

## 特長



- 28mm□モーター同等基板サイズ。
- クローズドループステップパルスジェネレータ + ドライバ機能内蔵 脱調レス制御
- 動作プログラム保持機能、 On the fly 動作
- 28V 0.7Arms 256μステップ & spreadCycle 低振動

## 仕様

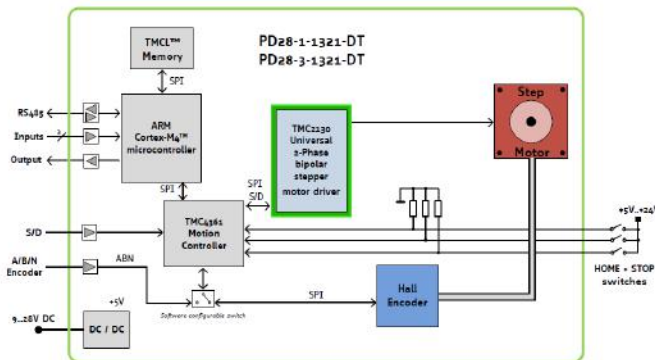
TMCM-1321	
軸数	1
電圧	10~24V
電流(rms)	0.67A
マイクロステップ	1~256
サイズ	28x28mm

インターフェース	
RS485	✓
CAN	
USB	
EtherCAT	
STEPパルス入力	✓
SPI	
UART	
GPIO	

機能	
ABNエンコーダ	✓
クローズドループ	✓
spreadCycle	✓
stealthChop	
stallGuard2	✓
coolStep	✓
dcStep	

機能	
sixPont制御	
S字制御	
台形制御	✓
microPlyer	
dcStep	
Passive breaking	
Programmable Microstep table	

## ソフトウェア&ブロック



ソフトウェア	
TMCL	✓
CANopen	
CoE	

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Hardware Version V 1.20 (Prototypes)

# HARDWARE MANUAL



## TMCM-1321-DT

1-Axis stepper  
Closed Loop controller/driver  
max. 0.7A RMS / 24V DC  
RS485



**stallGuard<sup>2</sup>**

TRINAMIC Motion Control GmbH & Co. KG  
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# 1 Life support policy

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Specifications are subject to change without notice.



## 2 Features

The TMCM-1321-DT is a single axis stepper motor controller and driver board with RS485 interface. It has been designed in order to be mounted on the rear side of a NEMA11 (28mm flange size) stepper motor and offers an integrated hall-sensor based encoder IC for (optional) closed loop operation. In addition to the on-board encoder the TMCM-1321-DT offers an A/B/N incremental encoder interface for an external encoder (e.g. motor mounted optical encoder) which can be used instead of the on-board encoder IC for closed loop operation (selectable in software). The module supports motor currents up to 0.7A RMS and supply voltages up to 24V DC nominal.

### MAIN CHARACTERISTICS

#### Motion controller

- Motion profile calculation in real-time
- On the fly alteration of motor parameters (e.g. position, velocity, acceleration)
- High performance microcontroller for overall system control and serial communication protocol handling

#### Bipolar stepper motor driver

- Up to 256 microsteps per full step
- High-efficient operation, low power dissipation
- Dynamic current control
- stallGuard2™ feature for stall detection

#### Interfaces

- RS485 2-wire communication interface
- Incremental A/B/N encoder interface for external encoder (e.g. motor mounted optical encoder), can be selected in software instead of the on-board hall-sensor based encoder IC for closed loop operation.
- Dedicated HOME, STOP\_L and STOP\_R inputs
- 1 open-drain output

#### Software

- TMCL™ remote (direct mode) and standalone operation with memory for up to 1024 TMCL commands
- Closed-loop support with integrated hall-sensor encoder IC
- Fully supported by TMCL-IDE (PC based integrated development environment)

#### Electrical data

- Supply voltage: +10V... +24V DC
- Motor current: up to 0.7A RMS (programmable)

#### Mechanical data

- Board size: 28mm x 28mm, overall height 9mm max. (without mating connectors and cables)
- Alignment holes for NEMA11 stepper motors (for mounting the board to the rear side of one of these stepper motors)

### 3 Order codes

The TMC-1321-DT is available as :

Order code	Description	Size of unit
PD28-1-1321-DT	1-Axis stepper driver, closed loop support, 0.7A RMS, 24V DC with NEMA11 stepper motor, 0.06Nm holding torque	28mm x 28mm x 52mm (overall without mating connectors)
PD28-3-1321-DT	1-Axis stepper controller / driver, closed loop support, linear ramps, 0.7A RMS, 24V DC with NEMA11 stepper motor, 0.12Nm holding torque	28mm x 28mm x 81mm (overall without mating connectors)

**Table 3.1: TMC-1321-DT mounted on NEMA11 stepper motor order codes**

A cable loom set is available for this module, also:

Order code	Description
TMC-1321-CABLE	Cable loom for TMC-1321-DT. Contains (see chapter 4.3, also): <ul style="list-style-type: none"> <li>- 1x cable loom for power, RS485 and I/O connector</li> <li>- 1x cable loom for external A/B/N encoder connector</li> </ul>

**Table 3.2: Cable loom order code**

## 4 Mechanical and Electrical Interfacing

### 4.1 Dimensions and Mounting Holes

The dimensions of the board are approx. 28mm x 28mm x 9 mm in order to fit on the back side of a 28mm (NEMA11) stepper motor. Maximum component height (height above PCB level) without mating connectors is around 6mm above PCB level and 2 mm below PCB level. There are two mounting holes for M2.5 screws for mounting to a NEMA11 stepper motor. There are additionally 2 alignment holes, approx. 15mm apart (see Figure 4.1) for NEMA11 stepper motors. With alignment holes at the same locations in the back bell of the stepper motor the use of adjustment pins will help to optimize the placement of the pcb and especially the on-board hall sensor based encoder IC relative to the center of the magnet at the back-end of the motor axis. This is vital for optimum performance of the integrated halls sensor based encoder.

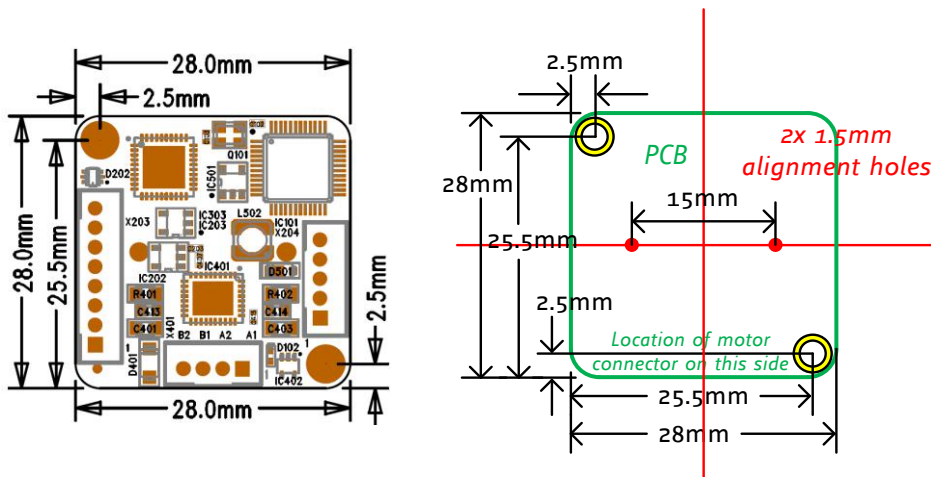


Figure 4.1 Dimensions of TCM-1321-DT, position of alignment and mounting holes

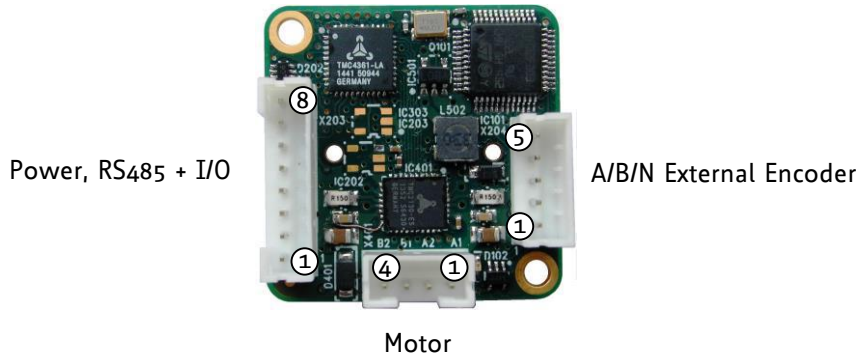
### 4.2 Board mounting considerations

The TCM-1321-DT offers two metal plated mounting holes. Both mounting holes are connected to board supply ground. Please keep this in mind when mounting the board to the rear side of a motor.



### 4.3 Connectors

The TMCM-1321-DT offers three connectors including the motor connector which is used for attaching the motor coils to the electronics. The Power, RS485 and I/O connector is used for power supply and RS485 serial wire communication. Furthermore, this connectors includes dedicated inputs for HOME, STOP\_L and STOP\_R switch connections and one general purpose open-drain output. In addition to the on-board hall sensor based encoder IC the TMCM-1321-DT offers an interface for an external incremental ABN encoder, also.



**Figure 4.2 Overview connectors**


Overview of connectors and mating connectors types:

Label	Connector type	Mating connector type
Power, RS485 + I/O	JST B8B-PH-K-S (JST PH series, 8pins, 2mm pitch)	Connector housing: JST PHR-8 Contacts: JST SPH-002T-Po.5S Wire: 0.22mm <sup>2</sup> , AWG 24
Motor	JST B4B-PH-K-S (JST PH series, 4pins, 2mm pitch)	Connector housing: JST PHR-4 Contacts: JST SPH-002T-Po.5S Wire: 0.22mm <sup>2</sup> , AWG 24
A/B/N External Encoder	JST B5B-PH-K-S (JST PH series, 5pins, 2mm pitch)	Connector housing: JST PHR-5 Contacts: JST SPH-002T-Po.5S Wire: 0.22mm <sup>2</sup> , AWG 24

**Table 4.1: Connectors and mating connectors, contacts and applicable wire**

### 4.3.1 Power, RS485 + I/O connector

The module offers a combined power, RS485 2-wire serial communication and I/O connector (JST PH series).



Pin	Label	Direction	Description
1	GND	Power (GND)	Common system supply and signal ground
2	VDD	Power (Supply input)	Supply voltage.
3	RS485+	Bidirectional	RS485 interface, diff. signal (non-inverting)
4	RS485-	Bidirectional	RS485 interface, diff. signal (inverting)
5	OUT_o	Output	General purpose open-drain output o (SIO o, 2, o/1 // <a href="#">set output o</a> )
6	HOME, IN_o	Input	Home / Reference switch input
			Alternate function 1: general purpose input o (GIO o, o // <a href="#">get logic level of input o</a> )
7	STOP_L, IN_1	Input	Left stop switch input
			Alternate function 1: general purpose input 1 (GIO 1, o // <a href="#">get logic level of input 1</a> )
8	STOP_R, IN_2	Input	Right stop switch input
			Alternate function 1: general purpose input 2 (GIO 2, o // <a href="#">get logic level of input 2</a> )

**Table 4.2: Power, RS485 + I/O connector**

*Please note:*

- RS485: there is no line termination etc. on-board. Please ensure proper RS485 cabling and line termination.
- Digital inputs: all inputs have pull-down resistors, input series resistors and protection diodes. This way inputs are protected for voltages up-to nom. +24V. The pull-down resistors also ensure a valid (low) level when left unconnected.
- Output: open-drain output supporting sink currents of up-to 100mA. It offers an integrated pull-down resistor (47k) to GND in order to ensure stable and valid logic levels (GND) without additional external components when not activated. The output includes a free-wheeling diode to VDD supply voltage (e.g. for inductive loads).

#### CAUTION

**Always keep the power supply voltage (VDD) below the upper limit of 28V!**

Otherwise the driver electronics will be seriously damaged. Especially, when the selected operating voltage is near the upper limit a regulated power supply is highly recommended.

### 4.3.2 Motor connector

As motor connector a 4pin JST EH-series 2.5mm pitch single row connector is available. The motor connector is used for connecting the four motor wires of the two motor coils of the bipolar stepper motor to the electronics.


	Pin	Label	Direction	Description
	1	OA1	Output	Pin 1 of motor coil A
	2	OA2	Output	Pin 2 of motor coil A
	3	OB1	Output	Pin 1 of motor coil B
	4	OB2	Output	Pin 2 of motor coil B

Table 4.4: Motor connector

<b>CAUTION</b>
<i><b>Do not connect or disconnect motor while driver stage is active and supplies current to the motor as this might permanently damage the driver stage!</b></i>

### 4.3.3 A/B/N External Encoder connector

For connection of an external incremental A/B/N encoder a 5pin JST PH-series 2mm pitch single row connector is available. This connector offers +5V supply (max. 100mA) for an external encoder and accepts either +5V TTL or open-collector signals as standard. The external encoder may be used as an alternative to the on-board hall sensor based encoder IC. Selection of encoder can be done in software.


	Pin	Label	Direction	Description
	1	GND	Power (GND)	System and signal ground
	2	+5V_OUT	Power (Supply out)	+5V output from on-board DC/DC converter. May be used in order to supply +5V to an external encoder. Up-to 100mA may be drawn from this output
	3	ENC_A	Input	Incremental encoder channel A input (internal 4k7 pull-up resistor to +5V)
	4	ENC_B	Input	Incremental encoder channel B input (internal 4k7 pull-up resistor to +5V)
	5	ENC_N	Input	Incremental encoder Null/Zero/Index channel input (internal pull-up resistor to +5V)

Table 4.5: A/B/N External Encoder connector

## 4.4 Power supply

For proper operation care has to be taken with regard to power supply concept and design. Due to space restrictions the TMCM-1321-DT includes about 20µF/35V of supply filter capacitors. These are ceramic capacitors which have been selected for high reliability and long life time. The module includes a 24V suppressor diode for over-voltage protection.

<b>CAUTION</b>
<i><b>Add external power supply capacitors!</b></i>
It is recommended to connect an electrolytic capacitor of significant size (e.g. 470µF/35V) to the power supply lines next to the TMCM-1321-DT!
Rule of thumb for size of electrolytic capacitor: $c = 1000 \frac{\mu F}{A} \times I_{SUPPLY}$

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.

***Do not connect or disconnect motor during operation!***

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.

***Keep the power supply voltage below the upper limit of 28V!***

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 7, operating values.

***There is no reverse polarity protection!***

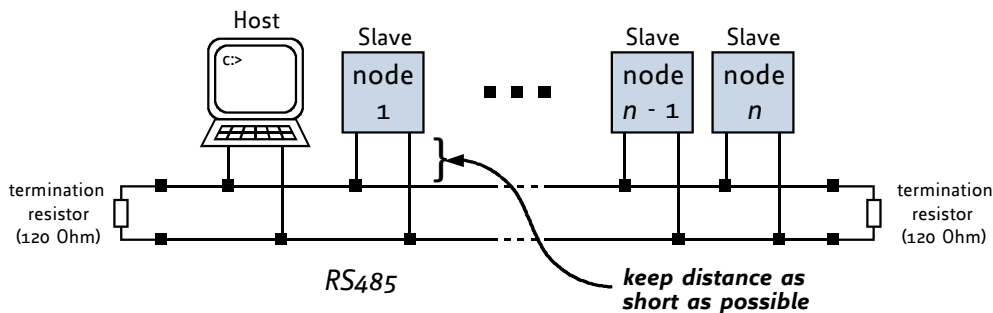
The module will short any reversed supply voltage due to internal diodes of the driver transistors.

## 4.5 RS485

For remote control and communication with a host system the TMCM-1321-DT provides a two wire RS485 bus interface. For proper operation the following items should be taken into account when setting up an RS485 network:

1. **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**

2. **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. The TMCM-1321-DT does not integrate any termination resistor. Therefore, 120 Ohm termination resistors at both ends of the bus have to be added externally.

3. **NUMBER OF NODES:**

The RS485 electrical interface standard (EIA-485) allows up to 32 nodes to be connected to a single bus. The bus transceivers used on the TMCM-1321-DT units (SN65HVD1781D) have a significantly reduced bus load and allow a maximum of 255 units to be connected to a single RS485 bus using TMCL firmware. *Please note: usually it cannot be expected to get reliable communication with the maximum number of nodes connected to one bus and maximum supported communication speed at the same time. Instead, a compromise has to be found between bus cable length, communication speed and number of nodes.*

4. **COMMUNICATION SPEED:**

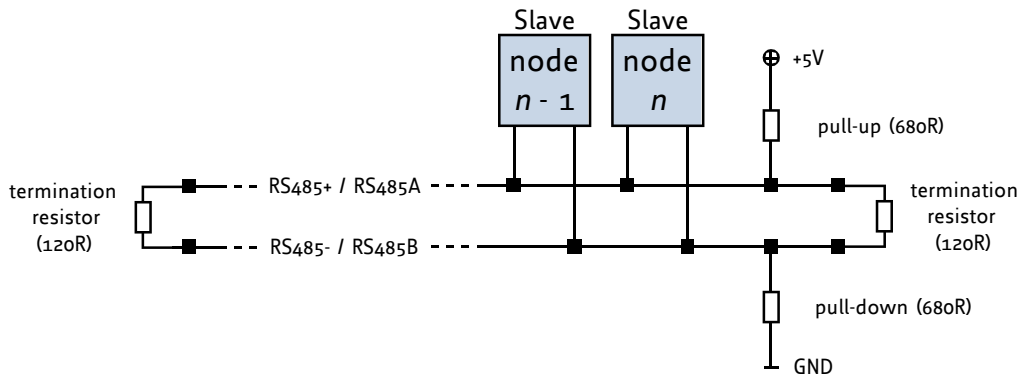
The maximum RS485 communication speed supported by the TMCM-1321-DT hardware is 1Mbit/s. Factory default is 9600 bit/s. *Please see separate TMCM-1321-DT TMCL firmware manual for information regarding other possible communication speeds below the upper limit in hardware.*

5. **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.

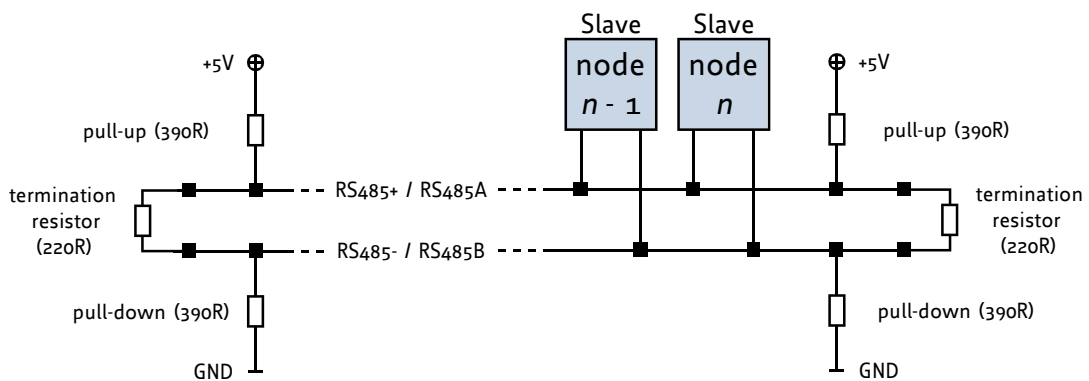
There are actually two options which can be recommended:

Add resistor (Bias) network on **one** side of the bus, only (120R termination resistor still at **both** ends):



**Figure 4.7: Bus lines with resistor (Bias) network on one side, only**

Or add resistor (Bias) network at **both** ends of the bus (like Profibus™ termination):



**Figure 4.8: Bus lines with resistor (Bias) network at both ends**

Certain RS485 interface converters available for PCs already include these additional resistors (e.g. USB-2-485 with bias network at one end of the bus).

## 5 Motor driver current

The on-board stepper motor driver operates current controlled. The driver current may be programmed in software with 32 effective scaling steps in hardware.

Explanation of different columns in table below:

**Motor current setting in software (TMCL)** These are the values for TMCL axis parameter 6 (motor run current) and 7 (motor standby current). They are used to set the run / standby current using the following TMCL commands:

```
SAP 6, 0, <value> // set run current
```

```
SAP 7, 0, <value> // set standby current
```

**Motor current  $I_{RMS}$  [A]** Resulting motor current based on motor current setting

Motor current setting in software (TMCL)	Current scaling step (CS)	Motor current $I_{COIL\_PEAK}$ [A]	Motor current $I_{COIL\_RMS}$ [A]
0..7	0	0.033	0.023
8..15	1	0.066	0.047
16..23	2	0.099	0.070
24..31	3	0.132	0.094
32..39	4	0.165	0.117
40..47	5	0.199	0.140
48..55	6	0.232	0.164
56..63	7	0.265	0.187
64..71	8	0.298	0.211
72..79	9	0.331	0.234
80..87	10	0.364	0.257
88..95	11	0.397	0.281
96..103	12	0.430	0.304
104..111	13	0.463	0.328
112..119	14	0.496	0.351
120..127	15	0.529	0.374
128..135	16	0.563	0.398
136..143	17	0.596	0.421
144..151	18	0.629	0.445
152..159	19	0.662	0.468
160..167	20	0.695	0.491
168..175	21	0.728	0.515
176..183	22	0.761	0.538
184..191	23	0.794	0.562
192..199	24	0.827	0.585
200..207	25	0.860	0.608
208..215	26	0.893	0.632
216..223	27	0.926	0.655
224..231	28	0.960	0.679
232..239	29	0.993	0.702
240..247	30	1.026	0.725
248..255	31	1.059	0.749

## 6 On-Board LEDs

The board offers one LED in order to indicate board status. The function of the LED is dependent on the firmware version. With standard TMCL firmware the green LED should be flashing slowly during operation.

### BEHAVIOR OF LEDs WITH STANDARD TMCL FIRMWARE

Status	Label	Description
Heartbeat	Run	This green LED flashes slowly during operation.

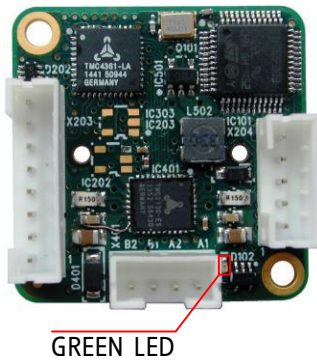


Figure 6.1 On-board LED

## 7 Reset to Factory Defaults

To reset factory defaults please follow instructions below:

1. Switch OFF power supply.
2. Short CLK <-> DIO pin of programming connector.
3. Switch ON power supply (on-board LED should start flashing with increased frequency).
4. Switch OFF power supply.
5. Remove short circuit.

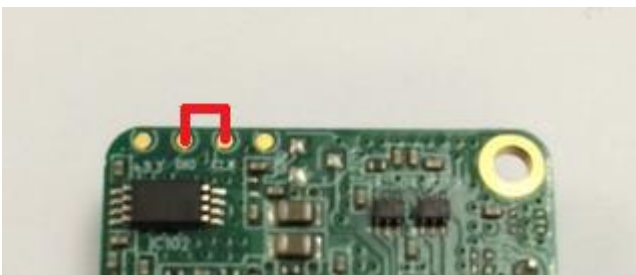


Figure 7.1 Reset to factory defaults



## 8 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
VDD	Power supply voltage for operation	9	12...24	28	V
I <sub>COIL_peak</sub>	Motor coil current for sine wave <b>peak</b> (chopper regulated, adjustable via software)	0		1	A
I <sub>COIL_RMS</sub>	Continuous motor current ( <b>RMS</b> )	0		0.7	A
I <sub>DD</sub>	Power supply current		<< I <sub>COIL</sub>	1.4 * I <sub>COIL</sub>	A
T <sub>ENV</sub>	Environment temperature at rated current (no forced cooling required)	-30		+40	°C

**Table 8.1 General operational ratings of module**

### OPERATIONAL RATINGS OF HOME + STOP SWITCHES

Symbol	Parameter	Min	Typ	Max	Unit
V <sub>HOME/STOP</sub>	Input voltage for HOME/STOP_L/STOP_R	0	0..+5V	+30	V
V <sub>HOME/STOP_LOW</sub>	Low level voltage for HOME/STOP_L/STOP_R (digital inputs)	0		2.6	V
V <sub>HOME/STOP_HIGH</sub>	High level voltage for HOME/STOP_L/STOP_R (digital inputs)	3.7		+30	V

**Table 8.2 Operational ratings of HOME + STOP switches inputs**

### OPERATIONAL RATINGS OF MULTIPURPOSE I/Os

Symbol	Parameter	Min	Typ	Max	Unit
V <sub>OUT_o</sub>	Voltage at open drain output OUT_o	0		VDD*)	V
I <sub>OUT_o</sub>	Output sink current of open drain output OUT_o			100	mA
V <sub>OUT_o</sub>	Voltage at output OUT_o (when switched off and without external load)		0		V
V <sub>IN_o/1/2</sub>	Input voltage for IN_o, IN_1, IN_2	0	0..+24V	+30	V
V <sub>IN_L_o/1/2</sub>	Low level voltage for IN_o, IN_1 and IN_2 (digital inputs)	0		2.6	V
V <sub>IN_H_o/1/2</sub>	High level voltage for IN_o, IN_1 and IN_2 (digital inputs)	3.7		+30	V

**Table 8.3 Operational ratings of I/Os**

*\*) Please note: due to the internal free-wheeling diode the voltage at this input has to be always equal or below the power supply voltage of the module (VDD)*

**OPERATIONAL RATINGS OF A/B/N EXTERNAL ENCODER INPUT**

Symbol	Parameter	Min	Typ	Max	Unit
V <sub>A/B/N</sub>	Input voltage for A/B/N encoder input signals	0	0..+5V	+5.5	V
V <sub>A/B/N_LOW</sub>	Low level voltage for A/B/N encoder input signals (digital inputs)	0		0.8	V
V <sub>A/B/N_HIGH</sub>	High level voltage for A/B/N encoder input signals (digital inputs)	1.5		+5.5	V

**Table 8.4 Operational ratings of HOME + STOP switches**

**OPERATIONAL RATINGS OF RS485 INTERFACE**

Symbol	Parameter	Min	Typ	Max	Unit
N <sub>RS485</sub>	Number of nodes connected to single RS485 network			256	
f <sub>RS485</sub>	Maximum bit rate supported on RS485 connection		9600	1000000	bit/s

**Table 8.5: Operational ratings of RS485 interface**

## 9 Functional Description

The TMC-1321-DT is a highly integrated controller/driver module which can be controlled via several serial interfaces. Communication traffic is kept low since all time critical operations (e.g. ramp calculations) are performed on board. The nominal supply voltage of the unit is 12V or 24V DC. The module is designed for both, standalone operation and direct mode. Full remote control of device with feedback is possible. The firmware of the module can be updated via the RS485 serial interfaces.

In Figure 9.1 the main parts of the PD18-x-1321-DT (TMC-1321-DT incl. stepper motor) are shown:

- microprocessor, which runs the TMCL operating system (connected to TMCL memory),
- motion controller, which calculates ramps and speed profiles internally by hardware,
- power driver with stallGuard2™ and its energy efficient coolStep™ feature and stealthChop™ for extremely quiet operation
- hall sensor based encoder which delivers the required feedback for closed loop operation. As an alternative an external (e.g. optical) incremental encoder may be used instead.

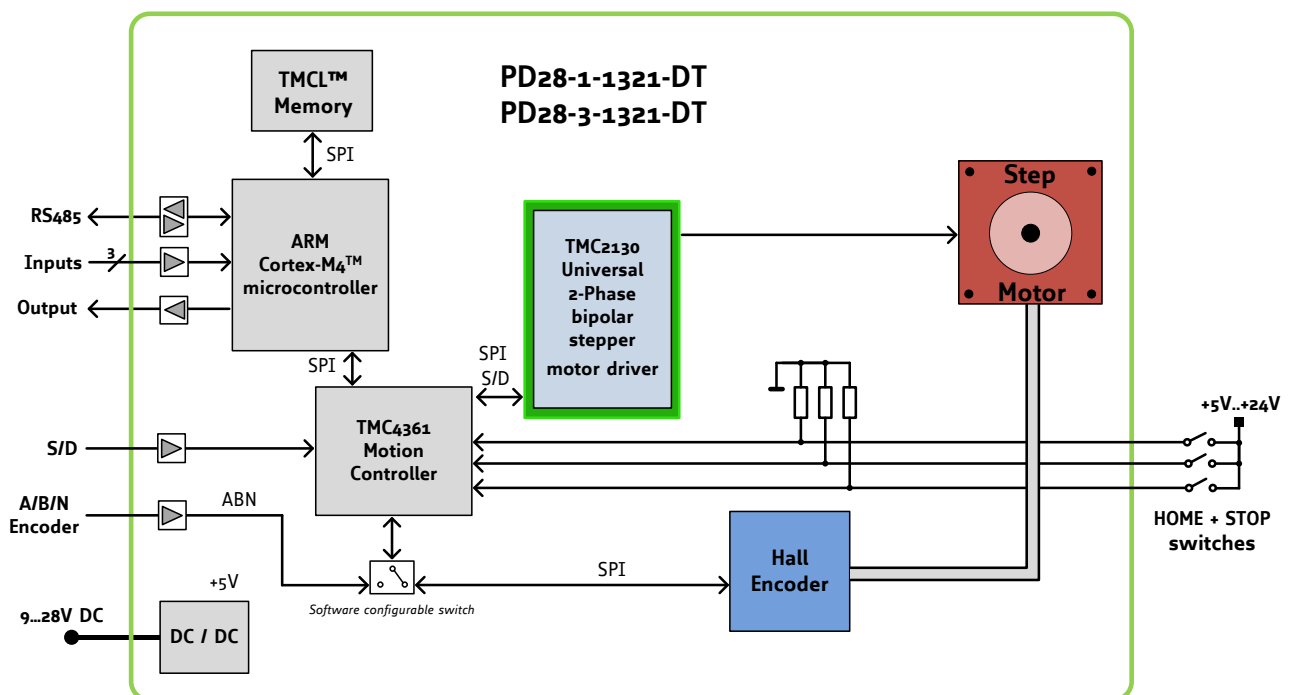


Figure 9.1 Main parts of the TMC-1321-DT + NEMA11 stepper motor

The TMC-1321-DT comes with the PC based software development environment TMCL-IDE for the Trinamic Motion Control Language (TMCM). Using predefined TMCL high level commands like *move to position* a rapid and fast development of motion control applications is guaranteed.

# 10 Revision History

## 10.1 Document revision

Version	Date	Author	Description
0.90	2017-JUL-27	GE	Preliminary version

Table 10.1: Document revision

# 11 References

- [JST] JST connector  
<http://www.jst.com>
- [TMCL-IDE] TMCL-IDE User Manual  
Manual available on <http://www.trinamic.com>.