Magnetically Coded Position and Angle Measurement System

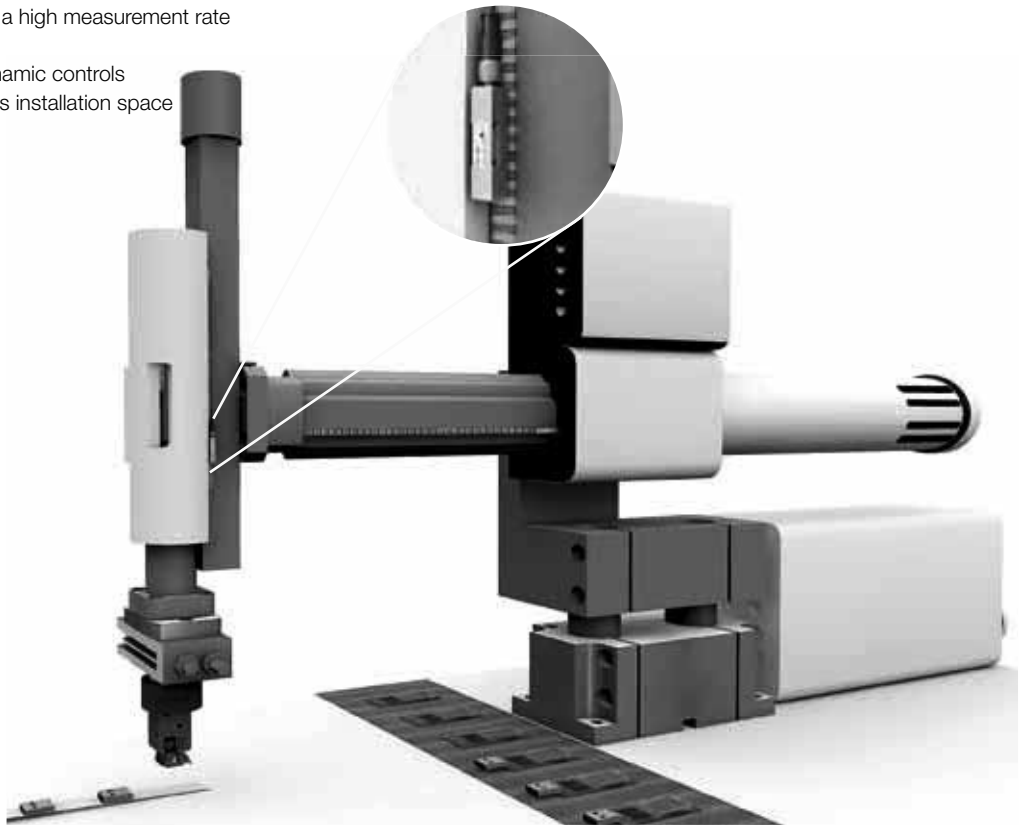
Magnetically Coded
Position and Angle Measurement System
Contents

A large range of position and angle measurement tasks or the dynamic, accurate detection of speed and rotational speeds of rotating shafts are solved in a wide variety of industries with magnetically coded systems.
A magnetic tape system consists of the sensor head, a tape for linear or rotary use, and accessories such as a counter display or guide system. The operating principle is non-contact and therefore wear-free. The measured value is available as an incremental or absolute output signal.
The tapes, magnetized using the Permagnet process specially developed by Balluff, enable the highest accuracy. High flexibility is offered by rolls of magnetic tape, with lengths available up to 48 m. Customized, fabricated solutions as well as special codings achieve optimum results.
The real-time-capable BML position measurement systems make the position information available within microseconds and therefore are optimum feedback systems in electric drive shafts.
By means of its extremely small dimensions and contactless measurement technology, BML allows for integration even in tight spaces or extreme ambient conditions. Expensive downtimes and service work are prevented from the outset by means of the wear-free operating principle; service-intensive encapsulation becomes unnecessary. Moreover, the contactless technology enables extremely high measurement speeds.

Magnetically Coded Position and Angle Measurement System
Applications

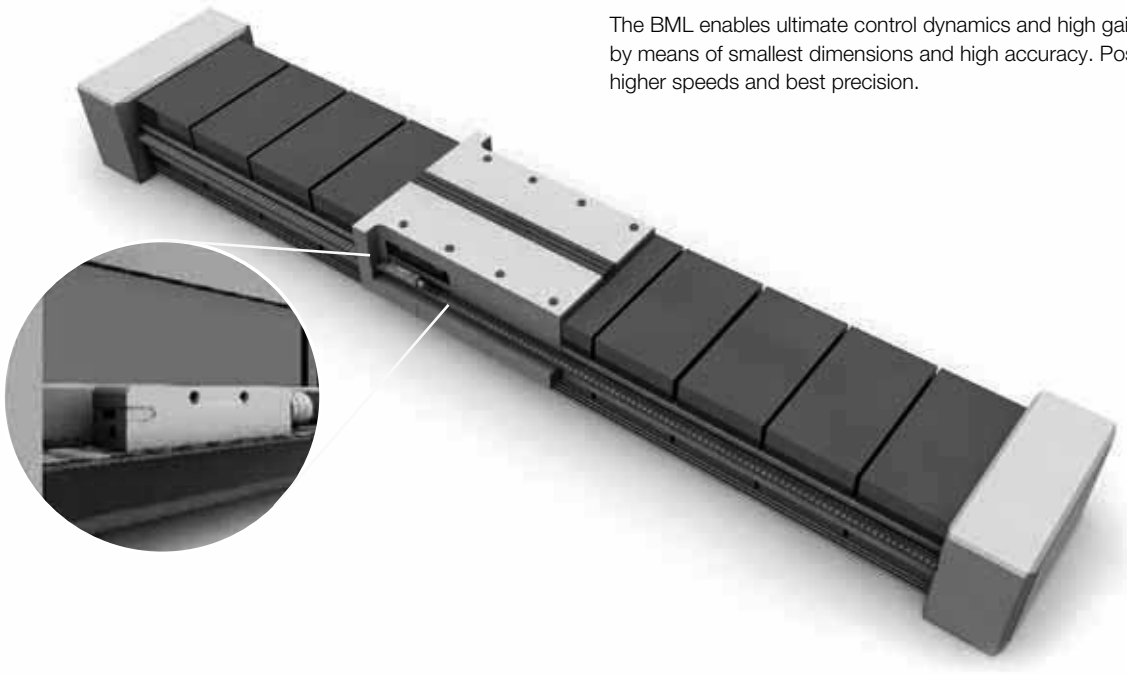
Feedback system for pick and place
With the smallest design of an absolute magnetic position measurement sensor and the option of measuring perpendicular to the tape, the magnetically coded position and angle measurement system BML provides position feedback in highly dynamic applications even in extremely tight spaces.

- Optimum control quality by means of a high measurement rate and linearity
- Additional analog signal for highly dynamic controls
- Unrivaled small metal housing reduces installation space



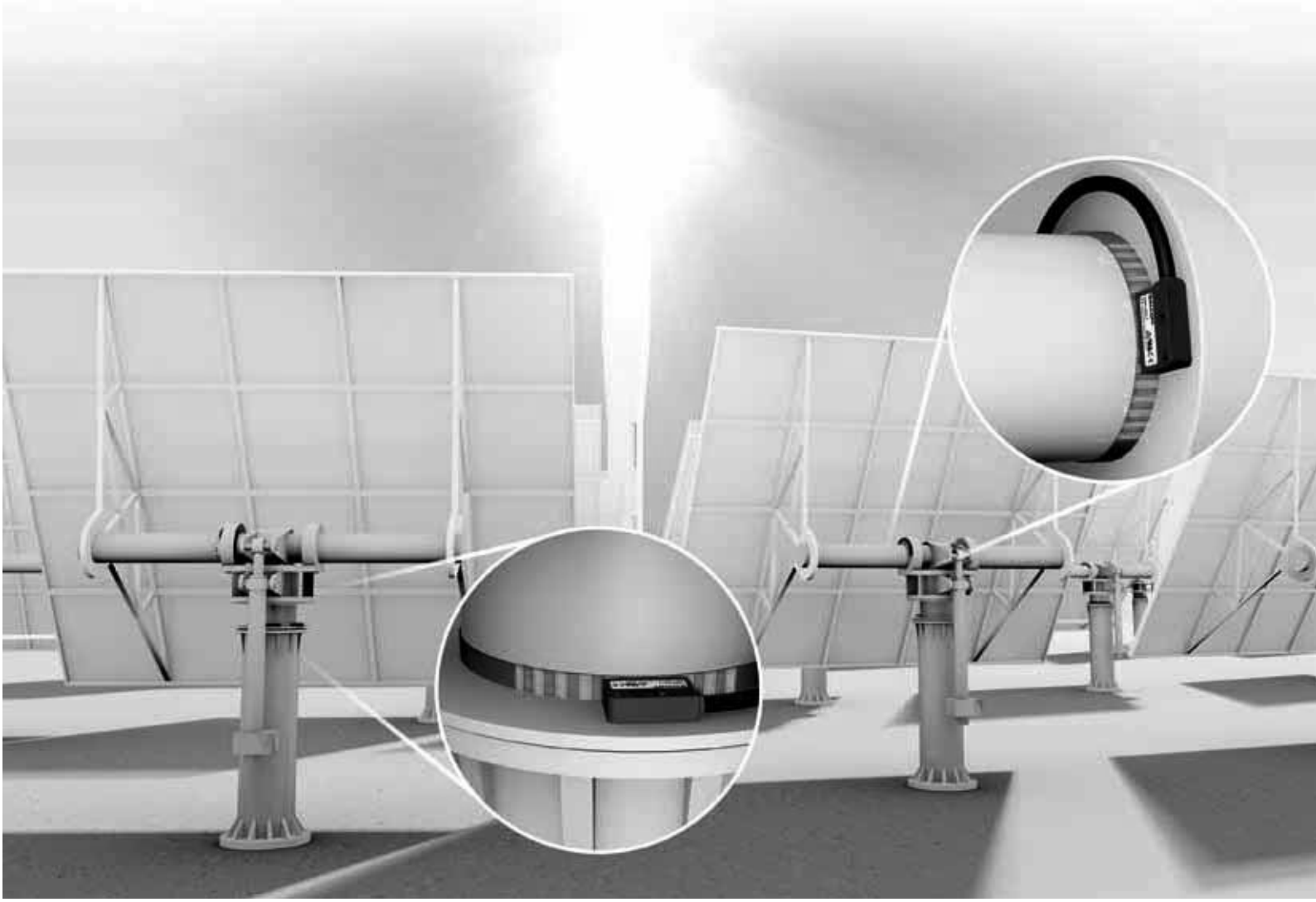
Fastest positioning with a high measurement rate and linearity. Small design reduces installation space.

Magnetically Coded Position and Angle Measurement System
Applications



The BML enables ultimate control dynamics and high gain factors by means of smallest dimensions and high accuracy. Position with higher speeds and best precision.

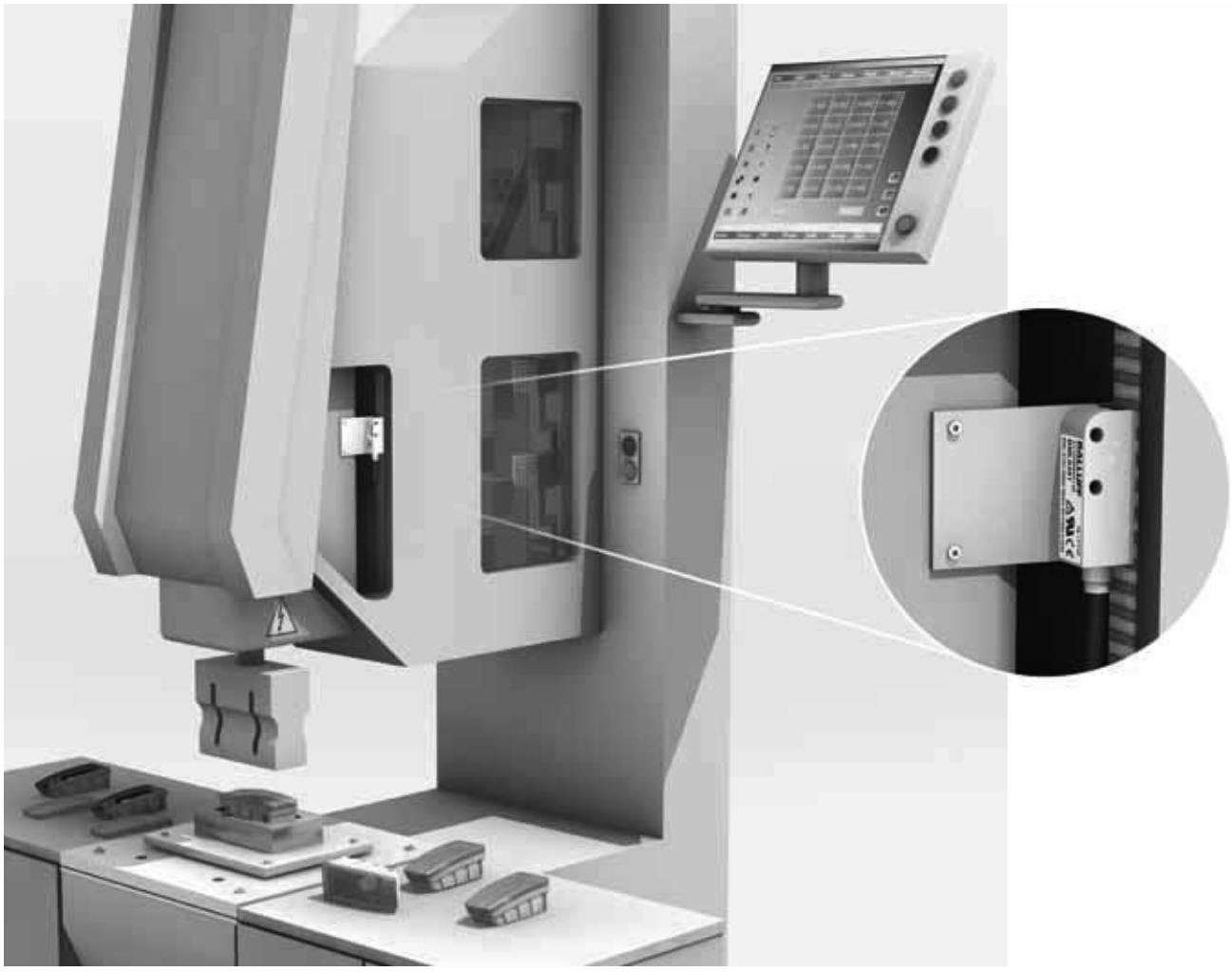
Successfully used for years to point mirrors towards the sun with high accuracy. With BML you achieve the best energy efficiency in concentrated solar power plants and parabolic trough power plants.



Magnetically Coded
Position and Angle Measurement System
Applications

Ultrasonic welding
Exact position feedback for perfect results. By means of direct absolute measurement on the load, inaccuracies and tolerance shifts are reliably eliminated.

- Exact results by means of position detection right on the load support
- Compact design
- Ideal for short strokes
- Long-term reliability
- Wear-free due to non-contact measuring

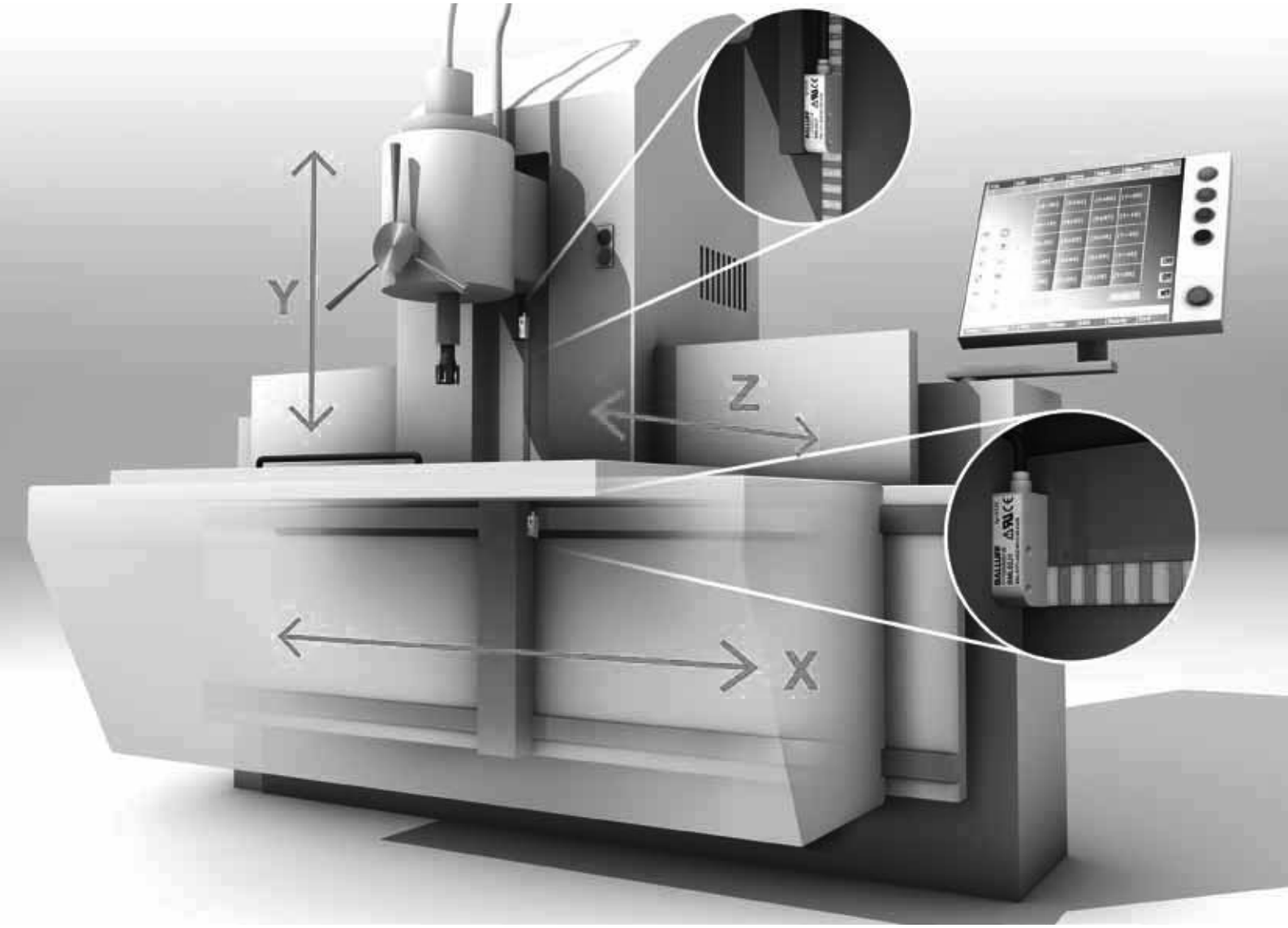


Quickly holds the welding tool on point and with millimeter precision.

Magnetically Coded Position and Angle Measurement System
Applications

The BML measurement system with sensor head and toroidal tape for highly accurate speed monitoring including detection of direction in the drive train.

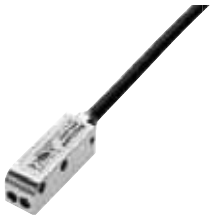
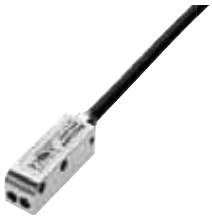
In universal milling machines, magnetically coded position and angle measurement systems BML are used for accurate positioning of the x, y, and z axes.



High precision and extended lengths

Series	**BML-S1H_-M3AA...**	**BML-S1H_-M3CA...**	**BML-S1G0...**		
Resolution	< 1 µm	< 1 µm	1...10 µm		
System accuracy	±7 µm	±7 µm	±20 µm		
Distance to tape	0.1…0.35 mm	0.1…0.35 mm	0.1…0.8 mm		
Linear tape	0...64 mm	0...256 mm	0...48 m		
Rotary tape (magnet ring) Ø 30...300 mm					
Angle measurement with magnetic tape < 360°	■	■			
Interfaces					
Absolute SSI	■	■	■		
Absolute BiSS C	■	■	■		
Incremental digital RS422 (TTL)			■		
Incremental digital HTL (as supply voltage 10...30 V)					
Incremental analog sin/cos (1 V_{pp})	■	■	■		

Magnetic tape	BML-M02-A…-M0009-A	BML-M02-A…-M0028-C	BML-M02-A…-E		
Pole pitch (fine interpolation track)	1 mm	1 mm	2 mm		
From page	22	22	30		


	BML-S1F_-Q...	BML-S1F_-A...	BML-S2B0-Q...	BML-S2E0-Q...	BML-S1C0-Q...	
	1...10 µm	up to 0.25 µm*	5...50 µm	5...50 µm	100...2000 µm	
	±10 µm	±10 µm	±50 µm	±100 µm	±100 µm	
	0.1…0.35 mm	0.1…0.35 mm	0.1...2 mm	0.1...2 mm	0.1...2 mm	
	0...48 m	0...48 m	0...48 m	0...48 m	0...48 m	
	■	■	■	■	■	
	■	■	■	■	■	
	■		■	■		
			■	■	■	
		■				





	BML-M02-I3…	BML-M02-I3…	BML-M02-I4…	BML-M02-I4…	BML-M02-I4…	
	1 mm	1 mm	5 mm	5 mm	5 mm	
	38	38	46	46	46	

* Depending on the customer's electronics

Magnetically Coded Position and Angle Measurement System
Function principle

The high-precision magnetic position and angle measurement system BML consists of a sensor head and a magnetically encoded tape. The sensor head glides over the tape, which is encoded with magnetic poles, with a gap of up to 2 mm.
Incremental systems make available the period changes of the tape encoded with alternating polarity as square- or sine-wave signals at the sensor output. The signals are processed using standard incremental inputs or sine-wave counter inputs of the electronic processor unit.
With the absolute systems, the absolute position is processed as an SSI or BiSS signal at the standard interface of the electronic processor unit. Additionally, the absolute BML makes a real-time incremental signal available for evaluation for fast control applications with high sample rates.

Magnetically coded systems are highly accurate and real-time-capable

Displacement sensors with a magnetically encoded tape are very robust and operate highly accurately and particularly fast as a measurement system. Resolution is down to 1 µm. Accuracy degrees of ±7 µm can be achieved. The BML has no trouble with absolute measurement of travel speeds up to 10 m/s and incremental measurement up to 20 m/s. The absolute position values can be clocked with up to 10 MHz. The measured position value is available in fractions of microseconds. The controller receives the incremental position signal in real time.

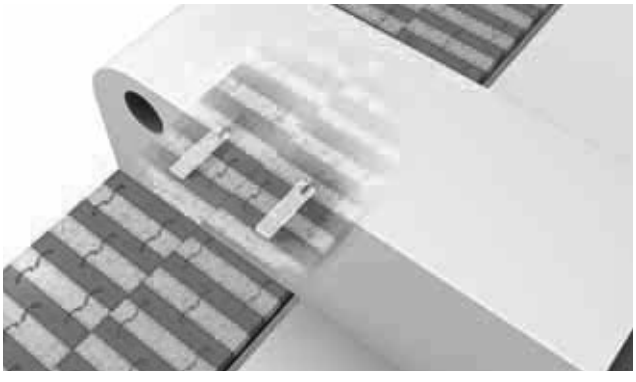
Non-contact and highly robust, even for applications in rough conditions

In addition to the high accuracy and real-time capability, the BiSS interface allows for bidirectional communication including signal error detection. Since the measurement system operates magnetically, unlike optical systems it is highly tolerant of contamination such as oil, swarf, or dust and does not require encapsulation. Unlike with inductive systems, with the BML, metal swarf merely causes attenuation and does not register as a measurement variable. These properties make it excellently suited for use in harsh or dusty industrial environments.

System features of absolute systems

- Non-contact operating principle
- Resolution down to 1 µm
- System accuracy to ±7 µm
- Absolute signal SSI and BiSS C
- Additional real-time signal
- Gap between sensor and tape up to 0.8 mm

Operating principle of absolutely coded position and angle measurement system BML



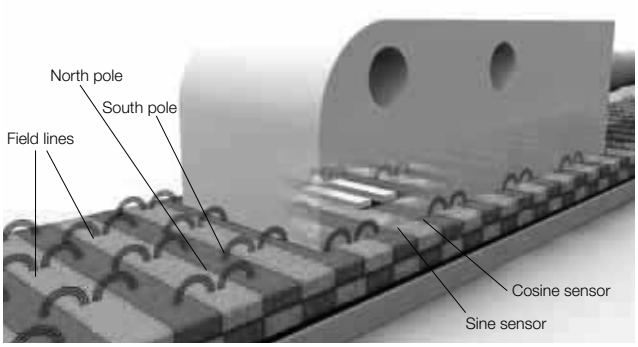
Perpendicular magnetic tape

Magnetically Coded Position and Angle Measurement System
Function principle

System features of incremental systems

- Non-contact operating principle
- Resolution down to 1 µm
- Digital square-wave signals RS422 (TTL) or 10...30 V (HTL)
- Sinusoidal output signals 1 V_{pp}
- Gap between sensor and tape up to 2 mm
- Reference and limit switch function

Operating principle of incremental position and angle measurement system BML



Perpendicular magnetic tape

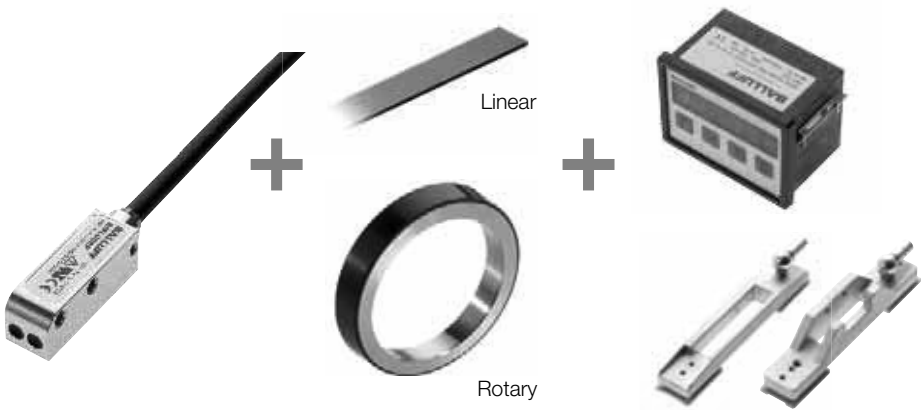
Customizing

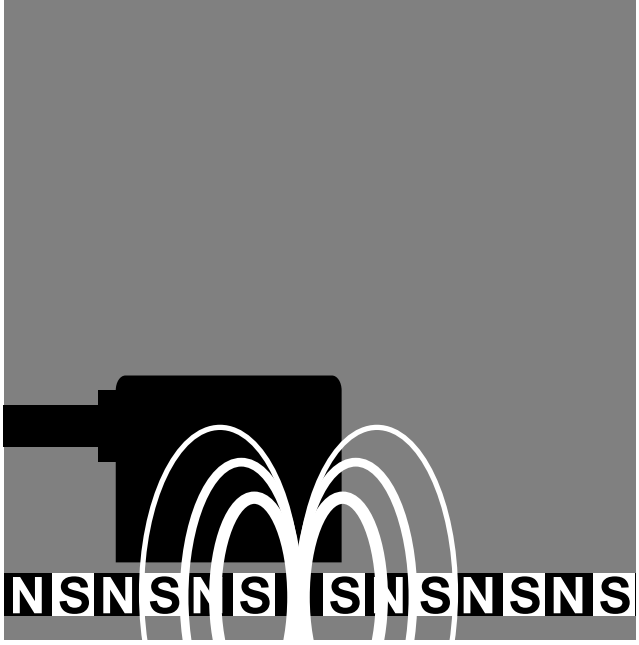
Do you have a very specific application?
Simply contact us! We offer you not just the standard product line, but also customized solutions. Some examples:

- Higher resolutions
- Other interpolation factors
- Higher travel speeds
- Larger read distances
- Special cables/plugs
- Special tape encodings
- Special designs/hubs

System overview

Sensor head | **Tape** | **Accessories**





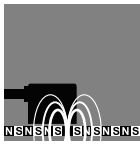
Magnetically Coded Position and Angle Measurement System

S1H Series, 1 µm Absolute

With the S1H sensor series, the magnetically coded position and angle measurement system BML provides high-resolution systems in robust metal housings.

By means of the absolute position detection, the position is immediately output even if the supply voltage fails and the system is switched on again, without a reference run. The particularly compact design and parallel or perpendicular use to the tape enables integration even under very tight installation conditions.

Contents



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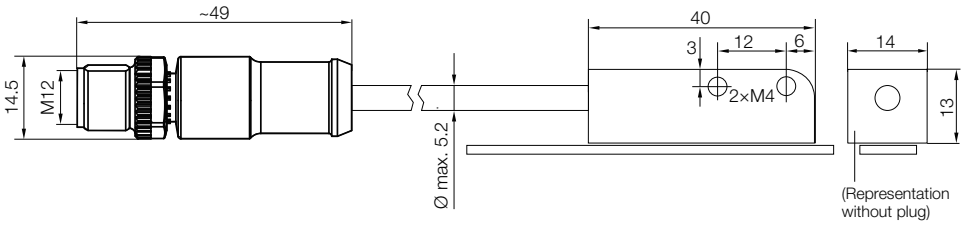
Features
- Absolute measurement system
- Additional sin/cos analog signal for fast control applications
- ±7 µm system accuracy
- 1 µm resolution
- Smallest design
- Rugged metal housing
- Mounted parallel or perpendicular to tape
- Signal period 1 mm

Caution!
Before design, installation and startup please familiarize yourself with the user's guide to be found at www.balluff.com.

Series	**BML-S1H...**
Output signal	Absolute: SSI or BiSS C, additional analog signal sin/cos 1 V_{pp}
Data format	16-bit (BML-S1H...-M3AA-…) or 18-bit (BML-S1H...-M3CA-…)
Resolution	< 1 µm (= 1000/1024 µm per LSB)
Part number	BML-S1H_-_6_C-M3_A-DO-KA00.3-S284
Repeat accuracy	±1 increment
Overall system accuracy	±7 µm
Supply voltage	5 V ±5%
Current consumption at 5 V supply voltage	< 50 mA + Controller current consumption, at 120 Ω load resistance
Max. read distance sensor/tape	0.35 mm (without cover strip)
Max. measuring length	64 mm (…-M3AA-…) or 256 mm (…-M3CA-…)
Pole pitch, analog track	1 mm
Max. travel speed	5 m/s (absolute)
Measurement rate	$f_{STANDARD}$ = 50 kHz (SSI), 10 MHz (BiSS C)
Operating temperature	–20...+80 °C
Storage temperature	–30...+85 °C
Housing material	Aluminum
Degree of protection	IP 67

All data applies in conjunction with tape BML-M02-A33... (see page 27)



Ordering example: sensor head

BML-S1H_-_6_C-M3_A-D0-KA00.3-S284

Approach direction	Interface	Coding	Length coding	Connection
1 Parallel	B BiSS (bidirectional, serial, synchronous)	Q Binary code, rising	A 64	KA00.3-S284
2 Perpendicular	S SSI (serial, synchronous)	R Gray code, rising	C 256	0.3 m cable with M12 connector, 12-pin

Preferred models

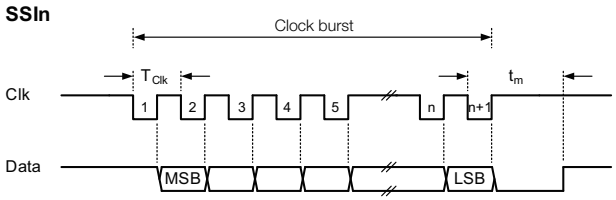
■ **BML-S1H1-S6QC-M3CA-D0-KA00.3-S284 (BML0393)**
Approach direction parallel to the tape, SSI interface, rising binary code, 256 series length coding, pigtail 0.3 m with M12 connector

■ **BML-S1H2-S6QC-M3CA-D0-KA00.3-S284 (BML0394)**
Approach direction perpendicular to the tape, SSI interface, rising binary code, 256 series length coding, pigtail 0.3 m with M12 connector

SSI interface

The SSI interface provides synchronous serial data transmission and is suitable for controllers from different manufacturers.
Reliable signal transmission, even with cable lengths of up to 400 m between controller and transducer. This is guaranteed by the especially interference-freeRS485/422 differential drivers and receivers. Any interference signals are effectively suppressed.
The standard BML is factory-configured with the following settings for the position output, which cannot be modified later:

- BML-S1H_-S6_C-M3A...: 16-bit
- BML-S1H_-S6_C-M3C...: 18-bit
- Binary or Gray-coded

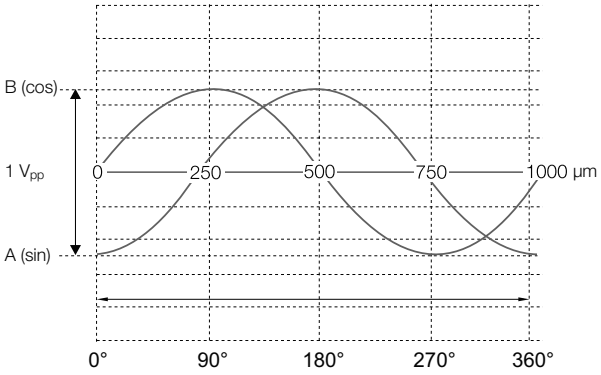


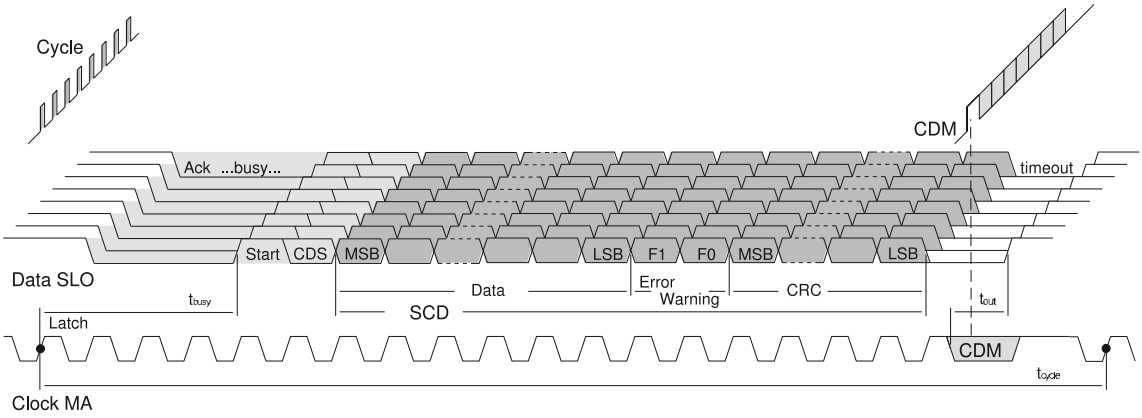
BiSS-C interface

BiSS C stands for the synchronous serial data transmitter and is suitable for controllers from different manufacturers.
Unlike SSI, the data transmission is bidirectional. In BiSS-C mode, settings can be (continuously) configured on the sensor head without interrupting the sensor data.
BiSS C supports CRC, warnings and error messages.

In addition to the SSI or BiSS signal, an analog real-time signal sin/cos 1 V_{pp} is output for highly dynamic control applications.

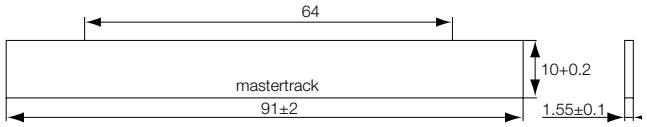
Additional analog real-time signal sin/cos 1 V_{pp}



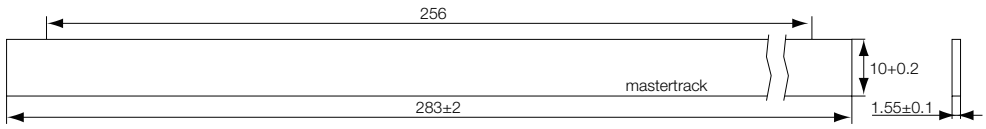


Series	**Magnetic tape**	**Magnetic tape**
Output signal	for BML-S1H with 64 mm measuring length	for BML-S1H with 256 mm measuring length
Ordering code	**BML039J**	**BML039K**
Part number	BML-M02-A33-A3-M0009-A	BML-M02-A33-A3-M0028-C
Length	91 mm	283 mm
Measuring length	64 mm	256 mm
Magnetic tape material	Rubber ferrite, stainless steel carrier	Rubber ferrite, stainless steel carrier
Cover strip material	Stainless steel	Stainless steel

BML039J

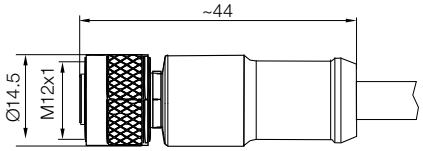


BML039K

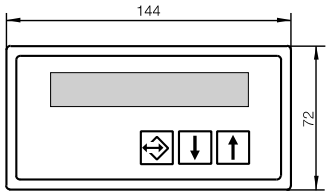


Connection cables

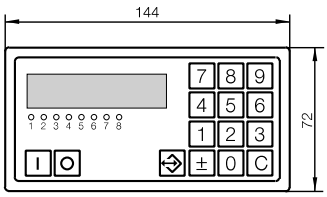
Accessories		**M12 connection cable** 12-pin, female straight	
Series		BML-S1H...-S284	
Length 2 m	**Ordering code**	**BCC09MW**	
	Part number	BCC M41C-0000-1A-169-PS0C08-020-C009	
Length 5 m	**Ordering code**	**BCC09MY**	
	Part number	BCC M41C-0000-1A-169-PS0C08-050-C009	
Length 10 m	**Ordering code**	**BCC09MZ**	
	Part number	BCC M41C-0000-1A-169-PS0C08-100-C009	
Length 15 m	**Ordering code**	**BCC09N0**	
	Part number	BCC M41C-0000-1A-169-PS0C08-150-C009	
Length 20 m	**Ordering code**	**BCC09N1**	
	Part number	BCC M41C-0000-1A-169-PS0C08-200-C009	
Material		PUR, with plug, molded, black	
Description/additional data		■ Cable: Ø 4.9 mm, 12×0.08 mm² ■ Bending radius: 15×D (dynamic), 7.5×D (static) ■ Temperature range: –25 °C...+70 °C	



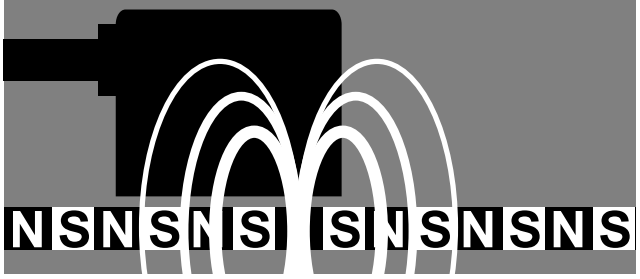
Series	BDD-AM 10-1-SSD	BDD-CC 08-1-SSD
	Digital display	CAM controller
	SSI Interface	SSI Interface
Ordering code	**BAE0069**	**BAE006F**
Part number	BDD-AM 10-1-SSD	BDD-CC 08-1-SSD
Features	■ 7 1/2-digit display with leading sign ■ LED display, 14 mm-high red 7-segment digits ■ Scalable measured values ■ Variable decimal place setting ■ Adjustable zero point ■ Supply voltage 10...32 V ■ 2 programmable relay outputs, each as limit switch/comparator ■ Cam ■ 2-point controller ■ 1 configurable input ■ External zeroing ■ Retention of the display value ■ Integrated transducer supply voltage 300 mA, 5 V or 24 V ■ Insulated DIN housing for mounting in front panel (clamp included in the scope of delivery)	■ 8 programmable outputs ■ 8 directional switching points possible ■ LED display, six 14-mm high red 7-segment digits ■ Switching points can be monitored using LEDs on the front panel ■ 300 switching points can be distributed over up to 15 programs ■ Adjustable top dead center/zero point shift ■ Dynamic dead-time compensation for each individual switching point ■ Multiple BDD-CC 08 units can be wired in parallel ■ Integrated transducer supply voltage 300 mA, 5 V or 24 V ■ Insulated DIN housing for mounting in front panel (clamp included in the scope of delivery)



Housing depth 110 mm



Housing depth 110 mm

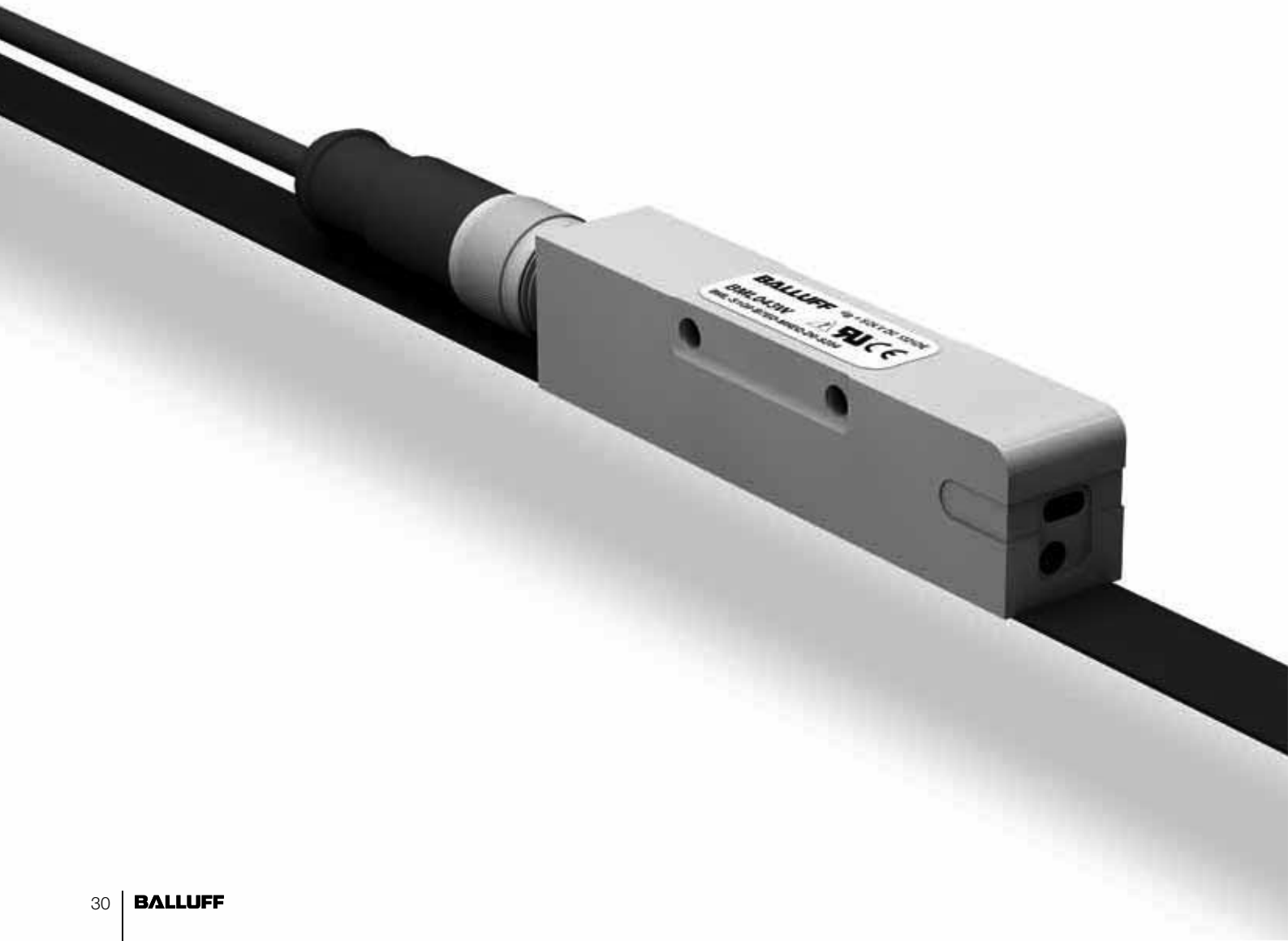


Magnetically Coded Position and Angle Measurement System

S1G Series, 1 µm Absolute

The absolutely coded position measurement system BML-S1G offers high resolutions at large measuring lengths.

The rugged metal housing with stainless steel-encapsulated floor protects against electromagnetic influences and allows for reliable operation even in heavily contaminated environments. With the absolute coding, the position value is available immediately after the system is switched on. The installation tolerances and the LED feedback make it really easy to set up and install the system. The diagnostic function enables fast error detection and thus provides for short downtimes during setup and when errors arise.



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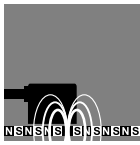

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Features
- Absolute measurement system
- Additional real-time signals for fast control applications (sin/cos or RS422)
- ±20 µm system accuracy
- 1 µm resolution
- Rugged metal housing
- Very easy installation with multicolored LED
- Large installation tolerances
- Signal period 2 mm
- Large length up to 48 m

Ordering example: sensor head

BML-S1G0-_7__-M5E_-_0-S284

Interface

B	BiSS C (bidirectional, serial, synchronous), absolute
S	SSI (serial, synchronous), absolute

Data format

Interface B:

E	Binary, rising (32-bit)

Interface S:

0	Binary, rising (24-bit)
1	Gray, rising (24-bit)
6	Binary, rising (25-bit)
7	Gray, rising (25-bit)
A	Binary, rising (26-bit)
B	Gray, rising (26-bit)
E	Binary, rising (32-bit)
F	Gray, rising (32-bit)

Resolution per LSB

C	~ 0.98 µm
D	1 µm
E	2 µm
F	5 µm
G	10 µm

Additional real-time signal

Z-9	None
A-D	Analog (sin/cos), period 2 mm
Q-D	Digital, 0.12 µs edge separation
Q-G	Digital, 1 µs edge separation
Q-L	Digital, 8 µs edge separation
Q-P	Digital, 24 µs edge separation

Connection

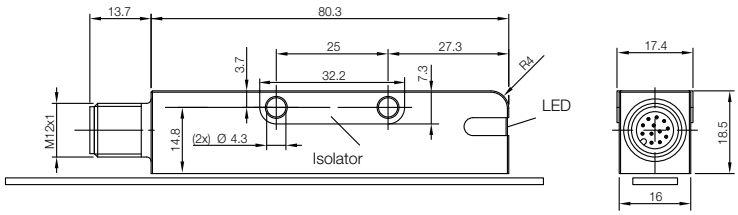
S284	M12 connector, axial with pin contacts, 12-pin

Preferred models
- **BML-S1G0-S7ED-M5EA-D0-S284 (BML041H)**
  SSI interface, 1 µm resolution, additional real-time signal sin/cos, M12 connector, 12-pin
- **BML-S1G0-B7ED-M5EZ-90-S284 (BML042T)**
  BiSS-C interface, 1 µm resolution, without real-time signal, M12 connector, 12-pin

S1G Series, Absolute
SSI Interface, BiSS-C interface

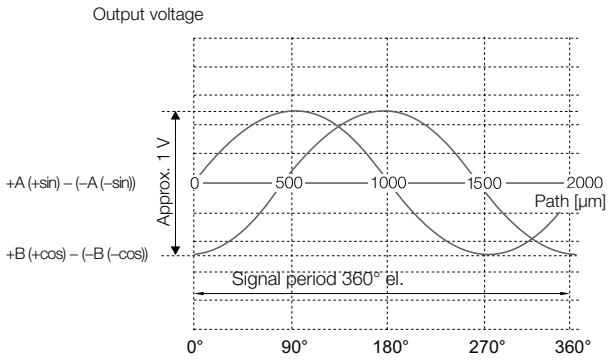
Series	**BML-S1G...**
Output signal	Absolute: SSI or BiSS C, additional real-time signal sin/cos, 1 V_{pp} or RS422
Data format	24, 25, 26 or 32 bit
Resolution	~0.98, 1, 2, 5 or 10 µm
Part number	BML-S1G0-B/S7_ _-M5E_-_0-S284
Repeat accuracy	±1 increment
Overall system accuracy	±20 µm
Supply voltage	5 V ±5 % and 10…28 V DC
Current consumption	70 mA at 24 V DC supply voltage
Max. read distance sensor/tape	0.8 mm (without cover strip)
Max. measuring length	48 m
Pole pitch, fine interpolation track	2 mm
Max. travel speed	10 m/s
Measurement rate	$f_{STANDARD}$ = 50 kHz (SSI), $f_{STANDARD}$ = 10 MHz (BiSS C)
Operating temperature	–20...+70 °C
Storage temperature	–25...+85 °C
Housing material	Zinc, surface coated
Degree of protection	IP 67

All data applies in conjunction with tape BML-M02-A33... (see page 35)



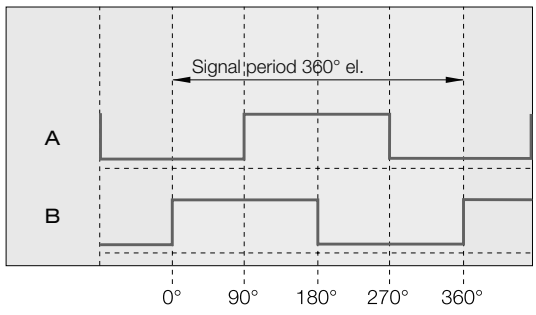
Additional analog, incremental real-time signal
(BML-S1G0-_ _ _ _-M5E**A**-_0-…)

In addition to the SSI or BiSS signal, an analog real-time signal sin/cos 1 V_{pp} is output for highly dynamic control applications.



Additional digital, incremental real-time signal
(BML-S1G0-_ _ _ _-M5E**Q**-_0-…)

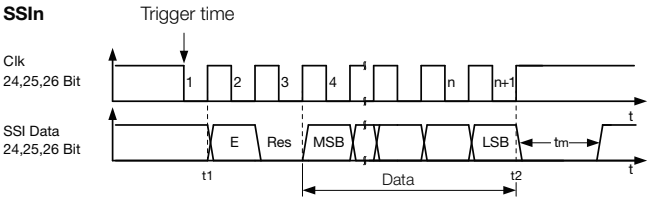
In addition to the SSI or BiSS signal, a digital differential voltage signal is output to the controller (RS422).



SSI Interface

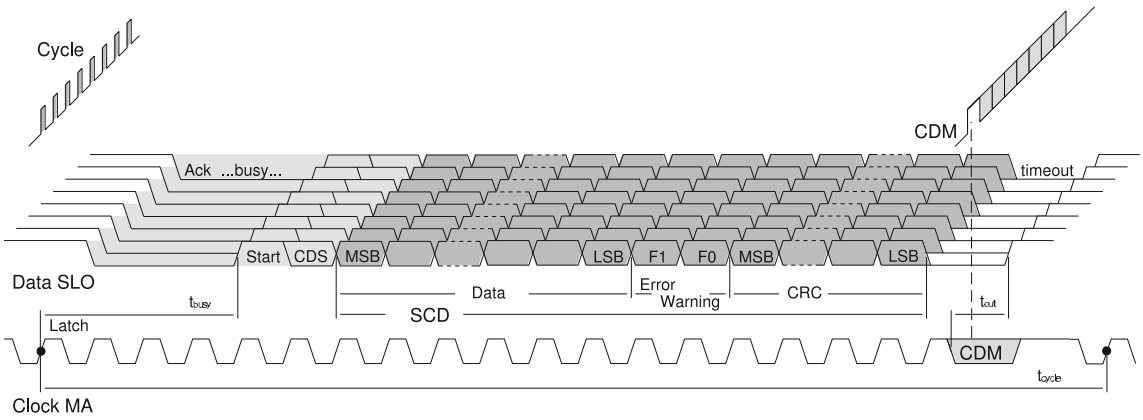
The SSI interface provides synchronous serial data transmission and is suitable for controllers from different manufacturers.
Reliable signal transmission, even with cable lengths of up to 400 m between controller and transducer. This is guaranteed by the especially interference-freeRS485/422 differential drivers and receivers. Any interference signals are effectively suppressed.
The standard BML is factory-configured with the following settings for the position output, which cannot be modified later:

- optionally 24, 25, 26 or 32-bit
- Binary or Gray-coded



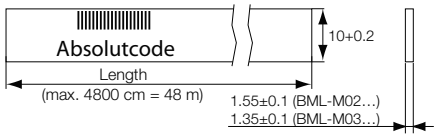
BiSS-C interface

BiSS C stands for the synchronous serial data transmitter and is suitable for controllers from different manufacturers.
Unlike SSI, the data transmission is bidirectional. In BiSS-C mode, settings can be (continuously) configured on the sensor head without interrupting the sensor data.
BiSS-C supports CRC, warnings and error messages.



Caution!
Before design, installation and startup please familiarize yourself with the user's guide to be found at www.balluff.com.

Series	**Magnetic tape**
Output signal	for BML-S1G
Ordering code	
Part number	BML-M02-A55-A3-M0100-E
Length	e.g. 100 cm
Magnetic tape material	Rubber ferrite, stainless steel carrier
Cover strip material	Stainless steel



Ordering example: magnetic tape

BML-M0_-A55-A_-M_ _ _ _-E

Thickness

2 1.55 mm
Has an adhesive strip for fastening
(with protective foil)
3 1.35 mm
Without adhesive strip

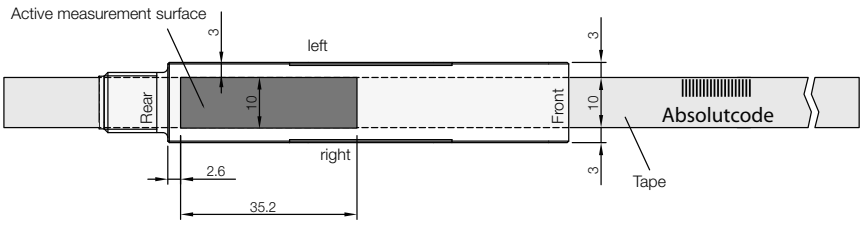
Cover strip

0 No cover strip
3 With cover strip

Length in cm

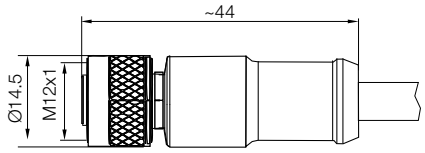
Order length,
max. 4800 = 48 m

Positioning

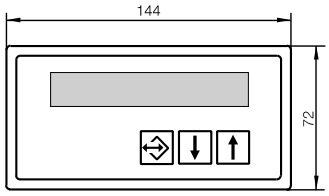


Connection cables

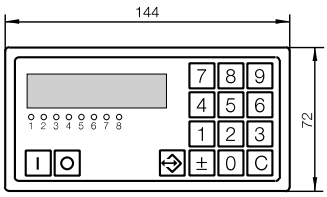
Accessories		**M12 connection cable** 12-pin, female straight	
Series		BML-S1H...-S284	
Length 2 m	**Ordering code**	**BCC09MW**	
	Part number	BCC M41C-0000-1A-169-PS0C08-020-C009	
Length 5 m	**Ordering code**	**BCC09MY**	
	Part number	BCC M41C-0000-1A-169-PS0C08-050-C009	
Length 10 m	**Ordering code**	**BCC09MZ**	
	Part number	BCC M41C-0000-1A-169-PS0C08-100-C009	
Length 15 m	**Ordering code**	**BCC09N0**	
	Part number	BCC M41C-0000-1A-169-PS0C08-150-C009	
Length 20 m	**Ordering code**	**BCC09N1**	
	Part number	BCC M41C-0000-1A-169-PS0C08-200-C009	
Material		PUR, with plug, molded, black	
Description/additional data		■ Cable: Ø 4.9 mm, 12×0.08 mm² ■ Bending radius: 15×D (dynamic), 7.5×D (static) ■ Temperature range: –25 °C...+70 °C	



Series	BDD-AM 10-1-SSD	BDD-CC 08-1-SSD
	Digital display	CAM controller
	SSI Interface	SSI Interface
Ordering code	**BAE0069**	**BAE006F**
Part number	BDD-AM 10-1-SSD	BDD-CC 08-1-SSD
Features	■ 7 1/2-digit display with leading sign ■ LED display, 14 mm-high red 7-segment digits ■ Scalable measured values ■ Variable decimal place setting ■ Adjustable zero point ■ Supply voltage 10...32 V ■ 2 programmable relay outputs, each as limit switch/comparator ■ Cam ■ 2-point controller ■ 1 configurable input ■ External zeroing ■ Retention of the display value ■ Integrated transducer supply voltage 300 mA, 5 V or 24 V ■ Insulated DIN housing for mounting in front panel (clamp included in the scope of delivery)	■ 8 programmable outputs ■ 8 directional switching points possible ■ LED display, six 14-mm high red 7-segment digits ■ Switching points can be monitored using LEDs on the front panel ■ 300 switching points can be distributed over up to 15 programs ■ Adjustable top dead center/zero point shift ■ Dynamic dead-time compensation for each individual switching point ■ Multiple BDD-CC 08 units can be wired in parallel ■ Integrated transducer supply voltage 300 mA, 5 V or 24 V ■ Insulated DIN housing for mounting in front panel (clamp included in the scope of delivery)



Housing depth 110 mm

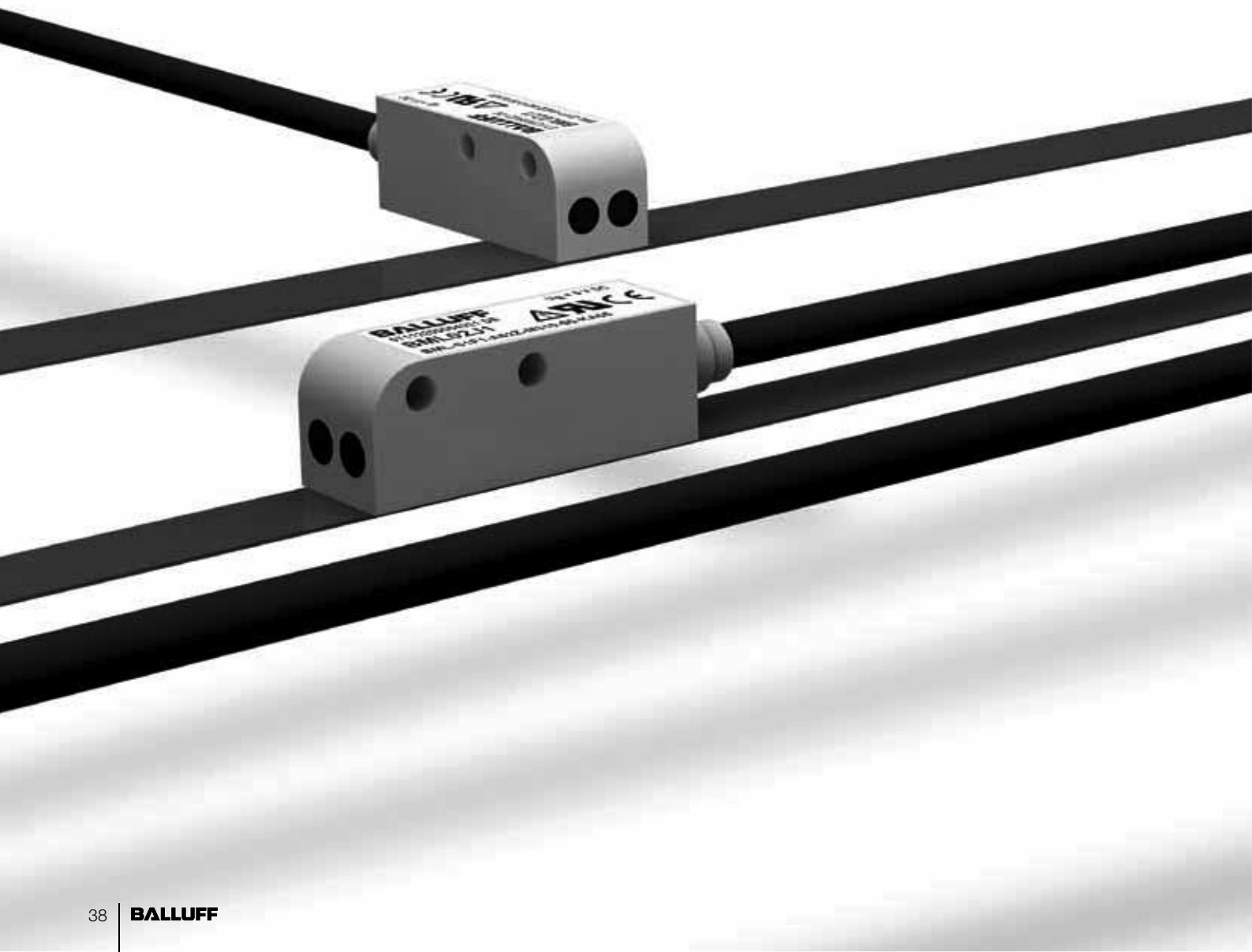


Housing depth 110 mm

Magnetically Coded Position and Angle Measurement System

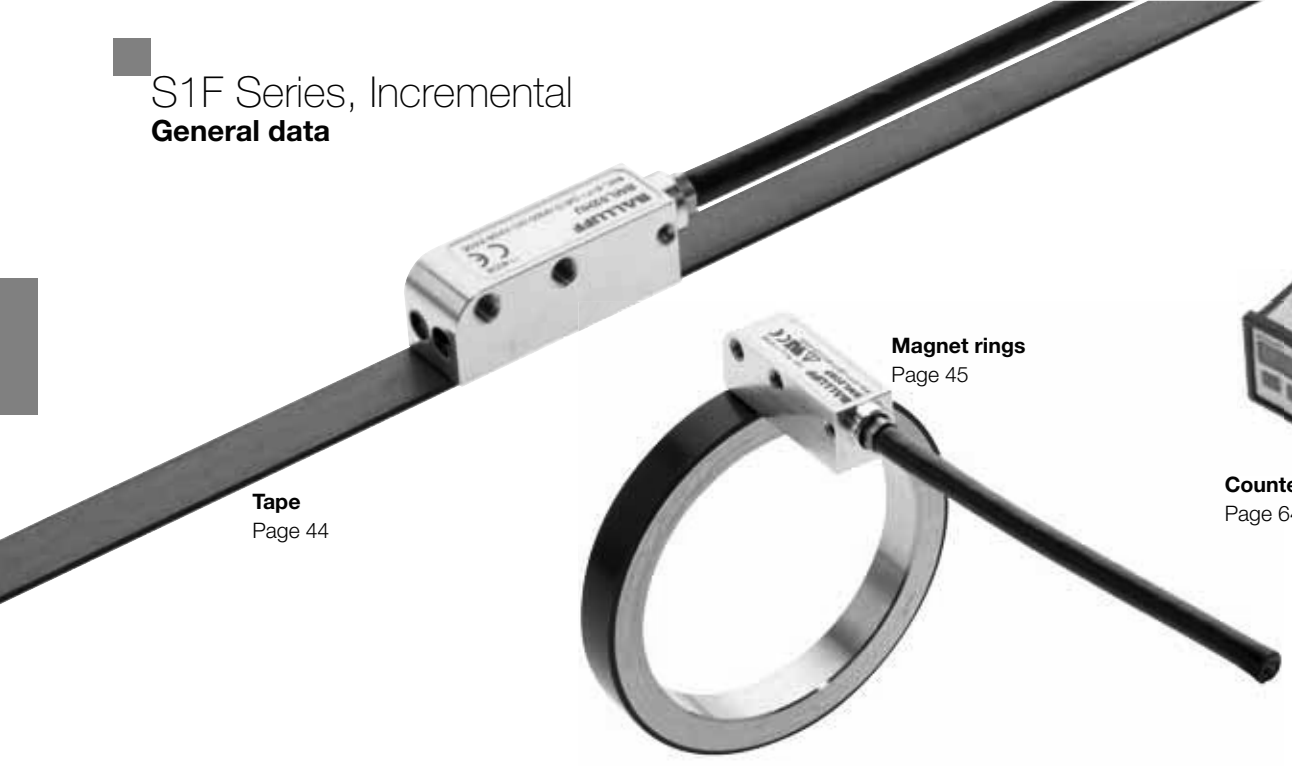
S1F Series, Incremental

With the S1F sensor heads, the magnetically coded position and angle measurement system BML provides high-resolution designs in robust metal housings. They also detect reference points on the tape. The S1F series can be used either parallel or perpendicular. The S1F series has an extremely compact design and is therefore easy to integrate in systems with restricted installation space.



Contents

S1F Series, Incremental
General data



Tape
Page 44

Magnet rings
Page 45

Counter display
Page 64

Features
- 1 µm resolution (digital)
- ±10 µm system accuracy permits high gain factors
- High repeat accuracy ±1 increment
- Reference signal
- Smallest design
- Rugged metal housing
- Mounted parallel or perpendicular to tape
- Pole pitch 1 mm

Ordering example: sensor head, pole width 1 mm

BML-S1F_-A62Z-M3_0-90-_ _ _ _ (with analog output signal sin/cos)
BML-S1F_-Q61_-M3_0-_0-_ _ _ _ (with digital square-wave signal RS422)

Approach direction
1 Parallel
2 Perpendicular

Resolution
D 1 µm
E 2 µm
F 5 µm
G 10 µm

Reference signal
0 None
1 Individually or fixed-periodic
2 Pole-periodic, only with digital design …-Q61_-…

Min. Edge separation*
D 0.12 µs
E 0.29 µs
F 0.48 µs
G 1 µs
H 2 µs
K 4 µs
L 8 µs
N 16 µs
P 24 µs

Connection
KA02 PUR cable 2 m
KA05 PUR cable 5 m
KA10 PUR cable 10 m
KA15 PUR cable 15 m
KA20 PUR cable 20 m

Sensor connectors (e.g. SUB-D) are available on request.
Better resolution and accuracy available on request.

*** For selection guide, see page 42:**
Resolution – speed – edge separation

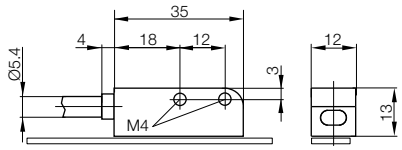
Preferred models
- **BML-S1F1-A62Z-M310-90-KA05 (BML02J1):**
  Installed parallel to tape, analog output sin/cos, with reference signal, 5 m cable
- **BML-S1F1-Q61D-M310-F0-KA05 (BML001A):**
  Installed parallel to tape, RS422 digital signal, with reference signal, 5-m cable, resolution 1 µm, edge separation 0.48 µs, max. travel speed 1 m/s

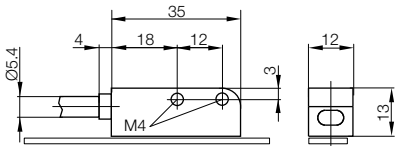
Compact and high-resolution

S1F Series, Incremental
General data

Series	**BML-S1F_-Q...**	**BML-S1F_-A...**
Output signal	Digital square-wave signals RS422 A, /A, B, /B, Z, /Z	Sinusoidal analog signals sin/cos A, /A, B, /B, Z, /Z
Resolution	1 µm, 2 µm, 5 µm or 10 µm	Depends on evaluation, up to 0.25 µm
Pole pitch signal periods	1 mm	1 mm
Part number	BML-S1F_-Q61_-M3_ 0-_0-_ _ _ _	BML-S1F_-A62Z-M3_ 0-90-_ _ _ _
Output voltage (A/B/Z)	RS422 to DIN 66259	1 V_{pp}
Overall system accuracy	±10 µm	±10 µm
Supply voltage	5 V ±5%	5 V ±5%
Current consumption at 5 V supply voltage	< 50 mA + current consumption of the controller (depending on internal resistance)	< 50 mA + current consumption of the controller (depending on internal resistance)
Max. read distance sensor/tape	0.35 mm	0.35 mm
Max. travel speed	20 m/s	20 m/s
Operating temperature	–20...+80 °C	–20...+80 °C
Housing material	Aluminum	Aluminum
Degree of protection	IP 67	IP 67

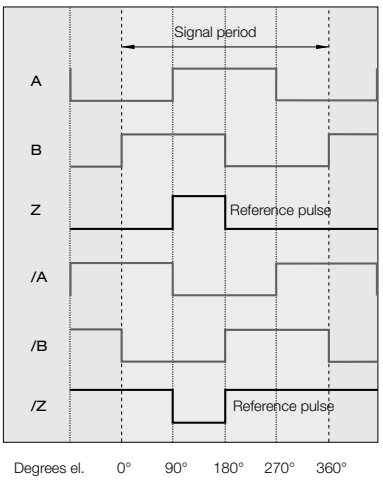
All specifications in conjunction with tape BML-...-I34... (see page 44).

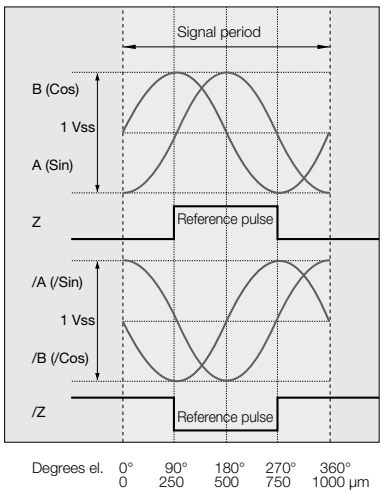




Digital square-wave signals RS422
- RS422 square-wave signals in acc. with DIN 66259
- Direction information = 90° phase-shifted
- Resolution = edge separation A/B
- Differential signals
- Reference pulse (optional)
- Terminating resistor ≥ 120 ohms (usually integrated in the processor unit)
- Forward movement: A before B

Sinusoidal analog signals 1 V_{pp}
- Sinusoidal voltage signals
- Direction information = 90° phase-shifted
- Signal period = 1000 µm
- Differential signals
- Reference pulse (optional)
- Terminating resistor ≥ 120 ohms (usually integrated in the processor unit)
- Forward movement: A before B





Caution!
Before design, installation and startup please familiarize yourself with the user's guide to be found at www.balluff.com.

The position measurement system BML must be exactly matched to the respective application. Use the technical selection guide.
For additional examples, see Basic Information and Definitions on page 68

Compatibility of the counting frequency of the controller and BML

Each sensor with a digital output signal has a characteristic minimum edge separation gap that the higher-level controller must reliably detect. We therefore recommend selecting a controller with a counting frequency that is higher than the theoretically calculated counting frequency.

Maximum travel speed, resolution and edge separation

The following table shows the relationship between the selected resolution of the sensor head, the minimum edge separation and the potential travel speed:

Min. edge separation		Counting frequency (signal periods)	V_{max} in accordance with edge separation and resolution Mechanical resolution			
			D 1 µm	**E** 2 µm	**F** 5 µm	**G** 10 µm
D	0.12 µs	2083.33 kHz	5 m/s	10 m/s	20 m/s	20 m/s
E	0.29 µs	862.07 kHz	2 m/s	4 m/s	10 m/s	10 m/s
F	0.48 µs	520.83 kHz	1 m/s	2 m/s	5.41 m/s	5.41 m/s
G	1 µs	250.00 kHz	0.65 m/s	1.3 m/s	2.95 m/s	2.95 m/s
H	2 µs	125.00 kHz	0.3 m/s	0.6 m/s	1.54 m/s	1.54 m/s
K	4 µs	62.50 kHz	0.15 m/s	0.3 m/s	0.79 m/s	0.79 m/s
L	8 µs	31.25 kHz	0.075 m/s	0.15 m/s	0.34 m/s	0.34 m/s
N	16 µs	15.63 kHz	0.039 m/s	0.079 m/s	0.19 m/s	0.19 m/s
P	24 µs	10.42 kHz	0.026 m/s	0.052 m/s	0.13 m/s	0.13 m/s

Table 1: Selection guide for maximum travel speed of the S1F series

Rotary applications
The position measurement system BML enables the detection of rotary movements. The rotary tapes can be matched to the respective application. Use the technical selection guide for rotary systems.

Determining the pulses per rotation
The number of required pulses per rotation varies depending on the application. It determines the resolution of the sensor head and the diameter of the magnet ring.

Sensor head resolution	**Pulses/revolution with 4-fold evaluation**		
	Ø of magnet ring, outside		
	72 mm	**75 mm**	**122 mm**
Ordering code	**BML002K**	**BML01KM**	**BML01EW**
D = 1 µm	228000	238000	384000
E = 2 µm	114000	119000	192000
F = 5 µm	45600	47600	76800
G = 10 µm	22800	23800	38400

Table 2: Selection guide for magnet rings from the S1F series

Maximum speed
The speed and the diameter of the magnet ring determine the speed of the ring on the sensor head.
The maximum travel speed that the sensor can still identify depends on the resolution and the edge separation of the sensor head. Resolution and edge separation can be selected. A maximum speed is then calculated using the following formula:

$$\text{Max. speed (rpm)} = \frac{60 \times \text{max. travel speed (m/s)}}{\pi \times \text{magnet ring diameter (m)}}$$

Refer to Table 1 for the maximum travel speed. When selecting a maximum speed for the application, we recommend using a value 10% lower than this value.

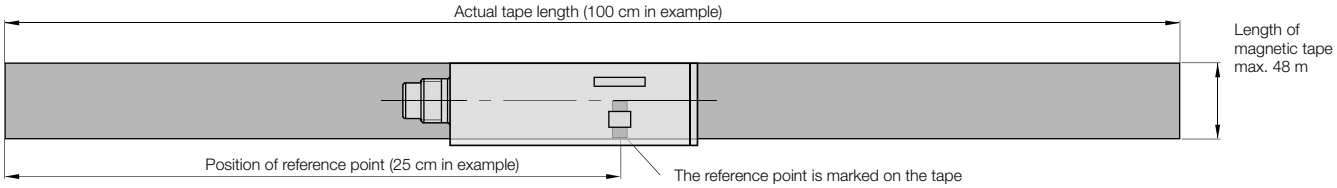
Example:
You are using a BML-S1F sensor with a resolution of 5 µm (F) and a minimum edge separation of 1 µs (G). For this sensor, Table 1 gives a maximum travel speed of 2.95 m/s.

If the magnet ring diameter is 72 mm = 0.072 m, a speed of 783 rpm can be achieved according to the formula.
The maximum speed of 705 rpm should not be exceeded.

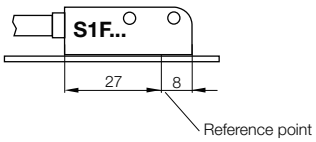
Look-up table for max. RPM, see Table 2, page 77.

Accessories can be found on **page 62.**

Position of single reference point using example of BML-M02-I34-A3-M0100-R0025/0000



Typical position of reference points in sensor head



Ordering example: fabricated magnetic tape, pole width 1 mm

B M L - M _ _ - I 3 _ - A _ - M _ _ _ _ - _ _ _ _ _

Design	Accuracy class	Cover strip	Length in cm	Reference point positions
02 1.55 mm thick, with adhesive strip	4 ±8 µm	0 Without cover strip	Order length, max. 4800 = 48 m	R0000 None or pole-periodic
03 1.35 mm thick, without adhesive strip	5 ±18 µm	3 With cover strip (thickness 0.15 mm)		Rxxxx/0000 Position of 1 reference point in cm
				Rxxxx/yyyy Position of no more than 2 reference points in cm
				C0006/yyyy Fixed-periodic* all yyyy cm, 0002, 0005, 0010, 0020

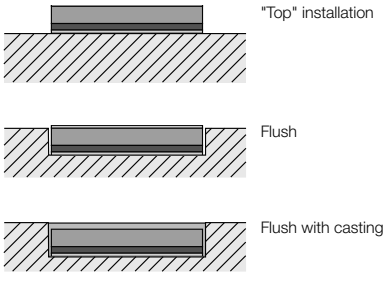
* Fixed-periodic reference point only for BML-M02-I34...

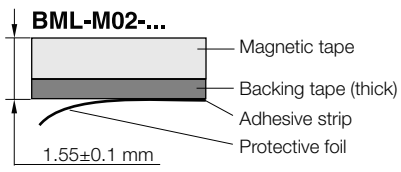
Ordering example: Magnetic tape by the roll, pole width 1 mm

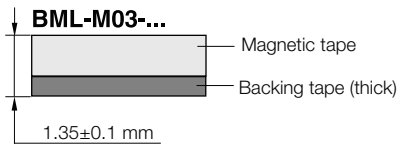
B M L - M 0 2 - I 3 _ - A 0 - T _ _ _ _ - R 0 0 0 0

Accuracy class	Length
4 ±8 µm	0500 5 m
5 ±18 µm	1000 10 m
(Better accuracy classes available on request.)	2400 24 m
	4800 48 m

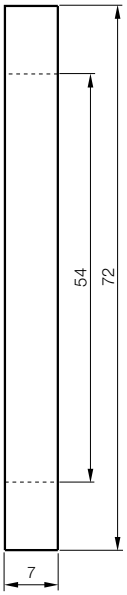
Magnetic tape mounting options

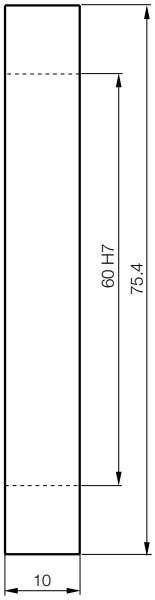


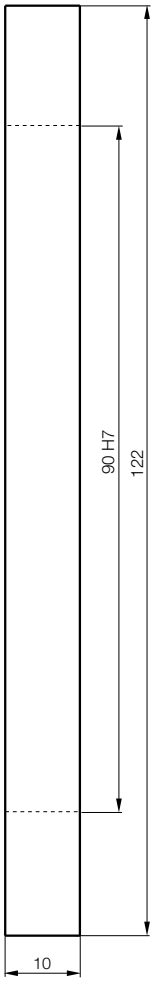




Series	Sensor family F	Sensor family F	Sensor family F
Ordering code	**BML002K**	**BML01KM**	**BML01EW**
Part number	BML-M20-I30-A0-M072/054-R0	BML-M31-I30-A0-M075/060-R0	BML-M30-I30-A0-M122/090-R0
Number of poles	228	238	384
Pole width	1 mm	1 mm	1 mm
With reference mark	No	No	No
Material	Hard ferrite	Elastomer on steel ring with fit H7	Elastomer on steel ring with fit H7







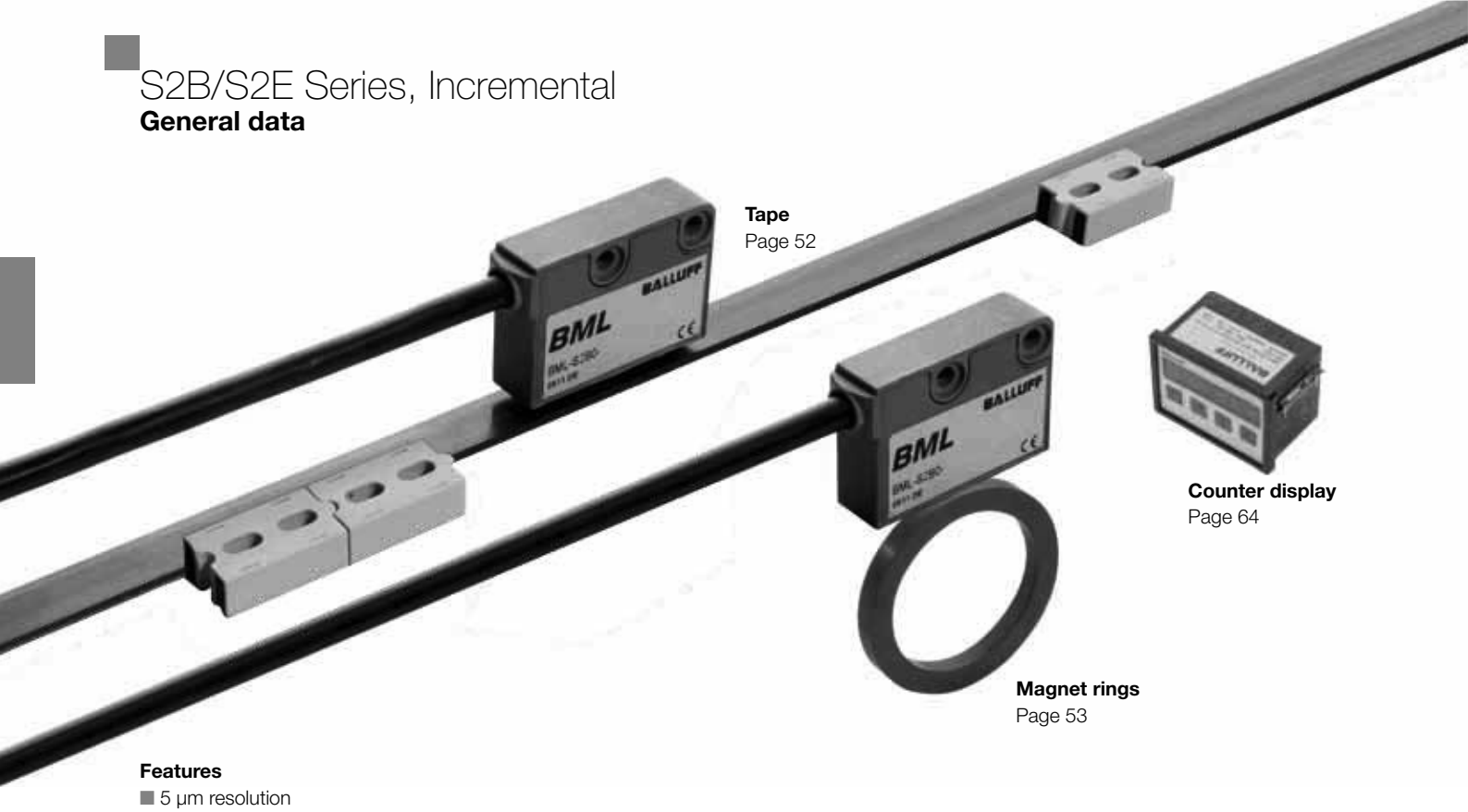
Magnetically Coded Position and Angle Measurement System

S2B/S2E/S1C Series, Incremental

With the S2B/S2E/S1C sensor heads, the magnetically coded position and angle measurement system BML provides three systems for optimum adaptation to your measuring task.
Resolution and accuracy can be appropriately selected depending on the application. Integration of reference points is also possible.
All three systems have a compact design and the same dimensions throughout the series, making them extremely versatile to integrate.

Contents

General data



Tape
Page 52

Counter display
Page 64

Magnet rings
Page 53

Features
- 5 µm resolution
- System accuracy to ±50 µm
- High repeat accuracy ±1 increment
- 20 m/s maximum travel speed
- Digital square-wave signals RS422 or 10...30 V
- Two freely positionable limit switches
- Reference signal
- LED display for reference signal
- Pole width 5 mm

Ordering example: sensor head, pole width 5 mm

BML-S2E0-Q_ _ _-M4_ _-_0-_ _ _ _
BML-S2B0-Q_ _ _-M4_ _-_0-_ _ _ _

Operating voltage	Output voltage	Resolution	Reference signal	Limit switch	Min. edge separation*	Connection
5 10...30 V	1 Digital square-wave signal RS422	F 5 µm	0 None	0 No limit switch	D 0.12 µs	KA02 PUR cable 2 m
6 5 V	3 Level same as supply voltage (only for 10...30 V)	G 10 µm	1 Individually or fixed-periodic	3 Two limit switches (including 1 set of magnets)	E 0.29 µs	KA05 PUR cable 5 m
		H 25 µm	2 Pole-periodic		F 0.48 µs	KA10 PUR cable 10 m
		K 50 µm			G 1 µs	KA15 PUR cable 15 m
					H 2 µs	KA20 PUR cable 20 m
					K 4 µs	
					L 8 µs	
					N 16 µs	
					P 24 µs	

Sensor connectors (e.g. SUB-D or M12 connectors) are available on request.

*** Selection guide, page 50:**
Resolution – speed – edge separation

Preferred models

- **BML-S2B0-Q53F-M410-D0-KA05 (BML0211)**
  Digital signal, 10...30 V, with reference signal, 5 m cable, resolution 5 µm, edge separation 0.12 µs, max. travel speed 20 m/s

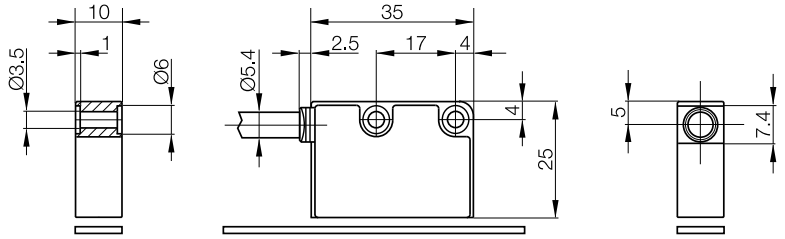
- **BML-S2E0-Q53G-M410-P0-KA05 (BML00JC)**
  Digital signal, 10...30 V, with reference signal, 5 m cable, resolution 10 µm, edge separation 24 µs, max. travel speed 26 cm/s

- **BML-S2E0-Q61F-M410-G0-KA05 (BML001E)**
  Digital signal, 5 V, with reference signal, 5 m cable, resolution 5 µm, edge separation 1 µs, max. travel speed 3.25 m/s

S2B/S2E Series, Incremental
General data

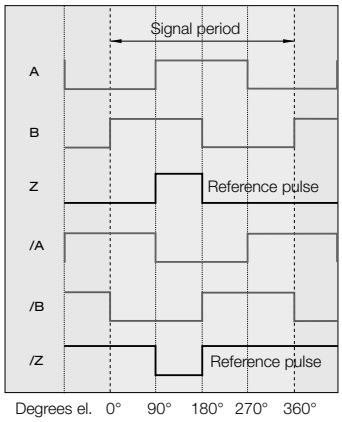
Series	**BML-S2B0-…**	**BML-S2E0-…**
Output signal	Digital square-wave signals A, /A, B, /B, Z, /Z (RS422) or A, B, Z (HTL)	Digital square-wave signals A, /A, B, /B, Z, /Z (RS422) or A, B, Z (HTL)
Resolution	5 µm, 10 µm, 25 µm or 50 µm	5 µm, 10 µm, 25 µm or 50 µm
Pole pitch, signal periods	5 mm	5 mm
Part number	BML-S2B0-Q_ _ _-M4_ _-_0-_ _ _ _	BML-S2E0-Q_ _ _-M4_ _-_0-_ _ _ _
Output voltage (A/B/Z)	RS422 as per DIN 66259 or as supply voltage 10...30 V	RS422 as per DIN 66259 or as supply voltage 10...30 V
Overall system accuracy	±50 µm	±100 µm
Supply voltage	10...30 V or 5 V ±5%	10...30 V or 5 V ±5%
Current consumption at 5 V supply voltage	< 50 mA + current consumption of the controller (depending on internal resistance)	< 50 mA + current consumption of the controller (depending on internal resistance)
Current consumption at 10...30 V supply voltage	< 40 mA + current consumption of the controller (depending on internal resistance)	< 40 mA + current consumption of the controller (depending on internal resistance)
Max. read distance sensor/tape	2 mm	2 mm
Max. travel speed	20 m/s	20 m/s
Operating temperature	–20...+80 °C	–20...+80 °C
Housing material	PBT	PBT
Degree of protection	IP 67	IP 67

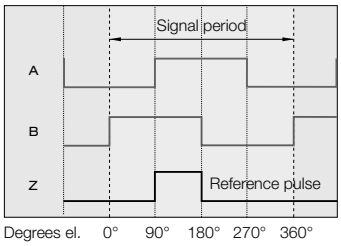
All specifications in conjunction with tape BML-...-I45-... (BML-S2B0...) or BML-...-I46-... (BML-S2E0...) at a read distance of 1 mm (see page 52).



Digital square-wave signals RS422
- RS422 square-wave signals in acc. with DIN 66259
- Direction information = 90° phase-shifted
- Resolution = edge separation A/B
- Differential signals
- Reference pulse (optional)
- Terminating resistor ≥ 120 ohms (usually integrated in the processor unit)
- Forward movement: A before B

Digital square-wave signals HTL
- Square-wave signals HTL = Level same as supply voltage
- Direction information = 90° phase-shifted
- Resolution = edge separation A/B
- Reference pulse (optional)
- Terminating resistor > 5 kOhms (usually integrated in the processor unit)
- Forward movement: A before B





Caution!
Before design, installation and startup please familiarize yourself with the user's guide to be found at www.balluff.com.

The position measurement system BML must be exactly matched to the respective application. Use the technical selection guide.
For additional examples, see Basic Information and Definitions on page 68.

Compatibility of the counting frequency of the controller and BML

Each sensor with a digital output signal has a characteristic minimum edge separation gap. that the higher-level controller must reliably detect. We therefore recommend selecting a controller with a counting frequency that is higher than the theoretically calculated counting frequency.

Maximum travel speed, resolution and edge separation

The following tables show the relationship between the selected resolution of the sensor head, the minimum edge separation and the potential travel speed:

Min. edge separation		Counting frequency (signal periods)	V_{max} in accordance with edge separation and resolution Mechanical resolution			
			F 5 µm	**G** 10 µm	**H** 25 µm	**K** 50 µm
D	0.12 µs	2083.33 kHz	20 m/s	20 m/s	20 m/s	20 m/s
E	0.29 µs	862.07 kHz	10 m/s	20 m/s	20 m/s	20 m/s
F	0.48 µs	520.83 kHz	5 m/s	10 m/s	20 m/s	20 m/s
G	1 µs	250.00 kHz	3.25 m/s	6.5 m/s	14.75 m/s	14.75 m/s
H	2 µs	125.00 kHz	1.5 m/s	3 m/s	7.7 m/s	7.7 m/s
K	4 µs	62.50 kHz	0.75 m/s	1.5 m/s	3.95 m/s	3.95 m/s
L	8 µs	31.25 kHz	0.375 m/s	0.75 m/s	1.7 m/s	1.7 m/s
N	16 µs	15.63 kHz	0.195 m/s	0.395 m/s	0.95 m/s	0.95 m/s
P	24 µs	10.42 kHz	0.13 m/s	0.26 m/s	0.65 m/s	0.65 m/s

Table 1: Selection guide for maximum travel speed of the S2B/S2E series

Rotary applications
The position measurement system BML enables the detection of rotary movements. The rotary tapes can be matched to the respective application. Use the technical selection guide for rotary systems.

Determining the pulses per rotation
The number of required pulses per rotation varies depending on the application. It determines the resolution of the sensor head and the diameter of the magnet ring.

Sensor head resolution	**Pulses/revolution with 4-fold evaluation**		
	Ø of magnet ring, outside		
	31 mm	**49 mm**	**72 mm**
Ordering code	**BML002T** **BML002L**	**BML002R** **BML002M**	**BML002P** **BML002N**
F = 5 µm	20000	32000	46000
G = 10 µm	10000	16000	23000
H = 25 µm	4000	6400	9200
K = 50 µm	2000	3200	4600

Table 2: Selection guide for magnet rings from the S2B/S2E series

Maximum speed
The speed and the diameter of the magnet ring determine the speed of the ring on the sensor head.
The maximum travel speed that the sensor can still identify depends on the resolution and the edge separation of the sensor head. Resolution and edge separation can be selected. A maximum speed is then calculated using the following formula:

$$\text{Max. speed (rpm)} = \frac{60 \times \text{max. travel speed (m/s)}}{\pi \times \text{magnet ring diameter (m)}}$$

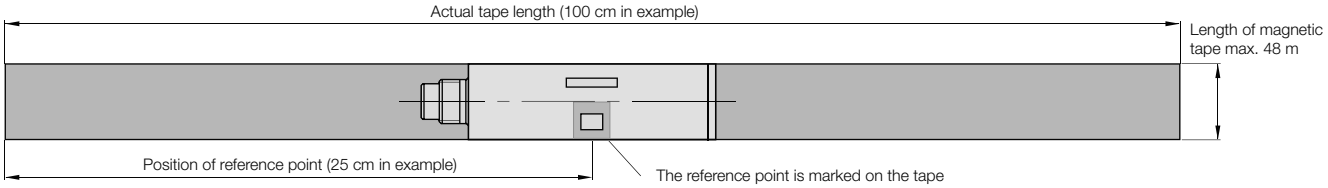
Refer to Table 1 for the maximum travel speed. When selecting a maximum speed for the application, we recommend using a value 10% lower than this value.
Example:
You are using a BML-S2B sensor with a resolution of 5 µm (F) and a minimum edge separation of 1 µs (G). For this sensor, Table 1 gives a maximum travel speed of 3.25 m/s.
If the magnet ring diameter is 48 mm = 0.048 m, a speed of 1293 rpm can be achieved using the formula. The maximum speed of 1164 rpm should not be exceeded.

Look-up table for max. RPM, see Table 2, page 77.

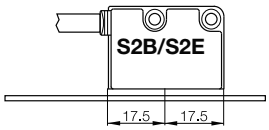
Magnetically Coded Position and Angle Measurement System
S1H Series
S1G Series
S1F Series
S2B/S2E Series
General Data
Technical Selection Guide
Magnetic Tape
Magnet Rings
S1C Series
General Data
Technical Selection Guide
Magnetic Tape
Magnet Rings
Accessories
Basic Information and Definitions

Accessories can be found on **page 62.**

Position of single reference point using example of BML-M02-I45-A0-M0100-R0025/0000



Typical position of reference points in sensor head



Ordering example: fabricated magnetic tape, pole width 5 mm

B M L - M _ _ - I 4 _ - A _ - M _ _ _ _ - _ _ _ _ _

Design

02 1.55 mm thick, with adhesive strip
03 1.35 mm thick, without adhesive strip

Accuracy class

5 ±18 µm
6 ±50 µm

Cover strip

0 Without cover strip
3 With cover strip (thickness 0.15 mm)

Length in cm

Order length, max. 4800 = 48 m

Reference point positions

R0000 None or pole-periodic
Rxxxx/0000 Position of 1 reference point in cm
Rxxxx/yyyy Position of no more than 2 reference points in cm
C0006/yyyy Fixed-periodic* all yyyy cm, 0005, 0010

* Fixed-periodic reference point only for type BML-M02-I45-…

Ordering example: Magnetic tape by the roll, pole width 5 mm

B M L - M 0 2 - I 4 _ - A 0 - T _ _ _ _ - R 0 0 0 0

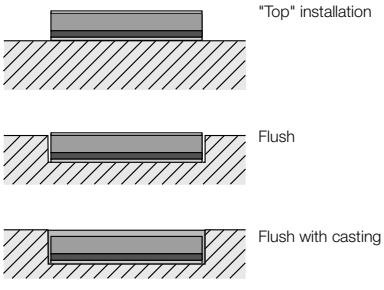
Accuracy class

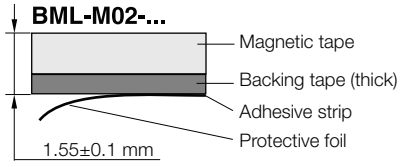
5 ±18 µm
6 ±50 µm
(Better accuracy classes available on request)

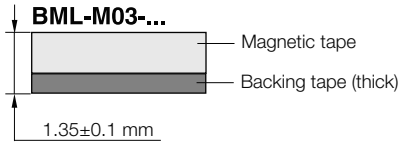
Length

0500 5 m
1000 10 m
2400 24 m
4800 48 m

Magnetic tape mounting options

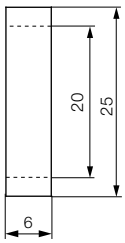


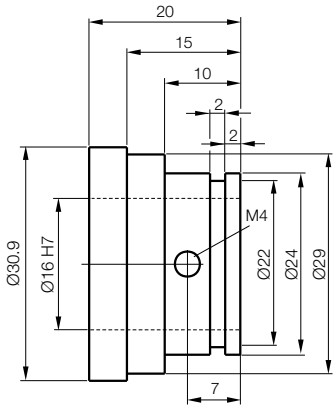




Magnet rings

Series	Sensor family B/E	Sensor family B/E
Ordering code	**BML04E2**	**BML002T**
Part number	BML-M33-I40-A0-M025/020-R0	BML-M22-I40-A0-M031/016-R0
Number of poles	16	20
Pole width	5 mm	5 mm
With reference mark	no	no
Material	Plastic	Hard ferrite/aluminum





Special solutions for a range of applications

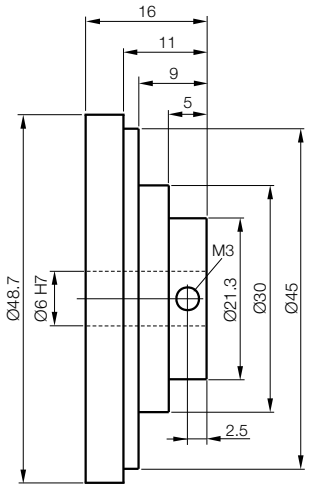
Magnet rings are suitable for all types of application where the monitoring of rotary movements is required. Due to the high resolution, synchronous run monitoring is just as easy to implement as precision angle positioning.

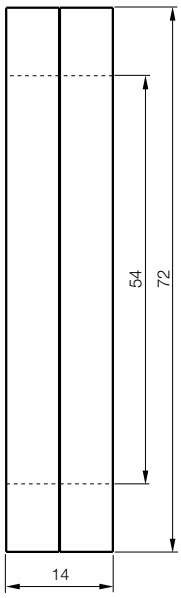
Balluff offers a range of standard rotary tapes that are suitable for most types of application. Due to the wide variety of different machine applications, special dimensions and magnetic configurations are available on request.

Even linear tapes can be used successfully in rotary applications. For example, the magnetic tape can simply be stuck to the shaft of a solar panel unit to monitor whether the panel is optimally aligned. Balluff also offers prefabricated magnetic tapes with holes for convenient, simplified installation.

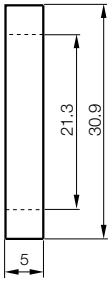
Magnet Rings

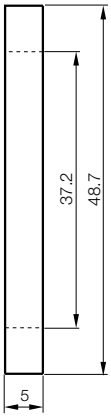
Series	Sensor family B/E	Sensor family B/E	
Ordering code	**BML002R**	**BML002P**	
Part number	BML-M21-I40-A0-M048/006-R0	BML-M20-I40-A0-M072/054-R1	
Number of poles	32	46	
Pole width	5 mm	5 mm	
With reference mark	No	Yes	
Material	Hard ferrite/aluminum	Hard ferrite	

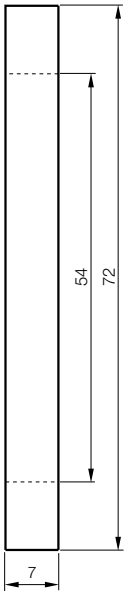




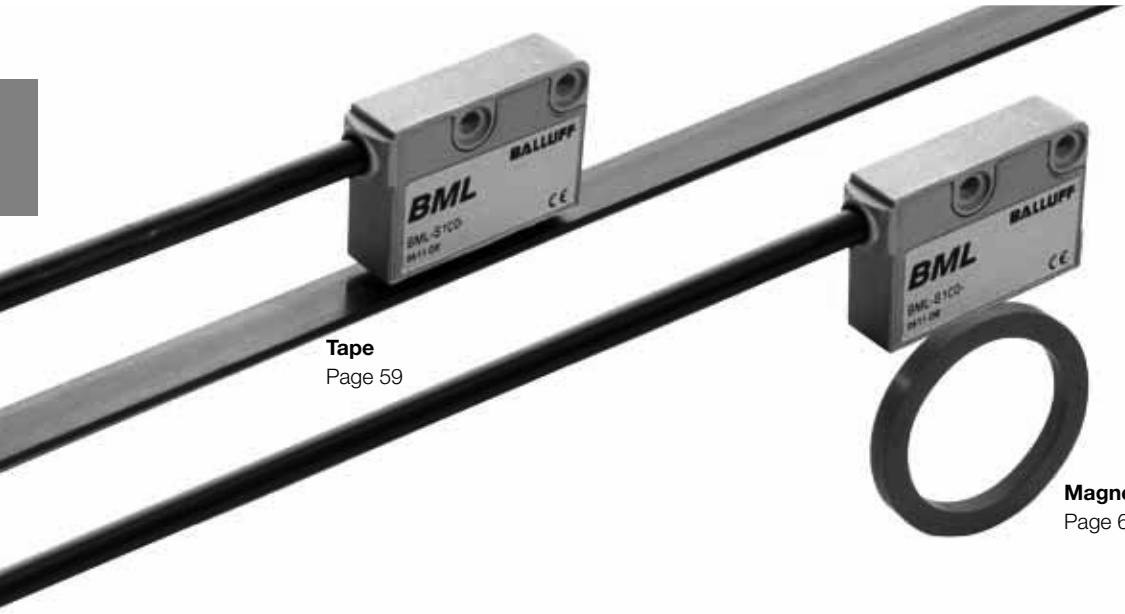
	Sensor family B/E	Sensor family B/E	Sensor family B/E
	BML002L	**BML002M**	**BML002N**
	BML-M20-I40-A0-M031/021-R0	BML-M20-I40-A0-M048/037-R0	BML-M20-I40-A0-M072/054-R0
	20	32	46
	5 mm	5 mm	5 mm
	No	No	No
	Hard ferrite	Hard ferrite	Hard ferrite







We offer custom solutions.
Contact us.



Tape
Page 59

Magnet rings
Page 61

Counter display
Page 64

Features
- 0.1 mm resolution
- High repeat accuracy ±1 increment
- 10 m/s maximum travel speed
- Gap between sensor and tape up to 2 mm
- Digital square-wave signals, output voltage 10...30 V (HTL)
- Cable connection
- 10...30 V DC supply voltage
- Pole width 5 mm

Ordering example: sensor head, pole width 5 mm

BML-S1C0-Q53_-M400-_0-_ _ _ _

Resolution

L	100 µm
M	200 µm
N	500 µm
P	1000 µm
R	2000 µm

Max. edge separation*

M	10 µs
R	100 µs

Connection

KA02	PUR cable 2 m
KA05	PUR cable 5 m
KA10	PUR cable 10 m
KA15	PUR cable 15 m
KA20	PUR cable 20 m

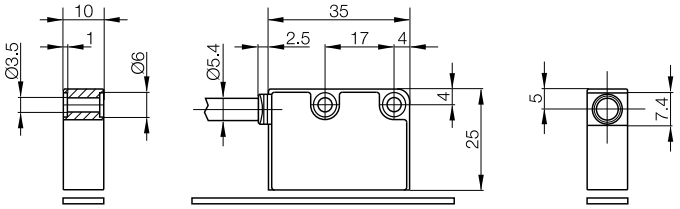
Sensor connectors (e.g. SUB-D or M12 connectors) are available on request.

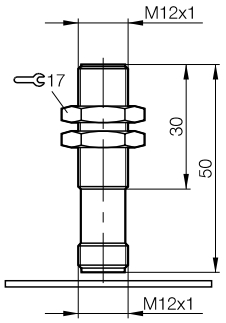
*** For selection guide, see page 58:**
Resolution – speed – edge separation

Preferred type
- **BML-S1C0-Q53L-M400-M0-KA05 (BML003U)**
  Digital signal, 10...30 V, 5 m cable, resolution 0.1 mm, edge separation 10 µs, max. travel speed up to 8 m/s

Series	**BML-S1C0-…**	**BMF 12M-…**
Output signal	Digital square-wave signals	PNP/NPN normally open 1 switching operation per pole
Resolution	0.1 mm, 0.2 mm, 0.5 mm, 1 mm, 2 mm	
Pole pitch, signal periods	5 mm	5 mm
Ordering code		**BMF0022**
Part number	BML-S1C0-Q53_-M400-_0-KA_ _	BMF 12M-PS-D-2-S4 (PNP normally open)
Ordering code		**BMF0021**
Part number		BMF 12M-NS-D-2-S4 (NPN normally open)
Output voltage (A/B)	Same as supply voltage 10...30 V	Supply voltage $-U_d$
Overall system accuracy	±100 µm	> ±5 mm
Supply voltage	10...30 V	10...30 V DC
Voltage drop U_d		≤ 3.15 V
Current consumption at 10...30 V supply voltage	< 40 mA + current consumption of the controller (depending on internal resistance)	200 mA
Max. read distance sensor/tape	2 mm	2 mm
Max. travel speed	10 m/s	7 kHz
Operating temperature	–20...+80 °C	–25...+85 °C
Housing material	PBT	Brass-coated
Degree of protection	IP 67	IP 67

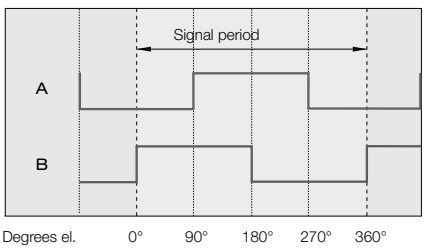
All data applies in conjunction with tape BML-…-I46-…
at a read distance of 1 mm (see page 59).





Digital square-wave signals HTL

- Square-wave signals HTL = Level same as supply voltage
- Direction information = 90° phase-shifted
- Resolution = edge separation A/B
- Terminating resistor ≥ 120 ohms (integrated in the processor unit)



The position measurement system BML must be exactly matched to the respective application. Use the technical selection guide.
For additional examples, see Basic Information and Definitions on page 68.

Compatibility of the counting frequency of the controller and BML
Each sensor with a digital output signal has a characteristic minimum edge separation gap. that the higher-level controller must reliably detect. We therefore recommend selecting a controller with a counting frequency that is higher than the theoretically calculated counting frequency.

Maximum travel speed, resolution and edge separation
The following tables show the relationship between the selected resolution of the sensor head, the minimum edge separation and the potential travel speed:

Min. edge separation		Counting frequency (signal periods)	V_{max} in accordance with edge separation and resolution Mechanical resolution				
			L 100 µm	**M** 200 µm	**N** 500 µm	**P** 1000 µm	**R** 2000 µm
M	10 µs	25.00 kHz	8 m/s	10 m/s	10 m/s	10 m/s	10 m/s
R	100 µs	2.50 kHz	0.9 m/s	1.8 m/s	4.2 m/s	8.8 m/s	10 m/s

Table 1: Selection guide for maximum travel speed of the S1C series

Rotary applications
The position measurement system BML enables the detection of rotary movements. The rotary tapes can be matched to the respective application. Use the technical selection guide for rotary systems.

Determining the pulses per rotation
The number of required pulses per rotation varies depending on the application. It determines the resolution of the sensor head and the diameter of the magnet ring.

Sensor head resolution	Pulses/revolution with 4-fold evaluation		
	Ø of magnet ring, outside		
	31 mm	49 mm	72 mm
Ordering code	BML002T BML002L	BML002R BML002M	BML002N
L = 100 µm	1000	1600	2300
M = 200 µm	500	800	1150
N = 500 µm	200	320	460
P = 1000 µm	100	160	230
R = 2000 µm	50	80	115

Table 2: Selection guide for magnet rings from the S1C series

Maximum speed
The speed and the diameter of the magnet ring determine the speed of the ring on the sensor head.
The maximum travel speed that the sensor can still identify depends on the resolution and the edge separation of the sensor head. Resolution and edge separation can be selected. A maximum speed is then calculated using the following formula:

$$\text{Max. speed (rpm)} = \frac{60 \times \text{max. travel speed (m/s)}}{\pi \times \text{magnet ring diameter (m)}}$$

Refer to Table 1 for the maximum travel speed. When selecting a maximum speed for the application, we recommend using a value 10% lower than this value.

Example:
You are using a BML-S1C sensor with a resolution of 100 µm (L) and a minimum edge separation of 10 µs (M). For this sensor, Table 1 gives a maximum travel speed of 8 m/s.
If the magnet ring diameter is 48 mm = 0.048 m, a speed of 3183 rpm can be achieved according to the formula.
The maximum speed of 2865 rpm should not be exceeded.

Look-up table for max. RPM, see Table 2, page 77.

Ordering example:
Fabricated magnetic tape, pole width 5 mm

BML-M__-I4_-A_-M____-R0000

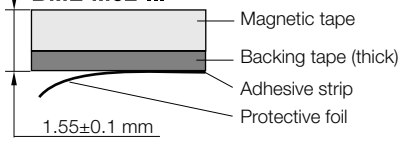
Design
- 02 1.55 mm thick, with adhesive strip
- 03 1.35 mm thick, without adhesive strip

Accuracy class
- 6 ±50 µm

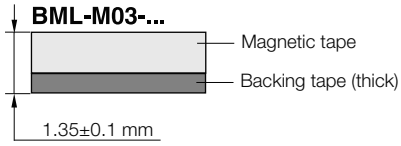
Cover strip
- 0 Without cover strip
- 3 With cover strip (thickness 0.15 mm)

Length in cm
Order length, max. 4800 = 48 m

BML-M02-...



BML-M03-...

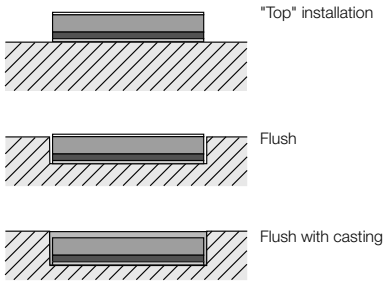


Ordering example:
Magnetic tape by the roll, pole width 5 mm

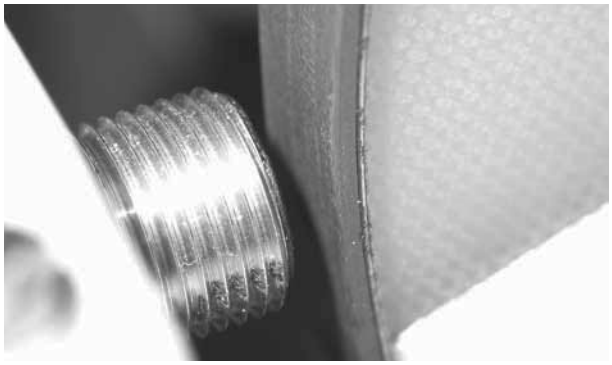
BML-M02-I46-A0-T____-R0000

Length
- 0500 5 m
- 1000 10 m
- 2400 24 m
- 4800 48 m

Magnetic tape mounting options
(also in magnetizable material)

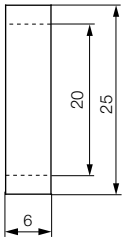


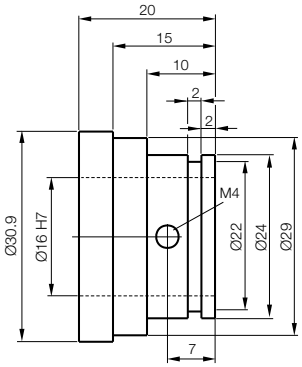
BMF 12M-PS-D-2-S4
Speed monitoring in rotary applications:
Simply more cost-effective.
Designed for the B/C/E sensor family, the magnet rings and magnetic tapes shown here allow you to measure speed by means of switching magnetic sensors from the BMF series. With its standard M12 thread, the BMF 12M-PS-D-2-S4 sensor can be installed in a wide range of applications. It can be installed as close as 2 mm from the magnet. A pulse signal that reflects the rotary speed is present at the switching output. The sensor can detect frequencies up to 7 kHz, therefore speeds of up to about 20,000 rpm are possible, depending on the selected tape.

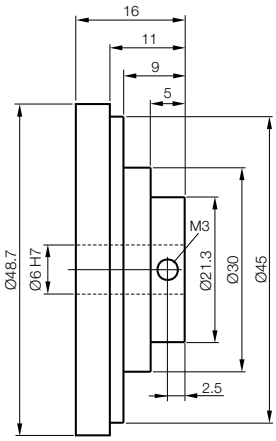


Accessories can be found on page 62.

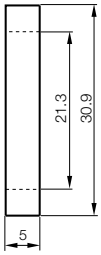
Series	Sensor family C	Sensor family C	Sensor family C	
Ordering code	**BML04E2**	**BML002T**	**BML002R**	
Part number	BML-M33-I40-A0-M025/020-R0	BML-M22-I40-A0-M031/016-R0	BML-M21-I40-A0-M048/006-R0	
Number of poles	16	20	32	
Pole width	5 mm	5 mm	5 mm	
With reference mark	No	No	No	
Material	Plastic	Hard ferrite/aluminum	Hard ferrite/aluminum	

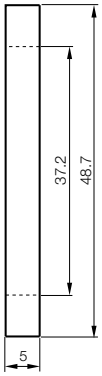


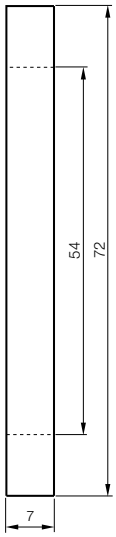




	Sensor family C	Sensor family C	Sensor family C
	BML002L	**BML002M**	**BML002N**
	BML-M20-I40-A0-M031/021-R0	BML-M20-I40-A0-M048/037-R0	BML-M20-I40-A0-M072/054-R0
	20	32	46
	5 mm	5 mm	5 mm
	No	No	No
	Hard ferrite	Hard ferrite	Hard ferrite







Special solutions for a range of applications

Magnet rings are suitable for all types of application where the monitoring of rotary movements is required. Due to the high resolution, synchronous run monitoring is just as easy to implement as precision angle positioning.

Balluff offers a range of standard rotary tapes that are suitable for most types of application. Due to the wide variety of different machine applications, special dimensions and magnetic configurations are available on request.

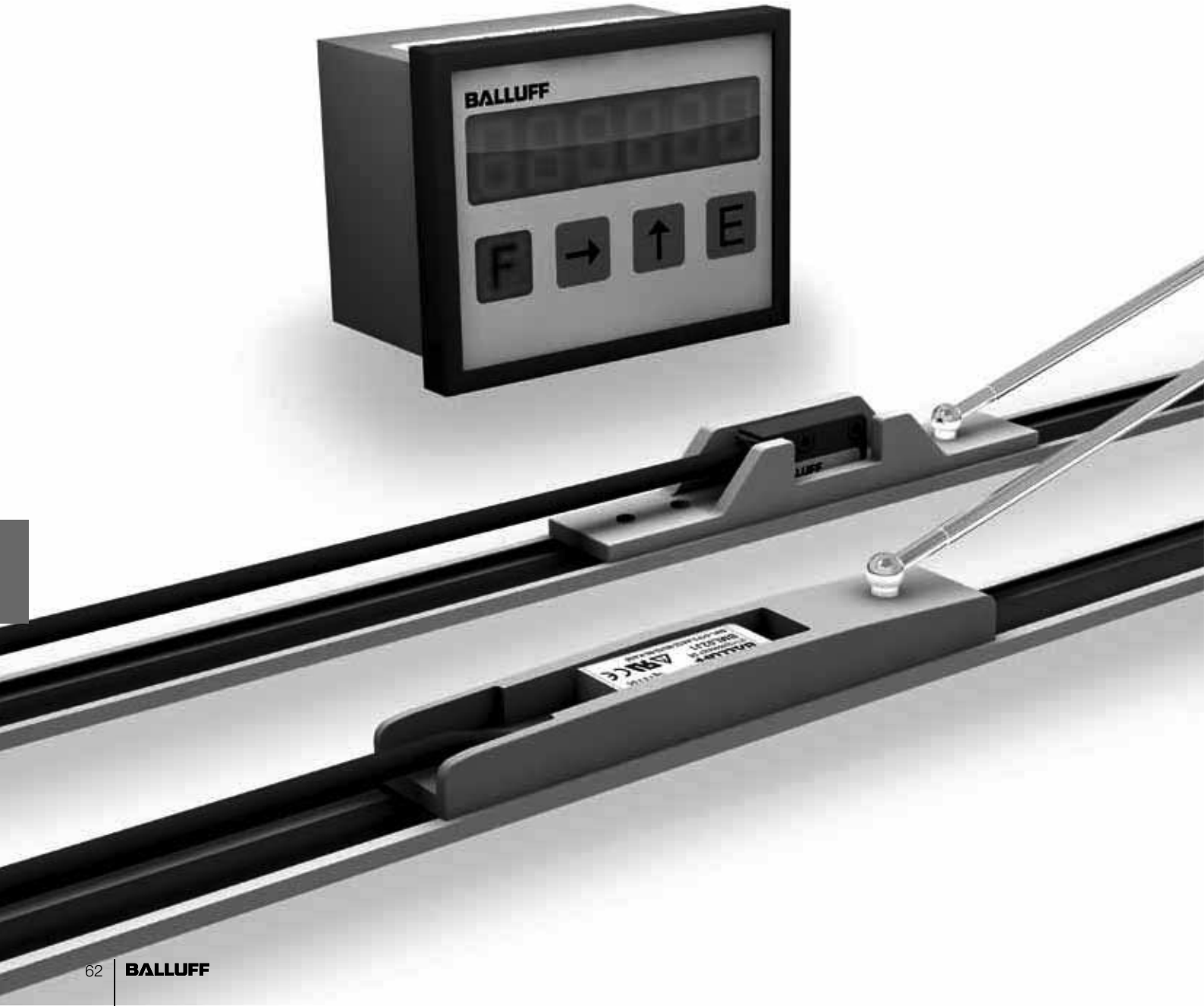
Even linear tapes can be used successfully in rotary applications. For example, the magnetic tape can simply be stuck to the shaft of a solar panel unit to monitor whether the panel is optimally aligned. Balluff also offers prefabricated magnetic tapes with holes for convenient, simplified installation.

We offer custom solutions.
Contact us.

Magnetically Coded Position and Angle Measurement System

Accessories

Counters and displays are available for all series to integrate the sensor systems perfectly into your application.
The range of sensor guides enables you to integrate robust, high-precision measurement systems even where there is no optimum guide.



Contents

Magnetically Coded Position and Angle Measurement System: Measuring and displaying speeds
Speed detection of shafts and spindles as well as simple rotary encoder tasks can be optimally implemented with the combination of BML, BDD, and the magnet ring tapes.

Series			
Interface			
Ordering code			
Part number			
Ordering code			
Part number			
Ordering code			
Part number			
Functions			
Features			
Use			

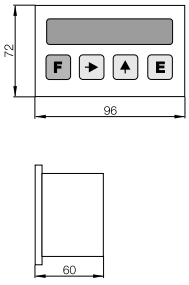
* Power adapter for connecting to 115 V/230 V, for example, BAE0001 or BAE00EN, on page 403.

Counter display

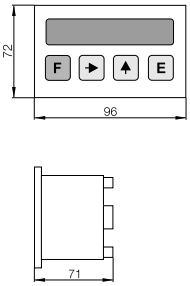



	BDD 610	BDD 611/BDD 622/BDD 632
	Single-axis counter for BML-S2B..., BML-S1C... and BML-S2E...	Single-axis, two-axis, three-axis counter for BML-S1F, BML-S2B, BML-S2E, BML-S1C
	BAE004J	**BAE004K**
	BDD 610-R3Q3-0-53-N-00 (2 dig. outputs)	BDD 611-R3Q4-0-52-N-00 (1 axis)
	BAE004H	**BAE004M**
	BDD 610-R3Q3-0-51-N-00 (2 dig. inputs)	BDD 622-R3Q4-0-52-N-00 (2 axes)
		BAE004P
		BDD 632-R3Q4-0-52-N-00 (3 axes)
	■ Set value ■ Actual value memory ■ Factor calculation ■ Count direction reversal ■ Up to 3 decimal places ■ Assignable key functions ■ Reset and set logic ■ Logic for inputs and outputs ■ Security code	■ Set value ■ Actual value memory ■ Factor calculation ■ Edge evaluation ■ Count direction reversal ■ Up to 3 decimal places ■ Assignable key functions ■ Reset and set logic ■ Absolute and incremental measurement ■ Offset logic ■ Sawtooth correction ■ Logic for inputs and outputs ■ Security code ■ Reference pulse
	■ Power supply 24 V DC* ■ 1×6-decade LED display ■ Digit height 14 mm ■ Incremental measurement system with tracks A, B ■ max. 25 kHz ■ 2 digital inputs (-51-) ■ 2 digital outputs (-53-)	■ Power supply 24 V DC* ■ 1×6/2×6/3×6-decade LED display ■ Incremental measurement system with tracks A, /A, B, /B, Z, /Z or A, B, Z ■ Digit height 14 mm ■ 4 digital inputs ■ 2 digital outputs ■ Min. edge separation with 4-fold evaluation: 250 µs ■ BDD 611: max. input frequency: Signal A or B: 1 MHz
	for BML-S2B0..., BML-S2E0... and BML-S1C0-…-Q53... min. edge separation Code M, N, P, R	For BML with supply voltage 5 V/10...30 V, output voltage RS422/HTL, min. edge separation Code E, F, G, H, K, L, M, N, P, R

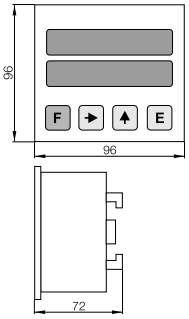
BDD 610



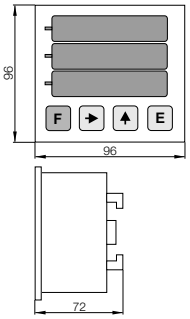
BDD 611



BDD 622



BDD 632



The sensor guide consists of an aluminum rail that retains the magnetic tape and a carriage with runners that guides the sensor head accurately. A standard joint rod is used for the mechanical connection.

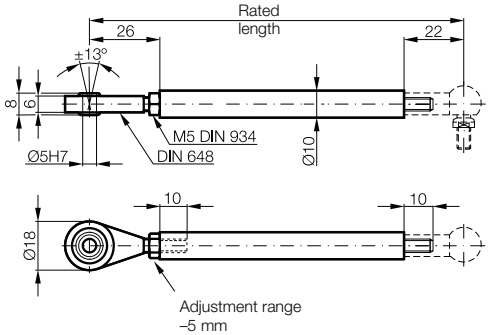
Features
- Customized lengths
- Easily attached by directly screwing on or using mounting elements
- Rails can be mounted side by side and elements disassembled
- Connection of drag chains possible
- Flat design, minimal space requirements
- Low costs
- Runners need no lubrication, thus no maintenance costs
- Minimum stock-keeping, since the universal concept works for various sensor heads
- Mounting aid for easy installation of the magnetic tape

Sensor guide	
Ordering code	
Part number	
Features	

You may cover the magnetic tape with a stainless steel cover strip to protect it from damage caused by swarf or chemicals.
Note that the permissible air gap between the sensor head and tape is reduced by the thickness of the cover strip with adhesive film (0.15 mm).

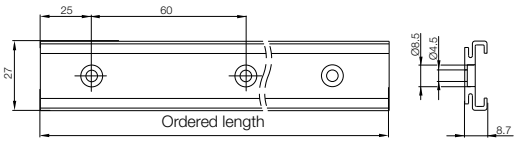
- Cover strip and magnetic tape can be ordered together in matching lengths (see tapes on page 44, 52, or 59).
- The cover strip is available in 4 different lengths.

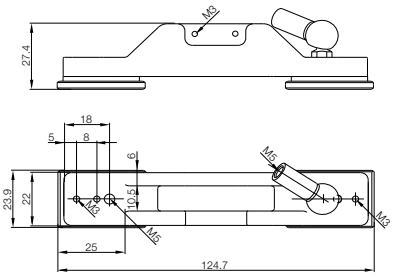
Accessories	Joint rod for BML-C01, BML-C02	
Ordering code	e.g. **BAM000P** (100 mm)	
Part number	BTL2-GS10-_ _ _ _-A	
Use	For connecting the sliding carriage to the machine	

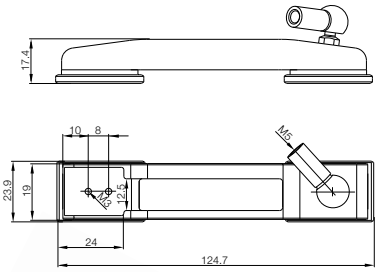


	Guide rail for sliding carriage BML-C01, BML-C02	Sliding carriage for sensors BML-S2B, BML-S2E, BML-S1C	Sliding carriage for sensors BML-S1F
	e.g. **BAM01N4** (3 m)	**BAM01MF**	**BAM01MH**
	BML-R01-M_ _ _ (order length in cm)	BML-C01	BML-C02
	■ Anodized aluminum ■ Mounting holes ■ Lateral groove for alternate mounting using brackets ■ Mountable side by side ■ Maintenance-free dry operation ■ Lubricant-free ■ Suitable for all linear tapes*	■ Aluminum ■ Fully mounted with runners ■ Connection for joint rod ■ Connection for drag chains ■ Maintenance-free dry operation ■ Lubricant-free	■ Aluminum ■ Fully mounted with runners ■ Connection for joint rod ■ Connection for drag chains ■ Maintenance-free dry operation ■ Lubricant-free

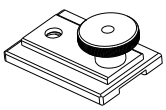
* Use the same length tape and rail and mechanically affix the tape at the ends.

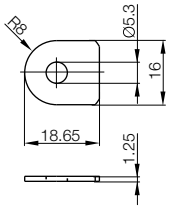


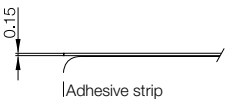




	Mounting guide	Brackets (2 pieces) for BML-R01	Cover strip from the roll for BML-M02, BML-M03			
	BAM01L9	**BAM01JL**	e.g. **BML001K** (10 m)			
	BML-Z0010	BML-Z0008	BML-A013-T_ _ _ _			
	Installing the magnetic tape on BML-R01	For lateral mounting of the rail and at transition points	0500 5 m	1000 10 m	2400 24 m	4800 48 m







Magnetically Coded Position and Angle Measurement System

Contents

Definitions

System accuracy

The accuracy of the sensor head depends largely on mechanical manufacturing tolerances and component tolerances; the accuracy of the tape is determined by the material quality and the magnetization grade.

The overall system accuracy or linearity class describes the deviations of the measured value from the real actual value. It contains the position deviations within any meter of the measurement section (or, when rotary: a rotation).

Accuracy of the tape BML-M02-I34

±8 µm

+

Accuracy of the sensor head BML-S1F...

±2 µm

=

±10 µm

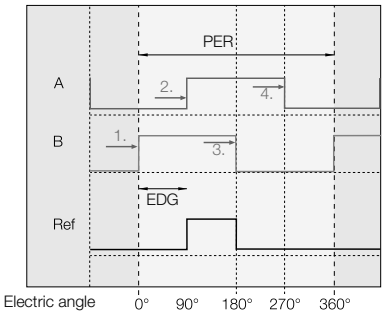
4x evaluation

With 4-fold evaluation, the controller counts every 4 edge changes within a signal period. A signal period = 4x selected resolution.

Example:
Sensor head 1 µm resolution, magnet ring with 384 poles (1 mm).

4 edges (each 1 µm) per signal period
= 4 µm period length
= 250 periods per pin
= 96,000 periods per 360°
(384,000 pulses per 360°)

During installation, make sure the sensor is correctly aligned over the

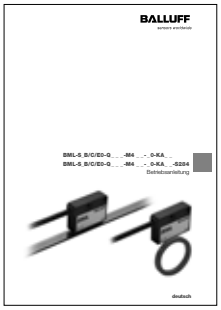


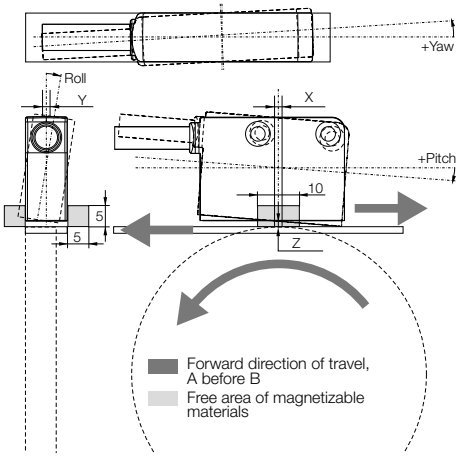
PER = a signal period
EDG = Edge separation

Installation tolerance

tape. To ensure the correct function and linearity class of the system, the distances and tolerances must be adhered to. We recommend an air gap of 0.1 mm (about paper thickness)

For detailed **installation instructions**, refer to our operating manual at www.balluff.de





Edge separation

With 4-fold evaluation, the following applies (each edge is counted):

$$\text{Period length} = \frac{\text{Counting frequency}}{4}$$

$$\text{Counting frequency} \geq \frac{1}{\text{Min. edge separation}}$$

Example:
Edge separation = 1 µs
Counting frequency = 1 MHz
Period length = 250 kHz

Important!
The controller/display must be able to count the minimum time-based edge separations shown in the tables (note the counting frequency of your controller).
The minimum edge separation may occur even when the system is at rest due to the internal interpolation procedure.
Always select the next higher travel speed or the next faster minimum edge separation; otherwise, during the evaluation by the controller, errors can arise in the position determination.

Repeat accuracy

Repeat accuracy is the value resulting when moving to the same position from the same direction under unchanging ambient conditions.

Incremental

After the system is switched on, the measured value currently available is not defined. A reference run to a defined point, a reference point, is necessary in order to obtain a position value. The position value is calculated by adding or subtracting individual, equal increments from the reference point.

Absolute

The measured value for the current position is available immediately after the system is switched on. Each position, e.g. a measurement section, is assigned an absolute, coded digital signal or an analog value. A reference run is not required.

Temperature coefficient

The temperature coefficient indicates the relative change in length as temperature changes. This means that temperature factors change the measured value by the indicated amount.

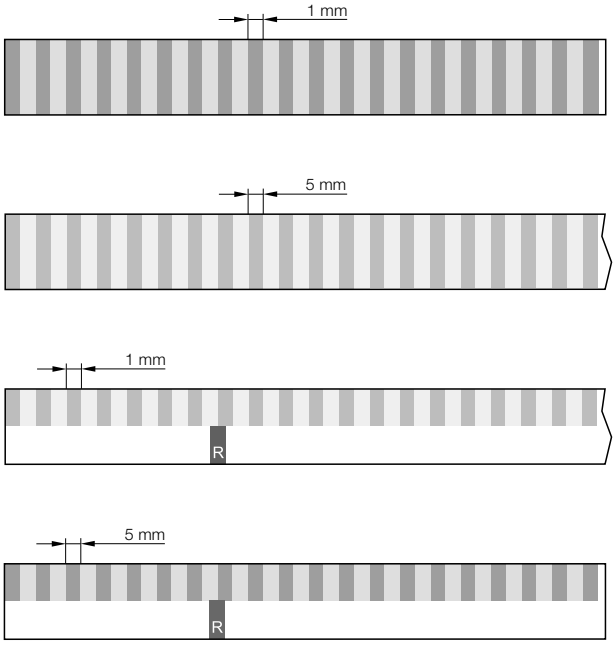
Measurement rate

The measurement rate is the frequency at which the output position information is updated. It can be the same as the number of measurements per second. A high measurement rate for rapidly changing positions is important if a process is time-critical.

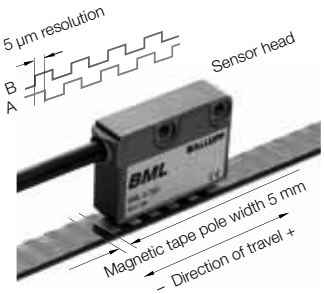
Tape, pole width

On the magnetic tape, there is a track with alternating magnetic north and south poles. In some variants, a second track with reference points is available.

The magnetic tapes exist in 1 mm (BML-M...-I3_-...) and 5 mm (BML-M...-I4_-...) pole width.



The magnetic tapes are available in various versions. Make sure the magnetic tape and sensor head fit together.

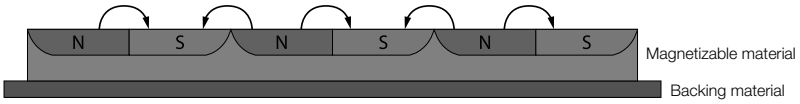


Interpolation

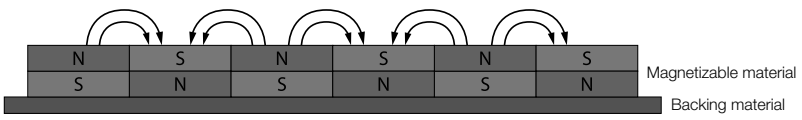
The magnetic period of the tape is interpolated by the sensor head with integrated interpolator with up to 10-bit (factor 1000).

Permagnet perpendicular magnetic tape

Standard magnetic tape



Permagnet perpendicular magnetic tape



+ larger field strength
+ better accuracy

Reference point function

For each incremental position measurement system, the reference position is essential as a starting point for the counting.
How the reference position is determined depends on the sensor head, the magnetic tape and the controller itself.
Advantages of the pole-periodic and fixed-periodic tapes: The tape can be bought in great lengths and cut to size by the customer.
The reference point functions are possible with linear and with round tapes (rings, only with sensor head BML-S2B/E, BML-S1F...).

Relationship between resolution, speed and edge separation (examples)

Sensor head design for controller with 4-fold evaluation:

Example 1: Resolution needed: F = 5 µm
- In table 1 on page 51: Select column 1.
  Max. travel speed = 7 m/s
- Select line 2 = 10 m/s.
  ➔ Edge separation E = 0.29 µs

Example 2: Resolution needed: G = 10 µm
- In table 1 on page 51: Select column 2.
  Max. counting frequency of the controller = 0.5 m/s
  edge separation H = 2 µs
- Select line 5.
  ➔ Maximum possible travel speed: 3 m/s

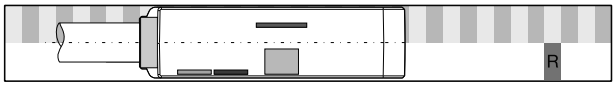
Example 3: Max. travel speed = 2 m/s
Controller detects min. edge separation M = 10 µs
- In table 1 on page 58: Select line 1.
- Select column 1.
  ➔ Maximum possible resolution L = 100 µm (BML-S1C)

Edge separation (= pulse width) min. edge separation [µs]		Controller identifies at least Max. counting frequency [kHz][1)]	Counting frequency (Signal period)
D	0.12	8,333	2,083.33
E	0.29	3.448	862.07
F	0.48	2.083	520.83
G	1	1.000	250.00
H	2	500	125.00
K	4	250	62.50
L	8	125	31.25
M	10	100	25.00
N	16	63	15.63
P	24	42	10.42
R	100	10	2.50

Table 1: Relationship of edge separation – counting frequency
[1)] Signal period = 1/4 × counting frequency

Single or double reference signal

System consisting of:
- BML-S_B/E…-M41_-…
  or BML-S1F...-M31...
- Tape BML-M…-I_ _-…-R_ _ _ _/0000 (single signal) or
  BML-M…-I_ _-…-R_ _ _ _/_ _ _ _ (double signal)

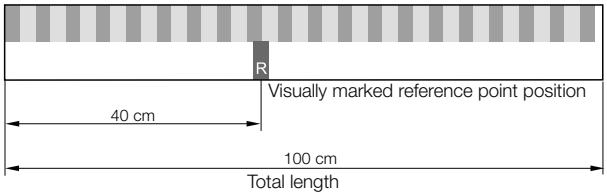


A sensor head with an additional reference point sensor can output a reference point signal as soon as it reaches the magnetically encoded reference point on the second track of the tape. No external reference switch is necessary.

Single reference point magnetic tape type BML-M...-R_ _ _ _ /0000

For the magnetic tape with single reference point, the reference point may be integrated as desired at any location. To determine the exact absolute position, the reference run must cover the entire length of the tape up to the reference point.

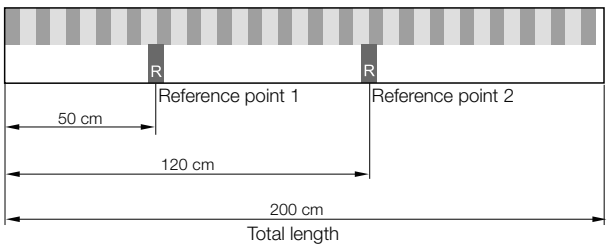
Ordering example for the tape shown below:
BML-M02-I45-A0-M0100-R0040/0000



Magnetic tape with two reference points, type BML-M...-R_ _ _ _ /_ _ _ _

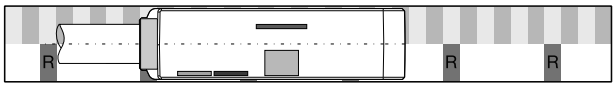
For the magnetic tape with two reference points, the reference point may be integrated as desired at any location. To determine the exact position, the reference run must cover the entire length of the tape up to the external selection switch. The external selection switch decides on the use of Z signals.

Ordering example for the tape shown below:
BML-M02-I46-A0-M0200-R0050/0120



Fixed-periodic reference signals

System consisting of:
- BML-S_B/E…-M41_-…
  or BML-S1F...-M31...
- Tape BML-M…-I_ _-…-C0006/_ _ _ _

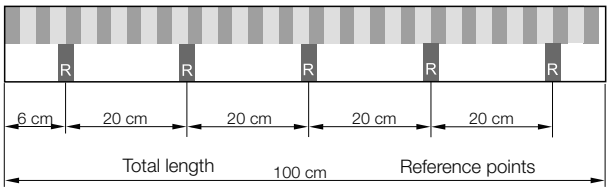


The sensor head with an additional reference point sensor can also be combined with a magnetic tape with fixed-periodic reference points. Here, the reference points are integrated across the entire length of the tape at certain constant intervals, such as every 10 cm. To determine the exact position, the reference run must go to the external selection switch.

Magnetic tape with fixed-periodic reference points, type BML-M...-C0006/_ _ _ _

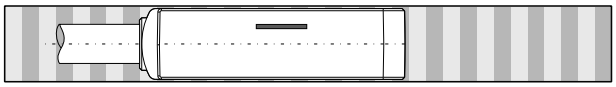
For magnetic tape with fixed-periodic reference points, the reference points are integrated across the entire length of the tape at certain constant intervals, such as every 20 cm. To determine the exact position, the reference run must extend to the external selection switch, which decides on the use of the Z signals.

Ordering example for the tape shown below:
BML-M02-I34-A0-M0100-C0006/0020



No or pole-periodic reference signal

System consisting of:
- BML-S_B/C/E…-M40_-… (none)
  or BML-S_B/E…-M42_-… (pole-periodic)
  or BML-S1F...-M30...
  or BML-S1F...-M32...
- Tape BML-M…-I_ _-…-R0000

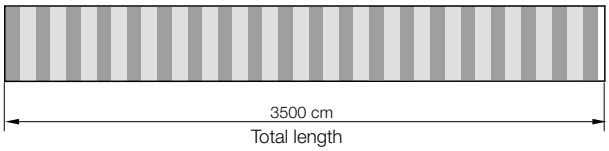


In the simplest position measurement system, the sensor head scans the magnetic periods with the incremental sensors. On the tape, there is a track with magnetic north and south poles. The position is determined by the controller by adding up the counted increments.
For the pole-periodic reference point signal, a reference point signal is output with each magnetic pole. In this case, an external reference switch has to be set on the selected reference point signal. The controller precisely evaluates the reference position when the switch and the reference point signal of the sensor head are active.

Pole-periodic magnetic tape, type BML-M...-R0000

The pole-periodic magnetic tape has alternating magnetic north and south poles, but no integrated reference point.

Ordering example for the tape shown below:
BML-M02-I34-A0-M3500-R0000



Maximum speed

The measurement system BML enables the detection of rotary movements. The speed and the diameter of the magnet ring determine the speed of the ring on the sensor head. The maximum travel speed that the sensor can still identify depends on the resolution and the edge separation of the sensor head. Resolution and edge separation can be selected. A maximum speed is then calculated using the following formula:

$$\text{Max. speed [rpm]} = \frac{60 \times \text{max. travel speed [m/s]}}{\pi \times \text{Magnet ring diameter [m]}}$$

For the maximum travel speed and minimum edge separation, see table 1 on page 51. Recommendation: max. speed 10 % less than determined speed value.

Max. travel speed	RPM Outer diameter				
	31 mm	49 mm	72 mm	75.4 mm	122 mm
20 m/s	12322	7795	5305	5066	3131
14.75 m/s	9087	5749	3913	3736	2309
10 m/s	6161	3898	2653	2533	1565
8.8 m/s	5422	3430	2334	2229	1378
8 m/s	4929	3118	2122	2026	1252
7.7 m/s	4744	3001	2042	1950	1205
6.5 m/s	4005	2533	1724	1646	1018
5 m/s	3080	1949	1326	1266	783
4.2 m/s	2588	1637	1114	1064	657
3.95 m/s	2434	1540	1048	1001	618
3.25 m/s	2002	**1267**[1)]	862	823	509
3 m/s	1848	1169	796	760	470
1.8 m/s	1109	702	477	456	282
1.7 m/s	1047	663	451	431	266
1.5 m/s	924	585	398	380	235
0.95 m/s	585	370	252	241	149
0.9 m/s	554	351	239	228	141
0.75 m/s	462	292	199	190	117
0.65 m/s	400	253	172	165	102
0.395 m/s	243	154	105	100	62
0.375 m/s	231	146	99	95	59
0.26 m/s	160	101	69	66	41
0.195 m/s	120	76	52	49	31
0.13 m/s	80	51	34	33	20

[1)] see example below
Table 2: Maximum speed of rotary tape (magnet ring)

Example

Sensor head BML-S2B… with a resolution of 5 µm (F) and a min. edge separation of 1 µs (G). From table 1 on page 51, for this sensor head, there is a max. travel speed of 3.25 m/s.
With a magnet ring diameter of 49 mm = 0.049 m, according to the formula, a speed of 1,267 rpm can be reached (the value can also be read out in table 2 (column 49 mm/line 3.25 m/s)). Under consideration of the recommendation to stay 10 % below this, a speed of 1,140 rpm is not to be exceeded.