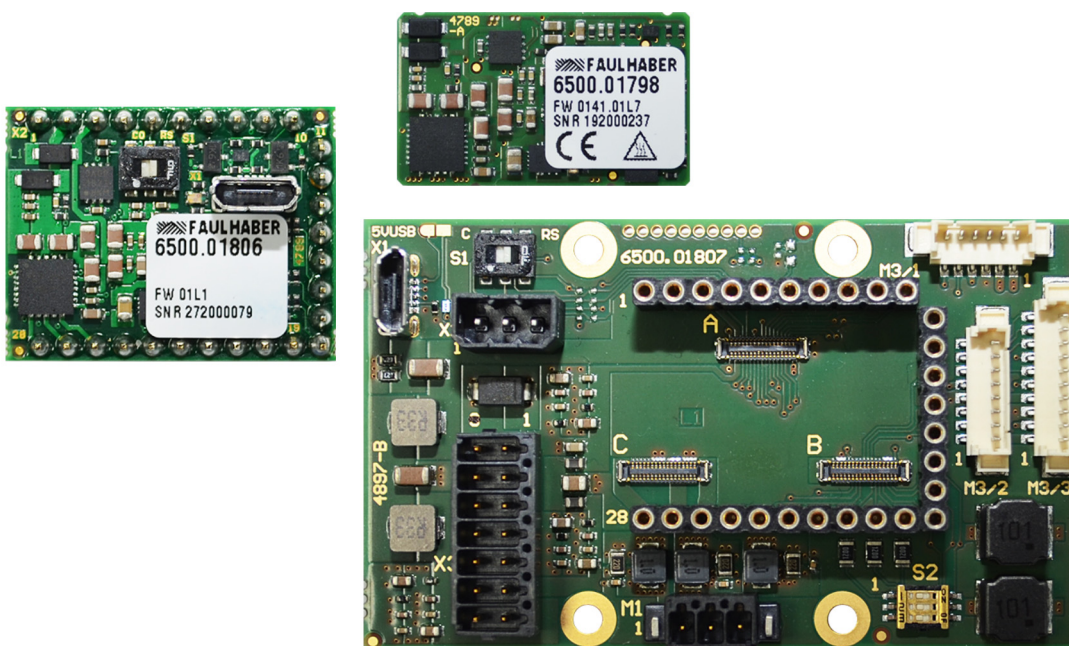


# Technical Manual

MC 3001 B/P



## Imprint

---

Version:  
2nd edition, 12.07.2021

Copyright  
by Dr. Fritz Faulhaber GmbH & Co. KG  
Daimlerstr. 23 / 25 · 71101 Schönaich

All rights reserved, including those to the translation.  
No part of this description may be duplicated, reproduced,  
stored in an information system or processed or  
transferred in any other form without prior express written  
permission of Dr. Fritz Faulhaber GmbH & Co. KG.

This document has been prepared with care.  
Dr. Fritz Faulhaber GmbH & Co. KG cannot accept any  
liability for any errors in this document or for the  
consequences of such errors. Equally, no liability can be  
accepted for direct or consequential damages resulting  
from improper use of the equipment.

The relevant regulations regarding safety engineering  
and interference suppression as well as the requirements  
specified in this document are to be noted and followed  
when using the software.

Subject to change without notice.

The respective current version of this technical manual is  
available on FAULHABER's internet site:  
[www.faulhaber.com](http://www.faulhaber.com)

# Content

<b>1</b>	<b>About this document .....</b>	<b>5</b>
1.1	Validity of this document .....	5
1.2	Associated documents .....	5
1.3	Using this document .....	5
1.4	List of abbreviations .....	6
1.5	Symbols and designations .....	7
<b>2</b>	<b>Safety .....</b>	<b>8</b>
2.1	Intended use .....	8
2.2	Safety instructions .....	9
2.3	Environmental conditions .....	9
2.4	EC directives on product safety .....	10
<b>3</b>	<b>Product description .....</b>	<b>11</b>
3.1	General product description .....	11
3.2	Product information .....	12
3.3	Product variants .....	13
3.3.1	Controller PCBs.....	13
3.3.1.1	Standard PCB with micro board-to-board connectors (MC3001 B).....	13
3.3.1.2	Standard PCB with plug connectors (MC 3001 P) .....	17
3.3.2	Motherboards .....	20
3.3.2.1	Instructions for using other motherboards.....	20
3.3.2.2	Motherboard 6500.01802.....	22
3.3.2.3	Motherboard 6500.01807.....	29
3.3.2.4	Motherboard 6500.01808.....	35
3.3.2.5	Motherboard 6500.01809.....	40
3.3.2.6	Motherboard 6500.01810.....	45
3.3.2.7	Motherboard 6500.01811.....	50
<b>4</b>	<b>Installation .....</b>	<b>55</b>
4.1	Mounting .....	55
4.1.1	Mounting instructions .....	55
4.1.2	Installation of Motion Controller PCBs.....	56
4.2	Electrical connection .....	57
4.2.1	Notes on the electrical connection .....	57
4.2.2	Drive connections.....	58
4.2.3	Connection of the power supply .....	59
4.2.3.1	Power supply.....	59
4.2.4	I/O circuit diagrams .....	60
4.2.5	External circuit diagrams .....	62
4.3	Electromagnetic compatibility (EMC) .....	65
4.3.1	Considered systems .....	65
4.3.2	Functional earthing .....	67
4.3.3	Cable routing .....	67
4.3.4	Shielding.....	69
4.3.4.1	Establishing the shield connection .....	70
4.3.4.2	Establishing shield connection with cable lug .....	71

## Content

4.3.5	Sensor and encoder interfaces .....	72
4.3.5.1	Analogue sensors and analogue Hall sensors .....	73
4.3.5.2	Incremental encoders / Digital Hall sensors / Digital sensors .....	73
4.3.5.3	Encoders with absolute interface .....	73
4.3.6	Using filters .....	73
4.3.6.1	EMC-compliant mounting of the Motion Controller with motherboard .....	74
4.3.6.2	PWM filter (motor-side) .....	74
4.3.6.3	Emission-reducing, ferrite-based filters (motor side) .....	74
4.3.6.4	Input-side filters .....	75
4.3.6.5	Insulation resistance .....	75
4.3.6.6	Coiling ferrite ring .....	75
4.3.7	Error avoidance and troubleshooting .....	76
<b>5</b>	<b>Maintenance and diagnostics .....</b>	<b>78</b>
5.1	Maintenance tasks .....	78
5.2	Diagnosis .....	78
5.3	Troubleshooting .....	78
<b>6</b>	<b>Accessories .....</b>	<b>79</b>
<b>7</b>	<b>Warranty .....</b>	<b>80</b>
<b>8</b>	<b>Additional documents .....</b>	<b>81</b>
8.1	Declaration of Conformity .....	81
8.2	Declaration of Incorporation .....	83

## About this document

# 1 About this document

## 1.1 Validity of this document

This document describes the installation and use of the FAULHABER MC 3001 series.

This document is intended for use by trained experts authorised to perform installation and electrical connection of the product.

All data in this document relate to the standard versions of the series listed above. Changes relating to customer-specific versions can be found in the corresponding data sheet.

## 1.2 Associated documents

For certain actions during commissioning and operation of FAULHABER products additional information from the following manuals is useful:

Manual	Description
Motion Manager 6	Operating instructions for FAULHABER Motion Manager PC software
Quick start guide	Description of the first steps for commissioning and operation of FAULHABER Motion Controllers
Drive functions	Description of the operating modes and functions of the drive
Accessories manual	Description of the accessories

These manuals can be downloaded in pdf format from the web page [www.faulhaber.com/manuals](http://www.faulhaber.com/manuals).

## 1.3 Using this document

- ▶ Read the document carefully before undertaking configuration, in particular chapter "Safety".
- ▶ Retain the document throughout the entire working life of the product.
- ▶ Keep the document accessible to the operating and, if necessary, maintenance personnel at all times.
- ▶ Pass the document on to any subsequent owner or user of the product.

## About this document

### 1.4 List of abbreviations

Abbreviation	Meaning
AC	Alternating Current
AES	Absolute encoder
AGND	Analogue Ground
AnIn	Analogue input
CAN	Controller Area Network
CAN_L	CAN-Low
CAN_H	CAN-High
CLK	Clock
CS	Chip Select
DigIn	Digital input
DigOut	Digital output
EFM	Electronics Filter Motor
EFS	Electronics Filter Supply
EMC	Electromagnetic compatibility
ESD	Electrostatic discharge
GND	Ground
I/O	Input/Output
MC	Motion Controller
Mot	Motor
n.c.	not connected
PWM	Pulse Width Modulation
RxD	Receive Data
SGND	Signal ground
TxD	Transmit data

## About this document

---

### 1.5 Symbols and designations



#### **CAUTION!**

Hazards due to hot surfaces. Disregard may lead to burns.

- ▶ Measures for avoidance



#### **NOTICE!**

Risk of damage.


- ▶ Measures for avoidance




Instructions for understanding or optimising the operational procedures

- ✓ Pre-requirement for a requested action

1. First step for a requested action

-  Result of a step

2. Second step of a requested action

-  Result of an action

- ▶ Request for a single-step action

## 2 Safety

### 2.1 Intended use

The Motion Controllers described here are designed for use as slaves for control and positioning tasks for the following motors:

- DC-Micromotors
- Linear DC-Servomotors
- Brushless DC-motors

The Motion Controller is suitable in particular for tasks in the following fields of application:

- Robotics
- Toolbuilding
- Automation technology
- Industrial equipment and special machine building
- Medical technology
- Laboratory technology

When using the Motion Controllers the following aspects should be observed:

- The Motion Controller contains electronic components and should be handled in accordance with the ESD regulations.
- Do **not** use the Motion Controller in environments where it will come into contact with water, chemicals and/or dust, **nor** in explosion hazard areas.
- The Motion Controller is **not** suitable for use in combination with stepper motors.
- The Motion Controller should be operated only within the limits specified in the data sheet.
- Please ask the manufacturer for information about use under individual special environmental conditions.



## Safety

---

### 2.2 Safety instructions



**NOTICE!**

Electrostatic discharges can damage the electronics.

- ▶ Wear conductive work clothes.
- ▶ Wear an earthed wristband.



**NOTICE!**

Foreign bodies can damage the electronics.

- ▶ Keep foreign objects away from the electronics.



**NOTICE!**

Inserting and withdrawing connectors whilst supply voltage is applied at the device can damage the electronics.

- ▶ Do not insert or withdraw connectors whilst supply voltage is applied at the device.

### 2.3 Environmental conditions

- ▶ Select the installation location so that clean dry air is available for cooling the Motion Controller.
- ▶ Select the installation location so that the air has unobstructed access to flow around the drive.
- ▶ When installed within housings and cabinets take particular care to ensure adequate cooling of the Motion Controller.
- ▶ Select a power supply that is within the defined tolerance range.
- ▶ Protect the Motion Controller against heavy deposits of dust, in particular metal dust and chemical pollutants.
- ▶ Protect the Motion Controller against humidity and wet.

### 2.4 EC directives on product safety

- ▶ The following EC directives on product safety must be observed.
- ▶ If the Motion Controller is being used outside the EU, international, national and regional directives must be also observed.

#### **Machinery Directive (2006/42/EC)**

The controllers with attached motor described in these installation instructions may be drive systems according to the Machinery Directive. They are therefore to be considered incomplete machines according to the Machinery Directive. Compliance is documented by the Declaration of Incorporation for the product and by the EC Declaration of the Conformity.

#### **EMC Directive (2014/30/EU)**

The directive concerning electromagnetic compatibility (EMC) applies to all electrical and electronic devices, installations and systems sold to an end user. In addition, CE marking can be undertaken for built-in components according to the EMC Directive. Conformity with the directive is documented in the Declaration of Conformity.

#### **Applied standards**

Various harmonised standards were applied to the products described in this technical manual; these standards are documented in the EC Declaration of Conformity. You can find the Declaration of Incorporation for the product and the EC Declaration of Conformity in chap. 8, p. 81.

### 3 Product description

#### 3.1 General product description

The MC 3001 products are unboxed versions of the FAULHABER Motion Controllers and control either DC, LM or BL motors. The Motion Controllers are configured here via the FAULHABER Motion Manager software V6 (version 6.7 and higher).


The drives can be operated in the network via the CANopen fieldbus 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 Motion Manager, the controllers can alternatively also be operated without communication interface.

The controllers can be plugged into a motherboard via 3 micro board-to-board connectors (MC 3001 B) or a 28-pin plug connector (MC 3001 P).

With the integrated output stage with optimised current measurement, DC, BL and LM motors from the FAULHABER product line from 06 to 30 mm can be controlled.

The following connections are available on the connector strip:

- Communications interfaces
- Common or separate power supplies between motor and controller
- Various inputs and outputs
- Motor phases
- Feedback components such as:
  - Digital/analogue Hall sensors
  - Incremental encoders with or without line drivers.

 Motion Controllers with RS232 or CANopen interface can also be operated independently of the communication interface if a function or a suitable sequence program was previously stored locally.

## Product description

### 3.2 Product information

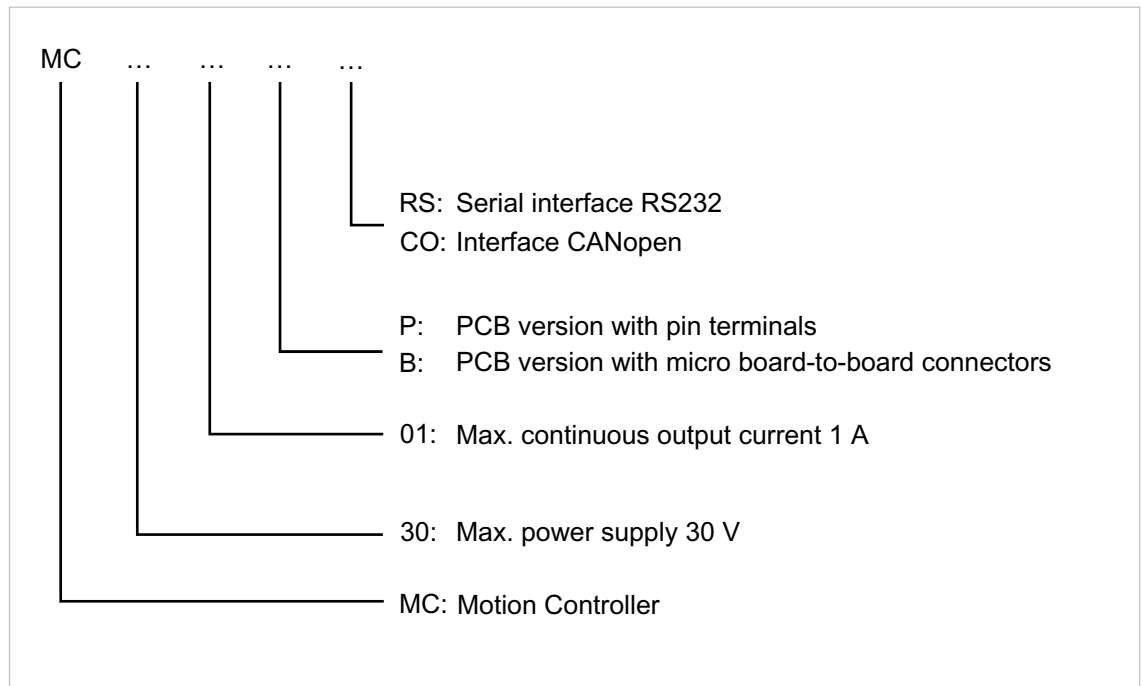


Fig. 1: Designation key

## Product description

### 3.3 Product variants

The following product variants are possible:

- MC 3001 B RS/CO
- MC 3001 P RS/CO

The Motion Controller PCBs can be mounted on a motherboard. The FAULHABER motherboard offers space for a Motion Controller PCB.

#### 3.3.1 Controller PCBs

##### 3.3.1.1 Standard PCB with micro board-to-board connectors (MC3001 B)

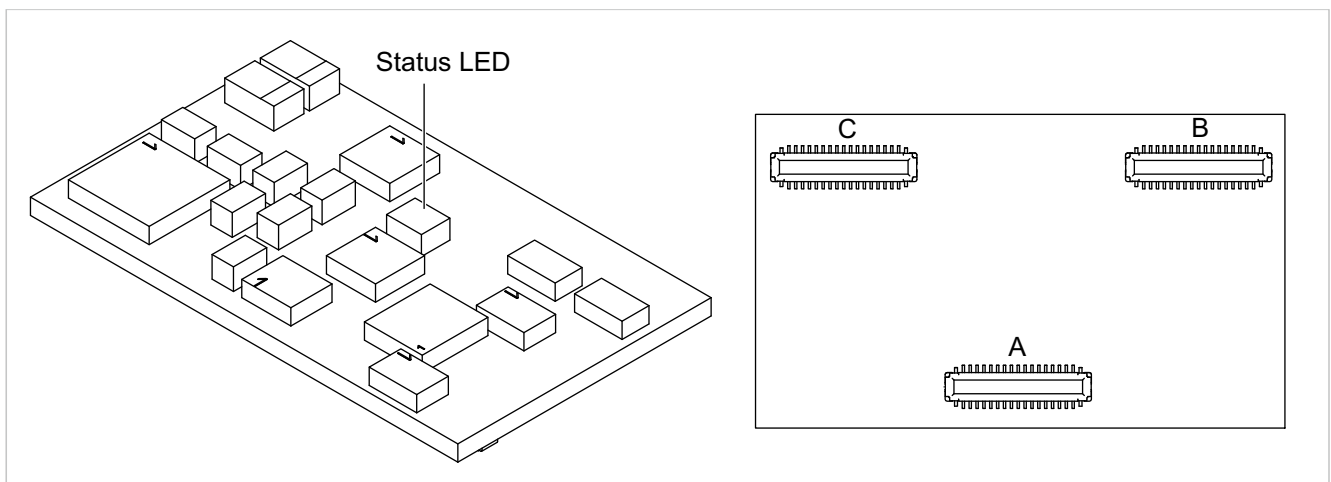


Fig. 2: Isometric view (left) and rear view (right) of the standard PCB with micro board-to-board connectors

#### State LED

Tab. 1: LED function

LED indicator	Function
Green (continuous light)	Device active.
Green (flashing)	Device active. However the state machine has not yet reached the <i>Operation Enabled</i> state.
Red (continuously flashing)	The drive has switched to a fault state. The output stage will be switched off or has already been switched off.
Red (error code)	Boot procedure failed. Please contact FAULHABER Support.

## Product description

### Pin assignment of the connector

The MC 3001 B Motion Controller has 3 connectors by means of which the connection between Motion Controller and motherboard or customer-specific peripherals is established.

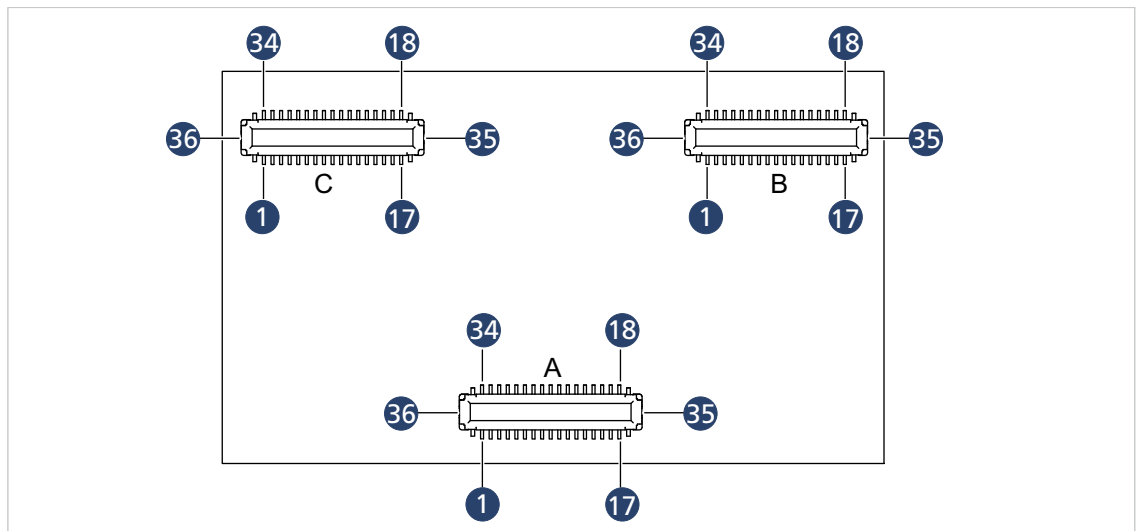


Fig. 3: Pin overview of the micro board-to-board connectors of the MC 3001 B



For technical data, see motherboard pin assignment.

Tab. 2: Pin assignment of connector A

Pin	Designation	Meaning
1	GND	Ground connection
2, 3	$U_p$	Power supply of the electronics
4	CAN-L	CAN-Low interface
5	CAN-H	CAN-High interface
6	GND	Ground connection
7	Reserved	Do not connect
8	GND	Ground connection
9	$U_{DD}$	5V supply connection for sensors
10	DigIn 1	Digital input
11	DigIn 2	Digital input
12	DigIn 3	Digital input
13	DigOut 1	Digital output
14	DigOut 2	Digital output
15	TxD	RS232 interface transmit direction
16	RxD	RS232 interface receive direction
17, 18	EGND	Earth connection
19	USB ID	USB port ID
20	USB D+	USB port D+
21	USB D-	USB port D-

## Product description

Pin	Designation	Meaning
22	USB VCC	USB port VCC
23...31	Reserved	Do not connect
32, 33	$U_p$	Power supply of the electronics
34, 35	GND	Ground connection
36	$U_{mot}$	Power supply of the motor


Tab. 3: Pin assignment of connector B

Pin	Designation	Meaning
1	$U_{DD}$	5V supply connection for sensors
2...4	GND	Ground connection
5...7	Reserved	Do not connect
8	n.c.	–
9	AnIn 1	Analogue input
10	AGND	Analogue ground connection
11	AnIn 2	Analogue input
12, 13	n.c.	–
14...16	GND	Ground connection
17	Reserved	Do not connect
18	GND	Ground connection
19	$\overline{\text{Channel A}}$	Encoder channel A (logically inverted signal)
20	$\overline{\text{Channel B}}$	Encoder channel B (logically inverted signal)
21	$\overline{\text{Index}}$	Index channel (logically inverted signal)
22	Index	Index channel
23	Channel B	Encoder channel B
24	Channel A	Encoder channel A
25, 26	Reserved	Do not connect
27	Sens A	Hall sensor A
28	Sens B	Hall sensor B
29	Sens C	Hall sensor C
30...33	GND	Ground connection
34	$U_{DD}$	5V supply connection for sensors
35	GND	Ground connection
36	$U_{DD}$	5V supply connection for sensors

## Product description

Tab. 4: Pin assignment of connector C

Pin	Designation	Meaning
1	n.c.	–
2...5	Reserved	Do not connect
6...9	GND	Ground connection
10...13	Phase B	Motor phase B
14...17	GND	Ground connection
18...28	Phase B	Motor phase B
29...34	Reserved	Do not connect
35	Phase C	Motor phase C
36	Phase A	Motor phase A

 The motor phase B signal is assigned multiple times to achieve sufficient current-carrying capacity. For the motor phase A and motor phase C connections, multiple assignment is not necessary since sufficient current-carrying capacity is achieved at pin 35 and pin 36 due to the design of the connector.



## Product description

### 3.3.1.2 Standard PCB with plug connectors (MC 3001 P)

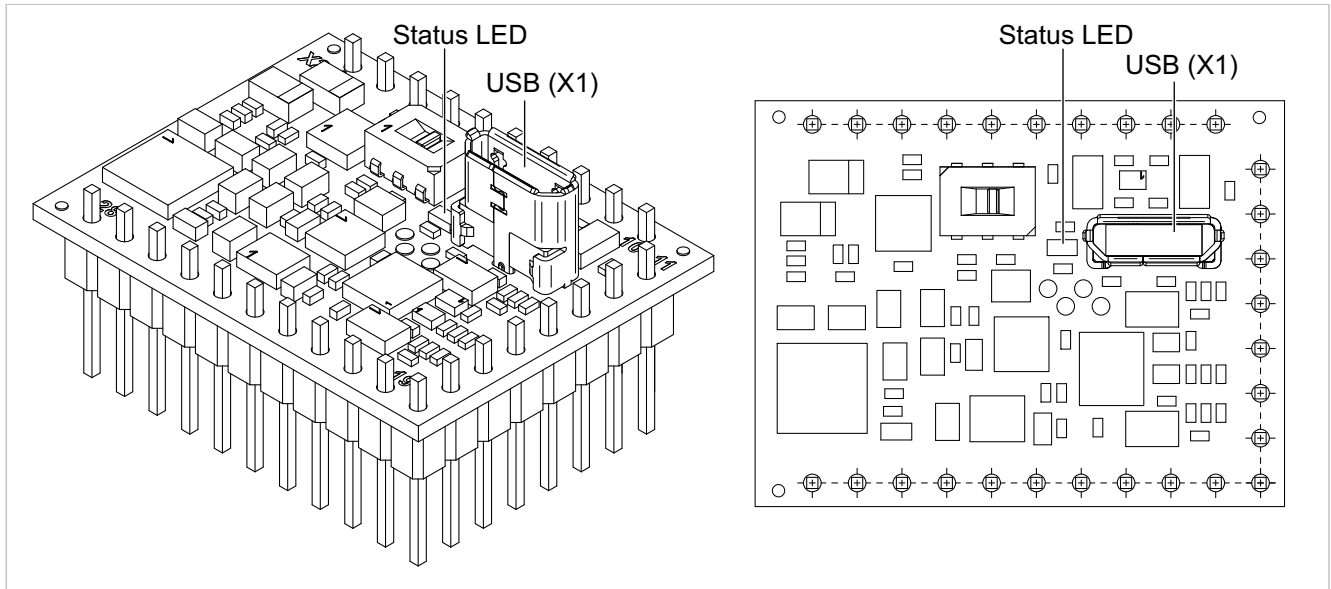


Fig. 4: Isometric view (left) and top view (right) of the standard PCB with plug connectors

#### State LED

Tab. 5: LED function

LED indicator	Function
Green (continuous light)	Device active.
Green (flashing)	Device active. However the state machine has not yet reached the <i>Operation Enabled</i> state.
Red (continuously flashing)	The drive has switched to a fault state. The output stage will be switched off or has already been switched off.
Red (error code)	Boot procedure failed. Please contact FAULHABER Support.

#### USB (X1)

Connection of the USB communication (USB micro B).

## Product description

### Pin assignment of the plug connector

The MC 3001 P Motion Controller has a connector strip by means of which the connection between Motion Controller and motherboard or customer-specific peripherals is established.

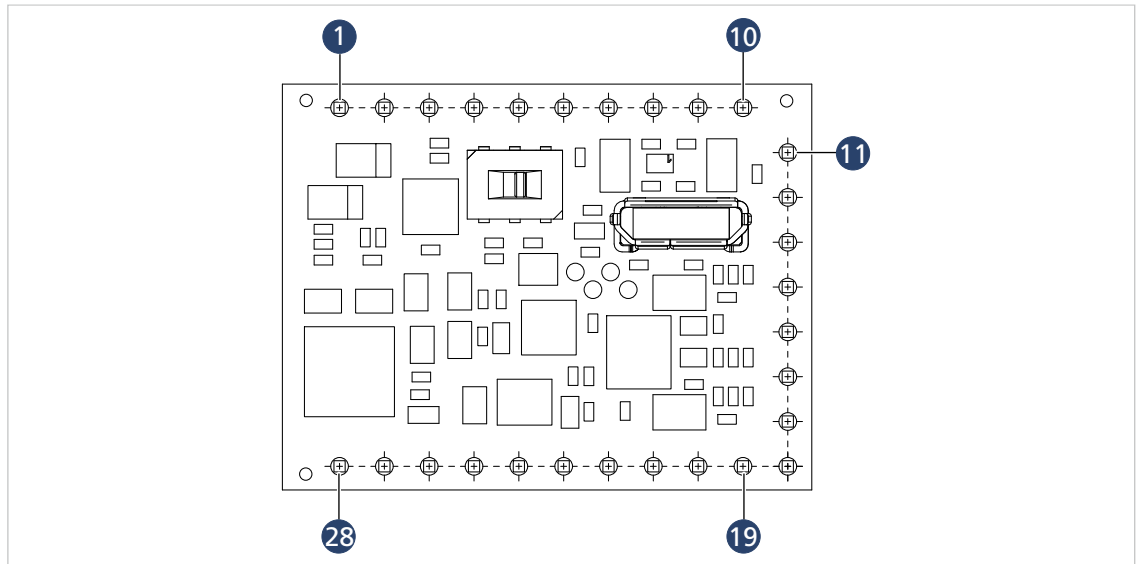


Fig. 5: Pin overview of the plug connector of the MC 3001 P



For technical data, see motherboard pin assignment.

Tab. 6: Pin assignment of the plug connector

Pin	Designation	Meaning
1	GND	Ground connection
2	$U_{mot}$	Power supply of the motor
3	$U_p$	Power supply of the electronics
4	CAN-H TxD	CAN-High interface RS232 interface transmit direction
5	CAN-L RxD	CAN-Low interface RS232 interface receive direction
6	DigIn 1	Digital input
7	DigIn 2	Digital input
8	DigIn 3	Digital input
9	DigOut 1	Digital output
10	DigOut 2	Digital output
11	EGND	Earth connection
12	GND	Ground connection
13	AnIn 1	Analogue input
14	AGND	Analogue ground connection
15	AnIn 2	Analogue input
16	Channel A	Encoder channel A (logically inverted signal)
17	Channel B	Encoder channel B (logically inverted signal)

## Product description

Pin	Designation	Meaning
18	$\overline{\text{Index}}$	Index channel (logically inverted signal)
19	Index	Index channel
20	Channel B	Encoder channel B
21	Channel A	Encoder channel A
22	Sens C	Hall sensor C
23	Sens B	Hall sensor B
24	Sens A	Hall sensor A
25	U <sub>DD</sub>	5V supply connection for sensors
26	Phase C	Motor phase C
27	Phase B	Motor phase B
28	Phase A	Motor phase A

## Product description

### 3.3.2 Motherboards


The following motherboards are available and each support both products MC 3001 B and MC 3001 P:

*Tab. 7: Available motherboards from FAULHABER*

Option	Description	Reference
6500.01802	MB1 MC 3001 for general combination with BL/DC-motors including Hall sensors and/or encoders	chap. 3.3.2.2, p. 22
6500.01807	MB1 MC 3001 for combination with DC-motors and encoders IE2, IEH2, IEH3(L)	chap. 3.3.2.3, p. 29
6500.01808	MB1 MC 3001 for combination with DC-motors and encoders IE3(L), IER3(L), IERS3(L)	chap. 3.3.2.4, p. 35
6500.01809	MB1 MC 3001 for combination with DC-motors and encoders PA2-100, HEM3	chap. 3.3.2.5, p. 40
6500.01810	MB1 MC 3001 for combination with BL-motors and encoders AESM, IEM3	chap. 3.3.2.6, p. 45
6500.01811	MB1 MC 3001 for combination with BL/DC-motors and encoders PA2-50, HXM	chap. 3.3.2.7, p. 50

When using other motherboards, observe the instructions in chap. 3.3.2.1, p. 20.

#### 3.3.2.1 Instructions for using other motherboards

 If motherboards other than those offered by FAULHABER are used (see Tab. 7), they must be manufactured in accordance with the following guidelines:

- PCB: IPC-A-600H Class 2
- Mounting/soldering: IPC-A-600E Class 2

The following sockets are recommended as counterparts to the controller connectors:

#### MC 3001 P

Manufacturer: W+P

Series: Socket Strip 10 (2 pieces)

Details: 10-pin, contact spacing 2.54, gold-plated

Manufacturer number: 153-010-1-50-00

Manufacturer: W+P

Series: Socket Strip 10 (1 piece)

Details: 8-pin, contact spacing 2.54, gold-plated

Manufacturer number: 153-008-1-50-00

For each MC 3001 P, 2x 10-pin sockets and 1x 8-pin socket are needed.

## Product description

### MC 3001 B

Manufacturer: Molex

Series: Slim Stack

Details: 34-pin + 2-pin edge contact, contact spacing 0.35 mm, gold-plated

Manufacturer number: 505413-3410

For each MC 3001 B, 3 sockets are needed.

Also observe the dimensions and tolerances shown in the following figures.

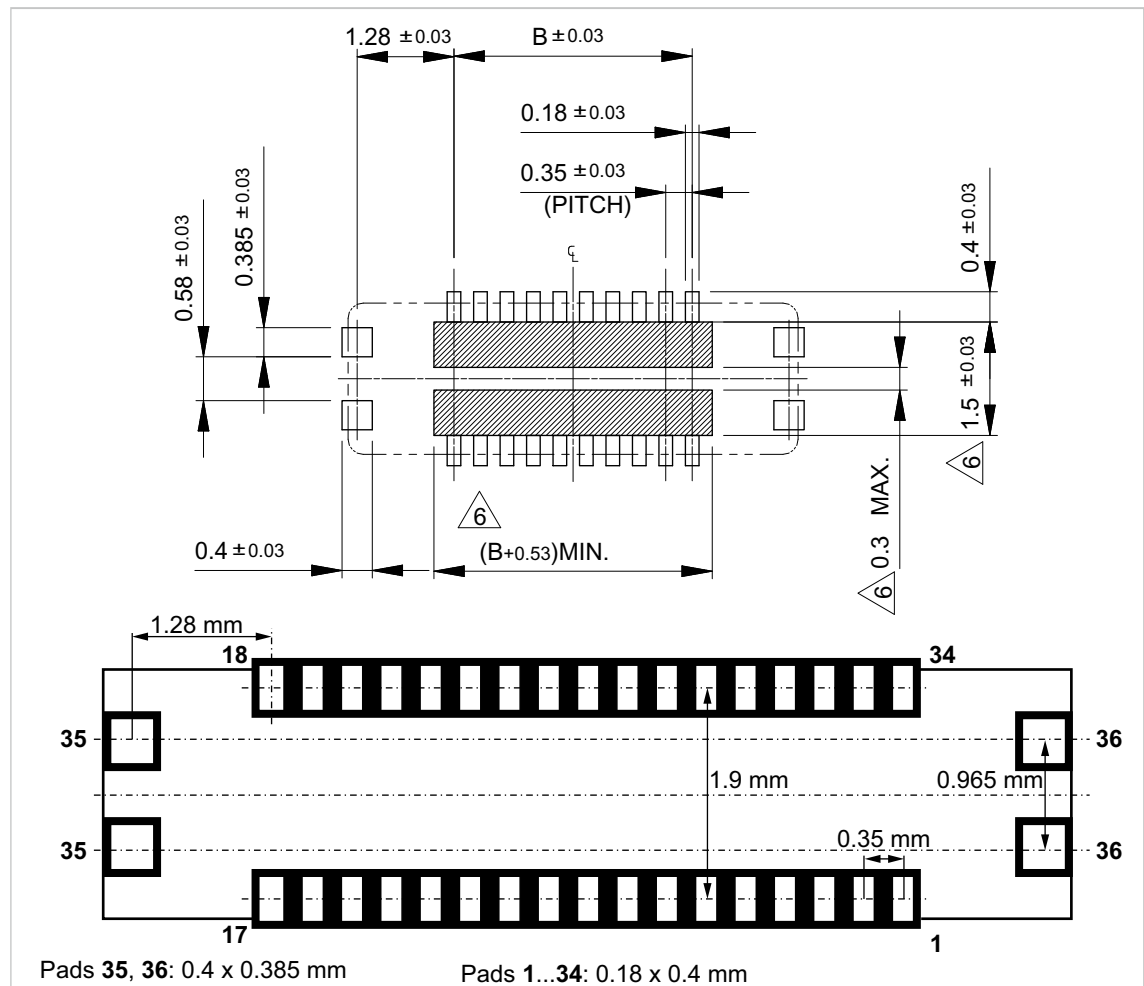


Fig. 6: Dimensions and tolerances of the sockets for controller connectors A, B and C

## Product description

### 3.3.2.2 Motherboard 6500.01802

With this motherboard, it is possible to combine FAULHABER BL/DC-motors as well as Hall sensors and/or encoders.

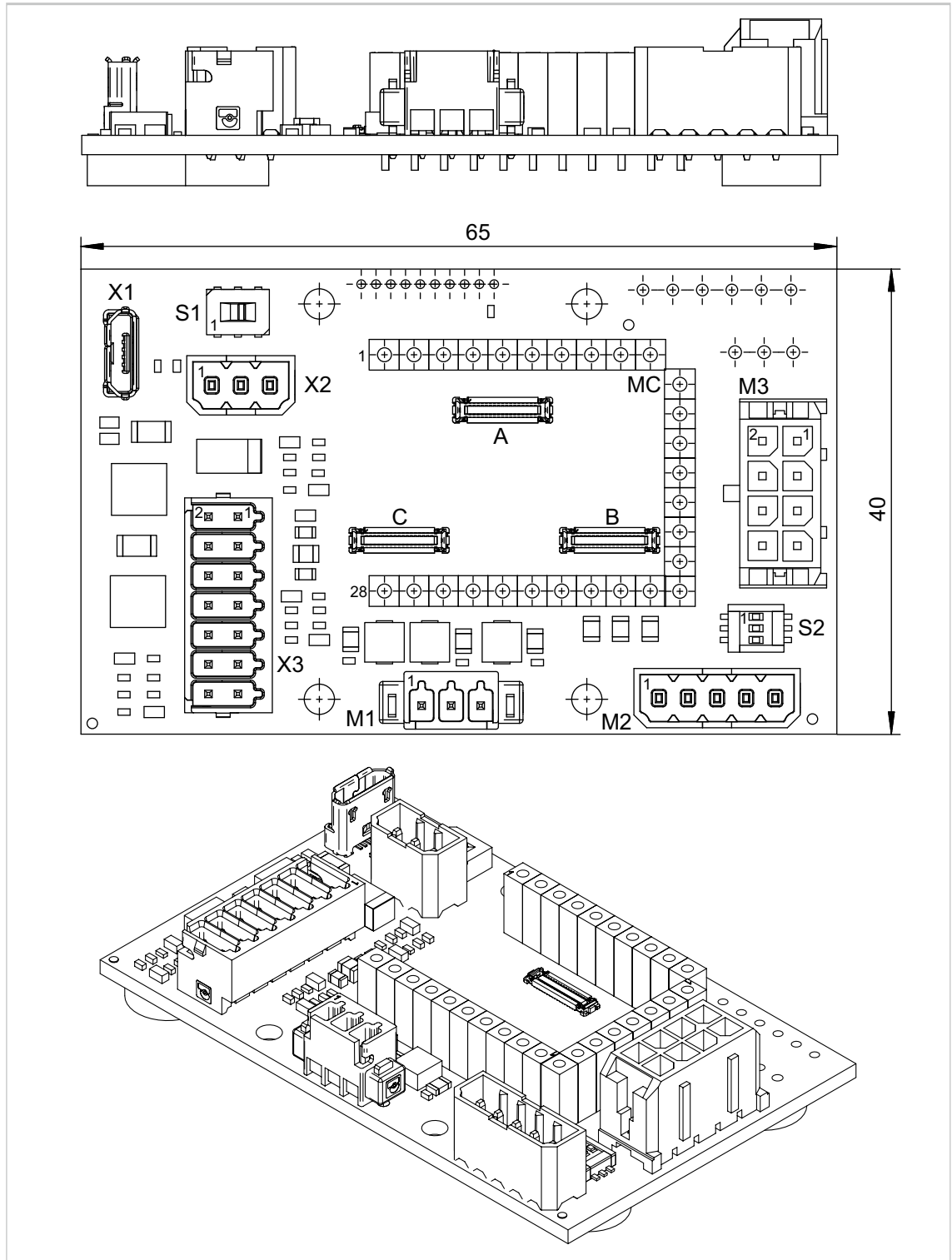


Fig. 7: Side view (top), top view (middle) and isometric view (bottom) of the motherboard 6500.01802

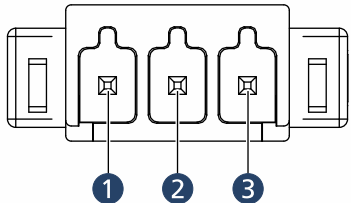
## Product description

Tab. 8: Connector overview of the motherboard 6500.01802

Designation	Function
A, B, C (controller)	MC 3001 B connection (for pin assignment, see chap. 3.3.1.1, p. 13)
MC (controller)	MC 3001 P connection (for pin assignment, see chap. 3.3.1.2, p. 17)
M1 (motor)	Connection of the motor phases
M2 (sensor)	Connection of the Hall sensors
M3 (encoder)	Connection of an incremental encoder with or without line driver Alternatively an absolute encoder can be connected with or without line driver
X1 (USB)	USB interface connection
X2 (COM)	CAN/RS232 interface connection
X3 (I/O)	Voltage supply of the controller and motor Inputs or outputs for external circuits
S1 (DIP switch COM)	Selection of the COM interface: <ul style="list-style-type: none"> <li>C: CAN</li> <li>RS: RS232</li> </ul>
S2 (DIP Switch Encoder Term)	Encoder terminal resistance: <ul style="list-style-type: none"> <li>Encoder without line driver: S2-1, S2-2 and S2-3 in <b>OFF</b> position</li> <li>Encoder with line driver (L version): S2-1, S2-2 and S2-3 in <b>ON</b> position</li> </ul>

### Motor connection (M1)

Tab. 9: Pin assignment of the BL motor connection (M1)

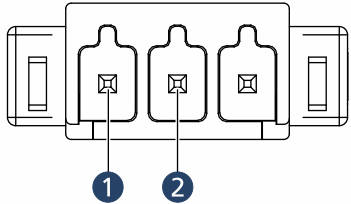
	Pin	Designation	Meaning
	1	Motor A	Connection of motor, phase A
	2	Motor B	Connection of motor, phase B
	3	Motor C	Connection of motor, phase C

Tab. 10: Electrical data of the motor connection (M1)

Designation	Value
Motor power supply	$0 \dots U_{\text{mot}}$ Max. 5 A 100 kHz

## Product description

Tab. 11: Pin assignment of the DC motor connection (M1)

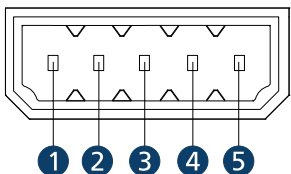
	Pin	Designation	Meaning
	1	Motor +	Connection of motor, positive pole
	2	Motor –	Connection of the motor, negative pole

Tab. 12: Electrical data of the DC motor connection (M1)

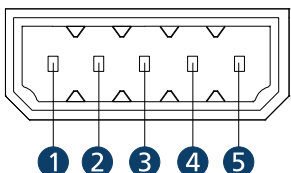
Designation	Value
Motor power supply	0...U <sub>mot</sub> Max. 5 A 100 kHz

### Sensor connection (M2)

Tab. 13: Pin assignment at sensor connection (M2) for 3 Hall sensor signals

	Pin	Designation	Meaning
	1	U <sub>DD</sub>	Power supply for sensors
	2	GND	Ground connection
	3	Sens A	Hall sensor A
	4	Sens B	Hall sensor B
	5	Sens C	Hall sensor C

Tab. 14: Pin assignment at sensor connection (M2) for sin/cos sensor

	Pin	Designation	Meaning
	1	U <sub>DD</sub>	Power supply for sensors
	2	GND	Ground connection
	3	COS(+)	Cosine signal
	4	SIN(+)	Sine signal
	5	n.c.	–

Tab. 15: Electrical data of the sensor connection (M2)

Designation	Value
Sensor power supply	5 V <100 mA
Sensor connection	<5 V



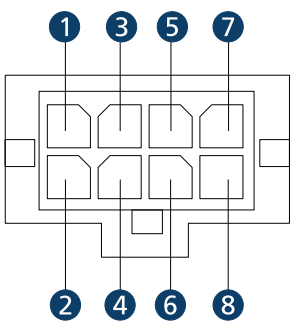
## Product description

### Encoder connection (M3)

The pin assignment of the encoder connector varies depending on the encoder type.

- Incremental encoder with or without line driver
- Absolute encoder with or without line driver.

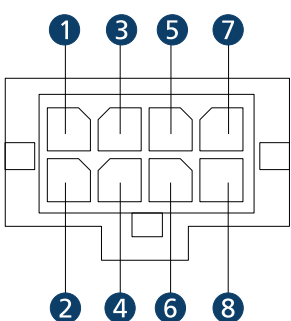
Tab. 16: Pin assignment for incremental encoder with line driver (M3)

	Pin	Designation	Meaning
	1	$U_{DD}$	Power supply for incremental encoder
	2	GND	Ground connection
	3	$\overline{\text{Channel A}}$	Encoder channel A (logically inverted signal)
	4	Channel A	Encoder channel A
	5	$\overline{\text{Channel B}}$	Encoder channel B (logically inverted signal)
	6	Channel B	Encoder channel B
	7	$\overline{\text{Index}}$	Encoder index (logically inverted signal)
	8	Index	Encoder index

Tab. 17: Electrical data for incremental encoder with line driver (M3)

Designation	Value
Power supply for incremental encoder	5 V <100 mA
Connection of the incremental encoder	<5 V <2 MHz 5 k $\Omega$

Tab. 18: Pin assignment for incremental encoder without line driver (M3)

	Pin	Designation	Meaning
	1	$U_{DD}$	Power supply for incremental encoder
	2	GND	Ground connection
	3	$\overline{\text{Channel A}}$	n.c.
	4	Channel A	Encoder channel A
	5	$\overline{\text{Channel B}}$	n.c.
	6	Channel B	Encoder channel B
	7	$\overline{\text{Index}}$	n.c.
	8	Index	Encoder index

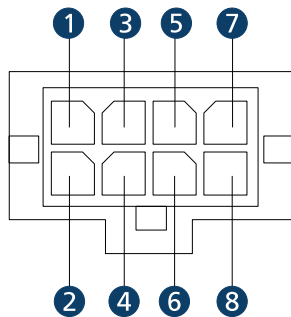
## Product description

Tab. 19: Electrical data for incremental encoder without line driver (M3)

Designation	Value
Power supply for incremental encoder	5 V <100 mA
Connection of the incremental encoder	<5 V <2 MHz 5 kΩ

Tab. 20: Pin assignment for absolute encoder with line driver (M3)

Pin	Designation	Meaning
1	$U_{DD}$	Power supply for absolute encoder
2	GND	Ground connection
3	$\overline{CS}$	Chip Select for absolute encoder (logically inverted signal)
4	CS	Chip Select for absolute encoder
5	$\overline{Data}$	Data for absolute encoder (logically inverted signal)
6	Data	Data for absolute encoder
7	$\overline{CLK}$	Clock for absolute encoder (logically inverted signal)
8	CLK	Clock for absolute encoder

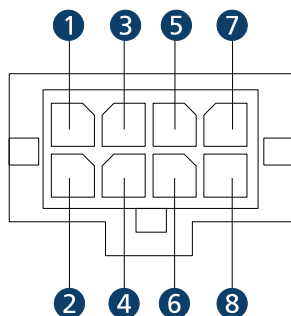


Tab. 21: Electrical data for absolute encoder with line driver (M3)

Designation	Value
Absolute encoder power supply	5 V <100 mA
Connection Chip Select	5 V
Connection data	<5 V 5 kΩ
Connection clock	5 V 1 MHz

Tab. 22: Pin assignment for absolute encoder without line driver (M3)

Pin	Designation	Meaning
1	$U_{DD}$	Power supply for absolute encoder
2	GND	Ground connection
3	$\overline{CS}$	n.c.
4	CS	Chip Select for AES
5	$\overline{Data}$	n.c.
6	Data	Data for AES
7	$\overline{CLK}$	n.c.
8	CLK	Clock for AES



## Product description

*Tab. 23: Electrical data for absolute encoder without line driver (M3)*

Designation	Value
Absolute encoder power supply	5 V <100 mA
Connection Chip Select	5 V
Connection data	<5 V 5 kΩ
Connection clock	5 V 1 MHz

### USB (X1)

*Tab. 24: USB port*

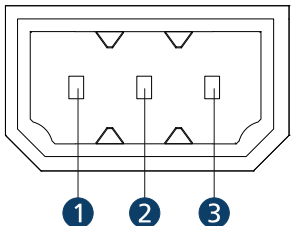
Designation	Meaning
	USB communication (USB micro B)

### COM port (X2)

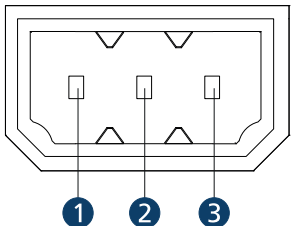
The pin assignment of the COM connection differs according to the type of communication. The distinction is made between the following types of communication:

- RS232
- CANopen

*Tab. 25: Pin assignment of the COM port (X2) for RS232*

	Pin	Designation	Meaning
	1	TxD	RS232 interface transmit direction
	2	RxD	RS232 interface receive direction
	3	GND	Ground connection

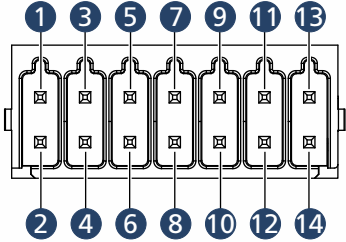
*Tab. 26: Pin assignment of the COM port (X2) for CANopen*

	Pin	Designation	Meaning
	1	CAN-H	CAN-High interface
	2	CAN-L	CAN-Low interface
	3	GND	Ground connection

## Product description

### I/O connection (X3)

Tab. 27: Pin assignment of the I/O connection (X3)

	Pin	Designation	Meaning
	1	$U_{DD}$	Power supply for external consumer loads
	2	GND	Ground connection
	3	DigOut 1	Digital output (open collector)
	4	DigOut 2	Digital output (open collector)
	5	DigIn 1	Digital input
	6	DigIn 2	Digital input
	7	DigIn 3	Digital input
	8	AnIn 1	Analogue input
	9	AnIn 2	Analogue input
	10	AGND	Ground connection for analogue inputs
	11	$U_p$	Power supply of the electronics
	12	GND	Ground connection
	13	$U_{mot}$	Power supply of the motor
	14	GND	Ground connection

Tab. 28: Electrical data for the I/O connection (X3)

Designation	Value
Power supply for external consumers	5 V <100 mA
DigOut	low = GND high = high resistance 27 k $\Omega$ Max. 0.7 A
DigIn	<30 V 27 k $\Omega$ <1 MHz TTL level: low < 0.5 V, high > 3.5 V PLC level: low < 7 V, high > 11.5 V
AnIn	$\pm 10$ V Reference potential: AGND
Power supply for controller	6...30 V $\leq 100$ mA (without external consumer)
Motor power supply	6...30 V

## Product description

### 3.3.2.3 Motherboard 6500.01807

With this motherboard, FAULHABER DC-motors can be combined with encoders of types IE2, IEH2 or IEH3(L). Motor connections M+ and M- can be connected here either via connector M1 or, with combined cables, via connector M3.

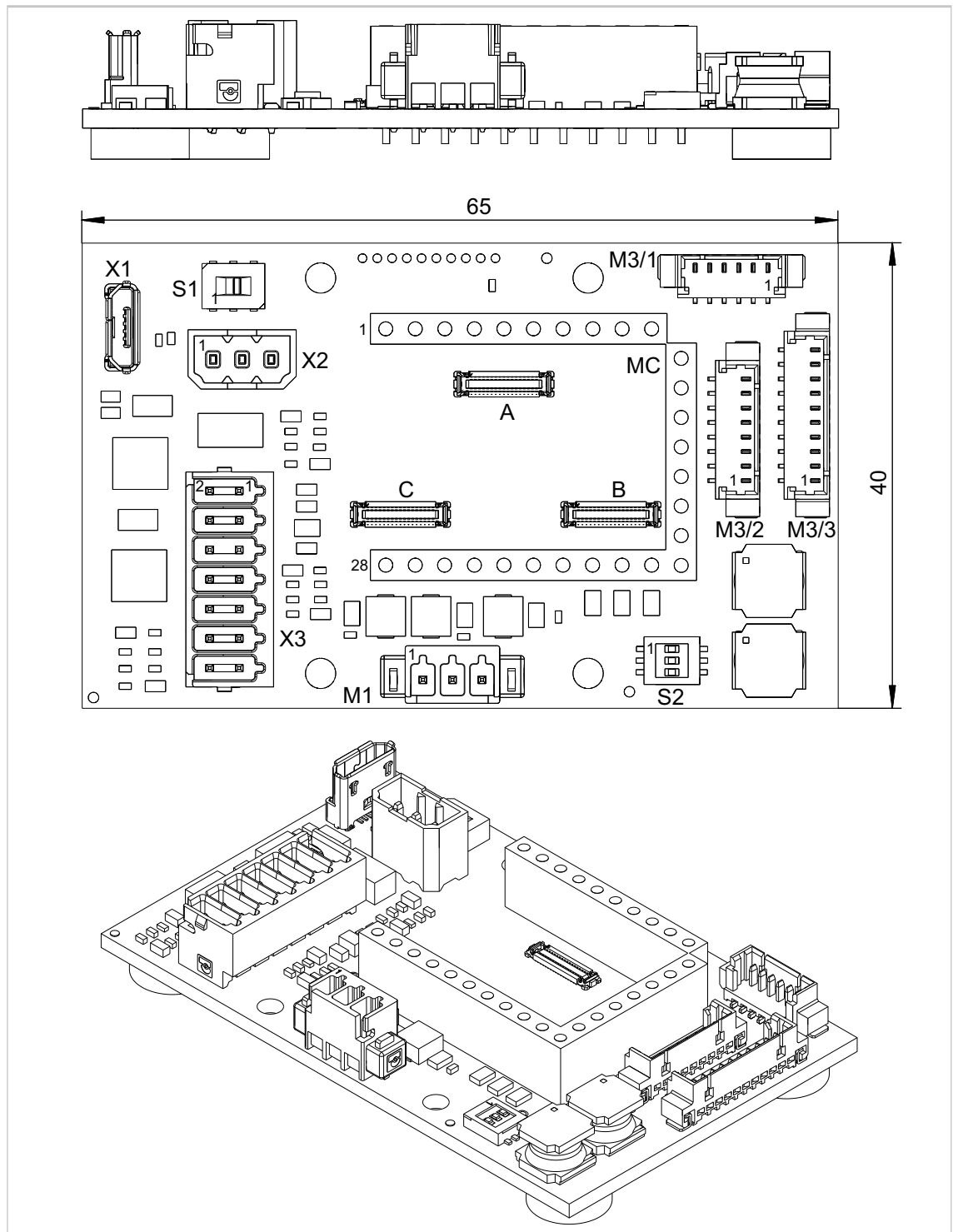


Fig. 8: Side view (top), top view (middle) and isometric view (bottom) of the motherboard 6500.01807

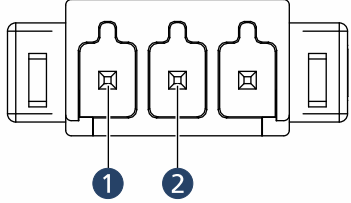
## Product description

Tab. 29: Connector overview of the motherboard 6500.01807

Designation	Function
A, B, C (controller)	MC 3001 B connection (for pin assignment, see chap. 3.3.1.1, p. 13)
MC (controller)	MC 3001 P connection (for pin assignment, see chap. 3.3.1.2, p. 17)
M1 (motor)	Connection of the motor phases
M3/1 (motor and encoder)	Connection of a motor with IE2 incremental encoder
M3/2 (motor and encoder)	Connection of a motor with IEH3 incremental encoder
M3/3 (motor and encoder)	Connection of a motor with IEH3L incremental encoder
X1 (USB)	USB interface connection
X2 (COM)	CAN/RS232 interface connection
X3 (I/O)	Voltage supply of the controller and motor Inputs or outputs for external circuits
S1 (DIP switch COM)	Selection of the COM interface: <ul style="list-style-type: none"> <li>C: CAN</li> <li>RS: RS232</li> </ul>
S2 (DIP Switch Encoder Term)	Encoder terminal resistance: <ul style="list-style-type: none"> <li>Encoder without line driver: S2-1, S2-2 and S2-3 in <b>OFF</b> position</li> <li>Encoder with line driver (L version): S2-1, S2-2 and S2-3 in <b>ON</b> position</li> </ul>

### Motor connection (M1)

Tab. 30: Pin assignment of the DC motor connection (M1)

	Pin	Designation	Meaning
	1	Motor +	Connection of motor, positive pole
	2	Motor –	Connection of the motor, negative pole

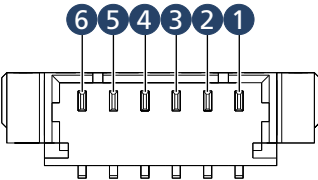
Tab. 31: Electrical data of the DC motor connection (M1)

Designation	Value
Motor power supply	0...U <sub>mot</sub> Max. 5 A 100 kHz

## Product description

### Motor and IE2 encoder connection (M3/1)

Tab. 32: Pin assignment of the motor and IE2 encoder connection (M3/1)

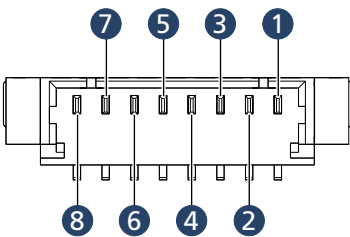
	Pin	Designation	Meaning
	1	Motor –	Connection of the motor, negative pole
	2	Motor +	Connection of motor, positive pole
	3	GND	Ground connection
	4	U <sub>DD</sub>	Power supply for incremental encoder
	5	Channel B	Encoder channel B
	6	Channel A	Encoder channel A

Tab. 33: Electrical data of the motor and IE2 encoder connection (M3/1)

Designation	Value
Motor power supply	0...U <sub>mot</sub> Max. 1 A 100 kHz
Power supply for incremental encoder	5 V <100 mA
Connection of the incremental encoder	<5 V <2 MHz 5 kΩ

### Motor and IEH3 encoder connection (M3/2)

Tab. 34: Pin assignment of the motor and IEH3 encoder connection (M3/2)

	Pin	Designation	Meaning
	1	–	n.c.
	2	Motor –	Connection of the motor, negative pole
	3	Motor +	Connection of motor, positive pole
	4	GND	Ground connection
	5	U <sub>DD</sub>	Power supply for incremental encoder
	6	Channel B	Encoder channel B
	7	Channel A	Encoder channel A
	8	Index	Encoder index

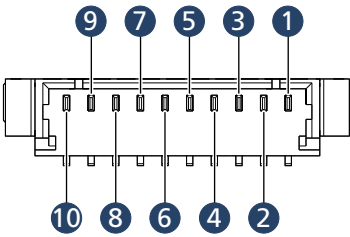
Tab. 35: Electrical data of the motor and IEH3 encoder connection (M3/2)

Designation	Value
Motor power supply	0...U <sub>mot</sub> Max. 1 A 100 kHz
Power supply for incremental encoder	5 V <100 mA
Connection of the incremental encoder	<5 V <2 MHz 5 kΩ

## Product description

### Motor and IEH3L encoder connection (M3/3)

Tab. 36: Pin assignment of the motor and IEH3L encoder connection (M3/3)

	Pin	Designation	Meaning
	1	Motor –	Connection of the motor, negative pole
	2	U <sub>DD</sub>	Power supply for incremental encoder
	3	GND	Ground connection
	4	Motor +	Connection of motor, positive pole
	5	$\overline{\text{Channel A}}$	Encoder channel A (logically inverted signal)
	6	Channel A	Encoder channel A
	7	$\overline{\text{Channel B}}$	Encoder channel B (logically inverted signal)
	8	Channel B	Encoder channel B
	9	$\overline{\text{Index}}$	Encoder index (logically inverted signal)
	10	Index	Encoder index

Tab. 37: Electrical data of the motor and IEH3L encoder connection (M3/3)

Designation	Value
Motor power supply	0...U <sub>mot</sub> Max. 1 A 100 kHz
Power supply for incremental encoder	5 V <100 mA
Connection of the incremental encoder	<5 V <2 MHz 5 kΩ

### USB (X1)

Tab. 38: USB port

Designation	Meaning
	USB communication (USB micro B)



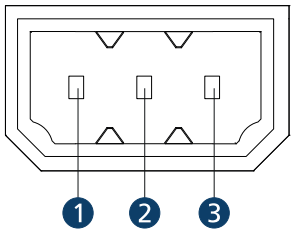
## Product description

### COM port (X2)

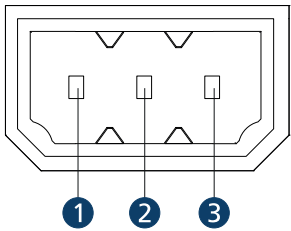
The pin assignment of the COM connection differs according to the type of communication. The distinction is made between the following types of communication:

- RS232
- CANopen

*Tab. 39: Pin assignment of the COM port (X2) for RS232*

	Pin	Designation	Meaning
	1	TxD	RS232 interface transmit direction
	2	RxD	RS232 interface receive direction
	3	GND	Ground connection

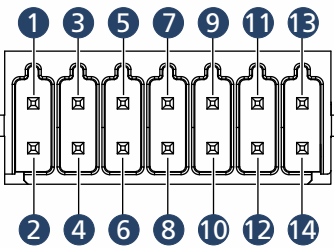
*Tab. 40: Pin assignment of the COM port (X2) for CANopen*

	Pin	Designation	Meaning
	1	CAN-H	CAN-High interface
	2	CAN-L	CAN-Low interface
	3	GND	Ground connection

## Product description

### I/O connection (X3)

Tab. 41: Pin assignment of the I/O connection (X3)

	Pin	Designation	Meaning
	1	$U_{DD}$	Power supply for external consumer loads
	2	GND	Ground connection
	3	DigOut 1	Digital output (open collector)
	4	DigOut 2	Digital output (open collector)
	5	DigIn 1	Digital input
	6	DigIn 2	Digital input
	7	DigIn 3	Digital input
	8	AnIn 1	Analogue input
	9	AnIn 2	Analogue input
	10	AGND	Ground connection for analogue inputs
	11	$U_p$	Power supply of the electronics
	12	GND	Ground connection
	13	$U_{mot}$	Power supply of the motor
	14	GND	Ground connection

Tab. 42: Electrical data for the I/O connection (X3)

Designation	Value
Power supply for external consumers	5 V <100 mA
DigOut	low = GND high = high resistance 27 k $\Omega$ Max. 0.7 A
DigIn	<30 V 27 k $\Omega$ <1 MHz TTL level: low < 0.5 V, high > 3.5 V PLC level: low < 7 V, high > 11.5 V
AnIn	$\pm 10$ V Reference potential: AGND
Power supply for controller	6...30 V $\leq 100$ mA (without external consumer)
Motor power supply	6...30 V

## Product description

### 3.3.2.4 Motherboard 6500.01808

With this motherboard, FAULHABER DC-motors can be combined with encoders of types IE3(L), IER3(L) or IERS3(L).

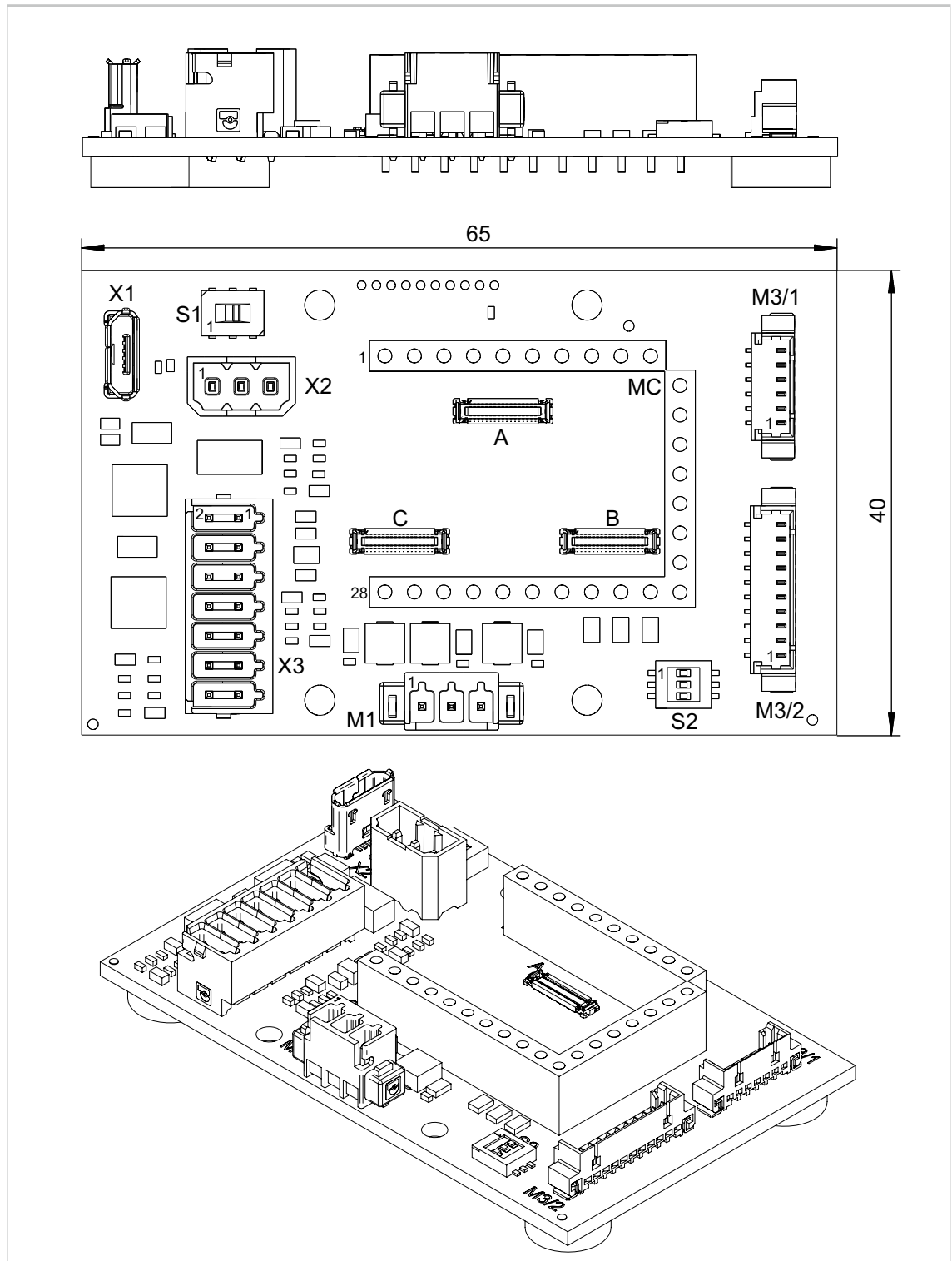


Fig. 9: Side view (top), top view (middle) and isometric view (bottom) of the motherboard 6500.01808

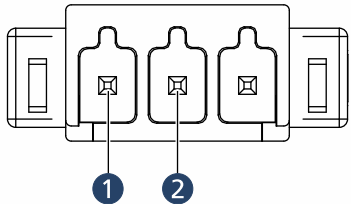
## Product description

Tab. 43: Connector overview of the motherboard 6500.01808

Designation	Function
A, B, C (controller)	MC 3001 B connection (for pin assignment, see chap. 3.3.1.1, p. 13)
MC (controller)	MC 3001 P connection (for pin assignment, see chap. 3.3.1.2, p. 17)
M1 (motor)	Connection of the motor phases
M3/1 (encoder)	Connection of an IE3 incremental encoder
M3/2 (encoder)	Connection of an IE3L incremental encoder
X1 (USB)	USB interface connection
X2 (COM)	CAN/RS232 interface connection
X3 (I/O)	Voltage supply of the controller and motor Inputs or outputs for external circuits
S1 (DIP switch COM)	Selection of the COM interface: <ul style="list-style-type: none"> <li>C: CAN</li> <li>RS: RS232</li> </ul>
S2 (DIP Switch Encoder Term)	Encoder terminal resistance: <ul style="list-style-type: none"> <li>Encoder without line driver: S2-1, S2-2 and S2-3 in <b>OFF</b> position</li> <li>Encoder with line driver (L version): S2-1, S2-2 and S2-3 in <b>ON</b> position</li> </ul>

### Motor connection (M1)

Tab. 44: Pin assignment of the DC motor connection (M1)

	Pin	Designation	Meaning
	1	Motor +	Connection of motor, positive pole
	2	Motor –	Connection of the motor, negative pole

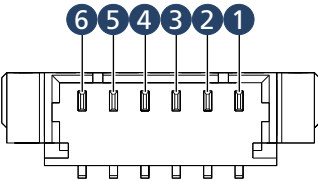
Tab. 45: Electrical data of the DC motor connection (M1)

Designation	Value
Motor power supply	0... $U_{mot}$ Max. 5 A 100 kHz

## Product description

### IE3 encoder connection (M3/1)

Tab. 46: Pin assignment of the IE3 encoder connection (M3/1)

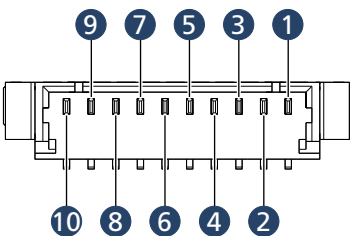
	Pin	Designation	Meaning
	1	–	n.c.
	2	Index	Encoder index
	3	GND	Ground connection
	4	U <sub>DD</sub>	Power supply for incremental encoder
	5	Channel B	Encoder channel B
	6	Channel A	Encoder channel A

Tab. 47: Electrical data of the IE3 encoder connection (M3/1)

Designation	Value
Power supply for incremental encoder	5 V <100 mA
Connection of the incremental encoder	<5 V <2 MHz 5 kΩ

### IE3L encoder connection (M3/2)

Tab. 48: Pin assignment of the IE3L encoder connection (M3/2)

	Pin	Designation	Meaning
	1	–	n.c.
	2	U <sub>DD</sub>	Power supply for incremental encoder
	3	GND	Ground connection
	4	–	n.c.
	5	Channel A	Encoder channel A (logically inverted signal)
	6	Channel A	Encoder channel A
	7	Channel B	Encoder channel B (logically inverted signal)
	8	Channel B	Encoder channel B
	9	Index	Encoder index (logically inverted signal)
	10	Index	Encoder index

Tab. 49: Electrical data of the IE3L encoder connection (M3/2)

Designation	Value
Power supply for incremental encoder	5 V <100 mA
Connection of the incremental encoder	<5 V <2 MHz 5 kΩ

## Product description

### USB (X1)

Tab. 50: USB port

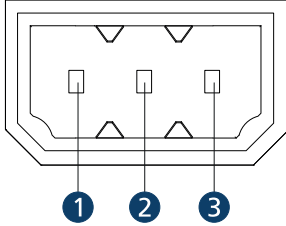
Designation	Meaning
	USB communication (USB micro B)

### COM port (X2)

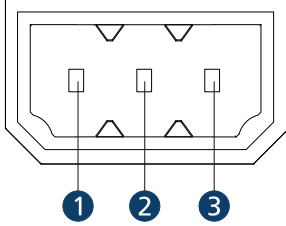
The pin assignment of the COM connection differs according to the type of communication. The distinction is made between the following types of communication:

- RS232
- CANopen

Tab. 51: Pin assignment of the COM port (X2) for RS232

	Pin	Designation	Meaning
	1	TxD	RS232 interface transmit direction
	2	RxD	RS232 interface receive direction
	3	GND	Ground connection

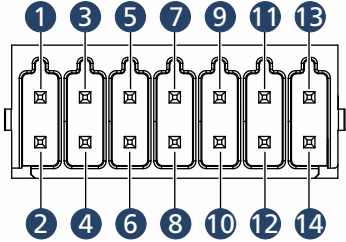
Tab. 52: Pin assignment of the COM port (X2) for CANopen

	Pin	Designation	Meaning
	1	CAN-H	CAN-High interface
	2	CAN-L	CAN-Low interface
	3	GND	Ground connection

## Product description

### I/O connection (X3)

Tab. 53: Pin assignment of the I/O connection (X3)

	Pin	Designation	Meaning
	1	$U_{DD}$	Power supply for external consumer loads
	2	GND	Ground connection
	3	DigOut 1	Digital output (open collector)
	4	DigOut 2	Digital output (open collector)
	5	DigIn 1	Digital input
	6	DigIn 2	Digital input
	7	DigIn 3	Digital input
	8	AnIn 1	Analogue input
	9	AnIn 2	Analogue input
	10	AGND	Ground connection for analogue inputs
	11	$U_p$	Power supply of the electronics
	12	GND	Ground connection
	13	$U_{mot}$	Power supply of the motor
	14	GND	Ground connection

Tab. 54: Electrical data for the I/O connection (X3)

Designation	Value
Power supply for external consumers	5 V <100 mA
DigOut	low = GND high = high resistance 27 k $\Omega$ Max. 0.7 A
DigIn	<30 V 27 k $\Omega$ <1 MHz TTL level: low < 0.5 V, high > 3.5 V PLC level: low < 7 V, high > 11.5 V
AnIn	$\pm 10$ V Reference potential: AGND
Power supply for controller	6...30 V $\leq 100$ mA (without external consumer)
Motor power supply	6...30 V

## Product description

### 3.3.2.5 Motherboard 6500.01809

With this motherboard, FAULHABER DC-motors can be combined with encoders of types PA2-100 or HEM3.

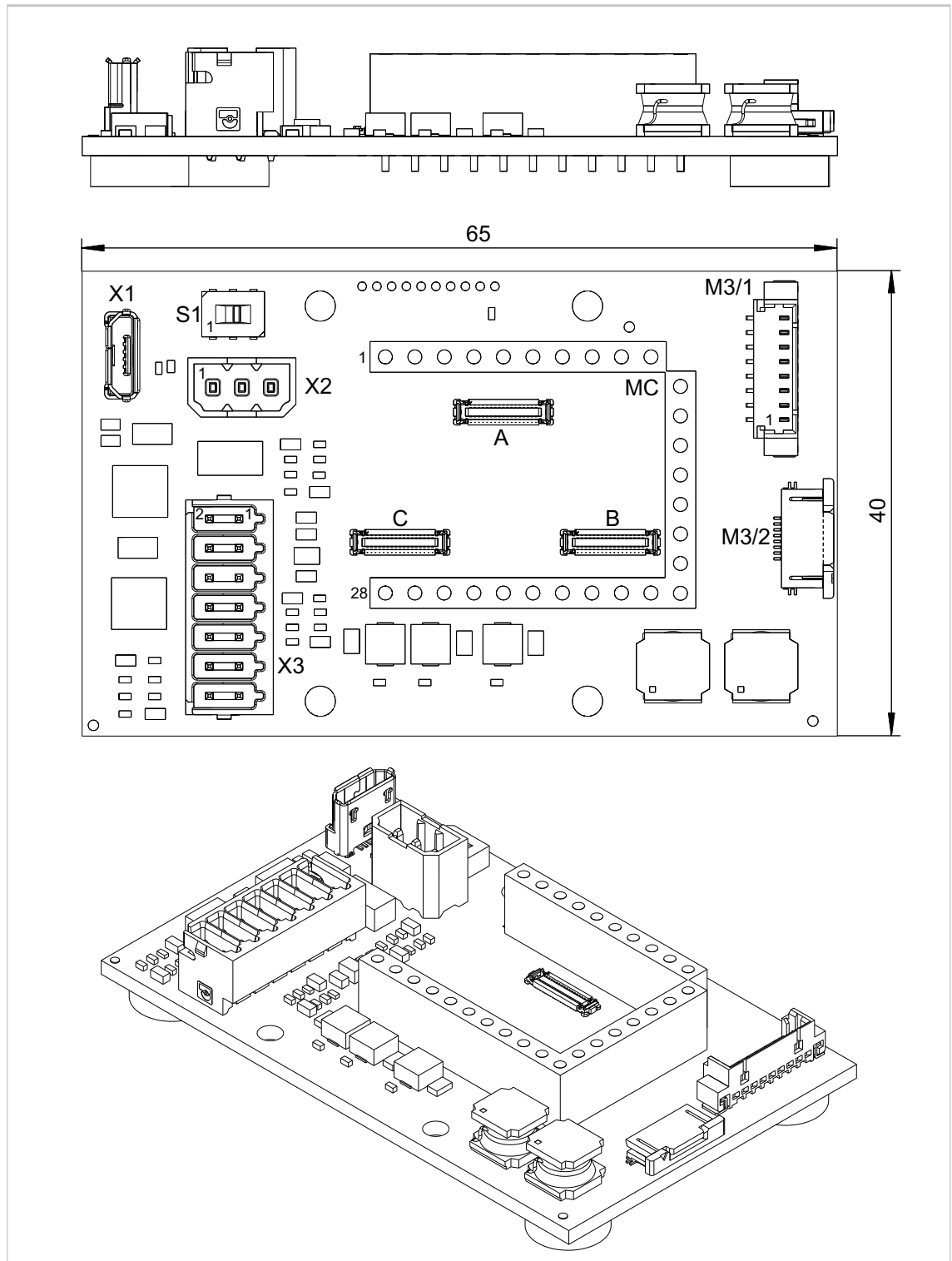


Fig. 10: Side view (top), top view (middle) and isometric view (bottom) of the motherboard 6500.01809



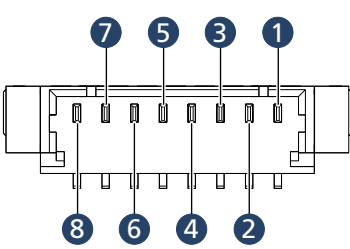
## Product description

Tab. 55: Connector overview of the motherboard 6500.01809

Designation	Function
A, B, C (controller)	MC 3001 B connection (for pin assignment, see chap. 3.3.1.1, p. 13)
MC (controller)	MC 3001 P connection (for pin assignment, see chap. 3.3.1.2, p. 17)
M3/1 (motor and encoder)	Connection of a motor with HEM3 incremental encoder
M3/2 (motor and encoder)	Connection of a motor with PA2-100 incremental encoder
X1 (USB)	USB interface connection
X2 (COM)	CAN/RS232 interface connection
X3 (I/O)	Voltage supply of the controller and motor Inputs or outputs for external circuits
S1 (DIP switch COM)	Selection of the COM interface: <ul style="list-style-type: none"> <li>▪ C: CAN</li> <li>▪ RS: RS232</li> </ul>

### Motor and HEM3 encoder connection (M3/1)

Tab. 56: Pin assignment of the motor and HEM3 encoder connection (M3/1)

	Pin	Designation	Meaning
	1	Motor –	Connection of the motor, negative pole
	2	GND	Ground connection
	3	U <sub>DD</sub>	Power supply for incremental encoder
	4	–	n.c.
	5	Channel B	Encoder channel B
	6	Channel A	Encoder channel A
	7	Index	Encoder index
	8	Motor +	Connection of motor, positive pole

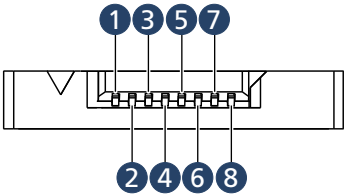
Tab. 57: Electrical data of the motor and HEM3 encoder connection (M3/1)

Designation	Value
Motor power supply	0...U <sub>mot</sub> Max. 1 A 100 kHz
Power supply for incremental encoder	5 V <100 mA
Connection of the incremental encoder	<5 V <2 MHz 5 kΩ

## Product description

### Motor and PA2-100 encoder connection (M3/2)

Tab. 58: Pin assignment of the motor and PA2-100 encoder connection (M3/2)

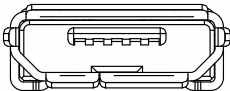
	Pin	Designation	Meaning
	1	Motor +	Connection of motor, positive pole
	2	Motor +	Connection of motor, positive pole
	3	U <sub>DD</sub>	Power supply for incremental encoder
	4	Channel A	Encoder channel A
	5	Channel B	Encoder channel B
	6	GND	Ground connection
	7	Motor –	Connection of the motor, negative pole
	8	Motor –	Connection of the motor, negative pole

Tab. 59: Electrical data of the motor and PA2-100 encoder connection (M3/2)

Designation	Value
Motor power supply	0...U <sub>mot</sub> Max. 1 A 100 kHz
Power supply for incremental encoder	3,3 V <100 mA
Connection of the incremental encoder	<5 V <2 MHz 5 kΩ

### USB (X1)

Tab. 60: USB port

Designation	Meaning
	USB communication (USB micro B)

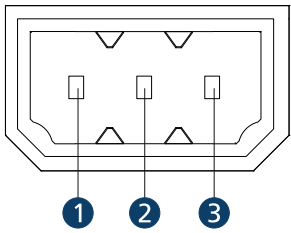
## Product description

### COM port (X2)

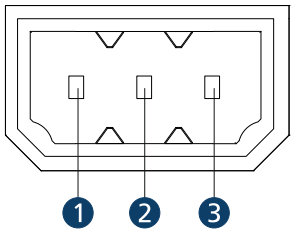
The pin assignment of the COM connection differs according to the type of communication. The distinction is made between the following types of communication:

- RS232
- CANopen

*Tab. 61: Pin assignment of the COM port (X2) for RS232*

	Pin	Designation	Meaning
	1	TxD	RS232 interface transmit direction
	2	RxD	RS232 interface receive direction
	3	GND	Ground connection

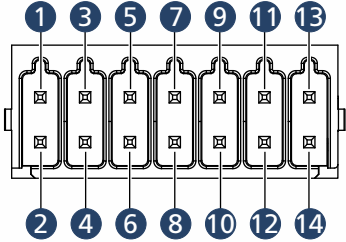
*Tab. 62: Pin assignment of the COM port (X2) for CANopen*

	Pin	Designation	Meaning
	1	CAN-H	CAN-High interface
	2	CAN-L	CAN-Low interface
	3	GND	Ground connection

## Product description

### I/O connection (X3)

Tab. 63: Pin assignment of the I/O connection (X3)

	Pin	Designation	Meaning
	1	$U_{DD}$	Power supply for external consumer loads
	2	GND	Ground connection
	3	DigOut 1	Digital output (open collector)
	4	DigOut 2	Digital output (open collector)
	5	DigIn 1	Digital input
	6	DigIn 2	Digital input
	7	DigIn 3	Digital input
	8	AnIn 1	Analogue input
	9	AnIn 2	Analogue input
	10	AGND	Ground connection for analogue inputs
	11	$U_p$	Power supply of the electronics
	12	GND	Ground connection
	13	$U_{mot}$	Power supply of the motor
	14	GND	Ground connection

Tab. 64: Electrical data for the I/O connection (X3)

Designation	Value
Power supply for external consumers	5 V <100 mA
DigOut	low = GND high = high resistance 27 k $\Omega$ Max. 0.7 A
DigIn	<30 V 27 k $\Omega$ <1 MHz TTL level: low < 0.5 V, high > 3.5 V PLC level: low < 7 V, high > 11.5 V
AnIn	$\pm 10$ V Reference potential: AGND
Power supply for controller	6...30 V $\leq 100$ mA (without external consumer)
Motor power supply	6...30 V

## Product description

### 3.3.2.6 Motherboard 6500.01810

With this motherboard, FAULHABER 0824B- and 1028B-BL-motors can be combined with encoders of types AESM or IEM3.

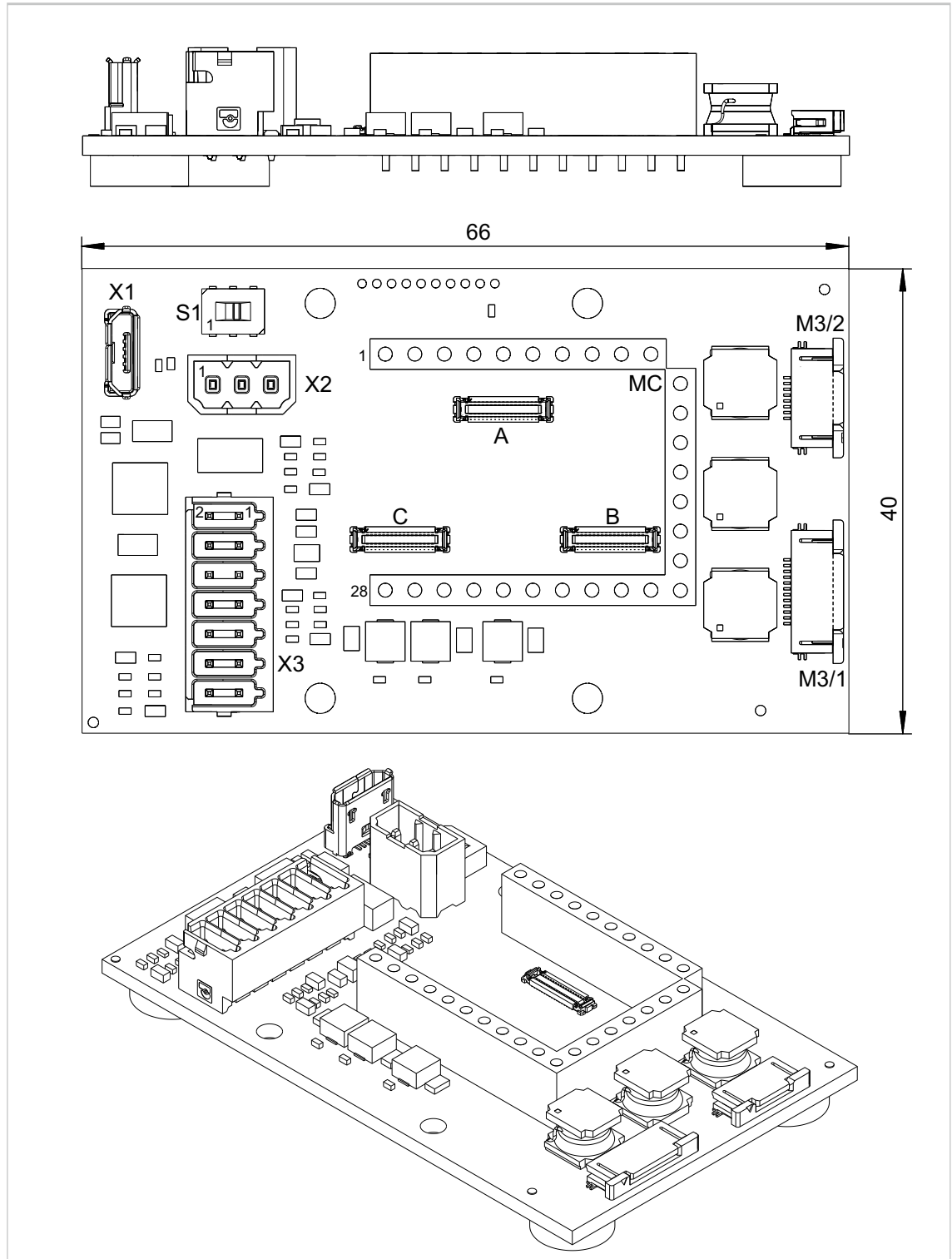


Fig. 11: Side view (top), top view (middle) and isometric view (bottom) of the motherboard 6500.01810

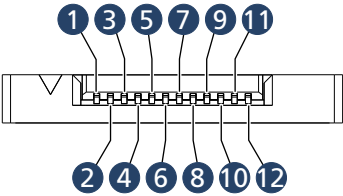
## Product description

Tab. 65: Connector overview of the motherboard 6500.01810

Designation	Function
A, B, C (controller)	MC 3001 B connection (for pin assignment, see chap. 3.3.1.1, p. 13)
MC (controller)	MC 3001 P connection (for pin assignment, see chap. 3.3.1.2, p. 17)
M3/1 (motor and encoder)	Connection of a motor with IEM3 incremental encoder
M3/2 (motor and encoder)	Connection of a motor with AESM single turn absolute encoder
X1 (USB)	USB interface connection
X2 (COM)	CAN/RS232 interface connection
X3 (I/O)	Voltage supply of the controller and motor Inputs or outputs for external circuits
S1 (DIP switch COM)	Selection of the COM interface: <ul style="list-style-type: none"> <li>▪ C: CAN</li> <li>▪ RS: RS232</li> </ul>

### Motor and IEM3 encoder connection (M3/1)

Tab. 66: Pin assignment of the motor and IEM3 encoder connection (M3/1)

	Pin	Designation	Meaning
	1	Motor C	Connection of motor, phase C
	2	Motor B	Connection of motor, phase B
	3	Motor A	Connection of motor, phase A
	4	GND	Ground connection
	5	U <sub>DD</sub>	Power supply for incremental encoder and Hall sensors
	6	Sens C	Hall sensor C
	7	Sens B	Hall sensor B
	8	Sens A	Hall sensor A
	9	Channel B	Encoder channel B
	10	Channel A	Encoder channel A
	11	Index	Encoder index
	12	–	n.c.

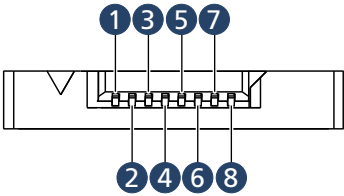
Tab. 67: Electrical data of the motor and IEM3 encoder connection (M3/1)

Designation	Value
Motor power supply	0...U <sub>mot</sub> Max. 1 A 100 kHz
Power supply for incremental encoder and Hall sensors	5 V <100 mA
Connection of the incremental encoder	<5 V <2 MHz 5 kΩ
Connection of the Hall sensors	<5 V

## Product description

### Motor and AESM encoder connection (M3/2)

Tab. 68: Pin assignment of the motor and AESM encoder connection (M3/2)

	Pin	Designation	Meaning
	1	Motor C	Connection of motor, phase C
	2	Motor B	Connection of motor, phase B
	3	Motor A	Connection of motor, phase A
	4	GND	Ground connection
	5	U <sub>DD</sub>	Power supply for absolute encoder
	6	CLK	Clock for absolute encoder
	7	–	n.c.
	8	Data	Data for absolute encoder

Tab. 69: Electrical data of the motor and AESM encoder connection (M3/2)

Designation	Value
Motor power supply	0...U <sub>mot</sub> Max. 1 A 100 kHz
Absolute encoder power supply	5 V <100 mA
Connection data	<5 V 5 kΩ
Connection clock	5 V 1 MHz

### USB (X1)

Tab. 70: USB port

Designation	Meaning
	USB communication (USB micro B)

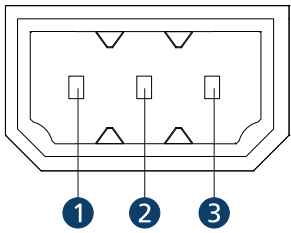
## Product description

### COM port (X2)

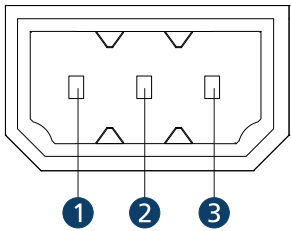
The pin assignment of the COM connection differs according to the type of communication. The distinction is made between the following types of communication:

- RS232
- CANopen

*Tab. 71: Pin assignment of the COM port (X2) for RS232*

	Pin	Designation	Meaning
	1	TxD	RS232 interface transmit direction
	2	RxD	RS232 interface receive direction
	3	GND	Ground connection

*Tab. 72: Pin assignment of the COM port (X2) for CANopen*

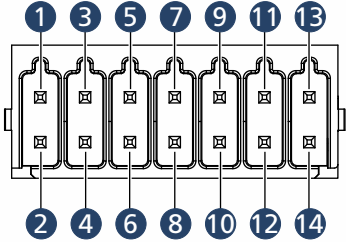
	Pin	Designation	Meaning
	1	CAN-H	CAN-High interface
	2	CAN-L	CAN-Low interface
	3	GND	Ground connection



## Product description

### I/O connection (X3)

Tab. 73: Pin assignment of the I/O connection (X3)

	Pin	Designation	Meaning
	1	$U_{DD}$	Power supply for external consumer loads
	2	GND	Ground connection
	3	DigOut 1	Digital output (open collector)
	4	DigOut 2	Digital output (open collector)
	5	DigIn 1	Digital input
	6	DigIn 2	Digital input
	7	DigIn 3	Digital input
	8	AnIn 1	Analogue input
	9	AnIn 2	Analogue input
	10	AGND	Ground connection for analogue inputs
	11	$U_p$	Power supply of the electronics
	12	GND	Ground connection
	13	$U_{mot}$	Power supply of the motor
	14	GND	Ground connection

Tab. 74: Electrical data for the I/O connection (X3)

Designation	Value
Power supply for external consumers	5 V <100 mA
DigOut	low = GND high = high resistance 27 k $\Omega$ Max. 0.7 A
DigIn	<30 V 27 k $\Omega$ <1 MHz TTL level: low < 0.5 V, high > 3.5 V PLC level: low < 7 V, high > 11.5 V
AnIn	$\pm 10$ V Reference potential: AGND
Power supply for controller	6...30 V $\leq 100$ mA (without external consumer)
Motor power supply	6...30 V

## Product description

### 3.3.2.7 Motherboard 6500.01811

With this motherboard, FAULHABER BL/DC-motors can be combined with encoders of types PA2-50 or HXM.

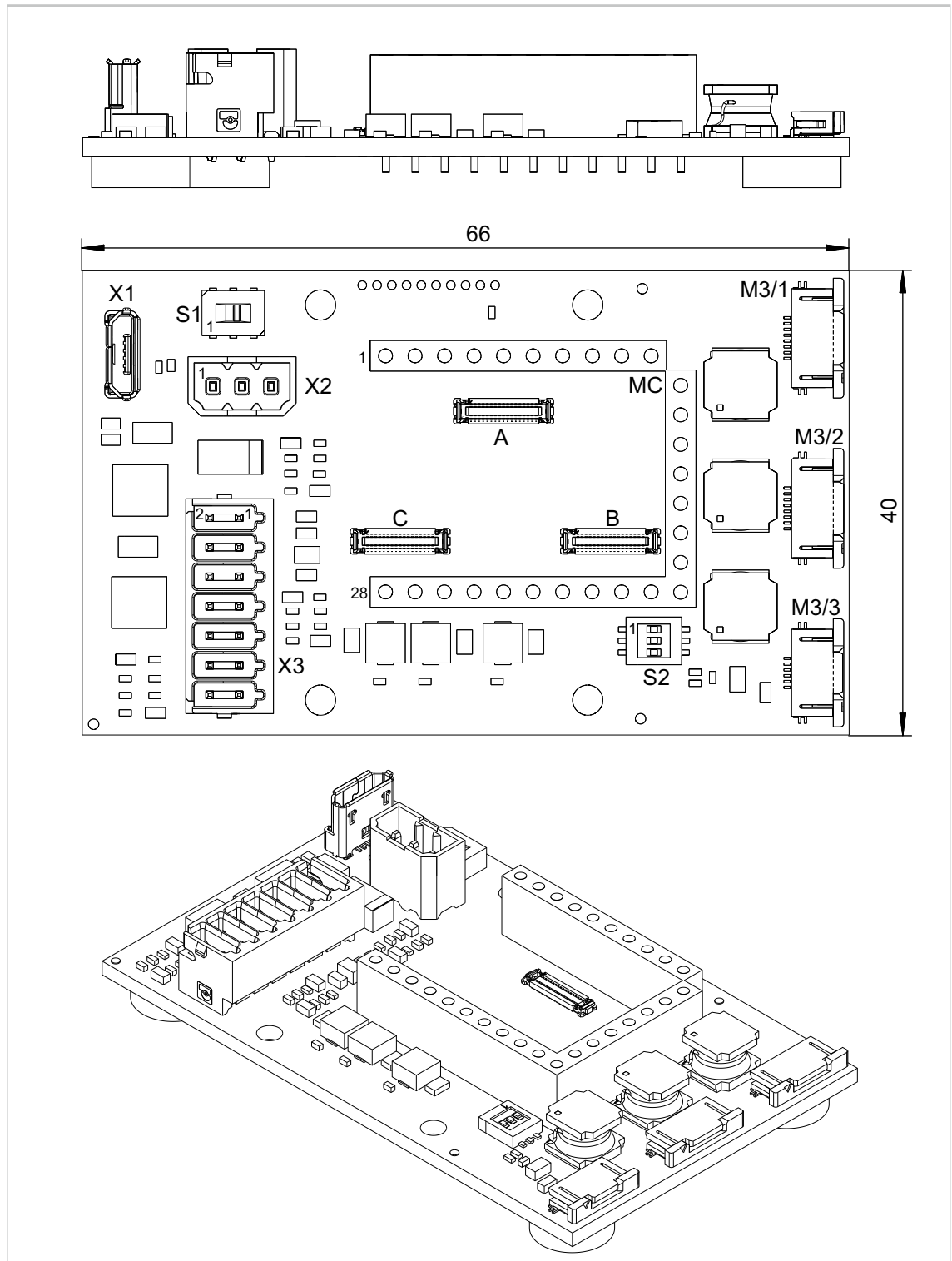


Fig. 12: Side view (top), top view (middle) and isometric view (bottom) of the motherboard 6500.01811

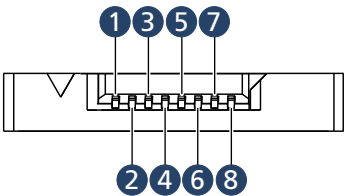
## Product description

Tab. 75: Connector overview of the motherboard 6500.01811

Designation	Function
A, B, C (controller)	MC 3001 B connection (for pin assignment, see chap. 3.3.1.1, p. 13)
MC (controller)	MC 3001 P connection (for pin assignment, see chap. 3.3.1.2, p. 17)
M3/1 (motor and sensors)	Connection of a BL or LM motor with Hall sensors and flexboard connection
M3/2 (motor and encoder)	Connection of a motor with HXM incremental encoder
M3/3 (motor and encoder)	Connection of a motor with PA2-50 incremental encoder
X1 (USB)	USB interface connection
X2 (COM)	CAN/RS232 interface connection
X3 (I/O)	Voltage supply of the controller and motor Inputs or outputs for external circuits
S1 (DIP switch COM)	Selection of the COM interface: <ul style="list-style-type: none"> <li>C: CAN</li> <li>RS: RS232</li> </ul>
S2 (DIP Switch HXM config)	HXM_CFG2 configuration: <ul style="list-style-type: none"> <li>High (16 pulse): S2-1 in <b>ON</b> position, S2-2 and S2-3 in <b>OFF</b> position</li> <li>Open (32 pulse): S2-2 in <b>ON</b> position, S2-1 and S2-3 in <b>OFF</b> position</li> <li>Low (64 pulse): S2-3 in <b>ON</b> position, S2-1 and S2-2 in <b>OFF</b> position</li> </ul>

### Motor and sensor connection (M3/1)

Tab. 76: Pin assignment of the motor and sensor connection (M3/1)

	Pin	Designation	Meaning
	1	Motor C	Connection of motor, phase C
	2	Motor B	Connection of motor, phase B
	3	Motor A	Connection of motor, phase A
	4	GND	Ground connection
	5	U <sub>DD</sub>	Power supply for Hall sensors
	6	Sens C	Hall sensor C
	7	Sens B	Hall sensor B
	8	Sens A	Hall sensor A

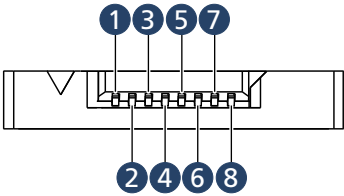
Tab. 77: Electrical data of the motor and sensor connection (M3/1)

Designation	Value
Motor power supply	0...U <sub>mot</sub> Max. 1 A 100 kHz
Power supply for Hall sensors	5 V <100 mA
Connection of the Hall sensors	<5 V

## Product description

### Motor and HXM encoder connection (M3/2)

Tab. 78: Pin assignment of the motor and HXM encoder connection (M3/2)

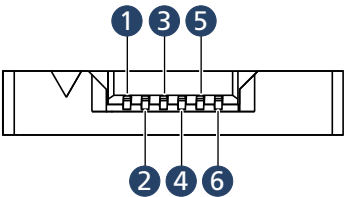
	Pin	Designation	Meaning
	1	Motor –	Connection of the motor, negative pole
	2	GND	Ground connection
	3	–	n.c.
	4	Channel B	Encoder channel B
	5	Channel A	Encoder channel A
	6	Index	Encoder index
	7	U <sub>DD</sub>	Power supply for incremental encoder
	8	Motor +	Connection of motor, positive pole

Tab. 79: Electrical data of the motor and HXM encoder connection (M3/2)

Designation	Value
Motor power supply	0...U <sub>mot</sub> Max. 1 A 100 kHz
Power supply for incremental encoder	5 V <100 mA
Connection of the incremental encoder	<5 V <2 MHz 5 kΩ

### Motor and PA2-50 encoder connection (M3/3)

Tab. 80: Pin assignment of the motor and PA2-50 encoder connection (M3/3)

	Pin	Designation	Meaning
	1	Motor +	Connection of motor, positive pole
	2	U <sub>DD</sub>	Power supply for incremental encoder
	3	Channel A	Encoder channel A
	4	Channel B	Encoder channel B
	5	GND	Ground connection
	6	Motor –	Connection of the motor, negative pole

Tab. 81: Electrical data of the motor and PA2-50 encoder connection (M3/3)

Designation	Value
Motor power supply	0...U <sub>mot</sub> Max. 1 A 100 kHz
Power supply for incremental encoder	3,3 V <100 mA
Connection of the incremental encoder	<5 V <2 MHz 5 kΩ

## Product description

### USB (X1)

Tab. 82: USB port

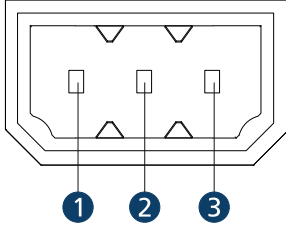
Designation	Meaning
	USB communication (USB micro B)

### COM port (X2)

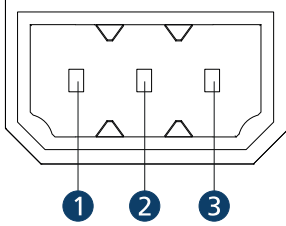
The pin assignment of the COM connection differs according to the type of communication. The distinction is made between the following types of communication:

- RS232
- CANopen

Tab. 83: Pin assignment of the COM port (X2) for RS232

	Pin	Designation	Meaning
	1	TxD	RS232 interface transmit direction
	2	RxD	RS232 interface receive direction
	3	GND	Ground connection

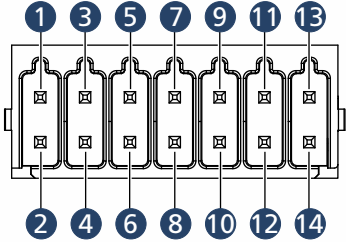
Tab. 84: Pin assignment of the COM port (X2) for CANopen

	Pin	Designation	Meaning
	1	CAN-H	CAN-High interface
	2	CAN-L	CAN-Low interface
	3	GND	Ground connection

## Product description

### I/O connection (X3)

Tab. 85: Pin assignment of the I/O connection (X3)

	Pin	Designation	Meaning
	1	$U_{DD}$	Power supply for external consumer loads
	2	GND	Ground connection
	3	DigOut 1	Digital output (open collector)
	4	DigOut 2	Digital output (open collector)
	5	DigIn 1	Digital input
	6	DigIn 2	Digital input
	7	DigIn 3	Digital input
	8	AnIn 1	Analogue input
	9	AnIn 2	Analogue input
	10	AGND	Ground connection for analogue inputs
	11	$U_p$	Power supply of the electronics
	12	GND	Ground connection
	13	$U_{mot}$	Power supply of the motor
	14	GND	Ground connection

Tab. 86: Electrical data for the I/O connection (X3)

Designation	Value
Power supply for external consumers	5 V <100 mA
DigOut	low = GND high = high resistance 27 k $\Omega$ Max. 0.7 A
DigIn	<30 V 27 k $\Omega$ <1 MHz TTL level: low < 0.5 V, high > 3.5 V PLC level: low < 7 V, high > 11.5 V
AnIn	$\pm 10$ V Reference potential: AGND
Power supply for controller	6...30 V $\leq 100$ mA (without external consumer)
Motor power supply	6...30 V

## 4 Installation

Only trained experts and instructed persons with knowledge of the following fields may install and commission the Motion Controller:

- Automation technology
- Standards and regulations (such as the EMC Directive)
- Low Voltage Directive
- Machinery Directive
- VDE regulations (DIN VDE 0100)
- Accident prevention regulations

This description must be carefully read and observed before commissioning.

Also comply with the supplementary instructions for installation (see chap. 2.3, p. 9).

### 4.1 Mounting

#### 4.1.1 Mounting instructions



##### **CAUTION!**

**The Motion Controller can become very hot during operation.**

- ▶ Place a guard against contact and warning notice in the immediate proximity of the controller.



##### **NOTICE!**

**Improper installation or installation using unsuitable attachment materials can damage the Motion Controller.**

- ▶ Comply with the installation instructions.



##### **NOTICE!**

**Installation and connection of the Motion Controller when the power supply is applied can damage the device.**

- ▶ During all aspects of installation and connection work on the Motion Controller, switch off the power supply.

## Installation

### 4.1.2 Installation of Motion Controller PCBs

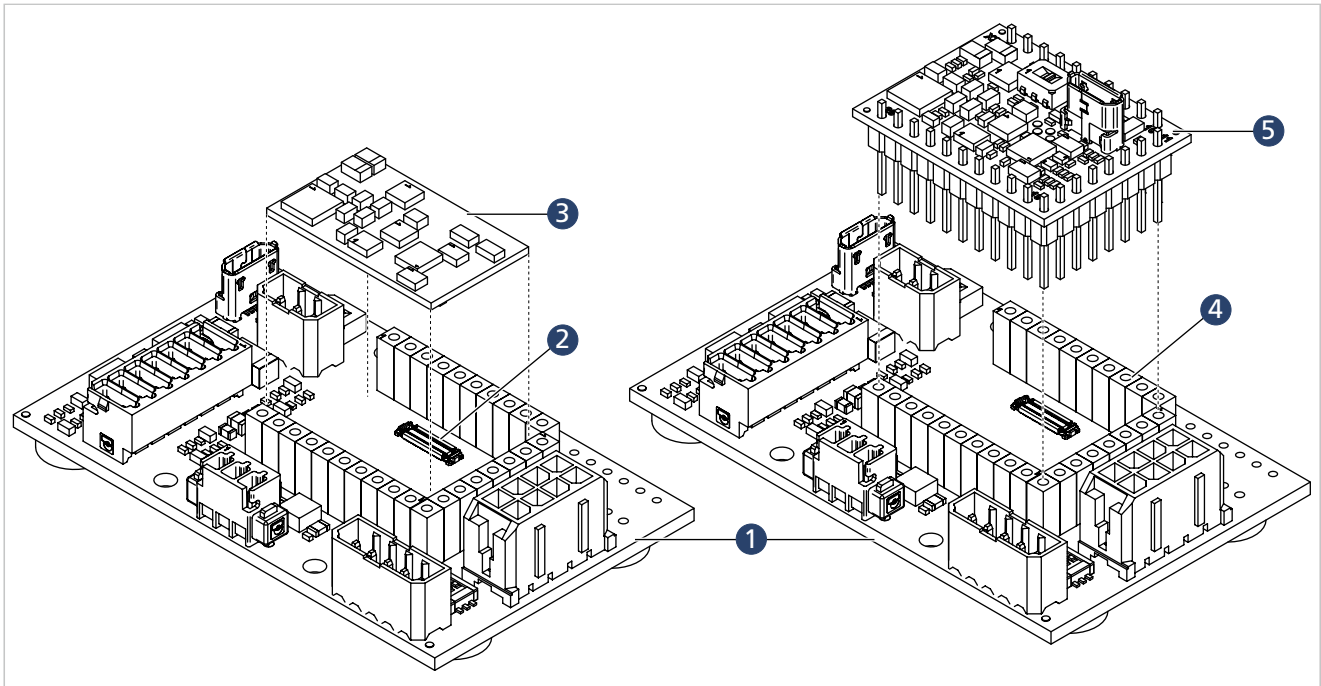


Fig. 13: Installation of a Motion Controller PCB (example: motherboard MB1 MC3001 6500.01802)



#### NOTICE!

Incorrect installation can damage the Motion Controller.

- ▶ Note orientation of the Motion Controller PCB acc. to Fig. 13.
- ▶ MC 3001 B: Connect the Motion Controller PCB (3) to the motherboard (1) using the 3 micro board-to-board connectors (2).
- ▶ MC 3001 P: Connect the Motion Controller PCB (5) to the motherboard (1) using the plug connections (4).



## Installation

### 4.2 Electrical connection

#### 4.2.1 Notes on the electrical connection



##### **WARNING!**

**Threat to health through high-frequency interference.**

The Motion Controller can cause high-frequency interference which can affect the function of electronic implants.

- ▶ Take appropriate interference suppression measures, particularly during use in residential environments.



##### **NOTICE!**

**Electrostatic discharges to the Motion Controller connections can damage the electronic components.**

- ▶ Observe the ESD protective measures.



##### **NOTICE!**

**Incorrect connection of the wires can damage the electronic components.**

- ▶ Connect the wires as shown in the connection assignment.



##### **NOTICE!**

**A short-term voltage peak during braking can damage the power supply or other connected devices.**

- ▶ For applications with high load inertia, the FAULHABER Braking Chopper of the BC 5004 series in 28 V operation can be used to limit overvoltages and thereby protect the power supply. For more detailed information see the data sheet for the Braking Chopper.

The Motion Controller contains a PWM output stage for controlling the motors. Power losses arising during operation and alternating electrical fields arising due to the pulsed control of the motors, must be dissipated and damped by appropriate installation.

- ▶ Connect the Motion Controller to a grounding system. This should be done preferably by mounting it on an earthed baseplate, or alternatively by connecting it to an earthed mounting rail.
- ▶ Make sure that potential equalisation is present between all coupled parts of the system. This applies even if the Motion Controller and motor are mounted separately.
- ▶ If several electrical devices or controllers are networked by means of RS232 or CAN, make sure that the potential difference between the earth potentials of the various parts of the system is less than 2 V.

✎ The cross-section of the required potential equalisation conductors between the various parts of the system is specified in VDE 100 and must satisfy the following conditions:

- At least 6 mm<sup>2</sup>
- Larger than half the cross-section of the supply conductor

## Installation

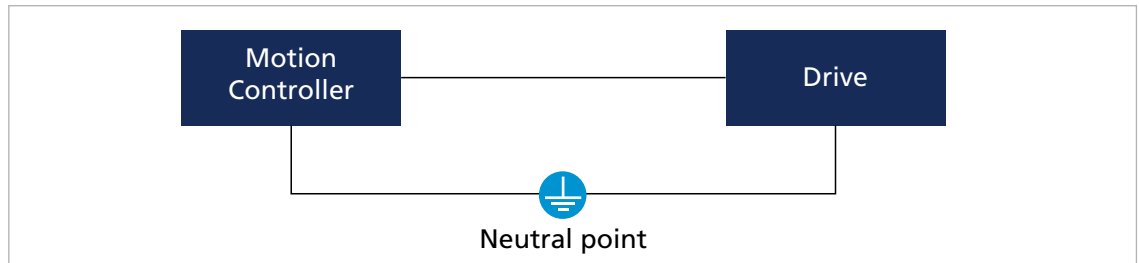


Fig. 14: Potential equalisation between electrically connected parts of the system

### 4.2.2 Drive connections

The maximum length of the cable between the Motion Controller and motor depends on the sensor system used and the electrical and magnetic fields in the environment.

Tab. 87: Guide values for the cable length

Encoder type	Unshielded length	Shielded length <sup>a)</sup>
Digital Hall sensors	0.5 m	2–5 m
Analogue Hall sensors	0.5 m	2–5 m
Incremental encoders without line driver	0.5 m	2–5 m
Incremental encoders with line driver	2 m	2–5 m
Absolute encoders without line driver	0.3 m	0.5 m
Absolute encoders with line driver	2 m	5 m

a) applies to cables separately shielded from the motor phase power cables.

**i** Encoders with line driver must be extended with twisted pair cables to improve the robustness. In doing so, the cables with the respective complementary signals must be twisted together.

Longer connection cables are generally permissible, but must be validated for the target installation.

Optimisation of the behaviour in respect of transient emission and interference resistance may require additional EMC measures (see chap. 4.3, p. 65)

## Installation

### 4.2.3 Connection of the power supply

- Discrete inputs and outputs (for instance for discrete set-point specification or for connection of limit switches and reference switches)
- Communication connections
- ▶ Make sure that the connection cables on the connection side are not longer than 3 m.
- ▶ Keep the shield connections for connection cables short and flat.

**i** The USB port is a pure configuration connection. A cable length of < 3 m also applies for the USB connection.

To reduce the effects on the DC power supply network, ferrite sleeves (such as WE 742 700 790) can be used on the supply cables.

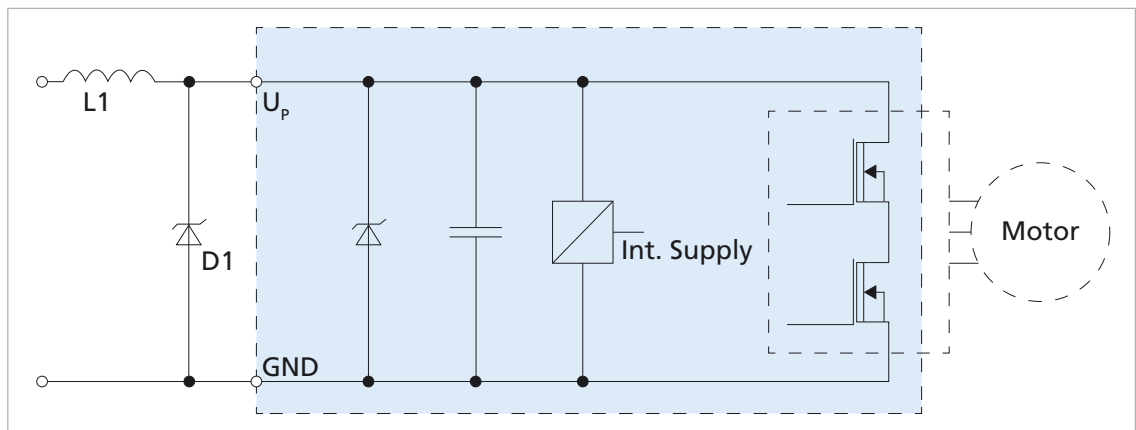


Fig. 15: EMC suppressor circuit

#### 4.2.3.1 Power supply

- ▶ Connect the Motion Controller to a sufficiently dimensioned power supply unit.
- ▶ During acceleration procedures, current peaks with values up to the peak current limit setting of the motor can occur for multiples of 10 ms.
- ▶ During braking procedures, energy can be regenerated and fed back into the DC power supply network. If this energy cannot be taken up by other drives, the voltage in the DC power supply network will rise. A limit value for the voltage that can be fed back during regenerative braking can be set in the Motion Controller. Alternatively the over-voltage can be dissipated by an additional external brake chopper, see the data sheet for the brake chopper.

## Installation

### 4.2.4 I/O circuit diagrams

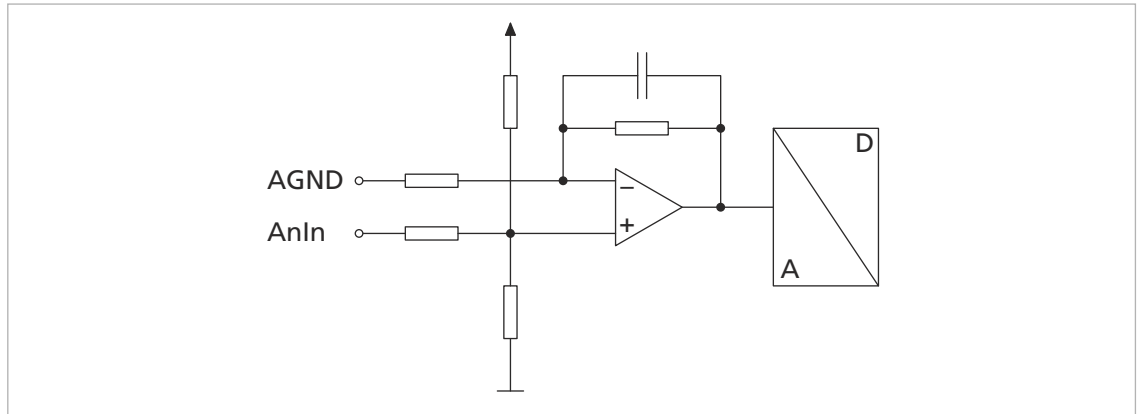


Fig. 16: Analogue input circuit diagram (internal)



So that the voltage drop on the supply side does not affect the speed specification value, connect the analogue input ground (AGND) to the power supply ground (GND).

The analogue inputs are executed as differential inputs. Both inputs use the same reference input.

The analogue inputs can be used flexibly:

- Specification of set-points for current, speed or position
- Connection of actual value encoders for speed or position
- Use as a free measurement input (queried via the interface)

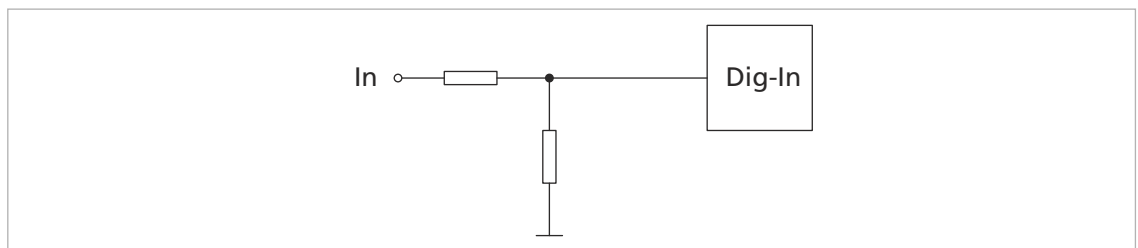
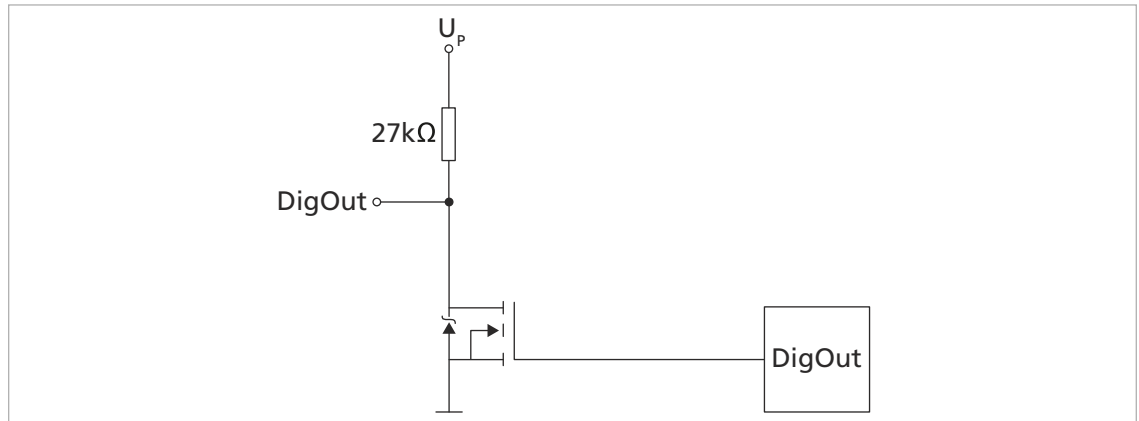


Fig. 17: Digital input circuit diagram (internal)

The digital inputs are switchable from the input level (PLC/TTL). The digital inputs can be configured for the following purposes (see the Drive Functions):

- Digital input for reference and limit switches
- Connection of an external encoder
- PWM (Pulse Width Modulation) set-point specification for current, speed and position

## Installation



*Fig. 18: Digital output circuit diagram (internal)*

The digital output has the following properties:

- Open collector switch to ground
- Monitored output current (switch opens in the event of an error)

A digital output can be assigned to an error output. It can be freely programmed.

## Installation

### 4.2.5 External circuit diagrams

#### Bipolar analogue set-point specification via potentiometer

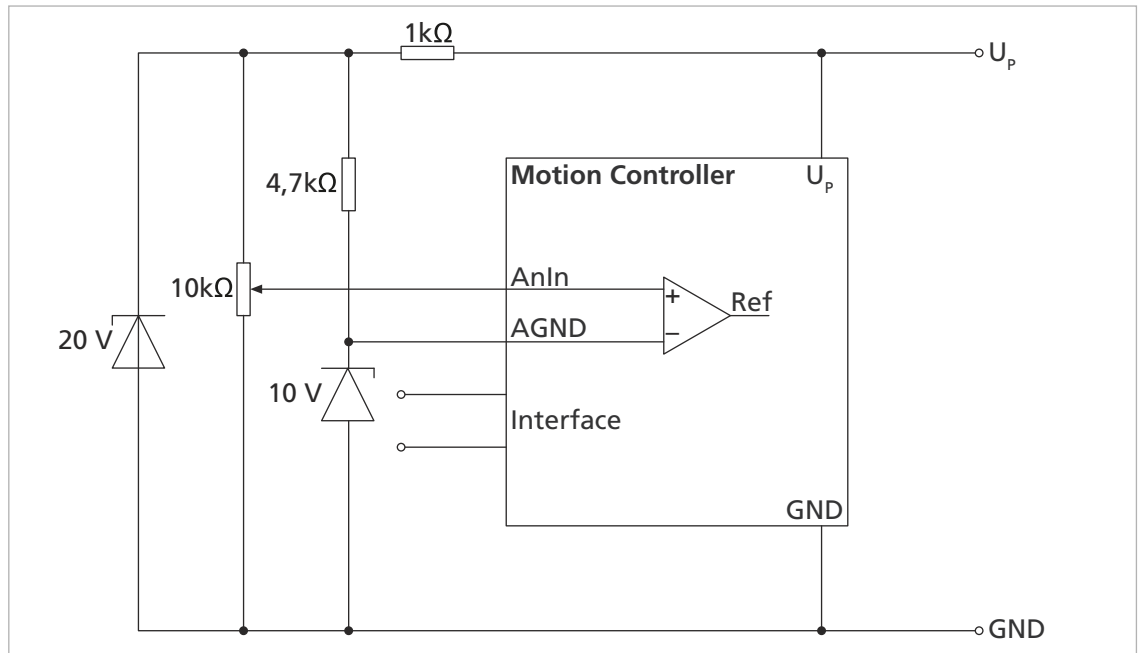


Fig. 19: Bipolar analogue set-point specification via potentiometer

#### Analogue set-point specification via potentiometer with internally set offset and scaling

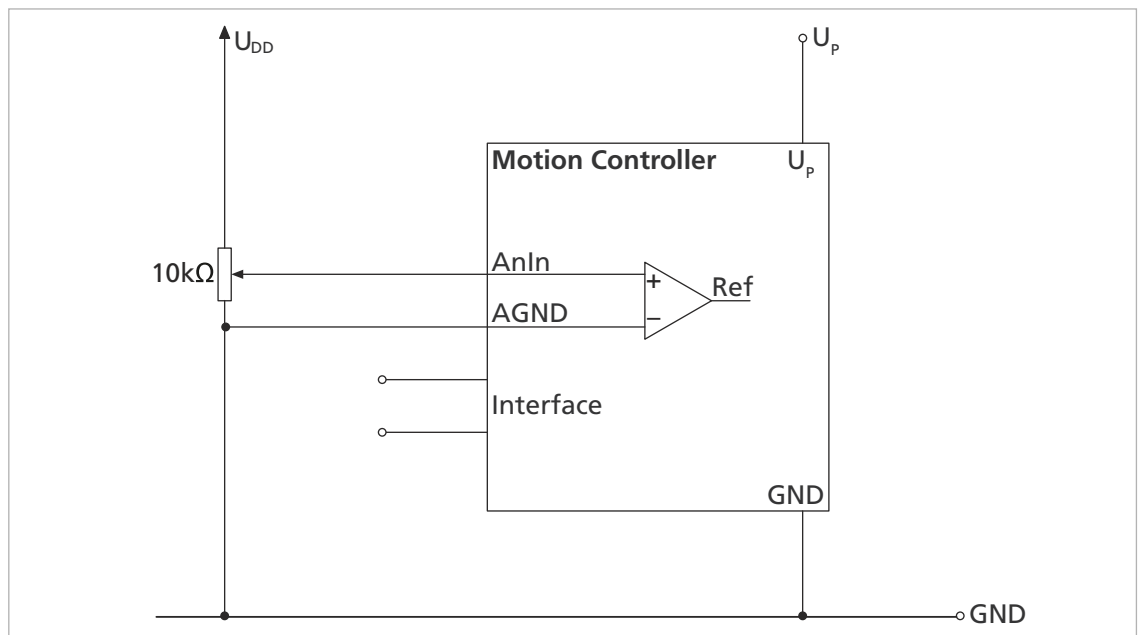


Fig. 20: Analogue set-point specification via potentiometer with internally set offset and scaling

## Installation

### Connection of reference and limit switches

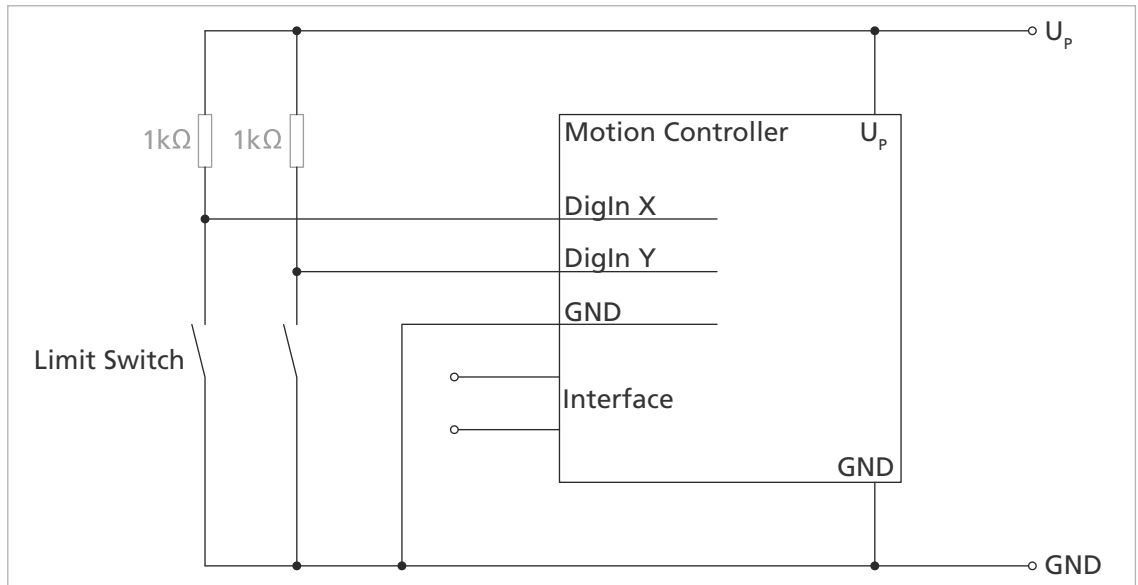


Fig. 21: Connection of reference and limit switches

**i** Depending on the type of switch it may be necessary to use additional pull-up resistors. No internal pull-up resistors are incorporated in the Motion Controller.

### Connection of an external incremental encoder

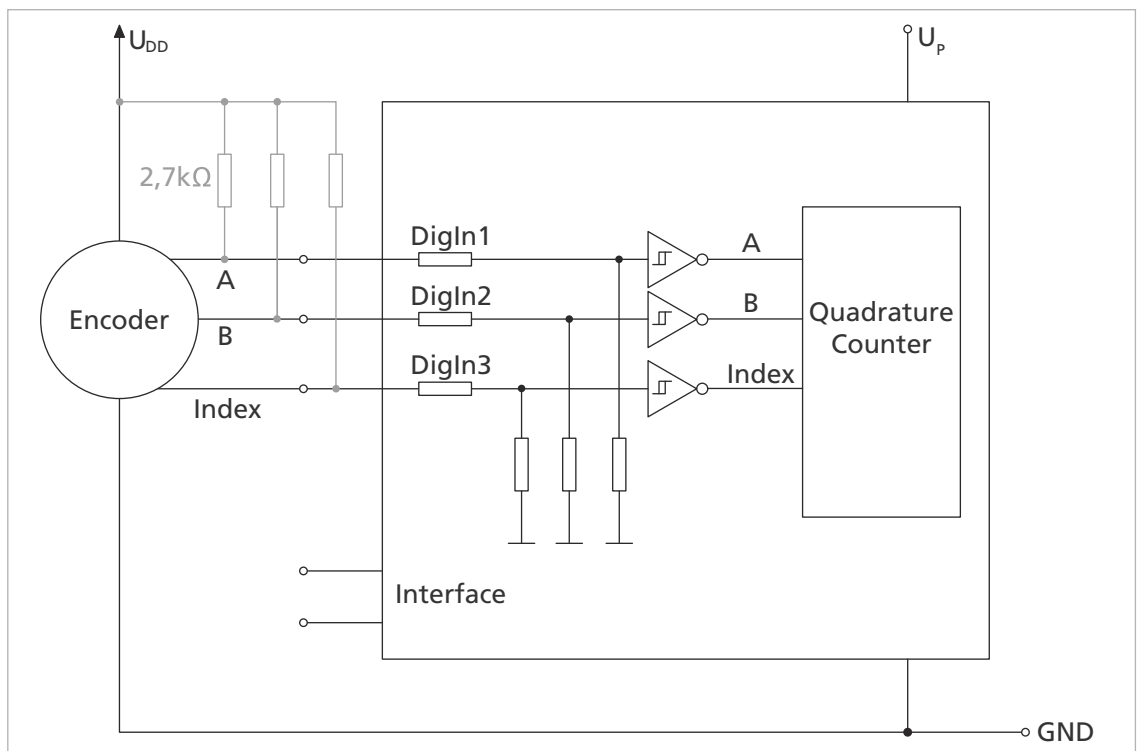


Fig. 22: Connection of an external incremental encoder

## Installation

**i** Depending on the type of encoder it may be necessary to use additional pull-up resistors. No internal pull-up resistors are incorporated in the Motion Controller.

### Wiring between PC/controller and a drive

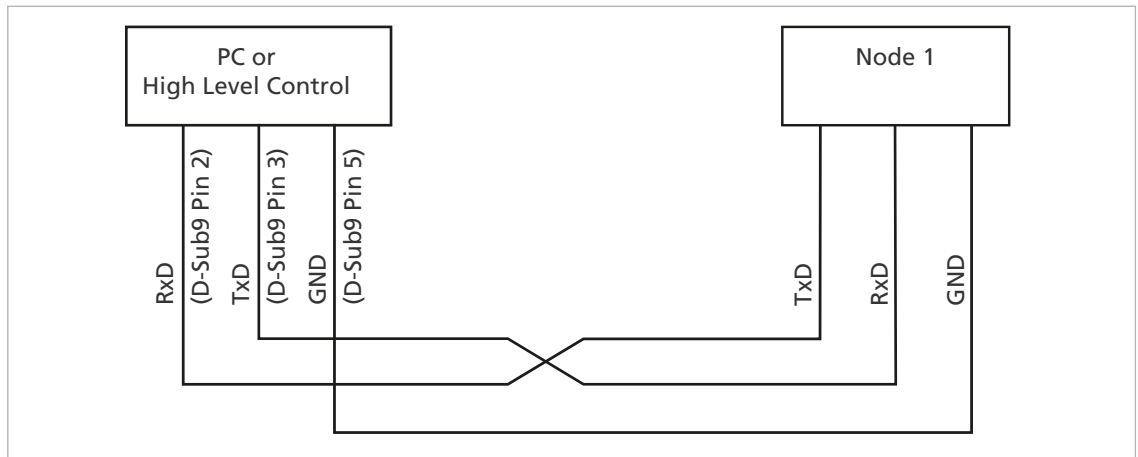


Fig. 23: Wiring between PC/controller and a drive

### Connection to the CANopen network

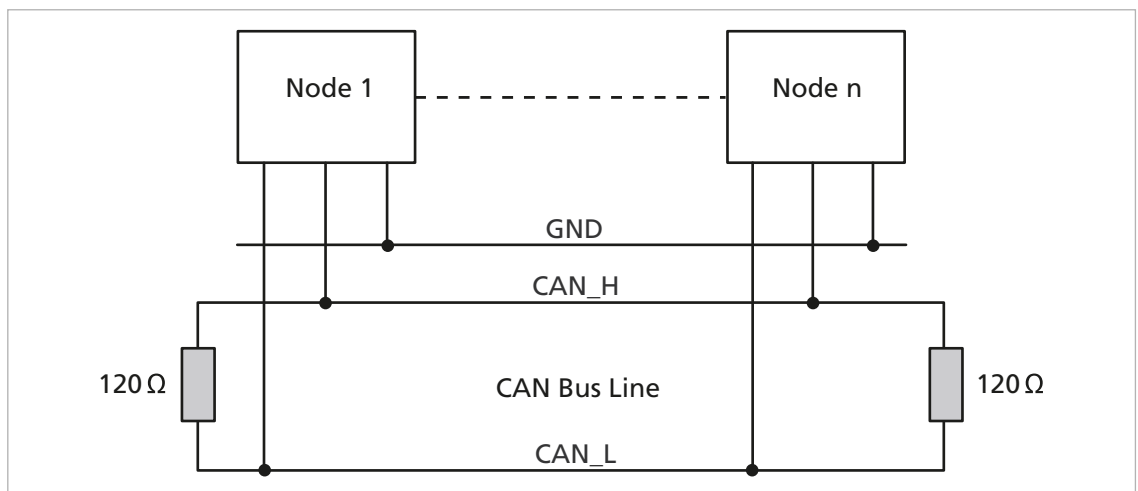


Fig. 24: Connection to the CANopen network

**i** If the CAN wiring is not laid in a straight line it may be necessary to individually optimise the amount and location of the terminating resistors. For instance in a star network a central 60 Ohm terminating resistor may be more suitable. When the optimum arrangement of terminating resistors is fitted, no accumulation of error frames should be evident.



## Installation

### 4.3 Electromagnetic compatibility (EMC)

- ▶ Follow the instructions in the following chapters to perform an EMC-compliant installation.



#### NOTICE!

Drive electronics with qualified limit values in accordance with EN-61800-3: Category C2 can cause radio interference in residential areas.

- ▶ For these drive electronics, take additional measures to limit the spread of radio interference.

#### 4.3.1 Considered systems

The following considerations assume installations that can be described with the following circuit diagrams.

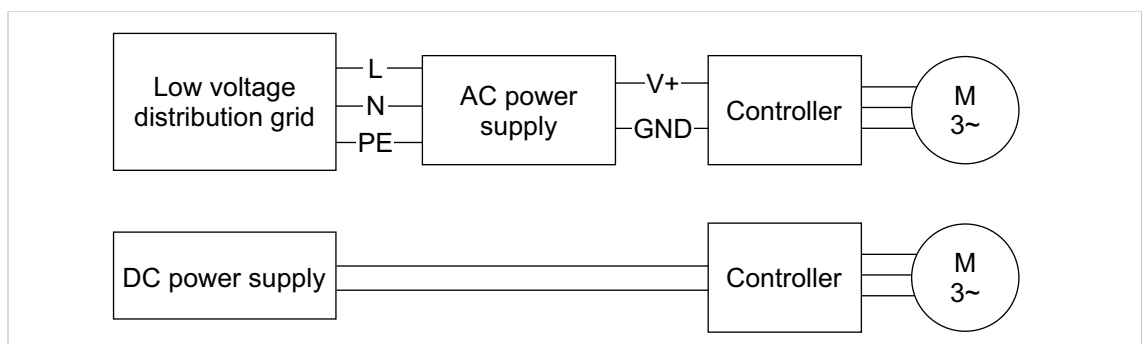


Fig. 25: Circuit diagrams of the considered systems

#### AC-mains system

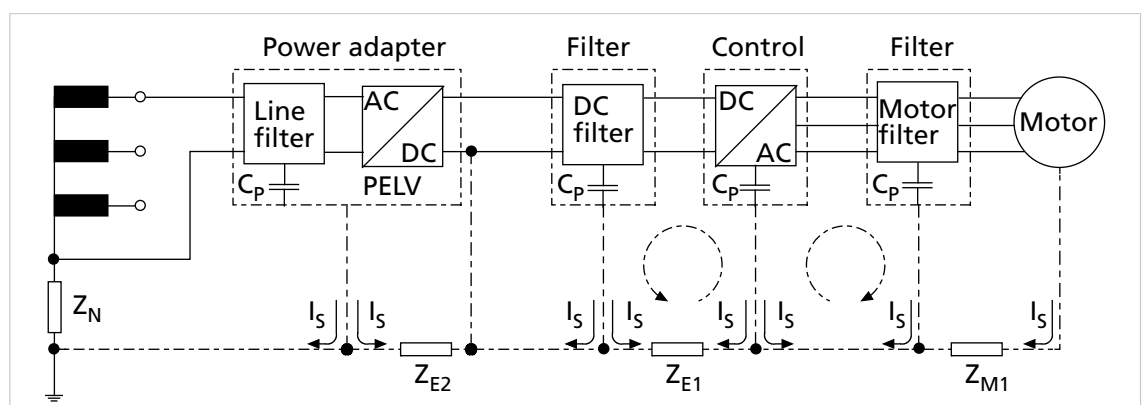


Fig. 26: Interference sources in an AC-mains system

- $Z_N$  Mains impedance of mains transformer – power supply connection
- $Z_{E1}$  Common-mode impedance of electronics on DC side
- $Z_{E2}$  Common-mode impedance of electronics on AC side – power supply connection
- $Z_{M1}$  Impedance of motor housing – controller
- $I_s$  Parasitic current
- $C_p$  Parasitic capacitance/filter capacitance

## Installation

Parasitic current usually arises from the following components:

- Semiconductors
- Capacitive portion of the motor supply line
- Parasitic elements in the motor

Operating the motors with PWM is the cause here.

The DC-DC converter in the device and the used switching power supply also produce interference that could affect the mains. The created interference of the DC-DC converter in the device is, however, normally of little relevance due to the switched power (<5 W).

In contrast to this are the switching power supply, which supplies the controller with motor voltage or electronics voltage, and the PWM drive. Depending on the design, quality and effectiveness of the integrated filters (where present), the power supply can also cause interference.

**i** The qualitative assessment of a power supply can be performed with an interference voltage test and a resistive load (e.g., fanless heater / hot plate).

### DC-mains system

Prerequisite for connecting to the DC mains is that the switching interference of the power supply be negligible. A linear power supply can be used to reduce this interference.

### Problem solutions

The interference may vary depending on load and installation.

Solution	Mode of action	Benefits	Disadvantages
3-phase common-mode choke / ferrite ring around all motor phases	Removes common-mode interference of the motor	<ul style="list-style-type: none"> <li>■ Removes RF common-mode interference</li> <li>■ Fast testing possible</li> </ul>	<ul style="list-style-type: none"> <li>■ Does not remove all interference</li> <li>■ Fabrication necessary</li> </ul>
PWM motor filter (e.g., EFM 5003 6501.00357)	Removes switching noise on the motor cable through DC averaging	Interference limited to input side	Does not remove all RF interference
Motor filters and ferrites (e.g., EFC 5008 6501.00351)	Removes RF interference on the motor cable	Optimum for radio emissions	Does not remove all low-frequency interference
Input filter upstream of the controller (e.g., EFS 5004 6501.00350)	Removes interference of the switching regulator and part of the motor interference on DC networks	Pass an interference voltage measurement with correct wiring	Does not remove interference on the motor side
Mains filter upstream of the switching power supply	Removes common-mode interference of the power supply	Very cost-effective solution	<ul style="list-style-type: none"> <li>■ Often only effective for power supply</li> <li>■ Does not remove all interference</li> </ul>

The mentioned variants are effective only if the following chapters are followed correctly.

## Installation

### 4.3.2 Functional earthing



#### **DANGER!**

**Danger to life through ground leakage currents  $\geq 3.5$  mA**

- ▶ Check the earthing of the devices for proper installation.

The earthing system is essential for discharging parasitic current and for a potential distribution in the system that is as uniform as possible. The most efficient systems have a star or mesh shape. A star-shaped connection is easier to implement.

- ▶ Ensure an adequate cross section and a very good electrical earth connection so that the contact resistances are low not only for the low-frequency currents.

The earth connection can be improved, e.g., by removing the oxide layers from the ends of conductors with fine sandpaper.

#### **For electrical safety:**

- ▶ Earth in accordance with current standards and guidelines.
- ▶ Use separate protective earth conductors for all necessary parts (e.g., mains supply, motor, controller).
- ▶ Keep earthing cable as short as possible.

#### **For functional earthing:**

- ▶ Use a braided shield that is meshed as tightly as possible.
- ▶ Direct contact with the earth plate is to be preferred.  
Therefore, avoid contact with the controller and then with the earth plate.
- ▶ Connections made over a large surface area are to be preferred.

### 4.3.3 Cable routing

The cable routing depends on various factors, such as:

- Is the cable shielded, twisted?
- Were interference-reducing measures taken?
- What material and what cable routing are used in the cable duct?
- Over what surface is the cable routed?

#### **Observe the following when laying the cables:**

- ▶ Use a full-surface, u-shaped and, if possible, metal cable duct.
- ▶ Lay the cables near the corners of the cable duct.
- ▶ Separate the cables by function where possible.
- ▶ Maintain distances when laying the cables.

The distances may vary depending on the zone in the switching cabinet.

- ▶ If possible, all cables should be twisted pairs or twisted and shielded in function groups (e.g., motor phases together, Hall sensors and supply together).

## Installation

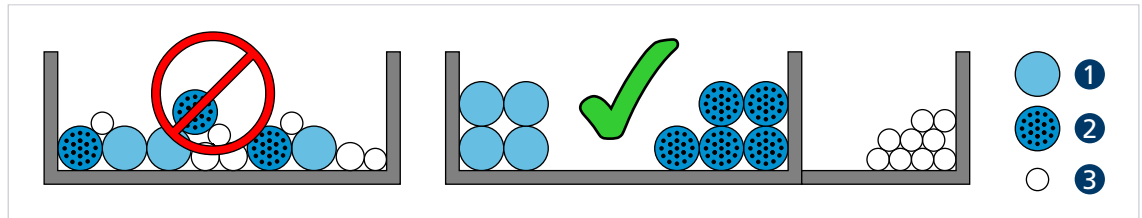


Fig. 27: Laying in the cable duct

- 1 High-current cable
- 2 Digital cable

- 3 Sensor cable

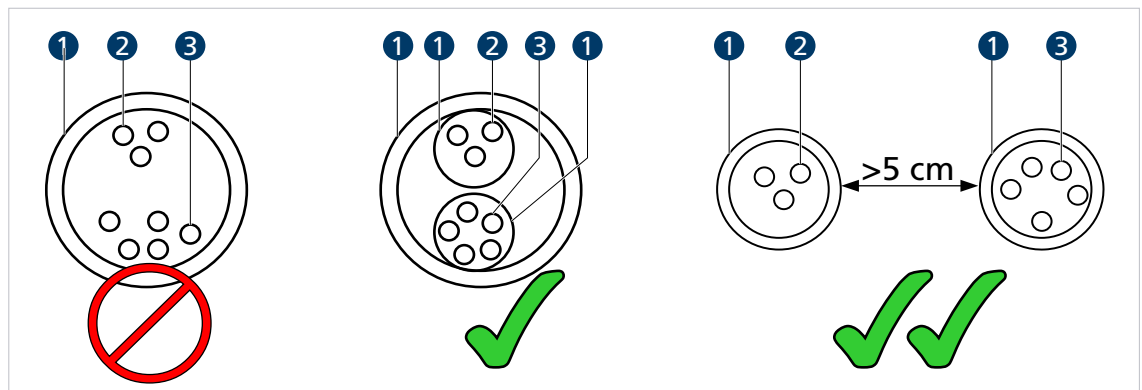


Fig. 28: Grouping and shielding of the cables

- 1 Shielding
- 2 Motor phase

- 3 Hall sensor

## Installation

### 4.3.4 Shielding

- ▶ Shield cables in all cases.  
Shield cables that are longer than 3 m with tightly meshed copper braiding.
- ▶ Shield all supply lines according to current guidelines/standards (e.g., IPC-A-620B) and connect using (round) shield clamp.  
In special cases (e.g., with pigtail) or after qualification, the shield can be omitted for the following cables:
  - Cables with length <50 cm
  - Cables with low power supplies (e.g., <20 V)
  - Sensor cables
- ▶ Connect shield clamps to a low-impedance (<0.3 Ω) earthing bar or earth plate.
- ▶ Establish a star-point earth connection (see chap. 4.3.2, p. 67).
- ▶ Lay the motor phases in a shield, separate from the sensor or encoder signals, and connect on at least the motor side (see 1 or 2 in Fig. 29).

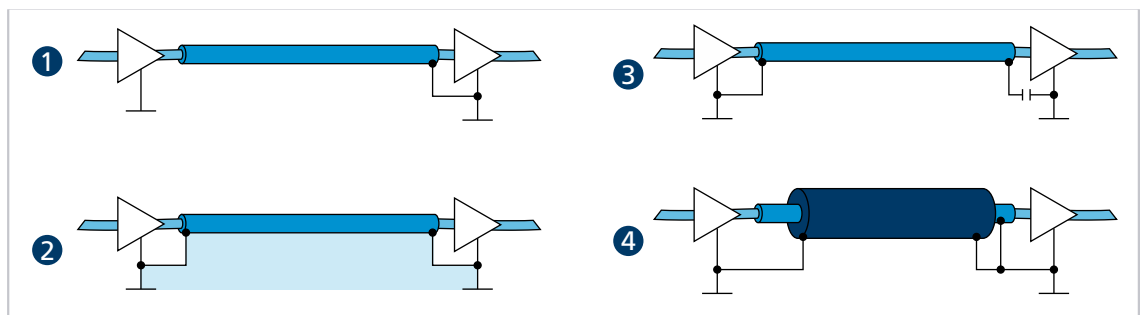


Fig. 29: Various possibilities for the shield connection

- 1 Suppressing electrical fields
- 2 Alternating magnetic field
- 3 Interruption of the earthing loop for direct currents or low-frequency currents
- 4 Discharging parasitic currents to the reference potential

The sensor signals can optionally be laid with the motor phases in a shared cable/insulation hose using another outer braided shield. This outer braided shield must be connected at both ends (e.g., 4 in Fig. 29). A solution such as 2 in Fig. 29 is not functional in every case for this configuration. If this is not possible by means of a ground offset, establish the RF connection via specially suited capacitors (e.g., safety capacitors such as Y1/Y2/X1/X2, see 3 in Fig. 29). In this case, do not connect the shield multiple times except at the motor connection and controller side.

## Installation

### 4.3.4.1 Establishing the shield connection

The best results when establishing a shield connection on the cable are achieved in the following way:

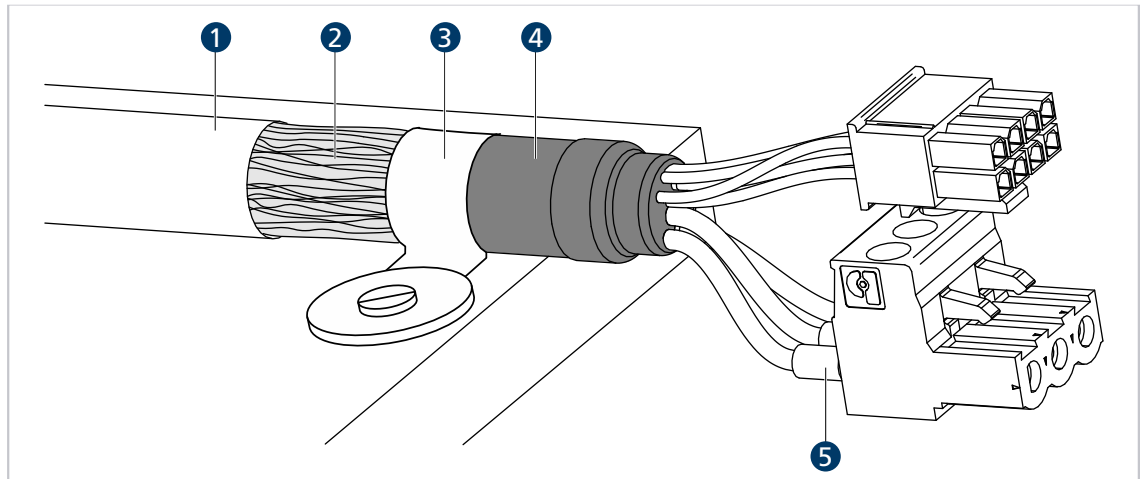


Fig. 30: Motor cable shield connection

- |                      |                      |
|----------------------|----------------------|
| 1 Outer cable shield | 4 Heat-shrink tubing |
| 2 Braided shield     | 5 Crimp-sleeve       |
| 3 Shield clamp       |                      |

1. Remove approx. 50-100 mm from the outer cable shield (1). Make certain that none of the fibres of the braided shield (2) are destroyed.
2. Either push back the shield or roll it up and fasten with heat-shrink tubing (4).
3. Optionally fit crimp-sleeves on the cable ends (5) and attach to the plug connectors.
4. Fasten the shield and the fixed end of the heat-shrink tubing with a cable tie (3).

## Installation

### 4.3.4.2 Establishing shield connection with cable lug

A shield connection with cable lug should be avoided whenever possible. If it is necessary, however, the connection should be established as follows.

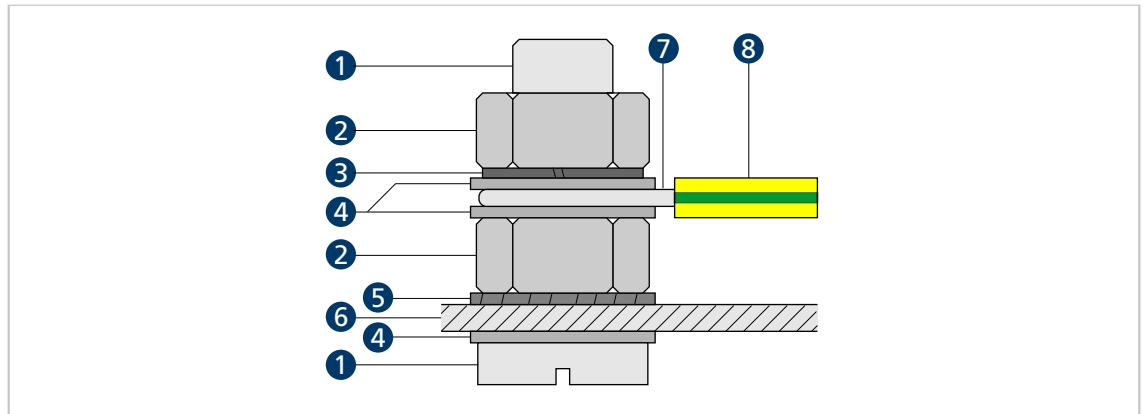


Fig. 31: Shield connection with cable lug

- |                 |                        |
|-----------------|------------------------|
| 1 Screw         | 5 Lock washer          |
| 2 Nut           | 6 Wall                 |
| 3 Spring washer | 7 Wire eyelet          |
| 4 Washer        | 8 Protective conductor |

1. Scrape the surface around the hole to remove as much of the oxide layer as possible.
2. Guide screw with washers through the cable lug.
3. Place lock washer on the screw.

Depending on the screw length, also position the lock washer against the roughened surface.

4. Fix screw with nut on the bottom side or screw into the thread.

## Installation

### 4.3.5 Sensor and encoder interfaces

Various solutions for different cable lengths are described in chap. 4.2.2, p. 58. The objective here should be to increase the signal quality to a reliably usable minimum.

The sensor systems used at FAULHABER for angle determination should be divided according to their useful frequency range. Depending on the frequency range, various filter measures are suitable.

- Analogue Hall sensors (very low frequency)
- Digital Hall sensors and quadrature interfaces
- Absolute encoder

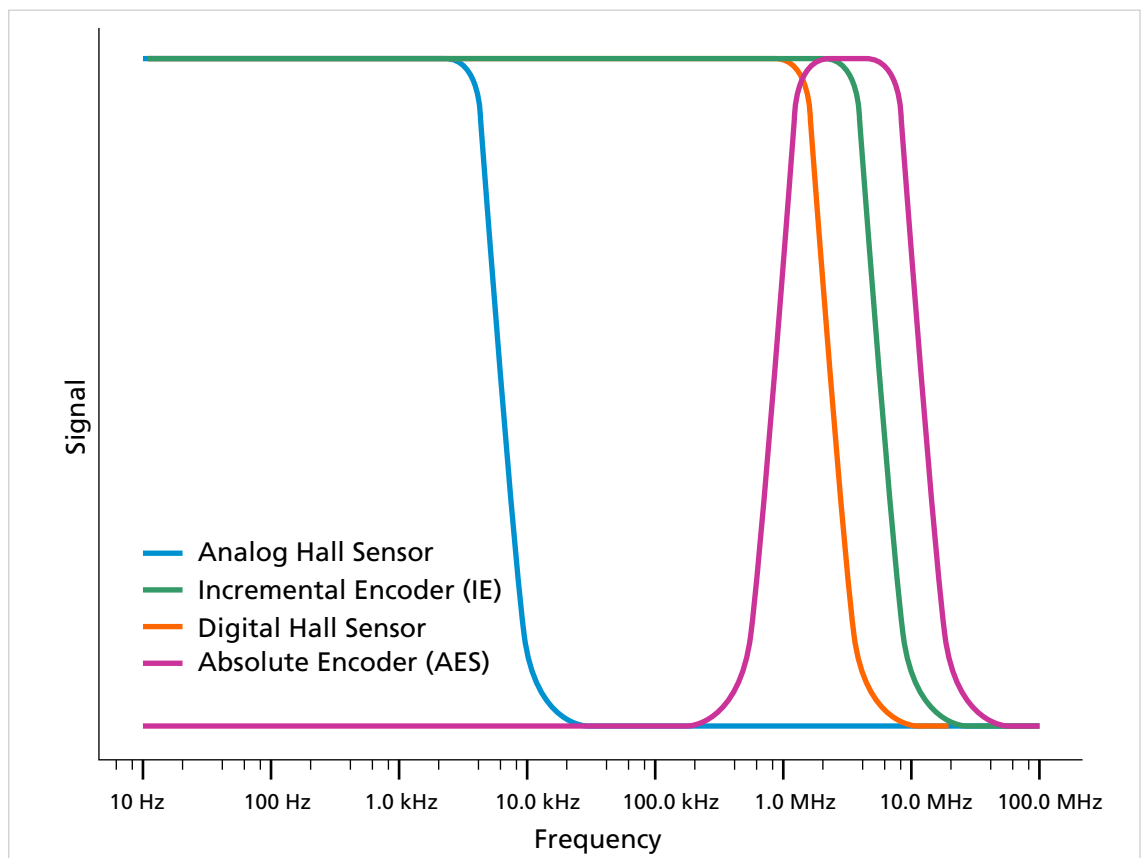


Fig. 32: Useful frequency ranges of the encoders

- ▶ To evaluate the interference on the signal (transmission quality), measure the signals.
- ▶ Make certain that no parasitic effects are measured. Select the reference potential correctly and measure directly on the controller if possible.

The following statement applies to all mentioned sensor systems: Differential signal transmission with line driver is an effective measure for increasing the interference immunity for longer cable lengths.

Additional measures for the various sensor systems can be found in the following sections.



## Installation

### 4.3.5.1 Analogue sensors and analogue Hall sensors

- ▶ Where possible, shield analogue sensor cables and lay them apart from (shielded) motor cables.
- ▶ Connect the shield on one end, ideally on the motor side.

**i** The signal quality can be improved with a capacitor (470 nF, dielectric strength > 100 V) between device shield and sensor supply (+5 V).

### 4.3.5.2 Incremental encoders / Digital Hall sensors / Digital sensors

**i** Due to the increased signal hysteresis, digital Hall sensors are more robust than analogue Hall sensors.

**i** Incremental encoders are robust due to a four-edge evaluation in the controller.

### 4.3.5.3 Encoders with absolute interface

- ▶ Connect the shield of the encoder lines on both ends.

On the controller side near the encoder plug connector, a terminal resistance of 120  $\Omega$  is highly recommended between Data+ and Data-. Depending on the version, terminating resistors are present on the motherboards and can be activated via DIP switch S2.

Alternatively, a so-called split termination can be used instead of the 120  $\Omega$  to increase the interference resistance. See also technical manual AEMTL (manual no. 7000.0x070).

**i** In the case of an absolute encoder interface, signal interference immediately results in invalid position values during the interference. A more interference-immune, differential data transmission is therefore advantageous.

### 4.3.6 Using filters

**i** Further information on the layout and design of passive filters is available on request.

The filters are divided into various function and current ranges.

Filter types:

- Input-side filters: filters on the power supply side
- Motor-side filters: filters that are connected between controller and motor in the motor phases

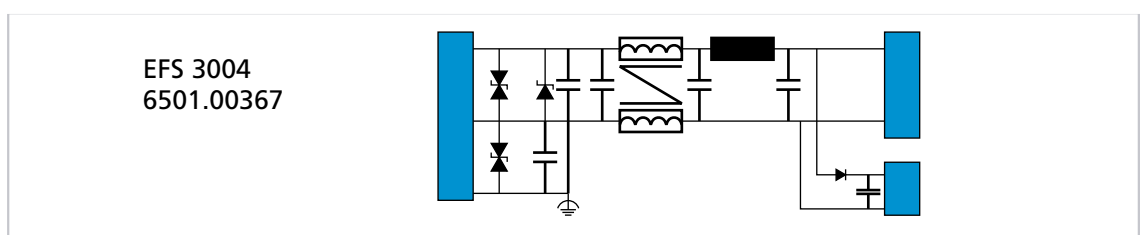


Fig. 33: Filter categories from FAULHABER

## Installation

### 4.3.6.1 EMC-compliant mounting of the Motion Controller with motherboard

The setup in Fig. 34 shows the assembly of a Motion Controller with motherboard. Each of the cable shields is connected to earth potential with low impedance using a shield clamp. Metallisations on screw connections on the PCB must also be connected to earth potential with low impedance (e.g., conductive base plate).

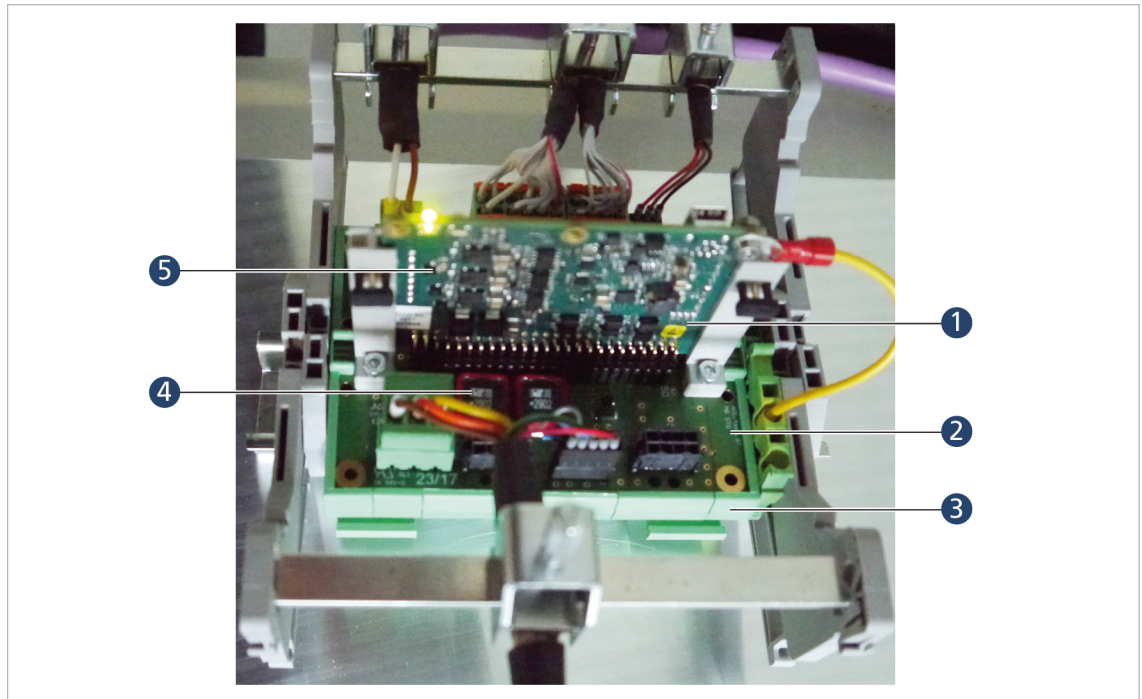


Fig. 34: Example for installation in a top-hat-rail housing

- |                         |                               |
|-------------------------|-------------------------------|
| 1 Motion Controller PCB | 4 Motor-side filter           |
| 2 Motherboard           | 5 Input-side filter (covered) |
| 3 Top-hat-rail housing  |                               |

### 4.3.6.2 PWM filter (motor-side)

Measures are provided in the device that come close to the effect of a PWM filter. Thus, an external PWM filter is only necessary in exceptional cases.

### 4.3.6.3 Emission-reducing, ferrite-based filters (motor side)

These filters can be found in similar form and mode of action on the motherboards. The filters reduce the rise time of the motor voltage/current and thereby reduce the high-frequency coupling currents on the shield.

## Installation

### 4.3.6.4 Input-side filters

Measures are provided on the motherboard that come very close to providing the interference-reducing effect. Additional input-side filters (FAULHABER 6501.00367) are usually only needed in ambient conditions that place particular requirements on the interference resistance or if the emissions are noticeable.

These filters are for applications that either cannot use the motor filter (e.g., integrated controllers) or in which the filtering by the motor filters is not sufficient. In this case, two filtering measures are used:

- Measure comparable to large capacitors (approx.  $>100 \mu\text{F}$ ) as close as possible to the controller and, where possible, low-ESR capacitances
- Discharge of common-mode interference with a common-mode choke, a low-pass filter and capacitors between functional earth and DC power supply

### 4.3.6.5 Insulation resistance

The filters from FAULHABER are not intended for an insulation resistance test. Discharging of the common-mode interference with capacitors prevents a meaningful result from an insulation resistance test.

### 4.3.6.6 Coiling ferrite ring

Ideally, ferrites made of manganese-zinc material are used that are active in the 1...10 MHz range. Typical diameters are between 25 and 35 mm onto which two to three windings with all 3 motor phases are wound simultaneously.

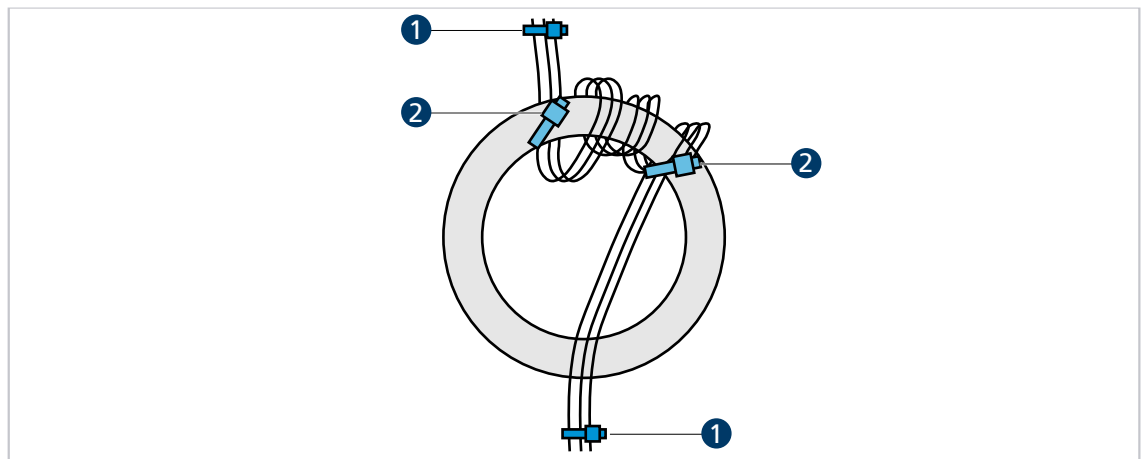


Fig. 35: Coiling ferrite ring

- 1 Fastening the motor phase cables      2 Fastening on the ferrite ring (optional)

1. Fasten motor phase cables, e.g., with cable ties (1), so that the motor side end of the cable points away from the user and the plug end of the cable points toward the user.
2. Simultaneously guide all three phases through the ferrite ring from below.
3. Guide the wound stranded wires back through the ring clockwise next to the first stranded wires so that a winding is created.
4. Wrap 2 further windings directly next to the existing windings in the same way.
- ⚠ There are 9 stranded wires in the ferrite ring.
5. Again secure the motor phase cables, e.g., with cable ties (2), on the ferrite ring.

## Installation

### 4.3.7 Error avoidance and troubleshooting

1. Can the problem clearly be traced back to the FAULHABER drive system?
  - a) Switch the output stage off and on.

The voltage controller mode is suitable here.
  - b) Unplug controller supply voltages or operate controller via a separate external power supply used solely for this purpose.
  - c) If present, switch off unnecessary system components.
2. Have the measures shown in chap. 4.3.2, p. 67 been performed and tested?
  - a) Can a uniform earth potential be ensured, e.g., by using large cable cross sections?
  - b) Is the RF quality of the connections ensured?
    - Establish connection through metal-to-metal connection elements.
    - Remove paints or other insulating materials. Check that the shield connection is correct.
3. Were the recommended cables used?
  - a) Select motor cables in the accessory catalog.
  - b) Motor cables must be shielded as they otherwise act as an antenna.

Unshielded cables could cause interference in the surrounding area. If uncertain, the shield can be doubled; for further information, see FAULHABER accessories catalog and chap. 4.3.4, p. 69.
4. Are the contacts correctly screwed down or properly plugged in?
5. Are the cables laid in accordance with the standards/directives (e.g., IPC-A-620B-2013)?
  - a) Sensor cables and encoders are to be laid at least 10 cm from the motor phases.
  - b) Lay sensor cables at least 10 cm from all other signal cables that are not also sensor cables. Alternatively, use absolute encoders and/or line drivers.
  - c) Keep cables away from high-voltage current and mains cables.
  - d) Only cross cables at an angle of 90°.
6. Is it necessary to use filters?
  - a) Use filters in the case of poor signal quality or if interference occurs/is to be expected.
  - b) Note the product listing in chap. 4.3.5, p. 72.

## Installation

### Conformity measurements

The following points must be observed during the conformity measurement:

Conducted interference voltage measurement	Radiated interference voltage measurement
<ul style="list-style-type: none"> <li>▪ When laying cables, remove all loops.</li> <li>▪ Lay the cables with a meandering shape.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Where possible, lay cables over an earth plate.</li> </ul>
<ul style="list-style-type: none"> <li>▪ Connect the shield of the motor cable on the motor side and as close as possible on the controller side.</li> <li>▪ The shield is to be connected over a large area, ideally with a round connection.</li> </ul>	<ul style="list-style-type: none"> <li>▪ The connection of the motor cable shield is to be as short as possible</li> <li>▪ Keep the motor cable as short as possible.</li> </ul>
<ul style="list-style-type: none"> <li>▪ Use an input filter. When selecting, pay attention to the difference of filter attenuation between 50 <math>\Omega</math> and realistic values 1/100 <math>\Omega</math> or 100/1 <math>\Omega</math> measurement.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Use a motor filter and keep the connection as short as possible.</li> </ul>
<ul style="list-style-type: none"> <li>▪ If possible, secure cable with shield clamps or with adhesive tape.</li> </ul>	

## Maintenance and diagnostics

### 5 Maintenance and diagnostics

#### 5.1 Maintenance tasks

The drive is generally maintenance-free. Where the device is mounted in a cabinet, depending on the deposition of dust the air filter should be regularly checked and cleaned if necessary.

#### 5.2 Diagnosis

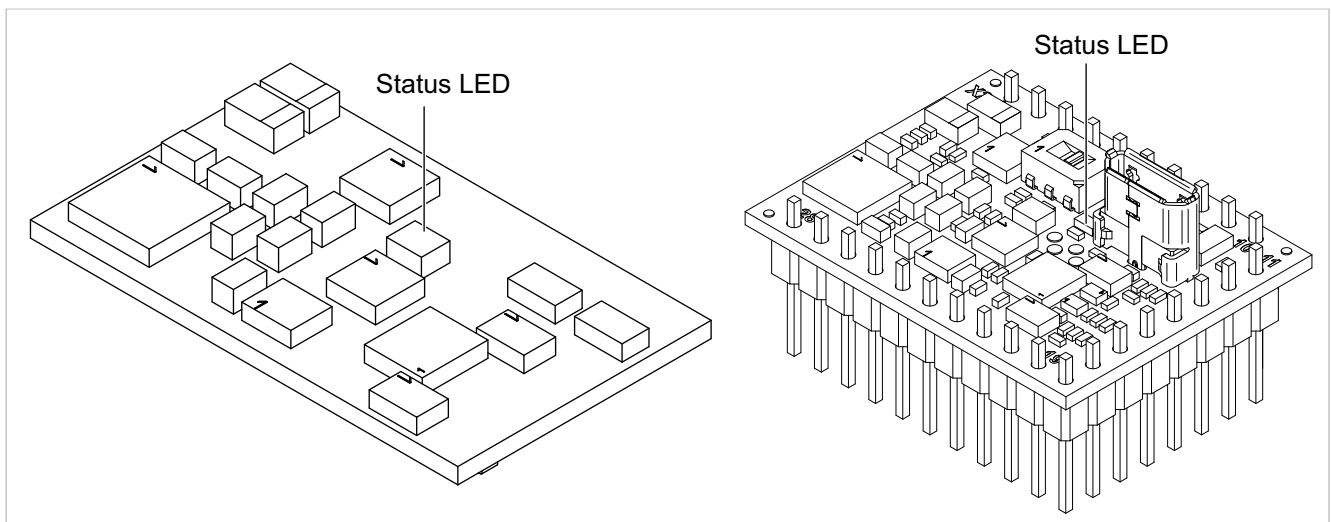


Fig. 36: Status LED standard PCB MC 3001 B (left) and MC 3001 P (right)

Tab. 88: LED overview

Designation	Function
State LED	<ul style="list-style-type: none"> <li>Green (continuous light): Device active.</li> <li>Green (flashing): Device active. However the state machine has not yet reached the <i>Operation Enabled</i> state.</li> <li>Red (continuously flashing): The drive has switched to a fault state. The output stage will be switched off or has already been switched off.</li> <li>Red (error code): Booting has failed. Please contact FAULHABER Support.</li> </ul>



The status LED is located below the product sticker. Even so, it is easily visible during operation.

#### 5.3 Troubleshooting

If unexpected malfunctions occur during operation according to the intended use, please contact your support partner.

### **6 Accessories**

Details of the following accessory parts can be found in the Accessories Manual:

- Connection cables
- Connector sets
- Additional equipment
- Motherboards, see Tab. 7

## Warranty

---

### **7 Warranty**

Products of the company Dr. Fritz Faulhaber GmbH & Co. KG are produced using the most modern production methods and are subject to strict quality inspections. All sales and deliveries are performed exclusively on the basis of our General Conditions of Sale and Delivery which can be viewed on the FAULHABER home page <https://www.faulhaber.com/gtc> and downloaded from it.



## Additional documents

### 8 Additional documents

#### 8.1 Declaration of Conformity

##### **EG–Konformitätserklärung** **EC Declaration of Conformity**

Dokument-Nr./Monat.Jahr:  
*Document-No./Month. Year:*

EG-00016-0001 / 04.2021

Der Hersteller:  
*The manufacturer:*

**Dr. Fritz Faulhaber GmbH & Co. KG**  
Daimlerstr. 23/25  
D-71101 Schönaich  
Germany

erklärt hiermit, dass das folgende Produkt  
*declares that the following product*

Produktbezeichnung:  
*Product designation:*

**MC3001B RS/CO**  
**MC3001P RS/CO**

Produkttyp:  
*Product type:*

**Motorcontroller**  
**Motor controller**

den wesentlichen Schutzanforderungen entspricht, die in der/den nachfolgenden Richtlinie(n) festgelegt sind:  
*fulfills the essential protection requirements defined within the following directive:*

**EMV-Richtlinie 2014/30/EU**  
**EMC-Directive 2014/30/EU**

Die Einhaltung dieser Richtlinie(n) setzt die Umsetzung aller in der technischen Dokumentation genannten Maßnahmen voraus.  
*The measures indicated in all technical documents must be fulfilled in order to meet the requirements of this directive.*

Diese Erklärung gilt für alle Exemplare, die in verschiedenen Leistungsdaten in dieser Serie hergestellt werden.  
*This statement should be valid for all derivatives produced according to the related construction drawings and electrical drawings, which are part of the technical documentation.*

Die Konformität wird in Bezug auf folgende angewandte harmonisierte Normen erklärt:  
*The declared conformity relates to the following harmonized standards*

- Anhang A / „Dokumentidentifikation“
- Annex A / Document identification

Die Anlage ist Bestandteil dieser Erklärung.  
*The annex is a component of this declaration.*

Schönaich,

09.02.2021  
(Datum)  
(date)

Dr. Thomas Bertolini,  
Geschäftsführung  
(Name, Chairman)

  
(Unterschrift)  
(signature)

## Additional documents

### **Anhang A zur Konformitätserklärung** ***Annex A to Declaration of Conformity***

Dokument-Nr./Monat.Jahr:  
*Document-No./Month. Year:*

EG-00016-0001 / 04.2021

Die Übereinstimmung mit den genannten EG-Richtlinien wurde durch Überprüfung gemäß nach folgender Fachgrundnorm nachgewiesen:

*The conformity with the EC guidelines was proven according to the following standards:*

Fundstelle <i>Document</i>	Ausgabedatum <i>Date of issue</i>	Richtlinienbezug <i>Related to directive</i>
EN 61800-3	2018	EMV Richtlinie EMC directive

## Additional documents

### 8.2 Declaration of Incorporation

**Einbauerklärung nach Anhang II B,  
EG-Maschinenrichtlinie 2006/42/EG**  
*Installation Declaration according to Appendix II B,  
EC Machinery Directive 2006/42/EC*

Dokument-Nr./Monat.Jahr:  
*Document No./Month.Year:*

EG-00017-001 / 04.2021

Der Hersteller:  
*The manufacturer:*

**Dr. Fritz Faulhaber GmbH & Co. KG**  
Daimlerstr. 23/25  
D-71101 Schönaich  
Germany

erklärt hiermit, dass es sich beim nachfolgend bezeichneten Produkt um eine Einbaukomponente (siehe unten) handelt und diese zum Einbau in eine Maschine bestimmt ist. Die Inbetriebnahme dieser unvollständigen Maschine ist solange untersagt, bis festgestellt wurde, dass die Gesamtmaschine, in die diese Komponente eingebaut werden soll, den grundlegenden Schutzanforderungen der hier genannten EG-Maschinenrichtlinie 2006/42/EG entspricht.

*herewith declares that the product designated below is an installable component (see below), and that it is intended for installation in a machine. It is prohibited to bring this incomplete machine into service until it has been proven that the machine as a whole in which this component is to be installed meets the basic safety requirements of the here mentioned EC Machinery Directive 2006/42/EC.*

Einbaukomponente:  
*Installable component::*

**MC3001B RS/CO**  
**MC3001P RS/CO**

Produkttyp:  
*Product type:*

**Motion Controller** (mit angeschlossenem Antrieb)  
**Motion Controller** (with attached electrical drive)

Gemäß Anhang VII Teil B der EG-Maschinenrichtlinie 2006/42/EG wurden spezielle technischen Unterlagen für diese unvollständige Maschine erstellt. Durch begründetes Verlangen einzelstaatlicher Stellen können diese in elektronischer Form übermittelt werden.

*Pursuant to Appendix VII, Part B of the EC Machinery Directive 2006/42/EC, specific technical documents have been created for this incomplete machine. On reasoned request by national authorities these documents may be transmitted in machine-readable format.*

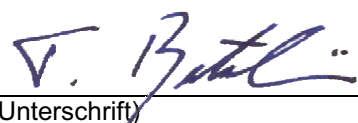
Der Bevollmächtigte für die Zusammenstellung und Übermittlung der relevanten technischen Unterlagen ist:  
*The person responsible for the compilation and transmission of the relevant technical documents is:*

Dr. Thomas Bertolini, Dr. Fritz Faulhaber GmbH & Co. KG, Daimlerstr. 23/25, 71101 Schönaich, Germany.

Schönaich,

09.02.2021  
(Datum)  
(Date)

Dr. Thomas Bertolini,  
Geschäftsführung  
(Name, Chairman)

  
(Unterschrift)  
(Signature)

