Elseta
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V0.1

ELSETA

IOMOD 4RTD

User manual

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DECLARATION OF CONFORMITY

(in accordance with ISO / IEC Guide 22 and EN Section 45014)
Manufacturer: UAB Aedilis
Address of the manufacturer L. Zamenhofo st. 5 LT Vilnius, Lithuania

We claim that:
The device IOMOD 4RTD

Conforms to the following standards:

EMC:
Radiation EN 55022 (Class A)
1 emitted radiation (30-1000 MHz)
Second radiation conductors (0.15-30 MHz)
EN 50082-1 immunity test
1 IEC 801-3: Radio-frequency electromagnetic field
2 IEC 801-2: Electrostatic discharge.
3 IEC 801-4: Quick periodic electrostatic discharges

Additional information:
The device complies with the Low Voltage Directive 73/23 / EEC and EMC Directive 89/336 / EEC.
Device assembly complies with the RoHS Directive.

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SAFETY REQUIREMENTS

These equipment operating notes, which must be met for your personal safety, as well as to avoid damage to the equipment, are marked with a warning triangle symbol and the various degrees of risk of falling within signs. All work related to electronic systems design, installation, commissioning, adjustment and maintenance should be carried out in accordance with the safety requirements.

EQUIPMENT MANUAL - USED SYMBOLS

Danger - important notice which may affect the safety of the user or device.

Attention - notice on possible problems that may arise in individual cases.

Information Notice - the information that is useful advice or special cases.

Warning of the danger. The work may be performed only by a qualified professional. Equipment installation, commissioning and maintenance may only be performed by a qualified professional. If the safety notes in this manual, the term refers to persons qualified specialists authorized to perform commissioning, grounding and labeling devices, systems and circuits. The person must: Be aware of occupational safety in the workplace. Need to understand the equipment components. Electrical equipment. Have the knowledge and skills to identify a component beneath the voltage.

To maintain the equipment necessary to always turn off the power supply before installing or dismantling works. It must be in mind that even though alone equipment, but can have a common ground connection. Always before connecting the power supply, cables and interconnect components must be inspected.

This product cannot be implemented, or resold to install in areas that are high-security as nuclear power plants, aircraft navigation, military equipment, transport traffic in management. In areas where equipment failure can result in of nature and human injury.

Do not operate the equipment in extreme weather conditions, as they may affect the operation of the equipment.

TABLE OF CONTENTS

1. 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.

2. Features

- Temperature sense with ±0.5 °C accuracy over all operating conditions;
- Selectable PT100 ar 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.

3. Device 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 Modbus (RTU) 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 register 0 and 1, where register 0 is least significant word. Two words read by Modbus represent a float type (IEEE-754 compatible) variable.

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 MODBUS and IEC-60870-103 functions described in paragraphs described below.

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

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 mapping 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

*if lower limit is set higher that upper limit, limits are switched in order. Temperature is encoded as signed integer.

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-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)**	**2 (R/W-1)**	**1 (R/W-0)**	**0 (R/W-0)**
RTD Code Hi Threshold Fault Enable	RTD Code Lo Threshold Fault Enable	RTD REFIN- > 0.85 x VBIAS Fault Enable	-	RTD FORCE-Open Fault Enable	RTD Overvoltage/ Undervoltage Fault Enable	-	-

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].

Fault registers

Faults registers 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 via USB. Default values are shown in brackets below.

Fault register[11:10] show 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 flag are usually set if unsuitable software or jumper settings are set or RTD is faulty or not connected. Note that fault bits are set if they are configured to be set in *Fault Mask register*.

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-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)**	**2 (R/W-1)**	**1 (R/W-0)**	**0 (R/W-0)**
RTD Code Hi Threshold Fault Enable	RTD Code Lo Threshold Fault Enable	RTD REFIN- > 0.85 x VBIAS Fault Enable	-	RTD FORCE-Open Fault Enable	RTD Overvoltage/ Undervoltage Fault Enable	-	-

4. Technical information

System		
1.	Dimensions	17.5 (H) x 101 (W) x 119 (L), mm
2.	Case	ABS, Black
3.	Working environment	Indoors
4.	Working temperature	-40 | +80°C
5.	Recommended operating conditions	5 – 60°C and 20 – 80% RH;
6.	Configuration	USB
7.	Firmware upgrade	USB – mass storage device
Electrical Characteristics		
8.	Termination Resistor	Selectable, 120Ω
9.	Power supply	9-33 VDC
10.	Current consumption	40mA @ 12VDC, 20mA @ 24VDC

5. 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

IOMOD4RTD 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.

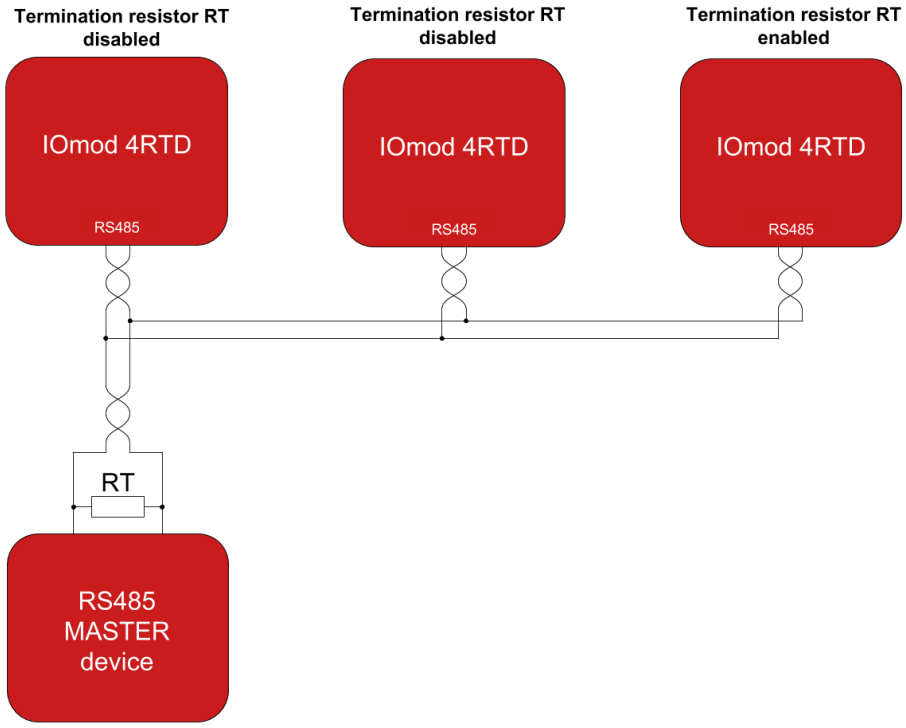

Fig. 5.1. Bus configuration example diagram

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 indications

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.

Fig. 5.2 shows front panel of a IOMOD 4RTD devices where all status indications can be seen.

Fig. 5.2. Status indications

RTD sensor connection

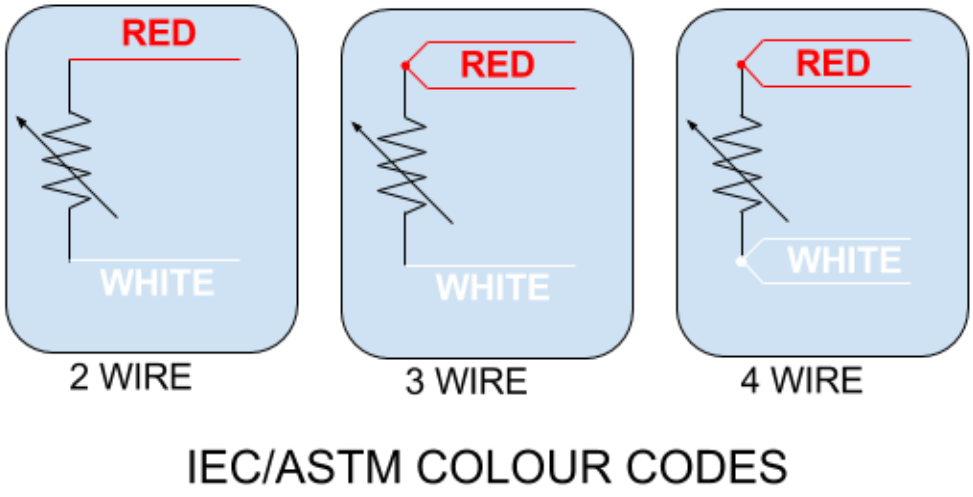

Fig. 5.3. RTD sensor colour codes

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.

6. 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.

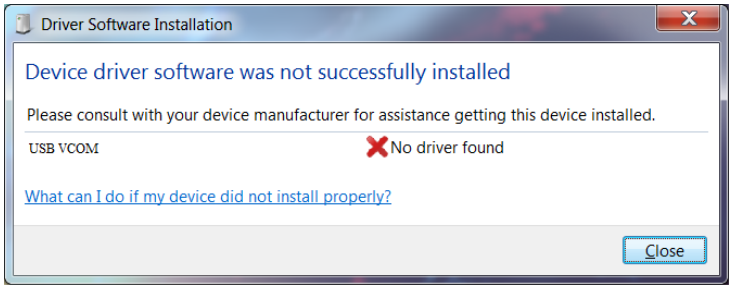

Fig. 6.1. Possible installation error

User then should manually install drivers by selecting downloaded driver folder:
Go to Control Panel -> Device Manager;
Select failed device;
Press “Update driver software”; following screen should appear:

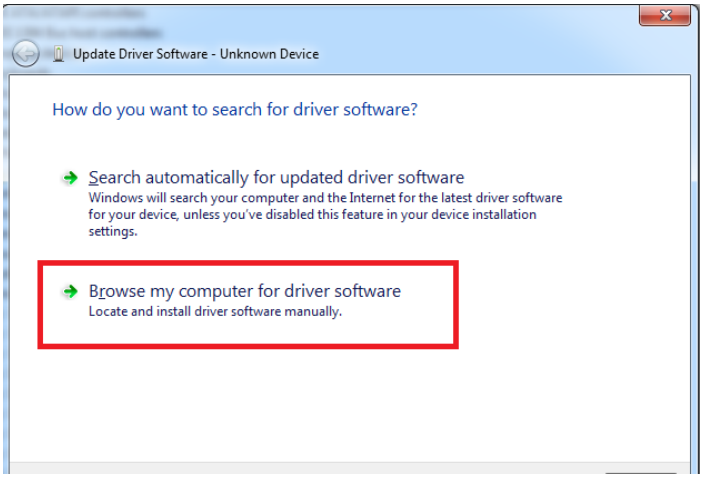

Fig. 6.2. Driver update screen

Select “x86” driver for 32bit machine, or x64 for 64 bit machine. If not sure, select root folder (folder in which x64 and x86 lays inside).

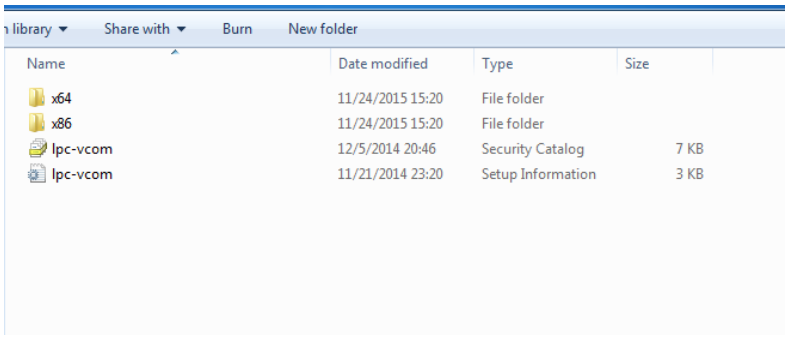

Fig. 6.3. Contents of folder used to install drivers

IOMOD 4RTD configuration with 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.

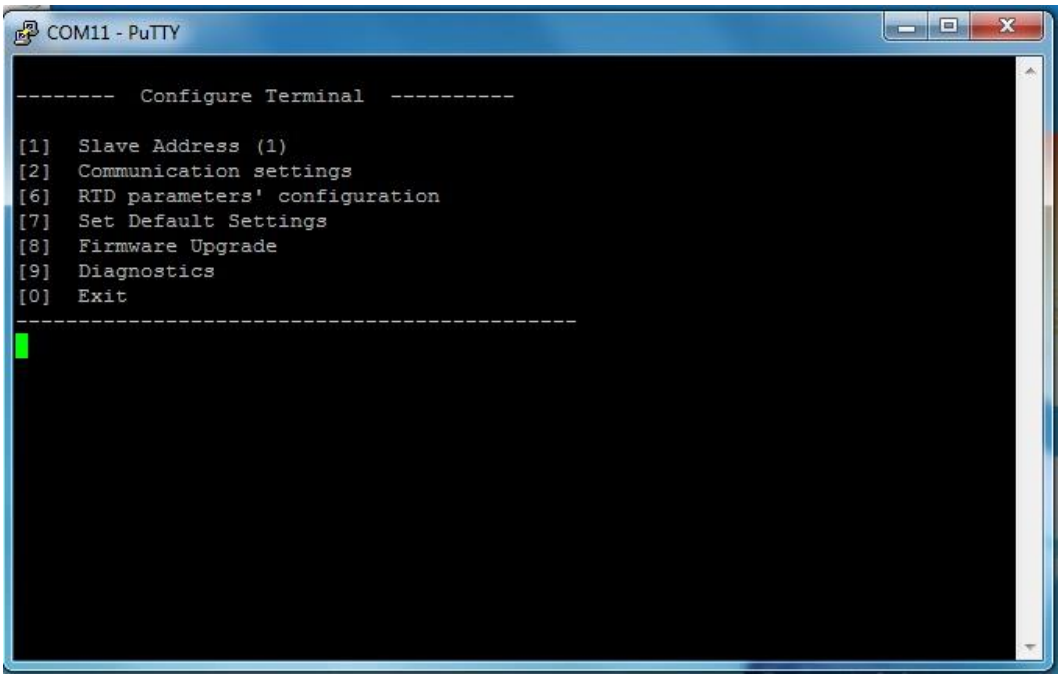

Fig. 6.4. Main configuration menu example

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.

Main Menu

Modbus

	Menu Name	Function	Values	Default Values
1.	Slave Address	Modbus Slave address / ID	1-247	(default: 1)
2.	Communication settings	Modbus baud rate; data, stop, parity bits; terminating resistor		(default: 9600, 8N1, 1 (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	Entering diagnostics mode	-	-
0.	Exit	Exit and disconnect	-	-

*When configuring RTD coefficients A, B and C, write values without their respective exponents (e.g. A=3.9083)

IEC-60870-103

	Menu Name	Function	Values	Default Values
1.	Link Address	Link Slave address	1-247	(default: 1)
2.	Baudrate & bits	Baud rate; data, stop, parity bits		(default: 9600, 8N1)
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 screen	Entering diagnostics mode	-	-
0.	Exit	Exit and disconnect	-	-

*When configuring RTD coefficients A, B and C, write values without their respective exponents (e.g. A=3.9083)

Firmware upgrade over USB

To update device firmware user must enter main configuration menu.
Enter Firmware update screen by pressing [4];
Confirm update by pressing [1];
Device now enters Firmware Upgrade mode.

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

Device reconnects as a mass storage device:

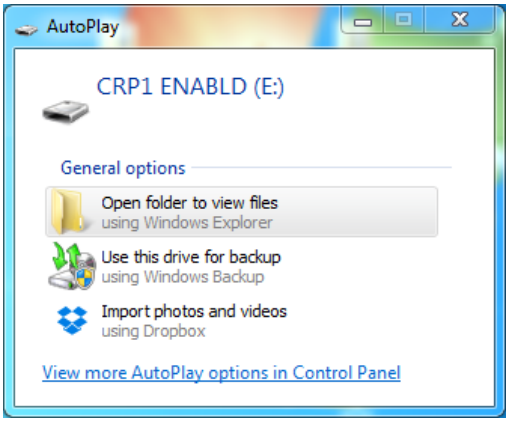

Fig. 6.5. Mass storage device window

User then should delete existing file “firmware.bin” and simply upload new firmware .bin file by dragging and dropping.

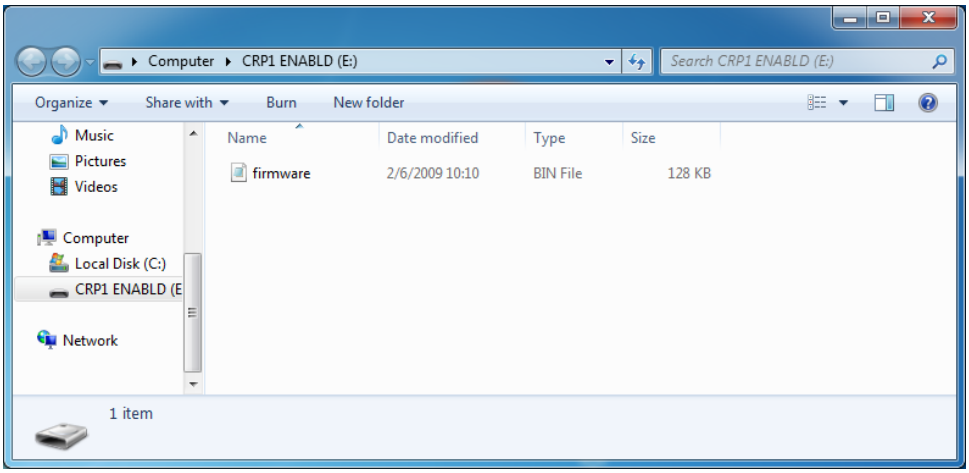

Fig. 6.6. Folder into which new firmware has to be uploaded

Reconnect device and check firmware version. It should now show that you upgraded your device.

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	-32768	5	Fault register RTD3
1	Read Input Registers (04)	19	16384	5	Fault register RTD4
1	Read Input Registers (04)	7	-15498	4	Temp RTD4 LSW
1	Read Input Registers (04)	0	16848	4	Temp RTD1 MSW
1	Read Input Registers (04)	2	-15498	4	Temp RTD2 MSW
1	Read Input Registers (04)	3	-15498	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 (03)	11	-1	4	Fault mask registers
1	Read Holding Registers (03)	12	-1	4	-
1	Read Holding Registers (03)	13	-1	4	-
1	Read Holding Registers (03)	14	-1	4	-
1	Read Holding Registers (03)	0	-200	4	Temperature limits
1	Read Holding Registers (03)	1	800	4	-
1	Read Holding Registers (03)	2	-190	4	-
1	Read Holding Registers (03)	3	800	4	-
1	Read Holding Registers (03)	4	-200	4	-
1	Read Holding Registers (03)	5	800	4	-
1	Read Holding Registers (03)	6	-200	4	-
1	Read Holding Registers (03)	7	800	4	-
1	Read Input Registers (04)	4	17502	4	Temp RTD3 MSW
1	Read Input Registers (04)	5	17502	4	Temp RTD3 LSW
1	Read Input Registers (04)	6	-15498	4	Temp RTD4 MSW
1	Read Input Registers (04)	16	0	4	Fault register RTD1
1	Read Input Registers (04)	17	16384	4	Fault register RTD2

Fig. 6.7. Example of results of Modbus testing

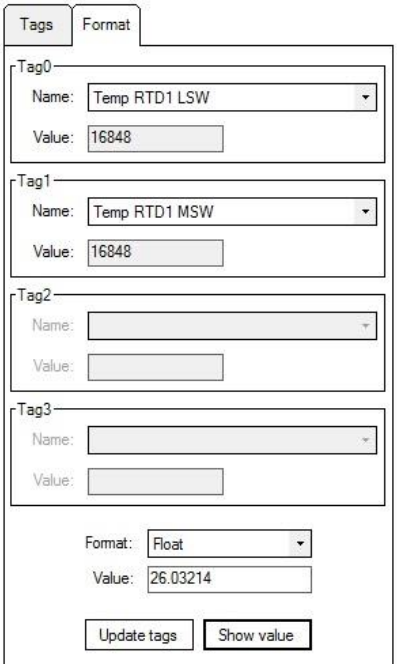

Fig.6.8. Representing temperature as float when using Modbus

Settings | Console | Events | Statistic | The Vinci Expert

TI	Couse	ASDU	FUN	INF	Value	Status	TimeTag	Count	Name
(TI=001)	General inter	1	8	1 (0)	ON[10]	SIN=0	[W]2018/02/14 00:01:11.660[IV]	1	-
(TI=001)	General inter	1	8	4 (0)	OFF[01]	SIN=0	[W]2018/02/14 00:01:12.004[IV]	2	-
(TI=005)	Start/restart	1	255	1 (0)	2	ASC=IOMODRTD F...	-	0	-
(TI=003)	cyclic	1	255	8 (0)	02000(048.8281%)	OV=1 IV=0	-	150	-
(TI=003)	cyclic	1	255	8 (1)	02096(051.1719%)	OV=1 IV=0	-	150	-
(TI=003)	cyclic	1	255	8 (2)	02000(048.8281%)	OV=1 IV=0	-	150	-
(TI=003)	cyclic	1	255	8 (3)	00252(006.1523%)	OV=0 IV=0	-	150	-
(TI=003)	cyclic	1	255	8 (4)	02048(050%)	OV=0 IV=0	-	150	-
(TI=003)	cyclic	1	255	8 (5)	00000(000%)	OV=0 IV=0	-	150	-
(TI=003)	cyclic	1	255	8 (6)	00000(000%)	OV=0 IV=0	-	150	-
(TI=003)	cyclic	1	255	8 (7)	00000(000%)	OV=0 IV=0	-	150	-
(TI=008)	End of g. int	1	255	0 (0)	SCAN:3	-	-	1	-
(TI=001)	General inter	1	8	2 (0)	OFF[01]	SIN=0	[W]2018/02/14 00:01:11.786[IV]	0	-
(TI=001)	General inter	1	8	3 (0)	OFF[01]	SIN=0	[W]2018/02/14 00:01:11.894[IV]	0	-

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

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

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*.

7. Information of the equipment manufacturer

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8. Document history

Version	Date	Author	Description
v0.1	2018.02.19	A.J.	First version