1.1 Validity
This guide describes the construction, function and setup options for the BTL6 Micropulse Transducer with EtherCAT® interface. It applies to types BTL6-V1_E-M____-A/B/Y/Z(8)-S115 (see Type code breakdown on page 16).

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. ► Instruction 1

Action sequences are numbered consecutively:
1. Instruction 1
2. Instruction 2

Note, tip
This symbol indicates general notes.

1.3 Scope of delivery
- BTL6 transducer
- Condensed guide

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

1.4 Approvals and markings

UL approval
File no.
E227256

EtherCAT® Registered trademark and patented technology. Licensed by Beckhoff Automation GmbH, Germany.

TwinCAT® Registered and licensed trademark of Beckhoff Automation GmbH. It is a software PLC that runs on a Windows PC.


The transducer meets the requirements of the following generic standards:
- EN 61000-6-1 (noise immunity)
- EN 61000-6-2 (noise immunity)
- EN 61000-6-3 (emission)
- EN 61000-6-4 (emission)

and the following product standard:
- EN 61326-2-3

Emission tests:
- RF emission
  EN 55016-2-3 (industrial and residential areas)

Noise immunity tests:
- Static electricity (ESD)
  EN 61000-4-2 Severity level 3
- Electromagnetic fields (RFI)
  EN 61000-4-3
- Electrical fast transients (burst)
  EN 61000-4-4 Severity level 3
- Surge
  EN 61000-4-5
  EN 61000-4-6 Severity level 3
- 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
PDO Process data object
ESI EtherCAT® slave information
2

2.1 Intended use

The 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. Specialists 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:

<table>
<thead>
<tr>
<th>SIGNAL WORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard type and source</td>
</tr>
<tr>
<td>► Measures to avoid hazards</td>
</tr>
</tbody>
</table>

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.
Construction and function

3.1 Construction

Electrical connection: The electrical connection is made via a connector (see Type code breakdown on page 16).

BTL housing: Aluminum housing containing the processing electronics.

Mounting thread: We recommend assembling these transducers on the fastening screw thread:
- BTL6-…-A/B: M18×1.5
- BTL6-…-Y/Z: 3/4”-16UNF

The transducer with Ø 10.2 mm has an additional thread at the end of the rod to support larger nominal lengths.

Magnet: Defines the position to be measured on the waveguide. Magnets are available in various models and must be ordered separately (see Accessories on page 14).

Only with BTL6-V12E...: A minimum spacing (L) of 65 mm must be maintained.

Nominal length: Defines the available measuring range. Rods with various nominal lengths from 25 mm to 4012 mm are available depending on the version:
- Ø 10.2 mm: Nominal length from 25 mm to 4012 mm
- Ø 8 mm: Nominal length from 25 mm to 1016 mm

Damping zone: Area at the end of the rod that cannot be used for measurements, but which may be passed over.

3.2 Function

The BTL6 transducer contains the waveguide which is protected by an outer stainless steel tube (rod). 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.

This information is transferred via the EtherCAT® interface. EtherCAT® is an industrial bus system based on the physical layer of the Ethernet (see www.ethercat.org).
4.1 Installation guidelines

Non-magnetizable material

1) Min. Ø D2 = Minimum diameter of the bore (see Tab. 4-1)

Fig. 4-1: Installation variant in non-magnetizable material

Magnetizable material

If using magnetizable material, the transducer must be protected against magnetic interference through suitable measures (e.g. spacer ring made of non-magnetizable material, a suitable distance from strong external magnetic fields).

1) Min. Ø D2 = Minimum diameter of the bore (see Tab. 4-1)

Fig. 4-2: Installation in magnetizable material

<table>
<thead>
<tr>
<th>Tube diameter</th>
<th>Bore diameter D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.2 mm</td>
<td>At least 13 mm</td>
</tr>
<tr>
<td>8 mm</td>
<td>At least 11 mm</td>
</tr>
</tbody>
</table>

Tab. 4-1: Bore diameter if installed in a hydraulic cylinder

4.2 Preparing for installation

Installation note: We recommend using non-magnetizable material to mount the transducer and magnet.

Horizontal assembly: If installing horizontally with nominal lengths > 500 mm, we recommend tightening the rod at the end (only possible with Ø 10.2 mm) or supporting it.

Hydraulic cylinder: If installed in a hydraulic cylinder, ensure that the minimum value for the bore diameter of the support piston is complied with (see Tab. 4-1).

Mounting hole: The transducer comes with an M18×1.5 (ISO) or 3/4"-16UNF (SAE) mounting thread. Depending on the version, a mounting hole must be made before assembly.

Fig. 4-3: Mounting hole M18x1.5 per ISO 6149 O-ring 15.4x2.1

Fig. 4-4: Mounting hole 3/4"-16UNF per SAE J475 O-ring 15.3x2.4

Magnet: Various magnets are available for the BTL6 transducer (see Accessories on page 14).
4.3 Installing the transducer

**NOTICE!**

**Interference in function**
Improper installation can compromise the function of the transducer and result in increased wear.
► The mounting surface of the transducer must make full contact with the supporting surface.
► The bore must be perfectly sealed (O-ring/flat seal).

► Make a mounting hole with thread (possibly with countersink for the O-ring) acc. to Fig. 4-3 or Fig. 4-4.
► Screw the transducer with mounting thread into the mounting hole (max. torque 100 Nm).
► Install the magnet (accessories).
► For nominal lengths > 500 mm: Tighten the rod at the end (only possible with Ø10.2 mm) or support it.

Suitable nuts for the mounting thread are available as accessories (see page 14).

4.3.1 Installation recommendation for hydraulic cylinders

If you seal the hole with a flat seal, the max. operating pressure will be reduced in accordance with the larger pressurized surface.
If installing horizontally in a hydraulic cylinder (nominal lengths > 500 mm), we recommend affixing a slide element to protect the rod end from wear.

Dimensioning of the detailed solutions is the responsibility of the cylinder manufacturer.

The slide element material must be suitable for the appropriate load case, medium used, and application temperatures. E.g. Torlon, Teflon or bronze are all possible materials.

The slide element can be screwed on or bonded.
► Secure the screws so they cannot be loosened or lost.
► Select a suitable adhesive.

Fig. 4-6: Detailed view and top view of slide element

There must be a gap between the slide element and piston bore that is sufficiently large for the hydraulic oil to flow through.

Options for fixing the magnet:
- Screws
- Threaded ring
- Press fitting
- Notches (center punching)

If installed in a hydraulic cylinder, the magnet should not make contact with the rod.

The hole in the spacer ring must ensure optimum guidance of the rod by the slide element.

Fig. 4-7: Fixing of magnet

An example of how to install the transducer with a supporting rod is shown in Fig. 4-8 on page 9.
4.4 Electrical connection

The transducer is connected via an S115 connector (see Accessories on page 15).

Note the information on shielding and cable routing.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Color</th>
<th>BTL6-V1 _ E interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>—</td>
<td>Not used(^1)</td>
</tr>
<tr>
<td>2</td>
<td>OG/WH Orange/white</td>
<td>Tx+</td>
</tr>
<tr>
<td>3</td>
<td>OG Orange</td>
<td>Tx-</td>
</tr>
<tr>
<td>4</td>
<td>—</td>
<td>Not used(^1)</td>
</tr>
<tr>
<td>5</td>
<td>GN/WH Green/white</td>
<td>Rx+</td>
</tr>
<tr>
<td>6</td>
<td>BU Blue</td>
<td>GND(^2)</td>
</tr>
<tr>
<td>7</td>
<td>BN Brown</td>
<td>+24 V</td>
</tr>
<tr>
<td>8</td>
<td>GN Green</td>
<td>Rx-</td>
</tr>
</tbody>
</table>

\(^1\) Unassigned leads can be connected to the GND on the controller side but not to the shield.

\(^2\) Reference potential for supply voltage and EMC-GND.

Tab. 4-2: Pin assignment of S115 connector

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%.
- Shield is internally connected to connector housing.

**Magnetic fields**

The position measuring system is a magnetostrictive system. It is important to maintain adequate distance between the transducer cylinder 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.

**Cable length**

The maximum cable length when using CAT5e cables is 100 m\(^3\).

\(^3\) Prerequisite: Construction, shielding and routing preclude the effect of any external noise fields.
5

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 readjust the transducer, if necessary.

Check for the correct values, especially after replacing the transducer or after repair by the manufacturer.

5.2 Operating notes

- Check the function of the transducer 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.
6.1 Device profile

The EtherCAT® bus is an industrial real-time bus system based on IEEE 802.3 100TX standard Ethernet technology.

6.1.1 Process image

![Process image diagram](image)

**Description of the BTL status:**

- **Bit 0: Error**
  If no error has occurred, the bit is at null (normal case). This bit is set if the detected number of magnets is less than the expected number of magnets.

- **Bit 4...6: Number of magnets detected**
  This bit field indicates the number of magnets.
  Examples:
  
<table>
<thead>
<tr>
<th>Number of Magnets</th>
<th>Bit Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (no magnet)</td>
<td>'000'</td>
</tr>
<tr>
<td>1</td>
<td>'001'</td>
</tr>
<tr>
<td>2</td>
<td>'010'</td>
</tr>
<tr>
<td>3</td>
<td>'011'</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
  etc.

- **Bit 7: Too many magnets detected**
  This bit is mapped if the detected number of magnets is greater than the number of magnets entered in the Config register.

**Note, tip**

The device description XML file can be downloaded from www.balluff.de. The file must be installed before usage.

**Description of the Cycle_Index register:**

The Cycle_Index register is a free running 16 bit counter. It counts in every measurement cycle.

**Description of the Position_1 register:**

The Position_1 register is a 32 bit integer value (DINT). It contains the actual position value in μm.

**Description of the Position_2 register:**

The Position_2 register contains the position value of the second magnet (BTL6-V1E-...). The register format is identical with that in the Position_1 register.
6.2 Automatic scanning

- The EtherCAT® system must be in a safe deenergized state before modules are connected to the EtherCAT® network.
- Switch on the operating voltage and run TwinCAT® System Manager in config mode.
- Scan the transducer as a box, see Fig. 6-3.

6.3 Appending a module manually

- The EtherCAT® system must be in a safe deenergized state before modules are connected to the EtherCAT® network.
- Switch on the operating voltage and run TwinCAT®.
- Append the box, see Fig. 6-4.

Fig. 6-4: Appending box

Select the appropriate box, see Figure 6-5

Then the TwinCAT® tree looks like Fig 6-6.

Fig. 6-5: Inserting an EtherCAT® device

Then the TwinCAT® tree looks like Fig 6-6.
## Technical data

### 7.1 Accuracy

The specifications are typical values at 24 V DC and room temperature, with a nominal length of 500 mm in conjunction with the BTL-P-1013-4R, BTL-P-1013-4S, BTL-P-1012-4R, or BTL-P-1014-2R magnet. The BTL 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.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>&lt; 10 µm</td>
</tr>
<tr>
<td>Repeat accuracy, typical</td>
<td>&lt; 30 µm</td>
</tr>
<tr>
<td>Sampling rate</td>
<td></td>
</tr>
<tr>
<td>Dependent on nominal length</td>
<td>500 µs to 3.5 ms</td>
</tr>
<tr>
<td>At nominal length = 500 mm</td>
<td>0.5 ms</td>
</tr>
<tr>
<td>Non-linearity at Nominal length ≤ 500 mm</td>
<td>±200 µm</td>
</tr>
<tr>
<td>Nominal length &gt; 500 mm</td>
<td>±0.04 % FS</td>
</tr>
<tr>
<td>Temperature coefficient(^1)</td>
<td>≤ 20 ppm/K</td>
</tr>
</tbody>
</table>

### 7.2 Ambient conditions

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature</td>
<td>0°C to +70°C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>−40°C to +100°C</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>&lt; 90%, non-condensing</td>
</tr>
<tr>
<td>Shock rating per EN 60068-2-27(^2)</td>
<td>50 g/6 ms</td>
</tr>
<tr>
<td>Continuous shock per EN 60068-2-29(^2)</td>
<td>50 g/2 ms</td>
</tr>
<tr>
<td>Vibration per EN 60068-2-6(^2) (note resonant frequency of the rod)</td>
<td>12 g, 10 to 2000 Hz</td>
</tr>
<tr>
<td>Degree of protection per IEC 60529 (when attached)</td>
<td>IP 67</td>
</tr>
</tbody>
</table>

### 7.3 Supply voltage

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage, stabilized(^3)</td>
<td>20 to 28 V DC</td>
</tr>
<tr>
<td>Ripple</td>
<td>≤ 0.5 V(_{pp})</td>
</tr>
<tr>
<td>Current draw (at 24 V DC)</td>
<td>≤ 100 mA</td>
</tr>
<tr>
<td>Inrush current</td>
<td>≤ 4 A/0.5 ms</td>
</tr>
<tr>
<td>Reverse polarity protection</td>
<td>Up to 36 V</td>
</tr>
<tr>
<td>Overvoltage protection</td>
<td>Up to 36 V (supply cables only)</td>
</tr>
<tr>
<td>Dielectric strength of GND to housing</td>
<td>500 V DC</td>
</tr>
</tbody>
</table>

\(^1\) Nominal length 500 mm, magnet in the middle of the measuring range
\(^2\) Individual specifications as per Balluff factory standard
\(^3\) For 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.
Accessories are not included in the scope of delivery and must be ordered separately.

### 8.1 Magnets

**BTL-P-1013-4R**

- **Weight:** Approx. 10 g
- **Housing:** Anodized aluminum

**BTL-P-1013-4S, BTL-P-1012-4R, BTL-P-1014-2R:**

**In the scope of delivery for the BTL-P-1013-4R, BTL-P-1013-4S, BTL-P-1012-4R:**

- **Spacer:** 8 mm, material: polyoxymethylene (POM)

**BTL5-P-4500-1 magnet (solenoid):**

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

**BTL-P-1028-15R (special accessories for applications with a supporting rod):**

- **Weight:** Approx. 68 g
- **Housing:** Anodized aluminum

---

---

### 8.2 Mounting nut

- **M18×1.5 mounting nut:** BTL-A-FK01-E-M18×1.5
- **3/4"16UNF mounting nut:** BTL-A-FK01-E-3/4"-16UNF
8.

Accessories (continued)

8.3 Connectors

For information on pin assignment, see Table 4-2 on page 9.

**BCC M488-0000-1A-000-43x834-000**

- Angled connector, freely configurable
- M12, 8-pin

Fig. 8-3: Connector BCC M488-0000-1A-000-43x834-000

**BCC M478-0000-1A-000-43x834-000**

- Straight connector, freely configurable
- M12, 8-pin

Fig. 8-4: Connector BCC M478-0000-1A-000-43x834-000
## Type code breakdown

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTL6-V1</td>
<td>Micropulse Transducer - Rod Style</td>
</tr>
<tr>
<td><em>E</em></td>
<td>Ethernet interface</td>
</tr>
<tr>
<td><em>M</em></td>
<td>Micropulse transducer</td>
</tr>
<tr>
<td><em>1</em></td>
<td>Supply voltage: 20 to 28 V DC</td>
</tr>
<tr>
<td><em>1</em></td>
<td>Number of magnets: 1 magnet</td>
</tr>
<tr>
<td><em>E</em></td>
<td>Ethernet interface type: EtherCAT®</td>
</tr>
<tr>
<td><em>M0500</em></td>
<td>Nominal length (4-digit): Metric specification in mm, nominal length 500 mm</td>
</tr>
<tr>
<td><em>A</em>/ <em>B</em>/ <em>Y</em>/ <em>Z</em></td>
<td>Rod version, fastening:</td>
</tr>
<tr>
<td><em>8</em></td>
<td>Electrical connection: 8-pin, M12 plug</td>
</tr>
</tbody>
</table>

**Micropulse Transducer - Rod Style**

**BTL6 - V 1 1 E - M0500 - B - S115**

- Micropulse transducer
- Ethernet interface
- Supply voltage: 1 = 20 to 28 V DC
- Number of magnets: 1 = 1 magnet, 2 = 2 magnets
- Ethernet interface type: E = EtherCAT®
- Nominal length (4-digit): M0500 = Metric specification in mm, nominal length 500 mm
- Rod version, fastening:
  - A = Metric mounting thread M18x1.5, O-ring, rod diameter 10.2 mm
  - B = Metric mounting thread M18x1.5, O-ring, rod diameter 10.2 mm
  - Y = 3/4"-16UNF thread, O-ring, rod diameter 10.2 mm
  - Z = 3/4"-16UNF thread, O-ring, rod diameter 10.2 mm
  - A8 = Metric mounting thread M18x1.5, O-ring, rod diameter 8 mm
  - B8 = Metric mounting thread M18x1.5, O-ring, rod diameter 8 mm
  - Y8 = 3/4"-16UNF thread, O-ring, rod diameter 8 mm
  - Z8 = 3/4"-16UNF thread, O-ring, rod diameter 8 mm
- Electrical connection: S115 = 8-pin, M12 plug
10.1 Converting units of length

1 mm = 0.03937008 inches

<table>
<thead>
<tr>
<th>mm</th>
<th>inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.03937008</td>
</tr>
<tr>
<td>2</td>
<td>0.07874016</td>
</tr>
<tr>
<td>3</td>
<td>0.11811024</td>
</tr>
<tr>
<td>4</td>
<td>0.15748031</td>
</tr>
<tr>
<td>5</td>
<td>0.19685039</td>
</tr>
<tr>
<td>6</td>
<td>0.23622047</td>
</tr>
<tr>
<td>7</td>
<td>0.27559055</td>
</tr>
<tr>
<td>8</td>
<td>0.31496063</td>
</tr>
<tr>
<td>9</td>
<td>0.35433071</td>
</tr>
<tr>
<td>10</td>
<td>0.393700787</td>
</tr>
</tbody>
</table>

Tab. 10-1: Conversion table mm to inches

1 inch = 25.4 mm

<table>
<thead>
<tr>
<th>inches</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25.4</td>
</tr>
<tr>
<td>2</td>
<td>50.8</td>
</tr>
<tr>
<td>3</td>
<td>76.2</td>
</tr>
<tr>
<td>4</td>
<td>101.6</td>
</tr>
<tr>
<td>5</td>
<td>127</td>
</tr>
<tr>
<td>6</td>
<td>152.4</td>
</tr>
<tr>
<td>7</td>
<td>177.8</td>
</tr>
<tr>
<td>8</td>
<td>203.2</td>
</tr>
<tr>
<td>9</td>
<td>228.6</td>
</tr>
<tr>
<td>10</td>
<td>254</td>
</tr>
</tbody>
</table>

Tab. 10-2: Conversion table inches to mm

10.2 Part label

Fig. 10-1: BTL6 part label