FAULHABER

Technical Manual

DC Motors

SXR

GXR

WE CREATE MOTION

EN

Imprint

Version:
1st edition, 31.08.2025

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 of DC-motors:

Motors with precious metal commutation	Motors with graphite commutation
▪ 1218/1228 SXR ▪ 1424/1437 SXR ▪ 1627 SXR	▪ 1437 GXR ▪ 1627 GXR

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 Performed changes

The following changes were made to this document:

Version	Changes
1. Edition, 31 August 2025	First edition

1.3 Associated documents

For the connection and operation of the microdrives described here on FAULHABER motor controllers, the notices in the instruction manuals are to be observed.

Manual	Description
Technical manual	Instructions for installation and use of the FAULHABER motion controllers or FAULHABER speed controllers
Accessories manual	Description of the accessories

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

1.4 Using this document

- Carefully read this document before installing and commissioning the motors, especially the chapter on 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.

1.5 List of abbreviations

Abbreviation	Meaning
AC	Alternating Current
ccw	Counterclockwise - shaft rotates counterclockwise as viewed from the A-side flange
cw	Clockwise - shaft rotates clockwise as viewed from the A-side flange
DC	Direct Current
ESD	Electrostatic discharge
GXR	Graphite-commutated motors
I_{DD}	Rated current consumption for encoders
IE	Incremental encoder
L	Line Driver
PELV	Protective Extra Low Voltage
PWM	Pulse Width Modulation
SELV	Safety Extra Low Voltage
SXR	Precious metal commutated motors
U_{DD}	Power supply for encoders

1.6 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

FAULHABER SXR and GXR DC-motors can be used as components of drive systems in a number of drive applications:

Typical application areas include:

- Industry and automation
- Medical sciences
- Motorized handheld devices
- Robotics
- Aerospace

When using the motors the following aspects should be observed:

- The motors should be operated only within the limits specified in the corresponding data sheet.
- In particular, the rated values given in the data sheet apply only for the installation situation specified there.
- Drive systems may only be placed on the market if the EMC for the intended application has been tested.
- Drive systems represent incomplete machines in the spirit of the Machinery Directive. At a minimum, the notices in this technical manual must be observed for safe operation.
- The motors are intended exclusively for operation on low voltage (SELV or PELV).

Please ask the manufacturer for information about individual use under special environmental conditions.

The motors of the SXR and GXR family can be combined with position sensors (encoders), gearheads and motor controllers to create drive systems.

2.2 Safety instructions

In addition to the safety risks described in this technical manual, application-specific dangers could arise during operation that cannot be foreseen by the manufacturer of the drives (e.g., risk of injury from driven components).

The manufacturer of the machine in which the motors are 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 Danger from overloading

FAULHABER SXR and GXR motors can be destroyed in the event of thermal overload.

- Limit the motor current depending on the surroundings and load duration.
- When using a pulse-width-modulated motor supply (PWM), perform one of the following measures to avoid additional losses:
  - Use a PWM filter between the supply and the motor.
  - Use PWM frequencies above 50 kHz.

Through the integrated protection model, FAULHABER motion controllers and speed controllers allow for very good motor protection even in dynamic operation.

2.2.2 Dangers in the event of damages and changes

Damage to the motor or other components of the drive system may impair its function. A damaged drive system 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 motor.
- Appropriately mark a defective or damaged drive system.
- Do **not** replace defective or damaged components of the drive system.
- Make no changes (modifications, repairs) to the motor or other components of the drive system.
- Have loose or defective connections immediately replaced by an electrician.
- After replacing a defective or damaged drive system, test and document the correct function.

2.2.3 Correct installation and commissioning

Errors during the installation and commissioning of the drive system could impair its function. An incorrectly installed drive system 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 drive system in suitable ESD packaging.
- Handle the drive system 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 motor or the encoder.
- Keep foreign bodies away from the drive.
- Install the drive system in a housing that protects it from mechanical influences and soiling and is adapted to the ambient conditions.

Installation and connection work whilst supply voltage is applied at the drive system can damage the electronics.
- Do **not** insert or withdraw connectors whilst supply voltage is applied at the drive system.
- Prior to all aspects of installation and connection work on the drive system, switch off the power supply.

Incorrect connection of the pins can damage the electronic components.
- Connect the wires as shown in the connection assignment.

2.2.4 Heat development

Electric motors may heat up during operation. If touched, there is a risk of burning.
- If necessary, protect the installed drive from direct contact and provide sufficient cooling.
- If necessary, affix a suitable warning sign in the immediate vicinity of the drive.

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.
- Keep the surroundings free of silicone as this can deposit on the commutation system and affect its function.

NOTICE!

Overheating of the motors

Without sufficient cooling via a flange mounting or circulating air, the motors may overheat during operation, possibly resulting in the specified rated operating points given in the data sheets not being achieved.

- Ensure sufficient cooling of the motors.

2.4 Forces and accelerations

Tensile load on the cables
See chap. 4.2.1, p. 19.

Forces on the shaft

- Design of the sintered bearing version:

Tab. 1: Sintered bearing versions

Motor	Radial in operation at 3,000 min^{-1} and a distance of 4.0 mm to the flange	Axial in operation at 3,000 min^{-1}	Axial at a standstill, without support	Axial at a standstill, with support
1218 1228	1.2 N	0.2 N	20 N	200 N
1424 1437	1.5 N	0.2 N	40 N	400 N
1627	1.5 N	0.2 N	40 N	400 N

- Design of the ball bearing version:

Tab. 2: Ball bearing versions

Motor	Radial in operation at 3,000 min^{-1} and a distance of 4.0 mm to the flange	Axial in operation at 3,000 min^{-1}	Axial at a standstill, without support	Axial at a standstill, with support
1218 1228	5 N	0.5 N	10 N	200 N
1424 1437	8 N	0.8 N	40 N	400 N
1627	8 N	0.8 N	40 N	400 N

- The service life of the motors may be shortened
  - if forces in excess of those listed above occur,
  - if axial and radial loads are combined,
  - if radial loads are applied at a large distance from the A-side bearing,
  - if the rated speed range is continuously exceeded,
  - if there is soiling, especially of the bearings,
  - if there is heavy reversing operation, even within the specified forces,
  - if there is overheating.

Accelerations

- Tested in accordance with standard: DIN EN 60068-2-27
  - Shock: 150 m/s^2, 11 ms
  - Sinusoidal oscillations: 10 Hz to 500 Hz, 100 m/s^2
  - Noise oscillations: 10 Hz to 1000 Hz, 200 m/s^2

In case of higher loads, contact the manufacturer.

2.5 EC directives on product safety

Low Voltage Directive 2014/35/EU regulates the provision in the European single market of electrical equipment with a supply voltage of between 75 V and 1500 V DC or between 50 V and 1000 V AC. The maximum supply voltage of FAULHABER products is below 50 V. FAULHABER products do not therefore fall within the scope of the low voltage directive. Unconditionally electrically safe operation is only assured with safety extra-low voltage (SELV). Operation with protective extra-low voltage with electrically safe isolation (PELV) is possible if adequate contact protection is provided.

EMC Directive 2014/30/EU regulates the provision in the European single market of electrical or electronic equipment that is sold to end users and that could generate electromagnetic interference when in operation or whose operation could be impaired by electromagnetic interference. As the design of drive systems and their wiring are heavily dependent on the respective application, interference-free operation is possible only if potential interference factors are consistently taken into consideration. For information on the compliant installation of motors, encoders and motor controllers, please refer to the instruction manuals for our motor controllers.

Machine Directive 2006/42/EC regulates the provision in the European single market of complete machines. In line with the machine directive, only such machines are labeled with a CE marking. Drive systems consisting of a motor controller and an electric motor generally constitute incomplete machines when installed in a machine. Information on safe operation can be found in the instruction manuals for our motor controllers.

RoHS Directive 2011/65/EC regulates the provision in the European single market of complete devices, but does not apply to their individual components. FAULHABER motors and drive systems do not therefore fall within the scope of this directive. FAULHABER supports its customers proactively by providing information concerning placing the products on the market. Details regarding the constituent materials defined in the RoHS directive as well as the used exceptions can therefore be found in the respective delivery note.

Waste Electrical and Electronic Equipment Directive 2012/19/EU defines measures by which the harmful effects of waste electrical and electronic equipment are to be avoided or mitigated. Affected devices must be disposed of separately at the end of their service life and are labeled with the symbol showing a crossed-out wheeled bin. To comply with local legal requirements, FAULHABER is registered as a distributing company in all EU countries, including Norway and Switzerland.

3 Product description

3.1 General product description

FAULHABER SXR and GXR motors are characterized by an especially high power density. The motors include a self-supporting copper coil that not only minimizes the inertia of the rotor but also gives the drives maximum dynamics and precise, cogging-free running. FAULHABER DC-motors are characterized by their very high efficiency.

The motors can be combined with encoders, gearheads and linear actuators from the FAULHABER portfolio.

SXR motors use precious-metal brushes for commutation. These have an especially low contact resistance. They are particularly well-suited for applications with relatively low-power, for battery operation and for applications with low start-up voltage.

GXR motors use graphite brushes for commutation. They have a large contact surface and achieve a strong contact force for optimal power transmission to the winding, even when shocks or vibrations occur.

3.2 Product information

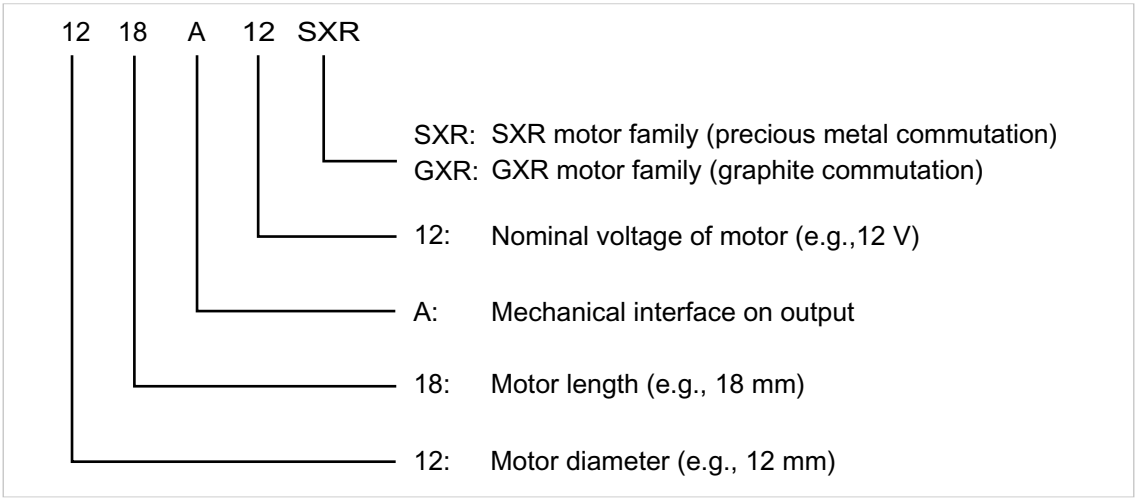


Fig. 2: Designation key: FAULHABER SXR/GXR using 1218 SXR as an example

Product description

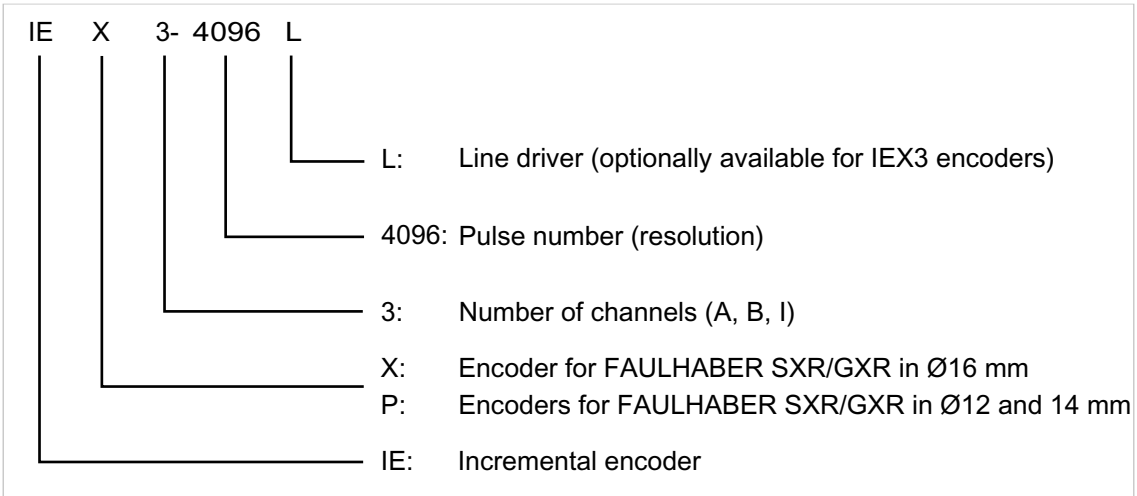


Fig. 3: Designation key for encoders in combination with FAULHABER SXR/GXR using IEX3-4096 L as an example

4 Installation

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

- 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. 11).

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 (see chap. 2.2.4, p. 10).

⚠ DANGER!

Incorrect handling and installation can cause the drive system to perform uncontrolled movements.

A damaged drive system can unexpectedly start, stop or jam. Depending on the use of the drive system, this can lead to severe or fatal injury.

- Observe the safety information in the chap. 2.2, p. 9.
- Use suitable fastening material (see the following chapter).

⚠ DANGER!

The function of the drive system is not ensured if the visual inspection criteria are not satisfied.

If the function is not ensured, the drive may start unexpectedly. Depending on the use of the drive system, this can lead to severe or fatal injury.

- Do not start up the drive system.

⚠ DANGER!

During operation, the drive system produces mechanical forces and movements.

- Protect the drive system and components driven by the drive system from being touched.

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. 3).

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 motor or excessively tightened fastening screws can cause irreparable damage to the mounting flange.

- Observe the maximum permissible radial load on the motor (see Tab. 3).
- Make sure that the screws are tightened in accordance with Tab. 3.

4.1.2 Mounting the motor

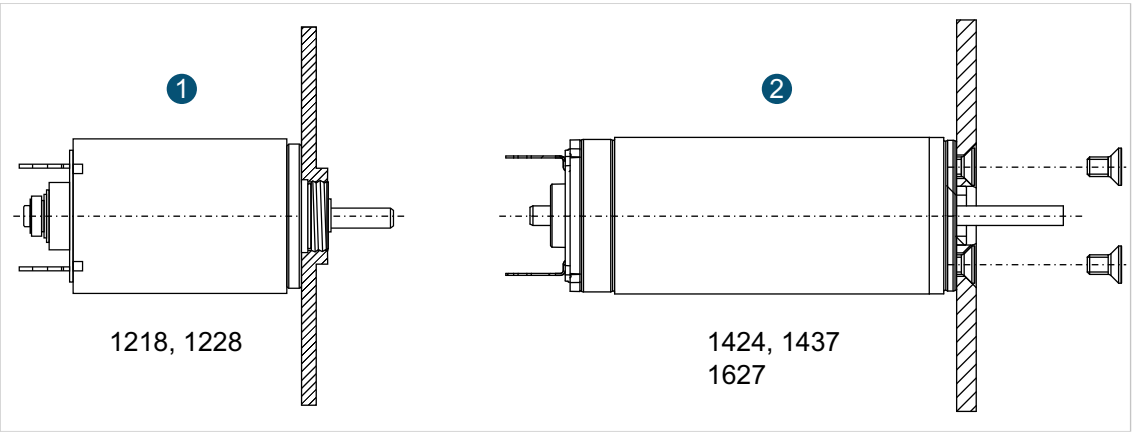


Fig. 4: Mounting arrangements

1 **Motors 1218 and 1228:** *Central thread that is screwed either directly into an internal thread on the mounting plate or fastened with a nut.*

2 **Motors with diameter of 14 and 16 mm:** *Screws on the front flange.*

- The motors have a collar on which they are centered.
- For details on the screw depth, see data sheet and Tab. 3.
- The tightening torques are determined by the selected strength class of the screws. We recommend a strength class of at least 8.8 or A2-70 and refer to VDI2230. The values in Tab. 3 are guide values for the maximum tightening torque.
- We recommend securing the screws with threadlockers.

Tab. 3: Mounting the motors

Motor	Thread size	Screw depth	Guide value for maximum tightening torque
1218 1228	1 x M5.5 0.5 mm pitch	Min. 1.5 mm	12 Ncm
1424 1437	6 x M1.6	Max. 1.7 mm	16 Ncm
1627	6 x M1.6	Max. 1.7 mm	16 Ncm

If axial forces occur when attaching parts to the motor shaft, the limits specified in the data sheet or chap. 2.4, p. 12 must be taken into account.

4.2 Electrical connection

4.2.1 Notes on the electrical connection

NOTICE!

Electrostatic discharges to the drive system 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.

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 the following information on the various motor versions).

NOTICE!

Damage to the motor caused by excessive heat input during soldering

Excessive heat input during soldering can damage the cover and the commutation system of the motor.

- When soldering, ensure that the motor is not heated too strongly.

NOTICE!

Damage to the motor caused by mechanical force on the terminal lugs

- Do not bend terminal lugs.
- Make sure that the terminal lugs remain free of mechanical stress during operation.

Motor with terminal lugs

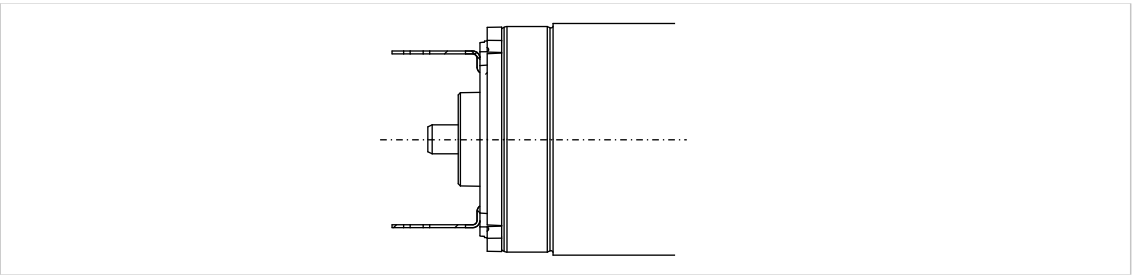


Fig. 5: Motor with terminal lugs

With positive electric voltage on the lug marked with +, the shaft rotates clockwise (cw) as viewed on the A-side of the motor.

Motor with cables

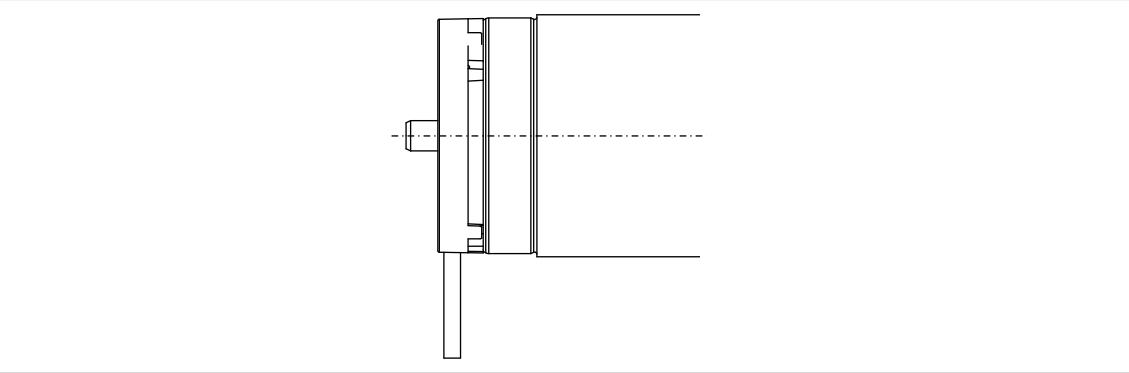


Fig. 6: Motor with cables

With positive electric voltage on the red cable, the shaft rotates clockwise (cw) as viewed on the A-side of the motor.

Tab. 4: Maximum permissible tensile loads for motors with cables

Motor	Cables	Permissible tensile load
1218 1228	2 x AWG26 1.27 mm Twin strands	0 N, without encoder 5 N, with encoder
1424 1437 1627	2 x AWG26 1.27 mm Twin strands	20 N

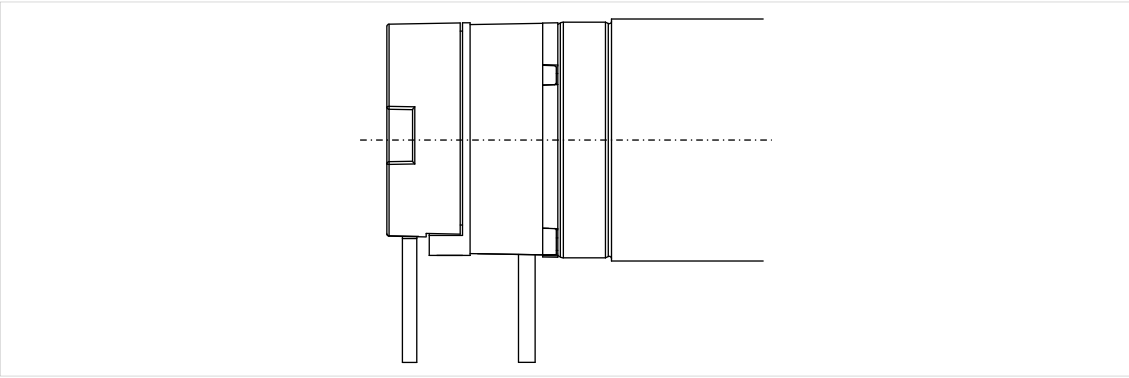


Fig. 7: Motor with encoder

NOTICE!

Damage to the cables

- Make sure that the cables are not subjected to abrasion, crushing or excessively tight bending radii during installation and operation.
- At temperatures below –10 °C, do not bend the cables.
- Make sure that the cables remain free of mechanical stress during operation.
- Observe the maximum permissible tensile loads in Tab. 5.

Tab. 5: Maximum permissible tensile loads for motors with cables

Motor	Encoders	Cables	Permissible tensile load
1218 1228 1424 1437	IEP3	5 x AWG28 1.00 mm Ribbon cable	10 N
1627	IEX3	6 x AWG28 1.27 mm Ribbon cable	20 N
	IEX3L	8 x AWG28 1.00 mm Ribbon cable	20 N

4.2.2 Electrical connection of the SXR and GXR motors

- Operate SXR/GXR DC-motors on a DC power supply or on motor controllers.
- Using the cables that are attached to the B-side solder eyes, connect the motor to the motor controller or to the DC power supply.
- Do **not** exceed the maximum speed specified in the data sheet and the current specified for intermittent operation specified in the data sheet.
- If necessary, take appropriate measures against EMC interference:
  - Observe EMC-compliant setup, see chap. 4.3, p. 28.
  - Install EMC filter directly on the motor.

4.2.2.1 Using PWM filters for SXR motors

FAULHABER SXR motors are DC-motors with precious-metal brushes. They are already internally equipped with RC suppression elements. The motors must not, therefore, be directly operated on a pulse-width-modulated supply (PWM), e.g., a typical motor controller.

- Operate FAULHABER SXR motors on a DC power supply.

or

- Use a PWM filter, e.g., the FAULHABER EFM series (see accessories manual).

In spite of the already internally installed suppression elements, the use of additional EMC protective measures may be necessary that then need to be installed directly on or near the motor.

4.2.3 Electrical connection of IEP3 encoders

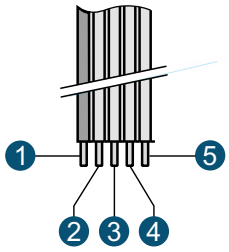
SXR and GXR motors with diameters of 12 mm and 14 mm can be combined with IEP3 encoders.

The following versions are available for the electrical connection:

- Tin-plated ends with a 5-pin ribbon cable in accordance with Tab. 6 (standard version)
- 8-pin Molex PicoBlade connector in accordance with Tab. 7

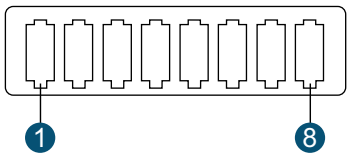
The version with PicoBlade connector is directly compatible with a number of accessory components that enable the direct connection of the drive system to a FAULHABER motion controller or speed controller.

Tab. 6: Standard pin assignment (contact spacing 1.00 AWG28)

	Wire	Designation	Meaning
	1[a)]	GND	Ground connection
	2	U_{DD}	Power supply
	3	Channel B	Output signal
	4	Channel A	Output signal
	5	Channel I	Output signal

a) Wire 1 is highlighted in a different color

Tab. 7: Pin assignment for connector option Molex PicoBlade 51021-0800

	Wire	Designation	Meaning
	1	n.c.	Reserved
	2	n.c.	Reserved
	3	n.c.	Reserved
	4	GND	Ground connection
	5	U_{DD}	Power supply
	6	Channel B	Output signal
	7	Channel A	Output signal
	8	Channel I	Output signal

Tab. 8: Electrical data – encoder supply

Parameter	Value
Power supply U_{DD}	3.0…3.6 V / 4.5…5.5 V[a)]
Rated current consumption I_{DD} (on non-loaded outputs)	Typical: 25 mA Maximum: 34 mA

a) The encoder supports both voltage ranges

Tab. 9: Electrical data – output signals

Parameter	Value
Driver capability I_{Out}	4 mA
Low level	<0.4 V
High level	U_{DD} = 3.3 V: >2.8 V U_{DD} = 5 V: >4.5 V

Typical connection

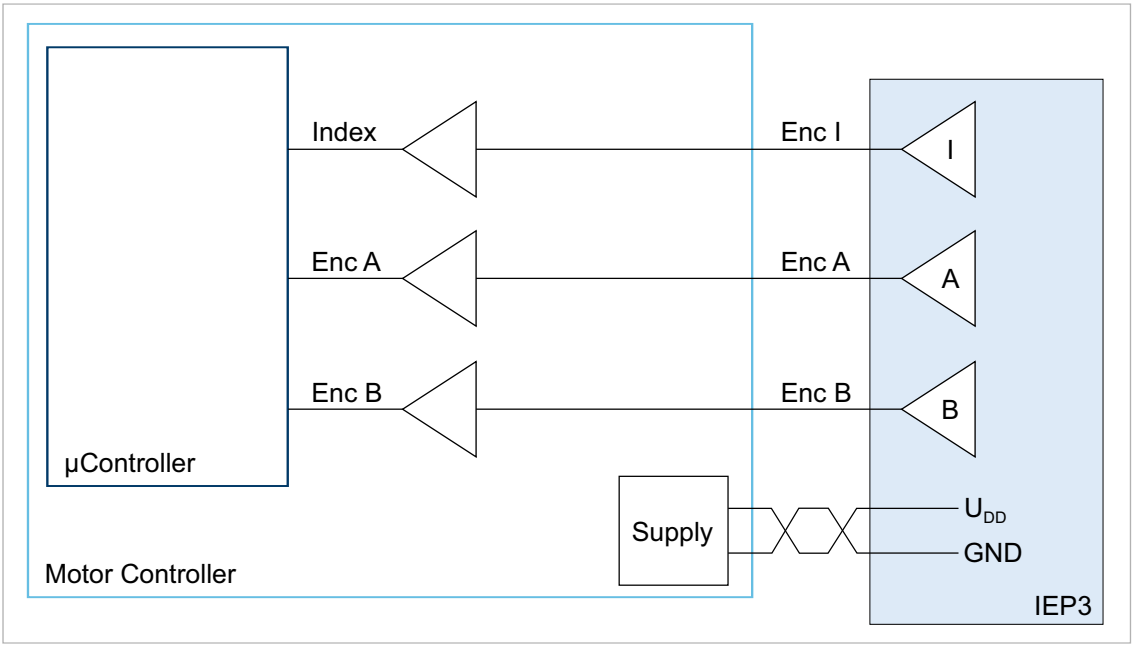


Fig. 8: Typical connection of IEP3 encoders

4.2.4 Electrical connection of IEX3 encoders without line driver

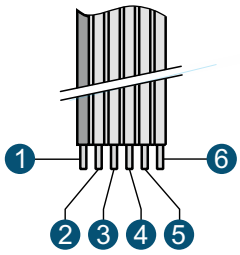
SXR and GXR motors with diameter of 16 mm can be combined with IEX3 encoders with and without line driver (RS422).

The following versions are available for the electrical connection of IEX3 encoders without line driver:

- Tin-plated ends with a 6-pin ribbon cable in accordance with Tab. 10 (standard version)
- 8-pin Molex PicoBlade connector in accordance with Tab. 11

The version with PicoBlade connector is directly compatible with a number of accessory components that enable the direct connection of the drive system to a FAULHABER motion controller or speed controller.

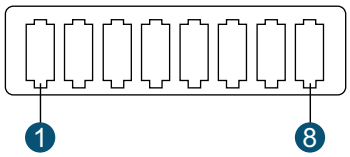
Tab. 10: Standard pin assignment (contact spacing 1.27 AWG28)



Wire	Designation	Meaning
1[a)]	n.c.	Reserved
2	GND	Ground connection
3	U_{DD}	Power supply
4	Channel B	Output signal
5	Channel A	Output signal
6	Channel I	Output signal

a) Wire 1 is highlighted in a different color

Tab. 11: Pin assignment for connector option Molex PicoBlade 51021-0800



Wire	Designation	Meaning
1	n.c.	Reserved
2	n.c.	Reserved
3	n.c.	Reserved
4	GND	Ground connection
5	U_{DD}	Power supply
6	Channel B	Output signal
7	Channel A	Output signal
8	Channel I	Output signal

Tab. 12: Electrical data – encoder supply

Parameter	Value
Power supply U_{DD}	3.0…3.6 V / 4.5…5.5 V[a)]
Rated current consumption I_{DD} (on non-loaded outputs)	Typical: 25 mA Maximum: 34 mA

a) The encoder supports both voltage ranges

Tab. 13: Electrical data – output signals

Parameter	Value
Driver capability I_{Out}	4 mA
Low level	<0.4 V
High level	U_{DD} = 3.3 V: >2.8 V U_{DD} = 5 V: >4.5 V

Typical connection

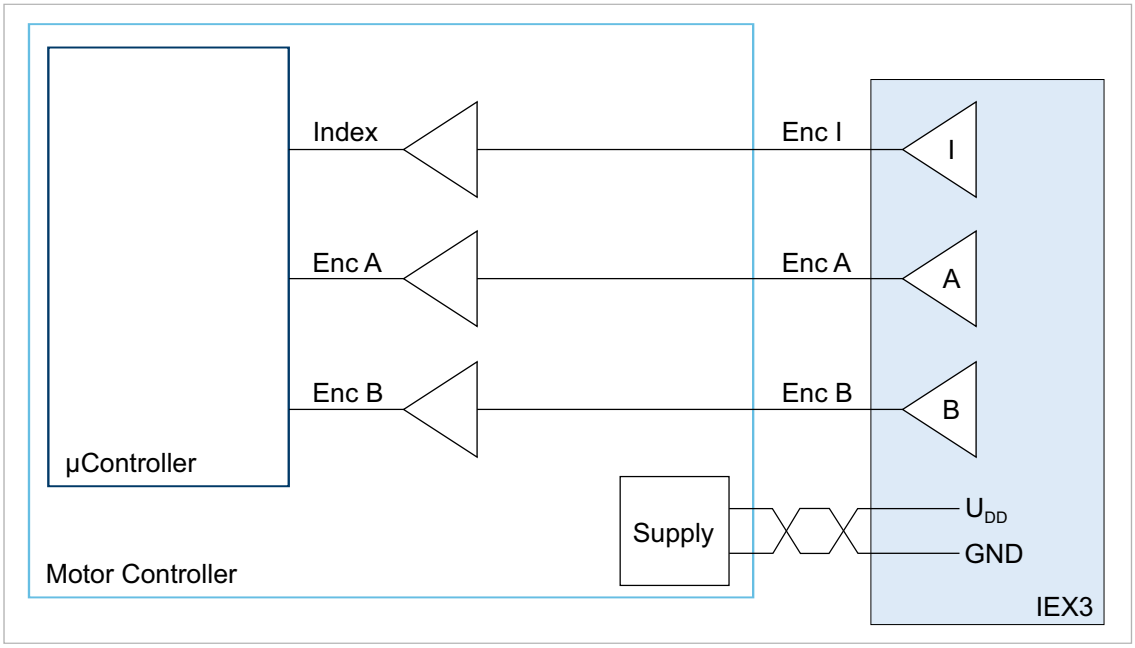


Fig. 9: Typical connection of IEX3 encoders

4.2.5 Electrical connection of IEX3 encoders with line driver

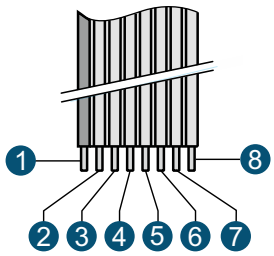
SXR and GXR motors with diameter of 16 mm can be combined with IEX3 encoders with and without line driver (RS422).

The following versions are available for the electrical connection of IEX3 encoders with line driver:

- Tin-plated ends with an 8-pin ribbon cable in accordance with Tab. 14 (standard version)
- 10-pin Molex PicoBlade connector in accordance with Tab. 15

The version with PicoBlade connector is directly compatible with a number of accessory components that enable the direct connection of the drive system to a FAULHABER motion controller or speed controller.

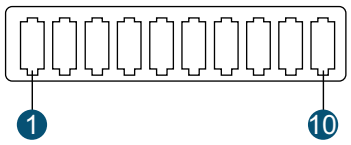
Tab. 14: Standard pin assignment (contact spacing 1.00 AWG28)



Wire	Designation	Meaning
1[a)]	U_{DD}	Power supply
2	GND	Ground connection
3	$\overline{\text{Channel A}}$	Output signal (logically inverted signal)
4	Channel A	Output signal
5	$\overline{\text{Channel B}}$	Output signal (logically inverted signal)
6	Channel B	Output signal
7	$\overline{\text{Channel I}}$	Output signal (logically inverted signal)
8	Channel I	Output signal

a) Wire 1 is highlighted in a different color

Tab. 15: Pin assignment for connector option Molex PicoBlade 51021-1000



Wire	Designation	Meaning
1	n.c.	Reserved
2	U_{DD}	Power supply
3	GND	Ground connection
4	n.c.	Reserved
5	$\overline{\text{Channel A}}$	Output signal (logically inverted signal)
6	Channel A	Output signal
7	$\overline{\text{Channel B}}$	Output signal (logically inverted signal)
8	Channel B	Output signal
9	$\overline{\text{Channel I}}$	Output signal (logically inverted signal)
10	Channel I	Output signal

Tab. 16: Electrical data – encoder supply

Parameter	Value
Power supply U_{DD}	3.0…3.6 V / 4.5…5.5 V[a)]
Rated current consumption I_{DD} (on non-loaded outputs)	Typical: 26 mA Maximum: 35 mA

a) The encoder supports both voltage ranges

Tab. 17: Electrical data – output signals

Parameter	Value
Differential voltage without load ($V_{Diff} = V_{ENC} - V_{NENC}$)	Minimum: 2.5 V Maximum: U_{DD}
Driver capability	100 mA

Typical connection

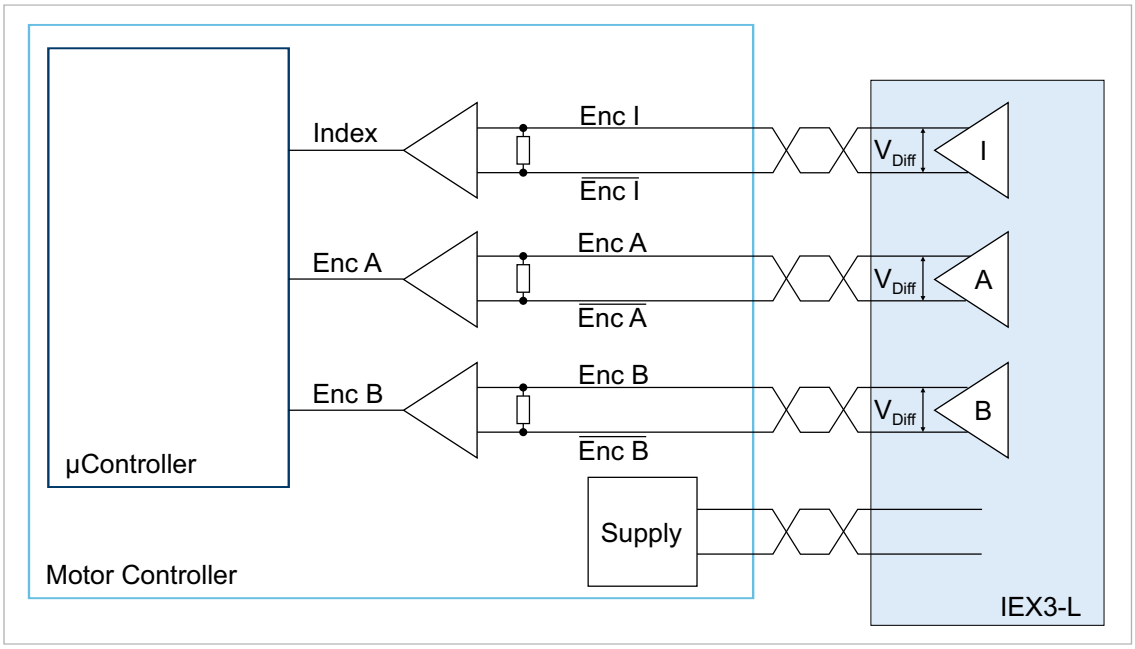


Fig. 10: Typical connection of IEX3 encoders with line driver

When connecting the line driver interface on the controller side:

- Use transceiver module:
  - The transceiver is already integrated in FAULHABER Motion Controllers of generation V3.0.
  - Recommended transceiver components: iC-HF, SN65LBC179, SN75179B, DS90LV019
- Terminating resistors:
  - Depending on the cable length, the use of terminating resistors is recommended to reduce signal interference.
  - Different variants are possible for termination on the receiver:

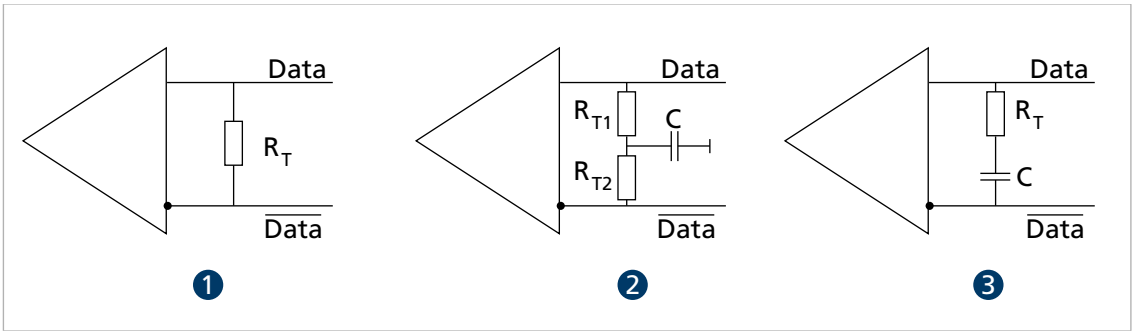


Fig. 11: Termination types

1 Standard
2 Split termination
3 AC termination

- Standard: Terminating resistor R_T = 100…130 Ω
- Split termination: The terminating resistor is split symmetrically (e. g. $R_{T1} = R_{T2} = 60$ Ω). The capacitor C (4.7…10 nF) discharges common-mode currents to ground. This leads to an increased interference resistance of the signal transmission.
- AC termination: A capacitor C in series with the terminating resistor R_T can reduce the power consumption and thus the power loss in R_T. The value of the capacitor must be matched to expected signal frequency.

When selecting the terminating resistor R_T, the power loss has to be considered. With a terminating resistor R_T of 120 Ω, a power loss of $P_V = U^2/R_T = (5\ V)^2/120\ \Omega \approx 0.21$ W results for the termination types (1) and (2), for example.

With twisted-pair cables, proper cable routing and shielding, transmission lengths of 5 m and more are possible, see chap. 4.3, p. 28.

4.3 Electromagnetic compatibility (EMC)

⚠ WARNING!

DC-motors can also cause high-frequency interference when operated on a DC power supply, 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.

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 routing the cables.

  The distances may vary depending on the zone in the switching cabinet.
- If possible, all related cables should be twisted pairs or twisted and shielded in function groups (e.g., motor connections together, encoder data cables and supply together).

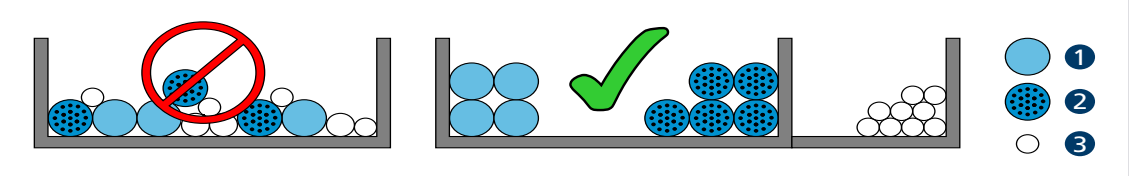


Fig. 12: Laying in the cable duct

1 Motor supplies
2 Digital control signals
3 Sensor cables

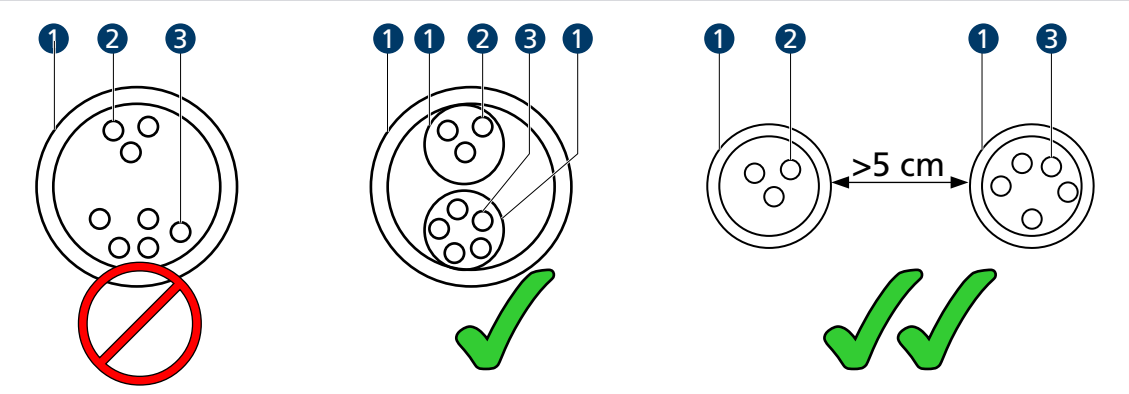


Fig. 13: Grouping and shielding of the connection cables

1 Shielding
2 Motor phase
3 Encoders

4.3.3 Shielding

- Shield connection cables in all cases.

  Shield connection 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. 14).

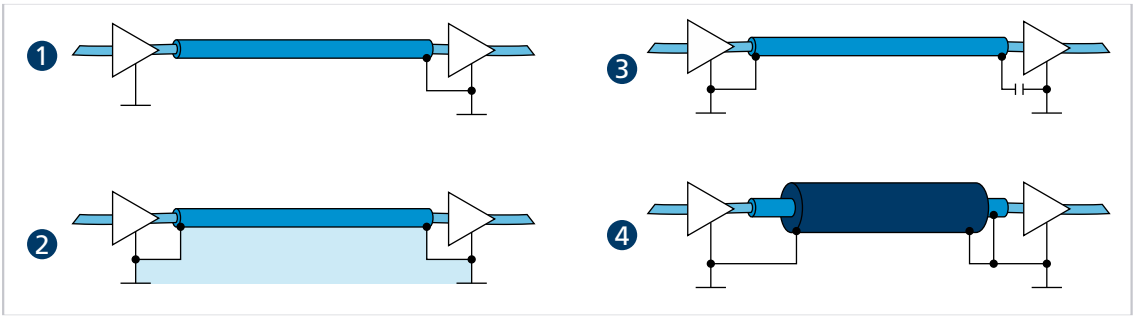


Fig. 14: Various possibilities for the shield connection

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. 14). A solution such as 2 in Fig. 14 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. 14). 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 connection cable are achieved in the following way:

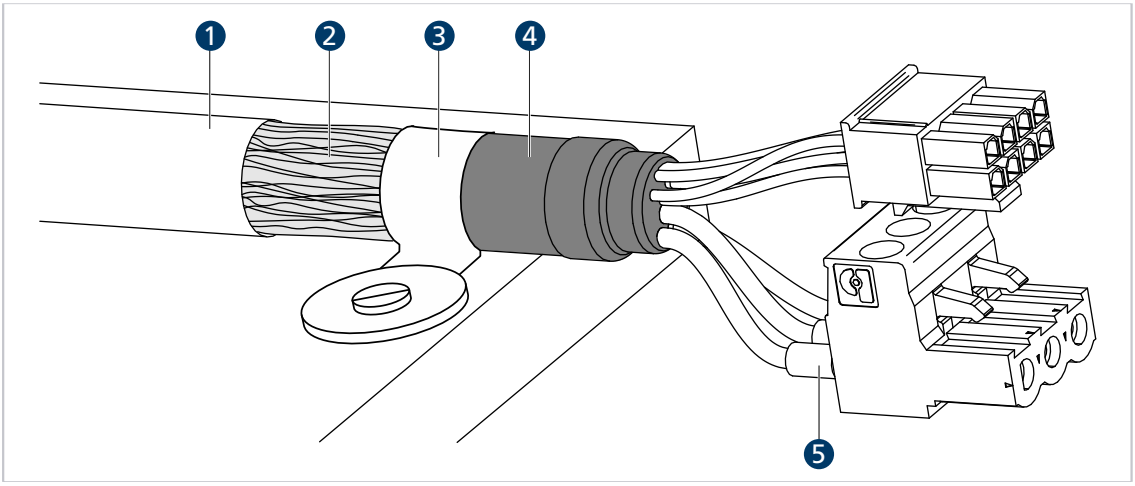


Fig. 15: Shield connection of motor connection cable on motor controller

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.

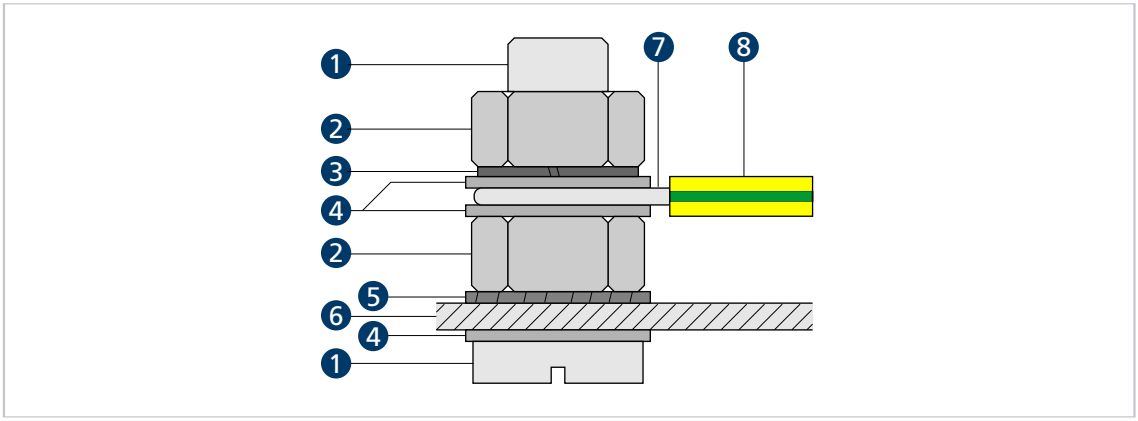


Fig. 16: Shield connection with cable lug

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.

Using an input-side filter in the supply of a controlled drive reduces its conducted interference.

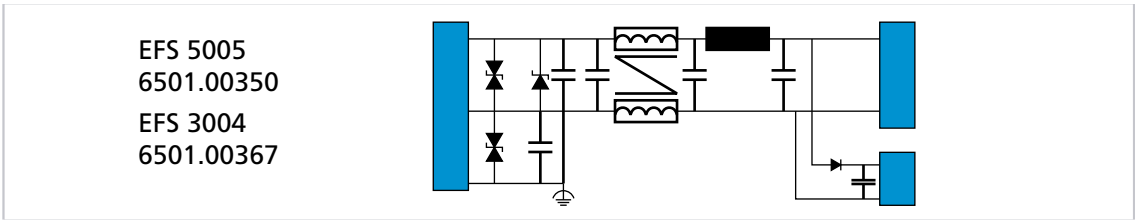


Fig. 17: Input-side filter from FAULHABER

4.3.4.1 Combined filter

For motors operated directly on a DC power supply, combined filters mounted in the immediate vicinity of the motor can significantly reduce transient emissions. In general, complex filters made of chokes, capacitors as well as resistors are used. They cover the lower, middle and upper frequency ranges.

- In the case of differential-mode interference such as current harmonics resulting from switching operation, X capacitors can be combined with non-magnetically coupled differential-mode chokes.
- In the case of common-mode interference, current-compensated common-mode chokes are used.

Corresponding filters for the supply line of motor controls are available as components with different insertion losses and rated currents.

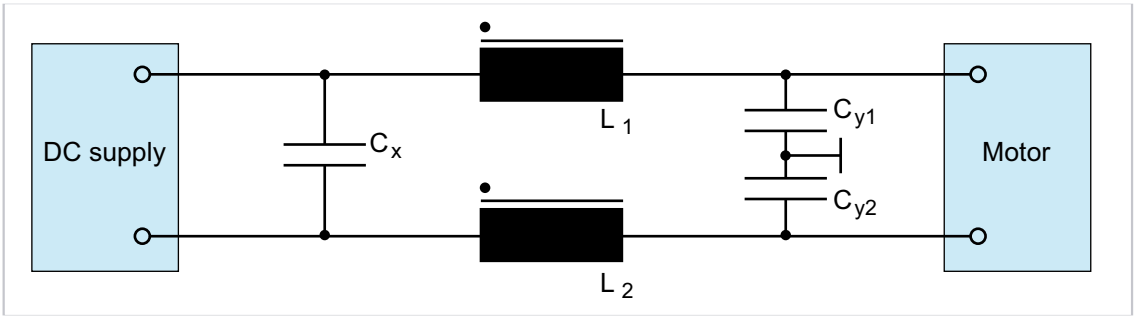


Fig. 18: Combined filter with linear chokes, X- and Y-capacitors

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

To attenuate the transient emissions, ferrite rings can be inserted in the cable near the source of interference. For DC-motors, the ferrites must be installed near the motor; for BLDC motors, the ferrites must be installed near the motor controller.

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 both motor connection cables are wound simultaneously.

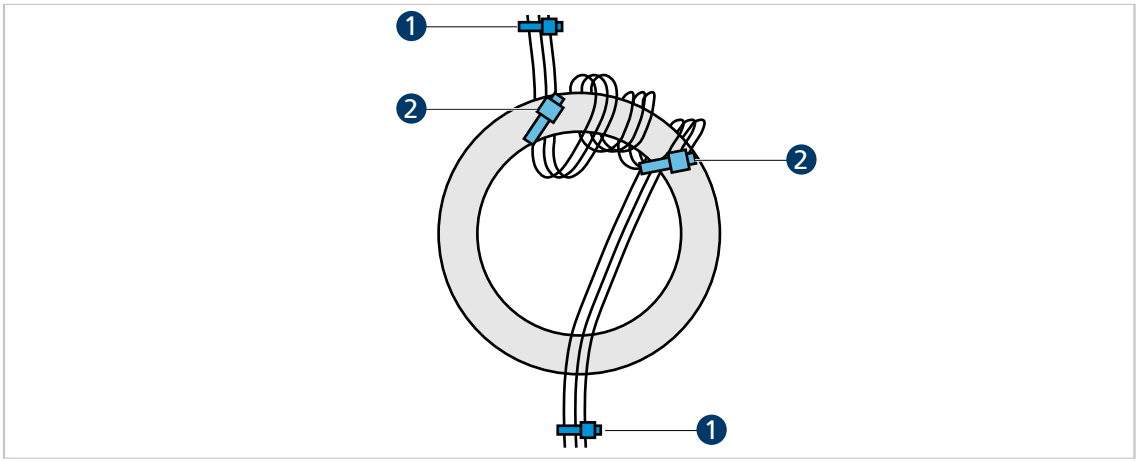


Fig. 19: Coiling ferrite ring

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

1. Fasten motor connection 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 both connections 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.
5. Again secure the motor connection 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. 28 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. 30.

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) Lay encoder connection cables at least 10 cm from the motor connection cables.

   b) Lay sensor connection cables at least 10 cm from all other signal cables that are not also sensor connection cables. Where possible, use incremental encoders with line driver.

   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. 33.

Conformity measurements

The following points must be observed during the conformity measurement:

Conducted interference voltage measurement	Radiated interference voltage measurement
▪ When routing cables, remove all loops. ▪ Lay connection cables with a meandering shape.	▪ Where possible, lay all connection cables over a grounding plate.
▪ Connect the shield of the motor connection cables 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 cable shields is to be as short as possible ▪ In particular, keep unshielded connection cables as short as possible.
▪ Use input filters for the used motor controller. 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 an EMC filter and keep the connection as short as possible.
▪ If possible, secure cables 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

FAULHABER SXR and GXR motors are 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 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/agb and downloaded from it.

7 Additional documents

7.1 Declaration of Conformity

EG–Konformitätserklärung
EC Declaration of Conformity

mit gefordertem Inhalt gemäß ISO/IEC 17050-1
with required content in accordance with ISO / IEC 17050-1

Dokument-Nr. / Monat, Jahr: *Document-no. / month, year:*	EG-00056-001 / 07.2025
Der Hersteller: *The manufacturer:*	**Dr. Fritz Faulhaber GmbH & Co. KG** Faulhaberstr. 1 D-71101 Schönaich Germany

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

Produktbezeichnung: *Product designation*:	**1218..SXR, 1218..SXR IEP3** **1228..SXR, 1228..SXR IEP3** **1424..SXR, 1424..SXR IEP3** **1437..SXR, 1437..SXR IEP3** **1437..GXR, 1437..GXR IEP3** **1627..SXR, 1627..SXR IEX3(L)** **1627..GXR, 1627..GXR IEX3(L)**
Produkttyp: *Product type:*	**DC-Motor, DC-Motor mit Encoder** ***DC-Motor, DC-Motor with encoder***

den grundlegenden Anforderungen entspricht, die in den nachfolgend bezeichneten Harmonisierungsrechtsvorschriften festgelegt sind:
complies with the essential requirements of the following harmonization legislations:

- Richtlinie 2011/65/EU des Europäischen Parlaments und des Rates vom 8.Juni 2011 zur Beschränkung der Verwendung bestimmter gefährlicher Stoffe in Elektro- und Elektronikgeräten – **kurz: RoHS-Richtlinie**
  Directive 2011/65 / EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment – ***short: RoHS directive***

- Richtlinie 2014/30/EU des Europäischen Parlaments und des Rates vom 26.Februar 2014 zur Angleichung der Rechtsvorschriften der Mitgliedstaaten über die elektromagnetische Verträglichkeit – **kurz: EMV Richtlinie**
  Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility – ***short: EMC directive***

DFF/FO_0408 – 01– 17.04.2018

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.

Additional documents

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

Die Übereinstimmung mit den genannten EG-Richtlinien wurde durch Überprüfung gemäß folgender Fachgrundnormen nachgewiesen:
The conformity with the EC guidelines was proven according to the following references to the relevant harmonized standards used:

Richtlinienbezug *Related to directive*	Fundstelle *Document*	Titel *Title*
RoHS-Richtlinie RoHS Directive	EN 50581:2012	Technische Dokumentation zur Beurteilung von Elektro- und Elektronikgeräten hinsichtlich der Beschränkung gefährlicher Stoffe
EMV Richtlinie EMC directive	EN 61800-3:2018-09	Drehzahlveränderbare elektrische Antriebe — Teil 3: EMV-Anforderungen einschließlich spezieller Prüfverfahren

Bevollmächtigter im Sinne des Anhangs II Nr. 1.A Nr. 2, 2006/42/EG für die Zusammenstellung der technischen Unterlagen:
Entitled person within the meaning of Annex II, point 1.A, No 2, 2006/42 / EC, for the compilation of technical documentation:

Schönaich, 25.06.2025 (Datum) *(date)* — Dr. Andreas Wagener, Head of Systems *Engineering* *(Name, position)* — (Unterschrift) *(signature)*

Die alleinige Verantwortung für die Ausstellung dieser Konformitätserklärung in Bezug auf die Erfüllung der grundlegenden Anforderung und die Anfertigung der technischen Unterlagen trägt der Hersteller / diese Erklärung wird verantwortlich für den Hersteller
Only the producer is responsible for providing this declaration of conformity, regarding essential requirements and providing technical documentation / this declaration is, responsible for the manufacturer

Dr. Fritz Faulhaber GmbH & Co. KG
Faulhaberstr. 1
D-71101 Schönaich
Germany

abgegeben durch
issued by

Schönaich, 25.06.2025 (Datum) *(date)* — Dr. Udo Haberland, Geschäftsführung *(Name, Management)* — (Unterschrift) *(signature)*

Diese Erklärung bescheinigt die Übereinstimmung mit den genannten Harmonisierungsrechtsvorschriften, beinhaltet jedoch keine Zusicherung von Eigenschaften.
This declaration assures conformity with the standards and directives cited, but does not represent any guarantee of specific features.

Additional documents

Zusatzangaben:
Additional information

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.

DFF/FO_0408 – 01– 17.04.2018

7.2 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-00057-001 / 07.2025
Der Hersteller: *The manufacturer:*	**Dr. Fritz Faulhaber GmbH & Co. KG** Faulhaberstr. 1 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::*	**1218..SXR, 1218..SXR IEP3** **1228..SXR, 1228..SXR IEP3** **1424..SXR, 1424..SXR IEP3** **1437..SXR, 1437..SXR IEP3** **1437..GXR, 1437..GXR IEP3** **1627..SXR, 1627..SXR IEX3(L)** **1627..GXR, 1627..GXR IEX3(L)**
Produkttyp: *Product type:*	**DC-Motor, DC-Motor mit Encoder** ***DC-Motor, DC-Motor with encoder***

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, Faulhaberstr. 1, 71101 Schönaich, Germany.

Schönaich,	15.06.2025 (Datum) *(Date)*	Dr. Udo Haberland, Geschäftsführung *(Name, Chairman)*	(Unterschrift) *(Signature)*

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