Linear Position Sensing and Measurement

The appropriate measuring principle for the optimal solution

0 mm  48000 mm

Linear Position Sensing and Measurement

Object Detection

Linear Position Sensing and Measurement

Condition Monitoring and Fluid Sensors

Industrial Networking and Connectivity

Industrial Identification

Systems and Service

Accessories

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

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.
Linear Position Sensing and Measurement

Contents

Magnetically Coded Position and Angle Measurement System BML

Micropulse Transducers BTL/BIW

Inductive Position Sensors BIL/BIP

Photoelectric Distance Sensors BOD

Inductive Distance Sensors BAW

Power Supplies

Worldwide Sales
Alphanumerical Directory
Magnetically Coded Position and Angle Measurement System
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.

Basic information and definitions can be found on page 54.

Accessories can be found on page 48.
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

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

### Magnetically Coded Position and Angle Measurement System

**Product overview**

<table>
<thead>
<tr>
<th>Series</th>
<th>BML-S1H_-M3AA...</th>
<th>BML-S1H_-M3CA...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>1...10 μm</td>
<td>1...10 μm</td>
</tr>
<tr>
<td>System accuracy</td>
<td>±7 μm</td>
<td>±7 μm</td>
</tr>
<tr>
<td>Distance to tape</td>
<td>0.1...0.35 mm</td>
<td>0.1...0.35 mm</td>
</tr>
<tr>
<td>Linear tape</td>
<td>0...64 mm</td>
<td>0...256 mm</td>
</tr>
<tr>
<td>Rotary tape (magnet ring)</td>
<td>Ø 30 to 300 mm</td>
<td></td>
</tr>
</tbody>
</table>

### Interfaces

- Absolute SSI
- Absolute BiSS-C
- Incremental digital RS422 (TTL)
- Incremental digital HTL (as supply voltage 10 to 30 V)
- Incremental analog sin/cos (1 V<sub>pp</sub>)

| From page | 18 | 18 |
## Magnetically Coded Position and Angle Measurement System

### Product Overview

#### Applications

- S1H series
- S1F series
- S2B/S2E/S1C series

#### Accessories

- Basic Information and Definitions

<table>
<thead>
<tr>
<th>BML-S1F_-Q...</th>
<th>BML-S1F_-A...</th>
<th>BML-S2B0-Q...</th>
<th>BML-S2E0-Q...</th>
<th>BML-S1C0-Q...</th>
</tr>
</thead>
<tbody>
<tr>
<td>1...10 μm</td>
<td>5 to 50 μm</td>
<td>5 to 50 μm</td>
<td>100 to 2000 μm</td>
<td></td>
</tr>
<tr>
<td>±10 μm</td>
<td>±10 μm</td>
<td>±50 μm</td>
<td>±100 μm</td>
<td>±100 μm</td>
</tr>
<tr>
<td>0.1...0.35 mm</td>
<td>0.1...0.35 mm</td>
<td>0.1...2 mm</td>
<td>0.1...2 mm</td>
<td>0.1...2 mm</td>
</tr>
<tr>
<td>0...48 m</td>
<td>0...48 m</td>
<td>0...48 m</td>
<td>0...48 m</td>
<td>0...48 m</td>
</tr>
</tbody>
</table>

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>26</td>
<td>26</td>
<td>34</td>
<td>34</td>
<td>34</td>
</tr>
</tbody>
</table>
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.

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.

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.

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

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 Vss)
- Gap between sensor and tape up to 0.35 mm

Operating principle of absolutely coded position and angle measurement system BML
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 Vss
- 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

- Linear
- Rotary
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.

S1H series
## S1H Series

### Contents

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<thead>
<tr>
<th>S1H</th>
<th>Page</th>
</tr>
</thead>
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<td>General data</td>
<td>20</td>
</tr>
<tr>
<td>Applications</td>
<td>21</td>
</tr>
<tr>
<td>SSI interface, BiSS-C interface</td>
<td>22</td>
</tr>
<tr>
<td>Tape, accessories</td>
<td>24</td>
</tr>
<tr>
<td>Digital display, CAM controller</td>
<td>25</td>
</tr>
</tbody>
</table>
S1H Series
General data

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

1 μm absolute
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 Vpp is output for highly dynamic control applications.
Additional analog real-time signal sin/cos 1 Vss
### S1H Series

**SSI interface, BiSS-C interface**

| Series | BML-S1H...
|---|---
| Output signal | Absolute: SSI or BiSS-C, additional analog signal sin/cos 1 V<sub>u</sub>
| 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-D0-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<sub>STANDARD</sub> = 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

<table>
<thead>
<tr>
<th>Interface</th>
<th>Coding</th>
<th>Length coding</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel</td>
<td>B (BiSS, bidirectional, serial, synchronous)</td>
<td>Q (Binary code, rising)</td>
<td>A 64</td>
</tr>
<tr>
<td>Perpendicular</td>
<td>S (SSI, serial, synchronous)</td>
<td>R (Gray code, rising)</td>
<td>C 256</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S (Binary code, falling)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>T (Gray code, falling)</td>
<td></td>
</tr>
</tbody>
</table>

### 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](http://www.balluff.de)
## S1H Series
### Tape, accessories

<table>
<thead>
<tr>
<th>Accessories</th>
<th>M12 connection cable, 12-pin, straight socket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series</td>
<td>BML-S1H...-S284</td>
</tr>
<tr>
<td>Ordering code</td>
<td>e.g. BCC09MY (5 m)</td>
</tr>
<tr>
<td>Part number</td>
<td>BCC M41C-0000-1A-169-PS0C08-_ _ _C009</td>
</tr>
<tr>
<td>Material</td>
<td>PUR with molded plug, black</td>
</tr>
</tbody>
</table>
| 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 to +70 °C |
| Available lengths/types   | 020 050 100 150 200 2 5 m 10 m 15 m 20 m |
### S1H Series
Digital display, CAM controller

<table>
<thead>
<tr>
<th>Series</th>
<th>BDD-AM 10-1-SSD</th>
<th>BDD-CC 08-1-SSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital display</td>
<td>CAM controller</td>
<td></td>
</tr>
<tr>
<td>SSI interface</td>
<td>SSI interface</td>
<td></td>
</tr>
</tbody>
</table>

#### Ordering code

<table>
<thead>
<tr>
<th>Part number</th>
<th>BAE0069</th>
<th>BAE006F</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDD-AM 10-1-SSD</td>
<td>BDD-CC 08-1-SSD</td>
<td></td>
</tr>
</tbody>
</table>

#### Features

- 7 1/2-digit display with leading sign
- LED display, 14 mm-high red 7-segment digits
- Scalable measured values
- Variable decimal point 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
- 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 controlled by LEDs on 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, 24 V
- Insulated DIN housing for mounting in front panel (clamp included in the scope of delivery)

![Housing depth 110 mm](image1.png)

![Housing depth 110 mm](image2.png)
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.
S1F Series
Contents

S1F
General data 28
Magnetic tape 30
Magnet rings 31
Technical selection guide 32
S1F Series
General data

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)

<table>
<thead>
<tr>
<th>Approach direction</th>
<th>Resolution</th>
<th>Reference signal</th>
<th>Min. Edge separation</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel</td>
<td>D 1 μm</td>
<td>0 None</td>
<td>D 0.12 μs</td>
<td>KA02 PUR cable 2 m</td>
</tr>
<tr>
<td></td>
<td>E 2 μm</td>
<td>1 Individually or fixed-periodic</td>
<td>E 0.29 μs</td>
<td>KA05 PUR cable 5 m</td>
</tr>
<tr>
<td></td>
<td>F 5 μm</td>
<td></td>
<td>F 0.48 μs</td>
<td>KA10 PUR cable 10 m</td>
</tr>
<tr>
<td></td>
<td>G 10 μm</td>
<td>2 Pole-periodic only with digital design</td>
<td>G 1 μs</td>
<td>KA15 PUR cable 15 m</td>
</tr>
<tr>
<td>Perpendicular</td>
<td></td>
<td></td>
<td></td>
<td>KA20 PUR cable 20 m</td>
</tr>
</tbody>
</table>

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
Compact and high-resolution

S1F Series

General data

<table>
<thead>
<tr>
<th>Series</th>
<th>BML-S1F_-Q...</th>
<th>BML-S1F_-A...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output signal</td>
<td>Digital square-wave signals RS422</td>
<td>Sinusoidal analog signals sin/cos processing-dependent</td>
</tr>
<tr>
<td>Resolution</td>
<td>1 μm, 2 μm, 5 μm or 10 μm</td>
<td>processing-dependent</td>
</tr>
<tr>
<td>Part number</td>
<td>BML-S1F_-Q61_-M3_0-<em>0-</em> _ _ _</td>
<td>BML-S1F_-A62Z-M3_0-90-_ _ _ _</td>
</tr>
<tr>
<td>Output voltage (A/B/Z)</td>
<td>RS422 to DIN 66259</td>
<td>1 Vpp</td>
</tr>
<tr>
<td>Overall system accuracy</td>
<td>±10 μm</td>
<td>±10 μm</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>5 V ±5%</td>
<td>5 V ±5%</td>
</tr>
<tr>
<td>Current consumption at 5 V operating voltage</td>
<td>&lt; 50 mA + current consumption of the controller (depending on internal resistance)</td>
<td>&lt; 50 mA + current consumption of the controller (depending on internal resistance)</td>
</tr>
<tr>
<td>Max. read distance sensor/tape</td>
<td>0.35 mm</td>
<td>0.35 mm</td>
</tr>
<tr>
<td>Max. traverse speed</td>
<td>20 m/s</td>
<td>20 m/s</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>−20...+80 °C</td>
<td>−20...+80 °C</td>
</tr>
<tr>
<td>Housing material</td>
<td>Al</td>
<td>Al</td>
</tr>
<tr>
<td>Degree of protection</td>
<td>IP 67</td>
<td>IP 67</td>
</tr>
</tbody>
</table>

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 Vpp
- 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
S1F Series
Magnetic tape

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__

<table>
<thead>
<tr>
<th>Design</th>
<th>Accuracy class</th>
<th>Cover strip</th>
<th>Length in cm</th>
<th>Reference point positions</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>1.55 mm thick, with adhesive strip</td>
<td>4 8 μm, overall accuracy ±10 μm</td>
<td>Order length, max. 4800 = 48 m</td>
<td>R0000 None or pole-periodic</td>
</tr>
<tr>
<td>03</td>
<td>1.35 mm thick, without adhesive strip</td>
<td>5 18 μm, overall accuracy ±20 μm</td>
<td>Rxxxy/ Position of 0000 1 reference point in cm</td>
<td></td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Accuracy class</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 8 μm, overall accuracy ±10 μm</td>
<td>0500 5 m</td>
</tr>
<tr>
<td>5 18 μm, overall accuracy ±20 μm</td>
<td>1000 10 m</td>
</tr>
</tbody>
</table>

Magnetic tape mounting options

- "Top"-Installation
- Flush
- Flush with casting

BML-M02...
Magnetic tape
Backig tape (thick)
Adhesive layer
Protective foil

BML-M03...
Magnetic tape
Backig tape (thick)
### S1F Series

**Magnet rings**

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

---

Magnet rings are essential components in various industrial applications, enabling accurate measurement and control. The S1F series, part of the Sensor Family F, is designed to offer precise and reliable performance. The table above details the specific characteristics of each model, including their part numbers, number of poles, pole width, and material properties. These specifications allow users to select the most appropriate model for their specific requirements, ensuring optimal functionality in their respective systems.

For more detailed information and technical specifications, please refer to the technical selection guide and the basic information and definitions sections provided in the document. Additionally, the image illustrates the physical dimensions of the magnet rings, providing a visual reference for size and shape considerations.
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:

<table>
<thead>
<tr>
<th>Min. edge separation</th>
<th>V_{\text{max}} in accordance with edge separation and resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mechanical resolution</td>
</tr>
<tr>
<td></td>
<td>D 1 μm</td>
</tr>
<tr>
<td>D 0.12 μs</td>
<td>5 m/s</td>
</tr>
<tr>
<td>E 0.29 μs</td>
<td>2 m/s</td>
</tr>
<tr>
<td>F 0.48 μs</td>
<td>1 m/s</td>
</tr>
<tr>
<td>G 1 μs</td>
<td>0.65 m/s</td>
</tr>
<tr>
<td>H 2 μs</td>
<td>0.3 m/s</td>
</tr>
<tr>
<td>K 4 μs</td>
<td>0.15 m/s</td>
</tr>
<tr>
<td>L 8 μs</td>
<td>0.075 m/s</td>
</tr>
<tr>
<td>N 16 μs</td>
<td>0.039 m/s</td>
</tr>
<tr>
<td>P 24 μs</td>
<td>0.026 m/s</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Sensor head resolution</th>
<th>Pulses/revolution with 4-fold evaluation</th>
<th>Ø of magnet ring, outside</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>72 mm</td>
</tr>
<tr>
<td>Ordering code</td>
<td></td>
<td>BML002K</td>
</tr>
<tr>
<td>D = 1 μm</td>
<td></td>
<td>228000</td>
</tr>
<tr>
<td>E = 2 μm</td>
<td></td>
<td>114000</td>
</tr>
<tr>
<td>F = 5 μm</td>
<td></td>
<td>45600</td>
</tr>
<tr>
<td>G = 10 μm</td>
<td></td>
<td>22800</td>
</tr>
</tbody>
</table>

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.
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.

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.
S2B/S2E/S1C Series

Contents

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Magnetic tape 38
Magnet rings 39
Technical selection guide 41

S1C
General data 42
Magnetic tape 44
Magnet rings 45
Technical selection guide 47
S2B/S2E Series
General data

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

Ordering example: sensor head

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

<table>
<thead>
<tr>
<th>Operating voltage</th>
<th>Output voltage</th>
<th>Resolution</th>
<th>Reference signal</th>
<th>Limit switch</th>
<th>Min. edge separation</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 10...30 V</td>
<td>1 Digital square-wave signal RS422</td>
<td>F 5 μm</td>
<td>0 None</td>
<td>0 No limit switch</td>
<td>D 0.12 μs</td>
<td>KA02 PUR cable 2 m</td>
</tr>
<tr>
<td>6 5 V</td>
<td>2 Level same as supply voltage (only for 10...30 V)</td>
<td>G 10 μm</td>
<td>1 Individually or fixed-periodic</td>
<td>3 Two limit switches (including 1 set of magnets)</td>
<td>E 0.29 μs</td>
<td>KA05 PUR cable 5 m</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>H 25 μm</td>
<td></td>
<td></td>
<td>F 0.48 μs</td>
<td>KA10 PUR cable 10 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>K 50 μm</td>
<td></td>
<td></td>
<td>G 1 μs</td>
<td>KA15 PUR cable 15 m</td>
</tr>
</tbody>
</table>

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 (BML00JG)
  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
<table>
<thead>
<tr>
<th>Series</th>
<th>BML-S2B0-...</th>
<th>BML-S2E0-...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output signal</td>
<td>Digital square-wave signals</td>
<td>Digital square-wave signals</td>
</tr>
<tr>
<td>Resolution</td>
<td>5 μm, 10 μm, 25 μm or 50 μm</td>
<td>5 μm, 10 μm, 25 μm or 50 μm</td>
</tr>
<tr>
<td>Part number</td>
<td>BML-S2B0-Q_ _ <em>-M4</em> _-<em>0-</em> _ _ _</td>
<td>BML-S2E0-Q_ _ <em>-M4</em> _-<em>0-</em> _ _ _</td>
</tr>
<tr>
<td>Output voltage (A/B/Z)</td>
<td>RS422 to DIN 66259 or same as operating voltage 10...30 V (without A/B/Z)</td>
<td>RS422 to DIN 66259 or same as operating voltage 10...30 V (without A/B/Z)</td>
</tr>
<tr>
<td>Overall system accuracy</td>
<td>±50 μm</td>
<td>±100 μm</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>10...30 V or 5 V ±5%</td>
<td>10...30 V or 5 V ±5%</td>
</tr>
<tr>
<td>Current consumption at 5 V supply voltage</td>
<td>&lt; 50 mA + current consumption of the controller (depending on internal resistance)</td>
<td>&lt; 50 mA + current consumption of the controller (depending on internal resistance)</td>
</tr>
<tr>
<td>Current consumption at 10 to 30 V supply voltage</td>
<td>&lt; 40 mA + current consumption of the controller (depending on internal resistance)</td>
<td>&lt; 40 mA + current consumption of the controller (depending on internal resistance)</td>
</tr>
<tr>
<td>Max. read distance sensor/tape</td>
<td>2 mm</td>
<td>2 mm</td>
</tr>
<tr>
<td>Max. traverse speed</td>
<td>20 m/s</td>
<td>20 m/s</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>–20...+80 °C</td>
<td>–20...+80 °C</td>
</tr>
<tr>
<td>Housing material</td>
<td>PBT</td>
<td>PBT</td>
</tr>
<tr>
<td>Degree of protection</td>
<td>IP 67</td>
<td>IP 67</td>
</tr>
</tbody>
</table>

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_ _ _ _-_ _ _ _ _

* 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

Magnetic tape mounting options

"Top"-Installation

Flush

flush with casting

BML-M02...

BML-M03...

Magnetic tape

Backing tape (thick)

Adhesive layer

Protective foil

1.55±0.1 mm

1.35±0.1 mm

Accuracy class

Length

4 18 μm, overall accuracy ±50 μm
5 50 μm, overall accuracy ±100 μm

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

Better accuracy classes available on request

(S2E... and S1C... only)
Magnetic rings

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

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.
S2B/S2E Series
Magnet rings

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

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.

**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:

<table>
<thead>
<tr>
<th>Min. edge separation</th>
<th>V_{\text{max}} in accordance with edge separation and resolution</th>
<th>Mechanical resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F 5 μm</td>
<td>G 10 μm</td>
</tr>
<tr>
<td>D 0.12 μs</td>
<td>20 m/s</td>
<td>20 m/s</td>
</tr>
<tr>
<td>E 0.29 μs</td>
<td>10 m/s</td>
<td>10 m/s</td>
</tr>
<tr>
<td>F 0.48 μs</td>
<td>5 m/s</td>
<td>5 m/s</td>
</tr>
<tr>
<td>G 1 μs</td>
<td>3.25 m/s</td>
<td>6.5 m/s</td>
</tr>
<tr>
<td>H 2 μs</td>
<td>1.5 m/s</td>
<td>3 m/s</td>
</tr>
<tr>
<td>K 4 μs</td>
<td>0.75 m/s</td>
<td>1.5 m/s</td>
</tr>
<tr>
<td>L 8 μs</td>
<td>0.375 m/s</td>
<td>0.75 m/s</td>
</tr>
<tr>
<td>N 16 μs</td>
<td>0.195 m/s</td>
<td>0.395 m/s</td>
</tr>
<tr>
<td>P 24 μs</td>
<td>0.13 m/s</td>
<td>0.26 m/s</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Sensor head resolution</th>
<th>Pulses/revolution with 4-fold evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø of magnet ring, outside</td>
<td></td>
</tr>
<tr>
<td>31 mm</td>
<td>49 mm</td>
</tr>
<tr>
<td>Ordering code</td>
<td>BML002T</td>
</tr>
<tr>
<td>F = 5 μm</td>
<td>20000</td>
</tr>
<tr>
<td>G = 10 μm</td>
<td>10000</td>
</tr>
<tr>
<td>H = 25 μm</td>
<td>4000</td>
</tr>
<tr>
<td>K = 50 μm</td>
<td>2000</td>
</tr>
</tbody>
</table>

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 1 μs (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.
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__

<table>
<thead>
<tr>
<th>Resolution</th>
<th>Max. edge separation</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>L 0.1 mm</td>
<td>M 10 μs</td>
<td>KA02</td>
</tr>
<tr>
<td>M 0.2 mm</td>
<td>R 100 μs</td>
<td>KA05</td>
</tr>
<tr>
<td>N 0.5 mm</td>
<td></td>
<td>KA10</td>
</tr>
<tr>
<td>P 1.0 mm</td>
<td></td>
<td>KA15</td>
</tr>
<tr>
<td>R 2.0 mm</td>
<td></td>
<td>KA20</td>
</tr>
</tbody>
</table>

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
# S1C Series

## General data

<table>
<thead>
<tr>
<th>Series</th>
<th>Output signal</th>
<th>Resolution</th>
<th>Ordering code</th>
<th>Part number</th>
<th>Output signal</th>
<th>Resolution</th>
<th>Ordering code</th>
<th>Part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>BML-S1C0-...</td>
<td>Digital square-wave</td>
<td>5 μm, 10 μm, 25 μm</td>
<td>BMF0022</td>
<td>BML-S1C0-Q53_...-M400_...-0-KA_...</td>
<td>PNP/NPN normally open</td>
<td>1 switching operation per pole</td>
<td>BMF 12M-PS-D-2-S4 (PNP normally open)</td>
<td>BMF 12M-NS-D-2-S4 (NPN normally open)</td>
</tr>
</tbody>
</table>

### Ordering code

<table>
<thead>
<tr>
<th>Part number</th>
<th>BMF0021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output voltage (A/B)</td>
<td>Same as operating voltage 10...30 V</td>
</tr>
<tr>
<td>Overall system accuracy</td>
<td>±100 μm</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>10...30 V</td>
</tr>
<tr>
<td>Voltage drop U_d</td>
<td>≤ 3.15 V</td>
</tr>
<tr>
<td>Current consumption at</td>
<td>&lt; 40 mA + current consumption of the controller (depending on internal resistance)</td>
</tr>
<tr>
<td>10 to 30 V supply voltage</td>
<td>200 mA</td>
</tr>
<tr>
<td>Max. read distance sensor/tape</td>
<td>2 mm</td>
</tr>
<tr>
<td>Max. travel speed</td>
<td>10 m/s</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>–20...+80 °C</td>
</tr>
<tr>
<td>Housing material</td>
<td>PBT</td>
</tr>
<tr>
<td>Degree of protection</td>
<td>IP 67</td>
</tr>
</tbody>
</table>

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)
### S1C Series

#### Magnetic tape

**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
```

<table>
<thead>
<tr>
<th>Length</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0500</td>
<td>5 m</td>
</tr>
<tr>
<td>1000</td>
<td>10 m</td>
</tr>
<tr>
<td>2400</td>
<td>24 m</td>
</tr>
<tr>
<td>4800</td>
<td>48 m</td>
</tr>
</tbody>
</table>

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

- **Top**-Installation
- Rush
- Rush with casting

---

**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.
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.
# S1C Series

## Magnet rings

We offer custom solutions. Simply contact us.

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

For more information, visit us online!
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:

<table>
<thead>
<tr>
<th>Min. edge separation</th>
<th>( V_{\text{max}} ) in accordance with edge separation and resolution</th>
<th>Mechanical resolution</th>
<th>N 500 μm</th>
<th>P 1000 μm</th>
<th>R 2000 μm</th>
</tr>
</thead>
<tbody>
<tr>
<td>M 10 μs</td>
<td>8 m/s</td>
<td>L 100 μm</td>
<td>10 m/s</td>
<td>10 m/s</td>
<td>10 m/s</td>
</tr>
<tr>
<td>R 100 μs</td>
<td>0.9 m/s</td>
<td>M 200 μm</td>
<td>10 m/s</td>
<td>4.2 m/s</td>
<td>8.8 m/s</td>
</tr>
</tbody>
</table>

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.

**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:

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

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.

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.
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.
Accessories
Contents

Accessories
Counter-Displays 50
Sensor guide 52
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.

<table>
<thead>
<tr>
<th>Series</th>
<th>Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ordering code</th>
<th>Part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordering code</td>
<td>Part number</td>
</tr>
<tr>
<td>Ordering code</td>
<td>Part number</td>
</tr>
</tbody>
</table>

Functions

Features

Use

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

<table>
<thead>
<tr>
<th>BDD 610</th>
<th>BDD 611/BDD 622/BDD 632</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-axis counter</td>
<td>Single- or multi-axis counter 1, 2, 3</td>
</tr>
<tr>
<td>for BML-S1B..., BML-S1C... and BML-S1E...</td>
<td>for all BML-Sxx...</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BAE004J</th>
<th>BAE004K</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDD 610-R3Q3-0-53-N-00 (2 dig. inputs)</td>
<td>BDD 611-R3Q4-0-52-N-00 (1 axis)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BAE004H</th>
<th>BAE004M</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDD 610-R3Q3-0-51-N-00 (2 dig. outputs)</td>
<td>BDD 622-R3Q4-0-52-N-00 (2 axes)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BAE004P</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDD 632-R3Q4-0-52-N-00 (3 axes)</td>
</tr>
</tbody>
</table>

### Features
- 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
- Power supply 24 V DC*
- 1×6-decade LED display
- Digit height 14 mm
- Incremental measuring system with tracks A, B
- max. 25 kHz
- 2 digital inputs (-51-)
- 2 digital outputs (-53-)

### Specifications
- For BML-S1B0..., BML-ST10... and BML-S1C0-... min. edge separation Code M, N, P, R
- For BML with supply voltage 5 V/10 to 30 V, output voltage RS422/HTL, min. edge separation Code E, F, G, H, K, L, M, N, P, R

---

* 24 V DC indicates the power supply voltage for the counter displays, which is commonly used in industrial automation systems. This voltage is suitable for most applications and ensures reliable operation over a wide range of conditions.
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

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

**Sensor guide**

<table>
<thead>
<tr>
<th>Ordering code</th>
<th>Part number</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.g. BAM000P</td>
<td>BTL2-GS10-</td>
<td></td>
</tr>
</tbody>
</table>

**Accessories**

<table>
<thead>
<tr>
<th>Joint rod</th>
<th>Order for BML-C01, BML-C02</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BAM000P</strong></td>
<td>(100 mm)</td>
</tr>
</tbody>
</table>

**Joint rod**

For connecting the sliding carriage to the machine

---

**Adjustment range**

-5 mm
**Accessories**

**Sensor guide**

<table>
<thead>
<tr>
<th>Guide rail for sliding carriage BML-C01, BML-C02</th>
<th>Sliding carriage for sensors BML-S2B, BML-S2E, BML-S1C</th>
<th>Sliding carriage for sensors BML-S1F</th>
</tr>
</thead>
<tbody>
<tr>
<td>e.g. <strong>BAM04N4 (3 m)</strong> BML-R01-M</td>
<td><strong>BAM01MF</strong> BML-C01</td>
<td><strong>BAM01MH</strong> BML-C02</td>
</tr>
</tbody>
</table>

- 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

---

**Mounting guide**

<table>
<thead>
<tr>
<th><strong>BAM01L9</strong> BML-Z0010</th>
<th>Brackets for BML-R01</th>
<th><strong>BAM01JL</strong> BML-Z0008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installing the magnetic tape on BML-R01</td>
<td>For lateral mounting of the rail and at transition points</td>
<td>Cover strip from the roll for BML-M02, BML-M03</td>
</tr>
<tr>
<td>e.g. <strong>BAM01L9</strong> BML-Z0010</td>
<td><strong>BAM01JL</strong> BML-Z0008</td>
<td>e.g. <strong>BML001K (10 m)</strong> BML-A013-T</td>
</tr>
</tbody>
</table>

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

---

**Adhesive strip**

- 18.65
- 5
- 12.7

---

**Basic Information and Definitions**

**Counter-Displays**

**S1H series**

**S1F series**

**S2B/S2E/S1C series**

**Accessories**

**Magnetically coded position and angle measurement system**

---

**BALLUFF**

www.balluff.com
Magnetically Coded Position and Angle Measurement System
Basic Information and Definitions
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).

**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°)

---

**Accuracy of the sensor head**

BML-S1F...

± 2 μm

**Accuracy of the tape**

BML-M02-I34

± 8 μm

**PER** = a signal period

**EDG** = Edge separation

---

Electric angle

0°  90°  180°  270°  360°

PER = a signal period

EDG = Edge separation
Basic Information and Definitions

Definitions

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

\[
\text{Period length} = \frac{\text{Counting frequency}}{4}
\]

Counting frequency of the controller ≥ \(\frac{1}{\text{Min. edge separation}}\)

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

- Larger field strength
- Better accuracy
Basic Information and Definitions
Examples and help for selecting the system

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)

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

Table 1: Relationship of edge separation – counting frequency

1) Signal period = 1/4 × counting frequency
Basic Information and Definitions
Examples and help for selecting the system

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_..._/0000 (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
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_..._/0000
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
Basic Information and Definitions

Examples and help for selecting the system

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

![Diagram of pole-periodic magnetic tape with alternating north and south poles.]
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.

<table>
<thead>
<tr>
<th>Max. travel speed</th>
<th>RPM</th>
<th>Outer diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 m/s</td>
<td>12,322</td>
<td>31 mm</td>
</tr>
<tr>
<td>14.75 m/s</td>
<td>9,087</td>
<td>49 mm</td>
</tr>
<tr>
<td>10 m/s</td>
<td>6,161</td>
<td>72 mm</td>
</tr>
<tr>
<td>8.8 m/s</td>
<td>5,422</td>
<td>75.4 mm</td>
</tr>
<tr>
<td>8 m/s</td>
<td>4,929</td>
<td>122 mm</td>
</tr>
<tr>
<td>7.7 m/s</td>
<td>4,744</td>
<td>31 mm</td>
</tr>
<tr>
<td>6.5 m/s</td>
<td>4,005</td>
<td>49 mm</td>
</tr>
<tr>
<td>5 m/s</td>
<td>3,080</td>
<td>72 mm</td>
</tr>
<tr>
<td>4.2 m/s</td>
<td>2,588</td>
<td>75.4 mm</td>
</tr>
<tr>
<td>3.95 m/s</td>
<td>2,434</td>
<td>122 mm</td>
</tr>
<tr>
<td>3.25 m/s</td>
<td>2,002</td>
<td>31 mm</td>
</tr>
<tr>
<td>3 m/s</td>
<td>1,848</td>
<td>49 mm</td>
</tr>
<tr>
<td>1.8 m/s</td>
<td>1,109</td>
<td>72 mm</td>
</tr>
<tr>
<td>1.7 m/s</td>
<td>1,047</td>
<td>75.4 mm</td>
</tr>
<tr>
<td>1.5 m/s</td>
<td>924</td>
<td>122 mm</td>
</tr>
<tr>
<td>0.95 m/s</td>
<td>585</td>
<td>31 mm</td>
</tr>
<tr>
<td>0.9 m/s</td>
<td>554</td>
<td>49 mm</td>
</tr>
<tr>
<td>0.75 m/s</td>
<td>462</td>
<td>72 mm</td>
</tr>
<tr>
<td>0.65 m/s</td>
<td>400</td>
<td>75.4 mm</td>
</tr>
<tr>
<td>0.395 m/s</td>
<td>243</td>
<td>122 mm</td>
</tr>
<tr>
<td>0.375 m/s</td>
<td>231</td>
<td>31 mm</td>
</tr>
<tr>
<td>0.26 m/s</td>
<td>160</td>
<td>49 mm</td>
</tr>
<tr>
<td>0.195 m/s</td>
<td>120</td>
<td>72 mm</td>
</tr>
<tr>
<td>0.13 m/s</td>
<td>80</td>
<td>75.4 mm</td>
</tr>
</tbody>
</table>

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.