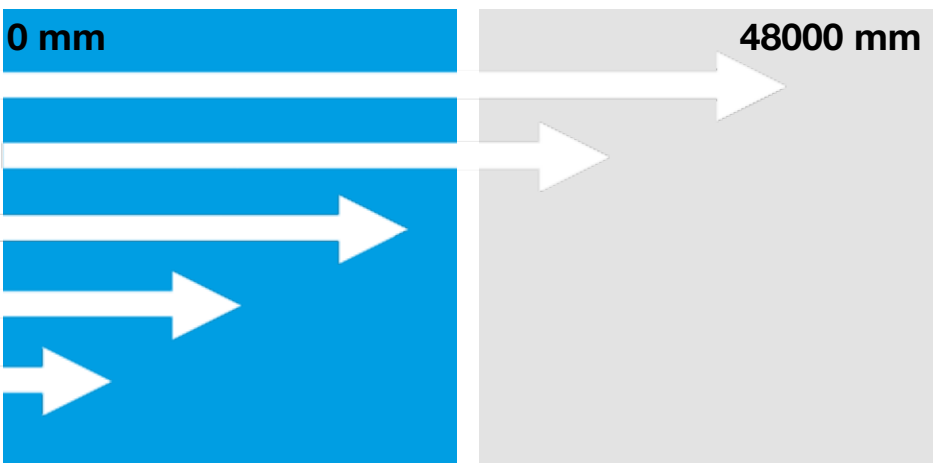
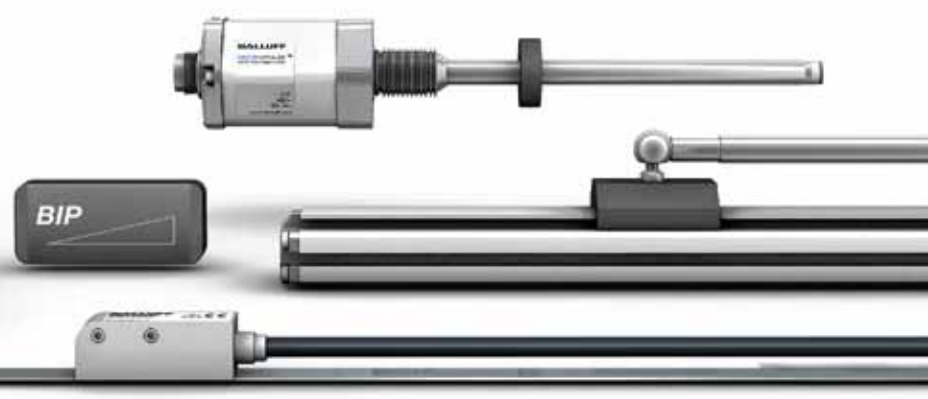
BALLUFF

*sensors worldwide*

# Linear Position Sensing and Measurement

**The appropriate measuring principle for the optimal solution**



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.**


CERTIFICATE

LISTED

# Linear Position Sensing and Measurement
## Contents



# 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 measuring 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 allows for extremely high measurement speeds.


Accessories can be found on **page 48.**

Basic information and definitions can be found on **page 54.**

# 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 BML-S1H provides position feedback in highly dynamic applications even in extremely tight spaces.

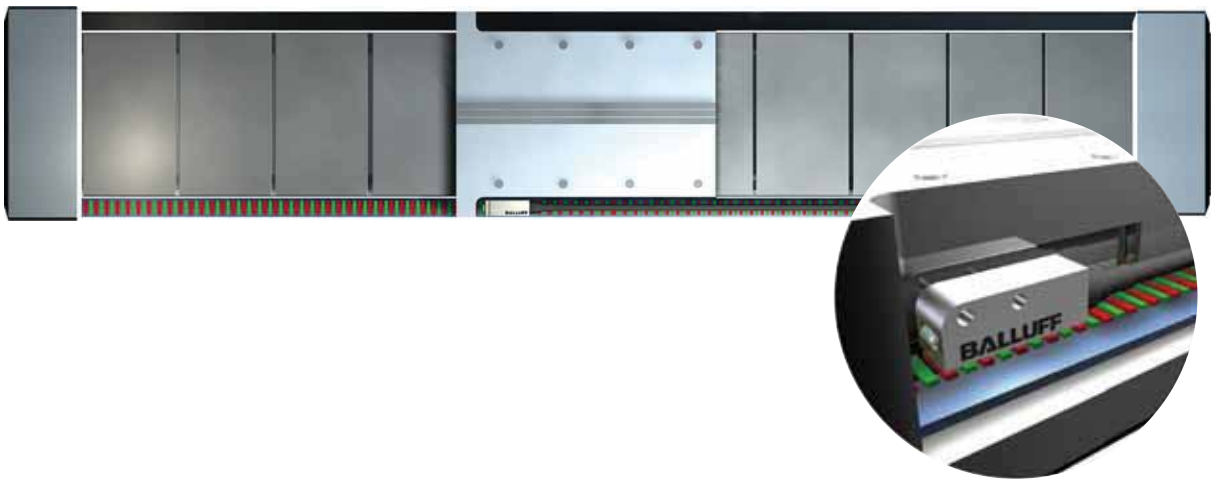
- Optimum control quality by means of a high measurement rate and linearity
- Additional analog signal for highly dynamic controls
- Smallest metal housing reduces installation space

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

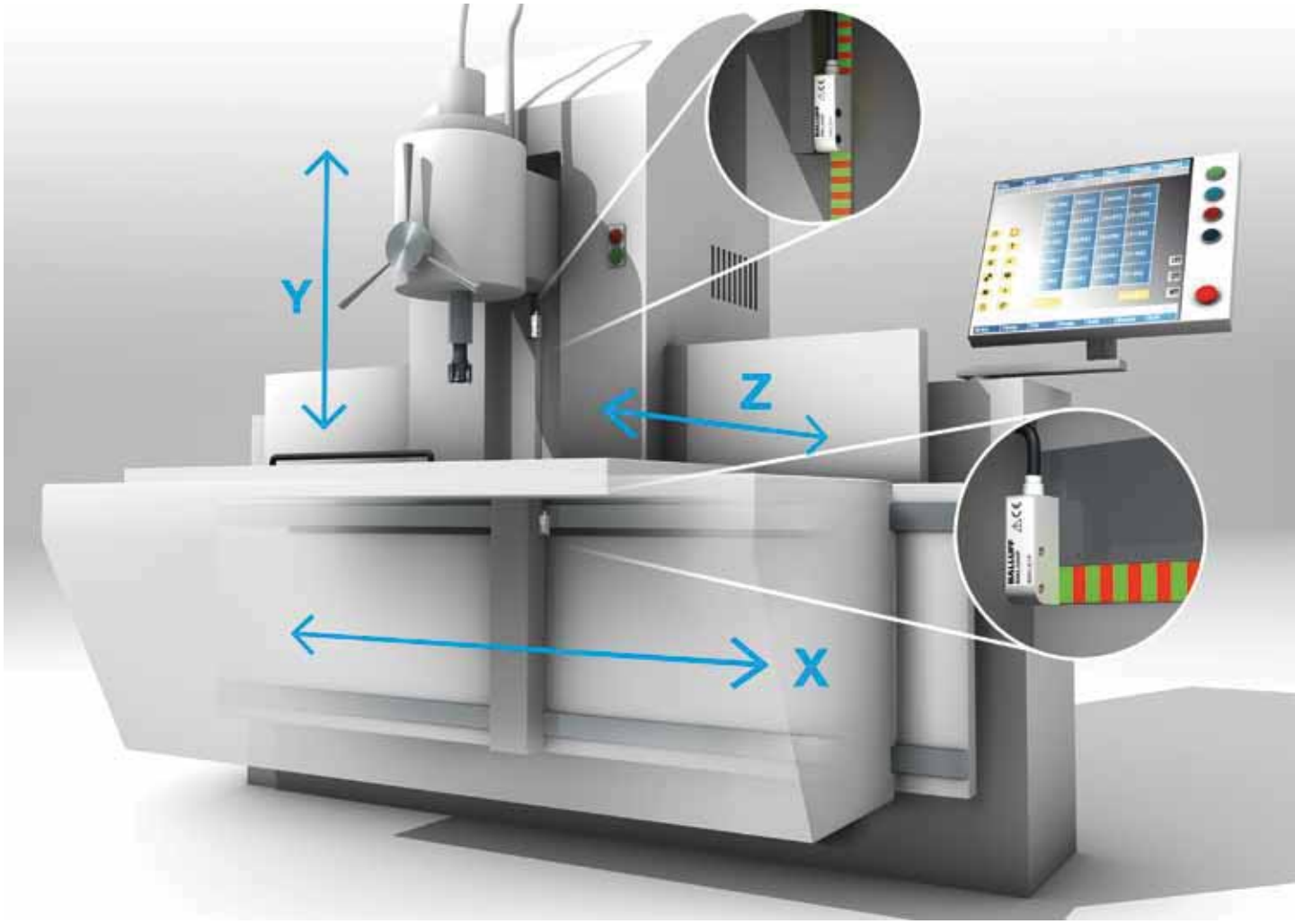
Successfully used for years for to point mirrors towards the sun with high accuracy. With BML you achieve the best energy efficiency in concentrated solar power plants and parabolic trough power plants.

# Magnetically Coded Position and Angle Measurement System
## Applications

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.




Universal milling machines use magnetically coded position and angle measurement systems BML for accurate positioning of the x, y, and z axes.

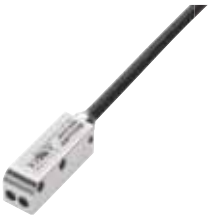


# High precision and extended lengths

| **Series** | **BML-S1H_-M3AA...** | **BML-S1H_-M3CA...** | | | |
|---|---|---|---|---|---|
| Resolution | 1...10 µm | 1...10 µm | | | |
| System accuracy | ±7 µm | ±7 µm | | | |
| Distance to tape | 0.1...0.35 mm | 0.1...0.35 mm | | | |
| Linear tape | 0...64 mm | 0...256 mm | | | |
| Rotary tape (magnet ring)<br>Ø 30 to 300 mm | | | | | |
| **Interfaces** | | | | | |
| Absolute SSI | ■ | ■ | | | |
| Absolute BiSS-C | ■ | ■ | | | |
| Incremental digital RS422 (TTL) | | | | | |
| Incremental digital HTL<br>(as supply voltage 10 to 30 V) | | | | | |
| Incremental analog sin/cos (1 $V_{ss}$) | ■ | ■ | | | |
| From page | 18 | 18 | | | |

# Magnetically Coded Position and Angle Measurement System

## Product overview


| | BML-S1F_-Q... | BML-S1F_-A... | BML-S2B0-Q... | BML-S2E0-Q... | BML-S1C0-Q... | |
|---|---|---|---|---|---|---|
| | 1...10 µm | | 5 to 50 µm | 5 to 50 µm | 100 to 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 | |
| | ■ | ■ | ■ | ■ | ■ | |
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| | | | | | | |
| | ■ | | ■ | ■ | | |
| | | | ■ | ■ | ■ | |
| | | ■ | | | | |
| | 26 | 26 | 34 | 34 | 34 | |

# 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 evaluation unit.
With the absolute systems, the absolute position is processed as an SSI or BiSS signal at the standard interface of the electronic evaluation 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 measuring 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 5 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.

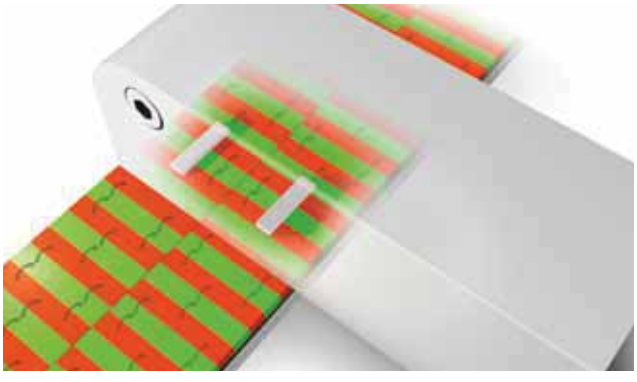
**Non-contact and highly robust, even for applications in rough conditions**

In addition to the high accuracy and real-time capability, the BiSS interface allows for bidirectional communication including signal error detection. Since the measuring system operates magnetically, unlike optical systems it is highly immune to 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 incremental signal analog sin/cos (1 $V_{SS}$)
- Gap between sensor and tape up to 0.35 mm

**Operating principle of absolutely coded position and angle measurement system BML**

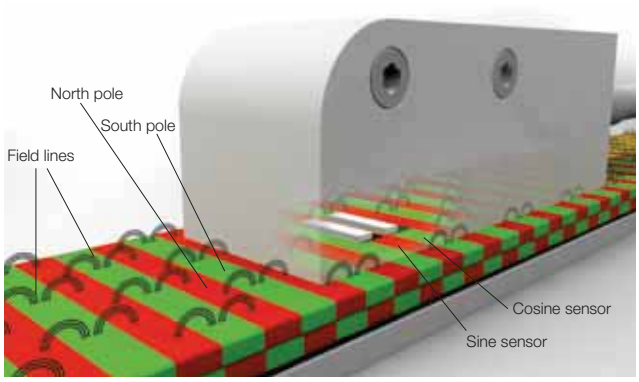


# Magnetically Coded Position and Angle Measurement System
## Function principle

**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 $V_{ss}$
- Gap between sensor and tape up to 2 mm
- Reference and limit switch function

**Operating principle of incremental position and angle measurement system BML**



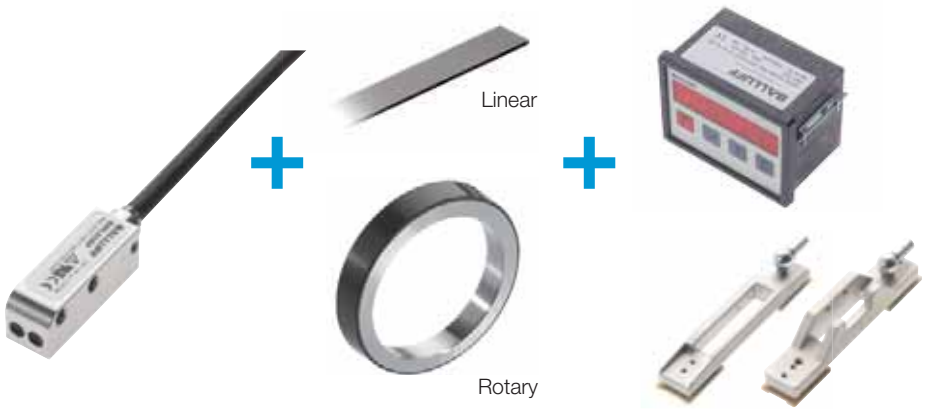

**Customizing**

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

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 use parallel or perpendicular to the tape enables integration even under very tight installation conditions.

# Contents



**Tape**
Page 24

**Digital display**
Page 24

**Connection cables**
Page 24

**Features**
- Absolute measuring 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

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

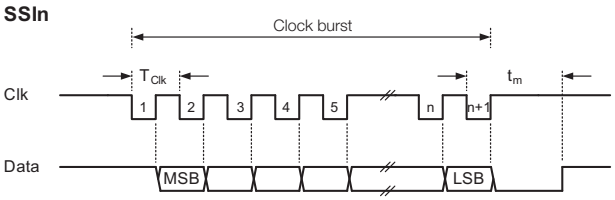
- Exact results by means of position detection right on the load support
- Compact design
- Ideal for short strokes
- Long-term reliability
- Wear-free due to non-contact measuring

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

### SSI interface

Synchronous serial data transmission 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-proof RS485/422 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-M2A...: 16-bit,
- BML-S1H_-S6_C-M2C...: 18-bit,
- Binary or Gray-coded
- Rising or falling

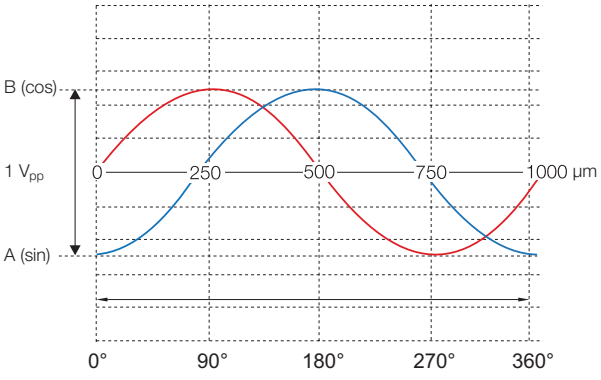


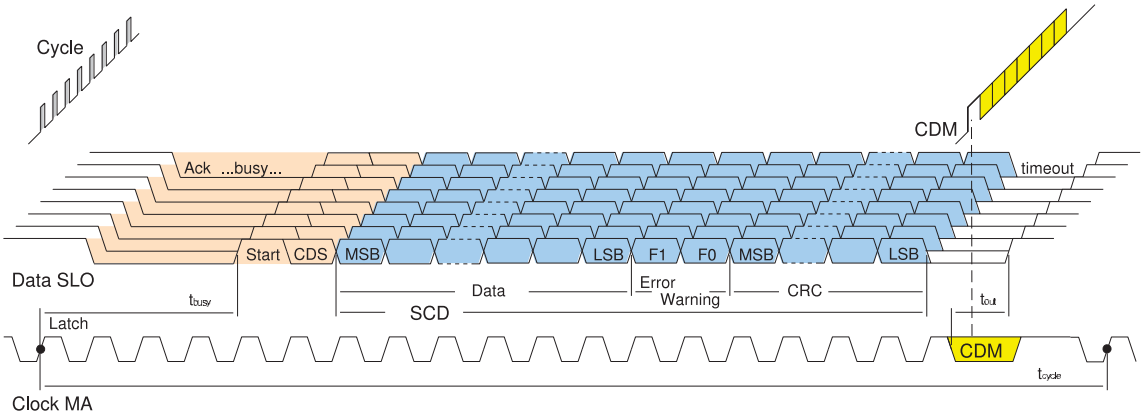

### BiSS-C interface

BiSS-C is a synchronous serial data transmitter and 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.

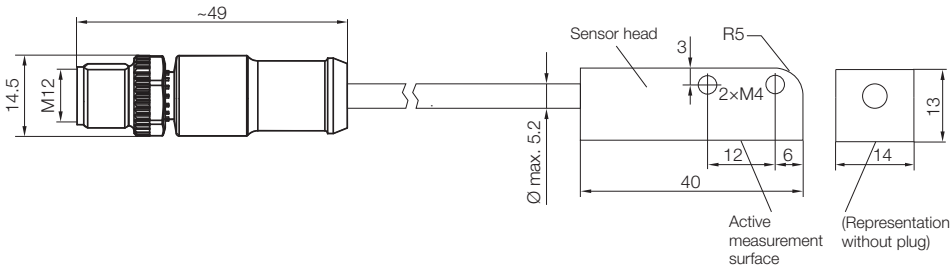
Additional analog real-time signal sin/cos 1 $V_{ss}$



| | |
|---|---|
| Series | **BML-S1H...** |
| Output signal | Absolute: SSI or BiSS-C, additional analog signal sin/cos 1 $V_{ss}$ |
| Data format | 16-bit (BML-S1H...-M3AA-...) or 18-bit (BML-S1H...-M2CA-...) |
| Resolution | 1/1.024 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 operating 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. traverse speed | 5 m/s (absolute) |
| Measurement rate for SSI | $f_{STANDARD}$ = 50 kHz |
| 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 24)




**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 plug, 12-pin |
| | | | | S | Binary code, falling | | | |
| | | | | T | Gray code, falling | | | |

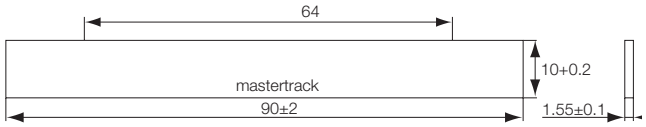
**Preferred models**

- **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 plug
- **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 plug

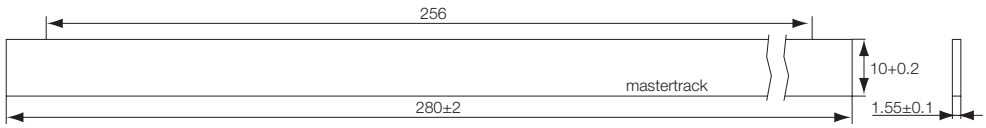
**Attention!**
**Please read the instructions in the user's guide before designing, installing, and commissioning! www.balluff.de**

| 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 | 90 mm | 280 mm |
| Measuring length | 64 mm | 256 mm |
| Magnetic tape material | Rubber ferrite | Rubber ferrite |
| Cover strip material | Stainless steel | Stainless steel |

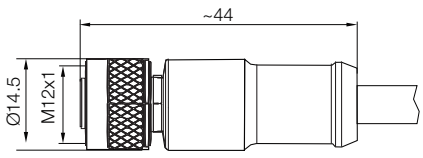
BML039J



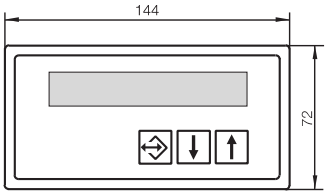

BML039K



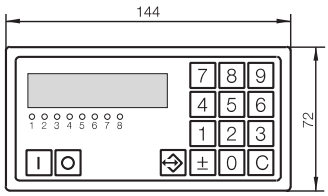

| Accessories | M12 connection cable, 12-pin, straight socket | | | | |
|---|---|---|---|---|---|
| Series | BML-S1H...-S284 | | | | |
| **Ordering code** | e.g. **BCC09MY** (5 m) | | | | |
| Part number | BCC M41C-0000-1A-169-PS0C08-_ _ _C009 | | | | |
| Material | PUR with molded plug, black | | | | |
| Description/additional data | ■ Cable: Ø 4.9 mm, 12×0.08 mm²<br>■ Bending radius:<br>15×D (dynamic), 7.5×D (static)<br>■ Temperature range: –25 °C to +70 °C | | | | |
| Available lengths/types | 020<br>2 m | 050<br>5 m | 100<br>10 m | 150<br>15 m | 200<br>20 m |



| 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<br>■ LED display, 14 mm-high red 7-segment digits<br>■ Scalable measured values<br>■ Variable decimal point setting<br>■ Adjustable zero point<br>■ Supply voltage 10...32 V<br>■ 2 programmable relay outputs, each as limit switch/comparator<br>■ Cam<br>■ 2-point controller<br>■ 1 configurable input<br>■ External zeroing<br>■ Retention of the display value<br>■ Insulated DIN housing for mounting in front panel (clamp included in the scope of delivery) | ■ 8 programmable outputs<br>■ 8 directional switching points possible<br>■ LED display, six 14-mm high red 7-segment digits<br>■ Switching points can be controlled by LEDs on front panel<br>■ 300 switching points can be distributed over up to 15 programs<br>■ Adjustable top dead center/zero point shift<br>■ Dynamic dead-time compensation for each individual switching point<br>■ Multiple BDD-CC 08 units can be wired in parallel<br>■ Integrated transducer supply voltage 300 mA, 24 V<br>■ 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

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



# General data

**Tape**
Page 30

**Magnet Rings**
Page 31

**Counter-Displays**
Page 50

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

**System selection:**
**Relationship between resolution, edge separation and speed**
Selection guide, page 32

**Ordering example: sensor head with digital square-wave signal RS422**

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

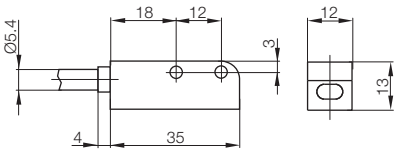
| Approach direction | | Resolution | | Reference signal | | Min. Edge separation | | Connection | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Parallel | D | 1 µm | 0 | None | D | 0.12 µs | KA02 | PUR cable 2 m |
| 2 | Perpen-dicular | E | 2 µm | 1 | Individually or fixed-periodic | E | 0.29 µs | KA05 | PUR cable 5 m |
| | | F | 5 µm | | | F | 0.48 µs | KA10 | PUR cable 10 m |
| | | G | 10 µm | 2 | Pole-periodic only with digital design ...-Q61_-... | 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 | | |

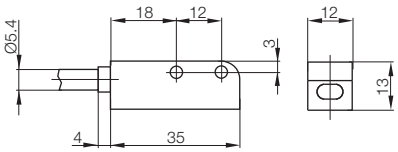
Sensor connectors (e.g. SUB-D) are available on request.
Better resolution available on request.

**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

| Series | BML-S1F_-Q... | BML-S1F_-A... |
|---|---|---|
| Output signal | Digital square-wave signals RS422 | Sinusoidal analog signals sin/cos |
| Resolution | 1 µm, 2 µm, 5 µm or 10 µm | processing-dependent |
| 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 operating 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. traverse speed | 20 m/s | 20 m/s |
| Operating temperature | –20...+80 °C | –20...+80 °C |
| Housing material | Al | Al |
| Degree of protection | IP 67 | IP 67 |

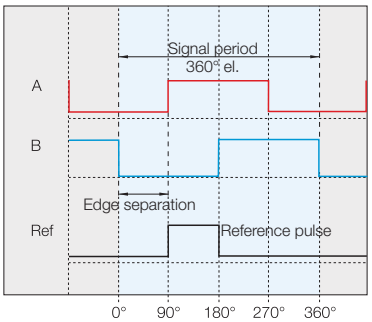
All specifications in conjunction with tape BML-...-I34... (see page 30).



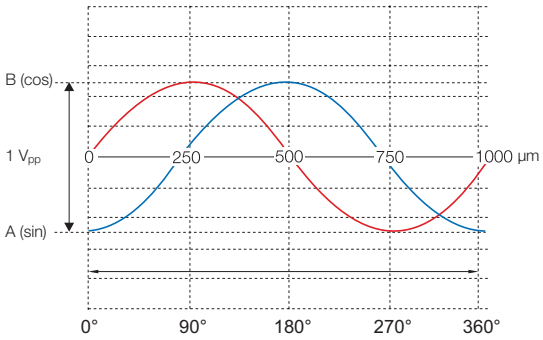

**Digital square-wave signals RS422**

- RS422 square-wave signals in acc. with DIN 66259
- 90° phase shifted
- Edge separation A/B corresponds to the resolution of the sensor head
- Differential signal
- Terminating resistor ≥ 120 ohms (integrated in the evaluation unit)



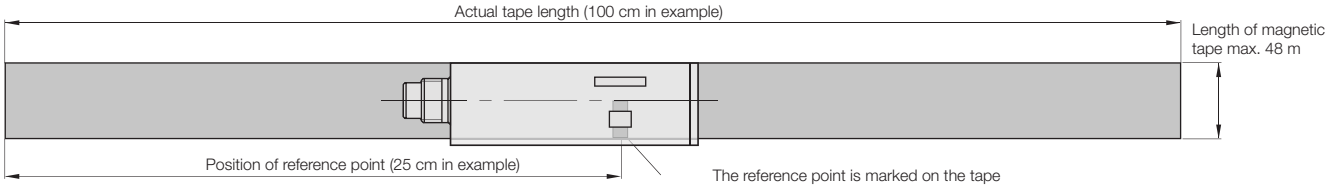

**Sinusoidal analog signals 1 $V_{pp}$**

- Sinusoidal voltage signals with inversion
- Signal period 360°, electrical = 1000 µm
- Terminating resistor ≥ 120 ohms (integrated in the evaluation unit)

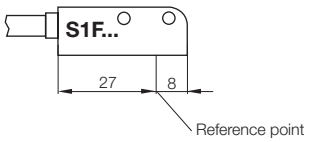



**Caution!**
**Please read the instructions in the user's guide before designing, installing, and commissioning! www.balluff.de**

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




**Typical position of reference points in sensor head**




**Fabricated magnetic tape, pole width 1 mm**

**BML-M_ _-I3_-A_-M_ _ _ _-_ _ _ _ _**

| Design | Accuracy class | Cover strip | Length in cm | Reference point positions |
|---|---|---|---|---|
| 02 1.55 mm thick, with adhesive strip | 4 8 µm, overall accuracy ±10 µm | 3 With cover strip (thickness 0.15 mm) | Order length, max. 4800 = 48 m | R0000 None or pole-periodic |
| 03 1.35 mm thick, without adhesive strip | 5 18 µm, overall accuracy ±20 µm | 0 18 µm, overall accuracy ±20 µm | | 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 |

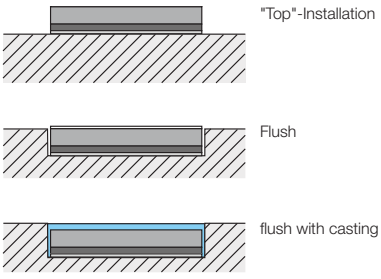
* Fixed-periodic reference point only for BML-M02-I34...

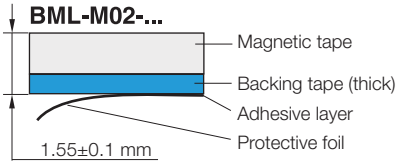
**Ordering example: Magnetic tape by the roll, pole width 1 mm**

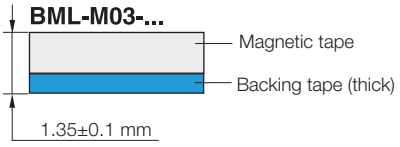
**BML-M02-I3_-A0-T_ _ _ _-R0000**

| Accuracy class | Length |
|---|---|
| 4 8 µm, overall accuracy ±10 µm | 0500 5 m |
| 5 18 µm, overall accuracy ±20 µm | 1000 10 m |
| (Better accuracy classes available on request.) | 2400 24 m |
| | 4800 48 m |

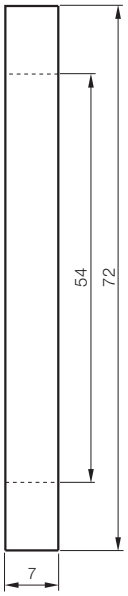
**Magnetic tape mounting options**

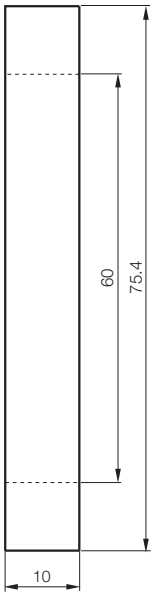


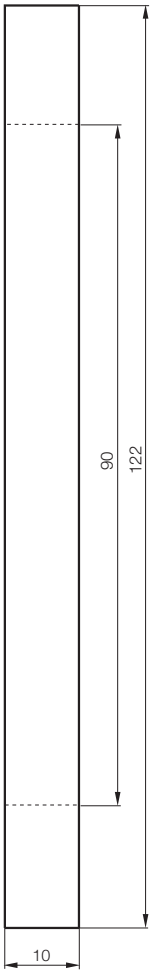



| Series | Sensor family F | Sensor family F | Sensor family F |
|---|---|---|---|
| **Ordering code** | **BML002K** | **BML01KM** | **BML01EW** |
| Part number | BML-M20-I30-A0-M072/054-R0 | BML-M31-I30-A0-M075/060-R0 | BML-M30-I30-A0-M122/090-R0 |
| Number of poles | 228 | 238 | 384 |
| Pole width | 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 |



The BML system enables precise adaptation to the relevant application. Balluff offers a technical selection guide that provides valuable assistance. For additional examples, see Basic Information and Definitions on page 54.

### Selecting a suitable controller

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.

Please use the following formula to select a suitable controller:

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

Example: If the sensor has a minimum edge separation gap of 1 µs, then a controller capable of detecting at least 1 MHz must be selected based on the above formula.

### 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 | | $V_{max}$ in accordance with edge separation and resolution<br>Mechanical resolution | | | |
|---|---|---|---|---|---|
| | | **D** 1 µm | **E** 2 µm | **F** 5 µm | **G** 10 µm |
| **D** | 0.12 µs | 5 m/s | 10 m/s | 20 m/s | 20 m/s |
| **E** | 0.29 µs | 2 m/s | 4 m/s | 10 m/s | 10 m/s |
| **F** | 0.48 µs | 1 m/s | 2 m/s | 5.41 m/s | 5.41 m/s |
| **G** | 1 µs | 0.65 m/s | 1.3 m/s | 2.95 m/s | 2.95 m/s |
| **H** | 2 µs | 0.3 m/s | 0.6 m/s | 1.54 m/s | 1.54 m/s |
| **K** | 4 µs | 0.15 m/s | 0.3 m/s | 0.79 m/s | 0.79 m/s |
| **L** | 8 µs | 0.075 m/s | 0.15 m/s | 0.34 m/s | 0.34 m/s |
| **N** | 16 µs | 0.039 m/s | 0.079 m/s | 0.19 m/s | 0.19 m/s |
| **P** | 24 µs | 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 BML system allows precision adaptation of rotary tapes to the relevant application.
Balluff offers a technical selection guide for rotary systems that provides valuable assistance.

**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 BML system enables the detection of rotary movements. The speed and the diameter of the magnetic 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.
With consideration for the reduced value, the speed should not exceed 705 rpm.

# Magnetically Coded Position and Angle Measurement System

## S2B/S2E/S1C series

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 38



**Counter-Displays**
Page 50

**Magnet Rings**
Page 39

### 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 to 30 V
- Two freely positionable limit switches
- Reference signal
- LED display for reference signal

### System selection

**Relationship between resolution, edge separation and speed**
Selection guide, see page 41

### Ordering example: sensor head

**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.

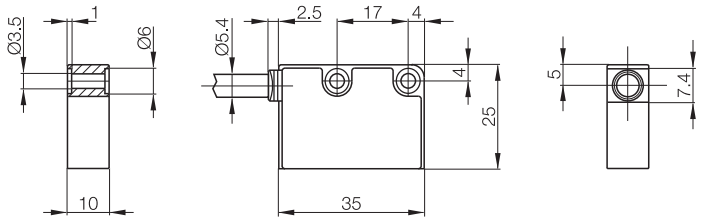
### Preferred models

- **BML-S2B0-Q53F-M410-D0-KA05 (BML0211)**
  Digital signal, 10 to 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 to 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
## General data

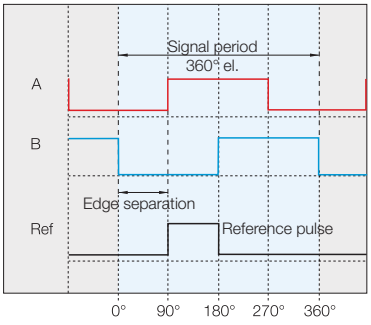
| Series | BML-S2B0-... | BML-S2E0-... |
|---|---|---|
| Output signal | Digital square-wave signals | Digital square-wave signals |
| Resolution | 5 µm, 10 µm, 25 µm or 50 µm | 5 µm, 10 µm, 25 µm or 50 µm |
| Part number | BML-S2B0-Q_ _ _-M4_ _-_0-_ _ _ _ | BML-S2E0-Q_ _ _-M4_ _-_0-_ _ _ _ |
| Output voltage (A/B/Z) | RS422 to DIN 66259 or same as operating voltage 10...30 V (without A/B/Z) | RS422 to DIN 66259 or same as operating voltage 10...30 V (without A/B/Z) |
| 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 to 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. traverse 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 38).



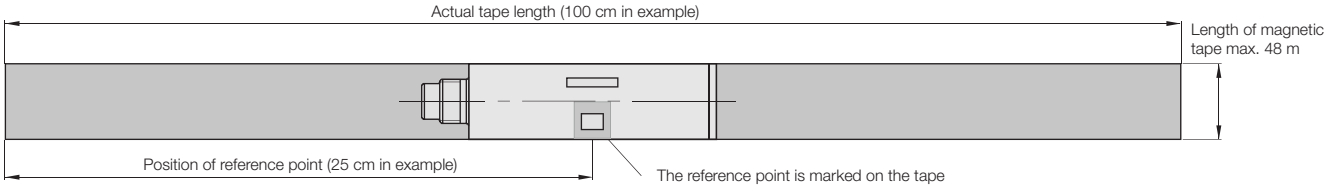

**Digital square-wave signals RS422**

- RS422 square-wave signals in acc. with DIN 66259
- 90° phase shifted
- Edge separation A/B corresponds to the resolution of the sensor head
- Differential signal (BML-S1A...)
- Terminating resistor ≥ 120 ohms (integrated in the evaluation unit)

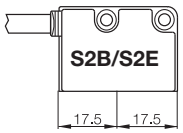



**Caution!**
**Please read the instructions in the user's guide before designing, installing, and commissioning! www.balluff.de**

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




**Typical position of reference points in sensor head**




**Fabricated magnetic tape, pole width 5 mm**

**BML-M_ _-I4_-A_-M_ _ _ _-_ _ _ _**

| Design | Accuracy class | Cover strip | Length in cm | Reference point positions |
|---|---|---|---|---|
| 02 1.55 mm thick, with adhesive strip | 4 18 µm, overall accuracy ±50 µm | 3 With cover strip | Order length, max. 4800 = 48 m | R0000 None or pole-periodic |
| 03 1.35 mm thick, without adhesive strip | 5 50 µm, overall accuracy ±100 µm (S2E... and S1C... only) | 0 Without cover strip | | 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 |

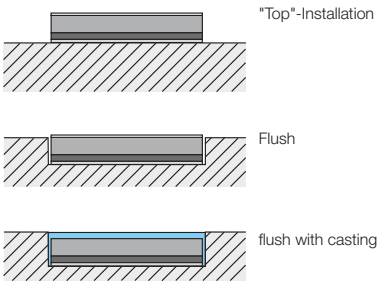
* Fixed-periodic reference point only for type BML-M02-I45-...

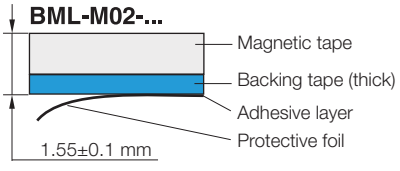
**Ordering example: Magnetic tape by the roll, pole width 5 mm**

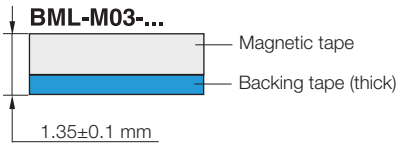
**BML-M02-I4_-A0-T_ _ _ _-R0000**

| Accuracy class | Length |
|---|---|
| 4 18 µm, overall accuracy ±50 µm | 0500 5 m |
| 5 50 µm, overall accuracy ±100 µm | 1000 10 m |
| (Better accuracy classes available on request) | 2400 24 m |
| | 4800 48 m |

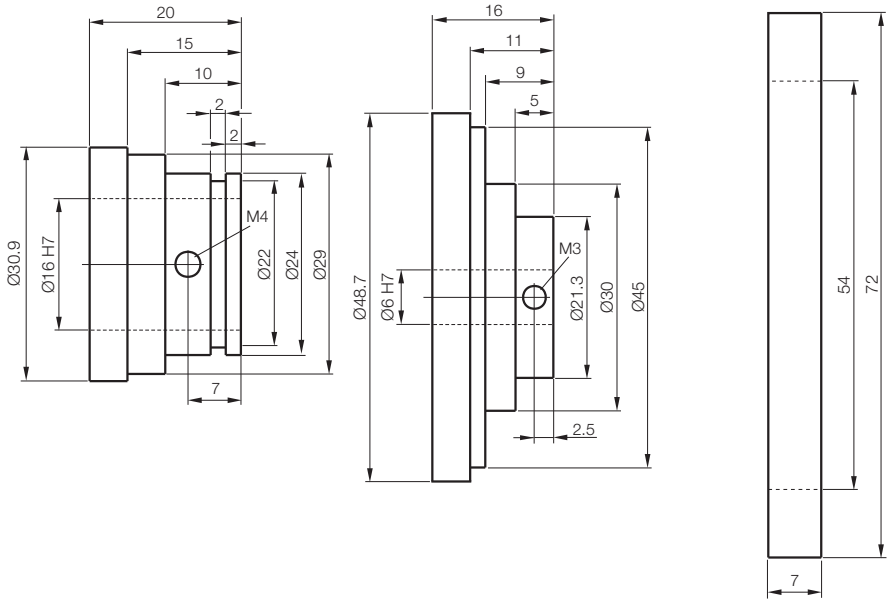
**Magnetic tape mounting options**



| Series | Sensor range B/C/E | Sensor range B/C/E | Sensor range B/C/E |
|---|---|---|---|
| **Ordering code** | **BML002T** | **BML002R** | **BML002P** |
| Part number | BML-M22-I40-A0-M031/016-R0 | BML-M21-I40-A0-M048/006-R0 | BML-M20-I40-A0-M072/054-R1 |
| Number of poles | 20 | 32 | 46 |
| Pole width | 5 mm | 5 mm | 5 mm |
| With reference mark | no | no | yes |
| Material | Hard ferrite/aluminum | Hard ferrite/aluminum | Hard ferrite |



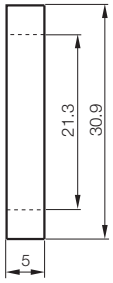

**Special solutions for a range of applications**

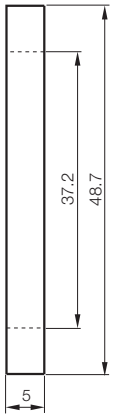
Magnetic rings are suitable for all types of applications where the monitoring of rotary movements is required. Due to the high resolution, synchronous run monitoring is just as easy to implement as precision angle positioning.

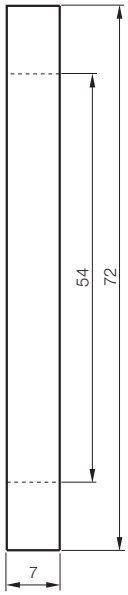
Balluff offers a range of standard rotary tapes that are suitable for most types of applications. Due to the wide variety of different machine applications, special dimensions and magnetic configurations are available on request.

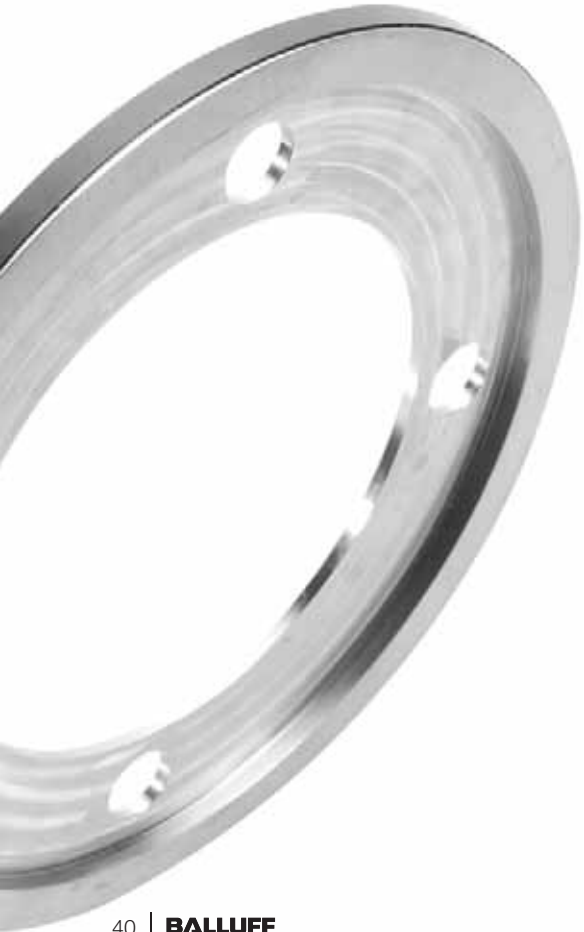
Even linear tapes have been used successfully in rotary applications. For example, the magnetic tape can be attached to the shaft of a solar panel unit to monitor whether the
panel is aligned perfectly with the sun. Balluff also offers prefabricated magnetic tapes with holes for convenient, simplified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

| Series | Sensor range B/C/E | Sensor range B/C/E | Sensor range B/C/E |
|---|---|---|---|
| **Ordering code** | **BML002L** | **BML002M** | **BML002N** |
| Part number | BML-M20-I40-A0-M031/021-R0 | BML-M20-I40-A0- M048/037-R0 | BML-M20-I40-A0-M072/054-R0 |
| Number of poles | 20 | 32 | 46 |
| Pole width | 5 mm | 5 mm | 5 mm |
| With reference mark | no | no | no |
| Material | Hard ferrite | Hard ferrite | Hard ferrite |



We offer custom solutions.
Simply contact us.

The BML system allows precision adaptation to the relevant application. Balluff offers a technical selection guide that provides valuable assistance. For additional examples, see Basic Information and Definitions on page 54.

**Selecting a suitable controller**
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.

Please use the following formula to select a suitable controller:

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

Example: If the sensor has a minimum edge separation of 1 µs, then a controller capable of detecting at least 1 MHz must be selected based on the above formula.

**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 | | $V_{max}$ in accordance with edge separation and resolution<br>Mechanical resolution | | | |
|---|---|---|---|---|---|
| | | **F** 5 µm | **G** 10 µm | **H** 25 µm | **K** 50 µm |
| **D** | 0.12 µs | 20 m/s | 20 m/s | 20 m/s | 20 m/s |
| **E** | 0.29 µs | 10 m/s | 20 m/s | 20 m/s | 20 m/s |
| **F** | 0.48 µs | 5 m/s | 10 m/s | 20 m/s | 20 m/s |
| **G** | 1 µs | 3.25 m/s | 6.5 m/s | 14.75 m/s | 14.75 m/s |
| **H** | 2 µs | 1.5 m/s | 3 m/s | 7.7 m/s | 7.7 m/s |
| **K** | 4 µs | 0.75 m/s | 1.5 m/s | 3.95 m/s | 3.95 m/s |
| **L** | 8 µs | 0.375 m/s | 0.75 m/s | 1.7 m/s | 1.7 m/s |
| **N** | 16 µs | 0.195 m/s | 0.395 m/s | 0.95 m/s | 0.95 m/s |
| **P** | 24 µs | 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 BML system allows precision adaptation of rotary tapes to the relevant application.
Balluff offers a technical selection guide for rotary systems that provides valuable assistance.

**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<br>Ø of magnet ring, outside | | |
|---|---|---|---|
| | 31 mm | 49 mm | 72 mm |
| **Ordering code** | **BML002T**<br>**BML002L** | **BML002R**<br>**BML002M** | **BML002P**<br>**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 magnetic rings from the S2B/S2E series

**Maximum speed**
The BML system enables the detection of rotary movements. The speed and the diameter of the magnetic 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 1µs (G). For this sensor, Table 1 gives a maximum travel speed of 3.25 m/s.
If the magnetic ring diameter is 48 mm = 0.048 m, a speed of 1293 rpm can be achieved using the formula. With consideration for the reduced value, the speed should not exceed 1164 rpm.


**Tape**
Page 44

**Magnet Rings**
Page 45

**Counter-Displays**
Page 50

**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 to 30 V (HTL)
- Cable connection
- 10 to 30 V DC supply voltage

**System selection**
**Relationship between resolution, edge separation and speed**
Selection guide, see page 47.

**Ordering example: sensor head**

**BML-S1C0-Q53_-M400-_0-KA_ _**

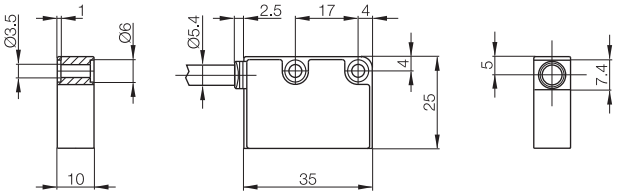
| Resolution | Max. edge separation | Connection |
|---|---|---|
| L 0.1 mm | M 10 µs | KA02 PUR cable 2 m |
| M 0.2 mm | R 100 µs | KA05 PUR cable 5 m |
| N 0.5 mm | | KA10 PUR cable 10 m |
| P 1.0 mm | | KA15 PUR cable 15 m |
| R 2.0 mm | | KA20 PUR cable 20 m |

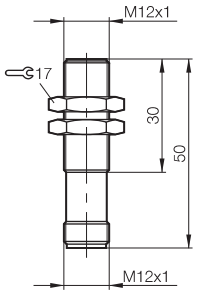
Sensor connectors (e.g. SUB-D or M12 connectors) are available on request.

**Preferred type**
- **BML S1C0-Q53L-M400-M0-KA05 (BML0034)**
  Digital signal, 10 to 30 V, 5 m cable, resolution 0.1 mm, edge separation 10 µs, max. travel speed up to 8 m/s

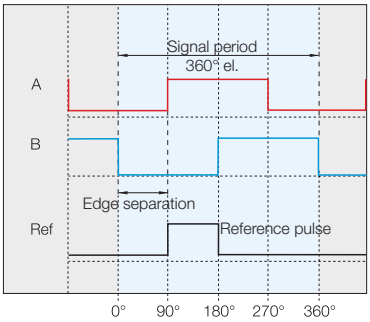
| Series | **BML-S1C0-...** | **BMF 12M-...** |
|---|---|---|
| Output signal | Digital square-wave signals | PNP/NPN normally open |
| Resolution | 5 µm, 10 µm, 25 µm or 50 µm | 1 switching operation per pole |
| **Ordering code** | | **BMF0022** |
| Part number | BML-S1C0-Q53_-M400-_0-KA_ _ | BMF 12M-PS-D-2-S4 (PNP normally open) |
| **Ordering code** | | **BMF0021** |
| Part number | | BMF 12M-NS-D-2-S4 (NPN normally open) |
| Output voltage (A/B) | Same as operating voltage 10...30 V | Supply voltage $-U_d$ |
| Overall system accuracy | ±100 µm | |
| Supply voltage | 10...30 V | 10...30 V DC |
| Voltage drop $U_d$ | | ≤ 3.15 V |
| Current consumption at 10 to 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 44).




**Digital square-wave signals HTL**
- Square-wave signals HTL
- 90° phase-shifted
- Edge separation A/B corresponds to the resolution of the sensor head
- Terminating resistor ≥ 120 ohms (integrated in the evaluation unit)



**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**

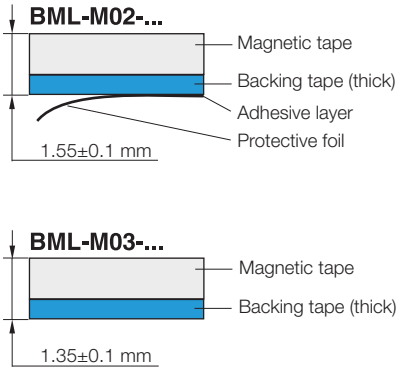
6 50 µm, overall accuracy ±100 µm

**Cover strip**

3 With cover strip
0 Without cover strip

**Length in cm**

Order length, max. 4800 = 48 m



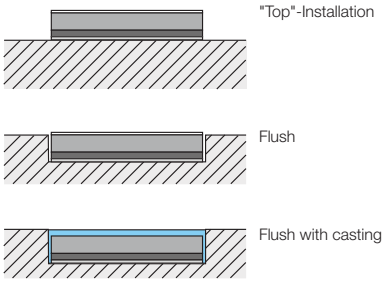

**Ordering example:**
**Magnetic tape by the roll, pole width 5 mm**

**BML-M02-I46-A0-T_ _ _ _-R0000**

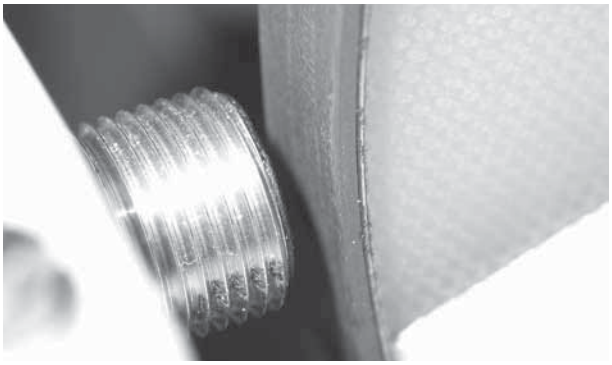
**Length**

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

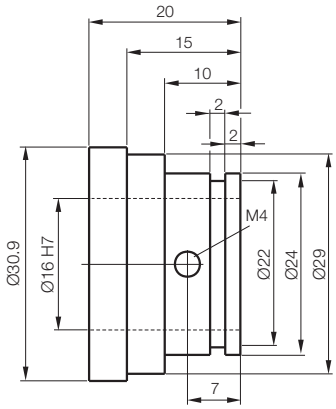
**Magnetic tape mounting options**
(also in magnetizable material)

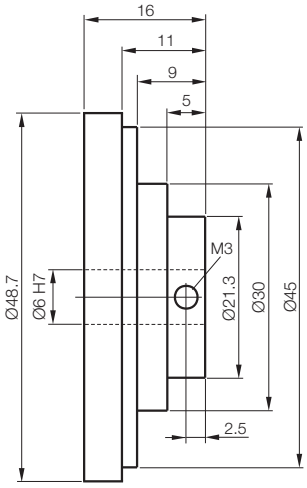



**BMF 12M-PS-D-2-S4**
**Speed monitoring in rotary applications:**
**Simply more cost-effective.**
Designed for the B/C/E sensor family, the magnet rings and magnetic tapes shown here allow you to measure speed by means of switching magnetic field sensors from the BMF series. With its standard M12 thread, the BMF 12M-PS-D-2-S4 sensor can be installed in a wide range of applications. and 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.



| Series | Sensor range B/C/E | Sensor range B/C/E |
|---|---|---|
| **Ordering code** | **BML002T** | **BML002R** |
| Part number | BML-M22-I40-A0-M031/016-R0 | BML-M21-I40-A0-M048/006-R0 |
| Number of poles | 20 | 32 |
| Pole width | 5 mm | 5 mm |
| With reference mark | no | no |
| Material | Hard ferrite/aluminum | Hard ferrite/aluminum |



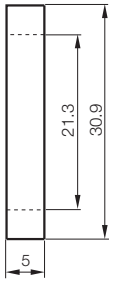

**Special solutions for a range of applications**

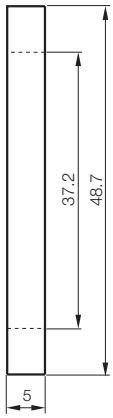
Magnetic rings are suitable for all types of application where the monitoring of rotary movements is required. Due to the high resolution, synchronous run monitoring is just as easy to implement as precision angle positioning.

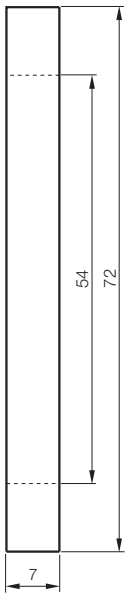
Balluff offers a range of standard rotary tapes that are suitable for most types of application. Due to the wide variety of different machine applications, special dimensions and magnetic configurations are available on request.

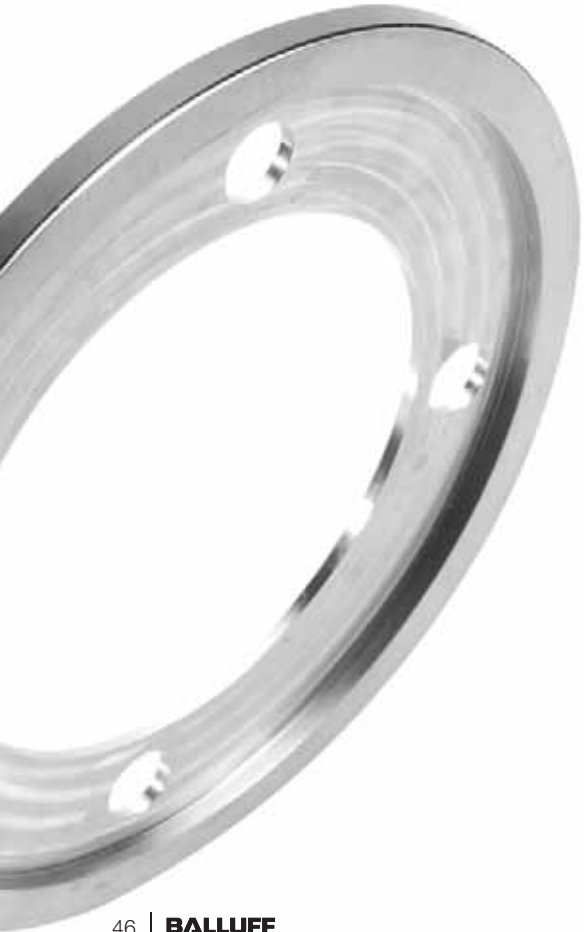
Even linear tapes have been used successfully in rotary applications. For example, the magnetic tape can be attached to the shaft of a solar panel unit to monitor whether the panel is aligned perfectly with the sun. Balluff also offers prefabricated magnetic tapes with holes for convenient, simplified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

| Series | Sensor range B/C/E | Sensor range B/C/E | Sensor range B/C/E |
|---|---|---|---|
| **Ordering code** | **BML002L** | **BML002M** | **BML002N** |
| Part number | BML-M20-I40-A0-M031/021-R0 | BML-M20-I40-A0-M048/037-R0 | BML-M20-I40-A0-M072/054-R0 |
| Number of poles | 20 | 32 | 46 |
| Pole width | 5 mm | 5 mm | 5 mm |
| With reference mark | no | no | no |
| Material | Hard ferrite | Hard ferrite | Hard ferrite |



We offer custom solutions.
Simply contact us.

The BML system allows precision adaptation to the relevant application. Balluff offers a technical selection guide that provides valuable assistance. For additional examples, see Basic Information and Definitions on page 54.

**Selecting a suitable controller**

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.

Please use the following formula to select a suitable controller:

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

Example: The sensor has a minimum edge separation of 1µs. Then the outcome, according to the formula above, is a controller that can detect at least 1 MHz.

**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 | | $V_{max}$ in accordance with edge separation and resolution<br>Mechanical resolution | | | | |
|---|---|---|---|---|---|---|
| | | **L** 100 µm | **M** 200 µm | **N** 500 µm | **P** 1000 µm | **R** 2000 µm |
| **M** | 10 µs | 8 m/s | 10 m/s | 10 m/s | 10 m/s | 10 m/s |
| **R** | 100 µs | 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 BML system allows precision adaptation of rotary tapes to the relevant application.
Balluff offers a technical selection guide for rotary systems that provides valuable assistance.

**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**<br>**BML002L** | **BML002R**<br>**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 magnetic rings from the S1C series

**Maximum speed**

The BML system enables the detection of rotary movements. The speed and the diameter of the magnetic 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.
With consideration for the reduced value, the speed should not exceed 2865 rpm.

# 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**

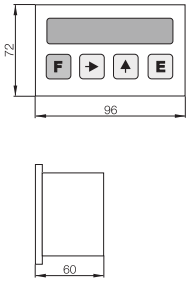
Speed detection of shafts and spindles as well as simple rotary encoder tasks can be optimally implemented with the combination of BML, BDD, and the magnet ring tapes.

| | | | |
|---|---|---|---|
| Series | | | |
| Interface | | | |
| | | | |
| **Ordering code** | | | |
| Part number | | | |
| **Ordering code** | | | |
| Part number | | | |
| **Ordering code** | | | |
| Part number | | | |
| Functions | | | |
| Features | | | |
| Use | | | |

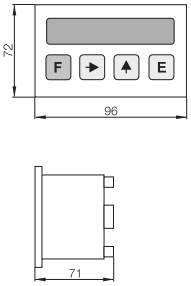
* Power supply unit for connecting to 115 V/230 V, for example, BAE0001 or BAE00EN on page 328.

| | **BDD 610** | **BDD 611/BDD 622/BDD 632** |
|---|---|---|
| | Single-axis counter<br>for BML-S1B..., BML-S1C...<br>and BML-S1E... | Single- or multi-axis counter 1, 2, 3<br>for all BML-Sxx... |
| | **BAE004J** | **BAE004K** |
| | BDD 610-R3Q3-0-53-N-00 (2 dig. inputs) | BDD 611-R3Q4-0-52-N-00 (1 axis) |
| | **BAE004H** | **BAE004M** |
| | BDD 610-R3Q3-0-51-N-00 (2 dig. outputs) | BDD 622-R3Q4-0-52-N-00 (2 axes) |
| | | **BAE004P** |
| | | BDD 632-R3Q4-0-52-N-00 (3 axes) |
| | ■ Set value<br>■ Actual value memory<br>■ Factor calculation<br>■ Count direction reversal<br>■ Up to 3 decimal places<br>■ Assignable key functions<br>■ Reset and set logic<br>■ Logic for inputs and outputs<br>■ Security code | ■ Set value<br>■ Actual value memory<br>■ Factor calculation<br>■ Edge evaluation<br>■ Count direction reversal<br>■ Up to 3 decimal places<br>■ Assignable key functions<br>■ Reset and set logic<br>■ Absolute and incremental measurement<br>■ Offset logic<br>■ Sawtooth correction<br>■ Logic for inputs and outputs<br>■ Security code<br>■ Reference pulse |
| | ■ Power supply 24 V DC*<br>■ 1×6-decade LED display<br>■ Digit height 14 mm<br>■ Incremental measuring system with tracks A, B<br>■ max. 25 kHz<br>■ 2 digital inputs (-51-)<br>■ 2 digital outputs (-53-) | ■ Power supply 24 V DC*<br>■ 1×6/2×6/3×6-decade LED display<br>■ Incremental measuring system with A, A, B, B, Z, Z or A, B, Z<br>■ Digit height 14 mm<br>■ 4 digital inputs<br>■ 2 digital outputs<br>■ Min. edge separation with 4-fold evaluation: 250 µs<br>■ BDD 611: max. input frequency: Signal A or B: 1 MHz |
| | for BML-S1B0..., BML-S1E0...<br>and BML-S1C0-...,<br>min. edge separation Code M, N, P, R | For BML with supply voltage 5 V/10 to 30 V, output voltage RS422/HTL,<br>min. edge separation Code E, F, G, H, K, L, M, N, P, R |

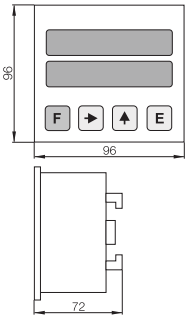
BDD 610



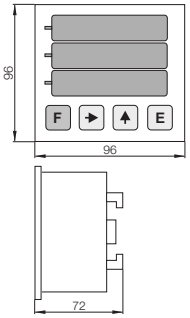

BDD 611




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 control arm is used for the mechanical connection.

**Features**

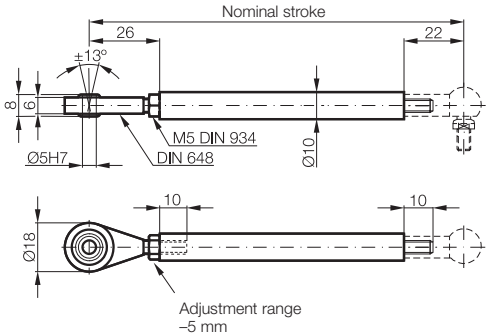
- Customized lengths
- Easily attached by directly screwing on or using mounting elements
- Rails can be mounted side by side and elements disassembled
- Connection of drag chains possible
- Flat design, minimal space requirements
- Low costs
- Runners need no lubrication, thus no maintenance costs
- 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 | |

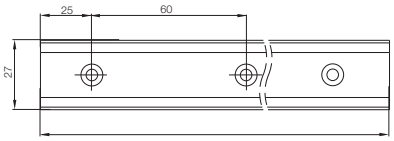
You may cover the magnetic tape with a stainless steel cover strip to protect it from damage caused by chips or chemicals.
Note that the permissible air gap between the sensor head and tape is reduced by the thickness of the cover strip with adhesive film (0.15 mm).

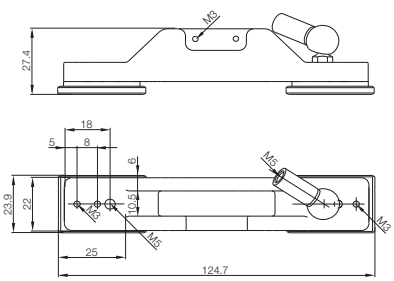
- Cover strip and magnetic tape can be ordered together in matching lengths (see tapes on page 30, 38, or 44).
- Cover strip by the roll can be ordered in 4 defined lengths.

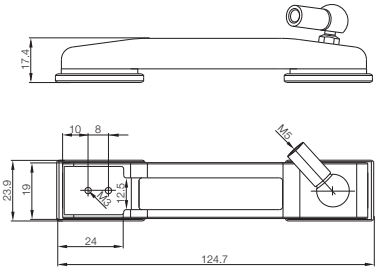
| Accessories | Joint rod<br>for BML-C01, BML-C02 | |
|---|---|---|
| **Ordering code** | e.g. **BAM000P** (100 mm) | |
| Part number | BTL2-GS10-_ _ _ _-A | |
| Use | For connecting the sliding carriage to the machine | |



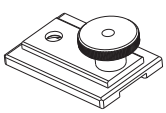
| | | |
|---|---|---|
| Guide rail<br>for sliding carriage BML-C01, BML-C02 | Sliding carriage<br>for sensors BML-S2B, BML-S2E, BML-S1C | Sliding carriage<br>for sensors BML-S1F |
| e.g. **BAM04N4** (3 m) | **BAM01MF** | **BAM01MH** |
| BML-R01-M_ _ _ | BML-C01 | BML-C02 |
| ■ Anodized aluminum<br>■ Mounting holes<br>■ Lateral groove for alternate mounting using brackets<br>■ Mountable side by side<br>■ Maintenance-free dry operation<br>■ Lubricant-free<br>■ Suitable for all linear tapes | ■ Aluminum<br>■ Fully mounted with runners<br>■ Connection for joint rod<br>■ Connection for drag chains<br>■ Maintenance-free dry operation<br>■ Lubricant-free | ■ Aluminum<br>■ Fully mounted with runners<br>■ Connection for joint rod<br>■ Connection for drag chains<br>■ Maintenance-free dry operation<br>■ Lubricant-free |

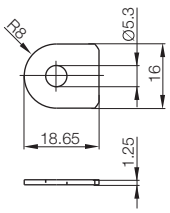


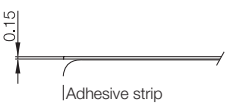




| | | | | |
|---|---|---|---|---|
| Mounting guide | Brackets<br>for BML-R01 | Cover strip from the roll<br>for BML-M02, BML-M03 | | |
| **BAM01L9** | **BAM01JL** | e.g. **BML001K** (10 m) | | |
| BML-Z0010 | BML-Z0008 | BML-A013-T_ _ _ _ | | |
| Installing the magnetic tape on BML-R01 | For lateral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





# Magnetically Coded Position and Angle Measurement System

# Contents



**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

=

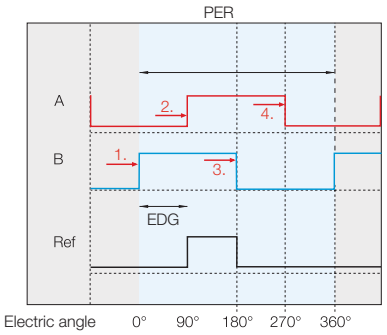
± 10 µm

**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 cycle
= 4 µm period length
= 250 periods per pin
= 96,000 periods per 360°
(384,000 pulses per 360°)




PER = a signal period
EDG = Edge separation

**Edge separation**

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

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

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

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 single identical 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.

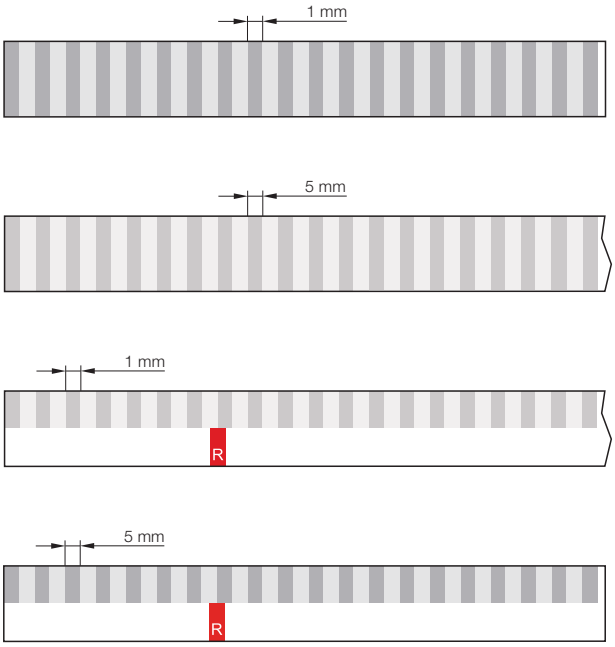
**Sampling rate**

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 sampling rate for rapidly changing positions is important when the process is time-critical.

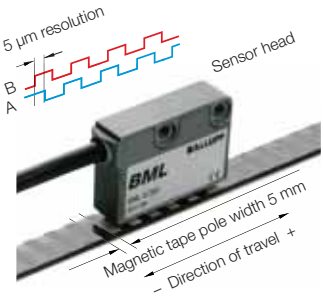
**Tape, pole width**

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 tape exists in 1 mm (BML-M...-I3_-...) and 5 mm (BML-M...-I4_-...) pole width.




The magnetic tape exists in various versions. You therefore have to take care that the magnetic tape and sensor head fit together.

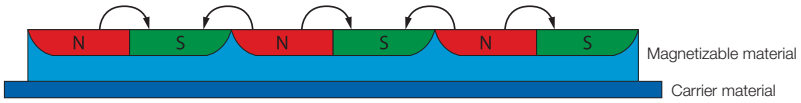



**Interpolation**

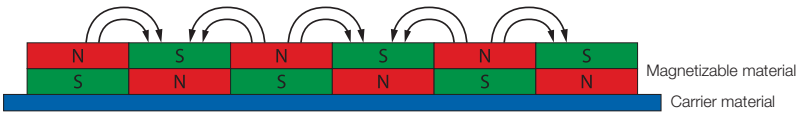
The magnetic period of the tape is interpolated by the sensor head with integrated interpolator with up to 10-bit (factor 1000).

**Permagnet® perpendicular magnetic tape**

Standard magnetic tape




Permagnet® perpendicular magnetic tape




+ larger field strength
+ better accuracy

**Reference point function**

For each incremental encoder system, the reference position is essential as a starting point for the counting.
How the reference point 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 41 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 41 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

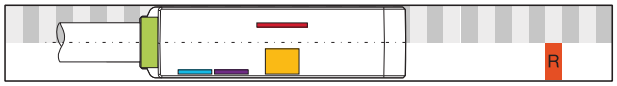
Example 3: Max. travel speed = 2 m/s
Controller detects min. edge separation M = 10 µs
- In table 1 on page 47 Select line 1.
- Select column 1.
  ➔ Maximum possible resolution L = 100 µm (BML-S1C)

| Edge separation (= pulse width) min. edge separation [µs] | | Controller identifies at least Max. counting frequency [kHz][1)] | Controller has the min. scan rate [kHz] |
|---|---|---|---|
| **D** | 0.12 | 8,333 | 16,667 |
| **E** | 0.29 | 3,448 | 6,897 |
| **F** | 0.48 | 2,083 | 4,167 |
| **G** | 1 | 1,000 | 2,000 |
| **H** | 2 | 500 | 1,000 |
| **K** | 4 | 250 | 500 |
| **L** | 8 | 125 | 250 |
| **M** | 10 | 100 | 200 |
| **N** | 16 | 63 | 125 |
| **P** | 24 | 42 | 83 |
| **R** | 100 | 10 | 20 |

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)

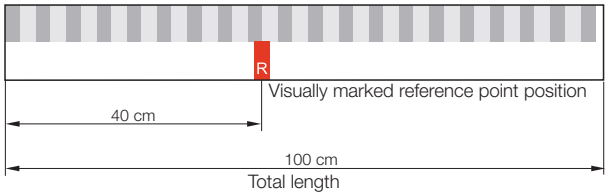



A sensor head with an additional reference point sensor can output a reference point signal as soon as it reaches the magnetically encoded reference point on the second track of the tape. No external reference switch is necessary.

**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.

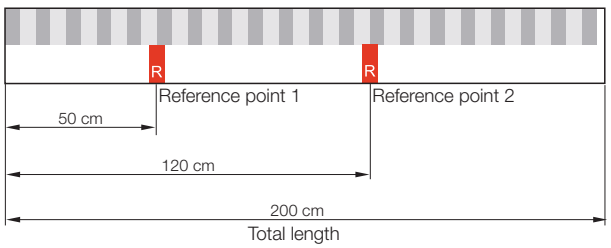
Ordering example for the tape shown below:
BML-M02-I45-A0-M0100-R0040/0000




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

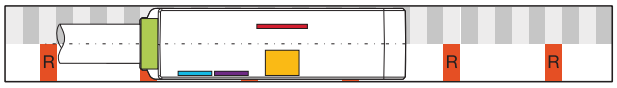
For the magnetic tape with two reference points, the reference point may be integrated as desired at any location. To determine the exact position, the reference run must cover the entire length of the tape up to the external selection switch. The external selection switch decides on the use of Z signals.

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/_ _ _ _

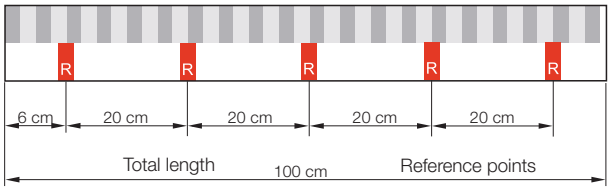



The sensor head with an additional reference point sensor can also be combined with a magnetic tape with fixed-periodic reference points. Here the reference points are integrated across the entire length of the tape at certain constant intervals, such as every 10 cm. To determine the exact position,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

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

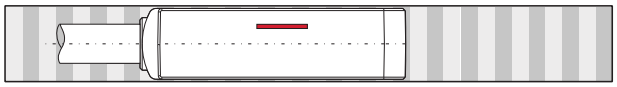
For magnetic tapes with fixed-periodic reference points, the reference points are integrated across the entire length of the tape at certain constant intervals, such as every 20 cm. To determine the exact position, the reference run must extend to the external selection switch, which decides on the use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

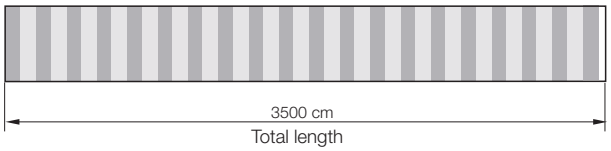


In the simplest position measuring system, the sensor head scans the magnetic periods with the incremental sensors. On the tape, there is a track with magnetic north and south poles. The position is determined by the controller by adding up the counted increments. With a pole-periodic reference point signal, with each magnetic pole, a reference point signal is output. 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 sensing 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 BML system enables the detection of rotary movements. The speed and the diameter of the magnetic 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:

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

For the maximum travel speed and minimum edge separation, see table 1 on page 41 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 | 12,322 | 7795 | 5,305 | 5,066 | 3,131 |
| 14.75 m/s | 9,087 | 5,749 | 3,913 | 3,736 | 2,309 |
| 10 m/s | 6,161 | 3,898 | 2,653 | 2,533 | 1,565 |
| 8.8 m/s | 5,422 | 3,430 | 2,334 | 2,229 | 1,378 |
| 8 m/s | 4,929 | 3,118 | 2,122 | 2026 | 1,252 |
| 7.7 m/s | 4,744 | 3,001 | 2042 | 1,950 | 1,205 |
| 6.5 m/s | 4,005 | 2,533 | 1,724 | 1,646 | 1018 |
| 5 m/s | 3,080 | 1949 | 1,326 | 1,266 | 783 |
| 4.2 m/s | 2,588 | 1,637 | 1,114 | 1,064 | 657 |
| 3.95 m/s | 2,434 | 1,540 | 1,048 | 1,001 | 618 |
| 3.25 m/s | 2,002 | **1267**[1)] | 862 | 823 | 509 |
| 3 m/s | 1,848 | 1169 | 796 | 760 | 470 |
| 1.8 m/s | 1,109 | 702 | 477 | 456 | 282 |
| 1.7 m/s | 1,047 | 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 (magnetic 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 41 for this sensor head, there is a max. travel speed of 3.25 m/s.
With a magnetic 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.