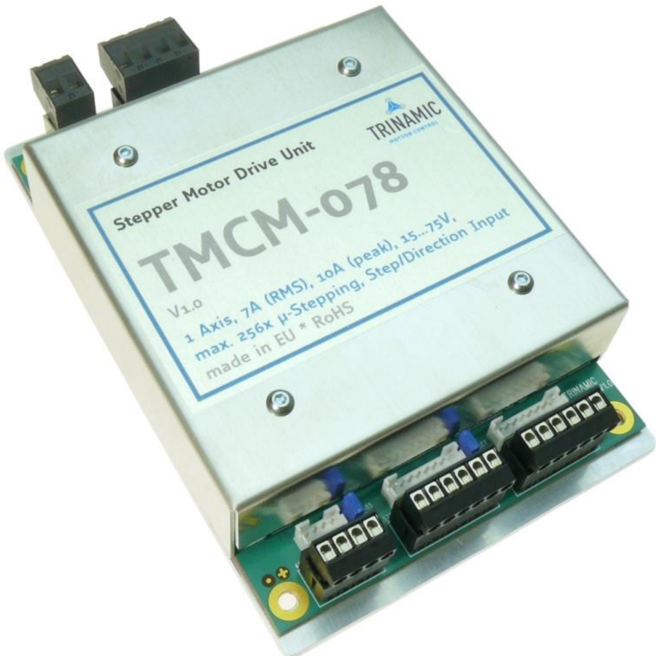
TMCM-078

Manual

1-axis stepper motor controller/driver module
7A RMS (9.8A peak) / 75V
with step-/ direction interface



TRINAMIC
MOTION CONTROL

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1 Features

The TMCM-078 is a single axis step / direction stepper motor driver unit. It is similar to the TMCM-IDX with higher power, more interface options and extended configuration possibilities. The TMCM-078 provides on-board DIP switches for easy configuration.
Operation via RS485 using simple ASCII format commands is also possible.
The TMCM-078 supports supply voltages of up to 75V and motor coil currents up to 7 A RMS (10A peak). Up to 256 micro steps are supported for either high accuracy or high speed.

All inputs and outputs are accessible either via pluggable screw connector or by high density (2mm) JST connectors.

Applications
- Step-/ Direction stepper driver for industrial applications
- Robotics
- Centralized motor driver mounted in switchboard
- Decentralized motor driver mounted near motor

Motor type
- Coil current from 0.7A to 7A RMS (10A peak)
- 15V to 75V nominal supply voltage (or any value in between)

Highlights
- Fully protected drive
- Digital selection of motor current and standby current
- Micro step resolution can be changed in order to get high accuracy or high speed
- Different chopper modes allow best adaptation to application / motor
- Many adjustment possibilities make this module the solution for many applications
- Size: 145 x 96 x 33 mm

Order code	Description
TMCM-078	75V, 7A TMCM-078 module

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.

3 Electrical and Mechanical Interfacing

3.1 Pinning

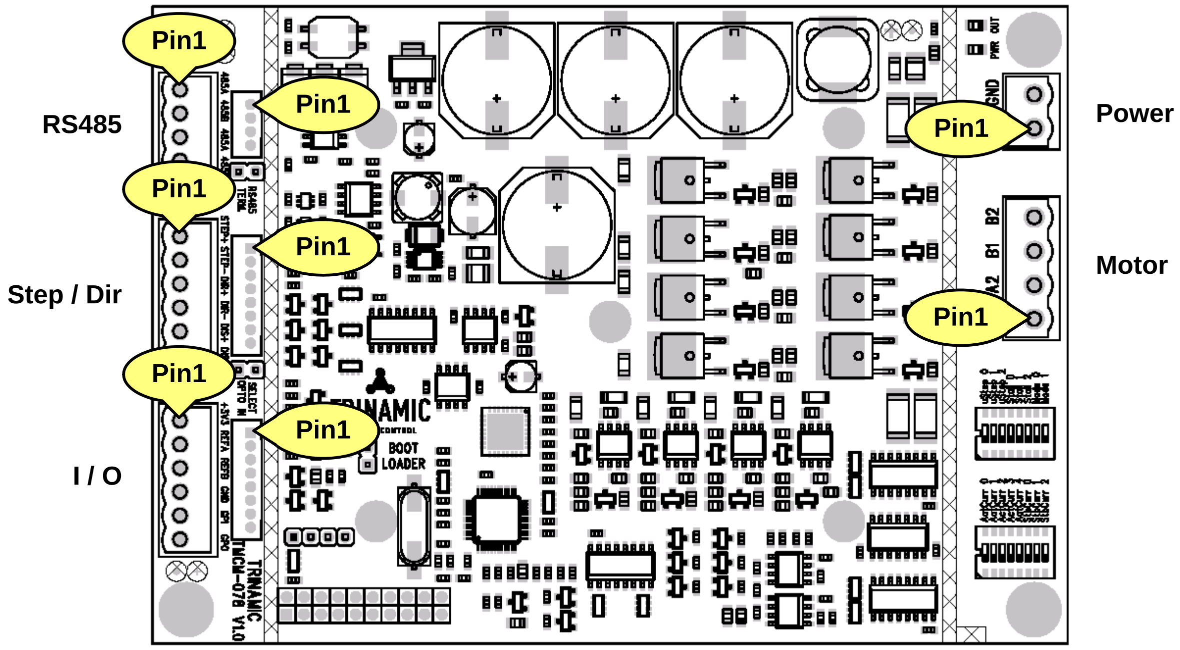


Figure 3.1: Pinning of TMCM-078

3.1.1 Power

Pin	Name	Function
1	+VS	Positive power supply voltage
2	GND	GND, power

Table 3.1: Power connector

3.1.2 Motor

Pin	Name	Function
1	OA1	Connections for motor coil A
2	OA2	
3	OB1	Connections for motor coil B
4	OB2	

Table 3.2: Motor connector

3.1.3 RS485

Pin	Name		Function
	Screw	JST	
1	RS485A	RS485A	RS485+ line
2	RS485B	RS485B	RS485- line
3	RS485A	RS485A	RS485+ line (same as pin 1)
4	RS485B	RS485B	RS485- line (same as pin 2)

Table 3.3: RS485 connector

3.1.4 Step / Dir

Screw connector			JST connector		
Pin	Name	Function	Pin	Name	Function
1	Step +	Optically isolated step input (positive)	1	+3.3V	Constant +3.3V output, reference
2	Step -	Optically isolated step input (negative)	2	S +	Differential step input (non inverted)
3	Dir +	Optically isolated direction input (positive)	3	S -	Differential step input (inverted)
4	Dir -	Optically isolated direction input (negative)	4	D +	Differential direction input (non inverted)
5	Disable +	Optically isolated disable input (positive)	5	D -	Differential direction input (inverted)
6	Disable -	Optically isolated disable input (negative)	6	Dis +	Differential disable input (non inverted)
--	--	--	7	Dis -	Differential disable input (inverted)
--	--	--	8	GND	GND

Table 3.4: Step-/Direction connector

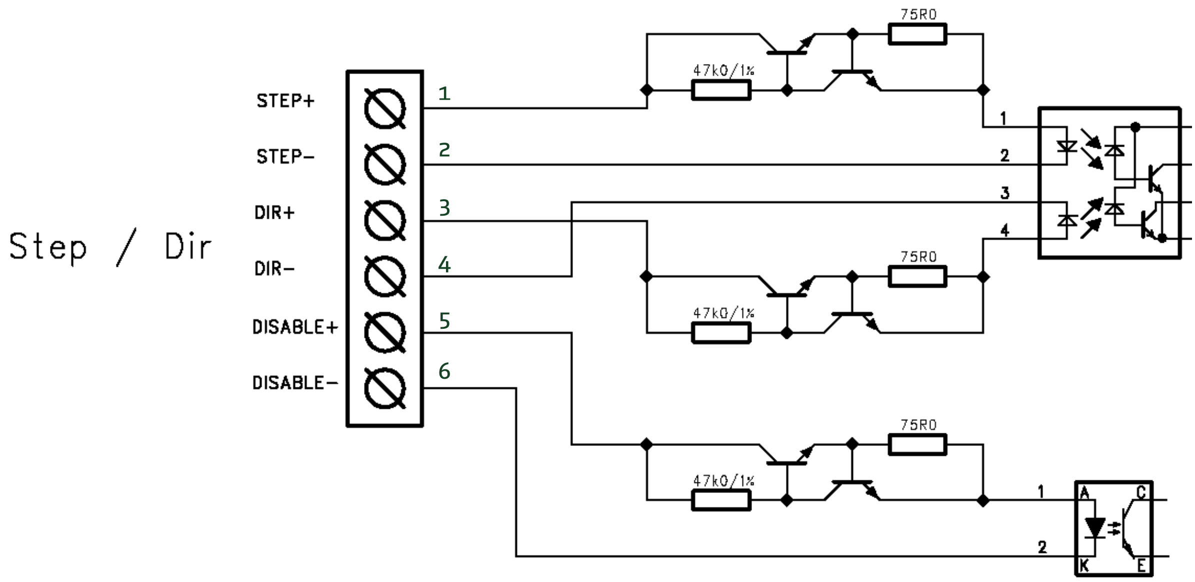


Figure 3.2: Opto isolated input circuit

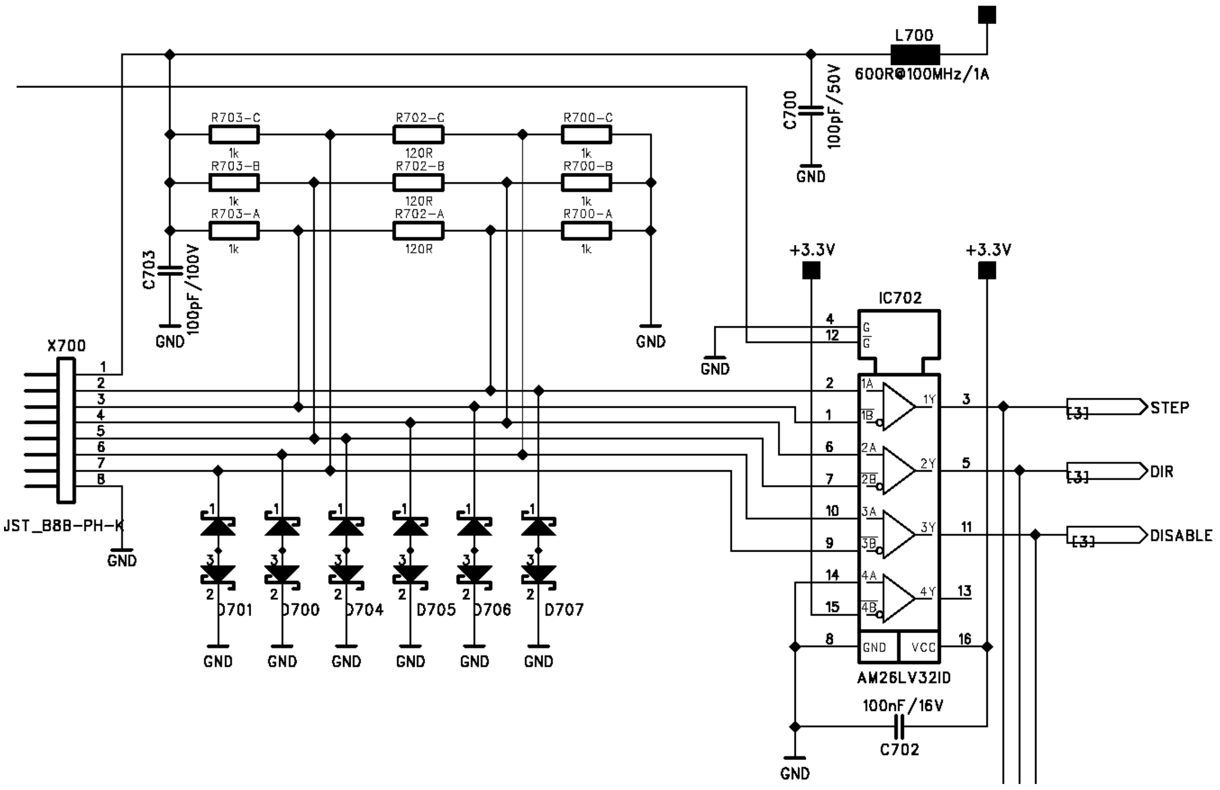


Figure 3.3: Differential input circuit

3.1.5 I / O

Pin	Name		Function
	Screw	JST	
1	+3.3V	+3.3V	Constant +3.3V output, reference
2	REFA	REFA	Reference signal A (integrated 3.9 K pull up resistor to +3.3V)
3	REFB	REFB	Reference signal B (integrated 3.9 K pull up resistor to +3.3V)
4	GND	GND	GND
5	GPI	GPI	General Purpose Input
6	GPO	GPO	General Purpose Output
7	--	RS485A	RS485 remote control access A, TTL input
8	--	RS485B	RS485 remote control access B, TTL input

Table 3.5: I/O connector

3.2 Jumper

3.2.1 Select Optically Isolation

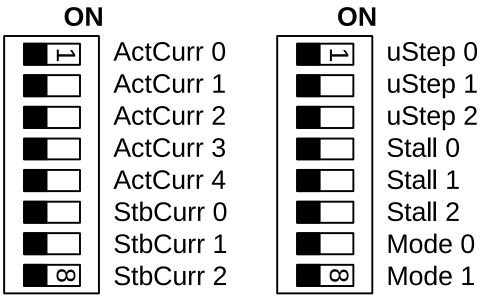
This jumper switches between two different kinds of step / direction interface circuits. If closed, the opto isolated interface circuit will be selected (pluggable screw connectors). If open, the differential input circuit can be used (JST connector). The opto isolated interface should be not used then.

3.2.2 RS485 Term

Close jumper in order to terminate the RS485 bus interface (120 Ohm resistor between RS485A and RS485B).

3.3 DIP switches

The most important settings (motor run current, motor standby current, microstep resolution, StallGuard functionality and operating mode) can be set by DIP switches. Please note that the settings of the DIP switches are only read right after the module has been powered on. So it is necessary to cycle power to make changes of the DIP switch settings take effect.
All parameters that can be set by the DIP switches can also be changed via RS485 commands (but the initial power-on settings are always taken from the DIP switches).



3.3.1 Motor current settings

The motor run current can be set independently from the motor standby current. There are five DIP switches altogether for setting the run current and three DIP switches for specifying the current reduction during motor stops / standby. Please note that the possible current settings in mode 1 are different from those in mode 0 and 2.

ActCurr switches					Motor run current (RMS)	
4	3	2	1	0	in mode 0 and 2	in mode 1
OFF	OFF	OFF	OFF	OFF	0.2A	0.65A
OFF	OFF	OFF	OFF	ON	0.4A	0.75A
OFF	OFF	OFF	ON	OFF	0.6A	0.85A
OFF	OFF	OFF	ON	ON	0.8A	1.0A
OFF	OFF	ON	OFF	OFF	1.0A	1.075A
OFF	OFF	ON	OFF	ON	1.2A	1.3A
OFF	OFF	ON	ON	OFF	1.4A	1.5A
OFF	OFF	ON	ON	ON	1.6A	1.7A
OFF	ON	OFF	OFF	OFF	1.8A	1.75A
OFF	ON	OFF	OFF	ON	2.0A	2.0A
OFF	ON	OFF	ON	OFF	2.2A	2.15A
OFF	ON	OFF	ON	ON	2.4A	2.15A
OFF	ON	ON	OFF	OFF	2.6A	2.6A
OFF	ON	ON	OFF	ON	2.8A	2.6A
OFF	ON	ON	ON	OFF	3.0A	3.0A
OFF	ON	ON	ON	ON	3.2A	3.4A
ON	OFF	OFF	OFF	OFF	3.4A	3.4A
ON	OFF	OFF	OFF	ON	3.6A	3.5A
ON	OFF	OFF	ON	OFF	3.8A	3.5A
ON	OFF	OFF	ON	ON	4.0A	4.0A

ActCurr switches					Motor run current (RMS)	
4	3	2	1	0	in mode 0 and 2	in mode 1
ON	OFF	ON	OFF	OFF	4.25A	4.0A
ON	OFF	ON	OFF	ON	4.5A	4.3A
ON	OFF	ON	ON	OFF	4.75A	4.3A
ON	OFF	ON	ON	ON	5A	5.2A
ON	ON	OFF	OFF	OFF	5.25A	5.2A
ON	ON	OFF	OFF	ON	5.5A	5.2A
ON	ON	OFF	ON	OFF	5.75A	5.2A
ON	ON	OFF	ON	ON	6A	5.2A
ON	ON	ON	OFF	OFF	6.25A	7A
ON	ON	ON	OFF	ON	6.5A	7A
ON	ON	ON	ON	OFF	6.75A	7A
ON	ON	ON	ON	ON	7A	7A

Table 3.6: Motor run current

The standby current can be set as a fraction of the motor run current using the DIP switches marked "StdCurr". The module will switch to standby current when there has been no step pulse for at least two seconds.

StbCurr switches			Standby current
2	1	0	
OFF	OFF	OFF	12.5% of motor run current
OFF	OFF	ON	25%
OFF	ON	OFF	37.5%
OFF	ON	ON	50%
ON	OFF	OFF	62.5%
ON	OFF	ON	75%
ON	ON	OFF	87.5%
ON	ON	ON	100%

Table 3.7: Motor stand-by current

3.3.2 Microstep resolution

The microstep resolution can be set using the DIP switches marked "uStep". The microstep resolutions that can be set depend on the selected operating mode.

uStep switches			Microstep resolution	
2	1	0	in mode 0 and 1	in mode 2
OFF	OFF	OFF	64	256
OFF	OFF	ON	32	128
OFF	ON	OFF	16	64
OFF	ON	ON	8	32
ON	OFF	OFF	4	16
ON	OFF	ON	2	8
ON	ON	OFF	1	4
ON	ON	ON	not used	2

Table 3.7: Microstep resolution

3.3.3 Stall detection

In operating mode 0, the general purpose output can be set or cleared automatically depending on the current stall level. This function can be controlled by the DIP switches marked "Stall". It can be useful to report a stall back to a step/direction controller.

Stall switches			Function (in mode 0 only)
2	1	0	
OFF	OFF	OFF	StallGuard switched off (GPO not controlled by StallGuard)
OFF	OFF	ON	GPO set when StallGuard level greater than 0, else cleared
OFF	ON	OFF	GPO set when StallGuard level greater than 1, else cleared
OFF	ON	ON	GPO set when StallGuard level greater than 2, else cleared
ON	OFF	OFF	GPO set when StallGuard level greater than 3, else cleared
ON	OFF	ON	GPO set when StallGuard level greater than 4, else cleared
ON	ON	OFF	GPO set when StallGuard level greater than 5, else cleared
ON	ON	ON	GPO set when StallGuard level greater than 6, else cleared

Table 3.7: Stall level settings

3.3.4 Mode setting

The operating mode can be chosen using the DIP switches marked "Mode". Please see chapter 5 for more explanation on the operating modes and how to choose the operating mode that suits best.

Mode switches		Function
1	0	
OFF	OFF	Mode 0 (SPI mode, best for high speed and mandatory for StallGuard)
OFF	ON	Mode 1 (PWM mode)
ON	OFF	Mode 2 (Phase mode; high resolution of up to 256 microsteps)
ON	ON	reserved

Table 3.7: Selection of operation mode

3.4 Dimensions

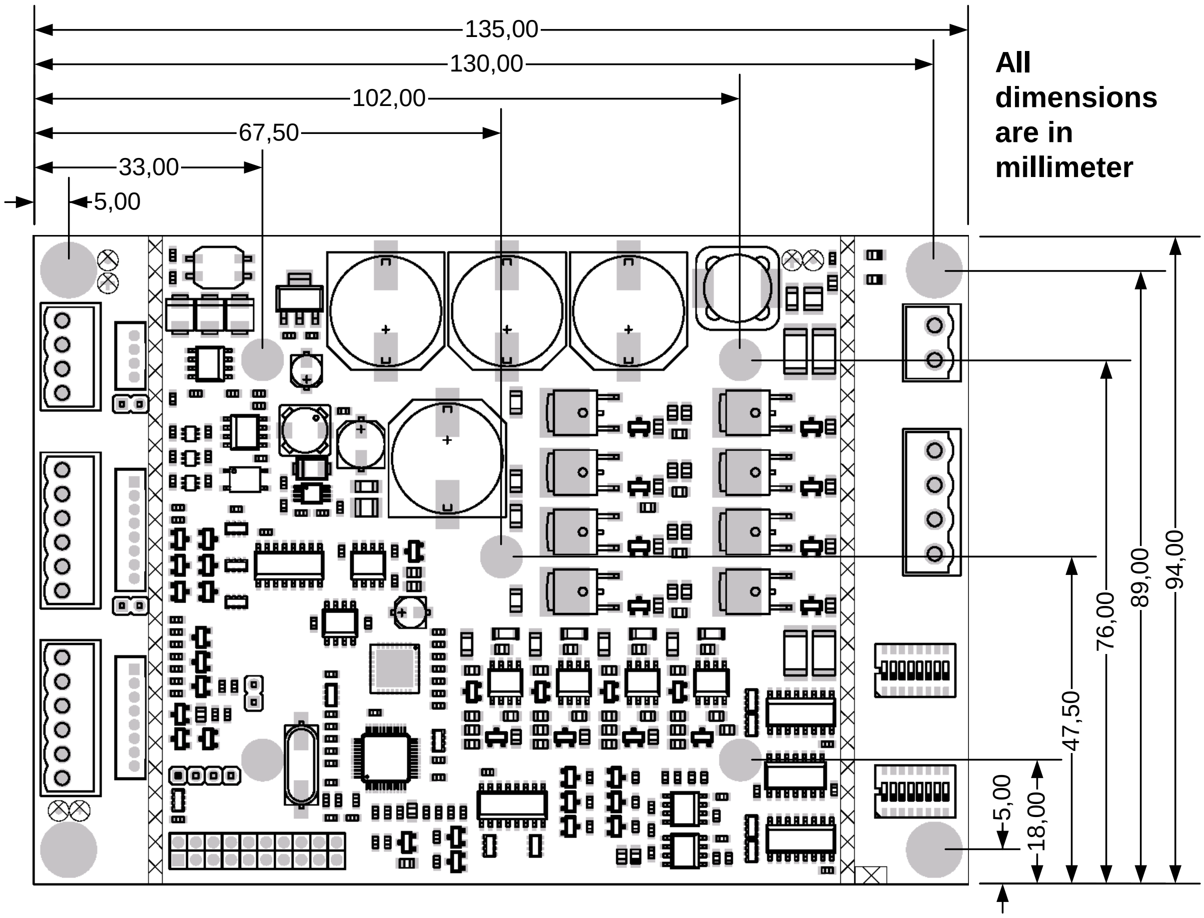


Figure 3.4: Circuit board dimensions

Height: 31mm

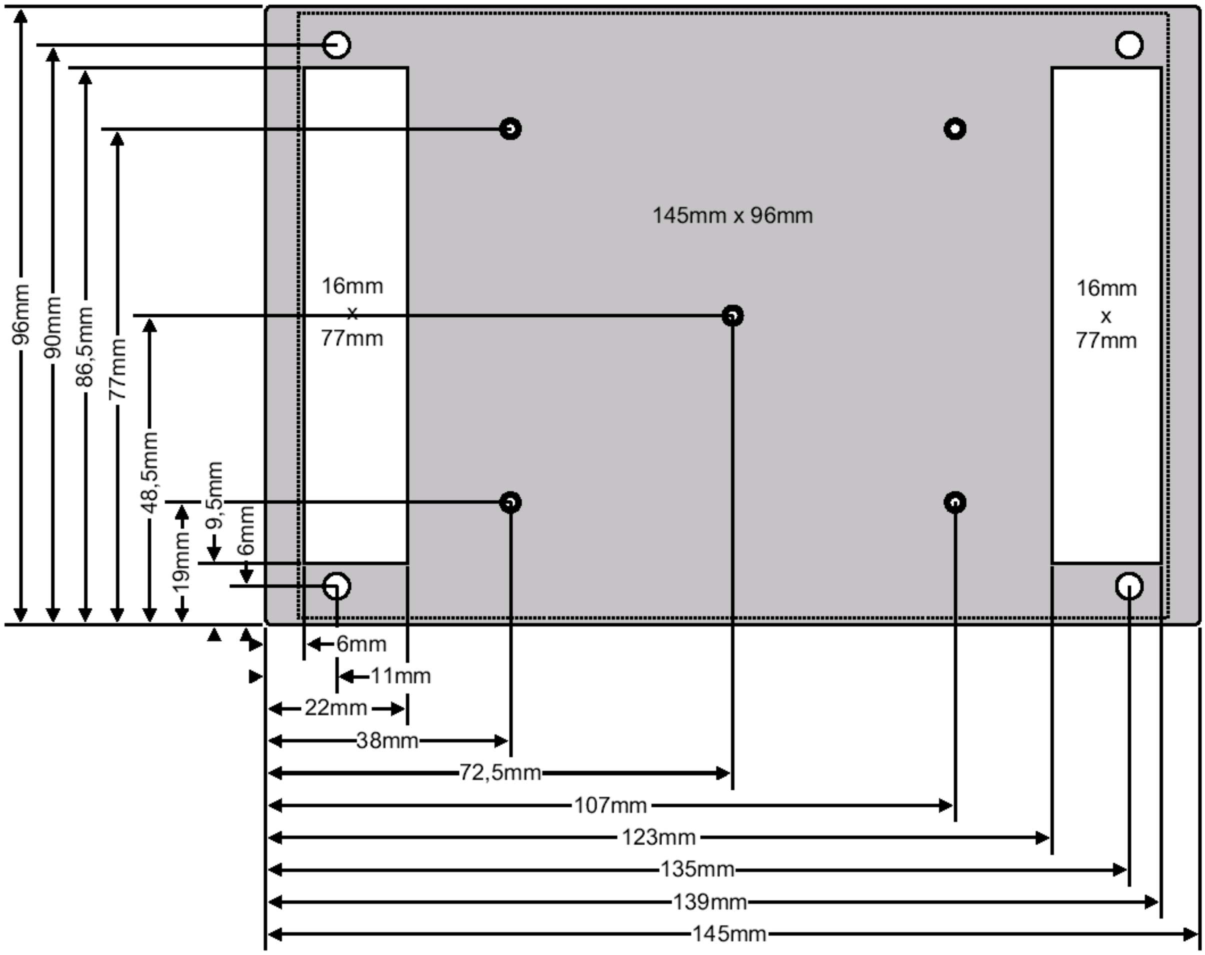


Figure 3.5: Base plate dimensions

3.5 Connectors

Name	Type	On TMCM-078	Mate	Site
Power supply	Screw	RIA type 320, RM5, 2 pin	RIA type 349, RM5, 2 pin	www.riaconnect.com
Motor	Screw	RIA type 320, RM5, 4 pin	RIA type 349, RM5, 4 pin	www.riaconnect.com
RS485	Screw	RIA type 183, RM3.5, 4 pin	RIA type 169,RM3.5, 4 pin	www.riaconnect.com
	JST	JST B4B-PH-K, RM2		www.farnell.com
Step / Dir	Screw	RIA type 183, RM3.5, 6 pin	RIA type 169,RM3.5, 6 pin	www.riaconnect.com
	JST	JST B8B-PH-K, RM2		www.farnell.com
I / O	Screw	RIA type 183, RM3.5, 6 pin	RIA type 169,RM3.5, 6 pin	www.riaconnect.com
	JST	JST B8B-PH-K, RM2		www.farnell.com

Table 3.6: Connectors

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		12 … 75		V
I_{COIL}	Motor coil current for sine wave peak (chopper reg., software adjustable)		0.7 … 9.8		A
I_{MC}	Nominal RMS motor current		0.5 … 7		A
f_{CHOP}	Motor chopper frequency (actual frequency depends on operation mode)		20 or 36		kHz
t_{SLP}	Coil output slope		300		ns
I_S	Power supply current		<< I_{COIL}	1.4 * I_{COIL}	A
V_{OPTON}	Signal active voltage at disable, step and direction input (optocoupler on), screw connector	3.5		24	V
V_{OPTOFF}	Signal inactive voltage at disable, step and direction input (optocoupler off), screw connector	0		2	V
I_{OPT}	Optocoupler current (internally regulated)		4	8	mA
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
T_{ENV}	Environment temperature	-25		70	°C
T_C	Temperature of case back (cooling plate)	-25		85	°C

Table 4.1: Operational Ratings

5 Getting Started

5.1 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 / direction mode the first time! You can store your own settings in the module permanently.

5.1.1 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.

5.1.1.1 Motor velocity

Whenever it is desired to maximize the motor velocity in a given application, it is important to understand limitations due to supply voltage and motor inductivity. Please consult your motor data sheet for this, as well as the choice of the chopper mode. Chopper mode 0 allows maximum motor velocity.

5.1.1.2 Operating 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.

$$2 \cdot V_N \le V_S \le 22 \ldots 25 \cdot V_N$$

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

5.1.1.3 Operating Mode 2 (PHASE)

In Table 5.1 and Figure 5.1 examples of maximum power supply voltages regarding current I_{COIL} and inductivity of your motor are specified.
For further information, including a formula and description how to calculate the maximum voltage for your setup, refer to 5.2.1.3

I_{COIL} (RMS)	L (min.)	V_S (max.)
7	0.536 mH	75 V
	0.343 mH	48 V
	0.171 mH	24 V
5.0	0,75 mH	75 V
	0,48 mH	48 V
	0,24 mH	24 V
4.0	0,94 mH	75 V
	0,6 mH	48 V
	0,3 mH	24 V
3.0 A	1,25 mH	75 V
	0.8 mH	48 V
	0.4 mH	24 V
2.0 A	1,875 mH	75 V
	1.2 mH	48 V
	0.6 mH	24 V
1.0 A	3,75 mH	75 V
	2.4 mH	48 V
	1.2 mH	24 V
0.5 A	7,5 mH	75 V
	4.8 mH	48 V
	2.4 mH	24 V

Table 5.1: Maximum voltage regarding motor current and inductivity

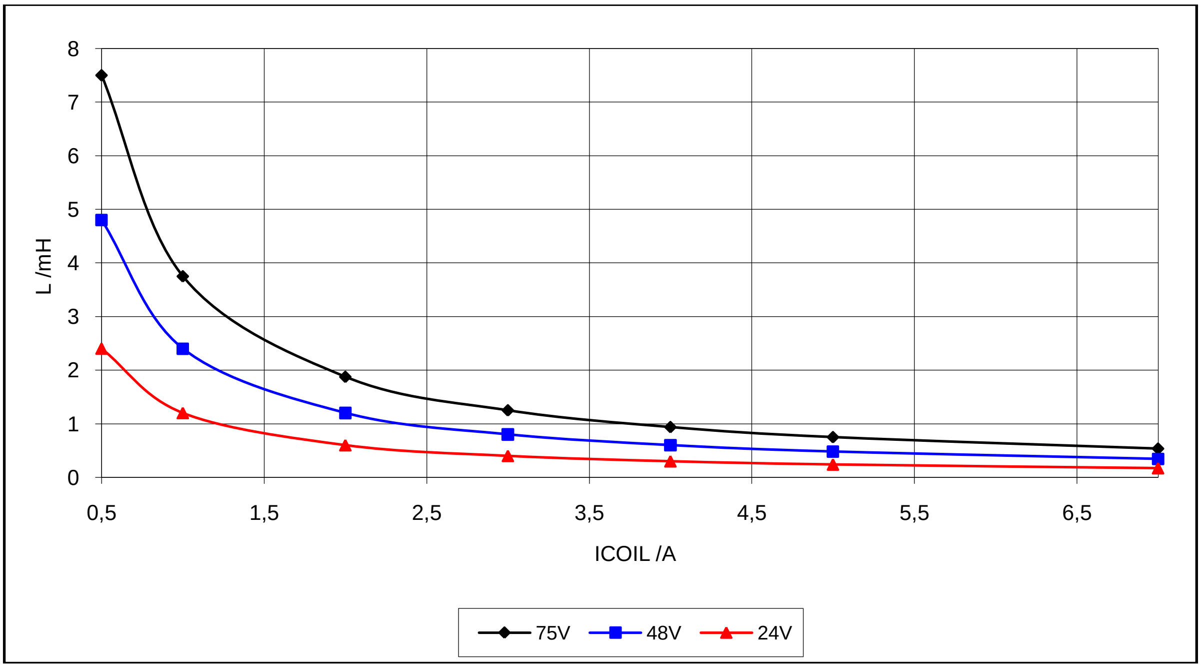


Figure 5.1: Maximum voltage regarding motor current and inductivity

Any combination of motor coil current and inductivity which is above the curve for maximum supply voltage (V_S) is possible to drive the motor in this mode. Check your motor data sheet, please.

If in doubt, please start with a lower supply voltage and check motor heating when raising the voltage.

5.2 Power Supply Requirements

The power supply voltage shall be in the limits as given in the chapter 4 under operational ratings. Please note that there is no protection against reverse polarity or too high voltage. The power supply typically should be within a range which fits the motor requirements, as described in chapter 5.1.1. 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 (1000µF for each ampere of RMS motor current 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

a) keep power supply cables as short as possible
b) use large diameter for power supply cables
c) if the distance to the power supply is large (i.e. more than 2-3m), use a robust 4700µF or similar additional filtering capacitor located near to the motor driver unit. Choose the capacitor voltage rating fitting to the maximum operating voltage.

The overall power rating mainly depends on the motor used and on the mechanical output power, i.e. the motor velocity and desired torque. As a thumb rule, a 42mm class motor will require a 10W (short motor) to 20W (long motor) power supply, while a 57mm motor will require 15W to 30W, when operated at maximum rated current and low velocities. Operation at very high velocities will increase the power demand up to the double value.

5.2.1 Operating Modes

5.2.1.1 Operating 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 operating mode for most motor drivers. It brings a medium microstep resolution of 16 microsteps and typically works good 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.

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

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

It uses a chopper frequency of about 36kHz.

5.2.1.2 Operating Mode 1 (PWM)

This mode is identical to the chopper mode 0 (SPI) mode, but it increases the microstep resolution at low velocities / stand still (up to 64 microsteps are possible).

$$2 \cdot V_N \leq V_S \leq 22...25 \cdot V_N$$
$$V_N = I_{COIL,MAX} \cdot R_{MOTOR}$$

5.2.1.3 Operating Mode 2 (PHASE)

This mode uses a different chopper scheme, which provides a very high microstep resolution and smooth motor operation. However motor dynamics and maximum velocity are quite limited. 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. The following calculation is based on the assumption that full motor current is set.

Check list:

Please take the motor inductivity L [mH] and motor rated full step coil current I_{COIL} [A] from the motor's data sheet:
Now choose a supply voltage for the module to fulfil the following comparison:

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

$$\Leftrightarrow \quad V_S \leq I_{COIL} \cdot 20 \cdot L[mH]$$

If your parameters do not fulfil 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 gets too hot.
If x is above 1.0, choose one of the other chopper modes.

See also 5.1.1.3 for graphical demonstration.

5.3 Step / Direction

The Step-Direction controls are as follows:

Motor	Velocity	Acceleration	Rotate right	Rotate left
Control	Step frequency	Increase of Step frequency	Differential voltage ≥ 3.5 V for screw and ≥ 0.4 V for JST connector	Differential voltage ≤ 2.0 V for screw and ≤ -0.4 V for JST connector

Table 5.2: External signals and motor reactions

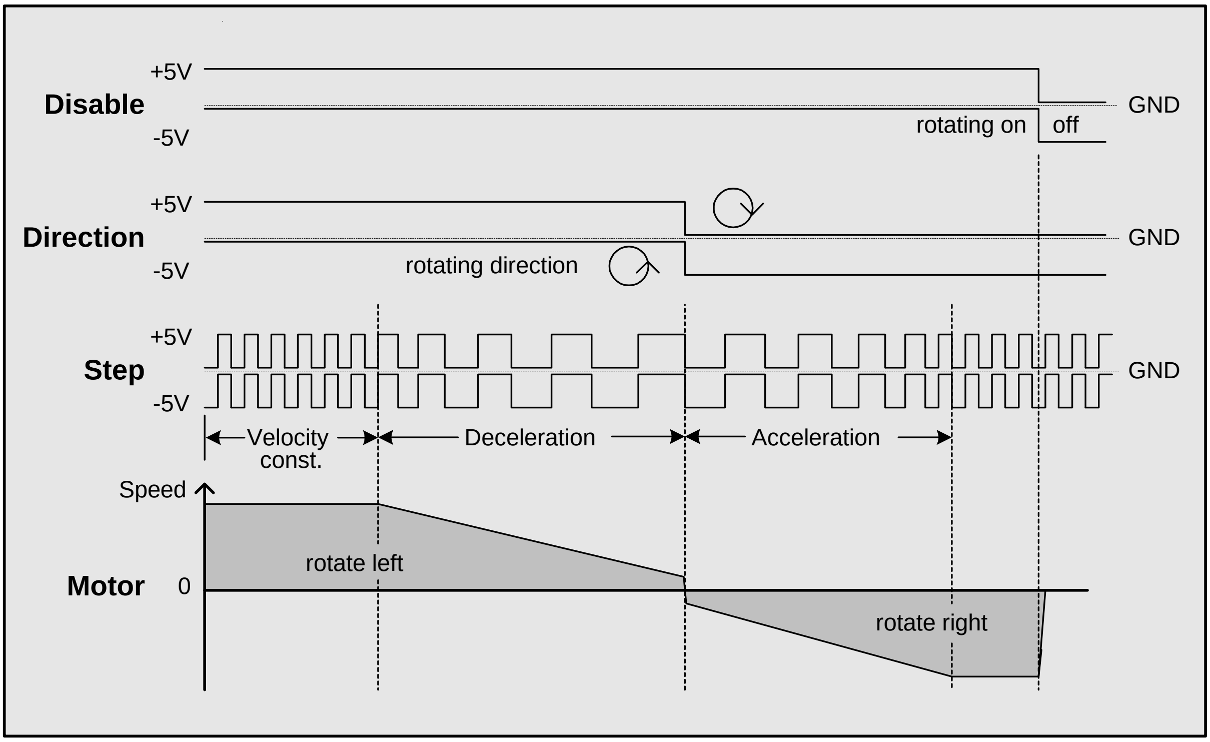


Figure 5.2: Differential Step-Direction signals and motor reactions (schematically)

For input circuit information please refer to Figure 3.2 and Figure 3.3.

5.3.1 Direction

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

Function Table:

Direction	Differential signal	
	Screw connector	JST connector
CW	≥ 3.5 V	≥ 0.4 V
CCW	≤ 2.0 V	≤ -0.4 V

5.3.2 Step

Description: 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:

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

Maximum frequency at screw connector (decoupled by opto couplers): The maximum Step input frequency is 350 kHz, aligned to the Direction signal. It is limited by the switching capabilities of the optocouplers. The minimum logic "0" time is 0.7 µs and the minimum logic "1" time is 2.0 µs. A step is triggered by the positive going edge of the signal (switching off of opto coupler).
Maximum frequency at a duty cycle of 1 ("0" time is 2.0 µs and "1" time is 2.0 µs) is 250 kHz.

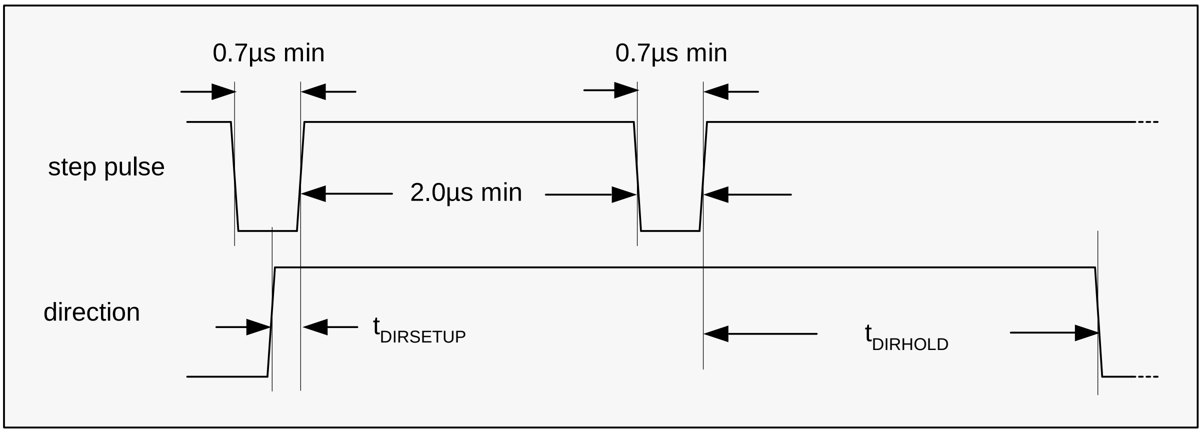


Figure 5.3: Step and Direction Signal (schematically, optocoupler input at screw connector)

Maximum frequency at JST connector: Even higher than at screw connector. Limited by microcontroller but not yet evaluated (approximately 300 kHz without microstep loss).

Function Table:

Step signal	Differential signal	
	Screw connector	JST connector
high	≥ 3.5 V	≥ 0.4 V
low	≤ 2.0 V	≤ -0.4 V

5.4 RS485 interface

The RS485 interface can control all functions of the TMCM-078. It is possible to change parameters, with this interface which are also valid in the other modes like max. velocity or acceleration. Most of the parameters that can be change by the RS485 commands (except those that are set by the DIP switches) can also be stored in the FlashROM of the module.
The factory default address setting is "A" and the default baud rate is 9600 baud. Use an appropriate RS485 interface (like Trinamic USB-2-485) to enter RS485 commands using a terminal program (e.g. Hyperterminal that is shipped with Windows).
Many commands are the same as those used on the TMCM-013 and IDX modules, but some commands are different. Also the parameter ranges of many commands are different from those on the TMCM-013 and IDX modules.

5.4.1 RS485 command overview

For RS485 commands type the address character (default is A) first, followed by a command from the following list and the parameters that the command needs. Then press the return key. A small command letter is in most cases used to read back the actual setting. All values are ASCII.

Command	Function	Description	Chapter
A, a	Acceleration	A: set Acceleration (µsteps/s²), 0 (default) selects step/direction mode) a: read back acceleration	5.4.2
C, c	Current	C: set motor current (0..31) c: read back motor current	5.4.3
D, d	Mixed decay	D: set mixed decay mode (0/1) d: read back mixed decay mode	5.4.4
E or e	Error readout	E or e: read driver error flags	5.4.5
G, g	StallGuard	G: set StallGuard threshold value (0..7) g: read out actual load value	5.4.6
H, h	Home	H: Start reference search h: Check if reference search still in progress	5.4.7
L, l	Limit switch	L: configure limit switches l: read back limit switch settings	5.4.8
M, m	Mode	M: select chopper mode (0..2) m: read back actual chopper mode	5.4.9
O	Output	O: set output state	5.4.10
P	Position	P: change position counter p: read back position counter	5.4.11
Q, q	Read I/Os	Q or q: read state of I/O lines	5.4.12
R, r	Reference search config.	R: configure reference search r: read back reference search parameters	5.4.13
T, t	RS485-Timeout	T: set RS485 delay t: read back RS485 delay	5.4.14
U, u	RS485 baud rate	U: set RS485 baud rate u: read back Rs485 baud rate	5.4.15
V, v	Velocity	V: accelerate to given velocity (µsteps/s) v: read out actual velocity	5.4.16
W	Write	Store parameters to FlashROM	5.4.17
X or x	Check version	X or x: output firmware revision number	5.4.18
Y, y	Standby current	Y: set standby current (1..8) y: read back standby current setting	5.4.19
Z, z	Microstep Resolution	Z: set microstep resolution (0..6) z: read back microstep resolution	5.4.20
@	Address	Change RS485 address character	5.4.21

Table 5.3: 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

5.4.2 Commands 'A' and 'a': Set or read back acceleration

The 'A' command sets the acceleration that is used in conjunction with the 'V' command. Setting the acceleration parameter to 0 enables the step/direction interface (this is also the factory default setting). Setting the accelerations parameter to any value greater than zero disables the step/direction interface and allows moving the motor via the RS485 interface using the 'V' command. The acceleration parameter is given in microsteps/s². This setting can also be stored permanently using the 'W' command.
The 'a' command outputs the actual acceleration setting.

5.4.3 Commands 'C' and 'c': Set or read back motor current

The 'C' command sets the maximum motor current. The parameter range is 0..31, according to table 3.6. This setting should not be changed while the motor is moving. The power-on setting for this command is set by the DIP switches.
The 'c' command outputs the actual motor current setting.

5.4.4 Commands 'D' and 'd': Set or read back mixed decay setting

The 'D' command sets the mixed decay behavior. The parameter can be 0, 1 or 2. Setting the parameter to 0 disables mixed decay. Setting it to 1 enables mixed decay. Setting the mixed decay parameter to 2 enables mixed decay, but mixed decay will automatically be disabled whenever a StallGuard reference search is started. This setting can also be stored permanently using the 'W' command.
The 'd' command outputs the actual mixed decay setting.

5.4.5 Commands 'E' and 'e': Read motor driver error status

In chopper mode 0, eight error flags are provided by the motor driver. The E or e command provides a value that has to be interpreted 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 5.4: Failure readout in SPI mode

In the other two modes there is only one error flag and thus the command only outputs '0' or '1':
1: short circuit or overtemperature
0: no failure

5.4.6 Commands 'G' and 'g': StallGuard

The StallGuard feature is available in mode 0 (SPI) only. It is a sensorless load measurement and stall-detection. Overload can be indicated before steps are lost. The G command does the same as the SallGuard DIP switches: it sets the StallGuard level at which the general purpose output will be set. The range of the parameter of this command is 0..7.

The command letter 'g' outputs the actual load 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.

Value	Description
0	StallGuard function is deactivated (default)
1..7	GPO is set when StallGuard value is equal to or greater than the given value.

Table 5.5: StallGuard

5.4.7 Command 'H' and 'h': start or check reference search

The 'H' command starts a reference search that must have been previously configured by an 'R' command. Its main use is to test the reference search configuration.
The 'h' command checks if a reference search is in progress. It outputs a '1' if this is the case or '0' if not.

5.4.8 Command 'L': limit switch configuration

The parameter 'L' defines at which state of the limit switch inputs the motor is to be stopped. The motor stops when the defined position is reached. The 'l' command outputs the actual limit switch configuration.

Bit	Motor stops when...
0	REF_B = 0 and direction positive
1	REF_A = 0 and direction negative
2	GPI = 0 (at any direction)
3	REF_B = 1 and direction positive
4	REF_A = 1 and direction negative
5	GPI = 1 (at any direction)
6	0: soft stop, 1: hard stop (no function in step/direction mode)

Table 5.6: Limit switch configuration

5.4.9 Command 'M' and 'm': Chopper mode

The 'M' command sets the chopper mode (0, 1 or 2). The 'm' command reads back the actual setting. The power-on setting can be selected using the DIP switches. The mode must not be changed while the motor is running as this can lead to step loss.

5.4.10 Command 'O': set the general purpose output

The 'O' command sets the state of the general purpose output.

Value	Description
0	0: GPO inactive (LED off)
1	1: GPO active (LED on)

Table 5.7: Output adjustment

5.4.11 Command 'P' and 'p': set and read position counter

The position value of the motor can be changed without actually moving the motor by the command "P".
The position counter can be read out by the command 'p'. Depending on the direction signal (or the actual velocity when using velocity mode) the position counter will be incremented or decremented with every microstep.

5.4.12 Command 'Q' or 'q': read the state of the I/O lines

The 'Q' command and also the 'q' command output the state of the I/O lines of the module. The number output by these commands has to be interpreted as follows:

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

Table 5.8: I/Os Readout

5.4.13 Command 'R' and 'r': configure automatic reference search

The 'R' command is used to configure the automatic power-on reference search feature. The command takes four parameters: the reference search mode, the reference search velocity, the reference search acceleration and (optional) the reference search StallGuard value.
The first parameter may have one of the following values:

Ref. Search Mode	Function
0	No reference search (default)
1	Reference search ends when REF_A input becomes high
2	Reference search ends when REF_A input becomes low
3	Reference search ends when REF_B input becomes high
4	Reference search ends when REF_B input becomes low
5	Reference search ends when GP input becomes high
6	Reference search ends when GP input becomes low
7	Reference search ends when StallGuard value reaches the level set by the DIP switches
8	Reference search ends when StallGuard value reaches the level given by the optional parameter

To make the GPO turn low at the end of the reference search add 32 to this value. To make the GPO turn high at the end of the reference search add 64 to this value.
To make the reference search start automatically at power-on, add 128 to this value (and do not forget to store the values using the W command then!).

The second parameter is the velocizy (given in microsteps/s) to be used during reference search. The third parameter is the acceleration (given in microsteps/s²) to be used to accelerate the motor to the reference search velocity (the A command is not used for this purpose – it can be set to zero in order to make the TMCM-078 switch back to step/direction mode after the reference search has finished).
The fourth parameter is only needed with reference search mode 8. This makes it possible to use different StallGuard threshold values for reference search and for normal operation.
The 'r' command output all four reference search parameters.

5.4.14 Command 'T' and 't': set RS485 delay

The 'T' command sets the time before characters received by the RS485 interface are echoed back. The delay time value is given in units of 0.1ms. The default value is 250 (25.0ms). The 't' command outputs the actual setting.

5.4.15 Command 'U' and 'u': set RS485 bit rate

The parameter 'U' changes the baud rate of the module for RS485 communication according to the following table:

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 5.9: Baud rate

The 'u' command outputs the actual baud rate setting.

5.4.16 Command 'V' and 'v': velocity mode

The velocity mode allows rotation of the motor without external signals. In order to use this feature an acceleration value different from zero has to be set first (using the A command). The velocity used with the 'V' command is given in microsteps/s.

A practical limit with most stepper motor types is about 20 rotations / second in chopper mode 0 and 5 rotations / second in chopper mode 2.

The 'v' commands outputs the actual velocity.

Example:
AV –50000 ⇒ ENTER: Accelerates motor to given velocity

5.4.17 Command 'W': store parameters to FlashROM

The W command stores the following settings to FlashROM so that they will become the power-on settings:

- Acceleration (set by command A)
- Limit switch functionality (set by command L)
- Reference search parameters (set by command R)
- RS845 delay (set by command T)
- RS485 baud raze (set by command U)
- RS485 address (set by command @)

Example:
AW ⇒ ENTER: All actual parameters from list above are stored to FLashROM.

Other settings are not stored as they have to be set using the DIP switches.

5.4.18 Command 'X' and 'x': firmware revision number

The 'X' command and the 'x' command print out the firmware revision number and also the actual temperature and the actual supply voltage of the device.

5.4.19 Command 'Y' and 'y': standby current setting

The 'Y' command sets the standby current. The parameter range is 1..8, where 1 means 1/8 and 8 means 8/8 (100%) of the run current (set by the 'C' command or the DIP switches). The power-on setting can be set using the DIP switches.
The 'y' command prints out the actual standby current setting.

5.4.20 Command 'Z' and 'z': change microstep resolution

The 'Z' command changes the microstep resolution. The 'z' command outputs the actual microstep resolution. The power-on setting can be set using the DIP switches.

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 5.10: 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.

5.4.21 Command '@': change RS485 address

This command changes the RS485 address letter. The new address letter must follow this command immediately (without any spaces in between).
To change the address letter of a TMCM-078 module from 'A' to 'X' type A@X then press ENTER.

6 Revision History

6.1 Documentation Revision

Version	Date	Author	Description
0.90	13-Nov-07	HC	Initial version
0.91	17-Jan-08	OK	DIP switch settings corrected
1.00		OK	RS485 commands added
1.01	28-May-08	OK	Error corrections, 'D' command added
1.02	10-Sep-08	OK	Figure 3.2 corrected

Table 6.1: Document Revision

6.2 Firmware Revision

Version	Comment	Description
1.00	3-Apr-08	First release
1.01	16-Apr-08	'D' command added
1.02	26-Jun-08	Motor current values corrected
1.03	8-Aug-08	ChopSync function added, acceleration and velocity fine-tuned

Table 6.2: Firmware Revision