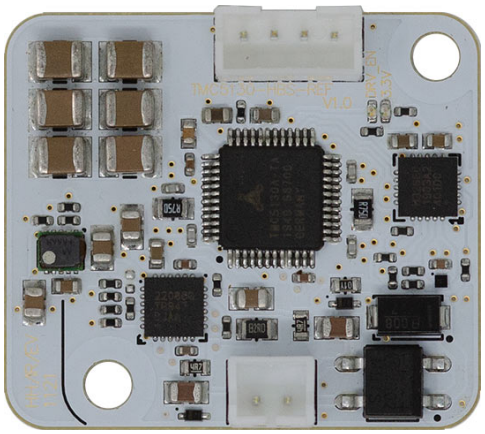
TMC5130-HBS-KIT HW & FW Manual

Hardware Version V1.00 | Document Revision V1.10 • 2021-08-19

TMC5130-HBS-KIT is an open source reference design for a Home Bus (HBS) connected stepper motor actuator. It is a stepper motor driver for voltages up to +24V and ca. 290mA of RMS phase current. StealthChop™ allows for ultra-silent stepper motor operation. It is controlled and powered via HBS with a single cable and comes with an onboard temperature sensor.



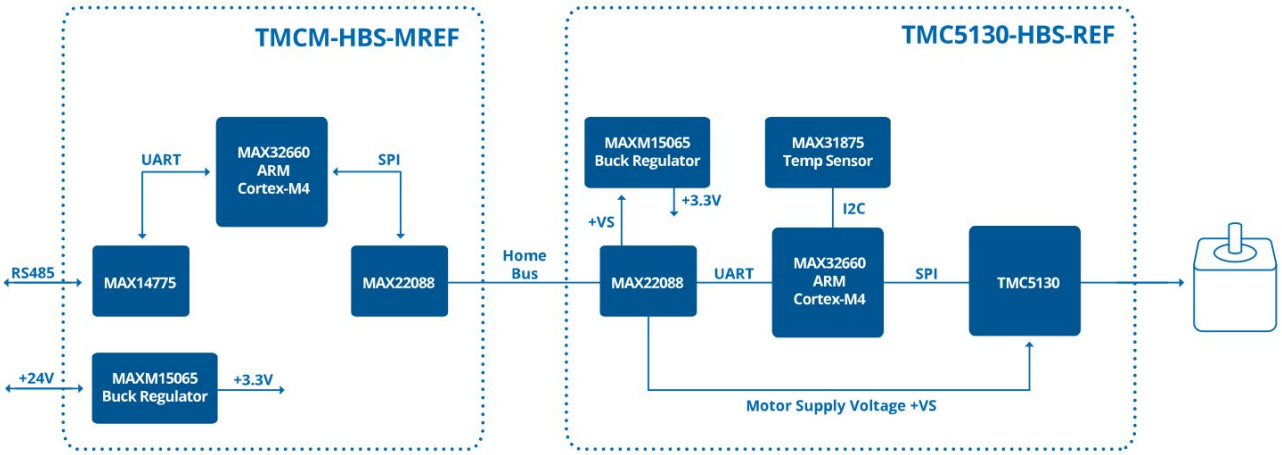
Features

- Single axis stepper motor driver and motion controller
- StealthChop™ ultra-silent chopper
- StallGuard2™ sensorless homing
- Up to 290mA phase RMS current
- Supply Voltage up to 24V
- Home Bus communication interface & TMCL™ communication protocol
- Onboard temperature sensor
- Open source hardware and firmware
- Kit: + Home Bus master board
- Kit: + stepper motor

Applications

- Blinds/flap Control
- Locks
- Building Automation
- Vending Machines

Simplified Block Diagram



Read entire documentation.

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1 Order Codes

Order Code	Description	Size (LxWxH)
TMC5130-HBS-KIT	Home Bus Reference Design Kit: - Home Bus connected stepper motor controller & driver - Home Bus master module with mating connectors - 2-wire JST-PH cable to connect master and slave (CABLE-PH02) - QSH2818-32-07-006 NEMA 8 stepper motor with JST PH connector	32x28x9 (mm)85x55x9 (mm)

Table 1: Order codes

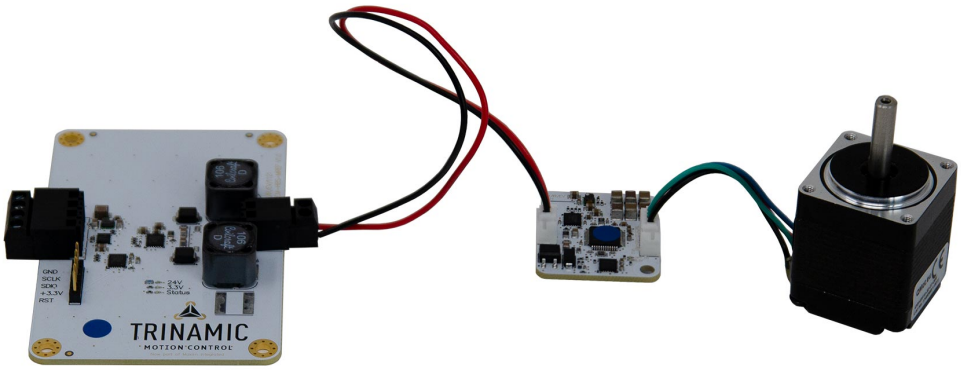

Figure 1: TMC5130-HBS-KIT Home Bus Reference Design Kit

2 Module Features

TMC5130-HBS-KIT is an open source reference design for a Home Bus (HBS) connected stepper motor actuator. It is a stepper motor driver for voltages up to +24V and ca. 290mA of RMS phase current. StealthChop™ allows for ultra-silent stepper motor operation. It is controlled and powered via the Home BUs with a single two-wire connection and comes with an onboard temperature sensor. The kit also contains a Home Bus master modules for communication with a workstation or other higher level controller via RS485.

- Two-wire Home Bus interface for power **and** communication.
  - More information on the Home Bus standard is available in Maxim Integrated's Application Note 7224
- Supply Voltage up 24V
- Motor phase currents up to 290mA RMS / 400mA peak
- 2x LED indicators
- TMCL™ -based firmware for configuration and permanent parameter storage
- StealthChop™ ultra-silent stepper motor operation
- StallGuard2™ sensorless homing
- Fully integrated SixPoint™ motion controller for smooth and adaptable motion profiles and ramping
- Home Bus master module
- NEMA11 stepper motor

2.1 Featured Products

- TMC5130A-TA - Fully integrated stepper motor driver and motion controller
- MAX22088GTG+ - Home Bus Compliant Transceiver with Integrated Power Transfer
- MAX32660GTP+ - Tiny, Ultra-Low-Power Arm Cortex-M4 Processor with FPU-Based Microcontroller (MCU) with 256KB Flash and 96KB SRAM
- MAX31875R0TZS+ - Low-Power I2C Temperature Sensor in WLP Package
- MAX14775EATA+ - ±65V Fault Protected 500Kbps/20Mbps Half-Duplex RS-485/RS-422 Transceivers
- MAXM15065AMB+ - 4.5V to 60V, 300mA Step-Down uSLIC Power Module

2.2 Open Source

This is an Open Source project! The following data is available as Open Source for download and own use:

- Module design, layout, manufacturing data, 3D files: https://www.trinamic.com/
- Complete firmware sources: https://github.com/trinamic/

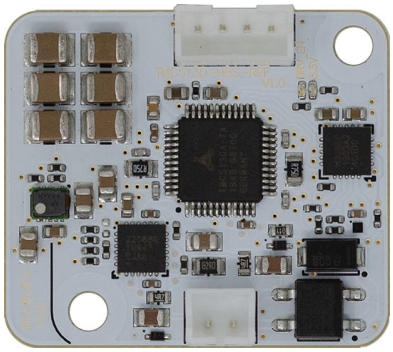

Figure 2: Home Bus stepper motor reference design (Home Bus slave node)

Figure 3: Home Bus master reference design

3 Mechanical Information

3.1 Homebus Slave

The Homebus Slave is a single FR4 board.
The size of the Homebus Slave is approximately 32mm x 28mm with two M3 mounting holes.
The maximum component height including PCB is approximately 9mm (without mating connectors).

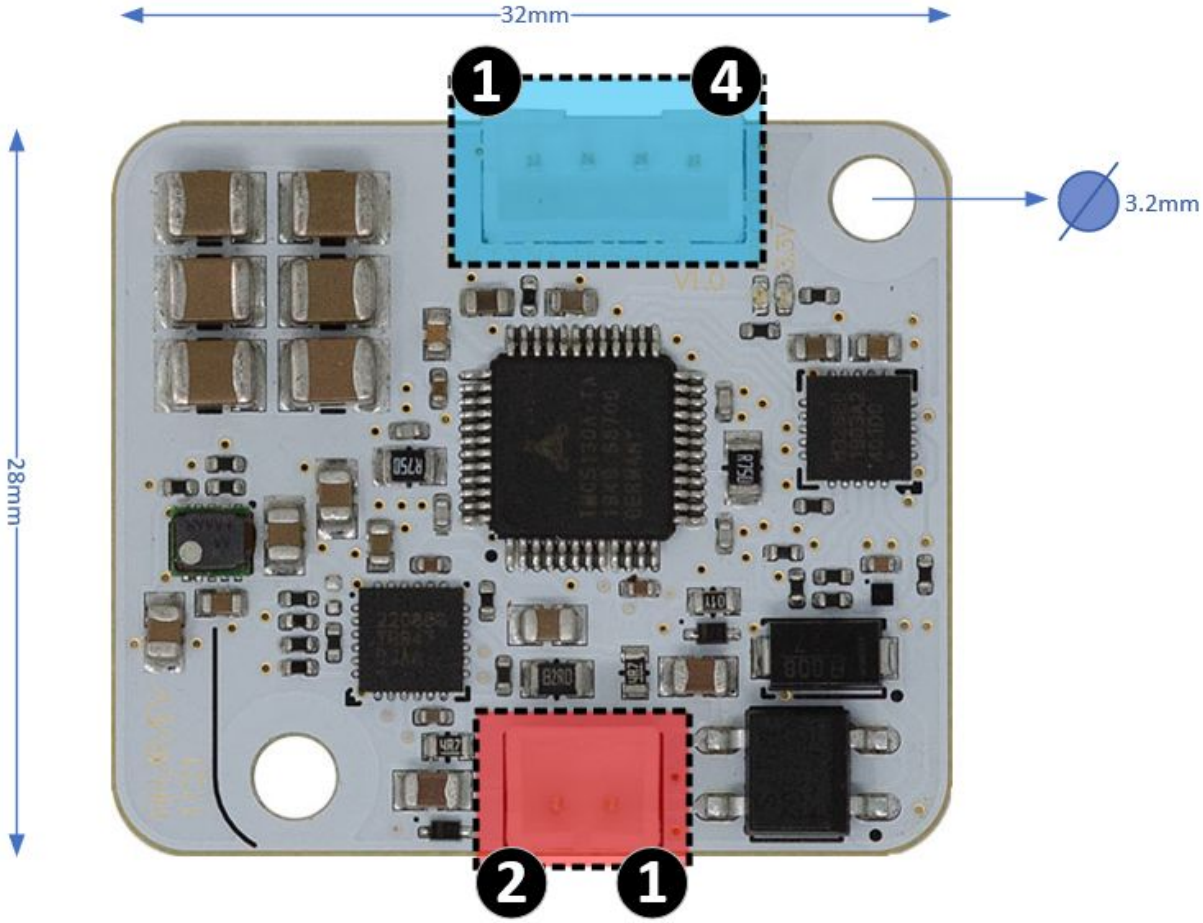

Figure 4: Homebus Slave top view and mechanical dimensions

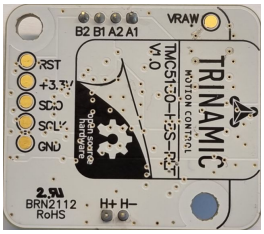

Figure 5: Homebus Slave bottom view

3.2 Homebus Master

The Homebus Master is a single FR4 board.
The size of the Homebus master is approximately 85mm x 55mm with four M3 mounting holes.
The maximum component height including PCB is approximately 9mm (without mating connectors).

Figure 6: Homebus Master top view and mechanical dimensions

Figure 7: Homebus Master bottom view

4 Connectors and LEDs

4.1 Homebus Slave

Connector types, pitch, and more information on the I/O signals and pin-out can be derived directly from the original/latest CAD and manufacturing data available as Open Source on GitHub:

https://github.com/trinamic/TMC5130-HBS-REF

4.1.1 Motor Connector

The motor connector is highlighted in blue in figure 4. The interface connector is a 4-pin JST PH Series connector.

- Part number: JST B4B-PH-K-S (JST PH series, 4pins, 2mm pitch)
- Connector housing: JST PHR-4
- Contacts: JST SPH-002T-P0.5S

Pin #	Signal / Label	Description	Range [Units]	Units
1	OA1	Motor phase A1	0...+VS	V
2	OA2	Motor phase A2	0...+VS	V
3	OB1	Motor phase B1	0...+VS	V
4	OB2	Motor phase B2	0...+VS	V

4.1.2 Home Bus Interface Connector

The interface connector is highlighted in red in figure 4. The interface connector is a 2-pin JST PH Series connector.

- Part number: JST B2B-PH-K-S (JST PH series, 2pins, 2mm pitch)
- Connector housing: JST PHR-2
- Contacts: JST SPH-002T-P0.5S

Pin #	Signal / Label	Description	Range [Units]	Units
1	H+	Home Bus positive rail max voltage	+28	V
2	H-	Home Bus negative/inverted rail minimum voltage	-6	V

4.1.3 SWD Programming Pads

The bottom side of the board contains the SWD programming pads for the internal MCU of the module.

- RST - MCU reset
- +3.3V - VCCIO
- SDIO - SWD IO line (at 3.3V level)

- SCLK - SWD clock line (at 3.3V level)
- GND - Ground

4.1.4 LEDs

There are two LEDs on the top side of the board. The connected signal names are written in the top side copper layer.

Signal / Label	Description	Color
3.3V	Indicator that the board is powered and the digital rail is up	Blue
DRV_EN	Indicator that the driver output bridges are enabled (on) or disabled (off)	Red

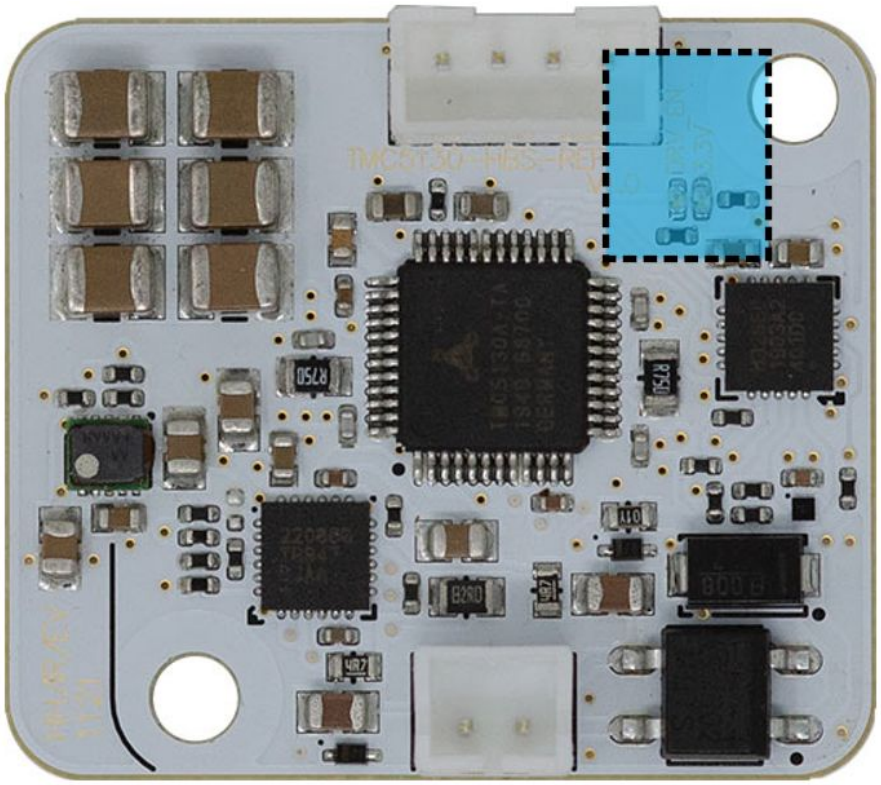

Figure 8: TMC5130-HBS-KIT LED indicators

4.2 Homebus Master

4.2.1 Power and RS485 Connector

The power and interface connector provides the supply power input and an RS485 interface.

Pin #	Signal / Label	Description	Range
1	+VS	Power Supply	max. 24V
2	RS485+	RS485 signal (non iverted)	...+VS
3	RS485-	RS485 signal (inverted)	
4	GND	Power and signal ground	

4.2.2 Homebus Connector

The homebus connector provides power and data signals for connecting the Homebus Slave module.

Pin #	Signal / Label	Description
1	H+	Home Bus positive rail
2	H-	Home Bus negative/inverted rail

4.2.3 SWD Programming Connector

The programming connector provides the SWD programming pads for the internal MCU of the module.

- RST - MCU reset
- +3.3V - VCCIO
- SDIO - SWD IO line (at 3.3V level)
- SCLK - SWD clock line (at 3.3V level)
- GND - Ground

5 Firmware Description

5.1 TMCL Protocol

The Homebus Slave firmware implements the TMCL protocol described in sections 5.1.1 and 5.1.2. It supports the direct mode of TMCL with a subset of the TMCL commands. In direct mode the TMCL communication follows a strict master/slave principle. A host computer (PC or microcontroller) acting as the interface bus master sends a command to the module. The TMCL interpreter on the module then interprets this command and does the necessary tasks for executing the specified command. Right after the command has been executed the module sends back a reply back to the bus master. The master must not send the next command before getting the reply of the last command.

5.1.1 Binary Command Format

The TMCL protocol follows a simple request/reply principle. The request is also called command, as it contains the command to be executed.

Every command has a mnemonic and a binary representation. When commands are sent from a host to a module, the binary format has to be used. Every command consists of a one-byte command field, a one-byte type field, a one-byte motor/bank field and a four-byte value field. So the binary representation of a command always has seven bytes. When a command is to be sent, it has to be enclosed by an address byte at the beginning and a checksum byte at the end. Thus the complete request consists of nine bytes.

The binary command format is as follows:

TMCL Command Format	
Bytes	Meaning
1	Module address
1	Command number
1	Type number
1	Motor or Bank number
4	Value (MSB first!)
1	Checksum

Table 7: TMCL Command Format

The checksum is calculated by adding up all bytes (including the module address byte) using 8-bit addition as shown in this C code example:

```
unsigned char i, Checksum;
unsigned char Command[9];

//Set the Command array to the desired command
Checksum = Command[0];
for(i=1; i<8; i++)
      Checksum+=Command[i];

   Command[8]=Checksum; //insert checksum as last byte of the command
//Now, send it to the module
```

5.1.2 Binary Reply Format

Every time a command has been sent to a module, the module sends a reply. The reply is also 9 byte long and formated is as follows:

TMCL Reply Format	
Bytes	Meaning
1	Reply address
1	Module address
1	Status (e.g. 100 means no error)
1	Command number
4	Value (MSB first!)
1	Checksum

Table 8: TMCL Reply Format

The reply contains a status code. The status code can have one of the following values:

TMCL Status Codes	
Code	Meaning
100	Successfully executed, no error
1	Wrong checksum
2	Invalid command
3	Wrong type
4	Invalid value
5	Configuration EEPROM locked
6	Command not available

Table 9: TMCL Status Codes

5.1.3 TMCL via Homebus

As the Homebus interface needs a DC-free encoding, simply sending the nine bytes of a TMCL datagram via the Homebus interface will not work. To implement this kind of encoding, two bytes are needed to represent each data byte. Thus a TMCL command or a TMCL reply sent via Homebus will need 18 bytes. This kind of encoding and decoding is also done in the TMC5130-HBS-KIT firmware. To learn more about Homebus data encoding please see Maxim Application Note 7224 and Maxim Application Note 7226. Also take a look at the firmware source code to see how encoding and decoding is done (it is based on these two application notes).

5.2 Supported TMCL Commands

This section gives a short overview of the available TMCL commands.

5.2.1 ROR (Rotate Right)

The motor is instructed to rotate with a specified velocity in right direction (increasing the position counter). The velocity is given in microsteps per second (pulse per second [pps]).

Internal function: Velocity mode is selected. Then, the velocity value is transferred to the target velocity (axis parameter #2).

Related commands: ROL, MST, SAP, GAP.

Mnemonic: ROR <axis>, <velocity>

Binary Representation			
Instruction	Type	Motor/Bank	Value
1	0	0	-2147483648...2147583647

Reply in Direct Mode	
Status	Value
100 - OK	don't care

Example
Rotate right motor 0, velocity 500.
Mnemonic: ROR 0, 500.

Binary Form of ROR 0, 500	
Field	Value
Target address	01_h
Instruction number	01_h
Type	00_h
Motor/Bank	00_h
Value (Byte 3)	00_h
Value (Byte 2)	00_h
Value (Byte 1)	01_h
Value (Byte 0)	$F4_h$
Checksum	$F7_h$

5.2.2 ROL (Rotate Left)

The motor is instructed to rotate with a specified velocity in left direction (decreasing the position counter). The velocity is given in microsteps per second (pulse per second [pps]).

Internal function: Velocity mode is selected. Then, the velocity value is transferred to the target velocity (axis parameter #2).

Related commands: ROR, MST, SAP, GAP.

Mnemonic: ROL <axis>, <velocity>

Binary Representation			
Instruction	Type	Motor/Bank	Value
2	0	0	-2147483648...2147583647

Reply in Direct Mode	
Status	Value
100 - OK	don't care

Example
Rotate left motor 0, velocity 500.
Mnemonic: ROL 0, 500.

Binary Form of ROL 0, 500	
Field	Value
Target address	01_h
Instruction number	02_h
Type	00_h
Motor/Bank	00_h
Value (Byte 3)	00_h
Value (Byte 2)	00_h
Value (Byte 1)	01_h
Value (Byte 0)	$F4_h$
Checksum	$F8_h$

5.2.3 MST (Motor Stop)

The MST command stops the motor using a soft stop.

Internal function: The velocity mode is selected. Then, the target velocity (axis parameter #2) is set to zero.

Related commands: ROR, ROL, SAP, GAP.

Mnemonic: MST <axis>

Binary Representation			
Instruction	Type	Motor/Bank	Value
3	0	0	0

Reply in Direct Mode	
Status	Value
100 - OK	don't care

Example
Stop motor 0.
Mnemonic: MST 0.

Binary Form of MST 0	
Field	Value
Target address	01_h
Instruction number	03_h
Type	00_h
Motor/Bank	00_h
Value (Byte 3)	00_h
Value (Byte 2)	00_h
Value (Byte 1)	00_h
Value (Byte 0)	00_h
Checksum	04_h

5.2.4 MVP (Move to Position)

With this command the motor will be instructed to move to a specified relative or absolute position. It will use the acceleration/deceleration ramp and the positioning speed programmed into the unit. This command is non-blocking - that is, a reply will be sent immediately after command interpretation and initialization of the motion controller. Further commands may follow without waiting for the motor reaching its end position. The maximum velocity and acceleration as well as other ramp parameters are defined by the appropriate axis parameters. For a list of these parameters please refer to section 5.2.9.
The range of the MVP command is 32 bit signed (-2147483648...2147483647). Positioning can be interrupted using MST, ROL or ROR commands.

Two operation types are available:

- Moving to an absolute position in the range from -2147483648...2147483647 ($-2^{31}...2^{31}-1$).
- Starting a relative movement by means of an offset to the actual position. In this case, the new resulting position value must not exceed the above mentioned limits, too.

Note The distance between the actual position and the new position must not be more than 2147483647 ($2^{31}-1$) position steps . Otherwise the motor will run in the opposite direction in order to take the shorter distance (caused by 32 bit overflow).

Internal function: Position mode is selected and the new position value is transferred to axis parameter #0 (target position).

Related commands: SAP, GAP, MST.

Mnemonic: MVP <ABS|REL>, <axis>, <position|offset>

Binary Representation			
Instruction	Type	Motor/Bank	Value
4	0 – ABS – absolute	0	<position>
	1 – REL – relative	0	<offset>

Reply in Direct Mode	
Status	Value
100 - OK	don't care

Example
Move motor 0 to position 90000.
Mnemonic: MVP ABS, 0, 90000

Binary Form of MVP ABS, 0, 90000	
Field	Value
Target address	01_h
Instruction number	04_h
Type	00_h
Motor/Bank	00_h
Value (Byte 3)	00_h
Value (Byte 2)	01_h
Value (Byte 1)	$5F_h$
Value (Byte 0)	90_h
Checksum	$F5_h$

Example
Move motor 0 from current position 10000 steps backward.
Mnemonic: MVP REL, 0, -10000

Binary Form of MVP REL, 0, -10000	
Field	Value
Target address	01_h
Instruction number	04_h
Type	01_h
Motor/Bank	00_h
Value (Byte 3)	FF_h
Value (Byte 2)	FF_h
Value (Byte 1)	$D8_h$
Value (Byte 0)	$F0_h$
Checksum	CC_h

5.2.5 SAP (Set Axis Parameter)

With this command most of the motion control parameters of the module can be specified. The settings will be stored in SRAM and therefore are volatile. That is, information will be lost after power off.

Info	For a table with parameters and values which can be used together with this command please refer to section 5.2.9.

Internal function: The specified value is written to the axis parameter specified by the parameter number.
Related commands: GAP, AAP.

Mnemonic: SAP <parameter number>, <axis>, <value>

Binary representation

Binary Representation			
Instruction	Type	Motor/Bank	Value
5	see chapter 5.2.9	0	<value>

Reply in Direct Mode	
Status	Value
100 - OK	don't care

Example Set the maximum positioning speed for motor 0 to 51200 pps.
Mnemonic: SAP 4, 0, 51200.

Binary Form of SAP 4, 0, 51200	
Field	Value
Target address	01_h
Instruction number	05_h
Type	04_h
Motor/Bank	00_h
Value (Byte 3)	00_h
Value (Byte 2)	00_h
Value (Byte 1)	$C8_h$
Value (Byte 0)	00_h
Checksum	$D2_h$

5.2.6 GAP (Get Axis Parameter)

Most motion / driver related parameters of the TMC5130-HBS-KIT can be adjusted using e.g. the SAP command. With the GAP parameter they can be read out. In standalone mode the requested value is also transferred to the accumulator register for further processing purposes (such as conditional jumps). In direct mode the value read is only output in the value field of the reply, without affecting the accumulator.

Info	For a table with parameters and values that can be used together with this command please refer to section 5.2.9.

Internal function: The specified value gets copied to the accumulator.
Related commands: SAP, AAP.

Mnemonic: GAP <parameter number>, <axis>

Binary Representation			
Instruction	Type	Motor/Bank	Value
6	see chapter 5.2.9	0	<value>

Reply in Direct Mode	
Status	Value
100 - OK	value read by this command

Example
Get the actual position of motor 0.
Mnemonic: GAP 1, 0.

Binary Form of GAP 1, 0	
Field	Value
Target address	01_h
Instruction number	06_h
Type	01_h
Motor/Bank	00_h
Value (Byte 3)	00_h
Value (Byte 2)	00_h
Value (Byte 1)	00_h
Value (Byte 0)	00_h
Checksum	08_h

5.2.7 RFS (Reference Search)

The TMC5130-HBS-KIT has a built-in reference search algorithm. The reference search algorithm provides different refrence search modes. This command starts or stops the built-in reference search algorithm. The status of the reference search can also be queried to see if it already has finished. (In a TMCL program it mostly is better to use the WAIT RFS command to wait for the end of a reference search.) Please see the appropriate parameters in the axis parameter table to configure the reference search algorithm to meet your needs (please see chapter 5.2.9).

Internal function: The internal reference search state machine is started or stoped, or its state is queried.

Related commands: SAP, GAP, WAIT.

Mnemonic: RFS <START|STOP|STATUS>, <motor>

Binary Representation			
Instruction	Type	Motor/Bank	Value
13	0 START — start reference search 1 STOP — stop reference search 2 STATUS — get status	0	0 (don't care)

Reply in Direct Mode (RFS START or RFS STOP)	
Status	Value
100 - OK	0 (don't care)

Reply in Direct Mode (RFS STATUS)		
Status	Value	
100 - OK	0	no ref. search active
	other values	reference search active

Example
Start reference search of motor 0.
Mnemonic: RFS START, 0.

Binary Form of RFS START	
Field	Value
Target address	01_h
Instruction number	$0D_h$
Type	00_h
Motor/Bank	00_h
Value (Byte 3)	00_h
Value (Byte 2)	00_h
Value (Byte 1)	00_h
Value (Byte 0)	00_h
Checksum	$0E_h$

5.2.8 GIO (Get Input)

With this command the status of the available general purpose outputs of the module can be read. The function reads a digital or an analog input port. Digital lines will read as 0 or 1, while the ADC channels deliver their 12 bit result in the range of 0...4095. In standalone mode the requested value is copied to the accumulator register for further processing purposes such as conditional jumps. In direct mode the value is only output in the value field of the reply, without affecting the accumulator. The actual status of a digital output line can also be read.

Internal function: The state of the i/o line specified by the type parameter and the bank parameter is read.

Related commands: SIO.

Mnemonic: GIO <port number>, <bank number>

Binary Representation			
Instruction	Type	Motor/Bank	Value
15	<port number>	<bank number> (0/1/2)	0 (don't care)

Reply in Direct Mode	
Status	Value
100 - OK	status of the port

Example
Get the value of ADC channel 0.
Mnemonic: GIO 0, 1.

Binary Form of GIO 0, 1	
Field	Value
Target address	01_h
Instruction number	$0F_h$
Type	00_h
Motor/Bank	01_h
Value (Byte 3)	00_h
Value (Byte 2)	00_h
Value (Byte 1)	00_h
Value (Byte 0)	00_h
Checksum	11_h

Reply (Status=no error, Value=302)	
Field	Value
Host address	02_h
Target address	01_h
Status	64_h
Instruction	$0F_h$
Value (Byte 3)	00_h
Value (Byte 2)	00_h
Value (Byte 1)	01_h
Value (Byte 0)	$2E_h$
Checksum	$A5_h$

Bank 1 – Analog Inputs
The analog input lines can be read back as digital or analog inputs at the same time. The analog values can be accessed in bank 1.

Analog Inputs in Bank 1			
Port	Description	Command	Range
9 - Temperature	Temperature	GIO 9, 1	[°C]

5.2.9 Axis Parameters

Axis parameters are accessed with the GAP and SAP command. In the table below, the parameter supported by the TMC5130-HBS-KITare shown.

Axis 0 Parameters of the TMC5130-HBS-KIT Module				
Number	Axis Parameter	Description	Range [Units]	Access
0	Target position	The desired target position in position mode	-2147483648 ...2147483647 [μsteps]	RW
1	Actual position	The actual position of the motor. Stop the motor before overwriting it. Should normally only be overwritten for reference position setting.	-2147483648 ...2147483647 [μsteps]	RW
2	Target speed	The desired speed in velocity mode. Not valid in position mode.	-7999774 ...7999774 [pps]	RW
3	Actual speed	The actual speed of the motor.	-7999774 ...7999774 [pps]	R
4	Maximum positioning speed	The maximum speed used for positioning ramps.	0...7999774 [pps]	RW
5	Maximum acceleration	Maximum acceleration in positioning ramps. Acceleration and deceleration value in velocity mode.	117...7629278 [pps^2]	RW
6	Maximum current	Motor current used when motor is running. The maximum value is 255 which means 100% of the maximum current of the module. The current can be adjusted in 32 steps:	0...255	RW

0...7	79...87	160...167	240...247
8...15	88...95	168...175	248...255
16...23	96...103	176...183	
24...31	104...111	184...191	
32...39	112...119	192...199	
40...47	120...127	200...207	
48...55	128...135	208...215	
56...63	136...143	216...223	
64...71	144...151	224...231	
72...79	152...159	232...239	

The most important setting, as too high values can cause motor damage.

Number	Axis Parameter	Description	Range [Units]	Access
7	Standby current	The current used when the motor is not running. The maximum value is 255 which means 100% of the maximum current of the module. This value should be as low as possible so that the motor can cool down when it is not moving. Please see also parameter 214.	0…255	RW
8	Position reached flag	This flag is always set when target position and actual position are equal.	0/1	R
10	Right limit switch state	The logical state of the right limit switch input.	0/1	R
11	Left limit switch state	The logical state of the left limit switch input.	0/1	R
12	Right limit switch disable	Deactivates the stop function of the right limit switch if set to 1.	0/1	RW
13	Left limit switch disable	Deactivates the stop function of the left limit switch if set to 1.	0/1	RW
14	Swap limit switches	Swap the left and right limit switches when set to 1.	0/1	RW
15	Acceleration A1	First acceleration between VSTART and V1 (in position mode only).	117…7629278 [pps^2]	RW
16	Velocity V1	First acceleration / decelaration phase target velocizy (in position mode only). Setting this value to 0 turns off the first acceleration / deceleration phase, maximum acceleration (axis parameter 5) and maximum decleration (axis parameter 17) are used only.	0…1000000 [pps]	RW
17	Maximum deceleration	Maximum deceleration in positioning ramps. Used to decelerate from maximum positiong speed (axis parameter 4) to velocity V1.	117…7629278 [pps^2]	RW
18	Deceleration D1	Deceletation bewteen V1 and VSTOP (in positioning mode only).	117…7629278 [pps^2]	RW
19	Velocity VSTART	Motor start velocity (in position mode only). Do not set VSTART higher than VSTOP.	0…249999 [pps]	RW
20	Velocity VSTOP	Motor stop velocity (in position mode only).	0…249999 [pps]	RW
21	Ramp wait time	Defines the waiting time after ramping down to zero velocity before next movement or direction inversion can start. Time range is 0 to 2 seconds. This setting avoids excess acceleration e.g. from VSTOP to -VSTART.	0…65535 [0.000032s]	RW
22	Speed threshold for CoolStep / fullstep	Speed threshold for de-activating CoolStep or switching to fullstep mode.	0…7999774 [pps]	RW

Number	Axis Parameter	Description	Range [Units]	Access
23	Minimum speed for DcStep	Minimum speed for switching to DcStep	0…7999774 [pps]	RW
24	Right limit switch polarity	Setting this parameter to 1 inverts the logic state of the right limit switch input.	0/1	RW
25	Left limit switch polarity	Setting this parameter to 1 inverts the logic state of the left limit switch input.	0/1	RW
26	Soft stop enable	Use soft stop when motor is stopped by a limit switch.	0/1	RW
27	High speed chopper mode	Switch to other chopper mode when measured speed is higher than axis parameter 22 when set to 1.	0/1	RW
28	High speed fullstep mode	Switch to fullstep mode when measured speed is higher than axis parameter 22 when set ot 1.	0/1	RW
31	Power down ramp	Controls the number of clock cycles for motor power down after a motion as soon as the motor has stopped and the setting time has expired. The smooth transition avoids a motor jerk upon power down. 0=instant power down, 15=longest possible power down ramp.	0…15 [0.16384s]	RW
32	DcStep time	This setting controls the reference pulse width for DcStep load measurement. It must be optimized for robust operation with maximum motor torque. A higher value allows higher torque and higher velocity, a lower value allows operation down to a lower velocity as set by axis parameter #23.	0…1023	RW
33	DcStep StallGuard	This setting controls stall detection in DcStep mode. Increase for higher sensitivity.	0…255	RW
140	Microstep resolution	Microstep resolutions per full step: 0 fullstep 1 halfstep 2 4 microsteps 3 8 microsteps 4 16 microsteps 5 32 microsteps 6 64 microsteps 7 128 microsteps 8 256 microsteps	0..8	RW

Number	Axis Parameter	Description	Range [Units]	Access
167	Chopper off time (TOff)	The off time setting controls the minimum chopper frequency. An off time within the range of 5μs to 20μs will fit. Off time setting for constant t Off chopper: $N_{CLK} = 12 + 32 * tOFF$ (Minimum is 64 clocks) Setting this parameter to zero completely disables all driver transistors and the motor can free-wheel.	0…15	RW
168	SmartEnergy current minimum (SEIMIN)	Sets the lower motor current limit for CoolStep operation by scaling the maximum current (see axis parameter 6) value. Minimum motor current: 0 - $\frac{1}{2}$ of CS 1 - $\frac{1}{4}$ of CS	0/1	RW
169	SmartEnergy current down step	Sets the number of StallGuard2 readings above the upper threshold necessary for each current decrement of the motor current. Number of StallGuard2 measurements per decrement: Scaling: 0…3: 32, 8, 2, 1 0: slow decrement 3: fast decrement	0…3	RW
170	SmartEnergy hysteresis	Sets the distance between the lower and the upper threshold for StallGuard2 reading. Above the upper threshold the motor current becomes decreased. Hysteresis: $([AP172] + 1) * 32$ Upper StallGuard threshold: $([AP172] + [AP170] + 1) * 32$	0…15	RW
171	SmartEnergy current up step	Sets the current increment step. The current becomes incremented for each measured StallGuard2 value below the lower threshold see SmartEnergy hysteresis start). Current increment step size: Scaling: 0…3: 1, 2, 4, 8 0: slow increment 3: fast increment / fast reaction to rising load	0…3	RW
172	SmartEnergy hysteresis start	The lower threshold for the StallGuard2 value (see SmartEnergy current up step). **Setting this to 0 (default) turns off CoolStep.**	0..15	RW
173	StallGuard2 filter enable	Enables the StallGuard2 filter for more precision of the measurement. If set, reduces the measurement frequency to one measurement per four fullsteps. In most cases it is expedient to set the filtered mode before using CoolStep. Use the standard mode for step loss detection. 0 - standard mode 1 - filtered mode	0/1	RW

Number	Axis Parameter	Description	Range [Units]	Access
174	StallGuard2 threshold	This signed value controls StallGuard2 threshold level for stall output and sets the optimum measurement range for readout. A lower value gives a higher sensitivity. Zero is the starting value. A higher value makes StallGuard2 less sensitive and requires more torque to indicate a stall.	-64...+63	RW
179	Vsense	Sense resistor voltage based current scaling. 0 - High current range: up to 1.4A RMS / 2A peak. 1 - Low current range: up to 0.7A RMS / 1A peak. Default value: 1. Please note: this parameter cannot be changed for hardware V1.2! The high current range is available for hardware V1.4 or higher only!	0/1	RW
180	SmartEnergy actual current	This status value provides the actual motor current setting as controlled by CoolStep. The value goes up to the CS value and down to the portion of CS as specified by SEIMIN. Actual motor current scaling factor: 0...31: 1/32, 2/32, ...32/32	0...31	R
181	Stop on stall	Below this speed motor will not be stopped. Above this speed motor will stop in case StallGuard2 load value reaches zero.	0...7999774 [pps]	RW
182	SmartEnergy threshold speed	Above this speed CoolStep becomes enabled.	0...7999774 [pps]	RW
186	PWM threshold speed	The StealthChop feature will be switched off when the actual velocity is higher than this value. It will be switched on when the actual velocity is below this value (and parameter #187 is greater than zero).	0...7999774 [pps]	RW
187	PWM gradient	Velocity dependent gradient for PWM amplitude (StealthChop). Setting this value to 0 turns off StealthChop.	0..15	RW
188	PWM amplitude	Maximum PWM amplitude when switching to StealthChop mode. Do not set too low. Values above 64 recommended.	0..255	RW
189	PWM scale	Actual PWM amplitude scaler (255=maximum voltage). In voltage mode PWM, this value allows to detect a motor stall.	0...255	R
191	PWM frequency	PWM frequency selection for StealthChop. 0 - f_{PWM} = 15.625kHz 1 - f_{PWM} = 23.426kHz 2 - f_{PWM} = 31.250kHz 3 - f_{PWM} = 39.024kHz	0...3	RW

Number	Axis Parameter	Description	Range [Units]	Access
192	PWM autoscale	PWM automatic amplitude scaling for StealthChop. 0 - User defined PWM amplitude. The current settings do not have any influence. 1 - Enable automatic current control.	0...1	RW
193	Reference search stall threshold	StallGuard threshold used for reference search.	-63...63	RW
194	Reference search speed	Velocity (pps) used for reference search.	0...7999774 [pps]	RW
195	Reference search stall Vmin	Below this speed the motor will not be stopped during reference search. Above this speed the motor will stop in case StallGuard load value reaches zero during reference search.	0...7999774 [pps]	RW
196	End stop distance	This parameter provides the distance between the two end stops after executing the RFS command.	0 ...2147483647 [μsteps]	R
206	Actual load value	Readout of the actual load value used for stall detection (StallGuard).	0...1023	R
207	Extended error flags	Error flag that will be set when the motor has been stopped by StallGuard. This flag will be cleared automatically after reading.	0...1	R
208	Motor driver error flags	A combination of the following values: Bit 0: StallGuard2 status (1: stall detected) Bit 1: Overtemperature (1: driver is shut down due to overtemperature) Bit 2: Overtemperature pre-warning (1: temperature threshold is exceeded) Bit 3: Short to ground A (1: short condition detected, driver currently shut down) Bit 4: Short to ground B (1: short condition detected, driver currently shut down) Bit 5: Open load A (1: no chopper event has happened during the last period with constant coil polarity) Bit 6: Open load B (1: no chopper event has happened during the last period with constant coil polarity) Bit 7: Stand still (1: no step pulse occurred during the last 2^{20} clock cycles)	0...255	R

Number	Axis Parameter	Description	Range [Units]	Access
214	Power down delay	Standstill period before the current will be ramped down to standby current. The standard value is 0 which means that the current will be immediately ramped down to standby current using the power down ramp (see parameter #31) after the motor has stopped. The delay time is given in units of 10ms which means that for example a value of 200 results in a delay time of 2000ms.	0...417 [10ms]	RW
251	Reverse shaft	Reverse the rotation direction of the motor shaft.	0/1	RW
255	Motor enable	Enable or disable the motor. 0: Motor disable 1: Motor enable (default)	0/1	RW

Table 10: All TMC5130-HBS-KIT Axis Parameters

5.2.10 Reference Search

The TMC5130-HBS-KIT slave module firmware also provides a built-in reference search routine. This reference search routines utilizes StallGuard™ to find a hard stop. In order to be able to use this reference search algorithm, StallGuard™ needs to be tuned first. This can be done with the help of the TMCL-IDE (CoolStep & StallGuard tool). When suitable speed and stall threshold values have been found, these values can be used for the reference search also. Use axis parameters #193, #194 and #195 to set the speed and StallGuard™ threshold values to be used with reference search.
The reference search can be started using the RFS START command. The motor will then first move in positive direction until a hard stop has been found. Then, the motor will move in negative direction until the other hard stop has been found. This way the distance between the two hard stops is measured. Finally, the position counter will be set to zero at the hard stop found in negative direction. Axis parameter #196 then provides the maximum distance (in microsteps) for moving from the zero point in positive direction.

5.3 Using the TMCL-IDE with the Reference Design

The Homebus Master module firmware implements an interface converter between TMCL via RS485 and TMCL via Homebus. This enables the user to use the TMCL-IDE for getting started with the Reference design. First, connect the Homebus Master to your power supply (max. 24V) and to an RS485 interface (connected to your PC) Connect the TMC5130-HBS-KIT slave module to the master module. The TMCL-IDE can then communicate with the slave module via the master module. In the TMCL-IDE, choose the correct COM port (your RS485 interface) and use 9600 baud and RS485 module address 1 as shown in figure 9.

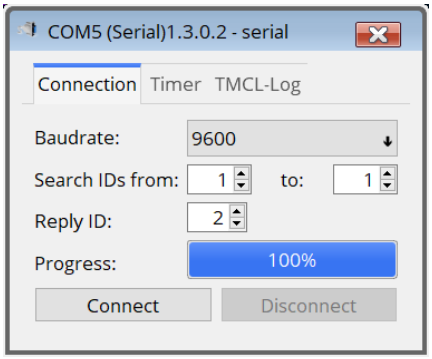

Figure 9: TMCL-IDE Connection Settings

The TMC5130-HBS-KIT reference design will be shown as a TMCM-0025 module by the TMCL-IDE. The different tools in the TMCL-IDE can be used to get the motor run and to read out the temperature sensor.

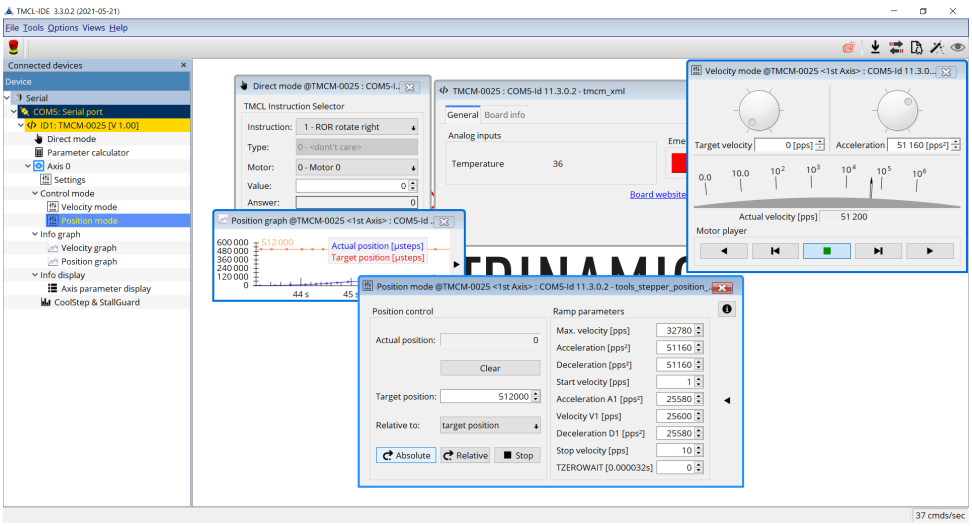

Figure 10: The TMCL-IDE showing the TMC5130-HBS-KIT Reference Design

5.4 Writing own Firmware

You are free to write your own firmware for the Homebus Slave module. Flashing and debugging of the MCU can be done via the Serial Wire Debug interface (SWD). Please see section 4.1.3 and figure 5 for more about the SWD interface.
It is also possible to modify the firmware for the Homebus Master module (for example to create an automated demonstration).

6 Operational Ratings and Characteristics

6.1 Absolute Maximum Ratings

Parameter	Symbol	Min	Max	Unit
H+ to H-	-	-0.3	+28	V
H+ to GND	-	-0.3	+28	V
H- to GND	-	-6	+6	V
Onboard Supply voltage	$+VS$	+9	+28	V
Abs. max. RMS motor phase current	$I_{phase,RMS}$		300	mA
Working temperature	T_A	-10	+50	°C

NOTICE

Never exceed the absolute maximum ratings! Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

6.2 Electrical Characteristics (Ambient Temperature 25°C)

Parameter	Symbol	Min	Typ	Max	Unit
Onboard Supply voltage	$+VS$	+9		+24	V
Onboard Digitial Supply and IO voltage	$+VCCIO$		+3.3		V
Continuous RMS motor phase current	$I_{phase,RMS}$			290	mA

Table 12: Electrical Characteristics

6.3 I/O Ratings (Ambient Temperature 25°C)

Parameter	Symbol	Min	Typ	Max	Unit
SWD programming pads	$VCCIO$		3.3		V

Table 13: I/O ratings

[1] This is the maximum current rating. This is not for continuous operation but depends on motor type, duty cycle, ambient temperature, and active/passive cooling measures.

[2] Working at high environmental temperatures may require additional cooling measures depending on duty cycle and maximum current/power draw.

6.4 Other Requirements

Specifications	Description or Value
Cooling	Free air or heat sink mounted with isolating gap pad
Working environment	Avoid dust, water, oil mist and corrosive gases, no condensation, no frosting

Table 14: Other Requirements and Characteristics

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9 Supplemental Directives

9.1 Producer Information

9.2 Copyright

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The documentation provided here, is for programmers and engineers only, who are equipped with the necessary skills and have been trained to work with this type of product.

The Target User knows how to responsibly make use of this product without causing harm to himself or others, and without causing damage to systems or devices, in which the user incorporates the product.

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9.7 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.

10 Revision History

10.1 Hardware Revision

Version	Date	Author	Description
1.00	02.05.2021	SK	Launch release.

Table 15: Hardware Revision

10.2 Firmware Revision

Version	Date	Author	Description
1.00	12.07.2021	OK	Launch release.

Table 16: Firmware Revision

10.3 Document Revision

Version	Date	Author	Description
1.00	06.08.2021	SK/OK	Launch release.
1.10	19.08.2021	SK	HBS connector pin numbers corrected.

Table 17: Document Revision