TMCM-102
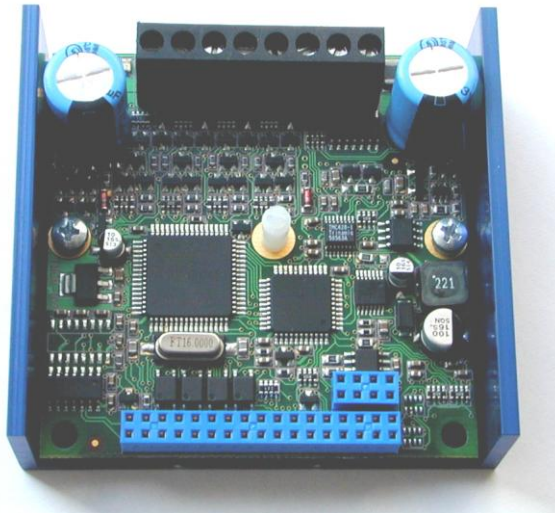
High Performance Stepper Motor Module with Encoder Interface

Version: 1.02
June 24th, 2009

TRINAMIC
MOTION CONTROL

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Order code	Description
TMCM-102-IF	1-axis controller/driver 3.5A / 48V with interface add-on board (standard)
TMCM-102	1-axis contr./driver 3.5A / 48V (on request)

Table 1.1: Order codes

1 Features

The **TMCM-102** is a single axis 2-phase stepper motor controller and driver module with an aluminium pro. le for quick and robust mounting. The built in encoder feedback makes it an optimum solution for high-reliability drives. This drive is optimally suited for industrial high-reliability applications. The power stage has very low dissipation when compared to competitors' products. Its interface add-on board concept allows for customer specific interface / connector selection. The TMCM-102 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" 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 on board. The TMCL program can be stored in the on-board EEPROM for stand-alone operation. The firmware of the module can be updated via the serial interface. With the StallGuard feature it is possible to detect motor overload or motor stall.

Applications
- driver with integrated intelligence
- high-precision drives with high dynamics and torque

Electrical data
- 18V to 55V motor supply voltage
- up to 3.5A RMS coil current RMS (5A peak)

Supported motors
- two-phase bipolar motors with 1A to 3.5A coil current
- incremental encoder (2 or 3 channel, single ended)

Interface
- RS422 or RS232 and CAN without add on-board)
- Additional interfaces with standard add on-board: RS485 and USB
- optically isolated inputs for reference and stop switches
- General purpose analog and digital I/Os

Features
- 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)
- closed loop for highly dependable drives
- StallGuard™ for sensorless motor stall detection

Software
- stand-alone operation using TMCL or remote controlled operation
- PC-based application development software TMCL-IDE included
- Optional simple to use ASCII protocol
- Optional command set similar to IMS483IE

Other
- connectors for all external signals
- RoHS compliant
- The standard adapter provides RS422 /RS232, CAN, RS485 and USB interfaces. Customized solutions are possible also. Please refer to adapter board information.

2 Life support policy

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Specifications are subject to change without notice.

3 Electrical and Mechanical Interfacing

3.1   Dimensions

In combination with an adapter board the overall height is increased to at least 33mm. Be aware that some connectors of the adapter may be upright.

To screw the module onto your application use M4 screws with a head diameter of maximum 7mm.

Figure 3.1: Dimensions

3.2   Connectors

The connectors onboard the module are
Base:
Connector 1: 2x17 pin, 2.54mm pitch socket board connector
Connector 2: 2x4 pin, 2.54mm pitch socket board connector
Connector 3: 1x8 pin screw connector
Adapter:
Please check special adapter board documentation because of varying customized adapters.

3.3   Connecting the Module

The TMCM-102 module consists of two PCBs: the base board and an adapter board. There are different adapter boards available or can be customized for your demands. Never connect or disconnect the modules from each other while they are powered.
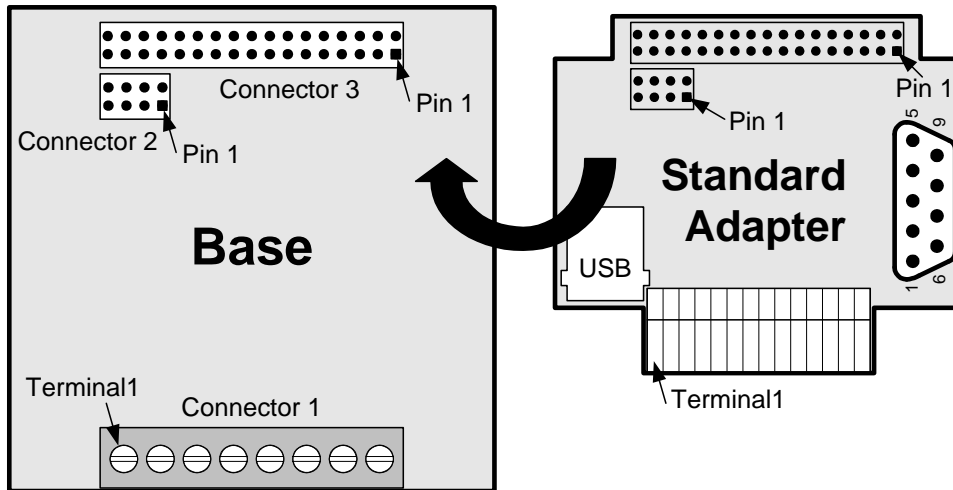
Figure 3.2: The TMCM-102 module and its connectors

3.3.1 Base Connector 1: Power supply and motor connection

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

Terminal	Name	Function
1	NC	Not connected
2	NC	Not connected
3	GND	Supply ground
4	VDD	Supply Voltage
5	OB 2	Motor connection, Coil B
6	OB 1	Motor connection, Coil B
7	OA 2	Motor connection, Coil A
8	OA 1	Motor connection, Coil A

Table 3.1: Base Connector 1 – Power supply and motor connection

3.3.2 Base Connector 2: CAN and SPI

Pin	Name	Function	PIN	Name	Function
1	CANH	CAN input High	2	MISO	SPI serial input (master in slave out)
3	CANL	CAN input Low	4	MOSI	SPI serial output (master out slave in)
5	GND	Ground	6	SPI_CLK	SPI serial clock
7	+5V	+5V supply	8	CS_EXT	SPI low active device select

Table 3.2: Base Connector 2 – CAN and SPI

3.3.3 Base Connector 3: I/Os to adapter

Pin	Name	Function	PIN	Name	Function
1	TX-	RS422 Transmit – (data out from indexer)	2	TX+	RS422 Transmit + (data out from indexer)
3	RX-	RS422 Receive – (data into indexer)	4	RX+	RS422 Receive + (data out from indexer)
5		Internally pulled down via 2k7 resistor. Not supported by TMCL.	6	IN1_A/D	Analog user controlled input #1. No internal resistors.
7	REF R	Optically isolated, active low limit switch input "Right"	8	STEP_OUT/RXD	Step clock output from indexer RS232 option: RS232 receive
9	OUT_2	User controlled output #2. No internal resistors.	10	DIR_OUT/TXD	Direction output from indexer. RS232 option: RS232 transmit
11	IN8	Digital user controlled input #8. Optically isolated, active low (needs power supply on pin 15)	12	ENC_A-	Differential encoder: Channel A-input
13	IN3_A/D	Analog user controlled input #3. No internal resistors.	14	ENC_B-	Differential encoder: Channel B-input
15	+5V	DC bias for input opto couplers	16	+5VDC	Logic supply out for encoder
17	OUT_1	User controlled output #1. No internal resistors.	18	ENC_N-	Differential encoder: Channel N-input
19	REF L	Optically isolated, active low limit switch input "Left"	20	GND	Logic supply ground connection
21	IN4	Digital user controlled input #4. No internal resistors. (TTL)	22	OUT_3	User controlled output #3. No internal resistors.
23	IN9	Digital user controlled input #9. Optically isolated, active low (needs power supply on pin 15)	24		Not supported by TMCL.
25	IN6	Digital user controlled input #6. No internal resistors. (TTL)	26	IN2_A/D	Analog user controlled input #2. No internal resistors.
27	ALARM	High voltage open collector output indicating driver fault condition.	28		Not supported by TMCL.
29	ENC_N+	Encoder option: Single ended: Channel N input Differential: Channel N+ input	30	IN7	Digital user controlled input #7. No internal resistors. (TTL)
31	FS	Active for one clock pulse at each on-pole fullstep position.	32	IN5	Digital user controlled input #5. No internal resistors. (TTL)
33	ENC_B+	Encoder option: Single ended: Channel B input Differential: Channel B+ input	34	ENC_A+	Encoder option: Single ended: Channel A input Differential: Channel A+ input

Table 3.3: Base Connector 3: I/Os to adapter

The in- and outputs can be used for special functions with IMS clone software. The functions are pin 11 (PARTY), pin 23 (HOME), pins 21, 25, 32 (JOG), pin 24 (MOVING), pin 28 (SOFTSTOP) and pin 30 (GO). Please refer to IMS clone documentation.

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_{DD}	Power supply voltage for operation	18	24 … 48	55	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}	Motor coil current for sine wave **RMS**	0	1.5 … 3.5	3.5	A
f_{CHOP}	Motor chopper frequency		36.8		kHz
I_S	Power supply current		$<< I_{COIL}$	$1.4 * I_{COIL}$	A
U_{+5V}	+5V output (max. 150mA load)	4.8	5.0	5.2	V
V_{ISO}	Isolation voltage of optocoupler		± 42	±100	V
I_{OPTON}	Signal current for optocoupler (internal 220Ohm resistor provided)	2.5	15	30	mA
V_{ANA}	INx_A/D analog measurement range		0 … 5		V
V_{INLO}	Input low level		0	0.9	V
V_{INHI}	Input high level (integrated pullup to +5V)	2.0	5		V
T_{ENV}	Environment temperature at rated current (no cooling)	-40		+60	°C
	Environment temperature at 80 % of rated current or 50% duty cycle (no cooling)	-40		+80	°C

Table 4.1: Operational Ratings

5 Functional Description

In Figure 5.1 the main parts oft the TMCM-102 module are shown. The module mainly consists of the µC, a TMC428 motion controller, a TMC249 stepper motor driver, the TMCL program memory (EEPROM) and the host interface (RS422 or RS232).
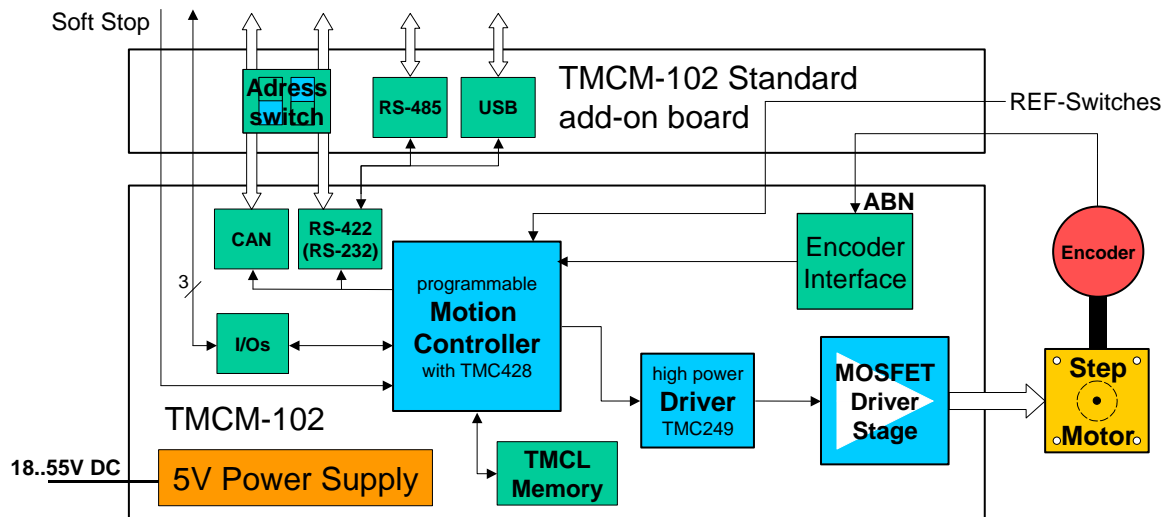

Figure 5.1: Main parts of the TMCM-102

5.1   Adapter Board

With the adapter board the large amount of possibilities provided by the base board can be customized and easily accessed.

The standard adapter board provides four interface variants: RS422 (or RS232), CAN, RS485 and USB interfaces, witch can be adjusted via onboard dip switches. Also it has 14 easily accessible I/Os such as limit switches, encoder interface, etc. Please check for standard adapter board documentation.

5.2   System Architecture (Base)

The TMCM-102 integrates a microcontroller with the TMCL (Trinamic Motion Control Language) operating system. The motion control real-time tasks are realized by the TMC428.

5.2.1 Microcontroller (µC)

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.

5.2.2 TMCL EEPROM

To store TMCL programs for stand alone operation the TMCM-102 module is equipped with a 16kByte EEPROM attached to the microcontroller. The EEPROM can store TMCL programs consisting of up to 2047 TMCL commands.

5.2.3 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.

5.2.4 TMC249 Motor Driver

The stepper motor driver used on the TMCM-102 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.

5.3 Power Supply Requirements

The TMCM-102 is equipped with a switching voltage regulator that generates the 5V supply voltage for the digital components of the module from the motor power supply. So only one supply voltage is needed for the module. The power supply voltage can be 18..55V DC. Please note that there is no protection against reverse polarity or too high voltage. The power supply typically should be within a range of **24 to 48V** to achieve highest motor performance. When using supply voltages near the upper limit, a regulated power supply becomes a must. Please ensure, that enough power filtering capacitors are provided in the system (2200µF or more recommended), in order to absorb mechanical energy fed back by the motor in stalling conditions. In larger systems a zener diode circuitry might be required, when motors are operated at high velocities.

The power supply should be designed in a way, that it supplies the nominal motor voltage at the desired maximum motor power. In no case shall the supply value exceed the upper / lower voltage limit. To ensure reliable operation of the unit, the power supply has to have a sufficient output capacitor and the supply cables should have a low resistance, so that the chopper operation does not lead to an increased power supply ripple directly at the unit. Power supply ripple due to the chopper operation should be kept at a maximum of a few 100mV.

Therefore we recommend to
   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 2200µF or larger additional filtering capacitor located near to the motor driver unit.

5.4 Communication Interface

The TMCM-102 has a CAN and either RS422 or RS232 interface. RS422 and RS232 are ordering options. 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. With an add on board the provided interfaces are easier to access and additional serial interfaces like RS485 and USB are provided. Please check [Standard add-on] manual for more information.

5.5   Encoder interface

The TMCM-102 provides an interface for single ended incremental encoders with TTL (5V) outputs. Use the encoder entrances A+ for A, B+ for B and (optional) N+ for N. Leave the others unconnected. The encoder counter can be read by software and can be used to control the exact positioning of the motor. This also makes closed loop operation possible. The +5V DC supply voltage can be used for the encoder. For greater orders differential encoders are supported on request, also.

The Encoder channel N is for nulling of the encoder counter. It can be selected as high or as low active, and it is automatically checked in parallel to the Encoder channel A and B inputs, to give an exact reference. It has to be determined by the user, which potential of the encoder A and B inputs correspond to the zero position. This depends on the actual encoder type used.

To read out or to change the position value of the encoder, axis parameter #209 is used. So, to read out the position of encoder 0 (the only one) use GAP 209, 0. The position values can also be changed using command SAP 209, 0, <n> , with n = ± **0**,1,2,…

To change the encoder settings of an encoder, axis parameter #210 is used:

Please note that the pre-scaler values can only be set and not read back or stored to EEPROM (it has to be initialized after every power down). To change the pre-scaler of encoder 0 use SAP 210, 0, <p>.

To select a pre-scaler, the following values can be used for <p>:

Value for <p>	Resulting pre-scaler	SAP command for motor 0 SAP 210, M0, <p>	Resulting steps per rotation for a 400 line (1600 quadrate count) encoder
64	0.125	SAP 210, M0, 64	200
128	0.25	SAP 210, M0, 128	400
256	0.5	SAP 210, M0, 256	800
512	**1**	**SAP 210, M0, 512**	**1600**
1024	2	SAP 210, M0, 1024	3200
2048	4	SAP 210, M0, 2048	6400
4096	8	SAP 210, M0, 4096	12800
8192	16	SAP 210, M0, 8192	25600
16384	32	SAP 210, M0, 16384	51200
32768	64	SAP 210, M0, 32768	102400

Table 5.1: TMCL – Pre-scaler values

Formula for resulting steps per rotation:
StepsPerRotation = LinesOfEncoder * 4 * PreScaler

There are some special functions that can also be configured using these values. To select these functions just add the following values to <p>:

Adder for <p>	SAP command for motor 0 SAP 210, M0, <p>
1	Encoder Channel A polarity for Null channel event (0=negative, 1=positive)
2	Encoder Channel B polarity for Null channel event (0=negative, 1=positive)
4	Clear encoder with next null channel event
16	Encoder Channel N polarity for encoder clearing (0=negative, 1=positive)

Table 5.2: Special encoder functions

Add up both values <p> from this tables to get the required value for the SAP210 command. The resulting pre-scaler is Value/512. Other pre-scaler values are possible, also.

- Automatic motor stop on deviation error is also usable. This can be set using axis parameter 212 (maximum deviation). This function is turned off when the maximum deviation is set to 0.

5.6 Additional In- and Outputs

The In- and Outputs are not protected, only IN8 and IN9 are optically isolated.

Name	Pin	Related [TMCL] command	Characteristics
IN1_A/D	0	GIO 0	Analog user controlled input #0. No internal resistors. 0…5V
IN2_A/D	26	GIO 1	Analog user controlled input #1. No internal resistors. 0…5V
IN3_A/D	13	GIO 2	Analog user controlled input #2. No internal resistors. 0…5V
IN4	21	GIO 3	Digital user controlled input #3. No internal resistors. TTL levels
IN5	32	GIO 4	Digital user controlled input #4. No internal resistors. TTL levels
IN6	25	GIO 5	Digital user controlled input #5. No internal resistors. TTL levels
IN7	30	GIO 6	Digital user controlled input #6. No internal resistors. TTL levels
IN8	11	GIO 7	Digital user controlled input #7. Optically isolated, active low
IN9	23	GIO 8	Digital user controlled input #8. Optically isolated, active low
OUT1	17	SIO 0, 2	Digital user controlled output #0. No internal resistors. TTL levels
OUT2	9	SIO 1, 2	Digital user controlled output #1. No internal resistors. TTL levels
OUT3	22	SIO 2, 2	Digital user controlled output #2. No internal resistors. TTL levels

Table 5.3: Additional In- and Outputs

5.7 Reference Switches

Two digital reference / stop switch inputs are provided (REF L= stop left and REF R = stop right). They are used as an absolute position reference for homing and to set a hardware limit for the motion range. Also a step loss of the system can be detected, e.g. due to overloading or manual interaction, by using a travel-switch. The inputs are optically isolated, active low and use TTL levels.

5.7.1 Left and right limit switches

The TMCM-301 can be configured so that a motor has a left and a right limit switch (Figure 5.2). *The motor stops when the traveler has reached one of the limit switches.*
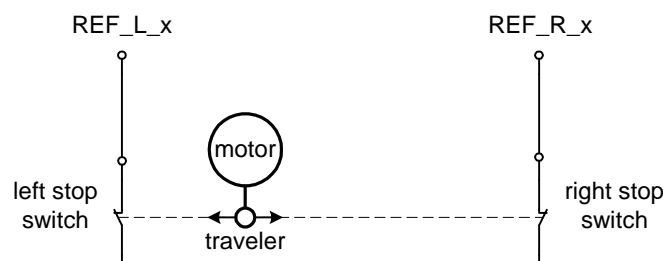

Figure 5.2: Left and right limit switches

5.7.2 Triple Switch Configuration

It is possible to program a tolerance range around the reference switch position. This is useful for a triple switch configuration, as outlined in Figure 5.3. In that configuration two switches are used as automatic stop switches, and one additional switch is used as the reference switch between the left

stop switch and the right stop switch. The left stop switch and the reference switch are wired together. The center switch (travel switch) allows for a monitoring of the axis in order to detect a step loss.
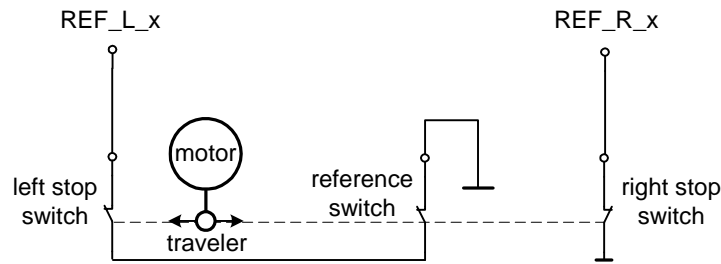
Figure 5.3: Limit switch and reference switch

5.7.3 One Limit Switch for circular systems

If a circular system is used (Figure 5.4), only one reference switch is necessary, because there are no end-points in such a system.
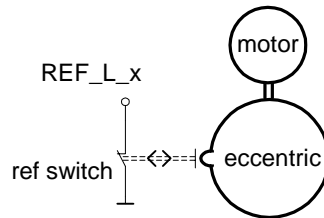
Figure 5.4: One reference switch

Note: In the actual TMCL, a function is available, which turns the motor left until the reference switch has been detected. Then the actual and target position are set to zero. In the future, two and three limit switches will also be supported.

5.8   StallGuard™ - Sensorless Motor Stall Detection

The integrated StallGuard™ feature makes it possible to detect if the mechanical load on a stepper motor is too high or if the traveler has been obstructed. The load value can be read using a TMCL command or the module can be programmed so that the motor will be stopped automatically when it has been obstructed or the load has been to high.

StallGuard can also be used for finding the reference position without the need for a reference switch: Just activate StallGuard and then let the traveler run against a mechanical obstacle that is placed at the end of the way. When the motor has stopped it is definitely at the end of its way, and this point can be used as the reference position.

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. **Mixed decay should be switched off while StallGuard is turned on in order to get usable results.**

Value	Description
0	StallGuard function is deactivated (default)
1..7	Motor stops when StallGuard value is reached

Table 5.4: StallGuard parameter SAP 205

To activate the StallGuard feature use the TMCL-command SAP 205 and set the StallGuard threshold value according to Table 5.4. The actual load value is given by GAP 206. The TMCL IDE has some tools which let you try out and adjust the StallGuard function in an easy way. They can be found at "StallGuard" in the "Setup"-menu and are described in the following chapters.

5.8.1 StallGuard adjusting tool

The StallGuard adjusting tool helps to find the necessary motor parameters when StallGuard is to be used. This function can only be used when a module is connected that features StallGuard. This is

checked when the StallGuard adjusting tool is selected in the "Setup" menu. After this has been successfully checked the StallGuard adjusting tool is displayed.
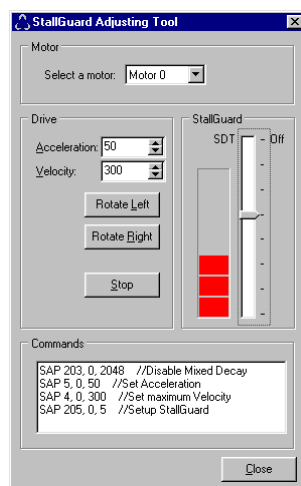
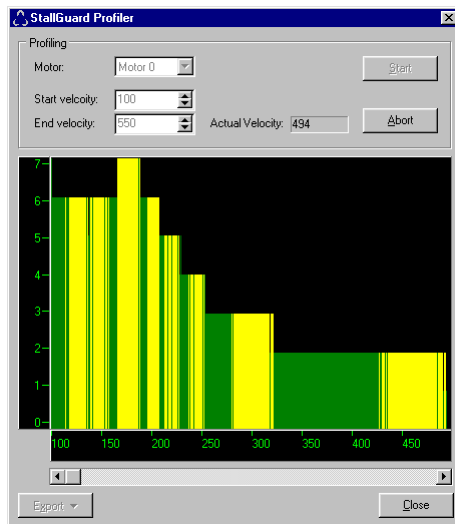First, select the axis that is to be used in the "Motor" area.

Now you can enter a velocity and an acceleration value in the "Drive" area and then click "Rotate Left" or "Rotate Right". Clicking one of these button will send the necessary commands to the module so that the motor starts running. The red bar in the "StallGuard" area on the right side of the windows displays the actual load value. Use the slider to set the StallGuard threshold value. If the load value reaches this value the motor stops. Clicking the "Stop" button also stops the motor.

All commands necessary to set the values entered in this dialogue are displayed in the "Commands" area at the bottom of the window. There, they can be selected, copied and pasted into the TMCL editor.

Figure 5.5: StallGuard adjusting tool

5.8.2 StallGuard profiler

The StallGuard profiler is a utility that helps you find the best parameters for using stall detection. It scans through given velocities and shows which velocities are the best ones. Similar to the StallGuard adjusting tool it can only be used together with a module that supports StallGuard. This is checked right after the StallGuard profiler has been selected in the "Setup" menu. After this has been successfully checked the StallGuard profiler window will be shown.

First, select the axis that is to be used. Then, enter the "Start velocity" and the "End velocity". The start velocity is used at the beginning of the profile recording. The recording ends when the end velocity has been reached. Start velocity and end velocity must not be equal. After you have entered these parameters, click the "Start" button to start the StallGuard profile recording. Depending on the range between start and end velocity this can take several minutes, as the load value for every velocity value is measured ten times. The "Actual velocity" value shows the velocity that is currently being tested and so tells you the progress of the profile recording. You can also abort a profile recording by clicking the "Abort" button.

The result can also be exported to Excel or to a text file by using the "Export" button.

Figure 5.6: The StallGuard Profiler

5.8.2.1   The result of the StallGuard profiler

The result is shown as a graphic in the StallGuard profiler window. After the profile recording has finished you can scroll through the profile graphic using the scroll bar below it. The scale on the vertical axis shows the load value: a higher value means a higher load. The scale on the horizontal axis is the velocity scale. The colour of each line shows the standard deviation of the ten load values that have been measured for the velocity at that point. This is an indicator for the vibration of the motor at the given velocity. There are three colours used:

* Green: The standard deviation is very low or zero. This means that there is effectively no vibration at this velocity.
* Yellow: This colour means that there might be some low vibration at this velocity.
* Red: The red colour means that there is high vibration at that velocity.

5.8.2.2   Interpreting the result

In order to make effective use of the StallGuard feature you should choose a velocity where the load value is as low as possible and where the colour is green. The very best velocity values are those where the load value is zero (areas that do not show any green, yellow or red line). Velocities shown in yellow can also be used, but with care as they might cause problems (maybe the motor stops even if it is not stalled).

Velocities shown in red should not be chosen. Because of vibration the load value is often unpredictable and so not usable to produce good results when using stall detection.

As it is very seldom that exactly the same result is produced when recording a profile with the same parameters a second time, always two or more profiles should be recorded and compared against each other.

5.9   Environment Temperature Considerations

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

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

6 Putting the TMCM-102 into Operation with TMCL

On the basis of a small example it is shown step by step how the TMCM-102 is set into operation. Users who are already familiar with TMCL and other Trinamic modules may skip this chapter.

Example: The following application is to be implemented on the TMCM-102 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 theTMCM-102 it is necessary to do the following things:

Step 1:   Connect the host interface to the PC

Step 2:   Connect the motor to the motor connector

Step 3:   Connect the power supply voltage to the module

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

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

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

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

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

        JA Loop                      //Infinite Loop
```

Step 6:   Click the "*Assemble*" icon to convert the TMCL program into byte code.
                  Then download the program to the TMCM-102 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 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:

Signal	Description	Range
f_{CLK}	clock-frequency	0..16 MHz
velocity	-	0..2047
a_max	maximum acceleration	0..2047
pulse_div	divider for the velocity. The higher the value is, the less is the maximum velocity default value = 0	0..13
ramp_div	divider for the acceleration. The higher the value is, the less is the maximum acceleration default value = 0	0..13
Usrs	microstep-resolution (microsteps per fullstep = 2^{usrs})	0..7 (a value of 7 is internally mapped to 6 by the TMC428)

Table 7.1: TMC428 Velocity parameters

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

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

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

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

The change in the pulse rate per time unit (pulse 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:

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

Example:
f_CLK = 16 MHz
velocity = 1000
a_max = 1000
pulse_div = 1
ramp_div = 1
usrs = 6

$$msf = \frac{16\,MHz \cdot 1000}{2^1 \cdot 2048 \cdot 32} = 122070.31 Hz$$

$$fsf[Hz] = \frac{122070.31}{2^6} = 1907.34 Hz$$

$$a = \frac{(16 Mhz)^2 \cdot 1000}{2^{1+1+29}} = 119.21 \frac{MHz}{s}$$

$$af = \frac{119.21 \frac{MHz}{s}}{2^6} = 1.863 \frac{MHz}{s}$$

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

$$RPS = \frac{fsf}{fullsteps\,per\,rotation} = \frac{1907.34}{72} = 26.49$$

$$RPM = \frac{fsf \cdot 60}{fullsteps\,per\,rotation} = \frac{1907.34 \cdot 60}{72} = 1589.46$$

8 TMCL

TMCL, the TRINAMIC Motion Control Language, is described in a separate documentation, the TMCL Reference and Programming Manual. This manual is provided on the TMC TechLib CD and on the web site of TRINAMIC: www.trinamic.com.
Please refer to these sources for updated data sheets and application notes.

The TMC TechLib CD-ROM including data sheets, application notes, schematics of evaluation boards, software of evaluation boards, source code examples, parameter calculation spreadsheets, tools, and more comes with every TRINAMIC module.

9 Revision History

9.1 Documentation Revision

Version	Comment	Author	Description
0.93	15-Feb-2007	HC	Preliminary Version
1.00	15-Mar-07	BD	Electrical Values updated
1.01	07-Nov-07	HC	Chapter 5.5: Encoder interface info updated
1.02	24-Jun-09	OK	Chapter 5.8 corrected

Table 9.1: Documentation Revisions

9.2 Firmware Revision

Version	Comment	Description
3.24	Initial Release	Please refer to TMCL documentation

Table 9.2: Firmware Revisions

10 References

[TMCL]   TMCL manual (see http://www.trinamic.com)
[Standard add-on] Standard Add-on-board manual (see http://www.trinamic.com)