Product overview / Technical basics

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You will find comprehensive information about the basic technical knowledge relating to our products on our home-page, at the address

www.kuebler.com/basics

Encoders | Introduction

Encoders can be used in applications, where length, positions, speed or an angular position are measured. They transform mechanical movements into electrical signals and can be divided into incremental and absolute measuring systems.

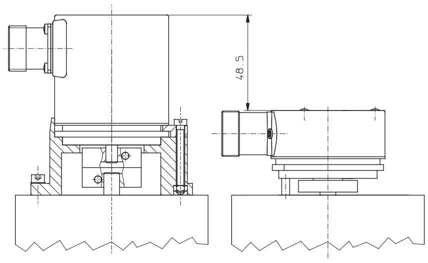
Incremental encoders generate pulses, where the number of pulses can be a measure of speed, length or position.

In absolute encoders, every position corresponds to an unique code pattern. No reference runs after starting-up are necessary as with incremental systems. Safety is increased and the time taken for reference runs is saved.

In principle we can supply all encoders, whether with a solid shaft or in a hollow shaft version.

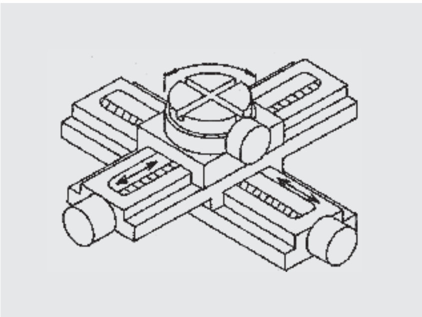
Using a hollow shaft encoder saves up 30 % of costs and up to 50 % of the required space compared to a shaft encoder. This is achieved by avoiding additional couplings, brackets and other assembly aids.

To mount a hollow shaft encoder it just needs to be pushed onto the shaft, clamped, and in the simplest case prevented from rotating by using a cylinder pin. Moreover, in principle, hollow shaft encoders require less installation depth.

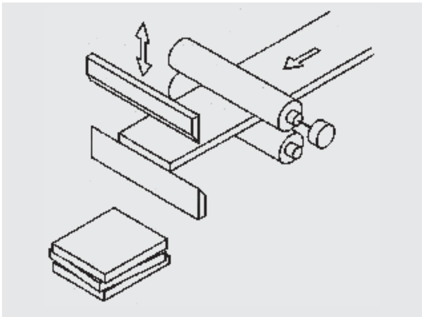


Application examples

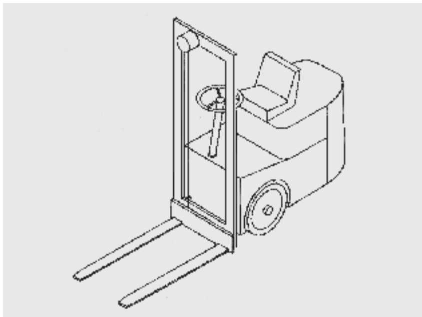
Angular measurement



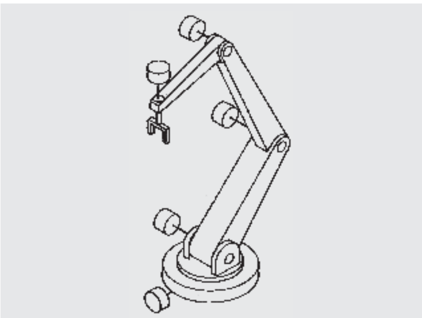
Positioning



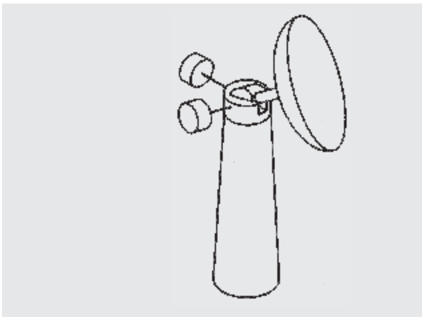
Detecting of fork's position



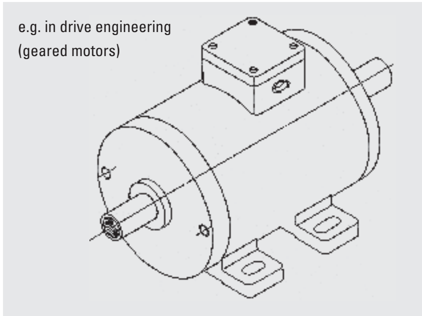
Detecting of position



Angular measurement



Velocity measurement



Encoders | Functional principle

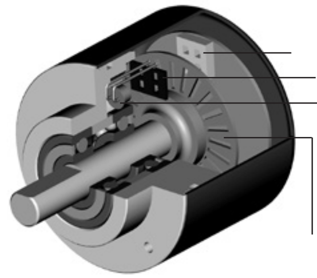
Assembly and function

Optical scanning (incremental)

A disc fitted with a grating, having a code pattern of slits and bars, is mounted so that it can rotate between an LED and a receiver.

The light emitted by the LED is modulated by the mask and grating and then strikes the receiver, which produces a signal proportional to the luminosity.

When the disc rotates this signal has a shape that approximates to a sine wave.



Optical scanning (absolut)

The light that is emitted by an LED is modulated by a code pattern, which is applied to a rotating disc; this is scanned by a special Kübler Opto ASIC. A unique bit pattern is assigned to each position and this is generally available as Gray Code.

The advantage, compared with incremental encoders, lies in the fact that any movement of the shaft whilst voltage is not applied is immediately detected when power is re-applied, ensuring the correct position is always available.

Encoders | **Incremental encoders**

Processing of the signals (optical, incremental encoders)

The sine wave signals are then processed in a specially designed electronic circuitry. Most controllers require square-wave signals on their input.

The signals are therefore pre-processed accordingly in the encoder and made available using various output circuits depending on the application.

Inverted signals

When used in environments, with a lot of electrical noise and/or if very long cable distances are required, we recommend using encoders with inverted (complementary) signals.

These signals are always available with output circuits of the RS422 type and sine wave outputs or optionally with push-pull outputs.

Resolution

The required angular or linear resolution of a application determines the number of pulses per revolution. Linear movements must first be converted into rotary, for example by means of a spindle.

Example:

An encoder is equipped with a measuring wheel. Every revolution corresponds to a distance of 200 mm (circumference). The accuracy should be 0.1 mm. What is the required resolution (ppr)?

given:
- Circumference of the measuring wheel = 200 mm
- Accuracy of the system = 0.1 mm

wanted:
- Resolution of the encoder [ppr] [1)]

$$\text{Resolution} = \frac{\text{Circumference}}{\text{Accuracy}}$$

The required resolution would be 2000 ppr [1)].

Pulse frequency

The required pulse frequency can be calculated as a result of the number of pulses per revolution (PPR) and the maximum speed (RPM). The maximum pulse frequency is shown in the data sheet specifications for each encoder.

Generally this is 300 KHz, but can be up to 800 KHz with high-resolution encoders.

Example:

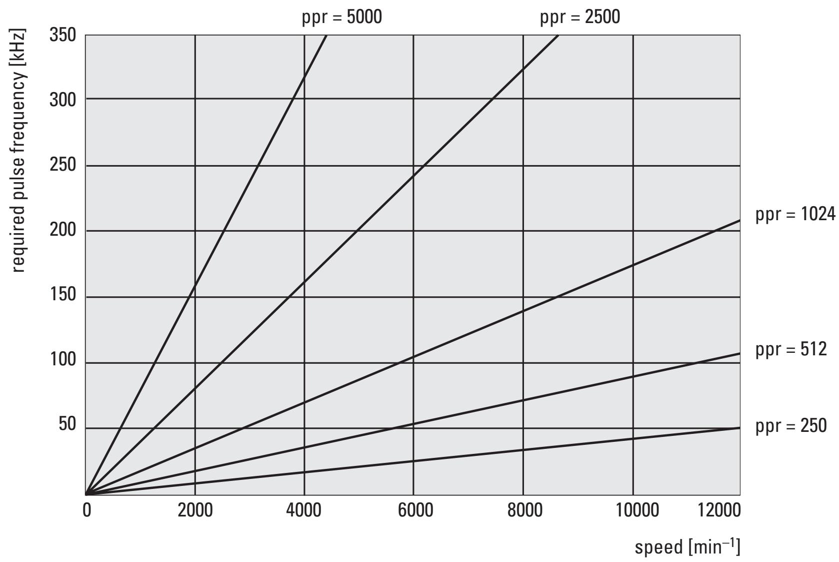
given:
- Speed = 3000 min^{-1}
- Resolution of the encoder= 1000 ppr [1)]

wanted:
- Required pulse frequency of the encoder

$$\text{Pulse frequency} = \frac{\text{Speed x Resolution}}{60}$$

The required pulse frequency is thus 50 KHz. This can now be compared with the maximum possible pulse frequency of the desired encoder.

This diagram can be used to estimate the required pulse frequency. [1)]



1) ppr = Pulses per revolution

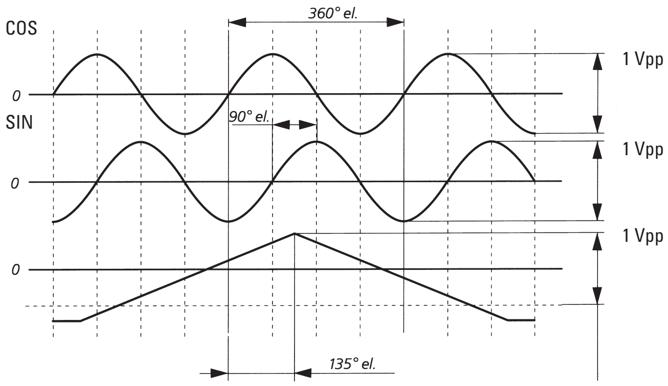
Encoders | **Incremental encoders**

Sine wave outputs

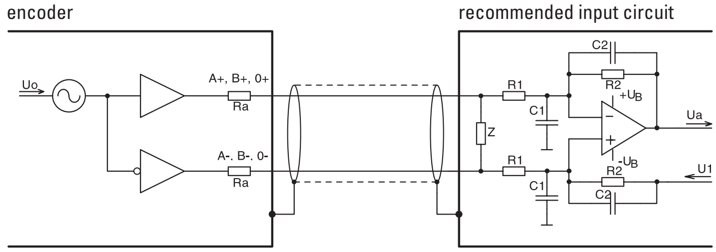
The sine wave signals are available as voltage signals. They can be further processed in the evaluation electronics. Due to the interpolation of the two signals, which are 90° out of phase, a very high resolution can be achieved.

Further they are very suitable for digital drives with a very slow movement, e.g. for grinding machines or lifts and elevators.

- Shaft turning clockwise, top view of shaft
- 0 pulse is generated once per turn (only with 5804 / 5824)



Output circuit and recommended input circuit for sine wave voltage signals



R_a = 10 Ω
C_1 = 150 pF
C_2 = 10 pF
R_1 = 10 kΩ
R_2 = 33 kΩ
U_0 = 2,5 V ±0,5 V

Z = 120 Ω
$U_1 = U_0$

operation amplifier:
e.g. MC33074

Encoders | Absolute encoders

Versions

Singleturn encoders

Depending on the number of divisions they generate unique positions per revolution. After one complete revolution the process re-commences at the start position.

They are suitable for angular measurement over a maximum of one turn of the shaft (=360°), for example in robotics, with cam controllers and in other controlled rotary motion.

Multiturn encoders

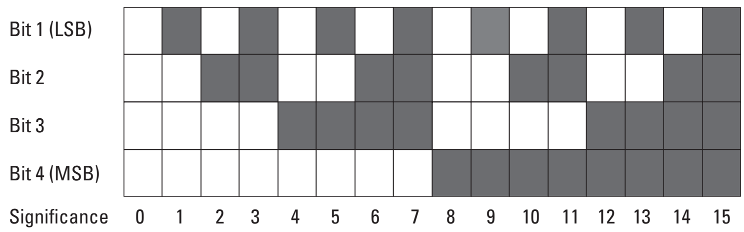
Up to 17 bit unique angular positions per revolution are provided. In addition the number of revolutions is detected. Up to 4096 (12 bit) unique revolutions can be made available on the output.

Multiturn encoders are suitable for angular measurement over more than one turn of a shaft, for example with longer traverse paths, such as high rack storage areas, cranes or machine tools.

Code types

Binary Code

The Binary Code can be processed very easily by computer systems. When using optical read-out, errors may occur, because the change from one bit to another on the different concentric tracks (LSB, LSB+1...) is not exactly synchronized. Due to this, without any correction of the code, the position information could be wrong.

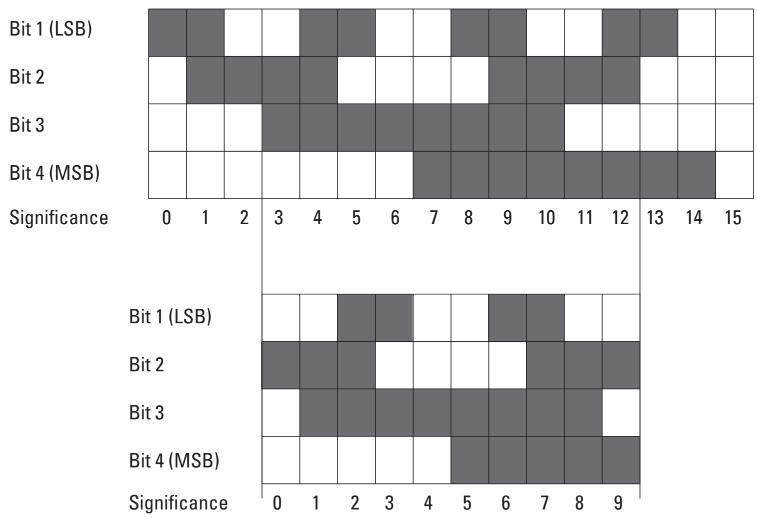


Gray Code

The Gray Code is a single-step code, which guarantees that from one position to the next only 1 bit changes. This leads to reliable scanning of the code and consequently of the positions.

Symmetrically capped Gray Code (Gray-Excess):

If a particular section of the complete Gray Code is extracted, this results in the so-called Gray Excess Code. This permits even-numbered divisions, such as 360, 720, 1000, and 1440.



Reversion of the Gray Code

The code values increase when the shaft is turning clockwise. The Gray Code is reversible, i.e. if the most significant bit (MSB) is inverted, the code values decrease when the shaft is turning clockwise.

Encoders | Absolute encoders

The mechanical Sendix Multiturn stage with gear

- Multiturn gear with purely optical scanning technology. Completely resistant to magnetic fields.
- First stage with double bearing layer.
- Special materials ensure temperature stability and long service life.
- Through hollow shaft diameter up to 14 mm
  - up to 15 mm as blind hollow shaft.
- Specially developed gear teeth allow for very high rotational speeds and eliminate wear.

Encoders | Absolute encoders

Outputs

To transfer the position data to a controller, different interfaces are available.

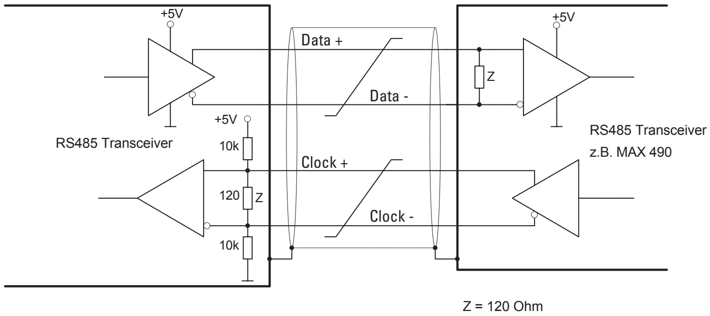
Synchronous Serial Interface (SSI)

Compared to the parallel interface, the SSI interface needs less components and the EMC characteristics are much better.

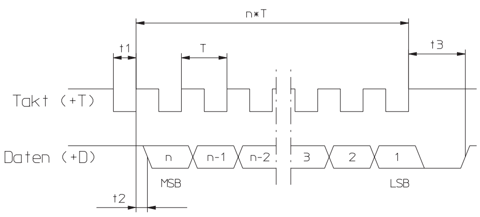
In addition less lines are needed for transmission and the possible cable length is much longer.

Output circuit and recommended input circuit

5862, 5882, 9081



Data transmission SSI



t_1 = T / 2

t_2 < 1 / (4 x fmax)

t_3 = Monoflop time (see below)

n = Resolution in bit

$1/f_{max} \leq T \leq 1/f_{min}$

f_{min} = min. clock rate (see data sheet)

f_{max} = max. clock rate (see data sheet)

At rest, the clock and data lines are at a high level. With the first falling clock-pulse edge, the current encoder data are stored in the buffer ready to be sent. With the next rising clock-pulse edge, the data are transmitted bit by bit, starting with the MSB. The transfer of a complete data word requires n+1 rising clock-pulse edges (n=resolution in bit), e.g. 14 clock signals for a complete readout of a 13 bit encoder.

After the last positive-going clock-pulse edge the data line will remain for the duration of the monoflop time t3 at a low level, until the encoder is ready for a new data word. The clock line must stay high for at least as long, and then can begin a new read-out sequence again with the next falling edge.

Please note!

Only for type 5850, 5870, 5862, 5882 and 9081:

The updating of the data occurs synchronously with the read-out cycle. So, the data are as up-to-date as the interval time between two read-outs.

A periodic read-out of the encoder in the application is therefore recommended, using appropriately short cycle times, so that current position values are constantly maintained. It is not possible to read out the same data word several times.

Monoflop time of the encoder: t_3 = max. 40µs

Only for the new Sendix absolute encoders:

The updating of the data occurs immediately with the first falling edge of the clock signal. The data are thus always up-to-date. If a repeated read-out of the same data word is desired, then a new clock sequence must be started within the time interval t_3. If the clock sequence is terminated before the necessary number of clock pulses, needed for a complete readout of the data word, has been transmitted, then after a further time interval t_3 the data line will go high again and signal that the last read-out sequence has been aborted. It will also indicate that it is ready for a new data word to be sent. Monoflop time of the encoder: t_3 = see data sheet.

Encoders | Absolute encoders

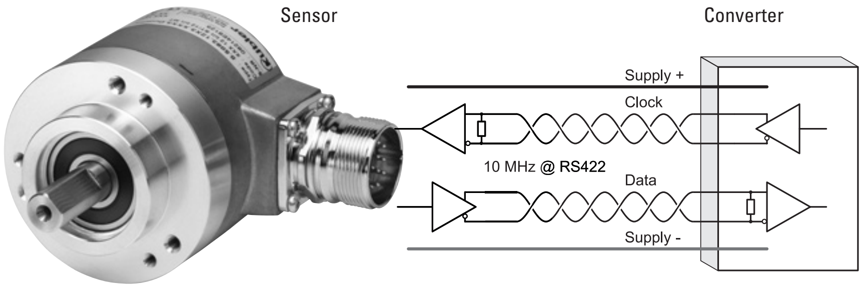
BiSS Interface

Point-to-point communication

- Bidirectional isochronous connection between drive, converter and sensor.
- Purely digital link for maximum performance, reliability and safety in transmission.
- Reduction of hardware, installation and maintenance work.

Advantages at a glance

- Flexible.
- Fast and safe.
- Cost-effective and non proprietary / Open source.
- Fully digital and bidirectional.
- Suitable for motor feedback systems.
- Plug and Play.



Extended possibilities with BiSS

- Motor data and maintenance information can be stored and read out easily in the encoder.
- Condition monitoring through register communication.

Easy supplementing of the BiSS master function

- The existing standard control hardware can mostly be used also for BiSS.
- Extension by firmware update is in most cases possible.
- BiSS as a real alternative to existing, RS422 or RS485-based interfaces.
- Fast and simple BiSS master implementation with free-of-charge BiSS IPs on processors and FPGAs.

Details about our BiSS interface can be found on our website at: www.kuebler.com/biss-interface

Encoders | Electromagnetic compatibility

EMC compliant installation

EMC = Electromagnetic compatibility

Safety modules monitor the signals from sensors and in particular from encoders very intensively. This is necessary, as an encoder signal contains positioning or rotational speed regulation information. EMC is considered as one of the main causes of malfunctions in plants and machines during installation and commissioning. Generally, EMC problems translate into sporadically occurring errors or phenomena.

Therefore, one of the main tasks of Safety-M safety modules is to detect and display such signal changes. What is sometimes wrongly described as availability problems is nothing but the effects of insufficient EMC measures.

Several guidelines are to be observed in order to maintain the best signal quality possible:

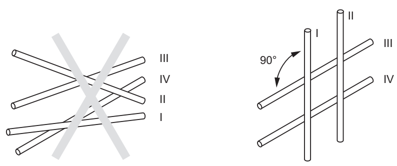
1) Cable routing

Cable routing strongly contributes to the EMC of a plant.
The cables must be classified in four groups I, II, III and IV:

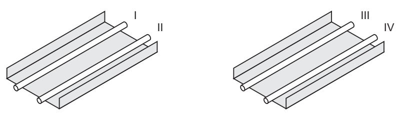
Group I:	Very sensitive to interference (Analog signals, measuring lines).
Group II:	Sensitive to interference (digital signals, sensor cables, 24 VDC switching signals, communication signals such as e.g. fieldbuses).
Group III:	Source of interference (control cables for inductive loads, unswitched power cables, motor brakes, contactors).
Group IV:	Strong source of interference (frequency converter output cables, welding plant power supply cables, switched power cables).

Lines should always be routed so that the signal lines are separated from the power supply lines:

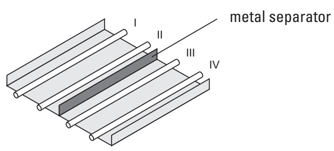
Cross lines of groups I, II and of groups III, IV at right angles.



Ideally:
route the lines in different cable channels.



Alternative:
separate the lines using a metal separator.



Encoders | Electromagnetic compatibility

2) Shielding

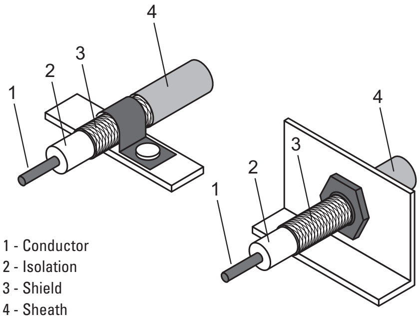
Signal lines should be shielded.

For long signal lines, the cable should be grounded at several locations along the line.

Screwed cable fittings should not interrupt the shield, but take it on (see chapter connection technology).

The shield should be applied on a large surface on the functional earth.

If possible, no compensation currents should flow through the shield. These currents appear when the mass does not have the same reference potential.

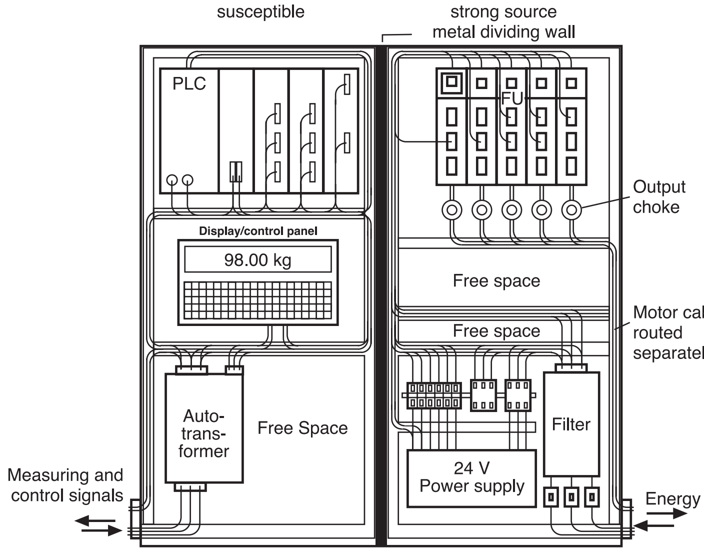


1 - Conductor
2 - Isolation
3 - Shield
4 - Sheath

3) Cabinet layout

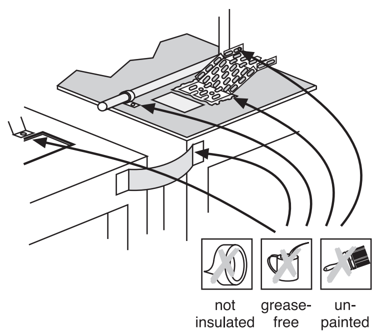
The products should be arranged in functional groups in a cabinet.

The cabinet itself should be equipped with a functional earth applied on large surfaces. The cabinet elements should be connected by means of high-frequency, low-impedance connections.

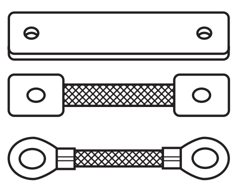


According to VDE 0100, the functional earth is not identical with the protective earth!

Protection against dangerous contact voltage is only a secondary task of the grounding connections.



Typical connections for proper potential equalisation, with the largest contact surface and cross-section possible.



Source: ZVEI

Encoders	Installing encoders	

Introduction

Encoders shafts and in turn their bearings are subjected to loads for a variety of reasons:

- Installation tolerances when mounting the encoders (radial and angular displacement).
- Thermal changes, e.g. linear expansion of the drive shaft.
- Effects of wear, e.g. radial runout of the drive shaft or vibrations.

These load factors have a direct effect on the life expectancy of the shaft bearings and on the quality of the signal.

Facilities must therefore be provided during installation to compensate for these forces. For encoders having a solid shaft this is generally done by using shaft couplings between the drive shaft and the encoder shaft. The solution with hollow shaft encoders is to use stator couplings, fixing brackets or torque stops between the encoder flange and the mounting surface.

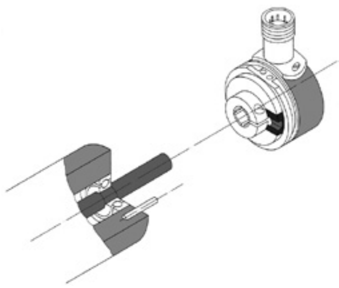
Not making use of a coupling but instead rigidly mounting the shaft and the encoder housing generally leads to unacceptably high loads on the bearings; the ensuing wear will cause the encoder to fail prematurely.

In order to avoid permanent damage of the encoder, certain bearing loads should not be exceeded.
If hollow shaft encoders are correctly installed and the torque stops or stator couplings that are available from Kübler are used, then no problems should occur. For solid shaft encoders the maximum permitted axial and radial loads are shown in the appropriate technical data.

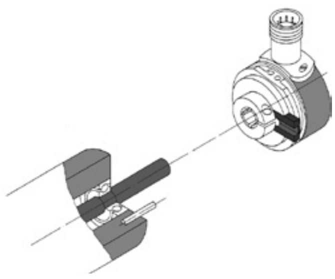
Mounting options for hollow shaft encoders

Hollow shaft encoder with torque stop and pin

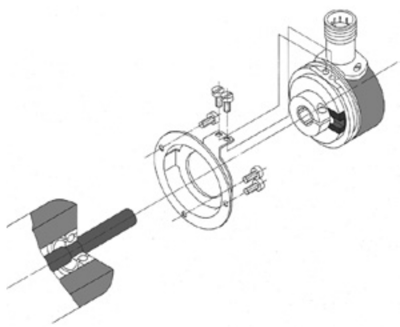
(easiest and fastest mounting)
Standard hollow shaft encoders are equipped with the torque stop (cylindrical pin not supplied).



Extended torque stop and long pin



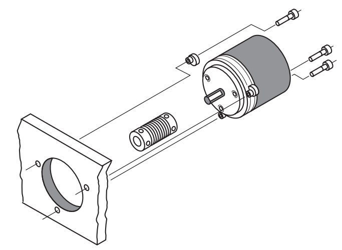
Stator coupling



Mounting examples for shaft encoders with synchronous flange

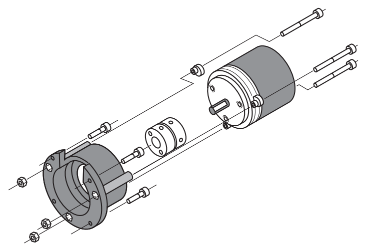
Fastening eccentrics + coupling

(to reduce shaft overload)



Assembly bell, fastening eccentrics + coupling

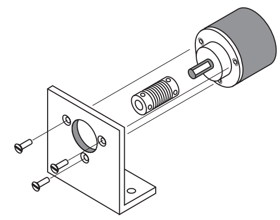
(to prevent shaft overload and to isolate the encoder thermally and electrically)



Mounting examples for shaft encoders with clamping bracket

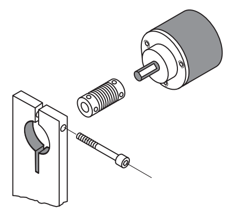
Angular bracket + coupling

(to reduce shaft overload)



Clamping device + coupling

(to reduce shaft overload)



Loading of encoder shaft bearings using coupling forces

With all spring couplings (shaft coupling, stator coupling, fixing bracket), alignment and axial errors are converted to a force that corresponds to the spring constant of the coupling.

This force has to be absorbed by the encoder shaft bearings. When installing an encoder, this should be done with as little force as possible, i.e. without any unnecessary initial tension on the coupling. If this is adhered to, then with all Kübler couplings adequate tolerance compensation is guaranteed for the whole service life of the encoder bearings.

This force does not occur with torque stops for hollow shaft encoders, where the encoder is prevented from turning also by means of a pin or rod.

Although the encoder is prevented from rotating due to a rigid interlock, the encoder is still free to move in any other direction. This is of course dependent on it being mounted in such a way that it has freedom to move radially and especially axially (thermal linear expansion of the drive shaft!).

Possible errors in accuracy due to couplings

1. Deviations in accuracy caused by torsion of a spring coupling (in particular shaft couplings).

This deviation in accuracy is defined by the torque to be transmitted (bearing friction and mass moment of inertia) and by the torsional spring constant of the torque stop.

The following applies:

$$\text{Max. error (degree)} = \frac{\text{max. torque [Ncm]}}{\text{torsional spring constant [Ncm/Grad]}}$$

The following table serves to estimate the ratio between such an error and the smallest increment of an encoder:

Relationship between the resolution of an encoder in bit and the smallest increment in angular degrees:

Resolution	binary	10 bit	11 bit	12 bit	13 bit	14 bit	17 bit
	ppr	1024	2048	4096	8192	16384	131072
Increment	degrees	0.352	0.176	0.088	0.044	0.022	0.0028
	degrees:min:sec	0:21:06	0:10:33	0:05:16	0:02:38	0:01:19	0:00:10
	sec	1266	633	316	158	79	10

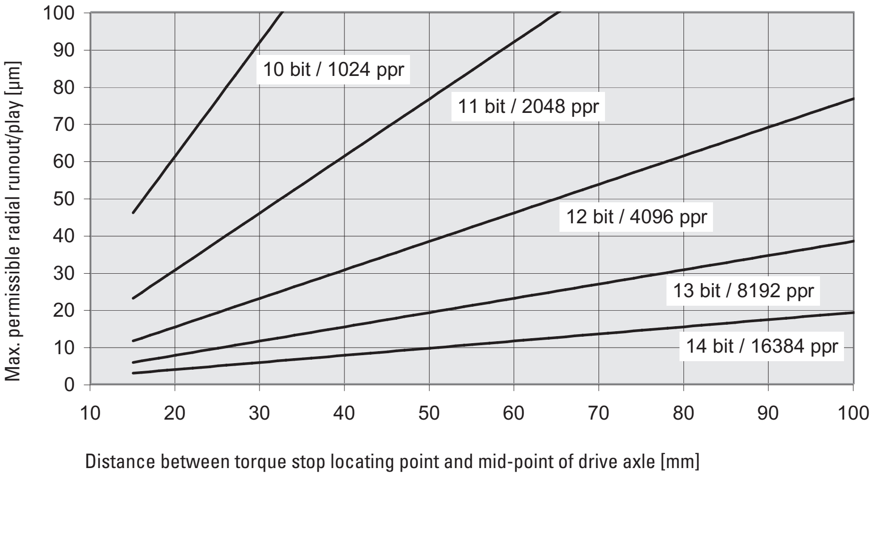
2. Deviations in accuracy caused by radial play in the drive shaft with asymmetrical mounting of the couplings.

Here one has to differentiate between couplings that are mounted in an axially symmetrical manner round the shaft (all shaft couplings, many stator couplings) and asymmetrically mounted couplings (many stator couplings, all mounting brackets and pin-based torque stops).

With asymmetrical couplings deviations in accuracy can arise due to radial movements of the drive shaft (radial runout/play); this is determined by the system. These deviations are dependent on the amount of the radial play and the distance of the torque stop locating point from the drive shaft.

The relationship is shown in the following diagram:

Maximum permissible radial runout to achieve an accuracy <1/2 LSB when using an asymmetrical 1 point torque stop.



Particular shaft loading due to toothed-wheels, gear-pulleys and similar elements

Measuring wheels, toothed wheels or gear pulleys, which are mounted directly on the encoder shaft, exert radial forces on the latter, dependent on prestressing and angular acceleration.

Kübler encoders are designed so that they can absorb these forces to a great extent. The maximum permissible load capacity of the shaft is shown in the technical data for the encoder.

If these load values may be exceeded in a particular application, then the encoder shaft must be isolated from the radial load by interposing an appropriate shaft with its own bearings that can absorb the forces.

Kübler offers suitable bearing blocks and bearing boxes for this purpose (please refer to the ‚Accessories' section in the catalogue).

Encoders | Technologies

Safety-Lock™

All Kübler encoders are equipped with the Safety-Lock™ bearing structure.

Safety-Lock™

Interlocked bearings, large bearing span and extra strong outer bearings ensure stability when subjected to vibration and tolerance of installation errors. Machine downtime and repairs are eliminated.

Safety-Lockplus™

The proven Safety-Lock™ construction with additional mechanically protected shaft seal.

HD-Safety-Lock™ = Safety-Lock™ + additional engineering

Floating bearing on the cover-side eliminates internal stress [1)]

- Mechanically decoupled sensor unit ensures constant signal quality with large temperature fluctuations and other adverse environmental influences. [1)]
- Dual seals on the shaft-side – friction seal against humidity, labyrinth seal against dust and water jet ingress.
- Very large, highly-robust flange bearings.
- Even greater bearing clearance.
- Extremely robust flange mounting due to screw-on housing.
- Bearing design incorporates integrated isolation (isolating inserts not required), tested up to 2.5 kV for high running accuracy; metal to metal connection for slip free mounting. [2)]

Benefits:

The resistance against adverse environmental conditions is greatly increased – especially against high bearing loads and high temperatures.

[1)] for Sendix H100 [2)] for Sendix H120

	Safety-Lock™	HD-Safety-Lock™
Stability with vibration	+	++
Robustness against installation errors	++	++
Radial load	80 N	400 N
Axial load	40 N	300 N
Elimination of internal stresses	0	++
Constant signal quality with extended temperatures	+	++
Mechanical protection of the seal	0	++

Encoders	Technologies	

Ageing compensation (optical encoders)

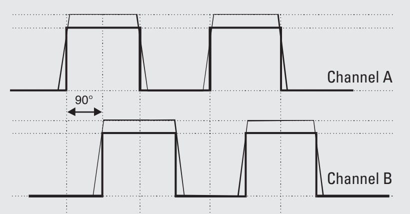
Every LED loses some of its luminosity over time. Without ageing compensation the excellent quality of the output signals would suffer.
The phase shift of 90° necessary to detect the direction of rotation would be lost. This effect however is prevented by means of special electronic circuitry.

Benefit:

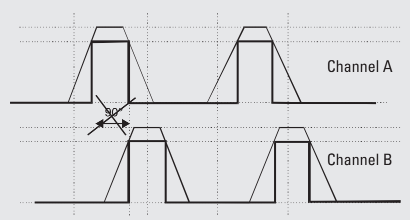
The ageing compensation circuit ensures the same signal, even after many years of operating time.

The downtime of machines will be reduced dramatically and the reliability is increased.

Signals of a new encoder



Signals of an older encoder without ageing compensation



Temperature compensation

This circuit ensures that the signal will remain the same over the whole working temperature range.

Benefit:

The positioning accuracy of a machine will not be affected by temperature changes.

Current consumption

The typical values for current consumption given in the catalogue apply for ambient temperature (23°C).

Because of the temperature compensation, the current consumption of the encoder rises with the temperature.

This increase in current is taken into consideration when giving the figure for maximum current consumption. The output currents are dependent on the user's input circuit and are therefore not included in the figures given; these should therefore be calculated and added in.

Short-circuit protection

The outputs of all the encoders are short-circuit protected, provided that the supply voltage is correctly wired. If an output is connected by mistake to 0 V or $+U_B$ or with another output, the device will not be damaged. As soon as the error is corrected, the encoder is ready for use again.

Benefit:

Wiring circuit errors during installation that often occur in the hectic of day-to-day industrial environments do not lead to the encoder being permanently damaged.

Environmental conditions

Kübler plus

The environmental conditions in which the encoder operates can have a significant influence on its service life, for example

- The ambient temperature.
- The expected shaft load.
- Soiling and humidity.
- Noise interference.

Thanks especially to the high-quality technology employed in our encoders, they are particularly suitable for use in harsh environments.

Numerous references from our customers, including Bosch, Siemens, Bombardier and from suppliers to the automotive industry, are proof of this.

Bearing life

All Kübler encoders are designed to ensure that their bearings give a long service life. This is subject of course to correct installation and to the load limits for the shaft (shaft encoders) being complied with or, in the case of hollow shaft encoders, being mounted with the appropriate stator couplings or torque stops.

The following diagrams show the expected service life of the shaft encoder bearings depending on the bearing load. The calculations are based on a mixed load, where the axial force components are always half of the radial shaft load.

The use of the torque stops and stator couplings that are offered ensure that the shaft load with the hollow shaft encoders as supplied from the factory is kept very small.

Connection Technology | Introduction

Introduction

All products of chapter connection technology have been tested and released in relation with the corresponding compatible Kübler sensors.

They ensure the full functionality and high signal quality of our sensors - this guarantee is supported by our competent customer service.

Your advantage:

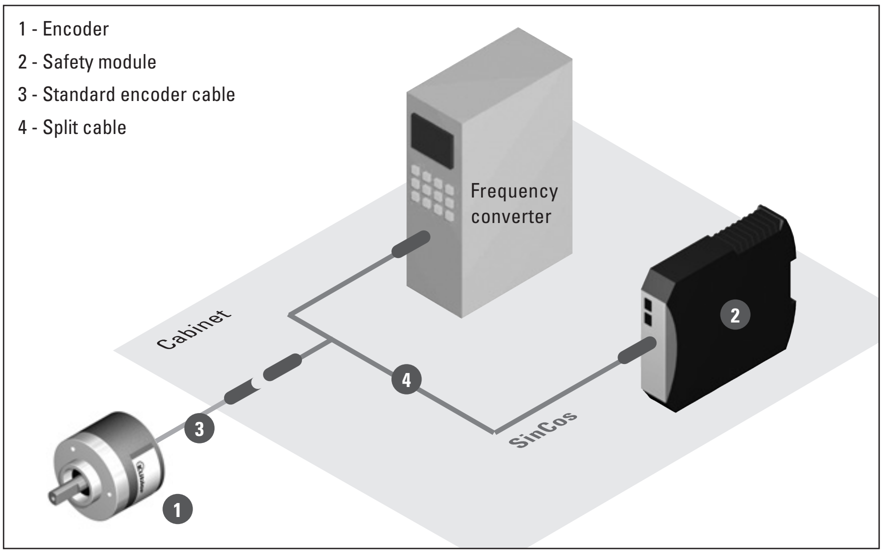
- Prevents from misconnections
  - No time-consuming search for errors.
- Optimal shielding
  - Prevents from EMC problems.
- Shorter mounting times
  - Time- and thus cost-savings.
- No time-consuming search for the suitable connector or cable
  - Time-savings and error prevention.

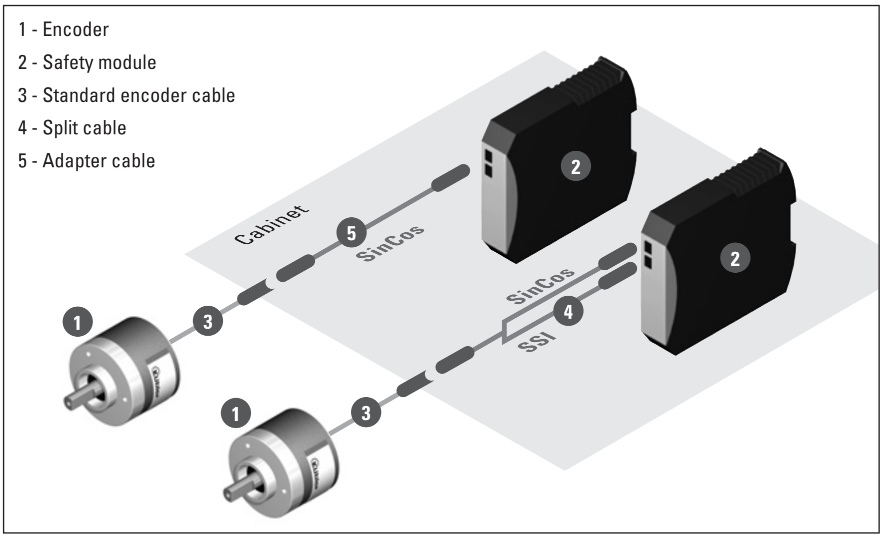
Pre-assembled cordsets for the Functional Safety technology

Kübler offers pre-assembled cordsets to connect an encoder with a Safety-M safety module.

Pre-assembled cordsets are divided into encoder cables and adapter and split cables.

- **Standard encoder cables** are intended to connect the encoder in the application to the cabinet. These cables are available in various materials to cover different environmental conditions and areas of application.
- **Adapter or split cables** are intended to split the signals for different devices / interfaces or to adapt connectors inside of the cabinet.





Connection Technology

Cables and connectors

Material information - cables

PVC

- Suitable for average mechanical stresses in the area of packaging machines and assembly and production lines.
- Good resistance against acids and alkalis and thus predestined for use in the food and beverage industry.
- Limited friction resistance and partial resistance to oils and chemicals.

PUR

- Flexible, PVC, silicone and halogen-free control cable with PUR cable jacket and polypropylene wire insulation.
- The cable is oil-resistant and non-flammable according to VDE 0472, and it is resistant to chemicals, hydrolysis and microbes.
- Temperature resistance from -30°C to + 90°C.
- Use is possible in trailing cable carriers with a bending radius equal at least to 10 x D.
- Thanks to its resistance to welding sparks, this cable is very well adapted for flexible use in the area of robotics, machine tools and metal cutting production.

Material information - connectors

Two material groups are used for the connectors described in the catalogue:

Metals for contacts and housings

- Contacts:
  Metal, CuZn, gilded.
- Connecting nut /compression screw:
  Metal, CuZn, nickel-plated.

Plastics for insulator and housing

- Contact carrier:
  Plastic, TPU, black.
- Body:
  Plastic, TPU, black.
- Seal:
  Plastic, fluorine rubber (FKM/FPM) FPM/FKM or nitrile-butadiene rubber (NBR).

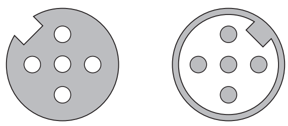
Coding of the M12 x 1 connectors

The connectors are coded to guarantee protection against polarity reversal. This coding is achieved by means of a peg or a notch in the contact carrier.

Kübler connectors make a distinction between A, B or D coding.

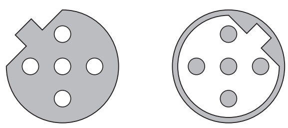
A-coding

Female connector with coupling nut: Coding notch
Male connector with external thread: Coding peg
Use: CANopen and 8-pin connector



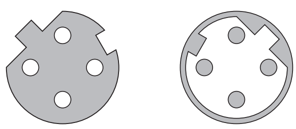
B-coding

Female connector with coupling nut: Coding peg
Male connector with external thread: Coding notch
Use: Profibus



D-coding

Female connector with coupling nut: Coding peg and Coding notch
Male connector with external thread: Coding peg and Coding notch
Use: Profinet and EtherCAT



Connection Technology	Cables and connectors	

Shielding

With round connectors, care must be taken to connect carefully the shielding braid of the cable to the shield connection of the connector.

An all-round contact (360°) is optimal.
Good (in practice often sufficient) shielding values are also reached by connecting the shielding braid firmly to the electrically conductive housing. Connectors purely out of plastic, without metal sleeve, providing no contact for the shielding braid, are not sufficient.

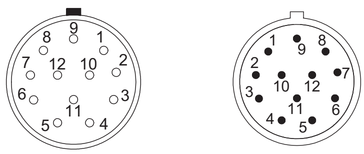
Furthermore, a proper contact with the mating connector is also important, as well as a good contact of the mating connector with the chassis of the equipment.

”Allround” shielding with Kübler cordsets

Counting direction cw/ccw

The counting direction of the connectors is indicated by cw for a clockwise arrangement and ccw for a counter-clockwise arrangement. The connector is always viewed from the mating side.

Top view of mating side



Counting direction cw (e.g. female connector)

Counting direction ccw (e.g. male connector)

Connection Technology

Optical fibre signal transmission

Description

The system is made up of an optical fibre transmitter and an optical fibre receiver.

The optical fibre transmitter converts the electrical signals of an encoder into optical fibre signals.
A simple glass fibre allows reliable transmission up to distances of 1500 m.

The receiver module converts the optical signals back into electrical signals.

The modules are available in various level and power supply voltage variants.

Main advantages of an optical fibre transmission:

- Insensitivity to electromagnetic interferences and to leakage effects between lines routed parallel.
- Significantly higher transmission speeds.
- The optical fibre cable can be routed through explosive atmospheres.
- Cost and weight savings thanks to reduced cabling work, especially for important cable lengths.

Mounting of optical fibre modules

The optical fibre modules can be mounted directly on a TS35 DIN rail (top-hat rail) according to EN 50022.

The installation width for every module is only 22.5 mm.

Laying and connection of glass fibre cables

Laying the cable is generally easy.

Care must nevertheless be taken to make sure that the bending radius does not become smaller than 30 mm for static laying and 60 mm for dynamic laying.

When connecting the cable, make sure that the bayonet catch is locked and remove the dust protection caps only just before connecting the cable.

Glass fibre cables

The modules can be connected together using 50/125 µm or 62.5/125 µm multimode glass fibre cables with ST/PC type connectors with bayonet catch. Single-mode Simplex patch cables are not suitable.

Kübler offers finished confectioned patch cables adapted to the optical fibre modules as accessories.

They ensure the full functionality and high signal quality of our sensors.

Functional Safety | System solutions

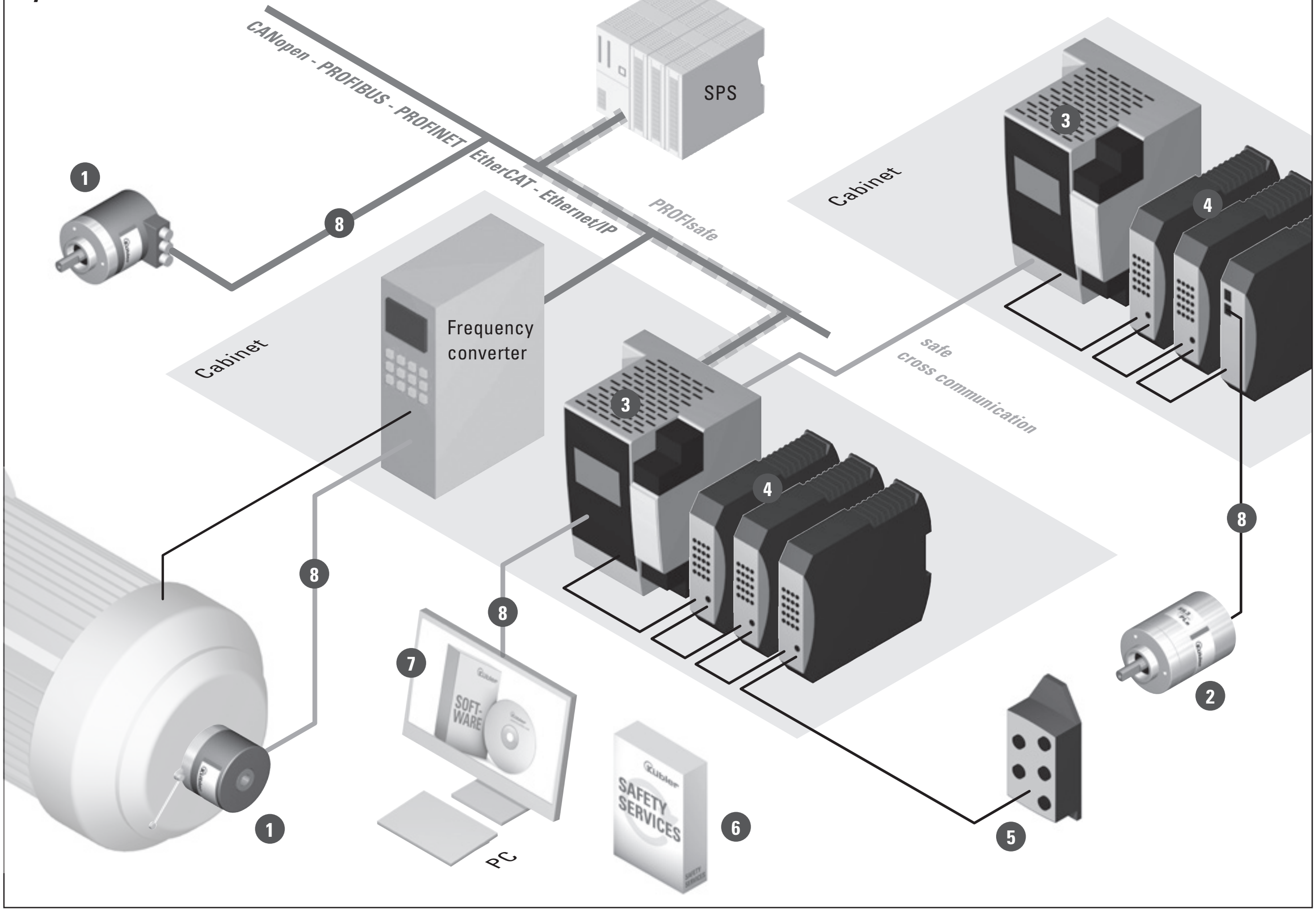
Kübler's extensive product portfolio of rotary and linear position and motion sensors, with the matching safe encoder evaluation devices, provides the basis for safe application-specific drive solutions. However, safe single components alone do not ensure a safe global application.

Legally compliant safety already begins when planning the machine, and this is why the Kübler service technicians and engineers offer a wide range of supports both for the plant manufacturer and for the operator.

The matter Functional Safety technology is simplified by the certified encoders of the Sendix SIL family, which includes both incremental, absolute and ATEX / IECEx encoders. The safe encoder evaluation devices of the Safety-M family include single compact standalone devices for simple applications as well as modular extendable compact controllers that can be connected via a gateway to any higher-level control system.

This allows realizing flexible safety release circuits integrating a safe speed and position monitoring to achieve simple machine safety. Kübler's technical safety solutions meet all high safety and reliability requirements.

System overview



1 Standard encoders
- Incremental and absolute encoders
- Fieldbus and Industrial Ethernet encoders
- Encoders with ATEX / IECEx approval

2 Safe encoders
- Incremental and absolute encoders
- Encoders with ATEX / IECEx approval

3 Safety modules
- **Safety-M modular** with fieldbus and Industrial Ethernet protocols, with safe protocols such as Profisafe, with safe cross communication
- **Safety-M compact** with integrated signal splitting, with internal signal conversion into RS422 or Analog signals

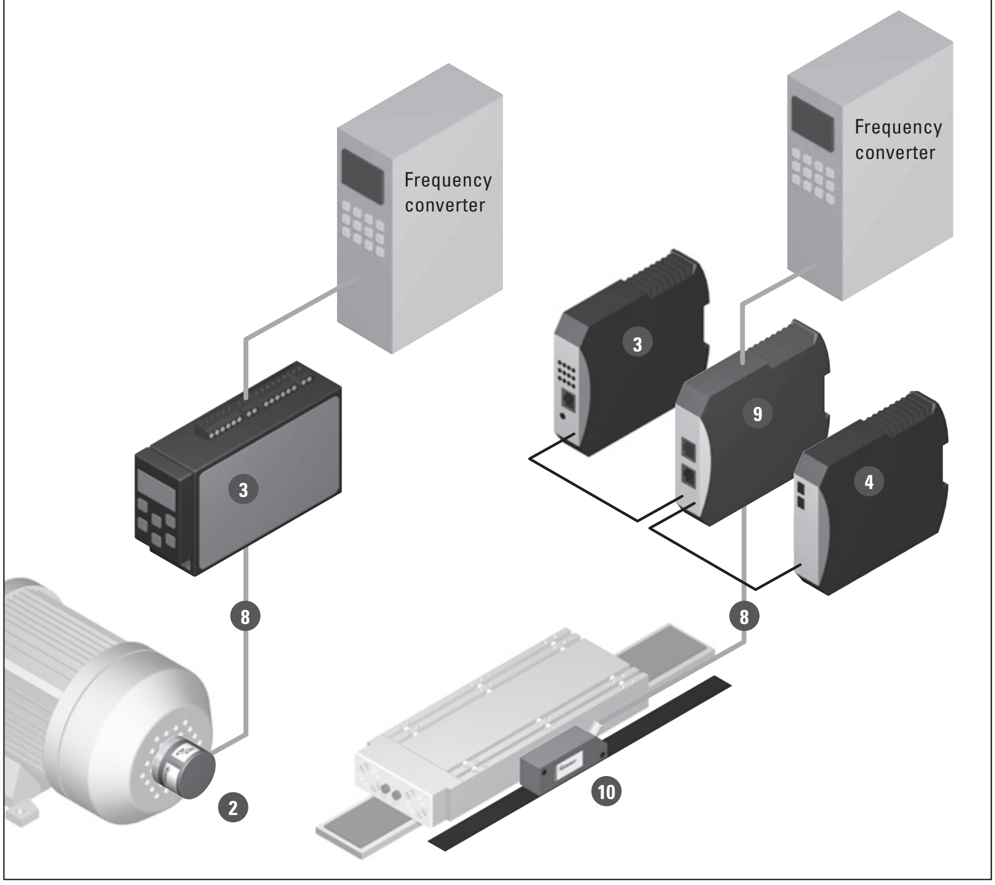
4 Extension modules
- Emergency stop with several release circuits
- Inputs (OSSD, Analog)
- Outputs (semiconductor, relays)
- Stop categories
- Rotary speed, position monitoring

Functional Safety | System solutions

Functional Safety has become an integral part of mechanical engineering.

With a view to machinery Directive 2006/42/EC, Kübler also provides MTTF values for its standard encoders. This allows the user to perform his own calculations in compliance with standard EN ISO 13849-1.

Intelligent, interference-insensitive and cost-effective wiring solutions with SMBS encoder adapter module



8 Connection technology

- M12, M23, RJ45 connectors
- Pre-assembled cordsets
- Adapter cable

9 Encoder signal splitting

- Different solutions: in the cable, as a module, fully integrated
- Easy installation
- EMC compliant

5 Decentralised input/output extensions

- With high IP67 protection level, for remote field installation
- Safe inputs and outputs

6 Safety services

- Preparation of risk analyses
- Elaboration of safety concepts
- On-site commissioning and acceptance
- Retrofit of existing machines

7 PC software

- SafeConfig
- SafeMonitor
- SafePLC
- SafePMT

10 Linear encoder systems

- Incremental and absolute linear systems

Functional Safety	System solutions	

Competence for SIL-compliant encoder projects

Integrated: **safety is achieved by the intelligent combination of encoder, controller and actuator.**
Efficient: **adapted to the requirements of the Functional Safety technology.**

Machinery Directive 2006/42/EC of the European Parliament applies to all manufacturers of machines, plants or separately sold safety components.

In order to keep both the extent of the work and the costs relating to new tests and approvals manageable, Kübler offers – as your partner for the implementation of your safety concept – its application know-how for safe position and motion sensors.

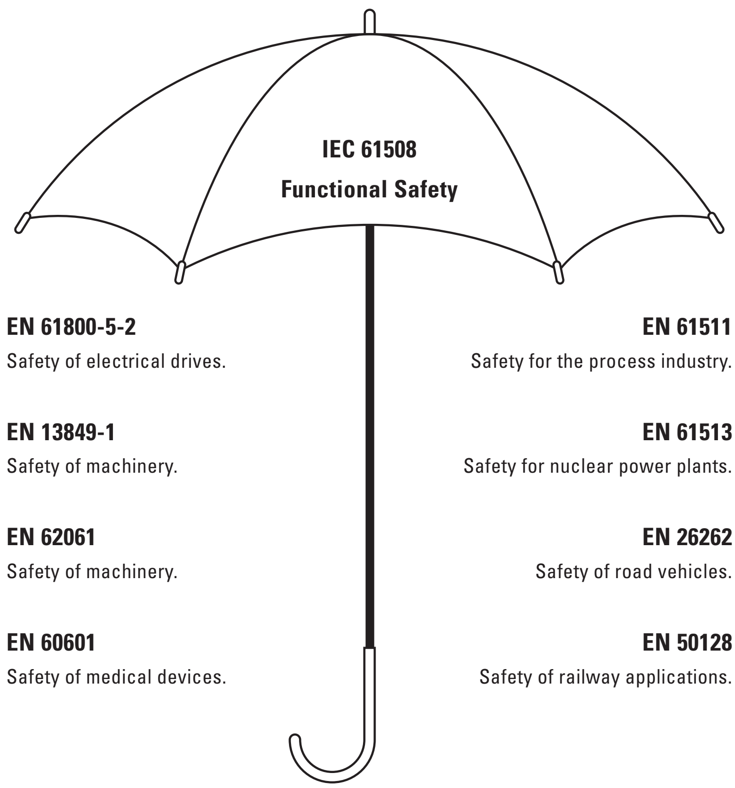
Procedure to determine the right components for your safety project:

1. Definition of the safety concept, including the drive.
2. Realisation of the safety structure: division into safety-related subsystems.
3. Implementation of a FMEA (failure effect analysis) for every subsystem.
4. Differentiation between "dangerous failures" and "safe failures".
5. The error rate of the whole system including the encoder must lie below a specific threshold.

Relevant standards

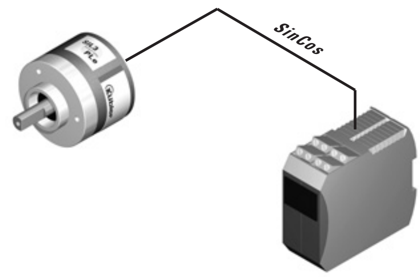
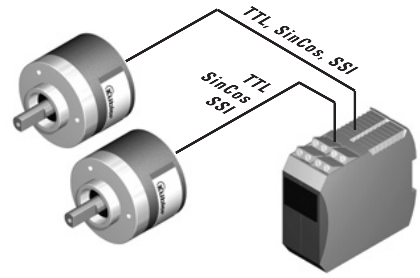
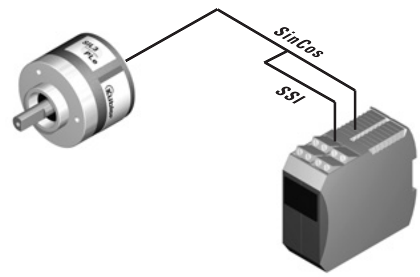
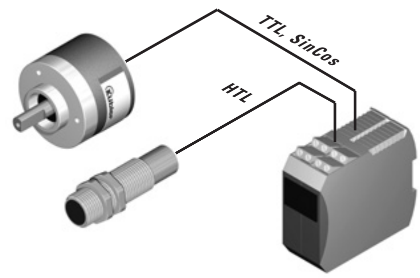
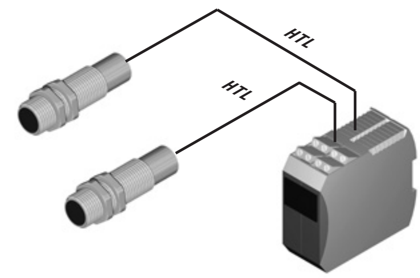
Standard IEC 61508 with its parts 1 up to 7 is known as an "umbrella standard".

Many various industry-specific standards have been derived from it.



Functional Safety | System solutions

Connection possibilities for safe motion monitoring

Graphic	Components
	1 x certified Sendix SIL encoder 1 x certified Safety-M safety module
	2 x encoders 1 x certified Safety-M safety module
	1 x certified absolute Sendix SIL encoder 1 x certified Safety-M safety module
	1 x encoder 1 x proximity switch 1 x certified Safety-M safety module
	2 x proximity switches 1 x certified Safety-M safety module

Functional Safety | **Encoders**

Incremental encoders for the Functional Safety technology

In order to achieve safe information with the incremental encoder, the controller must monitor the validity of the Analog, 90° phase-shifted sine/cosine signals with the help of the function $sin^2 + cos^2 = 1$.
If this check takes place continuously, a very high diagnostic coverage can be achieved.

In addition, the encoder manufacturer must certify that the information has been assessed from a safety-related point of view, from its generation, through its conditioning, up to its transmission. Only this allows assuming that sine and cosine are independent from each other and are therefore considered as two channels.

Absolute encoders for the Functional Safety technology

Achieving safe absolute position information requires either transmitting a safe position via a safe channel (e.g. safe fieldbus), or transmitting two independent pieces of information via standard interfaces.

Safe positioning using an absolute encoder with additional incremental tracks (such as e.g. Sendix SIL) is a particularly smart and cost-effective variant.

In this case, the controller reads the absolute value when initializing and can then set immediately the incremental value internally. From now on, the controller counts the incremental pulses and compares the result with the absolute positions that are also provided by the encoder. This way, relative counting is applied to the first channel and absolute counting to the second.

Safe mechanical connection between encoders and the applications

A 100% reliable mechanical connection is required for a safe function in the applications. Otherwise, no application with a certified encoder will be possible.

For hollow shaft encoders, exclusion of faults is achieved with suitably dimensioned mounting attachments. This is the case for all Sendix SIL encoders.

With shaft encoders, a shaft with a feather key or with a flat offers the possibility of safe connection for the application. Also special safety-oriented couplings offer here simple solutions.

Functional Safety

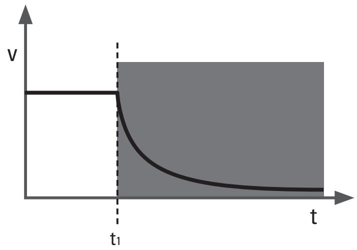
Safety functions for the drives technology

According to DIN EN 13849-1 and DIN EN 61800-5-2 up to SIL3/PLe/Cat.4 the following safety functions can be implemented with the encoder:

Safe Switch-Off

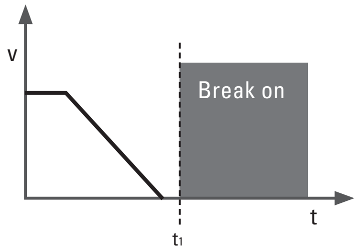
STO – Safe Torque OFF

Safe disabling of the torque on the drive by means of an immediate switching off of the energy supply.



SBC – Safe Break Control

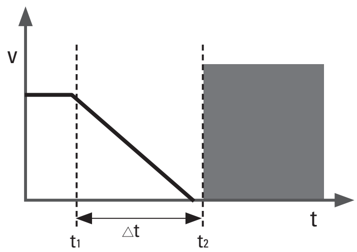
Safe de-energizing of the brake. This allows generating a braking torque.



Safe Standstill

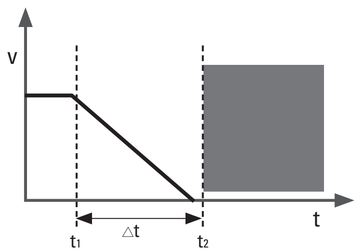
SS1 – Safe Stop 1

Safe monitored standstill followed by the disabling of the torque on the drive.



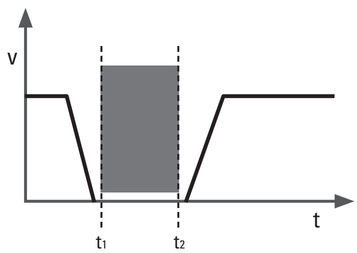
SS2 – Safe Stop 2

Safe monitored standstill followed by standstill monitoring, while the torque remains enabled.



SOS – Safe Operating Stop

The drive is maintained in its position electrically.

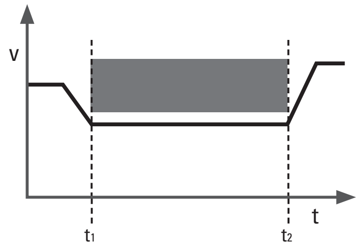


Functional Safety | Safety functions for the drives technology

Safe Motion

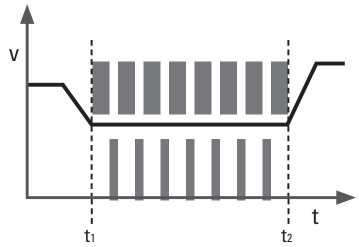
SLS – Safely-Limited Speed

Safe monitoring of a reduced drive speed.



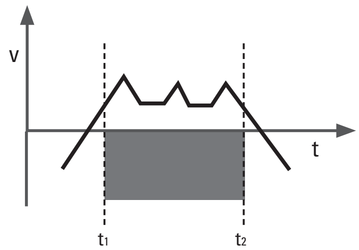
SSR – Safe Speed Range

The safely monitored speed must be within a corridor.



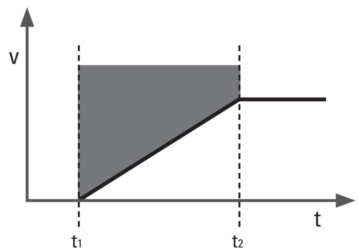
SDI – Safe Direction

Safe monitoring of the direction of movement of the drive.



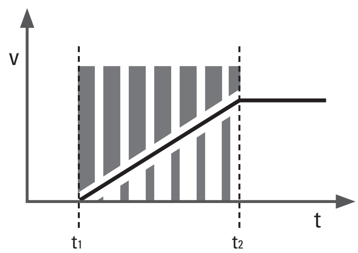
SLA – Safely-Limited Acceleration

Monitoring of the maximum acceleration of the drive.



SAR – Safe Acceleration Range

The safely monitored acceleration must be within a corridor.

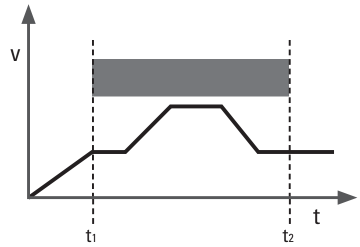


Functional Safety	Safety functions for the drives technology

Safe Monitoring

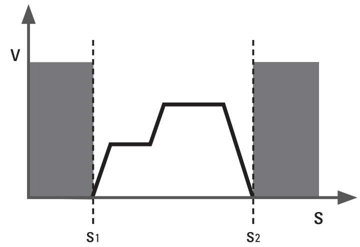
SSM – Safe Speed Monitor

Safe monitoring of a speed range.



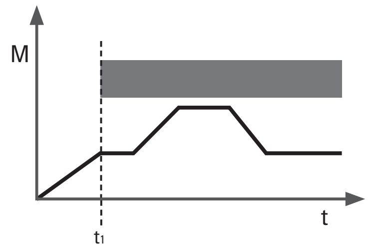
SCA – Safe Cam

Safe monitoring of a defined position range.



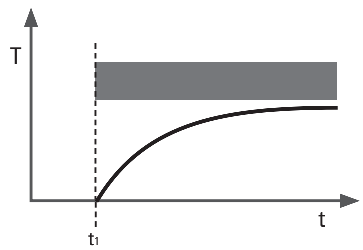
SLT – Safely-Limited Torque

Safe monitoring of a maximum torque.



SMT – Safe Motor Temperature

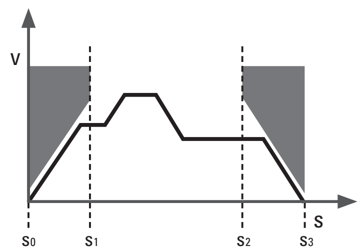
Safe monitoring of a maximum motor temperature.



Safe Positioning

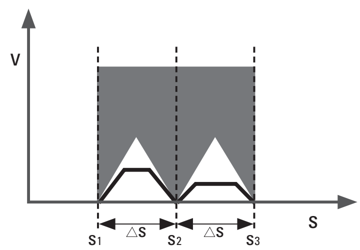
SLP – Safely-Limited Position

Safe monitoring of limit positions = safe software limit switches.



SLI – Safely-Limited Increment

Safe monitoring of an increment for the jog mode.



Glossary

Actuator

The word actuator relates to controlling or driving elements, e.g. motors, relays, frequency converters, valves, signal lights, etc., which convert electrical signals into mechanical movement (or other physical quantities, e.g. pressure, temperature).

American National Standards Institute (ANSI)

Comparable with the German DIN. ANSI is the US American standardization agency and is a member of the International Organization for Standardization (ISO).

Antivalence

Describes two different signals, e.g., for switching contacts, a normally closed and a normally open contact.

AS-Interface (AS-i)

Standard according to IEC 62026-2 for an actuator-sensor interface since 1999.

AS-i Safe

Safety-oriented communication through the standard AS interface (AS Interface Safety at Work).

Austrian Standards Institute (ASI)

Austrian member of the International Organization for Standardization (ISO).

Average Diagnostic Coverage (DCavg)

Describes the total diagnostic coverage to be achieved for a system, contrary to the diagnostic coverage, which is defined for every channel.

B10

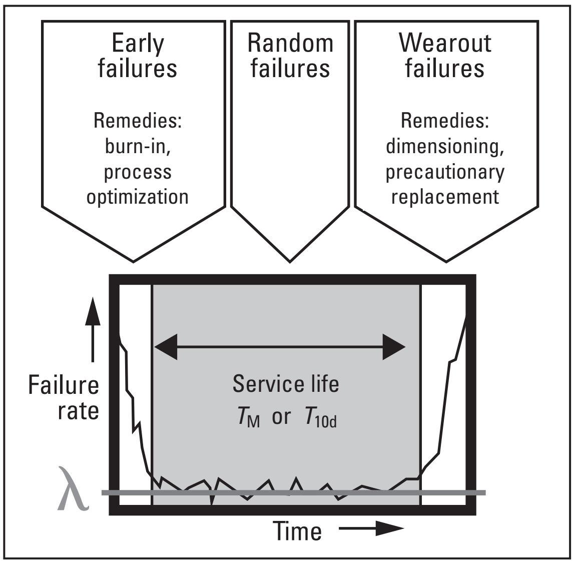
The B10 value for components affected by wear is expressed in the number of switching cycles: this is the number of switching cycles for which 10% of the samples failed during an endurance test (or: number of operating cycles after which 10% of the devices failed). The B10 value and the operating cycle allow calculating the failure rate for electromechanical components.

B10d

In contrast to the B10 value, this value describes exclusively the dangerous failures.

Bathtub Curve / Failure Distribution

The failure distribution describes the distribution in time of the failures of materials, electronic or mechanical components. In the safety technology, the used components must lie in the flat area of the failure rate curve.
Early failures and failures due to wear are prevented by stating a service life.



Source: BGIA Report 2/2008

Bit (Binary Digit)

Smallest discrete piece of information. A bit can be allocated the value 0 or 1.

Cable Color Coding
Code according to DIN IEC 757

abbreviation	color
BK	black
BN	brown
RD	red
OG	orange
YE	yellow
GN	green
BU	blue
VT	violet
GY	grey
WH	white
PK	pink
GD	gold
TQ	turquoise
SR	silver

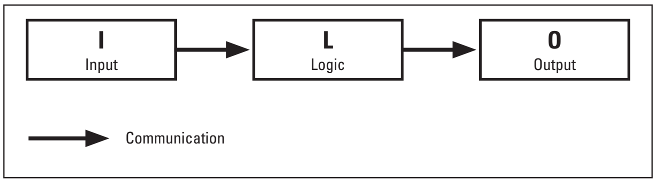
Glossary

Categories (Cat.)

The categories of EN ISO 13849-1 (B, 1, 2, 3 and 4) allow evaluating the performance of safety-relevant parts of a control when failures occur. They describe and classify the system architecture e.g. with redundancies or testing equipment.

Category B:

The control must be designed so that it can withstand the expected influences. System behavior:
A failure can lead to the loss of the safety function.

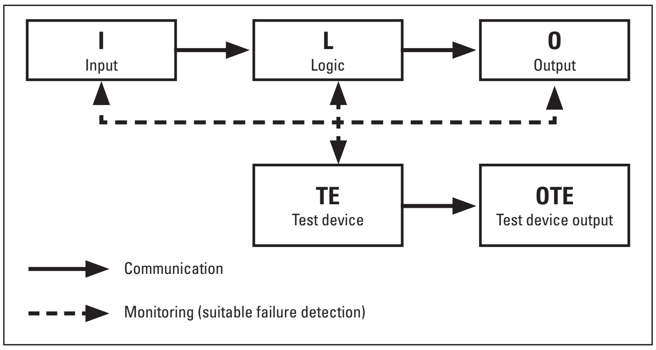


Category 1:

The requirement of B must be met; use of tried and tested safety-relevant components and principles. System behavior: as system behavior B, but with higher safety-related reliability.

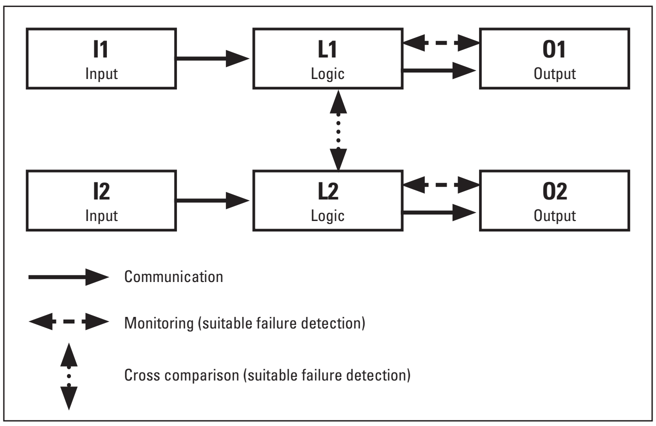
Category 2:

The requirement of B must be met; additional safety function check at appropriate intervals. System behavior: the occurrence of a failure can lead to the loss of the safety function between the checks.



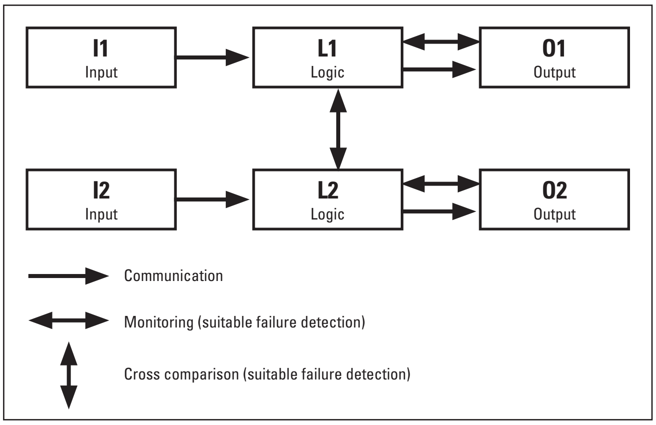
Category 3:

The requirement of B must be met, a single failure shall not lead to the loss of the safety function; single failures must be detected. The failure safety is increased by redundancy. System behavior: the safety function always is maintained in case of occurrence of single failures.



Category 4:

The requirement of B must be met; the single failure must be detected prior to or during the following request for the safety function.
The failure safety is increased by redundancy. System behavior: when failures occur, the safety function always remains maintained; the failures are detected in time.



ccw (counter clockwise)

Turning the encoder shaft in counterclockwise direction (in view of the shaft side of the encoder).

cw (clockwise)

Turning the encoder shaft in clockwise direction (in view of the shaft side of the encoder).

CIPsafety

Safe Common Industrial Protocol

Safety-oriented communication via standard EtherNet/IP or Sercos III.

Clock Output / Pulse Output

When wired accordingly, these special outputs apply defined clock signals/clock patterns to the inputs. This allows detecting cross-short-cuts.

Common Cause Failure (CCF)

Failure of several subassemblies due to a common cause (e.g. short-circui).
The CCF allows evaluating whether a system having e.g. a redundant structure withstands sufficiently such failures.

In standard EN ISO 13849-1, measures must be taken against these failures. Points can be scored for various measures, the sum of which must be >60 to demonstrate that the system is resistant enough.

Conformité Européenne (CE) (European Conformity)

The machine manufacturer is to mark his products with the CE mark if he wants to market his machine (Machinery Directive, "Protection against arbitrariness").

Remark: the CE marking for the Low-Voltage Directive is not comparable with the CE marking for the Machinery Directive.

Glossary

Cross Comparison

Cross comparison is the direct comparison of two events, values. In safety technology, this is used e.g. for redundant systems that monitor each other. Every system detects the faulty operation of the other system thanks to the different result of the same operation.

Cross-Short-Cut

Can only occur in case of multichannel device control and is a short-circuit between channels (e.g. in a two-channel sensor circuit).

Cyclic Redundancy Check (CRC)

The cyclic redundancy check, generally called CRC, is a method for determining a test value for data in order to detect errors during transmission or storage. A CRC is calculated prior to the transmission, and the receiver checks the data and calculates a second CRC after the transmission. If both CRCs are identical, the data has not been altered during transmission.

Danger Zone

Area in or around a machine in which a person is exposed to the risk of an injury or damage to health.

Demand Rate

Operating modes are subdivided in so-called demand rates. This allows displaying how frequently the safety function is requested.

A distinction is made between:

- Low Demand:
  Operating mode with low demand rate, in which the safety function is only carried out upon request to place the system in a defined safe state, with a request frequency that does not exceed once a year.
- High Demand:
  Operating mode with high demand rate, in which the safety function is only carried out upon request to place the system in a defined safe state, with a request frequency exceeding once a year.
- Continuous Demand:
  Operating mode with continuous demand, in which the safety function maintains the system in a safe state as a part of the normal operation.

Declaration of Conformity

Certificate issued by the manufacturer of the machine, certifying that the machine meets all relevant Machinery Directive provisions and can therefore be marketed. This is shown to the user by the CE mark.

Deutsches Institut Für Normung (DIN)

German member of the International Organization for Standardization (ISO).

Deutsche Kommission Elektrotechnik Elektronik Informationstechnik (DKE)

Deutsche Kommission Elektrotechnik Elektronik Informationstechnik, a body of the Deutsche Institut für Normung (DIN) and of the Verband der Elektrotechnik, Elektronik und Informationstechnik (VDE).

Diagnostic Coverage (DC)

Diagnostic coverage $\lambda_{dd}/\lambda_{total}$, with

•λ_{dd}, Rate of the detected dangerous failures.

•λ_{total}, Rate of all dangerous failures in total ($\lambda_{dd} + \lambda_{du}$).

$$DC = \frac{\sum \lambda_{dd}}{\sum \lambda_{dd} + \sum \lambda_{du}} = \frac{\sum \lambda_{dd}}{\sum \lambda_{d}}$$

The diagnostic coverage is subdivided in various classes in standard EN ISO 13849-1:

DC (diagnostic coverage)	
Designation	Range
small	DC < 60 %
low	60 % < DC < 90 %
medium	90 % < DC < 99 %
high	99 % < DC

Diversity

Describes the variety of something. Used in relation with redundancy to describe a redundancy created using different paths, i.e. using different means to realize a required function. It is understood as a strategy for increasing failure safety.

Emergency Stop

Emergency action intended to stop a process or movement that is becoming dangerous.

Endangering

Endangering (due to an event) represents a danger for the user and can lead to injury (potential source of harm).

Failure

Describes the condition of a device that is not able to carry out a requested function, with the exception of the inability during maintenance work, other scheduled actions or the lack of external means.

Failure Behavior

Describes the possibilities for a system to fail.

Failure Exclusion

Ability to resist failures. For certain components, defined failures can be excluded for the time of SRP/CS operation. A short-circuit can e.g. be excluded by safe cable routing. The justification of a failure exclusion must be documented!

Failure In Time (FIT)

Error measure describing the number of failures in 109 hours

1Fit = 10^{-9} 1/h

Glossary

Failure Mode Effect Analysis (FMEA)

Failure mode and effects analysis (failure effects analysis).

Analytic method for the systematic and complete registration of potential failures and failure conditions of components of a system and of their effect.

Failure Modes, Effects and Diagnostic Coverage Analysis (FMEDA)

In addition fo the FMEA, the FMEDA determines the Safe Failure Fraction (SFF) as an evaluation parameter for the Functional Safety Management according to IEC 61508.

Failure Probability

A statistical value for the failure of the component/of the system. The failure safety describes the safety achieved.

Failure Safety

Falure safety is the defined safety against a failure. The Performance Level (PL) or the Safety Integrity Level (SIL) describe a measure for failure safety in functional safety technology.

Failure Tolerance

Describes the resistance of a system against failures.

Feedback Loop

Electrical circuit for monitoring the controlled contactors/relays.

The function of the contactors/relays can be monitored by having an evaluation device read back the positively guided auxiliary contacts. If contactor/relay contacts are welded, the evaluation device prevents from re-starting.

Functional Safety (FS)

The part of the safety of an installation (e.g. machine, plant) that depends of the correct operation.

Institut Für Arbeitsschutz (IFA)

The Institute for Occupational Safety and Health of the German statutory accident insurance, former Berufsgenossenschaftliches Institut für Arbeitsschutz (BGIA) is a research and testing institute based in Sankt Augustin near Bonn.

[http://www.dguv.de/ifa]

International Electrotechnical Commission (IEC)

The International Electrotechnical Commission is an international standardization organization based in Geneva for standards in the electrotechnical and electronic field. Some standards have been developed jointly with the ISO.

International Standard Organisation (ISO)

International Organization for Standardization.

Harmonized Standard

The type A (basic standards), type B (group standards) and type C (product standards) allow applying the presumption of conformity ("compliance" with the Machinery Directive).

Low Voltage Directive (LVD)

Official designation: Directive 2006/95/EC of the European Parliament and of the Council of 12 December 2006 on the harmonization of the laws of Member States relating to electrical equipment designed for use within certain voltage limits.
It is used for the safety of electrically powered devices.

Mean Time Between Failures (MTBF)

Mean time between device failures.

Sum of MTTF (mean time to failure) and MTTR (mean time to repair). The mean time between failures is the time that elapses in normal device or plant operation before a new failure occurs.

Mean Time To Failure (MTTF)

Period of time between the first start-up and a failure.

The MTTF can be determined for components by means of the analysis of field data or predictions. With a constant failure rate, the average value of the failure-free operating time MTTF = $1/\lambda$, λ being the failure rate of the device (from a statistical point of view, it can be assumed that, after the expiration of the MTTF, 63.2 % of the concerned components have failed).

Mean Time To Dangerous Failure (MTTFd)

Period of time between the first start-up and a dangerous failure.

MTTFd = $1/\lambda_d$

MTTFd = 2x MTTF

MTTFd = B10d/0.1xnop

Mean Time To Repair (MTTR)

Mean time necessary for repairing a device.

MTTR is always significantly smaller that MTTF.

Mission Time™

Identical to the service life.

Muting

Is a bypass function. Neutralization of the safety function with additional sensors, limited in time and in accordance with the intended purpose
(EN ISO 13849-1:2006: temporary automatic bypass of a safety function).

National Fire Protection Association (NFPA)

The US-american National Fire Protection Association edits a comprehensive rule book about fire protection (National Fire Codes) that applies mainly in the USA. The NFPA corresponds approximately to the German Vereinigung zur Förderung des Deutschen Brandschutzes.

Glossary

Nationally Recognized Testing Laboratory (NRTL)

This laboratory can test products for use in the USE in compliance with NFPA79. An NRTL listing is equivalent to a certification.

Occupational Safety And Health Administration (OSHA)

US American federal authority in charge of safety issues in the industry. It can be compared with the German Institut für Arbeitsschutz of the German statutory accident insurances. The goal of this organizations is to reduce the number and consequences of accidents at work.

Operating Mode

The operating modes are various predictable conditions of a machine. The machine must be safe in any operating mode. A distinction is e.g. made between automatic operation, manual mode, set-up mode, maintenance mode.

Performance Level (PL)

Ability of safety-related parts to perform a safety function under foreseeable conditions (that should be taken into consideration), in order to achieve the expected risk reduction: from PLa …. PLe.

Performance Level Required (PLr)

Required Performance Level (see PL).

Probability Of Dangerous Failure Per Hour (PFH)

A failure probability measure of IEC 61508.

Probability Of Dangerous Failure On Demand (PFD)

A failure probability measure of IEC 61508.

Proof Test / Proof Test Interval

Proof test: periodic repeat inspection performed to detect failures in a SRECS so that, if necessary, the system can be reset to or as close as practically possible to an “as-new-condition” (derived from IEC 61508-4).

Presumption of Conformity

When the requirements of the harmonized standards of the Machinery Directive are met, it can be presumed that the requirements of the Machinery Directive are also met.

PUR - Polyurethanes

Polyurethanes are generally soft and elastic plastics or synthetic resins used in cable manufacturing. Used generally here as external sheathing.

PVC – Polyvinyl Chloride

Polyvinyl chloride is a plastic made soft and elastic by the addition of plasticizers and stabilizers, used in cable manufacturing. Used generally here as sheathing or cable insulation.

Qualification

Means the assessment of capabilities (qualifications) that are necessary for a determined task or requirement.

The verification that the capabilities are sufficient to meet the requirements in a reproducible way in practice is the content of the so-called validation.

Quantification

A quantification describes a result statement in the form of a numerical value, in which one or several characteristics of an object or the nature of a situation are reformulated as measurable quantities and numerical values.

Reaction Time

Time between the detection of the hazardoue event and the restoration of the safe condition.

Redundancy / Two-Channel Design

Presence of more means than those basically necessary for performing the intended tasks.

Reset

Reset is a switch-on function (ON) that brings a system back to a defined initialization status, it represents a restart interlock.

This may become necessary if the system does not operate correctly after a failure and does not react properly to inputs any more.

Response Time

Time that elapses between the powering of the device and its readiness for operation.

Risk

Combination of the probability of occurrence of damage and of the the extent of damage.

Risk Analysis

The risk analysis is a part of the risk assessment. It identifies the dangers in a machine.

Risk Assessment

Standard ISO 14121 includes procedures that are required for carrying out a risk assessment. The risk assessment includes a risk analysis followed by a risk evaluation.

Risk Evaluation

The risk analysis is a part of the risk assessment. It classifies the dangers in a machine.

Safe State

The safe state is the state in which a machine does not represent any danger for men, machines or the environment.

Glossary

Safety Arrangement

Is required wherever danger for men, machines end environment may occur. It can be achieved e.g. in the form of safety circuits with electronic components.

Safety Component

Component used for ensuring a safety function whose failure and/or malfunction endangers the safety of persons and that is not necessary for machine operation or that may be replaced with components usual for machine operation. Safety components are listed in Annex IV of Machinery Directive 2006/42/EC and receive a CE mark. Exemples of safety components:

Sensor-controlled protective equipment (light barriers, safety mats, electromagnetic detectors), automatic mobile protective equipment on machines in compliance with Letter A Number 9, 10 and 11, two-hand circuits, roll-over protection structures and falling-object protective structures.

Safety Integrity Level (SIL)

Safety Integrity Level, a requirement classification according to EN 61508 / EN 61511 / EN 62061. It is used for evaluating electrical/electronic/programmable electronic (E/E/PE) systems in terms of reliability of the safety functions.

Safety Function

Function (e.g. of a machine or control) whose failure (or breakdown) can increase the risk/the risks.

Safety-M

Family name of the safety modules of the Kübler company.

This family today includes several series:

- Safety-M compact
- Safety-M modular

Safety-M compact is a compact safety controller suitable especially for the drive safety functions. It has limited extension possibilities and is characterized by a very compact design.

Safety-M modular is a compact safety controller suitable especially for the drive safety functions. It is characterized by its freely selectable and modularly extensible functionality.

Safety Related Control Function (SRCF)

Safety-related control function performed by the SRECS with a defined Integrity Level, intended for maintaining the safe state of a machine or preventing an immediate increase of the risks.

Safety Related Electrical Control System (SRECS)

Safety-related electrical control system of a machine whose failure leads to an immediate increase of risks.

Safety Related Parts Of Control Systems (SRP/CS)

Safety-related part of a control system that reacts to safety-related input signals and generates safety-related output signals.

Schweizerische Normen-Vereinigung (SNV)

Swiss member of the International Organization for Standardization (ISO).

Service Life

Describes the maximum time a component may be operated from a safety technology point of view.

Short-Circuit

A practically unopposed conductive connection between two live electrical lines.

Shut-Off Path

Designs the section of the safety system used for shutting down the machine. This often also allows achieving the safe state, and this is why the function of the shut-off paths must be tested during validation.

Single-Failure-Proof

Describes a system that does not loose its safety in spite of a failure. This is classically achieved for systems as from category 3.

SIL Claim Limit (SIL CL)

Safety Integrity Level, a requirement classification according to EN 62061 [refer also to Safety Integrity Level (SIL)].

Sistema

Free software for the evaluation of the safety of controls within the framework of DIN EN ISO 13849-1. Issued by the IFA. The Windows tool simulates the structure of the safety-related control elements on the basis of the so-called planned architectures and calculates reliability values on various levels of detail including the attained performance level.

Glossary

Soiling and Humidity

The IP classification according to EN 60529 describes how the encoder is protected against particles and water. It is described as an abbreviation "IP" followed by two numbers.

These two tables summarise the most used IP ratings.

Protection against particles (first digit)

The higher the number the smaller the particles.

0	Not protected
1	Protected against particles 50 mm and larger
2	Protected against particles 12.5 mm and larger
3	Protected against particles 2.5 mm and larger
4	Protected against particles 1.0 mm and larger
5	Protected against dust
6	Dust proof

Our encoders have a protection up to IP69k.

Protection against water (second digit)

The higher the number, the higher the water pressure can be.

0	Not protected
1	Protected against vertically falling drops of water
2	Protected against vertically falling drops of water when enclosure is tilted up to 15°
3	Protected against spraying water
4	Protected against splashing water
5	Protected against water jets
6	Protected against powerful water jets
7	Protected against the effects of temporary immersion in water
8	Protected against the effects of continuous immersion in water

9k	Acc. to DIN 40050 / Part 9: protected against high-pressure water / steam jet cleaning

Speed Monitoring

Monitoring of the rotary speed of a mechanical movement (e.g. drive) in a defined speed window. This can be achieved without sensor (current, frequency) or by means of a (generally incremental) encoder.

Start Interlock / Restart

After having triggered a safety function or restored the power supply, the machine / plant must restart. Automatic restarting is only allowed for well-defined exceptions. Automatic restarting is prevented by a safety control device.

Stop Category

Term used in EN 60204-1 to define three different shutdown functions.

Refer to Safety Functions.

Temperature

Working temperature:

Is defined as the environmental temperature, in which the encoder will produce the signals defined in the data sheets.

Operating temperature:

Is defined as the environmental temperature, in which the encoder can be operated without incurring damage.

TPE – Thermoplastic Elastomers

Thermoplastic elastomers are plastics that are soft, as all classical elastomers. The material looses these rubber-elastic properties at high temperatures; it can then be formed.

Two-Hand Operation / Two-Hand Control

Two-hand operation is a safety concept/control unit for working on machines in which a crushing or shearing hazard is possible for the hands and therefore requires two-hand operation.

Working in the hazardous area is required to place or remove parts in presses, punching machines, casting machines and similar machines. The working stroke may only be triggered (started) when both hands have left the hazardous area. This is achieved thanks to a simultaneous and seperate actuation of switches or levers. The distance between the operating elements is chosen so as to make one-hand operation impossible.

The rule is standard DIN EN 574.

User Information

The user information includes all indications, instructions, descriptions required for the safe and intended operation of the machine, e.g.: pictograms on the machine, operating instructions, maintenance instructions etc.

Validation

Proof of the reproducibility of a result from a described procedure under defined conditions.

Verification

Proof that suspected or alleged circumstances are true.

Verband der Elektrotechnik, Elektronik und Informationstechnik (VDE)

The Verband der Elektrotechnik, Elektronik und Informationstechnik is a technical-scientific association in Germany. The VDE is committed to a better innovation climate, safety standards, modern engineering education and better public acceptance for technology.

Zero Signal

The zero signal is emitted once per revolution, it can be used e.g. as a reference signal during the first revolution after power on.