PD42-x-1243-IOLINK Hardware Manual

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PD42-x-1243 is a small easy-to-use mechatronic PANdrive™ IO-Link™ Actuator device. It combines a NEMA17 stepper motor with controller and driver electronics. The IO Link connection through standard 4-pin M12 connector offers full control over the NEMA17 stepper motor as well as provide a industry-standard IO Link communication protocol enabling control, configuration, and status monitoring.

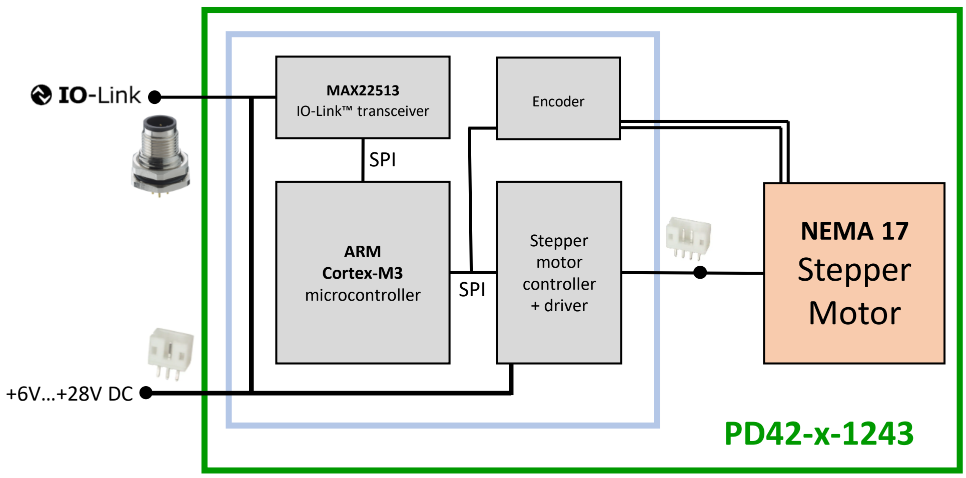
Features

- Stepper Motor **NEMA17** / 42mm
- **+6...+28V** DC Supply voltage
- Up to **1.2A RMS** motor current
- **IO-Link™** interface
- Integrated Motion Controller
- **PANdrive™** smart motor
- **StealthChop™** silent PWM mode
- **spreadCycle™** current control
- **StallGuard2™** load detection
- **CoolStep™** autom. current scaling
- Integrated absolute position sensor

Applications

- Laboratory Automation
- Manufacturing
- Semiconductor Handling
- Robotics
- Factory Automation
- Test & Measurement

Simplified Block Diagram



Read entire documentation.

TRINAMIC MOTION CONTROL
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Contents

1 Features

The PANdrive™ PD42-x-1243 is a compact full-mechatronic solution including a NEMA17 (42mm flange) size stepper motor with motor controller and driver electronics using a MAX22513 IO Link transceiver. The IO Link firmware allows to control the module using the 4-wire bi-directional point-to-point communication link with standardized technology (IEC 61131-9) that regulates how sensors and actuators in industrial systems interact with a main controller.

Motion Controller / Driver

- Supply voltage +24V DC (+6. . . +28V DC)
- Motor current: up to 1.2A RMS
- Highest microstep resolution, up to 256 microsteps per full step
- Motion profile calculation in real-time
- Live alteration of motor parameters (e.g. position, velocity, acceleration)
- spreadCycle™highly dynamic current control chopper
- stealthChop™for quiet operation and smooth motion
- High-precision sensorless load measurement with StallGuard2™
- Automatic current scaling algorithm CoolStep™ to save energy and keep your drive cool
- Operation via IO Link limited to max. IO Link power for applications with lower torque requirements
- Additional supply interface for applications with higher power requirements
- Integrated absolute position sensor

IO-Link Interface

- Robust connection through industry standard M12 connector
- MAX22513 IO Link transceiver
- Point-to-point 4-wire interface (L+, C/Q, and L-) is reverse voltage / short circuit protected

1.1 TRINAMIC's Unique Features

1.1.1 stealthChop™

stealthChop is an extremely quiet mode of operation for low and medium velocities. It is based on a voltage mode PWM. During standstill and at low velocities, the motor is absolutely noiseless. Thus, stealthChop operated stepper motor applications are very suitable for indoor or home use. The motor operates absolutely free of vibration at low velocities. With stealthChop, the motor current is applied by driving a certain effective voltage into the coil, using a voltage mode PWM. There are no more configurations required except for the regulation of the PWM voltage to yield the motor target current.

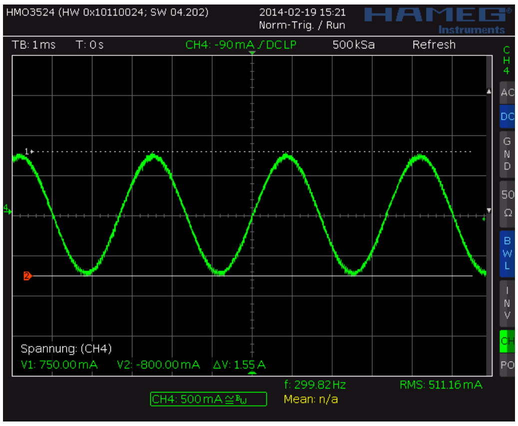

Figure 1: Motor coil sine wave current using stealthChop (measured with current probe)

1.1.2 spreadCycle™

The spreadCycle chopper is a high-precision, hysteresis-based, and simple to use chopper mode, which automatically determines the optimum length for the fast-decay phase. Several parameters are available to optimize the chopper to the application. spreadCycle offers optimal zero crossing performance compared to other current controlled chopper algorithms and thereby allows for highest smoothness. The true target current is powered into the motor coils.

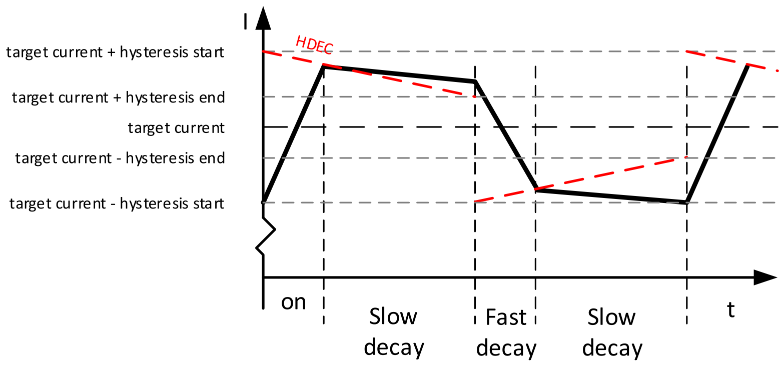

Figure 2: spreadCycle principle

1.1.3 stallGuard2

stallGuard2 is a high-precision sensorless load measurement using the back EMF of the motor coils. It can be used for stall detection as well as other uses at loads below those which stall the motor. The stallGuard2 measurement value changes linearly over a wide range of load, velocity, and current settings. At maximum motor load, the value reaches zero or is near zero. This is the most energy-efficient point of operation for the motor.

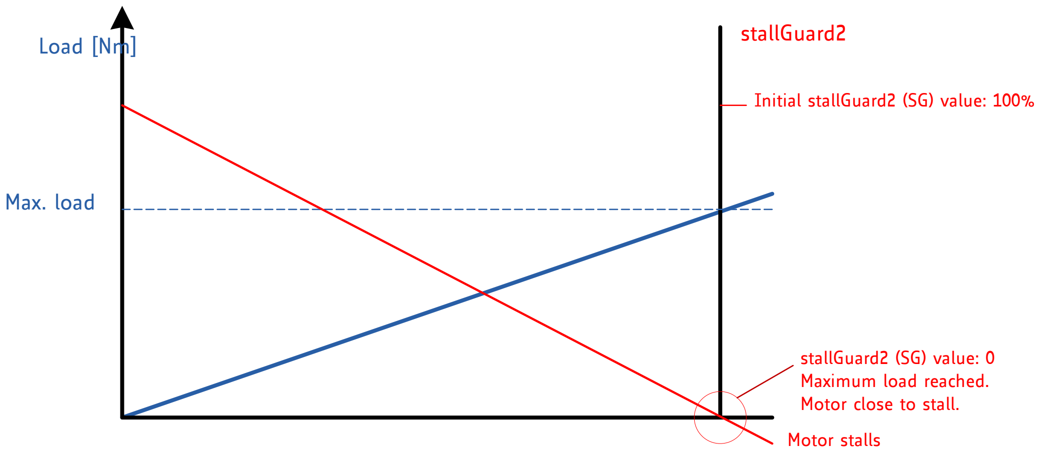

Figure 3: stallGuard2 Load Measurement as a Function of Load

1.1.4 coolStep

coolStep is a load-adaptive automatic current scaling based on the load measurement via stallGuard2. coolStep adapts the required current to the load. Energy consumption can be reduced by as much as 75%. coolStep allows substantial energy savings, especially for motors which see varying loads or operate at a high duty cycle. Because a stepper motor application needs to work with a torque reserve of 30% to 50%, even a constant-load application allows significant energy savings because coolStep automatically enables torque reserve when required. Reducing power consumption keeps the system cooler, increases motor life, and allows for cost reduction.

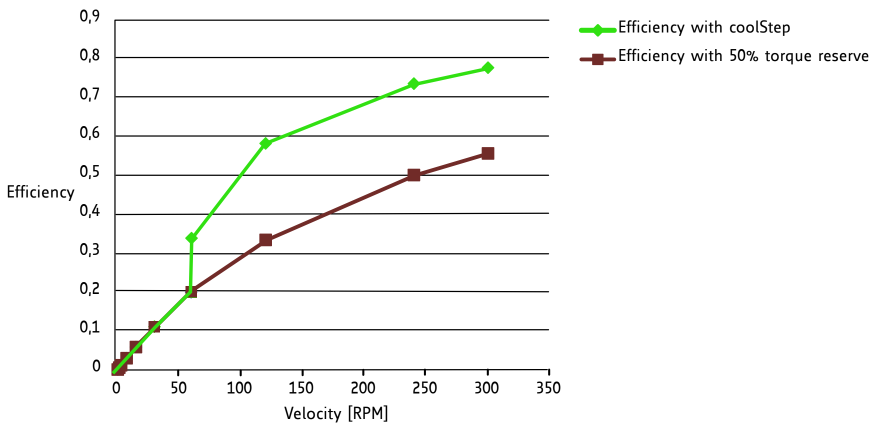

Figure 4: Energy Efficiency Example with coolStep

2 Order Codes

The following combination of motor and motor mounted controller is currently available:

*The length of the **PANdrive™** is specified without the length of the motor axis shaft. For the overall length of the product please add 25mm*

Order Code	Description	Size (WxHxL) incl. connector
PD42-1-1243	PANdrive™with NEMA17 stepper motor, 0.27Nm, 1.0A RMS, +24V DC, TMCM-1243 controller module, IO-Link interface	42mm x 42mm x 64mm
PD42-2-1243	PANdrive™with NEMA17 stepper motor, 0.35Nm, 1.0A RMS, +24V DC, TMCM-1243 controller module, IO-Link interface	42mm x 42mm x 68,5mm
PD42-3-1243	PANdrive™with NEMA17 stepper motor, 0.49Nm, 1.0A RMS, +24V DC, TMCM-1243 controller module, IO-Link interface	42mm x 42mm x 77,5mm

Table 1: Order Codes

3 Mechanical and Electrical Interfacing

The PD42-1-1243 consists of the QSH4218-35-10-027 NEMA17 / 42mm stepper motor with 1A RMS rated coil current and 0.27Nm holding torque. The PD42-2-1243 consists of the QSH4218-41-10-035 NEMA17 / 42mm stepper motor with 1A RMS rated coil current and 0.35Nm holding torque. The PD42-3-1243 consists of the QSH4218-51-10-049 NEMA17 / 42mm stepper motor with 1A RMS rated coil current and 0.49Nm holding torque. All three PANdrives™ include the same controller and driver module for up-to 1.2A RMS motor coil current mounted on the backside of the motor and an integrated sensOstep™ encoder for absolute position monitoring.

NOTICE

Note: In order to make proper use of the integrated sensOstep™ encoder (the sensor IC is placed on the bottom of the PCB) the TMCM-1243 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.

3.1 Stepper Motors Characteristics

Specifications	Parameter	Unit	**1-1243**	**2-1243**	**3-1243**
Step angle		°	1.8	1.8	1.8
Step angle accuracy		%	±5	±5	±5
Ambient temperature	T_{amb}	°C	-20...+50	-20...+50	-20...+50
Max. motor temperature	$T_{motor_{max}}$	°C	80	80	80
Shaft radial play (450g load)		mm	0,02	0,02	0,02
Shaft axial play (450g load)		mm	0,08	0,08	0,08
Max radial force (20mm from front flange)		N	28	28	28
Max axial force		N	10	10	10
Rated voltage	V_{rated}	V	5.3	4.5	5.0
Rated phase current	$I_{RMS_{rated}}$	A	1.0	1.0	1.0
Phase resistance at 20°C	R_{coil}	Ω	5.3	4.5	5.0
Phase inductance (typ.)	L_{coil}	mH	6.6	7.5	8.0
Holding torque		Nm	0.27	0.35	0.49
Insulation class			B	B	B
Rotor inertia		g cm2	35	54	68
Weight	M	kg	0.22	0.28	0.35

Table 2: PD42-x-1243 Motor Parameters

3.2 Dimensions of PD42-x-1243-IOLINK

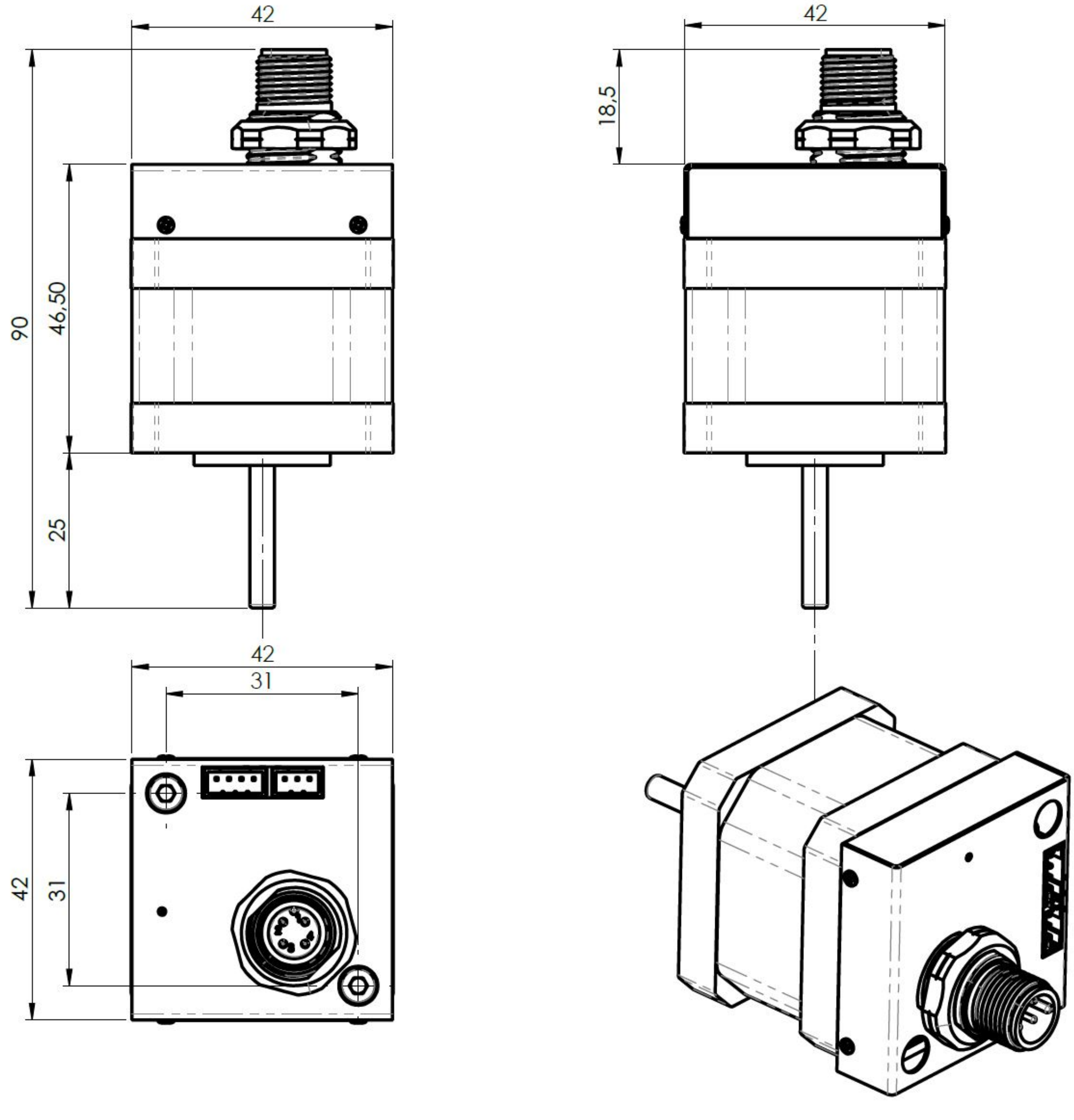

Figure 5: PD42-1-1243 with NEMA17 / 42mm stepper motor (all dimensions in mm)

3.3 Overall dimensions of NEMA17

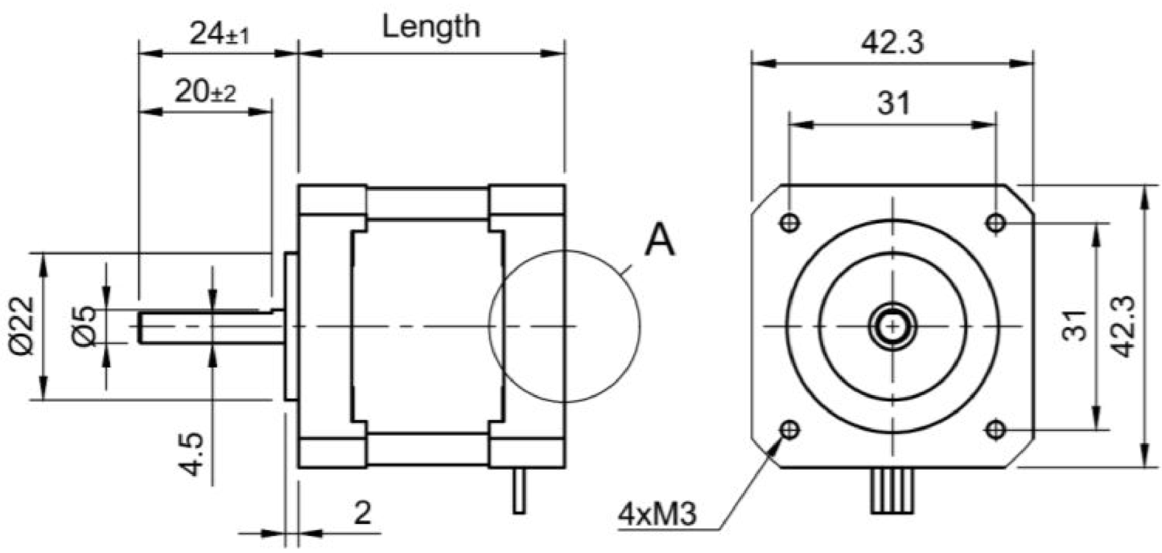

Figure 6: NEMA17 / 42mm stepper motor (all dimensions in mm)

3.4 Integrated sensOstep™ encoder

The PD42-x-1243-IOLINK 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.
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 commanded microstep 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 integrated encoder** In order to make proper use of the integrated sensOstep™ encoder (the sensor IC is placed on the bottom center of the pcb) the TMCM-1243 electronics should not be removed/moved relative to the motor! Otherwise encoder performance might suffer. Note: In case the integrated encoder feature is not used, the TMCM-1243 electronics module may be moved or even removed from the motor and placed somewhere else according to application requirements.

4 Connectors

The PD42-x-1243-IOLINK offers three connectors including the motor connector which is used for connecting the motor coils to the module. There are two connectors from the JST PH series: one motor connector with four pins (JST B4B-PH-K-S) and one power supply connector with three pins (JST B3B-PH-K-S). Separated from these, the most prominent connector on this product is the IO-Link 4-pin M12 plug.

NOTICE

Start with power supply OFF and do not connect or disconnect 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 voltage limits of the driver MOSFETs and might permanently damage them. Therefore, always switch off / disconnect power supply or at least disable driver stage before connecting / disconnecting motor.

Figure 7: PD42-x-1243-IOLINK connectors

Connector Types and Mating Connectors		
Connector	Connector type on-board	Mating connector type
Power	JST B3B-PH-K-S (JST PH series, 3pins, 2mm pitch)	Connector housing: JST PHR-3 Contacts: JST SPH-002T-P0.5S Wire: 0.22mm^2, AWG 24
Motor	JST B4B-PH-K-S (JST PH series, 4pins, 2mm pitch)	Connector housing: JST PHR-4 Contacts: JST SPH-002T-P0.5S Wire: 0.22mm^2, AWG 24
IO-Link	4-pin M12 (A-type, 1231 04 T9CP, male, 4-pin, 5mm pitch)	any M12 female 4-pin, A-type

Table 3: Connector Types and Mating Connectors of the PD42-x-1243-IOLINK

4.1 Power Supply Input Connector

The PD42-x-1243-IOLINK offers a 3pin JST PH series power supply input connector.

There are two ways to power the PANdrive:

For applications requiring just low torque the PANdrive can be used without additionl power via IO Link only. Thereby, the master supplies the required power at 24V over the IO Link supply. Typical master system can provide around 200-250mA here. In this mode, the pins 2 and 3 of the power supply connector are bridged with a jumper.

For applications requiring more torque the power supplied via the IO Link master might not be sufficient. Therefore, an additional +24V motor supply can be connected via the power supply connector. In this case, the jumper between pin 2 and 3 is to be removed. Auxiliary power must be connected to pins 1 (GND) and 2 (+24V). Pin 3 (L+) comes from the IO Link and can be left open in that case.

Power Connector Pin Assigment			
Pin	Label	Direction	Description
1	GND	Power Ground	Common system supply and signal ground
2	+VM	+24V (auxiliary) motor power input	(Auxiliary) power supply input for the motor driver stage (only the motor driver stage) *6. . . 28V*
3	L+	IO Link power output	This is the IO Link power output derived from the IO Link master. Keep open if not used for the motor driver stage. The digital circuits including the MCU is supplied via IO Link power.

Table 4: Power Supply Connector Pin Assignment

NOTICE **Do not connect or disconnect 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 voltage limits of the driver MOSFETs and might permanently damage them. Therefore, always switch off / disconnect power supply or at least disable driver stage before connecting / disconnecting motor.

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

4.2 Motor Connector

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

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

Pin	Label	Direction	Description
4	B1	out	Pin 2 of motor coil B

Table 5: Motor Connector Pin Assignment

NOTICE

Do not connect or disconnect 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 voltage limits of the driver MOSFETs and might permanently damage them. Therefore, always switch off / disconnect power supply or at least disable driver stage before connecting / disconnecting motor.

4.3 IO-Link M12 Connector

For serial communication through the PD42-x-1243-IOLINK M12 connector with the point-to-point IO-Link connection between the IO-Link master (multi-port controller or gateway) and the IO-Link device (actuator) this standard connector (usually M12) and a 3-wire cable up to 20 meters in length is used.

IO-Link Connector Pin Assignment			
Pin	Label	Direction	Description
1	L+	+24V	Common system supply
2	DO/DI	DI or DO	DO Aux Out/DI Aux input
3	GND	Power Ground	Common system signal ground
4	C/Q	Switching signal	IO-Link Transceiver Input/Output

Table 6: IO-Link M12 Connector Pin Assignment

5 On-Board LEDs

The board offers two LEDs in order to indicate board status. The green LED indicates if the module is in operation and flashing slowly if this is the case. The blue LED indicates if the +5V supply is functioning. During reset to factory default values the green LED will be flashing fast.

Figure 8: PD42-x-1243-IOLINK LEDs

6 Communication

6.1 IO-Link

IO-Link is a standardized technology (IEC 61131-9) regulating how sensors and actuators in industrial systems interact with a controller. For remote control and direct connection to a IO-Link master (multi-port controller or gateway) system the PD42-x-1243-IOLINK provides a 3-wire point-to-point IO-Link device port (M12). The master can have multiple ports (commonly four or eight). Each port of the master connects to a unique IO-Link device, which can operate in either SIO mode or bidirectional communication mode. IO-Link is designed to work with existing industrial architectures such as fieldbus or industrial Ethernet and connects to existing PLCs or human-machine interfaces (HMIs), enabling rapid adoption of this technology.

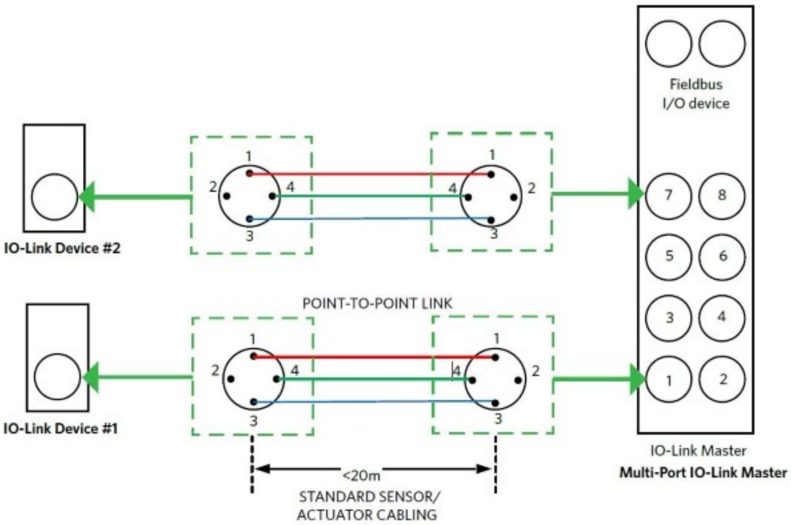

Figure 9: IO-Link Master/Device Setup

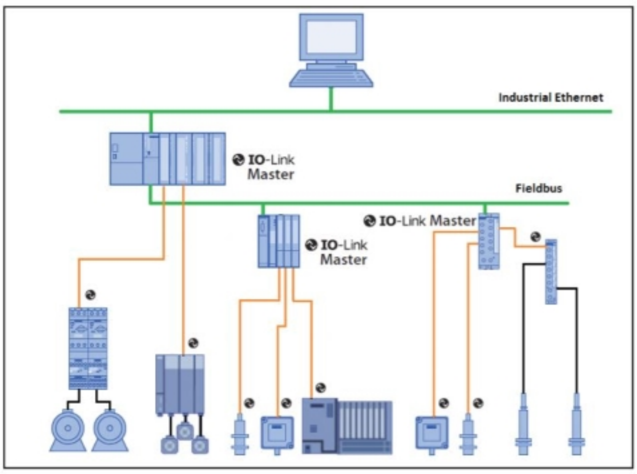

Figure 10: Example of system architecture using IO-Link Fieldbus and devices (sensors and actuators)

7 Torque curves

7.1 PD42-3-1241 Torque Curve

The following diagrams show the torque vs. speed curves for the PD42-1-1243, the PD42-2-1243, and the PD42-3-1243 at three different typical conditions. All measurements have been done in spreadCycle chopper mode. The measurement conditions are:

1. VDD =+24V, $I_{COILRMS}$ =1A, 1/256 microstepping
2. VDD =+24V, $I_{COILRMS}$ =1A, half stepping
3. VDD =+12V, $I_{COILRMS}$ =1A, half stepping

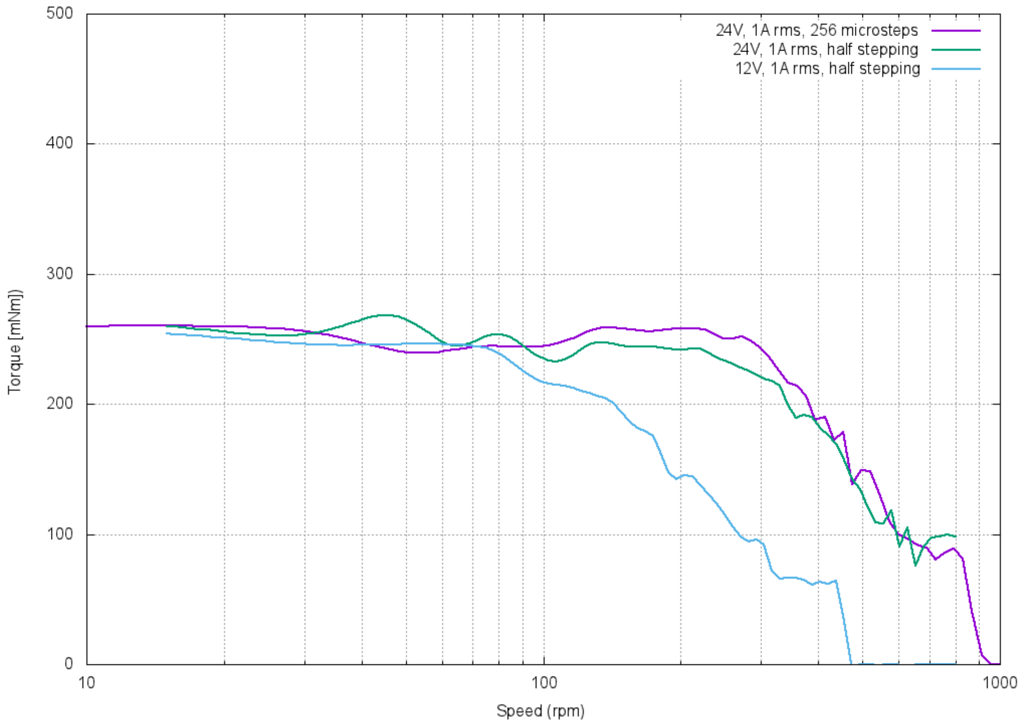

Figure 11: PD42-1-1243 torque vs. speed

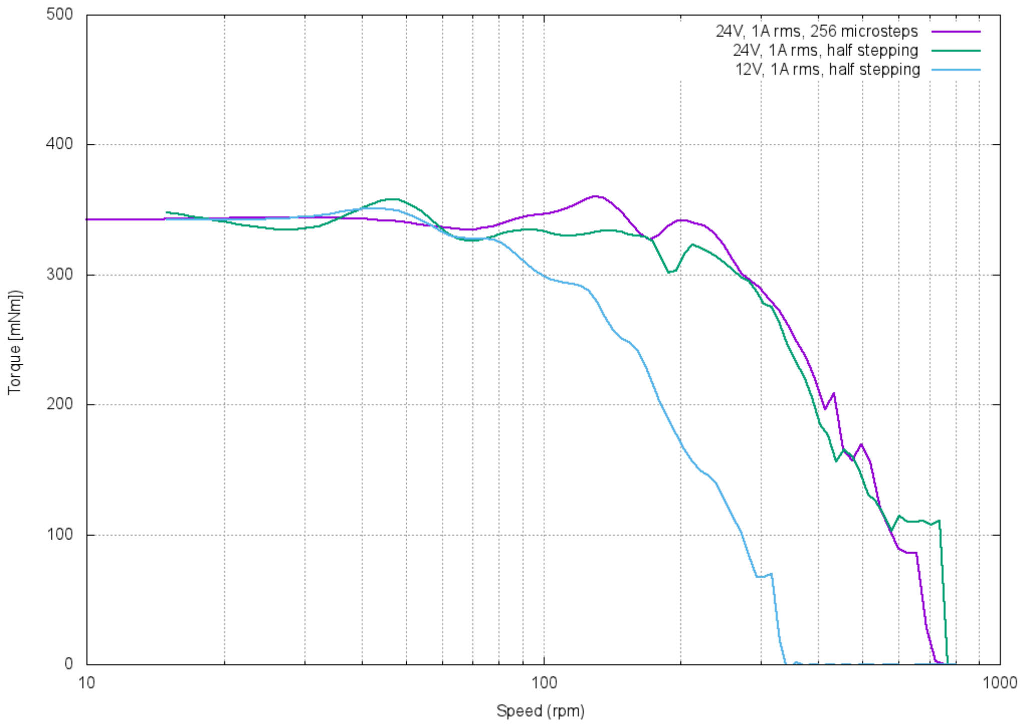

Figure 12: PD42-2-1243 torque vs. speed

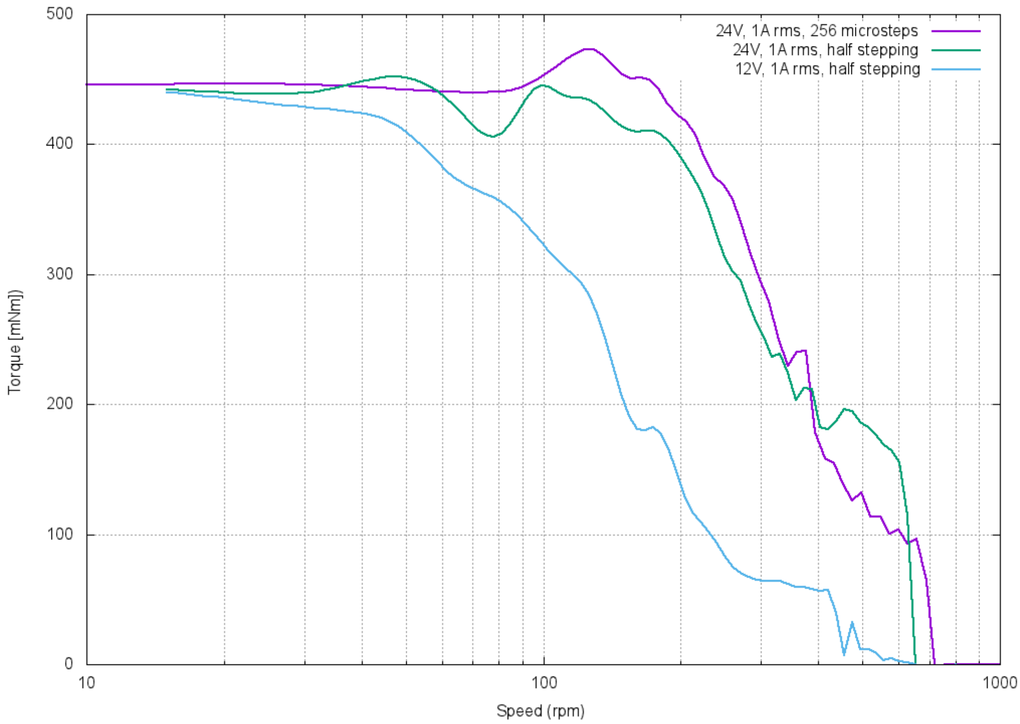

Figure 13: PD42-3-1243 torque vs. speed

8 Functional Description

The PD42-x-1243-IOLINK is a full mechatronic solution including a 42mm flange (NEMA17) bipolar stepper motor. It includes the controller / driver electronics and a choice between three different NEMA 17 / 42mm flange size bipolar hybrid stepper motors with different lengths and torques.

The PD42-x-1243-IOLINK can be controlled via IO-Link interface. The IO-Link connection through standard 4-pin M12 connector offers full control over the NEMA17 stepper motor as well as provide a industry-standard IO-Link communication protocol, enabling the opportunity of reconfigurable manufacturing solutions.

The PD42-x-1243-IOLINK contains the following main components:

- Microcontroller (ARM Cortex-M3™), responsible for overall control and communication
- Highly integrated advanced stepper motor controller supporting the two phase stepper motor
- Advanced stepper motor driver with stallGuard2™ and coolStep™ ensuring noiseless operation combined with maximum efficiency and best motor torque.
- MAX22513 low power IO-Link device transceiver
- Integrated voltage regulators (+5V and +3V3) required for supply of all on-board digital circuits
- Hall-based absolute position sensor

9 Operational Ratings and Characteristics

NOTICE **Never Exceed the absolute maximum ratings!** Keep the power supply voltage below the upper limit of +28V! 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.

General Operational Ratings					
Symbol	Parameter	Min	Typ	Max	Unit
$V_{AuxPower}$	Auxiliary power supply voltage	10	12. . . 24	28	V
V_{L+}	IO Link supply voltage		24		V
I_{Power}	Power supply current		<<I_{COIL_RMS}	1.4 x I_{COIL_RMS}	A
I_{COIL_PEAK}	Motor coil current for sine wave **peak (chopper regulated, adjustable via software)**	0	0. . . 1.4	1.7	A
I_{COIL_RMS}	Continuous motor current (**RMS)**	0	0. . . 1	1.2	A
T_{ENV}	Environmental temperature at rated current (no forced cooling reaquired)	-10		50	°C

Table 7: General operational ratings of the module

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12 Supplemental Directives

12.1 Producer Information

12.2 Copyright

12.3 Trademark Designations and Symbols

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12.4 Target User

The documentation provided here, is for programmers and engineers only, who are equipped with the necessary skills and have been trained to work with this type of product.

The Target User knows how to responsibly make use of this product without causing harm to himself or others, and without causing damage to systems or devices, in which the user incorporates the product.

12.5 Disclaimer: Life Support Systems

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12.7 Collateral Documents & Tools

This product documentation is related and/or associated with additional tool kits, firmware and other items, as provided on the product page at: www.trinamic.com.

13 Revision History

13.1 Hardware Revision

Version	Date	Author	Description
V1.0	2020-OCT-21	HH	Initial version.

Table 8: Hardware Revision

13.2 Document Revision

Version	Date	Author	Description
V1.00	2020-OCT-21	HH	Initial version of hardware manual.

Table 9: Document Revision