

# IOMOD 4RTD

IOMod 4RTD – industrial 4 temperature sensors module.

- Firmware version 1
  - IOMOD 4RTD User Manual Modbus
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Firmware version 1

# IOMOD 4RTD User Manual Modbus

## Introduction

IOMOD 4RTD is used for temperature data monitoring over Modbus, IEC-60870-103 using resistance temperature detector (RTD) platinum sensors. Up to 4 RTD temperature sensors can be connected at once.

## Features

- Temperature sense with  $\pm 0.5$  °C accuracy over 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 or IEC-60870-103 settings: Slave ID, baud rate, parity and stop bits, RS485 terminating resistor, etc.
- Firmware upgrade over USB.

## Operational Information

IOMOD uses Modbus (RTU) or IEC-60870-103 protocols over RS485 connection, which can be used for cable lengths up to 1500 meters and connect up to 30 devices on one line. Default Modbus and IEC-60870-103 settings are: 9600 bauds/s baudrate, 8N1, Slave (Link) address - 1.

To read temperature using protocol user can use device with default settings without configuring it.

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

For further information regarding setting temperature parameters and configurable options please refer to table shown below, also supported MODBUS functions described in paragraphs described below.

CONFIGURABLE OPTIONS	OVER USB	OVER MODBUS
Slave Address	Yes	No
Baudrate	Yes	No
Data, Stop and Parity bits	Yes	No
RS485 Terminating Resistor	Yes	No
RTD parameters	Yes	No
Default settings	Yes	No
Setting temperature limits	Yes	Yes
Fault configuration	Yes	Yes

## Status LED

Status LED can be in 2 colors :

Blue - Device connected to USB.

Green - Normal operation.

## Rx/Tx LED

The RX/TX LED on the IOMod flashes when data is either being transmitted or received via the RS485 port.

## FLT1, FLT2, FLT3, FLT4 LEDs

Input fault LEDs can be in 2 states :

Off - Normal operation.

Red - Input fault or faults occurred during operation of device.

## Supported MODBUS functions

### 01 (0x01) Read Coil Status

Used to read fault flags. Fault is implemented as high logic level if any configured fault has occurred, zero otherwise. Fault flags are cleared automatically if possible.

### 03 (0x03) Read Holding Registers

May be used to read holding registers containing temperature limits defined by user in degrees Celsius, fault mask register.

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 Modbus register mapping table below. If upper limit value is lower than lower limit value, these values are switched between them.

Fault mask registers contain information about fault bits that would be lifted in fault register if any particular fault for particular RTD has occurred. Its values for every four RTDs are kept at holding register of addresses 11 to 14.

### 04 (0x04) Read Input Registers

May be used to read current temperature values and faults.

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

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

### 06 (0x06) Preset Single Register

Used to set holding registers one by one described when explaining 03 Modbus function. That means that arbitrary value may be written to set up different temperature limits and faults masks.

## Modbus register table

Register (decimal)	Description	Value range
<b>Read coil status (01)</b>		
00010-00013	Reading fault flags	0-1
<b>Read holding register (03)</b>		
00000-00007	Get temperature limits (lower limit first)	-200-800
00011-00014	Fault Mask registers for RTDs	0-57836
<b>Read input registers (04)</b>		
00000-00007	Temperatures from RTD sensors, LSW first	0-65535
00016-00019	Fault registers for RTD sensors	0-57836
<b>Preset Single Register (06)</b>		
00000-00007	Set temperature limits (lower limit first)*	-200-800
00011-00014	Set Fault Mask register for RTDs	0-65535

## Fault registers

Fault registers (Modbus addresses - 16-19) are read-only. They represent faults that occurred during operation of device. To enable showing desired fault user should set appropriate bits in Fault mask register (Modbus addresses - 11-14) or via USB interface, entering Advanced Settings Tab in 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 RTD reading chip. These faults are usually lifted if unsuitable settings are set or RTD is faulty or not connected.

Fault register

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	-	-

Fault mask register

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/Un dervoltage	-	-

Technical information

System	
Dimensions	17.5 (H) x 101 (W) x 119 (L), mm
Case	ABS, black
Working environment	Indoor
Working temperature	-40   +80°C

Recommended operating conditions	5 – 60°C and 20 – 80% RH;
Configuration	USB
Firmware upgrade	USB – mass storage device
<b>Electrical characteristics</b>	
Termination resistor	Selectable, 120Ω
<b>Power</b>	
Power Supply	9-33 VDC
Current consumption	40mA @ 12VDC, 20mA @ 24VDC

## Device Connection

### Power connection

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

### RS485 serial interface

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

IOMOD 4RTD has 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 typical connection diagram on Fig. 5.1.

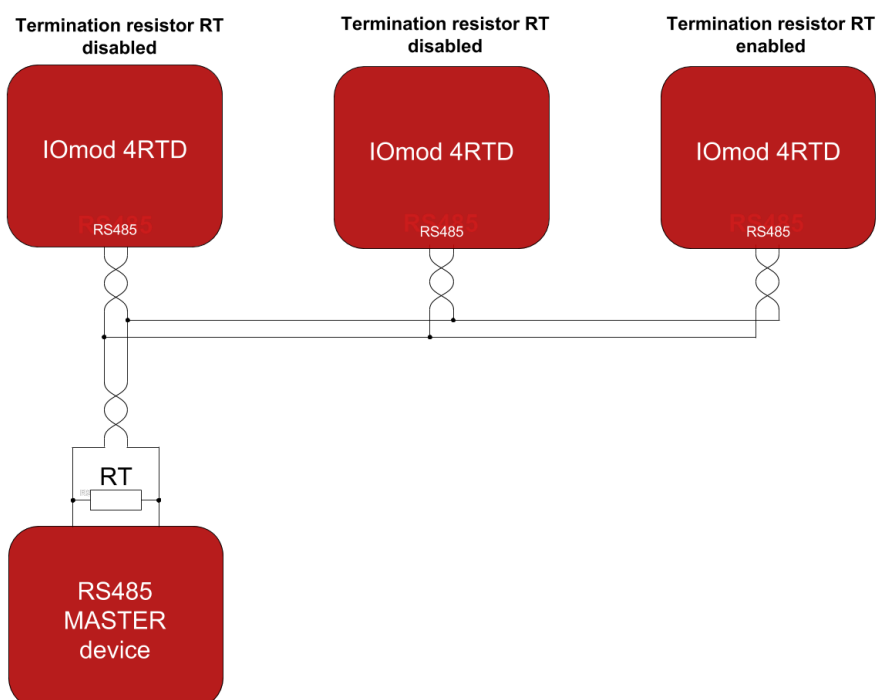


Fig. 5.1. Typical IOMod connection diagram

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

## Status indication

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

## RTD sensor connection

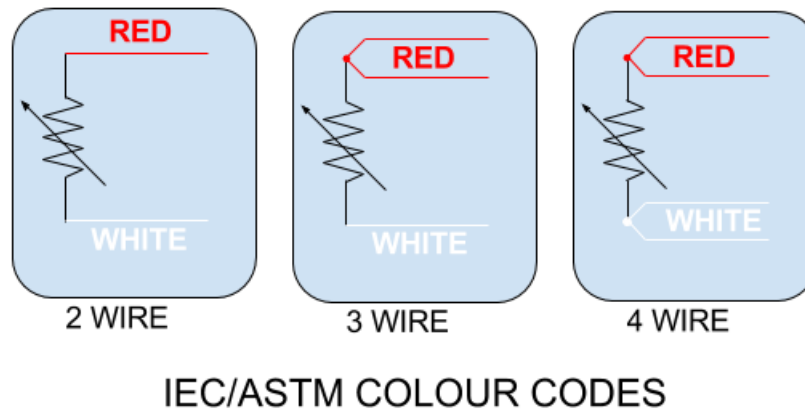


Fig. 5.3. RTD sensor colour codes

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 red wire to RTD+ and white wire (or black) to RTD- contacts. The connection between RTD+ and F+, RTD- and F- must be shorted.

3-wire RTD sensor: connect one red wire to RTD+, second red wire (compensating lead wire) to F+ and white (or black) wire to RTD-. The jumper between RTD- and F- must be shorted.

4-wire RTD sensor: connect red wires to RTD+ and F+ contacts, white (or black) wires to RTD- and F- contacts. No contacts shall be shorted.

## USB interface

IOMod 4RTD USB interface is used for configuration, diagnostics and firmware updates. IOMod 4RTD is powered through USB when connected, no extra power connection needed for operation. Use a USB mini B cable for connection.

# Configuration over USB

## Driver installation

Device requires USB drivers to work as a Virtual COM port. First-time connection between device and computer could result in "Device driver software was not successfully installed" error such as one shown in Fig.6.1.

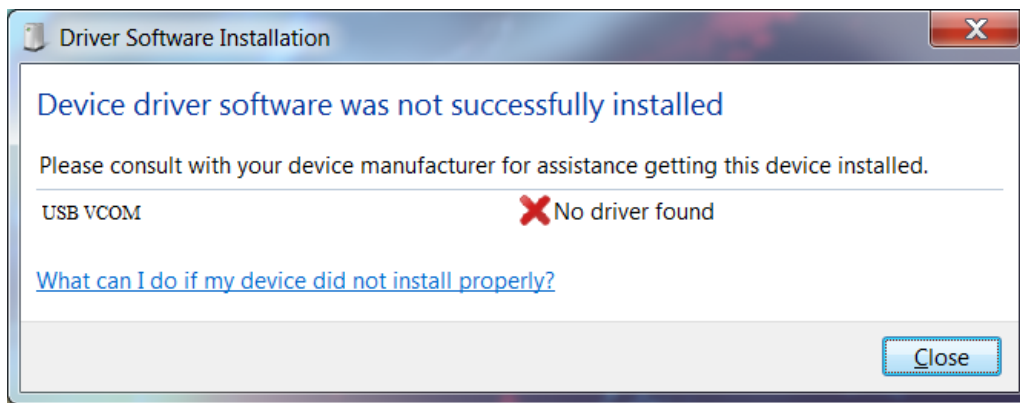


Fig. 6.1. Unsuccessful device software installation error

A user then should manually install drivers by selecting a downloaded driver folder:

- Go to Control Panel -> Device Manager;
- Select a failing device;
- Press "Update driver software"; screen as in Fig. 6.2. should appear:

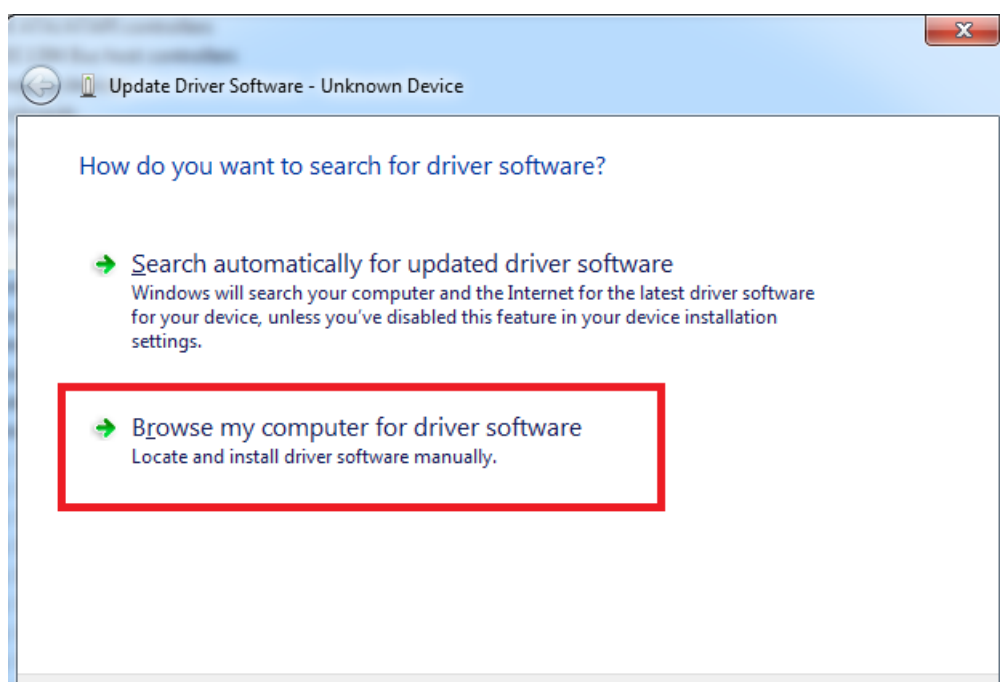


Fig. 6.2. Device driver software update message

- Select "x86" driver for a 32-bit machine or x64 for a 64-bit machine. If not sure, select a root folder (folder in which x64 and x86 lay inside, as in Fig. 6.3).

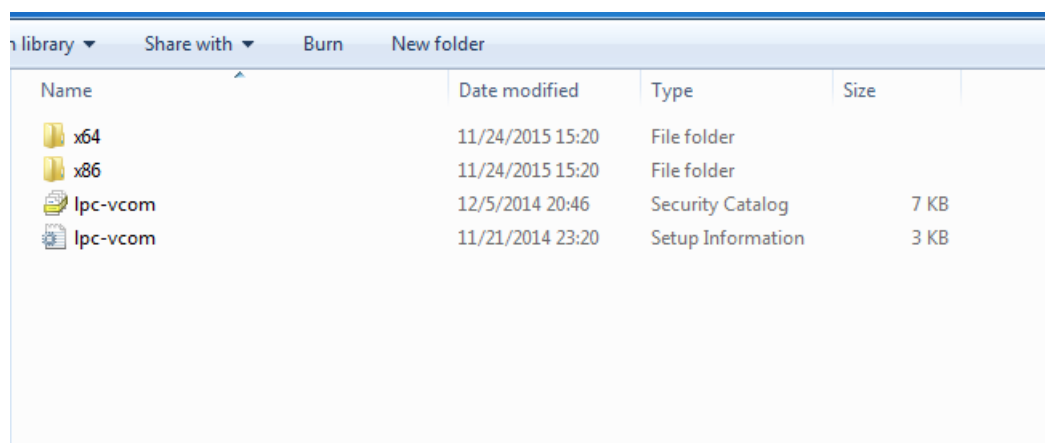


Fig. 6.3. Device driver folder content

## IOMod 4RTD configuration via PuTTY terminal



Configuration of IOMOD device is done through CLI (Command Line Interface) on virtual COM port. Drivers needed for MS Windows to install VCOM will be provided. To open up CLI simply connect to specific VCOM port with terminal software (it is advised to use PuTTY terminal software. If other software is being used, user might need to send <return> symbol after each command). When connected user should immediately see main screen similar to one in Fig.6.4.

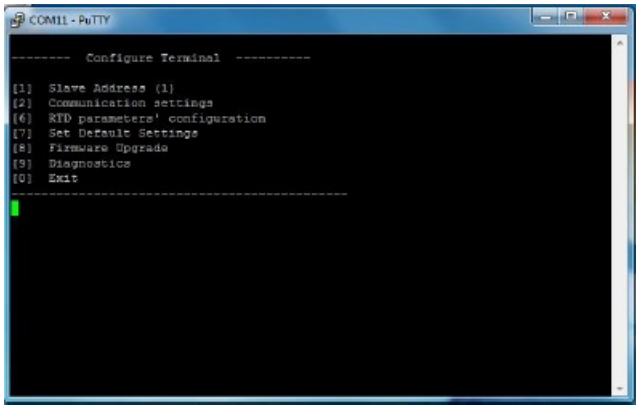


Fig. 6.4. The main menu for IOMod 4RTD

Navigation is performed by pressing number connected to its function. User then should proceed by following further on-screen instructions. For example, to set desired slave address, press [1] to enter Slave Address screen; enter new configuration; press [RETURN] to save, or [ESC] to cancel changes. When done, press [0] (exit) before disconnecting device. Default values are set by pressing [7] on main screen, and later confirming these changes by pressing [1].

If terminal window is accidentally closed without exiting, user can connect to terminal again, and press any key on keyboard to show up main menu once again.

Configuration of device is not possible when USB Simulation Mode is entered. To access configuration menu again user should reset device and then try again.

Modbus Main menu

	Menu Name	Function	Values	Default Values
1.	Slave Address	Modbus Slave address / ID	1-247	1
2.	Communication settings	[1] Baud rate, [2] Data, Stop and Parity Bits, [3] RS485 Terminating resistor	[1] 100 - 256000, [2] 8 Data bits + 1/2 Stop bits, Even/None/Odd Parity [3] Enabled/Disabled	[1] 9600, [2] 8N1, [3] Enabled
6.	RTD parameters' configuration*	Configuring Callendar-Van Dusen coefficients,RTD wire count, type, etc.		PT100, 2 wires, coefficients according to IEC-751
7.	Set Default Settings	Sets Default Settings	(1 to confirm, 0 to cancel)	-
8.	Firmware Upgrade	Mass Storage Device Firmware Upgrade	(1 to confirm, 0 to cancel)	-
9.	Diagnostics	Input / Output states	-	-
0.	Exit	Exit and disconnect	-	-

Firmware upgrade over USB

To update device firmware user must enter main configuration menu. Enter Firmware update screen by pressing [8]; Confirm update by pressing [1];

Device now enters Firmware Upgrade mode. Device reconnects as mass storage device (Fig 6.10.).


 It is recommended to close terminal window after entering firmware upgrade mode.



Fig. 6.10. Mass storage device warning

User then must delete existing file “firmware.bin”, and simply upload new firmware file by drag and drop. (Fig 6.11.)

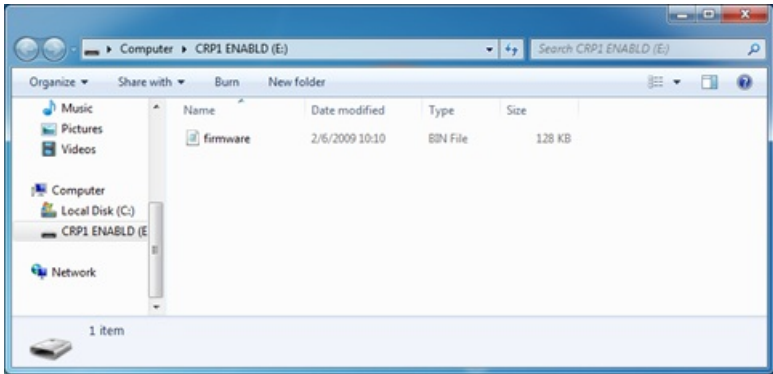


Fig. 6.11. Dragging and dropping new firmware file

Reconnect device and check firmware version. It should now represent the one it was updated to.

# Testing With “THE VINCI” software

To test IOMOD 4RTD with default settings, user can connect device through RS485 to Modbus or IEC-60870 (depending on firmware) master or using USB Simulation Mode. Example will show The Vinci Expert as serial interface converter and adapter to PC with The Vinci software. Default settings – 9600 baud; 8 data, no parity, 1 stop bit. When opening The Vinci software, choose Modbus serial – Master mode. In Settings tab, choose station number (default – 1); configure tags (as described in section 2. Device operational information); press Start and go to Statistic tab:

Station	Function	Address	Value	Count	Name
1	Read Input Registers (04)	18	-82768	5	Fault register RTD8
1	Read Input Registers (04)	19	16884	5	Fault register RTD4
1	Read Input Registers (04)	7	-16498	4	Temp RTD4 LSW
1	Read Input Registers (04)	0	16848	4	Temp RTD1 MSW
1	Read Input Registers (04)	2	-16498	4	Temp RTD8 MSW
1	Read Input Registers (04)	3	-16498	4	Temp RTD2 LSW
1	Read Input Registers (04)	1	16848	4	Temp RTD1 LSW
1	Read Coils (01)	10	OFF(0)	4	Faults
1	Read Coils (01)	11	OFF(0)	4	-
1	Read Coils (01)	12	OFF(0)	4	-
1	Read Coils (01)	13	OFF(0)	4	-
1	Read Holding Registers (08)	11	-1	4	Fault mask registers
1	Read Holding Registers (08)	12	-1	4	-
1	Read Holding Registers (08)	13	-1	4	-
1	Read Holding Registers (08)	14	-1	4	-
1	Read Holding Registers (08)	0	-300	4	Temperature limits
1	Read Holding Registers (08)	1	800	4	-
1	Read Holding Registers (08)	2	-190	4	-
1	Read Holding Registers (08)	3	800	4	-
1	Read Holding Registers (08)	4	-300	4	-
1	Read Holding Registers (08)	5	800	4	-
1	Read Holding Registers (08)	6	-300	4	-
1	Read Holding Registers (08)	7	800	4	-
1	Read Input Registers (04)	4	17502	4	Temp RTD8 MSW
1	Read Input Registers (04)	5	17502	4	Temp RTD8 LSW
1	Read Input Registers (04)	6	-16498	4	Temp RTD4 MSW
1	Read Input Registers (04)	16	0	4	Fault register RTD1
1	Read Input Registers (04)	17	16884	4	Fault register RTD2

Fig. 6.7. Example of results of Modbus testing

Tags

Format

Tag0

Name: Temp RTD1 LSW

Value: 16848

Tag1

Name: Temp RTD1 MSW

Value: 16848

Tag2

Name:

Value:

Tag3

Name:

Value:

Format: Float

Value: 25.032114

Update tags

Show value

Fig.6.8. Representing temperature as float when using Modbus

Fig. 6.8. represents how The Vinci software should be configured to represent temperature in IEEE- 754 standard float type when using Modbus communication.

# IOMOD 4RTD User Manual IEC 60870-5-103

## Introduction

IOMOD 4RTD is used for temperature data monitoring over Modbus or IEC-60870-103 using resistance temperature detector (RTD) platinum sensors. Up to 4 RTD temperature sensors can be connected at once.

## Features

- Temperature sense with  $\pm 0.5$  °C accuracy over 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 range from -200 up to 800 °C when using platinum RTD sensors;
- Configurable Modbus or IEC-60870-103 settings: Slave ID, baud rate, parity and stop bits, RS485 terminating resistor, etc.
- Firmware upgrade over USB.

## Operational Information

IOMOD uses Modbus (RTU) or IEC-60870-103 protocols over RS485 connection, which can be used for cable lengths up to 1500 meters and connect up to 30 devices on one line. Default Modbus and IEC-60870-103 settings are: 9600 bauds/s baudrate, 8N1, Slave (Link) address - 1.

To read temperature from any of aforementioned sensors using IEC-60870-103 protocol user should first configure it over USB. To send temperature values from desired RTD sensors it should first be enabled in RTD parameters menu. All temperature values are by default sent cyclically. 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 resolution of 0.1 °C unless full range of RTD (from -200°C to 800°C) is selected - then 1 °C resolution is achieved and temperature values are not multiplied by any multiplier.

For further information regarding setting temperature parameters and configurable options please refer to table shown below, also supported IEC-60870-103 functions described in paragraphs described below.

CONFIGURABLE OPTIONS	OVER USB	OVER IEC-60870-103
Slave Address	Yes	No
Baudrate	Yes	No
Data, Stop and Parity bits	Yes	No
RS485 Terminating Resistor	Yes	No
RTD parameters	Yes	No
Default settings	Yes	No
Setting temperature limits	Yes	No
Fault configuration	Yes	No

## Status LED

Status LED can be in 2 colors :

Blue - Device connected to USB.

Green - Normal operation.

## Rx/Tx LED

The RX/TX LED on the IOMod flashes when data is either being transmitted or received via the RS485 port.

## FLT1, FLT2, FLT3, FLT4 LEDs

Input fault LEDs can be in 2 states :

Off - Normal operation.

Red - Input fault or faults occurred during operation of device.

## IEC-60870-103 operation

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 the information using two methods for data transfer - either using the explicitly specified application service data units (ASDU) or using generic services for transmission of all the possible information. The standard supports some specific protection functions and provides the vendor a facility to incorporate its own protective functions on private data ranges.

IOMod 4RTD device might act as a IEC-60870-103 slave if appropriate firmware is uploaded. For more information about firmware upload check chapter Firmware upgrade over USB.

Master may read (if configured) temperature values from RTD sensors and data from user-configured fault registers. Fault is cleared and fault register is cleared automatically whenever fault condition disappears, therefore user could easily eliminate the source of fault without a need of hard reset. Fault mask reset register is also not set via IEC-60870-103, user should predefine it first via USB communication.

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

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

# Technical information

System	
Dimensions	17.5 (H) x 101 (W) x 119 (L), mm
Case	ABS, black
Working environment	Indoor
Working temperature	-40   +80°C
Recommended operating conditions	5 – 60°C and 20 – 80% RH;
Configuration	USB
Firmware upgrade	USB – mass storage device
Electrical characteristics	
Termination resistor	Selectable, 120Ω

Power	
Power Supply	9-33 VDC
Current consumption	40mA @ 12VDC, 20mA @ 24VDC

# Device Connection

## Power connection

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

## RS485 serial interface

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

IOMOD 4RTD has 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 typical connection diagram on Fig. 5.1.

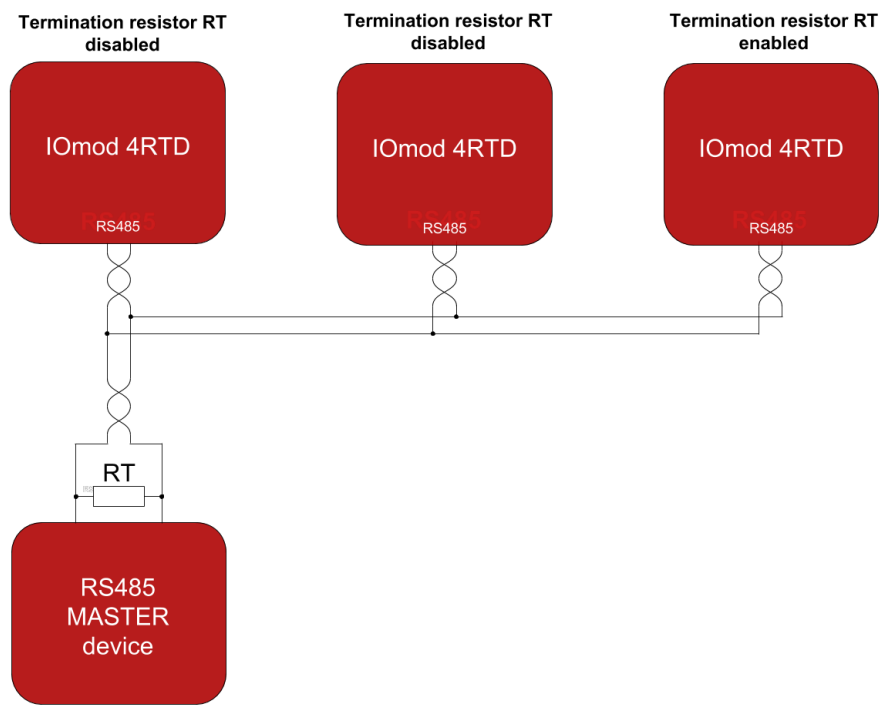


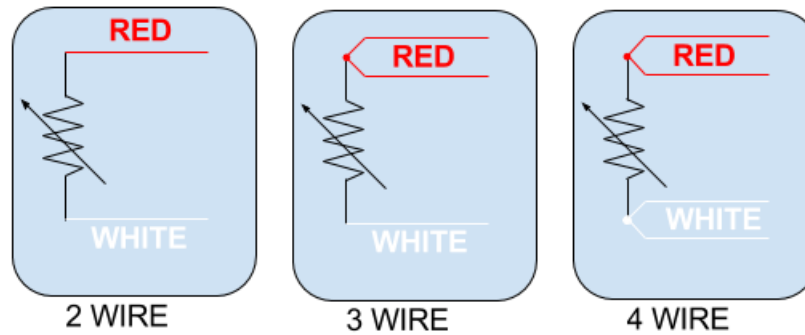
Fig. 5.1. Typical IOMod connection diagram

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

## Status indication

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

## RTD sensor connection



## IEC/ASTM COLOUR CODES

Fig. 5.3. RTD sensor colour codes

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 red wire to RTD+ and white wire (or black) to RTD- contacts. The connection between RTD+ and F+, RTD- and F- must be shorted.

3-wire RTD sensor: connect one red wire to RTD+, second red wire (compensating lead wire) to F+ and white (or black) wire to RTD-. The jumper between RTD- and F- must be shorted.

4-wire RTD sensor: connect red wires to RTD+ and F+ contacts, white (or black) wires to RTD- and F- contacts. No contacts shall be shorted.

## USB interface

IOMod 4RTD USB interface is used for configuration, diagnostics and firmware updates. IOMod 4RTD is powered through USB when connected, no extra power connection needed for operation. Use a USB mini B cable for connection.

# Configuration over USB

## Driver installation

Device requires USB drivers to work as a Virtual COM port. First-time connection between device and computer could result in "Device driver software was not successfully installed" error such as one shown in Fig.6.1.

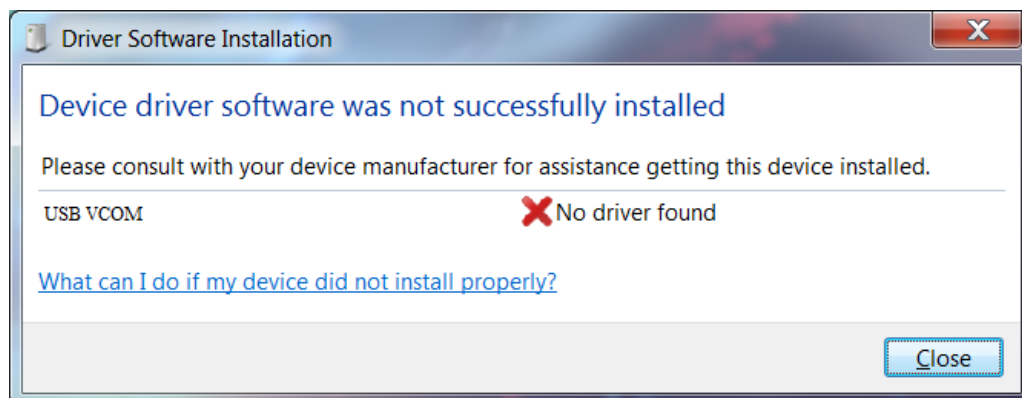


Fig. 6.1. Unsuccessful device software installation error

A user then should manually install drivers by selecting a downloaded driver folder:

- Go to Control Panel -> Device Manager;
- Select a failing device;
- Press "Update driver software"; screen as in Fig. 6.2. should appear:

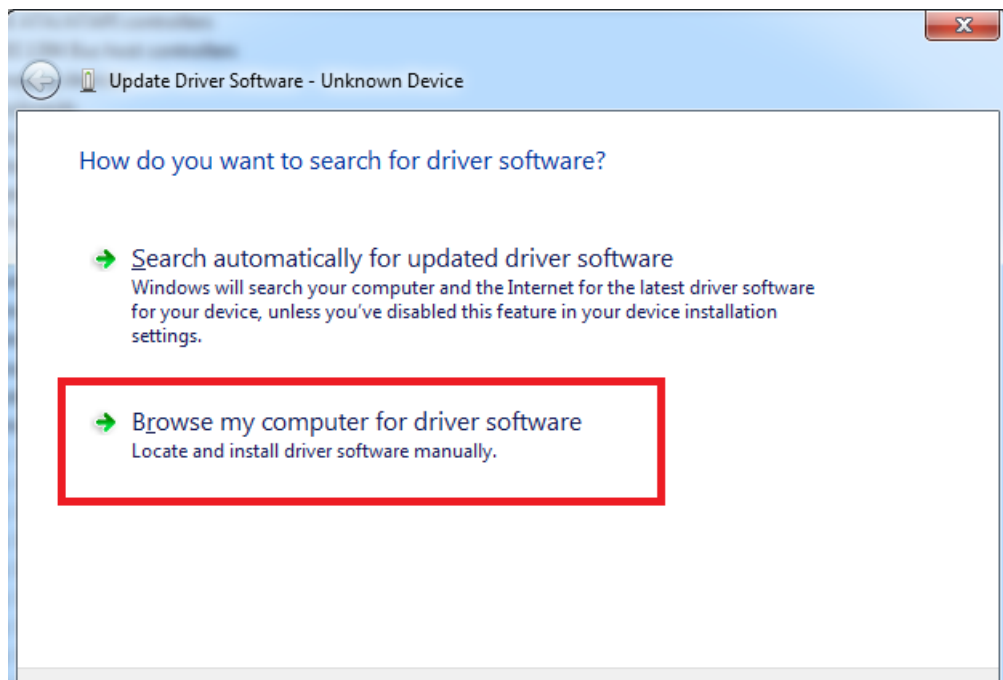


Fig. 6.2. Device driver software update message

- Select "x86" driver for a 32-bit machine or x64 for a 64-bit machine. If not sure, select a root folder (folder in which x64 and x86 lay inside, as in Fig. 6.3).

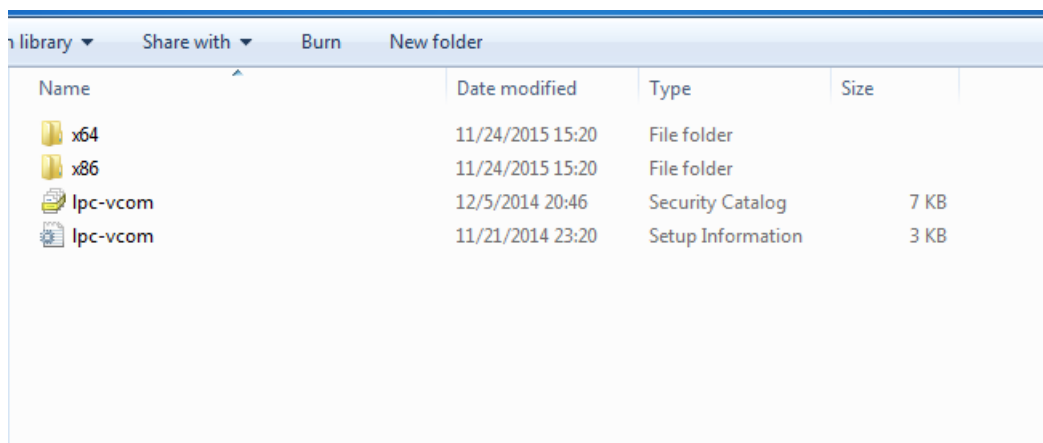


Fig. 6.3. Device driver folder content

## IOMod 4RTD configuration via PuTTY terminal

Configuration of IOMOD device is done through CLI (Command Line Interface) on virtual COM port. Drivers needed for MS Windows to install VCOM will be provided. To open up CLI simply connect to specific VCOM port with terminal software (it is advised to use PuTTY terminal software. If other software is being used, user might need to send <return> symbol after each command). When connected user should immediately see main screen similar to one in Fig.6.4.

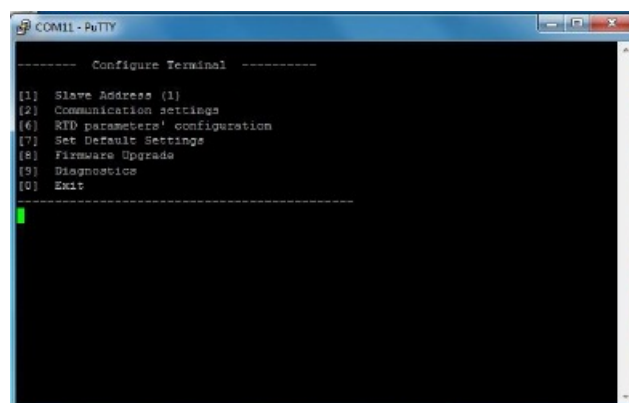


Fig. 6.4. The main menu for IOMod 4RTD



Navigation is performed by pressing number connected to its function. User then should proceed by following further on-screen instructions. For example, to set desired slave address, press [1] to enter Slave Address screen; enter new configuration; press [RETURN] to save, or [ESC] to cancel changes. When done, press [0] (exit) before disconnecting device. Default values are set by pressing [7] on main screen, and later confirming these changes by pressing [1].

If terminal window is accidentally closed without exiting, user can connect to terminal again, and press any key on keyboard to show up main menu once again.

Configuration of device is not possible when USB Simulation Mode is entered. To access configuration menu again user should reset device and then try again.

### IEC-60870-103 Main menu

	Menu Name	Function	Values	Default Values
1.	Link Address	Link Slave address	1-247	1
2.	Baudrate & bits	[1] Baud rate, [2] Data, Stop and Parity Bits, [3] RS485 Terminating resistor	[1] 100 - 256000, [2] 8 Data bits + 1/2 Stop bits, Even/None/Odd Parity [3] Enabled/Disabled	[1] 9600, [2] 8N1, [3] Enabled
3.	Data addressing config	Configuring input address function type	1-255	160
4.	RS485 Terminating resistor	Enabling or disabling terminating resistor	Enabled/Disabled	Enabled
6.	RTD parameters' configuration*	Configuring Callendar-Van Dusen coefficients, RTD wire count, type, etc.		PT100, 2 wires, coefficients according to IEC-751
7.	Set Default Settings	Sets Default Settings	(1 to confirm, 0 to cancel)	-
8.	Firmware Upgrade	Mass Storage Device Firmware Upgrade	(1 to confirm, 0 to cancel)	-
9.	Diagnostics	Input / Output states	-	-
0.	Exit	Exit and disconnect	-	-

## Firmware upgrade over USB

To update device firmware user must enter main configuration menu.

Enter Firmware update screen by pressing [8];

Confirm update by pressing [1];

Device now enters Firmware Upgrade mode. Device reconnects as mass storage device (Fig 6.10.).



It is recommended to close terminal window after entering firmware upgrade mode.



Fig. 6.10. Mass storage device warning

User then must delete existing file “firmware.bin”, and simply upload new firmware file by drag and drop. (Fig 6.11.)

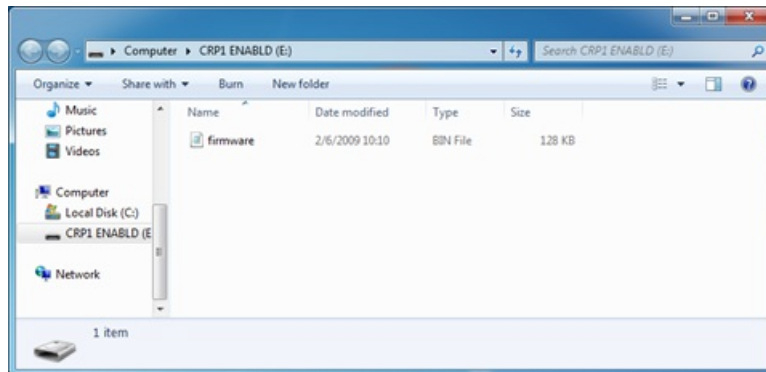


Fig. 6.11. Dragging and dropping new firmware file

Reconnect device and check firmware version. It should now represent the one it was updated to.

## Testing With “THE VINCI” software

To test IOMOD 4RTD with default settings, user can connect device through RS485 to Modbus or IEC-60870 (depending on firmware) master or using USB Simulation Mode. Example will show The Vinci Expert as serial interface converter and adapter to PC with The Vinci software. Default settings – 9600 baud; 8 data, no parity, 1 stop bit. When opening The Vinci software, choose Modbus serial – Master mode. In Settings tab, choose station number (default – 1); configure tags (as described in section 2. Device operational information); press Start and go to Statistic tab:

Settings	Console	Events	Statistic	The Vinci Expert						
Ti	Code	ADDR	PIB	INP	Value	Status	Time Tag	Count	Name	
(T2=001)	General Inter	1	0	1 (0)	0000	0000	[W]2010/02/14 00:01:11.660 [TV]	1	-	
(T2=001)	General Inter	1	0	4 (0)	0000	0000	[W]2010/02/14 00:01:12.004 [TV]	2	-	
(T2=001)	Revert/master	1	200	1 (0)	2	0000000000000000	-	0	-	
(T2=001)	cyclic	1	200	0 (0)	0000000000000000	0000	-	150	-	
(T2=001)	cyclic	1	200	0 (0)	0000000000000000	0000	-	150	-	
(T2=001)	cyclic	1	200	0 (0)	0000000000000000	0000	-	150	-	
(T2=001)	cyclic	1	200	0 (0)	0000000000000000	0000	-	150	-	
(T2=001)	cyclic	1	200	0 (0)	0000000000000000	0000	-	150	-	
(T2=001)	cyclic	1	200	0 (0)	0000000000000000	0000	-	150	-	
(T2=001)	cyclic	1	200	0 (0)	0000000000000000	0000	-	150	-	
(T2=001)	End of p. 1st	1	200	0 (0)	0000	-	-	1	-	
(T2=001)	General Inter	1	0	2 (0)	0000	0000	[W]2010/02/14 00:01:11.700 [TV]	0	-	
(T2=001)	General Inter	1	0	3 (0)	0000	0000	[W]2010/02/14 00:01:11.894 [TV]	0	-	

Fig. 6.9. Example of results of IEC-60870-103 testing

Fig.6.9 represent show example of results of IEC-60870-103 testing. Temperatures are shown and updated cyclically if they are configured to be shown via USB. To show inputs and outputs, send General Interrogation.

# IOMOD 4RTD User Manual IEC 60870-5-101

## Introduction

IOMOD 4RTD is used for temperature data monitoring over Modbus or IEC-60870-101 using resistance temperature detector (RTD) platinum sensors. Up to 4 RTD temperature sensors can be connected at once.

## Features

- Temperature sense with  $\pm 0.5$  °C accuracy over 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 range from -200 up to 800 °C when using platinum RTD sensors;
- Configurable Modbus or IEC-60870-101 settings: Slave ID, baud rate, parity and stop bits, RS485 terminating resistor, etc.
- Firmware upgrade over USB.

## Operational Information

IOMOD uses Modbus (RTU) or IEC-60870-101 protocols over RS485 connection, which can be used for cable lengths up to 1500 meters and connect up to 30 devices on one line. Default Modbus and IEC-60870-101 settings are: 9600 bauds/s baudrate, 8E1, Link address - 1.

To read temperature from any of aforementioned sensors using IEC-60870-101 protocol user should first configure it over USB. To send temperature values from desired RTD sensors it should first be enabled in RTD parameters menu. All temperature values are by default sent cyclically. 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 resolution of 0.1 °C unless full range of RTD (from -200°C to 800°C) is selected - then 1 °C resolution is achieved and temperature values are not multiplied by any multiplier.

All configurations can be done over USB.

### Status LED

Status LED can be in 2 colors :

Blue - Device connected to USB.

Green - Normal operation.

### Rx/Tx LED

The RX/TX LED on the IOMod flashes when data is either being transmitted or received via the RS485 port.

### FLT1, FLT2, FLT3, FLT4 LEDs

Input fault LEDs can be in 2 states :

Off - Normal operation.

Red - Input fault or faults occurred during operation of device.

## IEC 60870-5-101 working information

### Initialization

IOMod uses a standard IEC-60870-5-101 communication scheme. Initiation, control messages, and queries are initiated by the master (controlling station), while the IOMod device (controlled station) only answers these requests. Therefore, the first message should be sent by the master to start/restart communication (ResetOfRemoteLink). This message is answered by IOMod with an acknowledgment (ACK) to enable the master to proceed with sending other messages defined by the IEC-60870-5-101 protocol.

## Data polling

When initialization is complete, the master may request data from the IOMod device with general interrogation. Although according to the protocol specification IOMod will send data on value change. The 4RTD IOMod responds with type 30 (M\_SP\_TB\_1) a single point value with a time tag.

## Input messages

When input status changes, IOMod device filters input glitches through filters with a user-configurable filter time. When the filter is passed device sends a “Spontaneous” message with the 13 data types (M\_ME\_NC\_1), and “IOA” as the input pin number shifted by 4.

## Time synchronization

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

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.

# Technical information

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

# Device Connection

## Power connection

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

## RS485 serial interface

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

IOMOD 4RTD has 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 typical connection diagram on Fig. 1.

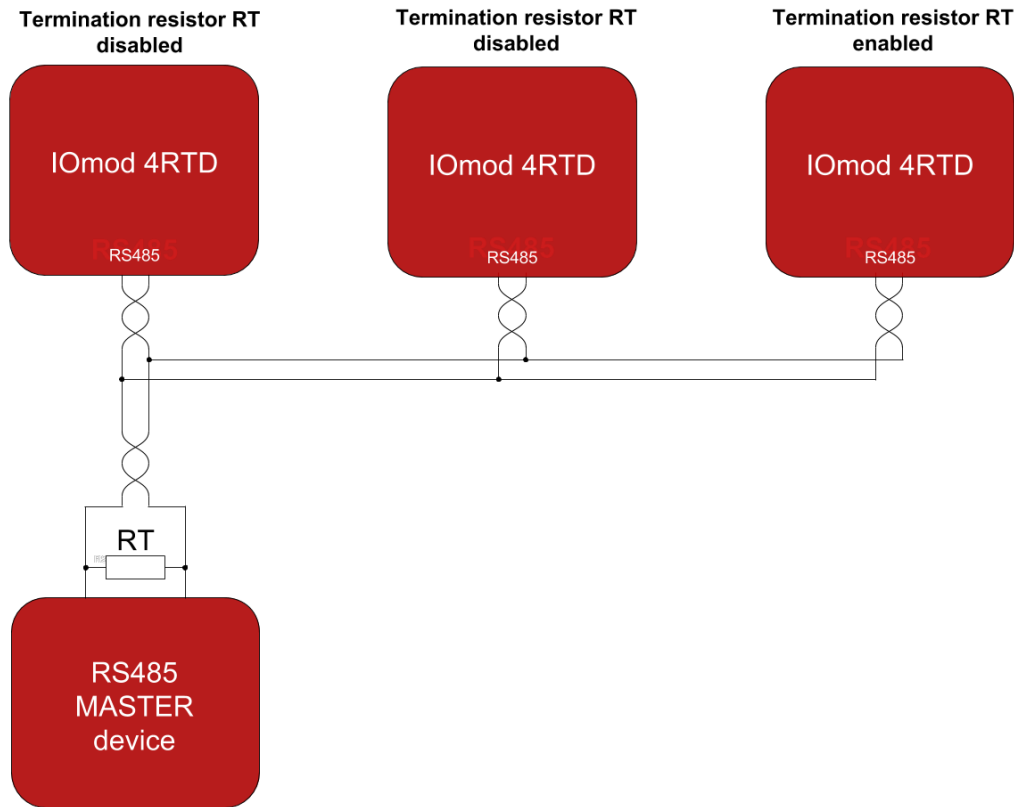


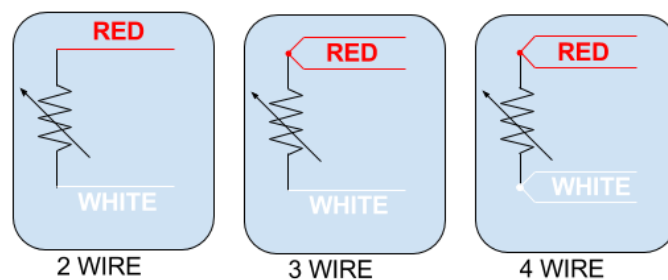
Fig. 1. Typical IOMod connection diagram

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

## Status indication

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

## RTD sensor connection



### IEC/ASTM COLOUR CODES

Fig. 2. RTD sensor color codes

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 red wire to RTD+ and white wire (or black) to RTD- contacts. The connection between RTD+ and F+, RTD- and F- must be shorted.

**3-wire RTD sensor:** connect one red wire to RTD+, second red wire (compensating lead wire) to F+ and white (or black) wire to RTD-. The jumper between RTD- and F- must be shorted.

4-wire RTD sensor: connect red wires to RTD+ and F+ contacts, white (or black) wires to RTD- and F- contacts. No contacts shall be shorted.

## USB interface

IOMod 4RTD USB interface is used for configuration, diagnostics and firmware updates. IOMod 4RTD is powered through USB when connected, no extra power connection needed for operation. Use a USB mini B cable for connection.

# Configuration over USB

## Driver installation

Device requires USB drivers to work as a Virtual COM port. First-time connection between device and computer could result in "Device driver software was not successfully installed" error such as one shown in Fig. 3.

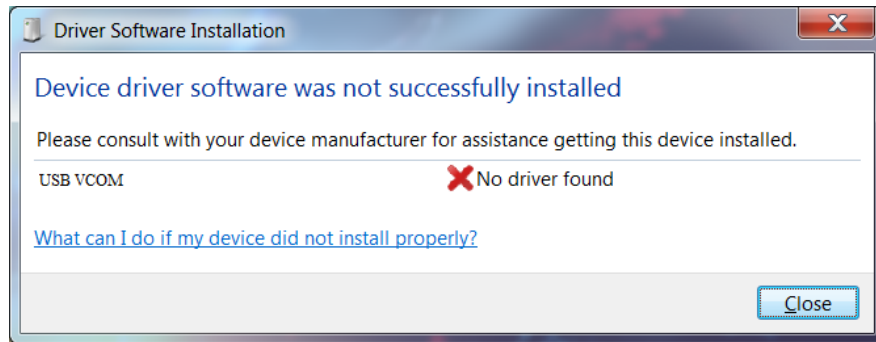


Fig. 3. Unsuccessful device software installation error

A user then should manually install drivers by selecting a downloaded driver folder:

- Go to Control Panel -> Device Manager;
- Select a failing device;
- Press "Update driver software"; screen as in Fig. 4. should appear:

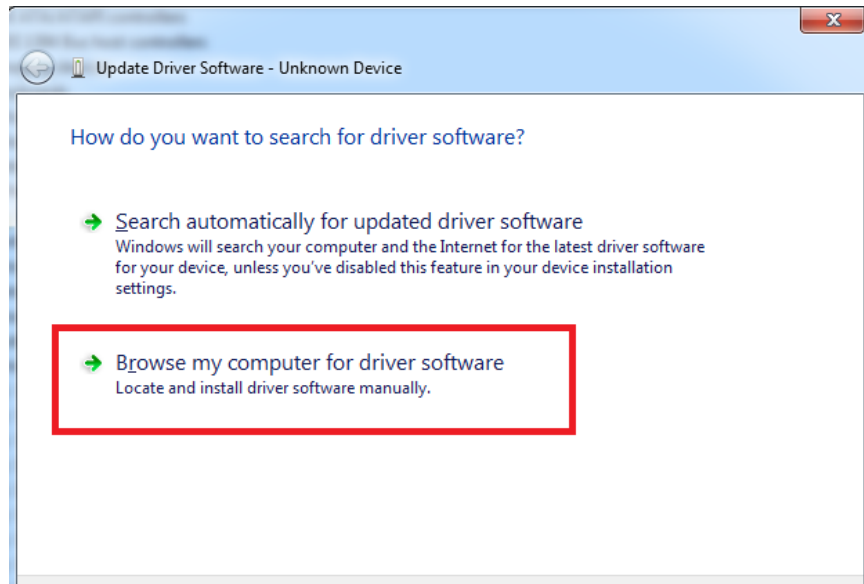


Fig. 4. Device driver software update message

- Select "x86" driver for a 32-bit machine or x64 for a 64-bit machine. If not sure, select a root folder (folder in which x64 and x86 lay inside, as in Fig. 5.)

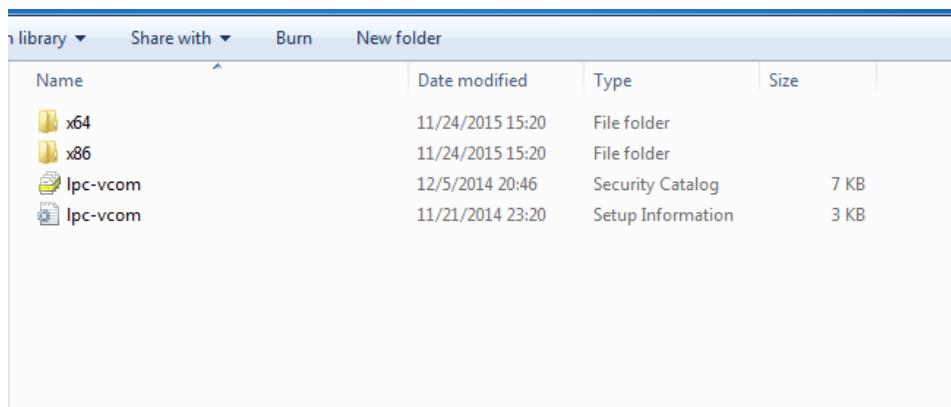


Fig. 5. Device driver folder content

## IOMod 4RTD configuration via PuTTY terminal

Configuration of IOMOD device is done through CLI (Command Line Interface) on virtual COM port. Drivers needed for MS Windows to install VCOM will be provided. To open up CLI simply connect to specific VCOM port with terminal software (it is advised to use PuTTY terminal software. If other software is being used, user might need to send <return> symbol after each command). When connected user should immediately see main screen similar to one in Fig. 6.

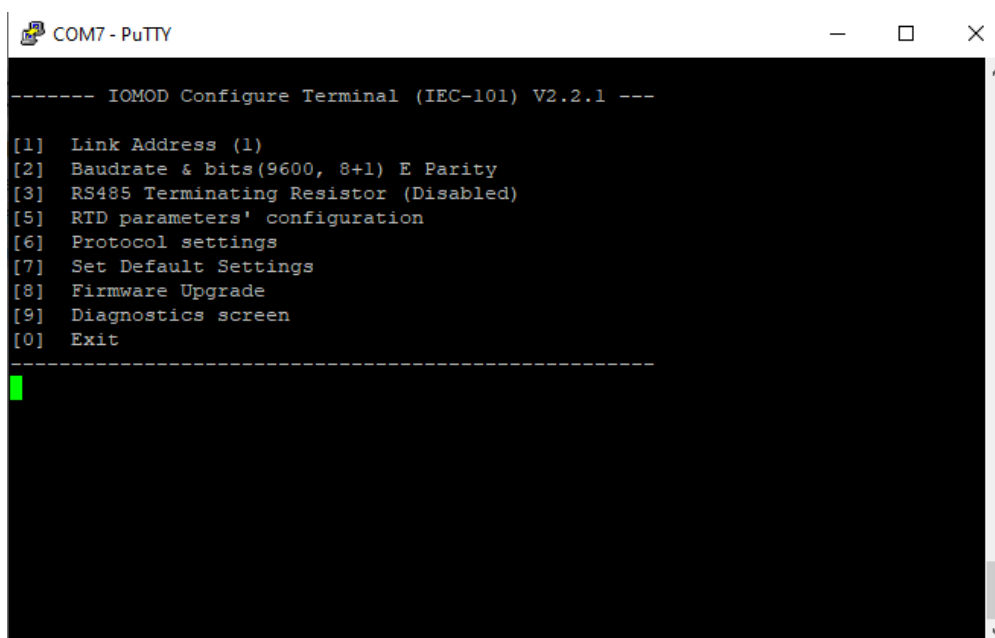


Fig. 6. The main menu for IOMod 4RTD

Navigation is performed by pressing number connected to its function. User then should proceed by following further on-screen instructions. For example, to set desired link address, press [1] to enter Link Address screen; enter new configuration; press [RETURN] to save, or [ESC] to cancel changes. When done, press [0] (exit) before disconnecting device. Default values are set by pressing [7] on main screen, and later confirming these changes by pressing [1].

If terminal window is accidentally closed without exiting, user can connect to terminal again, and press any key on keyboard to show up main menu once again.

Configuration of device is not possible when USB Simulation Mode is entered. To access configuration menu again user should reset device and then try again.

### IEC-60870-101 Main menu

	Menu name	Function	Values	Default values
1.	Link Address	Link address	1-255	1

2.	Baudrate & bits	[1] Set 8 Data bits + 1 stop bit [2] Set 8 Data bits + 2 stop bits [3] Configure Baudrate [4] Configure Parity	[1] Set 8 Data bits + 1 stop bit [2] 8 Data bits + 2 Stop bit [3]100-256000 [4] None/Odd/Even/Mark/Space	9600, 8E1
3.	RS485 Terminating resistor	Enabling or disabling terminating resistor	Enabled/Disabled	Disabled
5.	RTD parameters' configuration	RTD wire count, type, temperature limits, range selection etc.	[1] RTD type (0 - PT100, 1 - PT1000) [2] RTD wire count (Possible: 2,3,4) [3] RTD temperature limits (Possible -200-800°C) [5] RTD range selection in IEC-101 (1 - Full, 0 - Narrow) [6] RTD temperature in IEC-101 (Possible: ON/OFF)	[1] 0 (PT100) [2] 2 [3] -200-800°C [5] 0 [6] ON
5.8	Advanced settings	Configuring Callendar-Van Dusen coefficients and fault mask	[1] Configure RTD coefficient A [2] Configure RTD coefficient B [3] Configure RTD coefficient C [7] Configure fault mask	[1] 3.9083e-3 [2] -5.7750e-7 [3] -4.1830e-12 [7] 236
6.	Protocol settings	[1] Toggle 24/56 bit time [2] Change IOA size [3] Toggle measurements type [4] Toggle measurements time	[1] 24/56 bit [2] 1-3 [3] Integer/Float [4] Enabled/Disabled	[1] 56 bit [2] 1 [3] Integer [4] Disabled
7.	Set Default Settings	Sets Default Settings	(1 to confirm, 0 to cancel)	-
8.	Firmware Upgrade	Mass Storage Device Firmware Upgrade	(1 to confirm, 0 to cancel)	-
9.	Diagnostics	Input states	-	-
0.	Exit	Exit and disconnect	-	-

## Firmware upgrade over USB

To update device firmware user must enter main configuration menu.

Enter Firmware update screen by pressing [8];

Confirm update by pressing [1];

Device now enters Firmware Upgrade mode. Device reconnects as mass storage device (Fig. 7.)


	It is recommended to close terminal window after entering firmware upgrade mode
-------------------------------------------------------------------------------------	---------------------------------------------------------------------------------



Fig. 7. Mass storage device warning

User then must delete existing file "firmware.bin", and simply upload new firmware file by drag and drop. (Fig. 8.)



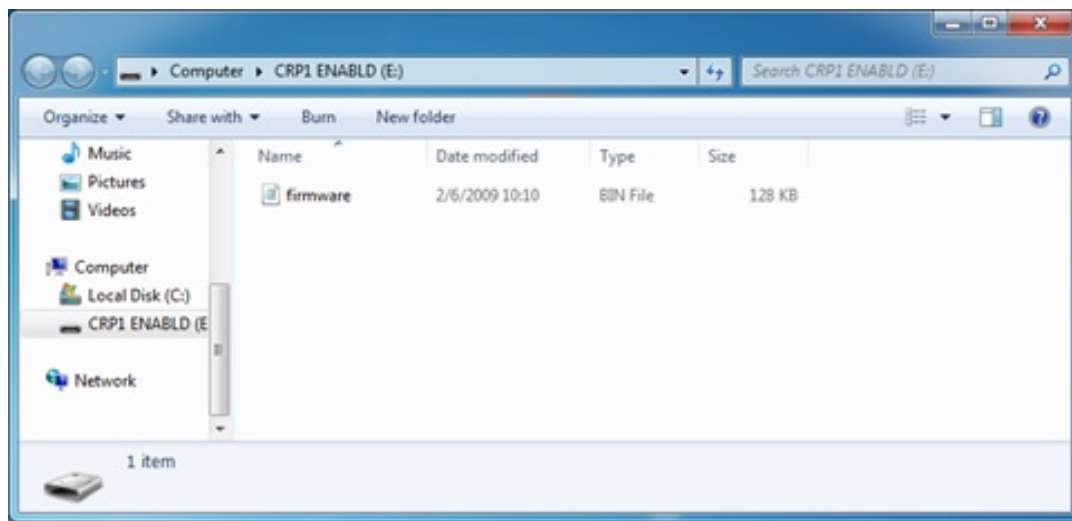


Fig. 8. Dragging and dropping new firmware file

Reconnect device and check firmware version. It should now represent the one it was updated to.

Firmware version 2

# IOMod 4RTD User Manual

## 1. Introduction

IOMod 4RTD is a standalone temperature sensor device. Designed to measure temperature over a wide range with high accuracy and repeatability even during frequent heating and cooling cycles. 4RTD is equipped with 4 temperature channels to enable temperature reading with default configuration. The measured values are transmitted to the host system via communication protocol **Modbus RTU**, **IEC 60870-5-101** or **IEC 60870-5-103**.

### 1.1 Features

- Firmware upgrade over USB, RS485;
- Configurable using the IOMod Utility application for user-friendly setup;
- RS485 interface with a switchable terminating resistor;
- Compact case with a removable transparent front panel;
- DIN rail mounting for seamless integration into industrial systems;
- Temperature sensing with  $\pm 0.5$  °C accuracy in all operating conditions;
- 2.5 kV (RMS) isolated RTD inputs;
- Temperature sensing ranges from -200 °C up to 800 °C when using platinum RTD sensors.

### 1.2 Block Diagram

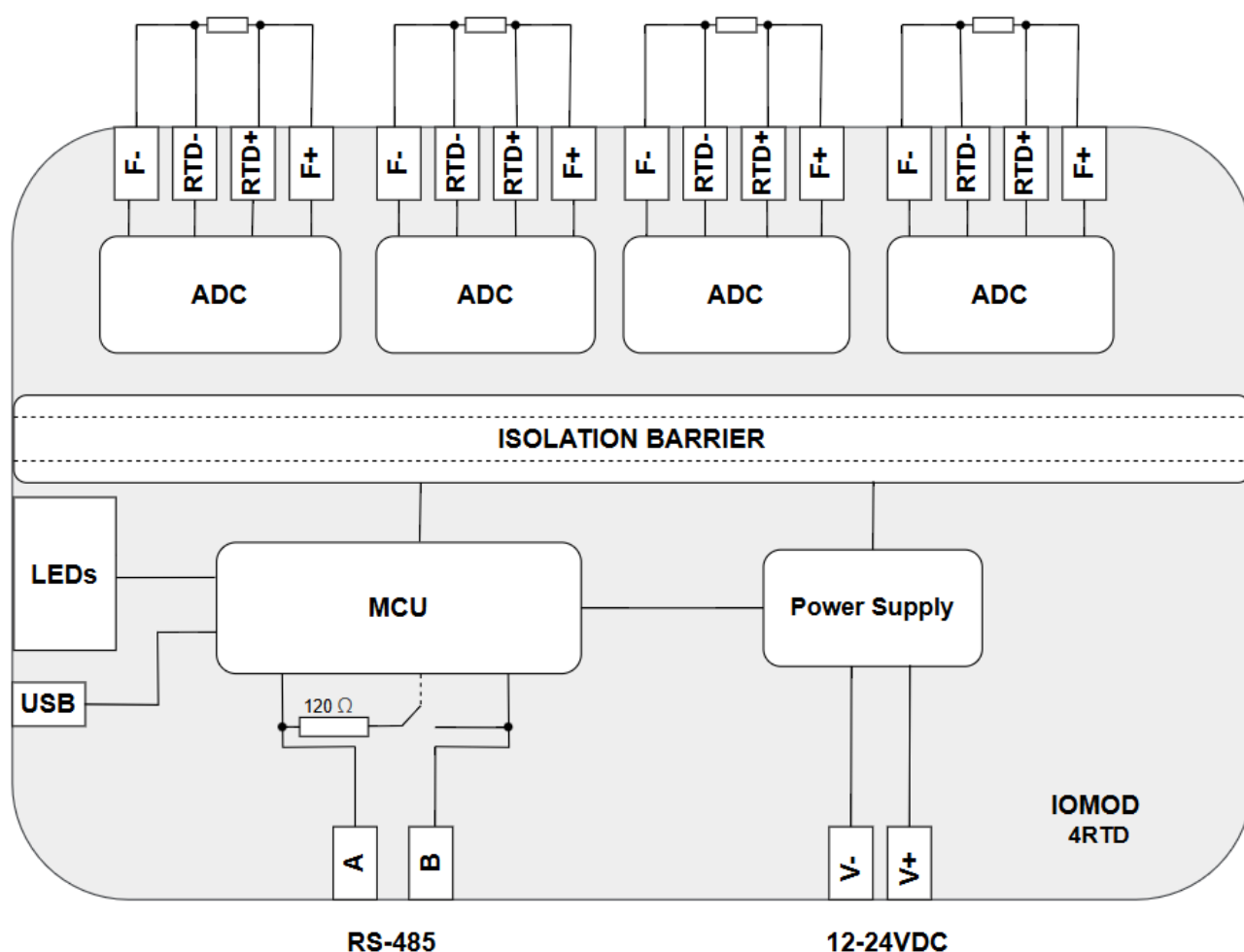


Fig. 1.2.1 IOMod 4RTD internal structure and block diagram

## 2. Hardware data

### 2.1 Mechanical drawings

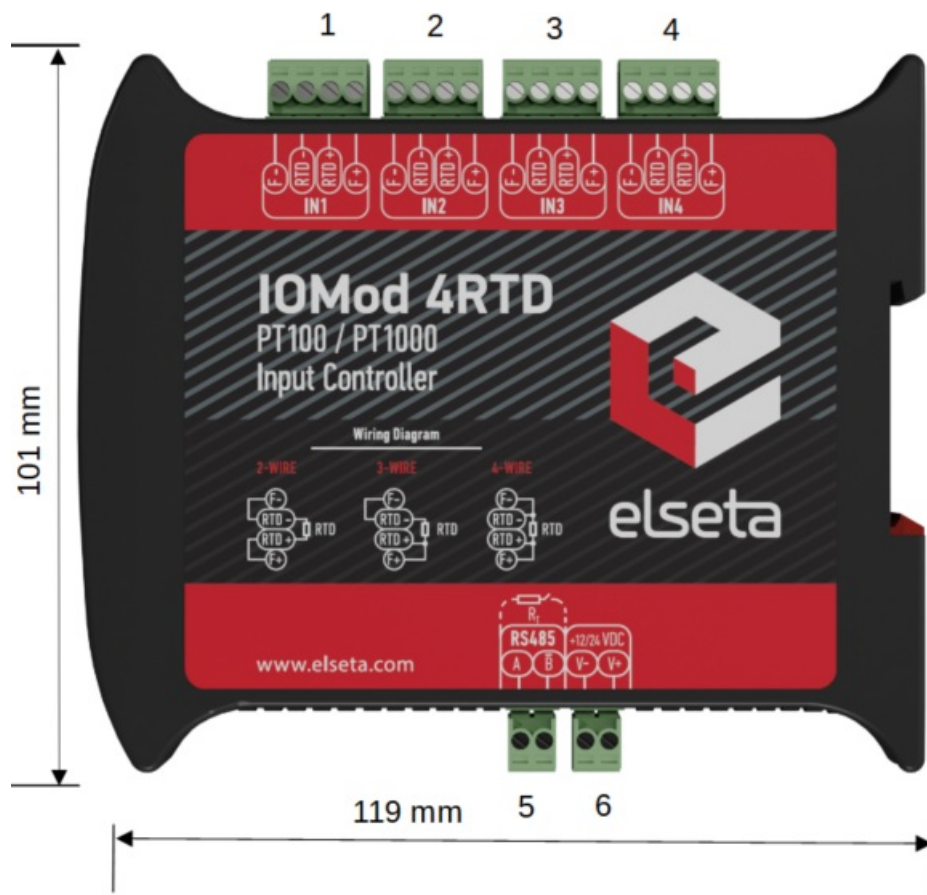


Fig. 2.1.1 IOMod 4RTD side view with dimensions and terminals description.  
1-4 sensor inputs, 5 - RS485 interface, 6 - power supply input

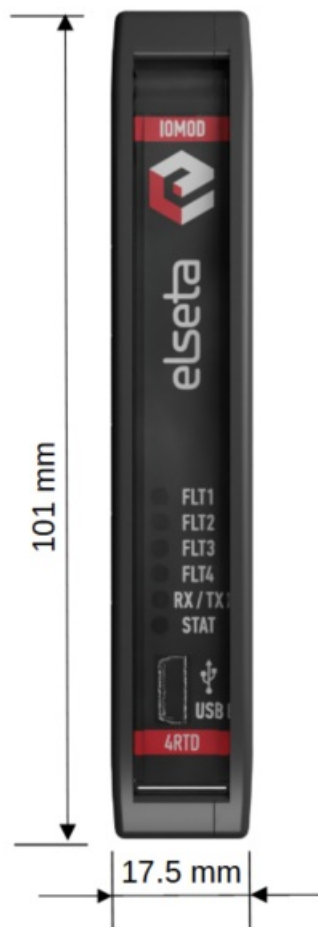


Fig. 2.1.2 IOMod 4RTD front view with dimensions

## 2.2 Terminal connections

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

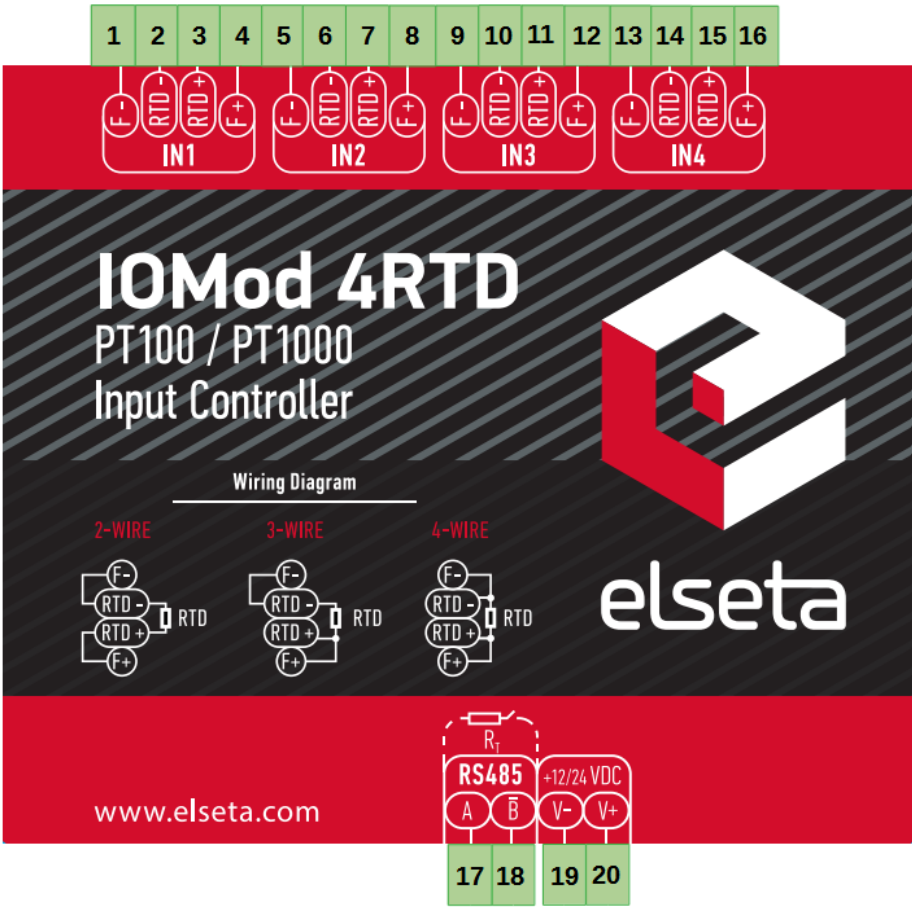


Fig. 2.2.1 IOMod 4RTD terminal diagram

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 negative terminal 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 positive terminal 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 input
18	B	

19	V-	Power source input
20	V+	

## 2.3 Status indication

IOMod 4RTD has six LEDs (Fig 2.3.1), which indicate the temperature related faults, communication and power statuses. The first 4 upper LED's (FLT1-FLT4) can identify whether the temperature related faults have occurred in any of the four input channels. 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 the main power source is connected and red light means at least one of the faults activated. They occur when something is wrong with either the power connection or RTD channels. RX/TX status LED indicates if RS485 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

□ (red)

At least one fault is active

## 3. Technical information

Table 3.1 Technical specifications.

System	
Dimensions	17.5 (H) x 101 (W) x 119 (L), mm
Case	IP20, blend PC/ABS self-extinguishing, black
Working environment	Indoor
Operating temperature	-40°C ... +80°C
Recommended operating conditions	5°C-60°C and 20%-80% RH
Configuration	USB, RS485
Firmware upgrade	USB, RS485
Electrical characteristics	
Termination resistor	Selectable, 120 Ω
Power	
Power Supply	9-33 VDC
Current consumption	40 mA @ 12 VDC, 20 mA @ 24 VDC

## 4. Mounting and installation

### 4.1 RTD sensor connection

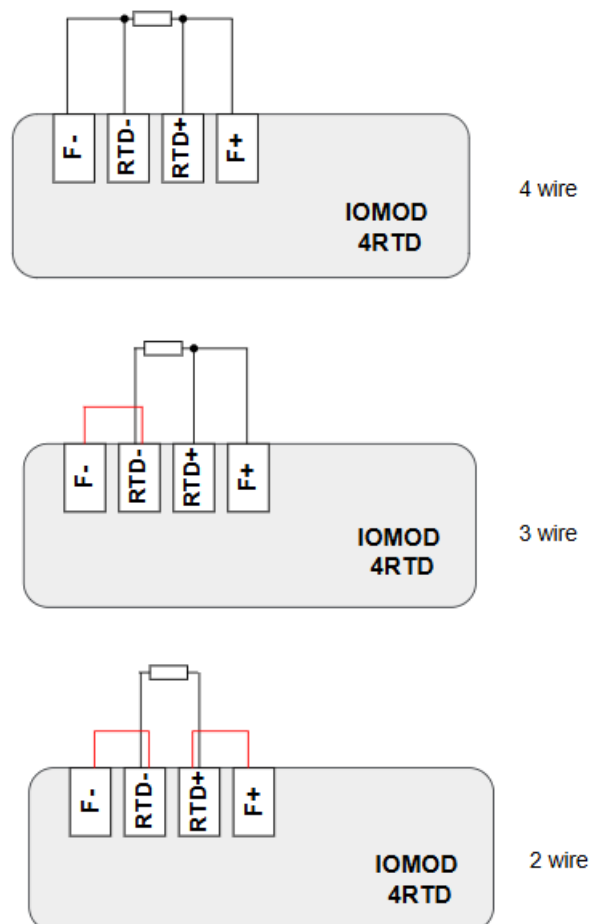


Fig. 4.1.1 3 types of RTD sensor connections. The red wire is shorted on the terminal plug

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 IOMod Utility. 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- terminals. The terminals RTD+ and F+, RTD- and F- must be short circuited (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 terminals RTD- and F- must be short circuited (Fig. 4.1.1).
- 4-wire RTD sensor: connect wires to RTD+ and F+ terminals and wires to RTD- and F- terminals. There is no need to short circuit any terminal in this scenario. (Fig. 4.1.1).

## 4.2 Power Supply

IOMod 4RTD can be powered through the main power connector by a +9-33 VDC power source or USB. Apply +9-33 VDC to V+ and 0 V to V-. The device has a built-in reverse voltage polarity, overcurrent and overvoltage protection.

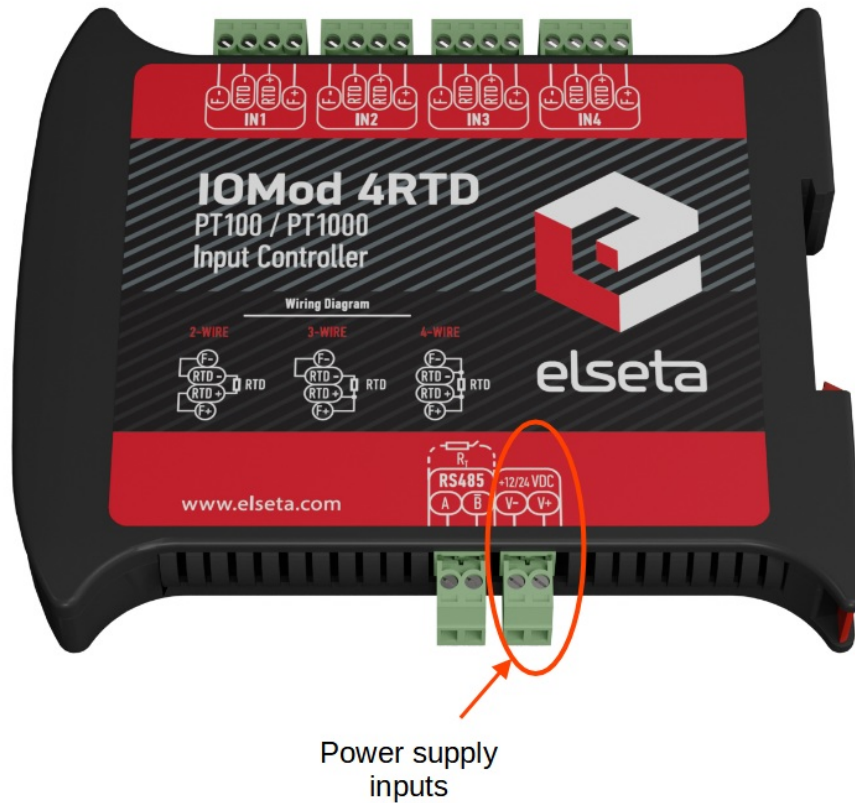


Fig. 4.2.1 Power supply inputs physical location

## 4.3 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.

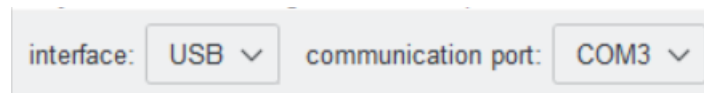


Fig. 4.3.1 IOMod Utility interface and communication port parameters





Fig. 4.3.2 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).

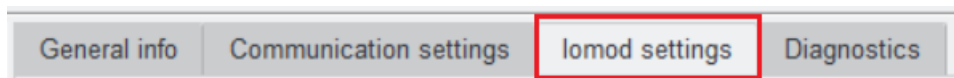


Fig. 5.1 IOMod settings tab

### 5.1 IOMod Settings

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

General info
Communication settings
**Iomod settings**
Diagnostics

Update time (ms)
10

Data type
short floating point value (13)

Input settings

Input 1 wire count
2/4 wire

Input 2 wire count
2/4 wire

Input 3 wire count
2/4 wire

Input 4 wire count
2/4 wire

Input 1 sensor type
PT100

Input 2 sensor type
PT100

Input 3 sensor type
PT100

Input 4 sensor type
PT100

AC filter
50Hz

Value range

Input 1 min value (°C)
-200.000

Input 1 max value (°C)
800.000

Input 2 min value (°C)
-200.000

Input 2 max value (°C)
800.000

Input 3 min value (°C)
-200.000

Input 3 max value (°C)
800.000

Input 4 min value (°C)
-200.000

Input 4 max value (°C)
800.000

Callendar-Van Dusen coefficients

Input 1 A
3.908

Input 1 B
-5.775

Input 2 A
3.908

Input 2 B
-5.775

Input 3 A
3.908

Input 3 B
-5.775

Input 4 A
3.908

Input 4 B
-5.775

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

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 a Modbus slave device. 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, 60 Hz	50 Hz
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.

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 (PT). The Callendar-Van Dusen equation is expressed below:

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

R<sub>T</sub> is resistance at a certain temperature, R<sub>0</sub> 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:

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

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

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

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).

## 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.

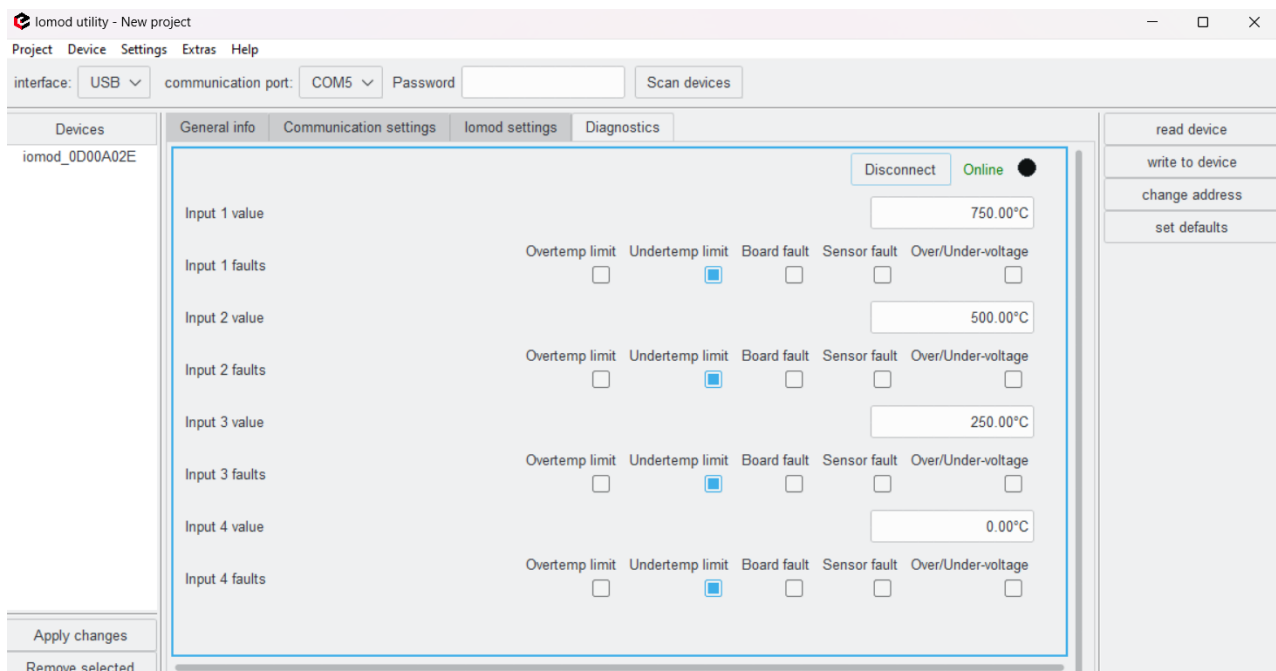


Fig. 5.2.1 IOMod Utility Diagnostics tab in online mode

## 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.

Table 6 Default communication parameters

Protocol	Baudrate	Parity	Stop bits	Wait byte count	Slave address	Link address size	ASDU size	COT size	IOA size	Input function	Output command function	Output status function
Modbus	19200	Even	1	8	1							
IEC 101	19200	Even	1	8	1	1	1	1	2			
IEC 103	19200	Even	1	8	1					253	254	254

**i** \*Default IOMod 4RTD communication protocol is Modbus

### 6.1 Modbus RTU Operational Information

To read temperatures from the RTD sensors with Modbus protocol, send the function code 4 request (Read Input Registers) to read addresses from 0 to 7. Each temperature measurand is saved as 32 bit float value and occupies two consecutive registers. 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) number. The Modbus RTU function code 4 may be used to read current temperature values and faults.

Fault register values are read as 16-bit input registers on addresses 10 to 14. The meanings of individual bits are explained below in the subsection Fault registers (Table 6.1.2).

Table 6.1.1 IOMod 4RTD Modbus input registers

Address (Dec)	Description	Data Type	Access
0-1	Input 1 value	Float	R
2-3	Input 2 value	Float	R
4-5	Input 3 value	Float	R

6-7	Input 4 value	Float	R
10	Input 1 fault	UINT16	R
11	Input 2 fault	UINT16	R
12	Input 3 fault	UINT16	R
13	Input 4 fault	UINT16	R

Fault registers (Modbus addresses 10-13) are read-only. They represent faults that occurred during the operation of the device. Descriptions of possible fault values are provided in the table below (6.1.2). If everything is functioning correctly, these registers will contain a value of 0. If there is an issue, an appropriate value will be indicated.

Table 6.1.2 Fault bit mask

Bit position	Description
0	Reserved (default: 0)
1	Reserved (default: 0)
2	RTD Overvoltage/Undervoltage - The measured voltage across the RTD is too high or too low, possibly indicating a wiring issue or sensor failure
3	RTD FORCE Open - The force lead (excitation current path) is open; the RTD may be disconnected
4	Reserved (default: 0)
5	RTD REF <sub>IN</sub> - > 0.85 x VBIAS - The negative reference voltage (REF <sub>IN</sub> -) is too high compared to the bias voltage, which could indicate a configuration or hardware issue
6	RTD Code Low Threshold - The digital output code from the RTD is lower than expected, possibly indicating a sensor or wiring issue
7	RTD Code High Threshold - The digital output code from the RTD is higher than expected, possibly indicating overheating or fault
8	Reserved (default: 0)
9	Reserved (default: 0)
10	Reserved (default: 0)
11	Reserved (default: 0)
12	Reserved (default: 0)
13	Reserved (default: 0)
14	RTD Temperature Lower Threshold - The measured temperature is below the configured lower threshold
15	RTD Temperature Upper Threshold - The measured temperature exceeds the configured upper threshold

## 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) starts 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.

Time synchronization is critical for logging events. To synchronize time, the master sends a Time Sync command C\_CS\_NA\_1 (103) with Cause of Transmission (COT) 6. According to the IEC 60870-5-101 protocol specification, time synchronization can be performed for multiple devices using broadcast messages. A master device sends a broadcast timesync command with a broadcast link address. This ensures consistent time-stamping for event recording and fault detection across the network.

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.

Table 6.2.1 IEC-60870-101 input values.

IOA	Description	TI*
1	input 1 value	11 (M_ME_NB_1) or 13 (M_ME_NC_1)
2	input 2 value	11 (M_ME_NB_1) or 13 (M_ME_NC_1)
3	input 3 value	11 (M_ME_NB_1) or 13 (M_ME_NC_1)
4	input 4 value	11 (M_ME_NB_1) or 13 (M_ME_NC_1)

 \*Depends on data type settings on IOMod (Scaled value or short floating point value)

## 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.

Time synchronization is critical for logging events. To synchronize time, the master sends a Time Sync command with function 0 and Cause of Transmission (COT) 8. According to the IEC 60870-5-103 protocol specification, time synchronization can be performed for multiple devices using broadcast messages. For broadcast time synchronization, the master device sends a periodic signal with a time stamp to synchronize the system time of slave devices. If synchronization fails, devices default to their local system time until they successfully resynchronize.

The master may read temperature values from RTD sensors and data from user-configured fault registers. The fault register is cleared automatically whenever the fault conditions disappear. Fault register values are read as standard-defined 12-bit measurands.

Table 6.3.1 IEC-60870-103 input values.

Type	INF	FUN	Description
3 (M_MEI_NA_3)	0	253	input 1 value
3 (M_MEI_NA_3)	1	253	input 2 value

3 (M_MEI_NA_3)	2	253	input 3 value
3 (M_MEI_NA_3)	3	253	input 4 value