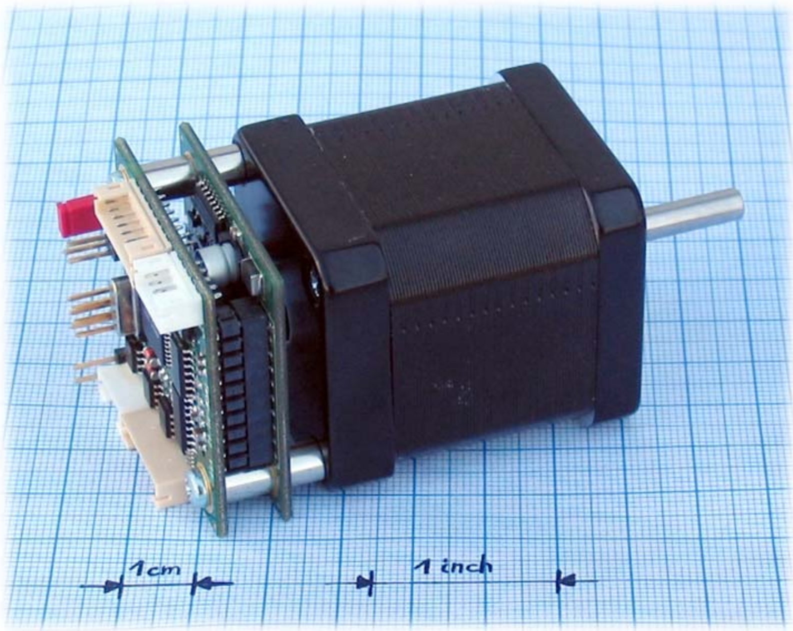
PANdrive PD-111-42

and

TMCM-111-42



42mm / NEMA-17 Stepper Motor Mechatronic Module

TMCM-111-42 Electronics Manual

Version: 1.24
June 13th, 2007

TRINAMIC
MOTION CONTROL

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Order Codes

Order code	Description	Dimensions [mm^3]
PD-111-42 (-option)	PANdrive	100 x 42 x 42
TMCM-111-42 (-option)	Motion control module	22 x 42 x 42
TMCM-111-42-CABLE	Cable loom for TMCM-111-42	
Option	**Host interface**	
485	With I^2C, RS232, RS485, Step/DIR interface	
CAN	With I^2C, RS232, CAN, Step/DIR interface	

Table 1.1: Order codes

1 Features

The TMCM-111-42 is an intelligent stepper motor controller and driver module to be mounted directly on a 42mm flange motor. This dual-PCB module converts the motor into a compact mechatronic device with bus oriented or stand-alone control. The motor, switches, power and the multi purpose I/Os can be connected with small pluggable connectors. The PD-111-42 is a full mechatronic solution including a 42mm flange high torque motor (NEMA17). Its high motor current allows up to 1200 RPM movement at 0.25Nm torque.

The TMCM-111 / PD-111 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 unit can be controlled via an RS-232, RS-485, I²C or CAN interface, with step / direction 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 StallGuard feature it is possible to detect motor overload or motor stall.

Electrical data

- up to 2.8A coil current RMS (4.0A peak)
- 7V to 28.5V motor supply voltage
- supports two phase bipolar motors with 0.3A to 2.8A RMS coil current

PANdrive Motor data

- The PANdrive motor is optimized for 2.8A RMS coil current to provide maximum torque at high velocities
- 0.25Nm torque at 1200 RPM with a 24V supply
- total length: 74mm for motor and electronics
- holding torque 0.47Nm

Interface

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

Features

- up to 64 times microstepping for high accuracy
- high current for highly dynamic drive
- 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, low power dissipation.

Software

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

Other

- pluggable JST connectors
- RoHS compliant latest from 1 July 2006
- Size: 42x42mm² (2 stacked PCBs)

2 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.

3 Electrical and Mechanical Interfacing

3.1 Dimensions

The overall height of the TMCM-111-42 is 22mm, The length of the PD-111-42 is about 100mm overall. Beware that connectors on the upper PCB are upright.

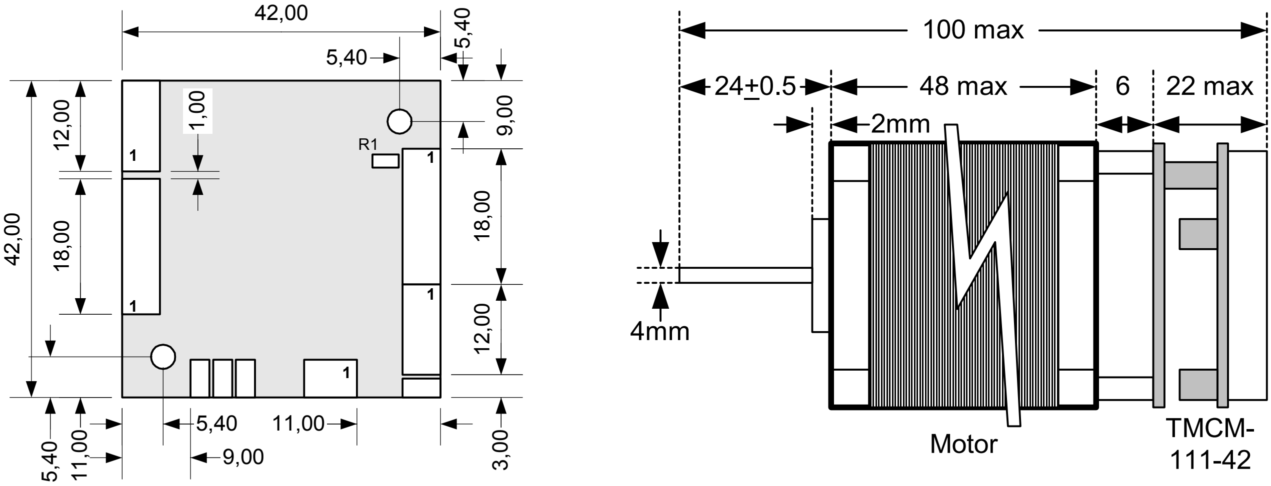

Figure 3.1: Dimensions of PD-111-42 and TMCM-111-42 (all dimensions in millimeters)

3.2 Connectors

Connector type JST 2mm PH series, the following plugs fit for:

- Power supply connector: PHR-5
- Additional I/O connector: PHR-8
- Interface connector RS232, RC485 or CAN and Step/DIR: PHR-8
- I²C connector: PHR-5

3.3 Connecting the module

Caveat:

- **Please always be sure that the boards are connected together correctly before connecting the power supply.**
- **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.**
- **Please do not mix up the Power connector (X1) and the IIC interface connector (X4). Connecting the power accidentally to X4 will destroy the module immediately!**

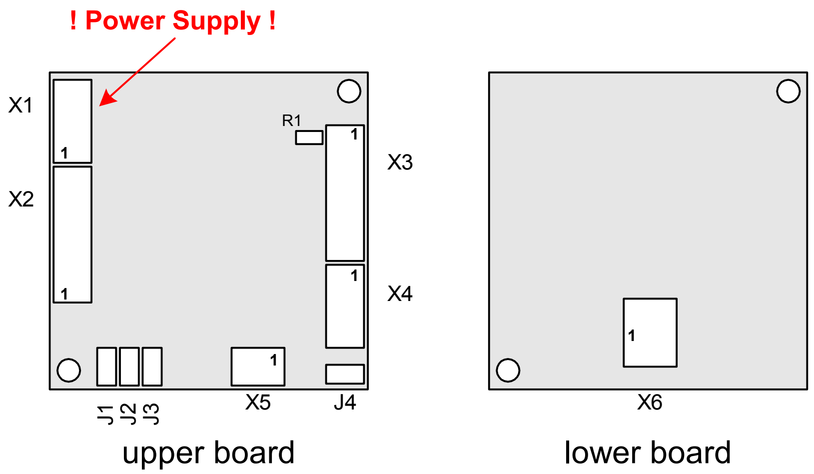

Figure 3.2: The TMCM-111-42 module

3.3.1 Connector X1: Power supply

Use this connector to connect the power. Please always use all the pins of this connector because of the high current. The pin assignment of this connector is as follows:

Pin	Function
1	+7..28.5V DC
2	+7..28.5V DC
3	GND
4	GND

Table 3.1: Connector X1 – Power supply

3.3.2 Connector X2: 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	Function
1	Left limit switch input (integrated pullup to 5V)
2	Right limit switch input (integrated pullup to 5V)
3	GND (0V)
4	General purpose output (open collector, max. 100mA)
5	VDD (same as connector X1, pin 1/2)
6	GND
7	General purpose input (Analog / Digital)
8	+5V DC output (max. 20mA)

Table 3.2: Connector X2

3.3.3 Connector X3: Interfaces

This connector provides the RS232, the RS485/CAN and Step/Direction interface. Jumper J1 selects which interface is to be used: If this jumper is open RS232 will be used. Close this jumper to use RS485/CAN. The unused interface pins should be connected to ground to avoid failures.
The pin assignment is as follows:

Pin	Function	
1	RS232 TxD (output)	
2	RS232 RxD (input)	
3	RS485 A (+) / CAN High	
4	RS485 B (-) / CAN Low	
5	Step/Direction	Step (High)
6	Step/Direction	Step (Low)
7	Step/Direction	Direction (High)
8	Step/Direction	Direction (Low)

Table 3.3: Connector X3 – Interfaces

3.3.4 Connector X4: Additional Interface I²C

For I²C interface use this connector. The interface that is to be used is software selectable. Please see the TMCL Reference Manual for more information about this matter.
In I²C mode, the pin assignments are as follows:

Pin	Function
1	GND
2	Do not connect
3	SDA
4	SCL
5	Do not connect

Table 3.4: Connector X4 – Interface I²C

3.3.5 Connector X5: ISP Connector

The 6-way (2x3) header on the module is the connector for an Atmel ISP programmer which can be used to program the CPU directly. **This is to be done by Trinamic only.** The ISP connector is not to be used by the user. Always leave this connector open.
The only purpose where this connector can be used by the user is to reset all settings of the module to their factory defaults. To do this, first power off the module. Then, put on a jumper that links pin 1 and pin 3 of this connector. Then, connect the power supply again. The activity LED now flashes very quickly. Now, disconnect the power supply again and remove the jumper. When the module is now switched on again, all settings will be restored to their factory defaults.

3.3.6 Connector X6: Motor Connector

The lower board is equipped with a 4-pin (2.54mm pitch) horizontal motor connector. Following connector from HR-Connectors can be used to connect with the motor:

A2542HB-4P (A2542-TB crimp contacts)

Pin	Function
1	OA1
2	OA2
3	OB1
4	OB2

Table 3.5: Connector X6 – Motor Connector

Earlier versions of the TMCM-111-42 have soldering holes for motor connection in place of the pluggable connector.

3.3.7 Jumpers J1, J2, J3 and J4

These three jumpers have the following functionality:

- **J1**: Interface selection. This jumper selects which interface is to be used when the module starts up. When this jumper is open it will be RS232, and when it is closed it will be RS485.
- **J3**: CAN/RS485 termination. Close this jumper to terminate the CAN/RS485 bus with a 120 Ohms resistor.
- **J2**: Step/Direction termination. Close jumper to terminate the ***step-signal*** with a 120 Ohms resistor.
- **J4**: Step/Direction termination. Close jumper to terminate the ***direction-signal*** with a 120 Ohms resistor.

3.3.8 Resistor array R1

This resistor array allows the using of non differential Step/Direction signals. This voltage divider generates the half potential of the Step/Direction supply voltage to the negative differential inputs.

3.4 Activity LED

The TMCM-111-42 module is equipped with an LED. 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 lights steadily.

4 Motor QMot QSH4218-48-28-047

4.1 Lead wire configuration

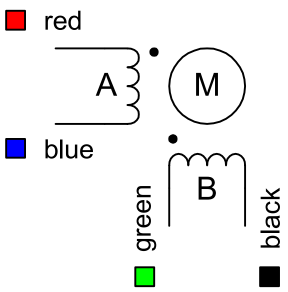

Figure 4.1: Lead wire configuration

Cable type	Coil	Function
Red	A	Motor coil A pin 1
Blue	A	Motor coil A pin 2
Green	B	Motor coil B pin 1
Black	B	Motor coil B pin 2

Table 4.1: Lead wire configuration

4.2 Technical Data

Specifications	Parameter	Units	Motor : QMot QSH4218-48-28-047
Step angle		degree	1.8
Rated Phase Current	I_{RMS_RATED}	A	2.8
Phase Resistance at 20°C	R_{COIL}	Ω	0.5 ± 10%
Phase Inductance (typ.)		mH	0.6 ± 20%
Holding Torque (typ.)		Ncm	47.29
		oz in	66.5
Rotor Inertia		g cm²	67.67
		oz in²	0.37
Connection Wires		N°	4
Flange Size (max.)		mm	42.2
Motor Length (max.)	L_{MAX}	mm	48
Axis Diameter		mm	4.0
Axis Length (typ.)		mm	22.0
Max radial force		N	28 (20mm from front flange)
Max axial force		N	10

Table 4.2: Motor technical data

4.3 Torque Figure

Conditions: 24VDC, 2.8A RMS / Phase, Bipolar, ½ Stepping (1.8 Step Motor)

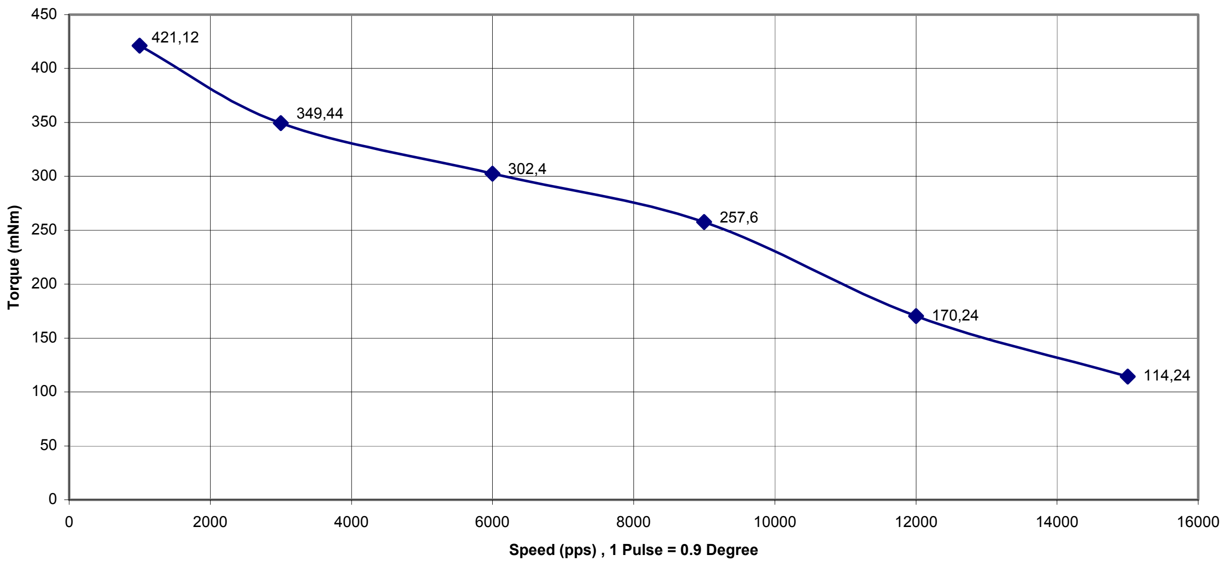

Figure 4.2: Torque figure

4.4 Choosing the Commutation Scheme

While the motor performance curves are depicted for fullstepping, most modern drivers provide a microstepping scheme. Microstepping uses a discrete sine and a cosine wave to drive both coils of the motor, and gives a very smooth motor behaviour as well as an increased position resolution. The amplitude of the waves is 1.41 times the nominal motor current, while the RMS values equals the nominal motor current. The stepper motor does not make loud steps any more – it turns smoothly! Therefore, 16 microsteps or more are recommended for a smooth operation and the avoidance of resonances. To operate the motor at fullstepping, some considerations should be taken into account.

Driver Scheme	Resolution	Velocity range	Torque	Comments
Fullstepping	200 steps per rotation	Low to very high. Skip resonance areas in low to medium velocity range.	Full torque if dampener used, otherwise reduced torque in resonance area	Audible noise especially at low velocities
Microstepping	200 * (number of microsteps per rotation)	Low to high.	Reduced torque at very high velocity	Low noise, smooth motor behaviour
Mixed: Microstepping and fullstepping for high velocities	200 * (number of microsteps per rotation)	Low to very high.	Full torque	At high velocities, there is no audible difference to fullstepping

Table 4.3: Comparing microstepping and fullstepping

Microstepping gives the best performance for most applications and can be considered as state-of-the art. However, fullstepping allows some ten percent higher motor velocities, when compared to microstepping. A combination of microstepping at low and medium velocities and fullstepping at high velocities gives best performance at all velocities and is most universal.

5 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 … 28	28.5	V
I_{COIL}	Motor coil current for sine wave **peak** (chopper regulated, adjustable via software) (adjust via Software)	0	0.4 … 4.0	4.0	A
I_{MC}	Continuous motor current (**RMS**)	0	0.3… 2.8	2.8	A
f_{CHOP}	Motor chopper frequency		36.8		kHz
I_S	Power supply current		<< 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, GPI (internal protection, DC)	-24	0 … 5	24	V
V_{ANA}	GPI analog measurement range (range switchable)		0 … 5 0 … 10		V
V_{STOPLO}	StopL, StopR low level input		0	0.9	V
V_{STOPHI}	StopL, StopR high level input (integrated 10k pullup 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 5.1: Operational Ratings

6 Functional Description

In Figure 6.1 the main parts of the TMCM-111-42 module are shown. The module mainly consists of the µC, a TMC428 motion controller, a TMC249 stepper motor driver, the TMCL program memory (EEPROM) and the host interfaces (RS232, RS485, IIC and CAN).

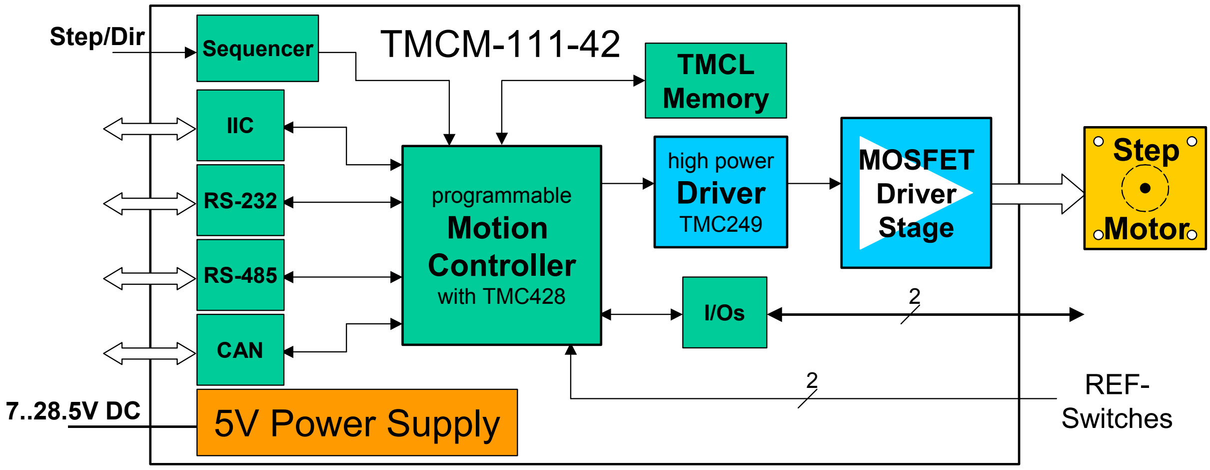

Figure 6.1: Application Environment

6.1 System Architecture

The TMCM-111 integrates a microcontroller with the TMCL (Trinamic Motion Control Language) operating system. The motion control real-time tasks are realized by the TMC428.

6.1.1 Microcontroller

On this module, the Atmel ATmega32 is used to run the TMCL operating system and to control the TMC428. The CPU has 32Kbyte flash memory and a 1Kbyte EEPROM. The microcontroller runs the TMCL (Trinamic Motion Control Language) 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 and 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. To connect the module with CAN or IIC interface to the PC to update the OS the Trinamic CANnes card or the Trinamic USB2X interface is needed

6.1.2 EEPROM

To store TMCL programs for stand alone operation the TMCM-111 module is equipped with a 16kByte EEPROM attached to the microcontroller. The EEPROM can store TMCL programs consisting of up to 2048 TMCL commands.

6.1.3 TMC428 Motion Controller

The TMC428 is a high-performance stepper motor control IC and 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.

6.1.4 TMC249 Motor Driver

The stepper motor drivers used on the TMCM-111-42 module is the TMC249 chip. This driver is very easy to use. It can control the currents for the two phases of the stepper motors. 64x microstepping and a maximum coil current of 4.0A is supported by this driver IC together with the high performance MOSFETs the module is equipped with.
As the power dissipation of the MOSFETs is very low no heat sink or cooling fan is needed. The temperature of the chips does not get high. The coils will be switched off automatically when the temperature or the current exceeds the limits and automatically switched on again when the values are within the limits.

6.2 Power Supply

The TMCM-111-42 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. So only one supply voltage is needed for the module. The power supply voltage can be 7..28.5 V DC. A higher voltage gives higher motor dynamics. Please note that there is no protection against reverse polarity or too high voltage.

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 users application compatible to any applicable EMC guidelines.

Therefore we recommend to

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

6.3 Communication Interface

The communication between the host and the module takes place via its host interface. This can be either RS232, RS485, IIC or CAN. Communication with the TMCM-111-42 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. The unused interface pins should be connected to ground to avoid failures.
Please see chapter 3.3.3 for the pin assignments of the interfaces.
To use the TMCL IDE with CAN interface either the Trinamic CANnes card or the Trinamic USB2X interface is needed. To use the IIC interface with the TMCL IDE the Trinamic USB2X interface is needed.

6.4 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 pullup resistors. Either opto-switches or mechanical switched with normally closed contact can be used. The 5V output can be used as an supply for opto-switches.

6.5 StallGuard™ - Sensorless Motor Stall Detection

The TMCM-111-42 module is equipped with the StallGuard feature. The StallGuard feature makes it possible to detect if the mechanical load on a stepper motor is too high or if the traveller has been obstructed. 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 to high.
StallGuard can also be used for finding the reference position without the need for a reference switch: Just activate StallGuard and then let the traveller run against a mechanical obstacle that is placed at the end of the way. 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 TMCL Reference and Programming 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. This is also described in the TMCL Reference and Programming Manual.
Mixed decay should be switched off when StallGuard operational in order to get usable results.

6.6 Thermal protection feature

The module is protected against over temperature of the power stage, to give reliable operation and a long life time. If the temperature of the power stage exceeds about 105°C (+/- 10°C), the actual current setting is reduced to 80%. Normal motor current is restored below 95°C. While this is only a small current reduction, it reduces power dissipation to about 65%. However, if a temperature of 120°C is exceeded, the motor drivers are completely switched off.
The temperature value can be read out with [TMCL] command GIO 5. A lower value means a higher temperature. The current reduction threshold value is 300, power stage off threshold value is 240.

6.7 Motor current setting

The motor current can be set in a range of 0 to 4.0A, using the TMCL software. 255 corresponds to the module's maximum I_{COIL} setting.

Setting	$I_{COIL,PP}$	$I_{COIL,RMS}$
255	4.0A	2.8A
225	3.5A	2.5A
180	2.8A	2.0A
135	2.1A	1.5A
90	1.4A	1.0A
45	0.7A	0.5A
27	0.4A	0.3A
0	0A	0A

Table 6.1: Motor Current Examples

7 Putting the TMCM-111 into Operation

On the basis of a small example it is shown step by step how the TMCM-111-42 is set into operation. Users who are already familiar with TMCL and other Trinamic modules may skip this chapter.

Example: The following application is to be implemented on the TMCM-111-42 module using the TMCL-IDE Software development environment.

A formula how "speed" is converted into a physical unit like rotations per seconds can be found in chapter 8.1.

The simple application is:

- Move the Motor to position 150000
- Wait 2 seconds
- Move the Motor back to position 0
- Wait 1 second
- Start again with the first step

To implement this simple application on theTMCM-111-42 it is necessary to do the following things:

Step 1: Connect the host interface to the PC

Step 2: Connect the motor to the motor connector

Step 3: Connect the power supply voltage to the module

Step 4: Switch on the power supply. The activity LED should start to flash. This indicates the correct configuration of the microcontroller.

Step 5: Start the TMCL-IDE Software development environment. Enter the program shown in the following listing. A description of the TMCL commands can be found in the TMCL Reference and Programming Manual.

```
//A simple example for using TMCL and the TMCL-IDE

        SAP 4, 0, 100              //Set the maximum speed

Loop:   MVP ABS, 0, 150000        //Move to position 150000
        WAIT POS, 0, 0
        WAIT TICKS, 0, 200
        MVP ABS, 0, 0             //Move back to position 0
        WAIT POS, 0, 0
        WAIT TICKS, 0, 100

        JA Loop                    //Infinite Loop
```

Step 6: Click the "*Assemble*" icon to convert the TMCL program into byte code.
Then download the program to the TMCM-111-42 module by clicking the "Download" icon.

Step 7: Click the "Run" icon. The downloaded program will now be executed.

A detailed documentation about the TMCL operations and the TMCL IDE can be found in the TMCL Reference and Programming Manual. The next chapter shows how the velocity and acceleration values are calculated.

8 TMCM-111 Operational Description

8.1 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. But these values can be calculated from the TMC428 parameters, as shown in this document. The parameters for the TMC428 are:

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 8.1: 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*

Example:
f_CLK = 16 MHz on the TMCM-111 module
velocity = 1000
a_max = 1000
pulse_div = 1
ramp_div = 1
usrs = 6

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

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

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

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

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

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

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

9 Software

TMCL, the Trinamic Motion Control Language is used to send commands from the host to the TMCM-111 module and to write programs that can be stored in the EEPROM of the module so that the module can execute the TMCL commands in a stand-alone mode.

TMCL is described in a separate documentation, the TMCL Reference and Programming Manual. This document also describes the TMCL Integrated Development Environment (TMCL IDE), a program running on Windows which allows easy development of TMCL applications.
All the manuals are provided on the TMC TechLib CD and on the web site of TRINAMIC Motion Control GmbH & Co. KG (http://www.trinamic.com). Also the latest versions of the firmware (TMCL operating system) and PC software (TMCL IDE) can be found there.

10 Revision History

10.1 Documentation Revision

Version	Comment	Author	Description
1.00	01-Mar-05	OK	Initial version
1.10	8-Jul-05	SZ	Connector pinning changed; ordering information added
1.20	16-Mar-06	HC	Added Pan-Drive documentation and major revision
1.21	21-Jul-06	HC	Added Motor connector and thermal protection info
1.22	04-Oct-06	HC	Corrected Resistor R1 information
1.23	30-May-07	HC	Additional motor technical data
1.24	13-June-07	HC	Positions of connectors added to dimensions

Table 10.1: Documentation Revisions

10.2 Firmware Revision

Version	Comment	Description
3.24	Initial Release	Please refer to TMCL documentation

Table 10.2: Firmware Revisions

11 References

[TMCL] TMCL manual (see http://www.trinamic.com)