

Hardware Version V 1.10

HARDWARE MANUAL



TMCM-1210

1-Axis stepper
controller/driver
max. 0.6A RMS / 24V DC
STOP / HOME switch input
hall sensor
RS485



stallGuard²

TRINAMIC Motion Control GmbH & Co. KG
Hamburg, Germany

www.trinamic.com



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1 Life support policy

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Specifications are subject to change without notice.



2 Features

The TMCM-1210 is a highly compact 20mm x 20mm single axis stepper motor controller and driver board with RS485 interface. It has been designed in order to be mounted on the rear side of a NEMA8 (20mm flange size) stepper motor and offers an integrated hall-sensor based encoder IC in addition to a reference switch input for easy homing / search of reference position. The module supports motor currents up to 0.6A RMS and supply voltages up to 24V DC nominal. It is available with standard TMCL firmware and supports stand-alone operation (TMCL programs with auto-start stored on-board) and remote control via RS485 interface.

MAIN CHARACTERISTICS

Motion controller

- Motion profile calculation in hardware in real-time
- Motion controller supports linear and sixPoint™ ramps
- On the fly alteration of motor parameters (e.g. position, velocity, acceleration)
- High performance microcontroller (Cortex-Mo+) for overall system control and serial communication protocol handling

Bipolar stepper motor driver

- Up to 256 microsteps per full step
- Highly integrated and highly-efficient operation
- Dynamic current control
- stallGuard2™ feature for stall detection

Interfaces

- RS485 2-wire communication interface
- Digital input INo (+24V compatible), can be used as reference switch or left and/or right stop switch input, also

On board hall sensor

- Absolute sensor within one motor rotation
- 12bit / 4096 steps / revolution max.
- Low-cost sensor - suitable for low velocity applications (few hundred rpm) – e.g. *initial reference search (together with HOME sensor input) after power-up*

Software

- TMCL™ remote (direct mode) and standalone operation with memory for up to 876 TMCL commands
- Fully supported by TMCL-IDE (PC based integrated development environment)

Electrical data

- Supply voltage: +7V... +30V DC
- Motor current: up to 0.6A RMS (programmable)

Mechanical data

- Board size: 20mm x 20mm, overall height 9mm max. (without mating connectors and cables)
- Mounting holes compatible with NEMA 8 stepper motors (for mounting the board to the rear side of a NEMA 8 stepper motor using two of the four existing screw)

Please see separate TMCM-1210 Firmware Manual for additional information regarding firmware functionality and TMCL programming.

3 Order codes

The TMC-1210 is available as:

| Order code | Description | Size of unit |
|------------|--|-------------------|
| TMC-1210 | 1-Axis stepper controller / driver, 0.6A RMS, 24V DC | 20mm x 20mm x 9mm |

A cable loom set is available for this module, also:

| Order code | Description |
|----------------|--|
| TMC-1210-CABLE | Cable loom for TMC-1210. Contains (see chapter 4.3, also): <ul style="list-style-type: none">- 1x cable loom for Power, RS485 and HOME connector- 1x cable loom for Motor connector |

Table 3.2: Cable loom order code

4 Mechanical and Electrical Interfacing

4.1 Dimensions and Mounting Holes

The dimensions of the board are approx. 20mm x 20mm x 9 mm in order to fit on the back side of a 20mm (NEMA8) stepper motor. Maximum component height (height above PCB level) without mating connectors is around 6mm above PCB level and 2 mm below PCB level. There are two mounting holes for M2 screws for mounting to a NEMA8 stepper motor.

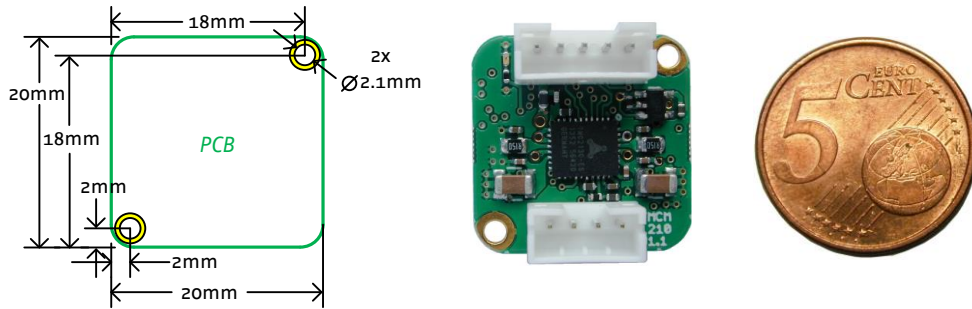


Figure 4.1 Dimensions of TMC-1210 and position of mounting holes (with comparison of size)

4.2 Board mounting considerations

The TMC-1210 offers two metal plated mounting holes. Both mounting holes are connected to power supply ground. Please keep this in mind when mounting the board to the rear side of a motor.

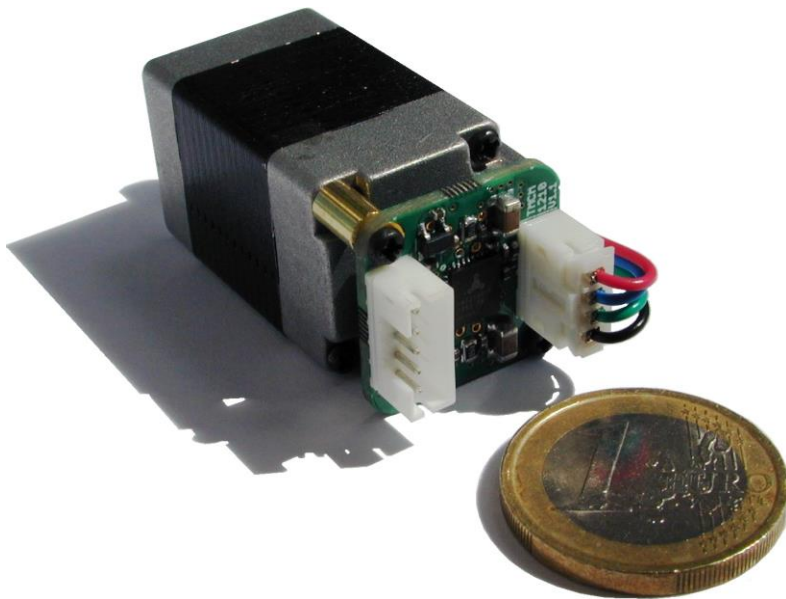


Figure 4.2: Example of TMC-1210 mounted to NEMA 8 stepper motor

4.3 Connectors

The TMC-1210 offers two connectors including the motor connector which is used for attaching the motor coils to the electronics. The Power, RS485 and HOME connector is used for power supply, RS485 serial wire communication and offers one digital input.

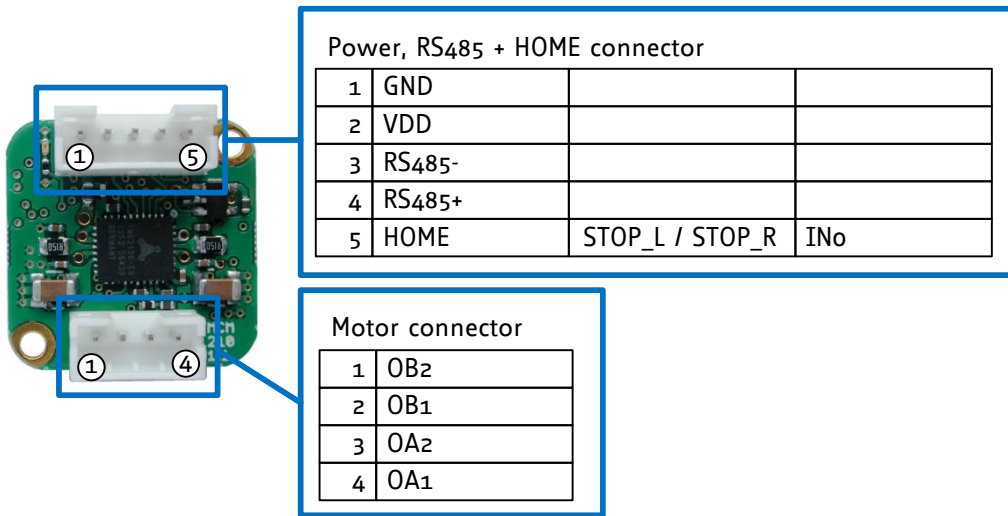


Figure 4.2 Overview connectors

Overview of connectors and mating connectors types:

| Label | Connector type | Mating connector type |
|-------------------------------|---|--|
| Power, RS485 + HOME connector | JST B5B-PH-K-S (JST PH series, 5pins, 2mm pitch) | Connector housing: JST PHR-5 Contacts: JST SPH-002T-Po.5S Wire: 0.22mm ² , AWG 24 |
| Motor connector | JST B4B-PH-K-S (JST PH series, 4pins, 2mm pitch) | Connector housing: JST PHR-4 Contacts: JST SPH-002T-Po.5S Wire: 0.22mm ² , AWG 24 |

Table 4.1: Connectors and mating connectors, contacts and applicable wire

4.3.1 Power, RS485 + HOME connector

The module offers one combined power, RS485 2-wire serial communication and digital input (HOME) connector (JST PH series).


| | Pin | Label | Direction | Description |
|---|-----|--------|-------------------|--|
|  | 1 | GND | Power (GND) | Supply and signal ground |
| | 2 | VCC | Power (Supply in) | Power supply input |
| | 3 | RS485- | Bi-directional | RS485 2-wire bus interface, diff. signal (inverting) |
| | 4 | RS485+ | Bi-directional | RS485 2-wire bus interface, diff. signal (non-inverting) |
| | 5 | HOME | Input | Digital input (accepts +24V signals), internal 10k pull-down resistor Can be used as: <ul style="list-style-type: none"> HOME switch input GAP 9, 0 // <i>home switch status</i> STOP_L / STOP_R input GAP 10, 0 // <i>right limit switch status</i> GAP 11, 0 // <i>left limit switch status</i> General purpose digital input o (INo) GIO 0, 0 // <i>INo</i> |

Table 4.2: Power, RS485 + INo connector

Please note:

- RS485: there is no line termination etc. on-board. Please ensure proper RS485 cabling and line termination.
- HOME / digital input INo: input offers pull-down resistor, input series resistor and protection diodes. This way input is protected for voltages up-to nom. +24V. The pull-down resistors also ensure a valid (low) level when left unconnected.

CAUTION

Always keep the power supply voltage (VDD) below the upper limit of 30V!

Otherwise the driver electronics will be seriously damaged. Especially, when the selected operating voltage is near the upper limit a regulated power supply is highly recommended.

4.3.2 Motor connector

As motor connector a 4pin JST PH-series 2mm pitch single row connector is available. The motor connector is used for connecting the four motor wires of the two motor coils of the bipolar stepper motor to the electronics.


|  | Pin | Label | Direction | Description |
|---|-----|-------|-----------|-----------------------|
| | 1 | OB2 | Output | Pin 2 of motor coil B |
| | 2 | OB1 | Output | Pin 1 of motor coil B |
| | 3 | OA2 | Output | Pin 2 of motor coil A |
| | 4 | OA1 | Output | Pin 1 of motor coil A |

Table 4.4: Motor connector

| CAUTION |
|--|
| <i>Do not connect or disconnect motor while driver stage is active and supplies current to the motor as this might permanently damage the driver stage!</i> |

4.4 Power supply

For proper operation care has to be taken with regard to power supply concept and design. Due to space restrictions the TMCM-1210 includes just about 20µF/35V of supply filter capacitors. These are ceramic capacitors which have been selected for high reliability and long life time.

| CAUTION |
|---|
| <p>Add external power supply capacitors!</p> <p>It is recommended to connect an electrolytic capacitor of significant size (e.g. 470µF/35V) to the power supply lines next to the TMCM-1210!</p> <p>Rule of thumb for size of electrolytic capacitor: $c = 1000 \frac{\mu F}{A} \times I_{SUPPLY}$</p> <p>In addition to power stabilization (buffer) and filtering this added capacitor will also reduce any voltage spikes which might otherwise occur from a combination of high inductance power supply wires and the ceramic capacitors. In addition it will limit slew-rate of power supply voltage at the module. The low ESR of ceramic-only filter capacitors may cause stability problems with some switching power supplies.</p> |
| <p>Do not connect or disconnect motor during operation!</p> <p>Motor cable and motor inductivity might lead to voltage spikes when the motor is disconnected / connected while energized. These voltage spikes might exceed voltage limits of the driver MOSFETs and might permanently damage them. Therefore, always disconnect power supply before connecting / disconnecting the motor.</p> |
| <p>Keep the power supply voltage below the upper limit of 30V!</p> <p>Otherwise the driver electronics will seriously be damaged! Especially, when the selected operating voltage is near the upper limit a regulated power supply is highly recommended. Please see also chapter 7, operating values.</p> |
| <p>No reverse polarity protection!</p> <p>The module will short any reversed supply voltage due to internal diodes of the driver transistors.</p> |

4.5 RS485

For remote control and communication with a host system the TMC-1210 provides a two wire RS485 bus interface. For proper operation the following items should be taken into account when setting up an RS485 network:

1. **BUS STRUCTURE:**

The network topology should follow a bus structure as closely as possible. That is, the connection between each node and the bus itself should be as short as possible. Basically, it should be short compared to the length of the bus.

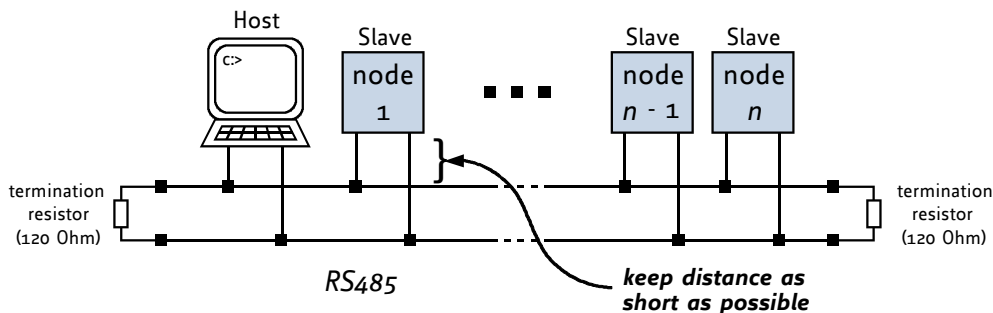


Figure 4.6: Bus structure

2. **BUS TERMINATION:**

Especially for longer busses and/or multiple nodes connected to the bus and/or high communication speeds, the bus should be properly terminated at both ends. The TMC-1210 does not integrate any termination resistor. Therefore, 120 Ohm termination resistors at both ends of the bus have to be added externally.

3. **NUMBER OF NODES:**

The RS485 electrical interface standard (EIA-485) allows up to 32 nodes to be connected to a single bus. The bus transceiver used on the TMC-1210 unit (SN65HVD3085E) has a significantly reduced bus load and allow a maximum of 255 units to be connected to a single RS485 bus using TMCL firmware. *Please note: usually it cannot be expected to get reliable communication with the maximum number of nodes connected to one bus and maximum supported communication speed at the same time. Instead, a compromise has to be found between bus cable length, communication speed and number of nodes.*

4. **COMMUNICATION SPEED:**

The maximum RS485 communication speed supported by the TMC-1210 hardware is 1Mbit/s. Factory default is 9600 bit/s. *Please see separate TMC-1210 TMCL firmware manual for information regarding other possible communication speeds below the upper limit in hardware.*

5. **NO FLOATING BUS LINES:**

Avoid floating bus lines while neither the host/master nor one of the slaves along the bus line is transmitting data (all bus nodes switched to receive mode). Floating bus lines may lead to communication errors. In order to ensure valid signals on the bus it is recommended to use a resistor network connecting both bus lines to well defined logic levels.

There are actually two options which can be recommended:

Add resistor (Bias) network on **one** side of the bus, only (120R termination resistor still at **both** ends):

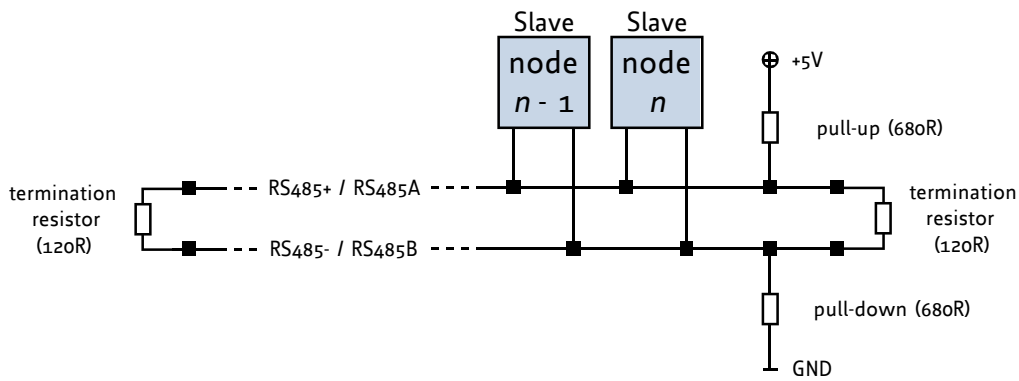


Figure 4.7: Bus lines with resistor (Bias) network on one side, only

Or add resistor (Bias) network at **both** ends of the bus (like Profibus™ termination):

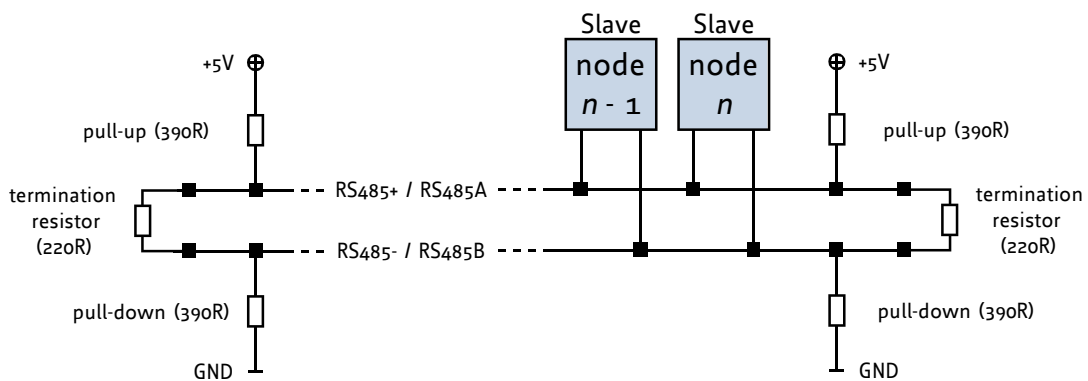


Figure 4.8: Bus lines with resistor (Bias) network at both ends

Certain RS485 interface converters available for PCs already include these additional resistors (e.g. USB-2-485 with bias network at one end of the bus).

5 Motor driver current

The on-board stepper motor driver operates current controlled. The driver current may be programmed in software with 32 effective scaling steps in hardware.

Explanation of different columns in table below:

Motor current setting in software (TMCL) These are the values for TMCL axis parameter 6 (motor run current) and 7 (motor standby current). They are used to set the run / standby current using the following TMCL commands:

SAP 6, 0, <value> // set run current

SAP 7, 0, <value> // set standby current

(read-out value with GAP instead of SAP. Please see separate TMCM-1210 firmware manual for further information)

Motor current I_{RMS} [A] Resulting motor current based on motor current setting

| Motor current setting in software (TMCL) | Motor current I_{COIL_PEAK} [A] | Motor current I_{COIL_RMS} [A] |
|--|------------------------------------|-----------------------------------|
| 0..7 | 0.06 | 0.04 |
| 8..15 | 0.08 | 0.06 |
| 16..23 | 0.10 | 0.07 |
| 24..31 | 0.13 | 0.09 |
| 32..39 | 0.15 | 0.11 |
| 40..47 | 0.18 | 0.13 |
| 48..55 | 0.21 | 0.15 |
| 56..63 | 0.24 | 0.17 |
| 64..71 | 0.26 | 0.19 |
| 72..79 | 0.29 | 0.21 |
| 80..87 | 0.32 | 0.23 |
| 88..95 | 0.35 | 0.25 |
| 96..103 | 0.38 | 0.27 |
| 104..111 | 0.41 | 0.29 |
| 112..119 | 0.43 | 0.30 |
| 120..127 | 0.46 | 0.32 |
| 128..135 | 0.49 | 0.34 |
| 136..143 | 0.51 | 0.36 |
| 144..151 | 0.54 | 0.38 |
| 152..159 | 0.56 | 0.40 |
| 160..167 | 0.59 | 0.42 |
| 168..175 | 0.62 | 0.44 |
| 176..183 | 0.64 | 0.45 |
| 184..191 | 0.67 | 0.47 |
| 192..199 | 0.70 | 0.49 |
| 200..207 | 0.72 | 0.51 |
| 208..215 | 0.75 | 0.53 |
| 216..223 | 0.77 | 0.55 |
| 224..231 | 0.80 | 0.57 |
| 232..239 | 0.82 | 0.58 |
| 240..247 | 0.84 | 0.60 |
| 248..255 | 0.87 | 0.62 |

6 On-Board LEDs

The board offers one LED in order to indicate board status. The function of the LED is dependent on the firmware version. With standard TMCL firmware the green LED should be flashing slowly during operation.

BEHAVIOR OF LEDs WITH STANDARD TMCL FIRMWARE

| Status | Label | Description |
|-----------|-------|---|
| Heartbeat | Run | This green LED flashes slowly during operation. |

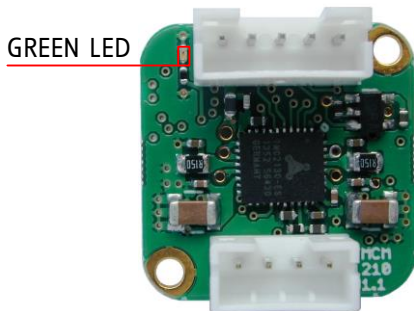


Figure 6.1 On-board LED

7 Reset to Factory Default Values

In order to reset all settings (e.g. incl. address and RS485 baud rate) to factory default values please follow instruction sequence below:

1. Switch OFF power supply.
2. Short programming pads on bottom of PCB as shown in figure 7.1.
3. Switch ON power supply (on-board LED should start flashing fast).
4. Switch OFF power supply.
5. Remove short circuit.

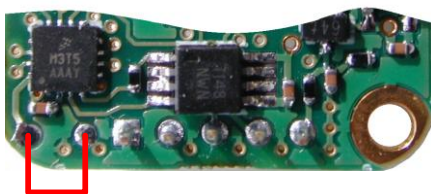


Figure 7.1 Reset to factory default values (bottom view of pcb)

8 EMC considerations

The TMCM-1210 contains ferrite beads on-board in line with the positive supply input and all 4 motor windings connections in addition to filter capacitors.

Tests have shown that it is possible to meet Class B emission standards using the bare TMCM-1210 (motor and power connected) with the motor running slowly at maximum current (0.7A RMS) and +24V supply voltage without additional / external filters.

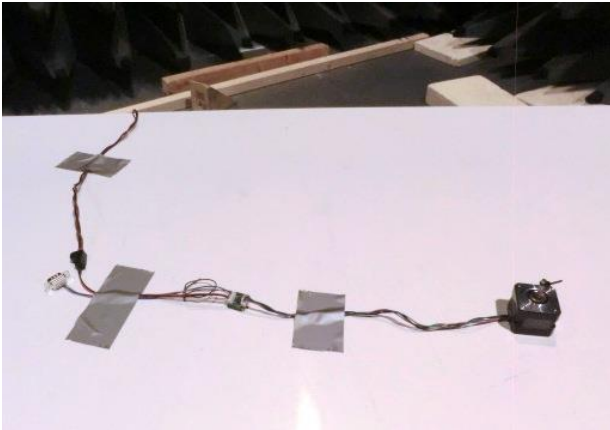


Figure 8.1: Setup with TMCM-1210 and attached motor (motor rotating slowly @ 0.7A RMS / 24V supply, stand-alone mode using on-board TMCL-autostart-program)

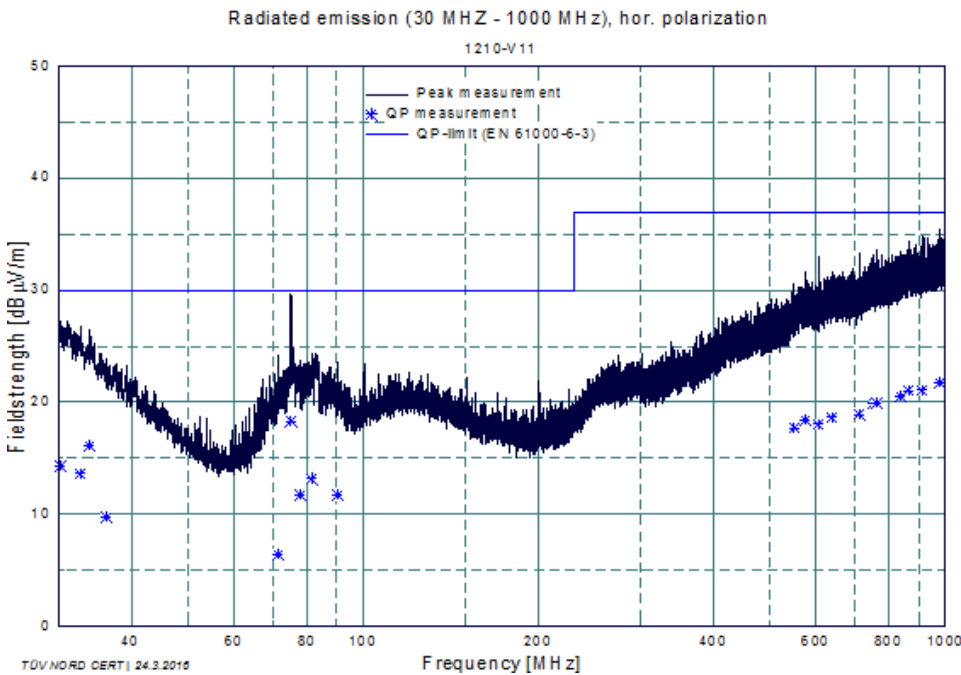


Figure 8.2: measurement results (example)

Please note that these measurement results using a bare TMCM-1210 unit with only motor and power supply connected do not imply any guarantee for a complete system with one or more integrated TMCM-1210 with meeting any emission limits.

9 Operational Ratings

The operational ratings show the intended or the characteristic ranges and should be used as design values.

In no case shall the maximum values be exceeded!

| Symbol | Parameter | Min | Typ | Max | Unit |
|------------------------|---|-----|----------------------|-------------------------|------|
| VDD | Power supply voltage for operation | 6 | 12...24 | 30 | V |
| I _{COIL_peak} | Motor coil current for sine wave peak (chopper regulated, adjustable via software) | 0 | | 0.9 | A |
| I _{COIL_RMS} | Continuous motor current (RMS) | 0 | | 0.6 | A |
| I _{DD} | Power supply current | | << I _{COIL} | 1.4 * I _{COIL} | A |
| T _{ENV} | Environment temperature at rated current (0.6A RMS) and rated voltage (+24V) (no forced cooling required) | -30 | | +40 | °C |

Table 9.1 General operational ratings of module

OPERATIONAL RATINGS OF HOME SWITCH

| Symbol | Parameter | Min | Typ | Max | Unit |
|------------------------|---|-----|-----|-----|------|
| V _{HOME} | Input voltage for HOME/STOP_L/STOP_R/INo | 0 | | +30 | V |
| V _{HOME_LOW} | Low level voltage for HOME/STOP_L/STOP_R/INo (digital input) | 0 | | 2 | V |
| V _{HOME_HIGH} | High level voltage for HOME/STOP_L/STOP_R/INo (digital input) | 4.6 | | +30 | V |

Table 9.2 Operational ratings of HOME + STOP switches / INo inputs

OPERATIONAL RATINGS OF RS485 INTERFACE

| Symbol | Parameter | Min | Typ | Max | Unit |
|--------------------|---|-----|------|---------|-------|
| N _{RS485} | Number of nodes connected to single RS485 network | | | 255 | |
| f _{RS485} | Maximum bit rate supported on RS485 connection | | 9600 | 1000000 | bit/s |

Table 9.3: Operational ratings of RS485 interface

10 Functional Description

The TCM-1210 is a highly integrated controller/driver module which can be controlled via several serial interfaces. Communication traffic is kept low since all time critical operations (e.g. ramp calculations) are performed on board. The nominal supply voltage of the unit is 12V or 24V DC. The module is designed for both, standalone operation and direct mode. Full remote control of device with feedback is possible. The firmware of the module can be updated via the RS485 serial interfaces.

In Figure 10.1 the main parts of the TCM-1210 are shown:

- microprocessor, which runs the TMCL operating system (connected to TMCL memory),
- motion controller (part of TMC2130), which calculates ramps and speed profiles internally by hardware,
- driver (part of TMC2130) with stallGuard2™ and its energy efficient coolStep™ feature and stealthChop™ for extremely quiet operation
- hall sensor based encoder which delivers position feedback at low speed (few 100rpm max.) – can be used for reference search e.g. after power-up

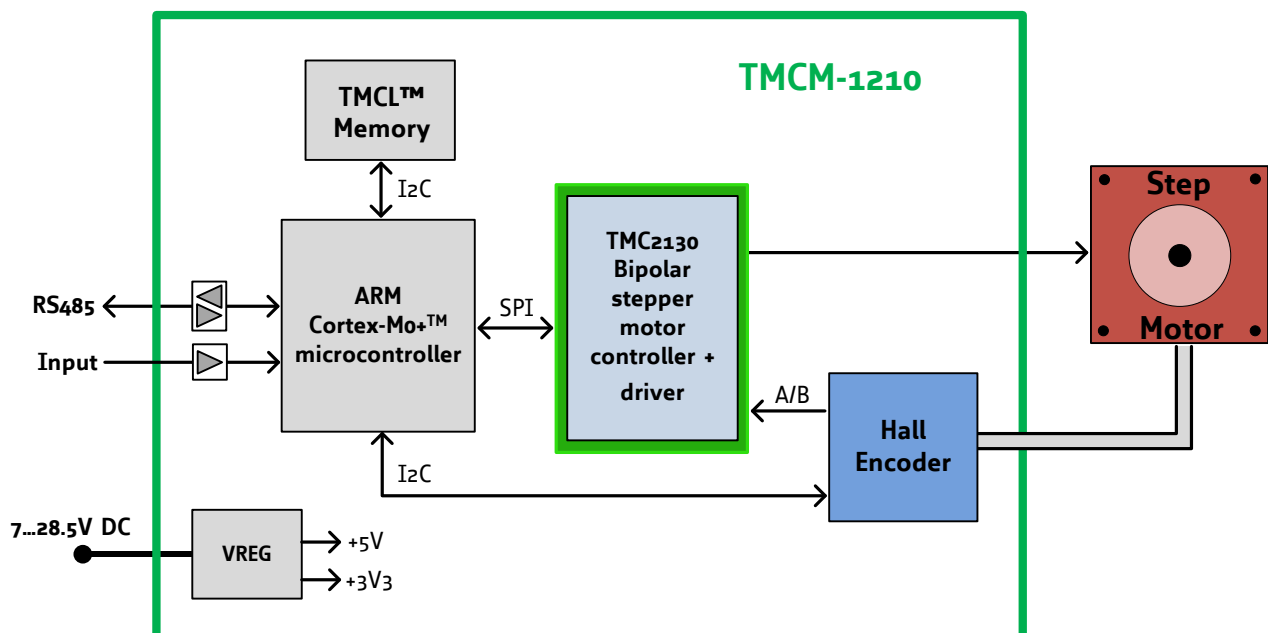


Figure 10.1 Main parts of the TCM-1210

The TCM-1210 comes with the PC based software development environment TMCL-IDE for the Trinamic Motion Control Language (TMCL). Using predefined TMCL high level commands like *move to position* a rapid and fast development of motion control applications is guaranteed.

Please refer to the *TMC2130 TMCL Firmware Manual* for more information about TMCL commands.

11 Revision History

11.1 Document revision

| Version | Date | Author | Description |
|---------|-------------|--------|--|
| 0.90 | 2016-APR-14 | GE | Initial version |
| 0.91 | 2017-SEP-04 | GE | Typos corrected |
| 0.92 | 2019-JAN-30 | GE | Description motor connector (chapter 4.3) corrected |
| 0.93 | 2019-FEB-13 | GE | Current setting table (chapter 5) corrected / updated (with measurement results) |
| | | | |

Table 11.1: Document revision

11.2 Hardware revision

| Version | Date | Description |
|-------------|-------------|--|
| TMC2130_V10 | 2014-DEC-17 | Initial version |
| TMC2130_V11 | 2015-JUN-25 | <ul style="list-style-type: none"> External digital input connected to REFL/REFR of TMC2130. /RESET input of processor not connected (used for programming, only) /CS and SCK connection between processor and TMC2130 corrected (signals exchanged) Footprint of protection diode for external digital input corrected |
| | | |
| | | |

Table 11.2: Hardware revision

12 References

| | |
|------------|---|
| [JST] | JST connector http://www.jst.com |
| [TMC2130] | TMC2130 datasheet Manual available on http://www.trinamic.com |
| [TMCL-IDE] | TMCL-IDE User Manual Manual available on http://www.trinamic.com . |

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