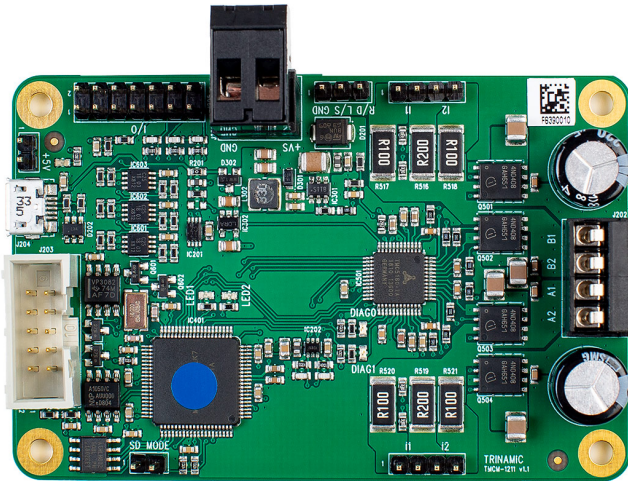


TMCM-1211 Hardware Manual

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The **TMCM-1211 StepRocker™** is a single axis motor controller/driver board for 2-phase bipolar stepper motors. It features the TRINAMIC motion controller/motor driver TMC5160 in combination with an ARM Cortex-M4™ (MK20DX128VLK7) processor. The Module is intended to be a fully functional development platform.



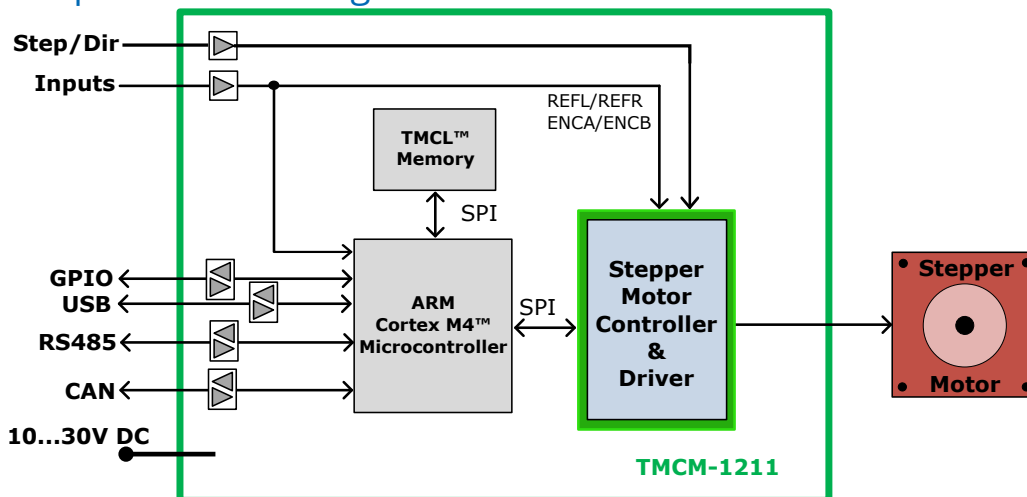
Features

- Single axis controller/driver for 2-phase bipolar stepper motor
- +10...30V DC supply voltage
- Up to 5.7A RMS motor current
- RS485 & USB interface
- Multi-purpose inputs and outputs

Applications

- Laboratory Automation
- Manufacturing
- Robotics
- Factory Automation
- Test & Measurement
- Technology evaluation
- First experiences with stepper motors
- Hobby applications

Simplified Block Diagram



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1 Features

The TMC5160 StepRocker™ is a single axis motor controller/driver board for 2-phase bipolar stepper motors. It features the TRINAMIC motion controller / motor driver TMC5160 in combination with an ARM Cortex-M4™ (MK20DX128VLK7) processor. The Module is intended to be a fully functional development platform.

Applications

- Highly compact single axis stepper motor controller/driver board for 2-phase bipolar stepper motors

Electrical data

- Supply voltage: +24V DC (+10... +30V DC)
- Motor current: up to 1.1A RMS, 3.4A RMS or 5.7A RMS (can be selected with jumpers)

Mechanical data

- Board size: 85mm x 55mm, height 15mm max. without mating connectors
- 4 mounting holes for M3 screws

Interfaces

- RS485 host interface
- USB 2.0 host interface (USB micro-B connector)
- Step/Dir input (TTL level)
- 3 multi-purpose inputs (can be used for ABN-encoder)
- 2 limit switch inputs (shared with Step/Dir inputs)
- 6 multi-purpose I/Os
- 2 open-drain outputs
- 1 analog input (0... 10V)
- µC programming interface SWD (single wire debug / pads on PCB)
- Retro-fit option: CAN 2.0B communication interface

Features

- TMC5160 integrated stepper motor controller and driver IC for 2-phase bipolar stepper motors
- stealthChop2™ for quiet movement
- spreadCycle™ chopper for highly dynamic motor control
- stallGuard2™ sensorless motor load detection
- coolStep™ current control for energy saving / reduced heat dissipation
- linear and sixPoint™ ramps with motion controller in hardware
- Up to 256 microsteps per fullstep
- EEPROM

Software

- TMCL™ remote (direct mode) and standalone operation (memory for up to 1024 TMCL™ commands)
- Fully supported by TMCL-IDE (PC based integrated development environment)



2 Order Codes

The standard version of the StepRocker™ has RS485 and USB interfaces (CAN transceiver **not** assembled). The module is pre-programmed with TRINAMICs TMCL™ firmware with all available features.

| TMC-1211 Order Code | | |
|---------------------|---|--------------------|
| Order Code | Description | Size (LxWxH) |
| TMC-1211 StepRocker | 1-axis bipolar stepper motor controller/-driver module with RS485 and USB, 5.7A RMS, +24V | 85mm x 55mm x 15mm |

Table 1: TMC-1211 Order Code



3 Mechanical and Electrical Interfacing

3.1 Size of board

The board with the controller/driver electronics has an overall size of 85mm x 55mm x 15mm without mating connectors. It offers four mounting holes for M3 screws (3.2mm diameter). All four mounting holes are connected to the ground plane (signal and supply ground) of the module.

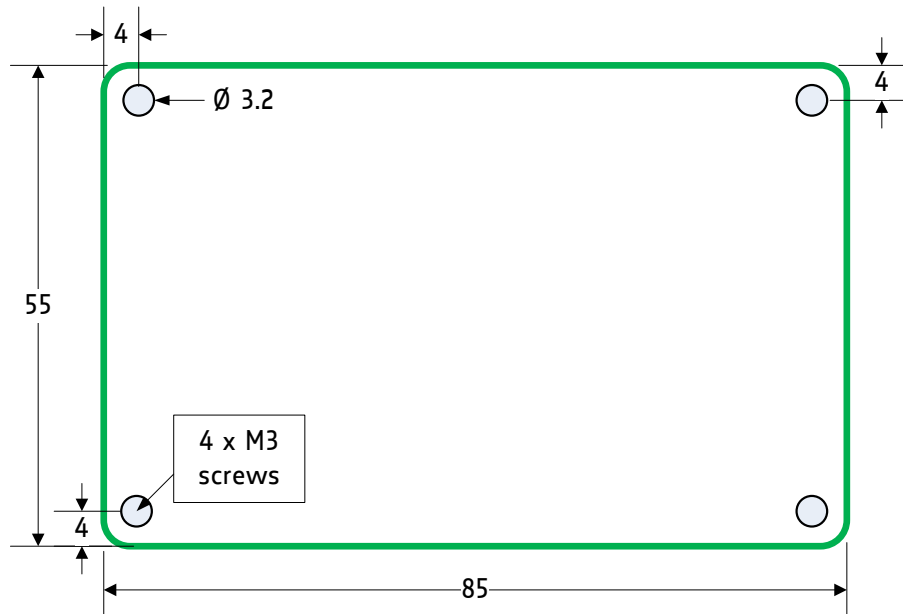


Figure 1: Board Dimensions and Positions of Mounting Holes (all Values in mm)



4 Connectors

The TMCM-1211 StepRocker™ has seven connectors altogether. There are two detachable screw connectors for power and motor and two interface connectors (micro-USB and RS485). Furthermore, the StepRocker offers one connector for step/direction and reference switch inputs, the GPIO connector, which can be used e.g. for connecting an ABN-encoder and one +5V supply output connector - e.g. for encoder or end switch supply.

NOTICE

Start with power supply OFF and do not connect or disconnect motor during operation! Motor cable and motor inductivity might lead to voltage spikes when the motor is (dis)connected while energized. These voltage spikes might exceed voltage limits of the driver MOSFETs and might permanently damage them. Therefore, always switch off / disconnect power supply or at least disable driver stage before connecting / disconnecting motor.

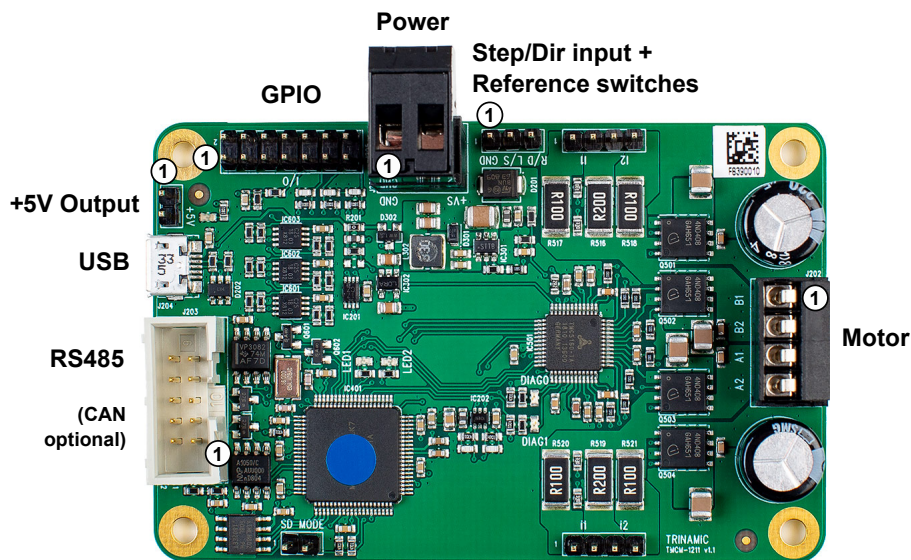


Figure 2: TMCM-1211StepRocker™ connectors

| Connector Types and Mating Connectors | | |
|---------------------------------------|--|---|
| Connector | Connector type on-board | Mating connector type |
| Power | RIA 220-02, 2 pin, 5.08mm pitch, shrouded header | RIA 249-02, screw type terminal block, pluggable, centerline 5.08mm pitch |
| Motor | RIA 183-04, 4 pin, 3.5mm pitch, shrouded header | RIA 169-04, screw type terminal block, pluggable, centerline 3.5mm pitch |
| USB | USB-micro-B female connector | USB-micro male connector |
| RS485/CAN | Low profile box header without locking bar, type 8380, 10 pin, DIN 41651, 2.54mm pitch | Low profile IDC socket connector, 10 pin, DIN 41651, 2.54mm pitch |
| GPIO | Header, 14 pin, 2.54mm pitch | Female connector with 2.54mm pitch |



| Connector | Connector type on-board | Mating connector type |
|-------------------------------------|-----------------------------|------------------------------------|
| Step/Dir input + reference switches | Header, 3pin, 2.54mm pitch | Female connector with 2.54mm pitch |
| +5V output | Header, 2 pin, 2.54mm pitch | Female connector with 2.54mm pitch |

Table 2: Connector Types and Mating Connectors of the TMCM-1211 StepRocker™

4.1 Power Connector

| Power Supply Connector Pin Assignment | | | |
|---------------------------------------|----------|---------------|--|
| Pin | Label | Direction | Description |
| 1 | GND | Power (GND) | Common system supply and signal ground |
| 2 | 10...30V | Power (input) | Power supply voltage |

Table 3: Power Supply Connector Pin Assignment

NOTICE

Do not connect or disconnect motor during operation! Motor cable and motor inductivity might lead to voltage spikes when the motor is (dis)connected while energized. These voltage spikes might exceed voltage limits of the driver MOSFETs and might permanently damage them. Therefore, always switch off / disconnect power supply or at least disable driver stage before connecting / disconnecting motor.

NOTICE

Take care of polarity, wrong polarity can destroy the board!

4.2 I/O Connector (Microcontroller)

The TMCM-1211 offers an on-board ARM Cortex-M4™ microcontroller with +3V3 powered IOs and +5V tolerant inputs. In order to be compatible with previous generations (stepRocker™ TMCM-1110), +5V output level-shifters/buffers have been integrated on-board. This way, all general purpose IO pins configured as outputs will deliver +5V TTL signals.

| I/O Connector Pin Assignment | | | |
|------------------------------|--------|-------------|---|
| Pin | Label | Direction | Description |
| 1 | GND | Power (GND) | Supply and signal ground |
| 2 | GND | Power (GND) | Supply and signal ground |
| 3 | PWMD_0 | in/out | General purpose I/O (+5V compatible, default: input) |
| 4 | PWMU_0 | in/out | General purpose I/O (+5V compatible, default: output) |
| 5 | PWMD_1 | in/out | General purpose I/O (+5V compatible, default: input) |



| Pin | Label | Direction | Description |
|-----|-------------|-----------|--|
| 6 | PWMU_1 | in/out | General purpose I/O (+5V compatible, default: output) |
| 7 | PWMD_2 | in/out | General purpose I/O (+5V compatible, default: input) |
| 8 | PWMU_2 | in/out | General purpose I/O (+5V compatible, default: output) |
| 9 | AIN_0 | in | Analog input. Input voltage range: 0...+10V Resolution: 12bit (0...4095) |
| 10 | PHASE_A | in | Encoder input channel A (+5V compatible, internal pull-up to +5V) |
| 11 | OpenDrain_1 | out | Open-drain output (max. 100mA) |
| 12 | PHASE_B | in | Encoder input channel B (+5V compatible, internal pull-up to +5V) |
| 13 | OpenDrain_2 | out | Open-drain output (max. 100mA) |
| 14 | PHASE_Z | in | Encoder input zero channel (+5V compatible, internal pull-up to +5V) |

Table 4: I/O Connector Pin Assignment

4.3 Motor Connector

The motor has to be connected to the motor connector, one phase (phase A) between A1 and A2 and the second phase (phase B) between B1 and B2.

| Motor Connector Pin Assignment | | | |
|--------------------------------|-------|-----------|-----------------------|
| Pin | Label | Direction | Description |
| 1 | B1 | out | Pin 1 of motor coil B |
| 2 | B2 | out | Pin 2 of motor coil B |
| 3 | A1 | out | Pin 1 of motor coil A |
| 4 | A2 | out | Pin 2 of motor coil A |

Table 5: Motor Connector Pin Assignment

NOTICE

Do not connect or disconnect motor during operation! Motor cable and motor inductivity might lead to voltage spikes when the motor is (dis)connected while energized. These voltage spikes might exceed voltage limits of the driver MOSFETs and might permanently damage them. Therefore, always switch off / disconnect power supply or at least disable driver stage before connecting / disconnecting motor.



4.4 Step/Dir Input + Reference Switches Connector

| Step/Dir and Reference Switches Input Connector Pin Assignment | | | |
|--|-----------|-------------|---|
| Pin | Label | Direction | Description |
| 1 | GND | Power (GND) | Signal and system ground |
| 2 | REFL/STEP | in | Input for left reference/limit switch or driver step pulse signal |
| 3 | REFR/DIR | in | Input for right reference/limit switch or driver direction signal |

Table 6: Step/Dir and Reference Switches Input Connector

4.5 RS485 and CAN Connector

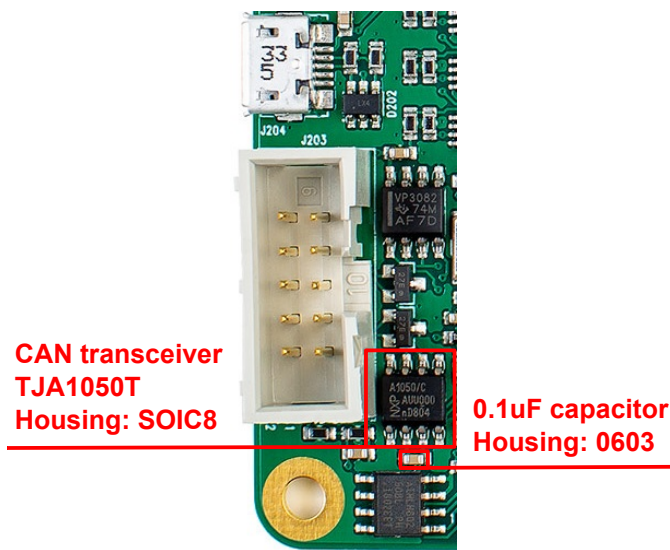
The standard TMCM-1211 StepRocker™ offers the RS485 interface, only.

| RS485/CAN Connector Pin Assignment | | | |
|------------------------------------|--------|----------------|--|
| Pin | Label | Direction | Description |
| 1 | | | |
| 2 | | | |
| 3 | CAN_L | bi-directional | differential CAN bus signal (inverting) - retro-fit option |
| 4 | CAN_H | bi-directional | differential CAN bus signal (non-inverting) - retro-fit option |
| 5 | GND | Power (GND) | Signal and system ground |
| 6 | RS485+ | bi-directional | differential RS485 bus signal (non-inverting) |
| 7 | RS485- | bi-directional | differential RS485 bus signal (inverting) |
| 8 | | | |
| 9 | | | |
| 10 | | | |

Table 7: RS485/CAN Connector Pin Assignment



4.5.1 Upgrade the StepRocker™ for CAN communication



The table above shows the pin configuration for CAN, too. Before starting with CAN it is necessary to solder a TJA1050T CAN transceiver with housing SOIC8 and a 0.1µ capacitor with housing 0603 on the TMCM-1211 StepRocker™. Afterwards, the StepRocker™ is ready for using the CAN interface.

Because of the pin assignment CAN and RS485 can be used at the same time.

Please note: it is not necessary to remove the RS485 transceiver.

4.6 USB Connector

A USB interface is available via a micro-USB connector. This module supports USB 2.0 Full-Speed (12Mbit/s) connections.

| USB Connector Pin Assignment | | | |
|------------------------------|-------|-------------------|--------------------------|
| Pin | Label | Direction | Description |
| 1 | VBUS | Power (+5V input) | +5V supply from the host |
| 2 | D- | bi-directional | USB Data- |
| 3 | D+ | bi-directional | USB Data+ |
| 4 | ID | | not connected |
| 5 | GND | Power (GND) | Signal and system ground |

Table 8: USB Connector Pin Assignment

4.7 Microcontroller Programming Interface

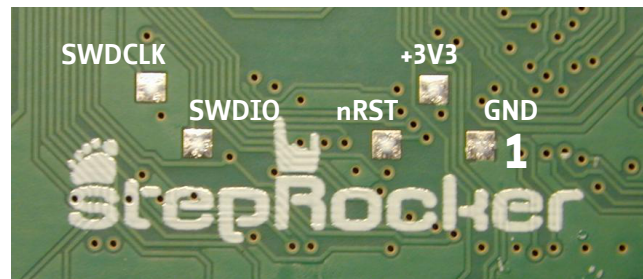
The programming pads for the microcontroller are located on the bottom side of the module. They are connected directly to the related processor pins - resp. GND or on-board generated +3V3 supply. These pins are used for programming of the bootloader and firmware during production + testing of the module.

| Programming Pads | | |
|------------------|-------|-------------------------------------|
| Pin | Label | Description |
| 1 | GND | Module and signal ground |
| 2 | +3V3 | +3V3 DC supply - generated on-board |
| 3 | nRST | Hardware reset input |



| Pin | Label | Description |
|-----|--------|----------------------|
| 4 | SWDIO | Serial wire data I/O |
| 5 | SWDCLK | Serial wire clock |

Table 9: Programming Pads on Bottom of the PCB



5 Jumper Settings

The TMCM-1211 StepRocker™ offers a number of jumpers for selection of different settings in hardware.

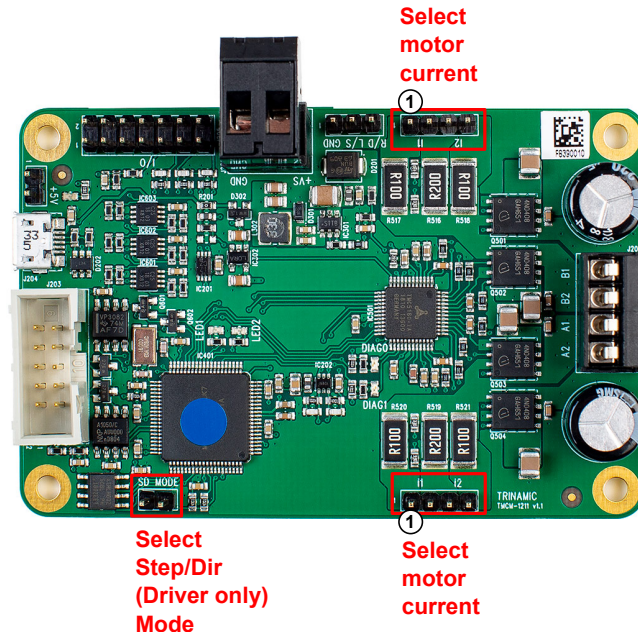


Figure 3: Jumper Settings of the TMCM-1211 StepRocker™

| Jumpers of the TMCM-1211 StepRocker™ | | |
|--------------------------------------|------------------------|--|
| Jumper | Label | Description |
| Select motor current | Jumper removed | Jumper removed: motor current up to 1.1A RMS |
| | Jumper pin 1-2 | 1 Jumper populated (pin 1-2): motor current up to 3.4A RMS |
| | Jumper pin 1-2 and 3-4 | 2 Jumper populated (pin 1-2 and pin 3-4): motor current up to 5.7A RMS |
| Select Step/Dir mode | Jumper removed | Remove jumper to enable on-board motion controller |
| | Jumper pin 1-2 | Set jumpers to select external motion controller. Step/Dir Signals from external motion controller have to be connected to Step/Dir In |

Table 10: Jumpers of the TMCM-1211 StepRocker™



6 LEDs

| LED Description | | |
|--|--------|---|
| Status | Label | Description |
| Power on | +5V | This orange LED lights up upon the power supply is available |
| LED1 without pre-defined functionality | LED1 | This yellow LED can be used customer specific. This LED is connected to PTA5 (pin 31) of the MK20DX128VLK7 microcontroller. |
| LED2 without pre-defined functionality | LED2 | This yellow LED can be used customer specific. This LED is connected to PTE5 (pin 6) of the MK20DX128VLK7 microcontroller. |
| TMC5160 diagnosis output 0 | DIAG_0 | This green LED lights up if the DIAG 0 output of the TMC5160 is pulled low. |
| TMC5160 diagnosis output 1 | DIAG_1 | This green LED lights up if the DIAG 1 output of the TMC5160 is pulled low. |

Table 11: LED Description

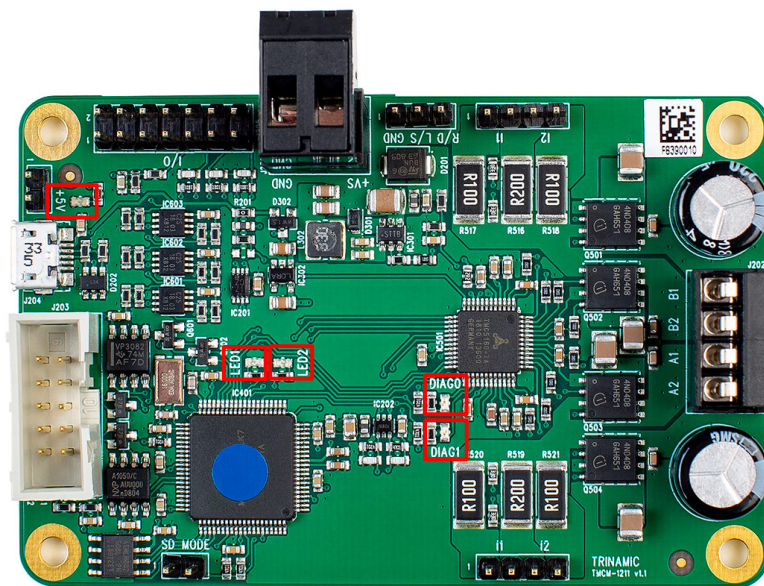


Figure 4: TCCM-1211 LEDs



7 Communication

7.1 RS485

For remote control and communication with a host system the TMCM-1211 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.

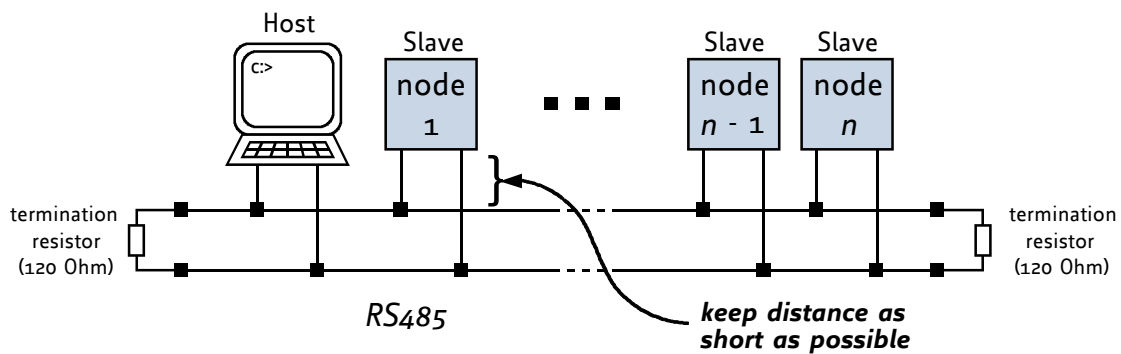


Figure 5: RS485 Bus Structure with Termination Resistors

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 TMCM-1211 does not intergate 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 stadard (EIA-485) allows up to 32 nodes to be connected to a single bus. The bus transceiver used on the TMCM-1211 units (SN65HVD3082ED) has just 1/8th of the standard bus load and allows a maximum of 256 units to be connected to a single RS485 bus.

4. **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 GND resp. +5V. In contrast to the termination resistors this network is normally required just once per bus. Certain RS485 interface converters available for PCs already include these additional resistors (e.g. USB-2-485).



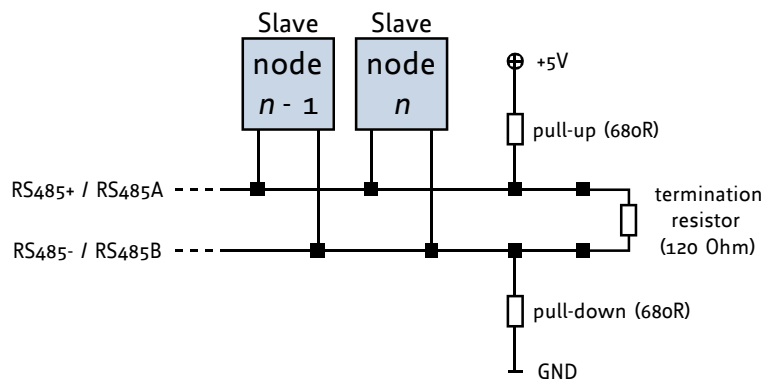


Figure 6: RS485 Bus Lines with Resistor Network

7.2 USB

For remote control and communication with a host system the TMCM-1211 StepRocker™ provides a USB 2.0 full-speed (12Mbit/s) interface (mini-USB connector). As soon as a USB-Host is connected the module will accept commands via USB. The TMCM-1211 supports USB self powered operation (External power supplied via the power supply connector) and USB bus powered operation, also (no external power is supplied via the power supply connector). During USB bus powered operation, only the core digital circuit parts will be operational. That is, the microcontroller itself and also the EEPROM. Of course, any motor movement will not be possible in this mode. This mode has been implemented in order to enable configuration / parameter setting / read-out, firmware updates etc. by just connecting a USB cable between the module and a host PC. No other connection / additional power supply is required.

7.3 CAN (Retro-fit Option)

For remote control and communication with a host system the TMCM-1211 StepRocker™ can be equipped with a CAN bus interface. Please note, that it is necessary to add CAN transceiver and filter capacitor first for the standard TMCM-1211 StepRocker™ version (see 4.5.1).

For proper operation the following items should be taken into account when setting up a CAN 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.

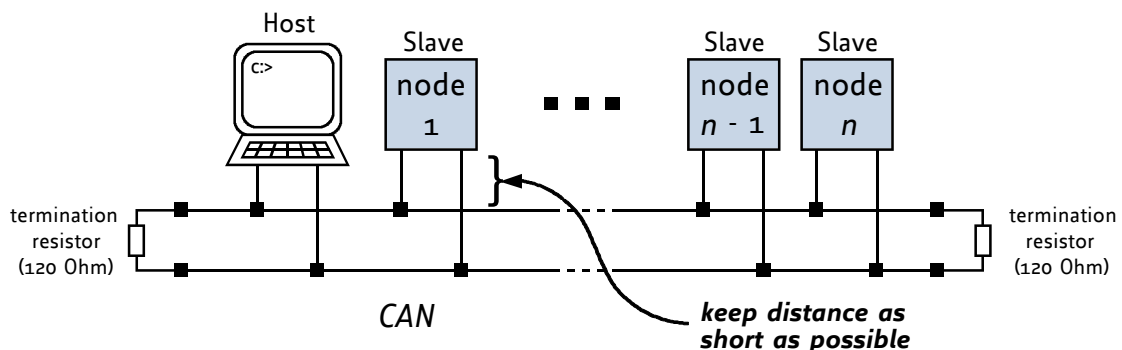


Figure 7: CAN Bus Structure with Termination Resistors



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-1211 does not integrate any termination resistor. Therefore, 120 Ohm termination resistors at both ends of the bus have to be added externally.



8 Functional Description

The TCCM-1211 is a highly integrated single axis controller/driver module for stepper motors. The TCCM-1211 can be controlled via RS485 or USB serial interfaces (CAN retro-fit option).

The TCCM-1211 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. Whereas the boot loader is installed during production and testing at TRINAMIC and remains usually untouched throughout the whole lifetime, the firmware can be updated by the user.

Communication traffic is kept low since all time critical operations, e.g. ramp calculation, are performed on-board. Full remote control of the device with feedback is possible. The firmware of the module can be updated via any of the serial interfaces.

The TCCM-1211 module contains the following main components:

- Microcontroller (ARM Cortex-M4™, MK20DX128VLK7), responsible for overall control and communication
- TMC5160 highly integrated stepper motor controller / driver. Step-/direction inputs, stop switch inputs and encoder inputs connected to TMC5160.
- MOSFET driver stage (8x NMOSFETs for bipolar stepper motor)
- RS485 and USB transceivers
- On-board voltage regulators (+5V and +3V3) required for supply of all on-board digital circuits

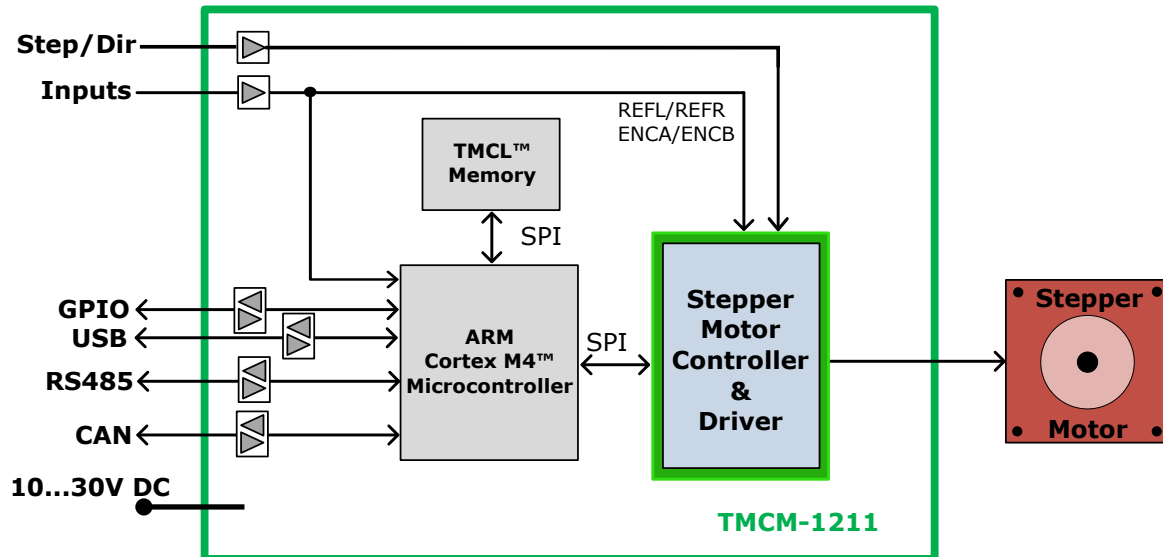


Figure 8: TCCM-1211 Block Diagram



9 Operational Ratings and Characteristics

NOTICE

Never Exceed the absolute maximum ratings! Keep the power supply voltage below the upper limit of +30V! Otherwise the board electronics will seriously be damaged! Especially, when the selected operating voltage is near the upper limit a regulated power supply is highly recommended.

| General Operational Ratings | | | | | |
|-----------------------------|---|-----|-----|-------------------|------|
| Symbol | Parameter | Min | Typ | Max | Unit |
| V _{Power} | Power supply voltage | 10 | 24 | 30 | V |
| V _{USB} | Power supply via USB connector | | 5 | | V |
| I _{USB} | Current withdrawn from USB supply when USB bus powered (no other supply connected) | | 40 | | mA |
| I _{COIL} | Motor coil current for sine wave peak (chopper regulated, adjustable via software) with 0, 1 or 2 jumper set | 0 | | 1.6 or 4.8 or 8.1 | A |
| I _{MC} | Continuous motor current (RMS) with 0, 1 or 2 jumper set | 0 | | 1.1 or 3.4 or 5.7 | A |
| T _{ENV} | Environmental temperature at rated current (no forced cooling required) | -25 | | 50 | °C |

Table 12: General Operational Ratings of the Module

| Operational Ratings of the RS485 Interface | | | | | |
|--|---|-----|-----|-----|------|
| Symbol | Parameter | Min | Typ | Max | Unit |
| N _{RS485} | Number of nodes connected to single RS485 network | | | 256 | |

Table 13: Operational Ratings of the RS485 Interface



10 Abbreviations used in this Manual

| Abbreviation | Description |
|--------------|------------------------------------|
| IDE | Integrated Development Environment |
| LED | Light Emmitting Diode |
| RMS | Root Mean Square value |
| TMCL | TRINAMIC Motion Control Language |

Table 14: Abbreviations used in this Manual



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13 Supplemental Directives

13.1 Producer Information

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13.7 Collateral Documents & Tools

This product documentation is related and/or associated with additional tool kits, firmware and other items, as provided on the product page at: www.trinamic.com.



14 Revision History

14.1 Hardware Revision

| Version | Date | Author | Description |
|---------|-------------|--------|--------------------------------------|
| V1.0 | 2018-JUN-21 | MM | First version. Prototypes, only. |
| V1.1 | 2018-JUL-17 | MM | Several corrections. Series version. |

Table 15: Hardware Revision

14.2 Document Revision

| Version | Date | Author | Description |
|---------|-------------|--------|--|
| 1.00 | 2018-OCT-08 | GE | First version |
| 1.10 | 2018-NOV-06 | GE | Several corrections (incl. order codes etc.) |

Table 16: Document Revision

