

# PDx-146-60-SE



## Hardware Manual

Version: 1.10  
2010-JUN-28



**TRINAMIC**  
MOTION CONTROL

Trinamic Motion Control GmbH & Co KG  
Sternstraße 67  
D - 20 357 Hamburg, Germany  
Phone +49-40-51 48 06 - 0  
FAX: +49-40-51 48 06 - 60  
<http://www.trinamic.com>

# Table of Contents

1	Life support policy .....	3
2	Features .....	4
3	Order codes .....	6
4	Mechanical and electrical interfacing .....	7
4.1	Size of the PANdrives™ .....	7
4.2	Connectors .....	8
4.2.1	CAN connector .....	8
4.2.2	Power and I/O connector .....	9
4.3	Rotary switches .....	12
4.4	SHUTDOWN input .....	12
4.5	General purpose inputs .....	13
4.6	BRAKE output .....	13
4.7	General purpose outputs .....	14
5	Operational ratings .....	15
6	Functional description .....	16
7	Revision history .....	17
7.1	Document revision .....	17
7.2	Hardware revision .....	17
8	References .....	17

# 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.

© TRINAMIC Motion Control GmbH & Co. KG 2009

Information given in this data sheet is believed to be accurate and reliable. However neither responsibility is assumed for the consequences of its use nor for any infringement of patents or other rights of third parties, which may result from its use.

Specifications are subject to change without notice.

## 2 Features

The PDX-146-60-SE is a full mechatronic device consisting of a NEMA 24 stepper motor (QSH6018: flange size 60mm), controller/driver electronics and integrated encoder.

### Electrical data

- Supply voltage: +24V DC nominal [+7V (min.) ... +34V (max.)]
- Motor coil current: up to 2.8A RMS (programmable)

### Stepper motor data

- Two phase NEMA 24/60mm flange size bipolar stepper motor with up to 2.8A RMS coil current.
- Currently four motors are available with different length and holding torque:

Specifications	Parameter	Units	QSH6018			
			-45-28-110	-56-28-165	-65-28-210	-86-28-310
Number of Leads		N°	8	8	8	8
Step Angle		°	1.8	1.8	1.8	1.8
Rated Voltage	$V_{RATED}$	V	2.1	2.52	3.36	4.17
Rated Phase Current	$I_{RMS\ RATED}$	A	2.8	2.8	2.8	2.8
Phase Resistance at 20°C	$R_{COIL}$	$\Omega$	0.75	0.9	1.2	1.5
Phase Inductance (typ.)		mH	2	3.6	4.6	6.8
Holding Torque		NM	1.1	1.65	2.1	3.1
Rotor Inertia		g cm <sup>2</sup>	275	400	570	840
Insulation Class			B	B	B	B
Weight		kg	0.6	0.77	1.2	1.4
Ambient Temperature		°C	-20 +50	-20 +50	-20 +50	-20 +50

**Table 2.1: Motor specifications of QSH6018**

### Interfaces

- 5 general purpose inputs including 3 inputs for reference and home switches (+24V compatible)
- 1 shutdown input (enable/disable driver stage in hardware – active low)
- general purpose outputs (open-drain)
- 1 output for connecting an external brake (open-drain)
- Step/Direction/Enable Input (Step/Direction support in hardware, differential, single ended and open collector signals accepted)
- Step/Direction/Enable Output (Master/Slave operation with multiple PDX-146-60-SE incl. electronic gearing supported in hardware, differential/single ended signal output)
- External Encoder Interface (incremental A/B/N input, differential, single ended and open collector encoder signals accepted)
- CAN (2.0B up to 1Mbit/s), RS232 and RS485 communication interfaces

### Features

- High-efficient operation, low power-dissipation (TMC239 stepper driver with external MOSFETs)
- Dynamic current control
- Integrated protection
- On the fly alteration of motor parameters (e.g. position, velocity, acceleration)
- Motion profile calculation in real-time (advanced TMC457 motion controller)
- Automatic ramp generation (trapezoid and S-shaped) in real-time in hardware
- Max. 1024 times micro stepping
- Integrated chopSync™ for high velocity operation
- Integrated sensOstep™ magnetic encoder (max. 4096 increments per rotation)
- rotary switches for CAN address setting

**Software**

- TMCL™ firmware
  - TMCL™ remote (direct mode) or stand-alone operation (memory for 2048 TMCL™ commands)
  - Fully supported by TMCL-IDE (PC based integrated development environment)
- CANopen firmware
  - DS301 + DSP402 profiles (DSP402: homing mode, profile position mode, velocity mode)

### 3 Order codes

The combination of motor and motor mounted controller/driver electronic (PANdrive™) is available with four different stepper motors:

Order code	Description	Dimensions [mm <sup>3</sup> ]
PD1-146-60-SE-option	PANdrive™ with 1.10Nm max./holding torque	60 x 94 x 71
PD2-146-60-SE-option	PANdrive™ with 1.65Nm max./holding torque	60 x 94 x 82
PD3-146-60-SE-option	PANdrive™ with 2.10Nm max./holding torque	60 x 94 x 91
PD4-146-60-SE-option	PANdrive™ with 3.10Nm max./holding torque	60 x 94 x 112

#### Firmware option:

Firmware option	Description
CANopen	DS301 + DSP402 (homing mode, profile position mode, velocity mode)
TMCL	TMCL™ firmware, default

**Table 3.1: Order codes**

The electronics hardware is the same for all versions. In case the selected motor and the firmware option are not relevant for a particular feature the manual will refer to all versions in general as PDX-146-60-SE.

## 4 Mechanical and electrical interfacing

### 4.1 Size of the PANdrives™

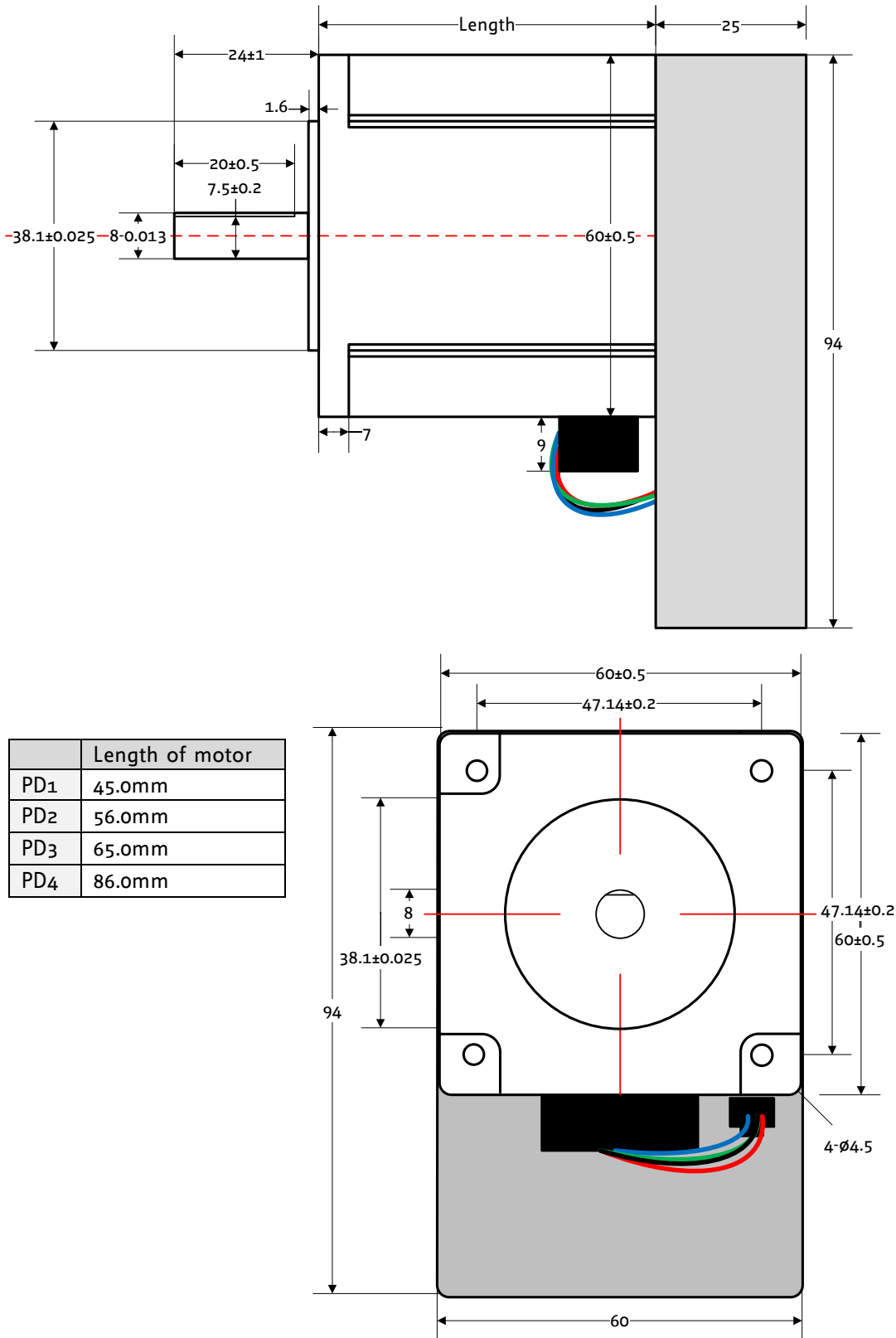


Figure 4.1: Dimensions of PDx-146-60-SE

## 4.2 Connectors

The PDx-146-60-SE provides two D-SUB connectors for external connections, a 9-pin D-SUB male connector for CAN communication and a 26-pin high density D-SUB male connector for power and additional I/Os.

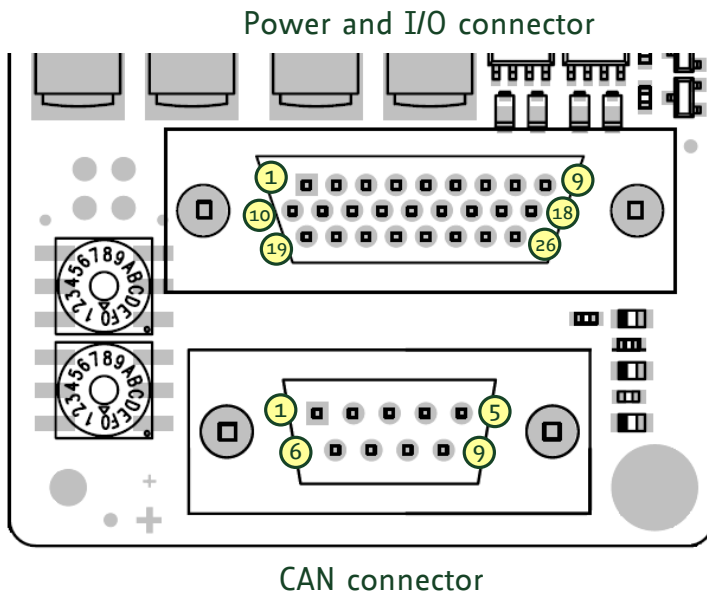


Figure 4.2: Position of connectors

### 4.2.1 CAN connector

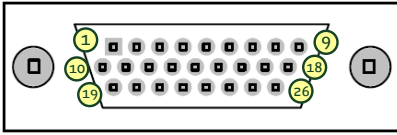
A 9-pin standard D-Sub connector (male) is used for CAN communication.

	Pin	Function	Description
	1		
	2	CAN_L	CAN bus line (dominant low)
	3	GND	CAN signal and system ground
	4		
	5		
	6		
	7	CAN_H	CAN bus line (dominant high)
	8		
	9		

Table 4.1: Connector for CAN

### 4.2.2 Power and I/O connector

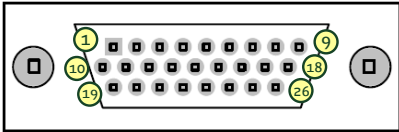
A 26-pin high density D-SUB connector (male) is used for power and input / output signals.

	Pin	Function	Alternate function	Description
	1	+24V		Power supply input (+24V nom.)
	2	/SHUTDOWN		Hardware shutdown input (+24V compatible, active low, internal 20k pull-down resistor)
	3	GND		Power and signal ground
	4	GND		Power and signal ground
	5	+24V		Power supply output (+24V nom.) e.g. for open-drain outputs
	6	/BRAKE		Open-drain output incl. free-wheeling diode connected to power supply input. Supports up to 1A RMS. Power PWM pre-driver included for programmable brake current.
	7	/OUT_2		Open-drain output incl. free-wheeling diode connected to power supply input. Supports up to 1A RMS.
	8	/OUT_1		Open-drain output incl. free-wheeling diode connected to power supply input. Supports up to 1A RMS.
	9	/OUT_0		Open-drain output incl. free-wheeling diode connected to power supply input. Supports up to 1A RMS.

**Table 4.2: Connector for Power and I/O**

*Remarks:*

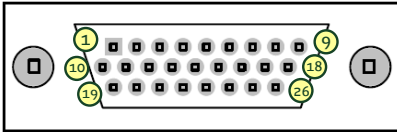
- /SHUTDOWN has to be connected to power supply / any voltage above 4.2V up-to max. supply voltage in order to enable driver stage. Leaving this input unconnected / connecting this input to ground will disable driver stage and prevent any motor movements
- Max. current for any pin of this connector incl. power supply should be limited to 3A RMS. Therefore, it is recommended to always connect all supply ground pins (3+4+19) and pay attention to the current sum through ground especially when using the general purpose and the brake output pins at the same time with high currents.

	Pin	Function	Alternate function	Description
	10	RS232_TxD		RS232 transmit data
	11	RS232_RxD		RS232 receive data
	12	RS485_L	TRG_L	RS485 bus line (dominant low) <b>or</b> trigger signal negative output (differential)
	13	RS485_H	TRG_H	RS485 bus line (dominant high) <b>or</b> trigger signal positive output (differential, single ended)
	14	IN_1		General purpose input 1 (+24V tolerant, internal 15k pull-down resistor), can be used as either digital or analogue input
	15	IN_0		General purpose input 0 (+24V tolerant, internal 15k pull-down resistor), can be used as either digital or analogue input
	16	STOP_L		Left stop switch input (+24V and +5V tolerant, internal 20k pull-down resistor, programmable 1k pull-up to +5V with protection diode)
	17	STOP_R		Right stop switch input (+24V and +5V tolerant, internal 20k pull-down resistor, programmable 1k pull-up to +5V with protection diode)
	18	HOME		Home switch input (+24V and +5V tolerant, internal 20k pull-down resistor, programmable 1k pull-up to +5V with protection diode)

**Table 4.2 (cont.): Connector for Power and I/O**

*Remarks:*

- General purpose inputs IN\_0 and IN\_1 may be used depending on configuration as either +24V compatible digital inputs (low level: max. 2.4V, high level: min. 6.3V) or as analog inputs with 0..+10V full scale analog input range
- Depending on firmware STOP\_L, STOP\_R and HOME inputs may be used as additional general purpose +24V / +5V tolerant digital inputs (low level: max. 1.6V, high level: min 4.2V)
- Internal 1k pull-up resistors for STOP\_L, STOP\_R and HOME inputs may be activated in case "opener" switches (open when activated) are connected between these inputs and ground
- Depending on firmware and configuration trigger output (TRG\_L and TRG\_H) will generate a trigger signal in case a programmable position has been reached

	Pin	Function	Alternate function	Description
	19	GND		Power and signal ground
	20	ENC_N-	ENABLE-	Encoder N-channel negative (differential) input <b>or</b> negative (differential) enable input/output for master or slave operation in step/direction mode
	21	ENC_N+	ENABLE+	Encoder N-channel positive (differential, single ended, open-collector) input <b>or</b> positive (differential, single ended) enable input/output for master or slave operation in step/direction mode
	22	ENC_B-	DIR-	Encoder B-channel negative (differential) input <b>or</b> negative (differential) direction input/output for master or slave operation in step/direction mode
	23	ENC_B+	DIR+	Encoder B-channel positive (differential, single ended, open-collector) input <b>or</b> positive (differential, single ended) direction input/output for master or slave operation in step/direction mode
	24	ENC_A-	STEP-	Encoder A-channel negative (differential) input <b>or</b> negative (differential) step input/output for master or slave operation in step/direction mode
	25	ENC_A+	STEP+	Encoder A-channel positive (differential, single ended, open-collector) input <b>or</b> positive (differential, single ended) step input/output for master or slave operation in step/direction mode
	26	+5V		+5V output e.g. for encoder power supply (max. 100mA)

**Table 4.2 (cont.): Connector for Power and I/O**

*Remarks:*

- This unit offers connection for an external incremental a/b/n encoder. Either the internal magnetic sensOstep™ or the external encoder may be used
- As an alternative to an external encoder the same pins may be used as step / direction inputs or outputs. Inputs and outputs are connected directly to the TMC457 [TMC457] motion controller. Therefore, step / direction signals are translated / generated directly in hardware. When configuring step / direction as output signals the device will act as master, synchronising one or more connected additional PDx-146-60-SE devices configured as slaves with step/direction inputs. This way, e.g. electronic gearing may be implemented.

### 4.3 Rotary switches

There are two rotary switches for defining the ID of the device in a CANopen network. Each one is used for setting four bits of the address (lower and upper part).

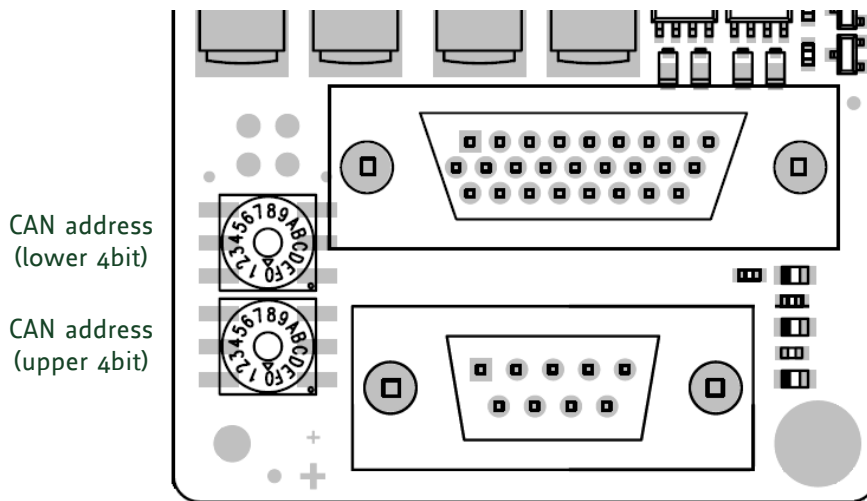


Figure 4.3: Position of rotary switches

### 4.4 /SHUTDOWN input

/SHUTDOWN has to be connected to the power supply (any voltage above 4.2V up to max. supply voltage) in order to enable the driver stage. **Leaving this input unconnected or connecting it to ground will disable the driver stage and prevent any motor movements.**

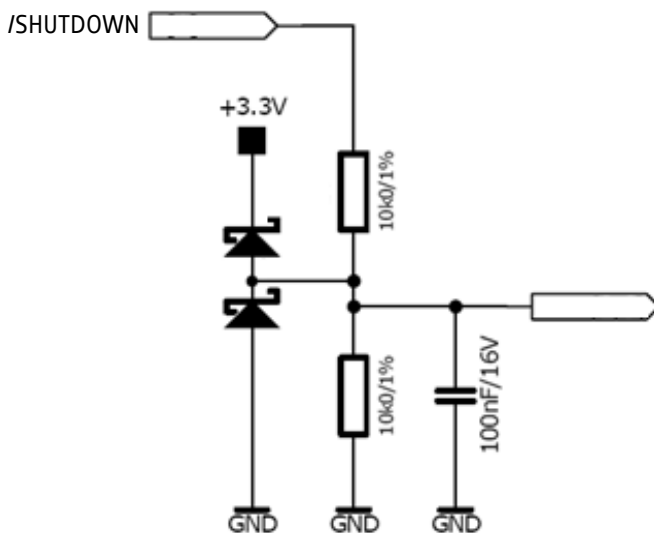


Figure 4.4: /SHUTDOWN input circuit

## 4.5 General purpose inputs

The general purpose inputs IN\_0 and IN\_1 may be used depending on their configuration

- as +24V compatible digital inputs (low level: max. 2.4V, high level: min. 6.3V) or
- as analogue inputs with 0... +10V full scale analogue input range.

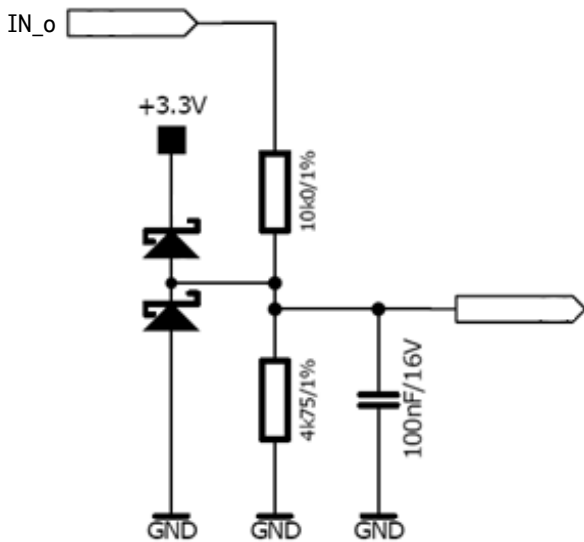


Figure 4.5: IN\_0 input circuit

## 4.6 /BRAKE output

The /BRAKE output offers power PWM for programmable brake current.

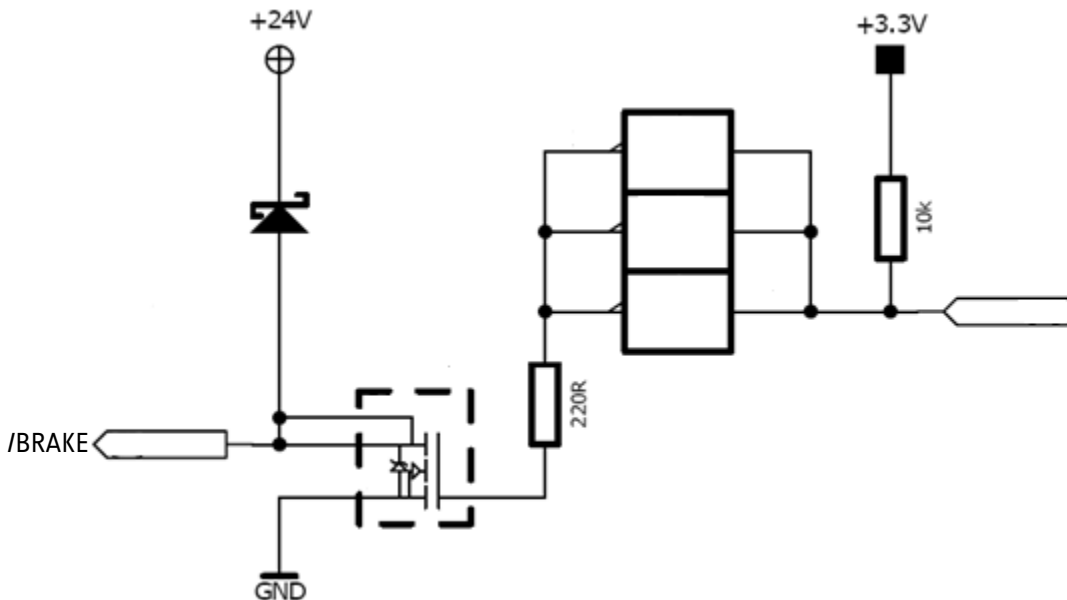


Figure 4.6: /BRAKE output circuit

## 4.7 General purpose outputs

The PDx-146-60-SE offers three general purpose open-drain outputs with integrated freewheeling diode: OUT\_0, OUT\_1, and OUT\_3. Please note, that the output voltage should not exceed the supply voltage.

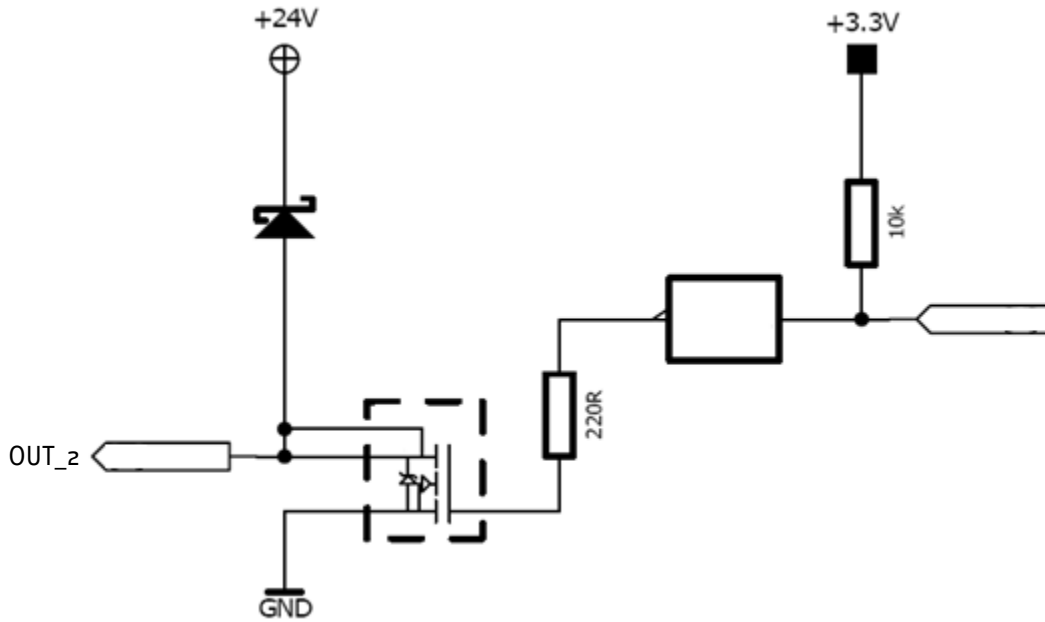


Figure 4.7. OUT\_2 output circuit

## 5 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	Type	Max	Unit
$V_{DD}$	Power supply voltage for operation	7	24	34	V
$I_{COIL\_peak}$	Motor coil current for sine wave <b>peak</b> (chopper regulated, adjustable via software)	0		4	A
$I_{COIL\_RMS}$	Continuous motor current ( <b>RMS</b> )	0		2.8	A
$I_{SUPPLY}$	Power supply current		$\ll I_{COIL}$	$1.4 * I_{COIL}$	A
$T_{ENV}$	Environment temperature at rated current (no forced cooling required)				°C
	Environment temperature at 80% of rated current or 50% duty cycle (no forced cooling required)				°C

Table 5.1: General operational ratings of the module

Symbol	Parameter	Min	Type	Max	Unit
$V_{/SHUTDOWN\_L}$	Low level input voltage for /SHUTDOWNW input	0		1.6	V
$V_{/SHUTDOWN\_H}$	High level input voltage for /SHUTDOWN input	4.2			V
$V_{STOP\_L/R/HOME\_L}$	Low level input voltage for STOP_L/R and HOME switch inputs			2.4	V
$V_{STOP\_L/R/HOME\_H}$	High level input voltage for STOP_L/R and HOME switch inputs	6.3			V
$V_{IN\_1/2\_L}$	Low level input voltage for general purpose inputs IN_1/2 (when configured as digital inputs)			2.4	V
$V_{IN\_1/2\_H}$	High level input voltage for general purpose inputs IN_1/2 (when configured as digital inputs)	6.3			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		10	V
$I_{/Brake}$	Output sink current for /BRAKE output			1	A
$I_{/OUT\_o/1/2}$	Output sink current for general purpose outputs /OUT_o/1/2			1	A

Table 5.2: Operational ratings of input and output signals

## 6 Functional description

In figure 6.1 the main parts of the PDx-146-60-SE are shown. The PDx-146-60-SE is a full mechatronic solution including a 60 mm flange motor (NEMA24). It combines an advanced motion controller electronic and a sensOstep™ encoder with a bipolar stepper motor and can be controlled via RS232, RS485 or CAN interface. Further there is the option for CANopen.

The chopSync™ feature allows high velocity operation avoiding resonances.

The PD-146-60-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 onboard.

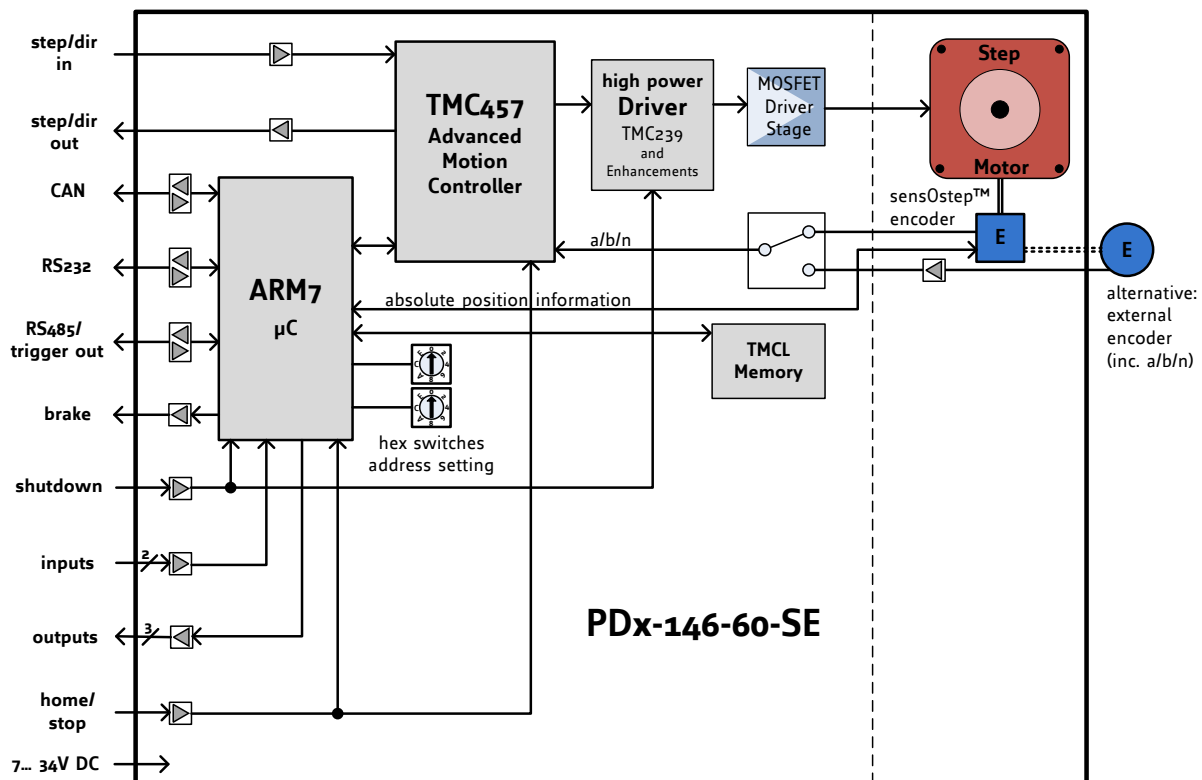


Figure 6.1: Main parts of PDx-146-60-SE

## 7 Revision history

### 7.1 Document revision

Version	Date	Author	Description
0.90	2008-07-01	GE	Initial version
1.00	2009-OCT-30	SD	Dimensions, circuits and functional description added, minor changes
1.10	2010-JUN-28	GE	Product picture and hardware revision updated

Table 7.1: Document revision

### 7.2 Hardware revision

Version	Date	Description
1.00	2009-06-02	Initial version
1.10	2009-07-07	Mechanical adjustments in line with enclosure design
1.20	2009-07-29	Exchange of driver transistors
1.30	2010-01-14	Minor corrections

Table 6.2: Hardware revision

## 8 References

- [QSH6018] QMOT Motor QSH6018 manual (see <http://www.trinamic.com>)  
 [TMC457] TMC457 advanced motion controller (see <http://www.trinamic.com>)