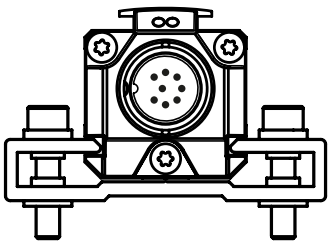
BALLUFF

sensors worldwide

BTL7-S5_ _(B)-M_ _ _ _-P-S32/S115/S147/KA_ _/FA_ _

User's Guide



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1 Notes to the user

1.1 Validity

This guide describes the construction, function and setup options for the BTL7 Micropulse Transducer with SSI interface. It applies to types
BTL7-S5_ _(B)-M_ _ _ _-P-S32/S115/S147/KA_ _/FA_ _
(see Type code breakdown from page 25).

The guide is intended for qualified technical personnel. Read this guide before installing and operating the transducer.

1.2 Symbols and conventions

Individual **instructions** are indicated by a preceding triangle.

► Action instruction 1

Action sequences are numbered consecutively:

1. Action instruction 1
2. Action instruction 2

Note, tip
This symbol indicates general notes.

1.3 Scope of delivery

– BTL7 transducer
– Mounting clamps with insulating sleeves and screws
– Condensed guide

The magnets are available in various models and must be ordered separately.

1.4 Approvals and markings

UL approval[1)]
File no.
E227256

[1)] Not for BTL7-...-FA_ _

US Patent 5 923 164
The US patent was awarded in connection with this product.

The CE Mark verifies that our products meet the requirements of the current EMC Directive.

The transducer meets the requirements of the following product standard:

– EN 61326-2-3 (noise immunity and emission)

Emission tests:

– RF emission
  EN 55011

Noise immunity tests:

– Static electricity (ESD)
  EN 61000-4-2 — Severity level 3
– Electromagnetic fields (RFI)
  EN 61000-4-3 — Severity level 3
– Electrical fast transients (burst)
  EN 61000-4-4 — Severity level 3
– Surge
  EN 61000-4-5 — Severity level 2
– Conducted interference induced by high-frequency fields
  EN 61000-4-6 — Severity level 3
– Magnetic fields
  EN 61000-4-8 — Severity level 4

More detailed information on the guidelines, approvals, and standards is included in the declaration of conformity.

1.5 Abbreviations

SSI Synchronous Serial Interface

2 Safety

2.1 Intended use

The BTL7 Micropulse Transducer, together with a machine controller (e.g. PLC), comprises a position measuring system. It is intended to be installed into a machine or system. Flawless function in accordance with the specifications in the technical data is ensured only when using original BALLUFF accessories. Use of any other components will void the warranty.

Opening the transducer or non-approved use are not permitted and will result in the loss of warranty and liability claims against the manufacturer.

2.2 General safety notes for the position measuring system

Installation and **startup** may only be performed by trained specialists with basic electrical knowledge. **Qualified personnel** are those who can recognize possible hazards and institute the appropriate safety measures due to their professional training, knowledge, and experience as well as their understanding of the relevant regulations pertaining to the work to be done.

The **operator** is responsible for ensuring that local safety regulations are observed.
In particular, the operator must take steps to ensure that a defect in the position measuring system will not result in hazards to persons or equipment.
If defects and unresolvable faults occur in the transducer, it should be taken out of service and secured against unauthorized use.

2.3 Explanation of the warnings

Always observe the warnings in these instructions and the measures described to avoid hazards.

The warnings used here contain various signal words and are structured as follows:

SIGNAL WORD
Hazard type and source Consequences if not complied with ► Measures to avoid hazards

The individual signal words mean:

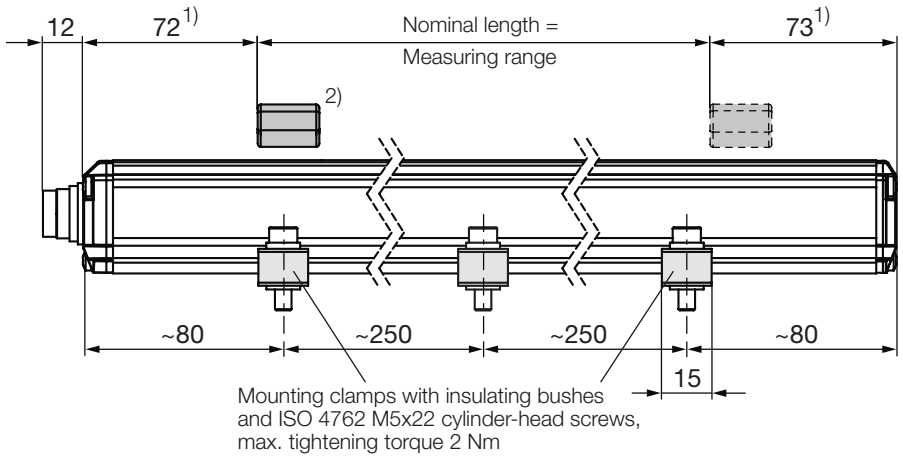
NOTICE
Identifies a hazard that could **damage or destroy the product**.
⚠ DANGER
The general warning symbol in conjunction with the signal word DANGER identifies a hazard which, if not avoided, **will certainly result in death or serious injury**.

2.4 Disposal

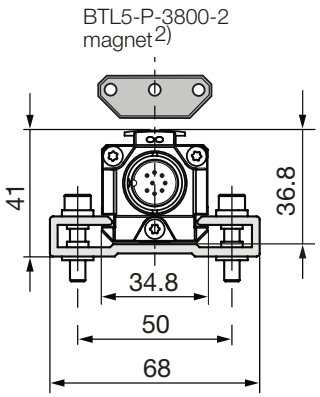
► Observe the national regulations for disposal.

3 Construction and function

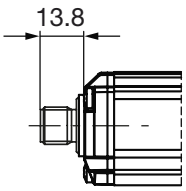
BTL7...-S32/S147



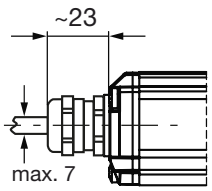
View from above on BTL7...-S32



BTL7...-S115



BTL7... cable



1) Unusable area

2) Not included in scope of delivery

Fig. 3-1: BTL7... transducer, construction

3.1 Construction

Electrical connection: The electrical connection is made via a cable or a connector (see Type code breakdown on page 25).

Housing: Aluminum housing containing the waveguide and processing electronics.

Magnet: Defines the position to be measured on the waveguide. Magnets are available in various models and must be ordered separately (see Accessories starting on page 21).

Nominal length: To optimally adapt the transducer to the application, nominal lengths from 50 mm to 7620 mm are available.

3 Construction and function (continued)

3.2 Function

The BTL7 transducer contains the waveguide which is protected by an aluminum housing. A magnet is moved along the waveguide. This magnet is connected to the system part whose position is to be determined.

The magnet defines the position to be measured on the waveguide.

An internally generated INIT pulse interacts with the magnetic field of the magnet to generate a torsional wave in the waveguide which propagates at ultrasonic speed.

The component of the torsional wave which arrives at the end of the waveguide is absorbed in the damping zone to prevent reflection. The component of the torsional wave which arrives at the beginning of the waveguide is converted by a coil into an electrical signal. The travel time of the wave is used to calculate the position that is output in antivalent form as synchronous serial data (SSI) on the RS-422 interface. This is done with a high level of precision and reproducibility within the measuring range indicated as the nominal length.

In addition to the position output value, the following functions can be selected (only BTL7-S510(B)-...):

- Differential position
- Velocity (with and without leading sign)
- Speed difference

3.3 LED display

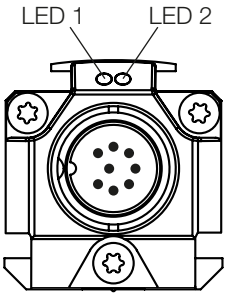


Fig. 3-2: BTL7 LED displays

LED 1	
Green	**Normal function** Magnet is within the limits.
Red	**Error** No magnet or magnet outside the limits.

LED 2	
Green	**Synchronous operation**[1)] Internal measurement is synchronous to SSI query.
Off	**Asynchronous operation**[1)] Internal measurement is asynchronous to SSI query.
Flashing green	**Programming mode** Only with BTL7-S510(B)-...

[1)] Asynchronous operation is reached when the external sampling rate is > $f_{A,max}$ or < 62.5 Hz (only with BTL7-S5_ _B-...), see the technical data on page 20, Fig. 8-1.

Note on configuration (only BTL7-S510(B)-...)
The entire function scope can only be configured with the PC software “Micropulse Configuration Tool”. To do this, the USB communication box must be connected (see Accessories on page 24).

When reading or writing data via the Micropulse Configuration Tool, LED 2 flashes green to display programming mode.

Behavior of LED 1 and the error value through the entire range:

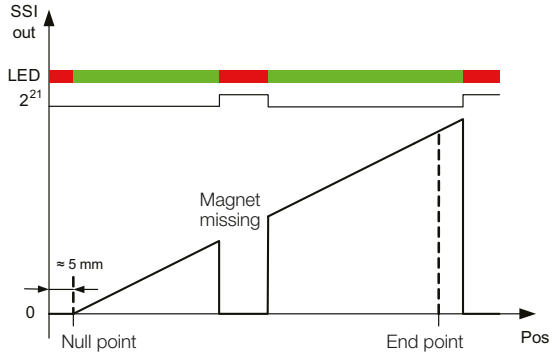


Fig. 3-3: Behavior of LED 1 and error value BTL7 ≥ 5 µm

For resolutions ≥ 5 µm, in the case of an error, bit 2^{21} is set. For resolutions < 5 µm, there is no error bit and the value 0 is output.

4 Installation and connection

4.1 Installing the transducer

NOTICE

Improper installation

Improper installation can compromise the function of the transducer and result in damage.

- ▶ For this reason, ensure that no strong electrical or magnetic fields are present in the immediate vicinity of the transducer.
- ▶ The recommended spacing for the installation must be strictly observed.

Any orientation is permitted. Mount the transducer on a level surface of the machine using the provided mounting clamps and cylinder-head screws. A sufficient number of mounting clamps is supplied.

In order to avoid the development of resonant frequencies from vibration loads, we recommend arranging the mounting clamps at irregular intervals.

The transducer is electrically isolated from the machine with the supplied insulating bushes (see Fig. 3-1).

1. Guide the transducer into the mounting clamps.
2. Attach transducer to the base using mounting screws (tighten screws in the clamps with max. 2 Nm).
3. Insert magnet (accessories).

The micropulse transducer in profile housing is suitable both for floating, i.e. non-contacting magnets (see Fig. 4-4 to Fig. 4-8), and for captive magnets (see Fig. 4-1 to Fig. 4-3).

4.2 Captive magnets

The following must be observed when installing the magnet:

- Avoid lateral forces.
- Connect the magnet to the machine member with a joint rod (see Accessories on page 21).

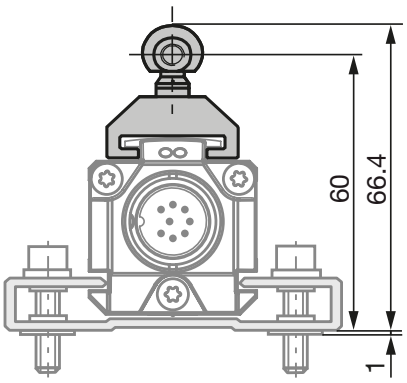


Fig. 4-1: Dimensions and distances with BTL5-F-2814-1S magnet

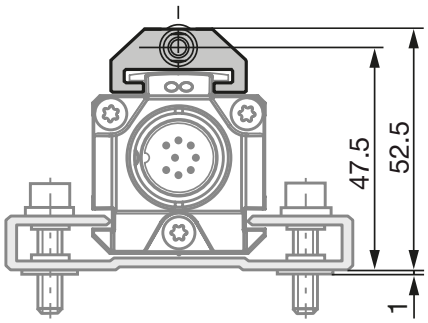


Fig. 4-2: Dimensions and distances with BTL5-T-2814-1S magnet

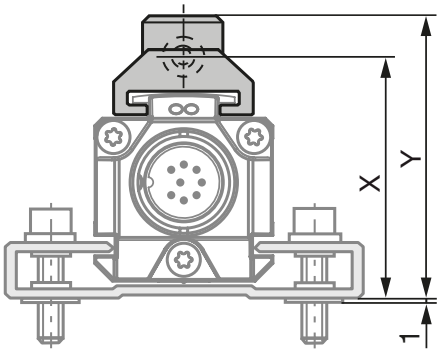


Fig. 4-3: Dimensions and distances with BTL5-M/N-2814-1S magnet

	BTL5-M-2814-1S	BTL5-N-2814-1S
Distance X	48.5 mm	57 mm
Distance Y	51 mm	59.5 mm

Tab. 4-1: Distances with BTL5-M/N-2814-1S magnet

4 Installation and connection (continued)

4.3 Floating magnets

The following must be observed when installing the magnet:

- To ensure the accuracy of the position measuring system, the magnet is attached to the moving member of the machine using non-magnetizable screws (stainless steel, brass, aluminum).
- The moving member must guide the magnet on a track parallel to the transducer.
- Ensure that the distance A between the magnets and parts made of magnetizable material is at least 10 mm (see Fig. 4-4 to Fig. 4-8).
- Maintain the following values for distance B between the magnet and transducer and for center offset C (see Fig. 4-4 to Fig. 4-8):

Type of magnet	Distance B[1)]	Offset C
BTL5-P-3800-2	0.1 to 4 mm	± 2 mm
BTL5-P-5500-2	5 to 15 mm	± 15 mm
BTL5-P-4500-1	0.1 to 2 mm	± 2 mm
BTL6-A-3800-2	4 to 8 mm[2)]	± 5 mm
BTL6-A-3801-2	4 to 8 mm[2)]	± 5 mm

[1)] The selected distance should stay constant over the entire measuring length.

[2)] For optimum measurement results, a distance B of 6 to 8 mm is recommended.

Tab. 4-2: Distance and offset for floating magnets

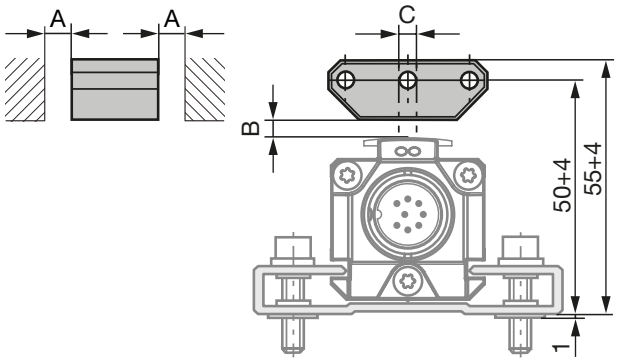


Fig. 4-4: Dimensions and distances with BTL5-P-3800-2 magnet

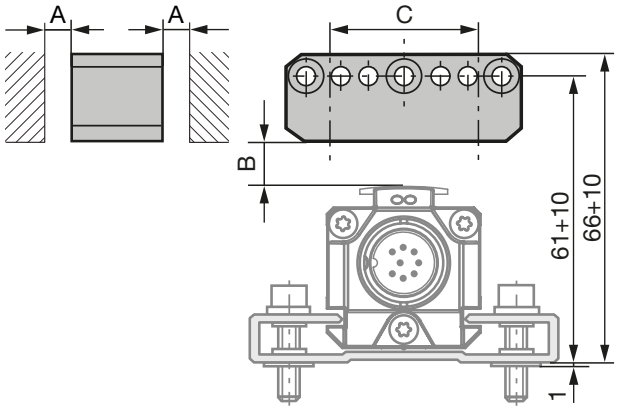


Fig. 4-5: Dimensions and distances with BTL5-P-5500-2 magnet

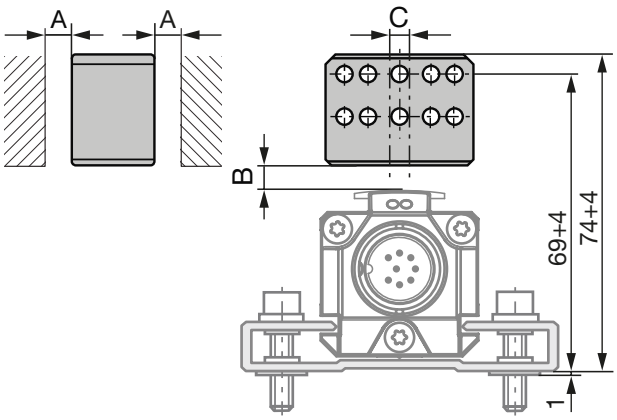


Fig. 4-6: Dimensions and distances with BTL6-A-3800-2 magnet

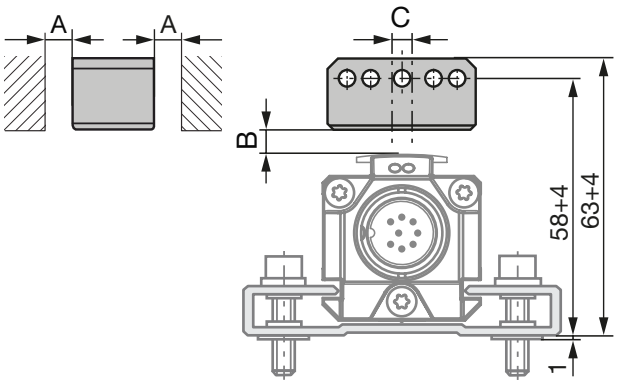


Fig. 4-7: Dimensions and distances with BTL6-A-3801-2 magnet

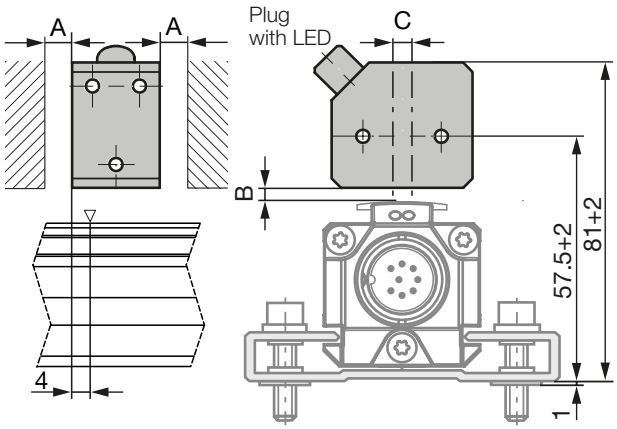


Fig. 4-8: Dimensions and distances with BTL5-P-4500-1 electromagnet (24 V/100 mA)

The measuring range is offset by 4 mm towards the BTL plug (see Fig. 4-8).

4 Installation and connection (continued)

4.4 Electrical connection

Depending on the model, the electrical connection is made using a cable or a connector.
The connection or pin assignments for the respective version can be found in Tab. 4-3 to Tab. 4-6.

> Note the information on shielding and cable routing on page 12.

4.4.1 Connector S32

	BTL7 standard	BTL7 USB-Configurable
Pin	**BTL7-S5_ _-...-S32 BTL7-S5_ _B-...-S32**	**BTL7-S510-...-S32 BTL7-S510B-...-S32**
1	+Clk	+Clk
2	+Data	+Data
3	–Clk	–Clk
4	Not used[1]	La[2]
5	–Data	–Data
6	GND	GND
7	10 to 30 V	10 to 30 V
8	Not used[1]	Lb[2]

[1] Unassigned leads can be connected to the GND on the controller side but not to the shield.

[2] Communication line

Tab. 4-3: Connection assignment BTL7...-S32

Fig. 4-9: Pin assignment of S32 (view from above on transducer), 8-pin M16 circular plug

4.4.2 Connector S115

	BTL7 standard	BTL7 USB-Configurable
Pin	**BTL7-S5_ _-...-S115 BTL7-S5_ _B-...-S115**	**BTL7-S510-...-S115 BTL7-S510B-...-S115**
1	+Clk	+Clk
2	+Data	+Data
3	–Clk	–Clk
4	Not used[1]	La[2]
5	–Data	–Data
6	GND	GND
7	10 to 30 V	10 to 30 V
8	Not used[1]	Lb[2]

[1] Unassigned leads can be connected to the GND on the controller side but not to the shield.

[2] Communication line

Tab. 4-4: Connection assignment BTL7...-S115

Fig. 4-10: Pin assignment of S115 (view from above on transducer), 8-pin M12 circular plug

4.4.3 Connector S147

	BTL7 standard
Pin	**BTL7-S5_ _-...-S147 BTL7-S5_ _B-...-S147**
1	–Data
2	+Data
3	+Clk
4	–Clk
5	10 to 30 V
6	GND
7	Not used[1]

[1] Unassigned leads can be connected to the GND on the controller side but not to the shield.

Tab. 4-5: Connection assignment BTL7...-S147

Fig. 4-11: Pin assignment of S147 (view from above on transducer), 7-pin M16 circular plug

4 Installation and connection (continued)

4.4.4 Cable connection

	BTL7 standard	BTL7 USB-Configurable
Cable color	**BTL7-S5_ _-...-KA BTL7-S5_ _-...-FA BTL7-S5_ _B-...-KA BTL7-S5_ _B-...-FA**	**BTL7-S510-...-KA BTL7-S510-...-FA BTL7-S510B-...-KA BTL7-S510B-...-FA**
YE yellow	+Clk	+Clk
GY gray	+Data	+Data
PK pink	–Clk	–Clk
RD red	Not used[1)]	La[2)]
GN green	–Data	–Data
BU blue	GND	GND
BN brown	10 to 30 V	10 to 30 V
WH white	Not used[1)]	Lb[2)]

[1)] Unassigned leads can be connected to the GND on the controller side but not to the shield.

[2)] Communication line

Tab. 4-6: Cable assignment BTL7... cable

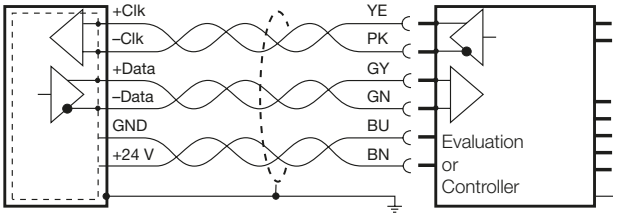


Fig. 4-12: Connection example for BTL7-S... cable 24 V DC with evaluation/controller

Clk, Data and supply are stranded in pairs (see Fig. 4-12).

4.5 Shielding and cable routing

Defined ground!
The transducer and the control cabinet must be at the same ground potential.

Shielding

To ensure electromagnetic compatibility (EMC), observe the following:

– Connect transducer and controller using a shielded cable.
Shielding: Braided copper shield with minimum 85% coverage.
– Connector version: Shield is internally connected to connector housing.
– Cable version: On the transducer side, the cable shielding is connected to the housing.

Magnetic fields

The position measuring system is a magnetostrictive system. It is important to maintain adequate distance between the transducer and strong, external magnetic fields.

Cable routing

Do not route the cable between the transducer, controller, and power supply near high voltage cables (inductive stray noise is possible).
The cable must be routed tension-free.

Bending radius for fixed cable

The bending radius for a fixed cable must be at least five times the cable diameter.

Cable length

BTL7-S…	Max. 500 m[1)]

[1)] Prerequisite: Construction, shielding and routing preclude the effect of any external noise fields. Required cable cross-section ≥ 0.6 mm² or ≤ AWG19

Tab. 4-7: Cable length BTL7-S…

For notes on cable length, see Technical data on page 20, Fig. 8-2.

Noise elimination

To avoid equipotential bonding (current flow) through the cable shield, please note the following:

– Use insulating bushes
– Put the control cabinet and the system in which the transducer is located to the same ground potential.

5 Startup

5.1 Starting up the system

⚠ DANGER

Uncontrolled system movement

When starting up, if the position measuring system is part of a closed loop system whose parameters have not yet been set, the system may perform uncontrolled movements. This could result in personal injury and equipment damage.

- ▶ Persons must keep away from the system's hazardous zones.
- ▶ Startup must be performed only by trained technical personnel.
- ▶ Observe the safety instructions of the equipment or system manufacturer.

1. Check connections for tightness and correct polarity. Replace damaged connections.
2. Turn on the system.
3. Check measured values and adjustable parameters and readjust the transducer, if necessary.

i Check for the correct values at the null point and end point, especially after replacing the transducer or after repair by the manufacturer.

5.2 Operating notes

- Check the function of the position measuring system and all associated components on a regular basis.
- Take the position measuring system out of operation whenever there is a malfunction.
- Secure the system against unauthorized use.

6 SSI interface

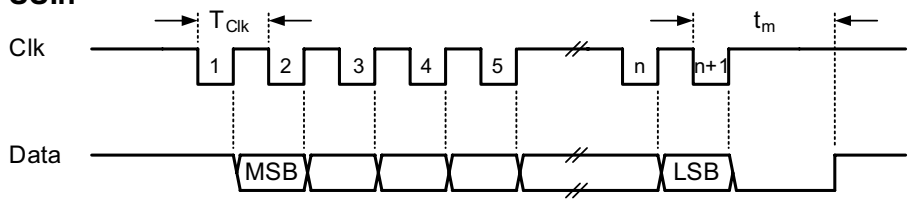
6.1 Principle

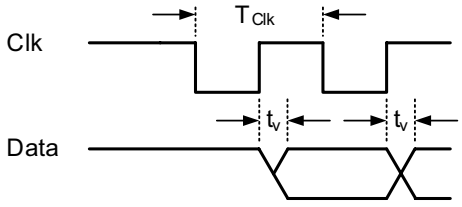
SSI stands for Synchronous Serial Interface and describes a digital synchronous interface with a differential clock line and a differential data line.
With the first falling clock edge, the data word to be output is buffered in the transducer to ensure data consistency. Data output takes place with the first rising clock edge, i.e. the transducer supplies a bit to the data line for each rising clock edge. In doing so, the line capacities and delays of drivers t_v when querying the data bits must be taken into account in the controller.

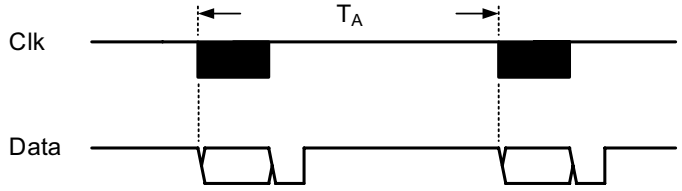
The max. clock frequency f_{Clk} is dependent on the cable length (see Technical data on page 20, Fig. 8-2). The t_m time, also called monoflop time, is started with the last falling edge and is output as the low level with the last rising edge. The data line remains at low until the t_m time has elapsed. Afterwards, the transducer is ready again to receive the next clock package.

With the BTL7-S_ _B-M..., position data is determined and output in a timely manner and synchronous to the external sampling period. For synchronous operation, the sampling period T_A must be in the range $T_{A,min} \leq T_A \leq 16$ ms. The transducer switches to asynchronous operation outside of this range. If the minimum sampling time is undercut, the transducer outputs the same position value several times. The external sampling rate is then greater than the internal rate. In addition, T_A must be long enough so that the next clock package does not occur in the t_m range of the previous package.

SSIn







T_{Clk}	=	$1 / f_{Clk}$	SSI clock period = 1/SSI clock frequency
T_A	=	$1/f_A$	Sampling period = 1/sampling rate
n			Number of bits to be transmitted (requires n+1 clock impulses)
t_m	=	$2 \cdot T_{Clk}$	Time until the SSI interface is ready again
t_v	=	150 ns	Transmission delay times (measured with a 1 m cable)

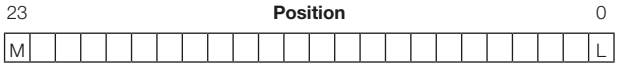
6 SSI interface (continued)

6.2 Data formats

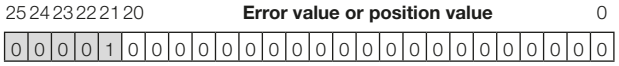
Standard BTL7 has the following factory settings for position output, which can no longer be changed retroactively:

- SSI24, SSI25 or SSI26
- Binary or Gray coded
- Rising or falling

The contents of the information to be transferred and the error value can be configured with the BTL7-S510(B)-…. Position, velocity, or differential position/velocity can be sent via Data. The MSB is always transmitted first.



Output of a position via SSI24
M = MSB (Most Significant Bit)
L = LSB (Least Significant Bit)



Example of an SSI26 with an error bit in bit location 21 and error value 0. The data length is 21 bits, the total bit number is 26. Four zeros are transmitted before the error bit.

SSI16

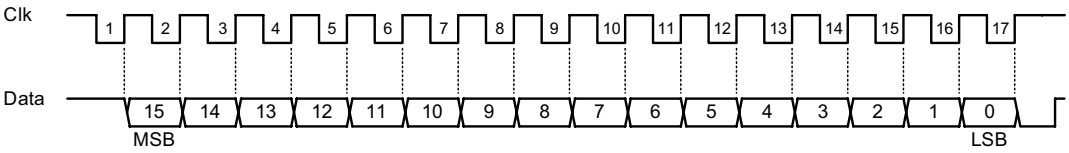


Fig. 6-1: Example of a complete SSI16 data transmission

Depending on the configuration, position or velocity data may have a leading sign with the BTL7-S510(B)-…. Negative values are output as a two's complement. With positive speeds, the magnet moves away from the connection side; with negative speeds it moves towards the connection side. The controller must be set to process signed data then.

6.3 Faulty SSI query

Underclocking

If there are too few clock edges, the current data level will be maintained for the time t_o ($t_o = 2 \cdot T_{Clk}$ timeout times) after the last negative edge from Clk. If, however, another positive edge occurs, the next bit will then be output. Afterwards, a T_o event will occur internally, the data output switches to low and then back to high after the time t_m has elapsed. The high level is maintained until the next clock burst. Time t_m starts after the end of time t_o.

Overclocking

If there are too many clock edges, the data output will switch to low after the correct number of cycles has been completed. The t_m timer is started again for every additional negative edge from Clk and the T_m event is set internally. Data switches back to high after the time t_m has elapsed.

A T_o or T_m event is displayed in the status field as a communication error in the Micropulse Configuration Tool. In short, a communication error is caused by the following:

- The bit number set in the transducer does not correspond to the bit number in the controller.
  $n_{BTL} > n_{PLC} \rightarrow T_o$ event
  $n_{BTL} < n_{PLC} \rightarrow T_m$ event
- The SSI clock frequency is too low
  $f_{Clk} < 9.771$ kHz $\rightarrow T_o$ event
- The pause between two clock packages is too short
  $\rightarrow T_m$ event

6 SSI interface (continued)

6.4 Synchronous and asynchronous operation

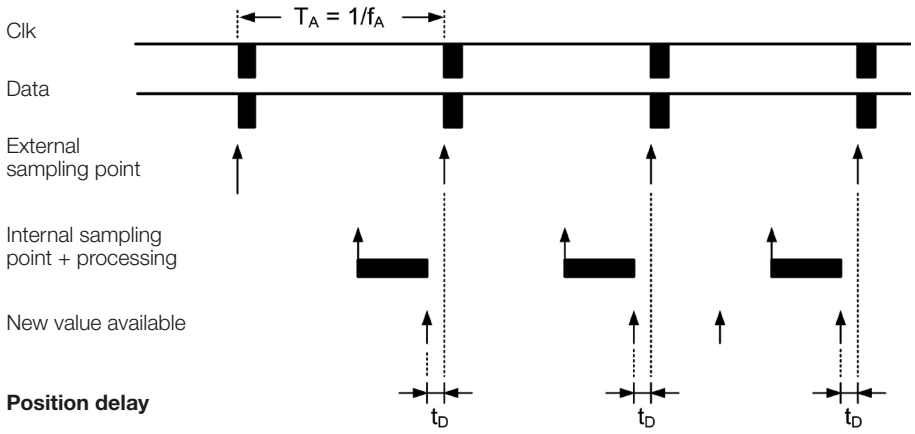
Synchronous operation

A uniform and brief timing is often required for control applications. The position delay t_D must be kept as short and constant as possible. Synchronous operation is thus intended for closed control loops. Here, the internal sensing cycle adjusts itself to the external sampling cycle. The following graphic clarifies this relationship:

Two boundary conditions must be taken into account during synchronous operation:

– The external sampling frequency f_A must be in the range 62.5 Hz < f_A < $f_{A,max}$. The maximum permissible sampling frequency $f_{A,max}$ is shown in Fig. 8-1 on page 20.
– The sampling frequency must be kept as constant as possible.

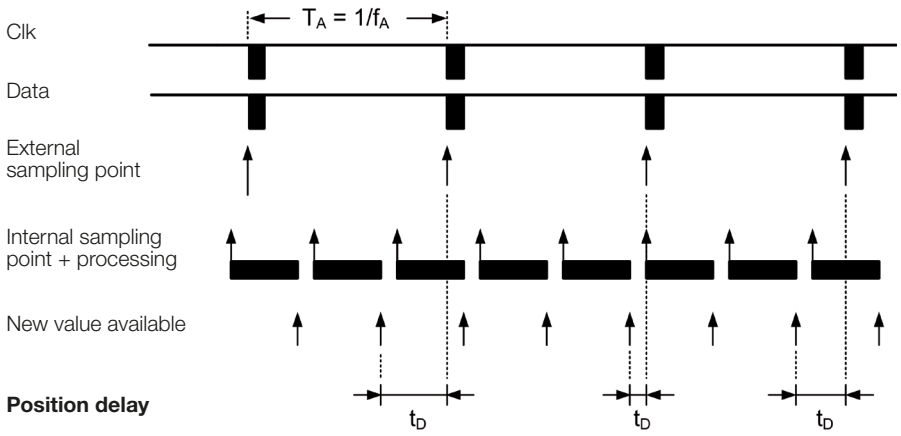
> The sampling frequency is the reciprocal value of the time between two clock packages and may not be confused with the SSI clock frequency.



Asynchronous operation

During asynchronous operation, the external sampling frequency is independent of the internal sampling frequency of the transducer. Depending on the external query point, the position is more or less current and the position delay t_D is not constant. In the worst case, it is equal to the internal sampling period. The transducer always works with the maximum possible internal sampling frequency. Due to the measuring principle, the maximum sampling frequency $f_{A,max}$ is dependent on the nominal length of the transducer.

The following graphic shows the behavior of internal and external sampling in asynchronous operation:



7 Configuration using the Micropulse Configuration Tool (only for BTL7-S510(B)-...)

7.1 Micropulse Configuration Tool

The BTL7-S510(B)-… transducer can be configured quickly and simply on a PC using the Micropulse Configuration Tool PC software.
The most important features include:

- Online display of the current position of the magnet
- Graphical support for setting the functions and curves
- Display of information on the connected transducer
- Selectable number formats and units for display
- Resetting to factory settings is possible
- Demo mode without having transducer connected

The PC software and associated manual can be found in the Internet under www.balluff.com.

7.2 Connecting the USB communication box

With BTL7-S510(B)-... transducers with connectors (S32/S115), the communication box must be looped in between the transducer and controller. The communication box is connected to the PC via a USB cable.

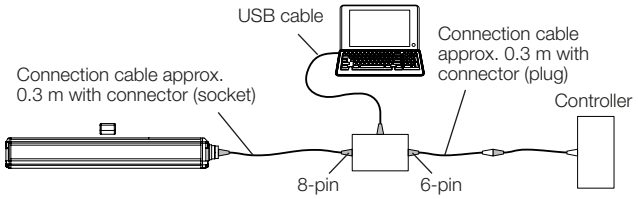


Fig. 7-1: Connecting the communication box with a connector

With a BTL7-S510(B)-… cable transducer, the communication lines La, Lb and GND must be connected to the USB communication box.

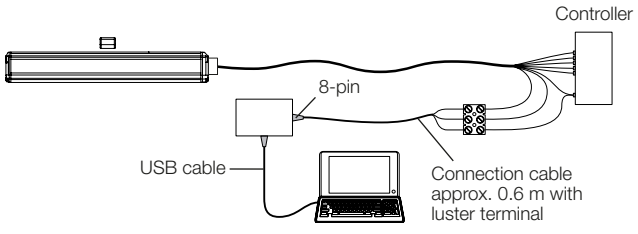


Fig. 7-2: Connecting the communication box with a cable connection

When reading or writing data via the Configuration Tool, LED 2 flashes green.

7.3 Configuration options

Prerequisites

- USB communication box connected to the transducer and PC.
- Software correctly installed.
- Transducer connected to the power supply.
- Magnet on transducer.

Output functions

- **Position:** Position in the measuring range.
- **Velocity:** Speed of the magnet; the sign indicates the direction of movement. A movement from the starting point to end point is output with a positive sign; a movement from the end point to the starting point is output with a negative sign.
- **Speed (unsigned):** Velocity of the magnet, the direction of movement cannot be read.
- **Differential position:** Distance between two magnets. Selection is only possible if two magnets have been selected.
- **Speed difference:** The speeds of two magnets are subtracted to form a sum. Selection is only possible if two magnets have been selected.

Freely configurable curve

- The gradient of the characteristic curve can be set by adjusting the resolution.
- The limits can be adjusted to the measuring range.
- The error value can be set.

Extended settings

- SSI interface: Change between synchronous and asynchronous mode
- Noise filter: Setting of various filter levels
- Average filter: Number of averaged values

Boundary conditions for several magnets

- Two magnets can only be selected if the nominal length is ≥ 90 mm.
- The distance between two magnets must be ≥ 65 mm.

DANGER

Uncontrolled system movement

When starting up, if the position measuring system is part of a closed loop system whose parameters have not yet been set, the system may perform uncontrolled movements. This could result in personal injury and equipment damage.

- ▶ Take the system out of operation before configuration.
- ▶ Only connect transducers to the communication box for configuration.
- ▶ Remove the communication box after configuration.

8 Technical data

8.1 Accuracy

The specifications are typical values for BTL7-S... at 24 V DC and room temperature, with a nominal length of 500 mm in conjunction with the BTL5-P-3800-2, BTL5-P-4500-1, BTL5-P-5500-2[1], BTL6-A-3800-2[1], BTL6-A-3801-2[1], BTL5-F-2814-1S, BTL5-T-2814-1S, BTL5-M-2814-1S or BTL5-N-2814-1S magnet.
The transducer is fully operational immediately, with full accuracy after warm-up.

> For special versions, other technical data may apply.
> Special versions are indicated by the suffix -SA on the part label.

Position resolution	0.5; 1; 2; 5; 10; 20; 40; 50; 100 µm (additionally 200; 500; 1000 µm with BTL7-S510(B)-…)
Non-linearity at	
Nominal length 50 to 5500 mm	
resolution ≤ 10 µm	≤ ±30 µm
resolution > 10 µm	≤ ±2 LSB
Nominal length 5501 to 7620 mm	±0.02 %
Hysteresis	≤ ±10 µm
Repeat accuracy	≤ ±5 µm (typ. ±2.5 µm)
Temperature coefficient[2]	≤ 15 ppm/K
Velocity resolution	0.1 mm/s
Min. detectable velocity	1 mm/s
Max. detectable velocity	10 m/s

8.2 Ambient conditions[3]

Operating temperature	–40°C to +85°C
Operating temperature for UL (only BTL7-...-KA...)	Max. +80°C
Storage temperature	–40°C to +100°C
Humidity	< 90%, non-condensing
Shock rating per EN 60068-2-27[4]	150 g/6 ms
Continuous shock per EN 60068-2-29[4]	150 g/2 ms
Vibration per EN 60068-2-6[4]	20 g, 10 to 2000 Hz
Degree of protection per IEC 60529	
Connector S32/S115/S147 (when attached)	IP 67
Cable	IP 68[4]

8.3 Supply voltage

Voltage, stabilized[5]	10 to 30 V DC
Ripple	≤ 0.5 V_{ss}
Current draw (at 24 V DC)	≤ 100 mA
Inrush current	≤ 500 mA/10 ms
Reverse polarity protection	Up to 36 V (supply to GND)
Overvoltage protection	Up to 36 V
Dielectric strength (GND to housing)	500 V AC

8.4 Output

Configurable bit number (only BTL7-S510(B)-...)	16-32
Coding	Binary or Gray
Characteristic	Rising or falling
SSI data	Position, velocity, absolute velocity, differential position, speed difference (between 2 magnets), error value
SSI clock frequency f_{Clk}	10 kHz to 1 MHz
Behavior at null point	BTL7 standard: No negative values below the null point
	BTL7-S510(B)-...: Configurable
Short-circuit protection	Signal lines Data+/–, Clk+/–, to +36 V or GND

8.5 Communication lines La, Lb

Short-circuit protection	Signal cable to GND

[1] In the position range 0...20 mm, the specified linearity limit can be exceeded by ±100 µm.

[2] Nominal length 500 mm, magnet in the middle of the measuring range

[3] For cULus LISTED: Use in enclosed spaces and up to a height of 2000 m above sea level.

[4] Individual specifications as per Balluff factory standard

[5] For cULus LISTED: The transducer must be externally connected via a limited-energy circuit as defined in UL 61010-1, a low-power source as defined in UL 60950-1, or a class 2 power supply as defined in UL 1310 or UL 1585.

8 Technical data (continued)

8.6 Dimensions, weights

Housing height	36.8 mm
Nominal length	50 to 7620 mm
Weight (depends on length)	Approx. 1.4 kg/m
Housing material	Aluminum

BTL7-...-KA_ _

Cable material	PUR cULus 20549 80 °C, 300 V, internal wiring
Cable temperature	–40°C to +90°C
Cable diameter	Max. 7 mm
Permissible bending radius	
Fixed routing	≥ 35 mm
Moved	≥ 105 mm

BTL7-...-FA_ _

Cable material	PTFE No UL approval available
Cable temperature	–55°C to +200°C
Cable diameter	Max. 7 mm
Permissible bending radius	
Fixed routing	≥ 35 mm
Moved	No permissible bending radius

8 Technical data (continued)

8.7 Connection to the evaluation unit

The maximum sampling frequency $f_{A,max}$, at which a new current value is available with each sampling, can be found in the following graphic:

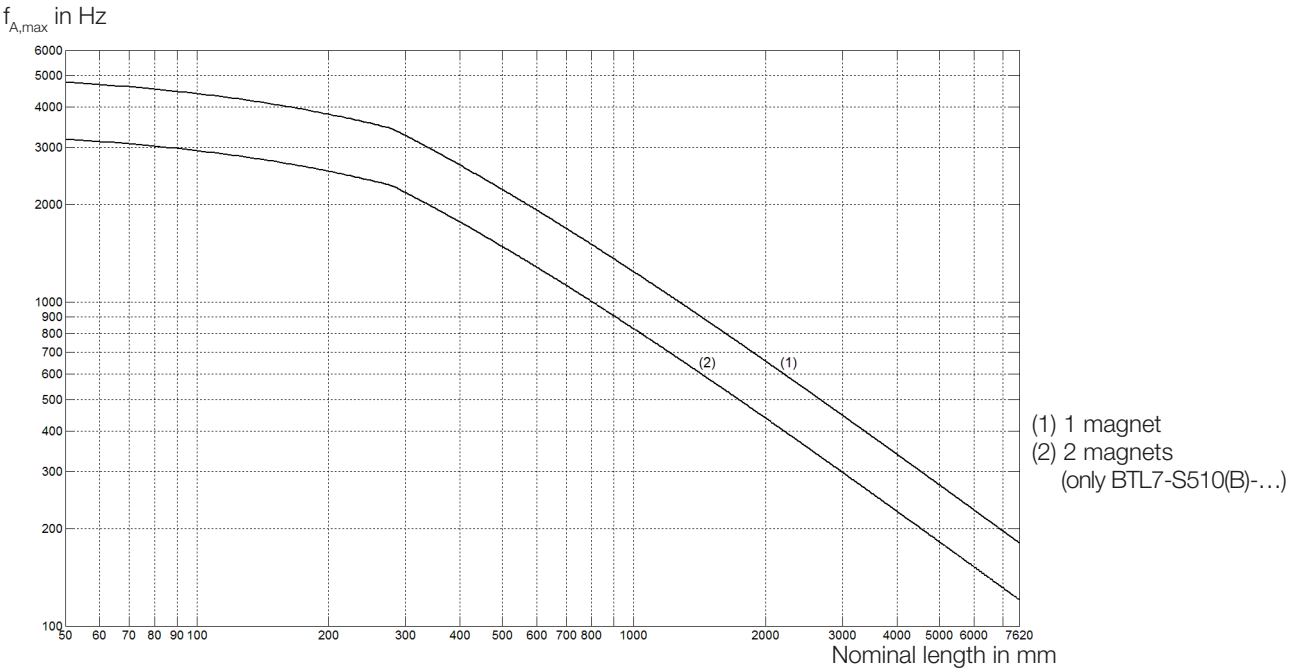


Fig. 8-1: Maximum sampling rate depending on the nominal length (for position output) The maximum sampling rate for velocity output is limited to 3.1 kHz.

The maximum SSI clock frequency $f_{CLK, max}$ is dependent on the cable length[1)]:

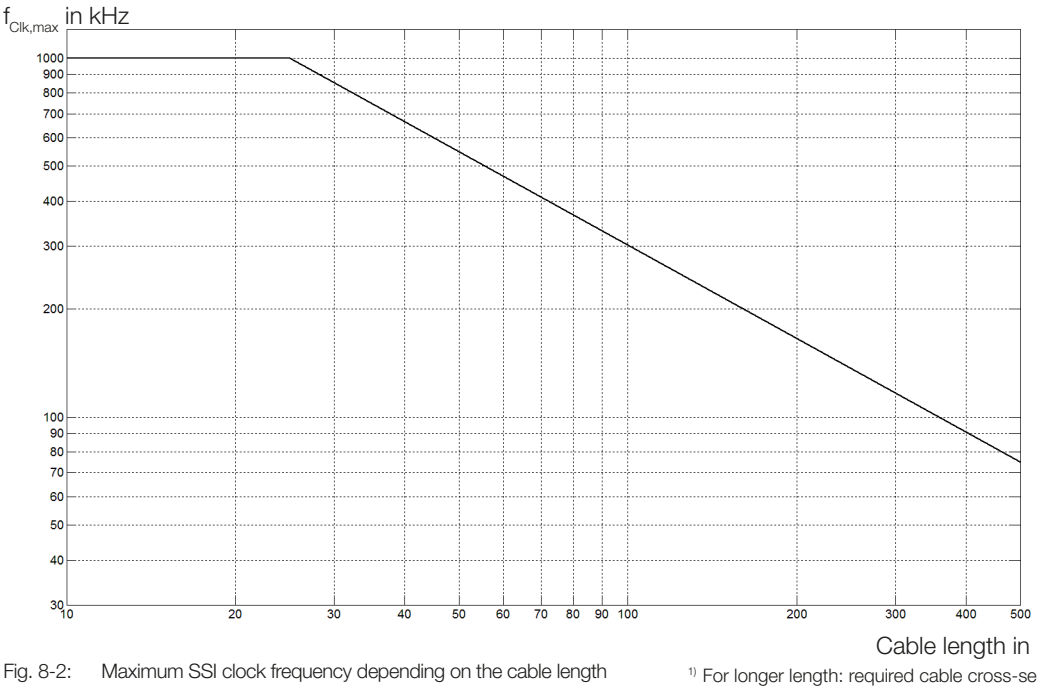


Fig. 8-2: Maximum SSI clock frequency depending on the cable length

[1)] For longer length: required cable cross-section ≥ 0.6 mm² or ≤ AWG19

9 Accessories

9.1 Captive magnets

BTL5-M/N-2814-1S

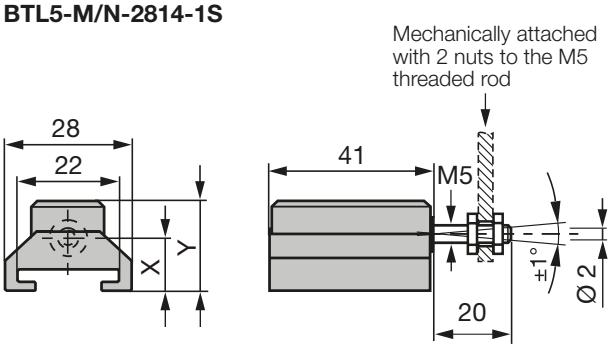


Fig. 9-1: Installation dimensions of BTL5-M/N-2814-1S magnet

	BTL5-M-2814-1S	BTL5-N-2814-1S
Distance X	12.5 mm	15 mm
Distance Y	21 mm	23.5 mm
Weight:	Approx. 32 g	Approx. 35 g
Housing:	Anodized aluminum	Anodized aluminum
Slide surface:	Plastic	Plastic

BTL5-F-2814-1S

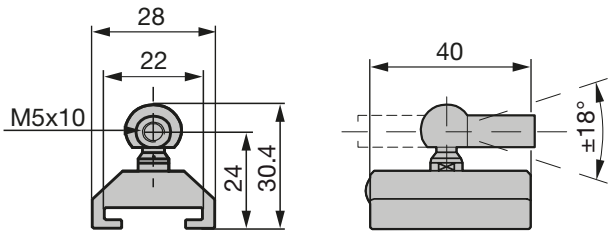


Fig. 9-2: Installation dimensions of BTL5-F-2814-1S magnet

Weight:	Approx. 28 g
Housing:	Anodized aluminum
Slide surface:	Plastic

BTL5-T-2814-1S

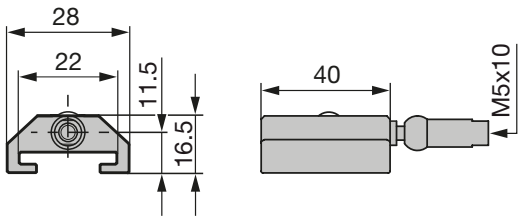


Fig. 9-3: Installation dimensions of BTL5-T-2814-1S magnet

Weight:	Approx. 28 g
Housing:	Anodized aluminum
Slide surface:	Plastic

9.2 BTL2-GS10-_ _ _ _-A joint rod

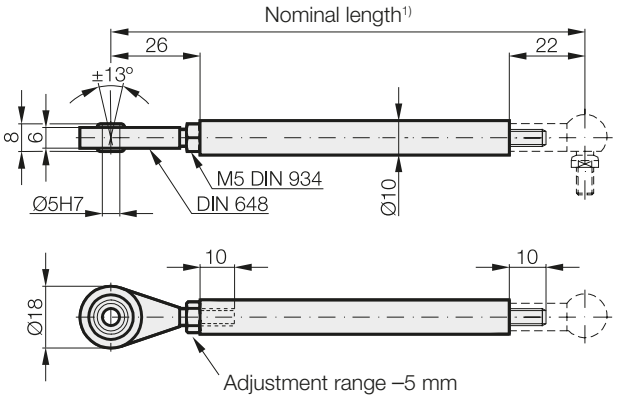


Fig. 9-4: BTL2-GS10-_ _ _ _-A joint rod

Weight:	Approx. 150 g/m
Material:	Aluminum

1) State the nominal length when ordering

Example: BTL2-GS10-**0100**-A (nominal length = 100 mm)

9 Accessories (continued)

9.3 Floating magnets

BTL5-P-3800-2

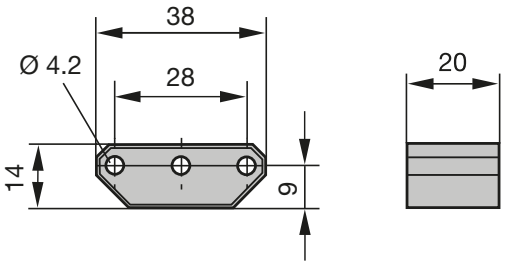


Fig. 9-5: Installation dimensions of BTL5-P-3800-2 magnet

Weight:	Approx. 12 g
Housing:	Plastic

BTL5-P-5500-2

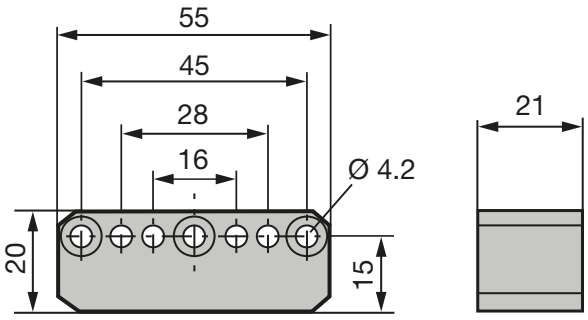


Fig. 9-6: Installation dimensions of BTL5-P-5500-2 magnet

Weight:	Approx. 40 g
Housing:	Plastic

BTL6-A-3800-2

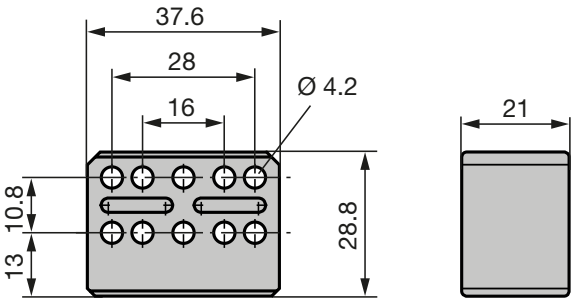


Fig. 9-7: Installation dimensions of BTL6-A-3800-2 magnet

Weight:	Approx. 30 g
Housing:	Plastic

BTL6-A-3801-2

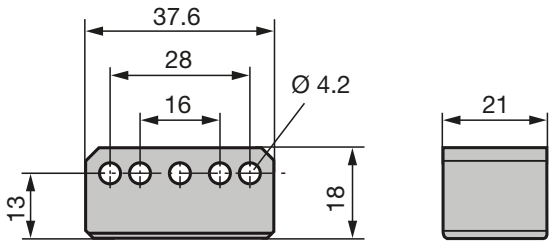


Fig. 9-8: Installation dimensions of BTL6-A-3801-2 magnet

Weight:	Approx. 25 g
Housing:	Plastic

BTL5-P-4500-1

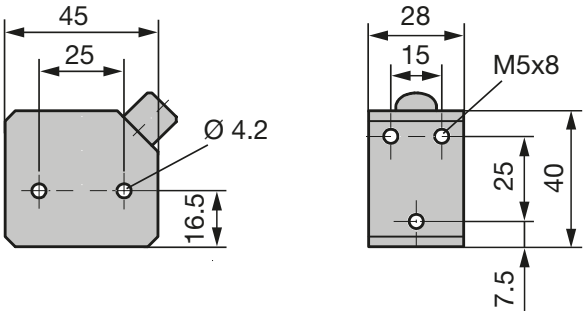


Fig. 9-9: Installation dimensions of BTL5-P-4500-1 magnet

Weight:	Approx. 90 g
Housing:	Plastic
Operating temperature:	–40°C to +60°C

Special advantage of the BTL5-P-4500-1 magnet: Several magnets on the same transducer can be separately switched on and off electrically (actuation with a PLC signal).

9 Accessories (continued)

9.4 Connectors and cables

9.4.1 BKS-S32/S33M-00, freely configurable

BKS-S32M-00

Straight connector, freely configurable M16 per IEC 130-9, 8-pin

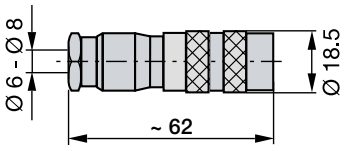


Fig. 9-10: Connector BKS-S32M-00

BKS-S33M-00

Angled connector, freely configurable M16 per IEC 130-9, 8-pin

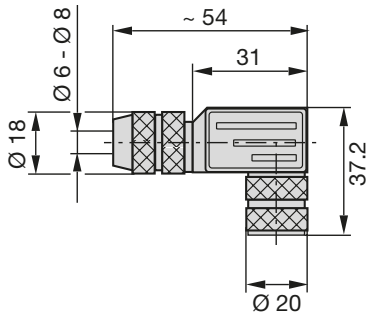


Fig. 9-11: Connector BKS-S33M-00

9.4.2 BKS-S232/S233-PU-_ _, preassembled

BKS-S232-PU-_ _

Straight connector, molded, preassembled M16, 8-pin
Various cable lengths can be ordered,
e.g. BKS-S232-PU-05: Cable length 5 m

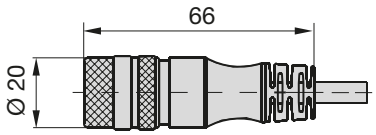


Fig. 9-12: Connector BKS-S232-PU-_ _

BKS-S233-PU-_ _

Angled connector, molded, preassembled M16, 8-pin
Various cable lengths can be ordered,
e.g. BKS-S233-PU-05: Cable length 5 m

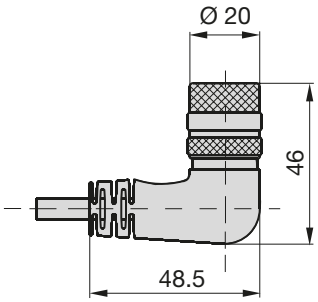


Fig. 9-13: Connector BKS-S233-PU-_ _

The outlet direction and the pin assignment for the BKS-S233-PU-_ _ is the same as that for BKS-S116-PU-_ _ (see Fig. 9-16 or Tab. 9-1).

9 Accessories (continued)

9.4.3 BKS-S115/S116-PU-_ _, preassembled

BKS-S115-PU-_ _

Straight connector, molded-on cable, preassembled M12, 8-pin
Various cable lengths can be ordered,
e.g. BKS-S115-PU-05: Cable length 5 m

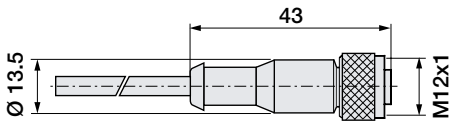


Fig. 9-14: Connector type BKS-S115-PU-_ _

BKS-S116-PU-_ _

Angled connector, molded-on cable, preassembled M12, 8-pin
Various cable lengths can be ordered,
e.g. BKS-S116-PU-05: Cable length 5 m

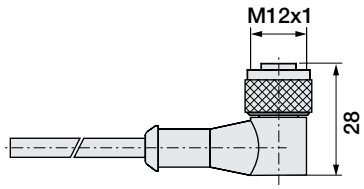


Fig. 9-15: Connector BKS-S116-PU_ _

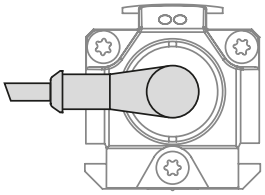


Fig. 9-16: Connector BKS-S116-PU_ _, outlet

Pin	Color
1	YE yellow
2	GY gray
3	PK pink
4	RD red
5	GN green
6	BU blue
7	BN brown
8	WH white

Tab. 9-1: BKS-S115/116-PU-_ _ pin assignment

9.4.4 BKS-S147/S148M-00, freely configurable

BKS-S147M-00

Straight connector, freely configurable M16 per IEC 130-9, 7-pin

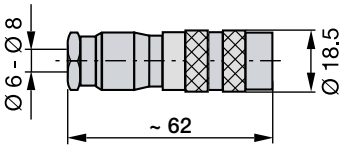


Fig. 9-17: Connector BKS-S147M-00

BKS-S148M-00

Angled connector, freely configurable M16 per IEC 130-9, 7-pin

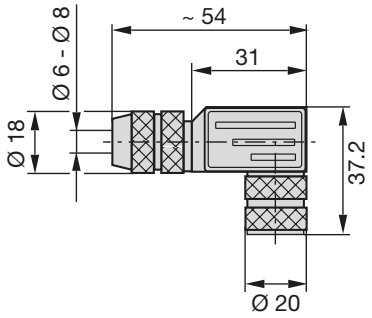


Fig. 9-18: Connector BKS-S148M-00

9.5 USB communication box

BTL7-A-CB01-USB-S32

For BTL7-S510(B)-... with connector type S32.
Scope of delivery: USB communication box, USB cable, 2 adapter cables each approx. 0.3 m, condensed guide.

BTL7-A-CB01-USB-S115

For BTL7-S510(B)-... with connector type S115.
Scope of delivery: USB communication box, USB cable, 2 adapter cables each approx. 0.3 m, condensed guide.

BTL7-A-CB01-USB-KA

For BTL7-S510(B)-... with cable connection.
Scope of delivery: USB communication box, USB cable, 1 adapter cable each approx. 0.6 m, condensed guide.

10 Type code breakdown

BTL7 standard

BTL7 - S 5 0 1 B - M0500 - P - S32

Micropulse transducer

SSI interface

Supply voltage:
5 = 10 to 30 V DC

Data format:

	24 bit		25 bit		26 bit
0 =	Binary, rising	6 =	Binary, rising	A =	Binary, rising
1 =	Gray, rising	7 =	Gray, rising	B =	Gray, rising
2 =	Binary, falling	8 =	Binary, falling	C =	Binary, falling
3 =	Gray, falling	9 =	Gray, falling	D =	Gray, falling

Resolution:

1 =	1 µm	3 =	10 µm	5 =	40 µm	7 =	2 µm	9 = 0.5 µm
2 =	5 µm	4 =	20 µm	6 =	100 µm	8 =	50 µm	

Synchronous/asynchronous operation:
B = Synchronous operation
Without B = Asynchronous operation

Nominal length (4-digit):
M0500 = Metric specification in mm, nominal length 500 mm (M0050 to M7620)

Construction:
P = Profile housing

Electrical connection:
S32 = 8-pin, M16 plug per IEC 130-9
S115 = 8-pin, M12 plug
S147 = 7-pin, M16 plug per DIN 45329
KA05 = Cable, 5 m (PUR)
FA05 = Cable, 5 m (PTFE)

10 Type code breakdown (continued)

BTL7 USB-Configurable

BTL7 - S 5 1 0 B - M0500 - P - S32

Micropulse transducer

SSI interface

Supply voltage:
5 = 10 to 30 V DC

Data format:
1 = 24 bit, Gray, rising (factory setting)

Resolution:
0 = 1 µm (factory setting)

Synchronous/asynchronous operation:
B = Synchronous operation
Without B = Asynchronous operation

Nominal length (4-digit):
M0500 = Metric specification in mm, nominal length 500 mm (M0050 to M7620)

Construction:
P = Profile housing

Electrical connection:
S32 = 8-pin, M16 plug per IEC 130-9
S115 = 8-pin, M12 plug
KA05 = Cable, 5 m (PUR)
FA05 = Cable, 5 m (PTFE)

11 Appendix

11.1 Converting units of length

1 mm = 0.0393700787 inch

mm	inch
1	0.03937008
2	0.07874016
3	0.11811024
4	0.15748031
5	0.19685039
6	0.23622047
7	0.27559055
8	0.31496063
9	0.35433071
10	0.393700787

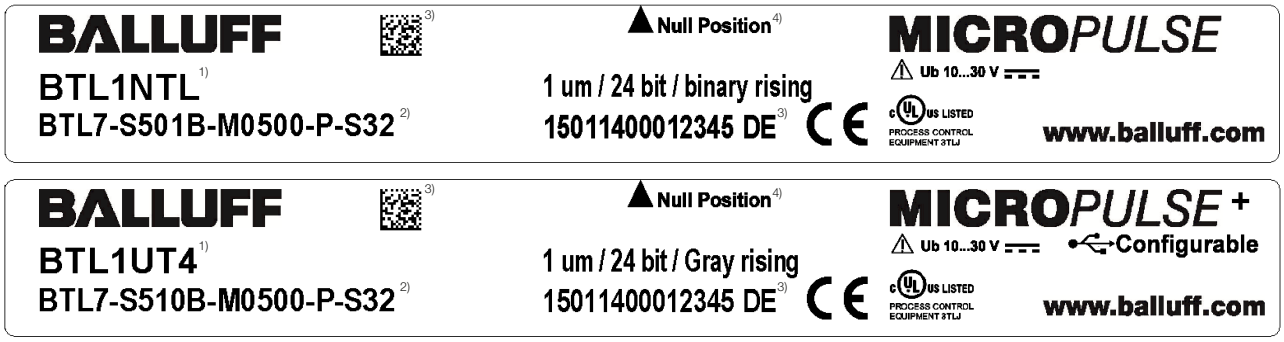
Tab. 11-1: Conversion table mm to inches

1 inch = 25.4 mm

inch	mm
1	25.4
2	50.8
3	76.2
4	101.6
5	127
6	152.4
7	177.8
8	203.2
9	228.6
10	254

Tab. 11-2: Conversion table inches to mm

11.2 Part label



1) Ordering code
2) Type
3) Serial number
4) Null mark

Fig. 11-1: BTL7 part label

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