
Infrared temperature sensor ITS

Manual

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Introduction

The manual contains information on specification, functionality, recommendations for usage, maintenance, packing, transportation, storage as well as connection of ITS sensor to the digital interfaces.

Please read this manual carefully before using the device.

Typical users

The document is intended for the personnel involved in the design, installation, commissioning and operation of the device.

Support

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ATTENTION:

- Use ITS as described in this manual only;
- ITS should be installed, operated and maintained by qualified personnel only;



NOTICE:

- The information contained in this document is a subject to change without notice;
- New features may be added to the devices without notice.
- The most up-to-date documentation and software are available for download from www.enip2.com

Glossary

- SCADA – Supervisory control and data acquisition;
- PC – personal computer;
- DAQ – Data acquisition;

1 General information

1.1 Overview

1.1.1 ITS devices are designed for remote temperature measurement. Main application of devices is temperature measurement of busbars in a switchgear panel of electric substation. Temperature is measuring by the built-in narrow field-of-view thermopile sensor.

1.1.2 The ITS device has a digital RS-485 interface designed as two RJ45 connectors that can be used to combine devices into one RS-485 bus. The sensor is also powered via the RJ45 connector. Data exchange is performed via Modbus RTU protocol.

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1.2 Design and dimensions

1.2.1 ITS sensors are available in two modifications ITS1 and ITS2, which differ in the measurement range and accuracy.

1.2.2 ITS devices are produced in molded plastic enclosure for din-rail (35 mm) mounting. On the front side of the device there are two RJ45 connectors and an infrared sensor.



Figure 1.1. ITS1 (left) and ITS2(right)

1.2.3 Dimensions, weight, installation method and IP code are shown in Table 1.1.

Table 1.1. Dimensions

| Parameter | ITS sensor |
|------------------------|----------------|
| Dimensions WHD, mm | 23 x 114 x 48 |
| Installation | DIN-rail 35 mm |
| IP code (IEC 60529-89) | IP20 |

1.2.4 Technical drawings of ITS devices are in the figure 1.2

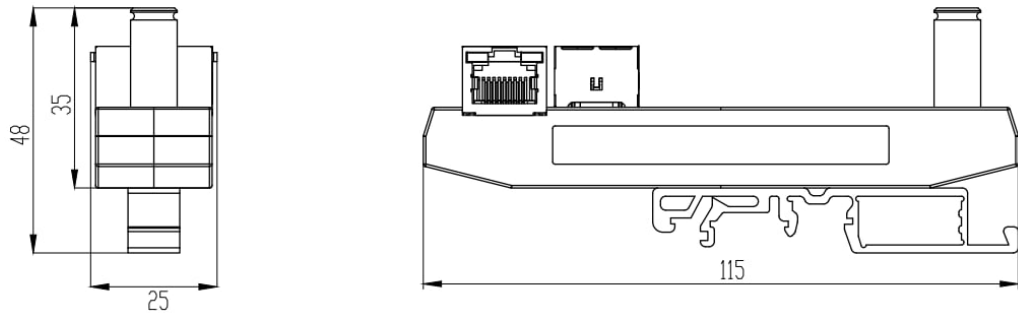


Figure 1.2. ITS dimensions

1.3 Specification

Table 1.2. ITS specification

| Parameter | ITS-1 | ITS-2 |
|--------------------------------------------------------------------------------------------------------------------------------------|---------------------|---------------------|
| Interfaces and communication protocols | RS-485, Modbus RTU | RS-485, Modbus RTU |
| Optical resolution | 1:8 | 1:8 |
| Measurement range | from -70 to +380 °C | from -40 to +250 °C |
| Measurement error, not exceed: - at an ambient temperature of 0...50 °C and object temperature 0...60 °C: - in other cases: | ±0,5°C ±4°C | ±3°C ±3°C |
| Operating temperature range | from -40 to +70 °C | from -20 to +70 °C |
| Power supply, VDC | 8...28 | 8...28 |
| Power consumption, W | 3 | 3 |

2 Technical features

2.1 Operating principle

2.1.1 The principle of operation of ITS sensors is as follows. The infrared radiation of the object hits the sensor lens and is converted into an electrical signal proportional to the temperature. Next, the electrical signal is processed, converted into the corresponding temperature value, and the resulting value is transmitted via the RS-485 digital interface.

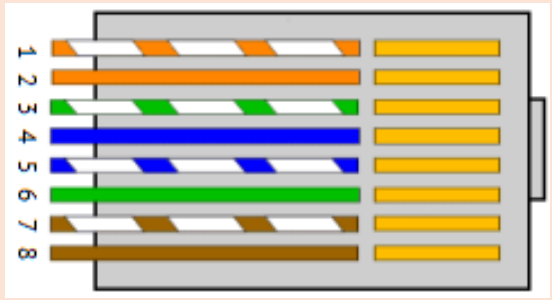
2.1.2 Sensors can be combined into a common bus using standard network patch cords and data can be transferred to ENIP-2 or a DAQ device.

2.2 Interfaces and protocols

2.2.1 ITS sensors support the Modbus RTU communication protocol.

2.2.2 Pinout of ITS RJ45 connectors:

| Interface | Signal | RJ45 pins |
|-----------|-----------------------|-----------|
| RS-485 | Power supply: +24 VDC | 1, 2 |
| | Power supply: 0 VDC | 3, 4 |
| | GND | 5 |
| | A (data+) | 7 |
| | B (data-) | 8 |



2.2.3 Both RJ45 connectors are identical to each other. Pins of the same name have a connection, it does not matter which connector the cable is connected to in the direction of the Master device, that polls Slave devices on the RS-485 bus.

3 Package contents

Package contents include:

- ITS sensor -1;
- ITS.265151.091 TR -1;

For all necessary documentation and software updates, please, visit our website:

www.enip2.ru

4 Operation

4.1 Operating instructions

ITS sensors must be operated in accordance with this instruction manual.

4.2 Operating restrictions

4.2.1 The ITS device is not designed to operate in explosive and aggressive environments.

4.2.2 During operation, the ITS sensor should not be exposed to direct heating by heat sources to temperature of more than plus 70 °C. There should be no sudden temperature fluctuations in the room, there should be no sources of strong electromagnetic fields near the installation site of the converters.

4.3 Before mounting

4.3.1 Make sure that packing has no defects.

4.3.2 Unpack, remove and inspect the device, make sure that there are no visible mechanical damages and check the packing contents.

4.4 Mounting instructions

4.4.1 Mount ITS sensor on DIN-rail 35mm.

4.4.2 Connect the ITS sensor to the RS-485 interface using a shielded twisted-pair cable. Wire cross section not less than 0.2 mm².

4.4.3 The sensor is powered via the RJ45 connector (please see pinout in section 2.2.2).

4.5 Installation recommendations

4.5.1 The accuracy of measurements depends on the thermal radiation coefficient of an object, which is defined as the ratio of the radiation power of an object at a given temperature to the radiation power of a completely black body (such a body has a coefficient of 1.0 and radiates the maximum amount of energy).

The thermal radiation coefficient depends on the surface properties of the object. Polished metal surfaces can have an emissivity close to zero, which makes it difficult to use the pyrometric method of temperature measurement, therefore, to increase the accuracy of measurements, it is necessary to pre-prepare the surface of the material.

To bring the thermal radiation coefficient of the material surface to a value close to 1.0, the simplest solution is to cover the area of the controlled surface with a layer of black paint with a diameter that overlaps the measurement spot.

4.5.2 Another important aspect of the measurement is the optical resolution of the sensor. It is the ratio of the measurement spot diameter to the distance to the object. Accordingly, the distance to the object is equal to the spot diameter divided by the resolution.

The accuracy of temperature measurement does not depend on distance as long as the size of the controlled surface is greater than the measurement spot diameter. If the surface size is smaller than the measurement spot, then the sensor receives radiation from foreign objects, which reduces the measurement accuracy.

For example, we have a 40 mm width busbar, respectively, the measurement spot diameter should be no more than 40 mm (it is better if it is 1.5-2 times less than the busbar width). The optimal spot diameter is 20-25 mm in this case. Since the optical resolution of the sensor is 1:8, then the optimal distance from the object where the sensor should be installed is $25 / (1:8) = 200$ mm.

4.5.3 An example of temperature measurement of busbars in a switchgear panel of electric substation is shown on figure 4.1.

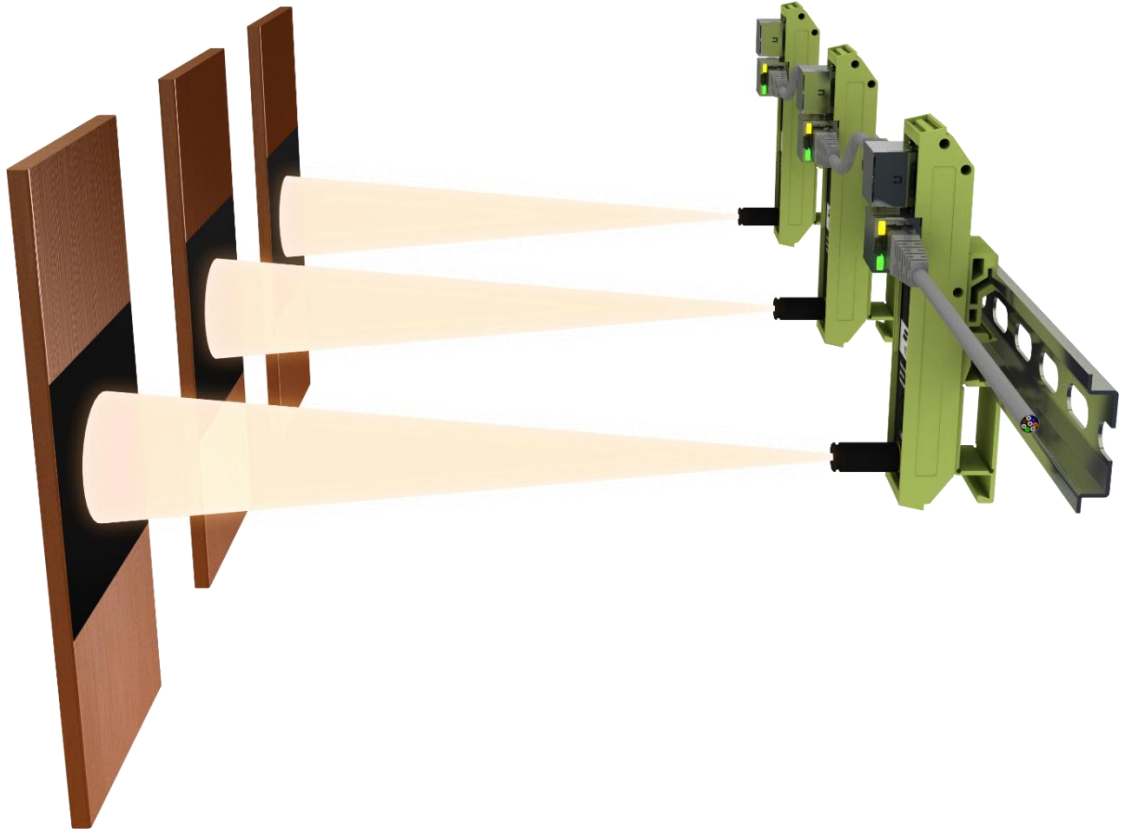


Figure 4.1. An example of busbars temperature measurement

4.5.4 The recommended location of ITS sensors in a switchgear panel D12-P series is shown on figure 4.2.

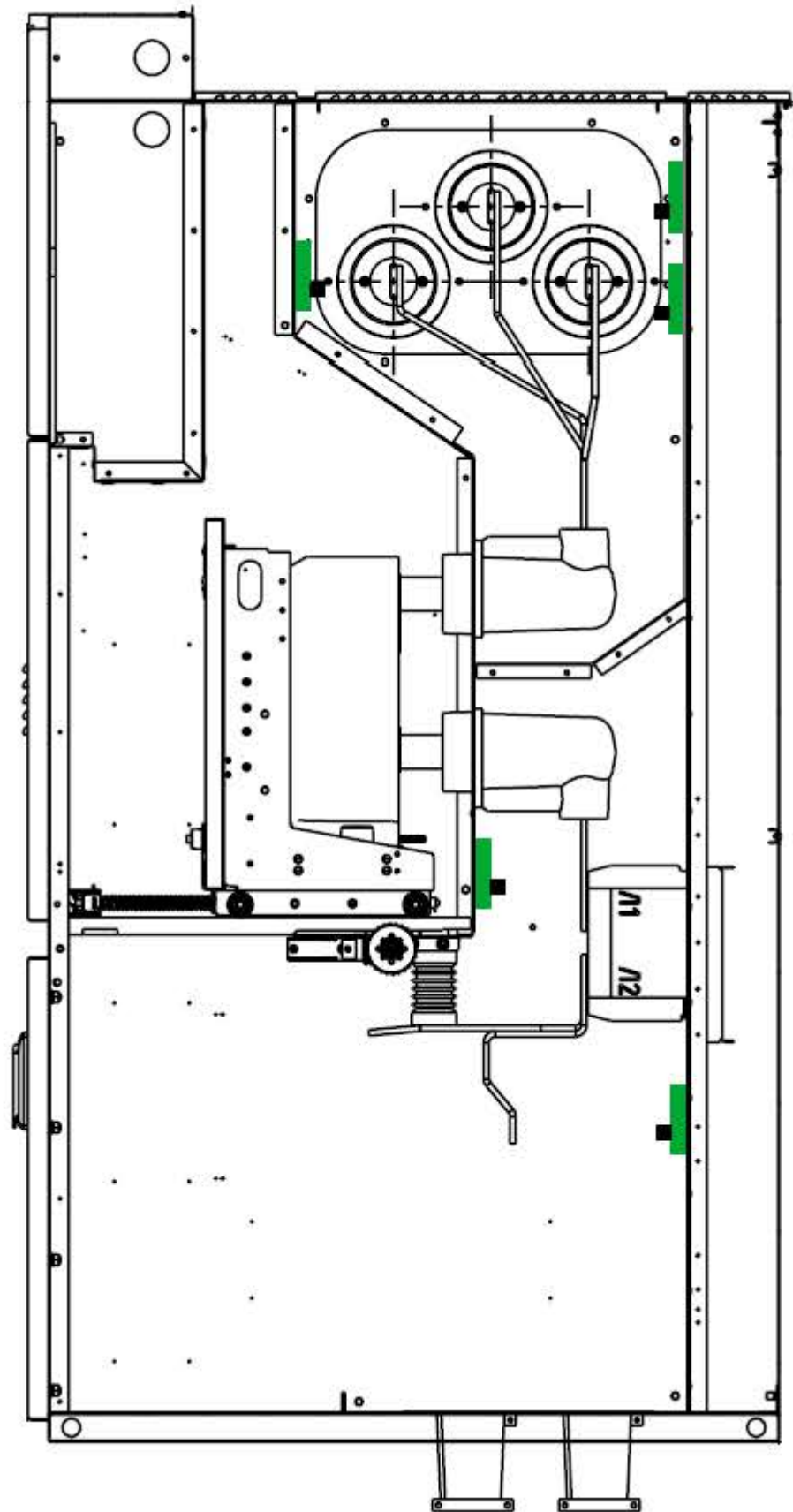


Figure 4.2. The location of ITS sensors in a switchgear panel D12-P series

5 Configuring

5.1 Sensor configuration

It is recommended to use a USB-RS-485 interface converter to connect the sensor to a PC. The connection is made in accordance with pinout specified in section 2.2.2.

Use ES Configurator software for sensor configuration. Do the following:

1. Select the device - ITS.
2. Select interface - RS-485.
3. Set the COM port settings: number, speed, parity.
4. Set the device address.
5. Click Identify.

After completing the above steps, the program screen should look like the one shown in Fig. 5.1.

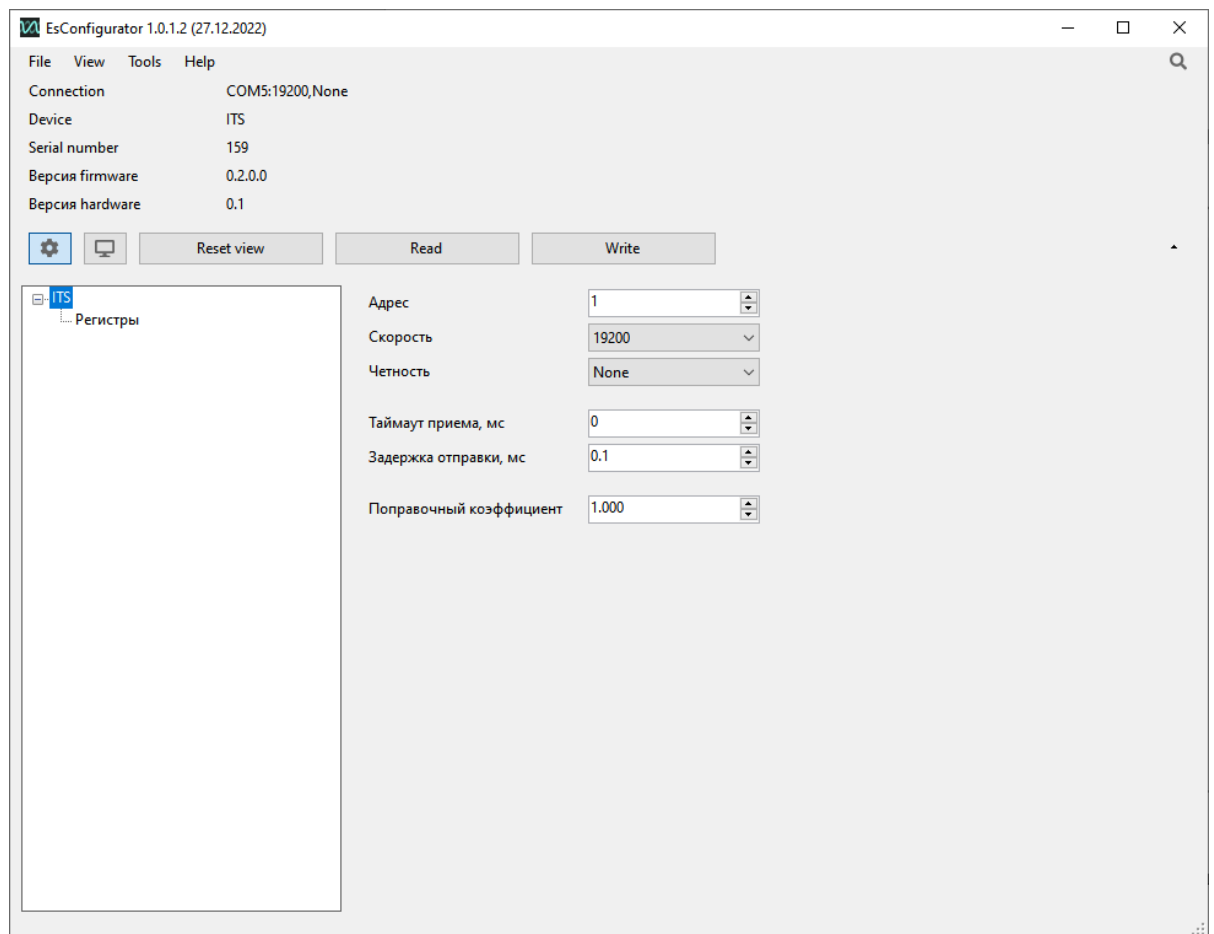


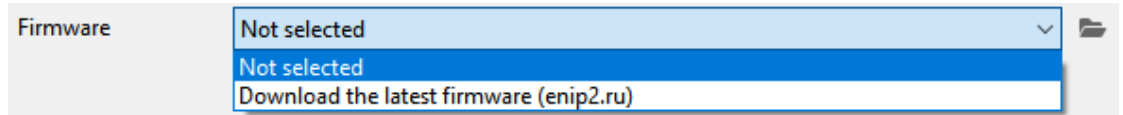
Figure 5.1. Connection if ITS to PC

Detailed description of ES Configurator software is in ENIP.411187.002([download](#)) manual.

5.2 Firmware update

To update the firmware, run the EsBootloader software, then follow the instructions below:

1. Select a series - Other.
2. Select the device - ITS.
3. Specify the connection interface - COM port.
4. For the serial port, you need to define the connection settings (port number, speed, parity).
5. Select the firmware file or download the latest version from the website.



6. Click the Auto, the program will switch to the waiting mode for the sensor to be restarted.

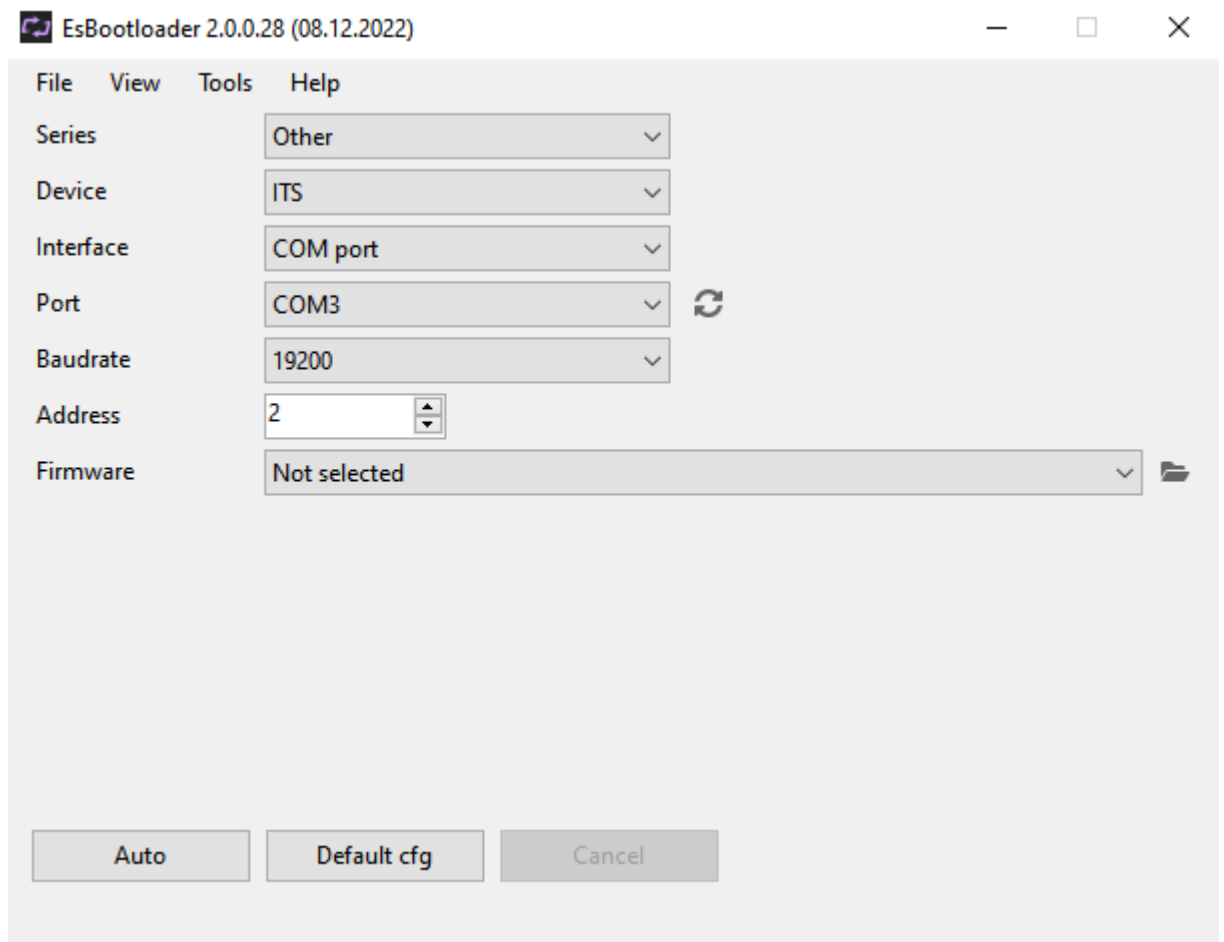


Figure 5.2. EsBootloader software

Download latest firmware and software here: enip2.ru/support

5.3 Data transfer setup

Data transfer is performed via RS-485 interface using Modbus RTU protocol. Use ES Configurator software to configure register addresses and corresponding values. Detailed information about Modbus protocol is given in Appendix B.

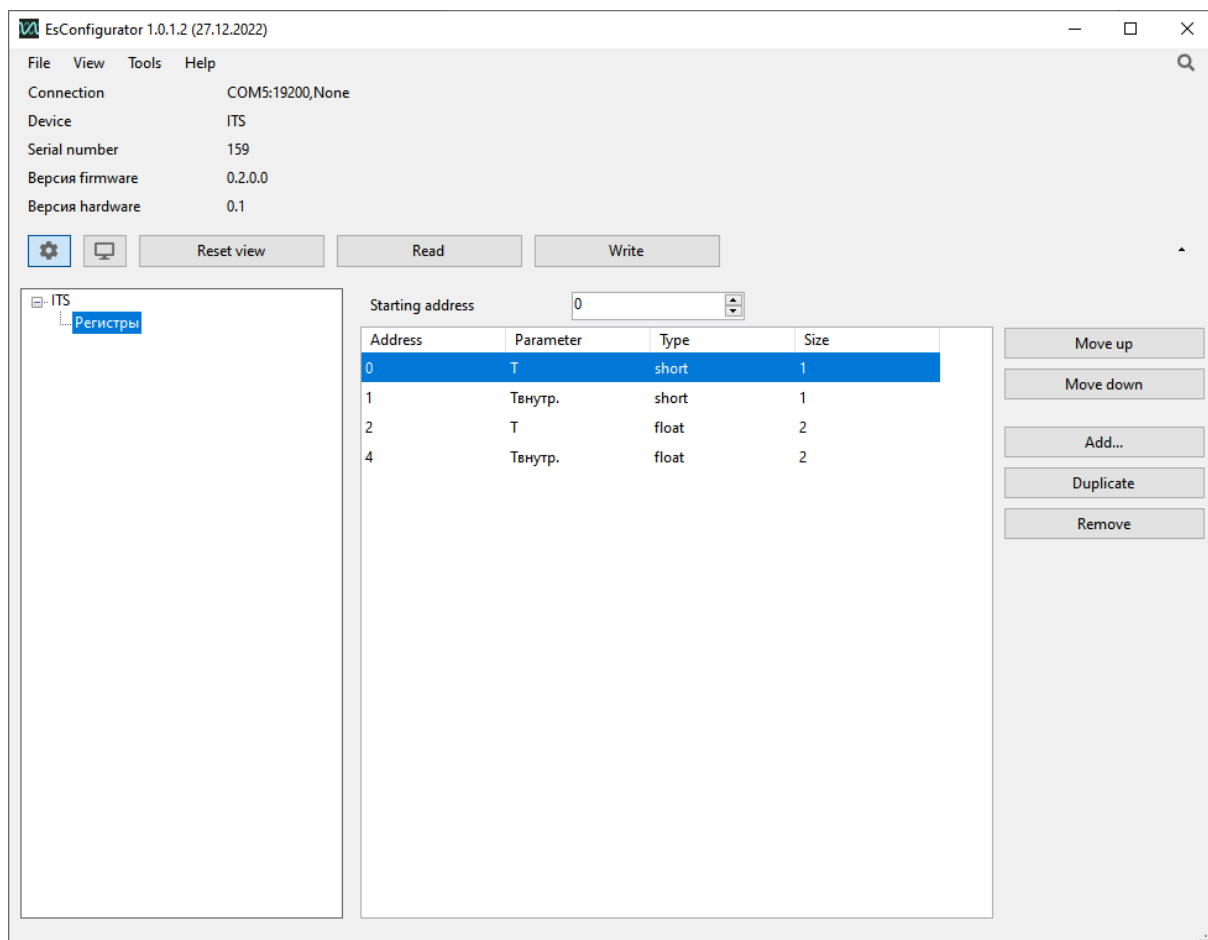


Figure 5.3.ITS sensor register addresses configuring

- 5.3.1 After connection to ITS is established do the following:
1. In the *External devices* section of the ENIP-2 configuration, add ITS sensors and specify their addresses (you can add up to 10 sensors), see fig. 5.4.
 2. In the *External measurements* section, check the box next to each connected sensor and set the required multiplier (for the ITS sensor, the multiplier is 0.1), see fig. 5.5.
- 5.3.2 After ITS sensors are added to ENIP-2 configuration it's available to read temperature values via any ENIP-2 communication protocol. For example, if you use Modbus TCP you should configure register addresses and corresponding temperature values in TCP-client section of ENIP-2 configuration.

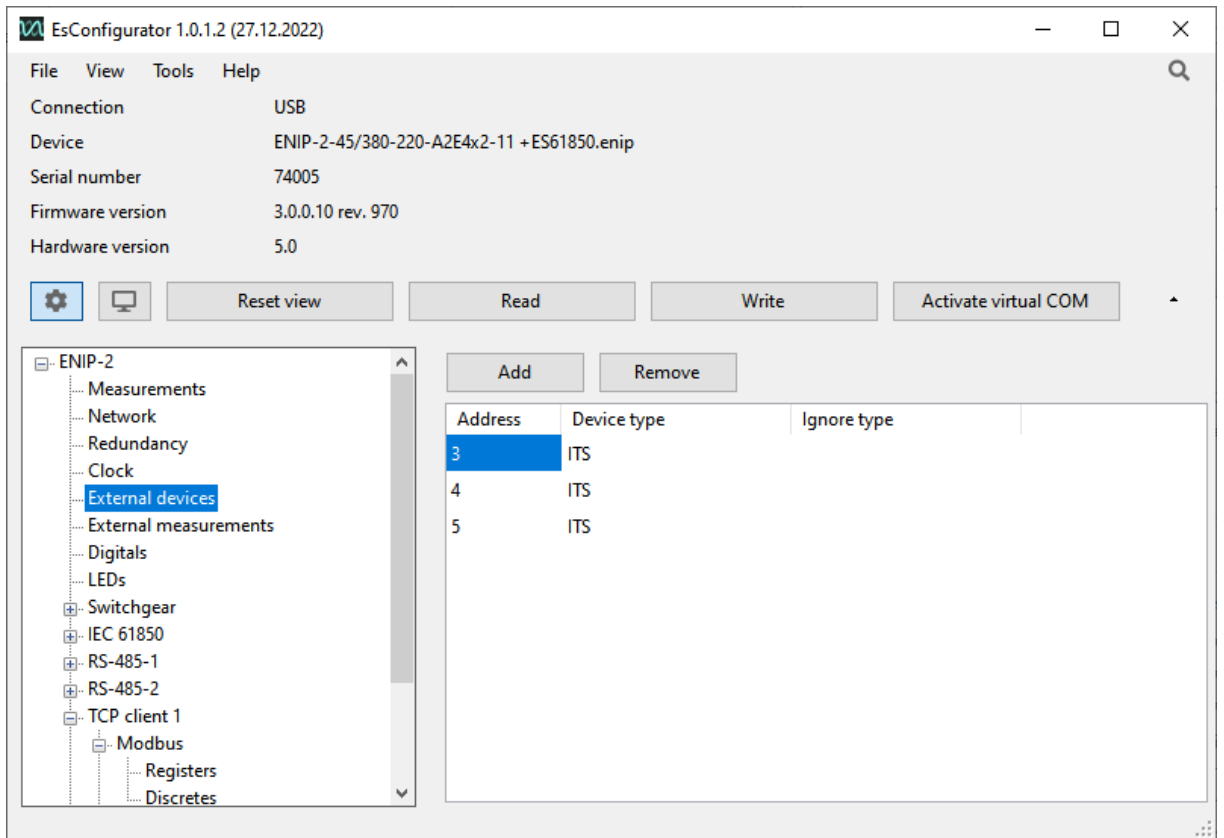


Figure 5.4. Add ITS sensors to ENIP-2 configuration

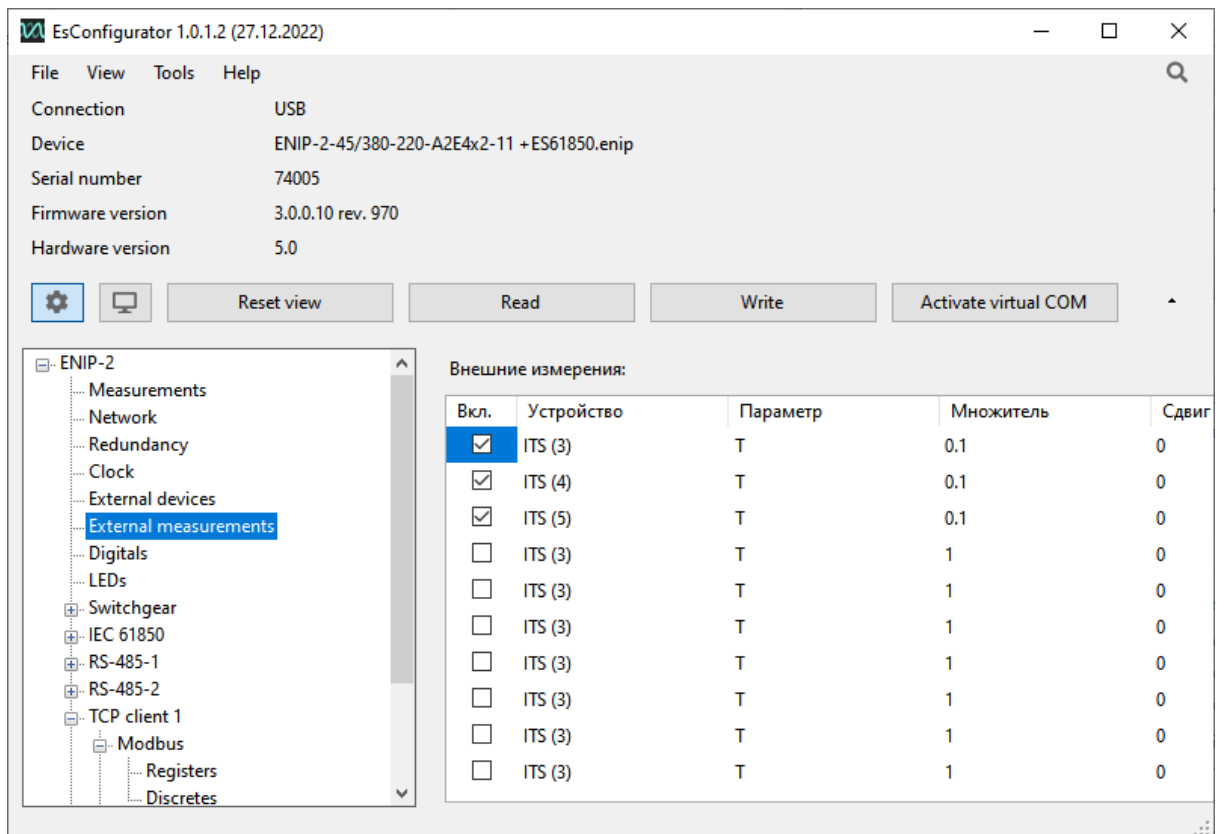


Figure 5.5. Enable ITS measurements in ENIP-2 configuration

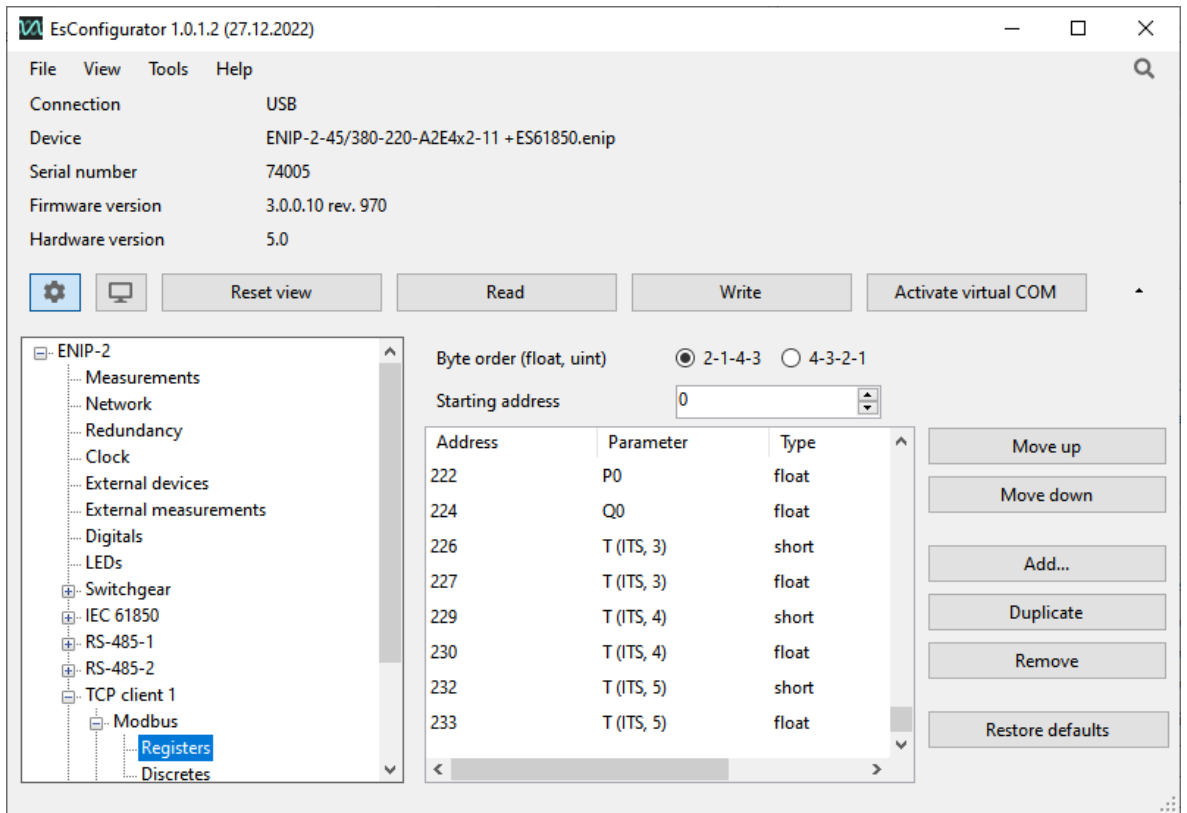


Figure 5.6. Configure Modbus register addresses for data transferring to SCADA system

6 Diagnostics

The ITS sensor's RJ45 connectors have LEDs, that can be used to diagnose the sensor. The list of LED states is presented in Table. 6.1.

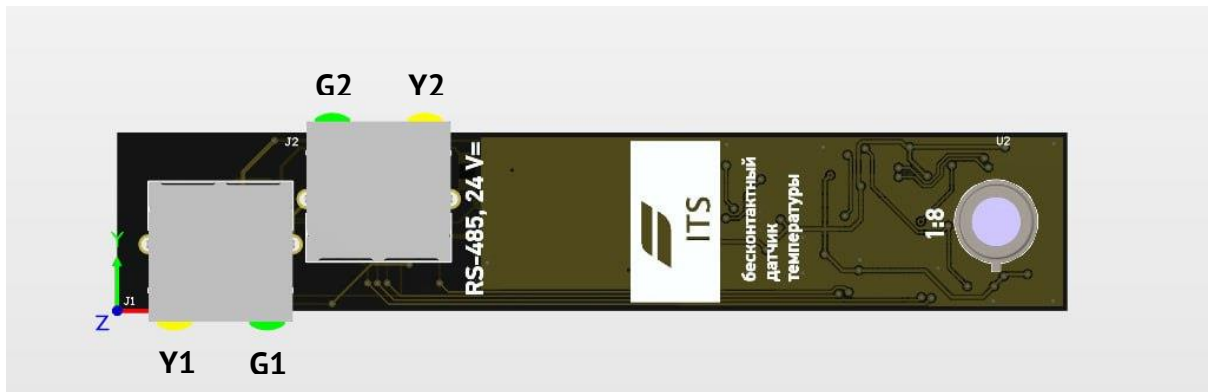


Figure 6.1. ITS sensor LED indicators

Table 6.1. The list of LED states

| LED | Indication | State |
|-----|------------------------|-------------------------|
| Y1 | ☑ Off | Normal state |
| | ⚠ Solid On | Sensor error |
| G1 | ☑ Solid On or flashing | Data transferring |
| | ⚠ Off | No data |
| G2 | ☑ On | Device is on |
| | ⚠ Off | Device is off, no power |
| Y2 | ☑ Solid On or flashing | Data transferring |
| | ⚠ Off | No data |

7 Labels

There are following labels on ITS sensor:

- device symbol;
- device name;
- serial number and year of manufacture;

8 Transportation, packing and storage

ITS sensors are transported in any covered transport (train, car, airplane). Transport conditions temperature is $-50...+70^{\circ}\text{C}$, relative humidity is 95 % at 30°C . Save ITS from impact during the transportation.

ITS is delivered in packaging case. Package contents is according to section 3.

Store the device in dry and clean location.

Appendix A. Wiring diagrams

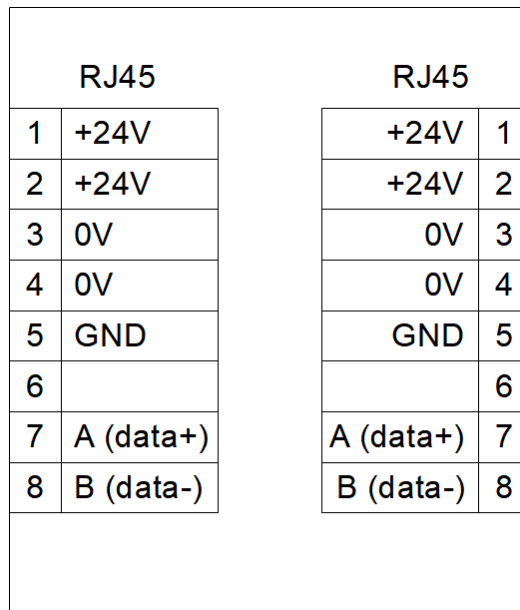


Figure A.1. Wiring diagram of ITS

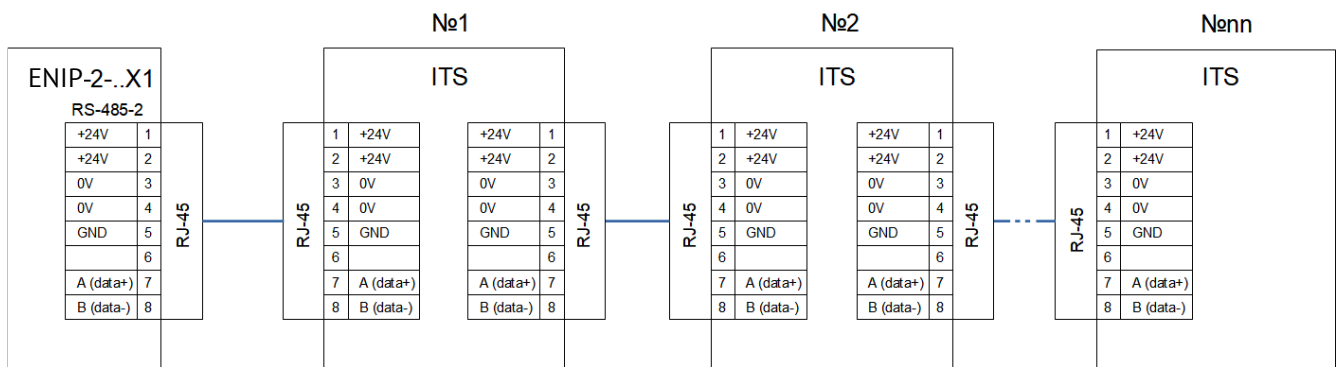


Figure A.2. Network diagram (ITS sensors connected to ENIP-2)

Appendix B. Modbus RTU protocol

General information

This appendix describes Modbus (Schneider Electric trademark) communication protocol. It's used for communication between the ITS and other control system devices.

For detailed information about Modbus, it is recommended to refer to the website www.modbus.org.

When using RTU mode, each byte of the message contains two 4-bit hexadecimal numbers. Each message is transmitted in a continuous stream.

RTU mode each byte format:

- Encoding system: 8-bit binary, hexadecimal 0 - 9, A - F
- Each byte of the message contains two hex numbers.

Bit assignment:

- 1 start bit
- 8 data bits, least significant bit (LSB) first
- • 1 parity bit; no parity bit
- • 1 stop bit if there is parity; 2 stop bits if no parity
- • Checksum: Cyclical Redundancy Check (CRC)

Message content

The message begins with a silence interval equal to the transmission time of 3.5 symbols at a given network baud rate. The first field is the device address.

The last character transmitted is also followed by a silence interval of at least 3.5 symbols. A new message must start no earlier than this interval.

Thus, if a new message starts before the 3.5 symbols interval, the receiving device will interpret it as a continuation of the previous message. In this case, an error is set, since there will be a mismatch in the checksums

| Start | Address | Function | Data | CRC | End |
|-------------|---------|----------|-----------|--------|-------------|
| T1-T2-T3-T4 | 8 bit | 8 bit | N x 8 bit | 16 bit | T1-T2-T3-T4 |

Address field

Frame address field contains 8 bits. The valid address is in the range 0 -247. Each slave device is assigned an address between 1 and 247. Address 0 is used for broadcast transmission and is recognized by each device. When the MODBUS protocol is used at a higher network level, broadcast transmission may not be supported or may be implemented by other methods.

Function field

Frame function field contains 8 bits. Number range is 1-255. When a slave device responds to the master it uses function code field to capture an error. In case of good response slave device repeats original function code.

Data field

The data field in a master-to-slave message contains additional information that the slave needs to perform the specified function. It may contain the addresses of registers or outputs, their number, the counter of the transmitted data bytes.

Checksum

Checksum field contains 16-bit value. Checksum is the result of Cyclical Redundancy Check (CRC) calculation performed on the message content.

CRC added to the message as the last field with least significant byte first

Symbol transmission format

Symbols are transmitted with least significant byte first.

- RTU frame with parity

| | | | | | | | | | | |
|-------|---|---|---|---|---|---|---|---|--------|------|
| start | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | parity | stop |
|-------|---|---|---|---|---|---|---|---|--------|------|

- RTU frame without parity

| | | | | | | | | | | |
|-------|---|---|---|---|---|---|---|---|------|------|
| start | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | stop | stop |
|-------|---|---|---|---|---|---|---|---|------|------|

Error check

Standard MODBUS network uses two methods of error check: parity check (even/odd) and checksum. Both of these checks are generated in master device. Slave device check every byte and whole message during receiving process. If slave device detects transmission error it doesn't form a response to the master. If there are no data

reception errors, the slave device (discrete I/O module) starts transmission no later than 25 ms from the moment the data reception from the master device is completed.

Parity check:

The user can configure devices to check parity (even/odd).

For example, 8-bit RTU mode contains following information:

1100 0101

Total number of “1” is 4. If even parity used parity bit will be equal 0 and total number of “1” will be even. If odd parity used parity bit will be equal 1 and total number of “1” with parity bit will be equal 5 (odd number).

CRC checksum:

CRC checksum contains two bytes. It’s calculated by sending device and added to the end of the message. Receiving device calculates the checksum during receiving process and compare it with CRC field of received message.

The counter of checksum is initialized with 0xFFFF. Only 8 bits of data used for CRC checksum calculation. Start, stop, parity bits are not included in the checksum.

In CRC generation process each byte of the message is XORed with the current contents of the checksum register. The result is shifted in the direction of the LSB, with the most significant bit filled with zero. If the LSB is 1, then the contents of the checksum register are XORed with the specified number. If the LSB is 0, then no XOR is done.

Shift repeats 8 times. After the last (eighth) shift was performed next byte is added to the current value of the checksum register and shift process repeats eight times as described above. The final content of the register is the CRC checksum.

CRC algorithm:

- 1) 16-bit register is loaded by 0xFFFF number and uses further as CRC register.
- 2) The first byte of the message is XORed with CRC register value. The result is put into CRC register.
- 3) CRC register is shifted to the right by 1 bit, the most significant bit filled with zero.
- 4) If the LSB is 0, step 3 is repeated. If the LSB is 1 CRC register is XORed with polynomial 0xA001.
- 5) Step 3 & 4 are repeated eight times.
- 6) Step 2-5 are repeated for the next message byte. This is repeated until all message bytes have been processed.

7) The final content of CRC register is the checksum.

Placing CRC in message:

When transmitting 16-bit CRC checksum low byte is transmitting first then the high byte. An example of CRC value of 0x1241:

| Address | Function | Bytes counter | Byte | Byte | Byte | Byte | CRC (least significant) | CRC (most significant) |
|---------|----------|---------------|------|------|------|------|-------------------------|------------------------|
| | | | | | | | 41 | 12 |

Supported functions

| Function code | Name | Description |
|---------------|------------------------|----------------------------|
| 03h | Read holding registers | Analog information reading |
| 04h | Read input registers | |

Addressing

The sensor provides following temperature values: T (object temperature) and T_{internal} (ambient temperature). Values are available in short and float data types. Short values are scaled.

You need to multiply the register value by the factor (it equals 0.1 for ITS sensor) to convert scaled value to temperature.

Float type registers contains values in format significand and base. This representation is defined in IEEE 754 standard.

You can configure register addressing other than the default in ES Configurator software. You can change the order of the registers as well. ES Configurator software has preconfigured addressing.

Default addressing:

| Address | Number of bytes | Value | Type | Factor |
|---------|-----------------|-------------------------|-------|--------|
| 0 | 1 | T | short | 0,1 |
| 1 | 1 | T _{internal} . | short | 0,1 |
| 2 | 2 | T | float | - |
| 4 | 2 | T _{internal} . | float | - |

You can read data from the sensor by 03 and 04 commands. An example of the request and the response to 03 command is below.

The request:

| Address | Function code | Start address | | Number of registers | | CRC | |
|---------|---------------|---------------|----|---------------------|----|-----|----|
| 02 | 03 | 00 | 00 | 00 | 01 | 84 | 39 |

The response:

| Address | Function code | Number of bytes to follow | | Register values | | CRC | |
|---------|---------------|---------------------------|--|-----------------|----|-----|----|
| 02 | 03 | 02 | | 00 | FC | FC | 05 |

The response contains short type value – 0x00FC, which corresponds to 252 in decimal. It's scaled value so you need to multiply it by 0.1 and the resulting temperature will be 25.2 °C.