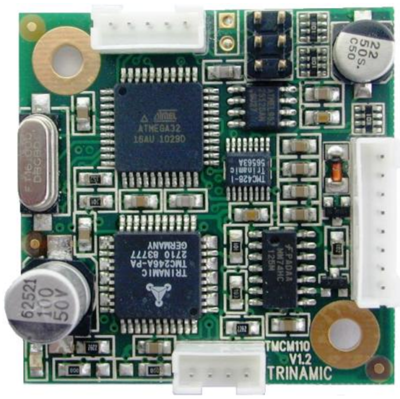
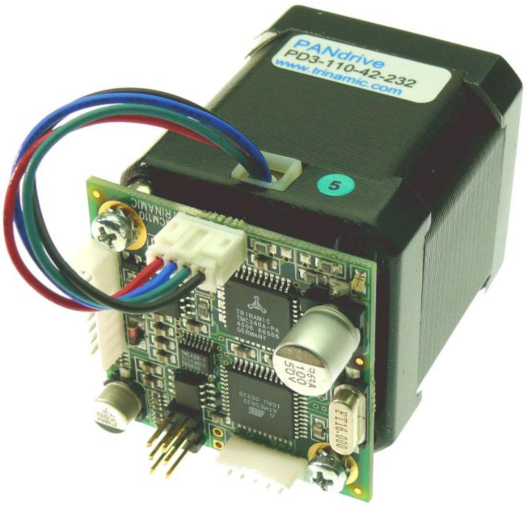
V 1.18

HARDWARE MANUAL



TMCM-110-42

controller / driver
up to 1.1A RMS / 24V
RS232, RS485, I2C or CAN
stallGuard™



PD*x*-110-42

full mechatronic device
up to 1.1A RMS / 24V
RS232, RS485, I2C or CAN
stallGuard™
NEMA17/42mm stepper motor

TRINAMIC Motion Control GmbH & Co. KG
Hamburg, Germany

www.trinamic.com

TRINAMIC
MOTION CONTROL

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1 Features

The PD-110-42 consists of an intelligent stepper motor controller and driver module mounted directly on a 42mm flange motor (NEMA 17). The TMCM-110 module converts the motor into a compact mechatronic device with bus oriented or stand-alone control. The motor, switches, power and the multipurpose I/Os can be connected via small pluggable connectors. The TMCM-110 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. The TMCM-110 can be controlled via an RS232, RS485, I²C or CAN interface (ordering option). 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 on board EEPROM for stand-alone operation. The firmware of the module can be updated via the serial interface. With the integrated stallGuard™ feature it is possible to detect motor overload or motor stall.

Electrical data

- up to 1.1A coil current RMS (1.5A peak)
- 7V to 34V motor supply voltage
- supports two phase bipolar motors with 0.3A to 1.1A coil current

PANdrive motor data

Specifications	Units	QSH4218		
		-35-10-027	-41-10-035	-51-10-049
Rated Voltage	V	5.3	4.5	5.0
Rated Phase Current	A	1.0	1.0	1.0
Phase Resistance at 20°C	Ω	5.3	4.5	5.0
Phase Inductance (typ.)	mH	6.6	7.5	8.0
Holding Torque (typ.)	Ncm	27	35	49
	oz in	38	50	69
Detent Torque	mNm	22	25	28
Rotor Inertia	g cm²	35	54	68
Weight (Mass)	Kg	0.22	0.28	0.35
Insulation Class		B	B	B
Dielectic Strength (for one minute)	VAC	500	500	500
Connection Wires	N°	4	4	4
Step Angle	°	1.8	1.8	1.8
Step angle Accuracy (max.)	%	5	5	5
Flange Size (max.)	mm	42.3	42.3	42.3
Motor Length (max.)	mm	33.5	38	47
Rear shaft hole depth	mm	5.0	5.0	5.0
Rear shaft hole diameter	mm	3.0	3.0	3.0
Axis Diameter	mm	5.0	5.0	5.0
Axis Length (typ.)	mm	24	24	24
Axis D-cut (0.5mm depth)	mm	20	20	20
Maximum Radial Force (20 mm from front flange)	N	28	28	28
Maximum Axial Force	N	10	10	10
Ambient temperature	°C	-20…+50	-20…+50	-20…+50

Table 1.1: Motor technical data

Interface

- RS232, RS485, I²C or CAN 2.0b host interface
- 2 inputs for reference and stop switches
- 1 general purpose input and 1 output

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Features

- up to 16 times microstepping
- memory for 2048 TMCL™ commands
- automatic ramp generation in hardware
- on the fly alteration of motor parameters (e.g. position, velocity, acceleration)
- stallGuard™ for sensorless motor stall detection
- full step frequencies up to 20kHz
- dynamic current control
- TRINAMIC driver technology: No heat sink required

Software

- stand-alone operation using TMCL™ or remote controlled operation
- PC-based application development software TMCL-IDE included

Other

- pluggable JST connectors
- RoHS compliant

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2 Order codes

Order code	Description	Dimensions [mm³]
PD1-110-42 (-option)	PANdrive 0.27Nm	53 x 42 x 42
PD2-110-42 (-option)	PANdrive 0.35Nm	59 x 42 x 42
PD3-110-42 (-option)	PANdrive 0.49Nm	69 x 42 x 42
TMCM-110-42 (-option)	Motion control module	15 x 42 x 42
Option	**Host interface**	
232	RS232 interface	
485	RS485 interface	
IIC	IIC interface (I^2C compatible serial 2 wire)	
CAN	CAN interface	

Table 2.1: Order codes

Please note, that RS232, RS485, and I^2C are assembly options of one and the same TMCM-110 printed circuit board. The TMCM-110-42-CAN module has a dedicated printed circuit board.

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3 Electrical and mechanical interfacing

3.1 Dimensions

3.1.1 Dimensions of the TMCM-110-452

The overall height of the module is 15mm. Please note that connectors on the front are upright.

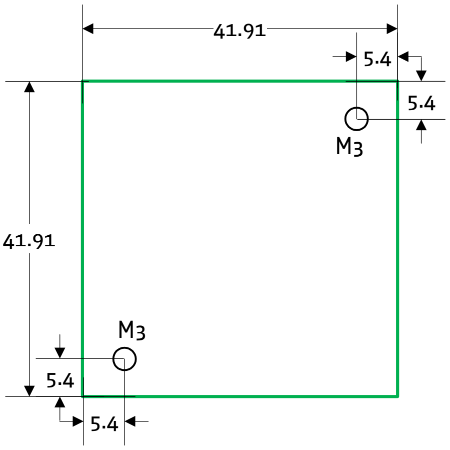
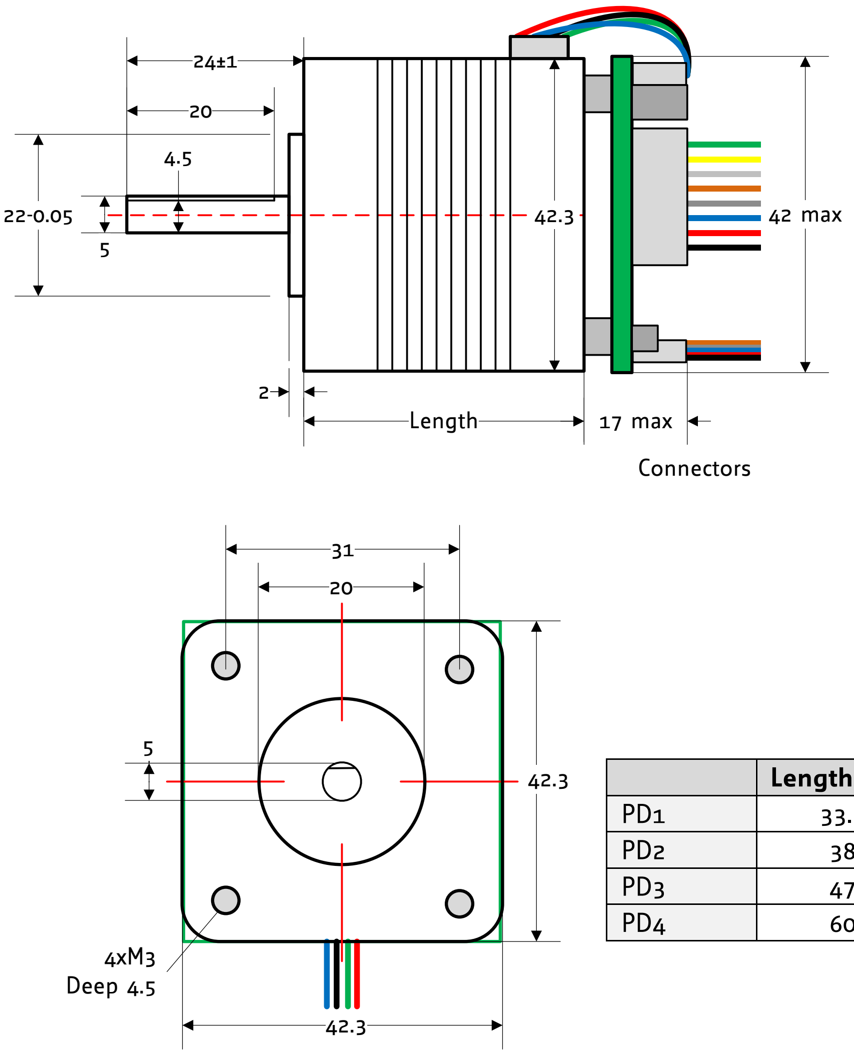


Figure 3.1: Board dimensions and mounting holes (all dimensions in millimeters)

3.1.2 Dimensions of the PDx-110-42



	Length of motor
PD1	33.5±1mm
PD2	38±1mm
PD3	47±1mm
PD4	60±1mm

Figure 3.2: Dimensions of the PDx-110-42

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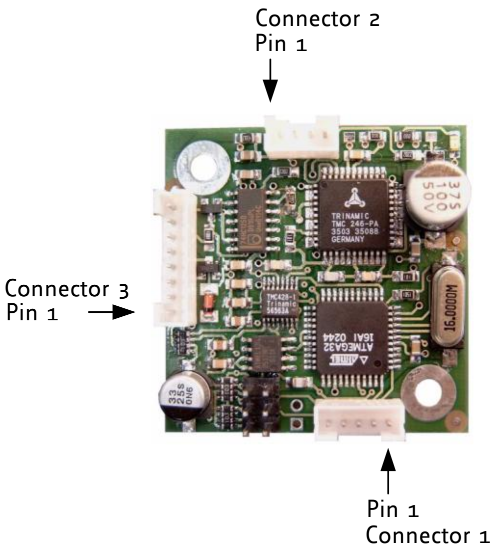
3.2 Connectors

The connector type is JST 2mm PH series. The TMCM-110 has the following connectors:



Connector 1	Power supply and host interface	JST PHR-5
Connector 2	Motor	JST PHR-4
Connector 3	Additional I/O	JST PHR-8

Figure 3.3: Connectors of the TMCM-110 (RS232 version)

<u>Connecting the module</u>

Never connect or disconnect a motor when the module is powered, as this may damage the module. Also, the motor driver is not protected against short circuits to ground.

To integrate the TMCM-110 on a user board, you can choose universal high precision female header rows, like Fischer electronic BLY1.50Z. The pin of the module has a square of 0.5mm * 0.5mm. To compensate for the height of the power capacitor on the TMCM-110, one hole is required at the corresponding position (diameter >=8 mm).

3.2.1 Connector 1: power supply and host interface

Use this connector to connect the power and the host interface (RS232, RS485, IIC or CAN).

<u>The pin assignments are different for the four available versions of the module:</u>

Pin	Function			
	RS232	**RS485**	**IIC**	**CAN**
1	GND	GND	GND	GND
2	+7..34V DC	+7..34V DC	+7..34V DC	+7..34V DC
3	GND	GND	GND	GND
4	RxD	RS485+	SCL	CAN +
5	TxD	RS485 -	SDA	CAN -

Table 3.1: Connector 1

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3.2.1.1 RS485 interface version

The RS485 interface version of the TMCM-110-42 includes an on-board RS485 bus termination resistor (120Ohm). The resistor can be enabled by setting a jumper (as in figure 4.4). In that case the 120 Ohm resistor will be placed between the two RS485+ and RS485- bus wires. Please note that termination is required for the first and the last node of an RS485 network. For all other nodes in-between the bus termination jumper has to be removed. Otherwise communication might be impossible or unreliable.

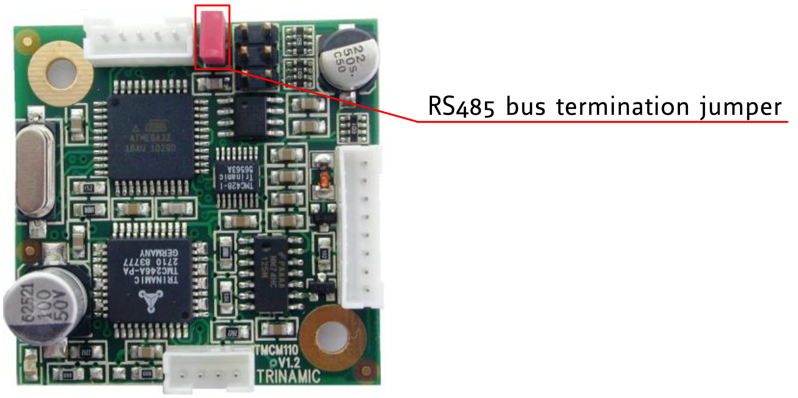

Figure 4.4 RS485 bus termination jumper (RS485 version)

3.2.1.2 CAN interface version

The CAN interface version of the TMCM-110-42 includes an on-board CAN bus termination resistor (120Ohm). The resistor can be enabled by setting a jumper (as in figure 4.5). In that case the 120 Ohm resistor will be placed between the two CAN+ and CAN- bus wires. Please note that termination is required for the first and the last node of a CAN network. For all other nodes in-between the bus termination jumper has to be removed. Otherwise communication might be impossible or unreliable.

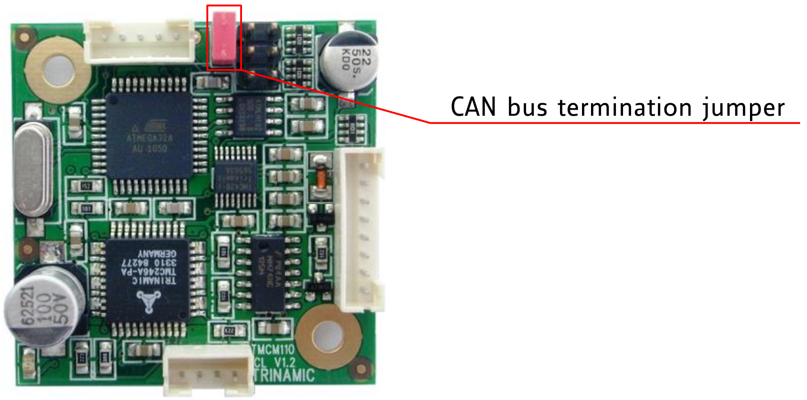

Figure 4.5: CAN bus termination jumper (CAN version)

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3.2.2 Connector 2: motor

Connect a two-phase bipolar stepper motor to this connector.

The pin assignment of this connector is as follows:

Pin	Function
1	Phase A1
2	Phase A2
3	Phase B1
4	Phase B2

Table 3.2: Connector 2

3.2.3 Connector 3: additional I/O

All other inputs and outputs of the module can be connected here. These are the limit switches, a general purpose input and a general purpose output. The limit switch inputs are equipped with internal pull-up resistors, so they have to be connected to GND via normally closed switches. The general purpose input can either be used as a digital TTL input or as an analogue input (0…5V). The general purpose output is an open collector output for a maximum current of 100mA. A freewheeling diode is also included so that e.g. a relay or a coil can be connected directly. Please note that the freewheeling diode is connected to the supply voltage and not to +5V, so when using e.g. a relay that is connected to +5V a freewheeling diode must be connected externally.

The pin assignment of this connector is as follows:

Pin	Name	Function
1	StopL	Left limit switch input (integrated 10K pull up to 5V)
2	StopR	Right limit switch input (integrated 10K pull up to 5V)
3	GND	Signal Ground
4	GPO	General purpose output 0 (open collector, max. 100mA, max. 40V)
5	VDD	VDD (same as connector 1, pin 2)
6	GND	Signal Ground
7	GPI	General purpose input (Analog / Digital)
8	+5V	+5V DC output (max. 20mA)

Table 3.3: Connector 3

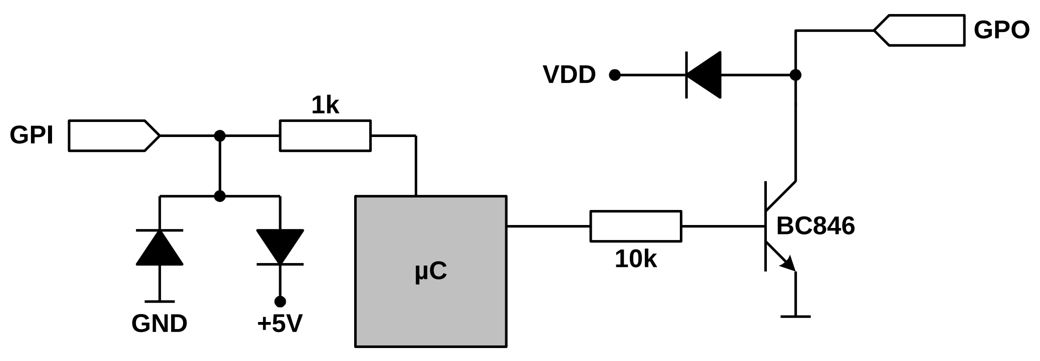

Figure 3.6: Wiring scheme for GPO and GPI

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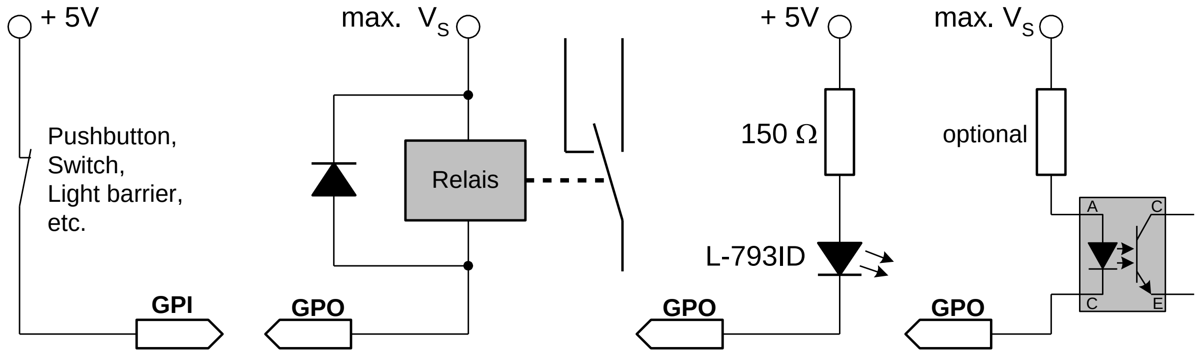

Figure 3.7: Examples for possible wirings for GPI and GPO

3.2.4 ISP connector

The 6pin (2x3pin) header on the module is the connector for an Atmel ISP programmer which can be used to program the CPU directly. This is done during production and testing at TRINAMIC, only. Please do not use and do not connect anything to this connector.

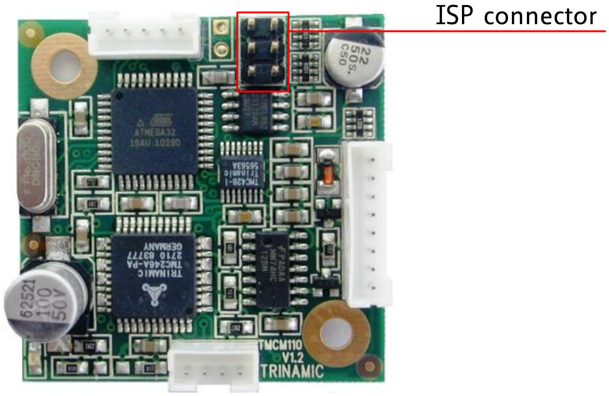

Figure 4.8: ISP connector (RS232 version)

3.3 Activity LED

The TMCM-110-42 module is equipped with an LED. Some TMCM-110-42 modules are equipped with a yellow LED and some other TMCM-110-42 modules are equipped with a red one. During normal operation this LED flashes. After resetting the configuration EEPROM it maybe takes some seconds before the LED starts flashing.

When the operating system is being downloaded to the module the LED is permanently on.

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4 Operational ratings

The operational ratings show the intended / the characteristic range for the values and should be used as design values. In no case shall the maximum values be exceeded.

Symbol	Parameter	Min	Typ	Max	Unit
V_S	Power supply voltage for operation	7	12… 30	34*	V
I_{COIL}	Motor coil current for sine wave **peak** (chopper regulated, adjustable via software) (adjust via Software)	0	0.4… 1.5	1.5	A
I_{MC}	Continuous motor current (**RMS**)	0	0.3… 1.1	1.1	A
f_{CHOP}	Motor chopper frequency		36.8		kHz
I_S	Power supply current		$\ll I_{COIL}$	$1.4 * I_{COIL}$	A
U_{+5V}	+5V output (max. 20mA load)	4.8	5.0	5.2	V
V_{GPO}	Open collector output, max. 100mA, freewheeling diode included			V_S	V
V_{INPROT}	Input voltage for StopL, StopR, GPI0 (internal protection, DC)	-24	0 … 5	24	V
V_{ANA}	GPI0 analog measurement range		0… 5		V
V_{STOPLO}	StopL, StopR low level input		0	0.9	V
V_{STOPHI}	StopL, StopR high level input (integrated 10k pull-up to +5V)	1.9	5		V
T_{ENV}	Environment temperature at rated current (no forced cooling required)	-40		45	°C
	Environment temperature at 80% of rated current or 50% duty cycle (no forced cooling required)	-40		60	°C

Table 4.1: Operational ratings

*** Please make sure that you have a TMC246A-PA driver chip on the module when using a supply voltage above 28.5V. All modules produced in 2006 and later have this chip.**

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5 Functional description

In **Error! Reference source not found.** the main parts of the PDx-110-42 module are shown. The module mainly consists of the µC, a TMC428 motion controller, a TMC246 stepper motor driver, the TMCL™ program memory (EEPROM) and the optional host interfaces (RS232, RS485, IIC and CAN).

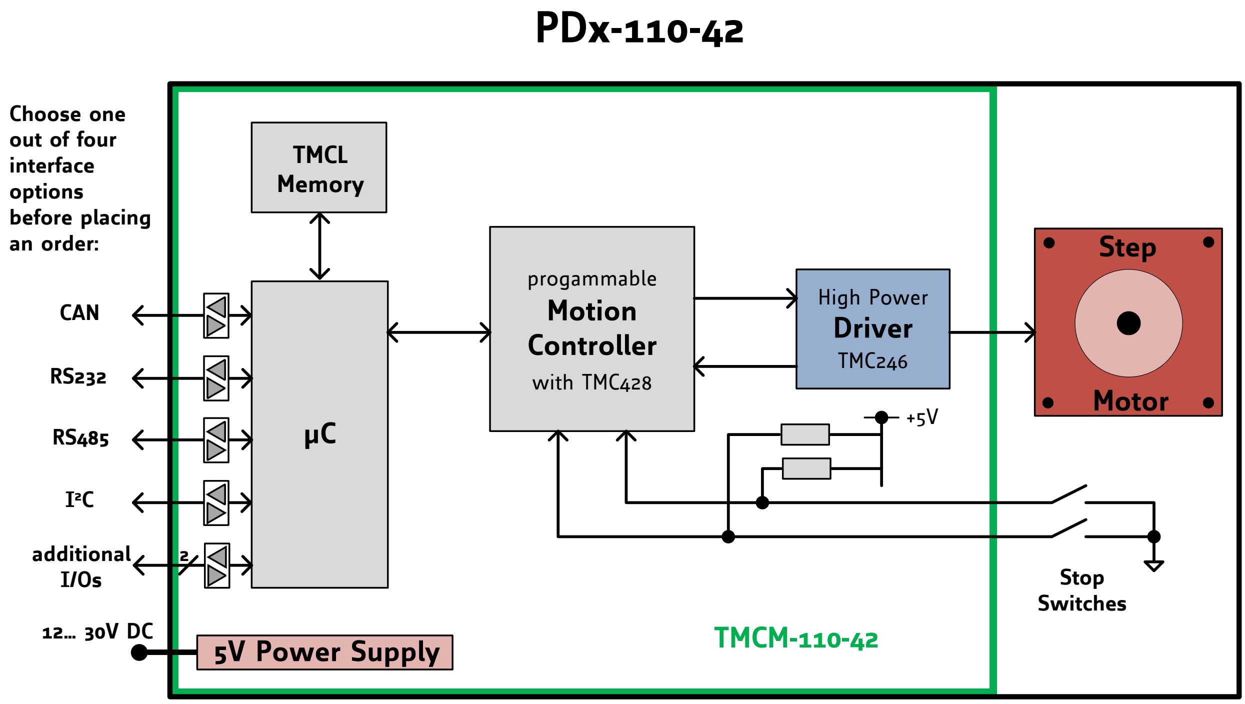

Figure 5.1: Main parts of the PDx-110-42

5.1 System architecture

The TMCM-110 integrates a microcontroller with the TMCL™ (Trinamic Motion Control Language) operating system. The motion control real-time tasks are realized by the TMC428.

5.1.1 Microcontroller

On this module, the Atmel ATmega32 is used to run the TMCL™ operating system and to control the TMC428. The CPU has a 32Kbyte flash memory and a 1Kbyte EEPROM. The microcontroller runs the TMCL™ operating system which makes it possible to execute TMCL™ commands that are sent to the module from the host via the interface. The microcontroller interprets the TMCL™ commands and controls the TMC428 which executes the motion commands.

The flash ROM of the microcontroller holds the TMCL™ operating system. The EEPROM memory of the microcontroller is used to permanently store configuration data.

The TMCL™ operating system can be updated via the host interface. Please use the latest version of the TMCL-IDE to do this. As already mentioned above the TRINAMIC CANnes CAN-Bus PCI-Card or the TRINAMIC USB-2-X interface converter is needed to connect modules with CAN or I²C interfaces to the PC to update the OS.

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5.1.2 EEPROM

To store TMCL™ programs for stand alone operations the TMCM-110 module is equipped with a 16kByte EEPROM attached to the microcontroller. The EEPROM can store TMCL™ programs consisting of up to 2048 TMCL™ commands.

5.1.3 TMC428 motion controller

The TMC428 is a high-performance stepper motor controller. It can control up to three 2-phase-stepper-motors (on this module, only one motor can be used). Motion parameters like speed or acceleration are sent to the TMC428 via SPI by the microcontroller. Calculation of ramps and speed profiles are done internally by hardware based on the target motion parameters.

5.1.4 TMC246 motor driver

The TMC246 motor driver is very dependable, because it provides a variety of protection and diagnostic features, which can be read out by the user software. The 16 times up to 32 times microstepping gives a quiet and precise motor operation. As the power dissipation of the TMC246 is very low no heat sink or cooling fan is needed. The temperature of these chips does not get too high easily. The coils will be switched off automatically when the temperature or the current exceed the limits. They are automatically switched on when the values are within the limits again.

5.2 Power supply

The TMCM-110-42 is equipped with a linear voltage regulator that generates the 5V supply voltage for the digital components of the module from the motor power supply. Because of that only one supply voltage is needed for the module. The power supply voltage can be 12… 30 V DC. A higher voltage gives higher motor dynamics. Please note that there is no protection against reverse polarity or too high voltage.

When using supply voltages near the upper limit of 34V, a regulated power supply becomes a must. Please ensure, that enough power filtering capacitors are provided in the system (470µF or more recommended per motor), in order to absorb mechanical energy fed back by the motor in stalling conditions.

The power supply should be designed in a way, that it supplies the nominal motor voltage at the desired maximum motor power. In no case shall the supply value exceed the upper/lower voltage limit. To ensure reliable operation of the unit, the power supply has to have a sufficient output capacitor and the supply cables should have a low resistance, so that the chopper operation does not lead to an increased power supply ripple directly at the unit. Power supply ripple due to the chopper operation should be kept at a maximum of a few 100mV. This also is important in order to make the user's application compatible to any applicable EMC guidelines.

Therefore we recommend to

- keep power supply cables as short as possible
- use large diameter for power supply cables
- use a robust 470µF or larger additional filtering capacitor located near to the motor driver unit, if the distance to the power supply is large (i.e. more than 2 - 6m)

5.3 Communication interfaces

The communication between the host and the module takes place via its host interface. This can be RS232, RS485, I²C or CAN. Please note that the TMCM-110-42 module can only be equipped with one of these interfaces. Communication with the TMCM-110-42 module is done using TMCL™ commands. The interface the module is equipped with is ready-to-use, so there are no external drivers or level shifters necessary.

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5.3.1 RS232

To connect the RS232 interface of a PC to the module you can use a extension cable or null modem cable (twisted, with female plugs at both ends). The difference is shown in Table 5.1.

	Null modem	Modem	
Female (Host)	**Female**	**Male**	**Signal**
1	4	1	
2	**3**	**2**	**RxD**
3	**2**	**3**	**TxD**
4	1	4	
5	**5**	**5**	**GND**
6	6	6	
7	8	7	
8	7	8	
9	9	9	

Table 5.1: RS232 connection to PC

5.3.2 RS485

For RS485 communication we recommend to use our USB-2-485 converter for fast communication. This converter switches to receive mode right after the last bit has been sent, without any delay. The pause time can be set to 0. It is also equipped with an RS485 termination network.

Not using the USB-2-485 a pause time between commands and a termination network may be necessary.

The telegram ***pause time*** value is milliseconds ±5%. This time depends on the converter used. Converters controlled by the RTS line need about 15ms, sometimes 25ms.

An ***RS485 termination network*** (1k from RS485+ to +5V, 1k form RS485- to GND, 100R between RS485+ and RS485-) may be necessary for faster communication, for longer distances, and it is recommended in any case.

5.3.3 CAN

To use the TMCL-IDE with CAN interface either the TRINAMIC CANnes card or the Trinamic USB-2-X interface converter is needed. Otherwise an additional CAN termination of 120 Ohms between CAN high and CAN low (at both ends of the cable) may be necessary.

5.3.4 I²C

To use the I²C interface with the TMCL-IDE the Trinamic USB-2-X interface is required.

5.4 Reference switches

Two digital reference/stop switch inputs are provided (StopL = stop left and StopR = stop right). They are used as an absolute position reference for homing and to set a hardware limit for the motion range. The inputs have internal pull-up resistors. Either opto-switches or mechanical switched with normally closed contact can be used. The 5V output can be used as a supply for opto-switches.

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5.5 stallGuard™ - sensorless motor stall detection

The integrated stallGuard™ feature gives a simple means to detect mechanical blocking of the motor. This can be used for precise absolute referencing, when no reference switch is available. The load value can be read using a TMCL™ command or the module can be programmed so that the motor will be stopped automatically when it has been obstructed or the load has been too high. Just activate stallGuard™ and then let the traveler run against a mechanical obstacle that is placed at the end of the operation area. When the motor has stopped it is definitely at the end of its way, and this point can be used as the reference position.

Please see the PDx-110-42 Firmware Manual on how to activate the stallGuard™ feature. The TMCL-IDE also has some tools which let you try out and adjust the stallGuard™ function in an easy way.

Mixed decay should be switched off when stallGuard™ is used in order to get good results.

5.6 Motor current setting

The motor current can be set in a range of 0… 1500, using the TMCL™ software. 1500 corresponds to the module's maximum I_{COIL} setting.

Setting	$I_{COIL,PP}$	$I_{COIL,RMS}$
1500	1.5A	1.06A
1410	1.41A	1.0A
1100	1.1A	0.8A
800	0.8A	0.6A
600	0.6A	0.4A
400	0.4A	0.3A
0	0A	0A

Table 5.2: Motor current examples

5.7 Microstep resolution

The microstep resolution can be set using the TMCL™ software. The default setting is 64 microsteps (which is the highest resolution).

For setting the microstep resolution with TMCL™ use instruction ***5: SAP, type 140: microstep resolution***. You can find the appropriate value in Table 5.3:

Value	microsteps
0	Do not use: For fullstep please see *fullstep threshold*
1	Halfstep (*not recommended*)
2	4
3	8
4	16
5	32
6	64

Table 5.3: Microstep resolution setting

Despite the possibility to set up to 64 microsteps, the motor physically will be positioned to a maximum of about 24 Microsteps, when it is operated with 32 or 64 microstep setting.

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5.8 Optimum motor settings

The following settings apply best for highest motor velocities with smooth motor behavior at low velocities. Mixed decay should be switched on constantly. The microstep resolution is 4 [TMCL], this means 16 times microstepping. The pulse devisor is set to 3.

Optimum Motor Settings	**Unit**	**QSH4218**		
		-35-10-027	**-41-10-035**	**-51-10-049**
		PD1	**PD2**	**PD3**
Motor current (RMS)	TMCL™ value	1414	1414	1414
	A	1	1	1
Motor voltage	V	24	24	24
Maximum microstep velocity = Fullstep threshold	TMCL™ value	330	270	220
	RPS	3.147	2.575	2.098
Maximum fullstep velocity	TMCL™ value	670	600	480
	RPS	6.389	5.722	4.578

Table 5.4: Optimum motor settings

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6 Operational description

6.1 Calculation: Velocity and acceleration vs. microstep- and fullstep frequency

The values of the parameters sent to the TMC428 do not have typical motor values (like rotations per second as velocity). Here, the parameter values can be calculated directly from the TMC428 parameters. Please refer to the PDx-110-42 Firmware Manual for more information about that.

Parameter	Description	Range
f_{CLK}	Clock frequency	16 MHz
velocity		0… 2047
a_max	Maximum acceleration	0… 2047
pulse_div	Velocity pre-divider. The higher the value is, the less is the maximum velocity. Default value = 3 Can be changed in TMCL™ using SAP 154.	0… 13
ramp_div	Acceleration pre-divider. The higher the value is, the less is the maximum acceleration default value = 7 Can be change in TMCL™ using SAP 153.	0… 13
Usrs	Microstep resolution (microsteps per fullstep = 2^{usrs}). Can be changed in TMCL™ using SAP 140.	0… 6

Table 6.1: TMC428 Velocity parameters

The **microstep-frequency** of the stepper motor is calculated with

$$usf[Hz] = \frac{f_{CLK}[Hz] \cdot velocity}{2^{pulse\_div} \cdot 2048 \cdot 32}$$ with usf: microstep-frequency

To calculate the **fullstep-frequency** from the microstep-frequency, the microstep-frequency must be divided by the number of microsteps per fullstep.

$$fsf[Hz] = \frac{usf[Hz]}{2^{usrs}}$$ with fsf: fullstep-frequency

The change in the pulse rate per time unit (microstep frequency change per second – the **acceleration a**) is given by

$$a = \frac{f_{CLK}^{\,2} \cdot a_{\max}}{2^{pulse\_div + ramp\_div + 29}}$$

This results in an acceleration in fullsteps of:

$$af = \frac{a}{2^{usrs}}$$ *with af: acceleration in fullsteps*

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Example:
f_CLK = 16 MHz on the TMCM-110 module
velocity = 1000
a_max = 1000
pulse_div = 1
ramp_div = 1
usrs = 6

$$msf = \frac{16\,MHz \cdot 1000}{2^1 \cdot 2048 \cdot 32} = \underline{\underline{122070.3125\,Hz}}$$

$$fsf[Hz] = \frac{122070.3125}{2^6} = \underline{\underline{1907.35 Hz}}$$

$$a = \frac{(16 Mhz)^2 \cdot 1000}{2^{1+1+29}} = \underline{\underline{119.208 \frac{MHz}{s}}}$$

$$af = \frac{119.208 \frac{MHz}{s}}{2^6} = \underline{\underline{1{,}863 \frac{MHz}{s}}}$$

If the stepper motor has e.g. 72 fullsteps per rotation, the number of rotations of the motor is:

$$RPS = \frac{fsf}{fullsteps\ per\ rotation} = \frac{1907.35}{72} = 26.49$$

$$RPM = \frac{fsf \cdot 60}{fullsteps\ per\ rotation} = \frac{1907.35 \cdot 60}{72} = 1589.458$$

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7 Revision history

7.1 Document revision

Version	Comment	Author	Description
1.00	Initial Release	OK	Initial version
1.03	2004-JUL-16	OK	CAN interface added
1.10	2004-JUL-27	OK	Major revision
1.11	2004-OCT-01	OK	Minor error corrections
1.12	2004-OCT-04	TG	Corrected mounting dimensions
1.13	2005-DEC-24	BD, HC	Added Pan-Drive documentation and major revision
1.14	2007-FEB-21	HC	Pull-up failure corrected (GPO), wiring scheme added for GPO/GPI
1.15	2007-JUN-20	HC	Additional interface information, added chapter 5.7 "Microstep Resolution" and 5.8 "Optimum motor settings"
1.16	2007-OCT-22	HC	Example wirings added (Figure 3.7); direct integration on user board info added (chapter 0)
1.17	2009-NOV-20	SD	Dimensions of the PANdrive™ (drawings) added. Minor changes and corrections.
1.18	2011-07-29	GE	New front page, hardware revision updated, RS485 and CAN termination jumper information added

Table 7.1: Document revision

7.2 Hardware revision

7.2.1 RS232, RS485, I2C interface version

RS232, RS485 and I2C are assembly options of the same printed circuit board version.

Version	Date	Description
1.0	2003-NOV-17	Initial Release
1.1	2007-FEB-27	Minor corrections
1.2	2008-JUN-09	Minor corrections
1.3	2011-JUL-09	Layout optimization

Table 7.2: Hardware revision (RS232, RS485, I2C)

7.2.2 CAN interface version

The CAN interface version uses a dedicated printed circuit board.

Version	Date	Description
1.0	2004-JUN-30	Initial Release
1.1	2008-JUN-18	Minor corrections
1.2	2011-MAR-18	Layout optimization

Table 7.3: Hardware revision (CAN)

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8 References

[PDx-110-42]	PDx-110-42 Firmware Manual (see http://www.trinamic.com)
[USB-2-X]	USB-2-X Manual (see http://www.trinamic.com)
[CANnes]	CANnes Manual (see http://www.trinamic.com)
[USB-2-485]	USB-2-485 Manual (see http://www.trinamic.com)

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