FAULHABER

Hardware MCST 3601

Technical Manual

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W E CREATE MOTION

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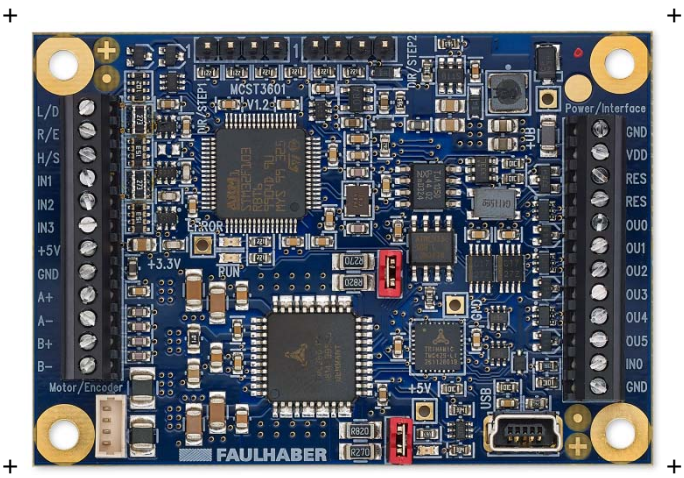
Hardware Version V1.2

HARDWARE MANUAL



MCST3601

1-Axis Stepper Controller / Driver
3-axes controller
Master / Slave operation
Up-to 1 A / 36 V
Incremental encoder input
GPIOs

UNIQUE FEATURES:

- **Compatible with the whole PRECIstep® stepper motor range**
- **Compact and fully programmable**
- **ASIC design**

POWERED BY: TRINAMIC MOTION CONTROL

Table of Contents

1 Features

The MCST3601 is a single axis controller/driver module for 2-phase bipolar stepper motors. It supports supply voltages up-to 36V DC and motor currents up-to 1A RMS (different motor current settings selectable in software and via two jumpers). The TMCL™ firmware allows for both, standalone operation and direct mode. The module can be configured as master (controller + driver) controlling up-to two external drivers in addition to the on-board one or as slave (driver only) with step/direction/enable inputs.

MAIN CHARACTERISTICS

Motion controller

- Motion profile calculation in real-time
- On the fly alteration of motor parameters (e.g. position, velocity, acceleration)
- High performance microcontroller for overall system control and serial communication protocol handling

Bipolar stepper motor driver

- Up to 256 microsteps per full step
- High-efficient operation, low power dissipation
- Dynamic current control
- Integrated protection

Interfaces

- USB device interface (on-board mini-USB connector)
  6x open drain outputs (24V compatible)
- REF_L / REF_R / HOME switch inputs (24V compatible with programmable pull-ups)
- 1x S/D input for the on-board driver (on-board motion controller can be deactivated)
- 2x Step / direction output for two separate external drivers (in addition to the on-board)
- 1x encoder input for incremental a/b/n encoder
- 3x general purpose digital inputs (24V compatible)
- 1x analog input (0 .. 10V)

Please note: not all functions are available at the same time as connector pins are shared

Software

- TMCL: standalone operation or remote controlled operation,
  program memory (non volatile) for up to 2048 TMCL commands, and
  PC-based application development software TMCL-IDE available for free.

Electrical and mechanical data

- Supply voltage: +24 V DC nominal (9… 36 V DC)
- Motor current: up to 1 A RMS / 1.5 A peak (programmable)
- Board size: 68mm + 47.5mm

2 Order Codes

Order code	Description	Size (mm^3)
MCST3601	Single axis bipolar stepper motor controller / driver electronics	68 x 47.5 x 13
MCST3601-SK		

Table 2.1 Order codes

3 Mechanical and Electrical Interfacing

3.1 Dimensions and Mounting Holes

The dimensions of the controller/driver board are approx. 68 mm x 47.5 mm x 13 mm. Maximum component height (height above PCB level) without mating connectors is around 9mm above PCB level and 2 mm below PCB level.

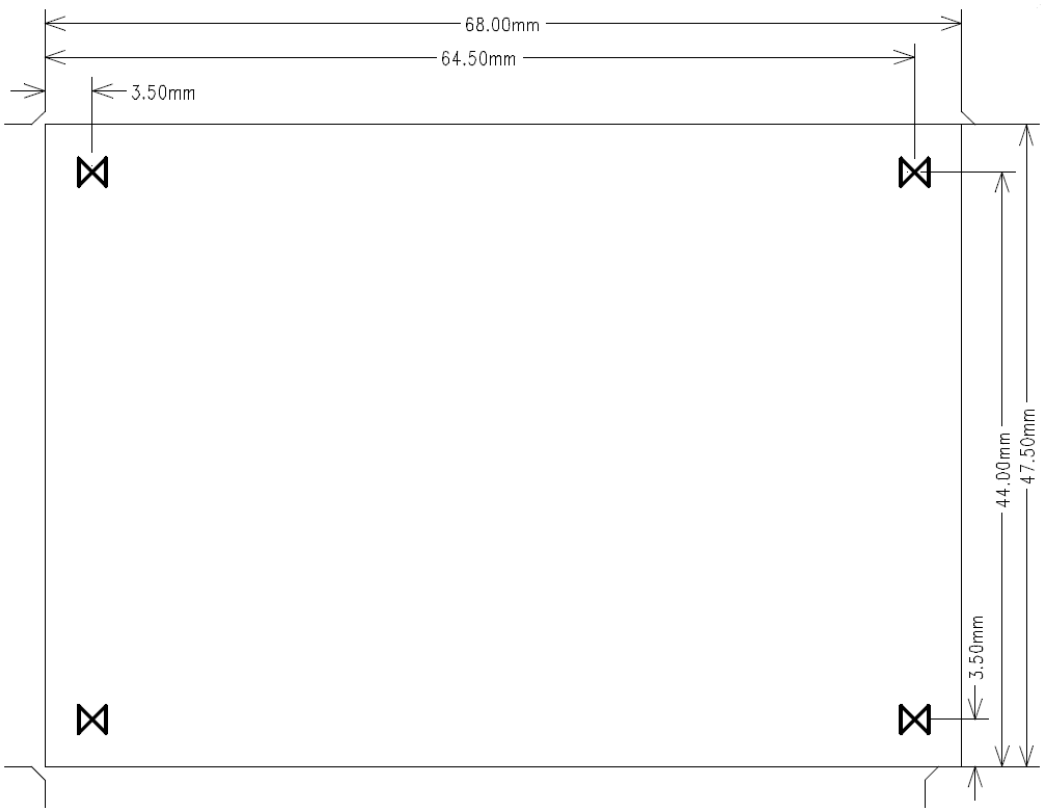


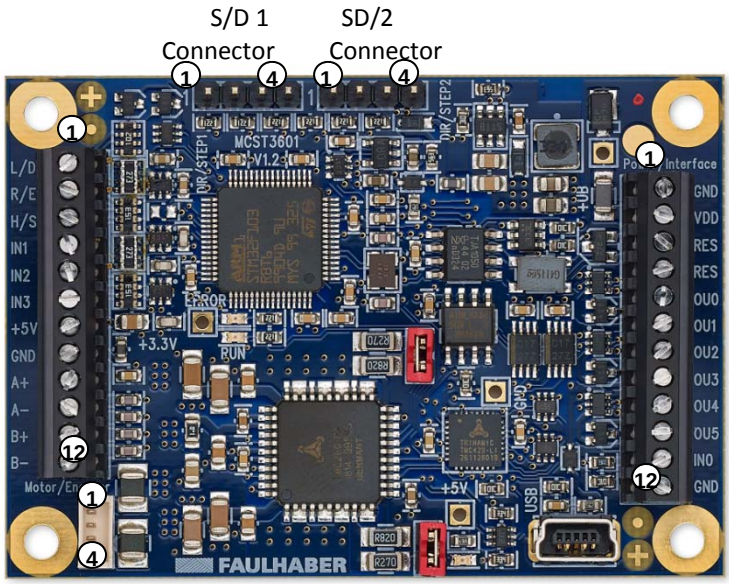
Figure 3.1 Dimension of MCST3601 and position of mounting holes

3.2 Connectors

The controller/driver board MCST3601 offers two rows of screw connectors at each end of the pcb. There is one additional motor connector and two single row headers for step direction output for axis one and two (please note that the internal driver axis has the number 0).

Motor / Encoder connector

1	REF_L / DIR_IN
2	REF_R / EN_IN
3	HOME / STEP_IN
4	ENC_A / IN1 (5V..24V)
5	ENC_B / IN2 (5V..24V)
6	ENC_N / IN3 (5V..24V)
7	+5VOUT / 100mA
8	GND
9	Motor Phase A+
10	Motor Phase A-
11	Motor Phase B+
12	Motor Phase B-



Power / Interface connector

1	GND
2	+9V ... +36V DC
3	CAN_H
4	CAN_L
5	OUT0 (OD 24V)
6	OUT1 (OD 24V)
7	OUT2 (OD 24V)
8	OUT3 (OD 24V)
9	OUT4 (OD 24V)
10	OUT5 (OD 24V)
11	IN0
12	GND

Figure 3.2 Overview connectors

Label	Connector type	Mating connector type
Motor / Encoder connector	Screw connector	Wire: up-to 0.5 mm^2
Power / Interface connector	Screw connector	Wire: up-to 0.5 mm^2
Motor connector	Molex PicoBlade, 4pin, 1.25mm pitch 53047-0410	Connector housing: Molex 51021-0400 Contacts: Molex 50079-8000 Wire: AWG 26-28
S/D 2 connector	Single row header, 4pins, 2.54mm pitch	Single row female plug, 4pins 2.54mm pitch
S/D 3 connector	Single row header, 4pins, 2.54mm pitch	Single row female plug, 4pins 2.54mm pitch
Mini-USB Connector	Molex 500075-1517 Mini USB Type B vertical receptacle	Any standard mini-USB plug

Table 3.1 Connectors and mating wires / connectors

3.2.1 Motor / Encoder connector

12 screw connectors located next to each other at one end of the board offer inputs for reference / home switches, an incremental a/b/n encoder including +5V encoder supply output and connection for the 2-phase bipolar stepper motor.

Pin	Label	Direc-tion	Description
1	REF_L / DIR_IN	Input	Left stop switch input, programmable pull-up to +5V or direction input in S/D operation mode
2	REF_R / EN_IN	Input	Right stop switch input, programmable pull-up to +5V or enable input in S/D operation mode
3	HOME / STEP_IN	Input	Home switch input, programmable pull-up to +5V or enable input in S/D operation mode
4	ENC_A / IN1	Input	Incremental encoder channel A input or digital input 1
5	ENC_B / IN2	Input	Incremental encoder channel B input or digital input 2
6	ENC_N / IN3	Input	Incremental encoder index / null channel I input or digital input 3
7	+5VOUT / 100mA	Power +5V output	+5V output. +5V generated from on-board DC/DC-converter. Output can be switched on/off in software
8	GND	Power (GND)	Signal and system ground
9	Motor Phase A+	Output	Motor driver output (motor axis 0), coil A
10	Motor Phase A-	Output	Motor driver output (motor axis 0), coil A
11	Motor Phase B+	Output	Motor driver output (motor axis 0), coil B
12	Motor Phase B-	Output	Motor driver output (motor axis 0), coil B

Table 3.2 Connector for reference switches, encoder and motor

CAUTION

Do not connect or disconnect motor during operation!

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.

3.2.2 Power / Interface connector

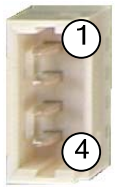
12 screw connectors located next to each other at the other end of the board include single power supply offer general purpose open-drain outputs, an incremental a/b/n encoder including +5V encoder supply output and connection for a 2-phase bipolar stepper motor..

Pin	Label	Direction	Description
1	GND	Power (GND)	System and signal ground
2	+9V .. 36V DC	Power (Supply in)	Power supply in. Common supply input for driver and logic part. All further required voltages are generated on-board from this voltage
3	Reserved		
4	Reserved		
5	OUT0	Output	Open drain output. Max. 100mA sink to ground capability with integrated freewheeling diode to power supply in
6	OUT1	Output	Open drain output. Max. 100mA sink to ground capability with integrated freewheeling diode to power supply in
7	OUT2	Output	Open drain output. Max. 100mA sink to ground capability with integrated freewheeling diode to power supply in
8	OUT3	Output	Open drain output. Max. 100mA sink to ground capability with integrated freewheeling diode to power supply in
9	OUT4	Output	Open drain output. Max. 100mA sink to ground capability with integrated freewheeling diode to power supply in
10	OUT5	Output	Open drain output. Max. 100mA sink to ground capability with integrated freewheeling diode to power supply in
11	IN0	Input	Analog input (0 .. 10V), can be used as digital input, too.
12	GND	Power (GND)	System and signal ground

Table 3.3 Connector for power, analog input and general purpose digital outputs

3.2.3 Motor Connector

A Molex PicoBlade™ 4pin 1.25mm pitch connector is available for motor connection (motor axis 0 in TMCL™ firmware). Please note: the 4 pins of this connector are directly connected to the motor driver output signals of the Motor / Encoder connector. Therefore, either use this connector or pin 9 to 12 of the Motor / Encoder connector for connecting a bipolar 2-phase stepper motor.



Pin	Label	Direction	Description
1	Motor Phase A+	Output	Motor driver output, coil A
2	Motor Phase A-	Output	Motor driver output, coil A
3	Motor Phase B+	Output	Motor driver output, coil B
6	Motor Phase B-	Output	Motor driver output, coil B

Table 3.4 Motor connector

CAUTION
Do not connect or disconnect motor during operation! 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.

3.2.4 S/D 1 connector

A 4 pin single row header with 2.54mm pitch is used for Step/Direction out for motor axis 1 (motor 1 in TMCL™ firmware).

Pin	Label	Direction	Description
1	DIR2	Output	Direction output for motor axis 1
2	STEP2	Output	Step output for second motor axis
3	EN2	Output	Enable output for second motor axis
4	GND	Power (GND)	Signal and supply ground

Table 3.5 Connector for Step / Direction output for the second motor axis

3.2.5 S/D 2 connector

A 4 pin single row header with 2.54mm pitch is used for Step/Direction out for motor axis 2 (motor 2 in TMCL™ firmware).

Pin	Label	Direction	Description
1	DIR3	Output	Direction output for motor axis 2
2	STEP3	Output	Step output for motor axis 2
3	EN3	Output	Enable output for motor axis 2
4	GND	Power (GND)	Signal and supply ground

Table 3.6 Connector for Step / Direction output for the third motor axis

3.2.6 Mini-USB connector

A 5pin mini-USB connector is available on-board for serial communication. This module supports USB 2.0 Full-Speed (12Mbit/s) connections.

Please note:

- *On-board digital core logic (mainly processor and EEPROM) will be powered via USB in case no other supply is connected. This mode of operation can be used to set parameters / download TMCL programs or perform firmware updates with the module connected via USB only or inside the machine while the machine is powered off.*

Pin	Label	Direction	Description
1	VBUS	Power (Supply input)	+5V supply from host
2	D-	Bidirectional	USB Data –
3	D+	Bidirectional	USB Data +
4	ID	Power (GND)	Connected to signal and system ground
5	GND	Power (GND)	Connected to signal and system ground

Table 3.7: Connector for USB

3.3 Power Supply

For proper operation care has to be taken with regard to power supply concept and design. Due to space and especially height restrictions the MCST3601 includes just about 40µF / 50V of supply filter capacitors. These are ceramic capacitors which have been selected for high reliability and long life time.

CAUTION
Add external power supply capacitor! It is recommended to connect an electrolytic capacitor of significant size (e.g. 470µF/35V) to the power supply lines next to the MCST3601! Rule of thumb for size of electrolytic capacitor: $c = 1000 \frac{\mu F}{A} \times I_{SUPPLY}$ 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.
Keep the power supply voltage below the upper limit of 36V! Otherwise the driver electronics might be seriously damaged! Especially, when the selected operating voltage is near the upper limit a regulated power supply is highly recommended.
There is no reverse polarity protection! The module will short any reversed supply voltage due to internal diodes of the driver transistors.

3.4 USB communication

For remote control and communication with a host system the MCST3601 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 MCST3601 support USB self powered operation (when an external power is supplied via the power supply connector) and USB bus powered operation (no external power supply via 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. Motor movements will not be possible. 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 additional cabling / external devices as e.g. power supply etc. are required in that case.

Please note that the module might draw current from the USB +5V bus supply even in USB self powered operation depending on the voltage level of this supply.

3.5 Inputs and Outputs

3.5.1 Reference and Home switch inputs

All three reference and home switch inputs REF_L / REF_R and HOME offer the same input circuit with voltage resistor dividers, limiting diodes against over- and under-voltage and programmable 1k pull-ups to +5V. The programmable pull-ups can be switched on or off together for all three inputs.

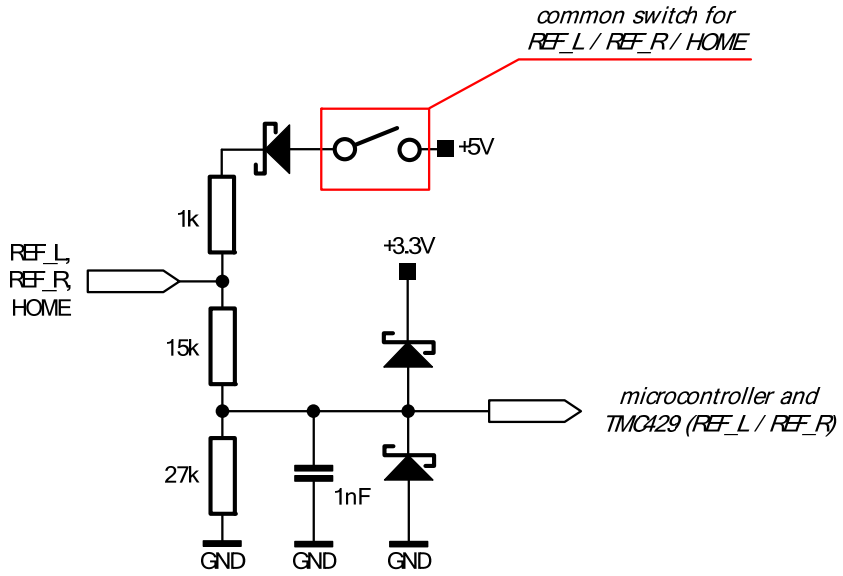


Figure 3.4: Reference switch input circuit (simplified diagram)

3.5.2 General purpose Inputs

The MCST3601 offers three general purpose digital inputs and one analog input. All inputs offer the same basic input protection circuit. The dedicated analog input has different input voltage dividers in order to support a full scale input voltage range of 0…+10V. The other digital inputs have been designed in order to be able to accept +5V and +24V signal levels.

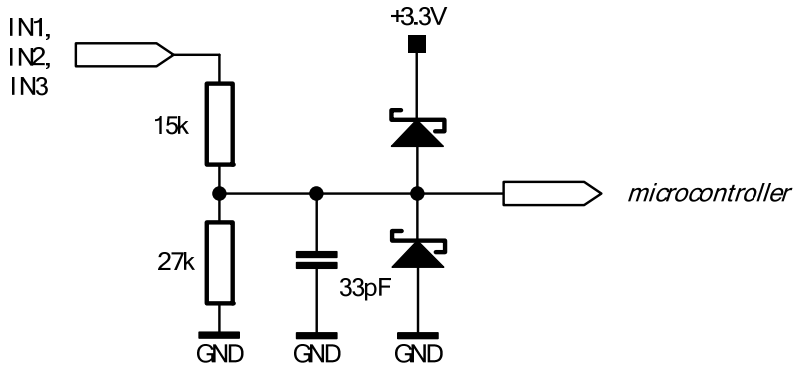


Figure 3.5: General purpose digital input circuit

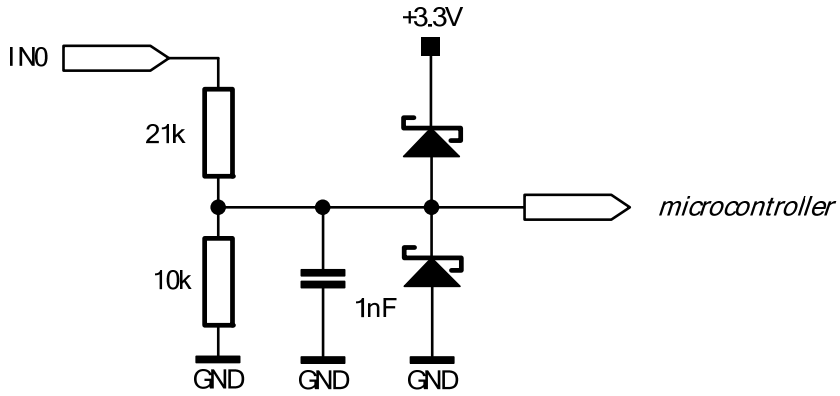


Figure 3.6: General purpose analog input circuit

The function of the inputs might differ depending on firmware version.

3.5.3 General purpose Outputs

The MCST3601 offers six general purpose outputs. All outputs are open-drain outputs. For all outputs a freewheeling diode (to power supply) is already integrated.

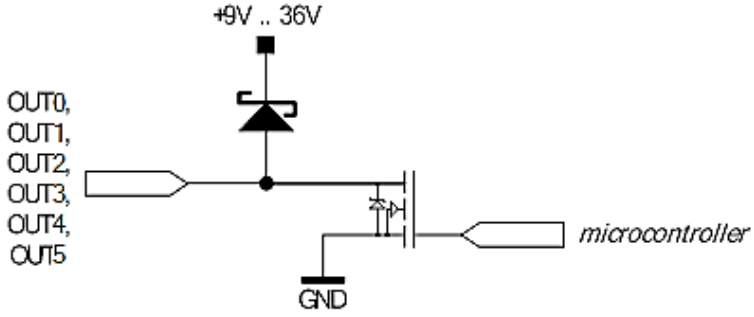


Figure 3.7: General purpose output (open-drain with freewheeling diode)

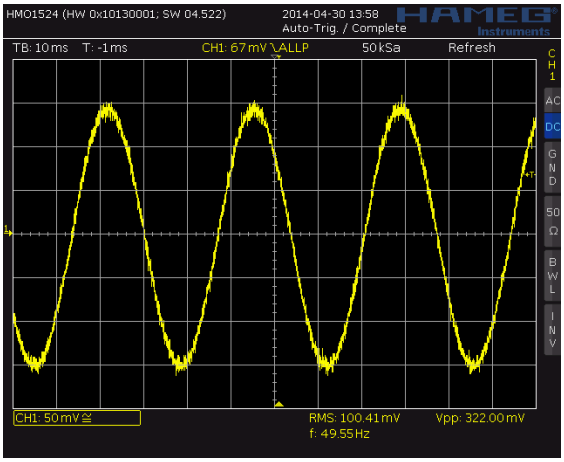
4 Motor driver current

The on-board stepper motor driver operates current controlled. The driver current may be programmed in software for each motor axis individually in two ranges (0.5A RMS and 1A RMS) with 32 effective scaling steps in hardware for each range.

In addition, via setting / closing two jumpers (see chapter 5) two lower current ranges () with 32 effective scaling steps in hardware for each range may be selected.

Motor current measured for one phase with max. current settings (incl. both Jumpers closed) and 256 microsteps:

CH1 (yellow): motor current [100mV / A]



Motor current with both Jumpers <u>set / closed</u>:

Motor current setting in software (TMCL)	Range setting in software (TMCL)	Current scaling step (CS)	Motor current I_{peak} [A]	Motor current I_{RMS} [A]
0..7	1	0	0.025	0.018
8..15	1	1	0.051	0.036
16..23	1	2	0.076	0.054
24..31	1	3	0.102	0.072
32..39	1	4	0.127	0.090
40..47	1	5	0.152	0.108
48..55	1	6	0.178	0.126
56..63	1	7	0.203	0.144
64..71	1	8	0.228	0.162
72..79	1	9	0.254	0.180
80..87	1	10	0.279	0.197
88..95	1	11	0.305	0.215
96..103	1	12	0.330	0.233
104..111	1	13	0.355	0.251
112..119	1	14	0.381	0.269
120..127	1	15	0.406	0.287
128..135	1	16	0.432	0.305
136..143	1	17	0.457	0.323
144..151	1	18	0.482	0.341

Motor current setting in software (TMCL)	Range setting in software (TMCL)	Current scaling step (CS)	Motor current I_{peak} [A]	Motor current I_{RMS} [A]
152..159	1	19	0.508	0.359
160..167	1	20	0.533	0.377
168..175	1	21	0.558	0.395
176..183	1	22	0.584	0.413
184..191	1	23	0.609	0.431
192..199	1	24	0.635	0.449
200..207	1	25	0.660	0.467
208..215	1	26	0.685	0.485
216..223	1	27	0.711	0.503
224..231	1	28	0.736	0.521
232..239	1	29	0.762	0.539
240..247	1	30	0.787	0.556
248..255	1	31	0.812	0.574
0..7	0	0	0.047	0.033
8..15	0	1	0.094	0.066
16..23	0	2	0.141	0.100
24..31	0	3	0.188	0.133
32..39	0	4	0.235	0.166
40..47	0	5	0.282	0.199
48..55	0	6	0.328	0.232
56..63	0	7	0.375	0.265
64..71	0	8	0.422	0.299
72..79	0	9	0.469	0.332
80..87	0	10	0.516	0.365
88..95	0	11	0.563	0.398
96..103	0	12	0.610	0.431
104..111	0	13	0.657	0.465
112..119	0	14	0.704	0.498
120..127	0	15	0.751	0.531
128..135	0	16	0.798	0.564
136..143	0	17	0.845	0.597
144..151	0	18	0.892	0.630
152..159	0	19	0.938	0.664
160..167	0	20	0.985	0.697
168..175	0	21	1.032	0.730
176..183	0	22	1.079	0.763
184..191	0	23	1.126	0.796
192..199	0	24	1.173	0.830
200..207	0	25	1.220	0.863
208..215	0	26	1.267	0.896
216..223	0	27	1.314	0.929
224..231	0	28	1.361	0.962
232..239	0	29	1.408	0.995
240..247	0	30	1,455	1.029
248..255	0	31	1.502	1.062

Motor current with both Jumpers removed / not closed:

Motor current setting in software (TMCL)	Range setting in software (TMCL)	Current scaling step (CS)	Motor current I_{peak} [A]	Motor current I_{RMS} [A]
0..7	1	0	0.006	0.004
8..15	1	1	0.013	0.009
16..23	1	2	0.019	0.013
24..31	1	3	0.025	0.018
32..39	1	4	0.031	0.022
40..47	1	5	0.038	0.027
48..55	1	6	0.044	0.031
56..63	1	7	0.050	0.036
64..71	1	8	0.057	0.040
72..79	1	9	0.063	0.044
80..87	1	10	0.069	0.049
88..95	1	11	0.075	0.053
96..103	1	12	0.082	0.058
104..111	1	13	0.088	0.062
112..119	1	14	0.094	0.067
120..127	1	15	0.101	0.071
128..135	1	16	0.107	0.076
136..143	1	17	0.113	0.080
144..151	1	18	0.119	0.084
152..159	1	19	0.126	0.089
160..167	1	20	0.132	0.093
168..175	1	21	0.138	0.098
176..183	1	22	0.145	0.102
184..191	1	23	0.151	0.107
192..199	1	24	0.157	0.111
200..207	1	25	0.163	0.116
208..215	1	26	0.170	0.120
216..223	1	27	0.176	0.124
224..231	1	28	0.182	0.129
232..239	1	29	0.189	0.133
240..247	1	30	0.195	0.138
248..255	1	31	0.201	0.142
0..7	0	0	0.012	0.033
8..15	0	1	0.023	0.016
16..23	0	2	0.035	0.025
24..31	0	3	0.046	0.033
32..39	0	4	0.058	0.041
40..47	0	5	0.070	0.049
48..55	0	6	0.081	0.058
56..63	0	7	0.093	0.066
64..71	0	8	0.105	0.074
72..79	0	9	0.116	0.082
80..87	0	10	0.128	0.090
88..95	0	11	0.139	0.099
96..103	0	12	0.151	0.107
104..111	0	13	0.163	0.115
112..119	0	14	0.174	0.123

Motor current setting in software (TMCL)	Range setting in software (TMCL)	Current scaling step (CS)	Motor current I_{peak} [A]	Motor current I_{RMS} [A]
120..127	0	15	0.186	0.132
128..135	0	16	0.198	0.140
136..143	0	17	0.209	0.148
144..151	0	18	0.221	0.156
152..159	0	19	0.232	0.164
160..167	0	20	0.244	0.173
168..175	0	21	0.256	0.181
176..183	0	22	0.267	0.189
184..191	0	23	0.279	0.197
192..199	0	24	0.291	0.205
200..207	0	25	0.302	0.214
208..215	0	26	0.314	0.222
216..223	0	27	0.325	0.230
224..231	0	28	0.337	0.238
232..239	0	29	0.349	0.247
240..247	0	30	0.360	0.255
248..255	0	31	0.372	0.263

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, <motor number 0..5>, <value> // set run current

SAP 7, <motor number 0..5>, <value> // set standby current
```

For <value> numbers between 0 and 255 are supported (see table)
(read-out value with GAP instead of SAP. Please see separate MCST3601 TMCL™ firmware manual for further information)

Range setting in software (TMCL)

This is the value for TMCL axis parameter 179 (Vsense). This value defines the current range. This value can be set using the following TMCL command:

```
SAP 179, <motor number 0..5>, <value> // = 0 high current range
                                      // = 1 low current range
```

For <value> either 0 or 1 is supported (see table)
(read-out value with GAP instead of SAP. Please see separate MCST3601 TMCL™ firmware manual for further information)

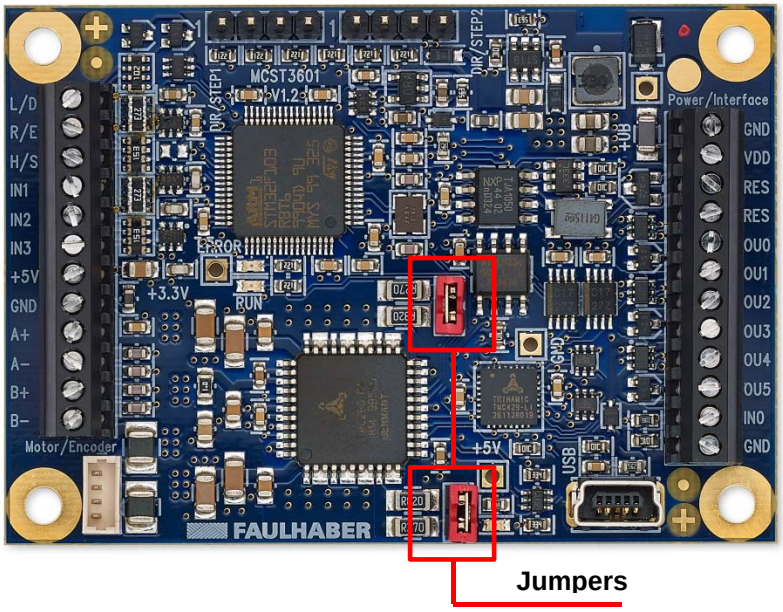
Motor current I_{RMS} [A]

Resulting motor current based on range and motor current setting

In addition to the settings in the table the motor current may be switched off completely (free-wheeling) individually for each motor using axis parameter 204 (see MCST3601 TMCL™ firmware manual).

5 Jumper

The MCST3601 offers 2 on-board Jumpers for selection of two different motor current ranges:



Jumper	Description
Closed	Max. motor current 1A RMS / 1.5A peak (with VSENSE = 0 (programmable)) Max. motor current 0.57A RMS / 0.8A peak (with VSENSE = 1 (programmable))
Open	Max. motor current 0.26A RMS / 0.37A peak (with VSENSE = 0 (programmable)) Max. motor current 0.14A RMS / 0.20A peak (with VSENSE = 1 (programmable))

Table 5.1 Jumper

*Please note: it is mandatory to either set **both jumpers** or leave both jumpers unpopulated.*

CAUTION
Do not remove / install jumpers while module is powered-on!

6 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	+9	12… 24	+36	V
I_{COIL_peak}	Motor coil current for sine wave peak with **jumper closed** and VSENSE = 0 (programmable)			1.6	A
I_{COIL_RMS}	Continuous motor current (RMS) with **jumper closed**			1.1	A
I_{COIL_peak}	Motor coil current for sine wave peak with **jumper open**			0.39	A
I_{COIL_RMS}	Continuous motor current (RMS) with **jumper open** and VSENSE = 0 (programmable)			0.27	A
I_{DD}	Power supply current		<< I_{COIL}	1.4 * I_{COIL}	A
I_{USB}	USB supply current in USB powered-mode		50		mA
I_{+5VOUT}	current at +5V output (for encoder supply)			100	mA
T_{ENV}	Environment temperature at maximum rated current (no forced cooling required)	-30*)		40*)	°C

Table 6.1 General operational ratings of module

*) preliminary data based on basic temperature tests.

OPERATIONAL RATINGS OF MULTIPURPOSE INPUTS

Symbol	Parameter	Min	Typ	Max	Unit
$V_{REF\_L/REF\_R/HOME/IN0/IN1/IN2/IN3}$	Input voltage range for REF_L, REF_R, HOME, IN0, IN1, IN2, IN3	0		30	V
$V_{REF\_L/REF\_R/HOME/IN1/IN2/IN3\_L}$	Low level input voltage for REF_L, REF_R, HOME, IN1, IN2, IN3			1.2	V
$V_{REF\_L/REF\_R/HOME/IN1/IN2/IN3\_H}$	High level input voltage for REF_L, REF_R, HOME, IN1, IN2, IN3	3.2			V
V_{IN0}	Full scale input voltage range for analog voltage input	0		10.3	V

Table 6.2 Operational ratings of multipurpose Inputs

OPERATIONAL RATINGS OF MULTIPURPOSE OUTPUTS

Symbol	Parameter	Min	Typ	Max	Unit
$V_{OUT1/OUT2/OUT3/OUT4/OUT5/OUT6}$	Voltage at open drain outputs OUT0/OUT1/OUT2/OUT3/OUT4/OUT5			+VDD [1)]	V
$I_{OUT1/OUT2/OUT3/OUT4/OUT5/OUT6}$	Output sink current of open drain outputs OUT0/OUT1/OUT2/OUT3/OUT4/OUT5			100	mA
I_{+5VOUT}	Current at +5V output (for encoder, active reference switch supply, etc.)			100	mA

Table 6.3 Operational ratings of multipurpose Outputs

[1)] Please note: free-wheeling diodes for all outputs (connected to positive supply voltage) are already included on-board. Therefore, the nom. voltage at these outputs should not exceed the power supply voltage of this module.

7 MCST3601 Operational Description

7.1 Calculation: Velocity and Acceleration vs. Microstep and Fullstep Frequency

The values of the parameters sent to the TMC429 do not have typical motor values like rotations per second as velocity. But these values can be calculated from the TMC429 parameters as shown in this section.

PARAMETERS OF TMC429

Signal	Description	Range
f_{CLK}	Clock-frequency	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… 8 (a value of 7 or 8 is internally mapped to 6 by the TMC429)

Table 7.1 TMC429 velocity parameters

MICROSTEP FREQUENCY

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

FULLSTEP 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:

Signal	value
$f_{\_CLK}$	16 MHz
velocity	1000
a_max	1000
pulse_div	1
ramp_div	1
usrs	6

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

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

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

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

CALCULATION OF THE NUMBER OF ROTATIONS

A stepper motor has e.g. 72 fullsteps per rotation.

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

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

8 Revision History

8.1 Document Revision

Version	Date	Author	Description
0.90	2013-OCT-01	GE	Initial draft version
0.91	2014-MAY-27	GE	Update for hardware version 1.1 Current settings (chapter 4) added
0.92	2014-SEP-12	DWI	Update pictures

Table 9.1 Document revision

8.2 Hardware Revision

Version	Date	Description
TMCM-1114-FH_V10	2013-JUL-30	First version
MCST3601_V11	2014-MAR-28	• USB powered option added (air wire from previous version removed) • Board size changed, labels added next to connector • Motor numbers in silk screen changed (to be compatible with TMCL™ IDE • Varistors at driver output added for better protection • Board renamed in MCST3601 • Solderstop blue, connectors Amphenol (black)
MCST3601_V12	2014-JUL-09	• CAN information suppressed

Table 9.2 Hardware revision

9 References

[TMC262] TMC262 Datasheet
[TMC429] TMC429 Datasheet
[TMCL-IDE] TMCL-IDE User Manual

For further information, please refer to www.trinamic.com

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FAULHABER
PRECISTEP SA

Rue des Gentianes 53
2300 La Chaux-de-Fonds
Switzerland
Tel. +41 32 910 6050
Fax +41 32 910 6059
info@precistep.com
www.faulhaber.com