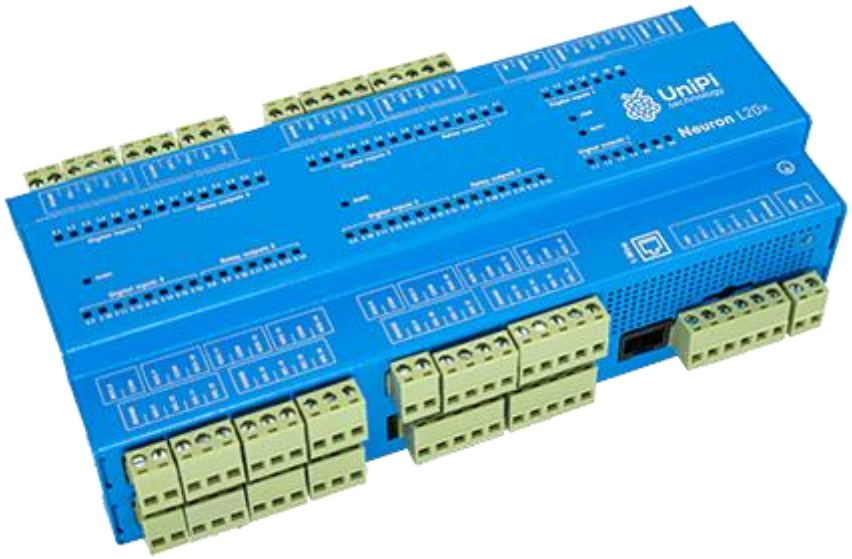
Product line of programmable controllers

UniPi Neuron



S101, S102, S103, M101, M102, M103, M201, M202, M203

M301, M302, M303, M401, M402, M403, L201, L202, L203

L301, L302, L303, L401, L402, L403

Contents

1 Introduction

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 extension modules for RS485 (Modbus) serial line.

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, watering systems)
- Control of complex applications (boiler rooms, cascade of boilers, 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
S10x	**4**	**4**	0	**1**	**1**	1	1	1
M10x	**12**	4	**8**	1	1	1	1	1
M20x	**20**	4	**14**	1	1	1	1	1
M30x	**34**	4	0	1	1	1	1	1
M40x	4	4	**28**	1	1	1	1	1
L20x	**36**	4	**28**	1	1	1	1	1
L30x	**64**	4	0	1	1	1	1	1
L40x	4	4	**56**	1	1	1	1	1

Each Neuron controller is available in three variations of CPU performance and other features:

x	CPU	RAM	Other features
1	**700 MHz**	**512 MB**	
2	**4×900 MHz**	**1 GB**	
3	**4×1.2 GHz**	**1 GB**	**WiFi + Bluetooth**

Example

Variant UniPi Neuron L203 features in total 64×Di, 4×Do, 1×Ai, 1×Ao, 1×10/100 Ethernet, 1×RS485, 1×1-Wire and processor 4×1.2 GHz a 1GB RAM

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.

Products are also compliant with Government Directives 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

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.

Note

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

Warning

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

2.1 Neuron product structure

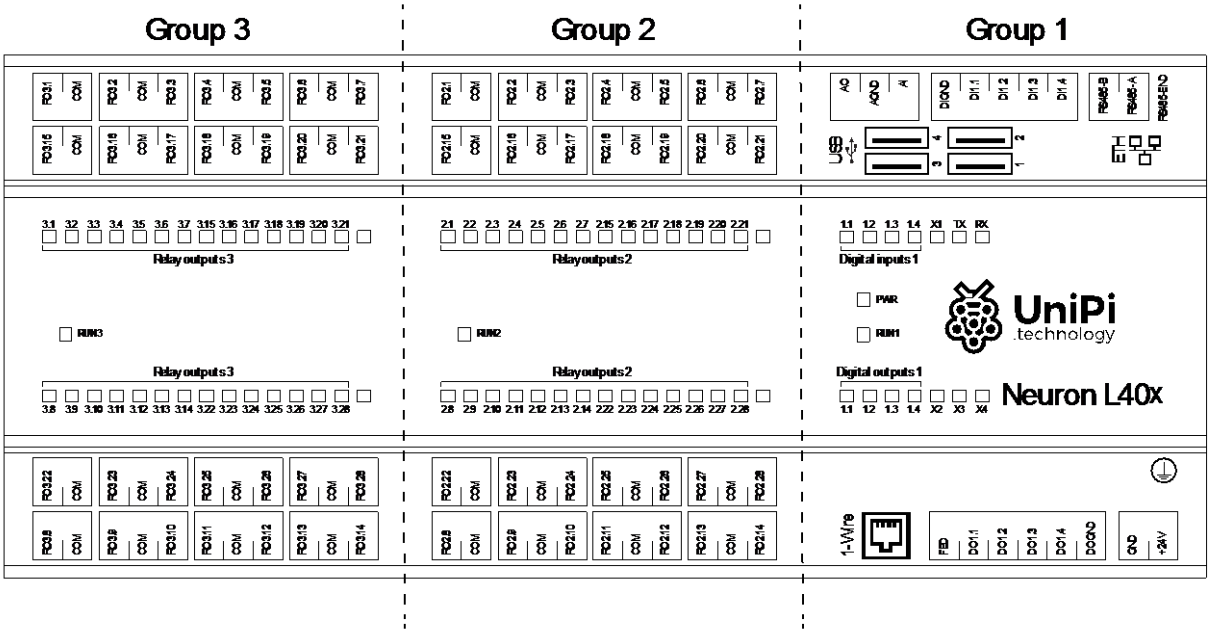
Each Neuron product is divided into 1 to 3 groups which depends on specific type of product. Groups are numbered from right to left in the direction from the main group (1). Each group consists of inputs, outputs, or communication channels – these are numbered from left to right separately for each group.

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 do 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.

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.

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



2.2 Description of connectors and indication LED diodes

2.2.1 LED diode description

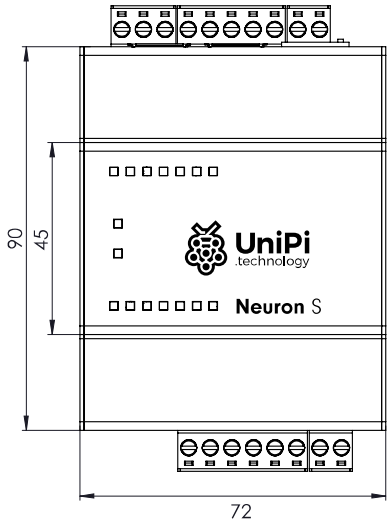
Name	State	Purpose	Color
PWR	On	Indication of power supply voltage	Red
RUN	Constantly On or Off	HW malfunction indication	Green
	Short blink after 2 sec	Communication OK	Green
	On for 2 sec + Off 2 sec	Communication timeout reached - MWD	Green
Digital inputs	On	Indication of log. 1 on input	Green
Digital outputs	On	Indication of switch on of output	Green
Relay outputs	On	Indication of switch on of output	Green
TX	Blinks	Serial link transmission indication	Green
RX	Blinks	Serial link reception indication	Green

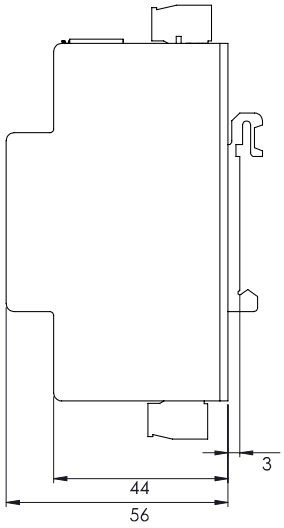
2.2.2 Connector description

Screw connector name	Purpose
+24V	Positive pole of power supply
GND	Negative pole of power supply
DI	Digital input
DIGND	Common connector of digital input – negative pole
DIVOUT	Positive pole of 24V DC for use witth digital inputs
DIVGND	Negative pole of 24V DC for use with digital inputs
DO	Digital output
DOGND	Common connector of digital output – negative pole
RO	Relay output
COM	Common connector of relay output
AI	Analog input
AO	Analog output
AGND	Common connector of negative pole of analog input / output
RS485-A/RS485-B	Connectors for RS485 communication interface

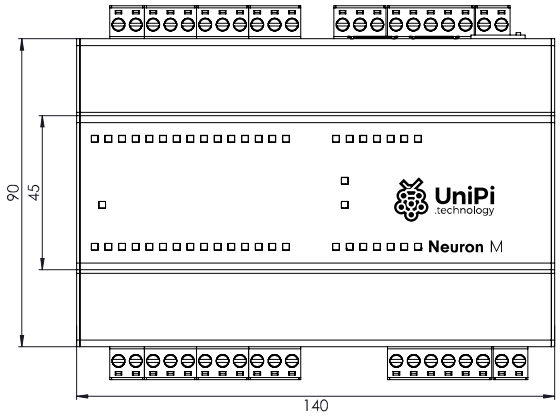
2.3 Dimensions

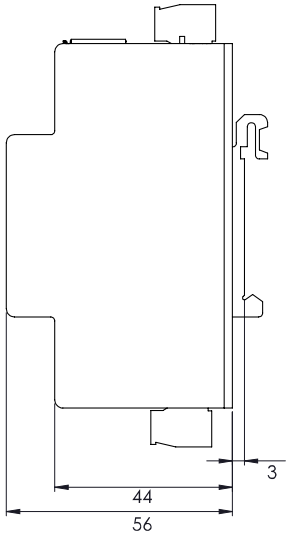
2.3.1 UniPi Neuron Type S



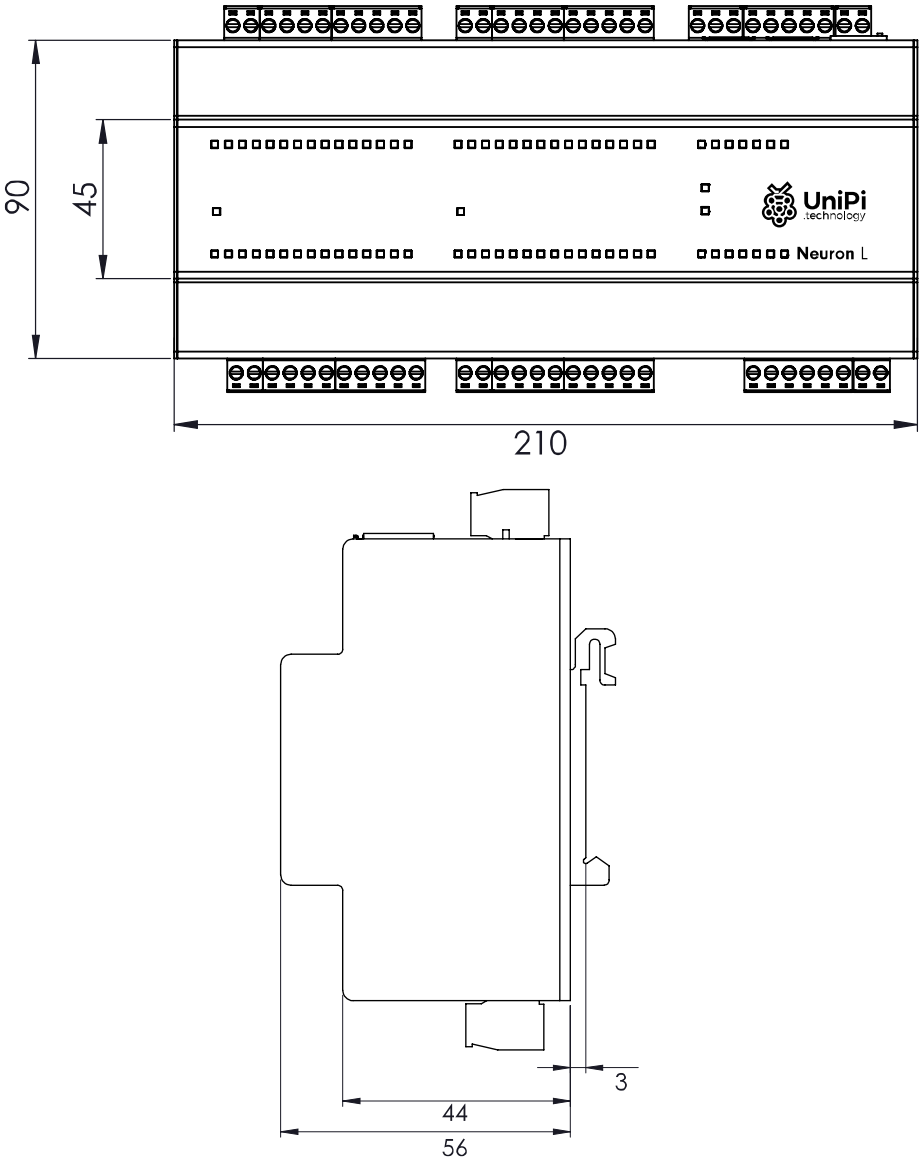


2.3.2 UniPi Neuron Type M





2.3.3 UniPi Neuron Type L



2.4 Device mounting

2.4.1 Mounting / demounting

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

Mounting

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 holder must be attached such way that the metal spring is positioned in the upper side of the device.

Mounting of product onto the DIN rail should be done as follows – attach the product onto the rail from above. Then by pulling down, squeeze the spring and pull the bottom side of the holder over the rail edge.

Attention
In case of installation of the device into a distribution box without forced circulation of air 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.

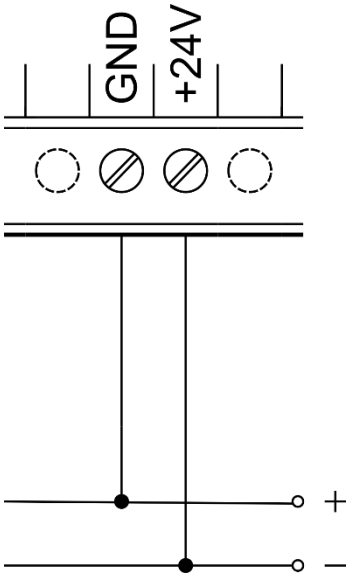
Demounting
Demounting of the device is done by opposite procedure. Pull the device down against the metal spring, once the holder is off the rail, remove the device completely by pulling it up.

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

Connection
For the connection of any cable there are removable screw connectors. Purpose of each screw connectors is depicted on the front 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.

2.4.2 Power supply connection

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



Attention
The device is classified as 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.

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

2.4.3 Communication line connection

2.4.3.1 RS-485

The RS-485 (EIA-485) serial line is made on screw connectors labeled as RS-485 (A and B). The device features optionally joinable terminator 100 Ω resistor marked with END (RS-485-END, BUS-END).

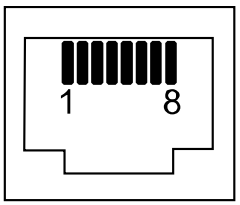
Note
For correct bus operation, it is necessary to connect terminator on both sides of the line.

2.4.3.2 1-Wire

Purpose of 1-Wire is passive data collection from 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 RJ45 jack.

Conductor purpose	Conductor number
V_{cc} (+5V)	4, 5
Data (DQ) outgoing	6
Data (DQ) ingoing	7
GND	3, 8
Unused	1, 2



Note
The ingoing conductor 7 is not used at bus master (because it is not needed) but must be used in all sensors (hubs) on the bus in order to maintain functionality. The table above and illustration of RJ45 connector serves for illustration of correct device connection to the bus to ensure correct functionality of the bus itself.

Note
1-Wire bus is implemented using six conductors, where two conductors are for data transmission (DQ), two ground conductors (GND) and two as power supply conductors (Vcc). 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:

- Follow 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).

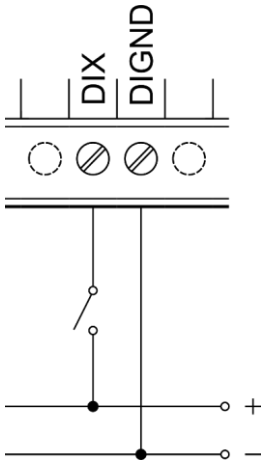
Note
These instructions are recommendations only and may vary depending on the environment, the total bus length and number of sensors.

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

2.4.4 Digital input connection

Digital inputs are usually used with devices such as switches (light switches, buttons), motion sensors, door contacts, and window contacts etc. Logic state 1 (switched on) of each input is signalized by relevant indication of LED diode on the front side of the product case.

For connection of external device to digital input there are screw connectors marked with DiX (or possibly DiY.X) and DiGND. Each digital input connector 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.



Note
For signalization of state of external devices connected to digital inputs it is recommended to use different power supply 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.

Extended functionality

Each digital input features along with state indicator also pulse counter.

If there are also digital (or relay) outputs as well digital inputs in the device, it is possible to use one of three so called Direct switch functions available for DiY.X inputs and DoY.X / RoY.X:

- Polarity – it is possible to achieve two possible behaviors using this function
  - 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 rising edge is 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).

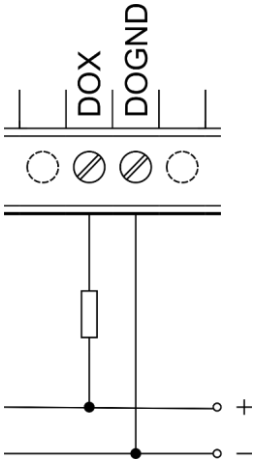
Note
Direct Switch functions can be configured only for matching input and output, i.e. only for input DiY.X and output DoY.X (or RoY.X), where each of numbers X and Y (if Y is stated) must be equal. It is not possible to configure function Direct Switch for one input and more outputs at the same time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

2.4.5 Digital output connection

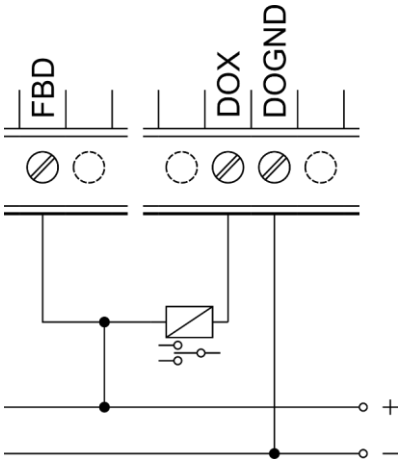
Digital outputs (semiconductor, connected as opened collectors) are accessible through DoX (DoY.X), DOGND and possibly FBD of a screw connector. Each group of digital outputs have common screw connector DOGND for negative pole connection of DC power supply. Screw connector of DoX serves for connection of electrical load of external device, which switches against the common potential. State of each output is signalized by corresponding indication LED diode on the front side of the device.

Note
Depending on software it is possible to configure digital outputs for 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 which is accessible through FBD screw connector. The following illustration shows a connection of external relay to digital output using integrated FBD diode.



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 the device.

2.4.6 Analog input connection

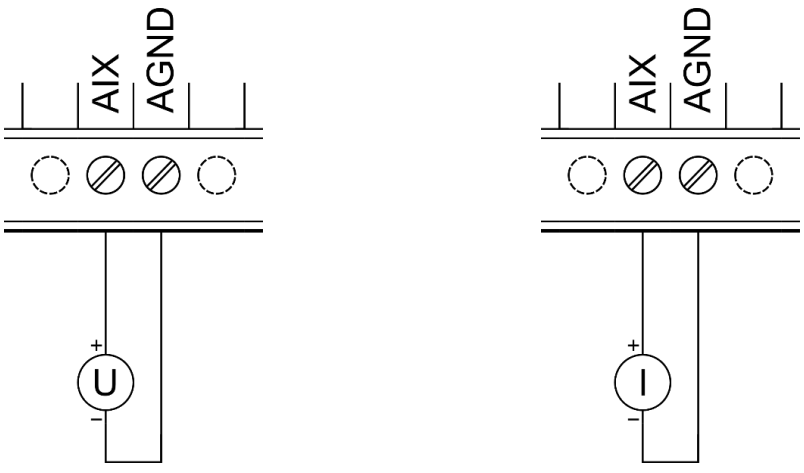
Analog input serves for reading voltage value in range 0-10 V or current in range 0-20 mA. The type of measurement is configured depending on used software.

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.

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

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

The following pictures illustrates connection of voltage and current source on connectors AI and AGND.



Note
It is not possible to measure resistance sensors through Analog inputs in Group 1. Such measurement is possible to achieve trough connection to Group 1 analog outputs. This fact is further described in chapter 2.4.7.

Measuring of voltage and current on analog input of group 1

For precise measurement of analog input, it is necessary to do a correction of converted value with reference voltage stored of 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.

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

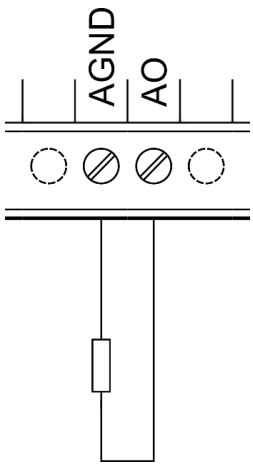
Current can be calculated in a similar way using the following formula.

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

2.4.7 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 0-20mA.

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 (e.g. Pt1000).

The following formula can be used to set the proper value of AO when set as voltage output.

$$V_{AO} = \frac{\left(V_{AO1_{desired}} - \frac{AO1_{Voffset}}{10000}\right)}{\frac{\left(3.3 * \frac{V_{ref}}{V_{refInt}}\right)}{4095} * \left(1 + \frac{A01_{Vdev}}{10000}\right) * 3}$$

Were the $V_{AO1desired}$ is the desired value in Volts.

Alternatively, the following formula can be used for current output.

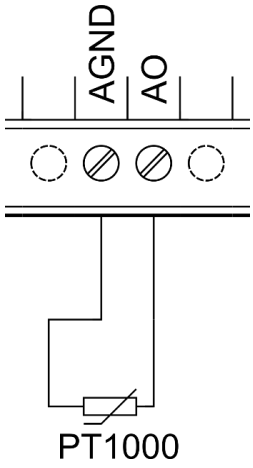
$$I_{AO} = \frac{\left(I_{AO1_{desired}} - \frac{AO1_{Aoffset}}{10000}\right)}{\frac{\left(3.3 * \frac{V_{ref}}{V_{refInt}}\right)}{4095} * \left(1 + \frac{A01_{Adev}}{10000}\right) * 10}$$

Were the $I_{AO1desired}$ is the desired value in mA.

Remember that the value written to the register should be truncated in order to fit in the 16bit register (the value must be integer within 0 – 4095).

Connection of PT1000 to AO of Group 1

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 resistance of sensors, more specifically temperature sensor Pt1000. Its connection is demonstrated in the following illustration.



Group 1 Analog output resistance measuring

For precise measurement 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.

$$U_{AI2_{true}} = \left(3.3 * \frac{V_{ref}}{V_{refInt}}\right) * \frac{AI_2}{4096} * \left(1 + \frac{AI2_{vdev}}{10000}\right) + \frac{AI2_{voffset}}{10000} \text{ [V]}$$

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

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

2.4.8 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 as 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 (normally opened) wiring thus their output equals zero when switched off.

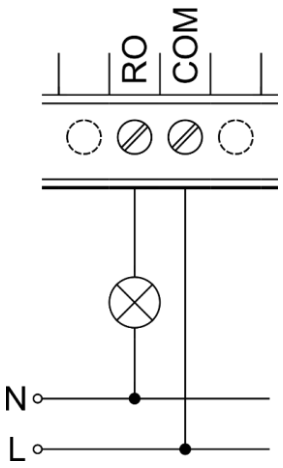
Corresponding indication LED diode on the front side of the device lights up when the output is switched on. It is optimal to accomplish overload and short circuit protection through external circuit breaker separately for each Relay output, or possibly for the whole RO group. Rated current and type 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.

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)

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



3 Software

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, 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. The application may run either on the Neuron controller itself or on another device within the network. Both options may be freely combined which brings the advantage of distributed system.

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

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

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 and coils 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. If access through unit 0 is used register numbers are shifted according to *100*(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 links

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 to be configured using the variables of UART_config (see the section 3.4.4.2).

3.2.2 1-Wire bus

1-Wire bus is implemented through DS2482 bridge connected to I^2C 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
DO	RW	Setting of digital output state
PWM	W	Number of pulses in logical 1
DI	R	Indication that digital input is switched on
Debounce	W	Setting of bouncing effect repression in 100µs
CNT	RW	Digital input pulse counter value
DS_enable	W	Enabling of Direct Switch function of DI
DS_polarity	W	DS function settings – polarity
DS_toggle	W	DS function settings – toggle
AI	R	Analog input value
AI_sw	W	Enabling of current input
AI_V_dev	R	Deviation from reference voltage
AI_V_offset	R	Measured voltage offset
AO	W	Analog output value settings
AO_sw	W	Enabling of current output
ULED	W	User interface LED settings
MWD_enable	W	Master Watchdog function enabling
MWD_timeout	W	Master Watchdog timeout in ms
Was_WD_boot	R	Indication reset over MWD in the past
Clear_WD_boot	W	Clear Was_WD_boot flag
UART_TXQ	R	Number of bytes wainting in buffer
UART_config	W	Serial bus configuration
PWM_prescale	W	PWM multiplier
PWM_cycle	W	PWM cycle
NV_save	W	Save current config as startup
Version	R	Firmware version
HwVersion	R	HW version
BoardSerial	R	Group board serial number
Num_DIDO	R	Nuber of digital inputs and outputs of group
Num_AIAOUART	R	Number of analog inputs, outputs and serial buses
Vref	R	Processor reference voltage
OW_off	W	1-Wire bus on/off
Reboot	RW	Group CPU reboot

Note
If letter R is in the register description it stands for the read-only variable. If 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 behavior 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 bounce repression, its value is presented in hundreds of μs (i.e. value 100 equals 10 ms). Impulse (positive edge) is processed as valid only in case it equals logical 1 for the whole configured 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 exceeding the maximum value, the counter is set to zero. The value can be programmatically changed 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 number of DI and DO/RO within the group 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 input.

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	Input	Output
True	False	True
True	True	False
False	False	False
False	True	True

DS_toggle
If this value is set True, after positive edge is detected on input, the output value of corresponding output is negated(toggled).

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 (prescale and duty cycle) settings is only one for each group. After enabling of PWM function 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 with $PWM_{prescale}$ and PWM_{cycle}. Its value can be calculated using the following formula:

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

Example
When PWM_prescale is set to 4799 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 Analog input / output functions

Setting of analog input/output type (current/voltage) is done with the AO_sw (or AI_sw) variable. Default value of this variable is set to False. Meaning of the possible values demonstrates the following table.

Value	Type
False	Voltage
True	Current

3.4.4 Other setting and informative functions

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

3.4.4.2 Serial buses
If product (controller) features serial bus, there are available variables UART_TXQ and UART_config. UART_TXQ contains the number of bytes waiting 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 receival is finished. In OS, Serial bus is accessible through virtual serial port pty**.** By opening the pty 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
15	38 400
4097	57 600
4098	115 200

3.4.4.3 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.

3.4.4.4 Master Watchdog (MWD)

Configuration of the Master Watchdog function is done through MWD_enable and MWD_timeout variable for each group. 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 (previously saved by to NV RAM) and the flag Was_WD_reboot is set to True. This flag is possible to reset through the variable Clear_WD_boot.

3.4.4.5 Reboot

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

3.4.4.6 Default state saving

Variable NV_save serves for saving the actual group configuration as a default. 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. Reboot of the group processor can be caused by the following actions: by MWD function, by writing True to Reboot variable or when disconnecting/connection power supply.

3.4.4.7 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
0	Receive buffer of seriál bus is not empty
1	Serial bus transmission finished
2	Modbus frame receival indication
3	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

Input screw connectors	DI
Common ground	DIGND
Galvanic isolation	Yes, between groups
Operation range	5 – 24 V DC
Input voltage for logical 0	Max. 3.5 V DC
Input voltage for logical 1	Min. 4,5 V DC
Input resistance for logical 1	6 200Ω
Minimal pulse width	20 µs
Delay logical 0 –> logical 1	20 µs
Delay logical 1 –> logical 0	60 µs

4.2 Digital outputs

Input screw connectors	DO
Common ground	DOGND
Galvanic isolation	No
Type of output	Transistor output – opened collector
Optional DO modes	PWM, frequence
Switched voltage	5 – 50 V DC
Switched current continual/pulse	750 mA / 1 A
Max. total current DO1.1 – DO1.4	1A
Time to switch on/off	Usually 130 ns / 20ns
Switching speed	Max. 200 kHz / 8bit
Inductive load solution	Possible to use flyback diode (FBD)

4.3 Analog input

Input screw connectors	AI
Common ground	AGNG
Galvanic isolation	No
Optional AI modes	Voltage measurement 0 – 10 V Current measurement 0 – 20 mA
Resolution	12 bits
Conversion speed	10µs
Type of protection	Integrated electrostatic discharge protection
Maximum input voltage	12 V
Measurement accuracy	±0.5%

4.4 Analog outputs

Input screw connectors	AO
Common ground	AGNG
Galvanic isolation	No
Optional AO modes	Voltage source 0 – 10 V Current source 0 – 20 mA Resistance measurement: 0 –2 kΩ, Ni1000, Pt1000
Resolution	12 bits
Conversion speed	1ms
Type of protection	Integrated electrostatic discharge protection

Maximum output voltage	10 V
Maximum output current	20 mA
Output voltage accuracy	±0.5%
Output current accuracy	±0.5%
Resistance measurement accuracy 0 – 2kOhm	±0.5%
Pt1000 measurement accuracy	±0.5%

4.5 Relay outputs

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

4.6 Installation and operating conditions

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