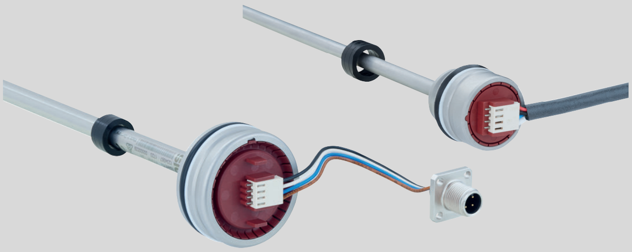
OPERATING INSTRUCTIONS

MAX

Linear encoder

SICK
Sensor Intelligence.



Product described

MAX linear encoder

Manufacturer

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Legal information

Original document

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Contents

1 About this document 6
- 1.1 Purpose of this document 6
- 1.2 Target audience 6
- 1.3 Further information 6
- 1.4 Symbols and document conventions 6
  - 1.4.1 Warning levels and signal words 6
  - 1.4.2 Information symbols 6

2 Safety information 7
- 2.1 General notes 7
- 2.2 Intended use 7
  - 2.2.1 Purpose of the device 7
- 2.3 Responsibility of user 7

3 Product description 9
- 3.1 Device variants 9
- 3.2 Product identification 9
- 3.3 Construction and function 10

4 Mounting 12
- 4.1 Preparation before installing the encoder 12
  - 4.1.1 Installation cavity for the linear encoder 12
  - 4.1.2 Installation cavity for the piston and piston rod 13
  - 4.1.3 Insertion chamfer 14
  - 4.1.4 Bore hole for the retaining screw 14
  - 4.1.5 Bore hole for the electrical connection 15
  - 4.1.6 Installation cavity for the position magnet 17
- 4.2 Installing the position magnet 17
- 4.3 Installing the encoder 18
  - 4.3.1 Positioning the O-ring and support ring 18
  - 4.3.2 Insertion in the cylinder 19
  - 4.3.3 Installation with an M12 connector system 20
  - 4.3.4 Installation with a cable connector and cable gland 21
- 4.4 Install the retaining screw 22
- 4.5 Cylinder handling after encoder installation 22
  - 4.5.1 Washing and drying the cylinder 22
  - 4.5.2 Electrostatic painting of the cylinder 23
  - 4.5.3 Mounting the cylinder on mobile hydraulic machines 23
  - 4.5.4 Electrical and electrostatic interference 23

5 Electrical installation 25
- 5.1 Electrical connection 25
  - 5.1.1 Connection diagram, pin assignment for 4-pin M12 male connector 25

5.1.2 Cable connection diagram.......... 25
5.1.3 Connection diagram, pin assignment for 5-pin M12 male connector.......... 25
5.1.4 Connection sequence.......... 26
5.2 Connection diagram for vehicle electronics.......... 26

6 Commissioning.......... 27
6.1 Putting the encoder into operation.......... 27
6.2 Select a suitable fuse.......... 27
6.3 Set up the filter wiring - analog.......... 27
6.4 Power-up and output signal in the event of a fault.......... 27
6.5 Bus termination - digital.......... 28
6.6 Tolerance considerations for the set point.......... 28
6.7 CAN bus protocols.......... 29
6.8 Communication objects.......... 30
6.8.1 CANopen.......... 30
6.8.2 SAE J1939.......... 31
6.9 Configuration and system startup.......... 31
6.9.1 Configuring CANopen.......... 31
6.9.2 Configuring SAE J1939.......... 33
6.9.3 System startup for CANopen.......... 34
6.9.4 System startup for SAE J1939.......... 34
6.9.5 Setting CANopen operating parameters.......... 34
6.9.6 Setting SAE J1939 operating parameters.......... 36
6.9.7 CANopen encoder data during operation.......... 36
6.9.8 SAE J1939 encoder data during operation.......... 36
6.9.9 CANopen error messages.......... 36
6.9.10 SAE J1939 error messages.......... 37

7 Maintenance.......... 38
7.1 Error table.......... 38
7.2 Checking the functioning of the encoder.......... 38
7.3 Repairs.......... 39
7.4 Testing and programming.......... 40

8 Transport and storage.......... 41
8.1 Transport and storage conditions.......... 41

9 Decommissioning.......... 42
9.1 Dismantling.......... 42
9.2 Disposal.......... 42

10 Technical data.......... 43
10.1 MAX Analog/PWM.......... 43
10.2 MAX Digital CANopen / SAE J1939.......... 46
10.3 Encoder dimensions.......... 48
10.4 Position magnet dimensions.......... 49

10.5 M12 flange dimensions........ 50

11 Annex........ 51

11.1 Accessories........ 51
11.2 Spare parts........ 53
11.3 CE Declaration of Conformity........ 55

1 About this document

1.1 Purpose of this document

In the following instructions, the MAX linear encoder 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 audience

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

- MAX quickstart
- Technical information - interface description

MAX product pages

- www.sick.com/MAX48
- www.sick.com/MAX30

1.4 Symbols and document conventions

1.4.1 Warning levels and signal words

Important

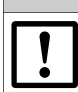
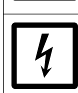
Hazard which could result in property damage.

Note

Tips

1.4.2 Information symbols

Table 1: Information symbols

Icon	Meaning
	Important technical information for this product
	Important information about electrical or electronic functions

2 Safety information

2.1 General notes

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 shutdown 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 conditions 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 MAX linear encoder is designed for position measurements in mobile hydraulic applications and therefore can be used to control the hydraulic components of construction machinery; e.g., in hydraulic cylinders. The rugged housing offers optimum protection against dust, climatic influences, vibrations, surrounding media, as well as electrical and magnetic fields.

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

2.3 Responsibility of user

Designated users

see "Target audience", page 6.

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, please contact SICK Customer Service.

Special local conditions

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

Read the operating instructions

- ▶ Read and follow the operating instructions in this document
- ▶ Follow all safety notes
- ▶ If there is anything you do not understand, please contact SICK Customer Service

Retention of documents

These operating instructions:

- Must be made available for reference.
- Must be conveyed to new owners.

3 Product description

3.1 Device variants

The device is available in the following variants:

- M12 male connector (4-pin or 5-pin) or 3-wire PUR cable

Output signals

- Analog (current, voltage)
- PWM
- Digital (CANopen, SAE J1939)

3.2 Product identification

Type code

Table 2: Type code (example)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
M	T	X	4	8	N	-	1	1	R	1	0	T	T				

Table 3: Type code Explanation

Position	Meaning	Description
1	Series	M = Mobile
2	Technology	A = Magnetostrictive
3	Installation type	X = Integrated (hydraulic cylinder)
4	Size	48 = MAX48 diameter 30 = MAX30 diameter
5		
6	Version	N = Non-Safety
7	Place holder	-
8	Diameter Pressure pipe	1 = 10 mm / 30 mm damping 2 = 10 mm / 36 mm damping 3 = 10 mm / 63 mm damping 7 = 7 mm / 30 mm damping 8 = 7 mm / 36 mm damping 9 = 7 mm / 63 mm damping
9	Voltage supply	1 = 12 VDC 2 = 24 VDC
10	Electrical Interface	V = Voltage A = Current C = Digital CANopen (250 kbit) J = Digital SAE J1939 (250 kbit) P = pulse-width modulation, 5 V signal
11	Signal output	10 = current (4 ... 20 mA) 10 = voltage (0.50 ... 4.50 V) 21 = voltage (4.75 ... 0.25 V) 7F = CANopen (node ID 7F Hex) JD = SAE J1939 (source address JD Hex) B = pulse width (10 ... 90%) D = frequency (250 Hz)
12		

Position	Meaning	Description
13	Connection type	A = M12 4-pin analog / PWM (1 = VDC; 2 = n.c.; 3 = GND; 4 = SIG) B = M12 4-pin analog / PWM (1 = VDC; 2 = SIG; 3 = GND; 4 = n.c.) M= M12 4-pin analog (1 = n.c.; 2 = VDC; 3 = GND; 4 = SIG) K = analog cable connection / PWM 3-wire cable C = M12 5-pin digital (1 = n.c.; 2 = VDC; 3 = GND; 4 = CAN_HI; 5 = CAN_LO) D = M12 5-pin digital (1 = VDC; 2 = n.c.; 3 = GND; 4 = CAN_HI; 5 = CAN_LO)
14	Connector length	A = 60 mm M12 E = 100 mm M12
15	Measuring range Position measurement in 1 mm steps	e.g., 0300 = 50 ... 300 mm
16		
17		
18		

3.3 Construction and function

Construction of the device

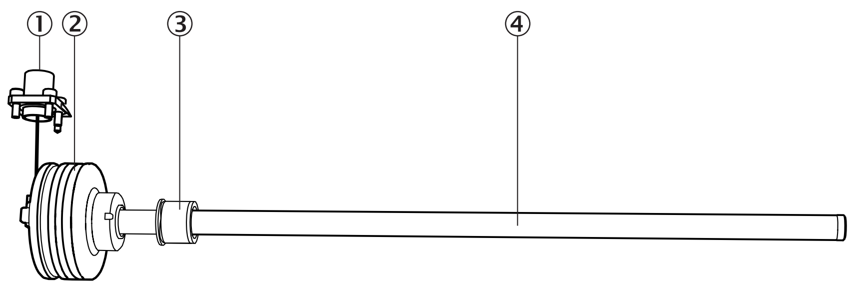


Figure 1: MAX design

① M12 connector system

② Protective housing (electronics)

③ Position magnet

④ Pressure pipe

Connector system:
The M12 connector system requires very little time to attach. It is suitable for applications in harsh environments up to IP69K (when using a suitable mating connector).

Protective housing (electronics):
The housing is designed to be installed in a hydraulic cylinder and protects the electronics against external influences.

Position magnet:
The position magnet is the only moving component in the measuring device when installed in the piston. The position magnet is located inside the piston and moves over the pressure pipe without contacting it. The magnet field that is produced during this process defines the current position of the piston.

Pressure pipe:
The pressure pipe is a pressure-resistant structure that is immersed into the cylinder piston rod. It contains the hermetically protected magnetostrictive sensing element.

Principle of operation

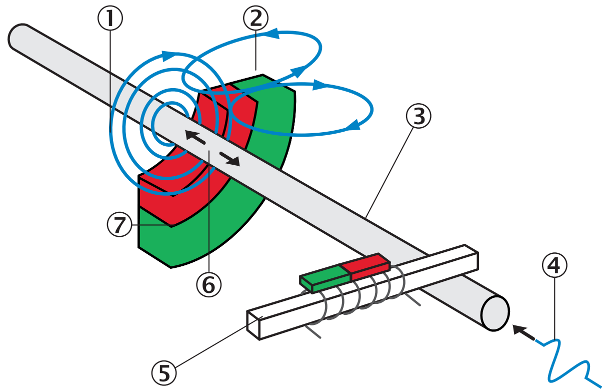


Figure 2: Schematic of the magnetostrictive measurement principle

①	Magnet field of the current pulse
②	Magnet field of the position magnet
③	Magnetostrictive sensor component
④	Current pulse
⑤	Sound wave converter
⑥	Structure-borne sound wave
⑦	Position magnet

The device operates on the magnetostrictive measurement principle that records the actual path of a position magnet:

The radial magnet field (1) generated by the current pulse (4) interacts with the magnet field (2) of the position magnet (7).

As a result of the interaction of the two magnet fields, a wave (ultrasonic) (6) is produced in the magnetostrictive device component (3). This travels to the converter (5), and the electronics produce an electrical output signal.

The time interval between the current pulse and the detection of the structure-borne sound wave is measured, thereby enabling the precise position of the magnet – which changes as the cylinder moves – to be determined. As this measurement principle does not require a reference point, no recalibration is necessary for this type of device.

The device is also maintenance-free as a result of the non-contact measurement.

4 Mounting

4.1 Preparation before installing the encoder

4.1.1 Installation cavity for the linear encoder

The method of installation depends on the cylinder design. Generally, the sensor is installed from the piston rod side. It is also possible to install the sensor from the head side of the cylinder.

The encoder dimensions are listed in the technical specifications: see "Encoder dimensions", page 48.

Fit dimensions and tolerances

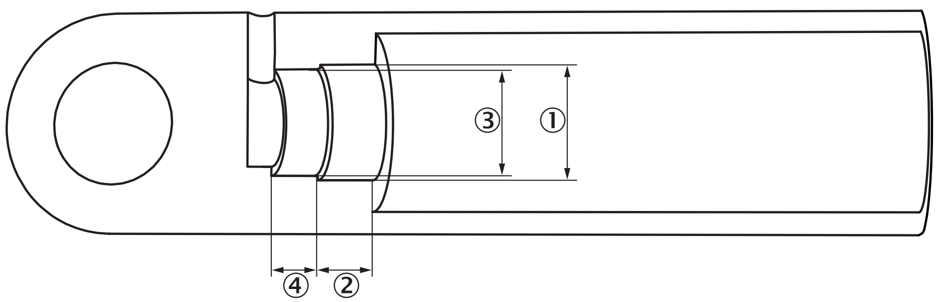


Figure 3: Encoder installation cavity dimensions

① Diameter for housing bore hole
② Depth for housing bore hole
③ Installation cavity diameter for electrical connection
④ Installation cavity depth for electrical connection

▶ Prepare an installation cavity for the encoder according to the following dimensions.

Table 4: Installation cavity for the housing and electrical connection

Type	Installation cavity for housing		Installation cavity for electrical connection	
	① Ø	② Depth [D]	③ Ø min. ... Ø max.	④ Depth [d]
MAX48	48H8	21.2 mm + 0.2	d > 32.5 mm d < 40 mm	≥ 10 mm
MAX30	31H8	22.7 mm +0.2	d > 26 mm d < 28 mm	≥ 10 mm

Mean roughness value of the surface: Ra < 0.8 mm.

4.1.2 Installation cavity for the piston and piston rod

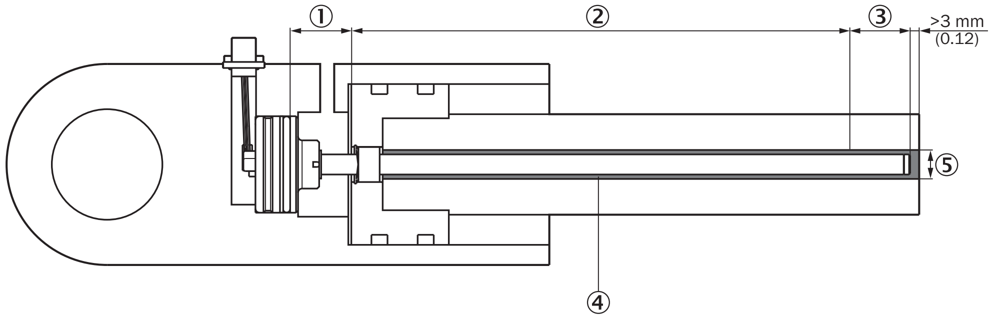


Figure 4: Encoder installed in the hydraulic cylinder – MAX48

① Null zone
② Measuring range
③ Damping
④ Diameter of the pressure pipe
⑤ Diameter of the piston rod bore hole

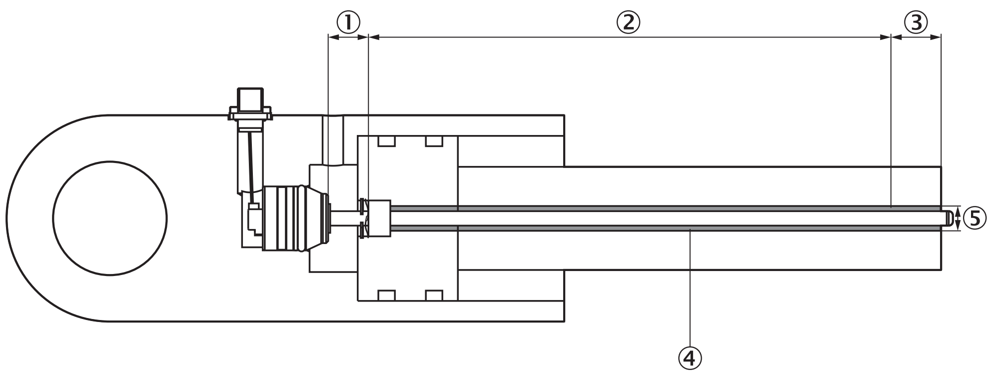


Figure 5: Encoder installed in the hydraulic cylinder – MAX30

① Null zone
② Measuring range
③ Damping
④ Diameter of the pressure pipe
⑤ Diameter of the piston rod bore hole

Table 5: Bore hole depth for the piston rod

① = Null zone	MAX48: 30 mm MAX30: 19.5 mm
② = Measuring range	as per the applicable data sheet and selected device variant
③ = Damping	

NOTE
The total bore hole depth comprises the measuring range (2), the damping (3), and an addition distance of 3 mm to the pressure pipe.

- ▶ Prepare an installation cavity for the piston rod in accordance with the following dimensions.

Table 6: Bore hole diameter for the piston rod

④ **Ø Pressure pipe**	⑤ **Ø Bore hole in the piston rod**
Ø 7 mm	Ø 10 mm
Ø 10 mm	Ø 12 mm / 13 mm

NOTICE
Ensure a consistent bore hole diameter of at least 12 mm.

Take into consideration the design and loading of the piston rod.

4.1.3 Insertion chamfer

To ensure proper and secure installation of the device in the cylinder, a insertion chamfer must be provided.

NOTICE
Risk of damage to the device during installation

The device can be damaged by any sharp edges present at the transition from the cylinder bore hole to the insertion chamfer on the O-ring.

- ▶ Prepare an insertion chamfer with a radius of 0.6 mm at the end of the cylinder bore hole.

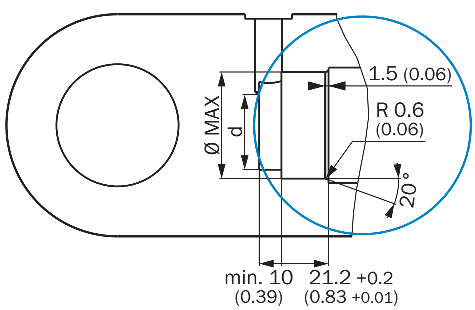


Figure 6: Insertion chamfer

4.1.4 Bore hole for the retaining screw

- ▶ Prepare a bore hole for the retaining screw in accordance with the following dimensions.

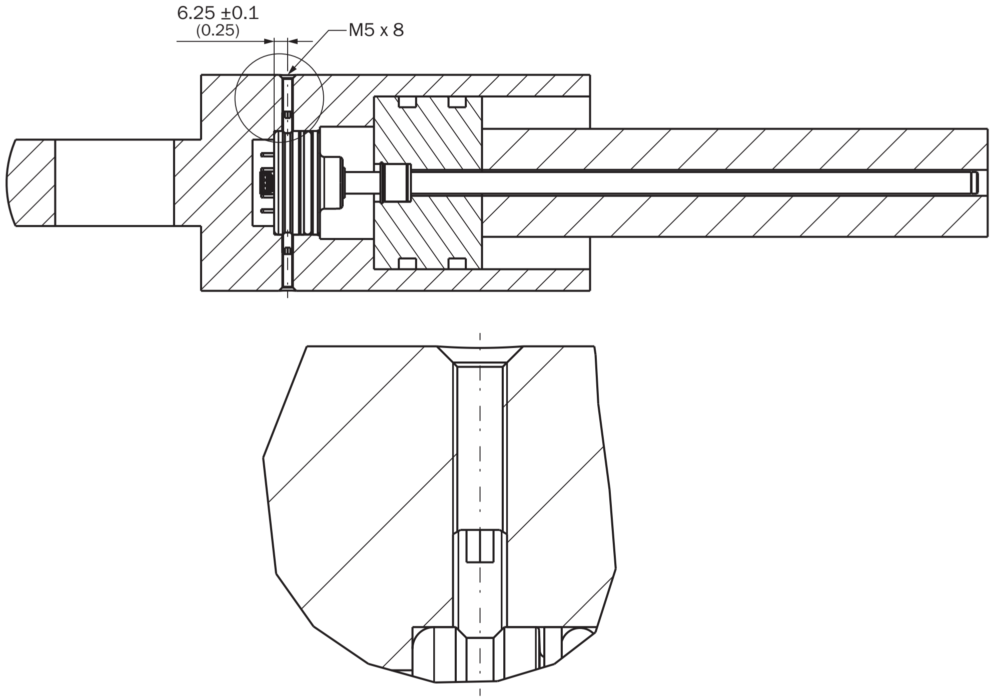


Figure 7: Installation cavity for the retaining screw

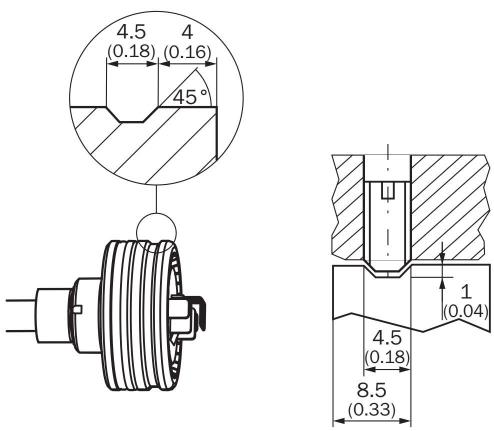


Figure 8: Retaining screw on the encoder housing

Permissible tightening torque for fastening screw: 0.5 Nm ... 1.0 Nm (taking into account the maximum force on the housing surface).

4.1.5 Bore hole for the electrical connection

M12 flange

▶ Prepare an installation cavity for the connector system and flange plate in accordance with the following dimensions.

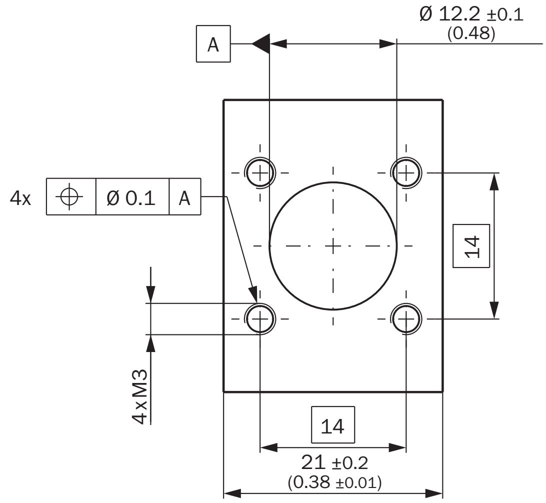


Figure 9: Dimensions of the flange plate bore holes

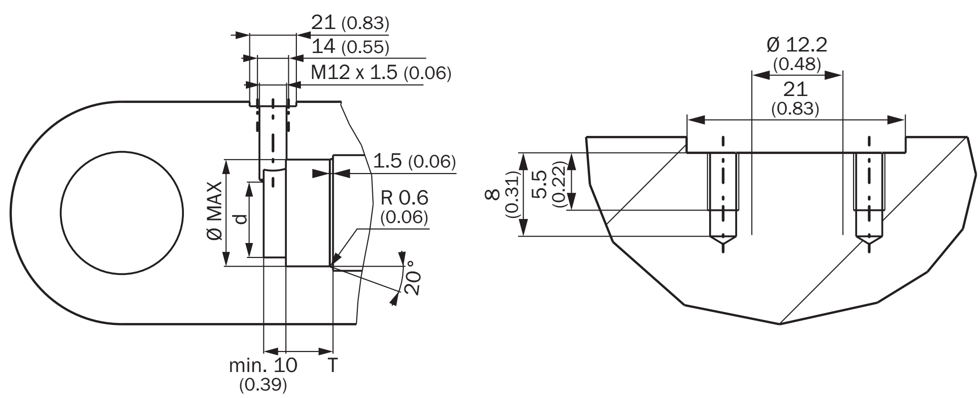


Figure 10: Dimensions of the connector system bore hole

Cable gland

▶ Prepare an installation cavity for the cable gland according to the following dimensions.

NOTICE

▶ Prepare a counterbore to suit the cable gland, see figure 40, page 52.

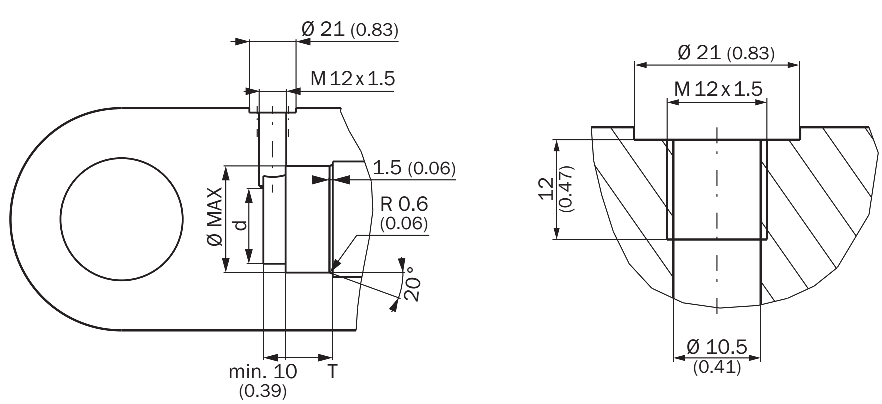


Figure 11: Dimensions of the cable gland bore hole

4.1.6 Installation cavity for the position magnet

▶ Prepare an installation cavity for the position magnet in accordance with the following dimensions.

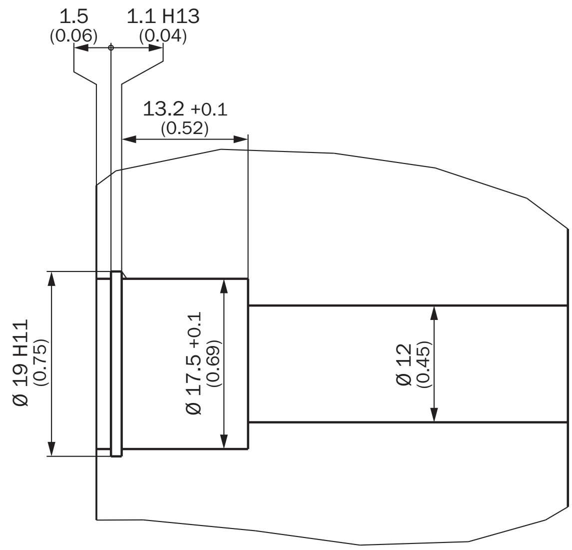


Figure 12: Dimensions of the position magnet installation cavity

4.2 Installing the position magnet

Table 7: Position magnet installation dimensions

① Corrugated spring washer	see figure 37, page 51
② Position magnet	17.4 x 12.0 x 10.6 mm
③ Circlip	DIN 472 - 18x1, alternatively see figure 39, page 52
Diameter of the position magnet bore hole	17.5 + 0.1 mm
Depth of the position magnet bore hole	13.2 + 0.1 mm

Sequence of work steps:

NOTICE

▶ Ensure that the retaining ring and the wave spring are made from **non**-magnetic material (non-ferritic steel).

▶ Ensure that the position magnet and the retaining ring do **not** rub against the pressure pipe.

- Smalley retaining ring (see figure 39, page 52): does not contain any internal edges or eyes for the pressure pipe.

▶ Observe the operating pressures: see "Technical data", page 43.

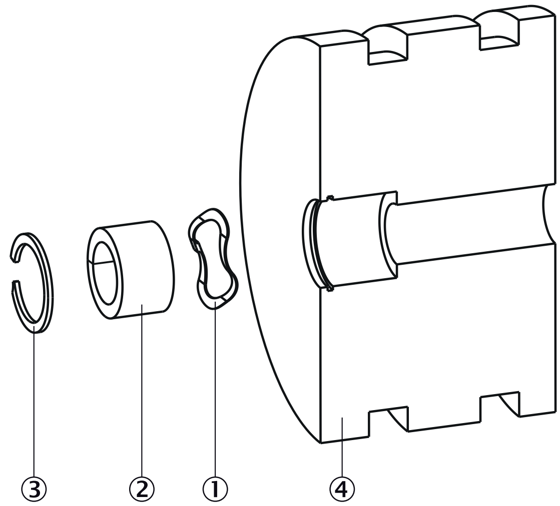


Figure 13: Installation of the position magnet

① Corrugated spring washer
② Position magnet
③ Circlip
④ Piston

1. Prepare the piston for installation of the magnet: see "Installation cavity for the position magnet", page 17.
2. Mount the corrugated spring washer.
3. Mount the position magnet.
4. Mount the retaining ring.

4.3 Installing the encoder

4.3.1 Positioning the O-ring and support ring

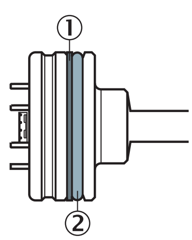


Figure 14: O-ring and support ring

① Support ring
② O-ring

The O-ring and support ring are pre-installed as shown in the figure and prevent oil from penetrating into the connector area.

4.3.2 Insertion in the cylinder

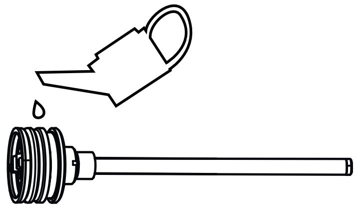


Figure 15: Encoder lubrication points

1. Lubricate the O-ring, support ring and pressure pipe.

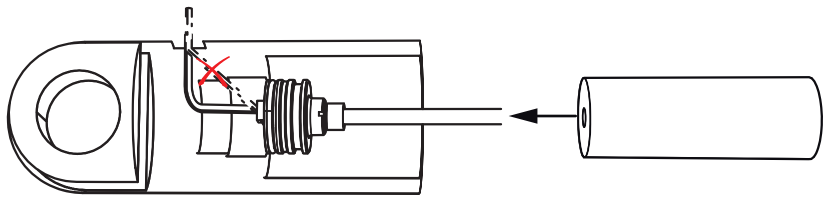


Figure 16: Tensile load at edges

NOTICE
Risk of damage to the connecting cables during installation.

Tensile loads and sharp edges can damage the stranded wires and connecting cables of the connector system.

▶ Avoid tensile loads and look out for sharp edges when installing the connector system.

2. Carefully insert the encoder into the cylinder.
3. Guide the connecting cable carefully through the cylinder wall (bore hole).
4. Depending on the device variant, following the relevant steps below:
   - M12 male connector system: see "Installation with an M12 connector system", page 20.
   - Cable connector/cable gland: see "Installation with a cable connector and cable gland", page 21.
5. Use a specially prepared sleeve (e.g., made from polyamide) to locate the device in its final position.
6. Carefully tap in the sleeve using a mallet.

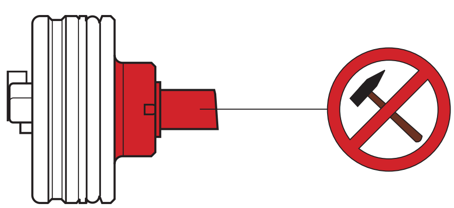


Figure 17: Profile side – MAX48

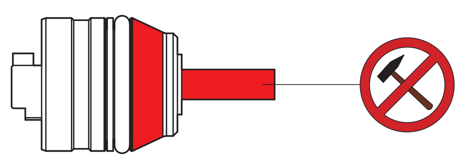


Figure 18: Profile side – MAX30

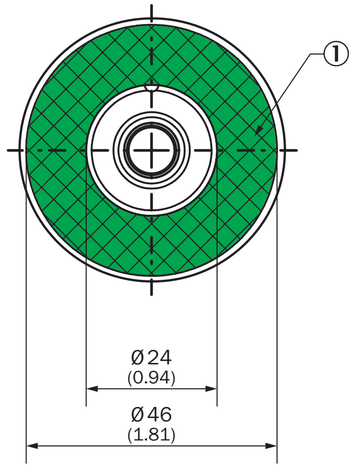


Figure 19: Face side – MAX48

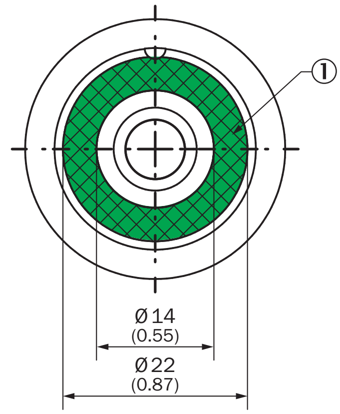


Figure 20: Face side – MAX30

① Mounting surface

NOTICE
Risk of damage to the device during installation.
Forces acting on the load-bearing features of the housing can damage the device.

▶ Do not apply any load on the pressure pipe or behind the head of the device when mounting the sensor.

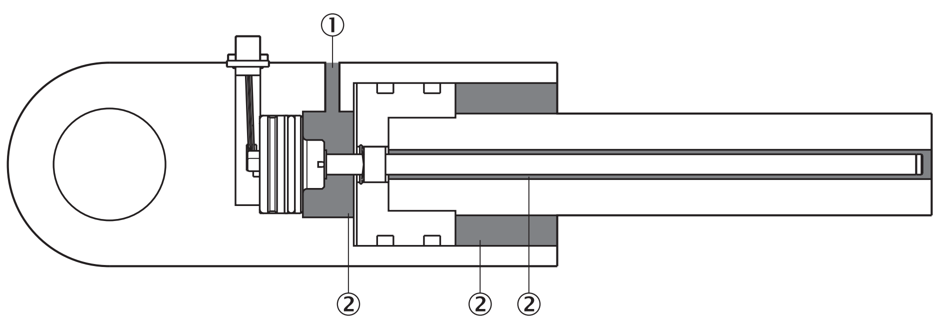


Figure 21: Areas requiring lubrication

① Oil inlet
② Areas requiring lubrication

7. Lubricate the indicated areas via the oil inlet.

4.3.3 Installation with an M12 connector system

The M12 connector system has an enclosure rating of IP69K and is pre-assembled ready for installation.

NOTE
When selecting the mating connector, ensure that it also has an enclosure rating of IP69K.

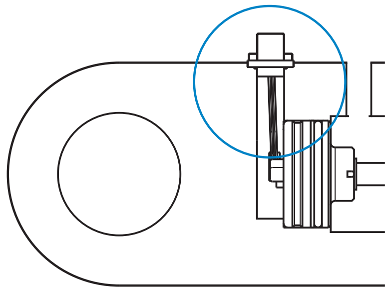


Figure 22: M12 connector system

1. Mount and engage the contact carrier in the flange plate.

NOTICE

▶ When mounting the contact carrier in the flange, ensure the lug of the contact carrier is aligned correctly.

2. Press the flange plate into the bore in the cylinder wall.
3. Fasten the flange plate using suitable screws or rivets.
4. Proceed to the next step, see step 5, page 19.

Recommended screws for mounting the M12 flange

The screws should be selected so that no collision with the coupling nuts of the connected mating connectors can occur, e.g.,:

- M3 socket head cap screw with flat head
- DIN 912 hexagon socket head cap screw
- ISO 14580 Torx screw
- DIN 84 slotted-head screw
- Comparable Phillips head screws or self-tapping screws

A soluble screw locking adhesive should be used when installing the screws.

Alternatively, the flange plate can be fastened using DIN 6660 button-head rivets.

4.3.4 Installation with a cable connector and cable gland

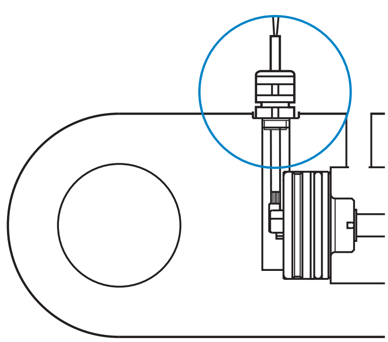


Figure 23: Encoder installed in the hydraulic cylinder with cable connector and cable gland

1. Guide the cable through the cable gland.
2. Mount the cable gland in the threaded bore.
3. Secure the tapered seal and coupling nut.
4. Proceed to the next step, see step 5, page 19.

Recommendations regarding the cable gland

For devices with a cable connection, a protection class rated (preferably IP68) metallic cable gland should be used for sealing and strain relief. The cable glands should also be protected against damage by surrounding them with metal profiles (e.g. U-steel). A suitable cable gland is available as an accessory, see figure 40, page 52.

Recommendations regarding connectors for devices with a cable connector

When installing connector plugs on devices with a cable connector, please consider the following:

- Enclosure rating: (preferably IP68)
- Connector housing:
  Metal or impact-resistant plastic (check media resistance)
- Protect against external influences: enclose the cable sheath and male connector
- Prevent fluid ingress: the cable sheath should ideally be coated with sealing compound at offset locations
- Polarity: ensure correct polarity
- Male connector with screw terminals:
  Apply ferrules and clamp all strands in the ferrule
- Soldered connections: no projecting strands or “cold joints”
- Crimp contacts: use a suitable tool to produce a gas tight crimp
- ESD protection: protect workplaces and persons from electrostatic discharge
- Prevent fluid ingress:
  Use suitable caps to seal the male connector after installation
- Screwed cable glands: protect by enclosing within steel profiles

4.4 Install the retaining screw

The retaining screw prevents the housing from moving in the axial direction. A DIN 913 M5x10 threaded pin with tapered head should be used for this purpose. Use a soluble screw locking adhesive when installing the threaded pin.

! **NOTICE**
Risk of damage to the device during installation.
The screw must only rest in the slot and not be tightened too hard.

▶ Tighten the screws with a torque of 0.5 Nm ... 1.0 Nm.

4.5 Cylinder handling after encoder installation

4.5.1 Washing and drying the cylinder

To protect the connecting cable and male device connector from ingress of cleaning agents, please observe the following:

Encoder with M12 connector system

- Drying temperature: max. 90 °C
- Pressure of the cleaning fluid: ≤ 5 bar
- Protective cap: use the supplied plastic protective cap
- In case of higher pressures: use a metallic protector
- Protection class: IP69K

Preventing ingress of cleaning agents into the electronics when washing cylinders with an already installed M12 male connector.

To protect cylinders with an installed linear encoder against water ingress during washing, a brass cap can be screwed onto the M12 male connector. Contact SICK for the relevant information.

Encoder with cable connector / installed male device connector

- Cable connectors/male device connector: protect against ingress of cleaning agents using suitable sheathing
- Screwed cable glands: protect against ingress of moisture

4.5.2 Electrostatic painting of the cylinder

The electrostatic painting process uses very high voltages (up to 100 kV) which can damage the electronics of the encoder integrated into the cylinder. To avoid damage, observe the following when painting the cylinder:

- To avoid electrical isolation of the piston rod and the cylinder/sensor housing, do not the suspend the cylinder by the piston rod
- Clean off all lacquer and other residues from the hanging devices in the paint shop, all connectors used to short-circuit the connecting wires, and all connections to the paint shop earth

Painting of cylinders with an installed encoder and M12 connector system or male device connector

To protect the sensor electronics, use metal protective caps that meet the following requirements:

- The cap must not be made from aluminum
- The cap must be made from a permanently electrically-conductive material
- The cap must have an M12x1 thread
- The cap must be screwed on until it contacts the flange plate on the connector as desired
- Always use a torque of ≥ 5 Nm when tightening the cap
- Make sure no paint particles get onto the thread or pin contacts

Any paint particles on the outside of the cap will not impair the sensor.

A suitable cap can be purchased from the manufacturer as an accessory.

Painting of cylinders with an installed encoder and cable connector or third-party connector

Cylinders with an installed encoder and cable connector cannot be electrostatically painted because the cable connector is not protected against over voltages. Reliable electrostatic painting is only possible when using a combination of M12 connector system and protective cap.

4.5.3 Mounting the cylinder on mobile hydraulic machines

When mounting the cylinder on mobile hydraulic machines, ensure no male connectors, cables or cable ends can be damaged in the process.

4.5.4 Electrical and electrostatic interference

Insulation tests

When performing insulation tests on mobile hydraulic machines, disconnect all encoder connection cables to avoid damage from high voltages.

Welding

Welding currents may be produced when carrying out welding work on nearby components. Welding currents can damage the pressure pipe or the electronics.

The following must also be observed when welding:

- Disconnect all electrical connections during welding
- Never fasten the grounding point to the piston rod or cylinder pipe
- Never perform welding work directly on the cylinder
- Never perform welding work near a cylinder with an encoder installed in it
- Welding currents and similar effects can also arise at any bearing location on the machine

5 Electrical installation

5.1 Electrical connection

The encoder is equipped with an M12 connector system.

A variant with a cable connection is also available. Male device connectors must be used in this case.

Enclosure ratings

To guarantee an IP69K enclosure rating (M12 connector system), a suitable mating connector must be used.

5.1.1 Connection diagram, pin assignment for 4-pin M12 male connector

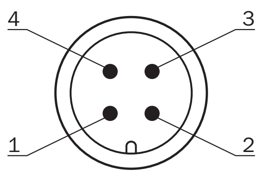


Figure 24: Pin assignment for 4-pin M12 connector

Pin assignment as per position 13 of the type code.

Table 8: Pin assignment for 4-pin M12 connector

Type code	A	B	M
12/24 VDC	1	1	2
GND (0 V)	3	3	3
Signal	4	2	4
n.c.	2	4	1

5.1.2 Cable connection diagram

Connection scheme as per position 13 (= “K”) of the type code.

Table 9: Allocation of wire colors (voltage)

12/24 VDC	BR (brown)
GND (0 V)	BL (blue)
Voltage signal	BK (black)

Table 10: Allocation of wire colors (current)

12/24 VDC	BR (brown)
GND (0 V)	BL (blue)
Current signal	WH (white)

5.1.3 Connection diagram, pin assignment for 5-pin M12 male connector

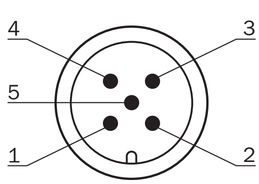


Figure 25: Pin assignment for 5-pin M12 connector

Pin assignment as per position 13 of the type code.

Table 11: Pin assignment for 5-pin M12 connector

Type code	C	D
12/24 VDC	2	1
GND (0 V)	3	3
CAN_HI	4	4
CAN_LO	5	5
n.c.	1	2

5.1.4 Connection sequence

Connect the wires in the following sequence:

1. Connect the 12/24 VDC voltage supply.
2. Connect the GND (0 V).
3. Connect the signal.

5.2 Connection diagram for vehicle electronics

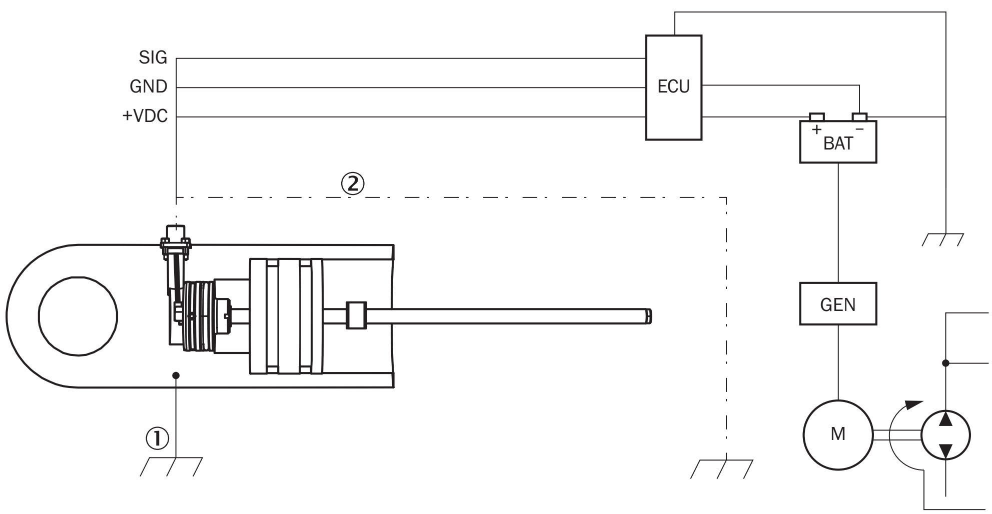


Figure 26: Connection diagram

① Chassis GND

② Cable shielding (optional)

To guarantee fault-free operation of the device, the cylinder must be connected to machine ground (Chassis GND).

The physical contact with another machine component equalizes the potential of the cylinder. If the cylinder is mounted in an insulated manner, a separate grounding must be provided, e.g., by connecting a ground strap directly to the cylinder.

Cable shielding

The encoder is adequately shielded by the cylinder when installed, and therefore has not been provided with its own shielding. If a shielded cable is used, it is necessary to check, depending on the application, whether one side or both sides of the shield should be connected to machine ground. Any high voltage or high frequency fields in the vicinity can influence the shielding and the signal in the cable.

6 Commissioning

6.1 Putting the encoder into operation

1. Check that the connectors have been connected correctly: see "Connection diagram, pin assignment for 4-pin M12 male connector", page 25.
2. Select a suitable fuse: see "Select a suitable fuse", page 27.
3. Set up the filter wiring: see "Set up the filter wiring - analog", page 27.
4. Put the device into operation.
5. Check the functioning of the encoder: see "Checking the functioning of the encoder", page 38.

6.2 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.

Table 12: Inrush current when switching the device on

Inrush current for an supply voltage of 12 VDC	2.5 A / 50 µsec typical
Inrush current for an supply voltage of 24 VDC	5.0 A / 50 µsec typical

6.3 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 (see "Technical data", page 43) and other sources of interference, e.g., electromagnetic interference, can also affect the quality of the analog output signal. To reduce the noise when acquiring analog measurement data, it is essential to use a filter.

A suitable filter, for example, is a combination of R1 = 50 Ω and C1 = 100 nF to 1 µF. This will keep the signal delay time within the cycle time (internal measurement frequency) while not changing the dynamic behavior significantly.

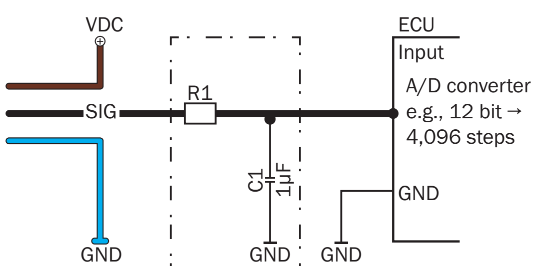


Figure 27: Filter wiring

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

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

When switching on the device, the signal output is ≥ F.S.O = Full Scale Output. After that the device is ready for use.

Table 13: Operational statuses and output signal

Output signal		
F.S.O	during power-up	in the event of a fault
4.00 ... 20.00 mA	Unusable signal	> 21.0 mA
0.50 ... 4.50 V		> 5.1 V
0.25 ... 4.50 V		> 5.1 V
0.50 ... 9.50 V		> 10.0 V
PWM (duty cycle)		≥ 99%
Digital: CANopen / SAE J1939	Boot message	Error message “FFFF”

Fault:

a) Position magnet missing
b) Position magnet in null or cushion zone
c) Malfunction or failure of the magnetostrictive element

During power-up (see "Technical data", page 43), the output signal is defined as an unusable signal. The machine controller must take this into consideration in its processing. After power-up, the linear encoder is ready for operation. The output signal behaves as described in the event of a fault.

6.5 Bus termination - digital

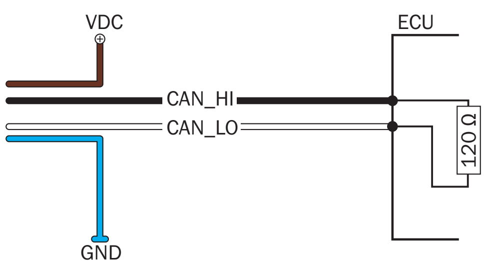


Figure 28: Bus termination

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.

6.6 Tolerance considerations for the set point

The set points (zero/end point) of the device are adjusted by the manufacturer to a tolerance of ± 1 mm.

NOTICE
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 14: Tolerances when operating the device without teach-in

Example for a measuring range of 400 mm				
	Analog VDC	Analog mA	PWM (duty cycle)	CANopen SAE J1939

Example for a measuring range of 400 mm				
Signal	0.5 … 4.5 V	4 … 20 mA	10 … 90%	PDO
Range	4000 mV	16 mA	80%	4,000 digits
Zero/end point ± 1.0 mm	± 10 mV	± 0.04 mA	± 0.2%	± 10 digits
Position magnet ± 1.0 mm	± 10 mV	± 0.04 mA	± 0.2%	± 10 digits
Mechanical assembly ± 0.5 mm	± 5 mV	± 0.02 mA	± 0.1%	± 5 digits
Total of all tolerances ± 2.5 mm	± 25 mV	± 0.10 mA	± 0.5%	± 25 digits

Table 15: Zero end point

Example for a measuring range of 400 mm				
Output	Analog VDC	Analog mA	PWM (duty cycle)	CANopen SAE J1939
Signal	0.5 … 4.50 V	4 … 20 mA	10 … 90%	PDO value
Zero point	± 25 mV	± 0.10 mA	± 0.5%	± 25 digits
min. zero point	0.475 V	3.90 mA	9.5%	275 digits
max. zero point	0.525 V	4.10 mA	10.5%	325 digits
End point (F.S.)	± 25 mV	± 0.10 mA	± 0.5%	± 25 digits
min. end point	4.475 V	19.90 mA	89.5%	3,975 digits
max. end point	4.525 V	20.10 mA	90.5%	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 16: Deviation from the limit values

Typical values			
	Cylinder stroke (mm)		
	200 mm	400 mm	800 mm
Output signal	Tolerances		
Analog VDC	± 25 mV	± 25 mV	± 15 mV
Analog mA	± 0.20 mA	± 0.10 mA	± 0.05 mA
PWM (10 … 90% duty cycle)	± 1.0%	± 0.5%	± 0.25%
CANopen / SAE J1939	± 25 digits	± 25 digits	± 25 digits

6.7 CAN bus protocols

CAN bus is a machine level, open field bus for serial data transmission between a central controller (master) and decentralized field devices (slaves). Various protocols can be used for the data transmission depending on the application. The device can be ordered with either CANopen or SAE J1939 protocol support. Each protocol is configured differently, which affects how the device is integrated into the network, and the operating characteristics of the device.

CANopen

The CANopen version of the device is suitable for operation as a slave in CAN bus networks using the CiA Standard DS 301 V3.0 data protocol. This protocol corresponds to the DS 406 V3.1 encoder profile. The device is connected directly to the bus as a node of the bus system. The device distinguishes between four different operating modes initiated by the controller. These modes are defined in the CANopen standard:

- Initialization: The device performs a hardware initialization and loads the most recently saved standard configuration.
- Pre-operational: The device can be configured via the CAN bus.
- Operational: The device sends its measurement data via the CAN bus.
- Stopped: The device stops transmitting data and waits for further commands.

SAE J1939

SAE J1939 is a multi-master protocol developed especially for applications in the mobile field, i.e. for commercial and conveyor vehicles, as well as for construction, agricultural and forestry machines. An SAE J1939 network consists of various ECUs (Electronic Control Units). An ECU can address messages to multiple CAs (Controller Applications). After commissioning, the bus subscribers are automatically assigned addresses. The CAN bus subscribers are now fully operable.

6.8 Communication objects

6.8.1 CANopen

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

- SDO (Service Data Object):
  SDOs are used to set or 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 slave, and in response the slave 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.

According to the CANopen protocol, each message has the following structure:

Table 17: Message in CANopen

SOF	Arbitration		Control	Data Field	CRC	ACK			EOF	Interframe Space
1	11	1	6	0..8 bytes	15	1	1	1	7	≥ 3

6.8.2 SAE J1939

SAE J1939 features an extended message arbitration and a 29-bit extended message identifier. This extension features a different message prioritization and assignment of bus subscribers. For large quantities of data, it is possible to utilize a separate transport protocol. The communication objects for SAE J1939 are:

- PDU (Protocol Data Unit):
  There are two types of PDUs. PDU1 is used for peer-to-peer data transmission, PDU2 is addressed to all bus subscribers.
- PG (Parameter Groups):
  PG refers to the grouping of process data and parameters for transmission in a message. This parameter group data structure ensures efficient bus loading.
- PGN (Parameter Group Number):
  The PGN is a unique and standardized identifier of the parameter group.
- SPN (Suspect Parameter Number):
  The SPN uniquely identifies a parameter signal and is prescribed by the protocol. This ensures that every SAE J1939 compatible device knows the parameter structure.
- TP (Transport Protocol):
  TP is used for separate data transmission above 8 bytes.

According to the SAE J1939 protocol, each message has the following structure:

Table 18: CAN bus data protocol with J1939 identifier

PDU												
SOF	Arbitration Identifier					Control	Data Field	CRC	ACK			EOF
1	Priority 3	2	PDU Format 8	PDU Specific 8	Source 8	6	0..8 bytes	15	1	1	1	7

6.9 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 accompanying programming instructions for details of all the available commands for configuring the device.

6.9.1 Configuring CANopen

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 19: LSS address

	CANopen
Vendor-ID	0x1000056
Product code	as per product key
Revision number	as per product 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

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

Every device or node 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 must be in the range of 1 - 127, and can be preset when ordering. 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 20: Setting the node ID

Data source	COB-ID	Data	Destination
Controller	0x7e5	04; 01; 00; 00; 00; 00; 00; 00	Sensor
Controller	0x7e5	11; 7d*; 00; 00; 00; 00; 00; 00	Sensor
Sensor	0x7e4	11; 00; 00; 00; 00; 00; 00; 00	Controller

* Node address values can be between 1 and 127 (for example 125).

A change in node address is effective immediately.

To permanently save the node address, the following command must be sent:

Table 21: Saving the node ID

Data source	COB-ID	Data	Destination
Controller	0x7e5	17	Sensor
Sensor	0x7e4	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 22: Baud rate as a function of cable length

Cable length	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
< 1000 m	50	06
< 2500 m	20	07
< 5000 m	10	08

The baud rate can be set using the following commands:

Table 23: Setting the baud rate

Data source	COB-ID	Data	Destination
Controller	0x7e5	04; 01; 00; 00; 00; 00; 00; 00	Sensor
Controller	0x7e5	13; 00; 02*; 00; 00; 00; 00; 00	Sensor
Sensor	0x7e4	13; 00; 00; 00; 00; 00; 00; 00	Controller

* 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:

Table 24: Saving the baud rate

Data source	COB-ID	Data	Destination
Controller	0x7e5	17; 00; 00; 00; 00; 00; 00; 00	Sensor
Sensor	0x7e4	17; 00; 00; 00; 00; 00; 00; 00	Controller

6.9.2 Configuring SAE J1939

In the SAE J1939 specification, the maximum length of the network is limited to 40 meters, and the baud rate is fixed at 250 kBit/sec. It is therefore not necessary to configure these parameters when integrating the device. Furthermore, the number of nodes is limited to 30 ECUs (Electronic Control Units). Each ECU can, however, control multiple CAs (Controller Applications). Up to 253 CAs in total can be implemented in the network.

NMT (Network Management)

SAE J1939 supports extended network management. This requires subscribers to first register themselves in the network with a unique address prior to system startup (address claiming). Normal bus operation is only started after all subscribers have successfully logged in. Correct address assignment is checked continuously during operation. A new source address can be assigned during operation. In addition to the source address, every bus subscriber is provided with a unique name to identify it within the network and to prioritize the allocation of addresses. The naming conventions are defined in SAE J1939 and are structured as follows:

Table 25: Naming structure for subscribers according to J1939

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Identify Number		Manufacturer Code		ECU Instance	Function

Table 26: Naming structure for subscribers according to J1939

Byte 6		Byte 7		
Reserved	Vehicle System	Vehicle System Instance	Industry Group	Arbitrary Address Capable

Table 27: Setting the source address

Data source	COB-ID	Data	Destination
Controller	0x10ff54d4	01; nSA*; 23; 01; 20; 07; 00; 00	Transducer
Transducer		No response	Controller

* nSA: new source address

6.9.3 System startup for CANopen

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** mode 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 28: Node start message

Data source	COB-ID	Data	Destination
Controller	0x000	01; 00*; 00; 00; 00; 00; 00; 00	Sensor

* 00: Starts all CAN nodes

To stop the sending of position data, it is necessary to send a pre-operational message:

Table 29: Pre-operational message

Data source	COB-ID	Data	Destination
Controller	0x000	80; 00*; 00; 00; 00; 00; 00; 00	Sensor

* 00: Sets all nodes to **pre-operational** mode

6.9.4 System startup for SAE J1939

After the device is connected to the network and switched on, it attempts to register itself with the network master using a source address. This address claiming is performed automatically by the network. After assignment of a unique network address, the device starts sending position data and is also ready to receive configuration data.

6.9.5 Setting CANopen 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 transmits 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 factory-default resolution of the device is 100 µm. The resolution for motion speed is set to 1 mm/s by default. For more information, see the programming instructions.
  - Cycle time:
    This setting is the cycle time for transmission of PDOs. The value can be in the range of 1 ... 65535 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 low and there are many subscribers, the bus can become overloaded due to the increased volume of data.
    The cycle time can be set using the following commands (e.g., 10, node ID = 127*):

Table 30: Setting the cycle time

Data source	COB-ID	Data	Destination
Controller	0x67f*	22; 00; 62; 00; 0A; 00; 00; 00	Sensor
Sensor	0x5ff*	60; 00; 62; 00; 00; 00; 00; 00	Controller

To permanently save the cycle time, the Save parameters command must be executed:

Table 31: Saving the cycle time

Data source	COB-ID	Data	Destination
Controller	0x67f*	22; 10; 10; 01; 73; 61; 76; 65	Sensor
Sensor	0x7ff*	60; 10; 10; 01; 00; 00; 00; 00	Controller

NOTE
The encoder may take up to 600 ms to respond.

6.9.6 Setting SAE J1939 operating parameters

The operating parameters of the SAE J1939 device variant can be set analogously to the CANopen variant. The device can receive configuration messages during operation, and will adopt the settings immediately after receiving the message.

The cycle time can be set using the following commands (e.g., 100*):

Table 32: Setting the cycle time

Data source	COB-ID	Data	Destination
Controller	0x18B2SAMA	4D; 54; 53; 00; 64*; 00*; 00; 00	Sensor

SA MAX CAN J1939 standard sensor source address
MA Master source address
* e.g., 64; 00: Bytes to configure transmission repetition rates

6.9.7 CANopen encoder data during operation

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

Data format

The resolution of the position data is fixed at 100 µm, 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 33: 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	

The position and speed are calculated as follows:

Position [µm] = position value [counts] * 100µm

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

6.9.8 SAE J1939 encoder data during operation

Data is outputted by means of a Data Record Message.

Table 34: Data Record Message

Identifier	DLC	D0	D1	D2	D3	D4	D5	D6	D7
0 x 18 PFPSSA	8	Position		Speed		Status	Error Code	Limit Status	0xFF

PF PDU format is fixed to 255 (0xFF)
PS PDU Specific can be 0-255 (0x00 - 0xFF)
SA MAX CAN J1939 standard sensor source address

6.9.9 CANopen error messages

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 35: Emergency object

Identifier	DLC	D0	D1	D2	D3	D4	D5	D6	D7
0x80 + node ID	8	Error Code		Error register	Manufacturer-specific				

The following errors are reported in the emergency object:

Table 36: Error codes

Error code	Relevance
0x0000	Device is operating without errors
0x5000	Device hardware error
0X6300	Data set error

6.9.10 SAE J1939 error messages

SAE J1939 does not provide separate error objects. The device status is reported with every PDU that is sent.

7 Maintenance

7.1 Error table

Table 37: Errors during installation

Error cause	Possible consequences
Incorrect pin assignment	No signals
Ambient temperature too high	Damage to the device components
Cylinder bore hole too small	Damage to the device components when installing the device
Not noticing pointy or sharp edges	Damage to male connectors, wires, cables
Careless handling of the device	Damage to the device components
Welding work after installation	Damage to the sensor housing or electronics due to welding currents
Damage to the cable	Short-circuiting or failure of the electronics
Male connector not sealed	Short-circuiting or corrosion of electronic components due to liquids
Ground or shielding connected incorrectly	Signal interference, possible damage to the electronics

Table 38: Errors during commissioning/operation

Output signal	
F.S.O	Output signal in the event of a fault
4.00 ... 20.00 mA	> 21.0 mA
0.50 ... 4.50 V	> 5.1 V
0.25 ... 4.50 V	> 5.1 V
0.50 ... 9.50 V	> 10.0 V
PWM (duty cycle)	> 99%
Digital: CANopen / SAE J1939	Error message “FFFF”

Fault:

a) Position magnet missing
b) Position magnet in null or cushion zone
c) Malfunction or failure of the magnetostrictive element

7.2 Checking the functioning of the encoder

Encoder with analog interface

To verify the proper operation of the device, perform the following checks:

- Connections and pin assignments
- Supply voltage
- Check the device by disconnecting it and testing it using an external supply
- Check the device using a multimeter as described below

Measure the VDC output signal

Measure the following output signals:

- 0.25 ... 4.75 VDC
- 0.5 ... 4.5 VDC
- 0.5 ... 9.5 VDC

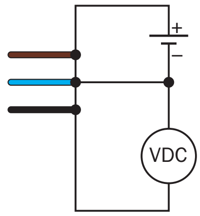


Figure 29: Measuring the output signal in VDC

1. Switch the measuring range of the multimeter to VDC.
2. Connect the multimeter to the signal lead and 0 V lead.
3. Connect the voltage supply (+12/24 V).
4. Connect 0 V (-0 V).

Measuring the 4 ... 20 mA output signal

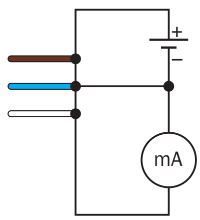


Figure 30: Measuring the output signal in mA

1. Switch the measuring range of the multimeter to mA.
2. Connect the multimeter to the signal lead and 0 V lead.
3. Connect the voltage supply (+12/24 V).
4. Connect 0 V (-0 V).

Alternative measuring method: using a resistor (e. g., 100 Ω):

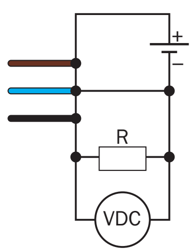


Figure 31: Measuring the output signal using a resistor

1. Connect the resistor to the signal lead and 0 V lead.
2. Switch the measuring range of the multimeter to VDC.
3. Connect the multimeter in parallel to the resistor.

When using a resistor of, for example, 100 Ω, the following values are displayed:

Table 39: Example measurement values

Supply	at 4 mA (null zone)	at 20 mA (end position)
12 V, 24 V	0.4 V	2 V

7.3 Repairs

All repair work on the device must be carried out by SICK Service.

7.4 Testing and programming

A test device is available for checking the device functionality.

To minimize error sources during functional testing, the test device must be connected directly to the encoder. A PC can be used to test the functioning of the device, and to configure the basic settings.

8 Transport and storage

8.1 Transport and storage conditions

When transporting the fully assembled cylinders, ensure the cable and male connector of the electrical connection are not subjected to tensile loads.

Store the cylinders in a dry place. When storing the cylinders on top of one another, ensure no male connectors or cables are crushed.

Cover the connectors and any free cable ends with an anti-static bag. The original packaging, for example, is suitable for this purpose. Also reuse the dust protection caps of the connector system when storing the device.

For the part numbers of the original packaging and the dust protection caps, see: see "Accessories", page 51.

9 Decommissioning

9.1 Dismantling

When dismantling the cylinder and when removing the encoder, ensure no male connectors, cables or cable ends can be damaged in the process.

9.2 Disposal

Any device which can no longer be used must be disposed of in an environmentally friendly manner in accordance with the applicable country-specific waste disposal regulations. As the device is categorized as electronic waste, it must never be disposed of with household waste.

10 Technical data

10.1 MAX Analog/PWM

Table 40: Technical data – MAX48 Analog / PWM

Performance	
Measurand	Position
Measuring range	MAX48: 0050 ... 2,500 mm (in 1 mm steps) MAX30: 0050 ... 1,500 mm (in 1 mm steps)
Unusable measuring range:	
Null zone (zero point)	MAX48: 30.0 mm MAX30: 19.5 mm
Damping (end point)	30.0 mm/ 36.0 mm/ 63.0 mm (depending on type)
Power-up delay	< 250 ms
Measuring frequency (internal)	2 ms
Setpoint tolerance Zero and end point of the usable piston stroke	≤ 1.0 mm
Resolution	0.1 mm typical (noise-free)
Hysteresis	± 0.1 mm
Linearity:	
Measuring ranges 50 ... 500 mm F.S.	typically ± 0.25 mm
Measuring ranges 501 ... 2,500 mm F.S.	typically ± 0.04%
Temperature drift (warm-up phase)	max. ± 0.25 mm

Analog interface	
Electrical interface	Analog
Voltage signal	0.25 ... 4.75 VDC 0.50 ... 4.50 VDC 0.50 ... 9.50 VDC 1.00 ... 9.00 VDC
Current signal	4 ... 20 mA

PWM interface	
Pulse width	05 ... 95% 10 ... 90% 15 ... 85% 20 ... 80% 25 ... 75%
Pulse rate	250 Hz 300 Hz 400 Hz 500 Hz

Electrical connection	
M12 male connector	4-pin, wire length 060 ... 240 mm (depending on type)
3-wire cable	3 x 0.32 mm^2 (AWG22), stripped 300 ... 10,000 mm (depending on type)

Electrical data	
Supply voltage	12 VDC (8 ... 16 VDC) 24 VDC (8 ... 30 VDC)

Electrical data	
Supply voltage ripple	< 1% p-p
Power consumption:	
12 VDC voltage signal	≤ 0.5 W
24 VDC voltage signal	≤ 0.5 W
24 VDC current signal / PWM	≤ 1.0 W
Current consumption:	
12 VDC voltage signal	≤ 30 mA
24 VDC voltage signal	≤ 20 mA
24 VDC current signal / PWM	≤ 40 mA
Load resistance:	
Voltage signal	RL ≥ 10 kΩ
Current signal	100 Ω < RL < 500 Ω
Switch-on current:	
12 VDC supply voltage	2.5 A / 50 µsec typical
24 VDC supply voltage	5.0 A / 50 µsec typical
Over voltage protection	ISO 16750-2: ≤ + 36 VDC on all poles
Reverse polarity protection	ISO 16750-2: on all poles
Insulation resistance	ISO 16750-2: Riso ≥ 10 MΩ, 60 sec
Dielectric strength	ISO 16750-2: 500 VDC (0 VDC to housing)

Dimensions	
Size	MAX48: 48f7 mm (for installation in a 48H8 clearance) MAX30: 31f7 mm (for installation in a 31H8 clearance)
Unusable range:	
Null zone (zero point)	MAX48: 30.0 mm MAX30: 19.5 mm
Damping (end point)	30.0 mm/ 36.0 mm/ 63.0 mm (depending on type)
Pressure pipe	Ø 7 mm or 10 mm (depending on type)
O-ring	MAX48: Ø 40.87 x 3.53 mm MAX30: Ø 24.99 x 3.53 mm
Support ring	MAX48: Ø 42.6 x 48 x 1.4 mm MAX30: Ø 31 x 25.8 x 1.4 mm
M12 flange	EN 61076-2-101 DM 20 x 20 mm - 14 mm hole pattern
3-wire cable	Ø 5.2 mm, 3 x 0.32 mm^2 (AWG22), stripped 300 ... 10,000 mm (depending on type)

Material	
Pressure pipe	Stainless steel 1.4306, AISI 304L
Electronics housing	Stainless steel 1.4305, AISI 303
O-ring	NBR 70
Support ring	PTFE
M12 male connector insert	Glass fiber reinforced polyamide, nickel-/gold-plated brass contacts
M12 flange	Stainless steel with O-ring (NBR70)
Cable	PUR cable sheath / PVC strand

Ambient data	
EMC	EU Directive 2014/30/EU CE marking EU Directive 2009/64/EU Agricultural machinery
Generic standards	
Immunity as per EN 61000-6-2	EN 61000-4-3 High-frequency electromagnetic fields EN 61000-4-4 Conducted fast transients (burst) EN 61000-4-5 Conducted emission voltage (surge) Class2 EN 61000-4-6 Conducted high-frequency signals EN 61000-4-8 Magnet fields
Radiated emissions as per EN 61000-6-3	CISPR25 High-frequency radiated interference
Immunity to interference Agricultural and forestry machines (ISO 14982) Construction machines EN 13309 / ISO13766	ISO 11452-2 High-frequency electromagnetic fields ISO 11452-4 Bulk Current Injection ISO 11452-5 Strip Line Method
Emitted interference Agricultural and forestry machines (ISO 14982) Construction machines EN 13309 / ISO13766	CISPR25 High-frequency radiated interference
Transient pulses	ISO 7637-2 test pulse 1/ 2a/2b /3a/3b /4 /5a/5b
ESD (air and contact discharge)	EN 61000-4-2 ISO/TR 10605

Enclosure rating	
Housing without electrical connection	ISO 16750-4: EN 60529 IP67 30 min - 1 m
Housing with cable connector	ISO 16750-4: EN 60529 IP67 30 min - 1 m
M12 male connector	ISO 16750-4: ISO 20653 IP69K with coupling on; Spraying: 30 sec. / 100 bar / 80 °C

Temperature ranges	
Operating temperature (operating condition) Allowing for fluid temperature and intrinsic heat-ing of the electronics	-40 °C ... +105 °C
Ambient temperature (fluid)	-30 °C ... +95 °C
Permissible relative humidity	EN60068-2-30: 90% r.H. (Condensation not permitted)
Storage	-20 °C ... +85 °C (r.H. 55%)

Resistance to shocks	
Drop test	ISO 16750-3: IEC 60068-2-31
Single shock	ISO 16750-3: IEC 60068-2-27: 100 g, 11 ms
Continuous shocks, 1,000 shocks per spatial axis	ISO 16750-3: IEC 60068-2-27: 50 g, 11 ms

Resistance to vibrations		
	Pressure pipe, Ø 10 mm	Pressure pipe, Ø 7 mm
Sine ISO 16750-3: IEC 60068-2-6	10 ... 55 Hz (3.5 mm pp) 55 ... 2,000 Hz 20 g (24 h/axis)	55 ... 2,000 Hz 15 g (24 h/axis)
Sine-on-random ISO 16750-3: IEC 60068-2-80	100 ... 440 Hz 11.3 g (r.m.s.) 10 ... 2,000 Hz 18.1 g (r.m.s.) (36 h/axis)	10 ... 2,000 Hz 13 g (r.m.s.) (36 h/axis)
Random ISO 16750-3: IEC 60068-2-64	10 Hz ... 2,000 Hz 20 g (r.m.s.) (48 h/axis) resonance peaks removed	10 Hz ... 2,000 Hz 15 g (r.m.s.) (48 h/axis) resonance peaks removed

Hydraulic pressure		
	Pressure pipe, Ø 10 mm	Pressure pipe, Ø 7 mm
Operating pressure P_N	400 bar	320 bar
Max. overload pressure during operation (P_Nx1.2)	480 bar	380 bar
Max. test pressure in cylinder (P_Nx1.5)	600 bar	480 bar

10.2 MAX Digital CANopen / SAE J1939

Table 41: Technical data – MAX48 Digital CANopen / SAE J1939

Performance	
Measurand	Position and speed
Measuring range	MAX48: 0050 ... 2,500 mm (in 1 mm steps) MAX30: 0050 ... 1,500 mm (in 1 mm steps) Speed: 0 ... 1,000 mm/sec
Unusable measuring range:	
Null zone (zero point)	MAX48: 30.0 mm MAX30: 19.5 mm
Damping (end point)	30.0 mm/ 36.0 mm/ 63.0 mm (depending on type)
Power-up delay	< 250 msec
Measuring frequency (internal)	Cycle time: CANopen 1 ms SAE J1939 20 ms
Setpoint tolerance Zero and end point of the usable piston stroke	≤ 1.0 mm
Solution	0.1 mm typical (noise-free)
Hysteresis	± 0.1 mm
Linearity:	
Measuring ranges 50 ... 500 mm F.S.	typically ± 0.25
Measuring ranges 501 ... 2,500 mm F.S.	typically ± 0.04%
Temperature drift (warm-up phase)	max. ± 0.25 mm

Digital interface	
Electrical interface	Digital
Bus protocols	CANopen as per CiA DS-301 V4.1 and SAE J1939
Device profile	DS-406 V3.1

Electrical connection	
M12 male connector	5-pin, wire length 060 ... 240 mm (depending on type)

Electrical data	
Supply voltage	24 VDC (8 ... 30 VDC)
Supply voltage ripple	< 1% p-p
Power consumption	≤ 1.0 W (24 VDC)
Current consumption	≤ 40 mA (24 VDC)
Bus termination	120 Ω
Switch-on current:	typically 5.0 A / 50 µsec (24 VDC supply voltage)
Over voltage protection	ISO 16750-2: ≤ +36 VDC on all poles
Reverse polarity protection	ISO 16750-2: on all poles

Electrical data	
Insulation resistance	ISO 16750-2: Riso ≥ 10 MΩ, 60 sec
Dielectric strength	ISO 16750-2: 500 VDC (0 VDC to housing)

Dimensions	
Size	MAX48: 48f7 mm (for installation in a 48H8 clearance) MAX30: 31f7 mm (for installation in a 31H8 clearance)
Unusable range:	
Null zone (zero point)	MAX48: 30.0 mm MAX30: 19.5 mm
Damping (end point)	30.0 mm/ 36.0 mm/ 63.0 mm (depending on type)
Pressure pipe	Ø 7 mm or 10 mm (depending on type)
O-ring	MAX48: Ø 40.87 x 3.53 mm MAX30: Ø 24.99 x 3.53 mm
Support ring	MAX48: Ø 42.6 x 48 x 1.4 mm MAX30: Ø 31 x 25.8 x 1.4 mm
M12 flange	EN 61076-2-101 DM 20 x 20 mm - 14 mm hole pattern

Material	
Pressure pipe	Stainless steel 1.4306, AISI 304L
Electronics housing	Stainless steel 1.4305, AISI 303
O-ring	NBR 70
Support ring	PTFE
M12 male connector insert	Glass fiber reinforced polyamide, nickel-/gold-plated brass contacts
M12 flange	Stainless steel with O-ring (NBR70)
Cable	PUR cable sheath / PVC strand

Ambient data	
EMC	EU Directive 2014/30/EU CE marking EU Directive 2009/64/EU Agricultural machinery
Generic standards	
Immunity as per EN 61000-6-2	EN 61000-4-3 High-frequency electromagnetic fields EN 61000-4-4 Conducted fast transients (burst) EN 61000-4-5 Conducted emission voltage (surge) Class2 EN 61000-4-6 Conducted high-frequency signals EN 61000-4-8 Magnet fields
Radiated emissions as per EN 61000-6-3	CISPR25 High-frequency radiated interference
Immunity to interference Agricultural and forestry machines (ISO 14982) Construction machines EN 13309 / ISO13766	ISO 11452-2 High-frequency electromagnetic fields ISO 11452-4 Bulk Current Injection ISO 11452-5 Strip Line Method
Emitted interference Agricultural and forestry machines (ISO 14982) Construction machines EN 13309 / ISO13766	CISPR25 High-frequency radiated interference
Transient pulses	ISO 7637-2 test pulse 1/ 2a/2b /3a/3b /4 /5a/5b
ESD (air and contact discharge)	EN 61000-4-2 ISO/TR 10605

Enclosure rating	
Housing without electrical connection	ISO 16750-4: EN 60529 IP67 30 min - 1 m

Enclosure rating	
M12 male connector	ISO 16750-4: ISO 20653 IP69K with coupling on; Spraying: 30 sec. / 100 bar / 80 °C

Temperature ranges	
Operating temperature (operating condition) Allowing for fluid temperature and intrinsic heating of the electronics	-40 °C ... +105 °C
Ambient temperature (fluid)	-30 °C ... +95 °C
Permissible relative humidity	EN60068-2-30: 90% r.H. (Condensation not permitted)
Storage	-20 °C ... +85 °C (r.H. 55%)

Resistance to shocks	
Drop test	ISO 16750-3: IEC 60068-2-31
Single shock	ISO 16750-3: IEC 60068-2-27: 100 g, 11 ms
Continuous shocks, 1,000 shocks per spatial axis	ISO 16750-3: IEC 60068-2-27: 50 g, 11 ms

Resistance to vibrations		
	Pressure pipe, Ø 10 mm	Pressure pipe, Ø 7 mm
Sine ISO 16750-3: IEC 60068-2-6	10 ... 55 Hz (3.5 mm pp) 55 ... 2,000 Hz 20 g (24 h/axis)	55 ... 2,000 Hz 15 g (24 h/axis)
Sine-on-random ISO 16750-3: IEC 60068-2-80	100 ... 440 Hz 11.3 g (r.m.s.) 10 ... 2,000 Hz 18.1 g (r.m.s.) (36 h/axis)	10 ... 2,000 Hz 13 g (r.m.s.) (36 h/axis)
Random ISO 16750-3: IEC 60068-2-64	10 Hz ... 2,000 Hz 20 g (r.m.s.) (48 h/axis) resonance peaks removed	10 Hz ... 2,000 Hz 15 g (r.m.s.) (48 h/axis) resonance peaks removed

Hydraulic pressure		
	Pressure pipe, Ø 10 mm	Pressure pipe, Ø 7 mm
Operating pressure P_N	400 bar	320 bar
Max. overload pressure during operation (P_Nx1.2)	480 bar	380 bar
Max. test pressure in cylinder (P_Nx1.5)	600 bar	480 bar

10.3 Encoder dimensions

MAX48

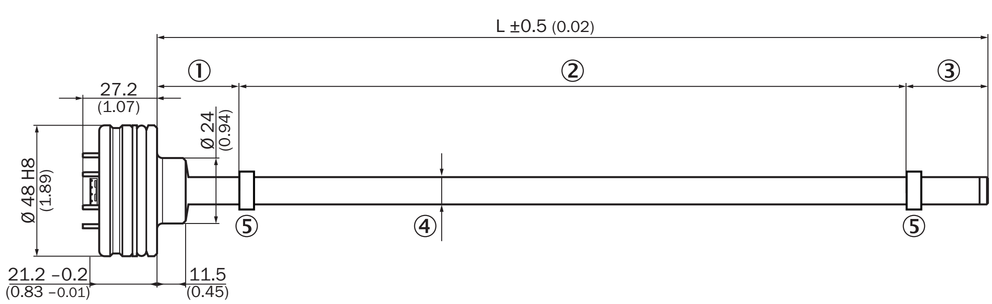


Figure 32: MAX48 dimensional drawing

① Null zone

② Measuring range

③ Damping
④ Diameter of the pressure pipe
⑤ Position magnet

MAX30

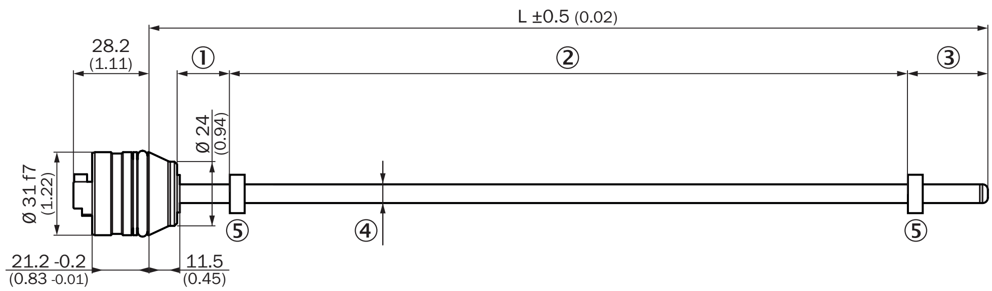


Figure 33: MAX30 dimensional drawing

① Null zone
② Measuring range
③ Damping
④ Diameter of the pressure pipe
⑤ Position magnet

10.4 Position magnet dimensions

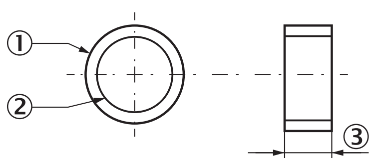


Figure 34: Dimensional drawing for position magnet

① Outer diameter
② Inner diameter
③ Height

Table 42: Dimensions of position magnet

Outer diameter	17.4 mm ± 0.1
Inner diameter	12.0 mm ± 0.1
Height	10.6 mm ± 0.1

Max. surface pressure or mechanical load, e.g., by spring washers: 40 N/mm² in the axial direction.

10.5 M12 flange dimensions

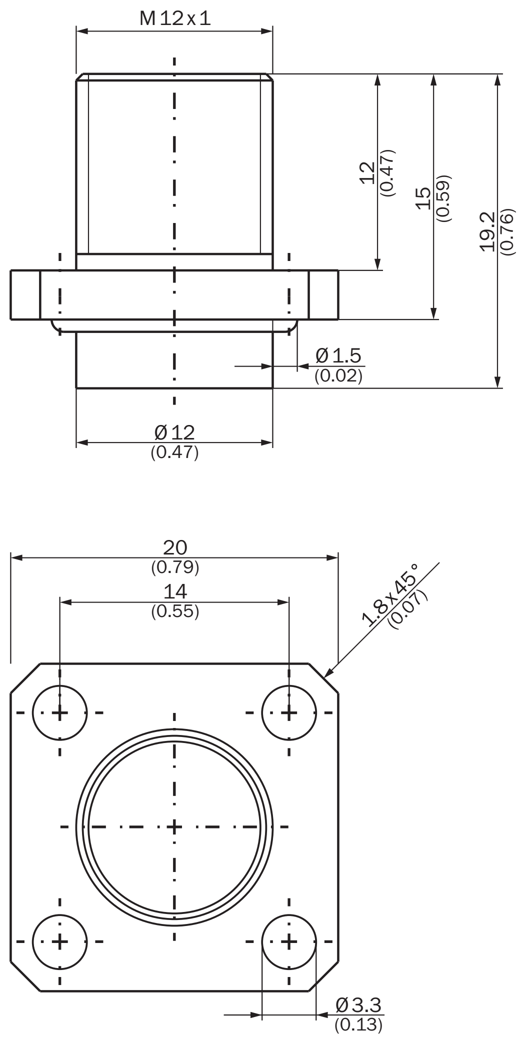


Figure 35: M12 flange dimensional drawing

11 Annex

11.1 Accessories

For installing the position magnet

NOTE
These components are required to install the linear encoder.

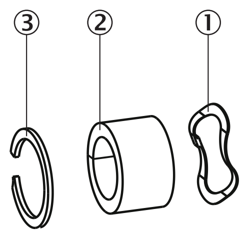


Figure 36: Installation sequence for the position magnet and required securing elements

①	Corrugated spring washer
②	Position magnet
③	Circlip

Position magnet

Not included with delivery. Available as accessory.

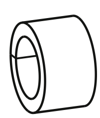


Figure 37: Position magnet

Corrugated spring washer

Not included with delivery. Available as accessory. (Manufacturer: Smalley)

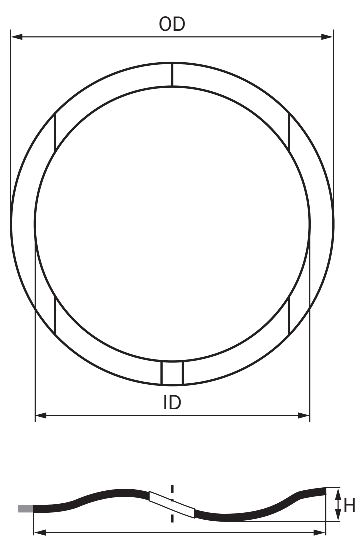


Figure 38: Corrugated spring washer

- Material: Stainless steel
- Dimensions: OD x ID x H 0.75 x 0.50 x 0.160 (inch)

Circlip

Not included with delivery. Available as accessory. (Manufacturer: Smalley)

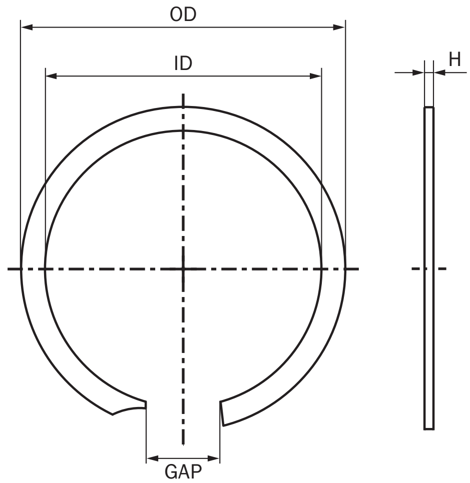


Figure 39: Circlip

- Material: Stainless steel
- Dimensions: OD x ID x H 19.18 x 18.0 x 0.94 (mm)

For installing the cable connection

Cable gland

Not included with delivery. Available as accessory.

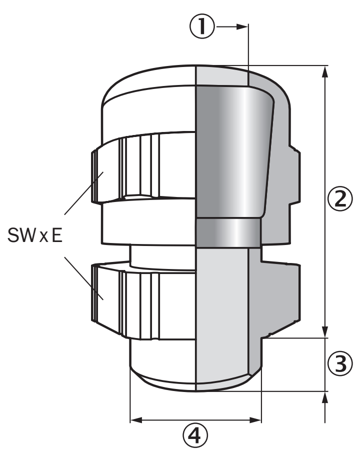


Figure 40: Cable gland

① Ø 8 ... 2 mm
② 21 mm
③ 5 mm
④ M12 x 1.5

- Material: nickel-plated brass housing
- Dimensions: SW x E (17 x 18.9 mm)

11.2 Spare parts

O-ring

Included with delivery (installed). Not available as accessory. (Manufacturer: Parker)

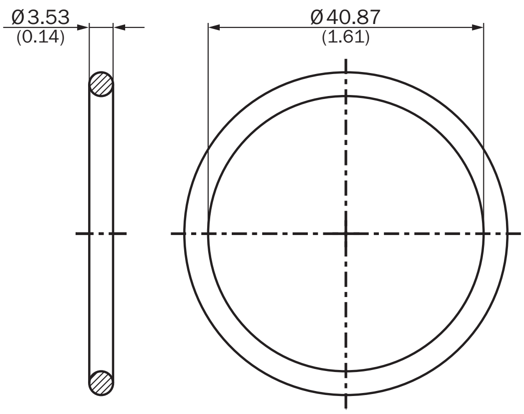


Figure 41: O ring – MAX48

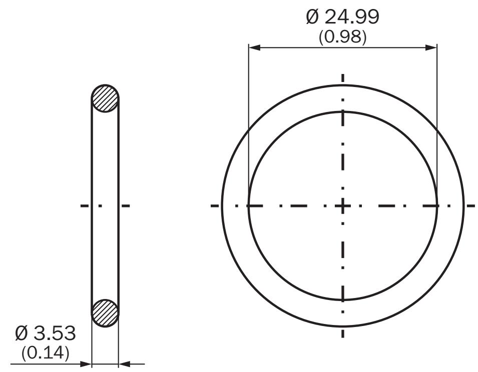


Figure 42: O ring – MAX30

- Material: NBR 70
- Dimensions (MAX48): 40.87 x 3.53
- Dimensions (MAX30): 24.99 x 3.53

Support ring

Included with delivery (installed). Available as accessory.

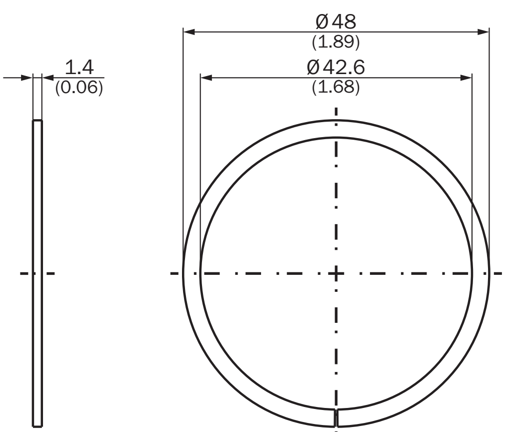


Figure 43: Support ring – MAX48

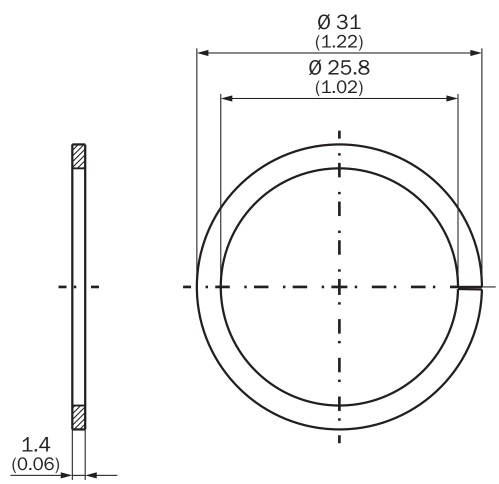


Figure 44: Support ring – MAX30

- Material: PTFE
- Dimensions (MAX48): 42.6 x 48.0 x 1.4
- Dimensions (MAX30): 25.8 x 32.0 x 1.4

M12 flange

Included with delivery (installed). Available as accessory.

- Material: nickel-plated brass housing, NBR 70 O-ring
- Dimensions: M12 x 1.20 x 20 mm - 14 mm hole pattern
- Mounting: 4 x M3x6 screws (not included with delivery)

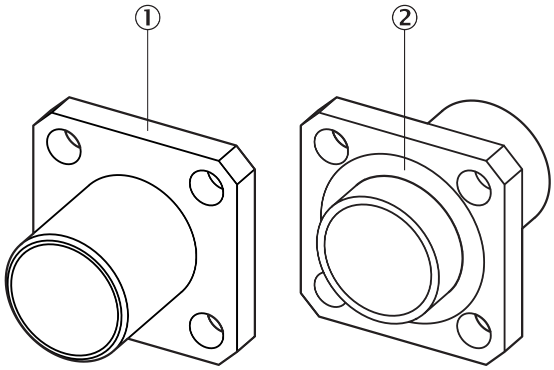


Figure 45: Accessories for M12 connector system

① M12 flange

② O-ring

M12 connecting cable

Included with delivery (installed). Available as accessory.

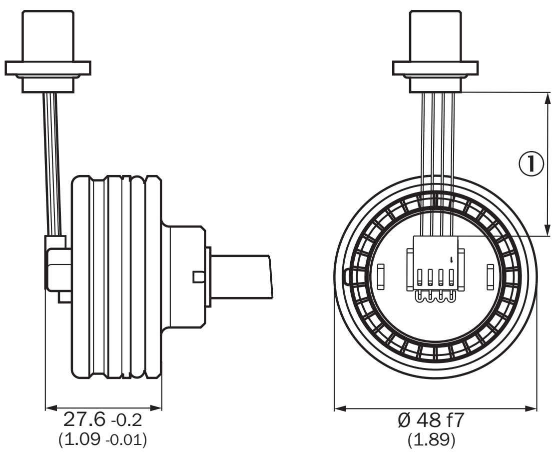


Figure 46: M12 connecting cable – MAX48

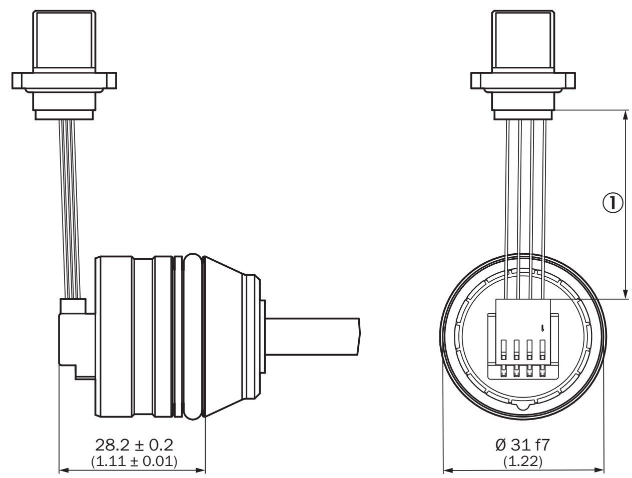


Figure 47: M12 connecting cable – MAX30

① Wire/cable length

- Material: Glass fiber reinforced polyamide M12 male connector, nickel-/gold-plated brass contacts
- Dimensions: 060 ... 240 mm cable lengths

Cable connector

Included with delivery (installed). Available as accessory.

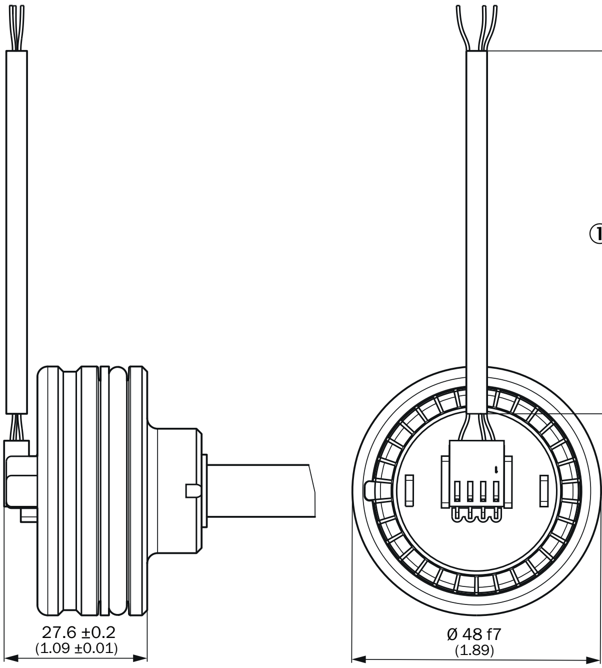


Figure 48: MAX48 cable connection

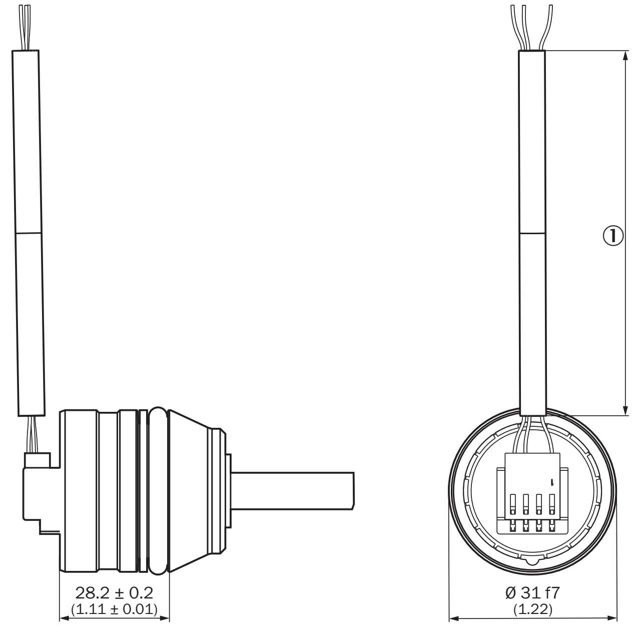


Figure 49: MAX30 cable connection

① Length of wire/cable

- Material: PUR sheath
- Dimensions: Ø 5.0 mm, 3 x 0.32 mm² (AWG 22), stripped
  Cable lengths 300 ... 10,000 mm

11.3 CE Declaration of Conformity

The CE Declaration of Conformity and other certificates can be downloaded from the Internet at:

- www.sick.com/MAX48
- www.sick.com/MAX30

8022793/ZXZ4/2018-07-24/en

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