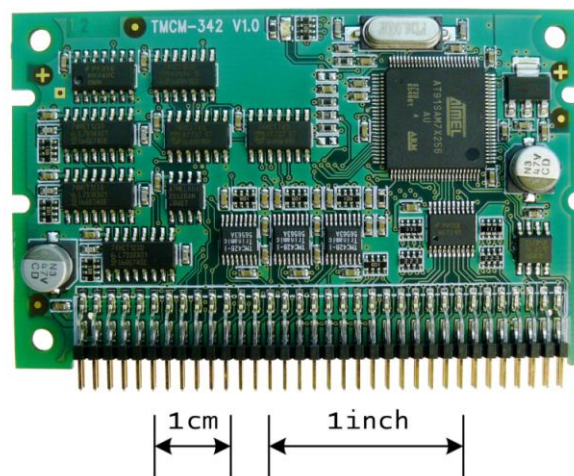


TMCM-342

3 - Axis Stepper Motor Motion Control Module with Step / Direction outputs



Manual

Version: 1.01
December 9th, 2008



Trinamic Motion Control GmbH & Co. KG
Sternstraße 67
D - 20357 Hamburg, Germany
<http://www.trinamic.com>

Table of Contents

1	Features.....	4
2	Life support policy.....	5
3	Electrical and Mechanical Interfacing.....	6
3.1	Dimensions.....	6
3.2	Connecting the Module.....	7
4	Operational Ratings.....	8
5	Functional Description.....	8
5.1	System Architecture	9
5.1.1	Microcontroller	9
5.1.2	TMCL EEPROM.....	9
5.1.3	TMC428 Motion Controller	9
5.1.4	Interface to the external drivers	9
5.2	Power Supply.....	9
5.3	Host Communication	10
5.3.1	CAN 2.0b.....	10
5.3.2	RS-232	10
5.3.3	RS-485	11
5.4	Step-/Direction output.....	12
5.5	Connecting the drivers.....	12
5.5.1	Connecting the TMC342 to a power driver module with Step/Direction-Interface.....	12
5.5.2	Connecting the TMC342 to drivers with an SPI-Interface.....	15
5.6	Power supply requirements with drivers.....	16
5.7	Ramp Profiles.....	18
5.8	Reference switches.....	19
5.8.1	Left and right limit switches	19
5.8.2	Triple Switch Configuration.....	19
5.8.3	One Limit Switch for circular systems	20
5.9	Serial Peripheral Interface (SPI)	20
5.10	Additional inputs and outputs.....	21
5.11	Miscellaneous Connections.....	21
6	Putting the TMC342 into Operation.....	22
7	Migrating from the TMC302 to the TMC342.....	23
8	TMC342 Operational Description	24
8.1	Calculation: Velocity and Acceleration vs. Microstep- and Fullstep-Frequency.....	24
9	TMCL.....	25
10	CANopen	25
11	Revision History.....	26
11.1	Documentation Revision.....	26
11.2	Hardware Revision.....	26
11.3	Firmware Revision	26
12	References	26

List of Figures

Figure 3.1: Dimensions.....	6
Figure 3.2: Pin order of the connector.....	7
Figure 5.1: Main parts of the TCM-342.....	8
Figure 5.2: Connecting CAN.....	10
Figure 5.3: Connecting RS-232.....	11
Figure 5.4: Connecting the RS-485 interface.....	11
Figure 5.5: Step/Direction output signals.....	12
Figure 5.6: Application Environment using the Step/Direction-Interface.....	13
Figure 5.7: Application with power module Monopack 2 with a Step/Direction-Interface.....	13
Figure 5.8: Application with TCM-023 with 3 Step/Direction-Interfaces (5V inputs required, please see latest TCM-023 documentation for modifications).....	14
Figure 5.9: Application with TCM-013 with a Step/Direction-Interface.....	14
Figure 5.10: Application Environment using the SPI-Interface.....	15
Figure 5.11: Application with an SPI-stepper motor driver.....	16
Figure 5.12: Power supply requirements for TCM-342 with additional driver.....	16
Figure 5.13: Power supply requirements for TMC-Modules in a bus system.....	17
Figure 5.14: Velocity profile in ramp mode.....	18
Figure 5.15: Velocity profile in velocity mode.....	18
Figure 5.16: Left and right limit switches.....	19
Figure 5.17: Limit switch and reference switch.....	19
Figure 5.18: One reference switch.....	20

List of Tables

Table 1.1: Order codes.....	4
Table 3.1: Pinout of the 68-Pin Connector.....	7
Table 4.1: Operational Ratings.....	8
Table 5.1: Pinning of Power supply.....	9
Table 5.2: Pinout for CAN Connection.....	10
Table 5.3: Pinout for RS-232 Connection.....	10
Table 5.4: Pinout for RS-485 Connection.....	11
Table 5.5: Pinout for using the Step/Direction-Interface.....	12
Table 5.6: Pinout for the connections using the SPI-Interface.....	15
Table 5.7: Pinout of the reference switch inputs.....	19
Table 5.8: Pinout Serial Peripheral Interface.....	20
Table 5.9: Additional I/O pins.....	21
Table 5.10: Miscellaneous Connections.....	21
Table 7.1: TMC428 Velocity parameters.....	24
Table 9.1: Documentation Revisions.....	26
Table 9.2: Hardware Revisions.....	26
Table 9.3: Firmware Revisions.....	26

1 Features

The TMCM-342 is a triple axis stepper motor controller module for external power drivers with step / direction interface. With its very small size it is dedicated to embedded applications, where centralized or de-centralized high power drivers are desired. The board can be connected to a baseboard or customized electronics with a pin connector. The TMCM-342 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. The TMCM-342 can be controlled via the serial UART interface (e.g. using a RS-232 or RS-485 level shifter) or via CAN. Communication traffic is kept very low since all time critical operations, e.g. ramp calculation, are performed on board. The TMCL operations can be stored in the onboard EEPROM for stand-alone operation. The firmware of the module can be updated via the serial interface as well as via the CAN interface.

Applications

- Controller board for control of up to 3 Step / Direction drivers e.g. TMCM-035, TMCM-023 (triple driver), IDX or PD-013-42 mechatronic module or TMCM-078 step/direction driver
- Versatile possibilities of applications in stand alone or host controlled mode

Electrical Data

- 5V DC logic power supply
- TTL / CMOS step / direction outputs

Interface

- RS-232, RS-485 (max. 115200bps) or CAN 2.0b (max. 1MBit/s) host interface
- Inputs for reference and stop switches, general purpose analog and digital I/Os

Highlights

- Three motion controllers for high step frequency
- Automatic ramp generation in Hardware
- On the fly alteration of motion parameters (e.g. position, velocity, acceleration)
- High dynamics: step frequencies up to 300kHz
- 1.8µs step pulse length and step to direction delay

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
- Size: 80x50mm²

Order code	Description
TMCM-342 (-option)	3-axis controller module with step/dir. Outputs
Related products	BB-302, TMCM-EVAL, BB-323-02
Option	
-H	horizontal pin connector (standard)
-V	vertical pin connector (on request)

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.

© TRINAMIC Motion Control GmbH & Co. KG 2008

Information given in this data sheet is believed to be accurate and reliable. However no responsibility is assumed for the consequences of its use nor for any infringement of patents or other rights of third parties, which may result from its use.

Specifications are subject to change without notice.

3 Electrical and Mechanical Interfacing

3.1 Dimensions

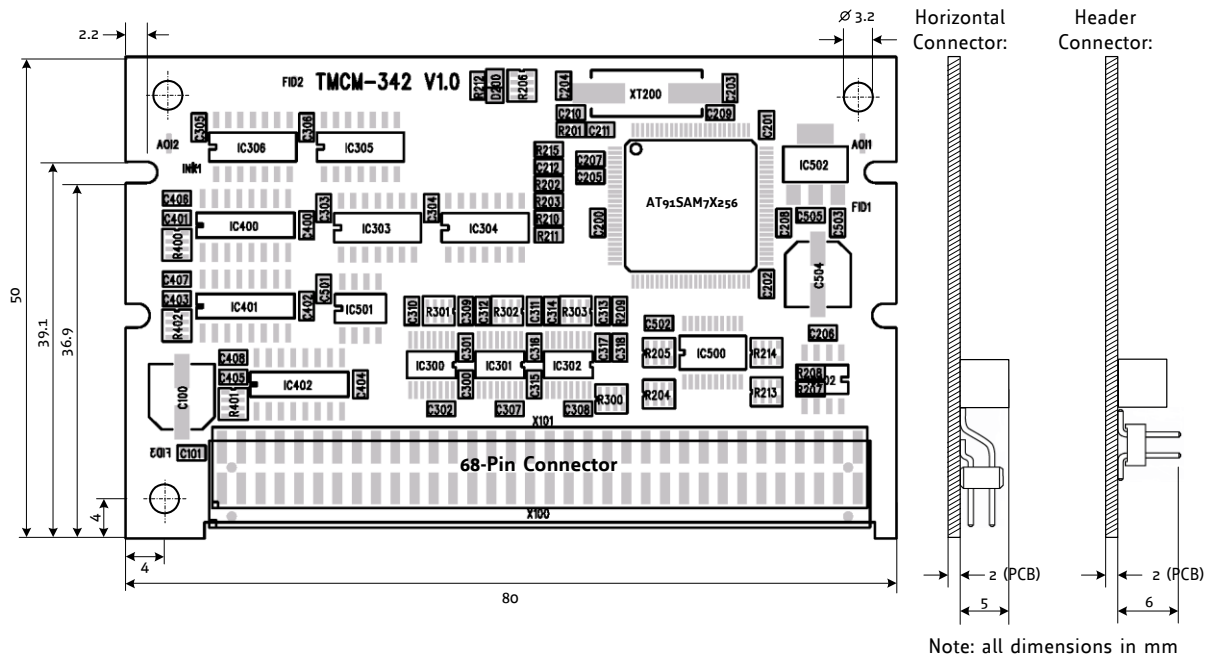


Figure 3.1: Dimensions

The size of the module (80x50mm) is the same as of many other Trinamic motion control modules. It also uses the same connector.

The 68 pin connector has a 2.0mm pitch.

3.2 Connecting the Module

The 68-pin connector provides communication to a host, configuration of the EEPROM and connection of step / direction drivers 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		+5VDC (+/- 5%) $I_{max}=50mA$	35	Out	STEP_M1
2		GND	36	Out	SPI_M2_CLK
3		+5VDC (+/- 5%)	37	Out	DIR_M1
4		GND	38	In	SPI_Mo_IN
5		Internally not connected	39	Out	STEP_M2
6		GND	40	In	SPI_M1_IN
7		Internally not connected	41	Out	DIR_M2
8		GND	42	In	SPI_M2_IN
9		Internally not connected	43	In	Shutdown
10		GND	44	-	Reserved
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 left	53	In	General Purpose input 4
20	Out	nSCS0	54	Out	General Purpose output 4
21	In	Reference Switch Motor 0 right	55	In	General Purpose input 5
22	Out	nSCS1	56	Out	General Purpose output 5
23	In	Reference Switch Motor 1 left	57	In	General Purpose input 6
24	Out	nSCS2	58	Out	General Purpose output 6
25	In	Reference Switch Motor 1 right	59	In	General Purpose input 7
26	Out	SPI_Mo_OUT	60	Out	General Purpose output 7
27	In	Reference Switch Motor 2 left	61		GND
28	Out	SPI_Mo_CLK	62		GND
29	In	Reference Switch Motor 2 right	63	-	Reserved
30	Out	SPI_M1_OUT	64	Out	RS-485 Direction
31	Out	STEP_Mo	65	InOut	CAN -
32	Out	SPI_M1_CLK	66	In	RS-232 RxD
33	Out	DIR_Mo	67	InOut	CAN +
34	Out	SPI_M2_OUT	68	Out	RS-232 TxD

Table 3.1: Pinout of the 68-Pin Connector

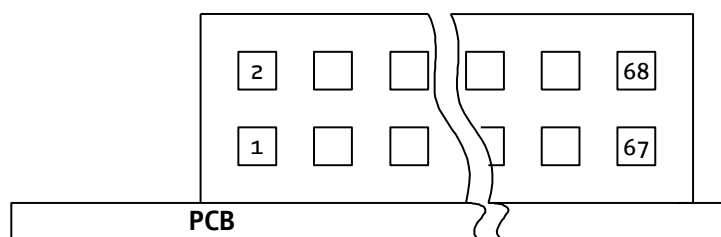


Figure 3.2: Pin order of the connector

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_{+5V}	+5V DC input (max. 300mA)	4.75	5.0	5.25	V
f_{STEP}	Maximum step frequency			300	kHz
t_{SPulse}	Step pulse length	1.5	1.8	2.4	μs
t_{S2D}	Step to direction delay	1.5	1.8	2.4	μs
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		0 ... 5		V
V_{INLO}	INx, StopL, StopR low level input		0	0.9	V
V_{INHI}	INx, StopL, StopR high level input	2	5		V
I_{OUTI}	OUTx max +/- output current (CMOS output) (sum for all outputs max. 50mA)		0..10	+/-20	mA
T_{ENV}	Environment temperature at rated current (no cooling)	-40		+70	$^{\circ}C$

Table 4.1: Operational Ratings

5 Functional Description

In Figure 5.1 the main parts of the TMCM-342 module are shown. The module mainly consists of three TMC428 motion controllers, the TMCL program memory (EEPROM) and the host interfaces (RS-232, RS-485 and CAN).

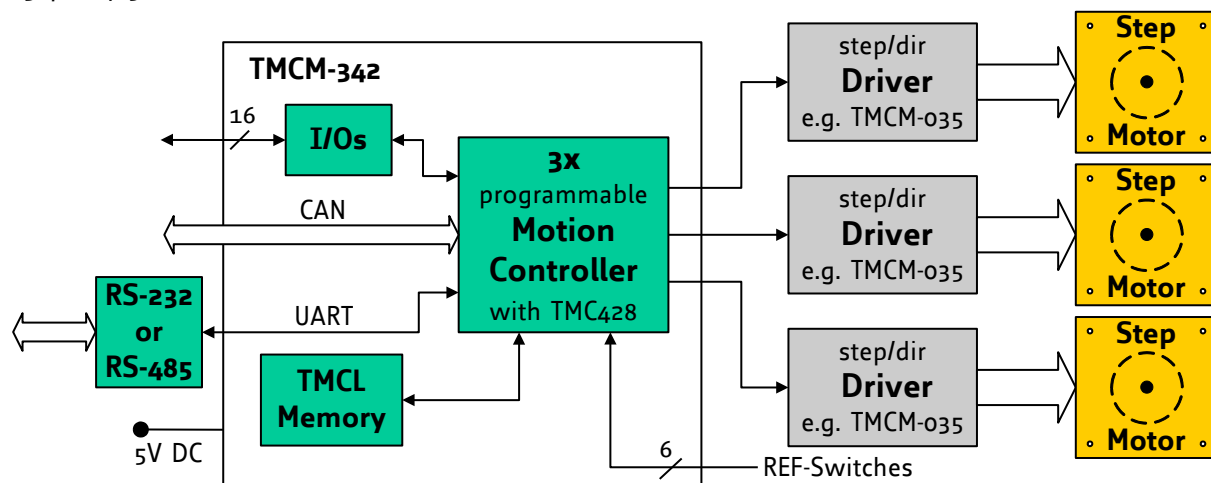


Figure 5.1: Main parts of the TMCM-342

5.1 System Architecture

The TMCM-342 integrates a microcontroller with the TMCL (Trinamic Motion Control Language) operating system. The motion control real-time tasks are realized by three TMC428 chips.

5.1.1 Microcontroller

On this module, the Atmel AT91SAM7X256 microcontroller is used to communicate with the host and the EEPROM 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, RS-485 and CAN interface. These commands are interpreted by the microcontroller and then converted into SPI-datagrams which are then sent to the TMC428.

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.

5.1.2 TMCL EEPROM

To store TMCL programs for stand-alone operation and for storing configuration data the TMCM-342 module is equipped with a 16kByte EEPROM attached to the microcontroller. The EEPROM can store TMCL programs consisting of up to 2048 TMCL commands.

5.1.3 TMC428 Motion Controller

The TMC428 is a high-performance stepper motor control IC and can control up to three 2-phase-stepper-motors. On the TMCM-342 three TMC428 are used to get fastest calculation of ramps and highest step frequencies. Motion parameters like speed or acceleration are sent to the TMC428 via SPI by the microcontroller. Calculation of ramps and speed profiles are done internally by hardware based on the target motion parameters.

5.1.4 Interface to the external drivers

Drivers are not included on the module. To drive stepper motors with this module, stepper motor drivers have to be added externally. To drive a stepper motor with the Step/Direction-Interface, a power driver module has to be added, which can evaluate the Step/Direction-signals. Also stepper motor drivers with an SPI-Interface can be added, but this module is mainly intended for use with Step/Direction drivers.

5.2 Power Supply

The power supply for the TMCM-342 is +5VDC for module functionality. Please use all listed pins for the power supply inputs and ground parallel. Refer to 6.

Pin	Function
1, 3	+5V DC (+/- 5%), $I_{max}=50mA$ power supply (plus current required for outputs)
2, 4, 6, 8, 10	Ground

Table 5.1: Pinning of Power supply

5.3 Host Communication

Communication to a host takes place via one or more of the onboard interfaces. The module provides a wide range of different interfaces, like CAN, RS-232 and RS-485. The following chapters explain how the interfaces are connected with the 68-pin connector.

5.3.1 CAN 2.0b

Pin Number	Direction	Name	Limits	Description
65	InOut	CAN -	-8...+18V	CAN Input / Output
67	InOut	CAN +	-8...+18V	CAN Input / Output

Table 5.2: Pinout for CAN Connection

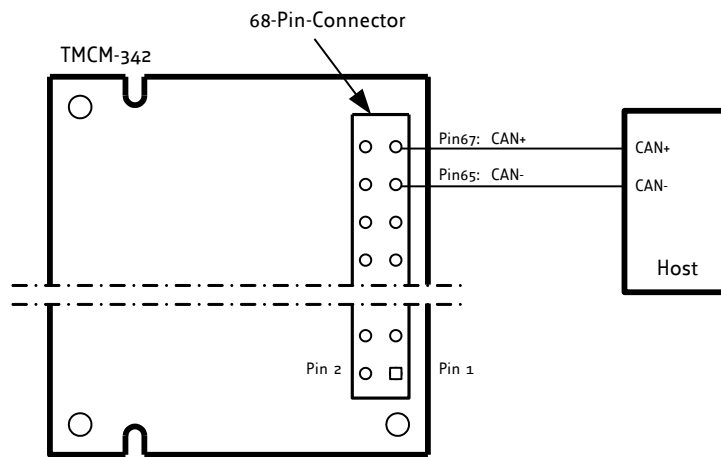


Figure 5.2: Connecting CAN

5.3.2 RS-232

Pin Number	Direction	Name	Limits	Description
66	In	RxD	TTL	RS-232 Receive Data
68	Out	TxD	TTL	RS-232 Transmit Data
2, 4, 6, 8, 10	In	GND	0V	Connect to ground

Table 5.3: Pinout for RS-232 Connection

Note: The module only provides serial signals with TTL level. For using RS232, a suitable RS232 level shifter (like MAX202) has to be added by the user.

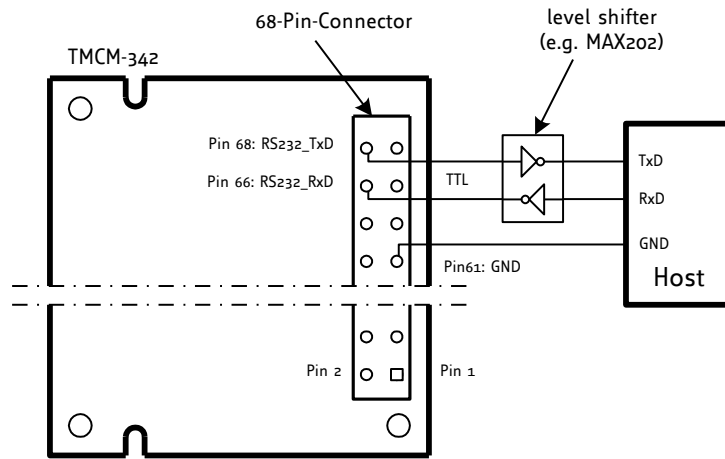


Figure 5.3: Connecting RS-232

5.3.3 RS-485

Pin Number	Direction	Name	Limits	Description
64	Out	RS485_DIR	TTL	Driver / Receiver enable for RS-485 Transceiver. 0: Receiver enable 1: Driver enable
66	In	RxD	TTL	RS-485 Receive Data
68	Out	TxD	TTL	RS-485 Transmit Data
2, 4, 6, 8, 10	In	GND	0V	Connect to ground

Table 5.4: Pinout for RS-485 Connection

Note: The TMCM-342 module only provides TTL level signals. For using RS485 a suitable RS485 transceiver (like MAX485) has to be added by the user.

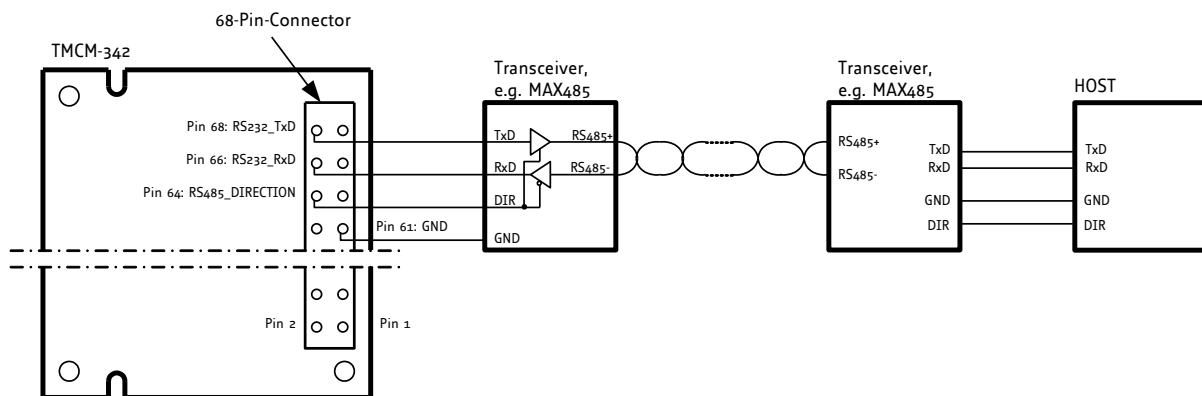


Figure 5.4: Connecting the RS-485 interface

Via RS-485 Interface it is possible to build up systems with of 31 (with repeater 254) modules, which are addressable by one host.

5.4 Step-/Direction output

The TMCM-342 generates step- and direction output signals, which are pre-conditioned in order to be directly connected to microstep driver units with 5V inputs. See Figure 5.5 for the output timing. Some driver units might require inverters / level shifters in order to adapt step polarity and voltage. You can use standard open collector level shifters like the SN7407 or inverters like SN7406. These devices allow level translation to 12V or 24V, or inversion of the step signal, if the device timing requires this. One 7406 or 7407 can shift all six output signals. In order not to lose any steps, please make sure that your driver unit can work with the step-to-direction delay and with the step impulse length.

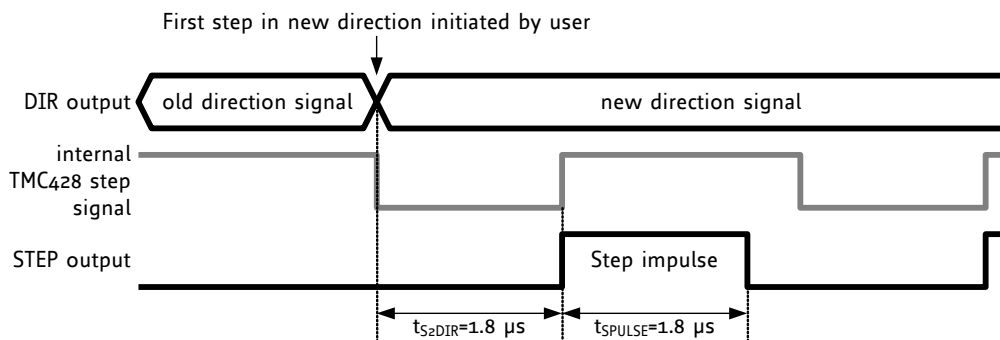


Figure 5.5: Step-/Direction output signals

5.5 Connecting the drivers

Because there are no stepper motor drivers included on the TMCM-342, an Add-On-Board has to be developed to drive the stepper motors. Some examples of Trinamic’s own driver modules are added below. Please refer to www.trinamic.com for more information. Normally, a step/direction interface is used to connect the driver. Using the SPI interface would also be possible, but is normally not used with this module (compare TMCM-301 for SPI applications).

5.5.1 Connecting the TMCM-342 to a power driver module with Step/Direction-Interface

Pin Number	Direction	Name	Limits	Description
31	Out	STEP_M0	TTL	Step-Signal for Driver 0
33	Out	DIR_M0	TTL	Direction-Signal for Driver 0
35	Out	STEP_M1	TTL	Step-Signal for Driver 1
37	Out	DIR_M1	TTL	Direction-Signal for Driver 1
39	Out	STEP_M2	TTL	Direction-Signal for Driver 2
41	Out	DIR_M2	TTL	Serial Clock for the Driver 2

Table 5.5: Pinout for using the Step/Direction-Interface

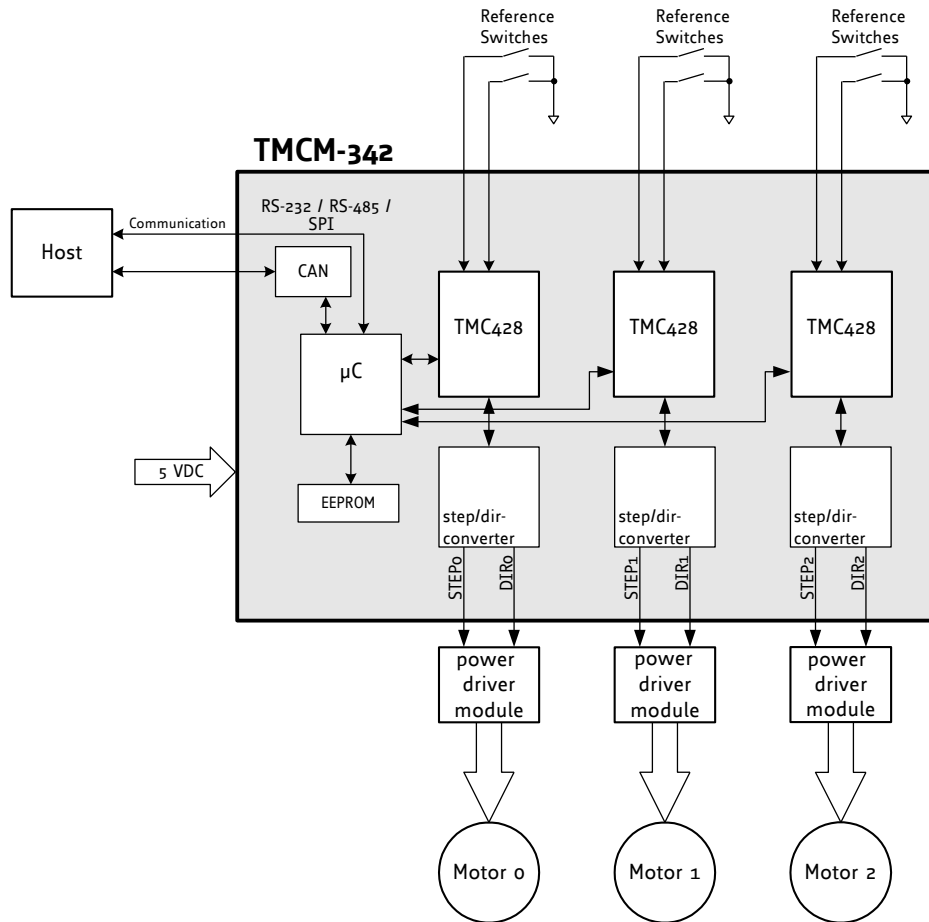
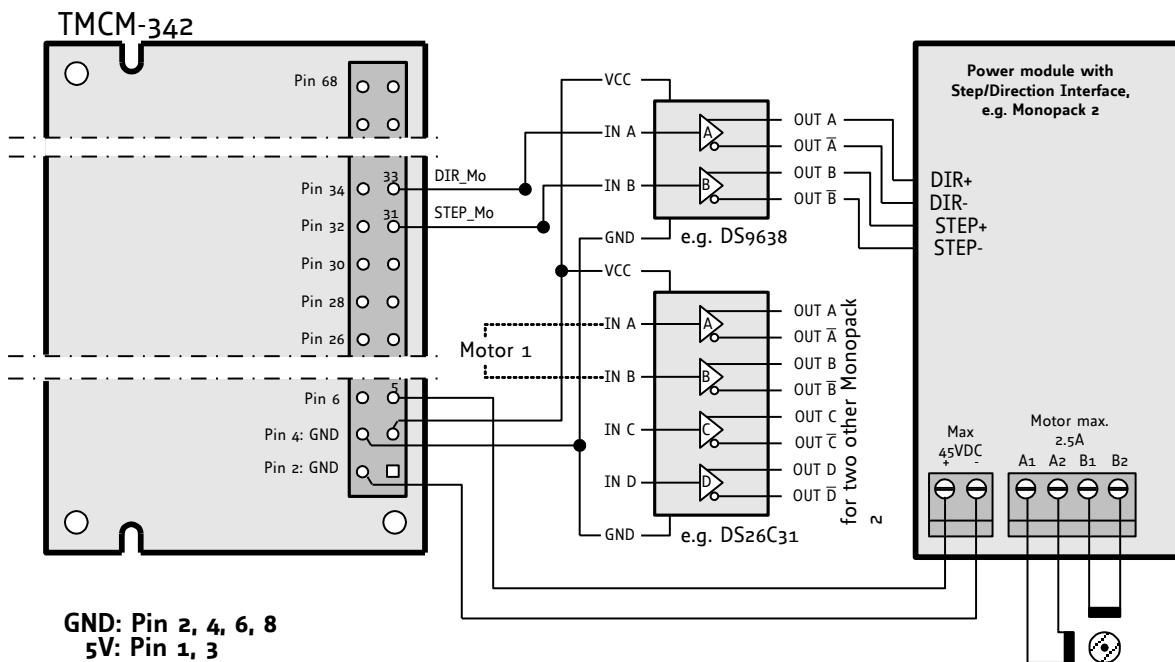


Figure 5.6: Application Environment using the Step/Direction-Interface

Examples: Connection of the TMCM-342 with the Monopack2 (power driver module with a Step/Direction-Interface), TCMC-023 or TCMC-013.



GND: Pin 2, 4, 6, 8
5V: Pin 1, 3

Figure 5.7: Application with power module Monopack 2 with a Step/Direction-Interface

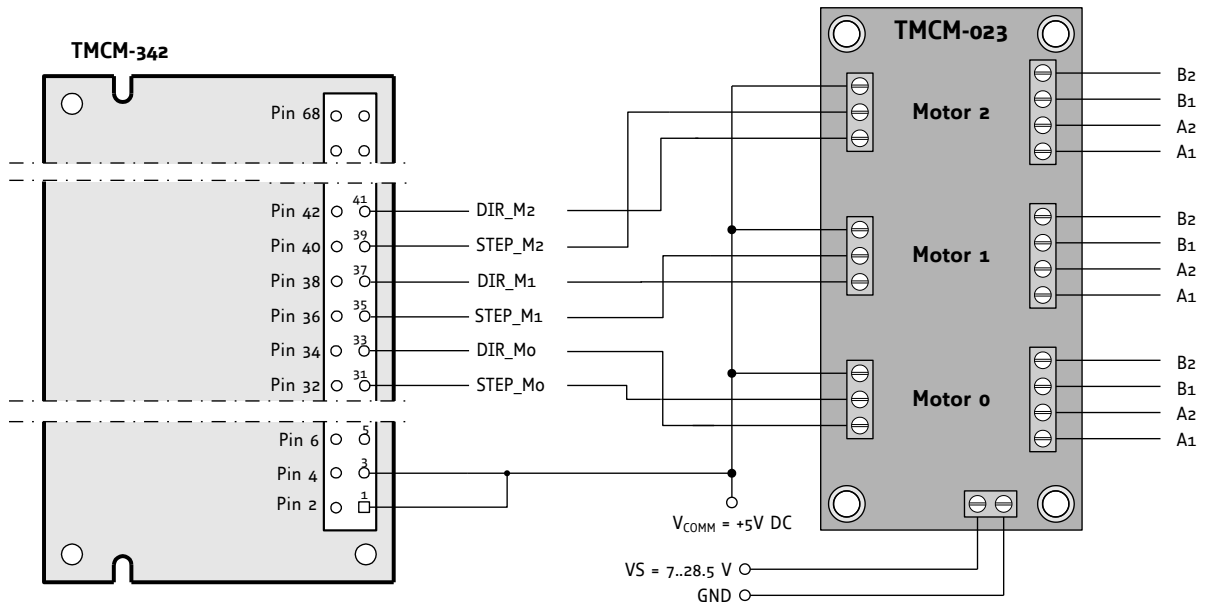


Figure 5.8: Application with TCM-023 with 3 Step/Direction-Interfaces (5V inputs required, please see latest TCM-023 documentation for modifications)

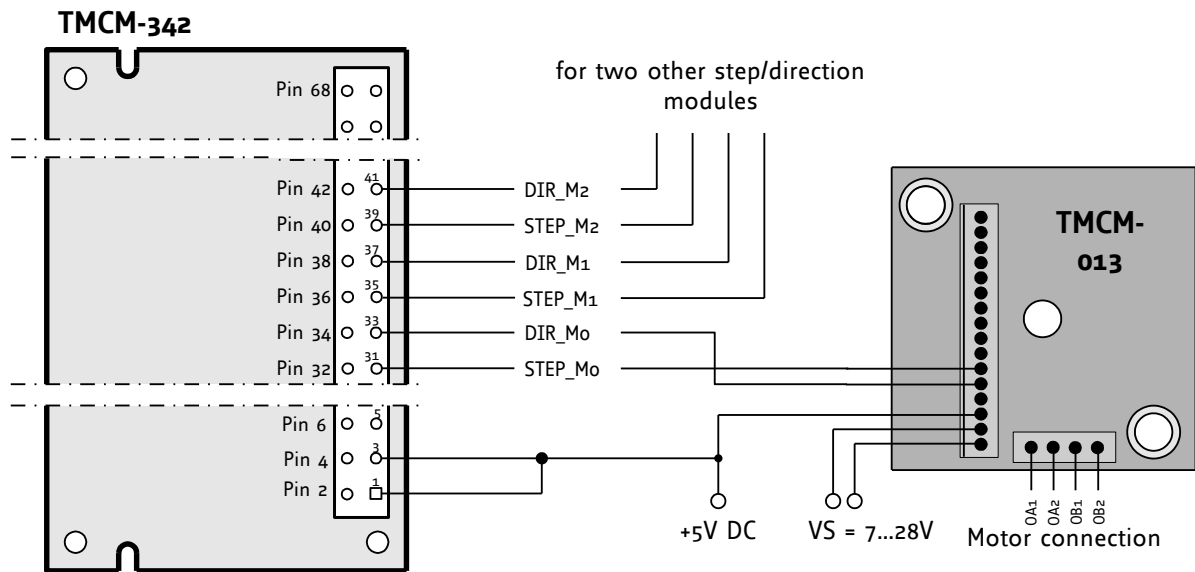


Figure 5.9: Application with TCM-013 with a Step/Direction-Interface

5.5.2 Connecting the TMCM-342 to drivers with an SPI-Interface

The pins connecting the TMCM-342 with the Add-On-Board using the SPI-Interface are listed in Table 5.6. This is only listed here for the sake of completeness. It is not directly supported by the firmware of the TMCM-342. Please use the TMCM-341 for using SPI motor drivers.

Pin Number	Direction	Name	Limits	Description
20	Out	nSCS0	TTL	Chip Select for Driver 0
22	Out	nSCS1	TTL	Chip Select for Driver 1
24	Out	nSCS2	TTL	Chip Select for Driver 2
26	Out	SPI_M0_OUT	TTL	SPI Data In for Driver 0
28	Out	SPI_M0_CLK	TTL	SPI Clock for Driver 0
30	Out	SPI_M1_OUT	TTL	SPI Data In for Driver 1
32	Out	SPI_M1_CLK	TTL	SPI Clock for Driver 1
34	Out	SPI_M2_OUT	TTL	SPI Data In for Driver 2
36	Out	SPI_M2_CLK	TTL	SPI Clock for Driver 2
38	In	SPI_M0_IN	TTL	SPI Data Out for Driver 0
40	In	SPI_M1_IN	TTL	SPI Data Out for Driver 1
42	In	SPI_M2_IN	TTL	SPI Data Out for Driver 2

Table 5.6: Pinout for the connections using the SPI-Interface

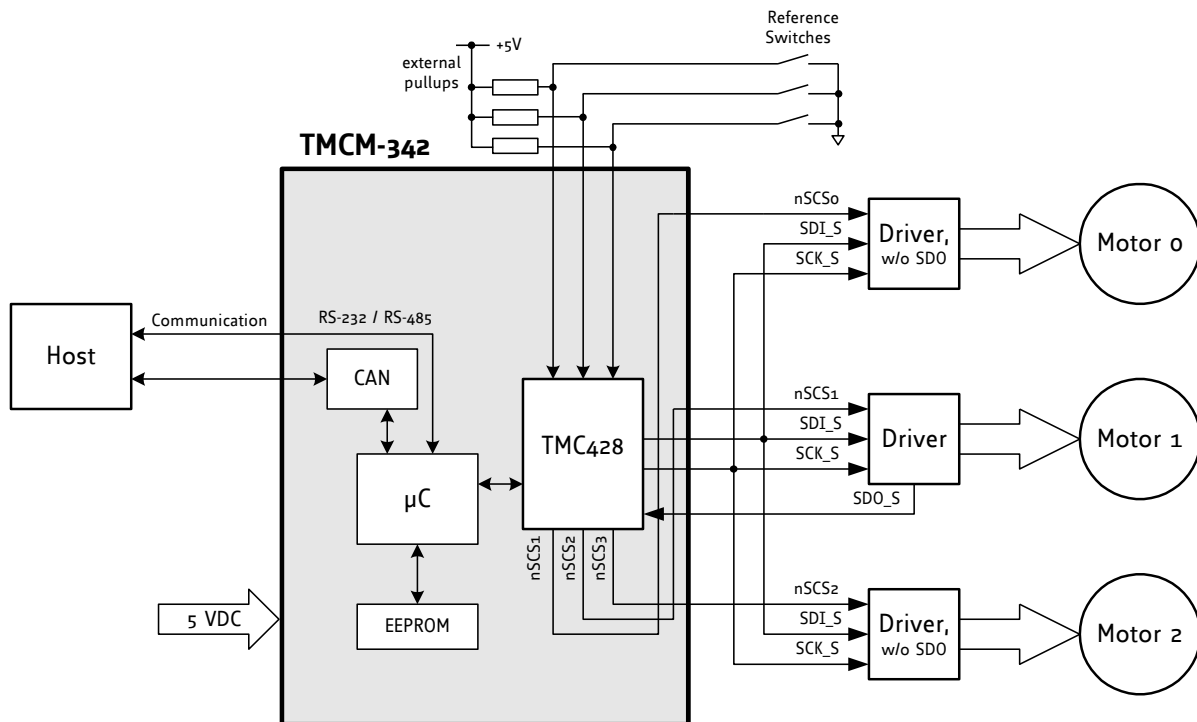


Figure 5.10: Application Environment using the SPI-Interface

Example : Using the TMC236 stepper motor driver with an SPI-interface

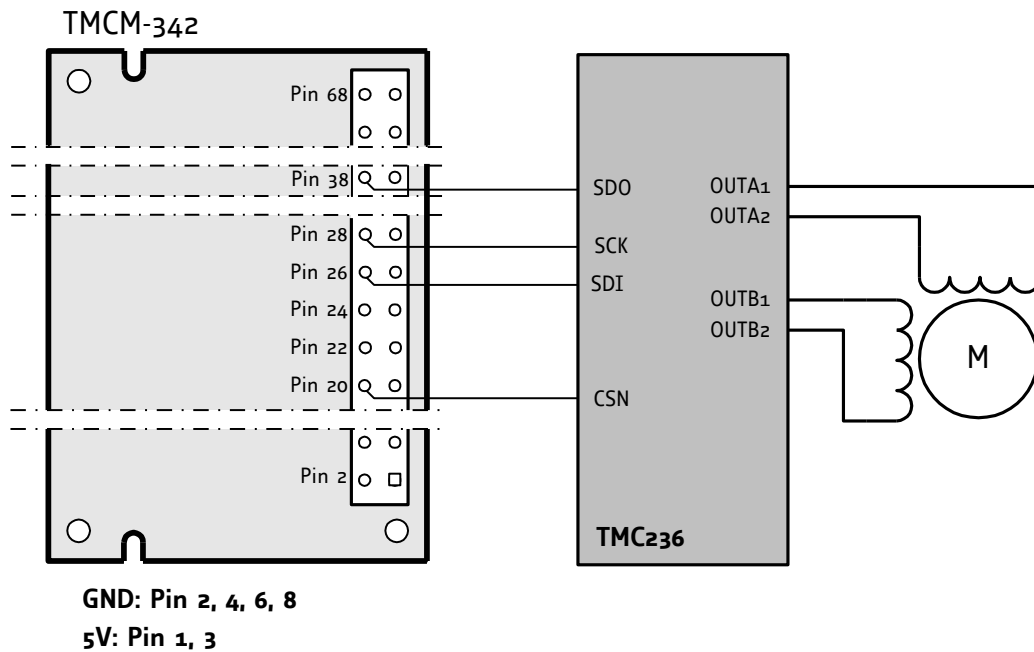


Figure 5.11: Application with an SPI-stepper motor driver

5.6 Power supply requirements with drivers

The TMCM-342 is supplied with +5VDC, the drivers need an additional power supply 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 drivers. This ensures a stable power supply and minimizes noise injected into the power supply cables. The choke especially becomes necessary with larger distributed systems using a common power supply.

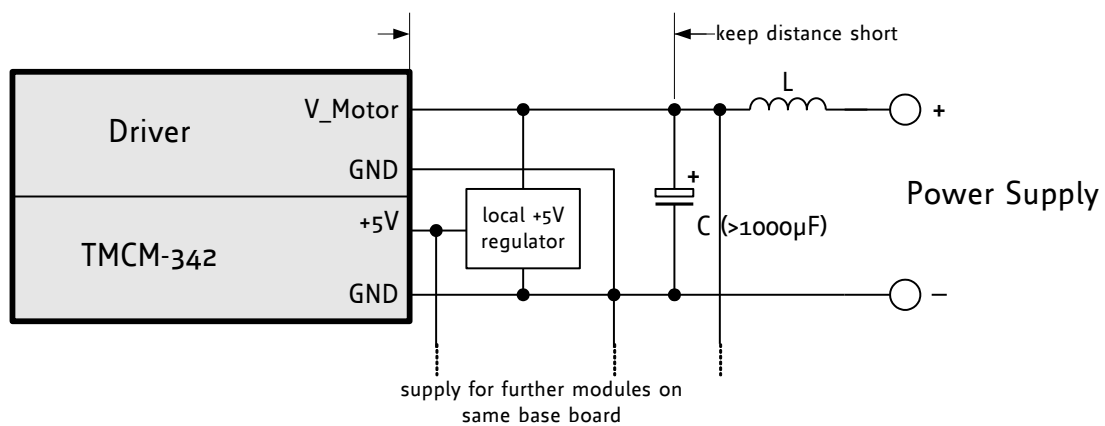


Figure 5.12: Power supply requirements for TMCM-342 with additional driver

Especially with 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. Not all hints have to be followed:

- 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 with the same power supply which are mounted in a distance of more than a few meters.
- 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 base-board.

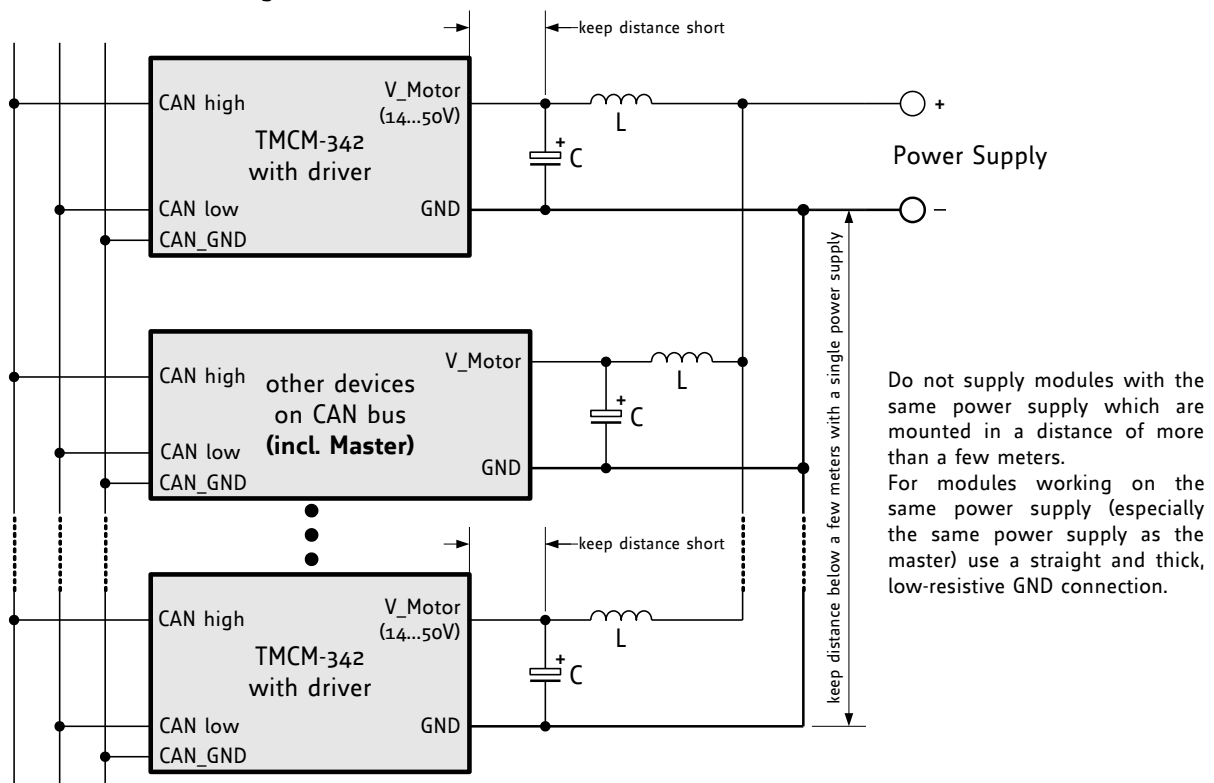


Figure 5.13: Power supply requirements for TMC-Modules in a bus system

For large systems, an optically decoupled CAN bus for each number of nodes, e.g. for each base board with a number of TMCM-34X modules with drivers may make sense, 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.

5.7 Ramp Profiles

The speed profile is automatically worked out by the TMCM-342 from the values for the minimum speed, maximum speed and acceleration specified by the user with the TMCL. Two modes of operation for the course of velocity are available for selection.

- In the **Ramp-Mode** the maximum acceleration (a_{max}), maximum (v_{max}) and minimum (v_{min}) speed and the target position (x_{target}) are specified to calculate the actual velocity. By giving the target position, the TMCM-342 calculates the speed profile of each stepper motor from the current position and the specified parameters and immediately converts it into a motion sequence. In Figure 5.14, an example of the motion sequence is shown. Here the motor accelerates from t_0 onwards with a_{max} till it reaches v_{max} in t_1 , then it moves itself with v_{max} up to t_2 , it then slows down with a_{max} till it reaches v_{min} in t_3 and then it travels with v_{min} till it reaches its target (x_{target}) in t_4 . On the right side of the Figure it can be seen that v_{max} cannot be reached if a_{max} is too small or the target (x_{target}) is too close.

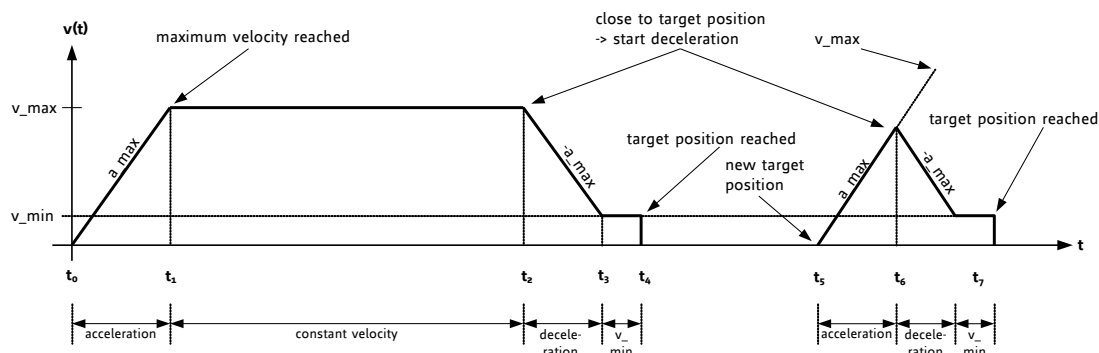


Figure 5.14: Velocity profile in ramp mode

- In **Velocity-Mode** the acceleration and the maximum speed is specified in the TMCM-342. Then the motor accelerates immediately with the specified value to the maximum speed and continues to run at constant speed till new values are sent to the TMCM-342. In Figure 5.15 the motion sequence for the velocity mode is shown as an example. Here the motor accelerates with a_{max} till it reaches the maximum velocity and then continues to run at constant speed with v_{max} till new a_{max} and v_{max} is specified. On the right side and at t_5 the v_{max} is not distinctly reached if a new parameter is prematurely given.

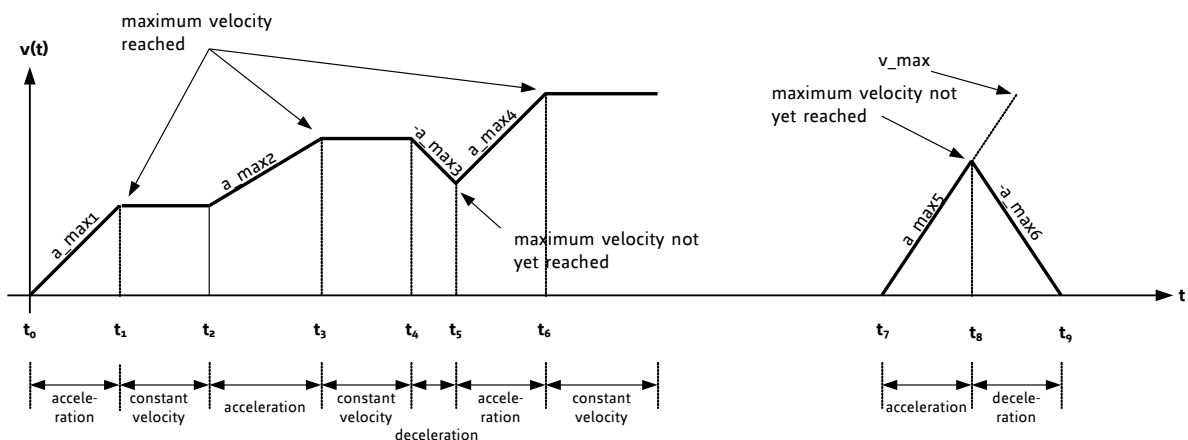


Figure 5.15: Velocity profile in velocity mode

A detailed explanation of the parameters and its calculation is given in the software description.

5.8 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. All reference switch inputs are equipped with pull-up resistors.

Pin Number	Direction	Name	Limits	Description
19	In	STOPoL	TTL	Left reference switch input for Motor #0
21	In	STOPoR	TTL	Right reference switch input for Motor #0
23	In	STOP1L	TTL	Left reference switch input for Motor #1
25	In	STOP1R	TTL	Right reference switch input for Motor #1
27	In	STOP2L	TTL	Left reference switch input for Motor #2
29	In	STOP2R	TTL	Right reference switch input for Motor #2

Table 5.7: Pinout of the reference switch inputs

5.8.1 Left and right limit switches

The TMCM-342 can be configured so that a motor has a left and a right limit switch (Figure 5.16). The motor stops when the traveler has reached one of the limit switches.

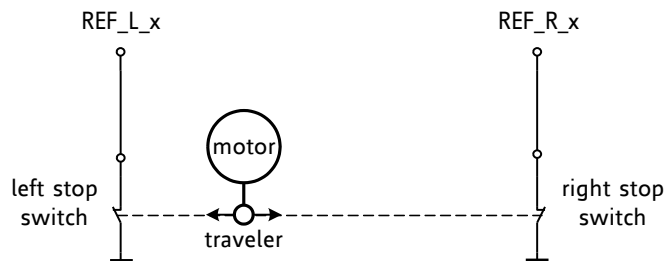


Figure 5.16: Left and right limit switches

5.8.2 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 5.17. 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.

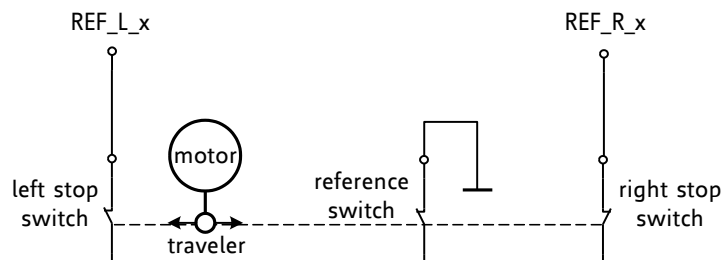


Figure 5.17: Limit switch and reference switch

5.8.3 One Limit Switch for circular systems

If a circular system is used (Figure 5.18), only one reference switch is necessary, because there are no end-points in such a system.

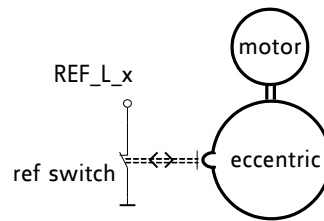


Figure 5.18: One reference switch

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.

5.9 Serial Peripheral Interface (SPI)

On-board communication is performed via the Serial Peripheral Interface (SPI), where 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 Number	Direction	Name	Limits	Description
11	Out	SPI_SELo	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 5.8: Pinout Serial Peripheral Interface

5.10 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 analog inputs.

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

Table 5.9: Additional I/O pins

5.11 Miscellaneous Connections

Pin Number	Direction	Name	Limits	Description
17	In	Reset	TTL	Reset, active low
18	Out	Alarm	TTL	Alarm, active high
43	In	Shutdown	TTL	Emergency stop

Table 5.10: Miscellaneous Connections

The functionality of the shutdown pin is configurable using in TMCL with global parameter 80 (please see the TMCL reference manual for information on this).

6 Putting the TMCM-342 into Operation

On the basis of a small example it is shown step by step how the TMCM-342 is set into operation. Experienced users could skip this chapter and proceed to chapter 6.

Example: The following application is to implement with the TMCL-IDE Software development environment in the TMCM-342 module. For data transfer between the host PC and the module the RS-232 interface is employed.

A formula how "speed" is converted into a physical unit like rotations per seconds can be found in chapter 8.1.

- 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 RS-232 Interface as specified in 5.3.2.

Step 2: Connect the motor drivers as specified in 5.4

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 to your driver module

Step 5: Switch on the power supply and the motor supply. An on-board LED should starting 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-342 module via the Icon "Download".

Step 8: Press Icon "Run". The desired program will be executed.

A documentation about the TMCL operations can be found in "TMCL Reference and Programming Manual". The next chapter discusses additional operations to turn the TMCM-342 into a high performance motion control system.

7 Migrating from the TMCM-302 to the TMCM-342

Migrating TMCM-302 applications to the TMCM-342 module is easy, as the TMCM-342 can replace a TMCM-302 without problems. The connector of the TMCM-342 is identical to the connector of the TMCM-302, so that a TMCM-342 can just be plugged into a slot that has originally been designed for a TMCM-302 (it can also use the same base boards as the TMCM-302). Also the TMCL firmware of the TMCM-342 module is highly compatible with the TMCM-302. However there are some slight differences that have to be observed (due to the fact that the TMCM-342 has many enhancements compared to the TMCM-302):

- Speed of TMCL program execution: TMCL programs run up twenty times faster than on the TMCM-302 module. In general, the developer of a TMCL program should not make assumptions about command execution times.
- 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 [TMCL] for details. The usage of this command also has to be adapted.
- Default CAN bit rate: the default CAN bit rate of the TMCM-342 module (e.g. after resetting it to factory default settings) is 1000kBit/s (in contrast to 250kBit/s on the TMCM-302).

All other TMCL commands and parameters are the same as with the TMCM-302 module.

8 TMC428 Operational Description

8.1 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	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 8.1: TMC428 Velocity parameters

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

$$\text{usf[Hz]} = \frac{f_{\text{CLK}}[\text{Hz}] \cdot \text{velocity}}{2^{\text{pulse_div}} \cdot 2048 \cdot 32} \quad \text{where "usf" means microstep-frequency}$$

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

$$\text{fsf[Hz]} = \frac{\text{usf[Hz]}}{2^{\text{Usrs}}} \quad \text{where "fsf" means fullstep-frequency}$$

The change in the pulse rate per time unit (pulse frequency change per second – the **acceleration a** is given by

$$a = \frac{f_{\text{CLK}}^2 \cdot a_{\text{max}}}{2^{\text{pulse_div} + \text{ramp_div} + 29}}$$

This results in an acceleration in fullsteps of:

$$\text{af} = \frac{a}{2^{\text{Usrs}}} \quad \text{where "af" means acceleration in fullsteps}$$

Example:

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

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

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

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

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

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

$$\text{RPS} = \frac{\text{fsf}}{\text{fullstepsper rotation}} = \frac{1907.34}{72} = 26.49$$

$$\text{RPM} = \frac{\text{fsf} \cdot 60}{\text{fullstepsper rotation}} = \frac{1907.34 \cdot 60}{72} = 1589.46$$

9 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 is available from TRINAMIC by request to info@trinamic.com

10 CANopen

The TMCM-342 module can also be used with the CANopen protocol. For this purpose, a special CANopen firmware has to be installed. To do this, download the latest version of the TMCM-342 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-342 module is then ready to be used with CANopen. Please see the CANopen manual provided on the Trinamic website and on the TechLibCD on how to use the TMCM-342 module with the CANopen protocol.

11 Revision History

11.1 Documentation Revision

Version	Date	Author	Description
1.00	14-May-2008	OK	Initial version
1.01	8-Dec-08	OK	Migration and CANopen chapters added

Table 11.1: Documentation Revisions

11.2 Hardware Revision

Version	Comment	Description
1.0	Initial release	First version of new generation TMC-342
1.1	Actual version	

Table 11.2: Hardware Revisions

11.3 Firmware Revision

Version	Comment	Description
4.07	Initial release	Please refer to TMCL documentation
4.15	Actual release	

Table 11.3: Firmware Revisions

12 References

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

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