

# Firmware version 1

- IOMOD 8AI User Manual Modbus
- IOMOD 8AI User Manual IEC 60870-5-103
- IOMOD 8AI User Manual IEC 60870-5-101

# IOMOD 8AI User Manual Modbus

## Introduction

IOMod 8AI is a compact-sized stand-alone Modbus (RTU) or IEC-60870-5-103 analog input controller. IOMod can be used for industrial applications where digital signaling is used and robust communication is needed. IOMod is an ideal solution for applications such as data acquisition, observation, process monitoring, testing and measurement at remote places. It is controlled over Modbus or IEC 60870-5-103 protocol, and can be used with any SCADA system.

## Features

- 8 analog inputs, each configurable separately
- All inputs are capable of measuring electrical voltage or current
- Inputs can be recalibrated according to the needs of a user
- RS485 communication
- LED input indications, + Data transmission (Rx and Tx) indication.
- Configurable over USB
- Drag-and-Drop firmware upgrade over USB
- A small sized case with removable front panel
- DIN rail mount
- Operating temperature: from -30 to +70°C
- Power Requirements: 12-24 VDC

## Operational Information

IOMod 8AI uses Modbus (RTU) or IEC 60870-5-103 protocol over RS485 interface. A protocol used by a device can be changed by uploading corresponding firmware. Default communication settings: 9600 baud/s baud rate, 8N1 port configuration, Slave address - 1.

## Common configuration information

1. Measurement type. A user can select measurement type (electrical current or voltage) on each channel individually.
2. Sensitivity selection. To increase a resolution of input measurement capture, a user can define in which range measurement will occur. The best resolution will be achieved within a shortest selected range. For all possible configurations refer to Technical Information and Configuration over USB described later in this document.
3. Measurement limits can be selected, which in turn set thresholds on underflow or overflow error statuses. Also, if a scaled integer data type is selected, these limits will be converted to values using limits stated in Casting data range for Modbus protocol.
4. Data type selection. A device can output float or scaled integer data types for each input individually for Modbus. Modbus input register read will then show raw float value (in milliamperes or millivolts) or scaled integer types. When a float data type is selected, each input will be represented as two Modbus registers (32-bits). These values can be later converted to IEEE-754 standard-compatible float values.
5. Casting data range. A device is capable of converting measurements into desired decimal values in a linear manner. For Modbus, a user can select between floating point data type – which will return a raw measurement of either voltage or current and scaled integer type – which conversion is freely definable. Note that the specification for IEC-60870-5-103 only lets 13-bit signed measurands, therefore only cast representation of true value can be used with absolute limits being [-4095, 4095].  
Fig. 3.2 shows how raw measurement (current in this case) is converted to an integer type. Conversion is done by defining measurement limits (from -25mA to 25mA) and casting data range (from 0 to 100). Measurement limits define thresholds for overflow and underflow errors respectively; casting data range defines limits (from 0 to 100) that value should be between after recalculation. Such a recalculation can be used in applications that require measurements in relative units such as percentage.  
A device can round measurements to lower conversion limit (in this case – to zero) if a measurement is near it:  $\pm 15\%$  of measurement value (Fig. 3.2). Live zero correction is a useful option for eliminating noise. As signals always have some noise level, such an option can compensate it to get a true zero value.

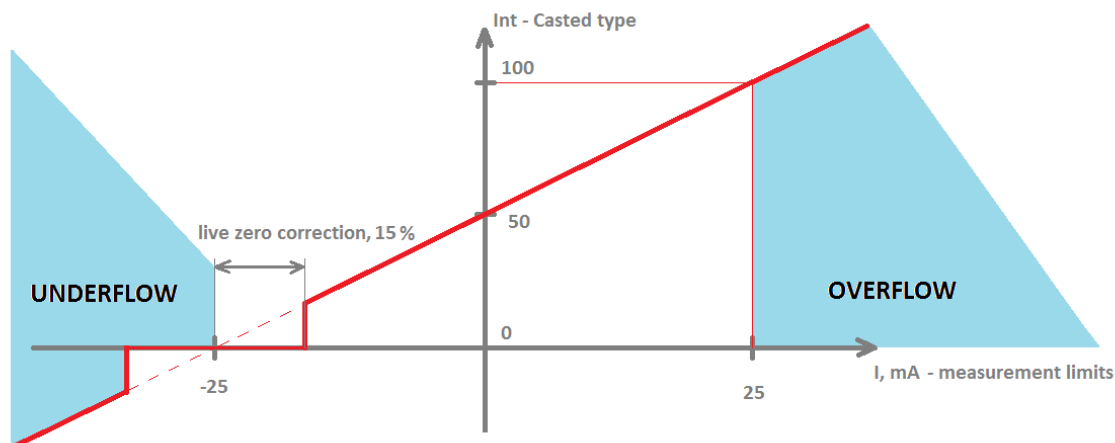


Fig. 3.2. Conversion graph from raw measurement to cast integer

## MODBUS operational information

Each input can be configured to represent 16-bit signed integer value or 32-bit float value. When the float data type is selected, the value will be shown as two registers for one input. When the 16-bit integer data type is selected, a value will be shown as one register. This means addresses of individual input and the maximum number of readable registers can differ according to user configuration.

Configure device over USB terminal. Modbus commands that can be used are shown in the table below.

## Supported MODBUS functions

### 02 (0x02) Read Input Status

Used to read analog input overflow and underflow statuses. First 8 inputs show each input underflow statuses (according to measurement limits option) and second 8 inputs show overflow statuses.

### 04 (0x04) Read Input Registers

Used to read measurements of at most 8 analog inputs. IOMod 8AI has 8 analog inputs from address 0 to address 15 (0000Fh). Different analog inputs can be cast in different data types configured over a USB interface.

### 02 (0x02) Read Input Status

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04 (0x04) Read Input Registers  
Used to read measurements of at most 8 analog inputs. IOMod 8AI has 8 analog inputs from address 0 to address 15 (0000Fh). Different analog inputs can be cast in different data types configured over a USB interface.

### Modbus register table

Modbus register table

Function	Register	Name	Description	Values range
02	00000-0000F	Read Input Status	Returns overflow and underflow statuses of each input. First 8 shows underflow status, last 8 shows overflow	0 - OK, 1 - error
04	00000-0000F	Read Input Registers	Returns Input values	0-65535 (decimal) of one Register

## Technical information

System	
Dimensions	101 x 119 x 17.5 mm
Case	ABS, black
Working environment	Indoor

Working temperature	-30°C +70°C
Recommended operating conditions	5 - 60°C and 20 - 80%RH;
Configuration	USB
Firmware upgrade	USB - mass storage device
<b>Electrical specifications</b>	
Inputs	16-bit resolution; Channel-Independent Programmable Input Ranges: ● Voltage input: ○ Bipolar: $\pm 10.24$ V, $\pm 5.12$ $\pm 2.56$ V ○ Unipolar: 10.24 V, 5.12 ● Current input: ○ Bipolar: $\pm 45.5$ mA, $\pm 22.75$ . and $\pm 11.38$ mA ○ Unipolar: 45.5 mA, 22.75 Overvoltage protection up to $\pm 20$ V;
<b>Power</b>	
Power Supply	9V to 33V
Current consumption	40mA @ 12VDC, 20mA @ 24VDC

## Mounting and installation guide

### IOMod 8AI RS485 interface

IOMod 8AI has integrated 120 $\Omega$  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 in Fig. 5.1.

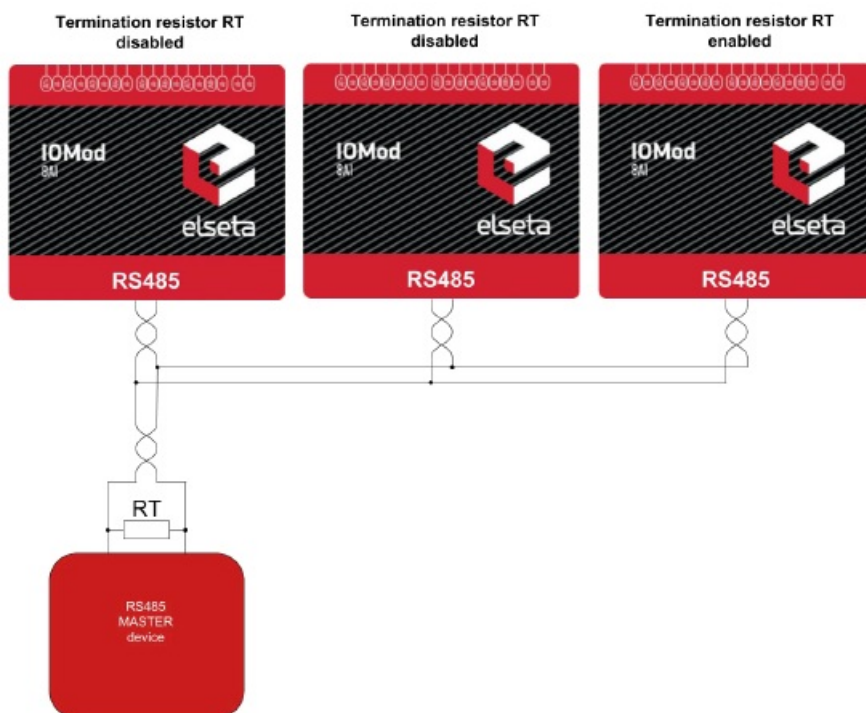


Fig. 5.1. Typical IOMod connection diagram

IOMod 8AI has 1/8 Unit load receiver which allows having up to 255 units on a single line (compared to standard 32 units). To reduce reflections keep the stubs (cable distance from main RS485 bus line) as short as possible.

## IOMod 8AI inputs

A typical application of IOMod 8AI unipolar and bipolar voltage inputs is shown in Fig. 5.2. See Configuration over USB chapter for instructions for analog input configuration.

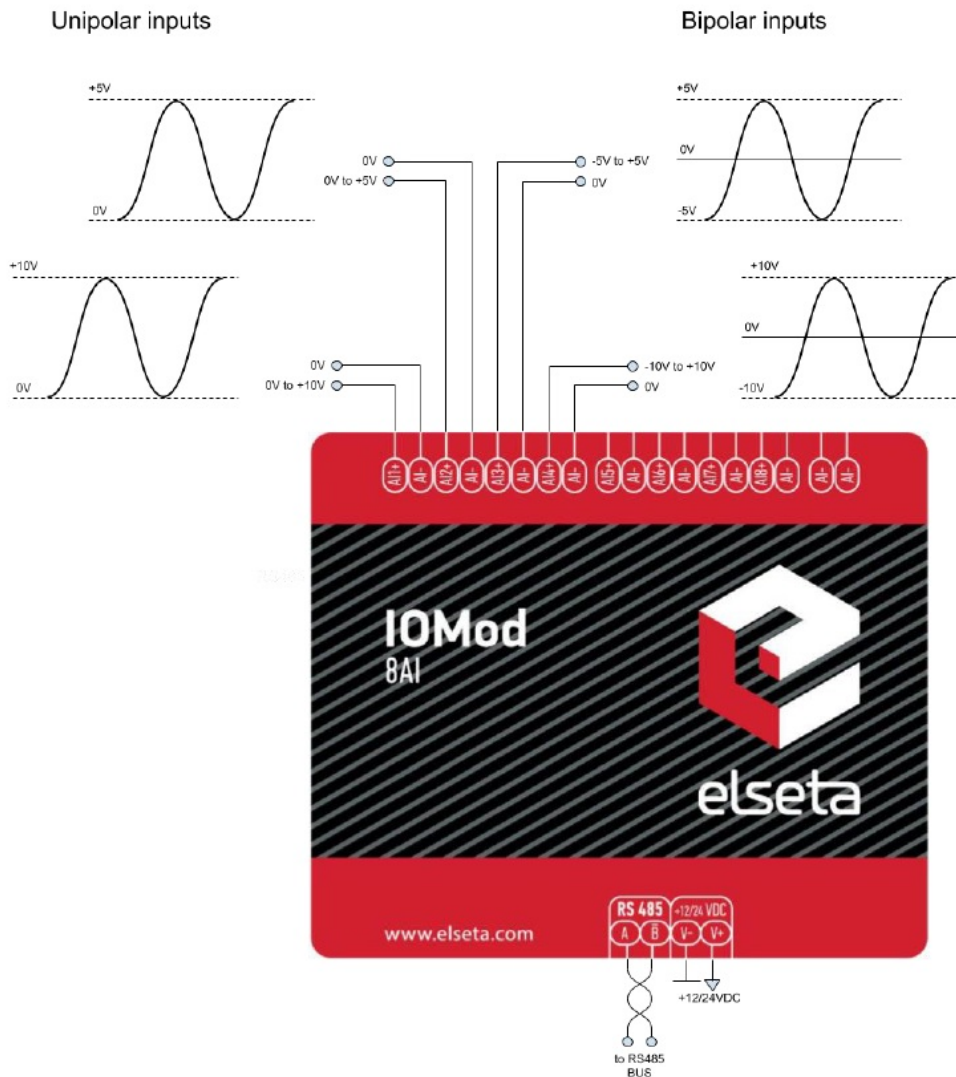


Fig. 5.2. Voltage input connection diagram for IOMod device

All analog inputs can be configured as current inputs to connect 0-20 mA, 4-20 mA or other current output sensors. Typical application of IOMod 8AI unipolar and bipolar current inputs is shown in

Fig. 5.3. See Configuration over USB chapter for instructions for analog input configuration.

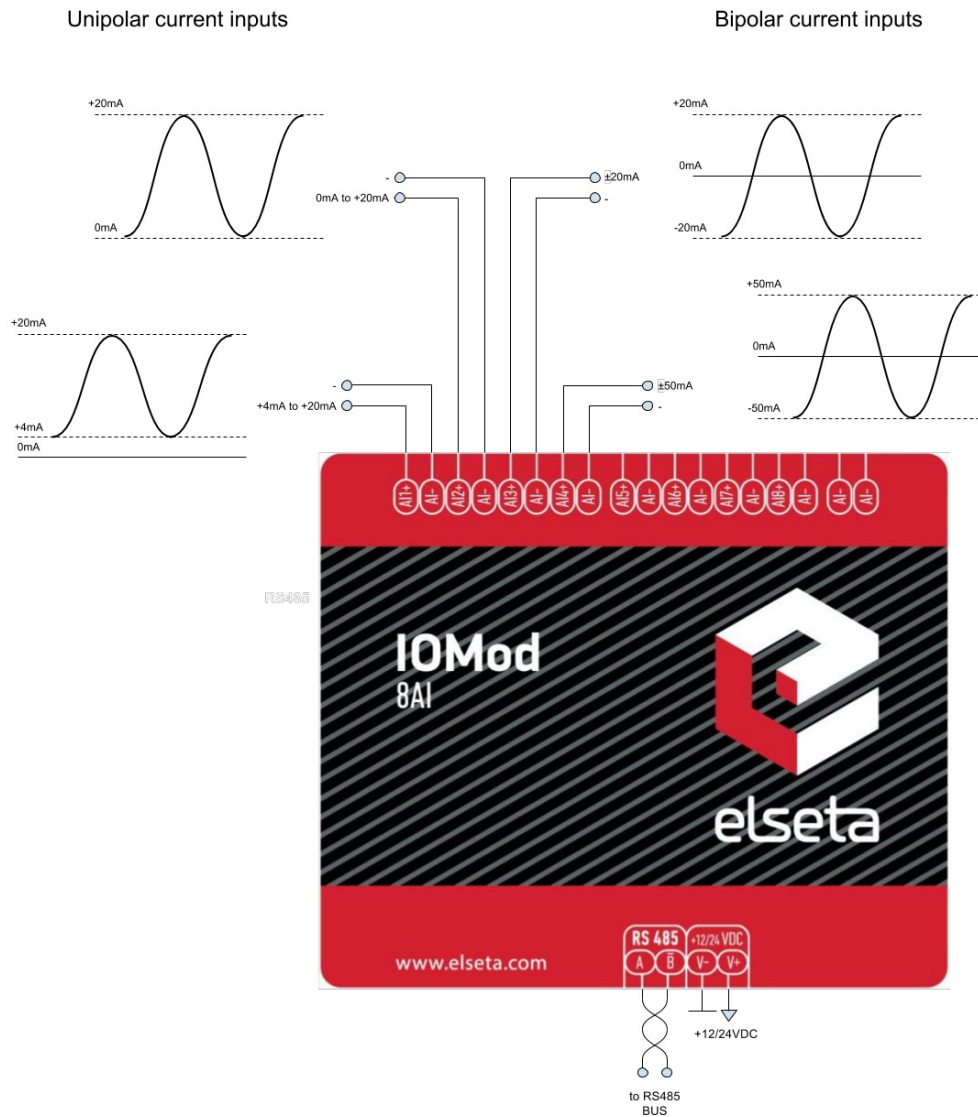


Fig. 5.3. Current input connection diagram for IOMod device

## Configuration over USB

### Driver installation

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

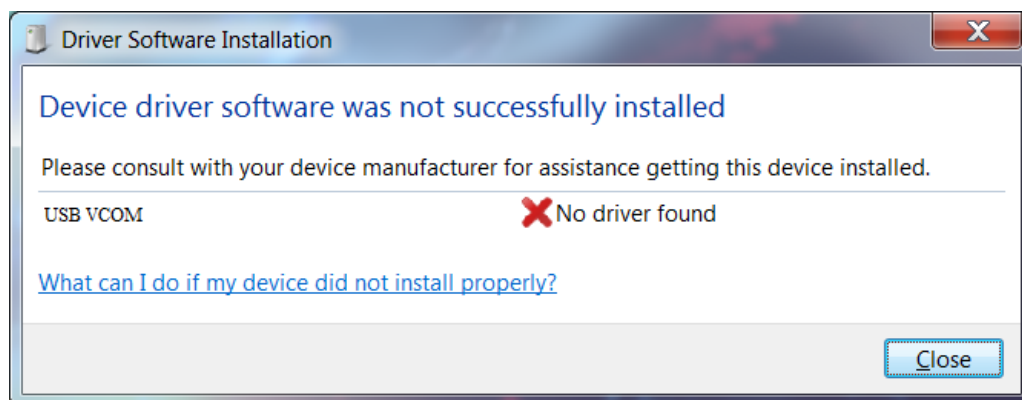


Fig. 6.1. Unsuccessful device software installation error

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:

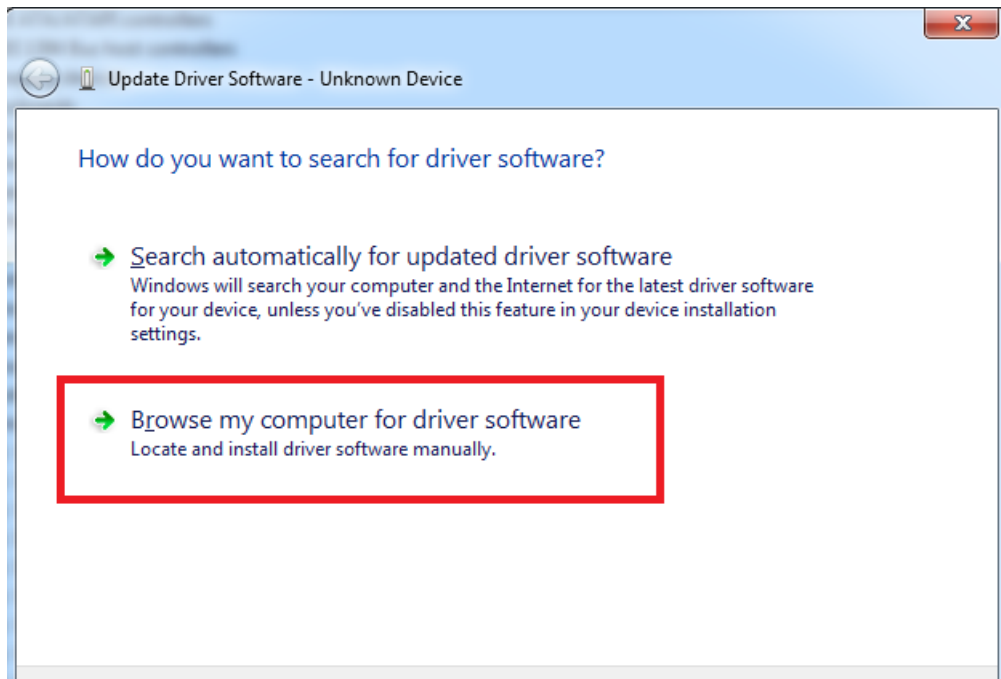


Fig. 6.2. Device driver software update message

- 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).

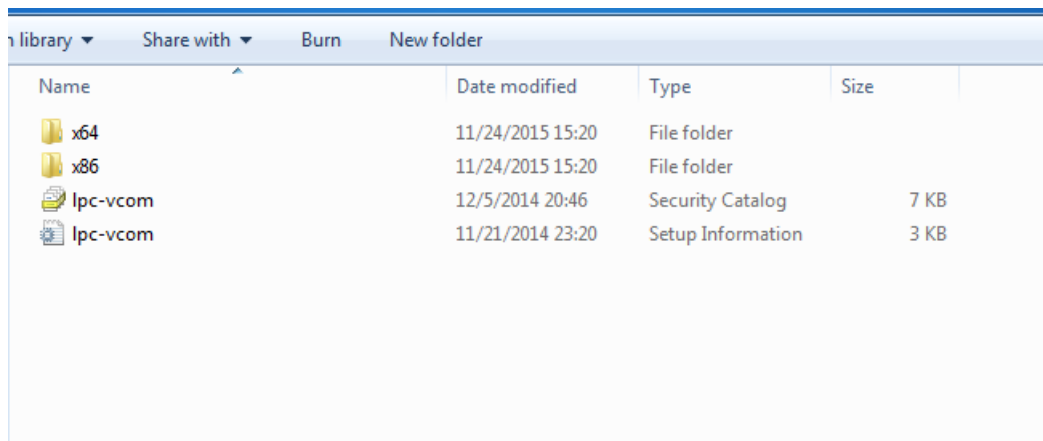


Fig. 6.3. Device driver folder content

## IOMod configuration via PuTTY terminal

A configuration of IOMod device is done through CLI (Command Line Interface) on the virtual COM port. Drivers needed for Microsoft Windows to install VCOM will be provided. To open up CLI simply connect to specific V-COM port with terminal software (advised to use PuTTY terminal software. If other software is being used, a user might need to send <return> symbol after each command). When connected user should immediately see the main screen.

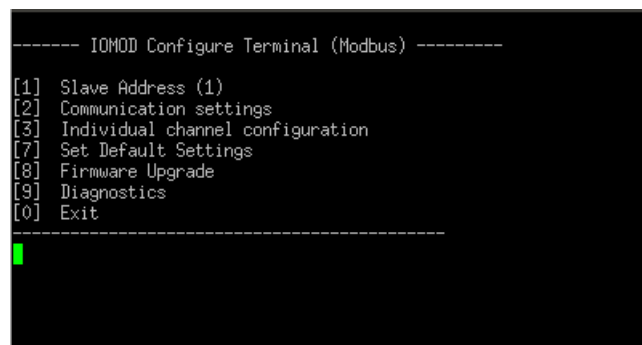


Fig. 6.4. The main menu for IOMod 8AI, Modbus firmware version

Navigation is performed by sending digits or other symbols to a terminal. A user then proceeds by following on-screen instructions. For example, to set baud rate, press [2] to enter Communication settings screen; press [1] to edit; 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 the main screen, and confirming changes [1].

If the terminal window is closed accidentally, a user can connect the terminal program again, and press any key on a keyboard to show the main menu 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
3.	Individual channel configuration	Channel configuration screen (see Table "Individual Channel Configuration")		
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	-	-

## Individual channel configuration

	MenuName	Function	Values	Default Values
[1]	Measure Current/Voltage	Selecting this option toggles measurement selection	-	-
[2]	Change sensitivity	Selecting a measurement range	[1] [-10.24 V, 10.24 V], [2] [-5.12 V, 5.12 V], [3] [-2.56 V, 2.56 V], [4] [0 V, 10.24 V], [5] [0 V, 5.12 V]	[1] [-10.24 V, 10.24 V]
[3]	Measurement limits	Entering floating point values to use them for marking overflow/underflow statuses	Floating values in a range defined by measuring sensitivity	-5 mV; 5mV
[4]	Cast to a scaled integer/float	Selecting this option toggles value casting selection		
[5]	Casting data range	Check <b>Common configuration information</b>		
[6]	Live zero tolerance			



0	Back	Back to last menu screen		
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## Measurements' calibration

Every device is shipped containing factory-predefined calibration coefficients. However, changing temperature and humidity conditions can affect the accuracy of measurements. To get the best accuracy, use the device at room temperature and if that is not possible, calibrate coefficients accordingly.

To enter the calibration screen (Fig. 6.6) from main menu press '@' symbol.

```
-----
Select a measurement to calibrate:
[1] Current
[2] Voltage
[] Back
█
```

Fig. 6.6. Analog inputs' calibration screen

In the calibration screen, either current or voltage coefficients can be selected. Selecting current by pressing [1] should enter additional screen (Fig. 6.7). Calibrating voltage is an identical process therefore only current setting is explained.

```
[1-8] Change current calibration coeffs for AIn
[*] Change all calibration coeffs at once
[] Cancel current calibration
█
```

Fig. 6.7. Current calibration screen

```
[1-8] Change current calibration coeffs for AIn
[*] Change all calibration coeffs at once
[] Cancel current calibration

Select mode for AI1
[1] Manual
[2] Automatic
[] Back

Currently coeff K for AI1 is: 1.0000
Enter new parameter value (<return> to save, <ESC> to cancel):

Currently coeff B for AI1 is: 0.0000
Enter new parameter value (<return> to save, <ESC> to cancel):
█
```

Fig. 6.8. Manual calibration coefficients' setting

```
[1-8] Change current calibration coeffs for AIn
[*] Change all calibration coeffs at once
[] Cancel current calibration

Select mode for AI1
[1] Manual
[2] Automatic
[] Back

Enter value in mA or press ESC to finish calibration:█
```

Fig.6.9. Automatic calibration coefficients' setting

All configuration coefficients can either be configured all at once or individually. The coefficient setting for all channels is done manually only. Tweaking individual channels, however, can be automatic (Fig. 6.9) as well as manual (Fig. 6.8). Selecting automatic calibration polls values that user inputs and tweaks coefficients to minimize the additive error. It is therefore advised to scan several values differing by the same value interval to get the best results. Pressing ESC finishes calibration and saves coefficients to non volatile memory.

## Protocol simulation over USB

After entering the diagnostics screen, protocol simulator can be turned on by pressing [9]. When it is on, the device will communicate over USB port rather than a RS-485 line. Communication on a RS-485 line is closed and all Modbus or IEC-60870-5-103 commands will only be accepted from USB. To exit this mode device must be restarted.

## 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.)

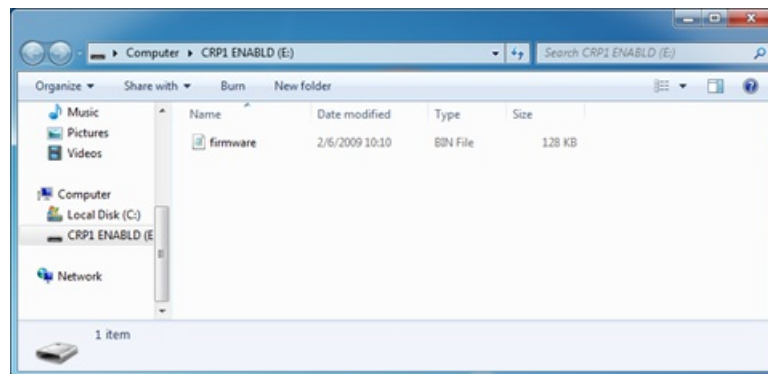


Fig. 6.11. Dragging and dropping new firmware file

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

## Testing With “THE VINCI” software

To test IOMod with default settings, a device should be connected through RS485 to Modbus master. Example using “The Vinci Expert” device as serial interface converter and adapter to PC with “The Vinci” software. Default settings for Modbus – 9600 baud/s baud rate; 8 data, no parity, 1 stop bit. When opening “The Vinci” software, choose Modbus serial – Master mode. In the Settings tab, choose station number (default – 1); configure tags (as described in section Modbus operational information); Press Start and go to “Statistic” tab as shown in Fig. 7.1.

THE VINCI PROTOCOL ANALYZER

File Tags Options Help

Protocol: MODBUS serial Mode: Master Port A: COM6 Baudrate: 9600 Format: even,8,1 Extra: Set VII

Stop

Settings Console Events Statistic The Vinci Expert

Station	Function	Address	Value	Count	Name
1	Read Holding Registers (04)	0	17674	134	AnalogI...
1	Read Holding Registers (04)	1	-3444	134	-
1	Read Holding Registers (04)	2	17674	134	-
1	Read Holding Registers (04)	3	-884	134	-
1	Read Holding Registers (04)	4	17674	133	-
1	Read Holding Registers (04)	5	-2164	133	-
1	Read Holding Registers (04)	6	17674	133	-
1	Read Holding Registers (04)	7	-6004	133	-
1	Read Holding Registers (04)	8	17674	133	-
1	Read Holding Registers (04)	9	-7284	133	-
1	Read Holding Registers (04)	10	17674	133	-
1	Read Holding Registers (04)	11	-6004	133	-
1	Read Holding Registers (04)	12	17674	133	-
1	Read Holding Registers (04)	13	-6004	133	-
1	Read Holding Registers (04)	14	17674	133	-
1	Read Holding Registers (04)	15	-2164	133	-

Tags Format

Tag0  
Name: AnalogInputs  
Value: 17674

Tag1  
Name: AnalogInputs  
Value: 17674

Tag2  
Name:   
Value:

Tag3  
Name:   
Value:

Format: Float  
Value: 2212.315

Update tags Show value

Fig. 7.1. Testing IOMod Modbus communication using “THE VINCI” software

THE VINCI PROTOCOL ANALYZER

File Tags Options Help

Protocol: IEC 60870-5-103 Mode: Master Port A: COM19 Baudrate: 9600 Format: none,8,1 Extra: Set VINCI ports Device manager Swap ports

Stop

Settings Console Events Statistic The Vinci Expert

TI	Cause	ASDU	FUN	INF	Value	Status	TimeTag	Count	Name
(TI=005)	Start/restart	1	255	1 (0)	2	ASC=IOMODSAI F...	-	0	-
(TI=003)	cyclic	1	255	160 (0)	04095 (099.97564)	OV=1 IV=0	-	46	-
(TI=003)	cyclic	1	255	160 (1)	04095 (099.97564)	OV=1 IV=0	-	45	-
(TI=003)	cyclic	1	255	160 (2)	04095 (099.97564)	OV=1 IV=0	-	45	-
(TI=003)	cyclic	1	255	160 (3)	04095 (099.97564)	OV=1 IV=0	-	45	-
(TI=003)	cyclic	1	255	160 (4)	04095 (099.97564)	OV=1 IV=0	-	45	-
(TI=003)	cyclic	1	255	160 (5)	04095 (099.97564)	OV=1 IV=0	-	45	-
(TI=003)	cyclic	1	255	160 (6)	04095 (099.97564)	OV=1 IV=0	-	45	-
(TI=003)	cyclic	1	255	160 (7)	04095 (099.97564)	OV=1 IV=0	-	45	-

System Tags

Address  
☐ Custom ASDU ASDU: 1  
☐ Custom Cause Cause: 1

General interrogation  
Send SCAN number: 0

Clock synchronisation  
Send ☐ IV ☐ SM ☐ SB  
☒ PC time 2018/12/14 08:53:58

General command  
FUN: 255 INF: 0 RII: 0  
ON OFF

Fig. 7.2. Testing IEC-60870-5-103 communication using “THE VINCI” software

# IOMOD 8AI User Manual IEC 60870-5-103

## Introduction

IOMod 8AI is a compact-sized stand-alone Modbus (RTU) or IEC-60870-5-103 analog input controller. IOMod can be used for industrial applications where digital signaling is used and robust communication is needed. IOMod is an ideal solution for applications such as data acquisition, observation, process monitoring, testing and measurement at remote places. It is controlled over Modbus or IEC 60870-5-103 protocol, and can be used with any SCADA system.

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- 8 analog inputs, each configurable separately
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- Inputs can be recalibrated according to the needs of a user
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- LED input indications, + Data transmission (Rx and Tx) indication.
- Configurable over USB
- Drag-and-Drop firmware upgrade over USB
- A small sized case with removable front panel
- DIN rail mount
- Operating temperature: from -30 to +70°C
- Power Requirements: 12-24 VDC

## Operational Information

IOMod 8AI uses Modbus (RTU) or IEC 60870-5-103 protocol over RS485 interface. A protocol used by a device can be changed by uploading corresponding firmware. Default communication settings: 9600 baud/s baud rate, 8N1 port configuration, Slave address - 1.

## Common configuration information

1. Measurement type. A user can select measurement type (electrical current or voltage) on each channel individually.
2. Sensitivity selection. To increase a resolution of input measurement capture, a user can define in which range measurement will occur. The best resolution will be achieved within a shortest selected range. For all possible configurations refer to Technical Information and Configuration over USB described later in this document.
3. Measurement limits can be selected, which in turn set thresholds on underflow or overflow error statuses. Also, if a scaled integer data type is selected, these limits will be converted to values using limits stated in Casting data range for Modbus protocol.
4. Data type selection. A device can output float or scaled integer data types for each input individually for Modbus. Modbus input register read will then show raw float value (in milliamperes or millivolts) or scaled integer types. When a float data type is selected, each input will be represented as two Modbus registers (32-bits). These values can be later converted to IEEE-754 standard-compatible float values.
5. Casting data range. A device is capable of converting measurements into desired decimal values in a linear manner. For Modbus, a user can select between floating point data type – which will return a raw measurement of either voltage or current and scaled integer type – which conversion is freely definable. Note that the specification for IEC-60870-5-103 only lets 13-bit signed measurands, therefore only cast representation of true value can be used with absolute limits being [-4095, 4095].  
Fig. 3.2 shows how raw measurement (current in this case) is converted to an integer type. Conversion is done by defining measurement limits (from -25mA to 25mA) and casting data range (from 0 to 100). Measurement limits define thresholds for overflow and underflow errors respectively; casting data range defines limits (from 0 to 100) that value should be between after recalculation. Such a recalculation can be used in applications that require measurements in relative units such as percentage.  
A device can round measurements to lower conversion limit (in this case – to zero) if a measurement is near it:  $\pm 15\%$  of measurement value (Fig. 3.2). Live zero correction is a useful option for eliminating noise. As signals always have some noise level, such an option can compensate it to get a true zero value.

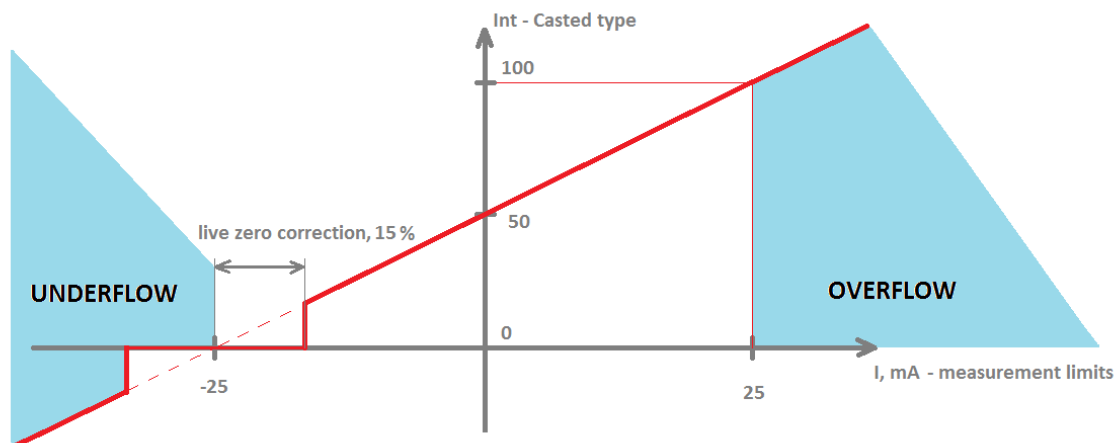


Fig. 3.2. Conversion graph from raw measurement to cast integer

## IEC 60870-5-103 operational information

IOMod with IEC-60870-5-103 firmware uses a standard communication scheme. Initiation, control messages and queries are initiated by a master (controlling station), while IOMod device (controlled station) only answers requests and sends values. The first message sent by master should be RESET CU to restart communication. When acknowledge (ACK) packet is sent from a slave device, a master may proceed with acquiring General Interrogation and sending Time synchronization packets.

When this initialization is complete, master should poll IOMod device with Class 1 and Class 2 requests. Class 2 is used when master polls for cyclic data. The controlled device responds when spontaneous data exists and master then sends a request for Class 1. Controlled station responds with a time-tagged message.

As IOMod 8AI doesn't have any digital inputs, only analog ones, general interrogation returns nothing. Values of measurements are returned cyclically without any additional request therefore commands sent will be ignored.

## Technical information

System	
Dimensions	101 x 119 x 17.5 mm
Case	ABS, black
Working environment	Indoor
Working temperature	-30°C +70°C
Recommended operating conditions	5 – 60°C and 20 – 80%RH;
Configuration	USB
Firmware upgrade	USB – mass storage device
Electrical specifications	
Inputs	16-bit resolution; Channel-Independent Programmable Input Ranges: ● Voltage input: ○ Bipolar: $\pm 10.24$ V, $\pm 5.12$ $\pm 2.56$ V ○ Unipolar: 10.24 V, 5.12 ● Current input: ○ Bipolar: $\pm 51.2$ mA, $\pm 25.$ and $\pm 12.8$ mA ○ Unipolar: 51.2 mA, 25.6 Overvoltage protection up to $\pm 20$ V;

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

# Mounting and installation guide

## IOMod 8AI RS485 interface

IOMod 8AI 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 in Fig. 5.1.

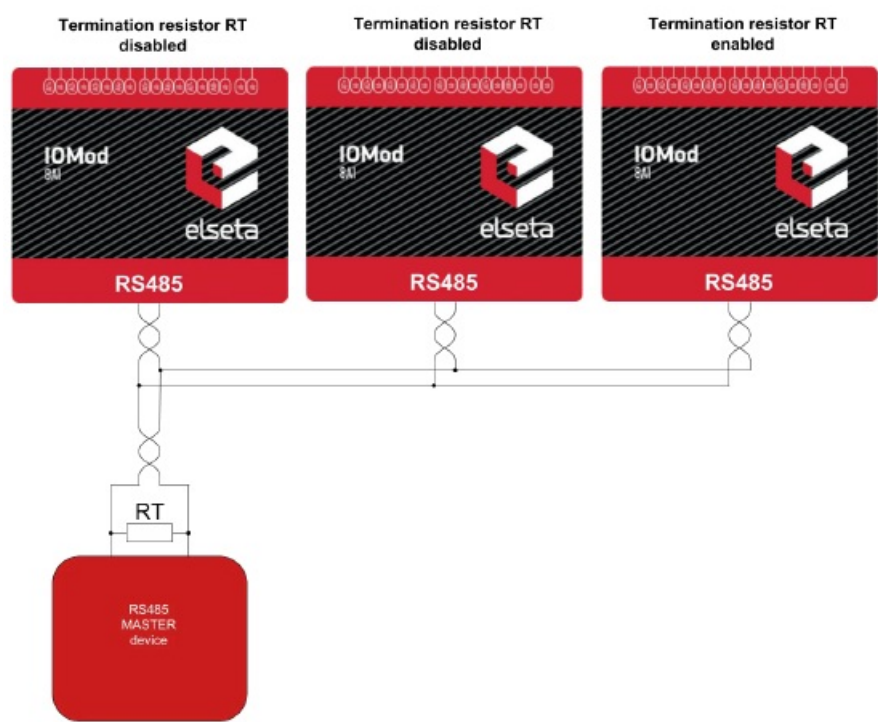


Fig. 5.1. Typical IOMod connection diagram

IOMod 8AI has 1/8 Unit load receiver which allows having up to 255 units on a single line (compared to standard 32 units). To reduce reflections keep the stubs (cable distance from main RS485 bus line) as short as possible.

## IOMod 8AI inputs

A typical application of IOMod 8AI unipolar and bipolar voltage inputs is shown in Fig. 5.2. See Configuration over USB chapter for instructions for analog input configuration.

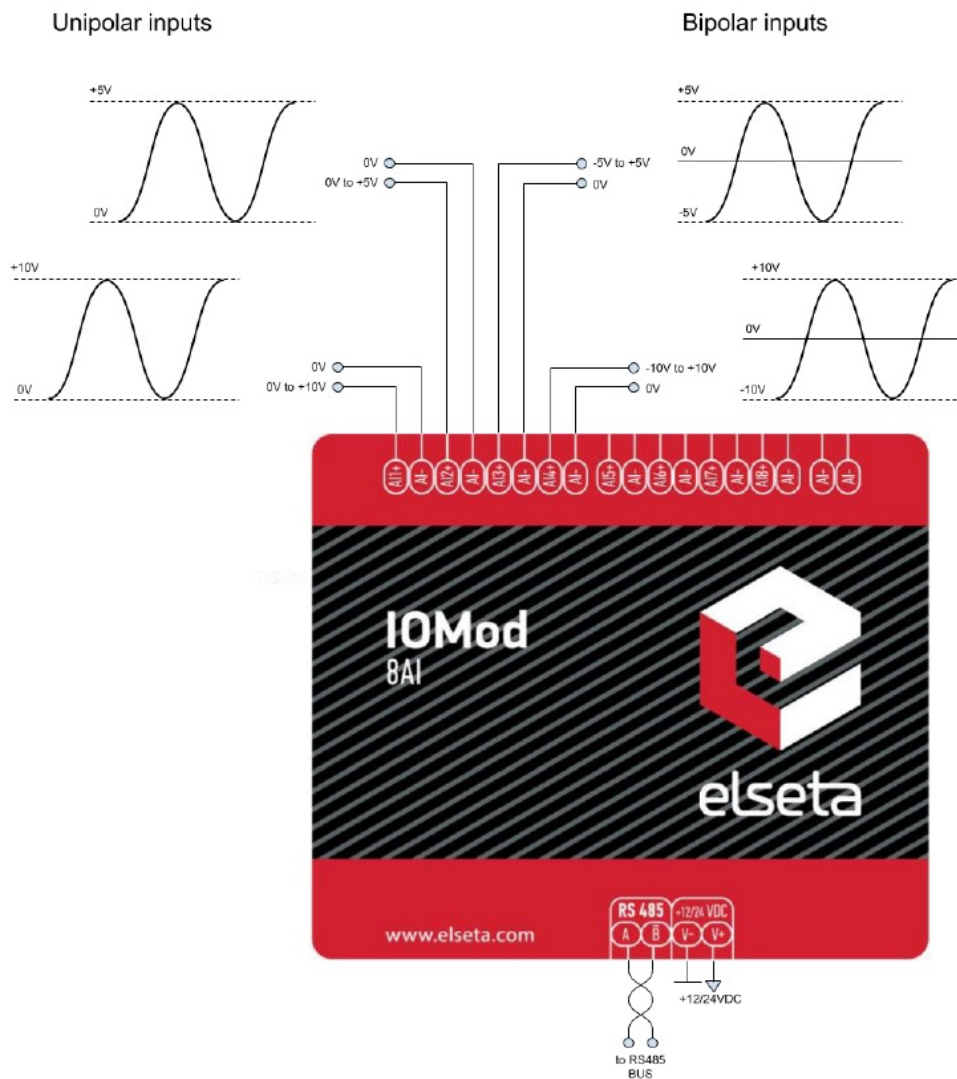


Fig. 5.2. Voltage input connection diagram for IOMod device

All analog inputs can be configured as current inputs to connect 0-20 mA, 4-20 mA or other current output sensors. Typical application of IOMod 8AI unipolar and bipolar current inputs is shown in

Fig. 5.3. See Configuration over USB chapter for instructions for analog input configuration.

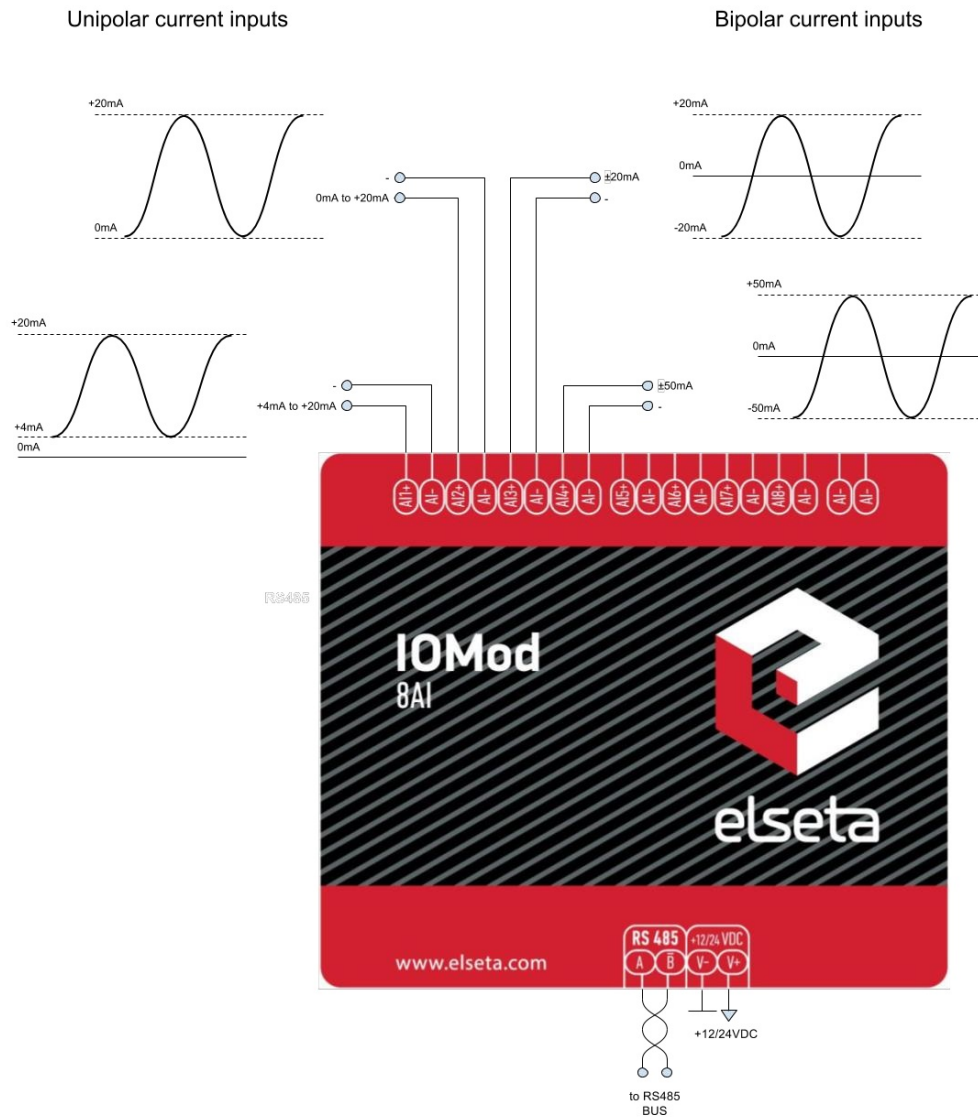


Fig. 5.3. Current input connection diagram for IOMod device

## Configuration over USB

### Driver installation

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

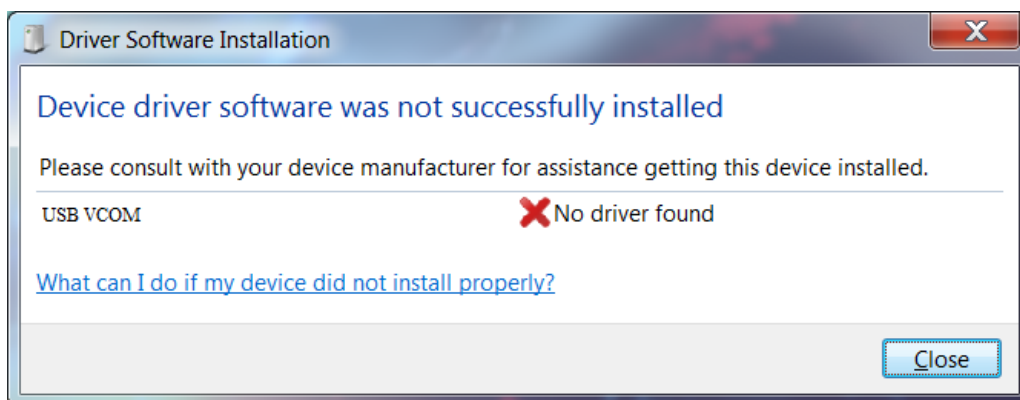


Fig. 6.1. Unsuccessful device software installation error

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:

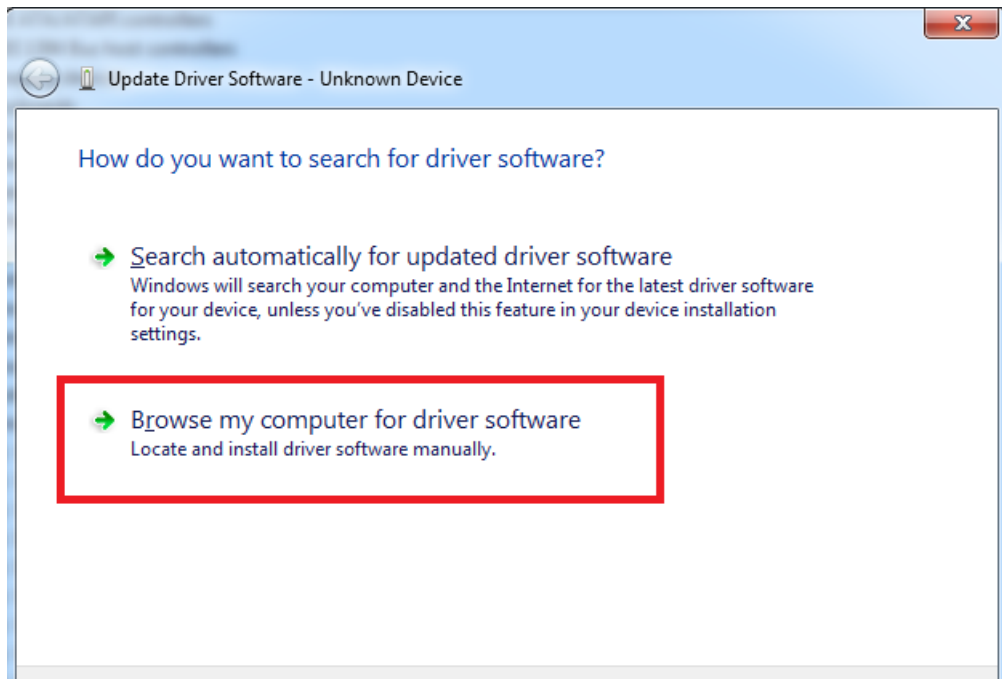


Fig. 6.2. Device driver software update message

- 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).

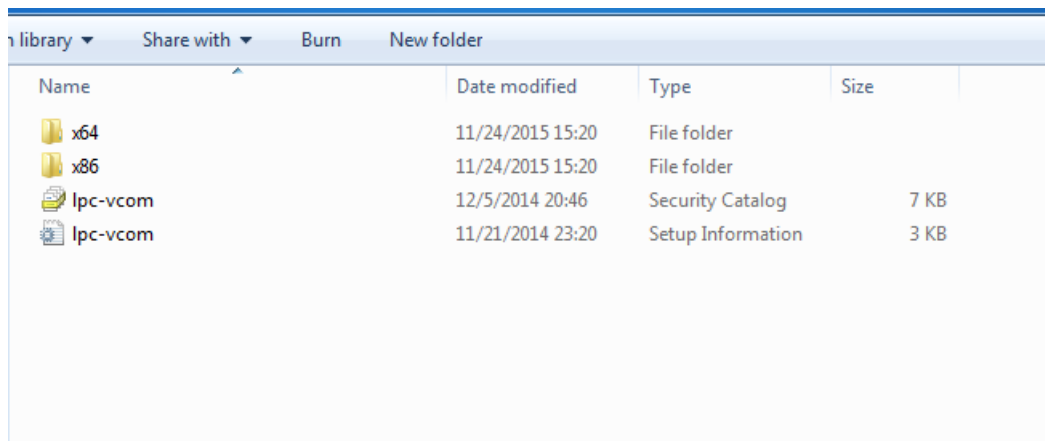


Fig. 6.3. Device driver folder content

## IOMod configuration via PuTTY terminal

A configuration of IOMod device is done through CLI (Command Line Interface) on the virtual COM port. Drivers needed for Microsoft Windows to install VCOM will be provided. To open up CLI simply connect to specific V-COM port with terminal software (advised to use PuTTY terminal software. If other software is being used, a user might need to send <return> symbol after each command). When connected user should immediately see the main screen.

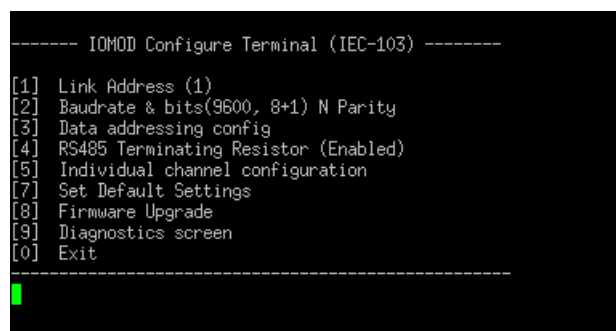


Fig. 6.4. The main menu for IOMod 8AI, IEC-60870-5-103 version

Navigation is performed by sending digits or other symbols to a terminal. A user then proceeds by following on-screen instructions. For example, to set baud rate, press [2] to enter Communication settings screen; press [1] to edit; 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 the main screen, and confirming changes [1].

If the terminal window is closed accidentally, a user can connect the terminal program again, and press any key on a keyboard to show the main menu again.

### IEC-60870-5-103 Main Menu

	Menu Name	Function	Values	Default Values
[1]	Link Address	Changing link address	1-247	1
[2]	Baudrate, parity and stopbits	[1] Set 8 Data bits + 1 Stop bit [2] Set 8 Data bits + 2 Stop bit [3] Configure baud rate [4] Configure Parity	[3] 100-256000 [4] None/ Odd /Even / Mark/ Space	3) 9600 [4] None
[3]	Data addressing config	Enters configuring screen for Input address (function type)	1-255	160
[4]	RS485 Terminating Resistor	RS485 120 Ohm Terminating Resistor	[1] Enable [2] Disable	Enabled
6.	Individual channel configuration	Channel configuration screen (see Table "Individual Channel Configuration")		
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	-	-

### Individual channel configuration

	MenuName	Function	Values	Default Values
[1]	Measure Current/Voltage	Selecting this option toggles measurement selection	-	-
[2]	Change sensitivity	Selecting a measurement range	[1] [-10.24 V, 10.24 V], [2] [-5.12 V, 5.12 V], [3] [-2.56 V, 2.56 V], [4] [0 V, 10.24 V], [5] [0 V, 5.12 V]	[1] [-10.24 V, 10.24 V]
[3]	Measurement limits	Entering floating point values to use them for marking overflow/underflow statuses	Floating values in a range defined by measuring sensitivity	-5 mV; 5mV
[0]	Back	Back to last menu screen		

### Measurements' calibration

Every device is shipped containing factory-predefined calibration coefficients. However, changing temperature and humidity conditions can affect the accuracy of measurements. To get the best accuracy, use the device at room temperature and if that is not possible, calibrate coefficients accordingly. To enter the calibration screen (Fig. 6.6) from main menu press '@' symbol.

```
-----
Select a measurement to calibrate:
[1] Current
[2] Voltage
[] Back
```

Fig. 6.6. Analog inputs' calibration screen

In the calibration screen, either current or voltage coefficients can be selected. Selecting current by pressing [1] should enter additional screen (Fig. 6.7). Calibrating voltage is an identical process therefore only current setting is explained.

```
[1-8] Change current calibration coeffs for AIIn
[*] Change all calibration coeffs at once
[] Cancel current calibration
```

Fig. 6.7. Current calibration screen

```
[1-8] Change current calibration coeffs for AIIn
[*] Change all calibration coeffs at once
[] Cancel current calibration

Select mode for AI1
[1] Manual
[2] Automatic
[] Back

Currently coeff K for AI1 is: 1.0000
Enter new parameter value (<return> to save, <ESC> to cancel):

Currently coeff B for AI1 is: 0.0000
Enter new parameter value (<return> to save, <ESC> to cancel):
```

Fig. 6.8. Manual calibration coefficients' setting

```
[1-8] Change current calibration coeffs for AIIn
[*] Change all calibration coeffs at once
[] Cancel current calibration

Select mode for AI1
[1] Manual
[2] Automatic
[] Back

Enter value in mA or press ESC to finish calibration:
```

Fig.6.9. Automatic calibration coefficients' setting

All configuration coefficients can either be configured all at once or individually. The coefficient setting for all channels is done manually only. Tweaking individual channels, however, can be automatic (Fig. 6.9) as well as manual (Fig. 6.8). Selecting automatic calibration polls values that user inputs and tweaks coefficients to minimize the additive error. It is therefore advised to scan several values differing by the same value interval to get the best results. Pressing ESC finishes calibration and saves coefficients to non volatile memory.

## Protocol simulation over USB

After entering the diagnostics screen, protocol simulator can be turned on by pressing [9]. When it is on, the device will communicate over USB port rather than a RS-485 line. Communication on a RS-485 line is closed and all Modbus or IEC-60870-5-103 commands will only be accepted from USB. To exit this mode device must be restarted.

## 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.)

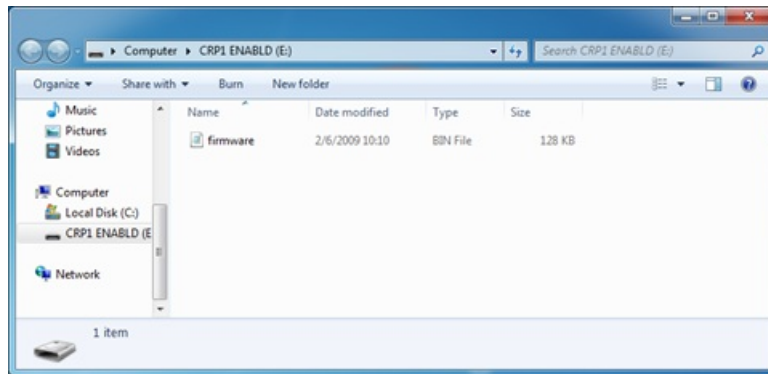


Fig. 6.11. Dragging and dropping new firmware file

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

## Testing With “THE VINCI” software

To test IOMod with default settings, a device should be connected through RS485 to IEC 60870-5-103 Master. Example using “The Vinci Expert” device as serial interface converter and adapter to PC with “The Vinci” software. Default settings for IEC-60870-5-103 – 9600 baud/s baud rate; 8 data, no parity, 1 stop bit. After opening “The Vinci” software choose IEC-60870-5-103 serial – Master mode. In “Settings” tab, choose station number (default – 1) and ASDU (default – 1); press “Start” and go to “Statistic” tab as shown in Fig. 7.2.

TI	Cause	ASDU	FUN	INF	Value	Status	Time Tag	Count	Name
(TI=005)	Start/restart	1	255	1 (0)	2	ASC=IOMOD8AI F...	-	0	-
(TI=003)	cyclic	1	255	160 (0)	04095 (099.9756%)	OV=1 IV=0	-	46	-
(TI=003)	cyclic	1	255	160 (1)	04095 (099.9756%)	OV=1 IV=0	-	45	-
(TI=003)	cyclic	1	255	160 (2)	04095 (099.9756%)	OV=1 IV=0	-	45	-
(TI=003)	cyclic	1	255	160 (3)	04095 (099.9756%)	OV=1 IV=0	-	45	-
(TI=003)	cyclic	1	255	160 (4)	04095 (099.9756%)	OV=1 IV=0	-	45	-
(TI=003)	cyclic	1	255	160 (5)	04095 (099.9756%)	OV=1 IV=0	-	45	-
(TI=003)	cyclic	1	255	160 (6)	04095 (099.9756%)	OV=1 IV=0	-	45	-
(TI=003)	cyclic	1	255	160 (7)	04095 (099.9756%)	OV=1 IV=0	-	45	-

Fig. 7.2. Testing IEC-60870-5-103 communication using “THE VINCI” software

# IOMOD 8AI User Manual IEC 60870-5-101

## Introduction

IOMod 8AI is a compact-sized stand-alone Modbus (RTU) or IEC60870-5-101 analog input controller. IOMod can be used for industrial applications where digital signaling is used and robust communication is needed. IOMod is an ideal solution for applications such as data acquisition, observation, process monitoring, testing and measurement at remote places. It is controlled over Modbus or IEC 60870-5-101 protocol, and can be used with any SCADA system.

## Features

- 8 analog inputs, each configurable separately
- All inputs are capable of measuring electrical voltage or current
- Inputs can be recalibrated according to the needs of a user
- RS485 communication
- LED input indications, + Data transmission (Rx and Tx) indication.
- Configurable over USB
- Drag-and-Drop firmware upgrade over USB
- A small sized case with removable front panel
- DIN rail mount
- Operating temperature: from -30 to +70°C
- Power Requirements: 12-24 VDC

## Operational Information

IOMod 8AI uses Modbus (RTU) or IEC 60870-5-103 protocol over RS485 interface. A protocol used by a device can be changed by uploading corresponding firmware. Default communication settings: 9600 baud/s baud rate, 8E1 port configuration, Link address - 1.

## Common configuration information

1. Measurement type. A user can select measurement type (electrical current or voltage) on each channel individually.
2. Sensitivity selection. To increase a resolution of input measurement capture, a user can define in which range measurement will occur. The best resolution will be achieved within a shortest selected range. For all possible configurations refer to Technical Information and Configuration over USB described later in this document.
3. Measurement limits can be selected, which in turn set thresholds on underflow or overflow error statuses. Also, if a scaled integer data type is selected, these limits will be converted to values using limits stated in Casting data range for Modbus protocol.
4. Data type selection. A device can output float or scaled integer data types for each input individually for Modbus. Modbus input register read will then show raw float value (in milliamperes or millivolts) or scaled integer types. When a float data type is selected, each input will be represented as two Modbus registers (32-bits). These values can be later converted to IEEE-754 standard-compatible float values.
5. Casting data range. A device is capable of converting measurements into desired decimal values in a linear manner. For Modbus, a user can select between floating point data type – which will return a raw measurement of either voltage or current and scaled integer type – which conversion is freely definable. Note that the specification for IEC-60870-5-101 only lets 13-bit signed measurands, therefore only cast representation of true value can be used with absolute limits being [-4095, 4095].
6. Fig. 1. shows how raw measurement (current in this case) is converted to an integer type. Conversion is done by defining measurement limits (from -25mA to 25mA) and casting data range (from 0 to 100). Measurement limits define thresholds for overflow and underflow errors respectively; casting data range defines limits (from 0 to 100) that value should be between after recalculation. Such a recalculation can be used in applications that require measurements in relative units such as percentage.  
A device can round measurements to lower conversion limit (in this case – to zero) if a measurement is near it:  $\pm 15\%$  of measurement value (Fig. 1.). Live zero correction is a useful option for eliminating noise. As signals always have some noise level, such an option can compensate it to get a true zero value.

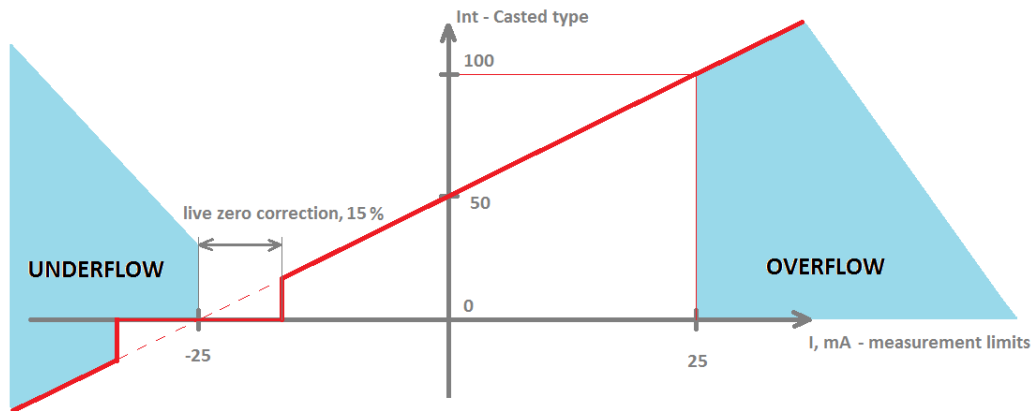


Fig. 1. Conversion graph from raw measurement to cast integer

## 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 8AI 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 30 data types (M\_SP\_TB\_1), and "IOA" as the input pin number shifted by 8.

### 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 [1,8] inputs.

## Technical information

System	
Dimensions	101 x 119 x 17.5 mm
Case	ABS, black
Working environment	Indoor
Working temperature	-30 °C+70°C

Recommended operating conditions	5 – 60°C and 20 – 80%RH;
Configuration	USB
Firmware upgrade	USB – mass storage device
<b>Electrical specifications</b>	
Inputs	16-bit resolution; Channel-Independent Programmable Input Ranges: ● Voltage input: ○ Bipolar: $\pm 10.24$ V, $\pm 5.12$ $\pm 2.56$ V ○ Unipolar: 10.24 V, 5.12 ● Current input: ○ Bipolar: $\pm 51.2$ mA, $\pm 25$ . and $\pm 12.8$ mA ○ Unipolar: 51.2 mA, 25.6 Overvoltage protection up to $\pm 20$ V;
<b>Power</b>	
Power Supply	9V to 33V
Current consumption	40mA @ 12VDC, 20mA @ 24VDC

## Mounting and installation guide

### IOMod 8AI RS485 interface

IOMod 8AI has integrated 120 $\Omega$  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 in Fig. 2.

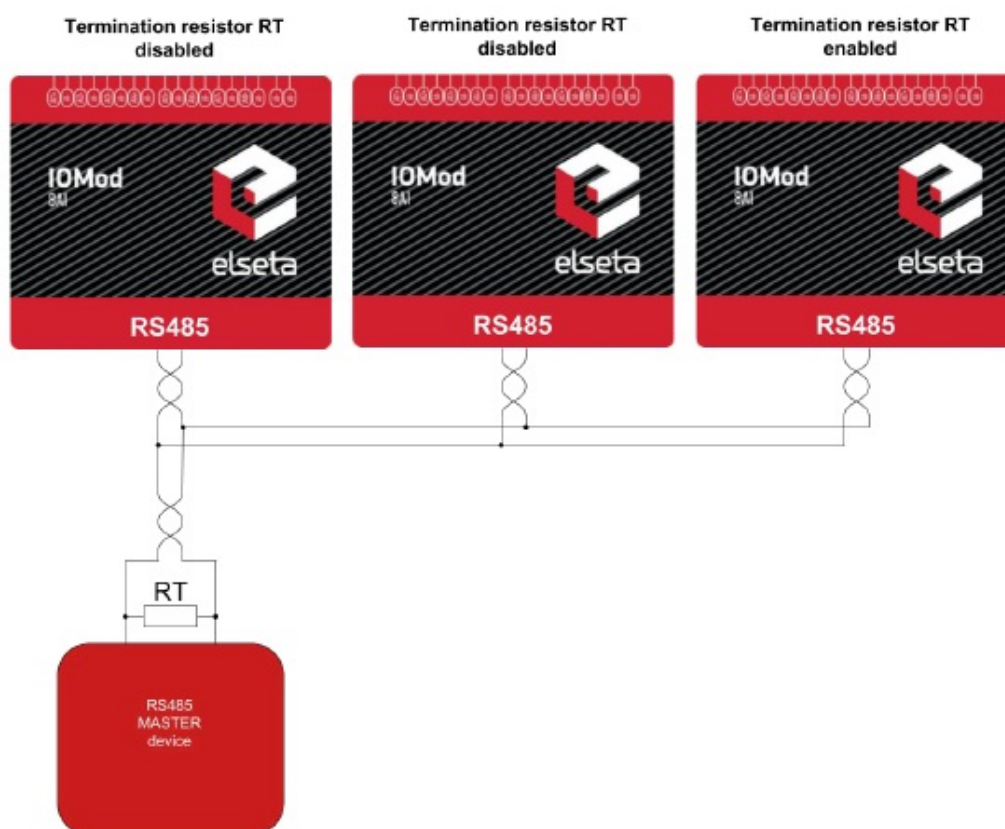


Fig. 2. Typical IOMod connection diagram

IOMod 8AI has 1/8 Unit load receiver which allows having up to 255 units on a single line (compared to standard 32 units). To reduce reflections keep the stubs (cable distance from main RS485 bus line) as short as possible.

### IOMod 8AI inputs

A typical application of IOMod 8AI unipolar and bipolar voltage inputs is shown in Fig. 3. See Configuration over USB chapter for instructions for analog input configuration.

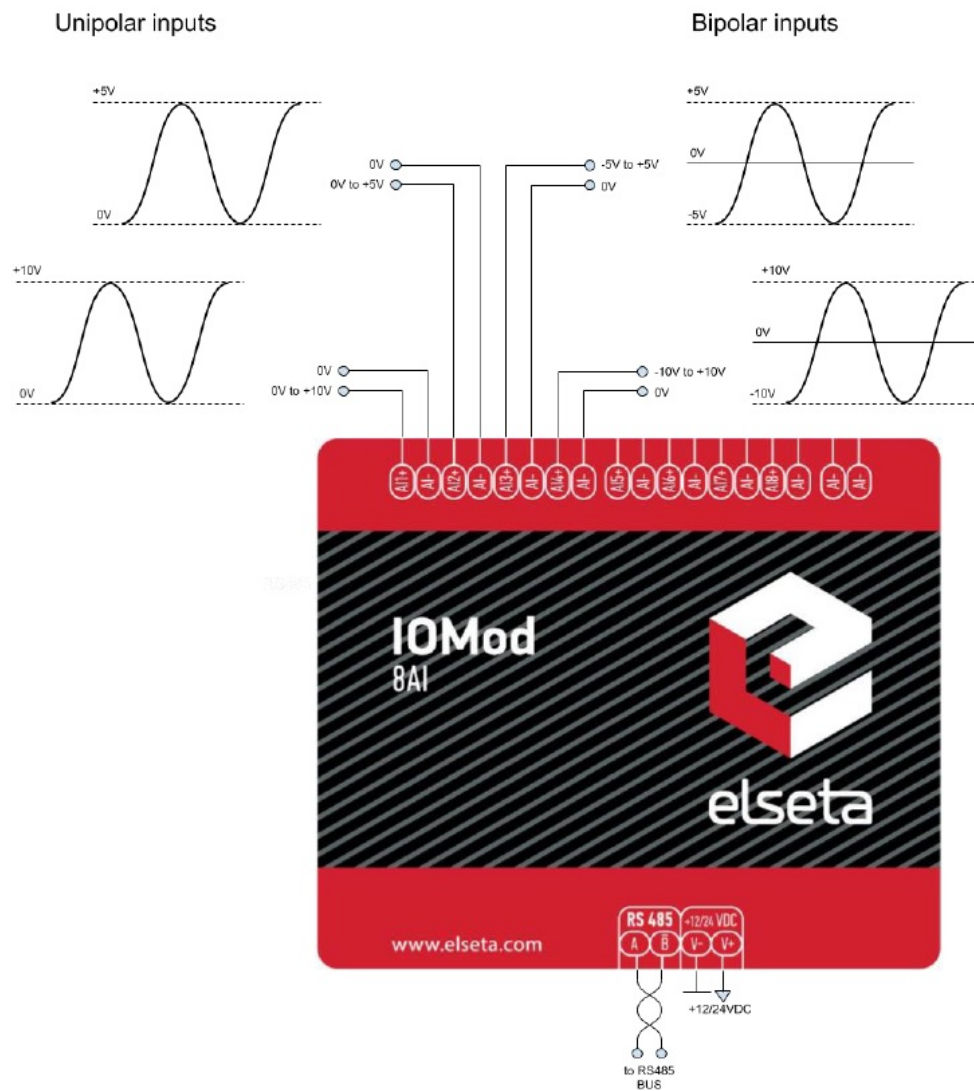


Fig. 3. Voltage input connection diagram for IOMod device

All analog inputs can be configured as current inputs to connect 0-20 mA, 4-20 mA or other current output sensors. Typical application of IOMod 8AI unipolar and bipolar current inputs is shown in Fig. 4. See Configuration over USB chapter for instructions for analog input configuration.



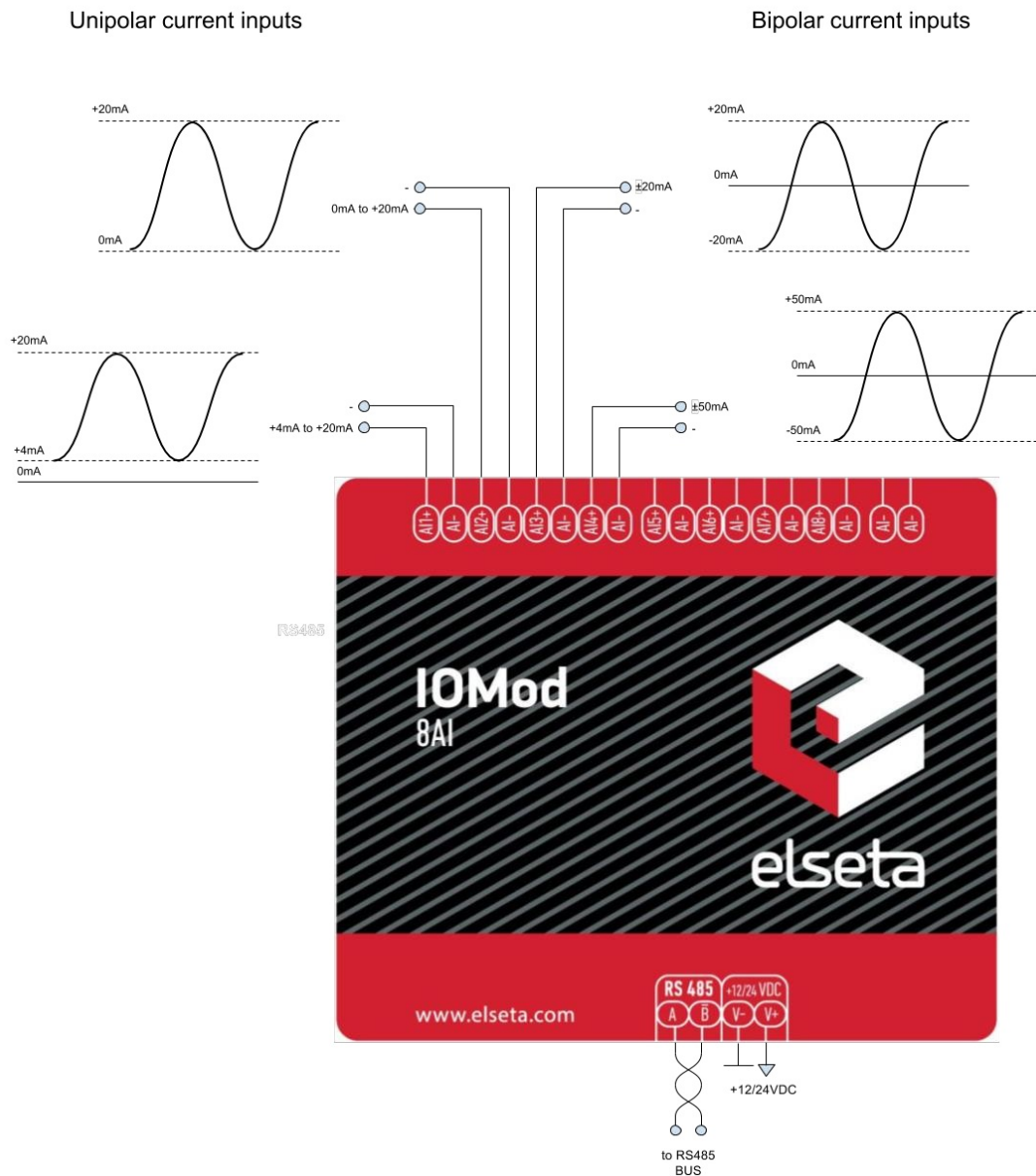


Fig. 4. Current input connection diagram for IOMod device

## Configuration over USB

### Driver installation

The device requires USB drivers to work as a Virtual COM port. The first-time connection between device and computer could result in "Device driver software was not successfully installed" error (as in Fig. 5.)

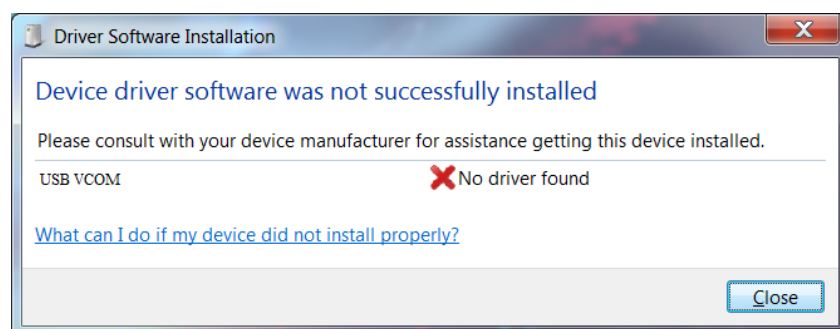


Fig. 5. Unsuccessful device software installation error

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. should appear:

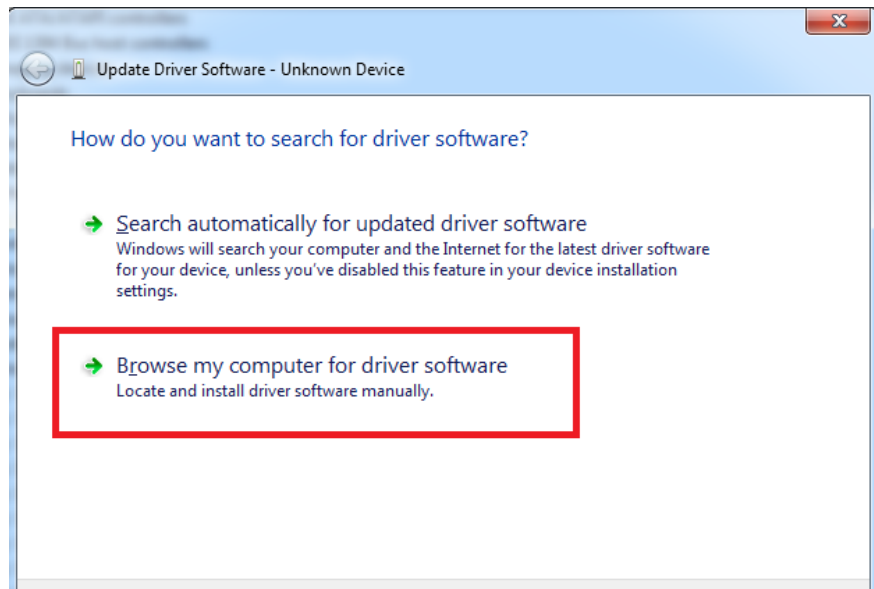


Fig. 6. Device driver software update message

- 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. 7.)

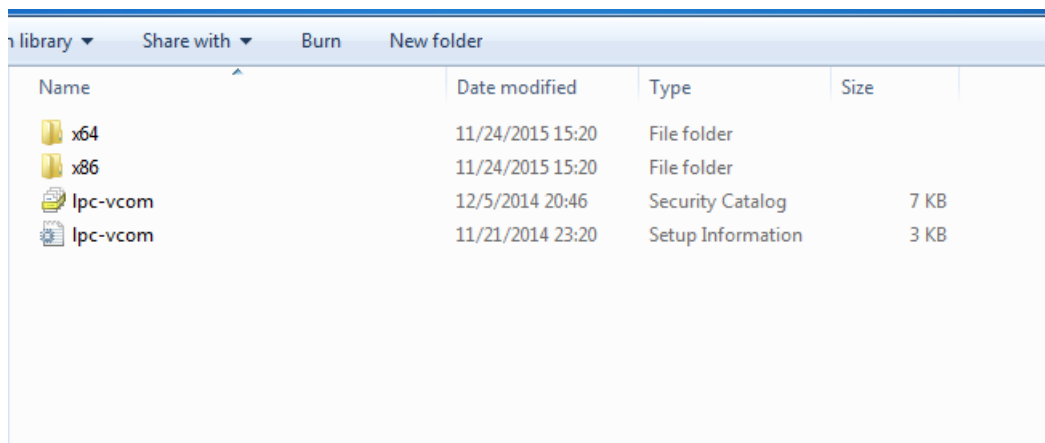


Fig. 7. Device driver folder content

## IOMod configuration via PuTTY terminal

A configuration of IOMod device is done through CLI (Command Line Interface) on the virtual COM port. Drivers needed for Microsoft Windows to install VCOM will be provided. To open up CLI simply connect to specific V-COM port with terminal software (advised to use PuTTY terminal software. If other software is being used, a user might need to send <return> symbol after each command). When connected user should immediately see the main screen.

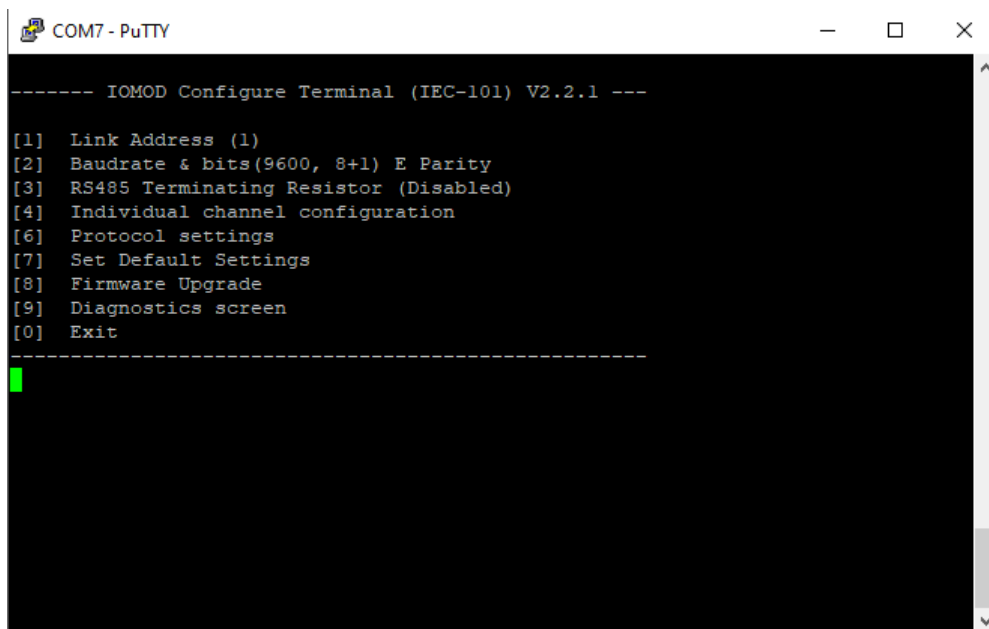


Fig. 8. The main menu for IOMod 8AI, IEC-60870-5-101 version

Navigation is performed by sending digits or other symbols to a terminal. A user then proceeds by following on-screen instructions. For example, to set baud rate, press [2] to enter Communication settings screen; press [3] to edit; 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 the main screen, and confirming changes [1].

If the terminal window is closed accidentally, a user can connect the terminal program again, and press any key on a keyboard to show the main menu again.

#### IEC-60870-5-101 Main Menu

	Menu name	Function	Values	Default values
[1]	Link Address	Changing link address	1-247	1
[2]	Baudrate, parity and stopbits	[1] Set 8 Data bits + 1 Stop bit [2] Set 8 Data bits + 2 Stop bit [3] Configure baud rate [4] Configure Parity	[3] 100-256000 [4] None/ Odd /Even / Mark/ Space	[3] 9600 [4] Even
[3]	RS485 Terminating Resistor	RS485 120 Ohm Terminating Resistor	[1] Enable [2] Disable	Disabled
[4]	Individual channel configuration	Channel configuration screen (see Table "Individual Channel Configuration")		
[6]	Protocol settings	-		
[6].[1]	Toggle 24/56 bit time	Changes time mode for info mode to 24 or 56 bits by pressing [1]	24/56	56 bit
[6].[2]	Change IOA size	[1] 1 [2] 2 [3] 3 [0] back	1-3	1
[6].[3]	Toggle measurements type	Changes measurement type to integer or float by pressing [3]	Integer/Float	Float
[6].[4]	Toggle measurement time	Enables or disables timed measurements by pressing [4]	Enabled/Disabled	Enabled
[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	Input states	-	-
[0]	Exit	Exit and disconnect	-	-

#### Individual channel configuration

	Menu name	Function	Values	Default values
--	-----------	----------	--------	----------------

[1]	Measure Current/Voltage	Selecting this option toggles measurement selection	-	-
[2]	Change sensitivity	Selecting a measurement range	[1] [-10.24 V, 10.24 V], [2] [-5.12 V, 5.12 V], [3] [-2.56 V, 2.56 V], [4] [0 V, 10.24 V], [5] [0 V, 5.12 V]	[1] [-10.24 V, 10.24 V]
[3]	Measurement limits	Entering floating point values to use them for marking overflow/underflow statuses	Floating values in a range defined by measuring sensitivity	[-10240.00 mV; 10210.00mV]
[4]	Live zero tolerance	Enter live zero tolerance (percent)	Floating values in a range defined by measuring sensitivity	(0.0000) %
[0]	Back	Back to last menu screen		

## Measurements' calibration

Every device is shipped containing factory-predefined calibration coefficients. However, changing temperature and humidity conditions can affect the accuracy of measurements. To get the best accuracy, use the device at room temperature and if that is not possible, calibrate coefficients accordingly.

To enter the calibration screen (Fig. 9.) from main menu press '@' symbol.

```

COM7 - PuTTY
----- IOMOD Configure Terminal (IEC-101) V2.2.1 -----
[1] Link Address (1)
[2] Baudrate & bits(9600, 8+1) E Parity
[3] RS485 Terminating Resistor (Disabled)
[4] Individual channel configuration
[6] Protocol settings
[7] Set Default Settings
[8] Firmware Upgrade
[9] Diagnostics screen
[0] Exit
-----
Select a measurement to calibrate:
[1] Current
[2] Voltage
[0] Back

```

Fig. 9. Analog inputs' calibration screen

In the calibration screen, either current or voltage coefficients can be selected. Selecting current by pressing [1] should enter additional screen (Fig. 10.) Calibrating voltage is an identical process therefore only current setting is explained.

```

COM7 - PuTTY
[1-8] Change current calibration coeffs for AIn
[*] Change all calibration coeffs at once
[0] Cancel current calibration

```

Fig.10. Current calibration screen

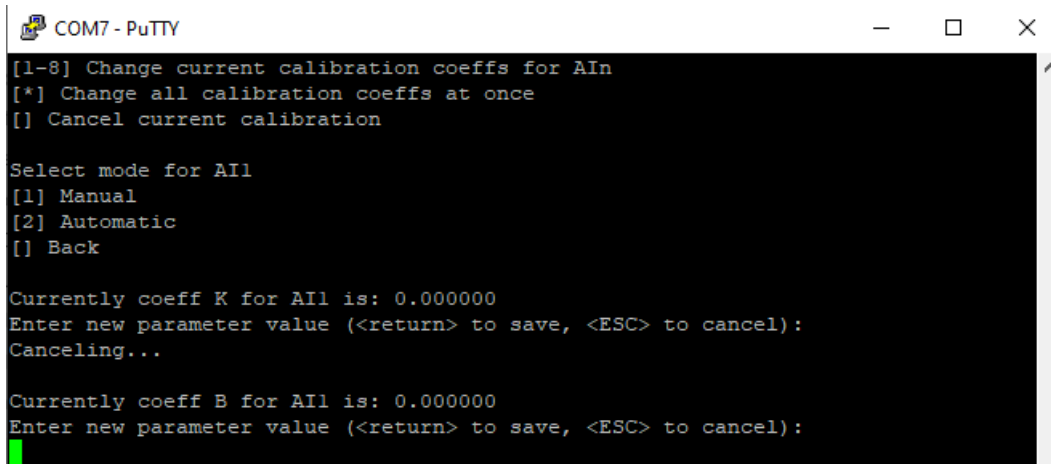


Fig. 10. Manual calibration coefficients' setting

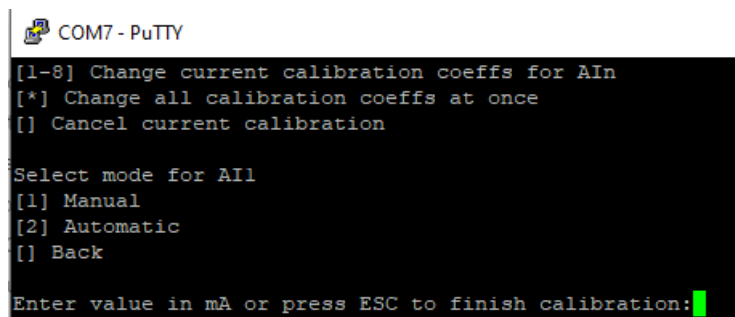


Fig. 11. Automatic calibration coefficients' setting

All configuration coefficients can either be configured all at once or individually. The coefficient setting for all channels is done manually only. Tweaking individual channels, however, can be automatic (Fig. 11.) as well as manual (Fig. 10.). Selecting automatic calibration polls values that user inputs and tweaks coefficients to minimize the additive error. It is therefore advised to scan several values differing by the same value interval to get the best results. Pressing ESC finishes calibration and saves coefficients to non volatile memory.

## Protocol simulation over USB

After entering the diagnostics screen, protocol simulator can be turned on by pressing [9]. When it is on, the device will communicate over USB port rather than a RS-485 line. Communication on a RS-485 line is closed and all Modbus or IEC-60870-5-101 commands will only be accepted from USB. To exit this mode device must be restarted.

## 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. 12.).



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



Fig. 12. Mass storage device warning

User then must delete existing file “firmware.bin”, and simply upload new firmware file by drag and drop. (Fig. 13.)

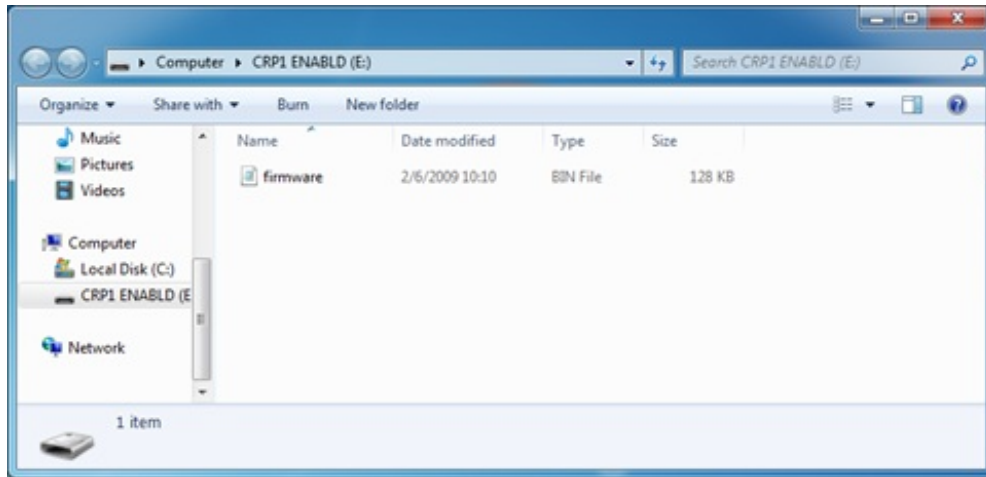


Fig. 13. Dragging and dropping new firmware file

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