Firmware version 2

- IOMOD 4RTD User Manual

IOMOD 4RTD User Manual

1. Introduction

IOMOD 4RTD uses resistance temperature detector (RTD) platinum sensors to monitor temperature data over Modbus, IEC-60870-103, or IEC-60870-101. Up to four RTD temperature sensors can be connected at once.

1.1 Features

● Temperature sense with ±0.5 °C accuracy in all operating conditions;
● Selectable PT100 or PT1000 RTD temperature sensor for every channel (2, 3 or 4 wire);
● 2.5kV(rms) isolated RTD inputs;
● Configurable temperature and sensors’ fault detection for every channel;
● Temperature sensing ranges from -200 up to 800 °C when using platinum RTD sensors;
● Configurable Modbus, IEC-60870-103 or IEC-60870-101 settings: Slave ID, baud rate, parity and stop bits, RS485 terminating resistor, etc.
● Firmware upgrade over USB, RS485 or Ser2Net.

1.2 Block Diagram

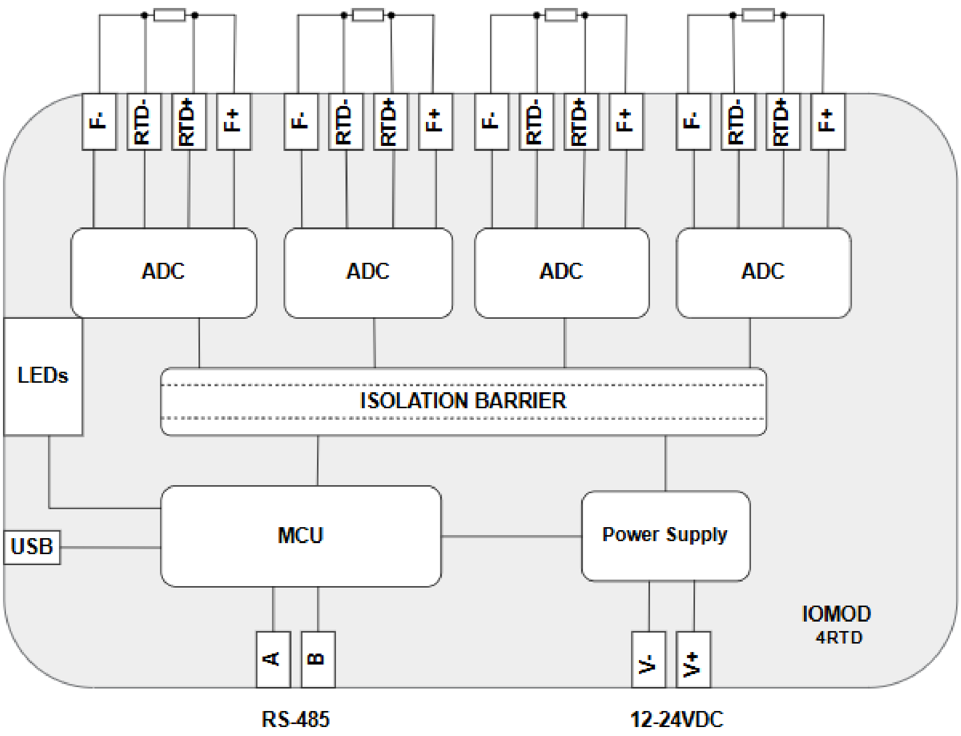


Fig. 1.2.1. IOMOD 4RTD internal structure and block diagram

2. Hardware data

2.1 Mechanical drawings

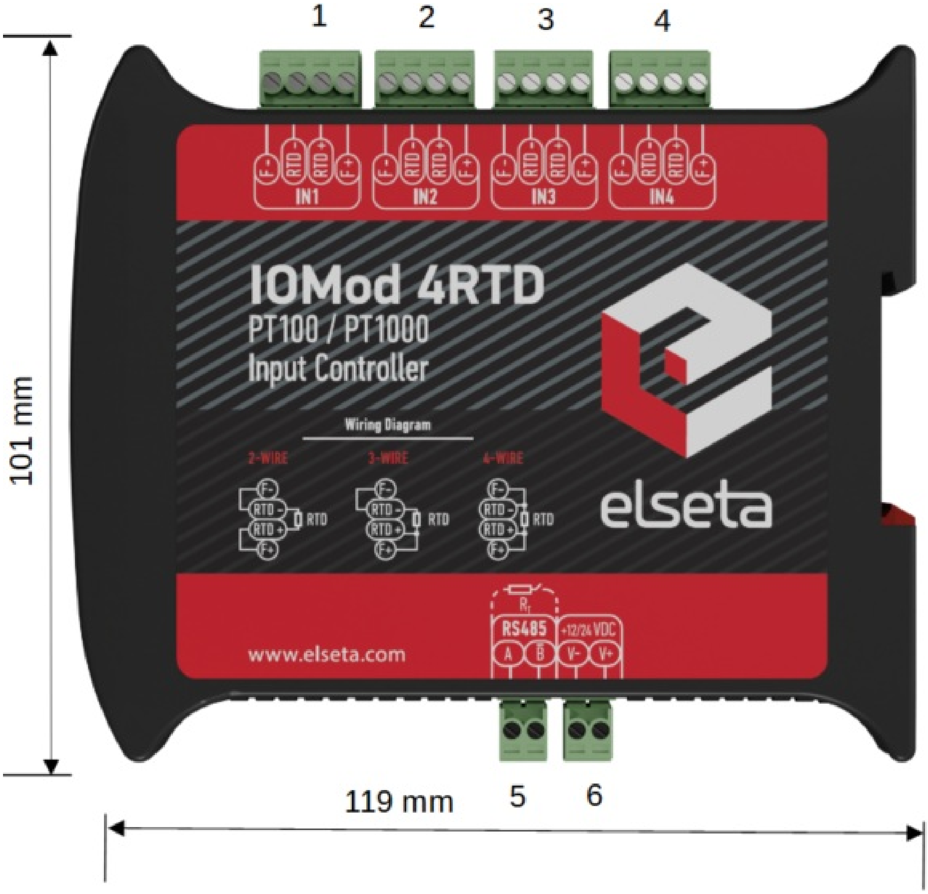
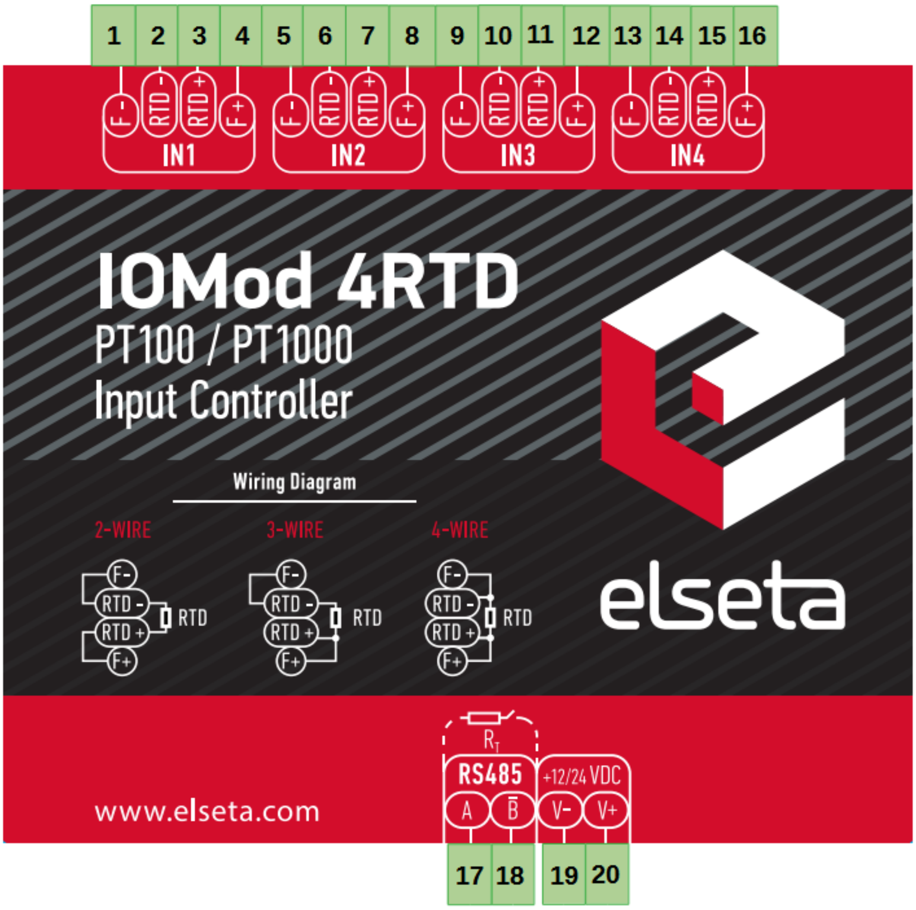


Fig. 2.1.1 IOMOD 4RTD side view with dimensions and terminals description. 1 - 4 sensor inputs, 5 - RS485 interface, 6 - power supply input

Fig. 2.1.2. IOMOD 4RTD front view with measurements

2.2 Terminal connections

IOMOD 4RTD has 20 terminals, which are depicted below:



Fif. 2.2.1 IOMOD 4RTD terminal diagram

The description of each terminal can be found in the table below:

Table 2.2.1 Terminal Specifications

Terminal number	Terminal name	Description
1, 5, 9, 13	F - (IN1–IN4)	The negative excitation terminal, completing the circuit for the supplied current.
2, 6, 10, 14	RTD - (IN1–IN4)	This terminal is connected to the low side of the RTD element, providing a reference voltage for accurate resistance measurement.
3, 7, 11, 15	RTD + (IN1–IN4)	This terminal is connected to the high side of the RTD element and measures the voltage drop across it.
4, 8, 12, 16	F + (IN1–IN4)	This is the positive excitation or supply current terminal that provides a constant current source to the RTD element.
17	A	RS485 non-inverting (positive) input
18	B̄	RS485 inverting (negative) input
19	V-	Negative power source input
20	V+	Positive power source input

2.3 Status indication

IOMOD 4RTD has six LEDs (Fig 2.3.1), which indicate the faults of RTD sensor inputs, communication and power statuses.

IOMOD 4RTD devices have indications that help users easily debug possible problems. Light-emitting diodes can show if an RTD fault has occurred on four RTD measuring channels (FLT1-FLT4). STAT LED indicates if a proper power connection is made - this LED is always on if the device has a power connection. Blue light means the device is only powered via USB, green light indicates proper power connection is made. There is no fault condition on the printed circuit board, and a red light means something is wrong with either the power connection or RTD channels. RX/TX status LED indicates if RS- 485 transmission is happening at the moment.

Fig. 2.3.1 IOMOD 4RTD LEDs physical location

The description of each IOMOD 4RTD LED can be found in the table below:

Table 2.3.1. Description of LEDs.

Name	LED color	Description
FLT1 - FLT4	○ (off)	Normal operation.
	□ (red)	Input fault or faults occurred during the operation of the device.
RX/TX	□ (green)	A blinking green light indicates active communication via the RS485 interface.
STAT	□ (green)	The power source is connected to the power supply input.

	(blue)	IOMOD 4RTD is connected to an external device via a USB mini cable.

3. Technical information

Table 3.1

System	
Dimensions	17.5 (H) x 101 (W) x 119 (L), mm
Case	ABS, black
Working environment	Indoor
Operating temperature	-40 | +80°C
Recommended operating conditions	5 – 60°C and 20 – 80% RH;
Configuration	USB, RS485
Firmware upgrade	USB, RS485
Electrical characteristics	
Termination resistor	Selectable, 120Ω
Power	
Power Supply	9-33 VDC
Current consumption	40mA @ 12VDC, 20mA @ 24VDC

4. Mounting and installation

4.1 RTD sensor connection

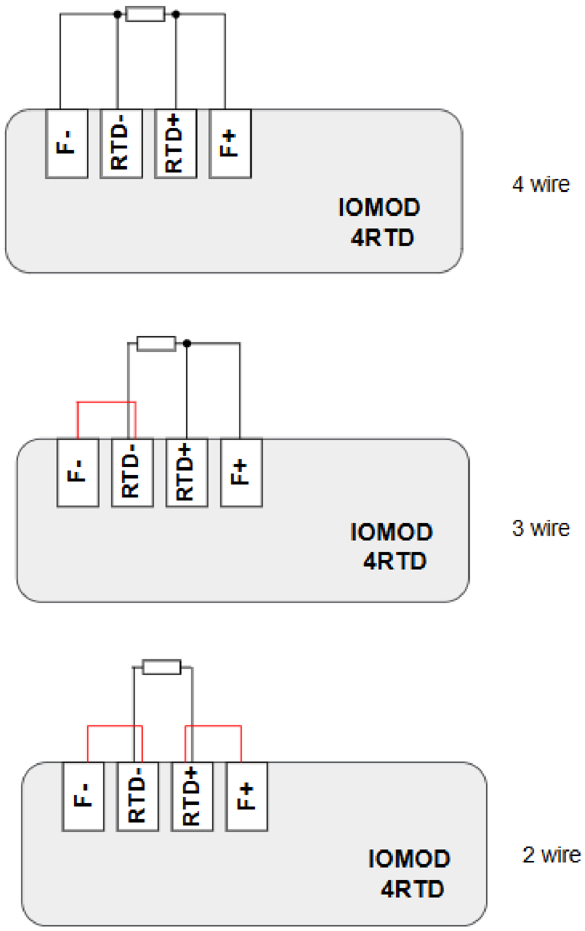


Fig. 4.1.1 RTD sensor connections, the red wire is shorted on the terminal plug

IOmod 4RTD accepts 2-wire, 3-wire or 4-wire connection types of RTD sensors (PT100, PT1000). Firstly, select a sensor type (PT100 or PT1000) using a USB terminal. Secondly, use the following instructions depending on the number of wires of a selected RTD sensor.

2-wire RTD sensor: connect wire to RTD+ and RTD- contacts. The connection between RTD+ and F+, RTD- and F- must be shorted (Fig. 4.1.1).

3-wire RTD sensor: connect one wire to RTD+, a second wire (compensating lead wire) to F+ and wire to RTD-. The jumper between RTD- and F- must be shorted (Fig. 4.1.1).

4-wire RTD sensor: connect wires to RTD+ and F+ contacts, and wires to RTD- and F- contacts. No contacts shall be shorted. (Fig. 4.1.1).

4.2 RS485 Interface

IOMod 4RTD has one RS485 connector. Connect the RS485 cable pair to contacts marked RS485/A and RS485/B. Connections should be made with the minimum possible cable stub.

IOMOD 4RTD has an integrated 120Ω termination resistor which can be enabled or disabled over USB configuration. It is recommended to use termination at each end of the RS485 cable. See the typical connection diagram in Fig. 4.2.1

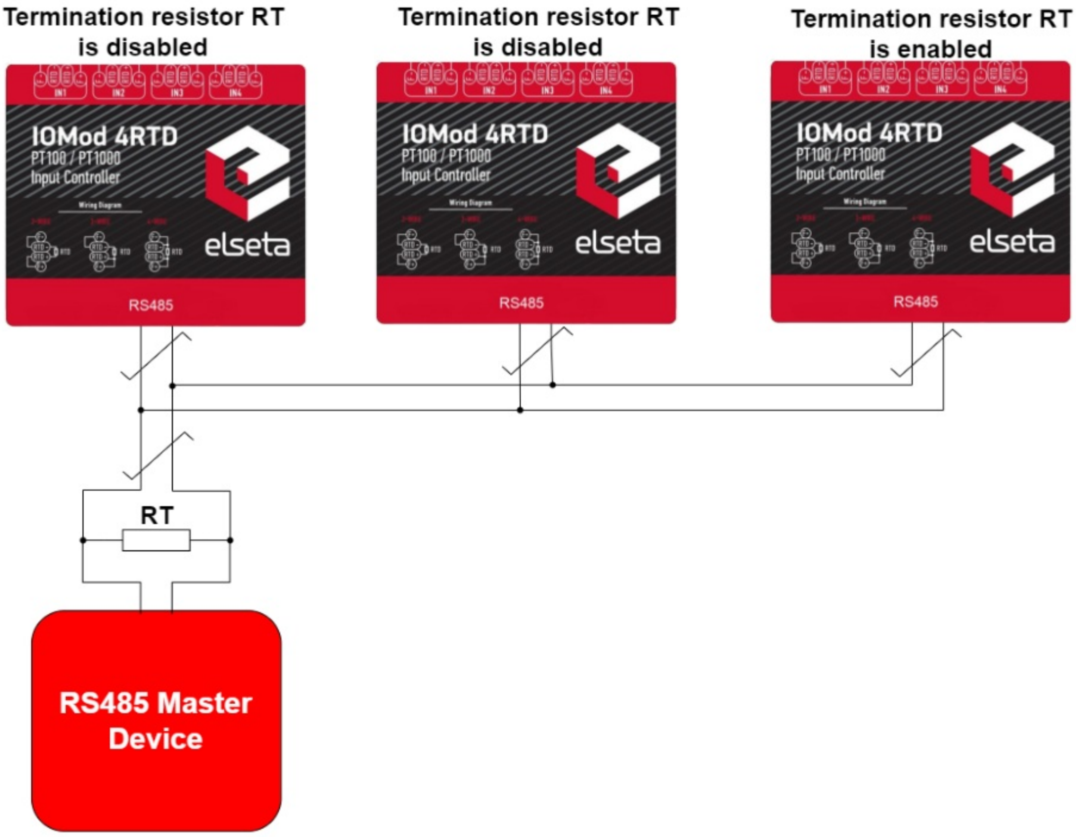


Fig. 4.2.1 Typical IOMod connection diagram

IOMOD 4RTD has a 1/8 Unit load receiver which allows up to 256 units on the line (compared to standard 32 units). To reduce reflections, keep the stubs (cable distance from the main RS485 bus line) as short as possible when connecting the device.

4.3 Power Supply

IOmod 4RTD can be powered through the main power connector +12/24 VDC or USB. Apply +12/24VDC to V+ and 0 V to V-. The device has a built-in reverse voltage polarity, overcurrent and overvoltage protection.

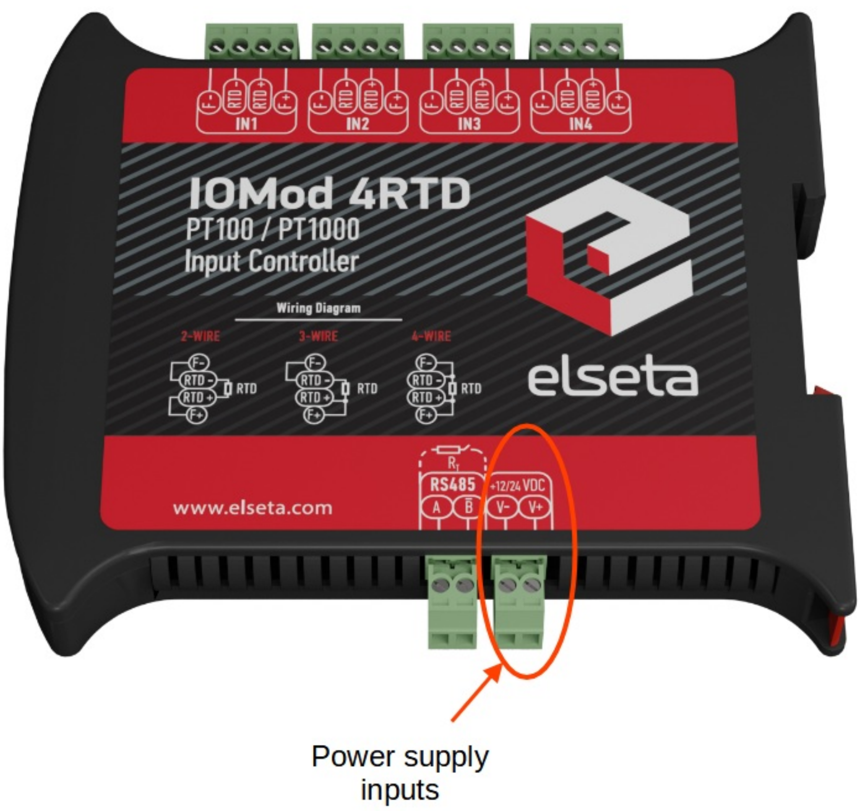


Fig. 4.3.1 Power supply inputs physical location

4.4 USB Connection

IOMOD 4RTD device has a USB-mini connection port. Its primary function is establishing a physical connection between the IOMOD and a PC. By selecting the USB interface and correct communication port in IOMod Utility (Fig. 4.4.1) a user can connect to the IOMod to control its parameters and monitor its measured data and the status of fault detection functions. Also, this connection can be used to power the module.

Fig. 4.4.1. IOMOD Utility interface and communication port parameters

Fig. 4.4.2. IOMOD 4RTD USB connection port physical location

5. Parametrization

In this section, the IOMOD 4RTD settings configuration is described. IOMod 4RTD configuration is performed via IOMOD Utility (the manual can be accessed here). All IOMOD-related settings can be found in the "Iomod settings" tab (Fig. 5.1).

Fig. 5.1. IOMod settings tab

5.1 Iomod Settings

To configure IOMOD 4RTD general settings open the "Iomod settings" tab in IOMOD Utility (Fig. 5.1.1).

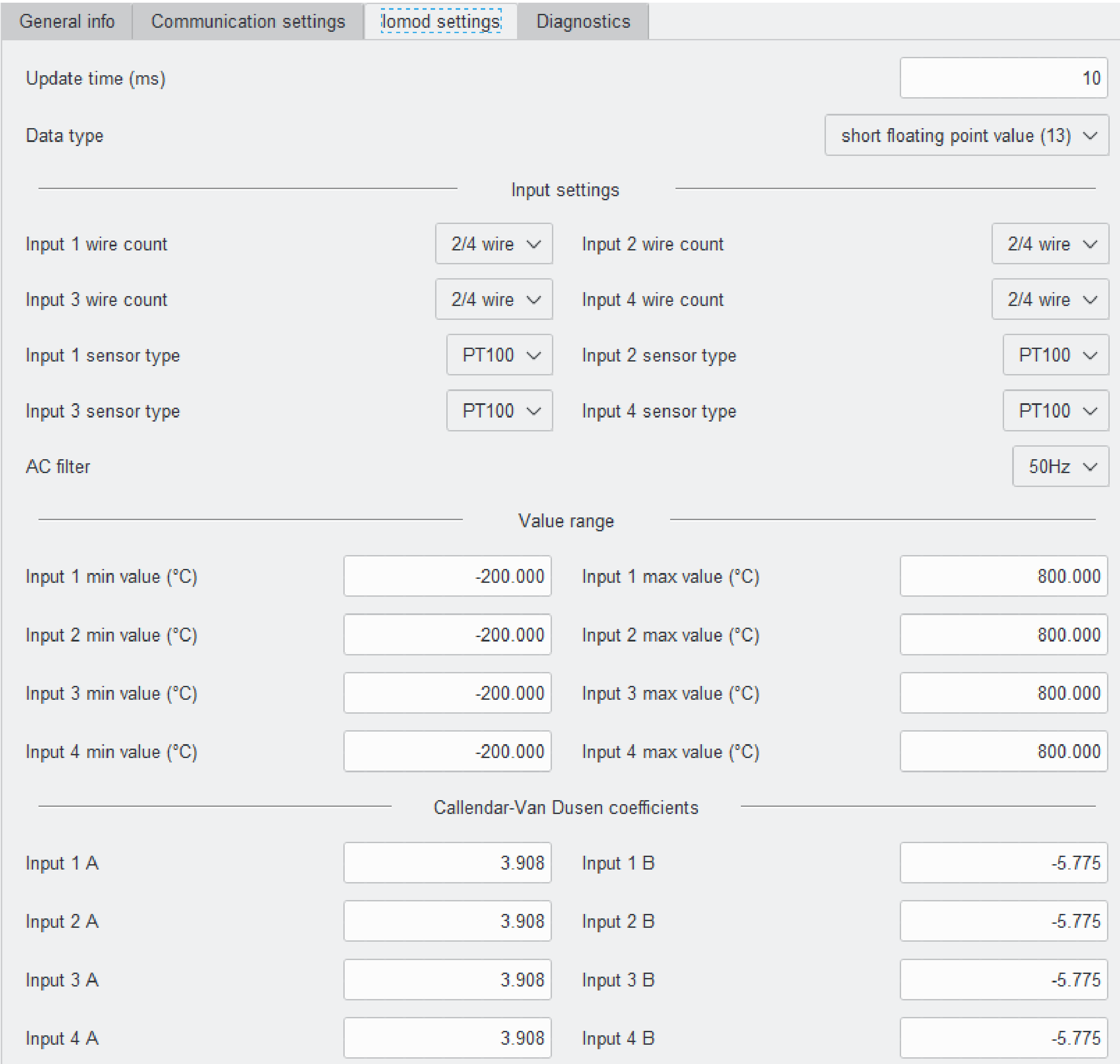


Fig. 5.1.1. IOMOD Utility with IOMOD 4RTD Iomod settings window opened

IOMOD Utility is a tool created to configure IOMODs with firmware version 2. This tool allows users to connect, configure, and diagnose IOMODs such as 8DI8DO, 8DI4RO, 16DI, 8AI, 4RTD, 4CS4VS, METER, and FPI. The Utility's interface allows users to connect to IOMOD via USB port, RS485, and ser2net. More information about this tool and its installation can be found on the documentation page IOMOD Utility.

To configure IOMOD 4RTD using IOMOD Utility, first connect to a device or create a template as explained in the IOMOD Utility documentation. Parameters for IOMOD 4RTD can be configured on the *Iomod settings* tab. IOMOD with default settings is configured as an IEC101 slave device. Default IOMOD parameters can be seen in the picture above.

The update time (ms) parameter is only available for protocols IEC101 and IEC103. This parameter specifies the frequency of data sent to the buffer, which is later can be read by a master station. The Data type parameter can be changed for the IEC101 protocol. The default data type is a short floating point value (type 13), but the scaled value (type 11) can be selected as well.

For each input, the user can select either 3 or 2/4 wire count, PT100 or PT1000 sensor type and AC filter frequency – 50 or 60 Hz. These settings should be configured according to the sensor parameters.

Value range can be set without any limitations. However, it is important to know that if the measured value is lower or higher than the set, data will be returned with an overflow flag. Configuring a reasonable value range for the measured temperature range is recommended.

The Callendar–Van Dusen equation is an equation that describes the relationship between resistance (R) and temperature (T) of platinum resistance thermometers (RTD). The Callendar–Van Dusen equation is expressed below:

$$R_T = R_0[1 + AT + BT^2 + (t - 100)CT^3]$$

R_T is resistance at a certain temperature, R_0 is resistance at 0˚C and T is the temperature in ˚C. A, B and C are known as the Callendar-Van Dusen constants, defined by the following equations:

$$A = \alpha + \frac{\alpha\delta}{100}$$

$$B = \frac{-\alpha\delta}{100^2}$$

$$C = \frac{-\alpha\beta}{100^4}$$

Alpha, beta and delta are constants that are found with the following equations:

$$\alpha = \frac{R_{100} - R_0}{100 + R_0}$$

$$\beta = constant\ if\ t < 0^{\circ}C, else\ zero$$

$$\delta = \frac{R_0[1+\alpha(260)] - R_{200}}{4.16 R_0 \alpha}$$

Knowing that the user can adjust the A and B coefficient values for each IOMOD 4RTD input. However, default values are set according to the European Industrial Standard (Standard DIN 43760, IEC 751).

The Iomod settings' available values and ranges can be seen in the table below (Table 5.1.1).

Table 5.1.1 IOMOD 4RTD parameter ranges and default values

Parameter	**Range**	**Default value**
Update time (ms)*	10-60000	10
Data type**	scaled value (11), short floating point value (13)	short floating point value (13)
Input [ ] wire count	3 wire, 2/4 wire	2/4 wire
Input [ ] sensor type	PT100, PT1000	PT100
AC filter	50Hz, 60Hz	50Hz
Input [ ] min value (˚C)	-200 – 800	-200.00
Input [ ] max value (˚C)	-200 – 800	800.00
Input [ ] A	3.908 – 3.985	3.908
Input [ ] B	(-5.775) – (-5.850)	-5.775

** The parameters are defined only for IEC 60870-5-103 and IEC 60870-5-101 communication protocols.*

*** The parameters are defined only for the IEC 60870-5-101 communication protocol.*

5.2 Diagnostics

The Utility diagnostics windows allow users to connect to IOMOD directly and observe the values in real time. The 4RTD diagnostics window shows values of inputs in Celsius and faults. If a certain fault appears, the Diagnostics window indicates it with a blue square next to a fault type.

To turn on real-time monitoring of both Diagnostics sections, the "Connect" button to the left of the "Offline" word designation needs to be pressed. After pressing the "Connect" button the word designation of Diagnostics mode changes to "Online", the black circle starts blinking and the button name changes to "Disconnect" (Fig. 5.2.1). When a fault is detected the checkboxes are going to be checked.

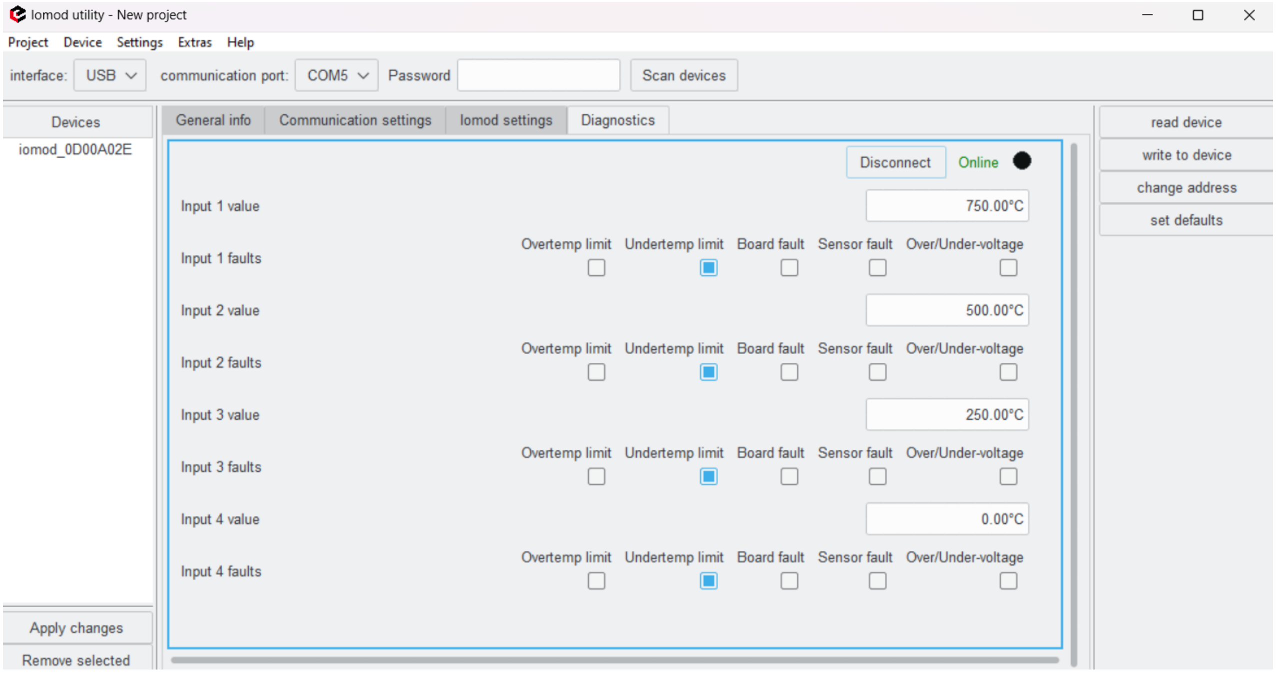


Fig. 5.2.1. IOMOD Utility Diagnostics tab in online mode

6. Communication protocols

IOMOD 4RTD uses Modbus (RTU), IEC-60870-103 or IEC-60870-101 protocols over Ser2Net or RS485 connection, which can be used for cable lengths up to 1500 meters and connect up to 30 devices on one line. Default Modbus, IEC-60870-103 and IEC-60870-101 settings are: 19200 bauds/s baudrate, 8E1, Slave (Link) address - 1.

6.1 Modbus RTU Operational Information

To read temperature from the RTD sensor with Modbus protocol, send the 04 Modbus command (Read Input Registers) with a resolution of two registers from 0 to 7. Odd numbers represent the least significant words, even numbers represent the most significant words. For example, to read the temperature measured by the first RTD, read registers 0 and 1, where register 0 is the least significant word. Two words read by Modbus represent a float type (IEEE-754 compatible) variable.

The IOMOD 4RTD uses Modbus RTU function code 1 to read fault flags. The fault is implemented as a high logic level if any configured fault has occurred; otherwise, it is zero. Fault flags are cleared automatically if possible. The Modbus RTU function code 3 may be used to read holding registers containing temperature limits defined by the user in degrees Celsius and fault mask registers.

Temperature limits are defined as 16-bit integer values. Values that are below or above the predefined limits are ignored. These limits are described in the Modbus register mapping table below. If the upper limit value is lower than the lower limit value, these values are switched between them.

Fault mask registers contain information about fault bits that would be lifted in the fault register if any particular fault for a specific RTD has occurred. Its values for every four RTDs are kept at the holding register of addresses 10 to 13.

The Modbus RTU function code 4 may be used to read current temperature values and faults.

As the temperature is kept as a 4-byte wide float value, two neighbouring registers are used to keep it. RTD values are kept at registers 0 to 7, with the least significant word first. Values read can be easily converted using any converter capable of converting floats based on the IEEE-754 standard.

Fault register values are read as 16-bit input registers on addresses 16 to 19. The meanings of individual bits are explained below in the subsection Fault registers.

The Modbus RTU function code 6 is used to set holding registers one by one, as described when explaining the 03 Modbus function. That means that arbitrary values may be written to set up different temperature limits and fault masks.

Table 6.1.1. Modbus function and registers supported by IOMOD 4RTD

Register (decimal)	Description	Value Range
	Read coil status (01)	

00010-00013	Reading fault flags	0-1
	Read holding register (03)	
00000-00007	Get temperature limits (lower limit first)	-200-800
00011-00014	Fault Mask registers for RTDs	0-57836
	Read input registers (04)	
00000-00007	Temperatures from RTD sensors, LSW first	0-65535
00016-00019	Fault registers for RTD sensors	0-57836
	Preset Single Register (06)	
00000-00007	Set temperature limits (lower limit first)*	-200-800
00011-00014	Set Fault Mask register for RTDs	0-65535

Fault registers (Modbus addresses - 16-19) are read-only. They represent faults that occurred during the operation of the device. To enable showing the desired fault user should set appropriate bits in the Fault mask register (Modbus addresses - 11-14) or via USB interface, entering Advanced Settings Tab in the RTD parameters menu. Fault registers and fault-masked registers are different for different temperature channels. Default values are shown in brackets below.

Fault register[15:14] shows flags that are lifted if temperature limits are exceeded. Bits[7:5,3:2] inform about faults that were detected by the RTD reading chip. These faults are usually lifted if unsuitable settings are set or RTD is faulty or not connected.

Table 6.1.2 Fault registers

15 (R-0)	14 (R-0)	13 (R-0)	12 (R-0)	11 (R-0)	10 (R-0)	9 (R-0)	8 (R-0)
RTD Temperature Hi Threshold	RTD Temperature Lo Threshold	-	-	-	-	-	-
7 (R-0)	6 (R-0)	5 (R-0)	4 (R-0)	3 (R-0)	2 (R-0)	1 (R-0)	0 (R-0)
RTD Code Hi Threshold	RTD Code Lo Threshold	RTD REFIN- > 0.85 x VBIAS	-	RTD FORCE Open	RTD Overvoltage/ Undervoltage	-	-

Table 7.1.3 Fault mask registers

15 (R/W-0)	14 (R/W-0)	13 (R/W-0)	12 (R/W-0)	11 (R/W-0)	10 (R/W-0)	9 (R/W-0)	8 (R/W-
RTD Temperature Hi Threshold Fault Enable	RTD Temperature Lo Threshold Fault Enable	-	-	-	-	-	-
7 (R/W-1)	6 (R/W-1)	5 (R/W-1)	4 (R/W-0)	3 (R/W-1)	(R/W2 -1)	1 (R/W 0) -	0 (R/W 0)
RTD Code Hi Threshold	RTD Code Lo Threshold	RTD REFIN- > 0.85 x VBIAS Fault	-	RTD FORCE Open	RTD Overvoltage/Undervoltage	-	-

6.2 IEC 60870-5-101 Operational Information

To read temperature using the IEC-60870-101 protocol, the user can use the device with default settings without configuring it. The data is sent via data type 13 (measured value, short floating point value). The information object addresses (IOA) are from 1 to 4. These values are represented as 12-bit integers in a range from -200°C to 200°C - temperature value is therefore multiplied by 10 to have a resolution of 0.1 °C unless the full range of RTD (from -200°C to 800°C) is selected - then the 1 °C resolution is achieved. Temperature values are not multiplied by any multiplier.

IOmod uses a standard IEC-60870-5-101 communication scheme. The master (controlling station) initiates initiation, control messages, and queries, while the IOMod device (controlled station) only answers these requests. Therefore, the master should send the first message to start/restart communication (ResetOfRemoteLink). IOMod answers this message with an acknowledgement (ACK) to enable the master to send other messages defined by the IEC-60870-5-

101 protocol.

When initialization is complete, the master may request data from the IOmod device with general interrogation. According to the protocol specification, IOMod will send data on value change. The 4RTD IOMod responds with a type 13 (M_SP_TB_1) measured value or a type 11 (M_ME_NB_1) scaled measured value.

When input status changes, the IOMod device filters input glitches through filters with a user-configurable filter time. When the filter is passed, the device sends a “Spontaneous” message with the 13 data type (M_ME_NC_1) or 11 data type (M_ME_NB_1) and “IOA” as the input number shifted by 4.

To initiate the time synchronization between devices the master must send a Clock Sync command. The command type is C_CS_NA_1 (103) and the Cause of Transmission (COT) has to be 6. The command has to be sent to the correct link address and CASDU, which is the same as the link address by default. If the sent frame is correct the IOMOD will respond with a C_CS_NA_1 (103) type command with the COT (cause of transmission) of 7 and the **p/n** bit will be positive (0) also the command will be time-tagged with the **device** time. If the time synchronization feature is disabled or the command is sent to an undefined CASDU the response is the same except the **p/n** bit will be negative (1).

General Interrogation (GI) is initiated by the master sending the General Interrogation command. The command type is C_IC_NA_1 (100) and the Cause of Transmission (COT) has to be 6. The command has to be sent to the correct link address and CASDU, which is the same as the link address by default. If the sent frame is correct the IOMod will respond with a C_IC_NA_1 (103) type command with the COT (cause of transmission) of 7 and the **p/n** bit will be positive (0). Otherwise, it will respond with the same command just that the **p/n** bit will be negative (1). Then the device will begin to send all of its data. After that's done the IOMOD will also send another 100 type command with the COT (cause of transmission) of 10 (ActTerm) meaning the general interrogation is over.

IOAs [1,4] inputs.

6.3 IEC 60870-5-103 operational information

With IEC-60870-103 fault register values are read as standard-defined 12-bit measurands. Users can define temperature upper and lower limit values for every RTD so that the overflow flag will be raised according to IEC-60870-103 standard rules for measurands when any limit is exceeded. Note that limit values are set globally so if a narrower range is selected limit values won’t be able to be higher than defined by the standard even if limits are explicitly defined as higher values. If a narrow range is selected for RTD but a higher temperature limit is above 200°C, reading temperatures above 200°C will be considered an overflow condition. Temperature limit flag bits are defined as Fault Register[11:10].

IEC 60870-5-103 is a standard for power system control and associated communications. It defines a companion standard that enables interoperability between protection equipment and devices of a control system in a substation. The device complying with this standard can send information using two data transfer methods—explicitly specified application service data units (ASDU) or generic services to transmit all possible information. The standard supports some specific protection functions and provides the vendor with a facility to incorporate its protective functions on private data ranges.

Using IOMOD firmware version 2, the IOmod 4RTD device might act as an IEC-60870-103 slave if so configured. Check the chapter Firmware Upgrade for more information about firmware upload.

The master may read (if configured) temperature values from RTD sensors and data from user-configured fault registers. The fault is cleared, and the fault register is cleared automatically whenever the fault condition disappears. Therefore, the user can easily eliminate the source of the fault without a need for a hard reset.

Fault register values are read as standard-defined 12-bit measurands. The meaning of individual bits is explained below, in the subsection Fault registers.

Users can define temperature upper and lower limit values for every RTD so that when any limit is exceeded, the overflow flag will be lifted according to IEC-60870-103 standard rules for measurands. Note that limit values are set globally so if a narrower range is selected limit values won’t be able to be higher than defined by the standard even if limits are explicitly defined as higher values. If a narrow range is selected for RTD but a higher temperature limit is above 200°C, reading temperatures above 200°C will be considered an overflow condition. Temperature limit flag bits are defined as Fault Register[11:10].