

# IOMOD 16DI

IOMod 16DI – industrial 16 digital input module.

- Firmware version 1
  - IOMOD 16DI User Manual Modbus
  - IOMOD 16DI User Manual IEC 60870-5-103
  - IOMOD 16DI User Manual IEC 60870-5-101
- Firmware version 2
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Firmware version 1

# IOMOD 16DI User Manual Modbus

## Introduction

IOMOD 16DI is small sized stand-alone Modbus (RTU) or IEC 60870-5-103 digital input controller. IOMOD is used for industrial applications, where digital signaling is used and robust communication is needed. IOMOD is 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

- 16 digital inputs with configurable active signal polarity, or input inversion; Pulse count and ON time count
- Galvanically isolated inputs
- Configurable over USB
- Drag And Drop firmware upgrade over USB
- RS485 communication
- LED input indications, + Data transmission (Rx and Tx) indication.
- Small sized case with removable front panel
- DIN rail mount
- Operating temperature: from -30 to +70°C
- Power Requirements: 12-24 VDC

## Device operational information

IOMOD 16DI uses Modbus (RTU) or IEC 60870-5-103 protocol over the RS485 interface. The protocol used by the device can be changed by uploading the corresponding firmware. Default communication settings are: 9600 baudrate, 8N1, Slave address - 1.

### 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.

## MODBUS operational information

To read all input statuses, send 02 Modbus command (Read Discrete Inputs) 03 Modbus command with resolution of first register (0) and a size of 16. Returned value will show 16 input states.

To read all input registers' values, send 04 Modbus command (Read input registers) with resolution of first register (0) and size of 80. Returned data will show pulse count (first register) and ON time (2<sup>nd</sup> and 3<sup>rd</sup> registers) for each input – pulse count of input #2 will be at register 4<sup>th</sup>, and so on. ON time will be shown as seconds. ON time and pulse count will increase when input pulse is longer than Filter time, which is configured by user in USB terminal menu. Shorter pulses will be ignored in both pulse and ON time registers. From software version 1.10, as capacity of input counter expanded to 32-bits, additional 32 registers depict such wider values in registers 00048-00079. All these registers can be set by using 06 Modbus command.

To invert input states by software, configure device over USB terminal. Modbus commands one may use are shown in table below.

## Supported MODBUS functions

### 02 (0x02) Read Discrete Inputs

Reads status of digital inputs (Off or On). IOMOD 16DI has 16 digital inputs from address 0 to address 0xF; These inputs are active-high or active-low according to supply given to reference input. User can turn on logical input inversion (through USB).

### 03 (0x03) Read Holding Registers

Lets user read counter/timer values dedicated to digital inputs. There are 80 MODBUS registers. Values held in these registers are explained in a table below. There are two types of values - Pulse Counter and On Timer, the latter

calculating the time that respective input was held in its active state.

#### 04 (0x04) Read Input Registers

Lets user read counter/timer values dedicated to digital inputs. There are 80 MODBUS registers. Values held in these registers are explained in a table below. There are two types of values - Pulse Counter and On Timer, the latter calculating the time in seconds that respective input was held in its active state. This function is deprecated and mirrors function 0x03 to conform to past versions of IOMOD 16DI.

#### 06 (0x06) Preset Single Register

Sets single register. Register addresses are identical to “*Read Input Registers*” addresses.

## Modbus register mapping table

Register	Description	Value range
<b>Read discrete inputs (02)</b>		
00000-00015	Reading digital inputs DI1-DI16	0-65535
<b>Read holding register (03), Read input register (04), Preset Single Register (06)</b>		
00000	Pulse count for DI1, Least Significant Word	0-65535
00001-00002	On time, in seconds, for DI1, Least Significant Word first	0-65535
...	...	...
00045	Pulse count for DI16, Least Significant Word	0-65535
00046-00047	On time, in seconds, for DI16, Least Significant Word first	0-65535
00048-00079	Pulse count for DI1-DI16, Least Significant Word First	0-65535

\*It is advised to set most significant word of counter/timer first

## Testing With “THE VINCI” software

To test IOMOD with default settings, user connects device 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 baudrate; 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 working information); Press start and go to “Statistic” tab:

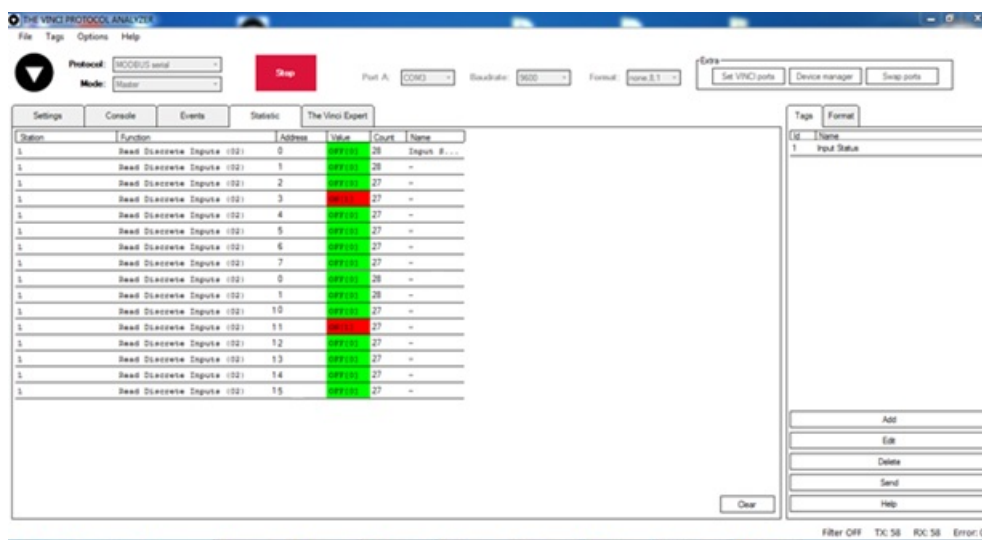


Fig. 3.1. Statistic tab in “The Vinci” application for Modbus communication

As seen in Fig. 3.1, Inputs are shown with info numbers 1-16, and function type - 160.

GI, time synchronization options can be found at right side of the program, in “System” tab.

Fig. 3.2 shows 1<sup>st</sup> + 2<sup>nd</sup> , 5<sup>th</sup> + 6<sup>th</sup> and 11<sup>th</sup> + 12<sup>th</sup> Inputs grouped (notice order of info numbers). These pairs is shown INTERM (00) because both inputs of pair are off (giving binary representation of 00b).

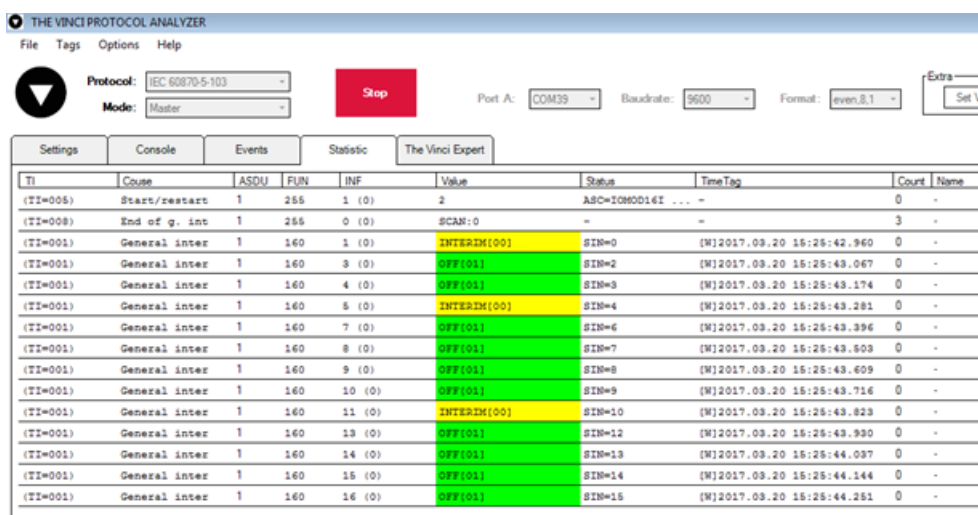


Fig.3.2. Statistic tab in “The Vinci” application for IEC-60870-5-103

## Technical information

	System	
1.	Dimensions	101 x 119 x 17.5, mm
2.	Case	ABS, black
3.	Working environment	Indoors
4.	Working temperature	-30   +70°C
5.	Recommended operating conditions	5 – 60°C and 20 – 80%RH;
6.	Configuration	USB

7.	Firmware upgrade	USB – mass storage device
	<b>Electrical specifications</b>	
8.	Inputs	16 X 2kV isolated 12-24VDC; ESD protected; Selectable inversion.
	<b>Power</b>	
9.	Power Supply	9V to 33V
10.	Current consumption	50mA @ 12VDC, 25mA @ 24VDC

## Mounting and installation guide

### IOMOD 16DI RS485 interface

IOMOD 16DI 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 on Fig. 5.1.

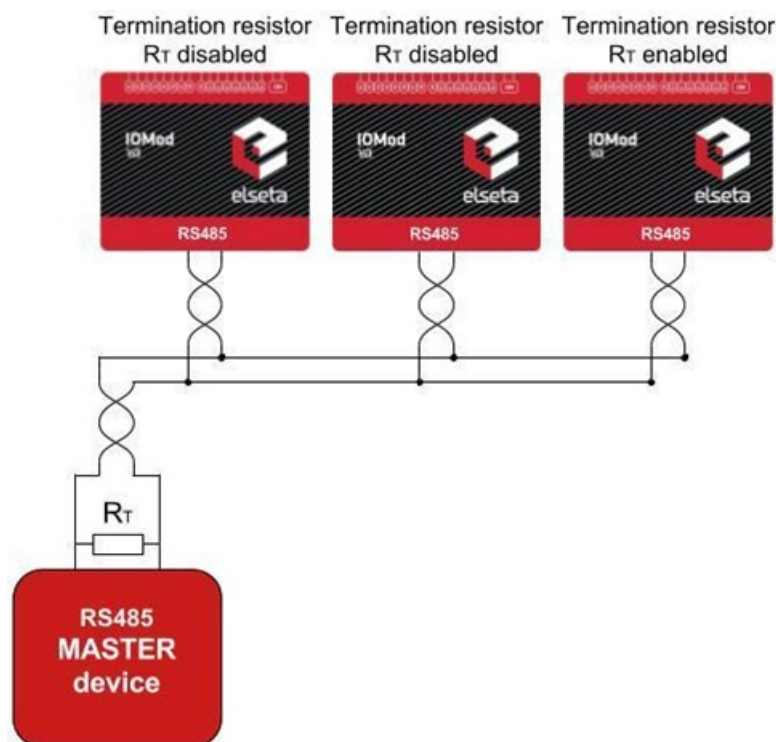


Fig. 5.1. Connection example

IOMOD 16DI 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.

### IOMOD 16DI inputs

Typical application of IOMOD 16DI inputs is shown on Fig. 5.2. When default configuration for inputs is applied, user will see inputs connected to +12/24V as “high” or state “1” and input status LED will glow.

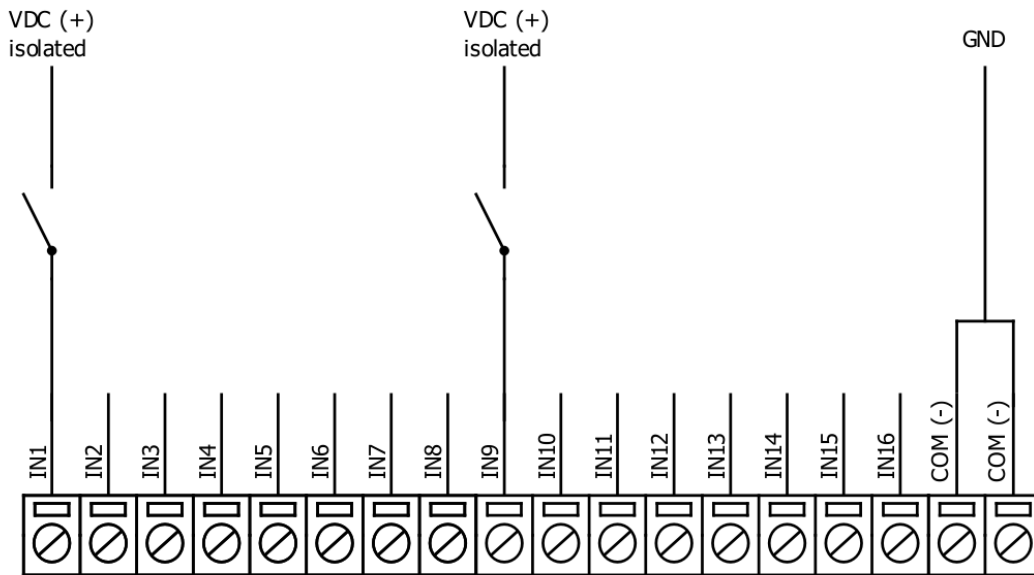


Fig. 5.2. Input configuration example

User can setup inputs to be driven by 0V (active low) signal (see Fig. 5.3). With this configuration, user will see inputs connected to 0V as “high” or state “1”, input status LED will glow.

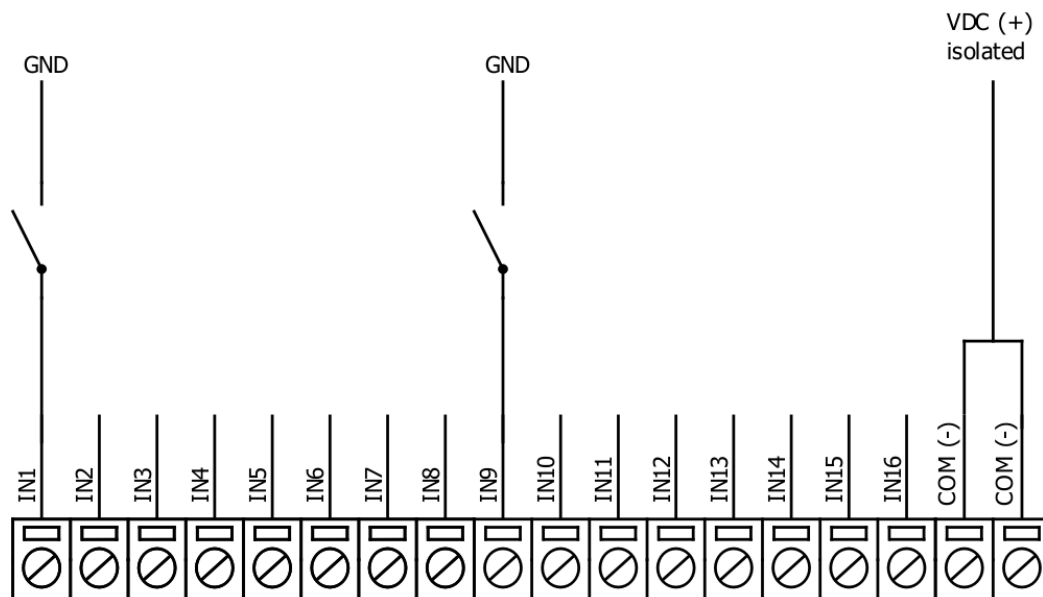


Fig. 5.3. Configuration of inverted inputs

## Configuration over USB

### Driver installation

Device requires USB drivers to work as virtual com port. First-time connection between device and computer could result in “Device driver software was not successfully installed” error (Fig. 6.1).

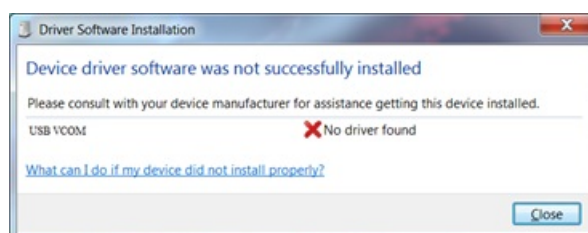


Fig. 6.1. Device driver error message

User then manually installs 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).

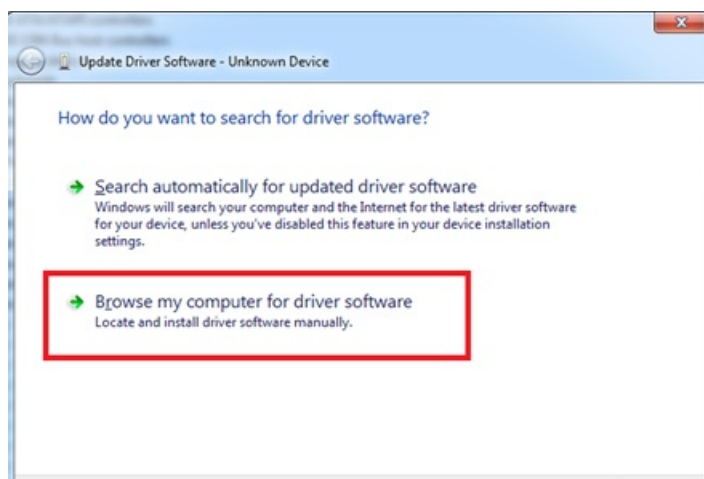


Fig. 6.2. Manually searching for device drivers

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

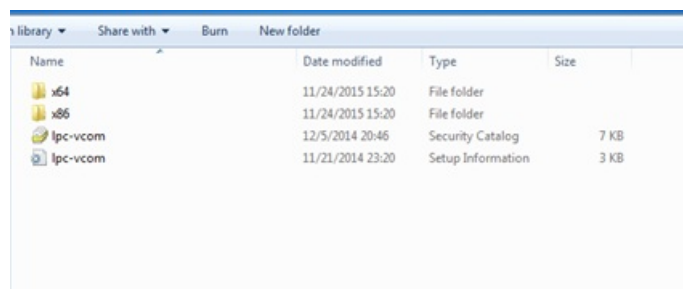


Fig. 6.3. Contents of device drivers' folder

## IOMOD 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 V-COM port with terminal software (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:

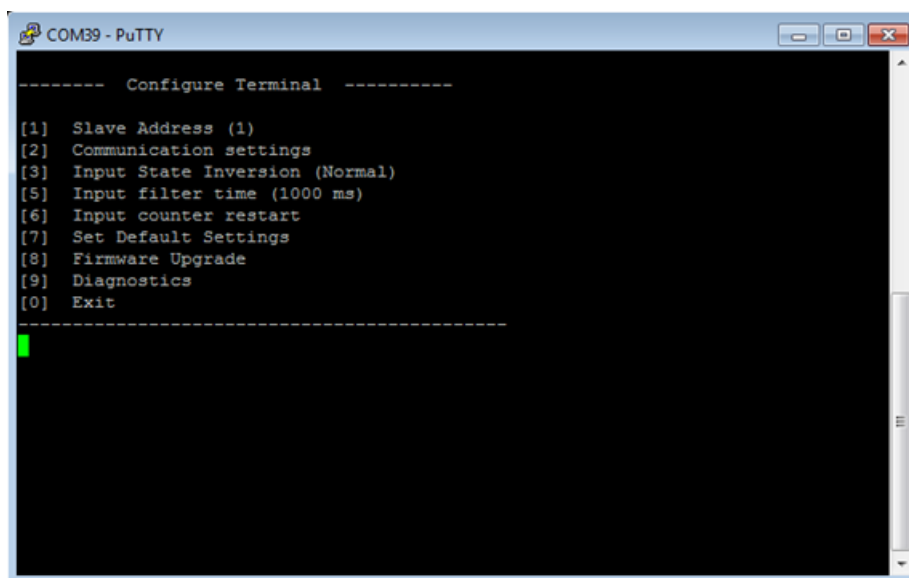


Fig. 6.4. Main menu example of configuration program via CLI

Navigation is performed by sending number to terminal. User then proceeds by following further on-screen instructions. For example, to set Baudrate, press [2] to enter Baudrate 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 is set by pressing [6] on main screen, and confirming changes [1].

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



## Main Menu

### Modbus

	Menu Name	Function	Values	Default Values
1.	Slave Address	Modbus Slave address / ID	1-247	(default: 1)
2.	Communication settings	Enters baudrate, data and parity bit, termination resistor screen	-	(default: 9600; 8+1+N; termination resistor - on)
3.	Input State Inversion	Input inversion (Inverts input states in modbus)	0 - 1 (off/on)	(default: 0)
5.	Input Filter time	Configures input pulse filter time	0 - 256000 (milliseconds)	(default: 100)
6.	Input counter restart	Restarts all input counter registers to 0	(1 to confirm, 0 to cancel)	-
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	-	-

## Protocol simulator

After entering diagnostics screen, user can turn on protocol simulator by pressing [9]. When protocol simulator is turned on, device will communicate through USB port rather than RS-485 line. Communication on RS-485 line is closed and all Modbus commands will be accepted only from USB. To exit this mode user must restart device.

## Firmware upgrade over USB



It is recommended to close terminal window when entered firmware upgrade mode.



Fig. 6.5. Reconnecting as a mass storage device

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

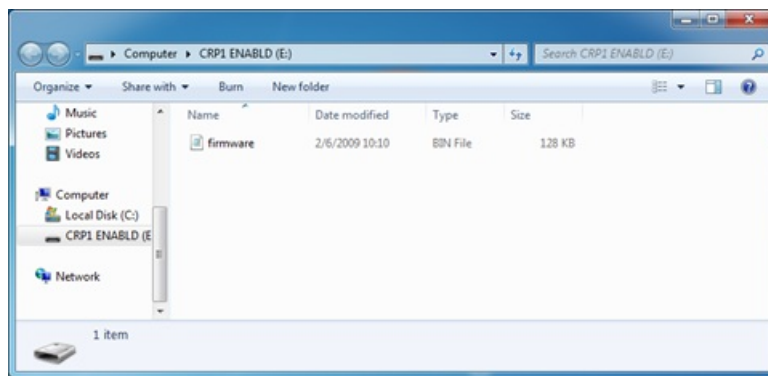


Fig. 6.6

Reconnect device, check firmware version and **set default settings**.

# IOMOD 16DI User Manual IEC 60870-5-103

## Introduction

IOMOD 16DI is small sized stand-alone Modbus (RTU) or IEC 60870-5-103 digital input controller. IOMOD is 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, control, 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

- 16 digital inputs;
- Configurable active input signal polarity or input inversion;
- Galvanically isolated inputs;
- Configuration over USB console;
- Drag and Drop firmware upgrade over USB mass storage;
- Modbus, IEC-60870-5-103 communication over RS485;
- Values with data and time information;
- Time synchronization over IEC-60870-5-103;
- Software selectable termination resistor on RS485;
- LED indication for input and data transmission;
- Easy integration with WCC Lite gateway and CloudIndustries.eu platform

## Operational information

IOMOD 16DI uses Modbus (RTU) or IEC 60870-5-103 protocol over RS485 interface. Protocol used by device can be changed by uploading a corresponding firmware. Default communication settings are: 9600 baud rate, 8N1, Slave address - 1.

### 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.

## IEC 60870-5-103 description

### Initialization:

IOMOD uses a standard IEC-60870-5-103 communication scheme. Initiation, control messages and queries are initiated by the master (controlling station), while IOMOD device (controlled station) only answers these requests. Therefore, the first message should be sent by master to start/restart communication (RESET CU or LINK RESET FCB). This message is answered by IOMOD with an acknowledgement (ACK) to enable master to proceed with sending other messages defined by IEC-60870-5-103 protocol. Other messages are ignored until a successful initialization has taken place.

IOMOD 8DI8DO configuration can be changed over USB interface with terminal console like PuTTY or similar.

### Data polling:

When initialization is complete, master may poll IOMOD device with both Class 1 and Class 2 requests. Class 2 is used when master polls for a cyclic data. Controlled device answers with a message containing Access Demand flag when spontaneous data exists and master then sends request for Class 1. IOMOD would then respond with time-tagged message.

On first Class 1 request IOMOD device always asks for the Access Demand to send an identification string. However, if there are spontaneous messages to be sent, they will be sent before the identification string.

### 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 “Spontaneous” message with “Function type” as input address (default function type of inputs – 160), and “Info number” as input pin number. Please note that spontaneous messages are answered with a four-byte time structure not containing date info. Controlling station should therefore be able to handle the signals sent before the start of a new day.

### Time synchronization:

To initiate the time synchronization between devices master must send variable frame, with function code “User data with ACK”, ASDU type “6” and Cause of Transmission “8”. Info elements must contain the 7-byte time structure.

As per IEC-60870-5-103 protocol specification time synchronization can be completed for multiple devices using broadcasting messages. It is included in IEC-60870-5-103 firmware since version 1.7.3. To broadcast time synchronization message, link address should be equal to 255.

### General interrogation:

General Interrogation (GI) is initiated by the master with variable frame, including function code “3” (User data with ACK), ASDU type “7” and Cause of Transmission “9”. Slave device then responds with an acknowledgement (ACK). Master gets GI data by polling with Class 2 request till slave transmits “End of GI” (Cause of Transmission – “10”). IOMOD device responds with a time-tagged message, including DPI states of inputs and outputs (Outputs are sent first). Output and input numbers are represented by “Info number” in protocol.

## Device configuration

### Input inversion and polarity selection:

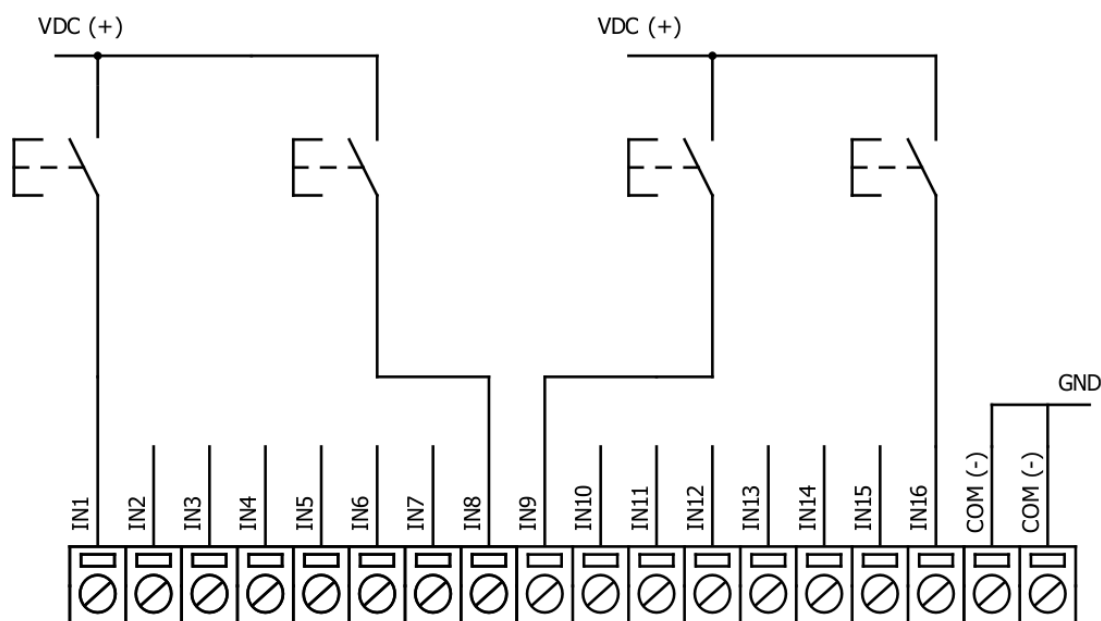
Input polarity selection (active signal selection) is done by connecting appropriate supply to COM pin. Further explained in section 5: Mounting and installation guide.

Input inversion does logical inversion of signals.

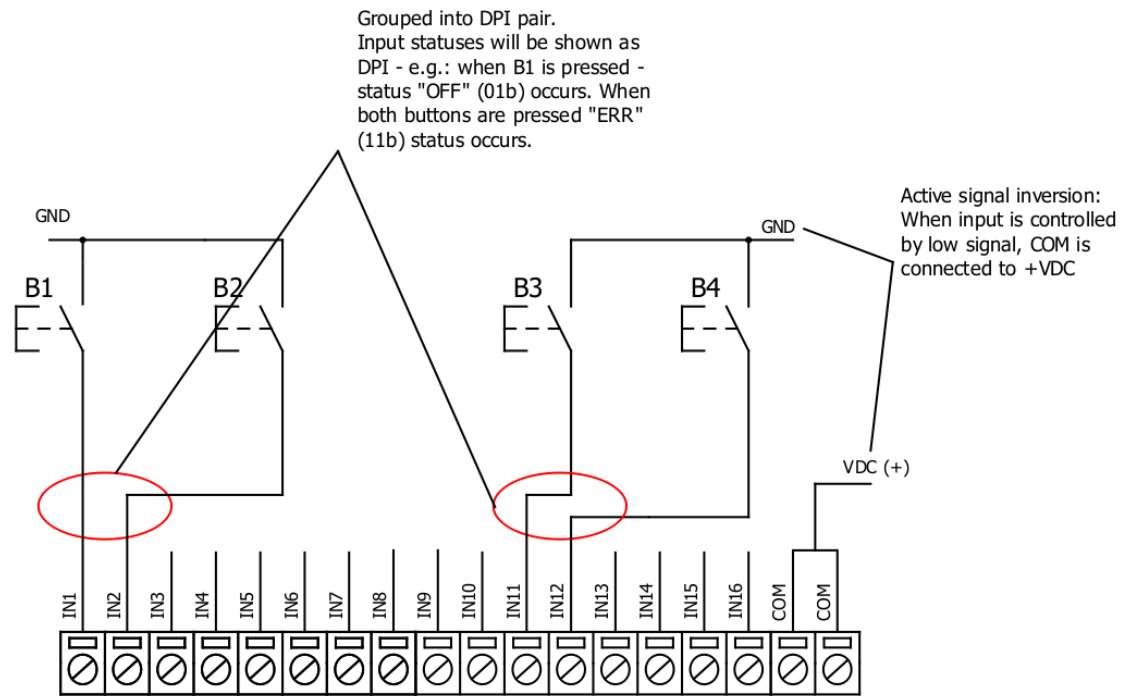
### Input grouping:

Sometimes two inputs must be captured as one DPI input. Inputs can be grouped into pairs of two. Only two neighbour pins can be grouped into pair, while first pin in pair must be an odd number pin. When grouped, second pin in the pair is not used anymore – all request to this pin generate an error. For example – IN1 and IN2 can be grouped, after that IN2 is not used; IN2 and IN3 *cannot* be grouped; IN3 and IN4 can be grouped, but IN4 is not used, etc.

Fig. 3.1 shows inputs ungrouped and controlled independently. In this mode, General Interrogation will be composed of 16 input states. Notice  $+V_{IO}$  and  $-V_{IO}$  connection: when COM is connected to negative power supply voltage, inputs are controlled by positive voltage.



In addition to this, Fig. 3.2 shows  $1^{st} + 2^{nd}$  and  $11^{th} + 12^{th}$  inputs are grouped into pair. Now, General Interrogation will be composed of 14 input states (with IN2 and IN12 missing). Input numbers is represented by “Info number” in protocol. Here, COM is connected to positive voltage of power supply and inputs are controlled by negative voltage.



### Input filter:

Input filter is a simple input glitch filter with a time input. This filter time corresponds to time that input must achieve without changing state before sending status change.

### Addressing configuration:

Devices Input address is configurable. This addresses in IEC 60870-5-103 protocol is considered as "Function Type". Input address is 160 by default.

Device is addressed in the line as "Link address", which is 1 by default.

## Testing With "THE VINCI" software

To test IOMOD with default settings, user connects device through RS485 to IEC 60870-5-103 master. Example using "The Vinci Expert" as serial interface converter and adapter to PC with "The Vinci" software. When opening "The Vinci" software, choose IEC 60870-5-103 - Master mode. Initial settings - 9600 baud rate; 8 data, no parity, 1 stop bit. Press Start, send Time synchronization, General interrogation and go to the "Statistic" tab:

As seen in Fig. 3.3, Inputs are shown with info numbers 1-16, function type - 160.

General Interrogation, Time Synchronization options can be found at right side of the program, in the "System" tab.



THE VINCI PROTOCOL ANALYZER									
File Tags Options Help									
<div>  <div> Protocol: IEC 60870-5-103 Mode: Master </div> <div>Stop</div> <div> Port A: COM39 Baudrate: 9600 Format: even,8,1 </div> <div> Extra Set VINCI ports </div> </div>									
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=IOMOD16I ...	-	0	-
(TI=008)	End of g. int	1	255	0 (0)	SCAN:0	-	-	3	-
(TI=001)	General inter	1	160	1 (0)	OFF[01]	SIN=0	[W]2017.03.20 15:21:53.973	0	-
(TI=001)	General inter	1	160	2 (0)	OFF[01]	SIN=1	[W]2017.03.20 15:21:54.082	0	-
(TI=001)	General inter	1	160	3 (0)	OFF[01]	SIN=2	[W]2017.03.20 15:21:54.189	0	-
(TI=001)	General inter	1	160	4 (0)	OFF[01]	SIN=3	[W]2017.03.20 15:21:54.296	0	-
(TI=001)	General inter	1	160	5 (0)	OFF[01]	SIN=4	[W]2017.03.20 15:21:54.403	0	-
(TI=001)	General inter	1	160	6 (0)	OFF[01]	SIN=5	[W]2017.03.20 15:21:54.510	0	-
(TI=001)	General inter	1	160	7 (0)	OFF[01]	SIN=6	[W]2017.03.20 15:21:54.617	0	-
(TI=001)	General inter	1	160	8 (0)	OFF[01]	SIN=7	[W]2017.03.20 15:21:54.724	0	-
(TI=001)	General inter	1	160	9 (0)	OFF[01]	SIN=8	[W]2017.03.20 15:21:54.831	0	-
(TI=001)	General inter	1	160	10 (0)	OFF[01]	SIN=9	[W]2017.03.20 15:21:54.938	0	-
(TI=001)	General inter	1	160	11 (0)	OFF[01]	SIN=10	[W]2017.03.20 15:21:55.045	0	-
(TI=001)	General inter	1	160	12 (0)	OFF[01]	SIN=11	[W]2017.03.20 15:21:55.152	0	-
(TI=001)	General inter	1	160	13 (0)	OFF[01]	SIN=12	[W]2017.03.20 15:21:55.259	0	-
(TI=001)	General inter	1	160	14 (0)	OFF[01]	SIN=13	[W]2017.03.20 15:21:55.367	0	-
(TI=001)	General inter	1	160	15 (0)	OFF[01]	SIN=14	[W]2017.03.20 15:21:55.475	0	-
(TI=001)	General inter	1	160	16 (0)	OFF[01]	SIN=15	[W]2017.03.20 15:21:55.583	0	-

Fig. 3.4 shows 1<sup>st</sup> + 2<sup>nd</sup>, 5<sup>th</sup> + 6<sup>th</sup> and 11<sup>th</sup> + 12<sup>th</sup> inputs grouped (notice order of info numbers). These pairs are shown INTERM (00) because both inputs of pair are off (giving binary representation of 00b).

THE VINCI PROTOCOL ANALYZER									
File Tags Options Help									
<div>  <div> Protocol: IEC 60870-5-103 Mode: Master </div> <div>Stop</div> <div> Port A: COM39 Baudrate: 9600 Format: even,8,1 </div> <div> Extra Set VIN </div> </div>									
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=IOMOD16I ...	-	0	-
(TI=008)	End of g. int	1	255	0 (0)	SCAN:0	-	-	3	-
(TI=001)	General inter	1	160	1 (0)	INTERIM[00]	SIN=0	[W]2017.03.20 15:25:42.960	0	-
(TI=001)	General inter	1	160	3 (0)	OFF[01]	SIN=2	[W]2017.03.20 15:25:43.067	0	-
(TI=001)	General inter	1	160	4 (0)	OFF[01]	SIN=3	[W]2017.03.20 15:25:43.174	0	-
(TI=001)	General inter	1	160	5 (0)	INTERIM[00]	SIN=4	[W]2017.03.20 15:25:43.281	0	-
(TI=001)	General inter	1	160	7 (0)	OFF[01]	SIN=6	[W]2017.03.20 15:25:43.396	0	-
(TI=001)	General inter	1	160	8 (0)	OFF[01]	SIN=7	[W]2017.03.20 15:25:43.503	0	-
(TI=001)	General inter	1	160	9 (0)	OFF[01]	SIN=8	[W]2017.03.20 15:25:43.609	0	-
(TI=001)	General inter	1	160	10 (0)	OFF[01]	SIN=9	[W]2017.03.20 15:25:43.716	0	-
(TI=001)	General inter	1	160	11 (0)	INTERIM[00]	SIN=10	[W]2017.03.20 15:25:43.823	0	-
(TI=001)	General inter	1	160	13 (0)	OFF[01]	SIN=12	[W]2017.03.20 15:25:43.930	0	-
(TI=001)	General inter	1	160	14 (0)	OFF[01]	SIN=13	[W]2017.03.20 15:25:44.037	0	-
(TI=001)	General inter	1	160	15 (0)	OFF[01]	SIN=14	[W]2017.03.20 15:25:44.144	0	-
(TI=001)	General inter	1	160	16 (0)	OFF[01]	SIN=15	[W]2017.03.20 15:25:44.251	0	-

# Technical information

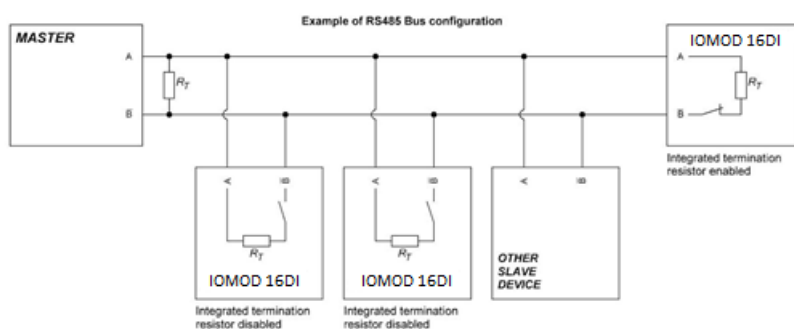
System	
Dimensions	101 x 119 x 17.5, mm
Case	IP20, blend PC/ABS self-extinguishing, black

Working environment	Indoors
Operating temperature	-40 , +85°C
Humidity	5-95% RH (non-condensing)
Configuration	USB – serial console
Firmware upgrade	USB – mass storage device
<b>Electrical specifications</b>	
Inputs	16 X 3kV isolated 12-24VDC; Selectable inversion.
<b>Power</b>	
Power Supply	9V to 33V
Current consumption	130 mA

# Mounting and installation guide

## IOMOD 16DI RS485 interface

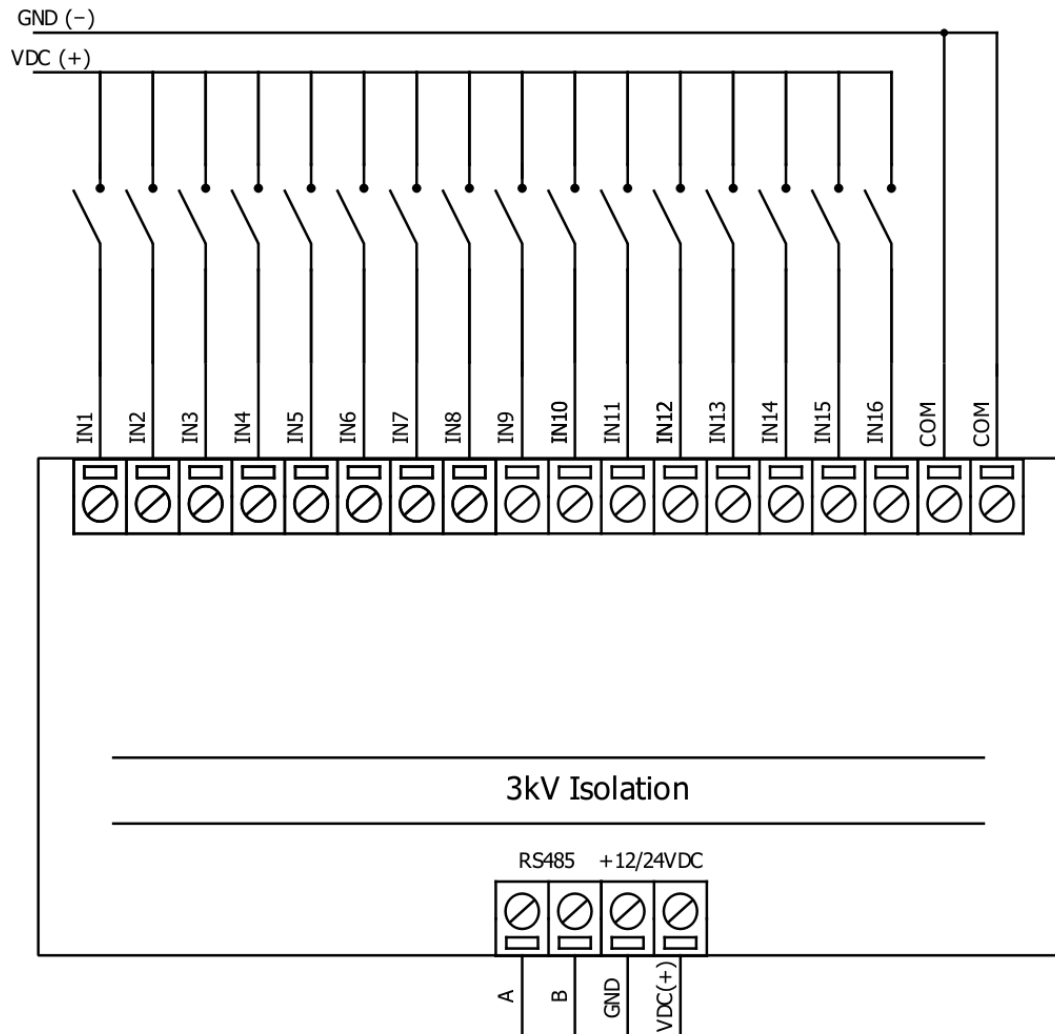
IOMOD 16DI has an integrated 120Ω termination resistor which can be enabled or disabled over USB configuration. It is recommended to use termination at each end of the RS485 cable. See typical connection diagram on Fig. 5.1.



IOMOD 16DI 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.

## IOMOD 16DI inputs

Typical application of IOMOD 16DI inputs is shown on Fig. 5.2. When default configuration for inputs is applied, user will see inputs connected to +12-24V as “high” or state “1” and input status LED will glow.

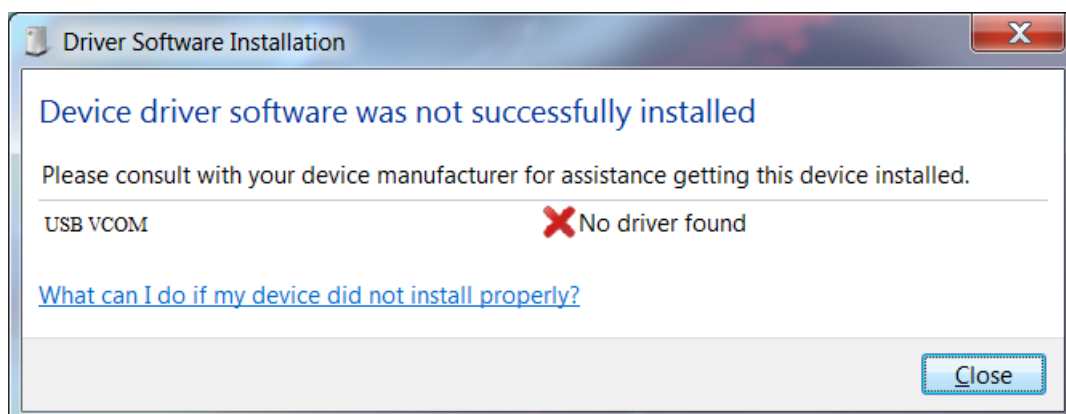


User also can configure to enable pull-up resistors (function is applied for all inputs) and software input inversion. With this configuration, user will see inputs connected to 0V (see Fig. 5.3) as “high” or state “1”, input status LED will NOT glow

# Configuration over USB

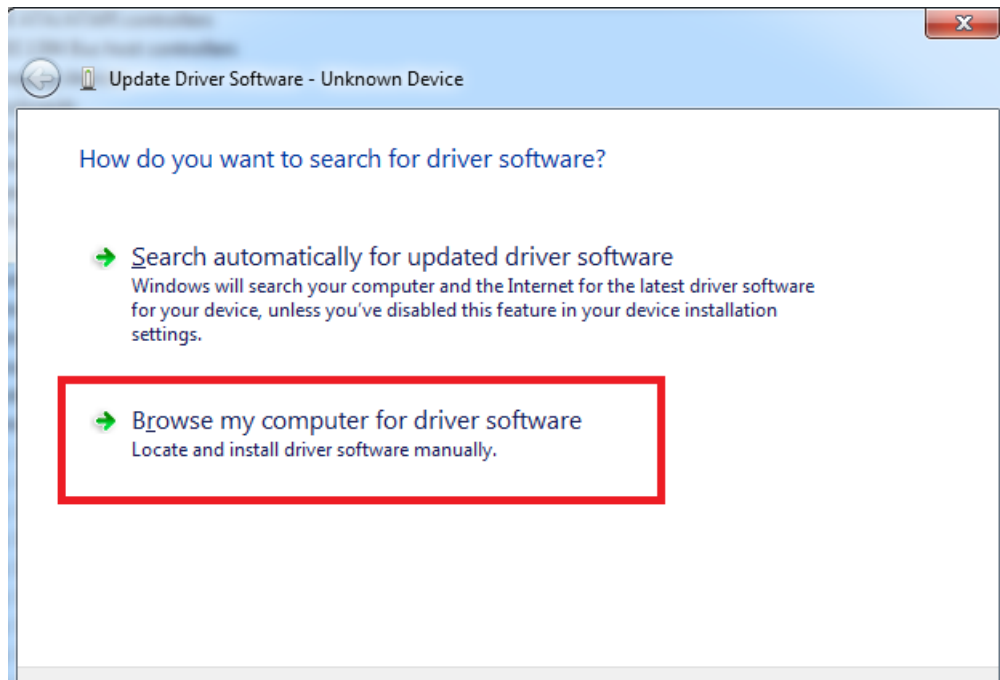
## Driver installation

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.





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

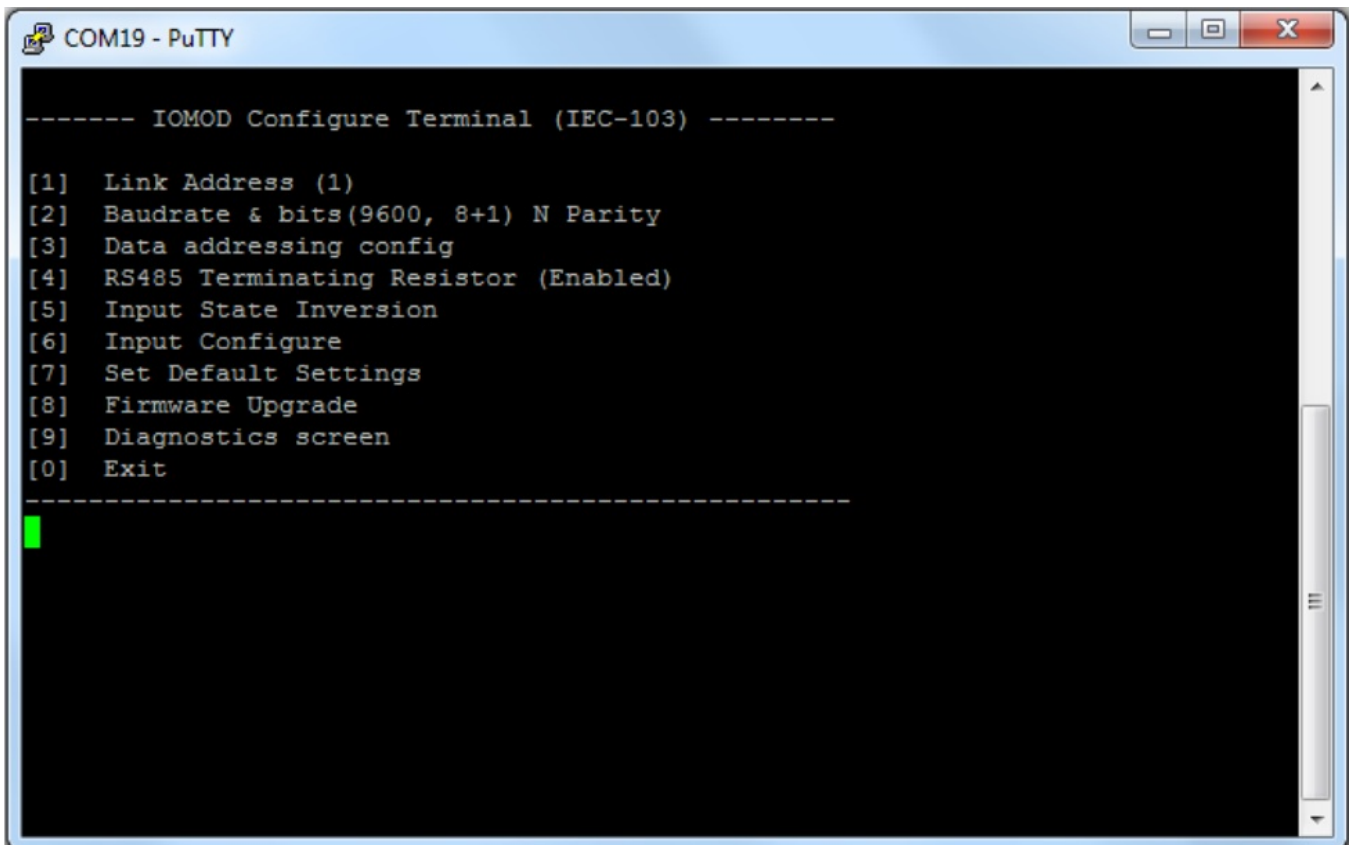


Select "x86" driver for 32bit machine, or x64 for 64bit machine. If not sure, select root folder (folder in which x64 and x86 lays inside).

Library ▾ Share with ▾ Burn New folder				
Name	Date modified	Type	Size	
x64	11/24/2015 15:20	File folder		
x86	11/24/2015 15:20	File folder		
lpc-vcom	12/5/2014 20:46	Security Catalog	7 KB	
lpc-vcom	11/21/2014 23:20	Setup Information	3 KB	

## IOMOD configuration with PuTTY terminal

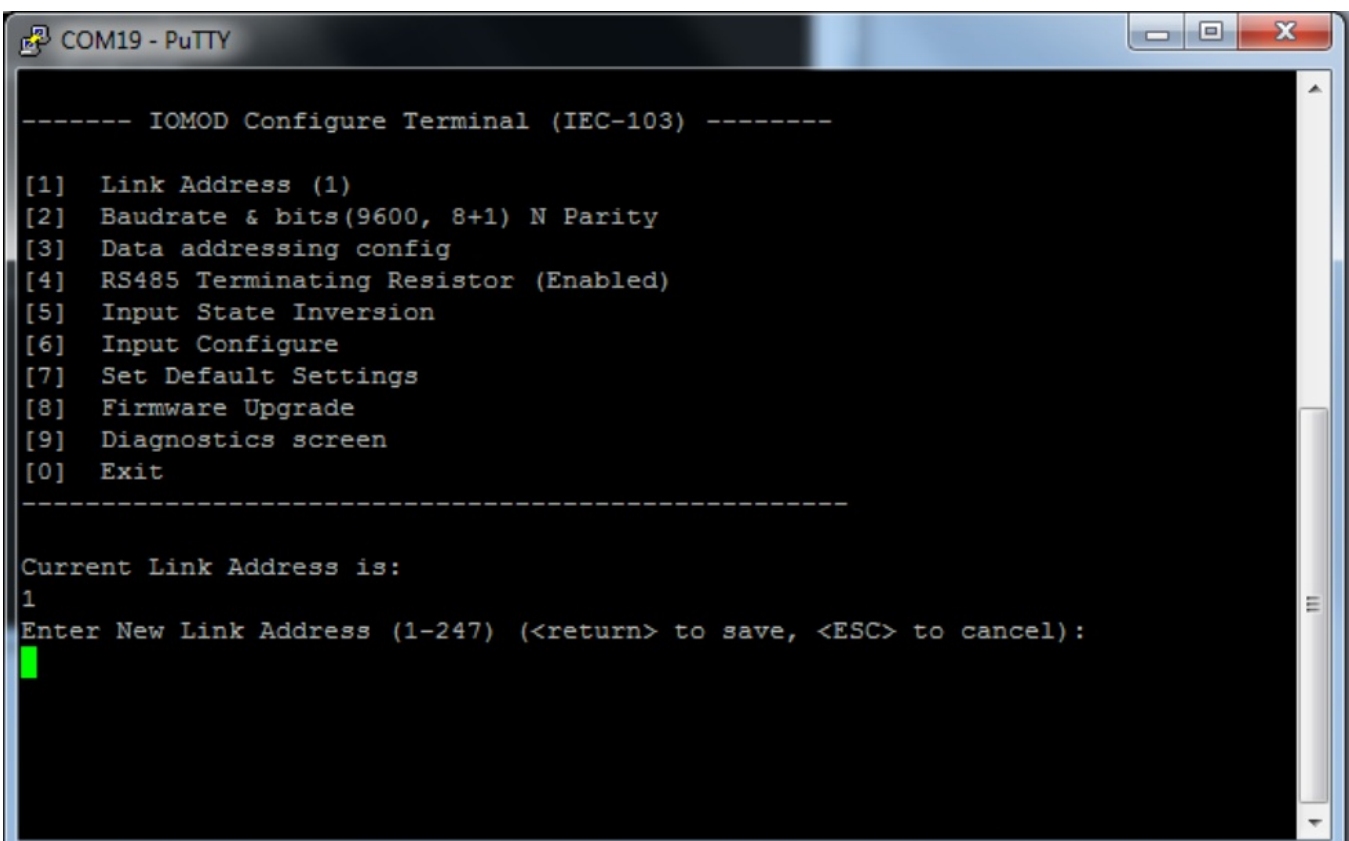
Configuration of IOMOD device is done through CLI (Command Line Interface) on virtual COM port. Drivers needed for MS Windows to install VCOM will be provided. To open up CLI simply connect to specific V-COM port with terminal software (advised to use PuTTY terminal software. If other software is being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



Navigation is performed by sending number to terminal. User then proceeds by following further on-screen instructions. For example, to set baud rate, press [2] to enter Baudrate 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 is set by pressing [6] on main screen, and confirming changes [1].

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

Main menu contains various possibilities of device configuration. A user can configure Link Address (Fig. 6.5), set communication settings (Fig. 6.6), change the input type (address) for input values (Fig. 6.7), change which input values are inverted (Fig. 6.8).



```
COM19 - PuTTY

----- IOMOD Configure Terminal (IEC-103) -----

[1] Link Address (1)
[2] Baudrate & bits(9600, 8+1) N Parity
[3] Data addressing config
[4] RS485 Terminating Resistor (Enabled)
[5] Input State Inversion
[6] Input Configure
[7] Set Default Settings
[8] Firmware Upgrade
[9] Diagnostics screen
[0] Exit

-----

Current Baudrate is:
9600
Data bits: 8 Stop bits: 1
[1] Set 8 Data bits + 1 Stop bit
[2] Set 8 Data bits + 2 Stop bit
[3] Configure Baudrate
[4] Configure Parity
[0] Back
```

```
COM19 - PuTTY

----- IOMOD Configure Terminal (IEC-103) -----

[1] Link Address (1)
[2] Baudrate & bits(9600, 8+1) N Parity
[3] Data addressing config
[4] RS485 Terminating Resistor (Enabled)
[5] Input State Inversion
[6] Input Configure
[7] Set Default Settings
[8] Firmware Upgrade
[9] Diagnostics screen
[0] Exit

-----

[1] Configure digital inputs' address [160]
[0] Back
```

```
COM19 - PuTTY

----- IOMOD Configure Terminal (IEC-103) -----

[1] Link Address (1)
[2] Baudrate & bits(9600, 8+1) N Parity
[3] Data addressing config
[4] RS485 Terminating Resistor (Enabled)
[5] Input State Inversion
[6] Input Configure
[7] Set Default Settings
[8] Firmware Upgrade
[9] Diagnostics screen
[0] Exit

-----

Input state inversion for individual pins.
Choose option and pin for which to apply it.
NOTE: Input inversion shall be set for individual pins
where grouped inputs are being used
[3] Choose pin
[0] Back

Write input number (1-16): █
```

```
COM19 - PuTTY

----- Diagnostics Screen V1.7.3 -----

Input #1 state: 0-
Input #2 state: 0-
Input #3 state: 0-
Input #4 state: 0-
Input #5 state: 0-
Input #6 state: 0-
Input #7 state: 0-
Input #8 state: 0-
Input #9 state: 0-
Input #10 state: 0-
Input #11 state: 0-
Input #12 state: 0-
Input #13 state: 0-
Input #14 state: 0-
Input #15 state: 0-
Input #16 state: 0-

[ ] Refresh
[9] Enter USB protocol simulator mode
[0] Back █
```

## Main Menu

	Menu Name	Function	Values	Default Values
--	-----------	----------	--------	----------------

	Menu Name	Function	Values	Default Values
1.	Link Address	Setts Link address	1-255	1
2.	Baudrate, Parity and stop bits	Enters configuring screen for communication settings	8+1 or 8+2 (Data+Stop), None, Odd, Even, Mark, Space (Parity)	9600, 8+1, Parity -None
3.	Data addressing config	Enters configuring screen for Input address (function type)	1 - 255	160
4.	RS485 Terminating Resistor	RS485 120 Ohms Terminating Resistor	0 - 1 (off/on)	1
5.	Input state inversion	Input inversion (Inverts input states in protocol logic)	0 - 1 (off/on)	0 (not inverted)
6.	Input configure	Enters screen for configuring (see 6.1 - 6.5 rows below)	-	-
6.1	Input grouping;	Groups or ungroups inputs	16 inputs ungrouped / 8 pairs grouped	All inputs ungrouped by default
6.2	Input filter time;	Input glitch filter - minimum stable time to detect input	1 - 60000 milliseconds	100

	Menu Name	Function	Values	Default Values
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	-	-

## Protocol simulator

When entered diagnostics screen, user can turn on protocol simulator by pressing [9]. When protocol simulator is turned on, device will communicate through USB port rather than RS-485 line. Communication on RS-485 line is closed and all IEC-103 commands will be accepted only from USB. To exit this mode user must restart device.

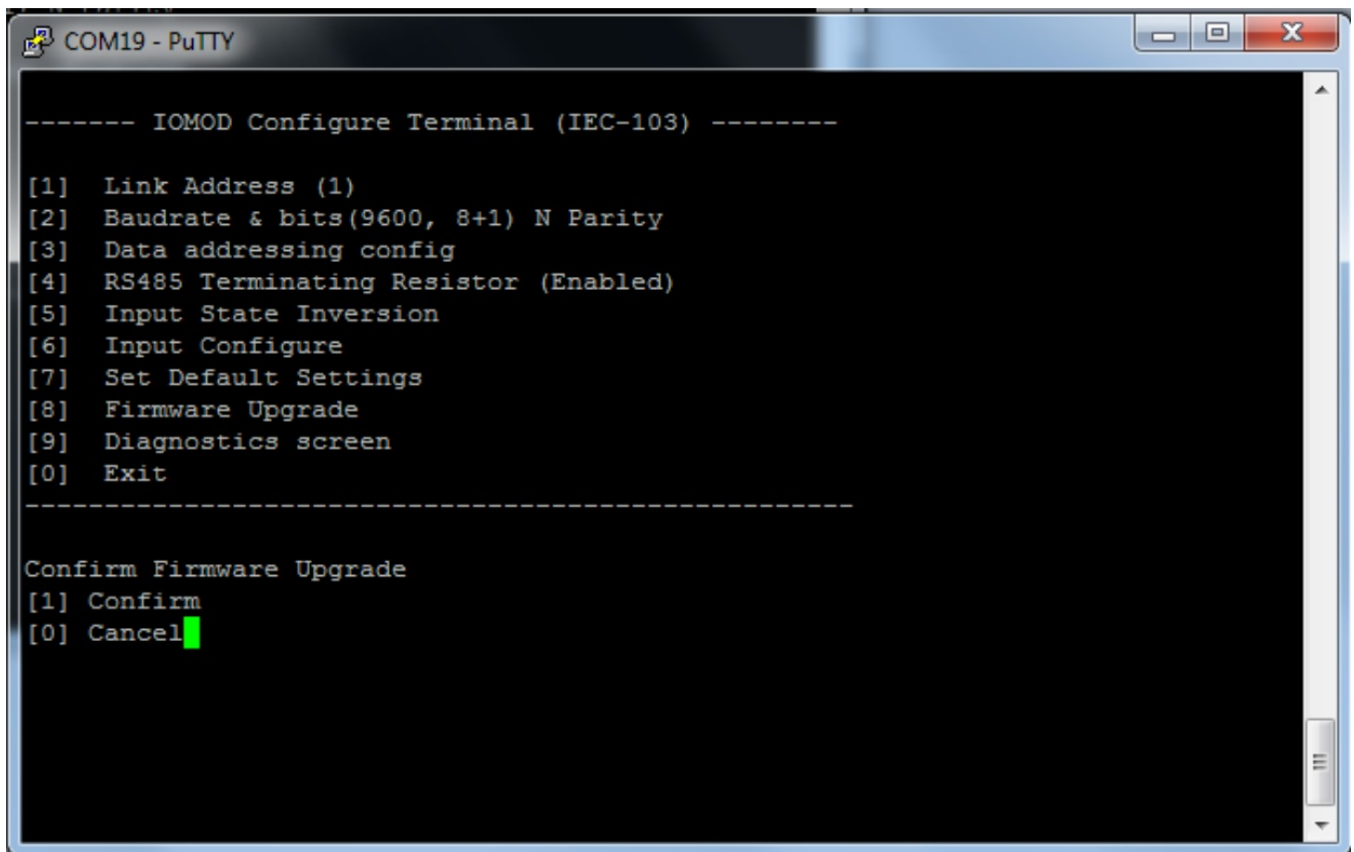
## Firmware upgrade over USB

To update device firmware user must enter main configuration menu.

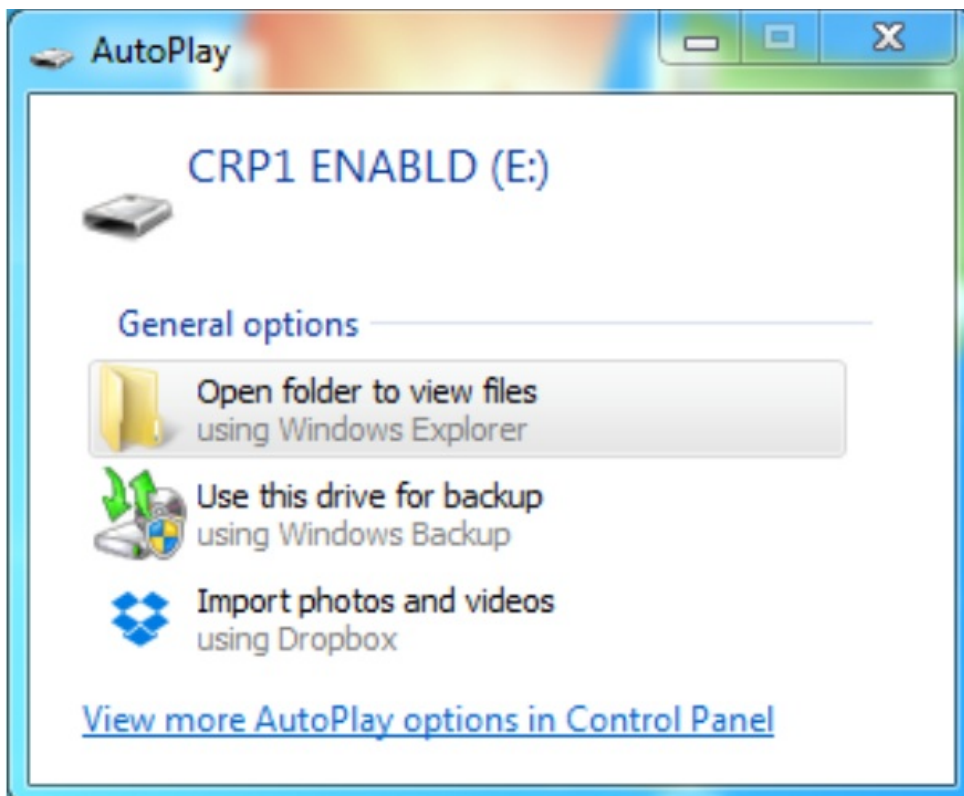
Enter Firmware update screen by pressing [4];

Confirm update by pressing [1];

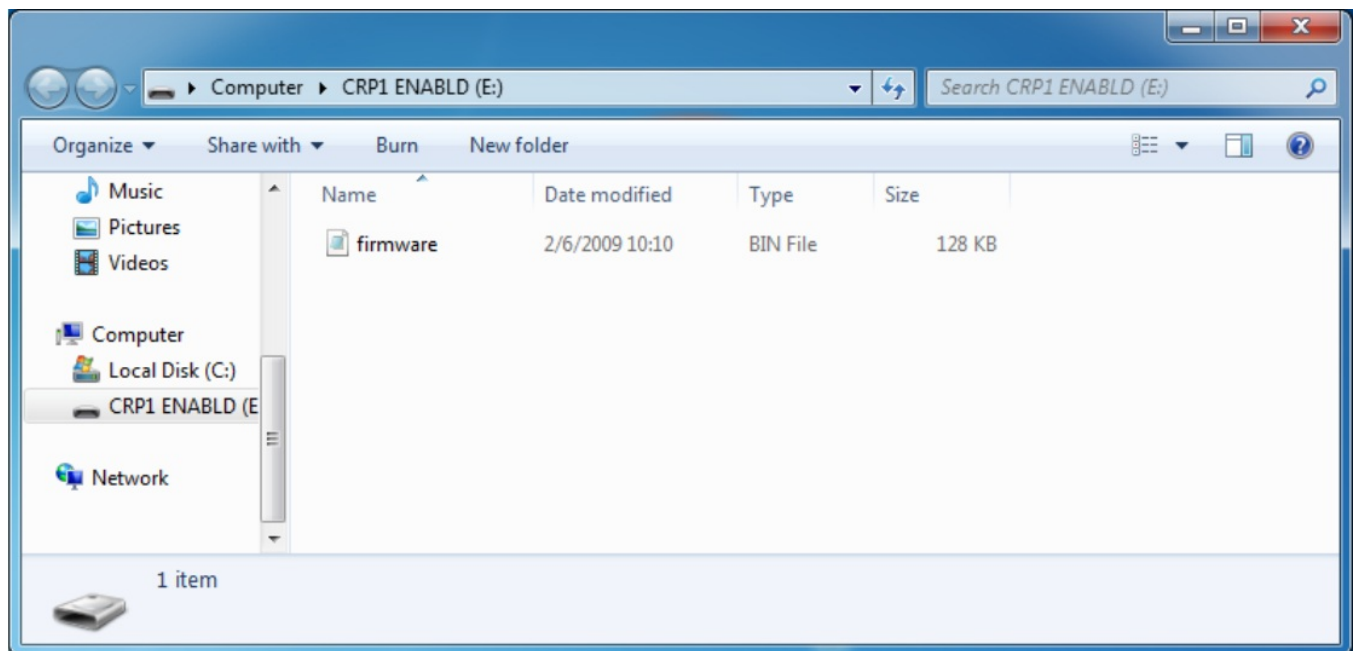
Device now enters Firmware Upgrade mode.



Device reconnects as mass storage device:



User then must delete existing file "firmware.bin", and simply drag and drop new firmware file.



Reconnect device, set default settings and check firmware version in Diagnostics screen.



# IOMOD 16DI User Manual IEC 60870-5-101

## Introduction

IOMOD 16DI is small sized stand-alone Modbus (RTU) or IEC 60870-5-101 digital input controller. IOMOD is 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, control, 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

- 16 digital inputs;
- Configurable active input signal polarity or input inversion;
- Galvanically isolated inputs;
- Configuration over USB console;
- Drag and Drop firmware upgrade over USB mass storage;
- Modbus, IEC-60870-5-101 communication over RS485;
- Values with data and time information;
- Time synchronization over IEC-60870-5-101;
- Software selectable termination resistor on RS485;
- LED indication for input and data transmission;
- Easy integration with WCC Lite gateway and CloudIndustries.eu platform

## Operational information

IOMOD 16DI uses Modbus (RTU) or IEC 60870-5-101 protocol over RS485 interface. Protocol used by device can be changed by uploading a corresponding firmware. Default communication settings are: 9600 baud rate, 8E1, Link address - 1.

### 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.

## IEC 60870-5-101 description

### 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 request status of link (function code = 9). This message is answered by IOMod with the status of link (function code = 11) if link is available. Otherwise there is going to be no response. After receiving the status of link the master will send Reset of remote link command (function code = 0) to restart the communication. The IOMod can respond with either acknowledgment (function code = 0, ACK) or Negative Acknowledgment (function code = 1, NACK). If IOMod respond is ACK then the initialization procedure is finished. The described procedure enables 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 16DI 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 16.

## 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 [1,16] - inputs

# Device configuration

### Input inversion and polarity selection:

Input polarity selection (active signal selection) is done by connecting appropriate supply to COM pin. Further explained in section 5: Mounting and installation guide.

Input inversion does logical inversion of signals.

### Input grouping:

Sometimes two inputs must be captured as one DPI input. Inputs can be grouped into pairs of two. Only two neighbor pins can be grouped into pair, while first pin in pair must be an odd number pin. When grouped, second pin in the pair is not used anymore – all request to this pin generate an error. For example – IN1 and IN2 can be grouped, after that IN2 is not used; IN2 and IN3 *cannot* be grouped; IN3 and IN4 can be grouped, but IN4 is not used, etc.

Fig. 1. shows inputs ungrouped and controlled independently. In this mode, General Interrogation will be composed of 16 input states. Notice  $+V_{IO}$  and  $-V_{IO}$  connection: when COM is connected to negative power supply voltage, inputs are controlled by positive voltage.

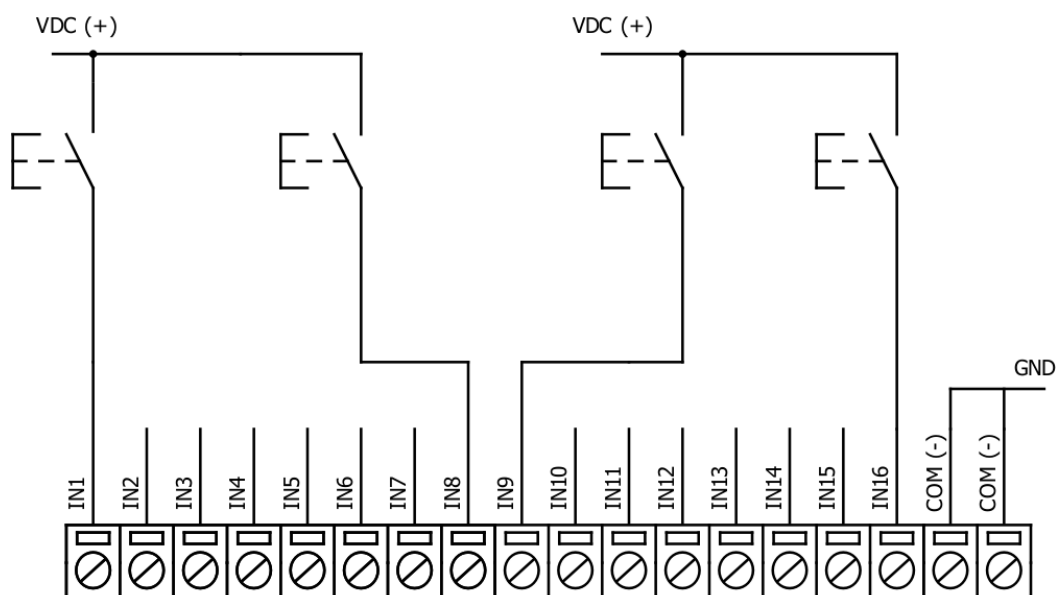


Fig. 1.

In addition to this, Fig. 2. shows  $1^{st} + 2^{nd}$  and  $11^{th} + 12^{th}$  inputs are grouped into pair. Now, General Interrogation will be composed of 14 input states (with IN2 and IN12 missing). Input numbers is represented by “Info number” in protocol. Here, COM is connected to positive voltage of power supply and inputs are controlled by negative voltage.

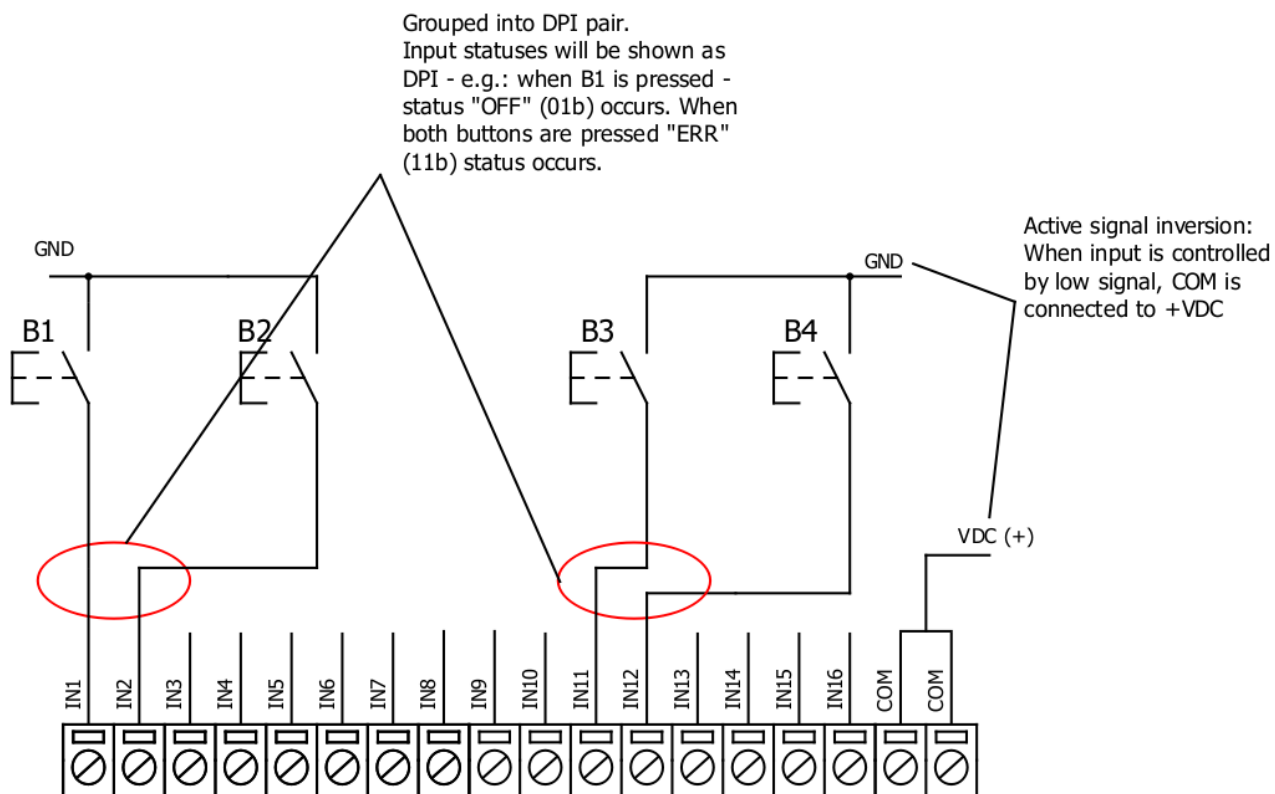


Fig. 2.

#### Input filter:

Input filter is a simple input glitch filter with a time input. This filter time corresponds to time that input must achieve without changing state before sending status change.

#### Addressing configuration:

Devices Input address is configurable. This addresses in IEC 60870-5-101 protocol is considered as "Function Type". Input address is 160 by default.

Device is addressed in the line as "Link address", which is 1 by default.

## Technical information

System	
Dimensions	101 x 119 x 17.5, mm
Case	IP20, blend PC/ABS self-extinguishing, black
Working environment	Indoors
Operating temperature	-40 , +85°C
Humidity	5-95% RH (non-condensing)
Configuration	USB – serial console
Firmware upgrade	USB – mass storage device
Electrical specifications	
Inputs	16 X 3kV isolated 12-24VDC; Selectable inversion.
Power	
Power Supply	9V to 33V
Current consumption	130 mA

## Mounting and installation guide

# IOMOD 16DI RS485 interface

IOMOD 16DI 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 typical connection diagram on Fig. 3.

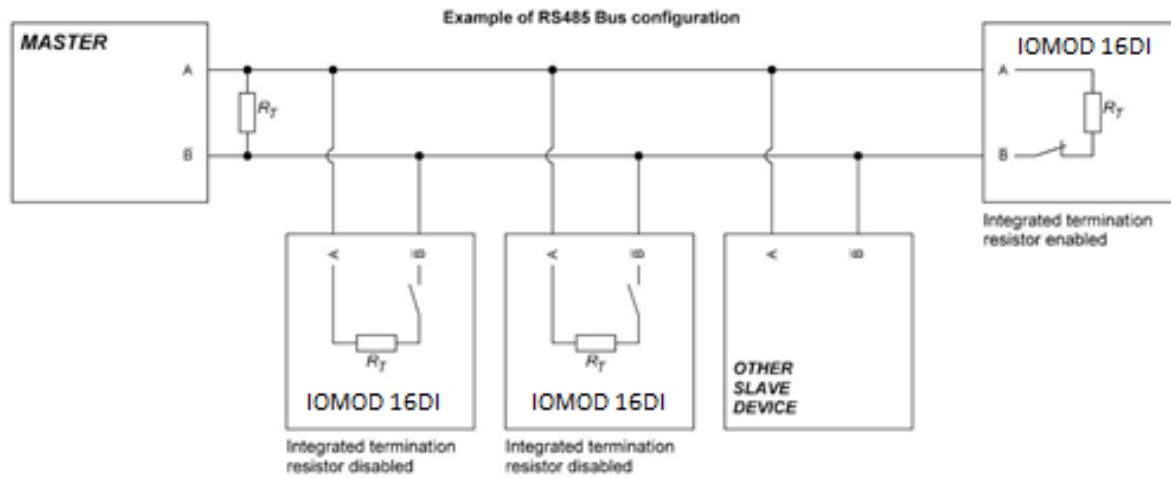


Fig. 3.

IOMOD 16DI 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.

## IOMOD 16DI inputs

Typical application of IOMOD 16DI inputs is shown on Fig. 4. When default configuration for inputs is applied, user will see inputs connected to +12-24V as "high" or state "1" and input status LED will glow.

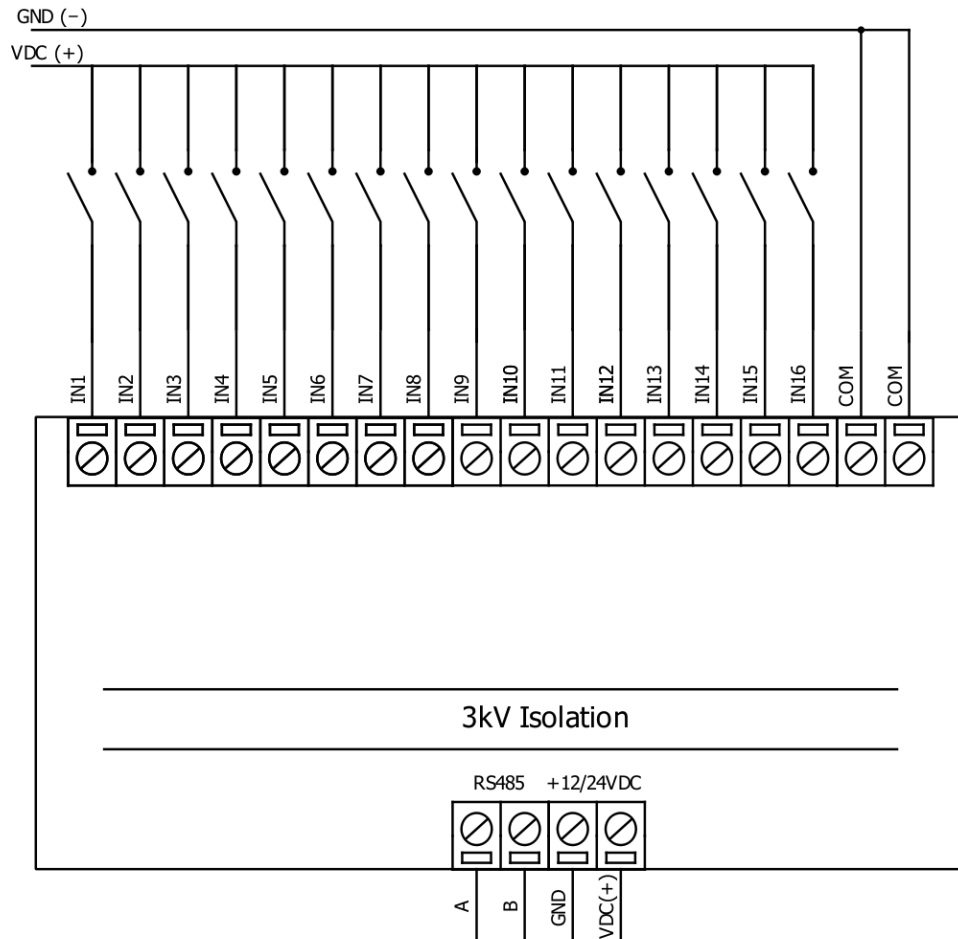


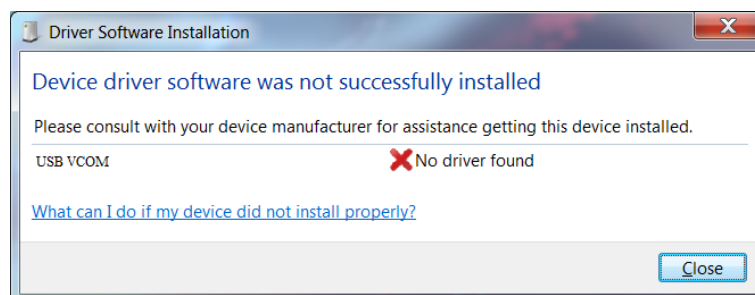
Fig. 4.

User also can configure to enable pull-up resistors (function is applied for all inputs) and software input inversion. With this configuration, user will see inputs connected to 0V as “high” or state “1”, input status LED will NOT glow

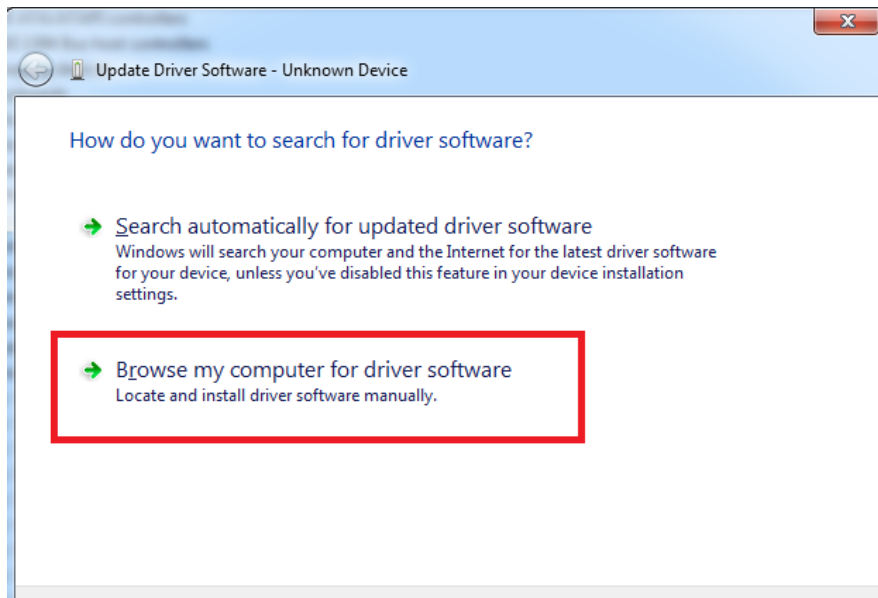
# Configuration over USB

## Driver installation

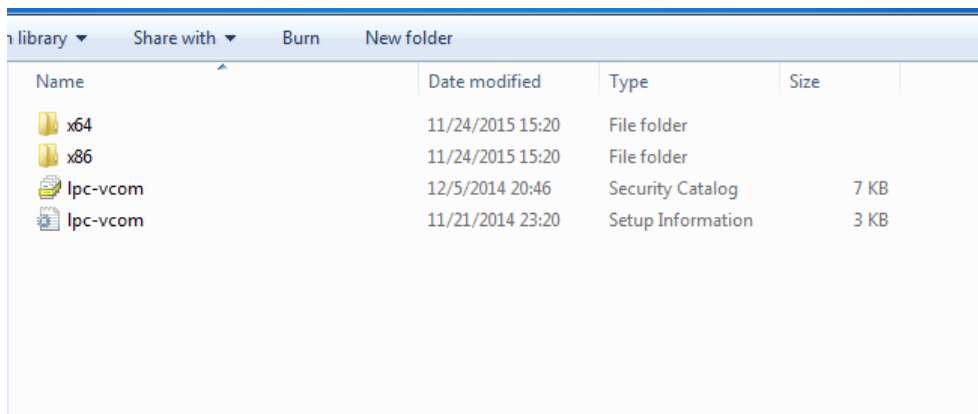
Device requires USB drivers to work as a Virtual COM port. First-time connection between device and computer could result in “Device driver was not successfully installed” error.



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



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



## IOMOD 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 V-COM port with terminal software (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 as in Fig. 5.

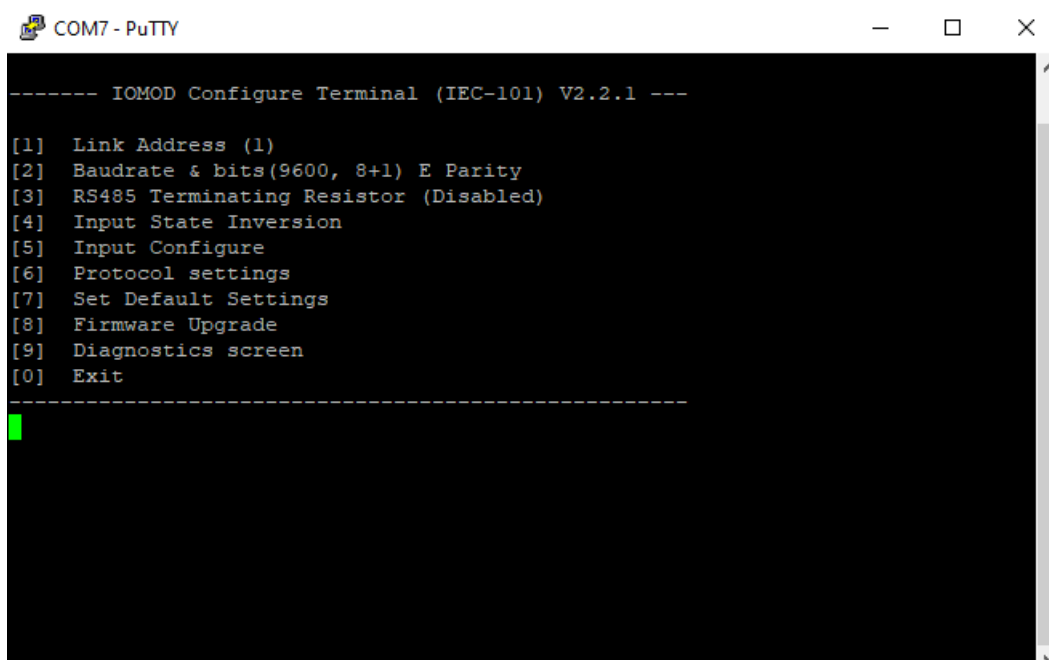
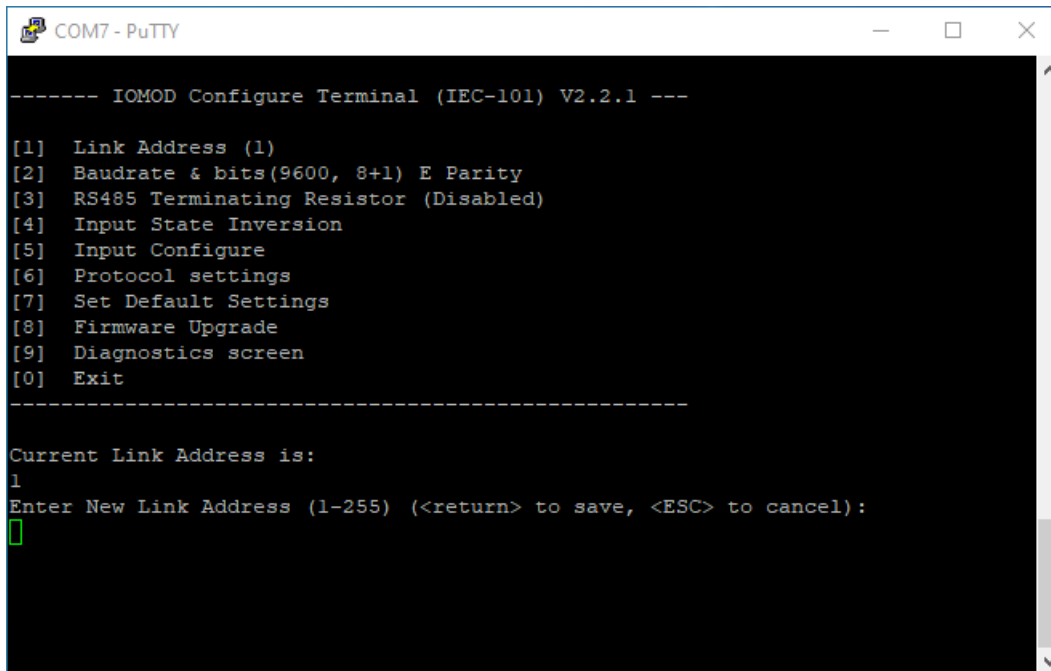


Fig.5

Navigation is performed by sending number to terminal. User then proceeds by following further on-screen instructions. For example, to set baud rate, press [3] to enter Baudrate 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 is set by pressing [7] on main screen, and confirming changes [1].

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

Main menu contains various possibilities of device configuration. A user can configure Link Address (Fig. 6.), set communication settings (Fig. 7.), change which input values are inverted (Fig. 8.). Fig. 9. shows diagnostics screen.



```
COM7 - PuTTY

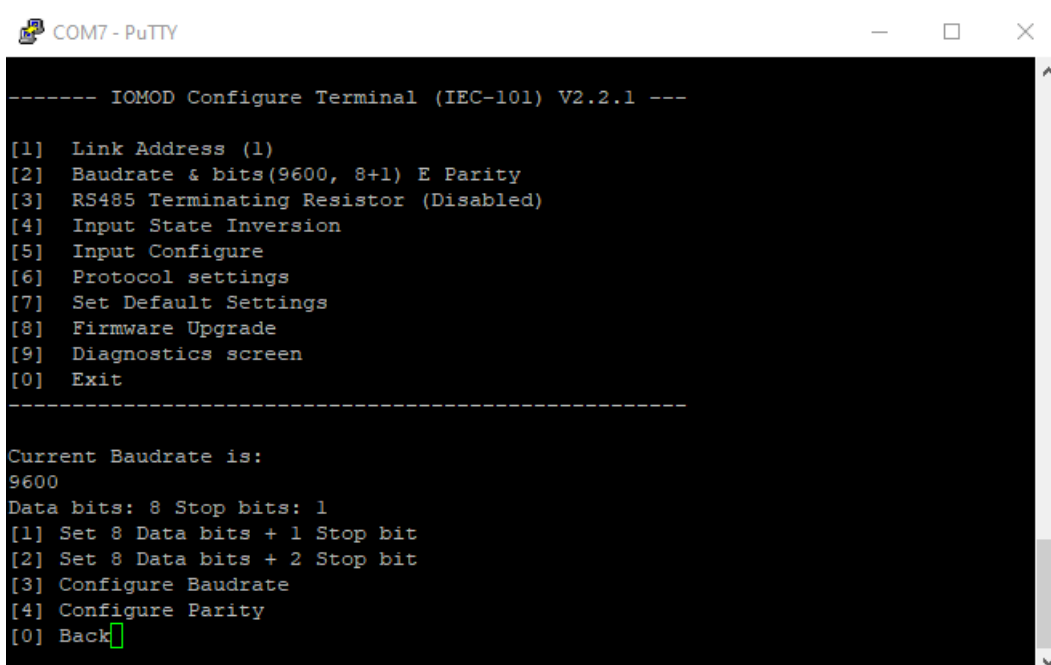
----- IOMOD Configure Terminal (IEC-101) V2.2.1 -----

[1] Link Address (1)
[2] Baudrate & bits(9600, 8+1) E Parity
[3] RS485 Terminating Resistor (Disabled)
[4] Input State Inversion
[5] Input Configure
[6] Protocol settings
[7] Set Default Settings
[8] Firmware Upgrade
[9] Diagnostics screen
[0] Exit

-----

Current Link Address is:
1
Enter New Link Address (1-255) (<return> to save, <ESC> to cancel):
█
```

Fig. 6.



```
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] Input State Inversion
[5] Input Configure
[6] Protocol settings
[7] Set Default Settings
[8] Firmware Upgrade
[9] Diagnostics screen
[0] Exit

-----

Current Baudrate is:
9600
Data bits: 8 Stop bits: 1
[1] Set 8 Data bits + 1 Stop bit
[2] Set 8 Data bits + 2 Stop bit
[3] Configure Baudrate
[4] Configure Parity
[0] Back█
```

Fig. 7.

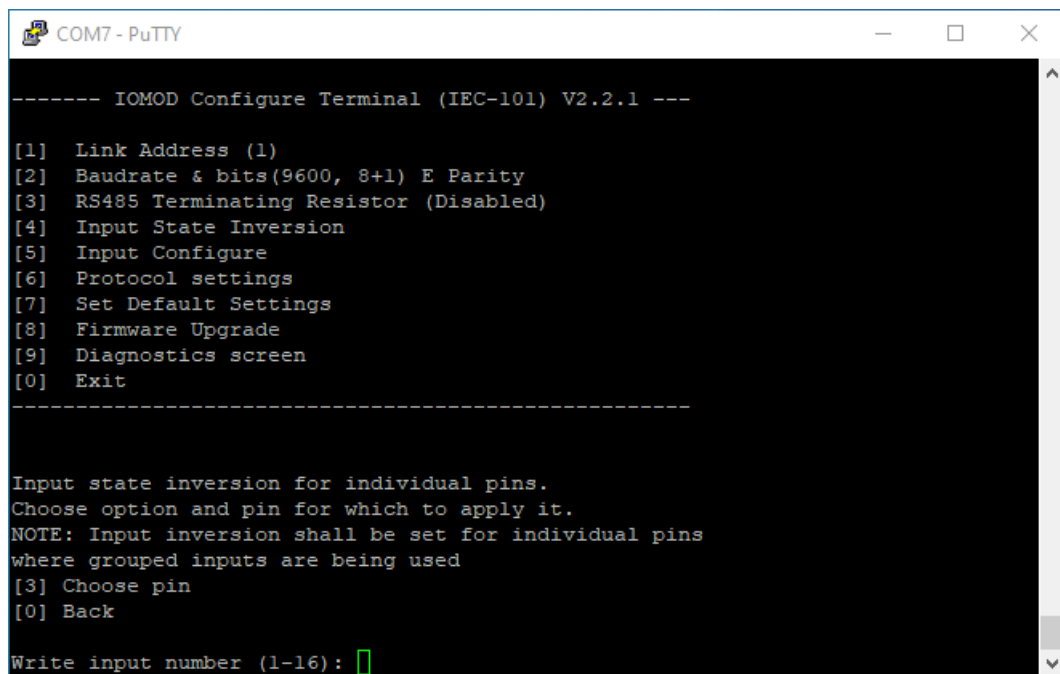


Fig. 8.

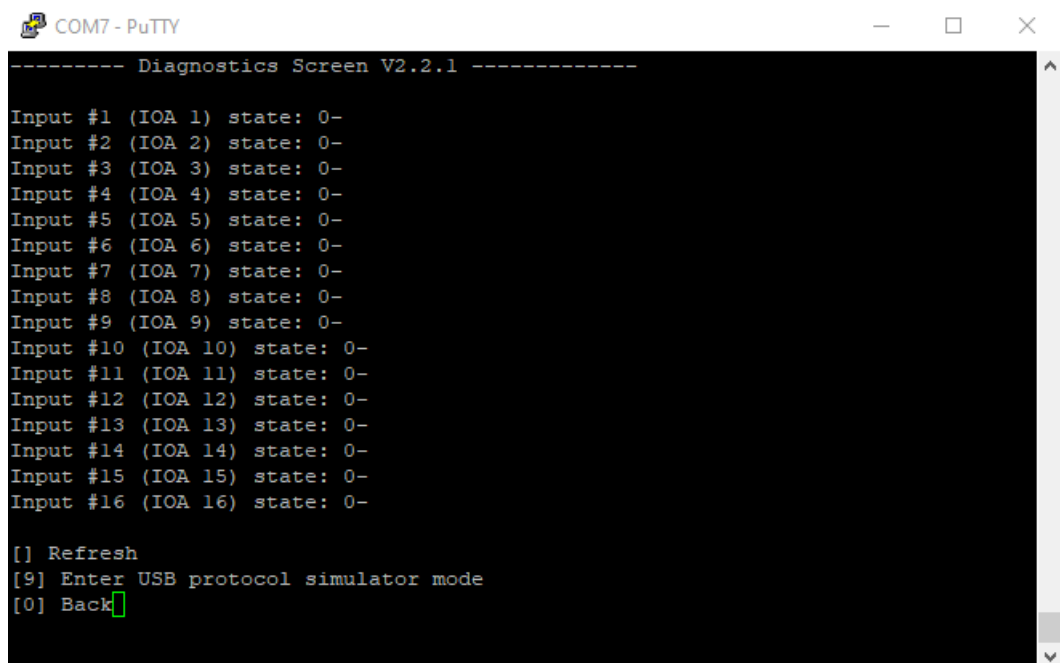


Fig. 9.

## Main Menu

	Menu name	Function	Values	Default values
1.	Link Address	Setts Link address	1-255	1
2.	Baudrate, Parity and stop bits	Enters configuring screen for communication settings	8+1 or 8+2 (Data + Stop), None, Odd, Even, Mark, Space (Parity)	9600, 8+1, Parity - Even
3.	RS485 Terminating Resistor	RS485 120 Ohms Terminating Resistor	0 - 1 (off/on)	0



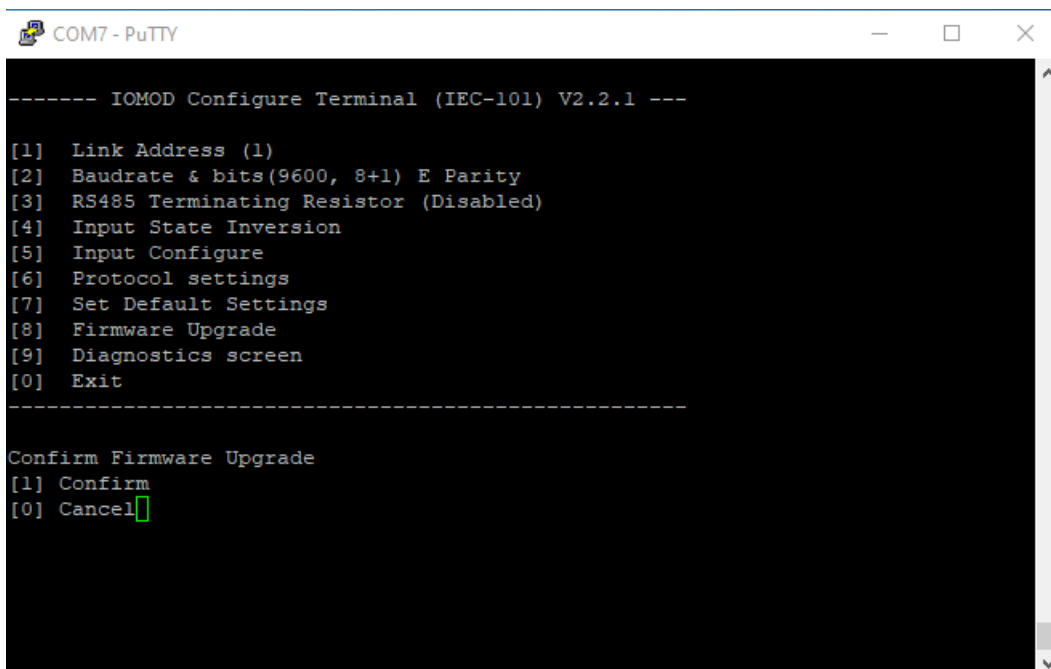
4.	Input state inversion	Input inversion (Inverts input states in protocol logic)	0 - 1 (off/on)	0 (not inverted)
5.	Input configure	Enters screen for configuring (see 5.1 - 5.2 rows below)	-	-
5.1	Input grouping;	Groups or ungroups inputs	16 inputs ungrouped / 8 pairs grouped	All inputs ungrouped by default
5.2	Input filter time;	Input glitch filter - minimum stable time to detect input	1 - 60000 milliseconds	100
6.	Protocol settings	Enters screen for protocol settings (see rows 6.1 - 6.2)	-	-
6.1	Toggle 24/56 bit time	Time mode for info objects	24/56	56
6.2	Change IOA size	IOA size	1-3	1
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	-	-

## Protocol simulator

When entered diagnostics screen, user can turn on protocol simulator by pressing [9]. When protocol simulator is turned on, device will communicate through USB port rather than RS-485 line. Communication on RS-485 line is closed and all IEC-101 commands will be accepted only from USB. To exit this mode user must restart device.

## Firmware upgrade over USB

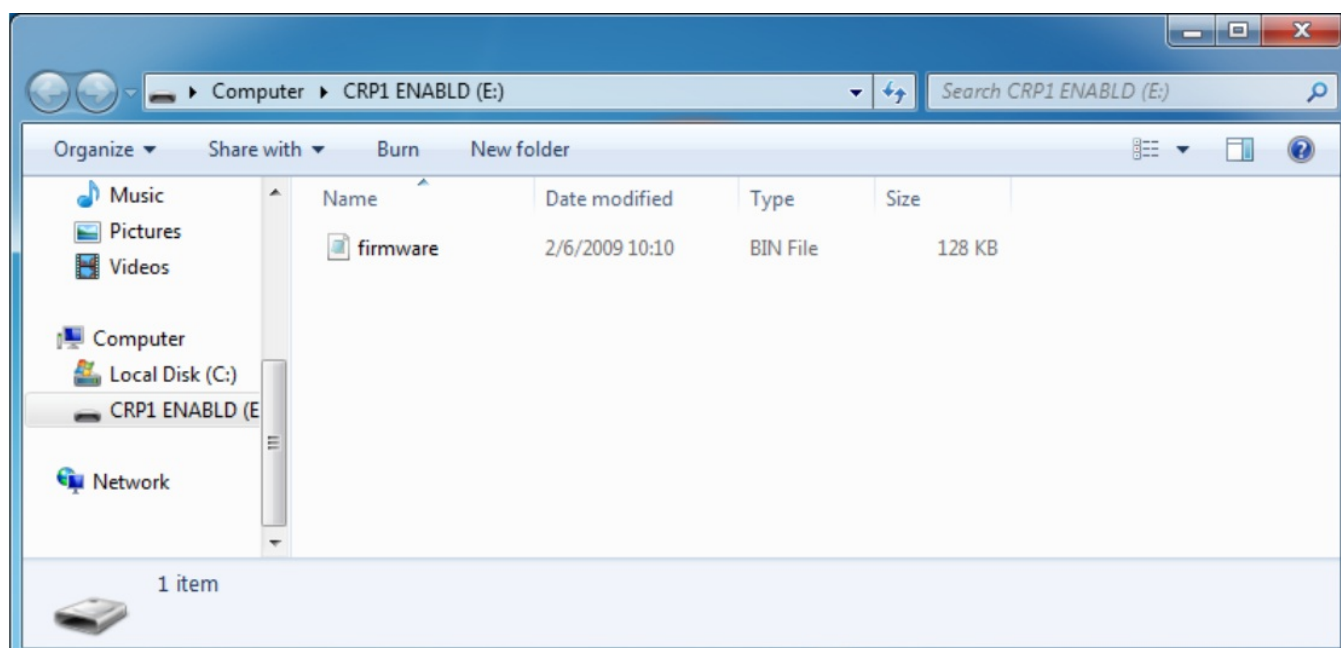
To update device firmware user must enter main configuration menu.  
Enter Firmware update screen by pressing [8];  
Confirm update by pressing [1];  
Device now enters Firmware Upgrade mode.



Device reconnects as mass storage device:



User then must delete existing file "firmware.bin", and simply drag and drop new firmware file.



Reconnect device, set default settings and check firmware version in Diagnostics screen.

Firmware version 2

# IOMod 16DI user manual

## 1. Introduction

The IOMod 16DI is a compact, standalone digital input controller compatible with **Modbus RTU**, **IEC 60870-5-101**, and **IEC 60870-5-103** protocols. It is designed for industrial applications that require digital signaling and robust communication. The IOMod is an ideal solution for process monitoring in remote locations and integrates seamlessly with any SCADA system.

### 1.1 Features

- 16 digital inputs;
- Pulse counting and ON-time measurement functionality;
- Galvanically isolated inputs for enhanced safety and reliability;
- Configurable using the IOMod utility app for user-friendly setup;
- RS485 communication for robust data exchange;
- LED indicators for input status, data transmission (Rx), and data reception (Tx);
- Compact case with a removable transparent front panel;
- DIN rail mounting for seamless integration into industrial systems.

### 1.2 Block diagram

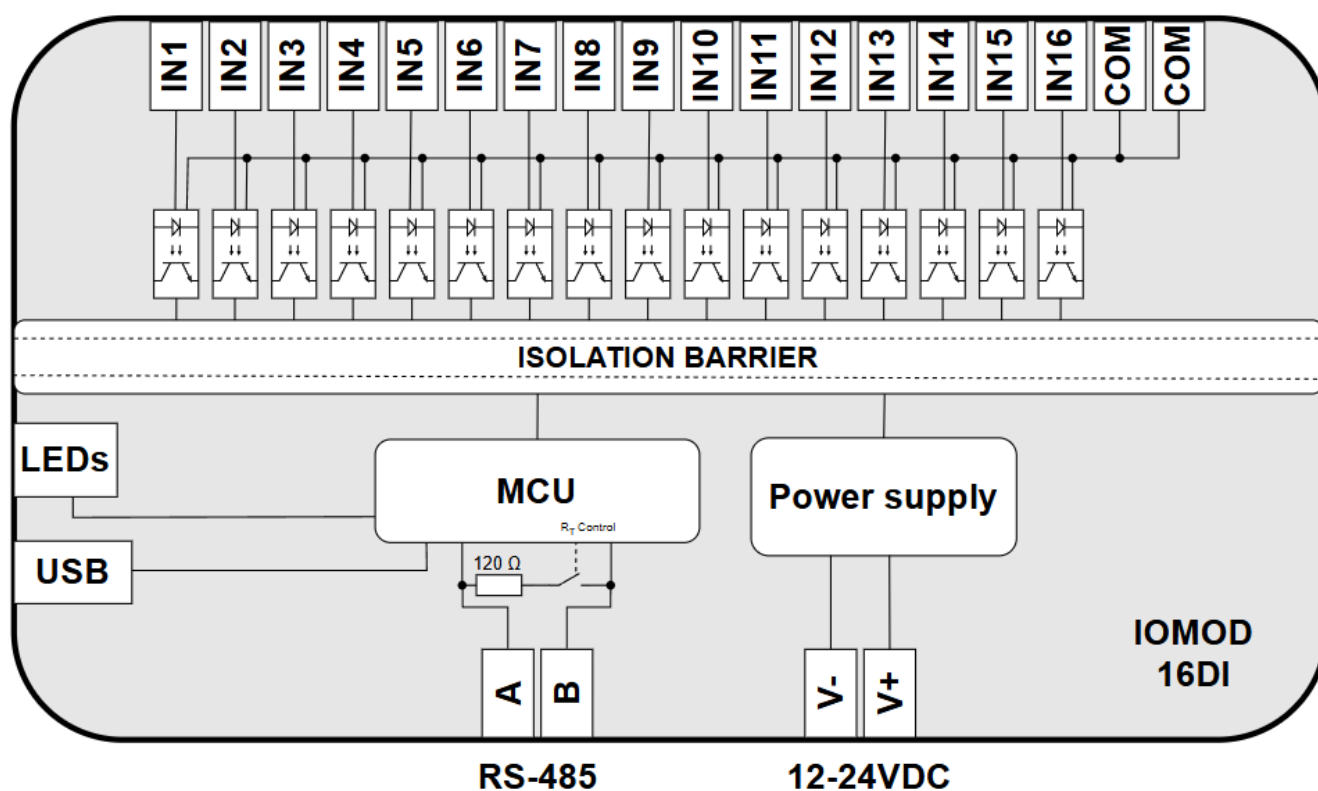


Fig. 1.2 IOMod 16DI internal structure and block diagram

## 2. Hardware data

### 2.1 Mechanical drawings

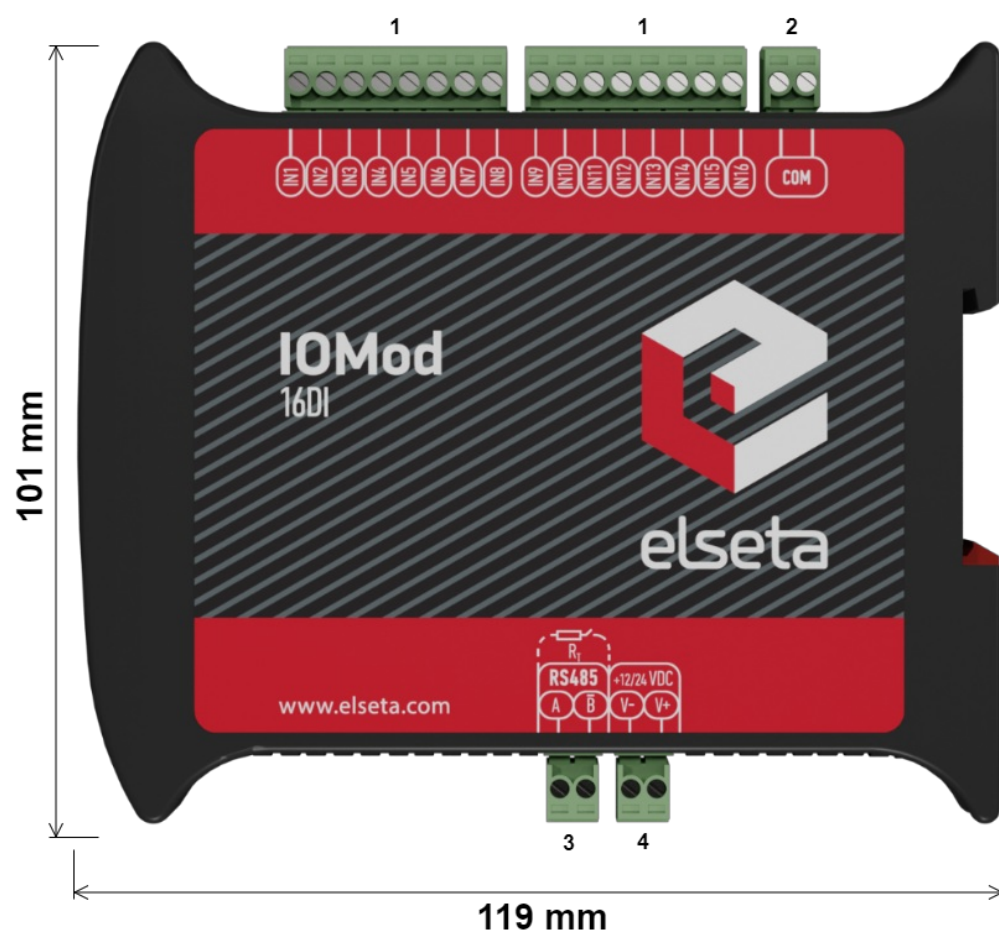


Fig. 2.1.1.1 IOMod 16DI side view with dimensions and terminals description. 1 - Digital inputs; 2 - Common inputs; 3 - RS485 interface; 4 - Power supply input

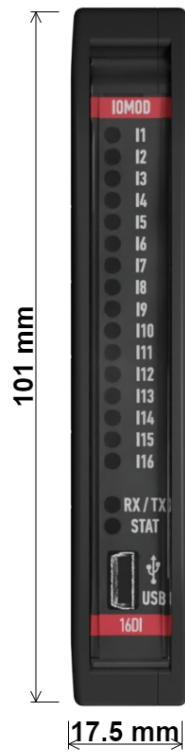


Fig. 2.1.1.2 IOMod 16DI front view with dimensions

## 2.2 Terminal connections

IOMod 16DI has 22 terminals, which are depicted below:



Fig. 2.2.1 IOMod 16DI terminals 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	DI1	Digital inputs
2	DI2	
3	DI3	
4	DI4	
5	DI5	
6	DI6	
7	DI7	
8	DI8	
9	DI9	
10	DI10	
11	DI11	

12	DI12	
13	DI13	
14	DI14	
15	DI15	
16	DI16	
17	COM	Common
18	COM	Common
19	A	RS485 input
20	B	RS485 input
21	V-	Power source input
22	V+	Power source input

## 2.3 Status indication

IOMod 16DI has LEDs (Fig. 2.3.1), which are used to indicate inputs, communication and power statuses.



Fig. 2.3.1 IOMod 16DI LEDs physical location

The description of each IOMod 16DI LED can be found in the table below:

Table 2.3.1 Description of LEDs

Name	LED color	Description
I1- I16	□ (orange)	Indicates input status
RX/TX	□ (green)	Flashing green light indicates active communication via RS485 interface



STAT	(green)	Power source is connected to the power supply input
	(blue)	IOMod 16DI is connected to an external device via USB mini cable

### 3. Technical information

Table 3.1 Technical specifications

System		
Dimension	101 x 119 x 17.5 mm	
Case	ABS, black	
Working environment	Indoor	
Operating temperature	-40°C ... +85°C	
Recommended operating conditions	5-60°C and 20-80%RH	
Configuration	USB, RS485	
Firmware upgrade	USB, RS485	
Electrical specifications		
Inputs	Nominal input voltage range	4-33VDC (@current 1.3mA - 16mA)
	Isolation	16 X 3kV <sub>(RMS)</sub>
Power		
Power Supply	9-33 VDC (full range)	
Current consumption	40 mA @ 12 VDC, 20 mA @ 24 VDC	

### 4. Mounting and installation

#### 4.1 Connection Diagrams

In this chapter the various options of connecting the device to systems are discussed.

##### 4.1.1 Digital inputs

The typical application of IOMod 16DI inputs is shown in Fig. 4.1.1. When the default configuration for the inputs is applied, the user will observe inputs connected to +12/24V as “high” or in state “1,” and the input status LED will illuminate.

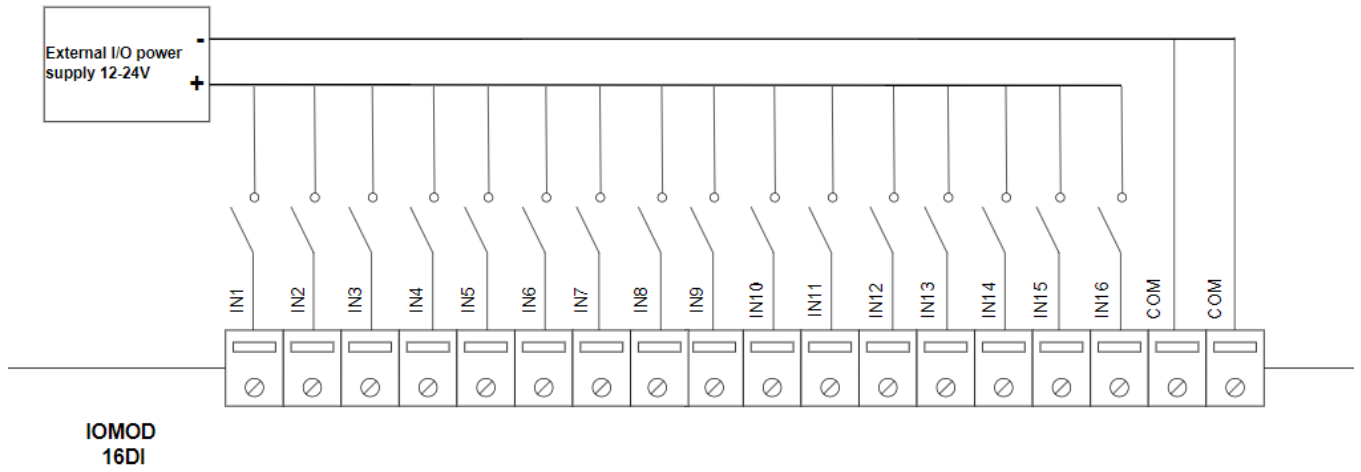


Fig. 4.1.1 Input configuration example

The user can configure the inputs to be driven by a 0V (active low) signal (see Fig. 4.1.2). With this configuration, inputs connected to 0V will be displayed as “high” or in state “1,” and the input status LED will illuminate.

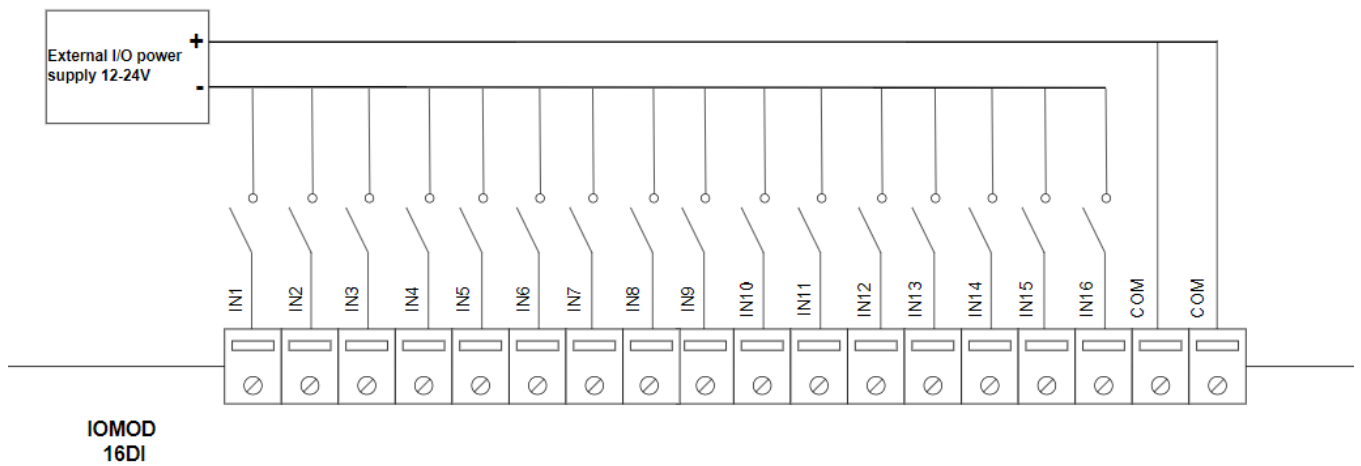


Fig. 4.1.2 Configuration of inverted polarity inputs

## 4.2 Power supply

IOMod 16DI needs to be powered by a 9-33 V power source. IOMod power supply inputs are located next to RS485 interface inputs (Fig. 4.2.1).

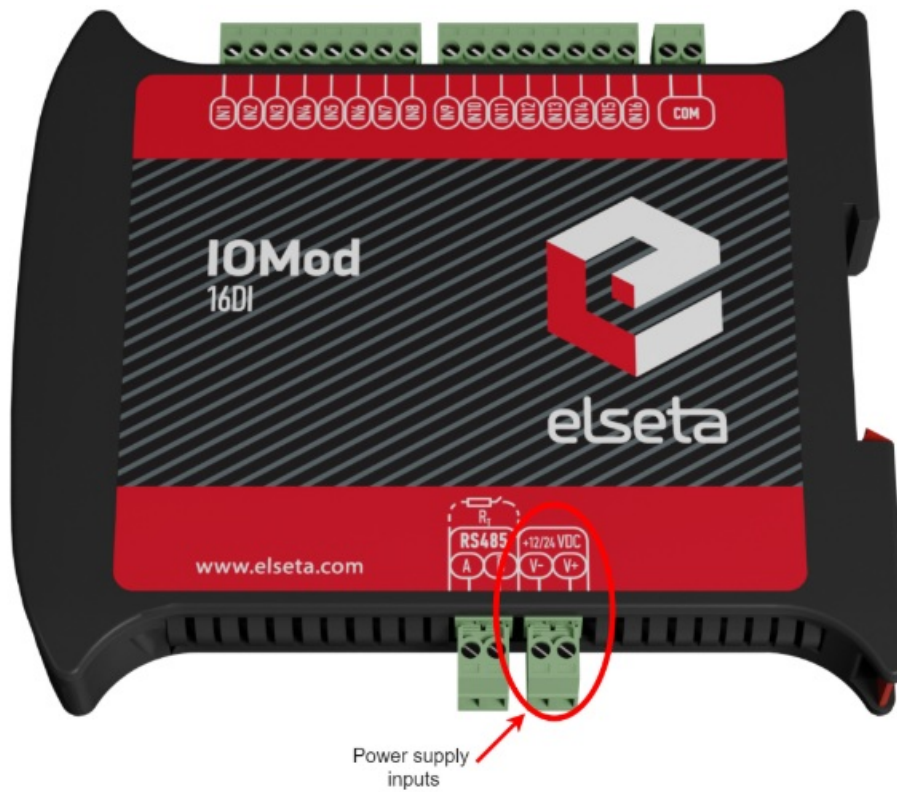


Fig. 4.2.1 Power supply inputs physical location

## 4.3 USB connection

The IOMod 16DI device features a USB-mini connection port, primarily used to establish a physical connection between the IOMod and a PC. By selecting the USB interface and the correct communication port in the IOMod Utility, the user can connect to the IOMod to control its parameters and monitor data.

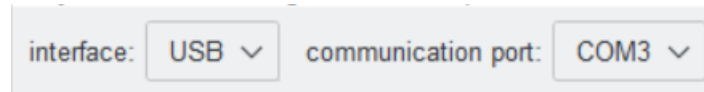


Fig. 4.3.1 IOMod Utility interface and communication port parameters

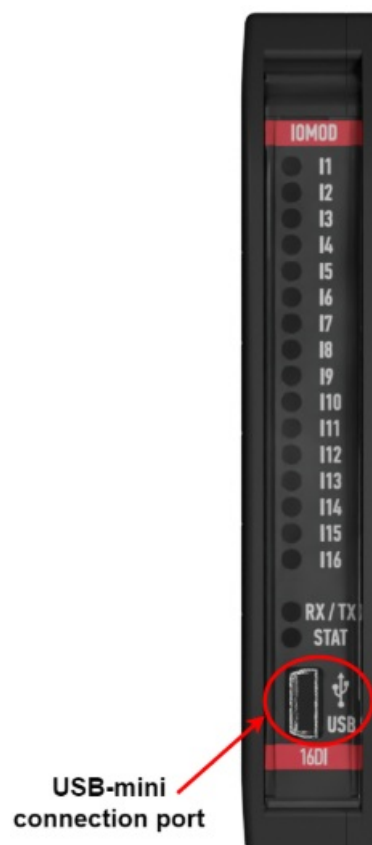



Fig. 4.3.2. IOMod 16DI USB connection port physical location

## 5. Parametrization

### IOMod 16DI default communication settings

Table 5.1 IOMod 16DI default communication protocol settings

Protocol	baudrate	parity	stop bits	wait byte count	slave address	link address size	ASDU size	COT size	IOA size	Input function
Modbus	19200	Even	1	8	1					
IEC 101	19200	Even	1	8	1	1	1	1	2	
IEC 103	19200	Even	1	8	1					253

 \*Default IOMod 16DI communication protocol is Modbus

### 5.1 Device settings for **Modbus** protocol

#### Communication settings

IOMod 16DI configuration is performed via IOMod Utility (the manual can be accessed [here](#)).



The screenshot shows the 'Communication settings' tab in the IOMod Utility application. The 'Protocol' is set to 'Modbus'. The 'Baudrate' is set to '19200'. The 'Parity' is set to 'E'. The 'Stop bits' are set to '1'. The 'Terminating resistor' is set to 'disabled'. The 'Bit wait time for packet' is set to '8'.

Fig. 5.1.1 Modbus protocol communication settings tab on IOMod utility app

For Modbus protocol users can set: Link address, baudrate, parity, stop bits, terminating resistor and bit wait time. See the table below for parameter ranges and default values (Table 5.1.1).

Table 5.1.1 Communication parameters range and default values

Parameter	Range	Default values
Link address	1-256	1
Baudrate	600, 1200, 2400, 4800, 9600, 19200, 28800, 38400, 57600, 76800, 115200	19200
Parity	None, Odd, Even, Mark, Space	Even
Stop bits	1, 2	1
Terminating resistor	Enable or disable	disabled
Bit wait time for packet	8-256	8

General IOMod settings

More device parameters can be changed with IOMod utility under IOMod settings tab. For Modbus protocol user can set input inversion and input filter.

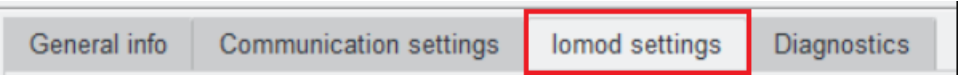


Fig. 5.1.2 IOMod settings tab on utility application

Input Inversion

If the user wants the input status to display as "ON" when the input signal is in a low state, the inputs can be logically inverted via IOMod utility application under the *IOMod settings* tab (Fig. 5.1.3)

When input inversion is enabled, the input state will show 1 (ON) when no signal is connected and will change to 0 (OFF) when the input is activated.

Note: The input indication LEDs are not affected by this inversion and will continue to reflect the actual signal state.

Example:

Input 2 has input inversion enabled in the IOMod Utility application. Both inputs, IN1 and IN2, are physically activated, and the LEDs on the IOMod are lit for both inputs. However, on the SCADA system:

- IN1 will be displayed as "1" (ON).
- IN2 will be displayed as "0" (OFF) due to the input inversion setting.

Input inversion can be enabled via IOMod utility application under the *IOMod settings* tab.

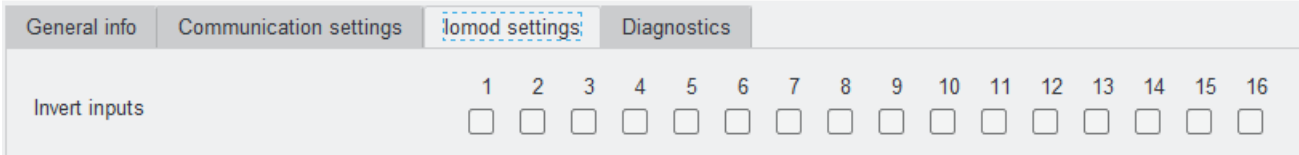


Fig. 5.1.3 Input inversion on IOMod utility app

Input filter

The filter time specifies the duration for which the input must remain stable before a status change is transmitted. The time interval is set in milliseconds. Default interval is 50 ms.

Input filter time can be set in the IOMod utility application under the *IOMod settings* tab (Fig. 5.1.4).

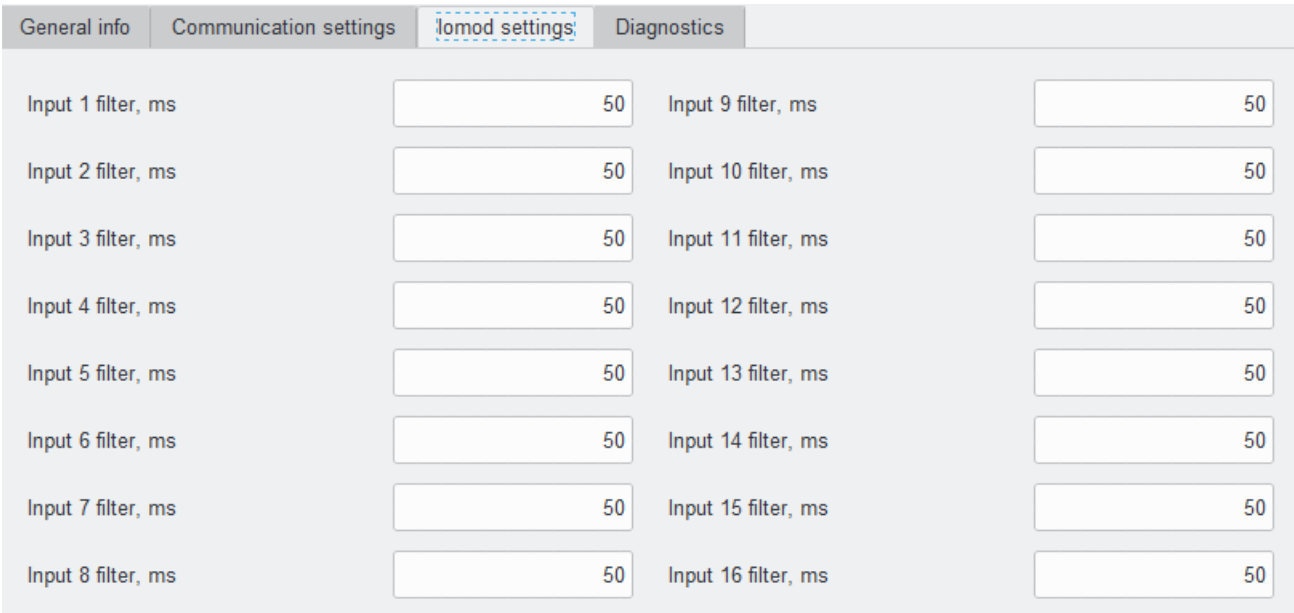


Fig. 5.1.4 Input filter on IOMod utility app

5.2 Device settings for IEC 60870-5-101 protocol

IOMod 16DI configuration is performed via IOMod Utility application (the manual can be accessed[here](#)).

General info
Communication settings
Iomod settings
Diagnostics

Protocol
IEC101

Baudrate
19200

Parity
E

Stop bits
1

Terminating resistor
☐

Bit wait time for packet
8

Time synchronization timeout
300

Link address size
1

ASDU size
1

COT size
1

IOA size
2

Fig. 5.2.1 Communication settings on the IOMod utility application

For IEC 60870-5-101 protocol users can set: Link address, baudrate, parity, stop bits, terminating resistor, bit wait time, time synchronization timeout, link address size, ASDU size, COT size, and IOA size using the IOMod utility application (Fig 5.2.1) See the table below for parameter ranges and default values for IEC 60870-5-101 protocol (Table 5.2.1).

Table 5.2.1 parameters range and default values of IOMod

Parameter	Range	Default values
Link address	1-65535*	1
Baudrate	600, 1200, 2400, 4800, 9600, 19200, 28800, 38400, 57600, 76800, 115200	19200
Parity	None, Odd, Even, Mark, Space	Even
Stop bits	1, 2	1
Terminating resistor	Enable or disable	disabled
Bit wait time for packet	8-256	8
Time synchronization timeout (s)	1-65535	300
Link address size	1, 2	1
ASDU size	1, 2	1
COT size	1, 2	1
IOA size	1, 2, 3	2

**i** \*To use Link address value greater than 256, Link address size must be set to "2".

General IOMod settings

More device parameters can be changed with IOMod utility application under IOMod settings tab. For the IEC 60870-5-101 protocol users can configure the following settings: input grouping, swap grouped inputs, invert inputs, and inputs filters.

Input Grouping

Certain applications require combining two inputs into a single DPI input. This is done by grouping two neighboring pins, where the first pin in the pair must be odd-numbered . When grouped, the second pin in the pair is not used anymore – all requests to this pin will generate an error.

Example:

- **Valid:** IN1 and IN2 (IN2 becomes unused).
- **Invalid:** IN2 and IN3.

Input grouping can be achieved via IOMod utility application under the *IOMod settings* tab (Fig. 5.2.2).

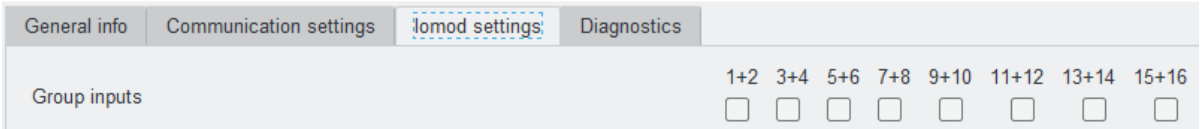


Fig. 5.2.2 Input grouping settings on IOMod utility app

Swap grouped inputs

Grouped inputs are referred to as Double Point Information (DPI) inputs. DPI signals consist of two bits of information, allowing for four possible states, thus providing more detail compared to single-point inputs. For example: The INDETERMINATE state might indicate that part of the equipment is turned off or that a mechanical component responsible for switching is stuck between states. The ERROR state could signify that both contacts are connected, possibly indicating a short circuit in the equipment.

Table 5.2.2 Double-point states

Value	State
00	indeterminate
01	off
10	on
11	error

Practical usage example of Swap Grouped Inputs setting: In a typical configuration, an active IN1 indicates the OFF position, and an active IN2 indicates the ON position. However, if a technician accidentally mismatches the cables during installation, resulting in IN1 indicating ON and IN2 indicating OFF, the Swap Grouped Inputs setting allows the positions of the inputs to be swapped without requiring any physical reconnection of the cables.

Swap grouped inputs can be enabled via IOMod utility application under the *IOMod settings* tab (Fig. 5.2.3).

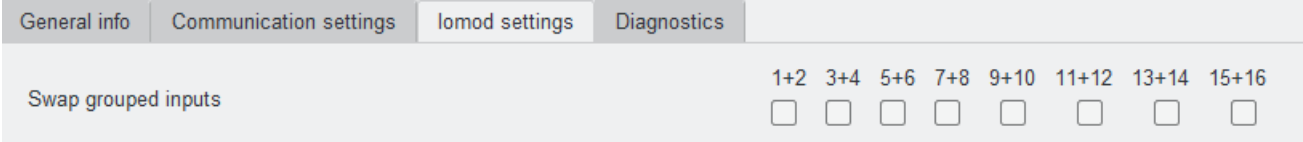


Fig. 5.2.3 Swap grouped inputs setting on IOMod utility application

Input inversion

Enables logical inversion of signal states. If the user wants the input status to display as "ON" when the input signal is in a low state, the inputs can be logically inverted

When input inversion is enabled, the input state will show 1 (ON) when input is deactivated and will change to 0 (OFF) when the input is activated.

Note: The input indication LEDs are not affected by this inversion and will continue to reflect the actual signal state.

Example:

Input 2 has input inversion enabled in the IOMod Utility application. Both inputs, IN1 and IN2, are physically activated, and the LEDs on the IOMod are lit for both inputs. However, on the SCADA system:

- IN1 will be displayed as "1" (ON).
- IN2 will be displayed as "0" (OFF) due to the input inversion setting.

Input inversion can enabled via IOMod utility application under the *IOMod settings* tab (Fig. 5.2.4)

General info	Communication settings	Iomod settings	Diagnostics
Invert inputs		1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	
		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	

Fig. 5.2.4 Input inversion setting on IOMod utility application

Input Filtering

The filter time specifies the duration for which the input must remain stable before a status change is transmitted. The time interval is set in milliseconds. The default interval is 50 ms.

Input filter time can be set in the IOMod utility application under the *IOMod settings* tab (Fig. 5.2.5).

General info	Communication settings	Iomod settings	Diagnostics
Input 1 filter, ms	<input type="text" value="50"/>	Input 9 filter, ms	<input type="text" value="50"/>
Input 2 filter, ms	<input type="text" value="50"/>	Input 10 filter, ms	<input type="text" value="50"/>
Input 3 filter, ms	<input type="text" value="50"/>	Input 11 filter, ms	<input type="text" value="50"/>
Input 4 filter, ms	<input type="text" value="50"/>	Input 12 filter, ms	<input type="text" value="50"/>
Input 5 filter, ms	<input type="text" value="50"/>	Input 13 filter, ms	<input type="text" value="50"/>
Input 6 filter, ms	<input type="text" value="50"/>	Input 14 filter, ms	<input type="text" value="50"/>
Input 7 filter, ms	<input type="text" value="50"/>	Input 15 filter, ms	<input type="text" value="50"/>
Input 8 filter, ms	<input type="text" value="50"/>	Input 16 filter, ms	<input type="text" value="50"/>

Fig. 5.2.5 Input filter time setting on IOMod utility application

5.3 Device settings for **IEC 60870-5-103** protocol

IOMod 16DI configuration is performed via IOMod Utility application (the manual can be accessed[here](#)).

General info	Communication settings	Iomod settings	Diagnostics
Protocol	IEC103		
Baudrate	19200		
Parity	E		
Stop bits	1		
Terminating resistor	<input type="checkbox"/>		
Bit wait time for packet	<input type="text" value="8"/>		
Time synchronization timeout	<input type="text" value="300"/>		
Input function	<input type="text" value="253"/>		
Output command function	<input type="text" value="254"/>		
Output status function	<input type="text" value="254"/>		

Fig. 5.3.1 Communication settings on the IOMod utility application

For IEC 60870-5-103 protocol users can set: Link address, baudrate, parity, stop bits, terminating resistor, bit wait time, time synchronization timeout, and input function using the IOMod utility application (Fig 5.3.1) See the table below for parameters range and default values for IEC 60870-5-103 protocol (Table 5.3.1).



Table 5.3.1 parameters range and default values of IOMod

Parameter	Range	Default values
Link address	1-256	1
Baudrate	600, 1200, 2400, 4800, 9600, 19200, 28800, 38400, 57600, 76800, 115200	19200
Parity	None, Odd, Even, Mark, Space	Even
Stop bits	1, 2	1
Terminating resistor	Enable or disable	disabled
Bit wait time for packet	8-256	8
Time synchronization timeout (s)	1-65535	300
Input function		253

### General IOMod settings

More device parameters can be changed with IOMod utility application under IOMod settings tab. For the IEC 60870-5-103 protocol user can set: input grouping, swap grouped inputs, invert inputs and filter inputs.

### Input Grouping

Certain applications require combining two inputs into a single DPI input. This is done by grouping two neighboring pins, where the first pin in the pair must be odd-numbered. When grouped, the second pin in the pair is not used anymore – all requests to this pin will generate an error.

Example:

- **Valid:** IN1 and IN2 (IN2 becomes unused).
- **Invalid:** IN2 and IN3.

Input grouping can be achieved via IOMod utility application under the *IOMod settings* tab (Fig. 5.3.2).

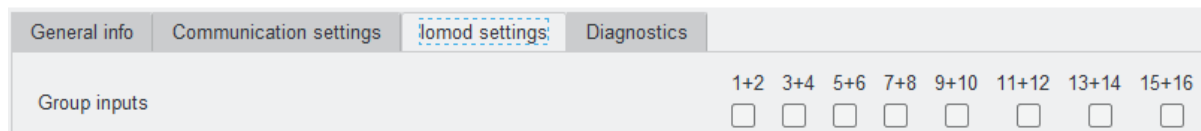


Fig. 5.3.2 Input grouping settings on IOMod utility app

### Swap grouped inputs

Grouped inputs are referred to as Double Point Information (DPI). DPI signals consist of two bits of information, allowing for four possible states, thus providing more detail compared to single-point inputs. For example: The INDETERMINATE state might indicate that part of the equipment is turned off or that a mechanical component responsible for switching is stuck between states. The ERROR state could signify that both contacts are connected, possibly indicating a short circuit in the equipment.

Table 5.3.2 Double-point states

Value	State
00	indeterminate
01	off

10	on
11	error

Practical usage example of Swap Grouped Inputs setting: In a typical configuration, an active IN1 indicates the OFF position, and an active IN2 indicates the ON position. However, if a technician accidentally mismatches the cables during installation, resulting in IN1 indicating ON and IN2 indicating OFF, the Swap Grouped Inputs setting allows the positions of the inputs to be swapped without requiring any physical reconnection of the cables.

Swap grouped inputs can be enabled via IOMod utility application under the *IOMod settings* tab (Fig. 5.3.3).

General info

Communication settings

Iomod settings

Diagnostics

Swap grouped inputs

1+2

☐

3+4

☐

5+6

☐

7+8

☐

9+10

☐

11+12

☐

13+14

☐

15+16

☐

Fig. 5.3.3 Swap grouped inputs setting on IOMod utility application

### Input inversion

Enables logical inversion of signal states. If the user wants the input status to display as "ON" when the input signal is in a low state, the inputs can be logically inverted

When input inversion is enabled, the input state will show 1 (ON) when no signal is connected and will change to 0 (OFF) when the input is activated.

Note: The input indication LEDs are not affected by this inversion and will continue to reflect the actual signal state.

Example:

Input 2 has input inversion enabled in the IOMod Utility application. Both inputs, IN1 and IN2, are physically activated, and the LEDs on the IOMod are lit for both inputs. However, on the SCADA system:

- IN1 will be displayed as "1" (ON).
- IN2 will be displayed as "0" (OFF) due to the input inversion setting.

Input inversion can be enabled via IOMod utility application under the *IOMod settings* tab (Fig. 5.3.4).

General info

Communication settings

Iomod settings

Diagnostics

Invert inputs

1

☐

2

☐

3

☐

4

☐

5

☐

6

☐

7

☐

8

☐

9

☐

10

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11

☐

12

☐

13

☐

14

☐

15

☐

16

☐

Fig. 5.3.4 Input inversion setting on IOMod utility application

### Input Filtering

The filter time specifies the duration for which the input must remain stable before a status change is transmitted. The time interval is set in milliseconds. The default interval is 50ms.

Input filter time can be set in the IOMod utility application under the *IOMod settings* tab (Fig. 5.3.5).

General info	Communication settings	Iomod settings	Diagnostics
Input 1 filter, ms	<input type="text" value="50"/>	Input 9 filter, ms	<input type="text" value="50"/>
Input 2 filter, ms	<input type="text" value="50"/>	Input 10 filter, ms	<input type="text" value="50"/>
Input 3 filter, ms	<input type="text" value="50"/>	Input 11 filter, ms	<input type="text" value="50"/>
Input 4 filter, ms	<input type="text" value="50"/>	Input 12 filter, ms	<input type="text" value="50"/>
Input 5 filter, ms	<input type="text" value="50"/>	Input 13 filter, ms	<input type="text" value="50"/>
Input 6 filter, ms	<input type="text" value="50"/>	Input 14 filter, ms	<input type="text" value="50"/>
Input 7 filter, ms	<input type="text" value="50"/>	Input 15 filter, ms	<input type="text" value="50"/>
Input 8 filter, ms	<input type="text" value="50"/>	Input 16 filter, ms	<input type="text" value="50"/>

Fig. 5.3.5 Input filter time setting on IOMod utility application

## 6. Communication protocols

The IOMod 16DI supports three communication protocols: **Modbus RTU**, **IEC 60870-5-101**, and **IEC 60870-5-103**. These protocols allow a user, via a master device, to read data from the IOMod. The desired communication protocol can be selected using the IOMod Utility application (Fig. 6.1) The Utility's interface allows users to connect to IOMod via USB port or RS485. More information about this tool and its installation can be found on detailed IOMod Utility manual [here](#).

General info	Communication settings	Iomod settings	Diagnostics
Protocol	<div>IEC101 ▾</div> <div> Modbus  ✓ IEC101  IEC103 </div>		
Baudrate			
Parity			

Fig. 6.1 IOMod utility app protocol selection window

### 6.1 Modbus RTU protocol operational information

Modbus RTU protocol is a simple and widely used messaging structure for serial communication. In the case of Modbus protocol IOMod 16DI will send data only after receiving correct queries from a master device. Supported Modbus function codes: FC1, FC2, FC3, FC6 and FC16.

#### 01 (0x01) Read Coil status

As the name implies, it is designed for reading digital data. In the context of IOMod 16DI FC1 requests allow to read digital input statuses. Please note that the input statuses cannot be overwritten separately but can only be read (R access).

#### 02 (0x02) Read Discrete Inputs

As the name implies, it is designed for reading digital data. In the context of IOMod 16DI FC2 requests allow to read digital input statuses. Please note that the input statuses cannot be overwritten separately but can only be read (R access).

#### 03 (0x03) Read Holding Registers

Allows the user to read counter/timer values dedicated to digital inputs. There are two types of values - Pulse Counter and On Timer. The pulse counter tracks the number of pulses for the respective input. While the On timer calculates the duration for which the respective input remained in its active state.

#### 06 (0x06) Preset Single Register

Sets single register. This command is used to change the values of Pulse counter and ON timer.

#### 16 (0x16) Preset Multiple Registers

Sets multiple registers. This command is used to change the values of Pulse counter and ON timer.

#### 6.1.1 Modbus register mapping table

Table 6.1.1 Modbus registers

Discrete Inputs FC02			
Address (Dec)	Description	Data type	Access
0	Read digital input DI1	BOOLEAN	R
1	Read digital input DI2	BOOLEAN	R
2	Read digital input DI3	BOOLEAN	R
3	Read digital input DI4	BOOLEAN	R
4	Read digital input DI5	BOOLEAN	R
5	Read digital input DI6	BOOLEAN	R
6	Read digital input DI7	BOOLEAN	R
7	Read digital input DI8	BOOLEAN	R
8	Read digital input DI9	BOOLEAN	R
9	Read digital input DI10	BOOLEAN	R
10	Read digital input DI11	BOOLEAN	R
11	Read digital input DI12	BOOLEAN	R
12	Read digital input DI13	BOOLEAN	R
13	Read digital input DI14	BOOLEAN	R
14	Read digital input DI15	BOOLEAN	R
15	Read digital input DI16	BOOLEAN	R

Holding Register FC03			
Address (Dec)	Description	Data type	Access
0	input 1 pulse count	UINT16	RW
1-2	input 1 on time	UINT32	RW
3	input 2 pulse count	UINT16	RW
4-5	input 2 on time	UINT32	RW
6	input 3 pulse count	UINT16	RW
7-8	input 3 on time	UINT32	RW
9	input 4 pulse count	UINT16	RW
10-11	input 4 on time	UINT32	RW
12	input 5 pulse count	UINT16	RW
13-14	input 5 on time	UINT32	RW

15	input 6 pulse count	UINT16	RW
16-17	input 6 on time	UINT32	RW
18	input 7 pulse count	UINT16	RW
19-20	input 7 on time	UINT32	RW
21	input 8 pulse count	UINT16	RW
22-23	input 8 on time	UINT32	RW
24	input 9 pulse count	UINT16	RW
25-26	input 9 on time	UINT32	RW
27	input 10 pulse count	UINT16	RW
28-29	input 10 on time	UINT32	RW
30	input 11 pulse count	UINT16	RW
31-32	input 11 on time	UINT32	RW
33	input 12 pulse count	UINT16	RW
34-35	input 12 on time	UINT32	RW
36	input 13 pulse count	UINT16	RW
37-38	input 13 on time	UINT32	RW
39	input 14 pulse count	UINT16	RW
40-41	input 14 on time	UINT32	RW
42	input 15pulse count	UINT16	RW
43-44	input 15 on time	UINT32	RW
45	input 16 pulse count	UINT16	RW
46-47	input 16 on time	UINT32	RW

## 6.2 IEC 60870-5-101 protocol operational information

### Introduction

IEC 60870-5-101 (IEC101) is a communication protocol designed for telecontrol applications in power systems, facilitating communication between a master station and slave devices. Unlike the Modbus protocol, IEC101 allows to transfer additional information like timestamp and quality attributes.

The IOMod 16DI uses the IEC101 protocol to transmit signals in a standardized format. Each signal is mapped to an Information Object Address (IOA) and assigned Type Identifier (TI). This format conveys binary status changes (e.g., whether a circuit breaker is open or closed) with associated timestamps.

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

Table 6.2.1 IEC 60870-5-101 protocol registers

IOA	Description	Type
1	input 1 SPI event	30 (M_SP_TB_1)
2	input 2 SPI event	30 (M_SP_TB_1)
3	input 3 SPI event	30 (M_SP_TB_1)
4	input 4 SPI event	30 (M_SP_TB_1)
5	input 5 SPI event	30 (M_SP_TB_1)

6	input 6 SPI event	30 (M_SP_TB_1)
7	input 7 SPI event	30 (M_SP_TB_1)
8	input 8 SPI event	30 (M_SP_TB_1)
9	input 9 SPI event	30 (M_SP_TB_1)
10	input 10 SPI event	30 (M_SP_TB_1)
11	input 11 SPI event	30 (M_SP_TB_1)
12	input 12 SPI event	30 (M_SP_TB_1)
13	input 13 SPI event	30 (M_SP_TB_1)
14	input 14 SPI event	30 (M_SP_TB_1)
15	input 15 SPI event	30 (M_SP_TB_1)
16	input 16 SPI event	30 (M_SP_TB_1)

Table 6.2.2 IEC 60870-5-101 protocol register table for grouped inputs

IOA	Description	Type
1	input 1-2 DPI event	31 (M_DP_TB_1)
3	input 3-4 DPI event	31 (M_DP_TB_1)
5	input 5-6 DPI event	31 (M_DP_TB_1)
7	input 7-8 DPI event	31 (M_DP_TB_1)
9	input 9-10 DPI event	31 (M_DP_TB_1)
11	input 11-12 DPI event	31 (M_DP_TB_1)
13	input 13-14 DPI event	31 (M_DP_TB_1)
15	input 15-16 DPI event	31 (M_DP_TB_1)

 \* SPI - single-point information, DPI - double-point information

Table 6.2.3 Double-point states

Value	State
00	intermediate
01	off
10	on

11	error
----	-------

### 6.3 IEC 60870-5-103 protocol operational information

**Introduction**

IEC 60870-5-103 (IEC103) is a communication protocol specifically designed for protection equipment in power systems, enabling communication between a master station and slave devices such as protection relays and Remote Terminal Units (RTUs). This protocol ensures efficient and reliable data exchange, focusing on events, fault records, and protection settings.

The IOMod 16DI utilizes the IEC103 protocol to transmit data in a standardized format. Signals are mapped to predefined Information Object Addresses (IOA) and Type Identifiers (TI). The protocol is optimized for transferring detailed information, such as event-driven data and device status updates, ensuring precise monitoring and control of power system protection devices.

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

Table 6.3.1 IEC 60870-5-103 protocol registers

Type	INF	FUN	Description
1 (M_TTM_TA_3)	1	253	input 1 event
1 (M_TTM_TA_3)	2	253	input 2 event
1 (M_TTM_TA_3)	3	253	input 3 event
1 (M_TTM_TA_3)	4	253	input 4 event
1 (M_TTM_TA_3)	5	253	input 5 event
1 (M_TTM_TA_3)	6	253	input 6 event
1 (M_TTM_TA_3)	7	253	input 7 event
1 (M_TTM_TA_3)	8	253	input 8 event
1 (M_TTM_TA_3)	9	253	input 9 event
1 (M_TTM_TA_3)	10	253	input 10 event
1 (M_TTM_TA_3)	11	253	input 11 event
1 (M_TTM_TA_3)	12	253	input 12 event
1 (M_TTM_TA_3)	13	253	input 13 event
1 (M_TTM_TA_3)	14	253	input 14 event
1 (M_TTM_TA_3)	15	253	input 15 event
1 (M_TTM_TA_3)	16	253	input 16 event

Table 6.3.2 IEC 60870-5-103 protocol register table for grouped inputs

Type	INF	FUN	Description
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1 (M_TTM_TA_3)	1	253	input 1-2 event
1 (M_TTM_TA_3)	3	253	input 3-4 event
1 (M_TTM_TA_3)	5	253	input 5-6 event
1 (M_TTM_TA_3)	7	253	input 7-8 event
1 (M_TTM_TA_3)	9	253	input 9-10 event
1 (M_TTM_TA_3)	11	253	input 11-12 event
1 (M_TTM_TA_3)	13	253	input 13-14 event
1 (M_TTM_TA_3)	15	253	input 15-16 event

Table 6.3.3 Double-point states

Value	State
00	intermediate
01	off
10	on
11	error