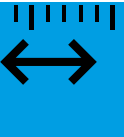


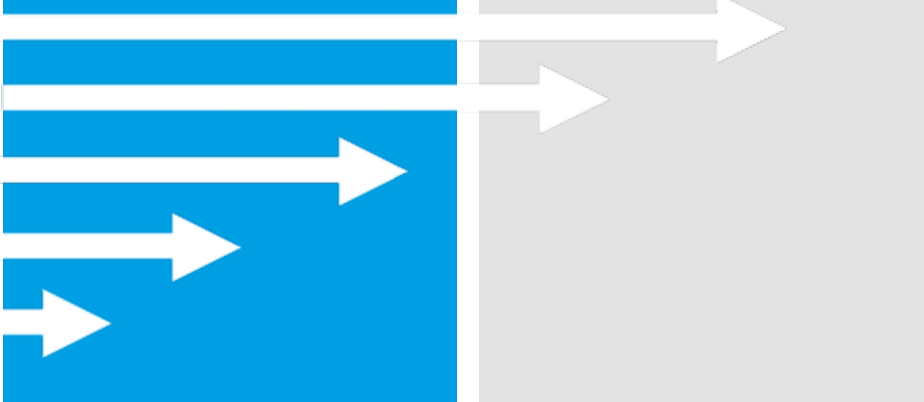
## Linear Position Sensing and Measurement

The appropriate measuring principle for the optimal solution



0 mm

48000 mm





With over 50 years of sensor experience, Balluff is a leading global sensor specialist with its own line of connectivity products for every area of factory automation. Balluff is based in Germany and has a tight international network of 54 representatives and subsidiaries.

Balluff stands for comprehensive systems from a single source, continuous innovation, state-of-the-art technology, highest quality, and greatest reliability. That's not all: Balluff also stands for exceptional customer orientation, customized solutions, fast worldwide service, and outstanding application assistance.

High-quality, innovative products tested in our own accredited laboratory and a quality management system certified according to DIN ISO 9001 (EN 2008) form a secure foundation for optimized added value for our customers.

Whether electronic and mechanical sensors, rotary and linear transducers, identification systems or optimized connection technology for high-performance automation, Balluff not only masters the entire technological variety with all of the different operating principles, but also provides technology that fulfills regional quality standards and is suitable for use worldwide. Wherever you are in the world, Balluff technology is never far away. You won't have to look far for your nearest Balluff expert.

Balluff products increase performance, quality and productivity around the world every day. They satisfy prerequisites for meeting demands for greater performance and cost reductions on the global market. Even in the most demanding areas. No matter how stringent your requirements may be, Balluff delivers state-of-the-art solutions.

**Fully exploit the potential of high quality: with superior position measurement technology for more efficiency.**

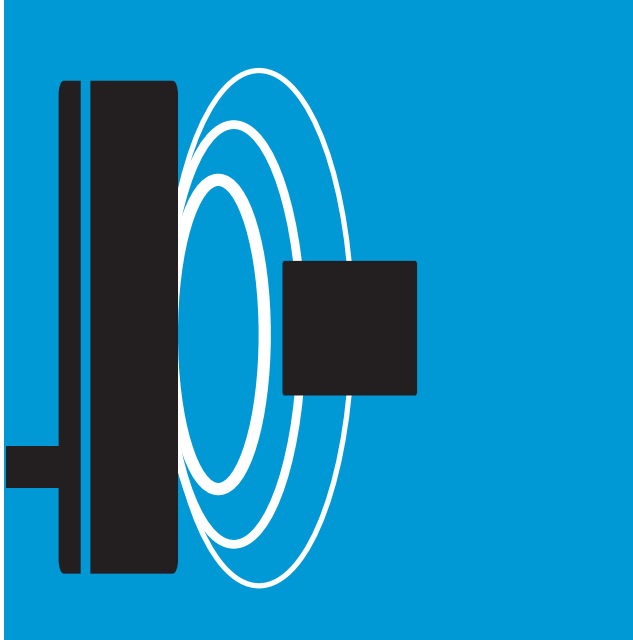


# Linear Position Sensing and Measurement

## Contents

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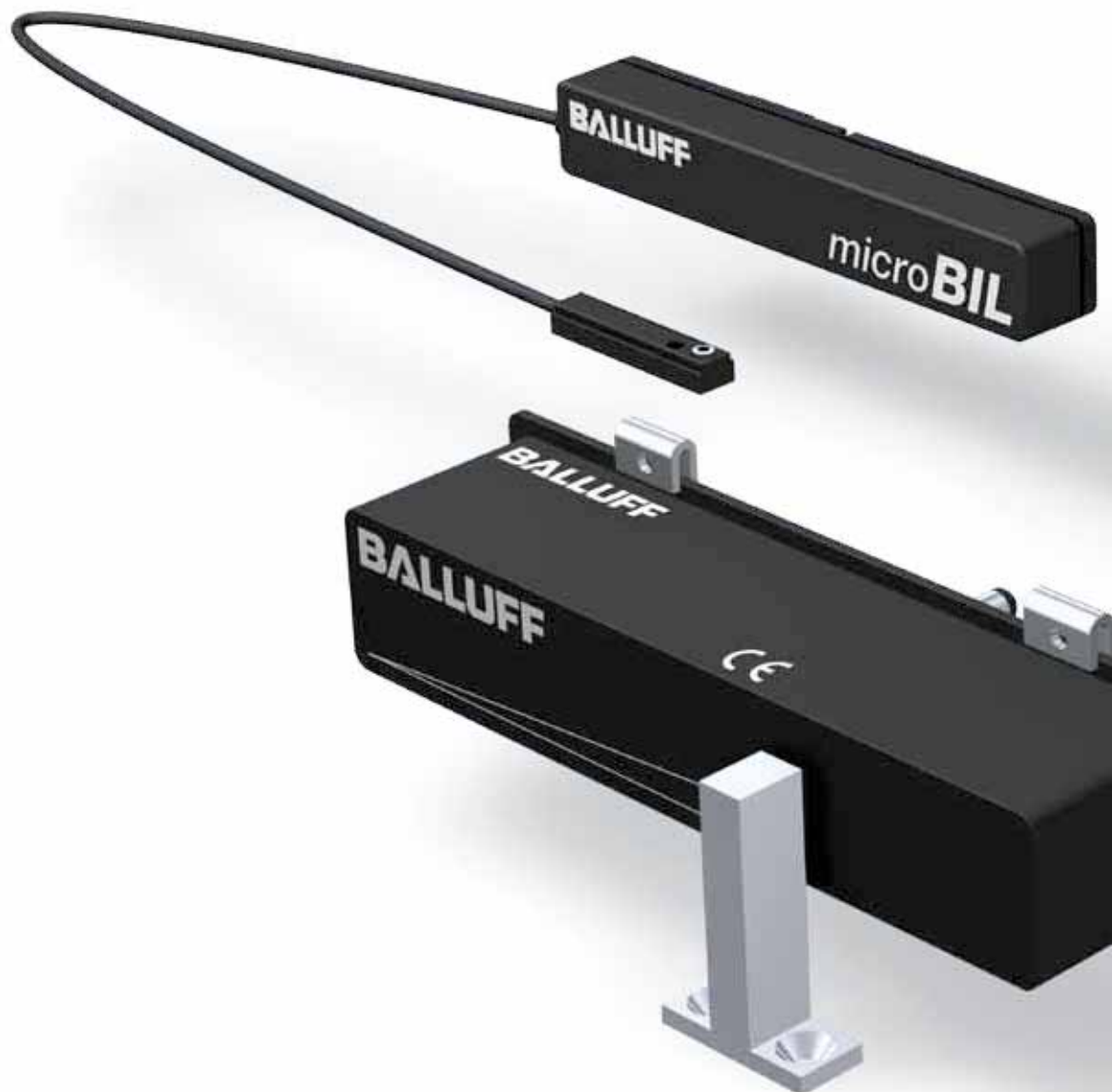


# Inductive Position Sensors

Inductive position sensors are typically used in automation equipment and toolmaking wherever adjustment values and positions have to be monitored in very tight spaces.

These displacement sensors are perfect for use in situations where no contact, being able to provide absolute measurement and having a compact design are critical features.

The fully enclosed design achieves a IP 67 degree of protection and makes these sensors resistant to stresses related to shocks and vibrations.



# Inductive Position Sensors

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<b>Inductive position sensors BIP</b>	274
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# SMARTSENS



Basic information and definitions can be found on page 280.

# Inductive Position Sensors

## Applications

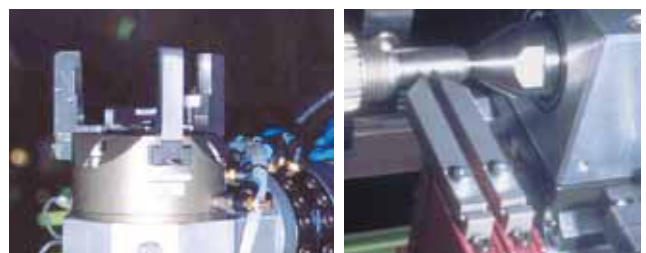
### BIL

Balluff magneto-inductive position sensors detect positions up to 160 mm away. Analog position sensors BIL measure **without contact and absolutely using a passive magnet**. The compact design means these sensors can be easily integrated into the application even when mounting space is extremely tight.



### Micro-BIL

The Micro-BIL detects the absolute position on pneumatic miniature grippers or compact cylinders using integrated permanent magnets; the sensor element can be easily installed in the T-slot. The analog output signal allows you to individually and flexibly detect end-of-travel and intermediate positions on gripper jaws or pistons.



# Inductive Position Sensors

## Applications

### BIP

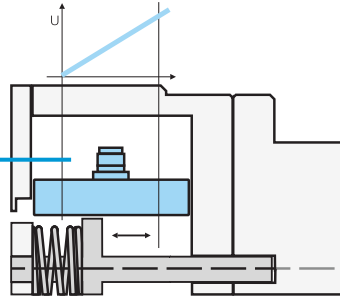
The inductive positioning system BIP is an accurate measuring system for detecting the position of metallic objects.

### Applications

The main application area of the BIP is linear position monitoring of drive spindles and clamping devices for tools and workpieces.

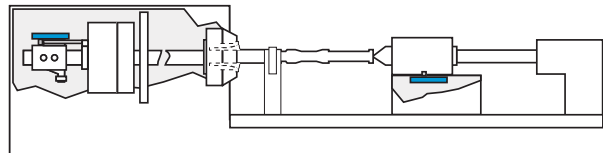
### The optimal sensor for monitoring clamping distance

Position sensor BIP in use at a drive spindle for tools



### Applications

These positioning systems BIP are ideal for integrated production monitoring because their unmatched effective length ratio makes installation possible in even the most confined applications.



Inductive position sensors  
**Applications**  
Summary

Magneto-inductive position sensors BIL

Inductive position sensors BIP

Basic Information and Definitions



**SMARTSENS**



**SMARTSENS**



**SMARTSENS**

Series	Micro-BIL	BIL 60	BIL 160	
Measuring range	0...10 mm	0...60 mm	0...160 mm	
Teachable analog output				
Resolution	±25 µm	±0.15 mm	±0.4 mm	
Linearity	±0.3 mm	±1 mm	±2.4 mm	
Repeat accuracy	±30 µm	±60 µm	±0.5 mm	
<b>Interfaces</b>				
Output	0...10 V	■	■	■
	4...20 mA	■	■	■
IO-Link				
<b>Target/magnet</b>				
Magnet	■	■	■	
Metal				
From page	269	270	271	



# Inductive Position Sensors Summary



	BIP 14	BIP 40	BIP 70	BIP 103
	0...14 mm	0...40 mm	0...70 mm	0...103 mm
	■	■	■	■
	14 µm	40 µm	80 µm	80 µm
	±250 µm	±400 µm	±300 µm	±400 µm
	±80 µm	±100 µm	±80 µm	±80 µm
	■	■	■	■
	■	■	■	■
	■	■	■	■
	■	■	■	■
	■	■	■	■
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Inductive position sensors  
Applications  
Summary

Magneto-inductive position sensors BIL

Inductive position sensors BIP

Basic Information and Definitions



# Inductive Position Sensors

## Magneto-inductive position sensors BIL

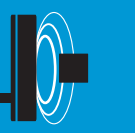
Magneto-inductive position sensors BIL are compact position sensors for position detection up to 160 mm away.

The magneto-inductive analog position sensor measures without contact and absolutely, using a wireless magnet.



<b>Magneto-inductive position sensors BIL</b>	
Summary	268
Micro-BIL, general data	269
BIL, general data	270
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## SMARTSENS



# Magneto-inductive Position Sensors Micro BIL

## Summary

### BIL features

- Wear-free since the position is detected without contact
- Insensitive to shock and vibration
- Absolute output signal: Voltage or current  
(cable break monitoring possible)
- Housing cross-section 15×15 mm
- Simple installation



### Features of the Micro-BIL

- Wear-free since the position is detected without contact
- Insensitive to shock and vibration
- Absolute output signal: Voltage or current  
(cable break monitoring possible)
- Adjustable measuring range, magnetic field strength
- Easy to install in the T-slot



Original mounting brackets and screws are recommended for attaching the Micro-BIL. Please order accessories separately.  
See page 272



becomes  
narrow

# Magneto-inductive Position Sensors Micro BIL

## General data



Output signal $U_{out}$	<b>Voltage 0...10 V or</b>	
Output signal $I_{out}$	<b>Current 4...20 mA</b>	
Working range $s_w$	0...10 mm	
Linear range $s_l$	0...10 mm	
<b>Ordering code</b>	<b>BIL0002</b>	
Part number	BIL ED0-B010P-02/30-S75	
Supply voltage $U_S$	At voltage output $U_{out}$ : $U_S = 15...30$ V DC, At current output $I_{out}$ : $U_S = 10...30$ V DC	
Field strength, axial $H_n$	10 kA/m typical	
-3dB width of the axial field distribution, typical (typical axial field strength – parallel to sensing surface)	2.5 mm	
Residual ripple	$\leq 10\%$ of $U_e$	
Rated insulation voltage $U_i$	75 V DC	
Effective distance $s_e$	5 mm	
Load resistance $R_L$	At voltage output $U_{out}$ : $R_L = \geq 2$ k $\Omega$ , At current output $I_{out}$ : $R_L = \leq 500$ $\Omega$	
No-load supply current $I_0$ at $U_e$	$\leq 30$ mA	
Polarity reversal protected	yes	
Short-circuit protected	yes	
Ambient temperature $T_a$	$-10...70$ °C	
Repeat accuracy $R_{BWN}$	$\leq \pm 30$ $\mu$ m	
Non-linearity	$\pm 0.3$ mm	
Temperature coefficient TC	Typical	+4 $\mu$ m/K
In the optimum range	Min.	+2 $\mu$ m/K
from 10...50 °C	max	+10 $\mu$ m/K
Power-on indicator	yes	
Programming indicator	yes	
Degree of protection as per IEC 60529	IP 67	
Housing material	PA fiberglass reinforced	
Connection	Plug connector	
Approval	cULus	
Recommended connector	BKS-S 74/BKS-S 75	



Inductive  
position sensors

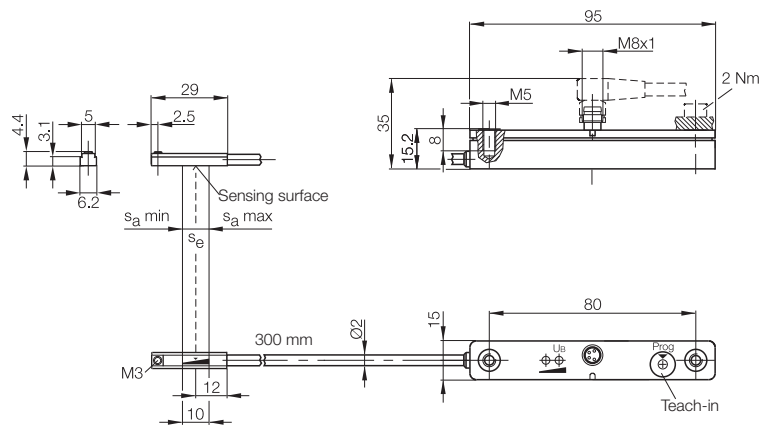
Magneto-  
inductive posi-  
tion sensors BIL

**Summary**  
**Micro-BIL**  
BIL  
Accessories

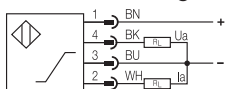
Inductive  
position sensors  
BIP

Basic  
Information and  
Definitions

Adjustment to different magnetic field strengths is possible at the touch of a button. The technical data refer to reference measurements. Different grippers/cylinders with differing magnetic fields may affect the technical data.



### Connection wiring diagram



Connect either the voltage or current output.

# Magneto-inductive Position Sensors BIL

## General data



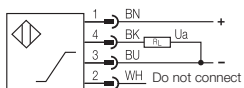
Output signal $U_{out}$	<b>Voltage 0...10 V, out-of-range 11 V</b>	
Output signal $I_{out}$		
Working range $s_w$	0...60 mm	
Linear range $s_l$	5...55 mm	
<b>Ordering code</b>	<b>BIL0001</b>	
Part number	BIL AMD0-T060A-01-S75	
Supply voltage $U_s$	15...30 V DC	
Residual ripple	$\leq 10\%$ of $U_e$	
Rated insulation voltage $U_i$	75 V DC	
Effective distance $s_e$	30 mm	
Load resistance $R_L$	$\geq 2$ k $\Omega$	
No-load supply current $I_0$ at $U_e$	$\leq 30$ mA	
Polarity reversal protected	yes	
Short-circuit protected	yes	
Ambient temperature $T_a$	$-10...+75$ °C	
Repeat accuracy $R_{BWN}$	$\leq \pm 60$ $\mu$ m	
Linearity	$\leq \pm 1$ mm	
Limit frequency ( $-3$ dB)	1500 Hz	
Measuring speed	$\leq 5$ m/s	
Temperature coefficient TC	Typical	$+5$ $\mu$ m/K
In the optimum range	Min.	$-20$ $\mu$ m/K
from $+10...+50$ °C	max	$+30$ $\mu$ m/K
Power-on indicator	yes	
Out-of-range indicator	yes	
Degree of protection as per IEC 60529	IP 67	
Housing material	PA mod.	
Connection	Plug connector	
Approval	cULus	
Recommended connector	BKS-S 74/BKS-S 75	

### Out-of-range function

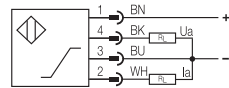
Magnet within working range:

- Output voltage 0...10 V or output current 4...20 mA
- LED not on
- Magnet outside the working range:
- Output voltage approx. 11 V or output current approx. 22 mA
- LED lights up

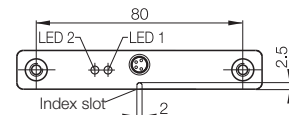
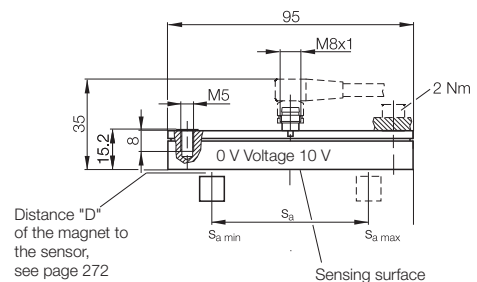
BIL AMD0...



BIL EMD0.../BIL ED0...



Connect either the voltage or current output.



Original mounting brackets and screws are recommended for attaching the BIL.

Please order accessories separately. See page 272



Inductive position sensors

Magneto-inductive position sensors BIL  
Summary  
Micro-BIL  
**BIL**  
Accessories

Inductive position sensors BIP

Basic Information and Definitions

**Voltage 0...10 V, out-of-range 11 V or current 4...20 mA, out-of-range 22 mA**

0...60 mm  
5...55 mm

**BIL0006**

BIL EMD0-T060A-01-S75

At voltage output  $U_{out}$ :  $U_S = 15...30$  V DC,

At current output  $I_{out}$ :  $U_S = 10...30$  V DC

$\leq 10\%$  of  $U_e$

75 V DC

30 mm

At voltage output  $U_{out}$ :  $R_L = \geq 2$  k $\Omega$ ,

At current output  $I_{out}$ :  $R_L = \leq 500$   $\Omega$

$\leq 30$  mA

yes

yes

-10...+75 °C

$\leq \pm 60$   $\mu$ m

$\leq \pm 1$  mm

1500 Hz

$\leq 5$  m/s

+5  $\mu$ m/K

-20  $\mu$ m/K

+30  $\mu$ m/K

yes

yes

IP 67

PA mod.

Plug connector

cULus

BKS-S 74/BKS-S 75

**Voltage 0...10 V or Current 4...20 mA**

0...160 mm  
0...160 mm

**BIL0004**

BIL ED0-P160A-01-S75

At voltage output  $U_{out}$ :  $U_S = 15...30$  V DC,

At current output  $I_{out}$ :  $U_S = 10...30$  V DC

$\leq 10\%$  of  $U_e$

75 V DC

80 mm

At voltage output  $U_{out}$ :  $R_L = \geq 2$  k $\Omega$ ,

At current output  $I_{out}$ :  $R_L = \leq 500$   $\Omega$

$\leq 25$  mA

yes

yes

-10...+75 °C

$\leq \pm 500$   $\mu$ m

$\leq \pm 2.4$  mm

300 Hz

$\leq 5$  m/s

-40  $\mu$ m/K

+120  $\mu$ m/K

-200  $\mu$ m/K

no

no

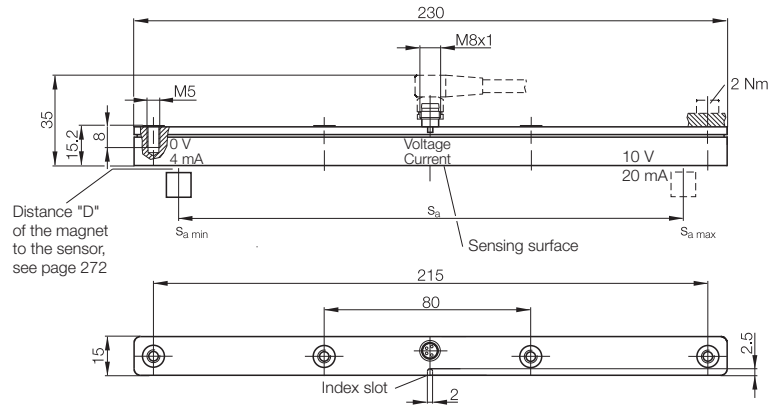
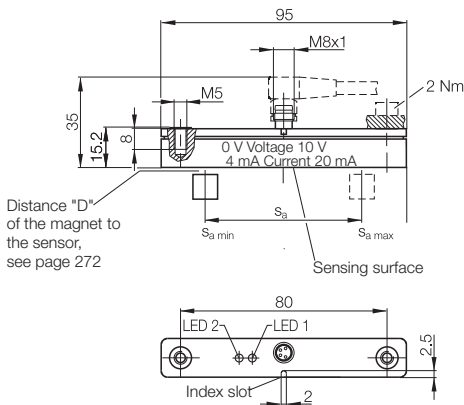
IP 67

PA mod.

Plug connector

cULus

BKS-S 74/BKS-S 75

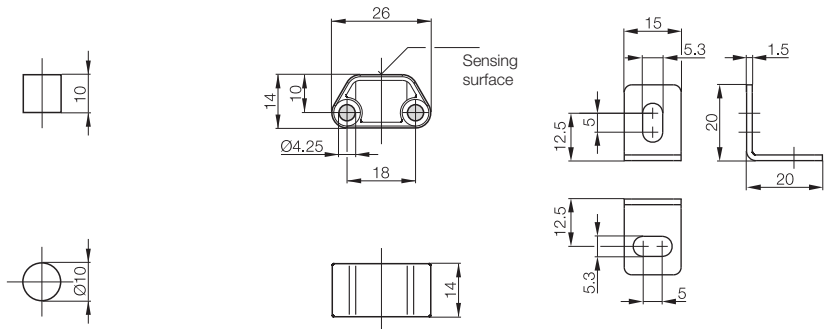


# Magneto-inductive Position Sensors BIL

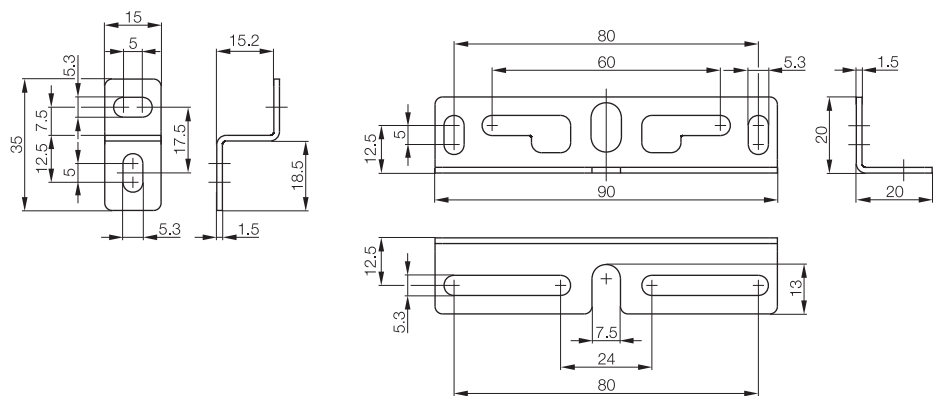
## Accessories



Description	<b>Magnet</b>	<b>Magnet</b>	<b>Mounting brackets</b>
Size	Ø 10×10 mm	26×14×14 mm	
<b>Ordering code</b>	<b>BAM0176</b>	<b>BAM0177</b>	<b>BAM00K4</b>
Part number	BIL 000-MH-A	BIL 001-MH-A	BIL 01-HW-1
Material	Hard ferrite	PA fiberglass reinforced	Stainless steel
Distance "D"	2 mm	1 mm	



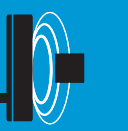
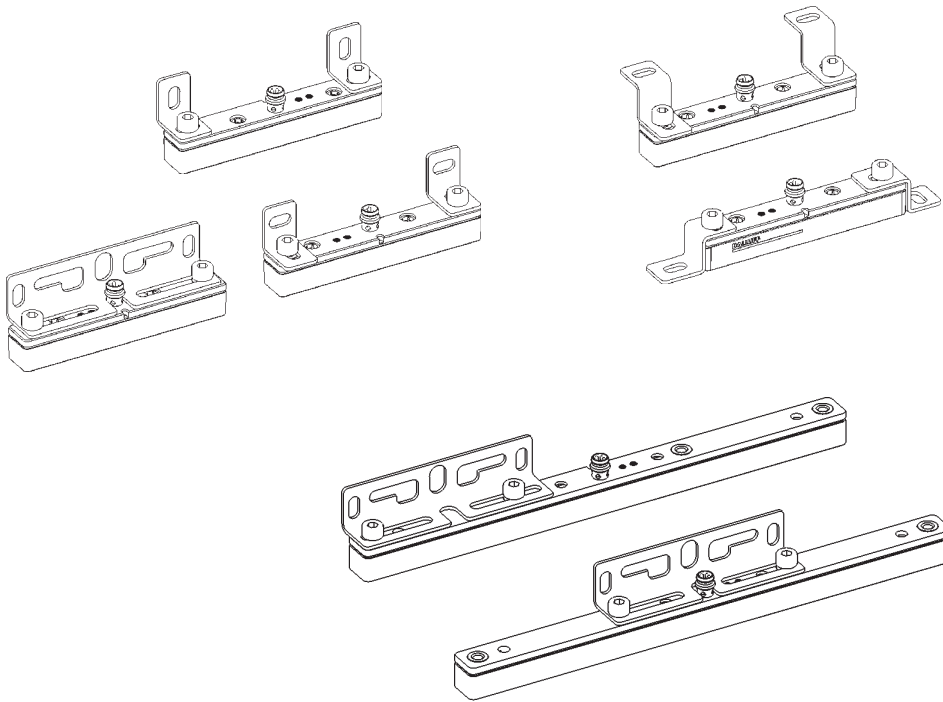
Description	<b>Mounting brackets</b>	<b>Mounting brackets</b>
<b>Ordering code</b>	<b>BAM00K5</b>	<b>BAM00K6</b>
Part number	BIL 01-HW-2	BIL 01-HW-3
Material	Stainless steel	Stainless steel





# Magneto-inductive Position Sensors BIL Accessories

## Mounting examples

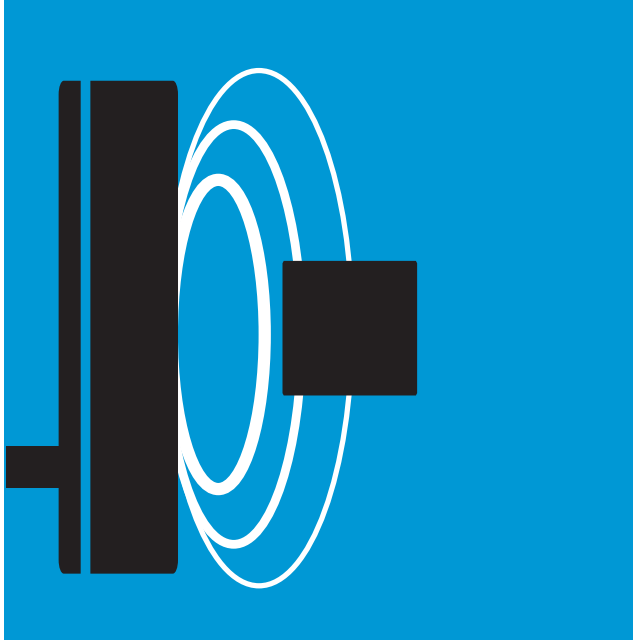


Inductive position sensors

Magneto-inductive position sensors BIL  
Summary  
Micro-BIL  
BIL  
**Accessories**

Inductive position sensors BIP

Basic Information and Definitions

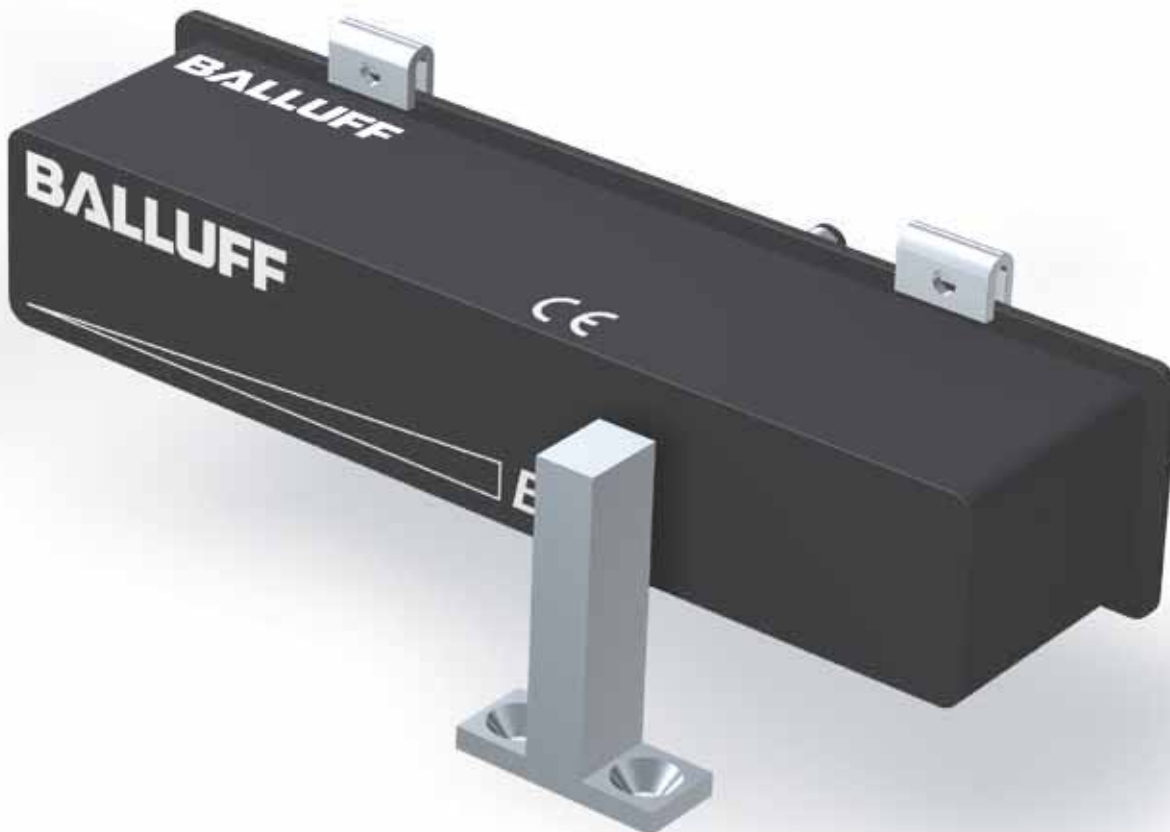
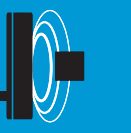


# Inductive Position Sensors

## Inductive Position Sensors BIP

Balluff magneto-inductive position sensors detect positions up to 103 mm away. Position sensors BIP measure without contact and absolutely using a passive non-magnetic magnet. The compact design means these sensors can be easily integrated into the application even when mounting space is extremely tight. Even the magnet can be designed as an integral part of an application. Analog and digital interfaces ensure easy usability.





- Absolute measuring principle, several measuring ranges, teachable
- High repeat accuracy and precision
- Optimal linearity and low temperature drift
- Optimized housing design for clamping distance monitoring
- Distance-proportional IO-Link output signal
- Standard output 0...10 V, 4...20 mA



Ordering code	
Part number	
Output signal	
Length of measuring range is teachable	
Detection range	
Target width (EC80)	
Target distance	
Resolution	
Repeat accuracy	
Linearity deviation	
Ambient temperature	
Connection	
Supply voltage	
Housing material	
Function indicator LED	

# Inductive Position Sensors BIP

## General data



BIP0001	BIP0007	BIP0008	BIP0002	BIP0004	BIP0005
BIP AD0-B014-01-EP02	BIP LD2-T014-01-EP02	BIP CD2-B014-01-EP02	BIP AD2-B040-02-S4	BIP LD2-T040-02-S4	BIP CD2-B040-02-S4
0...10 V	IO-Link	4...20 mA	0...10 V	IO-Link	4...20 mA
7...14 mm			20...40 mm		
0...14 mm			0...40 mm		
8 mm			14 mm		
0.5...2 mm			1...3 mm		
14 µm			40 µm		
±80 µm			±100 µm		
±250 µm			±400 µm		
-25...+70°C			-25...+85°C		
2 m cable			M12 connector		
15...30 V (IO-Link 18...30 V)			15...30 V (IO-Link 18...30 V)		
PA			PA		
yes			yes		



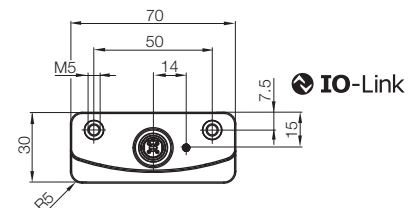
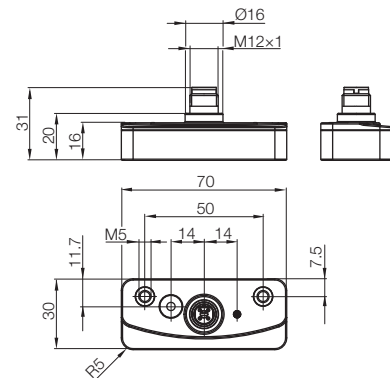
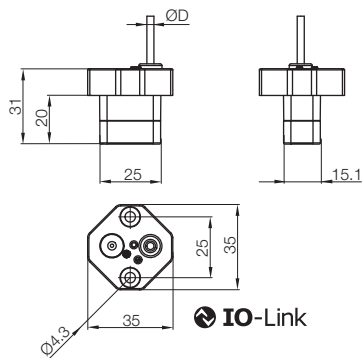
Inductive position sensors

Magneto-inductive position sensors BIL

Inductive position sensors BIP

General data

Basic Information and Definitions





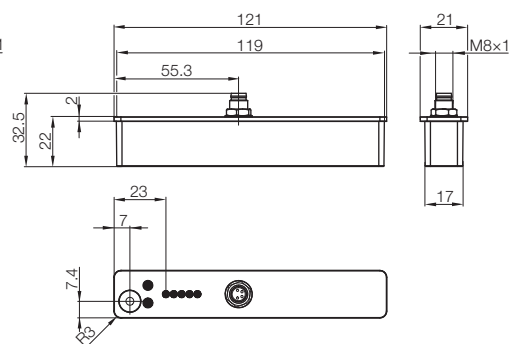
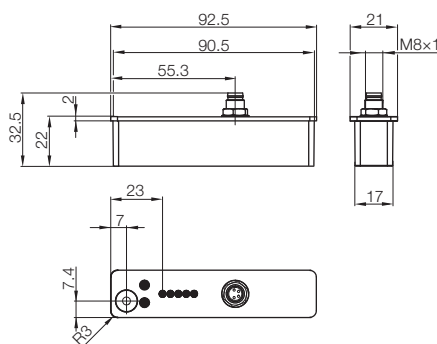
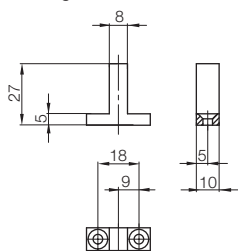
teachable



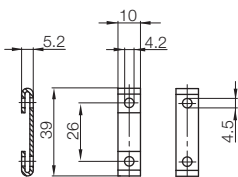
teachable

Ordering code	BIP000C	BIP000E
Part number	BIP ED2-B070-03-S75	BIP ED2-B103-03-S75
Output signal	0...10 V and 4...20 mA	0...10 V and 4...20 mA
Length of measuring range is teachable	35...70 mm	51.5...103 mm
Detection range	0...76.5 mm	0...105 mm
Target width (EC80)	8 mm	8 mm
Target distance	1...3 mm	1...3 mm
Resolution	80 µm	80 µm
Repeat accuracy	±80 µm	±80 µm
Linearity deviation	±300 µm	±400 µm
Ambient temperature	-25...+85°C	-25...+85°C
Connection	M8 connector	M8 connector
Supply voltage	16...30 V	16...30 V
Housing material	PBT	PBT
LED function indicator	yes	yes

Please order **Metal Target** separately.  
Type designation: BAM TG-XE-001  
Ordering code: BAM01CP



Two fastening clips incl. screws are included in the delivery.



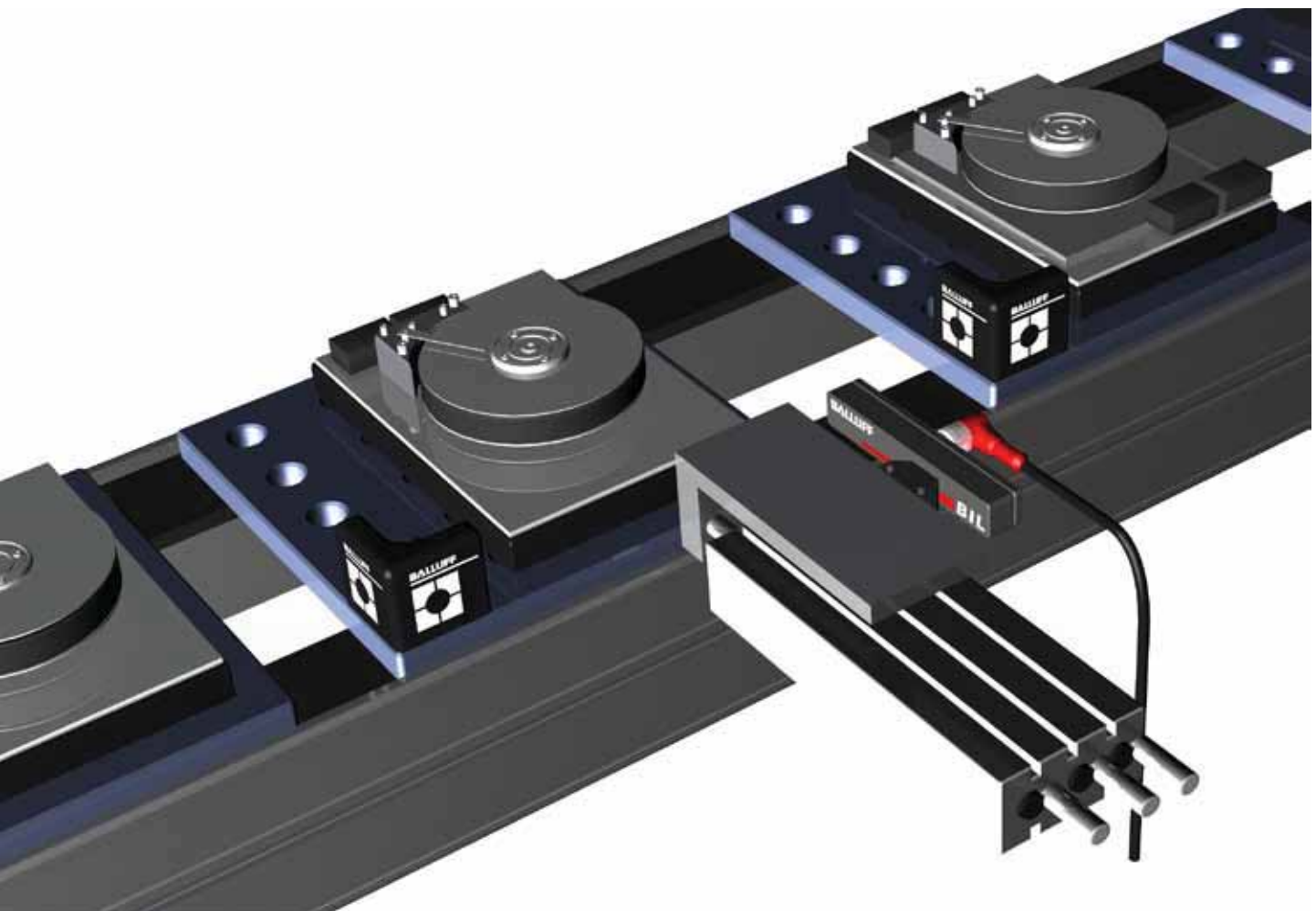
- Absolute measuring principle, several measuring ranges, teachable
- High repeat accuracy and precision
- Wide working temperature range and low temperature drift
- Optimized housing design, IP 67 degree of protection
- Standard output 0...10 V, 4...20 mA

# Inductive Position Sensors BIP

## Application

Inductive position sensors detect linear motion and provide a position-dependent output signal. The compact design makes them easy to integrate and monitor assembly and joining processes.

- Compact and easy to integrate
- Wear-free
- Absolute measuring principle
- High power density – Optimal measurement path ratio to the housing geometry
- Analog output signal or IO-Link



Inductive position sensors

Magneto-inductive position sensors BIL

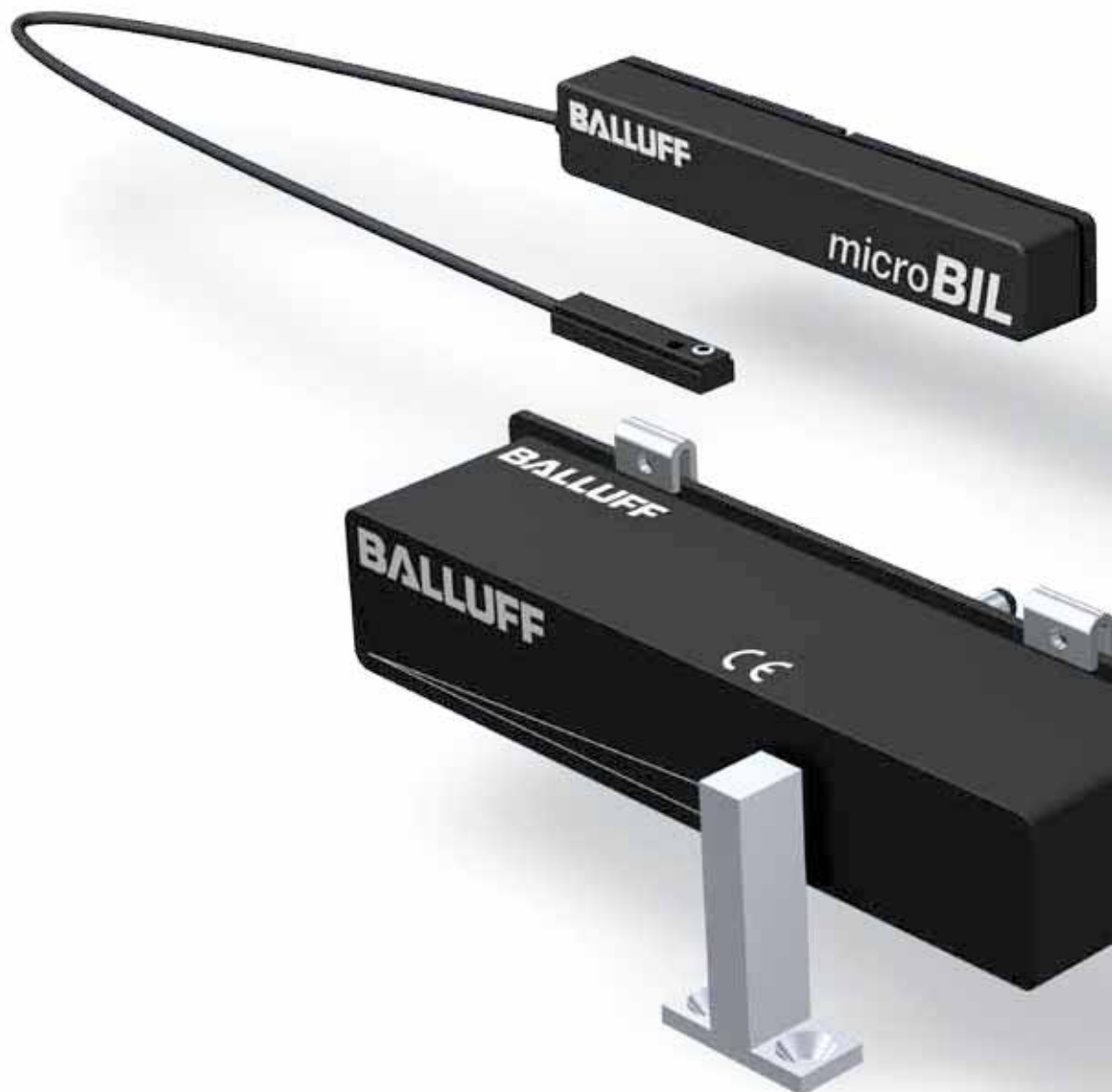
Inductive position sensors BIP

General data

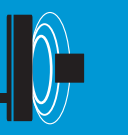
Basic Information and Definitions



# Inductive Position Sensors







## Definitions

### Position sensors with analog output

Position sensors with analog output are sensors that generate a continually varying output signal that depends on the distance between its sensing surface and the location of the magnet relative to the sensor.

### Working range $s_w$

Working range  $s_w$  is the travel path usable for position detection.

### Effective distance $s_e$

Effective distance  $s_e$  is the point in the middle of the linear range  $s_l$  and is used as the reference point for other specifications.

### Linear range $s_l$

Linear range  $s_l$  corresponds to the working range where the displacement sensor exhibits a defined linearity.

### Non-linearity

Non-linearity specifies the maximum deviation of the characteristic from a straight reference line. This value applies to the linear range.

### Measuring speed

Measurement speed indicates the ability to detect the position of an object moving with linear motion. The direction of movement of the object is assumed to be parallel to its sensing face.

### Response time

Response time is the time a sensor requires to reliably and steadily change the output signal. The specified time, which has been determined at the maximum measuring speed, includes both the electrical response time of the sensor and the time for the mechanical change of the damping state.

### Slope

Slope is a measure of the sensitivity of the sensor with respect to a distance change. This physical relationship can be calculated for position sensors as follows:

$$\text{Slope } S \text{ [V/mm]} = \frac{U_{\text{out max}} - U_{\text{out min}}}{s_w \text{ max} - s_w \text{ min}}$$

or

$$\text{Slope } S \text{ [mA/mm]} = \frac{I_{\text{out max}} - I_{\text{out min}}}{s_w \text{ max} - s_w \text{ min}}$$

### Temperature drift

Temperature drift is the shift a point experiences on the actual output curve at different temperatures. Temperature drift is described by the temperature coefficient.

### Temperature coefficient TC

Temperature coefficient TC describes the deviation of the sensor output signal under the effect of a temperature change, and thus represents a quality criterion for the sensor as well.

### Tolerance T

Tolerance T is a variable that defines the manufacturing tolerance band of the output curve, thereby determining the maximum sample deviation.

### Repeat accuracy R

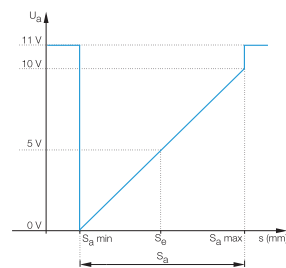
Repeat accuracy R is the value of output signal changes under defined conditions, expressed as a percentage of the upper distance. The measurement must be taken in the lower, upper and center area of the linear range. It corresponds to the repeat accuracy R of proximity switches and is determined under the same standardized conditions (EN 60947-5-2). Position sensors with analog output achieve the value R of  $\leq 5\%$  defined in the standard.

### Repeat accuracy $R_{BWN}$

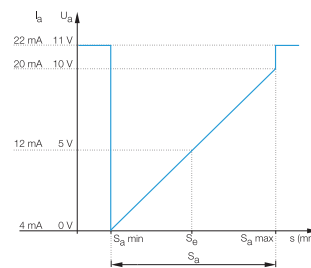
Repeat accuracy  $R_{BWN}$  describes the precision an analog sensor achieves when moving to a measuring point multiple times. This value, specified based on Balluff Factory Standard (BWN Pr. 44), describes the maximum deviation from this measuring point.

### Output curves

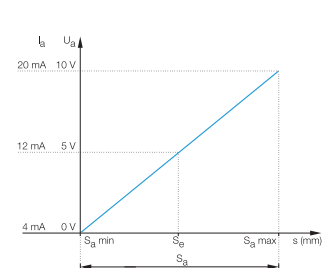
BIL AMD0...



BIL EMD0.../ BIP ED2...



BIL ED0.../ BIP AD.../ BIP CD...



Inductive position sensors

Magneto-inductive position sensors BIL

Inductive position sensors BIP

Basic Information and Definitions

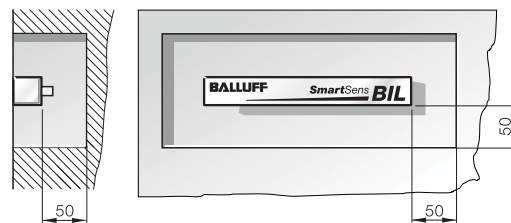
### Installation notices

It is recommended that the BIL and magnet be installed or attached to non-magnetizable materials, such as non-ferrous metals, austenitic steels, plastics, etc. This applies to the installation of both the sensor and the magnet.

Magnetizable materials may affect the geometry and strength of the effective encoder magnetic field.

Magnetic fields near the BIL can affect the output signal depending on their location and strength. This also applies to magnets neighboring BIL sensors.

### Recommended minimum distances from magnetizable materials or other BIL sensors



Values in mm

An area free of metals should be maintained all the way around the BIP's sensing surface in order to minimize the effects on the measuring signal caused by the installation material (see notes in the user's guide).

Invalid measurement signals may result if the sensor detects another metal part aside from the magnet.

