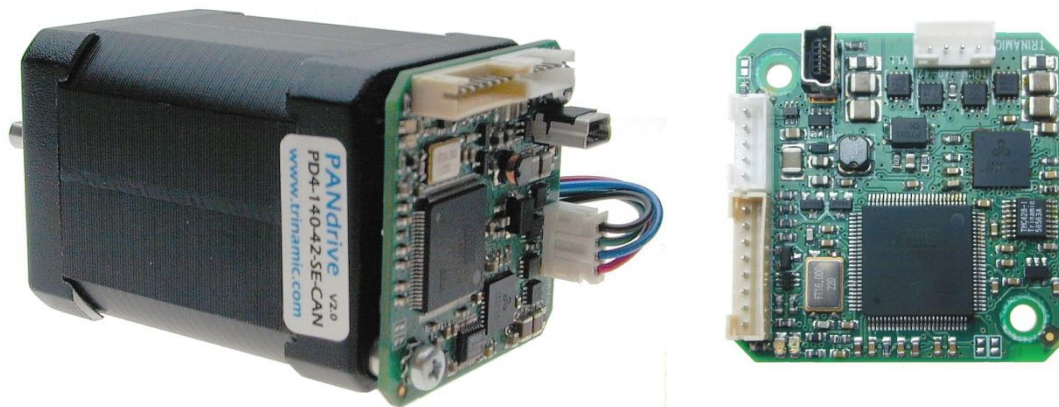


# PDx-140-42-SE

## TMCM-140-42-SE



## Hardware Manual

Version: 1.04  
2009-OCT-21



# TRINAMIC

MOTION CONTROL

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# 1 Life support policy

TRINAMIC Motion Control GmbH & Co. KG does not authorize or warrant any of its products for use in life support systems, without the specific written consent of TRINAMIC Motion Control GmbH & Co. KG.

Life support systems are equipment intended to support or sustain life, and whose failure to perform, when properly used in accordance with instructions provided, can be reasonably expected to result in personal injury or death.

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Specifications are subject to change without notice.

## 2 Features

The PDX-140-42-SE is a full mechatronic device consisting of a NEMA 17 (flange size 42mm) stepper motor, controller/driver electronics and integrated encoder. The electronics itself is also available without the motor as TCM-140-42-SE module.

### Applications

- Very compact single-axis stepper motor solutions
- Encoder feedback for high reliability operation (-SE option)

### Electrical data

- Supply voltage: +24V DC nominal (+7V .. +28.5V DC)
- Motor current: up-to 2.0A RMS (programmable)

### Integrated motor (for PDX-140-42-SE only)

- Two phase bipolar stepper motor with 2A RMS nom. coil current
- Holding torque: 0.22Nm, 0.36Nm, 0.44Nm or 0.7Nm

### Integrated encoder (for -SE option only)

- Integrated sensOstep™ magnetic encoder (max. 4096 increments per rotation) e.g. for step-loss detection under all operating conditions and positioning

### Integrated motion controller

- Motion profile calculation in real-time (TMC428 motion controller)
- On the fly alteration of motor parameters (e.g. position, velocity, acceleration)
- High performance ARM7 microcontroller for overall system control and serial communication protocol handling

### Integrated bipolar stepper motor driver

- Up-to 16 microsteps per full step
- High-efficient operation, low power dissipation (TMC249 stepper driver with external MOSFETs)
- Dynamic current control
- Integrated protection
- Integrated stallGuard™ for motor stall detection (e.g. elimination of end switches)
- Integrated chopSync™ for high velocity operation

### Interfaces

- 2 inputs for reference switches, 2 general purpose inputs and 2 general purpose outputs
- USB and either RS-232, RS-485 or CAN (2.0B up-to 1Mbit/s) communication interfaces

### Software

- Available with TMCL (all interface options) or CANopen (CAN interface option)
- TMCL: stand-alone operation or remote controlled operation
- TMCL: program memory (non volatile) for up-to 2048 TMCL commands
- TMCL: PC-based application development software TMCL-IDE available for free
- CANopen: CiA 301 + CiA 402 (homing mode, profile position mode and velocity mode) supported
- Please see separate TMCL and CANopen firmware manuals for additional information

### 3 Order codes

The PDX-140-42-SE is currently available with four different stepper motors (between 0.22Nm and 0.70Nm holding torque), three interface options in addition to the standard on-board USB interface (RS232, RS485 or CAN) and two firmware versions (TMCL and CANopen):

Order code	Description	Dimensions [mm <sup>3</sup> ]
PD1-140-42-SE-option	PANdrive with 0.22Nm max./holding torque	42x42x72
PD2-140-42-SE-option	PANdrive with 0.36Nm max./holding torque	42x42x76,5
PD3-140-42-SE-option	PANdrive with 0.44Nm max./holding torque	42x42x85,5
PD4-140-42-SE-option	PANdrive with 0.70Nm max./holding torque	42x42x98,5

**Table 3.1: Order codes (PDX-140-42-SE)**

The electronic module TCM-140-42-SE itself is also available with three interface options in addition to the standard on-board USB interface (RS232, RS485 or CAN) and two firmware versions (TMCL and CANopen):

Order code	Description	Dimensions [mm <sup>3</sup> ]
TCM-140-42-SE-option	Single axis bipolar stepper motor controller / driver electronics with integrated encoder electronics	board size: 42x42

**Table 3.2: Order codes (TCM-140-42-SE)**

Both versions offer the following options:

Option	Communication interface + firmware
232	USB (mini USB connector) and RS232 interface, TMCL firmware
485	USB (mini USB connector) and RS485 interface, TMCL firmware
CAN	USB (mini USB connector) and CAN interface, TMCL firmware
CANopen	USB (mini USB connector) and CAN interface, CANopen firmware

**Table 3.3: Options**

For cost critical applications and applications with reduced requirements with regard to position feedback both versions - with and without motor - are also available without sensOstep™ encoder as PDX-140-42 and TCM-140-42 on request.

## 4 Mechanical and electrical interfacing

### 4.1 Size of PDx-140-42-SE

Currently, there is a choice between four 42mm bipolar stepper motors with different lengths and different holding torques.

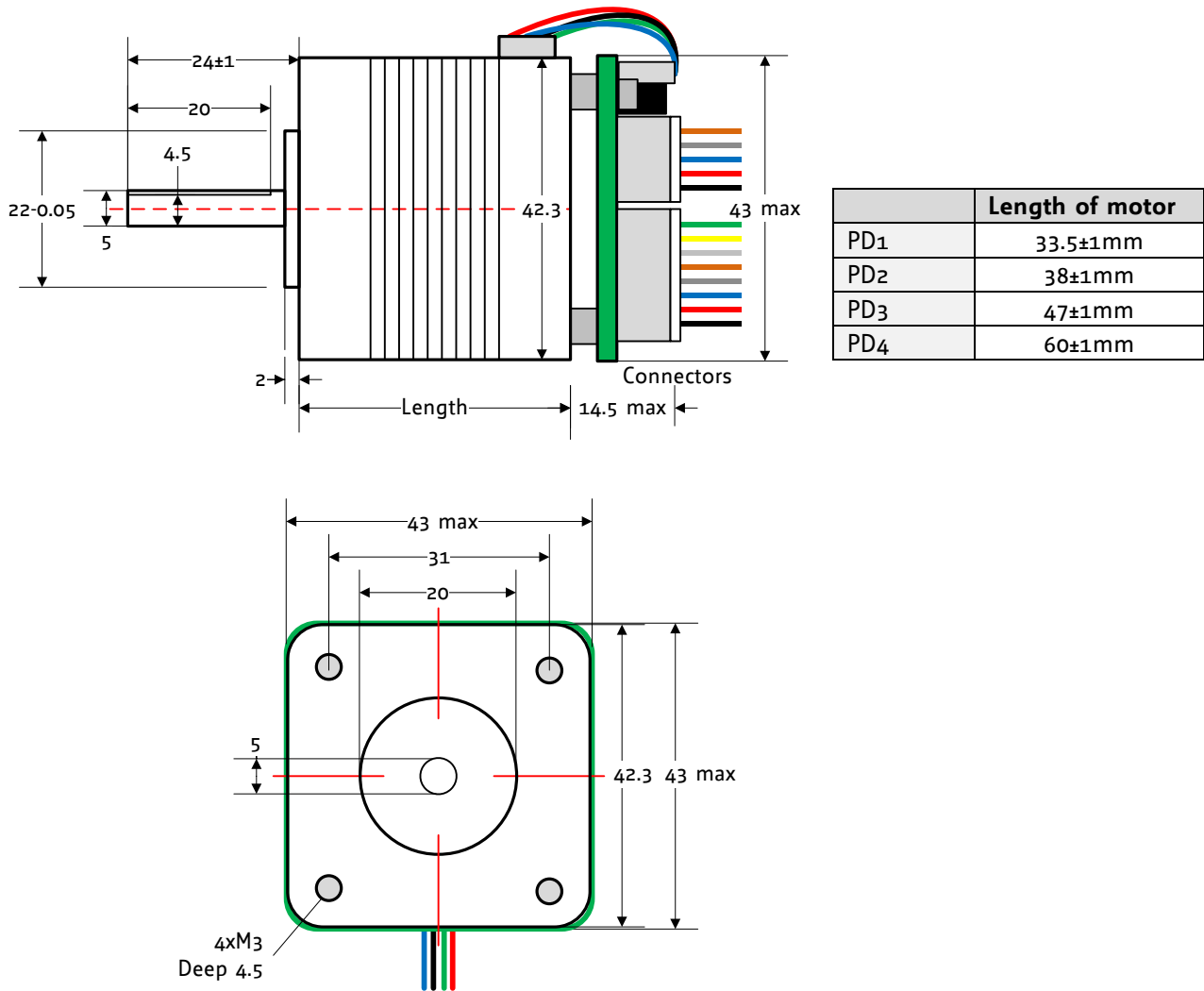


Figure 4.1: Dimensions PDx-140-42-SE (all values in mm)

## 4.2 Size of electronics (TCM-140-42-SE)

The electronic board has been designed in order to fit to a NEMA17 / 42mm size stepper motor with regard to board size and mounting holes. Board size is 42mm x 42mm and there are two mounting holes (size: 3.2mm) for M3 screws.

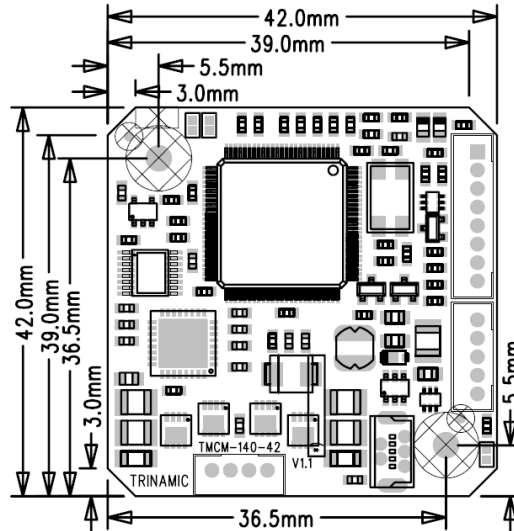


Figure 4.2: Dimensions TCM-140-42-SE (all values in mm)

## 4.3 Motor

Main characteristics of the four different motors available as part of the PDx-140-42-SE:

Specifications	Parameter	Units	QSH4218			
			-34-20-022	-38-20-036	-47-20-044	-60-20-070
Step angle		°	1.8	1.8	1.8	1.8
Step angle accuracy		%	+/-5	+/-5	+/-5	+/-5
Ambient temperature		°C	-20 ... +50	-20 ... +50	-20 ... +50	-20 ... +50
Max. motor temperature		°C	80	80	80	80
Shaft radial play (450g load)		mm	0.02	0.02	0.02	0.02
Shaft axial play (450g load)		mm	0.08	0.08	0.08	0.08
Max radial force (20mm from front flange)		N	28	28	28	28
Max axial force		N	10	10	10	10
Rated voltage	$V_{RATED}$	V	2.0	2.4	2.4	4.4
Rated phase current	$I_{RMS RATED}$	A	2.0	2.0	2.0	2.0
Phase resistance at 20°C	$R_{COIL}$	Ω	1.0	1.2	1.4	2.3
Phase inductance (typ.)		mH	1.6	2.2	2.1	6.0
Holding torque		Nm	0.22	0.36	0.44	0.70
Insulation class			B	B	B	B
Rotor inertia		g cm <sup>2</sup>	35	57	68	102
Weight		kg	0.22	0.24	0.35	0.5

Table 4.1: Technical motor data

## 4.4 Connectors

The PDx-140-42-SE / TCM-140-42-SE offers four connectors, a 5-pin power and serial communication interface connector, an 8-pin input/output connector, a 4-pin motor connector (with PDx-140-42-SE already connected to the attached motor) and a 5-pin mini-USB connector.

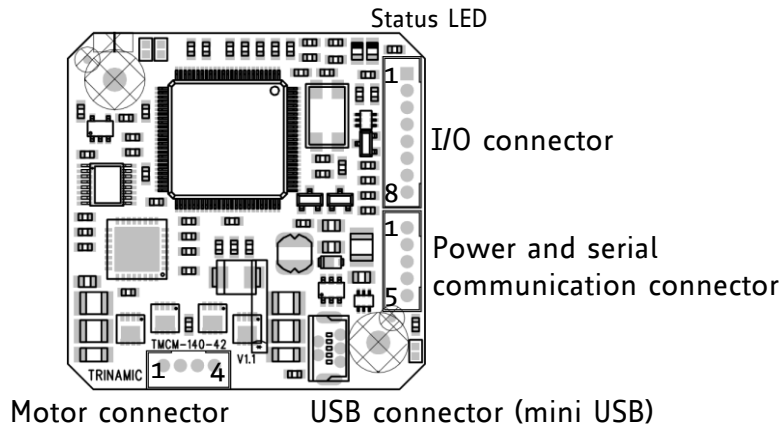


Figure 4.3: PDx-140-42-SE Connectors

### 4.4.1 Power and serial communication connector

A 5-pin JST PH series connector is used for power supply and serial communication. Three different communication interface standards are available with this unit (as options): RS232, RS485 and CAN.

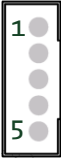
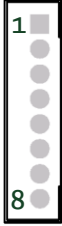
	Pin	RS232	RS485	CAN	Description
	1	GND	GND	GND	GND
2	VDD	VDD	VDD	VDD	Supply voltage (+24V DC nom.)
3	GND	GND	GND	GND	Power and signal ground
4	RS232_TxD	RS485A	CAN_L		
5	RS232_RxD	RS485B	CAN_H		

Table 4.2: Connector for power and communication

Mating connector from JST: PHR-5 (housing) and SPH-002T-P0.5S (crimp contact for AWG #30 to 24 / 0.05mm<sup>2</sup> to 0.22mm<sup>2</sup> wires).

### 4.4.2 I/O connector

An 8-pin JST PH series connector is used for input/output signals.


	Pin	Label	Direction	Description
	1	STOP_L	Input	Left stop switch input (+5V compatible)
	2	STOP_R	Input	Right stop switch input (+5V compatible)
	3	GND	Power (GND)	Power and signal ground
	4	VDD	Power	Supply voltage +24V DC nom.
	5	OUT_o	Output	General purpose output (open collector)
	6	OUT_1	Output	General purpose output (open collector)
	7	IN_o	Input	General purpose input (+5V and +24V compatible)
	8	IN_1	Input	General purpose input (+5V and +24V compatible)

**Table 4.3: Connector for power and I/O**

Mating connector from JST: PHR-8 (housing) and SPH-002T-Po.5S (crimp contact for AWG #30 to 24 / 0.05mm<sup>2</sup> to 0.22mm<sup>2</sup> wires).

### 4.4.3 Motor connector

A 4-pin JST PH series connector is used for connecting the motor.

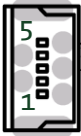
	Pin	Label	Direction	Description
	1	OA1	Output	2-phase stepper motor phase A
	2	OA2	Output	2-phase stepper motor phase A
	3	OB1	Output	2-phase stepper motor phase B
	4	OB2	Output	2-phase stepper motor phase B

**Table 4.4: Connector for motor**

Mating connector from JST: PHR-4 (housing) and SPH-002T-Po.5S (crimp contact for AWG #30 to 24 / 0.05mm<sup>2</sup> to 0.22mm<sup>2</sup> wires).

### 4.4.4 USB connector

A 5-pin mini-USB connector is available on board.

	Pin	Label	Description
	1	VBUS	+5V power
	2	D-	Data -
	3	D+	Data +
	4	ID	Not connected
	5	GND	Ground

**Table 4.5: Connector for USB**

## 4.5 Input/output circuits

The module offers 2 stop switch inputs, 2 general purpose inputs and 2 general purpose outputs. The stop switch inputs STOP\_L and STOP\_R are +5V tolerant and include 1k pull-up resistors to +5V. The general purpose inputs IN\_0 and IN\_1 accept e.g. 5V or 24V compatible signals and include 20k pull-down resistors.

The general purpose outputs are open-collector outputs with integrated freewheeling diodes. Max. sink current per output is 100mA and max. voltage at output when output is inactive / output transistor is switched off is limited to module supply voltage due to the integrated freewheeling diode.

## 5 Functional Description

The PANdrive PD-140-42-SE is a mechatronic solution including a 42 mm flange motor, a controller board and a sensOstep™ encoder. It offers four motor torque options and can be controlled via CAN, RS-232, RS-485 or USB interface. Power supply, interface and general purpose I/Os can be connected with high density JST connectors. The chopSync™ feature allows high speed movement avoiding resonances. The PD-140-42-SE 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“ or „constant rotation“ a rapid and fast development of motion control applications is guaranteed. Communication traffic is kept very low since all time critical operations, e.g. ramp calculation are performed on board. The TMCL program can be stored in the onboard EEPROM for stand-alone operation. In addition to TMCL CANopen is available as firmware option, also.

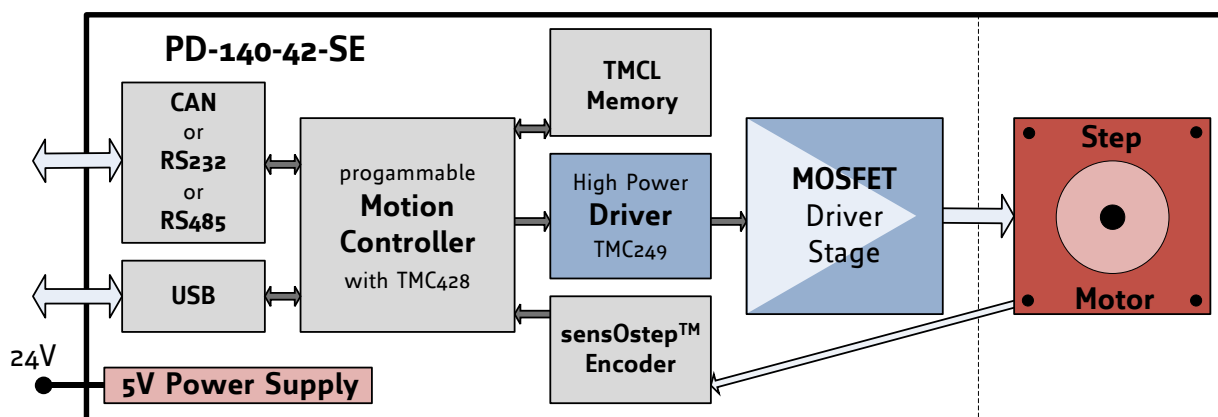


Figure 5.1: Main parts of the PDx-140-42-SE

## 6 Firmware

Currently, there are two different firmware versions available for this unit – TMCL and CANopen. TMCL is available for all interface options and is supplied as default firmware. Please refer to the TMCL firmware manual for this unit for more details [TMCL].

With the CAN interface option also CANopen is available as firmware. This firmware supports the CiA 301 and CiA 402 profiles with support for homing mode, profile position mode and velocity mode. For more details please refer to the CANopen manual [CANopen].

## 7 Torque curves

The following torque curves have been measured using the PANdrive PDx-140-42-SE with all four stepper motors available as part of this unit. The four different stepper motors all offer the same max. coil current but, differ with respect to holding torque, motor length, coil resistance and inductivity – to name a few. As rule of thumb, more holding torque means more copper, longer motor, more coil resistance and higher inductivity which limits the max. reachable velocity at the same supply voltage. All measurements were taken at +24V driver supply voltage and max. motor current.

The figures below include torque curves for microstep operation and full step operation. With full step mode it is possible to reach higher velocities whereas resonances normally prevent any smooth operation at lower speeds (see torque curves below). Therefore, TMCL firmware offers programmable automatic switch over between microstep operation at lower speeds and full-step operation at higher speed in order to take advantage of both modes (please see TMCL firmware manual, axis parameter 211).

### 7.1 PD1-140-42-SE

The PD1-140-42-SE is the most compact version of this PANdrive series with the shortest stepper motor.

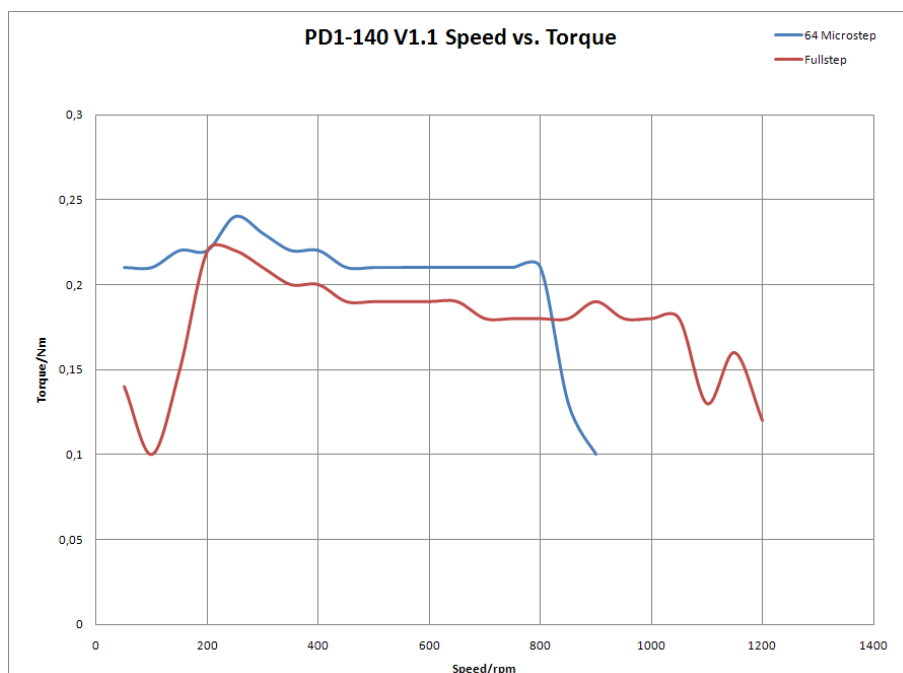


Figure 7.1: PD1-140-42-SE torque curve

## 7.2 PD2-140-42-SE

For applications where more torque is required than available with the PD1-140-42-SE, the PD2-140-42-SE might be an option.

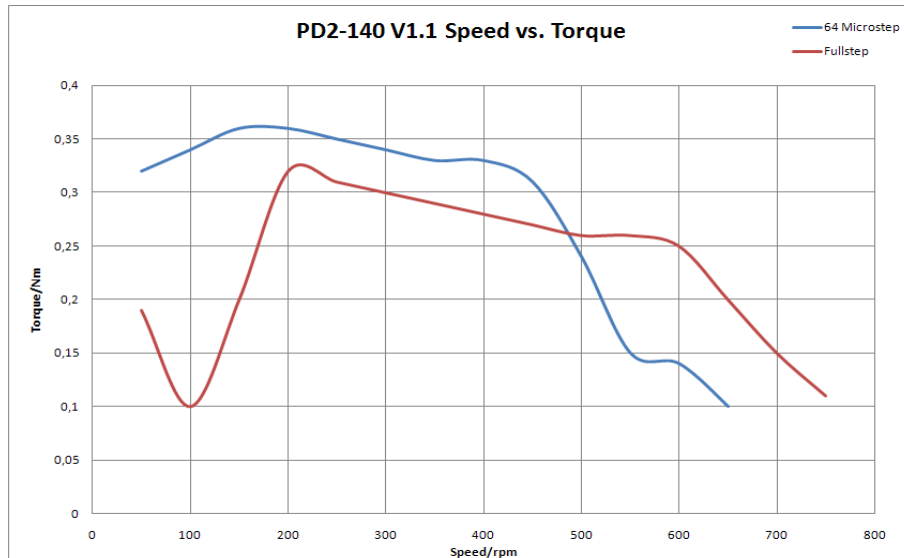


Figure 7.2: PD2-140-42-SE torque curve

## 7.3 PD3-140-42-SE

For applications where more torque is required than available with the PD2-140-42-SE, the PD3-140-42-SE might be an option.

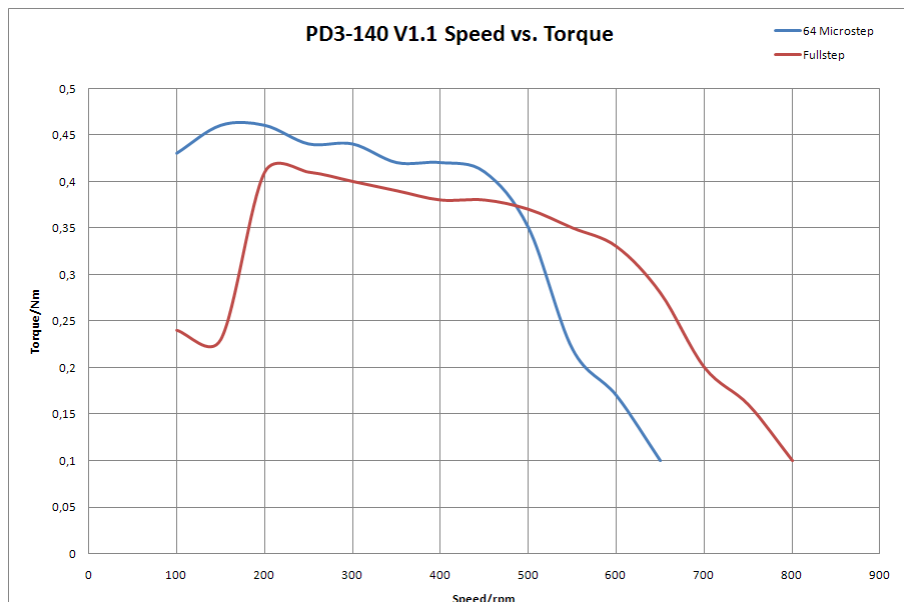


Figure 7.3: PD3-140-42-SE torque curve

## 7.4 PD4-140-42-SE

For applications where more torque is required than available with the PD3-140-42-SE, the PD4-140-42-SE might be an option. The PD4-140-42-SE is the version with highest holding torque and the longest stepper motor available for this PANdrive series.

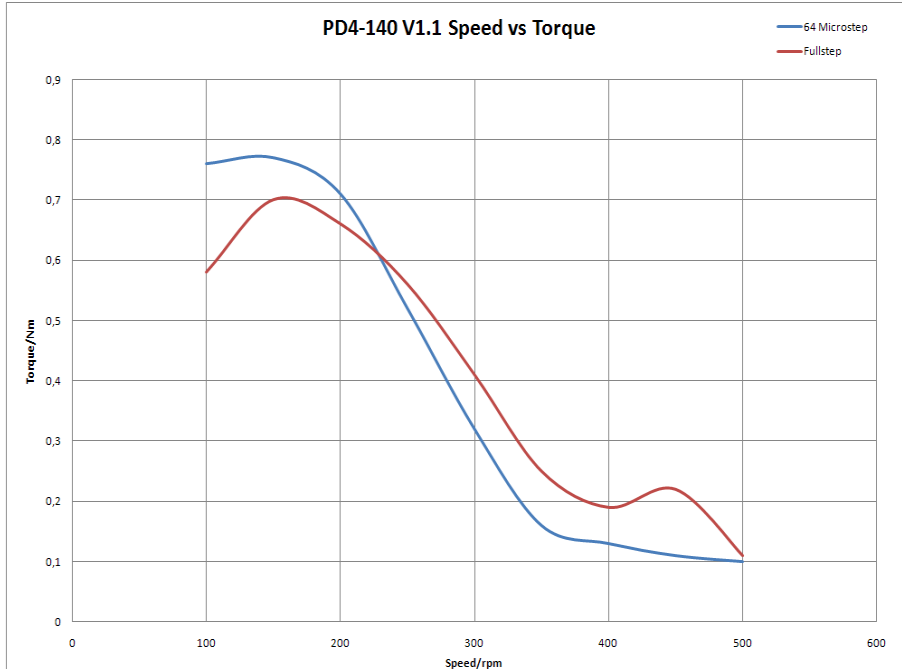


Figure 7.4: PD4-140-42-SE torque curve

## 8 Operational ratings

The operational ratings shown below should be used as design values. In no case should the maximum values been exceeded during operation.

Symbol	Parameter	Min	Typ	Max	Unit
Vcc	+24 DC input	7	24	28.5	V
$I_{COIL\_peak}$	Motor coil current for sine wave <b>peak</b> (chopper regulated, adjustable via software)	0		2.8 *)	A
$I_{COIL\_RMS}$	Continuous motor current ( <b>RMS</b> )	0		2 *)	A
$I_{SUPPLY}$	Power supply current		$\ll I_{COIL}$	$1.4 * I_{COIL}$	A
$T_{ENV}$	Environment temperature at max. current, 100% duty cycle (no forced cooling required)			+40 **)	°C

**Table 8.1: General operational ratings of the module**

\*) Please note: only PDx-140-42-SE and TCM-140-42-SE with pcb version 1.1 or newer support specified max. current over full temperature range. Older / pre-series versions may be limited with regard to temperature range and / or max. motor current.

\*\*\*) Test set-up / procedure: PANdrive PD4-140-42-SE mounted to a metal base plate in order to keep stepper motor temperature within limits for the motor during test (table 4.1) / test inside climate chamber with approx. 53l volume / no forced air convection during test / test duration at least 30min.

Please note: motor temperature should always be kept below upper limit for the motor - that is, motor / PANdrive should be mounted to an appropriate metal / cooling plate or frame. Especially, the longest available stepper motor which is part of the PD4-140-42-SE may easily reach 100°C or above when operated at full current over long time without being mounted to any heat-conducting structure or forced air convection. In case the TCM-140-42-SE electronic module is mounted close to the motor as with the PANdrives, the motor might substantially heat up the electronics and limit the maximum environmental temperature during operation. The unit may be operated at higher environmental temperatures than specified when the duty cycle of the motor and / or the motor current is reduced or in case the TCM-140-42-SE electronic module is mounted separately from the motor.

Symbol	Parameter	Min	Typ	Max	Unit
$V_{STOP\_L/R\_L}$	Low level input voltage for STOP_L/R switch inputs			0.9	V
$V_{STOP\_L/R\_H}$	High level input voltage for STOP_L/R switch inputs	1.9		5	V
$V_{IN\_1/2\_L}$	Low level input voltage for general purpose inputs IN_1/2 (when configured as digital inputs)			1.6	V
$V_{IN\_1/2\_H}$	High level input voltage for general purpose inputs IN_1/2 (when configured as digital inputs)	4.0		24	V
$V_{IN\_1/2\_ANA}$	Analog voltage full scale input range for general purpose inputs IN_1/2 (when configured as analog inputs)	0		6.6	V
$V_{OUT\_1/2}$	Maximum voltage at general purpose outputs (open collector output switched off)			$V_{CC} + 0.5$ *)	V
$I_{OUT\_1/2}$	Maximum output sink current for general purpose outputs (open collector)		10	100	mA

**Table 8.2: Operational ratings of input and output signals**

\*) limited to module supply voltage + 0.5V due to integrated freewheeling diode between general purpose output and module supply voltage

## 9 Revision history

### 9.1 Document revision

Version	Date	Author	Description
1.00	2008-07-23	GE	Initial version
1.01	2008-09-01	GE	Ordering codes added
1.02	2008-10-28	GE	CAN connector pin assignment corrected
1.03	2008-12-17	SD	Size of the unit and functional description added
1.04	2009-10-21	GE	New hardware version + torque curves added

Table 9.1: Document revision

### 9.2 Hardware revision

Version	Date	Description
1.00	2008-04-27	First version, reduced motor current
1.10	2009-06-29	Second version, full production (series) version

Table 9.2: Hardware revision

## 10 References

- [TMCL] PD-140 TMCL firmware manual (see <http://www.trinamic.com>)  
[CANopen] CANopen manual (see <http://www.trinamic.com>)