TMCM-1240 Hardware Manual

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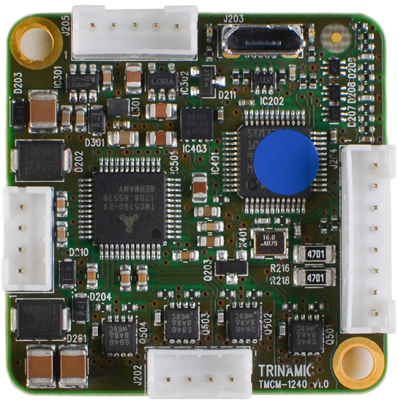
The TMCM-1240 is a single axis motor controller/driver board for 2-phase bipolar stepper motors with up-to 2A RMS motor current. It supports 6-point ramps in addition to linear ramps.



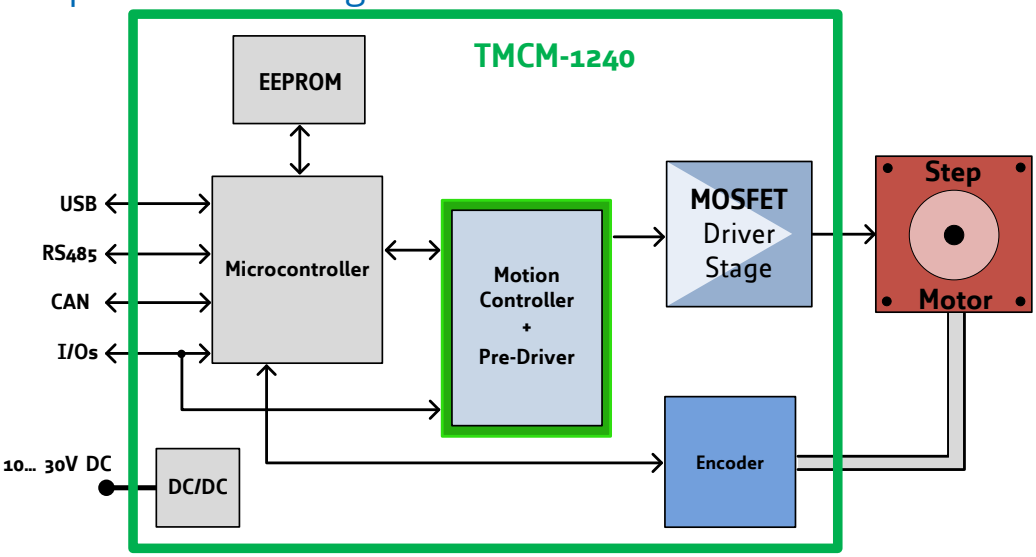
Features

- Single axis controller/driver for 2-phase bipolar stepper motor
- Linear and sixPoint™ ramps
- +10…30V DC supply voltage
- Up to 2A RMS motor current
- RS485, CAN & USB interface
- integrated sensOstep encoder and support for external encoder
- S/D interface
- multi-purpose inputs and outputs

Applications

- Laboratory Automation
- Manufacturing
- Semiconductor Handling
- Robotics
- Factory Automation
- Test & Measurement
- Life Science
- Biotechnology
- Liquid Handling

Simplified Block Diagram



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1 Features

The TMCM-1240 is a single axis motor controller/driver board for 2-phase bipolar stepper motors with up-to 2A RMS (2.8A peak) motor coil current. It supports linear ramps and unique sixPoint™ramps. It offers on-board sensOstep encoder and in addition, support for connection of external (incremental A/B) encoder. For driver-only applications, the TMCM-1240 offers optically isolated Step/Direction inputs. When using the on-board motion controller the optically isolated inputs are used for connection of end-switches. The standard version of the TMCM-1240 offers one analog input (0..10V range), two digital inputs and one open-drain output (100mA load max.) For communication in addition to USB (Micro-USB connector), RS485 and CAN serial interfaces are available. USB is intended mainly for firmware updates and parameter settings - supporting USB-powered operation (just the digital part) for easy data tranfer between PC and TMCM-1240 module. With CANopen firmware CANopen protocol is supported via the CAN interface.

Motion Controller

- Motion profile calculation in real-time
- On the fly alteration of motor parameters (e.g. position, velocity, acceleration)
- Linear and unique sixPoint™ramp in hardware
- Encoder interface and Reference / Stop switch inputs

Driver

- Motor current: up to 2A RMS (2.2A RMS max. / 3.1A peak, programmable in software)
- Supply voltage: +24V DC (+10… +30V DC)
- 256 microsteps per fullstep
- spreadCycle™highly dynamic current control chopper
- stealthChop™for quiet operation and smooth motion
- programmable Step/Dir interface for driver-only applications with microstep interpolation

Encoder

- integrated sensOstep absolut position magnetic encoder (resolution: 1024 increments per rotation) for step-loss detection under all operating conditions and positioning supervision (accuracy: +/- 5 encoder steps)
- support for external A/B incremental encoder in addition / as an alternative for the integrated encoder
- programmable encoder scaling and support for motor stop on encoder deviation

Interfaces

- RS485 interface (up-to 1Mbit/s)
- CAN interface (up-to 1Mbit/s)
- USB 2.0 full speed (12Mbit/s) device interface (micro-USB connector)
- Step/Dir input (optically isolated)
- Left and Right STOP switch inputs (optically isolated, shared with Step/Dir inputs)
- 2 general purpose digital inputs

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- Encoder input for incremental A/B encoder signals (shared with general purpose digital inputs)
- 1 analog input (0..10V nom. input range)
- HOME switch input (shared with analog input)

Mechanical data

- Board size: 37mm x 37mm, height 11mm max. without mating connectors
- 2 mounting holes for M3 screws

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). Please see TMCM-1240 TMCL firmware manual for more details
- CANopen firmware with CANopen standard protocol stack for the CAN interface. Please see TMCM-1240 CANopen firmware manual for more details.

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2 Order Codes

The standard version of the TMCM-1240 is pre-programmed with either TRINAMIC TMCL™ firmware or CANopen firmware.
On request a version with 3 analog inputs (0..10V) is available instead of one analog and two digital inputs on the I/O connector of the TMCM-1240. As this is an assembly version with different components concerning these inputs, only all mechanical data and all other electrical data are the same.

Order Code	Description	Size (LxWxH)
TMCM-1240-TMCL	1-axis bipolar stepper motor controller/driver, up-to 2A RMS motor current, 24V nom. supply, integrated sensOstep encoder, S/D input, ext. Encoder input, 1 analog input, 4 digital inputs, 1 OD output, CAN, RS485 and USB interfaces	37mm x 37mm x 11mm
TMCM-1240-CANopen	1-axis bipolar stepper motor controller/driver, up-to 2A RMS motor current, 24V nom. supply, integrated sensOstep encoder, S/D input, ext. Encoder input, 1 analog input, 4 digital inputs, 1 OD output, CAN, RS485 and USB interfaces	37mm x 37mm x 11mm
TMCM-1240-3A-TMCL	1-axis bipolar stepper motor controller/driver, up-to 2A RMS motor current, 24V nom. supply, integrated sensOstep encoder, S/D input, 3 analog inputs, 2 digital inputs, 1 OD output, CAN, RS485 and USB interfaces	37mm x 37mm x 11mm

Table 1: TMCM-1240 Order Code

A cable loom set is available for this module:

Order Code	Description
TMCM-1240-CABLE	Cable loom for TMCM-1240: • 1x cable loom for power supply connector (cable length 200mm, 4pin JST PH connector at one end, open wires at the other end) • 1x cable loom for RS485 + CAN connector (cable length 200mm, 5pin JST PH connector at one end, open wires at the other end) • 1x cable loom for motor connector (cable length 200mm, 4pin JST PH connector at one end, open wires at the other end) • 1x cable loom for I/O connector (cable length 200mm, 8pin JST PH connector at one end, open wires at the other end) • 1x Micro-USB cable

Table 2: TMCM-1240 Cable Loom

The TMCM-1240 is also available as motor mounted version together with NEMA17 / 42mm flange size stepper motor. Please refer to PD42-x-1240 PANdrive hardware manual for further details.

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3 Mechanical and Electrical Interfacing

3.1 Size of board

The board with the controller/driver electronics has an overall size of 37mm x 37mm x 11mm without mating connectors. Maximum component height (height above PCB level) without mating connectors is around 7mm above PCB level and 2.5 mm below PCB level. There are two mounting holes (3.2mm diameter) for M3 screws for mounting to a NEMA17 stepper motor.

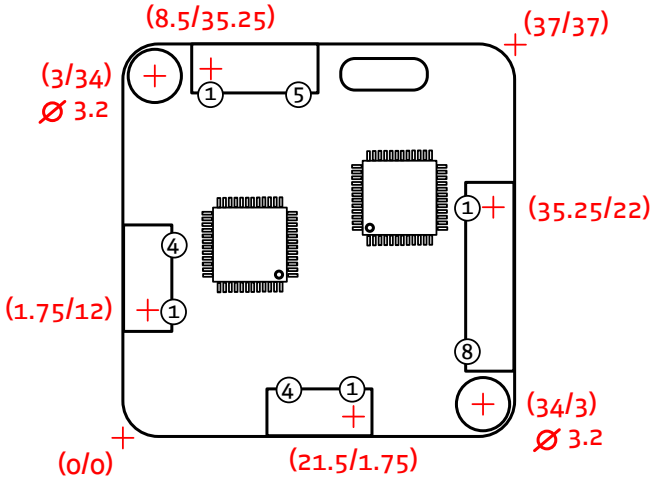

Figure 1: Board dimensions, position of mounting holes and position (pin 1) of connectors (all values in mm)

3.2 Board mounting considerations

The TMCM-1240 offers two metal plated mounting holes. Both mounting holes are connected to system and signal ground (same as power supply ground). In order to minimize distortion of signals and radiation of HF signals (improve EMC compatibility) especially in sensitive / noisy environments it is important to ensure a solid ground connection within the system. In order to support this, it is recommended to connect both mounting holes of the board in addition to the supply ground connection to system power supply ground. Nevertheless, this might not always be an option e.g. in case the metal system chassis / TMCM-1240 mounting plate is already connected to earth and a direct connection between supply ground (secondary side) and mains supply earth (primary side) is not desired / not an option. In this case plastic (e.g. made of nylon) spacers / distance bolts and screws should be used.

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4 Connectors

The TMCM-1240 offers five connectors altogehter. There is one motor and one power supply connector - both with four pins - and two interface connectors - one with five pins for RS485 and CAN and a dedicated micro-USB connector. All other inputs and outputs are concentrated on one 8 pin connector.

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.

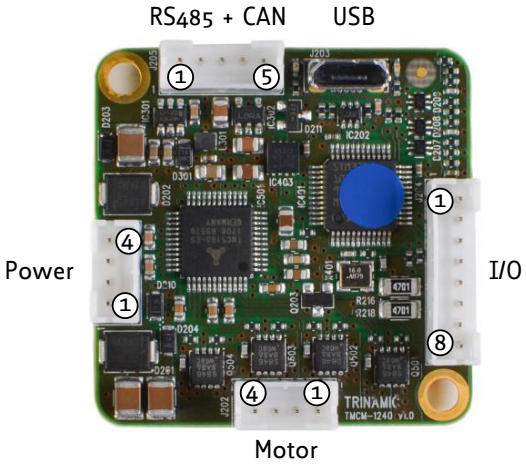

Figure 2: TMCM-1240 connectors

Connector Types and Mating Connectors		
Connector	Connector type on-board	Mating connector type
Power	JST B4B-PH-K-S (JST PH series, 4pins, 2mm pitch)	Connector housing: JST PHR-4 Contacts: JST SPH-002T-P0.5S Wire: 0.22mm2, AWG 24
Motor	JST B4B-PH-K-S (JST PH series, 4pins, 2mm pitch)	Connector housing: JST PHR-4 Contacts: JST SPH-002T-P0.5S Wire: 0.22mm2, AWG 24
RS485+CAN	JST B5B-PH-K-S (JST PH series, 5pins, 2mm pitch)	Connector housing: JST PHR-5 Contacts: JST SPH-002T-P0.5S Wire: 0.22mm2, AWG 24
USB	USB-micro B female connector	USB-micro B male connector
I/O	JST B8B-PH-K-S (JST PH series, 8pins, 2mm pitch)	Connector housing: JST PHR-8 Contacts: JST SPH-002T-P0.5S Wire: 0.22mm2, AWG 24

Table 3: Connector Types and Mating Connectors of the TMCM-1240

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4.1 Power Supply Input Connector

The TMCM-1240 offers one 4pin JST PH series power supply input connector. In addition to main power supply input and related ground connection this connector offers a separate logic supply input with the option to keep the on-board logic alive while the driver stage is switched off. It is not necesary to connect the logic supply input in case separate supplies are not required as the main power supply input will always supply power to the driver stage and the logic part.
The power supply input connector offers a driver enable input. This input has to be connected to any voltage above 3.5V up-to max. supply voltage of 30V in order to enable the driver stage. Leaving this pin unconnected or connected to ground (voltage below 2.4V) will disable the driver stage regardless of any settings in software. This input may be connected to main power supply input permanently in case an enable input in hardware is not required.

Power Supply Connector Pin Assigment			
Pin	Label	Direction	Description
1	GND	Power (GND)	Common system supply and signal ground
2	V_{MAIN}	Power (input)	Main power supply input for the driver and on-board logic *10...30V*
3	Enable	Digital input	Driver enable input. A voltage above 3.5V is required here in order to enable the on-board stepper motor driver. This input maybe connected to main power supply input in order to enable the driver stage (+24V tolerant input).
4	V_{LOGIC}	Power (input)	Optional separate power supply input for the on-board logic *10...30V*

Table 4: 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!**

NOTICE **Connect Enable pin** to voltage >3.5V in order to enable motor movements!

4.2 Motor Connector

A second 4pin JST PH series connector is available for connection of a 2-phase bipolar stepper motor.

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

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Pin	Label	Direction	Description
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.

NOTICE

Do not mix-up power supply and motor connectors!

4.3 RS485 + CAN Connector

For serial communication the TMCM-1240 offers selection between RS485, CAN and USB interfaces. While the USB interface is available for configuration and service of the board, mainly (e.g. parameter settings, firmware updates) a 5-pin JST PH series connector offers 2-wire RS485 and CAN interfaces for in system communication.

NOTICE

Due to hardware ressource sharing USB and CAN communication interfaces are not available at the same time. As soon as USB is physically attached to a host or hub the CAN interface will be switched off.

RS485 + CAN Connector Pin Assignment			
Pin	Label	Direction	Description
1	GND	Power (GND)	Common system supply and signal ground
2	RS485+	Bidirectional	RS485 interface, diff. signal (non-inverting)
3	RS485-	Bidirectional	RS485 interface, diff. signal (inverting)
4	CAN_H	Bidirectional	CAN interface, diff. signal (non-inverting)
5	CAN_L	Bidirectional	CAN interface, diff. signal (inverting)

Table 6: RS485 + CAN Connector Pin Assignment

4.4 USB Connector

For serial communication the TMCM-1240 offers selection between RS485, CAN and USB interfaces. The USB interface via on-board micro-USB connector (type B) is available for configuration and service of the board, mainly (e.g. parameter settings, firmware updates). The USB device interface supports full speed (12Mbit/s) communication and supports bus powered and self-powered operation. During bus-powered operation the low voltage logic part of the board will be powered, only. This includes the microcontroller and the non-volatile memory and therefore allows parameter settings and firmware updates of the board

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using a standard USB cable, only. Of course, for any motor movement main supply via supply input connector is required.

NOTICE Due to hardware ressource sharing USB and CAN communication interfaces are not available at the same time. As soon as USB is physically attached to a host or hub the CAN interface will be switched off.

USB Connector Pin Assignment			
Pin	Label	Direction	Description
1	VBUS	Power (+5V)	USB +5V nom. power supply input
2	D-	Bidirectional	USB interface, diff. signal (inverting)
3	D+	Bidirectional	USB interface, diff. signal (inverting)
4	ID	Input	connected to GND (via 100k resistor)
5	GND	Power (GND)	Common system supply and signal ground

Table 7: USB Connector Pin Assignment

4.5 I/O Connector

The TMCM-1240 offers several inputs (two of them optically isolated) and one digital (open-drain) output. The inputs include support for stop switches (left and right), home switch, step/direction, incremental A/B channel encoder and analog (0…+10V) input. All this functionality is available via one 8pin JST PH series I/O connector.

I/O Connector Pin Assignment			
Pin	Label	Direction	Description
1	GND	Power (GND)	Common system supply and signal ground
2	IN0/HOME	Input	Analog input (0…+10V) HOME switch input *+24V tolerant, programmable (separate) pull-up to +5V*
3	IN1/ENC_A	Input	General purpose digital input Incremental encoder input channel A *+24V tolerant, programmable pull-up (for IN1/IN2 together) to +5V*
4	IN2/ENC_B	Input	General purpose digital input Incremental encoder input channel B *+24V tolerant, programmable pull-up (for IN1/IN2 together) to +5V*
5	STOP_L/STEP	Input	STOP left switch input STEP pulse input *input optically isolated, +24V compatible*
6	STOP_R/DIR	Input	STOP right switch input DIR input *input optically isolated, +24V compatible*

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Pin	Label	Direction	Description
7	ISO_COM	Power	Common positive (+24V_ISO) or negative (GND_ISO) isolated supply input for optically isolated inputs
8	OUT0	Output (OD)	Open-Drain output. Output will be pulled low when activated. *Voltages up-to logic supply input level (or main supply input in case separate logic supply is not used) are supported here. Max. continuous pull-down current: 100mA*

Table 8: I/O Connector Pin Assignment

All pins marked light green offer functional isolation towards main supply input. In case this is not required ISO_COM may be connected to main ground or supply input, of course. The opto-couppler used are AC types. This way, either high side switches or low side switches for both inputs are supported.

5 On-Board LEDs

The board offers two LEDs in order to indicate board status. The function of both LEDs is dependent on the firmware version. With standard TMCL firmware the green LED should be flashing slowly during operation and the red LED should be off. When there is no valid firmware programmed into the board or during firmware update the red and green LEDs are permanently switched on. During reset to factory default values the green LED will be flashing fast. With CANopen firmware both LEDs are switched on/off/flashing according to standard defintion.

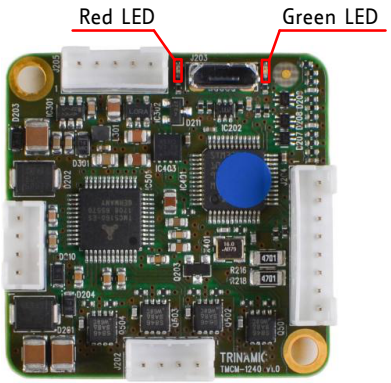

Figure 3: TMCM-1240 LEDs

6 Reset to Factory Defaults

It is possible to reset all settings in firmware for the TMCM-1240 to factory defaults without establishing a working communication connection. This might be helpful in case communication parameters of the preferred interface have been set to unknown values or got lost.
For this procedure two pads on the bottom side of the module have to be shorted (electrically connected with each other) during power-on.
Please perform the following steps:

1. Switch power supply OFF (and disconnect USB cable if applicable)
2. Short CLK and DIO pads of programming pads on bottom of pcb (see figure 4)

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3. Switch power supply ON again (or connect USB again if applicable)
4. Wait until the on-board red and green LEDs start flashing fast (this might take a while)
5. Switch power supply OFF again (and disconnect USB cable if applicable)
6. Remove short between pads
7. After switching power supply ON again (and / or connecting USB cable) all permanent settings have been restored to factroy defaults

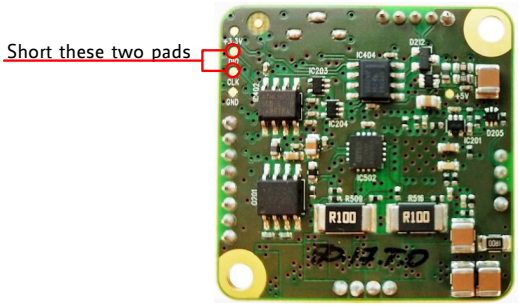

Figure 4: Reset to factory default settings

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7 I/Os

The I/O connector (8pin JST PH series) offers one analog input, two non-isolated digital inputs with integrated pull-ups (programmable) and two optically isolated inputs. All inputs can be used for different purposes explained in more detail in the following subsections.

7.1 Analog input IN0

The TMCM-1240 offers one analog input. The analog input voltage range is approx. 0..+10V. For voltages above +10V saturation takes place but, up-to 30V higher voltages are tolerated without destroying the input. For analog to digital conversion the integrated ADC of the on-board microcontroller is used. Resolution of this converter is 12bit (0..4095).

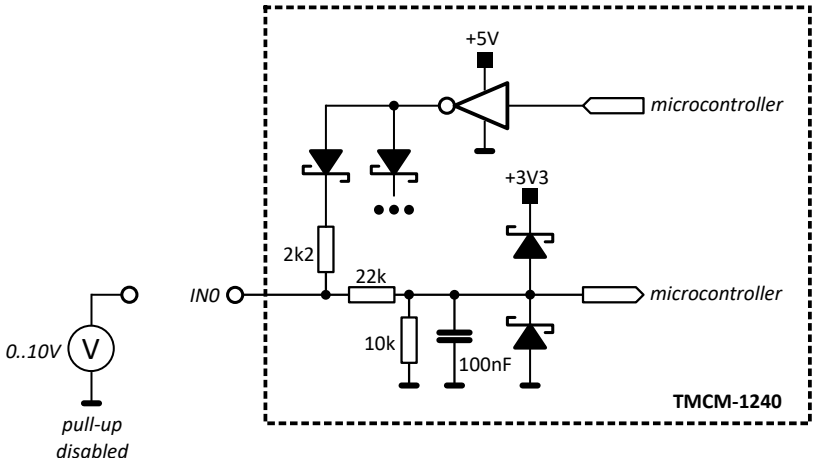

Figure 5: Analog input IN0

The analog input can be used as digital input, also. There is an integrated pull-up to +5V which can be switched on of off in software. When using this input as anlog input the pull-up should be usually switched off.

7.2 Digital inputs IN1 and IN2

The TMCM-1240 offers two digital inputs IN1 and IN2 which accept signals between 0 and 30V with voltages above approx. 2.9V recognized as logical '1' and below 1V as logical '0'. Both inputs offer intergated pull-ups to +5V which can be switched on or off in software (always together). When using the inputs with low-side switches (connected to GND), pull-ups usually should be switched on (default). In case high-side switches are used the pull-ups must be switched off. For push-pull signals the pull-ups may be either switched on or off.

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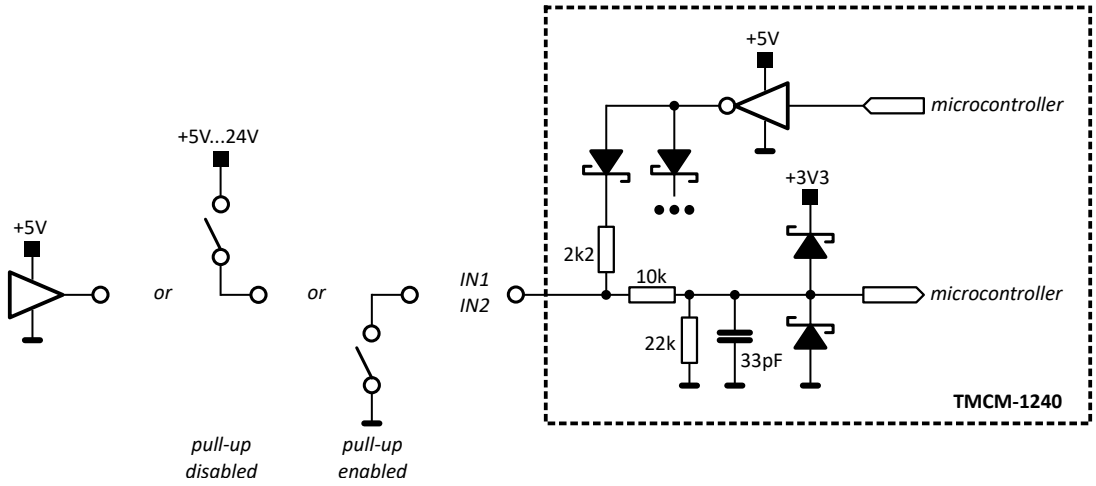

Figure 6: Digital inputs IN1 and IN2

7.3 HOME/STOP_L/STOP_R switch inputs

The TMCM-1240 offers two optically isolated inputs which can be used as left (STOP_L) and right (STOP_R) stop switch inputs. When enabled in software the STOP_L switch input will stop motor movement in negative direction (step counter decreasing) while activated. Likewise the STOP_R switch input will stop motor movement in positive direction (step counter increasing) while activated.

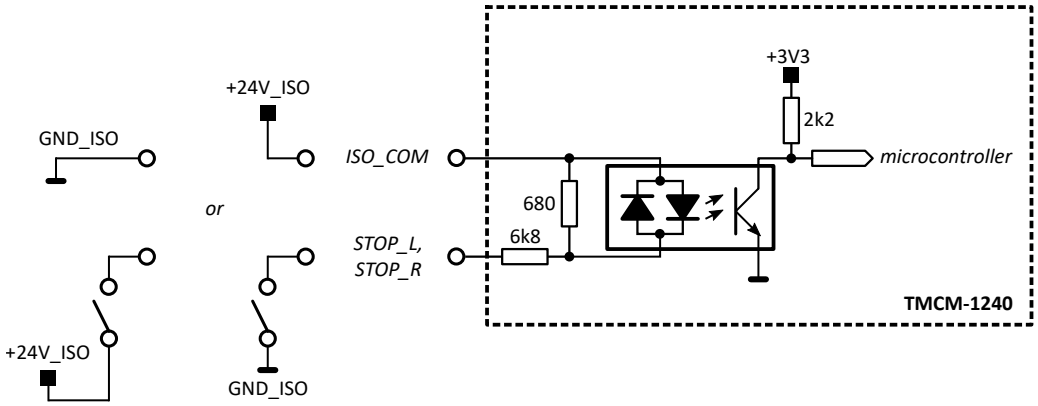

Figure 7: Stop switch inputs

A separated / isolated supply may be used for the switches - as indicated in the drawing (+24V_ISO and related GND_ISO) - but, same supply as for the TMCM-1240 can be used, also, of course.

7.4 External incremental encoder input

The TMCM-1240 offers an integrated hall-sensor based magnet encoder. In addition, an external incremental A/B encoder may be connected to the two digital inputs IN1 and IN2. Encoder with push-pull signals (e.g. +5V TTL) and open-drain output signals are supported (single-ended). For open-drain outputs the internal pull-ups should be activated in software (default mode).

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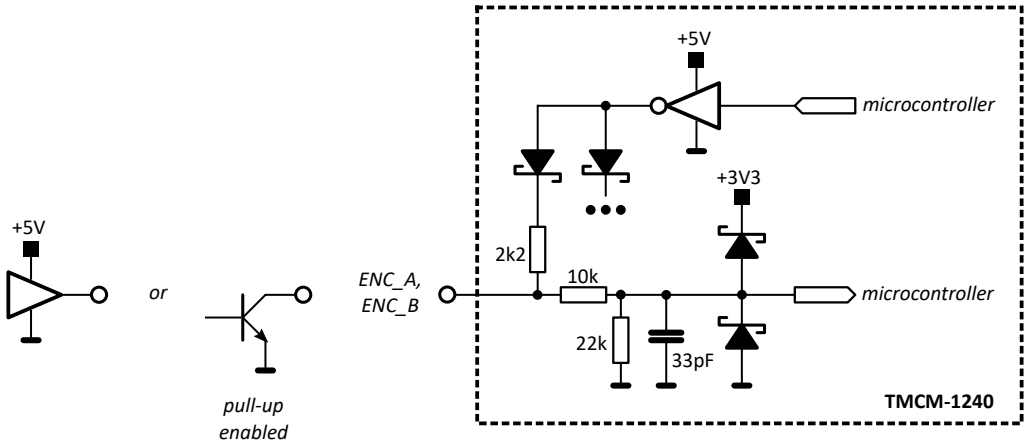

Figure 8: External encoder input

7.5 Step/Direction inputs

The TMCM-1240 may be used as driver with an external motion controller. In this case the Step/Direction output signals of the external motion controller may be connected to the optically isolated Step/Dir inputs of the TMCM-1240. Please note that these signals should be 24V signals. For lower voltage signals a simple small signal transistor maybe inserted as level converter.

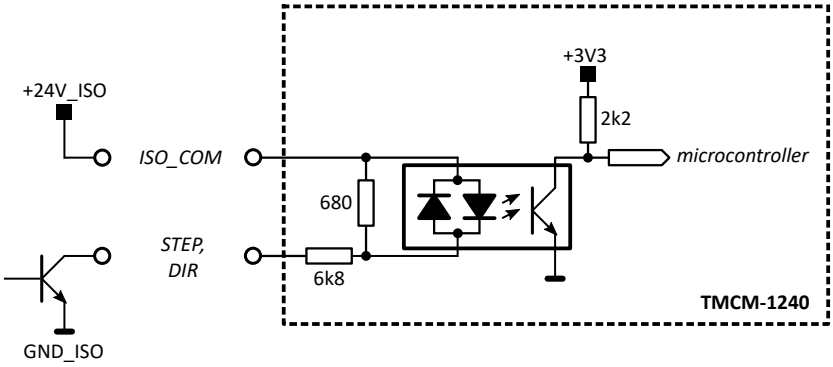

Figure 9: Step/Direction input

Due to limitations of the opto-isolators the maximum step frequency of these inputs is limited to around 20kHz. For higher motor speed the step interpolator of the driver stage should be activated or the microstep resolution reduced (default 256 microsteps per fullstep).

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8 Communication

8.1 RS485

For remote control and communication with a host system the TMCM-1240 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.

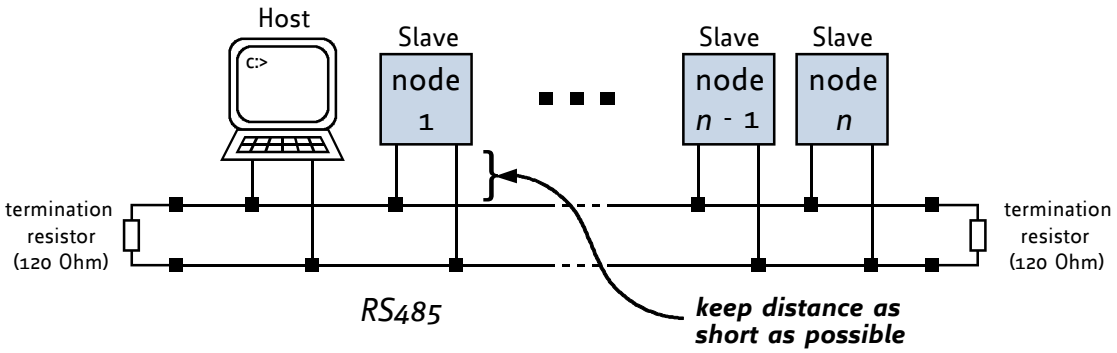

Figure 10: RS485 bus structure with termination resistors

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-1240 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 stadard (EIA-485) allows up to 32 nodes to be connected to a single bus. The bus transceiver used on the TMCM-1240 units (SN65HVD1781D) offers a significantly reduced bus load compared to the standard and allows a maximum of 255 units to be connected to a single RS485 bus using standard 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 TMCM-1240 hardware is 1Mbit/s. Factory default is 9600 bit/s. Please see separate TMCM-1240 TMCL firmware manual for information regarding other possible communication speeds below the upper hardware limit.

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):

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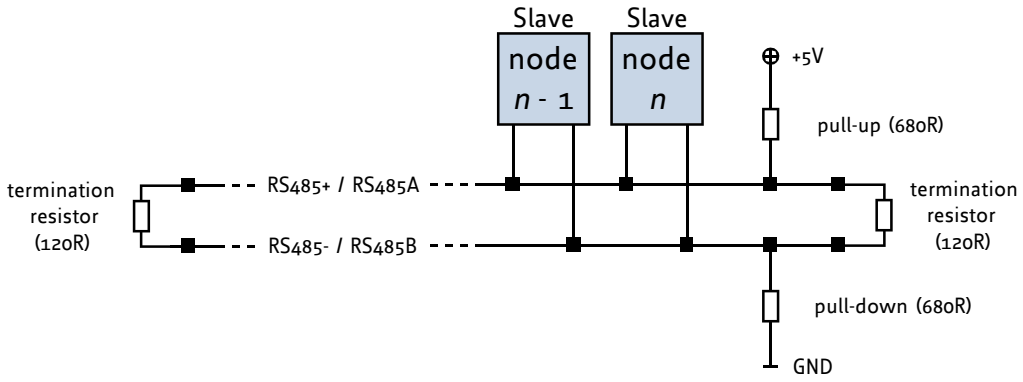

Figure 11: RS485 bus lines with resistor (bias) network on one side, only

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

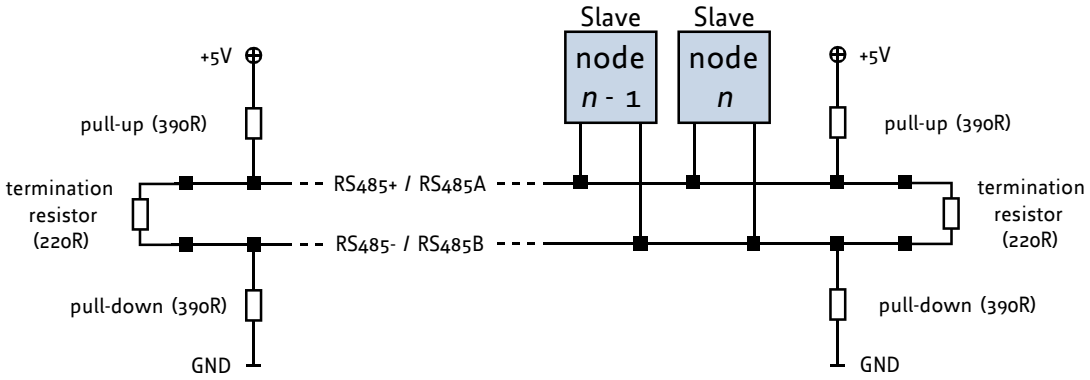

Figure 12: RS485 bus lines with Profibus™recommended line termination

8.2 CAN

For remote control and communication with a host system the TMCM-1240 provides a CAN bus interface. Please note that the CAN interface is not available in case USB is connected. 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.

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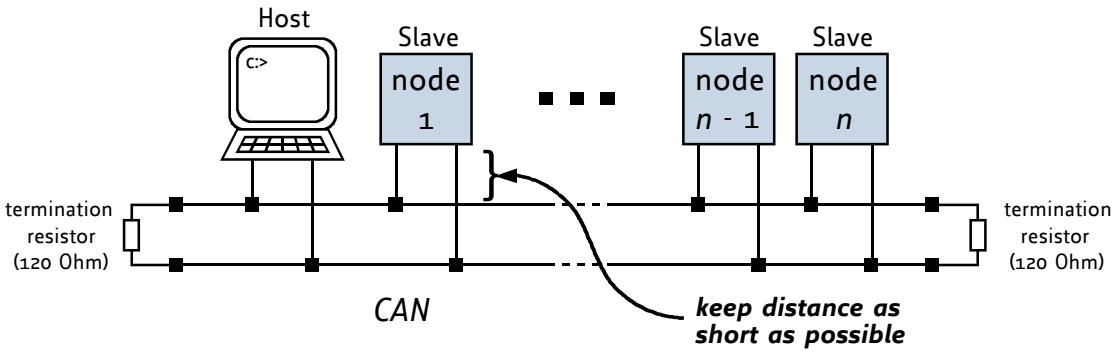

Figure 13: CAN bus structure with termination resistors

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 TMCM-1240 does not integrate any termination resistor. Therefore, 120 Ohm termination resistors at both ends of the bus have to be added externally.

3. *BUS TERMINATION:*
   The bus transceiver used on the TMCM-1240 units (TJA1051T) supports at least 110 nodes under optimum conditions. Practically achievable number of nodes per CAN bus highly depend on bus length (longer bus -> less nodes) and communication speed (higher speed -> less nodes).

9 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-1240 firmware manual for further information)

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

Motor Current Setting			
Motor current setting in software (TMCL)	Current scaling step (CS)	Motor current I_{COIL}[A] peak	Motor current I_{COIL}[A] RMS
0…7	0	0.102	0.072
8…15	1	0.203	0.144
16…23	2	0.305	0.215

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Motor current setting in software (TMCL)	Current scaling step (CS)	Motor current I_{COIL}[A] peak	Motor current I_{COIL}[A] RMS
24…31	3	0.406	0.287
32…39	4	0.508	0.359
40…47	5	0.609	0.431
48…55	6	0.711	0.503
56…63	7	0.813	0.575
64…71	8	0.914	0.646
72…79	9	1.016	0.718
80…87	10	1.117	0.790
88…95	11	1.219	0.862
96…103	12	1.320	0.934
104…111	13	1.422	1.005
112…119	14	1.523	1.077
120…127	15	1.625	1.149
128…135	16	1.727	1.221
136…143	17	1.828	1.293
144…151	18	1.930	1.364
152…159	19	2.031	2.133
160…167	20	2.133	1.508
168…175	21	2.234	1.580
176…183	22	2.336	1.652
184…191	23	2.438	1.724
192…199	24	2.539	1.795
200…207	25	2.641	1.867
208…215	26	2.742	1.939
216…223	27	2.844	2.011
224…231	28	2.945	2.083
232…239	29	3.047	2.154
240…247	30	3.148	2.226
248…255	31	3.250	2.298

Table 10: Available motor current settings

In addition to the settings in the table the motor current may be switched off completely (free-wheeling) using axis parameter 204 (see TMCM-1240 firmware manual).

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10 Functional Description

The TMCM-1240 is a highly integrated single axis controller/driver module for stepper motors with up-to 2A RMS / 2.8A peak motor coil current. The TMCM-1240 can be controlled via RS485, CAN or USB serial interfaces.
The TMCM-1240 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 via any serial interface.
Communication traffic is kept low since all time critical operations, e.g. ramp calculation, are perfomrmed 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 TMCM-1240 module contains the following main components:

- Microcontroller (ARM Cortex-M3™), responsible for overall control and communication
- Highly integrated advanced stepper motor controller supporting linear and unique 6-points ramps in hardware
- Advanced stepper motor driver with stallGuard2™ and coolStep™ with MOSFET driver stage (8x power N-MOSFETs for bipolar stepper motor)
- RS485, CAN and USB transceivers
- On-board voltage regulators (+5V and +3V3) required for supply of all on-board digital circuits

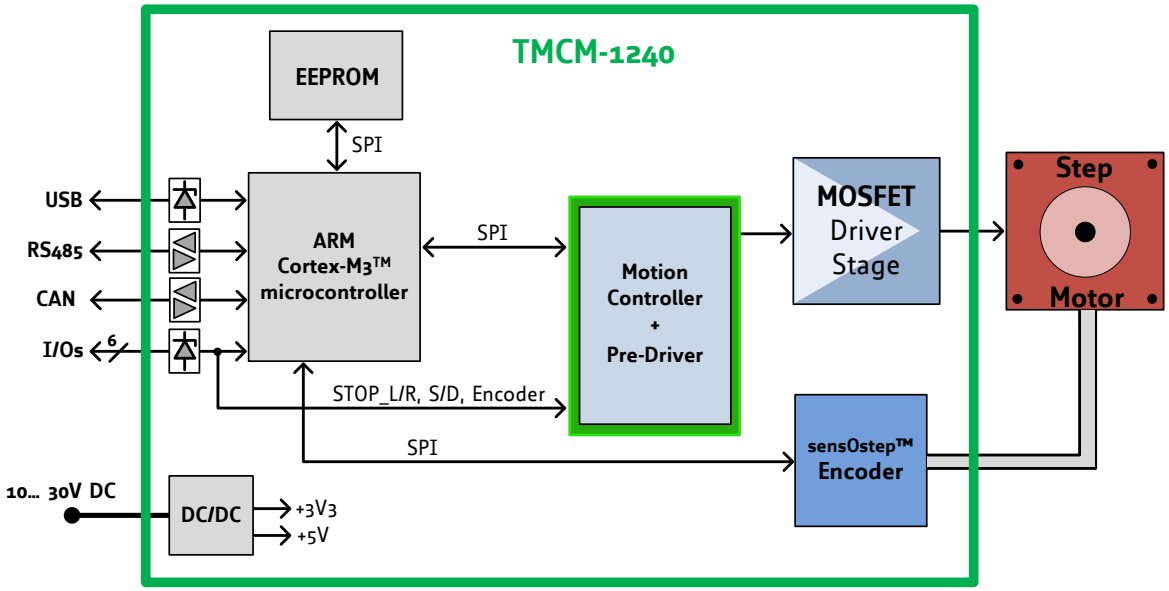

Figure 14: TMCM-1240 block diagram

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11 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	12…24	30	V
I_{Power}	Power supply current		<<I_{COIL_RMS}	1.4 x I_{COIL_RMS}	A
V_{USB}	Power supply via USB connector		5		V
I_{USB}	Current withdrawn from USB supply when USB bus powered (no other supply connected)		42		mA
I_{COIL_PEAK}	Motor coil current for sine wave **peak (chopper regulated, adjustable via software)**	0	0…2.8	3.1	A
I_{COIL_RMS}	Continuous motor current (**RMS)**	0	0…2	2.2[1]	A
T_{ENV}	Environmental temperature at rated current (no forced cooling reaquired)	-30		60	°C

Table 11: General operational ratings of the module

Operational Ratings of the I/Os					
Symbol	Parameter	Min	Typ	Max	Unit
V_{OUT0}	Voltage at open drain output OUT0 (switched off)	0		+V_{Power}	V
I_{OUT0}	Output sink current of open drain output OUT0 (switched on)			100	mA
$V_{IN0/1/2}$	Input voltage for IN0…IN2	0	0…+24	+30	V
V_{IN0}	Measurement range for analog input IN0	0		+10[2]	V
$V_{IN1/2_L}$	Low level voltage for IN1 and IN2 (digital inputs)			1	V
$V_{IN1/2_H}$	High level voltage for IN1 and IN2 (digital inputs)	2.9			V
V_{STOP_L/R_ON}	Switch-On opto-isolated inputs (voltage between input and ISO_COM)		20-24	30	V
V_{STOP_L/R_OFF}	Switch-off opto-isolated inputs (voltage between input and ISO_COM)	0	0-16		V

[1] Please note: 2.2A RMS will exceed connector specification. Therefore, continuous motor current should be limited to 2A RMS max. motor current

[2] approx. 0…+10.56V at the analog input IN0 is translated to 0…4095 (12bit ADC, raw values). Above approx. +10.56V the analog input will saturate but, not being damaged (up-to VDD).

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Operational Ratings of the I/Os					
Symbol	Parameter	Min	Typ	Max	Unit
$f_{STEP/DIR}$	Max. frequency for step/direction opto-isolated inputs		20		kHz

Table 12: Operational ratings of I/Os

Operational Ratings of the RS485 Interface					
Symbol	Parameter	Min	Typ	Max	Unit
N_{RS485}	Number of nodes connected to single RS485 network			256	
f_{RS485}	Max. speed for RS485 network			1Mbit/s	

Table 13: Operational ratings of the RS485 interface

Operational Ratings of the CAN Interface					
Symbol	Parameter	Min	Typ	Max	Unit
N_{CAN}	Number of nodes connected to single CAN network			>110	
f_{CAN}	Max. speed for CAN network			1Mbit/s	

Table 14: Operational ratings of the CAN interface

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12 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 15: Abbreviations used in this Manual

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15 Supplemental Directives

15.1 Producer Information

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16 Revision History

16.1 Hardware Revision

Version	Date	Author	Description
V1.0	2017-OCT-30	GE	Initial version.
V1.1	2017-NOV-28	GE	Minor changes: S/D support added.
V1.2	2018-DEC-05	GE	Driver stage MOSFETs and magnetic encoder IC replaced

Table 16: Hardware Revision

16.2 Document Revision

Version	Date	Author	Description
0.90	2017-NOV-29	GE	Initial version.
1.00	2018-FEB-19	GE	First release version.
1.10	2018-MAR-26	GE	I/O details added.
1.11	2018-MAY-03	OK	Typo corrections.
1.20	2019-MAY-24	SK	Module mechanical dimensions corrected.
1.21	2020-MAY-05	OK	I/O connector pin numbering corrected.

Table 17: Document Revision

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