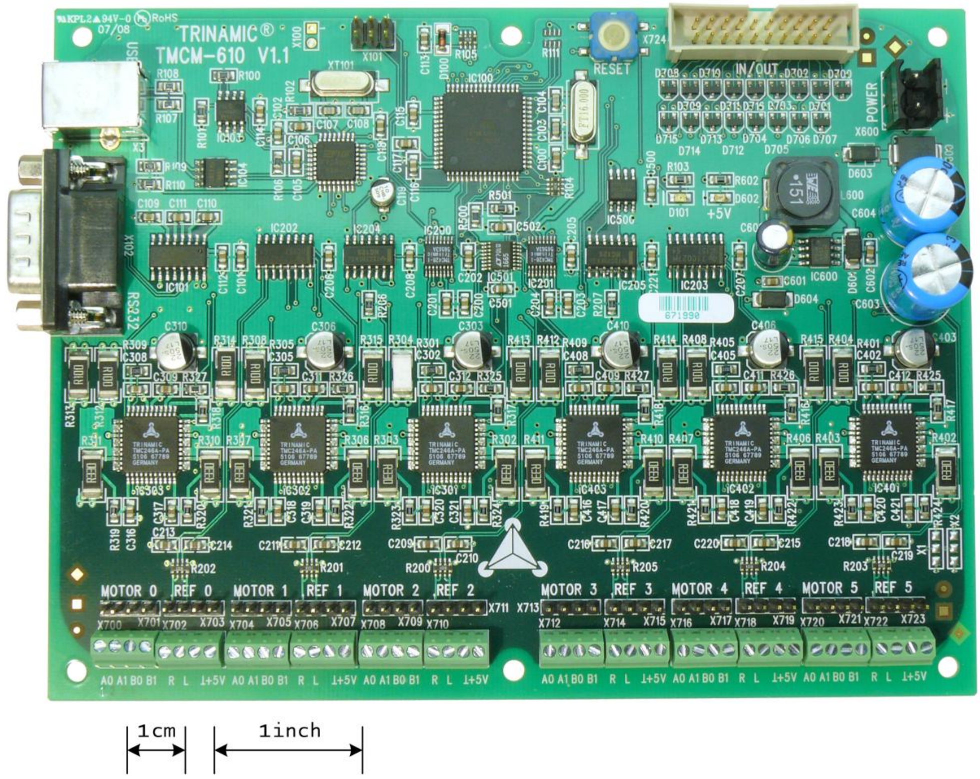
TMCM-610



Hardware Manual

Version: 1.14
2010-APR-30

TRINAMIC
MOTION CONTROL

Trinamic Motion Control GmbH & Co KG
Sternstraße 67
D - 20 357 Hamburg, Germany
Phone +49-40-51 48 06 - 0
FAX: +49-40-51 48 06 - 60
http://www.trinamic.com

Contents

1 Life support policy ... 4
2 Features ... 5
3 Order codes ... 6
4 Electrical and mechanical interfacing ... 7
4.1 Dimensions ... 7
4.2 Connecting the TMCM-610 module ... 7
4.2.1 Power supply ... 8
4.2.2 LED indicators ... 8
4.2.3 Motor connectors ... 8
4.2.4 Stop switches / reference switches ... 8
4.2.5 RS232 interface ... 9
4.2.6 USB interface ... 9
4.2.7 General purpose I/Os ... 9
4.2.8 Reset button ... 10
4.2.9 ISP connector – restore to factory default ... 10
5 Operational ratings ... 12
6 Functional description ... 13
6.1 System architecture ... 14
6.1.1 Microcontroller ... 14
6.1.2 TMCL™ EEPROM ... 14
6.1.3 TMC428 motion controller ... 14
6.1.4 Stepper motor drivers ... 14
6.2 stallGuard™ - sensorless motor stall detection ... 15
6.2.1 stallGuard™ adjusting tool ... 15
6.2.2 stallGuard™ profiler ... 16
6.3 Reference switches ... 17
6.3.1 Left and right limit switches ... 17
6.3.2 Triple switch configuration ... 17
6.3.3 One limit switch for circular systems ... 18
6.4 Microstep resolution ... 18
6.5 USB ... 19
7 Putting the TMCM-610 into operation ... 20
8 TMCM-610 operational description ... 21
8.1 Calculation: velocity and acceleration vs. microstep- and fullstep-frequency ... 21
9 TMCL™ ... 23
10 Revision history ... 24
10.1 Document revision ... 24
10.2 Firmware Revision ... 24

Figures

Figure 4.1: Dimensions 7
Figure 4.2: Overview of the connectors 7
Figure 4.3: Motor and reference switch connection 8
Figure 4.4: Internal wiring of the I/Os 10
Figure 4.5: Restoring all parameters to factory default 11
Figure 5.1: Main parts of the TMCM-610 13
Figure 6.2: stallGuard™ adjusting tool 15
Figure 6.3: The stallGuard™ profiler 16
Figure 6.4: Left and right limit switches 17
Figure 6.5: Limit switch and reference switch 17
Figure 6.6: One reference switch 18

Tables

Table 3.1: Order codes 6
Table 4.1: General purpose I/Os 9
Table 5.1: Operational ratings 12
Table 6.1: stallGuard™ parameter SAP 205 15
Table 6.2: Pinout reference switches 17
Table 6.3: Microstep resolution setting 18
Table 8.1: TMC428 velocity parameters 21
Table 10.1: Document revision 24
Table 10.2: Firmware revision 24

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-610 is a stepper motor controller and driver module that can drive up to six bipolar two-phase stepper motors with a peak coil current of up to 1.5A for each coil. The module provides a complete motion control system.

It can be remote operated via an RS232 interface or via a USB interface. The motors and switches can be easily connected with screw terminals. The connection of the multipurpose I/Os can be done via a dual-in-line pin connector. Traffic on the interfaces can be kept very low since all time-critical and CPU-intensive operations are done by the TMC428 stepper motor controller on the module.

The *Trinamic Motion Control Language* (TMCL™) is used to control the module. This language provides powerful commands that make it easy to control the module from a PC. The TMCM-610 can also run stand-alone, as programs written in TMCL™ can be stored permanently in an EEPROM on the module that can store programs which may contain up to 2048 commands.

Most features of this module are directly comparable to the well-known TMCM-303 and TMCM-310 modules. The TMCM-610 extends this to six motors. It uses a powerful ATmega64 microcontroller and two TMC428 motor controllers. As stepper motor drivers six TMC246 ICs are used. Their very low heat dissipation guarantees that the module can operate with no need for additional cooling. Also, the stallGuard™ feature can be used.

Applications
- Controller/driver board for control of up to six 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)
- 7V… 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 16 times microstepping
- TRINAMIC driver technology: No heat sink required
- Many adjustment possibilities make this module the solution 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

Other
- Motor and switches can be connected with screw terminals
- RoHS compliant latest from 1 July 2006
- Size: 160x120mm²

3 Order codes

Order code	Description	Dimensions [mm³]
TMCM-610/SG	6-axis controller/driver, RS232 and USB interfaces	160 x 120 x 29
Related products:		
QSH4218-35-10-027	QMot stepper motor 42mm, 1A, 0.27Nm	42.3 x 42.3 x 33,5
QSH4218-41-10-035	QMot stepper motor 42mm, 1A, 0.35Nm	42.3 x 42.3 x 38
QSH4218-51-10-049	QMot stepper motor 42mm, 1A, 0.49Nm	42.3 x 42.3 x 47

Table 3.1: Order codes

4 Electrical and mechanical interfacing

4.1 Dimensions

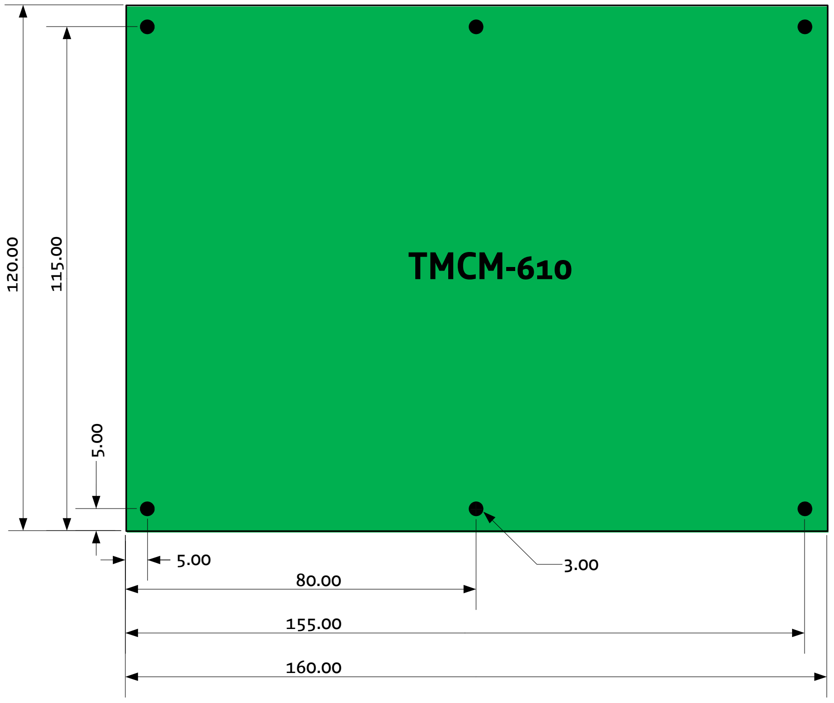


Figure 4.1: Dimensions

4.2 Connecting the TMCM-610 module

Figure 4.2 gives an overview of all the connectors. The following sections describe all the connectors in detail.

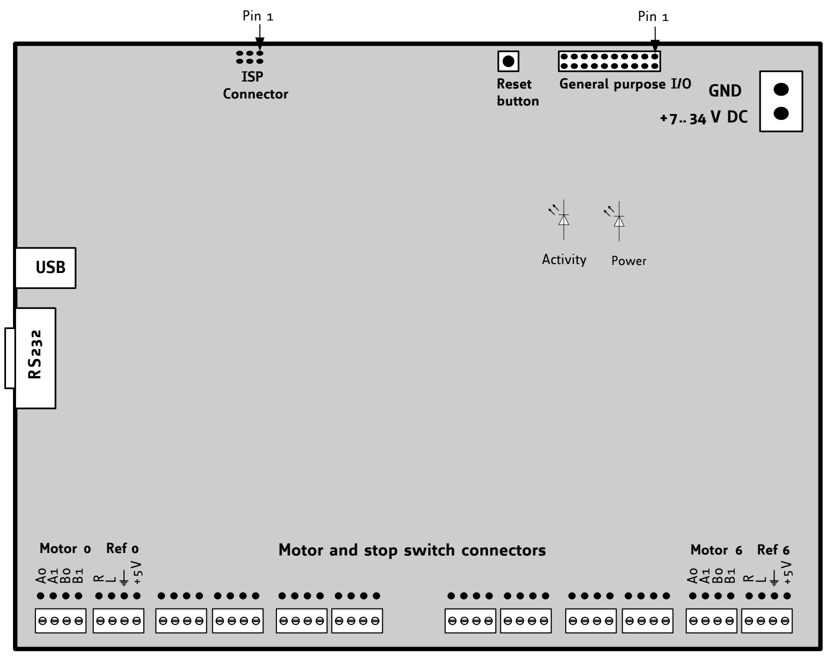


Figure 4.2: Overview of the connectors

4.2.1 Power supply

Connect a power supply of max. 34V DC here (the minimum operating voltage is 7V). The device is protected against wrong polarity by a diode that shorts the power supply when the polarity is wrong.

The onboard connector is a RIACON type 219 two pole connector, fitting mate is for example a RIACON type 249 (see http://www.riaconnect.com).

4.2.2 LED indicators

There are two LEDs on the board. The right LED (*Power*, on a rev. 1.0 board marked with *+5V*) lights up when the unit is powered. The other LED (*Activity*, on a rev. 1.0 board marked with *D101*) flashes when the unit is running normally.

4.2.3 Motor connectors

The stepper motors can either be connected to the screw terminals or to the connectors behind the screw terminals. They are electrically identical. The pin assignments of the connectors are printed on the board. Connect one coil of the motor to the terminals marked *A0* and *A1* and the other coil to the connectors marked *B0* and *B1*. See Figure 4.2.

Never connect or disconnect a motor while the unit is powered! This may damage the motor drivers and / or other parts of the unit!

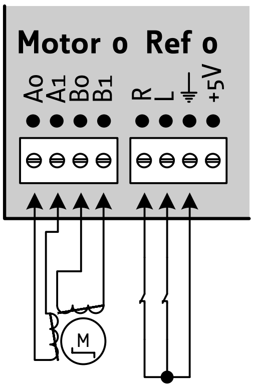


Figure 4.3: Motor and reference switch connection

4.2.4 Stop switches / reference switches

The stop switches can be connected to the *terminals* marked *L* and *R* and to the GND terminal. The switches are *normally closed*.

The reference switch connectors also have a *+5V terminal*. This is a 5V output that can be used to supply photo couplers or digital hall sensors.

The left stop switch is also used as the reference switch.

Attention:
On the version 1.0 of the board the stop switch connectors are marked wrongly (L and R have been interchanged). So, on a version 1.0 board, connect the left stop switch to the terminal marked with *R* and the right stop switch to the terminal marked with *L*.

The marking is corrected on the next version of the board.

4.2.5 RS232 interface

The RS232 interface is one way to connect the unit to a PC or a microcontroller with RS232 interface. All TMCL™ commands can be sent to the unit via this interface. A null modem cable has to be used to connect the TMCM-610 to a PC.

The following connections have to be made:

TMCM-610 pin	PC pin
2	3
3	2
5	5

The pin assignments of the RS232 socket of the TMCM-610 are as follows:

Pin number	Signal name
2	RxD
3	TxD
5	GND

All the other pins of this connector are not connected.

4.2.6 USB interface

The USB interface is also a way to connect the unit to a PC, when higher communication speed is needed. The interface supports the USB 2.0 standard. Please see chapter 6.5 on how to install the device driver that is needed to communicate with the TMCM-610 via USB.

The USB interface and the RS232 interface should not be used simultaneously.

4.2.7 General purpose I/Os

The general purpose I/O connector provides eight digital outputs and eight inputs that can either be used as digital or as analog inputs with 10 bit accuracy (thus there are no pull-ups). All digital inputs and outputs operate at TTL level, so the maximum voltage is 5V. The maximum current of each digital output is 20mA.

The pin assignments of the connector are as follows:

Pin	Signal	Pin	Signal
1	Output 0	2	Output 1
3	Output 2	4	Output 3
5	Output 4	6	Output 5
7	Output 6	8	Output 7
9	Alarm input	10	GND
11	Input 0	12	Input 1
13	Input 2	14	Input 3
15	Input 4	16	Input 5
17	Input 6	18	Input 7
19	+5V (Output)	20	GND

Table 4.1: General purpose I/Os

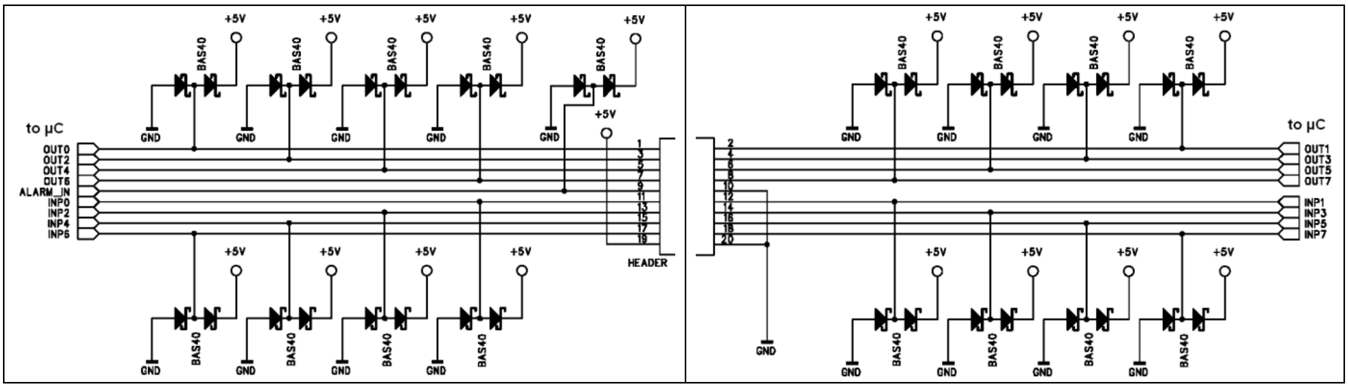


Figure 4.4: Internal wiring of the I/Os

The alarm input also is a digital input with TTL level and an internal pull-up resistor (the other inputs do not have internal pull-up resistors as it would not be possible to use them as analog inputs then). The functionality of this input can be configured (please see the TMCL™ Firmware Manual for details).

Pin 1 of the connector is shown in Figure 4.2. The pins with odd numbers are those near to the edge of the board.

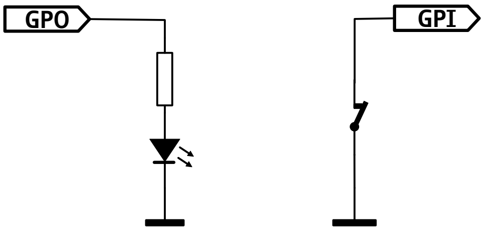


Figure 4.5: Examples for possible wirings for GPI and GPO

4.2.8 Reset button

Pressing the reset button resets the microcontroller. All motors are then stopped immediately and everything is re-initialized.

4.2.9 ISP connector – restore to factory default

This connector is used for two purposes:

- Programming the CPU via an in-circuit programmer. *This is to be done by TRINAMIC only and not by the user!* The user can upgrade the firmware via the RS232 or USB interface using the *Install OS* function in the TMCL-IDE.

- Restoring all parameters to their factory default values: Nearly all parameters can be stored in the EEPROM of the CPU. If some parameters have been set wrongly this can lead to a case of miss-configuration where the module cannot be reached by a PC any more. In such circumstances, all parameters can be reset to their factory default values by doing the following:

  1. Turn OFF the power.
  2. Link the pins 1 and 3 of the ISP connector with a jumper (as shown in Figure 4.6).
  3. Turn ON the power and wait until the *Activity* LED flashes fast (much faster than normal).
  4. Turn OFF the power.
  5. Remove the link between the pins 1 and 3 of the ISP connector.
  6. Turn ON the power and wait until the LED flashes normally (this can take some seconds).

  Now, all parameters are restored to their factory default values, and the unit should work normally again.

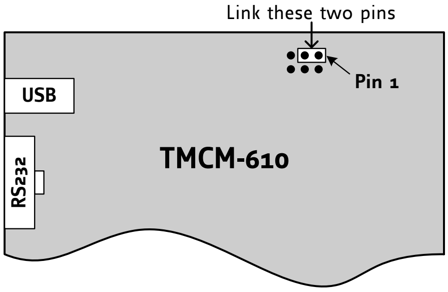


Figure 4.6: Restoring all parameters to factory default

5 Operational ratings

Symbol	Parameter	Min	Typ	Max	Unit
V_S	DC Power supply voltage for operation	7	12 … 28	34	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, GPI0 (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 (integrated 10k pullup to +5V for StopL / StopR)	2	5		V
I_{5VOUT}	+5V supply output current for external devices (sum of all pins)			200	mA
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		+70	°C

Table 5.1: Operational ratings

6 Functional description

Figure 6.1 depicts the main parts of the TMCM-610. It uses two TMC428 motion controller, six TMC246 stepper motor driver, the TMCL™ processor, the program memory (EEPROM), and the host interfaces (RS232 and USB).

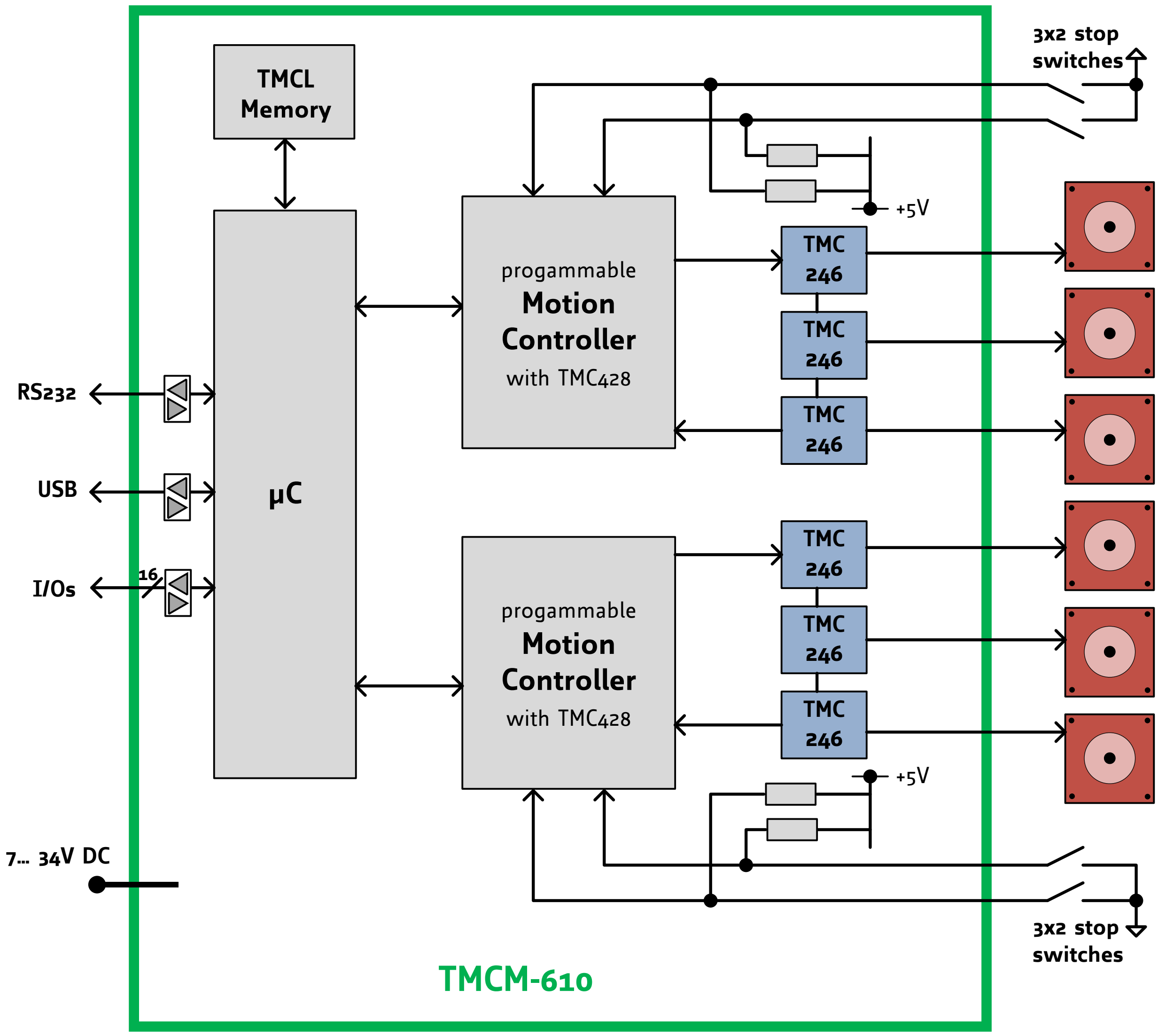


Figure 6.1: Main parts of the TMCM-610

6.1 System architecture

The TMCM-610 integrates a microcontroller with the TMCL™ (Trinamic Motion Control Language) operating system. The motion control real-time tasks are realized by the TMC428.

6.1.1 Microcontroller

On this module, the Atmel Atmega64 is used to run the TMCL™ operating system and to control the TMC428. The CPU has a 64Kbyte flash memory and a 2Kbyte EEPROM. The microcontroller runs the TMCL™ operating system which makes it possible to execute TMCL™ commands that are sent to the module from the host via the RS232 or USB interface. The microcontroller interprets the TMCL™ commands and controls the TMC428. The TMC428 calculates and executes the motion commands.

The flash ROM of the microcontroller holds the TMCL™ operating system. The EEPROM memory of the microcontroller is used to permanently store configuration data.

The TMCL™ operating system can be updated via the RS232 interface. Use the TMCL-IDE to do this.

6.1.2 TMCL™ EEPROM

To store TMCL™ programs for stand alone operation the TMCM-610 module is equipped with a 16kByte EEPROM attached to the microcontroller. The EEPROM can store TMCL™ programs consisting of up to 2048 TMCL™ commands.

6.1.3 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. The TMCM-610 has two TMC428 for 6 axes.

6.1.4 Stepper motor drivers

On TMCM-610 modules the TMCM246 driver chips are used. These chips are fully compatible with the TMC236 chips, but have the additional stallGuard™ feature. These drivers are very easy to use. They can control the currents for the two phases of the stepper motors. 16 times microstepping and maximum output current of 1500mA are supported by these driver ICs.

As the power dissipation of the TMC236 and 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.

6.2 stallGuard™ - sensorless motor stall detection

The TMCM-610/SG modules are equipped with the stallGuard™ option. The stallGuard™ option 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: 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. When switching on stallGuard™, the motor operation mode is changed and microstep resolution may be worse. Thus, stallGuard™ should be switched off when not in use.

Mixed decay should be switched off when stallGuard™ is operational in order to get usable results.

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

Table 6.1: stallGuard™ parameter SAP 205

To activate the stallGuard™ feature use the TMCL™ command SAP 205 and set the stallGuard™ threshold value according to Table 6.1. 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.

6.2.1 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.

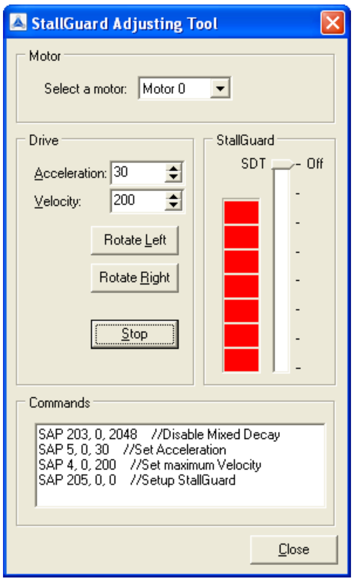


Figure 6.2: stallGuard™ adjusting tool

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.

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.

6.2.2 stallGuard™ profiler

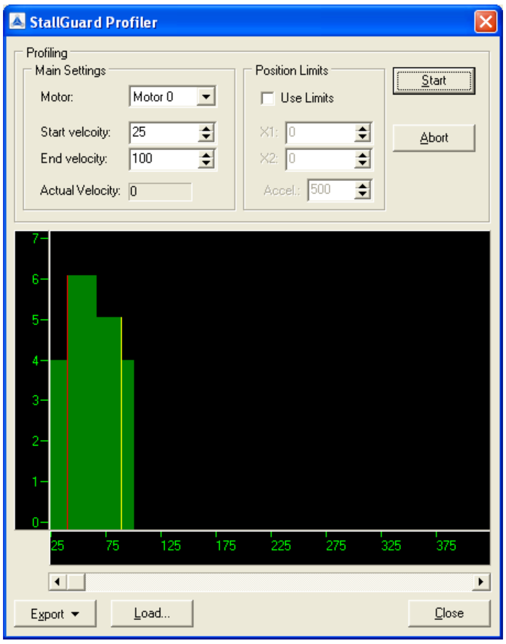


Figure 6.3: The stallGuard™ profiler

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. It 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.

6.2.2.1 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.

<u>There are three colours used:</u>

- 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.

6.2.2.2 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.

6.3 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. The TMCM-610 has one left and one right reference switch input for each motor.

Motor x	Direction	Name	Limits	Description
0, 1, 2, 3, 4, 5	in	R	TTL	Right reference switch input for Motor #X
0, 1, 2, 3, 4, 5	in	L	TTL	Left reference switch input for Motor #X

Table 6.2: Pinout reference switches

<u>Note</u>: 10k pullup resistors for reference switches are included on the module.

6.3.1 Left and right limit switches

The TMCM-610 can be configured so that a motor has a left and a right limit switch (Figure 6.4). The motor stops when the traveler has reached one of the limit switches.

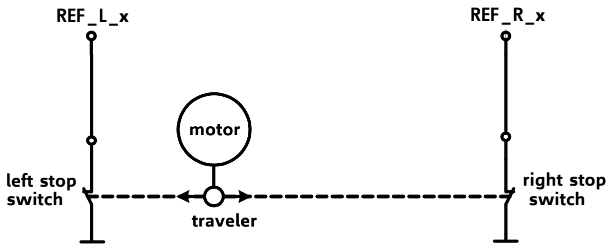


Figure 6.4: Left and right limit switches

6.3.2 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 6.5. 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.

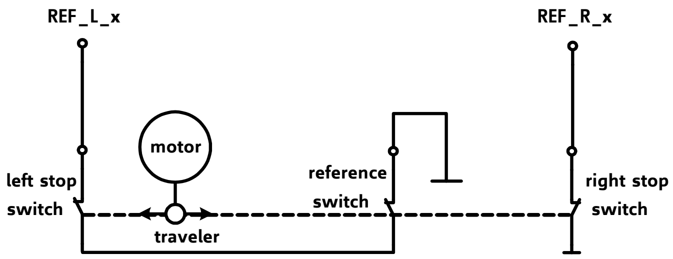


Figure 6.5: Limit switch and reference switch

6.3.3 One limit switch for circular systems

If a circular system is used (Figure 6.6), only one reference switch is necessary, because there are no end-points in such a system.

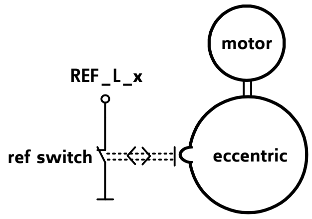


Figure 6.6: One reference switch

6.4 Microstep resolution

The microstep resolution can be set using TMCL™ software. The default setting is 64 microsteps which is the highest resolution.

To set the microstep resolution with TMCL™ use instruction 5: SAP, type 140: microstep resolution. You can find the appropriate value in Table 6.3. Please refer to the TMCM-610 TMCL™ Firmware Manual for more information about TMCL™ commands. This Manual is available on the TechLibCD or on www.trinamic.com.

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

Table 6.3: Microstep resolution setting

Despite the possibility to set up to 64 microsteps, the motor physically will be positioned to a maximum of about 24 Microsteps, when operated in 32 or 64 microstep setting.

6.5 USB

To make use of the USB interface, a device driver has to be installed first. There is a device driver shipped on the CD that can be used with Windows 98, Windows ME, Windows 2000 and Windows XP. The device driver cannot be used with Windows NT4 and Windows 95 as these operating systems do not support USB at all. In most Linux distributions the driver for the USB IC used on the TMCM-610 device (FT245BM) is already included in the kernel.

When the TMCM-610 module is connected to the USB interface of a PC for the first time, you will be prompted for a driver by the operating system. Now, insert the CD and select the *tmcm-610.inf* file there. The driver will then be installed and is now ready for use.

Please note that the TMCM-610 always needs its own power supply (self-powered) and is not powered by the USB bus. So the module will not be recognized if it is not powered.

To use the USB connection with the TMCL-IDE, at least version 1.31 of the IDE is needed. In the *connection screen* of the *options dialog*, select *USB (TMCM-610)* and then select the module in the *device list box*. Now all communication between the TMCL-IDE and the module uses the USB interface.

To control the TMCM-610 module form your own PC applications the USB version of the *TMCL™ Wrapper DLL* is needed.

7 Putting the TMCM-610 into operation

On the basis of a small example it is shown step by step how the TMCM-610 is set into operation. If you need more detailed information, please refer to the TMCM-610 TMCL™ Firmware Manual (available on the TechLibCD or on www.trinamic.com). Experienced users could skip this chapter and proceed to chapter 8.

Example: The following application is to implement with the TMCL-IDE Software development environment in the TMCM-610 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 8.1 (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 4.2.5.

Step 2: Connect the motors as specified in 4.2.3.

Step 3: Connect the power supply.

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

Step 5: Start the TMCL-IDE Software development environment. Type in the following programme:
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 6: Click on icon *assemble* to convert the TMCL™ commands into machine code.
Then download the program to the TMCM-610 module via the icon *download*.

Step 7: Press icon *run*. The desired program will be executed.

The program is stored to the EEPROM of the microcontroller. If the TMCL™ auto start option in *configure module* tab *other* is activated the program will be executed at each power on.

Documentation about the TMCL™ operations can be found in the TMCM-610 Firmware Manual (available on the TechLibCD or on www.trinamic.com). The next chapter discusses additional operations to turn the TMCM-610 into a high performance motion control system.

8 TMCM-610 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.

Parameters for the TMC428:

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

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

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

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

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

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

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

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

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

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

9 TMCL™

Like most of the other Trinamic motion control modules, the TMCM-610 is also equipped with TMCL™, the Trinamic Motion Control Language. The TMCL™ language in this unit has been extended so that six motors can be controlled with the normal TMCL™ commands. All axis parameters can be set independently for each motor.

TMCL™, the TRINAMIC Motion Control Language, is described in a separate documentation, the TMCM-610 TMCL™ Firmware Manual. This manual is provided on the TMC TechLibCD and on the web site of TRINAMIC: www.trinamic.com. Please refer to these sources for updated data sheets and application notes.

The TMC TechLibCD 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 on request and comes with each module.

10 Revision history

10.1 Document revision

Version	Date	Author	Description
1.00	2004-MAY-26	OK	Initial version, describes hardware rev. 1.0, software rev. 6.00
1.01	2004-OCT-01	OK	Minor corrections
1.02	2004-FEB-13	OK	Ordering information added
1.03	2005-SEP-28	OK	Dimensional drawing added
1.10	2006-SEP-16	HC	Major Revision
1.11	2007-JUN-20	HC	Added chapter 6.4 Microstep resolution
1.12	2007-DEC-18	HC	Internal wiring of I/Os added (chapter 4.2.7)
1.13	2008-JUN-08	OK	Interpolation features (MVP COORD) added
1.14	2010-APR-30	SD	Minor changes, new drawings

Table 10.1: Document revision

10.2 Firmware Revision

Version	Comment	Description
6.00	Initial Release	Please refer to TMCL™ documentation
6.31		Also supports interpolation features (MVP COORD command)

Table 10.2: Major Firmware revisions