HEIDENHAIN

Rotary Encoders

November 2012

Rotary encoders from HEIDENHAIN serve as measuring sensors for rotary motion, angular velocity and, when used in conjunction with mechanical measuring standards such as lead screws, for linear motion. Application areas include electrical motors, machine tools, printing machines, woodworking machines, textile machines, robots and handling devices, as well as various types of measuring, testing, and inspection devices.
The high quality of the sinusoidal incremental signals permits high interpolation factors for digital speed control.

Rotary encoders for separate shaft coupling

Electronic handwheel

Rotary encoders with mounted stator coupling

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.

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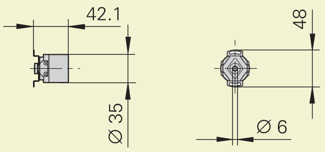
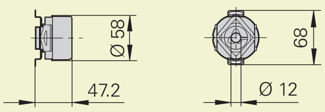
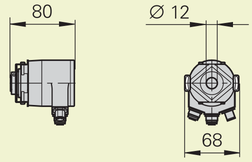
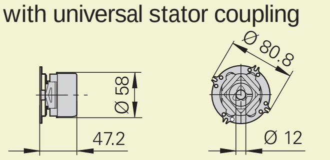
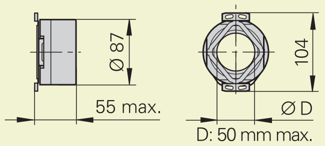
Rotary encoders for standard applications

Rotary encoder	**Absolute** **Singleturn**				**Multiturn** 4096 revolutions	
Interface	EnDat		SSI	PROFIBUS-DP PROFINET IO	EnDat	
Power supply	3.6 to 14 V DC	5 V DC	5 V DC or 10 to 30 V DC	9 to 36 V DC 10 to 30 V DC	3.6 to 14 V DC	5 V DC
With mounted stator coupling						
ECN/EQN/ERN 1000 series 	**ECN 1023** Positions/rev: 23 bits EnDat 2.2/22 **ECN 1013** Positions/rev: 13 bits EnDat 2.2/01	–	–	–	**EQN 1035** Positions/rev: 23 bits EnDat 2.2/22 **EQN 1025** Positions/rev: 13 bits EnDat 2.2/01	–
ECN/EQN/ERN 400 series 	**ECN 425** Positions/rev: 25 bits EnDat 2.2/22 **ECN 413** Positions/rev: 13 bits EnDat 2.2/01	–	**ECN 413** Positions/rev: 13 bits	–	**EQN 437** Positions/rev: 25 bits EnDat 2.2/22 **EQN 425** Positions/rev: 13 bits EnDat 2.2/01	–
ECN/EQN 400 series with field bus 	–	–	–	**ECN 413** Positions/rev: 13 bits	–	–
ECN/EQN/ERN 400 series with universal stator coupling 	**ECN 425** Positions/rev: 25 bits EnDat 2.2/22 **ECN 413** Positions/rev: 13 bits EnDat 2.2/01	–	**ECN 413** Positions/rev: 13 bits	–	**EQN 437** Positions/rev: 25 bits EnDat 2.2/22 **EQN 425** Positions/rev: 13 bits EnDat 2.2/01	–
ECN/ERN 100 series 	**ECN 125**[1] Positions/rev: 25 bits EnDat 2.2/22	**ECN 113** Positions/rev: 13 bits EnDat 2.2/01	–	–	–	–

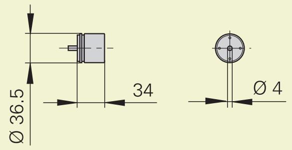
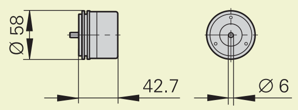
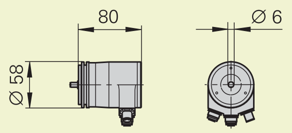
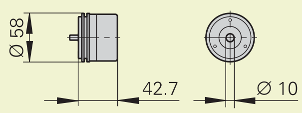
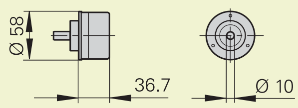
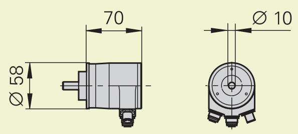
[1] Power supply 3.6 to 5.25 V DC
[2] Up to 10000 signal periods through integrated 2-fold interpolation
[3] Up to 36000 signal periods through integrated 5/10-fold interpolation (higher interpolation on request)

			Incremental				
	SSI 5 V DC or 10 to 30 V DC	PROFIBUS-DP PROFINET IO 9 to 36 V DC 10 to 30 V DC	TTL 5 V DC	TTL 10 to 30 V DC	HTL 10 to 30 V DC	1 V_{PP} 5 V DC	
	–	–	**ERN 1020** 100 to 3600 lines **ERN 1070**[3] 1000/2500/ 3600 lines	–	**ERN 1030** 100 to 3600 lines	**ERN 1080** 100 to 3600 lines	**26**
	EQN 425 Positions/rev: 13 bits	–	**ERN 420** 250 to 5000 lines	**ERN 460** 250 to 5000 lines	**ERN 430** 250 to 5000 lines	**ERN 480** 1000 to 5000 lines	**30**
	–	**EQN 425** Positions/rev: 13 bits	–	–	–	–	**34**
	EQN 425 Positions/rev: 13 bits	–	**ERN 420** 250 to 5000 lines	**ERN 460** 250 to 5000 lines	**ERN 430** 250 to 5000 lines	**ERN 480** 1000 to 5000 lines	**36**
	–	–	**ERN 120** 1000 to 5000 lines	–	**ERN 130** 1000 to 5000 lines	**ERN 180** 1000 to 5000 lines	**40**





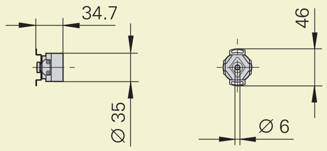
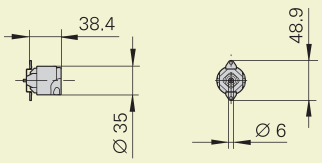
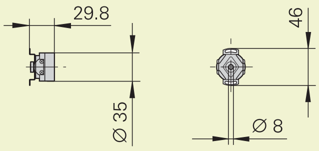
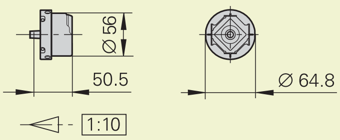
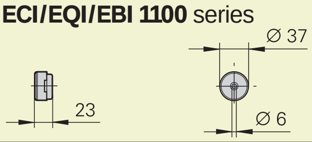
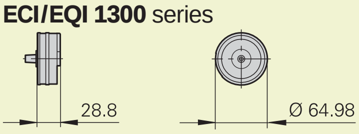
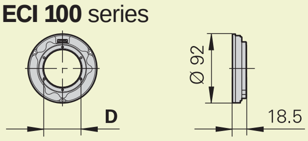
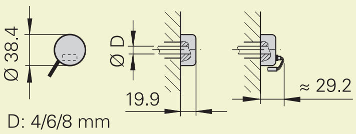
Selection guide
Rotary encoders for standard applications

Rotary encoder	**Absolute** **Singleturn**				**Multiturn** 4096 revolutions	
Interface	EnDat		SSI	PROFIBUS-DP PROFINET IO	EnDat	
Power supply	3.6 to 14 V DC	5 V DC	5 V DC or 10 to 30 V DC	9 to 36 V DC 10 to 30 V DC	3.6 to 14 V DC	5 V DC
For separate shaft coupling, with synchro flange						
ROC/ROQ/ROD 1000 series 	**ROC 1023** Positions/rev: 23 bits EnDat 2.2/22 **ROC 1013** Positions/rev: 13 bits EnDat 2.2/01	–	–	–	**ROQ 1035** Positions/rev: 23 bits EnDat 2.2/22 **ROQ 1025** Positions/rev: 13 bits EnDat 2.2/01	–
ROC/ROQ/ROD 400 **RIC/RIQ 400** series with synchro flange 	**ROC 425** Positions/rev: 25 bits EnDat 2.2/22 **ROC 413** Positions/rev: 13 bits EnDat 2.2/01	**RIC 418** Positions/rev: 18 bits EnDat 2.1/01	**ROC 413** Positions/rev: 13 bits	–	**ROQ 437** Positions/rev: 25 bits EnDat 2.2/22 **ROQ 425** Positions/rev: 13 bits EnDat 2.2/01	**RIQ 430** Positions/rev: 18 bits EnDat 2.1/01
ROC/ROQ 400 series with field bus 	–	–	–	**ROC 413** Positions/rev: 13 bits	–	–
ROC 425 for high accuracy 	**ROC 425** Positions/rev: 25 bits EnDat 2.2/01	–	–	–	–	–
For separate shaft coupling, with clamping flange						
ROC/ROQ/ROD 400 **RIC/RIQ 400** series with clamping flange 	**ROC 425** Positions/rev: 25 bits EnDat 2.2/22 **ROC 413** Positions/rev: 13 bits EnDat 2.2/01	**RIC 418** Positions/rev: 18 bits EnDat 2.1/01	**ROC 413** Positions/rev: 13 bits	–	**ROQ 437** Positions/rev: 25 bits EnDat 2.2/22 **ROQ 425** Positions/rev: 13 bits EnDat 2.2/01	**RIQ 430** Positions/rev: 18 bits EnDat 2.1/01
ROC/ROQ 400 series with field bus 	–	–	–	**ROC 413** Positions/rev: 13 bits	–	–

1) Up to 10000 signal periods through integrated 2-fold interpolation
2) Up to 36000 signal periods through integrated 5/10-fold interpolation (higher interpolation on request)

		Incremental				
SSI 5 V DC or 10 to 30 V DC	PROFIBUS-DP PROFINET IO 9 to 36 V DC 10 to 30 V DC	TTL 5 V DC	TTL 10 to 30 V DC	HTL 10 to 30 V DC	$1\,V_{PP}$ 5 V DC	
–	–	**ROD 1020** 100 to 3600 lines **ROD 1070**[2] 1000/2500/ 3600 lines	–	**ROD 1030** 100 to 3600 lines	**ROD 1080** 100 to 3600 lines	**42**
ROQ 425 Positions/rev: 13 bits	–	**ROD 426** 50 to 5000 lines[1]	**ROD 466** 50 to 5000 lines[2]	**ROD 436** 50 to 5000 lines	**ROD 486** 1000 to 5000 lines	**46**
–	**ROQ 425** Positions/rev: 13 bits	–	–	–	–	**50**
–	–	–	–	–	–	**52**
ROQ 425 Positions/rev: 13 bits	–	**ROD 420** 50 to 5000 lines	–	**ROD 430** 50 to 5000 lines	**ROD 480** 1000 to 5000 lines	**54**
–	**ROQ 425** Positions/rev: 13 bits	–	–	–	–	**58**

Selection guide
Rotary encoders for motors

Rotary encoder	Absolute Singleturn		Multiturn	
Interface Power supply	EnDat 3.6 to 14 V DC	5 V DC	EnDat 3.6 to 14 V DC	5 V DC
With integral bearing and mounted stator coupling				
ERN 1023 series 	–	–	–	–
ECN/EQN 1100 series 	**ECN 1123** Positions/rev: 23 bits EnDat 2.2/22 **Functional safety** on request **ECN 1113** Positions/rev: 13 bits EnDat 2.2/01	–	**EQN 1135** Positions/rev: 23 bits 4096 revolutions EnDat 2.2/22 **Functional safety** on request **EQN 1125** Positions/rev: 13 bits 4096 revolutions EnDat 2.2/01	–
ERN 1123 	–	–	–	–
ECN/EQN/ERN 1300 series 	**ECN 1325** Positions/rev: 25 bits EnDat 2.2/22 **Functional safety** on request **ECN 1313** Positions/rev: 13 bits EnDat 2.2/01	–	**EQN 1337** Positions/rev: 25 bits 4096 revolutions EnDat 2.2/22 **Functional safety** on request **EQN 1325** Positions/rev: 13 bits 4096 revolutions EnDat 2.2/01	–
Without integral bearing				
ECI/EQI/EBI 1100 series 	**ECI 1118** Positions/rev: 18 bits EnDat 2.2/22	**ECI 1118** Positions/rev: 18 bits EnDat 2.1/21 or EnDat 2.1/01	**EBI 1135** Positions/rev: 18 bits 65536 revolutions (battery buffered) EnDat 2.2/22	**EQI 1130** Positions/rev: 18 bits 4096 revolutions EnDat 2.1/21 or EnDat 2.1/01
ECI/EQI 1300 series 	–	**ECI 1319** Positions/rev: 19 bits EnDat 2.2/01	–	**EQI 1331** Positions/rev: 19 bits 4096 revolutions EnDat 2.2/01
ECI 100 series  D: 50 mm	**ECI 119** Positions/rev: 19 bits EnDat 2.1/21 or EnDat 2.1/01	–	–	–
ERO 1400 series  D: 4/6/8 mm	–	–	–	–

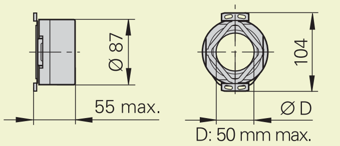
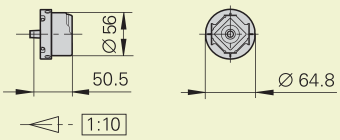
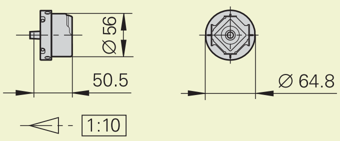
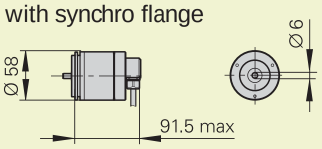
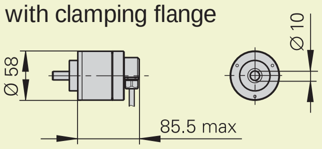
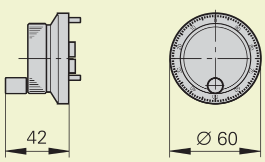
1) 8192 signal periods through integrated 2-fold interpolation
2) 37500 signal periods through integrated 5/10/20/25-fold interpolation

These rotary encoders are described in the ***Position Encoders for Servo Drives*** catalog.

	Incremental	
	⎍ TTL 5 V DC	∿ 1 V_{PP} 5 V DC
	ERN 1023 500 to 8192 lines 3 signals for block commutation	–
	–	–
	ERN 1123 500 to 8192 lines 3 signals for block commutation	–
	ERN 1321 1024 to 4096 lines **ERN 1326** 1024 to 4096 lines[1] 3 TTL signals for block commutation	**ERN 1381** 512 to 4096 lines **ERN 1387** 2048 lines Z1 track for sine commutation
	–	–
	–	–
	–	–
	ERO 1420 512 to 1024 lines **ERO 1470** 1000/1500[2]	**ERO 1480** 512 to 1024 lines

EBI see Product Information

Selection guide
Rotary encoders for special applications

Rotary encoder	**Absolute** **Singleturn**			**Multiturn** 4096 revolutions	
Interface Power supply	EnDat 3.6 to 14 V DC	5 V DC	SSI 5 V DC	EnDat 5 V DC	SSI 5 V DC
For drive control in elevators					
ECN/ERN 100 series IP 64 protection 	**ECN 125**[1] Positions/rev: 25 bits EnDat 2.2/22	**ECN 113** Positions/rev: 13 bits EnDat 2.2/01	–	–	–
ECN/EQN/ERN 400 series IP 64 protection 	**ECN 425** Positions/rev: 25 bits EnDat 2.2/22 **Functional safety** on request **ECN 413** Positions/rev: 13 bits EnDat 2.2/01	–	–	–	–
ECN/ERN 1300 series IP 40 protection 	**ECN 1325** Positions/rev: 25 bits EnDat 2.2/22 **Functional safety** on request **ECN 1313** Positions/rev: 13 bits EnDat 2.2/01	–	–	–	–
For potentially explosive atmospheres in zones 1, 2, 21 and 22					
ROC/ROQ/ROD 400[4] series with synchro flange 	–	**ROC 413** Positions/rev: 13 bits EnDat 2.1/01	**ROC 413** Positions/rev: 13 bits	**ROQ 425** Positions/rev: 13 bits EnDat 2.1/01	**ROQ 425** Positions/rev: 13 bits
ROC/ROQ/ROD 400[4] series with clamping flange 	–	**ROC 413** Positions/rev: 13 bits EnDat 2.1/01	**ROC 413** Positions/rev: 13 bits	**ROQ 425** Positions/rev: 13 bits EnDat 2.1/01	**ROQ 425** Positions/rev: 13 bits
Electronic handwheel					
HR 1120 	–	–	–	–	–

1) Power supply 3.6 to 5.25 V DC
2) Up to 10000 signal periods through integrated 2-fold interpolation
3) 8192 signal periods through integrated 2-fold interpolation
4) Versions with blind hollow shaft available upon request

Incremental

⎍ TTL 5 V DC	⎍ TTL 10 to 30 V DC	⎍ HTL 10 to 30 V DC	∿ 1 V_{PP} 5 V DC
ERN 120 1000 to 5000 lines	–	**ERN 130** 1000 to 5000 lines	**ERN 180** 1000 to 5000 lines
ERN 421 1024 to 5000 lines [2)]	–	–	**ERN 487** 2048 lines Z1 track for sine commutation
ERN 1321 1024 to 5000 lines **ERN 1326** 1024 to 4096 lines [3)] 3 TTL signals for block commutation	–	–	**ERN 1381** 512 to 4096 lines **ERN 1387** 2048 lines Z1 track for sine commutation
ROD 426 1000 to 5000 lines	**ROD 466** 1000 to 5000 lines	**ROD 436** 1000 to 5000 lines	**ROD 486** 1000 to 5000 lines
ROD 420 1000 to 5000 lines	–	**ROD 430** 1000 to 5000 lines	**ROD 480** 1000 to 5000 lines
HR 1120 100 lines	–		

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See product overview:
Rotary Encoders for the Elevator Industry

See catalog:
Encoders for Servo Drives

See product overview:
Rotary Encoders for Potentially Explosive Atmospheres

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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.

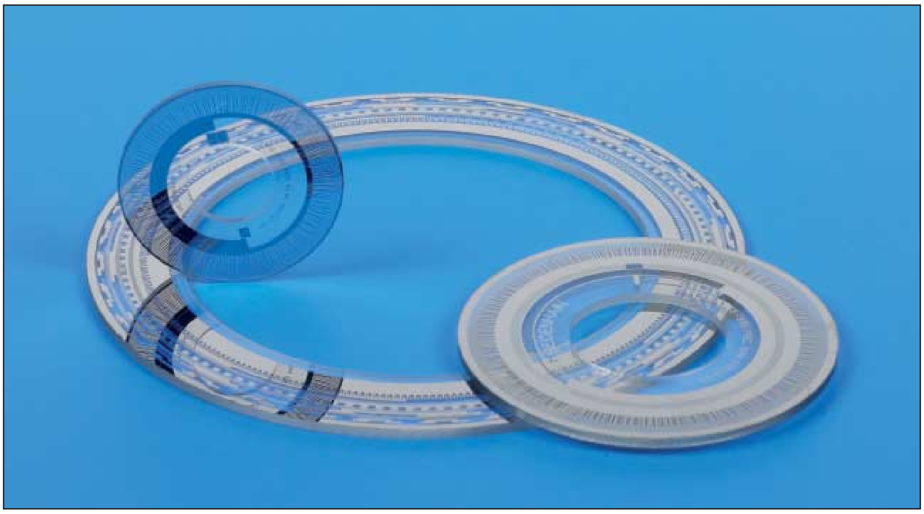
Encoders using the **inductive scanning principle** have graduation structures of copper/nickel. The graduation is applied to a carrier material for printed circuits.

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 **grating on the graduated disk**, which is designed as a serial code structure or—as on the ECN 100—consists of several parallel graduation tracks.

A separate incremental track (on the ECN 100 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.

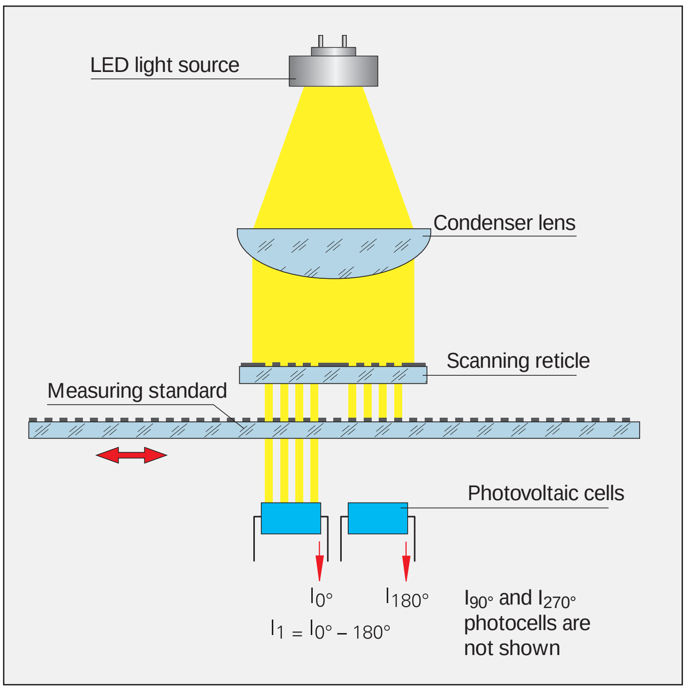
Circular graduations of incremental rotary encoders

Scanning methods

Photoelectric scanning
Most HEIDENHAIN encoders operate using the principle of photoelectric scanning. Photoelectric scanning of a measuring standard is contact-free, and as such, free of 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—the circular scale and the scanning reticle—are moved relative to each other. The carrier material of the scanning reticle is transparent. The graduation on the measuring standard can likewise be applied to a transparent surface, but also a 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

The ROC/ROQ 400/1000 and ECN/EQN 400/1000 absolute rotary encoders with optimized scanning have a single large photosensor instead of a group of individual photocells. Its structures have the same width as that of the measuring standard. This makes it possible to do without the scanning reticle with matching structure.

Other scanning principles
ECI/EBI/EQI and RIC/RIQ rotary encoders operate according to the inductive measuring principle. Here, graduation structures modulate a high-frequency signal in its amplitude and phase. The position value is always formed by sampling the signals of all receiver coils distributed evenly around the circumference.

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) lies within

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

which equals

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

The ROD rotary encoders generate 6000 to 10000 signal periods per revolution through signal doubling. The line count is important for the system accuracy.

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
16	± 480 angular seconds
32	± 280 angular seconds
512	± 60 angular seconds
2048	± 20 angular seconds
2048	± 10 angular seconds (ROC 425 with high accuracy)

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

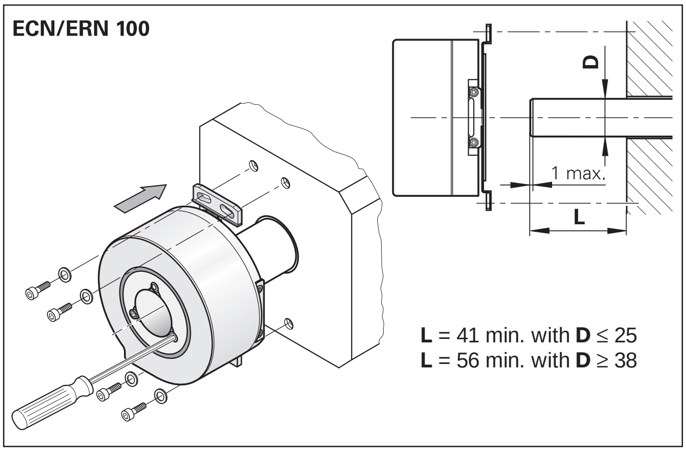
Rotary encoders with stator coupling

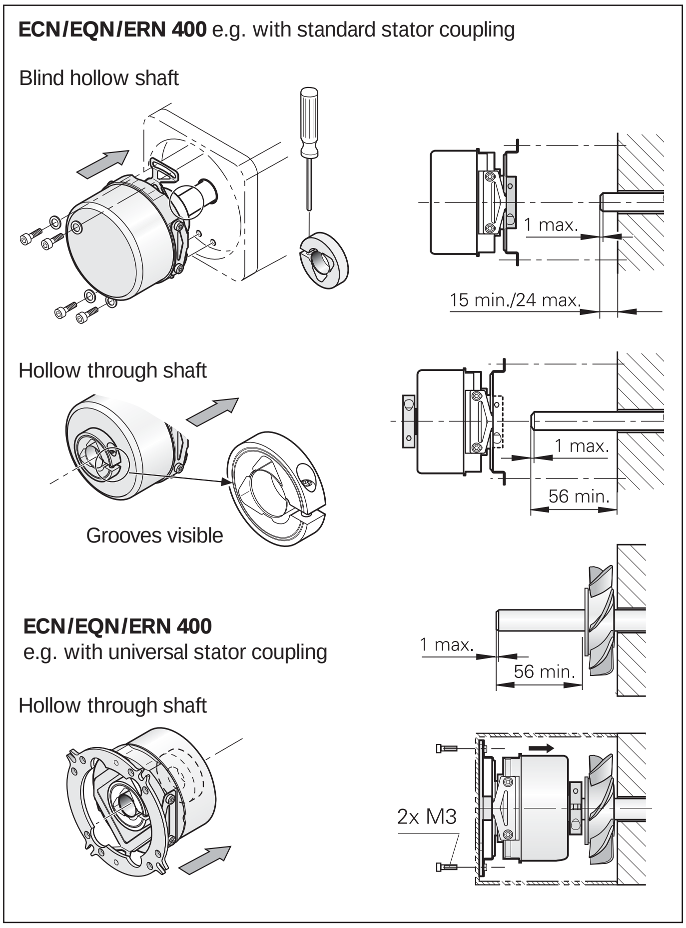
ECN/EQN/ERN rotary encoders have integrated bearings and a mounted stator coupling. They compensate radial runout and alignment errors without significantly reducing the accuracy. The encoder shaft is directly connected with the shaft to be measured. During angular acceleration of the shaft, the stator 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
ECN/EQN/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. Rotary encoders of the ECN/EQN/ERN 1300 series with taper shaft 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.



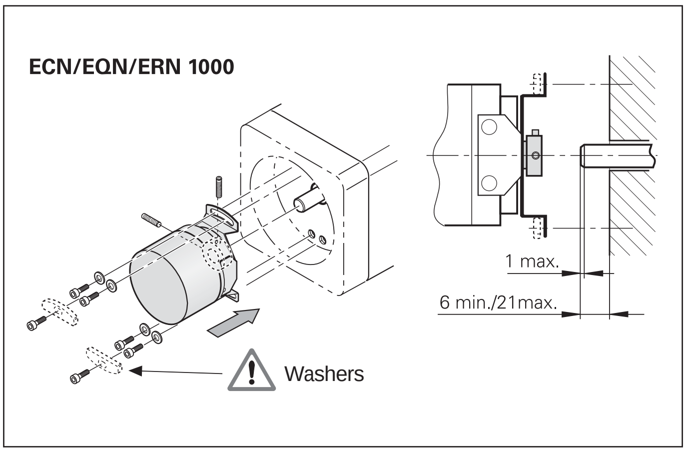


Dynamic applications require the highest possible natural frequencies f_N of the system (also see *General mechanical information).* This is attained by connecting the shafts on the flange side and fastening the coupling by four cap screws or, on the ECN/EQN/ERN 1000, with special washers.

Natural frequency f_N with coupling fastened by 4 screws

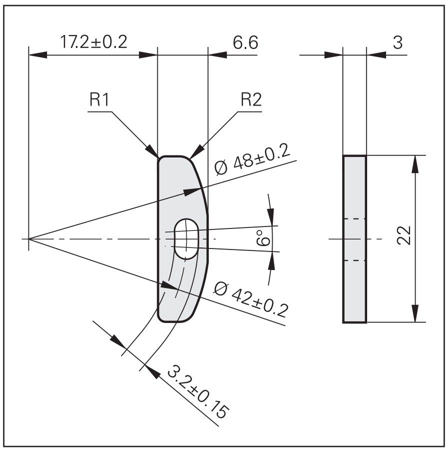
	Stator coupling	**Cable**	**Flange socket**	
			Axial	Radial
ECN/EQN/ ERN 400	Standard Universal	1550 Hz 1400 Hz[1]	1500 Hz 1400 Hz	1000 Hz 900 Hz
ECN/ERN 100		1000 Hz	–	400 Hz
ECN/EQN/ERN 1000		1500 Hz[2]	–	–

[1] Also when fastening with 2 screws
[2] Also when fastening with 2 screws and washers

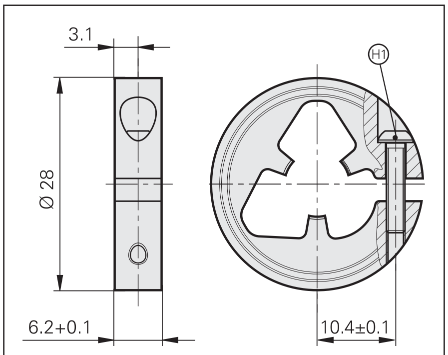


Mounting accessories

Washer
For ECN/EQN/ERN 1000
For increasing the natural frequency f_N and mounting with only two screws.
ID 334653-01



Shaft clamp ring
For ECN/EQN/ERN 400
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 12000 min^{-1}.
ID 540741-xx



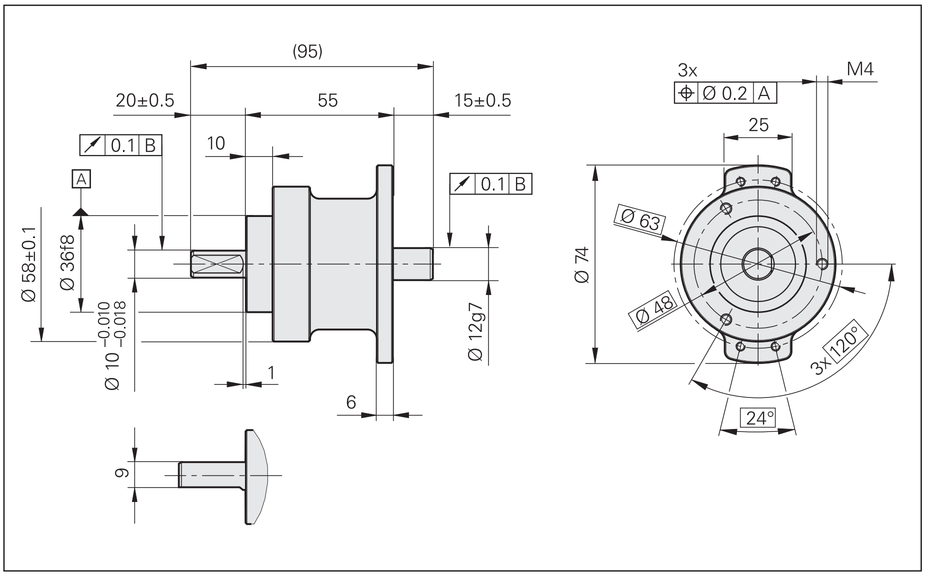
H1 = Clamping screw with X8 hexalobular socket, tightening torque 1.1 ± 0.1 Nm

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.

Bearing assembly
For ERN/ECN/EQN 400 series with blind hollow shaft
ID 574185-03

The bearing assembly is capable of absorbing large radial shaft loads. 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 (see page 15).

	Bearing assembly
Permissible speed n	≤ 6000 min^{-1}
Shaft load	Axial: 150 N; Radial: 350 N
Operating temperature	–40 to 100 °C



Torque supports for ECN/EQN/ERN 400
For simple applications with the ECN/EQN/ERN 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 510955-01

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 510861-01

General accessories

Screwdriver bit
For HEIDENHAIN shaft couplings
For ExN 100/400/1000 shaft couplings
For ERO shaft couplings

Width across flats	Length	ID
1.5	70 mm	350378-01
1.5 (ball head)		350378-02
2		350378-03
2 (ball head)		350378-04
2.5		350378-05
3 (ball head)		350378-08
4		350378-07
4 (with dog point)[1]		350378-14
TX8	89 mm 152 mm	350378-11 350378-12
TX15	70 mm	756768-42

[1] For screws as per DIN 6912 (low head screw with pilot recess)

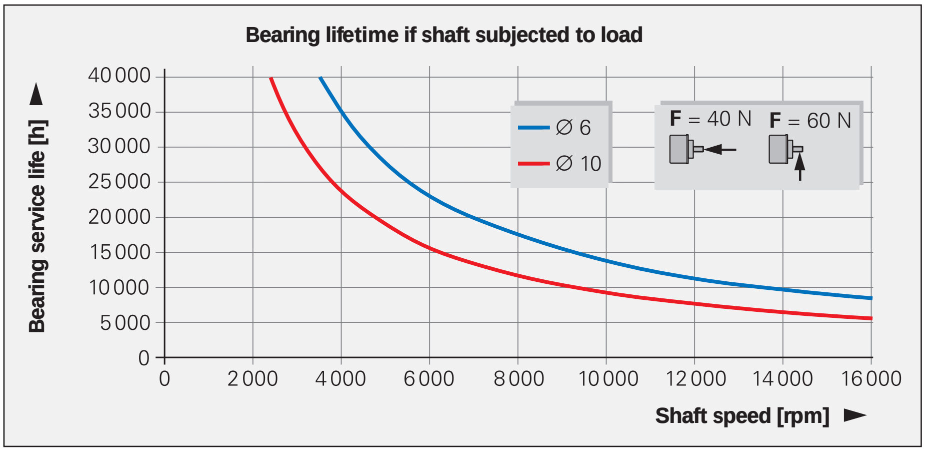
Screwdriver
Adjustable torque
0.2 Nm to 1.2 Nm ID 350379-04
1 Nm to 5 Nm ID 350379-05

Rotary encoders for separate shaft coupling

ROC/ROQ/ROD and **RIC/RIQ** 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/RIC/RIQ encoders are available (see *Shaft couplings*).

ROC/ROQ/ROD 400 and RIC/RIQ 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.

Bearing life span of ROC/ROQ/ROD 400 and RIC/RIQ 400
The service life to be expected of the bearings depends on the shaft speed and the shaft load as a function of the force application point. The maximum permissible load of the shaft at shaft end is listed in the specifications. The relationship between the bearing service life and the shaft speed at maximum shaft load is illustrated in the diagram for the shaft diameters 6 mm and 10 mm. With a load of 10 N axially and 20 N radially at the shaft end, the expected bearing service life at maximum shaft speed is more than 40000 hours.

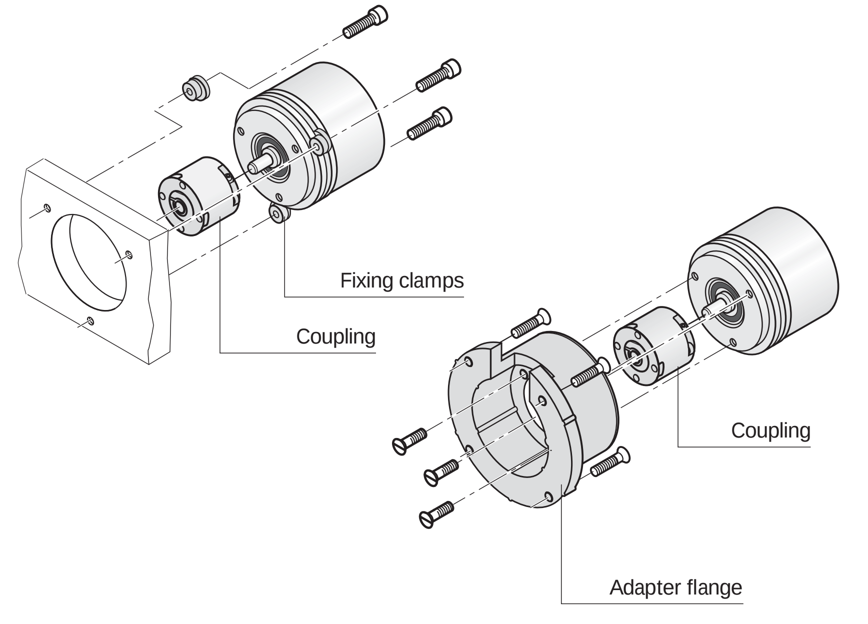


Rotary encoders with synchro flange

Mounting

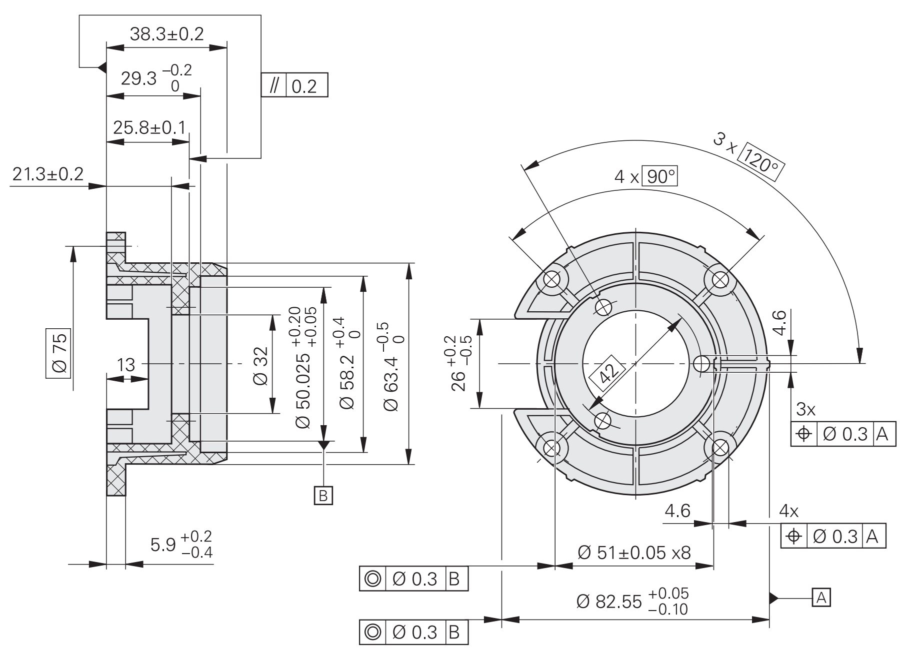
- by the synchro flange with three fixing clamps or
- by fastening threaded holes on the encoder flange to an adapter flange (for ROC/ROQ/ROD 400 or RIC/RIQ 400).

Rotary encoders with synchro flange

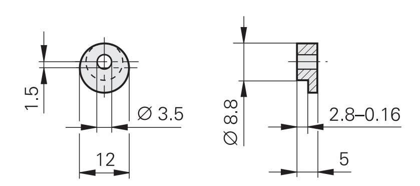


Mounting accessories

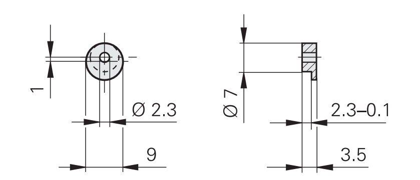
Adapter flange
(electrically nonconducting)
ID 257044-01



Fixing clamps
For ROC/ROQ/ROD 400 and RIC/RIQ 400 series
(3 per encoder)
ID 200032-01



Fixing clamps
For ROC/ROQ/ROD 1000 series
(3 per encoder)
ID 200032-02

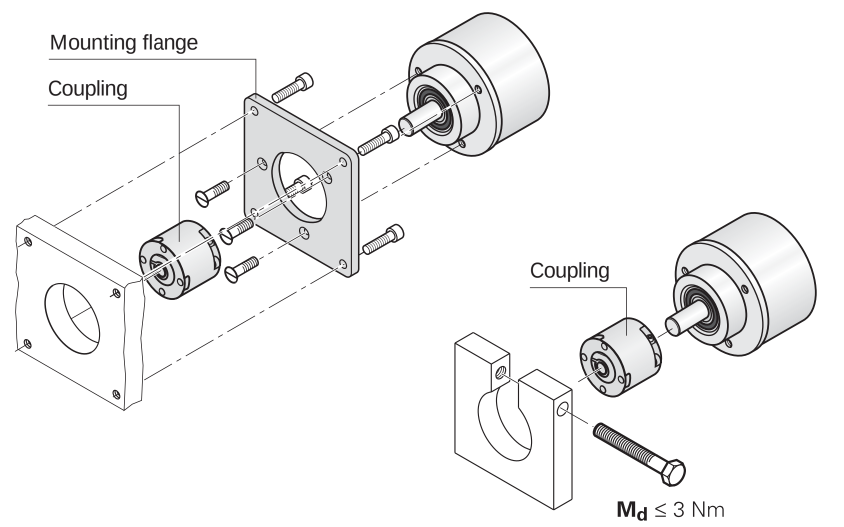


Rotary encoders with clamping flange

Mounting
- by fastening the threaded holes on the encoder flange to an adapter flange or
- by clamping at the clamping flange.

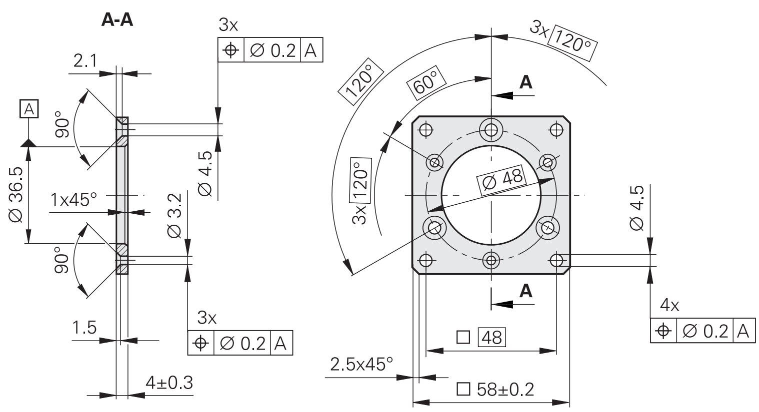
The centering collar on the synchro flange or clamping flange serves to center the encoder.

ROC/ROQ/ROD 400 with clamping flange

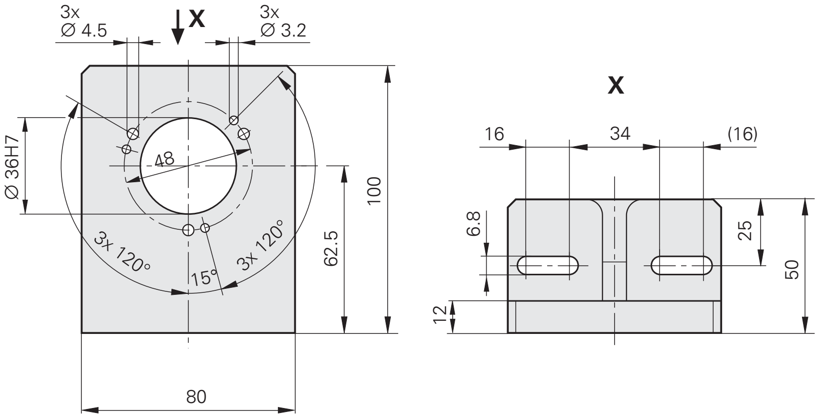


Mounting accessories

Mounting flange
ID 201437-01



Mounting bracket
ID 581296-01

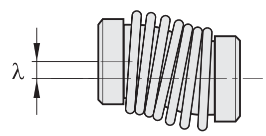


Shaft couplings

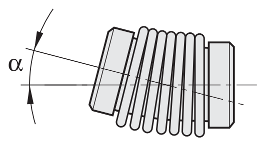
	ROC/ROQ/ROD 400				ROC/ROQ/ ROD 1000
	Diaphragm coupling	**With galvanic isolation**			**Metal bellows coupling**
	K 14	**K 17/01** **K 17/06**	**K 17/02** **K 17/04** **K 17/05**	**K 17/03**	**18EBN3**
Hub bore	6/6 mm	6/6 mm 6/5 mm	6/10 mm 10/10 mm 6/9.52 mm	10/10 mm	4/4 mm
Kinematic transfer error*	± 6”	± 10”			± 40“
Torsional rigidity	$500 \frac{Nm}{rad}$	$150 \frac{Nm}{rad}$	$200 \frac{Nm}{rad}$	$300 \frac{Nm}{rad}$	$60 \frac{Nm}{rad}$
Max. torque	0.2 Nm	0.1 Nm		0.2 Nm	0.1 Nm
Max. radial offset λ	≤ 0.2 mm	≤ 0.5 mm			≤ 0.2 mm
Max. angular error α	≤ 0.5°	≤ 1°			≤ 0.5°
Max. axial motion δ	≤ 0.3 mm	≤ 0.5 mm			≤ 0.3 mm
Moment of inertia (approx.)	$6 \cdot 10^{-6}$ kgm²	$3 \cdot 10^{-6}$ kgm²		$4 \cdot 10^{-6}$ kgm²	$0.3 \cdot 10^{-6}$ kgm²
Permissible speed	16000 min^{-1}	16000 min^{-1}			12000 min^{-1}
Torque for locking screws (approx.)	1.2 Nm				0.8 Nm
Weight	35 g	24 g	23 g	27.5 g	9 g

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

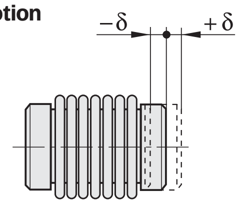
Radial offset



Angular error



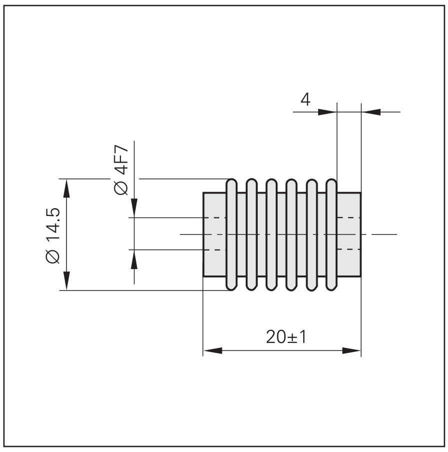
Axial motion



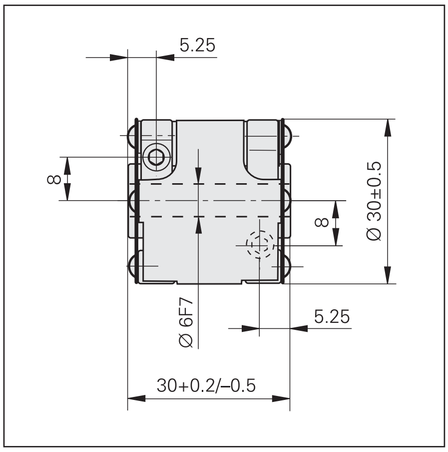
Mounting accessories

Screwdriver bit
Screwdriver
See page 16

Metal bellows coupling 18 EBN 3
For ROC/ROQ/ROD 1000 series
With **4 mm shaft diameter**
ID 200393-02



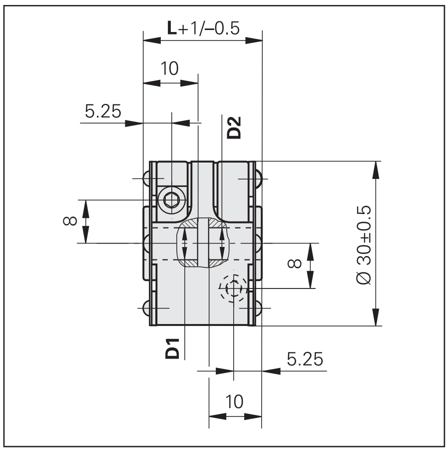
Diaphragm coupling K 14
For ROC/ROQ/ROD 400 and
RIC/RIQ 400 series
With **6 mm shaft diameter**
ID 293328-01



Recommended fit for the
mating shaft: h6

Diaphragm coupling K 17
with galvanic isolation
For ROC/ROQ/ROD 400 and
RIC/RIQ 400 series
With **6 or 10 mm shaft diameter**
ID 296746-xx

Suitable also for potentially explosive
atmospheres in zones 1, 2, 21 and 22



K 17 Variant	D1	**D2**	L
01	∅ 6 F7	**∅ 6 F7**	22 mm
02	∅ 6 F7	**∅ 10 F7**	22 mm
03	∅ 10 F7	**∅ 10 F7**	30 mm
04	∅ 10 F7	**∅ 10 F7**	22 mm
05	∅ 6 F7	**∅ 9.52 F7**	22 mm
06	∅ 5 F7	**∅ 6 F7**	22 mm

mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Safety-related position measuring systems

With the designation **Functional Safety**, HEIDENHAIN offers encoders that can be used in safety-related applications. These encoders operate as single-encoder systems with purely serial data transmission via EnDat 2.2. Reliable transmission of the position is based on two independently generated absolute position values and on error bits. These are then provided to the safe control.

Basic principle
HEIDENHAIN measuring systems for safety-related applications are tested for compliance with EN ISO 13849-1 (successor to EN 954-1) as well as EN 61508 and EN 61800-5-2. These standards describe the assessment of safety-related systems, for example based on the failure probabilities of integrated components and subsystems. This modular approach helps the manufacturers of safety-related systems to implement their complete systems, because they can begin with subsystems that have already been qualified. Safety-related position measuring systems with purely serial data transmission via EnDat 2.2 accommodate this technique. In a safe drive, the safety-related position measuring system is such a subsystem. A **safety-related position measuring system** consists of:
- Encoder with EnDat 2.2 transmission component
- Data transfer line with EnDat 2.2 communication and HEIDENHAIN cable
- EnDat 2.2 receiver component with monitoring function (EnDat master)

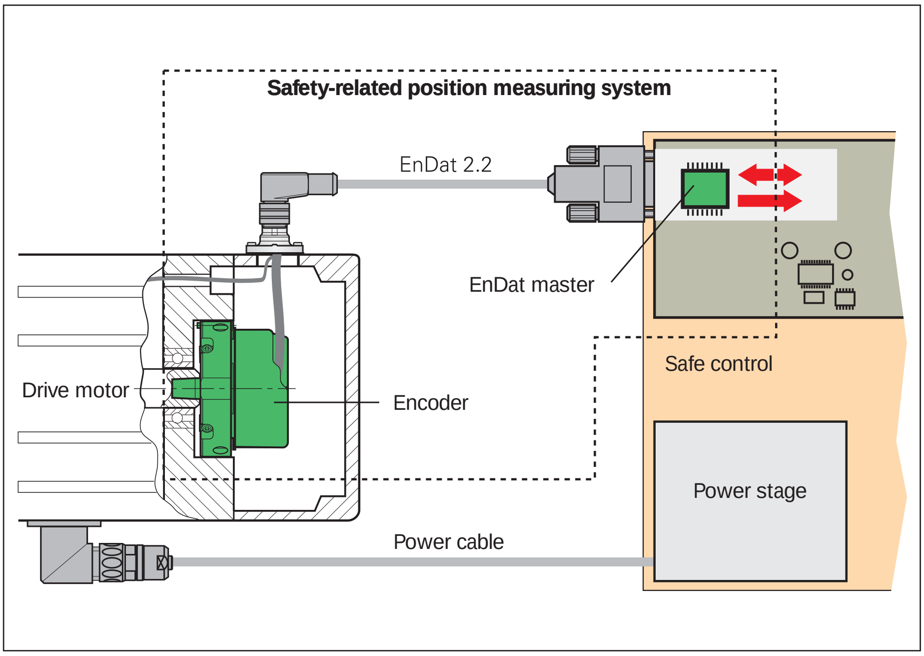
In practice, the **complete "safe servo drive" system** consists of:
- Safety-related position measuring system
- Safety-related control (including EnDat master with monitoring functions)
- Power stage with motor power cable and drive
- Physical connection between encoder and drive (e.g. rotor/stator connection)

Field of application
Safety-related position measuring systems from HEIDENHAIN are designed so that they can be used as single-encoder systems in applications with control category SIL-2 (according to EN 61508), performance level "d", category 3 (according to EN ISO 13849).

Additional measures in the control make it possible to use certain encoders for applications up to SIL-3, PL "e", category 4. The suitability of these encoders is indicated appropriately in the documentation (catalogs / product information sheets). The functions of the safety-related position measuring system can be used for the following safety tasks in the complete system (also see EN 61800-5-2):

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

Safety functions according to EN 61800-5-2



Complete safe drive system

Function
The safety strategy of the position measuring system is based on two mutually independent position values and additional error bits produced in the encoder and transmitted over the EnDat 2.2 protocol to the EnDat master. The EnDat master assumes various monitoring functions with which errors in the encoder and during transmission can be revealed. The two position values are then compared. The EnDat master then makes the data available to the safe control. The control periodically tests the safety-related position measuring system to monitor its correct operation. The architecture of the EnDat 2.2 protocol makes it possible to process all safety-relevant information and control mechanisms during unconstrained controller operation. This is possible because the safety-relevant information is saved in the additional information. According to EN 61508, the architecture of the position measuring system is regarded as a single-channel tested system.

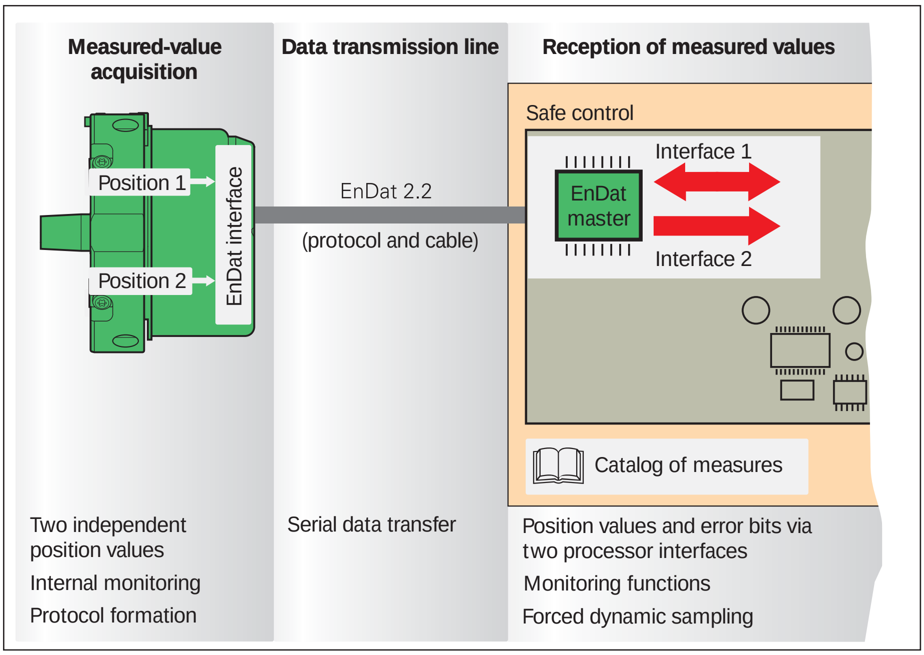
Documentation on the integration of the position measuring system
The intended use of position measuring systems places demands on the control, the machine designer, the installation technician, service, etc. The necessary information is provided in the documentation for the position measuring systems.

In order to be able to implement a position measuring system in a safety-related application, a suitable control is required. The control assumes the fundamental task of communicating with the encoder and safely evaluating the encoder data.

The requirements for integrating the EnDat master with monitoring functions in the safe control are described in the HEIDENHAIN document 533095. It contains, for example, specifications on the evaluation and processing of position values and error bits, and on electrical connection and cyclic tests of position measuring systems. Document 1000344 describes additional measures that make it possible to use suitable encoders for applications up to SIL-3, PL "e", category 4.

Machine and plant manufacturers need not attend to these details. These functions must be provided by the control. Product information sheets, catalogs and mounting instructions provide information to aid the selection of a suitable encoder. The **product information sheets** and **catalogs** contain general data on function and application of the encoders as well as specifications and permissible ambient conditions. The **mounting instructions** provide detailed information on installing the encoders.

The architecture of the safety system and the diagnostic possibilities of the control may call for further requirements. **For example, the operating instructions of the control must explicitly state whether fault exclusion is required for the loosening of the mechanical connection between the encoder and the drive.** The machine designer is obliged to inform the installation technician and service technicians, for example, of the resulting requirements.



Safety-related position measuring system

For more information on the topic of functional safety, refer to the technical information documents *Safety-Related Position Measuring Systems* and *Safety-Related Control Technology* as well as the product information document of the functional safety encoders.

General mechanical information

UL certification
All rotary encoders and cables in this brochure comply with the UL safety regulations for the USA and the "CSA" safety regulations for Canada.

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

- **Vibration**
  The encoders are qualified on a test stand to operate with the specified acceleration values at frequencies from 55 to 2000 Hz in accordance with EN 60068-2-6. However, if the application or poor mounting causes long-lasting resonant vibration, it can limit performance or even damage the encoder. **Comprehensive tests of the entire system are required.**
- **Shock**
  The encoders are qualified on a test stand for non-repetitive semi-sinusoidal shock to operate with the specified acceleration values and duration in accordance with EN 60068-2-27. This does not include **permanent shock loads**, which **must be tested in the application.**
- The **maximum angular acceleration** is 10^5 rad/s^2 (DIN 32878). This is the highest permissible acceleration at which the rotor will rotate without damage to the encoder. The actually attainable angular acceleration lies in the same order of magnitude (for deviating values for ECN/ERN 100 see *Specifications)*, but it depends on the type of shaft connection. A sufficient safety factor is to be determined through system tests.

Humidity
The max. permissible relative humidity is 75%. 93% is permissible temporarily. Condensation is not permissible.

Magnetic fields
Magnetic fields > 30 mT can impair proper function of encoders. If required, please contact HEIDENHAIN, Traunreut.

RoHS
HEIDENHAIN has tested the products for harmlessness of the materials as per European Directives 2002/95/EC (RoHS) and 2002/96/EC (WEEE). For a Manufacturer Declaration on RoHS, please refer to your sales agency.

Natural frequencies
The rotor and the couplings of ROC/ROQ/ROD and RIC/RIQ 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/RIC/RIQ 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 of the coupling in Hz
C: Torsional 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 rigidity of the encoder bearings and the encoder stators is also significant. If such loads occur in your application, HEIDENHAIN recommends consulting with the main facility in Traunreut.

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

Protection (EN 60529)
Unless otherwise indicated, all rotary encoders meet protection standard IP 64 (ExN/ROx 400: IP 67) according to EN 60529. This includes housings, cable outlets and flange sockets when the connector is fastened.
The **shaft inlet** provides protection to IP 64. 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.

Running noise
Running noise can occur during operation, particularly when encoders with integral bearing or multiturn rotary encoders (with gears) are used. The intensity may vary depending on the mounting situation and the speed.

Expendable parts
Encoders from HEIDENHAIN are designed for a long service life. Preventive maintenance is not required. They contain components that are subject to wear, depending on the application and manipulation. These include in particular cables with frequent flexing.
Other such components are the bearings of encoders with integral bearing, shaft sealing rings on rotary and angle encoders, and sealing lips on sealed linear encoders.

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 shown in this 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.

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.

Changes to the encoder
The correct operation and accuracy of encoders from HEIDENHAIN is ensured only if they have not been modified. Any changes, even minor ones, can impair the operation and reliability of the encoders, and result in a loss of warranty. This also includes the use of additional retaining compounds, lubricants (e.g. for screws) or adhesives not explicitly prescribed. In case of doubt, we recommend contacting HEIDENHAIN in Traunreut.

Temperature ranges
For the unit in its packaging, the **storage temperature range** is –30 °C to 80 °C (HR 1120: –30 °C to 70 °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 32878). 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). Temporarily increased self-heating can also occur after very long breaks in operation (of several months). Please take a two-minute run-in period at low speeds into account. Higher heat generation in the encoder means that a lower ambient temperature is required to keep the encoder within its permissible operating temperature range.

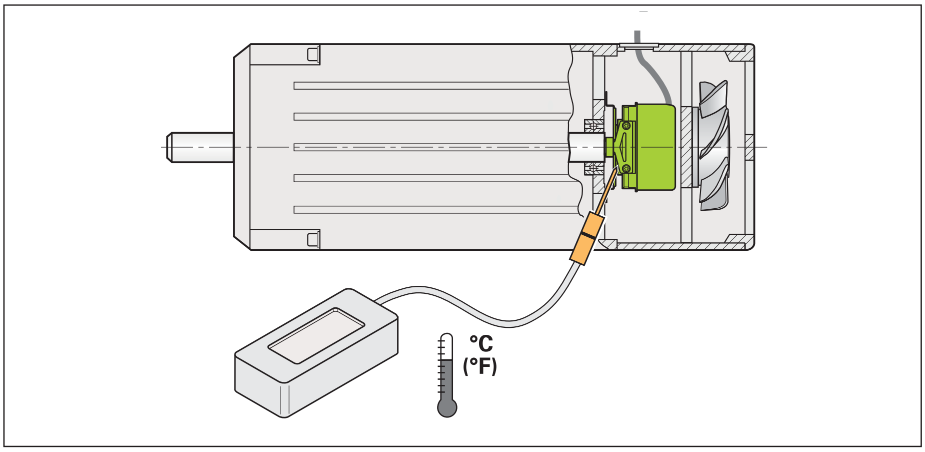
These tables show the approximate values of self-heating to be expected in the encoders. In the worst case, a combination of operating parameters can exacerbate self-heating, for example a 30 V power supply and maximum rotational speed. Therefore, the actual operating temperature should be measured directly 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/RIC/RIQ	Approx. + 5 K	Approx. + 10 K

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

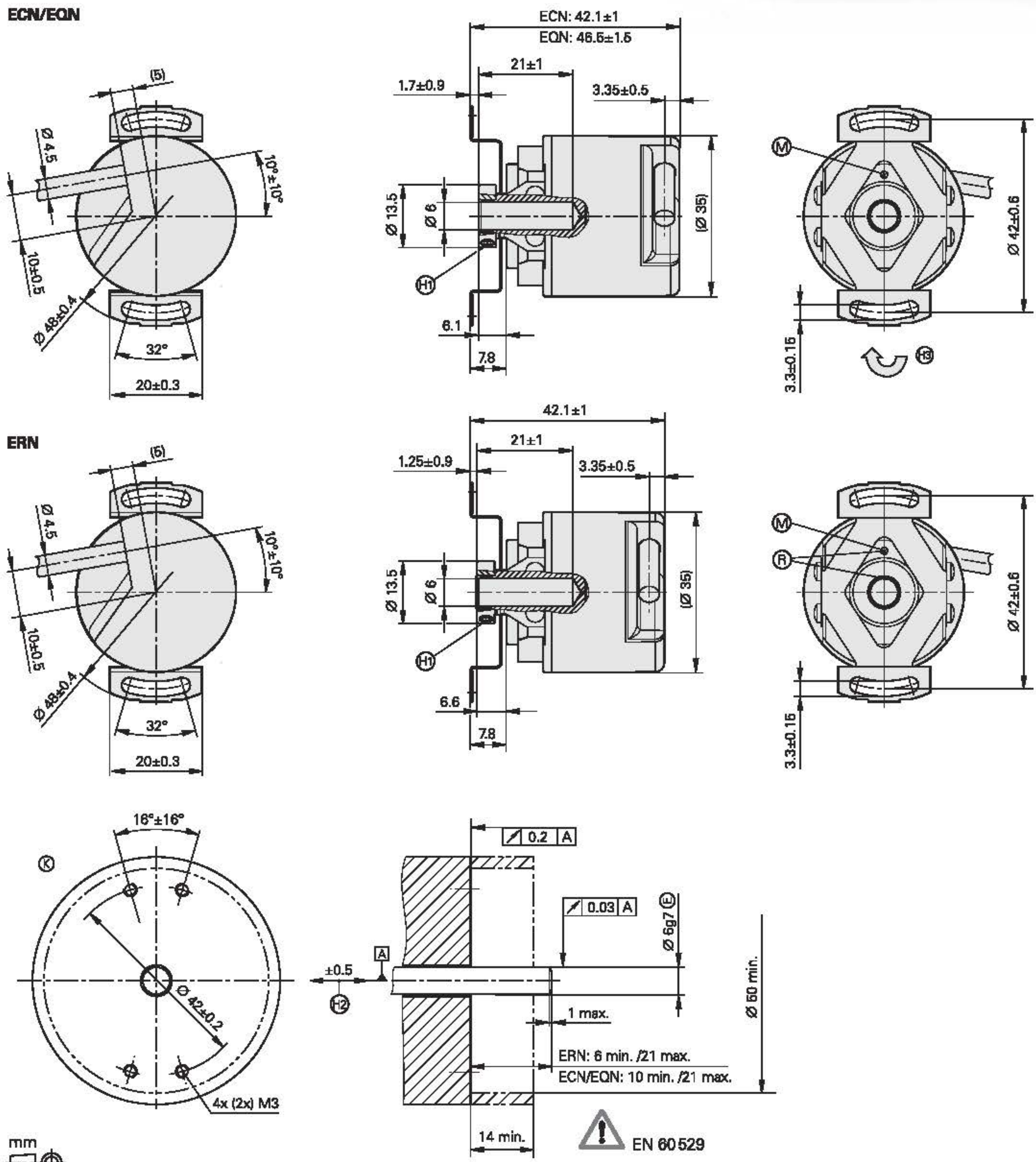
An encoder's typical self-heating values depend on its design characteristics at maximum permissible speed. The correlation between rotational speed and heat generation is nearly linear.



Measuring the actual operating temperature at the defined measuring point of the rotary encoder (see *Specifications*)

ECN/EQN/ERN 1000 series

- **Absolute and incremental rotary encoders**
- **Stator coupling for plane surface**
- **Blind hollow shaft**



mm

Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Ⓐ = Bearing of mating shaft
Ⓚ = Required mating dimensions
Ⓜ = Measuring point for operating temperature
Ⓡ = Reference mark position ± 20°
H1 = 2 screws in clamping ring. Tightening torque 0.6±0.1 Nm, width across flats 1.5
H2 = Compensation of mounting tolerances and thermal expansion, no dynamic motion
H4 = Direction of shaft rotation for output signals as per the interface description

	Incremental				
	ERN 1020	**ERN 1030**	**ERN 1080**	**ERN 1070**	
Incremental signals	TTL	HTLs	∼ 1 V_{PP}[1)]	TTL	
Line counts*	100 200 **250** 360 400 **500** 720 900 **1000** **1024** 1250 1500 2000 **2048** **2500** **3600**			**1000** **2500** **3600**	
Reference mark	One				
Integrated interpolation*	–			5-fold	10-fold
Cutoff frequency –3 dB Scanning frequency Edge separation a	– ≤ 300 kHz ≥ 0.39 µs	– ≤ 160 kHz ≥ 0.76 µs	≥ 180 kHz – –	– ≤ 100 kHz ≥ 0.47 µs	– ≤ 100 kHz ≥ 0.22 µs
System accuracy	1/20 of grating period				
Power supply **Current consumption** without load	5 V DC ± 10 % ≤ 120 mA	10 to 30 V DC ≤ 150 mA	5 V DC ± 10 % ≤ 120 mA	5 V DC ± 5 % ≤ 155 mA	
Electrical connection*	**Cable 1 m**/5 m, with or **without coupling** M23			**Cable 5 m without** M23 **coupling**	
Shaft	Blind hollow shaft D = 6 mm				
Mech. permiss. speed n	≤ 12000 min^{-1}				
Starting torque	≤ 0.001 Nm (at 20 °C)				
Moment of inertia of rotor	$\leq 0.5 \cdot 10^{-6}$ kgm^2				
Permissible axial motion of measured shaft	± 0.5 mm				
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)				
Max. operating temp.[2)]	100 °C	70 °C	100 °C	70 °C	
Min. operating temp.	*Fixed cable:* –30 °C *Moving cable:* –10 °C				
Protection EN 60529	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*

	**Absolute** **Singleturn** **ECN 1023**	**ECN 1013**
Absolute position values	**EnDat 2.2**	
Ordering designation	EnDat 22	EnDat 01
Positions per revolution	8388608 (23 bits)	8192 (13 bits)
Revolutions	–	
Code	Pure binary	
Elec. permissible speed Deviations[1]	12000 min^{-1} (for continuous position value)	4000 min^{-1}/12000 min^{-1} ± 1 LSB/± 16 LSB
Calculation time t_{cal} Clock frequency	≤ 7 µs ≤ 8 MHz	≤ 9 µs ≤ 2 MHz
Incremental signals	–	∼ 1 V_{PP}[2]
Line count	–	512
Cutoff frequency –3 dB	–	≥ 190 kHz
System accuracy	± 60"	
Power supply	3.6 to 14 V DC	
Power consumption (max.)	*3.6 V:* ≤ 600 mW *14 V:* ≤ 700 mW	
Current consumption (typical; without load)	*5 V:* 85 mA	
Electrical connection	Cable 1 m, with M12 coupling	Cable 1 m, with M23 coupling
Shaft	Blind hollow shaft ∅ 6 mm	
Mech. permiss. speed n	12000 min^{-1}	
Starting torque	≤ 0.001 Nm (at 20 °C)	
Moment of inertia of rotor	Approx. $0.5 \cdot 10^{-6}$ kgm^2	
Permissible axial motion of measured shaft	± 0.5 mm	
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)	
Max. operating temp.	100 °C	
Min. operating temp.	*Fixed cable:* –30 °C *Moving cable:* –10 °C	
Protection EN 60529	IP 64	
Weight	Approx. 0.1 kg	

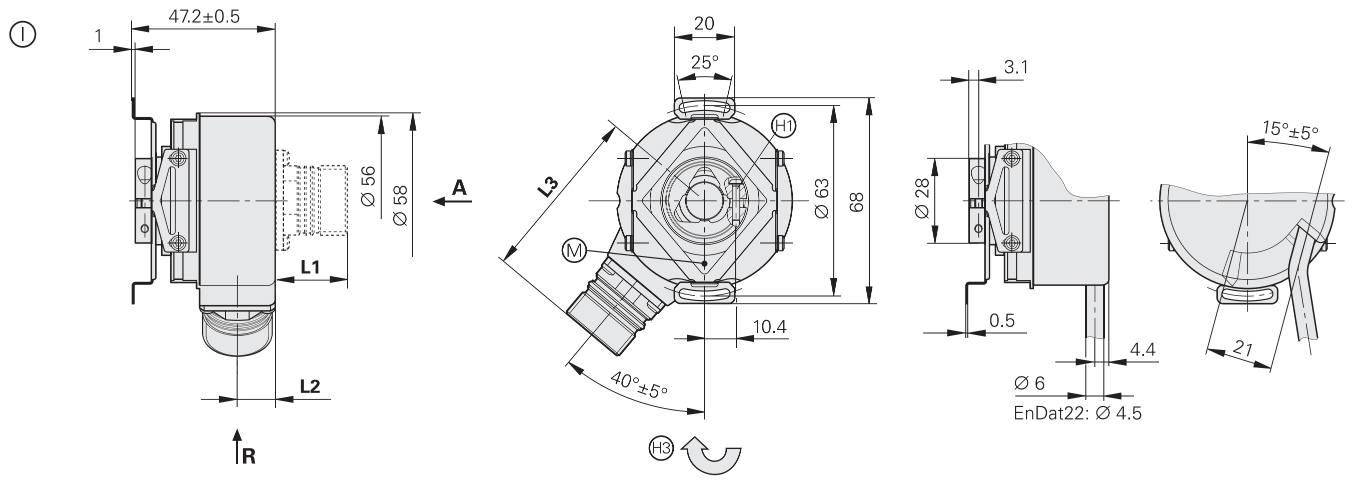
[1] Speed-dependent deviations between the absolute and incremental signals
[2] Restricted tolerances: Signal amplitude 0.80 to 1.2 V_{PP}

	Multiturn	
	EQN 1035	**EQN 1025**
	EnDat 22	EnDat 01
	8388608 (23 bits)	8192 (13 bits)
	4096 (12 bits)	
	12000 min^{-1} (for continuous position value)	4000 min^{-1}/12000 min^{-1} ± 1 LSB/± 16 LSB
	≤ 7 µs ≤ 8 MHz	≤ 9 µs ≤ 2 MHz
	–	∿ 1 V_{PP} 2)
	–	512
	–	≥ 190 kHz
	3.6 V: ≤ 700 mW *14 V:* ≤ 800 mW	
	5 V: 105 mA	
	Cable 1 m, with M12 coupling	Cable 1 m, with M23 coupling
	≤ 0.002 Nm (at 20 °C)	

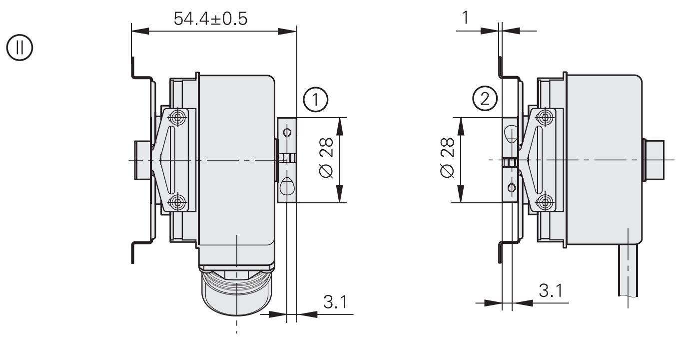
ECN/EQN/ERN 400 series

- Absolute and incremental rotary encoders
- Stator coupling for plane surface
- Blind hollow shaft or hollow through shaft

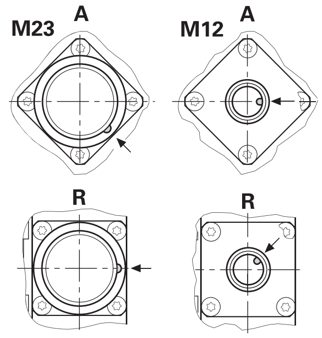
Blind hollow shaft

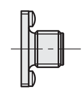
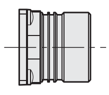


Hollow through shaft

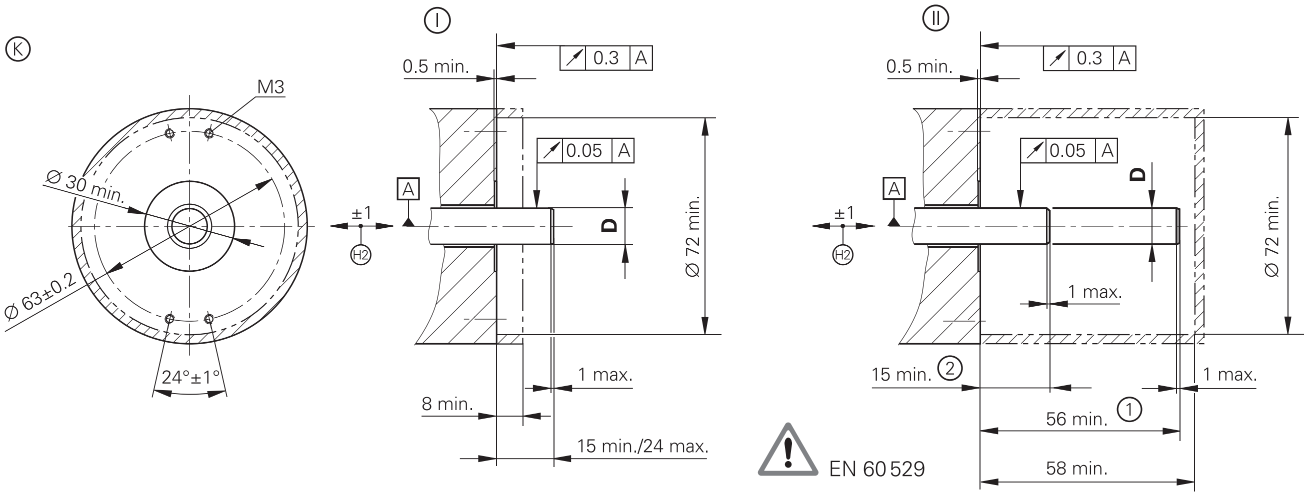


Connector coding
A = axial, **R** = radial



	Flange socket	
	M12	M23
		
L1	14	23.6
L2	12.5	12.5
L3	48.5	58.1

D
Ø 8g7 Ⓔ
Ø 12g7 Ⓔ



mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Cable radial, also usable axially
A = Bearing of mating shaft
K = Required mating dimensions
M = Measuring point for operating temperature
H1 = Clamping screw with X8 hexalobular socket
H2 = Compensation of mounting tolerances and thermal expansion, no dynamic motion permitted
H3 = Direction of shaft rotation for output signals as per the interface description
1 = Clamping ring on housing side (condition upon delivery)
2 = Clamping ring on coupling side (optionally mountable)

	Incremental			
	ERN 420	**ERN 460**	**ERN 430**	**ERN 480**
Incremental signals	⊓⊔ TTL		⊓⊔ HTL	∼ 1 V_{PP}[1]
Line counts*	250 500			–
	1000 1024 1250 2000 2048 2500 3600 4096 5000			
Reference mark	One			
Cutoff frequency –3 dB Scanning frequency Edge separation a	– ≤ 300 kHz ≥ 0.39 µs			≥ 180 kHz – –
System accuracy	1/20 of grating period			
Power supply **Current consumption** without load	5 V DC ± 10 % ≤ 120 mA	10 to 30 V DC ≤ 100 mA	10 to 30 V DC ≤ 150 mA	5 V DC ± 10 % ≤ 120 mA
Electrical connection*	• **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 = 8 mm** or **D = 12 mm**			
Mech. permissible speed n[2]	≤ 6000 min^{-1}/≤ 12000 min^{-1} [3]			
Starting torque At 20 °C Below –20 °C	*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			
Permissible axial motion of measured shaft	± 1 mm			
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2; *flange socket version:* 150 m/s^2 (EN 60068-2-6); higher values on request ≤ 1000 m/s^2 (EN 60068-2-27)			
Max. operating temp.[2]	100 °C	70 °C	100 °C[4]	
Min. operating temp.	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C			
Protection EN 60529	IP 67 at housing (IP 66 with hollow through shaft); IP 64 at shaft inlet			
Weight	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 supply voltage, see *General mechanical information*
[3] With two shaft clamps (only for hollow through shaft)
[4] 80° for ERN 480 with 4096 or 5000 lines

	Absolute Singleturn ECN 425	ECN 413	
Absolute position values*	**EnDat 2.2**	**EnDat 2.2**	**SSI**
Ordering designation	EnDat 22	EnDat 01	SSI 39r1
Positions per revolution	33554432 (25 bits)	8192 (13 bits)	
Revolutions	–		
Code	Pure binary		Gray
Elec. permissible speed Deviations[1]	≤ 12000 min^{-1} for continuous position value	*512 lines:* ≤ 5000/12000 min^{-1} ± 1 LSB/± 100 LSB *2048 lines:* ≤ 1500/12000 min^{-1} ± 1 LSB/± 50 LSB	≤ 12000 min^{-1} ± 12 LSB
Calculation time t_{cal} Clock frequency	≤ 7 µs ≤ 8 MHz	≤ 9 µs ≤ 2 MHz	≤ 5 µs –
Incremental signals	Without	∿ 1 V_{PP}[2]	
Line counts*	–	**512** 2048	**512**
Cutoff frequency –3 dB Scanning frequency Edge separation a	– – –	*512 lines:* ≥ 130 kHz; *2048 lines:* ≥ 400 kHz – –	
System accuracy	± 20“	*512 lines:* ± 60“; *2048 lines:* ± 20“	
Power supply*	**3.6 to 14 V DC**	**3.6 to 14 V DC**	5 V DC ± 5% or **10 to 30 V DC**
Power consumption (max.)	*3.6 V:* ≤ 600 mW *14 V:* ≤ 700 mW		*5 V:* ≤ 800 mW *10 V:* ≤ 650 mW *30 V:* ≤ 1000 mW
Current consumption (typical; without load)	*5 V:* 85 mA		*5 V:* 90 mA *24 V:* 24 mA
Electrical connection*	• **Flange socket** M12, radial • Cable 1 m, with M12 coupling	• **Flange socket** M23, radial • Cable 1 m, with M23 coupling or without connecting element	
Shaft*	**Blind hollow shaft** or **hollow through shaft; D = 8 mm** or **D = 12 mm**		
Mech. perm. speed n[3]	≤ 6000 min^{-1}/≤ 12000 min^{-1}[4]		
Starting torque At 20 °C Below –20 °C	*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		
Permissible axial motion of measured shaft	± 1 mm		
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2; *flange socket version:* ≤ 150 m/s^2 (EN 60068-2-6); higher values on request ≤ 1000 m/s^2 (EN 60068-2-27)		
Max. operating temp.[3]	100 °C		
Min. operating temp.	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C		
Protection EN 60529	IP 67 at housing; IP 64 at shaft inlet		
Weight	Approx. 0.3 kg		

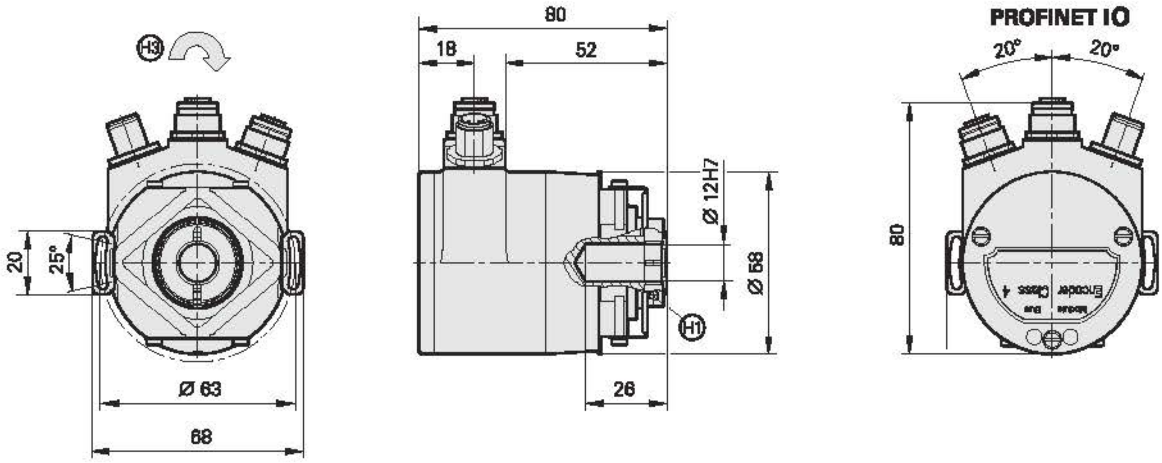
Bold: These preferred versions are available on short notice
***** Please select when ordering
[1] Speed-dependent deviations between the absolute value and incremental signal

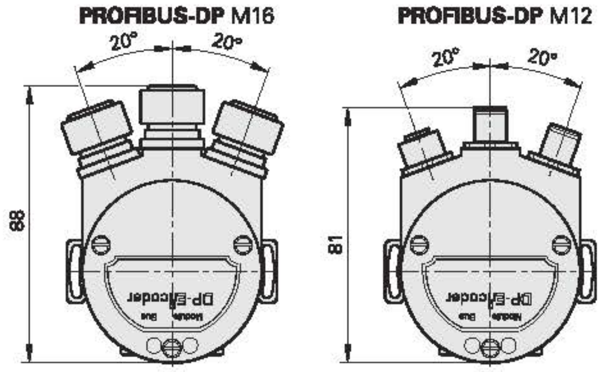
Multiturn		
EQN 437	**EQN 425**	
EnDat 2.2	**EnDat 2.2**	**SSI**
EnDat 22	EnDat 01	SSI 41r1
33554432 (25 bits)	8192 (13 bits)	
4096		
Pure binary		Gray
≤ 12000 min^{-1} for continuous position value	*512 lines:* ≤ 5000/10000 min^{-1} ± 1 LSB/± 100 LSB *2048 lines:* ≤ 1500/10000 min^{-1} ± 1 LSB/± 50 LSB	≤ 12000 min^{-1} ± 12 LSB
≤ 7 µs ≤ 8 MHz	≤ 9 µs ≤ 2 MHz	≤ 5 µs –
Without	∿ 1 V_{PP} [2)]	
–	**512** 2048	**512**
– – –	*512 lines:* ≥ 130 kHz; *2048 lines:* ≥ 400 kHz – –	
± 20“	*512 lines:* ± 60“; *2048 lines:* ± 20“	
3.6 to 14 V DC	**3.6 to 14 V DC**	5 V DC ± 5 % or **10 to 30 V DC**
3.6 V: ≤ 700 mW *14 V:* ≤ 800 mW		*5 V:* ≤ 950 mW *10 V:* ≤ 750 mW *30 V:* ≤ 1100 mW
5 V: 105 mA		*5 V:* 120 mA *24 V:* 28 mA
• **Flange socket** M12, radial • Cable 1 m, with M12 coupling	• **Flange socket** M23, radial • Cable 1 m, with M23 coupling or without connecting element	

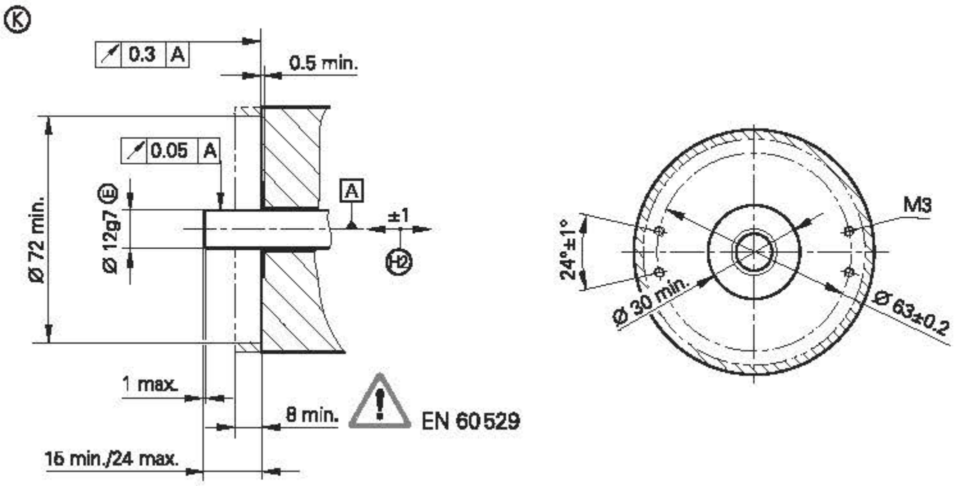
2) Restricted tolerances: Signal amplitude: 0.8 to 1.2 V_{PP}
3) For the correlation between the operating temperature and the shaft speed or power supply, see *General mechanical information*
4) With 2 shaft clamps (only for hollow through shaft)

ECN/EQN 400 series

- Absolute rotary encoders
- Stator coupling for plane surface
- Blind hollow shaft
- Field bus interface







A = Bearing of mating shaft
K = Required mating dimensions
H1 = Clamping screw with X8 hexalobular socket. Tightening torque 1.1±0.1 Nm
H2 = Compensation of mounting tolerances and thermal expansion, no dynamic motion permitted
H3 = Direction of shaft rotation for output signals as per the interface description

mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

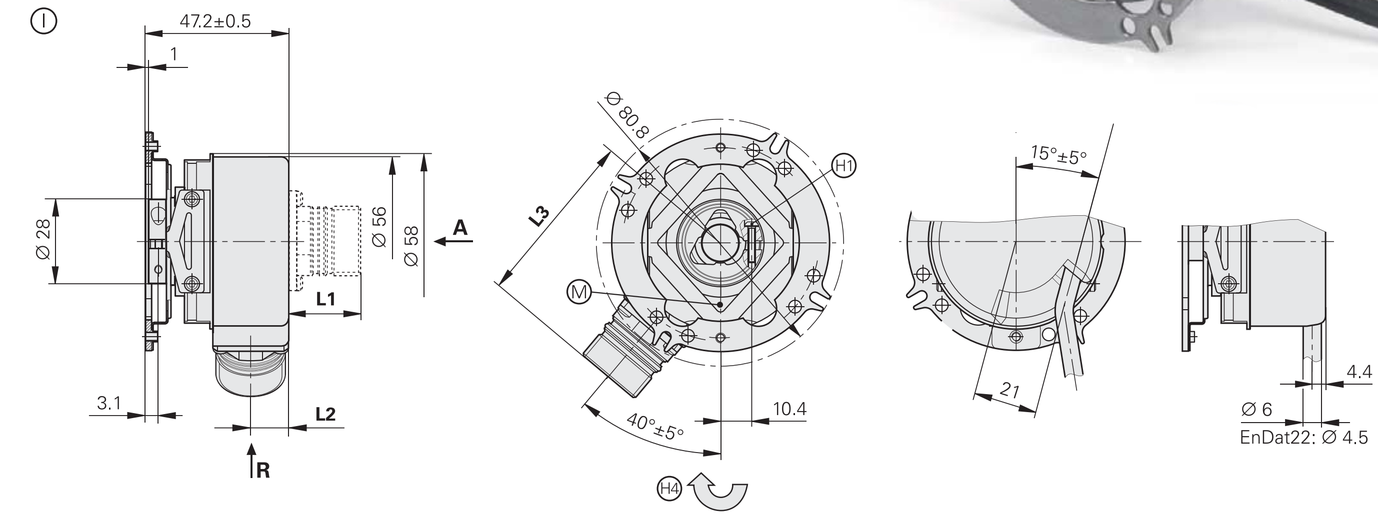
	Singleturn **ECN 413**		**Multiturn** **EQN 425**	
Absolute position values*	**PROFIBUS-DP**	**PROFINET IO**	**PROFIBUS-DP**	**PROFINET IO**
Positions per revolution	8192 (13 bits)			
Revolutions	–		4096	
Code	Pure binary			
Elec. permissible speed Deviations[1]	≤ 4000/15000 min^{-1} ± 400 LSB/± 800 LSB		≤ 5000/10000 min^{-1} ± 1 LSB/± 100 LSB	
Incremental signals	Without			
System accuracy	± 60“			
Power supply	**9 to 36 V DC**	**10 to 30 V DC**	**9 to 36 V DC**	**10 to 30 V DC**
Power consumption (max.)	*9 V:* ≤ 3.38 mW *36 V:* ≤ 3.84 mW			
Current consumption (typical; without load)	*24 V:* 125 mA			
Electrical connection*	• **Three flange sockets** M12, radial • M16 cable gland	**Three flange sockets** M12, radial	• **Three flange sockets** M12, radial • M16 cable gland	**Three flange sockets** M12, radial
Shaft	Blind hollow shaft, D = 12 mm			
Mech. permissible speed n[2]	≤ 6000 min^{-1}			
Starting torque At 20 °C Below –20 °C	≤ 0.01 Nm ≤ 1 Nm			
Moment of inertia of rotor	≤ $4.3 \cdot 10^{-6}$ kgm^2			
Permissible axial motion of measured shaft	± 1 mm			
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)			
Max. operating temp.[3]	70 °C			
Min. operating temp.	–40 °C			
Protection EN 60529	IP 67 at housing; IP 64 at shaft inlet			
Weight	Approx. 0.3 kg			

Bold: These preferred versions are available on short notice
***** Please select when ordering
[1] Speed-dependent deviations between the absolute value and incremental signal
[2] For the correlation between the operating temperature and the shaft speed or supply voltage, see *General mechanical information*

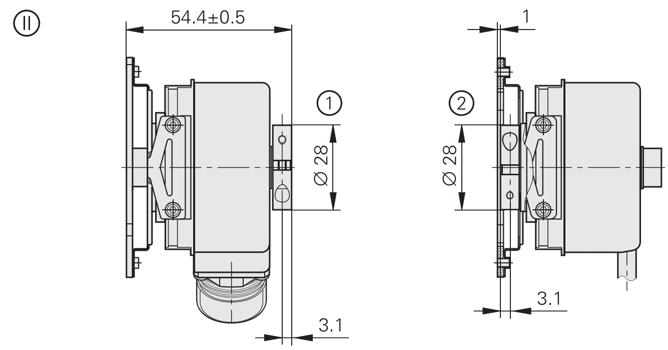
ECN/EQN/ERN 400 series

- Absolute and incremental rotary encoders
- Stator coupling for universal mounting
- Blind hollow shaft or hollow through shaft

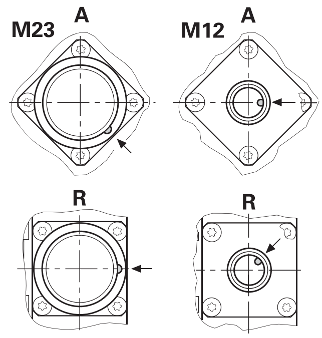
Blind hollow shaft

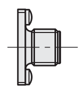
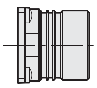


Hollow through shaft

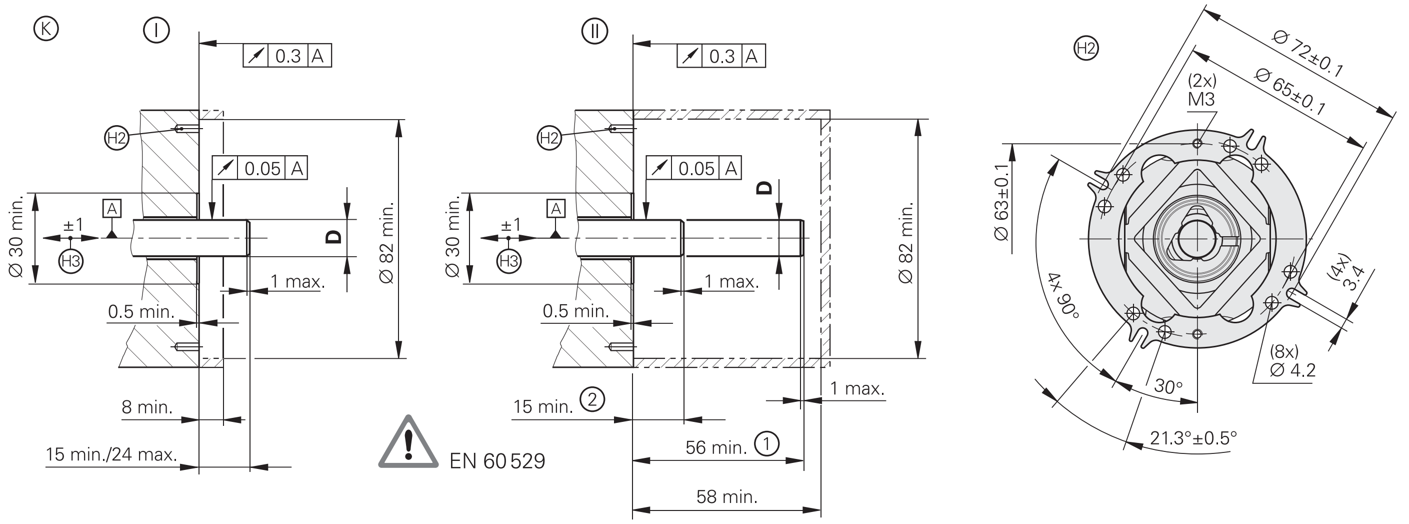


Connector coding
A = axial, **R** = radial



	Flange socket	
	M12 	**M23** 
L1	14	23.6
L2	12.5	12.5
L3	48.5	58.1

D
Ø 8g7 Ⓔ
Ø 12g7 Ⓔ



mm

Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Cable radial, also usable axially
Ⓐ = Bearing of mating shaft
Ⓚ = Required mating dimensions
Ⓜ = Measuring point for operating temperature
Ⓗ1 = Clamping screw with X8 hexalobular socket
Ⓗ2 = Hole circle for fastening, see coupling
Ⓗ3 = Compensation of mounting tolerances and thermal expansion, no dynamic motion permitted
Ⓗ4 = Direction of shaft rotation for output signals as per the interface description
① = Clamping ring on housing side (condition upon delivery)
② = Clamping ring on coupling side (optionally mountable)

	Incremental			
	ERN 420	**ERN 460**	**ERN 430**	**ERN 480**
Incremental signals	⊓⊔TTL		⊓⊔HTL	∿ 1 V_{PP}[1)]
Line counts*	250 500			–
	1000 1024 1250 2000 2048 2500 3600 4096 5000			
Reference mark	One			
Cutoff frequency –3 dB Scanning frequency Edge separation a	– ≤ 300 kHz ≥ 0.39 µs			≥ 180 kHz – –
System accuracy	1/20 of grating period			
Power supply **Current consumption** without load	5 V DC ± 10 % ≤ 120 mA	10 to 30 V DC ≤ 100 mA	10 to 30 V DC ≤ 150 mA	5 V DC ± 10 % ≤ 120 mA
Electrical connection*	• **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 = 8 mm** or **D = 12 mm**			
Mech. permissible speed n[2)]	≤ 6000 min^{-1}/≤ 12000 min^{-1} [3)]			
Starting torque At 20 °C Below –20 °C	*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			
Permissible axial motion of measured shaft	± 1 mm			
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2; *flange socket version:* 150 m/s^2 (EN 60068-2-6); higher values on request ≤ 1000 m/s^2 (EN 60068-2-27)			
Max. operating temp.[2)]	100 °C	70 °C	100 °C[4)]	
Min. operating temp.	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C			
Protection EN 60529	*At housing:* IP 67 (IP 66 for hollow through shaft) *At shaft inlet:* IP 64 (IP 66 available on request)			
Weight	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 supply voltage, see *General mechanical information*
[3)] With two shaft clamps (only for hollow through shaft)
[4)] 80° for ERN 480 with 4096 or 5000 lines

	Absolute **Singleturn** **ECN 425**	**ECN 413**	**ECN 413**
Absolute position values*	**EnDat 2.2**	**EnDat 2.2**	**SSI**
Ordering designation	EnDat 22	EnDat 01	SSI 39r1
Positions per revolution	33554432 (25 bits)	8192 (13 bits)	
Revolutions	–		
Code	Pure binary		Gray
Elec. permissible speed Deviations[1]	≤ 12000 min^{-1} for continuous position value	*512 lines:* ≤ 5000/12000 min^{-1} ± 1 LSB/± 100 LSB *2048 lines:* ≤ 1500/12000 min^{-1} ± 1 LSB/± 50 LSB	≤ 12000 min^{-1} ± 12 LSB
Calculation time t_{cal} Clock frequency	≤ 7 µs ≤ 8 MHz	≤ 9 µs ≤ 2 MHz	≤ 5 µs –
Incremental signals	Without	∼ 1 V_{PP}[2]	
Line counts*	–	**512** 2048	**512**
Cutoff frequency –3 dB Scanning frequency Edge separation a	– – –	*512 lines:* ≥ 130 kHz; *2048 lines:* ≥ 400 kHz – –	
System accuracy	± 20"	*512 lines:* ± 60"; *2048 lines:* ± 20"	
Power supply*	**3.6 to 14 V DC**	**3.6 to 14 V DC**	5 V DC ± 5% or **10 to 30 V DC**
Power consumption (max.)	*3.6 V:* ≤ 600 mW *14 V:* ≤ 700 mW		*5 V:* ≤ 800 mW *10 V:* ≤ 650 mW *30 V:* ≤ 1000 mW
Current consumption (typical; without load)	*5 V:* 85 mA		*5 V:* 90 mA *24 V:* 24 mA
Electrical connection*	• **Flange socket** M12, radial • Cable 1 m, with M12 coupling	• **Flange socket** M23, radial • Cable 1 m, with M23 coupling or without connecting element	
Shaft*	**Blind hollow shaft** or **hollow through shaft; D = 8 mm** or **D = 12 mm**		
Mech. perm. speed n[3]	≤ 6000 min^{-1}/≤ 12000 min^{-1} [4]		
Starting torque At 20 °C Below –20 °C	*Blind hollow shaft:* ≤ 0.01 Nm *Hollow through shaft:* ≤ 0.025 Nm ≤ 1 Nm		
Moment of inertia of rotor	≤ 4.3 · 10^{-6} kgm^2		
Permissible axial motion of measured shaft	± 1 mm		
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2; *flange socket version:* 150 m/s^2 (EN 60068-2-6); higher values on request ≤ 1000 m/s^2 (EN 60068-2-27)		
Max. operating temp.[3]	100 °C		
Min. operating temp.	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C		
Protection EN 60529	IP 67 at housing, IP 64 at shaft end (IP 66 available on request)		
Weight	Approx. 0.3 kg		

Bold: This preferred version is available on short notice

[1] Speed-dependent deviations between the absolute value and incremental signal

***** Please indicate when ordering

[2] Restricted tolerances: Signal amplitude 0.8 to 1.2 V_{PP}

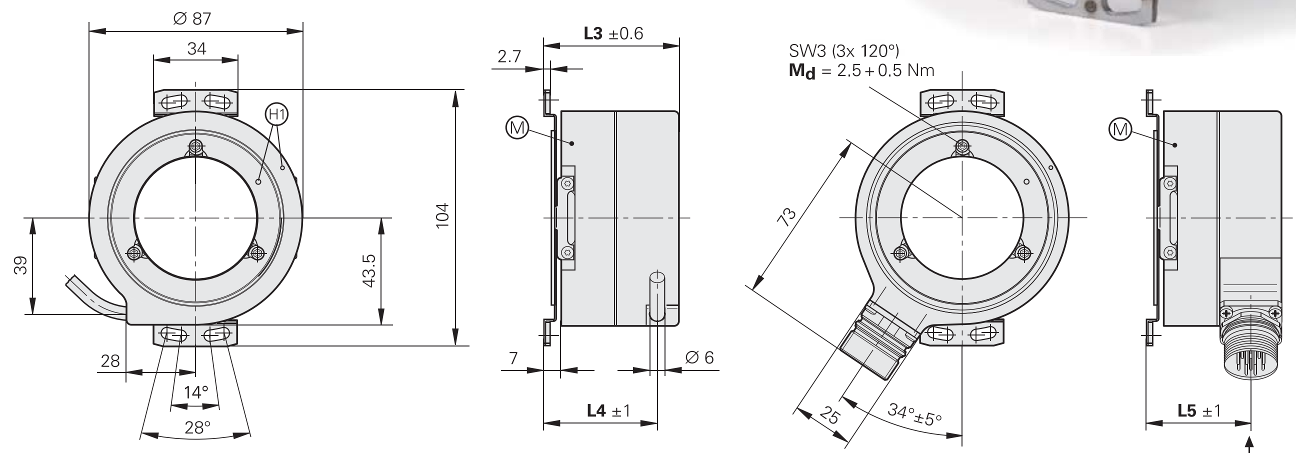
Multiturn		
EQN 437	**EQN 425**	**EQN 425**
EnDat 2.2	**EnDat 2.2**	**SSI**
EnDat 22	EnDat 01	SSI 41r1
33554432 (25 bits)	8192 (13 bits)	
4096		
Pure binary		Gray
≤ 12000 min^{-1} for continuous position value	*512 lines:* ≤ 5000/10000 min^{-1} ± 1 LSB/± 100 LSB *2048 lines:* ≤ 1500/10000 min^{-1} ± 1 LSB/± 50 LSB	≤ 12000 min^{-1} ± 12 LSB
≤ 7 µs ≤ 8 MHz	≤ 9 µs ≤ 2 MHz	≤ 5 µs –
Without	∿ 1 V_{PP}[2)]	
–	**512** 2048	**512**
– – –	*512 lines:* ≥ 130 kHz; *2048 lines:* ≥ 400 kHz – –	
± 20“	*512 lines:* ± 60“; *2048 lines:* ± 20“	
3.6 to 14 V DC	**3.6 to 14 V DC**	5 V DC ± 5 % or **10 to 30 V DC**
3.6 V: ≤ 700 mW *14 V:* ≤ 800 mW		*5 V:* ≤ 950 mW *10 V:* ≤ 750 mW *30 V:* ≤ 1100 mW
5 V: 105 mA		*5 V:* 120 mA *24 V:* 28 mA
• **Flange socket** M12, radial • Cable 1 m, with M12 coupling	• **Flange socket** M23, radial • Cable 1 m, with M23 coupling or without connecting element	

[3)] For the correlation between the operating temperature and the shaft speed or power supply, see *General mechanical information*
[4)] With 2 shaft clamps (only for hollow through shaft)

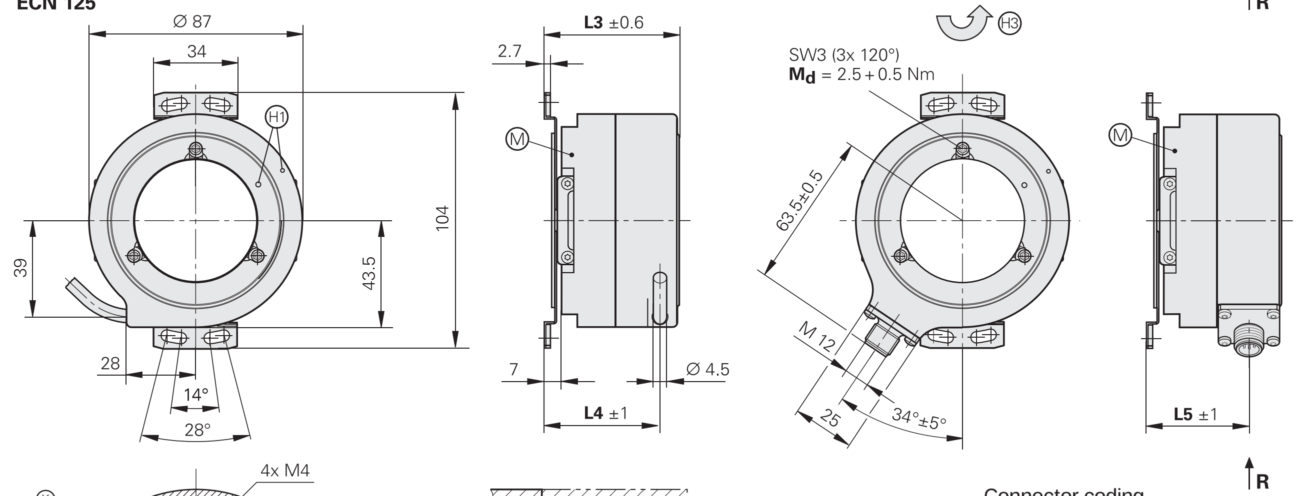
ECN/ERN 100 series

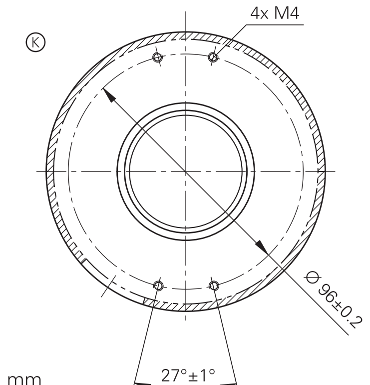
- **Absolute and incremental rotary encoders**
- **Stator coupling for plane surface**
- **Hollow through shaft**

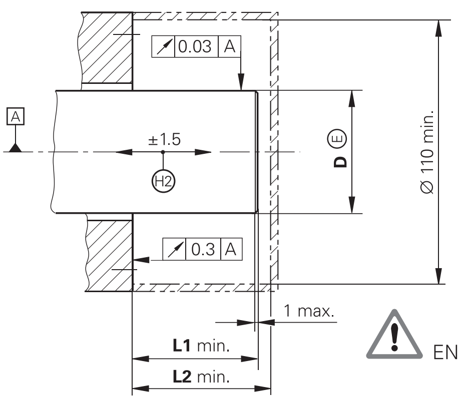
ERN 1x0/ECN 113



ECN 125



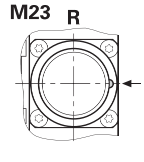




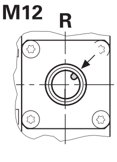
EN 60 529

Connector coding
R = radial

M23 **R**



M12 **R**



mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Cable radial, also usable axially
Ⓐ = Bearing
Ⓚ = Required mating dimensions
Ⓜ = Measuring point for operating temperature
Ⓗ1 = ERN: reference-mark position ± 15°; ECN: zero position ± 15°
Ⓗ2 = Compensation of mounting tolerances and thermal expansion, no dynamic motion
Ⓗ3 Direction of shaft rotation for output signals as per the interface description

D	L1	L2	L3	L4	L5
Ø 20h7	41	43.5	40	32	26.5
Ø 25h7	41	43.5	40	32	26.5
Ø 38h7	56	58.5	55	47	41.5
Ø 50h7	56	58.5	55	47	41.5

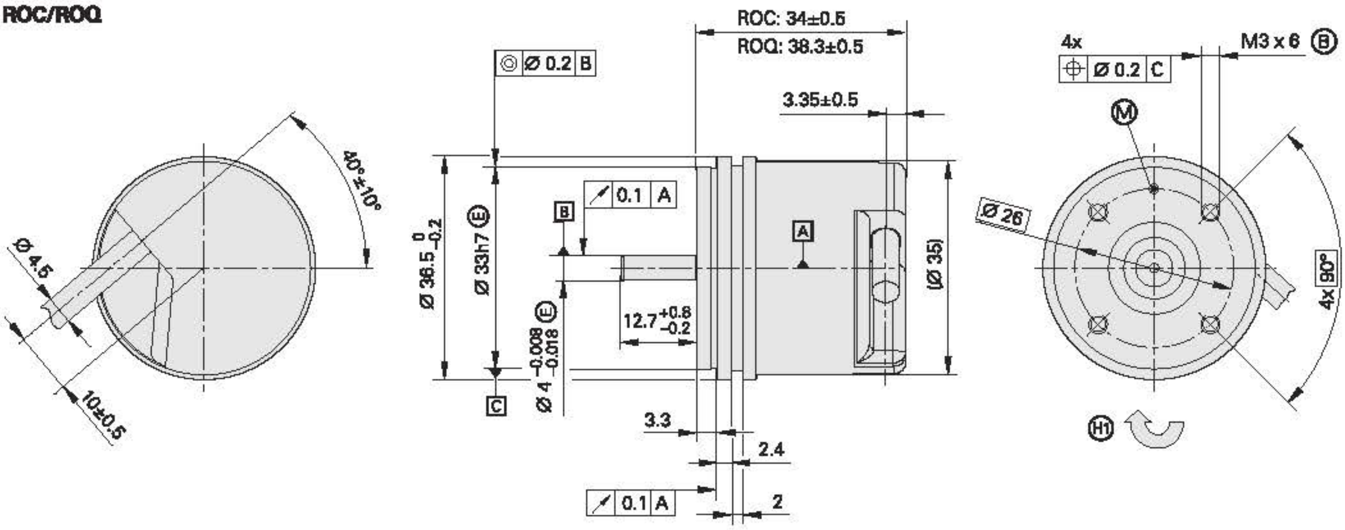
	Absolute		Incremental		
	Singleturn				
	ECN 125	**ECN 113**	**ERN 120**	**ERN 130**	**ERN 180**
Absolute position values*	**EnDat 2.2**	**EnDat 2.2**	**–**		
Ordering designation	EnDat 22	EnDat 01			
Positions per revolution	33 554 432 (25 bits)	8 192 (13 bits)	–		
Code	Pure binary		–		
Elec. permissible speed Deviations[1]	n_{max} for continuous position value	≤ 600 min^{-1}/n_{max} ± 1 LSB/± 50 LSB	–		
Calculation time t_{cal} Clock frequency	≤ 5 µs ≤ 8 MHz	≤ 0.25 µs ≤ 2 MHz	–		
Incremental signals	Without	∿ 1 V_{PP}[2]	⊓⊔ TTL	⊓⊔ HTL	∿ 1 V_{PP}[2]
Line counts*	–	**2048**	1000 **1024** 2048 2500 3600 **5000**		
Reference mark	–	–	One		
Cutoff frequency –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 DC ≤ 200 mA	5 V DC ± 5 % ≤ 180 mA	5 V DC ± 10 % ≤ 120 mA	10 to 30 V DC ≤ 150 mA	5 V DC ± 10 % ≤ 120 mA
Electrical connection*	• **Flange socket** M12, radial • Cable 1 m/5 m, with M12 coupling	• **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**				
Mech. perm. speed n[3]	*D > 30 mm:* ≤ 4 000 min^{-1} *D ≤ 30 mm:* ≤ 6 000 min^{-1}				
Starting torque At 20 °C	*D > 30 mm:* ≤ 0.2 Nm *D ≤ 30 mm:* ≤ 0.15 Nm				
Moment of inertia of rotor/ **angle acceleration**[4]	*D = 50 mm* 220 · 10^{-6} kgm^2/≤ 5 · 10^4 rad/s^2 *D = 38 mm* 350 · 10^{-6} kgm^2/≤ 2 · 10^4 rad/s^2 *D = 25 mm* 96 · 10^{-6} kgm^2/≤ 3 · 10^4 rad/s^2 *D = 20 mm* 100 · 10^{-6} kgm^2/≤ 3 · 10^4 rad/s^2				
Permissible axial motion of measured shaft	± 1.5 mm				
Vibration 55 to 2 000 Hz **Shock** 6 ms	≤ 200 m/s^2; ≤ 100 m/s^2 with flange-socket version (EN 60 068-2-6) ≤ 1 000 m/s^2 (EN 60 068-2-27)				
Max. operating temp.[3]	100 °C			85 °C (100 °C at U_P < 15 V)	100 °C
Min. operating temp.	*Flange socket or fixed cable:* –40 °C; *Moving cable:* –10 °C				
Protection[3] EN 60 529	IP 64				
Weight	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) Speed-dependent deviations between the absolute value and incremental signal
2) Restricted tolerances: Signal amplitude: 0.8 to 1.2 V_{PP}
3) For the correlation between the protection class, shaft speed and operating temperature, see *General mechanical information*
4) At room temperature, calculated; material of mating shaft: 1.4104

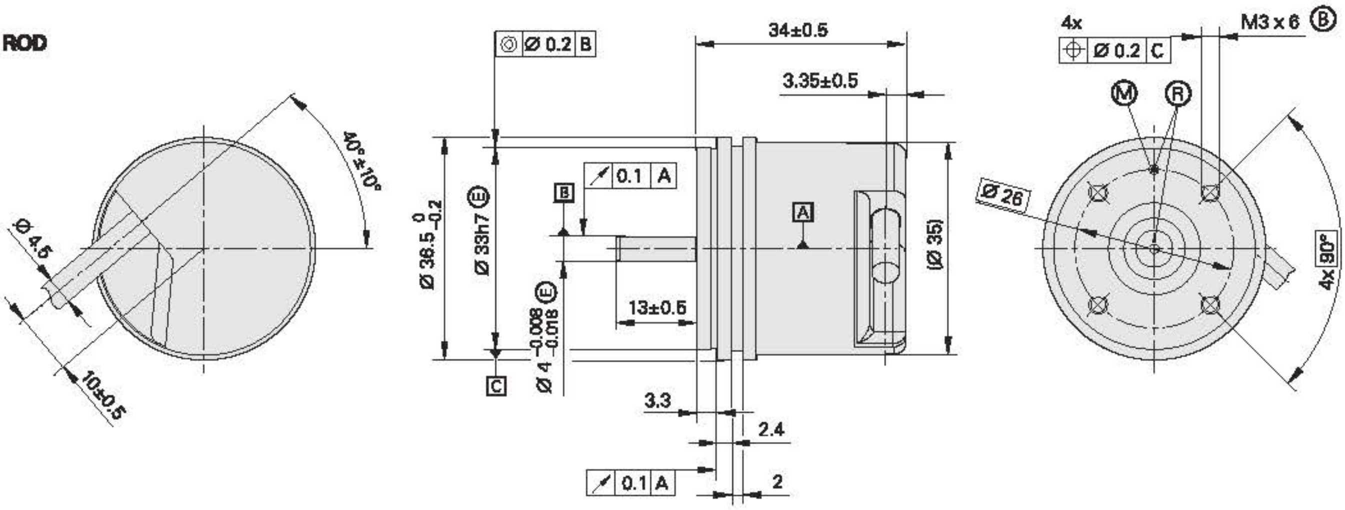
ROC, ROQ, ROD 1000 series

- **Absolute and incremental rotary encoders**
- **Synchro flange**
- **Solid shaft for separate shaft coupling**

ROC/ROQ



ROD



mm

Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Cable radial, also usable axially
Ⓐ = Bearing
Ⓑ = Threaded mounting hole
Ⓜ = Measuring point for operating temperature
Ⓡ = Reference mark position ± 20°
Ⓗ = Direction of shaft rotation for output signals as per the interface description

	Incremental				
	ROD 1020	ROD 1030	ROD 1080	ROD 1070	
Incremental signals	TTL	HTLs	∼ 1 V_{PP}[1)]	TTL	
Line counts*	100 200 **250** 360 400 **500** 720 900 **1000** **1024** 1250 1500 2000 **2048** **2500** **3600**			**1000** **2500** **3600**	
Reference mark	One				
Integrated interpolation*	–			5-fold	10-fold
Cutoff frequency –3 dB Scanning frequency Edge separation a	– ≤ 300 kHz ≥ 0.39 µs	– ≤ 160 kHz ≥ 0.76 µs	≥ 180 kHz – –	– ≤ 100 kHz ≥ 0.47 µs	– ≤ 100 kHz ≥ 0.22 µs
System accuracy	1/20 of grating period				
Power supply **Current consumption** without load	5 V DC ± 10 % ≤ 120 mA	10 to 30 V DC ≤ 150 mA	5 V DC ± 10 % ≤ 120 mA	5 V DC ± 5 % ≤ 155 mA	
Electrical connection	**Cable 1 m**/5 m, with or **without coupling** M23			**Cable 5 m without** M23 **coupling**	
Shaft	Solid shaft D = 4 mm				
Mech. permiss. speed n	≤ 12000 min^{-1}				
Starting torque	≤ 0.001 Nm (at 20 °C)				
Moment of inertia of rotor	≤ $0.5 \cdot 10^{-6}$ 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 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)				
Max. operating temp.[2)]	100 °C	70 °C	100 °C	70 °C	
Min. operating temp.	*Fixed cable:* –30 °C *Moving cable:* –10 °C				
Protection EN 60529	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*

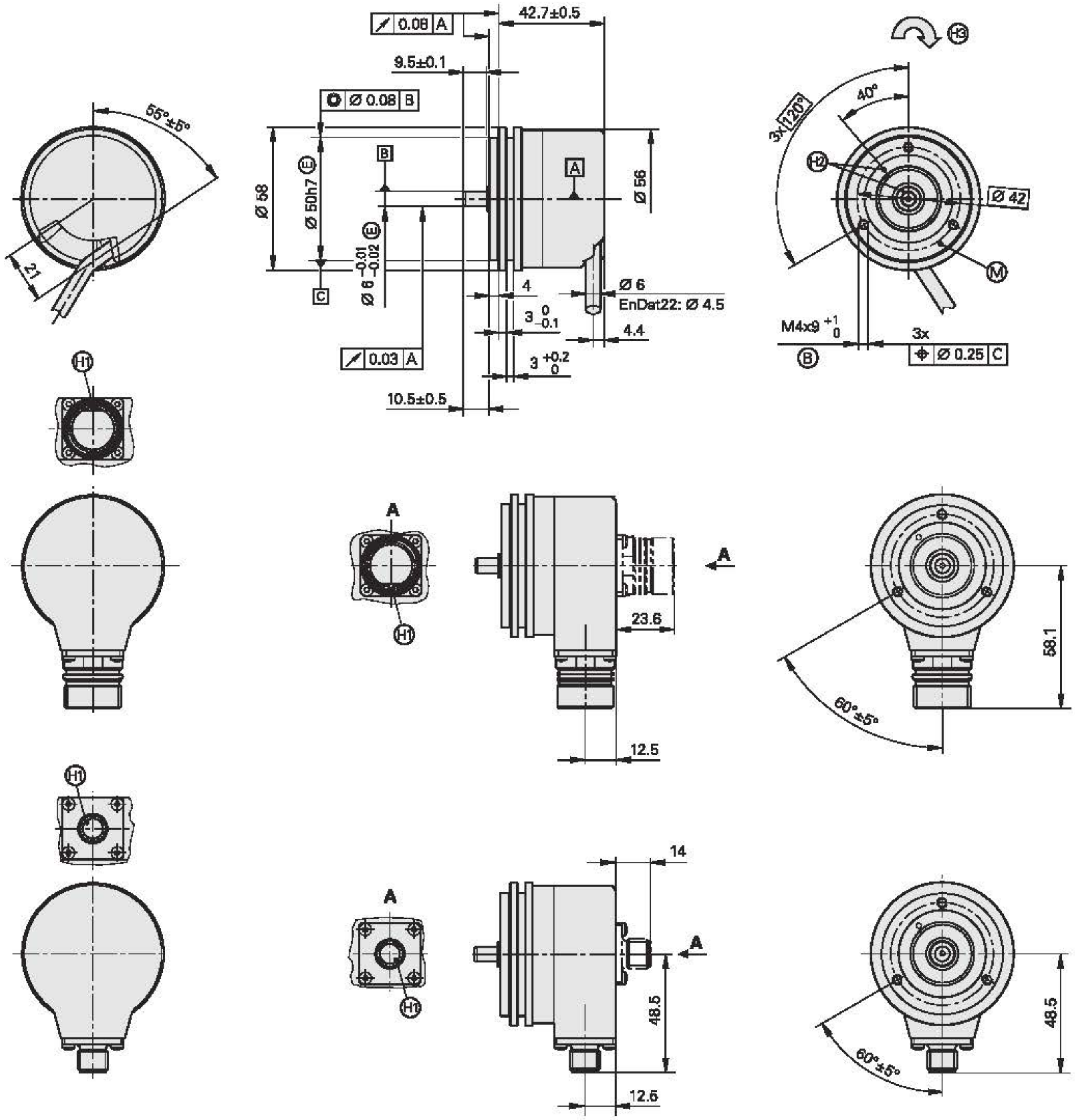
	**Absolute** **Singleturn** **ROC 1023**	**ROC 1013**
Absolute position values	**EnDat 2.2**	
Ordering designation	EnDat 22	EnDat 01
Positions per revolution	8388608 (23 bits)	8192 (13 bits)
Revolutions	–	
Code	Pure binary	
Elec. permissible speed Deviations[1]	12000 min^{-1} (for continuous position value)	4000 min^{-1}/12000 min^{-1} ± 1 LSB/± 16 LSB
Calculation time t_{cal} Clock frequency	≤ 7 µs ≤ 8 MHz	≤ 9 µs ≤ 2 MHz
Incremental signals	–	∼ 1 V_{PP}[2]
Line count	–	512
Cutoff frequency –3 dB	–	≥ 190 kHz
System accuracy	± 60“	
Power supply	3.6 to 14 V DC	
Power consumption (max.)	*3.6 V:* ≤ 600 mW *14 V:* ≤ 700 mW	
Current consumption (typical; without load)	*5 V:* 85 mA	
Electrical connection	Cable 1 m, with M12 coupling	Cable 1 m, with M23 coupling
Shaft	Stub shaft ∅ 4 mm	
Mech. permiss. speed n	12000 min^{-1}	
Starting torque	≤ 0.001 Nm (at 20 °C)	
Moment of inertia of rotor	Approx. $0.5 \cdot 10^{-6}$ 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 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)	
Max. operating temp.	100 °C	
Min. operating temp.	*Fixed cable:* –30 °C *Moving cable:* –10 °C	
Protection EN 60529	IP 64	
Weight	Approx. 0.09 kg	

[1] Speed-dependent deviations between the absolute and incremental signals
[2] Restricted tolerances: Signal amplitude 0.80 to 1.2 V_{PP}

Multiturn	
ROQ 1035	**ROQ 1025**
EnDat 22	EnDat 01
8388608 (23 bits)	8192 (13 bits)
4096 (12 bits)	
12000 min^{-1} (for continuous position value)	4000 min^{-1}/12000 min^{-1} ± 1 LSB/± 16 LSB
≤ 7 µs ≤ 8 MHz	≤ 9 µs ≤ 2 MHz
–	∼ 1 V_{PP} 2)
–	512
–	≥ 190 kHz
3.6 V: ≤ 700 mW *14 V:* ≤ 800 mW	
5 V: 105 mA	
Cable 1 m, with M12 coupling	Cable 1 m, with M23 coupling
≤ 0.002 Nm (at 20 °C)	

ROC/ROQ/ROD 400 and RIC/RIQ 400 series

- Absolute and incremental rotary encoders
- Synchro flange
- Solid shaft for separate shaft coupling



mm

Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Cable radial, also usable axially
Ⓐ = Bearing
Ⓑ = Threaded mounting hole; the thread depth will apply as of November 2012; previous depth: 5 mm
Ⓜ = Measuring point for operating temperature
Ⓗ1 = Connector coding
Ⓗ2 = ROD reference mark position on shaft and flange ±30°
Ⓗ3 = Direction of shaft rotation for output signals as per the interface description

	Incremental			
	ROD 426	**ROD 466**	**ROD 436**	**ROD 486**
Incremental signals	⊓⊔TTL		⊓⊔HTL	∿ 1 V_{PP}[1]
Line counts*	50 100 150 200 250 360 **500** 512 720			–
	1000 **1024** **1250** 1500 1800 **2000** **2048** **2500** **3600** **4096** **5000**			
	6000[2] 8192[2] 9000[2] 10000[2]		–	
Reference mark	One			
Cutoff frequency –3 dB Scanning frequency Edge separation a	– ≤ 300 kHz/≤ 150 kHz[2] ≥ 0.39 µs/≥ 0.25 µs[2]			≥ 180 kHz – –
System accuracy	1/20 of grating period (see page 11)			
Power supply **Current consumption** without load	5 V DC ± 10 % ≤ 120 mA	10 to 30 V DC ≤ 100 mA	10 to 30 V DC ≤ 150 mA	5 V DC ± 10 % ≤ 120 mA
Electrical connection*	• **Flange socket** M23, radial and axial • **Cable 1 m/**5 m, with or **without coupling** M23			
Shaft	Solid shaft D = 6 mm			
Mech. permiss. speed n	≤ 16000 min^{-1}			
Starting torque	≤ 0.01 Nm (at 20 °C)			
Moment of inertia of rotor	≤ $2.7 \cdot 10^{-6}$ kgm^2			
Shaft load[3]	*Axial:* ≤ 40 N; *Radial:* ≤ 60 N at shaft end			
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)			
Max. operating temp.[4]	100 °C	70 °C	100 °C[5]	
Min. operating temp.	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C			
Protection EN 60529	IP 67 at housing, IP 64 at shaft end (IP 66 available on request)			
Weight	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) Signal periods; generated through integrated 2-fold interpolation (TTL x 2)
3) See also *Mechanical design types and mounting*
4) For the correlation between the operating temperature and the shaft speed or supply voltage, see *General mechanical information*
5) 80° for ROD 486 with 4096 or 5000 lines

	Absolute Singletum ROC 425	ROC 413		RIC 418
Absolute position values*	**EnDat 2.2**	**EnDat 2.2**	**SSI**	**EnDat 2.1**
Ordering designation	EnDat 22	EnDat 01	SSI 39r1	EnDat 01
Positions per revolution	33554432 (25 bits)	8192 (13 bits)		262144 (18 bits)
Revolutions	–			
Code	Pure binary		Gray	Pure binary
Elec. permissible speed Deviations[1)]	≤ 12000 min^{-1} for continuous position value	*512 lines:* ≤ 5000/12000 min^{-1} ± 1 LSB/± 100 LSB *2048 lines:* ≤ 1500/12000 min^{-1} ± 1 LSB/± 50 LSB	12000 min^{-1} ± 12 LSB	≤ 4000/15000 min^{-1} ± 400 LSB/± 800 LSB
Calculation time t_{cal} Clock frequency	≤ 7 µs ≤ 8 MHz	≤ 9 µs ≤ 2 MHz	≤ 5 µs –	≤ 8 µs ≤ 2 MHz
Incremental signals	Without	∿ 1 V_{PP}[2)]		∿ 1 V_{PP}
Line counts*	–	**512** 2048	**512**	**16**
Cutoff frequency –3 dB	–	*512 lines:* ≥ 130 kHz; *2048 lines:* ≥ 400 kHz		≥ 6 kHz
System accuracy	± 20"	*512 lines:* ± 60"; *2048 lines:* ± 20"		± 480"
Power supply*	**3.6 to 14 V DC**	**3.6 to 14 V DC**	5 V DC ± 5% or **10 to 30 V DC**	**5 V DC** ± 5%
Power consumption (max.)	*3.6 V:* ≤ 600 mW *14 V:* ≤ 700 mW		*5 V:* ≤ 800 mW *10 V:* ≤ 650 mW *30 V:* ≤ 1000 mW	*5 V:* ≤ 950 mW
Current consumption (typical; without load)	*5 V:* 85 mA		*5 V:* 90 mA *24 V:* 24 mA	*5 V:* 125 mA
Electrical connection*	• **Flange socket** M12, radial • Cable 1 m, with M12 coupling	• **Flange socket** M23, axial or radial • Cable 1 m/5 m, with or without coupling M23		• **Flange socket** M23, radial • Cable 1 m, with M23 coupling
Shaft	Solid shaft D = 6 mm			
Mech. permiss. speed n	≤ 12000 min^{-1}			
Starting torque	≤ 0.01 Nm (at 20 °C)			
Moment of inertia of rotor	≤ $2.7 \cdot 10^{-6}$ kgm^2			
Shaft load	*Axial:* ≤ 40 N; *Radial:* ≤ 60 N at shaft end (see also *Mechanical design types and mounting)*			
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2; *flange socket version:* ≤ 150 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)			
Max. operating temp.[3)]	100 °C			
Min. operating temp.	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C			
Protection EN 60529	IP 67 at housing, IP 64 at shaft inlet[3)] (IP 66 available on request)			
Weight	Approx. 0.35 kg			

Bold: These preferred versions are available on short notice
***** Please select when ordering
[1)] Speed-dependent deviations between the absolute value and incremental signal

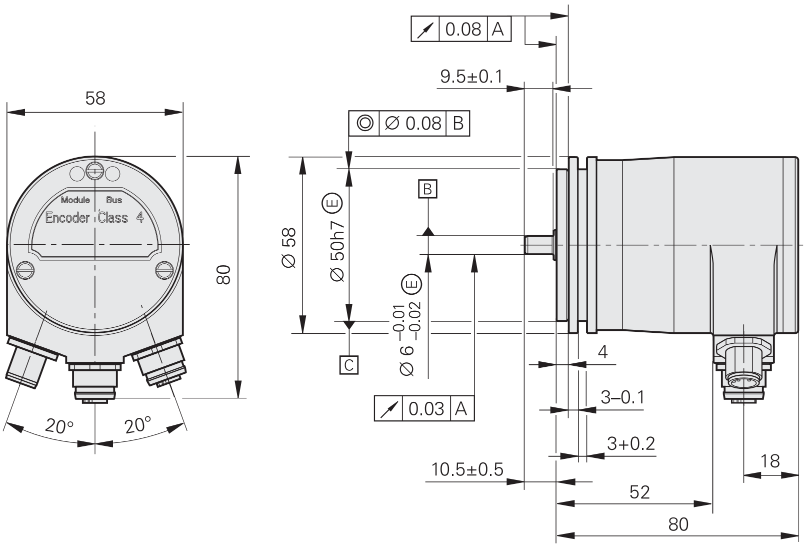
Multiturn			
ROQ 437	**ROQ 425**		**RIQ 430**
EnDat 2.2	**EnDat 2.2**	**SSI**	**EnDat 2.1**
EnDat 22	EnDat 01	SSI 41r1	EnDat 01
33554432 (25 bits)	8192 (13 bits)	8192 (13 bits)	262144 (18 bits)
4096			4096
Pure binary		Gray	Pure binary
≤ 12000 min^{-1} for continuous position value	*512 lines:* ≤ 5000/10000 min^{-1} ± 1 LSB/± 100 LSB *2048 lines:* ≤ 1500/10000 min^{-1} ± 1 LSB/± 50 LSB	10000 min^{-1} ± 12 LSB	≤ 4000/15000 min^{-1} ± 400 LSB/± 800 LSB
≤ 7 µs ≤ 8 MHz	≤ 9 µs ≤ 2 MHz	≤ 5 µs –	≤ 8 µs ≤ 2 MHz
Without	∼ 1 V_{PP} 2)		∼ 1 V_{PP}
–	**512** 2048	**512**	**16**
–	*512 lines:* ≥ 130 kHz; *2048 lines:* ≥ 400 kHz		≥ 6 kHz
± 20"	*512 lines:* ± 60"; *2048 lines:* ± 20"		± 480"
3.6 to 14 V DC	**3.6 to 14 V DC**	5 V DC ± 5 % or **10 to 30 V DC**	**5 V DC** ± 5 %
3.6 V: ≤ 700 mW *14 V:* ≤ 800 mW		*5 V:* ≤ 950 mW *10 V:* ≤ 750 mW *30 V:* ≤ 1100 mW	*5 V:* ≤ 1100 mW
5 V: 105 mA		*5 V:* 120 mA *24 V:* 28 mA	*5 V:* 150 mA
• **Flange socket** M12, radial • Cable 1 m, with M12 coupling	• **Flange socket** M23, axial or radial • Cable 1 m/5 m, with or without coupling M23		• **Flange socket** M23, radial • Cable 1 m, with M23 coupling

2) Restricted tolerances: Signal amplitude: 0.8 to 1.2 V_{PP}

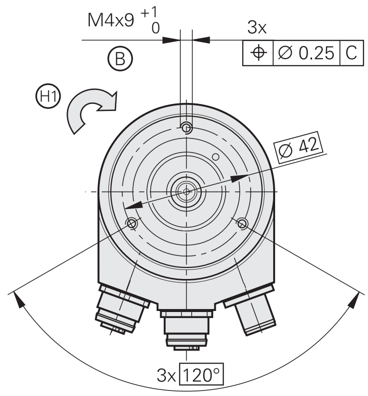
3) For the correlation between the operating temperature and shaft speed or power supply, see *General mechanical information*

ROC/ROQ 400 series

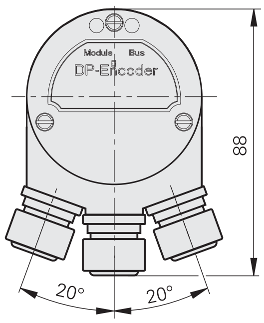
- **Absolute rotary encoders**
- **Synchro flange**
- **Solid shaft for separate shaft coupling**
- **Field bus interface**



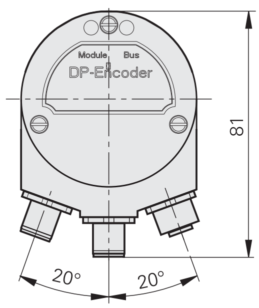
PROFINET IO



PROFIBUS-DP M16



PROFIBUS-DP M12



mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

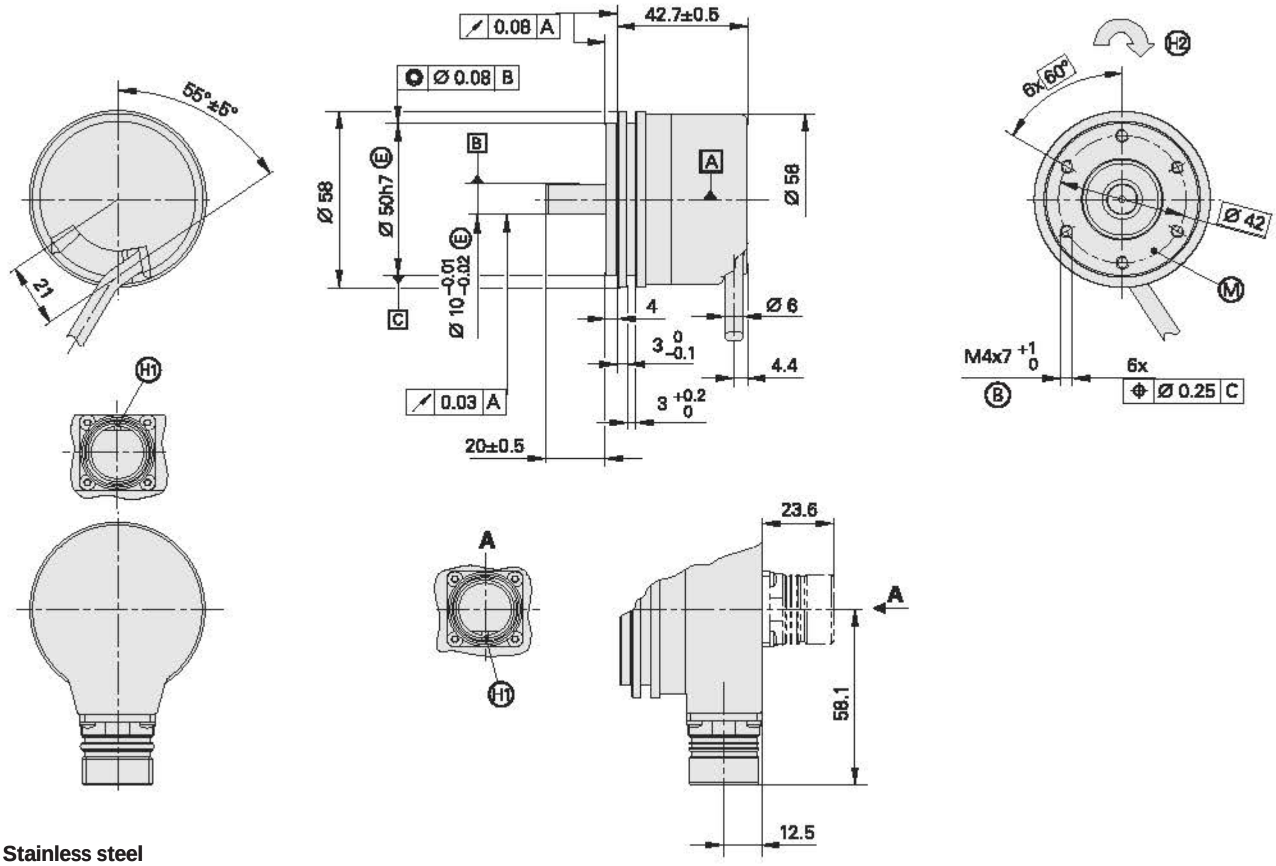
A = Bearing
B = Threaded mounting hole; the thread depth will apply as of November 2012; previous depth: 5 mm
H1 = Direction of shaft rotation for output signals as per the interface description

	Singleturn ROC 413		Multiturn ROQ 425	
Absolute position values*	**PROFIBUS-DP**	**PROFINET IO**	**PROFIBUS-DP**	**PROFINET IO**
Positions per revolution	8192 (13 bits)[2]			
Revolutions	–		4096[2]	
Code	Pure binary			
Elec. permissible speed Deviations[1]	≤ 5000/12000 min^{-1} ± 1 LSB/± 100 LSB		≤ 5000/10000 min^{-1} ± 1 LSB/± 100 LSB	
Incremental signals	Without			
System accuracy	± 60“			
Power supply	**9 to 36 V DC**	**10 to 30 V DC**	**9 to 36 V DC**	**10 to 30 V DC**
Power consumption (max.)	*9 V:* ≤ 3.38 W *36 V:* ≤ 3.84 W			
Current consumption (typical; without load)	*24 V:* 125 mA			
Electrical connection*	• **Three flange sockets** M12, radial • M16 cable gland	**Three flange sockets** M12, radial	• **Three flange sockets** M12, radial • M16 cable gland	**Three flange sockets** M12, radial
Shaft	Solid shaft D = 6 mm			
Mech. permiss. speed n	≤ 6000 min^{-1}			
Starting torque	≤ 0.01 Nm (at 20 °C)			
Moment of inertia of rotor	≤ 2.7 · 10^{-6} kgm^2			
Shaft load	*Axial:* ≤ 40 N; *Radial:* ≤ 60 N at shaft end (see also *Mechanical design types and mounting)*			
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)			
Max. operating temp.[3]	70 °C			
Min. operating temp.	–40 °C			
Protection EN 60529	IP 67 at housing, IP 64 at shaft inlet (IP 66 available on request)			
Weight	Approx. 0.35 kg			

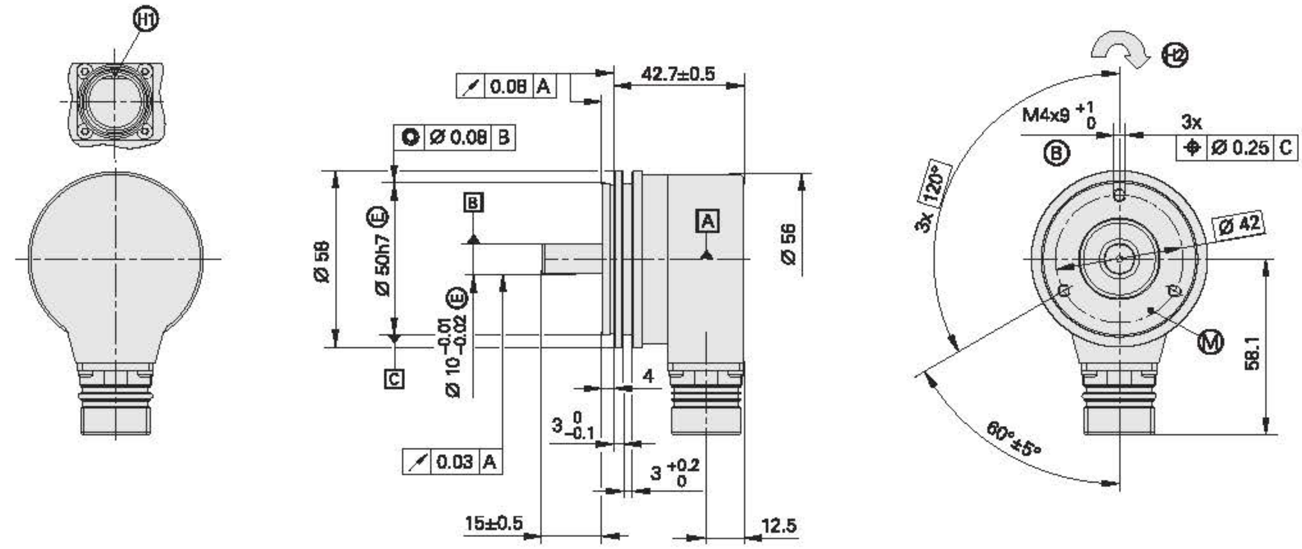
Bold: These preferred versions are available on short notice
* Please select when ordering
1) Speed-dependent deviations between the absolute value and incremental signal
2) These functions are programmable
3) For the correlation between the operating temperature and shaft speed or power supply, see *General mechanical information*

ROC 425 series

- **Absolute rotary encoders**
- **Steel synchro flange**
- **High accuracy**
- **Solid shaft for separate shaft coupling**
- **Version with stainless steel housing**



Stainless steel



mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Cable radial, also usable axially
A = Bearing
B = Threaded mounting hole; the thread depth will apply as of November 2012; previous depth: 5 mm
M = Measuring point for operating temperature
H1 = Connector coding
H2 = Direction of shaft rotation for output signals as per the interface description

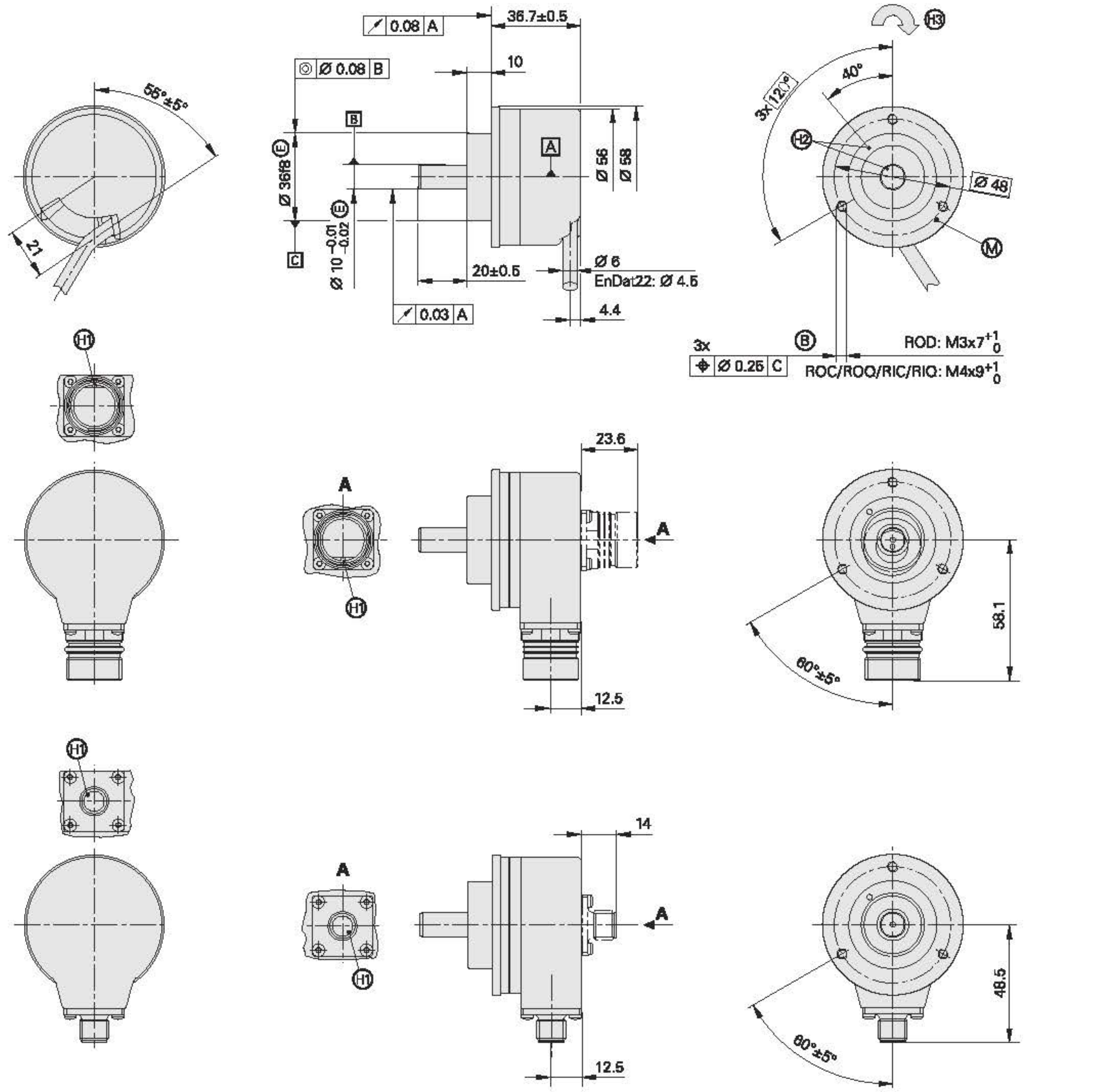
Stainless steel version	Material
Shaft	1.4104
Flange, housing, flange socket	1.4301 (V2A)

	Singleturn	
	ROC 425	ROC 425, stainless steel
Absolute position values	**EnDat 2.2**	
Ordering designation	EnDat 01	
Positions per revolution	33554432 (25 bits)	
Revolutions	–	
Code	Pure binary	
Elec. permissible speed Deviations[1]	≤ 1500/15000 min^{-1} ± 1200 LSB/± 9200 LSB	
Calculation time t_{cal} Clock frequency	≤ 9 µs ≤ 2 MHz	
Incremental signals	∿ 1 V_{PP}	
Line count	2048	
Cutoff frequency –3 dB	≥ 400 kHz	
System accuracy	± 10“	
Power supply	**3.6 to 14 V DC**	
Power consumption (max.)	*3.6 V:* ≤ 600 mW *14 V:* ≤ 700 mW	
Current consumption (typical; without load)	*5 V:* 85 mA	
Electrical connection*	• **Flange socket** M23, axial or radial • Cable 1 m/5 m, with or without coupling M23	• **Flange socket** M23, radial
Shaft	Solid shaft D = 10 mm, length 20 mm	Solid shaft D = 10 mm, length 15 mm
Mech. permiss. speed n	≤ 12000 min^{-1}	
Starting torque	≤ 0.025 Nm (at 20 °C) ≤ 0.2 Nm (at –40 °C)	≤ 0.025 Nm (at 20 °C) ≤ 0.5 Nm (at –40 °C)
Moment of inertia of rotor	≤ $2.1 \cdot 10^{-6}$ kgm^2	
Shaft load	*Axial:* ≤ 40 N; *Radial:* ≤ 60 N at shaft end (see also *Mechanical design types and mounting)*	
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)	
Max. operating temp.[3]	80 °C	
Min. operating temp.	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C	
Protection EN 60529	IP 67 at housing; IP 66 at shaft inlet	
Weight	Approx. 0.50 kg	Approx. 0.55 kg

Bold: These preferred versions are available on short notice
***** Please select when ordering
[1] Speed-dependent deviations between the absolute value and incremental signal
[2] Restricted tolerances: Signal amplitude: 0.8 to 1.2 V_{PP}
[3] For the correlation between the operating temperature and shaft speed or power supply, see *General mechanical information*

ROC/ROQ/ROD 400 and RIC/RIQ 400 series

- Absolute and incremental rotary encoders
- Clamping flange
- Solid shaft for separate shaft coupling



mm

Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Cable radial, also usable axially
A = Bearing
B = Threaded mounting hole; the thread depth will apply as of November 2012; previous depth: 5 mm
M = Measuring point for operating temperature
H1 = Connector coding
H2 = ROD: Reference mark position on shaft and flange ± 15°
H3 = Direction of shaft rotation for output signals as per the interface description

	Incremental		
	ROD 420	**ROD 430**	**ROD 480**
Incremental signals	⊓⊔ TTL	⊓⊔ HTL	∿ 1 V_{PP}[1)]
Line counts*	50 100 150 200 250 360 **500** 512 720		–
	1000 **1024** **1250** 1500 1800 **2000** **2048** **2500** **3600** **4096** **5000**		
Reference mark	One		
Cutoff frequency –3 dB Scanning frequency Edge separation a	– ≤ 300 kHz ≥ 0.39 µs		≥ 180 kHz – –
System accuracy	1/20 of grating period		
Power supply **Current consumption** without load	5 V DC ± 10 % ≤ 120 mA	10 to 30 V DC ≤ 150 mA	5 V DC ± 10 % ≤ 120 mA
Electrical connection*	• **Flange socket** M23, radial and axial • **Cable 1 m/**5 m, with or **without coupling** M23		
Shaft	Solid shaft D = 10 mm		
Mech. permiss. speed n	≤ 12000 min^{-1}		
Starting torque	≤ 0.01 Nm (at 20 °C)		
Moment of inertia of rotor	≤ $2.3 \cdot 10^{-6}$ kgm^2		
Shaft load[2)]	*Axial:* ≤ 40 N; *Radial:* ≤ 60 N at shaft end		
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)		
Max. operating temp.[3)]	100 °C[4)]		
Min. operating temp.	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C		
Protection EN 60529	IP 67 at housing, IP 64 at shaft end (IP 66 available on request)		
Weight	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) See also *Mechanical design types and mounting*
3) For the correlation between the operating temperature and the shaft speed or power supply, see *General mechanical information*
4) 80 °C for ROD 480 with 4096 or 5000 lines

	**Absolute**			
	Singletum			
	ROC 425	**ROC 413**		**RIC 418**
Absolute position values*	**EnDat 2.2**	**EnDat 2.2**	**SSI**	**EnDat 2.1**
Ordering designation	EnDat 22	EnDat 01	SSI 39r1	EnDat 01
Positions per revolution	33 554 432 (25 bits)	8 192 (13 bits)		262 144 (18 bits)
Revolutions	–			
Code	Pure binary		Gray	Pure binary
Elec. permissible speed Deviations[1]	≤ 12 000 min^{-1} for continuous position value	*512 lines:* ≤ 5 000/12 000 min^{-1} ± 1 LSB/± 100 LSB *2 048 lines:* ≤ 1 500/12 000 min^{-1} ± 1 LSB/± 50 LSB	12 000 min^{-1} ± 12 LSB	≤ 4 000/15 000 min^{-1} ± 400 LSB/± 800 LSB
Calculation time t_{cal} Clock frequency	≤ 7 µs ≤ 8 MHz	≤ 9 µs ≤ 2 MHz	≤ 5 µs –	≤ 8 µs ≤ 2 MHz
Incremental signals	Without	∼ 1 V_{PP}[2]		∼ 1 V_{PP}
Line counts*	–	**512** 2 048	**512**	**16**
Cutoff frequency –3 dB	–	*512 lines:* ≥ 130 kHz; *2 048 lines:* ≥ 400 kHz		≥ 6 kHz
System accuracy	± 20"	± 60"		± 480"
Power supply*	**3.6 to 14 V DC**	**3.6 to 14 V DC**	5 V DC ± 5 % or **10 to 30 V DC**	**5 V DC** ± 5 %
Power consumption (max.)	*3.6 V:* ≤ 600 mW *14 V:* ≤ 700 mW		*5 V:* ≤ 800 mW *10 V:* ≤ 650 mW *30 V:* ≤ 1 000 mW	*5 V:* ≤ 900 mW
Current consumption (typical; without load)	*5 V:* 85 mA		*5 V:* 90 mA *24 V:* 24 mA	*5 V:* 125 mA
Electrical connection*	• **Flange socket** M12, radial • Cable 1 m, with M12 coupling	• **Flange socket** M23, axial or radial • Cable 1 m/5 m, with or without coupling M23		• **Flange socket** M23, radial • Cable 1 m, with M23 coupling
Shaft	Solid shaft D = 10 mm			
Mech. permiss. speed n	≤ 12 000 min^{-1}			
Starting torque	≤ 0.01 Nm (at 20 °C)			
Moment of inertia of rotor	≤ 2.3 · 10^{-6} kgm^2			
Shaft load	*Axial:* ≤ 40 N; *Radial:* ≤ 60 N at shaft end (see also *Mechanical design types and mounting)*			
Vibration 55 to 2 000 Hz **Shock** 6 ms	≤ 300 m/s^2; ≤ 100 m/s^2 (EN 60 068-2-6); higher values on request ≤ 1 000 m/s^2 (EN 60 068-2-27)			
Max. operating temp.[3]	100 °C			
Min. operating temp.	*Flange socket or fixed cable:* –40 °C *Moving cable:* –10 °C			
Protection EN 60 529	IP 67 at housing, IP 64 at shaft inlet[3] (IP 66 available on request)			
Weight	Approx. 0.35 kg			

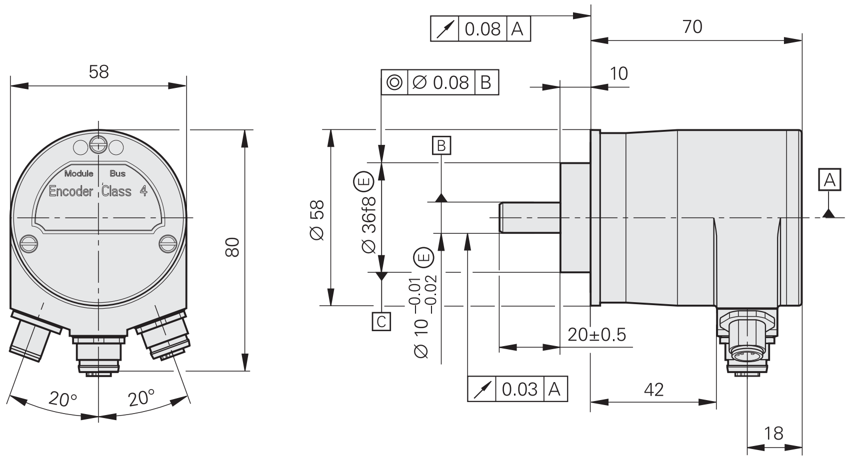
Bold: These preferred versions are available on short notice
***** Please select when ordering
[1] Speed-dependent deviations between the absolute value and incremental signal

Multiturn			
ROQ 437	**ROQ 425**		**RIQ 430**
EnDat 2.2	**EnDat 2.2**	**SSI**	**EnDat 2.1**
EnDat 22	EnDat 01	SSI 41r1	EnDat 01
33554432 (25 bits)	8192 (13 bits)	8192 (13 bits)	262144 (18 bits)
4096			4096
Pure binary		Gray	Pure binary
≤ 12000 min^{-1} for continuous position value	*512 lines:* ≤ 5000/10000 min^{-1} ± 1 LSB/± 100 LSB *2048 lines:* ≤ 1500/10000 min^{-1} ± 1 LSB/± 50 LSB	10000 min^{-1} ± 12 LSB	≤ 4000/15000 min^{-1} ± 400 LSB/± 800 LSB
≤ 7 µs ≤ 8 MHz	≤ 9 µs ≤ 2 MHz	≤ 5 µs –	≤ 8 µs ≤ 2 MHz
Without	∿ 1 V_{PP}[2]		∿ 1 V_{PP}
–	**512** 2048	**512**	**16**
–	*512 lines:* ≥ 130 kHz; *2048 lines:* ≥ 400 kHz		≥ 6 kHz
± 20"	± 60"		± 480"
3.6 to 14 V DC	**3.6 to 14 V DC**	5 V DC ± 5% or **10 to 30 V DC**	**5 V DC** ± 5%
3.6 V: ≤ 700 mW *14 V:* ≤ 800 mW		*5 V:* ≤ 950 mW *10 V:* ≤ 750 mW *30 V:* ≤ 1100 mW	*5 V:* ≤ 1100 mW
5 V: 105 mA		*5 V:* 120 mA *24 V:* 28 mA	*5 V:* 150 mA
• **Flange socket** M12, radial • Cable 1 m, with M12 coupling	• **Flange socket** M23, axial or radial • Cable 1 m/5 m, with or without coupling M23		• **Flange socket** M23, radial • Cable 1 m, with M23 coupling

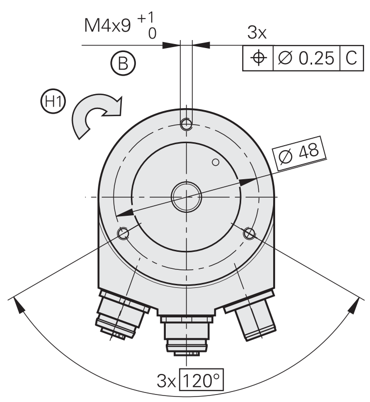
[2] Restricted tolerances: Signal amplitude: 0.8 to 1.2 V_{PP}
[3] For the correlation between the operating temperature and shaft speed or power supply, see *General mechanical information*

ROC/ROQ 400 series

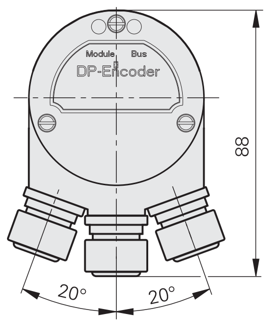
- **Absolute rotary encoders**
- **Clamping flange**
- **Solid shaft for separate shaft coupling**
- **Field bus interface**



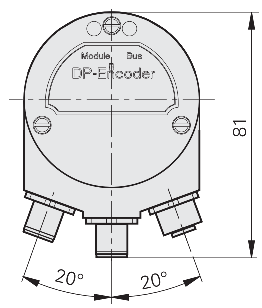
PROFINET IO



PROFIBUS-DP M16



PROFIBUS-DP M12



mm

Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

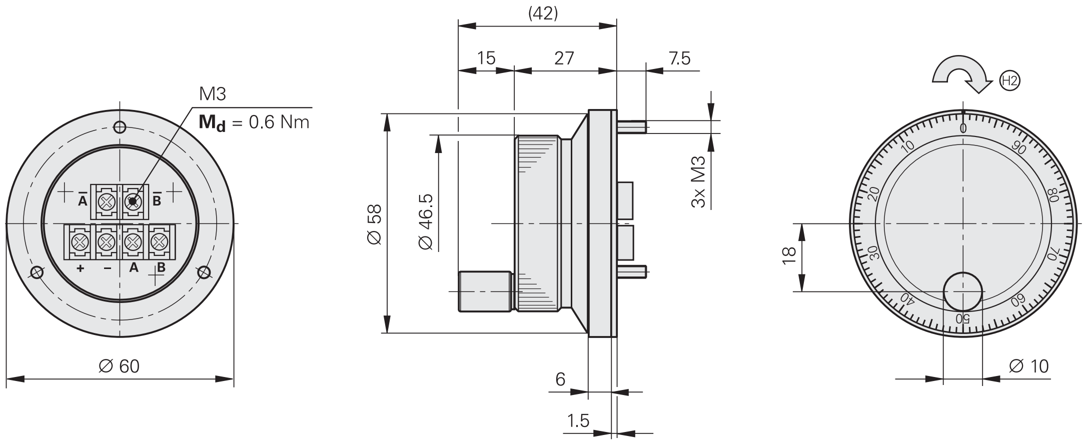
A = Bearing
B = Threaded mounting hole; the thread depth will apply as of November 2012; previous depth: 5 mm
H1 = Direction of shaft rotation for output signals as per the interface description

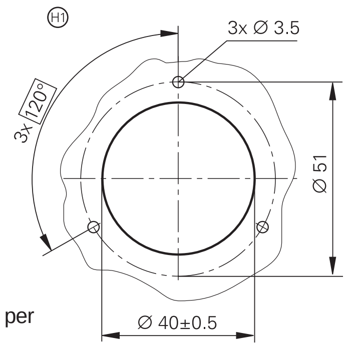
	Singleturn ROC 413		Multiturn ROQ 425	
Absolute position values*	**PROFIBUS-DP**	**PROFINET IO**	**PROFIBUS-DP**	**PROFINET IO**
Positions per revolution	8192 (13 bits)[2]			
Revolutions	–		4096[2]	
Code	Pure binary			
Elec. permissible speed Deviations[1]	≤ 5000/12000 min^{-1} ± 1 LSB/± 100 LSB		≤ 5000/10000 min^{-1} ± 1 LSB/± 100 LSB	
Incremental signals	Without			
System accuracy	± 60“			
Power supply	**9 to 36 V DC**	**10 to 30 V DC**	**9 to 36 V DC**	**10 to 30 V DC**
Power consumption (max.)	*9 V:* ≤ 3.38 W *36 V:* ≤ 3.84 W			
Current consumption (typical; without load)	*24 V:* 125 mA			
Electrical connection*	• **Three flange sockets** M12, radial • M16 cable gland	**Three flange sockets** M12, radial	• **Three flange sockets** M12, radial • M16 cable gland	**Three flange sockets** M12, radial
Shaft	Solid shaft D = 10 mm			
Mech. permiss. speed n	≤ 12000 min^{-1}			
Starting torque	≤ 0.01 Nm (at 20 °C)			
Moment of inertia of rotor	≤ $2.3 \cdot 10^{-6}$ kgm^2			
Shaft load	*Axial:* ≤ 40 N; *Radial:* ≤ 60 N at shaft end (see also *Mechanical design types and mounting)*			
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60068-2-6); higher values on request ≤ 1000 m/s^2 (EN 60068-2-27)			
Max. operating temp.[3]	70 °C			
Min. operating temp.	–40 °C			
Protection EN 60529	IP 67 at housing, IP 64 at shaft inlet[3] (IP 66 available on request)			
Weight	Approx. 0.35 kg			

Bold: These preferred versions are available on short notice
***** Please select when ordering
[1] Speed-dependent deviations between the absolute value and incremental signal
[2] These functions are programmable
[3] For the correlation between the operating temperature and shaft speed or power supply, see *General mechanical information*

HR 1120

- **Electronic handwheel**
- **Version for integration**
- **With mechanical detent**





mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

H1 = Cutout for mounting
H2 = Direction for output signals as per the interface description

	Incremental HR 1120
Incremental signals	⊓⊔TTL
Line count	100
Scanning frequency	≤ 5 kHz
Switching times	$t_+ / t_- \leq$ 100 ns
Power supply **Current consumption** without load	5 V DC ± 5% ≤ 160 mA
Electrical connection	Via M3 screw terminals
Cable length	≤ 30 m (cable not included in delivery)
Detent	Mechanical 100 detent positions per revolution Detent position within the low level of U_{a1} and U_{a2}
Mech. permissible speed	≤ 200 min^{-1}
Torque	≤ 0.1 Nm (at 25 °C)
Vibration (10 to 200 Hz)	≤ 20 m/s^2
Max. operating temp.	60 °C
Min. operating temp.	0 °C
Protection (EN 60529)	IP 00; IP 40 when mounted No condensation permitted
Weight	Approx. 0.18 kg

Mounting information
The HR 1120 is designed for mounting in a panel. CE compliance of the complete system must be ensured by taking the correct measures during installation.

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 amplitudes 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 ≙ 70 % of the signal amplitude
- –6 dB ≙ 50 % of the signal amplitude

The data in the signal description apply to motions at up to 20 % of the –3 dB cutoff frequency.

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.

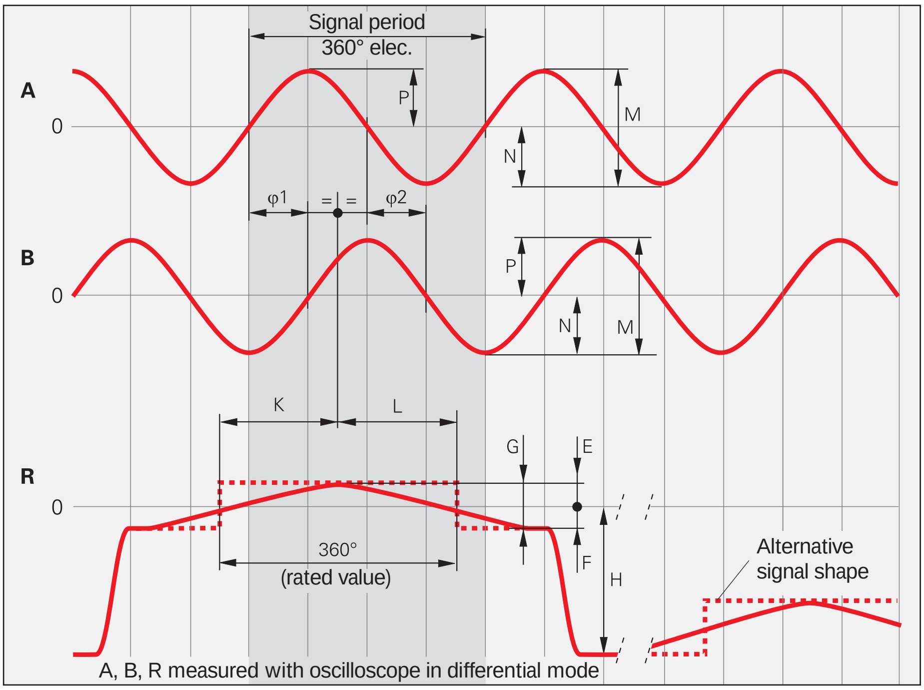
Measuring steps for **position measurement** are recommended in the specifications. For special applications, other resolutions are also possible.

Short-circuit stability
A temporary short circuit of one signal output to 0 V or U_P (except encoders with U_{Pmin} = 3.6 V) does not cause encoder failure, but it is not a permissible operating condition.

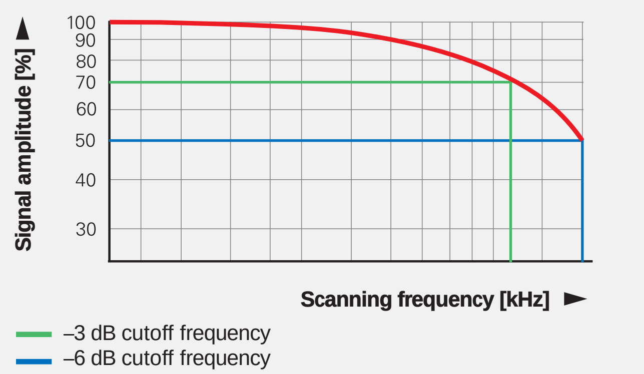
Short circuit at	20 °C	125 °C
One output	< 3 min	< 1 min
All outputs	< 20 s	< 5 s

Interface	Sinusoidal voltage signals ∿ **1 V_{PP}**
Incremental signals	**Two nearly sinusoidal signals A and B** Signal amplitude 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	**One or several signal peaks R** Usable component G: ≥ 0.2 V Quiescent value H: ≤ 1.7 V Switching threshold E, F: 0.04 to 0.68 V Zero crossovers K, L: 180° ± 90° elec.
Connecting cables Cable length Propagation time	Shielded HEIDENHAIN cable PUR [4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] Max. 150 m at 90 pF/m distributed capacitance 6 ns/m

These values can be used for dimensioning of the subsequent electronics. Any limited tolerances in the encoders are listed in the specifications. For encoders without integral bearing, reduced tolerances are recommended for initial operation (see the mounting instructions).



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



Input circuitry of subsequent electronics

Dimensioning
Operational amplifier MC 34074
Z_0 = 120 Ω
R_1 = 10 kΩ and C_1 = 100 pF
R_2 = 34.8 kΩ and C_2 = 10 pF
U_B = ±15 V
U_1 approx. U_0

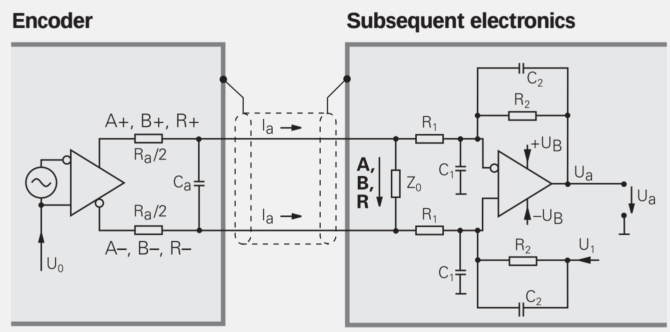
–3 dB cutoff frequency of circuitry
Approx. 450 kHz
Approx. 50 kHz with C_1 = 1000 pF
and C_2 = 82 pF
The circuit variant for 50 kHz does reduce the bandwidth of the circuit, but in doing so it improves its noise immunity.

Circuit output signals
U_a = 3.48 V_{PP} typically
Gain 3.48

Monitoring of the incremental signals
The following thresholds are recommended for monitoring of the signal level M:
Lower threshold: 0.30 V_{PP}
Upper threshold: 1.35 V_{PP}

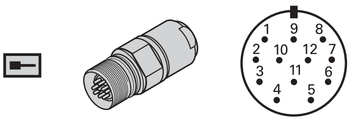
Incremental signals
Reference mark signal

R_a < 100 Ω, typically 24 Ω
C_a < 50 pF
ΣI_a < 1 mA
U_0 = 2.5 V ± 0.5 V (relative to 0 V of the power supply)

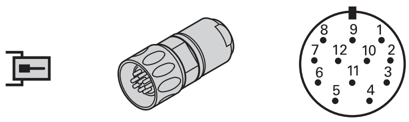


Pin layout

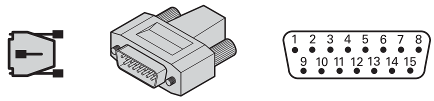
12-pin coupling, M23



12-pin connector, M23



15-pin D-sub connector
For IK 215/PWM 20



	Power supply				Incremental signals						Other signals		
12-pin coupling / connector	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	5/6/8/15	13	/
	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 in the encoder with the corresponding power line.

Electrical connection

Interfaces

Incremental signals ⊓⊔ TTL

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

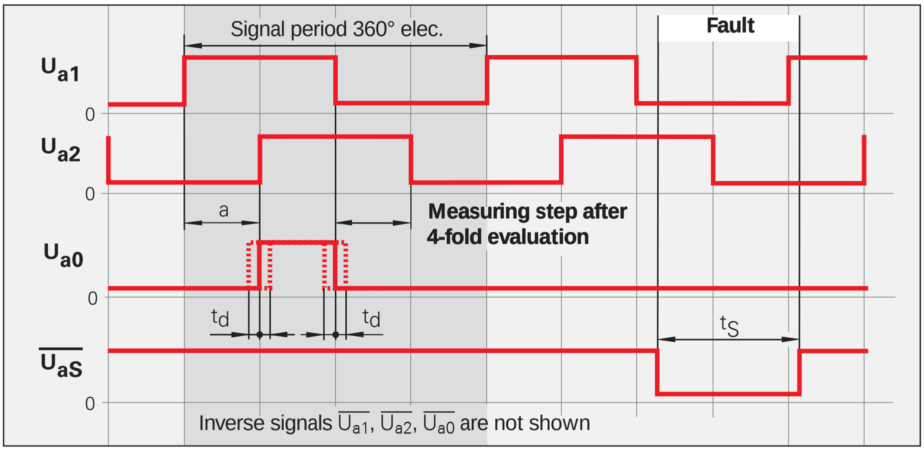
The **incremental signals** are transmitted as the square-wave pulse trains U_{a1} and U_{a2}, phase-shifted by 90° elec. The **reference mark signal** consists of one or more reference pulses U_{a0}, which are gated with the incremental signals. In addition, the integrated electronics produce their **inverted 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 to 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.**

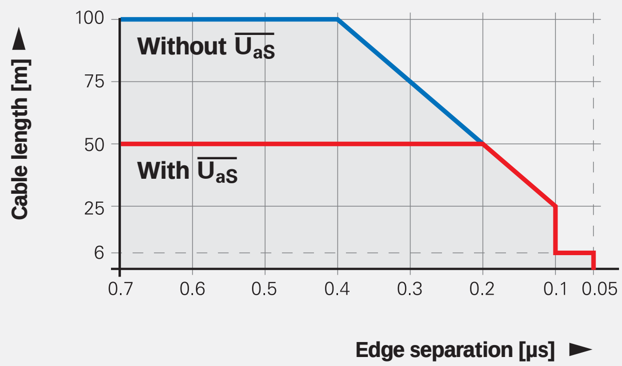
The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum **edge separation a** listed in the *Specifications* applies for the illustrated input circuitry with a cable length of 1 m, and refers to measurement at the output of the differential line receiver. Cable-dependent differences in the propagation times additionally reduce the edge separation by 0.2 ns per meter of cable. To prevent counting errors, design the subsequent electronics to process as little as 90 % of the resulting edge separation.
The max. permissible **shaft speed** or **traversing velocity** must never be exceeded.

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 TTL square-wave pulses U_{a0}** and their inverted pulses **$\overline{U_{a0}}$** 90° elec. (other widths available on request) $\lvert t_d \rvert \le 50$ ns
Fault-detection signal Pulse width	**1 TTL square-wave pulse $\overline{U_{aS}}$** Improper function: LOW (upon request: U_{a1}/U_{a2} high impedance) Proper function: HIGH $t_S \ge 20$ ms
Signal amplitude	Differential line driver as per EIA standard RS-422 $U_H \ge 2.5$ V at $-I_H = 20$ mA $U_L \le 0.5$ V at $I_L = 20$ mA
Permissible load	$Z_0 \ge 100\ \Omega$ Between associated outputs $\lvert I_L \rvert \le 20$ mA Max. load per output $C_{load} \le 1000$ pF With respect to 0 V Outputs protected against short circuit to 0 V
Switching times (10 % to 90 %)	$t_+ / t_- \le 30$ ns (typically 10 ns) with 1 m cable and recommended input circuitry
Connecting cables Cable length Propagation time	Shielded HEIDENHAIN cable PUR [4(2 × 0.14 mm^2) + (4 × 0.5 mm^2)] Max. 100 m ($\overline{U_{aS}}$ max. 50 m) at distributed capacitance 90 pF/m 6 ns/m



The permissible **cable length** for transmission of the TTL square-wave signals to the subsequent electronics depends on the edge separation a. It is at most 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 control system (remote sense power supply).

Permissible cable length
with respect to the edge separation

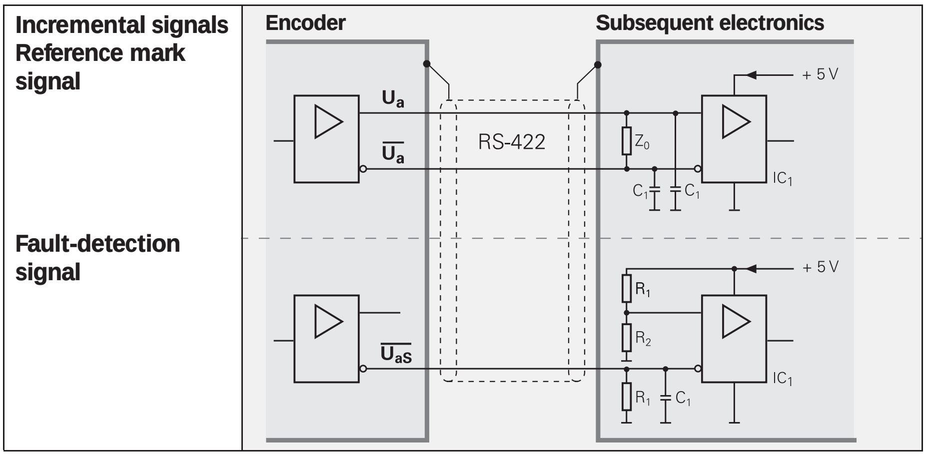


Input circuitry of subsequent electronics

Dimensioning

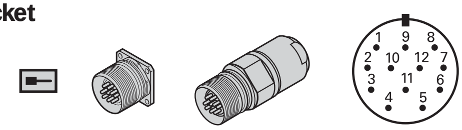
IC_1 = Recommended differential line receiver
DS 26 C 32 AT
Only for a > 0.1 µs:
AM 26 LS 32
MC 3486
SN 75 ALS 193

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

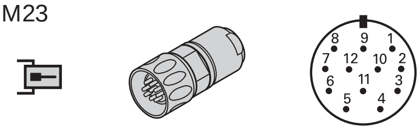


ERN, ROD pin layout

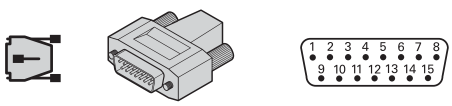
12-pin flange socket or coupling, M23



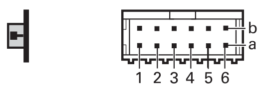
12-pin connector, M23



15-pin D-sub connector
For IK 215/PWM 20



12-pin PCB connector



	Power supply				Incremental signals						Other signals		
12-pin flange socket / connector	**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 in the encoder with the corresponding power line.
[1] **ERO 14xx:** free [2] **Exposed linear encoders:** TTL/11 µA_{PP} conversion for PWT

HR pin layout

Screw-terminal connection

	Power supply		Incremental signals			
Connection	**+**	**–**	**A**	**$\overline{A}$**	**B**	**$\overline{B}$**
Signal	**UP** 5 V	**U_N** 0 V	**U_{a1}**	**$\overline{U_{a1}}$**	**U_{a2}**	**$\overline{U_{a2}}$**

A shielded cable with a cross section of at least 0.5 mm^2 is recommended when connecting the handwheel to the power supply.
The handwheel is connected electrically via screw terminals. The appropriate wire end sleeves must be attached to the wires.

Interfaces

Incremental signals ⊓⊔ HTL, HTLs

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

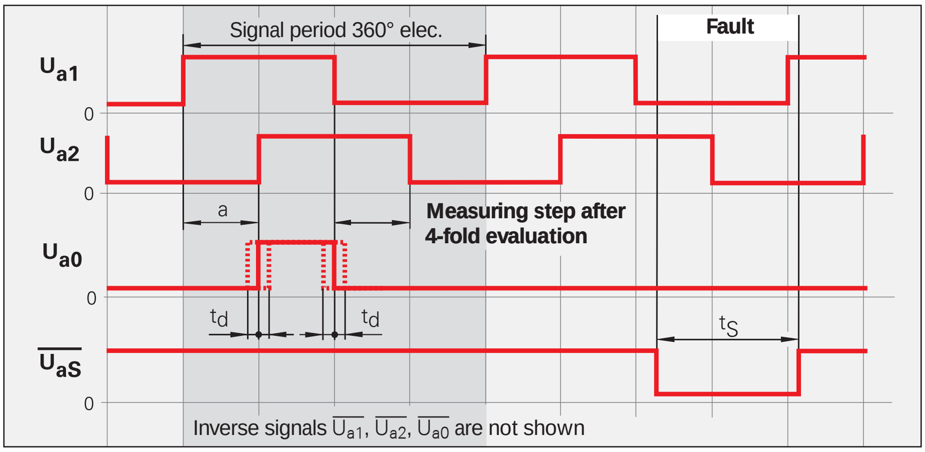
The **incremental signals** are transmitted as the square-wave pulse trains U_{a1} and U_{a2}, phase-shifted by 90° elec. The **reference mark signal** consists of one or more reference pulses U_{a0}, which are gated with the incremental signals. In addition, the integrated electronics produce their **inverted signals** $\overline{U_{a1}}$, $\overline{U_{a2}}$ and $\overline{U_{a0}}$ for noise-proof transmission (does not apply to HTLs).
The illustrated sequence of output signals—with U_{a2} lagging U_{a1}—applies to 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.

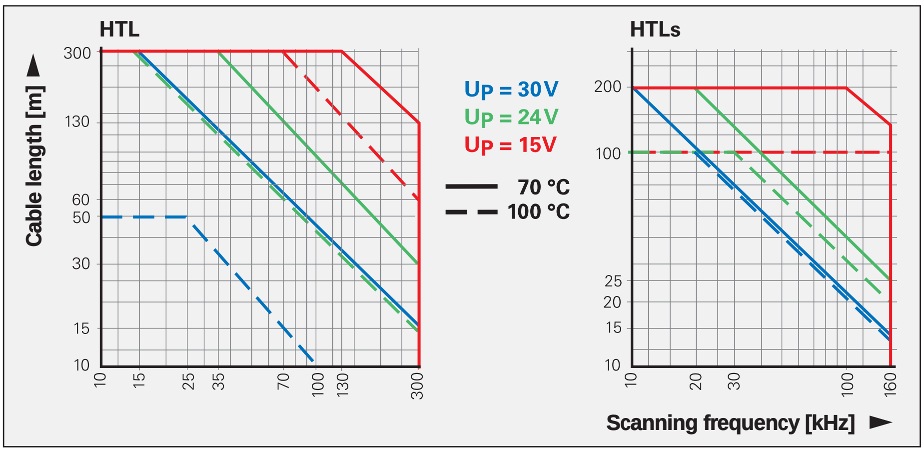
The distance between two successive edges of the incremental signals U_{a1} and U_{a2} through 1-fold, 2-fold or 4-fold evaluation is one **measuring step.**

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 errors, 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.

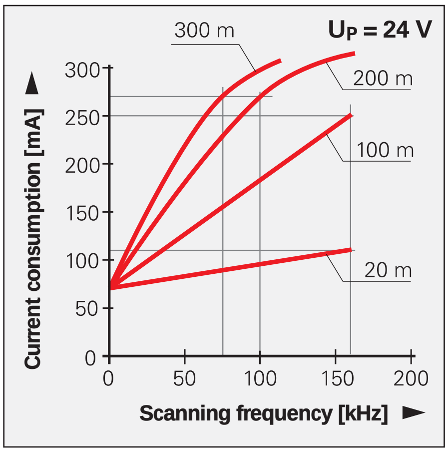
Interface	Square-wave signals ⊓⊔ **HTL**, ⊓⊔ **HTLs**
Incremental signals	**2 HTL square-wave signals U_{a1}, U_{a2}** and their inverted signals $\overline{U_{a1}}$, $\overline{U_{a2}}$ (*HTLs* without $\overline{U_{a1}}$, $\overline{U_{a2}}$)
Reference mark signal Pulse width Delay time	**1 or more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

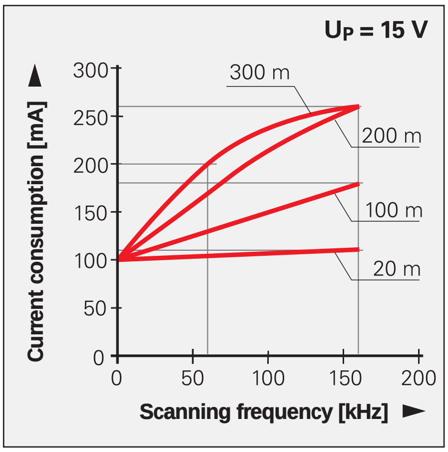


The permissible **cable length** for incremental encoders with HTL signals depends on the scanning frequency, the effective power supply, and the operating temperature of the encoder.



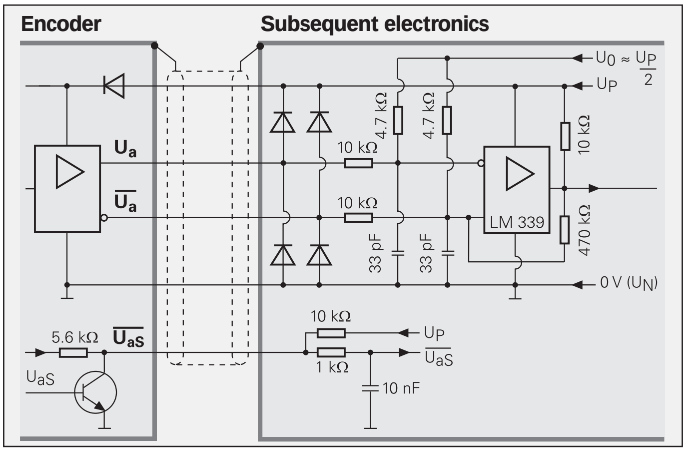
Current consumption
The current consumption for encoders with HTL output signals depends on the output frequency and the cable length to the subsequent electronics. The diagrams show typical curves for push-pull transmission with a 12-pin HEIDENHAIN cable. The maximum current consumption may be 50 mA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



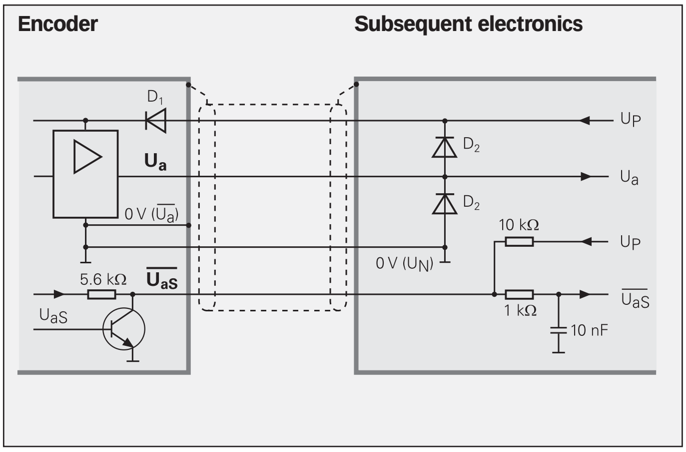


Input circuitry of subsequent electronics

HTL

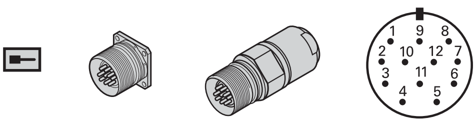


HTLs

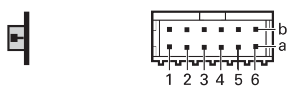


Pin layout

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**	**/**
HTL	**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**
HTLs						**0 V**		**0 V**		**0 V**			
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 in the encoder with the corresponding power line.

Interfaces

Absolute position values EnDat

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

For more information, refer to the *EnDat* Technical Information sheet or visit *www.endat.de*.

Position values can be transmitted with or without additional information (e.g. position value 2, temperature sensors, diagnostics, limit position signals).
Besides the position, additional data can be interrogated in the closed loop and functions can be performed with the EnDat 2.2 interface.

Parameters are saved in various memory areas, e.g.:

- Encoder-specific information
- Information of the OEM (e.g. "electronic ID label" of the motor)
- Operating parameters (datum shift, instruction, etc.)
- Operating status (alarm or warning messages)

Up to 100000 write accesses are permissible.

Monitoring and diagnostic functions of the EnDat interface make a detailed inspection of the encoder possible.

- Error messages
- Warnings
- Online diagnostics based on valuation numbers (EnDat 2.2)

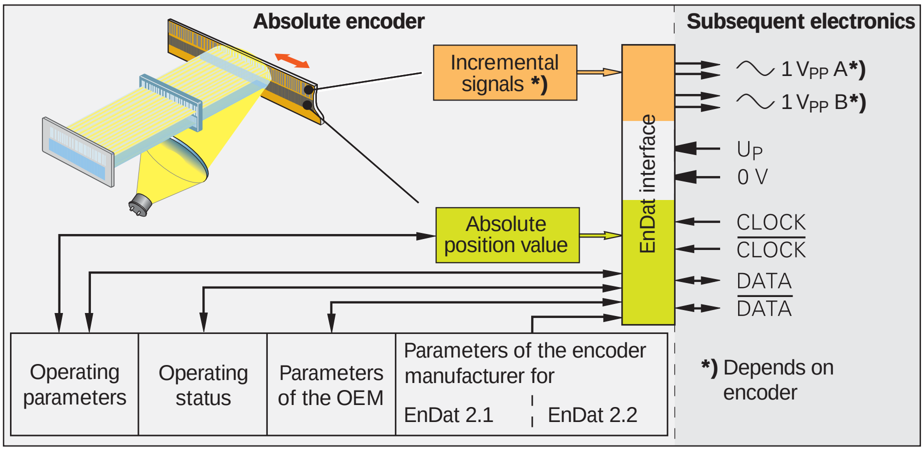
Incremental signals
EnDat encoders are available with or without incremental signals. EnDat 21 and EnDat 22 encoders feature a high internal resolution. An evaluation of the incremental signals is therefore unnecessary.

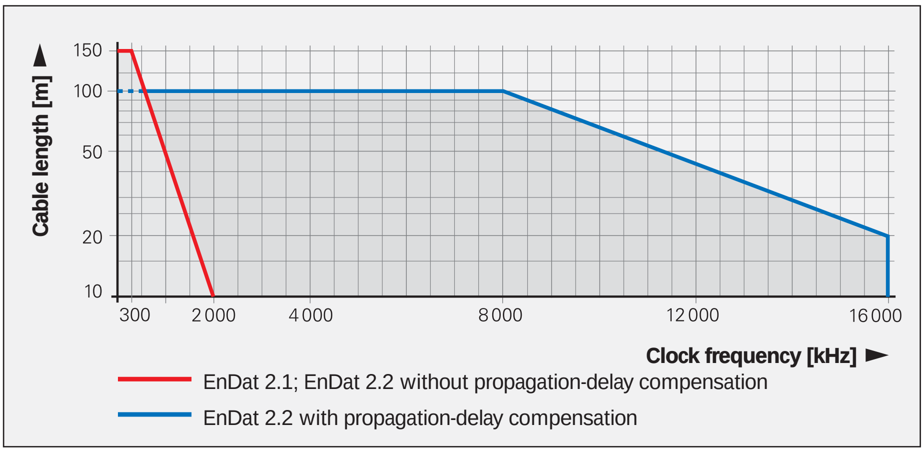
Clock frequency and cable length
The clock frequency is variable—depending on the cable length (max. 150 m)—between **100 kHz** and **2 MHz.** With propagation-delay compensation in the subsequent electronics, either clock frequencies **up to 16 MHz** are possible or cable lengths up to 100 m (for other values see *Specifications*).

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 the signals CLOCK, $\overline{\text{CLOCK}}$, DATA and $\overline{\text{DATA}}$
Data output	Differential line driver according to EIA standard RS 485 for DATA and $\overline{\text{DATA}}$ signals
Position values	Ascending during traverse in direction of arrow (see dimensions of the encoders)
Incremental signals	∼ $1\,V_{PP}$ (see *Incremental signals* $1\,V_{PP}$) depending on the unit

Ordering designation	**Command set**	**Incremental signals**	**Power supply**
EnDat 01	EnDat 2.1 or EnDat 2.2	With	See specifications of the encoder
EnDat 21		Without	
EnDat 02	EnDat 2.2	With	Expanded range 3.6 to 5.25 V DC or 14 V DC
EnDat 22	EnDat 2.2	Without	

Versions of the EnDat interface (bold print indicates standard versions)

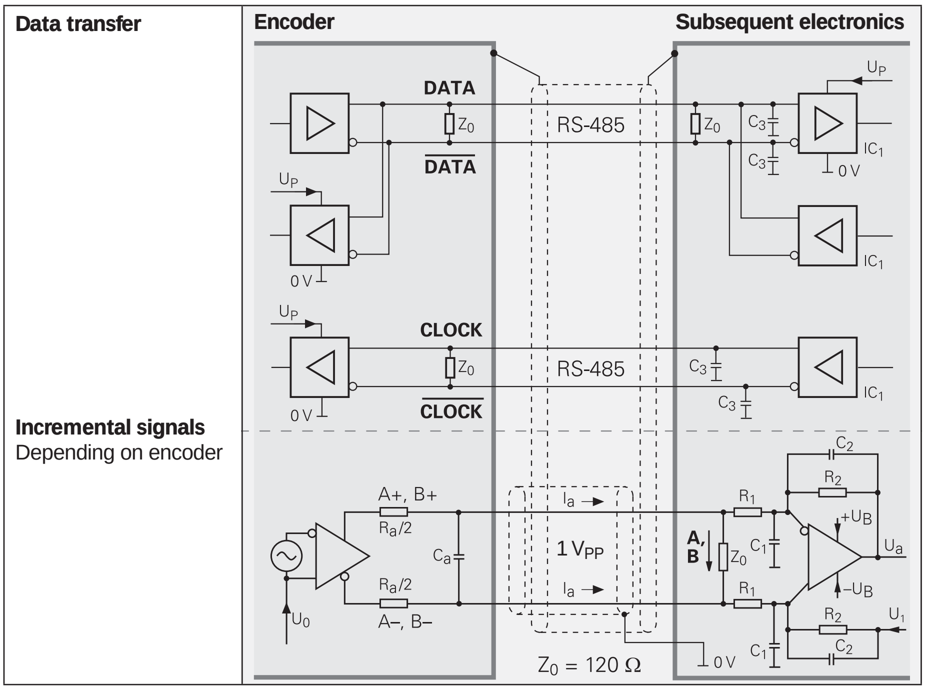




Input circuitry of subsequent electronics

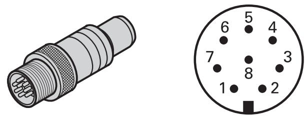
Dimensioning
IC_1 = RS 485 differential line receiver and driver

C_3 = 330 pF
Z_0 = 120 Ω



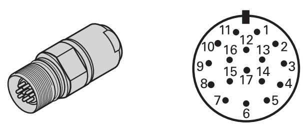
Pin layout

8-pin coupling, M12

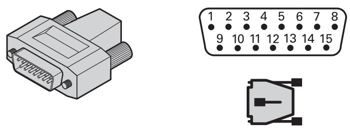


	Power supply				Absolute position values			
	8	**2**	**5**	**1**	**3**	**4**	**7**	**6**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

17-pin coupling, M23



15-pin D-sub connector, male
For IK 215/PWM 20



	Power supply					Incremental signals[1]				Absolute position values			
	7	**1**	**10**	**4**	**11**	**15**	**16**	**12**	**13**	**14**	**17**	**8**	**9**
	4	**12**	**2**	**10**	**6**	**1**	**9**	**3**	**11**	**5**	**13**	**8**	**15**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Internal 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

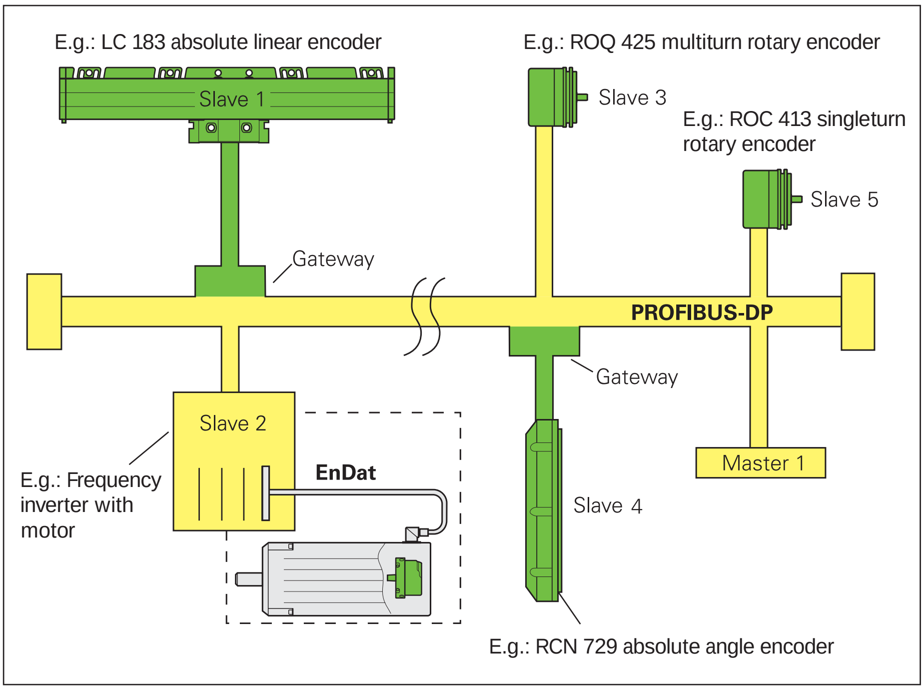
Cable shield connected to housing; **U_P** = Power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!
[1] Only with ordering designation EnDat 01 and EnDat 02

Interface
PROFIBUS-DP absolute position values

PROFIBUS-DP
PROFIBUS is a nonproprietary, open field bus in accordance with the international EN 50170 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 Mbps. 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.

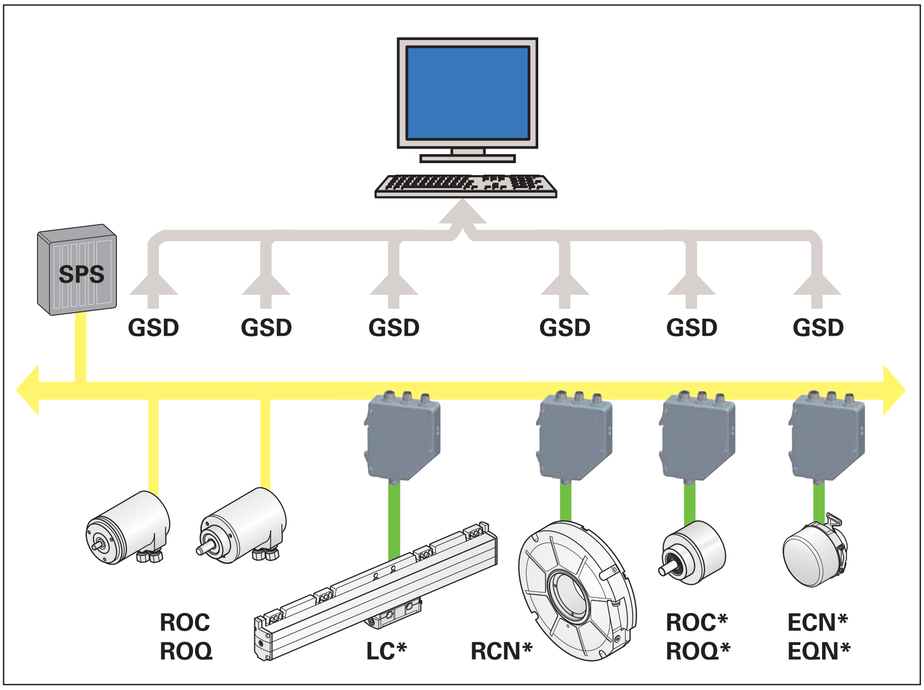


Bus structure of PROFIBUS-DP

Initial configuration
The characteristics of 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.

Two different GSD files are available for selection:
- GSD file for the DP-V0 profile
- GSD file for the DP-V1 and DP-V2 profiles



* With EnDat interface

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

DP-V0 profile
This profile can be obtained from the Profibus user organization (PNO) in Karlsruhe, Germany, under the order number 3.062. There are two classes defined in the profile, where class 1 provides minimum support, and class 2 allows additional, in part optional functions.

DP-V1 and DP-V2 profiles
These profiles can be obtained from the Profibus user organization (PNO) in Karlsruhe, Germany, under the order number 3.162. This profile also distinguishes between two device classes:

- Class 3 with the basic functions and
- Class 4 with the full range of scaling and preset functions.

Optional functions are defined in addition to the mandatory functions of classes 3 and 4.

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** and the velocity of the encoder can also be recorded.

Functions of the DP-V0 class

Feature *Data word width*	**Class**	**Rotational encoders** *≤ 16 bits*	 *≤ 31 bits*[1]	**Linear encoders** *≤ 31 bits*[1]
Pos. value, pure binary code	1,2	✓	✓	✓
Data word length	1,2	16	32	32
Scaling function Measuring steps/rev Total resolution	 2 2	 ✓ ✓	 ✓ ✓	 – –
Reversal of counting direction	1,2	✓	✓	–
Preset (output data 16 or 32 bits)	2	✓	✓	✓
Diagnostic functions Warnings and alarms	 2	 ✓	 ✓	 ✓
Operating time recording	2	✓	✓	✓
Velocity	2	✓[2]	✓[2]	–
Profile version	2	✓	✓	✓
Serial number	2	✓	✓	✓

[1] With data word width > 31 bits, only the upper 31 bits are transferred
[2] Requires a 32-bit configuration of the output data and 32 + 16-bit configuration of the input data

Functions of the DP-V1, DP-V2 classes

Feature *Data word width*	**Class**	**Rotational encoders** *≤ 32 bits*	 *> 32 bits*	**Linear encoders**
Telegram	3,4	81-84	84	81-84
Scaling function	4	✓	✓	–
Reversal of counting direction	4	✓	✓	–
Preset/Datum shift	4	✓	✓	✓
Acyclic parameters	3,4	✓	✓	✓
Channel-dependent diagnosis via alarm channel	3,4	✓	✓	✓
Operating time recording	3,4	✓[1]	✓[1]	✓[1]
Velocity	3,4	✓[1]	✓[1]	–
Profile version	3,4	✓	✓	✓
Serial number	3,4	✓	✓	✓

[1] Not supported by DP V2

Encoders with PROFIBUS-DP
The absolute rotary encoders with **integrated PROFIBUS-DP interface** are connected directly to the PROFIBUS.

Connection options:
- M12 connecting element
- M16 cable gland (terminal strip in the device)

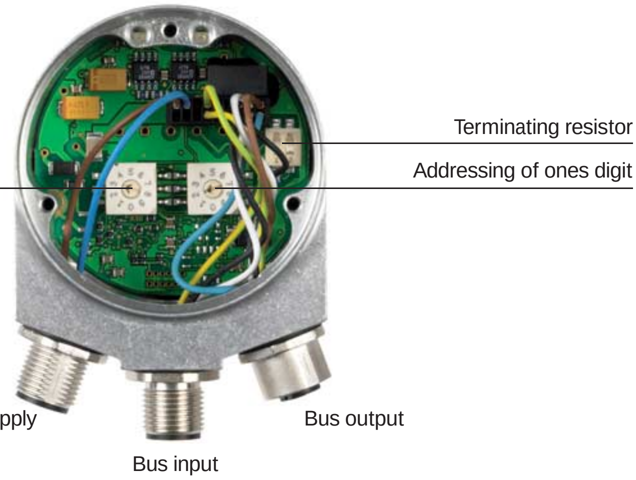
LEDs on the rear of the encoder display the power supply and bus status **operating states.**

The coding switches for the addressing (0 to 99) and for selecting the terminating resistor are easily accessible under the bus housing. The terminating resistor is to be activated if the rotary encoder is the last participant on the PROFIBUS-DP and the external terminating resistor is not used.

Accessories:
Adapter M12 (male), 4-pin, B-coded
Fits 5-pin bus output, with PROFIBUS terminating resistor.
Required for last participant if the encoder's internal terminating resistor is not to be used.
ID 584217-01

Mating connectors are required for connection via M12 connecting element:
Bus input:
M12 connector (female), 5-pin, B-coded
Bus output:
M12 coupling (male), 5-pin, B-coded
Power supply:
M12 connector, 4-pin, A-coded

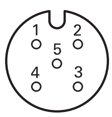
Connection via M12 connecting element



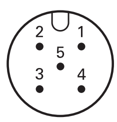
Connection via M16 cable gland

Pin layout of M12 connecting element

Mating connector:
Bus output
5-pin connector (female)
M12 B-coded



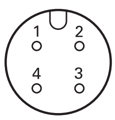
Mating connector:
Bus output
5-pin coupling (male)
M12 B-coded



	Power supply				Absolute position values	
	1	**3**	**5**	**Housing**	**2**	**4**
BUS in	**/**	**/**	**Shield**	**Shield**	**DATA (A)**	**DATA (B)**
BUS out	**U**[1)]	**0 V**[1)]	**Shield**	**Shield**	**DATA (A)**	**DATA (B)**

1) For supplying the external terminating resistor

Mating connector:
Power supply
4-pin connector (female)
M12 A-coded



	1	**3**	**2**	**4**
	U_P	**0 V**	**Vacant**	**Vacant**

Encoders with EnDat interface

All absolute encoders from HEIDENHAIN with EnDat interface can be connected to the PROFIBUS-DP over a **gateway**. The information available via PROFIBUS is generated on the basis of the EnDat 21 interface regardless of the encoder interface. The position value corresponds to the absolute value transmitted via the EnDat interface without interpolation of the 1 V_{PP} signals.

The complete interface electronics are integrated in the gateway, as well as a voltage converter for supplying EnDat encoders with 5 V DC ± 5 %. This 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.

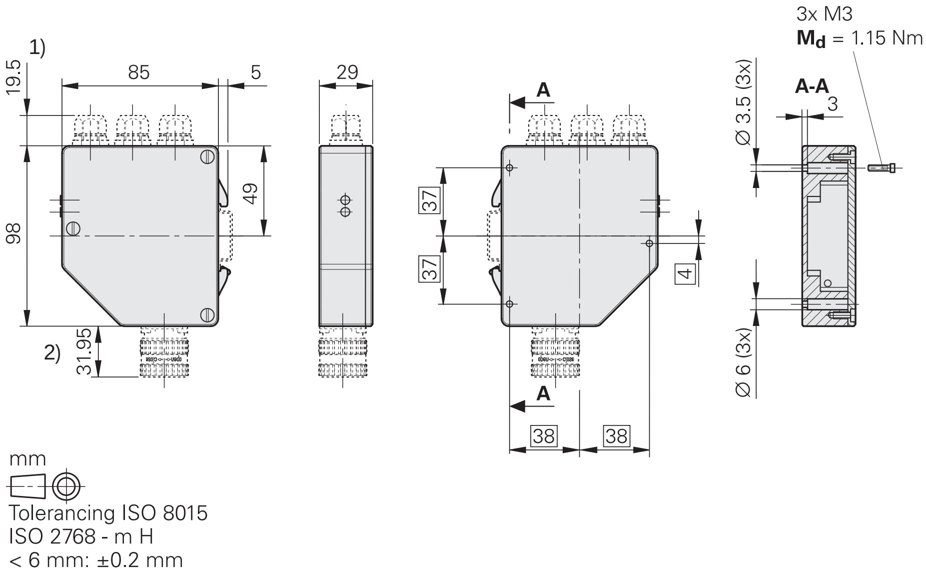
Besides the EnDat encoder connector, the gateway provides connections for the PROFIBUS and the power supply. In the gateway there are coding switches for addressing and selecting the terminating resistor.

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.

For more information, see the ***Gateway*** Product Information sheet.

Specifications	**PROFIBUS DP Gateway**
Input	Absolute encoders with EnDat interface
Connection*	M12 flange socket (female) 8-pin or M23 flange socket (female) 17-pin
Output	PROFIBUS DP-V0, classes 1 and 2 PROFIBUS DP-V1, DP-V2, classes 3 and 4 Integrated T-junction and bus termination (can be switched off)
PROFIBUS clock frequency	9.6 kb/s to 12 Mb/s
Bus connection* (bus in, bus out, power)	3 x M12 connecting element, 4 or 5 pins, or 3 x M16[1] cable gland (terminal strip in the device)
Cable length	≤ 400 m for 1.5 Mb/s ≤ 100 m for 12 Mb/s
Power supply	9 to 36 V DC; power consumption ≤ 4.8 W
Operating temperature	–40 to 80 °C
Protection EN 60529	IP 65
Fastening	Top-hat rail mounting[2]

* Please select when ordering
[1] Only in connection with the M23 input connector
[2] A mounting kit is available under ID 680406-01 for mounting on the existing holes of the ID 325771 gateway.



[1] Maximum values, depending on whether cable gland or M12
[2] Maximum values, depending on whether M12 or M23

Absolute position values PROFINET IO

PROFINET IO
PROFINET IO is the open Industrial Ethernet Standard for industrial communication. It builds on the field-proven function model of PROFIBUS-DP, but uses fast Ethernet technology as physical transmission medium and is therefore tailored for fast transmission of I/O data. It offers the possibility of transmission for required data, parameters and IT functions at the same time.

PROFINET makes it possible to connect local field devices to a controller and describes the data exchange between the controller and the field devices, as well as the parameterization and diagnosis. The PROFINET technique is arranged in modules. Cascading functions can be selected by the user himself. These functions differ essentially in the type of data exchange in order to satisfy high requirements on velocity.

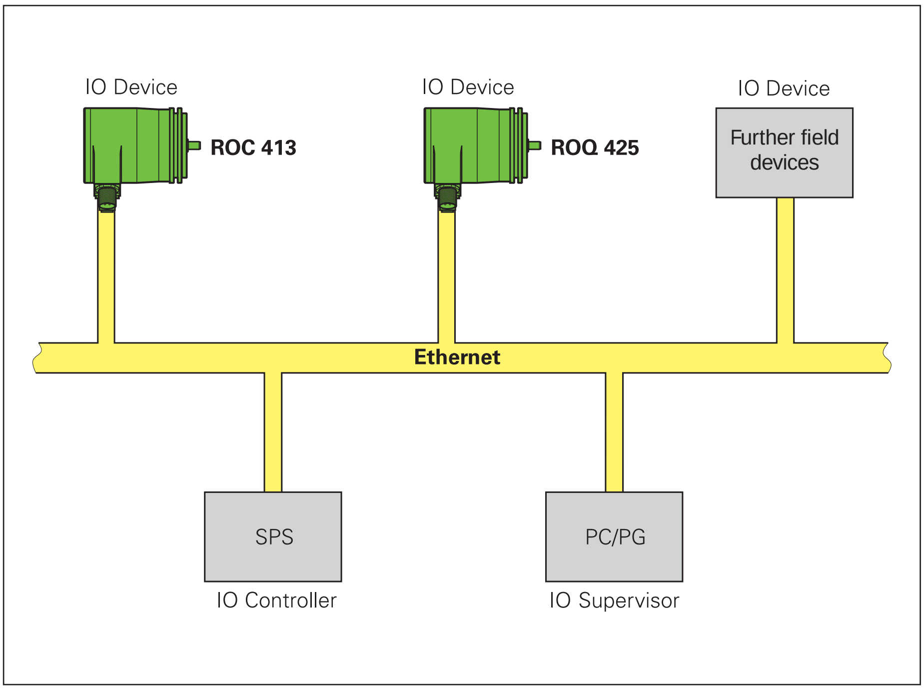
Topology and bus assignment
A PROFINET-IO system consists of:

- **IO controller** (control/PLC, controls the automation task)
- **IO device** (local field device, e.g. rotary encoder)
- **IO supervisor** (development or diagnostics tool, e.g. PC or programming device)

PROFINET IO functions according to the provider-consumer model, which supports communication between Ethernet peers. An advantage is that the provider transmits its data without any prompting by the communication partner.

Physical characteristics
HEIDENHAIN encoders are connected according to 100BASE-TX (IEEE 802.3 Clause 25) through one shielded, twisted wire pair per direction to PROFINET. The transmission rate is 100 Mbit/s (Fast Ethernet).

PROFINET profile
HEIDENHAIN encoders fulfill the definitions as per Profile 3.162, Version 4.1. The device profile describes the encoder functions. Class 4 (full scaling and preset) functions are supported. More detailed information on PROFINET can be ordered from the PROFIBUS User Organization PNO.



Supported functions	Class	Rotary encoders	
		Singleturn	Multiturn
Position value	3,4	✓	✓
Isochronous mode	3,4	✓	✓
Functionality of class 4	4	✓	✓
Scaling function	4	✓	✓
Measuring units per revolution	4	✓	✓
Total measuring range	4	✓	✓
Cyclic operation (binary scaling)	4	✓	✓
Noncyclic operation	4	✓	✓
Preset	4	✓	✓
Code sequence	4	✓	✓
Preset control G1_XIST1	4	✓	✓
Compatibility mode (encoder profile V.3.1)	3,4	✓	✓
Operating time	3,4	✓	✓
Velocity	3,4	✓	✓
Profile version	3,4	✓	✓
Permanent storage of the offset value	4	✓	✓
Identification & maintenance (I & M)		✓	✓
External firmware upgrade		✓	✓

Initial configuration
To put an encoder with a PROFINET interface into operation, a device identification record (GSD) must be downloaded and imported into the configuration software. The GSD contains the execution parameters required for a PROFINET-IO device.

Configuration
Profiles are predefined configurations of available functions and performance characteristics of PROFINET for use in certain devices or applications such as rotary encoders. They are defined and published by the workgroups of the PROFIBUS & PROFINET International (PI).

Profiles are important for openness, interoperability and exchangeability so that the end user can be sure that similar devices from different manufacturers function in a standardized manner.

Encoders with PROFINET
The absolute rotary encoders with integrated PROFIBUS interface are connected directly to the network. Addresses are distributed automatically over a protocol integrated in PROFINET. A PROFINET-IO field device is addressed within a network through its physical device MAC address.

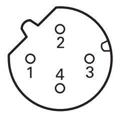
On their rear faces, the encoders feature two double-color LEDs for diagnostics of the bus and the device.

A terminating resistor for the last participant is not necessary.

Connection
PROFINET and the power supply are connected via the M12 connecting elements. The necessary mating connectors are:
PORTs 1 and 2:
M12 coupling (male), 4-pin, D-coded
Power supply:
M12 connector, 4-pin, A-coded

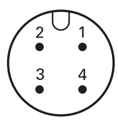
Pin layout

PORTs 1 and 2
4-pin connector (female)
M12 D-coded



	Absolute position values				
	1	**2**	**3**	**4**	**Housing**
PORT 1/2	**Tx+**	**Rx+**	**Tx–**	**Rx–**	**Shield**

Power supply
4-pin coupling (male)
M12 A-coded



	1	**3**	**2**	**4**
	U_P	**0 V**	**Vacant**	**Vacant**

Interfaces
SSI absolute position values

The **absolute position value** beginning with the Most Significant Bit (MSB first) is transferred on the DATA lines in synchronism with a CLOCK signal transmitted by the control. The SSI standard data word length for singleturn encoders is 13 bits, and for multiturn 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}*.

For the ECN/EQN 4xx and ROC/ROQ 4xx rotary encoders, 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.

- **Zeroing** (datum setting)
  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").

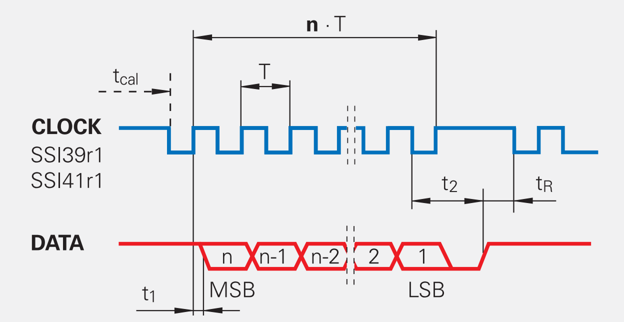
Interface	**SSI** serial
Ordering designation	*Singleturn:* SSI 39r1 *Multiturn:* SSI 41r1
Data transfer	Absolute position values
Data input	Differential line receiver according to EIA standard RS 485 for the CLOCK and $\overline{\text{CLOCK}}$ signals
Data output	Differential line driver according to EIA standard RS 485 for DATA and $\overline{\text{DATA}}$ signals
Code	Gray
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 (for ECN/EQN 4xx, ROC/ROQ 4xx) LOW < 0.25 x U_P HIGH > 0.6 x U_P t_{min} > 1 ms
Connecting cables 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. 100 m at 90 pF/m distributed capacitance 6 ns/m

Control cycle for complete data format
When not transmitting, the clock and data lines are on high level. The internally and cyclically formed 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. Encoders with SSI 39r1 and SSI 41r1 interfaces additionally require a subsequent clock pause t_R. If another data-output request (CLOCK) is received within this time (t_2 or t_2+t_R), 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. With the next rising clock edge the subsequent electronics adopts the data.

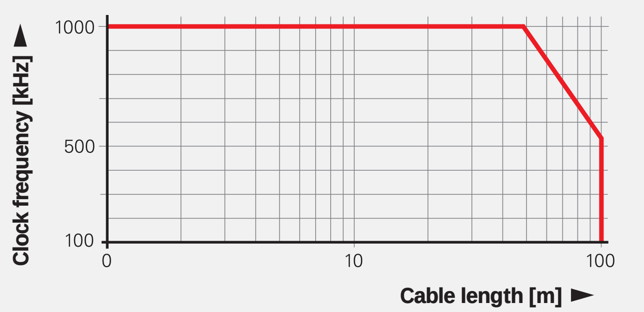
Data transfer

T = 1 to 10 µs
t_{cal} See *Specifications*
t_1 ≤ 0.4 µs (without cable)
t_2 = 17 to 20 µs
t_R ≥ 5 µs
n = Data word length
13 bits for ECN/ROC
25 bits for EQN/ROQ

$\overline{\text{CLOCK}}$ and $\overline{\text{DATA}}$ not shown



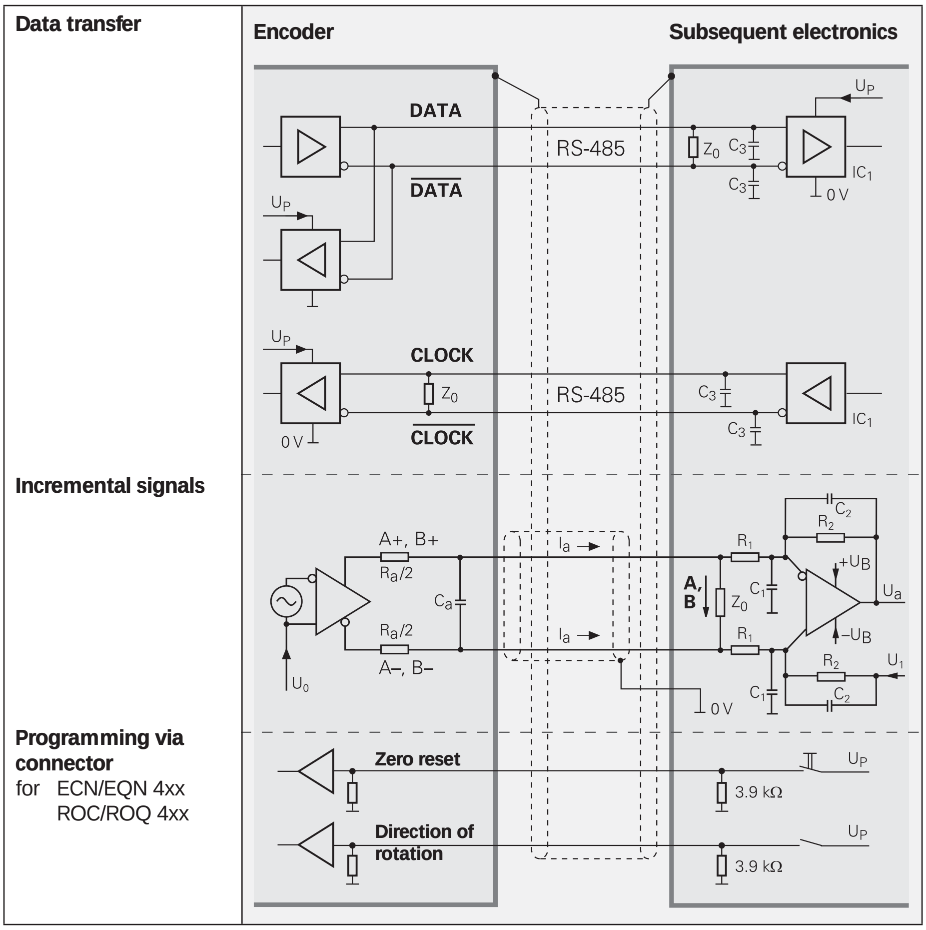
Permissible clock frequency with respect to cable lengths



Input circuitry of the subsequent electronics

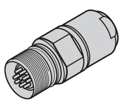
Dimensioning
IC_1 = Differential line receiver and driver
e.g. SN 65 LBC 176
LT 485

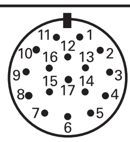
Z_0 = 120 Ω
C_3 = 330 pF (serves to improve noise immunity)

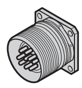


Pin layout

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	**Internal shield**	**A+**	**A–**	**B+**	**B–**	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**	**Direction of rotation**[1]	**Zero reset**[1]
	Brown/ Green	Blue	White/ Green	White	/	Green/ Black	Yellow/ Black	Blue/ Black	Red/ Black	Gray	Pink	Violet	Yellow	Black	Green

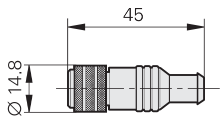
Shield on housing; **U_P** = power supply voltage
Sensor: With a 5 V supply voltage, the sensor line is connected in the encoder with the corresponding power line.
[1] Vacant on ECN/EQN 10xx and ROC/ROQ 10xx

Cables and connecting elements
General information

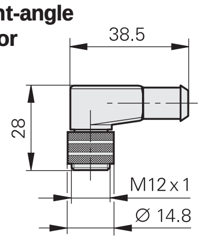
Connector (insulated): A connecting element with a coupling ring. Available with male or female contacts.

Symbols 

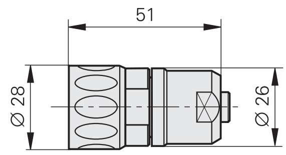
M12



M12 right-angle connector



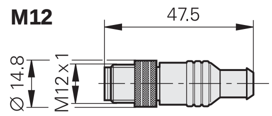
M23



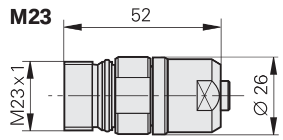
Coupling (insulated): Connecting element with external thread; available with male or female contacts.

Symbols 

M12

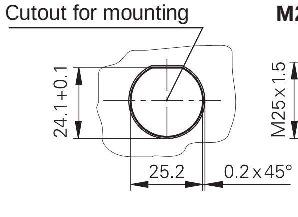


M23

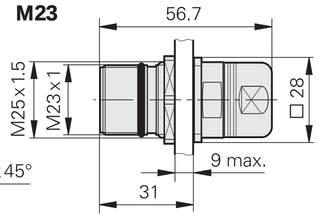


Mounted coupling with central fastening

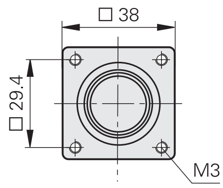
Cutout for mounting



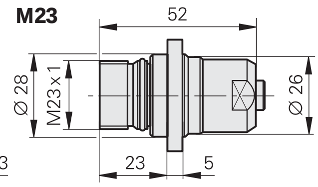
M23



Mounted coupling with flange



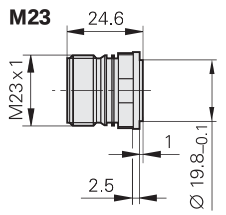
M23

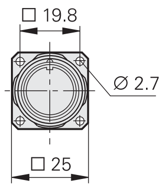


Flange socket: with external thread; permanently mounted on a housing, available with male or female contacts.

Symbols 

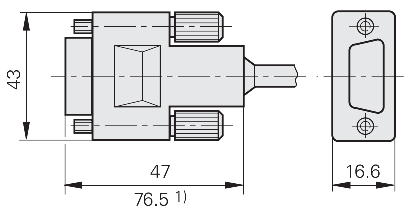
M23





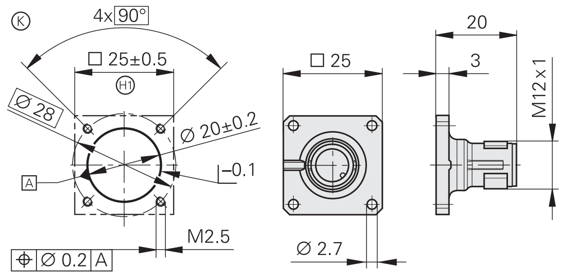
D-sub connector for HEIDENHAIN controls, counters and IK absolute value cards.

Symbols 



1) Interface electronics integrated in connector

M12 **flange socket** with motor-internal encoder cable



Ⓚ = Mating mounting holes
Ⓗ1 = Flatness 0.05 / Ra3.2

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

male or

female contacts.

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

Accessories for flange sockets and M23 mounted couplings

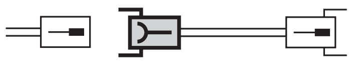
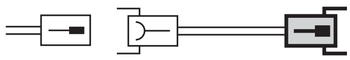
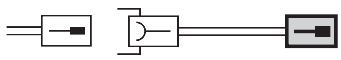
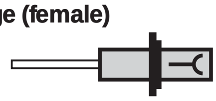
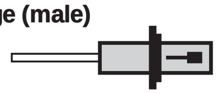
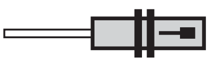
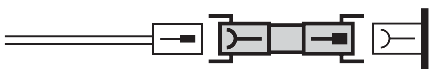
Bell seal
ID 266526-01

Threaded metal dust cap
ID 219926-01

Accessory for M12 connecting element
Insulation spacer
ID 596495-01

Connecting cables 1 V_{PP}, TTL

12-pin M23

		For ~ 1 V_{PP} ⊓⊔ TTL ⊓⊔ HTL
PUR connecting cables	**12-pin:** [4(2 × 0.14 mm^2) + (4 × 0.5 mm^2)]	**Ø 8 mm**
Complete with connector (female) and coupling (male)		298401-xx
Complete with connector (female) and connector (male)		298399-xx
Complete with connector (female) and D-sub connector (female), 15-pin, for TNC		310199-xx
Complete with connector (female) and D-sub connector (male), 15-pin, for PWM 20/EIB 741		310196-xx
With **one** connector (female)		309777-xx
Cable without connectors, ∅ 8 mm		244957-01
Mating element on connecting cable to connector on encoder cable	**Connector (female)** for cable ∅ 8 mm 	291697-05
Connector on connecting cable for connection to subsequent electronics	**Connector (male)** for cable ∅ 8 mm ∅ 6 mm 	291697-08 291697-07
Coupling on connecting cable	**Coupling (male)** for cable ∅ 4.5 mm ∅ 6 mm ∅ 8 mm 	291698-14 291698-03 291698-04
Flange socket for mounting on subsequent electronics	**Flange socket (female)** 	315892-08
Mounted couplings	**With flange (female)** ∅ 6 mm ∅ 8 mm 	291698-17 291698-07
	With flange (male) ∅ 6 mm ∅ 8 mm 	291698-08 291698-31
	With central fastening (male) ∅ 6 mm to 10 mm 	741045-01
Adapter ~ 1 V_{PP}/11 μA_{PP} For converting the 1 V_{PP} signals to 11 μA_{PP}; 12-pin M23 connector (female) and 9-pin M23 connector (male)		364914-01

EnDat connecting cables

		8-pin M12		17-pin M23
		For EnDat without incremental signals		**For EnDat** with incremental signals **SSI**
PUR connecting cables	**8-pin:** [(4 × 0.14 mm^2) + (4 × 0.34 mm^2)] **17-pin:** [(4 × 0.14 mm^2) + 4(2 × 0.14 mm^2) + (4 × 0.5 mm^2)]			
	Cable diameter	6 mm	3.7 mm	8 mm
Complete with connector (female) and coupling (male)		368330-xx	801142-xx	323897-xx *340302-xx*
Complete with right-angle connector (female) and coupling (male)		373289-xx	801149-xx	–
Complete with connector (female) and D-sub connector (female), 15-pin, for TNC (position inputs)		533627-xx	–	332115-xx
Complete with connector (female) and D-sub connector (female), 25-pin, for TNC (rotational speed inputs)		*641926-xx*	–	*336376-xx*
Complete with connector (female) and D-sub connector (male), 15-pin, for IK 215, PWM 20, EIB 741, etc.		524599-xx	801129-xx	350376-xx
Complete with right-angle connector (female) and D-sub connector (male), 15-pin, for IK 215, PWM 20, EIB 741, etc.		722025-xx	801140-xx	–
With **one** connector (female)		634265-xx	–	309778-xx 309779-xx[1)]
With one right-angle connector, (female)		606317-xx	–	–
Cable only		–	–	266306-01

Italics: Cable with assignment for “speed encoder“ input (MotEnc EnDat)
[1)] Without incremental signals

HEIDENHAIN measuring equipment

The **PWM 9** is a universal measuring device for checking and adjusting HEIDENHAIN incremental encoders. Expansion modules are available for checking the various types of 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 $11\ \mu A_{PP}$; $1\ V_{PP}$; TTL; HTL; EnDat*/SSI*/commutation signals *No display of position values or parameters
Functions	• **Measures** signal amplitudes, current consumption, operating voltage, scanning frequency • **Graphically displays** incremental signals (amplitudes, phase angle and on-off ratio) and the reference-mark signal (width and position) • **Displays 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 DC, max. 15 W
Dimensions	150 mm × 205 mm × 96 mm

PWM 20
The PWM 20 phase angle measuring unit serves together with the provided ATS adjusting and testing software for diagnosis and adjustment of HEIDENHAIN encoders.

	PWM 20
Encoder input	• EnDat 2.1 or EnDat 2.2 (absolute value with/without incremental signals) • DRIVE-CLiQ • Fanuc Serial Interface • Mitsubishi High Speed Serial Interface • SSI • $1\ V_{PP}$/TTL/$11\ \mu A_{PP}$
Interface	USB 2.0
Power supply	100 to 240 V AC or 24 V DC
Dimensions	258 mm x 154 mm x 55 mm

	ATS
Languages	Choice between English or German
Functions	• Position display • Connection dialog • Diagnosis • Mounting wizard for EBI/ECI/EQI, LIP 200, LIC 4000 and others • Additional functions (if supported by the encoder) • Memory contents
System requirements	PC (dual-core processor; > 2 GHz) Main memory > 1 GB Windows XP, Vista, 7 (32-bit/64-bit) 100 MB free space on hard disk

DRIVE-CLiQ is a registered trademark of the Siemens Aktiengesellschaft

General electrical information

Power supply

Connect HEIDENHAIN encoders only to subsequent electronics whose power supply is generated from PELV systems **(EN 50178).** In addition, overcurrent protection and overvoltage protection are required in safety-related applications.

If HEIDENHAIN encoders are to be operated in accordance with IEC 61010-1, power must be supplied from a secondary circuit with current or power limitation as per IEC 61010-1:2001, section 9.3 or IEC 60950-1:2005, section 2.5 or a Class 2 secondary circuit as specified in UL1310.

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

The values apply as measured at the encoder, i.e., without cable influences. The voltage can be monitored and adjusted with the encoder'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**:

$$\Delta U = 2 \cdot 10^{-3} \cdot \frac{1.05 \cdot L_C \cdot I}{56 \cdot A_P}$$

where
- ΔU: Voltage drop in V
- 1.05: Length factor due to twisted wires
- L_C: Cable length in m
- I: Current consumption in mA
- A_P: Cross section of power lines in mm²

The voltage actually applied to the encoder is to be considered when **calculating the encoder's power requirement.** This voltage consists of the supply voltage U_P provided by the subsequent electronics minus the line drop in the power lines. For encoders with an expanded supply range, the voltage drop in the power lines must be calculated under consideration of the nonlinear current consumption (see next page).

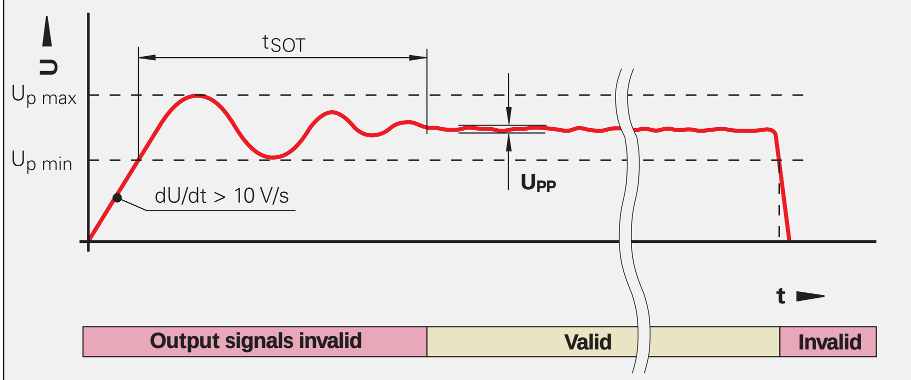
If the voltage drop is known, all parameters for the encoder and subsequent electronics can be calculated, e.g. voltage at the encoder, current requirements and power consumption of the encoder, as well as the power to be provided by the subsequent electronics.

Switch-on/off behavior of the encoders
The output signals are valid no sooner than after the switch-on time t_{SOT} = 1.3 s (2 s for PROFIBUS-DP) (see diagram). During the time t_{SOT} they can have any levels up to 5.5 V (with HTL encoders up to U_{Pmax}). If an interpolation electronics unit is inserted between the encoder and the power supply, this unit's switch-on/off characteristics must also be considered. If the power supply is switched off, or when the supply voltage falls below U_{min}, the output signals are also invalid. During restart, the signal level must remain below 1 V for the time t_{SOT} before power on. These data apply to the encoders listed in the catalog—customer-specific interfaces are not considered.

Encoders with new features and increased performance range may take longer to switch on (longer time t_{SOT}). If you are responsible for developing subsequent electronics, please contact HEIDENHAIN in good time.

Isolation
The encoder housings are isolated against internal circuits.
Rated surge voltage: 500 V
(preferred value as per VDE 0110 Part 1, overvoltage category II, contamination level 2)

Transient response of supply voltage and switch-on/switch-off behavior



Cable	Cross section of power supply lines A_P			
	1 V_{PP}/TTL/HTL	11 µA_{PP}	EnDat/SSI 17-pin	EnDat[5] 8-pin
Ø 3.7 mm	0.05 mm²	–	–	0.09 mm²
Ø 4.3 mm	0.24 mm²	–	–	–
Ø 4.5 mm EPG	0.05 mm²	–	0.05 mm²	0.09 mm²
Ø 4.5 mm **Ø 5.1 mm**	0.14/0.09[2] mm² 0.05[2), 3)] mm²	0.05 mm²	0.05/0.14[6] mm²	0.14 mm²
Ø 5.5 mm PVC	0.1 mm²	–	–	–
Ø 6 mm **Ø 10 mm**[1]	0.19/0.14[2), 4)] mm²	–	0.08/0.19[6] mm²	0.34 mm²
Ø 8 mm **Ø 14 mm**[1]	0.5 mm²	1 mm²	0.5 mm²	1 mm²

[1] Metal armor
[2] Rotary encoders
[3] Length gauges
[4] LIDA 400
[5] Also Fanuc, Mitsubishi
[6] Adapter cables for RCN, LC

Encoders with expanded supply voltage range

For encoders with expanded supply voltage range, the current consumption has a nonlinear relationship with the supply voltage. On the other hand, the power consumption follows a linear curve (see *Current and power consumption* diagram). The maximum power consumption at minimum and maximum supply voltage is listed in the **Specifications**. The maximum power consumption (worst case) accounts for:

- Recommended receiver circuit
- Cable length 1 m
- Age and temperature influences
- Proper use of the encoder with respect to clock frequency and cycle time

The typical current consumption at no load (only supply voltage is connected) for 5 V supply is specified for comparison.

The actual power consumption of the encoder and the required power output of the subsequent electronics are measured, while taking the voltage drop on the supply lines into consideration, in four steps:

***Step 1:* Resistance of the supply lines**

The resistance values of the supply lines (adapter cable and encoder cable) can be calculated with the following formula:

$$R_L = 2 \cdot \frac{1.05 \cdot L_C}{56 \cdot A_P}$$

***Step 2:* Coefficients for calculation of the drop in line voltage**

$$b = -R_L \cdot \frac{P_{Emax} - P_{Emin}}{U_{Emax} - U_{Emin}} - U_P$$

$$c = P_{Emin} \cdot R_L + \frac{P_{Emax} - P_{Emin}}{U_{Emax} - U_{Emin}} \cdot R_L \cdot (U_P - U_{Emin})$$

***Step 3:* Voltage drop based on the coefficients b and c**

$$\Delta U = -0.5 \cdot (b + \sqrt{b^2 - 4 \cdot c})$$

***Step 4:* Parameters for subsequent electronics and the encoder**

Voltage at encoder:
$U_E = U_P - \Delta U$

Current requirement of encoder:
$I_E = \Delta U / R_L$

Power consumption of encoder:
$P_E = U_E \cdot I_E$

Power output of subsequent electronics:
$P_S = U_P \cdot I_E$

Where:

U_{Emax}, U_{Emin}: Minimum or maximum supply voltage of the encoder in V

P_{Emin}, P_{Emax}: Maximum power consumption at minimum or maximum power supply, respectively, in W

U_P: Supply voltage of the subsequent electronics in V

R_L: Cable resistance (for both directions) in ohms

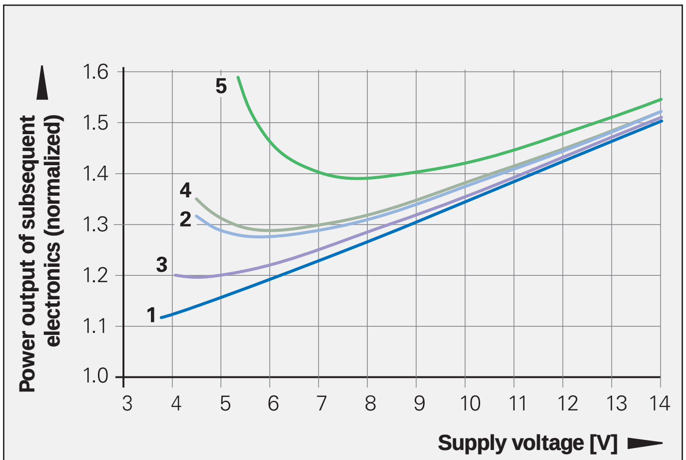
ΔU: Voltage drop in the cable in V

1.05: Length factor due to twisted wires

L_C: Cable length in m

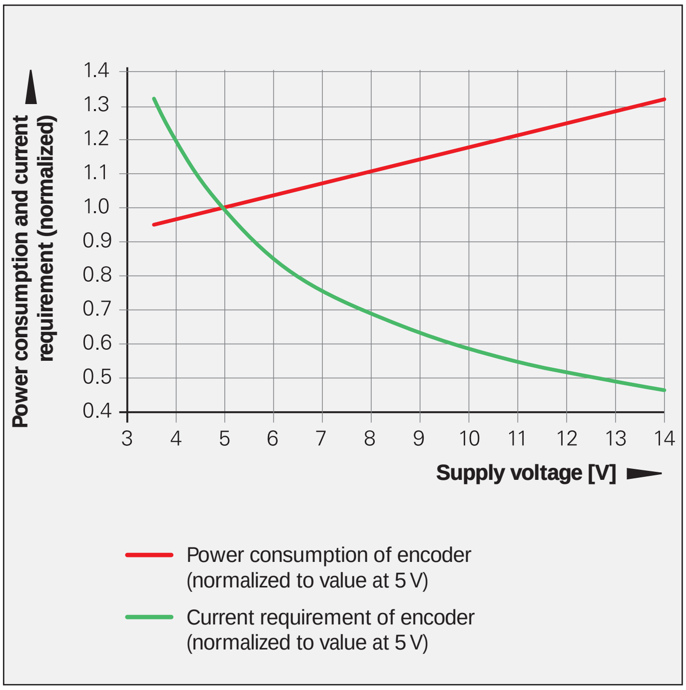
A_P: Cross section of power lines in mm^2

Influence of cable length on the power output of the subsequent electronics (example representation)



	Encoder cable/adapter cable	Connecting cables	Total
1	3 m	/	3 m
2	20 m	/	20 m
3	3 m	17 m	20 m
4	3 m	47 m	50 m
5	3 m	97 m	100 m

Current and power consumption with respect to the supply voltage (example representation)



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 the *Specifications*)
  and
- the **electrically** permissible shaft speed/ traversing velocity.
  For encoders with **sinusoidal output signals**, the electrically permissible shaft speed/traversing velocity is limited by the –3 dB/ –6 dB cutoff frequency or the permissible input frequency of the subsequent electronics.
  For encoders with **square-wave signals,** the electrically permissible shaft speed/ 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 angle 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}: Elec. permissible speed in min^{-1}
v_{max}: Elec. permissible traversing velocity in m/min
f_{max}: Max. scanning/output frequency of encoder or input frequency of subsequent electronics in kHz
z: Line count of the angle or rotary encoder per 360°
SP: Signal period of the linear encoder in µm

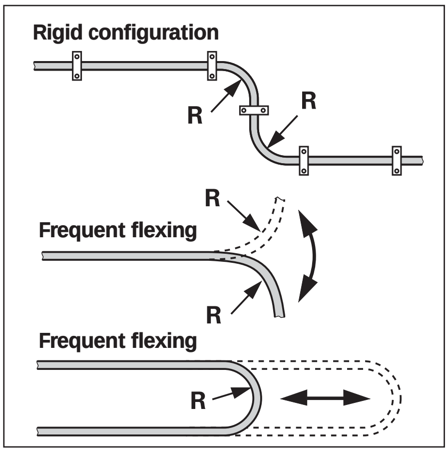
Cable

For safety-related applications, use HEIDENHAIN cables and connectors.

Versions
The cables of almost all HEIDENHAIN encoders and all adapter and connecting cables are sheathed in **polyurethane (PUR cables).** Most adapter cables for within motors and a few cables on encoders are sheathed in a **special elastomer (EPG cables).** These cables are identified in the specifications or in the cable tables with "EPG."

Durability
PUR cables are resistant to oil in accordance with **VDE 0472** (Part 803/test type B) and to hydrolysis and microbes in accordance with **VDE 0282** (Part 10). 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.

EPG cables are resistant to oil in accordance with **VDE 0472** (Part 803/test type B) and to hydrolysis in accordance with **VDE 0282** (Part 10). They are free of PVC, silicone and halogens. In comparison with PUR cables, they are only somewhat resistant to media, frequent flexing and continuous torsion.



Temperature range
HEIDENHAIN cables can be used for
rigid configuration (PUR) –40 to 80 °C
rigid configuration (EPG) –40 to 120 °C
frequent flexing (PUR) –10 to 80 °C

PUR cables with limited resistance to hydrolysis and microbes are rated for up to 100 °C. If needed, please ask for assistance from HEIDENHAIN Traunreut.

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

Cable	Bend radius R	
	Rigid configuration	**Frequent flexing**
Ø 3.7 mm	≥ 8 mm	≥ 40 mm
Ø 4.3 mm	≥ 10 mm	≥ 50 mm
Ø 4.5 mm EPG	≥ 18 mm	–
Ø 4.5 mm **Ø 5.1 mm**	≥ 10 mm	≥ 50 mm
Ø 6 mm **Ø 10 mm**[1)]	≥ 20 mm ≥ 35 mm	≥ 75 mm ≥ 75 mm
Ø 8 mm **Ø 14 mm**[1)]	≥ 40 mm ≥ 100 mm	≥ 100 mm ≥ 100 mm

1) Metal armor

Noise-free signal transmission

Electromagnetic compatibility/ CE-compliance
When properly installed, and when HEIDENHAIN connecting cables and cable assemblies are used, HEIDENHAIN encoders fulfill the requirements for electromagnetic compatibility according to 2004/108/EC with respect to the generic standards for:

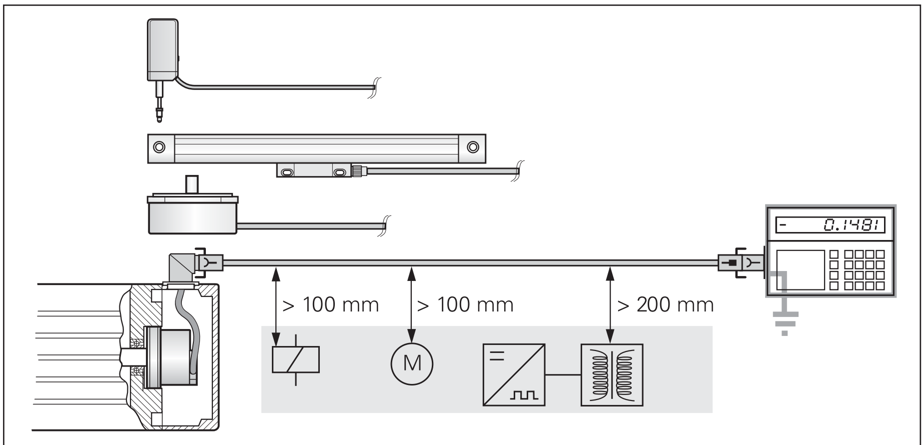
- **Noise immunity EN 61000-6-2:**
  Specifically:
  - ESD EN 61000-4-2
  - Electromagnetic fields EN 61000-4-3
  - Burst EN 61000-4-4
  - Surge EN 61000-4-5
  - Conducted disturbances EN 61000-4-6
  - Power frequency magnetic fields EN 61000-4-8
  - Pulse magnetic fields EN 61000-4-9
- **Interference EN 61000-6-4:**
  Specifically:
  - For industrial, scientific and medical equipment (ISM) EN 55011
  - For information technology equipment EN 55022

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 include:

- Strong magnetic fields from transformers, brakes 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

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

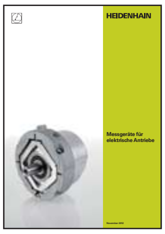
- Use only original HEIDENHAIN cables. Consider the voltage drop on supply lines.
- Use connecting elements (such as connectors or terminal boxes) with metal housings. Only the signals and power supply of the connected encoder may be routed through these elements. Applications in which additional signals are sent through the connecting element require specific measures regarding electrical safety and EMC.
- Connect the housings of the encoder, connecting elements and subsequent electronics through the shield of the cable. Ensure that the shield has complete contact over the entire surface (360°). For encoders with more than one electrical connection, refer to the documentation for the respective product.
- For cables with multiple shields, the inner shields must be routed separately from the outer shield. Connect the inner shield to 0 V of the subsequent electronics. Do not connect the inner shields with the outer shield, neither in the encoder nor in the cable.
- Connect the shield to protective ground as per the mounting instructions.
- Prevent contact of the shield (e.g. connector housing) with other metal surfaces. Pay attention to this when installing cables.
- Do not install signal cables in the direct vicinity of interference sources (inductive consumers such as contactors, 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.
- If compensating currents are to be expected within the overall system, a separate equipotential bonding conductor must be provided. The shield does not have the function of an equipotential bonding conductor.
- Provide power only from PELV systems **(EN 50178)** to position encoders. Provide high-frequency grounding with low impedance **(EN 60204-1 Chap. EMC).**
- For encoders with 11 µAPP interface: For extension cables, use only HEIDENHAIN cable ID 244955-01. Overall length: max. 30 m.



Minimum distance from sources of interference

Sales and Service
More information

Other devices for angular measurement from HEIDENHAIN include rotary encoders, which are used primarily on electrical motors, for elevator control and for potentially explosive atmospheres.
Angle encoders from HEIDENHAIN serve for high-accuracy position acquisition of angular movements.



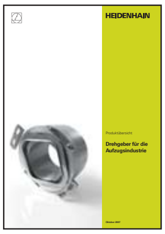
Catalog
Encoders for Servo Drives

Contents:
Rotary encoders
Angle encoders
Linear encoders

Catalog
Modular Magnetic Encoders

Catalog
Absolute Angle Encoders with Optimized Scanning

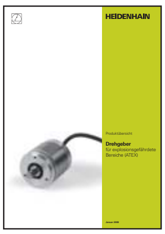
Contents:
Absolute angle encoders
RCN 2000, RCN 5000, RCN 8000



Product Overview
Rotary Encoders for the Elevator Industry

Catalog
Angle Encoders with Integral Bearing

Contents:
Absolute angle encoders
RCN
Incremental angle encoders
RON, RPN, ROD



Product Overview
Rotary Encoders for Potentially Explosive Atmospheres

Catalog
Angle Encoders without Integral Bearing

Contents:
Incremental angle encoders
ERA, ERP

Further HEIDENHAIN products
- Linear encoders
- Length gauges
- Measuring systems for machine tool inspection and acceptance testing
- Subsequent electronics
- NC controls for machine tools
- Touch probes

HEIDENHAIN on the Internet
Visit our home page at www.heidenhain.com for up-to-date information on:
- The company
- The products

Also included:
- Technical articles
- Press releases
- Addresses
- CAD drawings

Addresses in Germany

HEIDENHAIN is represented in Germany and all other important industrial nations as well. In addition to the addresses listed on the back page, there are many service agencies located worldwide. For their addresses, please refer to the Internet or contact HEIDENHAIN Traunreut.

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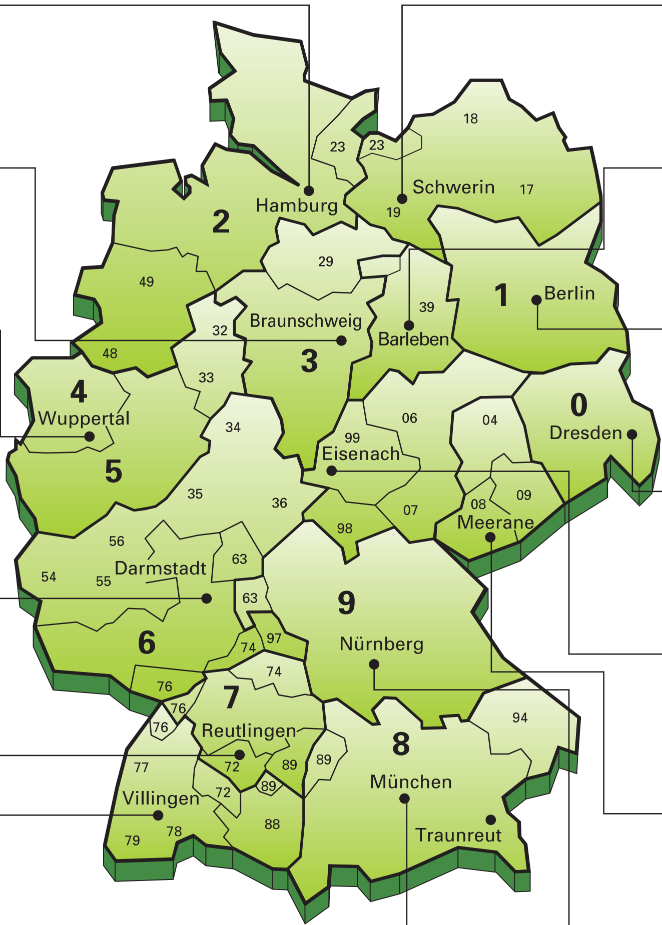

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