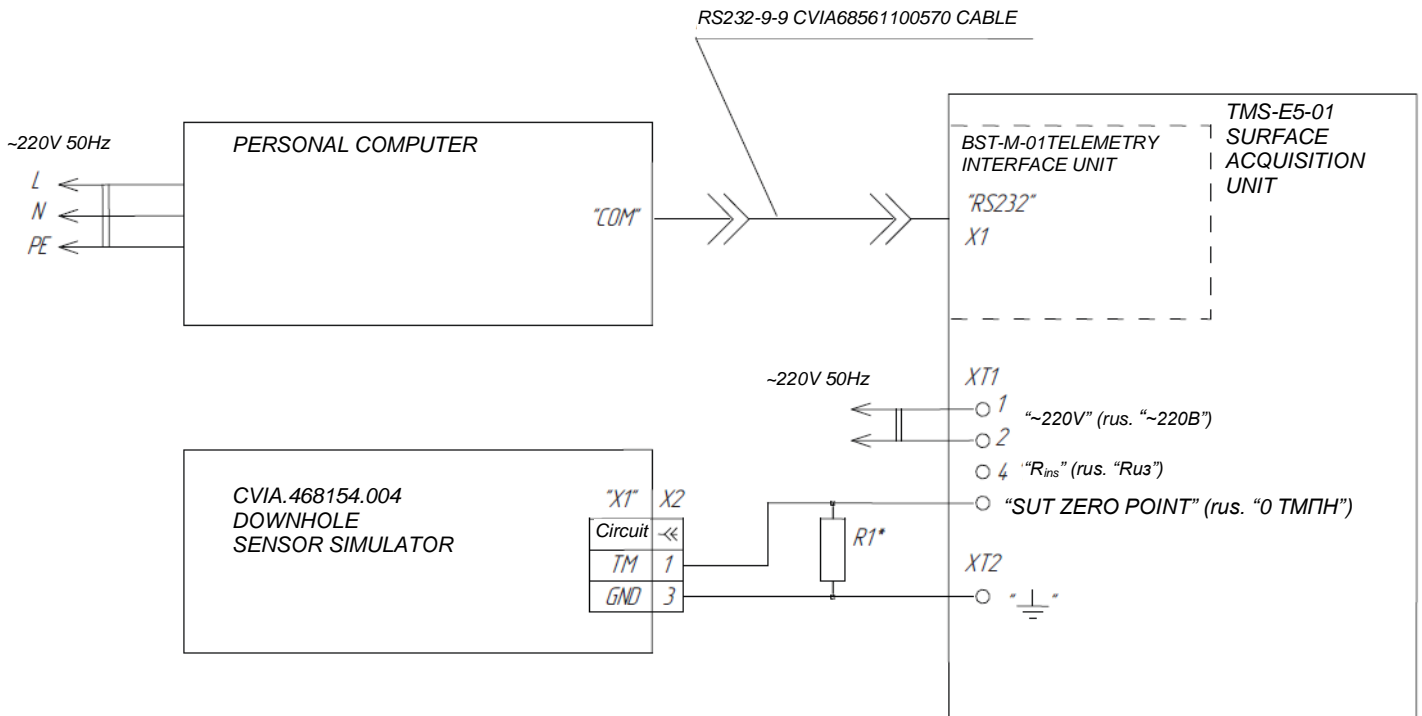


R1 – thermal element CVIA.405219.002 (rus. ЦВИЯ.405219.002).

Figure D.1 - Connection diagram of the TMS-E5-01 Surface Acquisition Unit.

Appendix E
 (mandatory)
Test Set-up

E.1 The test set-up for checking performance of the TMS-E5 Surface Acquisition Unit is given in the Figure E.1.



X2 - socket 231-203/026-000 WAGO.

Figure E.1 - Test Set-up.

* According to Table C.1 of Appendix C.

Reference regulatory documents

| Reference no. | Number of the chapter, subchapter, clause, subclause, listing, appendix of this document where the reference is given |
|---------------------------------------|---|
| GOST 9.014-78 (rus. ГОСТ 9.014-78) | 1.6.1 |
| GOST 10354-82 (rus. ГОСТ 10354-82) | 1.6.2 |
| GOST 14192-96 (rus. ГОСТ 14192-96) | 1.5.2 |
| GOST 15150-69 (rus. ГОСТ 15150-69) | 1.1.2, 4.1 |
| GOST 23170-78 (rus. ГОСТ 23170-78) | 1.6.1 |
| PR50.2.006-94 (rus. ПР50.2.006-94) | 2.3.1 |

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