FAULHABER

Brushless DC Servomotors
Series
2232…BX4(S)
2250…BX4(S)

Instruction Manual

EN

WE CREATE MOTION

Imprint

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The pertinent regulations regarding safety engineering and interference suppression as well as the specifications in this technical manual must be complied with when using the equipment.

Subject to change without notice.

The respective current version of this instruction manual is available on FAULHABER's internet site:
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1 Important Information

This instruction manual describes the handling and technical features of FAULHABER's series 22xx…BX4 brushless DC servomotors.

Series 22xx...BX4 drives can be optionally combined with integrated encoders, encoders with line drivers, absolute coders or speed controllers to form complete drive units.

- Please read through the complete instruction manual before using the motor.
- Keep this instruction manual in a safe place for later use.

The information given in this instruction manual refers to the standard version of the motors. Please refer to any additional information sheet provided in the event of differences in information due to a customer-specific motor modification.

1.1 Symbols used in this instruction manual

WARNING! ***Warning!***



This pictogram with the wording "Warning!" indicates an imminent danger which can result in physical injuries.

► *This arrow points out the appropriate action to take to prevent the imminent danger.*

CAUTION! ***Caution!***



This pictogram with the wording "Caution!" indicates an imminent danger which can result in slight physical injuries or material damage.

► *This arrow points out the appropriate precautions.*

REGULATION! ***Regulations, guidelines and directives***



This pictogram with the wording "Regulation" indicates a statutory regulation, guideline or directive which must be observed in the respective context of the text.

NOTE ***Note***



This "Note" pictogram provides tips and recommendations for use and handling of the component.

1 Important Information

1.2 Safety instructions

Observance of the following safety instructions is prerequisite for trouble-free and safe operation of the motor. Therefore, please carefully read through all the notes and follow them when using the motor.

Intended use

The servomotor is designed as a drive for small mechanisms, as well as for continuously running and positioning applications, e.g. pump and scanner drives or in metering technology.

- External control electronics are required to operate the motors without integrated speed controllers.
- The motor contains magnetic and electromagnetic components. Any effects as well as the specific relevant national regulations must be taken into account when using the motor.
- The motor may not be used in environments where contact with water, chemicals and/or dust is possible or in potentially explosive atmospheres!
- The forces, torques and accelerations acting on the motor are limited. See Chapter 7 “Technical Data”.
- Please ask the manufacturer for information about individual use under special ambient conditions.

2 Description

2.1 General product description

Product information

22 … S … BX4(S) …

IE3:	Encoder IE3 attachment
IE3 L:	Encoder IE3 with line driver attachment
AES:	Absolute encoder attachment
SC:	Speed Controller attachment
BX4: BX4S:	BX4 motor family
012:	Supply voltage of the motor 12 V
024:	Supply voltage of the motor 24 V
S:	Shaft diameter 3 mm
32:	Motor length 32 mm
50:	Motor length 50 mm
22:	Motor diameter 22 mm

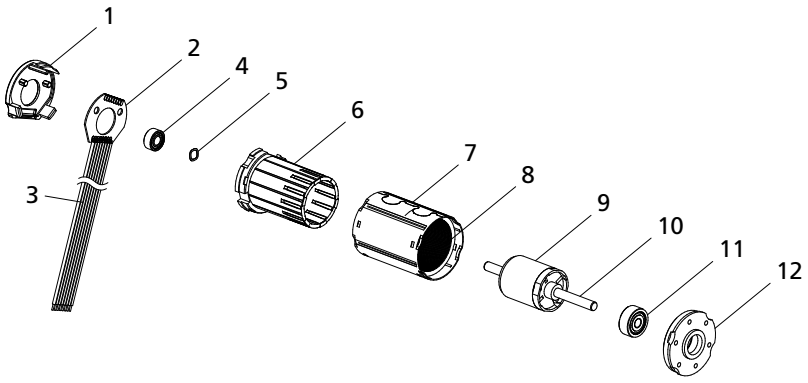
2.1.1 Motor without attachment

The servomotor is an electronically commuted (brushless) DC motor. Compared to mechanically commuted electric motors, its main outstanding feature is a much longer life.

The motor is based on the self-supporting coil technology, FAULHABER system, and essentially consists of a three-phase winding (stator) and a four-pole permanent magnet (rotor). The commutation takes place via an additional external control.

The rotor position is detected by 3 Hall signals.

FAULHABER's SC 2804 control is recommended for operation of the servomotor.



1 Cover	5 Spring	9 Rotor with permanent magnet
2 Adapter board	6 Winding with Hall sensors	10 Shaft
3 Ribbon cable	7 Housing	11 Front motor bearing
4 Rear motor bearing	8 Steel yoke	12 Mounting flange

2 Description

2.1 General product description

2.1.2 Motor with encoder IE3 or IE3 L

In this option, the servomotor described in Chapter 2.1.1 has an encoder with 3 output channels (IE3). A permanent magnet on the shaft generates a moving magnetic field which is measured and further processed by means of a rotary encoder. At the encoder's outputs there are two rectangular signals, phase-shifted by 90°, with up to 1024 pulses and one index pulse per motor.

The encoder is available with different pulse rates (32, 64, 128, 256, 512 or 1024 pulses/revolution). The pulse rate is included in the motor designation. Further resolutions of 1 – 127 pulses are available on request.

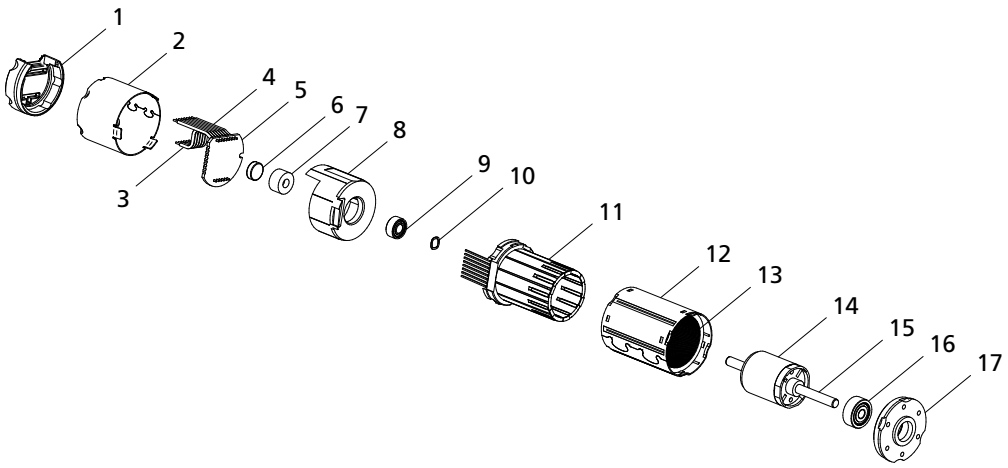
Example

Motor: 2232 … BX4S IE3-128 L

Features: Motor 2232 ... BX4S with encoder, 128 pulses/rotation, line driver

Line driver

Encoders with an "L" in the encoder designation have differential encoder signal outputs. Therefore, common-mode interferences are suppressed and longer supply connectors are enabled. The precise function is described in Chapter 4.2 “Motor with encoder IE3 or IE3 L”.



1 Cover
2 Built-on housing
3 Ribbon cable 1
4 Ribbon cable 2
5 Encoder board
6 Sensor magnet
7 Magnet holder
8 Mounting flange
9 Rear motor bearing
10 Spring
11 Winding with Hall sensors
12 Housing
13 Steel yoke
14 Rotor with permanent magnet
15 Shaft
16 Front motor bearing
17 Mounting flange

2 Description

2.1 General product description

2.1.3 Motor with AES absolute encoder

In this option, the servomotor described in Chapter 2.1.1 has an absolute encoder with serial interface.

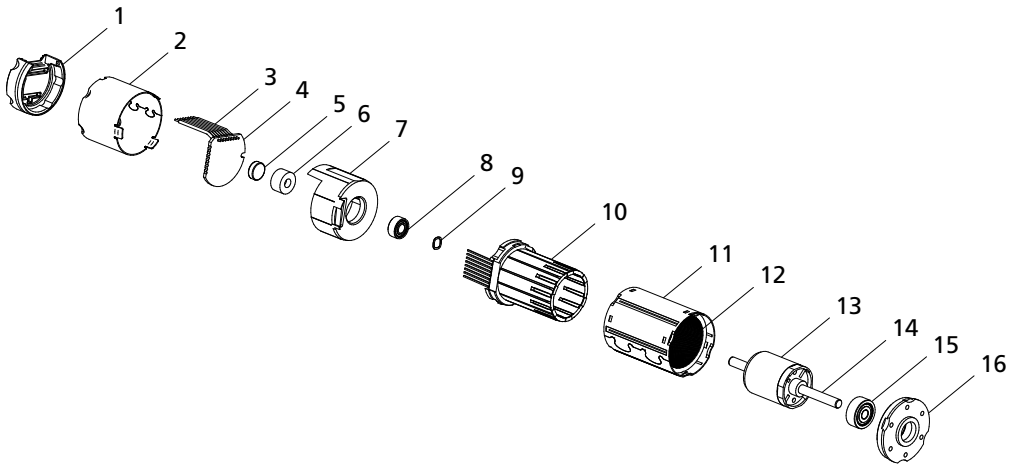
A permanent magnet on the shaft generates a moving magnetic field which is measured and further processed by means of a single chip rotary encoder.

Absolute angle information with a resolution of 4096 steps is available at the outputs, which can be queried via a serial interface (SSI).

Example

Motor: 2232 … BX4 AES-4096

Features: Motor 2232 … BX4 with absolute encoder, resolution 4096 steps/revolution



1 Cover
2 Built-on housing
3 Ribbon cable
4 Encoder board
5 Sensor magnet
6 Magnet holder
7 Mounting flange
8 Rear motor bearing
9 Spring
10 Winding with Hall sensors
11 Housing
12 Steel yoke
13 Rotor with permanent magnet
14 Shaft
15 Front motor bearing
16 Mounting flange

2 Description

2.1 General product description

2.1.4 Motor with SC speed controller

In this option, the servomotor described in Chapter 2.1.1 has integrated commutation electronics (SC speed controller), which provides diverse motor control possibilities.

The motor offers the following functions:

- Control of the speed through set value input or control of the speed through the motor voltage.
- Switchover of direction of rotation via switch input.
- Reading out the speed signal via the frequency output.

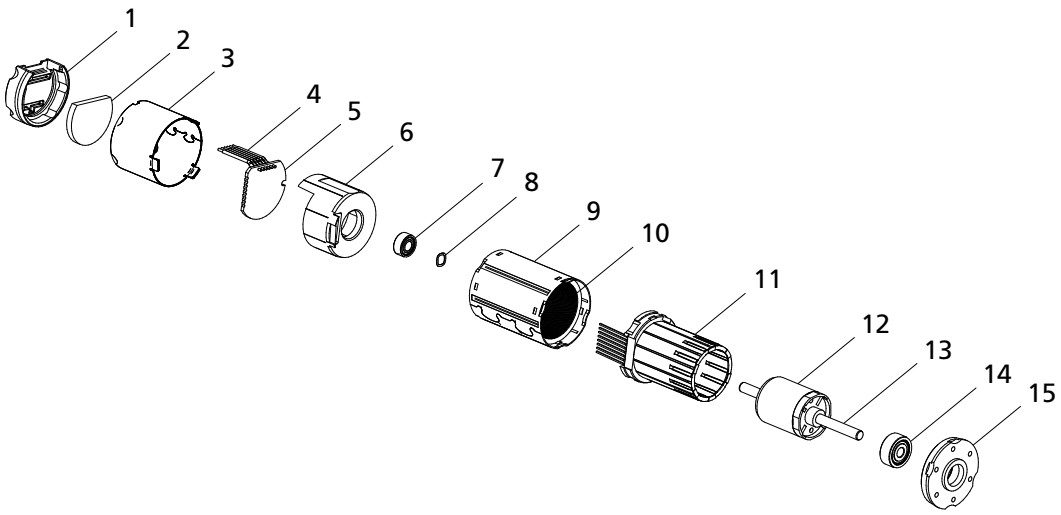
CAUTION!



Risk of damage

Switching over the motor's direction of rotation (reversing duty) too quickly can cause damage.

► *Do not use the speed controller for reversing duty.*



1 Cover
2 Heat transfer pad
3 Built-on housing
4 Ribbon cable
5 Controller board
6 Mounting flange
7 Rear motor bearing
8 Spring
9 Housing
10 Steel yoke
11 Winding with Hall sensors
12 Rotor with permanent magnet
13 Shaft
14 Front motor bearing
15 Mounting flange

3 Installation

3.1 Assembly

The servomotor must be installed according to certain specifications to prevent malfunctions and damage.

CAUTION!



Material damage

Incorrect installation or installation with the wrong fixing materials can cause irreparable damage to the motor's function and/or damage the motor.

► *Observe the following assembly instructions.*

Use environment

Depending on its use, the servomotor can get very hot. Appropriate heat dissipation possibilities must be provided.

Shaft load

When pressing parts on the motor shaft it must be held against on the opposite side. Otherwise the maximum allowable load values (axial at a standstill) must be noted and observed. See Chapter 7 “Technical Data”.

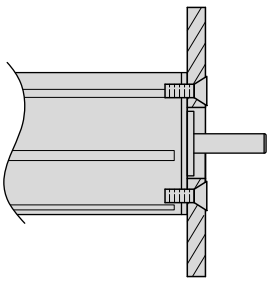
Mounting flange

When fixing the servomotor to the front flange, the screws must be locked as they can loosen at high temperatures. The maximum length of the fixing screws must be noted and observed as otherwise the motor will be destroyed. The depth of engagement in the motor may not exceed be exceeded. See Chapter 7 “Technical Data”.

The maximum tightening torques are usually limited by the strength of the screws. However, they may not exceed the data given in Chapter 7 “Technical Data”.

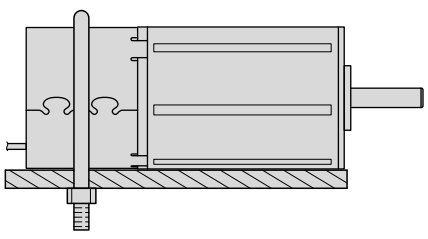
Right

The motor is fixed by the screws on the mounting flange.



Wrong

The motor is securely clamped to the attachment with a U-bolt.



Electrical connection

It is necessary to ensure that the ribbon cable is laid without risk of damage during installation and operation, e.g. through chafing, squeezing or too small bending radii. The maximum load of the cable must be noted and observed. See Chapter 7 “Technical Data”.

3 Installation

3.2 EMC compatible installation

CAUTION! ***Length of the connection leads***

The maximum length of the connection leads is limited.

► *All connection leads may not exceed a length of 3 m.*

Optimisation of performance with respect to emission and immunity requires the additional EMC measures:

- Ensuring the necessary immunity in industrial uses can require use of an EMC suppressor circuit.

Motor designation	Use environment	Interference type	Action
Motor without attachment	Industrial environment		
Motor with SC speed controller	Industrial environment	Emission	EMC suppressor circuit

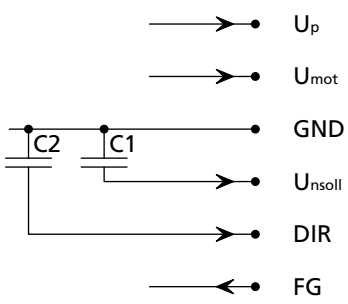
This table shows which additional EMC measures can be implemented to optimise the behaviour of the equipment in the intended environment with regard to immunity.

The units are intended for industrial use only. If the devices are used in the home, in business or in commerce or in a small business, appropriate measures must be taken to ensure that the emitted interference is below the permitted limits!

3.2.1 Description of the EMC measures

The EMC suppressor circuit (motor with Speed Controller SC only)

Circuit diagram 1



C1 Ceramic capacitor 220 nF
C2 Ceramic capacitor 220 nF

NOTE ***Capacitor C1:***

If the ceramic capacitor C1 is used, malfunctions can occur in $PWM_{ntarget}$ operating mode.

► *Use signal source with low internal resistance in $PWM_{ntarget}$ operating mode.*

NOTE ***Capacitor C2:***

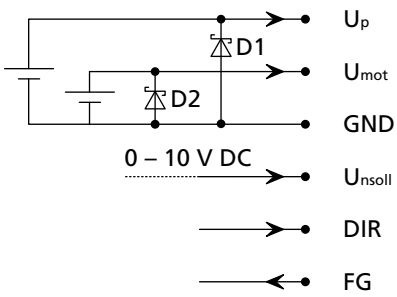
If using the ceramic capacitor C2, a firmware update with the Motion Manager PC firmware may no longer be possible.

► *Remove the C2 capacitor when updating the firmware.*

3 Installation

3.2 EMC compatible installation

Circuit diagram 2



Separate suppressor diodes (D1, D2) for U_P and U_{mot} if they have separate supply voltages.

If only one supply voltage is used, (bridge between U_P and U_{mot}), one suppressor diode (D1) is sufficient. D1 and D2 e.g. P6KE33A from STMicroelectronics

NOTE ***Exceptions:***

It may not be necessary to implement the additional EMC measures named. If the motor is fed e.g. from a CE-conforming power supply unit, the EMC suppressor circuit can be dispensable. In this case the power supply unit takes on the function of the EMC suppressor circuit according to circuit diagram 2.

NOTE ***Motor without attachment:***

A CE-conforming control, e.g. Faulhaber's SC 2804, is recommended for operation of the servomotor.

3 Installation

3.3 Connector pin assignment

3.3.1 Motor without attachment

The servomotor is equipped, as a standard, with an eight-core ribbon cable for the power supply to the motor phases and sensor technology as well as the signal transfer of the Hall sensors.

CAUTION!



Electronic damage /ESD protection

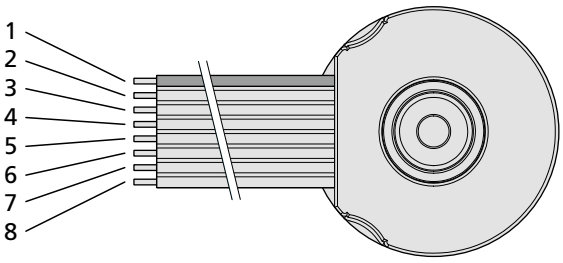
Electrostatic discharges at the connection pin assignment of the ribbon cable can result in irreparable damage to the motor.

► *It may only be processed in ESD protected workplaces.*

Incorrect connection of the cores can cause damage to or destruction of the electronics.

► *Connect the ribbon cable in accordance with the connector pin assignment, see table.*

Connection pin assignment of the ribbon cable



Core	Function
1 (red)	Phase C
2	Phase B
3	Phase A
4	GND
5	U_{DD}
6	Hall sensor C
7	Hall sensor B
8	Hall sensor A

3 Installation

3.3 Connector pin assignment

3.3.2 Motor with encoder IE3 or IE3 L

Apart from the eight-core connection cable for supplying the motor described in Chapter 3.3.1, the servomotor with encoder also has a six-core ribbon cable (ten-core in encoders with line driver) for the encoder's connections.

CAUTION!



Electronic damage / ESD protection

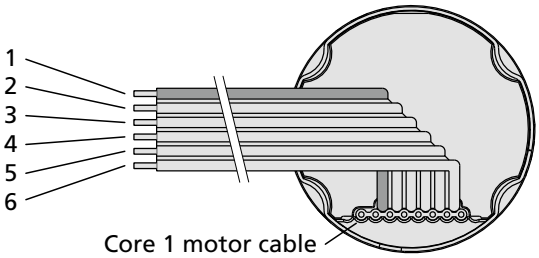
Electrostatic discharges at the connection pin assignment of the ribbon cable can result in irreparable damage to the motor.

► *It may only be processed in ESD protected workplaces.*

Incorrect connection of the cores can cause damage to or destruction of the electronics.

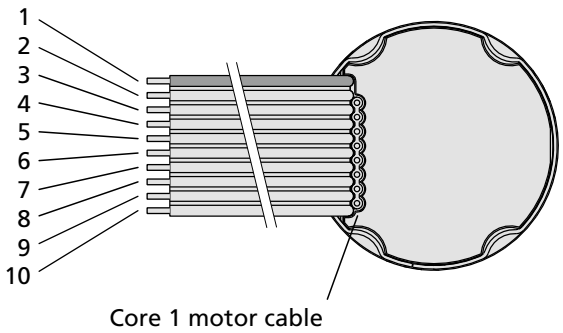
► *Connect the ribbon cable in accordance with the connector pin assignment, see table.*

Connection pin assignment of the ribbon cable for encoders without line driver (IE3)



Core	Function
1 (red)	n.c.
2	Channel I (index)
3	GND Enc
4	UDD Enc
5	Channel B
6	Channel A

Connection pin assignment of the ribbon cable for encoders with line driver (IE3 L)



Core	Function
1 (red)	n.c.
2	UDD Enc
3	GND Enc
4	n.c.
5	Channel $\overline{A}$
6	Channel A
7	Channel $\overline{B}$
8	Channel B
9	Channel $\overline{I}$ (index)
10	Channel I (index)

3 Installation

3.3 Connector pin assignment

3.3.3 Motor with AES absolute encoder

The servomotor with AES absolute encoder is equipped, as a standard, with an eight-core ribbon cable for the power supply to the phases and encoder, and for signal transfer of the angle information via a serial interface (SSI).

CAUTION!



Electronic damage / ESD protection

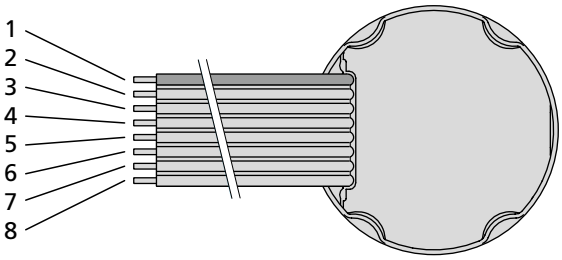
Electrostatic discharges at the connection pin assignment of the ribbon cable can result in irreparable damage to the motor.

► *It may only be processed in ESD protected workplaces.*

Incorrect connection of the cores can cause damage to or destruction of the electronics.

► *Connect the ribbon cable in accordance with the connector pin assignment, see table.*

Connection pin assignment of the ribbon cable



Core	Function
1 (red)	Phase C
2	Phase B
3	Phase A
4	GND_{Enc}
5	$U_{DD\ Enc}$
6	CLK
7	Res. ($\overline{CS}$)
8	DATA

3 Installation

3.3 Connector pin assignment

3.3.4 Motor with SC speed controller

The servomotor with integrated SC speed controller is equipped with a six-core ribbon cable for the power supply and control of the motor functions.

CAUTION!



Electronic damage /ESD protection

Electrostatic discharges at the connection pin assignment of the ribbon cable can result in irreparable damage to the motor.

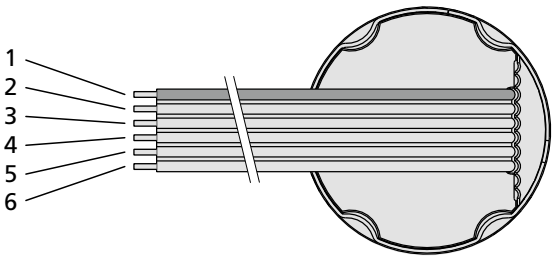
► *It may only be processed in ESD protected workplaces.*

Incorrect connection of the cores can cause damage to or destruction of the electronics.

► *Connect the ribbon cable in accordance with the connector pin assignment, see table.*

Connection pin assignment of the ribbon cable for motor with commutation electronics

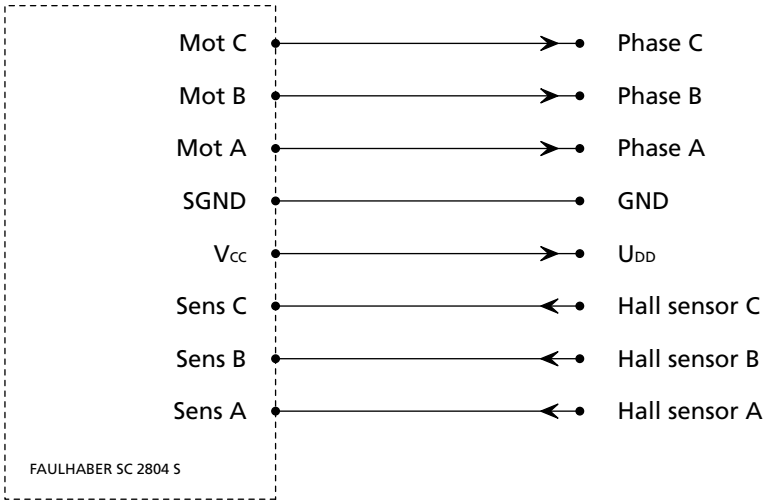
Core	Function	Value
1 (red)	U_P	5 … 28 V DC
2	U_{mot}	6 … 2 · U_N (max. 28 V DC)
3	GND	
4	U_{nsoll}	0 … 10 V DC | > 10 V DC … max. U_P not defined
5	DIR	to earth or U < 0.5 V = anti-clockwise, U > 3 V = clockwise
6	FG	(max. U_P, I_{max} 15 mA) 6 pulses per revolution



3 Installation

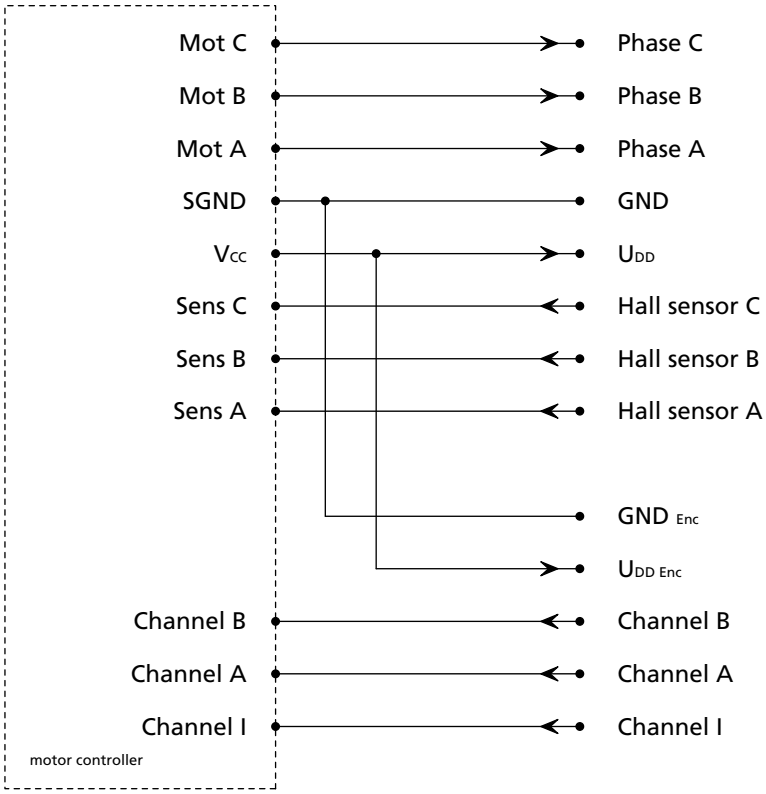
3.4 Connection examples

3.4.1 Motor without attachment



In the example the servomotor is operated with the FAULHABER control *SC 2804 S*.

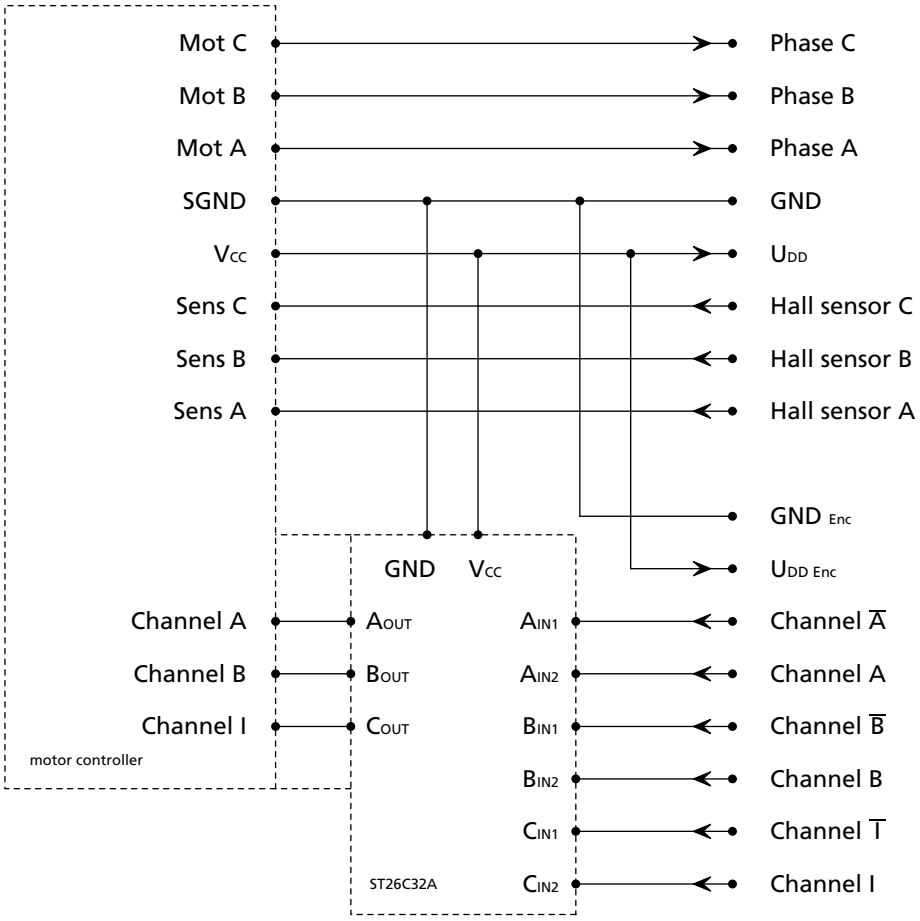
3.4.2 Motor with encoder IE3



3 Installation

3.4 Connection examples

3.4.3 Motor with encoder IE3 L

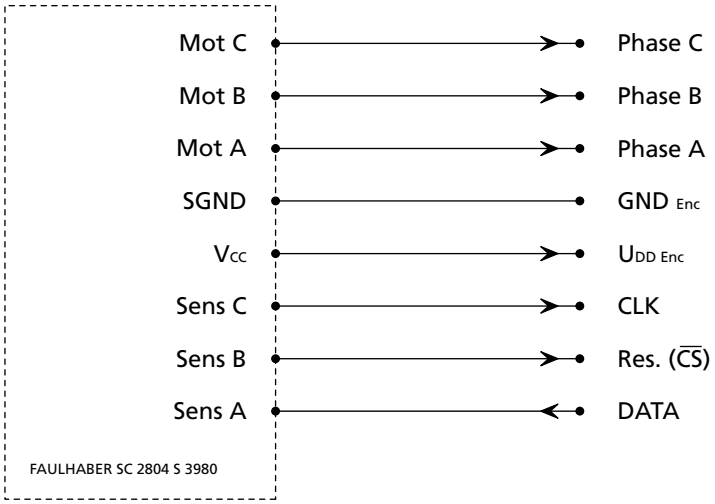


The differential encoder signals are joined with a TIA-422 compatible receiver module on the connection side (here: ST26C32A).

3 Installation

3.4 Connection examples

3.4.4 Motor with AES absolute encoder



In the example the servomotor is operated with the FAULHABER control *SC 2804 S 3980*.

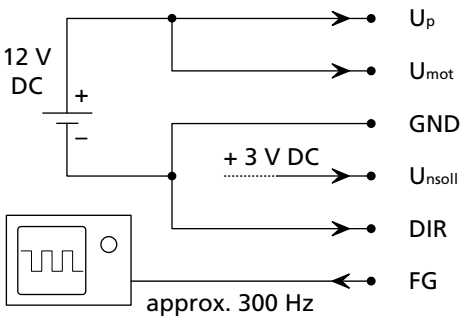
3 Installation

3.4 Connection examples

3.4.5 Motor with SC speed controller

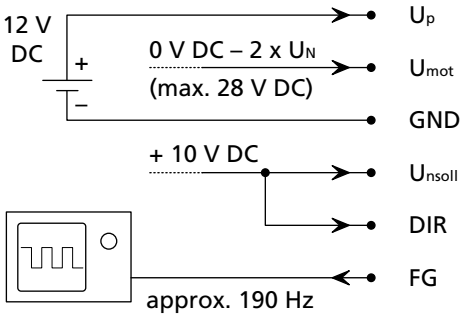
Two examples are given and are intended to clearly explain the operating modes of the servomotor with SC Speed controller. The figures given refer to a motor with a nominal voltage of 12 V.

Electronic speed control



The motor rotated anti-clockwise with approx. 3000 rpm, the speed is controlled electronically.

External speed control



The motor rotates e.g. with 1900 rpm in a clockwise direction, the speed is controlled by the motor voltage (U_{mot}). Approx. 190 Hz is measured at the frequency output (FG).

190 pulses/sec = 31.66 rev/sec,

31.66 rev/sec = 1900 rpm.

4 Functional Description

4.1 Motor without attachment

4.1.1 Connection functions

The servomotor requires and external control for operations and has the connection options listed in Chapter 3.

Phase C to Phase A (core 1 – 3)

The rotating field required to operate the motor is applied to phases C to A.

Voltage range: 0 V AC to U_{max}.

The following limits must be adhered to for U_{max}:

- Note and observe limit speed. See Chapter 7 “Technical Data”.
- U_{max} < 50 V AC (below the Low Voltage Directive).

CAUTION!



Harmonic components

When the servomotor is operated with block commutation or PWM, harmonic components can arise, as a result of which the emission behaviour of the motor can worsen.

- ▶ *Ensured operation of the motor within the EMC requires a harmonic-free rotating field, or the suggested FAULHABER control. See Chapter 3.4 “Connection examples”.*

GND (core 4)

Joint ground of the Hall sensors.

U_{DD} (core 5)

Supply voltage of the Hall sensors.

Voltage range: See Chapter 7 “Technical Data”.

Input current: < 18 mA.

Output signals Hall sensor C to Hall sensor A (core 6 – 8)

Signal output of the Hall sensors.

Voltage range: 0.1 V DC … U_{DD}.

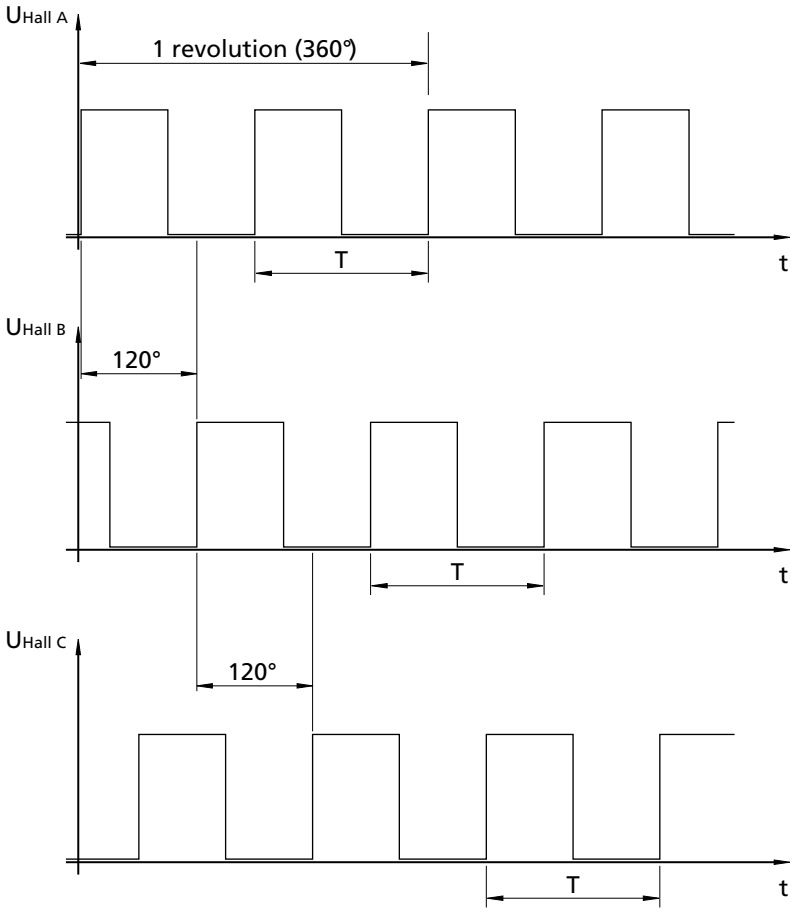
Output current: < 25 mA.

The output current results from the applied pull-up voltage and the pull-up resistance used.

Signal setup: The Hall signals are 120° out of phase with each other according to the phases. Due to the 4-pole version, the switching frequency is twice as high as the speed.

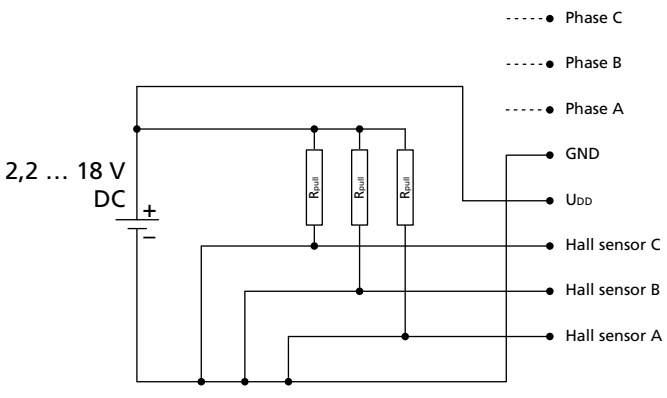
4 Functional Description

4.1 Motor without attachment



NOTE

The outputs of the Hall sensors are designed as open collectors. Therefore, pull-up resistances are required for operation.



- R_{pull}: ≥ 820 Ω

4 Functional Description

4.2 Motor with encoder IE3 or IE3 L

4.2.1 Connection functions

In addition to the connection functions described in Chapter 4.1 “Motor without attachment”, the servomotor with encoder also has a six-core ribbon cable (AWG28, ten core for encoders with line driver), which provides the encoder connection functions described here.

NOTE

For the motor with IE3-512 and IE3-1024, the applicable Hall sensor supply differs from Chapter 4.1.1. See Chapter 7 “Technical Data”. The outputs of the Hall sensors are implemented here as push-pull (CMOS and TTL compatible). Output current: max. 4 mA.

Encoder without line driver

Channel I (core 2)

Output signal index signal.

Pulse rate: 1 pulse / revolution.

GND Enc (core 3)

Ground connection for the encoder.

$U_{DD\ Enc}$ (core 4)

Supply voltage for the encoder.

Voltage range. See Chapter 7 “Technical Data”.

Channel B (core 5)

Output signal B of the pulse generator, 90°e offset from Channel A, COMES and TTL compatible.

Pulse rate (depending on the encoder setup): 32, 64, 128, 256, 512 or 1024 pulses/revolution.

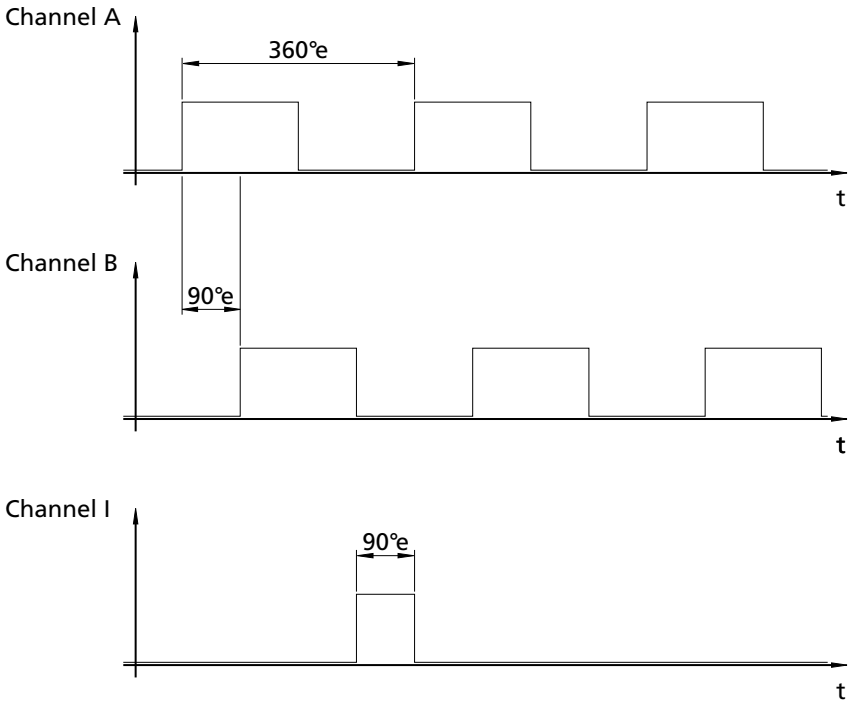
Channel A (core 6)

Output signal of the pulse generator, COMES and TTL compatible.

Pulse rate (depending on the encoder setup): 32, 64, 128, 256, 512 or 1024 pulses/revolution.

4 Functional Description

4.2 Motor with encoder IE3 or IE3 L



The display of the signals and phase displacement relates to a clockwise rotating motor (intended for output).

4 Functional Description

4.2 Motor with encoder IE3 or IE3 L

Encoder with line driver

In addition to the output signals Channel A, Channel B and Channel I, the encoder with line driver also provides the inverted signals Channel not A, Channel not B and Channel not I. These three differential signals must be joined together again on the connection side with a receiver module (e.g. ST26C32A from STM).

This symmetrical interface according to TIA-422 standard enables suppression of common mode interference and also enables longer supply conductors.

$U_{DD\ Enc}$ (core 2)

Supply voltage for the encoder, isolated from the motor.

Voltage range. See Chapter 7 “Technical Data”.

GND_{Enc} (core 3)

Ground connection for the encoder, isolated from the motor.

Channel $\overline{A}$ (core 5)

Inverted output signal A of the pulse generator, TIA-422 compatible.

Pulse rate (depending on the encoder setup): 32, 64, 128, 256, 512 or 1024 pulses/revolution.

Channel A (core 6)

Output signal A of the pulse generator, TIA-422 compatible.

Pulse rate (depending on the encoder setup): 32, 64, 128, 256, 512 or 1024 pulses/revolution.

Channel $\overline{B}$ (core 7)

Inverted output signal B of the pulse generator, 90°e offset to channel A, TIA-422 compatible.

Pulse rate (depending on the encoder setup): 32, 64, 128, 256, 512 or 1024 pulses/revolution.

Channel B (core 8)

Output signal B of the pulse generator, 90°e offset to channel A, TIA-422 compatible.

Pulse rate (depending on the encoder setup): 32, 64, 128, 256, 512 or 1024 pulses/revolution.

Channel I (core 9)

Inverted output signal index signal.

Pulse rate: 1 pulse /revolution.

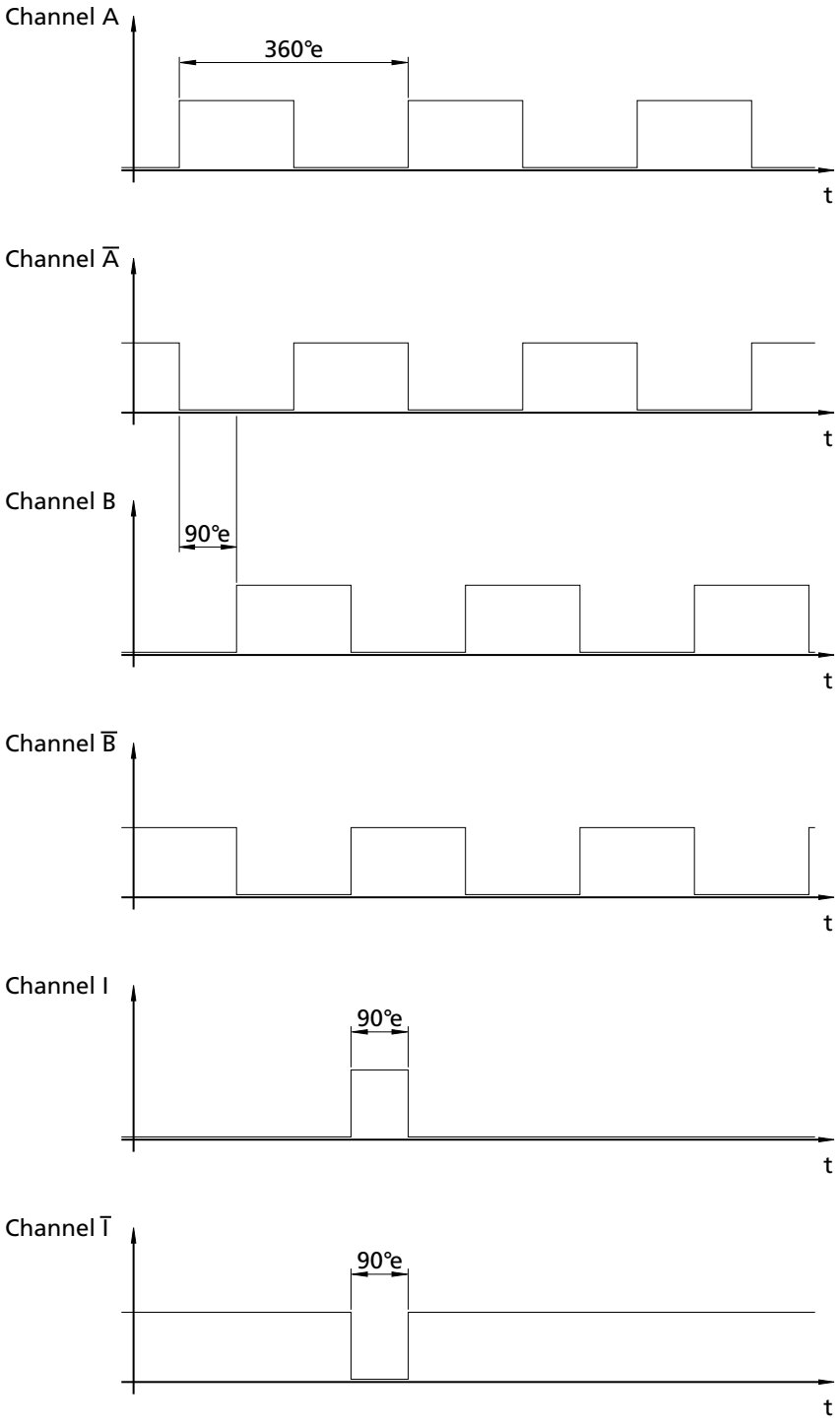
Channel $\overline{I}$ (core 10)

Output signal index signal.

Pulse rate: 1 pulse /revolution.

4 Functional Description

4.2 Motor with encoder IE3 or IE3 L



The display of the signals and phase displacement relates to a clockwise rotating motor (intended for output).

4 Functional Description

4.3 Motor with AES absolute encoder

4.3.1 Connection functions

The servomotor with AES absolute encoder requires an external control for operations and has the connection options listed in Chapter 3 “Installation”.

Phase C to Phase A (core 1 – 3)

The rotating field required to operate the motor is applied to phases C to A.

Voltage range: 0 V AC to U_{max}.

The following limits must be adhered to for U_{max}:

- Note and observe limit speed. See Chapter 7 “Technical Data”.
- U_{max} < 50 V AC (below the Low Voltage Directive).

GND $_{Enc}$ (core 4)

Ground connection for the absolute encoder.

$U_{DD\ Enc}$ (core 5)

Supply voltage for the absolute encoder.

Voltage range. See Chapter 7 “Technical Data”.

CLK (core 6)

Input for the clock signal of the serial interface (SSI).

Res. ($\overline{CS}$) (core 7)

Input reserved for chip select.

DATA (core 8)

Output for the data of the serial interface (SSI).

CAUTION!



Malfunction!

If a connection cable longer than 30 cm is used between the motor and control, malfunctions can occur during operation.

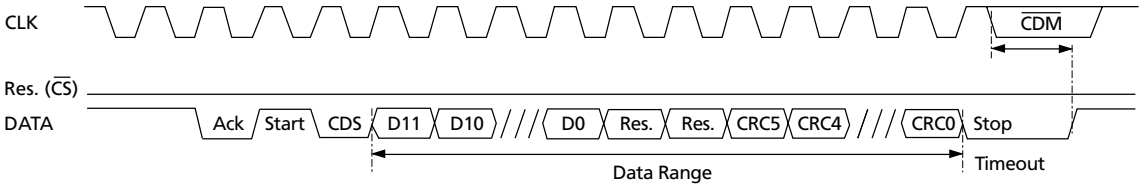
► *The usability of a longer connection cable must be checked for each individual case!*

4 Functional Description

4.3 Motor with AES absolute encoder

Synchronous serial interface (SSI)

The synchronous serial interface (SSI) is used to read out the absolute angle positions of the encoder.



After the encoder has sent the acknowledge (Ack), start and control bit (CDS) in the fixed cyclic start sequence, the binary 12 bit sensor data is sent.

Two reserved and six CRC bits then follow.

If no other clock signals are sent to the CLK cable ($\overline{CDM}$), the encoder runs in a timeout (16µs), which ends the communication. This is also optionally already possible after the 12 bit sensor data.

4 Functional Description

4.4 Motor with SC speed controller

4.4.1 Connection functions

The servomotor with integrated SC speed controller supports the following functions and/or operating modes:

- Control of the speed through the voltage at the set value input.
- Control of the speed through the coil voltage.
- Control of the direction of rotation at the switch input.
- Reading out the speed signal at the frequency output.

U_P (core 1)

Supply voltage for the electronics.

Voltage range. See Chapter 7 “Technical Data”.

U_{mot} (core 2)

Supply voltage for the motor winding.

Voltage range. See Chapter 7 “Technical Data”.

GND (core 3)

Common earth.

U_{nsoll} (core 4)

Control voltage for the target velocity.

Voltage range: 0 … 10 V DC | > 10 V DC … max. U_P not defined.

Resolution: See Chapter 7 “Technical Data”.

If U_{nsoll} > 10 V DC, the speed is regulated to the value corresponding to 10 V DC. This value is above the nominal speed so that full control occurs. If U_{mot} is increased so that the actual motor speed reaches this target value, it is limited by the speed control to the value corresponding to U_{nsoll} = 10 V DC.

The input impedance of this cable is approx. 5 kΩ.

DIR (core 5)

Switch input for the motor's direction of rotation.

to earth or U < 0.5 V anti-clockwise, U > 2.8 V = clockwise

4 Functional Description

4.4 Motor with SC speed controller

FG (core 6)

Digital output.

The digital output is a switch which switches to GND (open collector with integrated pull-up resistance of 22 kΩ).

Output voltage: max. U_P.

Output current: max. 15 mA.

The digital output can be configured for different tasks:

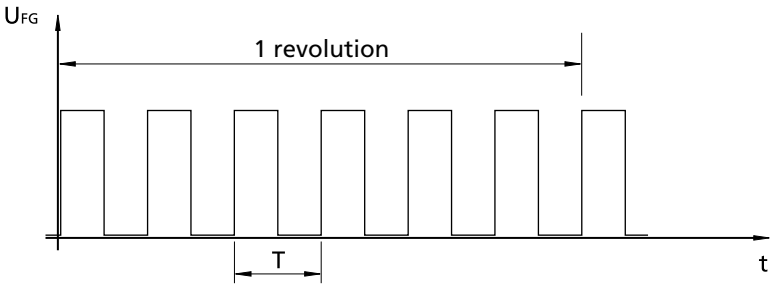
Error output

- Output switches to high level if current limiting is activated. The delay between activation of current limiting and activation of the output can be adjusted.
- Output switches to low level if current limiting is deactivated.

Frequency output

Frequency output for reading out the actual motor speed.

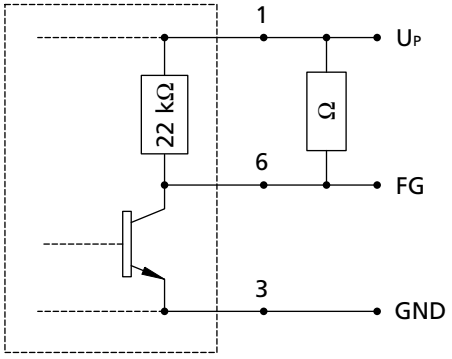
Signal setup: 6 pulses per motor revolution.



NOTE

Pull-up resistance

An additional, external pull-up resistance can be connected to increase the edge steepness. The maximum loadability of the digital output must be noted and observed. See circuit diagram:



Due to the coupling of the internal pull-up resistance between FG and the supply voltage U_P, conducted electromagnetic RF interference, which affects the supply voltage, can drastically worsen the frequency signal.

If operated properly and as intended, the speed and direct of rotation of the motor are not impaired by this interference.

4 Functional Description

4.4 Motor with SC speed controller

PWM operation

If U_{nsoll} is specified as the voltage at the motor it is operated with speed control. The speed is controlled by pulse width modulation (PWM), i.e. the motor tries to achieve a constant speed under fluctuating load.

Due to the technical requirements of the motor with SC speed controller, assuming the allowable maximum housing temperature is adhered to, the maximum possible continuous torque in PWM mode may be lower than under full control. The maximum thermally allowable continuous current reduces accordingly.

4.4.2 Configuration

The control parameters of the speed controller integrated in the motor can be individually adjusted to the respective application via a PC. This requires a programming adapter which can be ordered separately as well as a version of the FAULHABER Motion Manager PC software suitable for the speed controller.

The software is available on request or from the FAULHABER homepage http://www.faulhaber.com/MotionManager.

CAUTION!



Risk of damage

Before starting up, check the parameters configured in the control and if necessary adjust to the connected motor. Incorrectly set values can cause fatal damage to the motor and/or the speed controller.

In particular, the following parameters must be correctly set:

- *Duration and maximum current value,*
- *Generator voltage constant k_E and connected resistance R,*
- *Controller parameter.*

The servomotor is equipped with digital Hall sensors, with which the commutation signals can be determined. The actual speed value is determined via the time interval between the edges of the Hall sensor signals.

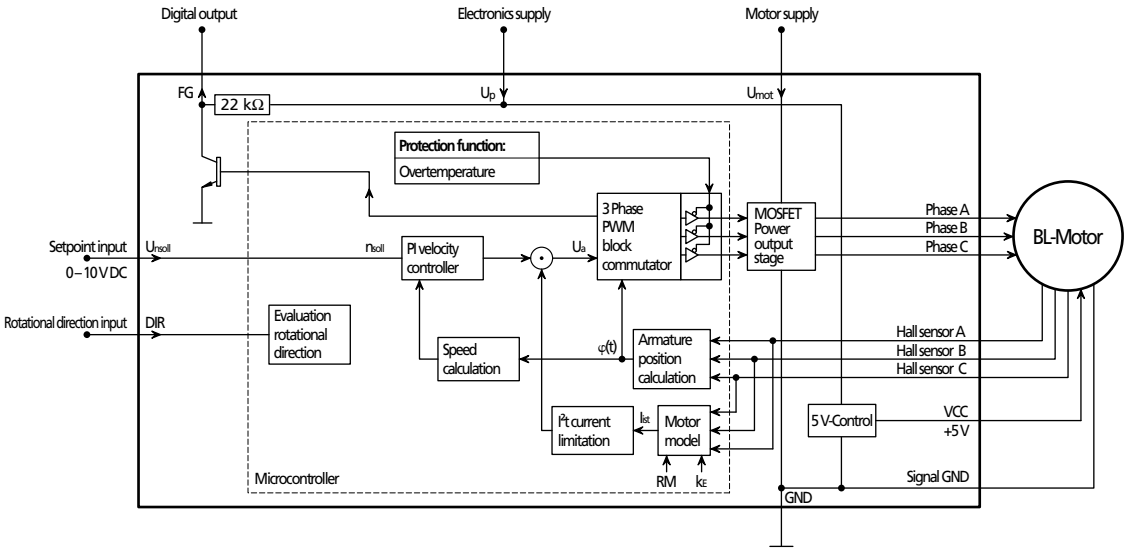
Preset default basic parameters:

- Due to the resolution of the digital Hall sensors, speeds from approx. 250 rpm can be stably controlled.
- PWM frequency at the power output stage: approx. 96 kHz.
- 2-quadrant operation with function for quick speed reduction: The motor windings are short-circuited for faster transition from higher to lower speeds.

4 Functional Description

4.4 Motor with SC speed controller

Block diagram



Setting options

- Pure 2-Quadrant operation without active braking option.

  If problems occur during operation with the braking function in the default setting it can be deactivated.
- Filtering (averaging) of the Hall sensor signals.

  If problems occur with the default setting the time of a complete electrical (half) motor revolution is evaluated to obtain a continuous speed signal. This can cause instable motor running at low speeds as the control dynamics worsen.
- Configuration of the digital output as error output.
- Frequency output can be configured to 6 or 2 pulses per revolution.
- Target velocity value via PWM signal at the target velocity input. See Chapter 4.4.3 “Special configurations”.
- Operation with fixed speed (fixed speed mode). See Chapter 4.4.3 “Special configurations”.
- Operation as voltage controller (volt mode). See Chapter 4.4.3 “Special configurations”.

4 Functional Description

4.4 Motor with SC speed controller

4.4.3 Special configurations

Further setting options exist in addition to the configurations described in Chapter 4.4.2.

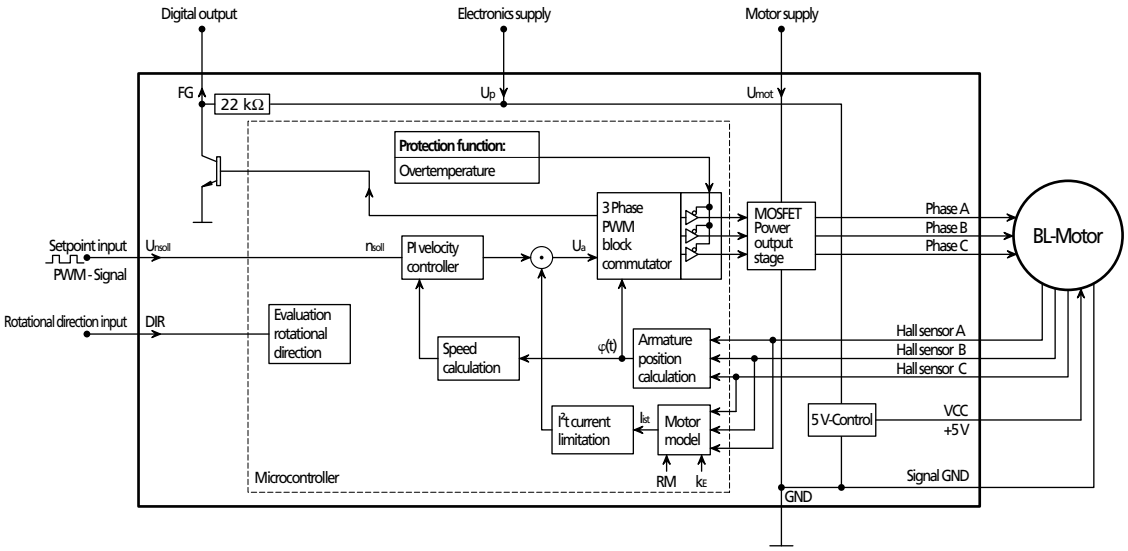
Presetting of target velocity value via PWM signal

The target velocity value can be input via a PWM signal if the target velocity input U_{nsoll} is appropriately configured. The target velocity value is proportional to the pulse duty factor.

Basic parameter for the pulse duty factor

- PWM frequency range: 500 Hz – 18 kHz.
- Motor stops at pulse duty factor < 2.0 %.
- Motor runs at pulse duty factor > 3.0 %.
- The target velocity is proportional to the pulse duty factor. The maximum target velocity at 100 % can be configured. See Chapter 4.4.4 “Parameter settings”.

Example block diagram (BL motor with Hall sensors):



Setting options

- The TTL and PLC levels can be configured as switching levels:

Mode	high level	low level
TTL	> 3.0 V DC	< 0.5 V DC
PLC	> 7.5 V DC	< 2.0 V DC

4 Functional Description

4.4 Motor with SC speed controller

Operation with fixed speed (fixed speed mode)

Fixed speed mode is possible for applications in which the servomotor is to be operated with a specific speed only. The target speed to be set if fixed via a parameter. See Chapter 4.4.4 “Parameter settings”.

Setting options for nominal speed value input U_{nsoll}

- Quick stop input (low level)
  Motor stops at U_{nsoll} > 0.1 V.
  Motor stops if connection is open.
  Motor runs at U_{nsoll} > 0.2 V.
- Quick stop input inverted (high level)
  Motor runs at U_{nsoll} < 2.0 V.
  Motor runs if connection is open.
  Motor stops at U_{nsoll} > 2.4 V.
- No function
  The motor always runs

Operation as voltage controller (volt mode)

The integrated speed controller can be configured for function as a voltage controller. The motor voltage is then output proportionally to the voltage at the nominal speed value input U_{nsoll}. The current limitation remains active.

With this configuration it is possible to use a master controller. The speed controller is then only used as a power amplifier and for commutation only.

Digital output (FG)

The digital output is a switch which switches to GND (open collector with integrated pull-up resistance of 22 kΩ). It can be configured for different tasks:

- Error output
- Frequency output

The detailed properties of the configurations are described in Chapter 4.4.1 “Connection functions”.

4 Functional Description

4.4 Motor with SC speed controller

4.4.4 Parameter settings

The following parameters can be used to adjust the integrated speed controller to the respective application.

Several parameters have a function in certain configurations only or with specific settings only.

Current limiting values

For the I²t current limiting, the peak current (I_{max}) and the motor continuous current (I_{Cont}) must be input. See also Chapter 4.4.5 "Technical information". The allowable values of the speed controller used as well as of the connected motor must be noted and observed.

Parameter	Meaning	max. value	Units
Peak current (I_{max})	Value for the maximum current allowed for a short time (transient maximum current).	3 000*	mA
Motor continuous current (I_{cont})	Value for the continuous current which is the limit value.	3 000*	mA

* Values depend on motor type. The values can be adjusted if necessary. Note the maximum allowable value for the motor!

Fixed speed value

For operation with a fixed speed the nominal speed value is input via an adjustable parameter. See Chapter 4.4.3 "Special configurations".

Parameter	Meaning	max. value	Units
Fixed speed value (N_{setFix})	Nominal speed value, which is input in operation with fixed speed.	65 535	rpm

Pulses per motor revolution

It is possible to configure the digital output FG as a frequency output (this is the default configuration).

Parameter	Meaning	Possible values	Units
Pulses per revolution	Number of pulses per revolution at the digital output.	2, 6	1/rev

Maximum speed value

When inputting the nominal speed value (as an analog voltage or as a PWM signal) the speed value, which is input at 10 V DC or at 100% pulse duty factor, can be set. The maximum speed value can therefore be adjusted to the application.

Different resolutions of the maximum speed value and different maximum values are possible, depending on the operating mode and motor type.

Parameter	Meaning	max. value	Units
Maximum speed value (N_{setMax})	Maximum nominal speed value at 10 V or 100 % pulse duty factor at the nominal speed value input U_{nsoll}.	60 000	rpm

4 Functional Description

4.4 Motor with SC speed controller

Controller parameters

The integrated speed controller is set in the factory so that problem free operation is usually possible. The speed controller has an integrated feature for specifying appropriate parameters if adjustment of the governor to the controlled system is necessary for special applications. See Chapter 4.4.5 “Technical information”.

The targets set for the control's properties also depend on the application.

Above all, a differentiation is made between the stiffness of the control, the uniformity of the speed within a revolution, the allowed system deviation, the allowed overswing and the required stability reserves.

The control circuit must also satisfy these requirements to that the controller parameters must also be adjusted with respect to these.

The PI speed controller used here enables two parameters to be set (proportional and integral-action component).

Parameter	Meaning	max. value	Units
V	Proportional component	32 767	Digit
VI	Proportional component multiplied by the integral-action component	65 535	Digit

Delayed Current Error (with error output only)

Activation of the output can be delayed. Even if the current is already limited the output is not activated until after the time input with DCE. As a result, short-term exceeding of the limit current can be ignored.

Parameter	Meaning	max. value	Units
Delayed Current Error (DCE)	Delay of activation of the error output	5 100	ms

4 Functional Description

4.4 Motor with SC speed controller

4.4.5 Technical information

I²t current limiting

The servomotor with integrated SC speed controller is equipped with current limiting which enables certain motor protection to be achieved.

- Peak current (I_{max})

  The current is limited to the peak current, provided that the thermal current model calculates a non-critical temperature.

- Continuous current (I_{cont})

  If the thermal current model reaches a critical temperature, continuous current is switched to.

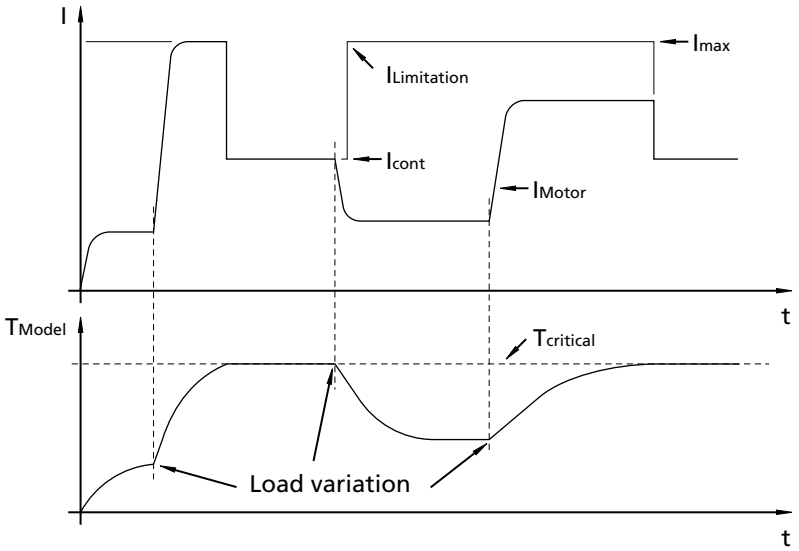
How the current limiting works:

When the motor starts, the peak current is preset as the set-point for the current controller. As the load increases, the current in the motor constantly increases until it finally reaches the peak current. The current controller then comes into operation and limits the current to this set-point.

A thermal current model operating in parallel calculates a model temperature from the actually flowing current. If this model temperature exceeds a critical value, continuous current is switched to and the motor current is regulated to this. Only when the load becomes so small that the temperature falls below the critical model temperature is peak current permitted again.

The following diagram symbolically shows how the current limiting functions by means of an envelope curve ($I_{limiting}$). The current may not rise above the values along this envelope curve.

The aim of this so-called I²t current limiting is not to heat the motor above the thermally allowable temperature by selecting a suitable continuous current. On the other hand, a high load should be temporarily possible in order to enable very dynamic movements.



4 Functional Description

4.4 Motor with SC speed controller

Overtemperature cut-off

The motor is deactivated if the temperature of the electronics exceeds the limit value of 100 °C.

The following condition must be fulfilled to reactivate the motor:

- Temperature below the preset limit value.

Adjustment of the controller parameters

The controller parameters are already preset for common applications. However, the controller parameters can be optimised to optimally adjust the controller to the respective application.

The digital controller operates with a sampling rate of approx. 500 µs.

Example of controller setting:

1. Set the initial configuration.
2. Increase controller gain (proportional component V).
3. Input speed jump from 1/3 of the maximum speed to 2/3.
4. Speed jump from 2/3 to 1/3 and observe behaviour.
5. Repeat steps 2 to 4, until the controller becomes unstable. Then reduce controller amplification until stability is reliably ensured.
6. Repeat steps 2 to 5 with proportional integral-action component (VI).

Effect of pulse width modulation (PWM)

The power output stage of the integrated speed controller operates with so-called pulse width modulation (PWM). At a fixed frequency (the PWM frequency) the pulse duty factor is set between the on time and the off time depending on the controller output value.

The advantage of this procedure is that the losses in the drive electronics are very low. In contrast, the losses in a linear output stage can be very large and it becomes hot.

When the PWM is used the motor's inductance is used as a filter for the current. Therefore, the PWM frequency should be high enough to adequately filter the current.

NOTE

Pulse duty factor

The PWM frequency of the speed controller is optimally matched to the connected motor. Nevertheless, it must be noted that with a low PWM pulse duty factor and larger motor load caused by short-term high current flow in the motor, substantially higher losses can occur than with a large pulse duty factor.

- ▶ *As large a pulse duty factor as possible should set in at the operating point. The required control reserve must also be noted and observed!*
- ▶ *To achieve this, if necessary, the motor operating voltage can be reduced.*

NOTE

Efficiency

Please note that a reduction in efficiency at the motor also reduces the maximum allowable current and therefore the maximum continuous torque.

5 Operation

5.1 Commissioning

Before starting up the servomotor together with a mechanism, the following points must be checked:

- The motor has been installed according to the specifications.
- The ribbon cable of the motor is connected according to the requirements (risk of polarity reversal!) and is laid so that it cannot be damaged during operation. The maximum load values must be noted and observed. See Chapter 7 “Technical Data”.
- Lengthening the connection leads can affect the function and properties with respect to EMC. All connection leads may not exceed a length of 3 m.
- The connected mechanism is installed free of blockages.
- The loads and stresses on the shaft (axial, radial and torques) are within the specified values. See Chapter 7 “Technical Data”.

CAUTION! ***Risk of injuries***



A risk of injuries can result from protruding rotating or moving parts of the driven mechanism.

► *Cover rotating and moving parts with appropriate devices.*

CAUTION! ***Risk of burns***



Depending on the load and ambient temperature, very high temperatures can occur on the surface of the unit.

► *Contact protection (guards) must be provided if necessary.*

6 Maintenance

6.1 Servicing / maintenance

The servomotor is designed to be maintenance free. No maintenance measures are necessary.

6.2 Troubleshooting

The servomotor is designed to be fault-free, provided the parameters given in this instruction manual are complied with. Should a malfunction occur in spite of this please contact the manufacturer.

Switchboard: +49(0)7031/638-0
E-Mail: info@faulhaber.de
Internet: www.faulhaber.com

7 Technical Data

7.1 Motor 2232…BX4 without attachment

		2232 S		012 BX4 S	024 BX4 S	012 BX4	024 BX4	
1	Nominal voltage	U_N		12	24	12	24	Volt
2	Terminal resistance, phase-phase	R		3,5	12,4	3,5	12,4	Ω
3	Output power [1]	$P_{2\ max.}$		3,8	3,9	7,6	7,7	W
4	Efficiency	$\eta_{max.}$		60,9	61,7	66,9	67,6	%
5	No-load speed	n_o		13 200	14 000	6 600	7 000	rpm
6	No-load current (with shaft ø 3,0 mm)	I_o		0,163	0,088	0,112	0,061	A
7	Stall torque	M_H		27,3	29,4	55,7	59,9	mNm
8	Friction torque, static	C_o		0,6	0,6	0,85	0,85	mNm
9	Friction torque, dynamic	C_v		$5,5 \cdot 10^{-5}$	$5,5 \cdot 10^{-5}$	$1,5 \cdot 10^{-4}$	$1,5 \cdot 10^{-4}$	mNm/rpm
10	Speed constant	k_n		1 173	616	579	304	rpm/V
11	Back-EMF constant	k_E		0,852	1,623	1,728	3,288	mV/rpm
12	Torque constant	k_M		8,14	15,50	16,50	31,40	mNm/A
13	Current constant	k_I		0,123	0,065	0,061	0,032	A/mNm
14	Slope of n-M curve	$\Delta n/\Delta M$		504	493	123	120	rpm/mNm
15	Terminal inductance, phase-phase	L		130	470	120	440	µH
16	Mechanical time constant	τ_m		22	22	6,7	6,5	ms
17	Rotor inertia	J		4,2	4,2	5,2	5,2	gcm^2
18	Angular acceleration	$\alpha_{max.}$		65	70	107	115	$\cdot 10^3 rad/s^2$
19	Thermal resistance	$R_{th\ 1}$ / $R_{th\ 2}$		2 / 17		2 / 17		K/W
20	Thermal time constant	τ_{w1} / τ_{w2}		4,1 / 360		4,1 / 370		s
21	Operating temperature range			– 40 ... + 100		– 40 ... + 100		°C
22	Shaft bearings		ball bearings, preloaded					
23	Shaft load max.:							
	– radial at 3 000 rpm (4 mm from mounting flange)		20					N
	– axial at 3 000 rpm		2					N
	– axial at standstill		20					N
24	Shaft play:							
	– radial	≤	0,015					mm
	– axial	=	0					mm
25	Housing material		stainless steel					
26	Weight		70					g
27	Direction of rotation		electronically reversible					
28	Number of pole pairs		2					
Recommended values - mathematically independent of each other								
29	Speed up to	$n_{e\ max.}$		34 000	34 000	22 000	22 000	rpm
30	Torque up to [1] [2]	$M_{e\ max.}$		6 / 10	6 / 10	12 / 19	12 / 19	mNm
31	Current up to [1] [2]	$I_{e\ max.}$		0,94 / 1,42	0,50 / 0,75	0,90 / 1,40	0,48 / 0,74	A

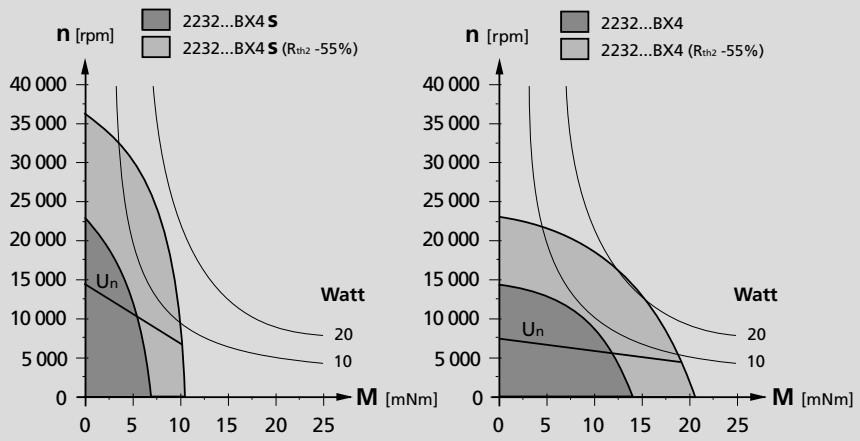
[1] at 5 000 rpm
[2] thermal resistance $R_{th\ 2}$ not reduced / thermal resistance $R_{th\ 2}$ by 55% reduced

Note:

The diagram indicates the recommended speed in relation to the available torque at the output shaft for a given ambient temperature of 22°C.

The diagram shows the motor in a completely insulated as well as thermally coupled condition ($R_{th\ 2}$ 55% reduced).

The nominal voltage (U_N) curve shows the operating point at nominal voltage in the insulated and thermally coupled condition. Any points of operation above the curve at nominal voltage will require a higher operating voltage. Any points below the nominal voltage curve will require less voltage.



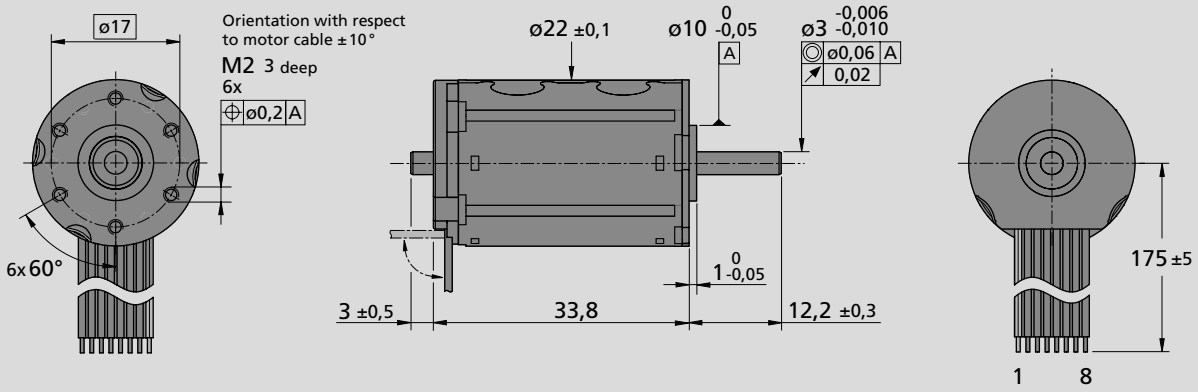
Recommended areas for continuous operation

7 Technical Data

7.1 Motor 2232…BX4 without attachment

Dimensional drawing

M 1:1

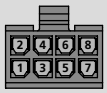


2232 S ... BX4 (S)

Options

- Connector variant (Option no. 3830)

  Motor:
  AWG 26 / PVC ribbon cable
  with connector Micro-Fit



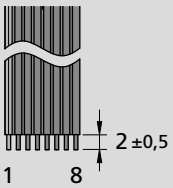
Full product description

- Examples:

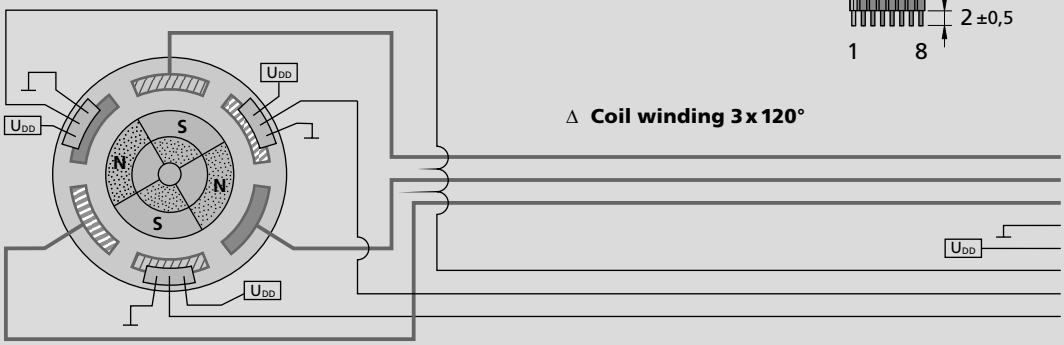
  2232S024BX4

  2232S012BX4S

Cable and connection information



Cable
Jacket Material: PVC
8 conductors, AWG 26
grid 1,27 mm
wires tinned



Δ Coil winding 3 x 120°

Connection

No.	Function
1	Phase C
2	Phase B
3	Phase A
4	GND
5	U_{DD} (2,2 ... 18V DC)
6	Hall sensor C
7	Hall sensor B
8	Hall sensor A

7 Technical Data

7.2 Motor 2232…BX4 with encoder IE3

		2232 S		012 BX4 S	024 BX4 S	012 BX4	024 BX4	IE3
1	Nominal voltage	U_N		12	24	12	24	Volt
2	Terminal resistance, phase-phase	R		3,5	12,4	3,5	12,4	Ω
3	Output power [1]	$P_{2\ max.}$		4,4	4,5	8,8	8,9	W
4	Efficiency	$\eta_{max.}$		60,9	61,7	66,9	67,6	%
5	No-load speed	n_o		13 200	14 000	6 600	7 000	rpm
6	No-load current (with shaft ø 3,0 mm)	I_o		0,163	0,088	0,112	0,061	A
7	Stall torque	M_H		27,3	29,4	55,7	59,9	mNm
8	Friction torque, static	C_o		0,6	0,6	0,85	0,85	mNm
9	Friction torque, dynamic	C_v		$5,5 \cdot 10^{-5}$	$5,5 \cdot 10^{-5}$	$1,5 \cdot 10^{-4}$	$1,5 \cdot 10^{-4}$	mNm/rpm
10	Speed constant	k_n		1 173	616	579	304	rpm/V
11	Back-EMF constant	k_E		0,852	1,623	1,728	3,288	mV/rpm
12	Torque constant	k_M		8,14	15,50	16,50	31,40	mNm/A
13	Current constant	k_I		0,123	0,065	0,061	0,032	A/mNm
14	Slope of n-M curve	$\Delta n/\Delta M$		504	493	123	120	rpm/mNm
15	Terminal inductance, phase-phase	L		130	470	120	440	µH
16	Mechanical time constant	τ_m		22	22	6,7	6,5	ms
17	Rotor inertia	J		4,2	4,2	5,2	5,2	gcm^2
18	Angular acceleration	$\alpha_{max.}$		65	70	107	115	$\cdot 10^3 rad/s^2$
19	Thermal resistance	$R_{th\ 1}$ / $R_{th\ 2}$		2 / 13		2 / 13		K/W
20	Thermal time constant	τ_{w1} / τ_{w2}		4,1 / 274		4,1 / 283		s
21	Operating temperature range			– 40 ... + 100		– 40 ... + 100		°C
22	Shaft bearings		ball bearings, preloaded					
23	Shaft load max.:							
	– radial at 3 000 rpm (4 mm from mounting flange)		20					N
	– axial at 3 000 rpm		2					N
	– axial at standstill		20					N
24	Shaft play:							
	– radial	≤	0,015					mm
	– axial	=	0					mm
25	Housing material		stainless steel					
26	Weight		81					g
27	Direction of rotation		electronically reversible					
28	Number of pole pairs		2					
Recommended values - mathematically independent of each other								
29	Speed up to	$n_{e\ max.}$		40 000	40 000	25 000	20 000	rpm
30	Torque up to [1] [2]	$M_{e\ max.}$		7 / 11	7 / 11	14 / 22	14 / 22	mNm
31	Current up to [1] [2]	$I_{e\ max.}$		1,06 / 1,61	0,58 / 0,86	1,05 / 1,60	0,56 / 0,85	A

[1] at 5 000 rpm

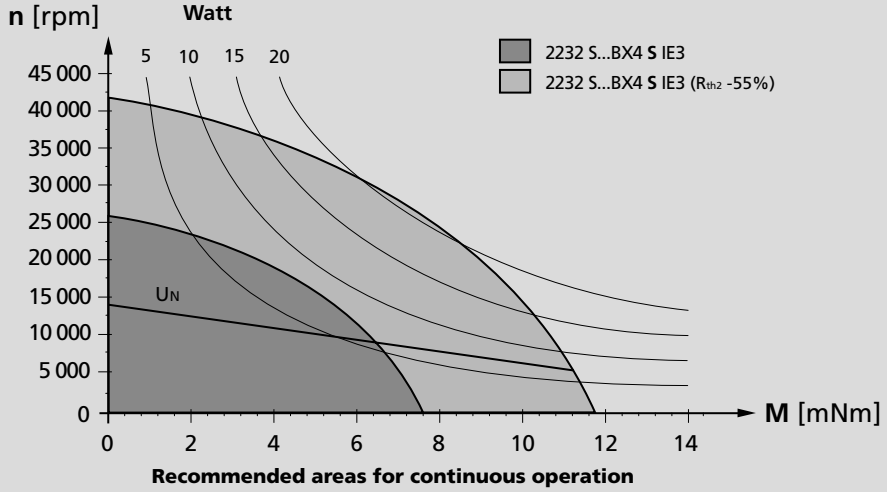
[2] thermal resistance $R_{th\ 2}$ not reduced / thermal resistance $R_{th\ 2}$ by 55% reduced

Note:

The diagram indicates the recommended speed in relation to the available torque at the output shaft for a given ambient temperature of 22°C.

The diagram shows the motor in a completely insulated as well as thermally coupled condition ($R_{th\ 2}$ 55% reduced).

The nominal voltage (U_N) curve shows the operating point at nominal voltage in the insulated and thermally coupled condition. Any points of operation above the curve at nominal voltage will require a higher operating voltage. Any points below the nominal voltage curve will require less voltage.



Recommended areas for continuous operation

7 Technical Data

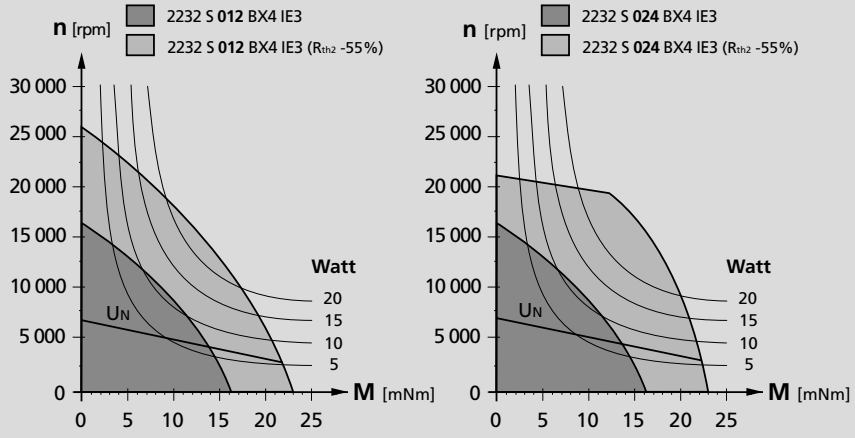
7.2 Motor 2232…BX4 with encoder IE3

Note:

The diagram indicates the recommended speed in relation to the available torque at the output shaft for a given ambient temperature of 22°C.

The diagram shows the motor in a completely insulated as well as thermally coupled condition ($R_{th\,2}$ 55% reduced).

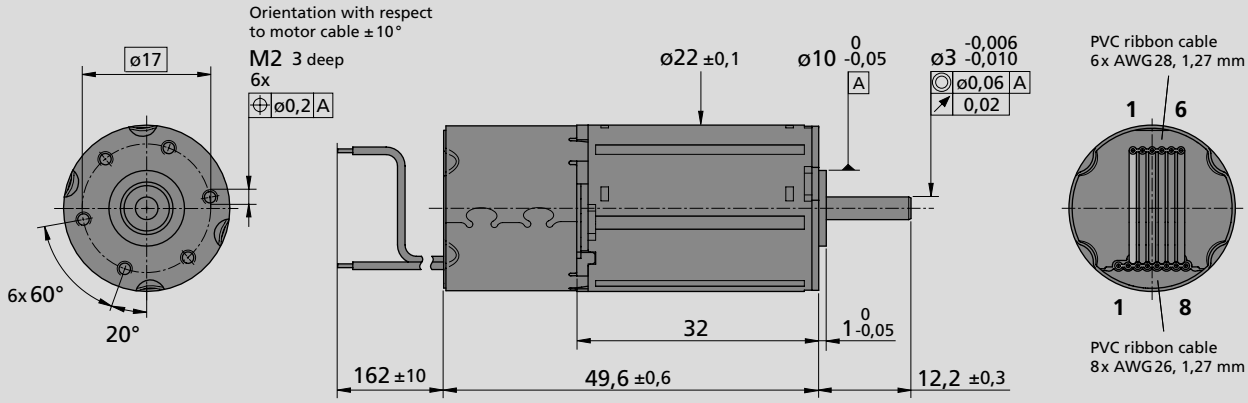
The nominal voltage (U_N) curve shows the operating point at nominal voltage in the insulated and thermally coupled condition. Any points of operation above the curve at nominal voltage will require a higher operating voltage. Any points below the nominal voltage curve will require less voltage.



Recommended areas for continuous operation

Dimensional drawing

M 1:1



2232 S ... BX4(S) IE3

Magnetic Encoder		IE3-32	IE3-64	IE3-128	IE3-256	IE3 - 512	IE3 - 1024	
Lines per revolution	N	32	64	128	256	512	1024	
Frequency range [1], up to	f	15	30	60	120	240	430	kHz
Signal output, square wave		2+1 Index						channels
Supply voltage Encoder	$U_{DD\,Enc}$	4,5 ... 5,5						V DC
Current consumption, typical [2]	$I_{DD\,Enc}$	typ. 16, max. 23						mA
Output current, max. allowable [3]	I_{OUT}	4						mA
Index Pulse width [4]	P_0	90 ± 45				90 ± 75		° e
Phase shift, channel A to B [4]	Φ	90 ± 45				90 ± 75		° e
Signal rise/fall time, max. (C_{LOAD} = 50 pF)	tr/tf	0,1/0,1						µs
Inertia of encoder magnet	J	0,08						gcm^2

Connection information Motor		IE3-32	IE3-64	IE3-128	IE3-256	IE3 - 512	IE3 - 1024	
Supply voltage Hallsensors [5]	U_{DD}	2,2 ...18				4,5 ... 5,5		V DC

[1] speed (rpm) = f (Hz) x 60/N
[2] $U_{DD\,Enc}$ = 5 V: with unloaded outputs
[3] $U_{DD\,Enc}$ = 5 V: low logic level < 0,4 V, high logic level > 4,5 V: CMOS- and TTL compatible
[4] at 5 000 rpm
[5] IE3-32/64/128/256 $U_{DD} \neq U_{DD\,ENC}$ (galvanically isolated)
IE3-512 / 1 024 $U_{DD} = U_{DD\,ENC}$

7 Technical Data

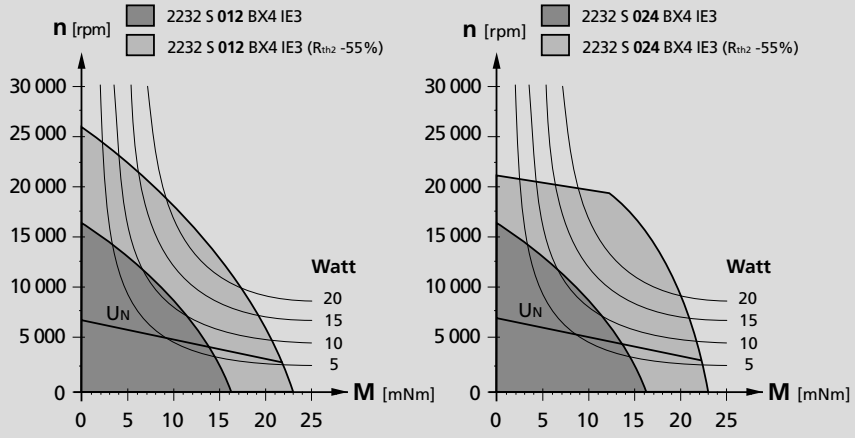
7.2 Motor 2232…BX4 with encoder IE3

Note:

The diagram indicates the recommended speed in relation to the available torque at the output shaft for a given ambient temperature of 22°C.

The diagram shows the motor in a completely insulated as well as thermally coupled condition ($R_{th\,2}$ 55% reduced).

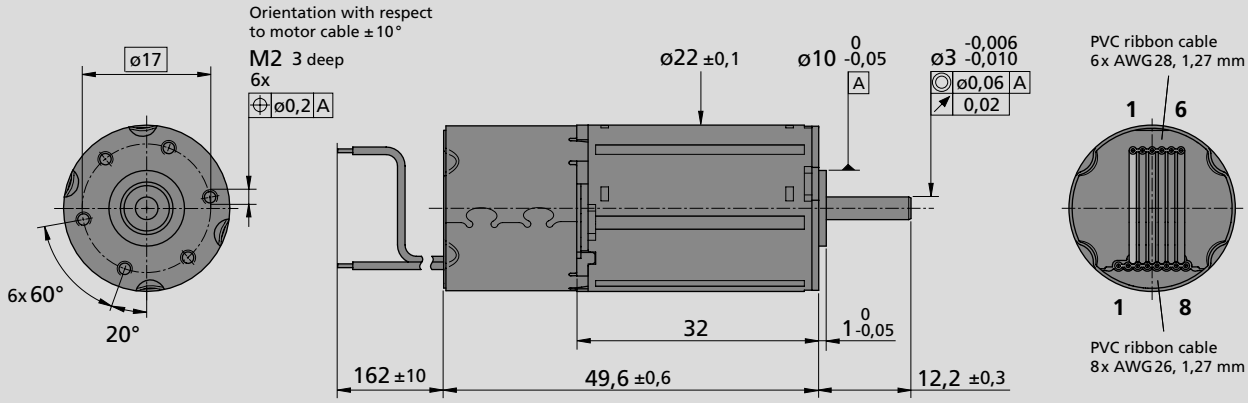
The nominal voltage (U_N) curve shows the operating point at nominal voltage in the insulated and thermally coupled condition. Any points of operation above the curve at nominal voltage will require a higher operating voltage. Any points below the nominal voltage curve will require less voltage.



Recommended areas for continuous operation

Dimensional drawing

M 1:1



2232 S ... BX4(S) IE3

Magnetic Encoder		IE3-32	IE3-64	IE3-128	IE3-256	IE3 - 512	IE3 - 1024	
Lines per revolution	N	32	64	128	256	512	1024	
Frequency range [1], up to	f	15	30	60	120	240	430	kHz
Signal output, square wave		2+1 Index						channels
Supply voltage Encoder	$U_{DD\,Enc}$	4,5 ... 5,5						V DC
Current consumption, typical [2]	$I_{DD\,Enc}$	typ. 16, max. 23						mA
Output current, max. allowable [3]	I_{OUT}	4						mA
Index Pulse width [4]	P_0	90 ± 45				90 ± 75		° e
Phase shift, channel A to B [4]	Φ	90 ± 45				90 ± 75		° e
Signal rise/fall time, max. (C_{LOAD} = 50 pF)	tr/tf	0,1/0,1						µs
Inertia of encoder magnet	J	0,08						gcm^2

Connection information Motor		IE3-32	IE3-64	IE3-128	IE3-256	IE3 - 512	IE3 - 1024	
Supply voltage Hallsensors [5]	U_{DD}	2,2 ...18				4,5 ... 5,5		V DC

[1] speed (rpm) = f (Hz) x 60/N
[2] $U_{DD\,Enc}$ = 5 V: with unloaded outputs
[3] $U_{DD\,Enc}$ = 5 V: low logic level < 0,4 V, high logic level > 4,5 V: CMOS- and TTL compatible
[4] at 5 000 rpm
[5] IE3-32/64/128/256 $U_{DD} \neq U_{DD\,ENC}$ (galvanically isolated)
IE3-512 / 1 024 $U_{DD} = U_{DD\,ENC}$

7 Technical Data

7.3 Motor 2232…BX4 with encoder IE3 L

		2232 S		012 BX4 S	024 BX4 S	012 BX4	024 BX4	IE3 L
1	Nominal voltage	U_N		12	24	12	24	Volt
2	Terminal resistance, phase-phase	R		3,5	12,4	3,5	12,4	Ω
3	Output power [1]	$P_{2\ max.}$		4,4	4,5	8,8	8,9	W
4	Efficiency	$\eta_{max.}$		60,9	61,7	66,9	67,6	%
5	No-load speed	n_o		13 200	14 000	6 600	7 000	rpm
6	No-load current (with shaft ø 3,0 mm)	I_o		0,163	0,088	0,112	0,061	A
7	Stall torque	M_H		27,3	29,4	55,7	59,9	mNm
8	Friction torque, static	C_o		0,6	0,6	0,85	0,85	mNm
9	Friction torque, dynamic	C_v		$5,5 \cdot 10^{-5}$	$5,5 \cdot 10^{-5}$	$1,5 \cdot 10^{-4}$	$1,5 \cdot 10^{-4}$	mNm/rpm
10	Speed constant	k_n		1 173	616	579	304	rpm/V
11	Back-EMF constant	k_E		0,852	1,623	1,728	3,288	mV/rpm
12	Torque constant	k_M		8,14	15,50	16,50	31,40	mNm/A
13	Current constant	k_I		0,123	0,065	0,061	0,032	A/mNm
14	Slope of n-M curve	$\Delta n/\Delta M$		504	493	123	120	rpm/mNm
15	Terminal inductance, phase-phase	L		130	470	120	440	µH
16	Mechanical time constant	τ_m		22	22	6,7	6,5	ms
17	Rotor inertia	J		4,2	4,2	5,2	5,2	gcm^2
18	Angular acceleration	$\alpha_{max.}$		65	70	107	115	$\cdot 10^3 rad/s^2$
19	Thermal resistance	$R_{th\ 1}$ / $R_{th\ 2}$		2 / 13		2 / 13		K/W
20	Thermal time constant	τ_{w1} / τ_{w2}		4,1 / 274		4,1 / 283		s
21	Operating temperature range			– 40 ... + 100		– 40 ... + 100		°C
22	Shaft bearings		ball bearings, preloaded					
23	Shaft load max.:							
	– radial at 3 000 rpm (4 mm from mounting flange)		20					N
	– axial at 3 000 rpm		2					N
	– axial at standstill		20					N
24	Shaft play:							
	– radial	≤	0,015					mm
	– axial	=	0					mm
25	Housing material		stainless steel					
26	Weight		81					g
27	Direction of rotation		electronically reversible					
28	Number of pole pairs		2					
Recommended values - mathematically independent of each other								
29	Speed up to	$n_{e\ max.}$		40 000	40 000	25 000	20 000	rpm
30	Torque up to [1] [2]	$M_{e\ max.}$		7 / 11	7 / 11	14 / 22	14 / 22	mNm
31	Current up to [1] [2]	$I_{e\ max.}$		1,06 / 1,61	0,58 / 0,86	1,05 / 1,60	0,56 / 0,85	A

[1] at 5 000 rpm

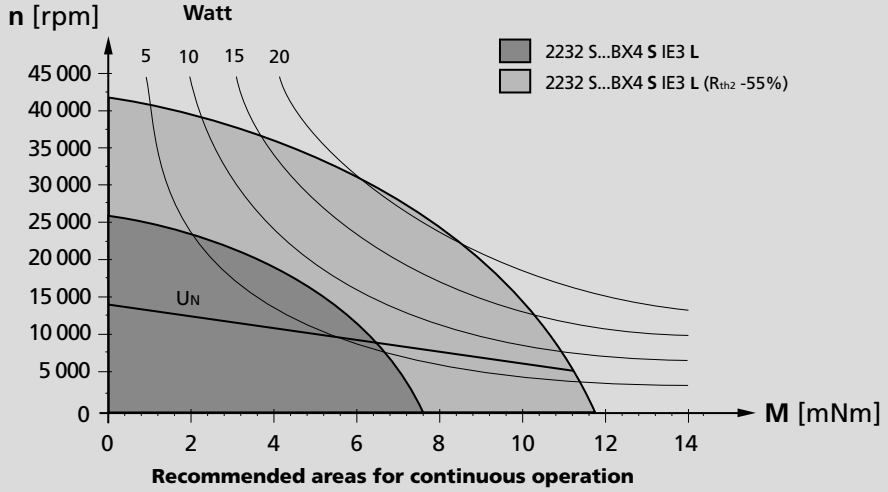
[2] thermal resistance $R_{th\ 2}$ not reduced / thermal resistance $R_{th\ 2}$ by 55% reduced

Note:

The diagram indicates the recommended speed in relation to the available torque at the output shaft for a given ambient temperature of 22°C.

The diagram shows the motor in a completely insulated as well as thermally coupled condition ($R_{th\ 2}$ 55% reduced).

The nominal voltage (U_N) curve shows the operating point at nominal voltage in the insulated and thermally coupled condition. Any points of operation above the curve at nominal voltage will require a higher operating voltage. Any points below the nominal voltage curve will require less voltage.



Recommended areas for continuous operation

7 Technical Data

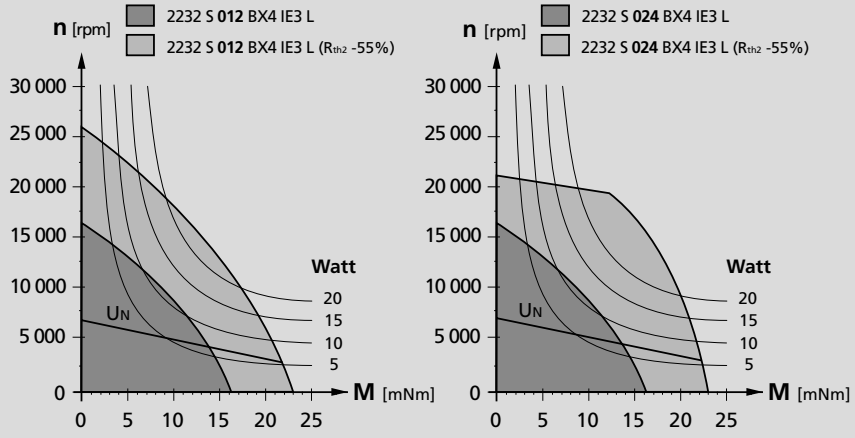
7.3 Motor 2232…BX4 with encoder IE3 L

Note:

The diagram indicates the recommended speed in relation to the available torque at the output shaft for a given ambient temperature of 22°C.

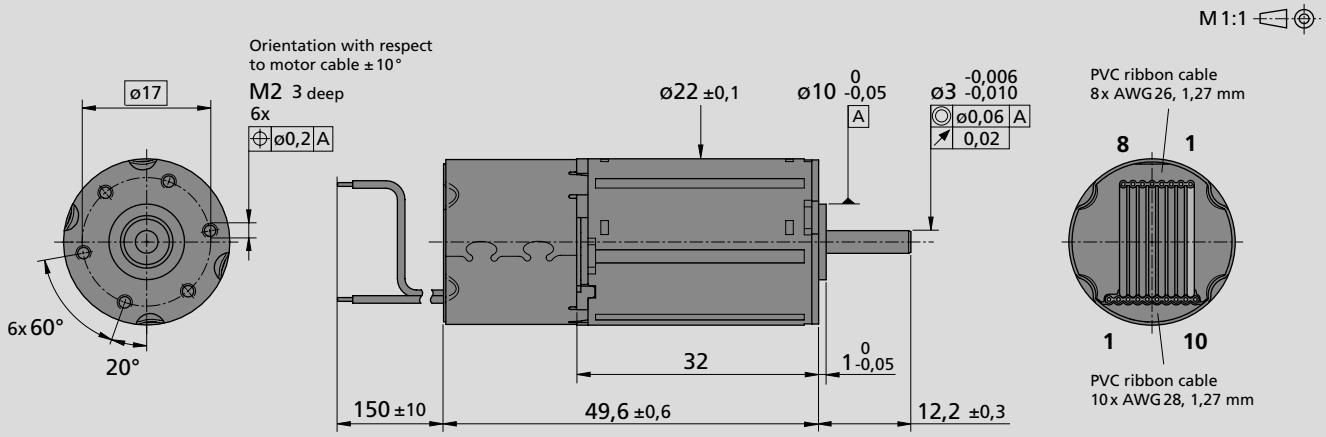
The diagram shows the motor in a completely insulated as well as thermally coupled condition ($R_{th\,2}$ 55% reduced).

The nominal voltage (U_N) curve shows the operating point at nominal voltage in the insulated and thermally coupled condition. Any points of operation above the curve at nominal voltage will require a higher operating voltage. Any points below the nominal voltage curve will require less voltage.



Recommended areas for continuous operation

Dimensional drawing



2232 S ... BX4(S) IE3 L

Magnetic Encoder		IE3-32 L	IE3-64 L	IE3-128 L	IE3-256 L	IE3-512 L	IE3-1024 L	
Lines per revolution	N	32	64	128	256	512	1024	
Frequency range [1], up to	f	15	30	60	120	240	430	kHz
Signal output, square wave		2+1 index and complementary outputs						channels
Supply voltage	$U_{DD\ Enc}$	4,5 ... 5,5						V DC
Current consumption, typical [2]	$I_{DD\ Enc}$	typ. 17, max. 25						mA
Index Pulse width [3]	P_0	90±45				90± 75		°e
Phase shift, channel A to B [3]	Φ	90±45				90±75		°e
Inertia of encoder magnet	J	0,08						gcm²

[1] speed (rpm) = f(Hz) x 60/N
[2] $U_{DD\ Enc}$ = 5 V: with unloaded outputs
[3] at 5 000 rpm

Notes: The output signals are TIA-422 compatible.
Examples of Line driver Receivers: ST26C32ABD (STM), ST26C32IP16 (EXAR), DS26C32AT (NSC).

7 Technical Data

7.3 Motor 2232…BX4 with encoder IE3 L

Features

In this version, the brushless DC servomotors have an encoder with 3 output channels. A permanent magnet on the shaft creates a moving magnetic field which is captured using a single-chip angular sensor and further processed. At the encoder outputs, two 90° phase-shifted rectangular signals are available with up to 1024 impulses and an index impulse per motor revolution.

The Line Driver version has differential signal outputs (TIA-422). Differential signals reduce ambient interference and are suitable for applications with high ambient interference. The line driver amplifies the encoder signal which means that long cables can be used without signal degradation. Differential signal outputs must be decoded by the appropriate receiver module.

The encoder is available in a variety of different resolutions and is suitable for speed control and positioning applications. The motor and encoder cables are connected via separate ribbon cables.

A detailed instruction manual is included with the product or is available online at www.faulhaber.com

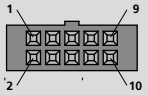
Other resolutions of 1 - 127 impulses are available on request.

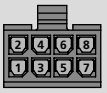
Options

- Connector variant (Option no.: 3589)

  Encoder:
  AWG 28 / PVC ribbon cable
  with connector DIN-41651 (pitch 2,54 mm)

  Motor:
  AWG 26 / PVC ribbon cable
  with connector Micro-Fit





Full product description

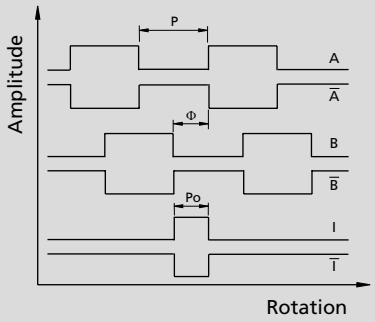
- Examples:

  2232S024BX4 IE3-1024 L

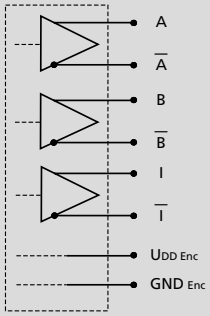
  2232S012BX4S IE3-32 L

Output signals / Circuit diagram / Connector information

Output signals
with clockwise rotation as seen from the shaft end



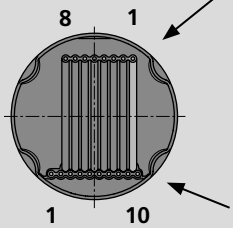
Output circuit



Admissible deviation of phase shift / Index pulse:

$$\Delta\Phi = \left| 90° - \frac{\Phi}{P} * 180° \right| \leq 75° \qquad \Delta P_o = \left| 90° - \frac{P_o}{P} * 180° \right| \leq 75°$$

Connection Motor



Connection Encoder

No.	Function
1	Phase C
2	Phase B
3	Phase A
4	GND
5	UDD (2,2 ... 18V DC)
6	Hall sensor C
7	Hall sensor B
8	Hall sensor A

No.	Function
1	n.c.
2	UDD Enc
3	GND Enc
4	n.c.
5	Channel Ā
6	Channel A
7	Channel B̄
8	Channel B
9	Channel Ī (Index)
10	Channel I (Index)

Caution:
Incorrect lead connection will damage the motor electronics!

7 Technical Data

7.4 Motor 2232…BX4 with absolute encoder AES

		2232 S		012 BX4 S	024 BX4 S	012 BX4	024 BX4	AES
1	Nominal voltage	U_N		12	24	12	24	Volt
2	Terminal resistance, phase-phase	R		3,5	12,4	3,5	12,4	Ω
3	Output power [1]	$P_{2\ max.}$		4,4	4,5	8,8	8,9	W
4	Efficiency	$\eta_{max.}$		60,9	61,7	66,9	67,6	%
5	No-load speed	n_o		13 200	14 000	6 600	7 000	rpm
6	No-load current (with shaft ø 3,0 mm)	I_o		0,163	0,088	0,112	0,061	A
7	Stall torque	M_H		27,3	29,4	55,7	59,9	mNm
8	Friction torque, static	C_o		0,6	0,6	0,85	0,85	mNm
9	Friction torque, dynamic	C_v		$5,5 \cdot 10^{-5}$	$5,5 \cdot 10^{-5}$	$1,5 \cdot 10^{-4}$	$1,5 \cdot 10^{-4}$	mNm/rpm
10	Speed constant	k_n		1 173	616	579	304	rpm/V
11	Back-EMF constant	k_E		0,852	1,623	1,728	3,288	mV/rpm
12	Torque constant	k_M		8,14	15,50	16,50	31,40	mNm/A
13	Current constant	k_I		0,123	0,065	0,061	0,032	A/mNm
14	Slope of n-M curve	$\Delta n/\Delta M$		504	493	123	120	rpm/mNm
15	Terminal inductance, phase-phase	L		130	470	120	440	µH
16	Mechanical time constant	τ_m		22	22	6,7	6,5	ms
17	Rotor inertia	J		4,2	4,2	5,2	5,2	gcm^2
18	Angular acceleration	$\alpha_{max.}$		65	70	107	115	$\cdot 10^3 rad/s^2$
19	Thermal resistance	$R_{th\ 1}$ / $R_{th\ 2}$		2 / 13		2 / 13		K/W
20	Thermal time constant	τ_{w1} / τ_{w2}		4,1 / 274		4,1 / 283		s
21	Operating temperature range			– 40 ... + 100		– 40 ... + 100		°C
22	Shaft bearings		ball bearings, preloaded					
23	Shaft load max.:							
	– radial at 3 000 rpm (4 mm from mounting flange)		20					N
	– axial at 3 000 rpm		2					N
	– axial at standstill		20					N
24	Shaft play:							
	– radial	≤	0,015					mm
	– axial	=	0					mm
25	Housing material		stainless steel					
26	Weight		81					g
27	Direction of rotation		electronically reversible					
28	Number of pole pairs		2					
Recommended values - mathematically independent of each other								
29	Speed up to	$n_{e\ max.}$		40 000	40 000	25 000	20 000	rpm
30	Torque up to [1] [2]	$M_{e\ max.}$		7 / 11	7 / 11	14 / 22	14 / 22	mNm
31	Current up to [1] [2]	$I_{e\ max.}$		1,06 / 1,61	0,58 / 0,86	1,05 / 1,60	0,56 / 0,85	A

[1] at 5 000 rpm

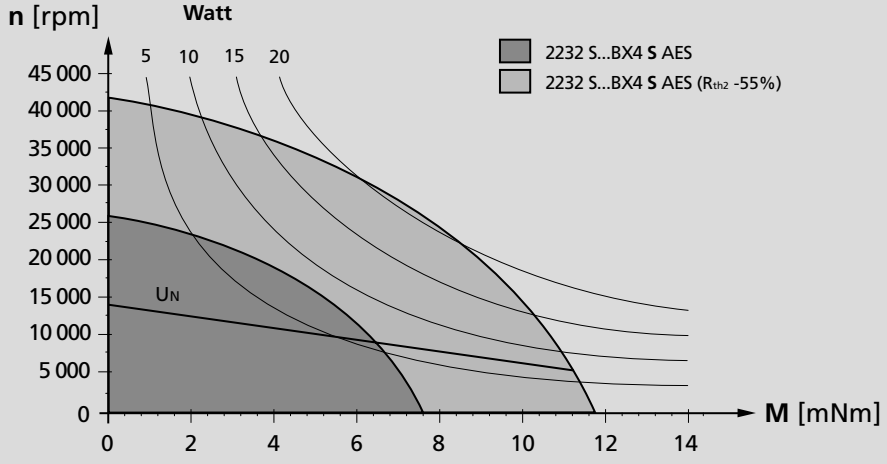
[2] thermal resistance $R_{th\ 2}$ not reduced / thermal resistance $R_{th\ 2}$ by 55% reduced

Note:

The diagram indicates the recommended speed in relation to the available torque at the output shaft for a given ambient temperature of 22°C.

The diagram shows the motor in a completely insulated as well as thermally coupled condition ($R_{th\ 2}$ 55% reduced).

The nominal voltage (U_N) curve shows the operating point at nominal voltage in the insulated and thermally coupled condition. Any points of operation above the curve at nominal voltage will require a higher operating voltage. Any points below the nominal voltage curve will require less voltage.



Recommended areas for continuous operation

7 Technical Data

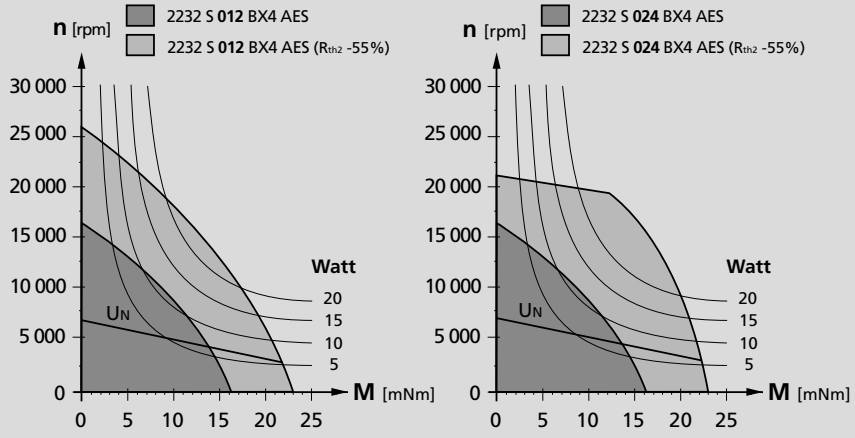
7.4 Motor 2232…BX4 with absolute encoder AES

Note:

The diagram indicates the recommended speed in relation to the available torque at the output shaft for a given ambient temperature of 22°C.

The diagram shows the motor in a completely insulated as well as thermally coupled condition ($R_{th\,2}$ 55% reduced).

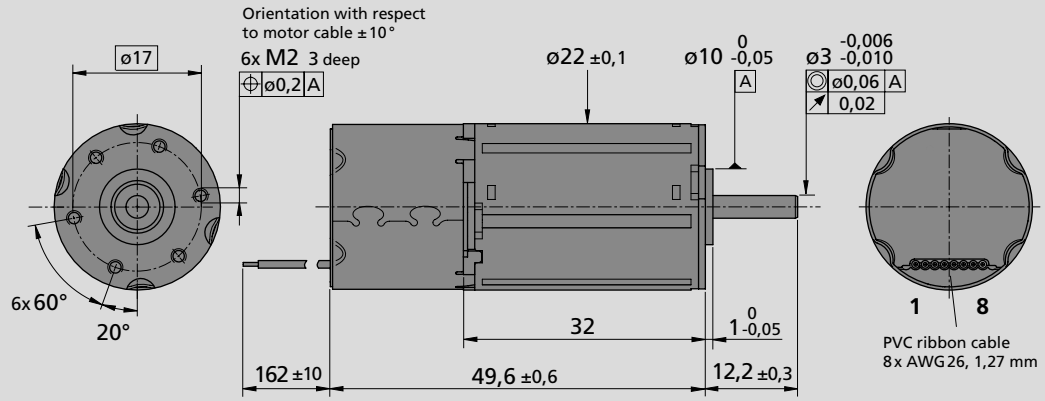
The nominal voltage (U_N) curve shows the operating point at nominal voltage in the insulated and thermally coupled condition. Any points of operation above the curve at nominal voltage will require a higher operating voltage. Any points below the nominal voltage curve will require less voltage.



Recommended areas for continuous operation

Dimensional drawing

M 1:1



2232 S ... BX4(S) AES

Magnetic Encoder		AES - 4096	
Lines per revolution (resolution)	N	4 096	
Signal output		Synchronous Serial Interface (SSI)	
Supply voltage	$U_{DD\ Enc}$	4,5 ... 5,5	V DC
Current consumption, typical [1]	$I_{DD\ Enc}$	typ. 16, max. 23	mA
Output current, max. (DATA) [2]		4	mA
Clock Frequency, max. (CLK)		2	MHz
Input low level (CLK)		0 ... 0,8	V
Input high level (CLK)		2 ... $U_{DD\ Enc}$	V
Setup time after power on, max.	t_{setup}	4	ms
Operating temperature range		– 40 ... +100	°C

[1] $U_{DD\ Enc}$ = 5 V: with unloaded outputs
[2] $U_{DD\ Enc}$ = 5 V: low logic level ≤ 0,4 V, high logic level ≥ 4,6 V

7 Technical Data

7.4 Motor 2232…BX4 with absolute encoder AES

Features

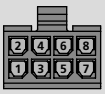
In this version, these brushless DC-Servomotors come equipped with an absolute encoder with a serial interface. A magnet on the motor shaft is registered by a single chip sensor to create the encoder signal. Absolute position information is then provided at the signal outputs and communicated via a serial (SSI) interface.

The absolute encoder is ideal for commutation, speed and position control of the motor. It can be used to create a sinusoidal commutation signal. The advantages are a reduced torque ripple, a higher efficiency, and reduced electrical noise generation.
Cabling is also reduced to a single motor / encoder flat cable.

A detailed instruction manual is included with the product or is available online at www.faulhaber.com

Options

- Connector variant (Option no. 3830)
  AWG 26 / PVC ribbon cable
  with connector Micro-Fit

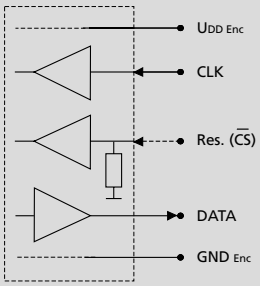


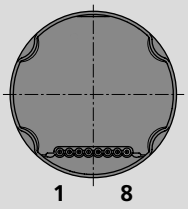
Full product description

- Examples:
  2232S024BX4 AES-4096
  2232S012BX4S AES-4096

Circuit diagram / Connector information

Output circuit





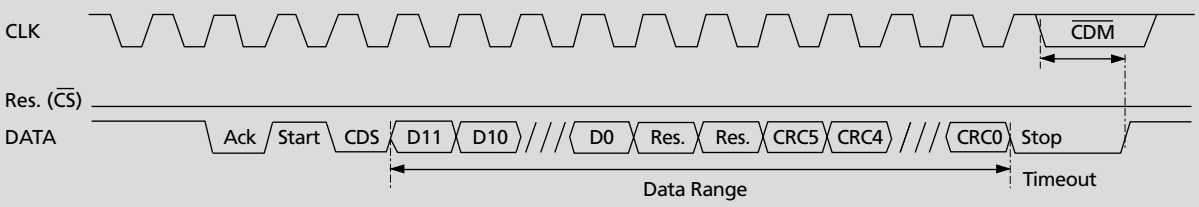
Connection

No.	Function
1	Phase C
2	Phase B
3	Phase A
4	GND Enc
5	UDD Enc
6	CLK
7	Res. (CS)
8	DATA

Caution:
Incorrect lead connection will damage the motor electronics!

Interface signals

Interface signals (SSI)



7 Technical Data

7.5 Motor 2232…BX4 with Speed Controller SC

		2232 S		012 BX4 S	024 BX4 S	012 BX4	024 BX4	SC
1	Nominal voltage	U_N		12	24	12	24	Volt
2	Terminal resistance, phase-phase	R		3,5	12,4	3,5	12,4	Ω
3	Output power [1]	$P_{2\ max.}$		4,4	4,5	8,8	8,9	W
4	Efficiency	$\eta_{max.}$		60,9	61,7	66,9	67,6	%
5	No-load speed	n_o		13 200	14 000	6 600	7 000	rpm
6	No-load current (with shaft ø 3,0 mm)	I_o		0,163	0,088	0,112	0,061	A
7	Stall torque	M_H		27,3	29,4	55,7	59,9	mNm
8	Friction torque, static	C_o		0,6	0,6	0,85	0,85	mNm
9	Friction torque, dynamic	C_v		$5,5 \cdot 10^{-5}$	$5,5 \cdot 10^{-5}$	$1,5 \cdot 10^{-4}$	$1,5 \cdot 10^{-4}$	mNm/rpm
10	Speed constant	k_n		1 173	616	579	304	rpm/V
11	Back-EMF constant	k_E		0,852	1,623	1,728	3,288	mV/rpm
12	Torque constant	k_M		8,14	15,50	16,50	31,40	mNm/A
13	Current constant	k_I		0,123	0,065	0,061	0,032	A/mNm
14	Slope of n-M curve	$\Delta n/\Delta M$		504	493	123	120	rpm/mNm
15	Terminal inductance, phase-phase	L		130	470	120	440	µH
16	Mechanical time constant	τ_m		22	22	6,7	6,5	ms
17	Rotor inertia	J		4,2	4,2	5,2	5,2	gcm^2
18	Angular acceleration	$\alpha_{max.}$		65	70	107	115	$\cdot 10^3 rad/s^2$
19	Thermal resistance	$R_{th\ 1}$ / $R_{th\ 2}$		2 / 13		2 / 13		K/W
20	Thermal time constant	τ_{w1} / τ_{w2}		4,1 / 274		4,1 / 283		s
21	Operating temperature range			– 40 ... + 85		– 40 ... + 85		°C
22	Shaft bearings		ball bearings, preloaded					
23	Shaft load max.:							
	– radial at 3 000 rpm (4 mm from mounting flange)		20					N
	– axial at 3 000 rpm		2					N
	– axial at standstill		20					N
24	Shaft play:							
	– radial	≤	0,015					mm
	– axial	=	0					mm
25	Housing material		stainless steel					
26	Weight		77					g
27	Direction of rotation		electronically reversible					
28	Number of pole pairs		2					
Recommended values - mathematically independent of each other								
29	Speed up to	$n_{e\ max.}$		22 500	17 000	14 500	8 500	rpm
30	Torque up to [1] [2]	$M_{e\ max.}$		7	7	13	13	mNm
31	Current up to [1] [2]	$I_{e\ max.}$		0,99	0,52	0,95	0,50	A

[1] at 5 000 rpm
[2] thermal resistance $R_{th\ 2}$ not reduced

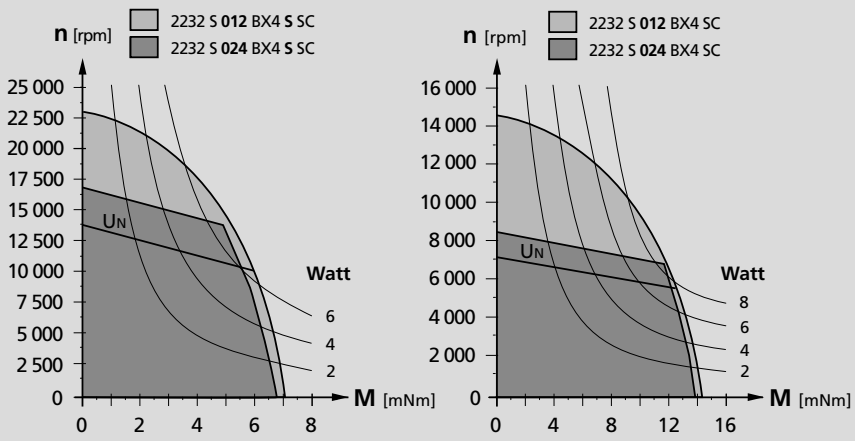
Note:

The diagram indicates the recommended speed in relation to the available torque at the output shaft for a given ambient temperature of 22°C.

The diagram shows the motor in a completely insulated condition.

The motor is factory pre-configured to a continuous current for the thermally insulated condition. The controller must be reconfigured with the easy to use Motion Manager Software for use with other parameter settings.

The nominal voltage (U_N) curve shows the operating point at nominal voltage in the insulated condition. Any points of operation above the curve at nominal voltage will require a higher operating voltage. Any points below the nominal voltage curve will require less voltage.

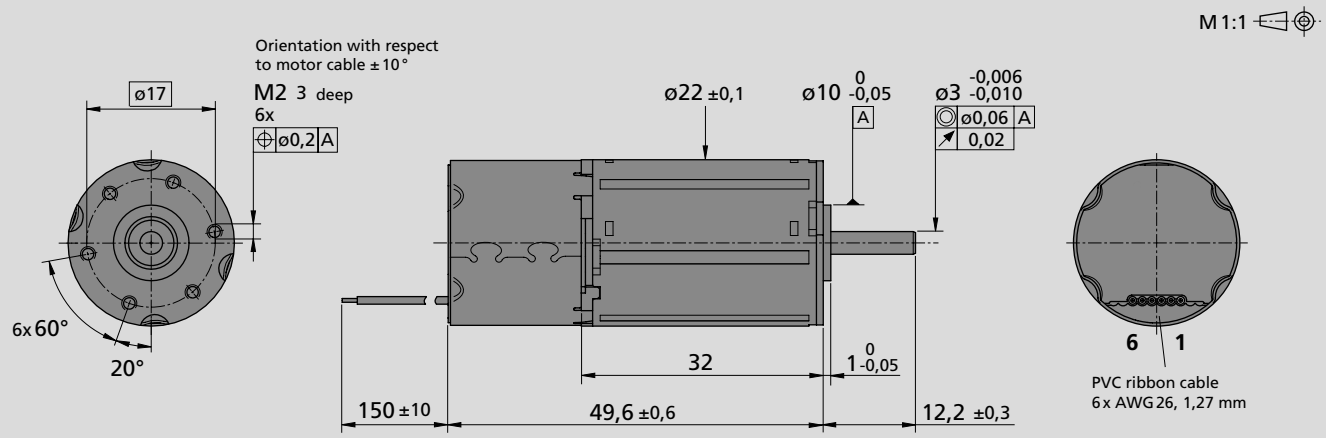


Recommended areas for continuous operation

7 Technical Data

7.5 Motor 2232…BX4 with Speed Controller SC

Dimensional drawing



2232 S ... BX4(S) SC

Speed Controller			012 BX4 S	024 BX4 S	012 BX4	024 BX4	SC
Power supply electronic	U_P	5 ... 28					V DC
Power supply motor	U_{mot}	6 ... 28					V DC
PWM switching frequency	f_{PWM}	96					kHz
Efficiency	η	95					%
Max. continuous output current [1]	I_{dauer}		1	0,5	1	0,5	A
Max. peak output current	I_{max}		2	1	2	1	A
Total standby current	I_{el}	0,020					A
Speed range electronic		400 ... 50 000 [2]					rpm
Scanning range		500					µs

[1] at 22°C ambient temperature and max. 60°C motor temperature respectively
[2] speed depend on motor operating voltage

Connection information			012 BX4 S	024 BX4 S	012 BX4	024 BX4	SC
Connection 1 "U_P":	power supply electronic	U_P					
Connection 2 "U_{mot}":	power supply electronic coil	U_{mot}					
Connection 3 "GND":	ground	ground					
Connection 4 "U_{nsoll}":							
– analog input	input voltage	U_{in} = 0 ... 10 V | > 10 V ... U_P » set speed value not defined					
	input resistance	R_{in} ≥ 5 kΩ					
	set speed value	per 1 V	2 000	2 000	1 000	1 000	rpm
		U_{in} < 0,15 V » motor stops					
		U_{in} > 0,3 V » motor starts					
Connection 5 "DIR":							
– analog input	direction of rotation	to ground or level < 0,5 V » counterclockwise					
		open or level > 3 V » clockwise					
	input resistance	R_{in} ≥ 10 kΩ					
Connection 6 "FG":		max. U_P; I_{max} = 15 mA; open collector with 22 kΩ pull-up resistor					
– digital output	frequency output	6 lines per revolution					

Features

In this variant, the brushless DC servomotors have an integrated Speed Controller. The motor is commutated using Hall sensors integrated into the motor. Speed control is via a PI regulator. The Speed Controller has a current limiting device which limits the maximum motor current if the thermal load is too high. Twice the continuous current is possible over a short time.

Using the **"FAULHABER Motion Manager"** software, the customer can modify the Speed Controller to special conditions of use.

The following parameters can be changed: current limit and regulator parameters.

Full product description

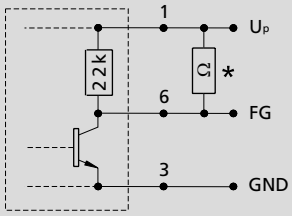
- Examples:
  2232S024BX4 SC
  2232S012BX4S SC

7 Technical Data

7.5 Motor 2232…BX4 with Speed Controller SC

Circuit diagram / Connection information

Output circuit



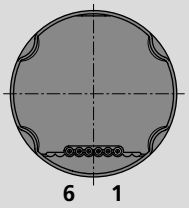
* An additional external pull-up resistor can be added to improve the rise time.
Caution: I_{OUT} max. 15 mA must not be exceeded!

Options

Connector variant (Option no.: 3809)
AWG 26 / PVC ribbon cable
with connector Micro-Fit
connector pin assignment:



Cable connection



Connection

No.	Function
1	U_P
2	U_{mot}
3	GND
4	U_{nsoll}
5	DIR
6	FG

Caution:
Incorrect lead connection will damage the motor electronics!

7 Technical Data

7.6 Motor 2250…BX4 without attachment

		2250 S		024 BX4 S	024 BX4	
1	Nominal voltage	U_N		24	24	Volt
2	Terminal resistance, phase-phase	R		5,9	5,9	Ω
3	Output power [1]	$P_{2\ max.}$		8,8	14,6	W
4	Efficiency	$\eta_{max.}$		70,4	75,0	%
5	No-load speed	n_o		10 500	6 000	rpm
6	No-load current (with shaft ø 3,0 mm)	I_o		0,105	0,072	A
7	Stall torque	M_H		84,7	149,0	mNm
8	Friction torque, static	C_o		0,75	1,20	mNm
9	Friction torque, dynamic	C_v		$1,4 \cdot 10^{-4}$	$2,4 \cdot 10^{-4}$	mNm/rpm
10	Speed constant	k_n		451	259	rpm/V
11	Back-EMF constant	k_E		2,218	3,860	mV/rpm
12	Torque constant	k_M		21,1	36,9	mNm/A
13	Current constant	k_I		0,047	0,027	A/mNm
14	Slope of n-M curve	$\Delta n/\Delta M$		125,6	41,4	rpm/mNm
15	Terminal inductance, phase-phase	L		250	240	µH
16	Mechanical time constant	τ_m		6,97	4,30	ms
17	Rotor inertia	J		5,3	10,0	gcm^2
18	Angular acceleration	$\alpha_{max.}$		160	149	$\cdot 10^3 rad/s^2$
19	Thermal resistance	$R_{th\,1}$ / $R_{th\,2}$		1,2 / 14	1,2 / 14	K/W
20	Thermal time constant	τ_{w1} / τ_{w2}		4,2 / 443	4,2 / 566	s
21	Operating temperature range			– 40 ... + 100	– 40 ... + 100	°C
22	Shaft bearings		ball bearings, preloaded			
23	Shaft load max.:					
	– radial at 3 000 rpm (4 mm from mounting flange)		20			N
	– axial at 3 000 rpm		2			N
	– axial at standstill		20			N
24	Shaft play:					
	– radial	≤	0,015			mm
	– axial	=	0			mm
25	Housing material		stainless steel			
26	Weight			90	106	g
27	Direction of rotation		electronically reversible			
28	Number of pole pairs		2			
Recommended values - mathematically independent of each other						
29	Speed up to	$n_{e\ max.}$		25 000	18 000	rpm
30	Torque up to [1] [2]	$M_{e\ max.}$		14 / 22	23 / 37	mNm
31	Current up to [1] [2]	$I_{e\ max.}$		0,79 / 1,20	0,74 / 1,18	A

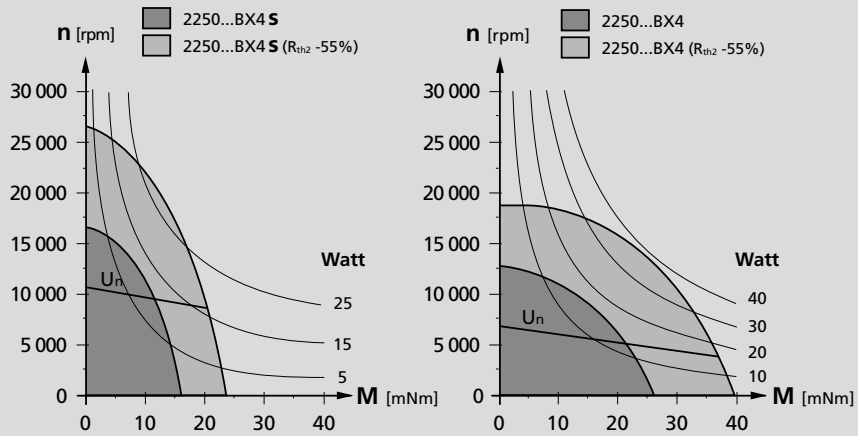
[1] at 5 000 rpm
[2] thermal resistance $R_{th\,2}$ not reduced / thermal resistance $R_{th\,2}$ by 55% reduced

Note:

The diagram indicates the recommended speed in relation to the available torque at the output shaft for a given ambient temperature of 22°C.

The diagram shows the motor in a completely insulated as well as thermally coupled condition ($R_{th\,2}$ 55% reduced).

The nominal voltage (U_N) curve shows the operating point at nominal voltage in the insulated and thermally coupled condition. Any points of operation above the curve at nominal voltage will require a higher operating voltage. Any points below the nominal voltage curve will require less voltage.



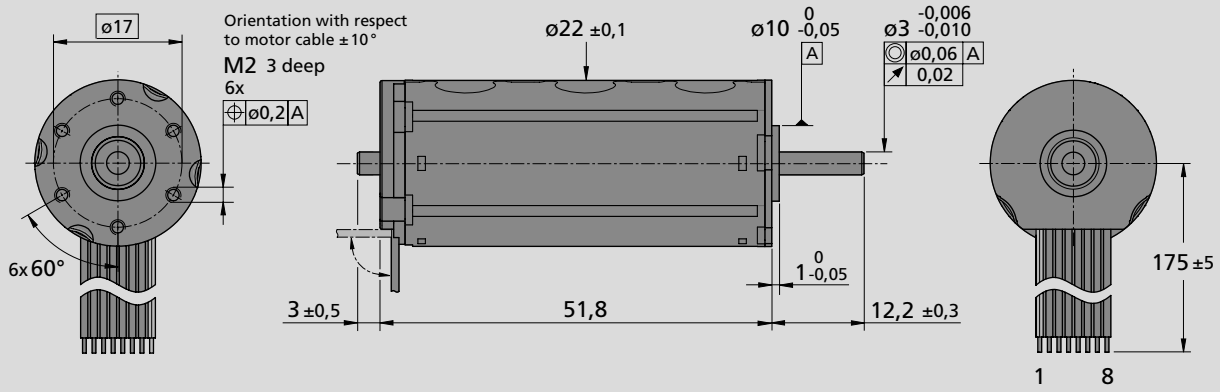
Recommended areas for continuous operation

7 Technical Data

7.6 Motor 2250…BX4 without attachment

Dimensional drawing

M 1:1

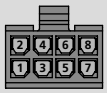


2250 S ... BX4 (S)

Options

- Connector variant (Option no. 3830)

  Motor:
  AWG 26 / PVC ribbon cable
  with connector Micro-Fit



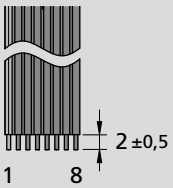
Full product description

- Examples:

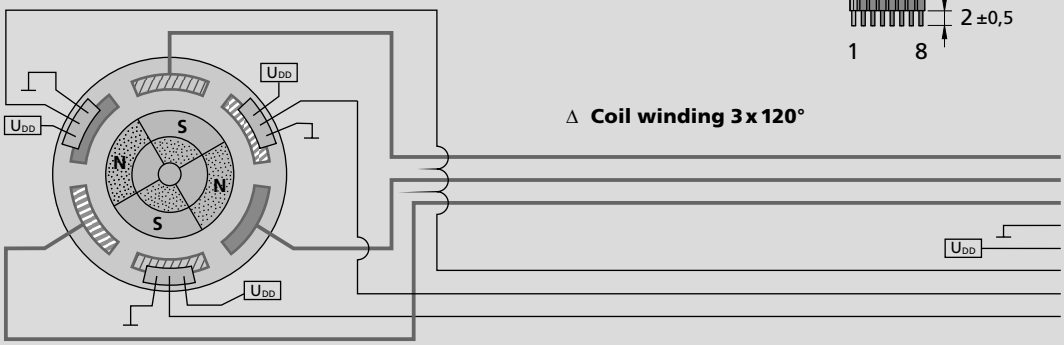
  2250S024 BX4

  2250S024 BX4 S

Cable and connection information



Cable
Jacket Material: PVC
8 conductors, AWG 26
grid 1,27 mm
wires tinned



Δ Coil winding 3 x 120°

Connection

No.	Function
1	Phase C
2	Phase B
3	Phase A
4	GND
5	UDD (2,2 ... 18V DC)
6	Hall sensor C
7	Hall sensor B
8	Hall sensor A

7 Technical Data

7.7 Motor 2250…BX4 with encoder IE3

		2250 S		024 BX4 S	024 BX4	IE3
1	Nominal voltage	U_N		24	24	Volt
2	Terminal resistance, phase-phase	R		5,9	5,9	Ω
3	Output power [1]	$P_{2\ max.}$		10,3	17,3	W
4	Efficiency	$\eta_{max.}$		70,4	75,0	%
5	No-load speed	n_o		10 500	6 000	rpm
6	No-load current (with shaft ø 3,0 mm)	I_o		0,105	0,072	A
7	Stall torque	M_H		84,7	149,0	mNm
8	Friction torque, static	C_o		0,75	1,2	mNm
9	Friction torque, dynamic	C_v		$1,4 \cdot 10^{-4}$	$2,4 \cdot 10^{-4}$	mNm/rpm
10	Speed constant	k_n		451	259	rpm/V
11	Back-EMF constant	k_E		2,218	3,860	mV/rpm
12	Torque constant	k_M		21,1	36,9	mNm/A
13	Current constant	k_I		0,047	0,027	A/mNm
14	Slope of n-M curve	$\Delta n/\Delta M$		125,6	41,4	rpm/mNm
15	Terminal inductance, phase-phase	L		250	240	µH
16	Mechanical time constant	τ_m		6,97	4,30	ms
17	Rotor inertia	J		5,3	10	gcm^2
18	Angular acceleration	$\alpha_{max.}$		160	149	$\cdot 10^3 rad/s^2$
19	Thermal resistance	$R_{th\ 1}$ / $R_{th\ 2}$		1,2 / 10,5	1,2 / 10,5	K/W
20	Thermal time constant	τ_{w1} / τ_{w2}		4,2 / 332	4,2 / 424	s
21	Operating temperature range			– 40 ... + 100	– 40 ... + 100	°C
22	Shaft bearings		ball bearings, preloaded			
23	Shaft load max.:					
	– radial at 3 000 rpm (4 mm from mounting flange)		20			N
	– axial at 3 000 rpm		2			N
	– axial at standstill		20			N
24	Shaft play:					
	– radial	≤	0,015			mm
	– axial	=	0			mm
25	Housing material		stainless steel			
26	Weight			101	117	g
27	Direction of rotation		electronically reversible			
28	Number of pole pairs		2			

Recommended values - mathematically independent of each other					
29	Speed up to	$n_{e\ max.}$	30 000	18 000	rpm
30	Torque up to [1] [2]	$M_{e\ max.}$	16 / 25	27 / 43	mNm
31	Current up to [1] [2]	$I_{e\ max.}$	0,92 / 1,40	0,89 / 1,37	A

[1] at 5 000 rpm

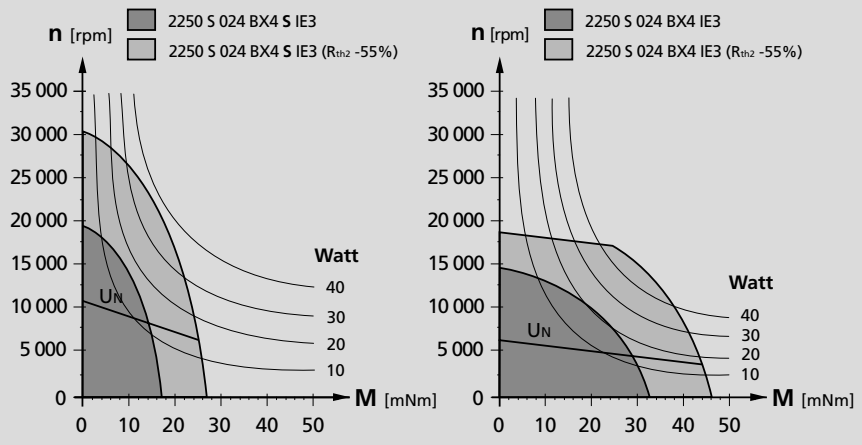
[2] thermal resistance $R_{th\ 2}$ not reduced / thermal resistance $R_{th\ 2}$ by 55% reduced

Note:

The diagram indicates the recommended speed in relation to the available torque at the output shaft for a given ambient temperature of 22°C.

The diagram shows the motor in a completely insulated as well as thermally coupled condition ($R_{th\ 2}$ 55% reduced).

The nominal voltage (U_N) curve shows the operating point at nominal voltage in the insulated and thermally coupled condition. Any points of operation above the curve at nominal voltage will require a higher operating voltage. Any points below the nominal voltage curve will require less voltage.

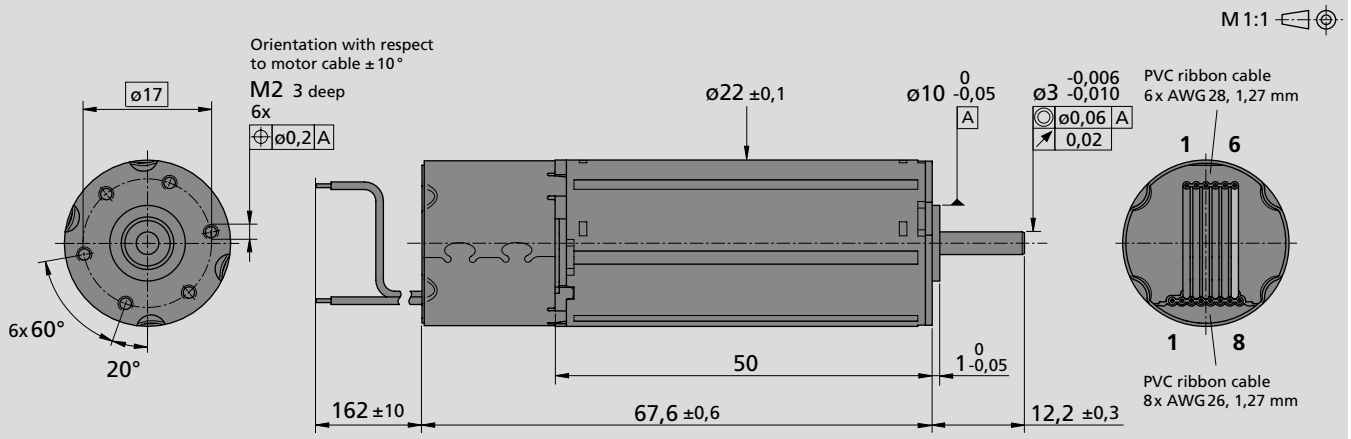


Recommended areas for continuous operation

7 Technical Data

7.7 Motor 2250…BX4 with encoder IE3

Dimensional drawing



2250 S ... BX4(S) IE3

Magnetic Encoder		IE3-32	IE3-64	IE3-128	IE3-256	IE3-512	IE3-1024	
Lines per revolution	N	32	64	128	256	512	1024	
Frequency range [1], up to	f	15	30	60	120	240	430	kHz
Signal output, square wave		2+1 Index						channels
Supply voltage Encoder	$U_{DD\ Enc}$	4,5 ... 5,5						V DC
Current consumption, typical [2]	$I_{DD\ Enc}$	typ. 16, max. 23						mA
Output current, max. allowable [3]	I_{OUT}	4						mA
Index Pulse width [4]	P_0	90 ± 45				90 ± 75		°e
Phase shift, channel A to B [4]	Φ	90 ± 45				90 ± 75		°e
Signal rise/fall time, max. (C_{LOAD} = 50 pF)	tr/tf	0,1/0,1						µs
Inertia of encoder magnet	J	0,08						gcm^2

Connection information Motor				
Supply voltage Hallsensors [5]	U_{DD}	2,2 ...18	4,5 ... 5,5	V DC

[1] speed (rpm) = f (Hz) x 60/N
[2] $U_{DD\ Enc}$ = 5 V: with unloaded outputs
[3] $U_{DD\ Enc}$ = 5 V: low logic level < 0,4 V, high logic level > 4,5 V: CMOS- and TTL compatible
[4] at 5 000 rpm
[5] IE3-32/64/128/256 $U_{DD} \neq U_{DD\ ENC}$ (galvanically isolated)
IE3-512 / 1 024 $U_{DD} = U_{DD\ ENC}$

Features

In this version, the brushless DC servomotors have an encoder with 3 output channels. A permanent magnet on the shaft creates a moving magnetic field which is captured using a single-chip angular sensor and further processed. At the encoder outputs, two 90° phase-shifted rectangular signals are available with up to 1024 impulses and an index impulse per motor revolution.

The encoder is available in a variety of different resolutions and is suitable for speed control and positioning applications. The motor and encoder cables are connected via separate ribbon cables.

A detailed instruction manual is included with the product or is available online at www.faulhaber.com

Other resolutions of 1 - 127 impulses are available on request.

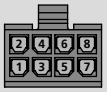
Options

- Connector variant (Option no. 3592)

Encoder:
AWG 28 / PVC ribbon cable
with connector PicoBlade (pitch 1,25 mm)



Motor:
AWG 26 / PVC ribbon cable
with connector Micro-Fit



Full product description

- Examples:

2250S024BX4 IE3-1024

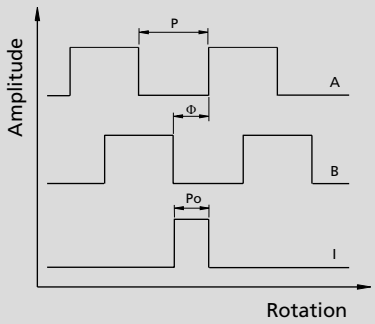
2250S024BX4S IE3-32

7 Technical Data

7.7 Motor 2250…BX4 with encoder IE3

Output signals / Circuit diagram / Connector information

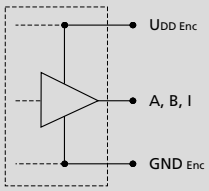
Output signals
with clockwise rotation as seen from the shaft end



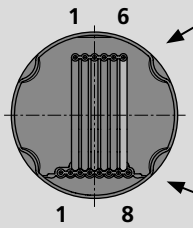
Admissible deviation of phase shift / Index pulse:

$$\Delta\Phi = \left| 90° - \frac{\Phi}{P} * 180° \right| \leq 75° \qquad \Delta P_o = \left| 90° - \frac{P_o}{P} * 180° \right| \leq 75°$$

Output circuit



Connection Encoder



Connection Motor

No.	Function
1	n.c.
2	Channel I (Index)
3	GND Enc
4	UDD Enc
5	Channel B
6	Channel A

No.	Function
1	Phase C
2	Phase B
3	Phase A
4	GND
5	UDD
6	Hall sensor C
7	Hall sensor B
8	Hall sensor A

Caution:
Incorrect lead connection will damage the motor electronics!

7 Technical Data

7.8 Motor 2250…BX4 with encoder IE3 L

		2250 S		024 BX4 S	024 BX4	IE3 L
1	Nominal voltage	U_N		24	24	Volt
2	Terminal resistance, phase-phase	R		5,9	5,9	Ω
3	Output power [1]	$P_{2\ max.}$		10,3	17,3	W
4	Efficiency	$\eta_{max.}$		70,4	75,0	%
5	No-load speed	n_o		10 500	6 000	rpm
6	No-load current (with shaft ø 3,0 mm)	I_o		0,105	0,072	A
7	Stall torque	M_H		84,7	149,0	mNm
8	Friction torque, static	C_o		0,75	1,2	mNm
9	Friction torque, dynamic	C_v		$1,4 \cdot 10^{-4}$	$2,4 \cdot 10^{-4}$	mNm/rpm
10	Speed constant	k_n		451	259	rpm/V
11	Back-EMF constant	k_E		2,218	3,860	mV/rpm
12	Torque constant	k_M		21,1	36,9	mNm/A
13	Current constant	k_I		0,047	0,027	A/mNm
14	Slope of n-M curve	$\Delta n/\Delta M$		125,6	41,4	rpm/mNm
15	Terminal inductance, phase-phase	L		250	240	µH
16	Mechanical time constant	τ_m		6,97	4,30	ms
17	Rotor inertia	J		5,3	10	gcm^2
18	Angular acceleration	$\alpha_{max.}$		160	149	$\cdot 10^3 rad/s^2$
19	Thermal resistance	$R_{th\ 1}$ / $R_{th\ 2}$		1,2 / 10,5	1,2 / 10,5	K/W
20	Thermal time constant	τ_{w1} / τ_{w2}		4,2 / 332	4,2 / 424	s
21	Operating temperature range			– 40 ... + 100	– 40 ... + 100	°C
22	Shaft bearings		ball bearings, preloaded			
23	Shaft load max.:					
	– radial at 3 000 rpm (4 mm from mounting flange)		20			N
	– axial at 3 000 rpm		2			N
	– axial at standstill		20			N
24	Shaft play:					
	– radial	≤	0,015			mm
	– axial	=	0			mm
25	Housing material		stainless steel			
26	Weight			101	117	g
27	Direction of rotation		electronically reversible			
28	Number of pole pairs		2			
Recommended values - mathematically independent of each other						
29	Speed up to	$n_{e\ max.}$		30 000	18 000	rpm
30	Torque up to [1] [2]	$M_{e\ max.}$		16 / 25	27 / 43	mNm
31	Current up to [1] [2]	$I_{e\ max.}$		0,92 / 1,40	0,89 / 1,37	A

[1] at 5 000 rpm

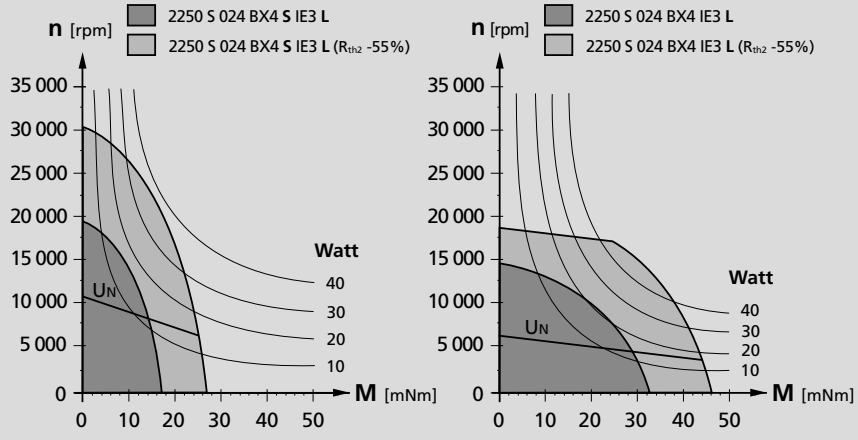
[2] thermal resistance $R_{th\ 2}$ not reduced / thermal resistance $R_{th\ 2}$ by 55% reduced

Note:

The diagram indicates the recommended speed in relation to the available torque at the output shaft for a given ambient temperature of 22°C.

The diagram shows the motor in a completely insulated as well as thermally coupled condition ($R_{th\ 2}$ 55% reduced).

The nominal voltage (U_N) curve shows the operating point at nominal voltage in the insulated and thermally coupled condition. Any points of operation above the curve at nominal voltage will require a higher operating voltage. Any points below the nominal voltage curve will require less voltage.

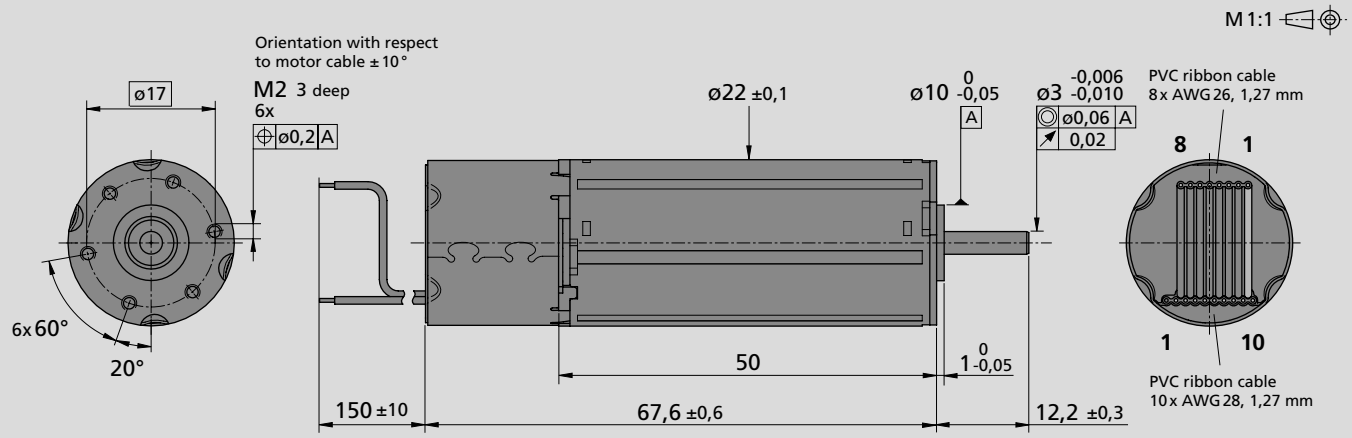


Recommended areas for continuous operation

7 Technical Data

7.8 Motor 2250…BX4 with encoder IE3 L

Dimensional drawing



2250 S ... BX4(S) IE3 L

Magnetic Encoder		IE3-32 L	IE3-64 L	IE3-128 L	IE3-256 L	IE3 - 512 L	IE3 - 1024 L	
Lines per revolution	N	32	64	128	256	512	1024	
Frequency range [1], up to	f	15	30	60	120	240	430	kHz
Signal output, square wave		2 + 1 index and complementary outputs						channels
Supply voltage	$U_{DD\ Enc}$	4,5 ... 5,5						V DC
Current consumption, typical [2]	$I_{DD\ Enc}$	typ. 17, max. 25						mA
Index Pulse width [3]	P_0	90 ± 45				90 ± 75		°e
Phase shift, channel A to B [3]	Φ	90 ± 45				90 ± 75		°e
Inertia of encoder magnet	J	0,08						gcm^2

[1] speed (rpm) = f (Hz) x 60/N
[2] $U_{DD\ Enc}$ = 5 V: with unloaded outputs
[3] at 5 000 rpm

Notes: The output signals are TIA-422 compatible.
Examples of Line driver Receivers: ST26C32ABD (STM), ST26C32IP16 (EXAR), DS26C32AT (NSC).

Features

In this version, the brushless DC servomotors have an encoder with 3 output channels. A permanent magnet on the shaft creates a moving magnetic field which is captured using a single-chip angular sensor and further processed. At the encoder outputs, two 90° phase-shifted rectangular signals are available with up to 1024 impulses and an index impulse per motor revolution.

The Line Driver version has differential signal outputs (TIA-422). Differential signals reduce ambient interference and are suitable for applications with high ambient interference. The line driver amplifies the encoder signal which means that long cables can be used without signal degradation. Differential signal outputs must be decoded by the appropriate receiver module.

The encoder is available in a variety of different resolutions and is suitable for speed control and positioning applications. The motor and encoder cables are connected via separate ribbon cables.

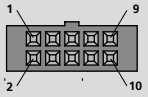
A detailed instruction manual is included with the product or is available online at www.faulhaber.com

Other resolutions of 1 - 127 impulses are available on request.

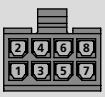
Options

- Connector variant (Option no.: 3589)

Encoder:
AWG 28 / PVC ribbon cable
with connector DIN-41651 (pitch 2,54 mm)



Motor:
AWG 26 / PVC ribbon cable
with connector Micro-Fit



Full product description

- Examples:

2250S024BX4 IE3-1024 L

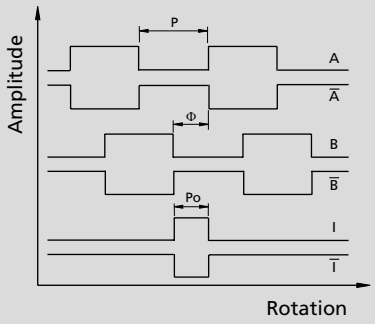
2250S024BX4S IE3-32 L

7 Technical Data

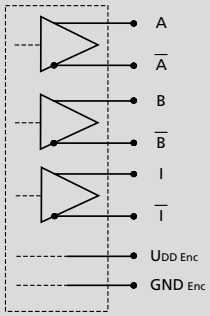
7.8 Motor 2250…BX4 with encoder IE3 L

Output signals / Circuit diagram / Connector information

Output signals
with clockwise rotation as seen from the shaft end



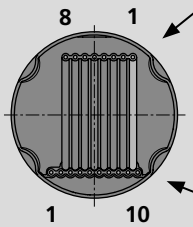
Output circuit



Admissible deviation of phase shift / Index pulse:

$$\Delta\Phi = \left| 90° - \frac{\Phi}{P} * 180° \right| \leq 75° \qquad \Delta P_o = \left| 90° - \frac{P_o}{P} * 180° \right| \leq 75°$$

Connection Motor



Connection Encoder

No.	Function
1	Phase C
2	Phase B
3	Phase A
4	GND
5	UDD (2,2 ... 18V DC)
6	Hall sensor C
7	Hall sensor B
8	Hall sensor A

No.	Function
1	n.c.
2	UDD Enc
3	GND Enc
4	n.c.
5	Channel Ā
6	Channel A
7	Channel B̄
8	Channel B
9	Channel Ī (Index)
10	Channel I (Index)

Caution:
Incorrect lead connection will damage the motor electronics!

7 Technical Data

7.9 Motor 2250…BX4 with absolute encoder AES

		2250 S		024 BX4 S	024 BX4	AES
1	Nominal voltage	U_N		24	24	Volt
2	Terminal resistance, phase-phase	R		5,9	5,9	Ω
3	Output power [1]	$P_{2\ max.}$		10,3	17,3	W
4	Efficiency	$\eta_{max.}$		70,4	75,0	%
5	No-load speed	n_o		10 500	6 000	rpm
6	No-load current (with shaft ø 3,0 mm)	I_o		0,105	0,072	A
7	Stall torque	M_H		84,7	149,0	mNm
8	Friction torque, static	C_o		0,75	1,2	mNm
9	Friction torque, dynamic	C_v		$1,4 \cdot 10^{-4}$	$2,4 \cdot 10^{-4}$	mNm/rpm
10	Speed constant	k_n		451	259	rpm/V
11	Back-EMF constant	k_E		2,218	3,860	mV/rpm
12	Torque constant	k_M		21,1	36,9	mNm/A
13	Current constant	k_I		0,047	0,027	A/mNm
14	Slope of n-M curve	$\Delta n/\Delta M$		125,6	41,4	rpm/mNm
15	Terminal inductance, phase-phase	L		250	240	µH
16	Mechanical time constant	τ_m		6,97	4,30	ms
17	Rotor inertia	J		5,3	10	gcm^2
18	Angular acceleration	$\alpha_{max.}$		160	149	$\cdot 10^3 rad/s^2$
19	Thermal resistance	$R_{th\ 1}$ / $R_{th\ 2}$		1,2 / 10,5	1,2 / 10,5	K/W
20	Thermal time constant	τ_{w1} / τ_{w2}		4,2 / 332	4,2 / 424	s
21	Operating temperature range			– 40 ... + 100	– 40 ... + 100	°C
22	Shaft bearings		ball bearings, preloaded			
23	Shaft load max.:					
	– radial at 3 000 rpm (4 mm from mounting flange)		20			N
	– axial at 3 000 rpm		2			N
	– axial at standstill		20			N
24	Shaft play:					
	– radial	≤	0,015			mm
	– axial	=	0			mm
25	Housing material		stainless steel			
26	Weight			101	117	g
27	Direction of rotation		electronically reversible			
28	Number of pole pairs		2			
Recommended values - mathematically independent of each other						
29	Speed up to	$n_{e\ max.}$		30 000	18 000	rpm
30	Torque up to [1] [2]	$M_{e\ max.}$		16 / 25	27 / 43	mNm
31	Current up to [1] [2]	$I_{e\ max.}$		0,92 / 1,40	0,89 / 1,37	A

[1] at 5 000 rpm

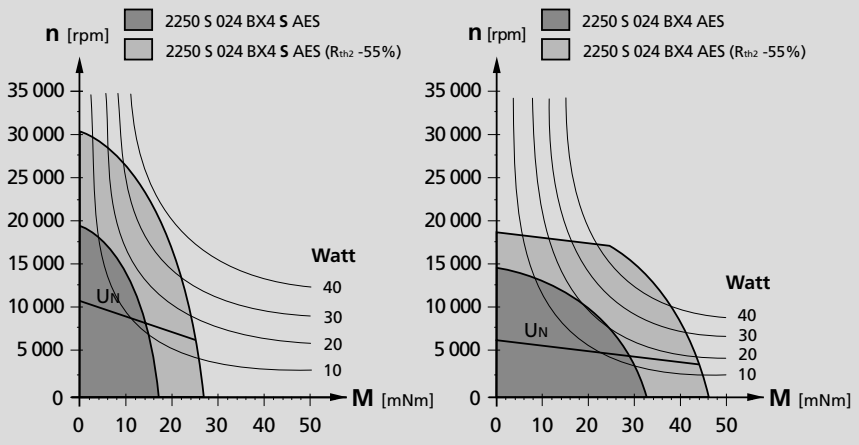
[2] thermal resistance $R_{th\ 2}$ not reduced / thermal resistance $R_{th\ 2}$ by 55% reduced

Note:

The diagram indicates the recommended speed in relation to the available torque at the output shaft for a given ambient temperature of 22°C.

The diagram shows the motor in a completely insulated as well as thermally coupled condition ($R_{th\ 2}$ 55% reduced).

The nominal voltage (U_N) curve shows the operating point at nominal voltage in the insulated and thermally coupled condition. Any points of operation above the curve at nominal voltage will require a higher operating voltage. Any points below the nominal voltage curve will require less voltage.

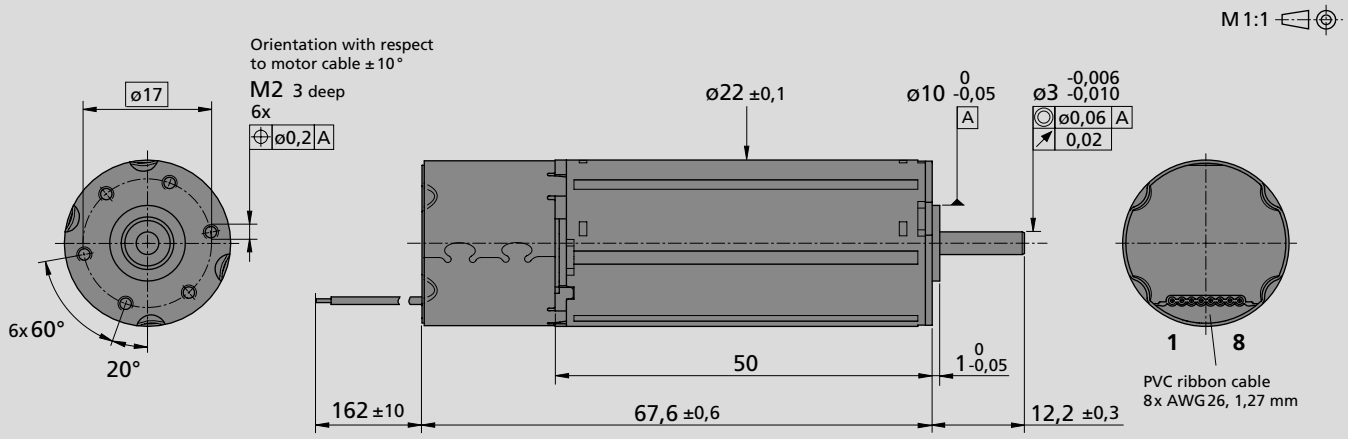


Recommended areas for continuous operation

7 Technical Data

7.9 Motor 2250…BX4 with absolute encoder AES

Dimensional drawing



2250 S ... BX4(S) AES

Magnetic Encoder		AES - 4096	
Lines per revolution (resolution)	N	4 096	
Signal output		Synchronous Serial Interface (SSI)	
Supply voltage	$U_{DD\ Enc}$	4,5 ... 5,5	V DC
Current consumption, typical [1]	$I_{DD\ Enc}$	typ. 16, max. 23	mA
Output current, max. (DATA) [2]		4	mA
Clock Frequency, max. (CLK)		2	MHz
Input low level (CLK)		0 ... 0,8	V
Input high level (CLK)		2 ... $U_{DD\ Enc}$	V
Setup time after power on, max.	t_{setup}	4	ms
Operating temperature range		– 40 ... +100	°C

[1] $U_{DD\ Enc}$ = 5 V: with unloaded outputs
[2] $U_{DD\ Enc}$ = 5 V: low logic level ≤ 0,4 V, high logic level ≥ 4,6 V

Features

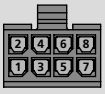
In this version, these brushless DC-Servomotors come equipped with an absolute encoder with a serial interface. A magnet on the motor shaft is registered by a single chip sensor to create the encoder signal. Absolute position information is then provided at the signal outputs and communicated via a serial (SSI) interface.

The absolute encoder is ideal for commutation, speed and position control of the motor. It can be used to create a sinusoidal commutation signal. The advantages are a reduced torque ripple, a higher efficiency, and reduced electrical noise generation.
Cabling is also reduced to a single motor / encoder flat cable.

A detailed instruction manual is included with the product or is available online at www.faulhaber.com

Options

- Connector variant (Option no. 3830)
  AWG 26 / PVC ribbon cable
  with connector Micro-Fit



Full product description

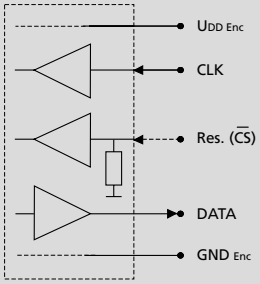
- Examples:
  2250S024BX4 AES-4 096
  2250S024BX4S AES-4 096

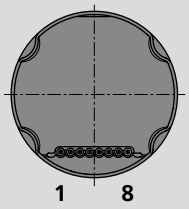
7 Technical Data

7.9 Motor 2250…BX4 with absolute encoder AES

Circuit diagram / Connector information

Output circuit





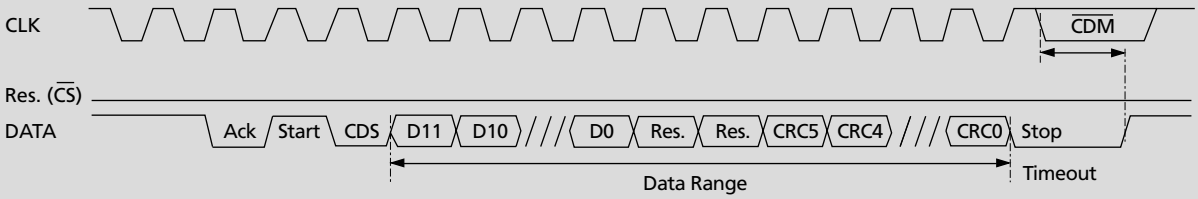
Connection

No.	Function
1	Phase C
2	Phase B
3	Phase A
4	GND Enc
5	UDD Enc
6	CLK
7	Res. (CS)
8	DATA

Caution:
Incorrect lead connection will damage the motor electronics!

Interface signals

Interface signals (SSI)



7 Technical Data

7.10 Motor 2250…BX4 with Speed Controller SC

		2250 S		024 BX4 S	024 BX4	SC
1	Nominal voltage	U_N		24	24	Volt
2	Terminal resistance, phase-phase	R		5,9	5,9	Ω
3	Output power [1]	$P_{2\ max.}$		10,3	17,3	W
4	Efficiency	$\eta_{max.}$		70,4	75,0	%
5	No-load speed	n_o		10 500	6 000	rpm
6	No-load current (with shaft ø 3,0 mm)	I_o		0,105	0,072	A
7	Stall torque	M_H		84,7	149,0	mNm
8	Friction torque, static	C_o		0,75	1,2	mNm
9	Friction torque, dynamic	C_v		$1,4 \cdot 10^{-4}$	$2,4 \cdot 10^{-4}$	mNm/rpm
10	Speed constant	k_n		451	259	rpm/V
11	Back-EMF constant	k_E		2,218	3,860	mV/rpm
12	Torque constant	k_M		21,1	36,9	mNm/A
13	Current constant	k_I		0,047	0,027	A/mNm
14	Slope of n-M curve	$\Delta n/\Delta M$		125,6	41,4	rpm/mNm
15	Terminal inductance, phase-phase	L		250	240	µH
16	Mechanical time constant	τ_m		6,97	4,30	ms
17	Rotor inertia	J		5,3	10	gcm^2
18	Angular acceleration	$\alpha_{max.}$		160	149	$\cdot 10^3 rad/s^2$
19	Thermal resistance	$R_{th\ 1}$ / $R_{th\ 2}$		1,2 / 10,5	1,2 / 10,5	K/W
20	Thermal time constant	τ_{w1} / τ_{w2}		4,2 / 332	4,2 / 424	s
21	Operating temperature range			– 40 ... +85	– 40 ... +85	°C
22	Shaft bearings		ball bearings, preloaded			
23	Shaft load max.:					
	– radial at 3 000 rpm (4 mm from mounting flange)		20			N
	– axial at 3 000 rpm		2			N
	– axial at standstill		20			N
24	Shaft play:					
	– radial	≤	0,015			mm
	– axial	=	0			mm
25	Housing material		stainless steel			
26	Weight			97	117	g
27	Direction of rotation		electronically reversible			
28	Number of pole pairs		2			

Recommended values - mathematically independent of each other

29	Speed up to	$n_{e\ max.}$		12 500	7 200	rpm
30	Torque up to [1] [2]	$M_{e\ max.}$		15	25	mNm
31	Current up to [1] [2]	$I_{e\ max.}$		0,84	0,79	A

[1] at 5 000 rpm
[2] thermal resistance $R_{th\ 2}$ not reduced

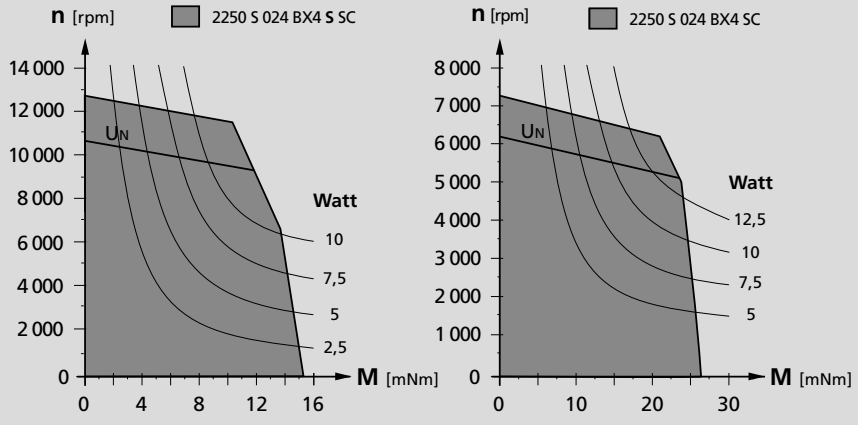
Note:

The diagram indicates the recommended speed in relation to the available torque at the output shaft for a given ambient temperature of 22°C.

The diagram shows the motor in a completely insulated condition.

The motor is factory pre-configured to a continuous current for the thermally insulated condition. The controller must be reconfigured with the easy to use Motion Manager Software for use with other parameter settings.

The nominal voltage (U_N) curve shows the operating point at nominal voltage in the insulated condition. Any points of operation above the curve at nominal voltage will require a higher operating voltage. Any points below the nominal voltage curve will require less voltage.

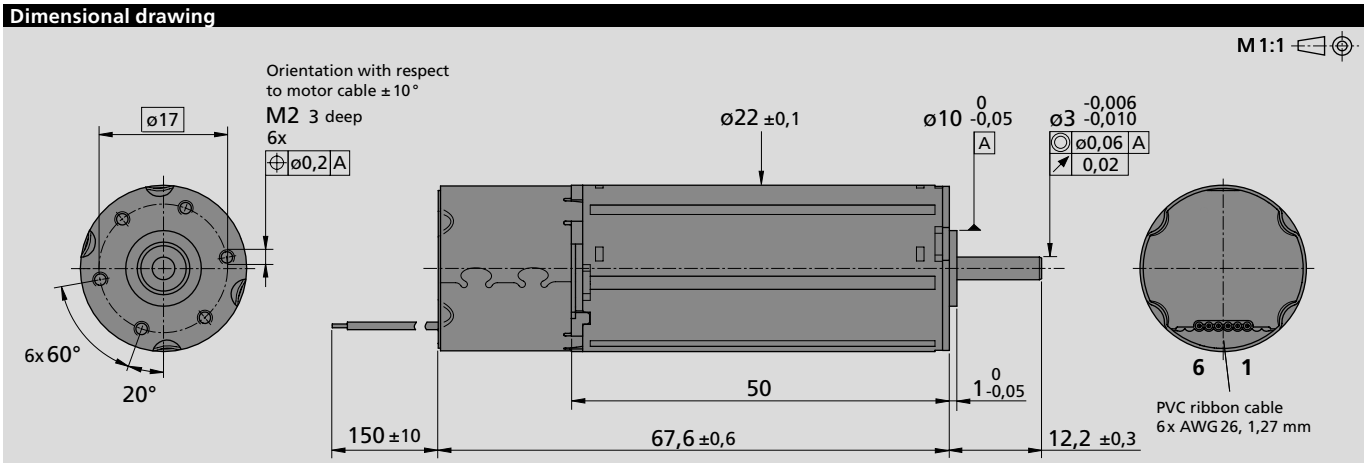


Recommended areas for continuous operation

7 Technical Data

7.10 Motor 2250…BX4 with Speed Controller SC

Dimensional drawing



2250 S ... BX4(S) SC

Speed Controller		024 BX4 S	024 BX4	SC
Power supply electronic	U_P	5 ... 28		V DC
Power supply motor	U_{mot}	6 ... 28		V DC
PWM switching frequency	f_{PWM}	96		kHz
Efficiency	η	95		%
Max. continuous output current [1]	I_{dauer}	0,8		A
Max. peak output current	I_{max}	1,6		A
Total standby current	I_{el}	0,020		A
Speed range electronic		400 ... 50 000 [2]		rpm
Scanning range		500		µs

[1] at 22°C ambient temperature and max. 60°C motor temperature respectively
[2] speed depend on motor operating voltage

Connection information		024 BX4 S	024 BX4	SC
Connection 1 "U_P":	power supply electronic	U_P		
Connection 2 "U_{mot}":	power supply electronic coil	U_{mot}		
Connection 3 "GND":	ground	ground		
Connection 4 "U_{nsoll}":				
– analog input	input voltage	U_{in} = 0 ... 10 V | > 10 V ... U_P » set speed value not defined		
	input resistance	R_{in} ≥ 5 kΩ		
	set speed value	per 1 V | 2 000	| 1 000	rpm
		U_{in} < 0,15 V » motor stops		
		U_{in} > 0,3 V » motor starts		
Connection 5 "DIR":				
– analog input	direction of rotation	to ground or level < 0,5 V » counterclockwise		
		open or level > 3 V » clockwise		
	input resistance	R_{in} ≥ 10 kΩ		
Connection 6 "FG":		max. U_P; Imax = 15 mA; open collector with 22 kΩ pull-up resistor		
– digital output	frequency output	6 lines per revolution		

Features

In this variant, the brushless DC servomotors have an integrated Speed Controller. The motor is commutated using Hall sensors integrated into the motor. Speed control is via a PI regulator. The Speed Controller has a current limiting device which limits the maximum motor current if the thermal load is too high. Twice the continuous current is possible over a short time.

Using the **"FAULHABER Motion Manager"** software, the customer can modify the Speed Controller to special conditions of use.

The following parameters can be changed: current limit and regulator parameters.

Full product description

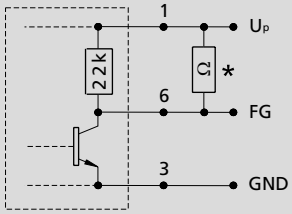
- Examples:
  2250S024BX4 SC
  2250S024BX4S SC

7 Technical Data

7.10 Motor 2250…BX4 with Speed Controller SC

Circuit diagram / Connection information

Output circuit



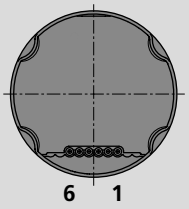
* An additional external pull-up resistor can be added to improve the rise time.
Caution: I_{OUT} max. 15 mA must not be exceeded!

Options

Connector variant (Option no.: 3809)
AWG 26 / PVC ribbon cable with connector Micro-Fit
connector pin assignment:



Cable connection



Connection

No.	Function
1	U_P
2	U_{mot}
3	GND
4	U_{nsoll}
5	DIR
6	FG

Caution:
Incorrect lead connection will damage the motor electronics!

7 Technical Data

7.11 Ambient conditions

CAUTION! ***Shock loads***



The noise emitted is increased and the life of the ball bearings and therefore of the servomotor becomes limited if they are exposed to impacts.

- *The servomotor can still function if it is not exposed to higher shock loads than defined according to EN 60068-2-27.*
- *The servomotor may not be exposed to higher vibration stresses than defined according to EN 60068-2-6.*

CAUTION! ***Risk of damage***



If the servomotor is installed on the mounting flange, the mounting flange can be damaged by high radial loads or stresses on the servomotor or by screws tightened with excessive torque.

- *Do not load the servomotor at the rear end with a radial force greater than 30 N.*
- *Tighten the screws with maximum 50 Ncm. Note the strength of the screws!*

NOTE ***Service life***



The full life is reached if the servomotor is not exposed to shock or vibration loads.

CAUTION! ***Risk of damage***



The ribbon cables may be damaged if the static or dynamic load is too high.

- *The tension exerted on the cable must not exceed 30 N in each direction. If the cable is exposed to constant tensile loads the limit is 17 N.*
- *In case of frequent bending, the recommended minimum bending radius is 10 mm. The possible number of bending cycles increases with increasing bending radius.*
- *If the radii are small the cable may not be bent several times as otherwise the Litz wires will break. The bending radii if laid once must be larger than 1.2 mm.*
- *The cable may not be bent at temperatures < -10 °C.*

8 EC Directives

REGULATION! The following EC Directives are important for users of the described products:

§

Machinery Directive (98/37/EC):

It applies to independently functioning machines or a chain of machines forming whole plants or systems. For built in components, non-operational machines, a manufacturer's declaration is submitted according to Annex II B of the Machinery Directive 98/37/EC.

Low-Voltage Directive (2006/95/EC):

It applies to all electrical equipment with a nominal voltage from 75 to 1 500 V DC, or from 50 to 1 000 V AC. The products described in this instruction manual do not fall within the scope of this Directive as they are designed for smaller voltages.

EMC Directive (2004/108/EC):

The Electromagnetic Compatibility (EMC) Directive applies to all electronic and electrical equipment, plant and systems sold to end users (consumers). In addition, CE marking can be undertaken for built-in components according to the EMC Directive. Compliance is documented by the Declaration of Conformity.

9 Manufacturer's Declaration

Manufacturer's Declaration according to the Machinery Directive 98/37/EC, Annex II B

The manufacturer:

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

herewith declares that the products named in the following are built in components and therefore, in the definition of Article 4 (2) of the Directive of the European Parliament and the Council dated 22 June 1998 on the harmonisation of the legal regulations of Member States for Machinery 98/37/EC – in short: the Machinery Directive – are not themselves functioning machines, and for this reason do not yet comply with all parts of the relevant provisions of the Machinery Directive.

Product name:

Micro drives, DC micro motors, step motors, motion control systems, precision gears, servo components, controls, micro-precision systems, linear DC servomotors, piezometric motors

Brand names:

FAULHABER, PRECIstep, FTB, penny-motor, smoovy, FAULHABER BX4, FAULHABER motion control, Quickshaft, Smartshell, PiezoMotor

It is prohibited to start up the motor until it has been established that the machine in which these components are to be installed is fully functional and conforms to the safety requirements of the Machinery Directive.

Schoenaich, 2008-02-04
(Place, Date)

Dr. Thomas Bertolini,
Executive Management



Signature

10 Warranty

Extract from our warranty conditions

Dr. Fritz Faulhaber GmbH & Co. KG products are produced to state of the art production methods and are subject to strict quality control.

Should, contrary to all expectations, defects occur, we undertake to find a remedy within the warranty period.

- We shall make good or replace defective goods, at our own discretion, within a reasonable period set by you and at our own cost. Replaced goods become our property and are to be returned to us.
- If improvement or replacement delivery is not possible or does not occur or fails for other reasons for which we are responsible within a period determined by you, you can opt to withdraw from the contract for the defective delivery or reduce the purchase price.
- We are not liable for damage to the goods caused by natural wear and tear, wear, unsuitable, improper or non-contractual use, incorrect assembly, installation or putting into service, excessive loading or improper change, improvement or repair work by you or third parties or incorrect or negligent treatment, provided these are not through our fault.
- Further claims, in particular claims for compensation instead of the performance and for compensation of other direct or indirect losses – including accompanying or consequential loss, for whatever legal reason – are excluded. This does not apply if
  a) we are maliciously silent with regard to a legal or material defect or have issued a guarantee for the nature of the goods,
  b) the loss is due to deliberate intent or gross negligence by us, our legal representatives or vicarious agents or are based on negligent breach of fundamental contract obligations by these persons, or
  c) culpable violation of duty by us, our legal representatives or vicarious agents which have resulted in physical injuries or damage to health.

  In the case of simple negligence, however, our obligation to pay damages is limited to the amount of typical, foreseeable losses for the type of contract.
- All defect claims including the claims for compensation covered by our terms and conditions of supply expire one year after delivery of the goods to your. The limitation period for replacements and improvements is 1 year but it expires at least when the original limitation period for the delivered object expires. The period for defects liability for a supplied object will be extended by the duration of the operational interruption caused by the making good work. Provisions concerning a shorter life of the object supplied within the scope of its intended use remain unaffected by this limitation provision.

For further information, please refer to our terms and conditions of supply, which we will pleased to make available on request.

Notes

FAULHABER

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