Product Safety
Functional
Safety

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Original manual

Incremental Encoder I_-58 with Functional Safety (FS)

Explosion protection housing

_A**70*

IV-58

IS-58 / IH-58

Pictures similar

Position Sensor:
DIN EN 61508/62061: SIL CL2
DIN EN ISO 13849: PL d

Speed Sensor:
DIN EN 61508/62061: SIL CL3
DIN EN ISO 13849: PL e

_Basic safety instructions
_Intended use
_General functional description
_Characteristics
_Mounting
_Installation/Commissioning
_Causes of faults and remedies

User Manual / Safety Manual

TR-ECE-BA-GB-0120v19 06/11/2026

Contents

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Document information

Release date / Rev. date:	06/11/2026
Document rev. no.:	TR-ECE-BA-GB-0120v19
File name:	TR-ECE-BA-GB-0120v19.docx
Author:	FRJ, KUC

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First release	07/15/2016	00
Translation of the actual revision	01/16/2017	08
- Chapter “Permitted cable length” added - Supplementation for variant with square-wave - Requirements of the fail-safe processing unit expanded - Technical data updated	04/10/2017	09
Concretion of requirements regarding the SCS in ch. 1.3 and 2.5	04/21/2017	10
Correction of the revision of the revision list	09/27/2018	11
Order number for the connectors on chapter 6.6.1	02/07/2019	12
Warning: Surge voltages in relation to the signals SIN+, SIN–, COS+, COS–, Ref+ or Ref–	10/23/2019	13
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- Warning notice "Handheld radio devices", in accordance with DIN EN 61800-5-2, chapter 7.2, subsection c)	07/03/2024	16
Chapter 5.2.3 “Torque arm – spring steel sheet” added	01/30/2025	17
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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 contains the following topics:

- General functional description
- Basic safety information with declaration of the intended use
- Characteristics
- Mounting
- Installation/Commissioning
- Error causes and remedies

As the documentation is arranged in a modular structure, this User Manual is supplementary to other documentation, such as product data sheets, dimensional drawings and brochures, etc.

1.1 Applicability

This User Manual applies exclusively for measuring system series in accordance with the following keys for the article numbers and type code with ***incremental interface*** and ***functional safety***:

See revision list:
www.tr-electronic.de/f/TR-ECE-TI-D-0301

The measuring system stands out due to 2 variants which are distinguished in the chapter “Main features” on page 9.
The variants are labeled with affixed nameplates and are components of a system.

The following documentation therefore also applies:

- operator’s operating instructions specific to the system
- this User Manual
- Pin assignment
- Product data sheet
- Optional: Ex User Manual

1.2 Abbreviations and terms used

A**70*	Explosion protection housing Ø 70 mm with built-in measuring system, all variants
I_58	Incremental encoder, all designs
DC_{avg}	***D***iagnostic ***C***overage Average diagnostic coverage
ESD	***E***lectro ***S***tatic ***D***ischarge
EU	***E***uropean ***U***nion
EMC	***E***lectro***M***agnetic ***C***ompatibility

…

…

Functional safety (FS)	Part of the overall system safety, which depends on the correct functioning of safety-related systems for risk reduction. Functional safety is ensured when each safety function is executed as specified.
Fault exclusion	Compromise between the technical safety requirements and the theoretical possibility of an error occurring
HTL	***H***igh-***T***hreshold-***L***ogic
IEC	International Electrotechnical Commission
IEEE	***I***nstitute of ***E***lectrical and ***E***lectronics ***E***ngineers
ISO	***I***nternational ***S***tandard ***O***rganization
$MTTF_d$	***M***ean ***T***ime ***T***o ***F***ailure (dangerous) Mean time until dangerous failure
PFD_{av}	***Av***erage ***P***robability of ***F***ailure on ***D***emand Average probability of failure of a safety function with low demand
PFH	***P***robability of ***F***ailure per ***H***our Operating mode with high requirement rate or continuous demand. Probability of dangerous failure per hour.
PFH_D	***P***robability of a **d**angerous ***F***ailure per ***H***our Average probability of a dangerous failure per hour according to ISO 13849-1.
PL	***P***erformance ***L***evel, according to ISO 13849-1: Discrete level, which specifies the capability of safety-related parts of a control to execute a safety function under foreseeable conditions.
SIL	***S***afety ***I***ntegrity ***L***evel, according to IEC 62061: Four discrete levels (SIL1 to SIL4). The higher the SIL of a safety-related system, the lower the probability that the system cannot execute the required safety functions.
SIS	***S***afety ***I***nstrumented ***S***ystem: is used to protect a dangerous process and reduce the risk of an accident. Process instruments are a constituent of a Safety Instrumented System. This comprises the essential components of a complete safety-relevant process unit: Sensor, fail-safe processing unit (control) and actuator
SCS	***S***afety ***C***omputer ***S***ystem with control function
Standard measuring system	Definition: Safety-related measuring system, without explosion protection
STP	***S***hielded ***T***wisted ***P***air
TTL	***T***ransistor-***T***ransistor-***L***ogic (RS422)
VDE	***V***erband ***d***er ***E***lektrotechnik, Elektronik und Informationstechnik (Association for Electrical, Electronic and Information Technologies)
Repeat test (proof test)	Repetitive test to detect hidden dangerous failures in a safety-related system.

1.3 General functional description

The rotary measuring system is a safe and incremental position measuring system.

The measuring system has been designed so that it can be used in systems which require the following safety functions according to EN 61800-5-2:

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

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

The following shaft designs can be used for the mechanical coupling:

- Solid shaft
- Blind shaft
- Hollow shaft

-Protective housing:
The mechanical coupling can only be made via a solid shaft.

Depending on the safety functions safety-related differences arise:

- SIL3/PLe/Cat.3, in conjunction with velocity oriented safety functions
- SIL2/PLd/Cat.3, in conjunction with positioning oriented safety functions

see chapter “Safety” -> “Functional safety” on page 19.

1.3.1 Main features

The entire system electronics has a discrete design. Neither microcontrollers nor programmable logic elements are contained in the system electronics. There is no interpolation or signal multiplexing. All signal lines are led separately within the electronics.

1.3.1.1 Variant 1 (IV58+FS01 SIN/COS, IH58+FS01 SIN/COS)

Incremental interface with analog output signals SIN±, COS± and Ref±; output level 1 Vss.
The safety-evaluated measuring system is designed for the implementation of safety-related functions in relation to speed and direction of rotation. In the downstream fail-safe processing unit an ideal error detection also occurs through evaluation of the annulus relationship “$SIN(x)^2 + COS(x)^2 = 1$”.
The Ref± reference signals are not evaluated from a safety viewpoint and may not be used for safety-oriented purposes.

1.3.1.2 Variant 2 (IV58+FS01 TTL/HTL, IH58+FS01 TTL/HTL)

Incremental interface with digital square-wave output signals K1±, K2± and K0±; output level in TTL or HTL logic.
The safety-evaluated measuring system is designed for the implementation of safety-related functions in relation to speed and direction of rotation.
An internal signal monitor constantly checks the annulus relationship "$SIN(x)^2 + COS(x)^2 = 1$". Safety-relevant errors are indicated by switching of the signal outputs to tri-state. The K0± reference signals are not evaluated from a safety viewpoint and may not be used for safety-oriented purposes.

1.3.2 Principle of the safety function

System safety results when:

- the scanning channel is single fault safe thanks to its own diagnostic measures and circuit measures
- the control checks that the received incremental data meet the expected tolerance window according to the application.
- for variant 1, the control also checks the annulus relationship $SIN(x)^2 + COS(x)^2 = 1$; if the result is outside the tolerance range, the incremental data must be evaluated as unsafe. In this way the control achieves an ideal error detection.
- when errors are detected the control introduces appropriate safety measures defined by the system manufacturer
- the system manufacturer ensures, through correct mounting of the measuring system, that the measuring system is always driven by the axis to be measured and is not overloaded. A fault exclusion is required for mounting the measuring system to the drive function.
- the system manufacturer carries out a proven test during commissioning
- the downstream fail-safe processing unit evaluates the measuring system differentially

2 Basic safety information

2.1 Definition of symbols and notes

⚠ DANGER	means that death or serious injury will occur if the required precautions are not met.
⚠ 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 protective measures against ESD according to DIN EN 61340 5-1 Supplement 1 must be applied.

2.2 General risks when using the product

The product, hereinafter referred to as ***the 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!***
Only use the measuring system in perfect technical condition, paying attention to safety and dangers, and in compliance with the ***User Manual***! Faults which could threaten safety should be eliminated without delay!

2.3 Intended use

The safety measuring system can be used for the detection of angular movement and processing of measured data for a downstream safety computer system in systems in which the **protection goals** of **"Protection of speed"** and **"Protection of direction of movement"** must be safely achieved. The complete processing chain of the safety function must then 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 check that the characteristics 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:

- observing all instructions in this User Manual,
- observing the nameplate and any prohibition or instruction symbols on the measuring system,
- observing the enclosed documentation, e.g. product insert, pin assignment etc.
- observing the operating instructions from the machine/system manufacturer,
- 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,
- observing and using the checklist in the appendix,
- safe mounting (form closure; recommended) of the measuring system to the driving axis, also see chapter "Mounting" from page 23

2.4 Non-intended use

⚠ WARNING

Danger of death, physical injury and damage to property in case of non-intended use of the measuring system!

➢ The following areas of use are especially forbidden:

- Standard measuring system:
  In environments where there is an explosive atmosphere
- for medical purposes

NOTICE

2.5 Usage in explosive atmospheres

When used in explosive atmospheres, the standard measuring system has to be installed in an appropriate explosion protective enclosure and subject to requirements.

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.

2.6 Safety functions of the fail-safe processing unit

The **S**afety **C**omputer **S**ystem (SCS), to which the measuring system is connected, must perform the following safety checks.
With regard to "Single fault safety" and "Ideal error detection" please see IFA directive "GS-IFA-M21". This can be downloaded under the following link:
www.tr-electronic.com/f/zip/TR-E-TI-DGB-0107

To enable the correct measures to be taken in the case of error, the following applies:

- **Safe state – passive, only for measuring system variant 1**
  In passive safe state the measuring system does not output any valid SIN±/COS± – signals to the downstream fail-safe processing unit. The processing unit detects the error through evaluation of the annulus relationship $SIN(x)^2 + COS(x)^2 = 1$. If the result is outside the tolerance range, the incremental data are evaluated as unsafe. The downstream fail-safe processing unit has an ideal error detection.
- **Safe state – active, only for measuring system variant 2**
  In active safe state the signal outputs are switched to tri-state. The processing unit detects the error via an implemented cable breakage detection.

2.6.1 Mandatory safety checks / measures

Measures for commissioning, changes	**SCS error reaction**
Check that the desired automation task is executed as required.	STOP

Check by the SCS	**SCS error reaction**
Check of incremental data according to the present automation task and safety function.	STOP
Two-channel monitoring of incremental outputs for cable breakage.	For tri-state state -> STOP
Only for variant 1 Evaluation of the condition $SIN(x)^2 + COS(x)^2 = 1$. The number of checks / revolution corresponds to the number of periods/revolution: 1024, 2048 or 4096 For the safety functions SDI, SS1, SS2, SOS, SSR, SSM an annulus monitoring with DC = 90 % is required. For the SLS safety function a two-channel evaluation of the frequency from (SIN/COS) with a DC of 90 % is required.	If outside tolerance -> STOP
Only for variant 2 A cable break detection is required for the evaluation of the square pulse signals. In the safe state, the output drivers are in tri-state (high-resistance state).	If a cable break is detected -> STOP
Only for variant 2 Evaluation of the incremental data in differential mode and verification with respect to antivalence, quadrature and against phase equivalence between channels A and B	If outside tolerance -> STOP

2.7 Warranty and liability

In principle the "General Terms and Conditions" of TR Electronic GmbH apply. These are available to the operator with the Order Confirmation or when the contract is concluded at the latest. Warranty and liability claims in the case of personal injury or damage to property are excluded if they result from one or more of the following causes:

- Non-intended use of the measuring system.
- Incorrect mounting, installation and commissioning of the measuring system.
- Work carried out incorrectly on the measuring system.
- Operation of the measuring system with technical defects.
- Unauthorized mechanical or electrical modifications to the measuring system.
- Unauthorized repairs.
- Third party interference and acts of God.

2.8 Organizational measures

- The User Manual must always be kept ready-to-hand at the place of use of the measuring system.
- In addition to the User Manual, the 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 operator is obliged to inform personnel about special operating features and requirements.
- Prior to commencing work, personnel working with the measuring system must have read and understood the chapter "Basic safety information".
- The type plate and any prohibition or instruction symbols applied on the measuring system must always be maintained in a legible state.
- Do not undertake any mechanical or electrical modifications to the measuring system, except for those expressly described in this User Manual.
- Repairs may only be undertaken by the manufacturer or a center or person authorized by the manufacturer.

2.9 Personnel selection and qualification; basic obligations

- All work on the measuring system must only be carried out by qualified personnel.

  Qualified personnel includes 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.

- The definition of “qualified personnel” also includes an understanding of the standards VDE 0105-100 and IEC 364 (source: e.g. Beuth Verlag GmbH, VDE-Verlag GmbH).

- The responsibility for assembly, installation, commissioning and operation must be clearly defined. The obligation exists to provide supervision for trainee personnel.

2.10 Safety information

Destruction, damage and malfunction of the measuring system!

- Only carry out wiring work or opening and closing of electrical connections with the system de-energized.
- Do not undertake any welding work if the measuring system is already wired or switched on.
- Falling below or exceeding the permissible ambient temperature limit values must be prevented through an appropriate heating/cooling measure at the place of installation.
- The measuring system must be installed so that no direct moisture can affect the measuring system.
- Suitable aeration/ventilation and heating/cooling measures must be provided at the place of installation to prevent the temperature falling below the dew point (condensation).
- If overvoltages of >7 V DC are inadvertently applied at the incremental analog output signals SIN+, SIN–, COS+, COS–, Ref+ or Ref–, the measuring system must be inspected at the factory, with specification of the reasons or circumstances. The measuring system must be shut down immediately.

⚠ WARNING

- Potential hazards resulting from interactions with other systems and equipment which are or will be installed in the vicinity must be checked. The user is responsible for taking appropriate measures.

NOTICE

- The power supply must be protected with a fuse suitable for the supply lead cross-section.
- Cables used must be suitable for the temperature range.
- A defective measuring system must 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.
- Opening the measuring system is forbidden.
- When storing and operating the measuring system unused connection plugs must either be provided with a mating plug or a protective cap. The appropriate IP protection class must be selected to meet the relevant requirements.
- 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 type plate specifies the technical characteristics of the measuring system. If the type plate is no longer legible or if the type plate is completely missing, the measuring system must not be operated.

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

⚠ WARNING

NOTICE

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.

– Touching the measuring system connection contacts with the fingers must be avoided, or the relevant ESD protective measures must be applied.

Disposal

– If disposal has to be undertaken after the lifespan of the device, the applicable country-specific regulations must be observed.

3 Transport / Storage

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

- Storage
  - Storage temperature: -40 to +90 °C
  - Store in a dry place

4 Technical data

4.1 Safety

Functional safety

DIN EN 61508 Part 1-7	**S**afety **I**ntegrity **L**evel (SIL):
- [1] SDI, SS1, SS2, SOS, SLP, SLI, SCA	- 2
- [1] SLS, SSR, SSM, SLA, SAR	- 3
EN ISO 13849-1	**P**erformance **L**evel:
- [1] SDI, SS1, SS2, SOS, SLP, SLI, SCA	- PLd / Cat. 3
- [1] SLS, SSR, SSM, SLA, SAR	- PLe / Cat. 3

Startup time	Time between POWER-UP and safe incremental output
Variant 1	≤ 30 ms
Variant 2	≤ 50 ms

PFH / PFH_D, "High demand" operating mode

Variant 1	$5.34 * 10^{-9}$ 1/h
Variant 2	$6.57 * 10^{-9}$ 1/h
Notice	Measuring system is used only in applications with high or continuous demand rate

$MTTF_d$	high
Variant 1	1558 a
Variant 2	622 a
[2] DC_{avg}	medium (90 %)
Internal process safety time	Time between occurrence of an F-error and alarm indication
Overall system	≤ 1 ms
Process safety angle	Angle between error occurrence and alarm indication
Through channel-internal self-diagnosis	± 0.3510°, at 1024 periods; ± 0.1760°, at 2048 periods; ± 0.0879°, at 4096 periods; in relation to the measuring system shaft
T_1, repeat test (proof test)	20 years

[1] according to EN 61800-5-2

[2] The assessment occurred in accordance with Note 2 on Table 6 of EN ISO 13849-1

4.2 Electrical characteristics, I_58

4.2.1 General

Supply voltage	10…30 V DC according to IEC 60364-4-41, SELV/PELV
Reverse polarity protection	yes
Short-circuit protection	yes, by internal 1 A safety fuse
Overvoltage protection	yes, up to ≤ 60 V DC
Power consumption without load	at 24 V DC
Analog output signals	< 20 mA
Square-wave output signals	< 40 mA

4.2.2 Device-specific

Accuracy

Usable resolution	10 bit, 11 bit, 12 bit; depending on the device configuration
Safety-related	+ 2 bit interpolated
Functional	+ 8 bit interpolated

Variant 1

Incremental analog output signals

Periods / revolution	1024, 2048, 4096 acc. to device variant
Incremental signals	SIN+, SIN–, COS+, COS–
Track position, electrical	90 °
Reference signals	Ref+, Ref–, once per revolution
Output level	1 Vss ± 0.2 V at 100 Ω, differential
Output current	20 mA
Output frequency	≤ 500 KHz
Short-circuit proof	yes, incremental signals and reference signals among each other, but not in relation to the supply voltage
Cable specification	see page 35

Variant 2

Incremental square-wave output signals

Pulses / revolution	1024, 2048, 4096 acc. to device variant
Incremental signals	K1+, K1–, K2+, K2–
Track position, electrical	90 °
Zero pulse	K0+, K0–, once per revolution
Output level TTL	EIA standard RS422 (2-wire)
Output level HTL	Push-pull, supply voltage
Output current	50 mA, per channel
Output frequency	≤ 100 KHz
Short-circuit proof	yes
Cable specification	see page 35

4.3 Ambient conditions, I_58

Vibration

DIN EN 60068-2-6 ..... ≤ 100 m/s², sine 50-2000 Hz

Shock

DIN EN 60068-2-27 ..... ≤ 1000 m/s², half sine 11 ms

EMC

Immunity to disturbance ..... EN 61000-6-2

Transient emissions ..... EN 61000-6-3

Working temperature ..... -40…+90 °C

Derating Hollow shaft, > 3000 rpm..... Ta = 90 – 0,0062 * (n – 3000) in °C

Storage temperature ..... -40 °…+90 °C, dry

Relative air humidity, DIN EN 60068-3-4..... 98 %, non-condensing

[3] Protection class, DIN EN 60529

Shaft side ..... IP 65

Housing side..... IP 67

[3] valid with screwed-on mating connector and/or screwed-on cable gland

4.4 Mechanical characteristics, I_58

4.4.1 Solid shaft

Mechanically permissible speed ..... ≤ 12,000 rpm

Electrically permissible speed

$n_{electric}$ [rpm] = (output frequency [Hz] / no. of pulses per rev.) * 60 rpm

Bearing life ..... ≥ 3.9 * 10^{10} revolutions at

Speed ..... ≤ 6000 rpm

Operating temperature ..... ≤ 60 °C

Shaft load, flange + 10 mm ..... ≤ 50 N axial, ≤ 100 N radial

Permissible angular acceleration ..... ≤ 10^4 rad/s^2

Moment of inertia, typical ..... 4.9 * 10^{-6} kg m^2

Start-up torque

at 20 °C ..... 3.4 Ncm

at 0 °C ..... 3.6 Ncm

at -20 °C ..... 7.8 Ncm

at -40 °C ..... 20 Ncm

Weight, typical ..... 0.3…0.5 kg

4.4.2 Hollow shaft

Mechanically permissible speed ..... ≤ 6,000 rpm

Note ..... Observe Derating for permissible working temperature

Electrically permissible speed

$n_{electric}$ [rpm] = (output frequency [Hz] / no. of pulses per rev.) * 60 rpm

Shaft load, axial/radial ..... Own mass

Bearing life ..... ≥ 3.9 * 10^{10} revolutions at

Speed ..... ≤ 6000 rpm

Operating temperature ..... ≤ 60 °C

Permissible angular acceleration ..... ≤ 10^4 rad/s^2

Moment of inertia, typical ..... 8.8 * 10^{-6} kg m^2

Start-up torque

at 20 °C ..... 3.4 Ncm

at 0 °C ..... 3.6 Ncm

at -20 °C ..... 3.8 Ncm

at -40 °C ..... 16 Ncm

Runout tolerance ..... ± 0.05 mm

Weight, typical ..... 0.3…0.5 kg

5 Mounting

- **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.

5.1 Solid shaft

As the installation situation is application-dependent, the following notes are not exhaustive.

5.1.1 Requirements

- Dimensions, as well as individual mounting options, can be found in the customer-specific drawing.
- A suitable coupling with form closure must be used for the application. When used in potentially explosive atmospheres, the coupling must have the appropriate approval, see Ex-User Manual. The coupling must be dimensioned so that fault exclusion is ensured for the mechanical mounting of the measuring system in accordance with DIN EN 61800-5-2, depending on the static and dynamic load cases. If this is not possible, the hazard must be incorporated into the risk assessment for the application in the form of a coupling breakage.
- 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,
  - the coupling and the measuring system are not axially loaded,
  - the clamping screws are tightened with the torque defined by the coupling manufacturer,
  - the coupling screws are secured against unintentional loosening.
- Axial slipping of the measuring system on the drive shaft must be prevented by the coupling fixing, see Figure 1, (1).
- General recommendation: Radial slipping (slip) of the measuring system on the drive shaft should be prevented by means of form closure by using a parallel key / groove combination (Figure 1, (2)); a coupling with groove can be used for this purpose.

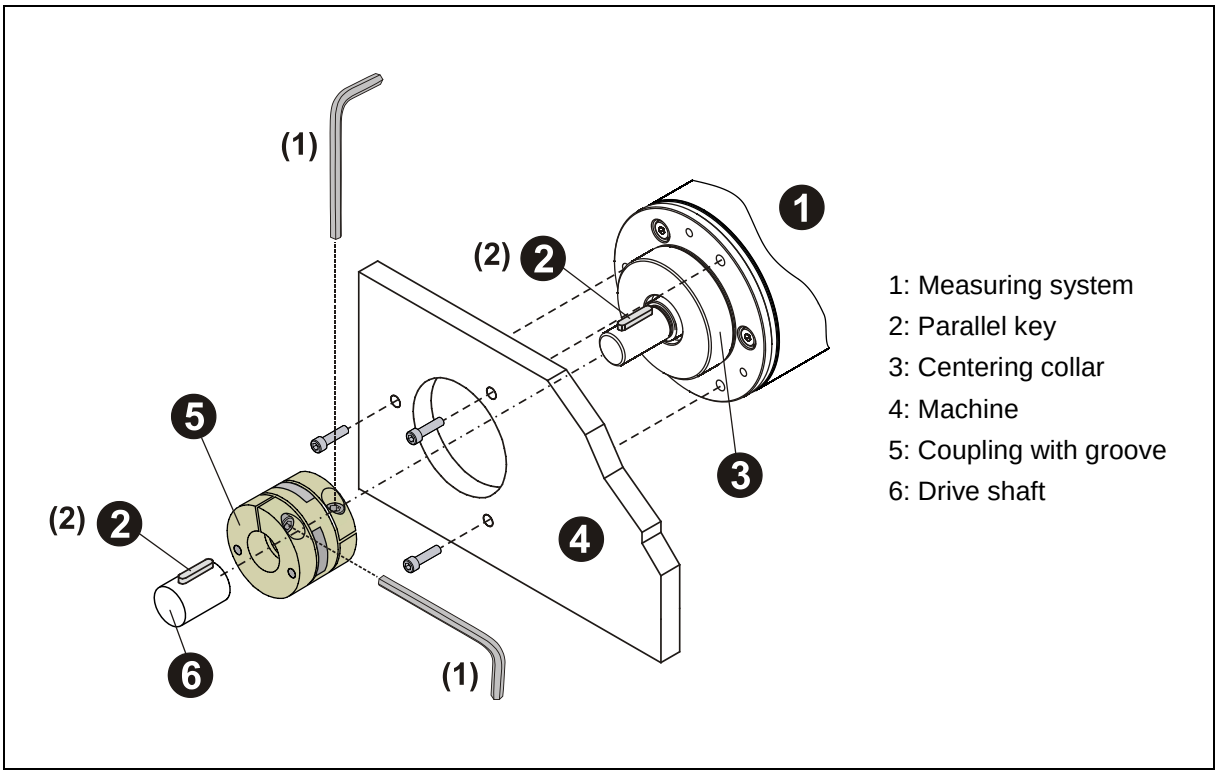


Figure 1: Flange mounting

5.2 Hollow shaft

As the installation situation is application-dependent, the following notes are not exhaustive.

5.2.1 Requirements

- 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, see Figure 2.
- Further measures may be required to prevent axial slipping of the measuring system.
- There may be no axial load on the clamping mechanism of the measuring system.
- The screw of the clamping ring must be tightened with 3 Nm using a torque wrench.
- The screw of the clamping ring must be secured such that it cannot be loosened accidentally.
- 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.

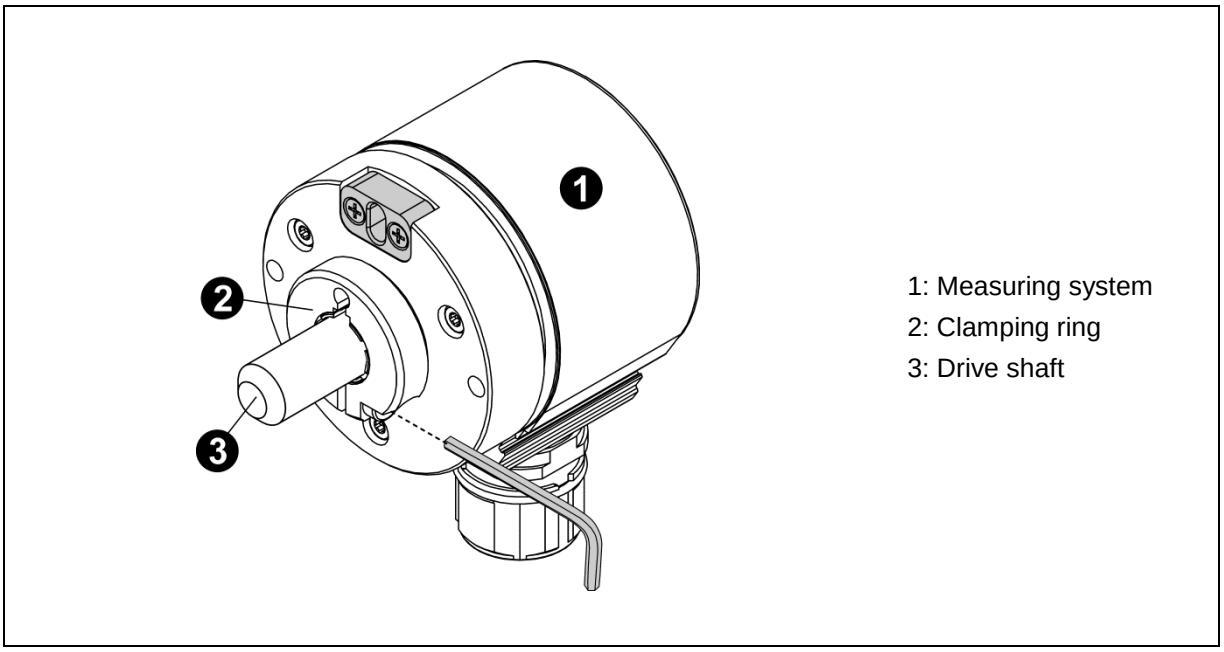


Figure 2: Friction locking

5.2.2 Dowel pin / groove insert

- A dowel pin is used to fix the measuring system on the drive end, see Figure 2.
- The dowel pin must extend at least 4 mm into the groove insert.
- The clamping ring assembly requirements must be observed, see Chapter: 5.2.1 “Requirements”.

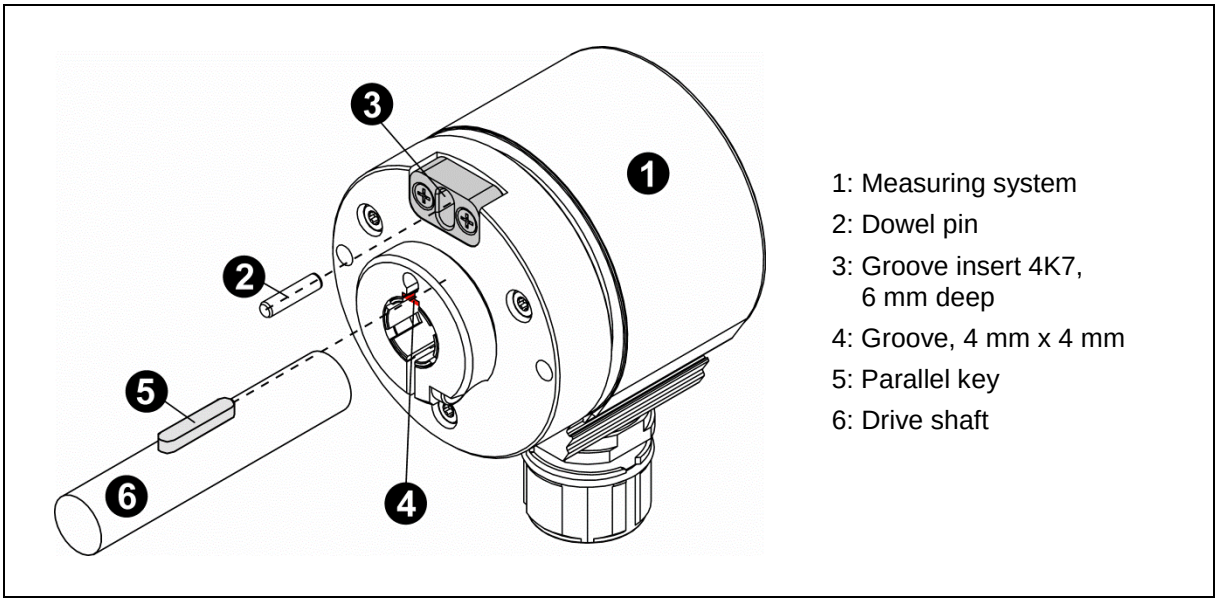


Figure 3: Positive engagement

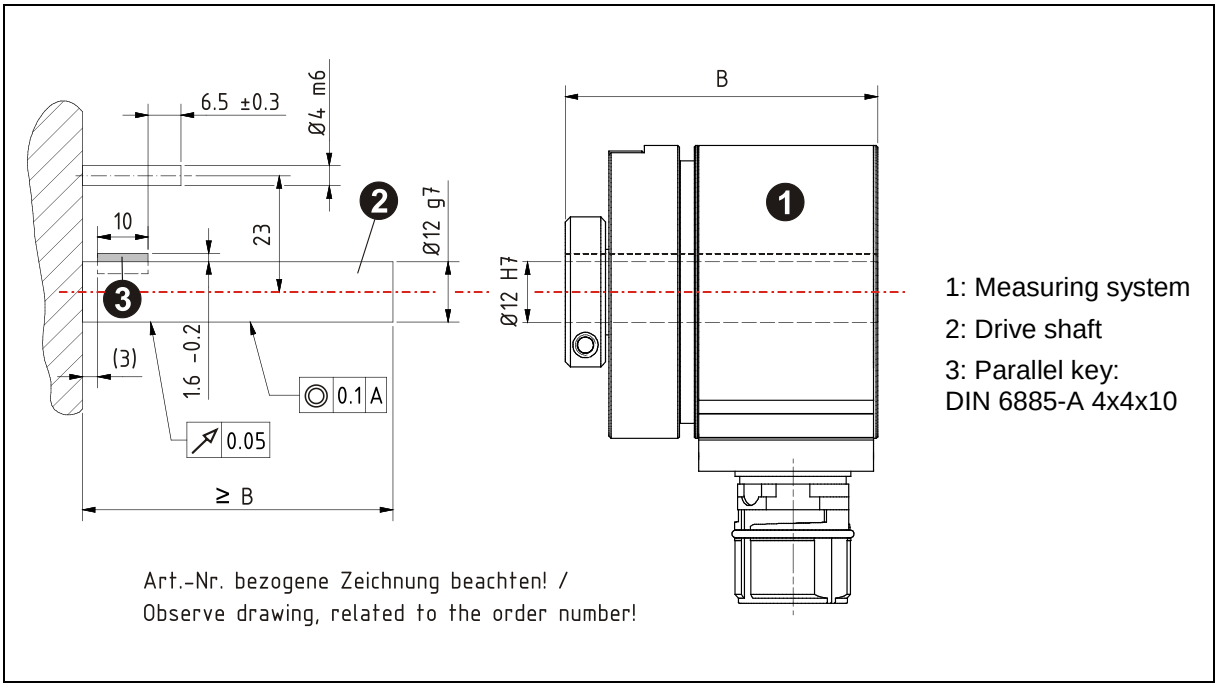


Figure 4: Requirements for the shaft mounting, example with shaft Ø 12 H7

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.

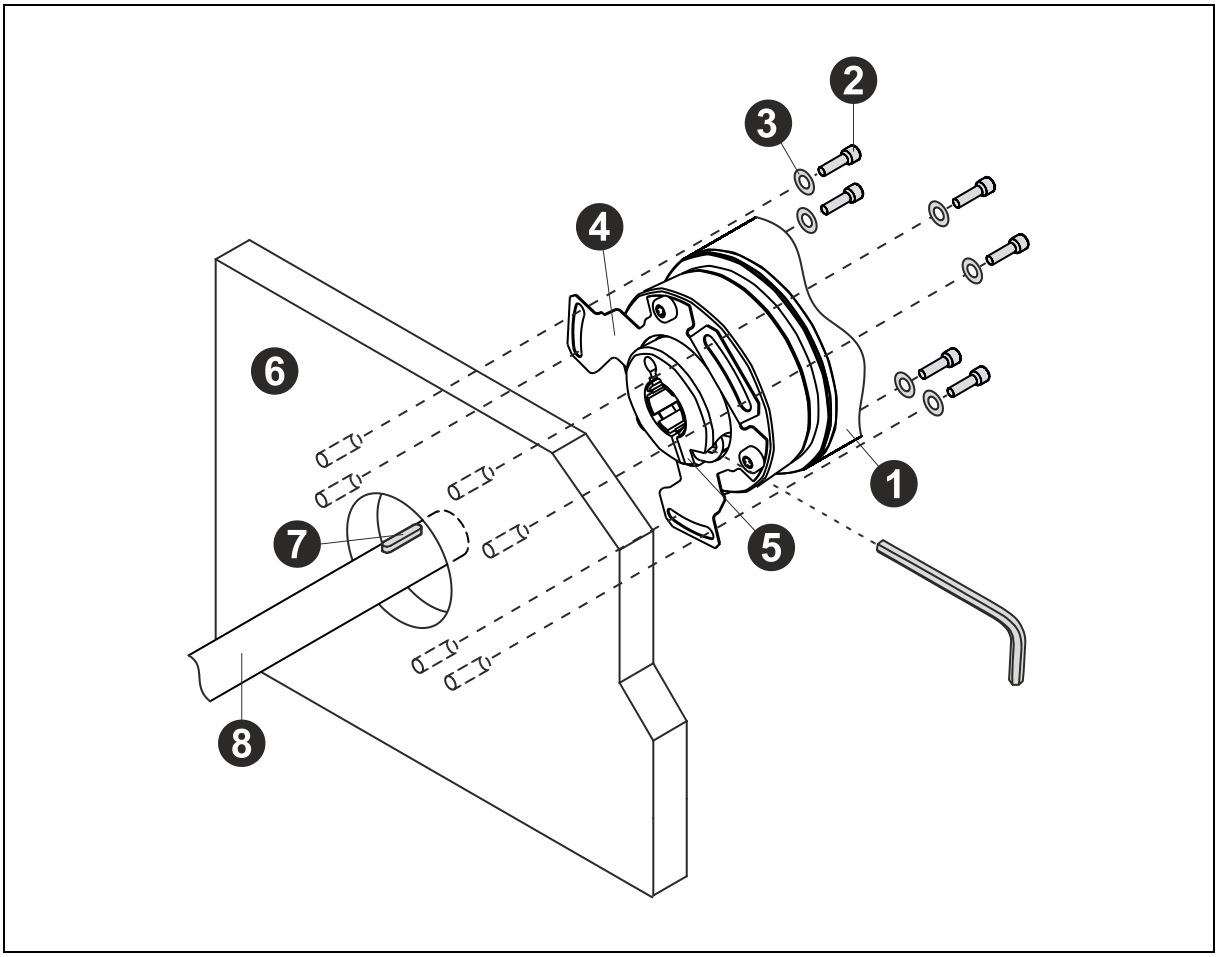


Figure 5: Assembly with torque arm (spring steel sheet), illustration showing the principle

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: 9 "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 8.
- 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 (machine) 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 clamping ring assembly requirements must be observed, see Chapter: 5.2.1 "Requirements".

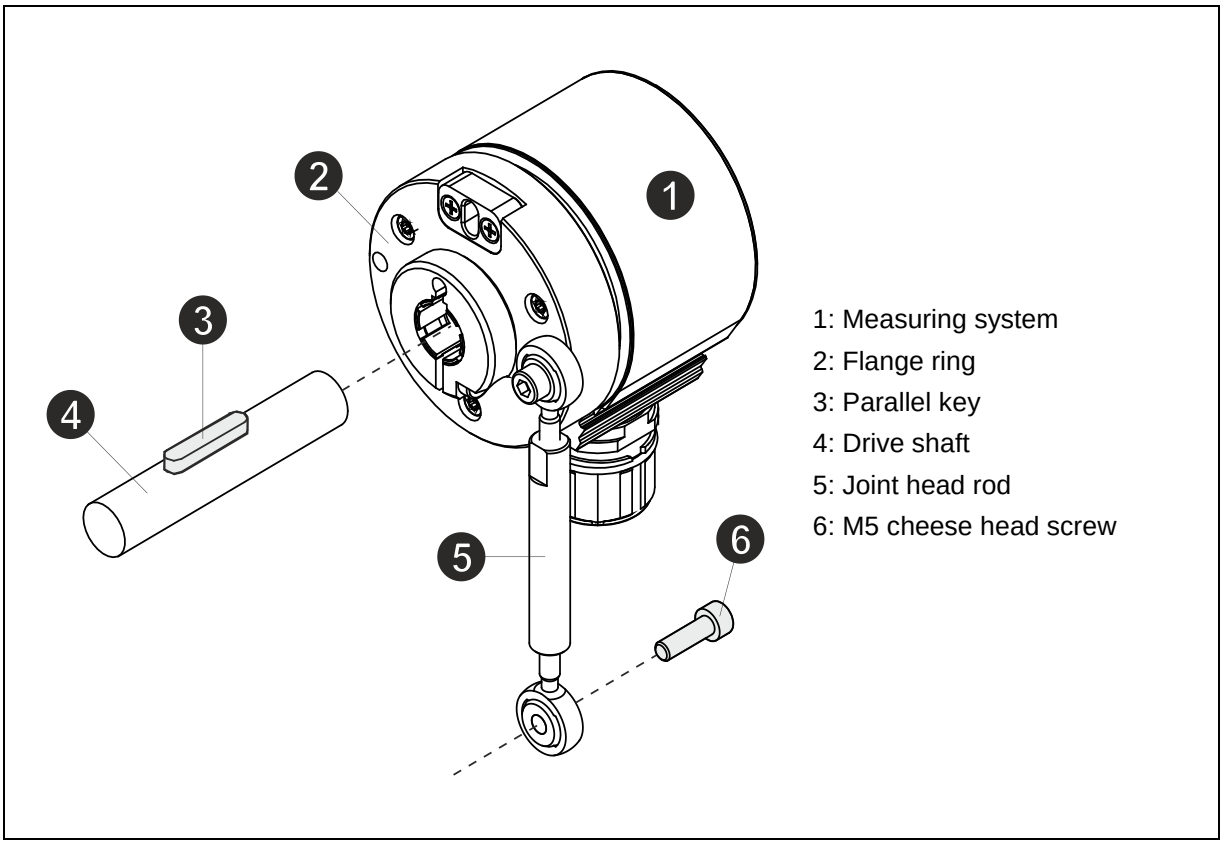


Figure 6: Positive engagement and joint head rod

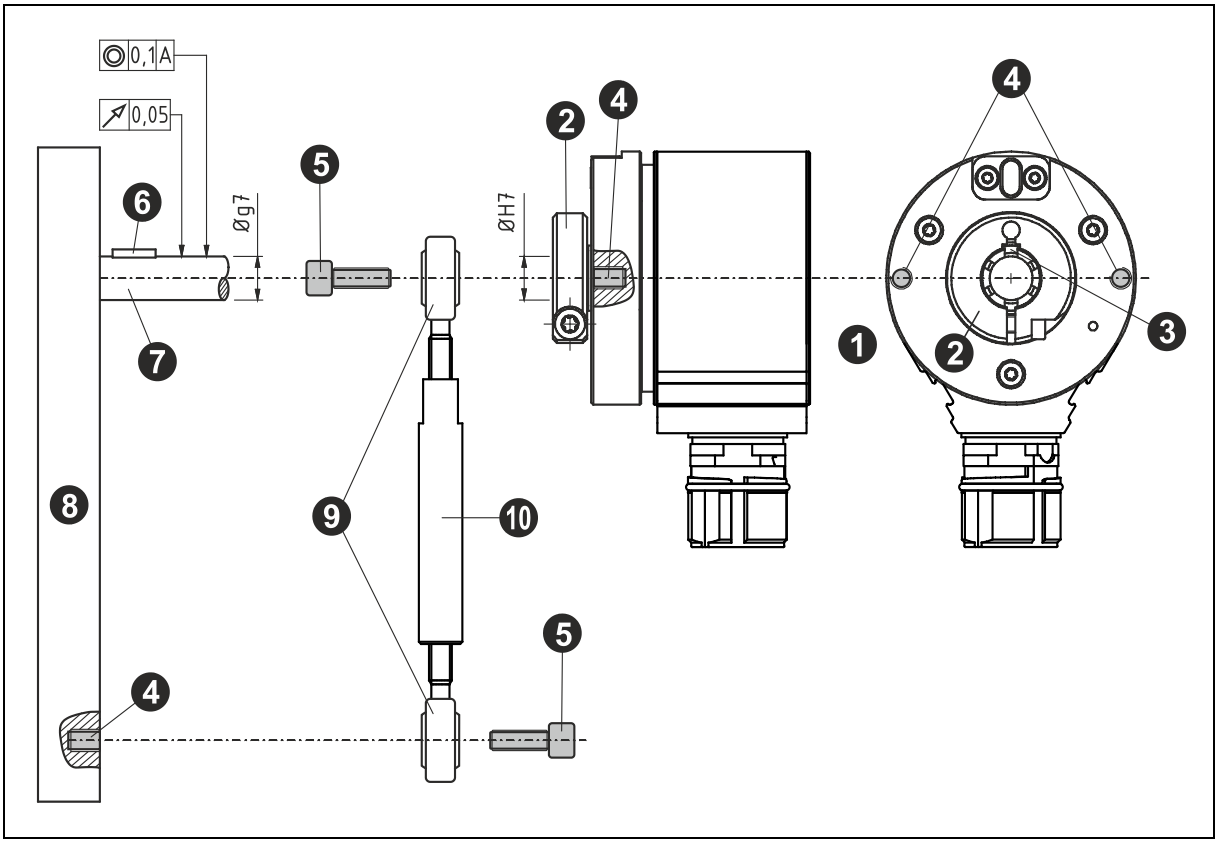


Figure 7: Shaft accommodation requirements

Components:

1: Measuring system with 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:

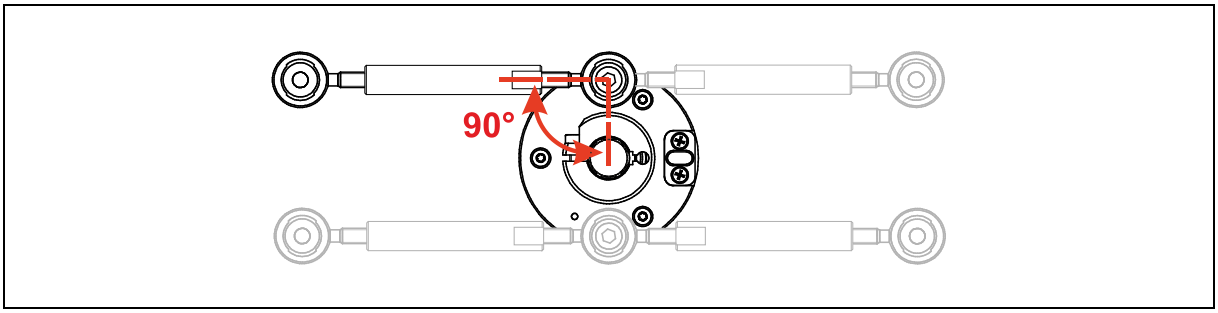


Figure 8: Joint head rod – mounting variants

6 Installation / Preparation for Commissioning

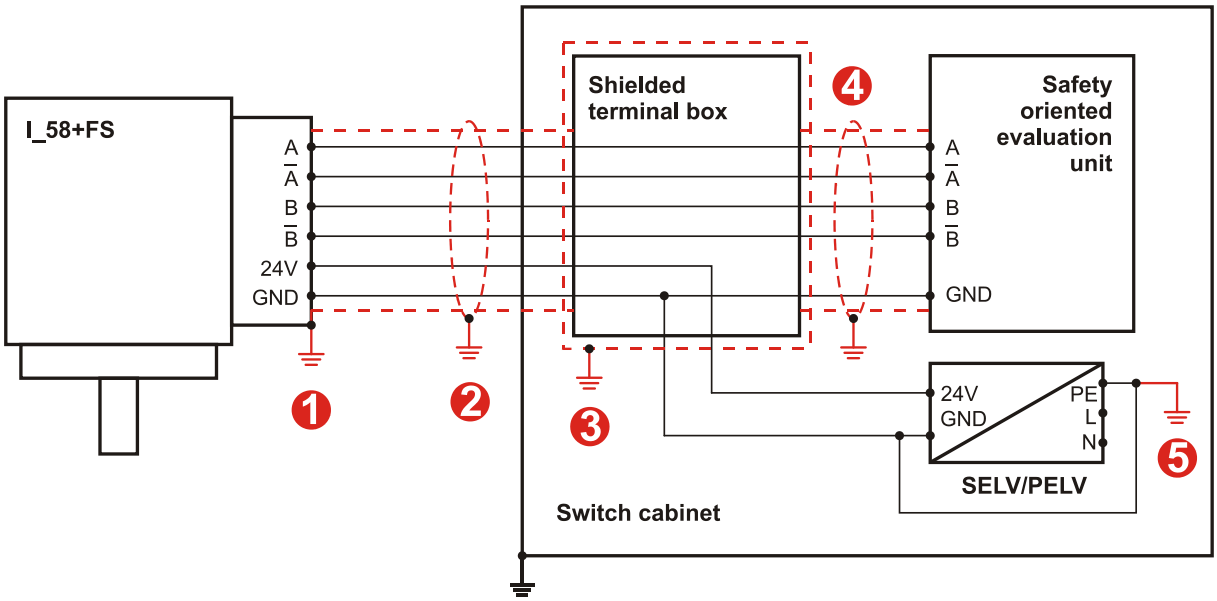
6.1 EMC requirements

⚠ WARNING ***Deactivation of the safety function due to radiated or conducted interference sources!***

- Radiated interference sources due to radiophones, lightning strikes in networks, mobile phones and emissions from individual devices can cause malfunctions in the measuring system.
- Conducted interference sources in particular, such as frequency-controlled drives (system perturbations), have a negative effect on the function of the measuring system.
  - ➢ The 24 V power supplies used must fulfil the requirements according to IEC 60364-4-41 SELV/PELV.
  - ➢ The shielding effect of cables must also be guaranteed after installation (bending radii!) and after connector changes. In cases of doubt, use more flexible and more reliable cables.
  - ➢ A 5-wire cable with a PE-conductor isolated from the N-conductor (so-called TN network) is recommended for the drive/motor cabling. This will largely prevent equipotential bonding currents and the development of interference.
  - ➢ A shielded and stranded data cable must be used to ensure high electromagnetic interference stability of the system. The shielding should be connected with low resistance to protective ground using large shield clips **at both ends**. The shielding should be grounded **in the switch cabinet only** if the machine ground is heavily contaminated with interference towards the switch cabinet ground.
  - ➢ Equipotential bonding measures must be provided for the complete processing chain of the system. Compensating currents due to potential differences across the shield to the measuring system must be avoided in particular.
  - ➢ Power and signal cables must be laid separately. During installation observe the national safety and installation guidelines for data and energy cables.
  - ➢ Observe the manufacturer's instructions for the installation of converters and for shielding power cables between frequency converter and motor.
  - ➢ Ensure adequate dimensioning of the energy supply.
  - ➢ Separation or delimitation of the measuring system from potential jammers.
  - ➢ Provide the use of filters.
  - ➢ Observe requirements for external and internal lightning protection.
  - ➢ To ensure safe and fault-free operation, the pertinent standards and directives must be observed. In particular, the applicable EMC directive and the shielding and grounding directives must be observed!
  - ➢ Upon completion of installation, a visual inspection with report should be carried out.

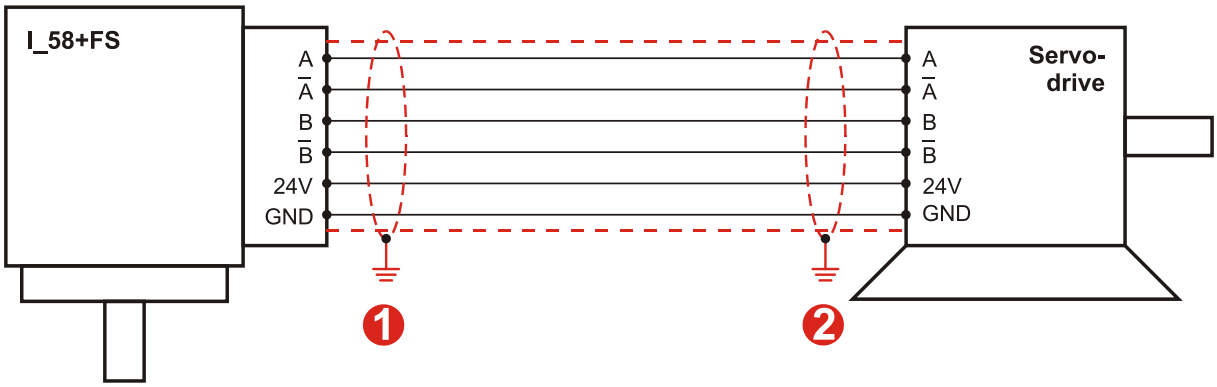
6.2 EMC conform wiring schemes

6.2.1 Connection scheme 1



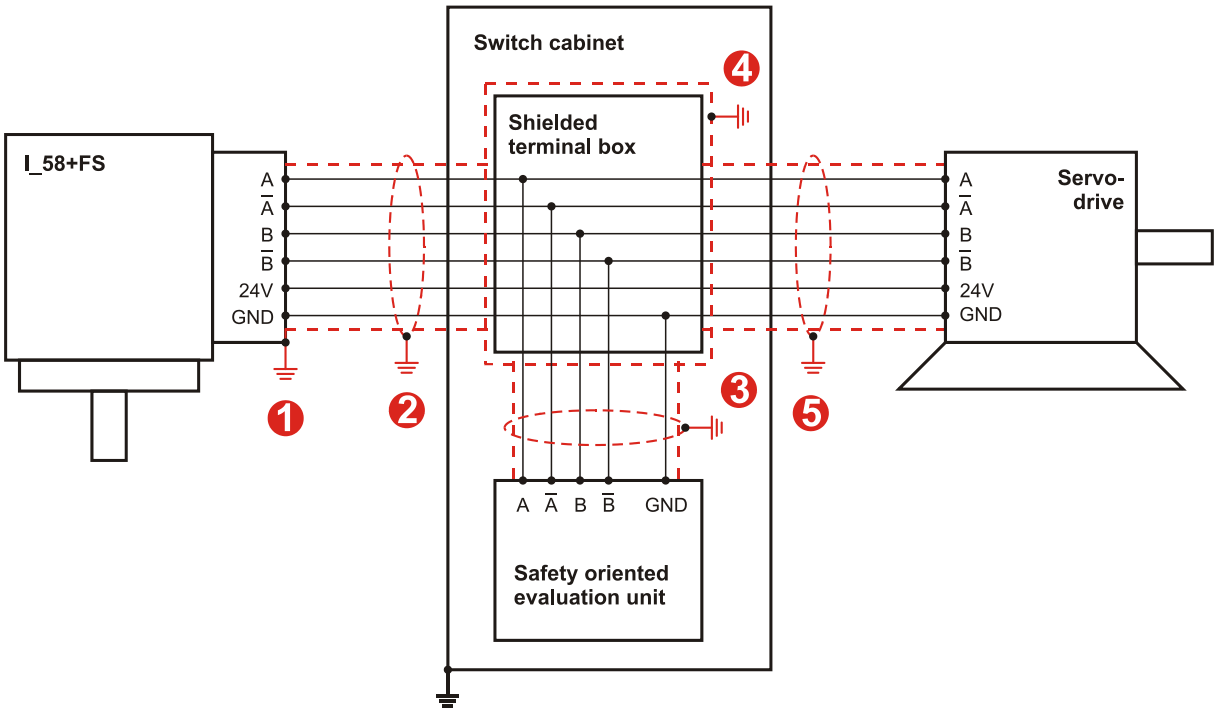
- 1x Ground connection (connection possibilities ❶, ❷, ❸, ❹ or ❺)
- Avoid ground loops
- Connect all shields double-sided
- Shielding must not be interrupted
- Twisted pair wires (A,/A), (B,/B)

6.2.2 Connection scheme 2



- 1x Ground connection (connection possibilities ❶ or ❷)
- Avoid ground loops
- Connect all shields double-sided
- Shielding must not be interrupted
- Twisted pair wires (A,/A), (B,/B)

6.2.3 Connection scheme 3



- 1x Ground connection (connection possibilities ❶, ❷, ❸, ❹ or ❺)
- Avoid ground loops
- Connect all shields double-sided
- Shielding must not be interrupted
- Twisted pair wires (A,/A), (B,/B)

6.3 Ground connection – measuring system

In principle, it is recommended that the ground connection of the measuring system has a good conductive connection to the functional earth of the machine.
This particularly applies to measuring systems with hollow or blind shaft at which the functional earth of the machine to the measuring system should be connected e.g. by cable eyes and a cable with min. 4 mm² (not contained in the extent of supply). For this purpose, corresponding thread drillings are available in the measuring system flange.

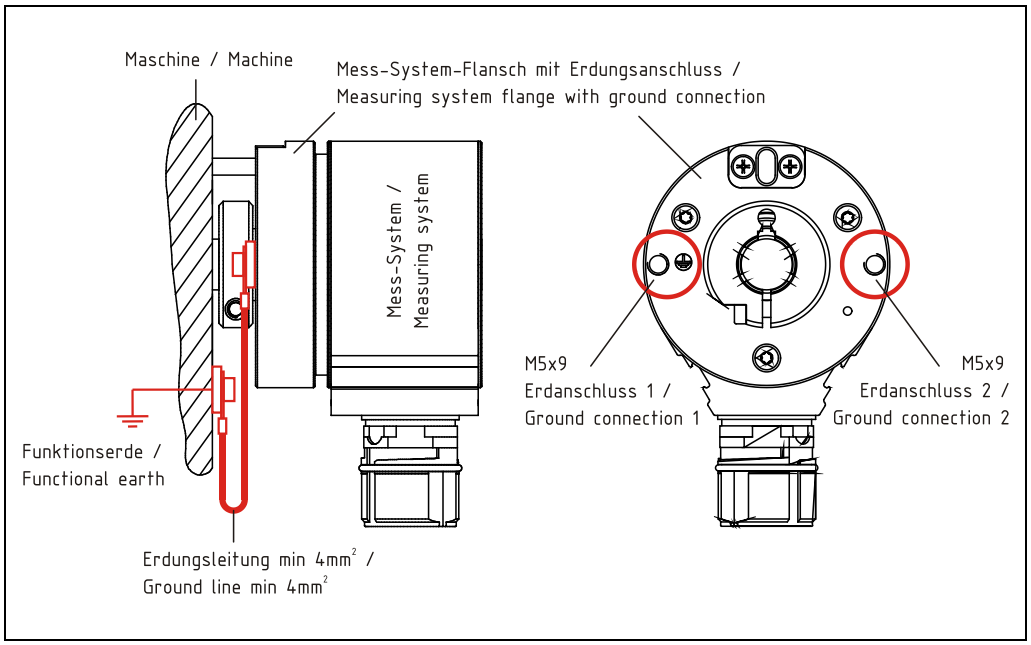


Figure 9: Ground connection – measuring system

-Protective housing:
Potential equalization cable - connection, see -User manual

6.4 Cable specification

Variant 1, analog incremental signals (SIN/COS)

Signal	Description
Supply	Min. 0.34 mm² and shielded, 0.5 mm² recommended. Generally the cable cross-section must be matched to the cable length.
SIN+ / SIN–	Min. 0.14 mm² and shielded, 0.25 mm² recommended. However, to ensure the signal quality and to minimize possible environmental influences, we recommend twisting each signal pair (±).
COS+ / COS–	
[4] Ref+ / Ref–	

Variant 2, square-wave incremental signals (TTL/HTL)

Signal	Description
Supply	Min. 0.34 mm² and shielded, 0.5 mm² recommended. Generally the cable cross-section must be matched to the cable length.
K1+ / K1–	Min. 0.14 mm² and shielded, 0.25 mm² recommended. However, to ensure the signal quality and to minimize possible environmental influences, we recommend twisting each signal pair (±).
K2+ / K2–	
[4] K0+ / K0–	

Ex-Protective housing:

The connection cable is an integral part of the explosion protection housing and cannot be freely selected. On the basis of the given cable parameters it must be checked, whether they meet the specific application requirements, see Ex-User manual.

[4] optional, the reference signal is not evaluated from a safety viewpoint

6.5 Permitted cable length

The permissible cable length at the transmission of incremental signals depends on the output frequency, the applied supply voltage and the ambient temperature of the measuring system, see the following diagrams.

The TR-own hybrid cable (Art.-No.: 64-200-021) was used for the measurements.

-Protective housing:

The error-free function of the incremental interface must be ensured with the cable used with the explosion protection housing and the application-dependent parameters must be checked before productive operation.

6.5.1 Analog incremental signals (SIN/COS)

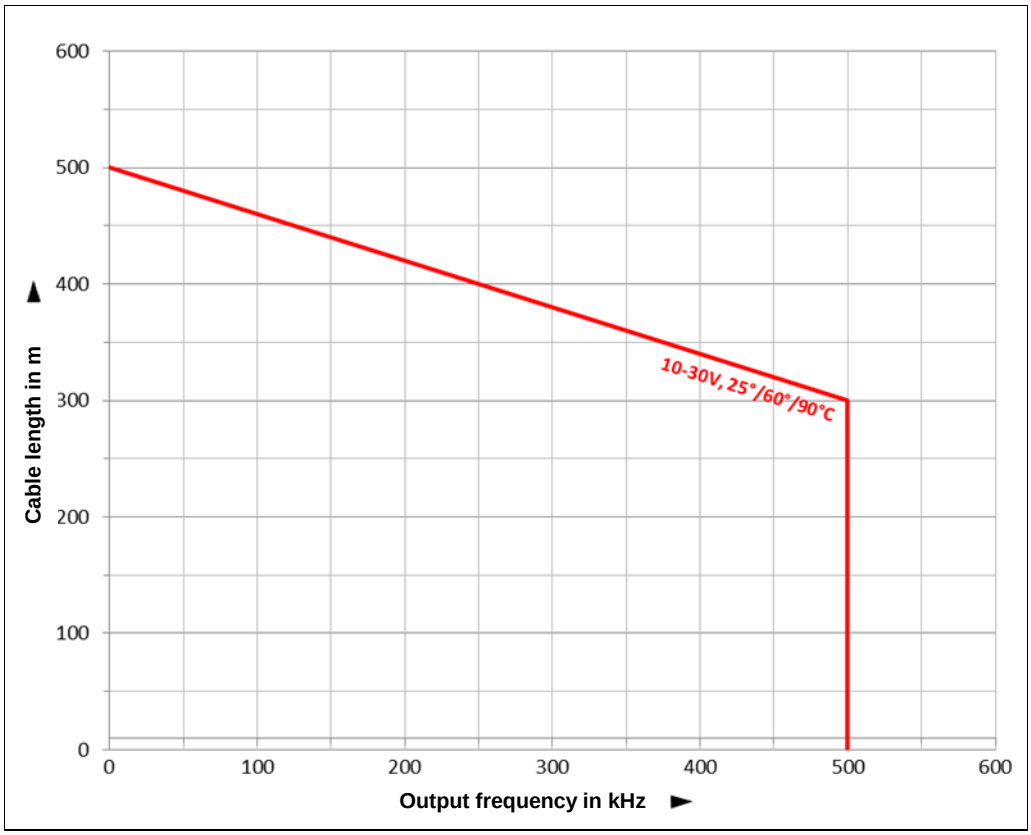


Figure 10: Maximum permissible cable length for SIN/COS interface

6.5.2 Square-wave incremental signals (TTL/HTL)

TTL interface:

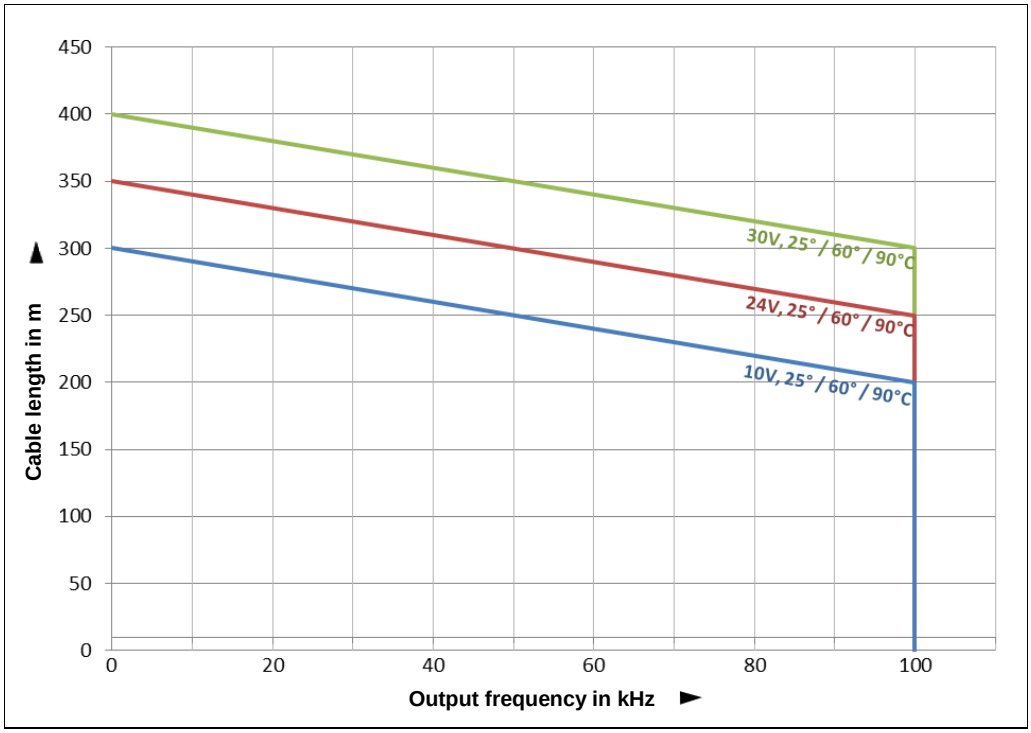


Figure 11: Maximum permissible cable length for TTL interface

HTL interface:

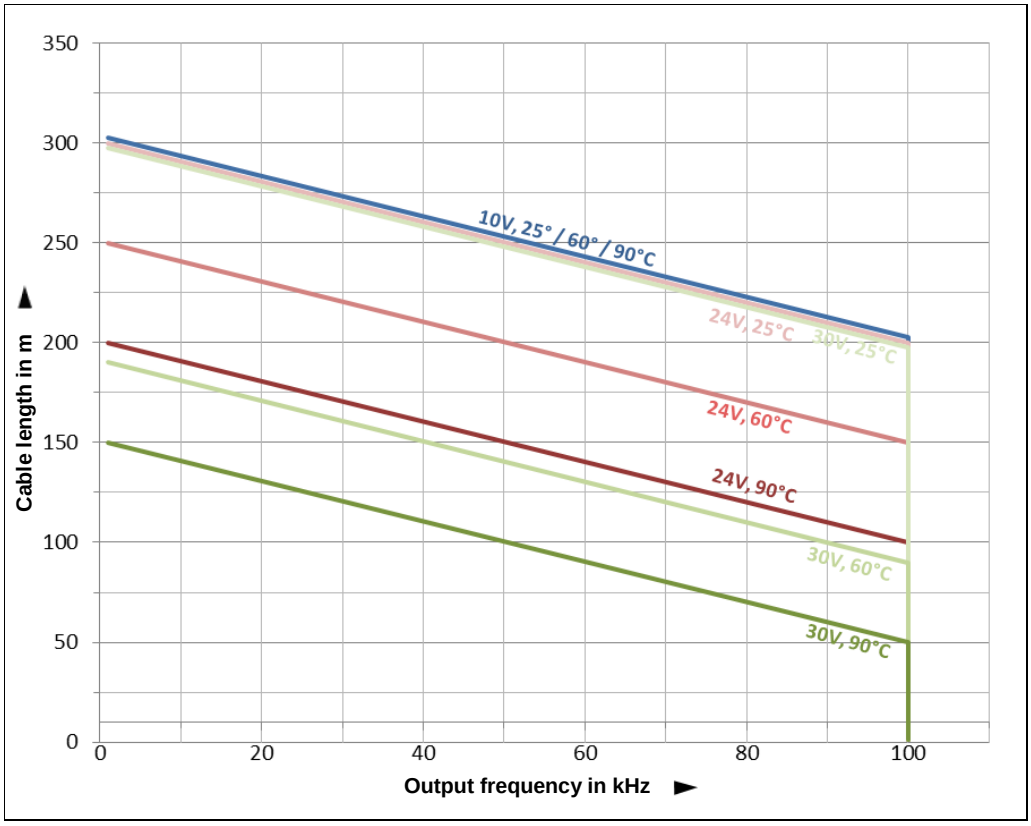


Figure 12: Maximum permissible cable length for HTL interface

6.6 Connection - Notes

Mainly, the electrical characteristics are defined by the variable connection technique.

The connection can be made only in connection with the device specific pin assignment!
At the delivery of the measuring system one device specific pin assignment in printed form is enclosed and it can be downloaded afterwards. Pin assignment download, see chapter 11.4.

6.6.1 Order number for the connectors

6.6.1.1 Suitably for the A coded male socket M12 - 8 pin.

Manufacturer	Name	Art no.
Binder (HTN: 99 1486 812 08)	Female socket – straight	62 000 1473
Murr	M12 Female socket, straight, shielded, with free cable end	7000-17121-286XXXX (e.g. 7000-17121-2860500 – 5 m) (e.g. 7000-17121-2862500 – 25 m)
Murr	M12 Female socket, 90° angled, shielded, with free cable end	7000-17141-2860150 (several cable lengths on request)

6.6.1.2 Suitably for the male socket M23 - 12 pin.

Manufacturer	Name	Art no.
Intercontec	Female socket, mating connector	62 000 249
TR - Electronic GmbH	System cable	90-397-XXX.X (e.g. 90-397-010.0 – 10 m)

7 Incremental interface

NOTICE

Danger of damage to subsequent electronics due to overvoltages caused by a missing ground reference point!

- If the ground reference point is completely missing, e.g. 0 V of the power supply not connected, voltages equal to the supply voltage can occur at the outputs of this interface.
  - ➢ It must be ensured that a ground reference point is present at all times,
  - ➢ or the system operator must provide appropriate protective mechanisms for the subsequent electronics.
- If the input voltage exceeds 30 V, these voltages occur accordingly at the HTL outputs. This can lead to damage of the output or input circuit of the downstream processing unit.

NOTICE

Danger of unnoticed damage to the internal electronics, due to unacceptable overvoltages!

- If overvoltages of >7 V DC are inadvertently applied at the incremental analog output signals SIN+, SIN–, COS+, COS–, Ref+ or Ref–, the measuring system must be checked in the factory.
  - ➢ The measuring system must be shut down immediately
  - ➢ When sending the measuring system to the factory, the reasons and circumstances relating to the overvoltage must be specified

The measuring system acquires the angular information from the connected process via the rotation of the shaft. A pulse disk is fixed to the shaft; this acquires the angular increments with a defined number of periods per revolution. A scanning unit with integrated optoelectronics generates electrical signals and outputs signal periods, which can be processed in a signal conditioner afterwards.

The resolution of the measuring system is defined by the number of light/dark segments (pulse number per revolution) on the pulse disk. A signal sequence of e.g. 1024 periods is output during one revolution. To evaluate the counting direction, a 2nd signal sequence with a 90° phase offset is output for the control.

The counter of an external control can be reset with an additional zero pulse, and the mechanics - control reference point can thus be defined.

7.1 Variant 1, analog incremental signals (SIN/COS)

The number of periods / revolution is dependent on the device variant. Resolutions of 1024, 2048 and 4096 periods / revolution are supported.

Measuring the signals against 0 V gives the following signal curve:

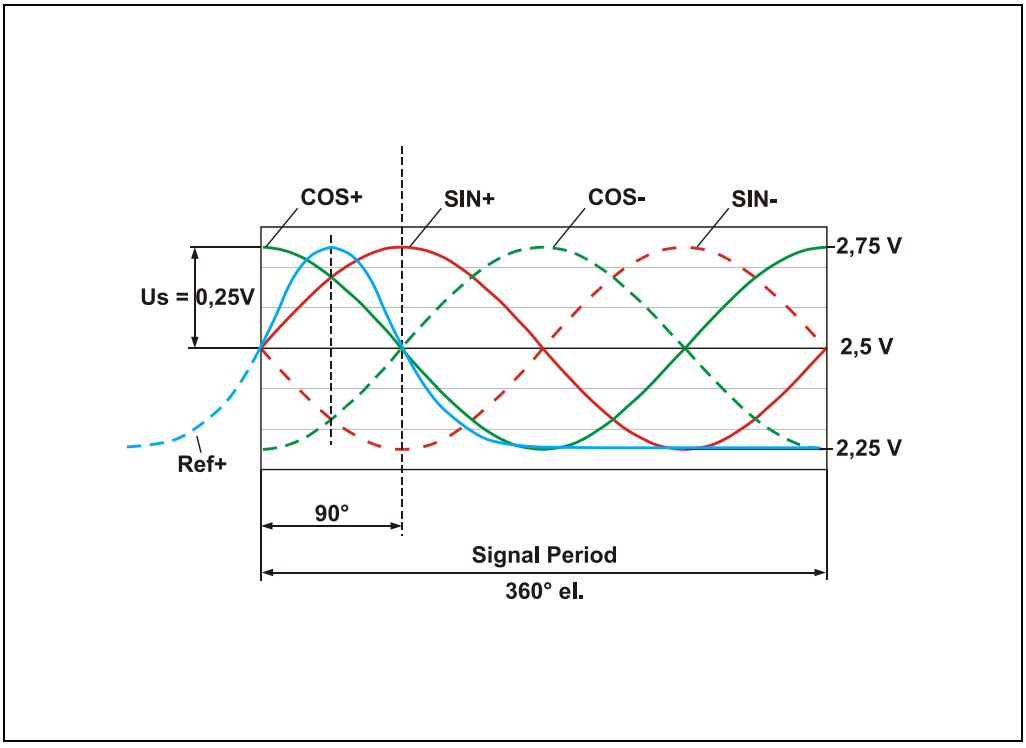


Figure 13: Signal curve with clockwise direction of rotation looking at the flange connection

Differential measurement of the signals gives the following signal curve:

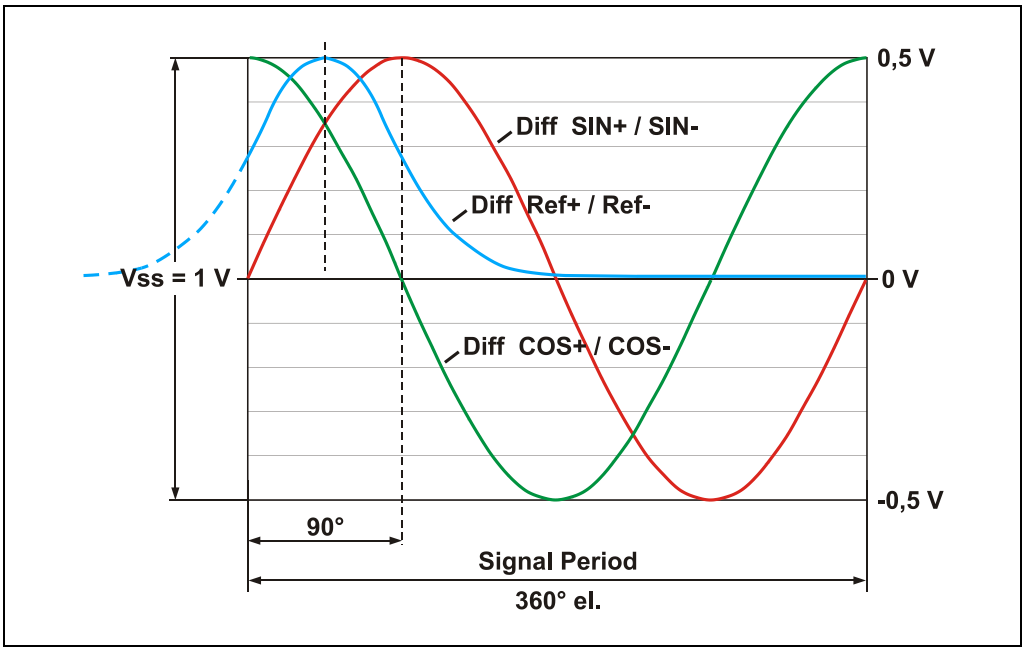


Figure 14: Signal curve with clockwise direction of rotation looking at the flange connection

7.2 Variant 2, square-wave incremental signals (TTL/HTL)

The number of pulses / revolution is dependent on the device variant. Resolutions of 1024, 2048 and 4096 pulses / revolution are supported.

The output levels are also specified by the factory setting; TTL output stages and HTL output stages are supported.

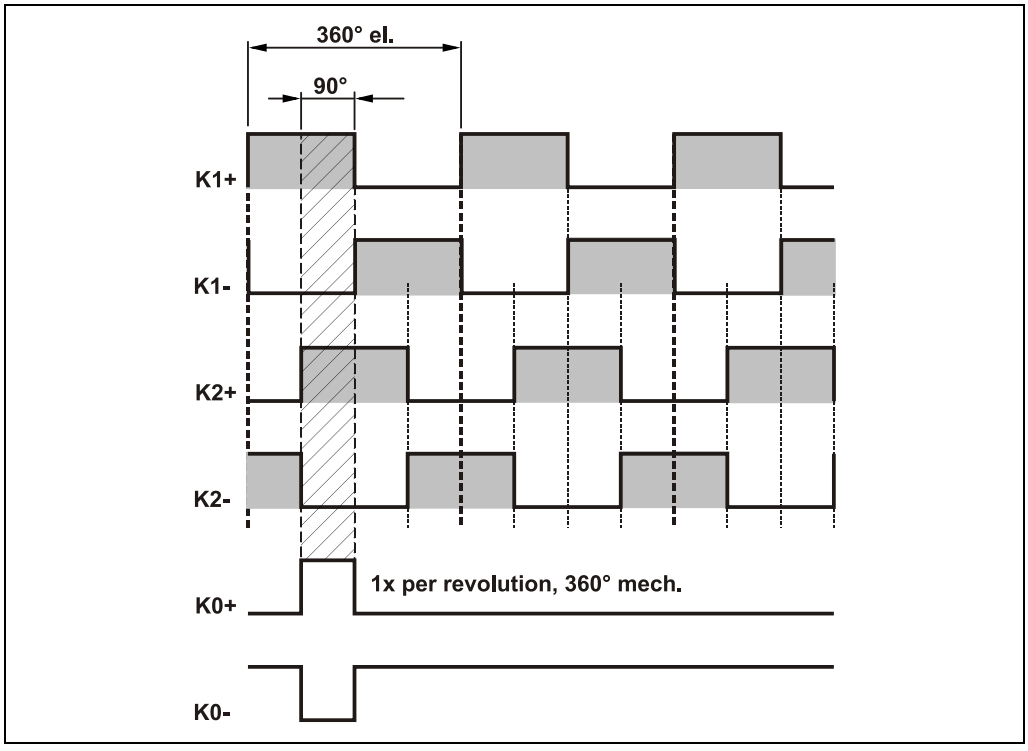


Figure 15: Signal curve with clockwise direction of rotation looking at the flange connection

8 Replacing the Measuring System

The following points must be noted when 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 GmbH.
- The new measuring system must be installed in accordance with the specifications and requirements in chapter "Mounting" on page 23 .
- The new measuring system must be connected in accordance with the specifications in chapter "Connection" on page 38 .
- Depending on the application, the output incremental value may need to be adjusted to the machine reference position.
- When recommissioning the replaced measuring system, correct functioning must be ensured first of all by means of a protected test run.

9 Accessories

Description	Order no.:
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

10 Checklist

We recommend that you work through the checklist during commissioning and when replacing the measuring system and store it as part of the overall system documentation.

Documentation basis	Date	Edited	Checked

Sub-item	To note	Can be found under	yes
Present user manual has been read and understood	–	Document no.: TR-ECE-BA-GB-0120	☐
Check that the measuring system can be used for the present automation task on the basis of the specified safety requirements	• Intended use • Safety functions of the fail-safe processing unit • Compliance with all technical data	• Chapter Intended use, page 11 • Chapter Safety functions of the fail-safe processing unit, page 13 • Chapter Technical data, page 19	☐
Fulfillment of the installation requirements	• Recommendation: Connection of the measuring system - shaft to the drive should be designed as form closure • The coupling to the drive must be over-dimensioned in accordance with **DIN EN 61800-5-2:2014-06 - Draft**	• Chapter Mounting, from page 23	☐
Voltage supply requirement	• The power supply used must meet the requirements of SELV/PELV (IEC 60364-4-41:2005)	• Chapter Electrical characteristics, page 20 • Chapter EMC requirements, page 31	☐
Correct electrical installation (shielding)	• Observance of basic rules for installation • Observance of wiring standards	• Chapter Installation / Preparation for Commissioning, Page 31	☐
System test after commissioning and modifications	• During commissioning and after any modifications all affected safety functions must be checked	• Chapter Safety functions of the fail-safe processing unit, page 13	☐
Device replacement	• It must be ensured that the new device corresponds to the replaced device • All affected safety functions must be checked	• Chapter Replacing the Measuring System, page 42 • Chapter Safety functions of the fail-safe processing unit, page 13	☐

11 Appendix

11.1 TÜV certificate

Download
- www.tr-electronic.com/f/TR-ECE-TI-DGB-0300

11.2 Revision list

Download
- www.tr-electronic.com/f/TR-ECE-TI-D-0301

11.3 EU Declaration of Conformity

Download
- www.tr-electronic.com/f/TR-ECE-KE-DGB-0340

11.4 Pin assignment

Download
- www.tr-electronic.com/service/downloads/pin-assignments.html
  The number of the pin assignment is noted on the nameplate of the measuring system.

11.5 Drawings

See drawing, related to the order number