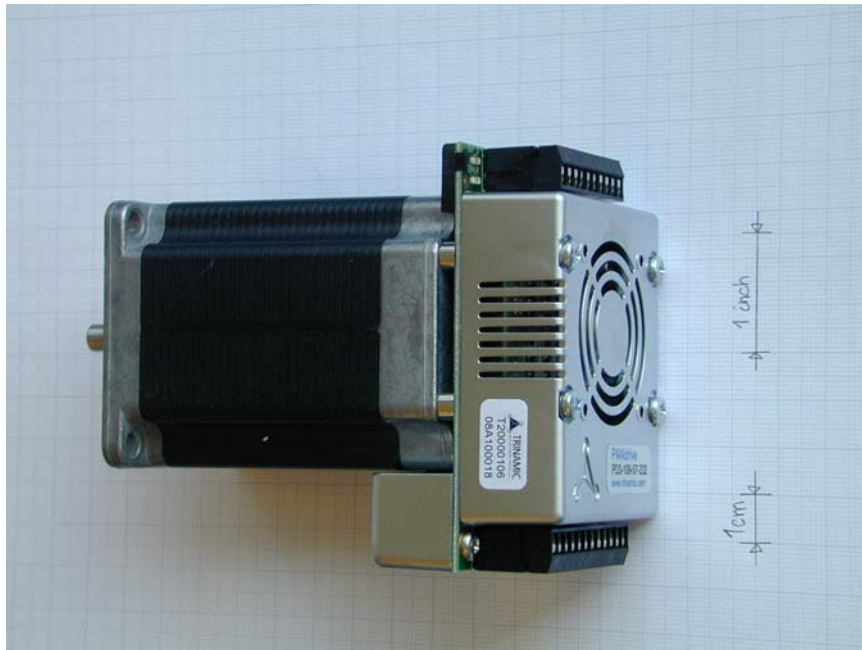


# PANDrive PD-109-57



## 57mm / NEMA-23 Stepper Motor Mechatronic Module

## TMCM-109-57 Electronics Manual

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# 1 Features

The PANdrive PD-109-57 is a full mechatronic solution including a 57mm flange motor. It is based on the TMCM-109-57 electronics and offers RS232, RS485 or step/direction interface. The power supply, interface and the multi purpose I/Os can be connected via two pluggable screw terminal connectors. The TMCM-109-57 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. 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™ (pat. pend.) feature it is possible to detect motor overload or motor stall.

## Applications

- decentralized mechatronic drive with integrated intelligence
- high-precision drives with high dynamics and torque

## Electrical data

- 18V to 55V motor supply voltage for highest motor dynamics
- up to 3.5A RMS nominal motor current

## Motor data

- all PANdrive Motors optimized for 3.0A RMS motor current
- please also refer to the motor datasheet

## Interface

- RS232, RS485 and step / direction (please request for CAN version)
- 2 inputs for reference and stop switches
- 1 general purpose input and 1 output

## Features

- up to 16 times microstepping
- memory for 2048 TMCL commands
- automatic ramp generation in hardware
- on the fly alteration of motion parameters (e.g. position, velocity, acceleration)
- StallGuard™ for sensorless motor stall detection
- optically isolated inputs for step, direction and disable
- dynamic current control

## Software

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

## Other

- Pluggable screw terminal connectors for all external signals
- RoHS compliant latest from 1 July 2006

Order code	Description	Dimensions [mm³]
PD1-109-57 (-option)	PANdrive 0.47Nm	71 x 57 x 57
PD2-109-57 (-option)	PANdrive 0.98Nm	85 x 57 x 57
PD3-109-57 (-option)	PANdrive 1.63Nm	108 x 57 x 57
Option	Host interface	
RS	RS232 and 485 interface plus step / direction	
CAN	CAN interface (please ask for availability)	

**Table 1.1: Order codes**

## 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.

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Specifications subject to change without notice.

## 3 Electrical and Mechanical Interfacing

### 3.1 Dimensions

#### 3.1.1 PCB Dimensions

Height: 22mm (allow for a minimum additional 3mm distance to the motor, 4-5mm are recommended)  
Four mounting holes in QMOT motor configuration (M3).

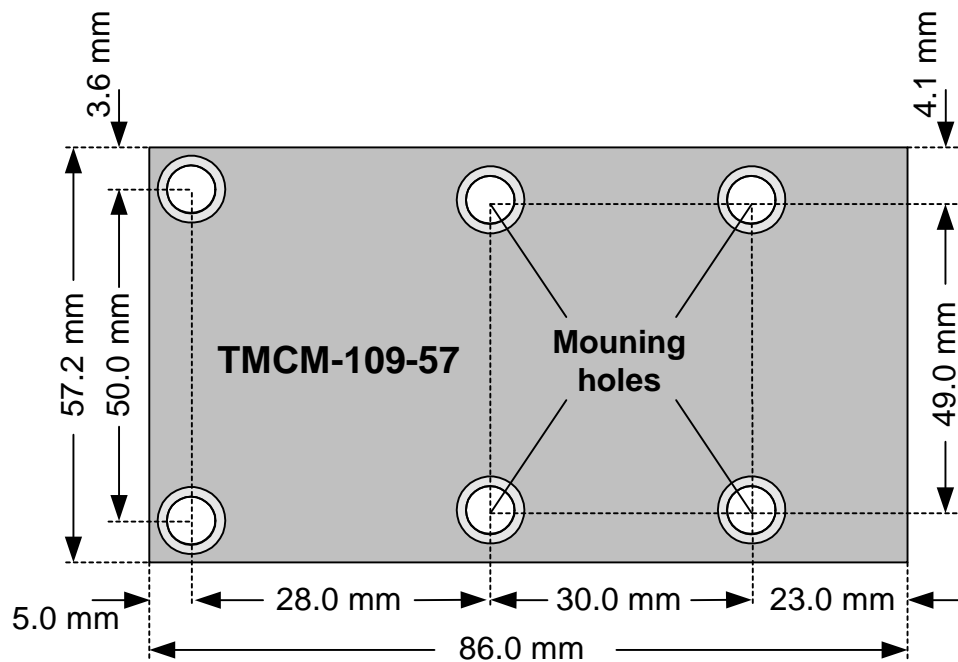


Figure 3.1: Dimensions of base PCB

### 3.1.2 PANDrive Dimensions

Attention: Please refer to latest QSH5718 motor manual for actual and exact motor dimensions.

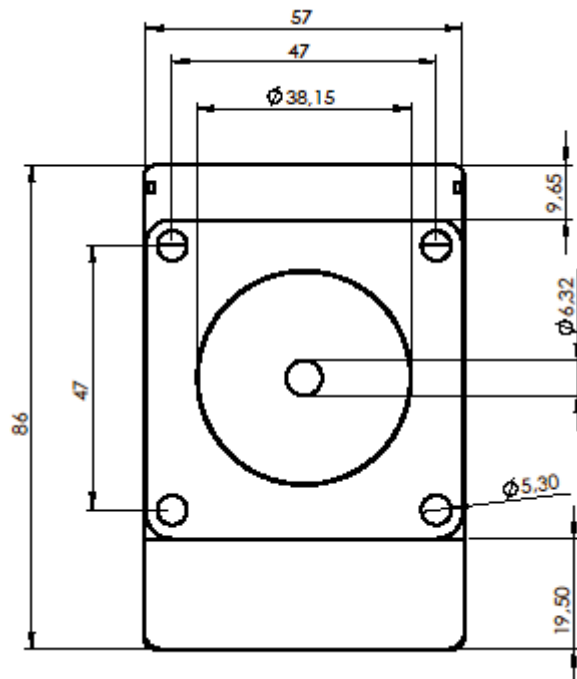


Figure 3.2 Front view of PANDrive

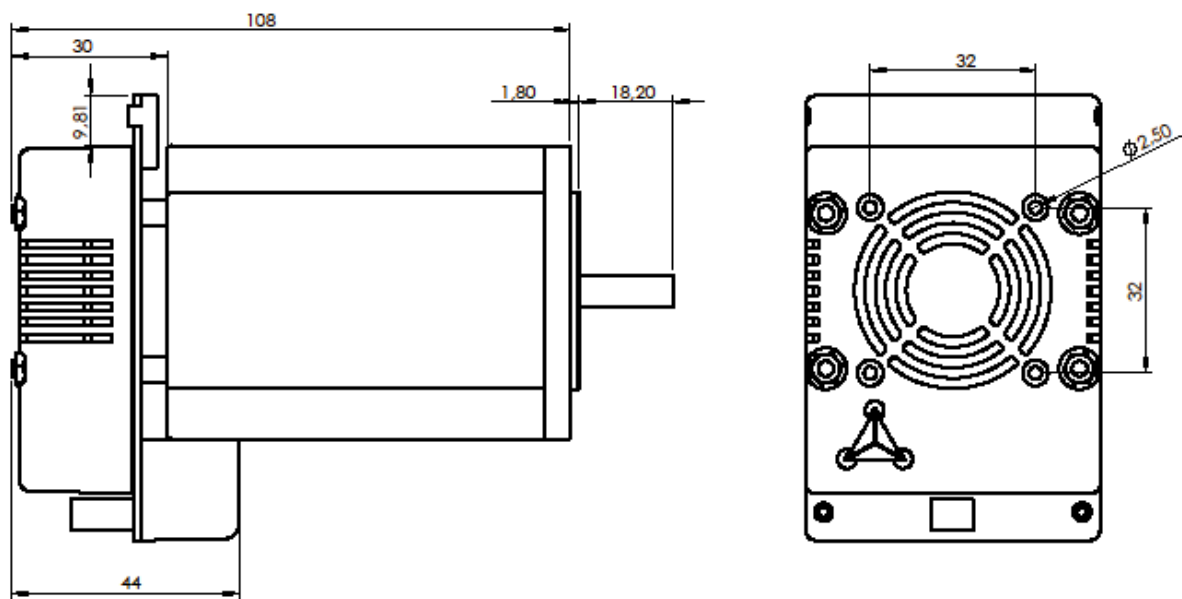


Figure 3.3 Side and rear view of PANDrive (108mm refers to PD3 motor)

## 3.2 Connectors

The connectors onboard of the module are 10 and a 12 pin female connector from RIACON: Type 183, RM 3.5mm

Fitting male connectors with screw terminals are: RIACON Type 169, RM 3.5mm.

Please refer to [www.riacconnect.com](http://www.riacconnect.com) for more detailed information.

### 3.3 Connecting the Module

The TCM-109 module consists of two PCBs: the CPU board and the base board. All the connectors can be found on the base board. They are shown in Figure 3.4.

*Attention: Never plug in the board in reverse direction!*

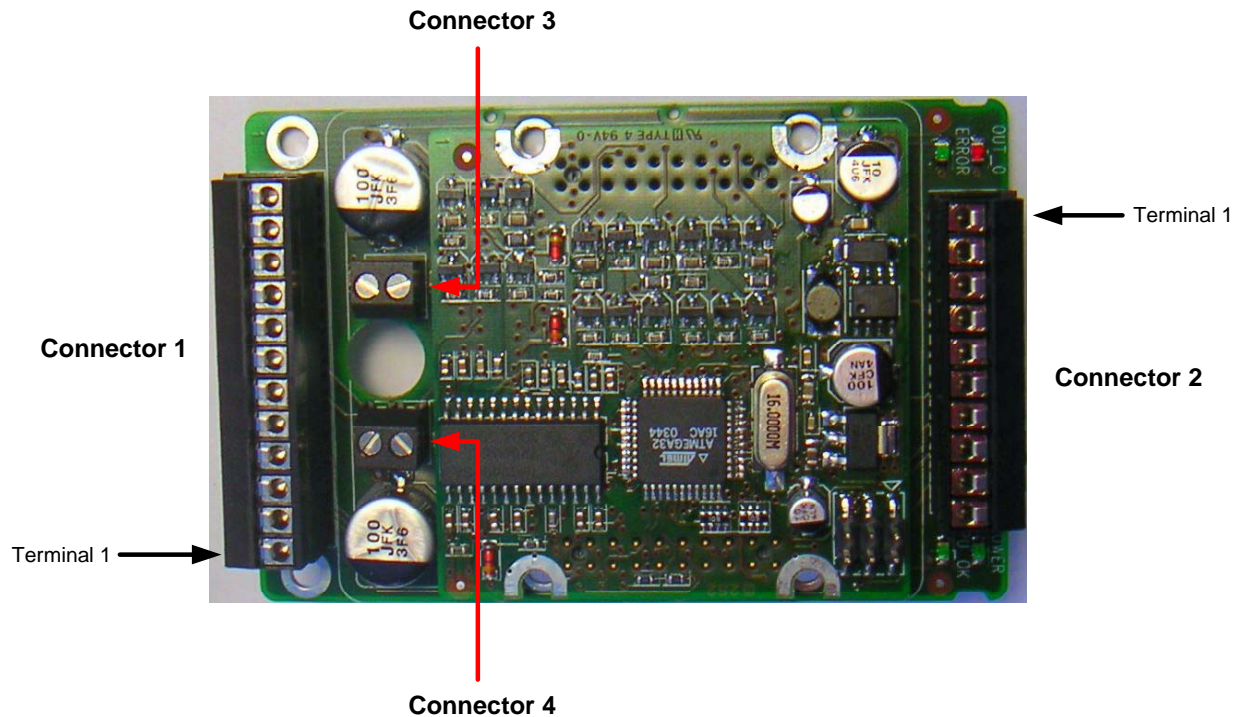


Figure 3.4: The TCM-109 module and its connectors

#### 3.3.1 Connector 1: Power Supply, RS485, Step/Direction

Use this connector to connect the module to the power supply. The connector also provides pins for RS485 and Step/Direction signals. To use the RS485 interface, it has to be enabled via the interface selection input (please see connector 2 pinning). The polarity of the shutdown input can be configured using TMCL (please see the TMCL Reference and Programming Manual for details). Please note that the shutdown input, the step input and the direction input are connected to photo couplers. The ground line of all three photo couplers is connected to terminal 5.

Terminal	Name	Function
1	GPO0	General purpose output 0 (same as connector 2, terminal 5) (open collector, max. 250mA, max. 40V, 1K pullup to 5V integrated)
2	Shutdown	Shutdown input (positive optocoupler input, polarity set via software)
3	Step In / GPI1	Step input / General purpose input 1 (positive optocoupler input)
4	Dir In / GPI2	Direction input / General purpose input 2 (positive optocoupler input)
5	OC_GND	Optocoupler ground
6	RS485-	RS485-
7	RS485+	RS485+
8	RS485-	RS485- (same as terminal 6)
9	RS485+	RS485+ (same as terminal 7)
10	GND	Ground
11	GND	Ground
12	+VM	+18..55V DC power supply

Table 3.1: Connector 1

### 3.3.2 Connector 2: RS232 and additional I/O

The RS232 interface and 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, if enabled via software. The general purpose input can either be used as a digital TTL input or as an analogue input with a voltage range of either 0..5V or 0..10V. This voltage range is selectable by software. The general purpose output is an open collector output for a maximum current of 250mA. Freewheeling diodes connected to the supply voltage are also included so that e.g. a 24V relay or a coil can be connected directly. The pin assignment of this connector is as follows:

Terminal	Name	Function
1	GND	Ground
2	IF select	Interface selection: Leave open to use RS232, connect to ground to use RS485.
3	TXD	RS232 TxD (output)
4	RXD	RS232 RxD (input)
5	GPO0	General purpose output 0 (same as connector 1, terminal 1) (open collector, max. 250mA, max. 40V, 1K pullup to 5V integrated)
6	GPI0	General purpose input 0 (max. 5V)
7	StopR	Right limit switch input (integrated 10K pullup to 5V)
8	StopL	Left limit switch input (integrated 10K pullup to 5V)
9	+5V	+5V output (max. 150mA) Can be used to supply 5V fan or optical switches.
10	GND	Ground

Table 3.2: Connector 2

## 3.4 Connecting the Motor (Connector 3 and 4)

Normally, the TMCM-109 module comes mounted on a suitable stepper motor. Should you have a module without a motor you can connect a two phase bipolar stepper motor yourself. To connect the motor there are two screw terminals adjacent to a cable feed through hole on the board. Connect one coil of the motor to one of the connectors and the other coil to the other connector. Please always make sure that the module is disconnected from the power supply before connecting or disconnecting a motor. Connecting or disconnecting a motor while the module is powered can damage the module! Connect one motor coil to connector 3 and the other motor coil to connector 4. The direction of the motor shaft can be reversed by changing the polarity of **one** coil.

**Do not connect or disconnect the motor while power on. Damage to the module may occur.**



## 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 <sub>S</sub>	Power supply voltage for operation	18	24 ... 48 <sup>1)</sup>	55 <sup>1)</sup>	V
I <sub>COIL</sub>	Motor coil current for sine wave <b>peak</b> (chopper regulated, adjustable via software)	0	2.1 ... 5.0	5.0	A
I <sub>MC</sub>	Continuous motor current ( <b>RMS</b> ) recommended for supply voltages up to 36 V	0	1.5 ... 3.5	3.5	A
	Continuous motor current ( <b>RMS</b> ), recommended for supply voltages exceeding 36 V	0	1.5 ... 3.0	3.5 <sup>2)</sup>	A
f <sub>CHOP</sub>	Motor chopper frequency		36.8		kHz
I <sub>S</sub>	Power supply current		<< I <sub>COIL</sub>	1.4 * I <sub>COIL</sub>	A
U <sub>+5V</sub>	+5V output (max. 150mA load)	4.8	5.0	5.2	V
V <sub>ISO</sub>	Isolation voltage of optocoupler		± 42	±100	V
V <sub>OPTION</sub>	Signal active voltage at enable, step and direction input (optocoupler on)	4	5 ... 24	27	V
I <sub>OPTION</sub>	Signal current for optocoupler (internally limited) (meas. at 24V)	11	15	18	mA
V <sub>OPTOFF</sub>	Signal inactive voltage at enable, step and direction input (optocoupler off)	-1	0	1.5	V
f <sub>Step</sub>	Step frequency			350	kHz
t <sub>delay</sub>	Direction hold time after step impulse active (falling) edge			0.7	µs
t <sub>setup</sub>	setup time before step impulse			2.0	µs
V <sub>INPROT</sub>	Input voltage for StopL, StopR, GPIO (internal protection, DC)	-24		24	V
V <sub>ANA</sub>	GPIO analog measurement range (20k voltage divider in high range)		0 ... 5 0 ... 10		V
V <sub>STOPLO</sub>	StopL, StopR low level input		0	0.9	V
V <sub>STOPHI</sub>	StopL, StopR high level input (integrated 10k pullup to +5V)	1.9	5		V
T <sub>ENV</sub>	Environment temperature at rated current (no cooling)	-40		+40	°C
	Environment temperature at 80 % of rated current or 50% duty cycle (no cooling)	-40		+60	°C

**Table 4.1: Operational Ratings**

1) Attention: First samples (until Oct. 05) are limited to a maximum of 38V supply voltage

2) Forced cooling might be required

## 4.1 Step, Direction and Disable Inputs

The inputs disable, dir and step are electrically isolated from the module. Their functional voltages  $V_{\text{OPTON}}$  and  $V_{\text{OPTOFF}}$  are directly depending on the input voltages ( $V_{\text{STEP}}$ ,  $V_{\text{DIR}}$  and  $V_{\text{DISABLE}}$ ). For off-state the input voltage has to be less than 1.5V ( $V_{\text{OPTOFF}}$ ) and for on-state it has to exceed 4.0V ( $V_{\text{OPTON}}$ ).

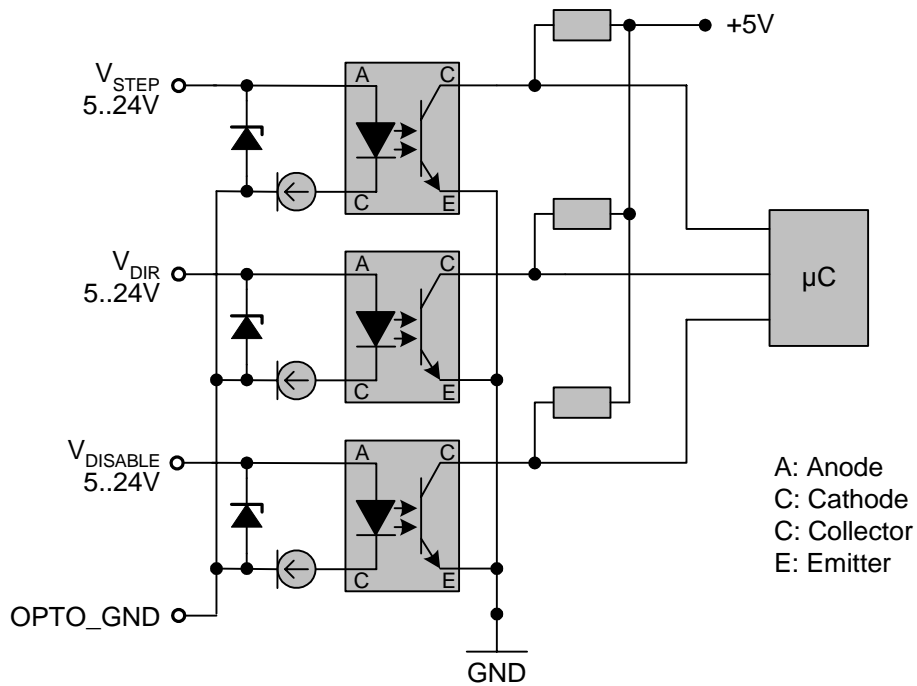


Figure 4.1: Step, Direction and Disable Inputs

Logic level:

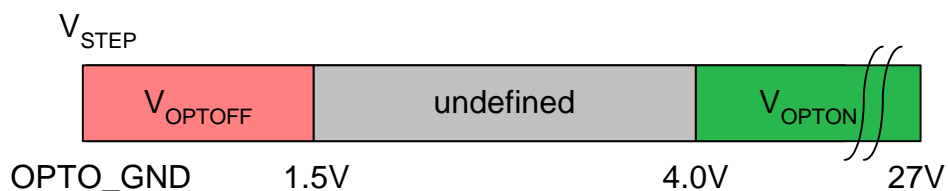


Figure 4.2: Example for Step, Direction and Disable inputs

## 5 Functional Description

In Figure 5.1 the main parts of the TMC109 module are shown. The module mainly consists of the  $\mu$ C, a TMC428 motion controller, a TMC249 stepper motor driver, the TMCL program memory (EEPROM) and the host interfaces (RS232 and RS485).

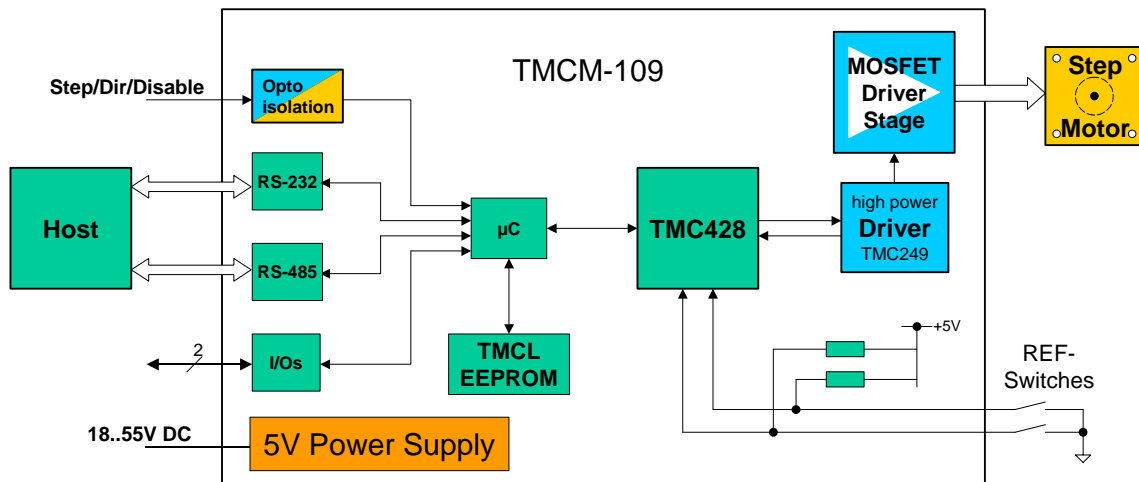


Figure 5.1: Main parts of the TCM-109

### 5.1 System Architecture

The TCM-109 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 ( $\mu$ C)

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, while an additional EEPROM memory holds the user TMCL programs.

The TMCL operating system can be updated only via the host interfaces. Please use the latest version of the TMCL IDE to do this.

#### 5.1.2 TMCL EEPROM

To store TMCL programs for stand alone operation the TCM-109 module is equipped with a 16kByte EEPROM attached to the microcontroller. The EEPROM can store TMCL programs consisting of up to 2047 TMCL commands.

#### 5.1.3 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.

#### 5.1.4 TMC249 Motor Driver

The stepper motor driver used on the TCM-109 module is the TMC249 chip. This driver is very dependable, because it provides a variety of protection and diagnostic features, which even can be read out by the user software. Its 16x up to 32x microstepping gives a quiet and precise motor operation. A maximum coil current of 5.0A is supported by this driver IC together with the high performance MOSFETs the module is equipped with.

## 5.2 Power Supply Requirements

The TMC109 is equipped with a switching 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 18..55V DC. Please note that there is no protection against reverse polarity or too high voltage. The power supply typically should be within a range of **24 to 48V** to achieve highest motor performance. When using supply voltages near the upper limit, a regulated power supply becomes a must. Please ensure, that enough power filtering capacitors are provided in the system (2200µF or more recommended), in order to absorb mechanical energy fed back by the motor in stalling conditions. In larger systems a zener diode circuitry might be required, when motors are operated at high velocities.

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.

### Therefore we recommend to

- keep power supply cables as short as possible
- use large diameter for power supply cables
- if the distance to the power supply is large (i.e. more than 2-3m), use a robust 2200µF or larger additional filtering capacitor located near to the motor driver unit.

## 5.3 Disable

The disable input works as an emergency shutdown. The polarity can be configured using TMCL (please see the TMCL Reference and Programming Manual for details).

It is in the users responsibility to stop the step impulses or set the velocity to zero before enabling the motor again, because it would start abruptly or loose track otherwise.

V <sub>OPTON</sub>	open wire	V <sub>OFF</sub>
polarity 1	polarity 2	

## 5.4 Communication Interface – RS232 and RS485

The communication between the host and the module takes place via its host interface. This can be either RS232 or RS485. The module is equipped with both interfaces, but only one interface can be used at a time. All interfaces integrated on the module are ready-to-use, so there are no external drivers or level shifters necessary. To select RS232, leave open the interface selection pin, for RS485 pull it to ground. Please see chapter 3.3 for the pin assignments of the interfaces.

Interface selection pin (connector 2, terminal 2)	Selected communication interface
open wire	RS232
pulled to ground	RS485

Communication with the TMC109 module is done using TMCL commands. Refer to TMCL manual for detailed information (8 References). When using the RS485 interface, the devices can be daisy-chained. Bus termination resistors in the range of 100 Ohms are typically required at each of the two ends of the cables.

## 5.5 Motor Current setting

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

Setting	$I_{COIL,PP}$	$I_{COIL,RMS}$
255	5.0A	3.54A
216	4.2A	3.0A
180	3.5A	2.5A
144	2.8A	2.0A
108	2.1A	1.5A
72	1.4A	1.0A
0	0A	0A

Table 5.1: Motor Current Examples

## 5.6 Step / Direction Interface

### 5.6.1 Direction Input

The direction signal changes the motors rotation from clockwise (CW) to counterclockwise (CCW) and vice versa. A change in the direction signal has to be aligned to the step pulse in order to specify the direction of each step (please refer to setup -/ hold times).

$V_{OPTON}$	GND	open wire
motor CW	motor CCW	

### 5.6.2 Step Input

The step signal directly influences the velocity and acceleration of the motor. The velocity depends on the frequency, the acceleration on the frequency's change per time.

**Frequency:** The maximum step input frequency is 350 kHz. The minimum logic "0" time is 0.7  $\mu$ s and the minimum logic "1" time is 2.0  $\mu$ s.

Extern	$V_{OPTON}$	GND	$V_{OPTOFF}$
Intern	HIGH	LOW	

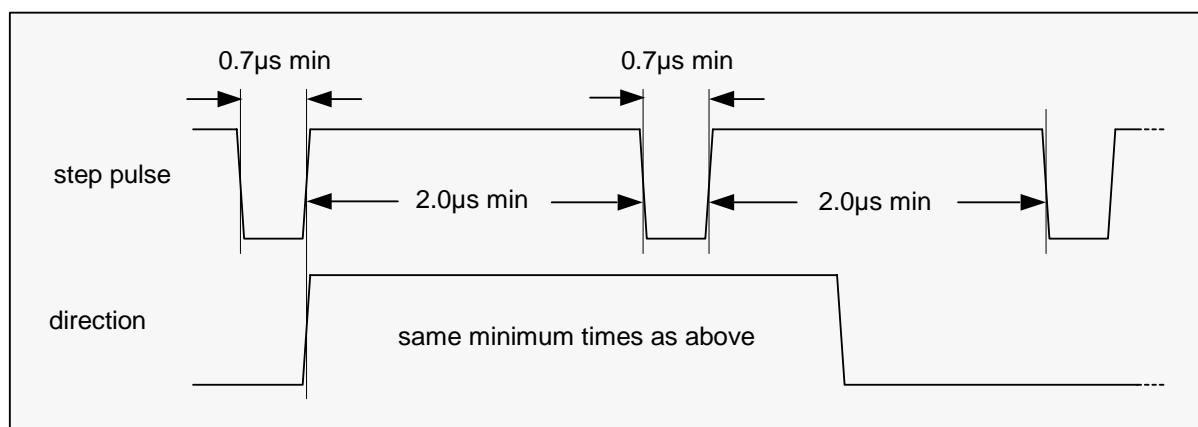


Figure 5.2: Step and Direction Signal

## 5.7 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.

## 5.8 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 traveller 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 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.

## 5.9 Environment Temperature Considerations

As the power dissipation of the MOSFETs is very low, no heat sink or cooling fan is needed, unless environment temperature is raised and the module continuously is operated at a high current.

When the output bridge temperature reaches a critical value, the output current is reduced by 20%. If the temperature still rises higher, the outputs become switched off. The coils are automatically switched on again when the temperature is within the limits again. An optional cooling fan can be mounted to cope with higher environment temperatures, when problems are perceived. The 5V power supply output can be used to operate a small fan.

## 5.10 LEDs

The TMCM-109 module is equipped with four LEDs that show the actual state of the module:

LED	Function
POWER	Shows that the module is powered
CPU_OK	Flashes during normal operation. After resetting the configuration EEPROM it may take some seconds before the LED starts flashing again. When the operating system is being downloaded to the module the LED lights steadily.
ERROR	On when the temperature of the MOSFETs is getting too high. The LED is off during normal operation
OUT_0	Shows the state of the general purpose output

## 6 Putting the TMCM-109 into Operation

On the basis of a small example it is shown step by step how the TMCM-109 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-109 module using the TMCL-IDE Software development environment.

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 the TMCM-109 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-109 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.

## 7 Revision History

### 7.1 Documentation Revision

Version	Comment	Author	Description
1.00	Initial Release	OK	
1.01	29-Jun-2005	BD	Added technical specs
1.03	09-Dec-2005	BD, HC	Added Pan-Drive documentation
1.04	23-Dec-05	BD	Added ordering info
1.06	30-Mar-2006	BD	Added mechanical dimensions for PANDrive
1.07	18-Jul-06	BD	Corrected mechanical dimensions

Table 7.1: Documentation Revisions

### 7.2 Firmware Revision

Version	Comment	Description
3.24	Initial Release	Please refer to TMCL documentation

Table 7.2: Firmware Revisions

## 8 References

[TMCL]

TMCL manual (see <http://www.trinamic.com>)