

Hardware Version V1.20

# HARDWARE MANUAL



## **PDX-108-28-SE**

Full Mechatronic Device  
Controller / Driver  
560mA RMS / 24V  
RS485  
sens0step™ Encoder

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# 1 Life support policy

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## 2 Features

The PDx-108-28-SE-485 is a full mechatronic device consisting of a NEMA 11 (flange size 28mm) stepper motor, controller/driver electronics and integrated sensOstep™ encoder.

### Applications

Extremely compact and decentralized stepper motor solution  
Position movement applications, where larger motors do not fit and higher torques are not required

### Electrical data

Supply voltage: +9V... +28V DC  
Motor current: up to 800mA peak / 560mA RMS (programmable)

### Stepper motor data

NEMA 11 (28mm flange size) two phase bipolar stepper motors  
Please also refer to the associated motor manual for more detailed information [QSH2818]

### Interfaces

2 general purpose inputs  
2 general purpose outputs  
RS485 2-wire communication interface

### Features

PD1-108-28-SE-485: smallest PANdrive™ available from TRINAMIC  
High-efficient operation, low power-dissipation  
Uses TMC222-SI highly integrated controller/driver IC  
Up to 16 microsteps per fullstep  
Integrated sensOstep™ magnetic encoder (max. 256 increments per rotation) for step-loss detection and absolute position information  
Integrated protection: overtemperature/undervoltage

### Software

TMCL™ remote (direct mode) and stand-alone operation (memory for 64 TMCL™ commands)  
Fully supported by TMCL-IDE (PC based integrated development environment)

### 3 Order codes

The combination of motor and motor mounted controller/driver electronic is currently available with two stepper motors (different length and holding torque).

Cables are not included. Add the appropriate cable loom to your order if required.

Order code	Description	Dimensions [mm <sup>3</sup> ]
PD1-108-28-SE-485	PANdrive 0.05Nm max. holding torque <sup>*)</sup>	28 x 28 x 45
PD3-108-28-SE-485	PANdrive 0.10Nm max. holding torque <sup>*)</sup>	28 x 28 x 64

**Table 3.1: Order codes**

<sup>\*)</sup> Max. holding torque at max. current (800mA peak / 560mA RMS) of the driver electronics

Option	Host interface
-485	RS485 interface

**Table 3.2: Option for order codes**

Component parts	Description
TMCM-108-CABLE	Cable loom for PANdrive.

**Table 3.3: Order code for component part**

## 4 Electrical and mechanical interfacing

The PDx-108-28-SE-485 consists of a 28mm / NEMA 11 stepper motor with controller/driver electronics mounted to the back of the motor. In order to make proper use of the integrated sensOstep™ encoder (the sensor IC is placed on the bottom of the pcb) the electronics should not be removed/moved relative to the motor (e.g. mounting it at a different location or with a different distance towards the motor). In case this encoder feature is not used, the electronics may be mounted according to different user requirements.

### 4.1 Size of board

The board with the controller/driver electronics has a size of 28mm x 28mm in order to fit on the back side of a NEMA11 (28mm flange size) stepper motor.

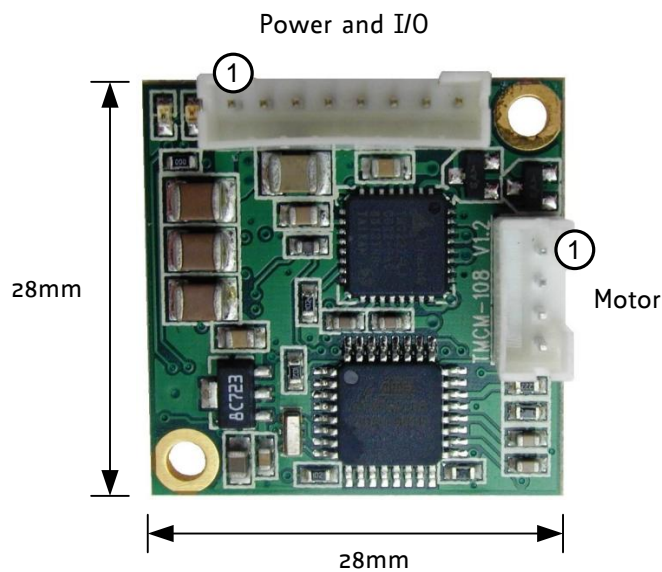


Figure 4.1: Top side of the board with connectors (all values in mm).

## 4.2 Size of unit

Currently, there is a choice between two 28mm stepper motors of different lengths and different torques. Please also refer to the manuals of the related stepper motors QSH2818-32-07-006 and QSH2818-51-07-012.

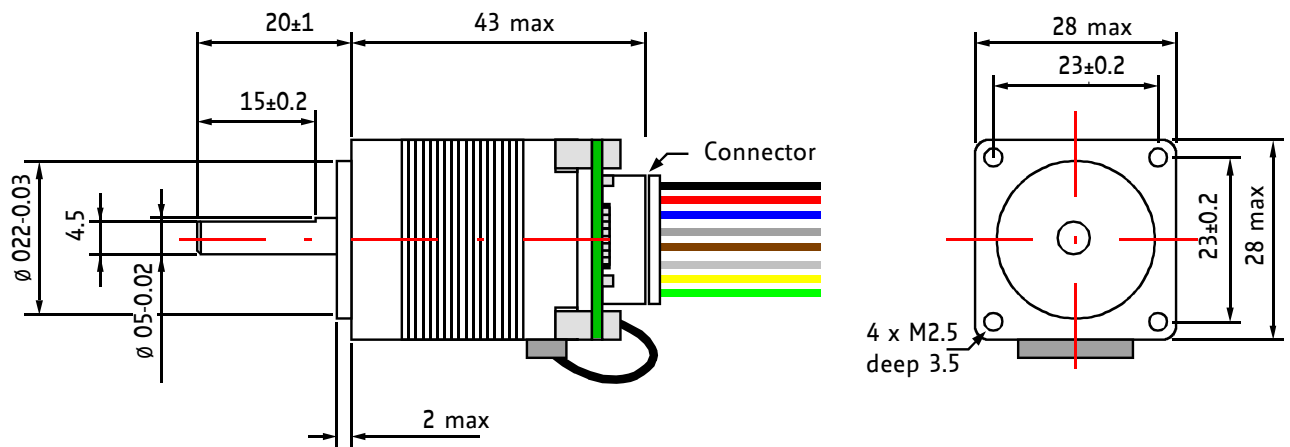


Figure 4.2: PD1-108-28-SE-485 with 2-phase 28mm stepper motor QSH2818-32-07-006

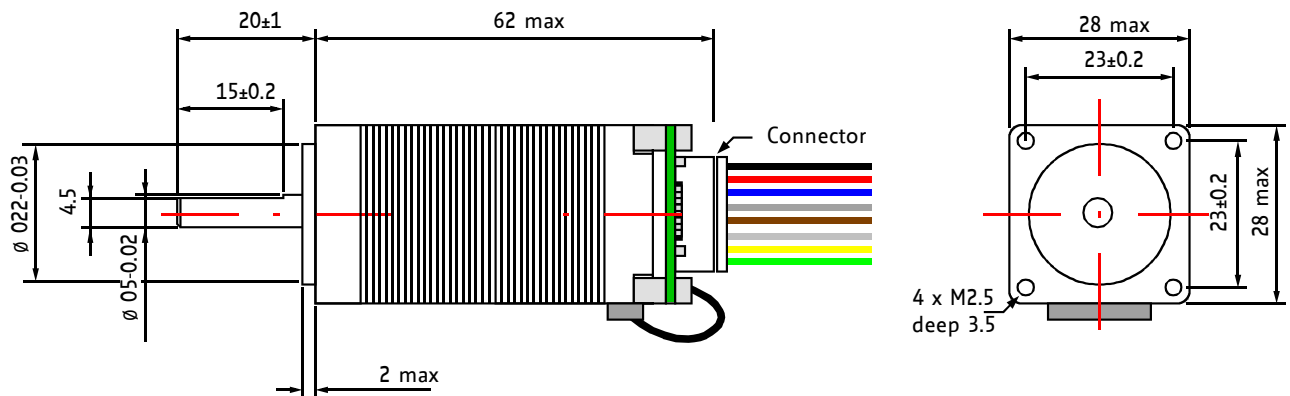


Figure 4.3: PD3-108-28-SE-485 with 2-phase 28mm stepper motor QSH2818-51-07-012

## 4.3 Torque curves

### 4.3.1 PD1-108-28-SE-485

Please find below the pull-out torque curve for the PDx-108-28-SE-485 integrated motor / electronics unit. The speed (x-axis) is defined as full steps per second. As the integrated motor offers 200 full steps per rotation, e.g. 200 full steps per second is equivalent to one rotation per second (rps) or 60 rotations per minute (rpm).

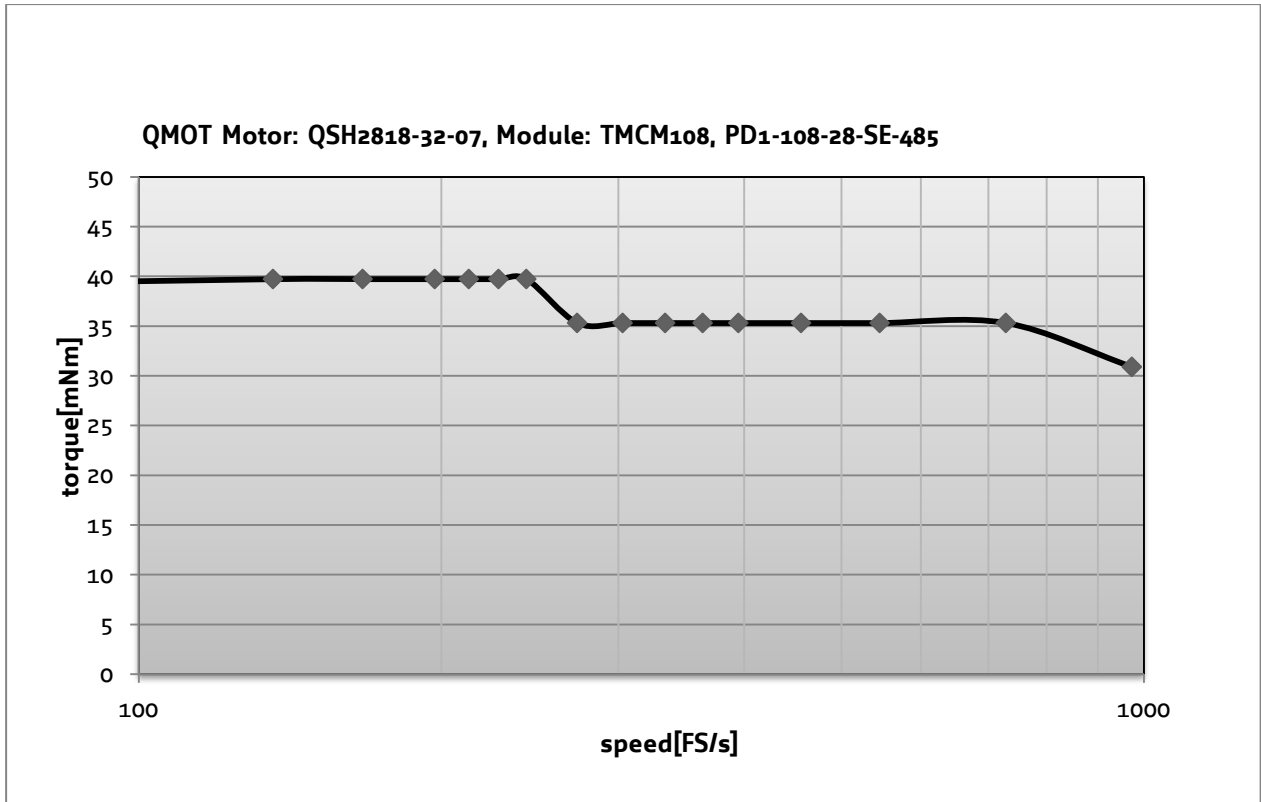


Figure 4.4: Torque curve for PD1-108-28-SE-485



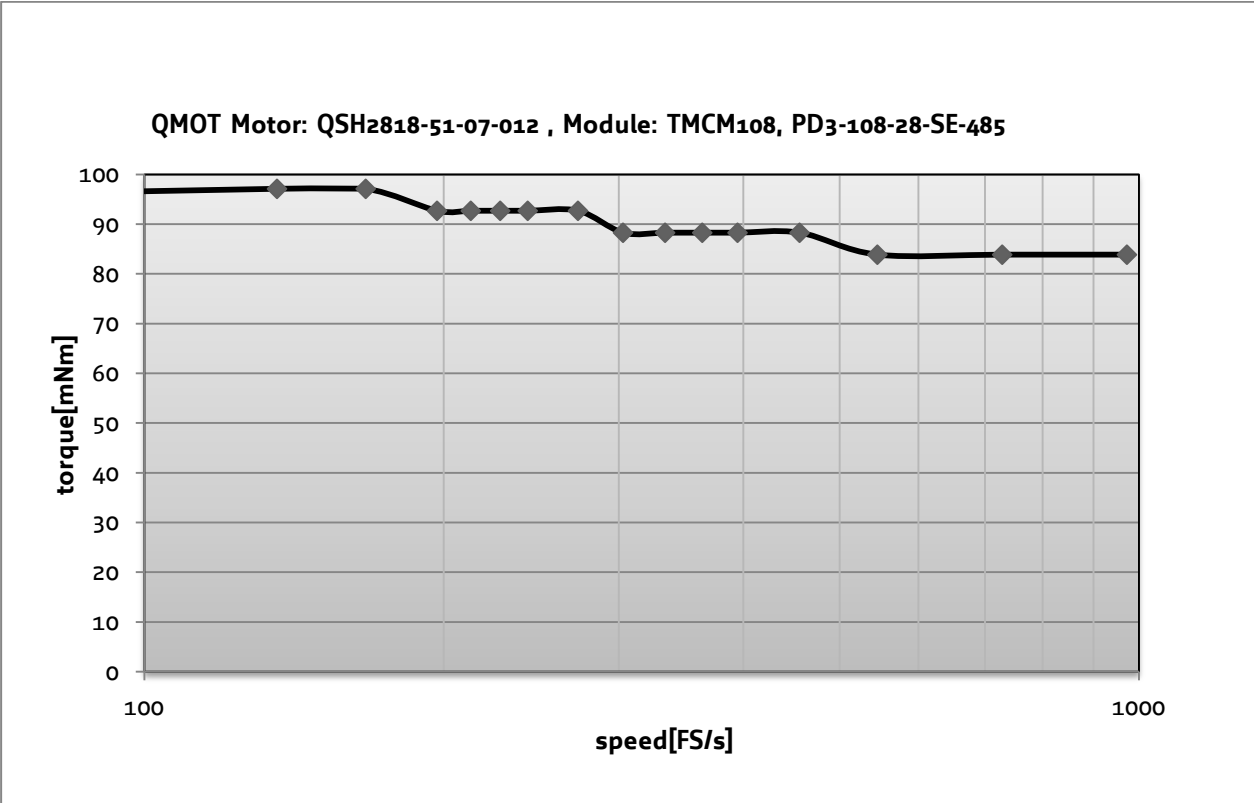
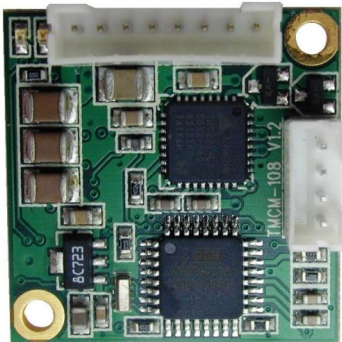


Figure 4.5: Torque curve for PD3-108-28-SE-485

## 4.4 Connectors

Due to the size of the module the space for connectors is rather limited. The PDX-108-28-SE-485 provides just one connector with 8 pins for power, communication and general purpose inputs and outputs. A second connector with 4 pins is used internally for connecting the motor wires.



**Table 4.1: Connectors**

Overview of connector and mating connector types:

Label	Connector type	Mating connector types
Power, communication, and I/O	CI0108P1VK0-LF CVIlux CI01 series, 8pins, 2mm pitch	Connector housing CVIlux: CI01085000-A Contacts CVIlux: CI01T011PE0-A <i>or</i> Connector housing JST: PHR-8 Contacts JST: SPH-002T-P0.5S Wire: 0.22mm <sup>2</sup>
Motor	CI0104P1VK0-LF CVIlux CI01 series, 4 pins, 2mm pitch	Connector housing CVIlux: CI01045000-A Contacts CVIlux: CI01T011PE0-A <i>or</i> Connector housing JST: PHR-4 Contacts JST: SPH-002T-P0.5S Wire: 0.22mm <sup>2</sup>

**Table 4.2: Connectors and mating connectors, contacts and applicable wire**

### 4.4.1 Power and I/O connector

An 8-pin 2mm pitch single row connector is used on the board.





	Pin	Label	Direction	Description
	1	GND	Power (GND)	GND
	2	VDD	Power (Supply)	VDD (+9V...+28V)
	3	RS485 A	Bidirectional	RS-485 interface (+)
	4	RS485 B	Bidirectional	RS-485 interface (-)
	5	GPI0	Input	Digital (0..+5V, up to +/-28V), analog (0..+5V)
	6	GPI1	Input	Digital (0..+5V, up to +/-28V), analog (0..+5V)
	7	GPO0	Output	Open collector, max. , 150mA
8	GPO1	Output	Open collector, max. , 150mA	

**Table 4.3: Power and I/O connector**

### 4.4.1.1 Power supply

For proper operation care has to be taken with regard to power supply concept and design. Due to space restrictions the PDx-108-28-SE-485 electronics includes just about 30µF/35V of supply filter capacitors. These are ceramic capacitors which have been selected for high reliability and long life time.

**CAUTION!**

	<p><b>Add external power supply capacitors!</b></p> <p>It is recommended to connect an electrolytic capacitor of significant (e.g. 470µF/35V) size (e.g. 470µF/35V) to the power supply lines next to the PD-108!</p> <p>Rule of thumb for size of electrolytic capacitor: <math>c = 1000 \frac{\mu F}{A} \times I_{SUPPLY}</math></p> <p>In addition to power stabilization (buffer) and filtering this added capacitor will also reduce any voltage spikes which might otherwise occur from a combination of high inductance power supply wires and the ceramic capacitors. In addition it will limit slew-rate of power supply voltage at the module. The low ESR of ceramic-only filter capacitors may cause stability problems with some switching power supplies.</p>
	<p><b>Do not connect or disconnect motor during operation!</b></p> <p>Motor cable and motor inductivity might lead to voltage spikes when the motor is disconnected / connected while energized. These voltage spikes might exceed voltage limits of the driver MOSFETs and might permanently damage them. Therefore, always disconnect power supply before connecting / disconnecting the motor.</p>
	<p><b>Keep the power supply voltage below the upper limit of 28V!</b></p> <p>Otherwise the driver electronics will seriously be damaged! Especially, when the selected operating voltage is near the upper limit a regulated power supply is highly recommended. Please see also chapter 6, operating values.</p>
	<p><b>There is no reverse polarity protection!</b></p> <p>The module will short any reversed supply voltage due to internal diodes of the driver transistors.</p>

### 4.4.2 Motor connector

The motor connector is used internally for connecting the four motor wires to the electronics.



	Pin	Label	Direction	Description
	1	OA1	Output	Pin 1, motor coil 1
	2	OA2	Output	Pin 2, motor coil 2
	3	OB1	Output	Pin 1, motor coil 1
4	OB2	Output	Pin 2, motor coil 2	

Table 4.4: Motor connector

**CAUTION!**

	<p><b>Keep the electronics free of (metal) particles!</b></p> <p>The integrated sensOstep™ encoder uses a magnet at the end of the motor axis in order to monitor position. The magnet naturally attracts especially tiny metal particles. These particles might be held on the top side of the PCB and even worse – start moving in accordance with the rotating magnetic field as soon as the motor starts moving. This might lead to shorts of electronic contacts / wires on the board and totally erratic behavior of the module! Use compressed air for cleaning the module if necessary.</p>
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## 4.5 Inputs and outputs

### 4.5.1 RS485

For remote control and communication with a host system the PDx-108-28-SE-485 provides a two wire RS485 bus interface. For proper operation the following items should be taken into account when setting up an RS485 network:

#### BUS STRUCTURE:

The network topology should follow a bus structure as closely as possible. That is, the connection between each node and the bus itself should be as short as possible. Basically, it should be short compared to the length of the bus.

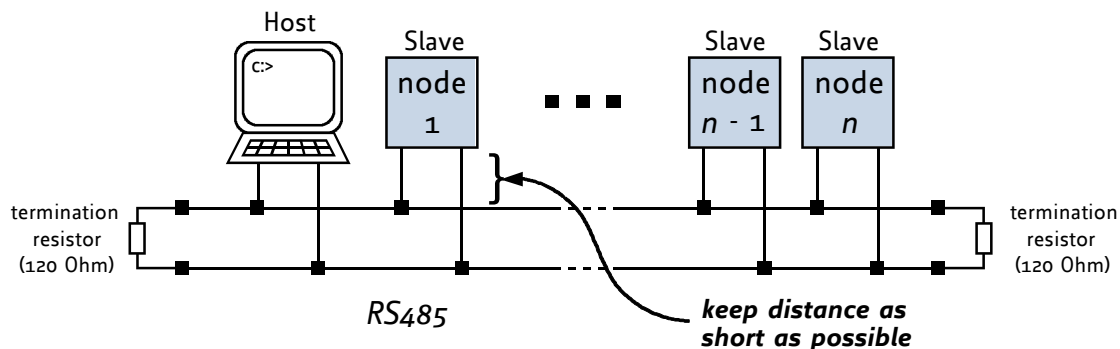


Figure 4.6: Bus structure

#### BUS TERMINATION:

Especially for longer busses and/or multiple nodes connected to the bus and/or high communication speeds, the bus should be properly terminated at both ends of the bus. The PDx-108-28-SE-485 integrates a 120 Ohm termination resistor that is placed between both RS485 bus wires by shortening two soldering pads (e.g. soldering dot or zero Ohm SMD resistor (0603)) on the pcb as shown below.

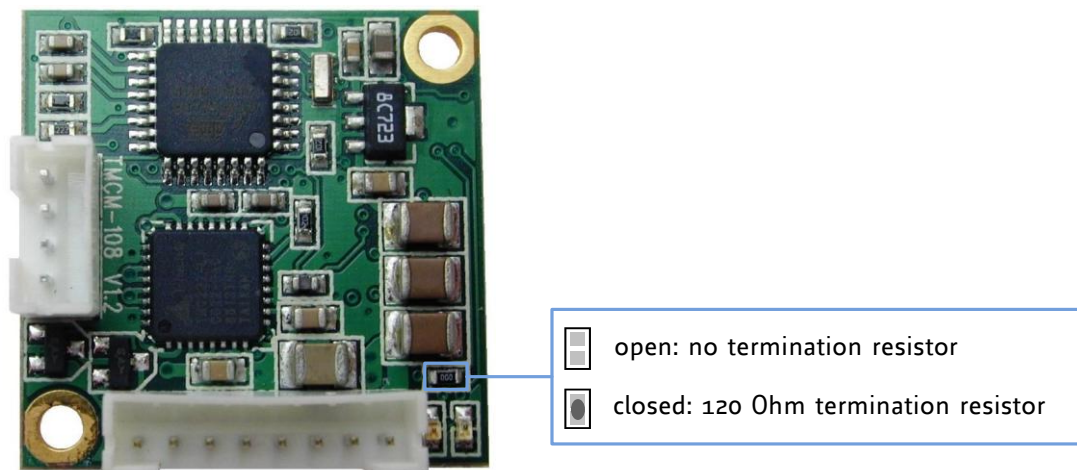


Figure 4.7: RS485 termination

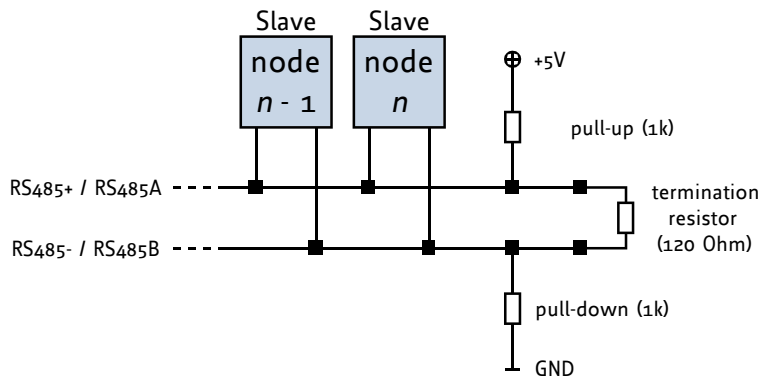
As default a zero Ohm resistor is assembled in order to activate 120 Ohm line termination on-board. This will simplify set-up in case the PDx-108-SE-485 is connected as last / first node in an RS485 network as there is no additional termination resistor necessary. Nevertheless, in any other case (e.g. separate bus termination, unit placed somewhere in the middle of the bus, several PDx-108-28-485 connected together) please make sure the zero Ohm resistor will be removed for proper RS485 operation!

**NUMBER OF NODES:**

The RS-485 electrical interface standard (EIA-485) allows up to 32 nodes to be connected to a single bus. The bus transceiver used for the PDX-108-28-SE units (SN65HVD485ED) has just half of the standard bus load and allows a maximum of 64 units to be connected to a single RS485 bus.

**NO FLOATING BUS LINES:**

Avoid floating bus lines while neither the host/master nor one of the slaves along the bus line is transmitting data (all bus nodes switched to receive mode). Floating bus lines may lead to communication errors. In order to ensure valid signals on the bus it is recommended to use a resistor network connecting both bus lines to well defined logic levels. In contrast to the termination resistors this network is normally required just once for a bus. Certain RS485 interface converters available for a PC already include these additional resistors (e.g. USB-2-485).



**Figure 4.8: Bus lines with resistor network**

### 4.5.2 General purpose inputs

The eight pin connector of the PDx-108-28-SE provides two general purpose inputs. These two inputs can be programmed in order to accept digital signals as well as analogue signals.

Both inputs are protected with 10k series resistors together with limiting diodes against voltages below 0V (GND) and above +5V DC.

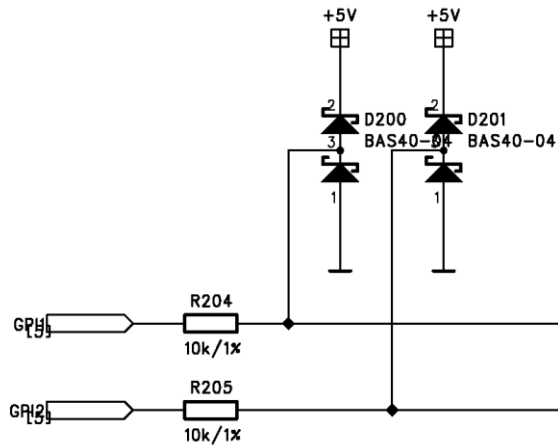


Figure 4.9: General purpose inputs

### 4.5.3 General purpose outputs

The eight pin connector of the PDx-108-28-SE provides two general purpose outputs. These two outputs are open-collector outputs and can sink up to 150mA each. The N-channel MOSFET transistors used [BSS123] can withstand voltages up to 100V at the outputs when switched off. Nevertheless, the voltages should be normally limited to the supply voltage of the unit.

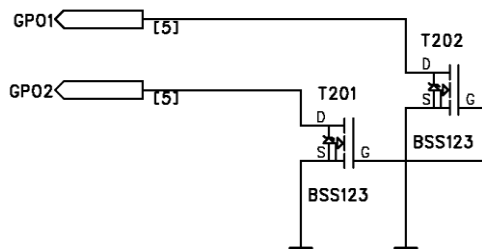


Figure 4.10: General purpose outputs

Attention: Please make sure to add external freewheeling diodes when connecting an inductive load (relays etc.).

## 5 Functional description

The PDx-108-28-SE-485 is a full mechatronic solution including a 28mm flange (NEMA11) bipolar stepper motor. It includes the controller/driver electronics, a sensOstep™ encoder and two different motors of different length and torque.

The PDx-108-28-SE-485 can be controlled via RS485 serial interface. The power supply, interface and the multipurpose I/Os can be connected via single small connectors.

The PDx-108-28-SE-485 comes with the PC based software development environment TMCL-IDE for the Trinamic Motion Control Language (TMCL™). Using predefined TMCL™ high level commands like *move to position* a rapid and fast development of motion control applications is guaranteed. Please refer to the PDx-108-28-SE-485 Firmware Manual for more information about TMCL™ commands.

Communication traffic is kept low since all time critical operations, e.g. ramp calculation are performed on board. Full remote control of device with feedback is possible. The firmware of the module can be updated via the serial interface.

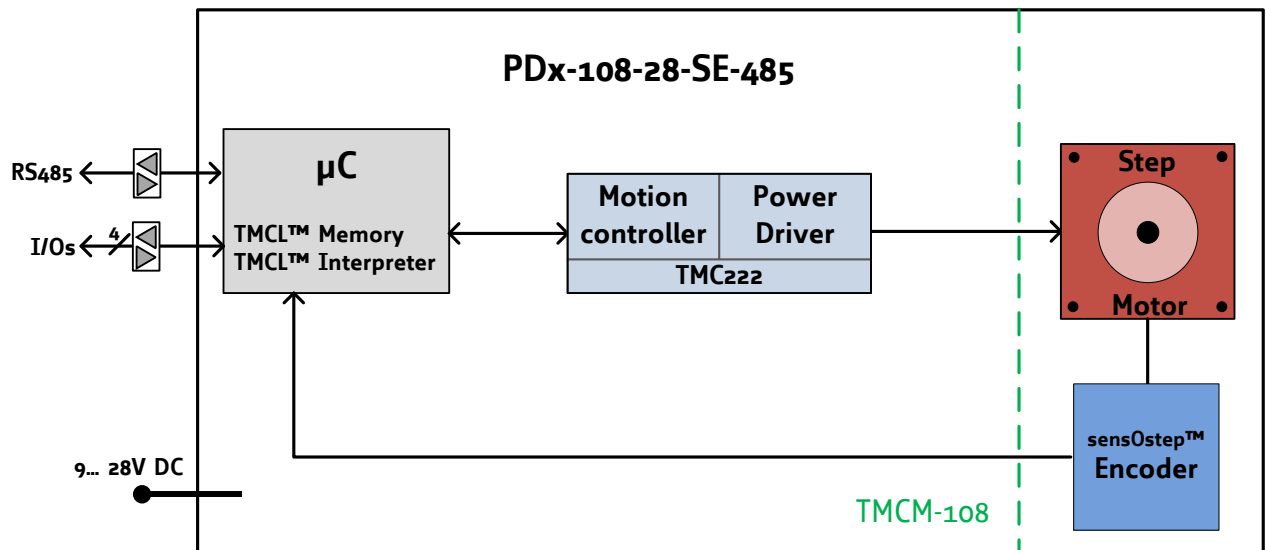


Figure 5.1: Main parts of PDx-108-28-SE-485

## 6 Operational ratings

The operational ratings show the intended or the characteristic ranges and should be used as design values. ***In no case shall the maximum values be exceeded.***

Symbol	Parameter	Min	Typ	Max	Unit
$V_{cc}$	Power supply voltage for operation	9	12... 24	28	V
$I_{COIL}$	Motor coil current for sine wave <b>peak</b> (chopper regulated, adjustable via software)	0		800	mA
$I_{MC}$	Continuous motor current ( <b>RMS</b> )	0		560	mA
$f_{CHOP}$	Motor chopper frequency	18	20	22	kHz
$I_s$	Power supply current		$\ll I_{COIL}$	$1.4 * I_{COIL}$	A
$T_{ENV}$	Environment temperature at rated current (no forced cooling required)	-40		45	°C
	Environment temperature at 80% of rated current or 50% duty cycle (no forced cooling required)	-40		60	°C

**Table 6.1: General operational ratings of the module**

Symbol	Parameter	Min	Typ	Max	Unit
$V_{GPO\ 0/1}$	Voltage at open collector output	0		$+V_{cc}$	V
$I_{GPO\ 0/1}$	Output sink current			150	mA
$V_{GPI\_digital\ 0/1}$	Input voltage for GPIO and GPI1 when used as digital input	$-V_{cc}$		$+V_{cc}$	V
$V_{GPI\_digital\_L\ 0/1}$	Low level voltage for GPIO and GPI1 when used as digital input	$-V_{cc}$		1,5	V
$V_{GPI\_digital\_H\ 0/1}$	High level voltage for GPIO and GPI1 when used as digital input	3		$+V_{cc}$	V
$V_{GPI\_analogue\ 0/1}$	Measurement range for GPIO and GPI1 when used as analogue input		0... +5		V

**Table 6.2: Operational ratings of the general purpost I/Os**

Symbol	Parameter	Min	Typ	Max	Unit
$N_{RS485}$	Number of nodes connected to single RS485 network			64	

**Table 6.3: Operational ratings of the RS485 interface**



## 7 Revision History

### 7.1 Hardware revision

Version	Date	Description
1.00	2007-JAN-19	Initial release
1.10	2007-OCT-22	Electrolytic capacitor has been replaced by ceramic capacitors
1.20	2008-JUN-16	Soldering holes for motor wires have been replaced by JST connector

Figure 7.1: Hardware revision

### 7.2 Document revision

Version	Date	Author GE – Göran Eggers SD – Sonja Dwersteg	Description
0.90	2007-JAN-12	GE	Initial version
0.91	2007-SEP-06	GE	Major update
0.92	2008-MAR-27	GE	TMCL™ support added
0.93	2008-JUN-23	GE	RS485 pin assignment corrected + TMCL™ standalone support
0.94	2008-SEP-01	GE	Separate hardware and TMCL™ firmware manuals
1.00	2010-MAY-31	SD	Minor corrections. Torque measurement for PD3-108-28- Se-485 added
1.01	2011-MAR-02	SD	New front page
1.02	2011-MAR-07	SD	Minor changes
1.03	2011-NOV-25	SD	Order codes new, design actualized, minor changes.
1.04	2011-DEC-05	SD	Dimensions of PANdrives corrected.
1.05	2013-JUL-26	SD	Connector types and information about power supply updated.

Figure 7.2: Document revision

## 8 References

[QSH2818-32-07-006]	NEMA11 / 28mm bipolar stepper motor used in PD1
[QSH2818-51-07-012]	NEMA11 / 28mm bipolar stepper motor used in PD3
[USB-2-485]	USB-2-485 interface converter
[BSS123]	N-Channel Logic Level Enhancement Mode Field Effect Transistor (Fairchild Semiconductor <a href="http://www.fairchildsemi.com/">http://www.fairchildsemi.com/</a> )
[TMC222]	TMC222 datasheet

TRINAMICs manuals are available on <http://www.trinamic.com>.