Linear measurement systems

Version		Miniature with encoder	Draw wire mechanics for encoders	Large draw wire mechanics for encoders
		compact	robust	for very long measurement range
Mechanical characteristics				
Measuring range	[mm]	up to 2000	up to 6000	up to 40000**
Resolution	[mm]	0,1	0,1	0,1
Temperature range	[°C]	–10 ... +80	–20 ... +80	–20 ... +80
Materials				
Housing		Plastic reinforced	Aluminum	Aluminum
Wire		Steel wire *	Steel, para wire	Steel wire, para wire
Suitable encoders/interfaces		2400 series with either incremental or analogue-(current, voltage) output	various incremental and absolute encoders	various incremental and absolute encoders
Page		250	254	257

* Over 1000 mm: plastic coated wire

Version		linear measurement system LIMES New	Measuring device	Encoder spring arm
		Magnetic sensor with magnetic band, not affected by dust, shavings, humidity	With rack ore measuring wheel. Holding device for encoder	– base plate can be oriented in 4 directions – choice of mounting locations – adjustable contact pressure – can be combined with all Kübler encoders and measuring wheels – aluminum construction
Mechanical characteristics				
Measuring range	[mm]	up to 90 000	no limit	
Resolution	[mm]	up to 0,005	up to 0,1 mm	
Temperature range	[°C]	–10 ... 70 °C	–20 ... + 70 °C	
Materials				
Housing		Sensor: plastic	Measuring wheel: Plastic or AL, Rack: steel	
Wire		Cable: PUR		
Suitable encoders/interfaces		Push-Pull or Line-Driver Inverted	depends from the encoder	
		246	259	261

Contact our sales department for advice, with no obligation, on the different combination options:
E-mail:
sales@kuebler.com

Connection Technology

M12 Connection technology, 8 pin

- Couplings
- Connectors
  – pre-assembled
  – for self-assembly

from page 268

M12 Connection technology Profibus

- Couplings
- Connectors
  – pre-assembled
  – for self-assembly
- Terminating Resistor

from page 276

M12 Connection technology CANopen/DeviceNet

- Couplings
- Connectors
  – pre-assembled
  – for self-assembly
- Terminating Resistor

from page 270

Angular connector optimised to installation height

- right angle connector with fixing nut, offering optimal installation hight
- for lead-through to ventilator plates on geared motors or control oriented
- 9, 12 or 17-pin, project oriented

from page 293

Connection Technology

Connectors

- wide choice of connectors
- with pin or socket insert
- 4-pin, 5-pin, 7-pin or 10-pin
- connectors with MIL approval
- right angle connectors
- Right angle connectors and plug-in connectors that meet MIL standards can also be supplied

from page 290

M23x1 Connectors

- wide choice of connectors
- 9-pin, 12-pin and 17-pin
- robust construction, metal body
- pin inserts can be supplied wired clockwise or counter clockwise

from page 292

Pre-assembled cables

- ready for use with Kübler encoders
- pre-wiring saves installation effort
- avoids wiring errors
- guarantees short-circuit protection
- available in following lengths: 2, 3, 5, 8, 10, 15, 25 and 30 m; other lengths on request

from page 296

Cable by the metre

- PVC cable
- PUR cable

from page 295

Accessories

Programming software Ezturn®

The software Ezturn® is a programming software to program any Kübler multiturn encoders of the latest generation. Ezturn® comes as part of a programming kit (power supply, interface, connector etc...). It allows easy modification of default encoder settings such as resolutions, outputs ... and provides enhanced functionality for your encoder such as setting cam outputs etc. On top of that, Ezturn® is a practical set-up aid for field installation of your encoder and may be used as a powerful field diagnostics tool, too.

from page 302

SSI Display Type **570**

- SSI clock frequency from 100 Hz up to 1 MHz
- Suitable for SSI protocols up to 25 Bit
- Version with 2 optocoupler outputs to work as limit or preset values; also available with tracking preset
- Large 15 mm high LED display, 6 digit, with adjustable brightness
- Version with scalable analogue output, resolution 14 Bit, 0…10 V, -10 … +10 V, 0 … 20 mA or 4 … 20 mA
- Version with serial interface

from page 303

Multi-function display type **571**

- Fast count input suitable for our ***LIMES*** linear measurement system (100 kHz)
- Many programmable measuring functions
- Programmable, scaleable display
- Large 15 mm high LED display, 6 digit, with adjustable brightness
- Version with scalable analogue output, resolution 14 Bit, 0…10 V, -10 … +10 V, 0 … 20 mA or 4 … 20 mA
- Version with serial interface

from page 304

Bracket adapters

Square or round brackets are used to match individual bracket size requirements or to provide an exact bracket compatibility with competing encoders. All adapters are made from Aluminum. They require clamping bracket encoders.

from page 305

Fastening eccentrics

Fastening eccentrics fit to Kübler encoders with synchronous brackets. Use at least three fastening eccentrics to mount an encoder.

from page 311

Tether arms

- Mounting kit for hollow shaft encoders
- Mounting component for encoder model A020
- Prevents radial play of the encoder
- Necessary axial play remains unaffected
- Materials:

– mounting element: stainless steel
– Screws: galvanised steel

from page 312

Accessories

Couplings

Kübler supplies two different kinds of couplings for shaft encoders:
– Bellow-type couplings recommended as an inexpensive and highly reliable type of coupling.
– Spring washer couplings
are mainly used in those cases where high speed and smaller angle displacement are required. They are easy to mount because they are detachable.

from page 318

Assembly bell

The Assembly bell allows a quick and a reliable mounting of shaft encoders with additional benefit of electrical and thermal insulation of the encoder. The assembly bell comes as a kit that includes coupling, screws etc...

– Easy and quickly encoder mounting
– Electrical and thermal insulation
– Delivered as a complete set

from page 321

Accessories for draw-wire encoder

- Guide pulley
- Extension cables 2 m, 5 m and 10 m

from page 325

Measuring wheels

A wide range of measuring wheels, perfectly adapted to Kübler encoders. Measuring wheels allow accurate length measurement of moving measured material. They are suitable for all types of fabrics, wood, plastic, metal, glass etc, depending on the surface finish or coating that is required, consisting of either metal or plastic.

from page 323

Bearing block

New

- By separating the bearing load and the sensor technology the encoder is well-protected even in harsh application conditions. This is, for example, a particular advantage with belts that can be tensioned differently such as occurs in lift construction (shaft copying)
- Simple upgrade, no mechanical adaptation
- Long service life, durable mounting

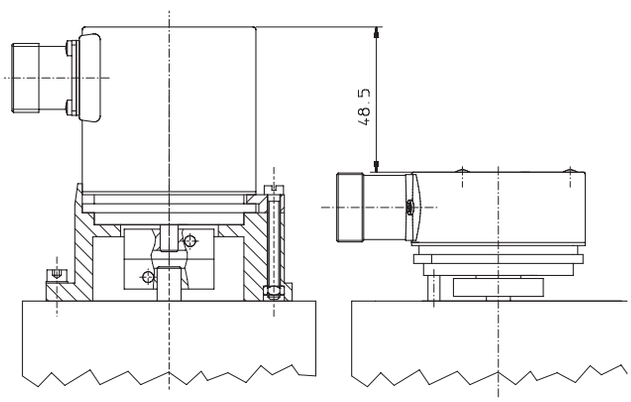
from page 320

Rotary Measuring Technology

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 unequivocal code pattern, so that even after a power cut the actual position is recognised.
In principle we can supply all encoders, whether with a solid shaft or in a hollow shaft version. Nowadays hollow-shaft encoders are becoming more and more popular. Kübler has been pioneering hollow shaft encoder technology for many years. 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 is simply necessary to put it on the shaft. Prevent the encoder from rotating by using a pin.
On top of that hollow shaft encoders require less installation height.
The basic advantages of hollow shaft encoders in comparison to shaft encoders are shown in the sketch below.



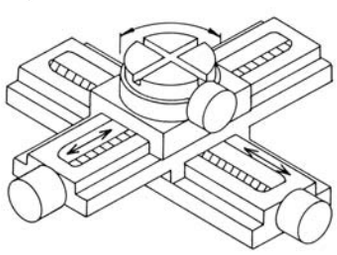
Example:

• shaft encoder	180.-	• hollow shaft encoder	190.-
• coupling	34.-	• simple pin	2.-
• bracket	27.-		
• mounting time	8.-	• mounting time	5.-
	249.-		197.-

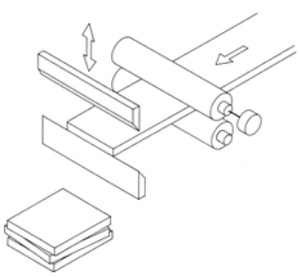
Result: Even if the basic costs of a hollow shaft encoder are slightly higher compared to a shaft encoder, the overall cost is more than 20% less.

Application examples

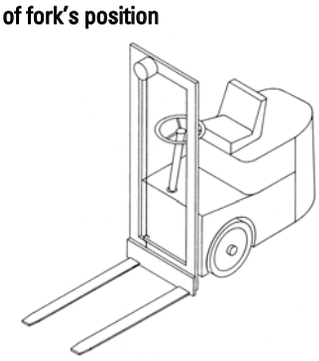
Positioning



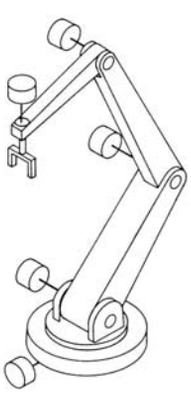
Length measurement



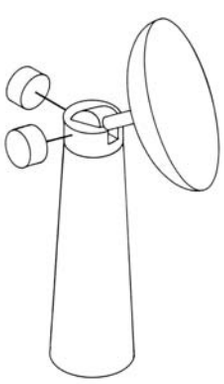
Detecting of fork's position



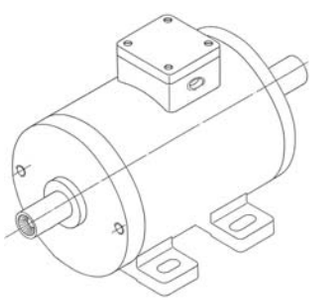
Detecting of position



Angular measurement



Velocity measurement



Rotary Measuring Technology

Conformity:

All Kübler encoders fully comply with the CE-regulations and are intensively tested in our EMC laboratories. They conform to CE requirements according to EN 61000-6-1, EN 61000-6-4 and EN 61000-6-3.

High quality of signals:

All encoders from Kübler, are equipped with ageing and temperature compensation to ensure a long term and stable signal also after many years of operation.

Approvals:

Many of our products are UL **(Underwriters Laboratories Inc.)** approved. Our products can also be supplied on request with EX approval for use in Hazardous Areas Zones 2 and 22. All new plant and equipment that is destined for use in explosion-protected areas must be installed according to Directive 94/9/EG (ATEX 100a). Our products that are approved for use in hazardous areas carry additional labelling in line with RL 94/9/EG and EN 50014.

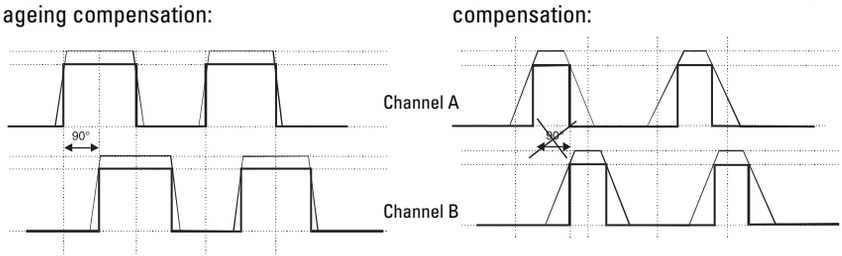
Kübler is active worldwide and has made a commitment to protecting the environment. Our products comply with the RoHS standards.

Ageing compensation:

Each LED will inevitably lose its power over a period of time. As a result, the output signal degrades. The phase shift between channel A and B of 90° becomes less and less. The direction of rotation may no longer be detected. A special electronic circuit, built into the Kübler specific ASIC, prevents this effect.

Signals of a new encoder or encoders with ageing compensation:

Signals of an older encoder without ageing compensation:



Benefit: The ageing compensation circuit ensures the same signal, even after many years of operating time. The down time of machines will be reduced dramatically and the reliability is increased.

Temperature compensation:

This specialised circuit ensures that the quality of the signal will stay on the same high level 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 +Ub 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.

Rotary Measuring Technology

Environmental conditions:

A significant influence on the lifetime of the encoder is set by the environment in which the encoder is operating, e.g.:

- The ambient temperature
- The expected shaft load
- The possible grade of dust/dirt and humidity/liquids

The support design and the use of high quality components makes our encoders suitable for applications in **rough conditions.**

Many references from customers including Bosch, Siemens and Bombardier are proof of this high quality.

Temperature:
Definition according to DIN standards 32 878

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 which the encoder can withstand without getting damaged.

Dirt/dust and humidity/water:

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.

The first digit defines the size of the particles. The higher the number the smaller the particles.

The second digit defines the resistance against water. The higher the number, the higher the water pressure can be.

Our encoders have a protection up to IP 67.

These two tables summarise the most used IP ratings:

Protection against particles (first digit):

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

Protection against water (second digit)

0	not protected
1	protected against vertically falling drops of water
2	protected against falling drops of water up to 15° from vertical
3	protected against water sprayed up to 60° from vertical
4	protected against water sprayed from all directions, limited ingress permitted
5	protected against low pressure jets from all directions, limited ingress permitted
6	protected against strong jets of water, e.g. for use on ship decks, limited ingress permitted
7	protection against the affects of immersion between 15 cm and 1 m
8	protected against long periods of immersion under pressure

Designation of colours
to DIN standard 757

abbreviation	colour
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

Rotary Measuring Technology - Encoders

Installing encoders

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.

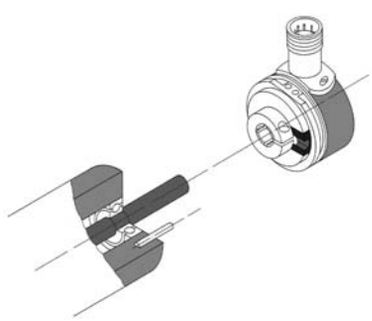
Facilities must therefore be provided during installation to compensate for these forces. For encoders having a solid shaft this is generally done by using shaft couplings between the drive shaft and the encoder shaft. The solution with hollow shaft encoders is to use stator couplings, fixing brackets or torque stops between the encoder bracket 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 will occur. For solid shaft encoders the maximum permitted axial and radial loads are shown in the appropriate technical data.

Mounting examples for hollow shaft encoders:

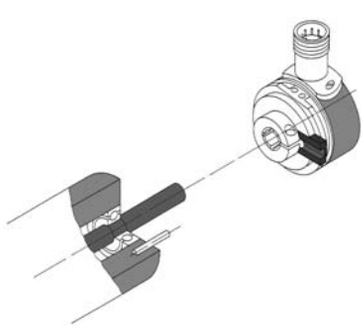
Mounting of a hollow shaft encoder with torque stop and pin (easiest and fastest mounting). Standard hollow shaft encoders are equipped with the torque stop.

Application:
If axial play is less than 0.5 mm. Resolution up to 2500 ppr (If no pulse doubling is used).



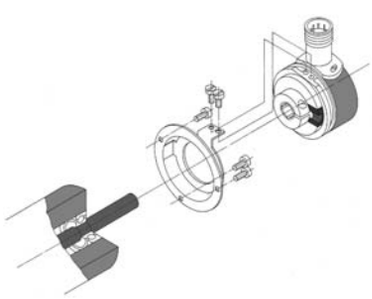
Mounting of a hollow shaft encoder with extended torque stop and long pin.
Art.No 8.0000.4600.0000

Application:
Specially recommended, if there is a large axial play. Due to the bigger mounting radius of the pin, the resolution can be higher (up to 3600 ppr, if no pulse doubling is used)



Mounting of a hollow shaft encoder with a stator coupling
Art.No 8.0010.1601.0000

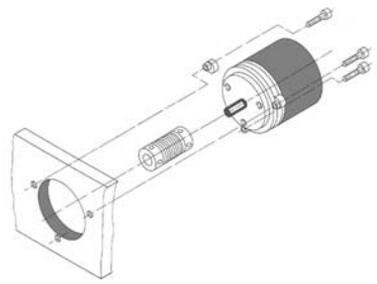
Application:
For higher resolution or if no pin can be used, due to mechanical restrictions.
No restrictions on resolution.



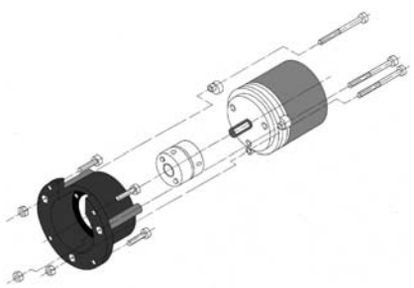
Rotary Measuring Technology

Mounting examples for shaft encoders with synchronous bracket:

Mounting with fastening eccentrics and coupling (to reduce shaft overload).

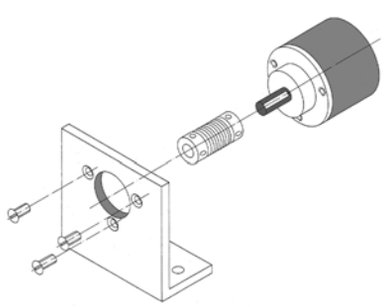


Mounting with assembly bell, fastening eccentrics and coupling (to prevent shaft overload and to insulate the encoder thermally and electrically).
Art.No 8.0000.4500.XXXX

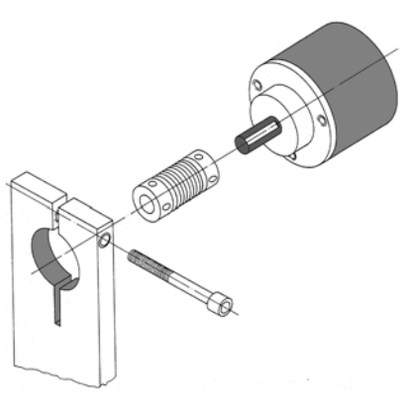


Mounting examples for shaft encoders with clamping bracket:

Mounting with an angular bracket and coupling (to reduce shaft overload).
e.g. Art.No 8.0010.2300.0000



Mounting with a commonly used clamping device and coupling (to reduce shaft overload).



Kübler

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:

Two reasons for errors in accuracy of 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:

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

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
	ppr	1024	2048	4096	8192	16384
Increment	degrees	0,352	0,176	0,088	0,044	0,022
	degrees:min:sec	0:21:06	0:10:33	0:05:16	0:02:38	0:01:19
	sec	1266	633	316	158	79

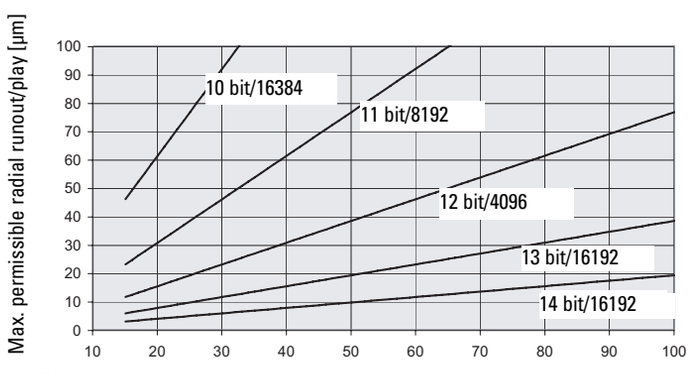
2. Deviations in accuracy caused by radial play in the drive shaft with asymmetrical mounting of the couplings

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

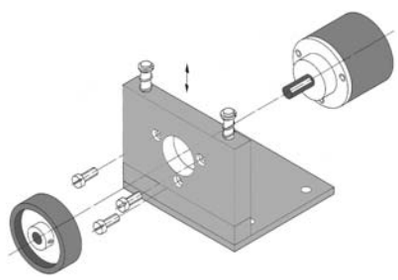


Rotary Measuring Technology - Encoders

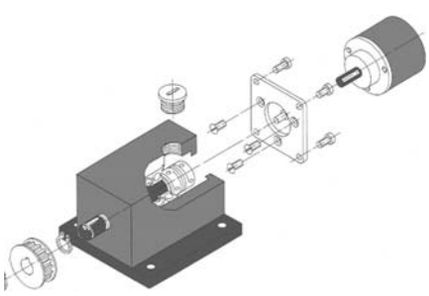
Shaft loads that result in particular from measuring wheels, belts and similar components

Measuring, toothed or belt wheels, mounted directly onto the encoder shaft, exert radial forces on the latter that are dependent on tension and angular acceleration. Kübler encoders are designed so that they are able to absorb a large extent of these forces. The maximum permissible shaft loading is shown in the technical data for the encoder. If in a particular application the load values are likely to exceed those given for the encoder, then the encoder shaft should be isolated from the radial load by means of an intermediate shaft having its own suitable bearings that can take up the forces. For this type of application Kübler offers a special bearing box (see the Accessories section in the catalogue).

Mounting an encoder using a displacement measuring device and a measuring wheel, e.g. for length measurement of film, fabrics etc.
Art.No. 8.0010.7000.0004



Mounting with bearing box, if shaft load is very high, e.g. belt-drives etc.
Art.No. 8.0010.8200.0004



Bearing block for solid and hollow shaft encoders

New

Fast and easy to upgrade and retrofit, increases the maximum bearing load by a number of times.

	Shaft encoder	Hollow shaft encoder
Art. No.	8.0010.8200.0006	8.0010.8400.0007

Rotary Measuring Technology - Encoders

Bearing life:

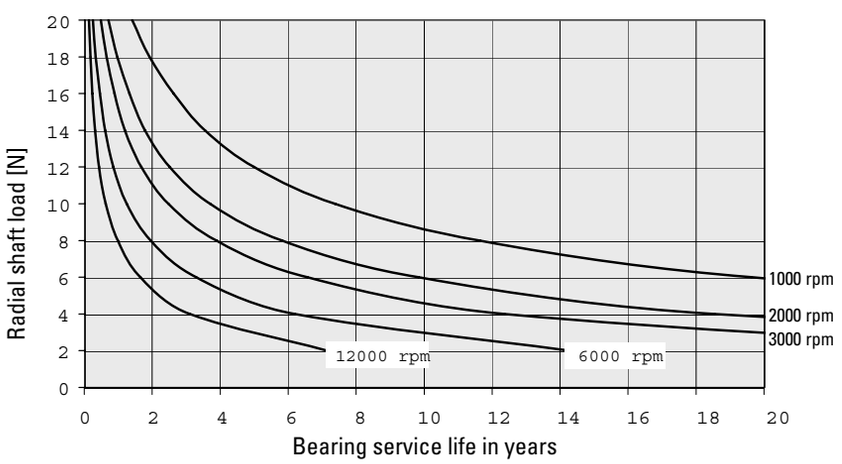
All Kübler encoders are designed to ensure that their bearings give a long service life. This is subject of course to correct installation and to the load limits for the shaft (shaft encoders) being complied with or, in the case of hollow shaft encoders, being mounted with the appropriate stator couplings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

The following diagrams show the expected service life of the shaft encoder bearings depending on the bearing load.

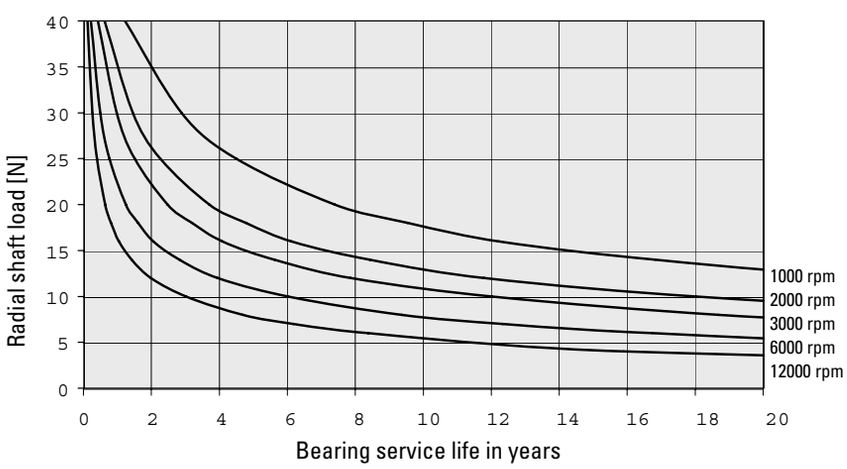
The calculations are based on a mixed load, where the axial force components are always half of the radial shaft load.

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.

Bearing life for shaft encoders Type 2400

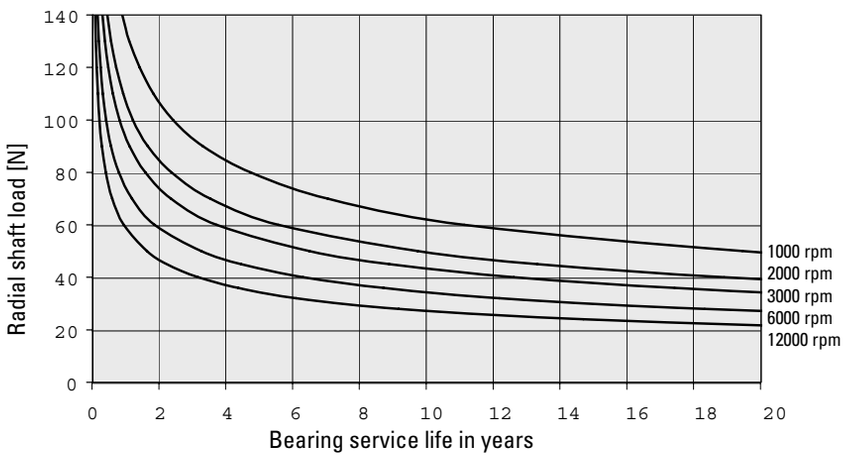


Bearing life for shaft encoders Type 36x0

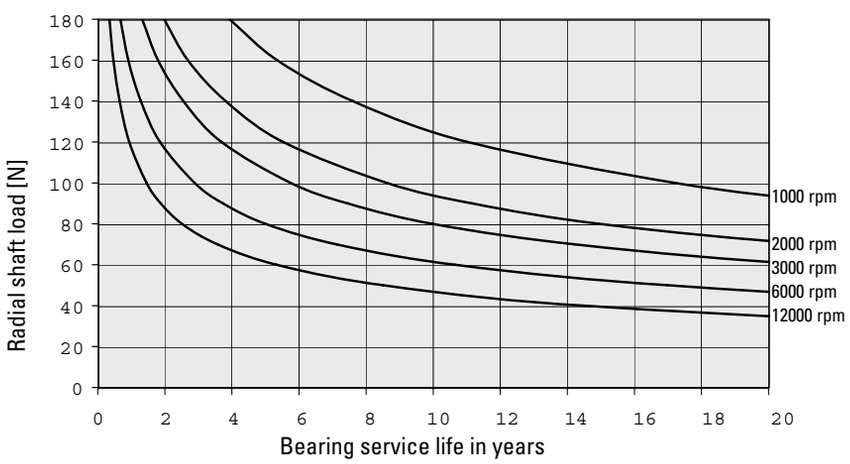


Rotary Measuring Technology - Encoders

Bearing life for shaft encoders Type 3700



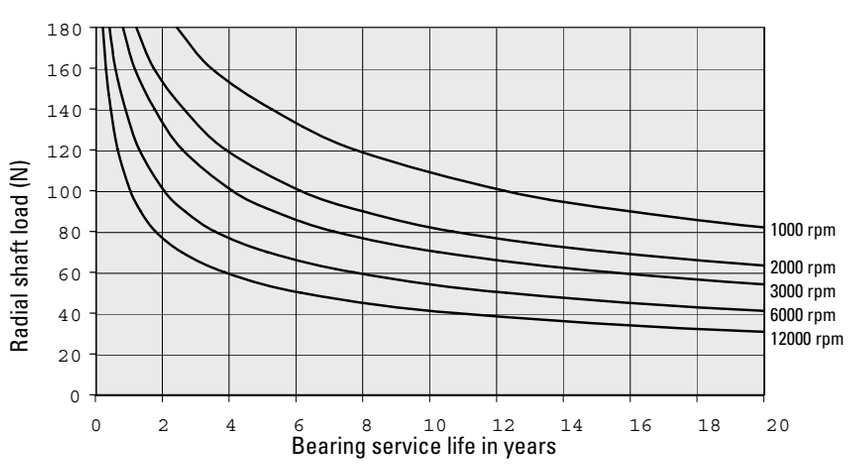
Bearing life for shaft encoders Type 58xx



Bearing life for shaft encoders of the Sendix series

Sendix® inkremental

Sendix® absolut



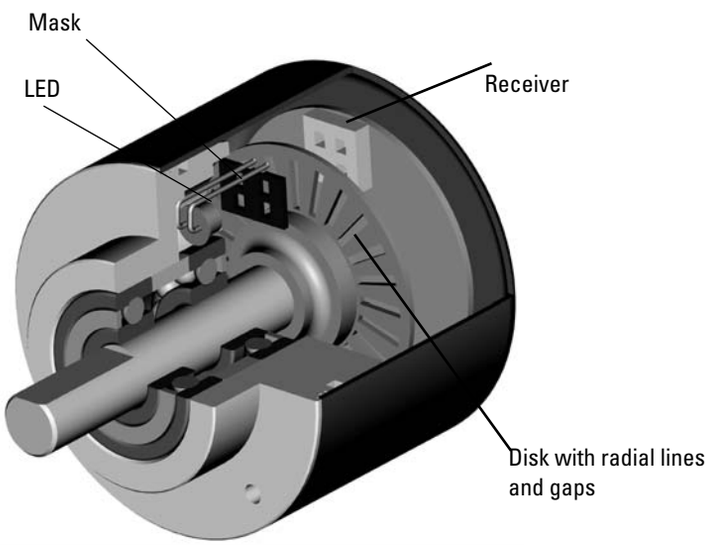
Rotary Measuring Technology

Incremental encoder

Assembly and function:

Kübler encoders operate on an electro-optical scanning principle.

A disk with a radial grating of lines and gaps rotates between a light source (mostly an LED) and a receiver which produces a sine wave signal proportional to the light received.



Mechanical advantages of Kübler encoders

Sturdy bearing construction: "Safety-Lock TM design"

- 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.

- Ideal for use outdoors thanks to its solid die-cast housing and radial shaft seal. The Sendix Inkremenal benefits from a high IP 67 protection rating and a wide operating temperature range from –40 °C up to +85 °C.

Rotary Measuring Technology

Processing of the signals:

The sine wave signals are processed further in an electronic circuitry, usually a Kübler specific ASIC. This is necessary because most controllers (like e.g. Kübler counters) require digital signals with a certain voltage level. For that the signals are pre-processed in the encoder. The pre-processed signals are provided by the output circuit depending on the application.

Selecting an incremental encoder:

When selecting the encoder, following parameters should be considered in addition to the topic mentioned on page 19.

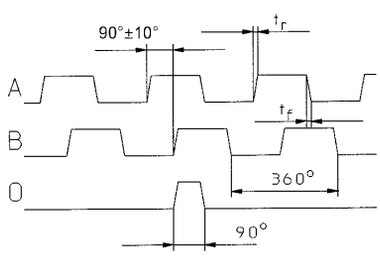
Number of channels:

Encoders with one output channel

Encoders with one output channel are used where no direction sensing is needed, e.g. speed control or length measuring.

Encoders with two output channels

Applications, where the direction of a rotation should be sensed, e.g. positioning, require encoders with two channels A and B being shifted 90° out of phase. By detecting the phase shift, the direction can be located.

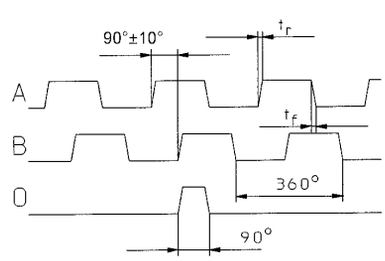


- Shaft turning clockwise, top-view of shaft
- Inverted signals available
- 0-pulse is linked to AND with channel A and B

t_r = rise time
t_f = fall time

Encoders with three output channels

In addition to the two channels A and B there is a zero signal available, that appears once per turn. This can be used e.g. as a reference signal during the first revolution after power up.



- Shaft turning clockwise, top-view of shaft
- Inverted signals available
- 0-pulse is linked to AND with channel A and B

tr = rise time
tf = fall time

Rotary Measuring Technology

Multiplication of pulses:

The resolution of a two channel encoder can be multiplied by two or four using a special edge detecting.

An encoder with physically 5000 pulses per revolution can generate 20000 pulses per revolution using this technique.

Inverted signals:

When used in environments, with a lot of electrical noise and/or if very long cable distances are required, we recommend to use encoders with inverted (complementary) signals. These signals are always available with output circuits of the RS 422 type and sine wave outputs. Kübler also offers them for push-pull outputs.

Resolution:

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: U = 200 [mm]

Accuracy of the system: G = 0.1 [mm]

Wanted: Resolution of the encoder: A = ? [pulses/resolution]

$$\text{resolution} = \frac{\text{Circumference}}{\text{Accuracy}} = \frac{U}{G}$$

The required resolution would be 2000 ppr (pulses per revolution).

Rotary Measuring Technology

Pulse frequency:

The required pulse frequency can be calculated. This is based on the number of pulses per turn (ppr) and the speed (rpm). The max. pulse frequency is listed for each encoder. Usually it is 300 kHz. Kübler also offers high resolution encoders with a pulse frequency of up to 800 kHz.

Example:
how to calculate the required pulse frequency f_{max}:

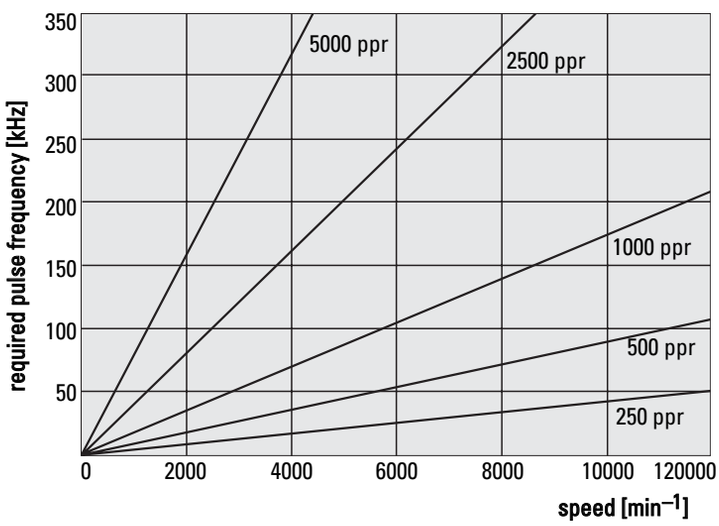
Given: Speed n= 3000 min^{-1}

Resolution of the encoder
R = 1000 ppr

$$f_{max} = \frac{n \times A}{60}$$

The required pulse frequency is 50 kHz. Now you can compare this result with the data of the encoder you would like to choose.

This diagram can be used as a quick guide for the most common resolutions:



Outputs and voltage supplies (overview):

Kübler offers a wide range of possible outputs and voltage supplies for any application.

Output	Inverted signals	Voltage supply
RS 422	Yes	5 V DC
RS 422	Yes	10 ... 30 V DC or 5 ... 30 V DC
Push Pull output	No	10 ... 30 V DC or 5 ... 30 V DC
Push Pull output	Yes	10 ... 30 V DC or 5 ... 30 V DC
Push Pull (7272)	Yes	5 ... 30 V DC
Sine wave voltage output	Yes	5 V DC
Sine wave voltage output	Yes	10 ... 30 V DC

If the encoder is used in an environment with strong electrical noise and long cables we highly recommend the use of inverted signals.

Sensor outputs:

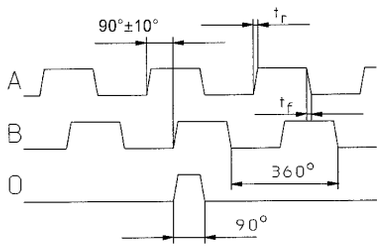
The sensor outputs are used if the distance from the encoder to the control unit is very long and the voltage supply at the encoder could drop due to this long distance.
The input impedance of the sensor inputs (Controller) is very high, and the voltage drop on the sensor output line is almost zero. Due to this it is possible to detect the actual supply voltage of the encoder (e.g. 4.2 V instead of 5 V). Based on this information the controller will increase the voltage supply to e.g. 5.8 V.

Rotary Measuring Technology

Digital outputs:

The sine wave signal from the optical system is first digitised to have square wave signals available.

- Shaft turning clockwise, top view of shaft
- Inverted signals are available
- 0-pulse is linked to AND with channel A and B



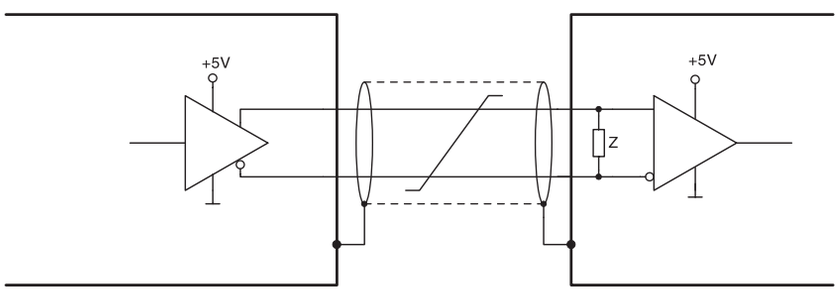
To transmit the signals there are two possible outputs available. RS 422 (TTL compatible) or push-pull (covers PNP or NPN). When choosing the suitable output for the application the following points have to be considered:

- The corresponding unit / controller the encoder will be connected to
- The distance from the encoder to the receiver unit
- The sensitivity against electrical noise or other interference

RS 422:

Output circuit and recommended input circuit

Encoder — recommended input circuit



RS 422 line driver

RS 422 line receiver
e.g. AM26 C 32
Z = 120 Ω

Push-pull outputs:

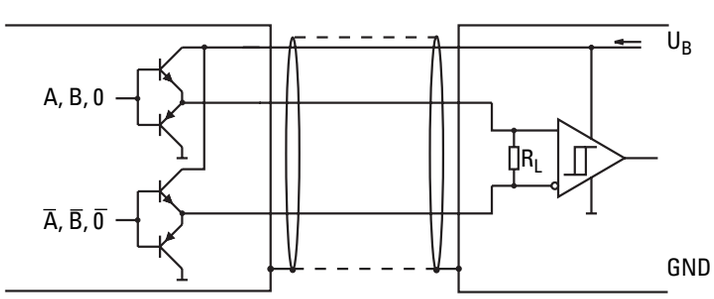
Push-pull outputs are suitable for count interface cards, electronic counters or PLC inputs. They are available in **two versions:**

Push-pull:
- Push-pull with integrated wave impedance adjustment, recommended cable impedance 40 … 150 Ω
- Recommended for long cable lengths, high pulse frequencies and output voltages to 30 V
- With or without inverted (complementary) signals

Push-pull (7272):
- Universal line driver 5 … 30 V with low-level (max 0.5 V)
- Recommended for cable lengths up to 30 m
- With inverted signals

Output circuit and recommended input circuit push-pull with inverted signals:

Encoder — recommended input circuit



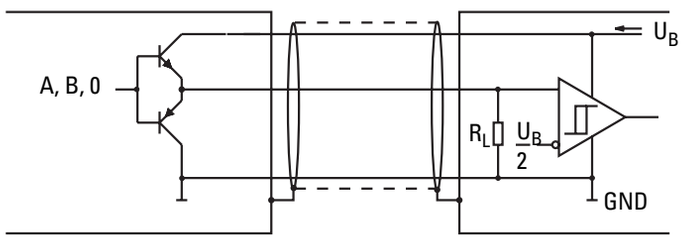
integrated push-pull driver

R_L = 1 kΩ

Rotary Measuring Technology

Output circuit and recommended input circuit push-pull without inverted signals:

encoder recommended input circuit

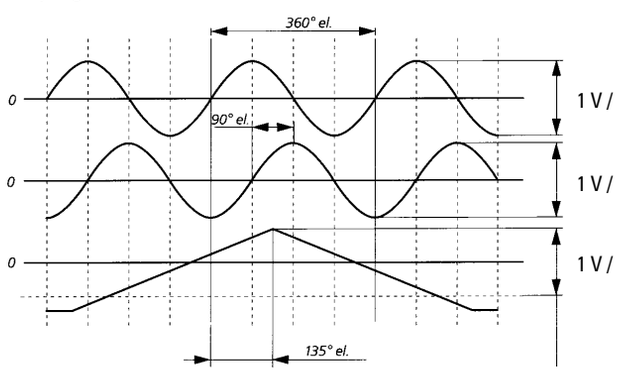


Integrated push-pull driver RL = 1 kΩ

Sine wave outputs:

The sine wave signals are available as voltage signals. They can be further processed and be multiplied by a factor of usually 10, 20, 50, 100, 400, 500, 1000 res. binary factors (512, 1024). Due to the interpolation of the two signals, which are 90° out of phase, a very high resolution can be achieved.

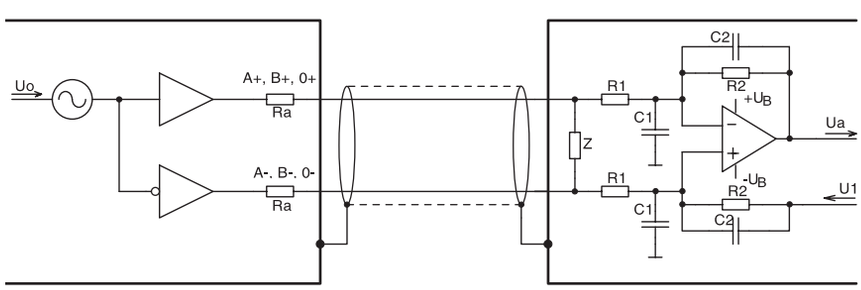
This makes these kind of signals specially useful for applications where very high resolutions are required. Further they are very suitable for digital drives with a very slow and precise movement, e.g. for grinding machines or lifts and elevators.



- Shaft turning clockwise, top view of shaft
- 0-pulse is generated once per turn

Output circuit and recommended input circuit for sine wave voltage signals:

encoder recommended input circuit



R_a = 10 Ω Z = 120 Ω OPV: e.g. MC33074

C_1 = 150 pF $U_1 = U_0$

C_2 = 10 pF

R_1 = 10 kΩ

R_2 = 33 kΩ

U_0 = 2.5 V ±0.5 V

Rotary Measuring Technology

Cable length:

Depending on the output circuit and the electrical noise the following cable lengths are recommended:

Output circuit	max. cable length	Encoder connected to e.g.
Push-pull without inverted signals	100 m	Kübler counter/PLC
Push-pull with inverted signals	250 m	PLC/IPC[1)]
Push-Pull with inverted signals (7272)	30 m	
RS 422 with inverted signals	up to 1000 m (> 50 m depending on frequency)	PLC/IPC[1)]
Voltage sine with inverted signals	50 m	PLC/IPC[1)]

[1)] IPC = industrial PC

Annotations:

- Depending on the application the recommended cable length can be shorter, especially in areas with strongly electrical noise.
- Always use shielded cables
- The core diameter of the signal cores should be ≥ 0.14 mm^2
- The core diameter of the voltage supply cores should be large enough depending on the cable length, that the voltage supply of the encoder is high enough and the signals do not go below the minimum levels!

We strictly recommend the use of the cable types written down in the accessories.

Rotary Measuring Technology

Absolute encoder

Design and function:

Absolute encoders have a disk with a digital coding on concentric tracks. This code is read by a Kübler Opto-Asic. A unique bit pattern is assigned to each position.

The advantage is, that after power failure true position verification is available as soon as power is up again, even if the shaft was moved during the dead state.

Advantage: No reference drives after starting-up are necessary as with incremental systems. Safety is increased and the time taken for reference drives is saved.

Mechanical advantages of Kübler encoders:

Sturdy bearing construction: "Safety-Lock TM design"

- 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.
- Ideal for use outdoors thanks to its solid die-cast housing and radial shaft seal. The Sendix Inkremenal benefits from a high IP 67 protection rating and a wide operating temperature range from –40 °C up to +85 °C.

Selecting an absolute encoder:

When selecting the right absolute encoder the following parameters should be considered in addition to the recommendations on page 20.

- Supply voltage
- Type of code
- Interface (SSI, parallel, fieldbus, 4 ... 20 mA)

Versions:

Singleturn encoders:
Depending on the number of divisions they generate up to 16384 (14 Bit) unique positions per turn. This corresponds to an angular resolution of 0.022° (= 1.3'). After one revolution the process re-starts.

Singleturn encoders can be used in applications where revolution is sufficient, e.g. measurement of angles, robotic.

Multiturn encoders:
They are available with up to 8192 (13 Bit) definite angular positions per revolution and in addition 4096 (12 Bit) definite revolutions. This corresponds to 33.5 million definite positions.

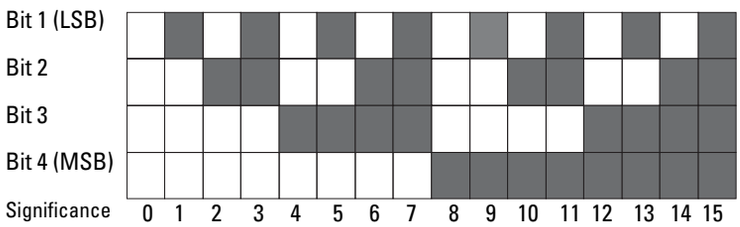
Multiturn encoders can be used for positioning applications e.g. automatic storage, retired systems, lift elevators, cranes, machine tool, etc.

Rotary Measuring Technology

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.



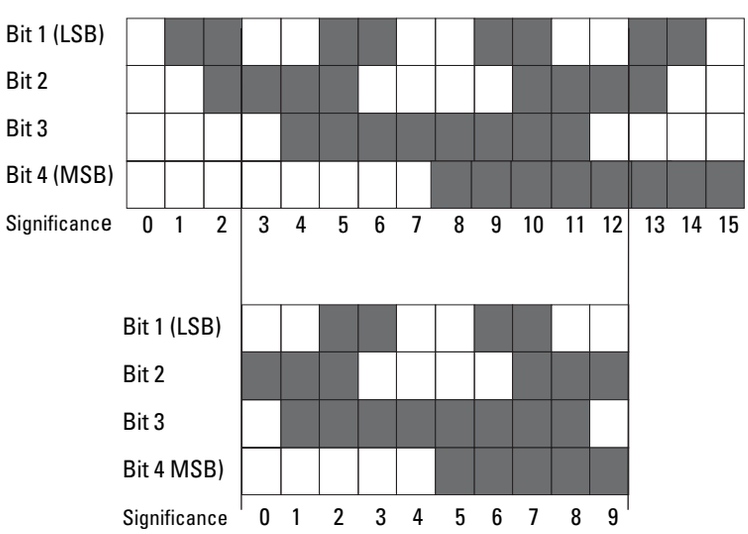
Gray Code:

The Gray Code is a single-step code. This indicates, that from one position to the next only 1 bit is changed. The reliability of the code detection is increased, which leads to a high position-reliability.

The Gray Code is used to optically read out the position for all absolute encoders

Symmetrically cut Gray Code (Gray-Excess):

The extraction of a defined part of the Gray Code leads to the gray-excess code. This code enables the generation of non binary based divisions, e.g. 360, 720, 1000, 1440.



Rotary Measuring Technology

Reversion of the Gray Code:

The code values increase when the shaft is turning clockwise. If the most significant bit (MSB) is inverted, the code values decrease when the shaft is turning clockwise

Programmability

The encoder type series 5862, 5882 and 9081 are user programmable. For this you can use the Kübler programming tool Ezturn® For further information please look at page 303.

Patented Integrative Technology®:

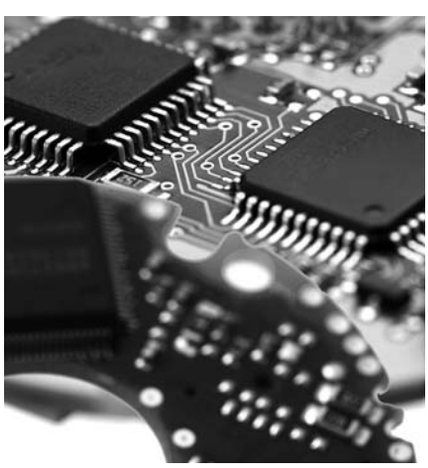
Integrative Technology, developed and patented by Kübler, is a package of measures that ensures compact construction, high signal quality, high shock resistance - up to 2500 m/s2, high reliability and a high level of immunity to EMC.

This is achieved using an Opto ASIC, a multilayer board and an especially shock resistant and space-saving method of mounting the sensor unit. In addition the use of a highly optimized interface ASIC ensures the integration of several hundred individual components. Components that had previously been needed to balance the system, such as balancing potentiometers, can be dispensed with.

Advantages of Integrative technology:

Singleturn shaft encoders are available with the same dimensions as their incremental correspondents. This allows an easy mechanical substitution.

Singleturn hollow shaft encoders at a resolution from up to 16384 divisions (14 Bit) require an installation height of only 42 mm. Also in terms of multiturn encoders, Integrative Technology® allows an installation height of only 50 mm (with a diameter of up to 28 mm and a resolution of 25 Bit (13x12 Bit)).



Rotary Measuring Technology

The multiturn gear module – armed to the teeth (12 Bit resolution)

Mechanical or electronic gears?

Absolute singleturn and multiturn encoders have established themselves as the standard method for measuring linear displacement or angular position. With absolute encoders a reference trip is no longer needed after system start-up or a power-down. Multiturn encoders in particular are now being employed, where previously incremental encoders had predominated, for example with geared motors or in lifts.

Today all manner of multiturn encoders are available in a variety of designs. As a rule the manufacturers offer either mechanical gears for 'counting turns', or swear by electronic counters with electronic data storage. They are critical of any other technology.

The fact is however: it is not a case of which is better or worse; each technology has its advantages and drawbacks. Only the actual application can decide.

Absolute Multiturn Encoders from Kübler – mechanical or electrical ?

Unique:
The optimal solution from Kübler
– fits your application.

Kübler PLUS

Characteristics	Geared Multiturn NEW! Sendix® absolut	Existing type series Electronic Multiturn
For use near to strong magnetic fields, e.g. for geared motors with brake	**Very good:** Sendix absolut encoders are 100% resistant to magnetic fields. They succeed against other geared solutions, which to some extent use magnetic sensor technology. No battery required!	**Limited:** Because of magnetic sensitive parts (as is common with encoders with electronic multiturn).
High dynamic – high precision feedback	**Very good:** Highly deterministic and fast, allow feedback cycle times << 20 µs, sine/cosine Outputs as option.	**Good:** With optional incremental tracks A/B.
Outdoor applications Wet environment	**Very good:** Sendix absolut up to IP 67.	**Good:** Up to IP 65.
Very high or low temperatures e.g. outdoor applications	**Very good:** Sendix absolut for a wide temperature range of -40 °C bis 90 °C.	**Good:** -20°C ... +80 °C.
Limited space Large hollow shaft	**Good:** Sendix absolut is the first encoder on the market to offer a through hollow shaft up to 14 mm or blind hollow shaft solutions up to 15 mm. This offers space-saving possibilities.	**Very good:** Integrative and Intelligent Sensing Technology permits hollow shafts up to 28 mm or the slimmest multiturn encoder on the market, with an installation depth from only 42 mm with through hollow shaft.
Safety critical equipment	**Very good**	**Limited:** To some extent mechanical gears are prescribed.
Programmability	**Limited:** Resolution Single-turn, Offset, Code direction, configuration by factory (configuration software in preparation).	**Very good:** full range scaleable and additional features like 4 programmable outputs (with EzTurn).
Set Up	**Very good:** SET-Push button and Status-LED facilitate the set up locally, additional DIR- and SET-Inputs.	**Good:** SET- and DIR-Inputs.

Rotary Measuring Technology

Outputs

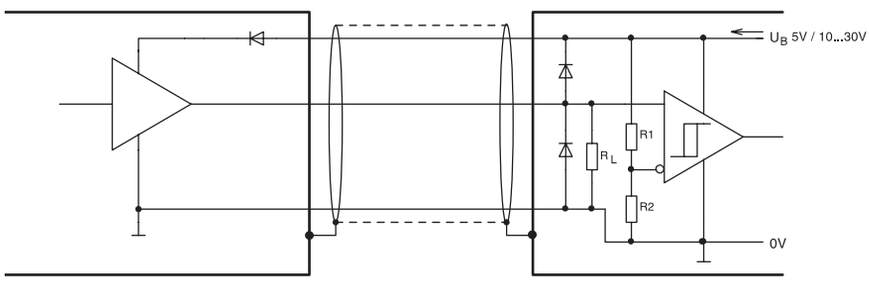
To transfer the position data to a controller, different interfaces are available.

Parallel output:

This type of transfer is very fast. All bits of a position are transferred simultaneously each via a separate line.

Output circuit and recommended input circuit parallel interface:

encoder recommended input circuit



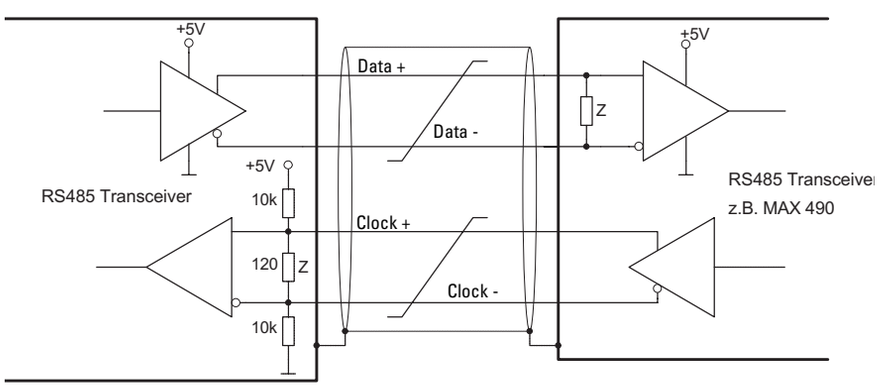
Integrated push-pull driver

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 cores are needed for transmission and the possible cable length is much longer.

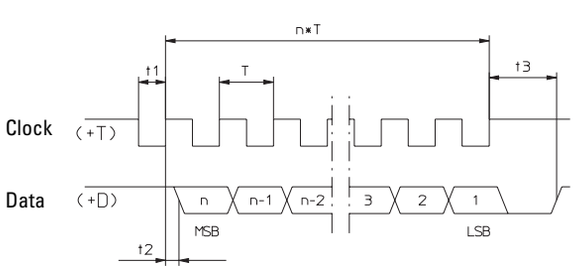
Output circuit and recommended input circuit for multiturn encoders with SSI output

Encoder types 5850,5870 and 7031 have inputs galvanically isolated by opto-couplers.



Z = 120 Ohm

Data transmission SSI:



t1 = T / 2
t2 < 1 / (4 x fmax)
t3 = Monoflop time (see below)
n = Resolution in Bit
1/ fmax =< T =< 1 / fmin
fmin = min. SSI clock rate (see data sheet)
fmax = max. SSI 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 next

positive-going clock-pulse edge the data line will remain 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 series 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: t3 = max. 40µs

Only for the new Sendix Absolut 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 t3. 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 t3 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: t3 = see data sheet.

BiSS Interface:

New

Open, digital sensor interface (BiSS)

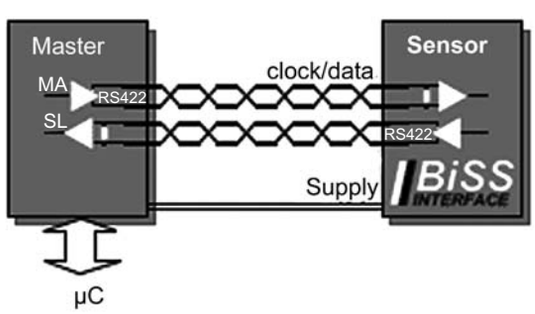
The bidirectional digital sensor interface (BiSS) assures the communication between the encoder and the measuring device or drive control and can if required simultaneously transfer the measured values of up to 8 sensors.

For 1 to 8 subscribers the interface master provides the clock signal for the simultaneous capturing of all position data as well as for the subsequent synchronous serial data transmission. Only 4 unidirectional RS422 data lines are required; the minimal slave electronics is located directly in the sensor ICs.

When the master sends the clock pulse on the line MA, the slave will reply on the return line SL with the captured position data. Commands or parameters are exchanged via a PWM clock sequence, although this is not necessary for the startup of the BiSS protocol.

With every data cycle the master learns and compensates for the signal transit times, thus enabling high clock rates up to 10Mbit/s even with cable lengths of 100 m. Varying cable conditions, for example due to drag movement, are corrected.

The synchronization accuracy between several encoders on a number of axes is less than 1 microsecond; moreover the master keeps the signal transit times that have been experienced transparent for the controller and thus enables a further optimization.

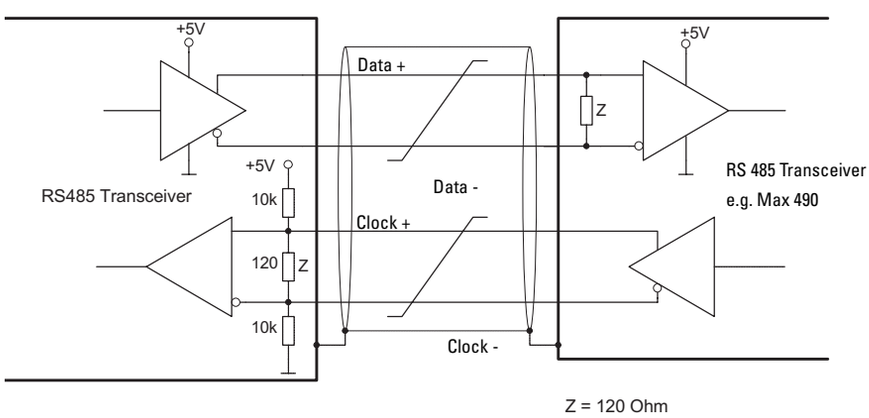


Rotary Measuring Technology

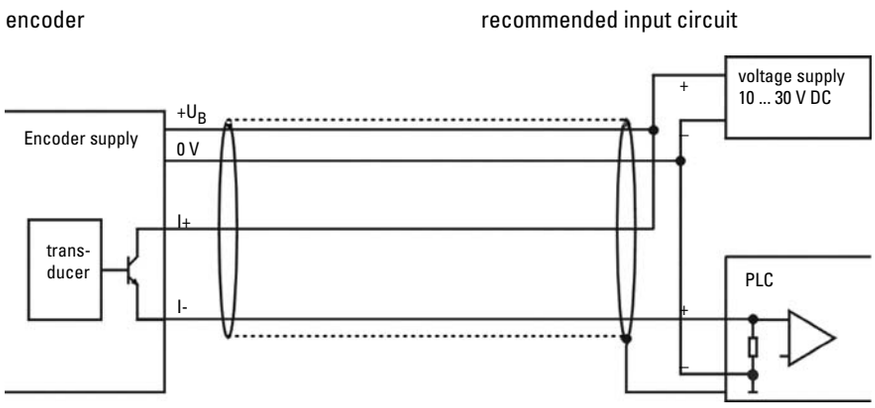
The BiSS protocol classifies each subscriber into various data areas: sensor data, multi-cycle data and register data. These data areas are laid out differently with respect to the possibility to access them and to their transmission performance, so covering a wide variety of sensor applications. A bidirectional communication parameter for configuring the device, and if need be for so-called OEM parameters, is placed as is customary in the register data area. Data that change slowly such as speed of rotation or motor temperature occupy the multi-cycle data area, whereas data that are changing quickly occupy the sensor data area.

This means that there is no problem in achieving control cycle times under 10 - even for data words up to 64 bit. Enough space is available for redundancy and as a rule is used for implementing a CRC (cyclic redundancy check). As they are only framed by a start and a stop bit, the sensor data is transferred at the best possible user data rate; a single multi-cycle data bit is optional. Similarly detected and triggered, the multi-cycle data bits form a second in-band protocol and contribute to the redundancy of the sensor data – permanent monitoring of the drive status and operation is possible, without interfering with the controller cycle. Specific device developments by individual users are not restricted or made more expensive by a need to be compatible with other BiSS products. A BiSS subscriber is described with only a few parameters and an XML device description file that comes with the product simplifies the startup of the controller.

Output circuit and recommended input circuit for absolute encoders with a BiSS output

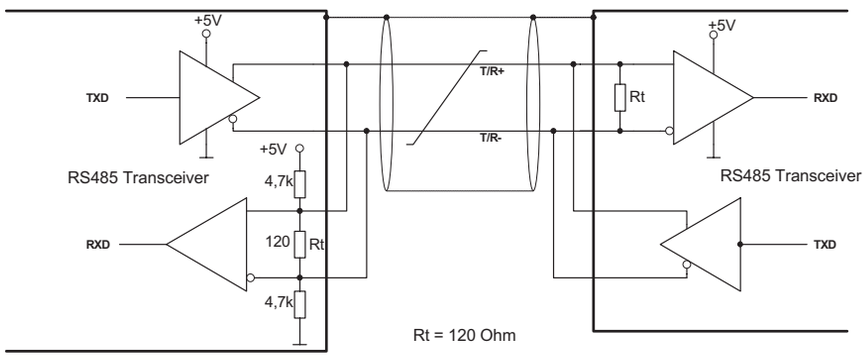


Type of connection and recommended input circuit for encoder for encoder type 5850 and 7031 with current interface 4 ...20 mA



Rotary Measuring Technology

Output circuit and recommended input circuit for encoder
with **RS485 interface (half-duplex)**
e.g. 5862, 5882, 9081:



Encoders with internal termination have a fixed terminating resistor Rt built in. This variant is designed for point-to-point transmissions between 2 devices. With devices having external termination the user must activate the terminating resistor by placing a jumper between pins 5 and 6. This option is suitable to the construction of bus systems with several encoders. With bus systems, the EIA-485 standard recommends terminating each end of a data link circuit with a terminating resistor. The RS-485 interface is asynchronous. In half-duplex operation it is not possible to send and receive at the same time. The data transmission is controlled via ESC commands.

Cable length:

Depending on the desired output circuit, we recommend the following cable lengths:

Interface and output circuit	max. cable length	Connected to
Parallel CMOS/TTL	2 m	PLC/IPC[1)]
Parallel push-pull	100 m	PLC/IPC[1)]
SSI	up to 1200 m	PLC/IPC[1)]
RS 422 /RS 485	(>50 m depending on frequency)	
Analogue 4 ... 20 mA	200 m	

[1)] IPC = Industrial PC
[2)] Depends on clock frequency: at 100 kHz L_{max} approx. 250 m; at f = 250 kHz L_{max} approx. 50 m

Annotations:

- Depending on the application the max. allowed cable length can be shorter, especially in areas with strong electrical noise.
- Always use shielded cables
- The core diameter of the signal cores should be $\geq 0.14\ mm^2$
- The core diameter of the voltage supply cores should be large enough depending on the cable length, that the voltage supply of the encoder is high enough and the signals do not go below the minimum levels!
  We strictly recommend the use of the cable types written down in the accessories.

Rotary Measuring Technology - Fieldbus

Bus systems:

The use of a network of sensor-actuator bus systems has essential advantages:

- Reduced expenditure concerning connection: All members are linked by one cable.
- Wide range diagnostics and programming possibility of the units.

In the following please find the available bus systems:

PROFIBUS

CANopen

DeviceNet

CAN:

CANopen

- CAN fulfils the real time demands of the automobile industries (ABS, airbag, motor management)
- Multi-Master system
- The message text (speed, position...) itself is marked by an identifier through the whole network, instead of indexing the nodes.
- Check for importance of message
- Accept or ignore ® network wide broadcasting
- high allocation on the network
- Monitoring (high reliability)
- Bus Specification according to CAN High Speed ISO/DIN 11898 for transmission rates of up to 1 MBaud.

Introduction

The Kübler Profibus encoder is an absolute multiturn encoder. The version described sends its current position to another station via the "CAN-bus" transmission medium (physically: screened and twisted two-wire line).
The serial bus system CAN (Controller Area Network), which had been originally developed for automotive uses, is gaining ground in industrial automation technology. The system is multimaster compatible, i.e. several CAN- stations are able to request the bus at the same time. The data transfer is regulated by the message's priority. The message with the highest priority (determined by the identifier) will be received immediately. Within the CAN system, there are message identifiers but no transport addresses. The message which is being sent can be received by all stations at the same time (broadcast). Because of a message filtering, the station only accepts messages which are important for itself. The identifier transmitted with the message is the basis for the decision if the message will be accepted or not.
The bus coupler is standardised according to the international standard ISO-DIS 11898 (CAN High Speed) and allows data to be transferred at a maximum rate of 1 MBit/ s.
The most significant feature of the CAN-protocol is its high level of transmission reliability (Hamming distance = 6). The CAN-Controller Intel 82527 used in the encoder is basic as well as full-CAN compatible and supports the CAN-specification 2.0 part B (standard protocol with 11-bit-identifier as well as extended protocol with 29-bit identifier). Until today , only 11-bit identifiers have been used for CANopen.

The CANopen Profile

CANopen allows:
- Auto-configuration of the network
- Easy access to all device parameters
- Device synchronization
- Cyclic and event-driven process data exchange
- Simultaneous reading and writing of data

CANopen uses four Communication Objects (COBs) with different characteristics.
- Process Data Objects (PDOs) for real-time data
- Service Data Objects (SDOs) for the transfer of parameters and programs
- Network Management (NMT, Lifeguarding)
- Pre-defined Objects (for time stamping and emergency messages).

All device parameters are filed in an Object Dictionary. This Object Dictionary contains the description, data type and structure of the parameters as well as the address (index).

The Object Dictionary is divided in 3 parts:
– Communication Profile
– Device Profile
– Manufacturer-specific section.

Implemented Profiles:

- CAN openEncoder Profil DS 406 V3.1
- CAN openLift Profile DS417 V1.1

For further information, see www.can-cia.org

Kübler PLUS

Rotary Measuring Technology - Fieldbus

DeviceNet:

DeviceNet™

- Master/Slave and peer-to-peer capabilities
- Transport of control-oriented information such as process data
- Supports up to 64 nodes
- Simultaneous support of network powered and self-powered devices
- Protection in case of wiring errors
- Recognition of identical node addressing (duplicate MAC-ID detection)
- **Bus specification to CAN High-Speed ISO/DIN 11898 for transmission rates of 125 Kbits, 250 Kbits or 500 Kbits**

Detailed description of DeviceNet

The Kübler DeviceNet encoder is an absolute multiturn encoder, which sends its current position to other stations on the bus via the DeviceNet interface. The serial bus system CAN (Controller Area Network) that was originally developed for applications in the automotive industry is also becoming more widespread in automation technology. It is multimaster capable, i.e. several DeviceNet nodes can simultaneously request the current position.

Data transfer is controlled by the priority of the message. With DeviceNet there are no node addresses, only message identifiers. The message being sent can be received simultaneously by all nodes (Broadcast). Because of message filtering each node only accepts messages meant for it. The criterion for this decision is the identifier transmitted with each message.

The bus interface meets international standards. The CAN controller used works equally well with Basic as well as Full CAN and supports the CAN specification 2.0 Part B (standard protocol with 11 bit identifier as well as the extended protocol with 29 bit identifier).

Field of application

The Kübler DeviceNet encoder is used in systems, when the position of a drive or machine part is detected and must then be communicated on to a controller.

The encoder carries out this task as a node on the bus.

The DeviceNet profile:

Communications system:	Producer/Consumer	
Control Architectures:	Strobe I/O, Change of State I/O, or Cyclic Interval I/O	
Speed Example:	< 1 ms for eight closed controllers	
Cable length and bus speed:	Baud rate	Distance
Speed	125 Kbps	500 m
	250 Kbps	250 m
	500 Kbps	100 m
Bus topology:	Linear (trunkline/dropline), supply and signal are on the same line.	
Power supply:	24 V DC rated at up to 8A	
Number of nodes:	max. 64	
Standard Used:	CAN (ISO 11898)	
Media Access Method:	Multi-cast messaging	
Governing body:	Open DeviceNet Vendor Association (ODVA)	

Rotary Measuring Technology - Fieldbus

Profile
Device Profile for Encoders
DSE 354-01

This profile describes the mandatory specification of the encoder interface, independent of the manufacturer. It defines which DeviceNet functions are used and how they need to be applied. This standard allows to have a bus system which does not depend on the manufacturer.
The device profile is structured into several object classes.

Classes:

Object Class	Implementation	Instance
Identify	required	1
Message Router	required	1
DeviceNet	required	1
Connection	required	at least 1 - Explicit, I/O
Assembly	required	at least 1
Parameter	optional	1 (5)
Position Sensor	required	1

Data transmission:

Instance	Name	Access
1	Code Sequence	r/w
2	Scaling Function Control	r/w
3	Position Format	ro
4	Measuring units per Revolution	r/w
5	Total Measuring Range	r/w
6	Position Measuring Steps	ro
7	Preset Value	r/w
8	Position Value	ro
9	Operating Status	ro
10	Single Turn Resolution	ro
11	Number of distinguishable revolutions	r/w
12	Alarm Flag	ro
13	Generated Alarms	ro
14	Supported Alarms	ro
15	Warning Flag	ro
16	Generated Warnings	ro
17	Supported Warnings	ro
18	Serial Number	ro

Encoder node number

The node number of the encoder is set by hardware via 6 DIP switches on the bus wiring backplane.
The following settings are possible:
Nodes: 0 … 63
Baud rate: 125, 250, 500 Kbits.

Rotary Measuring Technology - Fieldbus

Profibus: General Information

The basic functions of PROFIBUS DP are described in extracts at this place. For additional information, please refer to the standards of PROFIBUS DP, i.e. DIN 19245-3 and EN 50170 respectively.

Introduction

The Kübler Profibus encoder is an absolute multiturn absolut encoder. The version described sends its current position to another station via the transmission medium "PROFIBUS DP" (physically: screened and twisted pair line). The Profibus encoder supports all class 1 and 2 functions listed in the encoder profile.
PROFIBUS-DP is standardised and binding, but manufacturer-independent definition for a variety of applications in the field of production, process and automation. The requirements of openness and independence from the manufacturer are stipulated in the European standard EN 50 170.

PROFIBUS-DP permits the communication between devices produced by different manufacturers without any particular adaptations of the interfaces. PROFIBUS DP is a special standard version for a fast data exchange within the field level which has been optimised in terms of speed and low connection costs. Central with local field devices like drives, valves, or encoders. The data exchange between these devices is predominantly cyclical. The communication functions required for this exchange are determined by the functions of the PROFIBUS DP according to the EN 50 170 European standard.

Field of application

Within systems, when the position of a drive or of any other part of a machine has to be recorded and transmitted to the control system, the encoder is taking over this function. For instance positioning tasks can be resolved by the encoder. Therefor the feedback signal which gives information about the present drive position is sent back via PROFIBUS DP to the positioning unit.

Basic function of the Profibus DP

The central control system (master) cyclically reads out the input information from the slaves and transmits the output information to the slaves. For this purpose, the bus cycle time has to be shorter than the program cycle time of the central control system (e.g. SPC, or IPC), which amounts of approx. 10 ms for several applications.

Beside the cyclical user data transfer, the PROFIBUS DP version also disposes of powerful functions for diagnosis and initial operation procedures. The data traffic is controlled by watchdog functions on both the slave and the master side. As mentioned below the basic functions of the PROFIBUS DP are summarised.

PROFIBUS DP Basic Functions

Transmission technology:
- RS-485 twisted pair line
- Baud rates ranging from 9.6 kbit/s up to 12 Mbit/s

Bus access:
- Monomaster or multimaster systems possible
- Token passing procedure between the masters and master-slave procedures for slaves
- master and slave devices, max. of 126 stations at a single bus

Communication:
- Point-to-point (user data communication) or multicast (control commands)
- cyclical master-slave user data communication and acyclical master-master data transfer

Operating state:
- Operate: cyclical transfer of input and output data
- Stop: only master-master data transfer is possible
- Clear: The input data are read, the output data remain in the safe status
- **Synchronisation:** Control commands enable a synchronisation of the input and output data
- Sync mode: Output data is being synchronised

Rotary Measuring Technology - Fieldbus

PROFIBUS DP Basic Functions
(continued)

Functionality:
- Address assignment for the DP slaves via the bus
- Cyclical user data transfer between DP master and DP slave(s)
- Configuration of the DP master (DPM1) via the bus
- Single DP slaves are dynamically activated or deactivated
- Control of the DP slave's configuration.
- Powerful diagnostic functions, 3 stepped diagnostic message levels.
- Maximum of 246 byte input and output data per DP slave possible
- Synchronisation of in- and/ or output

• Protection functions:
- Access protection of the DP slaves' input/ output
- All messages are transferred with a hamming distance of HD=4
- Response control at the DP slaves
- Monitoring of the user data communication with adjustable control timer at the master

Device types:
- DP master class 2 (DPM2), e.g. programming/project planning devices
- DP master class 2 (DPM2), e.g. central automation devices like SPC, PC
- DP slave e. g. devices with binary or analogue input/output, drives, valves.

Diagnostic function

The extensive diagnostic functions of PROFIBUS DP allow a quick localisation of possible errors. The diagnostic messages are transmitted by means of the bus and are joined together at the master.

System Performance

To ensure a high level of exchangeability between the devices, the system performance of PROFIBUS DP has also been standardised. It is mainly determined by the operational status of the DPM1. The DPM1 can either be controlled locally or via bus by the project planning device. The following three main states are available:

Operate
The DPM1 has entered the data transfer phase. In case of a cyclical data traffic, the input is read by the DP slaves while the output is transferred to the DP slaves. After an error has occured during the data transfer phase of DPM1, the response of the system is determined by the parameter “Auto Clear” - e.g. failure of a DP slave. If this parameter has been set to true, the DPM1 will set the output of all the respective DP slaves to the safe status, as soon as a DP slave is no longer available for user data communication. Afterwards, the DPM1 changes to the clear status. If this parameter is = false, the DPM1 remains, even if an error occurs, in the operate status, and the user can determine the response of the system at his own decision.

Stop
There is no data traffic between DPM1 and the DP slaves.

Clear
The DPM1 reads the input information of the DP slaves and maintains the safe status of the DP slaves' output.

Cyclical data transfer between DPM1 and the DP SLAVES

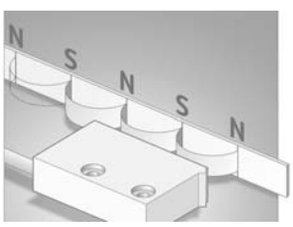
The data traffic between the DPM1 and the respective DP slaves is automatically handled by the DPM1 in a fixed, recurring order. When configuring the bus system, the user assigns a DP slave to the DPM1. In addition the slaves are in- or excluded from the user data communication. The data traffic between the DPM1 and the DP slaves is subdivided in three phases : parameterisation, configuration, and data transfer. Before including a DP slave in the data transfer phase, the DPM1 checks during the parameterisation and configuration phase, whether the planned set configuration corresponds to the actual configuration of the device. For this check, the device type, the information on the format and the length as well as the number of input and output lines have to be correct. Due to this check it is ensured that the parameterisation is reliable and correct at the end. In addition to the user communication, which is automatically executed by the DPM1, the user can request the new parameterisation data to be sent to the DP slaves.

Linear Measuring Technology

Magnetic measuring system *LIMES*
up to 90 m measuring length
up to 0.005 mm resolution

Idea

A magnetic sensor is guided across a magnetic band without coming into contact with it. The changes in polarity on the magnetic band are counted and intermediate values are interpolated. Our engineers have fine-tuned the system to such a degree that resolutions up to 0.005 mm are possible. The system is not affected by dust, shavings or humidity and is resistant to many liquids and to oil. Assembly is easy - the magnetic band just has to be glued into place. There are no problems for calibration.



Kübler PLUS

The distance between the sensor and the magnetic band can be up to 2 mm. Repeat accuracy is very high.

Everything from one source

Due to our comprehensive know-how in the field of counting and process technology, we also offer a suitable digital display for the ***LIMES*** L1 measuring system.

Magnetic sensor ***LIMES*** L1 and magnetic band ***LIMES*** B1

Multi-function display model 571.

Where is our LIMES system used?

The measuring system offers an economical alternative to optical systems in applications where the high accuracy of the glass rules is not absolutely necessary but where up till now no other suitable alternative has been available.

Because of its rugged construction the measuring system can now be used even in tough industrial environments.

The system is not affected by vibration nor is it damaged if subjected to high shock loads. Our flexible magnetic band offers a further interesting area of application, due to the fact that it can be fitted round very large shafts. The maximum length of the magnetic band is 90 m!

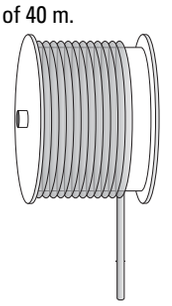
Linear Measuring Technology

Draw wires
Measuring lengths up to 40 m
Resolution up to 0.1 mm

Idea

At the core of a draw wire encoder is a drum mounted on bearings, onto which a wire is wound. The winding takes place via a spring-loaded device. An encoder counts the number of revolutions. If the circumference of the roll is known, the length can be calculated. Draw wires transform linear movements into rotary movements. These movements are measured by encoders.

We offer a wide range extending from miniature draw-wire encoders up to draw-wire encoders with a measuring range of 40 m.



Mini

Standard

Maxi

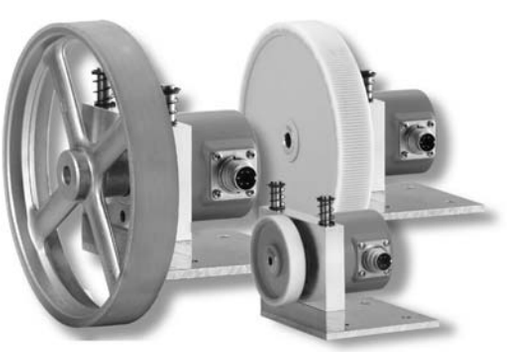
Linear Measuring Technology

Length measuring kits.
Unlimited length
Resolution up to 0.1 mm

We transfered our know-how we achieved in the area of sensor and counting technology to our measuring kits. We deliver the measuring wheel, the encoder and the counter - **all from a single source**.

Just plug in and go. No need to spend a lot of time and effort gathering together components to suit.

We deliver the complete sets.



Connection technology

Why M12 connection technology?

– **Lower costs, easy installation**
using pre-assembled cables reduces the time required for startup and connection.

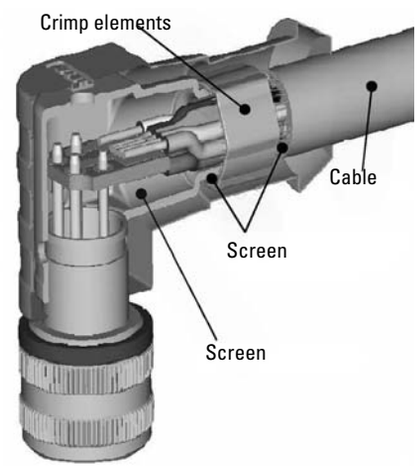
– **Higher quality**
due to avoidance of installation errors
– **qualitative high-grade shielding**
for optimum EMC protection

Area of application

– **Encoders with fieldbus connections**
of Kübler Company: CANopen, DeviceNet, Profibus-DP
- Standard encoders with M12 connectors

Technical information on connectors

Example of the shielding design of an M12 Profibus-DP connector



Notes on the materials used:

Contacts and body

Brass is the basic material employed. The materials used determine the characteristics of the contacts, for example:
– electrical conductivity
– max. operating temperature
– strength or spring characteristics

The surfaces are coated with either gold or silver, in order to protect the contacts and body from aggressive environmental influences and to improve the conductivity.

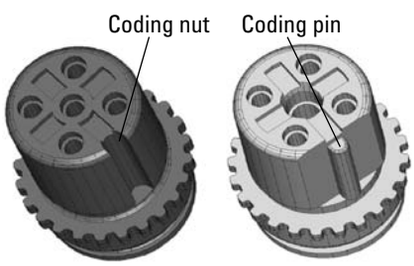
Handle and Body

Polyamide (PA) and polyurethane (TPU) are the main base materials employed here.

These materials are characterised by:
- Flexibility over a wide temperature range
- High wear resistence
- Good dynamic load capacity
- Good resistance to chemicals

Connector coding:

The connectors are coded to ensure safe connections. This coding is achieved by means of a pin or a nut on the contact carrier. A distinction is made between A and B(W) coding. The B(W) coded variant includes in the pin contact carrier a so-called mandrel. This mandrel is situated around the middle contact and increases the creeping distance. This leads to higher electricity and voltage values.



A-coded, for power supply use, 4-pin

B(W)-coded for bus use, 5-pin