TRINAMIC PD42-x-1241 Hardware PAN Drive Stepper User Manual

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Introduction

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The PANdrive™PD42-1-1240, PD42-2-1240, PD42-3-1240 and PD42-4-1240 are small and compact full mechatronic solutions including NEMA17 / 42mm flange size stepper motors, the TMCM-1240 controller/driver electronics and TRINAMIC™ sensOstep™ encoder for step-loss detection.

Features

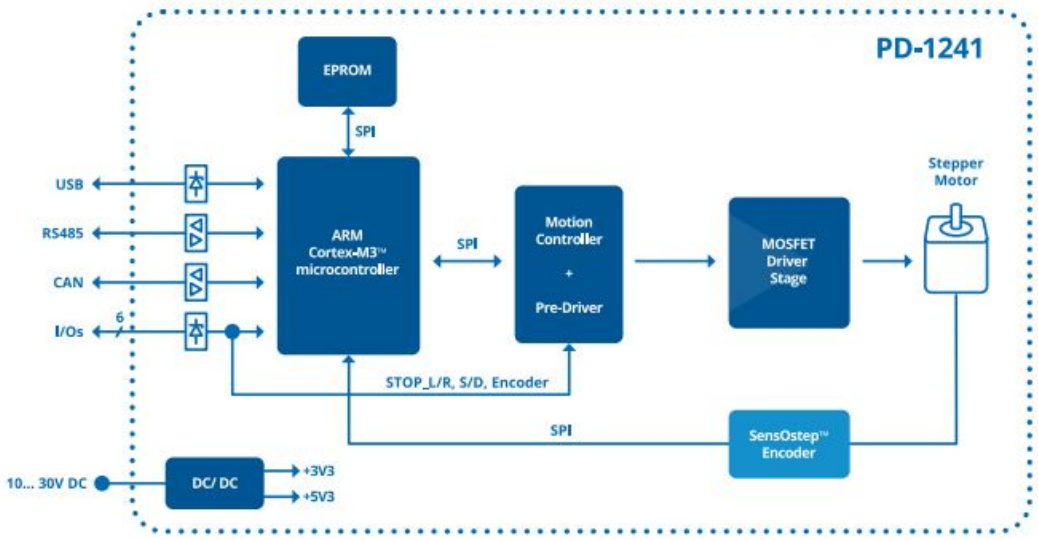
- Stepper Motor NEMA17 / 42mm
- 0.4Nm or 0.8Nm holding torque
- motor optimized for speed (>5k rpm possible @24V supply)
- with controller/driver
- Linear and sixPoint™ ramps
- +10. . . 30V DC supply voltage
- Up to 3A RMS motor current
- RS485, CAN & USB interface
- integrated sensOstep encoder and support for external encoder
- S/D interface
- multi-purpose inputs and outputs
    - Life Science
    - Biotechnology
    - Liquid Handling

Applications

- Laboratory Automation
- Manufacturing
- Semiconductor Handling
- Robotics

- Factory Automation
- Test & Measurement

Simplified Block Diagram



Features

The PANdrive™ PD42-3-1241 and PD42-4-1241 are small and compact full mechatronic solutions including a NEMA17 / 42mm ¸ange size stepper motor of different length and torque, the TMCM-1241 controller/driver electronics and TRINAMIC sensOstep™ encoder for step-loss detection. Both PANdrive includes a stepper motor with high current coil windings (up to 3A RMS) designed especially for higher speed operations (when comparing with the PD42-x-1240 line of PANdrives™). With the PD42-3-1241 more than 5000rpm are possible at 24V supply voltage. This PANdrive supports both, stand-alone operation e.g. using the on-board I/Os together with the build-in TMCL scripting feature and remote operation using one of the available communication interfaces and even a mixture of both.

Motion Controller

- Motion profile calculation in real-time
- On-the-fly alteration of motor parameters (e.g. position, velocity, acceleration)
- Linear and unique six Point™ ramp in hardware
- Encoder interface and Reference / Stop switch inputs

Driver

- Motor current: up to 3A RMS (4.3A peak, programmable in software)
- Supply voltage: +24V DC (+10. . . +30V DC)
- 256 micro steps per full step
- spreadCycle™highly dynamic current control chopper
- stealthChop™for quiet operation and smooth motion
- programmable Step/Dir interface for driver-only applications with micro step interpolation

Encoder

- integrated sensOstep absolute position magnetic encoder (resolution: 1024 increments per rotation) for step-loss detection under all operating conditions and positioning supervision (accuracy: +/- 5 encoder steps)
- support for external A/B incremental encoder, in addition, / as an alternative for the integrated en-coder
- programmable encoder scaling and support for a motor stop on encoder deviation

Interfaces

- RS485 interface (up to 1Mbit/s)
- CAN interface (up to 1Mbit/s)
- USB 2.0 full-speed (12Mbit/s) device interface (micro-USB connector)
- Step/Dir input (optically isolated)
- Left and Right STOP switch inputs (optically isolated, shared with Step/Dir inputs)
- 2 general-purpose digital inputs
- Encoder input for incremental A/B encoder signals (shared with general-purpose digital inputs)
- 1 analog input (0..10V nom. input range)
- HOME switch input (shared with analog input)

Software

- TMCL™ remote (direct mode) and standalone operation (memory for up to 1024 TMCL™ commands), fully supported by TMCL-IDE (PC-based integrated development environment). Please see the PD42-x1240 TMCL firmware manual for more details
- CANopen firmware with CANopen standard protocol stack for the CAN interface. Please see PD42- x-1240 CANopen firmware manual for more details.

Order Codes
The combination of motor and motor-mounted controller/driver electronic is currently available with four stepper motors (different lengths and holding torque): The length of the PANdrives is specified without the length of the axis. For the overall length of the product please add 26mm

Table 1: Order Code

Order Code	Description	Size (LxWxH)
PD42-3-1241-TMCL	PANdrive™with NEMA17 stepper motor, 0.4Nm max. TMCM-1241 electronics, 3A RMS, +24V, RS485, CAN , USB, sensOstep™encoder, TMCL firmware	42mm x 42mm x 60mm
PD42-3-1241-CANopen	PANdrive™with NEMA17 stepper motor, 0.4Nm max. TMCM-1241 electronics, 3A RMS, +24V, RS485, CAN , USB, sensOstep™encoder, CANopen firmware	42mm x 42mm x 60mm
PD42-4-1241-TMCL	PANdrive™with NEMA17 stepper motor, 0.8Nm max. TMCM-1241 electronics, 3A RMS, +24V, RS485, CAN , USB, sensOstep™encoder, TMCL firmware	42mm x 42mm x 73mm
PD42-4-1241-CANopen	PANdrive™with NEMA17 stepper motor, 0.8Nm max. TMCM-1241 electronics, 3A RMS, +24V, RS485, CAN , USB, sensOstep™encoder, CANopen firmware	42mm x 42mm x 73mm

Table 2: TMCM-1241 Cable Loom

A cable loom set is available for this module:

Order Code	Description
PD-1241-CABLE	Cable loom for PD42-1241: • 1x cable loom for power supply connector (cable length 200mm, 4pin JST EH connecto r at one end, open wires at the other end) • 1x cable loom for RS485 + CAN connector (cable length 200mm, 5pin JST PH connect or at one end, open wires at the other end) • 1x cable loom for motor connector (cable length 200mm, 4pin JST EH connector at one end, open wires at the other end) • 1x cable loom for I/O connector (cable length 200mm, 8pin JST PH connector at one e nd, open wires at the other end) • 1x Micro-USB cable

The TMCM-1240 controller/driver electronics are also available separately. Please refer to the TMCM-1240 hardware manual for further details.

Mechanical and Electrical Interfacing
The PD42-3-1241 consists of the QSH4218-47-28-040 NEMA17 / 42mm stepper motor with 2.8A RMS rated coil current and 0.4Nm holding torque. The PD42-4-1241 consists of the QSH4218-80-30-060 NEMA17 / 42mm stepper motor with 3A RMS rated coil current and 0.8Nm holding torque. Both include the TMCM- 1241 controller/driver electronic for up-to 3A RMS motor coil current mounted on the backside of the motor and an integrated sensOstep™ encoder. Please see also the TMCM-1241 hardware and firmware manuals for more details.

Note: To make proper use of the integrated sensOstep™ encoder (the sensor IC is placed on the bottom of the PCB) the TMCM-1240 electronics should not be removed/moved relative to the motor. In case the integrated encoder feature is not used, the electronics may be moved or even removed from the motor and placed somewhere else according to application requirements.

Dimensions of PD42-x-1241

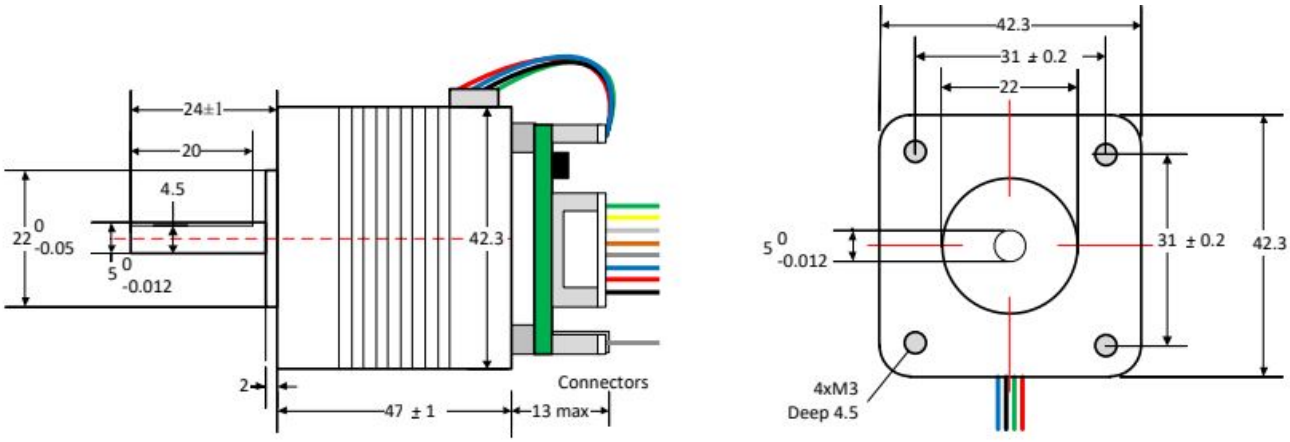


Figure 1: PD42-3-1241 with NEMA17 / 42mm stepper motors (all dimensions in mm)

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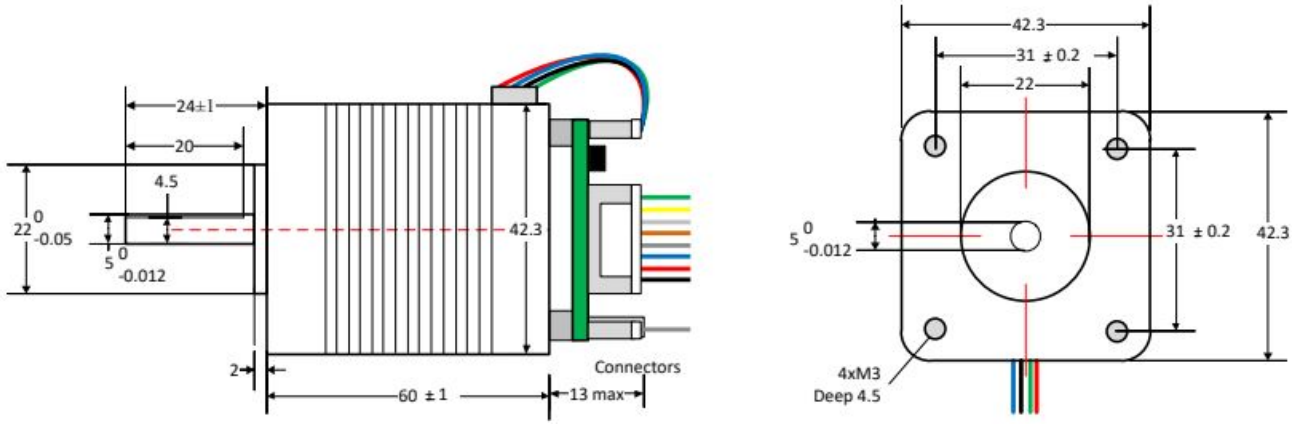

Figure 2: PD42-4-1241 with NEMA17 / 42mm stepper motors (all dimensions in mm)

Stepper motor

Main characteristics of the four different motors available as part of the PANdrive™:

Table 3: NEMA17 / 42mm stepper motor technical data

Specifications	Unit	PD42-3-1241	PD42-4-1241
Step angle	°	1.8	1.8
Step angle accuracy	%	+/-5	+/-5
Ambient temperature	°C	-20.. .+50	-20.. .+50
Max. motor temperature	°C	80	80
Shaft radial play (450g load)	mm	0.02	0.02
Shaft axial play (450g load)	mm	0.08	0.08
Max radial force (20mm from front flange)	N	28	28
Max axial force	N	10	10
Rated voltage	V	1.4	3.3
Rated phase current	A	2.8	3
Phase resistance at 20°C	Ω	0.5	1.1
Phase inductance (typ.)	mH	0.6	2.7
Holding torque	Nm	0.40	0.80
Insulation class		B	B
Rotor inertia	g cm2	68	102
Weight	kg	0.35	0.5

Integrated sensOstep™ encoder

The PD42-x-1241 PANdrives offer integrated sensOstep™ encoders based on hall sensor technology. As the name “sensOstep™“ already indicates intended use of this type of compact and highly integrated encoder is step loss detection of motor movements. As soon as the motor has been moved to a new location the position may be verified using this encoder feedback. In case the stepper motor has lost one or multiple steps during movement e.g. due to overload / any obstacle encountered during movement the motor axes will jump for at least one electrical period / 4 full steps. This can be detected using the integrated encoder. In addition, step losses may be already detected during motor movements using the “deviation” setting available as part of the TMCL firmware (see PD42-x-1240 / TMCM-1240 firmware manual for more details).

While the encoder offers 10bit (1024 steps) resolution per motor revolution the absolute position information is less accurate and depends on the displacement of the hall sensor-based encoder IC relative to the magnet and motor axis among other factors. Every PANdrive™ has been tested for maximum deviation of +/- 5 encoder steps (static performance) relative to the commanded micro step target position during final tests after assembly at our factory. This will ensure more than adequate performance of the integrated sensOstep™ encoder for step loss detection during motor movements.

NOTICE: Do not disassemble PANdrive™ when using the integrated encoder To make proper use of the integrated sensOstep™ encoder (the sensor IC is placed on the bottom centre of the PCB) the TMCM-1240 electronics should not be removed/moved relative to the motor! Otherwise, encoder performance might suffer / not work.

Note: In case the integrated encoder feature is not used, the TMCM-1240 electronics may be moved or even removed from the motor and placed somewhere else according to application requirements.

NOTICE: Keep the electronics free of (metal) particles! The integrated sensOstep™ encoder uses a magnet at the end of the motor axis to monitor the position of the motor axis. 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 by the rotating magnetic field as soon as the motor starts moving. This might lead to shorts of electronic contacts/wires on the board and erratic behaviour of the module! Use compressed air for cleaning the module if necessary (especially in prototype setups).

To prevent shorts and better protect the electronics the TMCM-1240 printed circuit board is coated after assembly of components.

Connectors

The PD42-x-1241 offers five connectors including the motor connector which is used for connecting the motor coils to the electronics. There is one motor and one power supply connector – both with four pins – and two interface connectors – one with five pins for RS485 and CAN and a dedicated micro-USB connector. All other inputs and outputs are concentrated on one 8-pin connector.

NOTICE: Start with the power supply OFF and do not connect or disconnect the motor during operation! Motor cable and motor inductivity might lead to voltage spikes when the motor is (dis)connected while energized. These voltage spikes might exceed the voltage limits of the driver MOSFETs and might permanently damage them. Therefore, always switch off / disconnect the power supply or at least disable the driver stage before connecting/disconnecting the motor.

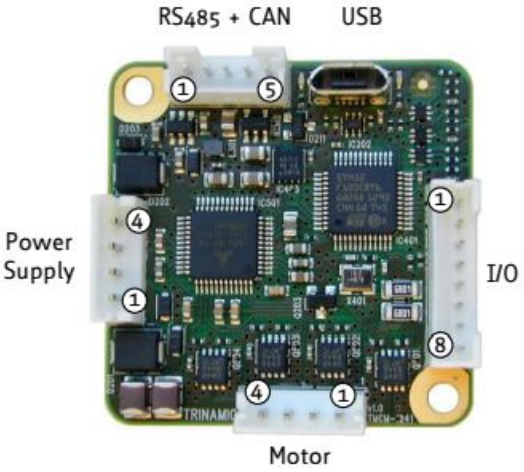

Figure 3: PD42-x-1241 connectors

Table 4: Connector Types and Mating Connectors of the PD42-x-1241

Connector Types and Mating Connectors		
Connector	Connector type on-board	Mating connector type
Power	JST B4B-EH-A (JST EH series, 4pins, 2.5mm pitch)	Connector housing: JST EHR-4 Contacts: JST SEH-001T-P0.6 Wire: 0.33mm2, AWG 22
Motor	JST B4B-EH-A (JST EH series, 4pins, 2.5mm pitch)	Connector housing: JST EHR-4 Contacts: JST SEH-001T-P0.6 Wire: 0.33mm2, AWG 22
RS485+CAN	JST B5B-PH-K-S (JST PH series, 5pins, 2mm pitch)	Connector housing: JST PHR-5 Contacts: JST SPH-002T-P0.5S Wire: 0.22mm2, AWG 24
USB	USB-micro B female connector	USB-micro B male connector
I/O	JST B8B-PH-K-S (JST PH series, 8pins, 2mm pitch)	Connector housing: JST PHR-8 Contacts: JST SPH-002T-P0.5S Wire: 0.22mm2, AWG 24

Power Supply Input Connector

The PD42-x-1241 offers one 4-pin JST PH series power supply input connector. In addition to the main power supply input and related ground connection, this connector offers a separate logic supply input with the option to keep the on-board logic alive while the driver stage is switched off. It is not necessary to connect the logic supply input in case separate supplies are not required as the main power supply input will always supply power to the driver stage and the logic part.

The power supply input connector offers a driver-enabled input. This input has to be connected to any voltage above 3.5V up to max. supply voltage of 30V to enable the driver stage. Leaving this pin unconnected or connected to the ground (voltage below 2.4V) will disable the driver stage regardless of any settings in the software. This input may be connected to the main power supply input permanently in case an enable input in hardware is not required.

Table 5: Power Supply Connector Pin Assignment

Power Supply Connector Pin Assignment			
Pin	Label	Direction	Description
1	GND	Power (GND)	Common system supply and signal ground
2	VMAIN	Power (input)	Main power supply input for the driver and on-board logic *10. . . 30V*
3	Enable	Digital input	Driver enables input. A voltage above 3.5V is required here to enable the on-board stepper motor driver. This in- put may be connected to the main power supply input to enable the driver stage (+24V tolerant input).
4	VLOGIC	Power (input)	Optional separate power supply input for the on-board logic *10. . . 30V*

NOTICE: Do not connect or disconnect the motor during operation! Motor cable and motor inductivity might lead to voltage spikes when the motor is (dis)connected while energized. These voltage spikes might exceed the voltage limits of the driver MOSFETs and might permanently damage them. Therefore, always switch off /

disconnect the power supply or at least disable the driver stage before connecting/disconnecting the motor.

NOTICE: Take care of polarity, wrong polarity can destroy the board!

NOTICE: Connect the Enable pin to voltage >3.5V to enable motor movements!

Motor Connector
A second 4pin JST PH series connector is available for connection of a 2-phase bipolar stepper motor

Table 6: Motor Connector Pin Assignment

Motor Connector Pin Assignment			
Pin	Label	Direction	Description
1	B1	out	Pin 1 of motor coil B
2	B2	out	Pin 2 of motor coil B
3	A1	out	Pin 1 of motor coil A
4	A2	out	Pin 2 of motor coil A

NOTICE: Do not connect or disconnect the motor during operation! Motor cable and motor inductivity might lead to voltage spikes when the motor is (dis)connected while energized. These voltage spikes might exceed the voltage limits of the driver MOSFETs and might permanently damage them. Therefore, always switch off / disconnect the power supply or at least disable the driver stage before connecting/disconnecting the motor.

NOTICE: Do not mix up power supply and motor connectors!

RS485 + CAN Connector
For serial communication, the PD42-x-1241 offers selection between RS485, CAN and USB interfaces. While the USB interface is available for configuration and service of the board, mainly (e.g. parameter settings, firmware updates) a 5-pin JST PH series connector offers 2-wire RS485 and CAN interfaces for in-system communication.

NOTICE: Due to hardware resource sharing USB and CAN communication interfaces are not available at the same time. As soon as USB is physically attached to a host or hub the CAN interface will be switched off.

Table 7: RS485 + CAN Connector Pin Assignment

RS485 + CAN Connector Pin Assignment			
Pin	Label	Direction	Description
1	GND	Power (GND)	Common system supply and signal ground
2	RS485+	Bidirectional	RS485 interface, diff. signal (non-inverting)
3	RS485-	Bidirectional	RS485 interface, diff. signal (inverting)
4	CAN_H	Bidirectional	CAN interface, diff. signal (non-inverting)
5	CAN_L	Bidirectional	CAN interface, diff. signal (inverting)

USB Connector
For serial communication, the PD42-x-1241 offers selection between RS485, CAN and USB interfaces. The USB interface via an on-board micro-USB connector (type B) is available for configuration and service of the board, mainly (e.g. parameter settings, firmware updates). The USB device interface supports full-speed (12Mbit/s) communication and supports bus-powered and self-powered operation. During bus-powered operation, the low-voltage logic part of the board will be powered, only. This includes the microcontroller and the non-volatile memory and therefore allows parameter settings and firmware updates of the board using a standard USB cable, only. Of course, for any motor movement main supply via supply input connector is required.

NOTICE: Due to hardware resource sharing USB and CAN communication interfaces are not available at the same time. As soon as USB is physically attached to a host or hub the CAN interface will be switched off.

Table 8: USB Connector Pin Assignment

USB Connector Pin Assignment			
Pin	Label	Direction	Description
1	VBUS	Power (+5V)	USB +5V nom. power supply input
2	D-	Bidirectional	USB interface, diff. signal (inverting)
3	D+	Bidirectional	USB interface, diff. signal (inverting)
4	ID	Input	connected to GND (via 100k resistor)
5	GND	Power (GND)	Common system supply and signal ground

I/O Connector
The PD42-x-1241 offers several inputs (two of them optically isolated) and one digital (open-drain) output. The inputs include support for stop switches (left and right), home switch, step/direction, incremental A/B channel encoder and analog (0… +10V) input. All this functionality is available via one 8-pin JST PH series I/O connector.

Table 9: I/O Connector Pin Assignment

All pins marked light green offer functional isolation towards the main supply input. In case this is not required ISO_COM may be connected to the main ground or supply input, of course. The opto-coupler used are AC types. This way, either high-side switches or low-side switches for both inputs are supported.

I/O Connector Pin Assignment			
Pin	Label	Direction	Description
1	GND	Power (GND)	Common system supply and signal ground
2	IN0/HOME	Input	Analog input (0. . .+10V) HOME switch input *+24V tolerant, programmable (separate) pull-up to +5V*
3	IN1/ENC_A	Input	General purpose digital input Incremental encoder input channel A *+24V tolerant, programmable pull-up (for IN1/IN2 together) to +5V*
4	IN2/ENC_B	Input	General purpose digital input Incremental encoder input channel B *+24V tolerant, programmable pull-up (for IN1/IN2 together) to +5V*
5	STOP_L/STEP	Input	STOP left switch input STEP pulse input *input optically isolated, +24V compatible*
6	STOP_R/DIR	Input	STOP right switch input DIR input *input optically isolated, +24V compatible*
7	ISO_COM	Power	Common positive (+24V_ISO) or negative (GND_ISO) isolated supply input for optically isolated inputs
8	OUT0	Output (OD)	Open-Drain output. The output will be pulled low when activated. *Volt ages up to logic supply input level (or main supply input in case a separate logic supply is not used) are supported here. Max. continuou s pull-down current: 100mA*

All pins marked light green offer functional isolation towards the main supply input. In case this is not required ISO_COM may be connected to the main ground or supply input, of course. The opto-coupler used are AC types. This way, either high-side switches or low-side switches for both inputs are supported.

On-Board LEDs

The board offers two LEDs to indicate board status. The function of both LEDs is dependent on the firmware version. With standard TMCL firmware, the green LED should be flashing slowly during operation and the red LED should be off. When there is no valid firmware programmed into the board or during a firmware update the red and green LEDs are permanently switched on. During reset to factory default values the green LED will be flashing fast. With CANopen firmware, both LEDs are switched on/off/flashing according to standard definition.

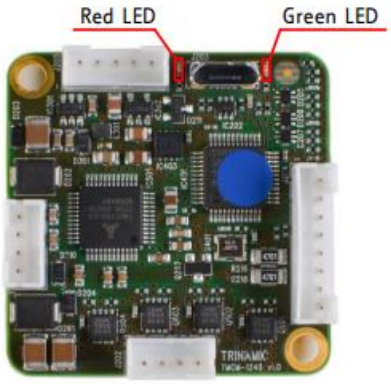

Figure 4: PD42-x-1241 LEDs

Reset to Factory Defaults
It is possible to reset all settings in the firmware for the PD42-x-1240 to factory defaults without establishing a working communication connection. This might be helpful in case communication parameters of the preferred interface have been set to unknown values or got lost.

For this procedure, two pads on the bottom side of the module have to be shorted (electrically connected) during power-on.
Please perform the following steps:

1. Switch the power supply OFF (and disconnect the USB cable if applicable)
2. Short CLK and DIO pads of programming pads on the bottom of PCB (see figure 5)
3. Switch the power supply ON again (or connect USB again if applicable)
4. Wait until the on-board red and green LEDs start flashing fast (this might take a while)
5. Switch the power supply OFF again (and disconnect the USB cable if applicable)
6. Remove the short between the pads
7. After switching the power supply ON again (and/or connecting the USB cable) all permanent settings have been restored to factory defaults

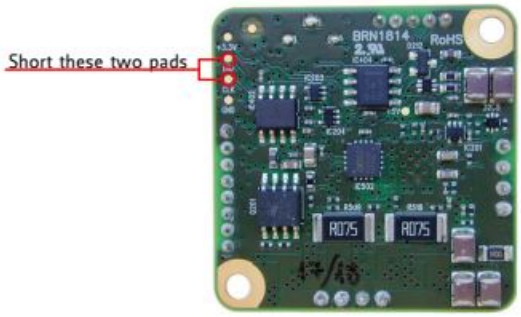

Figure 5: Reset to factory default settings

I/Os
The I/O connector (8pin JST PH series) offers one analog input, two non-isolated digital inputs with integrated pull-ups (programmable) and two optically isolated inputs. All inputs can be used for different purposes explained in more detail in the following subsections.

Analog input IN0
The PD42-x-1240 offers one analog input. The analog input voltage range is approx. 0..+10V. For voltages above +10V saturation takes place but, to 30V higher voltages are tolerated without destroying the input. For analog to digital conversion the integrated ADC of the on-board microcontroller is used. The resolution of this converter is 12bit (0..4095).

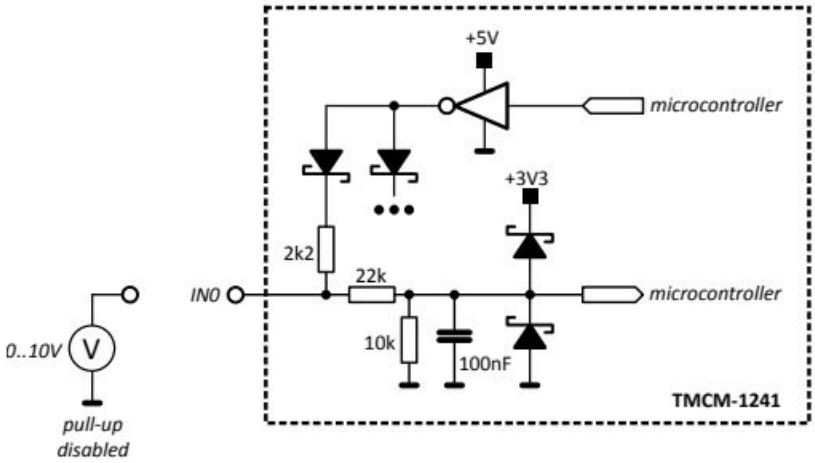

Figure 6: Analog input IN0

The analog input can also be used as digital input, also. There is an integrated pull-up to +5V which can be switched on or off in software. When using this input as analog input the pull-up should be usually switched off.

Digital inputs IN1 and IN2

The PD42-x-1241 offers two digital inputs IN1 and IN2 which accept signals between 0 and 30V with voltages above approx. 2.9V is recognized as logical '1' and below 1V as logical '0'. Both inputs offer integrated pull-ups to +5V which can be switched on or off in software (always together). When using the inputs with low-side switches (connected to GND), pull-ups usually should be switched on (default). In case high-side switches are used the pull-ups must be switched off. For push-pull signals, the pull-ups may be either switched on or off.

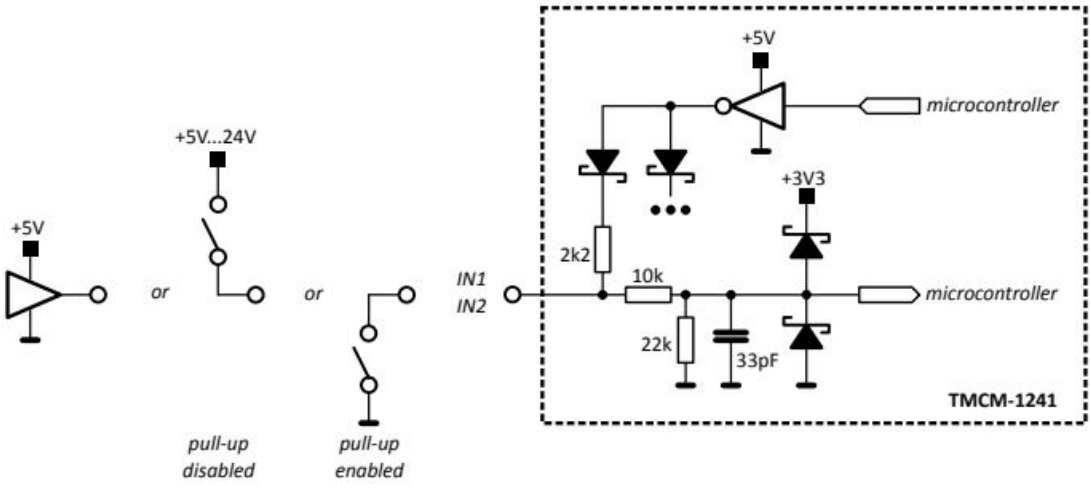

Figure 7: Digital inputs IN1 and IN2

HOME/STOP_L/STOP_R switch inputs

The PD42-x-1241 offers two optically isolated inputs which can be used as left (STOP_L) and right (STOP_R) stop switch inputs. When enabled in software the STOP_L switch input will stop motor movement in the negative direction (step counter decreasing) while activated. Likewise, the STOP_R switch input will stop motor movement in a positive direction (step counter increasing) while activated.

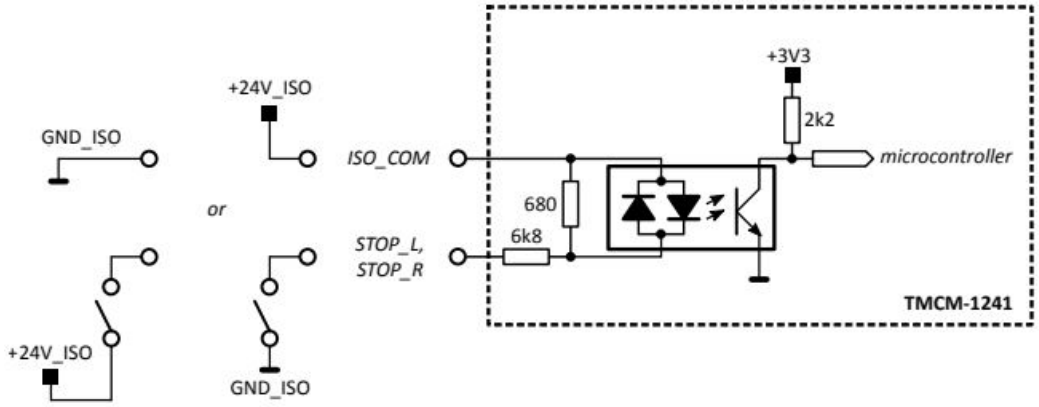

Figure 8: Stop switch inputs

A separated/isolated supply may be used for the switches – as indicated in the drawing (+24V_ISO and related GND_ISO) – but, the same supply as for the PD42-x-1241 can also be used, also, of course.

External incremental encoder input

The PD42-x-1241 offers an integrated hall-sensor-based magnet encoder. In addition, an external incremental A/B encoder may be connected to the two digital inputs IN1 and IN2. Encoder with push-pull signals (e.g. +5V TL) and open-drain output signals are supported (single-ended). For open-drain outputs, the internal pull-ups should be activated in software (default mode).

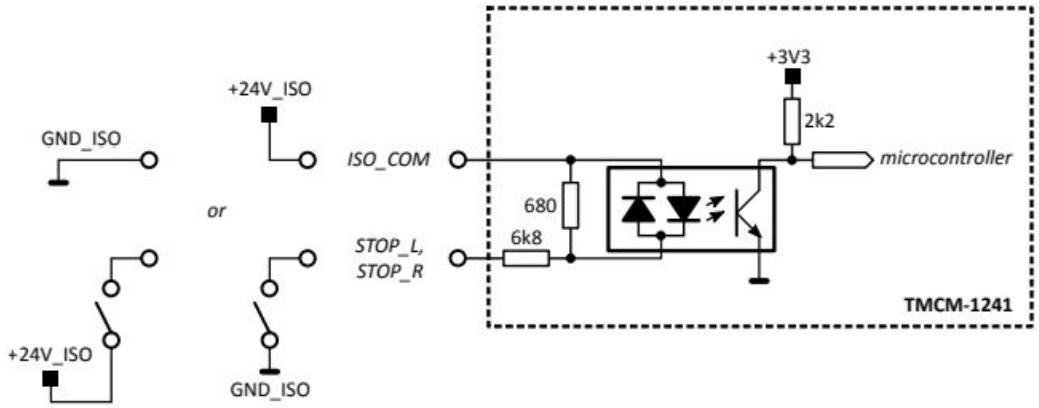

Figure 8: Stop switch inputs

Step/Direction inputs

The PD42-x-1241 may be used as a driver with an external motion controller. In this case, the Step/Direction output signals of the external motion controller may be connected to the optically isolated Step/Dir inputs of the PD42-x-1241. Please note that these signals should be 24V signals. For lower voltage signals a simple small signal transistor may be inserted as a level converter.

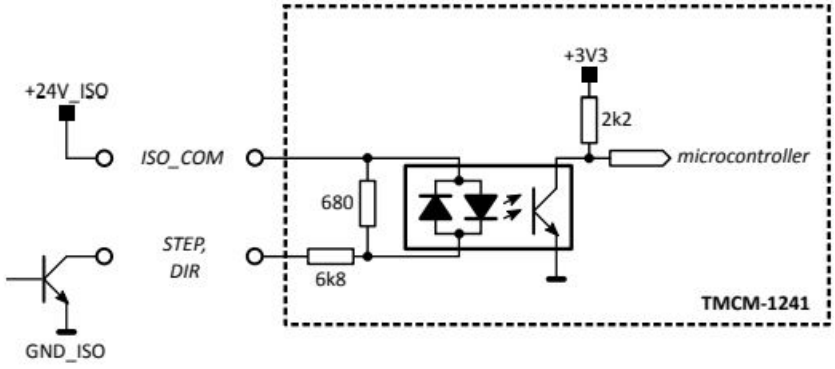

Figure 10: Step/Direction input

Due to the limitations of the opto-isolators, the maximum step frequency of these inputs is limited to around

20kHz. For higher motor speed the step interpolator of the driver stage should be activated or the microstep resolution reduced (default 256 microsteps per fullstep).

Communication

RS485

For remote control and communication with a host system, the PD42-x-1240 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. It should be short compared to the length of the bus.

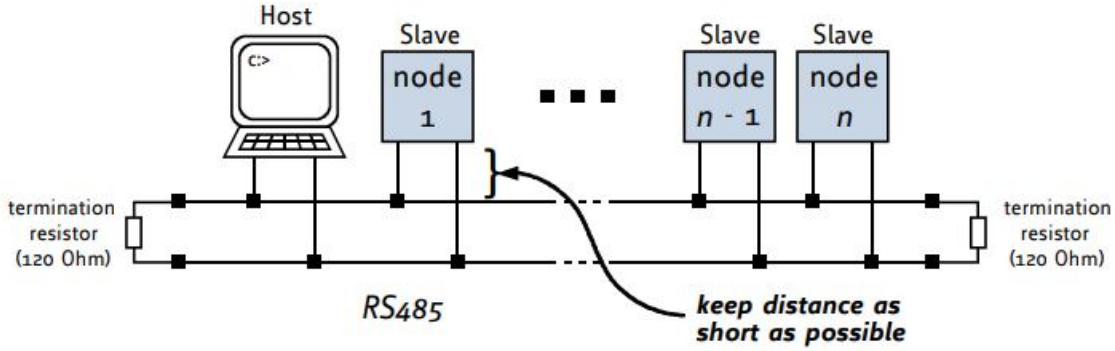

Figure 11: RS485 bus structure with termination resistors

2. **BUS TERMINATION:**

   The bus transceiver used on the PD42-x-1241 units (TJA1051T) supports at least 110 nodes under optimum conditions. The practically achievable number of nodes per CAN bus highly depends on bus length (longer bus -> fewer nodes) and communication speed (higher speed -> fewer nodes).

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 transceiver used on the PD42-x-1240 units (SN65HVD1781D) offers a significantly reduced bus load compared to the standard and allows a maximum of 255 units to be connected to a single RS485 bus using standard 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 PD42-x-1240 hardware is 1Mbit/s. Factory default is 9600 bit/s. Please see the separate PD42-x-1240 TMCL firmware manual for information regarding other possible communication speeds below the upper hardware limit.

5. **NO FLOATING BUS LINES:**

   Avoid floating bus lines while neither the host/master nor one of the slaves along the bus line are transmitting data (all bus nodes switched to receive mode). Floating bus lines may lead to communication errors. 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 two options that can be recommended: Add resistor (bias) network on one side of the bus, only (120R termination resistor still at both ends):

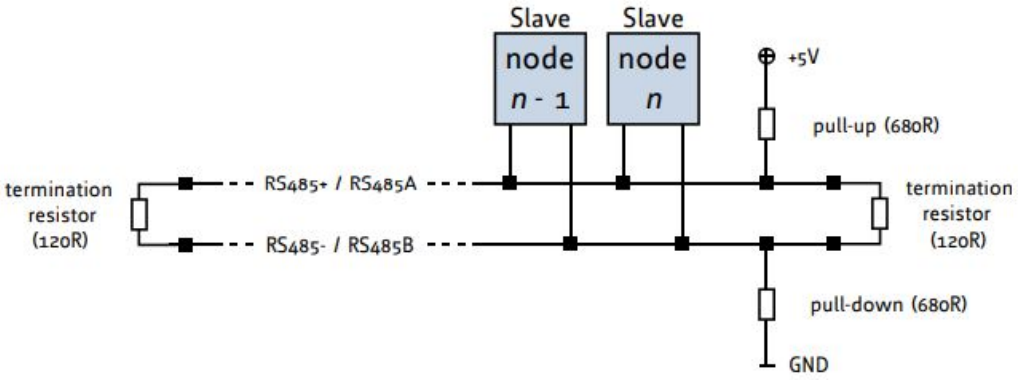

Figure 12: RS485 bus lines with resistor (bias) network on one side, only

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

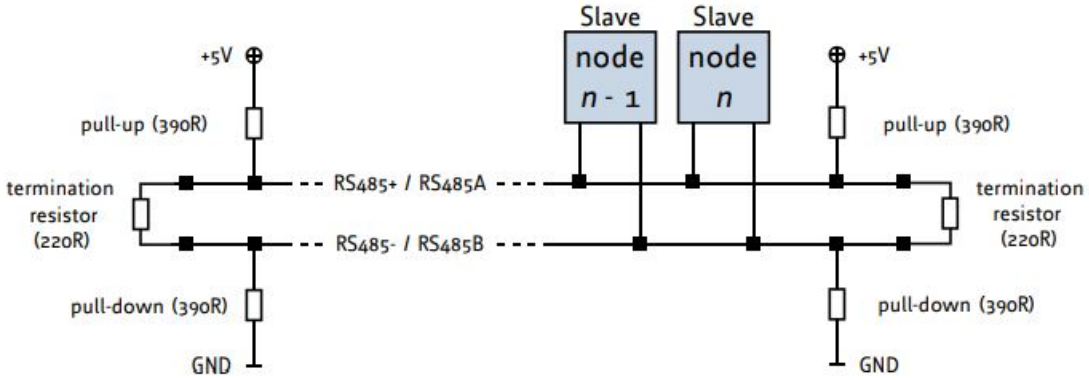

Figure 13: RS485 bus lines with Profibus™recommended line termination

CAN

For remote control and communication with a host system, the PD42-x-1240 provides a CAN bus interface. Please note that the CAN interface is not available in case the USB is connected. For proper operation, the following items should be taken into account when setting up a CAN 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. It should be short compared to the length of the bus.

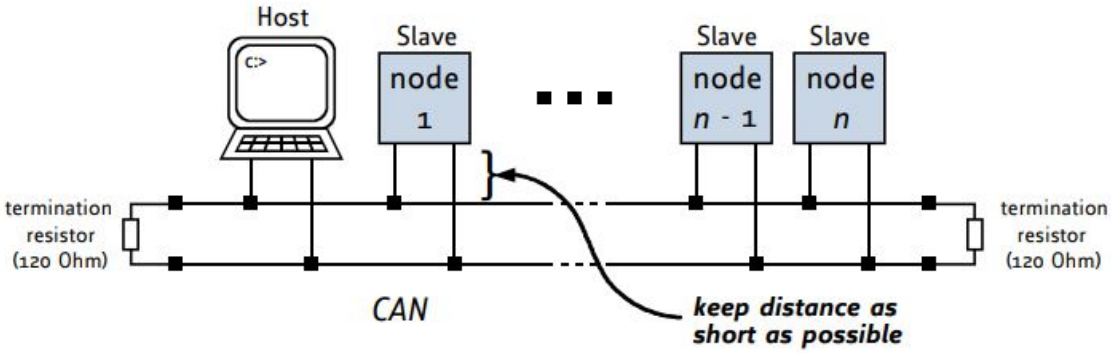

Figure 14: CAN bus structure with termination resistors

2. **BUS TERMINATION:**

   Especially for longer buses and/or multiple nodes connected to the bus and/or high communication speeds, the bus should be properly terminated at both ends. The PD42-x-1240 does not integrate any termination resistor.

Therefore, 120 Ohm termination resistors at both ends of the bus have to be added externally.

3. **BUS TERMINATION:**

   The bus transceiver used on the PD42-x-1241 units (TJA1051T) supports at least 110 nodes under optimum conditions. The practically achievable number of nodes per CAN bus highly depends on bus length (longer bus -> fewer nodes) and communication speed (higher speed -> fewer nodes).

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 the table below:

Motor current setting in software (TMCL)

These are the values for TMCL axis parameters 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
```

(read-out value with GAP instead of SAP. Please see the separate PD42-x-1240 firmware manual for further information)

Motor current IRMS [A] Resulting in motor current based on the motor current setting

Table 11: Available motor current settings

Motor Current Setting			
Motor current setting in software (TMCL)	Current scaling step (CS)	Motor current I_{COIL}[A] peak	Motor current I_{COIL}[A] RMS
0. . . 7	0	0.135	0.096
8. . . 15	1	0.271	0.192
16… 23	2	0.406	0.287

32… 39	4	0.677	0.479
40… 47	5	0.813	0.575
48… 55	6	0.948	0.670
56… 63	7	1.083	0.766
64… 71	8	1.219	0.862
72… 79	9	1.354	0.958
80… 87	10	1.490	1.053
88… 95	11	1.625	1.149
96… 103	12	1.760	1.245
104… 111	13	1.896	1.341
112… 119	14	2.031	1.436
120… 127	15	2.167	1.532
128… 135	16	2.302	1.628
136… 143	17	2.438	1.724
144… 151	18	2.573	1.819
152… 159	19	2.708	1.915
160… 167	20	2.844	2.011
168… 175	21	2.979	2.107
176… 183	22	3.115	2.011
184… 191	23	3.250	2.298
192… 199	24	3.385	2.394
200… 207	25	3.521	2.490
208… 215	26	3.656	2.585
216… 223	27	3.792	2.681
224… 231	28	3.927	2.777
232… 239	29	4.063	2.873
240… 247	30	4.198	2.968
248… 255	31	4.333	3.064

In addition to the settings in the table, the motor current may be switched off completely (free-wheeling) using axis parameter 204 (see PD42-x-1240 firmware manual).

Torque Curves

PD42-3-1241 Torque Curve

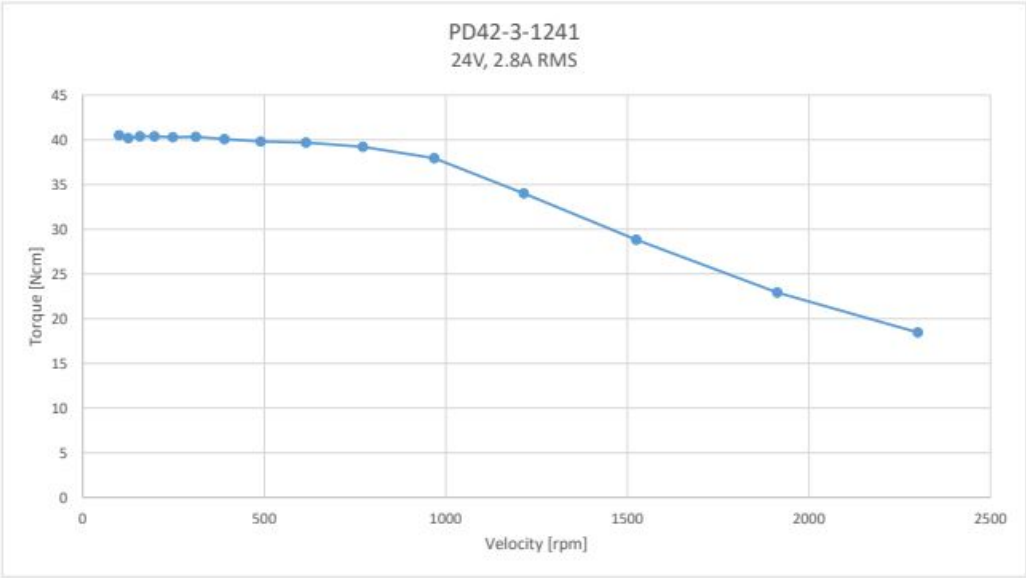

Figure 15: PD42-3-1241 torque vs. velocity 24V / 2.8A RMS, 256μsteps

PD42-4-1241 Torque Curve

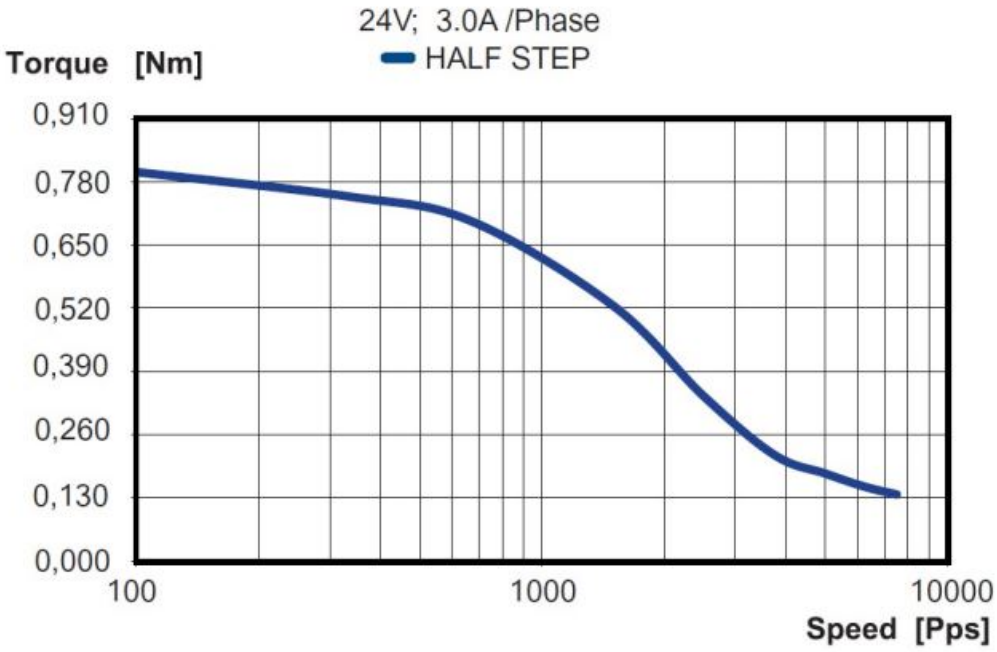

Figure 16: PD42-4-1241 torque vs. velocity 24V / 3A RMS, Halfstep

Functional Description

The PD42-x-1241 is a full mechatronic solution including a 42mm flange (NEMA17) bipolar stepper motor. It includes the controller/driver electronics TMCM-1241 and a choice between four different NEMA 17 / 42mm flange size bipolar hybrid stepper motors with different lengths and torque.

The PD42-x-1241 can be controlled via USB, RS485 or CAN serial interfaces. There are three general-purpose digital inputs that can be used, also as STOP_L / STOP_R / HOME switch inputs (for reference movements, as end switches etc. depending on firmware, mode and configuration) or for connecting an additional external encoder (incremental A/B/N). In addition, there is one dedicated analog input for 0… +10V analog signals and two general-purpose outputs (one open-drain and one switchable +5V supply output).

The PD42-x-1241 with TMCL™ firmware option is supported by 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 PD42-x-1241 or TMCM-1241 firmware manuals for more information about TMCL™ commands.

Communication traffic is kept low since all time critical operations, e.g. ramp calculation are performed on board. Complete stand-alone or full remote control or anything in between is possible. The firmware of the module can be updated via the serial interface. As an alternative to TMCL, a CANopen firmware is available.

The PD42-x-1241 contains the following main components:

- Microcontroller (ARM Cortex-M3™), responsible for overall control and communication
- Highly integrated advanced stepper motor controller supporting linear and unique 6-point ramps in hardware
- Advanced stepper motor driver with stallGuard2™ and coolStep™ with MOSFET driver stage (8x power N-MOSFETs for bipolar stepper motor)
- RS485, CAN and USB transceivers
- On-board voltage regulators (+5V and +3V3) required for the supply of all on-board digital circuits

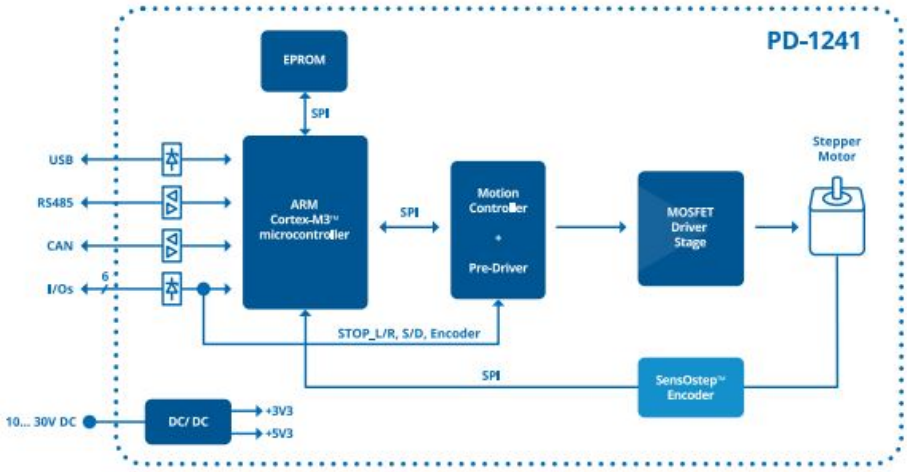

Figure 17: PD42-x-1241 block diagram

Operational Ratings and Characteristics

Never Exceed the absolute maximum ratings!
Keep the power supply voltage below the upper limit of +30V! Otherwise, the board electronics will seriously be damaged! Especially, when the selected operating voltage is near the upper limit a regulated power supply is highly recommended.

Table 12: General operational ratings of the module

General Operational Ratings					
Symbol	Parameter	Min	Typ	Max	Unit
VPower	Power supply voltage	10	12… 24	30	V
IPower	Power supply current		<<ICOIL_RMS	1.4 x ICOIL_RMS	A
VUSB	Power supply via USB connector		5		V
IUSB	Current withdrawn from USB supply when USB bus powered (no other supply connected)		42		mA
ICOIL_PEAK	Motor coil current for sine wave **peak (chopper regulated, adjustable via software)**	0	0. . . 4	4.3	A
ICOIL_RMS	Continuous motor current (**RMS)**	0	0. . . 2.8	3	A
TENV	Environmental temperature at rated current (no forced cooling required)	-30		50	°C

Table 13: Operational ratings of I/Os

Operational Ratings of the I/Os					
Symbol	Parameter	Min	Typ	Max	Unit
VOUT0	The voltage at open drain output OUT0 (switched off)	0		+VPower	V
IOUT0	Output sink current of open drain output OUT0 (switched on)			100	mA
VIN0/1/2	Input voltage for IN0. . . IN2	0	0. . .+24	+30	V
VIN0	Measurement range for analog input IN0	0		+101	V
VIN1/2_L	Low level voltage for IN1 and IN2 (digital inputs)			1	V
VIN1/2_H	High level voltage for IN1 and IN2 (digital inputs)	2.9			V
VSTOP_L/R_ON	Switch-on optoisolated inputs (voltage between input and ISO_COM)		20-24	30	V
VSTOP_L/R_OFF	Switch off optoisolated inputs (voltage between input and ISO_COM)	0	0-16		V
FTP/DIR	Max. frequency for step/direction optoisolated inputs		20		kHz

Symbol	Parameter	Min	Typ	Max	Unit

Table 14: Operational ratings of the RS485 interface

Operational Ratings of the RS485 Interface					
Symbol	Parameter	Min	Typ	Max	Unit
NRS485	Number of nodes connected to a single RS485 network			256	
fRS485	Max. speed for RS485 network			1Mbit/s	

Table 15: Operational ratings of the CAN interface

Operational Ratings of the CAN Interface					
Symbol	Parameter	Min	Typ	Max	Unit
NCAN	Number of nodes connected to a single CAN network			>110	
fCAN	Max. speed for CAN network			1Mbit/s	

Abbreviations used in this Manual

Table 16: Abbreviations Used in this Manual

Abbreviation	Description
IDE	Integrated Development Environment
LED	Light Emitting Diode
RMS	Root Mean Square value
TMCL	TRINAMIC Motion Control Language

Supplemental Directives

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Revision History

Hardware Revision

Table 17: Hardware Revision

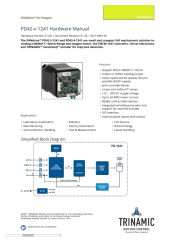
Version	Date	Author	Description
V1.0	2018-MAR-27	GE	Initial version.

Document Revision

Table 18: Document Revision

Version	Date	Author	Description
1.00	2018-MAY-07	GE	Initial version based on TMCM-1241 hardware manual.
1.10	2018-MAY-11	GE	Torque curve added.
1.20	2018-MAY-17	GE	PD42-4-1241 added.
1.21	2018-JUL-17	SK	Fixed Order Codes.
1.22	2018-SEP-03	GE	Product image updated.
1.23	2019-JAN-02	GE	Dimension drawing corrected.
1.24	2020-MAR-28	GE	PD42-4-1241 torque curve caption corrected.
1.25	2020-MAY-05	OK	I/O connector pin numbering corrected.
1.26	2021-AUG-18	OK	New block diagram.

Documents / Resources

	**TRINAMIC PD42-x-1241 Hardware PAN Drive Stepper** [pdf] User Manual PD42-3-1241, PD42-4-1241, PD42-x-1241 Hardware PAN Drive Stepper, PD42-x-1241, Hardware PAN Drive Stepper, PAN Drive Stepper, Drive Stepper, Stepper

References

- **User Manual**