HEIDENHAIN

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Modular Magnetic Encoders

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The ERM modular encoders from HEIDENHAIN consist of a magnetized scale drum and a scanning unit with magnetoresistive sensor. Their MAGNODUR measuring standard and the magnetoresistive scanning principle make them particularly tolerant to contamination.

Typical applications include machines and equipment with **large hollow shaft diameters** in environments with large amounts of airborne particles and liquids, for example on the spindles of lathes or milling machines, for reduced accuracy requirements.

Information on
- Angle encoders without integral bearing
- Angle encoders with integral bearing
- Angle encoders with optimized scanning
- Rotary encoders
- Encoders for servo drives
- Exposed linear encoders
- Linear encoders for numerically controlled machine tools
- HEIDENHAIN interface electronics
- HEIDENHAIN controls

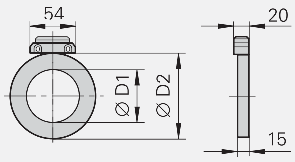
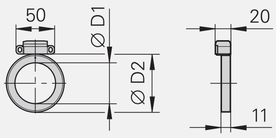
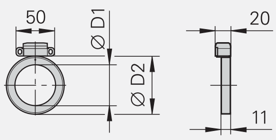
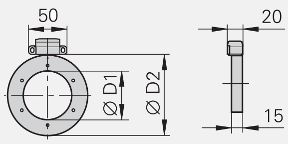
is available on request as well as on the Internet at www.heidenhain.de.

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.

Contents

Selection Guide

	Overall dimensions in mm	**Diameter**	**Line count**	**Signal period** (approx.)
ERM 200 Series		D1: 40 to 410 mm D2: 75.44 to 452.64 mm	600 to 3600	400 µm
ERM 2400 Series		D1: 40 mm; 55 mm D2: 64.37 mm; 75.44 mm	512; 600	400 µm
ERM 2900 Series		D1: 55 mm D2: 77.41 mm	256	1000 µm
ERM 2410 Series		D1: 40 mm to 410 mm D2: 75.44 to 452.64 mm	600 to 3600	400 µm

1) The absolute position value is generated internally from the incremental signals after traverse over two reference marks.

Mechanically permissible speed	Mounting	Interface	Model	Page
19000 min^{-1} to 3000 min^{-1}	Fastening by axial screws	TTL	**ERM 220**	**18**
		1 V_{PP}	**ERM 280**	
42000 min^{-1}; 36000 min^{-1}	Friction-locked fastening by clamping the drum	1 V_{PP}	**ERM 2484**	**24**
33000 min^{-1}; 27000 min^{-1}	Friction-locked fastening by clamping the drum; additional slot for feather key as anti-rotation element	1 V_{PP}	**ERM 2485**	
35000 min^{-1}	Friction-locked fastening by clamping the drum	1 V_{PP}	**ERM 2984**	**26**
19000 min^{-1} to 3000 min^{-1}	Fastening by axial screws	EnDat 2.2/22[1)]	**ERM 2410**	**30**

Range of Applications

The robust ERM modular magnetic encoders are especially suited for use in production machines. Their large inside diameters offered, their small dimensions and the compact design of the scanning head predestine them for:

- The C axis of lathes
- Spindle orientation on milling machines
- Auxiliary axes
- Integration in gear stages
- Speed measurement on direct drives

The signal periods of approx. 400 µm or 1000 and the special MAGNODUR procedure for applying the grating achieve the accuracy values and shaft speeds required by these applications.

Accuracy
The typical application for ERM 200 encoders is on the C axis of lathes, especially for the machining of bar-stock material. Here the graduation of the ERM modular encoder is usually on a diameter that is approximately twice as large as the workpiece to be machined. The accuracy and reproducibility of the ERM also achieve sufficient workpiece accuracy values for milling operations with lathes (classical C-axis machining).

Example:
Accuracy of a workpiece from bar-stock material, ∅ 100 mm;
ERM 280 encoder on C axis with

- Accuracy: ± 12“ with 2048 lines
- Drum outside diameter: 257.50 mm

Δφ = ± tan12“ x radius
Δφ = ± 2.9 µm

Calculated position error: ± 2.9 µm

Conclusion:
For bar-stock material with a diameter of 100 mm, the maximum position error that can result from the encoder is less than ± 3 µm. Eccentricity errors must also be considered, but these can be reduced through accurate mounting.

Spindle speeds
The ERM circumferential-scale drums can operate at high shaft speeds. Ancillary noises, such as from gear-tooth systems, do not occur. The maximum shaft speeds listed in the specifications suffice for most applications.

Typical applications for the ERM 2400 and ERM 2900 are fast spindles, particularly main spindles with hollow shaft and compact dimensions. The speed can reach up to 42000 min^{-1}.

Measuring Principle

Measuring standard
HEIDENHAIN encoders incorporate measuring standards of periodic structures known as graduations.

Magnetic encoders use a graduation carrier of magnetizable steel alloy. A write head applies strong local magnetic fields in different directions to form a graduation with 400 µm or 1 000 µm (with ERM 2984) per signal period consisting of north poles and south poles (MAGNODUR process). Due to the short distance of effect of electromagnetic interaction and the very narrow scanning gaps required, finer magnetic graduations have significantly tighter mounting tolerances.

Magnetic Scanning
The permanently magnetic MAGNODUR graduation is scanned by magnetoresistive sensors. They consist of resistive tracks whose resistance changes in response to a magnetic field. When a voltage is applied to the sensor and the scale drum moves relative to the scanning head, the flowing current is modulated according to the magnetic field.

The special geometric arrangement of the resistive sensors and the manufacture of the sensors on glass substrates ensure a high signal quality. In addition, the large scanning surface allows the signals to be filtered for harmonic waves. These are prerequisites for minimizing position errors within one signal period.

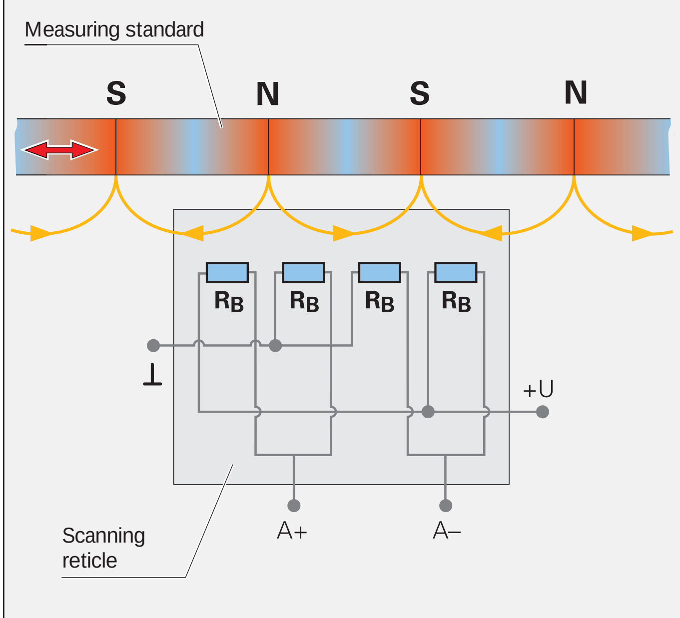
A structure on a separate track produces a reference mark signal. This makes it possible to assign this absolute position value to exactly one measuring step.

Magnetoresistive scanning is used primarily for comparatively low-accuracy applications, or for applications where the machined parts are relatively small compared to the scale drum.

Incremental measuring method
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. The shaft speed is determined through mathematical derivation of the change in position over time.

Since an absolute reference is required to ascertain positions, the scale drums are provided with an additional track that bears a **reference mark** or multiple reference marks. The absolute position on the scale, 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. On the ERM 2410, the scale drum features distance-coded reference marks. Here the absolute reference is established by scanning two neighboring reference marks (see *Angle for absolute reference* in the Specifications).

Magnetoresistive scanning principle



Magnetoresistive sensors for B+ and B– not shown

Measuring Accuracy

The accuracy of angular measurement is mainly determined by:

- The quality of the graduation
- The quality of the scanning process
- The quality of the signal processing electronics
- The eccentricity of the graduation to the bearing
- The error of the bearing
- The coupling to the measured shaft

The **system accuracy** given in the *Specifications* is defined as follows:

The system accuracy reflects position errors within one revolution as well as those within one signal period. The extreme values of the total deviations of a position are within the system accuracy ± a.

For **encoders without integral bearing,** additional deviations resulting from mounting, errors in the bearing of the drive shaft, and adjustment of the scanning head must be expected. These deviations are not reflected in the system accuracy.

Position error within one revolution becomes apparent in larger angular motions.

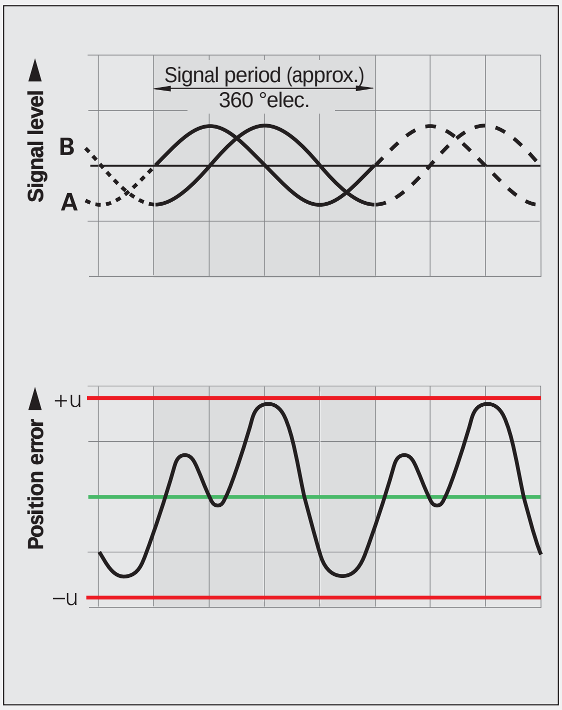
Position deviations within one signal period already become apparent in very small angular motions and in repeated measurements. They especially lead to speed ripples in the speed control loop. These deviations within one signal period are caused by the quality of the sinusoidal scanning signals and their subdivision. The following factors influence the result:

- The size of the signal period
- The homogeneity and period definition of the graduation
- The quality of scanning filter structures
- The characteristics of the detectors
- The stability and dynamics during the further processing of the analog signals

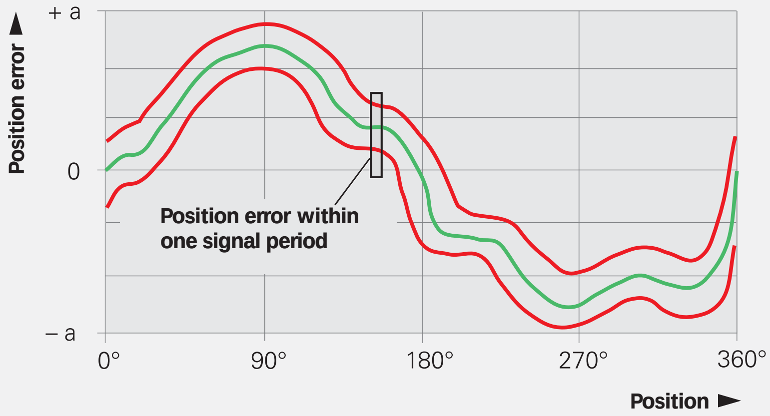
HEIDENHAIN encoders take these factors of influence into account, and permit interpolation of the sinusoidal output signal with typical subdivision accuracy values of better than ± 1 % of the signal period.

However, the 400 µm or 1000 µm signal periods of ERM modular magnetic encoders are relatively large. Angle encoders using the photoelectric scanning principle are better suited for higher accuracy requirements: Along with their better system accuracy, they also feature significantly smaller signal periods (typically 20 µm), and therefore have correspondingly smaller position errors within one signal period.

Position error within one signal period



Position errors within one revolution



In addition to the system accuracy, the mounting and adjustment of the scanning head and of the scale drum normally have a significant effect on the accuracy that can be achieved with encoders without integral bearings. Of particular importance are the mounting eccentricity and radial runout of the measured shaft.

In order to evaluate the **total accuracy,** each of the significant errors must be considered individually.

1. Directional deviations of the graduation

The extreme values of the directional deviation with respect to their mean value are shown in the *Specifications* as the graduation accuracy. The graduation accuracy and the position error within a signal period comprise the system accuracy.

2. Errors due to eccentricity of the graduation to the bearing

Under normal circumstances, the graduation will have a certain eccentricity relative to the bearing once the ERM's scale drum is mounted. In addition, dimensional and form deviations of the shaft can result in added eccentricity.

The following relationship exists between the eccentricity e, the graduation diameter D and the measuring error Δφ (see illustration below):

$$\Delta\varphi = \pm 412 \cdot \frac{e}{D}$$

Δφ = Measuring error in " (angular seconds)
e = Eccentricity of the radial grating to the bearing in µm (1/2 the radial deviation)
D = Scale-drum diameter (= drum outside diameter) in mm
M = Center of graduation
φ = "True" angle
φ' = Scanned angle

Graduation diameter D	Error per 1 µm of eccentricity
D = 64 mm	± 6.4"
D = 75 mm	± 5.5"
D = 77 mm	± 5.4"
D = 113 mm	± 3.6"
D = 129 mm	± 3.2"
D = 151 mm	± 2.7"
D = 176 mm	± 2.3"
D = 257 mm	± 1.6"
D = 327 mm	± 1.3"
D = 453 mm	± 0.9"

3. Error due to radial deviation of the bearing

The equation for the measuring error Δφ is also valid for radial deviation of the bearing if the value e is replaced with the eccentricity value, i.e. half of the radial deviation (half of the displayed value).

Bearing compliance to radial shaft loading causes similar errors.

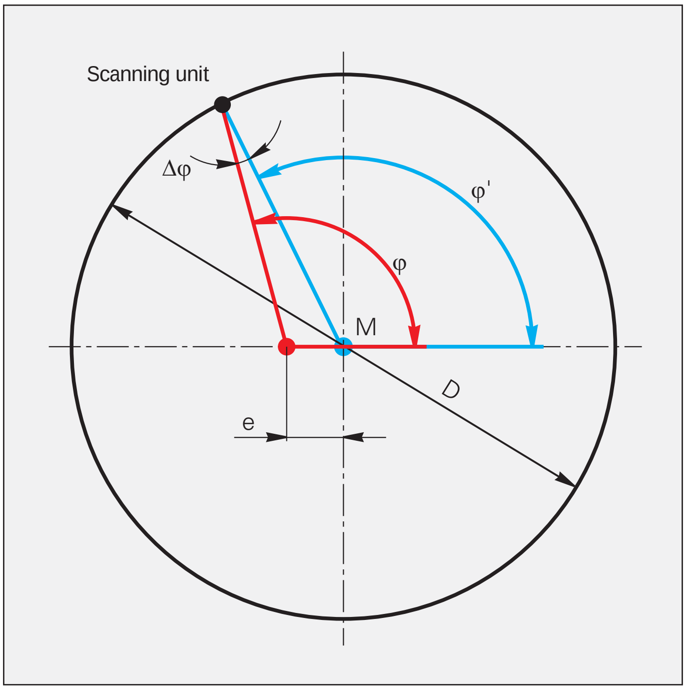
4. Position error within one signal period $\Delta\varphi_u$

The scanning units of all HEIDENHAIN encoders are adjusted so that the maximum position error values within one signal period will not exceed the values listed below, with no further electrical adjusting required at mounting.

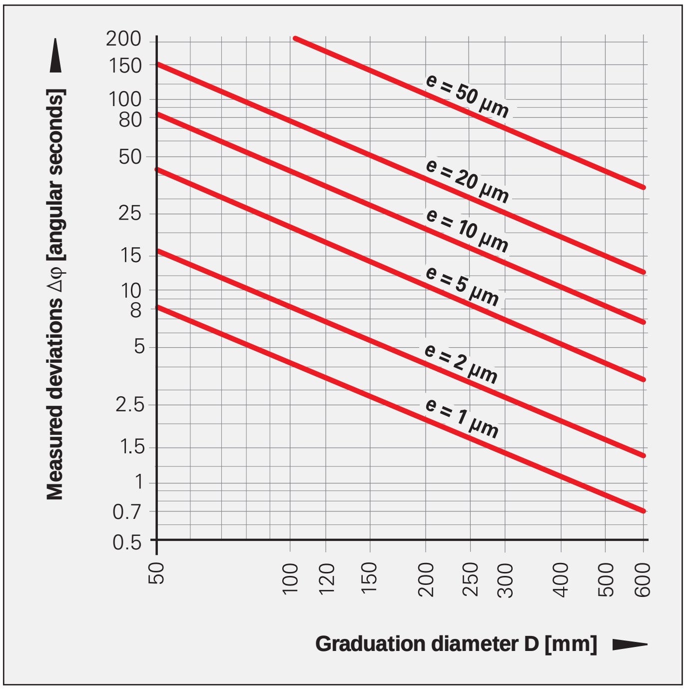
Line count	Position error within one signal period $\Delta\varphi_u$
3600	≤ ± 5"
2600	≤ ± 6"
2048	≤ ± 7"
1400	≤ ± 11"
1200	≤ ± 12"
1024	≤ ± 13"
900	≤ ± 15"
600	≤ ± 22"
512	≤ ± 26"
256	≤ ± 55"

The values for the position errors within one signal period are already included in the system accuracy. Larger errors can occur if the mounting tolerances are exceeded.

Eccentricity of the graduation to the bearing



Resultant measured deviations Δφ for various eccentricity values e as a function of graduation diameter D



Mechanical Design Types and Mounting

Mounting
The ERM modular encoders consist of a circumferential scale drum and the corresponding scanning head. Special design features assure comparatively fast mounting and easy adjustment.

Versions
There are two different signal periods available for the ERM modular magnetic encoders (ERM 200, ERM 24x0: ca. 400 µm; ERM 2900: approx. 1 mm). This results in differing line counts for nearly identical outside diameters, making it possible to use these encoders for very different types of spindle applications.

The scale drum is available in three versions. The **TTR ERM 200** and **TTR ERM 200C** scale drums are fastened with axial screws. The insides of the **TTR ERM 2404** and **TTR ERM 2904** scale drums are smooth. Only a friction-locked connection (clamping of the drum) is to be used to prevent them from rotating unintentionally. The **TTR ERM 2405** scale drums feature a keyway. The feather key is only intended for the prevention of unintentional rotation. The transmission of torque via the feather key is not permissible. A friction-locked connection is to be used here, as with the TTR ERM 2404 scale drum. The special shape of the drum's inside ensures stability even at the maximum permissible speeds.

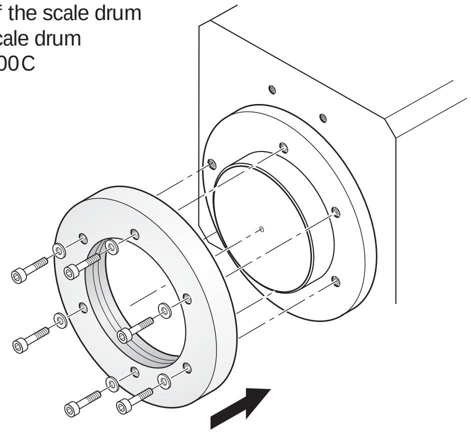
Mounting the TTR ERM 200 scale drum
The circumferential scale drum is slid onto the drive shaft and fastened with screws. The scale drum is centered via the centering collar on its inner circumference. HEIDENHAIN recommends using a slight oversize on the shaft for mounting the scale drum. Only then do the rotational velocities listed in the *Specifications* apply. For easier mounting, the scale drum may be slowly warmed on a heating plate over a period of approx. 10 minutes to a temperature of at most 100 °C. In order to check the radial runout and assess the resulting deviations, testing of the rotational accuracy before mounting is recommended.

Back-off threads are used for dismounting the scale drums.

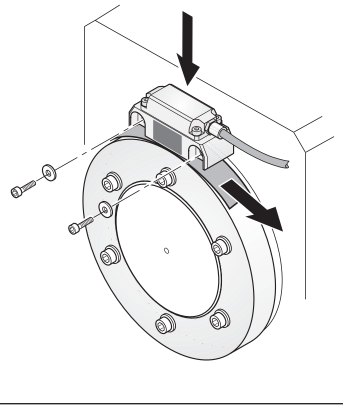
Mounting the TTR ERM 2x0x scale drum
The circumferential scale drum is slid onto the drive shaft and clamped. The scale drum is centered via the centering collar on its inner circumference. In order to keep the eccentricity of the graduation to the bearing resulting from mounting to a minimum, and the resulting deviations in accuracy as well, the gap between the shaft and centering collar should be as small as possible. The clamping of the scale drum depends on the mounting situation. The clamping force must be applied evenly over the plane surface of the drum. The necessary mounting elements depend on the design of the customer's equipment, and are therefore the responsibility of the customer. The frictional connection must be strong enough to prevent unintentional rotation or skewing in axial and radial directions, even at high speeds and accelerations. The scale drum may not be modified for this purpose, such as by drilling holes or countersinks in it.

Mounting the scanning head
In order to mount the scanning head, the spacer foil is applied to the surface of the circumferential scale drum. The scanning head is pressed against the foil and fastened. The foil is then removed.

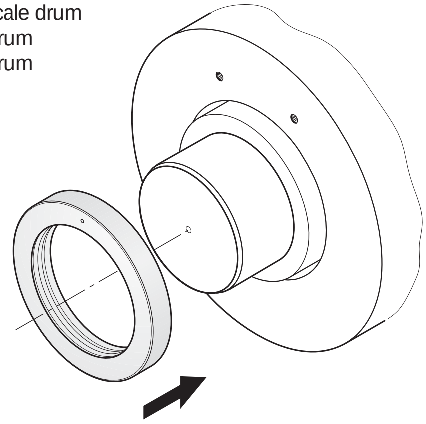
Mounting of the scale drum
ERM 200 scale drum
TTR ERM 200C



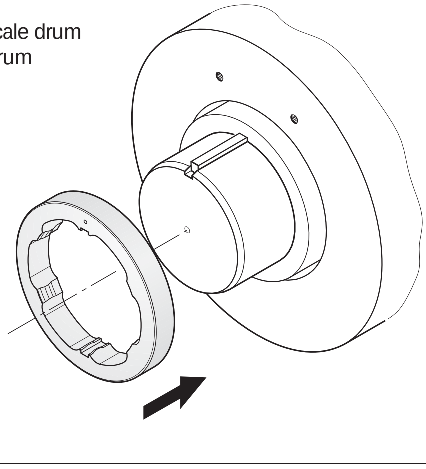
Mounting of the scanning head
e.g. AK ERM 280



Mounting of the scale drum
ERM 2404 scale drum
ERM 2904 scale drum



Mounting of the scale drum
ERM 2405 scale drum



General Mechanical Information

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

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

- The indicated maximum values for **vibration** are valid according to EN 60068-2-6.
- The maximum permissible acceleration values (semi-sinusoidal shock) for **shock and impact** are valid for 6 ms (EN 60068-2-27).

  Under no circumstances should a hammer or similar implement be used to adjust or position the encoder.

Temperature range
The **operating temperature range** indicates the ambient temperature limits between which the encoders will function properly.

The **storage temperature range** from –30 °C to +70 °C is valid when the unit remains in its packaging.

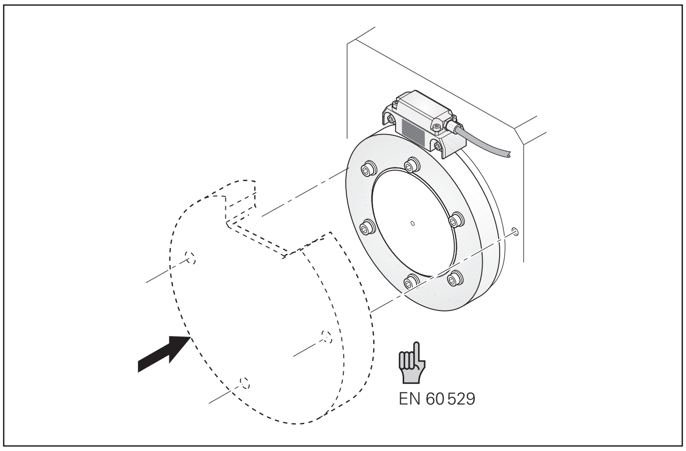
Rotational velocity
The maximum permissible shaft speeds were determined according to FKM guidelines. This guideline serves as mathematical attestation of component strength with regard to all relevant influences and it reflects the latest state of the art. The requirements for fatigue strength (10^7 changes of load) were considered in the calculation of the permissible shaft speeds. Because installation has significant influence, all requirements and instructions in the Specifications and mounting instructions must be followed for the rotational velocity data to be valid.

Expendable parts
HEIDENHAIN encoders contain components that are subject to wear, depending on the application and handling. These include in particular moving cables. Pay attention to the minimum permissible bending radii.

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.

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

The specifications given in the brochure apply to the specific encoder, not to the complete system. Any operation of the encoder outside of the specified range or for any other than the intended applications is at the user's own risk.
In safety-related systems, the higher-level system must verify the position value of the encoder after switch-on.



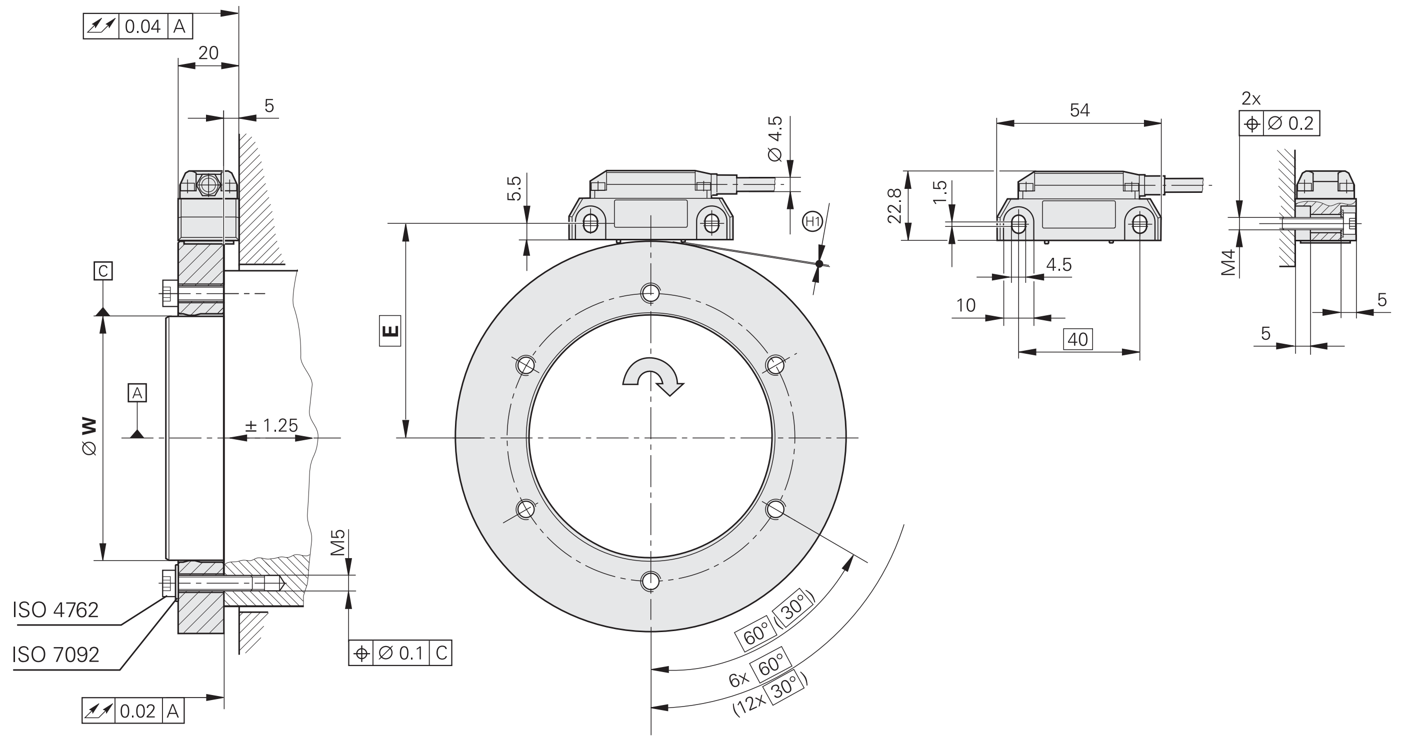
Protection against contact

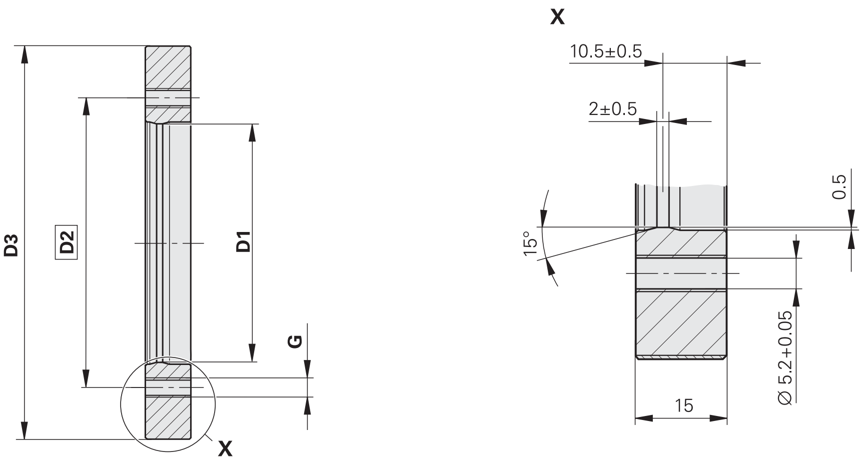
ERM 200 Series

- **Modular encoders**
- **Magnetic scanning principle**

in mm

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





D1	W		D2	D3	E	G
∅ 40 –0.007	∅ 40	+0.009/+0.002	∅ 50	∅ 75.44	43.4	6x M6
∅ 70 –0.008	∅ 70	+0.010/+0.002	∅ 85	∅ 113.16	62.3	6x M6
∅ 80 –0.008	∅ 80	+0.010/+0.002	∅ 95	∅ 128.75	70.1	6x M6
∅ 120 –0.010	∅ 120	+0.013/+0.003	∅ 135	∅ 150.88	81.2	6x M6
∅ 130 –0.012	∅ 130	+0.015/+0.003	∅ 145	∅ 176.03	93.7	6x M6
∅ 180 –0.012	∅ 180	+0.015/+0.003	∅ 195	∅ 257.50	134.5	6x M6
∅ 220 –0.014	∅ 220	+0.018/+0.004	∅ 235	∅ 257.50	134.5	6x M6
∅ 295 –0.016	∅ 295	+0.020/+0.004	∅ 310	∅ 326.90	169.2	6x M6
∅ 410 –0.018	∅ 410	+0.025/+0.005	∅ 425	∅ 452.64	232.0	12x M6

A = Bearing
H1 = Mounting distance of 0.15 mm set with spacer foil
Direction of shaft rotation for output signals according to interface description

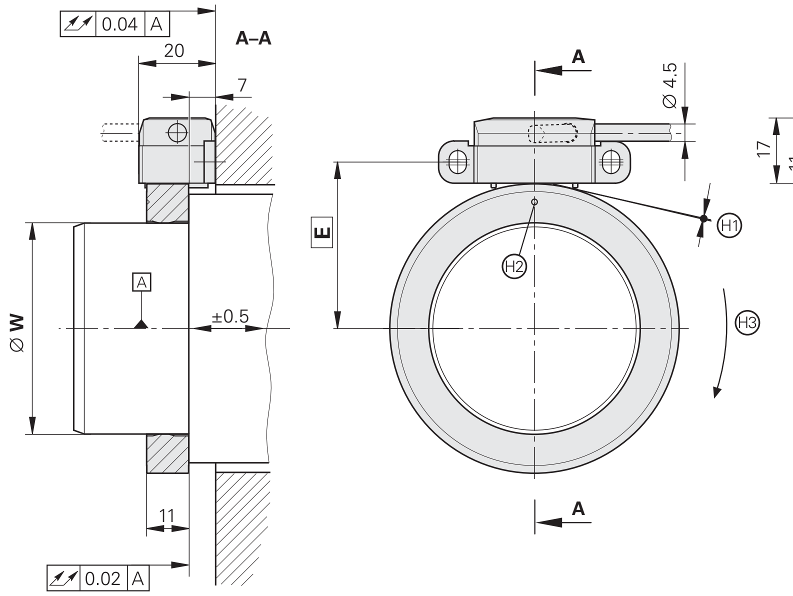
Scanning head	**AK ERM 220**	**AK ERM 280**
Incremental signals	⊓⊔ TTL	∼ 1 V_{PP}
Cutoff frequency –3 dB Scanning frequency	– ≤ 350 kHz	≥ 300 kHz –
Signal period	Approx. 400 µm	
Line count*	See Scale Drum	
Power supply	5 V ± 10 % DC	
Current consumption	≤ 150 mA (without load)	
Electrical connection*	Cable 1 m, with or without coupling	
Cable length	≤ 100 m (with HEIDENHAIN cable)	≤ 150 m (with HEIDENHAIN cable)
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 400 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)	
Operating temperature	–10 °C to 100 °C	
Protection EN 60529	IP 67	
Weight	Approx. 0.15 kg (with cable)	

Scale drum	**ERM 200 scale drum**								
Measuring standard	MAGNADUR graduation; signal period of approx. 400 µm								
Inside diameter*	40 mm	70 mm	80 mm	120 mm	130 mm	180 mm	220 mm	295 mm	410 mm
Outside diameter	75.44 mm	113.16 mm	128.75 mm	150.88 mm	176.03 mm	257.50 mm	2570.50 mm	326.90 mm	452.64 mm
Line count*	600	900	1024	1200	1400	2048	2048	2600	3600
System accuracy[1]	± 36“	± 25“	± 22“	± 20“	± 18“	± 12“	± 12“	± 10“	± 9“
Accuracy of the graduation[2]	± 14“	± 10“	± 9“	± 8“	± 7“	± 5“	± 5“	± 4“	± 4“
Reference mark	One								
Mech. permissible speed	≤ 19000 min^{-1}	≤ 14500 min^{-1}	≤ 13000 min^{-1}	≤ 10500 min^{-1}	≤ 9000 min^{-1}	≤ 6000 min^{-1}	≤ 6000 min^{-1}	≤ 4500 min^{-1}	≤ 3000 min^{-1}
Moment of inertia of the rotor	$0.34 \cdot 10^{-3}$ kgm^2	$1.6 \cdot 10^{-3}$ kgm^2	$2.7 \cdot 10^{-3}$ kgm^2	$3.5 \cdot 10^{-3}$ kgm^2	$7.7 \cdot 10^{-3}$ kgm^2	$38 \cdot 10^{-3}$ kgm^2	$23 \cdot 10^{-3}$ kgm^2	$44 \cdot 10^{-3}$ kgm^2	$156 \cdot 10^{-3}$ kgm^2
Permissible axial motion	± 1.25 mm								
Weight approx.	0.35 kg	0.69 kg	0.89 kg	0.72 kg	1.2 kg	3.0 kg	1.6 kg	1.7 kg	3.2 kg

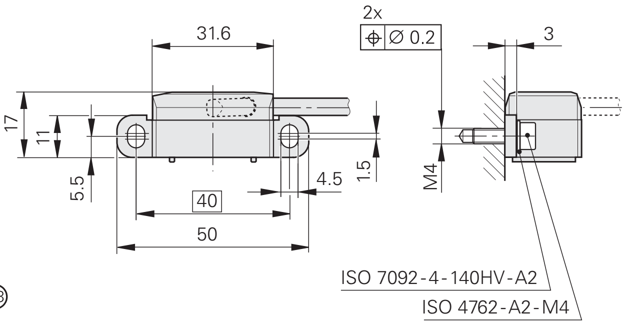
* Please select or indicate when ordering
1) Before installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the drive shaft are not included.
2) For other errors, see *Measuring Accuracy*

ERM 2400/ERM 2900 Series

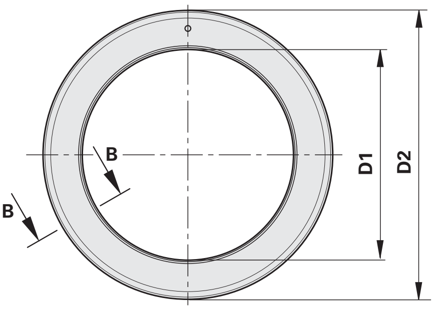
- Modular encoders
- Magnetic scanning principle
- Compact dimensions
- Two signal periods

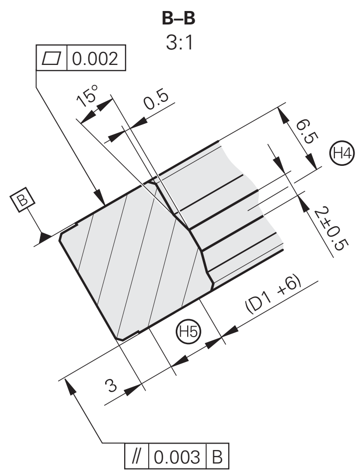


ERM 2x80 scanning head

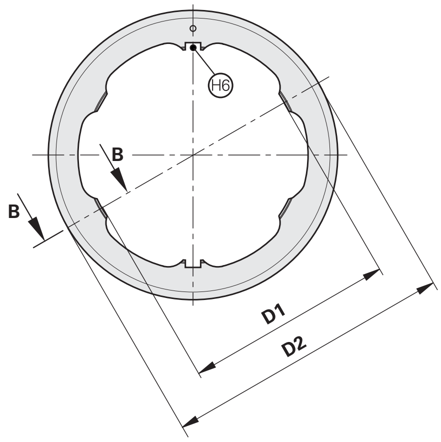


ERM 2x04 scale drum





ERM 2405 scale drum



in mm

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

Ⓐ = Bearing
Ⓗ1 = Mounting clearance set with spacer foil
ERM 2400: 0.15 mm
ERM 2900: 0.30 mm
Ⓗ2 = Reference mark
Ⓗ3 = Positive direction of rotation for output signals
Ⓗ4 = Centering collar
Ⓗ5 = Clamping area (applies to both sides)
Ⓗ6 = Slot for feather key 4x4x10 (as per DIN 6885 shape A)

	D1	W	D2	E
ERM 2400	Ø 40 +0.010/+0.002	Ø 40 0/–0.006	Ø 64.37	37.9
	Ø 55 +0.010/+0.002	Ø 55 0/–0.006	Ø 75.44	43.4
ERM 2900	Ø 55 +0.010/+0.002	Ø 55 0/–0.006	Ø 77.41	44.6

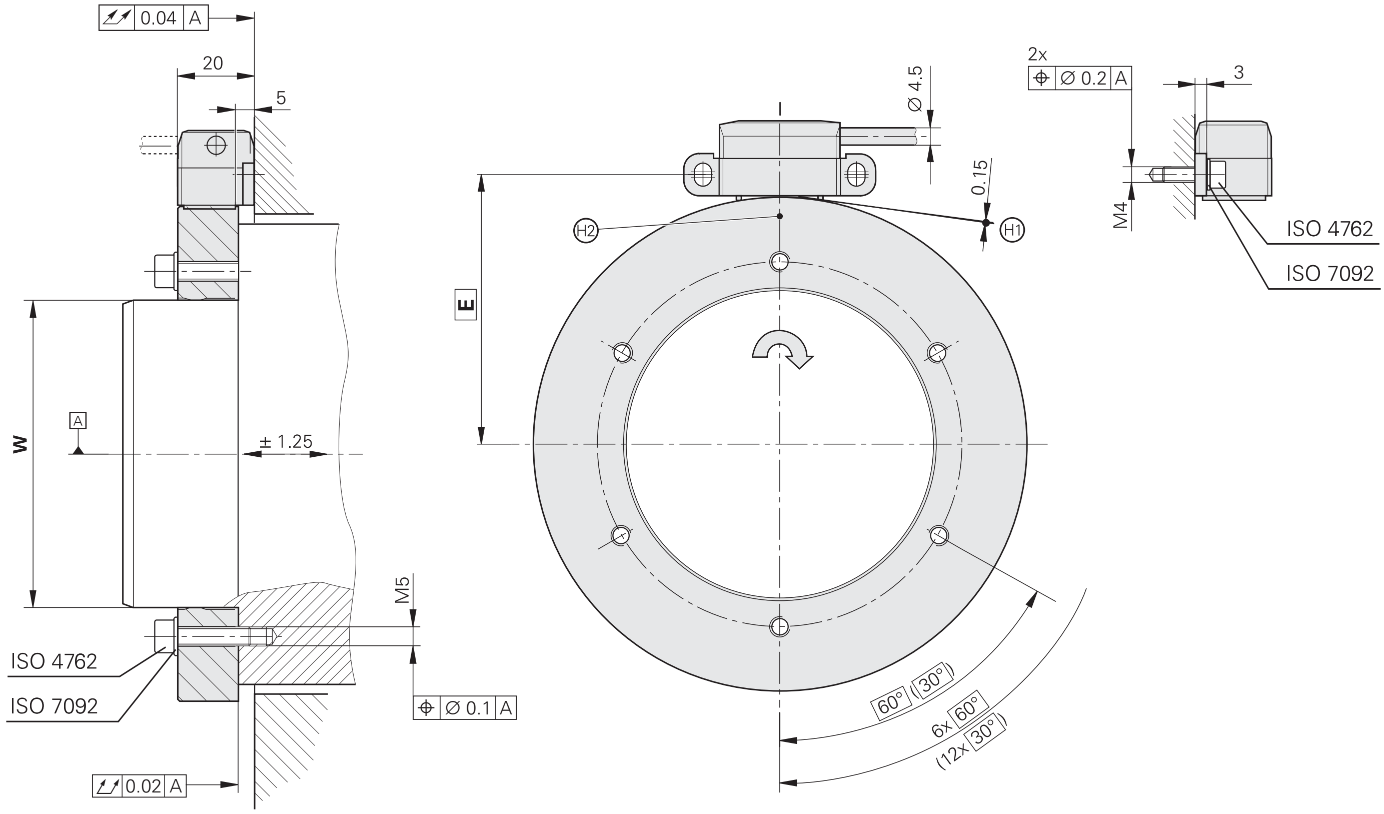
Scanning head	AK ERM 2480	AK ERM 2980
Incremental signals	∿ 1 V_{PP}	
Cutoff frequency –3 dB	≤ 300 kHz	
Signal period	Approx. 400 µm	Approx. 1000 µm
Line count*	See Scale Drum	
Power supply	5 V ± 10 % DC	
Current consumption	≤ 150 mA (without load)	
Electrical connection*	Cable 1 m, with or without coupling; cable outlet axial or radial	
Cable length	≤ 150 m (with HEIDENHAIN cable)	
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 400 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)	
Operating temperature	–10 °C to 100 °C	
Protection EN 60529	IP 67	
Weight	Approx. 0.15 kg (with cable)	

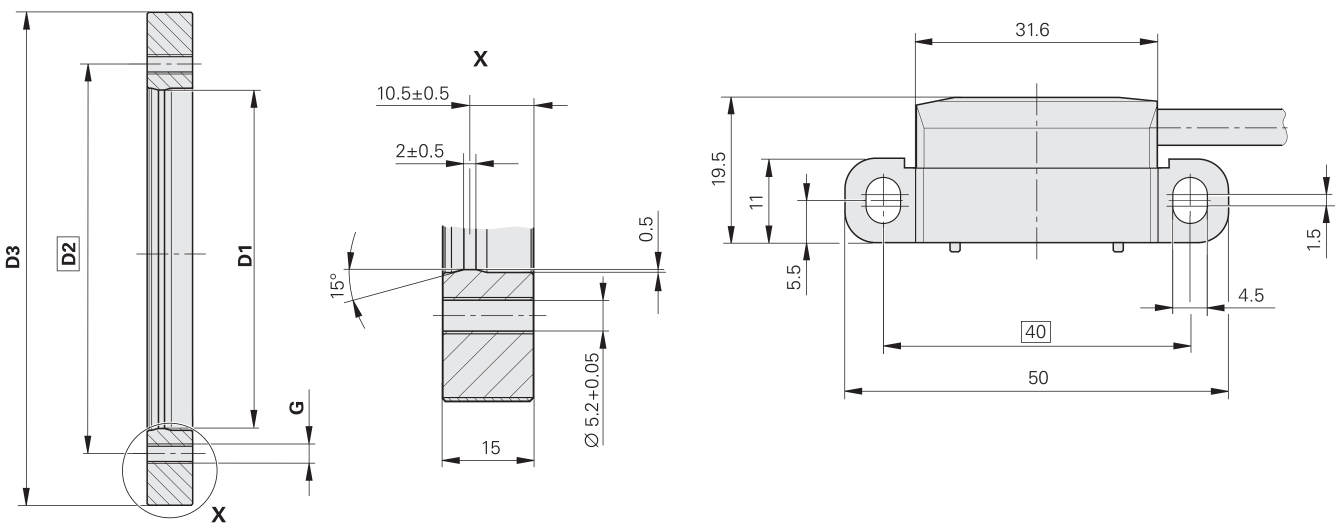
Scale drum	ERM 2404		ERM 2405		ERM 2904
Measuring standard	MAGNODUR graduation				
Signal period	Approx. 400 µm				Approx. 1000 µm
Inside diameter*	40 mm	55 mm	40 mm	55 mm	55 mm
Outside diameter	64.37 mm	75.44 mm	64.37 mm	75.44 mm	77.41 mm
Line count*	512	600	512	600	256
System accuracy[1)]	± 43“	± 36“	± 43“	± 36“	± 70“
Accuracy of the graduation[2)]	± 17“	± 14“	± 17“	± 14“	± 15“
Reference mark	One				
Mech. permissible speed	≤ 42000 min^{-1}	≤ 36000 min^{-1}	≤ 33000 min^{-1}	≤ 27000 min^{-1}	≤ 35000 min^{-1}
Moment of inertia of the rotor	$0.12 \cdot 10^{-3}$ kgm^2	$0.19 \cdot 10^{-3}$ kgm^2	$0.11 \cdot 10^{-3}$ kgm^2	$0.17 \cdot 10^{-3}$ kgm^2	$0.22 \cdot 10^{-3}$ kgm^2
Permissible axial motion	± 0.5 mm				
Weight approx.	0.17 kg	0.17 kg	0.15 kg	0.15 kg	0.19 kg

* Please indicate or select when ordering. Other line counts/dimensions available upon request.
1) Before installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the drive shaft are not included.
2) For other errors, see *Measuring Accuracy*

ERM 2410 Series

- **Modular encoders**
- **Magnetic scanning principle**
- **Incremental measuring method with distance-coded reference marks**
- **Integrated counting function for absolute position-value output**
- **Absolute position value after traverse of two reference marks (see "Angle for absolute reference")**





in mm

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

A = Bearing
H1 = Mounting distance of 0.15 mm set with spacer foil
H2 = Reference mark position
Direction of shaft rotation for output signals according to interface description

D1	W		D2	D3	E	G
⌀ 40 –0.007	⌀ 40	+0.009/+0.002	⌀ 50	⌀ 75.44	43.4	6x M6
⌀ 70 –0.008	⌀ 70	+0.010/+0.002	⌀ 85	⌀ 113.16	62.3	6x M6
⌀ 80 –0.008	⌀ 80	+0.010/+0.002	⌀ 95	⌀ 128.75	70.1	6x M6
⌀ 120 –0.010	⌀ 120	+0.013/+0.003	⌀ 135	⌀ 150.88	81.2	6x M6
⌀ 130 –0.012	⌀ 130	+0.015/+0.003	⌀ 145	⌀ 176.03	93.7	6x M6
⌀ 180 –0.012	⌀ 180	+0.015/+0.003	⌀ 195	⌀ 257.50	134.5	6x M6
⌀ 220 –0.014	⌀ 220	+0.018/+0.004	⌀ 235	⌀ 257.50	134.5	6x M6
⌀ 295 –0.016	⌀ 295	+0.020/+0.004	⌀ 310	⌀ 326.90	169.2	6x M6
⌀ 410 –0.020	⌀ 410	+0.025/+0.005	⌀ 425	⌀ 452.64	232.0	12x M6

Scanning head	AK ERM 2410
Interface	EnDat 2.2
Ordering designation	EnDat 22
Integrated interpolation	16384-fold (14 bits)
Clock frequency	≤ 8 MHz
Calculation time t_{cal}	≤ 5 µs
Signal period	Approx. 400 µm
Line count*	See Scale Drum
Power supply	3.6 to 14 V DC
Power consumption[1]	*At 14 V:* 110 mA; *at 3.6 V:* 300 mA (maximum)
Current consumption (typical)	*At 5 V:* 90 mA (without load)
Electrical connection	Cable, 1 m, with M12 coupling (8-pin)
Cable length	≤ 150 m (with HEIDENHAIN cable)
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 300 m/s² (EN 60068-2-6) ≤ 1000 m/s² (EN 60068-2-27)
Operating temperature	–10 °C to 100 °C
Protection EN 60529	IP 67
Weight	Approx. 0.1 kg (with cable)

Scale drum	TTR ERM 200C								
Measuring standard	MAGNADUR graduation, signal period approx. 400 µm								
Inside diameter*	40 mm	70 mm	80 mm	120 mm	130 mm	180 mm	220 mm	295 mm	410 mm
Outside diameter	75.44 mm	113.16 mm	128.75 mm	150.88 mm	176.03 mm	257.50 mm	2570.50 mm	326.90 mm	452.64 mm
Line count*	600	900	1024	1200	1400	2048	2048	2600	3600
System accuracy[2]	± 36“	± 25“	± 22“	± 20“	± 18“	± 12“	± 12“	± 10“	± 9“
Accuracy of the graduation[3]	± 14“	± 10“	± 9“	± 8“	± 7“	± 5“	± 5“	± 4“	± 4“
Reference marks	Distance-coded								
Angle for absolute reference	≤ 36°	≤ 24°	≤ 22.5°	≤ 24°	≤ 18°	≤ 22.5°	≤ 22.5°	≤ 14°	≤ 12°
Mech. permissible speed	≤ 19000 min^{-1}	≤ 14500 min^{-1}	≤ 13000 min^{-1}	≤ 10500 min^{-1}	≤ 9000 min^{-1}	≤ 6000 min^{-1}	≤ 6000 min^{-1}	≤ 4500 min^{-1}	≤ 3000 min^{-1}
Moment of inertia of the rotor	$0.34 \cdot 10^{-3}$ kgm^2	$1.6 \cdot 10^{-3}$ kgm^2	$2.7 \cdot 10^{-3}$ kgm^2	$3.5 \cdot 10^{-3}$ kgm^2	$70.7 \cdot 10^{-3}$ kgm^2	$38 \cdot 10^{-3}$ kgm^2	$23 \cdot 10^{-3}$ kgm^2	$44 \cdot 10^{-3}$ kgm^2	$156 \cdot 10^{-3}$ kgm^2
Permissible axial motion	± 1.25 mm								
Weight approx.	0.35 kg	0.69 kg	0.89 kg	0.72 kg	1.2 kg	3.0 kg	1.6 kg	1.7 kg	3.2 kg

***** Please select when ordering
1) See *General Electrical Information*
2) Before installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the drive shaft are not included.
3) For other errors, see *Measuring Accuracy*

Interfaces

Incremental Signals ∿ 1 V_{PP}

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

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

The **reference mark signal** R has a usable component G of approx. 0.5 V. Next to the reference mark, the output signal can be reduced by up to 1.7 V to a quiescent level 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.

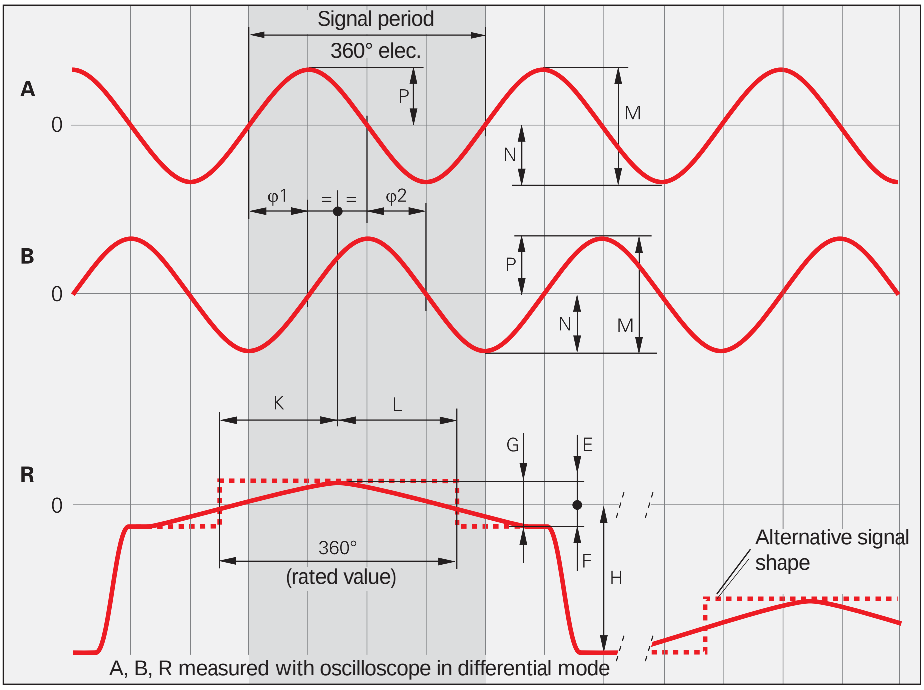
Measuring steps for **position measurement** are recommended in the specifications. For special applications, other resolutions are also possible.

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.

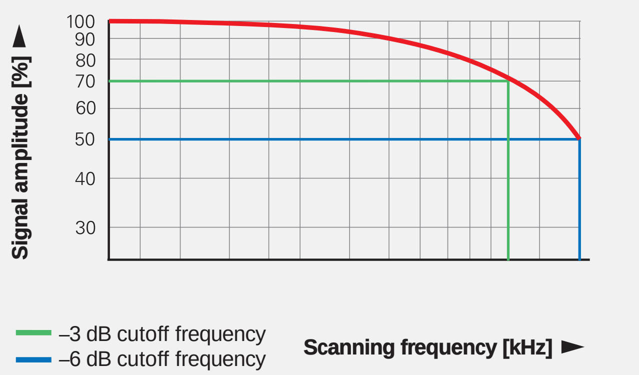
Short circuit at	20 °C	125 °C
One output	< 3 min	< 1 min
All outputs	< 20 s	< 5 s

Interface	Sinusoidal voltage signals ∿ **1 V_{PP}**
Incremental signals	**2 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 cable Cable length Propagation time	Shielded HEIDENHAIN cable PUR [4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] Max. 150 m with 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 the subsequent electronics

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

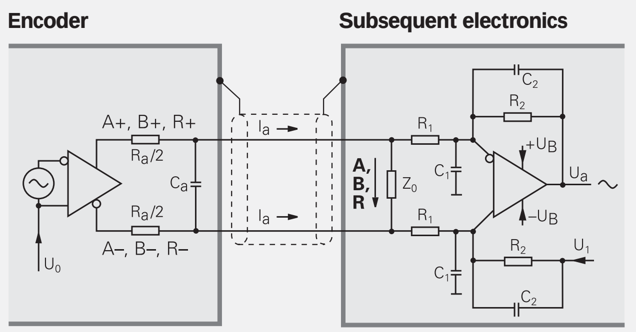
–3 dB cutoff frequency of circuitry
Approx. 450 kHz
Approx. 50 kHz with $C_1 = 1000$ pF
and $C_2 = 82$ pF
The circuit variant for 50 kHz does reduce the bandwidth of the circuit, but in doing so it improves its noise immunity.

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}

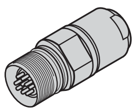
Incremental signals
Reference-mark signal

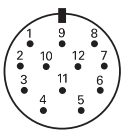
$R_a < 100\ \Omega$, typically 24 Ω
$C_a < 50$ pF
$\Sigma I_a < 1$ mA
$U_0 = 2.5\ V \pm 0.5\ V$
(relative to 0 V of the power supply)



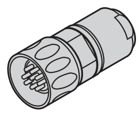
Pin layout

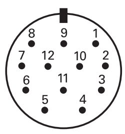
12-pin M23 **coupling**



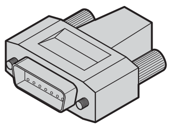


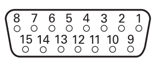
12-pin M23 **connector**



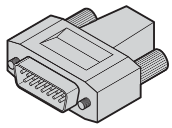


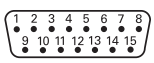
15-pin D-sub connector
For HEIDENHAIN controls and IK 220





15-pin D-sub connector
For encoder or IK 215





	Power supply				Incremental signals						Other signals		
	12	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**9**	**7**	**/**
	1	**9**	**2**	**11**	**3**	**4**	**6**	**7**	**10**	**12**	**5/8/13/15**	**14**	**/**
	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**
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	/	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!

Interfaces
Incremental Signals ⊓⊔ TTL

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

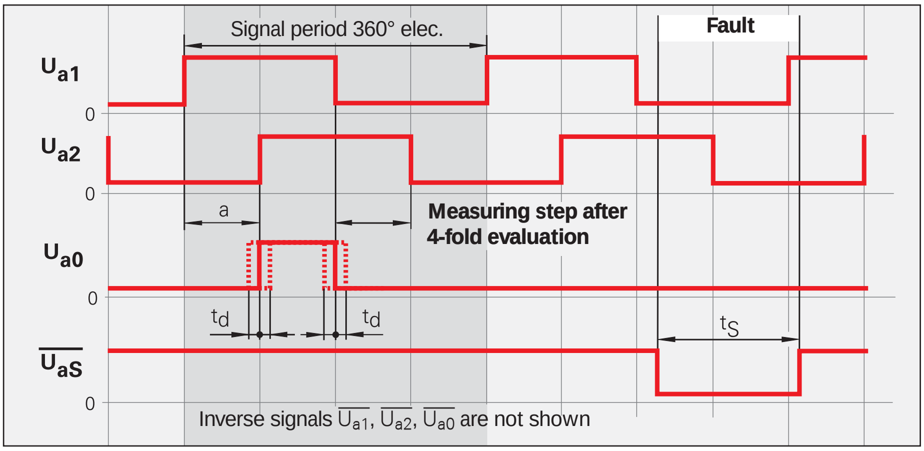
The **incremental signals** are transmitted as the square-wave pulse trains U_{a1} and U_{a2}, phase-shifted by 90° elec. The **reference mark signal** consists of one or more reference pulses U_{a0}, which are gated with the incremental signals. In addition, the integrated electronics produce their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

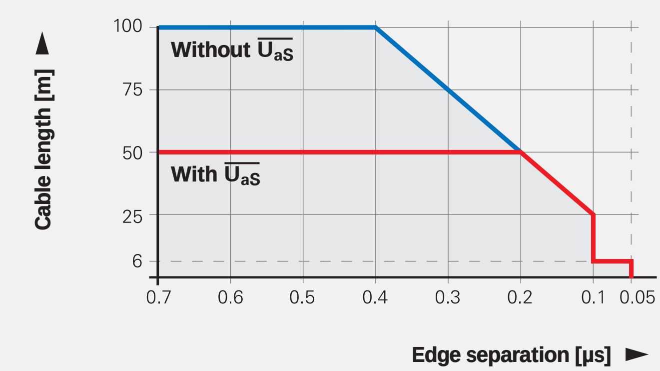
The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum **edge separation a** listed in the *Specifications* applies to the illustrated input circuitry with a cable length of 1 m, and refers to a measurement at the output of the differential line receiver. Propagation-time differences in cables additionally reduce the edge separation by 0.2 ns per meter of cable length. To prevent counting 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); *LS 323:* ungated $\lvert t_d \rvert \leq 50$ ns
Fault-detection signal Pulse width	**1 TTL square-wave pulse $\overline{U_{aS}}$** Improper function: LOW (upon request: U_{a1}/U_{a2} high impedance) Proper function: HIGH $t_S \geq 20$ ms
Signal amplitude	Differential line driver as per EIA standard RS-422 $U_H \geq 2.5$ V at $-I_H = 20$ mA $U_L \leq 0.5$ V at $I_L = 20$ mA
Permissible load	$Z_0 \geq 100\ \Omega$ between associated outputs $\lvert I_L \rvert \leq 20$ mA max. load per output $C_{load} \leq 1000$ pF with respect to 0 V Outputs protected against short circuit to 0 V
Switching times (10 % to 90 %)	$t_+ / t_- \leq 30$ ns (typically 10 ns) with 1 m cable and recommended input circuitry
Connecting cable Cable length Propagation time	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).

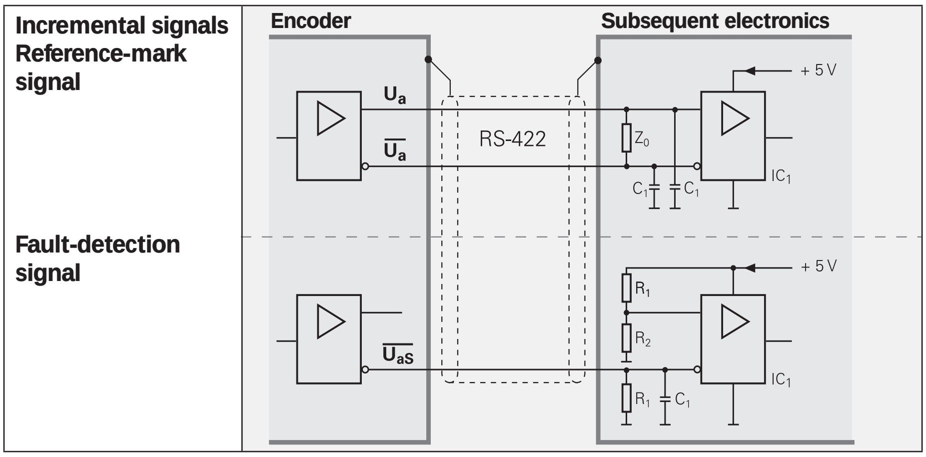
Permissible cable length
with respect to the edge separation



Input circuitry of the subsequent electronics

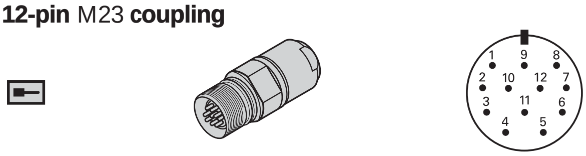
Dimensioning
IC_1 = Recommended differential line receiver
DS 26 C 32 AT
Only for a > 0.1 µs:
AM 26 LS 32
MC 3486
SN 75 ALS 193

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

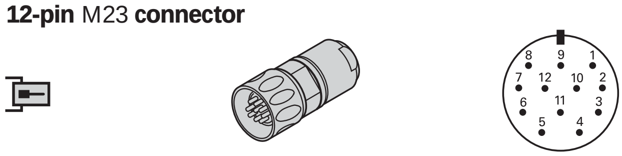


Pin layout

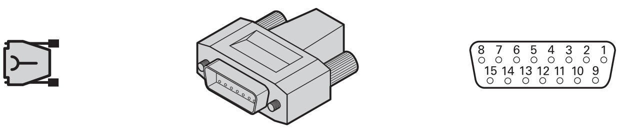
12-pin M23 **coupling**



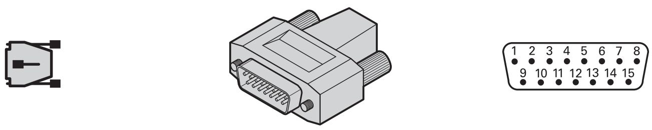
12-pin M23 **connector**



15-pin D-sub connector
For HEIDENHAIN controls and IK 220



15-pin D-sub connector
For encoder or IK 215



	Power supply				Incremental signals						Other signals		
12-pin M23 coupling / connector	**12**	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**7**	**/**	**9**
15-pin D-sub (HEIDENHAIN controls / IK 220)	**1**	**9**	**2**	**11**	**3**	**4**	**6**	**7**	**10**	**12**	**14**	**5/8/13**	**15**
15-pin D-sub (encoder / IK 215)	**4**	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**13**	**5/6/8**	**15**
	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

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) **ERO 14xx:** Vacant
2) **Exposed linear encoders:** Switchover TTL/11 µA_{PP} for PWT, otherwise vacant

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 information 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, instructions, etc.)
- Operating status (alarm or warning messages)

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)

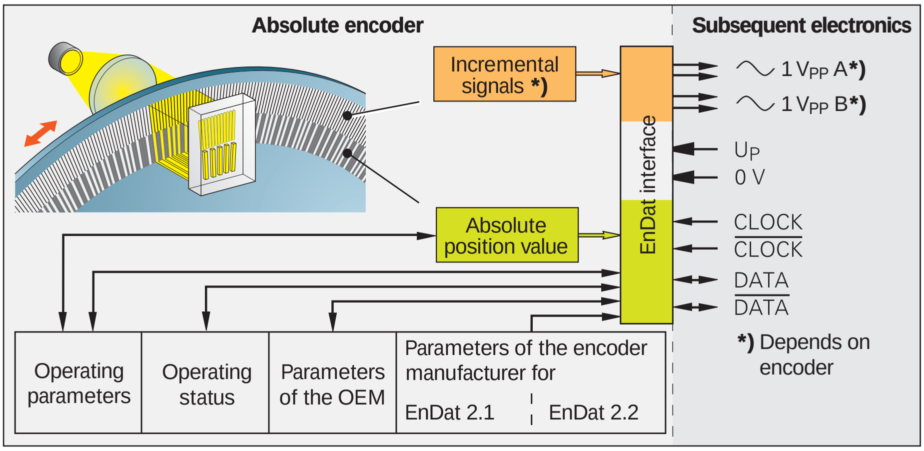
Incremental signals
EnDat encoders are available with or without incremental signals. EnDat 21 and EnDat 22 encoders feature a high internal resolution. An evaluation of the incremental signal is therefore unnecessary.

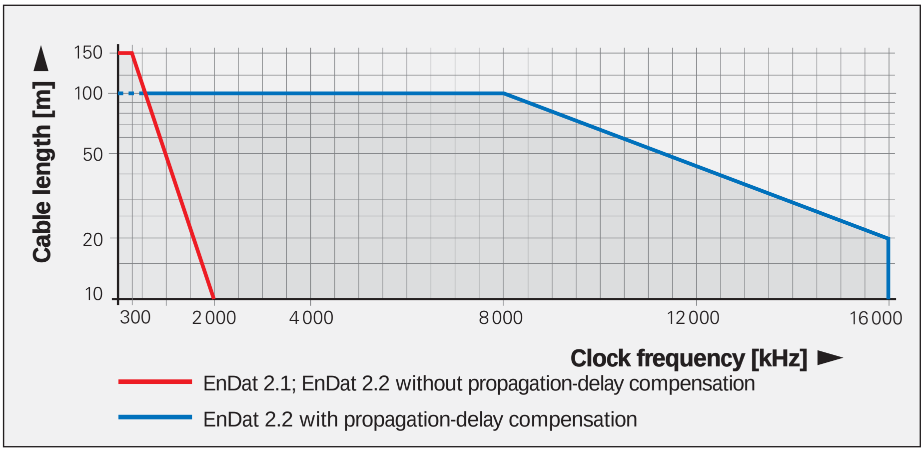
Clock frequency and cable length
The clock frequency is variable—depending on the cable length—between **100 kHz** and **2 MHz.** With propagation-delay compensation in the subsequent electronics, clock frequencies up to **16 MHz** at cable lengths up to 100 m are possible.

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 the signals DATA and $\overline{\text{DATA}}$
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 or 14 V
EnDat 22	EnDat 2.2	Without	

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





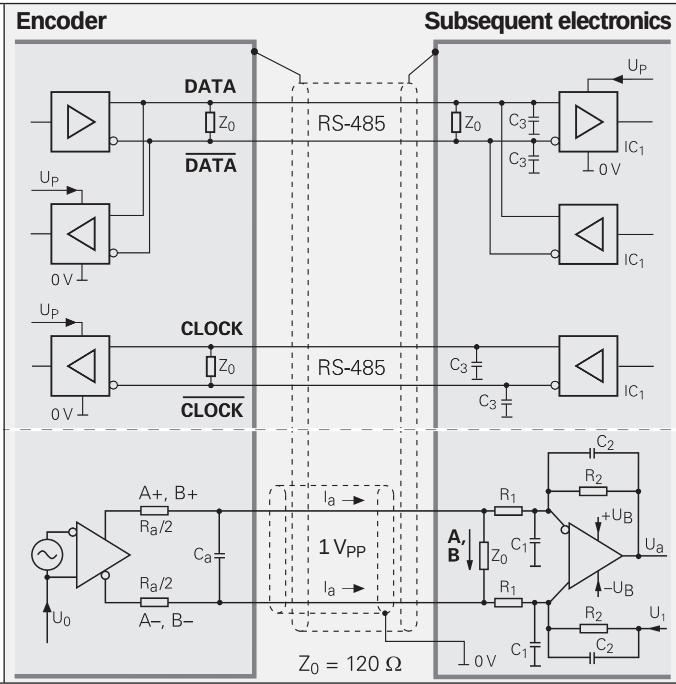
Input circuitry of the subsequent electronics

Dimensioning
IC_1 = RS 485 differential line receiver and driver

C_3 = 330 pF
Z_0 = 120 Ω

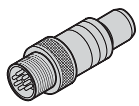
Data transfer

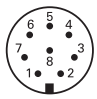
Incremental signals depending on encoder



Pin layout

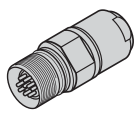
8-pin M12 **coupling**

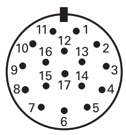




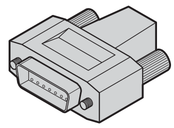
	Power supply				Absolute position values			
	8	**2**	**5**	**1**	**3**	**4**	**7**	**6**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

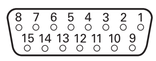
17-pin M23 **coupling**





15-pin D-sub connector
For HEIDENHAIN controls and IK 220





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

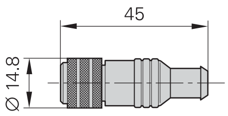
Cable shield connected to housing; **U_P** = power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!
[1] Only with ordering designations EnDat 01 and EnDat 02

Cables and Connecting Elements
General Information

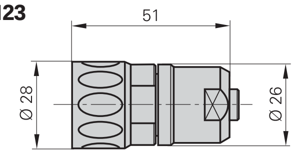
Connector (insulated): A connecting element with a coupling ring. Available with male or female contacts.

Symbols 

M12



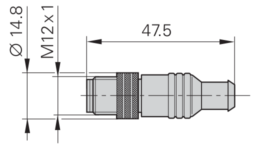
M23



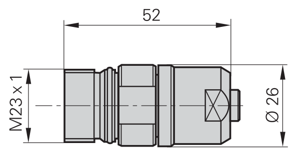
Coupling (insulated): Connecting element with external thread; available with male or female contacts.

Symbols 

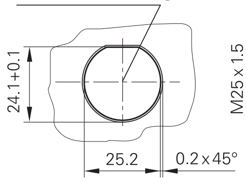
M12



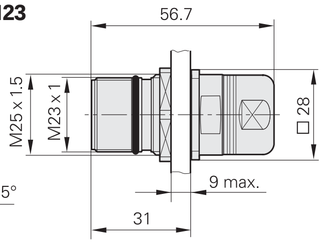
M23



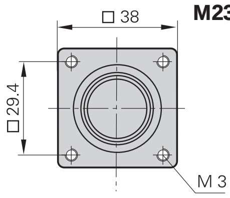
Mounted coupling with central fastening



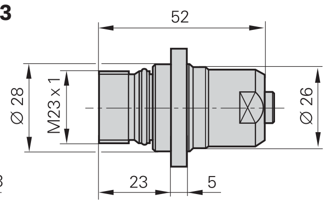
M23



Mounted coupling with flange



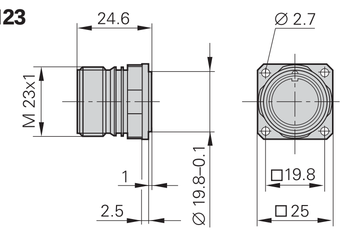
M23



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

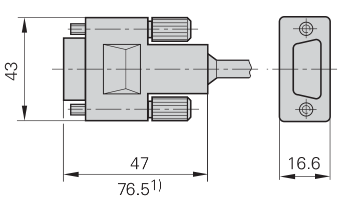
Symbols 

M23



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

Symbols 



[1] With integrated interpolation electronics

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

male contacts or

female contacts.

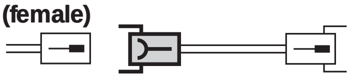
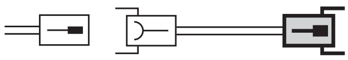
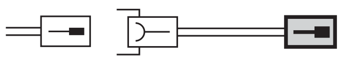
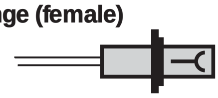
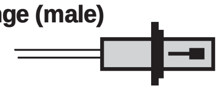
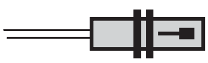
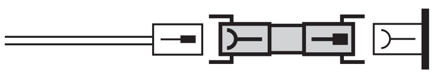
When engaged, the connections are **protected** to IP 67 (D-sub connector: IP 50; EN 60529). When not engaged, there is no protection.

Accessories for flange sockets and M23 mounted couplings

Bell seal
ID 266526-01

Threaded metal dust cap
ID 219926-01

Connecting Cable

		8-pin M12	12-pin M23
		For **EnDat** without incremental signals	For ∿ **1 V_{PP}** ⊓⊔ **TTL**
PUR connecting cables	**8-pin:** [(4 × 0.14 mm^2) + (4 × 0.34 mm^2)] **12-pin:** [4(2 × 0.14 mm^2) + (4 × 0.5 mm^2)]	**Ø 6 mm**	**Ø 8 mm**
Complete with connector (female) and coupling (male)		368330-xx	298401-xx
Complete with connector (female) and connector (male)		–	298399-xx
Complete with connector (female) and D-sub connector (female) for IK 220		533627-xx	310199-xx
Complete with connector (female) and D-sub connector (male) for IK 115/IK 215		524599-xx	310196-xx
With one connector (female)		634265-xx	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 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

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**:

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

where

- ΔU: Voltage attenuation 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 mm^2

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 at the encoder. 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

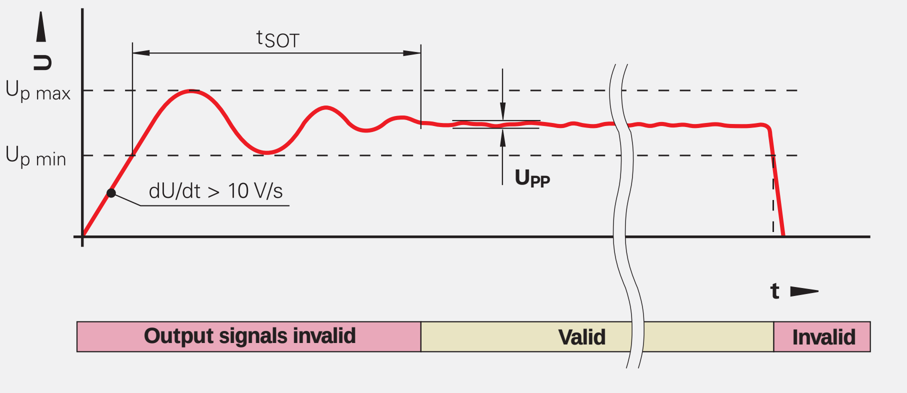
The output signals are valid no sooner than after switch-on time t_{SOT} = 1.3 s (2 s for PROFIBUS-DP) (see diagram). During time t_{SOT} they can have any levels up to 5.5 V (with HTL encoders up to U_{Pmax}). If an interpolation electronics unit is inserted between the encoder and the power supply, 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 up. These data apply to the encoders listed in the catalog—customer-specific interfaces are not included.

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 mm^2	–	–	0.09 mm^2
Ø 4.3 mm	0.24 mm^2	–	–	–
Ø 4.5 mm EPG	0.05 mm^2	–	0.05 mm^2	0.09 mm^2
Ø 4.5 mm **Ø 5.1 mm**	0,14/0,09[2] mm^2 0,05[2), 3)] mm^2	0.05 mm^2	0.05 mm^2	0.14 mm^2
Ø 6 mm **Ø 10 mm**[1]	0,19/0,14[2), 4)] mm^2	–	0.08 mm^2	0.34 mm^2
Ø 8 mm **Ø 14 mm**[1]	0.5 mm^2	1 mm^2	0.5 mm^2	1 mm^2

[1] Metal armor [2] Rotary encoders [3] Length gauges [4] LIDA 400
[5] Also Fanuc, Mitsubishi

Encoders with expanded voltage supply 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 power consumption at maximum supply voltage (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.

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 in four steps:

Step 1: Resistance of the supply lines

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

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

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:
$I_E = \Delta U / R_L$

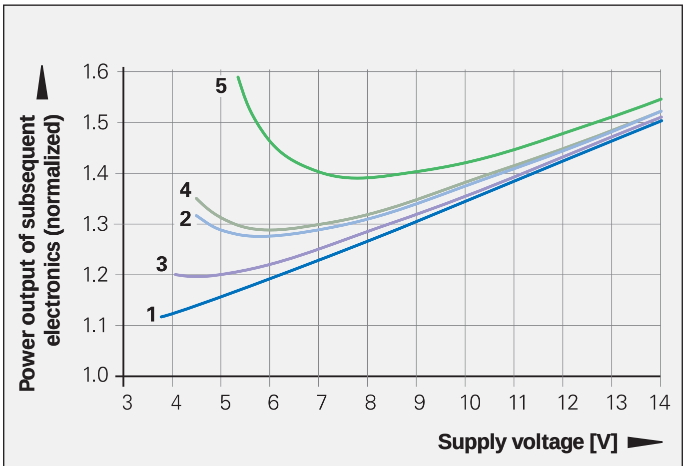
Power consumption of encoder:
$P_E = U_E \cdot I_E$

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

Where:

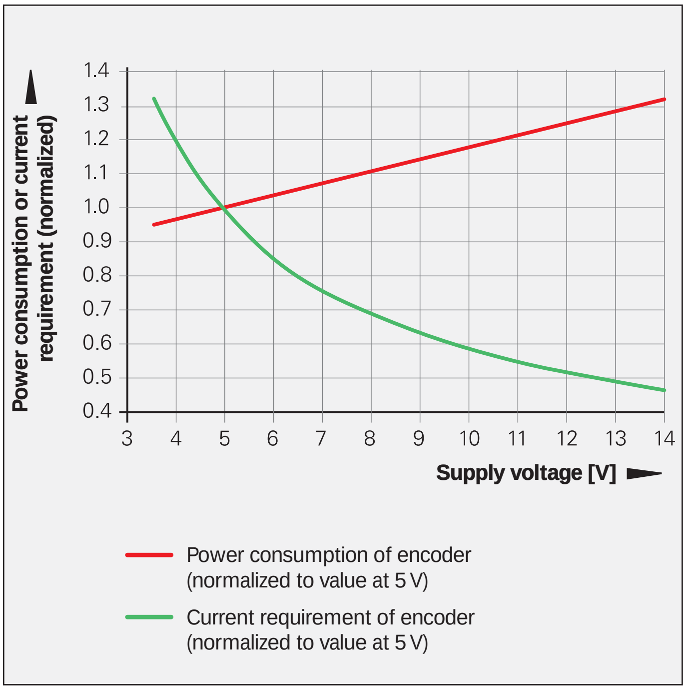
U_{Emax}, U_{Emin}: Minimum or maximum supply voltage of the encoder in V
P_{Emin}, P_{Emax}: Maximum power consumption at minimum or maximum power supply, respectively, in W
U_S: Supply voltage of the subsequent electronics in V
R_L: Cable resistance (for both directions) in ohms
ΔU: Voltage drop in 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 cable	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 –3dB/ –6dB 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 frequency f_{max} of the encoder
  and
  – the minimum permissible edge separation a for the subsequent electronics.

For angular or rotary encoders

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

For linear encoders

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

Where:
n_{max}: 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

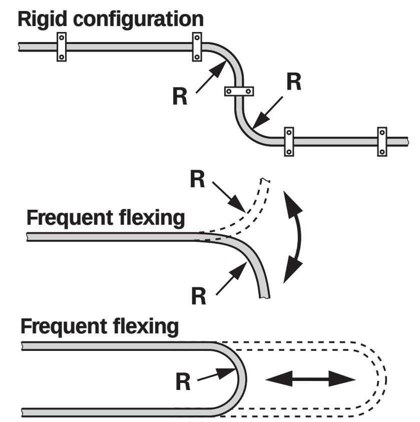
Cable

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 cable).** Most adapter cables for within motors and a few cables on encoders are sheathed in a **special elastomer (EPG cable).** These cables are identified in the specifications or in the cable tables with "EPG."

Durability
PUR cables are resistant to oil and hydrolysis in accordance with **VDE 0472** (Part 803/test type B) and resistant to 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 silicone and halogens. In comparison with PUR cables, they are only conditionally 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:

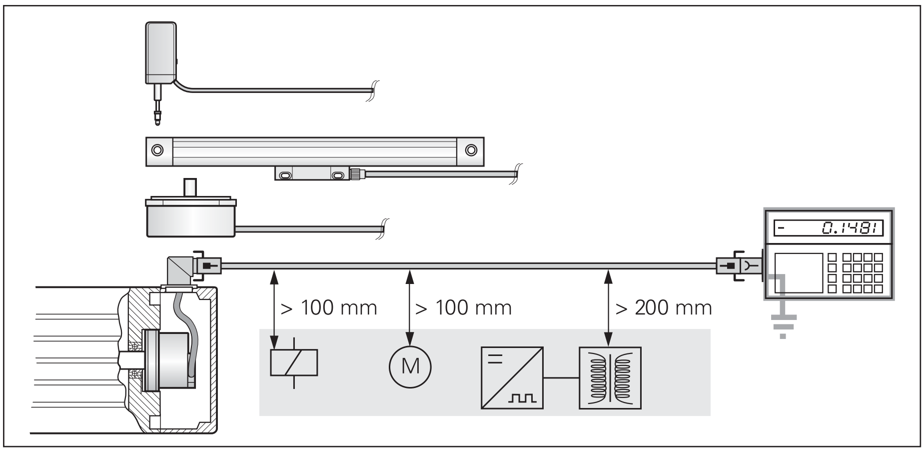
- **Noise EN 61 000-6-2:**
  Specifically:
  - ESD — EN 61 000-4-2
  - Electromagnetic fields — EN 61 000-4-3
  - Burst — EN 61 000-4-4
  - Surge — EN 61 000-4-5
  - Conducted disturbances — EN 61 000-4-6
  - Power frequency magnetic fields — EN 61 000-4-8
  - Pulse magnetic fields — EN 61 000-4-9
- **Interference EN 61 000-6-4:**
  Specifically:
  - For industrial, scientific and medical equipment (ISM) — EN 55 011
  - For information technology equipment — EN 55 022

Transmission of measuring signals— electrical noise immunity
Noise voltages arise mainly through capacitive or inductive transfer. Electrical noise can be introduced into the system over signal lines and input or output terminals.
Possible sources of noise 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 attenuation 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 contacts, motors, frequency inverters, solenoids, etc.).
  - Sufficient decoupling from interference-signal-conducting cables can usually be achieved by an air clearance of 100 mm or, when cables are in metal ducts, by a grounded partition.
  - A minimum spacing of 200 mm to inductors in switch-mode power supplies is required.
- 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.
- Only provide power from PELV systems **(EN 50 178) to position encoders.** Provide high-frequency grounding with low impedance **(EN 60 204-1 Chap. EMC)**.
- For encoders with 11-µApp interface: For extension cables, use only HEIDENHAIN cable ID 244 955-01. Overall length: max. 30 m.



Minimum distance from sources of interference

HEIDENHAIN Measuring Equipment
For Incremental Encoders

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

	PWM 9
Inputs	Expansion modules (interface boards) for 11 μA_{PP}; 1 V_{PP}; TTL; HTL; EnDat*/SSI*/commutation signals *No display of position values or parameters
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, max. 15 W
Dimensions	150 mm × 205 mm × 96 mm

The **PWT** is a simple adjusting aid for HEIDENHAIN incremental encoders. In a small LCD window the signals are shown as bar charts with reference to their tolerance limits.

	PWT 10	PWT 17	PWT 18
Encoder input	∿ 11 μA_{PP}	⊓⊔TTL	∿ 1 V_{PP}
Functions	Measurement of signal amplitude Wave-form tolerance Amplitude and position of the reference mark signal		
Power supply	Via power supply unit (included)		
Dimensions	114 mm x 64 mm x 29 mm		

For Absolute Encoders

HEIDENHAIN offers an adjusting and testing package for diagnosis and adjustment of HEIDENHAIN encoders with absolute interface.

- **IK 215** PC expansion board
- **ATS** adjusting and testing software

	IK 215
Encoder input	• EnDat 2.1 or EnDat 2.2 (absolute value with/without incremental signals) • FANUC serial interface • Mitsubishi High Speed Serial Interface • SSI
Interface	PCI bus, Rev. 2.1
System requirements	• Operating system: Windows XP (Vista upon request) • Approx. 20 MB free space on the hard disk
Signal subdivision for incremental signals	Up to 65536-fold
Dimensions	100 mm x 190 mm

	ATS
Languages	Choice between English or German
Functions	• Position display • Connection dialog • Diagnostics • Mounting wizard for ECI/EQI • Additional functions (if supported by the encoder) • Memory contents

Windows is a registered trademark of the Microsoft Corporation.

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