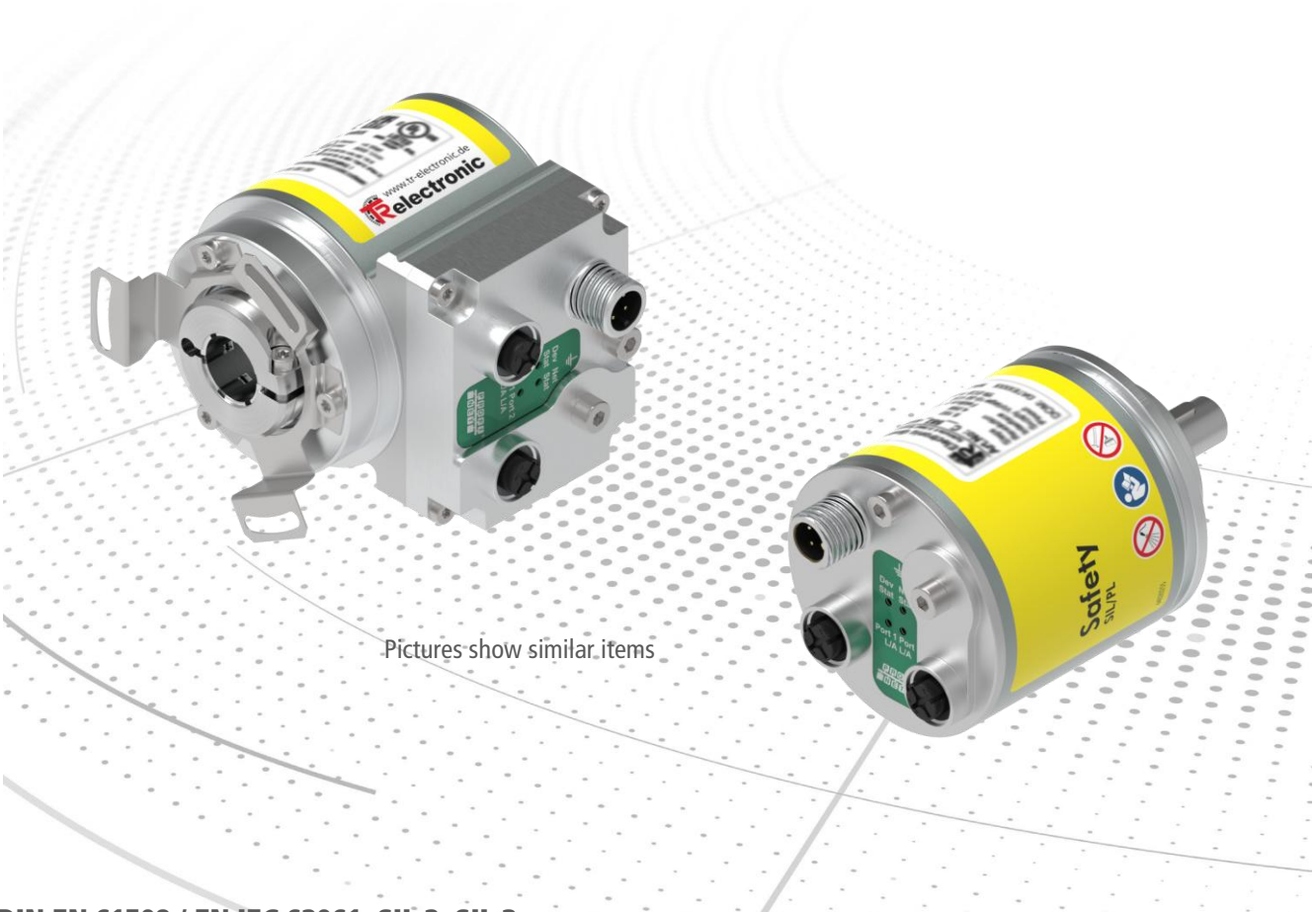
Original manual

Absolute Encoder CD_-582
Safety Manual



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DIN EN 61508 / EN IEC 62061: SIL 2, SIL 3
DIN EN ISO 13849: PL d / PL e

_Basic safety instructions
_Intended use
_General functional description
_General characteristics
_Assembly

Safety Manual

TR-ECE-BA-GB-0142v19 06/11/2026

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Contents

Contents

Revision index

Modification	Date	Index
First release	05/28/2019	00
Draw-wire box added	06/12/2019	01
Specification of the start-up torque of the shaft	09/20/2019	02
Parallel key details and generalizations	01/23/2020	03
- Option IP67: Specification of the break-away torque (solid shaft) - Specification of the start-up torque with diagram	02/27/2020	04
Accessories: threaded rod / joint head M5	05/13/2020	05
- Assembly for blind-hole and hollow shaft with torque holder supplemented - Tightening torque for clamping ring screw defined at 2 Nm	12/13/2021	06
Assembly amended by clamping jaws and joint head rod	06/07/2022	07
In the new edition of EN IEC 62061:2021, the term SIL CL is omitted	09/19/2023	08
Reference to interface-specific user manuals added	12/19/2023	09
Safety functions "SLA" and "SAR" added	12/20/2023	10
Accuracy information on the speed output	02/08/2024	11
Notes on decommissioning or demounting	03/11/2024	12
- Warning notice "Handheld radio devices", in accordance with DIN EN 61800-5-2, chapter 7.2, subsection c) - Interface-specific user manual EtherCAT/FSoE, TR-ECE-BA-GB-0177 added	07/02/2024	13
“Address correction”	08/14/2024	14
“Enclosure Option: Heavy Duty 115” added	04/03/2025	15
Chapter “IT security vulnerabilities” added	05/05/2025	16
- Reference to pollution degree 2, according to IEC 60664-1 - Safety functions according to DIN EN IEC 61800-5-3: SAP, SSV and SAV	09/08/2025	17
Acceleration tolerance range added	12/03/2025	18
Safely attaching the measuring system: A form-locking is no longer required, but is only generally recommended	06/11/2026	19

1 General information

This Manual addresses the following topics:

- General functional description
- Basic safety information with declaration of the intended use
- General specifications
- Assembly

Since it has a modular structure, this Manual is supplementary to other documentations, such as product data sheets, dimensional drawings, brochures, interface-specific user manuals, etc.

1.1 Applicability

This Manual applies exclusively to measuring system series according to the following keys for article numbers and types:

Article number

* 1	* 2	* 3	* 4	* 5	-	* 6	* 6	* 6	* 6	* 6

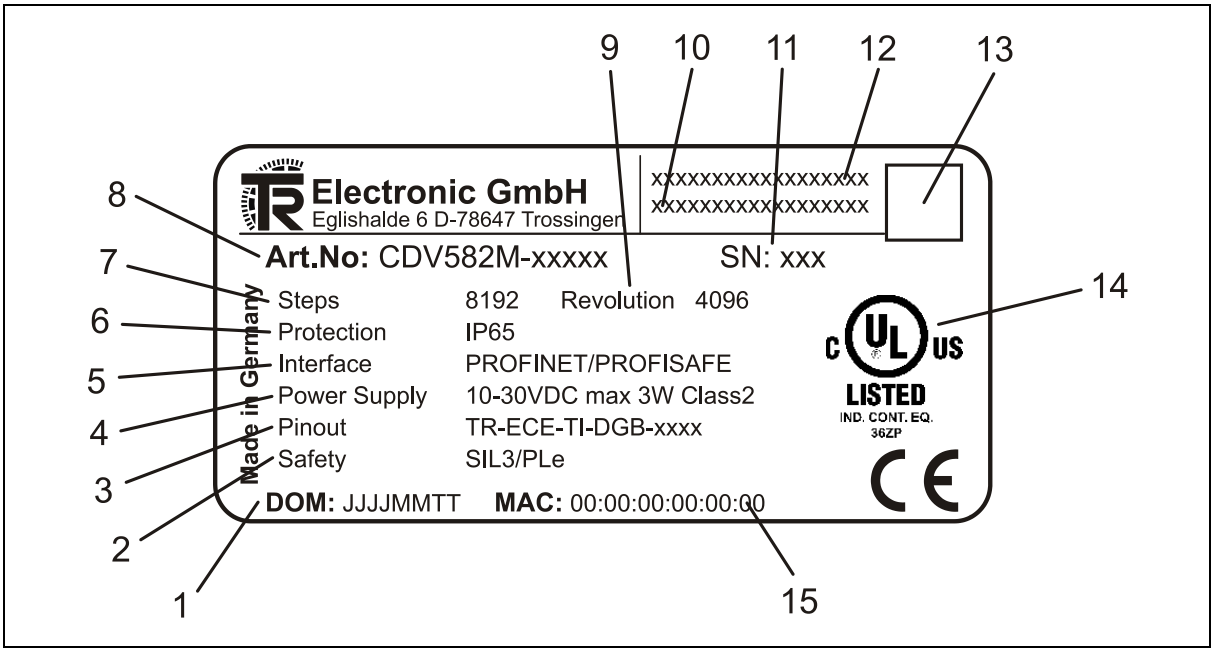
Position	Designation	Description
* 1	A C	Explosion protection enclosure (ATEX); Absolute encoder, programmable
* 2	D	Redundant dual scanning unit
* 3	V H S W	Solid shaft Hollow shaft Blind shaft Rope length transmitter (wire)
* 4	582	Outer diameter ∅ 58 mm, Generation 2
* 5	M S	Multi-turn Singleturn
* 6	-	Consecutive number

* = placeholder

Type key

See Revision Lists:
CD_582M +FS02: www.tr-electronic.de/f/TR-ECE-TI-DGB-0343
CD_582M +FS03: www.tr-electronic.de/f/TR-ECE-TI-DGB-0349

The products are labeled with affixed nameplates and are components of a system.



1:	Date of manufacture in the format YYYY: Year, MM: Month, DD: Tag
2:	Maximum achievable Safety Integrity Level or Performance Level, see Chapter 4.1 on Page 20
3:	Number or identifier of the enclosed pin assignment, see Chapter 11 -> Pin assignments on Page 49
4:	- Supply voltage range, max. power consumption, see Chapter 11 -> Product data sheets on Page 49 - Class 2 power supply unit with UL/CSA approval, see Chapter 2.5 on Page 12.
5:	Measuring system – interface / security log, see Chapter 11 -> -> Interface-specific User Manual on Page 49
6:	IP rating (IP-Code), to DIN EN 60529
7:	Resolution in steps per revolution
8:	Article Number or Order Number
9:	Number of revolutions
10:	Optional customer note
11:	Devices – Serial no.
12:	Optional additional note
13:	Data Matrix Code
14:	UL/CSA approval, see Chapter 2.5 on Page 12
15:	MAC address, for IP-based measuring system interface

1.2 Other Applicable Documents

- The responsible organization's system-specific operating instructions
- This Safety Manual
- Pin assignment
- interface-specific User Manual
- Product data sheet
- optional: Ex User Manual

1.3 Abbreviations and terms used

$B10_d$	Number of operations that a device will operate prior to 10 % of a sample of those devices would fail to danger
CDx	Absolute encoder with redundant dual scanning unit, all designs
EMC	***E***lectro***M***agnetic ***C***ompatibility
ESD	***E***lectro ***S***tatic ***D***ischarge
Fault exclusion	Compromise between technical safety requirements and the theoretical possibility that an error occurs
Functional safety	Part of the overall system safety, which depends on the correct functioning of safety instrumented systems for risk reduction. Functional safety is ensured when each safety function is executed as specified.
IEC	International Electrotechnical Commission
ISO	***I***nternational ***S***tandard ***O***rganisation
$MTTF_d$	***M***ean ***T***ime ***T***o ***F***ailure, ***d***angerous
n_{op}	Number of operations/cycles in one year
PL	***P***erformance ***L***evel according to EN ISO 13849-1
SIL	***S***afety ***I***ntegrity ***L***evel: Four discrete levels (SIL1 to SIL4). The higher the SIL of a safety instrumented system, the lower the probability that the system cannot execute the required safety functions.
Standard measuring-system	Definition: Safety instrumented measuring system, without explosion protection
VDE	***V***erband ***d***er ***E***lektrotechnik, Elektronik und Informationstechnik (Association for Electrical, Electronic and Information Technologies e.V.)

1.4 General functional description

The rotary measuring system is a safe and absolute multi-turn position measuring system with a safety protocol and a standardized interface that is, however, NOT safety instrumented.

The safety measuring system consists of a **redundant, dual-channel system** in which

- variant 1: optical and magnetic scanning units, or
- variant 2: two magnetic scanning units

are arranged on a drive shaft that is designed either as a hollow shaft, a blind-hole shaft, or as a solid shaft.

The measuring system has primarily been designed for use in systems that require safe position detection.
The additional safe velocity measurements allow the following safety functions to be implemented according to DIN EN 61800-5-2 respectively to DIN EN IEC 61800-5-3:

DIN EN 61800-5-2:

- Safe Direction (SDI)
- Safe Stop 1 (SS1)
- Safe Stop 2 (SS2)
- Safe Operating Stop (SOS)
- Safely Limited Velocity (SLS)
- Safe Velocity Range (SSR)
- Safe Velocity Monitor (SSM)
- Safely-Limited Position (SLP)
- Safe Cam (SCA)
- Safely-Limited Acceleration (SLA)
- Safe Acceleration Range (SAR)

DIN EN IEC 61800-5-3:

- Safe Absolut Position (SAP)
- Safe Speed Value (SSV)
- Safe Acceleration Value (SAV)

As a sensor, the measuring system is always part of a safety chain.

The above-mentioned safety functions are all derived in some form from the safe position and speed detection provided by the measuring system. It is the responsibility of the user to generate these safety functions themselves and to qualify them as suitable for the safety instrumented application.

2 Basic safety instructions

2.1 Definition of symbols and notes

⚠ DANGER	means that death or serious injury will occur if the user fails to take the respective precautionary measures.
⚠ WARNING	means that death or serious injury can occur if the required precautions are not met.
⚠ CAUTION	means that minor injuries can occur if the required precautions are not met.
NOTICE	means that damage to property can occur if the required precautions are not met.
	indicates important information or features and application tips for the product used.
	means that appropriate ESD protective measures according to DIN EN 61340-5-1 supplementary sheet 1 must be taken.

2.2 General risks when using the product

The product, hereinafter referred to as ***measuring system***, is manufactured according to state-of-the-art technology and accepted safety rules.

Nevertheless, non-intended use can pose a danger to life and limb of the user or third parties, or lead to impairment of the measuring system, or other property values!

The measuring system may only be used in technically perfect condition in accordance with its intended use and the instructions set out in the **Other Applicable Documents** and only by safety-conscious persons who are fully aware of the risks involved in operating the measuring system. Faults which could threaten safety should be eliminated without delay!

2.3 IT security vulnerabilities

The measuring system has a digital fieldbus interface that is designed for operation in networked control systems. The measuring system contains software that enables network communication. No sensitive information is stored on the device itself. The standardized fieldbus protocols are not protected against attacks, e.g., MITM (man in the middle), by default. The system integrator must implement appropriate protective measures when designing the control network.

2.4 Residual risk

According to EN ISO 12100-1 “Safety of machinery – Basic concepts, general principles for design”, residual risk is defined as the risk remaining after application of all protective measures.
Risk itself is defined as the “combination of the likelihood of a hazard and the severity of the potential damage”.

During the entire safety lifecycle, TR Electronic has applied risk minimizing measures and methods according to the state of the art and technology – however, residual risks still remain even when properly using the measuring system!

Residual risks are not only indicated in this chapter, but also in all relevant parts of the entire document, in some cases also by referencing the corresponding interface-specific user manual.

The risk assessment of the entire system required by the EU Machinery Directive requires knowledge of all **Other Applicable Documents**, including any documented general conditions, safety instructions and residual risks, and to incorporate such into the company’s own risk assessment.

2.5 UL / CSA approval

The nameplate of measuring systems with this approval carry the UL symbol:

File No.: E300802

Measuring system running UL applications may therefore only be operated on NEC Class 2 approved power supply units. For further information, please refer to this document: TR-ECE-TI-DGB-0152

2.6 Intended use

The safety measuring system can be used for the detection of angular movement and processing of measured data for a downstream safety host in systems in which the **safety-related requirements of "Safeguarding travel", "Safeguarding velocity" or "Safeguarding direction of travel"** must be reliably achieved. In this case, the complete processing chain of the safety function must satisfy the requirements of the applied safety standard.
The safety measuring system may only be used in safety applications in conjunction with a control certified according to the applied safety standard.
The system manufacturer must verify that the properties of the measuring system satisfy his application-specific safety requirements. The responsibility or decision regarding the use of the measuring system lies with the system manufacturer.

Intended use also includes:

- following all instructions provided in the other applicable documents,
- observing the nameplate and any prohibition or instruction symbols on the measuring system;
- observing enclosed documents,
- operating the measuring system within the limit values specified in the technical data;
- ensuring that the fail-safe processing unit fulfills all required safety functions;
- ensuring that the checklist – part 1 in the present document and part 2 in the interface-specific User Manual – is used and went through completely;
- safely attaching (form-locking; recommended) the measuring system to the driving axis.

2.7 Non-intended use

Any non-intended use of the measuring system results in the risk of death, physical injury and damage to property.

⚠ WARNING

NOTICE

- The following areas of use are especially forbidden:
  - standard measuring-system:
    in environments with an explosive atmosphere according to the ATEX Directive
  - for medical purposes in accordance with the Medical Devices Directive
  - as a step or climbing aid
  - for wiring as antitwist protection (torque arm)
  - as an abutment for tension chains and belts

2.8 Usage in explosive atmospheres

The standard measuring system must be installed in an appropriate explosion protection enclosure as required when used in explosive atmospheres.

The products are labeled with an additional Ex marking on the nameplate.

The “intended use” as well as any information on the safe usage of the ATEX-compliant measuring system in explosive atmospheres are contained in the Ex User Manual.

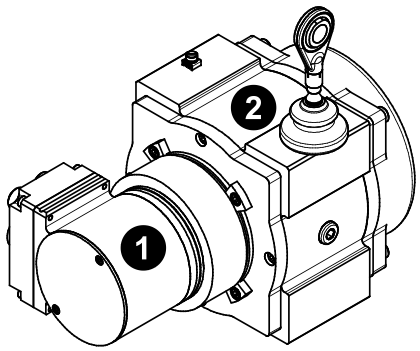
Standard measuring systems that are installed in the explosion protection enclosure and are intended for use with safety instrumented applications can therefore be used in explosive atmospheres.

When the measuring system is installed in the explosion protection enclosure, which means that it meets explosion protection requirements, the properties of the measuring system will no longer be as they were originally.

Following the specifications in the Ex User Manual, please check whether the properties defined in that manual meet the application-specific requirements.

Fail-safe usage requires additional measures and requirements. Such measures and requirements must be determined prior to initial commissioning and must be taken and met accordingly.

2.9 Combination measuring system and draw-wire box (CDW582)



❶: Measuring system
Device type 1 with SIL value or PL value

❷: Draw-wire box
Device type 3 with B10d value

Figure 1: Combination measuring system and draw-wire box

From a safety viewpoint the combination of measuring system and draw-wire box is a series connection with a device type 1 (measuring system) and a device type 3 with a category 1 structure in accordance with EN ISO 13849-1 (draw-wire box).

Device type 1 is characterized by the fact that the device can already be used as the safety-relevant part of a control system.

Device type 3 refers to devices with a failure behavior which is dependent on the switching frequency (cycle) and in terms of the draw-wire corresponds to complete extension and retraction of the wire. This fact is expressed by the **B10d-value** and represents the average number of cycles by which 10 % of the components have failed dangerously. The draw-wire box has not been developed in accordance with any specific safety standard, but this does not in principle exclude its use in accordance with DIN EN 61508, EN ISO 13849-1 or IEC 62061.

Generally, however, the use of such devices, if they are used as a safety-relevant part of a control system, must be independently assessed by the user in relation to safety.

As the combination of measuring system and draw-wire box is a series connection, this "unified structure" must be reassessed in relation to safety. The component with the lowest reliability in the series connection is determining for the highest possible level of safety that can be achieved. For mechanical reasons draw-wires only have a limited number of cycles, which in turn is strongly dependent on the type used.

In practice this means that the draw-wire is the limiting component in the series connection and the safety requirement level of the measuring system can never be achieved for the unified structure. For this reason there is also no TÜV certification for the combination of measuring system and draw-wire box!

This fact means that the unified structure may only be used as the subsystem of a safety function if the safety requirement level of the unified structure corresponds to the required safety requirement level for the subsystem.

To enable the user to assess the safety function, TR Electronic provides the relevant safety indicators in the product data sheets valid for the respective measuring system,
see www.tr-electronic.com/s/S020955.

TR Electronic can provide the relevant B10d value for the draw-wire box on request.

1) The $MTTF_d$ value for the draw-wire box can be calculated as follows:

$$MTTF_d = \frac{B10_d}{0.1 * n_{op}}$$

The total $MTTF_d$ value for the draw-wire box + measuring system can be calculated from this:

$$MTTF_{d\ (total)} = \frac{(MTTF_{d\ (draw\text{-}wire\ box)} * MTTF_{d\ (measuring\ system)})}{(MTTF_{d\ (draw\text{-}wire\ box)} + MTTF_{d\ (Mess\text{-}System)})} = \text{value in years [a]}$$

1) Abbreviations, also see page 8

2.10 Safety functions of the fail-safe processing unit

It is mandatory that the **safety control**, which the measuring system is connected to, executes the safety checks required by the interface-specific User Manual.

2.11 Warranty and liability

The “General Terms and Conditions” of TR Electronic GmbH are generally applicable. They will be submitted to the responsible organization along with the order confirmation or on conclusion of the contract at the latest. Warranty and liability claims are excluded in the event of personal injury or damage to property if they result from one or more of the following causes:

- Non-intended use of the measuring system.
- Improper assembly, installation, commissioning and programming of the measuring system.
- Work on the measuring system that is carried out improperly.
- Operation of the measuring system with technical defects.
- Unauthorized mechanical or electrical modifications to the measuring systems.
- Unauthorized repairs.
- Catastrophic events beyond human control and acts of God.

2.12 Organizational measures

- The other applicable documents must always be within reach where the measuring system is used.
- In addition to the other applicable documents, generally valid legal and other binding regulations on accident prevention and environmental protection must be observed and communicated.
- The respective applicable national, local and system-specific provisions and requirements must be observed and communicated.
- The responsible organization is obliged to inform personnel on special operating features and requirements.
- Personnel handling the measuring system must have read and understood the Safety Manual, in particular Chapter “Basic safety instructions” prior to commencing work.
- It must be ensured that the nameplate and any prohibition or instruction symbols provided on the measuring system are always legible.
- Do not modify the measuring system in any mechanical or electrical way; the only modifications allowed are those expressly described in the other applicable documents.
- Repairs may only be made by the manufacturer or a center or person authorized by the manufacturer.

2.13 Personnel selection and qualification; basic duties

- Only qualified personnel may work with the measuring system.
  Qualified personnel are persons, who, through their training, experience and instruction, as well as their knowledge of the relevant standards, provisions, accident prevention regulations and operating conditions, have been authorized by the persons responsible for the system to carry out the required work and are able to recognize and avoid potential hazards. Such personnel is capable of identifying and avoiding potential hazards.
- The additional definitions of “qualified personnel” given in the VDE 0105-100 and IEC 364 standards must also be understood (source: e.g. Beuth Verlag GmbH, VDE-Verlag GmbH).
- The responsibilities for assembly, installation, commissioning and operation must be clearly defined. Personnel to be trained or educated must be supervised.

2.14 Safety-related instructions

- **The instructions listed below must be followed to prevent destruction, damage and malfunction of the measuring system and downstream electronic devices.**
  - Wiring work may only be carried out and electrical connections only be opened and closed while the system is de-energized.
  - Voltages equal to the supply voltage at the additional incremental interface output. Ensure the ground reference point is present at all times, respectively the organization responsible for the system must provide appropriate protective measures for downstream electronic devices.
  - Cable outlets of mating connectors must always be secured with a cable grip against pulling out.
  - Do not carry out any welding work after the measuring system has already been wired or switched on.
  - Ambient temperature values may never fall below or exceed the permissible limit values; this must be ensured by taking the appropriate heating/cooling measures at the place of installation.
  - The measuring system must be installed such that it is not exposed to any direct moisture.

⚠ WARNING

NOTICE

  - Suitable aeration/ventilation and heating/cooling measures must be taken at the place of installation to prevent the temperature falling below the dew point (condensation).
  - Potential hazards resulting from interactions with other systems and equipment which are or will be installed in the vicinity must be determined. The user is responsible for taking appropriate measures.
  - Voltage supply must be protected with a fuse suitable for the supply lead cross-section.
  - Cables used must be suitable for the temperature range.
  - If defective, the measuring system may not be operated.
  - Make sure that the installation environment is protected from aggressive media (acids, etc.).
  - Avoid shocks (e.g., hammer blows) to the shaft during installation / demounting.
  - It is prohibited to open the measuring system.
  - After having set the address switches and LEDs, ensure that they are no longer accessible by firmly closing the access with the screw plug.
  - Connector plugs of the measuring system that are unused during storage, operation and/or demounting of the system have to be provided either with a mating connector or a protective cap. The IP degree of protection is to be selected according to requirements.

Continued on the following page

⚠ WARNING

NOTICE

- The measuring system is designed for use in environments with pollution degree 2 according to IEC 60664-1: *"Only non-conductive pollution occurs; however, temporary conductivity due to condensation must be expected occasionally"* (e.g., due to hand perspiration). Therefore, care must be taken during installation to ensure that pollution degree 2 is maintained. This applies in particular to the installation of connections, the attachment of protective caps to unconnected connections, and the replacement of the device.
- The nameplate specifies the technical properties of the measuring system. If the nameplate is no longer legible or is completely missing, the measuring system may no longer be put into operation.
- The measuring system cannot detect a break in the coupling or the torque arm. The operator must include this circumstance in the safety concept of the system.

⚠ WARNING

NOTICE

- **Deactivation of the safety function by radiation-bound sources of interference**

Handheld radio devices that are operated within a radius of less than 20 cm of the power drive system (e.g. motor, frequency converter, measuring system, etc.) can deactivate the safety function of the measuring system or the safety sub-function of the complete power drive system.

- It must be ensured that handheld radio devices can only be operated at a distance of more than 20 cm from the measuring system.

- **The measuring system contains components and assemblies susceptible to electrical discharge, which can be destroyed if incorrectly handled.**
  - Do not touch the connection contacts of the measuring system with your fingers or apply the relevant ESD protective measures.

- **Disposal**
  - Electronic waste is hazardous waste.
    The disposal must observe the local regulations.

3 Transport / Storage

- Shipping information
  - Do not drop the device or subject it to heavy impacts!
    The device contains an optical system.
  - Only use the original packaging.
    Inappropriate packaging material may cause damage to the unit in transit.

- Storage
  - Storage temperature: see product data sheet
  - Store at a dry place

4 Technical Data – general

4.1 Functional safety

The achievable Safety Integrity Level or Performance Level depends on the device and is noted on the nameplate.

DIN EN 61508 Part 1-7, Safety Integrity Level (SIL), EN IEC 62061	SIL 2 or SIL 3
EN ISO 13849-1, Performance Level	PLd / Cat. 3 or PLe / Cat. 4

4.2 Safety functions

DIN EN 61800-5-2, Electric power drive systems	SDI, SS1, SS2, SOS, SLS, SSR, SSM, SLP, SCA, SLA, SAR
DIN EN IEC 61800-5-3, Electric power drive systems	SAP, SSV, SAV
Operating mode or requirement rate, DIN EN 61508	high or continuous

The measuring system, functioning as a sensor, is always part of a safety chain.

4.3 Supply

The measuring system may only be operated on SELV/PELV (IEC 60364-4-41:2005) compliant power supply units.

Measuring system running UL applications may only be operated on NEC Class 2 approved power supply units.

Nominal voltage	24 V DC
Power consumption	≤ 6 Watt

4.4 Tolerance ranges - safety-related speed output

In accordance with DIN EN 61800-5-2 "Electrical power drive systems", the tolerance ranges of the safety-related speed output are specified and explained in more detail below.

The measuring systems were measured accordingly and the data evaluated. The specified tolerance ranges were multiplied by a safety factor (4) in order to compensate for construction-related specimen scatter.

In principle, the measuring system is subject to a static measurement inaccuracy, which is larger with a purely magnetic scanning system (CD_582MM) than with an optical/magnetic (CD_582M) scanning system.

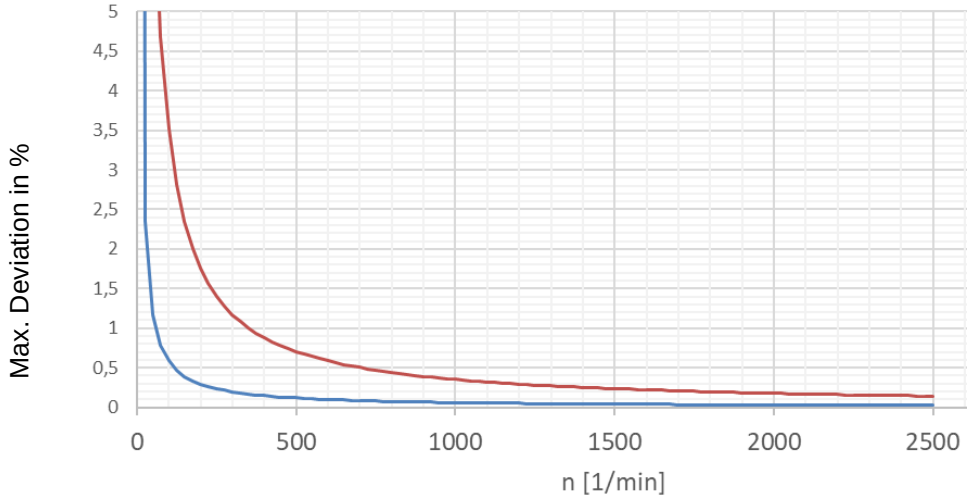
Due to the fact that the speed value must first be calculated (integration time) before it can be output, there is always a delayed speed output (tracking error) in the acceleration phases, in addition to the measurement inaccuracy. The size of the tracking error is proportional to the acceleration.

4.4.1 Static measurement inaccuracy

As the value of the absolute error does not change with different `Integration times` or `Resolutions` (Number of steps/Revolutions), these two variables have no influence on the specified tolerance range.

Scanning type	**Tolerance range** [1/min]
optical/magnetic	± 0.6
magnetic/magnetic	± 3.6

The lower the speed, the larger the effect of the tolerance range on the percentage deviation from the real actual value. The following figure provides an overview of the specified tolerance range:



blue curve: scanning mode = optical/magnetic; red curve: scanning mode = magnetic/magnetic

Figure 2: Estimation of the deviation of the speed specification in percent via the speed

4.4.2 Tracking error

The size of the tracking error depends on the acceleration. If the acceleration = 0 and no filtering is set, the tracking error will be 0 after the integration time has been reached at the latest.

The maximum tracking error results from the difference between the `Target Position` and the `Actual Position` and can be calculated using the following formula:

$$\text{Tracking error}_{max} = (a * t_{int}) - ((0.5 * a * t_{int}^{2}) / t_{int})$$

a: Acceleration in [revolutions/(min*s)]
t_{int}: Adjusted integration time in [ms]

The following example should illustrate the circumstances better:

Given:
Integration time t_{int} = 100 ms
Acceleration of a = 5000 rev. / (min*s) to the target speed of 2000 rev. / min

Note:
With this acceleration, the target speed of 2000 rpm would be reached after just 0.4 s.

Searched for:
Maximum tracking error in revolutions / min, according to the formula above:

= (5000 rev. / (min * s) * 0.1 s) – (0.5 * 5000 rev. / (min*s) * (0.1 s^2)) / 0.1 s

$$= \frac{5000 \text{ rev.} * 0.1 \text{ s}}{\text{min} * \text{s}} - \frac{0.5 * 5000 \text{ rev.} * 0.1 \text{ s}^2}{\text{min} * \text{s} * 0.1 \text{ s}}$$

$$= \frac{500 \text{ rev.}}{\text{min}} - \frac{250 \text{ rev.}}{\text{min}}$$

= **250 revolutions / min**

Curve of the specified calculation example:

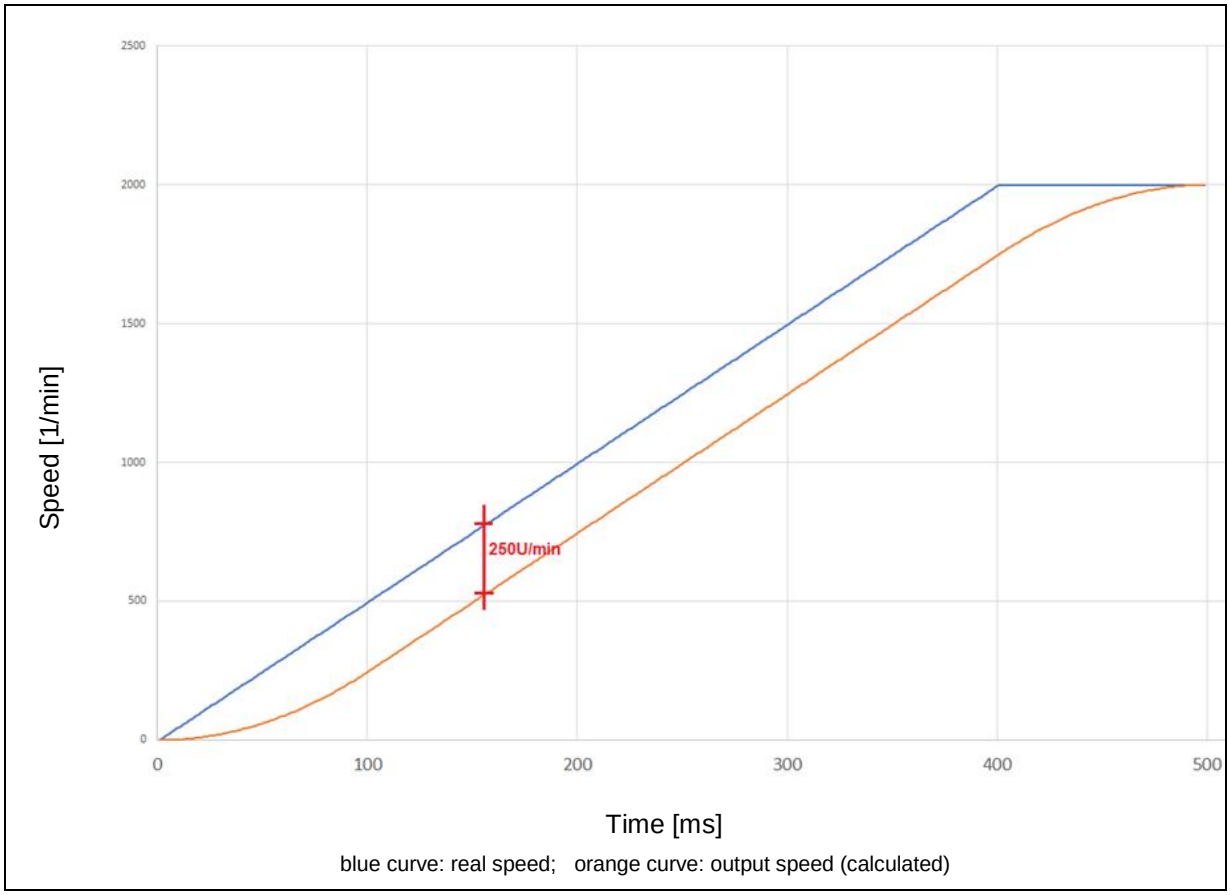


Figure 3: Estimation of the tracking error at an acceleration speed of 5000 rev./(min*s)

With an integration time of 100 ms, the reference calculation value is already modified with a new value after a quarter of the acceleration phase. From this point onwards, the tracking error no longer increases. After the integration time of 100 ms has been reached, the maximum value is therefore 250 rpm. At the end of the acceleration phase, it takes another 100 ms until the speed no longer shows a tracking error.

4.5 Tolerance ranges – safety-oriented acceleration output

In accordance with DIN EN 61800-5-3 “Electrical power drive systems”, the tolerance ranges for the safety-related acceleration output are specified and explained in more detail below.

The measuring systems were measured accordingly and the data evaluated. The specified tolerance ranges were multiplied by a safety factor (4) in order to compensate for construction-related specimen scatter.

In principle, the measuring system is subject to a static measurement inaccuracy, which is larger with a purely magnetic scanning system (CD_582MM) than with an optical/magnetic (CD_582M) scanning system.

Due to the fact that the speed value must first be calculated (integration time) before it can be output, there is always a delayed speed output (tracking error) in the acceleration phases, in addition to the measurement inaccuracy. The size of the tracking error is proportional to the acceleration.

4.5.1 Static measurement inaccuracy

Since the amount of absolute error does not change with different `integration times` or `resolutions` (number of steps/revolutions), these two variables have no influence on the specified tolerance range.

Scanning type	**Tolerance range** [rev./s²]
optical/magnetic	± 0,8
magnetic/magnetic	± 4,7

The lower the acceleration, the larger the effect of the tolerance range on the percentage deviation from the real actual value. The following figure provides an overview of the specified tolerance range:

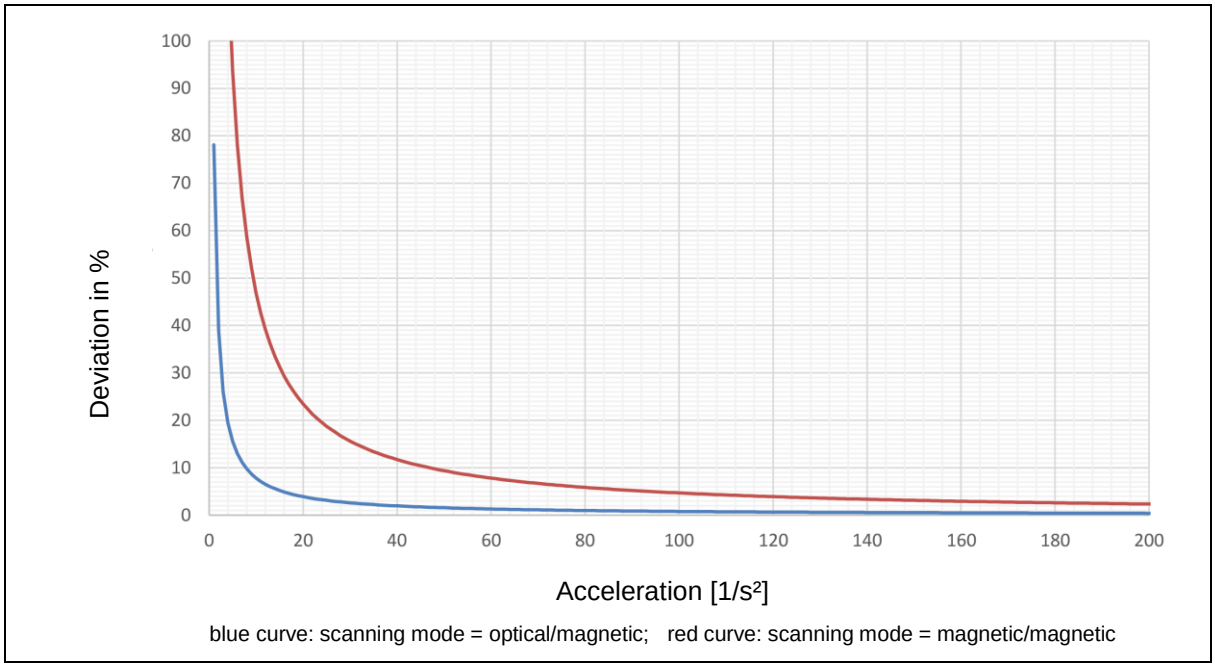


Figure 4: Estimation of the deviation of the acceleration specification in percent via the acceleration

4.5.2 Tracking error

The magnitude of the tracking error depends on the acceleration. If the acceleration = 0 and no filtering is set, the tracking error is = 0 at the latest after the integration time has elapsed.

During the jerk phase, the measurement system acceleration always has a tracking error. The transition from jerk = 0 to a constant jerk from a standstill is considered.

The measured value of acceleration is formed from the current speed and a speed in the past. The error in the speed in the past results in the tracking error.

The maximum tracking error is calculated after the integration time from the start of the jerk. It is calculated from the difference between the actual acceleration value (real) and the error from the measurement.

The following formula is used to determine the maximum tracking error:

Tracking error = a_real – a_calc

$$\text{Tracking error}_{max} = j*t_{int} – (1/6*j * t_{int}^3 - 1/3 * j * (t_{int}/2)^3) * 4 / t_{int}$$

The following example illustrates this point more clearly:

Given:

Integration time [t_{int}] = 100 ms
Speed [v] = 0 rev./s
Acceleration [a] = 0 rev./s²
Jerk [j] = 5 rev./s³

Searched for:

Maximum tracking error in [rev./s²]

Tracking error$_{max}$ = $j*t_{int} – (1/6*j * t_{int}^3 - 1/3 * j * (t_{int}/2)^3) * 4 / t_{int}$
= 0,5* 1/s² - (0,0008333 – 0,000208) * 4 / 0,1
= 0,5 – 0,000625 * 4 / 0,1
= 0,25 rev./s²

Curve of the specified calculation example:

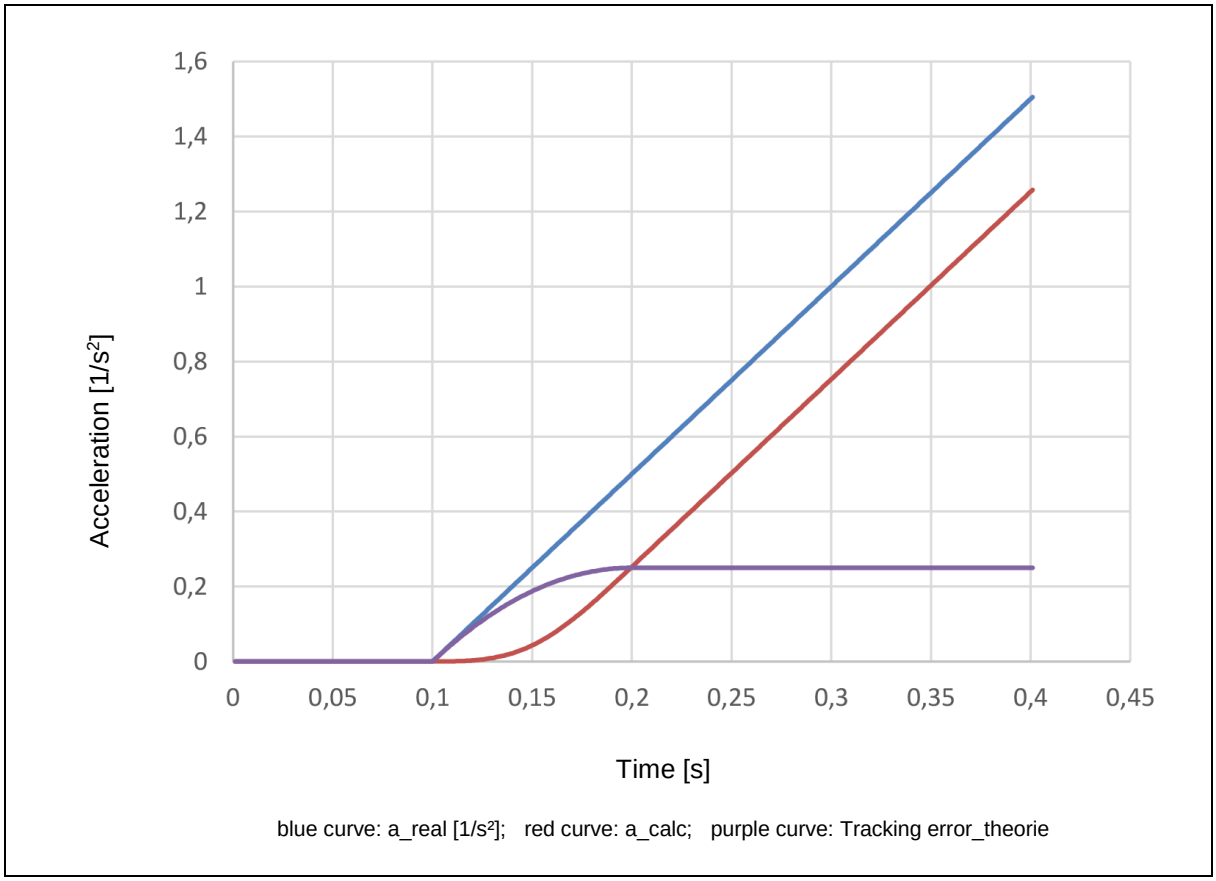


Figure 5: Example of tracking error due to speed difference at j = 5 rev./s³ and t_{int} = 100 ms

5 Assembly

- **If the safety functions are deactivated because of an unstable shaft drive, there will be the danger of death, serious physical injury and/or damage to property!**
  - ➢ The system manufacturer must ensure "**Failure Exclusion**" through design measures: The mechanical coupling of the measuring system via the shaft and its mounting must be guaranteed at all times. To this end, the requirements of the following standards, each under the heading "Adjustable speed electrical power drive systems – Safety requirements," must be complied with:
    - DIN EN 61800-5-2:2017: Complete drive systems
      – in particular Table D.8: "Motion and position feedback sensors"
    - DIN EN IEC 61800-5-3:2024: Safety instrumented measuring system (Encoder)
      – in particular Table G.1: "Mechanic fault list and fault exclusions"

⚠ DANGER

NOTICE

- ➢ As a general rule, it is recommended to prevent radial slippage of the measuring system on the drive shaft by using a parallel key / groove combination to ensure a form-locking.
- ➢ In general, the requirements and acceptance conditions for the complete system must be taken into account when the measuring system is attached.
- ➢ All fastening screws must be secured such that they cannot be loosened accidentally.
- ➢ In case of applications with low ambient temperatures, the start-up torque will be increased. This fact must be taken into account during assembly and when providing the shaft drive.

Due to the variety of measurement system series and the variety of types within a measurement system series, the following text and dimensions information must be considered as exemplary and have to be adapted to the specific product.

5.1 Solid shaft

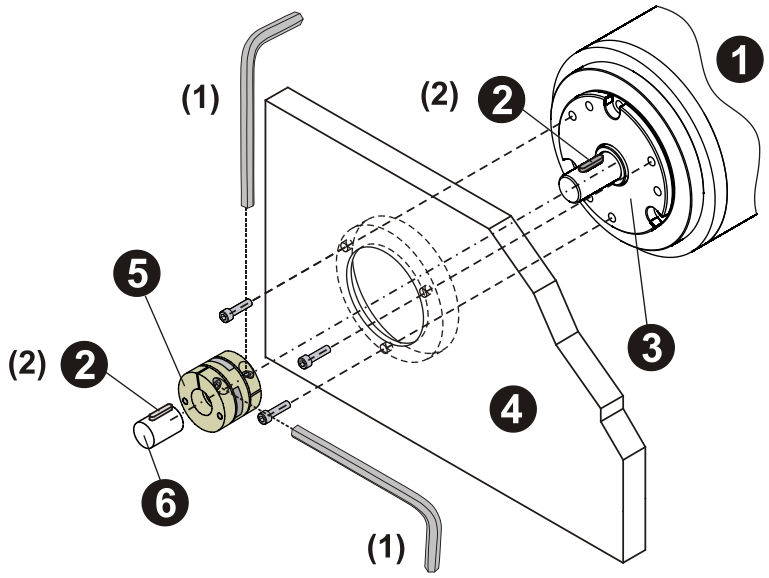
The following instructions are not exhaustive as the assembly situation may be different for each application.

5.1.1 Assembly of the clutch (general)

- The coupling used must be suitable for the application and allow form-locking connection.
- The coupling manufacturer's information and installation requirements must be observed.
- In particular, you must ensure that
  - the coupling is suitable for the specified speed and the potential axial offset,
  - installation is on a grease-free shaft,
  - there is no axial load on the coupling and the measuring system,
  - the clamping screws are tightened with the torque defined by the coupling manufacturer,
  - the coupling screws are secured such that they cannot be loosened accidentally.
- Axial slipping of the measuring system on the drive shaft must be prevented by fixing the coupling in position, see Chapter: 5.1.2 Figure 6, (1).
- General recommendation: Radial slipping of the measuring system on the drive shaft should be prevented by a form-locking connection, using a parallel key / groove combination for example (Chapter: 5.1.2 Figure 6, (2)); a coupling with groove can be used for this purpose.

5.1.2 Flange installation

- On the machine side, the measuring system is mounted to the flange (centering collar) with three screws.
- The flange plate for mounting the flange on the machine must have a suitable centering collar.
- The screws must be tightened with a tightening torque of 2.2 Nm and secured against unintentional loosening with a medium-strength screw locking device.
  - Ensure the thread is sufficiently long for the screws to be completely screwed in.
- The assembly instructions for the assembly of the coupling must be observed, see Chapter: 5.1.1 “Assembly of the clutch (general)”.



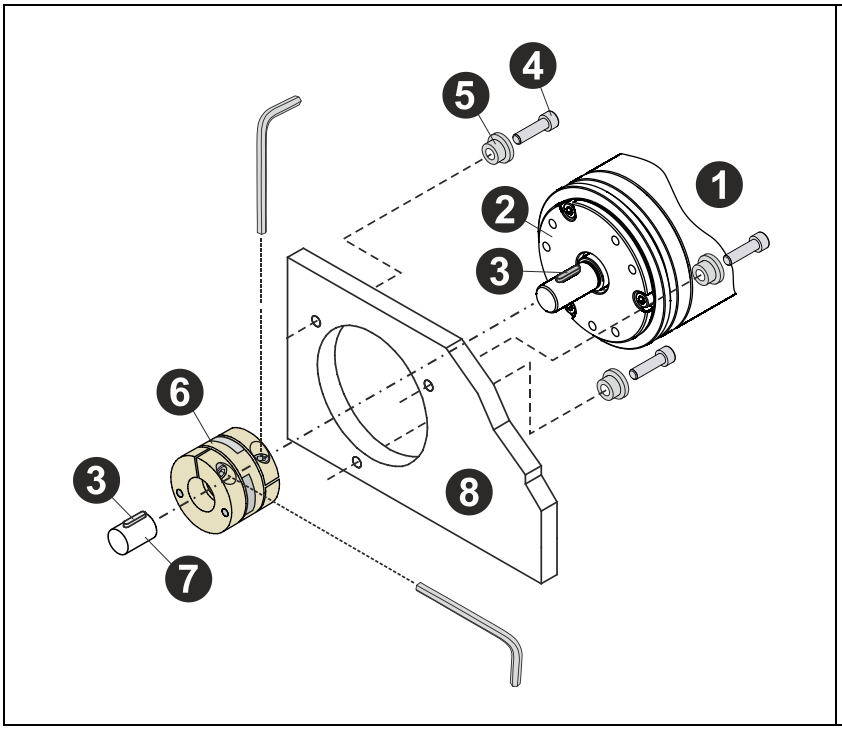
Components:

1: Measuring system
2: Parallel key, according to article number in the referenced drawing
3: Centering collar
4: Flange plate (machine)
5: Coupling with groove
6: Drive shaft

Figure 6: Installing the flange, illustration showing the principle

5.1.3 Servo clamps

- Please refer to the customer-specific drawing for any variations in size and individual assembly options.
- 3 servo clamps are used for the assembly. The servo clamps are distributed around the measuring system and offset by 120° and are each fastened to the flange plate with an M4 screw.
- The flange plate for mounting the flange on the machine must have a suitable centering collar.
- Use M4 steel screws (recommended: coated steel screws, e.g. galvanized) with a strength class of min. 6.8 (recommended: 8.8) to attach the servo clamps to the flange plate.
  - Depending on the environmental conditions, stainless steel screws with a strength class of at least 70 should be used.
- The M4 screws must be tightened with a tightening torque of 2.2 Nm and secured against unintentional loosening with a medium-strength screw locking device.
  - Ensure the thread is sufficiently long for the screws to be completely screwed in.
- The minimum thread reach into the flange plate is 4 mm in steel and 6 mm in aluminum.
- The surfaces to be secured should be free of any lubricants or dirt.
- The type of servo clamps must match the outer diameter of the flange ring and mounted according to the “up” orientation.
  - Correctly oriented servo clamps will lie flat on the flange plate when the key engages the flange groove.
- The assembly instructions for the assembly of the coupling must be observed, see Chapter: 5.1.1 “Assembly of the clutch (general)”.



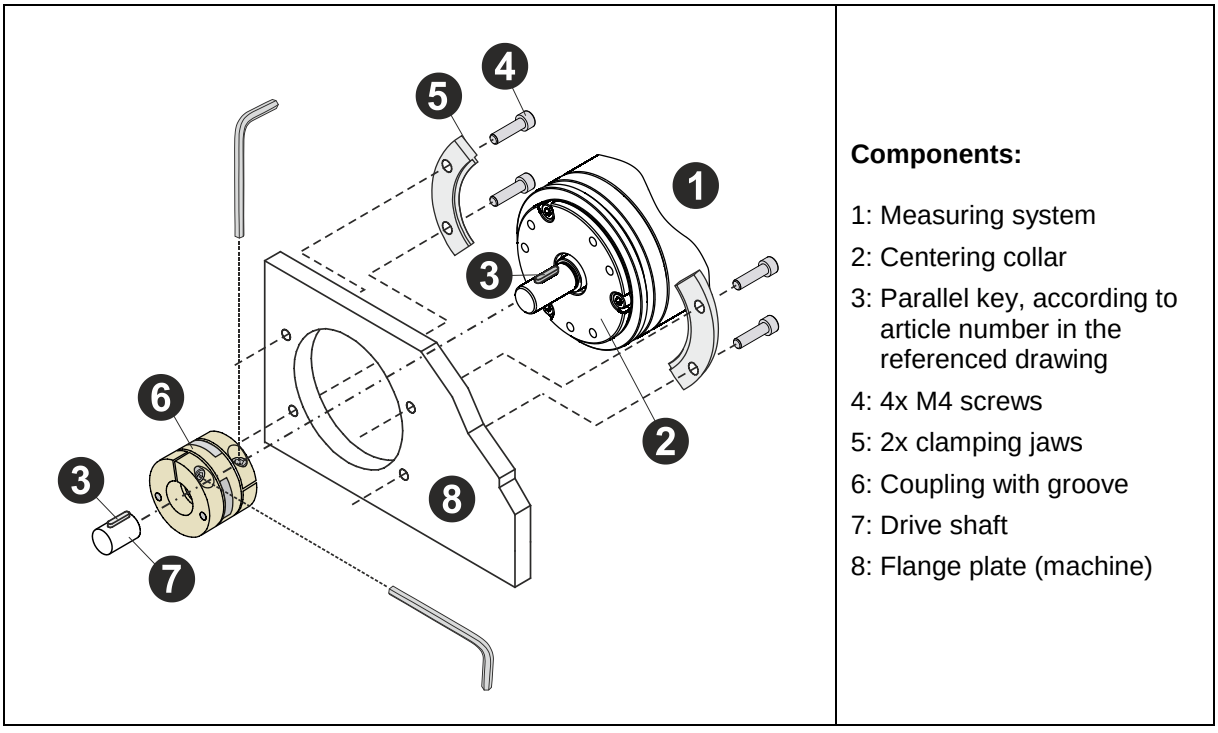
Components:

1: Measuring system
2: Centering collar
3: Parallel key, according to article number in the referenced drawing
4: 3x M4 screws
5: 3x servo clamps
6: Coupling with groove
7: Drive shaft
8: Flange plate (machine)

Figure 7: Assembly with servo clamps, illustration showing the principle

5.1.4 Clamping jaws

- Please refer to the customer-specific drawing for any variations in size and individual assembly options.
- 2 clamping jaws are used for assembly, which should be offset, if possible, by 180° and fastened to the flange plate with two M4 screws each.
- Use M4 steel screws (recommended: coated steel screws, e.g. galvanized) with a strength class of min. 6.8 (recommended: 8.8) to attach the clamping jaws to the flange plate.
  - Depending on the environmental conditions, stainless steel screws with a strength class of at least 70 should be used.
- The M4 screws must be tightened with a tightening torque of 2.2 Nm and secured against unintentional loosening with a medium-strength screw locking device.
  - Ensure the thread is sufficiently long for the screws to be completely screwed in.
- The minimum thread reach into the flange plate is 4 mm in steel and 6 mm in aluminum.
- The surfaces to be secured should be free of any lubricants or dirt.
- The type of clamping jaws must match the outer diameter of the flange ring and mounted according to the “up” orientation.
  - Correctly oriented clamping jaws will lie flat on the flange plate when the key engages the flange groove.
- The specifications for mounting the clamping claws in relation to the pitch circle of the threaded holes must be observed so that the clamping jaw can engage in the flange groove.
- The assembly instructions for the assembly of the coupling must be observed, see Chapter: 5.1.1 “Assembly of the clutch (general)”.



Components:

1: Measuring system
2: Centering collar
3: Parallel key, according to article number in the referenced drawing
4: 4x M4 screws
5: 2x clamping jaws
6: Coupling with groove
7: Drive shaft
8: Flange plate (machine)

Figure 8: Assembly with clamping jaws, illustration showing the principle

5.2 Blind hole / hollow shaft

The following instructions are not exhaustive as the assembly situation may be different for each application.

5.2.1 Assembly of the clamping ring (general)

- Please refer to the customer-specific drawing for any variations in size and individual assembly options.
- The measuring system must be installed on a grease-free shaft.
- Axial slipping of the measuring system on the drive shaft must be prevented by fixing the clamping ring in position.
  - Further measures may be required to prevent axial slipping of the measuring system.
- General recommendation: Radial slipping of the measuring system on the drive shaft should be prevented by a form-locking connection, using a parallel key / groove combination for example.
- There may be no axial load on the clamping mechanism of the measuring system.
- The screw of the clamping ring must be tightened with 2 Nm using a torque wrench and secured against unintentional loosening with a medium-strength screw locking device.

Requirement for the customer-provided shaft:

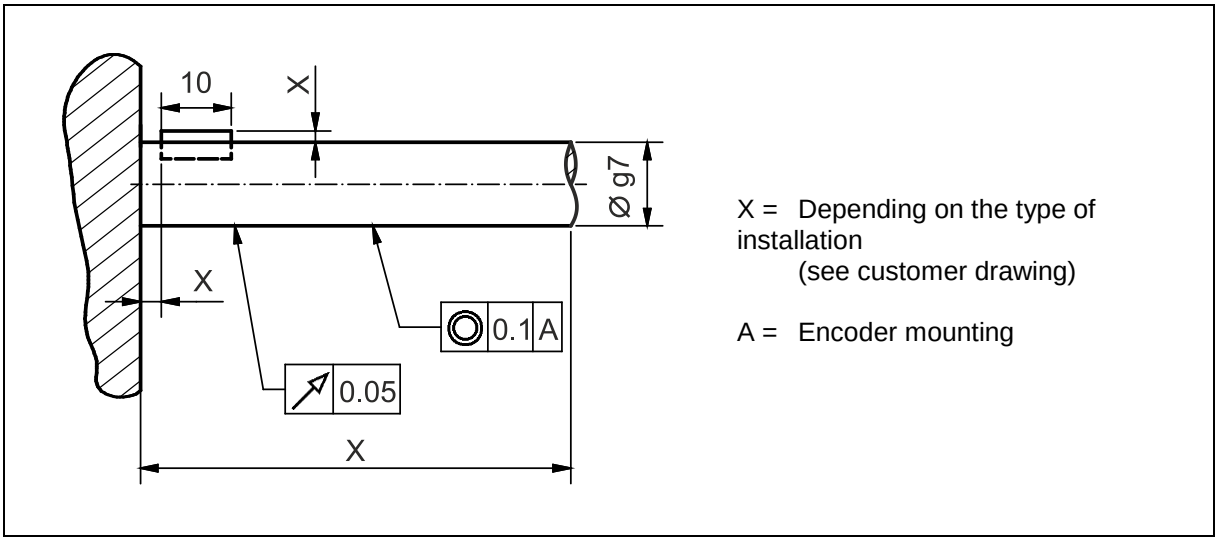


Figure 9: Requirement for the customer-provided shaft

5.2.2 Dowel pin / groove insert

- A dowel pin is used to fix the measuring system on the drive end, see Figure 10.
- The dowel pin must extend at least 4 mm into the groove insert, max.5.5 nm. The distance from the measuring system flange **Y** to the customer-provided device plane **X** must be > 1.5 mm, see Figure 10.
- The assembly instructions for the assembly of the clamping ring must be observed, see Chapter: 5.2.1 „Assembly of the clamping ring (general)“.

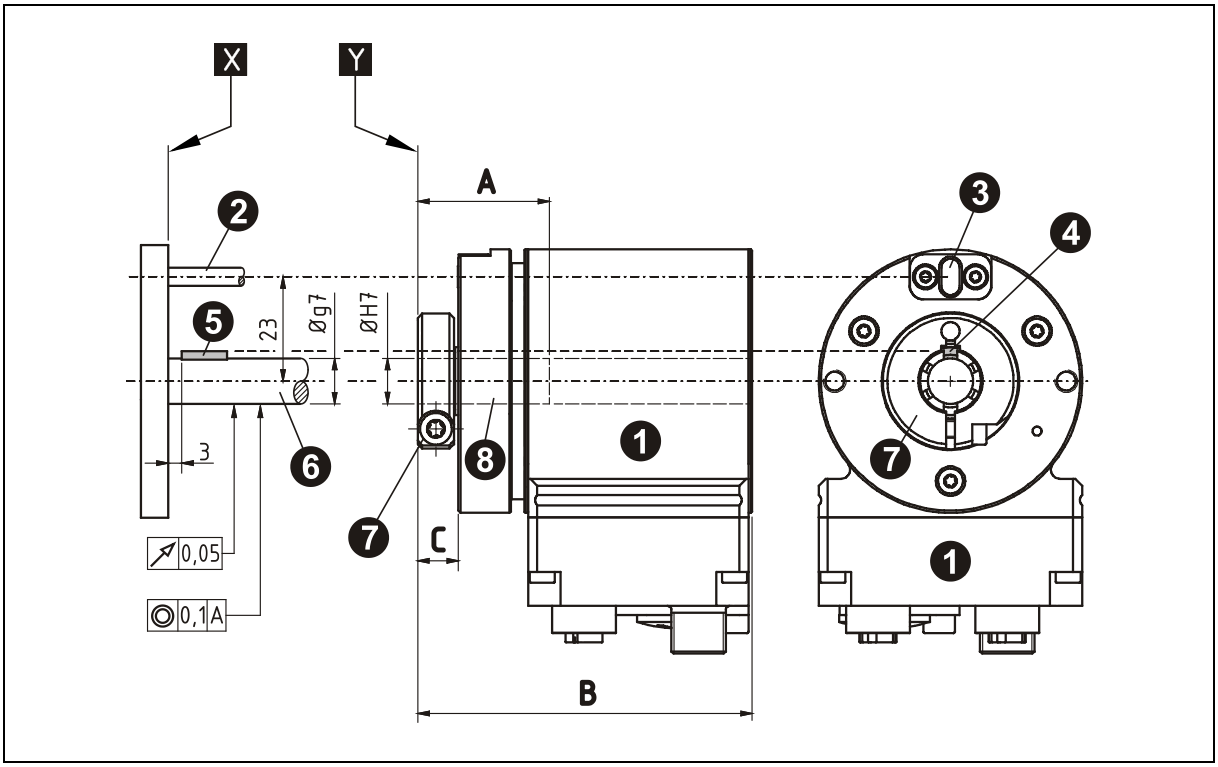


Figure 10: Installation with dowel pin and groove insert, illustration showing the principle

Components:

1: Measuring system with blind hole or hollow shaft
(H7 fit, according to article number in referenced drawing)

2: Dowel pin, provided by customer: Diameter 4 mm with m6 fit
Length = distance between reference planes X and Y + deviation C + an immersion depth of 4 ... 5.5 mm

3: Groove insert 4K7, 6 mm deep

4: Groove, according to the article number in the referenced drawing

5: Parallel key, according to the article number in the referenced drawing

6: Drive shaft with g7 fit, provided by customer

7: Clamping ring with screw, tightening torque = 2 Nm, secured against loosening

8: Measuring system – shaft with H7 fit, according to article number in referenced drawing

Dimensions:

A: Immersion depth for model with blind-hole shaft, according to article number in referenced drawing

B: Immersion depth for model with hollow shaft, according to article number in referenced drawing

C: Clamping ring width, according to the article number in the referenced drawing

Reference planes, minimum clearance:

X: customer-provided device plane

Y: front surface of clamping ring

Minimum clearance: > 1.5 mm

5.2.3 Torque arm – spring steel sheet

⚠ DANGER

- **Danger of death, serious physical injury and/or damage to property if the safety functions are deactivated by loosening the torque arm!**

NOTICE

- The installation specifications described below must be strictly observed.

- The ambient conditions specified in the article number-specific data sheet, the shaft load, and the axially and radially permissible shaft movement tolerances must be observed.
- Dead-line assembly in idle state.
- Push the measuring system onto the drive shaft.
- Each of the three torque arm wings must be attached to the machine with two M3 cheese head screws and suitable washers.
  - The sheet metals must not be warped or prestressed.
  - The screw connections must be secured against unintentional loosening with medium-strength screw locking devices.
  - The nominal tightening torque for an M3 coarse-pitch thread applies according to the strength class of the screw. Minimum tightening torque 0.5 Nm.
- Attach the clamping ring to the drive shaft with the clamping ring screw and apply a 2 Nm tightening torque. The torque arm must not be warped or prestressed.
- The torque arm is corrosion resistant in an industrial atmosphere. Special ambient conditions / media must be clarified with TR Electronic.
- Improperly mounted or damaged torque arms must not be used.
- The assembly instructions for the assembly of the clamping ring must be observed, see Chapter: 5.2.1 „Assembly of the clamping ring (general)“.

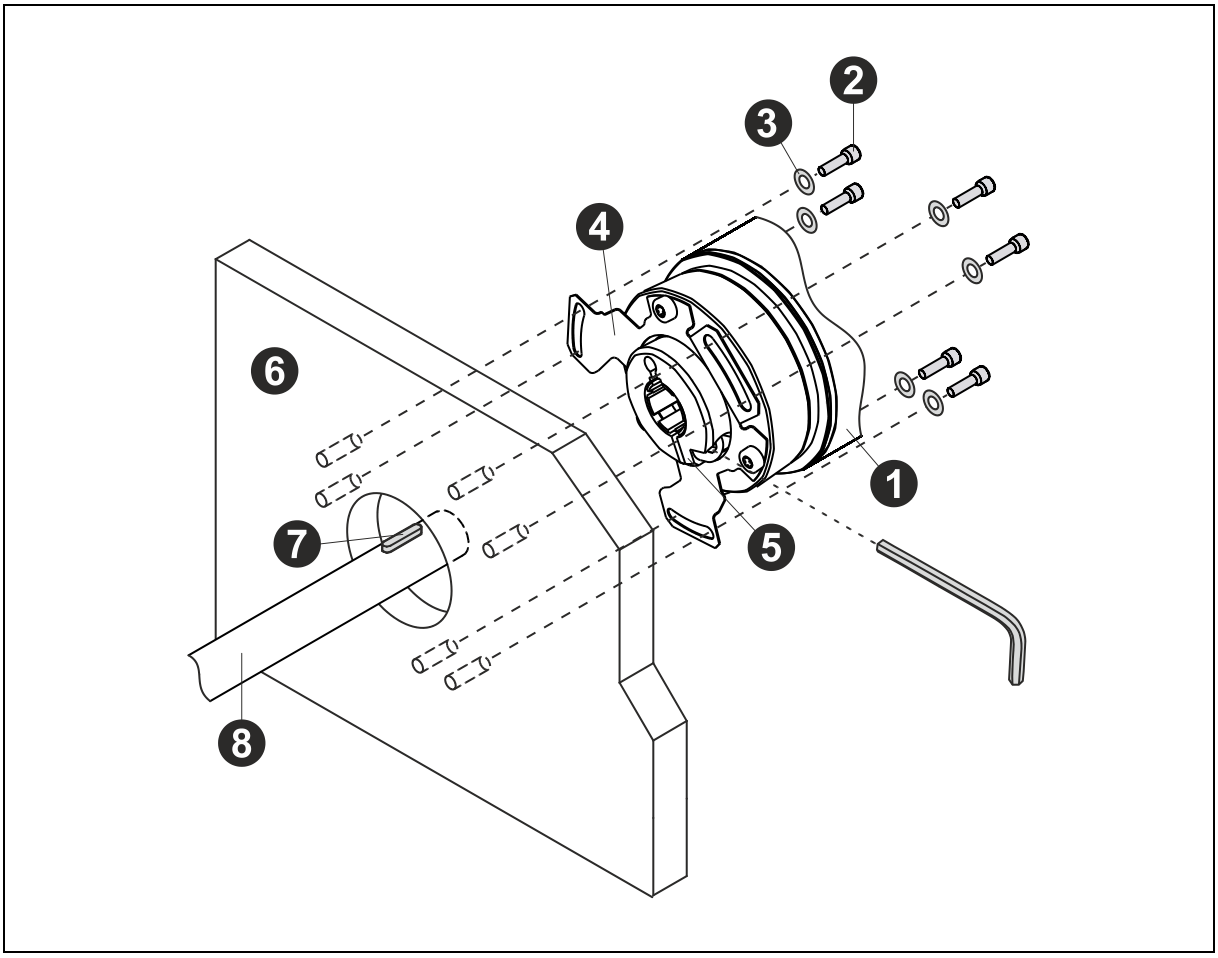


Figure 11: Assembly with torque arm (spring steel sheet), illustration showing the principle

Components:

1: Measuring system with H7 fit, according to article number in referenced drawing
2: 6x cheese head screw M3
3: 6x washer
4: Torque arm, according to the article number in the referenced drawing
5: Clamping ring with screw, tightening torque = 2 Nm, secured against loosening
6: Flange plate (machine)
7: Parallel key, according to the article number in the referenced drawing
8: Drive shaft with g7 fit, provided by customer

5.2.4 Torque arm – joint head rod

- Please refer to the customer-specific drawing for any variations in size and individual assembly options. Please refer to the manufacturer's individual technical data for joint head rod specifications, such as the permissible tilt angle of the joint head.
- Two joint heads, a threaded rod and two M5 cheese head screws are required for assembly. See Chapter: 10 "Accessories".
- Attach the joint head rod to one of the two M5 threaded holes when mounting it to the measuring system flange.
- For maximum support of the measuring system, the joint head rod must be mounted at a 90° angle to the line connecting the threaded hole to the center of the shaft, see Figure 13.
- The M5 screws must be tightened with a tightening torque of 2.2 Nm and secured against unintentional loosening with a medium-strength screw locking device.
  - Ensure the thread is sufficiently long for the screws to be completely screwed in.
- The minimum thread reach into the flange plate is 4 mm in steel and 6 mm in aluminum. The minimum thread reach into the measuring system flange is 6 mm.
- The mounting surfaces should be free of any lubricants or dirt.
- The assembly instructions for the assembly of the clamping ring must be observed, see Chapter: 5.2.1 „Assembly of the clamping ring (general)".

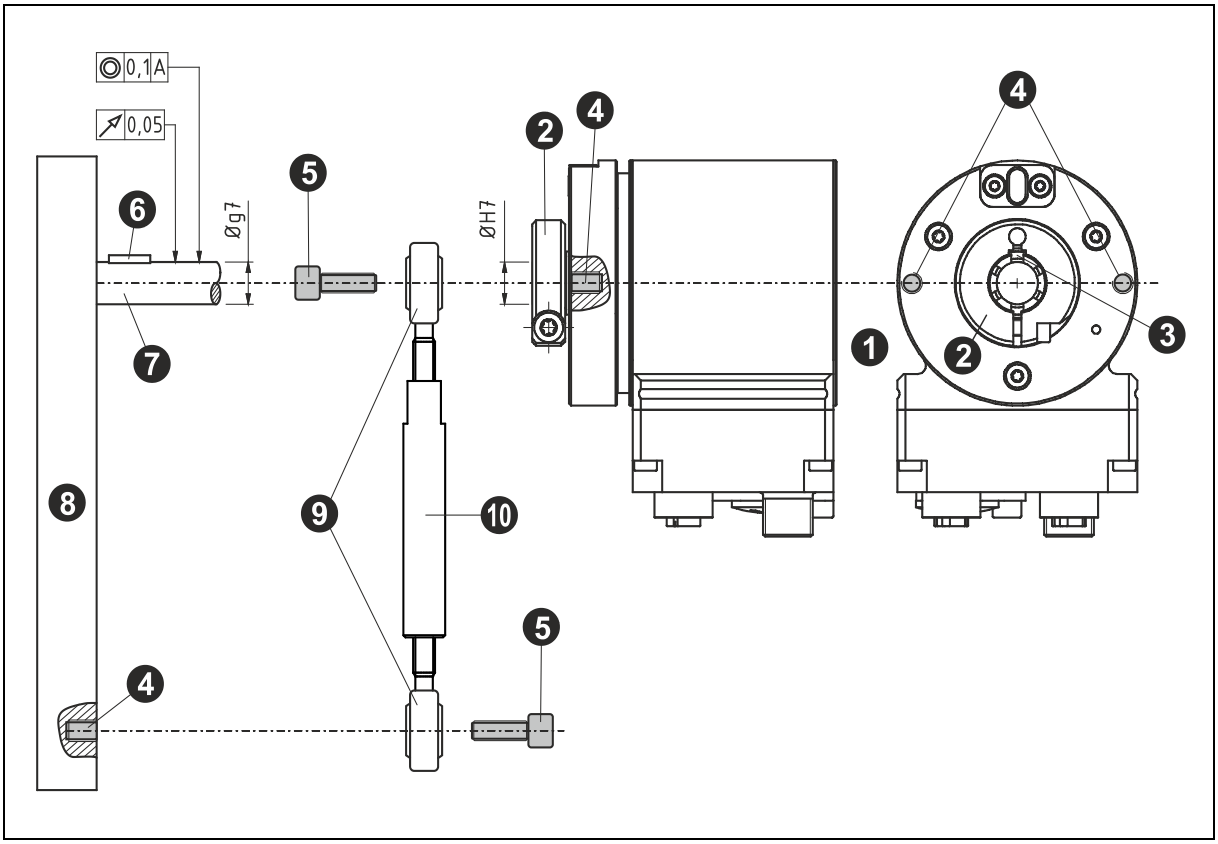


Figure 12: Assembly with joint head rod, illustration showing the principle

Components:

1: Measuring system with blind hole or hollow shaft
(H7 fit, according to article number in referenced drawing)
2: Clamping ring with screw
3: Groove, according to the article number in the referenced drawing
4: M5 threaded hole
5: 2x M5 cheese head screws
6: Parallel key, according to the article number in the referenced drawing
7: Drive shaft with g7 fit, provided by customer
8: Flange plate (machine)
9: 2x joint head
10: Threaded rod

Mounting variants:

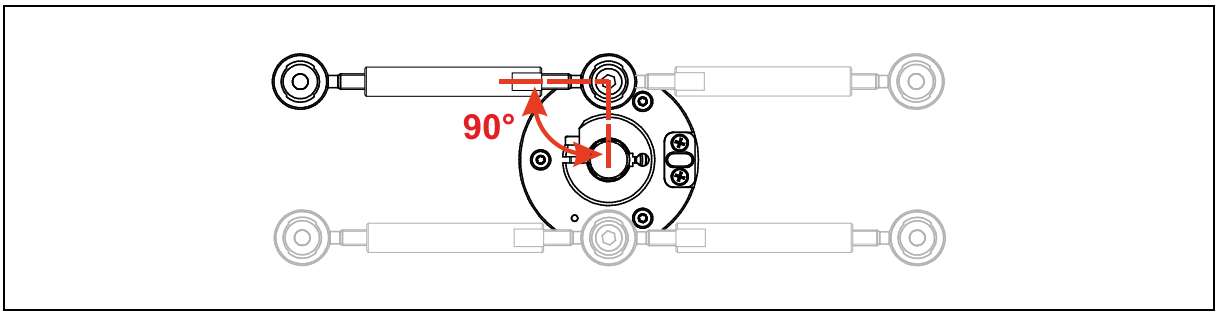


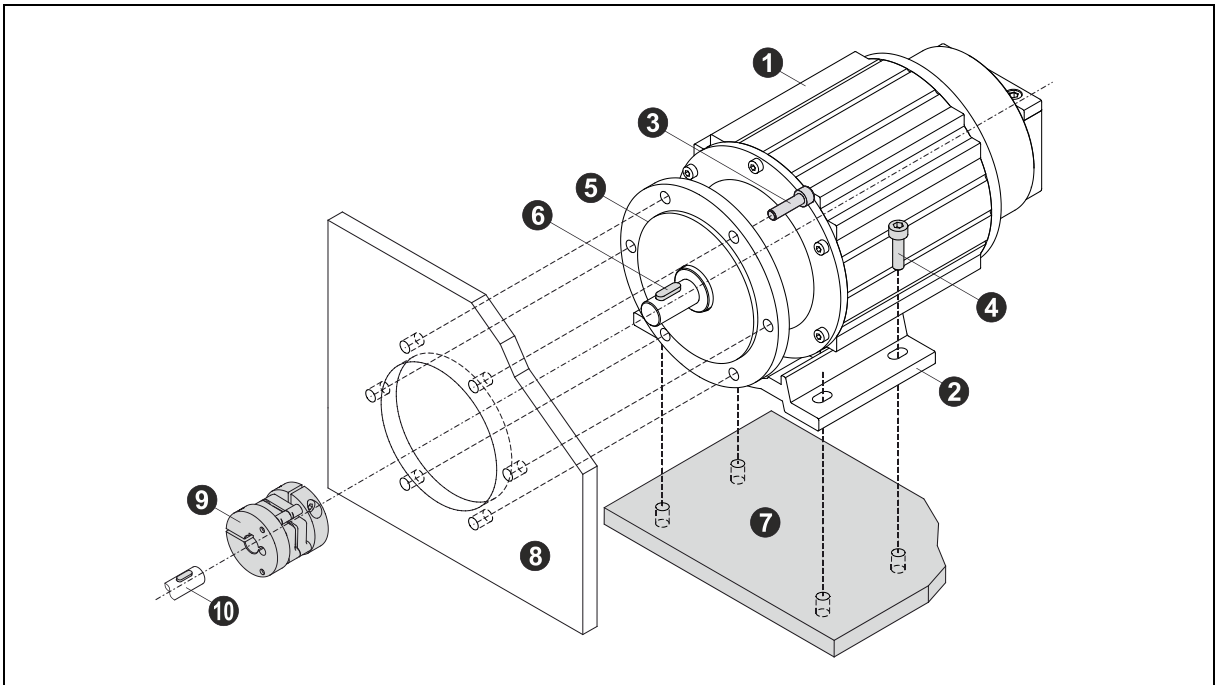
Figure 13: Joint head rod – mounting variants

5.3 Enclosure Option: Heavy Duty 115

5.3.1 Mounting

- The measuring system installed in a heavy duty 115 enclosure is mounted on the machine side using six screws through the device flange.
- The centering collar with the fit j6 centers the shaft. The customer's flange plate should have a suitable centering collar.
- The mounting base only carries the weight of the measuring system and must be screwed to the mounting surface with four screws without tension.
- All screws must be tightened to the appropriate torque and secured against unintentional loosening with medium-strength thread locker.
  - Make sure that the thread length is sufficient and that the screws can be screwed in completely.
- The assembly instructions for coupling assembly must be observed, see chapter: 5.1.1 “Assembly of the clutch (general)”.

- Dimensions are to be taken from the customer-specific drawing.
- Tolerance specifications of the coupling manufacturer must be taken into account.



Components:

1:	Measuring system	6:	Parallel key
2:	Mounting base	7:	Mounting surface *
3:	6x M6, Allen screws *	8:	Flange plate (machine) *
4:	4x M6, Allen screws *	9:	Coupling with groove *
5:	Device flange with centering collar	10:	Drive shaft *

Figure 14: Mounting example, heavy duty 115 enclosure

* Customer side

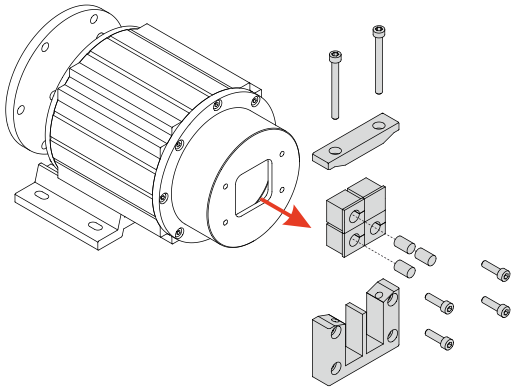
5.3.2 Connection

For measuring systems that are installed in an optional heavy duty 115 enclosure, the following steps must be observed when connecting:

Step 1:

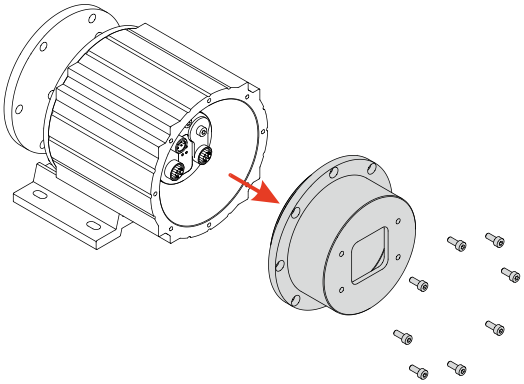
Remove the 4x cylinder head screws from the cable entry module using a 4 mm Allen key. Remove the cable entry module from the cover hood and disassemble it.

The sealing plugs in the grommets must be removed according to the number and position of the cables used.



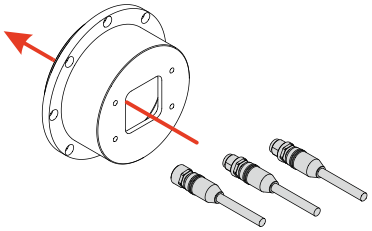
Step 2:

Remove the 8x cylinder head screws from the cover using a 3 mm Allen key. Pull the cover hood off the enclosure tube.



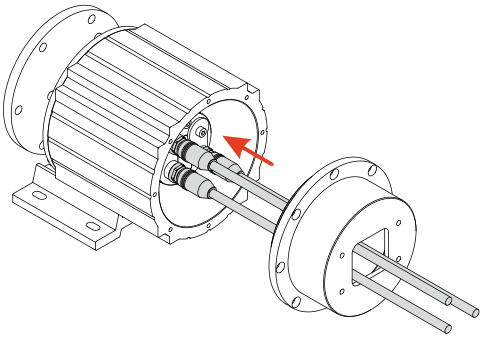
Step 3:

Feed the signal and supply lines one after the other through the opening in the cover hood.



Step 4:

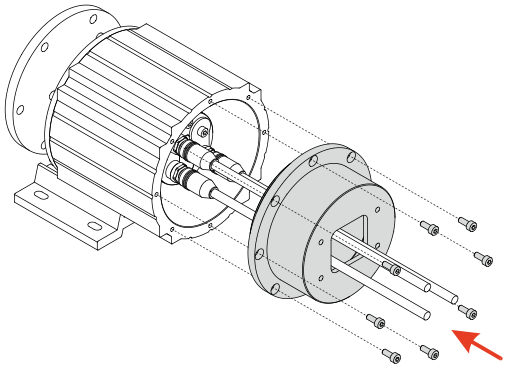
Connect the signal and supply lines to the measuring system and screw them tight.



Step 5:

Screw the cover hood back onto the housing tube using the 8x M4x10 cylinder head screws.

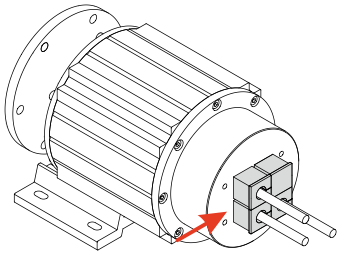
Note the alignment of the cover hood!



Step 6:

Place the grommets around the cables so that they are flush with the cover hood.

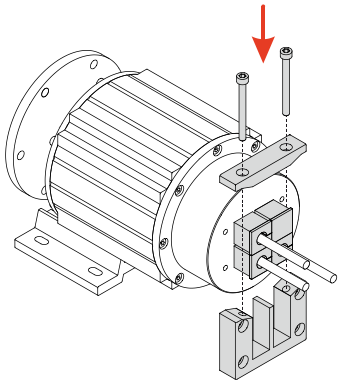
To ensure that the seal is tight, the individual installation direction of the grommets in relation to one another and the plug pattern of the installed measuring system must be observed. The sizes of the grommets must be selected according to the cable diameter.



Step 7:

Slide the frame of the cable entry module onto the grommets and pull it up to the stop of the cover. Screw the cable entry module tightly together with the 2x cylinder head screws.

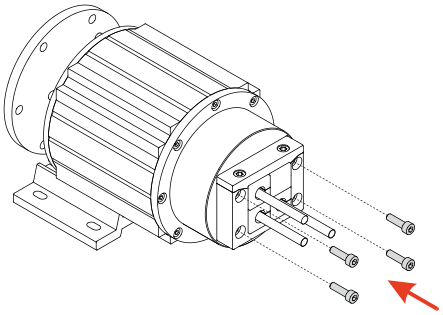
To ensure a tight seal, the frame and the yoke (cover) of the cable entry module must be positioned with the rubberized sealing side facing the cover hood.



Step 8:

Screw the cable entry module to the cover hood using the 4x M5x18 cylinder head screws.

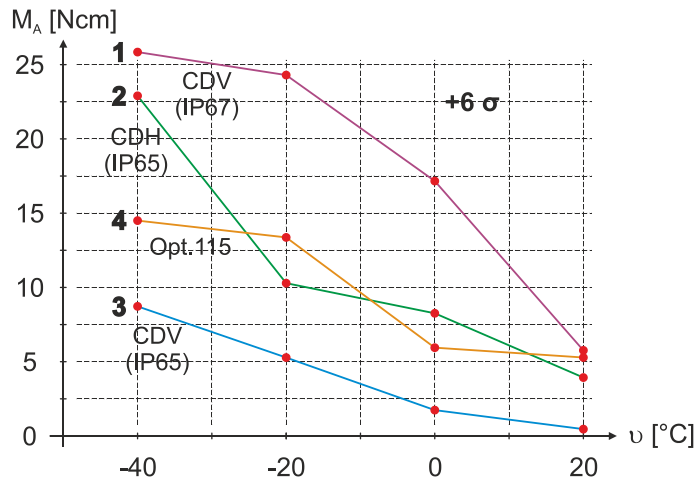
Care must be taken to ensure that the installation of the cable entry module does not exert too much pressure on the cables and thus on the measuring system!



5.4 Shaft turning moments (worst-case)

Temperature [°C]	Break-away torques / Start-up torques in [Ncm] at +6 σ			
	1 (IP67, CDV)	**2** (IP65, CDH)	**3** (IP65, CDV)	**4** (Option 115)
20	5.76 / 4.67	3.93 / 3.76	0.46 / 0.34	5,7 / 5,4
0	17.16 / 10.13	8.26 / 5.75	1.74 / 1.43	5,8 / 5,5
-20	24.30 / 9.86	10.29 / 8.04	5.41 / 3.59	13,7 / 6,7
-40	25.85 / 11.67	22.90 / 16.60	8.73 / 7.30	14,7 / 11,7

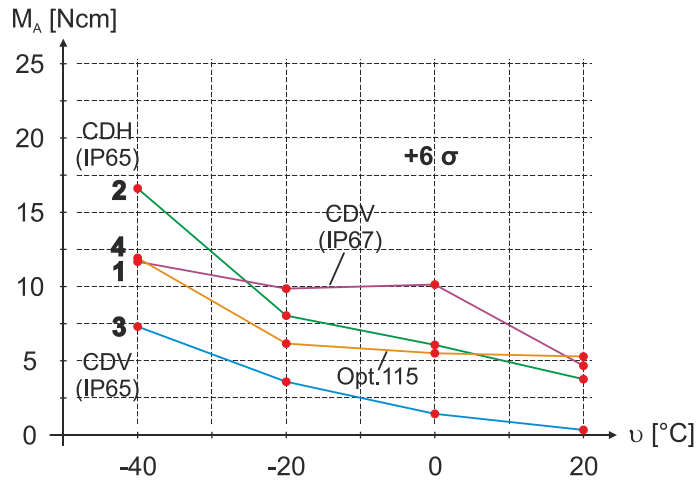
The break-away torque is the maximum torque that occurs after the temperature load (0, -20 and -40 °C) to set the shaft in motion. The start-up torque must be applied after breaking to set the shaft in motion. The difference between break-away torque and start-up torque arises, e.g. through ice formation at low temperatures.



M_A: Break-away torque
ϑ: Temperature

At +6 Sigma

Figure 15: Break-away torques



M_A: Start-up torque
ϑ: Temperature

At +6 Sigma

Figure 16: Start-up torques

5.5 Potential equalization – connection

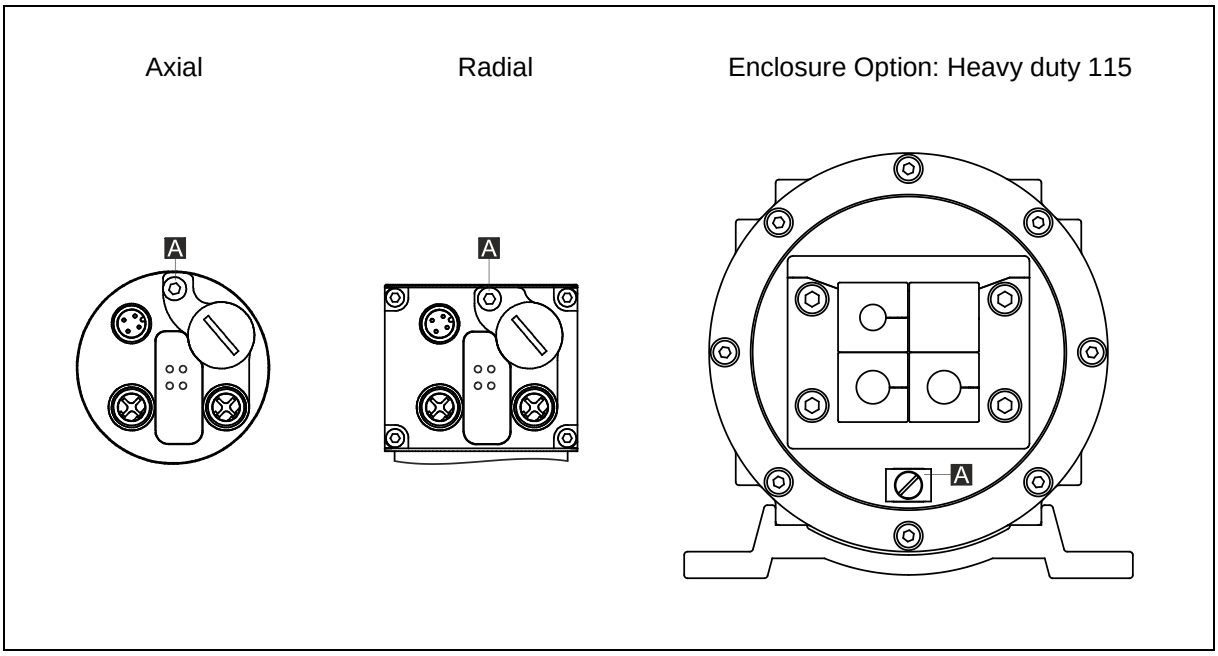


Figure 17: Grounding point

A: M4 thread or screw clamp for equipotential bonding

6 Replacing the measuring system

Ensure that you meet the following requirements while replacing the measuring system:

- The new measuring system must have the same article number as the measuring system being replaced; any deviations must be expressly clarified with TR Electronic.
- When the new measuring system is used, it must be ensured that the hardware switch settings comply with the previous settings.
- The new measuring system must be installed in accordance with the specifications and requirements in Chapter “Assembly” on Page 27.
- The new measuring system must be connected in accordance with the specifications in the interface-specific User Manual.
- Since the parameters of the measuring system are usually stored in the control, the new measuring system is parameterized with the projected settings in the start-up phase. If this mechanism fails, it must be ensured that the settings for the new measuring system are the same as those for the old one.
- Depending on the application, the output position value must possibly be adjusted to the reference position of the machine. The position value must be adjusted as specified in the interface-specific User Manual.
- Before the replaced measuring system is recommissioned, its proper functioning must be verified in a protected test run.

7 Checklist, Part 1 of 2

We recommend that you print out and work through the checklist for commissioning, replacing the measuring system and when changing the parameterization of a previously accepted system and store it as part of the overall system documentation.

Documentation reason	Date	edited	checked

Sub-item	Note	Reference	yes
This Safety Manual was read and understood	–	Document no.: TR-ECE-BA-GB-0142	☐
Interface-specific User Manual	• Go through and use the checklist part 2 of 2	See Chapter Document Download on Page 49	☐
Verify that the measuring system can be used for the present automation task based on the specified safety requirements	• Intended use • Compliance with all technical data	• Chapter Intended use, Page 13 • Chapter Document Download -> Product data sheets, Page 49 • Interface-specific User Manual (Checklist, part 2 of 2)	☐
Meeting the assembly requirements defined in the Safety Manual	• Safe mechanical attachment of the measuring system. General recommendation: Form-locking connection of the driving shaft to the measuring system	• Chapter Assembly, Page 27	☐
Supply voltage	• The power supply unit used must meet the requirements of	• Chapter Document Download -> Product data sheets, Page 49 • Interface-specific User Manual (Checklist, part 2 of 2)	☐
Proper – electrical installation (shielding) – Network installation	• Comply with general installation rules • Comply with wiring standards • Comply with the guidelines provided by the relevant field bus user organizations	• Interface-specific User Manual (Checklist, part 2 of 2)	☐
After commissioning and parameter changes – System test – Validation (Settings – Axis)	• During commissioning and whenever parameters have been changed – all relevant safety functions involved must be checked – if several (similar) axes are used, make sure that the settings have been made for the desired axis	• Interface-specific User Manual (Checklist, part 2 of 2)	☐

Continued on next page

Continued

Sub-item	Note	Reference	yes
Preset adjustment function	• Legacy mode: The preset adjustment function may only be executed when the axis in question is at standstill • Ensured the preset adjustment function can not be triggered unintentionally • After execution of the preset adjustment function, the new position must be checked before restarting	• Interface-specific User Manual (Checklist, part 2 of 2)	☐
Device replacement	• Ensure that the new device corresponds to the replaced device • All affected safety functions must be checked	• Chapter Replacing the measuring system, Page 43 • Interface-specific User Manual (Checklist, part 2 of 2)	☐
Verification and validation of the programming system (Control system / Software)	• Ensure that all functional and performance related requirements for the safety-related parts of the programming system are met. Particularly, this applies to changing the program version.	• Safety of machinery – safety related parts of control systems – DIN EN ISO 13849-1 – DIN EN ISO 13849-2	☐

8 Maintenance

The measuring system requires no maintenance by the operator.

However, if the bearing life of the product is exceeded within a service life of 20 years, the metering system must be taken out of service and sent to the manufacturer.

After 20 years of use, the measuring system must be subjected to a proof test.

For more information, please refer to these standards

– DIN EN 62061 and
– DIN EN 61508

titled “Safety of Machinery – Functional safety of electrical/electronic/programmable electronic safety-related systems”.

The procedure must be coordinated with the manufacturer.

9 Decommissioning / demounting

When decommissioning or demounting, the following instructions from the chapter "Safety-related instructions" must be observed in particular:

- Wiring work may only be carried out and electrical connections only be opened and closed while the system is de-energized.

- Avoid shocks (e.g., hammer blows) to the shaft during installation / demounting.

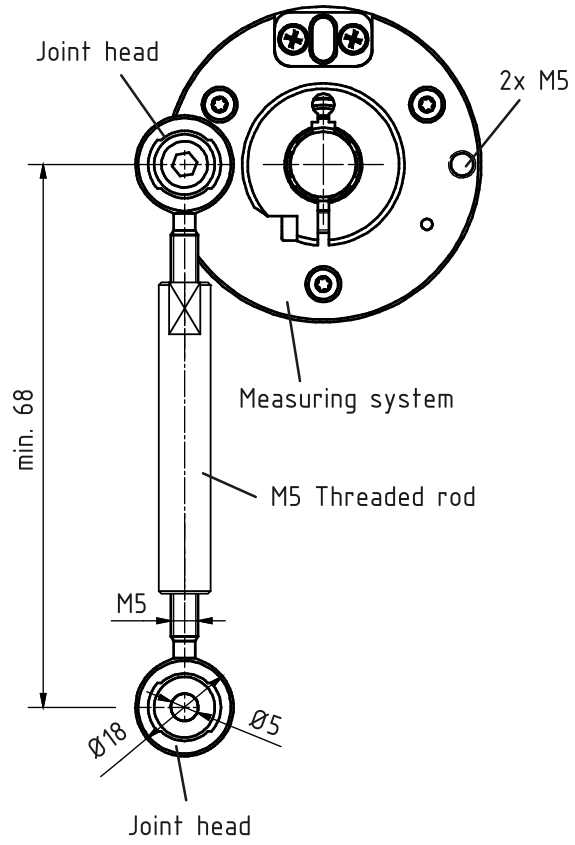
Connector plugs of the measuring system that are unused during storage, operation and/or demounting of the system have to be provided either with a mating connector or a protective cap. The IP degree of protection is to be selected according to requirements.

10 Accessories

Protective caps / O-Ring

Designation	Part number
Protective cap yellow, M12x1 female thread with O-ring, IP65. Suitable for supply voltage connector	62-000-1664
Protective cap black, M12x1 male thread without O-ring, IP50. Suitable for bus and incremental interface connector	62-000-1344
O-Ring DIN-3771 7x1 NBR 70 SHORE Suitable for protective cap 62-000-1344 --> IP65	26-000-332

Optional torque holder with joint head and threaded rod M5



Designation	Part number
Joint head M5	49-280-002
Threaded rod M5, ⌀ 10 mm x 60 mm	49-917-026
Threaded rod M5, ⌀ 10 mm x 105 mm	49-995-200
Threaded rod M5, ⌀ 10 mm x 360 mm	49-917-022

11 Document Download

Safety Manual

Designation	Link
Absolute Encoder CD_-582	www.tr-electronic.de/f/TR-ECE-BA-GB-0142

Interface-specific User Manuals

Designation	Link
PROFINET/PROFIsafe	www.tr-electronic.de/f/TR-ECE-BA-GB-0139
EtherNet/IP – CIP-Safety	www.tr-electronic.de/f/TR-ECE-BA-GB-0163
POWERLINK/openSAFETY	www.tr-electronic.de/f/TR-ECE-BA-GB-0169
CANopen/CANopen Safety	www.tr-electronic.de/f/TR-ECE-BA-GB-0171
EtherCAT/FSoE	www.tr-electronic.de/f/TR-ECE-BA-GB-0177

Pin assignments

Link
www.tr-electronic.com/service/downloads/pin-assignments.html

Product data sheets

Designation	Link
Absolute Encoder CD_-582	www.tr-electronic.com/s/S020955

EU Declaration of Conformity

Link
CD_582M +FS02: www.tr-electronic.de/f/TR-ECE-KE-DGB-0354 CD_582M +FS03: www.tr-electronic.de/f/TR-ECE-KE-DGB-0358