FAULHABER

Drive Electronics
Technical Information

WE CREATE MOTION

≋≋ FAULHABER

Speed Controller

Technical Information

Connection variants

DC-Micromotor with encoder and programming adapter (optional)

To customer application

Speed Controller

Brushless DC-Servomotor with digital or analog Hall sensors

USB interface

Brushless DC-Servomotor without Hall sensors (sensorless operation)

Brushless DC-Servomotor with absolute encoder (AES)
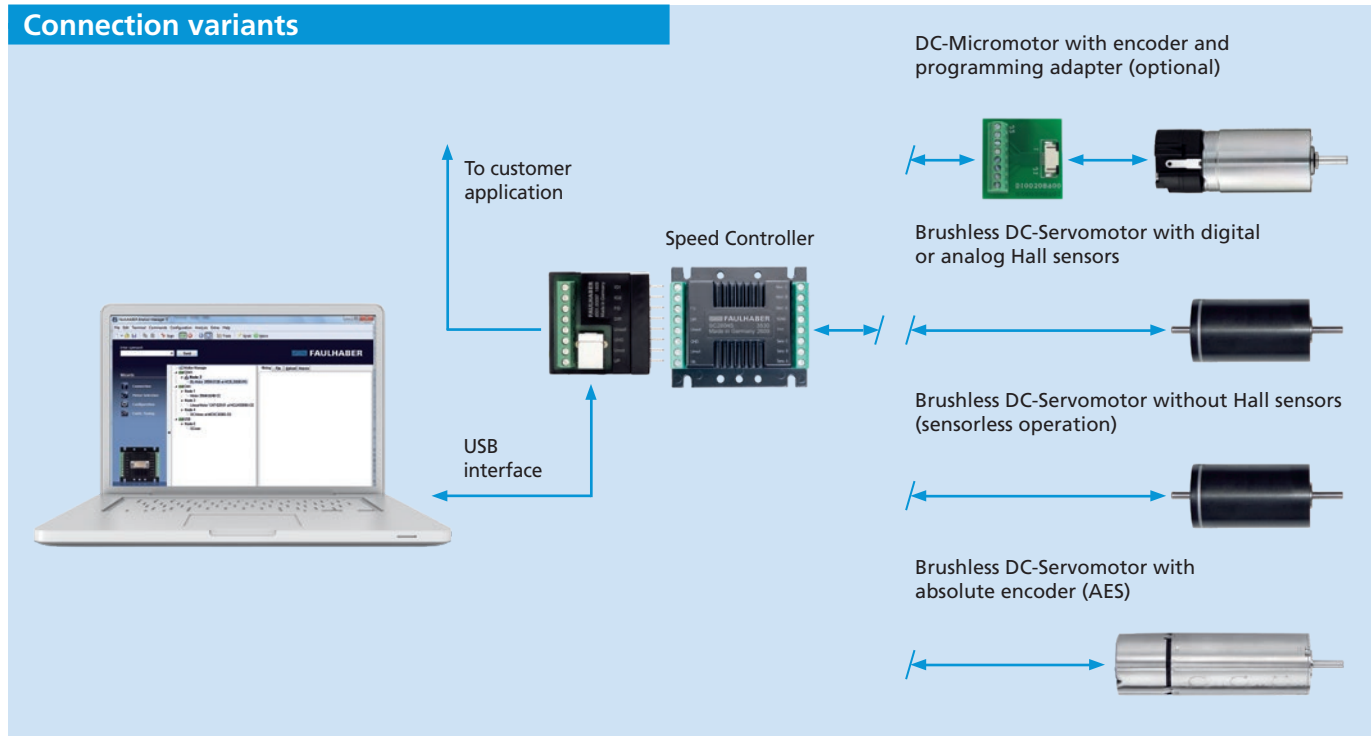
General Information

FAULHABER Speed Controllers are highly dynamic speed controllers for controlling:

■ DC-Motors with and without incremental encoder

■ BL motors with analog or digital Hall sensors

■ BL motors with AES absolute encoder

■ BL motors with digital Hall sensors and incremental encoders

Depending on the size and delivery state, different motor and sensor combinations can be operated on the Speed Controller.

The different sizes as well as the flexible connection possibilities open a wide range of applications in areas such as laboratory technology and equipment manufacturing, automation technology, pick-and-place machines and machine tools, or pumps.

Controller	DC sensorless	DC + encoder	BL sensorless	BL + D-Hall	BL + A-Hall	BL + AES
SC 1801	●	●	●	●	(2)	(2)
SC 2402/2804	●	●	●	● (1)	(2)	(2)
SC 5004/5008	-	●	-	● (1)	(2)	(2)

1) Optionally also available with additional incremental encoder input
2) Optionally available

Product code
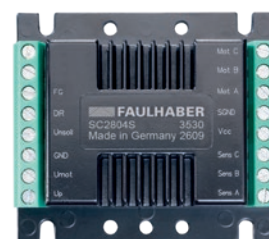
SC	Speed Controller
28	Max. supply voltage (28V)
04	Max. continuous output current (4A)
S	Housing with screw terminal
3530	Operating mode (brushless motor with digital Hall sensors)

SC 28 04 S 3530

Speed Controller
Technical Information

General Information

FAULHABER Speed Controllers can be adapted to the application via the FAULHABER Motion Manager software. The type and scaling of the setpoint input, the operating mode and the control parameters can be adjusted. The USB programming adapter for Speed Controllers is used for configuration.

Speed Controllers are available with or without housing. The variants with housing are connected via screw terminals; the unhoused circuit-board variants can be directly plugged into a master board.

Interfaces – discrete I/O

- Analog input as set value input for setting the speed via PWM or analog voltage value
- Digital input as switching input for defining the direction of rotation of the motor
- Digital output, can be programmed either as frequency output or as error output

Note

Device manuals for installation and start-up, as well as the FAULHABER Motion Manager software, are available on request or on the Internet under www.faulhaber.com. Not all Speed Controllers are suitable for all operating modes. Detailed information on the individual operating modes can be found in the respective data sheets as well as in the technical manual.

Benefits

- Compact design
- Scalable in current and voltage
- Simple wiring
- Adapted versions for connecting different motors
- Integrated current limiting (motor protection)
- Controller setting can be configured in combination with Motion Manager via programming adapters
- Extensive range of supported DC-micromotors and brushless DC-servomotors

Speed Controller

Description & Operating Modes

Operating modes

The speed is controlled via a PI controller with variable parameters.

Depending on the version, the speed is determined via the connected sensor system or sensorless from the motor current.

Setpoint specification can be performed using an analog value or a PWM signal. The direction of rotation is changed via a separate switching input; the speed signal can be read out via the frequency output.

The motors can optionally be operated as a voltage controller or in fixed speed mode.

BL motors with digital or analog Hall sensors
In the "BL motors with Hall sensors" configuration, the motors are operated with speed control, whereby the signals from the Hall sensors are used for commutation and determination of the actual speed.

BL motors without Hall sensors (sensorless mode)
No Hall sensors are used in this configuration; instead, the back-EMF of the motor is used for commutation and speed control.

BL motors with absolute encoder
This mode can only be selected in combination with the appropriate hardware.
 In this configuration, the encoder outputs an absolute position. This is used for commutation as well as for speed control. Owing to the high resolution of the encoder, it is possible to achieve low speeds in this mode.

BL motors with digital Hall sensors and brake/enable input
In this configuration, the motors are operated with speed control. The additional brake and enable inputs enable easier connection of the control to e.g. PLCs or safety circuits.

BL motors with digital Hall sensors and encoder
In this configuration, the Hall sensors output the information for commutation. The speed is controlled according to the signal from the incremental encoder.
For this reason, it is also possible to achieve extremely low speeds with a high-resolution encoder.

DC-Motors with encoder
In the "DC motors with encoder" configuration, the motors are operated with speed control. An incremental encoder is required as a speed actual value encoder.

DC-Motors without encoder
In the "sensorless DC motors" configuration, the motors are operated with speed control whereby, depending on the load condition, either the back electromotive force (EMF) or IxR compensation is used for speed actual value acquisition.
 Matching to the respective motor type is required for this operating mode.

A number of other parameters can also be changed using the **"FAULHABER Motion Manager" software**:

- Controller parameters
- Output current limiting
- Fixed speed
- Encoder resolution
- Speed setpoint specification via analog or PWM signal
- Maximum speed or maximum speed range

Protective functions

FAULHABER Speed Controllers determine the temperature of the motor winding from the motor load characteristic. Dynamically, a peak current which is typically 2 times larger than the continuous current is available as a result; with a continuously higher load, the current is limited to the set continuous current.
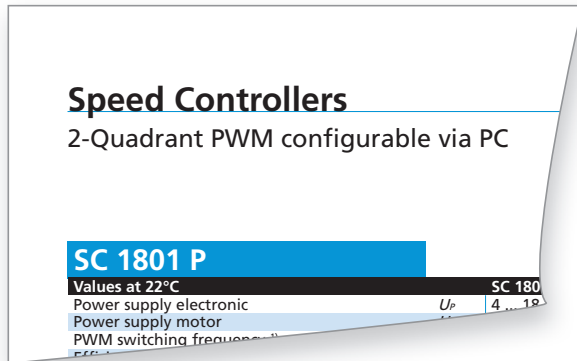
In the case of frequent reversing operation with large connected masses, it is recommended to use a Motion Controller.

Special functions

For special applications, special functions such as ramps, switchable fixed speeds or more complex processes can be implemented ex works depending on the additional inputs. This allows FAULHABER Speed Controllers to be optimally adapted to the requirements of the specific application.

FAULHABER

Speed Controllers
2-Quadrant PWM configurable via PC

SC 1801 P

Values at 22°C		SC 180
Power supply electronic	U_P	4 ... 18
Power supply motor		
PWM switching frequency		

Notes on technical data sheet

The following data sheet values of the Speed Controllers are measured or calculated at an ambient temperature of 22°C.

Speed Controllers generally feature separate supply inputs for motor and electronics with the same ground connection; if necessary, these inputs can also be used as a common supply.

Power supply for electronics U_P [V DC]
Describes the range of the permissible supply voltage for the control electronics.

Power supply for motor U_{mot} [V DC]
Describes the range of the permissible supply voltage of the connected motor.

PWM switching frequency f_{PWM} [kHz]
Pulse width modulation describes the change of the electrical voltage between two values. The motors connected to the SCs have a low electrical time constant. To keep the losses associated with PWM low, a high switching frequency is necessary.

Electronics efficiency η [%]
Ratio between consumed and delivered power of the control electronics.

Max. continuous output current I_{cont} [A]
Describes the current that the controller can continuously deliver to the connected motor at 22°C ambient temperature without additional cooling.

Max. peak output current $I_{max.}$ [A]
Describes the current that the controller can reach in S2 operation (cold start without additional cooling) at nominal conditions under constant load for the time specified in the data sheet without exceeding the thermal limit. Unless otherwise defined, the value that applies for the peak current is equal to two times the continuous current.

Standby current for the electronics I_{el} [A]
Describes the additional current consumption of the control electronics.

Operating temperature range [°C]
Shows the minimum and maximum operating temperature under nominal conditions.

Housing material
Housing materials and, if necessary, surface treatment.

Mass [g]
The typical mass of the standard controller may vary due to the different components.

Note

Speed range
The speed that can be reached in combination with a motor depends on the available voltage, the respective motor type and the maximum processing speed of the selected speed controller.

The maximum speed range refers to motors with one pole pair. On motors with a larger number of pole pairs, the speed range decreases accordingly.

$$\text{Maximum speed} = \frac{\text{Maximum speed with number of pole pairs 1}}{\text{Number of pole pairs of the connected motor}}$$

Motion Controllers

Feature Comparison

General Information

FAULHABER Motion Controllers are highly dynamic positioning systems, available in housed and unhoused variants and control DC, LM or BL motors. The Motion Controllers are configured here via the FAULHABER Motion Manager.

The drives can be operated in the network via the CANopen or EtherCAT fieldbus interface (only MC V3.0). In smaller setups, networking can also be performed via the RS232 interface. The Motion Controllers operate in the network in principle as a slave; master functionality for actuating other axes is not provided.

After basic commissioning via Motion Manager, the controllers can alternatively also be operated without communication interface.

Generation V2.5
- Proven technology for BL, DC and LM motors
- Very simple configuration and start-up

- Numerous configuration options
- Successfully used in medical and laboratory technology, equipment manufacturing, automation, medical technology and aerospace
- Also available in very small sizes

Generation V3.0
A new generation of controllers for applications that go beyond the features and performance offered by the V2.5 controller series.
- More power, faster control, new operating modes
- One controller for all motor types and encoder systems
- Flexible use of the I/Os for setpoints and actual values
- Additional I/Os and interfaces
- Sequential programs can be programmed in BASIC for simple, local automation in all interface technologies
- Expanded diagnostic functions
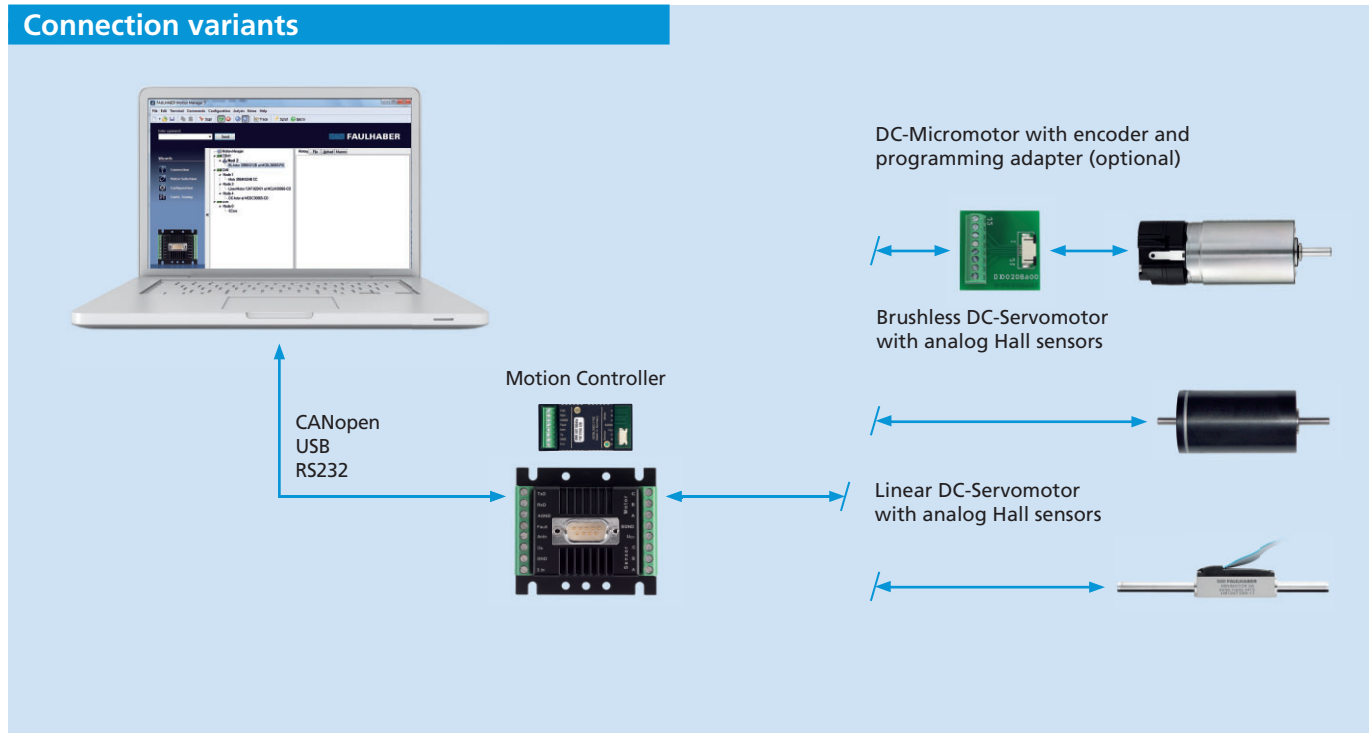- Simple start-up via Motion Manager beginning with version 6.0

	Generation V2.5		Generation V3.0	
	MCxx 3002	**MCxx 3003/06**	**MC 5004**	**MC 5005/10**
Voltage ranges	■ Motor: max. 30V ■ Electronics: max. 30V, optionally separated		■ Motor: max. 50V ■ Electronics: max. 50V, separated standard	
Continuous current	2A	3 / 6A	4A	5 / 10A
Peak current	3A	10A	12A	15 / 30A
Motor types	■ MCDC: DC + Encoder ■ MCBL: BL + A-Hall ■ MCLM: LM + A-Hall		■ DC motors with pos. / speed sensor ■ BL motors with pos. / speed sensor ■ LM motors with pos. / speed sensor	
Speed and position sensors	see motor types		■ DC motors: incremental[1], AES Encoder[1], SSI encoder[1], analog value (potentiometer/tachometer) ■ BL/LM motors: D-Hall, D-Hall + Encoder[1], A-Hall, AES encoder[1], SSI encoder[1], analog value (potentiometer/tachometer)	
Inputs/outputs	MCDC: DigIn: max. 5 DigOut: max. 1 AnIn ±10V: 1 Optional connection of a second reference encoder (Gearing mode). Not all I/Os available depending on wiring.	MCBL/MCLM: DigIn: max. 3 DigOut: max. 1 AnIn ±10V: 1	DigIn: 8 DigOut: 3 AnIn ±10V: 2 Optional connection of a second reference encoder (Gearing mode).	DigIn: 3 DigOut: 2 AnIn ±10V: 2
Communication	RS232 or CANopen		USB, RS232 and/or CANopen, EtherCAT	
Controller	Position, speed, current limiting		Position, speed, current / torque	
Operating modes	■ Depending on the interface variant, position, speed and current control with setpoint input via the interface or analog (RS)		■ Profile Position mode (PP) and Profile Velocity mode (PV), taking into account profile settings ■ Cyclic Synchronous Position, speed or torque (CSP, CSV or CST) ■ Analog input for position, speed, torque or voltage (APC, AVC, ATC, volt)	
Profile operation	Linear trapezoidal profiles in all operating modes		Linear or sin² speed in PP and PV modes	
Autonomous processes	Available in the versions with RS232 interface		Up to eight sequential programs in all versions, with optional password protection	

[1] with and without Line driver

Motion Controllers

Technical Information

Connection variants

DC-Micromotor with encoder and programming adapter (optional)

Brushless DC-Servomotor with analog Hall sensors

Motion Controller

CANopen
USB
RS232

Linear DC-Servomotor with analog Hall sensors

Features

FAULHABER Motion Controllers of generation V2.5 are highly dynamic positioning systems for controlling different motors and sensor systems:

■ MCDC 300x: DC-Motors with incremental encoder

■ MCBL 300x: BL-motors with analog Hall signals

■ MCLM 300x: LM-motors with analog Hall signals

In addition to use as a servo drive with controlled position, the speed can also be controlled. Via the integrated current control, the torque is limited and the electronics or the connected motor protected against overload.

Motion Controllers of generation V2.5 are available in various sizes and performance classes as well as with RS232 or with CAN interface and, as a result, can also be integrated in networks. In addition to operation on a PC, the systems can also be operated on all common industrial controls.

The Motion Controllers are available with or without housing. The variants with housing are connected via screw terminals; the unhoused circuit-board variants can be directly plugged into a master board.

Benefits

■ Compact design

■ Can be controlled either via RS232 or CAN interface

■ Minimal wiring requirements

■ Configurable using the "FAULHABER Motion Manager" software and USB interface

■ Extensive range of accessories

■ Simple start-up

Product code
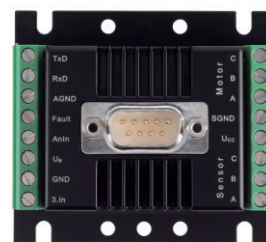
MC	Motion Controller
B L	For Brushless DC-Motors
30	Max. supply voltage (30 V)
06	Max. continuous output current (6 A)
S	Housing with screw terminal
CO	CAN interface

MC BL 30 06 S CO

Motion Controllers
Configuration, networking, interfaces

Operating modes

Positioning operation
The drive moves to the preset target position and, in doing so, maintains the specified limits for speed and position. The dynamics of the control can be adapted to a wide range of loads. Limit switches can be evaluated directly. The position can be initialised via limit switches or a reference switch.

Speed control
The drive controls the preset target speed via a PI speed controller without lasting deviation.

Current control
Protects the drive by limiting the motor current to the set peak current. By means of integrated thermal models, the current is limited to the continuous current if necessary.

Motion profiles
Acceleration and brake ramp as well as the maximum speed can be preset in speed and positioning operation.

Autonomous operation
In version RS, freely programmable processes can be stored in the Motion Controller. Operation is then also possible without RS232 interface.

Protective features
■ Protection against ESD
■ Overload protection for electronics and motor
■ Self-protection from overheating
■ Overvoltage protection in generator mode

Operating modes (RS version)
■ Position control
  – with setpoint input via the interface
  – with analog setpoint
  – gearing mode
  – stepper motor operation
■ Speed control
  – with setpoint input via the interface
  – with analog setpoint
■ Torque control
  – with setpoint input via the interface
  – with analog setpoint
■ Operation as Servo Amplifier in voltage controller mode

Operating modes (CO version)
■ Profile Position mode (PP)
■ Profile Velocity mode (PV)
■ Homing mode

Options

Separate supply of power to the motor and electronic actuator is optional (important for safety-critical applications).
Third input is not available with this option. Depending on the controller, additional programming adapters and connection aids are available. The modes and parameters can be specially pre-configured on request.

Interfaces – discrete I/O

Setpoint input
Depending on the operating mode, setpoints can be input via the command interface, via an analog voltage value, a PWM signal or a quadrature signal.

Error output (Open Collector)
Configured as error output (factory setting). Also usable as digital input, free switch output, for speed control or signaling an achieved position.

Additional digital inputs
For evaluating reference switches.

Interfaces – position encoder

Depending on the model, one of the listed interfaces for the position and speed sensor is supported.

Analog Hall signals
Three analog Hall signals, offset by 120°, in Brushless DC-Motors and Linear DC-Servomotors.

Incremental encoder
In DC-Micromotors and as additional sensors for Brushless DC-Motors.

Motion Controllers

Configuration, networking, interfaces

Networking

FAULHABER Motion Controllers of generation V2.5 are available in all two networking versions.

RS – systems with RS232 interface
Ideal for equipment manufacturing and for all applications in which the controller is also to be used without a higher level controller. Using Net mode, it is also possible to operate multiple RS controllers on an RS232 interface.

CO – CANopen acc. to CiA 402
The ideal variant for the operation of a FAULHABER Motion Controller on a PLC – directly via the CANopen interface or via a gateway on, e.g., Profibus/ProfiNET or on EtherCAT.

Interfaces – Bus Connection

Version with RS232
For coupling to a PC with a transfer rate of up to 115 kbaud. Multiple drives can be connected to a single controller using the RS232 interface. As regards the control computer, no special arrangements are necessary. The interface also offers the possibility of retrieving online operational data and values.

A comprehensive ASCII command set is available for programming and operation. This can be preset from the PC using the "FAULHABER Motion Manager" software or from another control computer.

Additionally, there is the possibility of creating complex processes from these commands and storing them on the drive. Once programmed as a speed or positioning controller via the analog input, as step motor or electronic gear unit, the drive can operate independently of the RS232 interface.

Version with CANopen CO
A controller variant with CANopen interface is available to allow optimal integration in a wide variety of different applications. CANopen is ideal for networking microdrives because the interface can also be integrated in small electronics modules. Its size and the efficient communication procedures mean that it is ideally suited for use in industrial automation.

The CO version provides the CiA 402 standard operating modes. All the parameters are directly stored in the object directory. Configuration can therefore be performed with the help of the FAULHABER Motion Manager or by applying available standardized configuratons tools common to the automation market.

The CO version is particularly suitable for users who already use various CANopen devices or operate the Motion Controllers on a PLC. With dynamic PDO mapping it is possible to achieve highly efficient networking on the CAN.

Motion Controllers

Configuration, networking, interfaces

Features CO

	CO
NMT with node guarding	•
Baud rate	1 Mbit max., LSS
EMCY object	•
SYNCH object	•
Server SDO	1 x
PDOs	4 x Rx 4 x Tx each with dynamic mapping
PDO ID	adjustable
Configuration	Motion Manager from V5
Trace	Any PDO
Standard operating modes - Profile Position Mode - Profile Velocity Mode - Homing	•

The model supports the CANopen communication profile acc. to CiA 301 V4.02. Transfer rate and node number are set via the network in accordance with the LSS protocol as defined in CiA 305 V1.11.

For this purpose, we recommend using the latest version of the FAULHABER Motion Manager.

Note

Device manuals for installation and commissioning, communication and function manuals as well as the "FAULHABER Motion Manager" software are available on request or on the Internet under www.faulhaber.com.

Motion Controllers

Configuration, networking, interfaces

Motion Controllers
V2.5, 4-Quadrant PWM
with RS232 or CAN interface

MCDC 3002 P

Values at 22°C		MCDC
Power supply electronic	U_B/U_{EL}	8 ... 30
Power supply motor [1]		
PWM switching frequency		
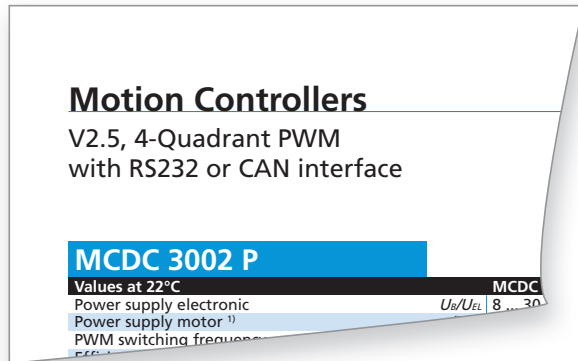
Notes on technical data sheet

The following data sheet values of the Motion Controllers of generation V2.5 are measured or calculated at an ambient temperature of 22°C. In their standard version, the Motion Controllers do not have separate supply inputs for motor and electronics, but can optionally be equipped with these inputs (via 3rd input).

Power supply for electronics U_B/U_{EL} [V DC]
Describes the range of the permissible supply voltage for the control electronics.

Power supply for motor -- /U_B [V DC]
Describes the range of the permissible supply voltage of the connected motor.

PWM switching frequency f_{PWM} [kHz]
Pulse width modulation describes the change of the electrical voltage between two values. The motors connected to the MCs have a low electrical time constant. To keep the losses associated with PWM low, a high switching frequency is necessary.

Electronics efficiency η [%]
Ratio between consumed and delivered power of the control electronics.

Max. continuous output current I_{cont} [A]
Describes the current that the controller can continuously deliver to the connected motor at 22°C ambient temperature without additional cooling.

Max. peak output current $I_{max.}$ [A]
Describes the current that the controller can reach in S2 operation (cold start without additional cooling) at nominal conditions under constant load for the time specified in the data sheet without exceeding the thermal limit. Depending on the size and version, the value is up to three times higher for the ratio of peak current to continuous current.

Standby current for the electronics I_{el} [A]
Describes the additional current consumption of the control electronics.

Operating temperature range [°C]
Shows the minimum and maximum operating temperature under nominal conditions.

Housing material
Housing materials and, if necessary, surface treatment.

Mass [g]
The typical mass of the standard controller may vary within the individual interface variants due to the different components.

Note

Speed range
The speed that can be reached in combination with a motor depends on the available voltage, the respective motor type and the maximum processing speed of the selected motion controller.

The maximum speed range refers to motors with one pole pair. On motors with a larger number of pole pairs, the speed range decreases accordingly.

$$\text{Maximum speed} = \frac{\text{Maximum speed with number of pole pairs 1}}{\text{Number of pole pairs of the connected motor}}$$

Motion Controller

Technical Information

Features

FAULHABER Motion Controllers of generation V3.0 are highly dynamic, optimally tuned positioning controllers for use in combination with DC-micromotors as well as BL and LM DC-servomotors from FAULHABER's line of motors. The motor type can be configured during commissioning using the FAULHABER Motion Manager from version 6.0.

In addition to use as a servo drive with controlled position, the speed or current can also be controlled. The actual values for speed and position can be ascertained here using a number of supported sensor systems. Limit switches and reference switches can be directly connected.

The control setpoints can be preset via the communication interface, via the analogue input or a PWM input or can come from internally stored sequential programs.

Supported as communication interfaces are – depending on the device – USB and RS232, CANopen and, optionally, EtherCAT. All functions of the drive are available here without limitation via all interfaces.

Product code
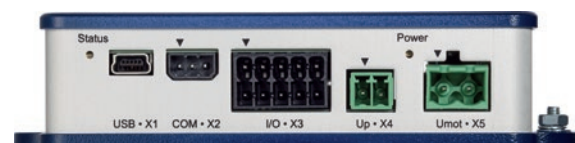
MC	Motion Controller	MC 50 05 S RS
50	Max. supply voltage (50 V)	
05	Max. continuous output current (5 A)	
S	Housing with plug-in connections	
RS	RS232 interface	

FAULHABER Motion Controllers of generation V3.0 are available in four sizes and four power classes:

- **MC 3001** – with a continuous current of up to 1.4 A, can be plugged directly into a motherboard and is optimised for the combinatorics with motors from the lower power range of the product line.
- **MC 3603** – with a continuous current of up to 3A, optimized for the combinatorics with motors from the lower to middle power range.
- **MC 5004** – with a continuous current of up to 4 A, can be plugged directly into a motherboard and offers most I/Os.
- **MC 5005** – with a continuous current of up to 5 A, is the ideal partner for most motors from the FAULHABER product portfolio.
- **MC 5010** – with a continuous current of up to 10 A, is also suitable for applications with higher power requirements. Especially well suited for use in combination with the highly dynamic BL motors.

The possible applications are diverse: from laboratory automation to industrial equipment manufacturing, automation technology and robotics to aerospace.

The connection to the motors is established via pre-configured plugs or extension cables, which are available for all supported motors as options or as accessories.

Benefits

- One controller for all motor types and encoder types
- Very dynamic control
- Ideally matched to FAULHABER DC, BL and LM motors
- Various setpoint and actual value interfaces
- Stand-alone operation possible in all variants
- Connection via simple plug concept
- Fast feedback with status LEDs
- Commissioning with the free FAULHABER Motion Manager from version 6.0
- Extensive mounting accessories available
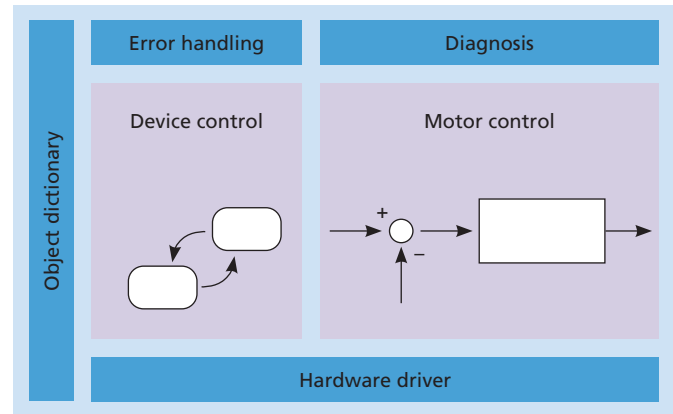
Operating modes

Motor control
Current, speed and position of the drive can be controlled via the controller cascade. By means of the optional pilot paths, even the fastest movements can be reliably controlled in a reproducible manner. Adjustable filters enable adaptation to a wide range of encoders and loads.

Motion profiles
Acceleration and brake ramp as well as the maximum speed can be preset in speed and positioning operation in the Profile Position Mode (PP) and Profile Velocity Mode (PV) operating modes.

Autonomous operation
Up to eight sequential programs written in BASIC can be stored and executed directly on the controller. One of these can be configured from the autostart application. Access protection can be activated.

Protection and diagnostic functions
FAULHABER Motion Controllers of generation V3.0 protect motors and electronics against overload by means of thermal models. The supply voltage is monitored and can also be used in regenerative operation. External devices are thereby protected against overvoltage during dynamic operation.

Profile Position Mode (PP) / Profile Velocity Mode (PV)
For applications in which only the target of the movement is specified for the controller. The acceleration and brake ramp as well as a possible maximum speed are taken into account via the integrated profile generator. Profile-based movements are, thus, suited for a combination with standard networks, such as RS232 or CANopen.

Cyclic Synchronous Position (CSP) / Cyclic Synchronous Velocity (CSV) / Cyclic Synchronous Torque (CST)
For applications in which a higher-level controller performs the path planning, even synchronised for multiple axes. The setpoints for position, speed and current are constantly updated. Typical update rates are in the range of a few milliseconds. Cyclic modes are, thus, primarily suited for combination with EtherCAT. CANopen can also be used.

Analogue Position Control (APC) / Analogue Velocity Control (AVC) / Analogue Torque Control (ATC)
For applications in which the setpoints of the control are specified as an analogue value or, e.g., via a directly connected reference encoder. These operating modes are therefore particularly well suited for stand-alone operation without higher-level master.

Voltage mode (VOLT)
In the voltage mode, only a current limiting controller is used. All control loops are closed by a higher-level system. The setpoint can be set via the communication system or via an analogue input.

Interfaces – discrete I/O
Three to eight digital inputs for connecting limit and reference switches or for connecting a reference encoder. The logic levels are switchable.

Two analogue inputs (±10V) are available that can be freely used as setpoint or actual value.

Two to three digital outputs are available that can be freely used as error output, for direct actuation of a holding brake or as flexible diagnosis output.

Interfaces – position encoder
FAULHABER Motion Controllers of generation V3.0 support all sensor systems typically used on micro motors for position and speed as well as analogue or digital Hall signals, incremental encoders with and without Line Driver or protocol-based AES or SSI encoders.

Options

With the exception of the MC 3001 series, all controllers can optionally be equipped ex works with an EtherCAT interface.

For highly dynamic applications, the use of a braking chopper can help to dissipate recovered energy.

Networking

RS – systems with RS232 interface
Ideal for device construction and for all applications in which the Motion Controller is to be operated on an embedded controller. Using Net mode, it is also possible to operate multiple RS controllers on an RS232 interface. The transmission rate can lie between 9600 baud and 115 kbaud.

CO – CANopen acc. to CiA 402
The ideal variant for the operation of a FAULHABER Motion Controller on a PLC – directly via the CANopen interface or via a gateway on, e.g., Profibus/ProfiNET or on EtherCAT. Dynamic PDO mapping as well as node guarding or heartbeat are supported. Refresh rates for setpoint and actual values are typically from 10 ms here.

ET – EtherCAT
Motion Controller with direct EtherCAT interface. The controllers are addressed via CoE via the CiA 402 servo drive profile. Ideal in combination with a high-performance industrial controller that also performs path planning and interpolation of the movement for multiple axes. Refresh rates for setpoint and actual values from 0.5 ms are supported.

Interfaces – Bus Connection

Configuration
All Motion Controllers of generation V3.0 are equipped with a USB interface. This is intended primarily as a configuration interface. Via a USB to RS232 or USB to CAN converter, the drives can alternatively likewise be configured without restriction.

All described operating modes and functions are available independent of the used communication interface.

The interfaces can also be used in parallel, thereby allowing a drive to be integrated in an industrial interface via the CANopen or EtherCAT interface, while diagnostics are evaluated with the trace function via the USB interface.

General Information

System description

The products of the MC 3001, MC 3603, MC 5004, MC 5005 and MC 5010 series are variants of the FAULHABER Motion Controllers with and without housing and control either DC, LM or BL motors. The Motion Controllers are configured here via the FAULHABER Motion Manager.

The drives can be operated in the network via the CANopen or EtherCAT fieldbus interface. In smaller setups, networking can also be performed via the RS232 interface.

The Motion Controller operates in the network in principle as a slave; master functionality for actuating other axes is not provided.

After basic commissioning via the Motion Manager, the controllers can alternatively also be operated without communication interface.

The controllers of the MC 3001 series can be plugged into various motherboards via either board-to-board connectors or pin strips depending on the feedback component that is used.

The controllers of the MC 5004 series can be plugged into a motherboard via the 50-pin connector strip.

In its standard product line, FAULHABER offers various motherboards with from one to four axes for this purpose.

The controllers of the MC 3603, MC 5005 and MC 5010 series are secured to a flat base plate via the mounting holes. With optional accessories, mounting is also possible on a DIN rail.

Modifications and accessories

FAULHABER specialises in the adaptation of its standard products for customer-specific applications. The following standard options and accessory parts are available for FAULHABER Motion Controller MC V3.0:

- Connection cables for the supply and motor side
- Adapter sets for encoders
- Connector sets
- Motherboard MC 3001 / MC 5004
- Programming adapter
- Starter kits
- Customized motherboards, special configuration and firmware

Motion Controller

Technical Information

Motion Controllers

V3.0, 4-Quadrant PWM
with RS232, CANopen or EtherCAT interfa...

MC 5004 P		
Values at 22°C		MC 500
Power supply electronic	U_P	12 ... 50
Power supply motor	U_{mot}	0
PWM switching frequency		
Efficiency electr...		
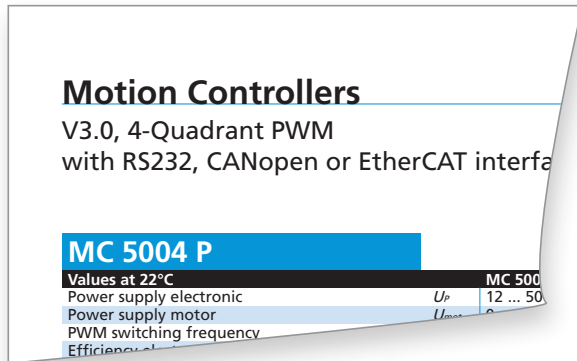
Explanatory Notes for Data Sheets

The following data sheet values of the Motion Controllers are measured or calculated at an ambient temperature of 22°C.

Motion Controllers of generation V3.0 generally feature – with the same ground connection – separate supply inputs for motor and electronics; if necessary, these inputs can also be used as a common supply.

Power supply for electronics U_p [V DC]
Describes the range of the permissible supply voltage for the control electronics.

Power supply for motor U_{mot} [V DC]
Describes the range of the permissible supply voltage for the motors connected to the MCs.

PWM switching frequency f_{PWM} [kHz]
Pulse width modulation describes the change of the electrical voltage between two values. Bell-type armature motors have a low electrical time constant. To keep the losses associated with PWM low, a high switching frequency is necessary. In generation V3.0, this value is fixed at 100 kHz. Through the type of pulse pattern generation (centre aligned), the switching frequency effective at the motor is twice as high.

Electronics efficiency η [%]
Ratio between consumed and delivered power of the control electronics.

Max. continuous output current I_{cont} [A]
Describes the current that the controller can continuously deliver to the connected motor at 22°C ambient temperature without additional cooling.

Max. peak output current $I_{max.}$ [A]
Describes the current that the controller can reach in S2 operation (cold start without additional cooling) at nominal conditions under constant load for the time specified in the data sheet without exceeding the thermal limit. Unless otherwise defined, the value that applies for the peak current is equal to three times the continuous current.

Standby current for the electronics I_{el} [A]
Describes the additional current consumption of the control electronics.

Operating temperature range [°C]
Shows the minimum and maximum operating temperature under nominal conditions.

Mass [g]
The typical mass of the standard controller may vary within the individual interface variants due to the different components.

Note

Speed range
The speed that can be reached in combination with a motor depends on the available voltage, the respective motor type and the maximum processing speed of the selected motion controller.

The maximum speed range refers to motors with one pole pair. On motors with a larger number of pole pairs, the speed range decreases accordingly.

$$\text{Maximum speed} = \frac{\text{Maximum speed with number of pole pairs 1}}{\text{Number of pole pairs of the connected motor}}$$

Manuals/Software

Device manuals for installation and commissioning, communication and function manuals as well as the "FAULHABER Motion Manager" software are available on request or on the Internet under www.faulhaber.com.

Motion Controller
Software
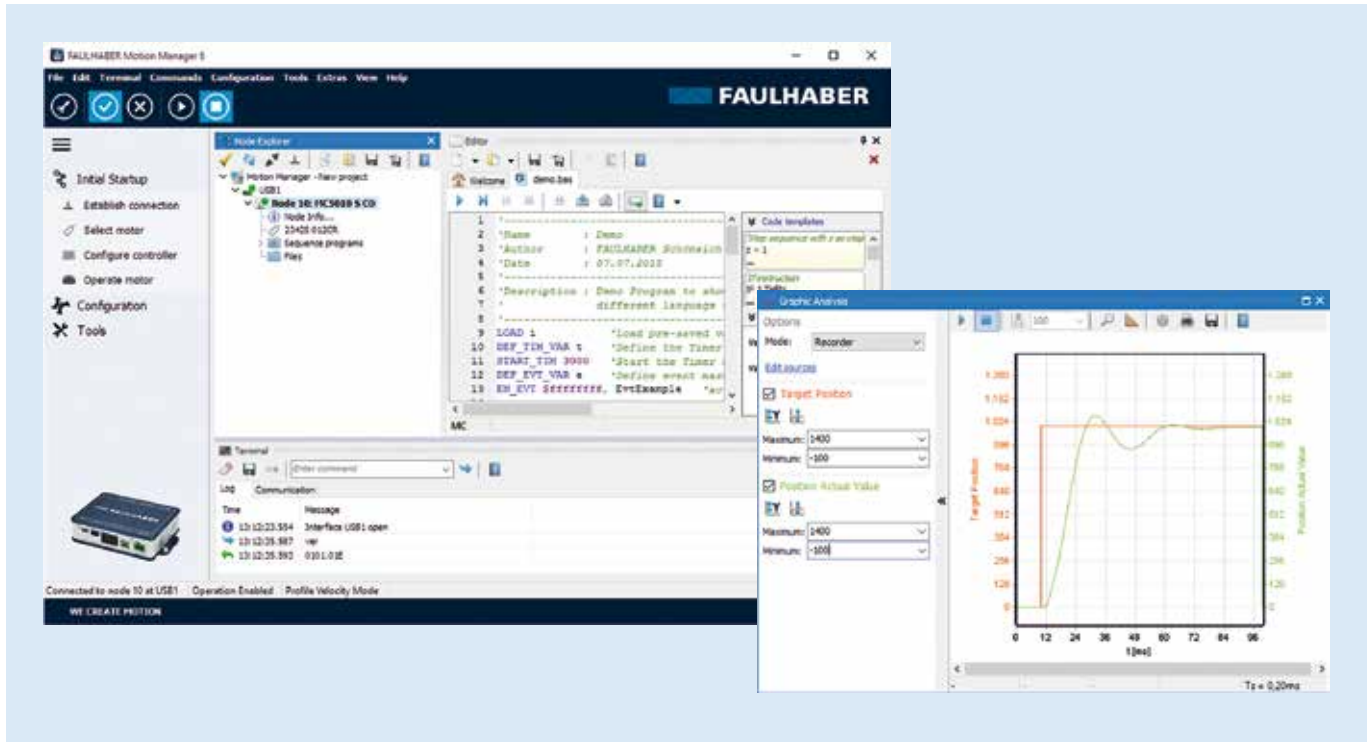
FAULHABER Motion Manager

The powerful 'FAULHABER Motion Manager' software is available for commissioning and configuring drive systems with motion and speed controllers.

Motion Manager generally supports interfaces RS232, USB and CANopen. Depending on the connected device, it may, however, be necessary to use an interface adapter, e.g., during the configuration of a Motion Control System via USB.

The graphical user interface makes uniform and intuitive procedures possible independent of the device family and interface used.

Supported Interfaces	Motion Controllers Motion Control Systems	Speed Controller Speed Control Systems
RS232	●	●
USB	●	●
CANopen	●	

The software is characterised by the following features:
- Start-up support wizards
- Access to connected devices via Node-Explorer
- Configuration of drive functions and controller parameters using convenient, coordinated dialogues for the respective device family
- Context-sensitive online help
- Only for Motion Controllers:
  - Graphical analysis tools for drive behaviours and controller setting
  - Macro function for execution of program sequences
  - Development environment for sequential pro-grammes and Visual Basic Script programmes

New features in Motion Manager 6:
- Completely revised user interface with window docking function
- Node-Explorer with integrated project management
- Support for the MC V3.0 family Motion Controller
  - Controller configuration with route identification
  - Expanded graphical analysis options
  - Further tools for operation and controller tuning

Motion Controller

Software

"FAULHABER Motion Manager" for Microsoft Windows can be downloaded from www.faulhaber.com free of charge.

Commissioning and Configuration

FAULHABER Motion Manager can be used to easily access settings and parameters of the connected controller.

Wizards assist during the commissioning of a controller. Drive units detected on the selected interfaces are displayed in the device explorer.

The current interface and display settings can be saved in project files.

Sequential programs for saving and execution can be created, edited, transferred and executed on the devices. Possibilities for error detection and monitoring the program flow are also available.

The operation of a controller and the execution of motion tasks are performed via:

- Graphical operating elements
- Command entries
- Macro functions
- Programming of sequences via Visual Basic Script (VBScript)

Control parameters such as setpoints and actual values can be recorded in Logger or Recorder mode via a graphical analysis function. Additional tools are available for the creation and optimisation of control parameters.

Stepper motors Motion Controller

Technical Information

Connection variants

Standard cable with Molex connector

Flex PCB adapter

Motion Controller

USB

Wires plugged to the connecting terminal
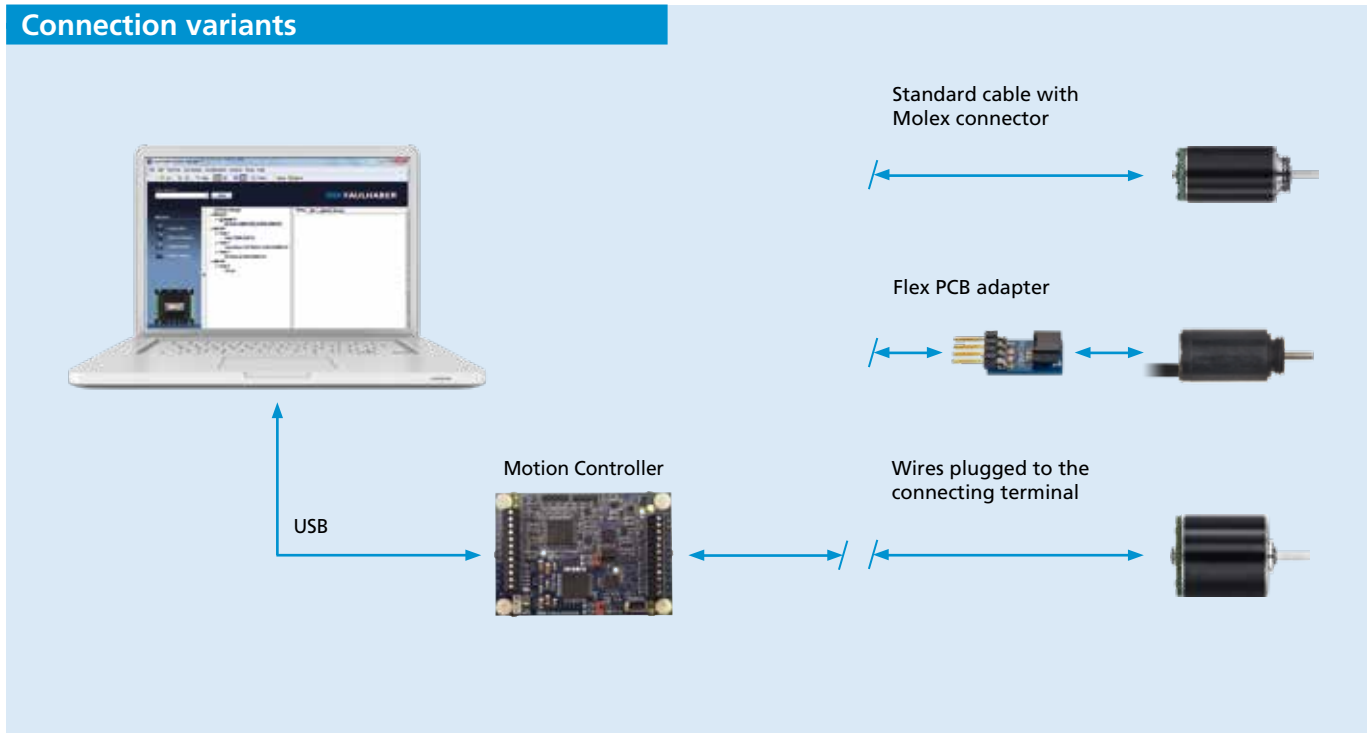
Features

FAULHABER stepper motor motion controllers are highly dynamic positioning systems tailored specifically to the requirements of micro stepper motor operations.

In addition to be able to control the whole FAULHABER stepper motor range, the controllers are capable of managing three axes positioning (requires 2 additional boards). Reference search and encoder management functions are part of the numerous features offered by the controllers.

A complete IDE is included, allowing the user to benefit from the full range of functionalities, through a very comprehensive and user friendly interface.

The integrated systems require less space, as well as making installation much simpler thanks to their reduced wiring.

Benefits

- ■ Fully programmable via software (Graphic User Interface)
- ■ USB interface
- ■ 9V…36VDC / 50mA to 1.1A
- ■ Microstepping up to 1/256
- ■ 4 GPI and 7 GPO
- ■ Can be used as step/direction driver only
- ■ Reference input (for homing functions)
- ■ Compatible with LabView
- ■ Board size: 68mm x 47.5mm

Product Code

MC	Motion Controller
ST	Stepper Motor
36	Max. supply voltage (36V)
01	Max. continuous output current (1A)

MC ST 36 01

Stepper motors Motion Controller

Technical Information

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

Software
- TMCL™: standalone operation or remote controlled operation
- PC-based application development software TMCL™ – IDE available for free.

Operating modes

Standalone
A program is stored in the controller board memory, and starts when the system is powered ON. The software is able to react with external stimulus, such as digital I/Os, encoders, sensors, etc. Standard processor instructions list as well as complete list of motor positioning control functions are available for the programmer.

Direct mode
Using IDE "direct mode" functions, the user is able to send instructions to the board one by one, through USB link. Status information and position/speed values can be read in real time by the user, thanks to dedicated GUI.

Remote software
The controller can be remotely controlled through USB link, by any user developed software. Labview and C++ libraries are available to be used with the controller.

Special functions

Speed profiles
Motors movements are realized using user definable speed profiles. The latter can be setup using a complete parameter calculator interface, helping the user to find the most suited speed values.

StallGuard™
Stall detection feature allows the controller to react in case of step losses, and can also be used to detect any motor hard stop reach.

CoolStep™
Current flowing to the motor is automatically adapted in case of load variation. This feature allows a reduced power consumption of the whole system.

Homing
Reference search process can be done automatically by the controller on startup. The user can setup the way to perform the operation (direction, switches number, origin location, etc.).
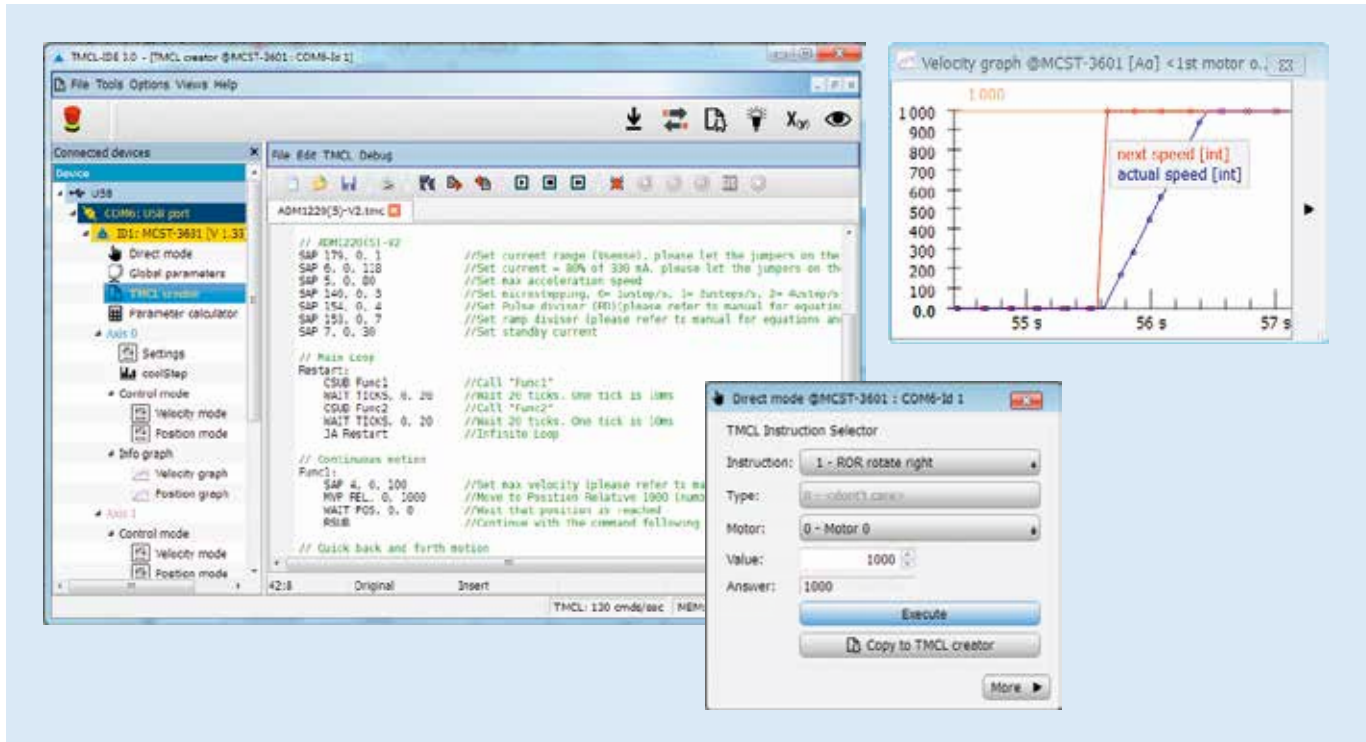
Interfaces

- 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.

Notes

Device manuals for installation and start up, communication and function manuals, and the "TMCL™ – IDE" software are available on request and on the Internet at www.faulhaber.com.

Stepper motors Motion Controller
Software

TMCL™ – IDE

The high-performance software solution "TMCL™ – IDE" enables users to control and configure the stepper motors controller, through USB interface.

"TMCL™ – IDE" software and lots of program examples can be downloaded free of charge from www.faulhaber.com.

Startup and configuration

Drivers and libraries are automatically installed together with the TMCL™-IDE software. Connected controller device is immediately detected and recognized by the software. The graphical user interface can be used to read out, change and reload configurations. Individual commands or complete parameter sets and program sequences can be entered and transferred to controller.

Operation of drives is also supported by several wizards, helping user to easily setup all the parameters.

Quickstart, hardware and firmware complete user manuals are also available for the user and can be downloaded free of charge from www.faulhaber.com. Please refer to the Quickstart manual before first use.

FAULHABER

More information

- faulhaber.com
- faulhaber.com/facebook
- faulhaber.com/youtubeEN
- faulhaber.com/linkedin
- faulhaber.com/instagram

DFF_TL_03-2023_EN

FAULHABER GROUP