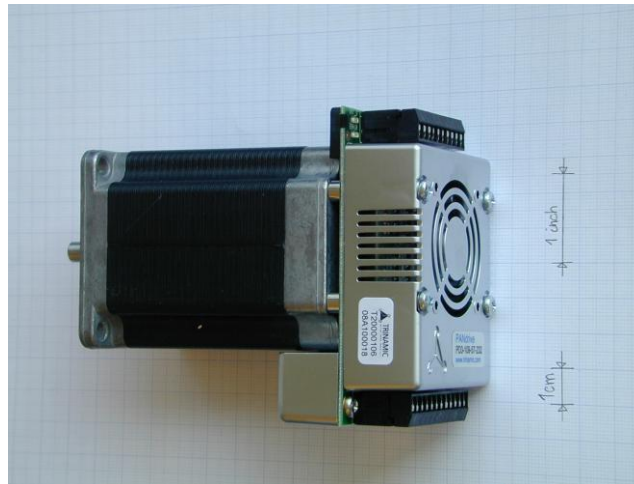


PANdrive PD-109-57



57mm / NEMA-23 Stepper Motor Mechatronic Module

TMCM-109-57 Electronics Manual

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Contents

1	Features.....	4
2	Life support policy.....	5
3	Electrical and Mechanical Interfacing.....	6
3.1	Dimensions.....	6
3.1.1	PCB Dimensions.....	6
3.1.2	PANdrive Dimensions.....	7
3.2	Connectors.....	7
3.3	Connecting the Module.....	8
3.3.1	Connector 1: Power Supply, RS485, GPI1/2.....	8
3.3.2	Connector 2: RS232 and additional I/O.....	9
3.4	Connecting the Motor (Connector 3 and 4).....	9
4	Operational Ratings.....	10
4.1	GPI1, GPI2 and Disable Inputs.....	11
5	Functional Description.....	12
5.1	System Architecture.....	12
5.1.1	Microcontroller (μC).....	12
5.1.2	TMCL EEPROM.....	12
5.1.3	TMC428 Motion Controller.....	12
5.1.4	TMC249 Motor Driver.....	12
5.2	Power Supply Requirements.....	13
5.3	Disable.....	13
5.4	Communication Interface – RS232 and RS485.....	13
5.5	Motor Current setting.....	14
5.6	Microstep Resolution.....	14
5.7	Optimum motor settings.....	15
5.8	Reference Switches.....	15
5.9	StallGuard™ - Sensorless Motor Stall Detection.....	15
5.10	Environment Temperature Considerations.....	15
5.11	State indication LEDs.....	16
5.12	Firmware update.....	16
5.13	Resetting the module.....	16
6	Putting the TCM-109 into Operation.....	17
7	TCM-109 Operational Description.....	18
7.1	Calculation: Velocity and Acceleration vs. Microstep- and Fullstep Frequency.....	18
8	Software.....	19
9	Revision History.....	20
9.1	Documentation Revision.....	20
9.2	Firmware Revision.....	20
10	References.....	20

List of Figures

Figure 3.1: Dimensions of base PCB	6
Figure 3.2 Front view of PANdrive	7
Figure 3.3 Side and rear view of PANdrive (length of 108mm refers to PD3 motor)	7
Figure 3.4: The TMC109 module and its connectors	8
Figure 4.1: GPI1, GPI2 and Disable Inputs	11
Figure 4.2: Example for GPI1, GPI2 and Disable inputs	11
Figure 5.1: Main parts of the TMC109	12

List of Tables

Table 1.1: Order codes	4
Table 3.1: Connector 1	8
Table 3.2: Connector 2	9
Table 4.1: Operational Ratings	10
Table 5.1: Motor Current Examples	14
Table 5.2: Microstep resolution setting	14
Table 5.3: Optimum motor settings	15
Table 5.4: State indication LEDs	16
Table 7.1: TMC428 Velocity parameters	18
Table 9.1: Documentation Revisions	20
Table 9.2: Firmware Revisions	20

1 Features

The PANdrive PD-109-57 is a full mechatronic solution including a 57mm flange motor. It is based on the TCM-109-57 electronics and offers RS232 and RS485 interface. The power supply, interface and the multi purpose I/Os can be connected via two pluggable screw terminal connectors. The TCM-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
- 3 general purpose inputs and 1 general purpose output

Features

- up to 64 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 two general purpose inputs and the disable input
- 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 July 1st, 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	

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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Information given in this data sheet is believed to be accurate and reliable. However no responsibility is assumed for the consequences of its use or for any infringement of patents or other rights of third parties, which may result from its use.

Specifications are 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).

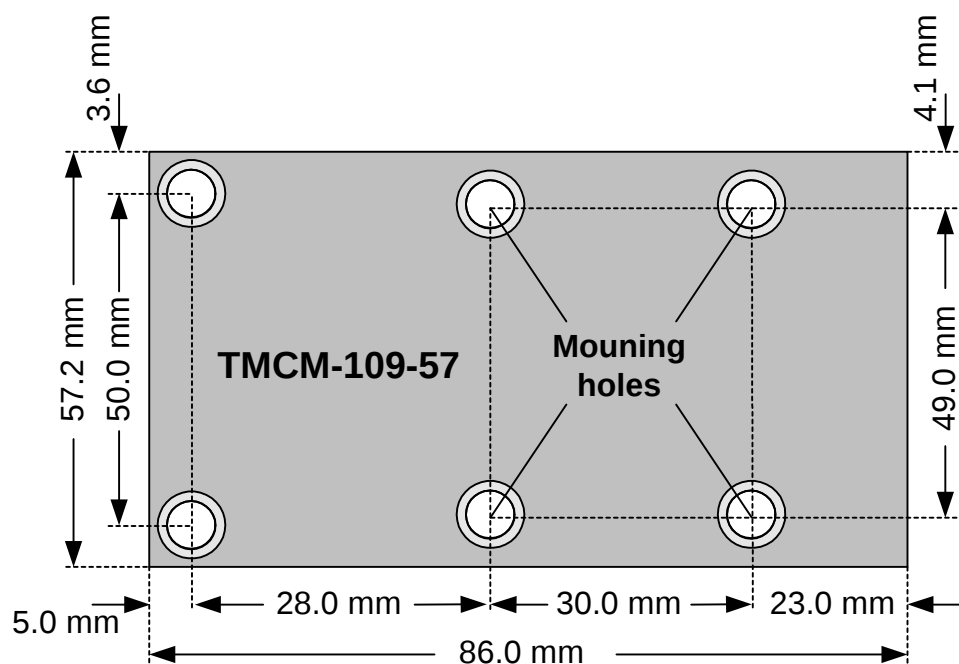


Figure 3.1: Dimensions of base PCB

3.1.2 PANdrive Dimensions

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

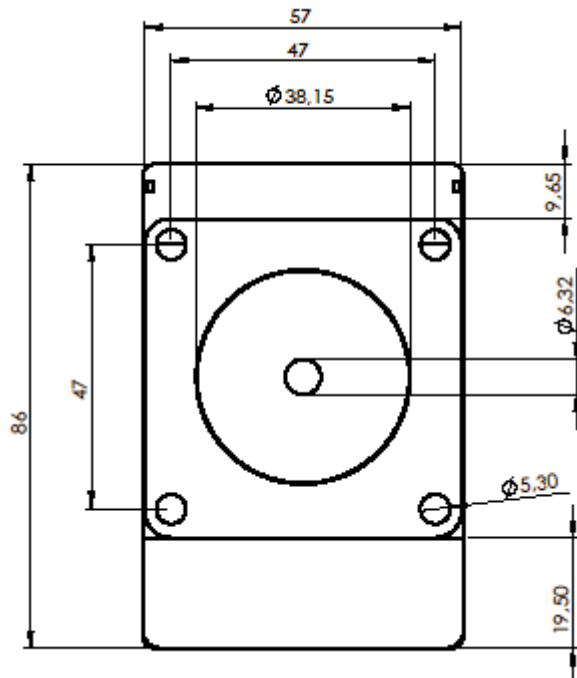


Figure 3.2 Front view of PANdrive

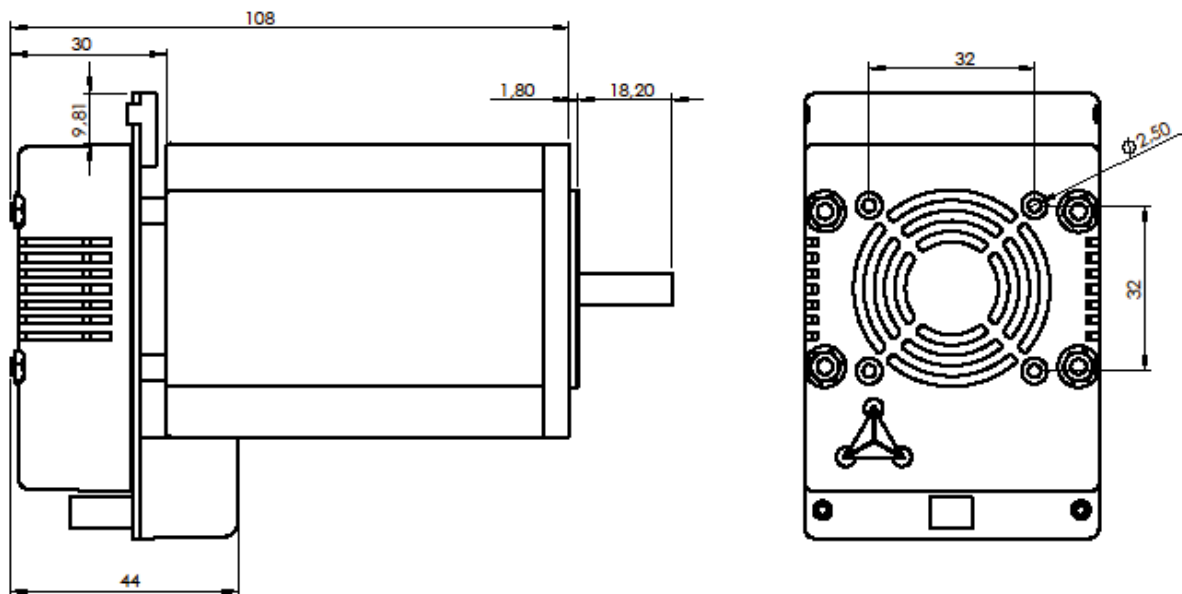


Figure 3.3 Side and rear view of PANdrive (length of 108mm refers to PD3 motor)

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 for more detailed information.

3.3 Connecting the Module

The TCMC-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!

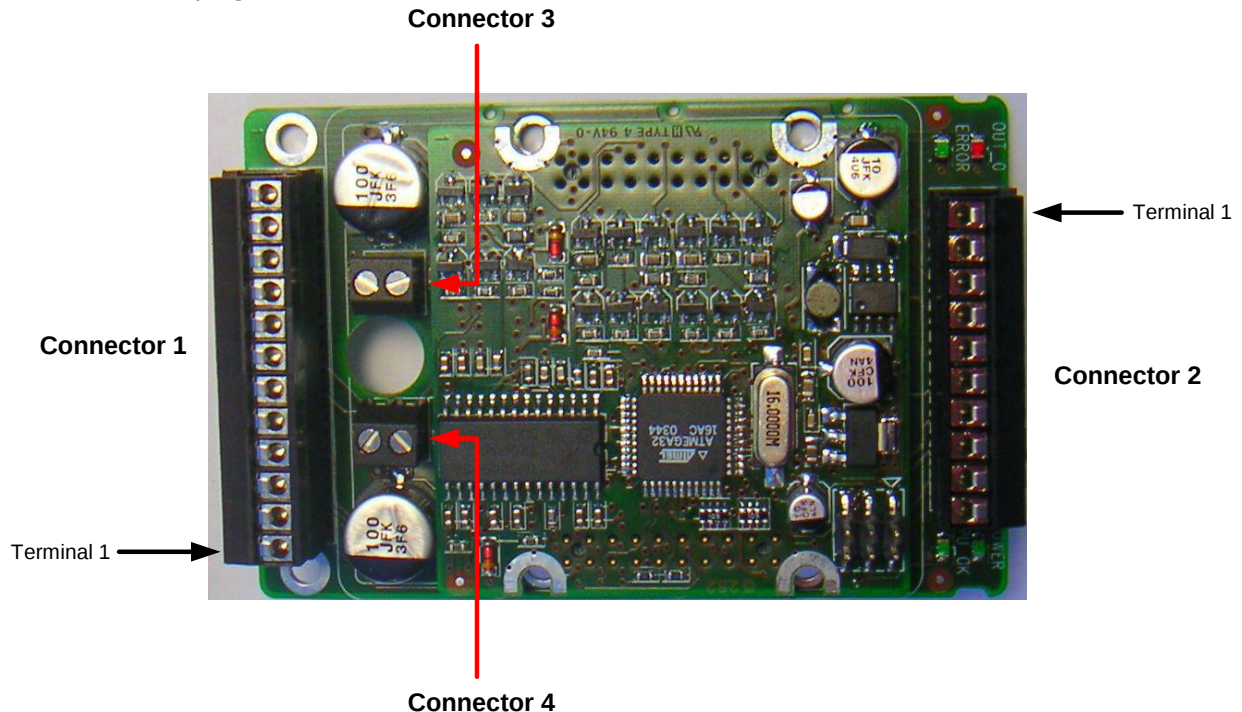


Figure 3.4: The TCMC-109 module and its connectors

3.3.1 Connector 1: Power Supply, RS485, GPI1/2

Use this connector to connect the module to the power supply. The connector also provides pins for the RS485 and the general purpose input 1 and 2 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 and general purpose inputs 1 and 2 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 pull up to 5V integrated)
2	Shutdown	Shutdown input (positive optocoupler input, polarity set via SW, SGP 80)
3	GPI1	General purpose input 1 (positive optocoupler input)
4	GPI2	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	GPOo	General purpose output o (same as connector 1, terminal 1) (open collector, max. 250mA, max. 40V, 1K pullup to 5V integrated)
6	GPIo	General purpose input o (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 TCM-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_S	Power supply voltage for operation	18	24 ... 48 ¹⁾	55 ¹⁾	V
I_{COIL}	Motor coil current for sine wave peak (chopper regulated, adjustable via software)	0	2.1 ... 5.0	5.0	A
I_{MC}	Continuous motor current (RMS) recommended for supply voltages up to 36 V	0	1.5 ... 3.5	3.5	A
	Continuous motor current (RMS), recommended for supply voltages exceeding 36 V	0	1.5 ... 3.0	3.5 ²⁾	A
f_{CHOP}	Motor chopper frequency		36.8		kHz
I_S	Power supply current		$< I_{COIL}$	$1.4 \cdot I_{COIL}$	A
U_{+5V}	+5V output (max. 150mA load)	4.8	5.0	5.2	V
V_{ISO}	Isolation voltage of optocoupler		± 42	± 100	V
V_{OPTON}	Signal active voltage at enable, step and direction input (optocoupler on)	4	5 ... 24	27	V
I_{OPTON}	Signal current for optocoupler (internally limited) (meas. at 24V)	11	15	18	mA
V_{OPTOFF}	Signal inactive voltage on enable, GPI1 and GPI2 input (optocoupler off)	-1	0	1.5	V
V_{INPROT}	Input voltage for StopL, StopR, GPIO (internal protection, DC)	-24		24	V
V_{ANA}	GPIO analog measurement range (20k voltage divider in high range)		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 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 GPI1, GPI2 and Disable Inputs

The GPI1, GPI2 inputs and the disable input are optically isolated inputs. Their functional voltages V_{OPTON} and V_{OPTOFF} are directly depending on the input voltages (V_{GPI1} , V_{GPI2} and V_{DISABLE}). For off-state the input voltage has to be less than 1.5V (V_{OPTOFF}) and for on-state it has to exceed 4.0V (V_{OPTON}).

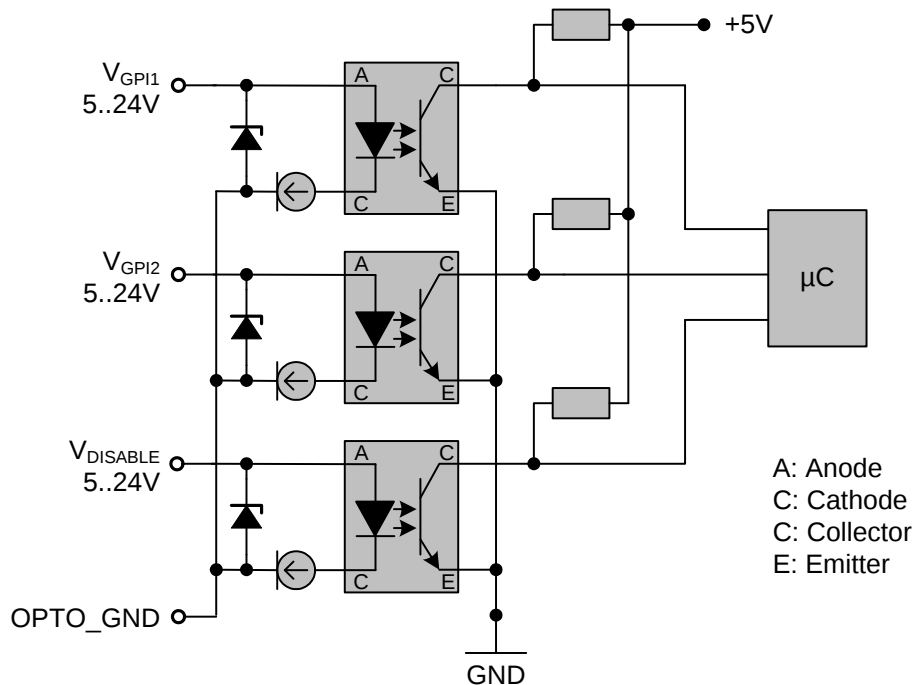


Figure 4.1: GPI1, GPI2 and Disable Inputs

Logic level:

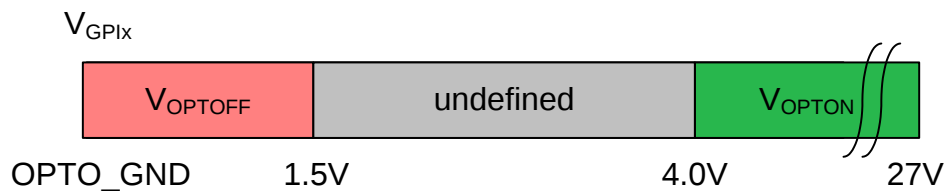


Figure 4.2: Example for GPI1, GPI2 and Disable inputs

5 Functional Description

In Figure 5.1 the main parts of the TCM-109 module are shown. The module mainly consists of the μ C, a TMC428 motion controller, a TMC249 stepper motor driver, the TMCL program memory (EEPROM) and the host interfaces (RS232 and RS485).

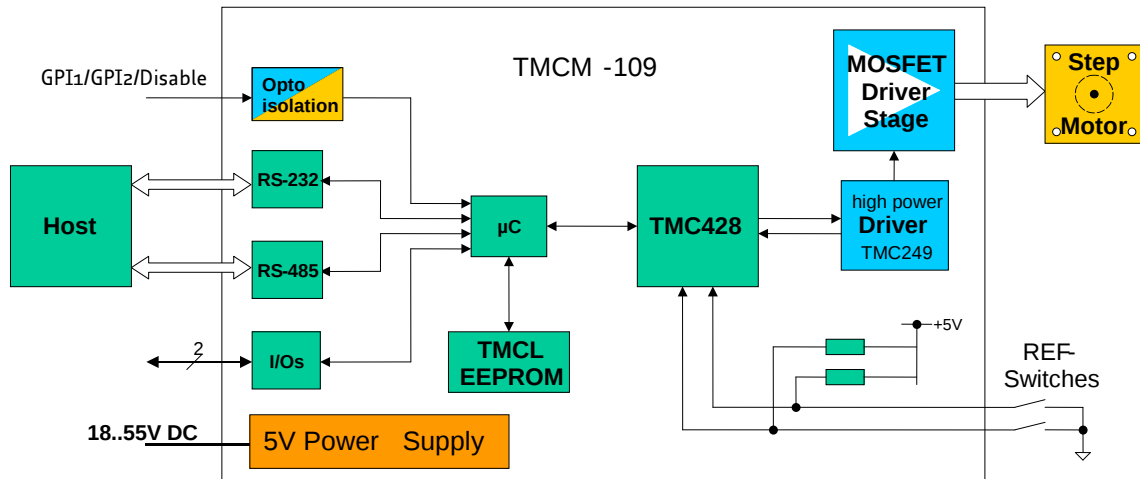


Figure 5.1: Main parts of the TCM-109

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 (μ 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 standalone 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 TCM-109 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 stall 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_{OPTON}	open wire	V_{OPTOFF}
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 TCM-109 module is done using TMCL commands. Refer to TMCL manual for detailed information (10 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 (inst. 5: SAP, type 6: max. current). 255 corresponds to the module's maximum I_{COIL} setting.

Setting	$I_{\text{COIL,PP}}$	$I_{\text{COIL,RMS}}$
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 Microstep Resolution

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

To set the microstep resolution with TMCL use instruction 5: SAP, type 140: microstep resolution. You can find the appropriate value in Table 5.2.

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 5.2: 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 operated in 32 or 64 microstep setting.

5.7 Optimum motor settings

Following settings apply best for highest motor velocities with smooth motor behavior at low velocities. Mixed decay should be switched on constantly. Microstep resolution is 4 (TMCL), this is 16 times microstepping. The pulse divisor is set to 3.

Optimum Motor Settings	Motor voltage	Unit	QSH5718		
			-41-30-047	-55-30-098	-79-30-163
			PD ₁	PD ₂	PD ₃
Motor current (RMS)		TMCL value	220	204	204
		A	3	2.8	2.8
Maximum microstep velocity = Fullstep threshold	24 V	TMCL value	620	240	180
		RPS	5.913	2.289	1.717
Maximum fullstep velocity		TMCL value	1450	580	400
		RPS	13.828	5.531	3.815
Maximum microstep velocity = Fullstep threshold	48 V	TMCL value	800	410	280
		RPS	7.629	3.910	2.670
Maximum fullstep velocity		TMCL value	2040	1000	810
		RPS	19.455	9.537	7.725

Table 5.3: Optimum motor settings

5.8 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.

5.9 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 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.

5.10 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.

5.11 State indication LEDs

The TCM-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_o	Shows the state of the general purpose output

Table 5.4: State indication LEDs

5.12 Firmware update

Use the "Install OS" function of the TMCL-IDE. It is located in the "Setup" menu.

5.13 Resetting the module

The reset to factory default values can be done using the TMCL IDE. Select "Setup", "Configure module", the "Other" tab and then "Restore Factory Default".

If problems with the communication occur the reset procedure of the TCM-109 (PANdrive) is as follows:

1. Turn off the power.
2. Link pins 1 and 3 of the programming connector (as shown in the picture on the right) by hardware.
3. Turn the power on and wait until the LED on the module flashes fast (much faster than normally).
4. Turn the power off.
5. Remove the link between the pins.
6. Turn the power on and wait until the LED flashes normally (this can take some seconds).

All settings are now restored to factory default, and the module can be used again normally.



6 Putting the TCM-109 into Operation

On the basis of a small example it is shown step by step how the TCM-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 TCM-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 TCM-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

    JTA Loop           //Infinite Loop
```

Step 6: Click the "Assemble" icon to convert the TMCL program into byte code. Then download the program to the TCM-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 TMC428 Operational Description

7.1 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 7.1: TMC428 Velocity parameters

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

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

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

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

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:

$$af = \frac{a}{2^{Usrs}} \text{ with af: acceleration in fullsteps}$$

Example:

$f_{CLK} = 16 \text{ MHz}$ on the TCM-109 module
 $velocity = 1000$
 $a_{max} = 1000$
 $pulse_div = 1$
 $ramp_div = 1$
 $usrs = 6$

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

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

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

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

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

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

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

8 Software

TMCL, the Trinamic Motion Control Language is used to send commands from the host to the TCM-109 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.

9 Revision History

9.1 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
1.08	18-Oct-2006	HC	Added resetting information
1.09	20-June-2007	HC	Chapter 5.6 "Microstep resolution", 7 "Operational Description" and 5.7 "Optimum motor settings" added
1.10	17-October-2007	HC	Step / Direction firmware information (chapter 4.1 and Fehler! Verweisquelle konnte nicht gefunden werden.)
1.11	8-Dec-08	OK	Step / Direction inputs and all sections related to this removed

Table 9.1: Documentation Revisions

9.2 Firmware Revision

Version	Comment	Description
3.35	Actual revision	Please refer to TMCL documentation

Table 9.2: Firmware Revisions

10 References

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