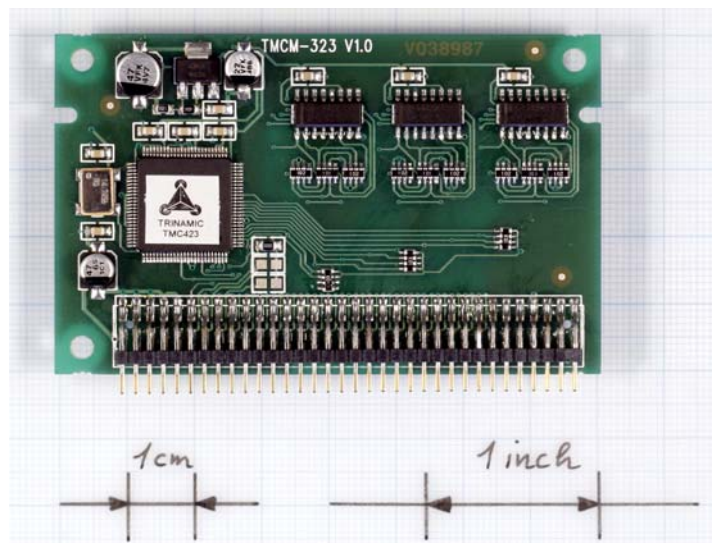


# TMCM-323

## 3- Axis Encoder Interface Module



## Manual

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# TRINAMIC

## MOTION CONTROL

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# 1 Features

The TMCM-323 is a triple axis encoder interface module. It extends three-axis motion control modules for closed loop operation. With its very small size it is dedicated to embedded applications. The board can be connected to a baseboard or to customized electronics with a pin connector. The TMCM-323 interfaces the 3-axis TMCM modules TMCM-301, TMCM-302 or TMCM-303 via SPI. The TMCM-323 contains three real time counters for the incremental encoders so that the actual position data is available without software timing problems.

## Applications

- Encoder interface for three-axis motion control modules
- Provides encoder interface for TMCM-301, TMCM-302 and TMCM-303

## Encoders

- Two or three channel encoders (differential or TTL/CMOS single ended)

## Highlights

- Resolution option adapts encoder resolution to motor microstep resolution in fast hardware
- Extends TMCM-301, TMCM-302 or TMCM-303 for position feedback
- Encoder frequencies up to 4M count/s
- Interface: SPI to host processor
- N-channel event can snapshot encoder counter
- 24 bit encoder counter resolution
- Encoder interface chip: TMC423
- no additional software required

## Other

- 68 pin connector (2 x 34 pins, 2mm pitch) carries all signals
- RoHS compliant latest from 1 July 2006
- Size: 80x50mm<sup>2</sup>

Order code	Description
TMCM-323 (-option)	3-axis Encoder
Related products	BB-323-02, BB-323-03, TMCM-EVAL
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.

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Specifications subject to change without notice.

### 3 Electrical and Mechanical Interfacing

#### 3.1 Dimensions

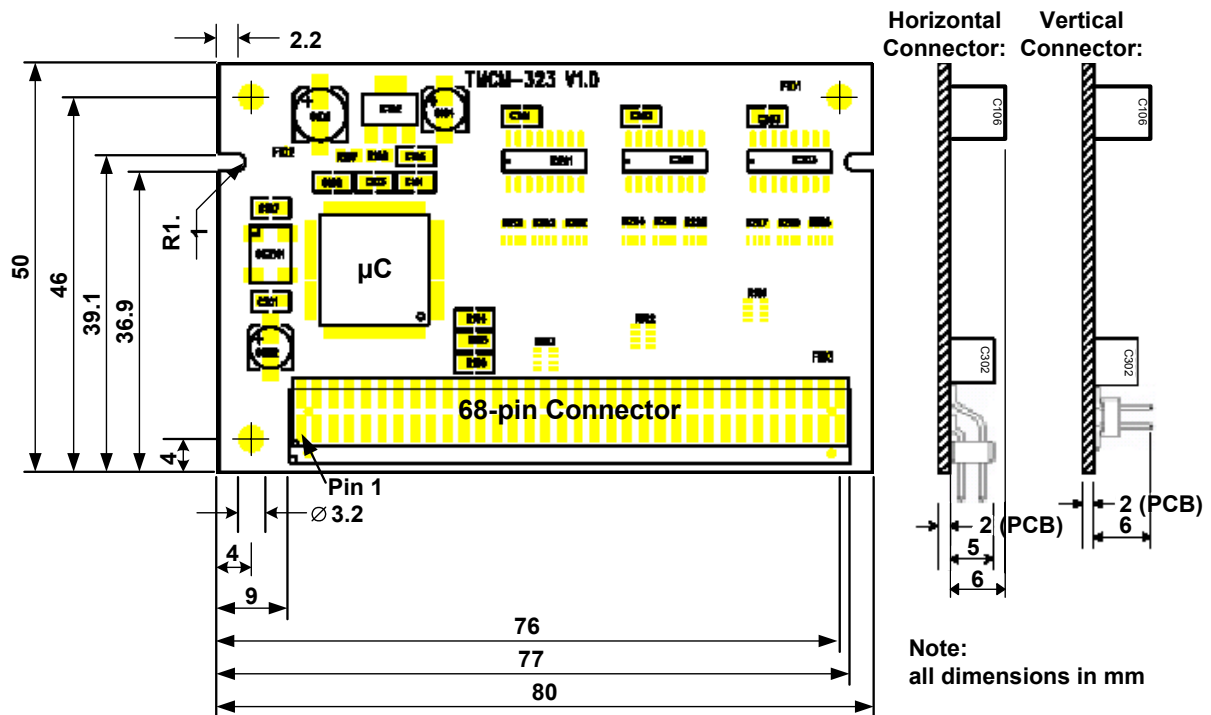


Figure 3.1: Dimensions

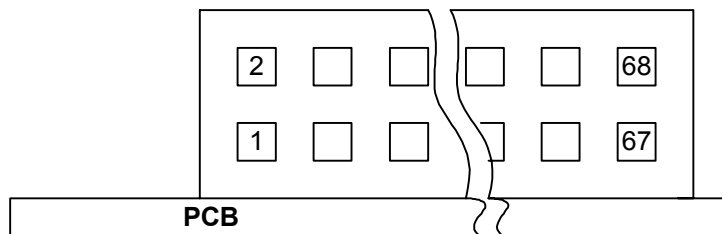


Figure 3.2: Enumeration of pins

## 3.2 Pin assignments

The following table gives an overview of the pin assignments of the 68-pin connector. 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	Signal	Pin	Signal
1	+5V (supply voltage)	2	GND
3	+5V (supply voltage)	4	GND
5	not used, internally connected to pins 7 and 9	6	GND
7	not used, internally connected to pins 5 and 9	8	GND
9	not used, internally connected to pins 5 and 7	10	GND
11	SPI_SEL0 (input, low active)	12	SPI_CLK (input)
13	SPI_SEL1 (input, low active)	14	SPI_MISO (output)
15	SPI_SEL2 (input, low active)	16	SPI_MOSI (input)
17	RESET (input, low active)	18	INT (output, do not connect)
19	Encoder 0 A+	20	Encoder 0 A output
21	Encoder 0 A-	22	Encoder 0 A input
23	Encoder 0 B+	24	Encoder 0 B output
25	Encoder 0 B-	26	Encoder 0 B input
27	Encoder 0 N+	28	Encoder 0 N output
29	Encoder 0 N-	30	Encoder 0 N input
31	Encoder 1 A+	32	Encoder 1 A output
33	Encoder 1 A-	34	Encoder 1 A input
35	Encoder 1 B+	36	Encoder 1 B output
37	Encoder 1 B-	38	Encoder 1 B input
39	Encoder 1 N+	40	Encoder 1 N output
41	Encoder 1 N-	42	Encoder 1 N input
43	Encoder 2 A+	44	Encoder 2 A output
45	Encoder 2 A-	46	Encoder 2 A input
47	Encoder 2 B+	48	Encoder 2 B output
49	Encoder 2 B-	50	Encoder 2 B input
51	Encoder 2 N+	52	Encoder 2 N output
53	Encoder 2 N-	54	Encoder 2 N input
55	not connected	56	not connected
57	not connected	58	not connected
59	not connected	60	not connected
61	GND	62	GND
63	not connected	64	not connected
65	not connected	66	not connected
67	not connected	68	not connected

Table 3.1: Pinout 68-pin connector

## 4 Operational Ratings

Symbol	Parameter	Min	Typ	Max	Unit
$V_{+5V}$	+5V DC input 80mA	4.8	5.0	5.2	V
$V_{\text{single,low}}$	Low input level for single ended encoders	-0.3	0	0.8	V
$V_{\text{single,high}}$	High input level for single ended encoders	2.0	5	5.3	V
$V_{\text{common}}$	Common voltage for differential encoders	-7		12	V
$V_{\text{diff}}$	Differential input voltage	-6		+6	V

Table 4.1: Operational Ratings

## 5 Functional Description

In Figure 5.1 an application for the TMCM-323 is shown. The functionality of a TMCM-323 with a TMCM-30X is given in an easy way in combination with the baseboards BB-323-02 or BB-323-03. Please refer to the baseboard manuals ([www.trinamic.com](http://www.trinamic.com)).

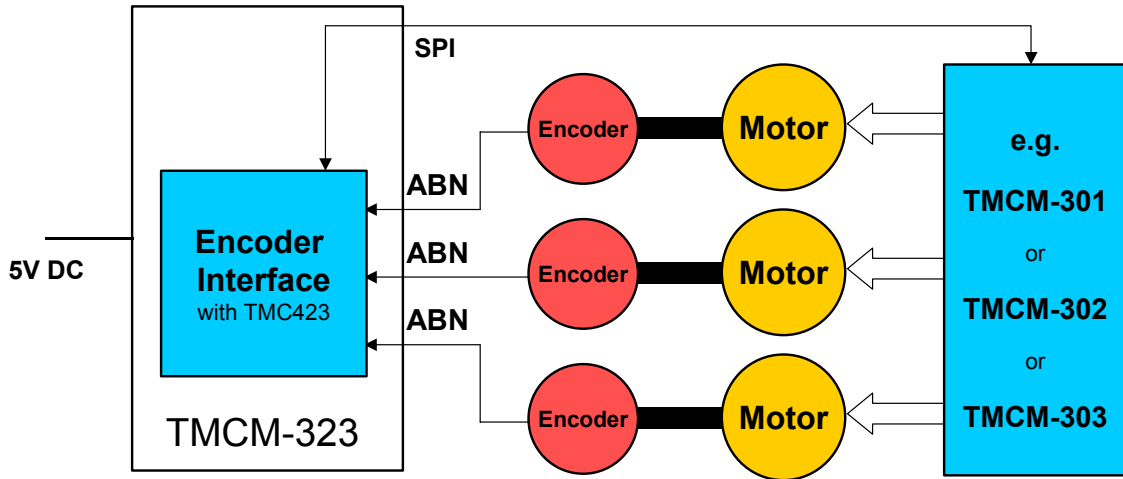


Figure 5.1: Application for TMCM-323

### 5.1 Supply voltage

Only a supply voltage of 5V and approximately 80mA is needed. Connect the supply voltage to pins 1 and 3 of the module. Please bear in mind that the encoders also need their supply voltage (please refer to the data sheet of your encoder). The encoders are not powered by the TMCM-323 module.

### 5.2 Connecting encoders

Digital incremental encoders with either single ended or differential outputs can be used. It is also possible to connect a single ended encoder to one and a differential encoder to another input. The connection is demonstrated in Figure 5.2.

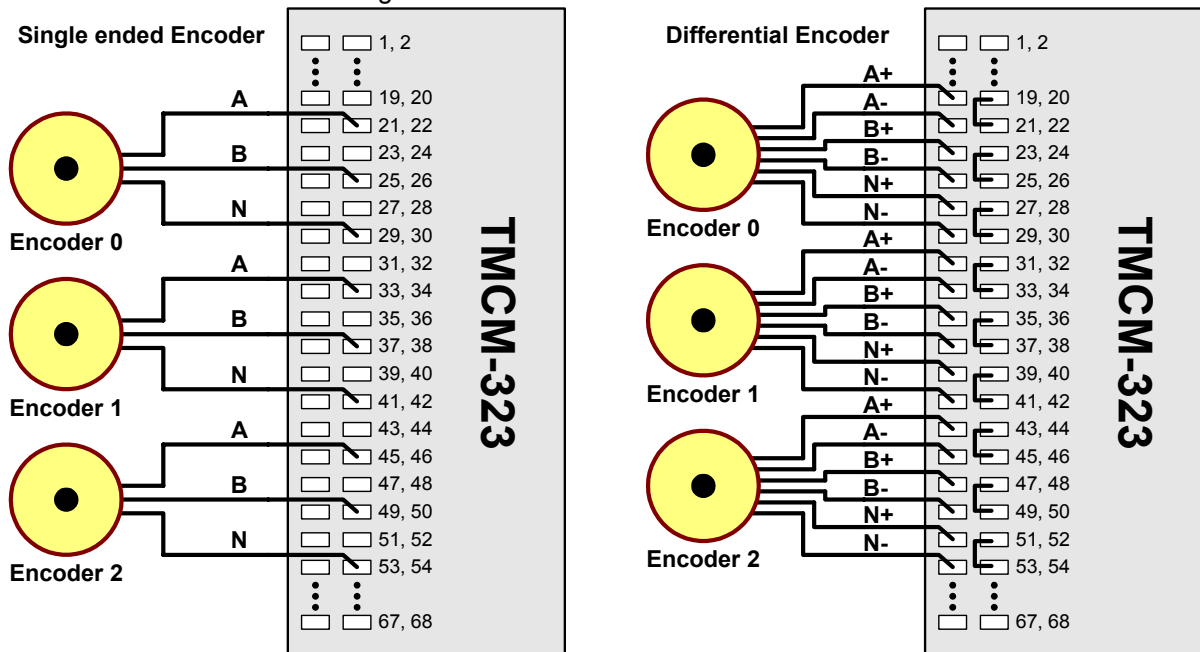


Figure 5.2: Connecting Single Ended and Differential Encoders

### 5.2.1 Connecting encoders with single ended outputs

To connect an encoder with single ended outputs to channel 0 the following connections have to be made:

- Encoder channel A to pin 22 of the TMCM-323
- Encoder channel B to pin 26 of the TMCM-323
- Encoder null channel (N) to pin 30 of the TMCM-323.
- Pins 20, 24, 28 and 19, 21, 23, 25, 27 are not used in this case and should be left open.

To connect an encoder with single ended outputs to channel 1 the following connections have to be made:

- Encoder channel A to pin 34 of the TMCM-323
- Encoder channel B to pin 38 of the TMCM-323
- Encoder null channel (N) to pin 42 of the TMCM-323.
- Pins 32, 36, 40 and 31, 33, 35, 37, 39, 41 are not used in this case and should be left open.

To connect an encoder with single ended outputs to channel 2 the following connections have to be made:

- Encoder channel A to pin 46 of the TMCM-323
- Encoder channel B to pin 50 of the TMCM-323
- Encoder null channel (N) to pin 54 of the TMCM-323.
- Pins 44, 48, 52 and 43, 45, 47, 49, 51, 53 are not used in this case and should be left open.

### 5.2.2 Connecting encoders with differential outputs

For connecting encoders with differential outputs the TMCM-323 module is equipped with differential line receivers. Their inputs are connected to the pins 19, 21, 23, 25, 27, 29, 31, 33, 35, 37, 39, 41, 43, 45, 47, 49, 51, 53 and their outputs are connected to the pins 20, 24, 28, 32, 36, 40, 44, 48, 52 of the module. They can also be used to convert other differential signals into single ended signals.

To connect an encoder with differential outputs to channel 0 the following connections have to be made:

- Encoder channel A+ to pin 19 and encoder channel A- to pin 21 of the TMCM-323
- Encoder channel B+ to pin 23 and encoder channel B- to pin 25 of the TMCM-323
- Encoder channel N+ to pin 27 and encoder channel N- to pin 29 of the TMCM-323
- Connect pin 20 to pin 22, pin 24 to pin 26 and pin 28 to pin 30 of the TMCM-323.

To connect an encoder with differential outputs to channel 1 the following connections have to be made:

- Encoder channel A+ to pin 31 and encoder channel A- to pin 33 of the TMCM-323
- Encoder channel B+ to pin 35 and encoder channel B- to pin 37 of the TMCM-323
- Encoder channel N+ to pin 39 and encoder channel N- to pin 41 of the TMCM-323
- Connect pin 32 to pin 34, pin 36 to pin 38 and pin 40 to pin 42 of the TMCM-323.

To connect an encoder with differential outputs to channel 2 the following connections have to be made:

- Encoder channel A+ to pin 43 and encoder channel A- to pin 45 of the TMCM-323
- Encoder channel B+ to pin 47 and encoder channel B- to pin 49 of the TMCM-323
- Encoder channel N+ to pin 51 and encoder channel N- to pin 53 of the TMCM-323
- Connect pin 44 to pin 46, pin 48 to pin 50 and pin 52 to pin 54 of the TMCM-323.



## 5.3 Interfacing to other modules

For interfacing to other TMCM modules or microcontrollers the SPI interface is used. The SPI pins of the TMCM-323 modules (pins 12, 14 and 16) and one of the selection pins (normally pin 11) are directly connected to the TMC423 encoder interface chip that is used on the TMCM-323 module. To connect the TMCM-323 module to a TMCM-301, TMCM-302 or TMCM-303 module the following connections are needed:

TMCM-301/302/303 pin	TMCM-323 pin
12	12
14	14
16	16
11 or 13 or 15	11

**Table 5.1: SPI connection to other TMCM modules**

The reset pin (17) of the TMCM-323 module must be connected to a reset circuit. Alternatively, it can be connected to an output pin that must be set low and then high again at startup.

TMCL version 3.21 or higher provides some special commands to configure the TMCM-323 module and to read out encoder values. Please see chapter 6 for additional information. When connecting the TMCM-323 to other microcontrollers instead of a TMCM module please see the TMC423 datasheet on how to program the TMC423 encoder interface chip.

## 6 Using the TMCM-323 module with TMCL

### 6.1 Initializing the encoder

TMCL version 3.25 or higher provides some special functions to initialize the TMCM-323 and to read out or reset the encoder positions (TMCL versions 3.21, 3.22, 3.23 and 3.24 also provide these functions, but there is a bug in the encoder initialization functions of these TMCL versions. So please use at least version 3.25).

First of all, the TMCM-30x module must be configured so that it can talk to the TMCM-323 module. To accomplish this, the global parameter #74 (encoder configuration) is used. This parameter is normally set to 0, so that no TMCM-323 module is connected. To make use of a TMCM-323 that is connected to a TMCM-30x module this parameter has to be set depending on which SPI\_SEL pin is used:

SPI_SEL pin of the TMCM-30x module	Global parameter #74 setting
SPI_SEL0 (pin 11)	1
SPI_SEL1 (pin 13)	2
SPI_SEL2 (pin 15)	3

**Table 6.1: TMCL – SPI selection**

When the global parameter #74 is set to 1, 2 or 3 the TMCM-30x tries to initialize the TMCM-323 at startup.

To read out or to change the position value of an encoder, axis parameter #209 is used. So, to read out the position of encoder 0 use GAP 209, 0. To read out the position of encoder 1 use GAP 209, 1 and to read out the position of encoder 2 use GAP 209, 2.

The position values can also be changed using SAP commands. SAP 209, 0, <n> will change the value of encoder 0 to <n>. The same can be done with encoder 1 and 2.

To change the pre-scaler value 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 change the pre-scaler of encoder 1 use SAP 210, 1, <p> and to change the pre-scaler of encoder 2 use SAP 210, 2, <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
<b>512</b>	<b>1</b>	<b>SAP 210, M0, 512</b>	<b>1600</b>
800	1.5625	SAP 210, M0, 800	2500
66144	1.6	SAP 210, M0, 66144	2560
1024	2	SAP 210, M0, 1024	3200
1600	3.125	SAP 210, M0, 1600	5000
67104	3.2	SAP 210, M0, 67104	5120
2048	4	SAP 210, M0, 2048	6400
3200	6.25	SAP 210, M0, 3200	10000
68672	6.4	SAP 210, M0, 68672	10240
4096	8	SAP 210, M0, 4096	12800
6400	12.5	SAP 210, M0, 6400	20000
71808	12.8	SAP 210, M0, 71808	20480
8192	16	SAP 210, M0, 8192	25600
78432	25.6	SAP 210, M0, 78432	40960
16384	32	SAP 210, M0, 16384	51200
32768	64	SAP 210, M0, 32768	102400

**Table 6.2: TMCL – Pre-scaler values**

Formula for resulting steps per rotation:

$$\text{StepsPerRotation} = \text{LinesOfEncoder} * 4 * \text{PreScaler}$$

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

Add to <p>	Special function
16	Null channel is active high (default: null channel is active low)
8	Hold encoder value only when null channel is triggered (default: always hold encoder value)
4	Clear encoder value when null channel is triggered (default: do not clear on null channel)
2	Trigger null channel at every N signal (default: only at next N signal)
1	Add when rotating CCW, subtract when rotating CW (default: add on CW, subtract on CCW)

**Table 6.3: TMCL – Special function**

**Example:** For a pre-scaler value of 4 with an active high null channel use a p-value of 2048+16 =2064

## 6.2 Additional parameter functions

### 6.2.1 Recovering from a deviation error

After the motor has been stopped because the maximum tolerance has been exceeded, the motor will be stopped and the display displays the number of this motor. To recover from such a situation, you first have to set the value of the motor position register and the value of the encoder position register to the same value again.

- Query the encoder value using GAP 209
- Set the motor position to this value using SAP 1

Alternatively, you can do it the other way round:

- Query the motor position register using GAP 1
- Set the encoder position register to this value using SAP 209

Another alternative would be to set both registers to some other (but the same) value.

After the motor and encoder register are set to the same value again, you can move the motor again using the normal motion commands.

### 6.2.2 Error message caused by deviation error

If a motor is stopped because of a deviation error, the TMCM-323 module initiates an error message. This error message consists of the following seven bytes:

Byte	Meaning
0	Module address
1	Reason for the error 139: Encoder deviation
2	Always 0
3	Always 0
4	Always 0
5	Always 0
6	Number of the motor that caused the error (0..2)

**Table 6.4: Deviation or StallGuard error message**

This error message can be switched on or off. This is controlled by bit 7 of the “system error mask” that can be set using SGP 72, 0, <n>. SGP 72, 0, 128 turns on the error message and SGP 72, 0, 0 turns it off.

### 6.2.3 Grouping some motors

For grouping motors, a “group index” can be set for every motor using SAP 213. The following rules apply for the group index:

- A motor that has a group index of 0 does not belong to any group at all
- Motors that have the same group index belong to the same group
- All motors that belong to one group must be controlled by the same module.

This method allows a great flexibility for grouping motors together.

For example, to form one group of motors 1 and 3, motor 2 not belonging to any group, set the group indices of motor 1 and 3 to 1 and the group index of motor 2 to 0 by issuing the following commands:

```
SAP 213, 1, 1
SAP 213, 3, 1
SAP 213, 2, 0
```

The groups are applied to the commands ROL, ROR, MST, MVP ABS and MVP REL. If one of these commands is issued for one motor that belongs to a group, all the other motors belonging to that group will also get the same command. In the current TMCL version (1.64), grouping does not apply to all the other commands. So, acceleration, velocity and other parameters have to be set separately for every motor. This might change in future versions.

The group settings also apply for deviation errors or motor stall: When a motor that belongs to a group is stopped because of a stall or a deviation error, all other motors belonging to this group will also be stopped.

To remove a motor from a group just set its group index to zero.

## 7 Documentation Revision

Version	Date	Author	Description
1.00	11-May-2005	OK	Initial Version
1.01	21-Sep-2005	OK	Adapted to TMCL version 3.25, error corrections
1.10	31-Jul-2006	HC	Major Revision, Dimensions added
1.11	25-Oct-2006	HC	Additions to pre-scaler function
1.12	29-Nov-2006	HC	6.2 Additional parameter functions added

**Table 7.1: Documentation Revisions**