FAULHABER

Technical Manual

22xx...BX4 CSD/CCD/COD

32xx...BX4 CS/CC/CO

3564...B CS/CC/CO

WE CREATE MOTION

EN

Imprint

Version:
4th edition, 22.05.2023

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

Content

Content

1 About this document

1.1 Validity of this document

This document describes the installation and use of the following series:

- 22xx...BX4 CSD/CCD/COD
- 32xx...BX4 CS/CC/CO
- 3564...B CS/CC/CO

This document is intended for use by trained experts authorized 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
Communications manual	Interface description – RS232
Communications manual	Interface description – CANopen with FAULHABER channel
Communications manual	Interface description – CANopen CiA 402
Software manual	Operating instructions for FAULHABER Motion Manager PC software

These manuals can be downloaded in pdf format from the web page 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.

1.4 List of abbreviations

Abbreviation	Meaning
AnIn	Analog input
AGND	Analog Ground
CAN	Controller Area Network
CAN_L	CAN-Low
CAN_H	CAN-High
CC CCD	Controller with CANopen interface (Faulhaber channel)
CO COD	Controller with CANopen interface acc. to CiA 402
CS CSD	Controller with serial RS232 interface
DigIn	Digital input
DigOut	Digital output
EMC	Electromagnetic compatibility
ESD	Electrostatic discharge
FAULT	Fault output
GND	Ground
PLC	Programmable Logic Controller
PWM	Pulse Width Modulation
RxD	Receive Data
TTL	Transistor Transistor Logic
TxD	Transmit data

1.5 Symbols and designations

⚠ DANGER!

Danger with high level of risk: if not avoided, death or serious injury will result.

- Measures for avoidance

⚠ WARNING!

Danger with medium level of risk: if not avoided, death or serious injury may result.

- Measures for avoidance

⚠ CAUTION!

Danger with low level of risk: if not avoided, minor or moderate injury may result.

- Measures for avoidance

NOTICE!

Risk of damage.

- Measures for avoidance

Instructions for understanding or optimizing 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 for control and positioning tasks for the following motors:

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

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

- DC-motors
- 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.

2.2 Safety instructions

In addition to the safety risks described in this technical manual, machine-specific dangers could arise that cannot be foreseen by the manufacturer of the Motion Controller (e.g., risk of injury from driven components). The manufacturer of the machine in which the Motion Controller is installed must perform a risk analysis in accordance with the regulations applicable to the machine and inform the end user of the residual risks.

2.2.1 Dangers in the event of damages and changes

Damage to the Motion Controller can impair its functions. A damaged Motion Controller can unexpectedly start, stop or jam. This can result in damage to other components and materials.

- Do **not** start up a drive system with a defective or damaged Motion Controller.
- Appropriately mark a defective or damaged Motion Controller.
- Do **not** replace defective or damaged components of the Motion Controller.
- Make no changes (modifications, repairs) to the Motion Controller.
- Have loose or defective connections immediately replaced by an electrician.
- After replacing a defective or damaged Motion Controller, test and document the correct function.

2.2.2 Correct installation and commissioning

Errors during the installation and commissioning of the Motion Controller could impair its function. An incorrectly installed Motion Controller can unexpectedly start, stop or jam. This can result in damage to other components and materials.

- Follow the instructions for installation and commissioning given in these installation instructions exactly.
- Only have work on electrical operating equipment performed by an electrician.
- During all work on the electrical equipment, observe the 5 safety rules:
  a) Disconnect from power
  b) Secure against being switched on again
  c) Check that no voltage is present
  d) Ground and short-circuit
  e) Cover or block-off adjacent parts that are under voltage

Electrostatic discharges can damage the electronics.

- Store and transport the Motion Controller in suitable ESD packaging.
- Handle the Motion Controller in compliance with the ESD handling regulations (e.g. wear an ESD wristband, ground surrounding components).
- During installation, ensure that components in the surroundings cannot be electrostatically discharged.

Soiling, foreign bodies, humidity and mechanical influences can damage the electronics.

- Keep foreign objects away from the electronics.
- Install the Motion Controller in a housing that protects it from mechanical influences and is adapted to the ambient conditions (protection class determination).

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

Incorrect connection of the pins can damage the electronic components.

- Connect the wires as shown in the connection assignment.

2.2.3 Heat development

Active components may cause the Motion Controller to heat up. If touched, there is a risk of burning.

- Protect the Motion Controller against being touched and cool sufficiently.
- If necessary, affix a suitable warning sign in the immediate vicinity of the controller.

Fig. 1: Suitable warning sign acc. to DIN EN ISO 7010

2.3 Environmental conditions

- Select the installation location so that clean dry air is available for cooling the motor.
- 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 motor.
- Select a power supply that is within the defined tolerance range.
- Protect the motor against heavy deposits of dust, in particular metal dust and chemical pollutants.
- Protect the motor against humidity and wet.

2.4 EC directives on product safety

- The following EC directives on product safety must be observed.
- If the Motion Control Systems are 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 this technical manual 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 harmonized 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. 42.

WEEE Directive (2012/19/EU)
The directive on the disposal of electrical and electronic devices prescribes the separate collection of old electrical and electronic devices. The products described in this technical manual fall within the scope of this directive.

3 Product description

3.1 General product description

The drive systems integrate a brushless DC servomotor, a high-resolution actual value encoder and a Motion Controller in a compact, complete drive unit.

The motor commutation is achieved electronically so that the service life of a FAULHABER Motion Control Systems depends mainly on the service life of the motor bearings. FAULHABER uses high-precision, preloaded ball bearings in all of its systems with integrated Motion Controller. The following factors influence the service life of the bearings:

- Static, dynamic, axial and radial bearing loads
- Thermal environmental conditions
- Speed
- Vibrational and shock loads
- Level of precision to which the shaft is coupled to the given application

For highly dynamic servo applications requiring very high torque in the most compact dimensions, the integrated FAULHABER BX4 Series 4-pin DC-Servomotors are recommended. They have the following features:

- Robust design with just a few components
- Adhesive-free construction
- Long service life
- Ideal for hostile ambient conditions (e.g. extreme temperatures and high vibrational and shock loads)

Thanks to their robust construction and their compact design, the FAULHABER Motion Control Systems of the V2.5 generation are perfectly suited for use in automation applications.

As an option, the motor and control electronics can be supplied with power separately (important for safety-relevant applications). In this case, the 3rd input is no longer available.

Depending on the drive, additional programming adapters and connection aids are available.

Special preconfiguration of the modes and parameters is possible on request.

3.2 Product information

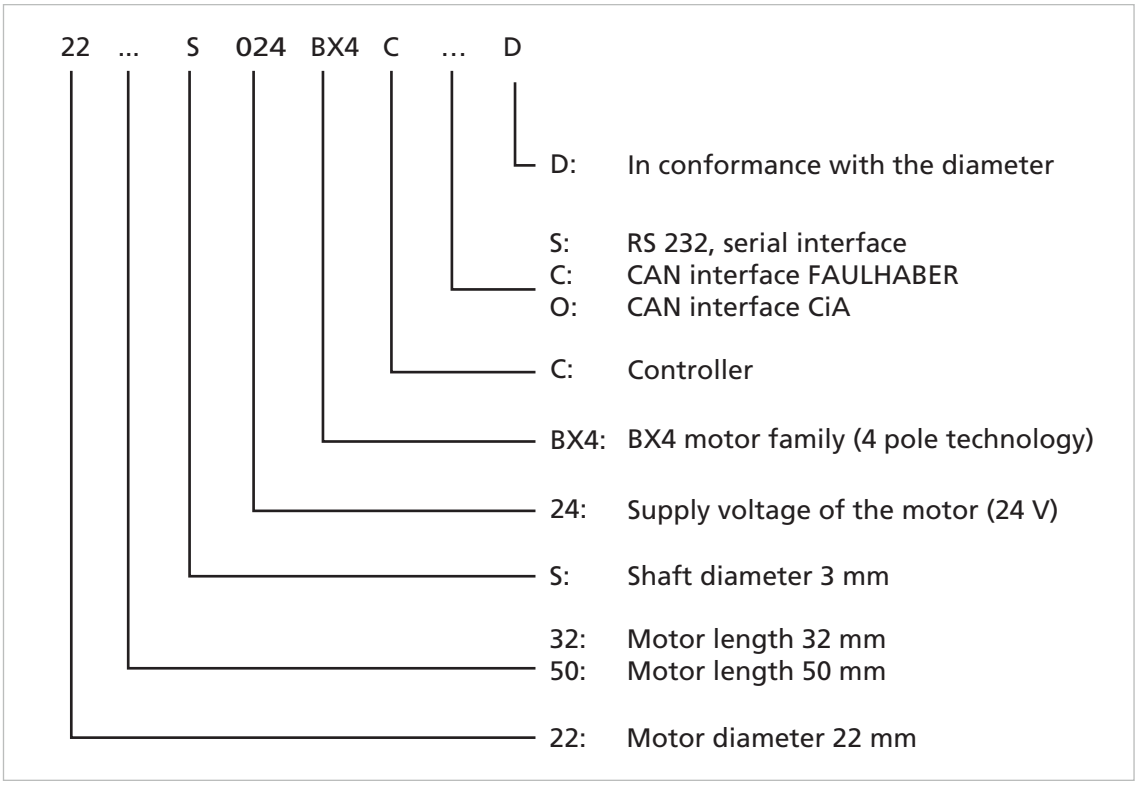


Fig. 2: Designation key for motor series 22xx

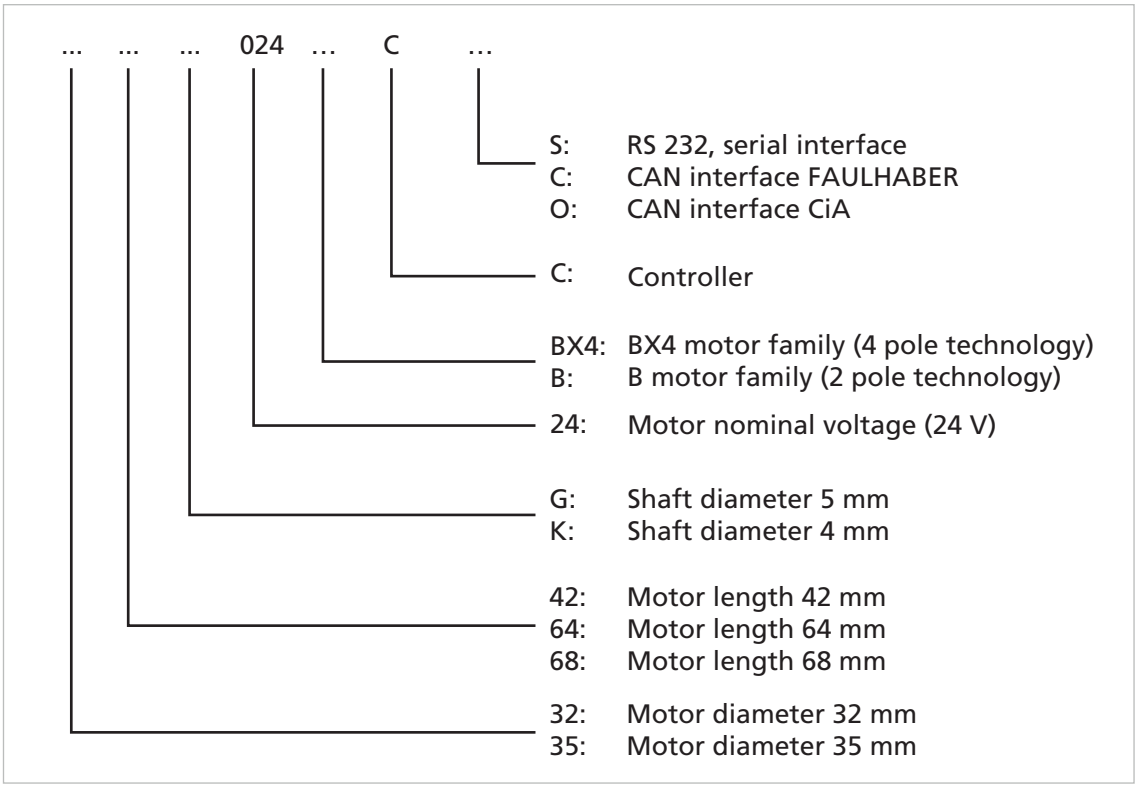


Fig. 3: Designation key for motor series 32xx and 3564

3.3 Product variants

Tab. 1: Product variants – Motion Control Systems

Motor series	Sensors	Speed range (min^{-1}) [a]	Power supply Electronics/motor (V DC) [b]	Peak current (A) [c]
2232…BX4 CxD	Analog Hall	5…8 000	8…30	3
2250…BX4 CxD	Analog Hall	5…7 000	8…30	3
3242…BX4 Cx	Analog Hall	5…6 500	12…30	5
3268…BX4 Cx	Analog Hall	5…6 500	12…30	8
3564…B Cx	Analog Hall	5…12 000	12…30	8

a) Speed range depends on the power supply.

b) As an option, the motor and control electronics can be provided with separate power supplies, e.g. for safety-relevant applications (special number 2993). In this case, the 3rd input for digital signals is no longer available.

c) Depending on the cooling factor, operating point and ambient temperature, the current limitation parameter can be adapted using the FAULHABER Motion Manager. The specified values apply in the case of 22 °C ambient temperature and max. 60 °C motor temperature and the nominal voltage for motor and electronics.

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. 10).

4.1 Mounting

4.1.1 Mounting instructions

⚠ CAUTION!

The motor can become very hot during operation.

- Place a guard against contact and warning notice in the immediate proximity of the motor.
- Ensure that adequate heat dissipation is provided.

NOTICE!

Installation and connection of the motor when the power supply is applied can damage the device.

- Prior to all aspects of installation and connection work on the motor, switch off the power supply.

NOTICE!

The motor can be damaged if mounted incorrectly.

- Observe the maximum screw-in depth of the fastening screws (see Tab. 2).

NOTICE!

Excessive loads on the motor shaft can cause irreparable damage to the motor.

- When attaching parts to the motor shaft, observe the maximum permissible load values (see the product data sheet) of the shaft.

NOTICE!

Excessive radial loads on the servomotor or excessively tightened fastening screws can cause irreparable damage to the mounting flange.

- Observe the maximum permissible radial load on the motor (see Tab. 2).
- Make sure that the screws are tightened in accordance with Tab. 2.

4.1.2 Mounting the motor

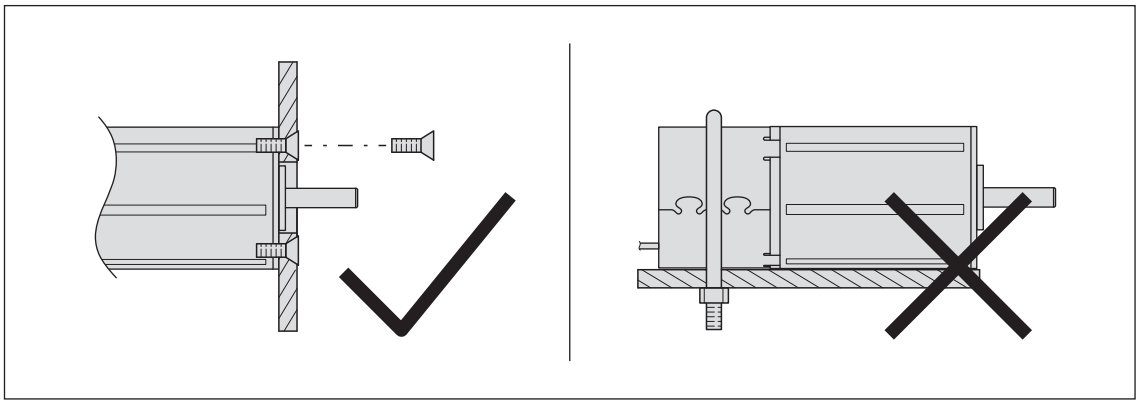


Fig. 4: Mounting example – 22xxBX4 CxD series

1. Secure the front flange of the motor to a suitable surface using fastening screws (for the screw size and torque, see Tab. 2).
2. Protect the fastening screws to prevent displacement due to the effect of heat.
3. If necessary, attach parts to the motor shaft.

Information on the used flange can be found in the product data sheet.

Tab. 2: Attachment specifications

Motor series	Screw type	Thread depth (mm)	Max. tightening torque (Ncm)	Radial motor load, max. (N)
22xx…BX4 CxD	M2	3.0	50	30
32xx…BX4 Cx	M3	4.0	50	30
3564…B Cx	M2	5.0	50	30

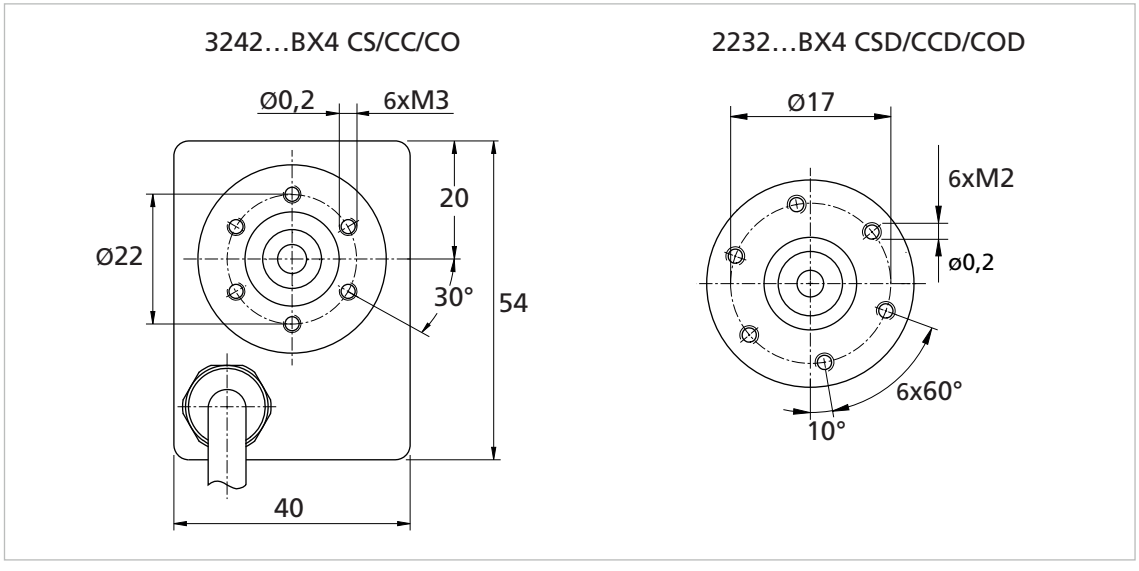


Fig. 5: Flange details (examples)

4.2 Electrical connection

4.2.1 Notes on the electrical connection

NOTICE!

Electrostatic discharges to the motor connections can damage the electronic components

- Observe the ESD protective measures.
- Carry out work only at ESD-protected workstations.
- Connect the connections as per the pin assignment (see chap. 4.2.3.1, p. 19)

NOTICE!

Risk of damage caused by back-induced voltage.

If the motor shaft is driven externally, the motor acts as a generator. The generated voltage can damage the electronics of the motor. The generated DC voltage (U_B) corresponds to the product of speed (n) and electromotive force constant (k_n).

- Connect the electronics supply of the motor to a power supply unit during installation or connect the U_B and GND connections to each other.
- Do not drive the motor above the specified maximum and nominal speed, even if a gearhead is used.
- Use an EMC suppressor circuit (see chap. 4.3, p. 30).

NOTICE!

Extreme static or dynamic loads on the connection cable can cause the cable to be damaged.

- Make sure that the connection cable is not subjected to abrasion, crushing or excessively tight bending radii during installation and operation.
- Do not bend the cable at temperatures < –10 °C.
- Comply with permissible loads (see Tab. 3).

Tab. 3: Permissible loads of the connection cables

Motor series	Cable type	Permissible loads
22xx…BX4 CxD	1.27 AWG26 Ribbon cable	Maximum tensile load: 30 N Continuous tensile load: <17 N Bending radius with repeated installation: >10 mm Bending radius with one-off installation: >1.2 mm

Motor series	Cable type	Permissible loads
32xx…BX4 Cx	8-wire AWG24 Round cable	Maximum tensile load: 50 N Continuous tensile load: <25 N Bending radius with repeated installation: >15 mm [a)] Bending radius with one-off installation: >15 mm[a)]
3564…B Cx	8-wire AWG24 Round cable	Maximum tensile load: 50 N Continuous tensile load: <25 N Bending radius with repeated installation: >15 mm [a)] Bending radius with one-off installation: >15 mm[a)]

a) Special version (e.g. for drag chain operation) on request

4.2.2 Electrical connection of motor

NOTICE!

Risk of damage caused by inadequately dimensioned power supply unit.

Using an inadequately dimensioned power supply unit can result in malfunctions.

- Make sure that the power supply unit is adequately dimensioned.

✓ The connection cables are <3 m

1. Take the appropriate EMC protective measures (see chap. 4.3, p. 30).
2. Take the appropriate ESD protective measures.
3. Connect the ribbon cable and round cable as per the pin assignment (see chap. 4.2.3.1, p. 19).
4. Connect the power supply as described in the explanation below.

There are 2 options for supplying power to the motor and the FAULHABER Motion Controller:

Power supply with common electronics supply

In the case of power supply with common electronics supply, the controller and motor are switched off simultaneously if a fault occurs. After interruption of the power supply, the reference run must be performed again.

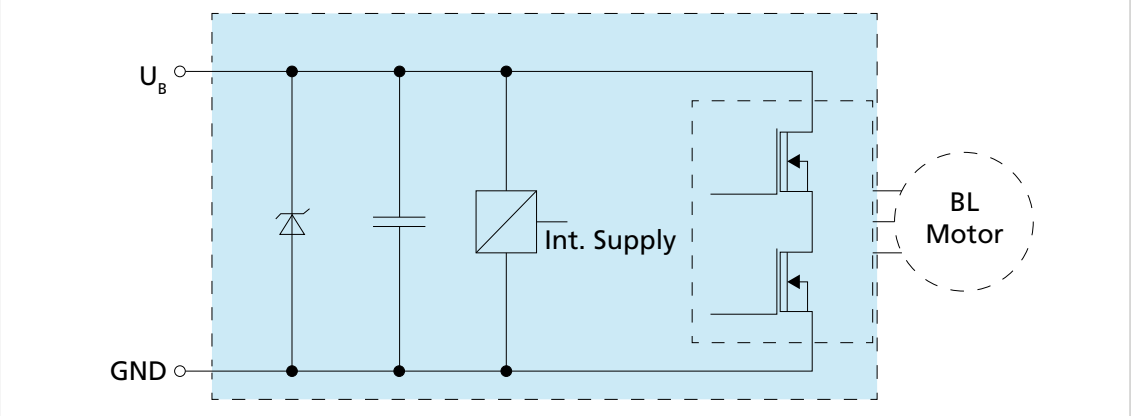


Fig. 6: Circuit diagram – common electronics supply

Power supply with separate electronics supply

In the case of power supply with separate electronics supply, the motor supply can be switched off (e.g. by means of a safety relay) in the event of a fault while the controller continues to be supplied. As a result, the reference run does not need to be performed again after a fault because the sensor supply of the motor was maintained during the fault. In the case of a separate electronics supply, power is supplied using the connection 3.In / U_{EL} in addition to the connection U_B. Motion Controllers with a separate electronics supply do not therefore have a third digital input.

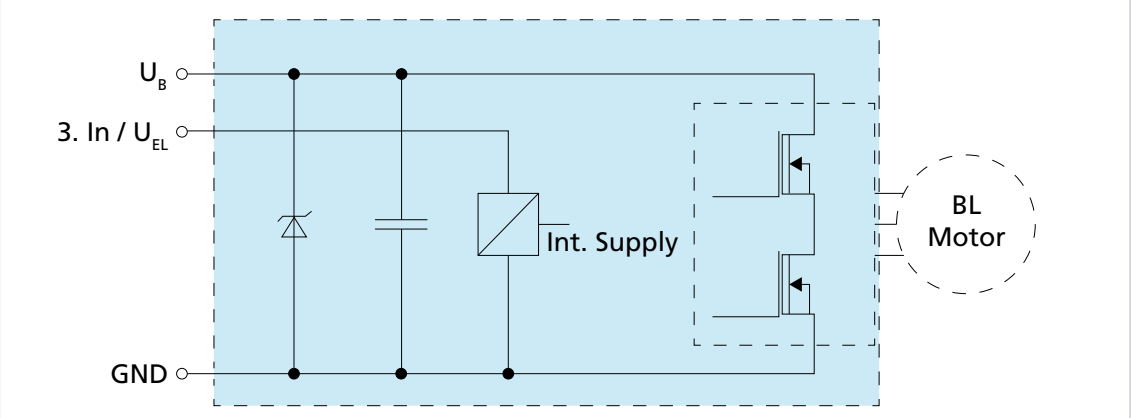


Fig. 7: Circuit diagram – separate electronics supply

4.2.3 Supply connections

4.2.3.1 Pin assignment

NOTICE!

Incorrect polarity can cause irreparable damage to the electronics

- Connect the motor in accordance with the pin assignment.

22xx...BX4 CxD

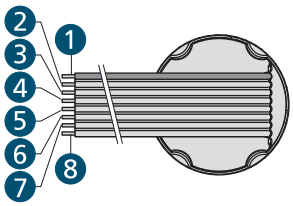
The signal level of the digital inputs can be reconfigured to TTL via the interface.

- Standard (PLC): low 0…4.5 V / high 12.5 V…U_B
- TTL: low 0…0.5 V / high 2.5 V…U_B

The following controller parameters are preset:

- Sampling rate: 200 µs
- Resolution of internal encoders: 3,000 lines per revolution

Tab. 4: Pin assignment of ribbon cable 22xx...BX4 CxD



Wire	Designation	Meaning
1 [a]	3. In	3rd input, optional electronics supply U_{EL}
2	U_B	Power supply
3	GND	Common ground
4	AnIn	Analog input
5	AGND	Analog GND
6	FAULT	Fault output
7	RxD/CAN-L	RS232 RxD/CAN-Low
8	TxD/CAN-H	RS232 TxD/CAN-High

a) Wire 1 is highlighted in a different color

Tab. 5: Electrical data for 22xx...BX4 CSD/CCD/COD

Wire	Designation	Value
1 (3. In)	Digital input	Input resistance R_{in} = 22 kΩ
	Power supply of the electronics [a]	8…30 V DC
2 (U_B)	Power supply	8…30 V DC
3 (GND)	Ground	Ground reference U_B
4 (AnIn)	Analog input for speed set value	Voltage signal ±10 V
	PWM input for speed set value	Frequency range 100…2,000 Hz Duty cycle 50%: 0 min^{-1}
	Digital input	Input resistance 5 kΩ / 24 V
	External encoder (CH A)	f_{max} = 400 kHz
	Input for step frequency	f_{max} = 400 kHz
5 (AGND)	Ground reference AnIn	
	External encoder (CH B)	f_{max} = 400 kHz
6 (FAULT)	Fault output	No fault ➞ switched through to GND
	Digital output	Open collector, max. U_B / 30 mA
	Digital input	Input resistance R_{in} = 100 kΩ
7 (RxD/CAN-L) [b]	Communication	RS232 RxD/CAN-L
8 (TxD/CAN-H) [b]	Communication	RS232 TxD/CAN-H

a) special number 2993

b) Wiring depends on the selected product CSD/CCD/COD

32xx...BX4 Cx and 3564...B Cx

The signal level of the digital inputs can be reconfigured to TTL via the interface.

- Standard (PLC): low 0…7.0 V / high 12.5 V…U_B
- TTL: low 0…0.5 V / high 3.5 V…U_B

The following controller parameters are preset:

- Sampling rate: 200 µs
- Resolution of internal encoders: 3,000 lines per revolution

Tab. 6: Pin assignment of round cable 32xx...BX4 CS/CC/CO and 3564...B CS/CC/CO

Color	Designation	Meaning
Red	3. In	3rd input, optional electronics supply U_{EL}
Pink	U_B	Power supply
Blue	GND	Common ground
Brown	AnIn	Analog input
Gray	AGND	Analog GND
White	FAULT	Fault output
Yellow	RxD/CAN-L	RS232 RxD/CAN-Low
Green	TxD/CAN-H	RS232 TxD/CAN-High

Tab. 7: Electrical data for 32xx...BX4 CS/CC/CO and 3564...B CS/CC/CO

Wire	Designation	Value
Red (3rd In)	Digital input	Input resistance R_{in} = 22 kΩ
	Power supply of the electronics [a]	12…30 V DC
Pink (U_B)	Power supply	12…30 V DC
Blue (GND)	Ground	Ground reference U_B
Brown (AnIn)	Analog input for speed set value	Voltage signal ±10 V
	PWM input for speed set value	Frequency range 100…2,000 Hz Duty cycle 50%: 0 min^{-1}
	Digital input	Input resistance 5 kΩ / 24 V
	External encoder (CH A)	f_{max} = 400 kHz
	Input for step frequency	f_{max} = 400 kHz
Gray (AGND)	Ground reference AnIn	
	External encoder (CH B)	f_{max} = 400 kHz
White (FAULT)	Fault output	No fault ➞ switched through to GND
	Digital output	Open collector, max. U_B / 30 mA
	Digital input	Input resistance R_{in} = 100 kΩ
Yellow (RxD/CAN-L) [b]	Communication	RS232 RxD/CAN-L
Green (TxD/CAN-H) [b]	Communication	RS232 TxD/CAN-H

a) special number 2993

b) Wiring depends on the selected product CS/CC/CO

4.2.3.2 I/O circuit diagrams

Analog input internal circuit

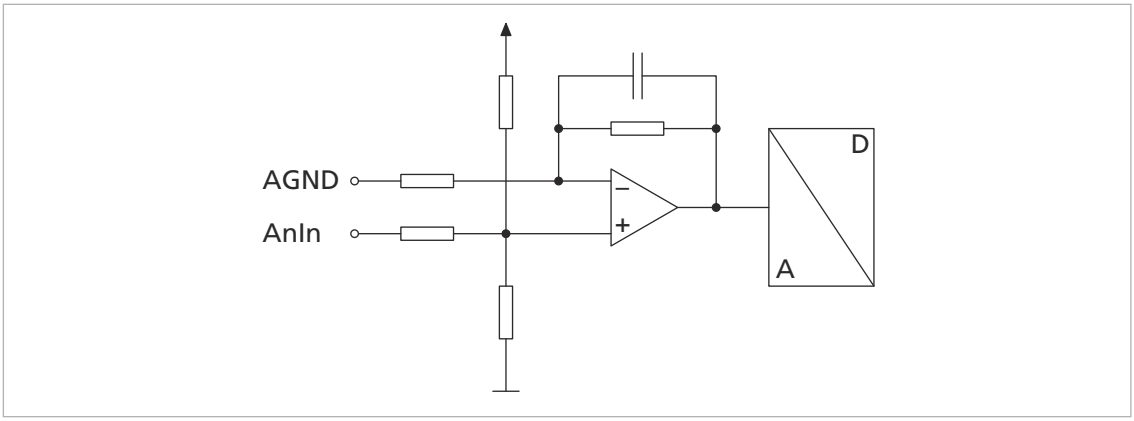


Fig. 8: Analog input circuit diagram (internal)

Evaluation of the analogue input (AnIn) is done by determining the difference relative to AGND.

- AGND must be connected to ensure safe operation.
- If AGND is switched directly to GND, the resulting signal can change if the voltage on the ground cable (GND) drops under load.
- Connect AGND directly to the reference point of the set-point source.
- Connect ground of the voltage source (GND).

Depending on the selected option and configuration, the analog input can have the following functions:

- Speed set value specification via analog voltage
- Speed set value specification via PWM signal
- Current limitation value via analogue voltage
- Specification of the set position via analogue voltage
- Digital input for reference and limit switches
- Connection for an external pulse encoder

Internal circuit – 3rd input

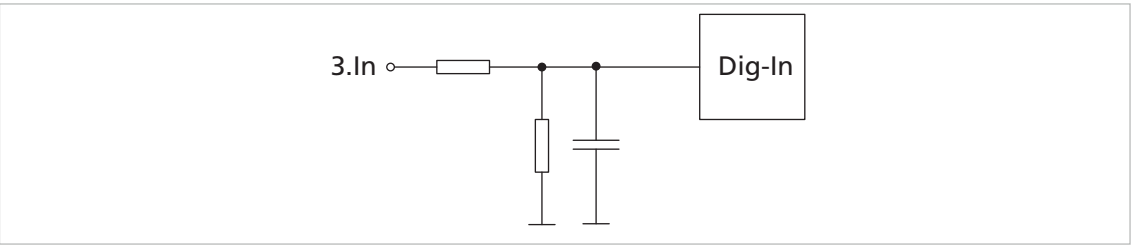


Fig. 9: Internal circuit – 3rd input

The input level of the digital input (3.In) can be switched (PLC/TTL). The digital input (3. In) can have the following functions:

- Digital input for reference and limit switches
- Input for the electronics voltage supply in the case of motor versions with separate electronics supply

Internal circuit – fault (Dig I/O)

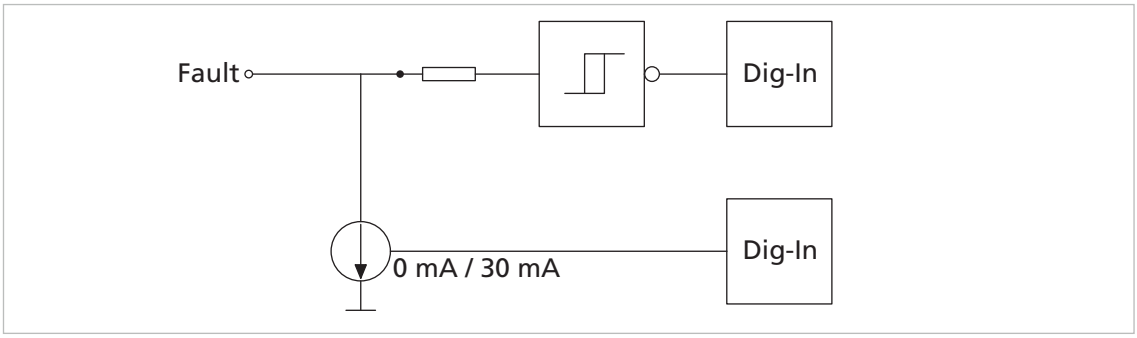


Fig. 10: Internal circuit – fault (Dig I/O)

NOTICE!

Damage to electronics

The electronics of the fault connection can be damaged in the following cases:

Fault output is not configured as an input and a voltage is being applied to the fault output.

Voltage applied at the fault output is greater than the power supply of the Motion Controller.

Voltage supply of the sensors is active while the power supply of the Motion Controller is inactive.

- Check the settings of the fault output before applying a voltage.
- Match the power supply of the sensors and of the Motion Controller to each other. The power supply of the sensors must not be greater than the power supply of the Motion Controller.

Recommendation: If the fault output is used as an input, connect an external resistor (1 kΩ/0.25 W) in series.

The fault output is factory-configured as an output. Before being wired as an input, the FAULT pin must be configured accordingly (see Communications Manual).

The fault output has the following features:

- Open collector switch to ground
- Output resistance in open state (high level): 100 kΩ
- Switch opens in the event of a fault (high level)
- Output current limited to approx. 30 mA. The voltage in the open state must not exceed the power supply (maximum U_B).
- Short-circuit-proof

The fault output can be configured for the following functions:

- Pulse output
- Digital output (freely programmable)
- Reference input or digital input
- Rotation direction input

4.2.3.3 Connection examples: 22xx...BX4 motor series

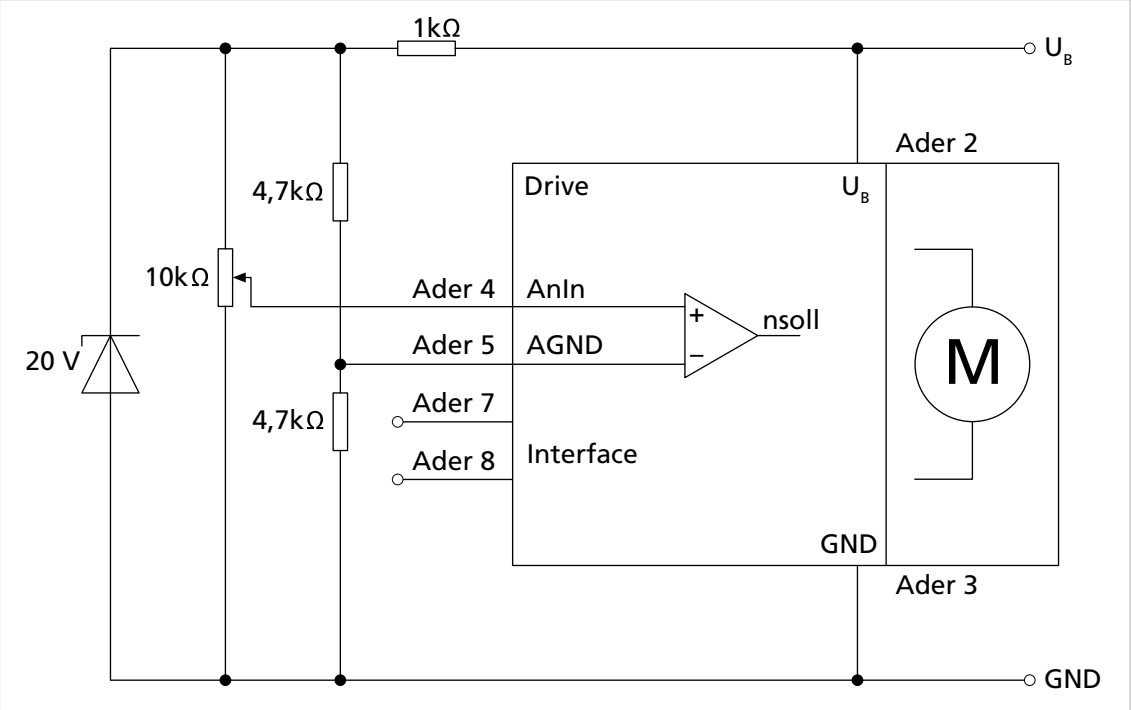


Fig. 11: Connection example of bipolar analog set value specification via potentiometer (22xx...BX4)

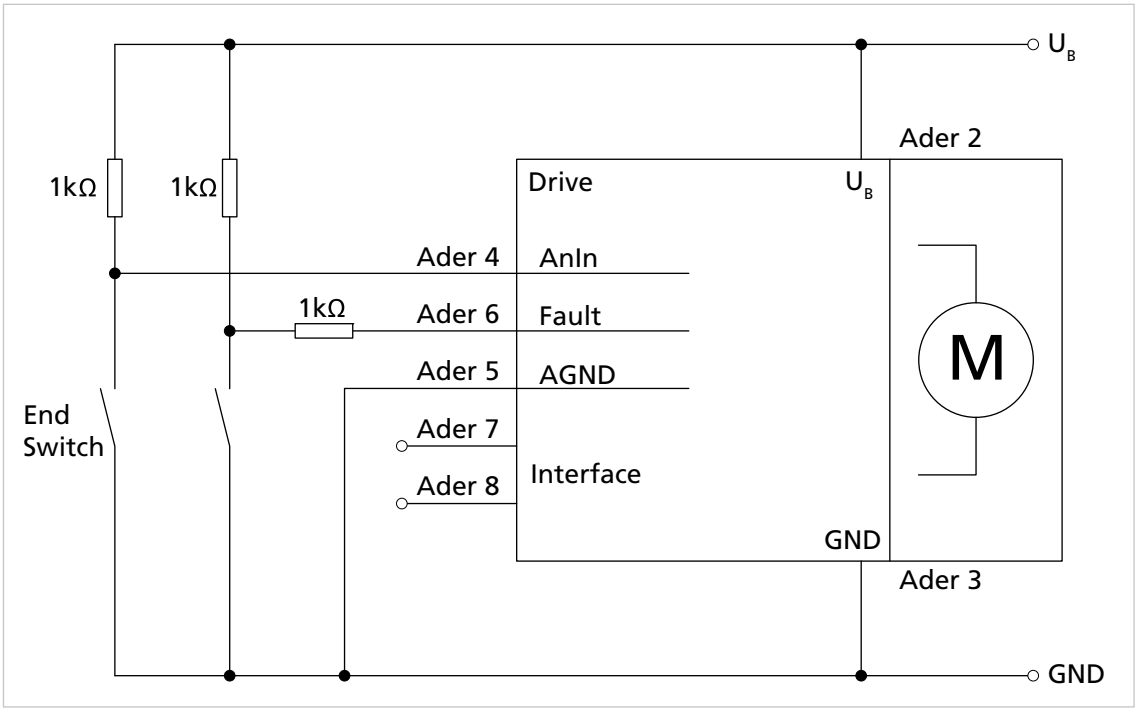


Fig. 12: Connection example: reference and limit switches (22xx...BX4)

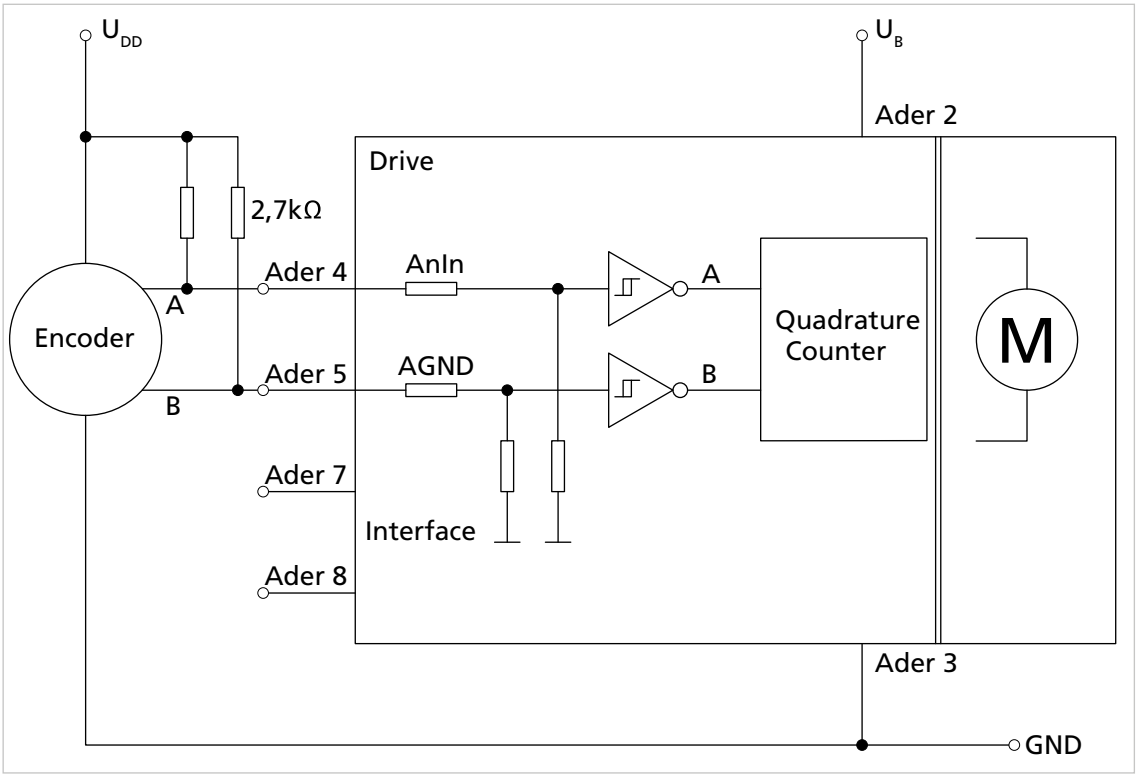


Fig. 13: Connection example: external encoder (22xx...BX4)

Depending on the type of encoder it may be necessary to use external pull-up resistors. No pull-up resistors are required for FAULHABER IE2, IE3 and IER3 encoders.

4.2.3.4 Connection examples: 32xx...BX4 motor series

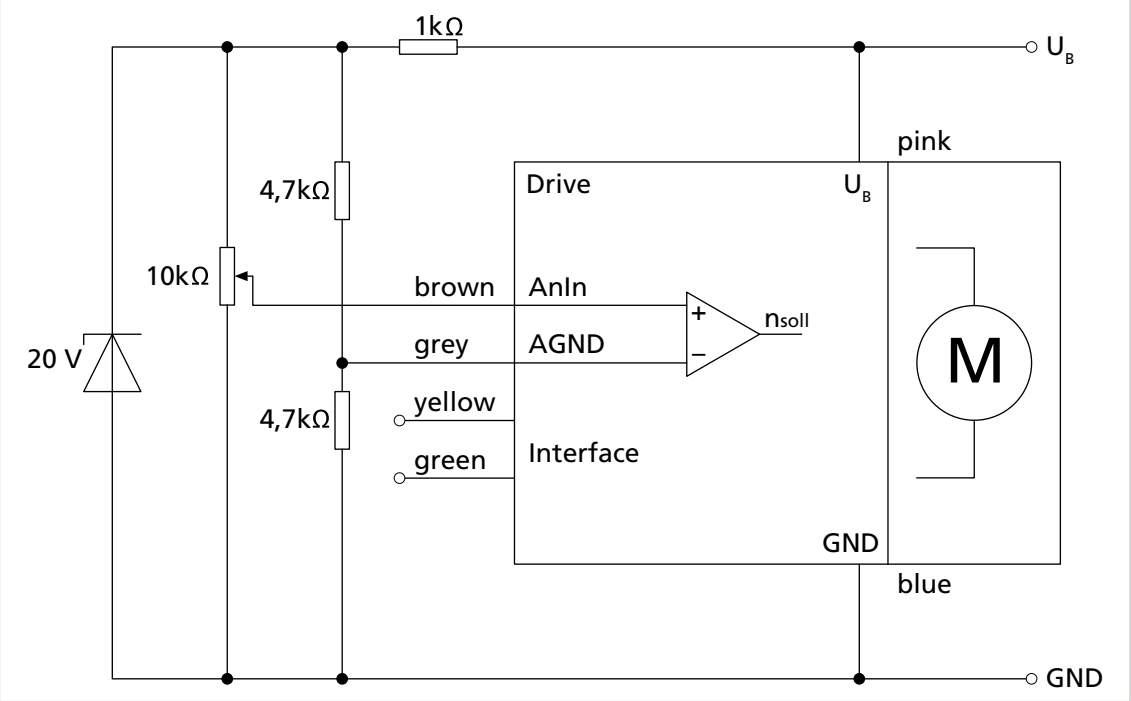


Fig. 14: Connection example of bipolar analog set value specification via potentiometer (32xx....BX4)

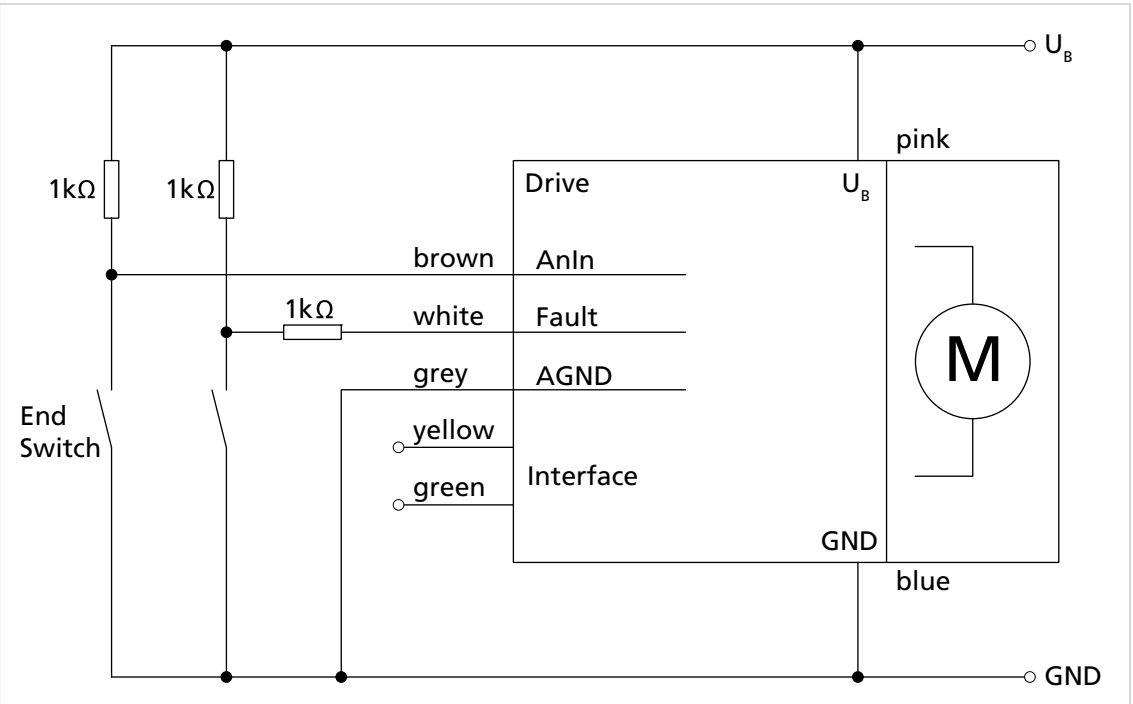


Fig. 15: Connection example: reference and limit switches (32xx...BX4)

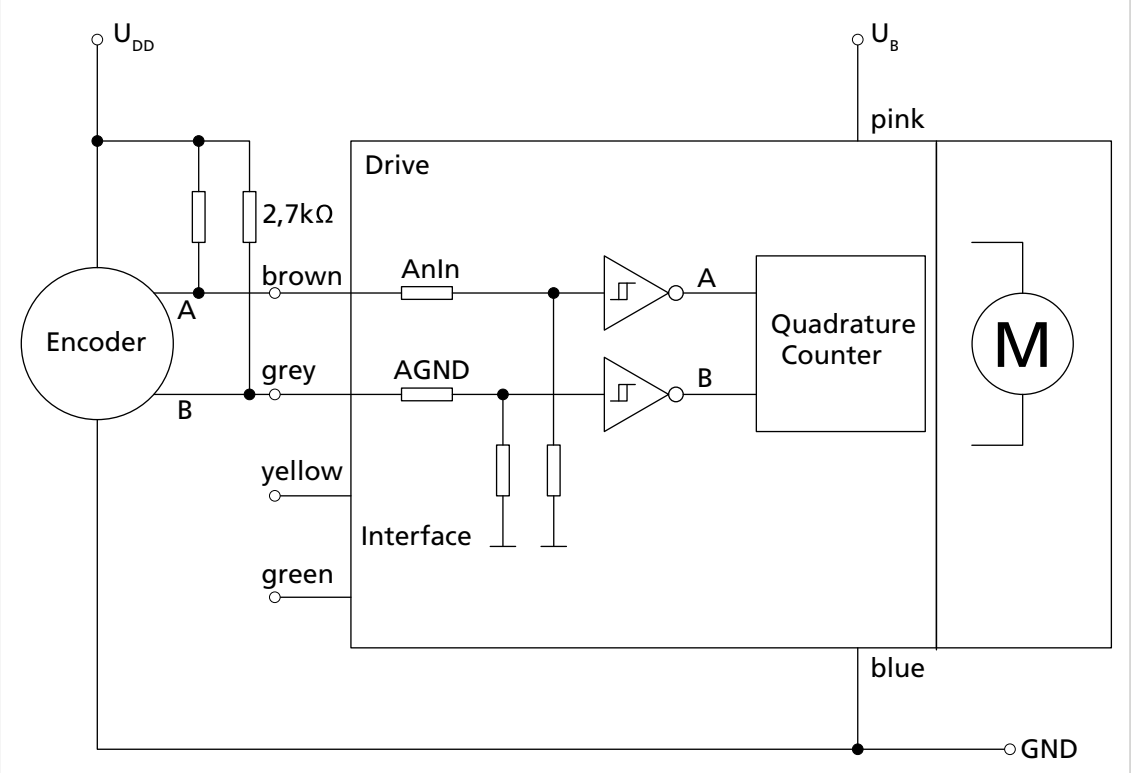


Fig. 16: Connection example: external encoder (32xx...BX4)

4.2.3.5 Connection examples: communication

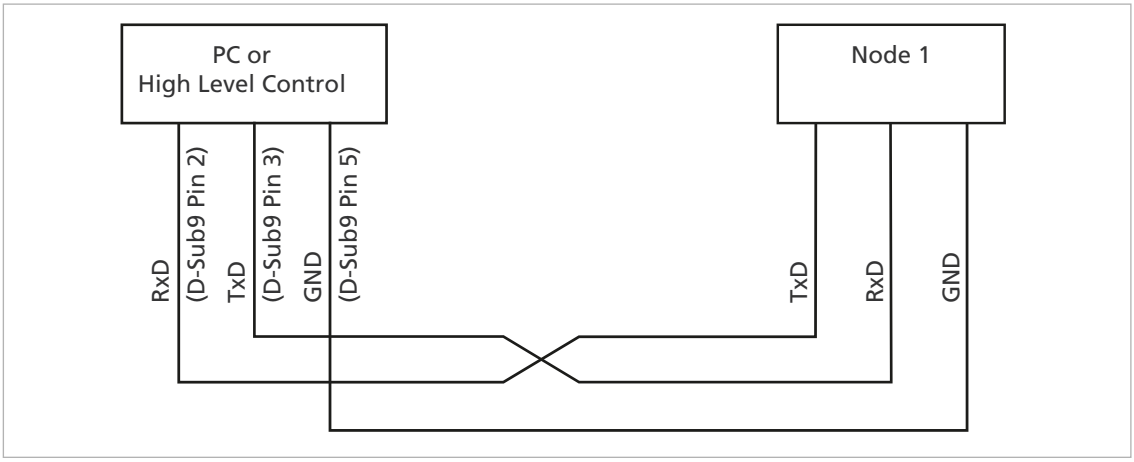


Fig. 17: Wiring between PC/controller and a drive

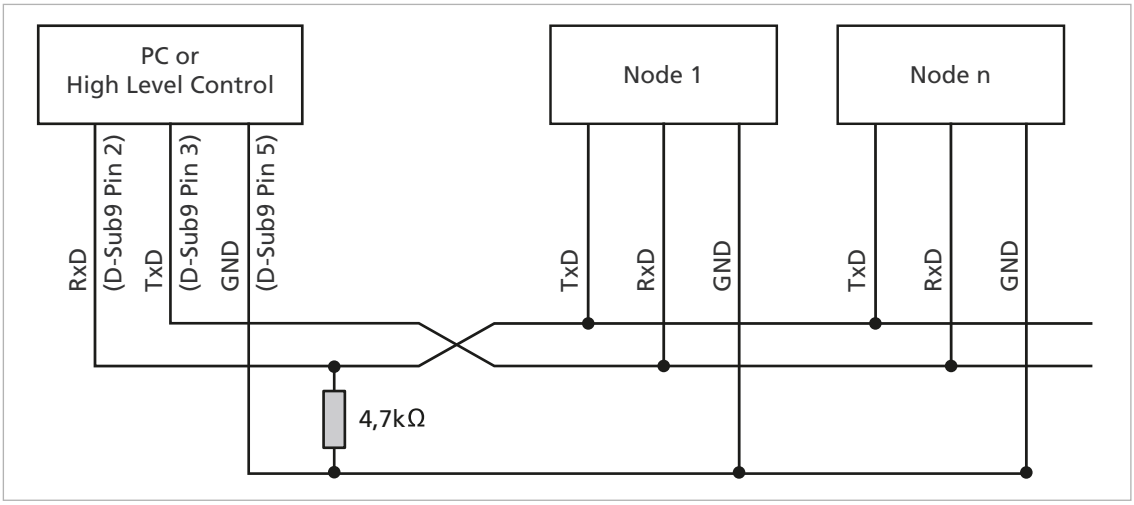


Fig. 18: Wiring with several Motion Control Systems in RS232 network operation

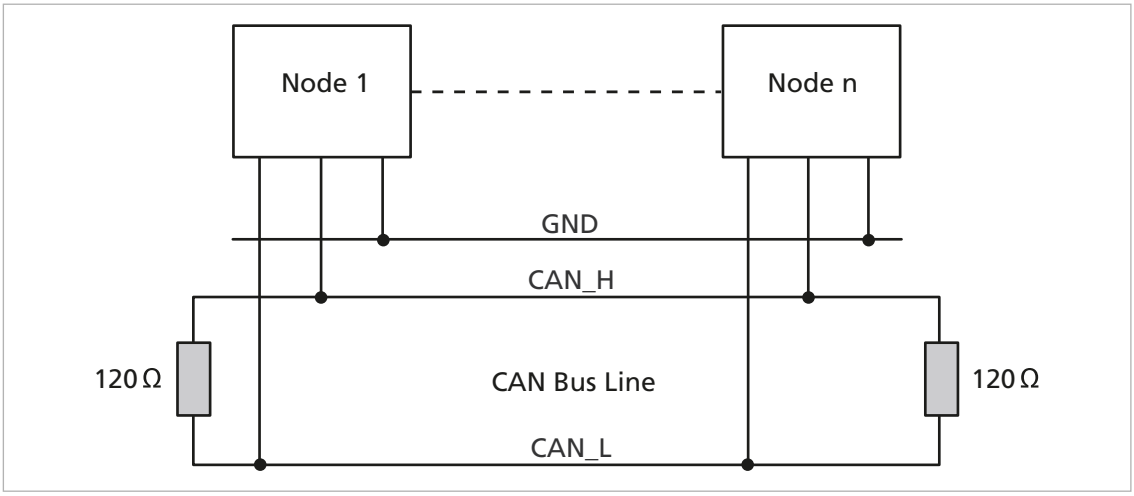


Fig. 19: Connection to the CANopen network

The baud rate and node number are set using the Motion Manager or by entering a command directly (see Communications Manual and Software Manual).

The maximum cable length is limited by the transfer rate and the signal propagation times acc. to Tab. 8.

Tab. 8: Maximum cable length as a function of baud rate

Baud rate (kBit/s)	Max. cable length (incl. stub cable)
1000	25 m
500	100 m
250	250 m
125	500 m
50	1000 m
25	2500 m
10	5000 m

CAN is a bus system to which all nodes are connected in parallel. A connection resistance of 120 Ω must be connected at both ends of the bus cable. In addition to the two signal lines CAN_H and CAN_L, the nodes also need to be connected to each other by means of a common GND cable.

- If several electrical devices or controllers are networked by means of RS232 or CAN, make sure that the potential difference between the ground potentials of the various parts of the system is less than 2 V.

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

- At least 6 mm^2
- Larger than half the cross-section of the supply conductor

4.3 Electromagnetic compatibility (EMC)

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

⚠ WARNING!

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

- Take appropriate interference suppression measures, particularly during use in residential environments.
- Observe the notices for EMC-compliant setup.

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 Functional earthing

⚠ DANGER!

Danger to life through ground leakage currents ≥3.5 mA

- Check the grounding of the devices for proper installation.

The grounding 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 ground connection so that the contact resistances are low not only for the low-frequency currents.

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

For electrical safety:

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

For functional earthing:

- Use a braided shield that is meshed as tightly as possible.
- Direct contact with the grounding plate is to be preferred.

  Therefore, avoid contact with the controller and then with the grounding plate.
- Connections made over a large surface area are to be preferred.

4.3.2 Cable routing

⚠ WARNING!

Voltages >25 V AC are generated and transmitted in the drive system.

- Set up the wiring of the drive system in a touch-proof manner.
- Only operate the drive system on an SELV or PELV power supply network.

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).

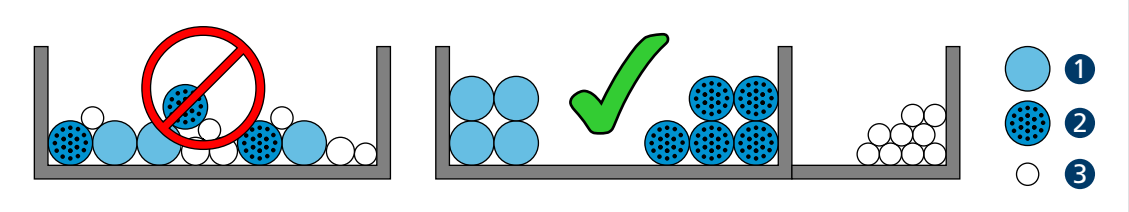


Fig. 20: Laying in the cable duct

1 High-current cable
2 Digital cable
3 Sensor cable

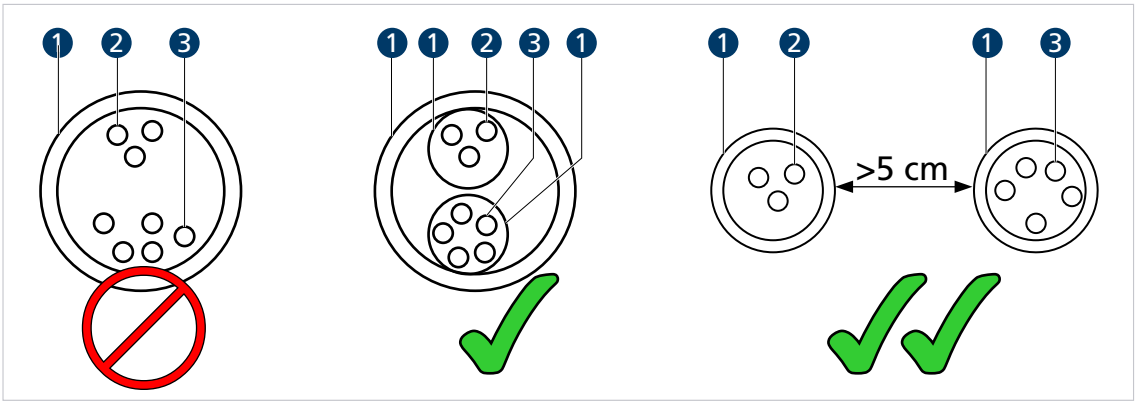


Fig. 21: Grouping and shielding of the cables

1 Shielding
2 Motor phase
3 Hall sensor

4.3.3 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) grounding bar or grounding plate.

  A connection to the controller housing should only be made if no grounding bar is available.

- Establish a star-point ground connection.

- 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. 22).

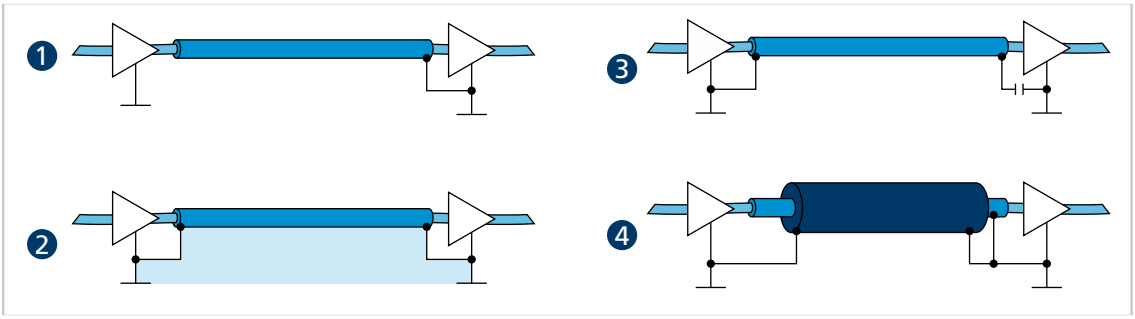


Fig. 22: Various possibilities for the shield connection

1 Suppressing electrical fields
2 Alternating magnetic field
3 Interruption of the ground 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. 22). A solution such as 2 in Fig. 22 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. 22). In this case, do not connect the shield multiple times except at the motor connection and controller side.

4.3.3.1 Establishing the shield connection

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

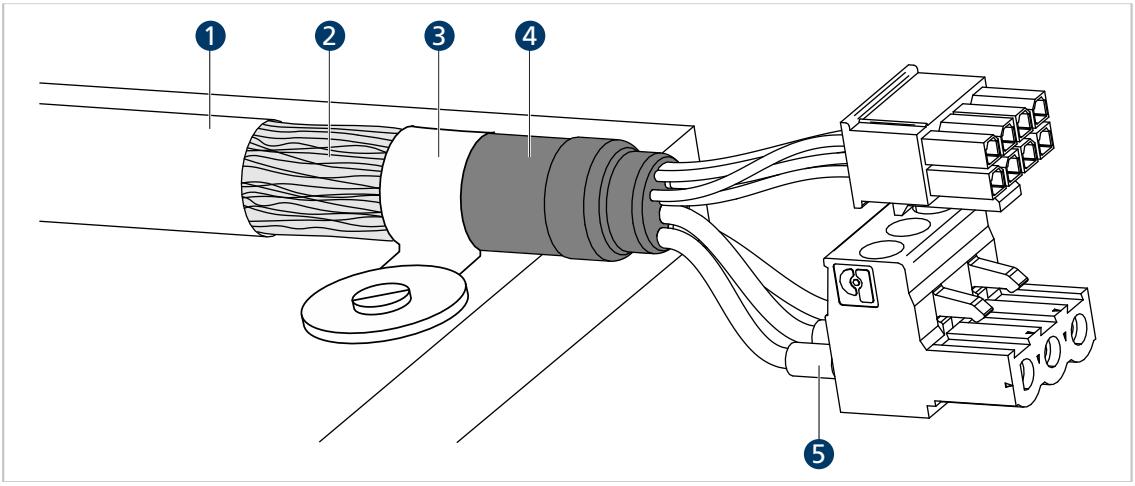


Fig. 23: Motor cable shield connection

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

1. Remove approx. 50-100 mm from the outer cable shield (1). Make certain that none of the fibers 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).

4.3.3.2 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.

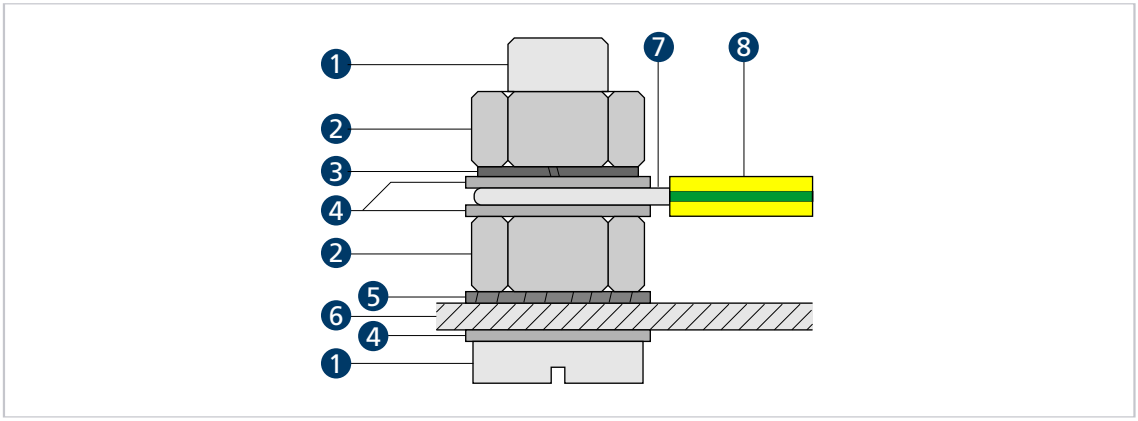


Fig. 24: Shield connection with cable lug

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.

4.3.4 Using filters

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

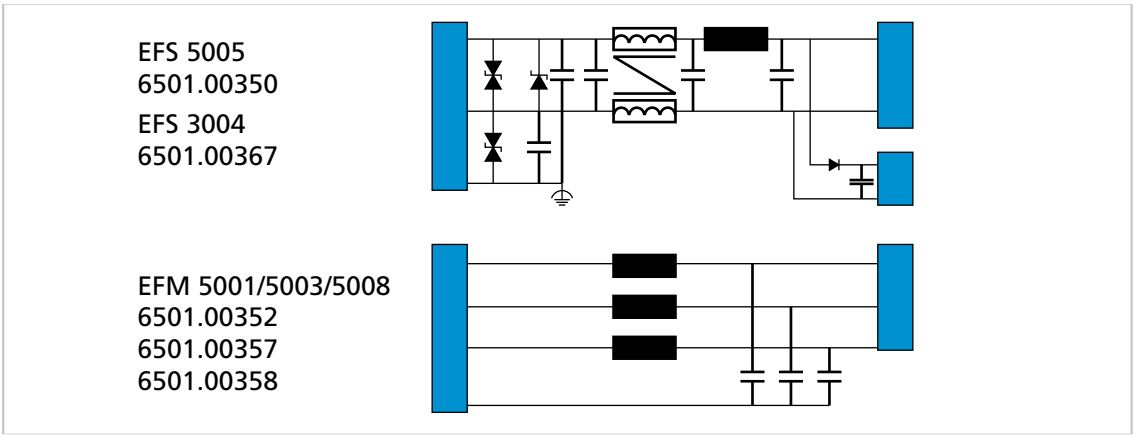


Fig. 25: Filter categories from FAULHABER

4.3.4.1 Input-side filters

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 µF) 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

4.3.4.2 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.

4.3.4.3 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.

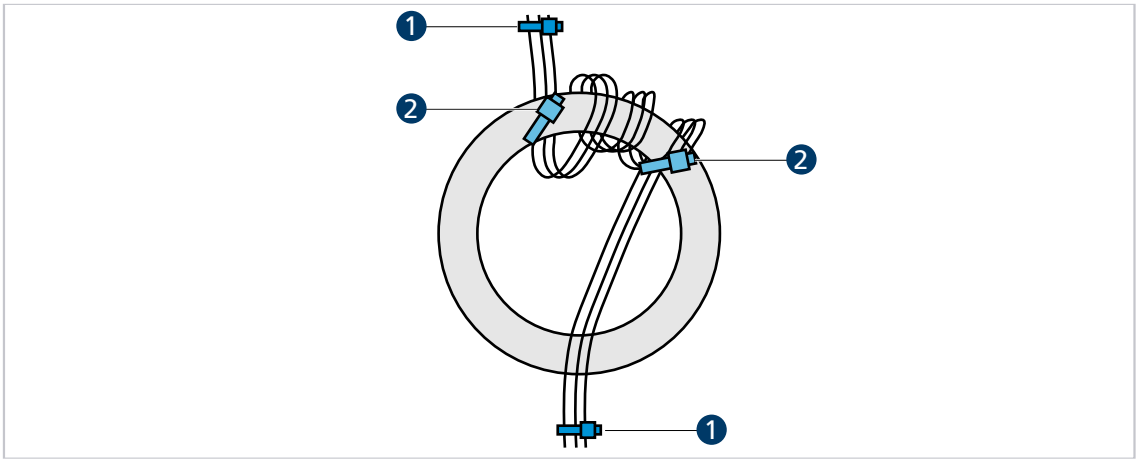


Fig. 26: Coiling ferrite ring

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.

4.3.5 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. 4.3.1, p. 30 been performed and tested?
   a) Can a uniform ground 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. 4.3.3, p. 32.

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. 4.3.4, p. 35.

Conformity measurements

The following points must be observed during the conformity measurement:

Conducted interference voltage measurement	Radiated interference voltage measurement
▪ When laying cables, remove all loops. ▪ Lay the cables with a meandering shape.	▪ Where possible, lay cables over a grounding plate.
▪ Connect the shield of the motor cable on the motor side and as close as possible on the controller side. ▪ The shield is to be connected over a large area, ideally with a round connection.	▪ The connection of the motor cable shield is to be as short as possible ▪ Keep the motor cable as short as possible.
▪ Use an input filter. When selecting, pay attention to the difference of filter attenuation between 50 Ω and realistic values 1/100 Ω or 100/1 Ω measurement.	▪ Use a motor filter and keep the connection as short as possible.
▪ If possible, secure cable with shield clamps or with adhesive tape.	

5 Maintenance

5.1 Maintenance instructions

NOTICE!

Damage to the motor caused by contact with solvents.

- During operation and maintenance protect the housing against contact with solvents or substances containing solvents.

5.2 Maintenance tasks

The motor 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.

5.3 Troubleshooting

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

6 Accessories

The following accessories are available:

Article	Article no.
Contact adapter	6501.00065
Contact adapter	6501.00113

Details on configuration can be found in the Motion Manager manual (see chap. 1.2, p. 5).

Details on the connection sequence can be found in the product data sheet of the respective contact adapter.

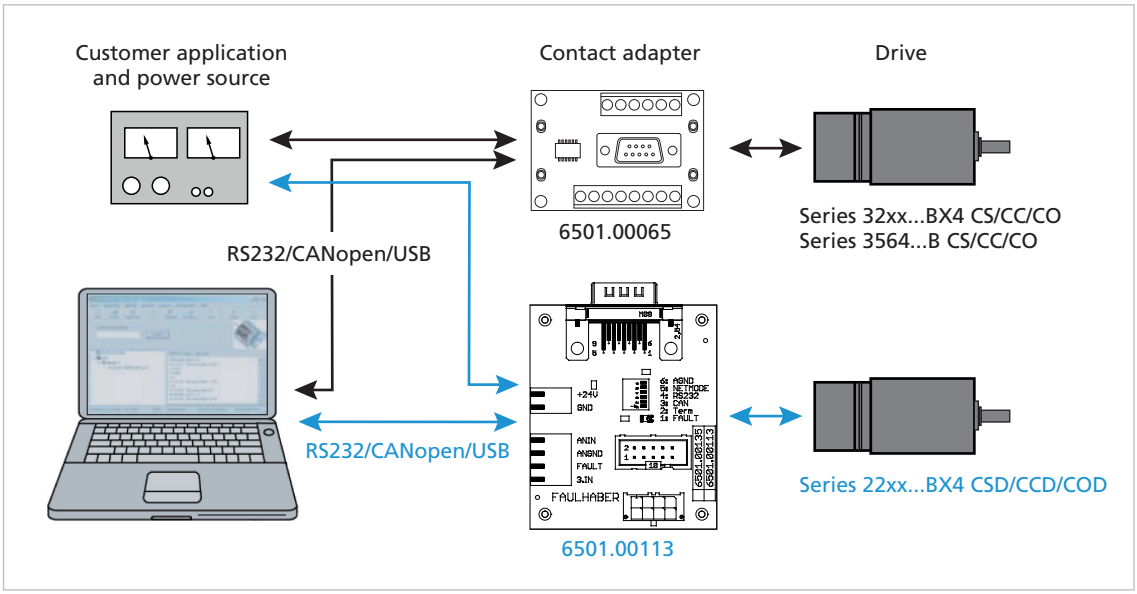


Fig. 27: Setup with contact adapter

Information on other accessories can be found in the main catalog.

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 www.faulhaber.com/gtc and downloaded from it.

8 Additional documents

8.1 Declaration of Conformity 22xx...BX4 CSD/CCD/COD

EG–Konformitätserklärung
EC Declaration of Conformity

Dokument-Nr./Monat.Jahr: *Document-No./Month.Year:*	EG-00030-001 / 06.2021
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*:	**2232 S xx BX4 CxD** **2250 S xx BX4 CxD**
Produkttyp: *Product type:*	**Motor mit integriertem Motion Controller** ***Motor with integrated Motion Controller***

den wesentlichen Schutzanforderungen entspricht, die in der/den nachfolgenden Richtline(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 derivates 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,	01. 07. 21 (Datum) *(date)*	Dr. Thomas Bertolini, Geschäftsführung *(Name, Chairman)*	T. Bertolini (Unterschrift) *(signature)*

Anhang A zur Konformitätserklärung
Annex A to Declaration of Conformity

Dokument-Nr./Monat.Jahr: *Document-No./Month.Year:*	EG-00030-001 / 06.2021

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 *Document*	Ausgabedatum *Date of issue*	Richtlinienbezug *Related to directive*
EN 61800-3	2018	EMV Richtlinie EMC directive

8.2 Declaration of Incorporation 22xx...BX4 CSD/CCD/COD

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-00031-001 / 06.2021
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::*	**2232 S xx BX4 CxD** **2250 S xx BX4 CxD**
Produkttyp: *Product type:*	**Motor mit integriertem Motion Controller** ***Motor with integrated Motion Controller***

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

Schönaich,	01. 07. 21 (Datum) *(Date)*	Dr. Thomas Bertolini, Geschäftsführung *(Name, Chairman)*	F. Bertolini (Unterschrift) *(Signature)*

8.3 Declaration of Conformity 32xx...BX4 CS/CC/CO and 3564...B CS/CC/CO

EG–Konformitätserklärung
EC Declaration of Conformity

Dokument-Nr./Monat.Jahr: *Document-No./Month.Year:*	EG-00034-001 / 07.2021
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*:	**32xx BX4 Cx,** **3564 B Cx**
Produkttyp: *Product type:*	**Motor mit integriertem Motion Controller** ***Motor with integrated Motion Controller***

den wesentlichen Schutzanforderungen entspricht, die in der/den nachfolgenden Richtline(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 derivates 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,	12.07.21 (Datum) *(date)*	Dr. Thomas Bertolini, Geschäftsführung *(Name, Chairman)*	T. Bertolini (Unterschrift) *(signature)*

Anhang A zur Konformitätserklärung
Annex A to Declaration of Conformity

Dokument-Nr./Monat.Jahr: *Document-No./Month.Year:*	EG-00034-001 / 07.2021

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 *Document*	Ausgabedatum *Date of issue*	Richtlinienbezug *Related to directive*
EN 61800-3	2018	EMV Richtlinie EMC directive

8.4 Declaration of Incorporation 332xx...BX4 CS/CC/CO and 3564...B CS/CC/CO

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-00035-001 / 07.2021
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::*	**32xx BX4 Cx,** **3564 B Cx**
Produkttyp: *Product type:*	**Motor mit integriertem Motion Controller** ***Motor with integrated Motion Controller***

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:

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Schönaich,	12.07.21 (Datum) *(Date)*	Dr. Thomas Bertolini, Geschäftsführung *(Name, Chairman)*	F. Bertolini (Unterschrift) *(Signature)*

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7000.05062, 4th edition, 22.05.2023