OPERATING INSTRUCTIONS

DAX®

Linear encoder

SICK
Sensor Intelligence.

Described product

DAX® Linear Encoder

Manufacturer

SICK AG
Erwin-Sick-Str. 1
79183 Waldkirch
Germany

Legal information

Original document

This document is an original document of SICK AG.

Contents

1 About this document

1.1 Purpose of this document

In the following instructions, the linear encoder DAX® is referred to simply as “encoder” or “device”.

These operating instructions describe:

- Device components
- Mechanical preparation of the device
- Electrical preparation of the device
- Necessary maintenance work for safe operation

1.2 Target groups

This document is intended for technicians (persons with technical expertise) tasked with installing and maintaining the device.

These technicians must be trained on the device.

Only trained electricians are permitted to carry out work on the electrical system or electrical assemblies.

1.3 Further information

- DAX® quickstart

Document number	Link
8028139	

- Technical information - interface description

Interface	Document number	Link
Analog	8028135	
CANopen®	8028137	

DAX® product pages

- www.sick.com/DAX®

1.4 Symbols and document conventions

1.4.1 Warning levels and signal words

Important

Hazard which could result in property damage.

Note

Tips

1.4.2 Information symbols

Table 1: Information symbols

Icon	Meaning
	Important technical information for this product

Icon	Meaning
	Important information about electrical or electronic functions

2 Safety information

2.1 General safety notes

Safety notes and complete information on the DAX linear encoder are available for download in the Internet at www.sick.com/DAX®.

Should persons be placed at risk, or operating equipment potentially be damaged in the event of a malfunction or failure of the device, this must be prevented by means of suitable protective devices, e.g., emergency stop systems.

If the device is not functioning correctly, it must be taken out of operation and secured against unauthorized operation.

To guarantee proper operation of the device, please observe the following:

- Protect the device against mechanical stress during installation.
- Do not open the device.
- Connect the device with the correct polarity, supply voltage, and control pulses.
- Observe the permissible operating and ambient condition for the device.
- Regularly check the device for correct operation and document the results.

2.2 Intended use

2.2.1 Purpose of the device

The linear encoders in the DAX® product family are suitable for determining the absolute position of piston rods in hydraulic cylinders and linear movements in industrial plants. Thanks to magnetostrictive technology, the encoder is completely wear- and maintenance-free. Individual configuration options ensure customized integration in nearly any application.

The device is a component and must be connected to a suitable electronic control unit.

2.3 Responsibility of user

Designated users

see "Target groups", page 5.

Correct project planning

- This document assumes that appropriate project planning has been carried out before delivery of the device (e.g., based on the SICK application questionnaire), and the device is in the required delivery state based on that planning (see supplied system documentation).
  - ► If you are not certain whether the device corresponds to the state defined during project planning or in the supplied system documentation, contact SICK Customer Service.

Special local conditions

In addition to the notes in these operating instructions, follow all local laws, technical rules and company-internal operating directives applicable at the respective device installation location.

Read operating instructions

- ► Read and follow the information in these operating instructions.
- ► Observe all safety notes.
- ► If there is anything you do not understand, contact SICK Customer Service.

Retention of documents

These operating instructions:

- must be made available for reference
- passed on to new owners

3 Product description

NOTE
See DAX® product pages www.sick.com/DAX®

3.1 DAX® device variants

The device is currently available in 3 housing variants:

		
DAX® Threaded Rod design with screw-in thread for use in industrial hydraulic cylinders	**DAX® Slider** The versatile profile variant with slide profile	**DAX® Low Profile** Profile variant especially suitable for tight installation situations

Each housing variant is available with the following interfaces and connection types:

Table 2: Interfaces and connection types

Analog	CANopen®
1xM12 male connector, 5-pin	1xM12 male connector, 5-pin
1xM12 male connector, 8-pin	

Output signals

- Analog (0 ... 10 V or 4 ... 20 mA)
- CANopen®

NOTE
See DAX® product pages www.sick.com/DAX®

3.2 Product identification

The breakdown and explanation of the values can be found in the respective data sheet and in the product configuration www.sick.com/DAX®

3.2.1 Output characteristics

3.2.1.1 Analog

The output signal can be output as voltage (0 ... 10 V) or current (4 ... 20 mA).

The analog output signal can be output via either one PIN or two PINs:

- Analog with one signal output (PIN signal 1 rising or PIN signal 1 falling)
- Analog with two signal outputs (PIN signal 1 rising and PIN signal 2 falling or PIN signal 1 falling and PIN signal 2 rising)

CAUTION
For the analog sensor with two outputs, both outputs must be terminated, regardless of whether both signals or only one signal is evaluated.

3.2.1.2 CANopen®

The digital output can be output with either one or two position magnets. All magnets must be configured to count either forward or backward.

The position signal can be output in two ways:

Forward:

- The minimum position value is located at the beginning of the measuring range, immediately after the null zone.

Reverse:

- The minimum position value is located at the end of the measuring range, immediately before the damping zone.

4 Mounting

4.1 DAX® rod variants

4.1.1 Prepare for installation

4.1.1.1 General notes on installation preparation

Recommended materials:

We recommend using non-magnetizable materials for holding the DAX® and the position magnet.

Horizontal mounting:

For horizontal mounting with a measuring range > 500 mm, the rod must be supported.

Hydraulic cylinder:

When installing the device in a hydraulic cylinder, ensure the minimum value for the bore diameter of the receiving piston.

Position magnets:

Different position magnets are available for the DAX® (see "Accessories", page 45).

4.1.2 Installation recommendation for DAX® Threaded in non-magnetizable material

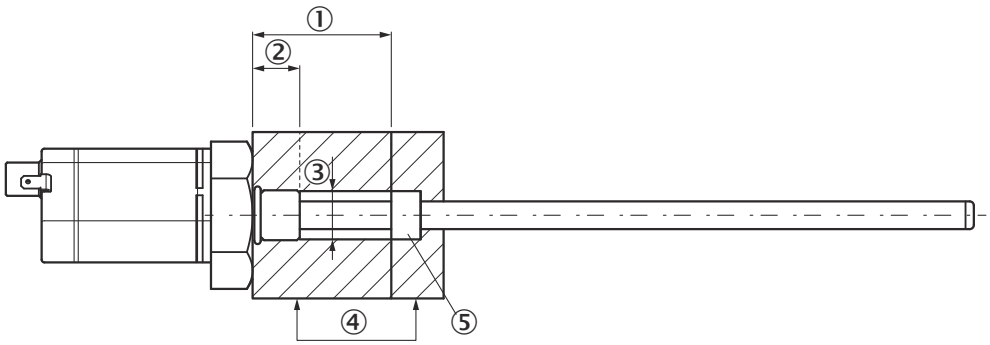


Figure 1: Installation variant in non-magnetizable material

① Zero zone (type-dependent)
② Thread length (type-dependent)
③ Thread type (type-dependent)
④ Non-magnetizable material
⑤ Position magnet

4.1.3 Installation recommendation for DAX® Threaded in magnetizable material

When using magnetizable material, we recommend protecting the DAX® from magnetic interference by taking suitable measures (e.g., spacer ring made of non-magnetizable material, sufficient distance from strong external magnetic fields).

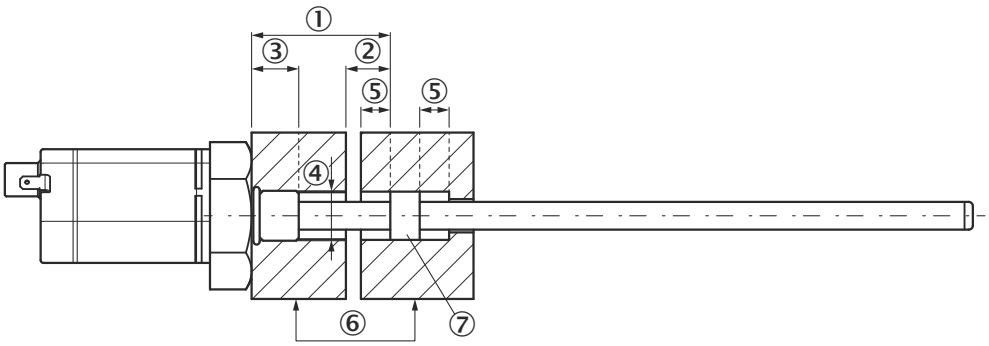


Figure 2: Installation recommendation for DAX® Threaded in magnetizable material

① Zero zone (type-dependent)
② Distance between position magnet and magnetic material (> 15 mm)
③ Thread length (type-dependent)
④ Thread type (type-dependent)
⑤ Non-magnetic spacer (recommendation 8 mm)
⑥ Magnetizable material
⑦ Position magnet

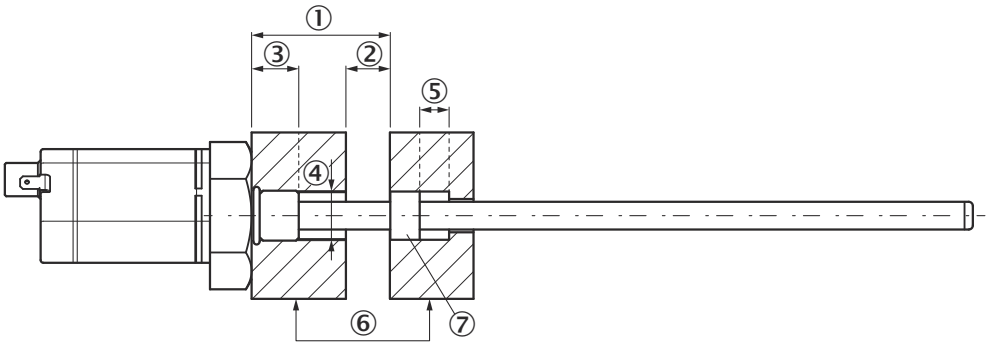


Figure 3: Installation recommendation for DAX® Threaded in magnetizable material

① Zero zone (type-dependent)
② Distance between position magnet and magnetic material (> 15 mm)
③ Thread length (type-dependent)
④ Thread type (type-dependent)
⑤ Non-magnetic spacer (recommendation 8 mm)
⑥ Magnetizable material
⑦ Position magnet

4.1.4 Preparations for installation in the cylinder base

Threaded bore:

DAX® rod variants have an M18×1.5 (according to ISO) or 3/4"-16UNF (according to SAE) thread for securing the device in the cylinder base. Depending on the type, the corresponding threaded bore must be prepared according to the following specifications before mounting the device:

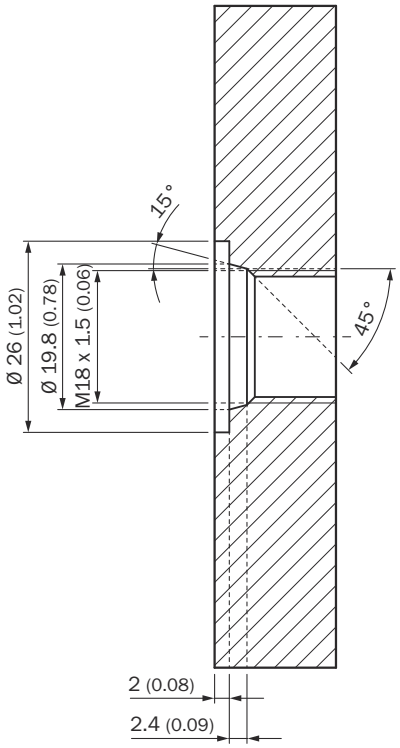


Figure 4: Threaded bore M18x1.5 according to ISO 6149, 15.3x2.2 O-ring

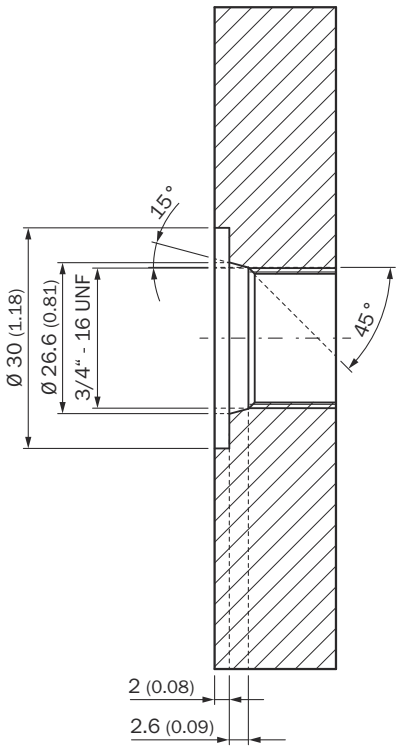


Figure 5: Threaded bore 3/4" - 16UNF according to SAE J475, 16.36x2.21 O-ring

4.1.5 Installation preparations for piston/piston rod

4.1.5.1 Preparation for ring magnet/C-magnet in piston

4.1.5.1.1 Preparation for ring magnet and C-magnet in piston rod with retaining ring in non-magnetizable material

Prepare an installation cavity for the position magnet according to the following drawing:

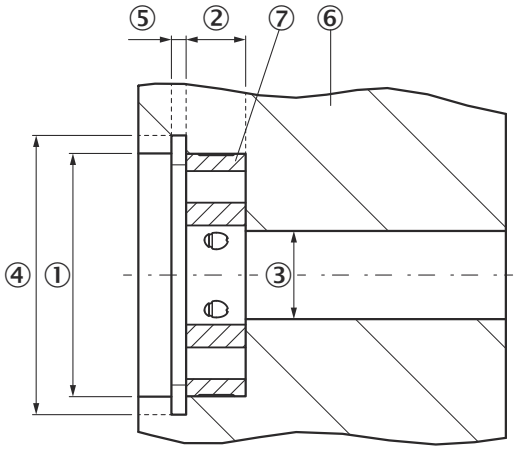


Figure 6: Preparation for ring magnet and C-magnet in piston rod with retaining ring in non-magnetizable material

① Bore diameter for the position magnet (outer diameter of magnet + 0.1 mm)
② Bore depth for the position magnet (height of magnet + 0.1 mm)
③ Bore diameter for the piston rod (12 mm)
④ Groove diameter for the retaining ring
⑤ Groove width for the retaining ring
⑥ Non-magnetizable material
⑦ Position magnet

4.1.5.1.2 Preparation for ring magnet and C-magnet in piston rod with screw connection in non-magnetizable material

Prepare an installation cavity for the position magnet according to the following drawing:

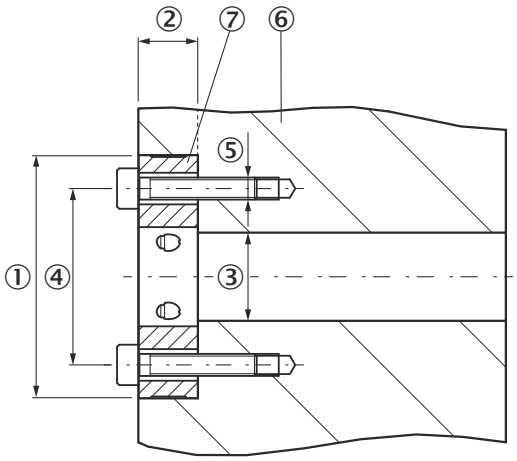


Figure 7: Preparation for ring magnet and C-magnet in piston rod with screw connection in non-magnetizable material

① Bore diameter for the position magnet (outer diameter of magnet + 0.1 mm)
② Bore depth for the position magnet (height of magnet + 0.1 mm)
③ Bore diameter for the piston rod (12 mm)
④ Hole pattern with pitch diameter for securing the position magnet
⑤ M4 bore diameter for securing the position magnet
⑥ Non-magnetizable material
⑦ Position magnet

4.1.5.1.3 Preparation for ring magnet and C-magnet in piston rod with retaining ring in magnetizable material

Prepare an installation cavity for the position magnet according to the following drawing:

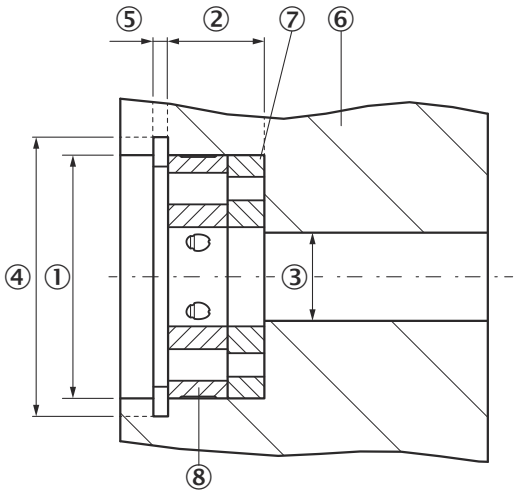


Figure 8: Preparation for ring magnet and C-magnet in piston rod with retaining ring in magnetizable material

① Bore diameter for the position magnet (outer diameter of magnet + 0.1 mm)
② Bore depth for the position magnet (height of magnet + height of non-magnetic spacer + 0.1 mm)
③ Bore diameter for the piston rod (12 mm)
④ Groove diameter for the retaining ring
⑤ Groove width for the retaining ring
⑥ Magnetizable material
⑦ Non-magnetic spacer – recommendation: 8 mm
⑧ Position magnet

4.1.5.1.4 Preparation for ring magnet and C-magnet in piston rod with screw connection in magnetizable material

Prepare an installation cavity for the position magnet according to the following drawing:

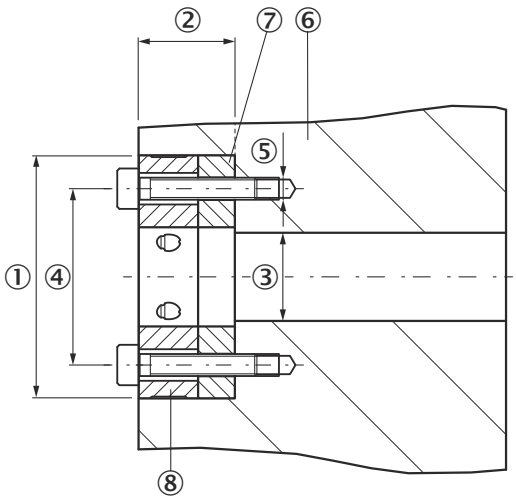


Figure 9: Preparation for ring magnet and C-magnet in piston rod with screw connection in magnetizable material

① Bore diameter for the position magnet (outer diameter of magnet + 0.1 mm)
② Bore depth for the position magnet (height of magnet + height of non-magnetic spacer + 0.1 mm)
③ Bore diameter for the piston rod (12 mm)
④ Hole pattern with pitch diameter for securing the position magnet
⑤ M4 bore diameter for securing the position magnet
⑥ Magnetizable material
⑦ Non-magnetic spacer – recommendation: 8 mm
⑧ Position magnet

4.1.5.2 Preparing the piston rod installation cavity

Prepare the installation cavity for the pressure pipe of the encoder according to the following dimensions:

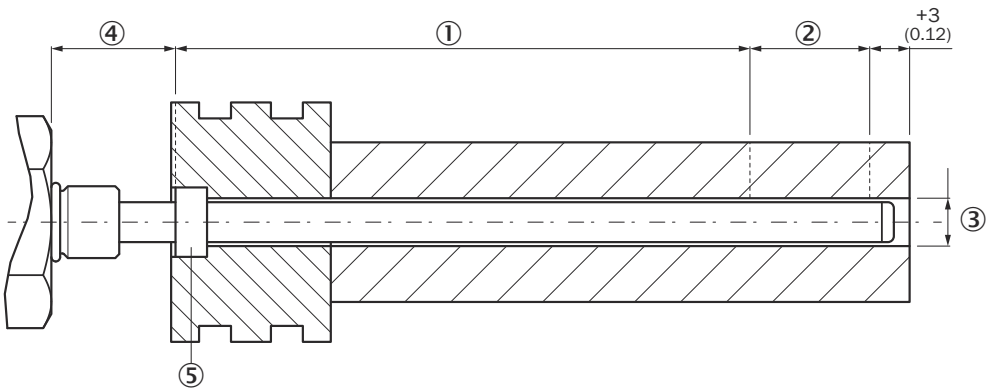


Figure 10: Piston and piston rod

① Measuring range (type-dependent)
② Damping (type-dependent)
③ Diameter of the piston rod bore (12 mm)
④ Null zone (type-dependent)

Table 3: Bore hole depth for the piston rod and installation cavity for electrical connection

Null zone ④	As per the applicable data sheet and selected device variant
Measuring range ①	
Damping ②	

NOTE

The total bore hole depth comprises the measuring range ①, the damping ②, the null zone ④ and an additional distance of 3 mm to the pressure pipe. The bore diameter (d) in the piston rod is 12 mm (for a pressure pipe of 10 mm outer diameter).

4.1.5.3 Preparation for alternative installation of ring magnet, C-magnet and block magnet

When mounting the device outside a hydraulic cylinder, use a non-magnetizable installation aid for position magnets. The position magnet must not rub against the rod during installation. Depending on the position magnet used, observe the distance tolerances to the linear encoder and the maximum permissible tightening torques.

Mount the C-magnets concentrically.

Details on the minimum distance around the position magnet to magnetizable material:

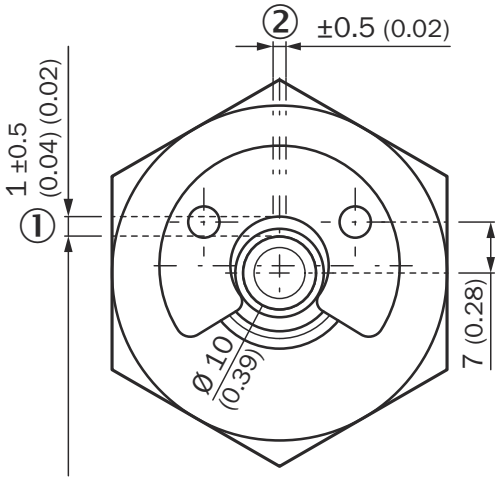


Figure 11: Minimum distance around the position magnet to magnetizable material

① Nominal distance + permissible amount of distance tolerance

② Permissible center offset

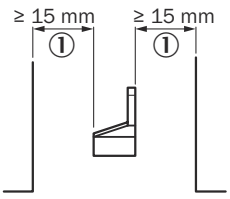


Figure 12: Minimum distance between position magnets and parts made of magnetizable material

① Minimum distance between position magnets and parts consisting of magnetizable material

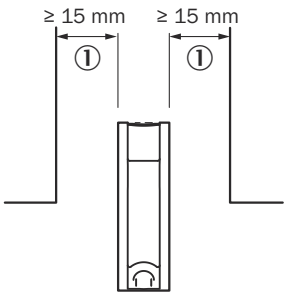


Figure 13: Minimum distance between position magnets and parts made of magnetizable material

① Minimum distance between position magnets and parts consisting of magnetizable material

4.1.6 Performing the installation

4.1.6.1 Mounting in the cylinder base

CAUTION
Functional impairment

Improper assembly can impair the function of the DAX® and lead to increased wear.

- ► The contact surface of the DAX® must be in full contact with the mounting surface.
- ► The bore must be perfectly sealed (O-ring).
- ► Lubricate the O-ring and pressure pipe before installation.
- ► To screw in the device, apply force to the hexagonal flange only. Do not turn the triangular housing.

NOTE
When screwing on the sensor, observe the maximum tightening torque of 50 Nm. Grease the O-ring before screwing in the device.

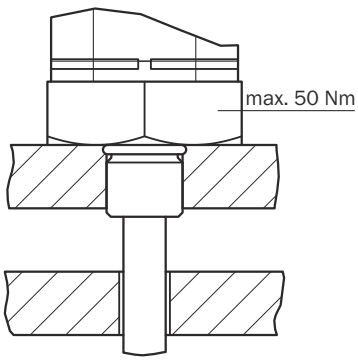


Figure 14: Mounting in the cylinder base

4.1.6.2 Mounting the magnet in the piston

NOTICE

- Make sure that the retaining ring and the corrugated spring washer are made from **non-magnetic** material (e.g., non-ferritic steel).
- Ensure that the position magnet and the non-magnetic spacer or retaining ring do **not** rub on the pressure pipe.
  - Example suitable retaining ring: BEF-MK-SR-xx does not contain any internal edges or eyelets to the pressure pipe.
- Observe the operating pressures.

Sequence of work steps:

- Prepare the piston for installation of the magnet: see "Installation preparations for piston/piston rod", page 14
- If necessary, use a corrugated spring washer or a non-magnetic spacer.
- Mount the position magnet.
- Insert the retaining ring and fasten using M4 screws. Observe the maximum permissible screwing torque of the respective position magnet when screwing it in.

4.2 DAX® profile variants

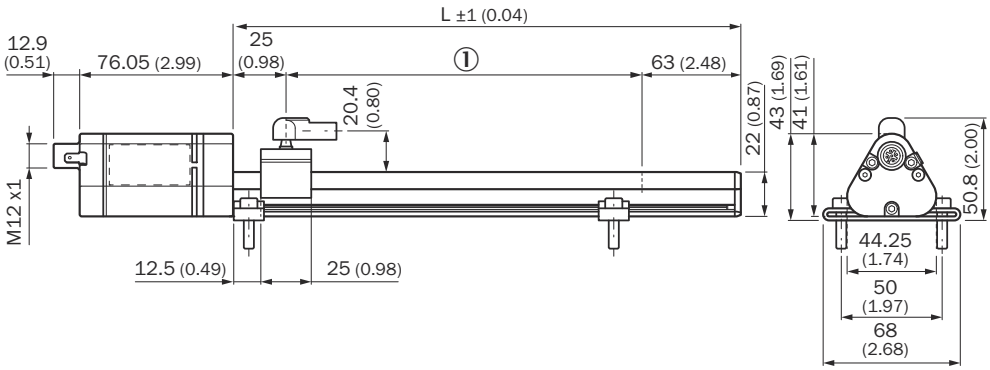


Figure 15: DAX® Slider with slider magnet

① Measuring range

WARNING
Improper mounting

Improper mounting can impair the function of the linear encoder and cause damage.

- Make sure that no strong electric or magnetic fields occur in the immediate vicinity of the linear encoder.
- When installing the device, the specified clearances must be observed.

The installation position is arbitrary. Use the supplied mounting brackets to mount the linear encoder on a flat surface of the machine. A sufficient number of mounting brackets have been supplied.

NOTE

To avoid the generation of resonance frequencies during vibration loads, we recommend positioning the mounting brackets at irregular distances.

4.2.1 Mounting the DAX® profile variants

Installation procedure

1. Prepare the substrate for installation of the linear encoder. For this purpose, drill two holes 50 mm apart in the substrate per mounting bracket.
   For the slider housing design, locate the first mounting bracket directly on the sensor head and the last mounting bracket approx. 100 mm before the end of the slider profile.
   For more information, see the DAX® Slider dimensional drawing "DAX® profile variants", page 20
2. Guide the linear encoder into the mounting brackets.
3. Secure the linear encoder to the substrate using suitable fixing screws (recommendation: M5 x 20 according to DIN 6912) (tighten the screws in the brackets to max. 5 Nm).
4. Mount the position magnet (accessory). To do so, follow the instructions in section see "Position magnets", page 22.

NOTE

Position magnets

Depending on the housing variant, the DAX® linear encoder in the profile design is suitable both for free-floating, i.e. non-contacting position magnets and for guided position magnets.

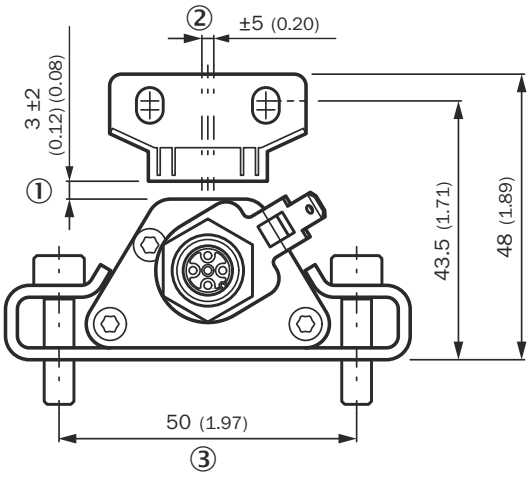


Figure 16: Mounting the DAX® profile variants - Low Profile

① Nominal distance + permissible amount of distance tolerance
② Permissible center offset
③ Recommendation: M5 x 20

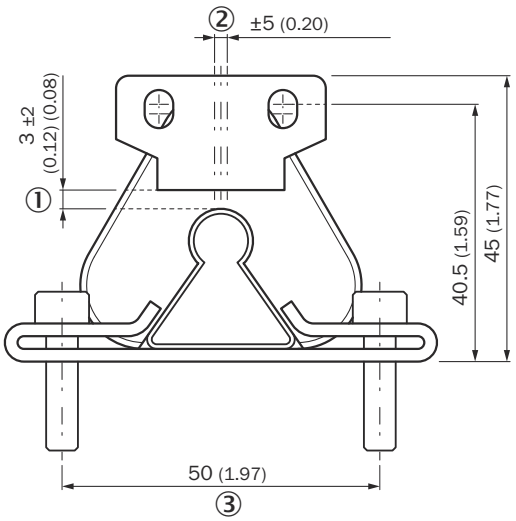


Figure 17: Mounting the DAX® profile variants - Slider

① Nominal distance + permissible amount of distance tolerance
② Permissible center offset
③ Recommendation: M5 x 20

4.3 Position magnets

4.3.1 Overview of position magnets

Table 4: Overview of position magnets

Magnet type	Compatibility
Ring magnet	
	**DAX® Threaded** • Rotationally symmetric magnetic field
C-magnet	
	**DAX® Slider and DAX® Threaded** • Magnet operates non-contact • Height tolerances can be compensated
Block magnet	

Magnet type	Compatibility
	**DAX® Slider, DAX® Low Profile and DAX® Threaded** • The magnet can be removed from the sensor (e.g., for maintenance position in machines) • Height tolerances can be compensated
Slide magnet	
	**DAX® Slider** • The slide magnet is guided on the slide profile • The distances between the position magnet and linear encoder are precisely defined and thus allow the best possible performance characteristics • Easy connection in a wide range of applications thanks to the ball joint

Overview of all accessories see "Accessories", page 45

4.3.2 Mounting the guided position magnet (slide magnet)

Note the following when installing the position encoder:

- ► Avoid lateral forces.
- ► Connect the position magnet to the machine part via an articulated rod.

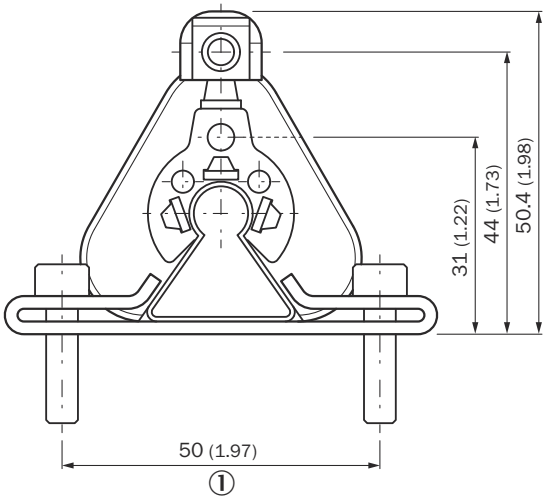


Figure 18: Dimensions and distances for MAG-S-H29-xx position magnet on DAX® Slider

① Recommendation: M5 x 20

4.3.3 Mounting free-floating position magnets (C-magnet and block magnet)

Note the following when installing free-floating position magnets:

- ► To ensure the accuracy of the position measuring system, the position magnet is secured to the moving machine part using non-magnetizable screws (stainless steel, brass, aluminum).
- ► The moving machine part must guide the position magnet on a path parallel to the linear encoder.
- ► The distance ① between the position magnet and parts made of magnetizable material must be at least 15 mm (see figure 22, page 25 and see figure 23, page 26).
- ► The following values must be observed for the nominal distance ① between the position magnets and linear encoder and for the center offset ② (see figure 19, page 24 , see figure 20, page 24 and see figure 21, page 25):

Table 5: Distance and offset for the position magnets

Position magnet type	Nominal distance ①	Height distance tolerance ①	Center offset ②
MAG-B-180-xx	3 mm	1 ... 5 mm	± 5 mm
MAG-C-330-xx	1 mm	0.5 – 1.5 mm	± 0.5 mm

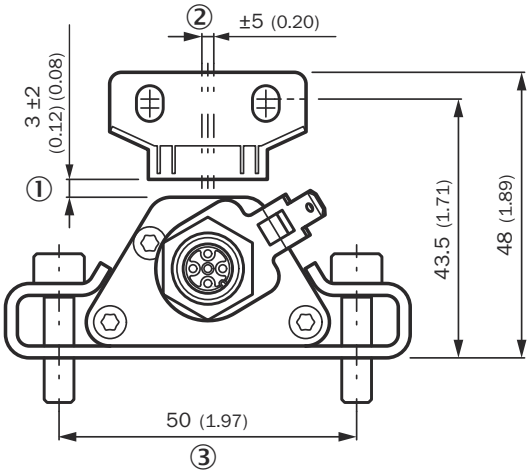


Figure 19: Dimensions and distances for MAG-B-180-xx position magnet on DAX® Low Profile

① Nominal distance + permissible amount of distance tolerance
② Permissible center offset
③ Recommendation: M5 x 20

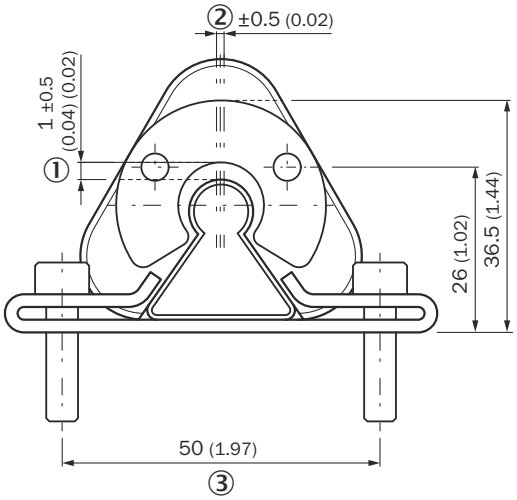


Figure 20: Dimensions and distances for MAG-B-180-xx position magnet on DAX® Slider

① Nominal distance + permissible amount of distance tolerance
② Permissible center offset
③ Recommendation: M5 x 20

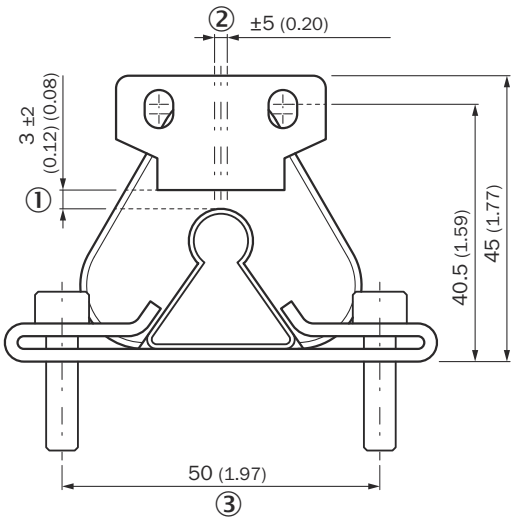


Figure 21: Dimensions and distances for MAG-B-180-xx position magnet on DAX® Slider

① Nominal distance + permissible amount of distance tolerance
② Permissible center offset
③ Recommendation: M5 x 20

Misalignments are compensated for via the air gap.

- Surface pressure of the position magnet: Type-dependent, see the technical data of the position magnet used.
- Tightening torque for the M4 screws: Max. 1 Nm, use washers if necessary.

CAUTION

Mount the C-magnets concentrically.

Mount the block magnets centered over the linear encoder profile. Do not exceed the maximum permissible air gap. Install the sensor so that the sensor rod/linear encoder profile is aligned parallel to the direction of movement of the position magnet. In this way, you avoid damage to the magnet driver, magnet, and linear encoder profile.

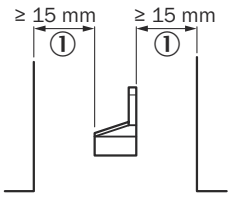


Figure 22: Minimum distance between position magnets and parts made of magnetizable material

① Minimum distance between position magnets and parts consisting of magnetizable material

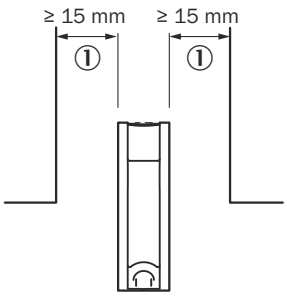


Figure 23: Minimum distance between position magnets and parts made of magnetizable material

① Minimum distance between position magnets and parts consisting of magnetizable material

4.3.4 Using multiple position magnets on one linear encoder

- Two position magnets can only be selected for nominal measuring range lengths ≥ 100 mm.
- The distance between two position magnets must be ≥ 50 mm.

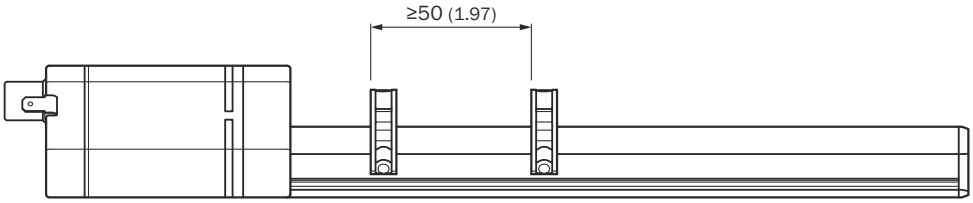


Figure 24: DAX® Slider with C-magnet (MAG-C-250-01)

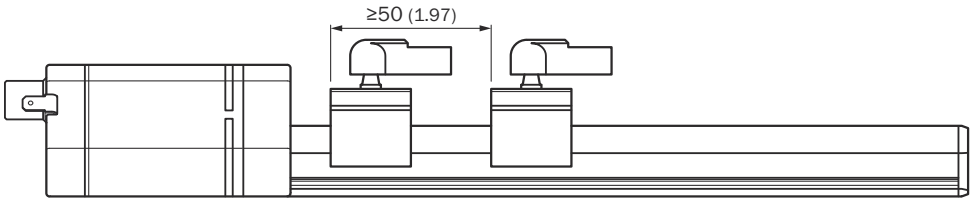


Figure 25: DAX® Slider with slider magnet

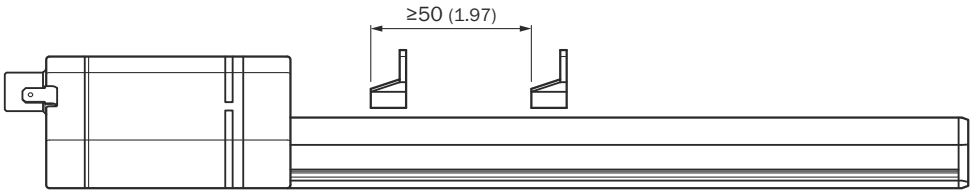


Figure 26: DAX® Slider with block magnet

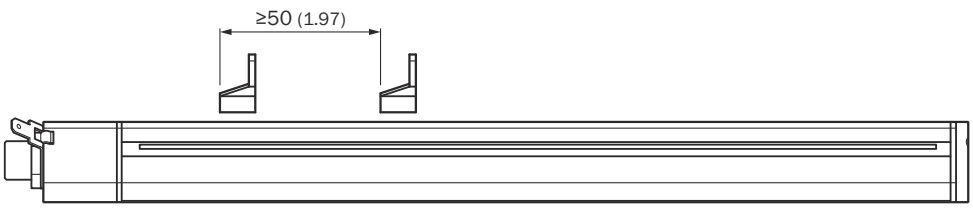


Figure 27: DAX® Low Profile with block magnet

CAUTION
If the minimum distance between two magnets specified above is not adhered to, a valid position value cannot be guaranteed.

5 Electrical installation

The installation location and cabling have a significant influence on the electromagnetic compatibility (EMC) of the linear encoder. Correct connection of this active electronic system, and the EMC of the overall system must be assured by means of suitable connectors, a shielded cable, and grounding. Overvoltages or incorrect connections can damage the electronics despite reverse polarity protection.

NOTE

1 Do not mount the sensors in the area of strong magnetic and electric interference fields.
2 Never connect or disconnect the sensor while it is live.

Connection instructions

- ► Use low impedance, twisted pair and shielded cable. Connect the shield externally in the control unit to ground.
- ► Lay the control and signal lines spatially separated from power cables and away from motor lines, frequency converters, valve lines, switching relays, etc.
- ► Use only metal connectors. Place the shield on the connector housing.
- ► Place shields on both cable ends over a large area and the cable clamps on functional earth.
- ► Make earth connections short and with a large cross-section. Avoid earth loops.
- ► In the event of potential differences between the ground connection of the machine and the electronics, no equalizing current must flow across the shield.
- ► **Recommendation:** Use a equipotential bonding line with a large cross-section.
- ► Use only a stabilized voltage supply. Adhere to the specified connection values.

Cable laying

Do not lay the cable between the displacement sensor, control unit and voltage supply near power lines (inductive interference possible).

Particularly critical are inductive interferences caused by mains harmonics (e.g., from phase-angle controllers), for which the cable shield offers only little protection.

Notes on cable laying

Do not lay the cable between DAX®, the control unit and the voltage supply near power lines. Lay the cable with strain relief.

Maximum length of cable

DAX® with analog interface: max. 30 m.

DAX® with CANopen® interface: max. 25 m (at 1 Mbaud)

Longer cables can be used if external interference fields remain ineffective due to the structure, shielding and routing.

Magnetic fields

The linear encoder is a magnetostrictive system. Ensure a sufficient distance between the linear encoder and strong external magnetic fields, otherwise the measuring system may suffer interference.

5.1 Shielding and earthing

NOTE
Defined earthing
The position sensor and controller should be at the same earth potential.

Shielding

The following instructions must be observed to ensure electromagnetic compatibility (EMC):

- ► Connect the DAX® and controller using a shielded cable. Shielding: braiding of copper single wires, coverage at least 85%.
- ► Make sure that the shield is applied over a large area on both sides to ensure the best possible signal quality.
- ► DAX® Connector type: Connect the shield in the plug connector with the connector housing and ensure that it is flush.

Earthing of profile and rod sensors

Connect the sensor electronics housing to the machine earth via the ground lug located on the linear encoder.

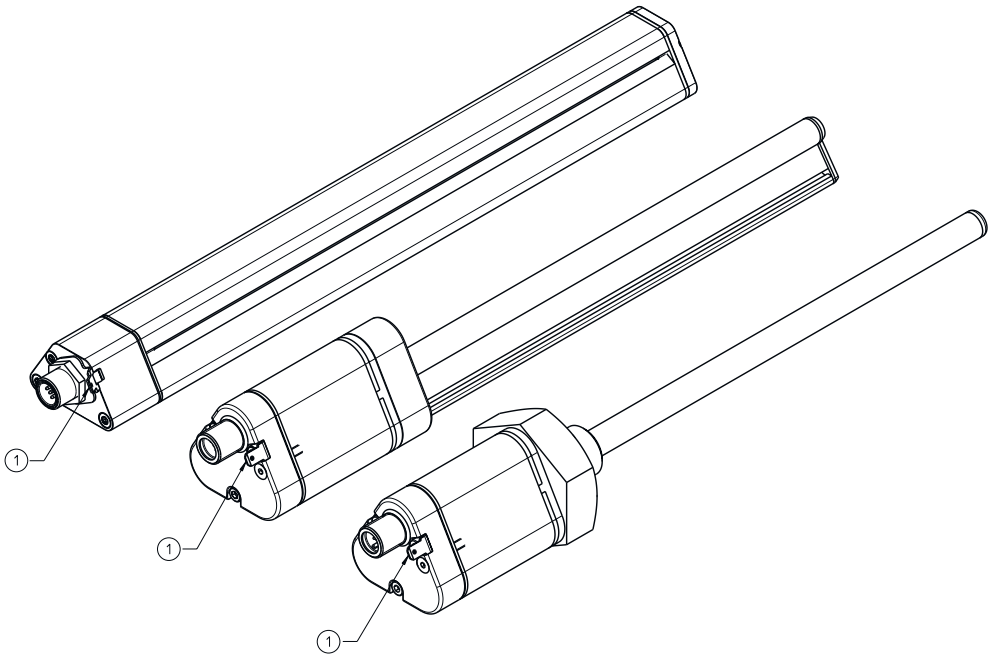


Figure 28: Sensor grounding

① Sensor grounding

5.2 Wiring diagram for the M12 connector

5.2.1 Analog M12, 5-pin

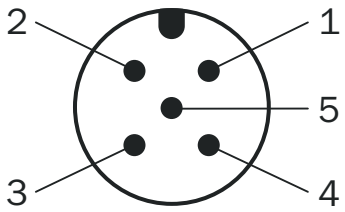


Figure 29: Pin assignment M12 - 5-pin

① +24 V DC
② Signal 1
③ Power ground
④ Signal 2
⑤ Output signal ground (0 V)

NOTE
Incorrect wiring between the two signal lines may result in an incorrect position value.

5.2.2 Analog M12, 8-pin

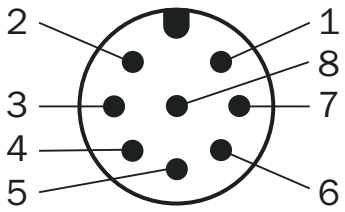


Figure 30: Pin assignment M12 - 8-pin

① Output signal ground (0 V PIN 3)
② Output signal ground (0 V PIN 5)
③ Signal 2
④ N.C.
⑤ Signal 1
⑥ Power ground
⑦ +24 V DC
⑧ N.C.

NOTE
Incorrect wiring between the two signal lines may result in an incorrect position value.

5.2.3 CANopen® M12 – 5-pin

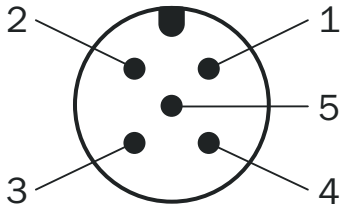


Figure 31: Pin assignment M12 - 5-pin

① N. C.
② V DC
③ GND
④ CAN HIGH
⑤ CAN LOW

6 LED flashing behavior

During the start-up time, both LEDs light up for max. 1 sec. After this, the flashing behavior starts as described in "LED flashing behavior: analog", page 32 and "LED flashing behavior: CANopen®", page 32.

6.1 LED flashing behavior: analog

Table 6: LED flashing behavior: analog

Status	Green LED	Red LED	Output value
Normal operating state	ON	OFF	Valid output value
Missing magnet	OFF	ON	Output of an error value (> 10.5 V / > 21 mA)
Magnet outside the measuring range	OFF	ON	Output of an error value (> 10.5 V / > 21 mA)
Invalid number of magnets	OFF	ON	Valid output value
“High temperature” warning	OFF	Slow flashing	Valid output value
Low supply voltage < 12.2 V ± 0.2 V for 10 V < 18.5 V ± 0.2 V for 4-10 mA	OFF	Slow flashing	< 0.1 V / < 3.5 mA [1]
Programming mode	Blinking	OFF	> 5 V
Flash memory error	Flashing (50%)	Flashing (50%)	Error value

1 Note: Hysteresis of about 5 seconds

6.2 LED flashing behavior: CANopen®

Table 7: LED flashing behavior: CANopen®

Status	Green LED	Red LED	Output value	Error value
Normal operating state	ON	OFF	Valid output value (0x0000)	-
Missing magnet	20%	80%	0xFFFFFFFF	0x0004/0x0007
Magnet outside the measuring range	20%	80%	<0 or >maximum value	0x0003
Invalid number of magnets	20%	80%	Valid output value	0x0000
Distance between the position magnets too small[1]	20%	80%	Valid output value	0x0100
“High temperature” warning	20%	80%	Valid output value	0x0040
Low supply voltage < 7 ± 0.2 V High supply voltage > 52 ± 1 V	20%	80%	Valid output value	0x0020
Pre-operational mode	1x AN (50%)	1x AN (50%)	-	-
Flash memory error	OFF	Blinking	-	-

1 Too small = between ≤ 50 mm and ≥ 25 mm distance between magnets; distances below 25 mm can result in an incorrect position measurement.

7 Commissioning

7.1 Tolerance considerations for the set point

The set points (zero/end point) of the device are calibrated ex works with a tolerance of ± 1 mm.

NOTICE

The following information relates primarily to installation and use in hydraulic cylinders. Further tolerances must be observed when installing the cylinder.

During teach-in, the piston rod moves to the zero point and to the end point in order to eliminate all tolerances in the cylinder/encoder combination. The measured signals are programmed in the controller accordingly. When operating the device without teach-in, please note the following tolerance-related information:

Table 8: Tolerances for operation without teach-in

Example for a measuring range of 400 mm			
Sensor output	Analog V DC	Analog mA	CANopen®
Signal	0 ... 10 V	4 ... 20 mA	PDO telegram
Range	10,000 mV	16 mA	4,000 digits
Zero end point ± 1.0 mm	± 25 mV	± 0.04 mA	± 10 digits
Position magnet ± 1.0 mm	± 25 mV	± 0.04 mA	± 10 digits
Mechanical assembly ± 0.5 mm	± 13 mV	± 0.02 mA	± 5 digits
Total of all tolerances ± 2.5 mm	± 63 mV	± 0.10 mA	± 25 digits

Table 9: Zero end point

Example for a measuring range of 400 mm			
Sensor output	Analog V DC	Analog mA	CANopen®
Signal	0 ... 10 V	4 ... 20 mA	PDO telegram
Zero point	± 63 mV	± 0.10 mA	± 25 digits
Min. zero point	-0.063 V	3.9 mA	275 digits
Max. zero point	+0.063 V	4.1 mA	325 digits
End point (F.S)	± 63 mV	± 0.10 mA	± 25 digits
Min. end point	9.937 V	19.9 mA	3,975 digits
Max. end point	10.063 V	20.10 mA	4,025 digits

After installation of the encoder in the cylinder, deviations from the target values will arise due to these permissible tolerances. These deviations must be taken into consideration when setting limit values in the controller:

Table 10: Deviation from the limit values

Typical values			
	Cylinder stroke (mm)		
	200 mm	400 mm	800 mm
Output signal	Tolerances		
Analog V DC	± 50 mV	± 25 mV	± 12.5 mV
Analog mA	± 0.20 mA	± 0.10 mA	± 0.05 mA
CANopen®	± 25 digits	± 25 digits	± 25 digits

7.2 Commissioning the linear encoder (analog)

- Check that the electrical connectors have been connected correctly see "Analog M12, 5-pin", page 30
- Select a suitable fuse: see “Select a suitable fuse” see "Select a suitable fuse", page 34
- Select the terminator, if applicable see "Termination (analog)", page 34
- Set up the filter wiring: see “Set up the filter wiring - analog" see "Set up the filter wiring (analog)", page 34
- Put the device into operation

7.2.1 Select a suitable fuse

When selecting a suitable fuse, the transient peak current when switching on the device for the time must be taken into consideration:

Start-up current for a supply voltage of 24 V DC: typ. 5.0 A / 50 µsec

7.2.2 Set up the filter wiring (analog)

Thermal noise, for example from resistors, becomes evident when the signal output is amplified sufficiently. The supply voltage ripple and other sources of interference, e.g., electromagnetic interference, can also affect the quality of the analog output signal. To reduce the smoke suppression when acquiring analog measurement data, it is essential to use a filter. A combination of R1 = 50 Ω and C1 = 100 nF to 1 µF is suitable, for example.

This will keep the signal delay time within the cycle time (internal measurement frequency) while not changing the dynamic behavior significantly.

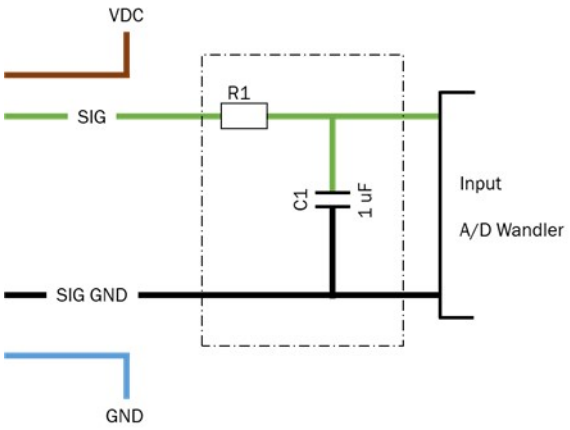


Figure 32: Filter wiring

NOTICE

The A/D converter at the input of the installed electrical controller will determine the resolution of the encoder, e.g.,:

- 8 bit = 256 steps
- 10 bit = 1,024 steps
- 12 bit = 4,096 steps

7.2.3 Termination (analog)

For the analog sensor with two outputs, both outputs must be terminated, regardless of whether both or only one signal are evaluated.

7.2.4 Analog interface details

For more detailed information on the analog interface, please refer to the relevant technical Information at www.sick.com/DAX®. You can find the information in the download area of the relevant part number. To do so, enter the product part number in the search field (part number: see the “P/N” or “Ident. no.” field on the type label).

7.3 Commissioning the linear encoder (CANopen®)

7.3.1 EDS file

An EDS file is available to make connecting the DAX® CANopen® to a CANopen® controller easy (it can be found at www.sick.com/DAX®). To do so, enter the product part number in the search field (part number: see the entry in the “P/N” or “Ident. no.” field on the type label).

7.3.2 Bus termination (CANopen®)

Data transmission in the CAN bus is serial (2-wire bus system). The voltage difference between the CAN_HI and CAN_LO data lines is one bit of information. To prevent signal reflections, the data lines must be terminated with a 120 Ω terminator on the open bus end. The terminator must be inserted between CAN_HI and CAN_LO.

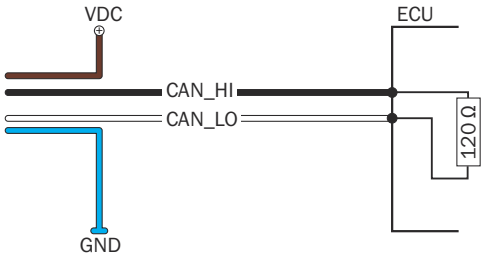


Figure 33: Bus termination

7.3.3 Node ID/baud rate

The following requirements must be met for communication with the controller: A correct node ID must be configured at the DAX® CANopen®.

The following are correct:

- A node ID that is unallocated in the CANopen® network
- A node ID that the controller expects

The DAX® CANopen® must be set to the same baud rate as the master.

The following parameters are set at the factory for the DAX® CANopen®:

- Node ID: 127 (7F)
- Baud rate: (type-dependent according to device configuration)

7.3.4 Communication objects

When the device is in operational mode, the control unit integrated into the device convert the measurement data into CAN messages, and transmit these messages on the CAN bus. They can be received and processed by the controller there. The CAN bus uses the following communication objects for data transmission:

SDO (Service Data Object):

- SDOs are used to set and query parameters relating to the encoder configuration. These are accessed from the internal object directory of the device. To process SDOs, the device must be in either the pre-operational or operational mode.

PDO (Process Data Object):

- PDOs transmit process data, such as position and speed, to the controller. PDOs are only generated in operational mode.

NMT (Network Management):

- NMTs control the status of the network and individual components. They can also be used for monitoring purposes using the following objects:
  - SYNC object:
    The SYNC object synchronizes the bus communication, i.e. synchronous PDOs are sent to the controller after a SYNC object is received.
  - Emergency object:
    The emergency object sends error messages. As they generally have a higher priority than PDOs, these emergency objects will be transmitted first.
  - Nodeguard object:
    The CANopen® linear encoder uses the node guarding protocol to perform the error control services of the CANopen® network.
    The bus master uses a remote frame to send a nodeguard message to the CANopen® device, and in response the device reports its current NMT status using a standard nodeguard message. The nodeguard frame format, and the NMT state value definitions are shown in the following tables. The nodeguard protocol is activated as default.

7.3.5 CANopen State Machine

As in every CANopen® device, a socalled CANopen® state machine is implemented in the DAX® CANopen. A differentiation is made between the following statuses:

Table 11: Status of the CANopen® state machine

Status	Description
Initializing	The initialization starts. The device application and the device communication are initialized. Then the node switches automatically to the Pre- operational status.
Pre-Operational	DAX® is ready for configuration, acyclic communication can take place via SDO. However, DAX® is not yet able to participate in PDO communication and also does not send any emergency messages.
Operational	In this status DAX® is fully operational and can transmit messages independently (PDOs, emergency messages).
Stopped	In this status DAX® is disabled for communication (active connection monitoring via node guarding remains active).

7.3.6 Node Guard/Heartbeat-Protokoll

The heartbeat mechanism for a CANopen® device is implemented as a cyclic transmission of the heartbeat message by the heartbeat encoder. One or more CANopen® devices in the network support this heartbeat message. If the heartbeat cycle for the heartbeat encoder fails, the host is informed about this event. The format for node guard/heartbeat frames and NMT state value definitions are shown in the table below. The node guard message and the heartbeat message differ only in the bit in the node guard protocol, unlike the heartbeat message, used to change the state of the data MSB.

Table 12: Node guard / heartbeat protocol message

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
700h + Node ID	Tx	1	STATE	-	-	-	-	-	-	-

Table 13: Node guard / heartbeat protocol data

STATE	Meaning
00h	Bootup
04h	Stopped
05h	Operational
7fh	Pre-Operational

NOTE
The COB-ID can be read from the object dictionary using the index “100Eh”. The COB-ID of the boot-up message cannot be changed.

7.3.7 Configuration and system startup

After electrical connection to the network, the device is ready for commissioning and configuration. Before actual system startup, the communication parameters for operation need to be set in the CAN bus. Only the basic procedure is described in these operating instructions. Please refer to the “Technical information (8028137)” for details on all the available commands for configuring the device www.sick.com/DAX® can be found.

Setting the node parameters

To be able to operate the device in a CAN bus network, it is necessary to first configure the network characteristics. The basic settings for integrating a bus subscriber are made using LSS (Layer Setting Services). Every device (node) in the CAN network is uniquely identified by its LSS address. This address is composed as follows:

Table 14: LSS address

	CANopen®
Vendor ID	1000056h
Product code	According to the production key
Revision number	According to the production key
Serial number	Actual serial number of the CANopen® encoder

Parameters specific to the CAN bus, such as baud rate and node ID, are also configured and saved via the LSS service. Both the baud rate and node ID of the encoder must be configured for operation in the specific CAN bus implementation.

Setting the node ID

DANGER
When programming the node ID, only one device must be connected.

Every device must be assigned a number (node ID). This number is used to identify the node within the CANopen® network. Each node ID must be unique. The CANopen® node ID is in the range 1 - 127. To ensure error-free operation of the network, the ID of every node in the CAN bus must be unique.

The node ID of the device can be set using the following command sequence:

Table 15: Setting the node ID

Data source	COB-ID	Data	Destination
Controller	7e5h	04; 01; 00; 00; 00; 00; 00; 00	Sensor

Data source	COB-ID	Data	Destination
Controller	7e5h	11; 7d[1]; 00; 00; 00; 00; 00; 00	Sensor
Sensor	7e4h	11; 00; 00; 00; 00; 00; 00; 00	Controller

1 Node address values can be between 1 and 127 (e.g., 125)

A change in node address is effective immediately. To permanently save the node address, the following command must be sent:

Table 16: Saving the node ID

Data source	COB-ID	Data	Destination
Controller	7e5h	17	Sensor
Sensor	7e4h	17; 00; 00; 00; 00; 00; 00; 00	Controller

Setting the baud rate

The baud rate indicates the speed of operation of the device and also the entire CAN bus. The device and entire network must be set to the same baud rate.

The maximum baud rate is limited by the cable length used for the CAN network as a whole. The device is delivered with a preset, order-dependent baud rate. If this baud rate needs to be changed, it can be configured via the LSS.

Table 17: Baud rate as a function of cable length

Length of cable	Baud rate (kBit/s)	Table index
< 25 m	1000	00
< 50 m	800	01
< 100 m	500	02
< 250 m	250	03
< 500 m	125	04
< 1,000 m	50	06
< 2,500 m	20	07
< 5,000 m	10	08

The baud rate can be set using the following commands:

Table 18: Setting the baud rate

Data source	COB-ID	Data	Destination
Controller	7e5h	04; 01; 00; 00; 00; 00; 00; 00	Sensor
Controller	7e5h	13; 00; 02[1]; 00; 00; 00; 00; 00	Sensor
Sensor	7e4h	13; 00; 00; 00; 00; 00; 00; 00	Controller

1 Table index

The baud rate becomes active after saving the changes, and the next time the encoder is switched on. To save the baud rate, the following command must be sent:

Data source	COB-ID	Data	Destination
Controller	7e5h	17; 00; 00; 00; 00; 00; 00; 00	Sensor
Sensor	7e4h	17; 00; 00; 00; 00; 00; 00; 00	Controller

7.3.8 Parameterizing CANopen®

7.3.9 CANopen® - system start

After configuring the node parameters, the device can be integrated into the network. When switched on or reset, the encoder performs a hardware initialization to bring all components into a defined initial state. Next the device- and communication-specific parameters are loaded from an EEPROM and the configuration adopted.

Once the initialization has been completed, the device reports its node ID and pre-operational status to the network master by means of a boot-up message. While in this mode, the device can be configured via service data objects (SDOs). The SDO identifiers are generated automatically based on the node ID. The communication via SDOs to configure the device takes the form of a peer-to-peer connection between the network master and the device. The identifiers for the other objects are also allocated according to the CANopen® standard. They can, however, be changed at any time in the CANopen® network via a DBT master. If necessary, the changed parameters can be saved in the EEPROM and loaded automatically the next time the device is switched on and configured.

Once the configuration process is finished, the encoder is switched from pre-operational to operational mode using a Start_Remote_Node command. While in this mode, user data can be transmitted (via PDOs). The transmission of the PDOs can occur in one of two ways:

Either the encoder sends its data cyclically, or data transmission is triggered by the receipt of a SYNC object.

To initiate the sending of position messages by the encoder, it is necessary to first send a node start message:

Table 19: Node start message

Data source	COB-ID	Data	Destination
Controller	000h	01; 00[1]; 00; 00; 00; 00; 00; 00	Sensor

1 NODE ID "00" Sets all nodes to pre-operational status

7.3.10 CANopen® - configuring the operating parameters

At system startup (power-on reset), the device loads the operating parameters stored in the EEPROM. These are either the factor-set values, or previously changed and saved values.

Changes are made, for example, via SDOs while in pre-operational mode. The identifiers are automatically set to suitable default values and saved when programming the node ID. They can subsequently be changed.

These operating parameters are stored in the object directory of the device, which provides the means for implementing the internal characteristics and functions of the device, as well as external communication. For this purpose, the object directory is divided into two parts: a Communication Profile, and a Device Profile.

Communication Profile:

- The Communication Profile contains the parameters relevant to communication, e.g., identifier settings and PDO configuration settings. The device is equipped with the encoder communication protocol (Device Profile for Encoder – DS406 Vers. 3.1). This enables devices from different manufacturers to be easily linked to one another and replaced.

PDO transmission type:

- By default, the PDO transmission type is set to asynchronous, i.e. the encoder transmits its process data independently according to the configured cycle time. The PDO transmission type can also be set in such a way that process data is only sent after a SYNC message is received.

PDO object mapping:

- The device does not support dynamic mapping or changing of the mapping parameters. PDO1 and PDO2 transmit the position and speed.

Error messages:

- The device automatically sends an emergency object when an error arises.

Device profile:

- The parameters important to the operation of the encoder, such as position resolution, speed resolution, and cycle time, are stored in the Device Profile. Two important operating parameters are:
  Resolution:
  - The resolution of the linear encoder is type-dependent according to the configuration. The resolution for motion speed is set to 1 mm/s by default. You can find more information in the “Technical Information (80xxxxx)” document.

  Cycle time:
  - This setting is the cycle time for transmission of PDOs. The value can be in the range of 1 ... 65,535 ms. Programming the cycle time (object 6200) only affects the PDO1 event timer (see DS406 V3.0).
  - The cycle time setting must match the setting configured for the CAN bus network. If the cycle time is too short, and the baud rate is high and there are many subscribers, the bus can become overloaded due to the increased volume of data. The cycle time is set using the following commands (e.g., 10, Node ID =127*):

Table 20: Setting the cycle time

Data source	COB-ID	Data	Destination
Controller	67fh*	22; 00; 62; 00; 0A; 00; 00; 00	Sensor
Sensor	5ffh*	60; 00; 62; 00; 00; 00; 00; 00	Controller

Table 21: Saving the cycle time

Data source	COB-ID	Data	Destination
Controller	67fh*	22; 10; 10; 01; 73; 61; 76; 65	Sensor
Sensor	7ffh*	60; 10; 10; 01; 00; 00; 00; 00	Controller

7.3.11 CANopen® - encoder data during operation

Data is output by means of a Process Data Object (PDO). The PDO contains the position and speed data.

Data format

The resolution of the position data depends on the type (according to the configuration of the respective linear encoder) and the resolution of the speed data is 1 mm/s. The currently set values can be read under index 6005 of the object directory. All position data are stored as 32-bit integer values, and speed data as 16-bit integer values.

Table 22: PDO allocation when using the default settings

Identifier	DLC	D0	D1	D2	D3	D4	D5
180h + Node ID	6	Position magnet 1				Speed magnet 1	

Calculation of position and speed:

Position [µm] = position value [digits] * resolution in µm (type-dependent)

Speed [mm/s] = speed value [digits] * 1 mm/s

7.3.12 CANopen® - error message

An emergency object is sent whenever there is a change to the internal error status register (even if the error has since been rectified). The object comprises 8 data bytes and is structured as follows:

Table 23: Emergency object

Identifier	DLC	D0	D1	D2	D3	D4	D5
0x80 + Node ID	8	Error code		Error register	Manufacturer-specific		

The following errors are reported in the emergency object:

Table 24: Error codes

Error codes	Meaning
0000h	Device is operating without errors
5000h	Device hardware error
6300h	Data set error

There are other error registers in addition to the table of error codes.

Table 25: Emergency Object message

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
80h + Node ID	Tx	8	Emergency Error Code		Error Register Object 1001h	Status reg 1002h				00h

Table 26: Error codes

Error Code (hex)	Meaning
0000h	Error Reset or No Error
3110h	Supply voltage exceeded
4000h	Temperature range exceeded
5000h	Device hardware
6000h	Device software
8100h	Communication error
8130h	Node guarding error
FF00h	Device profile error

Table 27: Error register

Error Register (hex)	Meaning
00h	Not an error
01h	Data set error
04h	Supply voltage error
08h	Temperature error
10h	Communication error

Error Register (hex)	Meaning
20h	Device profile
80h	Error with the manufacturer/device hardware

7.4 Using a 2nd position magnet with CANopen®

When using CANopen®, up to 2 position magnets can be used on one linear encoder. It should be noted that the 1st position magnet communicates the process data in PDO1, and the 2nd position magnet transmits the process data in PDO2.

The following communication settings are the default according to CIA:

PDO1: Asynchronous mode (TXPDO-1 transmission type = FFh)

PDO2: Synchronous mode (TXPDO-2 transmission type = 01h)

If the two PDOs are to behave in the same way, the transmission type in objects 1800.2h and 1801.2h must be set to the same value.

E.g., both PDOs communicate within a 10 ms cycle depending on the event timer:

PDO1: Object 1800.2h = FFh and object 1800.5h = 0Ah

PDO2: Object 1801.2h = FFh and object 1801.5h = 0Ah

Saving the configuration: Object 1010.1h = 73 61 76 65h

7.5 Power-up and output signal in the event of a fault

During power-up, the signal output for analog devices is ≥ F.S.O = Full Scale Output. After that the device is ready for use. The signal output is only available to CANopen® devices after the boot-up time.

Table 28: Operational statuses and output signal

Output signal		
Output variant	During the power-up	If an error occurs
4 ... 20 mA	(≥ F.S.O)	> 21 mA
0 ... 10 V		> 10.8 V
CANopen®	Bootup message	Position value = 0xFFFFFFFF and EMCY message

Fault:

a) Missing position magnet
b) Position magnet in zero or damping zone
c) Malfunction or failure of the magnetostrictive element

During the power-up delay (see "Technical data", page 44), the output signal is defined as an unusable signal. The machine controller must take this into consideration in its processing. After the power-up delay, the linear encoder is ready for operation. The output signal behaves as described in the event of a fault.

8 Transport and storage

8.1 Storage

Store the device under the following conditions:

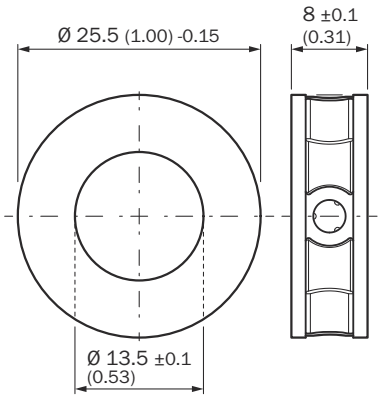
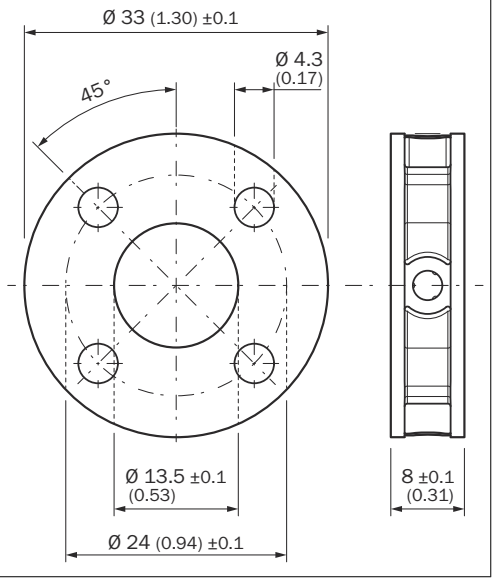
- Recommendation: Use original packaging.
- Do not store outdoors.
- Store in a dry area that is protected from dust.
- To allow any residual dampness to evaporate, do not package in airtight containers.
- Do not expose to any aggressive substances.
- Protect from sunlight.
- Avoid mechanical shocks.
- For storage periods of longer than 3 months, check the general condition of all components and packaging on a regular basis.

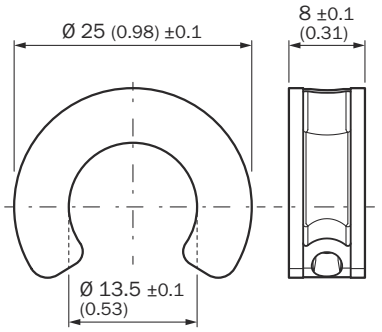
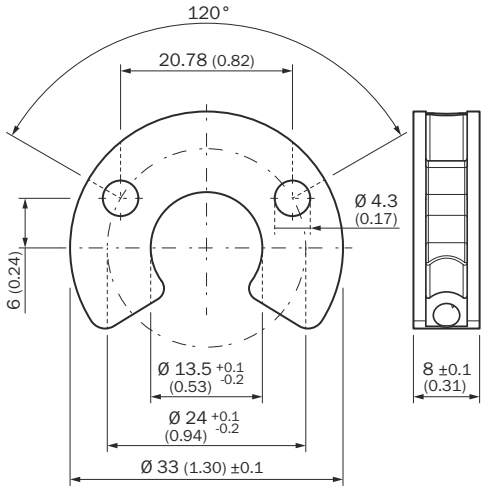
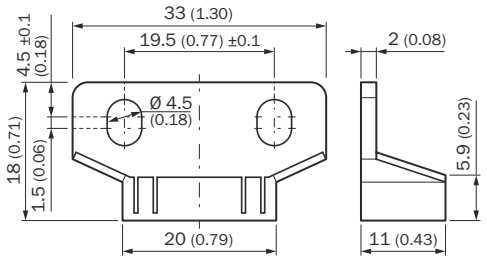
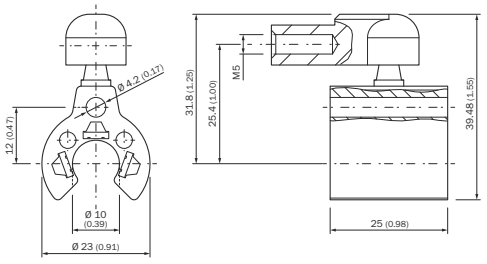
9 Technical data

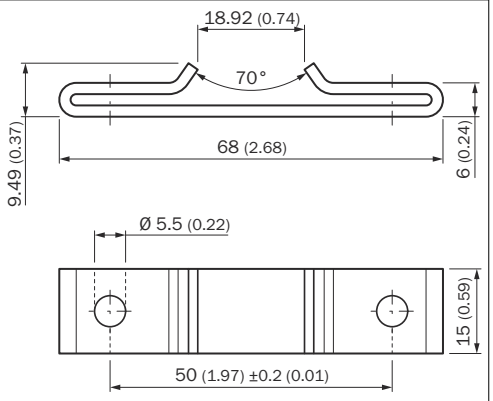
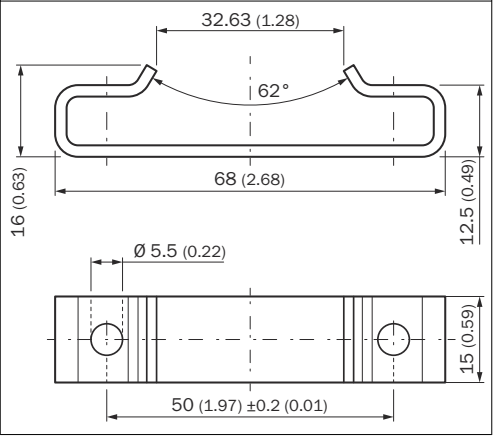
You can obtain the technical data (specification parameters, dimensional drawings, STEP files and information on suitable accessories as well as the current operating instructions for the product at www.sick.com. To do so, enter the product part number in the search field (part number: see the entry in the “P/N” or “Ident. no.” field on the type label).

10 Annex

10.1 Accessories

Type	Designation	Dimensional drawing
Ring magnet	MAG-0-255-xx	
	MAG-0-330-xx	

Type	Designation	Dimensional drawing
C-magnet	MAG-C-250-xx	
	MAG-C-330-xx	
Block magnet	MAG-B-180-xx	
Slide magnet	MAG-S-H29-xx	

Type	Designation	Dimensional drawing
Clamping bracket	BEF-KH-SL1-xx	
	BEF-KH-LP1-xx	

10.2 Conformities and certificates

You can obtain declarations of conformity, certificates, and the current operating instructions for the product at www.sick.com. To do so, enter the product part number in the search field (part number: see the entry in the “P/N” or “Ident. no.” field on the type label).

10.2.1 Compliance with EU directives

EU declaration of conformity (extract)

The undersigned, representing the manufacturer, herewith declares that the product is in conformity with the provisions of the following EU directive(s) (including all applicable amendments), and that the standards and/or technical specifications stated in the EU declaration of conformity have been used as a basis for this.

10.2.2 Compliance with UK statutory instruments

UK declaration of conformity (extract)

The undersigned, representing the following manufacturer herewith declares that this declaration of conformity is issued under the sole responsibility of the manufacturer. The product of this declaration is in conformity with the provisions of the following relevant UK Statutory Instruments (including all applicable amendments), and the respective standards and/or technical specifications have been used as a basis.

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