HEIDENHAIN

Rotary Encoders

November 2005

Rotary encoders with mounted stator coupling

Rotary encoders for separate shaft coupling

The catalogs for
- Angle encoders
- Exposed linear encoders
- Sealed linear encoders
- Position encoders for servo drives
- HEIDENHAIN subsequent electronics

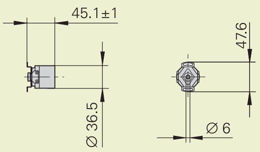
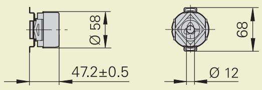
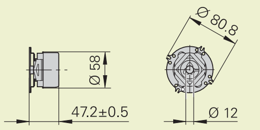
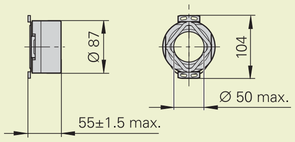
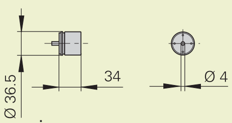
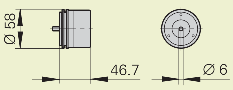
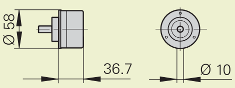
are available upon request.

This catalog supersedes all previous editions, which thereby become invalid. The basis for ordering from HEIDENHAIN is always the catalog edition valid when the contract is made.

Standards (ISO, EN, etc.) apply only where explicitly stated in the catalog.

Content

Selection Guide

Rotary Encoders	Absolute Singleturn				Multiturn	
Interface Power supply	EnDat 2.2/01 5 V	EnDat 2.2/22 3.6 to 5.25 V	SSI 5 V or 10 to 30 V	PROFIBUS-DP 10 to 30 V	EnDat 2.2/01 5 V	EnDat 2.2/22 3.6 to 5.25 V
With Built-in Stator Coupling						
ERN 1000 series 	–	–	–	–	–	–
ECN/EQN/ERN 400* series 	**ECN 413** Positions/rev: 13 bits	**ECN 425** Positions/rev: 25 bits	**ECN 413** Positions/rev: 13 bits	–	**EQN 425** Positions/rev: 13 bits 4096 revolutions	**EQN 437** Positions/rev: 25 bits 4096 revolutions
ECN/EQN/ERN 400* series with universal stator coupling 	**ECN 413** Positions/rev: 13 bits	**ECN 425** Positions/rev: 25 bits	–	–	**EQN 425** Positions/rev: 13 bits 4096 revolutions	**EQN 437** Positions/rev: 25 bits 4096 revolutions
ECN/ERN 100 series 	**ECN 113** Positions/rev: 13 bits	**ECN 125** Positions/rev: 25 bits	**ECN 113** Positions/rev: 13 bits	–	–	–
For Separate Shaft Coupling						
ROD 1000 series 	–	–	–	–	–	–
ROC/ROQ/ROD 400* series With synchro flange 	**ROC 413** Positions/rev: 13 bits	**ROC 425** Positions/rev: 25 bits	**ROC 410** **ROC 412** **ROC 413** Positions/rev: 10/12/13 bits	**ROC 413** Positions/rev: 13 bits	**ROQ 425** Positions/rev: 13 bits 4096 revolutions	**ROQ 437** Positions/rev: 25 bits 4096 revolutions
	ROC 415 **ROC 417** Positions/rev: 15/17 bits			–		
ROC/ROQ/ROD 400* series with clamping flange 	**ROC 413** Positions/rev: 13 bits	**ROC 425** Positions/rev: 25 bits	**ROC 413** Positions/rev: 13 bits	**ROC 413** Positions/rev: 13 bits	**ROQ 425** Positions/rev: 13 bits 4096 revolutions	**ROQ 437** Positions/rev: 25 bits 4096 revolutions

*Versions with EEx protection on request

			Incremental				
	SSI 5 V or 10 to 30 V	PROFIBUS-DP 10 to 30 V	⊓⊔TTL 5 V	⊓⊔TTL 10 to 30 V	⊓⊔ HTL 10 to 30 V	∿ 1 V_{PP} 5 V	
	–	–	**ERN 1020** 100 to 3600 lines	–	**ERN 1030** 60 to 3600 lines	**ERN 1080** 100 to 3600 lines	**14**
	EQN 425 Positions/rev: 13 bits 4096 revolutions	–	**ERN 420** 250 to 5000 lines	**ERN 460** 250 to 5000 lines	**ERN 430** 250 to 5000 lines	**ERN 480** 1000 to 5000 lines	**16**
	–	–	**ERN 420** 250 to 5000 lines	**ERN 460** 250 to 5000 lines	**ERN 430** 250 to 5000 lines	**ERN 480** 1000 to 5000 lines	**20**
	–	–	**ERN 120** 1000 to 5000 lines	–	**ERN 130** 1000 to 5000 lines	**ERN 180** 1000 to 5000 lines	**24**
	–	–	**ROD 1020** 100 to 3600 lines	–	**ROD 1030** 60 to 3600 lines	**ROD 1080** 100 to 3600 lines	**26**
	ROQ 425 Positions/rev: 13 bits 4096 revolutions	**ROQ 425** Positions/rev: 13 bits 4096 revolutions	**ROD 426** 50 to 10 000 lines	**ROD 466** 50 to 10 000 lines	**ROD 436** 50 to 5000 lines	**ROD 486** 1000 to 5000 lines	**28**
							32
	ROQ 425 Positions/rev: 13 bits 4096 revolutions	**ROQ 425** Positions/rev: 13 bits 4096 revolutions	**ROD 420** 50 to 5000 lines	–	**ROD 430** 50 to 5000 lines	**ROD 480** 1000 to 5000 lines	**34**







Measuring Principles

Measuring Standard

HEIDENHAIN encoders with optical scanning incorporate measuring standards of periodic structures known as graduations. These graduations are applied to a carrier substrate of glass or steel.

These precision graduations are manufactured in various photolithographic processes. Graduations are fabricated from:
- extremely hard chromium lines on glass,
- matte-etched lines on gold-plated steel tape, or
- three-dimensional structures on glass or steel substrates.

The photolithographic manufacturing processes developed by HEIDENHAIN produce grating periods of typically 50 µm to 4 µm.

These processes permit very fine grating periods and are characterized by a high definition and homogeneity of the line edges. Together with the photoelectric scanning method, this high edge definition is a precondition for the high quality of the output signals.

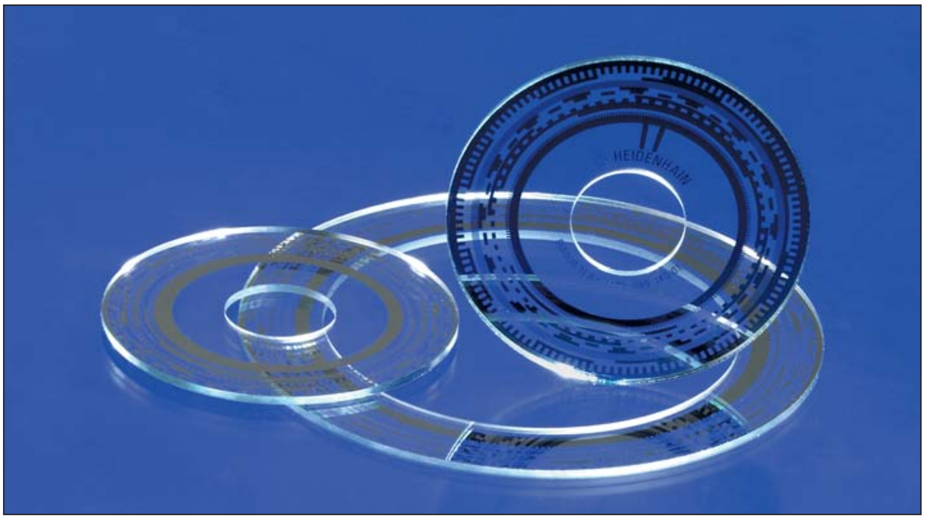
The master graduations are manufactured by HEIDENHAIN on custom-built high-precision ruling machines.

Measuring Methods

With the **absolute measuring method,** the position value is available from the encoder immediately upon switch-on and can be called at any time by the subsequent electronics. There is no need to move the axes to find the reference position. The absolute position information is read **from the disk graduation,** which consists of several parallel graduation tracks.

The track with the finest grating period is interpolated for the position value and at the same time is used to generate an optional incremental signal.

In **singleturn encoders** the absolute position information repeats itself with every revolution. **Multiturn encoders** can also distinguish between revolutions.

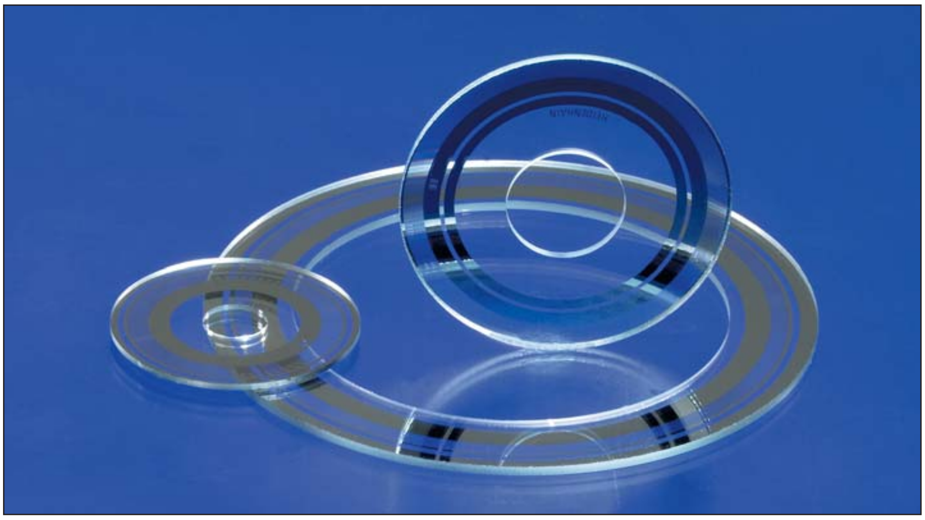


Circular graduations of absolute rotary encoders

With the **incremental measuring method,** the graduation consists of a periodic grating structure. The position information is obtained **by counting** the individual increments (measuring steps) from some point of origin. Since an absolute reference is required to ascertain positions, the graduated disks are provided with an additional track that bears a **reference mark.**

The absolute position established by the reference mark is gated with exactly one measuring step.

The reference mark must therefore be scanned to establish an absolute reference or to find the last selected datum.

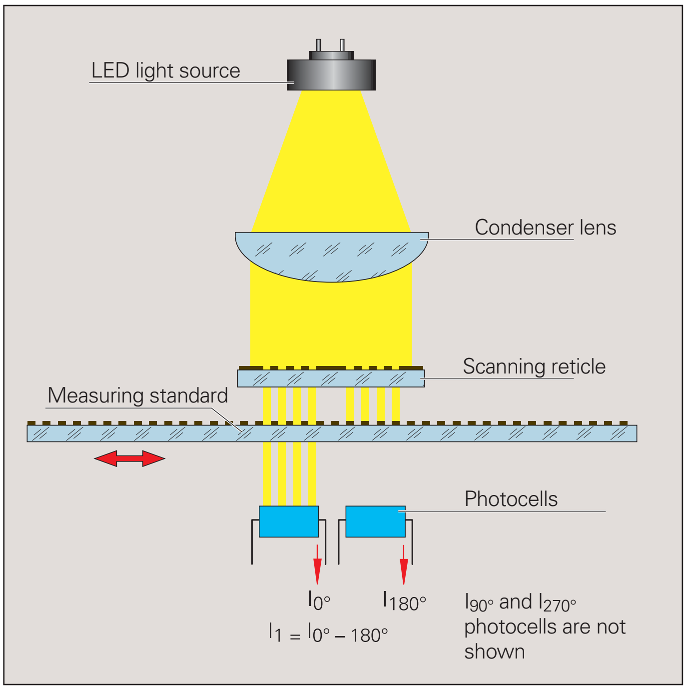

Circular graduations of incremental rotary encoders

Scanning Methods

Photoelectric scanning
Most HEIDENHAIN encoders operate using the principle of photoelectric scanning. The photoelectric scanning of a measuring standard is contact-free, and therefore without wear. This method detects even very fine lines, no more than a few microns wide, and generates output signals with very small signal periods.

The ECN, EQN, ERN and ROC, ROQ, ROD rotary encoders use the imaging scanning principle.

Put simply, the imaging scanning principle functions by means of projected-light signal generation: two graduations with equal grating periods are moved relative to each other—the scale and the scanning reticle. The carrier material of the scanning reticle is transparent, whereas the graduation on the measuring standard may be applied to a transparent or reflective surface. When parallel light passes through a grating, light and dark surfaces are projected at a certain distance. An index grating with the same grating period is located here. When the two gratings move relative to each other, the incident light is modulated. If the gaps in the gratings are aligned, light passes through. If the lines of one grating coincide with the gaps of the other, no light passes through. Photovoltaic cells convert these variations in light intensity into nearly sinusoidal electrical signals. Practical mounting tolerances for encoders with the imaging scanning principle are achieved with grating periods of 10 µm and larger.



Photoelectric scanning according to the imaging scanning principle

Accuracy

The accuracy of position measurement with rotary encoders is mainly determined by
- the directional deviation of the radial grating,
- the eccentricity of the graduated disk to the bearing,
- the radial deviation of the bearing,
- the error resulting from the connection with a shaft coupling (on rotary encoders with stator coupling this error lies within the system accuracy),
- the interpolation error during signal processing in the integrated or external interpolation and digitizing electronics.

For **incremental rotary encoders** with line counts up to 5000:
The maximum directional deviation at 20 °C ambient temperature and slow speed (scanning frequency between 1 kHz and 2 kHz) lie within

$$\pm \frac{18° \text{ mech.} \cdot 3600}{\text{Line count } z} \text{ [angular seconds]}$$

which equals

$$\pm \frac{1}{20} \text{ grating period.}$$

ROD rotary encoders with 6000 to 10 000 signal periods per revolution have a system accuracy of ± 12 angular seconds.

The accuracy of absolute position values from **absolute rotary encoders** is given in the specifications for each model.

For absolute rotary encoders with **complementary incremental signals,** the accuracy depends on the line count:

Line count	**Accuracy**
512	± 60 angular seconds
2048	± 20 angular seconds
8192	± 10 angular seconds

The above accuracy data refer to incremental measuring signals at an ambient temperature of 20 °C and at slow speed.

Mechanical Design Types and Mounting
Rotary Encoders with Integral Bearing and Stator Coupling

ECN/EQN/ERN rotary encoders have integrated bearings and a mounted stator coupling. They compensate radial runout and alignment errors without significantly reducing the accuracy. The encoder shaft is directly connected with the shaft to be measured. During angular acceleration of the shaft, the stator coupling must absorb only that torque caused by friction in the bearing. The stator coupling permits axial motion of the measured shaft:

ECN/EQN/ERN 400:	± 1 mm
ERN 1000:	± 0.5 mm
ECN/ERN 100:	± 1.5 mm

Mounting
The rotary encoder is slid by its hollow shaft onto the measured shaft, and the rotor is fastened by two screws or three eccentric clamps. For rotary encoders with hollow through shaft, the rotor can also be fastened at the end opposite to the flange. With their with taper shafts, rotary encoders of the ECN/EQN/ERN 1300 series are particularly well suited for repeated mounting (see brochure titled *Position Encoders for Servo Drives).* The stator is connected without a centering collar on a flat surface. The **universal stator coupling** of the ECN/EQN/ERN 400 permits versatile mounting, e.g. by its thread provided for fastening it from outside to the motor cover. Dynamic applications require the highest possible natural frequencies f_N of the system (also see *General Mechanical Information).* This is attained by connecting the shafts on the flange side and fastening the coupling by four cap screws or, on the ERN 1000, with special washers (see *Mounting Accessories).*

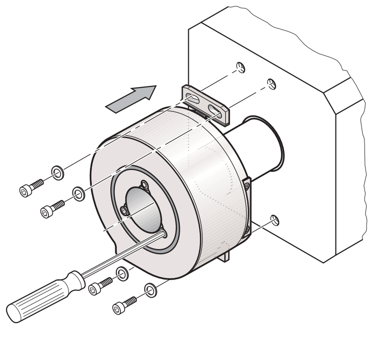
Natural frequency f_N with coupling fastened by 4 screws

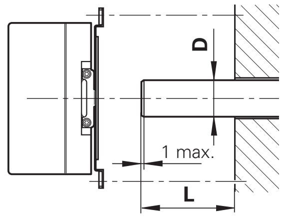
	Stator coupling	Cable	Flange socket	
			Axial	Radial
ECN/EQN/ ERN 400	Standard Universal	1550 Hz 1400 Hz[1]	1500 Hz 1400 Hz	1000 Hz 900 Hz
ECN/ERN 100		1000 Hz	–	400 Hz
ERN 1000		950 Hz[2]	–	–

[1] Also when fastening with 2 screws
[2] Also when fastening with 2 screws and thrust pads

If the encoder shaft is subject to high loads, for example from friction wheels, pulleys, or sprockets, HEIDENHAIN recommends mounting the ECN/EQN/ ERN 400 with a bearing assembly (see *Mounting Accessories).*

ECN/ERN 100



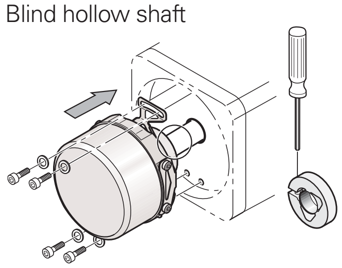


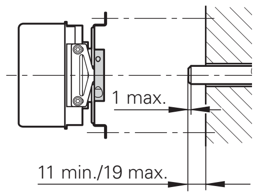
ECN:
L = 41 min. with **D** ≤ 25
L = 56 min. with **D** ≥ 38

ERN:
L = 46 min. with **D** ≤ 25
L = 56 min. with **D** ≥ 38

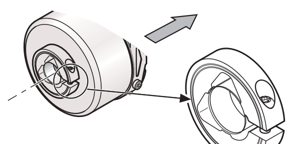
ECN/EQN/ERN 400 e.g. with standard stator coupling

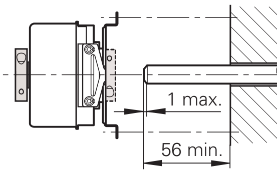
Blind hollow shaft





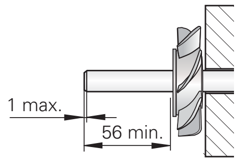
Hollow through shaft



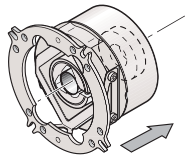


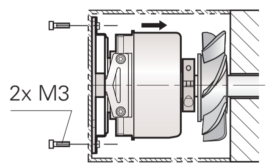
Grooves remain visible

ECN/EQN/ERN 400
e.g. with universal stator coupling

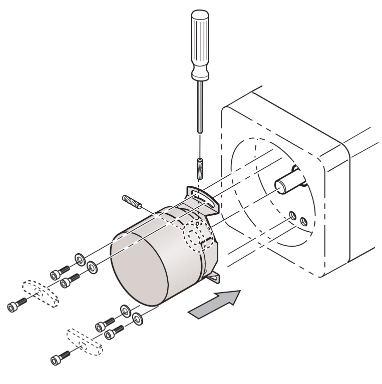


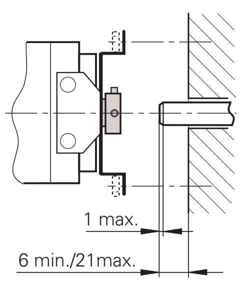
Hollow through shaft





ERN 1000



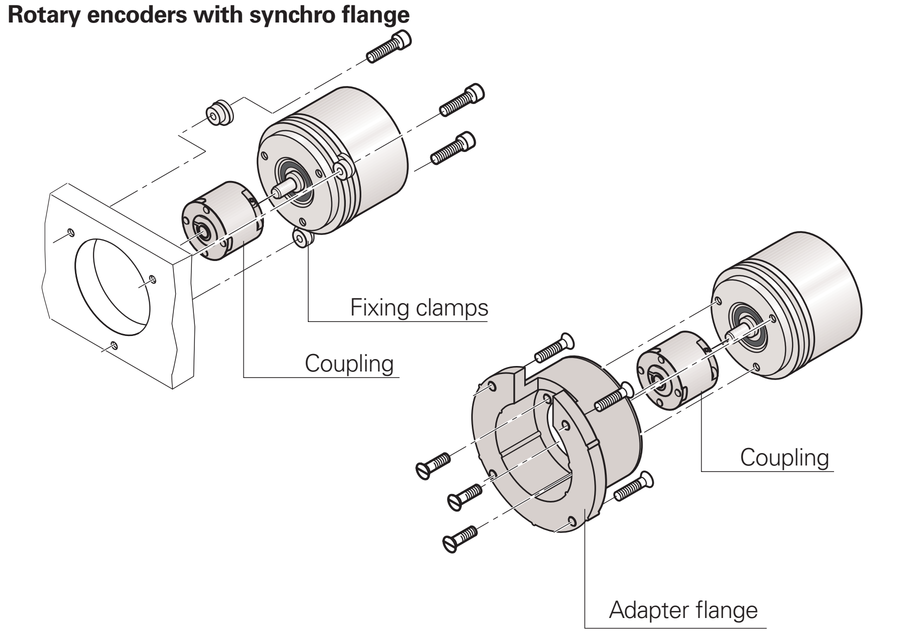


Rotary Encoders with Integral Bearing for Separate Shaft Coupling

ROC/ROQ/ROD rotary encoders have integrated bearings and a solid shaft. The encoder shaft is connected with the measured shaft through a separate rotor coupling. The coupling compensates axial motion and misalignment (radial and angular offset) between the encoder shaft and measured shaft. This relieves the encoder bearing of additional external loads that would otherwise shorten its service life. Diaphragm and metal bellows couplings designed to connect the rotor of the ROC/ROQ/ROD encoders are available (see *Shaft Couplings)*.

ROC/ROQ/ROD 400 series rotary encoders permit high bearing loads (see diagram). They can therefore also be mounted directly onto mechanical transfer elements such as gears or friction wheels.
If the encoder shaft is subject to relatively high loads, for example from friction wheels, pulleys, or sprockets, HEIDENHAIN recommends mounting the ECN/EQN/ERN 400 with a bearing assembly.

Rotary encoders with synchro flange



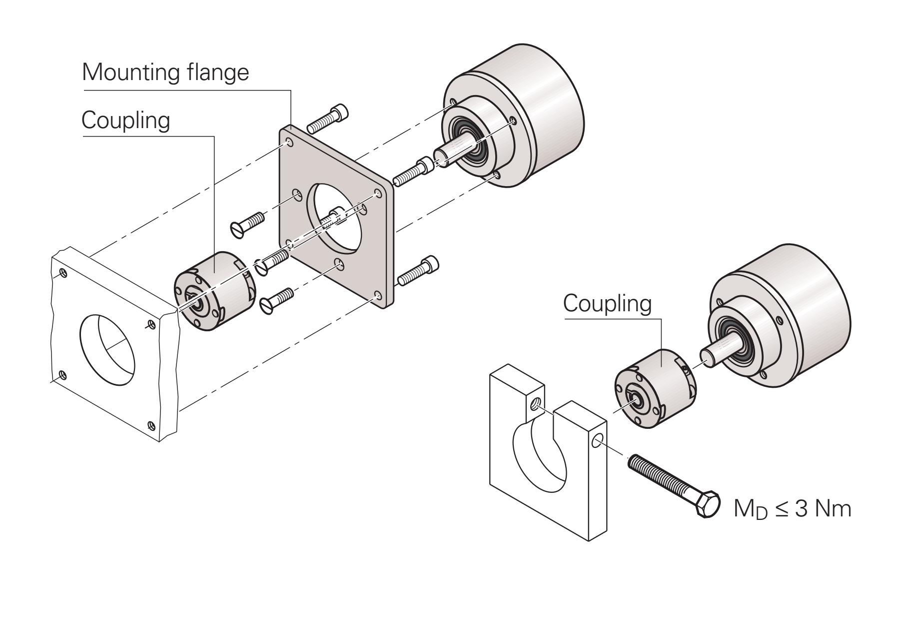
Mounting

Rotary encoders with synchro flange
- by the synchro flange with three fixing clamps (see Mounting Accessories), or
- by the fastening thread on the flange face and an adapter flange (for ROC/ ROQ/ROD 400 see *Mounting Accessories)*.

Rotary encoders with clamping flange
- by the fastening thread on the flange face and an adapter flange (see *Mounting Accessories)* or
- by clamping at the clamping flange.

The centering collar on the synchro flange or clamping flange serves to center the encoder.

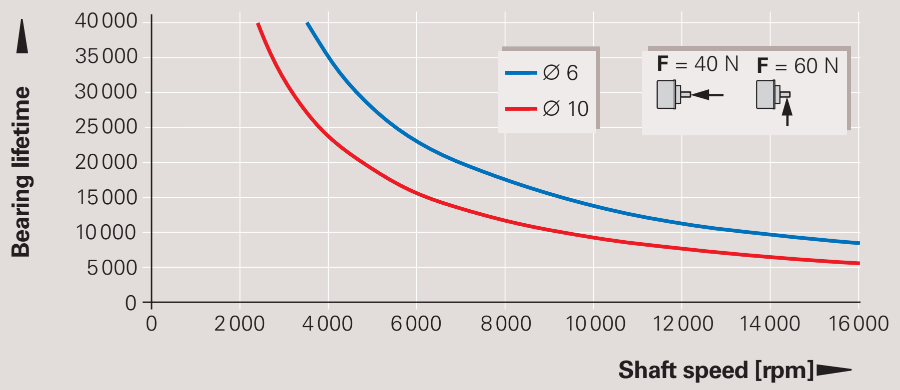
ROC/ROQ/ROD 400 with clamping flange



Bearing lifetime of ROC/ROQ/ROD 400

The lifetime of the shaft bearing depends on the shaft load, the shaft speed, and the point of force application. The values given in the specifications for the shaft load are valid for all permissible speeds, and do not limit the bearing lifetime. The diagram shows an example of the different bearing lifetimes to be expected at further loads. The different points of force application of shafts with 6 mm and 10 mm diameters have an effect on the bearing lifetime.

Bearing lifetime if shaft subjected to load

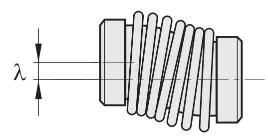


Shaft Couplings

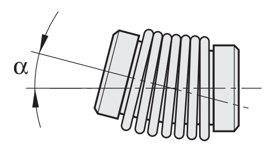
	ROC/ROQ/ROD 400				ROD 1000	ROC 415, ROC 417	
	Diaphragm couplings with galvanic isolation				Metal bellows coupling	Diaphragm coupling	Flat coupling
	K 14	K 17/01 K 17/06	K 17/02 K 17/04	K 17/03	18EBN3	K 03	K 18
Hub bore	6 mm	6 mm 6/5 mm	6/10 mm 10 mm	10 mm	4/4 mm	10 mm	10 mm
Kinematic transfer error*	± 6″	± 10″			± 40″	± 2″	± 3″
Torsional rigidity	$500 \frac{Nm}{rad}$	$150 \frac{Nm}{rad}$	200 Nm	$300 \frac{Nm}{rad}$	$60 \frac{Nm}{rad}$	$1500 \frac{Nm}{rad}$	$1200 \frac{Nm}{rad}$
Max. torque	0.2 Nm	0.1 Nm	rad	0.2 Nm	0.1 Nm	0.2 Nm	0.5 Nm
Max. radial offset λ	≤ 0.2 mm	≤ 0.5 mm			≤ 0.2 mm	≤ 0.3 mm	
Max. angular error α	≤ 0,5°	≤ 1°			≤ 0,5°	≤ 0,5°	
Max. axial offset δ	≤ 0.3 mm	≤ 0.5 mm			≤ 0.3 mm	≤ 0.2 mm	
Moment of inertia (approx.)	$6 \cdot 10^{-6} kgm^2$	$3 \cdot 10^{-6} kgm^2$		$4 \cdot 10^{-6} kgm^2$	$0.3 \cdot 10^{-6} kgm^2$	$20 \cdot 10^{-6} kgm^2$	$75 \cdot 10^{-6} kgm^2$
Permissible speed	16 000 rpm	16 000 rpm			12 000 rpm	10 000 rpm	1 000 rpm
Torque for locking screws (approx.)	1.2 Nm				0.8 Nm	1.2 Nm	
Weight	35 g	24 g	23 g	27.5 g	9 g	100 g	117 g

*With radial misalignment λ = 0.1 mm, angular error α = 0.15 mm over 100 mm ≙ 0.09° to 50 °C

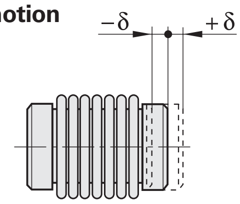
Radial misalignment



Angular error



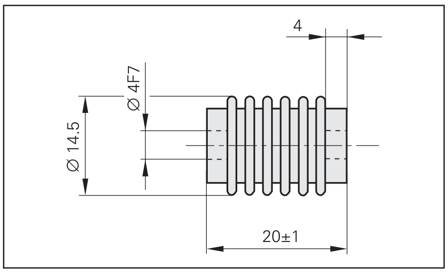
Axial motion



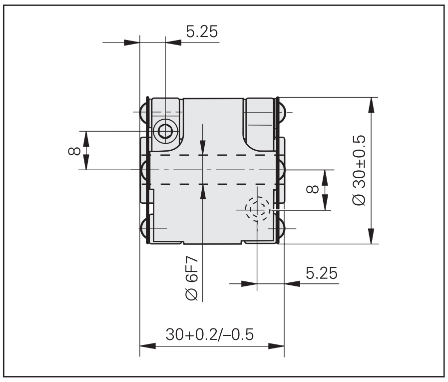
Mounting Accessories

Screwdriver bit
Screwdriver
See page 23

18 EBN 3 metal bellows coupling
for encoders of the ROD 1000 series
with **4 mm shaft diameter**
Id. Nr. 200393-02

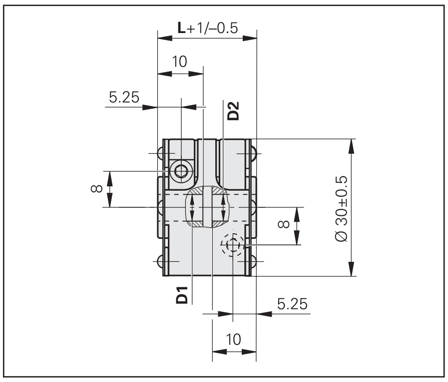


K14 diaphragm coupling
for ROC/ROQ/ROD 400 Series
with **6 mm shaft diameter**
Id. Nr. 293328-01



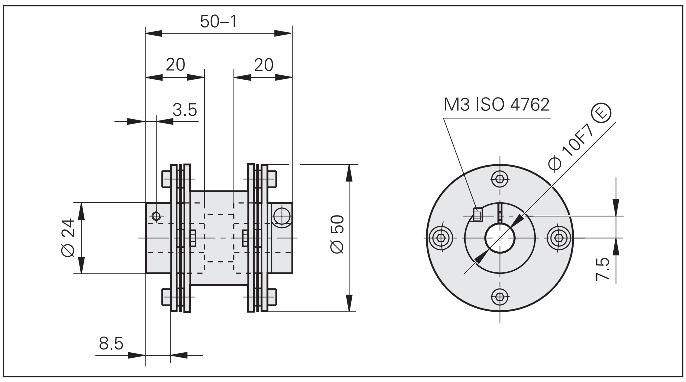
Recommended fit for the customer shaft: h6

K 17 diaphragm coupling with galvanic isolation
for ROC/ROQ/ROD 400 Series
with **6 or 10 mm shaft diameter**
Id. Nr. 296746-xx

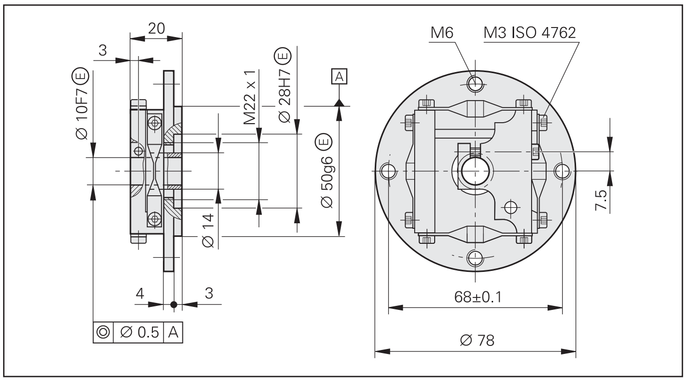


K 17 variants	D1	**D2**	L
01	Ø 6 F7	**Ø 6 F7**	22 mm
02	Ø 6 F7	**Ø 10 F7**	22 mm
03	Ø 10 F7	**Ø 10 F7**	30 mm
04	Ø 10 F7	**Ø 10 F7**	22 mm
06	Ø 5 F7	**Ø 6 F7**	22 mm

K 03 diaphragm coupling
Id. Nr. 200313-04
for
ROC 417
ROC 415



K 18 flat coupling
Id.-Nr. 202227-01
for
ROC 417
ROC 415



Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

A = Ball bearing

General Mechanical Information

UL certification
All rotary encoders and cables in this brochure comply with the UL safety regulations "cULus" for the USA and the "CSA" safety regulations for Canada. They are listed under file no. E205635.

Acceleration
Encoders are subject to various types of acceleration during operation and mounting.

- The indicated maximum values for **vibration** are apply for frequencies of 55 to 2000 Hz **(IEC 60068-2-6).** Any acceleration exceeding permissible values, for example due to resonance depending on the application and mounting, might damage the encoder. **Comprehensive tests of the entire system are required.**
- The maximum permissible acceleration values (semi-sinusoidal shock) for **shock and impact** are valid for 6 ms and 2 ms, respectively **(IEC 60068-2-27).** Under no circumstances should a hammer or similar implement be used to adjust or position the encoder.
- The **permissible angular acceleration** for all encoders is over $10^5 rad/s^2$.

The maximum values for vibration and shock indicate the limits up to which the encoder can be operated without failure. For an encoder to realize its highest potential accuracy, the environmental and operating conditions described under Measuring Accuracy must be ensured.

If the application includes increased shock and vibration loads, please ask for comprehensive assistance from HEIDENHAIN.

Natural frequencies
The rotor and the couplings of ROC/ROQ/ROD rotary encoders, as also the stator and stator coupling of ECN/EQN/ERN rotary encoders, form a single vibrating spring-mass system.

The **natural frequency f_N** should be as high as possible. A prerequisite for the highest possible natural frequency on **ROC/ROQ/ROD rotary encoders** is the use of a diaphragm coupling with a high torsional rigidity C (see *Shaft Couplings).*

$$f_N = \frac{1}{2 \cdot \pi} \cdot \sqrt{\frac{C}{I}}$$

f_N: Natural frequency in Hz
C: Torsionial rigidity of the coupling in Nm/rad
I: Moment of inertia of the rotor in kgm^2

ECN/EQN/ERN rotary encoders with their stator couplings form a vibrating spring-mass system whose **natural frequency f_N** should be as high as possible. If radial and/or axial acceleration forces are added, the stiffness of the encoder bearings and the encoder stators are also significant. If such loads occur in your application, HEIDENHAIN recommends consulting with the main facility in Traunreut.

Protection against contact (IEC 60529)
After encoder installation, all rotating parts must be protected against accidental contact during operation.

Degree of protection (IEC 60529)
Unless otherwise indicated, all rotary encoders meet protection standard IP64 (ExN/ROx 400: IP 67) according to IEC 60529.

This includes housings, cable outlets and flange sockets when the connector is fastened. The **shaft inlet** provides protection to IP 64 or IP 65. Splash water should not contain any substances that would have harmful effects on the encoder parts. If the standard protection of the shaft inlet is not sufficient (such as when the encoders are mounted vertically), additional labyrinth seals should be provided.

Many encoders are also available with protection to class IP 66 for the shaft inlet. The sealing rings used to seal the shaft are subject to wear due to friction, the amount of which depends on the specific application.

Expendable parts
HEIDENHAIN encoders contain components that are subject to wear, depending on the application and manipulation. These include in particular the following parts:

- LED light source
- Bearings in encoders with integral bearing
- Shaft sealing rings for rotary and angular encoders
- Cables subject to frequent flexing

System tests
Encoders from HEIDENHAIN are usually integrated as components in larger systems. Such applications require **comprehensive tests of the entire system** regardless of the specifications of the encoder.

The specifications given in the brochure apply to the specific encoder, not to the complete system. Any operation of the encoder outside of the specified range or for any other than the intended applications is at the user's own risk.

In safety-oriented systems, the higher-level system must verify the position value of the encoder after switch-on.

Mounting
Work steps to be performed and dimensions to be maintained during mounting are specified solely in the mounting instructions supplied with the unit. All data in this catalog regarding mounting are therefore provisional and not binding; they do not become terms of a contract.

Temperature ranges
For the unit in its packaging, the **storage temperature range** is –30 to 80 °C. The **operating temperature range** indicates the temperatures that the encoder may reach during operation in the actual installation environment. The function of the encoder is guaranteed within this range (DIN 32 878). The operating temperature is measured on the face of the encoder flange (see dimension drawing) and must not be confused with the ambient temperature.

The temperature of the encoder is influenced by:
- Mounting conditions
- The ambient temperature
- Self-heating of the encoder

The self-heating of an encoder depends both on its design characteristics (stator coupling/solid shaft, shaft sealing ring, etc.) and on the operating parameters (rotational speed, power supply). Higher heat generation in the encoder means that a lower ambient temperature is required to keep the encoder within its permissible operating temperature range.

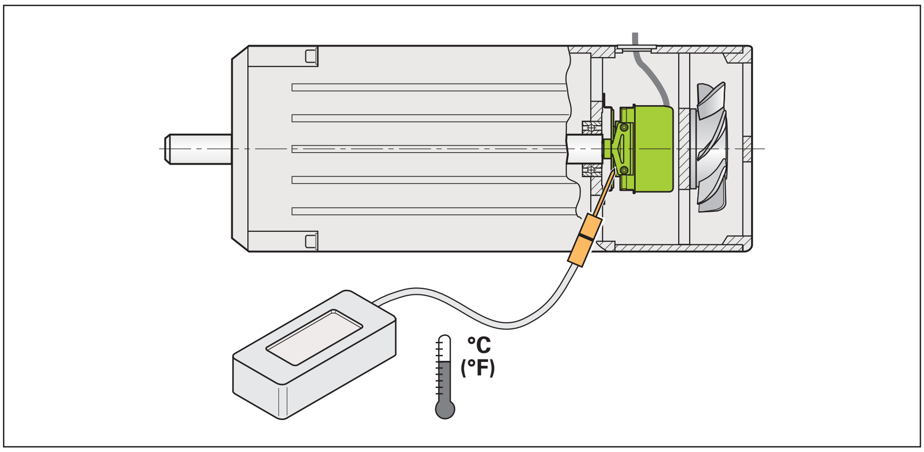
These tables show the approximate values of self-heating to be expected in the encoders. In the worst case, a combination of operating parameters can exacerbate self-heating, for example a 30 V power supply and maximum rotational speed. Therefore, the actual operating temperature should be measured directly at the encoder if the encoder is operated near the limits of permissible parameters. Then suitable measures should be taken (fan, heat sinks, etc.) to reduce the ambient temperature far enough so that the maximum permissible operating temperature will not be exceeded during continuous operation. For high speeds at maximum permissible ambient temperature, special versions are available on request with reduced degree of protection (without shaft seal and its concomitant frictional heat).

Self-heating at supply voltage		**15 V**	**30 V**
	ERN/ROD	Approx. +5 K	Approx. +10 K
	ECN/EQN/ROC/ROQ	Approx. +5 K	Approx. +10 K

Typical self-heating of the encoder at power supplies from 10 to 30 V. In 5-V versions, self-heating is negligible.

Heat generation at speed n_{max}		
Solid shaft	**ROC/ROQ/ROD**	Approx. + 5 K with protection class IP 64 Approx. + 10 K with protection class IP 66
Blind hollow shaft	**ECN/EQN/ERN 400**	Approx. + 30 K with protection class IP 64 Approx. + 40 K with protection class IP 66
	ERN 1000	Approx. +10 K
Hollow through shaft	**ECN/ERN 100** **ECN/EQN/ERN 400**	Approx. + 40 K with protection class IP 64 Approx. + 50 K with protection class IP 66

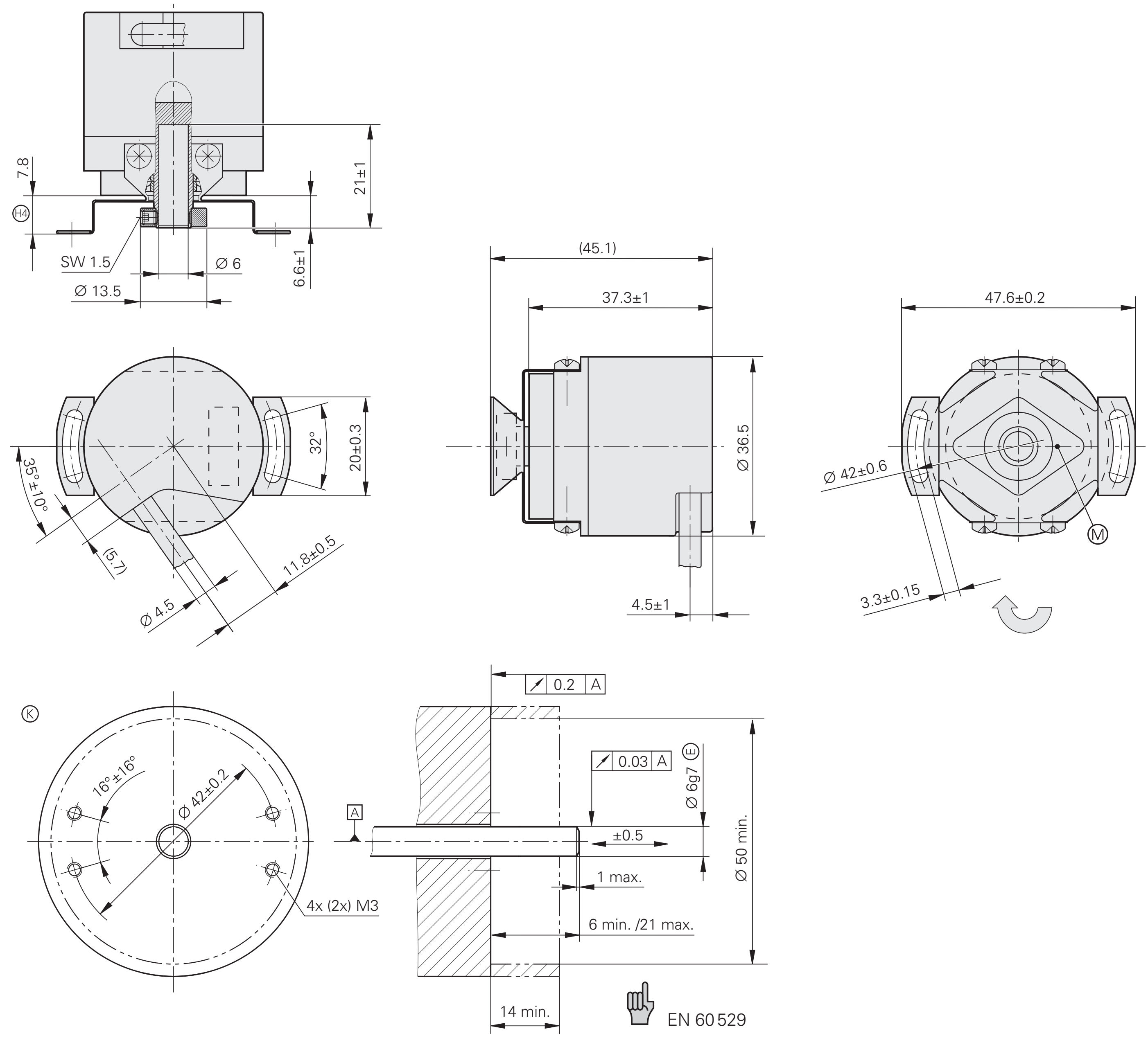
An encoder's typical self-heating values depend on its design characteristics at maximum permissible speed. The correlation between rotational speed and heat generation is nearly linear.



Measuring the actual operating temperature directly at the encoder

ERN 1000 Series

- **Rotary encoders with mounted stator coupling**
- **Compact dimensions**
- **Blind hollow shaft Ø 6 mm**



Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

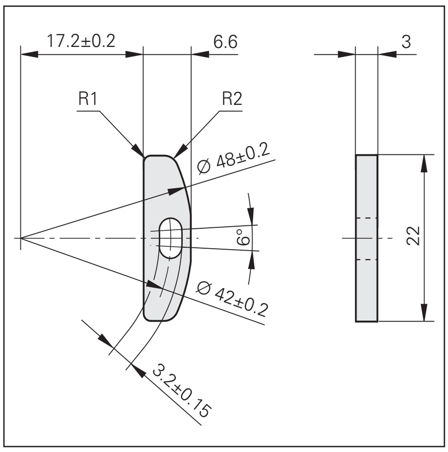
Cable radial, also usable axially
A = Ball bearing
K = Required mating dimensions
H4 = Variable depending on the coupling
Direction of shaft rotation for output signals is described in interface description.

	Incremental		
	ERN 1020	**ERN 1030**	**ERN 1080**
Incremental signals	⊓⊔TTL	⊓⊔HTL	∿ 1 V_{PP} 1)
Line counts*	100 200 250 360 400 500 720 900 1000 1024 1250 1500 2000 2048 2500 **3600**		
Cutoff freq. –3 dB Scanning frequency Edge separation *a*	– ≤ 300 kHz ≥ 0.39 µs	– ≤ 160 kHz ≥ 0.76 µs	≥ 180 kHz – –
Power supply **Current consumption** without load	5 V ± 10% ≤ 150 mA	10 to 30 V ≤ 150 mA	5 V ± 10% ≤ 150 mA
Electrical connection*	**Cable 1 m**/5 m, with or **without coupling** M23		
Max. cable length	100 m		150 m
Shaft	Blind hollow shaft D = 6 mm		
Mech. permissible speed *n*	10 000 rpm		
Starting torque	≤ 0.001 Nm (at 20 °C)		
Moment of inertia of rotor	$0.5 \cdot 10^{-6}$ kgm^2		
Permissible axial motion of measured shaft	± 0.5 mm		
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (IEC 60 068-2-6) ≤ 1000 m/s^2 (IEC 60 068-2-27)		
Max. operating temperature 2)	100 °C	70 °C	100 °C
Min. operating temp.	*Rigid configuration:* –40 °C *Moving cable:* –10 °C		
Protection 2) IEC 60 529	IP 64		
Weight	Approx. 0.1 kg		

Bold: These preferred versions are available on short notice
* Please select when ordering
1) Restricted tolerances: Signal amplitude 0.8 to 1.2 V_{PP}
2) For the correlation between the operating temperature and the shaft speed or supply voltage, see General Mechanical Information

Mounting Accessories
for ERN 1000 Series

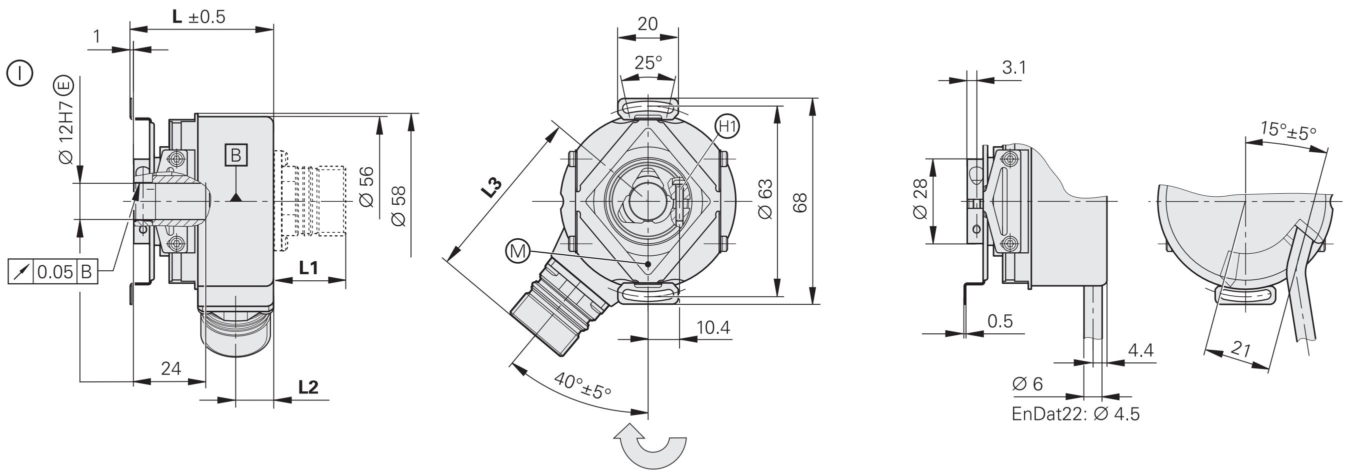
Washer
For increasing the natural frequency f_N and mounting with only two screws
Id. Nr. 334 653-01



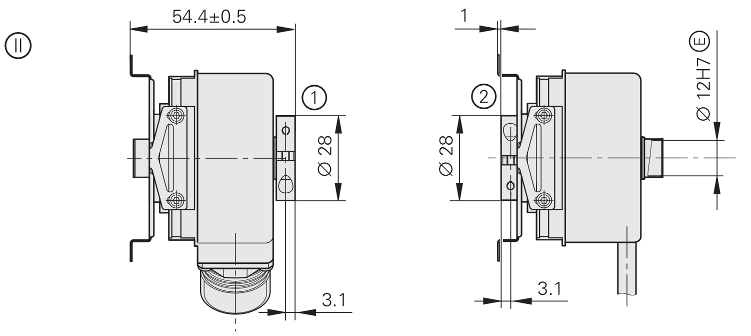
ECN/EQN/ERN 400 Series

- Rotary encoders with mounted stator coupling
- Blind hollow shaft or
  Hollow through shaft

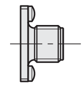
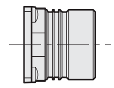
Blind hollow shaft

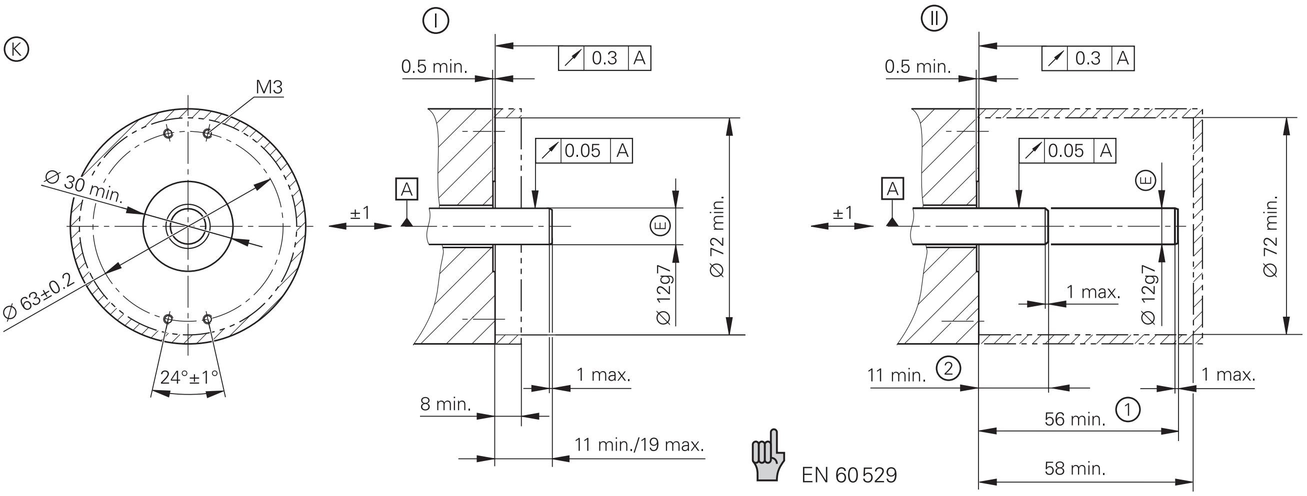


Hollow through shaft



	L
ERN **ECN/EQN 512 lines**	47.2
ECN/EQN 2048 lines **ECN 425/EQN 437**	47.7

	Flange socket	
	M12 	**M23** 
L1	14	23,6
L2	12,5	12,5
L3	48,5	58,1



EN 60 529

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

Cable radial, also usable axially
A = Ball bearing
B = Bearing of encoder
M = Measuring point for operating temperature
K = Required mating dimensions
H1 = Clamping screw M2.5 with hexalobular socket X8
H2 = Hole circle for fastening, see coupling
① = Clamping ring on housing side (status at delivery)
② = Clamping ring on coupling side (optionally mountable)
Direction of shaft rotation for output signals is described in interface description.

	Absolute						Incremental			
	Singleturn			Multiturn						
	ECN 425	ECN 413	ECN 413	EQN 437	EQN 425	EQN 425	ERN 420	ERN 460	ERN 430	ERN 480
Absolute position values*	**EnDat 2.2**	**EnDat 2.2**	**SSI**	**EnDat 2.2**	**EnDat 2.2**	**SSI**	–			
Ordering designation	EnDat 22	EnDat 01		EnDat 22	EnDat 01					
Positions per rev	33554432 (25 bits)	8192 (13 bits)		33554432 (25 bits)	8192 (13 bits)		–			
Revolutions	–			4096			–			
Code	Pure binary		Gray	Pure binary		Gray	–			
Elec. permissible speed/at accuracy	≤ 12000 rpm for continuous position value	*512 lines:* ≤ 5000 rpm/± 1 LSB ≤ 12000 rpm/± 100 LSB *2048 lines:* ≤ 1500 rpm/± 1 LSB ≤ 12000 rpm/± 50 LSB		≤ 12000 rpm for continuous position value	*512 lines:* ≤ 5000 rpm/± 1 LSB ≤ 10000 rpm/± 100 LSB *2048 lines:* ≤ 1500 rpm/± 1 LSB ≤ 10000 rpm/± 50 LSB		–			
Calculation time t_{cal}	≤ 5 µs	≤ 0.25 µs	≤ 0.5 µs	≤ 5 µs	≤ 0.25 µs	≤ 0.5 µs	–			
Incremental signals	Without	∼ 1 V_{PP}[1]		Without	∼ 1 V_{PP}[1]		⊓⊔ TTL		⊓⊔ HTL	∼ 1 V_{PP}[1]
Line counts*	–	**512** 2048	**512**	–	**512** 2048	**512**	250[4] 500[4] **1000** **1024** **1250** **2000** **2048** **2500** **3600** **4096** **5000**			
Cutoff freq. –3 dB Scanning frequency Edge separation *a*	– – –	*512 lines:* ≤ 100 kHz; *2048 lines:* ≥ 200 kHz – –		– – –	*512 lines:* ≥ 100 kHz; *2048 lines:* ≥ 200 kHz – –		– ≤ 300 kHz ≥ 0.39 µs			≥ 180 kHz – –
System accuracy	± 20"	*512 lines:* ± 60"; *2048 lines:* ± 20"		± 20"	*512 lines:* ± 60"; *2048 lines:* ± 20"		1/20 of grating period			
Power supply*	**3.6 to 5.25 V**	**5 V** ± 5 %	5 V ± 5 % or **10 to 30 V**	**3.6 to 5.25 V**	**5 V** ± 5 %	5 V ± 5 % or **10 to 30 V**	**5 V** ± 10 %	**10 to 30 V**	**10 to 30 V**	**5 V** ± 10 %
Current consumption without load	≤ 150 mA	≤ 160 mA	≤ 160 mA	≤ 180 mA	≤ 200 mA	≤ 200 mA	120 mA	100 mA	150 mA	120 mA
Electrical connection*	• **Flange socket** M12, radial • Cable 1 m, with coupling M12	• **Flange socket** M23, radial • Cable 1 m, with coupling M23 or without connecting element		• **Flange socket** M12, radial • Cable 1 m, with coupling M12	• **Flange socket** M23, radial • Cable 1 m, with coupling M23 or without connecting element		• **Flange socket** M23, radial and axial (with blind hollow shaft) • **Cable** 1 m, **without connecting element**			
Shaft*	**Blind hollow shaft** or hollow through shaft **D = 12 mm**						**Blind hollow shaft** or hollow through shaft **D = 12 mm**			
Mech. perm. speed *n*[2]	≤ 6000 rpm/≤ 12000 rpm[5]						≤ 6000 rpm/≤ 12000 rpm[5]			
Starting torque at 20 °C below -20 °C	*Blind hollow shaft:* ≤ 0.01 Nm *Hollow through shaft:* ≤ 0.025 Nm ≤ 1 nm						*Blind hollow shaft:* ≤ 0.01 Nm *Hollow through shaft:* ≤ 0.025 Nm ≤ 1 nm			
Moment of inertia of rotor	$4.3 \cdot 10^{-6}$ kgm^2						$4.3 \cdot 10^{-6}$ kgm^2			
Permissible axial motion of measured shaft	± 1 mm						± 1 mm			
Vibration 55 to 2000 Hz **Shock** 6 ms/2 ms	≤ 300 m/s^2[3] (IEC 60068-2-6) ≤ 1000 m/s^2/≤ 2000 m/s^2 (IEC 60068-2-27)						≤ 300 m/s^2[3] (IEC 60068-2-6) ≤ 1000 m/s^2/≤ 2000 m/s^2 (IEC 60068-2-27)			
Max. operating temperature[2]	*U_P = 5 V:* 100 °C *U_P = 10 to 30 V:* 85 °C						100 °C	70 °C	100 °C	
Min. operating temperature	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C						*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C			
Protection IEC 60529	IP 67 at housing; IP 64 at shaft inlet						IP 67 at housing (IP 66 with hollow through shaft); IP 64 at shaft inlet			
Weight	Approx. 0.3 kg						Approx. 0.3 kg			

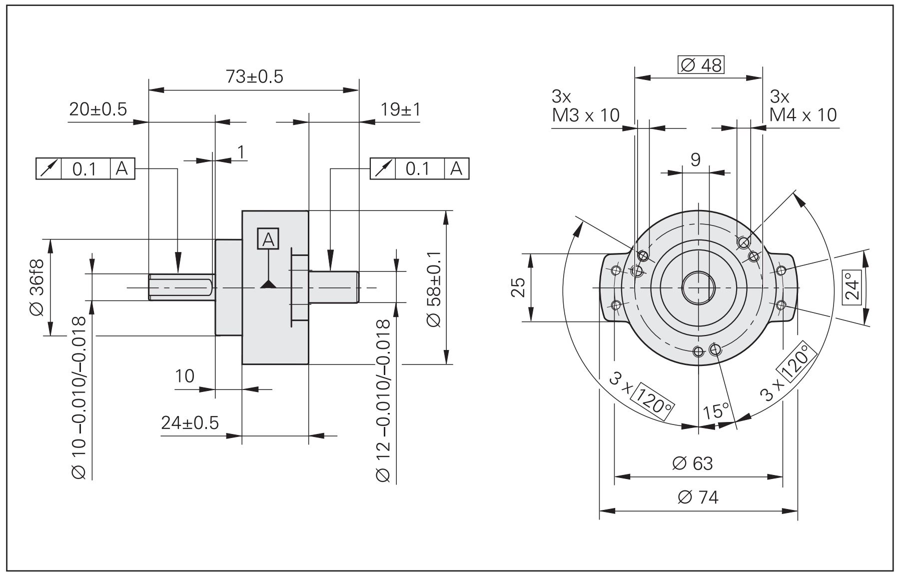
Bold: These preferred versions are available on short notice
***** Please select when ordering

1) Restricted tolerances: Signal amplitude 0.8 to 1.2 V_{PP}
2) For the correlation between the operating temperature and the shaft speed or power supply, see *General Mechanical Information*
3) 150 m/s^2 with flange socket version
4) Not with ERN 480
5) With two shaft clamps (only for hollow through shaft)

Mounting Accessories

for ERN/ECN/EQN 400 Series

Shaft clamp ring
Torque supports
Screwdriver
Screwdriver bit
See page 23

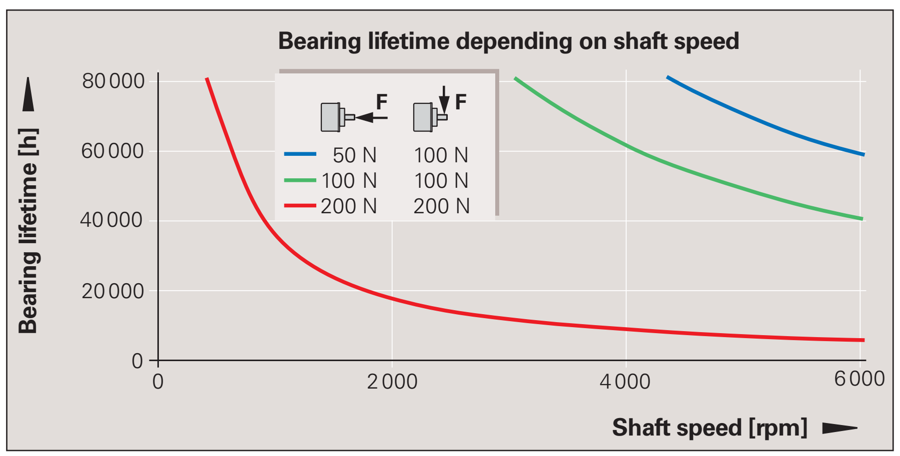


Bearing assembly
for ERN/ECN/EQN 400 series
with blind hollow shaft
Id. Nr. 324320-01

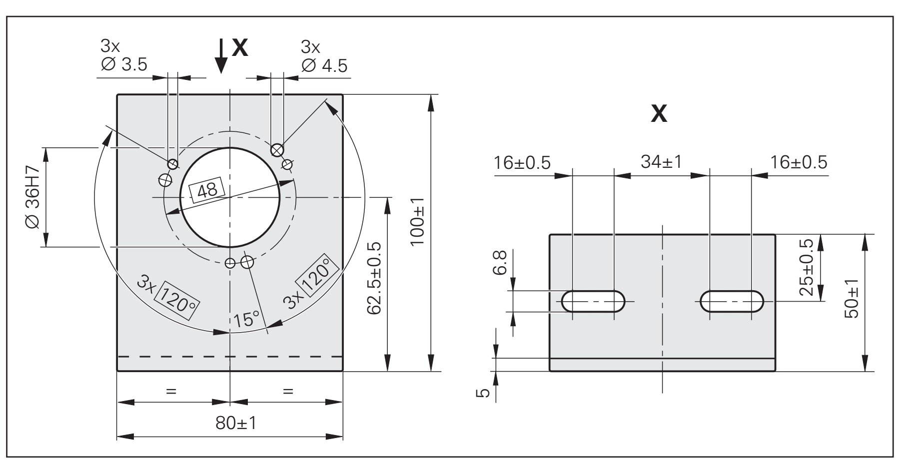
	Bearing assembly
Permissible speed *n*	Max. 6000 rpm
Shaft load	200 N axial and radial
Operating temperature	–40 to 100 °C

The bearing assembly is capable of absorbing large radial shaft loads. It is therefore particularly recommended for use in applications with friction wheels, pulleys, or sprockets. It prevents overload of the encoder bearing. On the encoder side, the bearing assembly has a stub shaft with 12-mm diameter and is well suited for the ERN/ECN/EQN 400 encoders with blind hollow shaft. Also, the threaded holes for fastening the stator coupling are already provided. The flange of the bearing assembly has the same dimensions as the clamping flange of the ROD 420/430 series.

The bearing assembly can be fastened through the threaded holes on its face or with the aid of the mounting flange or the mounting bracket.



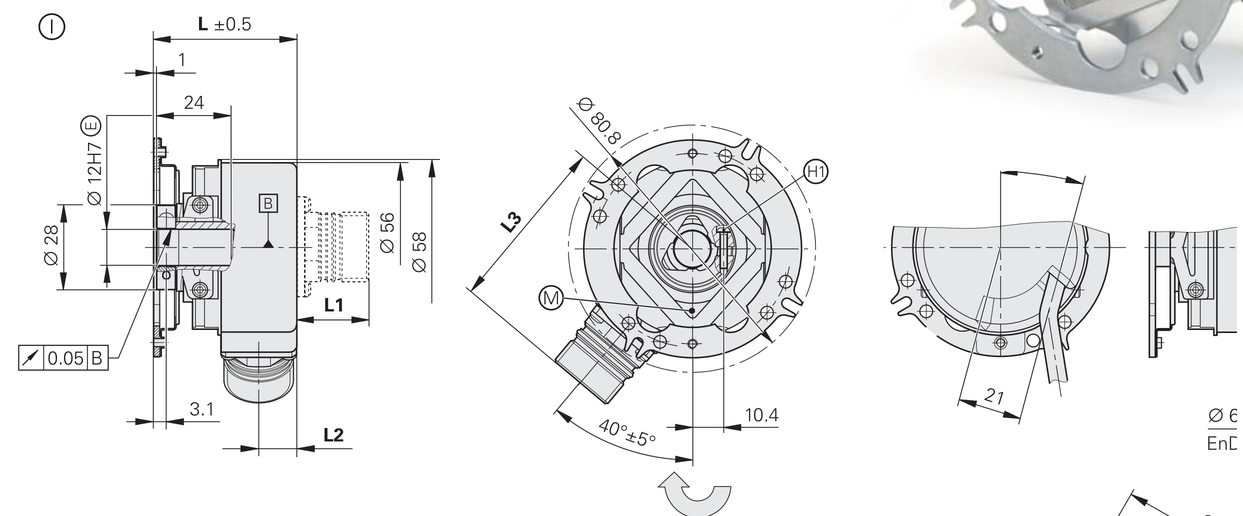
Mounting bracket
for bearing assembly
Id. Nr. 324322-01



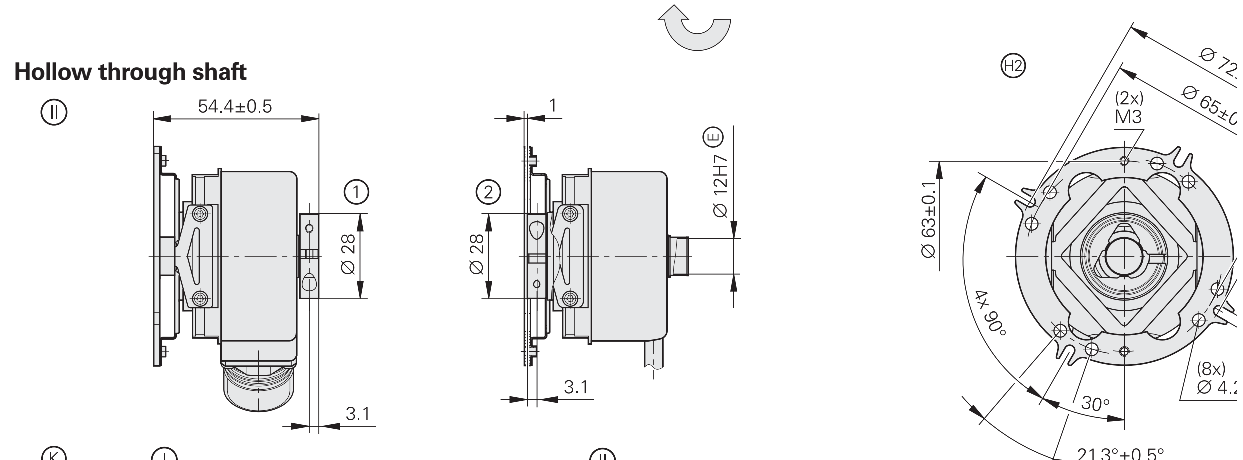
ECN/EQN/ERN 400 Series

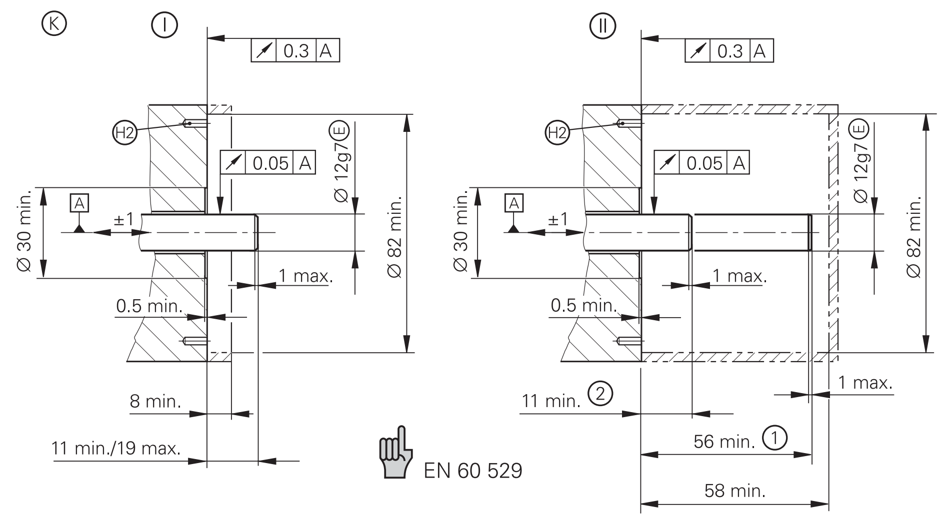
- **Rotary encoders with mounted universal stator coupling**
- **Blind hollow shaft or Hollow through shaft**

Blind hollow shaft



Hollow through shaft





	L
ERN ECN/EQN 512 lines	47.2
ECN/EQN 2048 lines ECN 425/EQN 437	47.7

	Flange socket	
	M12	**M23**
L1	14	23,6
L2	12,5	12,5
L3	48,5	58,1

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

Cable radial, also usable axially
Ⓐ = Ball bearing
Ⓑ = Bearing of encoder
Ⓜ = Measuring point for operating temperature
Ⓚ = Required mating dimensions
H1 = Clamping screw M2.5 with hexalobular socket X8
H2 = Hole circle for fastening, see coupling
① = Clamping ring on housing side (status at delivery)
② = Clamping ring on coupling side (optionally mountable)
↻ = Direction of shaft rotation for output signals is described in interface description.

	Absolute						Incremental			
	Singleturn			Multiturn						
	ECN 425	ECN 413	ECN 413	EQN 437	EQN 425	EQN 425	ERN 420	ERN 460	ERN 430	ERN 480
Absolute position values*	**EnDat 2.2**	**EnDat 2.2**	**SSI**	**EnDat 2.2**	**EnDat 2.2**	**SSI**	–			
Ordering designation	EnDat 22	EnDat 01		EnDat 22	EnDat 01					
Positions per rev	33 554 432 (25 bits)	8192 (13 bits)		33 554 432 (25 bits)	8192 (13 bits)		–			
Revolutions	–			4096			–			
Code	Pure binary		Gray	Pure binary		Gray	–			
Elec. permissible speed/at accuracy	≤ 12 000 rpm for continuous position value	*512 lines:* ≤ 5000 rpm/± 1 LSB ≤ 12 000 rpm/± 100 LSB *2048 lines:* ≤ 1500 rpm/± 1 LSB ≤ 12 000 rpm/± 50 LSB		≤ 12 000 rpm for continuous position value	*512 lines:* ≤ 5000 rpm/± 1 LSB ≤ 10 000 rpm/± 100 LSB *2048 lines:* ≤ 1500 rpm/± 1 LSB ≤ 10 000 rpm/± 50 LSB		–			
Calculation time t_{cal}	≤ 5 µs	≤ 0.25 µs	≤ 0.5 µs	≤ 5 µs	≤ 0.25 µs	≤ 0.5 µs	–			
Incremental signals	Without	∼ 1 V_{PP}[1]		Without	∼ 1 V_{PP}[1]		⊓⊔TTL		⊓⊔HTL	∼ 1 V_{PP}[1]
Line counts*	–	**512** 2048	**512**	–	**512** 2048	**512**	250[4] 500[4] **1000 1024 1250 2000 2048 2500 3600 4096 5000**			
Cutoff freq. –3 dB Scanning frequency Edge separation *a*	– – –	*512 lines:* ≤ 100 kHz; *2048 lines:* ≥ 200 kHz – –		– – –	*512 lines:* ≥ 100 kHz; *2048 lines:* ≥ 200 kHz – –		– ≤ 300 kHz ≥ 0.39 µs			≥ 180 kHz – –
System accuracy	± 20"	*512 lines:* ± 60"; *2048 lines:* ± 20"		± 20"	*512 lines:* ± 60"; *2048 lines:* ± 20"		1/20 of grating period			
Power supply* **Current consumption** without load	**3.6 to 5.25 V** ≤ 150 mA	**5 V** ± 5 % ≤ 160 mA	5 V ± 5 % or **10 to 30 V** ≤ 160 mA	**3.6 to 5.25 V** ≤ 180 mA	**5 V** ± 5 % ≤ 200 mA	5 V ± 5 % or **10 to 30 V** ≤ 200 mA	**5 V** ± 10 % 120 mA	**10 to 30 V** 100 mA	**10 to 30 V** 150 mA	**5 V** ± 10 % 120 mA
Electrical connection*	• **Flange socket** M12, radial • Cable 1 m, with coupling M12	• **Flange socket** M23, radial • Cable 1 m, with coupling M23 or without connecting element		• **Flange socket** M12, radial • Cable 1 m, with coupling M12	• **Flange socket** M23, radial • Cable 1 m, with coupling M23 or without connecting element		• **Flange socket** M23, radial and axial (with blind hollow shaft) • **Cable** 1 m, **without connecting element**			
Shaft*	**Blind hollow shaft** or hollow through shaft **D = 12 mm**						**Blind hollow shaft** or hollow through shaft **D = 12 mm**			
Mech. perm. speed *n*[2]	≤ 6000 rpm/≤ 12 000 rpm [5]						≤ 6000 rpm/≤ 12 000 rpm [5]			
Starting torque at 20 °C below -20 °C	*Blind hollow shaft:* ≤ 0.01 Nm *Hollow through shaft:* ≤ 0.025 Nm ≤ 1 nm						*Blind hollow shaft:* ≤ 0.01 Nm *Hollow through shaft:* ≤ 0.025 Nm ≤ 1 nm			
Moment of inertia of rotor	$4.3 \cdot 10^{-6}$ kgm²						$4.3 \cdot 10^{-6}$ kgm²			
Permissible axial motion of measured shaft	± 1 mm						± 1 mm			
Vibration 55 to 2000 Hz **Shock** 6 ms/2 ms	≤ 300 m/s² [3] (IEC 60 068-2-6) ≤ 1000 m/s²/≤ 2 000 m/s² (IEC 60 068-2-27)						≤ 300 m/s² [3] (IEC 60 068-2-6) ≤ 1000 m/s²/≤ 2 000 m/s² (IEC 60 068-2-27)			
Max. operating temperature[2]	*U_P = 5 V:* 100 °C *U_P = 10 to 30 V:* 85 °C						100 °C	70 °C	100 °C	
Min. operating temperature	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C						*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C			
Protection IEC 60 529	IP 67 at housing; IP 64 at shaft inlet						IP 67 at housing (IP 66 with hollow through shaft); IP 64 at shaft inlet			
Weight	Approx. 0.3 kg						Approx. 0.3 kg			

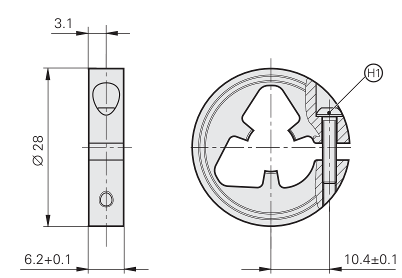
Bold: These preferred versions are available on short notice
***** Please select when ordering

1) Restricted tolerances: Signal amplitude 0.8 to 1.2 V_{PP}
2) For the correlation between the operating temperature and the shaft speed or power supply, see *General Mechanical Information*
3) 150 m/s² with flange socket version
4) Not with ERN 480
5) With two shaft clamps (only for hollow through shaft)

Mounting Accessories

for ERN/ECN/EQN 400 Series

Shaft clamp ring
By using a second shaft clamp ring, the mechanically permissible speed of rotary encoders with hollow through shaft can be increased to a maximum of 12 000 rpm.
Id. Nr. 540 741-03



H1 = Clamping screw M2.5 with hexalobular socket X8

Torque Supports for the ERN/ECN/EQN 400
For simple applications with the ERN/ECN/EQN 400, the stator coupling can be replaced by torque supports.

The following kits are available

Wire torque support
The stator coupling is replaced by a flat metal ring to which the provided wire is fastened.
Id. Nr. 510 955-01

Pin torque support
Instead of a stator coupling, a "synchro flange" is fastened to the encoder. A pin serving as torque support is mounted either axially or radially on the flange. As an alternative, the pin can be pressed in on the customer's surface, and a guide can be inserted in the encoder flange for the pin.
Id. Nr. 510 861-01

Screwdriver bit
for HEIDENHAIN shaft couplings, for ExN 100/400/1000 shaft clamps, for ERO shaft clamps

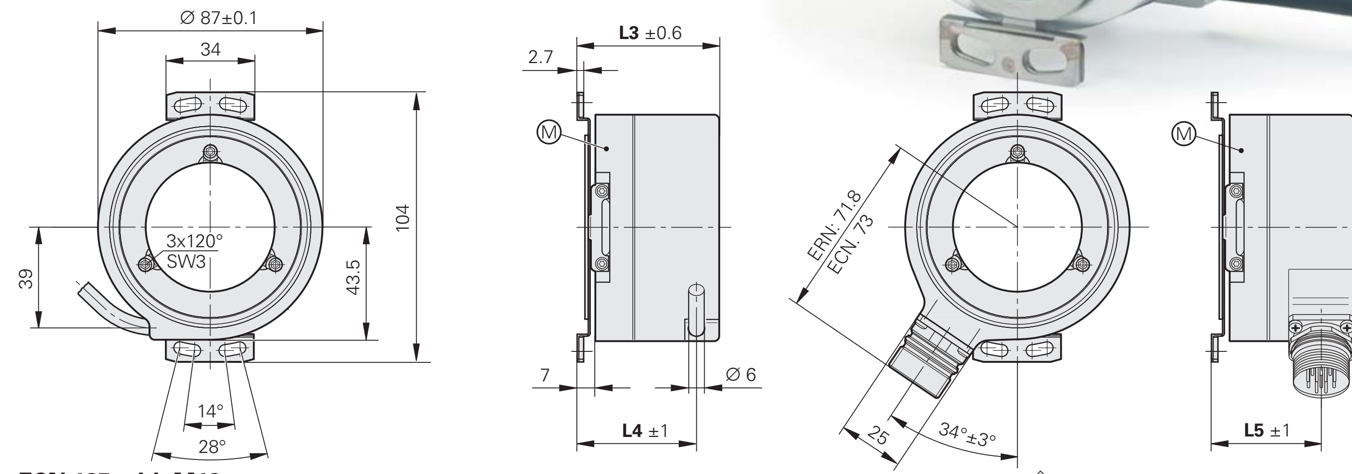
Width across flats	Length	Id. Nr.
2 (ball head)	70 mm	350 378-04
3 (ball head)		350 378-08
1,5		350 378-01
2		350 378-03
2.5		350 378-05
4		350 378-07
TX8	89 mm 152 mm	350378-11 350 378-12

Screwdriver
Adjustable torque
0.2 Nm to 1 Nm Id. Nr. 350 379-01
0.5 Nm to 5 Nm Id. Nr. 350 379-02

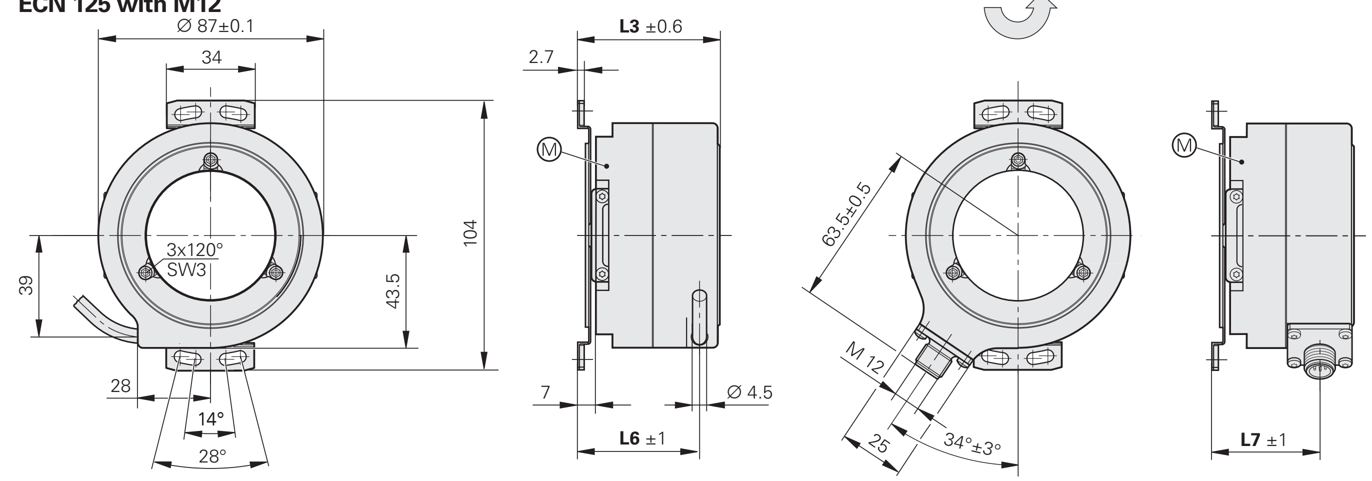
ECN/ERN 100 Series

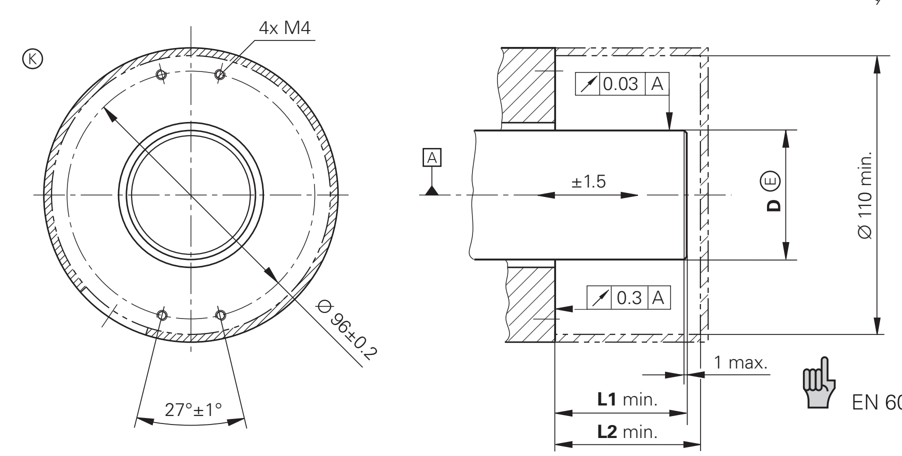
- **Rotary encoders with mounted stator coupling**
- **Hollow through shaft up to Ø 50 mm**

ERN 1x0/ECN 113



ECN 125 with M12





EN 60 529

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

Cable radial, also usable axially
A = Ball bearing
K = Required mating dimensions
M = Measuring point for operating temperature
Direction of shaft rotation for output signals is described in interface description.

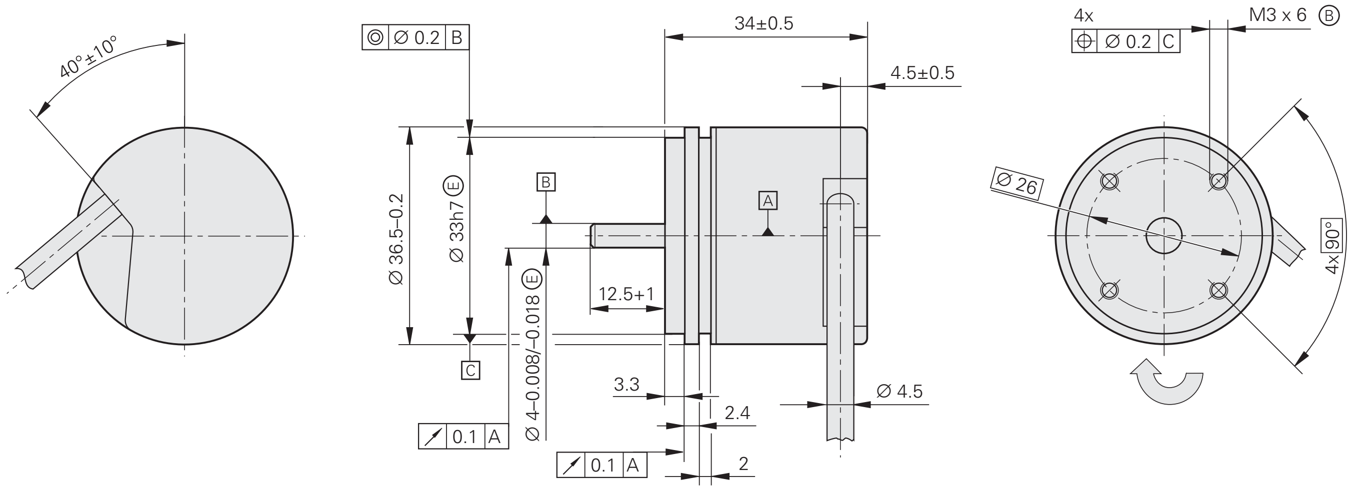
D	Model	L1	L2	L3	L4	L5	L6	L7
Ø 20h7	ERN	46	48.5	45	37	32.5	32	26.5
	ECN	41	43.5	40	32	26.5		
Ø 25h7	ERN	46	48.5	45	37	32.5	32	26.5
	ECN	41	43.5	40	32	26.5		
Ø 38h7	ERN	56	58.5	55	46	42.5	47	41.5
	ECN				47	41.5		
Ø 50h7	ERN	56	58.5	55	46	42.5	47	41.5
	ECN				47	41.5		

	Absolute Singleturn ECN 125	 ECN 113	 ECN 113	Incremental ERN 120	 ERN 130	 ERN 180
Absolute position values*	**EnDat 2.2**	**EnDat 2.2**	**SSI**	–		
Ordering designation	EnDat 22	EnDat 01				
Positions per rev	33 554 432 (25 bits)	8192 (13 bits)		–		
Code	Pure binary		Gray	–		
Elec. permissible speed/at accuracy	n_{max} for continuous position value	≤ 660 rpm/± 1 LSB n_{max}/± 50 LSB		–		
Calculation time t_{cal}	≤ 5 µs	≤ 0.25 µs	≤ 0.5 µs	–		
Incremental signals	Without	∼ 1 V_{PP} [1]		⊓⊔ TTL	⊓⊔ HTL	∼ 1 V_{PP} [1]
Line counts*	–	**2 048**		1000 1024 2048 2500 3600 **5000**		
Cutoff freq. –3 dB Scanning frequency Edge separation *a*	– – –	Typically ≥ 200 kHz – –		– ≤ 300 kHz ≥ 0.39 µs		Typ. ≥ 180 kHz – –
System accuracy	± 20"			1/20 of grating period		
Power supply **Current consumption** without load	3.6 to 5.25 V ≤ 200 mA	5 V ± 5% ≤ 180 mA	5 V ± 5 % [2] ≤ 180 mA	5 V ± 10% ≤ 150 mA	10 to 30 V ≤ 200 mA	5 V ± 10% ≤ 150 mA
Electrical connection*	• **Flange socket** M12, radial • Cable 1 m/5 m, with coupling M12	• **Flange socket** M23, radial • **Cable 1 m**/5 m, with or **without coupling** M23		• **Flange socket** M23, radial • **Cable 1 m**/5 m, with or **without coupling** M23		
Shaft*	Hollow through shaft D = 20 mm, **25 mm,** 38 mm, **50 mm**			Hollow through shaft D = 20 mm, **25 mm,** 38 mm, **50 mm**		
Mech. perm. speed *n* [3]	*D > 30 mm:* ≤ 4000 rpm *D ≤ 30 mm:* ≤ 6000 rpm			*D > 30 mm:* ≤ 4000 rpm *D ≤ 30 mm:* ≤ 6000 rpm		
Starting torque at 20 °C	*D > 30 mm:* ≤ 0.2 Nm *D ≤ 30 mm:* ≤ 0.15 Nm			*D > 30 mm:* ≤ 0.2 Nm *D ≤ 30 mm:* ≤ 0.15 Nm		
Moment of inertia of rotor	*D = 50 mm* 220 · 10^{-6} kgm^2 *D = 38 mm* 350 · 10^{-6} kgm^2 *D = 25 mm* 96 · 10^{-6} kgm^2 *D = 20 mm* 100 · 10^{-6} kgm^2			*D = 50 mm* *240 · 10–6 kgm*^{2} *D = 38 mm* *350 · 10–6 kgm*^{2} *D = 25 mm* *80 · 10–6 kgm*^{2} *D = 20 mm* 85 · 10^{-6} kgm^2		
Permissible axial motion of measured shaft	± 1.5 mm			± 1.5 mm		
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 200 m/s^2 [4] (IEC 60 068-2-6) ≤ 1000 m/s^2 (IEC 60 068-2-27)			≤ 200 m/s^2 [4] (IEC 60 068-2-6) ≤ 1000 m/s^2 (IEC 60 068-2-27)		
Max. operating temperature [3]	100 °C			100 °C	85 °C (100 °C at U_P < 15 V)	100 °C
Min. operating temperature	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C			*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C		
Protection [3] IEC 60 529	IP 64			IP 64		
Weight	0.6 kg to 0.9 kg depending on the hollow shaft version			0.6 kg to 0.9 kg depending on the hollow shaft version		

Bold: These preferred versions are available on short notice
* Please select when ordering
1) Restricted tolerances: Signal amplitude 0.8 to 1.2 V_{PP}
2) 10 to 30 V via connecting cable with voltage converter
3) For the correlation between the protection class, shaft speed and operating temperature, see *General Mechanical Information*
4) 100 m/s^2 with flange socket version

ROD 1000 Series

- **Rotary encoders for separate shaft coupling**
- **Compact dimensions**
- **Synchro flange**



Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

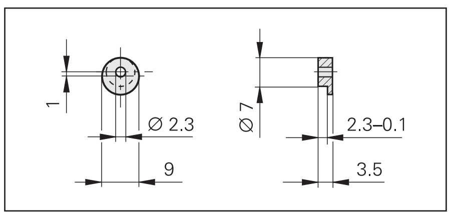
Cable radial, also usable axially
A = Ball bearing
B = Threaded mounting hole
Direction of shaft rotation for output signals is described in interface description.

	Incremental		
	ROD 1020	ROD 1030	ROD 1080
Incremental signals	⊓⊔TTL	⊓⊔HTL	∼ 1 V_{PP}[1]
Line counts*	100 200 **250** 360 400 **500** 720 900 **1000** **1024** 1250 1500 2000 **2048** **2500** **3600**		
Cutoff freq. –3 dB Scanning frequency Edge separation *a*	– ≤ 300 kHz ≥ 0.39 µs	– ≤ 160 kHz ≥ 0.76 µs	≥ 180 kHz – –
Power supply* **Current consumption** without load	5 V ± 10% ≤ 150 mA	10 to 30 V ≤ 150 mA	5 V ± 10% ≤ 150 mA
Electrical connection*	**Cable 1 m**/5 m, with or **without coupling** M23		
Max. cable length	100 m		150 m
Shaft*	Solid shaft D = 4 mm		
Mech. permissible speed *n*	10 000 rpm		
Starting torque	≤ 0.001 Nm (at 20 °C)		
Moment of inertia of rotor	$0.45 \cdot 10^{-6}$ kgm^2		
Shaft load	Axial 5 N Radial 10 N at shaft end		
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (IEC 60 068-2-6) ≤ 1000 m/s^2 (IEC 60 068-2-27)		
Max. operating temperature[2]	100 °C	70 °C	100 °C
Min. operating temperature	*Rigid configuration:* –40 °C *Moving cable:* –10 °C		
Protection IEC 60 529	IP 64		
Weight	Approx. 0.09 kg		

Bold: These preferred versions are available on short notice
***** Please select when ordering
[1] Restricted tolerances: Signal amplitude 0.8 to 1.2 V_{PP}
[2] For the correlation between the operating temperature and the shaft speed or supply voltage, see *General Mechanical Information*

Mounting Accessories

Fixing clamps for encoders of the ROD 1000 series
(3 per encoder)
Id. Nr. 200 032-02

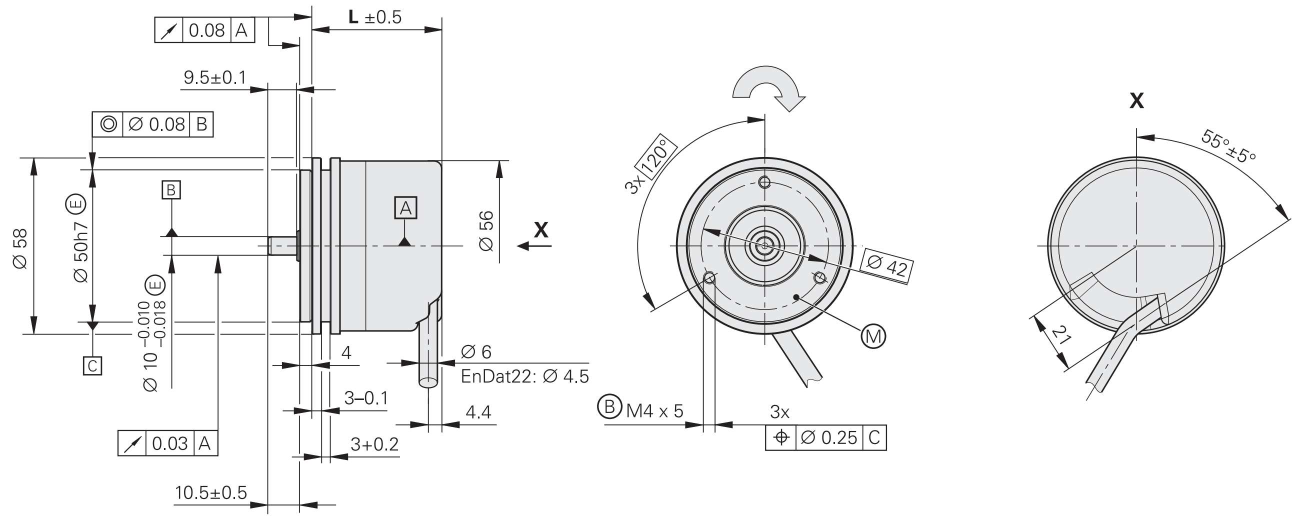


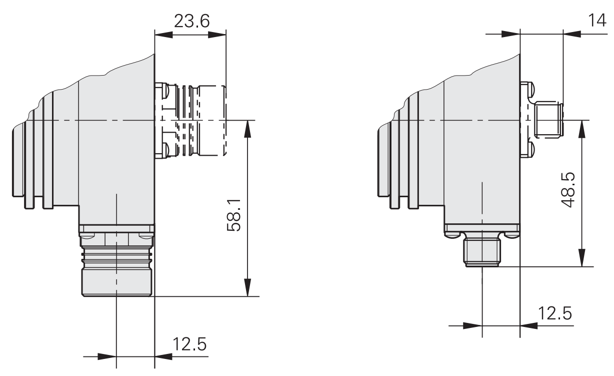
Shaft coupling
See *Shaft Couplings*

ROC/ROQ/ROD 400 Series with Synchro Flange

Rotary encoders for separate shaft coupling

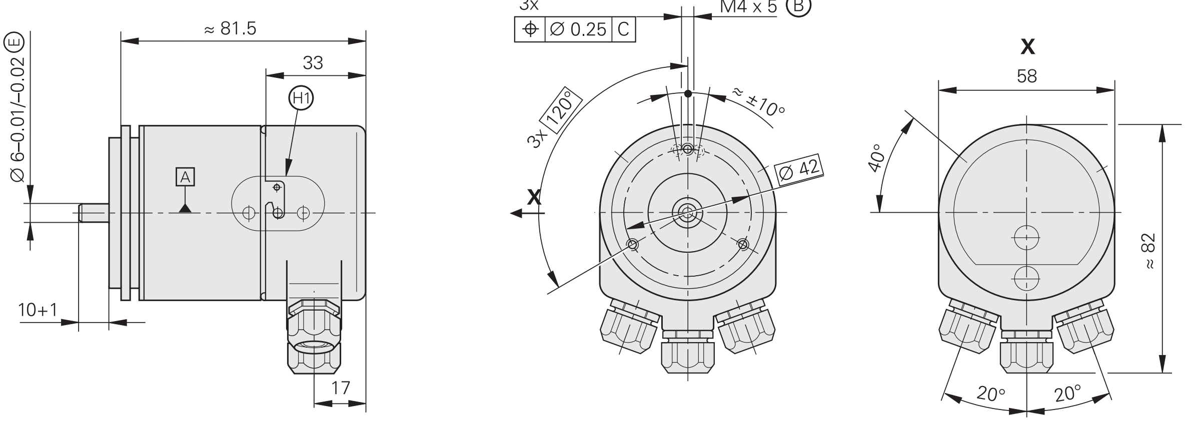
ROC/ROQ/ROD 4xx





	L
ROD **ROC/ROQ 512 lines**	42.7
ROC/ROQ 2048 lines **ROC 425/ROQ 437**	43.2

ROC 413/ROQ 425 with PROFIBUS DP



Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

Cable radial, also usable axially
A = Ball bearing
B = Threaded mounting hole
H1 = Shown rotated by 40°
Direction of shaft rotation for output signals is described in interface description.

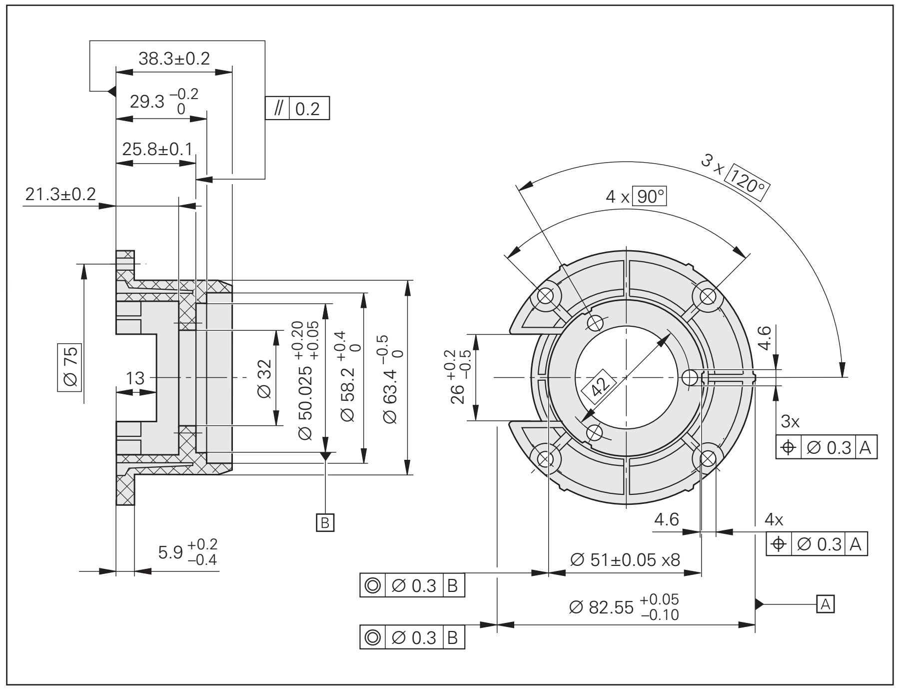
	Absolute								Incremental			
	Singleturn				**Multiturn**							
	ROC 425	**ROC 413**	**ROC 410** **ROC 412** **ROC 413**	**ROC 413**	**ROQ 437**	**ROQ 425**	**ROQ 424** **ROQ 425**	**ROQ 425**	**ROD 426**	**ROD 466**	**ROD 436**	**ROD 486**
Absolute position values*	**EnDat 2.2**	**EnDat 2.2**	**SSI**	**PROFIBUS-DP**	**EnDat 2.2**	**EnDat 2.2**	**SSI**	**PROFIBUS-DP**	–			
Ordering designation	EnDat 22	EnDat 01			EnDat 22	EnDat 01						
Positions per rev	33 554 432 (25 bits)	8192 (13 bits)	1024 (10 bits) 4096 (12 bits) 8192 (13 bits)	8192 (13 bits)[2]	33 554 432 (25 bits)	8192 (13 bits)	4096 (12 bits) 8192 (13 bits)	8192 (13 bits)[2]	–			
Revolutions	–				4 096			4 096[2]	–			
Code	Pure binary		Gray	Pure binary	Pure binary		Gray	Pure binary	–			
Elec. permissible speed/ at accuracy	≤ 12 000 rpm for continuous position value	*512 lines:* ≤ 5 000 rpm/± 1 LSB ≤ 12 000 rpm/± 100 LSB *2 048 lines:* ≤ 1 500 rpm/± 1 LSB ≤ 12 000 rpm/± 50 LSB			≤ 12 000 rpm for continuous position value	*512 lines:* ≤ 5000 rpm/± 1 LSB ≤ 10 000 rpm/± 100 LSB *2 048 lines:* ≤ 1500 rpm/± 1 LSB ≤ 10 000 rpm/± 50 LSB			–			
Calculation time t_{cal}	≤ 5 µs	≤ 0.25 µs	≤ 0.5 µs	–	≤ 5 µs	≤ 0.25 µs	≤ 0.5 µs	–	–			
Incremental signals	Without	∿ 1 V_{PP}[1]		–	Without	∿ 1 V_{PP}[1]		–	⎍ TTL		⎍ HTL	∿ 1 V_{PP}[1]
Line counts*	–	**512** 2048	**512**	512 (internal only)	–	**512** 2 048	**512**	512 (internal only)	50 100 150 200 250 360 **500** 512 720 **1000** **1024** **1250** 1500 1800 **2000** **2048** **2500** **3600** **4096** **5000** 6 000[4] 8 192[4] 9 000[4] 10 000[4]			–
Cutoff freq. –3 dB Scanning frequency Edge separation *a*	– – –	*512 lines:* ≥100 kHz; *2048 lines:* ≥ 200 kHz – –		–	– – –	*512 lines:* ≥100 kHz; *2048 lines:* ≥ 200 kHz – –		–	– ≤ 300 kHz/≤ 150 kHz[4] ≥ 0.39 µs/≥ 0.25 µs[4]			≥ 180 kHz – –
System accuracy	± 20"	*512 lines:* ± 60"; *2 048 lines:* ± 20"		± 60"	± 20"	*512 lines:* ± 60"; *2 048 lines:* ± 20"			1/20 of grating period			
Power supply*	**3.6 to 5.25 V**	**5 V** ± 5 %	5 V ± 5 % or **10 to 30 V**	10 to 30 V	**3.6 to 5.25 V**	**5 V** ± 5 %	5 V ± 5 % or **10 to 30 V**	10 to 30 V	**5 V** ± 10 %	**10 to 30 V**	**10 to 30 V**	**5 V** ± 10 %
Current con. without load	≤ 150 mA	≤ 160 mA	≤ 160 mA	≤ 125 mA at 24 V	≤ 180 mA	≤ 200 mA	≤ 200 mA	≤ 125 mA at 24 V	120 mA	100 mA	150 mA	120 mA
Electrical connection*	• **Flange socket** M12, radial • Cable 1 m, with coupling M12	• **Flange socket** M23, axial or radial • Cable 1 m/5 m, with or without coupling M23		Screw terminals; radial cable exit	• **Flange socket** M12, radial • Cable 1 m, with coupling M12	• **Flange socket** M23, axial or radial • Cable 1 m/5 m, with or without coupling M23		Screw terminals; radial cable exit	• **Flange socket** M23, radial and axial • **Cable 1 m**/5 m, with or **without coupling** M23			
Shaft	Solid shaft D = 6 mm								Solid shaft D = 6 mm			
Mech. permissible speed *n*	≤ 12 000 rpm								≤ 16 000 rpm			
Starting torque	≤ 0.01 Nm (at 20 °C)								≤ 0.01 Nm (at 20 °C)			
Moment of inertia of rotor	$2.7 \cdot 10^{-6}$ kgm²			$3.6 \cdot 10^{-6}$ kgm²	$2.7 \cdot 10^{-6}$ kgm²			$3.8 \cdot 10^{-6}$ kgm²	$2.7 \cdot 10^{-6}$ kgm²			
Shaft load[5]	Axial 10 N/radial 20 N at shaft end								Axial 10 N/radial 20 N at shaft end			
Vibration 55 to 2000 Hz **Shock** 6 ms/2 ms	≤ 300 m/s² (IEC 60 068-2-6) ≤ 1000 m/s2/≤ 2000 m/s² (IEC 60 068-2-27)								≤ 300 m/s² (IEC 60 068-2-6) ≤ 1000 m/s²/≤ 2000 m/s² (IEC 60068-2-27)			
Max. operating temp.	*U_P = 5 V:* 100 °C; *U_P = 10 to 30 V:* 85 °C			60 °C	*U_P = 5 V:* 100 °C; *U_P = 10 to 30 V:* 85 °C			60 °C	100 °C	70 °C	100 °C	
Min. operating temp.	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C			–20 °C	*Flange socket or fixed cable:*–40 °C *Moving cable:* –10 °C			-20 °C	*Flange socket or fixed cable:*–40 °C *Moving cable:* –10 °C			
Protection IEC 60 529	IP 67 at housing; IP 64 at shaft end[3]								IP 67 at housing; IP 64 at shaft end[3]			
Weight	Approx. 0.35 kg								Approx. 0.3 kg			

Bold: These preferred versions are available on short notice
* Please select when ordering
1) Restricted tolerances: Signal amplitude 0.8 to 1.2 V_{PP}
2) These functions are programmable
3) IP 66 upon request
4) Only on ROD 426, ROD 466 through integrated signal doubling
5) Also see *Mechanical Design and Installation*

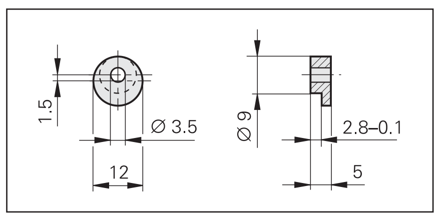
Mounting Accessories

for ROC/ROQ/ROD 400 series with synchro flange

Adapter flange
(electrically nonconducting)
Id. Nr. 257 044-01



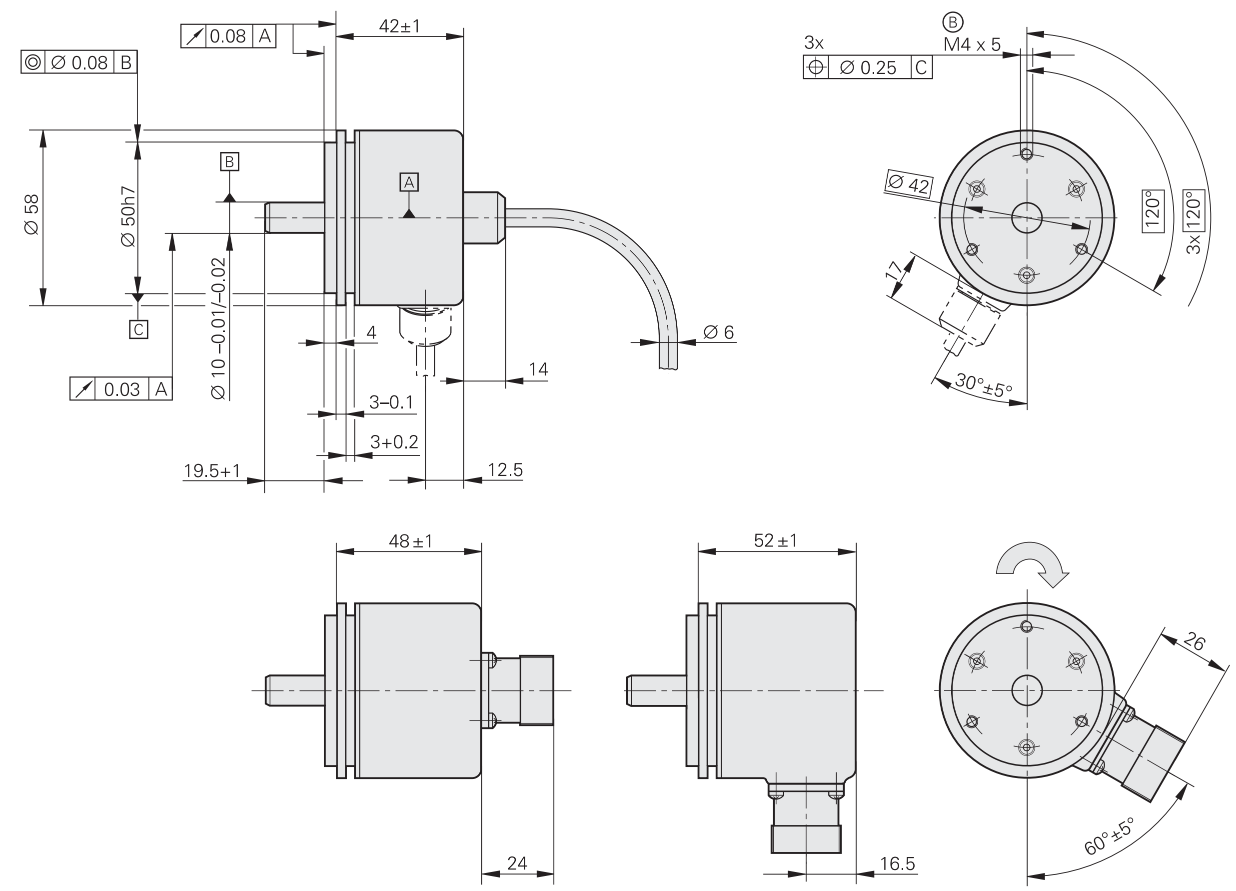
Fixing clamps
(3 per encoder)
Id. Nr. 200 032-01



Shaft coupling
See *Shaft Couplings*

ROC 415, ROC 417

- **Rotary encoders for separate shaft coupling**
- **Synchro flange**
- **High absolute resolution**
  32768 position values per revolution (15 bits) or
  131072 position values per revolution (17 bits)



Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

Cable radial, also usable axially
A = Ball bearing
B = Threaded mounting hole
Direction of shaft rotation for output signals is described in interface description.

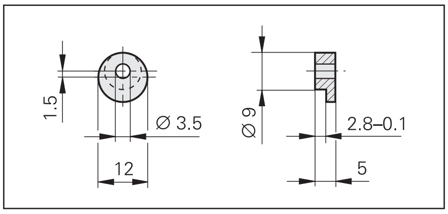
	Absolute Singleturn ROC 415	ROC 417
Absolute position values	EnDat 2.1	
Positions per rev	32 768 (15 bits)	131 072 (17 bits)
Code	Pure binary	
Elec. permissible speed/at accuracy	60 rpm/± 2 LSB 200 rpm/± 50 LSB	
Calculation time t_{cal}	≤ 0.25 µs	
Incremental signals	∼ 1 V_{PP}[1)]	
Line counts	8192	
Cutoff freq. –3 dB	≥ 100 kHz	
Power supply **Current consumption** without load	5 V ± 5% ≤ 250 mA	
Electrical connection*	• **Flange socket** M23, axial or radial • Cable 1 m/5 m, with or without coupling M23	
Shaft	Solid shaft D = 10 mm	
Mech. permissible speed *n*	≤ 10 000 rpm	
Starting torque	≤ 0.025 nm (at 20 °C)	
Moment of inertia of rotor	$3.6 \cdot 10^{-6}$ kgm^2	
Shaft load	Axial 10 N Radial 20 N at shaft end	
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (IEC 60 068-2-6) ≤ 1000 m/s^2 (IEC 60 068-2-27)	
Max. operating temp.	80 °C	
Min. operating temp.	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C	
Protection IEC 60 529	IP 67 at housing IP 66 at shaft inlet	
Weight	Approx. 0.4 kg	

Bold: These preferred versions are available on short notice
* Please select when ordering
1) Restricted tolerances: Signal amplitude 0.8 to 1.2 V_{PP}

Mounting Accessories

Fixing clamps
(3 per encoder)
Id. Nr. 200 032-01

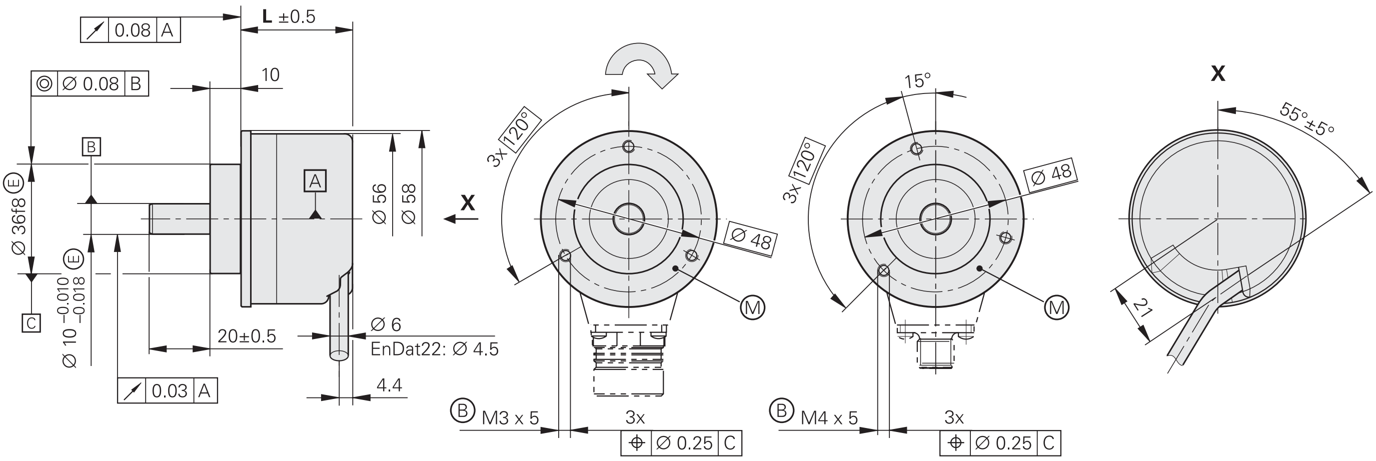
Shaft coupling
See *Shaft Couplings*

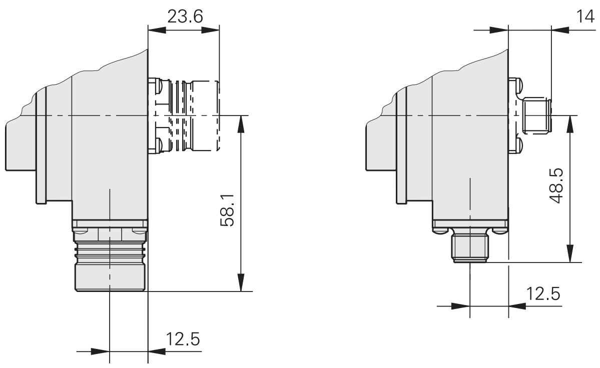


ROC/ROQ/ROD 400 Series with Clamping Flange

Rotary encoders for separate shaft coupling

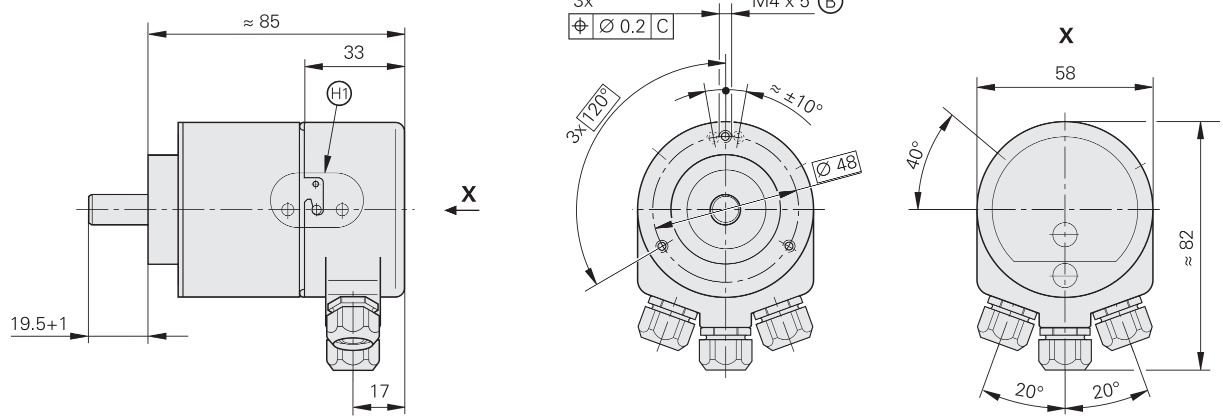
ROC/ROQ/ROD 4xx





	L
ROD **ROC/ROQ 512 lines**	36.7
ROC/ROQ 2048 lines **ROC 425/ROQ 437**	37.2

ROC 413/ROQ 425 with PROFIBUS DP



Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

Cable radial, also usable axially
A = Ball bearing
B = Threaded mounting hole
M = Measuring point for operating temperature
H1 = Shown rotated by 40°
Direction of shaft rotation for output signals is described in interface description.

	Absolute								Incremental		
	Singleturn				Multiturn						
	ROC 425	ROC 413	ROC 413	ROC 413	ROQ 437	ROQ 425	ROQ 424 ROQ 425	ROQ 425	ROD 420	ROD 430	ROD 480
Absolute position values*	**EnDat 2.2**	**EnDat 2.2**	**SSI**	**PROFIBUS-DP**	**EnDat 2.2**	**EnDat 2.2**	**SSI**	**PROFIBUS-DP**	–		
Ordering designation	EnDat 22	EnDat 01			EnDat 22	EnDat 01					
Positions per rev	33 554 432 (25 bits)	8192 (13 bits)		8192 (13 bits)[2]	33 554 432 (25 bits)	8192 (13 bits)	4096 (12 bits) 8192 (13 bits)	8192 (13 bits)[2]	–		
Revolutions	–				4 096			4 096[2]	–		
Code	Pure binary		Gray	Pure binary	Pure binary		Gray	Pure binary	–		
Elec. permissible speed/at accuracy	≤ 12 000 rpm for continuous position value	≤ 5 000 rpm/± 1 LSB ≤ 12 000 rpm/± 100 LSB			≤ 12 000 rpm for continuous position value	≤ 5 000 rpm/± 1 LSB ≤ 10 000 rpm/± 100 LSB			–		
Calculation time t_{cal}	≤ 5 µs	≤ 0.25 µs	≤ 0.5 µs	–	≤ 5 µs	≤ 0.25 µs	≤ 0.5 µs	–	–		
Incremental signals	Without	∿ 1 V_{PP}[1]		–	Without	∿ 1 V_{PP}[1]		–	⊓⊔ TTL	⊓⊔ HTL	∿ 1 V_{PP}[1]
Line counts*	–	**512**		512 (internal only)	–	**512**		512 (internal only)	50 100 150 200 250 360 500 512 720		–
									1000 1024 1250 1500 1800 2000 2048 2500 3600 **4096** **5000**		
Cutoff freq. –3 dB Scanning frequency Edge separation *a*	– – –	≥ 100 kHz – –		–	– – –	≥ 100 kHz – –		–	– ≤ 300 kHz ≥ 0.39 µs		≥ 180 kHz – –
System accuracy	± 20"	± 60"			± 20"	± 60"			1/20 of grating period		
Power supply* **Current consumption** without load	**3.6 to 5.25 V** ≤ 150 mA	**5 V** ± 5 % ≤ 160 mA	5 V ± 5 % or **10 to 30 V** ≤ 160 mA	10 to 30 V ≤ 125 mA at 24 V	**3.6 to 5.25 V** ≤ 180 mA	**5 V** ± 5 % ≤ 200 mA	5 V ± 5 % or **10 to 30 V** ≤ 200 mA	10 to 30 V ≤ 125 mA at 24 V	**5 V** ± 10 % 120 mA	**10 to 30 V** 150 mA	**5 V** ± 10 % 120 mA
Electrical connection*	• **Flange socket** M12, radial • Cable 1 m, with coupling M12	• **Flange socket** M23, axial or radial • Cable 1 m/5 m, with or without coupling M23		Screw terminals, radial cable outlet	• Flange socket M12, radial • Cable 1 m, with coupling M12	• **Flange socket** M23, axial or radial • Cable 1 m/5 m, with or without coupling M23		Screw terminals, radial cable outlet	• **Flange socket** M23, radial and axial • **Cable 1 m/**5 m, with or **without coupling** M23		
Shaft	Solid shaft D = 10 mm								Solid shaft D = 10 mm		
Mech. permissible speed *n*	≤ 12 000 rpm								≤ 12 000 rpm		
Starting torque	≤ 0.01 Nm (at 20 °C)								≤ 0.01 Nm (at 20 °C)		
Moment of inertia of rotor	2.8 · 10^{-6} kgm^2			3.6 · 10^{-6} kgm^2	2.8 · 10^{-6} kgm^2			3.6 · 10^{-6} kgm^2	2.6 · 10^{-6} kgm^2		
Shaft load[4]	Axial 10 N/radial 20 N at shaft end								Axial 10 N/radial 20 N at shaft end		
Vibration 55 to 2000 Hz **Shock** 6 ms/2 ms	≤ 300 m/s^2 (IEC 60 068-2-6) ≤ 1000 m/s^2/≤ 2000 m/s^2 (IEC 60 068-2-27)								≤ 300 m/s^2 (IEC 60 068-2-6) ≤ 1000 m/s^2/≤ 2 000 m/s^2 (IEC 60 068-2-27)		
Max. operating temp.	*U_P = 5 V:* 100 °C *U_P = 10 to 30 V:* 85 °C			60 °C	*U_P = 5 V:* 100 °C *U_P = 10 to 30 V:* 85 °C			60 °C	100 °C		
Min. operating temp.	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C			-20 °C	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C			-20 °C	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C		
Protection IEC 60 529	IP 67 at housing; IP 64 at shaft end[3]								IP 67 at housing; IP 64 at shaft end[3]		
Weight	Approx. 0.35 kg								Approx. 0.3 kg		

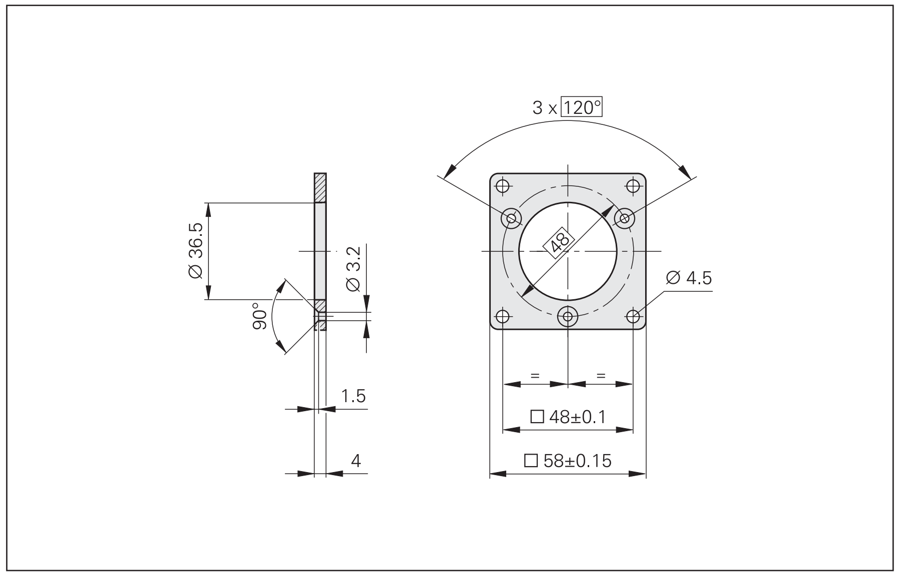
Bold: These preferred versions are available on short notice
***** Please select when ordering

1) Restricted tolerances: Signal amplitude 0.8 to 1.2 V_{PP}
2) These functions are programmable
3) IP 66 upon request
4) Also see *Mechanical Design and Installation*

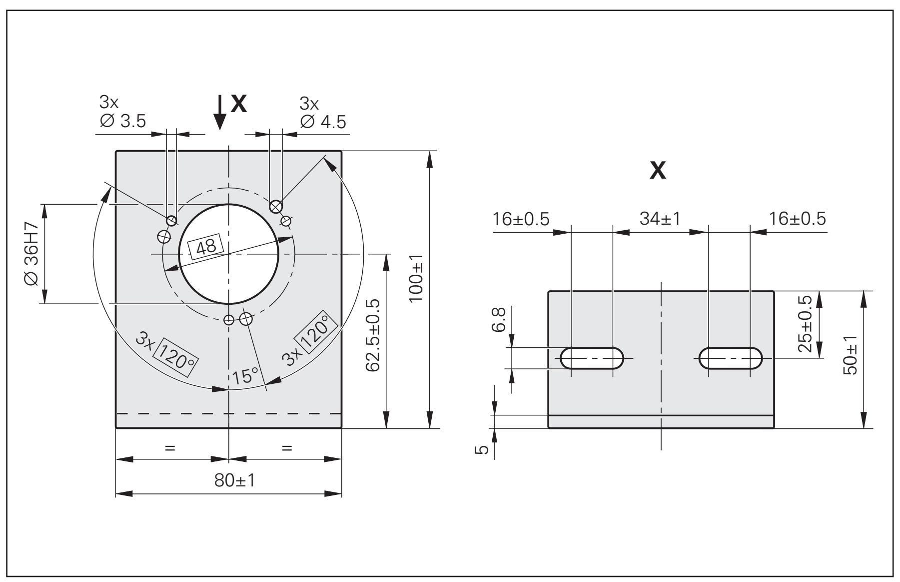
Mounting Accessories

for ROC/ROQ/ROD 400 series with clamping flange

Mounting flange
Id. Nr. 201 437-01



Mounting bracket
Id. Nr. 324 322-01



Shaft coupling
See *Shaft Couplings*

Interfaces

Incremental Signals ∿ 1 V_{PP}

HEIDENHAIN encoders with ∿ 1 V_{PP} interface provide voltage signals that can be highly interpolated.

The sinusoidal **incremental signals** A and B are phase-shifted by 90° elec. and have an amplitude of typically 1 V_{PP}. The illustrated sequence of output signals—with B lagging A—applies for the direction of motion shown in the dimension drawing.

The **reference mark signal** R has a usable component *G* of approx. 0.5 V. Next to the reference mark, the output signal can be reduced by up to 1.7 V to a quiescent value *H*. This must not cause the subsequent electronics to overdrive. Even at the lowered signal level, signal peaks with the amplitude *G* can also appear.

The data on **signal amplitude** apply when the power supply given in the specifications is connected to the encoder. They refer to a differential measurement at the 120 ohm terminating resistor between the associated outputs. The signal amplitude decreases with increasing frequency. The **cutoff frequency** indicates the scanning frequency at which a certain percentage of the original signal amplitude is maintained:

- –3 dB cutoff frequency: 70 % of the signal amplitude
- –6 dB cutoff frequency: 50 % of the signal amplitude

Interpolation/resolution/ measuring step
The output signals of the 1 V_{PP} interface are usually interpolated in the subsequent electronics in order to attain sufficiently high resolutions. For **velocity control,** interpolation factors are commonly over 1000 in order to receive usable velocity information even at low speeds.

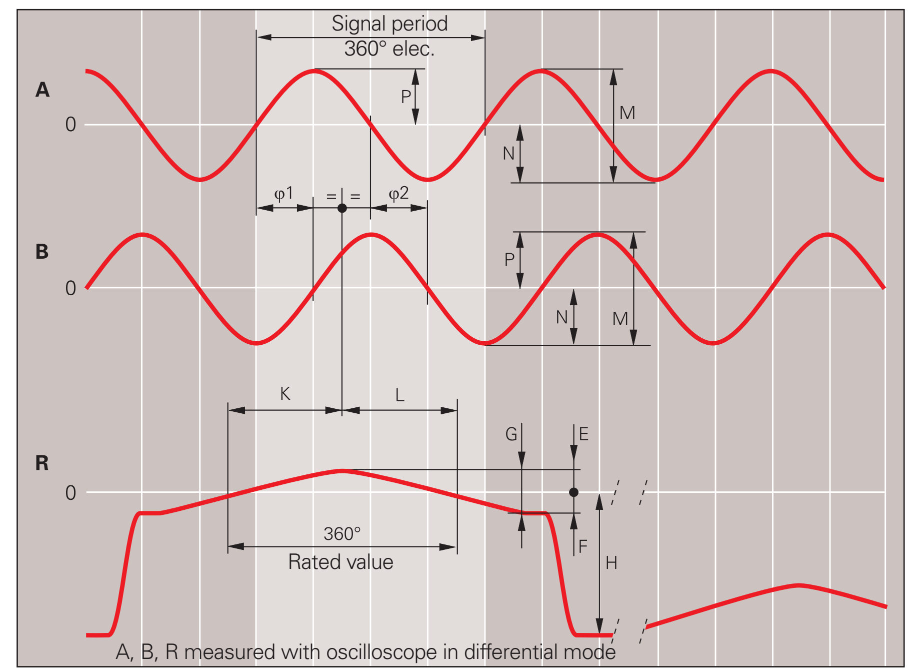
Measuring steps for **position measurement** are recommended in the specifications. For special applications, other resolutions are also possible.

Short-circuit stability
A temporary short circuit of one output to 0 V or U_P does not cause encoder failure, but it is not a permissible operating condition.

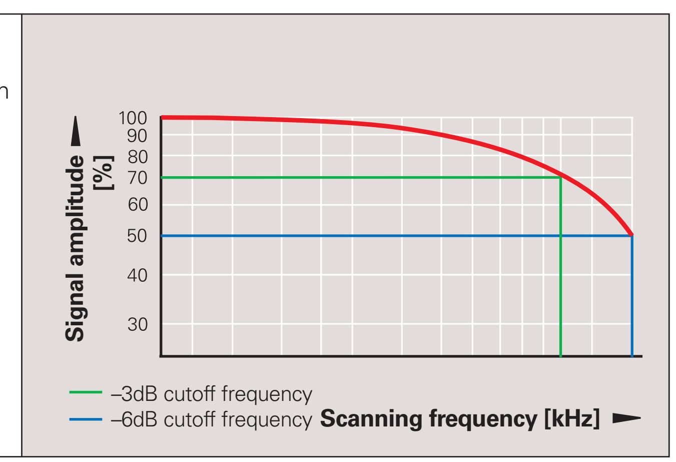
Short circuit at	20 °C	125 °C
One output	< 3 min	< 1 min
All outputs	< 20 s	< 5 s

Interface	Sinusoidal voltage signals ∿ **1 V_{PP}**	
Incremental signals	**2 sinusoidal signals A and B**	
	Signal level M:	0.6 to 1.2 V_{PP}; typically 1 V_{PP}
	Asymmetry |P – N|/2M:	≤ 0.065
	Amplitude ratio M_A/M_B:	0.8 to 1.25
	Phase angle |φ1 + φ2|/2:	90° ± 10° elec.
Reference mark signal	**1 or more signal peaks R**	
	Usable component G:	0.2 to 0.85 V
	Quiescent value H:	0.04 V to 1.7 V
	Switching threshold E, F:	≥ 40 mV
	Zero crossovers K, L:	180° ± 90° elec.
Connecting cable	HEIDENHAIN cable with shielding PUR [4(2 x 0.14 mm²) + (4 x 0.5 mm²)]	
Cable length	Max. 150 m distributed capacitance 90 pF/m	
Propagation time	6 ns/m	

Any limited tolerances in the encoders are listed in the specifications.



Cutoff frequency
Typical signal amplitude curve with respect to the scanning frequency



Input circuitry of the subsequent electronics

Dimensioning
Operational amplifier MC 34074
$Z_0 = 120\ \Omega$
$R_1 = 10\ k\Omega$ and $C_1 = 100$ pF
$R_2 = 34.8\ k\Omega$ and $C_2 = 10$ pF
$U_B = \pm 15$ V
U_1 approx. U_0

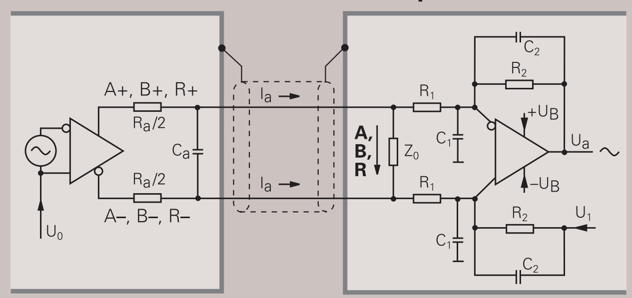
–3dB cutoff frequency of circuitry
Approx. 450 kHz
Approx. 50 kHz with $C_1 = 1000$ pF
and $C_2 = 82$ pF
This circuit variant does reduce the bandwidth of the circuit, but in doing so it improves its noise immunity.

Circuit output signals
$U_a = 3.48\ V_{PP}$ typical
Gain 3.48

Signal monitoring
A threshold sensitivity of 250 mV_{PP} is to be provided for monitoring the 1 V_{PP} incremental signals.

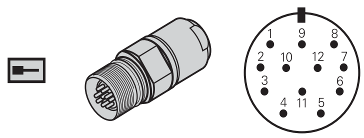
Incremental signals
Reference mark signal

$R_a < 100\ \Omega$, typ. $24\ \Omega$
$C_a < 50$ pF
$\Sigma I_a < 1$ mA
$U_0 = 2.5\ V \pm 0.5\ V$
(relative to 0 V of the power supply)

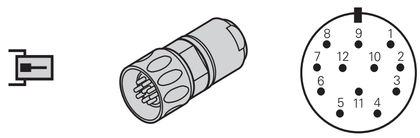


Pin layout

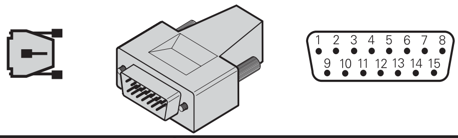
12-pin coupling M23



12-pin connector M23



15-pin D-sub connector
for IK 115/IK 215 or on encoder



	Power supply				Incremental signals						Other signals		
12-pin M23	12	2	10	11	5	6	8	1	3	4	9	7	/
15-pin D-sub	4	12	2	10	1	9	3	11	14	7	5/8/13/15	14	/
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**Vacant**	**Vacant**	**Vacant**
Cable	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	/	Violet	Yellow

Shield on housing; **U_P** = power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line

Interfaces
Incremental Signals ⊓⊔TTL

HEIDENHAIN encoders with ⊓⊔TTL interface incorporate electronics that digitize sinusoidal scanning signals with or without interpolation.

The **incremental signals** are transmitted as the square-wave pulse trains U_{a1} and U_{a2}, phase-shifted by 90° elec. The **reference mark signal** consists of one or more reference pulses U_{a0}, which are gated with the incremental signals. In addition, the integrated electronics produce their **inverse signals** $\overline{U_{a1}}$, $\overline{U_{a2}}$ and $\overline{U_{a0}}$ for noise-proof transmission. The illustrated sequence of output signals—with U_{a2} lagging U_{a1}—applies for the direction of motion shown in the dimension drawing.

The **fault-detection signal** $\overline{U_{aS}}$ indicates fault conditions such as breakage of the power line or failure of the light source. It can be used for such purposes as machine shut-off during automated production.

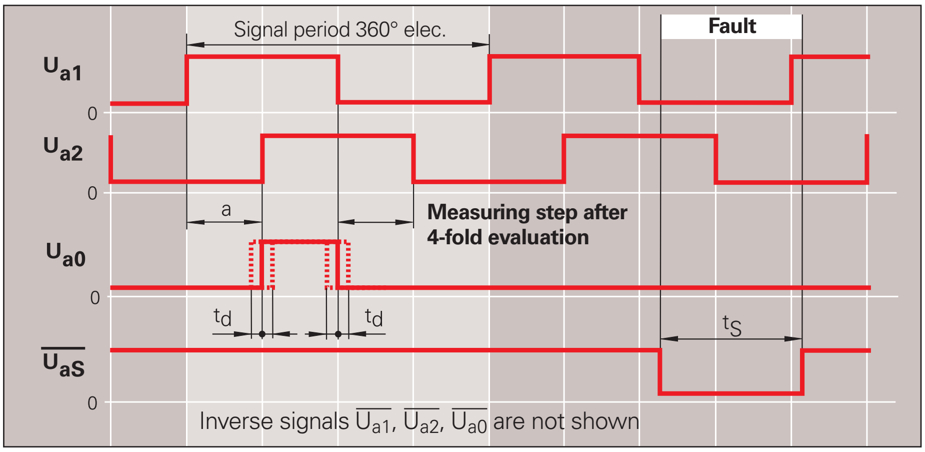
The distance between two successive edges of the incremental signals U_{a1} and U_{a2} through 1-fold, 2-fold or 4-fold evaluation is one **measuring step.**

The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum **edge separation** *a* listed in the *Specifications* applies for the illustrated input circuitry with a cable length of 1 m, and refers to a measurement at the output of the differential line receiver. Propagation-time differences in cables additionally reduce the edge separation by 0.2 ns per meter of cable length. To prevent counting error, design the subsequent electronics to process even as little as 90% of the resulting edge separation.

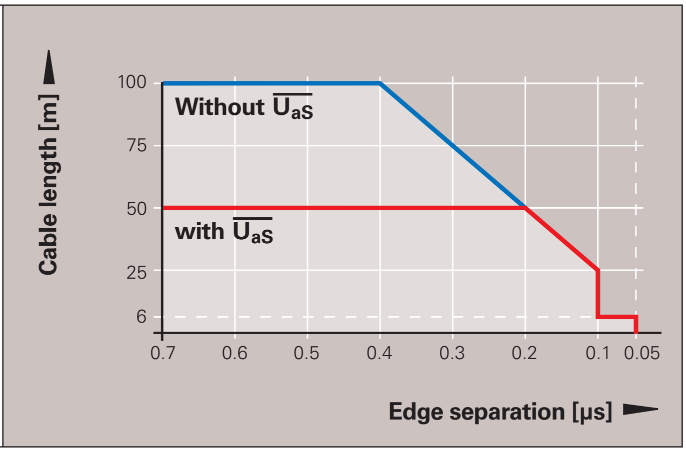
The max. permissible **shaft speed** or **traversing velocity** must never be exceeded.

The permissible **cable length** for transmission of the TTL square-wave signals to the subsequent electronics depends on the edge separation *a*. It is max. 100 m, or 50 m for the fault detection signal. This requires, however, that the power supply (see *Specifications*) be ensured at the encoder. The sensor lines can be used to measure the voltage at the encoder and, if required, correct it with an automatic system (remote sense power supply).

Interface	Square-wave signals ⊓⊔ **TTL**
Incremental signals	**2 TTL square-wave signals U_{a1}, U_{a2}** and their inverted signals **$\overline{U_{a1}}$, $\overline{U_{a2}}$**
Reference mark signal Pulse width Delay time	**1 or more square-wave pulses U_{a0}** and their inverted pulses **$\overline{U_{a0}}$** 90° elec. (other widths available on request); *LS 323:* ungated $\|t_d\| \leq 50$ ns
Fault detection signal Pulse width	**1 TTL square-wave pulse $\overline{U_{aS}}$** Improper function: LOW (upon request: U_{a1}/U_{a2} at high impedance) Proper function: HIGH $t_S \geq 20$ ms
Signal level	Differential line driver as per EIA standard RS 422 $U_H \geq 2.5$ V at $-I_H = 20$ mA $U_L \leq 0.5$ V at $I_L = 20$ mA
Permissible load	$Z_0 \geq 100\ \Omega$ between associated outputs $\|I_L\| \leq 20$ mA max. load per output $C_{load} \leq 1000$ pF with respect to 0 V Outputs protected against short circuit to 0 V
Switching times (10% to 90%)	$t_+ / t_- \leq 30$ ns (typically 10 ns) with 1 m cable and recommended input circuitry
Connecting cable Cable length Propagation time	HEIDENHAIN cable with shielding PUR [4(2 × 0.14 mm²) + (4 × 0.5 mm²)] Max. 100 m ($\overline{U_{aS}}$ max. 50 m) distributed capacitance 90 pF/m 6 ns/m



Permissible cable length
with respect to the edge separation



Input circuitry of the subsequent electronics

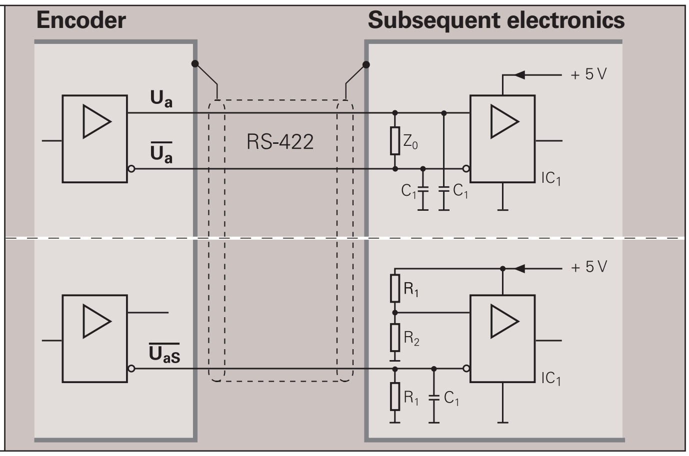
Dimensioning

IC_1 = Recommended differential line receiver
DS 26 C 32 AT
Only for *a* > 0.1 µs:
AM 26 LS 32
MC 3486
SN 75 ALS 193

R_1 = 4.7 kΩ
R_2 = 1.8 kΩ
Z_0 = 120 Ω
C_1 = 220 pF (serves to improve noise immunity)

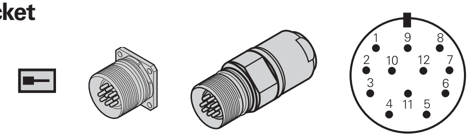
Incremental signals
Reference mark signal

Fault detection signal

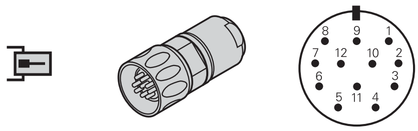


Pin layout

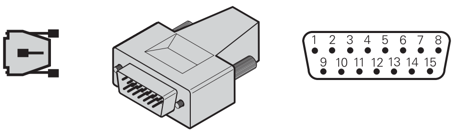
12-pin flange socket or coupling M23



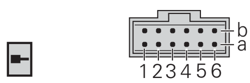
12-pin connector M23



15-pin D-sub connector at encoder



12-pin PCB connector



	Power supply				Incremental signals						Other signals		
12-pin M23	**12**	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**7**	**/**	**9**
15-pin D-sub	**4**	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**13**	**5/6/8**	**15**
12-pin PCB	**2a**	**2b**	**1a**	**1b**	**6b**	**6a**	**5b**	**5a**	**4b**	**4a**	**3a**	**3b**	**/**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**U_{a1}**	**$\overline{U_{a1}}$**	**U_{a2}**	**$\overline{U_{a2}}$**	**U_{a0}**	**$\overline{U_{a0}}$**	**$\overline{U_{aS}}$**[1]	**Vacant**	**Vacant**[2]
Cable	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	Violet	–	Yellow

Shield on housing; **U_P** = power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
[1] **LS 323/ERO 14xx:** Vacant [2] **Exposed linear encoders:** TTL/11 µAPP conversion for PWT

Interfaces

Incremental Signals ⊓⊔ HTL

HEIDENHAIN encoders with ⊓⊔ HTL interface incorporate electronics that digitize sinusoidal scanning signals with or without interpolation.

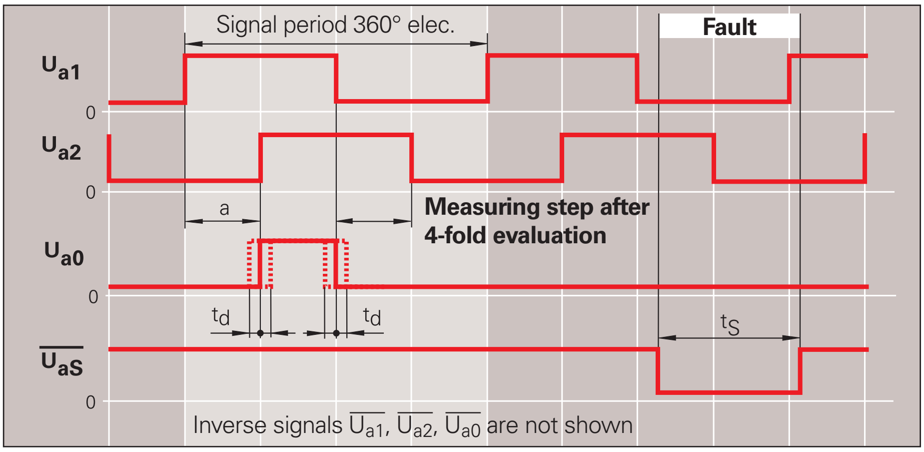
The **incremental signals** are transmitted as the square-wave pulse trains U_{a1} and U_{a2}, phase-shifted by 90° elec. The **reference mark signal** consists of one or more reference pulses U_{a0}, which are gated with the incremental signals. In addition, the integrated electronics produce their **inverse signals** $\overline{U_{a1}}$, $\overline{U_{a2}}$ and $\overline{U_{a0}}$ for noise-proof transmission (not with ERN/ROD 1x30). The illustrated sequence of output signals—with U_{a2} lagging U_{a1}—applies for the direction of motion shown in the dimension drawing.

The **fault-detection signal** $\overline{U_{aS}}$ indicates fault conditions such as failure of the light source. It can be used for such purposes as machine shut-off during automated production.

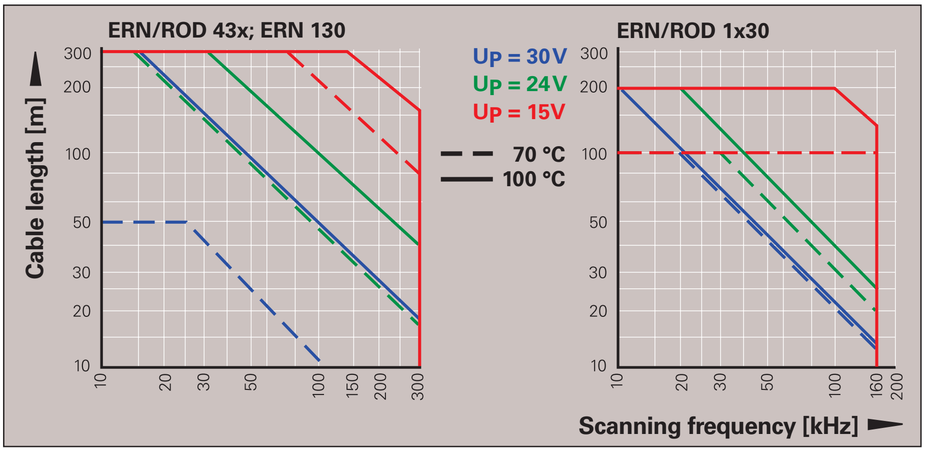
The distance between two successive edges of the incremental signals U_{a1} and U_{a2} through 1-fold, 2-fold or 4-fold evaluation is one **measuring step.**

The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum **edge separation** *a* listed in the *Specifications* refers to a measurement at the output of the given differential input circuitry. To prevent counting error, the subsequent electronics should be designed to process as little as 90% of the edge separation *a*. The max. permissible **shaft speed** or **traversing velocity** must never be exceeded.

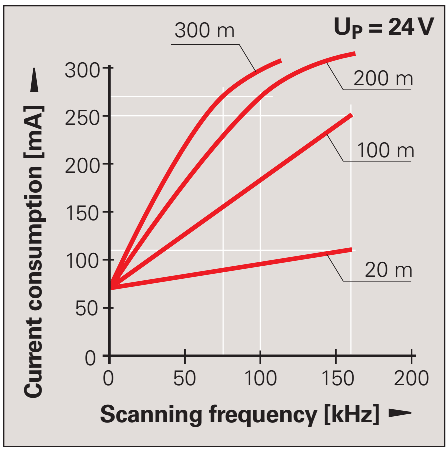
Interface	Square-wave signals ⊓⊔ **HTL**
Incremental signals	**2 HTL square-wave signals U_{a1}, U_{a2}** and their inverse signals **$\overline{U_{a1}}$, $\overline{U_{a2}}$** (*ERN/ROD 1x30* without $\overline{U_{a1}}$, $\overline{U_{a2}}$)
Reference mark signal Pulse width Delay time	**One or more HTL square-wave pulses U_{a0}** and their inverse pulses **$\overline{U_{a0}}$** (*ERN/ROD 1x30* without $\overline{U_{a0}}$) 90° elec. (other widths available on request) $\lvert t_d \rvert \le 50$ ns
Fault detection signal Pulse width	**1 HTL square-wave pulse $\overline{U_{aS}}$** Improper function: LOW Proper function: HIGH $t_S \ge 20$ ms
Signal level	$U_H \ge 21$ V with $-I_H = 20$ mA; $U_L \le 2.8$ V with $I_L = 20$ mA — with power supply $U_P = 24$ V, without cable
Permissible load	$\lvert I_L \rvert \le 100$ mA — max. load per output, (except $\overline{U_{aS}}$) $C_{load} \le 10$ nF — with respect to 0 V Outputs short-circuit proof max. 1 min. after 0 V and U_P (except $\overline{U_{aS}}$)
Switching times (10% to 90%)	$t_+/t_- \le 200$ ns (except $\overline{U_{aS}}$) with 1 m cable and recommended input circuitry
Connecting cable Cable length Propagation time	HEIDENHAIN cable with shielding PUR [4(2 × 0.14 mm²) + (4 × 0.5 mm²)] Max. 300 m (*ERN/ROD 1x30* max. 100 m) distributed capacitance 90 pF/m 6 ns/m

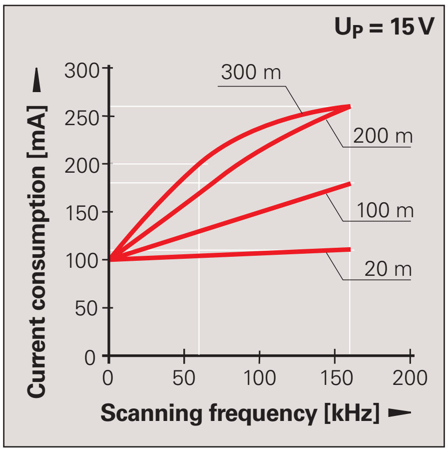


The permissible **cable length** for incremental encoders with HTL signals depends on the scanning frequency, the effective power supply, and the operating temperature of the encoder.

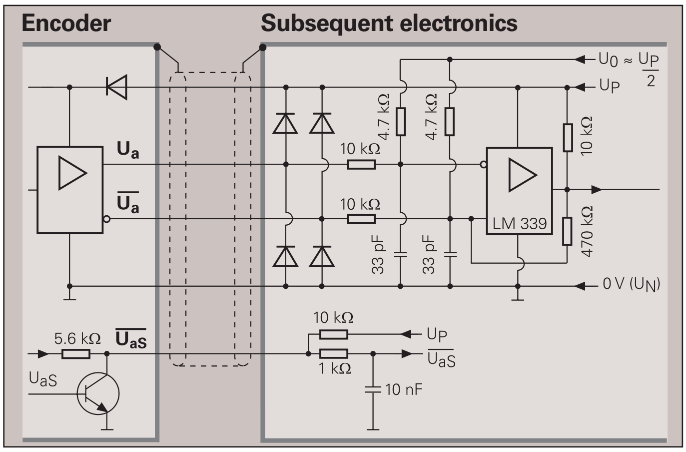


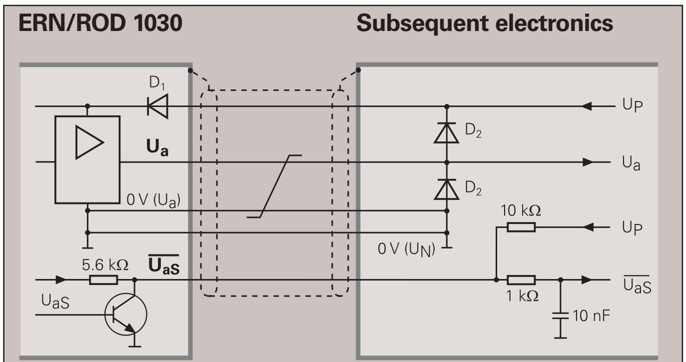
Current consumption
The current consumption for encoders with HTL output signals depends on the output frequency and the cable length to the subsequent electronics. The diagrams at right show typical curves for push-pull signal transmission with a 12-line HEIDENHAIN cable. The maximum current consumption can be 50 mA higher.





Input circuitry of the subsequent electronics

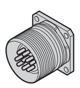


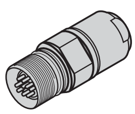


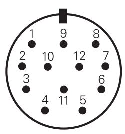
For cable lengths > 50 m, the corresponding 0 V signal lines must be connected with 0 V of the subsequent electronics to increase noise immunity.

Pin layout

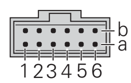
12-pin flange socket or coupling M23







12-pin PCB connector



	Power supply				Incremental signals						Other signals		
Flange socket / coupling	12	2	10	11	5	6	8	1	3	4	7	/	9
PCB connector	2a	2b	1a	1b	6b	6a	5b	5a	4b	4a	3a	3b	/
	U_P	Sensor U_P	0 V	Sensor 0 V	U_{a1}	$\overline{U_{a1}}$	U_{a2}	$\overline{U_{a2}}$	U_{a0}	$\overline{U_{a0}}$	$\overline{U_{aS}}$	Vacant	Vacant
Cable	Brown/Green	Blue	White/Green	White	Brown	Green	Gray	Pink	Red	Black	Violet	/	Yellow

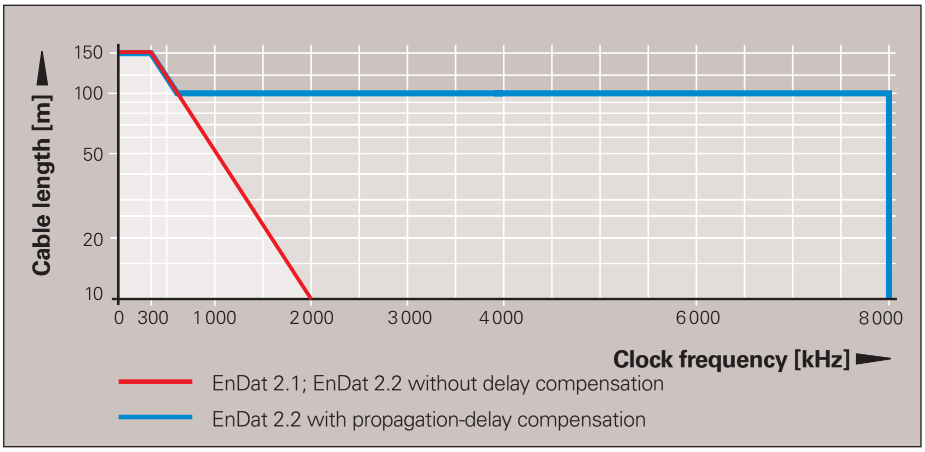
Shield on housing; **U_P** = power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
ERN 1x30, ROD 1030: 0 V instead of inverse signals $\overline{U_{a1}}$, $\overline{U_{a2}}$, $\overline{U_{a0}}$

Interfaces
Absolute Position Values EnDat

The EnDat interface is a digital, **bidirectional** interface for encoders. It is capable of transmitting **position values** from both absolute and—with EnDat 2.2—incremental encoders, as well as reading and updating information stored in the encoder, or of saving new information. Thanks to the **serial transmission method** only **four signal lines** are required. The data are transmitted **in synchronism** with the clock signal from the subsequent electronics. The type of transmission (position values, parameters, diagnostics, etc.) is selected by mode commands that the subsequent electronics send to the encoder.

Clock frequency and cable length
Without propagation-delay compensation, the **clock frequency**—depending on the cable length—is variable between **100 kHz** and **2 MHz.** Because large cable lengths and high clock frequencies increase the signal run time to the point that they can disturb the unambiguous assignment of data, the delay can be measured in a test run and then compensated. With this **propagation-delay compensation** in the subsequent electronics, clock frequencies up to **8 MHz** at cable lengths up to a maximum of 100 m are possible. The maximum clock frequency is mainly determined by the cables and connecting elements used. To ensure proper function at clock frequencies above 2 MHz, use only original ready-made HEIDENHAIN cables.

Interface	**EnDat** serial bidirectional
Data transfer	Absolute position values, parameters and additional information
Data input	Differential line receiver according to EIA standard RS 485 for CLOCK, $\overline{\text{CLOCK}}$, DATA and $\overline{\text{DATA}}$ signals
Data output	Differential line driver according to EIA standard RS 485 for the DATA and $\overline{\text{DATA}}$ signals
Code	Pure binary code
Position values	Ascending during traverse in direction of arrow (see Dimensions)
Incremental signals	∼ 1 V_{PP} (see *Incremental Signals 1 V_{PP}*) depending on unit
Connecting cable With Incremental Without signals	HEIDENHAIN cable with shielding PUR [(4 x 0.14 mm^2) + 4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] PUR [(4 x 0.14 mm^2) + (4 x 0.34 mm^2)]
Cable length	Max. 150 m
Propagation time	Max. 10 ns; approx. 6 ns/m

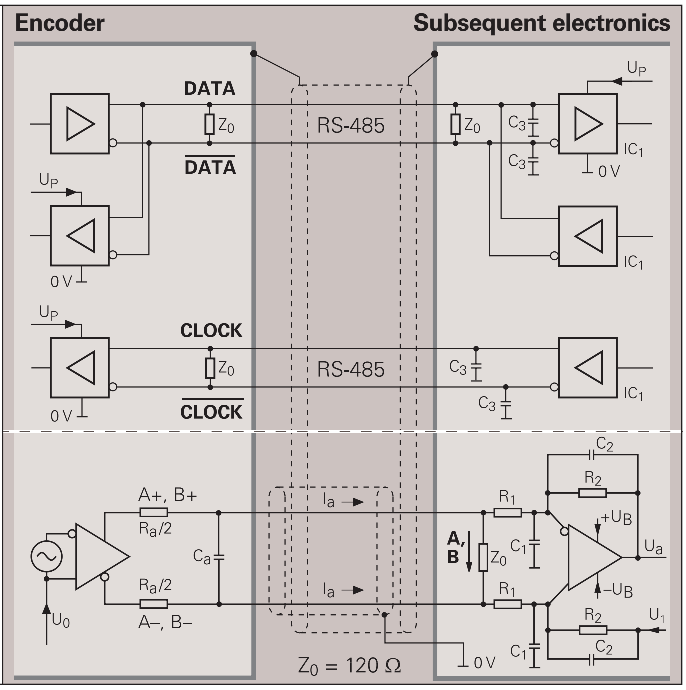


Input circuitry of the subsequent electronics

Dimensioning
IC_1 = RS 485 differential line receiver and driver

C_3 = 330 pF
Z_0 = 120 Ω

Data transfer



Incremental signals
Depends on encoder

Versions

The extended EnDat interface version 2.2 is compatible in its communication, command set and time conditions with version 2.1, but also offers significant advantages. It makes it possible, for example, to transfer additional information with the position value without sending a separate request for it. The interface protocol was expanded and the time conditions were optimized. In addition, encoders with ordering designations EnDat 02 or EnDat 22 have an extended power supply range.

Both EnDat 2.1 and EnDat 2.2 are available in versions with or without incremental signals. EnDat 2.2 encoders feature a high internal resolution. Therefore, depending on the control technology being used, interrogation of the incremental signals is not necessary. To increase the resolution of EnDat 2.1 encoders, the incremental signals are evaluated in the subsequent electronics.

Command set
The command set is the sum of all available mode commands. The EnDat 2.2 command set includes EnDat 2.1 mode commands. When a mode command from the EnDat 2.2 command set is transmitted to EnDat-01 subsequent electronics, the encoder or the subsequent electronics may generate an error message.

EnDat with command set 2.2 (includes EnDat 2.1 command set)

- Position values for incremental and absolute encoders
- Additional information on position value
  - Diagnostics and test values
  - Absolute position values after reference run of incremental encoders
  - Parameter upload/download
  - Commutation
  - Acceleration
  - Limit position signal
  - Temperature of the encoder PCB
  - Temperature evaluation of an external temperature sensor (e.g. in the motor winding)

EnDat with command set 2.1

- Absolute position values
- Parameter upload/download
- Reset
- Test command and test values

Interface	Command set	Ordering designation	Version	Clock frequency
EnDat	EnDat 2.1 or EnDat 2.2	EnDat 01	With incremental signals	≤ 2 MHz
		EnDat 21	without incremental signals	
	EnDat 2.2	EnDat 02	With incremental signals	≤ 2 MHz
	EnDat 2.2	EnDat 22	without incremental signals	≤ 8 MHz

Benefits of the EnDat Interface

- **Automatic self-configuration:** All information required by the subsequent electronics is already stored in the encoder
- **High system security** through alarms and messages for monitoring and diagnosis
- **High transmission reliability** through cyclic redundancy checking
- Faster configuration during installation: **Datum shifting** through offsetting by a value in the encoder

Other benefits of EnDat 2.2

- **A single interface** for all absolute and incremental encoders
- **Additional information** (limit switch, temperature, acceleration)
- **Quality improvement:** Position value calculation in the encoder permits shorter sampling intervals (25 µs)

Advantages of purely serial transmission specifically for EnDat 2.2 encoders

- **Simple subsequent electronics** with EnDat receiver chip
- **Simple connection technology:** Standard connecting elements (M12 — 8-pin) single-shielded standard cable and low wiring costs
- **Minimized transmission times** through adaptation of the data word length to the resolution of the encoder
- **High clock frequencies** up to 8 MHz. Position values available in the subsequent electronics after only approx. 10 µs
- **Support for state-of-the-art machine designs** e.g. direct drive technology

Functions

The EnDat interface transmits absolute position values or additional physical quantities (only EnDat 2.2) in an unambiguous time sequence and serves to read from and write to the encoder's internal memory. Some functions are available only with EnDat 2.2 mode commands.

Position values can be transmitted with or without additional information. The additional information types are selectable via the Memory Range Select (MRS) code. Other functions such as parameter reading and writing can also be called after the memory area and address have been selected. Through simultaneous transmission with the position value, additional information can also be requested of axes in the feedback loop, and functions executed with them.

Parameter reading and writing is possible both as a separate function and in connection with the position value. Parameters can be read or written after the memory area and address is selected.

Reset functions serve to reset the encoder in case of malfunction. Reset is possible instead of or during position value transmission.

Servicing diagnosis makes it possible to inspect the position value even at standstill. A test command has the encoder transmit the required test values.

You can find more information in the *Technical Information for EnDat 2.2* document or on the Internet at www.endat.de.

Selecting the Transmission Type

Transmitted data are identified as either position values, position values with additional information, or parameters. The type of information to be transmitted is selected by mode commands. **Mode commands** define the content of the transmitted information. Every mode command consists of three bits. To ensure reliable transmission, every bit is transmitted redundantly (inverted or double). If the encoder detects an erroneous mode transmission, it transmits an error message. The EnDat 2.2 interface can also transfer parameter values in the additional information together with the position value. This makes the current position values constantly available for the control loop, even during a parameter request.

Control cycles for transfer of position values

The transmission cycle begins with the first falling **clock edge.** The measured values are saved and the position value calculated. After two clock pulses (2T), to **select the type of transmission** the subsequent electronics transmit the mode command „Encoder transmit position value" (with/without additional information).

After successful calculation of the absolute position value (t_{cal}—see table), the **start bit** begins the data transmission from the encoder to the subsequent electronics. The subsequent **error messages,** error 1 and error 2 (only with EnDat 2.2 commands), are group signals for all monitored functions and serve as failure monitors.

Beginning with the LSB, the encoder then transmits the absolute **position value** as a complete data word. Its length varies depending on which encoder is being used. The number of required clock pulses for transmission of a position value is saved in the parameters of the encoder manufacturer. The data transmission of the position value is completed with the **Cyclic Redundancy Check** (CRC).

In EnDat 2.2, this is followed by additional information 1 and 2, each also concluded with a CRC. With the end of the data word, the clock must be set to HIGH. After 10 to 30 µs or 1.25 to 3.75 µs (with EnDat 2.2 parameterizable recovery time t_m) the data line falls back to LOW. Then a **new data transmission** can begin by starting the clock.

Mode commands

Mode commands		
• Encoder transmit position value • Selection of the memory area • Encoder receive parameters • Encoder transmit parameters • Encoder receive reset[1] • Encoder transmit test values • Encoder receive test commands	**EnDat 2.1**	**EnDat 2.2**
• Encoder transmit position value with additional information • Encoder transmit position value and receive selection of memory area[2] • Encoder transmit position value and receive parameters[2] • Encoder transmit position value and transmit parameters[2] • Encoder transmit position value and receive error reset[2] • Encoder transmit position value and receive test command[2] • Encoder receive communication command[3]		

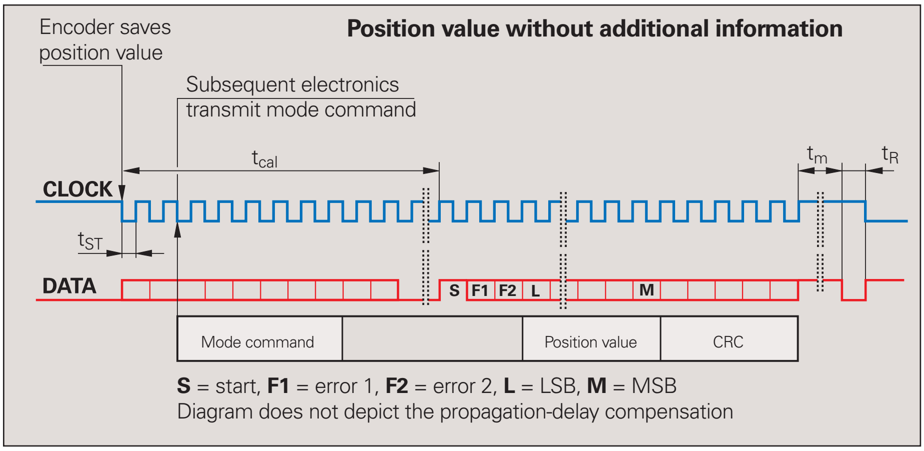
1) Same reaction as switching the power supply off and on
2) Selected additional information is also transmitted
3) Reserved for encoders that do not support the safety system

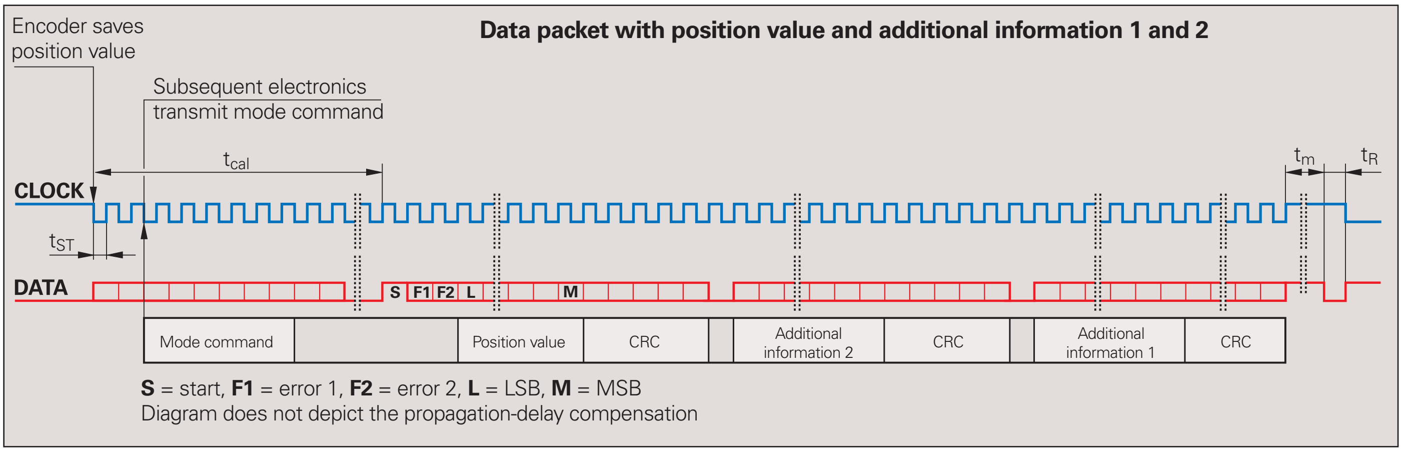
Absolute linear encoders have different processing times t_{cal} for position values for EnDat 2.1 and EnDat 2.2 mode commands (see the *Specifications* in the *Linear Encoders for Numerically Controlled Machine Tools* brochure). If the incremental signals are evaluated for axis control, then the EnDat 2.1 mode commands should be used. Only in this manner can an active error message be transmitted synchronously to the currently requested position value. EnDat 2.1 mode commands should not be used for purely serial position-value transfer for axis control.

		Without delay compensation	**With delay compensation**
Clock frequency	f_c	100 kHz ... 2 MHz	100 kHz ... 8 MHz
Calculation time for **Position value** **Parameters**	 t_{cal} t_{ac}	 See *Specifications* Max. 12 ms	
Recovery time	t_m	*EnDat 2.1:* 10 to 30 µs *EnDat 2.2:* 10 to 30 µs or 1.25 to 3.75 µs ($f_c \geq 1$ MHz) (parameterizable)	
	t_R	Max. 500 ns	
	t_{ST}	–	2 to 10 µs
Data delay time	t_D	(0.2 + 0.01 x cable length in m) µs	
Pulse width	t_{HI} t_{LO}	0.2 to 10 µs 0.2 to 50 ms/30 µs (with LC)	Pulse width fluctuation HIGH to LOW max. 10%

EnDat 2.2 – Transfer of Position Values

EnDat 2.2 can transmit position values with or without additional information.

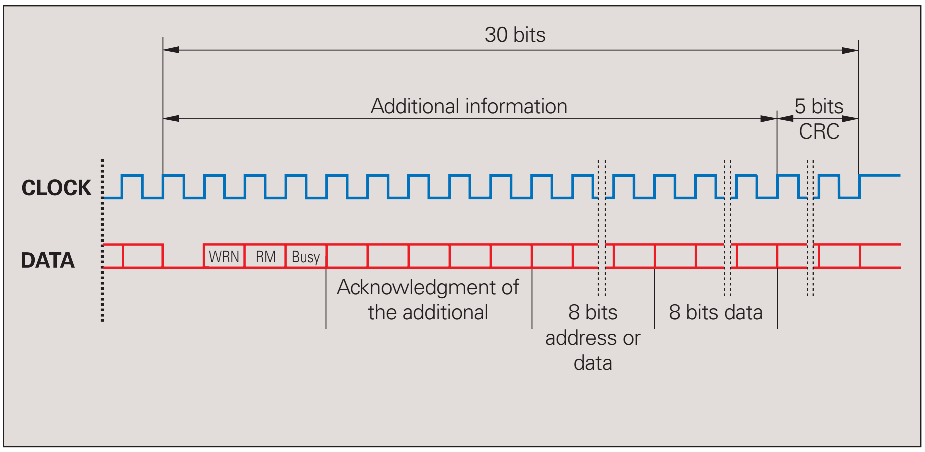




Additional information

With EnDat 2.2, one or two pieces of additional information can be appended to the position value. Each additional information is 30 bits long with LOW as first bit, and ends with a CRC check. The additional information supported by the respective encoder is saved in the encoder parameters.

The content of the additional information is determined by the MRS code and is transmitted in the next sampling cycle for additional information. This information is then transmitted with every sampling until a selection of a new memory area changes the content.



The additional information always begins with:	The additional information can contain the following data:	
Status data Warning—WRN Reference mark—RM Parameter request—busy **Acknowledgment** of additional information	**Additional information 1** Diagnosis Position value 2 Memory parameters MRS-code acknowledgment Test values Temperature	**Additional information 2** Commutation Acceleration Limit position signals

EnDat 2.1 – Transfer of Position Values

EnDat 2.1 can transmit position values with interrupted clock pulse (as in EnDat 2.2) or continuous clock pulse.

Interrupted clock

The interrupted clock is intended particularly for time-clocked systems such as closed control loops. At the end of the data word the clock signal is set to HIGH level. After 10 to 30 µs (t_m), the data line falls back to LOW. Then a new data transmission can begin by starting the clock.

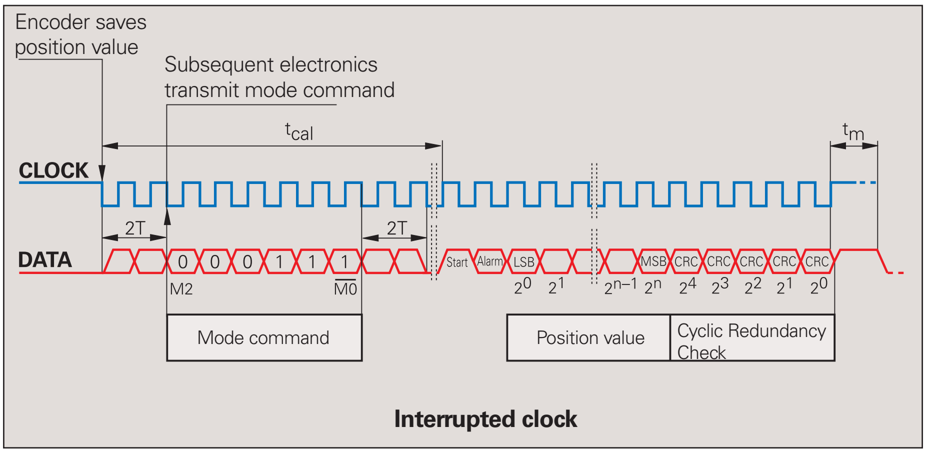
Continuous clock

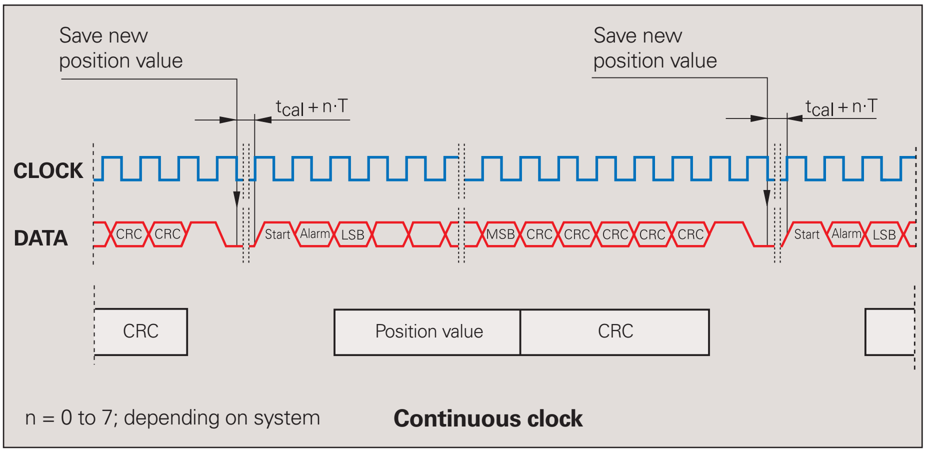
For applications that require fast acquisition of the measured value, the EnDat interface can have the clock run continuously. Immediately after the last CRC bit has been sent, the data line is switched to high for one clock cycle, and then to low. The new position value is saved with the very next falling edge of the clock and is output in synchronism with the clock signal immediately after the start bit and alarm bit. Because the mode command *Encoder transmits position value* is needed only before the first data transmission, the continuous-clock transfer mode reduces the length of the clock-pulse group by 10 periods per position value.

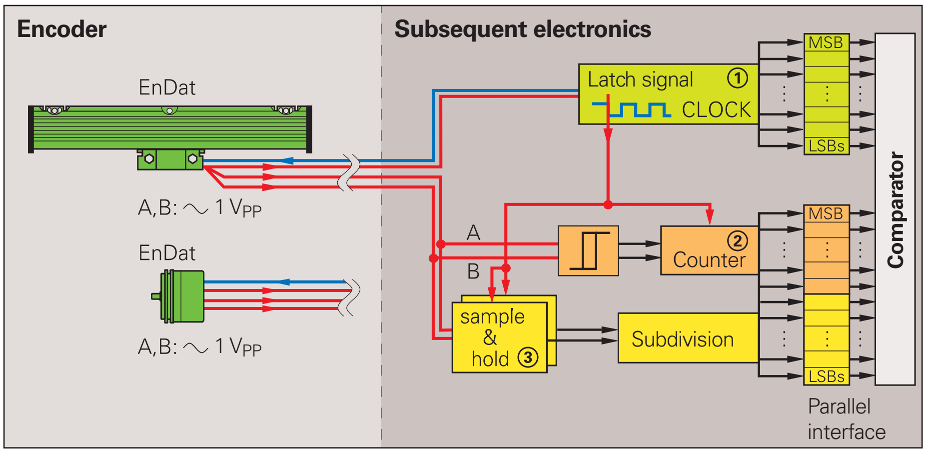
Synchronization of the serially transmitted code value with the incremental signal

Absolute encoders with EnDat interface can exactly synchronize serially transmitted absolute position values with incremental values. With the first falling edge (latch signal) of the CLOCK signal from the subsequent electronics, the scanning signals of the individual tracks in the encoder and counter are frozen, as are the A/D converters for subdividing the sinusoidal incremental signals in the subsequent electronics.

The code value transmitted over the serial interface unambiguously identifies one incremental signal period. The position value is absolute within one sinusoidal period of the incremental signal. The subdivided incremental signal can therefore be appended in the subsequent electronics to the serially transmitted code value.







After power on and initial transmission of position values, two redundant position values are available in the subsequent electronics. Since encoders with EnDat interface guarantee a precise synchronization—regardless of cable length—of the serially transmitted absolute value with the incremental signals, the two values can be compared in the subsequent electronics. This monitoring is possible even at high shaft speeds thanks to the EnDat interface's short transmission times of less than 50 µs. This capability is a prerequisite for modern machine design and safety systems.

Parameters and Memory Areas

The encoder provides several memory areas for parameters. These can be read from by the subsequent electronics, and some can be written to by the encoder manufacturer, the OEM, or even the end user. Certain memory areas can be write-protected.

The parameters, which in most cases are set by the OEM, largely define the function of the encoder and the EnDat interface. When the encoder is exchanged, it is therefore essential that its parameter settings are correct. Attempts to configure machines without including OEM data can result in malfunctions. If there is any doubt as to the correct parameter settings, the OEM should be consulted.

Parameters of the encoder manufacturer

This write-protected memory area contains all **information specific to the encoder,** such as encoder type (linear/angular, singleturn/multiturn, etc.), signal periods, position values per revolution, transmission format of position values, direction of rotation, maximum speed, accuracy dependent on shaft speeds, warnings and alarms, part number and serial number. This information forms the basis for **automatic configuration.** A separate memory area contains the parameters typical for EnDat 2.2: Status of additional information, temperature, acceleration, support of diagnostic and error messages, etc.

Parameters of the OEM

In this freely definable memory area, the OEM can store his information, e.g. the "electronic ID label" of the motor in which the encoder is integrated, indicating the motor model, maximum current rating, etc.

Operating parameters

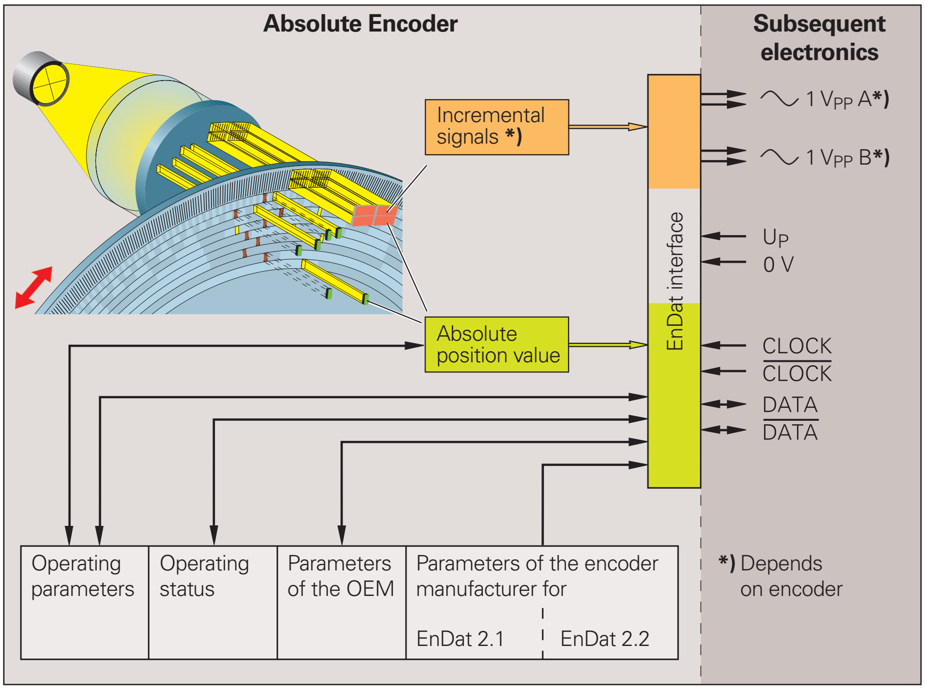
This area is available for a **datum shift** and the configuration of diagnostics. It can be protected against overwriting.

Operating status

This memory area provides detailed alarms or warnings for diagnostic purposes. Here it is also possible to activate write protection for the OEM parameter and operating parameter memory areas, and to interrogate their status. Once **write protection** is activated, it cannot be removed.

Safety System

The safety system is in preparation. Safety-oriented controls are the planned application for encoders with EnDat 2.2 interface. Refer to IEC 61 800 standard *Adjustable speed electrical power drive systems* Part 5-2.



Monitoring and Diagnostic Functions

The EnDat interface enables comprehensive monitoring of the encoder without requiring an additional transmission line. The alarms and warnings supported by the respective encoder are saved in the "parameters of the encoder manufacturer" memory area.

Error message

An error message becomes active if a **malfunction of the encoder** might result in incorrect position values. The exact cause of the disturbance is saved in the "operating status" memory and can be interrogated in detail. Errors include, for example,

- Light unit failure
- Signal amplitude too low
- Error in calculation of position value
- Power supply too high/low
- Current consumption is excessive

Here the EnDat interface transmits the error bits, error 1 and error 2 (only with EnDat 2.2 commands). These are group signals for all monitored functions and serve for failure monitoring. The two error messages are generated independently from each other.

Warning

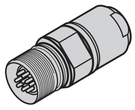
This collective bit is transmitted in the status data of the additional information. It indicates that certain **tolerance limits of the encoder** have been reached or exceeded—such as shaft speed or the limit of light source intensity compensation through voltage regulation—without implying that the measured position values are incorrect. This function makes it possible to issue preventive warnings in order to minimize idle time.

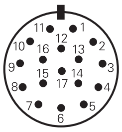
Cyclic Redundancy Check

To ensure **reliability of data transfer,** a cyclic redundancy check (CRC) is performed through the logical processing of the individual bit values of a data word. This 5-bit long CRC concludes every transmission. The CRC is decoded in the receiver electronics and compared with the data word. This largely eliminates errors caused by disturbances during data transfer.

Pin Layout EnDat

17-pin coupling M23

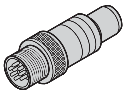


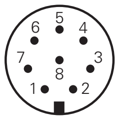


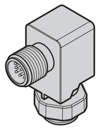
	Power supply					Incremental signals[1]				Absolute position values			
	7	1	10	4	11	15	16	12	13	14	17	8	9
	U_P	**Sensor** U_P	0 V	**Sensor** 0 V	**Inside shield**	**A+**	**A–**	**B+**	**B–**	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
	Brown/ Green	Blue	White/ Green	White	/	Green/ Black	Yellow/ Black	Blue/ Black	Red/ Black	Gray	Pink	Violet	Yellow

Shield on housing; **U_P** = power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!
[1] Not with EnDat 2.2, order designation 22

8-pin coupling M12



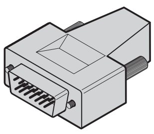


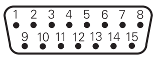


	Power supply				Absolute position values			
	2	8	1	5	3	4	7	6
	U_P[1]	**U_P**	**0 V**[1]	**0 V**	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
	Blue	Brown/Green	White	White/Green	Gray	Pink	Violet	Yellow

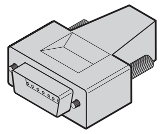
Shield on housing; **U_P** = power supply voltage
[1] for power lines configured parallel
Vacant pins or wires must not be used!

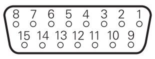
15-pin D-sub connector, male
for IK 115/IK 215





15-pin D-sub connector, female
for HEIDENHAIN controls and IK 220





	Power supply					Incremental signals[1]				Absolute position values			
(male)	4	12	2	10	6	1	9	3	11	5	13	8	15
(female)	1	9	2	11	13	3	4	6	7	5	8	14	15
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Inside shield**	**A+**	**A–**	**B+**	**B–**	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
	Brown/ Green	Blue	White/ Green	White	/	Green/ Black	Yellow/ Black	Blue/ Black	Red/ Black	Gray	Pink	Violet	Yellow

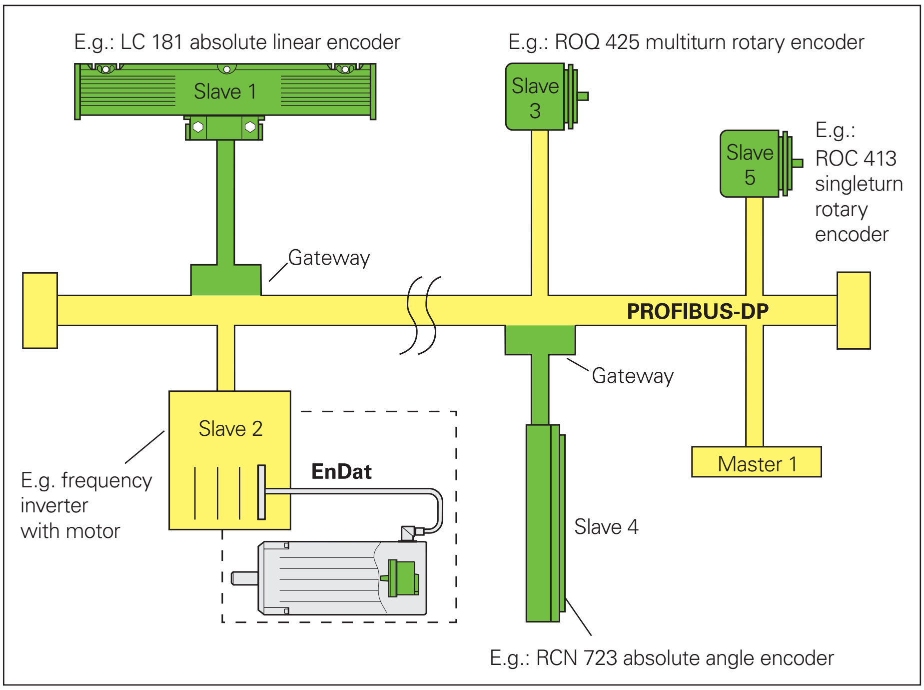
Shield on housing; **U_P** = power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!
[1] Not with EnDat 2.2, order designation 22

Interface
PROFIBUS-DP Absolute Position Values

PROFIBUS-DP
PROFIBUS is a nonproprietary, open field bus in accordance with the international EN 50 170 standard. The connecting of sensors through field bus systems minimizes the cost of cabling and reduces the number of lines between encoder and subsequent electronics.

Topology and bus assignment
The PROFIBUS-DP is designed as a linear structure. It permits transfer rates up to 12 Mbit/s. Both mono-master and multi master systems are possible. Each master can serve only its own slaves (polling). The slaves are polled cyclically by the master. Slaves are, for example, sensors such as absolute rotary encoders, linear encoders, or also control devices such as motor frequency inverters.

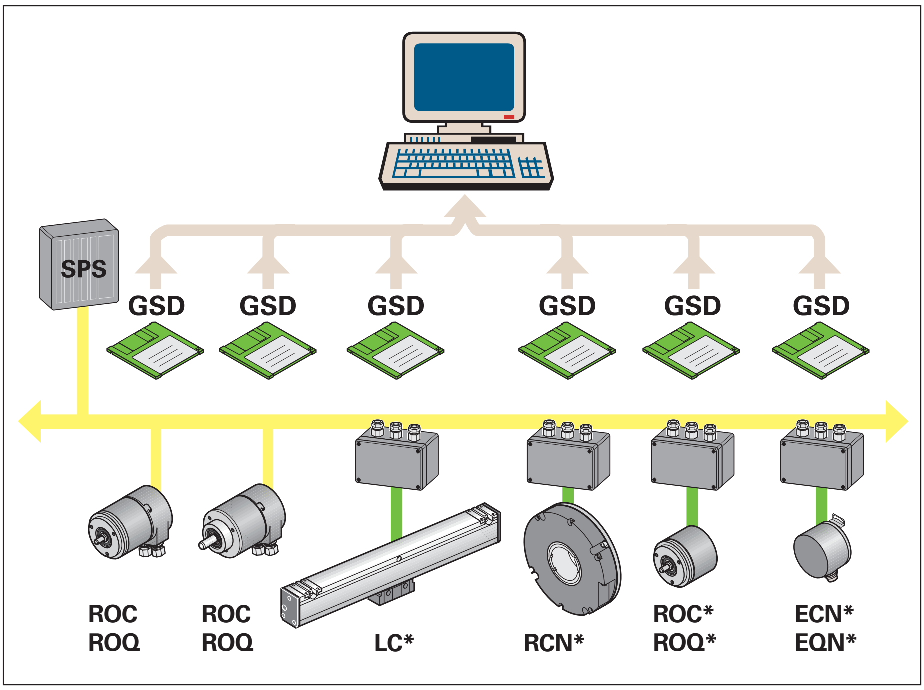
Physical characteristics
The electrical features of the PROFIBUS-DP comply with the RS-485 standard. The bus connection is a shielded, twisted two-wire cable with active bus terminations at each end.



Bus structure of PROFIBUS-DP

Self-configuration
The characteristics of the HEIDENHAIN encoders required for system configuration are included as "electronic data sheets"—also called device identification records (GSD)—in the gateway. These device identification records (GSD) completely and clearly describe the characteristics of a unit in an exactly defined format. This makes it possible to integrate the encoders into the bus system in a simple and application-friendly way.

Configuration
PROFIBUS-DP devices can be configured and the parameters assigned to fit the requirements of the user. Once these settings are made in the configuration tool with the aid of the GSD file, they are saved in the master. It then configures the PROFIBUS devices every time the network starts up. This simplifies exchanging the devices: there is no need to edit or reenter the configuration data.



* with EnDat interface

PROFIBUS-DP profile
The PNO (PROFIBUS user organization) has defined a standard, nonproprietary profile for the connection of absolute encoders to the PROFIBUS-DP, thus ensuring high flexibility and simple configuration on all systems that use this standardized profile.

You can request the profile for absolute encoders from the PNO in Karlsruhe, Germany, under the order number 3.062. There are two classes defined in the profile, whereby class 1 provides minimum support, and class 2 allows additional, in part optional functions.

Supported functions
Particularly important in decentralized field bus systems are the **diagnostic functions** (e.g. warnings and alarms), and the **electronic ID label** with information on the type of encoder, resolution, and measuring range. But also programming functions such as counting direction reversal, **preset/ zero shift** and **changing the resolution (scaling)** are possible. The **operating time** of the encoder can also be recorded.

Operating status
In addition to the transfer of the diagnostic functions over the PROFIBUS-DP, the operating statuses of the
- supply voltage and
- bus status

are displayed by LEDs on the rear of the encoder.

Characteristic	Class	ECN 113[1)] ECN 413[1)] ROC 413	EQN 425[1)] ROQ 425	ROC 415[1)] ROC 417[1)]	LC 481[1)] LC 182[1)]
Position value in pure binary code	1, 2	✓	✓	✓	✓
Data word length	1, 2	16	32	32	32
Scaling function					
Measuring steps/rev	2	✓	✓	✓[2]	–
Total resolution	2	✓	✓	–	–
Reversal of counting direction	1, 2	✓	✓	✓	–
Preset/Datum shift	2	✓	✓	✓	–
Diagnostic functions Warnings and alarms	2	✓	✓	✓	✓
Operating time recording	2	✓	✓	✓	✓
Profile version	2	✓	✓	✓	✓
Serial number	2	✓	✓	✓	✓

1) Connectible with EnDat Interface over gateway to PROFIBUS-DP
2) Scaling factor in binary steps

Connection
The absolute rotary encoders with **integrated PROFIBUS-DP interface** feature screw terminals for the PROFIBUS-DP and the power supply. The cable is connected over three PG7 screw connections on the bus housing. Here the coding switches are located for addressing (0 to 99) and selecting the terminating resistor, which is to be activated if the rotary encoder is the last participant on the PROFIBUS-DP. All connections and controls are easily accessible in the bus housing.

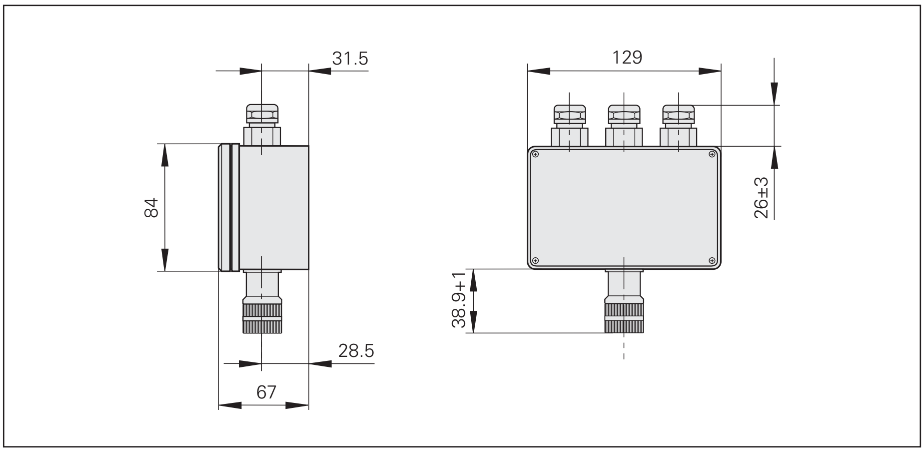
Connection via gateway
All absolute encoders from HEIDENHAIN with **EnDat interface** are suitable for PROFIBUS-DP. The encoder is electrically connected through a **gateway.** The complete interface electronics are integrated in the gateway, which offers a number of benefits:

- Simple connection of the field bus cable, since the terminals are easily accessible.
- Encoder dimensions remain small.
- No temperature restrictions for the encoder. All temperature-sensitive components are in the gateway.
- No bus interruption when an encoder is exchanged.

Besides the EnDat encoder connector, the gateway provides connections for the PROFIBUS and the power supply. In the gateway there are coding switches for addressing and selecting the terminating resistor.

Since the gateway is connected directly to the bus lines, the cable to the encoder is not a stub line, although it can be up to 150 meters long.

	Gateway
Power supply	10 to 30 V/Max. 400 mA (internal voltage converter to 5 V ± 5 % for EnDat encoders)
Protection	IP 67
Operating temperature	–40 °C to 80 °C
Electrical connection EnDat PROFIBUS-DP	 Flange socket 17-pin Terminations, PG9 cable exit
Id. Nr.	325 771-01



Interfaces
SSI Absolute Position Values

The **absolute position value,** beginning with the most significant bit, is transferred over the data lines (DATA) in synchronism with a CLOCK signal from the control. The SSI standard data word length for singleturn absolute encoders is 13 bits, and for multiturn absolute encoders 25 bits. In addition to the absolute position values, sinusoidal **incremental signals** with 1-V_{PP} levels are transmitted. For signal description see *Incremental signals 1* V_{PP}.

The following **functions** can be activated via the programming inputs of the interfaces by applying the supply voltage U_P:

- **Direction of rotation**
- Continuous application of a HIGH level to pin 2 reverses the direction of rotation for ascending position values.

- **Zero reset** (setting to zero)
- Applying a positive edge (t_{min} > 1 ms) to pin 5 sets the current position to zero.

Note: The programming inputs must always be terminated with a resistor (see input circuitry of the subsequent electronics).

Interface	**SSI** serial
Data transfer	Absolute position values
Data input	Differential line receiver according to EIA standard RS 485 for the CLOCK and $\overline{CLOCK}$ signals
Data output	Differential line driver according to EIA standard RS 485 for the DATA and $\overline{DATA}$ signals
Code	Gray code
Ascending position values	With clockwise rotation (viewed from flange side) (can be switched via interface)
Incremental signals	∿ 1 V_{PP} (see *Incremental Signals 1* V_{PP})
Programming inputs Inactive Active Switching time	Direction of rotation and zero reset LOW < 0.25 x U_P HIGH > 0.6 x U_P t_{min} > 1 ms
Connecting cable Cable length Propagation time	HEIDENHAIN cable with shielding PUR [(4 x 0.14 mm^2) + 4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] Max. 150 m distributed capacitance 90 pF/m 6 ns/m

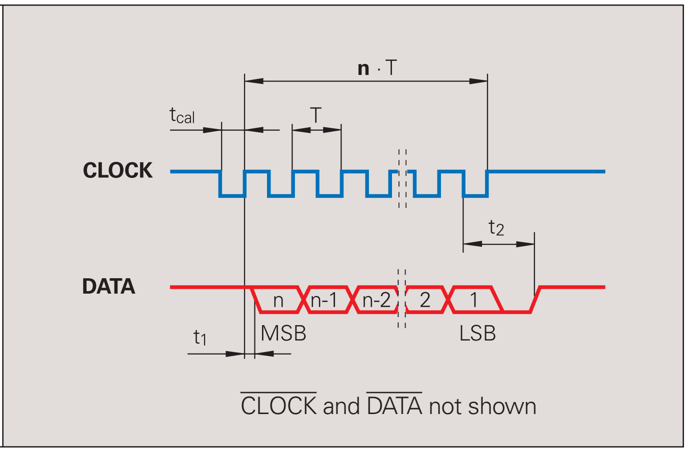
Control cycle for complete data word
When not transmitting, the clock and data lines are on high level. The current position value is stored on the first falling edge of the clock. The stored data is then clocked out on the first rising edge.

After transmission of a complete data word, the data line remains low for a period of time (t_2) until the encoder is ready for interrogation of a new value. If a falling clock edge is received within t_2, the same data will be output once again.

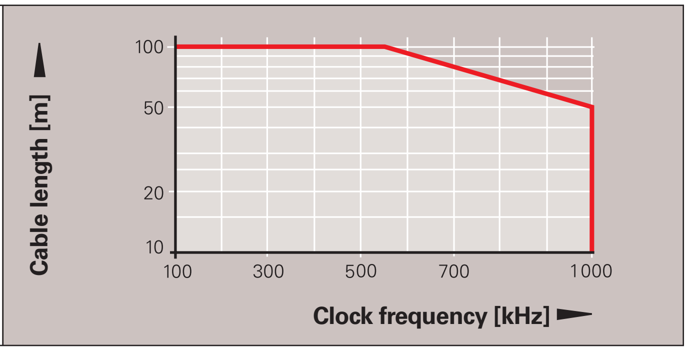
If the data output is interrupted (CLOCK = high for t ≥ t_2), a new position value will be stored on the next falling edge of the clock, and on the subsequent rising edge it will be clocked out to the subsequent electronics.

Data transfer

T = 1 to 10 µs
t_{cal} see *Specifications*
t_1 ≤ 0.4 µs (without cable)
t_2 = 17 to 20 µs
n = Data word length
13 bits with ECN/ROC
25 bits with EQN/ROQ



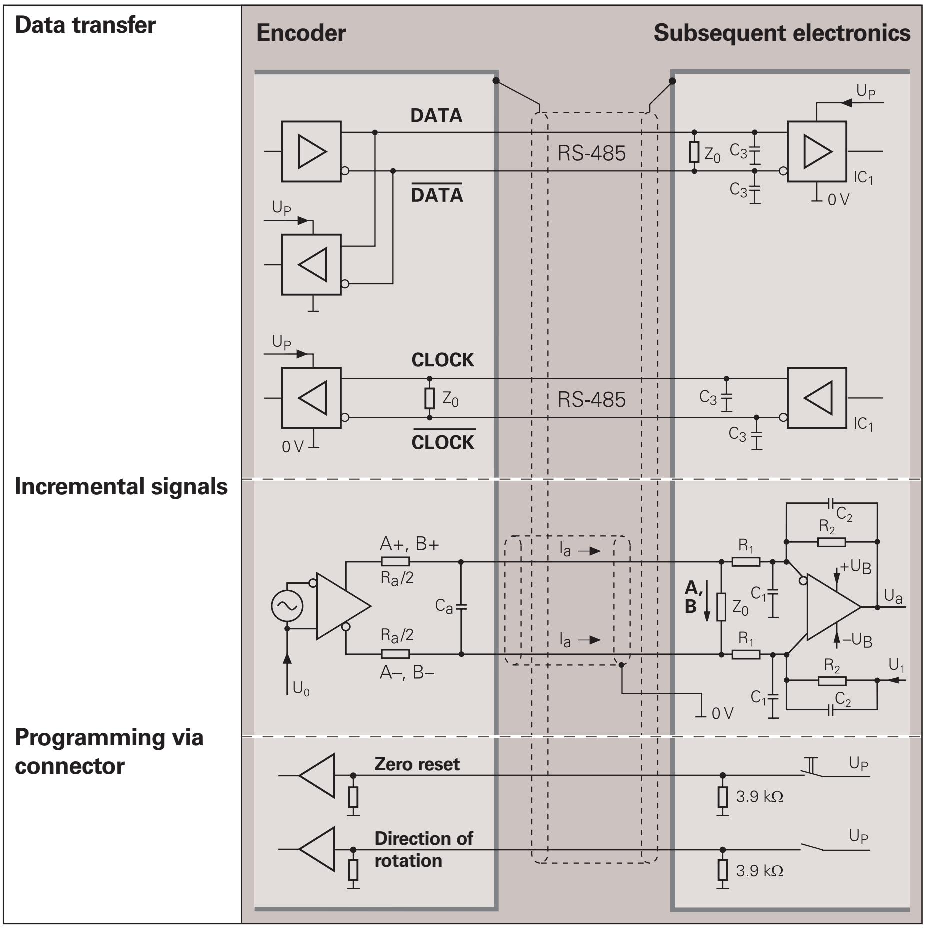
Permissible clock frequency with respect to cable lengths



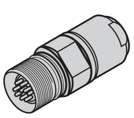
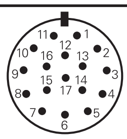
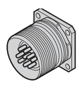
Input circuitry of the subsequent electronics

Dimensioning
IC_1 = Differential line receiver and driver
E.g. SN 65 LBC 176
LT 485

Z_0 = 120 Ω
C_3 = 330 pF (serves to improve noise immunity)



Pin layout

17-pin coupling M23     															
	Power supply					Incremental signals				Absolute position values				Other signals	
	7	1	10	4	11	15	16	12	13	14	17	8	9	2	5
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Inside shield**	**A+**	**A–**	**B+**	**B–**	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**	**Direction of rotation**	**Zero reset**
	Brown/ Green	Blue	White/ Green	White	/	Green/ Black	Yellow/ Black	Blue/ Black	Red/ Black	Gray	Pink	Violet	Yellow	Black	Green

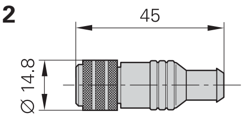
Shield on housing; **U_P** = power supply voltage
Sensor: With a 5 V supply voltage, the sensor line is connected internally with the corresponding power line.

Connecting Elements and Cables
General Information

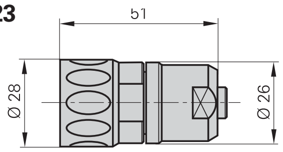
Connector insulated:
Connecting element with coupling ring.
Available with male or female contacts.

Symbols 

M12



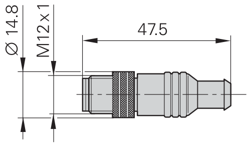
M23



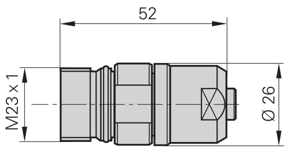
Connector insulated:
Connecting element with external thread.
Available with male or female contacts.

Symbols 

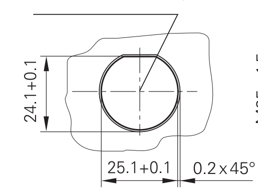
M12



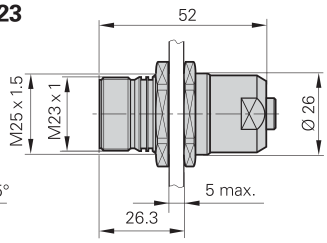
M23



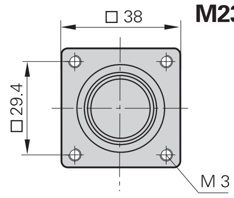
Mounted coupling with central fastening



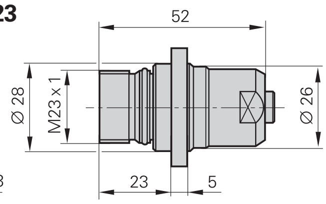
M23



Mounted coupling with flange



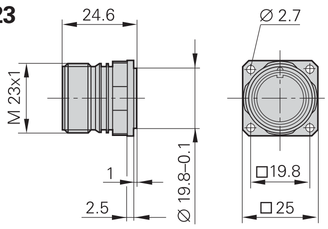
M23



Flange socket: Permanently mounted on the encoder or a housing, with external thread (like the coupling), and available with male or female contacts.

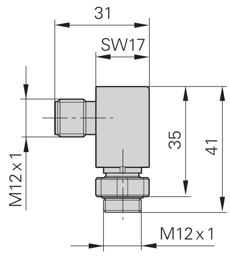
Symbols 

M23

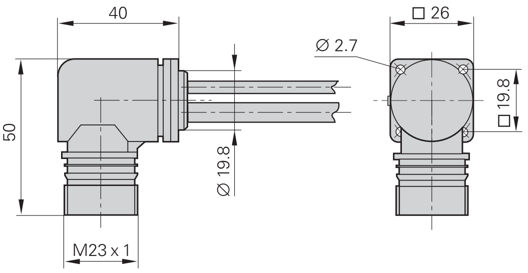


Right-angle flange socket (rotatable) on adapter cable inside the motor with connection for temperature sensor

M12

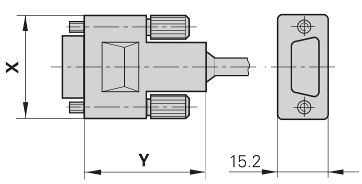


M23



D-sub connector: For HEIDENHAIN controls, counters and IK absolute value cards.

Symbols 

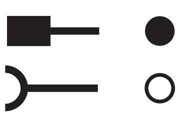


x: 41,7 **y:** 15,2

The pins on connectors are **numbered** in the direction opposite to those on couplings or flange sockets, regardless of whether the connecting elements are

male or

female.



When engaged, the connections provide **protection** to IP 67 (D-sub connector: IP 50; IEC 60529). When not engaged, there is no protection.

Accessories for flange socket and M23 mounted couplings

Bell seal
Id. Nr. 266526-01

Threaded metal dust cap
Id. Nr. 219926-01

Connecting Cables

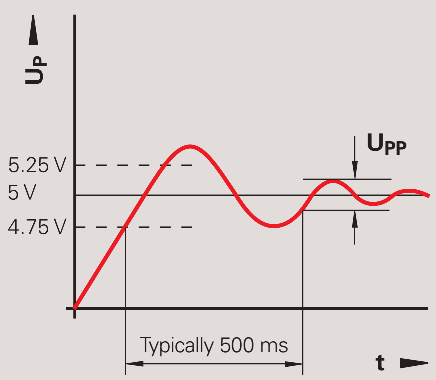
		8-pin M12	12-pin M23	17-pin M23
		for EnDat without incremental signals	**for** ∿ **1 V_{PP}** ⊓⊔ **TTL**	**For EnDat** with incremental SSI signals
PUR connecting cable	**8-pin:** [(4 × 0.14 mm^2) + (4 × 0.34 mm^2)] **Ø 6 mm** **12-pin:** [4(2 × 0.14 mm^2) + (4 × 0.5 mm^2)] **Ø 8 mm** **17-pin:** [(4 × 0.14 mm^2) + 4(2 × 0.14 mm^2) + (4 × 0.5 mm^2)] **Ø 8 mm**			
Complete with connector (female) and coupling (male)		368 330-xx	298 401-xx	323 897-xx
Complete with connector (female) and connector (male)		–	298 399-xx	–
Complete with connector (female) and D-sub connector (female) for IK 220		530 627-xx	310 199-xx	332 115-xx
Complete with connector (female) and D-sub connector (male) for IK 115/IK 215		524 599-xx	310 196-xx	324 544-xx
With one connector (female)		559 346-xx	309 777-xx	309 778-xx
Cable only, Ø 8 mm		–	244 957-01	266 306-01
Mating element on connecting cable to connector on encoder cable	**Connector (female)** for cable Ø 8 mm	–	291 697-05	291 697-26
Connector on cable for connection to subsequent electronics	**Connector (female)** for cable Ø 8 mm Ø 6 mm	–	291 697-08 291 697-07	291 697-27
Coupling on connecting cable	**Coupling (male)** for cable Ø 4.5 mm Ø 6 mm Ø 8 mm	–	291 698-14 291 698-03 291 698-04	291 698-25 291 698-26 291 698-27
Flange socket for connection to subsequent electronics	**Coupling (female)**	–	315 892-08	315 892-10
Mounted couplings	**With flange (female)** Ø 6 mm Ø 8 mm	–	291 698-17 291 698-07	291 698-35
	With flange (male) Ø 6 mm Ø 8 mm	–	291 698-08 291 698-31	291 698-41 291 698-29
	With central fastening (male) Ø 6 mm	–	291 698-33	291 698-37
Adapter connector ∿ **1 V_{PP}/11 μA_{PP}** For converting the 1 V_{PP} signals to 11 μA_{PP}; M23 connector (female) 12-pin and M23 connector (male) 9-pin		–	364 914-01	–

General Electrical Information

Power Supply

The encoders require a **stabilized dc voltage U_P** as power supply. The respective specifications state the required power supply and the current consumption. The permissible ripple content of the dc voltage is:

- High frequency interference $U_{PP} < 250$ mV with $dU/dt > 5$ V/µs
- Low frequency fundamental ripple $U_{PP} < 100$ mV



Initial transient response of the supply voltage e.g. 5 V ± 5 %

The values apply as measured at the encoder, i.e., without cable influences. The voltage can be monitored and adjusted with the device's **sensor lines.** If a controllable power supply is not available, the voltage drop can be halved by switching the sensor lines parallel to the corresponding power lines.

Calculation of the **voltage drop:**

$$\Delta U = 2 \cdot 10^{-3} \cdot \frac{L_C \cdot I}{56 \cdot A_P}$$

with

ΔU: Voltage attenuation in V
L_C: Cable length in m
I: Current consumption of the encoder in mA (see *Specifications*)
A_P: Cross section of power supply lines in mm²

Electrically Permissible Speed/ Traversing Speed

The maximum permissible shaft speed or traversing velocity of an encoder is derived from

- the **mechanically** permissible shaft speed/traversing velocity (if listed in *Specifications*), and
- the **electrically** permissible shaft speed or traversing velocity.

For encoders with **sinusoidal output signals,** the electrically permissible shaft speed or traversing velocity is limited by the –3dB/ –6dB cutoff frequency or the permissible input frequency of the subsequent electronics.

For encoders with **square-wave signals,** the electrically permissible shaft speed or traversing velocity is limited by

- the maximum permissible scanning/ output frequency f_{max} of the encoder and
- the minimum permissible edge separation *a* for the subsequent electronics

For angular or rotary encoders

$$n_{max} = \frac{f_{max}}{z} \cdot 60 \cdot 10^3$$

For linear encoders

$$v_{max} = f_{max} \cdot SP \cdot 60 \cdot 10^{-3}$$

where

n_{max}: Electrically permissible speed in rpm
v_{max}: Electrically permissible speed in m/min
f_{max}: Maximum scanning/ output frequency of the encoder or input frequency of the subsequent electronics in kHz
z: Line count of the angle or rotary encoder per 360°
SP: Signal period of the linear encoder in µm

Cable

Lengths
The cable lengths listed in the *Specifications* apply only for HEIDENHAIN cables and the recommended input circuitry of subsequent electronics.

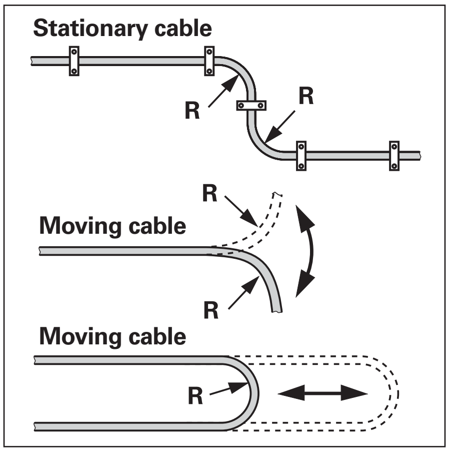
Durability
All encoders have polyurethane (PUR) cables. PUR cables are resistant to oil, hydrolysis and microbes in accordance with **VDE 0472.** They are free of PVC and silicone and comply with UL safety directives. The **UL certification** AWM STYLE 20963 80 °C 30 V E63216 is documented on the cable.

Temperature range
HEIDENHAIN cables can be used:

for stationary cables	–40 to 85 °C
for moving cables	–10 to 85 °C

Cables with limited resistance to hydrolysis and microbes are rated for up to 100 °C.

Bending radius
The permissible bending radii *R* depend on the cable diameter and the configuration:



HEIDENHAIN cables	Cross section of power supply lines A_P			
	1 V_{PP}/TTL/HTL	**11 µApp**	**EnDat/SSI** 17-pin	**EnDat** 8-pin
Ø 3.7 mm	0.05 mm²	–	–	–
Ø 4.5/5.1 mm	0.14/0.05²⁾ mm²	0.05 mm²	0.05 mm²	–
Ø 6/10¹⁾ mm	0.19/ 0.14³⁾ mm²	–	0.08 mm²	0.34 mm²
Ø 8/14¹⁾ mm	0.5 mm²	1 mm²	0.5 mm²	1 mm²

1) Metal armor   2) Only on length gauges   3) Only for LIDA 400

HEIDENHAIN cables	Stationary cable	Moving cable
Ø 3.7 mm	R ≥ 8 mm	R ≥ 40 mm
Ø 4.5 mm **Ø 5.1 mm**	R ≥ 10 mm	R ≥ 50 mm
Ø 6 mm	R ≥ 20 mm	R ≥ 75 mm
Ø 8 mm	R ≥ 40 mm	R ≥ 100 mm
Ø 10 mm¹⁾	R ≥ 35 mm	R ≥ 75 mm
Ø 14 mm¹⁾	R ≥ 50 mm	R ≥ 100 mm

Reliable Signal Transmission

Electromagnetic compatibility/ CE compliance
When properly installed, HEIDENHAIN encoders fulfill the requirements for electromagnetic compatibility according to 89/336/EEC with respect to the generic standards for:

- **Noise immunity IEC 61 000-6-2:**
  Specifically:

– ESD	IEC 61 000-4-2
– Electromagnetic fields	IEC 61 000-4-3
– Burst	IEC 61 000-4-4
– Surge	IEC 61 000-4-5
– Conducted disturbances	IEC 61 000-4-6
– Power frequency magnetic fields	IEC 61 000-4-8
– Pulse magnetic fields	IEC 61 000-4-9

- **Interference IEC 61 000-6-4:**

Specifically:

– For industrial, scientific and medical (ISM) equipment	IEC 55 011
– For information technology equipment	IEC 55 022

Transmission of measuring signals—electrical noise immunity
Noise voltages arise mainly through capacitive or inductive transfer. Electrical noise can be introduced into the system over signal lines and input or output terminals.
Possible sources of noise are:

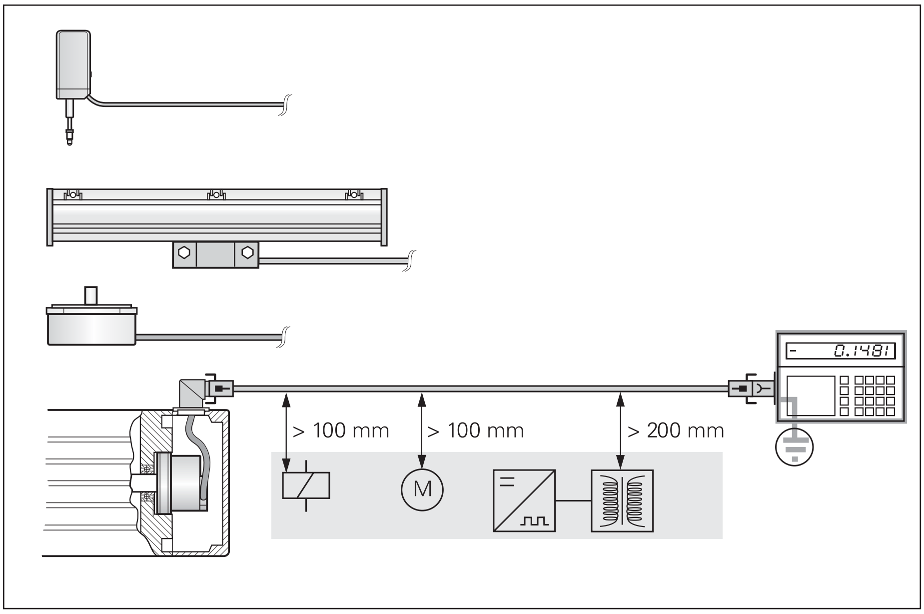
- Strong magnetic fields from transformers and electric motors
- Relays, contactors and solenoid valves
- High-frequency equipment, pulse devices, and stray magnetic fields from switch-mode power supplies
- AC power lines and supply lines to the above devices

Isolation
The encoder housings are isolated against all circuits.
Rated surge voltage: 500 V
(preferred value as per VDE 0110 Part 1)

Protection against electrical noise
The following measures must be taken to ensure disturbance-free operation:

- Use only original HEIDENHAIN cables. Watch for voltage attenuation on the supply lines.
- Use connectors or terminal boxes with metal housings. Do not conduct any extraneous signals.
- Connect the housings of the encoder, connector, terminal box and evaluation electronics through the shield of the cable. Connect the shielding in the area of the cable inlets to be as induction-free as possible (short, full-surface contact).
- Connect the entire shielding system with the protective ground.
- Prevent contact of loose connector housings with other metal surfaces.
- The cable shielding has the function of an equipotential bonding conductor. If compensating currents are to be expected within the entire system, a separate equipotential bonding conductor must be provided.
  See also EN 50178/4.98 Chapter 5.2.9.5 regarding "protective connection lines with small cross section."
- Connect HEIDENHAIN position encoders only to subsequent electronics whose power supply is generated through double or strengthened insulation against line voltage circuits. Also see **IEC 364-4-41:** 1992, modified Chapter 411 regarding "protection against both direct and indirect touch" (PELV or SELV).
- Do not lay signal cables in the direct vicinity of interference sources (inductive consumers such as contacts, motors, frequency inverters, solenoids, etc.).
- Sufficient decoupling from interference-signal-conducting cables can usually be achieved by an air clearance of 100 mm or, when cables are in metal ducts, by a grounded partition.
- A minimum spacing of 200 mm to inductors in switch-mode power supplies is required. See also **EN 50 178**/4.98 Chapter 5.3.1.1 regarding cables and lines, **EN 50 174-2**/09.01 Chapter 6.7 regarding grounding and potential compensation.
- When using **multiturn encoders in electromagnetic fields** greater than 30 mT, HEIDENHAIN recommends consulting with the main facility in Traunreut.

Both the cable shielding and the metal housings of encoders and subsequent electronics have a shielding function. The housings must have the **same potential** and be connected to the main signal ground over the machine chassis or by means of a separate potential compensating line. Potential compensating lines should have a minimum cross section of 6 mm^2 (Cu).



Minimum distance from sources of interference

HEIDENHAIN Measuring Equipment and Counter Cards

The **IK 215** is an adapter card for PCs for inspecting and testing absolute HEIDENHAIN encoders with EnDat or SSI interface. All parameters can be read and written via the EnDat interface.

	IK 215
Encoder input	EnDat (absolute value or incremental signals) or SSI
Interface	PCI bus, Rev. 2.1
Application software	**Operating system:** Windows 2000/XP **Features:** Display of position value Counter for incremental signals EnDat functionality Installation software for EXI 1100/1300
Signal subdivision for incremental signals	Up to 65 536-fold
Dimensions	100 mm x 190 mm

The **PWM 9** is a universal measuring device for checking and adjusting HEIDENHAIN incremental encoders. There are different expansion modules available for checking the different encoder signals. The values can be read on an LCD monitor. Soft keys provide ease of operation.

	PWM 9
Inputs	Expansion modules (interface boards) for 11 μA_{PP}; 1 V_{PP}; TTL; HTL; EnDat*/SSI*/commutation signals *No display of position values or parameters
Features	• **Measurement** of signal amplitudes, current consumption, operating voltage, scanning frequency • **Graphic display** of incremental signals (amplitudes, phase angle and on-off ratio) and the reference signal (width and position) • **Display symbols** for the reference mark, fault detection signal, counting direction • **Universal counter,** interpolation selectable from single to 1024-fold • **Adjustment support** for exposed linear encoders
Outputs	• Inputs are connected through to the subsequent electronics • BNC sockets for connection to an oscilloscope
Power supply	10 to 30 V, max. 15 W
Dimensions	150 mm × 205 mm × 96 mm

IK 220
Universal PC counter card
The IK 220 is an expansion board for AT-compatible PCs for recording the measured values of **two incremental or absolute linear or angle encoders.** The subdivision and counting electronics **subdivide** the **sinusoidal input signals** up to **4096-fold.** A driver software package is included in delivery.

For more information, see the *IK 220 Product Information* sheet.

	IK 220			
Input signals (switchable)	∼ 1 V_{PP}	∼ 11 μA_{PP}	EnDat 2.1	SSI
Encoder inputs	Two D-sub connectors (15-pin), male			
Max. input frequency	500 kHz	33 kHz	–	
Max. cable length	60 m		10 m	
Signal subdivision (signal period: meas. step)	Up to 4096-fold			
Data register for measured values (per channel)	48 bits (44 bits used)			
Internal memory	For 8192 position values			
Interface	PCI bus (plug and play)			
Driver software and demonstration program	**For WINDOWS 98/NT/2000/XP** In VISUAL C++, VISUAL BASIC and BORLAND DELPHI			
Dimensions	Approx. 190 mm × 100 mm			

Customer Service — Worldwide

HEIDENHAIN is represented by subsidiaries in all important industrial nations. In addition to the addresses listed here, there are many service agencies located worldwide. For more information, visit our Internet site or contact HEIDENHAIN in Traunreut, Germany.

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