

IOMOD 4RTD

IOMod 4RTD – industrial 4 temperature sensors module.

- Firmware version 1
 - IOMOD 4RTD User Manual Modbus
 - IOMOD 4RTD User Manual IEC 60870-5-103
 - IOMOD 4RTD User Manual IEC 60870-5-101
- Firmware version 2
 - IOMOD 4RTD User Manual

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 ± 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
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

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/Undervoltage	-	-

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.

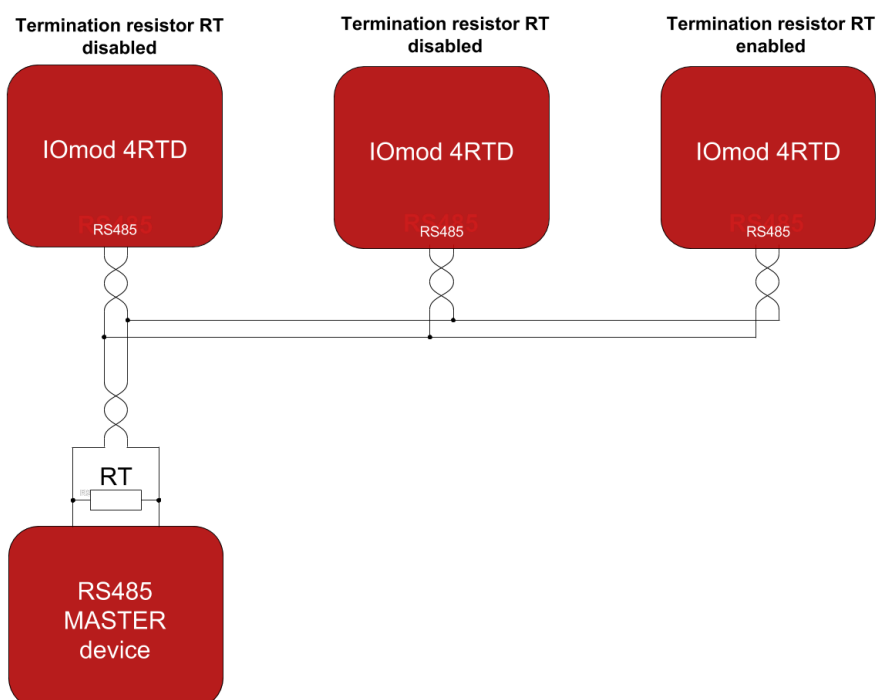


Fig. 5.1. Typical IOMod connection diagram

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

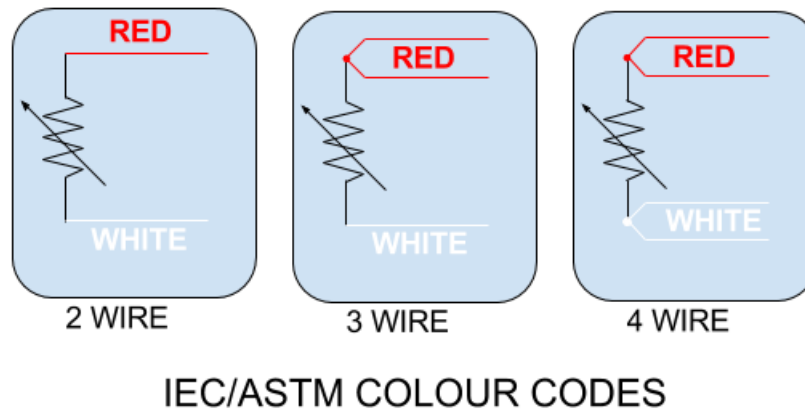


Fig. 5.3. RTD sensor colour codes

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.

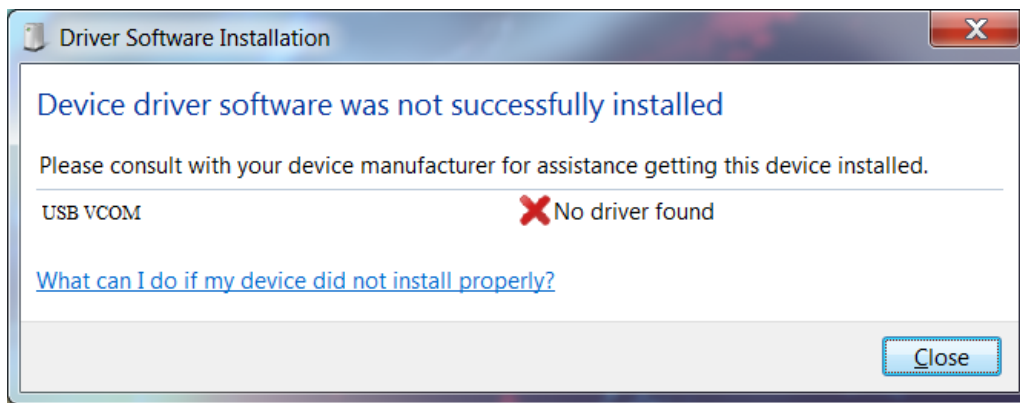


Fig. 6.1. Unsuccessful device software installation error

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:

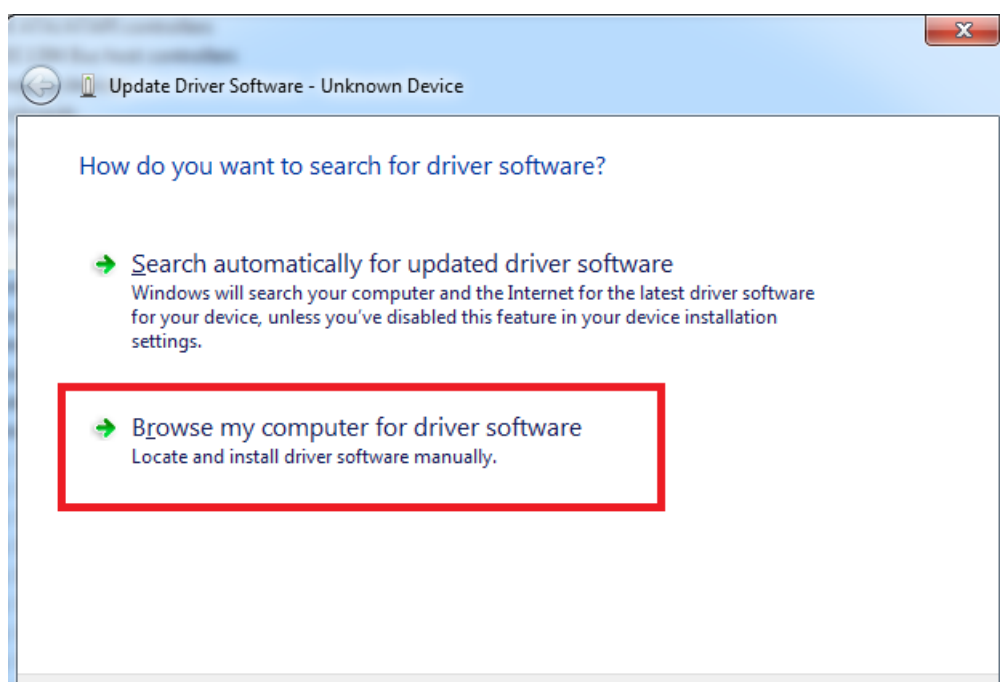


Fig. 6.2. Device driver software update message

- 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).

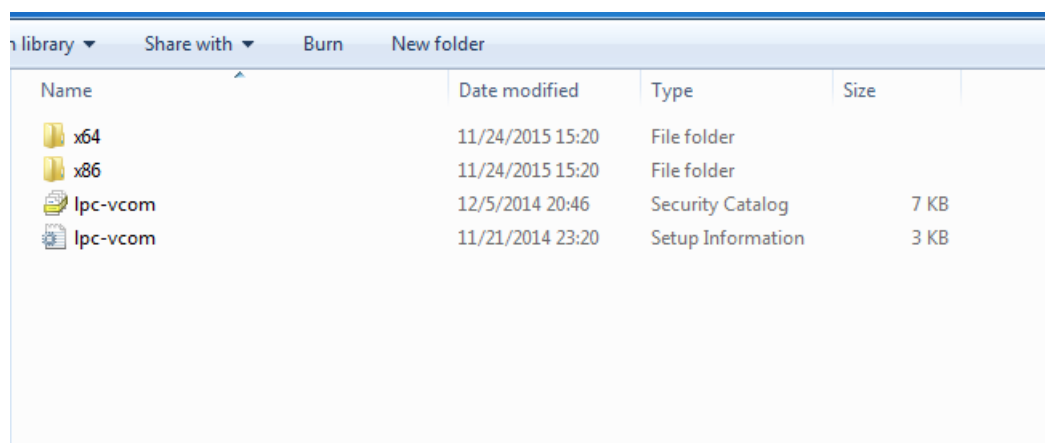


Fig. 6.3. Device driver folder content

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.

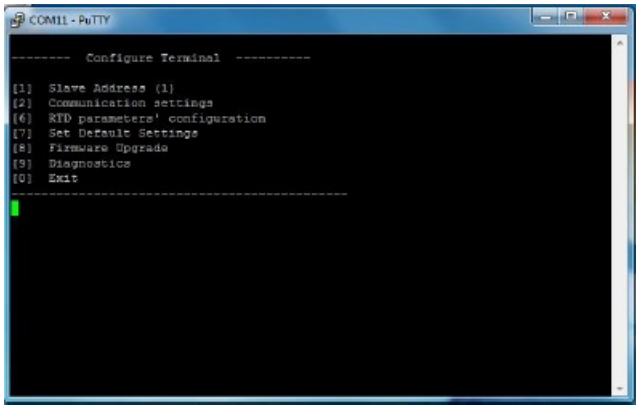


Fig. 6.4. The main menu for IOMod 4RTD

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.)

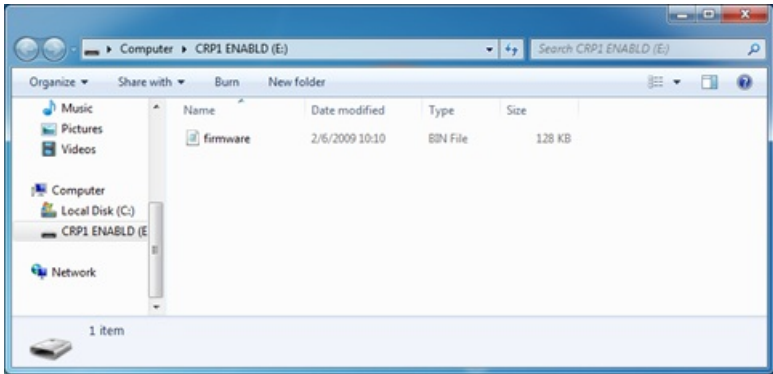


Fig. 6.11. Dragging and dropping new firmware file

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 ± 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.

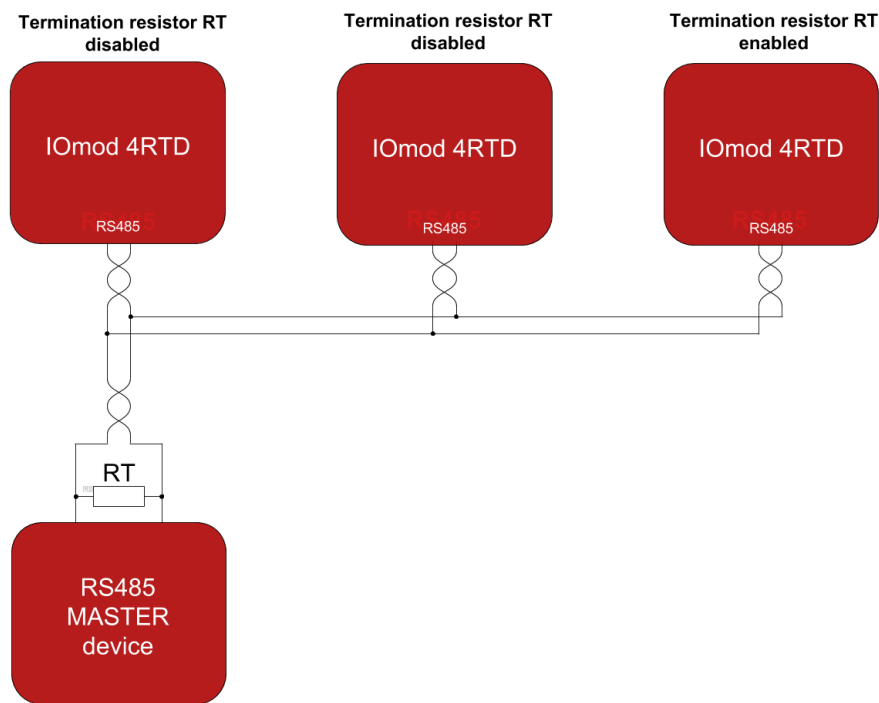


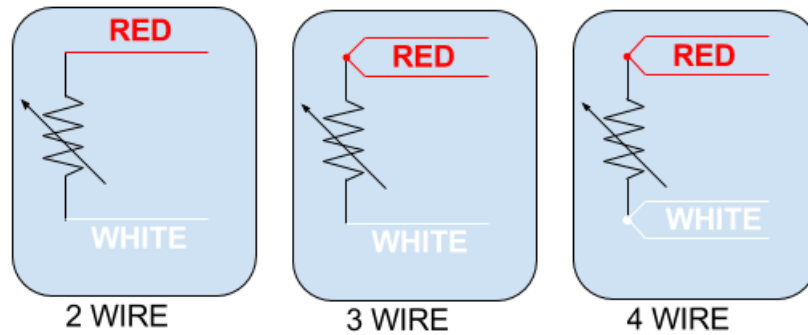
Fig. 5.1. Typical IOMod connection diagram

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.

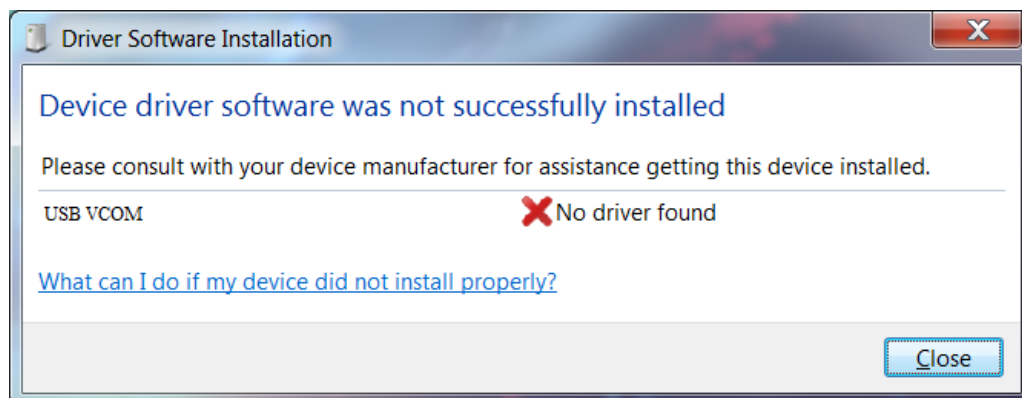


Fig. 6.1. Unsuccessful device software installation error

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:

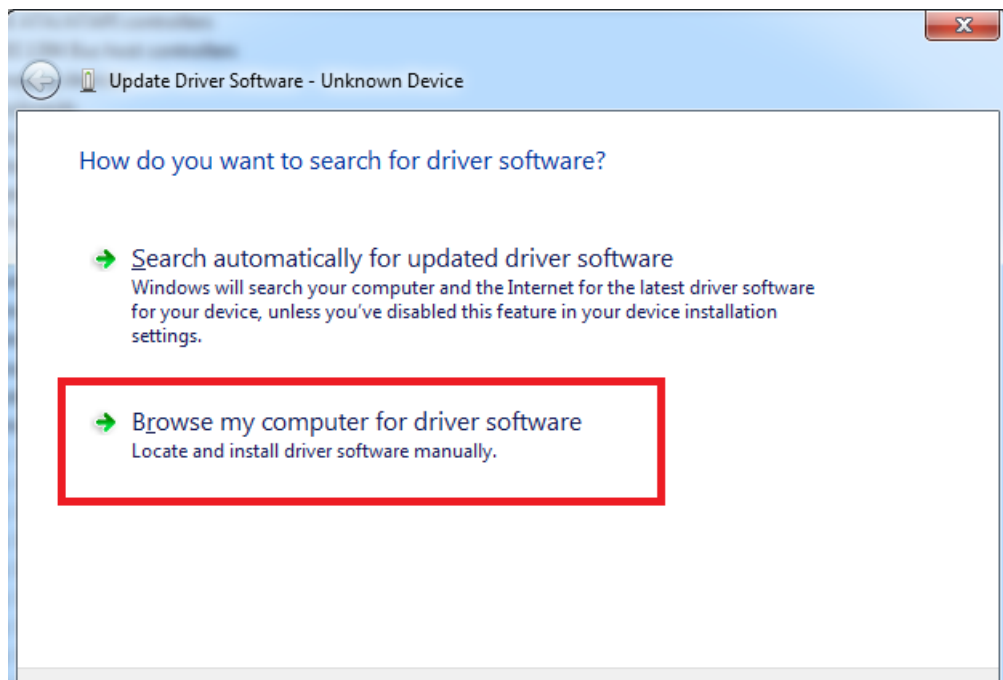


Fig. 6.2. Device driver software update message

- 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).

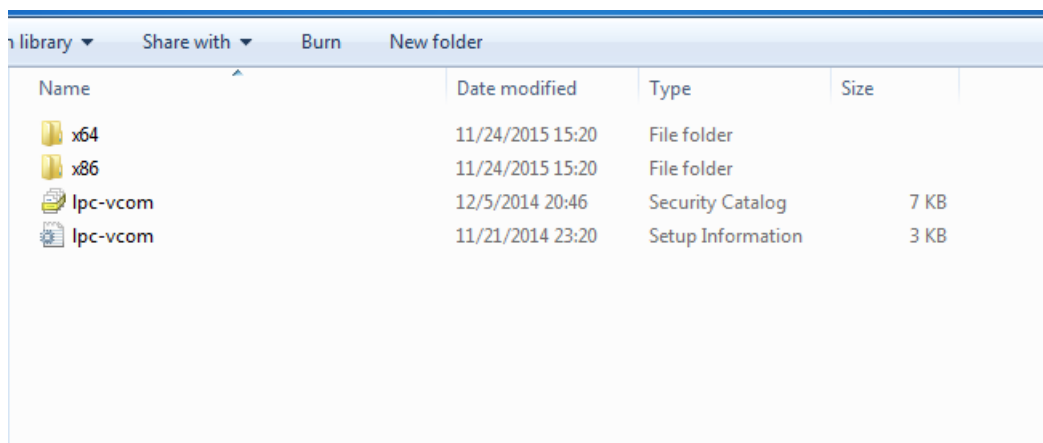


Fig. 6.3. Device driver folder content

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.

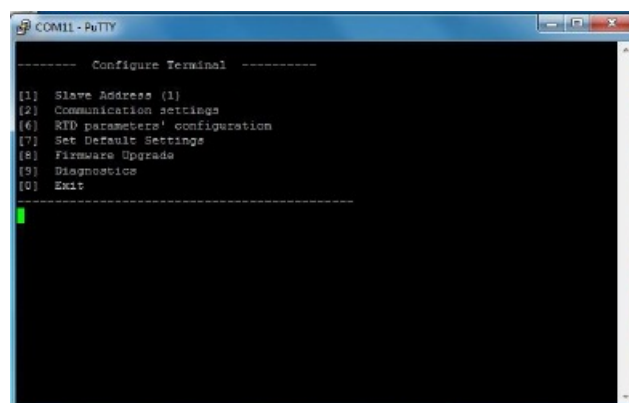


Fig. 6.4. The main menu for IOMod 4RTD

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.



Windows Explorer window showing the contents of the CRP1 ENABLED (E:) drive.

Address bar: Computer > CRP1 ENABLED (E:)

Search: Search CRP1 ENABLED (E:)

Organize | Share with | Burn | New folder

Left sidebar (Navigation pane):

- Music
- Pictures
- Videos
- Computer
- Local Disk (C:)
- CRP1 ENABLED (E:)**
- Network

Main pane (Details view):

Name	Date modified	Type	Size
firmware	2/6/2009 10:10	BIN File	128 KB

Status bar: 1 item

Fig. 6.11. Dragging and dropping new firmware file

Testing With “THE VINCI” software

Settings	Console	Events	Status	The Virus Expert					
ID	Code	ASCI	PIN	IMP	Value	Status	True Tag	Count	Name
(77=081)	General Inter	1	0	1 (8)	00000000	ED=0	[W]2018/02/14 00:01:11.660[TV]	1	-
(77=081)	General Inter	1	0	4 (8)	00000001	ED=0	[W]2018/02/14 00:01:12.004[TV]	2	-
(77=088)	Start/mainark	1	288	1 (8)	0	A0C0E0D8D8D8 F...	-	0	-
(77=093)	cyclic	1	268	0 (8)	00000000.00000000	0x00 0x00	-	150	-
(77=093)	cyclic	1	268	0 (2)	00000001.173204	0x00 0x00	-	150	-
(77=093)	cyclic	1	268	0 (2)	00000000.00000000	0x00 0x00	-	150	-
(77=093)	cyclic	1	268	0 (2)	00000000.10000000	0x00 0x00	-	150	-
(77=093)	cyclic	1	268	0 (4)	0000000000	0x00 0x00	-	150	-
(77=093)	cyclic	1	268	0 (8)	000000000000	0x00 0x00	-	150	-
(77=093)	cyclic	1	268	0 (4)	000000000000	0x00 0x00	-	150	-
(77=093)	cyclic	1	268	0 (7)	000000000000	0x00 0x00	-	150	-
(77=098)	End of g. stat	1	288	0 (8)	00000000	-	-	1	-
(77=081)	General Inter	1	0	2 (8)	00000001	ED=0	[W]2018/02/14 00:01:11.798[TV]	0	-
(77=081)	General Inter	1	0	3 (8)	00000001	ED=0	[W]2018/02/14 00:01:11.894[TV]	0	-

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 ± 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.

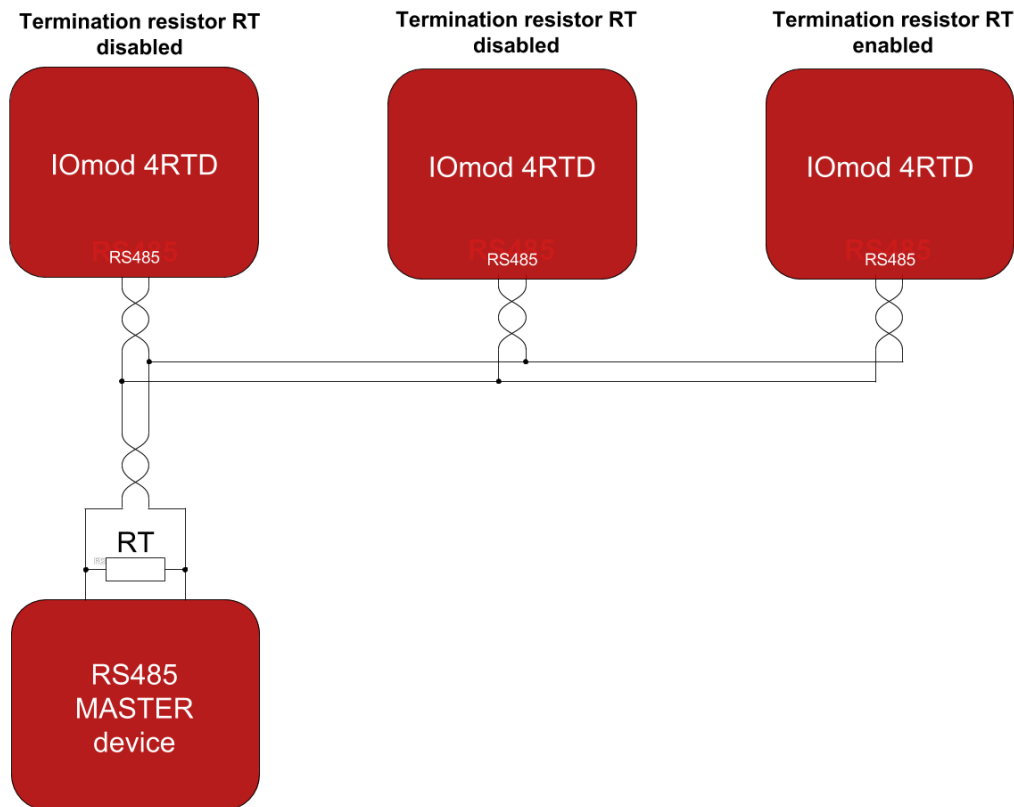


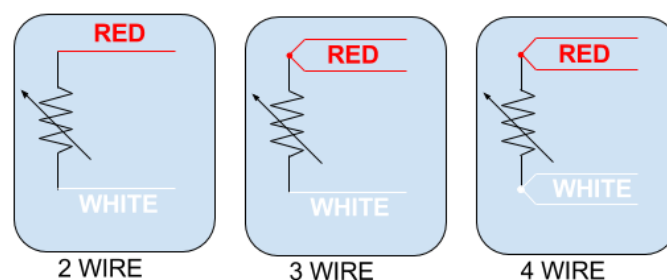
Fig. 1. Typical IOMod connection diagram

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.

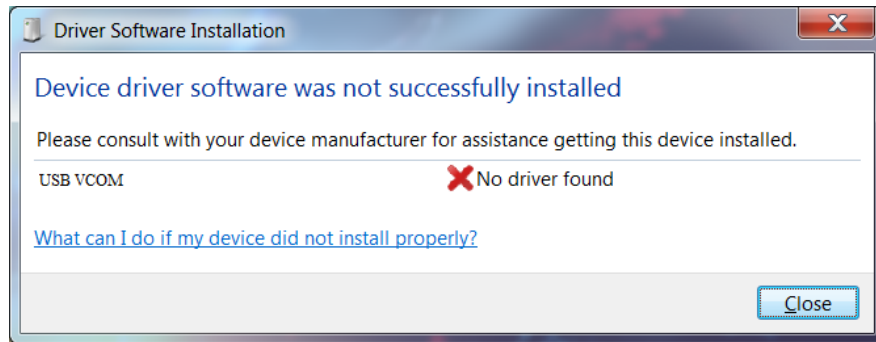


Fig. 3. Unsuccessful device software installation error

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:

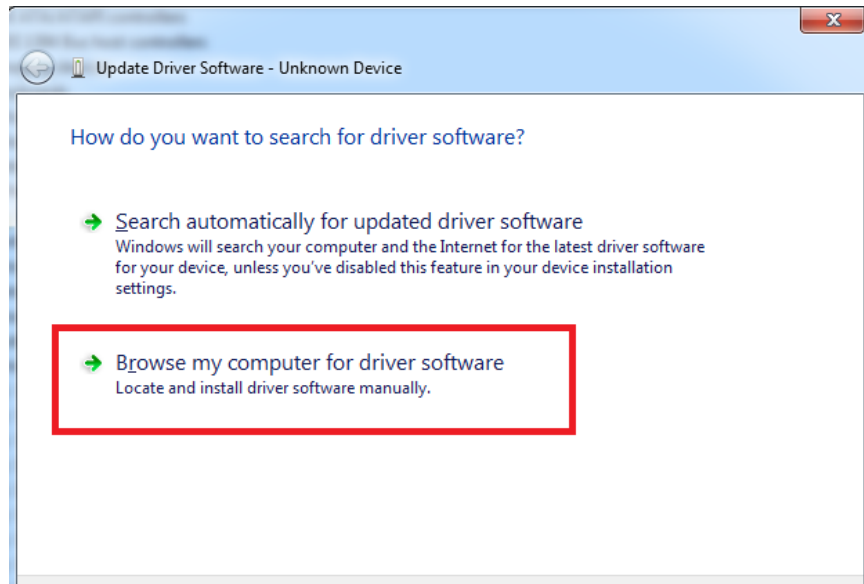


Fig. 4. Device driver software update message

- 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.)

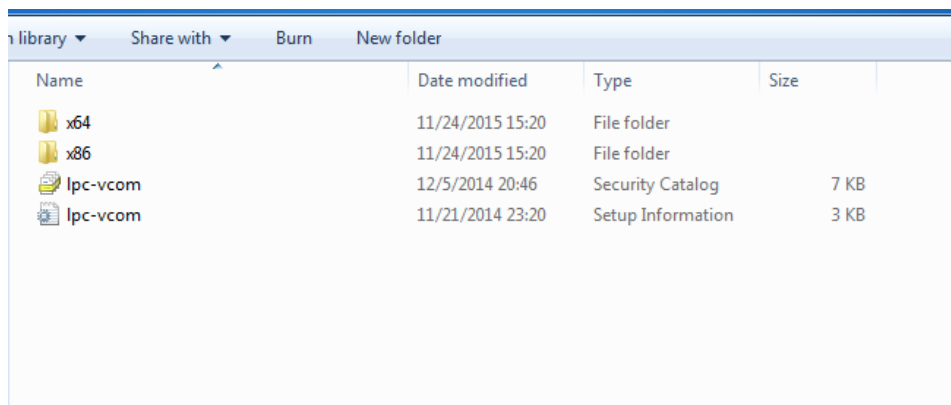


Fig. 5. Device driver folder content

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.

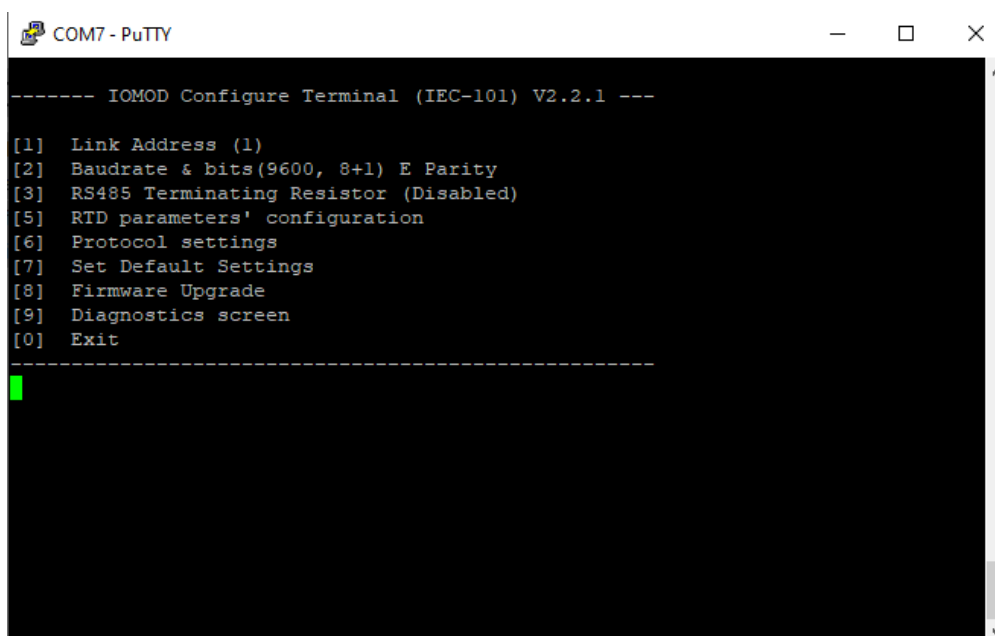


Fig. 6. The main menu for IOMod 4RTD

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.)

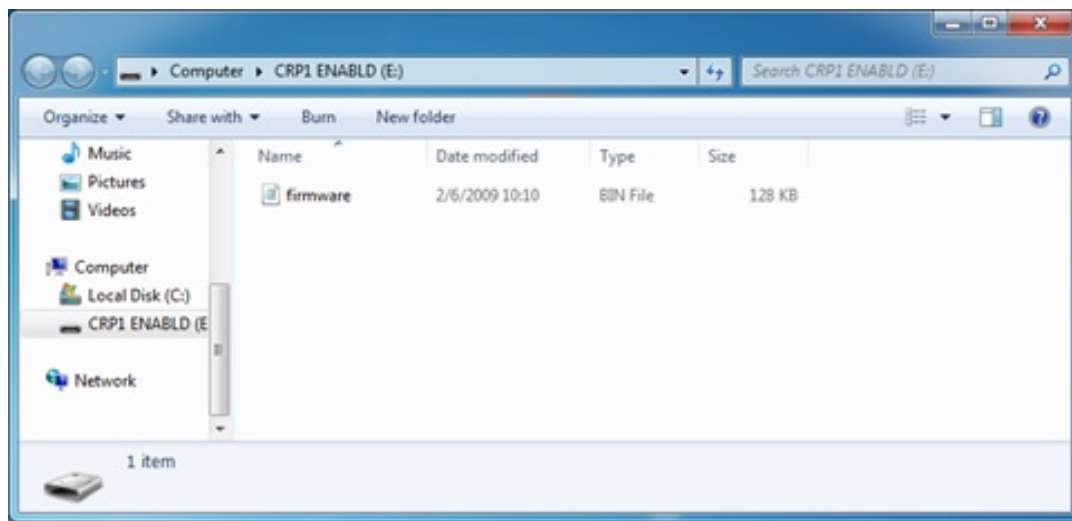


Fig. 8. Dragging and dropping new firmware file

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 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

- Firmware upgrade over USB, RS485;
- Configurable using the IOMOD Utility app 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 ± 0.5 °C accuracy in all operating conditions;
- 2.5kV(rms) isolated RTD inputs;
- Temperature sensing ranges from -200 up to 800 °C when using platinum RTD sensors;

1.2 Block Diagram

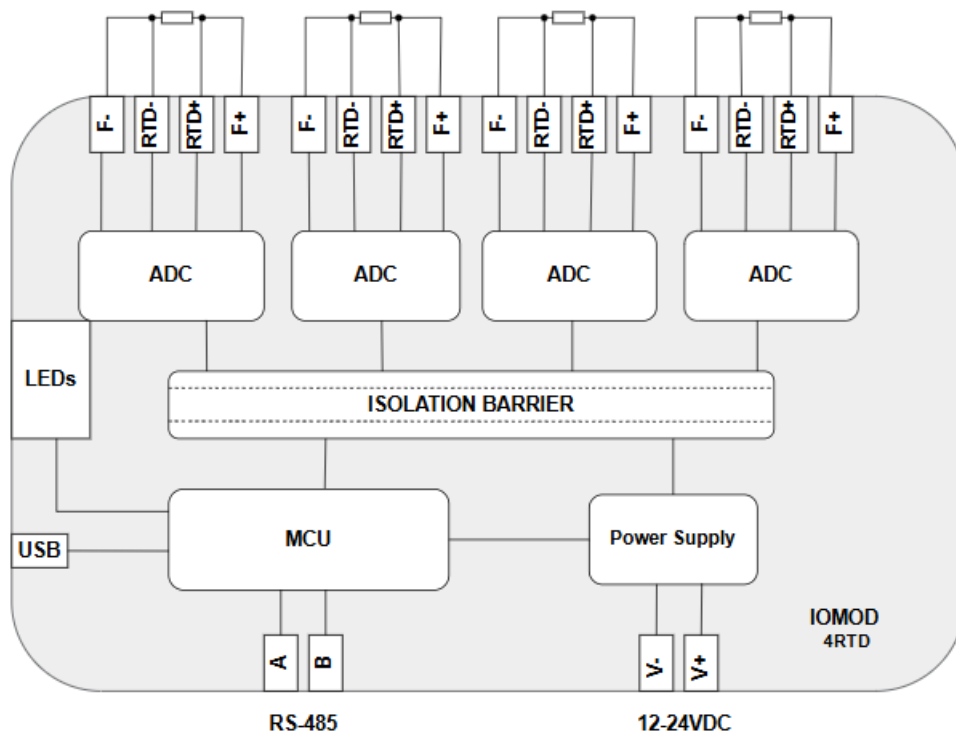


Fig. 1.2.1. IOMOD 4RTD internal structure and block diagram

2. Hardware data

2.1 Mechanical drawings

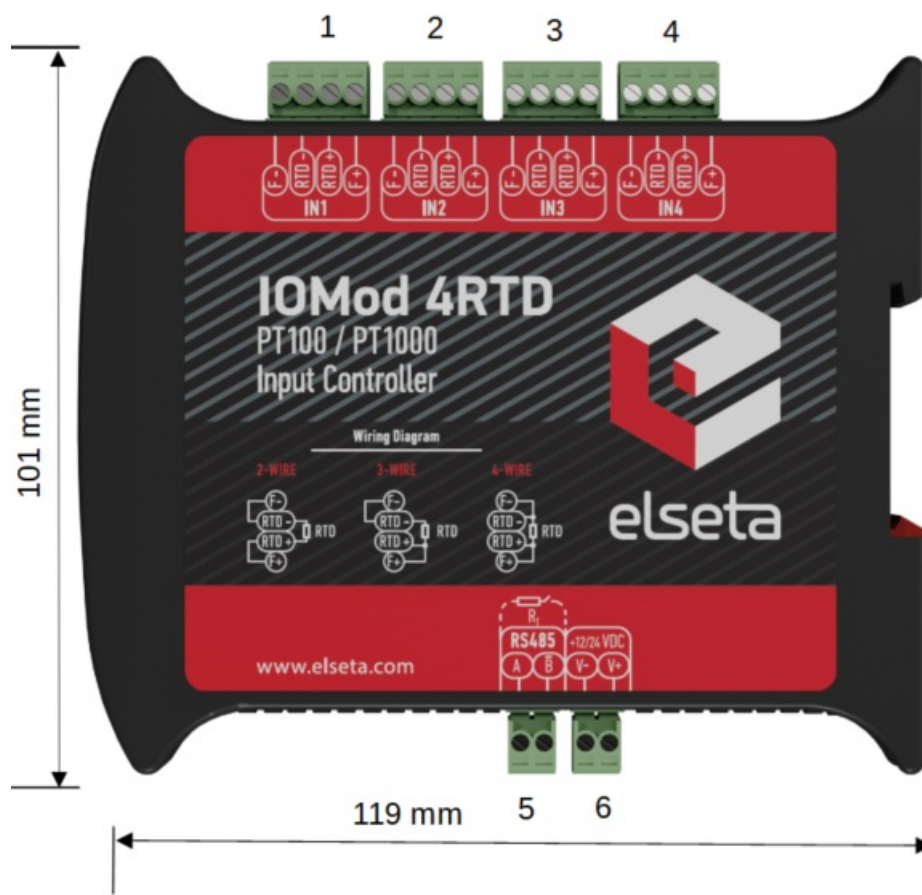


Fig. 2.1.1.1 IOMOD 4RTD side view with dimensions and terminals description. 1 - 4 sensor inputs, 5 - RS485 interface, 6 - power supply input

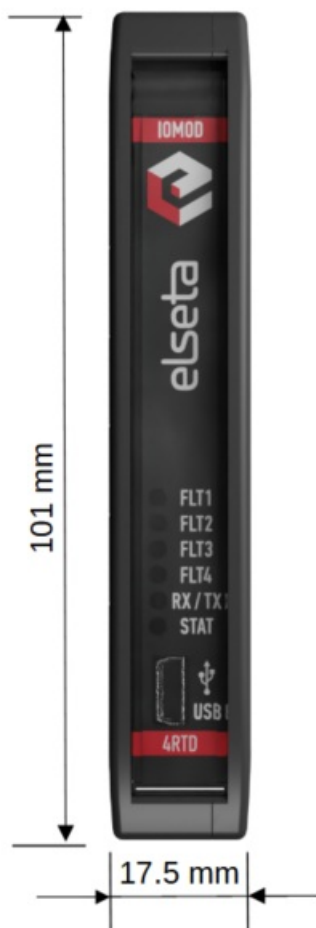
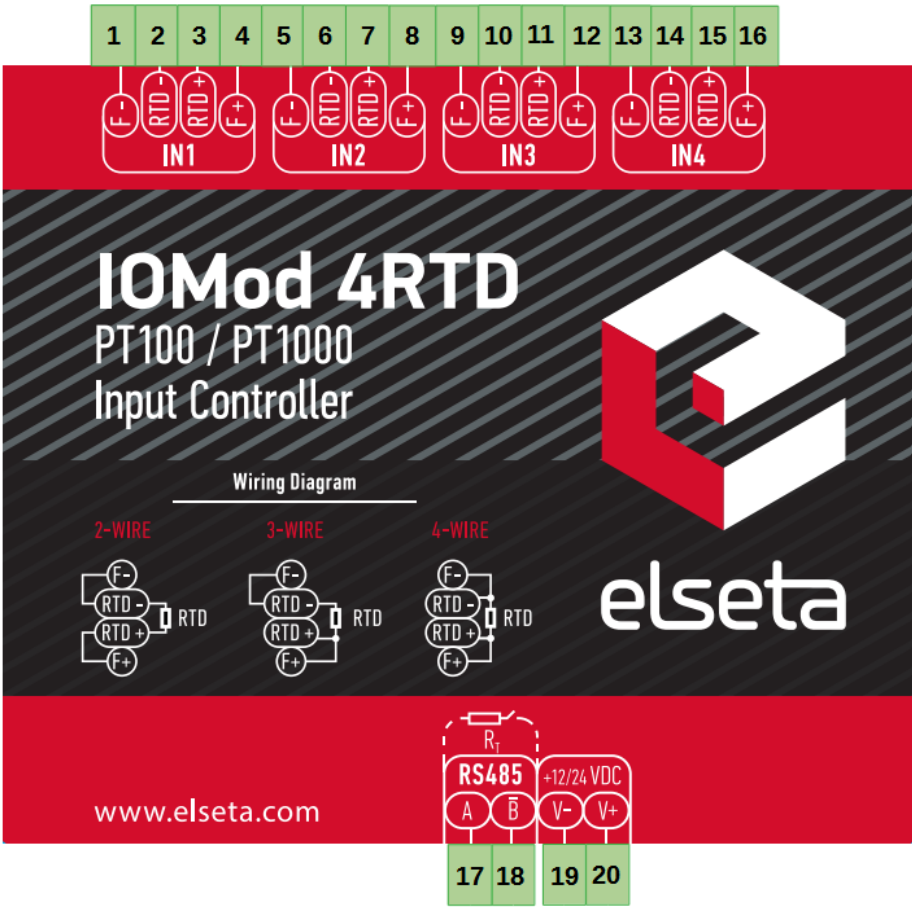


Fig. 2.1.1.2. IOMOD 4RTD front view with measurements

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 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 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

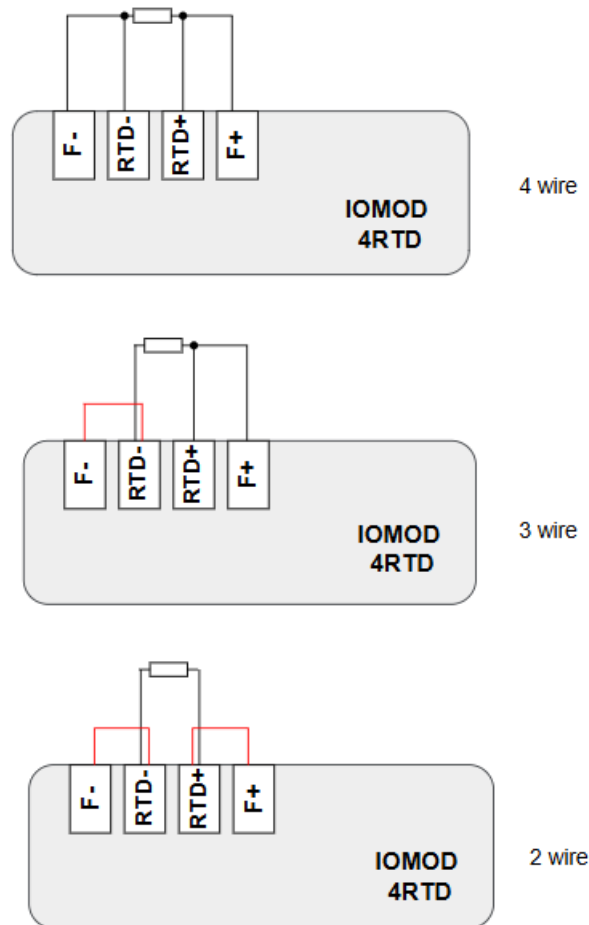


Fig. 4.1.1 RTD sensor connections, the red wire is shorted on the terminal plug

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

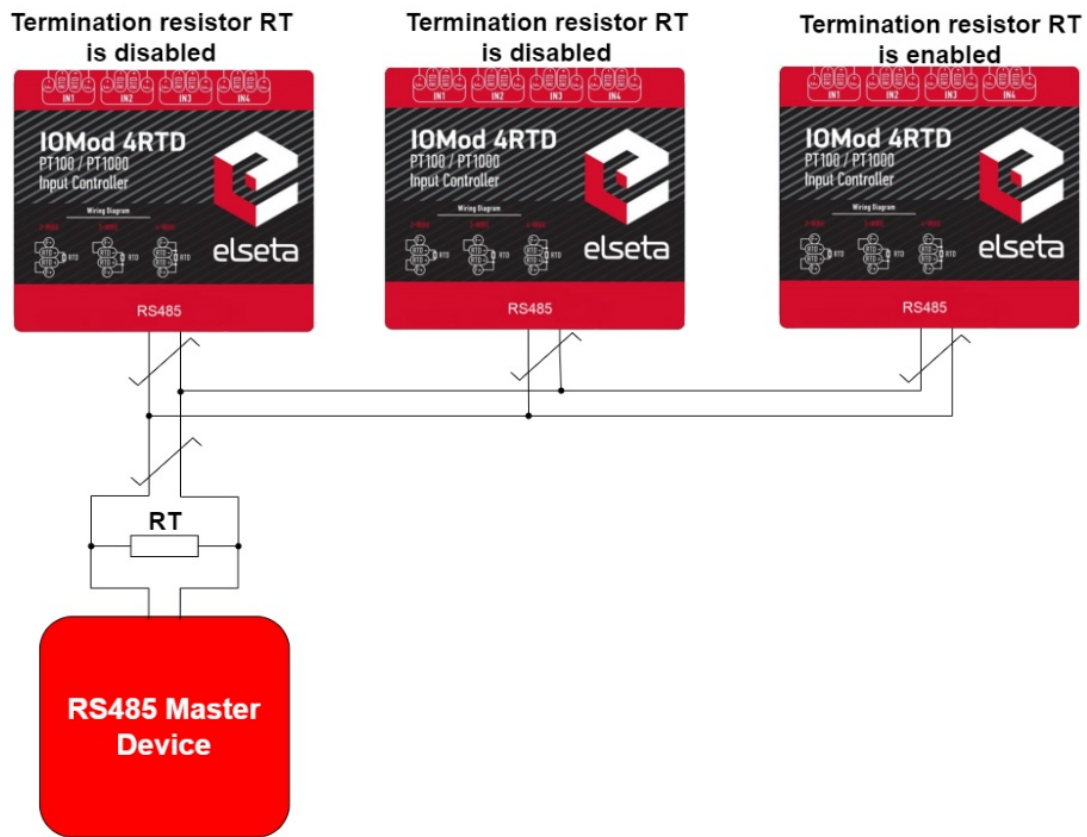


Fig. 4.2.1 Typical IOMod connection diagram

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.

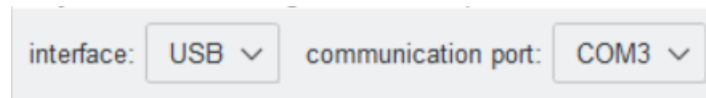


Fig. 4.4.1. IOMOD Utility interface and communication port parameters



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).

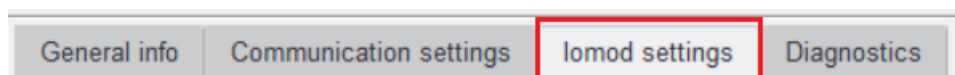


Fig. 5.1. IOMod settings tab

5.1 Iomod Settings

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

General info		Communication settings		Iomod settings		Diagnostics	
Update time (ms)				<input type="text" value="10"/>			
Data type				<input type="text" value="short floating point value (13)"/>			
Input settings							
Input 1 wire count	<input type="text" value="2/4 wire"/>	Input 2 wire count	<input type="text" value="2/4 wire"/>				
Input 3 wire count	<input type="text" value="2/4 wire"/>	Input 4 wire count	<input type="text" value="2/4 wire"/>				
Input 1 sensor type	<input type="text" value="PT100"/>	Input 2 sensor type	<input type="text" value="PT100"/>				
Input 3 sensor type	<input type="text" value="PT100"/>	Input 4 sensor type	<input type="text" value="PT100"/>				
AC filter				<input type="text" value="50Hz"/>			
Value range							
Input 1 min value (°C)	<input type="text" value="-200.000"/>	Input 1 max value (°C)	<input type="text" value="800.000"/>				
Input 2 min value (°C)	<input type="text" value="-200.000"/>	Input 2 max value (°C)	<input type="text" value="800.000"/>				
Input 3 min value (°C)	<input type="text" value="-200.000"/>	Input 3 max value (°C)	<input type="text" value="800.000"/>				
Input 4 min value (°C)	<input type="text" value="-200.000"/>	Input 4 max value (°C)	<input type="text" value="800.000"/>				
Callendar-Van Dusen coefficients							
Input 1 A	<input type="text" value="3.908"/>	Input 1 B	<input type="text" value="-5.775"/>				
Input 2 A	<input type="text" value="3.908"/>	Input 2 B	<input type="text" value="-5.775"/>				
Input 3 A	<input type="text" value="3.908"/>	Input 3 B	<input type="text" value="-5.775"/>				
Input 4 A	<input type="text" value="3.908"/>	Input 4 B	<input type="text" value="-5.775"/>				

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:

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

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

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

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).

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.

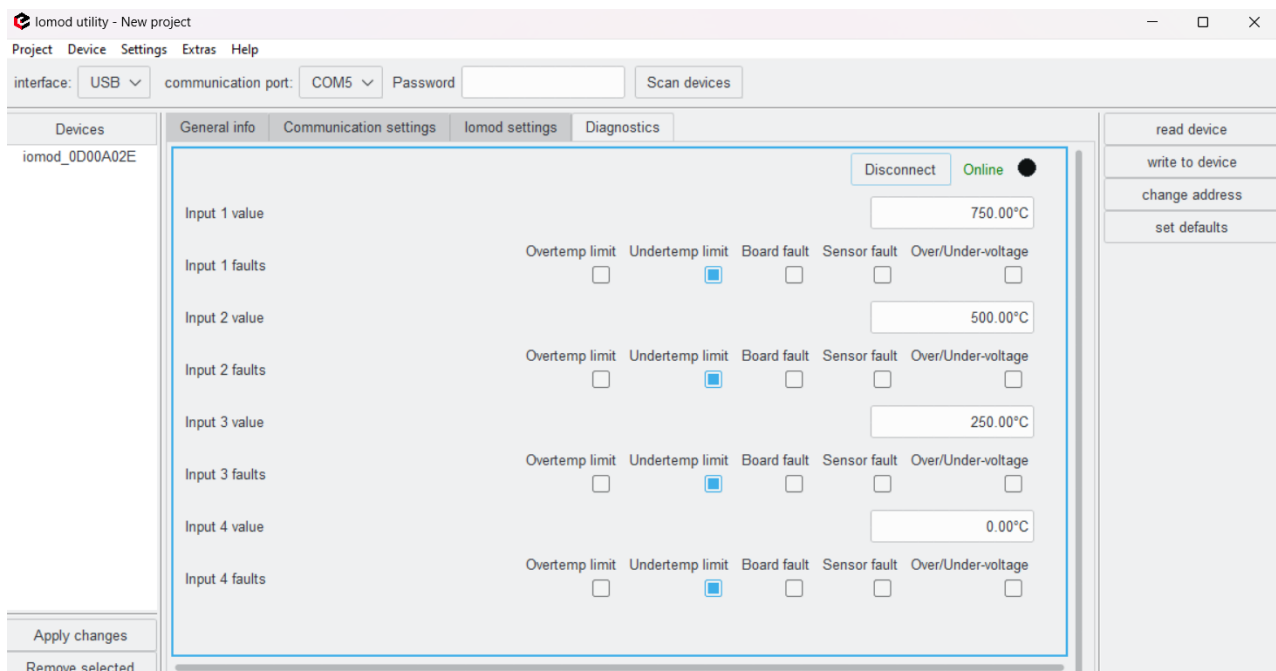


Fig. 5.2.1. IOMOD Utility Diagnostics tab in online mode

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-0)
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].