HEIDENHAIN

Angle Encoders
without
Integral Bearing

September 2011

Information on
- Angle encoders with integral bearing
- Absolute 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

HEIDENHAIN Angle Encoders

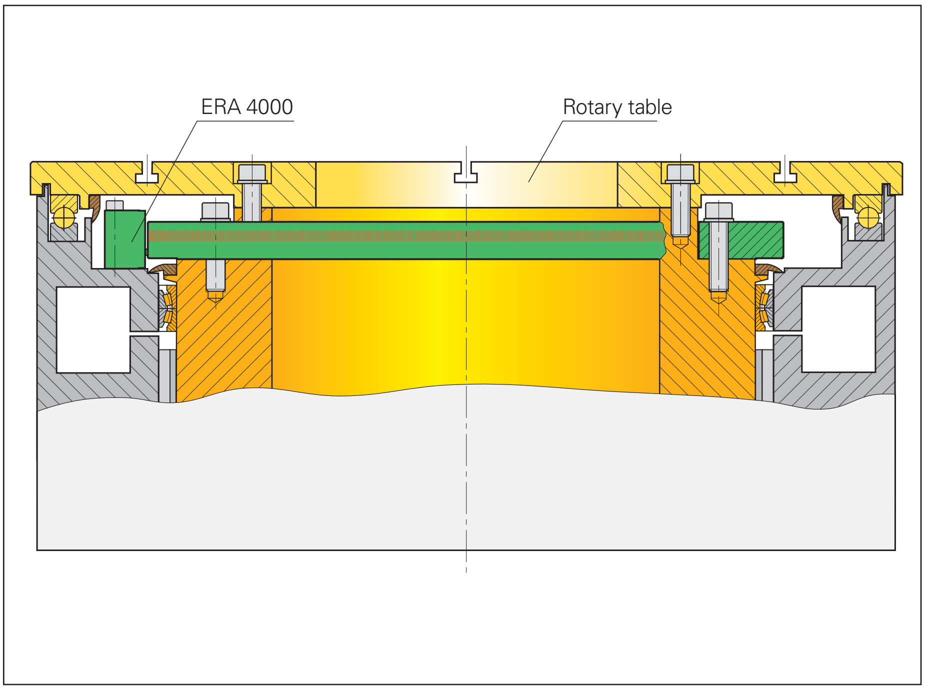
The term angle encoder is typically used to describe encoders that have an accuracy of better than ± 5" and a line count above 10 000.

These angle encoders are found in applications that require the **highly accurate measurement of angles** in the range of a few angular seconds, e.g. in rotary tables and swivel heads on machine tools, C axes on lathes, but also in measuring equipment and telescopes.

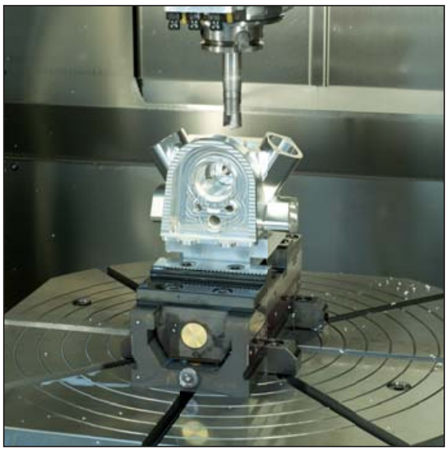
Other applications, such as scanners, positioning systems, printing units or beam deflection systems, require **high repeatability** and/or a **high angular resolution.** Encoders for such applications are likewise referred to as angle encoders.

In contrast, rotary encoders are used in applications where accuracy requirements are less stringent, e.g. in automation, electrical drives, and many other applications.

The tables on the following pages list different types of angle encoders to suit various applications and meet different requirements.



The **ERA 4000** angle encoder mounted onto the rotary table of a machine tool



Rotary table on a machine tool

X-Y-theta table

Radio telescope

Angle encoders without integral bearing
The angle encoders without integral bearing (modular angle encoders) **ERP, ERO** and **ERA** consist of two components—a scanning head and a graduation carrier, which must be aligned with each other during mounting. The eccentricity of the shaft as well as installation and adjustment therefore have a decisive effect on the achievable accuracy.

Modular angle encoders are available with various graduation carriers:
- ERP/ERO: Glass circular scale with hub
- ERA 4000: Steel drum
- ERA 6000/7000/8000: Steel tape

Angle encoders without integral bearing are designed for integration in machine elements or components. They are designed to meet the following requirements:
- Large hollow shaft diameters (up to 10 m with a scale tape)
- High shaft speeds
- No additional starting torque from shaft seals
- High reproducibility
- High adaptability to mounting space (versions with scale tape available as full circles or circle segments)

Because angle encoders without integral bearing are supplied without enclosure, the required degree of protection must be ensured through proper installation.

Selection Guide on pages 6 to 9

Angle encoders with integral bearing
The angle encoders with integral bearing, **RCN, RON, RPN** and **ROD,** are complete, sealed systems. They are characterized by their simple mounting and uncomplicated adjustment. The integrated stator coupling (with the RCN, RON and RPN) or the separate shaft coupling (with the ROD) compensates axial motion of the measured shaft.

Angle encoders with integrated stator coupling therefore provide excellent dynamic performance because the coupling must absorb only that torque caused by friction in the bearing during angular acceleration of the shaft.

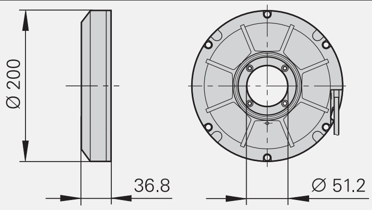
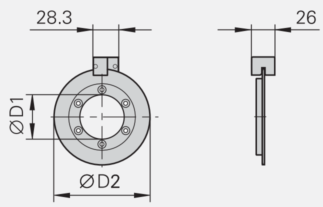
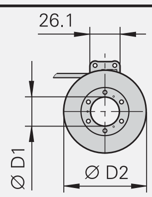
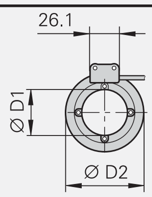
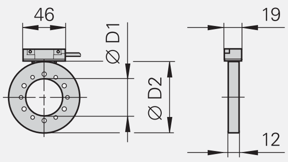
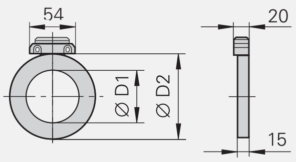
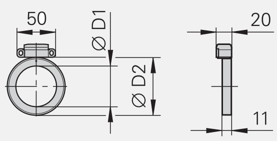
Other advantages:
- Compact size for limited installation space
- Hollow shaft diameters up to 100 mm to provide space for power lines, etc.
- Simple installation
- Large mounting tolerances

Selection Guide on pages 10 to 13

You can find more detailed information on **angle encoders with integral bearing** on the Internet at *www.heidenhain.de* or in our separate catalog.

Selection Guide

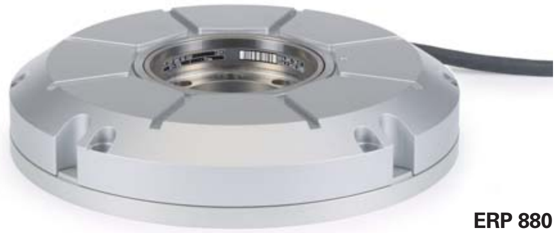
Angle Encoders and Modular Encoders without Integral Bearing – Grating on Massive Scale Carrier

Series	Version and mounting	Overall dimensions in mm	Diameter D1/D2	System accuracy[1]	Mechanically permissible speed
Angle encoders with graduation on glass disk					
ERP 880	Phase-grating graduation on glass disk with hub; screwed onto front of shaft		–	± 1″	≤ 1000 min^{-1}
ERP 4000	Phase-grating graduation on glass disk with hub; screwed onto front of shaft		D1: 8 mm D2: 44 mm	± 5″	≤ 300 min^{-1}
ERP 8000	Phase-grating graduation on glass disk with hub		D1: 50 mm D2: 108 mm	± 2″	≤ 100 min^{-1}
ERO 6000	METALLUR graduation on glass disk with hub; screwed onto front of shaft		D1: 25/95 mm D2: 71/150 mm	± 5″/ ± 3″	≤ 1600 min^{-1}/ ≤ 800 min^{-1}
ERO 6100	Chrome graduation on glass; screwed onto front of shaft		D1: 41 mm D2: 70 mm	± 15″	≤ 3500 min^{-1}
Angle encoders with graduation on steel scale drum					
ERA 4x80	Scale drum with centering collar; screwed onto front of shaft		D1: 40 mm to 512 mm D2: 76.5 mm to 560.46 mm	± 9.4″ to ± 2.3″	≤ 10000 min^{-1} to ≤ 1500 min^{-1}
ERA 4282	Scale drum for increased accuracy; screwed onto front of shaft		D1: 40 mm to 270 mm D2: 76.5 mm to 331.31 mm	± 5.1″ to ± 2.0″	≤ 10000 min^{-1} to ≤ 2500 min^{-1}
Modular encoders with magnetic graduation					
ERM 200	Steel scale drum with MAGNODUR graduation; screwed onto front of shaft		D1: 40 mm to 410 mm D2: 75.44 to 452.64 mm	± 36″ to ± 9″	≤ 19000 min^{-1} to ≤ 3000 min^{-1}
ERM 2400	Steel scale drum with MAGNODUR graduation; fastened by clamping		D1: 40/55 mm D2: 64.37/ 75.44 mm	± 43″/± 36″	≤ 42000 min^{-1}/ ≤ 36000 min^{-1}
ERM 2900			D1: 55 mm D2: 77.41 mm	± 70″	≤ 25000 min^{-1}

[1] Before installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft are not included.

	Incremental signals			Model	Page
	Signal periods per revolution	**Output signals**	**Reference marks**		
	180000	∿ 1 V_{PP}	One	**ERP 880**	**36**
	131072	∿ 1 V_{PP}	None	**ERP 4080**	**38**
	360000	∿ 1 V_{PP}	None	**ERP 8080**	
	9000/ 18000	∿ 1 V_{PP}	One	**ERO 6080**	**40**
	45000 to 900000[2)]	⊓⊔ TTL	One	**ERO 6070**	
	4096	∿ 1 V_{PP}	One	**ERO 6180**	**42**
	12000 to 52000	∿ 1 V_{PP}	Distance-coded	**ERA 4280 C**	**44**
	6000 to 44000			**ERA 4480 C**	
	3000 to 13000			**ERA 4880 C**	
	12000 to 52000	∿ 1 V_{PP}	Distance-coded	**ERA 4282 C**	**48**
	600 to 3600	⊓⊔ TTL	One	**ERM 220**	Catalog: *Magnetic Modular Encoders*
		∿ 1 V_{PP}		**ERM 280**	
	512/600	∿ 1 V_{PP}	One	**ERM 2485**	
	256	∿ 1 V_{PP}	One	**ERM 2984**	

2) Through integrated interpolation



ERP 880

ERP 4080

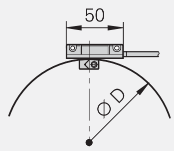
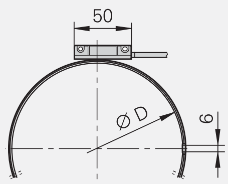
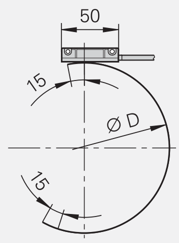
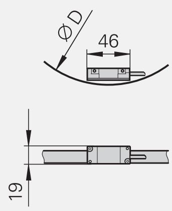
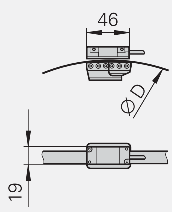
ERO 6080

ERA 4000

ERM 280

Selection Guide

Angle Encoders without Integral Bearing – Graduation on Steel Tape

Series	Version and mounting	Overall dimensions in mm	Diameter D1/D2	System accuracy[1)]	Mechanically permissible speed
Angle encoders with graduation on steel tape					
ERA 6000	Steel scale tape for external mounting, full-circle version; scale tape is tensioned on the outside circumference		159.07 mm to 1 146.54 mm	± 15″ to ± 80″	≤ 200 min^{-1} to ≤ 83 min^{-1}
ERA 6006	Steel scale tape with elastic intermediate layer for external mounting, full-circle version; scale tape is tensioned on the outside circumference		153.35 mm to 1 140.12 mm	± 50″ to ± 350″	≤ 200 min^{-1} to ≤ 83 min^{-1}
ERA 6002	Steel scale tape for external mounting, segment version; scale tape is glued on		≥ 150 mm	Scale-tape accuracy: ± 30 µm/m	Depends on the diameter
ERA 7000	Steel scale tape for internal mounting, full circle version[2)]; scale tape is tensioned on the outside circumference		458.62 mm to 1 146.10 mm	± 1.6″ to ± 4.0″	≤ 250 min^{-1} to ≤ 220 min^{-1}
ERA 8000	Steel scale tape for external mounting, full circle version[2)]; scale tape is tensioned on the outside circumference		458.11 mm to 1 145.73 mm	± 1.9″ to ± 4.8″	Approx. ≤ 45 min^{-1}

[1)] Before installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft are not included.
[2)] Segment versions upon request
[3)] After integrated interpolation

Incremental signals			Model	Page
Signal periods per revolution	**Output signals**	**Reference marks**		
25000 to 1800000[3]	⊓⊔TTL	Every 100 mm	**ERA 6070**	**58**
2500 to 18000	∼ 1 V_{PP}		**ERA 6080**	
25000 to 1800000[3]	⊓⊔TTL	Every 100 mm	**ERA 6076**	**60**
2500 to 18000	∼ 1 V_{PP}		**ERA 6086**	
50/250/500 signal periods per mm[3]	⊓⊔TTL	Every 100 mm	**ERA 6072**	**62**
5 signal periods per mm	∼ 1 V_{PP}		**ERA 6082**	
36000 to 90000	∼ 1 V_{PP}	Distance-coded	**ERA 7480 C**	**50**
36000 to 90000	∼ 1 V_{PP}	Distance-coded	**ERA 8480 C**	**54**

ERA 6080

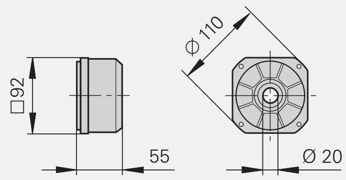
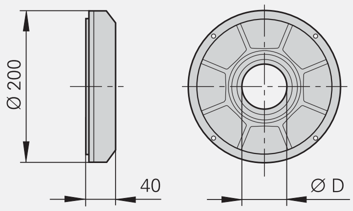
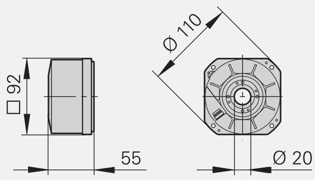
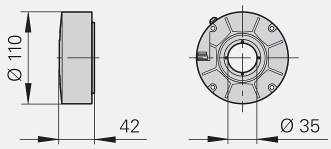
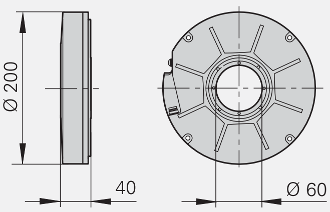
ERA 6086

ERA 6082

ERA 7480

ERA 8480

Selection Guide
Absolute Angle Encoders with Integral Bearing

Series	Overall dimensions in mm	System accuracy	Mechanically permissible speed	Incremental signals	
				Signal periods per revolution	Output signals
Angle encoders with integrated stator coupling					
RCN 200		± 5"	3000 min^{-1}	–	–
				–	–
		± 2.5"		–	–
				–	–
RCN 700		± 2"	1000 min^{-1}	–	–
				–	–
RCN 800	D: 60 mm and 100 mm	± 1"	1000 min^{-1}	–	–
				–	–
Angle encoders with integrated stator coupling and optimized scanning					
RCN 2000		± 5" ± 2.5"	≤ 1500 min^{-1}	16384	∼ 1 V_{PP}
		± 5" ± 2.5"		–	–
RCN 5000		± 5" ± 2.5"	≤ 1500 min^{-1}	16384	∼ 1 V_{PP}
		± 5" ± 2.5"		–	–
RCN 8000		± 2" ± 1"	≤ 500 min^{-1}	32768	∼ 1 V_{PP}
		± 2" ± 1"		–	–

	Absolute position values		Model	For more information
	Positions per revolution	Data interface		
	8388608 ≙ 23 bits	Fanuc 02	**RCN 223 F**	Catalog: *Angle Encoders with Integral Bearing*
	8388608 ≙ 23 bits	Mit 02-4	**RCN 223 M**	
	134217728 ≙ 27 bits	Fanuc 02	**RCN 227 F**	
	134217728 ≙ 27 bits	Mit 02-4	**RCN 227 M**	
	134217728 ≙ 27 bits	Fanuc 02	**RCN 727 F**	
	134217728 ≙ 27 bits	Mit 02-4	**RCN 727 M**	
	134217728 ≙ 27 bits	Fanuc 02	**RCN 827 F**	
	134217728 ≙ 27 bits	Mit 02-4	**RCN 827 M**	
	67108864 ≙ 26 bits	EnDat 2.2 / 02	**RCN 2380** **RCN 2580**	Catalog: *Absolute Angle Encoders with Optimized Scanning*
	268435456 ≙ 28 bits	EnDat 2.2/22	**RCN 2310** **RCN 2510**	
	67108864 ≙ 26 bits	EnDat 2.2 / 02	**RCN 5380** **RCN 5580**	
	268435456 ≙ 28 bits	EnDat 2.2/22	**RCN 5310** **RCN 5510**	
	536870912 ≙ 29 bits	EnDat 2.2 / 02	**RCN 8380** **RCN 8580**	
		EnDat 2.2/22	**RCN 8310** **RCN 8510**	

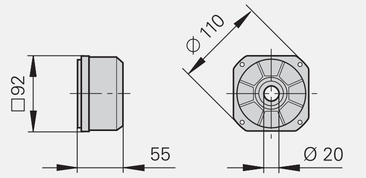
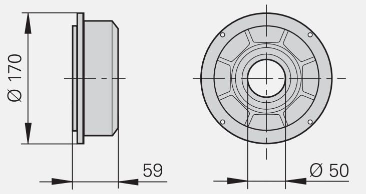
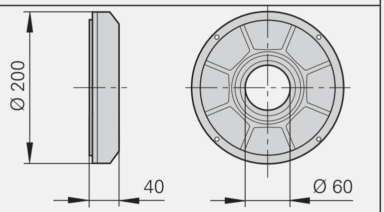
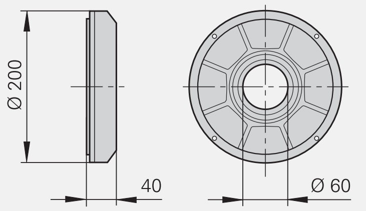
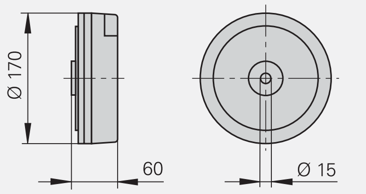
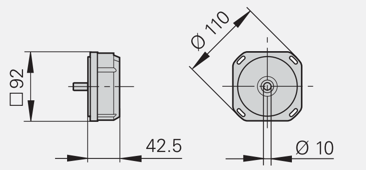
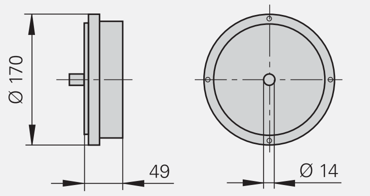
RCN 2000

RCN 5000

RCN 8000

Selection Guide

Incremental Angle Encoders with Integral Bearing

Series	Overall dimensions in mm	System accuracy	Mechanically permissible speed	Incremental signals Signal periods per revolution
Angle encoders with integrated stator coupling				
RON 200		± 5″	3000 min^{-1}	18000[2)]
				180000/90000[2)]
				18000
		± 2.5″		18000
RON 700		± 2″	1000 min^{-1}	18000
				18000/36000
RON 800 **RPN 800**		± 1″	1000 min^{-1}	36000
				180000
RON 900		± 0.4″	100 min^{-1}	36000
Angle encoders for separate shaft coupling				
ROD 200		± 5″	10000 min^{-1}	18000[2)]
				180000[2)]
				18000
ROD 700		± 2″	1000 min^{-1}	18000/36000
ROD 800		± 1″	1000 min^{-1}	36000

[1)] After integrated interpolation

	Output signals	Model	For more information
	⊓⊔TTL	**RON 225**	Catalog: *Angle Encoders with Integral Bearing*
	⊓⊔TTL	**RON 275**	
	∼ 1 V_{PP}	**RON 285**	
	∼ 1 V_{PP}	**RON 287**	
	∼ 1 V_{PP}	**RON 785**	
	∼ 1 V_{PP}	**RON 786**	
	∼ 1 V_{PP}	**RON 886**	
	∼ 1 V_{PP}	**RPN 886**	
	∼ 11 μA_{PP}	**RON 905**	
	⊓⊔TTL	**ROD 220**	Catalog: *Angle Encoders with Integral Bearing*
	⊓⊔TTL	**ROD 270**	
	∼ 1 V_{PP}	**ROD 280**	
	∼ 1 V_{PP}	**ROD 780**	
	∼ 1 V_{PP}	**ROD 880**	

RON 285

RON 786

RON 905

ROD 280

ROD 780

Measuring Principles
Measuring Standard

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

These graduations are applied to a glass or steel substrate. Glass scales are used primarily in encoders for speeds up to 10000 min^{-1}. Steel drums are used for higher speeds—up to 20000 min^{-1}. The scale substrate for large diameters is a steel tape.

HEIDENHAIN manufactures the precision graduations in specially developed, photolithographic processes.

- AURODUR: matte-etched lines on gold-plated steel tape with typical graduation period of 40 µm
- METALLUR: contamination-tolerant graduation of metal lines on gold, with typical graduation period of 20 µm
- DIADUR: extremely robust chromium lines on glass (typical graduation period of 20 µm) or three-dimensional chrome structures (typical graduation period of 8 µm) on glass
- SUPRADUR phase grating: optically three dimensional, planar structure; particularly tolerant to contamination; typical graduation period of 8 µm and less
- OPTODUR phase grating: optically three dimensional, planar structure with particularly high reflectance, typical graduation period of 2 µm and less

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.

Circular graduations of angle encoders

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. Since an absolute reference is required to ascertain positions, the measuring standard is provided with an additional track that bears a **reference mark**. 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.

In some cases, this may require rotation by up to nearly 360°. To speed and simplify such "reference runs," many encoders feature **distance-coded reference marks**—multiple reference marks that are individually spaced according to a mathematical algorithm. The subsequent electronics find the absolute reference after traversing two successive reference marks—meaning only a few degrees of traverse (see nominal increment I in the table).

Encoders with distance-coded reference marks are identified with a "C" behind the model designation (e.g. ERA 4200C).

With distance-coded reference marks, the **absolute reference** is calculated by counting the signal periods between two reference marks and using the following formula:

$$\alpha_1 = (\text{abs } A - \text{sgn } A - 1) \times \frac{I}{2} + (\text{sgn } A - \text{sgn } D) \times \frac{\text{abs } M_{RR}}{2}$$

where:

$$A = \frac{2 \times \text{abs } M_{RR} - I}{GP}$$

where:

α_1 = Absolute angular position of the first traversed reference mark to the zero position in degrees

abs = Absolute value

sgn = Sign function ("+1" or "–1")

M_{RR} = Measured distance between the traversed reference marks in degrees

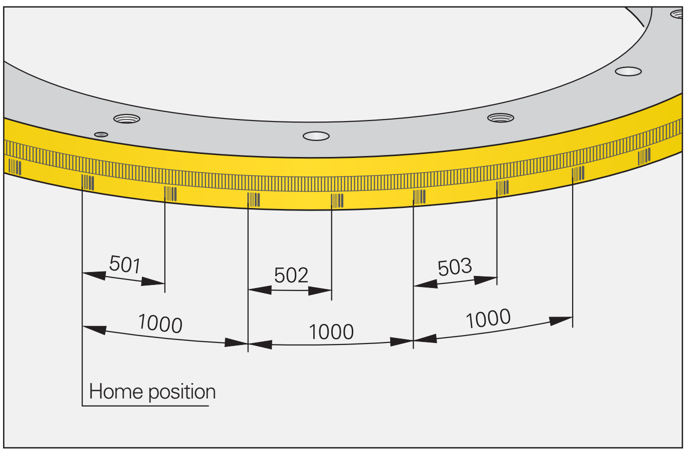
I = Nominal increment between two fixed reference marks (see tables)

GP = Grating period ($\frac{360°}{\text{Line count}}$)

D = Direction of rotation (+1 or –1). Proper rotation (indicated in the mating dimensions) equals +1.

ERA 7480C, ERA 8480C

Line count z	Number of reference marks	Nominal increment I
36000	72	10°
45000	90	8°
90000	180	4°



Schematic representation of a circular graduation with distance-coded reference marks (ERA 4480 with 20000 lines as example)

ERA 4000C

Line count for grating period			Number of reference marks	Nominal increment I
20 µm	40 µm	80 µm		
–	–	3000	6	120°
8192	4096	4096	8	90°
–	–	5000	10	72°
12000	6000	–	12	60°
–	–	7000	14	51.429°
16384	8192	8192	16	45°
20000	10000	10000	20	36°
24000	12000	12000	24	30°
–	–	13000	26	27.692°
28000	14000	–	28	25.714°
32768	16384	–	32	22.5°
40000	20000	–	40	18°
48000	24000	–	48	15°
52000	26000	–	52	13.846°
–	38000	–	76	9.474°
–	44000	–	88	8.182°

Scanning the Measuring Standard
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.

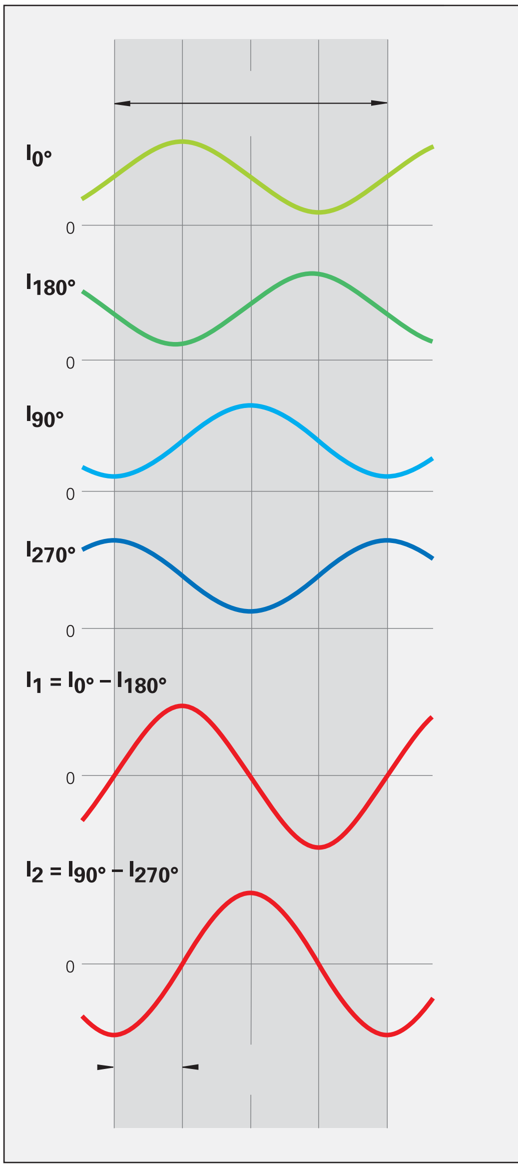
The finer the grating period of a measuring standard is, the greater the effect of diffraction on photoelectric scanning. HEIDENHAIN uses two scanning principles with angle encoders:

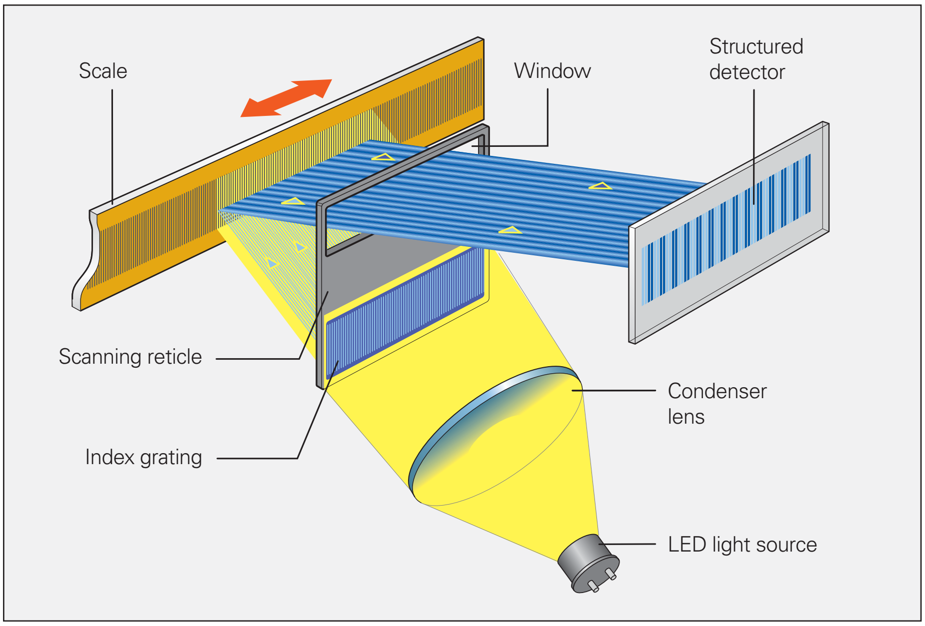
- The **imaging scanning principle** for grating periods from 10 µm to approx. 70 µm.
- The **interferential scanning principle** for very fine graduations with grating periods of 4 µm and smaller.

Imaging scanning principle
Put simply, the imaging scanning principle functions by means of projected-light signal generation: two graduations with equal grating periods are moved relative to each other—the scale and the scanning reticle. The carrier material of the scanning reticle is transparent, whereas the graduation on the measuring standard may be applied to a transparent or reflective surface.
When parallel light passes through a grating, light and dark surfaces are projected at a certain distance. An index grating with the same grating period is located here. When the two gratings move relative to each other, the incident light is modulated. If the gaps in the gratings are aligned, light passes through. If the lines of one grating coincide with the gaps of the other, no light passes through.

Photovoltaic cells convert these variations in light intensity into electrical signals. The specially structured grating of the scanning reticle filters the light to generate nearly sinusoidal output signals. The smaller the period of the grating structure is, the closer and more tightly toleranced the gap must be between the scanning reticle and circular scale. Practical mounting tolerances for encoders with the imaging scanning principle are achieved with grating periods of 10 µm and larger.

The ERA angle encoders, for example, operate according to the imaging scanning principle.

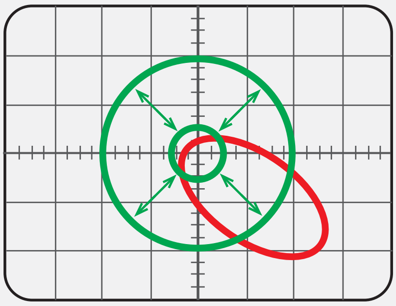




Photoelectric scanning in accordance with the imaging principle with a steel scale and single-field scanning

The sensor generates four nearly sinusoidal current signals ($I_{0°}$, $I_{90°}$, $I_{180°}$ and $I_{270°}$), electrically phase-shifted to each other by 90°. These scanning signals do not at first lie symmetrically about the zero line. For this reason the photovoltaic cells are connected in a push-pull circuit, producing two 90° phase-shifted output signals $\mathbf{I_1}$ and $\mathbf{I_2}$ in symmetry with respect to the zero line.

In the X/Y representation on an oscilloscope the signals form a Lissajous figure. Ideal output signals appear as a centered circle. Deviations in the circular form and position are caused by position error within one signal period (see *Measuring Accuracy*) and therefore go directly into the result of measurement. The size of the circle, which corresponds with the amplitude of the output signal, can vary within certain limits without influencing the measuring accuracy.



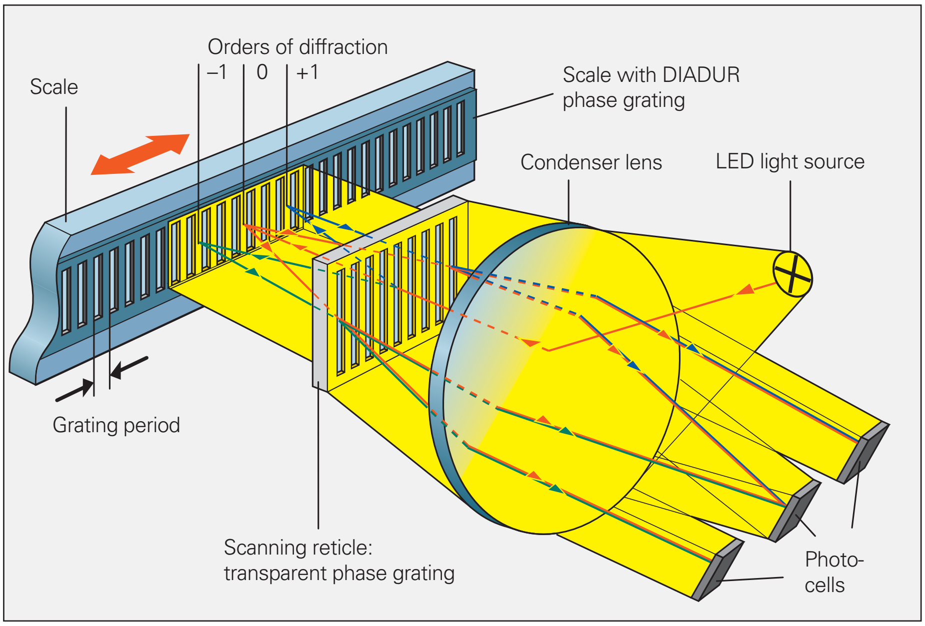
XY representation of the output signals

Interferential Scanning Principle
The interferential scanning principle exploits the diffraction and interference of light on a fine graduation to produce signals used to measure displacement.
A step grating is used as the measuring standard: reflective lines 0.2 µm high are applied to a flat, reflective surface. In front of that is the scanning reticle—a transparent phase grating with the same grating period as the scale.
When a light wave passes through the scanning reticle, it is diffracted into three partial waves of the orders –1, 0, and +1, with approximately equal luminous intensity. The waves are diffracted by the scale such that most of the luminous intensity is found in the reflected diffraction orders +1 and –1. These partial waves meet again at the phase grating of the scanning reticle where they are diffracted again and interfere. This produces essentially three waves that leave the scanning reticle at different angles. Photovoltaic cells convert this alternating light intensity into electrical signals.

A relative motion of the scanning reticle to the scale causes the diffracted wave fronts to undergo a phase shift: when the grating moves by one period, the wave front of the first order is displaced by one wavelength in the positive direction, and the wavelength of diffraction order –1 is displaced by one wavelength in the negative direction. Since the two waves interfere with each other when exiting the grating, the waves are shifted relative to each other by two wavelengths. This results in two signal periods from the relative motion of just one grating period.

Interferential encoders function with average grating periods of 4 µm and finer. Their scanning signals are largely free of harmonics and can be highly interpolated. These encoders are therefore especially suited for high resolution and high accuracy. Even so, their generous mounting tolerances permit installation in a wide range of applications.

The ERP angle encoders, for example, operate according to the interferential scanning principle.



Photoelectric scanning in accordance with the interferential scanning principle and single-field scanning

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, and
- the coupling to the measured shaft.

The **system accuracy** for angle encoders without integral bearing 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 **angle encoders without integral bearing,** additional deviations resulting from mounting, error in the bearing of the measured shaft, and adjustment of the scanning head must be expected (see *Application-Dependent Error*). These deviations are not reflected in the system accuracy.

For **angle encoders with integral bearing** and integrated stator coupling, this value also includes the error due to the shaft coupling. For angle encoders with integral bearing and separate shaft coupling, the angle error of the coupling must be added to the system accuracy of the encoder (see *Angle Encoders with Integral Bearing* catalog).

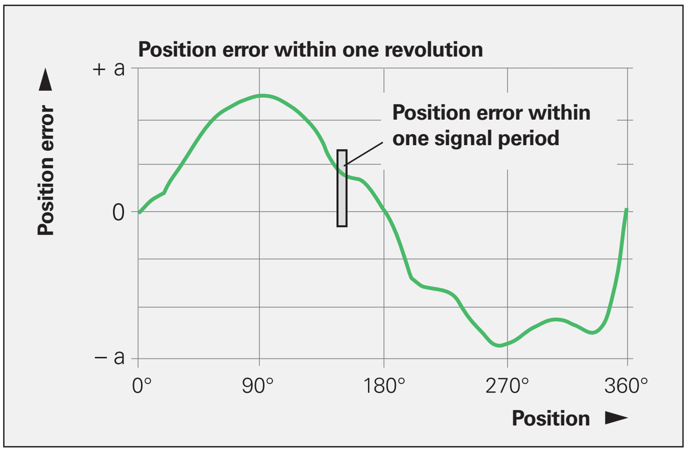
Position error within one revolution becomes apparent in larger angular motions.

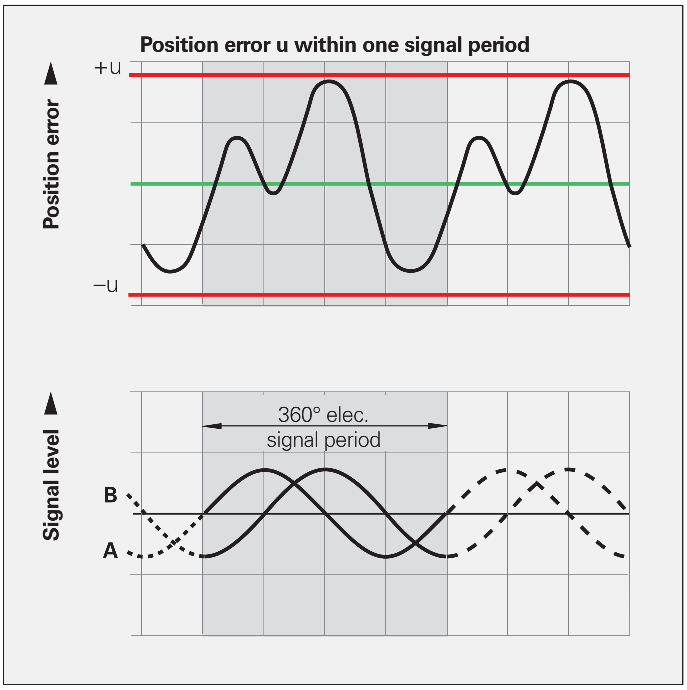
Position errors within one signal period already become apparent in very small angular motions and in repeated measurements. They especially lead to speed ripples in the speed control loop. These errors within one signal period are caused by the quality of the sinusoidal scanning signals and their subdivision.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

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

HEIDENHAIN angle encoders take these factors of influence into account and permit interpolation of the sinusoidal output signal with subdivision accuracies of better than ± 1 % of the signal period (ERP 880: ± 1.5 %, ERA 6000: ± 2.5 %).

Example:
Angle encoder with 32 768 sinusoidal signal periods per revolution
One signal period corresponds to approx. 0.011° or approx. 40". With a signal quality of ± 1 %, this results in a maximum position error within one signal period of approx. ± 0.000 11°, or approx. ± 0.40".





For its ERP, ERO and ERA 4000 angle encoders, HEIDENHAIN prepares individual calibration charts and ships them with the encoder.

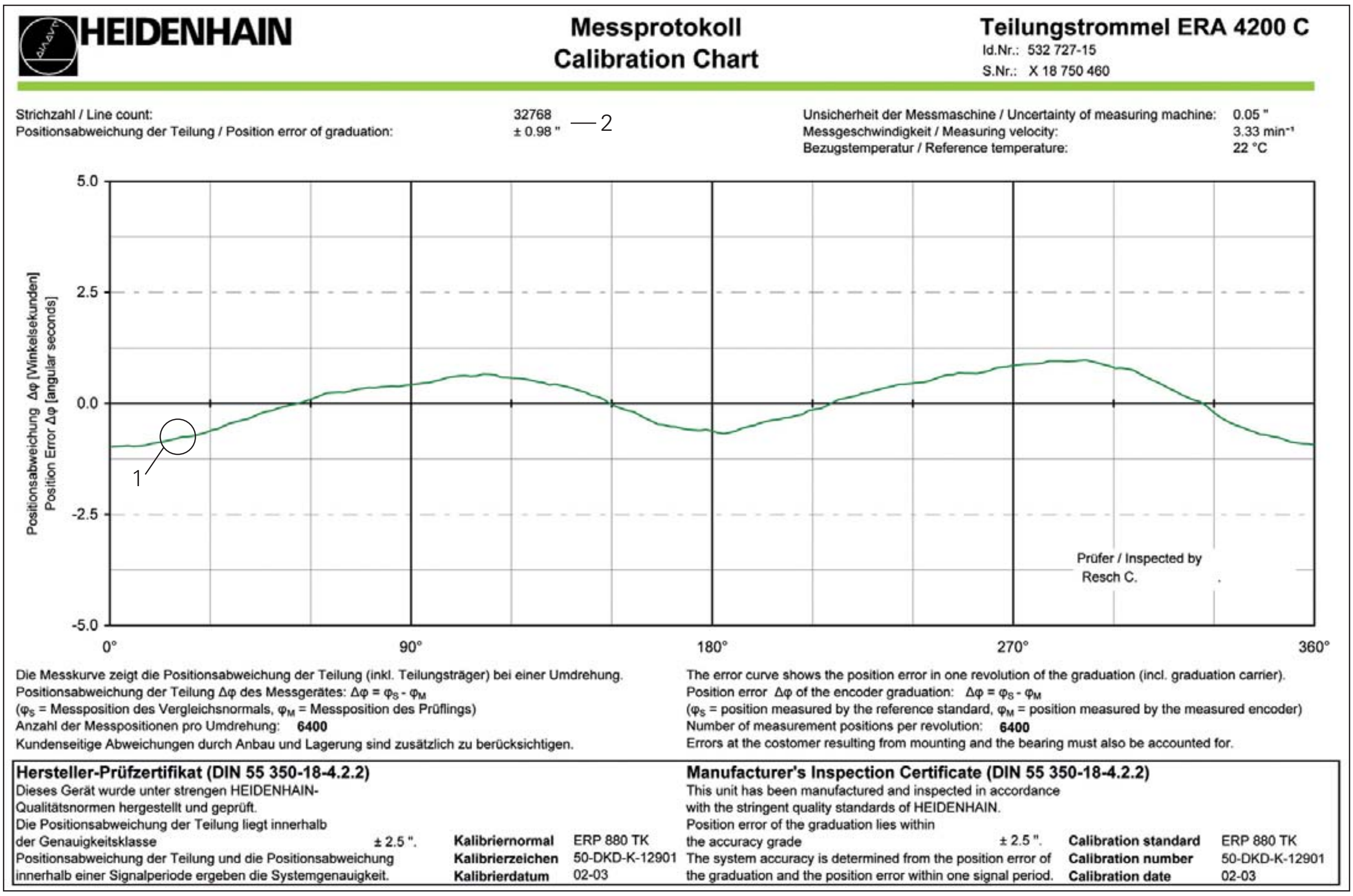
The calibration chart documents the accuracy of the graduation (including its substrate or hub) and serves as a traceability record to a calibration standard. Additional error caused by mounting and the bearing of the measured shaft is not included in the accuracy data.

The graduation accuracy is ascertained through a large number of measuring points during one graduation. The positions per revolution are chosen to include error within the graduation period in the measurement.
All measured values acquired in this manner lie within the specified graduation accuracy (see *Specifications*).

The **calibration chart** confirms the specified accuracy of the encoder. The **calibration standard** indicated in the manufacturer's inspection certificate documents traceability to recognized national and international standards.

The deviations are ascertained at constant temperatures (22 °C) during the final inspection and are indicated on the calibration chart.

Calibration chart example:
ERA 4200C scale drum
1 Graphic representation of the graduation error
2 Result of calibration



Application-Dependent Error

In addition to the system accuracy, the mounting and adjustment of the scanning head normally have a significant effect on the accuracy that can be achieved with angle encoders without integral bearings. Of particular importance are the mounting eccentricity of the graduation and the radial runout of the measured shaft. In order to evaluate the **total accuracy,** each of the significant errors must be considered individually.

1. Directional error of the graduation
ERP, ERO, ERA 4000
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.

ERA 6000, ERA 7000, ERA 8000
The extreme values of the directional error depend on
- the graduation accuracy (*Specifications*),
- the irregular scale-tape expansion during mounting,
- mounting surface form deviations, and
- error at the scale-tape butt joints (of full-circle applications).

The special graduation manufacturing process and the butt joints precisely machined by HEIDENHAIN reduce directional error of the graduation to within 2 to 5 angular seconds (with accurate mounting) for the **ERA 7000 and ERA 8000.**

ERA 6002, ERA 7481 C, ERA 8481 C, ERA 8482 C
In these segment solutions, the additional angular error Δφ **occurs when the nominal scale-tape bearing-surface diameter is not exactly maintained:**

$$\Delta\varphi = (1 - D'/D) \cdot \varphi \cdot 3600$$

where
Δφ = Segment deviation in angular seconds
φ = Segment angle in degrees
D = Nominal scale-tape carrier diameter
D' = Actual scale-tape carrier diameter

This error can be eliminated if the line count per 360° z' valid for the actual scale-tape carrier diameter D' can be entered in the control. The following relationship is valid:

$$z' = z \cdot D'/D$$

where z = Nominal line count per 360°
z' = Actual line count per 360°

The angle actually traversed in segment versions should be measured with a comparative encoder, such as an angle encoder with integral bearing.

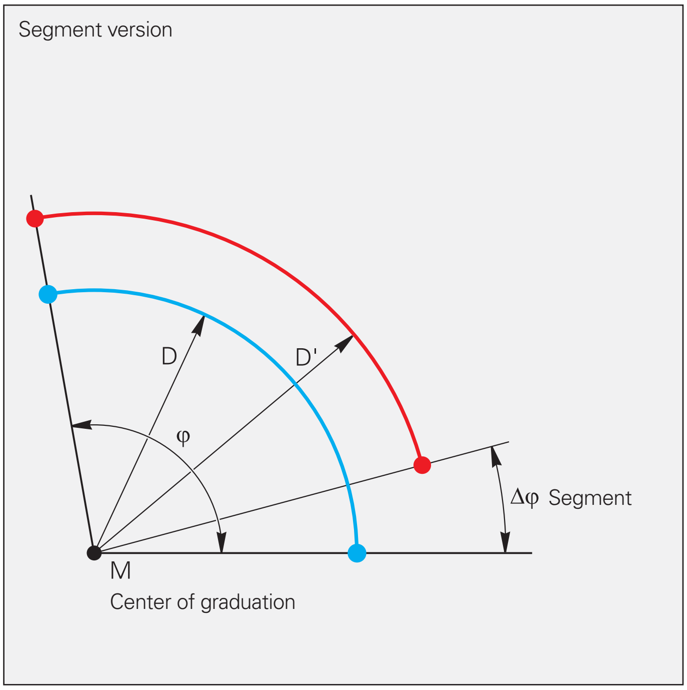
2. Errors due to eccentricity of the graduation to the bearing
Under normal circumstances, the graduation will have a certain eccentricity relative to the bearing once the disk/hub assembly, scale drum or scale tape is mounted. In addition, dimensional and form error of the mating shaft caused by the positioning of the centering collar can result in added eccentricity.

The following relationship is valid:

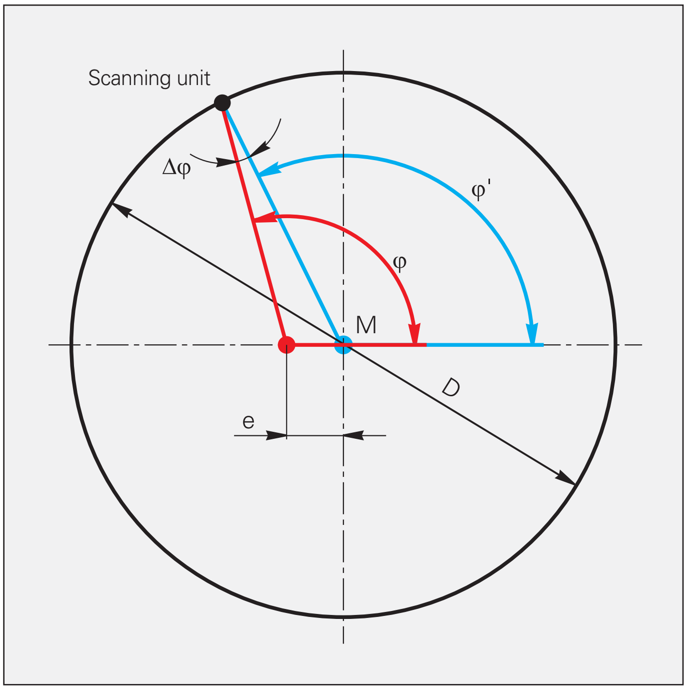
$$\Delta\varphi = \pm 412 \cdot \frac{e}{D}$$

Δφ = Measuring error in " (angular seconds)
e = Eccentricity of the graduation to the bearing in µm
D = Graduation centerline diameter
M = Center of graduation
φ = "True" angle
φ' = Scanned angle

Angular error due to variations in scale-tape carrier diameter



Eccentricity of the graduation to the bearing



Model	Graduation centerline diameter D
ERP 880	D = 126 mm
ERP 4000	D = 40 mm
ERP 8000	D = 104 mm
ERO 6000	D = 64 mm or 142 mm
ERO 6100	D = 64 mm
ERA 4000	D ≙ drum outside diameter
ERA 6000 ERA 7000 ERA 8000	D ≙ diameter of tape seating surface

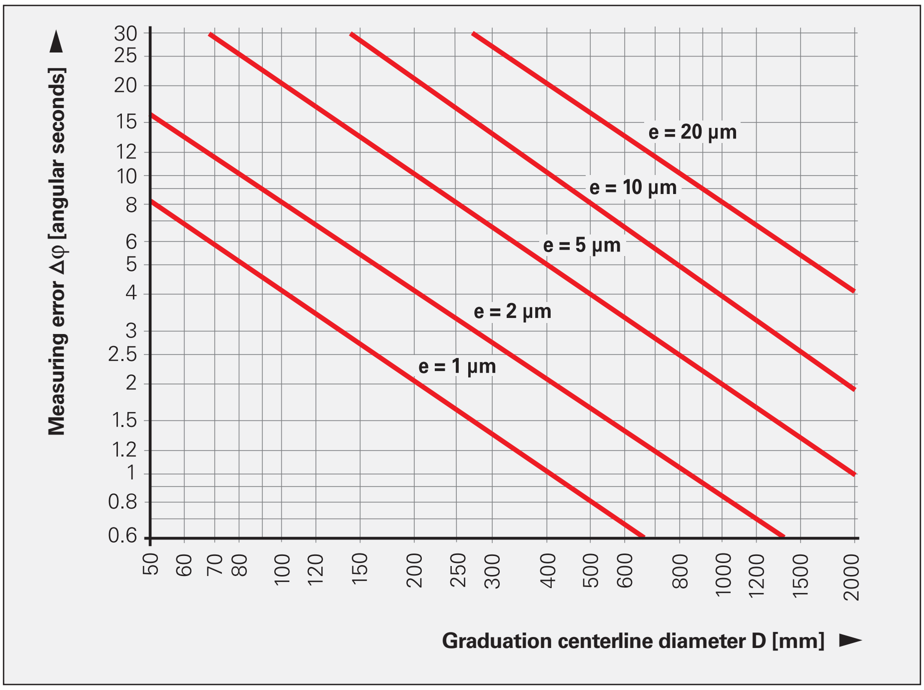
3. Error due to radial error of the bearing
The equation for the measuring error Δφ **is also valid for radial error of the bearing if the value e is replaced with the eccentricity value, i.e. half of the radial error (half of the displayed value).**

Bearing compliance to radial shaft loading causes similar errors.

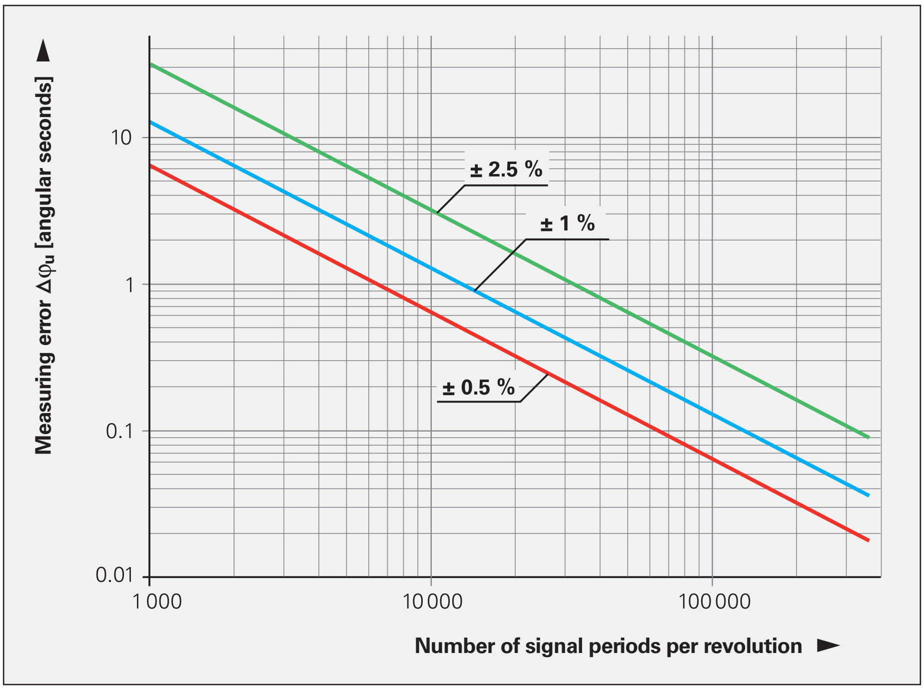
4. Position error within one signal period $\Delta\varphi_u$
The scanning units of all HEIDENHAIN encoders are adjusted so that the maximum position error values within one signal period will not exceed the values listed below—with no further electrical adjusting required at mounting.

Model	**Position error within one signal period** in percent of the signal period
ERP 880	± 1.5 %
ERA 4000	± 1 % (typically ± 0.5 %)
ERA 7000 ERA 8000 ERO 6000 ERP 4000 ERP 8000	± 1 %
ERA 6000	± 2.5 %

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



Resultant measuring error Δφ **for various eccentricity values e as a function of mean graduation diameter D**



Resultant measuring error $\Delta\varphi_u$ **depending on the number of signal periods per revolution with different position errors within one signal period**

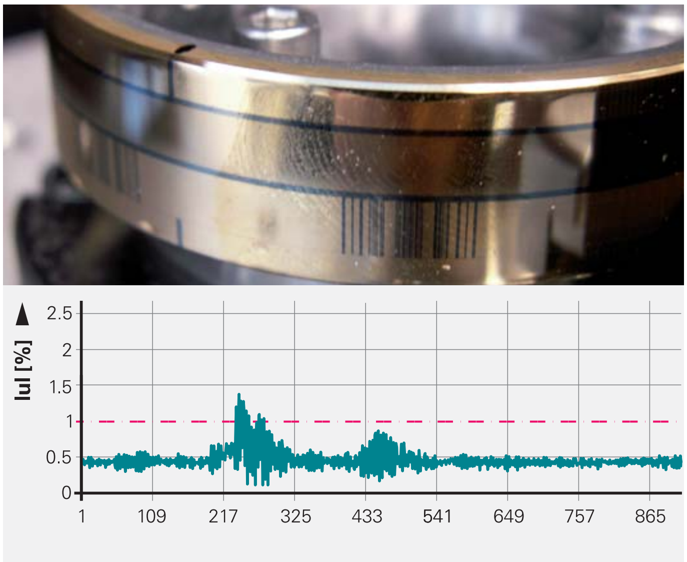
Reliability

Exposed angle encoders without integral bearing from HEIDENHAIN are optimized for use on fast, precise machines. In spite of the exposed mechanical design they are highly tolerant to contamination, ensure high long-term stability, and are quickly and easily mounted.

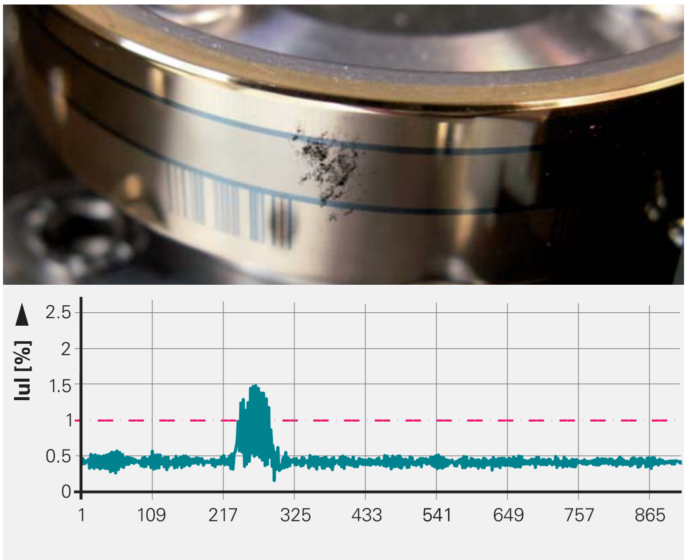
Lower sensitivity to contamination
Both the high quality of the grating and the scanning method are responsible for the accuracy and reliability of the encoders. Encoders from HEIDENHAIN operate with **single-field scanning.** Only one scanning field is used to generate the scanning signals. Local contamination on the measuring standard (e.g. fingerprints or oil accumulation) influences the light intensity of the signal components, and therefore of the scanning signals, in equal measure. The output signals do change in their amplitude, but not in their offset and phase position. They remain highly interpolable, and the position error within one signal period remains small.

The **large scanning field** additionally reduces sensitivity to contamination. In many cases this can prevent encoder failure. Even if the contamination from printer's ink, PCB dust, water or oil is up to 3 mm in diameter, the encoders continue to provide high-quality signals. The position errors within one revolution remain far below the specified accuracy.

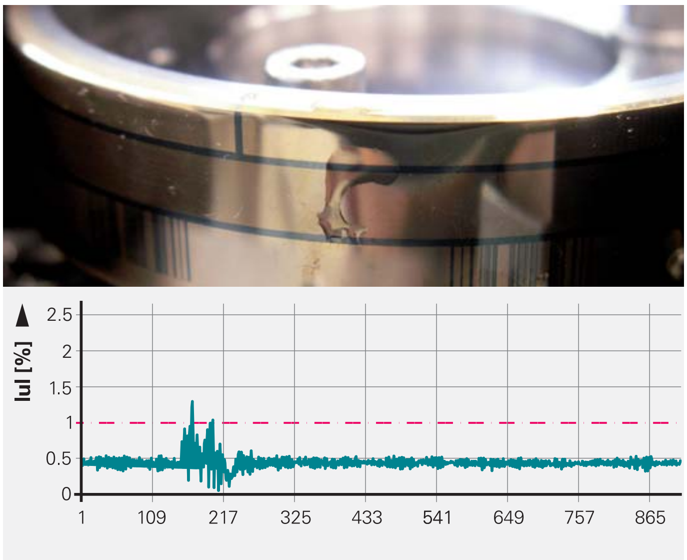
The figures at right show the results of contamination tests with ERA 4000 encoders. The maximum position errors within one signal period |u| are indicated. Despite significant contamination, the specified value of ± 1 % is exceeded only slightly.



Contamination by fingerprint



Contamination by toner dust

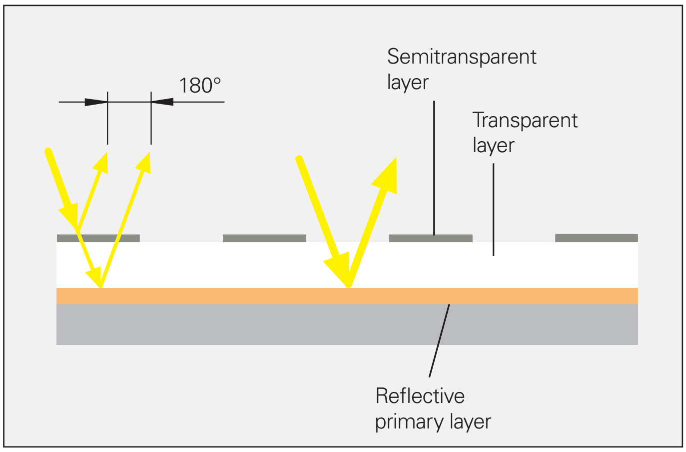


Contamination by water drops

Durable measuring standards
By the nature of their exposed design, the measuring standards of angle encoders without integral bearing are less protected from their environment. HEIDENHAIN therefore always uses tough gratings manufactured in special processes.

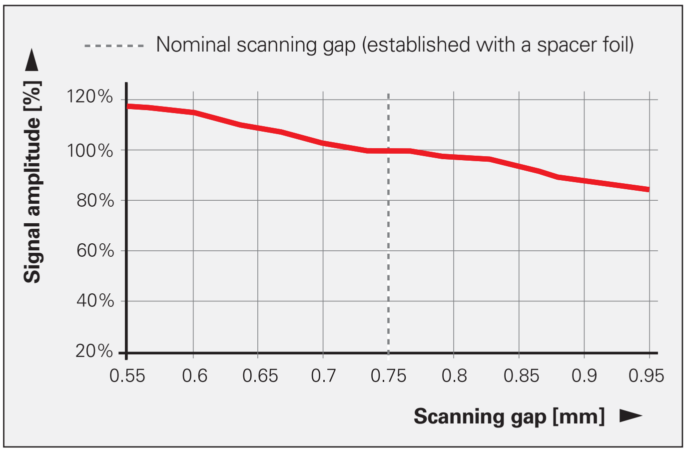
In the DIADUR process, hard chrome structures are applied to a glass or steel carrier.

In the METALLUR process a reflective gold layer is covered with a thin layer of glass. On this layer are lines of chromium only several nanometers thick, which are semitransparent and act as absorbers. Measuring standards with METALLUR graduations have proven to be particularly robust and insensitive to contamination because the low height of the structure leaves practically no surface for dust, dirt or water particles to accumulate.



Composition of a METALLUR graduation

Application-oriented mounting tolerances
The mounting tolerances of angle encoders without integral bearing from HEIDENHAIN have only a slight influence on the output signals. In particular, variations in the scanning gap between the graduation carrier and scanning head cause only negligible change in the signal amplitude, and barely affect the position error within one signal period. This behavior is substantially responsible for the high reliability of angle encoders from HEIDENHAIN.



Influence of the scanning gap on the signal amplitude for ERA 4000

Mechanical Design Types and Mounting

General Information

The angle encoders without integral bearing consist of the scanning head and graduation carrier. The graduation carrier can either be a scale tape or a massive component, such as a scale drum or disk/hub assembly. The motion of the scanning head and graduation relative to each other is determined solely via the machine bearing. For this reason the machine must be designed from the very beginning to meet the following prerequisites:

- The **bearing** must be designed such that the mounting tolerances of the encoders are maintained and the accuracy requirements expected for the axis are fulfilled (see *Specifications*) during mounting as well as operation.
- The **mounting surface** for the graduation carrier must meet the demands of the respective encoder regarding flatness, roundness, eccentricity and the diameter.
- To facilitate **adjustment** of the scanning head to the graduation, it should be fastened to a bracket or using appropriate fixed stops.

All angle encoders without integral bearing with **massive graduation carriers** are designed so that the specified accuracy can actually be achieved in the application.

- The special design of the scale drums and disk/hub assemblies is a crucial factor: the profile, reference surfaces, position of the graduation relative to the mounting surface, mounting holes, etc. all ensure that the mounting and operation only marginally influence the accuracy of the encoders.
- The mounting methods and alignment strategies ensure the highest possible reproducibility.
- For testing and calibration purposes, the encoders are mounted at HEIDENHAIN exactly the same way as in the application later. This makes it possible to exactly apply the accuracy determined at HEIDENHAIN to the machine.

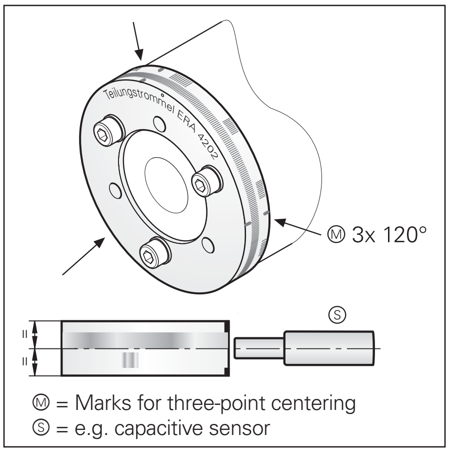
Centering the graduation
Since graduations from HEIDENHAIN have a very high degree of accuracy, the attainable overall accuracy is predominantly affected by mounting errors (mainly eccentricity errors).
Various possibilities for centering, depending on the encoder and mounting method, are possible for minimizing the eccentricity errors in practice.

1. Centering collar
The graduation carrier is pushed or shrunk onto the shaft. However, this very simple strategy requires a very exact shaft geometry.

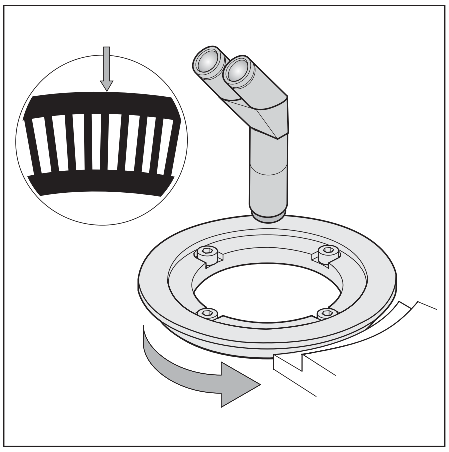
2. Three-point centering
The graduation carrier is centered over three positions at 120° increments marked on the carrier. That way, any roundness errors of the surface on which the carrier is being centered do not affect the exact alignment of the axis center point.

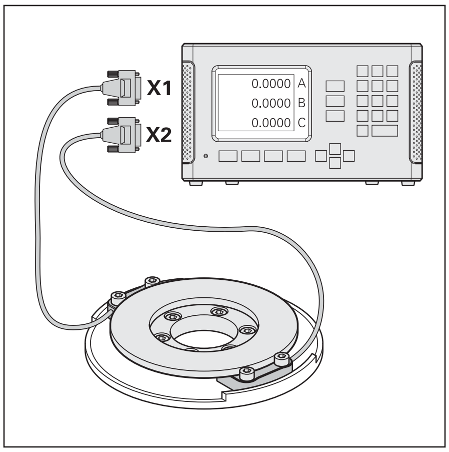
3. Optical centering
Graduation carriers made from glass are often centered with the aid of a microscope. This method uses the clear and unambiguous reference edges or centering rings on the graduation carriers.

4. Centering with two scanning heads
This strategy is suited for all angle encoders without integral bearing with massive graduation carriers. Since HEIDENHAIN graduations typically have long-range error characteristics, and the graduation or position value itself is used as reference here, this is the most exact of all centering strategies.



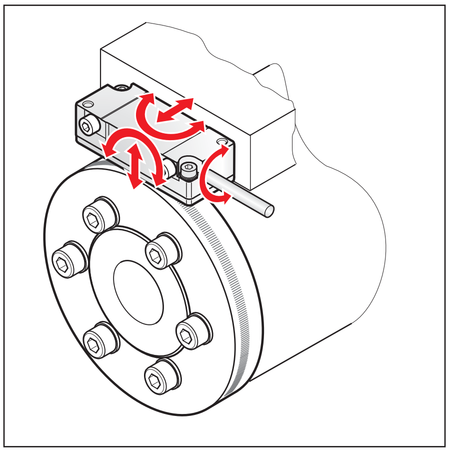
Three-point centering


Optical centering



Centering with two scanning heads

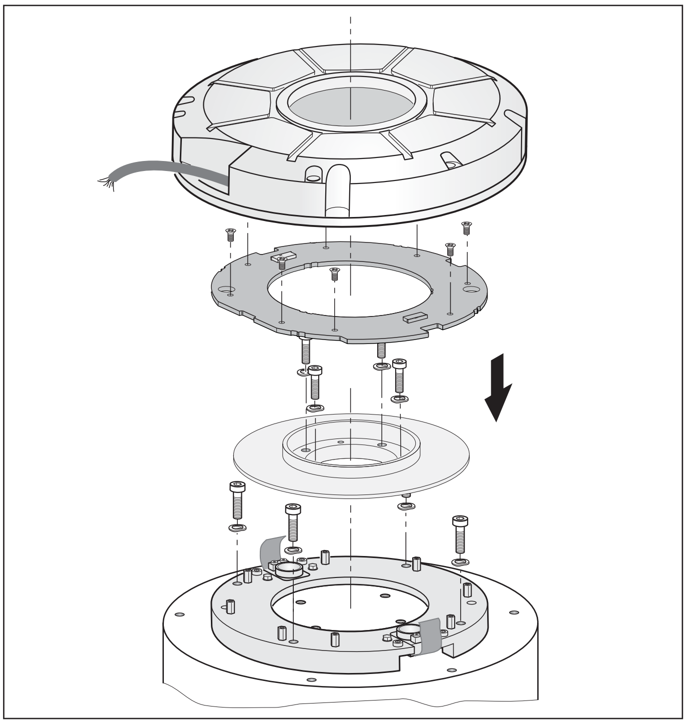
Scanning heads
Since final assembly of the angle encoders without integral bearing takes place on the machine, exact mounting of the scanning head is necessary once the graduation carrier has been mounted. For exact alignment of the scanning head to the scale, it must in principle be aligned and adjustable in five axes (see illustration). This adjustment is greatly facilitated by the design of the scanning heads, with the corresponding mounting strategy and large mounting tolerances. For example, mounting of the scanning heads for ERA encoders is reduced to using the included spacer foil to set to scanning gap correctly.



ERP 880

The ERP 880 modular angle encoder consists of the following components: scanning unit, disk/hub assembly, and PCB. Cover caps for protection from contact or contamination can be supplied as accessories.

Mounting the ERP 880
First the scanning unit is mounted on the stationary machine part with an alignment accuracy to the shaft of ± 1.5 µm. Then the disk/hub assembly is screwed onto the front of the shaft, and is also aligned with a maximum eccentricity of ± 1.5 µm to the scanning unit. Then the PCB is attached and connected to the scanning unit. Fine adjustment takes place with "electrical centering" using the PWM 9 (see *HEIDENHAIN Measuring Equipment*) and an oscilloscope. A cover cap can protect the ERP 880 from contamination.



Mounting the ERP 880 (in principle)

IP 40 cover cap
With sealing ring for IP 40 protection
Cable, 1 m, with male coupling, 12-pin
ID 369774-01

IP 64 cover cap
With shaft sealing ring for IP 64 protection
Cable, 1 m, with male coupling, 12-pin
ID 369774-02

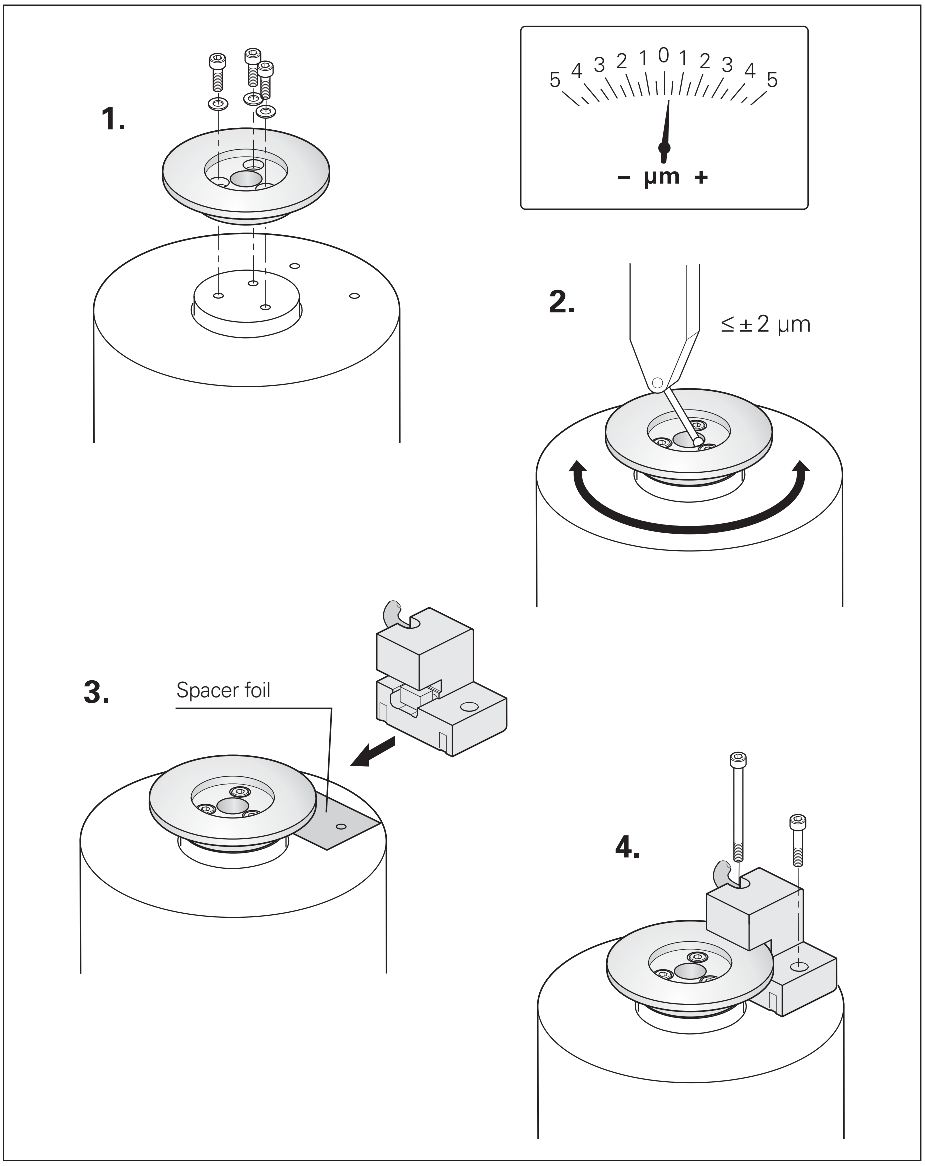
Mechanical Design Types and Mounting
ERP 4080/ERP 8080

The ERP 4080 and ERP 8080 modular angle encoders are intended for measuring tasks requiring utmost precision and resolution. They use interferential scanning of a phase grating, and consist of a scanning head and a disk/hub assembly.

Determining the axial mounting tolerance
To attain the greatest possible accuracy, it is important to ensure that the wobble of the shaft and the wobble of the disk/hub assembly do not add to each other. The positions of the maximum and minimum wobble of the hub are marked. The wobble of the shaft is to be measured and the maximum and minimum positions determined. The disk/hub assembly is then mounted such that the remaining wobble is minimized.

Mounting the disk/hub assembly
The disk/hub assembly is slid onto the drive shaft, centered using the inside diameter of the hub, and fastened with screws. The circular scale can be centered using a dial indicator on the inside diameter of the hub, or optically using the centering circle integrated in the circular scale, or electrically with the aid of a second, diametrically opposed scanning head.

Mounting the scanning head
The scanning head is fastened with two screws (or with the mounting aid) and the appropriate spacer foils on the mounting surface so that it can be moved slightly. The scanning head is adjusted electronically with the aid of the PWM 9 or PWT 18 (see *HEIDENHAIN Measuring Equipment*) by moving the scanning head within the mounting holes until the output signals reach an amplitude of ≥ 0.9 V_{PP}.



Accessories
Mounting aid
For adjusting the scanning head
ID 622 976-02

Adapter for length gauges
For measuring the mounting tolerances
ID 627 142-01

Spacer foils
For axial position adjustment

10 µm	ID 619 943-01
20 µm	ID 619 943-02
30 µm	ID 619 943-03
40 µm	ID 619 943-04
50 µm	ID 619 943-05
60 µm	ID 619 943-06
70 µm	ID 619 943-07
80 µm	ID 619 943-08
90 µm	ID 619 943-09
100 µm	ID 619 943-10

Set (one foil per gap from
10 µm to 100 µm): ID 619 943-11

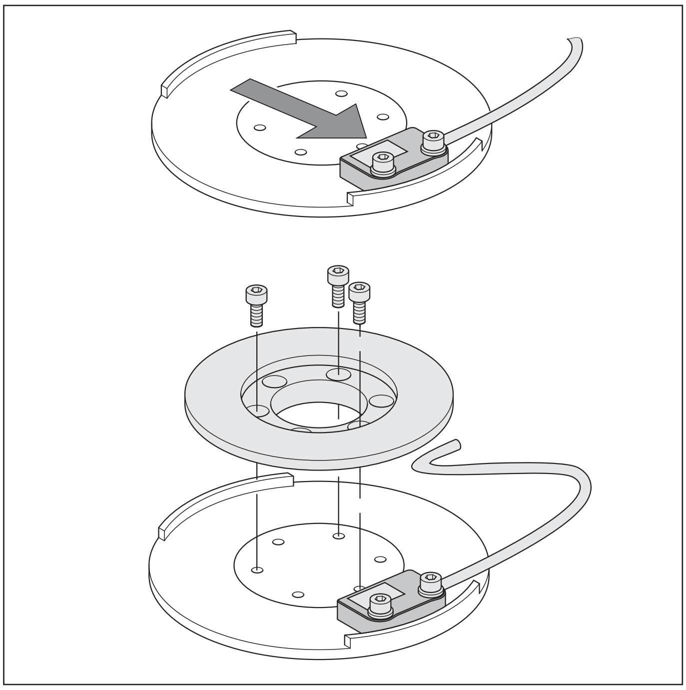
ERO 6000, ERO 6100

The ERO 6000 and ERO 6100 modular angle encoders consist of a scanning head and a disk/hub assembly. These are positioned and adjusted relative to each other on the machine.

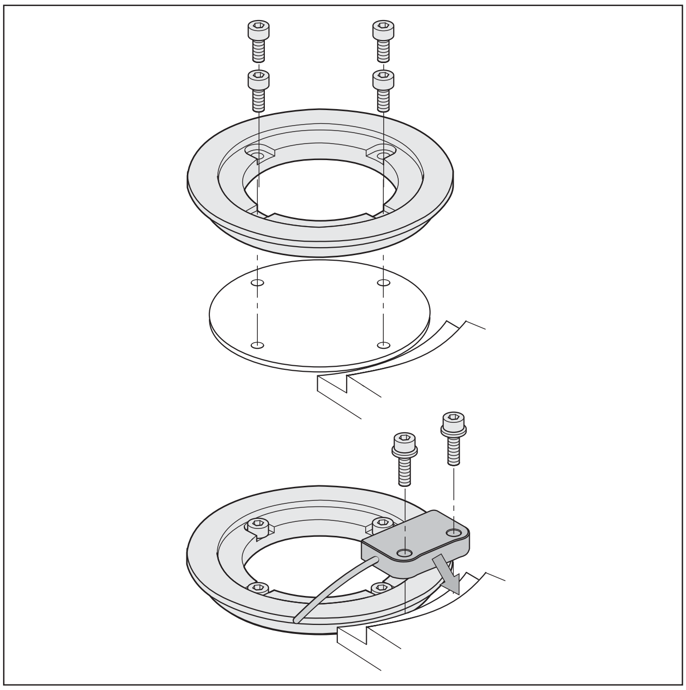
Mounting the ERO 6000
A mating surface with fixed stop and defined inside diameter is advantageous for simple mounting of the scanning head. The scanning head is pressed against this mounting surface and secured with two screws. No further alignment is necessary. Then the disk/hub assembly is screwed onto the front of the shaft, and centered either mechanically via three-point centering or electrically. The scanning gap between the scanning head and graduated disk is already defined by the mounting surface, so no further adjustment is necessary here either.

Mounting the ERO 6100
The disk/hub assembly is mounted on the shaft axially and centered optically. A mounting bracket with stop edge and defined inside diameter, and that can be adjusted axially, is advantageous for simple mounting of the scanning head. The scanning head is pressed against the stop surfaces of the mounting bracket and then secured with two screws. The included spacer foil is used to correctly set the scanning gap between the scanning head and graduated disk, and the mounting bracket is then secured.

The output signals are checked with the PWT. An APE 381 interface electronics unit is necessary for the ERO 6x80 (see *HEIDENHAIN Measuring Equipment*)



Mounting the ERO 6000



Mounting the ERO 6100

Mechanical Design Types and Mounting
ERA 4000 Series

The ERA 4000 modular angle encoders are supplied as two components: the scale drum and the scanning head.

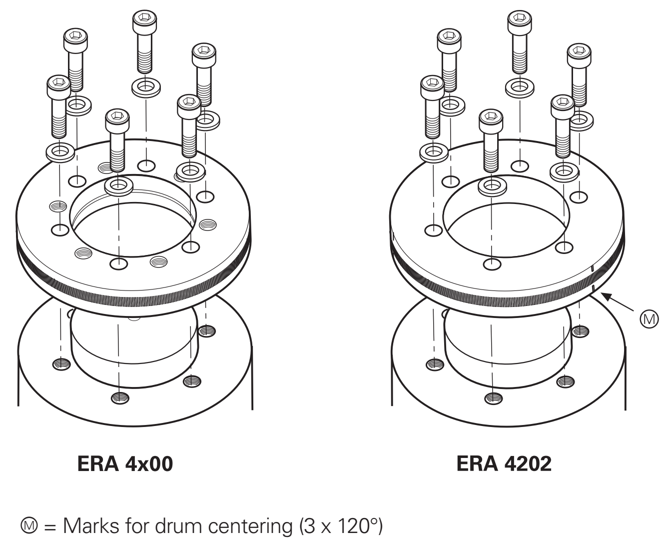
The **scanning heads** of the ERA 4000 series feature very compact dimensions. The **scale drums** of the ERA 4000 are available in different versions to suit the particular application. The ERA 4x80 versions are available with various grating periods depending on the accuracy requirements. The appropriate scanning heads are shown in the table at right. Special design measures are required to protect the ERA from contamination. The ERA 4480 angle encoders are also available for various drum diameters with a protective cover. A special scanning head (with compressed-air inlet) is needed for versions with protective cover. The protective cover suited to the scale drum diameter must be ordered separately.

Special design features of the ERA modular angular encoders assure comparatively fast mounting and easy adjustment.

Mounting the ERA 4x00 scale drum
The 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. The drum does not need to be adjusted. HEIDENHAIN recommends using a slightly oversized shaft for mounting the scale drum. For mounting, the scale drum may be slowly warmed on a heating plate over a period of approx. 10 minutes to a maximum temperature of 100 °C.

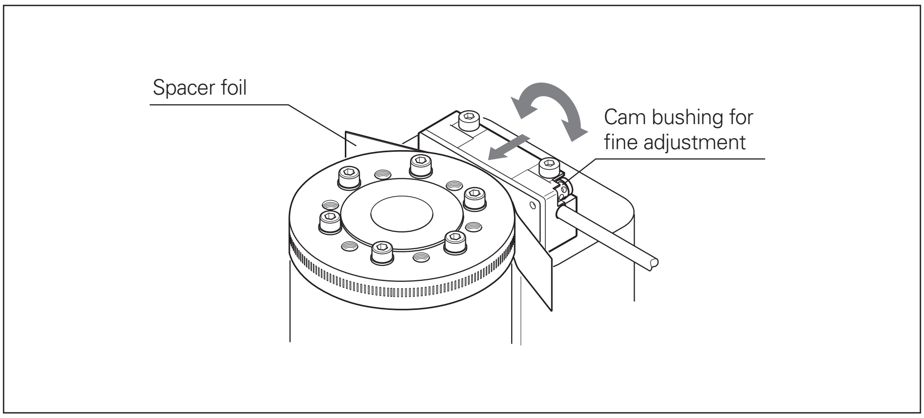
Mounting the ERA 4202 scale drum
The scale drum is centered over three positions at 120° increments on its circumference and fastened with screws. The benefits of three-point centering and the solid design of the scale drum make it possible to attain a very high accuracy when the encoder is mounted, with relatively little mounting effort. The positions for centering are marked on the scale drum.

Application	Scale drum	Grating periods	Model	Fitting scanning head
High shaft speeds	Centering collar	20 µm	ERA 4200	ERA 4280
		40 µm	ERA 4400	ERA 4480
		80 µm	ERA 4800	ERA 4880
Increased positioning accuracy and high shaft speeds	Three-point centering	20 µm	ERA 4202	ERA 4280



Mounting the scale drums

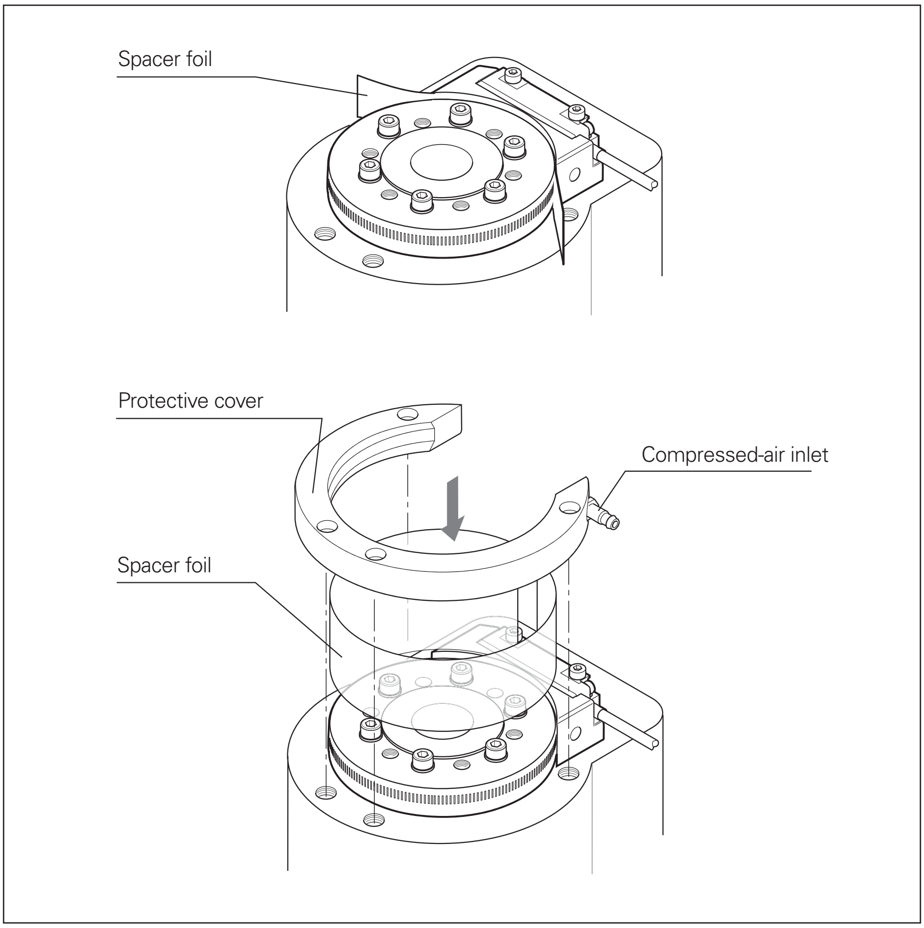
Mounting the scanning head
In order to mount the scanning head, the spacer foil is held against the circumference of the scale drum. The scanning head is pressed against the foil and fastened. The foil is then removed. ERA 4000 encoders with 20 µm grating period also feature a cam bushing for fine adjustment of the scanning field.



Mounting the scanning head

Mounting the protective cover
The ERA 4480 modular angle encoders with protective cover are available in various diameters. This cover provides additional protection against contamination when compressed air is applied.

The scale drum and the scanning unit are mounted as described above. The separate spacer foil supplied with the protective cover is placed around the scale drum. It protects the scale drum when mounting the protective cover, and ensures that a constant scanning gap is maintained. Then the protective cover is slid onto the scale drum and secured. The spacer foil is removed. For information about the compressed-air inlet see *General Mechanical Information.*

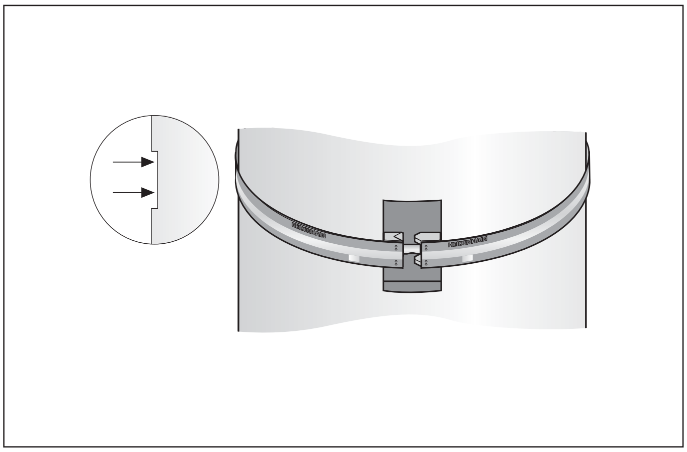


Mounting an ERA 4480 with protective cover

Mechanical Design Types and Mounting
ERA 6000

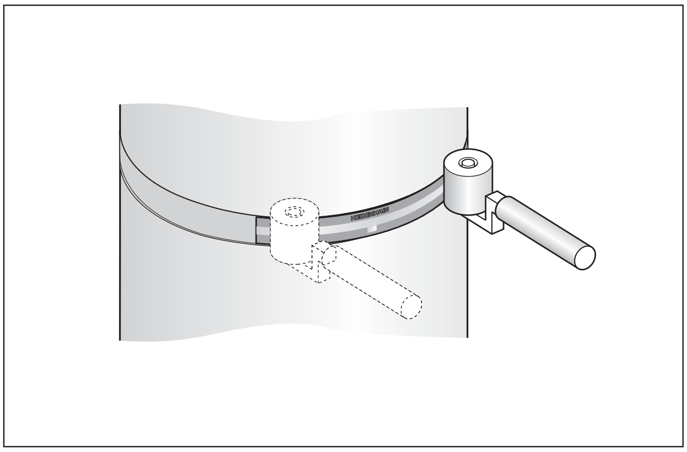
The ERA 6000 modular angle encoders consist of a scanning head and a scale tape for mounting on the outside diameter of a machine element. They are positioned and adjusted relative to each other on the machine.
There are several versions of the scale tape:

- **ERA 6000:** Full-circle version with tensioning cleat
- **ERA 6002:** Circle-segment version, scale tape is glued on
- **ERA 6006:** Full-circle version with tensioning cleat, scale tape with elastic intermediate layer for lower quality of the mating surface and modest dynamic demands



Mounting the ERA 6000 scale tape

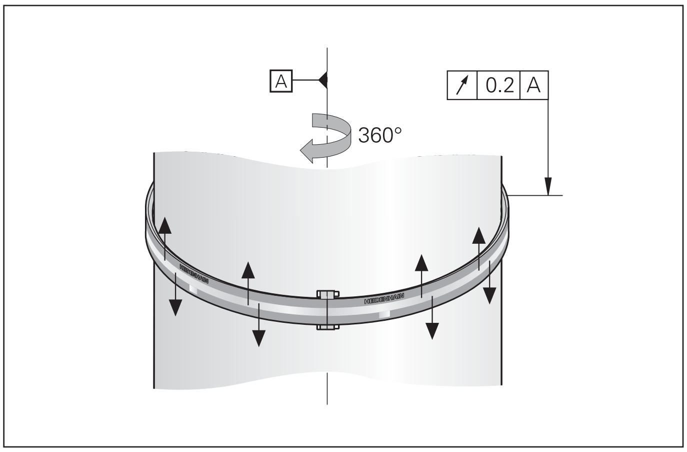
Mounting the ERA 6000 scale tape
The scale tape is supplied with a premounted tensioning cleat. An **external slot** or stop edge is advantageous for mounting. A recess must be provided for the tensioning cleat. The scale tape is aligned along the slot edge and tensioned using the tensioning cleat. The tensioning cleat is then secured with adhesive or screws from the installation kit.



Mounting the ERA 6002 scale tape

Mounting the ERA 6002 scale tape
The steel scale-tape is glued directly to the mounting surface with a PRECIMET adhesive film, and pressure is evenly distributed with a roller (accessory). A slot or stop edge is advantageous for lateral alignment of the scale tape.

Mounting the ERA 6006 scale tape
The scale tape is supplied with a premounted and extremely flat tensioning cleat. The scale tape is mounted directly on the outside circumference of the mating surface. No recess is necessary for the tensioning cleat. The pre-tensioned scale tape is aligned perpendicular to the shaft’s axis and then tensioned using the tensioning cleat. The tensioning cleat is then secured with adhesive.



Mounting the ERA 6006 scale tape

Superfluous reference marks are deactivated once mounting is finished.

Accessories
Roller for scale tape with PRECIMET
ID 276885-01

Mounting kit for securing the tensioning cleat of ERA 6000 encoders
ID 685303-01

Mounting of the scanning head
There are several options for mounting the scanning head. The gap to the scale tape is simply set with the mounting aid (accessory) or a spacer foil (included).

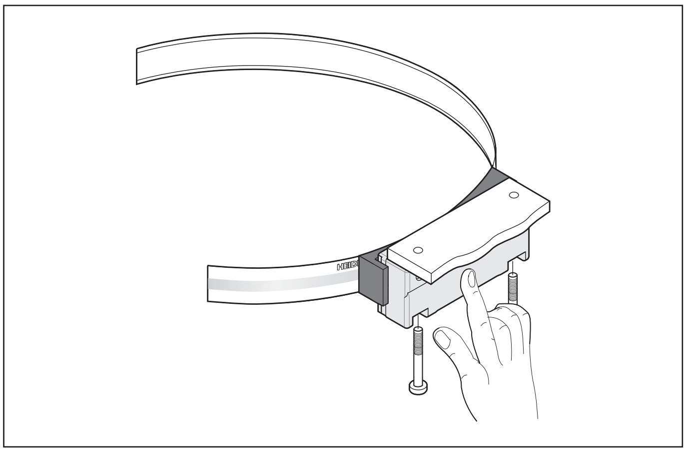
Adjusting the ERA 6080 scanning head
The quality of the output signals can be checked using HEIDENHAIN's PWT 18 phase-angle testing unit. When the scanning head is moved along the scale tape, the PWT 18 graphically displays the quality of the signals as well as the position of the reference mark.

Adjusting the ERA 6070 scanning head
The quality of the output signals can be checked using HEIDENHAIN's PG 27 testing unit or PS 27 test connector. LEDs report the status of the incremental signals and reference mark when the scanning head is moved along the scale tape.

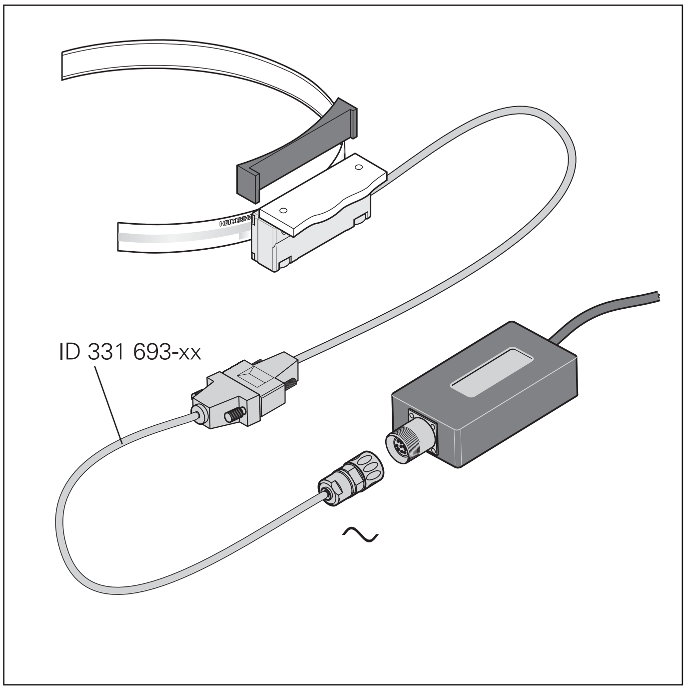
For descriptions of the PWT, PG and PS, see *HEIDENHAIN Measuring Equipment.*

Accessories
Mounting aid for scanning head
ID 679213-xx

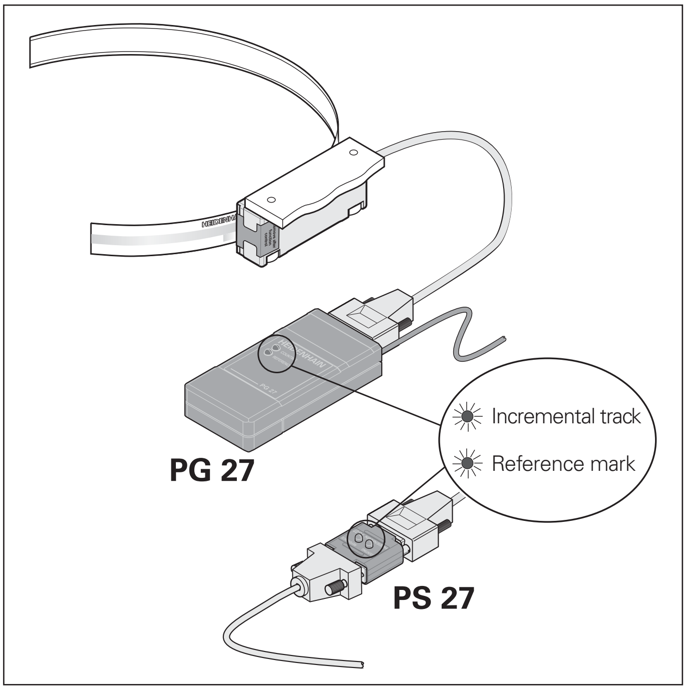
Adapter cable for ERA 6080 for connection to PWT
ID 331693-xx



Mounting the ERA 60x0 scanning head



Adjustment with PWT



Adjustment with PG 27

Mechanical Design Types and Mounting
ERA 7000 and ERA 8000 Series

The ERA 7000 and ERA 8000 angle encoders consist of a scanning unit and a one-piece steel scale tape. The steel scale tape is available up to a length of 30 m. The tape is mounted on the
- **inside diameter** (ERA 7000 series) or
- the **outside diameter** (ERA 8000 series)

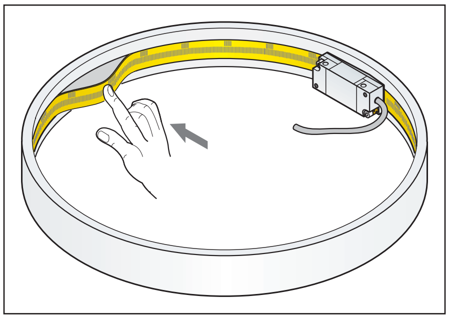
of a machine element.

The ERA 74x0C und ERA 84x0C angle encoders are designed for **full-circle applications.** Thus, they are particularly suited to hollow shafts with large inside diameters (from approx. 400 mm) and to applications requiring an accurate measurement over a large circumference, e.g. large rotary tables, telescopes, etc.

In applications where there is no full circle, or measurement is not required over 360°, **circle segments** are available.

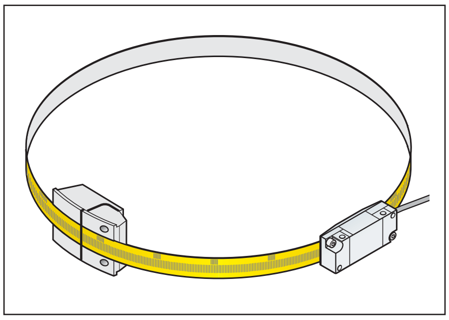
Mounting the scale tape for full-circle applications

ERA 74x0C: An **internal slot** with a specified diameter is required as scale tape carrier. The tape is inserted starting at the butt joint and is clicked into the slot. The length is cut so that the tape is held in place by its own force.



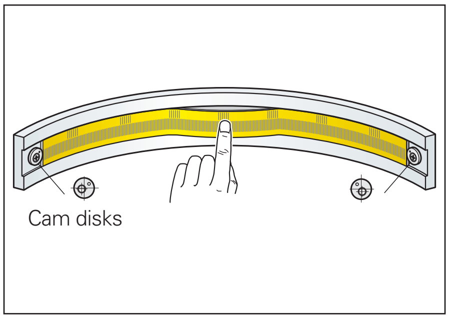
ERA 84x0C: The scale tape is supplied with the halves of the tensioning cleat already mounted on the tape ends. An **external slot** is necessary for mounting. A recess must also be provided for the tensioning cleat. After the scale tape has been inserted, it is fastened aligned along the slot edge and tensioned using the tensioning cleat.

The scale tape ends are manufactured so exactly that only minor signal-form deviations can occur in the area of the butt joint. To make sure that the scale tape does not move within the slot, it is fixed with adhesive at multiple points in the area of the butt joint.

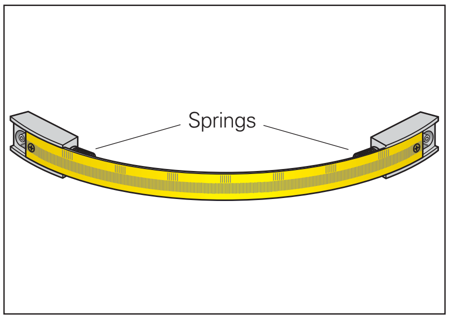


Mounting the scale tape for circle segments

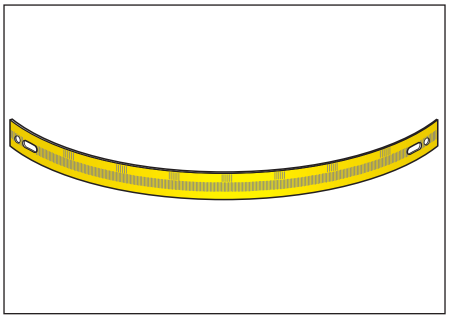
ERA 74x1C: An internal slot with a specified diameter is required. The two cam disks fixed in this slot are adjusted so that the scale can be snapped into the slot under pressure.



ERA 84x1C: The scale tape is supplied with premounted end pieces. An external slot with recesses for the bearing pieces is required for placing the scale tape. The end pieces are fitted with tension springs, which create an optimal bearing preload for increasing the accuracy of the scale tape, and evenly distribute the expansion over the entire length of the scale tape.



ERA 84x2C: An external slot or one-sided axial stop is recommended for placing the scale tape. The scale tape is supplied without tensioning elements. It must be preloaded with a spring balance, and secured using the two oblong holes.

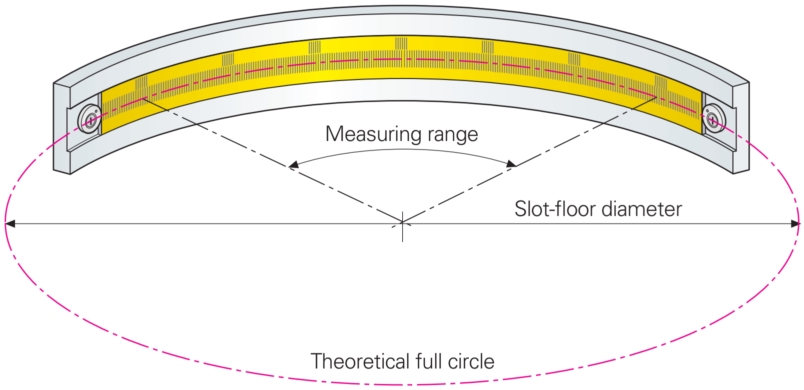


Specification of slot-floor diameter
In order to guarantee the correct functioning of the distance-coded reference marks, the circumference must be a multiple of 1 000 grating periods. The association between the slot-floor diameter and the line count can be seen in the table.

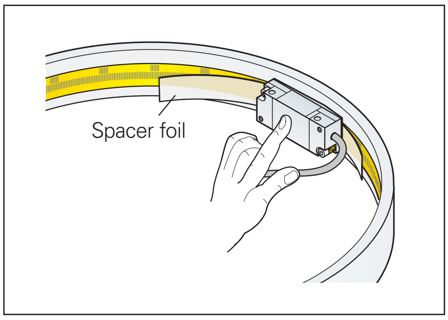
	Slot-floor diameter in mm	Measuring range in degrees for segment versions
ERA 7000C	n · 0.01273112 +0.3	n_1 · 4.583204 : (D–0.3)
ERA 8000C	n · 0.0127337 –0.3	n_1 · 4.584121 : (D+0.3)

n = line count of full circle; n_1 = line count of measuring range
D = slot-floor diameter [mm]

Specification of segment angle
For segment versions the angle available as measuring range must be a multiple of 1 000 grating periods. Also, the circumference of the theoretical full circle must be a multiple of 1 000 grating periods, since this often simplifies integration with the numeric control.

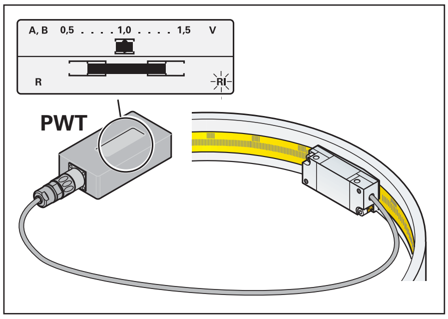


Mounting the scanning head
In order to mount the scanning head, the spacer foil is held against the circumference of the scale drum. The scanning head is pressed against the foil and fastened. The foil is then removed. In addition, the scanning field can be finely adjusted via a cam bushing.

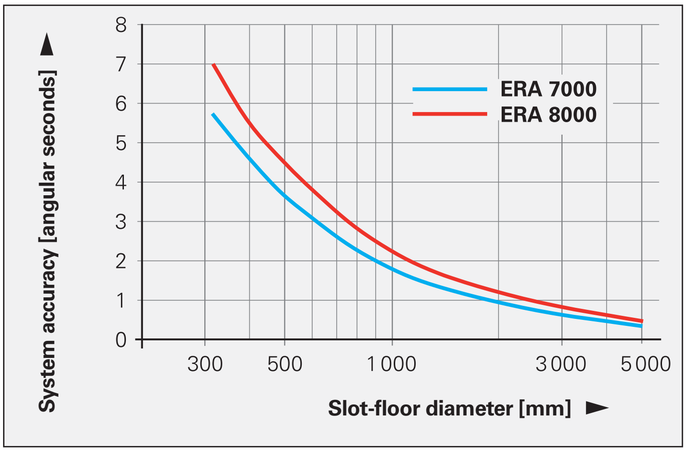


Checking the output signals at the butt joint
In order to check whether the scale tapes of the ERA 74x0C and ERA 84x0C have been mounted correctly, the output signals should be checked at the butt joint—before the adhesive has hardened.

The quality of the output signals can be checked using HEIDENHAIN's PWT phase-angle testing unit. When the scanning head is moved along the scale tape, the PWT graphically displays the quality of the signals as well as the position of the reference mark.
The PWM 9 phase angle measuring unit calculates a quantitative value for the deviation of the actual output signals from the ideal signal (see *HEIDENHAIN Measuring Equipment*).



System accuracy for any diameters
The specifications for the ERA 7000 and ERA 8000 only show the system accuracies for some sample diameters. The system accuracies for other diameters, including segment versions, can be seen in this diagram.



General Mechanical Information

Protection
For angle encoders **without integral bearing,** the necessary protection against contamination and contact must be ensured during installation through design measures such as additional labyrinth seals.

Unless otherwise indicated, all RCN, RON, RPN and ROD angle encoders **with integral bearing** meet protection standard IP 67 according to EN 60529 or IEC 60529 for the housing and cable outlet, and IP 64 at shaft inlet.

Some versions of the ERA 4480 angle encoders up to a drum inside diameter of 180 mm are available with an optional protective cover. Connection to a source of compressed air slightly above atmospheric pressure provides additional protection against contamination.

The compressed air introduced directly into the encoders must be cleaned by a micro filter, and must comply with the following quality classes as per **ISO 8573-1 (1995 edition):**

- Solid contaminant: Class 1 (max. particle size 0.1 µm and max. particle density 0.1 mg/m^3 at 1 · 10^5 Pa)
- Total oil content: Class 1 (max. oil concentration 0.01 mg/m^3 at 1 · 10^5 Pa)
- Maximum pressure dew point: Class 4, but with reference conditions of +3 °C at 2 · 10^5 Pa

The required air flow varies depending on the encoder (e.g. 7 to 10 l/min per linear encoder); permissible pressure is in the range of 0.6 to 1 bar (9 to 14 psi). The compressed air must flow through connecting pieces with integrated throttle.

Accessories:
Connecting piece, straight
with throttle and gasket
ID 226270-xx

Connecting piece, straight, short
with throttle and gasket
ID 275239-xx

M5 coupling joint, swiveling
with seal
ID 207834-xx

HEIDENHAIN offers the **DA 300 compressed air unit** (filter combination with pressure regulator and fittings) for purifying and conditioning the compressed air.

Accessory:
DA 300 compressed air unit
ID 348249-01

The compressed air introduced into the DA 300 must fulfill the requirements of the following quality classes as per ISO 8573-1 (1995 edition):

- Max. particle size and density of solid contaminants:
  Class 4 (max. particle size: 15 µm, max. particle density: 8 mg/m^3)
- Total oil content:
  Class 4 (oil content 5 mg/m^3)
- Max. pressure dew point:
  Not defined,
  Class 7

DA 300

For more information, ask for our *DA 300* Product Information sheet.

Temperature range
The angle encoders encoders are inspected at a **reference temperature** of 22 °C. The system accuracy given in the calibration chart applies at this temperature. The **operating temperature range** indicates the ambient temperature limits between which the angle encoders will function properly. The **storage temperature range** of –30 °C to +80 °C is valid when the unit remains in its packaging (ERP 4080/ERP 8080: 0 °C to 60 °C).

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

Acceleration
Angle 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.

Rotational velocity
The maximum permissible shaft speeds for the ERA 4000 angle encoders series were determined according to the FKM guideline. 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.

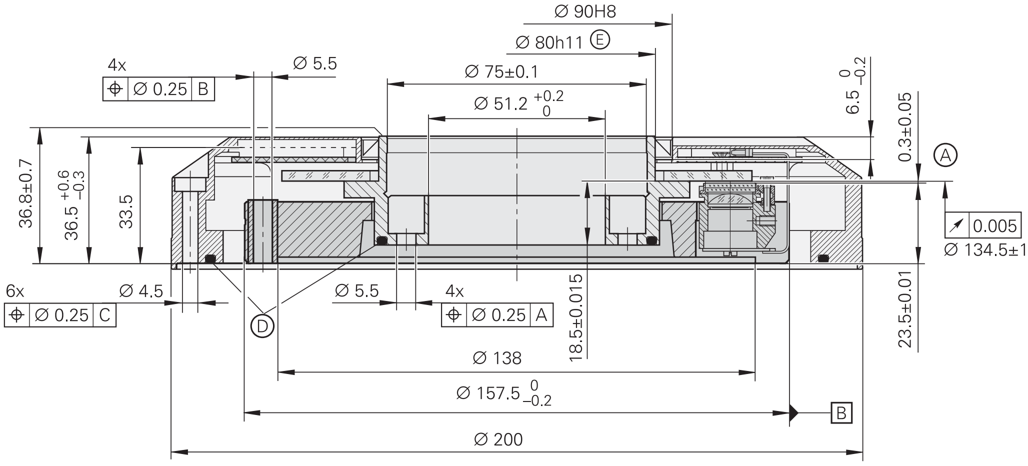
Expendable parts
Encoders from HEIDENHAIN are designed for a long service life. Preventive maintenance is not required. They contain components that are subject to wear, depending on the application and manipulation. These include in particular cables with frequent flexing.
Other such components are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

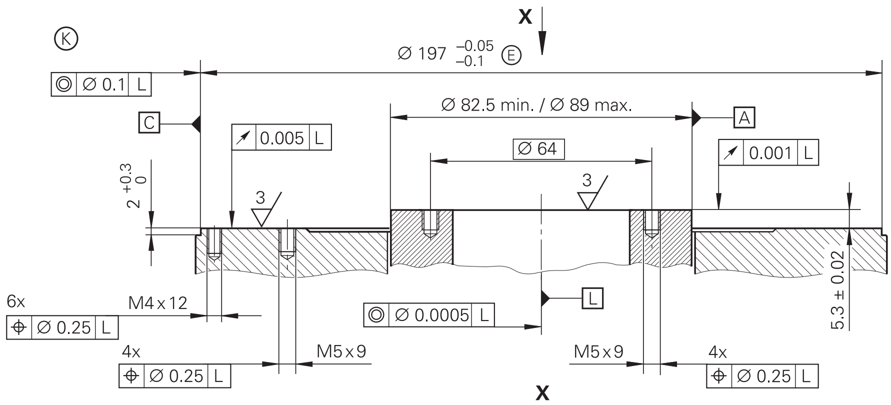
System tests
Encoders from HEIDENHAIN are usually integrated as components in larger systems. Such applications require **comprehensive tests of the entire system** regardless of the specifications of the encoder.
The specifications given in this brochure apply to the specific encoder, not to the complete 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.

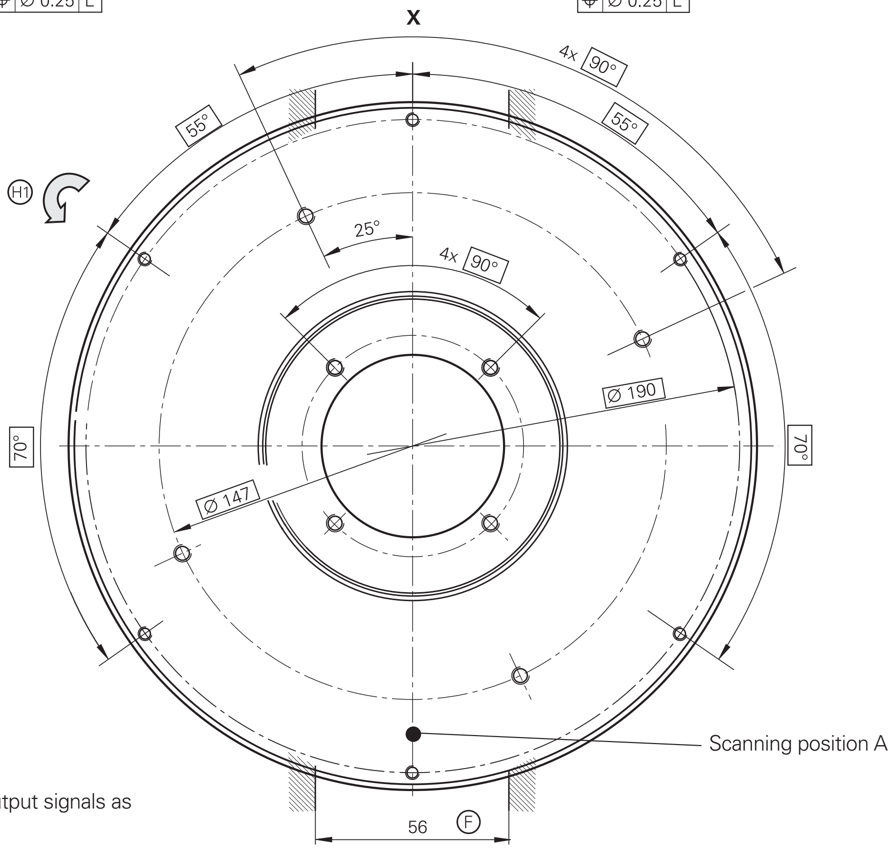
Mounting
Work steps to be performed and dimensions to be maintained during mounting are specified solely in the mounting instructions supplied with the unit. All data in this catalog regarding mounting are therefore provisional and not binding; they do not become terms of a contract.

ERP 880

Incremental angle encoder for very high accuracy
- **High resolution**
- **Protective cover as accessory**







mm

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

Cable radial, also usable axially
Ⓐ = Disk-to-scanning-reticle gap
Ⓛ = Axis of bearing rotation
Ⓚ = Required mating dimensions
Ⓕ = Space needed for service
Ⓓ = Seal
Ⓗ1 = Direction of shaft rotation for output signals as per the interface description

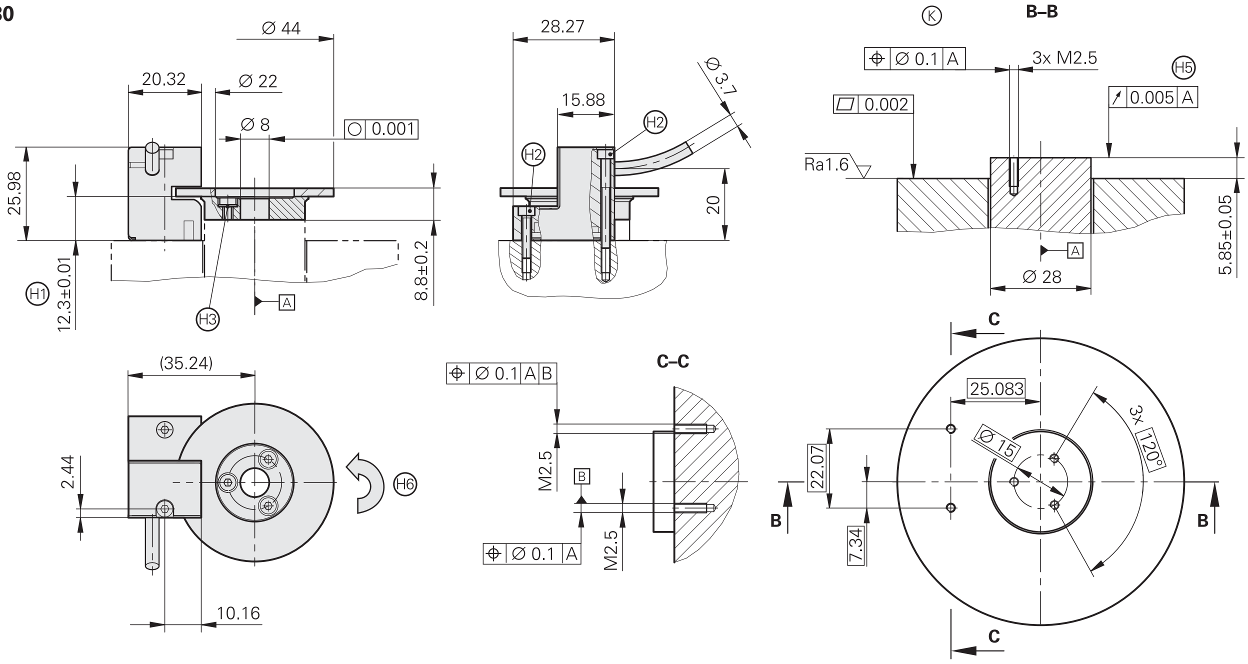
	ERP 880		
Incremental signals	∼ 1 V_{PP}		
Signal periods	180000		
Reference mark	One		
Cutoff frequency –3 dB –6 dB	≥ 800 kHz ≥ 1.3 MHz		
System accuracy[1)]	± 1"		
Accuracy of graduation	± 0.9"		
Power supply	DC 5 V ± 10 %		
Current consumption Without load	≤ 250 mA		
Electrical connection	*With cover:* Cable 1 m, with M23 coupling *Without cover:* Via 12-pin PCB connector (adapter cable ID 372164-xx)		
Cable length	≤ 150 m (with HEIDENHAIN cable)		
Hub inside diameter	51.2 mm		
Mech. permissible speed	≤ 1000 min^{-1}		
Moment of inertia of rotor	$1.2 \cdot 10^{-3}$ kgm^2		
Permissible axial motion of measured shaft	≤ ± 0.05 mm		
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 50 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)		
Operating temperature	0 °C to 50 °C		
Protection* EN 60529	*Without cover:* IP 00	*With cover:* IP 40	*With cover and rotary shaft seal:* IP 64
Starting torque	–		0.25 Nm
Weight	3.0 kg	3.1 kg incl. cover	

* Please select when ordering
1) Before installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft are not included.

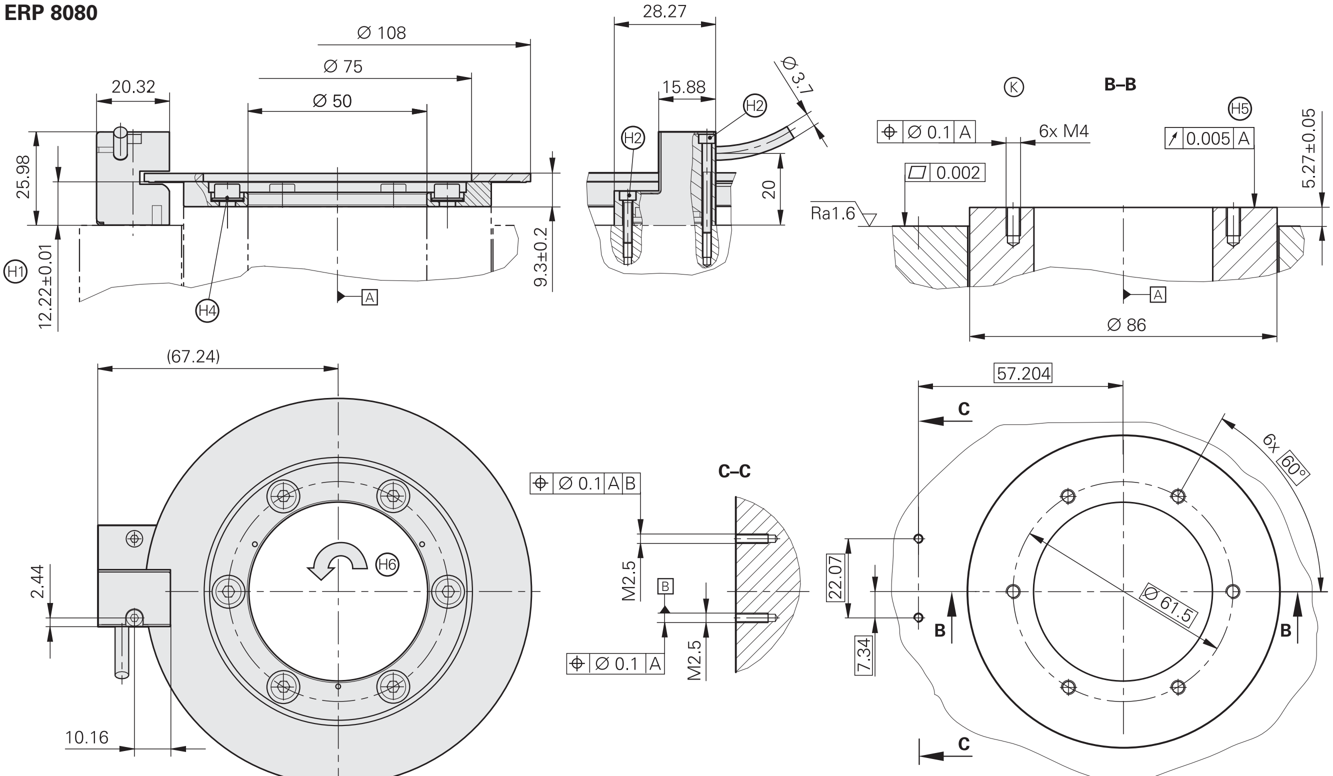
ERP 4080/ERP 8080

Incremental angle encoder for high accuracy
- **Highest resolution**
- **Consists of scanning head and disk/hub assembly**

ERP 4080



ERP 8080



mm

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

Ⓐ = Bearing
Ⓚ = Required mating dimensions
(H1) = Mounting clearance set with spacer foil
(H2) = Cylinder head screw ISO 4762–A2–M2.5
(H3) = Cylinder head screw ISO 4762–A2–M2.5 and washer ISO 7089–2.5–140HV–A2
(H4) = Cylinder head screw ISO 4762–A2–M4 and washer ISO 7089–4–140HV–A2
(H5) = Mounting surface not convex
(H6) = Direction of shaft rotation for output signals as per the interface description

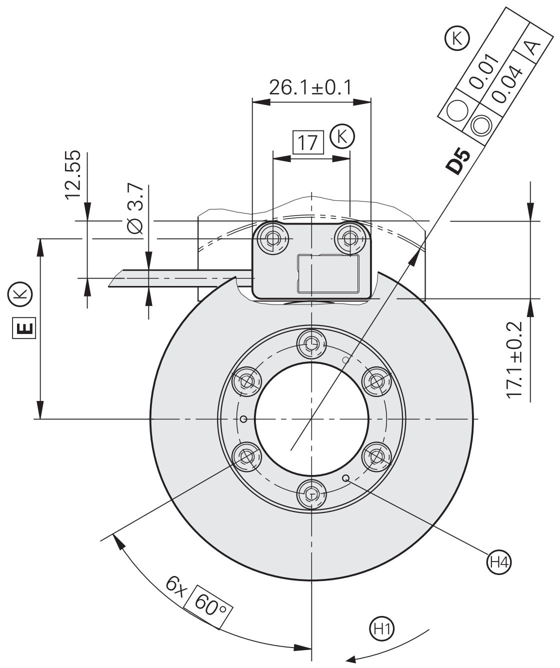
Scanning head	AK ERP 4080	AK ERP 8080
Incremental signals	~ 1 V_{PP}	
Cutoff frequency –3 dB	≥ 250 kHz	
Power supply	DC 5 V ± 5 %	
Current consumption Without load	≤ 150 mA	
Electrical connection	Cable 1 m, with D-sub connector (15-pin)	
Cable length	≤ 30 m (with HEIDENHAIN cable)	
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 50 m/s^2 (EN 60068-2-6) ≤ 500 m/s^2 (EN 60068-2-27)	
Operating temperature	15 °C to 40 °C	
Protection EN 60529	IP 00 (for clean room application)	
Weight	approx. 33 g (without cable)	

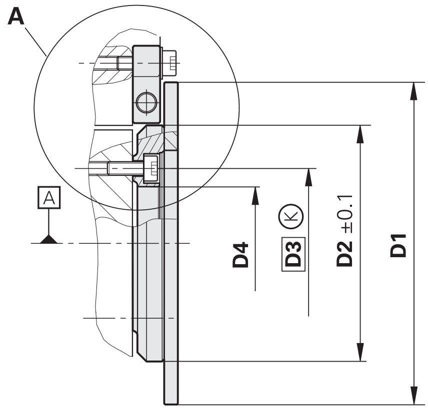
Graduated disk	TKN ERP 4080	TKN ERP 8080
Measuring standard	Phase-grating graduation on glass	
Hub inside diameter	8 mm	50 mm
Signal periods	131072	360000
System accuracy[1]	± 5"	± 2"
Accuracy of the graduation[2]	± 2"	± 1"
Reference mark	None	
Mech. permissible speed	≤ 300 min^{-1}	≤ 100 min^{-1}
Moment of inertia of rotor	$5 \cdot 10^{-6}$ kgm^2	$250 \cdot 10^{-6}$ kgm^2
Permissible axial motion of measured shaft	≤ ± 0.01 mm (including wobble)	
Weight	approx. 36 g	approx. 180 g

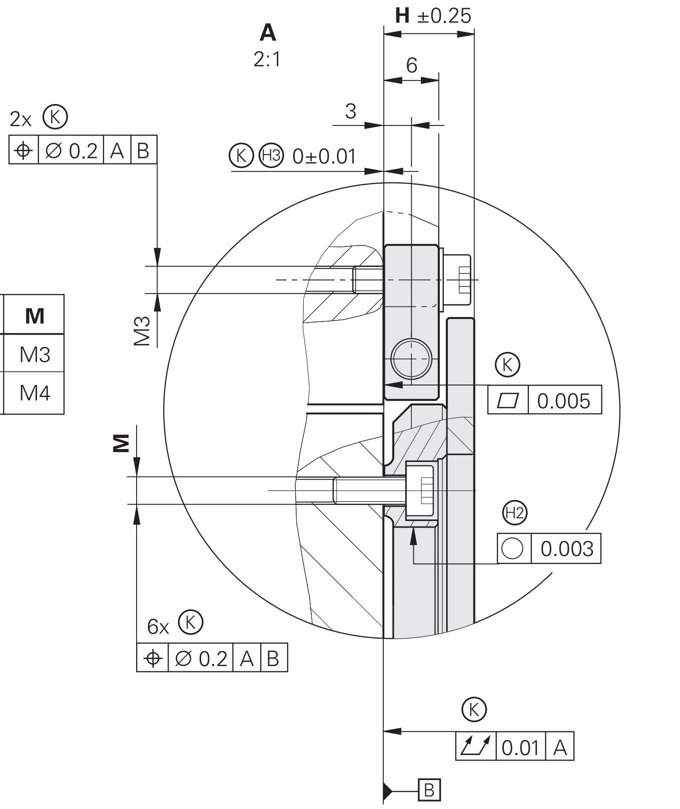
[1] Before installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft are not included.
[2] For other errors, see *Measuring Accuracy*

ERO 6000 Series

Incremental angle encoder for high accuracy
- **Compact size**
- **Low weight, low moment of inertia**
- **Consists of scanning head and disk/hub assembly**







D1	D2	D3	D4	D5	E	H	M
Ø 71	Ø 52	Ø 33	Ø 25H6	Ø 88.9H6	39.7	9.9	M3
Ø 150	Ø 130	Ø 107	Ø 95 $^{+0.015}_{0}$	Ø 166H6	78.7	10.2	M4

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

A = Bearing
K = Required mating dimensions
H1 = Positive direction of rotation
H2 = Centering collar
H3 = Mounting tolerance between mounting surface of scanning head and disk/hub assembly
H4 = Marks for centering the circular scale (3 x 120°)

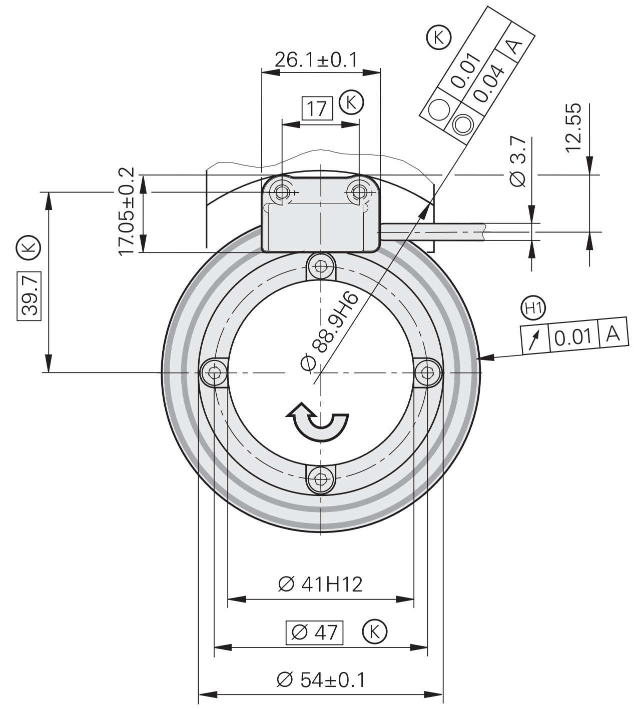
Scanning head	AK ERO 6080	AK ERO 6070		
Incremental signals	∼ 1 V_{PP}	⊓⊔ TTL x 5	⊓⊔ TTL x 10	⊓⊔ TTL x 50
Reference-mark signal	Square-wave pulse			
Integrated interpolation*	–	5-fold	10-fold	50-fold
Cutoff frequency –3 dB	≥ 200 kHz	–	–	–
Scanning frequency	–	≤ 200 kHz	≤ 100 kHz	≤ 25 kHz
Edge separation a	–	≥ 0.220 µs	≥ 0.220 µs	≥ 0.175 µs
Power supply	DC 5 V ± 5%			
Current consumption Without load	< 100 mA	< 200 mA		
Electrical connection	Cable 3 m with male D-sub connector (15-pin), interface electronics for ERO 6070 in the connector			
Cable length	≤ 30 m			
Vibration 55 to 2000 Hz **Shock** 6 ms	200 m/s^2 400 m/s^2			
Operating temperature	0 °C to 50 °C			
Protection EN 60529	IP 00			
Weight (approx.) Scanning head Connector Cable	 6 g (without cable) 32 g 22 g/m	 6 g (without cable) 140 g 22 g/m		

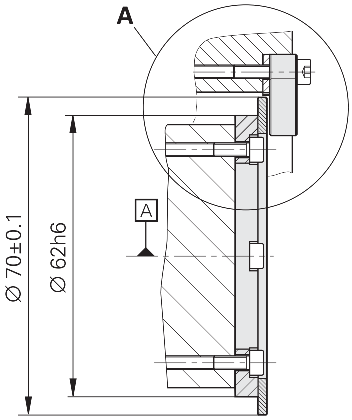
Graduated disk	TKN ERO 6000	
Measuring standard	METALLUR graduation on glass	
Hub inside diameter	25 mm	95 mm
Circular scale outside diameter	71 mm	150 mm
Signal periods*	9000	18000
System accuracy[1)]	± 5″	± 3″
Accuracy of the graduation[2)]	± 3″	± 2″
Reference marks	One	
Mech. permissible speed	≤ 1600 min^{-1}	≤ 800 min^{-1}
Moment of inertia	44 x 10^{-6} kgm^2	1.1 x 10^{-3} kgm^2
Permissible axial motion	≤ 0.1 mm	
Weight	approx. 84 g	approx. 323 g

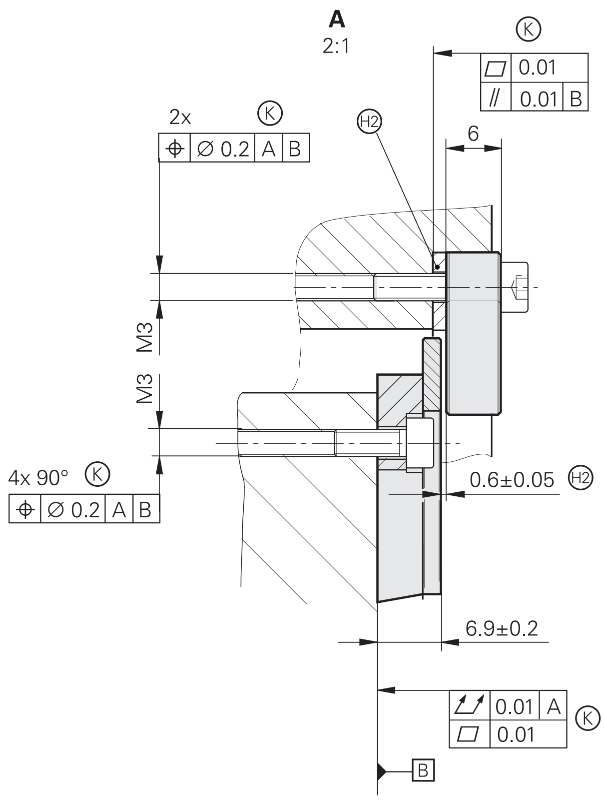
* Please select when ordering
1) Before installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft are not included.
2) For other errors, see *Measuring Accuracy*

ERO 6180

Incremental angle encoder
- **Compact size**
- **Low weight, low moment of inertia**
- **Consists of scanning head and disk/hub assembly**







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

A = Bearing
K = Required mating dimensions
H1 = Centering of the circular scale with hub by the customer via the graduation
H2 = Scanning gap adjustment by means of a shim
Direction of scanning unit motion for output signals in accordance with interface description

Scanning head	AK ERO 6180
Incremental signals	∼ 1 V_{PP}
Reference-mark signal	Square-wave pulse
Cutoff frequency –3 dB	≥ 200 kHz
Power supply	DC 5 V ± 5%
Current consumption Without load	< 100 mA
Electrical connection	Cable 3 m with D-sub connector (male, 15-pin)
Cable length	≤ 30 m
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 400 m/s^2 (EN 60068-2-27)
Operating temperature	0 °C to 50 °C
Protection EN 60529	IP 00
Weight (approx.) Scanning head Connector Cable	 6 g (without cable) 32 g 22 g/m

Graduated disk	TKN ERO 6100
Measuring standard	Chromium graduation on glass
Hub inside diameter	41 mm
Circular scale outside diameter	70 mm
Signal periods	4096
System accuracy[1)]	± 15″
Accuracy of the graduation[2)]	± 10″
Reference marks	One
Mech. permissible speed	≤ 3500 min^{-1}
Moment of inertia	50 x 10^{-6} kgm^2
Permissible axial motion	≤ 0.1 mm
Weight	approx. 71 g

1) Before installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft are not included.
2) For other errors, see *Measuring Accuracy*

ERA 4280 C, ERA 4480 C, ERA 4880 C

Incremental angle encoder for high accuracy
- **Steel scale drum with centering collar**
- **Optional protective cover available for ERA 4480 C**
- **Consists of scanning head and scale drum**

ERA 4000

ERA 4000 with protective cover

Scanning head	
Incremental signals	
Cutoff frequency –3 dB	
Power supply	
Current consumption without load	
Electrical connection	
Cable length	
Vibration 55 to 2 000 Hz **Shock** 6 ms	
Operating temperature	
Weight (approx.)	Scanning head

Scale drum	
Measuring standard Expansion factor	
Drum inside diameter*	
Drum outside diameter*	
Signal periods/ System accuracy[1]	ERA 4200
	ERA 4400
	ERA 4800
Accuracy of the graduation[2]	
Reference marks	
Mechanically permissible speed	
Moment of inertia of rotor	
Perm. axial movement	
Protection* EN 60 529	
Without protective cover	
With protective cover[3] and compressed air	
Weight (approx.)	Scale drum
	Protective cover

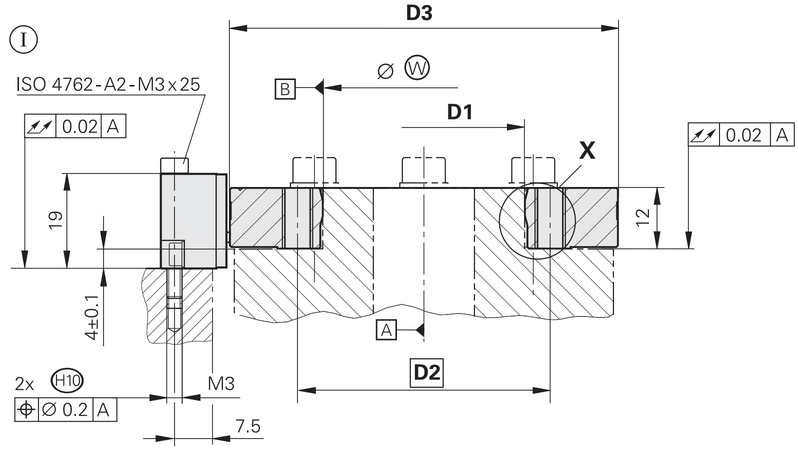
AK ERA 4280 graduation period 20 µm **AK ERA 4480** graduation period 40 µm **AK ERA 4880** graduation period 80 µm
∼ 1 V_{PP}
≥ 350 kHz
DC 5 V ± 10%
< 100 mA
Cable 1 m, with M23 coupling (12-pin)
≤ 150 m (with HEIDENHAIN cable)
≤ 200 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)
–10 °C to +80 °C
20 g; *Scanning head for protective cover:* 35 g (each without cable)

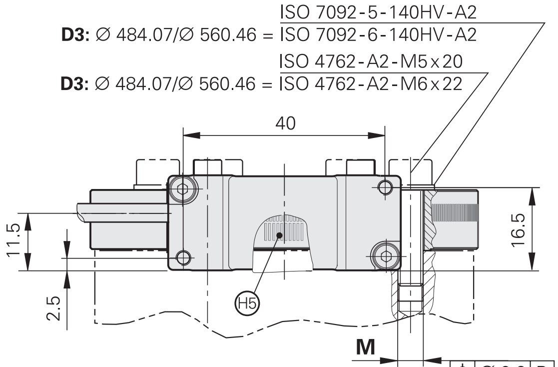
TTR ERA 4200 C graduation period 20 µm **TTR ERA 4400 C** graduation period 40 µm **TTR ERA 4800 C** graduation period 80 µm								
Steel drum $\alpha_{therm} \approx 10.5 \cdot 10^{-6}$ K^{-1}								
40 mm	70 mm	80 mm	120 mm	150 mm	180 mm	270 mm	425 mm	512 mm
76.75 mm	104.63 mm	127.64 mm	178.55 mm	208.89 mm	254.93 mm	331.31 mm	484.07 mm	560.46 mm
12000/± 6.1″	16384/± 4.5″	20000/± 3.7″	28000/± 3.0″	32768/± 2.9″	40000/± 2.9″	52000/± 2.8″	–	–
6000/± 7.2″	8192/± 5.3″	10000/± 4.3″	14000/± 3.5″	16384/± 3.3″	20000/± 3.2″	26000/± 3.0″	38000/± 2.4″	44000/± 2.3″
3000/± 9.4″	4096/± 6.9″	5000/± 5.6″	7000/± 4.4″	8192/± 4.1″	10000/± 3.8″	13000/± 3.5″	–	–
± 5″	± 3.7″	± 3″	± 2.5″				± 2″	
Distance-coded								
10000 min^{-1}	8500 min^{-1}	6250 min^{-1}	4500 min^{-1}	4250 min^{-1}	3250 min^{-1}	2500 min^{-1}	1800 min^{-1}	1500 min^{-1}
$0.27 \cdot 10^{-3}$ kgm^2	$0.81 \cdot 10^{-3}$ kgm^2	$1.9 \cdot 10^{-3}$ kgm^2	$7.1 \cdot 10^{-3}$ kgm^2	$12 \cdot 10^{-3}$ kgm^2	$28 \cdot 10^{-3}$ kgm^2	$59 \cdot 10^{-3}$ kgm^2	$195 \cdot 10^{-3}$ kgm^2	$258 \cdot 10^{-3}$ kgm^2
≤ ± 0.5 mm (scale drum relative to scanning head)								
IP 00								
IP 40	–	IP 40	IP 40	–	IP 40	IP 40	–	
0.28 kg	0.41 kg	0.68 kg	1.2 kg	1.5 kg	2.3 kg	2.6 kg	3.8 kg	3.6 kg
0.07 kg	–	0.12 kg	0.17 kg	–	0.26 kg	0.35 kg	–	

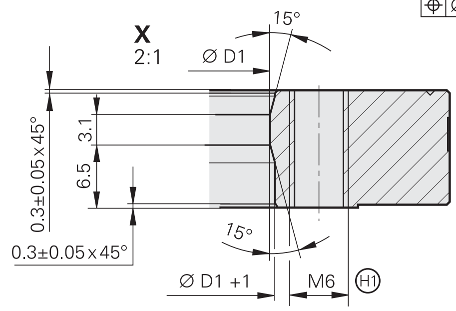
***** Please select when ordering
[1] Before installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft are not included.
[2] For other errors, see *Measuring Accuracy*
[3] Only with ERA 4480; the protective cover must be ordered separately

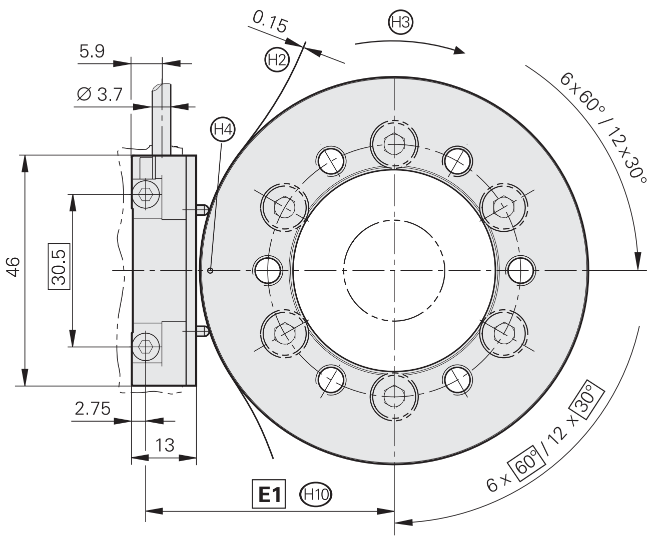
ERA 4280 C, ERA 4480 C, ERA 4880 C

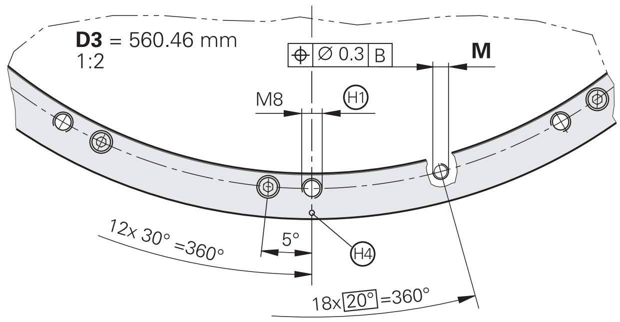
Without Protective Cover

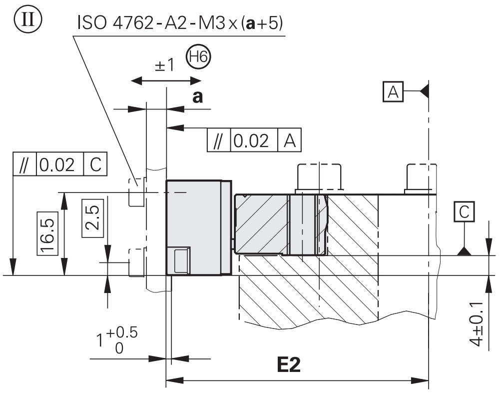




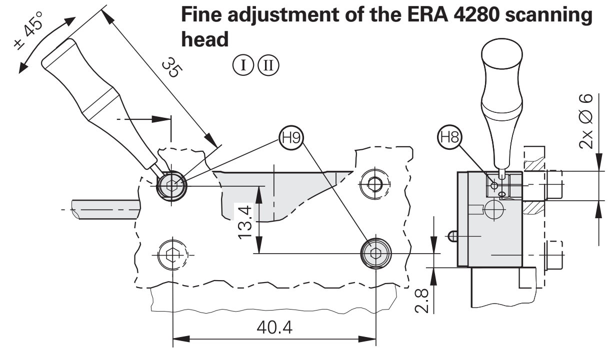


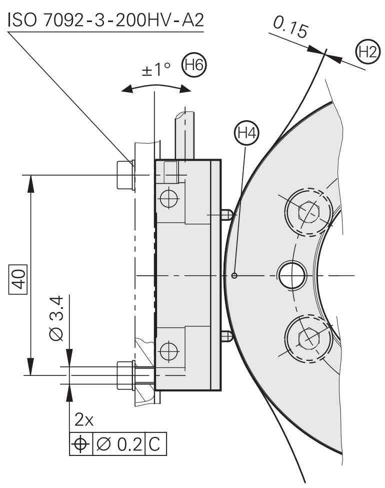






Fine adjustment of the ERA 4280 scanning head





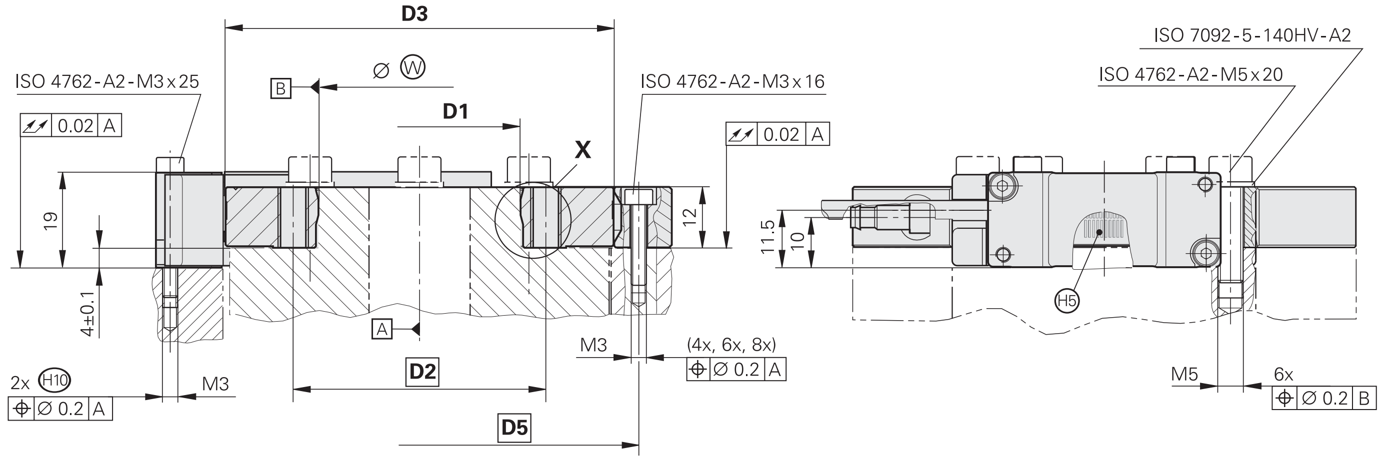
mm

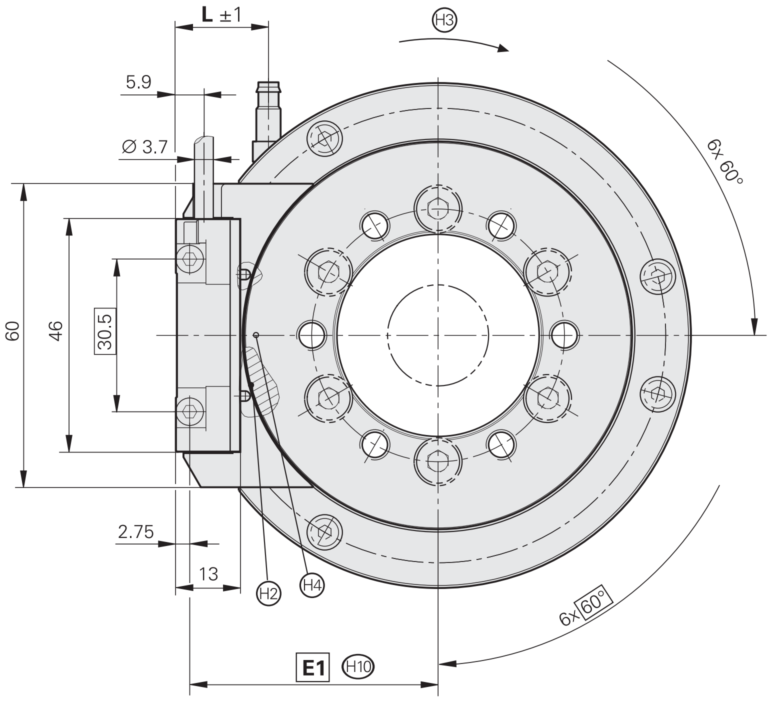
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

D1	W	*)	D2	D3	E1	E2	L	M
Ø 40 –0.001/–0.005	Ø 40 +0.004	0.001	Ø 50	Ø 76.75	49.34	52.08	18.6	6x M5
Ø 70 –0.001/–0.005	Ø 70 +0.005	0.001	Ø 85	Ø 104.63	63.28	66.02	/	6x M5
Ø 80 –0.001/–0.005	Ø 80 +0.006	0.0015	Ø 95	Ø 127.64	74.78	77.52	15.5	6x M5
Ø 120 –0.001/–0.008	Ø 120 +0.008	0.002	Ø 140	Ø 178.55	100.24	102.98	14.5	6x M5
Ø 150 –0.001/–0.008	Ø 150 +0.008	0.002	Ø 165	Ø 208.89	115.41	118.15	/	6x M5
Ø 180 –0.001/–0.008	Ø 180 +0.010	0.003	Ø 200	Ø 254.93	138.43	141.17	12.7	6x M5
Ø 270 0/–0.01	Ø 270 +0.012	0.003	Ø 290	Ø 331.31	176.62	179.36	/	12x M5
Ø 425 0/–0.01	Ø 425 +0.015	0.006	Ø 445	Ø 484.07	253.00	255.74	/	12x M6
Ø 512 0/–0.015	Ø 512 +0.016	0.007	Ø 528	Ø 560.46	291.19	293.93	/	18x M6

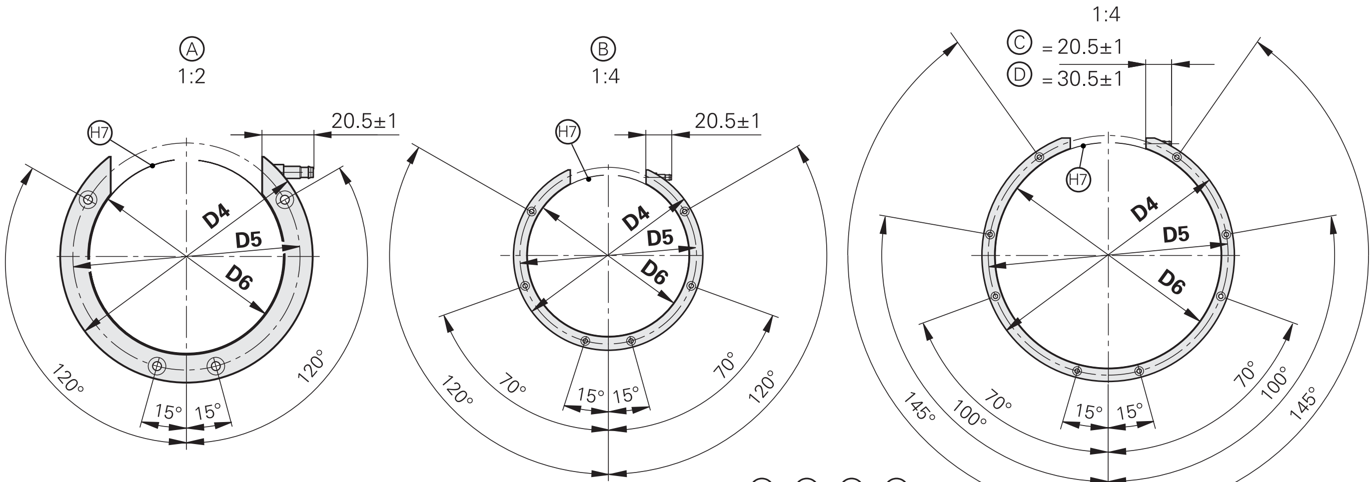
***)** Roundness of mating diameter for shaft

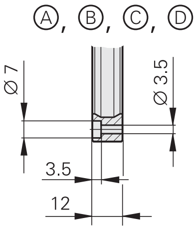
ERA 4480 C
With Protective Cover





I, II = Mounting options
A = Bearing
H1 = Back-off thread
H2 = Mounting clearance (spacer foil)
H3 = Positive direction of rotation for output signals as per interface description
H4 = Marker for reference mark, position tolerance with respect to reference mark: ±1.0 mm
H5 = Reference mark
H6 = Ensure adjustability of mounting surface for scanning head
H7 = Mounting clearance 0.15 mm (protective cover)
H8 = Cam bushing
H9 = Holes required for fine adjustment
H10 = Position tolerance for threaded holes for securing the scanning head

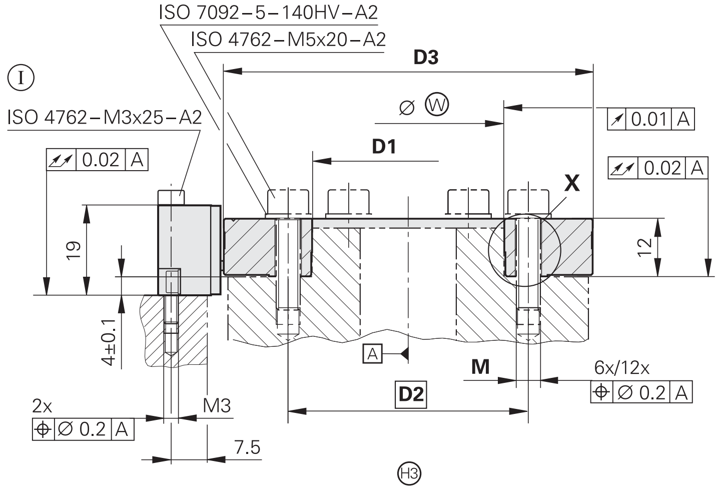


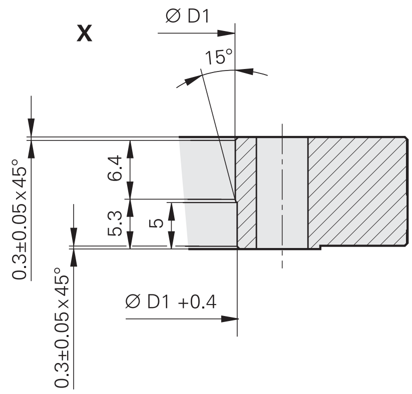


	A	B	C	D
D3	Ø 76.75	Ø 127.64	Ø 178.55	Ø 254.93
D4	Ø 100	Ø 150	Ø 200	Ø 278
D5	Ø 90	Ø 140	Ø 190	Ø 268
D6	Ø 77.2	Ø 128.2	Ø 179.1	Ø 255.6

ERA 4282 C

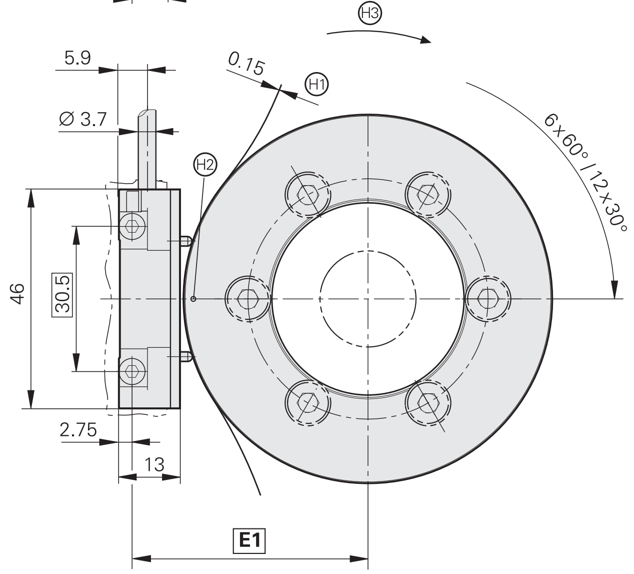
Incremental angle encoder for high accuracy
- **Steel scale drum for increased accuracy requirements**
- **Consists of scanning head and scale drum**

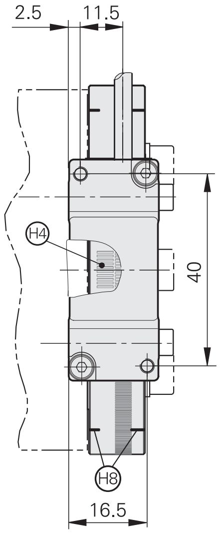




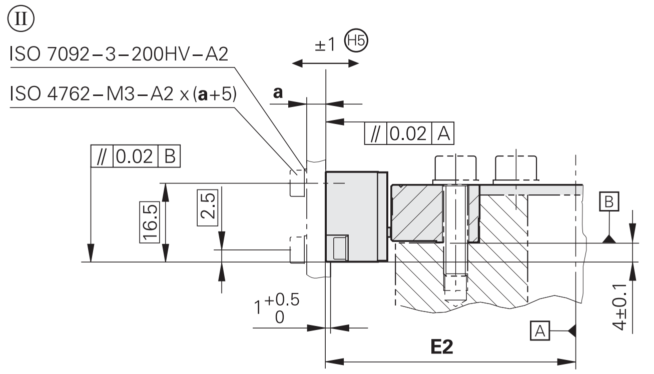
mm

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

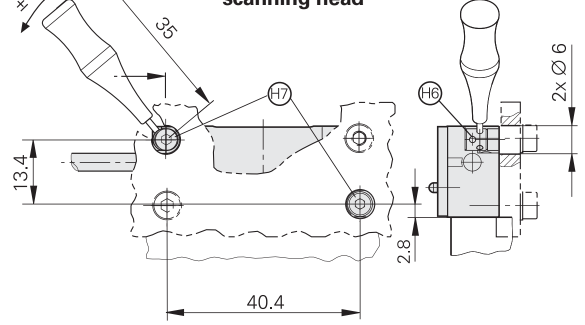


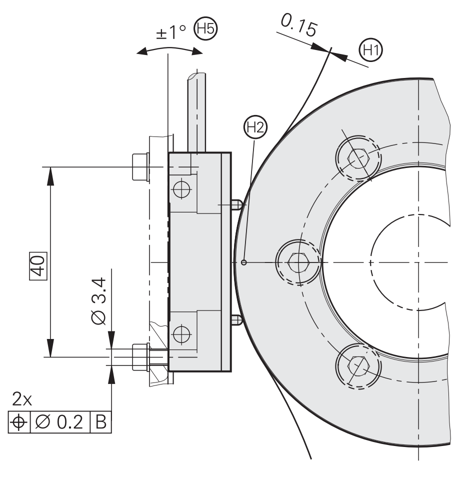


Ⅰ, Ⅱ = Mounting options
A = Bearing
H1 = Mounting clearance (spacer foil)
H2 = Marker for reference mark
H3 = Positive direction of rotation for output signals as per interface description
H4 = Reference mark
H5 = Ensure adjustability of mounting surface for scanning head
H6 = Cam bushing
H7 = Mounting holes for fine adjustment (only for ERA 4280 scanning head)
H8 = Marks for drum centering (3 x 120°)
W = Mating shaft



Fine adjustment of the ERA 4280 scanning head





D1	W	D2	D3	E1	E2	M
Ø 40 +0.07/+0.05	Ø ≤ 40	Ø 50	Ø 76.75	49.34	52.08	M5 6x
Ø 70 +0.07/+0.05	Ø ≤ 70	Ø 85	Ø 104.63	63.28	66.02	M5 6x
Ø 80 +0.07/+0.05	Ø ≤ 80	Ø 95	Ø 127.64	74.78	77.52	M5 6x
Ø 120 +0.07/+0.05	Ø ≤ 120	Ø 140	Ø 178.55	100.24	102.98	M5 6x
Ø 150 +0.07/+0.05	Ø ≤ 150	Ø 165	Ø 208.89	115.41	118.15	M5 6x
Ø 180 +0.07/+0.05	Ø ≤ 180	Ø 200	Ø 254.93	138.43	141.17	M5 6x
Ø 185 +0.07/+0.05	Ø ≤ 185	Ø 197	Ø 208.89	115.41	118.15	M3 12x
Ø 210 +0.07/+0.05	Ø ≤ 210	Ø 230	Ø 254.93	138.43	141.17	M3 12x
Ø 270 +0.07/+0.05	Ø ≤ 270	Ø 290	Ø 331.31	176.62	179.36	M5 12x

Scanning head	AK ERA 4280
Incremental signals	∿ 1 V_{PP}
Cutoff frequency –3 dB	≥ 350 kHz
Power supply	DC 5 V ± 10%
Current consumption Without load	< 100 mA
Electrical connection	Cable 1 m, with M23 coupling (12-pin)
Cable length	≤ 150 m (with HEIDENHAIN cable)
Vibration 55 to 2000 Hz **Shock** 6 ms	≤100 m/s^2 (EN 60068-2-6) ≤ 500 m/s^2 (EN 60068-2-27)
Operating temperature	–10 °C to +80 °C
Weight	approx. 20 g (without cable)

Scale drum	TTR ERA 4202C								
Measuring standard Grating period Expansion factor	Steel drum 20 µm $\alpha_{therm} \approx 10.5 \cdot 10^{-6}$ K^{-1}								
Drum inside diameter*	40 mm	70 mm	80 mm	120 mm	150 mm	180 mm	185 mm	210 mm	270 mm
Drum outside diameter*	76,75 mm	104.63 mm	127.64 mm	178.55 mm	208.89 mm	254.93 mm	208.89 mm	254.93 mm	331.31 mm
Line count	12000	16384	20000	28000	32768	40000	32768	40000	52000
System accuracy[1]	± 5.1″	± 3.8″	± 3.2″	± 2.5″	± 2.3″	± 2.2″	± 2.3″	± 2.2″	± 2.0″
Accuracy of the graduation[2]	± 4″	± 3″	± 2.5″	± 2″	± 1.9″	± 1.8″	± 1.9″	± 1.8″	± 1.7″
Reference marks	Distance-coded								
Mech. permissible speed	10000 min^{-1}	8500 min^{-1}	6250 min^{-1}	4500 min^{-1}	4250 min^{-1}	3250 min^{-1}	3250 min^{-1}	3250 min^{-1}	2500 min^{-1}
Moment of inertia of rotor	$0.28 \cdot 10^{-3}$ kgm^2	$0.83 \cdot 10^{-3}$ kgm^2	$2.0 \cdot 10^{-3}$ kgm^2	$7.1 \cdot 10^{-3}$ kgm^2	$12 \cdot 10^{-3}$ kgm^2	$28 \cdot 10^{-3}$ kgm^2	$6.5 \cdot 10^{-3}$ kgm^2	$20 \cdot 10^{-3}$ kgm^2	$59 \cdot 10^{-3}$ kgm^2
Perm. axial movement	≤± 0.5 mm (scale drum relative to scanning head)								
Protection EN 60529	IP 00								
Weight (approx.)	0.30 kg	0.42 kg	0.70 kg	1.2 kg	1.5 kg	2.3 kg	0.66 kg	1.5 kg	2.6 kg

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

ERA 7000 Series

Incremental angle encoder for high accuracy
- **Steel scale tape for internal mounting**
- **Full-circle and segment versions, also for very large diameters**
- **Consists of scanning head and scale tape**

ERA 7480

ERA 7481

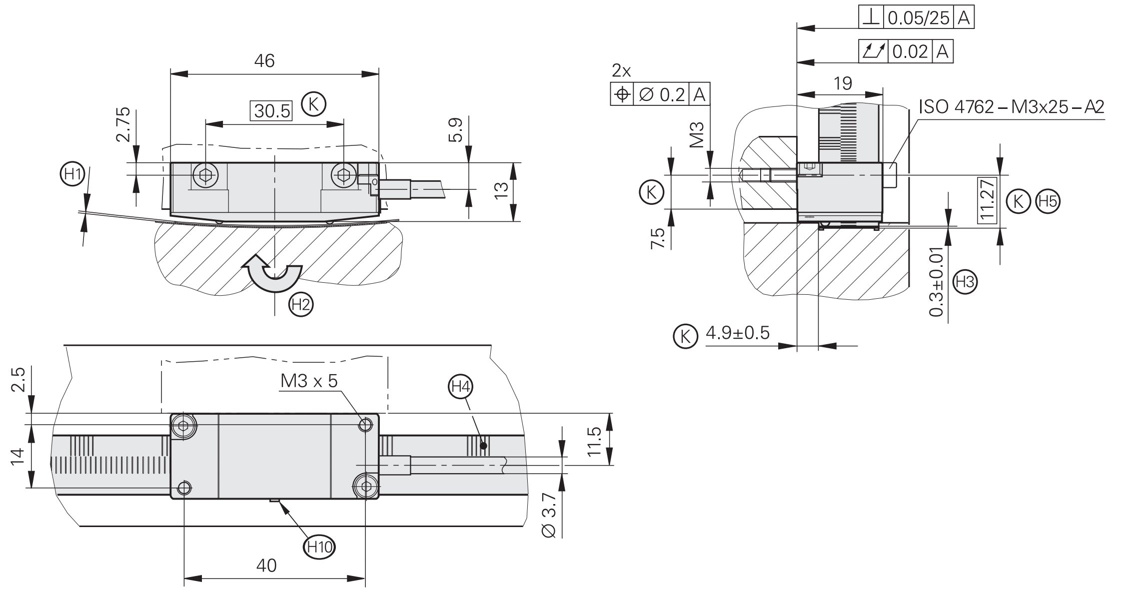
Scanning head	AK ERA 7480
Incremental signals	∼ 1 V_{PP}
Cutoff frequency –3 dB	≥ 350 kHz
Power supply	DC 5 V ± 5%
Current consumption Without load	< 100 mA
Electrical connection	Cable 1 m, with M23 coupling (12-pin)
Cable length	≤ 150 m (with HEIDENHAIN cable)
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)
Operating temperature	–10 °C to +80 °C
Weight	approx. 20 g (without cable)

Scale tape		MSB ERA 7400 C full-circle version MSB ERA 7401 C segment version		
Measuring standard Grating period Expansion factor		Steel scale-tape with METALLUR graduation 40 µm $\alpha_{therm} \approx 10.5 \cdot 10^{-6} K^{-1}$		
Scale-slot diameter*	Full circle	458.62 mm	573.20 mm	1146.10 mm
	Segment	≥ 400		
Line count/ System accuracy[1]	Full circle	36000/± 4.0″	45000/± 3.2″	90000/± 1.6″
	Segment	Depends on mating surface diameter		
Accuracy of the graduation[2]		± 3 µm/m of tape length		
Reference mark		Distance-coded		
Mech. permissible speed[3]		$\leq 250\ min^{-1}$	$\leq 250\ min^{-1}$	$\leq 220\ min^{-1}$
Perm. axial movement		≤ 0.5 mm (scale tape relative to scanning head)		
Permissible expansion coefficient of shaft		$\alpha_{therm} \approx 9 \cdot 10^{-6} K^{-1}$ to $12 \cdot 10^{-6} K^{-1}$		
Protection EN 60529		IP 00		
Weight		approx. 30 g/m		

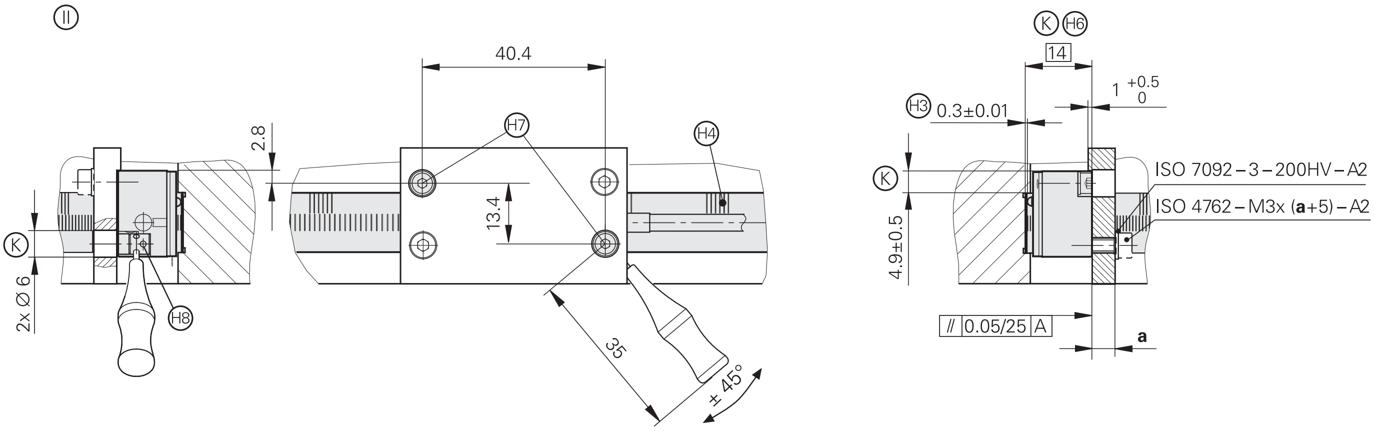
* Please select when ordering
[1] Before installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft are not included.
[2] For other errors, see *Measuring Accuracy*
[3] Higher speeds available on request

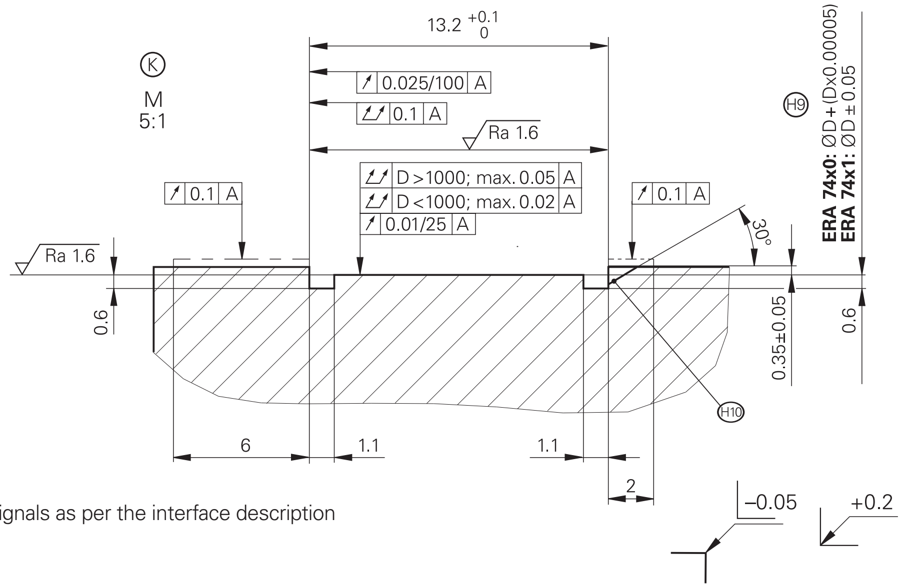
ERA 7000 Series

Ⓘ



Ⓘⓘ



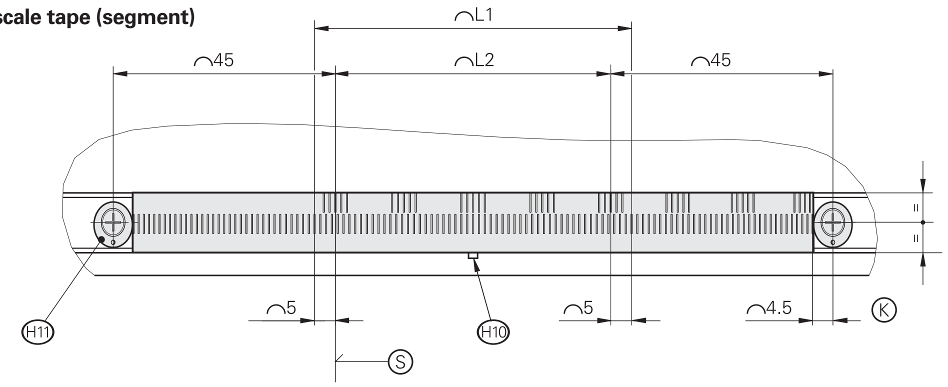


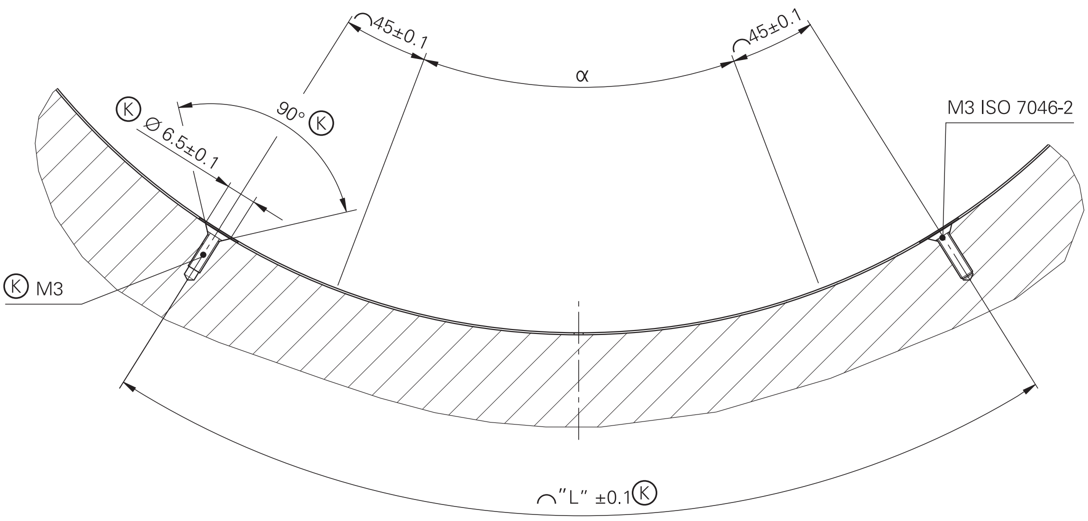
mm

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

Ⓘ, Ⓘⓘ = Mounting options
A = Bearing
K = Required mating dimensions
H1 = Mounting clearance (spacer foil)
D<1000: 0.15 mm; D>1000: 0.5 mm
H2 = Positive direction of rotation for output signals as per the interface description
H3 = Scale-tape thickness
H4 = Reference mark
H5 = Distance between scale-tape slot floor and threaded mounting hole
H6 = Distance between scale-tape slot floor and scanning head's rear mounting surface
H7 = Holes required for fine adjustment
H8 = Cam bushing (Moiré setting)
H9 = Scale-tape slot-floor Ø D
H10 = Notch for removing the scale tape (b = 2 mm)

ERA 74x1 scale tape (segment)





$$D = \frac{n \times 0.04 \times 0.9999}{\pi} + 0.3$$

$$\alpha = \frac{n \times 0.04 \times 0.9999}{(D - 0.3) \times \pi} \times 360°$$

$$L2 = n \times 0.04 \times 0.9999$$

Ⓚ = Required mating dimensions
Ⓢ = Beginning of measurement
H10 = Notch for removing the scale tape (b = 2 mm)
H11 = Cam disk for tensioning the scale tape
⌒ = Radian measure in the neutral axis, pay attention to the scale-tape thickness
⌒L = Position of the threaded mounting holes
⌒L1 = Traverse path
⌒L2 = Measuring range in radian measure

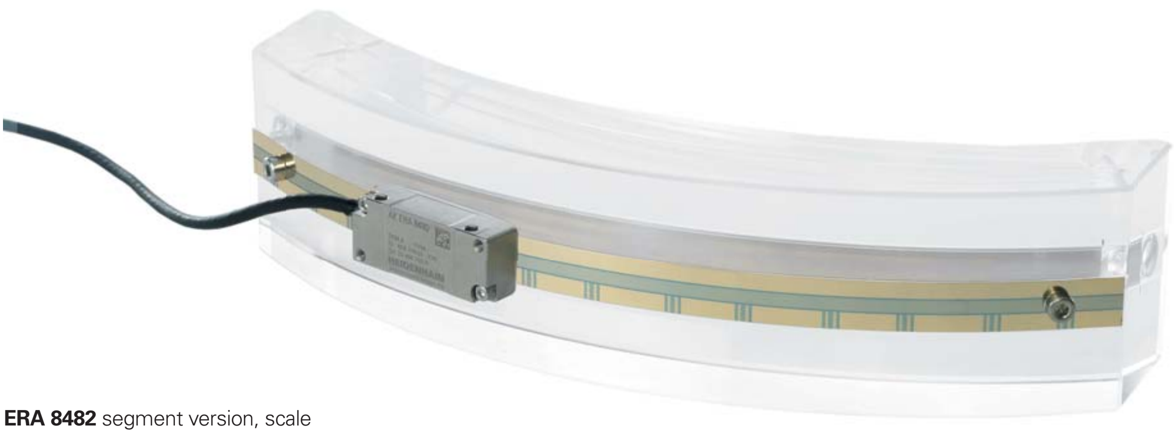
n = Line count
D = Slot-floor diameter
α = Measuring range in degrees (segment angle)
π = 3.1415

ERA 8000 Series

Incremental angle encoder for high accuracy
- **Steel scale tape for external mounting**
- **Full-circle and segment versions, also for very large diameters**
- **Consists of scanning head and scale tape**

ERA 8480 full-circle version

ERA 8481 segment version, scale tape secured with tensioning elements



ERA 8482 segment version, scale tape without tensioning elements

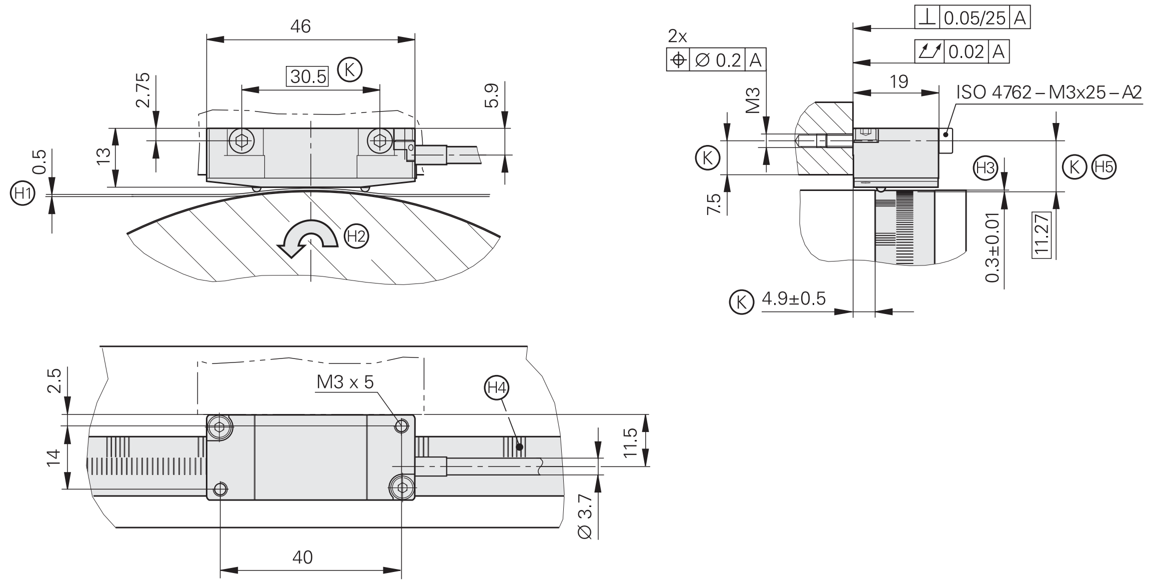
Scanning head	**AK ERA 8480**
Incremental signals	∼ 1 V_{PP}
Cutoff frequency –3 dB	≥ 350 kHz
Power supply	DC 5 V ± 5%
Current consumption Without load	< 100 mA
Electrical connection	Cable 1 m, with M23 coupling (12-pin)
Cable length	≤ 150 m (with HEIDENHAIN cable)
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)
Operating temperature	–10 °C to +80 °C
Weight	approx. 20 g (without cable)

Scale tape		**MSB ERA 8400 C** full-circle version **MSB ERA 8401 C** segment version with tensioning elements **MSB ERA 8402 C** segment version without tensioning elements		
Measuring standard Grating period Expansion factor		Steel scale-tape with METALLUR graduation 40 µm $\alpha_{therm} \approx 10.5 \cdot 10^{-6} K^{-1}$		
Scale-slot diameter*	Full circle	458.11 mm	572.72 mm	1 145.73 mm
	Segment	≥ 400		
Line count/ System accuracy[1]	Full circle	36000/± 4.8"	45000/± 3.9"	90000/± 1.9"
	Segment	Depends on mating surface diameter		
Accuracy of the graduation[2]		± 3 µm/m of tape length		
Reference mark		Distance-coded		
Mech. permissible speed[3]		≤ 50 min^{-1}	≤ 50 min^{-1}	≤ 45 min^{-1}
Perm. axial movement		≤ 0.5 mm (scale tape relative to scanning head)		
Permissible expansion coefficient of shaft		$\alpha_{therm} \approx 9 \cdot 10^{-6} K^{-1}$ to $12 \cdot 10^{-6} K^{-1}$		
Protection EN 60529		IP 00		
Weight		approx. 30 g/m		

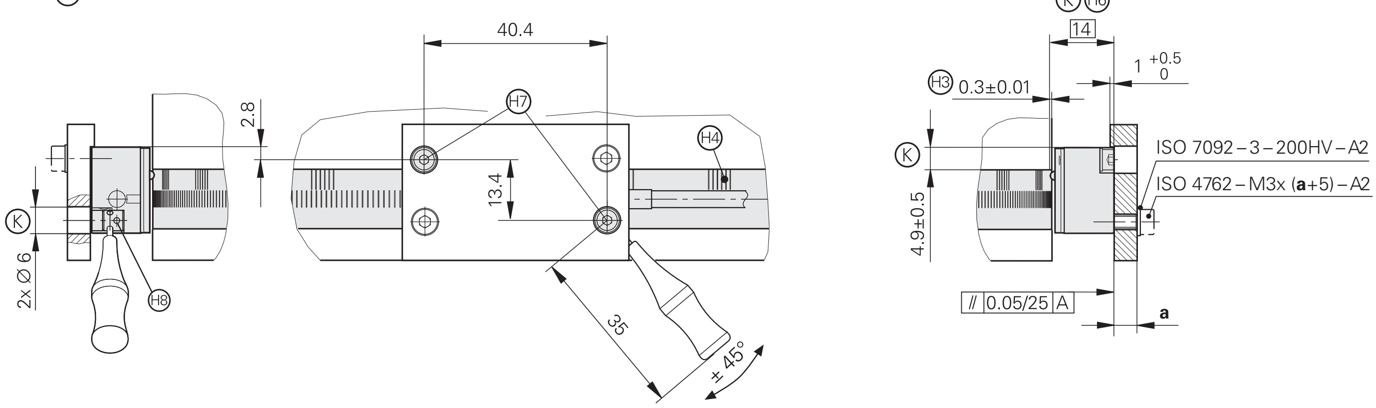
* Please select when ordering
[1] Before installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft are not included.
[2] For other errors, see *Measuring Accuracy*
[3] Higher speeds available on request

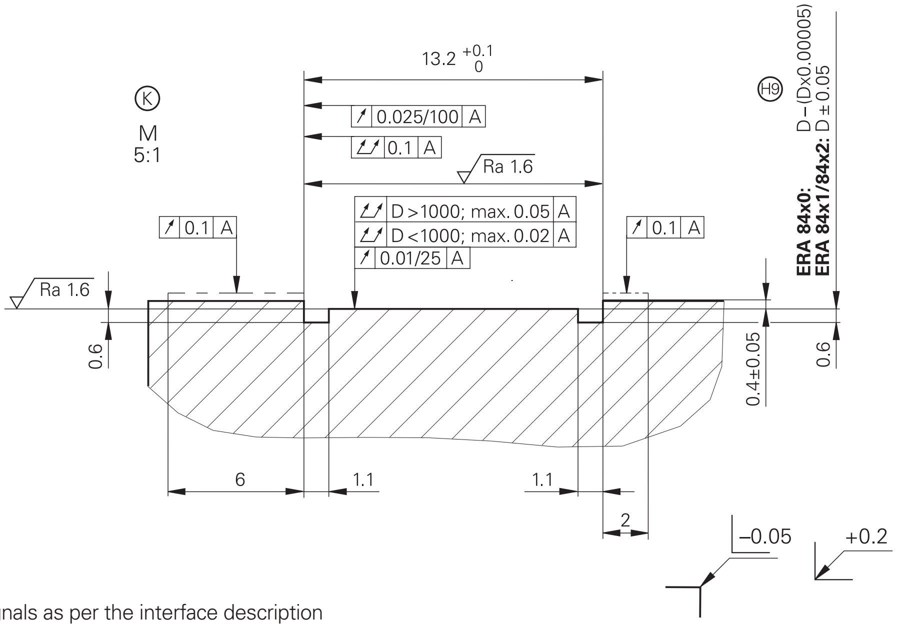
ERA 8000 Series

Ⓘ



Ⓘ





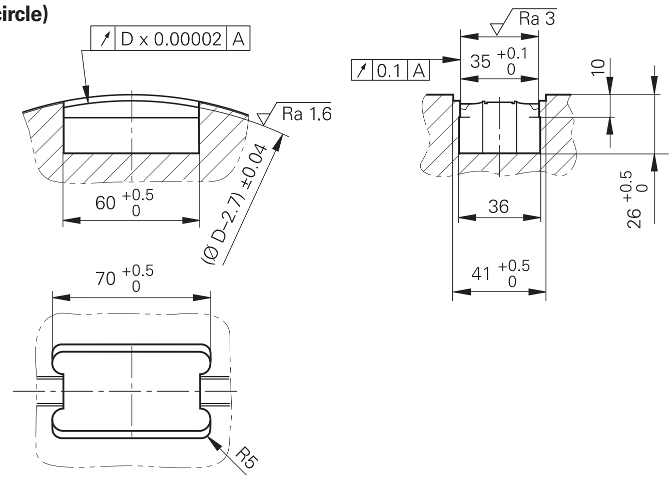
mm

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

Ⓘ, Ⓘ = Mounting options
A = Bearing
Ⓚ = Required mating dimensions
Ⓗ1 = Mounting clearance (spacer foil)
Ⓗ2 = Positive direction of rotation for output signals as per the interface description
Ⓗ3 = Scale-tape thickness
Ⓗ4 = Reference mark
Ⓗ5 = Distance between scale-tape slot floor and threaded mounting hole
Ⓗ6 = Distance between scale-tape slot floor and scanning head’s rear mounting surface
Ⓗ7 = Holes required for fine adjustment
Ⓗ8 = Cam bushing (Moiré setting)
Ⓗ9 = Scale-tape slot-floor Ø D

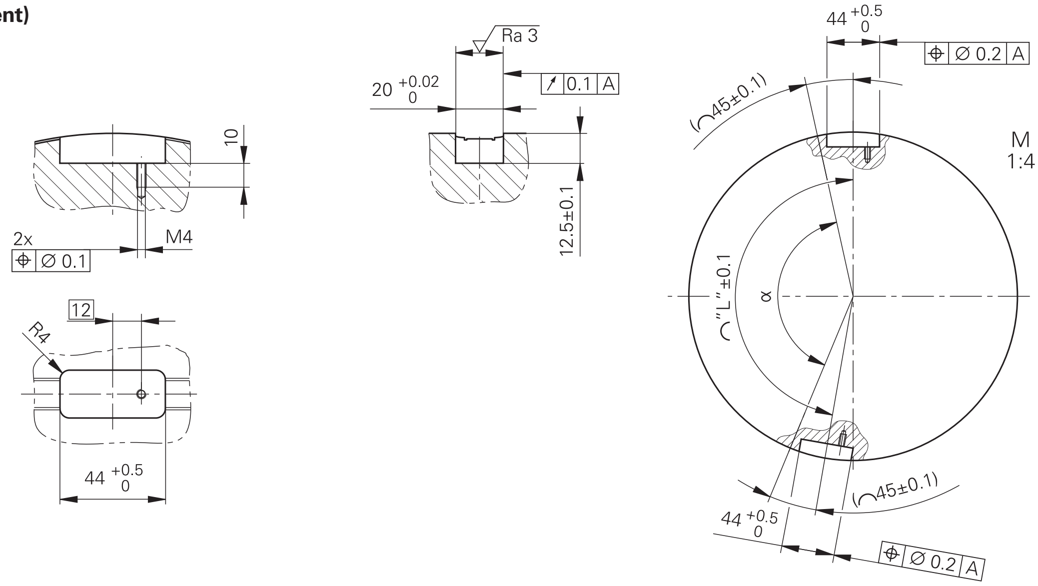
ERA 84x0 scale tape (full circle)

Ⓚ
M
1:2



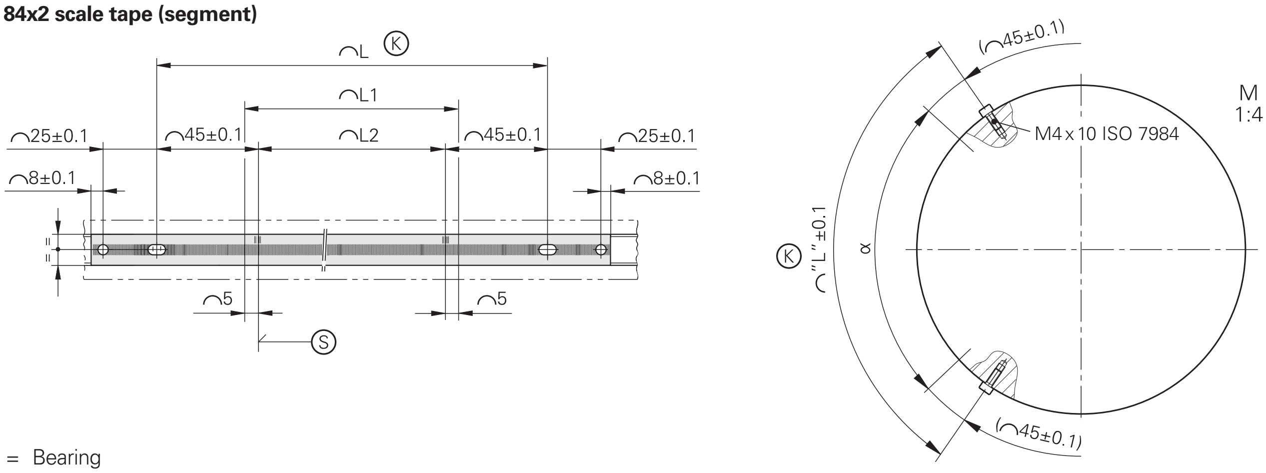
ERA 84x1 scale tape (segment)

Ⓚ
M
1:2



ERA 84x2 scale tape (segment)

M
1:2



Ⓐ = Bearing
Ⓚ = Required mating dimensions
Ⓢ = Beginning of measurement
⌒ = Radian measure in the neutral axis, pay attention to the scale-tape thickness
⌒L = Position of the two end-piece openings or threaded mounting holes
⌒L1 = Traverse path
⌒L2 = Measuring range in radian measure

n = Line count
D = Slot-floor diameter
α = Measuring range in degrees (segment angle)
π = 3.1415

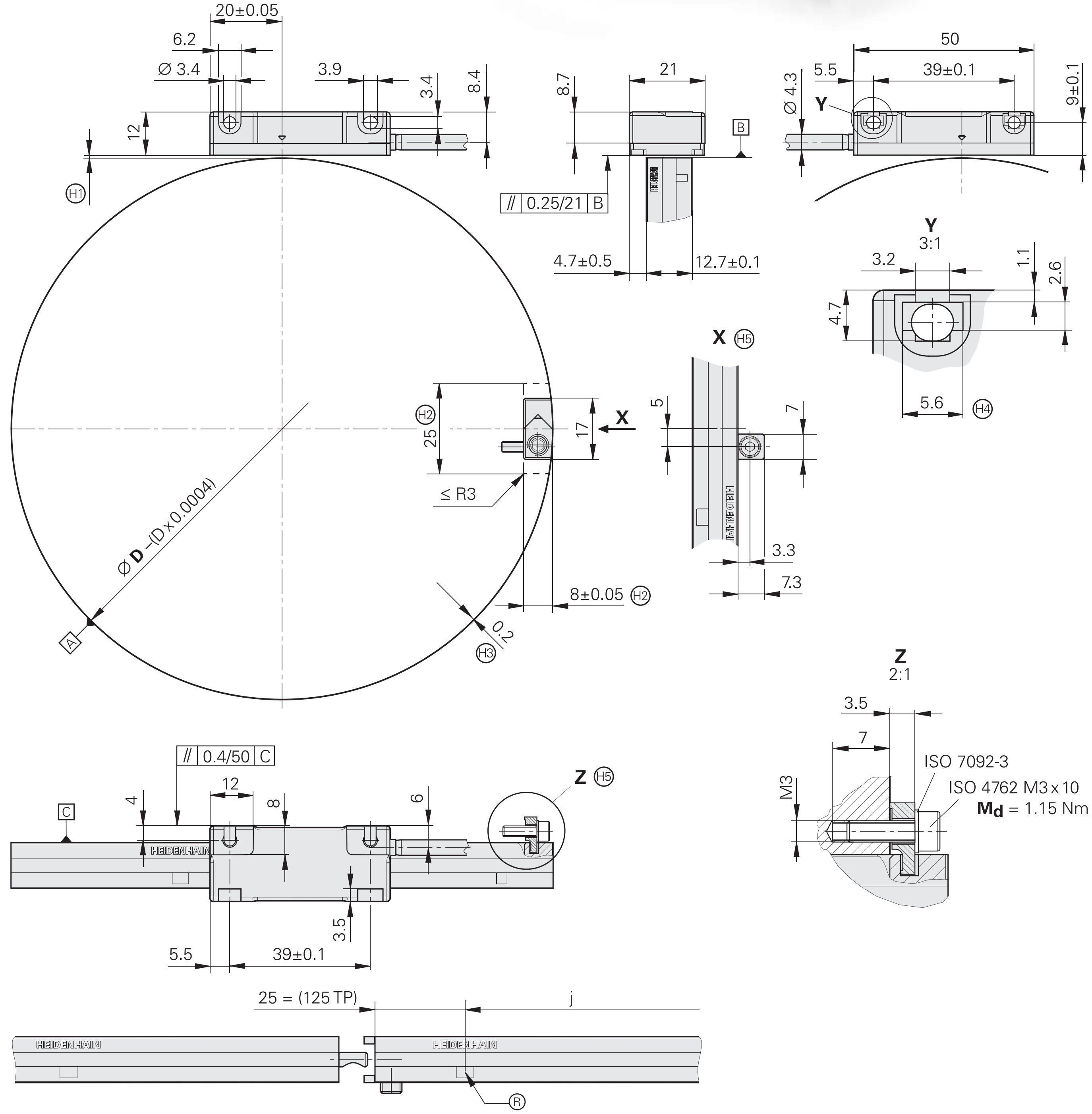
$$D = \frac{n \times 0.04 \times 1.0001}{\pi} - 0.3$$

$$\alpha = \frac{n \times 0.04 \times 1.0001}{(D + 0.3) \times \pi} \times 360°$$

$$L2 = n \times 0.04 \times 1.0001$$

ERA 6000 Series

Incremental angle encoder
- **Steel scale tape for external mounting**
- **Full-circle version with tensioning cleat**
- **Consists of scanning head and scale tape**



D = Shaft diameter
TP = Grating period 200 µm
j = Additional reference marks spaced every n x 100 mm
Ⓐ = Bearing
Ⓡ = Reference mark
Ⓗ1 = **D** < Ø 500 = 0.75+0.2/–0.1
D ≥ Ø 500 = 0.75+0.4/–0.2
Ⓗ2 = Space for tensioning cleat
Ⓗ3 = Scale-tape thickness
Ⓗ4 = Hexagonal nut as per ISO 4032–M3 SW5.6
Ⓗ5 = Optional installation kit

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

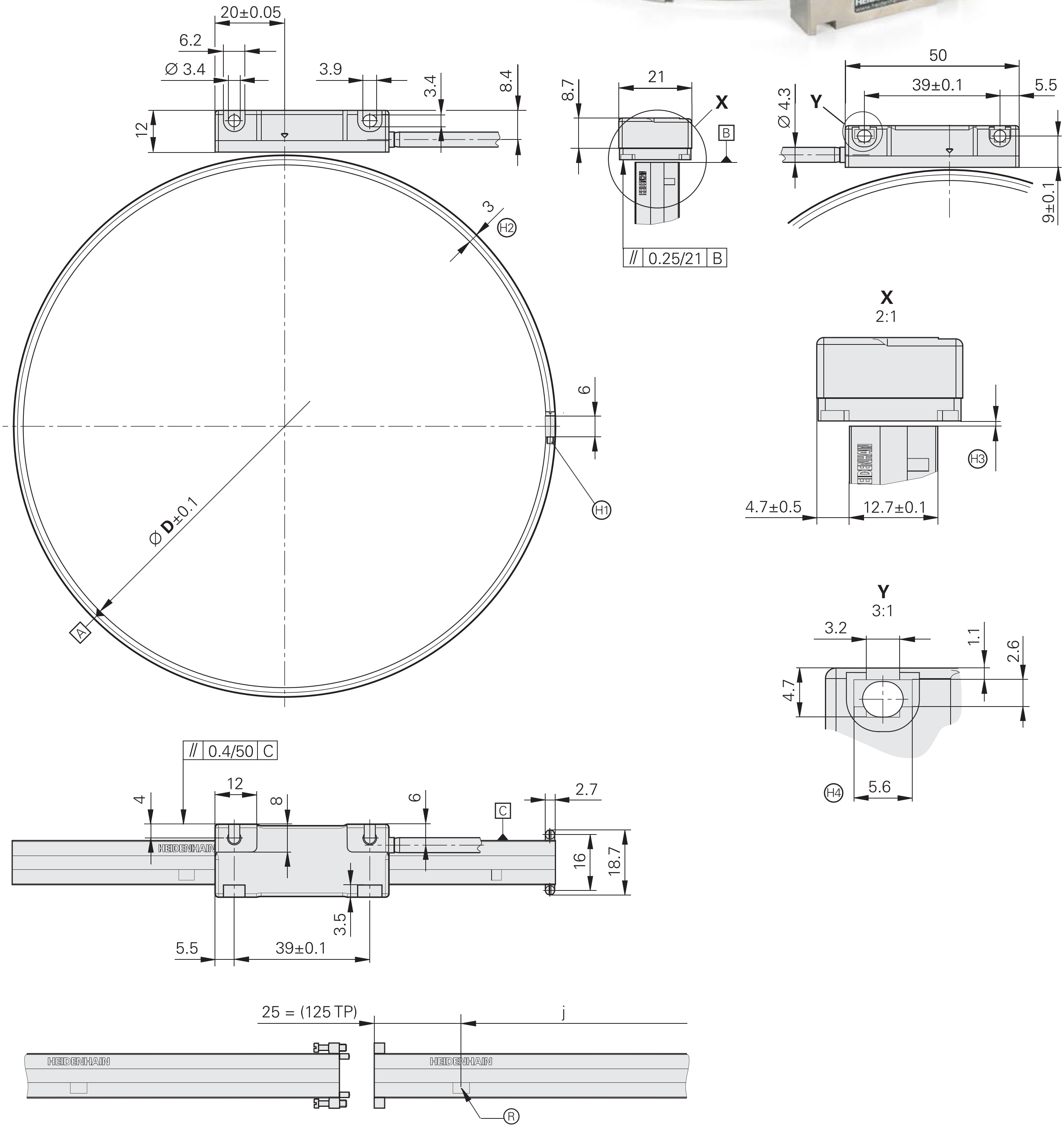
Scanning head	AK ERA 6080	AK ERA 6070		
Incremental signals	∿ 1 V_{PP}	⊓⊔TTL x 10	⊓⊔TTL x 50	⊓⊔TTL x 100
Integrated interpolation*	–	10-fold	50-fold	100-fold
Cutoff frequency –3 dB	≥ 90 kHz	–	–	–
Scanning frequency	–	≤ 50 kHz	≤ 25 kHz	≤ 12.5 kHz
Edge separation a	–	≥ 0.465 µs	≥ 0.175 µs	≥ 0.175 µs
Power supply	DC 5 V ± 5%			
Current consumption Without load	< 110 mA	< 140 mA		
Electrical connection	Cable 3 m, with D-sub connector (15-pin)			
Cable length	≤ 30 m (with HEIDENHAIN cable)			
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 200 m/s^2 ≤ 500 m/s^2			
Operating temperature	0 °C to 50 °C			
Protection EN 60529	IP 00			
Weight (approx.) Scanning head Connector Cable	 20 g (without cable) 32 g 30 g/m			

Scale tape	MSB ERA 6000				
Measuring standard Grating period Expansion factor	Steel scale tape 200 µm $\alpha_{therm} \approx 10 \cdot 10^{-6} K^{-1}$				
Scale-slot diameter*	159.07 mm	229.15 mm	318.34 mm	636.88 mm	1 146.54 mm
Line count[1]	2500	3600	5000	10000	18000
System accuracy[2]	± 80″	± 60″	± 40″	± 20″	± 15″
Accuracy of the graduation[3]	± 30 µm/m of tape length				
Reference marks	Selectable every 100 mm				
Mech. permissible speed[4]	≤ 200 min^{-1}	≤ 200 min^{-1}	≤ 200 min^{-1}	≤ 150 min^{-1}	≤ 83 min^{-1}
Permissible axial motion	≤ 0.5 mm (scale tape relative to scanning head)				
Permissible expansion coefficient of shaft	$\alpha_{therm} = 9 \cdot 10^{-6} K^{-1}$ to $12 \cdot 10^{-6} K^{-1}$				
Weight	approx. 12 g + 20 g/m				

***** Please select when ordering
1) Other line counts upon request (minimum 2350; maximum 18000)
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*
4) Higher speeds upon request

ERA 6006 Series

Incremental angle encoder
- **Steel scale tape with elastic intermediate layer for external mounting**
- **Full-circle version with tensioning cleat**
- **Consists of scanning head and scale tape**



D = Shaft diameter
TP = Grating period 200 µm
j = Additional reference marks spaced every n x 100 mm
Ⓐ = Bearing
Ⓡ = Reference mark
Ⓗ1 = M2 tensioning screw
Ⓗ2 = Scale-tape thickness
Ⓗ3 = **D** < Ø 500 = 0.75+0.2/–0.1
D ≥ Ø 500 = 0.75+0.4/–0.2
Ⓗ4 = Hexagonal nut as per ISO 4032–M3 SW5.6

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

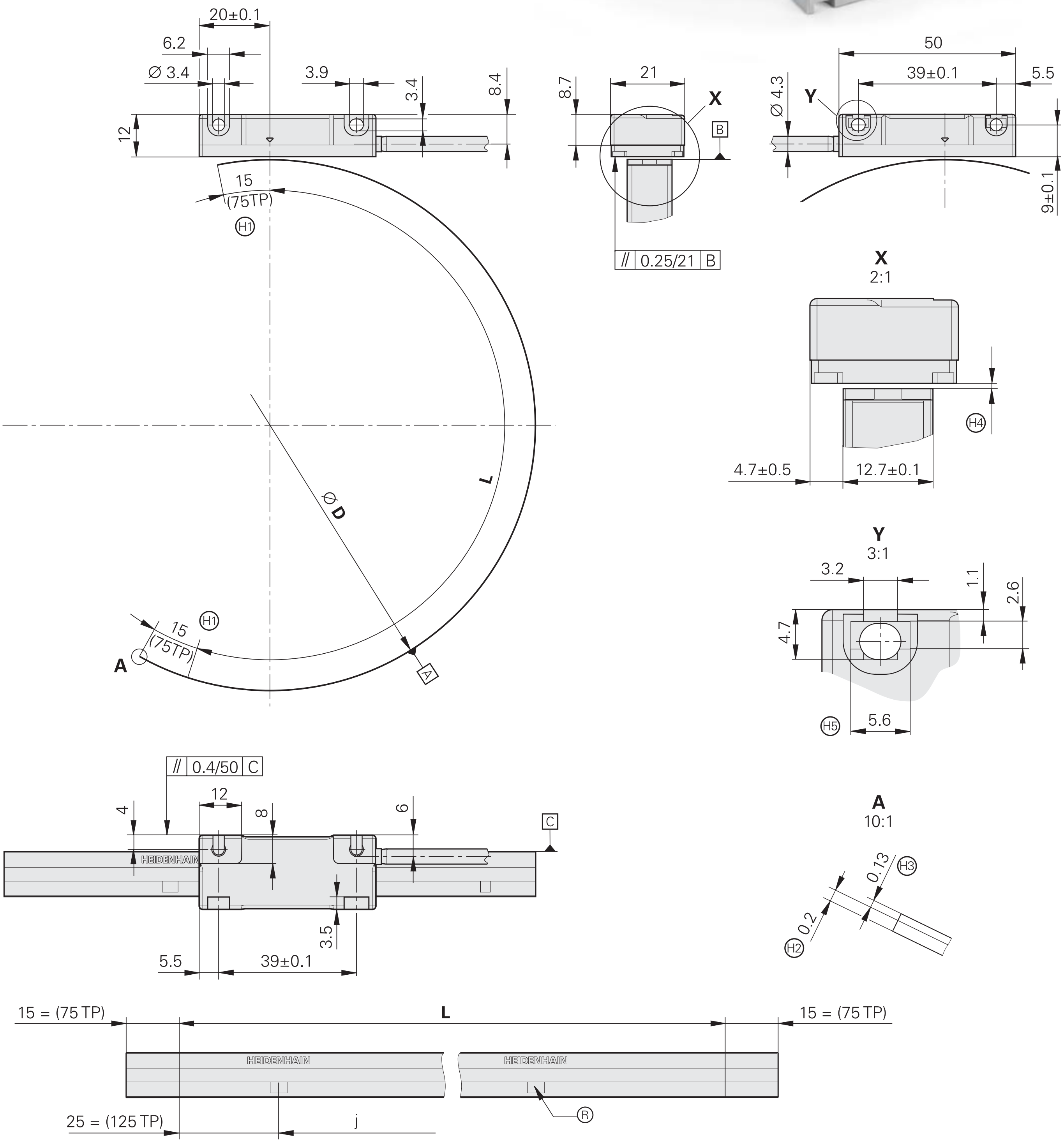
Scanning head	AK ERA 6080	AK ERA 6070		
Incremental signals	∿ 1 V_{PP}	⊓⊔TTL x 10	⊓⊔TTL x 50	⊓⊔TTL x 100
Integrated interpolation*	–	10-fold	50-fold	100-fold
Cutoff frequency –3 dB	≥ 90 kHz	–	–	–
Scanning frequency	–	≤ 50 kHz	≤ 25 kHz	≤ 12.5 kHz
Edge separation a	–	≥ 0.465 µs	≥ 0.175 µs	≥ 0.175 µs
Power supply	DC 5 V ± 5%			
Current consumption Without load	< 110 mA	< 140 mA		
Electrical connection	Cable 3 m, with D-sub connector (15-pin)			
Cable length	≤ 30 m (with HEIDENHAIN cable)			
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 200 m/s^2 ≤ 500 m/s^2			
Operating temperature	0 °C to 50 °C			
Protection EN 60529	IP 00			
Weight (approx.) Scanning head Connector Cable	 20 g (without cable) 32 g 30 g/m			

Scale tape	MSB ERA 6006				
Measuring standard Grating period Expansion factor	Steel scale tape 200 µm $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$				
Scale-slot diameter*	153.35 mm	223.38 mm	312.51 mm	630.82 mm	1140.12 mm
Line count[1]	2500	3600	5000	10000	18000
System accuracy[2]	± 350″	± 250″	± 200″	± 100″	± 50″
Accuracy of the graduation[3]	± 30 µm/m of tape length				
Reference marks	Selectable every 100 mm				
Mech. permissible speed[4]	≤ 200 min^{-1}	≤ 200 min^{-1}	≤ 200 min^{-1}	≤ 150 min^{-1}	≤ 83 min^{-1}
Permissible axial motion	≤ 0.5 mm (scale tape relative to scanning head)				
Permissible thermal diameter change	≤ ± 0.2 mm (between shaft and scale tape)				
Weight	approx. 2.5 g + 45 g/m				

***** Please select when ordering
[1] Other line counts upon request (minimum 2350; maximum 18000)
[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*
[4] Higher speeds upon request

ERA 6002 Series

Incremental angle encoder
- **Steel scale tape for external mounting**
- **Segment version**
- **Simple mounting of the scale tape by adhesive**
- **Consists of scanning head and scale tape**



D = Shaft diameter
L = Measuring range
TP = Grating period 200 µm
j = Additional reference marks spaced every n x 100 mm
A = Bearing
R = Reference mark
H1 = Allowance
H2 = Steel scale tape
H3 = Adhesive tape
H4 = **D** < Ø 500 = 0.75+0.2/–0.1
D ≥ Ø 500 = 0.75+0.4/–0.2
H4 = Hexagonal nut as per ISO 4032–M3 SW5.6

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

Scanning head	**AK ERA 6080**	**AK ERA 6070**		
Incremental signals	~ 1 V_{PP}	⊓⊔ TTL x 10	⊓⊔ TTL x 50	⊓⊔ TTL x 100
Integrated interpolation*	–	10-fold	50-fold	100-fold
Cutoff frequency –3 dB	≥ 90 kHz	–	–	–
Scanning frequency	–	≤ 50 kHz	≤ 25 kHz	≤ 12.5 kHz
Edge separation a	–	≥ 0.465 µs	≥ 0.175 µs	≥ 0.175 µs
Power supply	DC 5 V ± 5%			
Current consumption Without load	< 110 mA	< 140 mA		
Electrical connection	Cable 3 m, with D-sub connector (15-pin)			
Cable length	≤ 30 m (with HEIDENHAIN cable)			
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 200 m/s^2 ≤ 500 m/s^2			
Operating temperature	0 °C to 50 °C			
Protection EN 60529	IP 00			
Weight (approx.) Scanning head Connector Cable	 20 g (without cable) 32 g 30 g/m			

Scale tape	**MSB ERA 6002**
Measuring standard Grating period Expansion factor	Steel scale tape 200 µm $\alpha_{therm} \approx 10 \cdot 10^{-6}$ K^{-1}
Scale-slot diameter*	≥ 150 mm 1)
Line count*	Min. 300, max. 50000 (5 lines/mm)
Accuracy of the graduation 2)	± 30 µm/m of tape length
Reference marks	Selectable every 100 mm
Permissible axial motion	≤ 0.5 mm (scale tape relative to scanning head)
Weight	approx. 20 g/m

* Please select when ordering
1) For mating diameters < 400 mm the scale tape is pre-bent
2) 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 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.

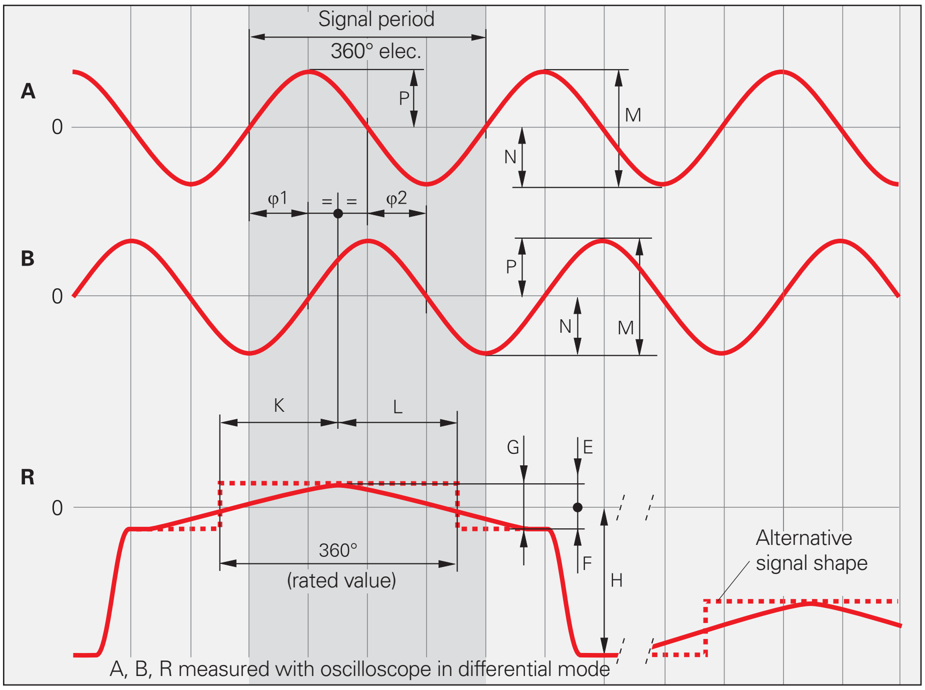
Measuring steps for **position measurement** are recommended in the specifications. For special applications, other resolutions are also possible.

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.

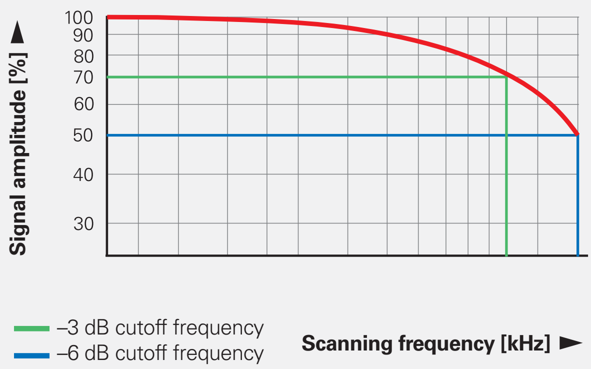
Short circuit at	20 °C	125 °C
One output	< 3 min	< 1 min
All outputs	< 20 s	< 5 s

Interface	Sinusoidal voltage signals ~ **$1\ V_{PP}$**
Incremental signals	**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 $\|\varphi 1 + \varphi 2\|/2$: 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 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 the 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

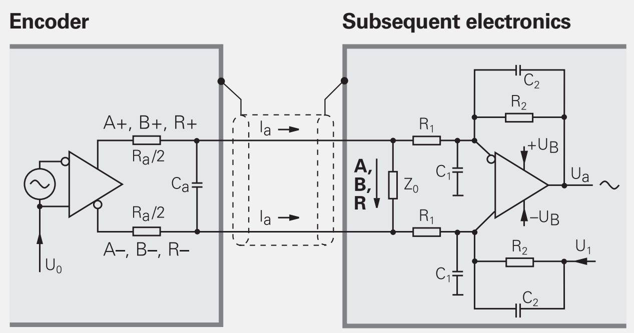
–3 dB cutoff frequency of circuitry
Approx. 450 kHz
Approx. 50 kHz with C_1 = 1000 pF
and C_2 = 82 pF
The circuit variant for 50 kHz does reduce the bandwidth of the circuit, but in doing so it improves its noise immunity.

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

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

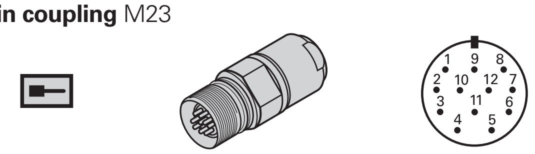
Incremental signals
Reference-mark signal

R_a < 100 Ω, typ. 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)

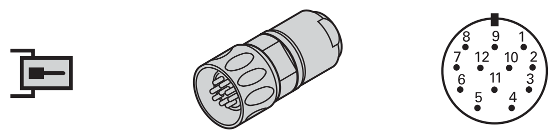


Pin layout

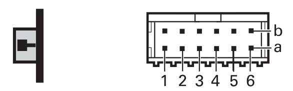
12-pin coupling M23



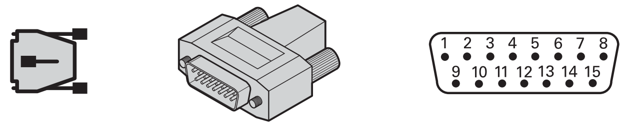
12-pin connector M23



12-pin PCB connector
on ERP 880



15-pin D-sub connector



	Power supply				Incremental signals						Other signals		
12-pin coupling / connector M23	**12**	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**9**	**7**	**/**
12-pin PCB connector	**2a**	**2b**	**1a**	**1b**	**6b**	**6a**	**5b**	**5a**	**4b**	**4a**	**3b**	**3a**	**/**
15-pin D-sub connector	**4**	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**5/6/8**	**13**	**15**
	U_P	**Sensor** U_P[2]	**0 V**	**Sensor** 0 V[2]	**A+**	**A–**	**B+**	**B–**	**R+**[1]	**R–**[1]	**Vacant**	**Vacant**	**Vacant**
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 (*ERO 6x80:* in the connector) with the corresponding power line.
Vacant pins or wires must not be used!

[1] **ERP 4080/ERP 8080:** Vacant
[2] **ERA 608x:** Vacant

Interfaces
Incremental Signals ⊓⊔TTL

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

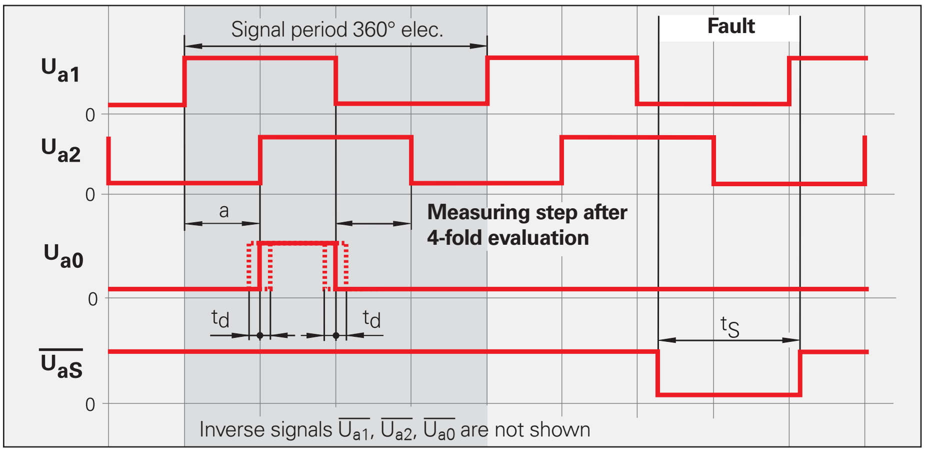
The **incremental signals** are transmitted as the square-wave pulse trains U_{a1} and U_{a2}, phase-shifted by 90° elec. The **reference mark signal** consists of one or more reference pulses U_{a0}, which are gated with the incremental signals. In addition, the integrated electronics produce their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

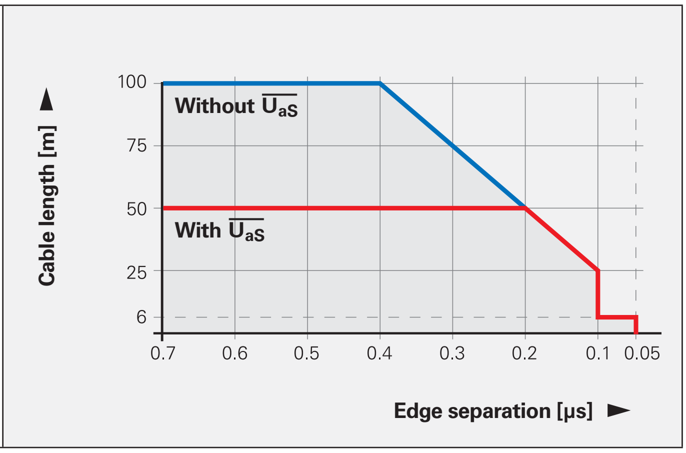
The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum **edge separation a** listed in the *Specifications* applies for the illustrated input circuitry with a cable length of 1 m, and refers to measurement at the output of the differential line receiver. 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 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 *ERN 1x23:* 10 mA $U_L \leq 0.5$ V at $I_L = 20$ mA *ERN 1x23:* 10 mA
Permissible load	$Z_0 \geq 100\ \Omega$ between associated outputs $\lvert I_L \rvert \leq 20$ mA max. load per output (*ERN 1x23:* 10 mA) $C_{load} \leq 1\,000$ 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 mm²) + (4 × 0.5 mm²)] 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

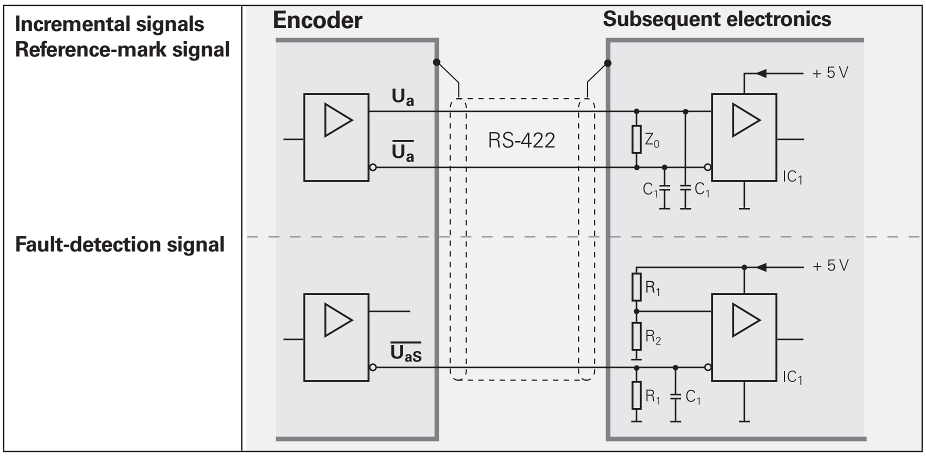


Input circuitry of the subsequent electronics

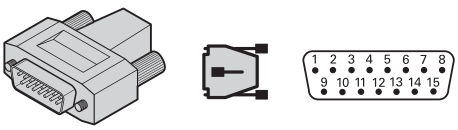
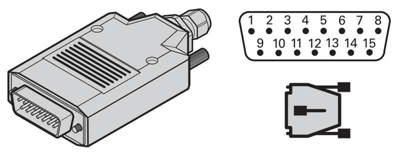
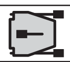
Dimensioning

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

15-pin D-sub connector 	15-pin D-sub connector with integrated interface electronics 												
	Power supply				Incremental signals						Other signals		
	**4**	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**13**	**5/6/8**	**15**
	U_P	**Sensor** U_P[2]	**0 V**	**Sensor** 0 V[2]	**U_{a1}**	**$\overline{U_{a1}}$**	**U_{a2}**	**$\overline{U_{a2}}$**	**U_{a0}**	**$\overline{U_{a0}}$**	**$\overline{U_{aS}}$**	**Vacant**	**Vacant**[1]
	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 (*ERO 6x70:* in the connector) with the corresponding power line.
Vacant pins or wires must not be used!

[1] **ERO 6x70:** Switchover TTL/11 µAPP for PWT, otherwise vacant
[2] **ERA 607x:** Vacant

HEIDENHAIN Measuring Equipment
For Incremental Angle Encoders

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 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 1 024-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	DC 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		

The **PG 27** and **PS 27** electronic mounting aids permit fast and simple checking of the functions. Multicolored LEDs allow a qualitative evaluation of incremental and reference mark signals.

	PG 27	PS 27
Encoder input	⊓⊔ TTL	⊓⊔ TTL (signals are connected through)
Design	Housing	D-sub connector
Function	Two multicolored LEDs showing whether the signals are within or outside the tolerance	
Power supply	Via power adapter	Via subsequent electronics

The **APE 381** interface electronics unit is necessary in order to connect PWM/PWT units to encoders with signal-error compensation. The APE 381 deactivates the signal-error compensation integrated in the scanning head, permitting evaluation of the uncompensated 1 V_{PP} output signals of the encoder.

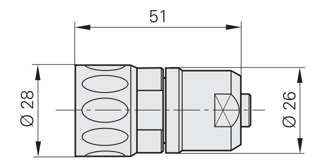
	APE 381
Encoder input	∿ 1 V_{PP} (signals are connected through)
Design	Cable with D-sub connector
Function	Switch-off of the signal-error compensation integrated in the scanning head
Power supply	Via subsequent electronics

Cables and Connecting Elements
General Information

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

Symbols 

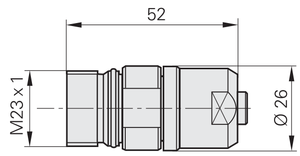
M23



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

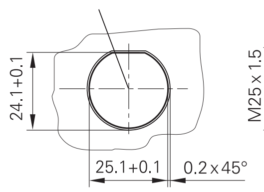
Symbols 

M23

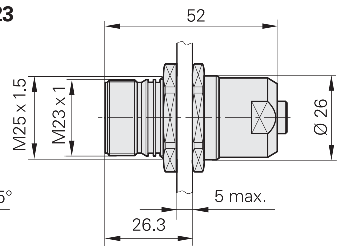


Mounted coupling with central fastening

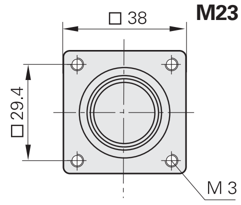
Cutout for mounting



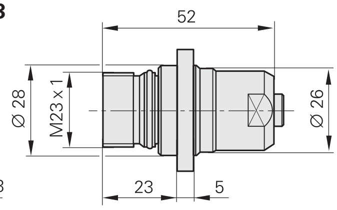
M23



Mounted coupling with flange



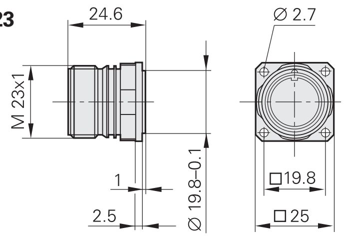
M23



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

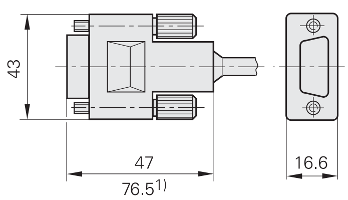
Symbols 

M23



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

Symbols 

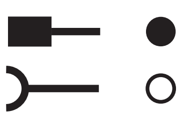


1) With integrated interpolation electronics

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.



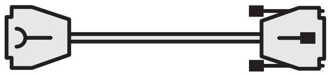
When engaged, the connections are **protected** to IP 67 (D-sub connector: IP 50; EN 60529). When not engaged, there is no protection.

Accessories for flange sockets and M23 mounted couplings

Bell seal
ID 266526-01

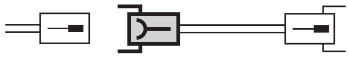
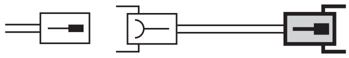
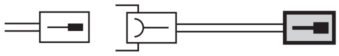
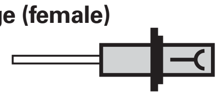
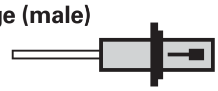
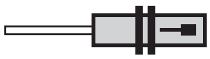
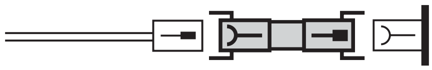
Threaded metal dust cap
ID 219926-01

Connecting Cables

		12-pin M23	
PUR connecting cable [6(2 x 0.19 mm²)]			
PUR connecting cable [4(2 × 0.14 mm²) + (4 × 0.5 mm²)]		Ø 8 mm	Ø 6 mm[1)]
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) for IK 220/ND 780		310199-xx	
Complete with connector (female) and D-sub connector (male) for IK 115/IK 215/ ND 280/ND 287/EIB 741		310196-xx	
With **one** connector (female)		309777-xx	
Complete with D-sub connector (female) and M23 connector (male)		331693-xx	355215-xx
With **one** D-sub connector (female)		332433-xx	355209-xx
Complete with D-sub connectors (female and male)		335074-xx	355186-xx
Complete with D-sub connectors (female and female) for IK 220/ND 780		335077-xx	349687-xx
Cable without connectors		244957-01	291639-01
Output cable for ERP 880		Ø 4.5 mm	
With **one** 12-pin PCB connector	 Length 1 m	372164-01	

1) Cable length for Ø 6 mm: max. 9 m

Connecting Elements

				12-pin M23
Mating element on connecting cable to connecting element on encoder	**Connector (female)** 	for cable	Ø 8 mm	291 697-05
Connector for connection to subsequent electronics	**Connector (male)** 	for cable	Ø 8 mm Ø 6 mm	291 697-08 291 697-07
Coupling on encoder cable or connecting cable	**Coupling (male)** 	for cable	Ø 3.7 mm Ø 4.5 mm Ø 6 mm Ø 8 mm	291 698-14 291 698-14 291 698-03 291 698-04
Flange socket for mounting on subsequent electronics	**Flange socket (female)** 			315 892-08
Mounted couplings	**With flange (female)** 		Ø 6 mm Ø 8 mm	291 698-17 291 698-07
	With flange (male) 		Ø 6 mm Ø 8 mm	291 698-08 291 698-31
	With central fastening (male) 		Ø 6 mm to 10 mm	291 698-33 741 045-01
Adapter ∿ 1 VPP/11 µAPP For converting the 1 VPP signals to 11 µAPP; 12-pin M23 connector (female) and 9-pin M23 connector (male)				364 914-01

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**:

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

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

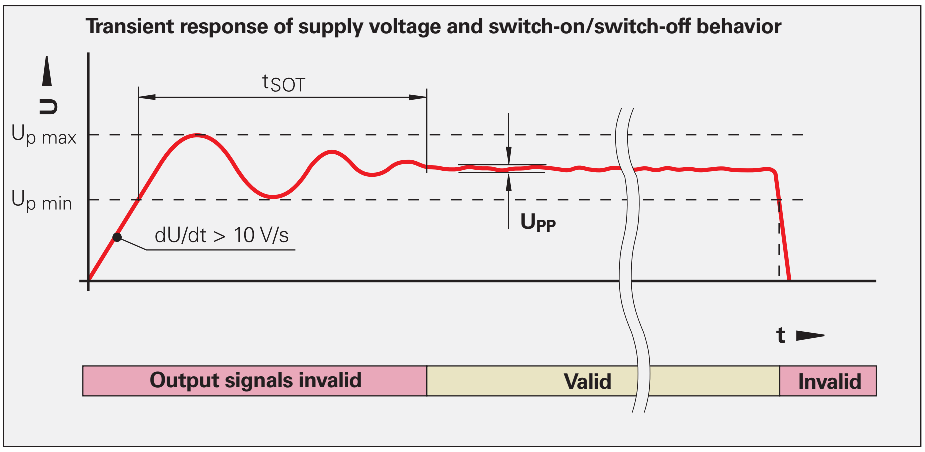
The voltage actually applied to the encoder is to be considered when **calculating the encoder's power requirement.** This voltage consists of the supply voltage U_P provided by the subsequent electronics minus the line drop at the encoder. For encoders with an expanded supply range, the voltage drop 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 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 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)



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	0.05/0.14[6] mm^2	0.14 mm^2
Ø 6 mm **Ø 10 mm**[1]	0.19/0.14[2, 4] mm^2	–	0.08/0.19[6] 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
[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.

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 power lines**

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

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

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

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

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

***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

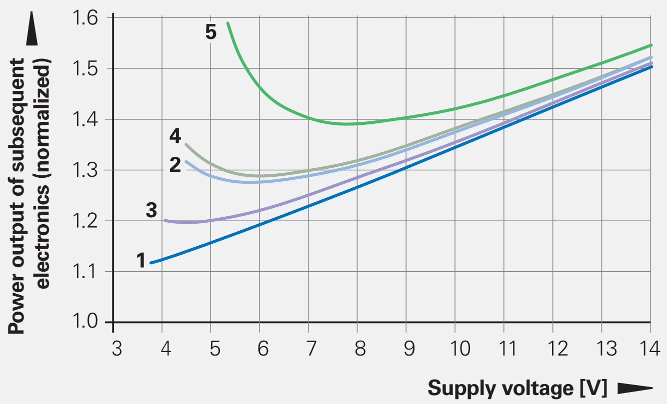
ΔU: Voltage drop in the cable in V

1.05: Length factor due to twisted wires

L_C: Cable length in m

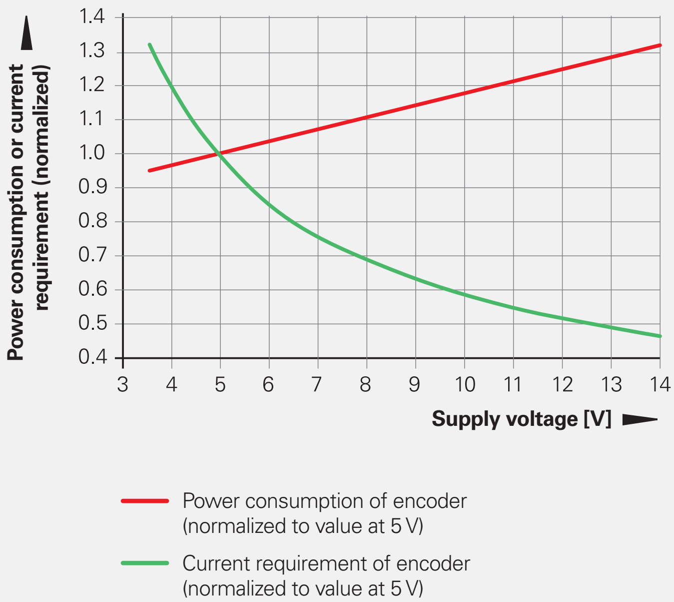
A_P: Cross section of power lines in mm^2

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



	Encoder cable/adapter cable	Connecting 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 –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 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

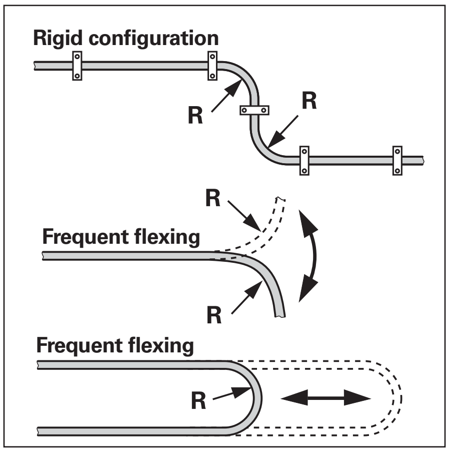
Cables

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 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:

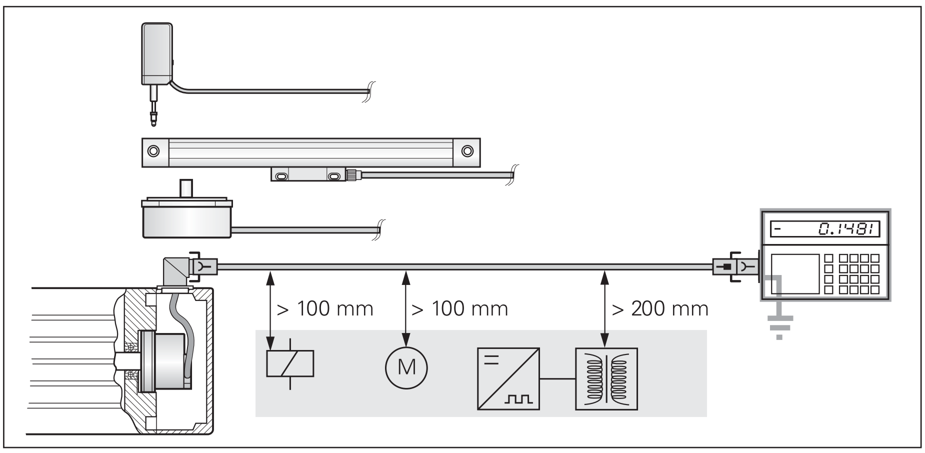
- **Noise immunity EN 61 000-6-2:**
  Specifically:
  - ESD — EN 61 000-4-2
  - Electromagnetic fields — EN 61 000-4-3
  - Burst — EN 61 000-4-4
  - Surge — EN 61 000-4-5
  - Conducted disturbances — EN 61 000-4-6
  - Power frequency magnetic fields — EN 61 000-4-8
  - Pulse magnetic fields — EN 61 000-4-9
- **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.0
- 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 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

Evaluation and Display Units

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

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

	IK 220			
Encoder inputs switchable	∿ 1 V_{PP}	∿ 11 μA_{PP}	EnDat 2.1	SSI
Connection	Two D-sub connections (15-pin, male)			
Input frequency	≤ 500 kHz	≤ 33 kHz	–	
Signal subdivision	4096-fold		–	
Internal memory	8192 position values per input			
Interface	PCI bus (plug and play)			
Driver software and demo program	**For Windows 2000/XP/Vista/7** in VISUAL C++, VISUAL BASIC and BORLAND DELPHI			

IBV / APE series
Interpolation and digitizing electronics
Interpolation and digitizing electronics interpolate and digitize the sinusoidal output signals (∿ 1 V_{PP}) from HEIDENHAIN encoders up to 400-fold, and convert them to TTL square-wave pulse trains.

IBV 101

For more information, see the *IBV 100, IBV 600* and *APE 371* Product Information documents, as well as the *Interface Electronics* Product Overview.

	IBV 101	IBV 102	IBV 660 B	APE 371
Design	Housing			Connector
Protection	IP 65			IP 40
Encoder input	∿ 1 V_{PP}			
Connection	*IBV:* M23 flange socket, 12-pin, female *APE:* D-sub connector, 15-pin, female, or M23 connector, 12-pin, female			
Interpolation switchable	5-fold 10-fold	20-fold 25-fold 50-fold 100-fold	25-fold 50-fold 100-fold 200-fold 400-fold	5-fold 10-fold 20-fold 25-fold 50-fold 100-fold
Output	• Two ⊓⊔ TTL square-wave pulse trains U_{a1} and U_{a2} and their inverted signals $\overline{U_{a1}}$ and $\overline{U_{a2}}$ • Reference pulse U_{a0} and $\overline{U_{a0}}$ • Fault detection signal $\overline{U_{aS}}$ • Limit and homing signals H, L (for APE 371)			
Power supply	5 V ± 5 %			

EIB series
External interface box
The external interface box subdivides the sinusoidal output signals from HEIDENHAIN encoders and converts them into absolute position values with the aid of the integrated counting function. When the reference mark is crossed, the position value is defined with respect to a fixed reference point.

EIB 392

For more information, see the *EIB 192* and *EIB 392* Product Information sheets.

	EIB 192	**EIB 392**
Design	Housing	Connector
Protection	IP 65	IP 40
Encoder input	∿ 1 V_{PP}	
Connection	M23 connector (12-pin), female	• D-sub connector (15-pin), female • M23 connector (12-pin), female
Signal subdivision	≤ 16384-fold	
Interface (output)	*EIB 192/EIB 392:* EnDat 2.2 *EIB 192 F/EIB 392 F:* Fanuc Serial Interface *EIB 192 M/EIB 392 M:* Mitsubishi High Speed Serial Interface	
Power supply	5 V ± 5 %	

EIB 741
External interface box
The EIB 741 is ideal for applications requiring high resolution, fast measured-value acquisition, mobile data acquisition or data storage.
Up to four incremental or absolute HEIDENHAIN encoders can be connected to the EIB 741. The data is output over a standard Ethernet interface.

For more information, see the *EIB 741* Product Information sheet.

	EIB 741		
Encoder inputs switchable	∿ 1 V_{PP}	EnDat 2.1	EnDat 2.2
Connection	Four D-sub connections (15-pin, female)		
Input frequency	≤ 500 kHz	–	
Signal subdivision	4096-fold	–	
Internal memory	Typically 250000 position values per input		
Interface	Ethernet as per IEEE 802.3 (≤ 1 Gbit)		
Driver software and demo program	**For Windows, Linux, LabView** Program examples		

ND 200
Digital readouts for one axis
HEIDENHAIN encoders with 11 µA$_{PP}$ or 1 V$_{PP}$ signals and EnDat 2.2 interface can be connected to the digital readouts of the ND 200 series. The **ND 280** readout provides the basic functions for simple measuring tasks. The **ND 287** also features other functions such as sorting and tolerance check mode, minimum/maximum value storage, measurement series storage. It calculates the mean value and standard deviations and creates histograms and control charts. The ND 287 permits optional connection of a second encoder for sum/difference measurement or of an analog sensor. The ND 28x units have serial interfaces for measured value transfer.

For more information, see the *Digital Readouts/Linear Encoders* brochure.

	ND 280	ND 287
Encoder input[1]	1 x ∼ 11 µA$_{PP}$; ∼ 1 V$_{PP}$ or EnDat 2.2	
Connection	D-sub, 15-pin, female	
Input frequency	∼ ≤ 500 kHz; ≤ 100 kHz	
Signal subdivision	Up to 4096-fold (adjustable)	
Display step (adjustable)	*Linear axis:* 0.5 to 0.002 µm *Angular axis:* 0.5° to 0.00001° and/or 00°00′00.1″	
Functions	• REF reference mark evaluation • 2 datums	
	–	• Sorting and tolerance checking • Measurement series (max. 10000 measured values) • Minimum/maximum value storage • Statistics functions • Sum/difference display (option)
Switching I/O	–	Yes
Interface	V.24/RS-232-C; USB (UART); Ethernet (option for ND 287)	

[1] Automatic detection of interface

ND 780
ND 522, ND 523
Digital readouts for 2 and 3 axes
Digital readouts of the ND 500 and ND 780 series from HEIDENHAIN are designed for use on manually operated machine tools. The **ND 780** has a color flat-panel display and splash-protected full-travel keys. The **ND 500** readouts have a monochrome flat-panel display and membrane keys.

ND 780

For more information, see the *Digital Readouts/Linear Encoders* brochure.

	ND 780	ND 522	ND 523
Encoder inputs[1]	3 x ∼ 1 V$_{PP}$	2 x ⊓⊔ TTL	3 x ⊓⊔ TTL
Connection	15-pin female D-sub connections	9-pin female D-sub connections	
Input frequency	≤ 100 kHz		
Signal subdivision	Up to 1024-fold	1/2/4-fold evaluation	
Display step	*Linear axis:* 1 mm to 0.0001 mm *Angular axis:* 1° to 0.0001° (00° 00′ 01″)		
Functions *Miscellaneous*	• Contour monitoring		
Milling	• Calculation of positions for hole patterns (polar and Cartesian patterns) • Cutting data calculator		
Turning	• Radius/diameter display • Separate/sum display for Z and Z_O • Taper calculator		
Interfaces	RS-232-C/V.24	USB	

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