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HARDWARE MANUAL

TMCM-343

**3-axis stepper
controller / driver
300mA up to 1.1A RMS
nominal supply: 8V… 34V DC
TMCL™ / CANopen firmware**

CANopen

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TRINAMIC
MOTION CONTROL

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1 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.

2 Features

The TMCM-343 is a compact and versatile triple axis 2-phase stepper motor controller and driver module. It provides a complete motion control solution at a very small size for embedded applications. Using the integrated additional I/Os it even can do complete system control applications. The board can be connected to a baseboard or customized electronics with a pin connector. The TMCM-343 comes with the PC based software development environment TMCL-IDE. Using predefined TMCL™ (Trinamic Motion Control Language) high level commands like *move to position* or *constant rotation* rapid and fast development of motion control applications is guaranteed. Host communication is possible via the serial UART interface (e.g. using an RS232 or RS485 level shifter) or via CAN. All time critical operations, e.g. ramp calculation are performed onboard. A user 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 optional stallGuard™ feature it is possible to detect overload and stall of the motor.

Applications
- Controller/driver board for control of up to 3 axes
- Versatile possibilities of applications in stand alone or PC controlled mode

Motor type
- Coil current from 300mA to 1.1A RMS (1.5A peak)
- 8V to 34V nominal supply voltage

Highlights
- Automatic ramp generation in hardware
- stallGuard™ option for sensorless motor stall detection
- Full step frequencies up to 20kHz
- On the fly alteration of motion parameters (e.g. position, velocity, acceleration)
- Local reference move using sensorless stallGuard™ feature or reference switch
- Coil current adjustable by software
- Up to 64 times microstepping
- TRINAMIC driver technology: No heat sink required
- Adjustment possibilities. Therefore this module offers solutions for a great field of demands

Software
- Stand-alone operation using TMCL™ or remote controlled operation
- TMCL™ program storage: 16 KByte EEPROM (2048 TMCL™ commands)
- PC-based application development software TMCL-IDE included
- Special firmware for CANopen protocol support also available

Other
- 68 pin connector carries all signals
- RoHS compliant latest from 1 July 2006
- Size: 80 x 50mm²

4 Order codes

Order code	Description	Dimensions
TMCM-343 (-option)	3-axis controller/driver module 1.1A, 34V	80 x 55 x 8 mm^3
Products related to TMCM-343		
BB-303 (-option)	Baseboard for TMCM-343	80 x 50 x 15 mm^3
BB-323-03	Baseboard for TMCM-343	96.5 x 79 x 60 mm^3
TMCM-323	3-axis encoder	80 x 53 x 8 mm^3
TMCM-EVAL	Evaluation baseboard	160 x 100 x 24 mm^3
Options for TMCM-343		
-H	horizontal pin connector (standard)	
-V	vertical pin connector (on request)	

Table 4.1: Order codes

5 Electrical and mechanical interfacing

5.1 Dimensions

The 68 pin connector has a 2.0mm pitch.
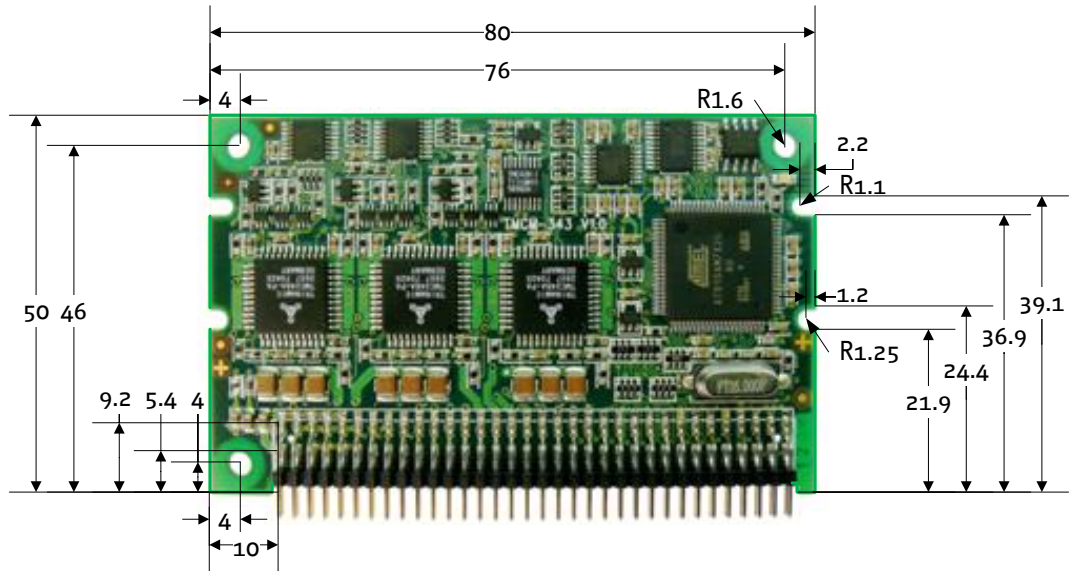
Figure 5.1: Front view of TMCM-343 (all values in mm)
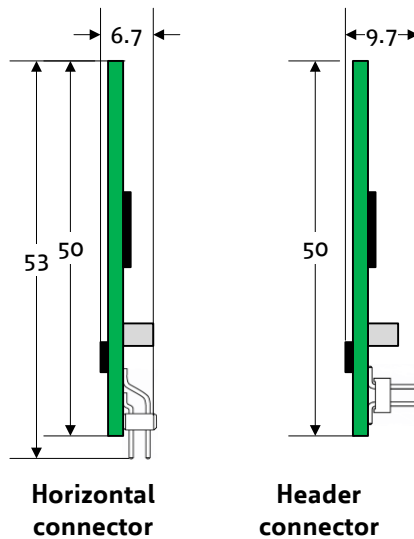
Figure 5.2: Ordering options for the connector (all values in mm)

5.2 Connecting the module

The 68-pin connector provides communication to a host, configuration of the EEPROM and connection of motors as well as connection of reference switches. Pin 1 of this connector is located in the lower left corner on the top site, while the connector is pointing towards the user.

Pin	Direction	Description	Pin	Direction	Description
1	In	+5VDC (+/- 5%) I_{max}=300mA	35	-	Reserved
2	In	GND	36	out	Motor2 A0
3	In	+5VDC (+/- 5%)	37	-	Reserved
4	In	GND	38	out	Motor2 A1
5	In	V_Motor (+7 to 34VDC)	39	-	Reserved
6	In	GND	40	out	Motor2 B0
7	In	V_Motor (+7 to 34VDC)	41	-	Reserved
8	In	GND	42	out	Motor2 B1
9	In	V_Motor (+7 to 34VDC)	43	-	Reserved
10	In	GND	44	in	Shutdown
11	Out	SPI Select 0	45	in	General Purpose input 0
12	Out	SPI Clock	46	out	General Purpose output 0
13	Out	SPI Select 1	47	in	General Purpose input 1
14	In	SPI MISO	48	out	General Purpose output 1
15	Out	SPI Select 2	49	in	General Purpose input 2
16	Out	SPI MOSI	50	out	General Purpose output 2
17	In	Reset, active low	51	in	General Purpose input 3
18	Out	Alarm	52	out	General Purpose output 3
19	In	Reference Switch Motor 0 right	53	in	General Purpose input 4
20	Out	Motor0 A0	54	out	General Purpose output 4
21	In	Reference Switch Motor 0 left	55	in	General Purpose input 5
22	Out	Motor0 A1	56	out	General Purpose output 5
23	In	Reference Switch Motor 1 right	57	in	General Purpose input 6
24	Out	Motor0 B0	58	out	General Purpose output 6
25	In	Reference Switch Motor 1 left	59	in	General Purpose input 7
26	Out	Motor0 B1	60	out	General Purpose output 7
27	In	Reference Switch Motor 2 right	61	in	GND
28	Out	Motor1 A0	62	in	GND
29	In	Reference Switch Motor 2 left	63	-	Reserved
30	Out	Motor1 A1	64	out	RS485 Direction
31	-	Reserved	65	in and out	CAN -
32	Out	Motor1 B0	66	in	RS232 RxD
33	-	Reserved	67	in and out	CAN +
34	Out	Motor1 B1	68	out	RS232 TxD

Table 5.1: Pinout of the 68-Pin connector
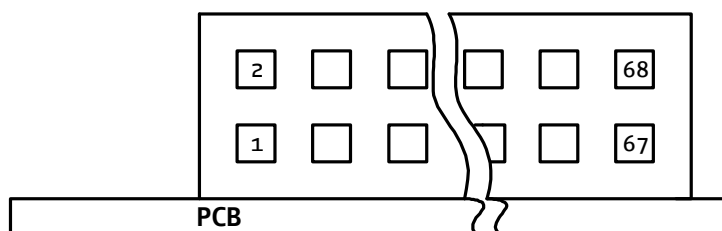
Figure 5.3: Pin order of the connector

5.3 Power supply requirements

Two different power supplies have to be provided for the TMCM-343: +5VDC for the controller part and +7… 34VDC for the motor supply. Please connect all listed pins for the power supply inputs and ground in parallel. It is recommended to use capacitors of some 1000µF and a choke close to the module for the motor supply. This ensures a stable power supply and minimizes noise injected into the power supply cables. The choke especially becomes necessary in larger distributed systems using a common power supply.
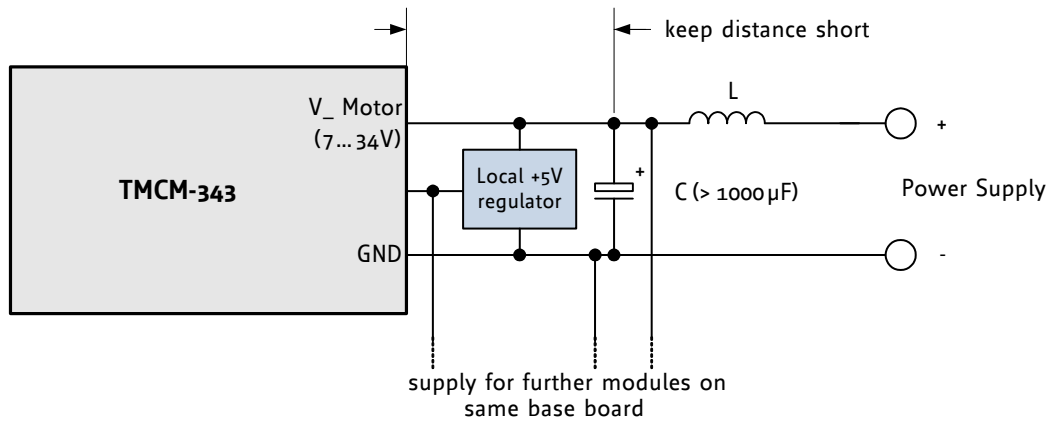
Figure 5.4: Power supply requirements for TMCM-343

Especially in bus controlled systems (e.g. CAN or RS485) it is important to ensure a stable ground potential of all modules. The stepper driver modules draw peak currents of some ampere from the power supply. It has to be made sure, that this current does not cause a substantial voltage difference on the interface lines between the module and the master, as disturbed transmissions could result.

The following hints help avoiding transmission problems in larger systems:

- Use power supply filter capacitors of some 1000µF on the base board for each module in order to take over current spikes. A choke in the positive power supply line will prevent current spikes from changing the GND potential of the base board, especially when a central power supply is used.
- Optionally use an isolated power supply for the TMCM-Modules (no earth connection on the power supply, in case the CAN master is not optically decoupled)
- Do not supply modules which are mounted in a distance of more than a few meters with the same power supply.
- For modules working on the same power supply (especially the same power supply as the master) use a straight and thick, low-resistive GND connection.
- Use a local +5V regulator on each baseboard.
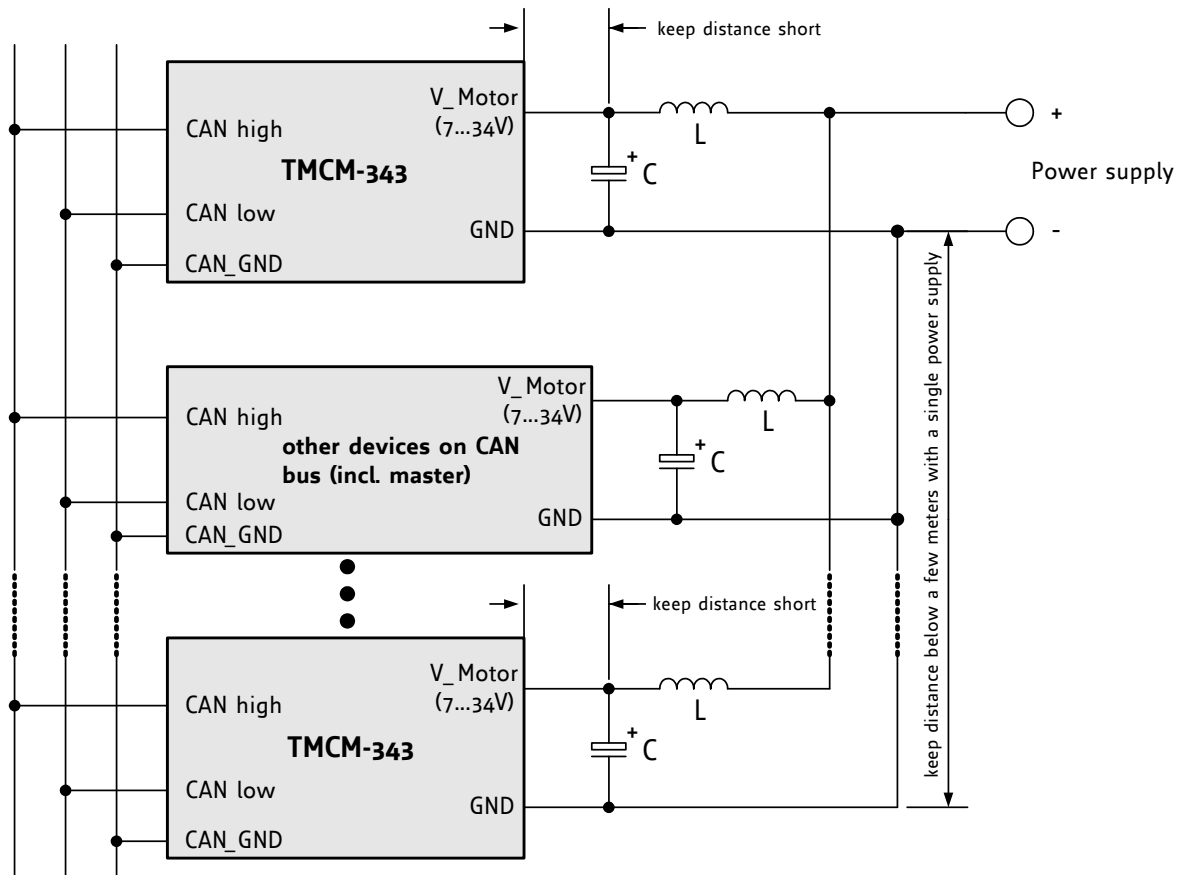
Figure 5.5: Power supply requirements for TRINAMIC modules in a bus system

- In large systems it may make sense to use an optically decoupled CAN bus for each number of nodes, e.g. for each base board with a number of TMCM-34x modules, especially when a centralized power supply is to be used.

- Be aware that different ground potentials of the CAN sender (e.g. a PC) and the power supply may damage the modules.

- Please make sure that the GND lines of the CAN sender and the module(s) and power supplies are connected by a cable.

6 Operational ratings

The operational ratings show the intended or rather 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	DC Power supply voltage for operation	7	12 … 28	34	V
V_{+5V}	+5V DC input (max. 50mA / no OUT load)	4.8	5.0	5.2	V
I_{COIL}	Motor coil current for sine wave peak (chopper regulated, adjustable via software)	0	0.3 … 1.5	1.5	A
f_{CHOP}	Motor chopper frequency		36.8		kHz
I_S	Power supply current (per motor)		$<< I_{COIL}$	$1.4 * I_{COIL}$	A
V_{INPROT}	Input voltage for StopL, StopR, GPIo (internal protection diodes)	-0.5	0 … 5	V_{+5V}+0.5	V
V_{ANA}	INx analog measurement range (resolution: 10bit / range: 0..1023)		0 … 5.5		V
V_{INLO}	INx, StopL, StopR low level input		0	0.9	V
V_{INHI}	INx, StopL, StopR high level input (integrated 10k pull-up to +5V for Stop)	2	5		V
I_{OUTI}	OUTx max +/- output current (CMOS output) (sum for all outputs max. 50mA)			+/-20	mA
T_{ENV}	Environment temperature at rated current (no cooling)	-40		+80	°C

Table 6.1: Operational ratings

7 Functional description

In Figure 7.1 the main parts of the TMCM-343 module are shown. The module mainly consists of a processor, a TMC428 motion controller, three TMC246 stepper motor drivers, the TMCL™ program memory (EEPROM) and the host interfaces RS232, RS485 and CAN.
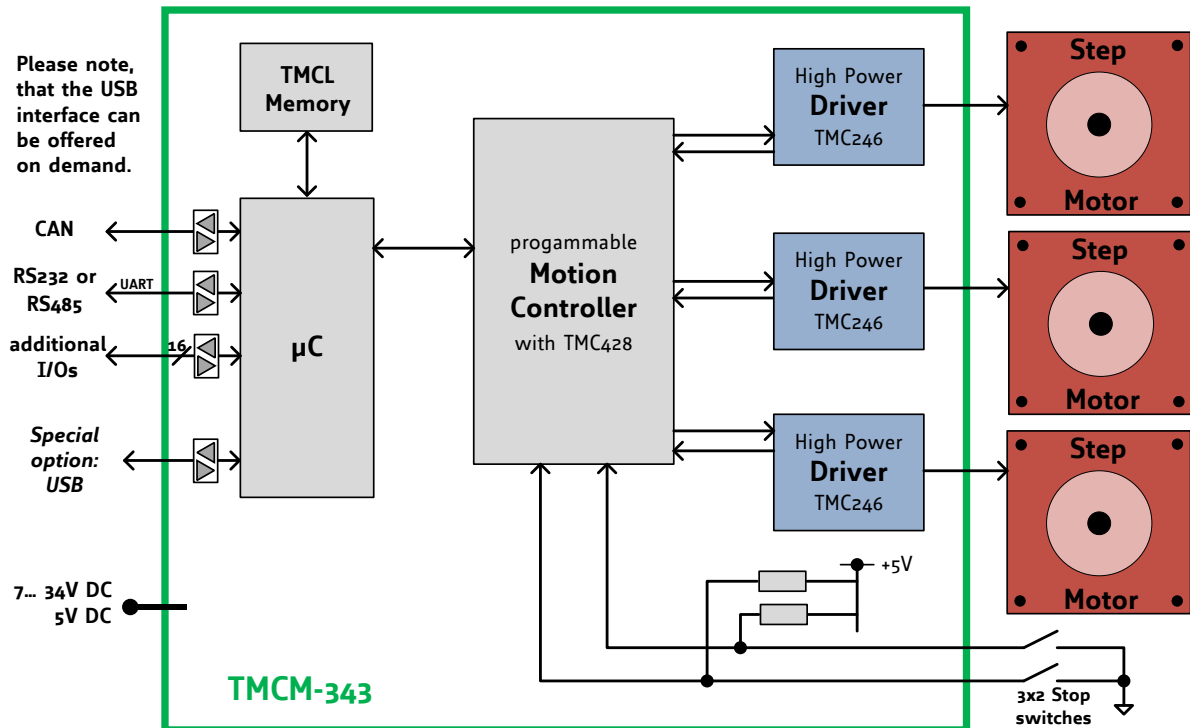
Figure 7.1: Main parts of the TMCM-343

7.1 System architecture

The TMCM-343 integrates a microcontroller with the TMCL™ (Trinamic Motion Control Language) operating system. The motion control real-time tasks are realized by the TMC428.

7.1.1 Microcontroller

On this module, the Atmel AT91SAM7X256 is used to run the TMCL™ operating system and to control the TMC428. The CPU has 256KB flash memory and a 64KB RAM. The microcontroller runs the TMCL™ (Trinamic Motion Control Language) operating system which makes it possible to execute TMCL™ commands that are sent to the module from the host via the RS232, RS485 and CAN interface. The microcontroller interprets the TMCL™ commands and controls the TMC428 which executes the motion commands.

The flash ROM of the microcontroller holds the TMCL™ operating system. The TMCL™ operating system can be updated via the RS232 interface or via the CAN interface. Use the TMCL-IDE to do this.

7.1.2 EEPROM

To store TMCL™ programs for stand-alone operation the TMCM-343 module is equipped with a 16kByte EEPROM attached to the microcontroller. The EEPROM can store TMCL™ programs consisting of up to 2048 TMCL™ commands. The EEPROM is also used to store configuration data.

7.1.3 TMC428 motion controller

The TMC428 is a high-performance stepper motor control IC and can control up to three 2-phase-stepper-motors. 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.

7.1.4 Stepper motor drivers

On the TMCM-343 modules the TMCM246 chips are used. These chips have the stallGuard™ feature.
As the power dissipation of TMC246 chips is very low no heat sink or cooling fan is needed. The temperature of the chips does not get high. The coils will be switched off automatically when the temperature or the current exceeds the limits and automatically switched on again when the values are within the limits again.

The TMCM-343 module is equipped with a circuit that extends the microstep resolution of the TMC246 chips to true 64 times microstepping. The maximum peak coil current of each stepper motor driver chip is 1500mA.

7.2 Power supply

Two different power supplies have to be provided for the TMCM-343: +5VDC for the module functionality and +7… 34VDC for the motor supply. Please use all listed pins for the power supply inputs and ground parallel.

Pin	Function
1, 3	+5V DC (+/- 5%), I_{max} = 50mA power supply
2, 4	Ground
5, 7, 9	+7… 34V DC motor power supply
6, 8, 10	Ground

Table 7.1: Pinning of power supply

7.3 Motor connection

Never connect or disconnect the motors while the TMCM-343 Module is switched on. Doing this will destroy the driver ICs!

The TMCM-343 controls up to three 2-phase stepper motors.

Table 7.2 shows how to connect the three motors with the 68-pin connector:

Pin Number	Direction	Name	Motor Numbers and Coils
20	out	Motor0_A0	Motor #0, Coil A0
22	out	Motor0_A1	Motor #0, Coil A1
24	out	Motor0_B0	Motor #0, Coil B0
26	out	Motor0_B1	Motor #0, Coil B1
28	out	Motor1_A0	Motor #1, Coil A0
30	out	Motor1_A1	Motor #1, Coil A1
32	out	Motor1_B0	Motor #1, Coil B0
34	out	Motor1_B1	Motor #1, Coil B1
36	out	Motor2_A0	Motor #2, Coil A0
38	out	Motor2_A1	Motor #2, Coil A1
40	out	Motor2_B0	Motor #2, Coil B0
42	out	Motor2_B1	Motor #2, Coil B1

Table 7.2: Pinout for motor connections
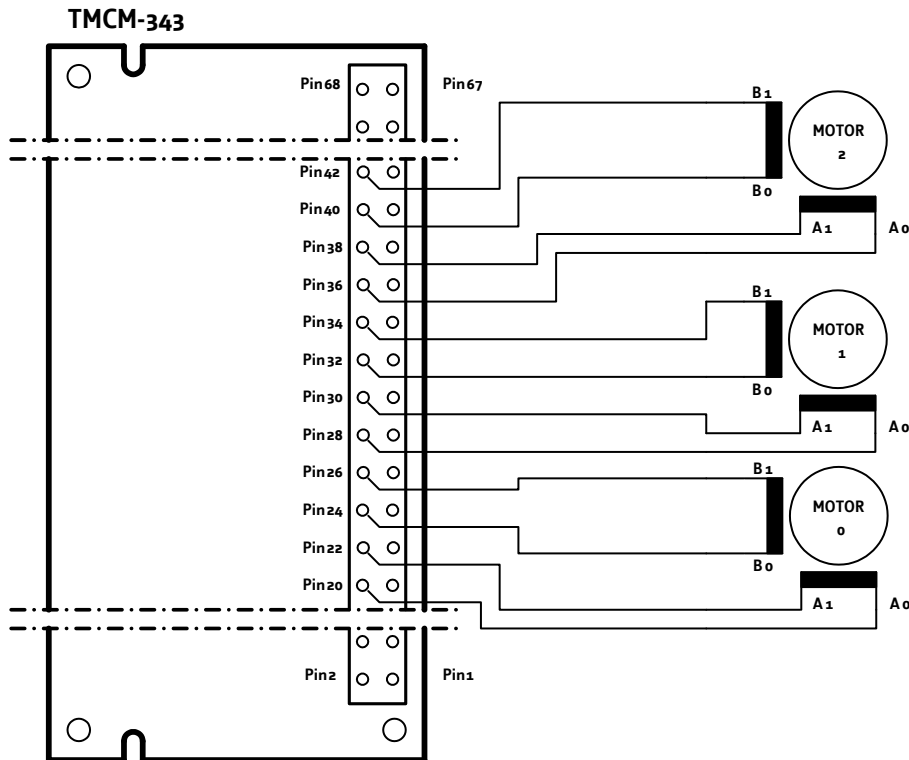
Figure 7.2: Connecting the motors

7.4 Host communication

The communication to a host takes place via one or more of the onboard interfaces. The module provides a range of different interfaces, like CAN, RS232, and RS485. The following chapters explain how the interfaces are connected with the 68-pin connector.

7.4.1 CAN 2.0b

Pin	Direction	Name	Limits	Description
65	in and out	CAN -	-8... +18V	CAN input/output
67	In and out	CAN +	-8... +18V	CAN input/output

Table 7.3: Pinout for CAN connection
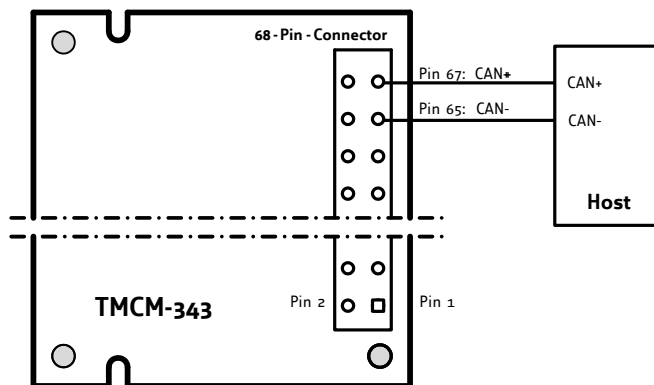
Figure 7.3: Connecting CAN

7.4.2 RS232

Pin	Direction	Name	Limits	Description
66	in	RxD	TTL	RS232 receive data
68	out	TxD	TTL	RS232 transmit data
2, 4, 6, 8, 10	in	GND	0V	Connect to ground

Table 7.4: Pinout for RS232 connection

The module only provides a serial interface at TTL level. For using RS232 a suitable level shifter has to be added by the user (e.g. MAX202).
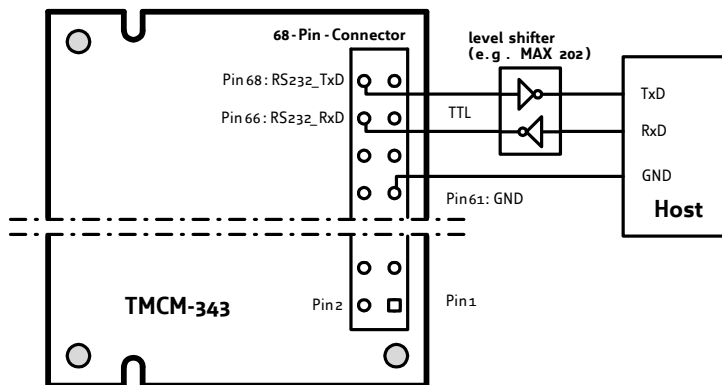
Figure 7.4: Connecting RS232

7.4.3 RS485

Pin Number	Direction	Name	Limits	Description
64	Out	RS485_DIR	TTL	Driver/receiver enable for RS485 transceiver. 0: receiver enable 1: driver enable
66	In	RxD	TTL	RS485 receive data
68	Out	TxD	TTL	RS485 transmit data
2, 4, 6, 8, 10	In	GND	0V	Connect to ground

Table 7.5: Pinout for RS485 connection

The TMCM-343 module only provides a serial interface at TTL level. To use RS485 a suitable RS485 transceiver (like MAX485) has to be added by the user.
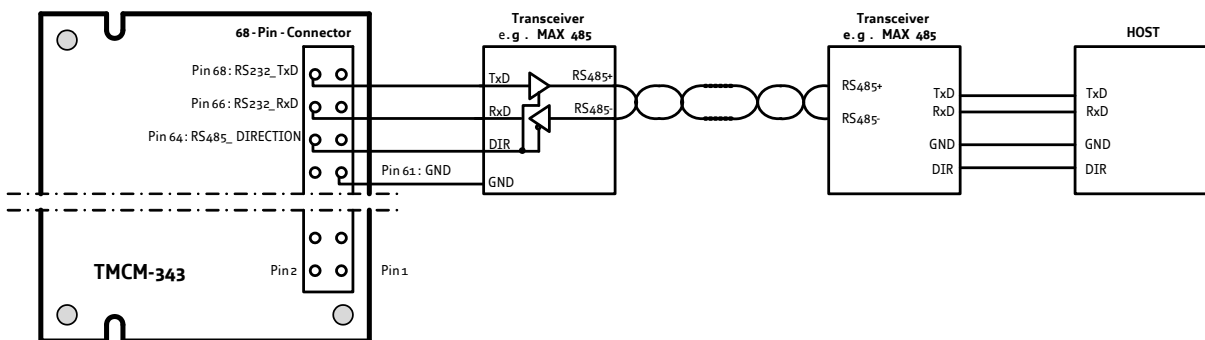
Figure 7.5: Connecting RS485

7.5 stallGuard™ - sensorless motor stall detection

The TMCM-343 modules are equipped with the stallGuard™ feature. The 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 too high.

stallGuard™ can also be used for finding the reference position without the need for a reference switch: 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.

For using 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 in use in order to get usable results.

Value	Description
0	stallGuard™ function is deactivated (default)
1… 7	Motor stops when stallGuard™ value is reached and position is not set zero.

Table 7.6: stallGuard™ parameter SAP 205

To activate the stallGuard™ feature use the TMCL™ command SAP 205 and set the stallGuard™ threshold value according to Table 7.6. 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. Please refer to the TMCM-341/342/343 TMCL™ Firmware Manual for further information about working with TMCL-IDE.

7.5.1 stallGuard™ adjusting tool
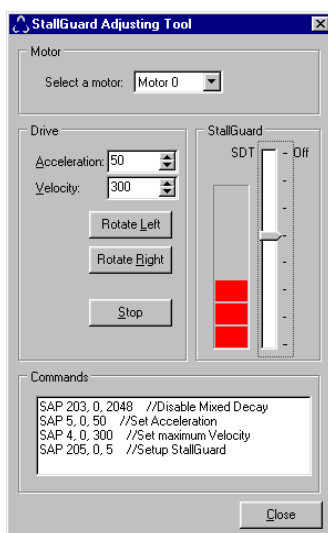
The stallGuard™ adjusting tool helps to find the necessary motor parameters when stallGuard™ is to be used. This function can only be used when a module is connected that features stallGuard™. This is checked when the stallGuard™ adjusting tool is selected in the *Setup* menu. After this has been successfully 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 buttons 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.

Figure 7.6: stallGuard™ adjusting tool

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.

7.5.2 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.
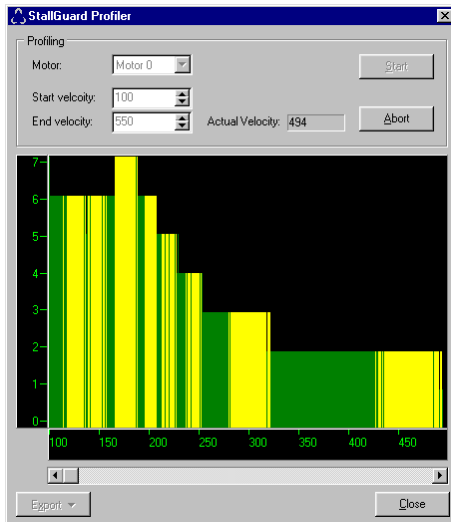

First, select the axis that is to be used. Then, enter the *Start velocity* and the *End velocity*. The start velocity is used at the beginning of the profile recording. The recording ends when the end velocity has been reached. Start velocity and end velocity must not be equal. After you have entered 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 7.7: The stallGuard™ profiler

7.5.2.1 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 color 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 colors used:

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

7.5.2.2 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 color 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.

7.6   Reference switches

With reference switches, an interval for the movement of the motor or the zero point can be defined. Also a step loss of the system can be detected, e.g. due to overloading or manual interaction, by using a travel-switch.

Pin	Direction	Name	Limits	Description
19	in	STOP0R	TTL	Right reference switch input for Motor #0
21	in	STOP0L	TTL	Left reference switch input for Motor #0
23	in	STOP1R	TTL	Right reference switch input for Motor #1
25	in	STOP1L	TTL	Left reference switch input for Motor #1
27	in	STOP2R	TTL	Right reference switch input for Motor #2
29	in	STOP2L	TTL	Left reference switch input for Motor #2

Table 7.7: Pinout reference switches

10k pull-up resistors for reference switches are included on the module.

7.6.1 Left and right limit switches

The TMCM-343 can be configured so that a motor has a left and a right limit switch (Figure 7.8).

The motor stops when the traveler has reached one of the limit switches.
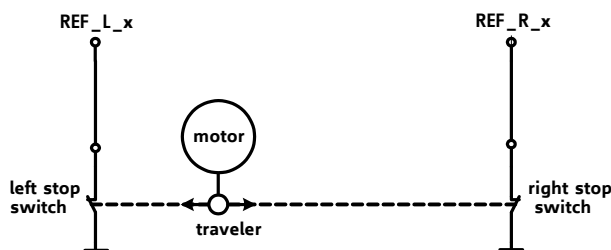
Figure 7.8: Left and right limit switches

7.6.2 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 7.9. 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.
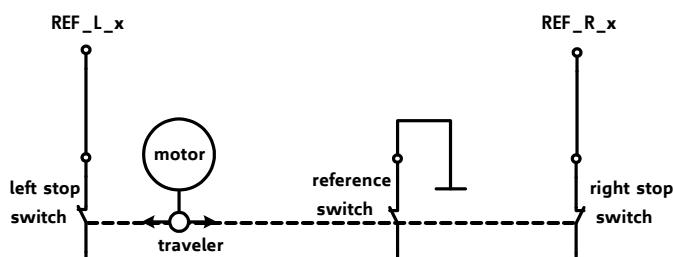
Figure 7.9: Limit switch and reference switch

7.6.3 One limit switch for circular systems

If a circular system is used (Figure 7.10), only one reference switch is necessary, because there are no end-points in such a system.

Figure 7.10: One reference switch

7.7 Serial peripheral interface (SPI)

On-board communication is performed via the Serial Peripheral Interface (SPI). The microcontroller acts as master. For adaptation to user requirements, the user has access to this interface via the 68-pin connector. Furthermore three chip select lines can be used for addressing of external devices.

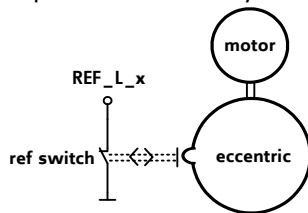| Pin	Direction	Name	Limits	Description
11	out	SPI_SEL0	TTL	Chip Select Bit0
13	out	SPI_SEL1	TTL	Chip Select Bit1
15	out	SPI_SEL2	TTL	Chip Select Bit2
12	out	SPI_CLK	TTL	SPI Clock
14	in	SPI_MISO	TTL	SPI Serial Data In
16	out	SPI_MOSI	TTL	SPI Serial Data Out

Table 7.8: Pinout SPI

7.8 Additional inputs and outputs

The module is equipped with eight TTL input pins and eight TTL output pins, which are accessible via the 68-pin connector. The input pins can also be used as analogue inputs.

Pin	Direction	Name	Limits	Description
45	in	INP_0	TTL	digital and analogue input pin 0, input
47	in	INP_1	TTL	digital and analogue input pin 1, input
49	in	INP_2	TTL	digital and analogue input pin 2, input
51	in	INP_3	TTL	digital and analogue input pin 3, input
53	in	INP_4	TTL	digital and analogue input pin 4, input
55	in	INP_5	TTL	digital and analogue input pin 5, input
57	in	INP_6	TTL	digital and analogue input pin 6, input
59	in	INP_7	TTL	digital and analogue input pin 7, input
46	out	Out_0	TTL	digital output pin 0, output
48	out	Out_1	TTL	digital output pin 1, output
50	out	Out_2	TTL	digital output pin 2, output
52	out	Out_3	TTL	digital output pin 3, output
54	out	Out_4	TTL	digital output pin 4, output
56	out	Out_5	TTL	digital output pin 5, output
58	out	Out_6	TTL	digital output pin 6, output
60	out	Out_7	TTL	digital output pin 7, output

Table 7.9: Additional I/O pins

7.9 Miscellaneous connections

Pin	Direction	Name	Limits	Description
17	in	Reset	TTL	Reset, active low
18	out	Alarm	TTL	Alarm, active high
44	in	Shutdown	TTL	Emergency stop

Table 7.10: Miscellaneous connections

The functionality of the shutdown pin is configurable using in TMCL™ with global parameter 80 (please see the TMCM-341/342/343 TMCL™ Firmware Manual for information on this).

7.10 Microstep resolution

The TMCM-343 supports a true 64 microstep resolution. To meet your needs, the microstep resolution can be set using the TMCL™ software. The default setting is 64 microsteps, which is the highest resolution. For setting the microstep resolution with the TMCL™ firmware use instruction 5: SAP, type 140: microstep resolution.

You can find the appropriate value in Table 7.11.

Value	microsteps
0	Do not use: for fullstep please see *fullstep threshold*
1	2
2	4
3	8
4	16
5	32
6	64

Table 7.11: Microstep resolution setting

8 Putting the TMCM-343 into operation

On the basis of a small example it is shown step by step how the TMCM-343 is set into operation. Experienced users could skip this chapter and proceed to chapter 9.

Example: The following application is to implement with the TMCL-IDE Software development environment in the TMCM-343 module. For data transfer between the host PC and the module the RS232 interface is employed.

A formula how *speed* is converted into a physical unit like rotations per seconds can be found in chapter *Calculation: Velocity and acceleration vs. microstep and fullstep* frequency.

- Turn Motor 0 left with speed 500
- Turn Motor 1 right with speed 500
- Turn Motor 2 with speed 500, acceleration 5 and move between position +10000 and –10000.

Step 1:   Connect the RS232 Interface as specified in 7.7.

Step 2:   Connect the motors as specified in 7.3.

Step 3:   Connect the power supply.
                 +5 VDC to pins 1 or 3
                 Ground to pins 2, 4, 6, 8 or 10
Step 4:   Connect the motor supply voltage
                 +10 to 30 VDC to pins 5, 7, 9
Step 5:   Switch on the power supply and the motor supply. An on-board LED should start to flash. This indicates the correct configuration of the microcontroller.
Step 6:   Start the TMCL-IDE Software development environment. Open file test2.tmc. The following source code appears on the screen:
                 A description for the TMCL commands can be found in Appendix A.

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

        ROL 0, 500                  //Rotate motor 0 with speed 500
        WAIT TICKS, 0, 500
        MST 0
        ROR 1, 250                  //Rotate motor 1 with 250
        WAIT TICKS, 0, 500
        MST 1

        SAP 4, 2, 500               //Set max. Velocity
        SAP 5, 2, 50                //Set max. Acceleration
Loop:   MVP ABS, 2, 10000           //Move to Position 10000
        WAIT POS, 2, 0              //Wait until position reached
        MVP ABS, 2, -10000          //Move to Position -10000
        WAIT POS, 2, 0              //Wait until position reached
        JA Loop                     //Infinite Loop
```

Step 7:   Click on Icon *Assemble* to convert the TMCL™ into machine code.
                 Then download the program to the TMCM-343 module via the Icon *Download.*
Step 8:   Press Icon *Run.* The desired program will be executed.

Please refer to the TMCM-341/342/343 TMCL™ Firmware Manual for further information about the commands.

The next chapter discusses additional operations to turn the TMCM-343 into a high performance motion control system.

9 Migrating from the TMCM-303 to the TMCM-343

Migrating TMCM-303 applications to the TMCM-343 is easy, as the TMCM-343 can replace a TMCM-303 without problems. The connector of the TMCM-343 is identical to the connector of the TMCM-303, so that a TMCM-343 can just be plugged into the slot for a TMCM-303 (it can also use the same base boards as the TMCM-303). Also the TMCL™ firmware of the TMCM-343 is highly compatible with the TMCM-303.

However there are some slight differences that have to be observed (due to the fact that the TMCM-343 has some enhancements compared to the TMCM-303):

- Speed of TMCL™ program execution: TMCL™ programs run up twenty times faster than on the TMCM-303 module. In general, the developer of a TMCL™ program should not make assumptions about command execution times.
- Axis parameters 6 and 7 (run current and stand by current): The range of these parameters is now 0… 255 and no longer 0… 1500. These parameter settings must be adapted.
- Axis parameters 194 and 195: The reference search speeds are now specified directly (1… 2047) and no longer as fractions of the maximum positioning speed. These settings have to be adapted.
- MVP COORD: The parameter of the MVP COORD command is different (to make it compatible with the six axis modules). Please see the TMCM-341/342/343 TMCL™ Firmware Manual for details. The usage of the MVP COORD command also has to be adapted.
- Default CAN bit rate: the default CAN bit rate of the TMCM-343 module (e.g. after resetting it to factory default settings) is 1000kBit/s (in contrast to 250kBit/s on the TMCM-303.

All other TMCL™ commands and parameters are the same as with the TMCM-303.

10 TMCM-343 operational description

10.1 Calculation: Velocity and acceleration vs. microstep and fullstep frequency

The values of the parameters sent to the TMC428 do not have typical motor values like rotations per second as velocity. But these values can be calculated from the TMC428-parameters as shown in this document.

The parameters for the TMC428 are:

Signal	Description	Range
f_{CLK}	clock-frequency	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 10.1: TMC428 velocity parameters

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

$$usf[Hz] = \frac{f_{CLK}[Hz] \cdot velocity}{2^{pulse\_div} \cdot 2048 \cdot 32}$$ 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.

$$fsf[Hz] = \frac{usf[Hz]}{2^{usrs}}$$ 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 acceleration in fullsteps of:

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

Example:

Signal	value
f$_{CLK}$	16 MHz
velocity	1000
a_max	1000
pulse_div	1
ramp_div	1
usrs	6

$$msf = \frac{16MHz \cdot 1000}{2^1 \cdot 2048 \cdot 32} = 12207031Hz$$

$$fsf[Hz] = \frac{12207031}{2^6} = 1907.34Hz$$

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

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

Calculation of the number of rotations:

A stepper motor has e.g. 72 fullsteps per rotation.

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

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

11 TMCL™

TMCL™, the TRINAMIC Motion Control Language, is described in separate documentations, which refer to the specific products (e.g. TMCM-341/342/343 TMCL™ Firmware Manual). The manuals are provided on the TMC TechLibCD and on www.trinamic.com. Please refer to these sources for updated data sheets and application notes.

The TMC TechLibCD includes data sheets, application notes, and schematics of evaluation boards, software of evaluation boards, source code examples, parameter calculation spreadsheets, tools, and more.

12 CANopen

The TMCM-343 module can also be used with the CANopen protocol. For this purpose, a special CANopen firmware has to be installed. To do that, download the latest version of the TMCM-343 CANopen firmware from the Trinamic website or use the version provided on the TechLib CD and install it using the firmware update function of the TMCL-IDE (Setup/Install OS). The TMCM-343 module is then ready to be used with CANopen. Please see the specific CANopen manual provided on the TRINAMIC website and on the TechLibCD on how to use the TMCM-343 module with the CANopen protocol.