



**Product line of programmable controllers and extension modules**

**Unipi Neuron**



S103, S103-G,

M103, M203, M303, M523

L203, L303, L403, L523, L533

xS11, xS51

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# 1 Introduction

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## What is UniPi Neuron?

UniPi Neuron is a product line of compact freely programmable controllers for automatic regulation and monitoring in residential and commercial premises and light industry areas, except for system which are critical for security.

Whole Neuron product line consists of a variety of controllers which differ in configuration and number of inputs / outputs. It also includes Neuron extension modules for RS485 bus (Modbus).

## What can be UniPi Neuron products used for?

Products of Neuron line can be used in a variety of implementations thanks to a great variability of Input / Output configurations in controllers and in extension modules. Implementations examples are:

- Single-purpose devices (heat pumps, automatic barrier gate control)
- Monitoring and data collection systems
- Home automation / Smart Homes (light switching, automatic shutters, grass watering systems)
- Complex applications (Control of boiler rooms, cascade boiler control, air-conditioning systems)

## Available Neuron models

The following table describes input / output and communication interface configurations of each Neuron controller.

Models	DI	DO	RO	AI	AO	Ethernet	RS485	1-Wire
<b>S103</b>	<b>4</b>	<b>4</b>	<b>0</b>	<b>1</b>	<b>1</b>	1	1	1
<b>M103</b>	<b>12</b>	4	<b>8</b>	1	1	1	1	1
<b>M203</b>	<b>20</b>	4	<b>14</b>	1	1	1	1	1
<b>M303</b>	<b>34</b>	4	0	1	1	1	1	1
<b>M523</b>	8	4	5	<b>5</b>	<b>5</b>	1	<b>2</b>	1
<b>L203</b>	<b>36</b>	4	<b>28</b>	1	1	1	1	1
<b>L403</b>	4	4	<b>56</b>	1	1	1	1	1
<b>L523</b>	24	4	19	<b>5</b>	<b>5</b>	1	<b>2</b>	
<b>L533</b>	12	4	10	<b>9</b>	<b>9</b>	1	<b>3</b>	1

Each Neuron controller has these common parameters:

CPU	RAM	Others
4×1.2 GHz	<b>1 GB</b>	<b>Wifi + Bluetooth</b>

## Available Neuron Extension models

The following table describes input / output and communication interface configurations of each Neuron extension.

Models	DI	DO	RO	AI	AO
<b>xS11</b>	<b>12</b>	<b>0</b>	<b>13</b>	<b>0</b>	<b>0</b>
<b>xS51</b>	<b>4</b>	<b>0</b>	<b>5</b>	<b>4</b>	<b>4</b>

## **Certification**

Devices of Neuron product line have CE marking and ES Declaration of Conformity. They are compliant with ČSN EN 6095-1 ed. 2, ČSN EN 61000-6-3 ed. 2, ČSN EN 55014-1 ed. 3, ČSN EN 55022 ed. 3 and with EMC standards.

Products are also compliant with government orders and EU directives including all amendments:

- GD no. 17/2003 Coll. as amended, 2006/95/EC – including amendments
- GD no. 616/2006 Coll. as amended, 2004/108/ES – including amendments
- LVD - 2014/35/EU
- EMC – 2014/30/EC

## **Identification for countries outside the EU**

Device is to be distributed as a development board.

## 2 Installation and connection

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### Basic instructions

Always follow these instructions during the installation:

- Make sure you meet the actual standards and rules and all regional and state regulations.
- Always turn off the power supply before any manipulation (mounting / demounting).
- Use a wire with appropriate wire gauge.
- Do not exceed screw torque of removable screw connectors.
- Follow installation and operating conditions.
- Keep the cabling as short as possible. If longer cables are necessary, you should use shielded versions. You should always route your cables in pairs: i.e. one neutral conductor plus one phase conductor or signal line.
- Always keep separate:
  - The AC wiring
  - High-voltage DC circuits with high-frequency switching cycles
  - Low-voltage signal wiring
- Ensure that the wires are installed with appropriate strain relief.
- Installation of the device must be performed in stable and closed distribution box.

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### Note

Neuron devices may only be installed and wired by skilled personnel who are familiar with and follow relevant rules, regulations, and standards.

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### Warning

It's an open device. Death, serious bodily injury, or considerable property damage can occur. Box, Neuron device is installed in, must be accessible only with a key. Access to the must be allowed only to authorized personnel.

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### 2.1 Neuron product structure

Each Neuron product is divided into 1 to 3 groups which depends on specific type of product. Groups are numbered from right to left in the direction from the main group (1). Each group consists of inputs, outputs, or communication channels – these are numbered from left to right separately for each group.

Some advanced features are only available to specific group. Each group features its own processor, which handles events and monitors communication with the main processor. Groups does not communicate with each other. Connectors of given group are always divided according to the purpose to avoid possible mistake. The purpose of each screw connector is described atop the product case. The position of connector corresponds with the position in the description.

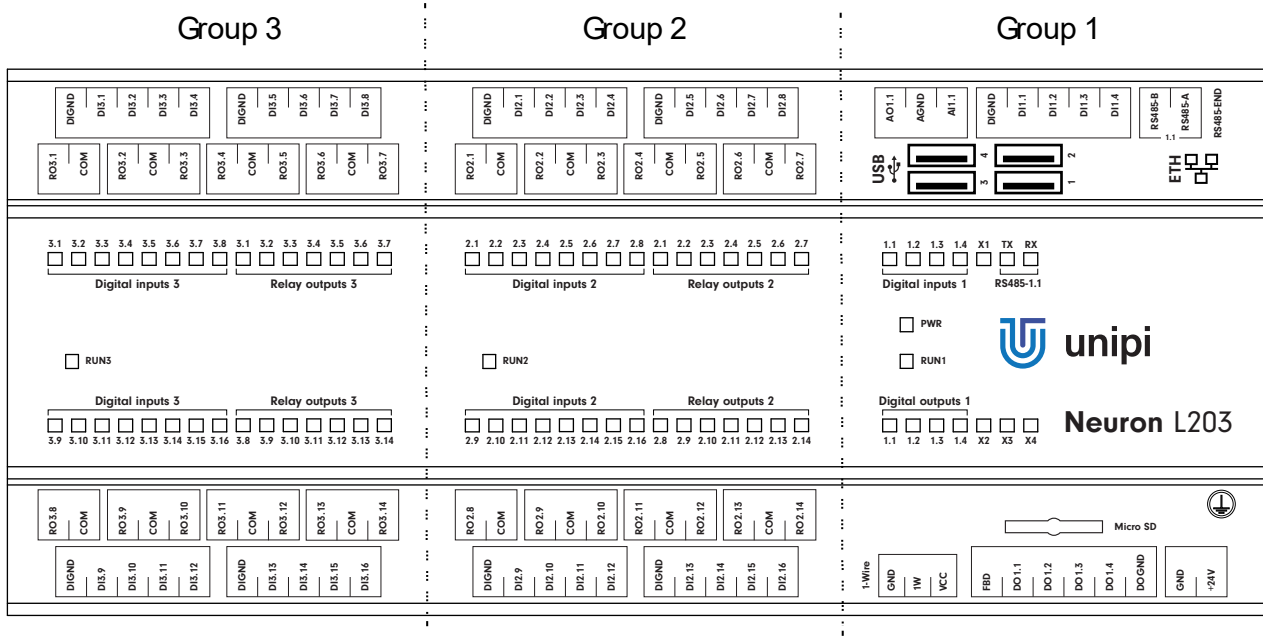
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### Note

Screw connectors are numbered like DiX or DiY.X. – the X stands for the number of input / output while the Y stands for the group number. If no group number is stated it is always the group 1.

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The following picture shows numbering of inputs, outputs, and groups of the product Neuron L40x.



## 2.2 Control units and extension modules

Control units compared to extension modules feature CPU and memory for custom program settings on OS Linux (for more see chapter 3). Extension modules are connected to control units over RS485 with Modbus communication protocol and it is not possible to store custom system within.

### 2.2.1 Neuron control units

The advantage of control units is the possibility to load custom program thanks to the open Linux platform. The other advantage is a high-speed communication within the unit resulting in minimal latency when executing commands. Control units also feature communication interfaces such as Ethernet, RS485/RS232, 1-Wire and other. It is also possible to equip them with additional module for wireless communication - GPRS, ZigBee, Lora, Sigfox, etc.

### 2.2.2 Neuron Extension modules

Extension are used to increase the number of inputs and outputs in the system even for greater distances thanks to RS485 communication line with Modbus protocol. Extension modules which have digital or relay output and also digital inputs can use Direct Switch (more on this topic in chapter 3.4.1).

### Communication parameter settings

It is possible to configure communication parameters in two ways. Either directly via integrated DIP switch (hardware settings) or through software configuration in the corresponding registers (software settings).

Hardware configuration always supersedes the software configuration. To enable software configuration the hardware configuration must be set to 0.

### Default settings

By default, all DIP switches are set to Off state which equals to address 0 and so the preconfigured software settings take place. Default software settings has the following parameters: **19 200 bps, 8 data bits, no parity, Modbus address 15.**

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**Note**

Models, where the communication speed and parity cannot be set by hardware, are preconfigured to use 19 200 bps without parity.

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### 2.2.2.1 Hardware settings

The integrated DIP switch is used to configure communication of the device. Purpose of each switch is always described atop the box above the DIP switch.

Purpose of each switch also describes the following table:

Switch	Description	Off state	On state
1	Modbus address	-	Bit weight 1
2	Modbus address	-	Bit weight 2
4	Modbus address	-	Bit weight 4
8	Modbus address	-	Bit weight 8
19,2 / 9,6	Bit rate	19 200 bps	9 600 bps
E / N	Parity	Even	None

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**Example configuration – Address 3, 9 600 bps, even parity**

Address switches 1 and 2 set to On state (lower position), switches 4 and 8 set to Off state (upper position). Switch 19,2/9,6 set to On state and switch E/N set to Off state.

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**Note**

Please note that the switch no. 2 in some models is not used. Its number is not relevant nor has a meaning. The true meaning of each DIP switch is described atop the module case.

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### 2.2.2.2 Software settings

Software settings is done via corresponding registers of the device. More specifically registers UART\_mode (for communication parameter settings) and Modbus\_Address (for device address settings).

Register UART\_mode is described in detail in Modbus register map of each extension module.

Register Modbus\_Address is supposed to store values in range from 1 – 254. If the value written to this register is not in that range, the configuration is ignored.

To apply the configuration of both registers it is necessary to save configuration (chapter 3.4.3.6) and restart the device either via software (chapter 3.4.3.5) or manually by power cycle.

After the restart the module communicates according to the newly set configuration values.

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**Note**

Saving the configuration also saves the complete current configuration as default including output settings and other parameters (more in chapter 3.4.3.6).

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## 2.3 Description of connectors and indication LED diodes

### 2.3.1 LED diode description

Name	Function	Purpose	Color
PWR	Emit light	Indication of power supply voltage	Red
RUN	Emit light/Not emit light	HW malfunction indication	Green
	Short blink after 2 sec	Communication OK	Green
	Emit light 2 sec + not emit light 2 sec	Communication timeout reached MWD	Green



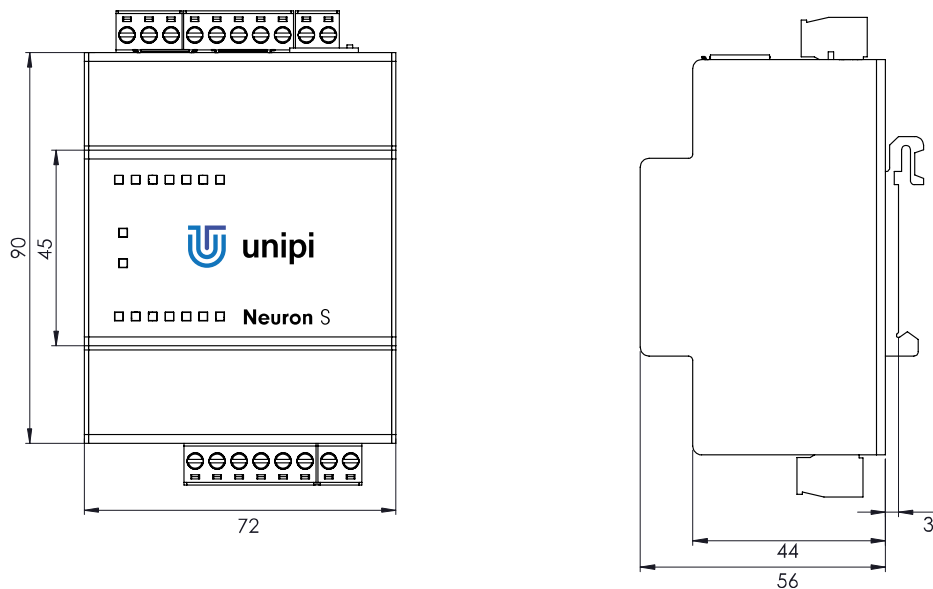
<b>Digital inputs</b>	Emit light	Indication of Log 1 on input	Green
<b>Digital outputs</b>	Emit light	Indication of switch on output	Green
<b>Relay outputs</b>	Emit light	indication of switch on output	Green
<b>TX</b>	Blink	Serial link transmission indication	Green
<b>RX</b>	Blink	Serial link reception indication	Green
<b>ULED</b>	Emit light	User programmable LED	Green

### 2.3.2 Connector description

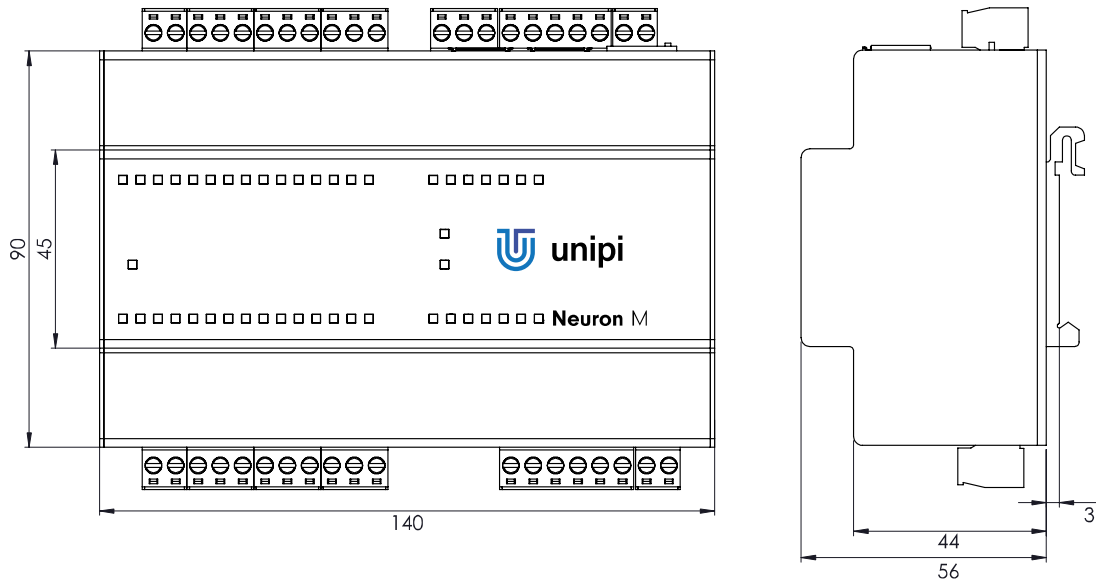
Screw connector name	Purpose
<b>+24V</b>	Positive pole of power supply
<b>GND</b>	Negative pole of power supply
<b>DI</b>	Digital input
<b>DIGND</b>	Common screw connector of digital input – negative pole
<b>DIVOUT</b>	Positive pole 24V for use with digital inputs
<b>DIVGND</b>	Negative pole 24V for use with digital inputs
<b>DO</b>	Digital output
<b>DOGND</b>	Common screw connector of digital output – negative pole
<b>RO</b>	Relay output
<b>COM</b>	Common screw connector of relay output
<b>AI</b>	Analog input
<b>AIS</b>	Current source for given AI
<b>AO</b>	Analog output – universal
<b>AOV</b>	Analog output – Voltage only
<b>AGND</b>	Common screw connector of negative pole of analog input / output
<b>RS485-A/RS485-B</b>	Screw connectors for RS485 communication interface

## 2.4 Dimensions

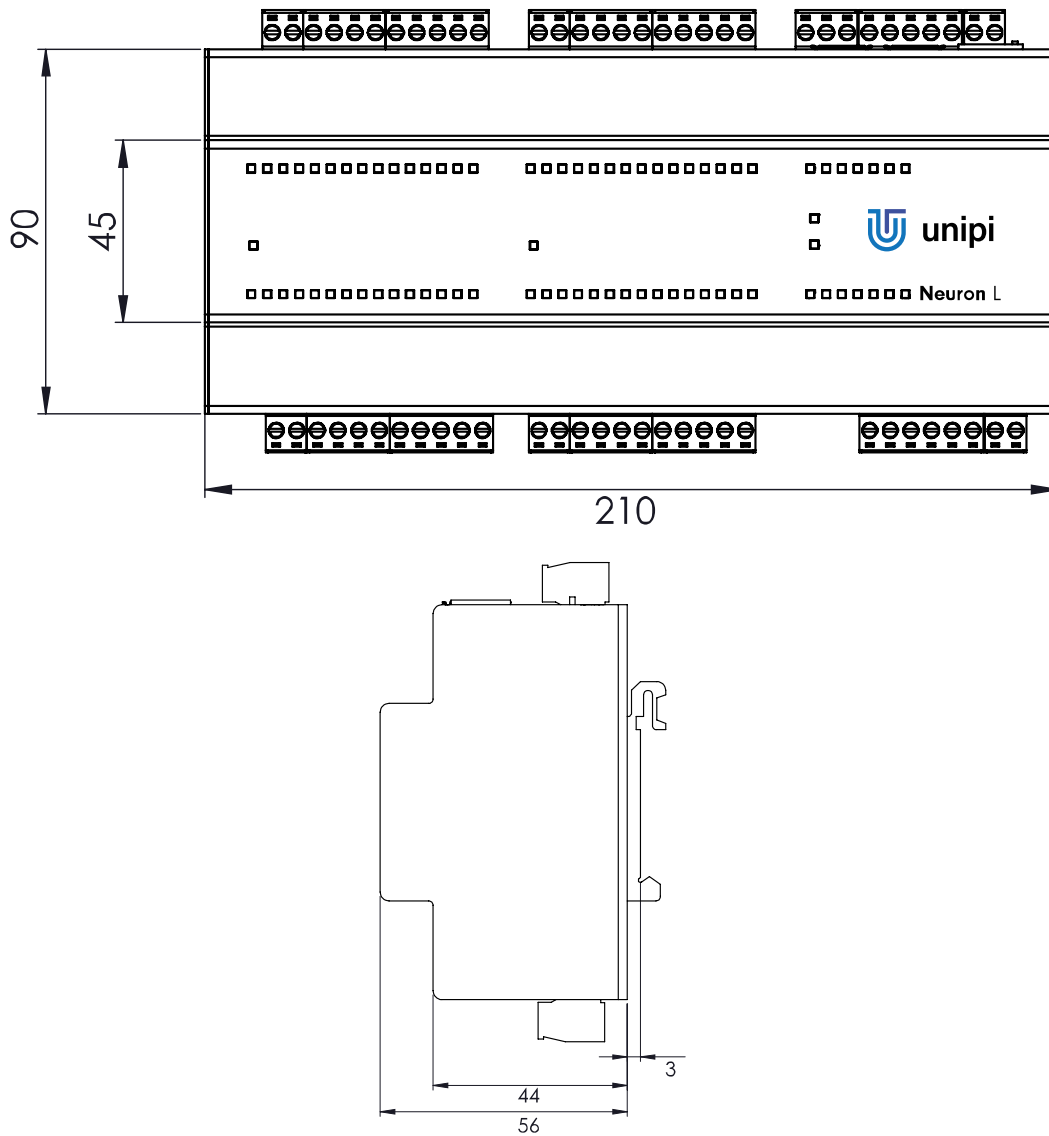
### 2.4.1 UniPi Neuron Type S



### 2.4.2 UniPi Neuron Type M



### 2.4.3 UniPi Neuron Type L



## 2.5 Device mounting

### 2.5.1 Mounting / demounting

All products of the Neuron product line are designed for mounting onto 35 mm DIN EN 50022.

#### Mounting

Mounting of product onto the rail should be done as follows – attach the product onto the rail, first by the side of DIN rail holder which has the metal spring. Then by pulling against, you squeeze the spring and pull the other side of the holder over the rail edge. If no DIN rail holder is attached to the Neuron product it is necessary to attach it first with provided screws. When attaching the DIN rail holder, the metal spring must be positioned to the upper side of the device.

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#### Attention

In case of installation of the device into the distribution box where there is no forced air circulation there must be minimum 80 mm space between the sides of the device and the walls of the distribution box. If it is not possible to provide sufficient air circulation in the distribution box it is necessary to enhance air circulation with installed ventilation fan. Maximum temperature of air entering the device must not exceed the values stated in chapter 4.6.

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#### Demounting

Demounting of the device is done with opposite procedure. Drag the device down against the metal spring, remove the spring-less side off the holder edge, then remove the part with metal spring off.

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#### Note

Make sure you disconnected the device from the power supply before demounting.

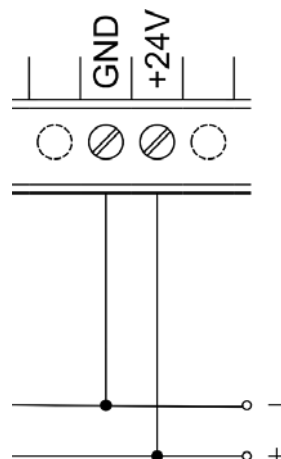
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#### Connection

For the connection of any cable there are removable screw connectors. Purpose of each screw connectors is depicted on the top side of the product case. For cable montage into screw connectors always use flat screwdriver size 3 mm or 3.5 mm. Do not exceed maximum torque which is stated in the chapter 4.6.

### 2.5.2 Power supply connection

To ensure correct operation of the device it is necessary to connect power supply 24 V DC into screw connector for +24V (positive pole) and screw connector GND (negative pole). Information about tolerance of recommended power supply voltage and consumption of electricity are described in detail in the datasheet of each device and on product label.



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**Attention**

The device has appliance class 1. That is why it is also necessary to connect protective ground conductor to ground connector of the device marked on the case with ⚡ symbol. For ground conductor connection use cable eye and provided M4 screw.

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**Note**

DIN rail with the installed device must be connected to protective ground conductor.

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### 2.5.3 Communication line connection

#### 2.5.3.1 RS-485

RS-485 connection (EIA-485) is done on screw connectors for RS-485 marked with A and B. The device features optionally connectable terminator (100 Ω) marked with END (RS-485-END, BUS-END).

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**Note**

For correct bus operation, it is necessary to connect terminator on both sides of the line.

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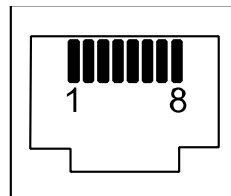
Neuron extension modules are to be connected over communication interface RS485. Parameter configuration description is in chapter 2.2.2.

#### 2.5.3.2 1-Wire

1-Wire bus purpose is a passive data collection from the connected sensors (e.g. thermometer, humidity sensor). The connection is done via RJ45 connector marked as 1-Wire. Connection of more devices on 1-Wire bus is done via a hub (1-Wire 8 port hub, SKU number: 2014021).

Description of 1-Wire bus conductors in unshielded RJ45 jack.

Conductor purpose	Conductor number
V <sub>cc</sub> (+5V)	4, 5
Data (DQ) transmission	6
Data (DQ) reception	7
GND	3, 8
Not used	1, 2



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**Note**

Incoming conductor (7) is not used in the Control unit – it is used only as a data output conductor at the connected sensor. The table and picture of RJ45 connector above serves for illustration of correct device connection to the bus to ensure correct functionality of the bus itself.

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**Note**

1-Wire bus is implemented with six conductors, where two conductors are for data transmission (DQ), two ground conductors (GND) and two powering conductors (V<sub>cc</sub>). Two data conductors are used to minimize the distance between sensor and the bus (Bus serialization). That enhances bus reliability and maximizes the number of sensors.

---

For reliable bus functioning, it is necessary to follow these instructions:

- Observe the presented connection schema of UTP cable.
- Make the distance between end device (sensor) and the input / output conductor as short as possible.
- Do not connect more than 15 sensors to a single channel.
- For multiple HUB interconnection use shielded or foiled twisted pair cable (STP or FTP) and connect the shielding to the ground conductor.
- Use 24 AWG cable with diameter 0,5 mm (e.g. Cat. 5e).

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**Note**

These instructions are recommendations only and may vary depending on the bus length and number of sensors.

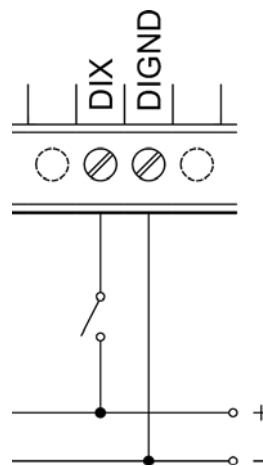
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1-Wire channel features RESET function, which serves for resetting of the whole 1-Wire bus. This may be useful when installing in unstable environment. RESET configuration depends on chosen software as further described in chapter 3.

## 2.5.4 Digital input connection

To digital inputs are usually connected devices such e.g. switches (light switches, buttons), motion sensors, door contacts, and window contacts etc. Logic state 1 (switched on) of each input is signaled via relevant indication LED diode on the top side of the product case.

For the connection of external device to digital input there are screw connectors marked with DiX (or possibly DiY.X) and DiGND. All digital input connectors share a common ground connector for connection of negative pole of DC voltage source. Voltage source positive pole is to be connected over external device to DiX connector as shows the picture below.



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**Note**

For signalization of state of external devices connected to digital inputs we recommend different voltage to provide proper galvanic isolation.

---

**Do not miss!**

Some models feature its own 24V DC power source for use with digital inputs. Its output leads to screw connectors DIVGND and DIVOUT. For correct functioning of digital inputs with this power supply it is also necessary to interconnect DIVGND and DIGND. Maximum current on each of the DIVOUT screw connectors is limited to 120 mA which is enough for 30 digital inputs.

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### Extended functionality

Each digital input features along with state indicator also pulse counter. If there are used digital (or relay) outputs in the device, it is possible to use 1 of the 3 so called Direct switch functions available for DiY.X inputs and DoY.X / RoY.X.

- Polarity – it is possible to achieve two possible behaviors with these functions
  - Identity – The input state is written to the output
  - Negation – Negated input state is written to the output.
  - More information in chapter 3.4.1.3
- Toggle – if positive edge detected on input, the output is negated

These functions are evaluated directly in the processor within the group and are not dependent on the control software. Direct switch functions are useful for example for light switching or handling similar

time-critical applications (typical output reaction time equals input reaction time as further described in chapter 4.1).

**Note**

You can configure Direct Switch functions for matching input and output only, i.e. only for input DiY.X and output DoY.X (or RoY.X), where number Y (if Y is stated) must be equal. It is not possible to configure function Direct Switch for one input and more outputs at the same time or for combination of input and output from different I/O Groups.

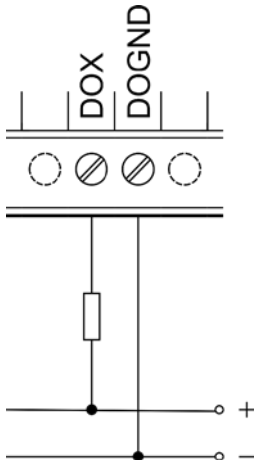
2.5.5 Digital output connection

Digital outputs (semiconductor, connected as opened collectors) are accessible through DoX (DoY.X), DoGND and possibly FBD screw connectors of Digital I/O's. All digital outputs have common screw connector DoGND for negative pole connection of DC power supply. Screw connector of DoX serves for connection of electrical load of external device, which switches against the common potential. State switch of each output is signaled via corresponding indication LED diode atop the device.

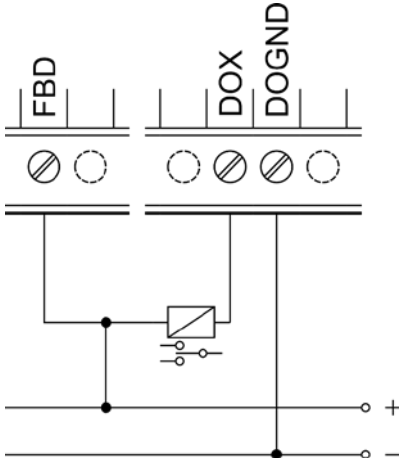
**Note**

Depending on software it is possible to configure digital outputs to PWM (Pulse wide modulation) mode.

The following illustration demonstrates basic connection of digital output.



At some electrical loads connected to Digital output (such as external relay) it is appropriate to make use of flyback diode accessible through FBD screw connector. The following illustration depicts a connection of external relay to digital output while using integrated FBD diode.



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**Attention**

Integrated flyback diode is designed for connection of devices within the group of digital outputs. Using flyback diode for different connections may cause permanent damage to Neuron device.

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### 2.5.6 Analog input connection

Analog input usually serves for reading Voltage 0-10 V, Current 0-20 mA or resistance sensors (e.g. temperature sensor Pt1000). Type of measurement is configured depending on used software.

Negative pole of measured external device is to be connected to screw connector of AGND while positive pole is to be connected to screw AIY.X connector.

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**Note**

In default Neuron is set to voltage measurement to avoid potential device / sensor damage in case of inappropriate external device.

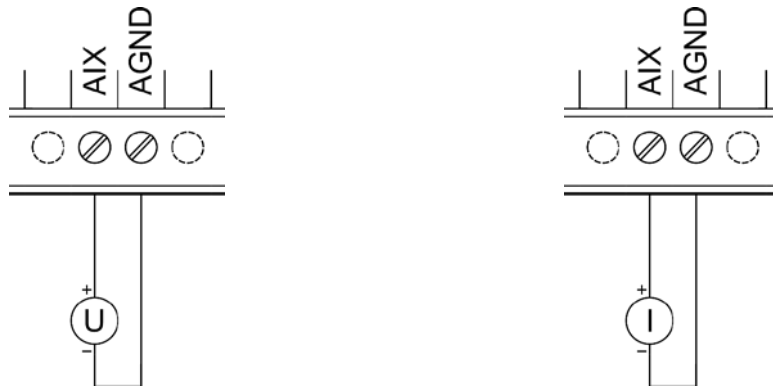
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**Attention**

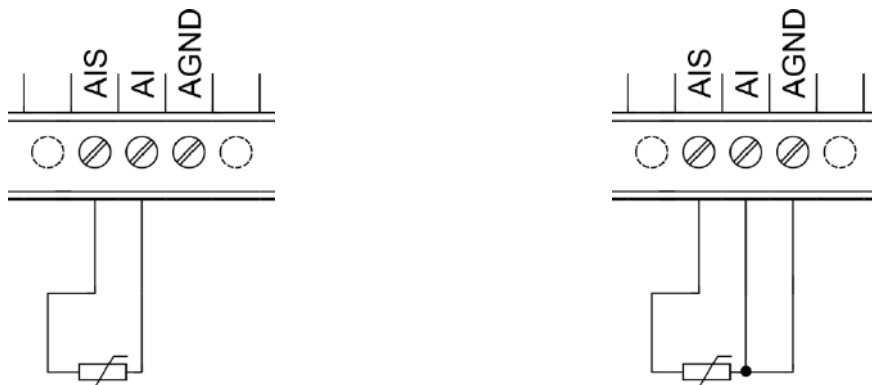
Depending on type of output value (either voltage or current) of external device it is first necessary to check measurement configuration of Neuron through the chosen software before actual connection of the external device.

---

The following illustrations depict measurement of voltage and current source on screw connectors AI and AGND.



Resistance sensors can be connected to the analog inputs to inputs other than in group 1 using two or three conductors. The advantage of using three conductors is that it eliminates the measurement error caused by resistance of the used conductor.



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**Note**

It is not possible to measure resistance sensors through Analog inputs in Group 1. Such measurement is possible to achieve through connection to Group 1 analog outputs and also by using analog inputs of other groups.

---

**Measuring of voltage and current on analog input of group 1**

For correct measurement of analog input, it is necessary to do a correction of converted value with reference voltage stored in the processor and also a correction of other coefficients read directly from corresponding registers. For doing so there is a following formula of voltage calculation.

$$U_{AI1true} = \left( 3.3 * \frac{V_{ref}}{V_{refInt}} \right) * 3 * \frac{V_{AI}}{4096} * \left( 1 + \frac{AI1_{dev}}{10000} \right) + \frac{AI1_{offset}}{10000} \text{ [V]}$$

Current can be calculated in a similar way using the following formula.

$$I_{AI1true} = \left( 3.3 * \frac{V_{ref}}{V_{refInt}} \right) * \frac{V_{AI}}{4096} * 10 * \left( 1 + \frac{AI1_{dev}}{10000} \right) + \frac{AI1_{offset}}{10000} \text{ [mA]}$$

The type of measurement is set according the used SW in register AI settings according to the following table.

Settings	Type of measurement
0	Voltage 0 – 10 V
1	Current 0 – 20 mA

**Measuring on analog inputs other than group 1**

Analog inputs of groups other than group 1 provides precise measurement of voltage, current and resistance. The type of measurement is set according the used SW in register AI mode according to the following table. The value read from register Analog Input equals the actual measured value in displayed in the table.

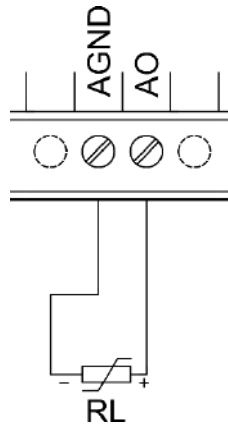
Settings	Type of measurement
0	Off
1	Voltage 0 – 10 V
2	Voltage 0 – 2.5 V
3	Current 0 – 20 mA
4	Resistance (two conductors) 0 – 1 960 Ω
5	Resistance (three conductors) 0 – 100 kΩ

### 2.5.7 Analogue output connection

Analog outputs serve for regulation of external devices (such as three-way valves or heat exchangers) by output analogue signal in range of either 0-10 V or 0-20m A.

External device is to be connected to screw connectors of AOY.X and AOGND. The following illustration demonstrates connection of external device to analog output.





### Note

Analog output in the Group 1 features the possibility of measuring resistor sensors.

The type of desired analog output has to be set using the AO setting register according to the following table.

Settings	Output type	Note
0	Voltage 0 – 10 V	
1	Current 0 – 20 mA	
3	Resistance measurement	Since Firmware 5.0

### Setting voltage/current on analog output of group 1

The following formula described the calculation of value that should be written to register AI according to the target value on analog output in case of using it as voltage source:

$$V_{AO} = \frac{\left( V_{AO1desired} - \frac{AO1Voffset}{10000} \right)}{\frac{\left( 3.3 * \frac{V_{ref}}{V_{refInt}} \right)}{4095} * \left( 1 + \frac{AO1Vdev}{10000} \right) * 3}$$

Where  $V_{AO1desired}$  is the target value in Volts.

Accordingly, the following formula should be used when using the analog output as current source.

$$I_{AO} = \frac{\left( I_{AO1desired} - \frac{AO1Aoffset}{10000} \right)}{\frac{\left( 3.3 * \frac{V_{ref}}{V_{refInt}} \right)}{4095} * \left( 1 + \frac{AO1Adev}{10000} \right) * 10}$$

Where is the target value in mA.

The resulting value has to be corrected in order to be written to register where the value can be only in range 0 – 4095.

### Setting voltage on analog output other than group 1

Setting of voltage on analog outputs other than in group 1 is done directly by write to register AO without the need of such calculation. The register expects values in range of 0 – 4000 which equals the range of 0 – 10 V. The following formula can be used to calculate the value:

$$V_{AO} = \frac{4000}{10} * V_{AO_{desired}}$$

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### Example

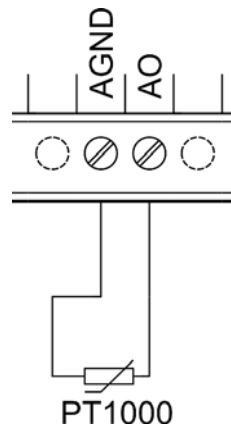
To set 5,5V on analog output AO2.1 user should write value 2200 to the register called Analog Output 2.1.

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### Measuring resistance on AO1

Alternative function of analogue output in Group 1 while set to current source is the measuring of connected resistor. This feature is suitable for reading of resistance sensors, more specifically temperature sensor Pt1000. Its connection is demonstrated in the following illustration.

Since firmware version 5.0 the support of resistance reading is integrated directly into the firmware thus it is possible to directly read the measured resistance when register AO settings is properly configured (As described above).



For precise measuring of analog output, it is necessary to do a correction of read value with reference voltage stored in the group processor with a help of the following formula and setting of output current to for example 1 mA.

$$U_{AI2_{true}} = \left( 3.3 * \frac{V_{ref}}{V_{refInt}} \right) * \frac{AI2}{4096} * \left( 1 + \frac{AI2_{vdev}}{10000} \right) + \frac{AI2_{voffset}}{10000} [V]$$

Where each of the variables equals directly the values read from the corresponding registers. Conversion to resistance is done with the following formula according to the set output current and measured voltage.

$$R = \frac{U}{I}$$

### 2.5.8 Relay output connection

Relay outputs are to be connected to RoY.X and COM screw connectors and serve for switching two-state components with either AC or DC voltage. COM screw connector serves supply of switched voltage for devices connected to the same connector. Screw connector of RoY.X serves for conducting of switched voltage of the given relay output. Relays are connected in NO wiring thus their output equals zero when switched off.

Corresponding indication LED diode atop the Neuron device lights up when the output is switched on. It is optimal to accomplish overload and short circuit protection through external circuit breaker separately for each Relay output, or possibly for the whole RO group. Rated current and type of the circuit breaker is to be chosen appropriately according to electrical load and its characteristics while considering maximum current of the output, eventually group of outputs.

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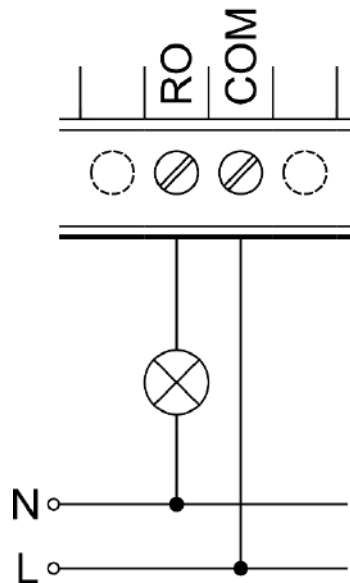
**Note**

In case of connected inductive load (such as electromotor, coil of a relay or contactor or even power cabling in complex electroinstallations) it is recommended to protect relay outputs with an appropriate external component (e.g. varistor, RC circuit, or diode with an appropriate characteristics).

In case of connected capacitive load (such as power supplies for LED lightning) it is recommended to protect the contacts of the relay against the current surge with a thermistor connected in series with the output of the relay with appropriate characteristics.

---

The following illustration demonstrates connection of load with AC voltage to relay output.



## 3 Software

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Thanks to opened design of the whole system user is not restricted to use just one specific software for regulation and configuration. Overview and guides for all compatible software platforms is available on [www.unipi.technology](http://www.unipi.technology), eventually on the website dedicated to each specific software platform.

As a basic provided software for simple implementation of user application is OS Linux and communication interface Modbus on TCP protocol. This image can be freely downloaded from [downloads.unipi.technology](http://downloads.unipi.technology). Regulation application may run either on PLC itself or on another device within the network. Both options may be freely combined which brings the advantage of distributed system.

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### Important

1-Wire bus is not accessible through TCP Modbus as well as other serial buses. If you need to use these it is necessary to implement their solution in chosen software platform. For more see chapter 3.2.

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Further extension of application interface is web portal which serves for basic configuration of the device available over HTTP protocol on port 8088.

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### Important

Not all parameters/functions apply also for extension modules as they have not integrated given interfaces (e.g. 1-Wire, RS485 master), for more information see chapter 2.2.

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### 3.1 Modbus register and coil mapping description

For accessing each of the registers and coils there are two possible methods. As each group features its own processor all the registers of the given group are accessible through **unit** (address) according to the Group number (i.e. 1 – 3) and at the same time through **unit 0** through which all registers / coils of the given product are accessible. If access through unit 0 is used register numbers are shifted according to  $100 * (\text{group\_number} - 1)$  formule. Thus, it is possible to use both methods.

---

### Example

Register 1 of the Group 1 is accessible through the unit 1 on the address 1 and through the unit 0 on the register 1 as well. Register 1 of the group 2 is accessible through the unit 2 on register 1 and through the unit 0 on the register 101.

---

### 3.2 Serial buses

Application providing TCP Modbus server on the provided OS Linux automatically detects product version in which it is used. Mainly it provides access to interface for available inputs / outputs. It is necessary to solve serial buses (e. g. 1-Wire) and serial links in a different manner.

#### 3.2.1 Serial lines (RS-485, RS-232, ...)

TCP Modbus server creates virtual serial buses in the folder `/dev/extcomm/` (pty – pseudodeterminal). These are mapped in two ways (similarly to registers) through the folders:

- `/dev/extcomm/group_number/serial_bus_number`
  - Here the group numbers and serial numbers equals the physical description on the cover
- `/dev/extcomm/0/0...X`
  - In this folder, all buses are numbered accordingly to serialization of all available serial buses.

---

### Example

Serial bus RS485 in product Neuron S103 is accessible through `/dev/extcomm/0/0` and through `/dev/extcomm/1/0`.

Opening the serial prevents the setting of parity. That and the other parameters of the serial bus are controlled over the variables of `UART_config` (see the section 3.4.3.2).

### 3.2.2 1-Wire bus

1-Wire bus is implemented through DS2482 bridge connected to I<sup>2</sup>C interface of the main processor (in the OS Linux accessible through standard drivers located in `/dev/class/i2c/`).

For making it operational it is possible to use various other methods along with those described below.

- DS2482 kernel module
  - Support implemented right in the OS kernel (module DS2482)
- OWFS (1-Wire File System)
  - Solution providing access to 1-Wire devices directly through the file system

### 3.3 Variable overview

The following table describes the meaning of each of variables and values, they represent. Detailed description of variables and registers is further described in documentation of Modbus maps accessible online.

Name	R/W	Meaning
<b>DO</b>	RW	Setting of digital output state
<b>PWM</b>	W	Number of pulses in logical 1
<b>DI</b>	R	Indication of digital input switched on
<b>Debounce</b>	W	Setting of flash repression in 100µs
<b>CNT</b>	RW	Digital input pulse counter value
<b>DS_enable</b>	W	Enabling of Direct Switch function for DI
<b>DS_polarity</b>	W	DS function settings – polarity
<b>DS_toggle</b>	W	DS function settings – toggle
<b>AI</b>	R	Analog input value
<b>AI_sw</b>	W	Enabling of current input
<b>AI_V_dev</b>	R	Deviation from reference voltage
<b>AI_V_offset</b>	R	Measured voltage offset
<b>AO</b>	W	Analog output value settings
<b>AO_settings</b>	W	Configuration of analog output
<b>ULED</b>	W	User interface LED settings
<b>MWD_enable</b>	W	Master Watchdog function enabling
<b>MWD_timeout</b>	W	Master Watchdog timeout in ms
<b>Was_WD_boot</b>	R	Indication of last reset over MWD
<b>Clear_WD_boot</b>	W	Setting of reset indication over MWD
<b>UART_TXQ</b>	R	Number of bytes not sent off in bus buffer
<b>UART_config</b>	W	Serial bus settings
<b>PWM_prescale</b>	W	PWM multiplier
<b>PWM_cycle</b>	W	PWM cycle
<b>NV_save</b>	W	Saving of preset values
<b>Version</b>	R	Firmware version
<b>HwVersion</b>	R	HW version
<b>BoardSerial</b>	R	Modul board serial number
<b>Num_DIDO</b>	R	Nuber of digital inputs and outputs
<b>Num_AIAOUART</b>	R	Number of analog inputs, outputs and serial buses
<b>Vref</b>	R	Processor reference voltage
<b>OW_off</b>	W	1-Wire bus on/off
<b>Reboot</b>	RW	Group CPU reboot

---

**Note**

If letter R is in the register description it stands for the read-only variable. In letter W is in the register description it stands for write variable. If letters RW are in the register description it stands for variable possible to read and write into at the same time (i.e. its values can change not depending on the program – e.g. CNT).

---

## 3.4 Function description

### 3.4.1 Digital input functions

Correct functioning of digital inputs depends on configuration of Debounce variable depending on connected switch and on the environment in which the device is installed.

#### 3.4.1.1 *Debounce*

Function Debounce serves for input flash repression, its value is presented in hundreds of  $\mu\text{s}$  (i.e. value 100 equals 10 ms). Impulse (positive edge) is processed as valid only in case it equals logical 1 for the whole set duration.

#### 3.4.1.2 *Counter*

This function serves as a pulse counter (counter of positive edges) on digital inputs. With each valid pulse its value is incremented by one and written into the variable. While reading the maximum value, the counter is set to zero. Presetting of a value is possible by writing into the variable CNT\_set.

#### 3.4.1.3 *Direct switch*

This function allows mapping of event or state of digital input to digital output within the group (moreover the group numbers of DI and DO/RO must be the same). Enabling of the function is done by writing True value into DS\_enable of the desired digital input. If DS\_enable variable is equal to False, settings of DS\_toggle and DS\_polarity is ignored.

---

**Note**

Each input which allows DS has corresponding DS\_enable, DS\_polarity and DS\_toggle variables. Thus, it is possible to configure different behavior for each.

---

### **DS\_polarity**

With this function, it is possible to achieve two states of behavior. If DS\_polarity is set True the output switches to the state opposite to of the input. Otherwise if set False the output value equals the input value. Exact description of the behavior demonstrates the following table.

DS_polarity	Vstup	Výstup
True	False	True
True	True	False
False	False	False
False	True	True

### **DS\_toggle**

If this value is set True, during the positive edge detection on input, the output value of corresponding output is negated.

### 3.4.2 Digital output functions

#### 3.4.2.1 *PWM*

Pulse width modulation (PWM) serves for analog signal transmission with binary signal. PWM can be activated for each digital output separately, but frequency settings is one only for each group and is shared. After PWM function enabling it is first necessary to set DO variable of chosen output to 0 and then change the PWM variable value. PWM variable value states the period length of logical 1 in the number of cycles on the given output.

---

**Note**

If DO is switched on, PWM value is ignored. On the contrary if PWM value is different than 0 and DO is switched from 1 to 0, PWM function is activated.

---

Cycle length  $T_c$  is set using the PWM\_prescale and PWM\_cycle. PWM\_cycle is basically resolution of the PWM thus value of PWM can only be set from 0 to the value of PWM\_cycle. Its value can be calculated with the following formula:

$$T_c = \frac{(PWM_{prescale} + 1)}{48MHz} * (PWM_{cycle} + 1)$$

Alternative calculation of PWM\_prescale, where f is the chosen PWM frequency in Hz. **Remember that the final result must be rounded to a whole number.**

$$PWM_{prescale} = \frac{48MHz}{f * (PWM_{cycle} + 1)} - 1$$

---

### Example

When PWM\_prescale is set to 4751 and PWM\_cycle is set to 100,  $T_c$  equals 10ms (100Hz). Furthermore, setting of PWM value to 50 duty cycle will equal 50% on frequency 100Hz.

---

## 3.4.3 Other setting and informative functions

### 3.4.3.1 ULED

Some models feature freely programmable LED diodes marked as X1 ... 4. Diode control is done through ULED variables for each diode separately.

### 3.4.3.2 Serial buses

If product features serial bus, there are available variables UART\_TXQ and UART\_config. UART\_TXQ contains the number of bytes ready to be sent off through the serial bus. If the buffer capacity overflows, overflowing data will be ignored.

Variable UART\_config serves for serial bus parameters setting. Meaning of each bit of this variable describes the following table.

Bits	Description
0 .. 12	Communication speed
13	Parity on / off
14	0 = even/1 = odd parity
15	Modbus RTU

Bit for Modbus RTU servers for setting of HW support for Modbus protocol to serial bus, where setting bit to 1 it is generated interruption until the Modbus RTU frame receipt is terminated. In OS, Serial bus is accessible through virtual serial port **pty** by opening of which it is also possible to set the communication speed. Nevertheless parity is necessary to set through above described bits of UART\_config variable. Speed of communication in UART\_config demonstrates the following table.

Value	Speed [bps]
11	2 400
12	4 800
13	9 600
14	19 200

<b>15</b>	38 400
<b>4097</b>	57 600
<b>4098</b>	115 200

### 3.4.3.3 1-Wire bus enabling

Models featuring 1-Wire bus also feature function for bus enabling/disabling. In default settings, the value of OW\_off variable is set to False, thus the bus is enabled. Setting it to True disables the bus.

### 3.4.3.4 Master Watchdog (MWD)

It is possible to set it through MWD\_enable and MWD\_timeout variable for each. These variables determine condition for Watchdog activation. Master watchdog monitors communication with the given group. If there is no communication with the group for the preset duration (typically communication with the master control program), processor of the group reboots, outputs of the group are set to default state and the flag Was\_WD\_reboot is set to True. This flag is possible to reset through the variable Clear\_WD\_boot.

### 3.4.3.5 Reboot

It is possible to reboot each group by writing True to the variable Reboot. After the reboot the last saved default settings is loaded.

### 3.4.3.6 Default state saving

Variable NV\_save serves for saving the actual group settings as a default settings. This setting (PWM, PWM\_prescale, PWM\_cycle, debounce, UART\_config, DO, AO, AO\_sw, DS\_enable, DS\_polarity, DS\_toggle) is loaded during the group reboot, when MWD function activates, when using Reboot variable or when disconnected from power supply and reconnected again.

### 3.4.3.7 Product version

For correct reading of values stored into two registers it is necessary to exchange high and low byte of each register.

## SWVersion

Contains processor firmware version of the given group stored in two bytes, where the high byte is number of the main version and the low byte is the sub-version.

## Num\_DI/DO

Each group provides information about number of digital inputs and outputs. Number of inputs is stored in the high byte and the number of outputs is stored in the low byte.

## Num\_AI/AO/UART

Number of analog inputs is stored in this variable in the high byte. Number of analog outputs is stored in the four high bits of the low byte and the number of serial buses is stored in the low 4 bits of the low byte.

## HwVersion

Variable HwVersion contains encoded production mark of the board, its version and its sub-version. High byte contains the encoded production mark, lower byte is separated into 4 high bits holding the main version number and the 4 low bits holding the sub-version number.

## BoardSerial

Serial number of the board is stored into 2 Modbus registers of size 32 bits.

## InterruptMask

This variable serves for interruption detection and it is stored in two bytes. Meaning of each bit demonstrates the following table.

Bit	Meaning
<b>0</b>	Receive buffer of serial bus is not empty
<b>1</b>	Serial bus transmission finished
<b>2</b>	Modbus frame receival indication
<b>3</b>	Digital input changed state



## TrueVref

Reference value of 3.3V processor of the given group. This value serves as reference for precise measuring on analog inputs of the given group.

Recalculation of the value acquired from registers to the correct reference value describes the following formula.

$$V_{TrueVref} = 3.3 * \frac{V_{ref}}{V_{refInt}}$$

## 4 Technical details

### 4.1 Digital inputs

<b>Input screw connectors</b>	DI
<b>Common ground</b>	DIGND
<b>Galvanic isolation</b>	Yes, among terminals
<b>Operation range</b>	5 – 24 V DC
<b>Isolation voltage</b>	5 kV
<b>Input voltage for logical 0</b>	Max. 3.5 V DC
<b>Input voltage for logical 1</b>	Min. 5 V DC
<b>Input resistance for logical 1</b>	6 200Ω
<b>Minimal pulse width</b>	20 μs
<b>Delay logical 0 → logical 1</b>	20 μs
<b>Delay logical 1 → logical 0</b>	60 μs

### 4.2 Digital outputs

<b>Input screw connectors</b>	DO
<b>Common ground</b>	DOGND
<b>Galvanic isolation</b>	No
<b>Type of output</b>	Transistor output – open collector
<b>Optional DO modes</b>	PWM, frequency
<b>Switched voltage</b>	5 – 50 V DC
<b>Switched current continual/pulse</b>	750 mA / 1 A
<b>Time to switch on/off</b>	Usually 130 ns / 20ns
<b>Switching speed</b>	Max. 200 kHz / 8bit
<b>Inductive load solution</b>	Possible to use flyback diode (FBD)

### 4.3 Analog input

	Group 1 (Ai1)	Group 2,3 + Extensions
<b>Input screw connectors</b>	AI	AI, AIS
<b>Common ground</b>	AGNG	AGND
<b>Galvanic isolation</b>	No	Yes
<b>Optional AI modes</b>	Voltage measurement 0 – 10 V Current measurement 0 – 20 mA	Voltage measurement 0 – 10 V Current measurement 0 – 20 mA Resistance measurement 0 – 1960 Ω Resistance measurement 0 – 100 kΩ
<b>Resolution</b>	12 bits	24 bits resistance measurement 16 bits voltage and current measurement
<b>Conversion speed</b>	10 μs	400 ms resistance measurement 60 μs voltage and current measurement
<b>Type of protection</b>	Integrated electrostatic discharge protection	Integrated electrostatic discharge protection
<b>Maximum input voltage</b>	12 V	15 V
<b>Measurement accuracy</b>	±0.5 %	± 0,2 %
<b>Input resistance for current measurement</b>	100 Ω	100 Ω

#### 4.4 Analog outputs

	Group 1 (Ai1)	Group 2,3 + Extensions
<b>Input screw connectors</b>	AO	AOV
<b>Common ground</b>	AGNG	AGND
<b>Galvanic isolation</b>	No	Yes
<b>Optional AO modes</b>	Voltage source 0 – 10 V Current source 0 – 20 mA Resistance measurement: 0 – 2 k $\Omega$ , Ni1000, Pt1000	Voltage source 0 – 10 V
<b>Resolution</b>	12 bits	12 bits
<b>Conversion speed</b>	1ms	300 $\mu$ s
<b>Type of protection</b>	Integrated electrostatic discharge protection	Integrated electrostatic discharge protection
<b>Maximum output voltage</b>	10 V	10 V
<b>Maximum output current</b>	20 mA	20 mA
<b>Output voltage accuracy</b>	$\pm 0.5$ %	$\pm 0,5$ %
<b>Output current accuracy</b>	$\pm 0.5$ %	
<b>Resistance measurement accuracy 0-<math>\infty</math>Ohm</b>	$\pm 0.5$ %	
<b>Pt1000 measurement accuracy</b>	$\pm 0.5$ %	

#### 4.5 Relay outputs

<b>Output screw connectors</b>	RO
<b>Common ground</b>	COM
<b>Galvanic isolation</b>	Yes
<b>Type of output</b>	Electromechanical unprotected relay
<b>Switched voltage</b>	250 V AC/30 V DC
<b>Switched current</b>	5 A
<b>Short-term</b>	5 A
<b>COM current</b>	10 A
<b>Time to switch on/off</b>	10 ms
<b>Mechanical lifetime</b>	5 000 000
<b>Electrical lifetime</b>	100 000
<b>Short circuit protection</b>	No
<b>ESD protection</b>	No
<b>Inductive load solution</b>	External – RC, varistor, dioda
<b>Isolation voltage</b>	4 000 V AC

#### 4.6 RS485 interface

<b>Screw connectors</b>	RS485-A, RS485-B
<b>Galvanic isolation</b>	Ano
<b>Isolation voltage</b>	1000 V
<b>ESD protection</b>	$\pm 15$ kV
<b>Baud rates</b>	2 400 bps, 4 800 bps, 9 600 bps, 19 200 bps, 38 400 bps, 57 600 bps, 115 200 bps
<b>Input impedance</b>	12 k $\Omega$
<b>Input voltage hysteresis</b>	70 mV
<b>Output characteristics</b>	$\pm 2,5$ V

## 4.7 Installation and operating conditions

<b>Operating temperature</b>	0 °C .. + 55 °C
<b>Storage temperature</b>	-25 °C .. +70 °C
<b>Dielectrical strength</b>	In accordance with EN 60950
<b>Degree of protection IP (IEC 529)</b>	IP20
<b>Operation position</b>	Vertical
<b>Installation</b>	On DIN rail 35 mm into distribution boxes
<b>Connection</b>	Trough removable screw connectors
<b>Wire gauge</b>	Max. 2,5 mm <sup>2</sup>
<b>Connector screw torque</b>	Max. 0,4 Nm