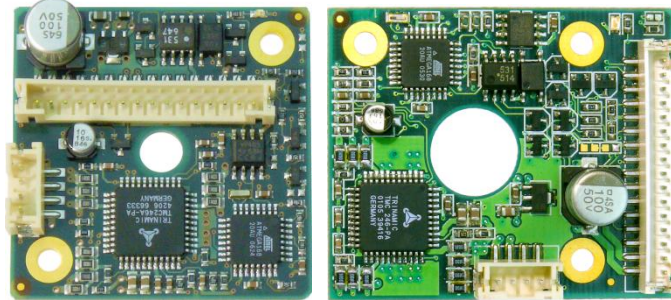


V 1.24

HARDWARE MANUAL



TMCM-013-42 TMCM-013-42-LA

controller / driver
up to 1A RMS / 30V DC
RS485
step/direction driver



PDx-013-42

controller / driver
up to 1A RMS / 30V DC
RS485
step/direction driver

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1 Life support policy

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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 are subject to change without notice.



2 Features

The PD-013-42 is a mechatronic stepper motor module with step-/direction interface plus remote configuration access. It is based on the TCM-013-42 one axis stepper motor controller and driver for integration directly on a NEMA-17 motor. With up to 1.5A coil current it operates from a single 7 to 30V power supply. It provides step/direction, RS485 and an optional pseudo DC interface for remote control. Up to 256 micro steps are available for either high accuracy or high speed. It integrates velocity and torque control as well as positioning mode. An update of the firmware is possible via the serial interface. The system features sensorless stall detection (stallGuard™). The TCM-013-LA supports NEMA-17 linear actuators.

Applications

- Mechatronic step-/ direction stepper driver for general decentralized applications
- Robotics
- Remote diagnostics / feedback allows for high-reliability drives

Motor type

- Coil current from 300mA to 1A RMS (1.5A peak)
- 7V to 30V nominal supply voltage

PANdrive Motor data

- all PANdrive motors optimized for 1A RMS coil current
- 200 fullsteps per revolution
- please refer to motor data sheet for detailed motor information

Highlights

- Remote controlled diagnostics and parameterization (RS485)
- Reference move and turn CW / CCW via RS485
- Standalone operation, adjusted via RS485
- Fully protected drive
- Digital selection of motor current and standby current
- Local reference move using sensorless StallGuard™ feature or reference switch
- All setup parameters are stored in internal EEPROM, no bus system required in end application
- Micro step resolution can be changed to get high accuracy or high speed with the possibility to combine both
- Different chopper modes allow best adaptation to application / motor
- Many adjustment possibilities make this module the solution for a great field of demands

Other

- pluggable JST connectors
- RoHS compliant

3 Order codes

The TCM-013 motion control module can be mounted directly on NEMA-17 motors.
The TCM-013-LA supports NEMA-17 linear actuators.

Cables are not included. Add the appropriate cable loom to your order if required.

Order code	Description	Dimensions [mm ³]
PD1-013-42 (-option)	PANdrive 0.27Nm	53 x 42 x 42
PD2-013-42 (-option)	PANdrive 0.35Nm	59 x 42 x 42
PD3-013-42(-option)	PANdrive 0.49Nm	69 x 42 x 42
TCM-013 (-option)	Motion control module for NEMA-17 motors	14 x 42 x 42
TCM-013-LA (-option)	Motion control module for NEMA-17 linear actuators	14 x 42 x 50

Table 3.1: PANdrive™ and module order codes

Option	Host interface
-485	RS485

Table 3.2: Option for order code

Component parts	Description
TCM-013-CABLE	Cable loom for module and PANdrive™.

Table 3.3: Order code for component parts

4 Electrical and mechanical interfacing

4.1 Pinning

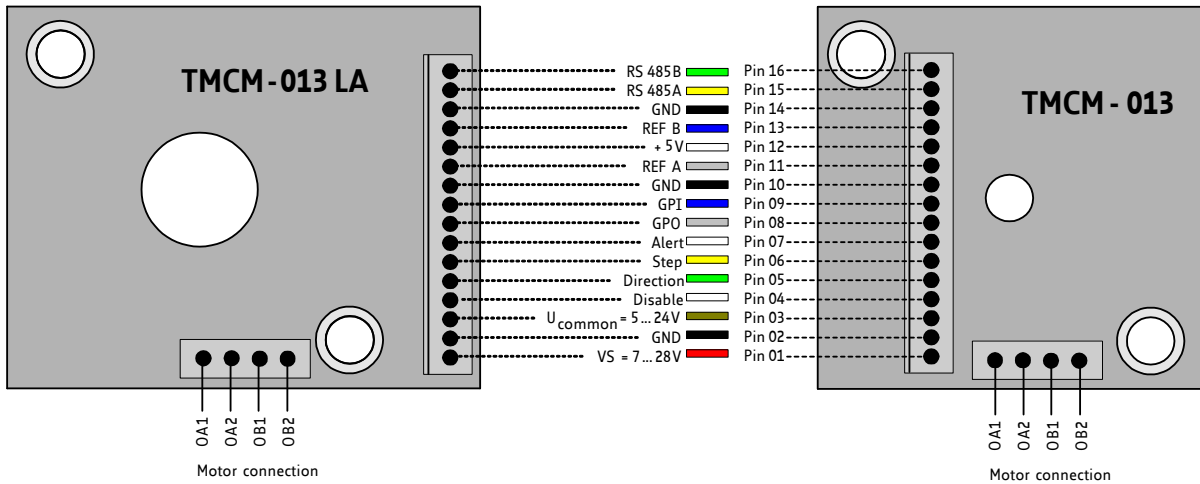


Figure 4.1: Pinning of TCMC-013 and TCMC-013-LA

The numbering printed on the 16 pin connector is reversed. Pin number 1 can be identified by the red cable for power supply.

Pin	Number	Function
VS	1	Positive power supply voltage
GND	2	GND, power
V _{COM}	3	Reference voltage for step-direction inputs. Positive optocoupler supply. Required for negative logic.
Disable	4	Tie to GND to shut down motor power, leave open or at V _{COM} otherwise
Direction	5	Tie to GND to inverse motor direction, leave open or at V _{COM} otherwise
Step	6	Step signal, optically isolated (Cathode of optocoupler)
Alert	7	Alert output, for wiring scheme see Figure 7.2
GPO	8	General Purpose Output, for wiring scheme see Figure 7.2
GPI	9	General Purpose Input
GND	10	GND reference
REF A	11	Reference Signal A
+5V	12	Constant +5V output, reference
REF B	13	Reference Signal B
GND	14	GND for RS485
RS485 +	15	RS485 remote control access +, TTL input
RS485 -	16	RS485 remote control access -, TTL input
OA1, OA2		Connections for motor coil A
OB1, OB2		Connections for motor coil B

Table 4.1: Pinning of TCMC-013 and TCMC-013-LA

4.2 Dimensions

42mm*42mm*14mm (Height is measured by the highest part on PCB, be aware that the connectors are upright). The mounting holes and the center hole for TCMC-013 are 3.2mm. The center hole of the TCMC-013-42 is 6.0mm and of the TCMC-013LA 12.5mm.

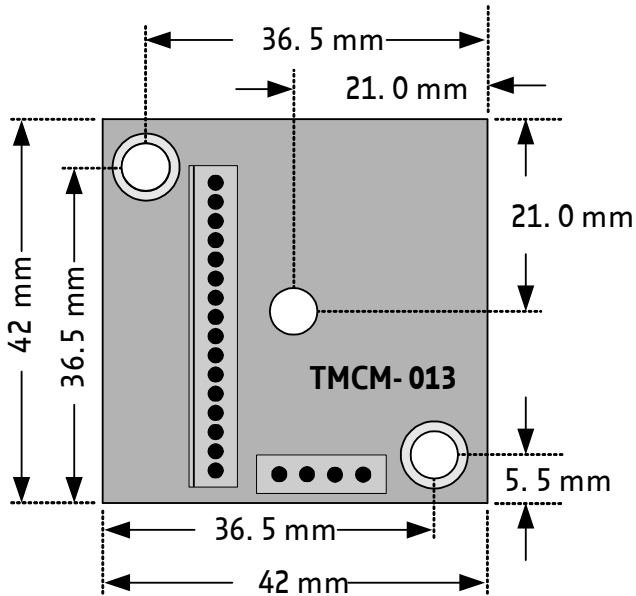


Figure 4.2: Dimensions for TCMC-013

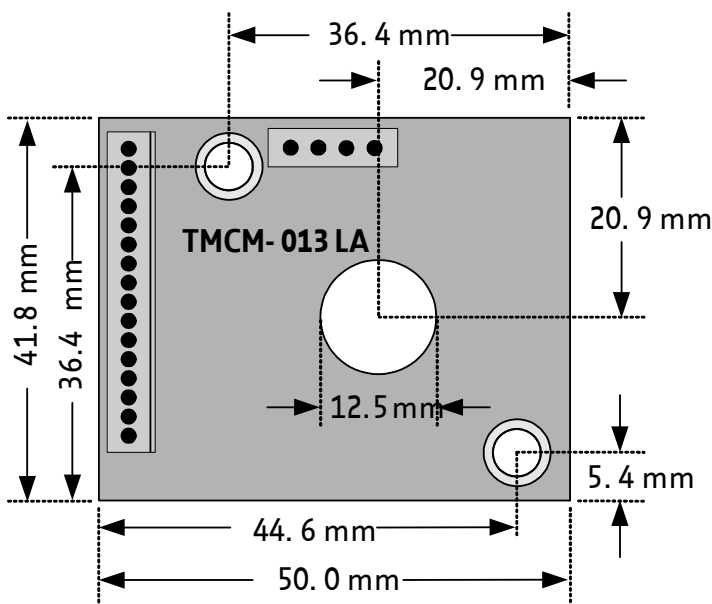


Figure 4.3: Dimensions for TCMC-013LA

4.3 Connectors

The numbering printed on the 16 pin connector is reversed. The red cable is pin 1.

Both connectors are crimp connectors series B4B-PH-SM3-TB, PH-connector.

Motor: 4 pin connector

Control: 16 pin connector

5 Operational ratings

The operational ratings show the intended 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 .. 24	30	V
I_{COIL}	Motor coil current for sine wave peak (chopper regulated, adjustable via software)		440..1500		mA
I_{MC}	Effective motor current (RMS)		300 .. 1000	1000	mA
f_{CHOP}	Motor chopper frequency (actual frequency depends on operation mode)		20 / 36		kHz
I_S	Power supply current		$\ll I_{COIL}$	$1.4 * I_{COIL}$	A
V_{ISO}	Isolation voltage of optocoupler		± 42	± 100	V
V_{COM}	Supply voltage for step, direction and disable; (inputs have negative logic)		5 .. 24	27	V
V_{OPTON}	Signal active voltage at disable, step and direction input (optocoupler on, measured from U_{COM} to input)	3.5	4.5 .. 24	30	V
V_{OPTOFF}	Signal inactive voltage at disable, step and direction input (optocoupler off, measured from U_{COM} to input)	-5.5	0	2	V
I_{OPT}	Optocoupler current (internally regulated)		4	8	mA
f_{STEP}	Step frequency			350	kHz
t_{STEPLO}	Step impulse low time (optocoupler on)	0.7			μs
t_{STEPHI}	Step impulse high time (optocoupler off)	2.0			μs
$t_{DIRSETUP}$	Direction setup time to rising edge of step input	0			μs
$t_{DIRHOLD}$	Direction hold time after rising edge of step input	3.0			μs
V_{GPI}	Input voltage on GPI	-2	0 ... 5	30	V
V_{GPO}	Output voltage on GPO and Alert (open collector)	-1		100	V
I_{GPO}	Output current on GPO and Alert (open collector)			-150	mA
T_{ENV}	Environment temperature for operation	-25		70	$^{\circ}C$

Table 5.1: Operational ratings

5.1 Step, direction and disable inputs

The inputs disable, dir and step are electrically isolated from the module. The inputs are related to V_{COM} . In a typical application, U_{COM} shall be tied to the positive supply voltage of the master and the inputs are driven by open collector or push / pull outputs. V_{OPTOFF} and V_{OPTON} must not exceed V_{COM} to avoid reverse polarity for the optocouplers.

OFF: $V_{COM} - V_{IN} < 1.0V$
 ON: $V_{COM} - V_{IN} \geq 3.5V$

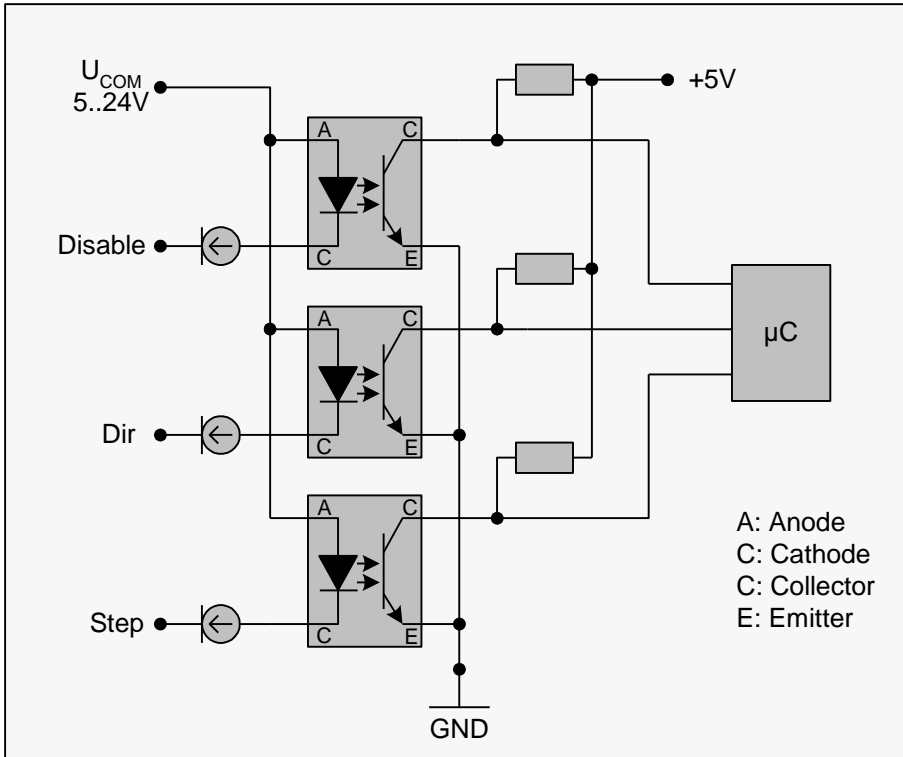
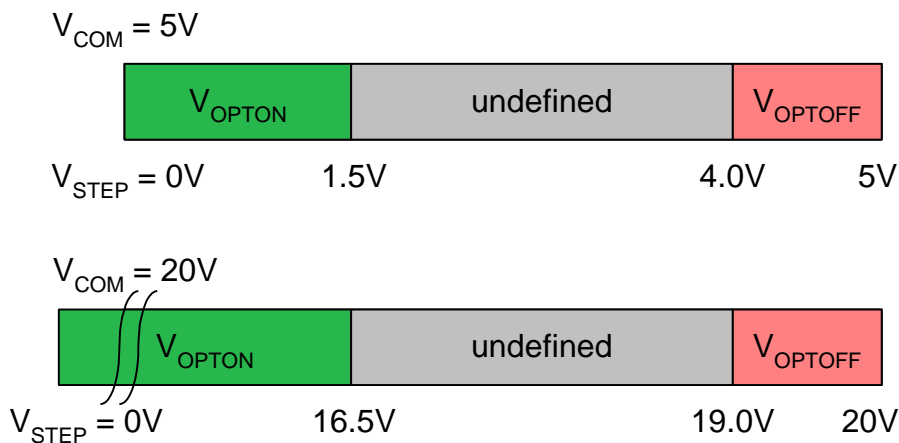


Figure 5.1: Step, direction and disable inputs

Examples:



7 Functional description

The TCMC-013 module has three different modes to control a stepper motor: step/direction, RS485 and eventually pseudo DC-mode. With the RS485 it is possible to change parameters and save them to the EEPROM of the module to have all options in any mode. Therefore there are different settings (like microstep resolution) possible in step/direction mode, also.

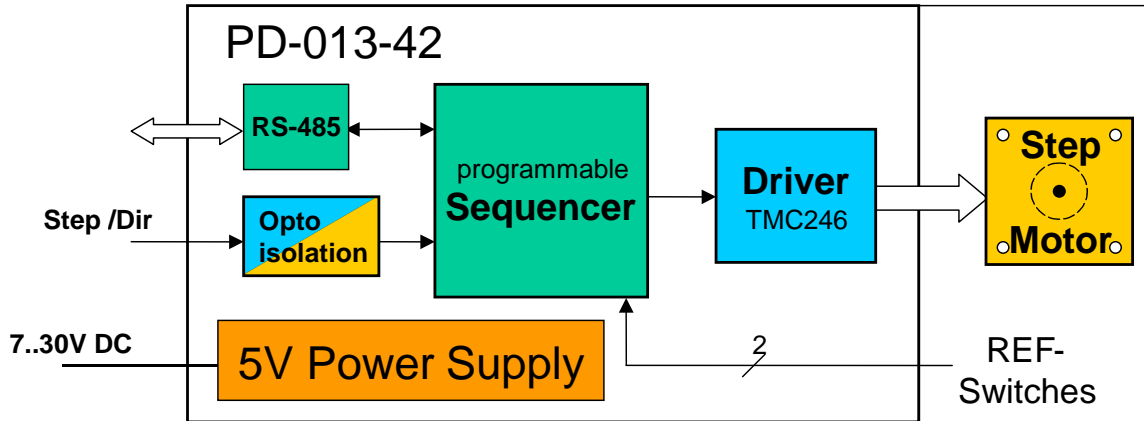


Figure 7.1: Main parts of PD-013-42

7.1 Disable

The disable works as an emergency shutdown. Connected to ground all power to the motor will shut down independent of the current settings.

It is in the user's responsibility to stop the step impulses or set the velocity to zero before enabling the motor again, because it starts abrupt otherwise.

Function Table:

V_{OPTON}	open wire	V_{OPTOFF}
motor disabled	motor enabled	

7.2 RS485 interface

The RS485 interface can control all functions of the TCMC-013. It is possible to change parameters, with this interface which are also valid in the other modes like max. velocity or acceleration. The parameters can be written to the EEPROM to obtain the changes after a restart.

A *reset to factory default* is possible. Default address byte is A and default baud rate is 9600 baud. This mode can only be used with an appropriate RS485 interface. Commands are sent with a terminal program. Please refer to the start-up, please

7.2.1 RS485 commands

For RS485 commands write the address byte (default is A) first, followed by a command from the following list. A small command letter provides the actual setting. All values are ASCII.

Command	Function	Description	Range	Factory Default
A, a	Acceleration	Acceleration: $v = 28.96 * a$	0... 2500000	0
C, c	Set Motor Current	Motor current in percentage of maximum current (0... 100% * 1500mA). Refer to 7.2.1.1	0... 100	50
E	Failure Readout	Provides Failure readout. Refer 7.2.1.2	8 Bit (SPI) 1Bit (others)	
G, g	stallGuard™	In mode 0 (SPI) the stallGuard™ feature is functional. 'g' provides the actual stallGuard™ load value, not the setting. Refer 7.2.1.3	-7... 0... +7	0
L, l	Limit switch	Used to switch on and off reference run values. Refer 7.2.1.4	byte	
M, m	Select Mode	Select chopper mode: 0:SPI, 1:PWM, 2:PHASE, 3 & 4: Combinations, Refer 7.3	0, 1, 2, 3, 4	0
N, n	Alert	Alert output adjustments, Refer 7.2.1.5	2 bit	0
O, o	Set Output	Output adjustments, Refer 7.2.1.6	2 bit	0
P	Set Position	Set position without moving the motor. See command 'R' to read out current value.	32 bit	0
Q	Read I/Os	Provides out of the I/O the values of the ports GPI, REF_A, REF_B, GPO and ALARM. Refer to 7.2.1.7		
R	Read Current Position	Provides the current position of the motor. See command 'P' to manipulate this value.	32 bit	
S	Changes address byte	Capital letter followed by the command 'S' makes this letter the new address byte: ("BS" makes "B" the new address byte)		A
T, t	RS485-Timeout	Sets the RS485-Timeout		
U, u	Set baud rate	Sets baud rate for RS485 communication. Refer to 7.2.1.9	0...7	0
V, v	Velocity for Rotation	Velocity for rotation/reference run $v = n * 0.149157 \mu\text{steps/s}$ Additional parameter 0 or missing: Carriage Return (CR) comes after acceleration phase Additional Parameter 1: no delay of CR	+/- 2500000 0/1	0
W	Store parameters to EEPROM	Stores actual settings of different parameters to EEPROM to restart with the same performance. Refer 7.2.1.11		
X	Version number	Provides version number of implemented Software		
Y, y	Standby current	Sets 0... 100% of maximum current after 1 second motor inactivity. For no standby current use the same value as for "Set motor current".	0... 100	20
Z, z	Microstep Resolution	Sets the maximum microstep resolution (0: max; 6: min). Refer to 0 and Table 7.10	0... 6	0

Table 7.1: RS485 commands

Examples:

1. Set chopper mode to SPI Mode: AM 0 ⇒ ENTER
2. Read out the actual mode: Am ⇒ ENTER
3. Change Microstep resolution ¼ of max. resolution: AZ 2 ⇒ ENTER

Example for test move:

- **Different accelerations and velocities**
- AA 500, AV 50000, AV -50000 ⇒ try other AA 0...8000, AV 0...400000
- **Max. current – test of torque**
- AA 500, AV 50000, AC 200 ⇒ test torque manually ⇒ AC 20 ⇒ test torque
- **Read and set position**
- AV 0, AR, AA 500, AV 50000, AR, AP 0, AR

7.2.1.1 Motor current (C) setting with RS485 command

The motor current can be set by the user. Therefore use the RS485 command AC in addition with a percent value. For calculating the actual setting, use the 100% values as shown in the table. Internally the current is regulated by two independent parameters for the best module/motor performance possible.

For chopper mode 2, the maximum setting is about 75% to 90%. At higher settings the microstep behavior of the motor may become harsh. The actual maximum depends on the actual motor. This is a precaution to avoid the motor coil current raising above the 100% setting at any time. Not all currents can be continuously driven at all supply voltages and cooling circumstances. Please take care of the motor current limitations.

AC	I _{COIL,PP}	I _{COIL,RMS}	% to max. I _{COIL}
100	1.50A	1.06A	100% *)
80	1.20A	0.85A	75%
66	1.00A	0.71A	66%
50	0.75A	0.53A	50%
33	0.50A	0.35A	33%
20	0.30A	0.21A	25%
0	0A	0.00A	0%

Table 7.2: Motor current examples

*) not possible for chopper mode 2

7.2.1.2 Failure readout (E)

The TCM-013 provides a full driver failure analyses in SPI mode (8 Bit).

The returned bit assignments are as follows:

Bit	Name	Function	Remark
7	OT	overtemperature	"1" = driver chip off due to overtemperature
6	OTPW	temperature prewarning	"1" = driver chip prewarning temperature exceeded
5	UV	driver undervoltage	"1" = undervoltage on VS
4	OCHS	overcurrent high side	3 PWM cycles with overcurrent within 63 PWM cycles
3	OLB	open load bridge B	Open load detection can occur at fast motion also.
2	OLA	open load bridge A	Open load detection can occur at fast motion also.
1	OCB	overcurrent bridge B low side	Short circuit detected. Please check motor wiring.
0	OCA	overcurrent bridge A low side	Short circuit detected. Please check motor wiring.

Table 7.3: Failure readout in SPI mode

In the other two modes the failure analysis consists of only one bit:

- 1: short circuit or overtemperature
- 0: no failure

7.2.1.3 stallGuard™ (G)

The stallGuard™ feature is available in the default mode 0 (SPI) only. It is a sensorless load measurement and stall-detection. Overload is indicated before steps are lost. The command letter *g* (small) does not provide the setting (-7 ... 7) but the actual stallGuard™ value (motor load), so easy calibration is possible. To use stallGuard™ in an actual application, some manual tests should be done first, because the stallGuard™ level depends upon the motor velocities and on the occurrence of resonances. When switching on stallGuard, the motor operation mode is changed and microstep resolution may be worse. Thus, stallGuard™ should be switched off when not in use.

Value	Description
-7... -1	Motor stops when stallGuard™ value is reached and position is set zero (useful for reference run).
0	StallGuard™ function is deactivated (default)
1... 7	Motor stops when stallGuard™ value is reached and position is not set zero.

Table 7.4: stallGuard™

The stallGuard™ function can also be activated when using step/direction mode. In step/direction mode the motor will not be stopped when the stallGuard™ value is reached, but the general purpose output will be controlled by the stallGuard™ value: when the actual load value is greater than the stallGuard™ value, the GPO will be switched on, and when the actual load value is lower or equal to the stallGuard™ limit, the GPO will be switched off. This can be used to signal a stall to the step/direction controller. When the stallGuard™ function is de-activated (0, default) the GPO will not be changed by stallGuard.

7.2.1.4 Limit switch (L)

The parameter 'L' defines the different reference entrances of the module. The motor stops when the defined position is reached.

Bit	Motor stops at
0	REF_B = 0
1	REF_A = 0
2	GPI = 0
3	REF_B = 1
4	REF_A = 1
5	GPI = 1
6	0: soft stop, 1: hard stop
7	0: sets position zero 1: sets position not to zero

Table 7.5: Limit switch

To activate a reference switch set the appropriate bit to 1 (decimal entry). When motor stops the position counter is set to zero.

Example:

AL 8 ⇒ ENTER activates REF_B = 1. When destination reached motor stops and position counter is set to zero.

7.2.1.5 Alert settings (N)

The bit settings are as follows:

Bit	Value	Description
0	0	ALARM output is inactive
	1	ALARM output is active
1	0	No function
	1	ALARM is set to active when driver detects a failure

Table 7.6: Alert adjustments

7.2.1.6 Output setting (O)

The bit settings are as follows:

Bit	Value	Description
0	0	0: GPO inactive (LED off)
	1	1: GPO active (LED on)
1	0	No function
	1	Output is changed at end of reference run

Table 7.7: Output adjustment

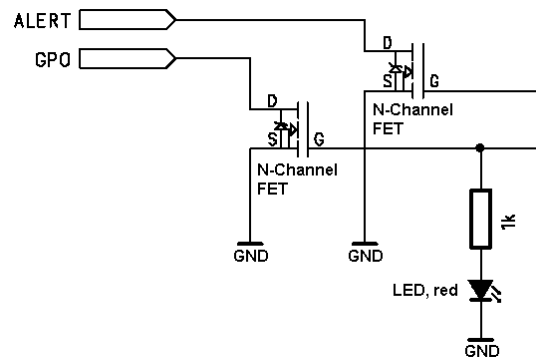


Figure 7.2: Alarm and GPO

7.2.1.7 Set position (P), read current position (R)

The position value of the motor can be changed by the command *P*. When changing this value just the motors positioning counter is changed. The motor does no according movement. The actual position can be read out by the command *R*.

7.2.1.8 I/Os readout (Q)

Command:

AQ ⇒ ENTER

Bit	7	6	5	4	3	2	1	0
Port	0	0	0	GPI	REF_A	REF_B	GPO	ALARM

Table 7.8: I/Os Readout

7.2.1.9 Baud rate (U)

The parameter *U* changes the baud rate of the module for RS485 communication.

Parameter U	Baud rate
0	9600 baud
1	14400 baud
2	19200 baud
3	28800 baud
4	38400 baud
5	57600 baud
6	76800 baud
7	115200 baud

Table 7.9: Baud rate

7.2.1.10 Velocity mode (V and A)

The velocity mode allows rotation of the motor without external signals. In order to rotate the motor, please set an acceleration value different from zero. The velocity is given by the following equation when parameter n is used.

The velocity mode allows the rotation of the motor without external step/direction signals. To make use of this, an acceleration different from zero has to be set first using the A (acceleration) command (setting the acceleration to zero will switch back to step/direction mode). The desired speed can then be set using the V command. The motor will accelerate adequate. The sign of the speed defines the direction of rotation. The speed parameter is calculated as follows:

$$v[\text{microsteps/s}] = n \cdot 0.149157 [\text{microsteps/s}]$$

$$v[\text{steps/s}] = \frac{n \cdot 0.149157}{\text{Microstep resolution}} [\text{steps/s}]$$

$$v[\text{rotations/s}] = \frac{n \cdot 0.149157}{\text{Microstep resolution} \cdot \text{Fullsteps of motor}} [\text{rotations/s}]$$

For a 200 step motor at 64 microsteps this results in:

$$v[\text{rotations/s}] = \frac{n}{85815} [\text{rotations/s}]$$

A practical limit for most stepper motor types is ca. 20 rotations/sec in chopper mode 0. In chopper mode 2 it is 5 rotations/sec.

As a second parameter value 0 or 1 is optional.

The V command also has a second parameter: leaving it out or setting it to 0 will send the carriage return character of the echo back at once. Setting the second parameter to 1 will delay the sending of the carriage return character until the desired speed has been reached.

Example:

AA 1000 ⇒ ENTER Set acceleration to 1000
 AV -50000 ⇒ ENTER Accelerate to speed -50000
 AV 0 1 ⇒ ENTER Decelerate to zero, delaying the CR until the motor is standing

7.2.1.11 Store parameters to EEPROM (W)

This command stores different parameters to the EEPROM to restart with the same settings after power down.

The stored parameters are:

- Current setting (set by command C)
- Selected Mode (set by command M)
- Alert adjustments (set by command N)
- Output adjustments (set by command O)
- RS485 parameters (set by command U)
- Microstep resolution (set by command Z)

Example:

AW ⇒ ENTER stores all parameters in the EEPROM

7.2.1.12 Microstep resolution (Z)

The microstep resolution can be set by the user. It depends on the maximum resolution which differs in the three chopper modes (see 7.3). The maximum resolution is divided by the parameter Z.

Parameter Z		Microstep resolution		
		SPI	PWM	Phase (default)
0	max resolution	64 *)	64	256
1	1/2 max	32 **)	32	128
2	1/4 max	16	16	64
3	1/8 max	8	8	32
4	1/16 max	4	4	16
5	1/32 max	2	2	8
6	1/64 max	1	1	4

Table 7.10: Adjustment of Microstep Resolution

*) Simulated microsteps, the actual microsteps of the motor are not improved.

***) Simulated microsteps, the actual microsteps are improves but do not reach 32 microsteps.

Example:

AZ 2 ⇒ ENTER sets the microstep resolution to a quarter of the maximum resolution.

7.3 Chopper modes

7.3.1 Chopper mode 0 (SPI) / default mode

In this mode, the motor coil current is regulated on a chopper-cycle-by chopper-cycle bias. This is the standard operation mode for most motor drivers. It brings a medium microstep resolution of 16 microsteps and typically works well with most motors and a high range of supply voltage and motor current settings. A resolution of up to 64 microsteps can be simulated but the motor precision is only slightly improved compared to 16 microsteps and the same as with 32 microsteps.

The maximum supply voltage (V_S) of the motor must not exceed 22-25 times the nominal motor voltage (V_N), regarding the multiplication of $I_{COIL, MAX}$ and R_{MOTOR} . A higher value would lead to an excess of motor rating. The minimum supply voltage has to be above two times the nominal motor voltage.

$$2 \cdot V_N \leq V_S \leq 22..25 \cdot V_N$$

$$V_N = I_{COIL, MAX} \cdot R_{MOTOR}$$

It uses a chopper frequency of about 36kHz.

7.3.2 Chopper mode 1 (PWM)

This mode is identical to the SPI mode, but it increases the microstep resolution at low velocities / stand still.

$$2 \cdot V_N \leq V_S \leq 22..25 \cdot V_N$$

$$V_N = I_{COIL, MAX} \cdot R_{MOTOR}$$

7.3.3 Chopper mode 2 (PHASE)

This mode uses a different chopper scheme, which provides a very high microstep resolution and smooth motor operation. Care has to be taken concerning the selection of motor and supply voltage:

The motor is chopped with 20kHz, and the coil sees a 50% duty cycle at full supply voltage when the coil current is meant to be zero. This is only true for the average, but the motor still sees an alternating current and thus an alternating magnetic field. Now, care has to be taken in order to keep this current to a value

which is significantly lower than the motor maximum coil current. If it is too high, the motor has significant magnetization losses and coil power dissipation, and would get much too hot, even with zero average current. The only possibility to limit this effect is to operate with a comparatively low supply voltage.

Check list:

Follow the motor inductivity L [mH] and motor rated full step coil current I_{COIL} [A] of the motor data sheet. Now, choose a supply voltage for the module to fulfill the following comparison:

$$\frac{V_S \cdot 25\mu s}{L} \leq I_{COIL} \cdot 0.5$$

$$\Leftrightarrow V_S \leq I_{COIL} \cdot 20k \cdot L$$

If your parameters do not fulfill the equation, i.e. you calculate a supply voltage which is below the modules' operation specs or which does not fit your system requirements, try the following.

Calculate x:

$$x = \frac{V_S}{I_{COIL}} \cdot \frac{0.025}{L[mH]}$$

- If x is below 0.5, everything is OK.
- If x is in the range 0.5 to 1.0 try operating your motor and check if motor or driver get too hot.
- If x is above 1.0 choose one of the other chopper modes.

See chapter 7.4 for graphical demonstration, also.

7.3.4 Chopper mode 3 (Phase and SPI)

This mode combines the modes 2 (Phase) and 0 (SPI) in order to provide highest accuracy at lower velocities and also the possibility for faster movements. Through the switching between modes some microsteps may be lost. Microstep resolution must not be higher than 64. It is set according to Phase mode, so possible values for Z (microstep resolution) are 2, 3 or 4.

μ steps	Phase to SPI		SPI to Phase	
	V-value	Rounds/s	V-value	Rounds/s
64	192000	2.24	25000	0.29
32	96000	2.24	12500	0.29
16	48000	2.24	6250	0.29

Table 7.11: Chopper mode 3 switching velocities

Conversion of values above to motors with different fullstep resolutions:

$$v_{motor}(rounds/s) = \frac{v_{table}(rounds/s)}{200} \cdot motors \text{ fullsteps per revolution}$$

7.3.5 Chopper mode 4 (PWM and SPI)

This mode combines the modes 1 (PWM) and 0 (SPI) in order to provide higher accuracy (up to 64 microsteps) at lower velocities and also the possibility for faster movements. For higher velocities in SPI mode the microstep resolution is always 16, but set resolution is simulated. Through the switching between modes some microsteps may be lost. Microstep resolution must not be higher than 64. It is set according to Phase mode, so possible values for Z (microstep resolution) are 2, 3 or 4. This mode should only be used in very special occasions and mode 3 should be preferred if a combination of high accuracy at slow movements and high speed is needed.

7.4 Step/direction

Additional Parameters can be set by RS485 i.e. to set a maximum velocity or microsteps per round. The high levels of the step / direction signals have to be as high as the voltage at V_{COM} . For 5V signals e.g. generated by the TCM-302 V_{COM} has to be 5V also. The step / direction high signal can be up to 24V with matched voltage at V_{COM} .

The Step/direction controls are as follows:

Motor	Velocity	Acceleration	Rotate right	Rotate left
Control	Step frequency	Increase or decrease of Step frequency	Direction open wired or connected to V_{COM}	Direction connected to Ground

Table 7.12: External signals and motor reactions

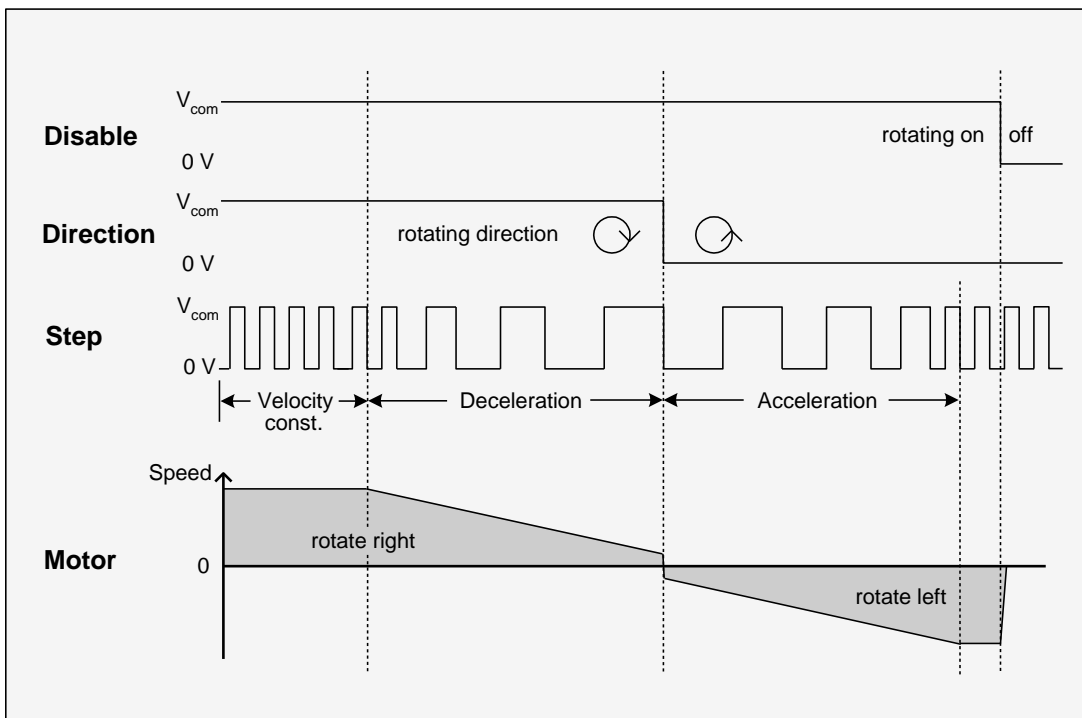


Figure 7.3: Step/direction signals and motor reactions

7.4.1 Direction

The Direction signal changes the motors rotation from clockwise (CW) to counterclockwise (CCW) and vice versa.

Function Table:

GND	open wire	$V_{COM} = 5... 24V$
motor CW	motor CCW turn	

7.4.2 Step

The Step signal controls the velocity and acceleration of the motor. The velocity depends on the frequency, the acceleration on the change of the frequency. One step impulse represents one microstep. Calculation of rotations per second (refer to 0):

$$v[\text{rotations/s}] = \frac{\text{Step input frequency}}{\text{Fullsteps} \cdot \text{Microstep resolution}} [\text{rotations/s}]$$

The maximum step input frequency is 350kHz, aligned to the Direction signal. The minimum logic 0 time is 0.7 μ s and the minimum logic 1 time is 2.0 μ s. A step is triggered by the positive going edge of the signal (switching off of optocoupler).

Function Table:

Extern	GND	open wire	$V_{COM} = 5... 24V$
Intern	HIGH	LOW	

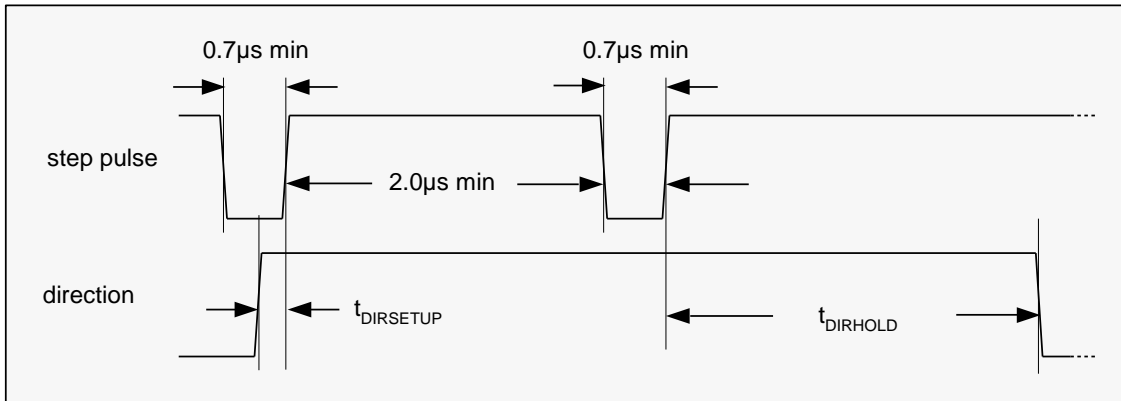


Figure 7.4: Step and Direction Signal

7.5 Firmware update

Start the program TCMC013boot.exe for the firmware update (available on www.trinamic.com):

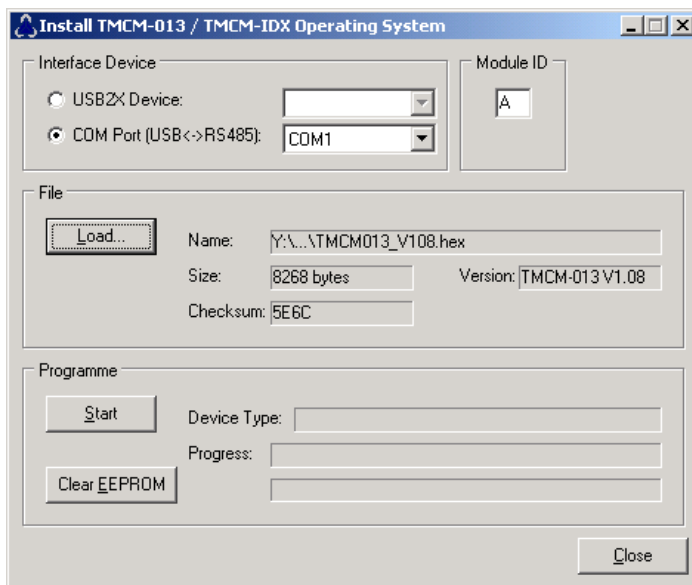


Figure 7.5: Firmware update tool

- Choose your RS485 connection.
- Select your Module ID (default is A).
- Load the new firmware file (e.g. TCMC013_V1.08.hex), to download from www.trinamic.com.
- Start the update process.

Check your firmware version at the end of the update process with command AX.

7.6 Reset to factory default

When the baud rate or the address of a module is not known, it makes sense to restore factory default settings: switch OFF the module and short circuit pin 1 and pin 3 of the free contacts for a 6-pin connector on the backside of the module. Turn on the module and switch it off again for removing the short circuit. All settings are now at factory default.

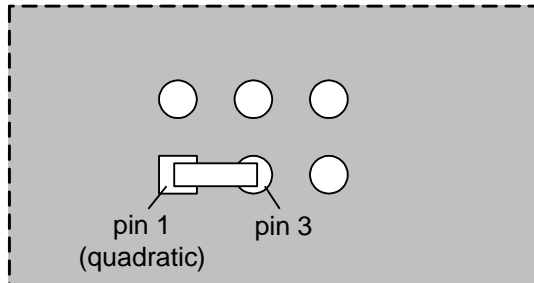


Figure 7.6: Reset to factory default

8 Getting started

8.1 Assembly of parts

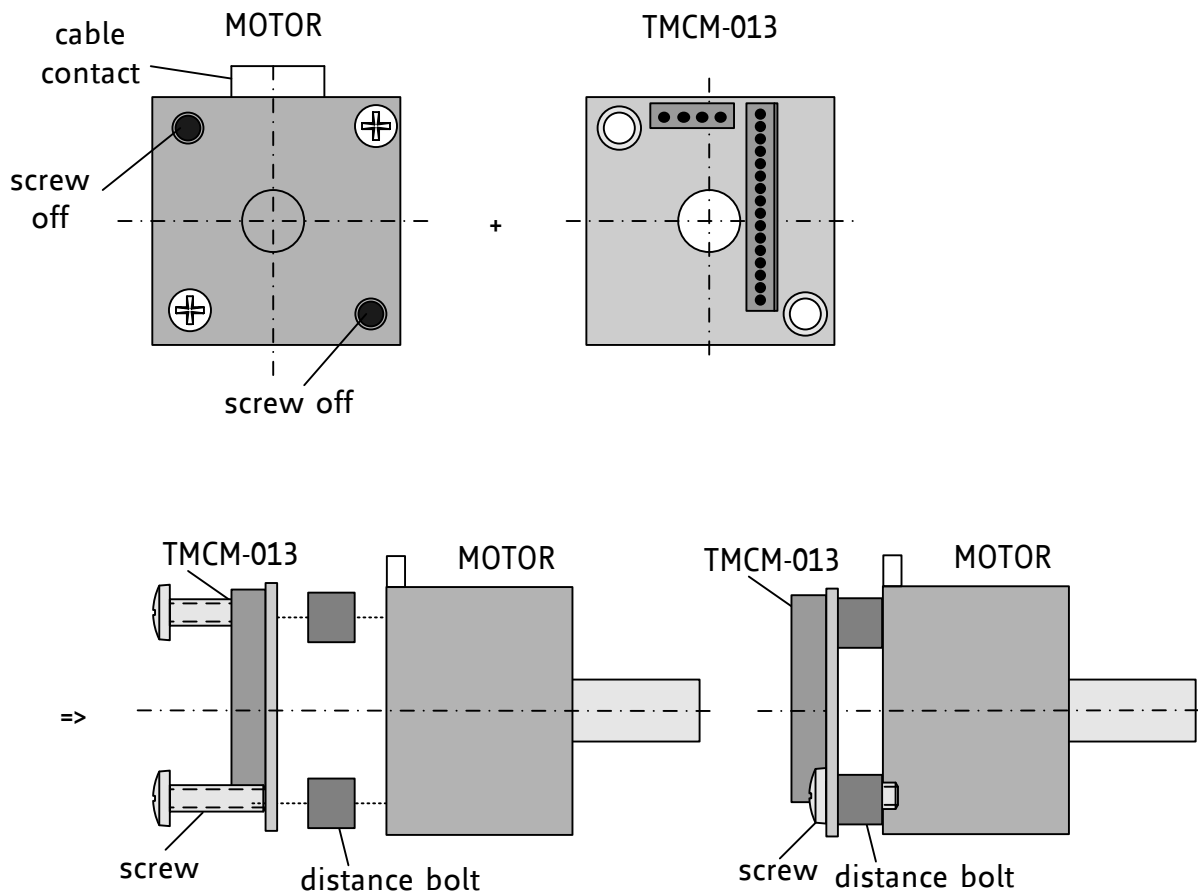


Figure 8.1: Assembly of parts

We recommend a minimum distance between the TCM-013 and motor of 5mm. The module can be directly attached to the motor back bell with an electrical insulation spacer. Appropriate cooling might be necessary if the motor itself gets very hot.

8.2 Motor

Attention:

- Do not connect or disconnect the motor while power on. Damage to the module may occur.
- Attention: A too high motor current setting can damage you motor! If in doubt, start with a low current setting and check motor temperature. If the motor heats up very quickly, check all settings. The motor shall never reach a temperature above 100°C under any circumstances. Some stepper motors need contact to metallic parts to allow continuous operation. Mind the default settings when you operate in step/dir mode the first time. You can store your own settings in the module permanently.

8.2.1 Motor choice

Care has to be taken concerning the selection of motor and supply voltage. In the different chopper modes different criteria apply. Modes 0 and 1 are quite insensitive to the motor choice, while Mode 2 is very sensitive, because it uses a different motor current regulation scheme. This chapter gives some mathematical information on the motor choice, but you can skip it if you want to experiment with a given motor. Normally, best results will be achieved when operating the given motor in a range of 50 to 100% of nominal motor current (see motor data sheet). Mode 2 and mode 1 are mainly intended for slow, smooth

and very exact movements, due to the high microstepping resolution. For most dynamic operation choose mode 0 or the combined modes 3 and 4 (which use mode 1 or 2 for slow movements and switch to mode 0 at a defined velocity).

8.2.2 Motor velocity

If you need a high velocity in a given application it is necessary to understand limitations due to supply voltage and motor inductivity. Please refer to your motor data sheet and choose the chopper mode adequate. Chopper mode 0 allows maximum motor velocity.

8.2.3 Chopper Modes 0 (SPI / Default Mode) and 1 (PWM)

In these two modes the maximum supply voltage (V_S) of the motor must not exceed 22-25 times the nominal motor voltage (V_N), regarding the multiplication of $I_{COIL, MAX}$ and R_{MOTOR} . A higher value would lead to an excess of motor rating.

The minimum supply voltage has to be above two times the nominal motor voltage.

$$2 \cdot V_N \leq V_S \leq 22 \dots 25 \cdot V_N$$

$$V_N = I_{COIL, MAX} \cdot R_{MOTOR}$$

8.2.4 Chopper Mode 2 (PHASE)

In Table 8.1 and Figure 8.2 examples of maximum supply voltages V_S regarding the current I_{COIL} and inductivity L of your motor are specified.

For further information, including a formula and description how to calculate the maximum voltage for your setup, refer to 7.3.3.

I_{COIL} (RMS)	L (min.)	V_S (max.)
1000 mA	1.2 mH	24 V
	0.9 mH	18 V
	0.6 mH	12 V
	0.35 mH	7 V
700 mA	1.7 mH	24 V
	1.3 mH	18 V
	0.9 mH	12 V
	0.5 mH	7 V
500 mA	2.4 mH	24 V
	1.8 mH	18 V
	1.2 mH	12 V
	0.7 mH	7 V
350 mA	3.4 mH	24 V
	2.6 mH	18 V
	1.7 mH	12 V
	1.0 mH	7 V

Table 8.1: Maximum supply voltage regarding motor current and inductivity

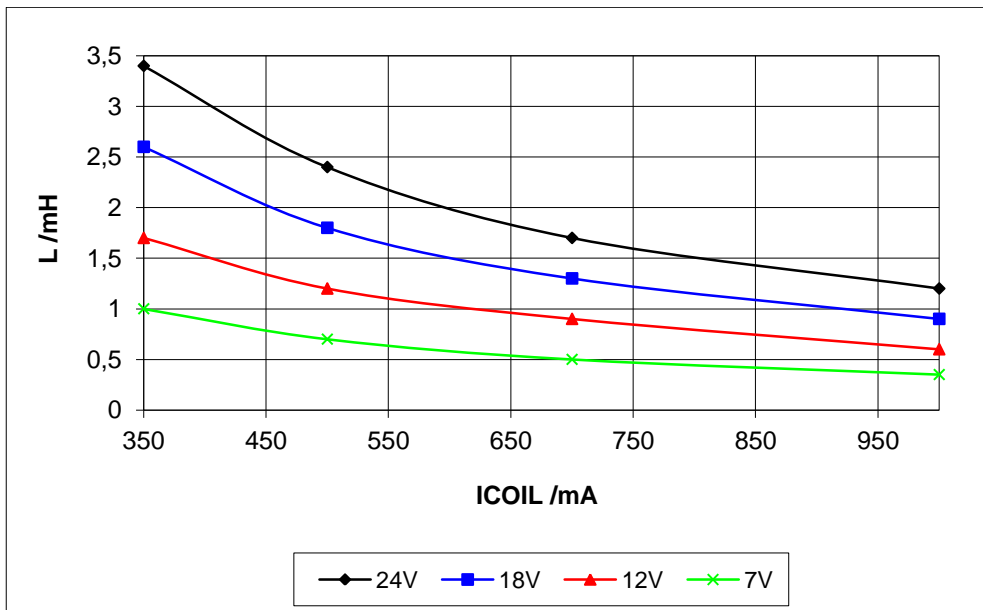


Figure 8.2: Maximum Supply Voltage regarding Motor Current and Inductivity

Any combination of motor coil current and inductivity witch is above the curve for maximum supply voltage (V_s) is possible to drive the motor in this mode. Check your motor datasheet please. If in doubt, please start with a lower supply voltage and check motor heating when raising the voltage.

8.2.5 Connecting motor and power supply

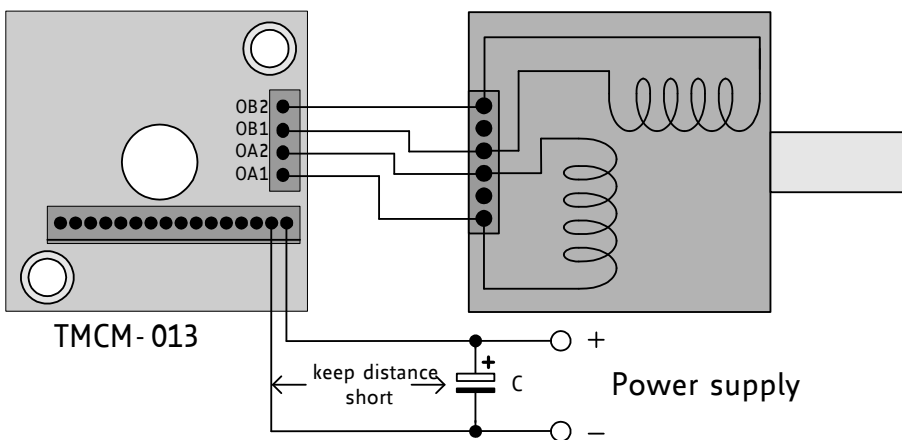


Figure 8.3: Connecting motor and power supply

8.3 Power supply requirements

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**

8.4 Connections for step/direction mode

The step-direction-mode is enabled if the acceleration is set to 0 (default) using the RS485. The example input signals of Figure 8.4 are schematically (see chapter 5.1 for more information):

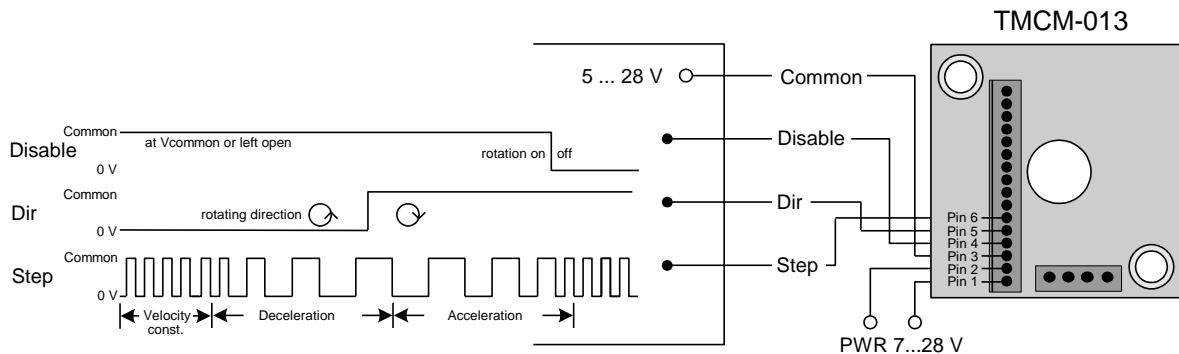


Figure 8.4: Contacts for step/direction

The maximum step frequency is 350 kHz (limited by the optocouplers).

8.5 Connections for RS485 interface

The RS485 mode allows for configuration of motor parameters as well as remote control of the motor.

8.5.1 Interface installation

To connect the module to a PC a RS485 interface is required, for example TRINAMICs USB-2-485 or any other RS485 adapter like standard RS232 to RS485 converters. Input A has to be connected to pin 15 of the TCMC-013 and Input B to pin 16.

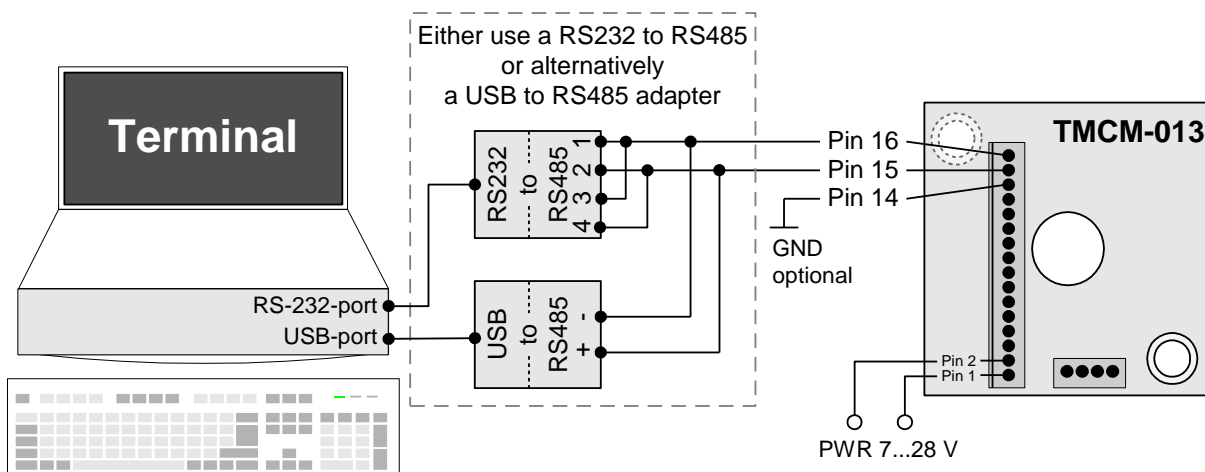
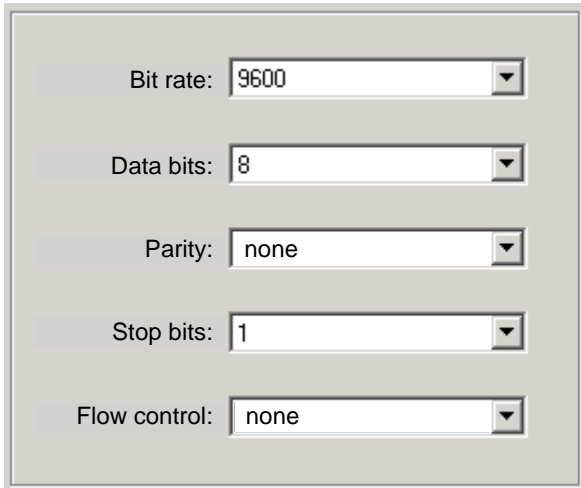


Figure 8.5: Contacts for RS485 with an adapter

8.5.2 Control with terminal program

Having installed the hardware, the TCM-013 can be controlled with any terminal program, like HyperTerminal that comes with MS-Windows. Following steps are described for HyperTerminal but are similar for the other terminal programs:

1. Start HyperTerminal
2. A window for a new connection opens. Fill in a name and select icon. Press OK.
3. Select the appropriate COM-port and press OK.
4. Fill in the values like in Figure 8.6 and confirm with OK.



The image shows a screenshot of the HyperTerminal 'New Connection Wizard' dialog box. It contains five settings, each with a dropdown menu:

- Bit rate: 9600
- Data bits: 8
- Parity: none
- Stop bits: 1
- Flow control: none

Figure 8.6: Connection settings for RS485

Type into the terminal window commands like `AV 50000`, `AA 300` or `Ac` and execute each with ENTER. With standard RS485 adapters the typed value may be echoed and lines like `AAVV 5500000000` for the typed `AV 50000` appear. The value sent to the module is the typed one and not the displayed. Try to change ASCII settings (concerning echo) in HyperTerminal.

An acceleration differing from zero is required to get velocities in RS485 mode. Setting or storing this value to the EEPROM disables step/direction control until acceleration is set to zero again (and eventually stored) or the board is reset to factory default.

9 Revision history

9.1 Document revision

Version	Comment	Author	Description
1.10	First Release	HC	Full functionality for firmware V1.05
1.11	PD-release	BD	Includes PANdrive order codes
1.12	Limit switch	HC	Added Limit switch documentation
1.13	Updates	HC	stallGuard™ added with RS485 command 'G', formerly used for output setting (LED) now command 'O'. Switched default mode to SPI.
1.15	Updates	HC	RS485 connection documentation revised
1.16	Updates	HC	Power supply requirements, velocity mode, modes 3 and 4, GPO, GPI wiring scheme included
1.17	Updates	HC	Firmware update included
1.18	Corrections	HC	Step / direction timing
1.19	Corrections	HC	Chopper mode 2 - inductivities, microstep resolution corrected
1.20	Addition	HC	Reversed connector numbering, step/dir high signal has to match V_{COM}
1.21	Update	HC	RS485 command 'W' clarified, Figure 8.4 corrected (disable)
1.22	Addition	OK	Additional feature of firmware V1.12 (stallGuard™ with step/direction) added.
1.23	Correction	OK	Address setting procedure corrected
1.24	Correction	SD	Order codes new, new design, minor changes

Table 9.1: Document revision

9.2 Firmware revision

Version	Comment	Description
1.05	Pls. update	
1.07	Bug fix	Full functionality with some possibilities to expand
1.08	Bug fix, new options	Added chopper modes 3 and 4, modified V command, corrected RS485 bug (always echoing of CR at earlier versions)
1.09	Bug fix	'E' command corrected (output was shifted by four bits)
1.10	New options	'X' command can also be given as lower case letter Option 2 for 'O' command added Mixed decay automatically disabled when StallGuard enabled Mixed decay can be disabled without turning on stallGuard™ using G8
1.11	Improvement	stallGuard™ improved by filtering
1.12	New option	stallGuard™ also usable in step/direction mode (controls GPO then)
1.13	Improvement	Motor powered (with stand by current) directly after enabling in all modes

Table 9.2: Firmware revision