



HEIDENHAIN



Modular Angle Encoders With Optical Scanning



Information on

- Sealed angle encoders
- Rotary encoders
- Encoders for servo drives
- Exposed linear encoders
- Linear encoders for numerically controlled machine tools
- HEIDENHAIN interface electronics
- HEIDENHAIN controls

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

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



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



For more information:

Comprehensive descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

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	ERP 880	$\pm 0.9''$	38
	ERP 4080/ERP 8080	To $\pm 1.0''$	40
	ERO 6000 series	To $\pm 2.0''$	42
	ERO 6180	$\pm 10''$	44
	ECA 4000 series	To $\pm 1.5''$	46
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Angle encoders from HEIDENHAIN

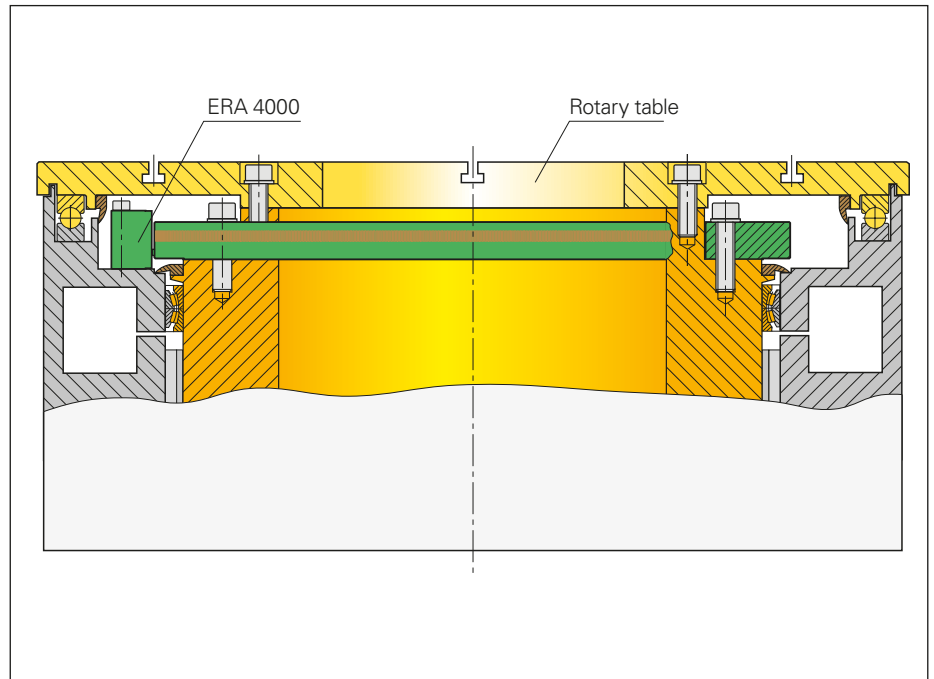
The term angle encoder is typically used to describe encoders that have an accuracy of better than $\pm 5''$ and a line count above 10000.

Angle encoders are found in applications requiring precision angular measurement to accuracies within several arc seconds.

Examples:

- Rotary tables on machine tools
- Swivel heads on machine tools
- C axes on lathes
- Measuring machines for gears
- Printing units of printing machines
- Spectrometer
- Telescopes

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

Angle encoders differ in the following mechanical design principles:

Sealed angle encoders with hollow shaft and stator coupling

The structural arrangement of the stator coupling causes the coupling to absorb only that torque resulting from the bearing friction, particularly during angular acceleration of the shaft. These angle encoders therefore provide excellent dynamic performance. Thanks to the stator coupling, the system accuracy includes the error of the shaft coupling.

The **RCN**, **RON** and **RPN** angle encoders have an integrated stator coupling, while the **ECN** is externally mounted.

Other advantages:

- Compact size for limited installation space
- Hollow shafts up to 100 mm
- Simple installation
- Also available with **Functional Safety**

Selection guide

- For absolute angle encoders see page 12/13
- For incremental angle encoders see page 14/15



RCN 8580 absolute angle encoder



ROD 880 incremental angle encoder with **K 16** flat coupling



ERA 4000 incremental angle encoder



ERM 2000 incremental angle encoder

Sealed angle encoders for separate shaft coupling

ROD and **ROC** angle encoders with solid shafts are particularly suitable for applications with higher speeds or for which larger mounting tolerances are required. The shaft couplings allow axial tolerances of up to ± 1 mm.

For selection guide see page 14/15

Modular angle encoders with optical scanning

The angle gauges without integral bearing, **ERP**, **ERO** and **ERA**, are particularly suitable for high accuracy applications with limited installation space. Particular advantages:

- Large hollow shaft diameter (up to 10 mm with a scale tape)
- High shaft speeds up to 20000 rpm
- No additional starting torque from shaft seals
- Segment versions
- Also available with **Functional Safety**

Modular angle encoders with optical scanning are available with various graduation carriers:

- **ERP/ERO**: Glass circular scale with hub
- **ERA/ECA 4000**: Steel drum
- **ERA 7000/8000**: Steel scale tape

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

For selection guide see page 6 to 9

Modular angle encoders with magnetic scanning

The robust **ERMs** are especially suited for use in production machines. The large inside diameters available, their small dimensions and the compact design of the scanning head predestine them for

- the C axis of lathes,
- for simple rotary and tilting axes (for example, for speed control on direct drives or for installation in gear stages),
- spindle orientation on milling machines or auxiliary axes.

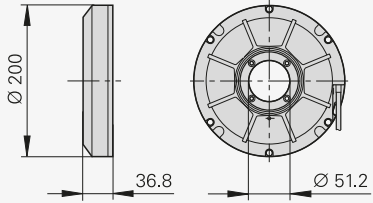
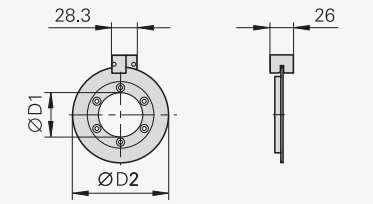
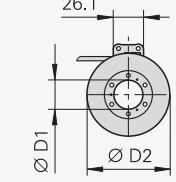
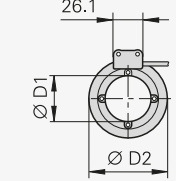
For selection guide see page 10/11

 **For more information:**

You can find detailed information on sealed angle encoders on the Internet at www.heidenhain.de or in the brochures *Sealed Angle Encoders* and *Modular Angle Encoders with Magnetic Scanning*.

Selection guide

Modular angle encoders with optical scanning

Series	Version and mounting	Overall dimensions in mm	Diameter D1/D2	Accuracy of graduation	Mechanically permissible speed ¹⁾
Angle encoders with graduation on glass disk					
ERP 880	Phase grating on glass disk with hub; screwed onto front of shaft		–	±0.9"	≤ 1000 rpm
ERP 4000	Phase grating on glass disk with hub; screwed onto front of shaft		D1: 8 mm D2: 44 mm	±2"	≤ 300 rpm
ERP 8000			D1: 50 mm D2: 108 mm	±1"	≤ 100 rpm
ERO 6000	METALLUR graduation on glass disk with hub; screwed onto front of shaft		D1: 25/95 mm D2: 71/150 mm	±5"/ ±3.5"	≤ 1600 rpm/ ≤ 800 rpm
ERO 6100	Chrome graduation on glass; screwed onto front of shaft		D1: 41 mm D2: 70 mm	±10"	≤ 3500 rpm

¹⁾ Possibly restricted in operation by electrically permissible speed

²⁾ Through integrated interpolation

	Interface	Signal periods/rev	Reference marks	Model	Page
	~ 1 V _{PP}	180000	One	ERP 880	38
	~ 1 V _{PP}	131072	No	ERP 4080	40
	~ 1 V _{PP}	360000	No	ERP 8080	
	~ 1 V _{PP}	9000/ 18000	One	ERO 6080	42
	□□TTL	45000 to 900000 ²⁾	One	ERO 6070	
	~ 1 V _{PP}	4096	One	ERO 6180	44



ERP 880



ERP 4080



ERO 6080

Series	Version and mounting	Overall dimensions in mm	Diameter D1/D2	Accuracy of graduation	Mechanically permissible speed ¹⁾
Angle encoders with graduation on steel scale drum					
ECA 4000 ²⁾³⁾	Steel scale drum with three-point centering		D1: 70 mm to 512 mm three-point centering D2: 104.63 mm to 560.46 mm	±3" to ±1.5"	≤ 15000 rpm to ≤ 8500 rpm
	Steel scale drum with centering collar			±3.7" to ±2"	
ERA 4x80	Steel scale drum with three-point centering		D1: 40 mm to 512 mm D2: 76.5 mm to 560.46 mm	±5" to ±2"	≤ 10000 rpm to ≤ 1500 rpm
	Steel scale drum with centering collar			D1: 40 mm to 270 mm D2: 76.5 mm to 331.31 mm	±4" to ±1.7"
Angle encoders with graduation on steel tape					
ERA 7000	Steel scale tape for internal mounting, full-circle version ⁴⁾ ; scale tape is tensioned on the outside circumference		458.62 mm to 1146.10 mm	± 3.9" to ± 1.6"	≤ 250 rpm to ≤ 220 rpm
ERA 8000	Steel scale tape for external mounting, full-circle version ⁴⁾ ; scale tape is tensioned on the outside circumference		458.11 mm to 1145.73 mm	± 4.7" to ± 1.9"	≈ ≤ 45 rpm

1) Possibly restricted in operation by electrically permissible speed

2) Also available with **Functional Safety**

3) Also available for vacuum applications

4) Segment versions on request

	Interface	Signal periods/rev	Reference marks	Model	Page
	EnDat 2.2	–	–	ECA 4412	46
	Fanuc α i			ECA 4492 F	
	Mitsubishi			ECA 4492 M	
	Panasonic			ECA 4492 P	
	EnDat 2.2			ECA 4410	
	Fanuc α i			ECA 4490 F	
	Mitsubishi			ECA 4490 M	
	Panasonic			ECA 4490 P	
	$\sim 1 V_{PP}$	12000 to 52000	Distance-coded or one	ERA 4280 C	54
		6000 to 44000		ERA 4480 C	
		3000 to 13000		ERA 4880 C	
	$\sim 1 V_{PP}$	12000 to 52000	Distance-coded or one	ERA 4282 C	58
	$\sim 1 V_{PP}$	36 000 to 90000	Distance-coded	ERA 7480 C	60
	$\sim 1 V_{PP}$	36 000 to 90000	Distance-coded	ERA 8480 C	64



ECA 4000



ERA 4000



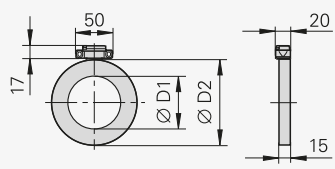
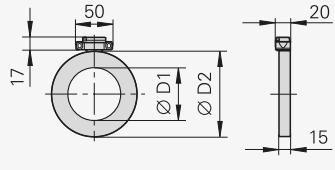
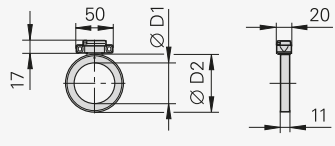
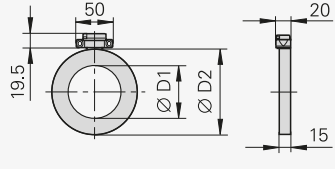
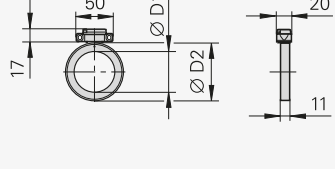
ERA 7480



ERA 8480

Selection guide

Modular angle encoders with magnetic scanning

	Overall dimensions in mm	Diameter	Line count	Signal period
ERM 2200 series		D1: 70 mm to 380 mm D2: 113.16 mm to 452.64 mm	1800 to 7200	≈ 200 μm
ERM 2400 series		D1: 40 mm to 410 mm D2: 75.44 mm to 452.64 mm	600 to 3600	≈ 400 μm
		D1: 40 mm to 100 mm D2: 64.37 mm to 128.75 mm	512 to 1024	≈ 400 μm
		D1: 40 mm; 55 mm D2: 64.37 mm; 75.44 mm	512; 600	
ERM 2410 series		D1: 40 mm to 410 mm D2: 75.44 mm to 452.64 mm	600 to 3600	≈ 400 μm
ERM 2900 series		D1: 40 mm to 100 mm D2: 58.06 mm to 120.96 mm	192 to 400	≈ 1000 μm

¹⁾ The position value is formed in the encoder from the incremental signals after crossing two reference marks.

²⁾ Possibly restricted in operation by electrically permissible speed

Mechanically permissible speed ²⁾	Interface	Model	Further Information
14500 rpm Up to 3000 rpm	~ 1 V _{PP}	AK ERM 2280 TTR ERM 2200C	Brochure: <i>Modular Angle Encoders with Magnetic Scanning</i>
19000 rpm Up to 3000 rpm	□ TTL	AK ERM 2420 TTR ERM 2400	
	~ 1 V _{PP}	AK ERM 2480 TTR ERM 2400	
42000 rpm to 20000 rpm	~ 1 V _{PP}	AK ERM 2480 TTR ERM 2404	
33000 rpm; 27000 rpm	~ 1 V _{PP}	AK ERM 2480 TTR ERM 2405	
19000 rpm Up to 3000 rpm	EnDat 2.2 ¹⁾	AK ERM 2410 TTR ERM 2400C	
47000 rpm to 16000 rpm	~ 1 V _{PP}	AK ERM 2980 TTR ERM 2904	



ERM 2280



ERM 2480



ERM 2484



ERM 2485

Selection guide

Absolute sealed angle encoders

Series	Overall dimensions in mm	System accuracy	Mechanically perm. speed	Position values/ Revolution	Interface	
With integrated stator coupling						
RCN 2000		± 5"	≤ 1500 rpm	67 108 864 ± 26 bits	EnDat 2.2	
		± 2.5"			268 435 456 ± 28 bits	EnDat 2.2
						Fanuc αi
		Mitsubishi				
		EnDat 2.2				
				Fanuc αi		
Mitsubishi						
RCN 5000		± 5"	≤ 1500 rpm	67 108 864 ± 26 bits	EnDat 2.2	
		± 2.5"			268 435 456 ± 28 bits	EnDat 2.2
						Fanuc αi
		Mitsubishi				
		EnDat 2.2				
		Fanuc αi				
Mitsubishi						
RCN 8000		± 2"	≤ 500 rpm	536 870 912 ± 29 bits	EnDat 2.2	
		± 1"			536 870 912 ± 29 bits	EnDat 2.2
						Fanuc αi
		Mitsubishi				
		EnDat 2.2				
		Fanuc αi				
Mitsubishi						
With mounted stator coupling						
ECN 200		± 10"	≤ 3000 rpm	33 554 432 ± 25 bits	EnDat 2.2	
					EnDat 2.2	
				83 886 08 ± 23 bits	Fanuc α	
					Mitsubishi	

	Incremental signals	Signal periods/rev	Type	Further Information
	~ 1 V _{pp}	16384	RCN 2380	Brochure: <i>Sealed Angle Encoders</i>
	-	-	RCN 2310	
	-	-	RCN 2390 F	
	-	-	RCN 2390 M	
	~ 1 V _{pp}	16384	RCN 2580	
	-	-	RCN 2510	
	-	-	RCN 2590 F	
	-	-	RCN 2590 M	
	~ 1 V _{pp}	16384	RCN 5380	
	-	-	RCN 5310	
	-	-	RCN 5390 F	
	-	-	RCN 5390 M	
	~ 1 V _{pp}	16384	RCN 5580	
	-	-	RCN 5510	
	-	-	RCN 5590 F	
	-	-	RCN 5590 M	
	~ 1 V _{pp}	32768	RCN 8380	
	-	-	RCN 8310	
	-	-	RCN 8390 F	
	-	-	RCN 8390 M	
	~ 1 V _{pp}	32768	RCN 8580	
	-	-	RCN 8510	
	-	-	RCN 8590 F	
	-	-	RCN 8590 M	
	~ 1 V _{pp}	2048	ECN 225	Brochure: <i>Sealed Angle Encoders</i>
	-	-	ECN 225	
	-	-	ECN 223 F	
	-	-	ECN 223 M	



RCN 2000



RCN 5000



RCN 8000
Ø 60 mm



RCN 8000
Ø 100 mm



ECN 200
Ø 50 mm

Selection guide

Incremental sealed angle encoders

Series	Overall dimensions in mm	System accuracy	Mechanically permissible speed ¹⁾	Interface
With integrated stator coupling				
RON 200		± 5"	≤ 3000 rpm	□ TTL
		± 2.5"		□ TTL
RON 700		± 2"	≤ 1000 rpm	~ 1 V _{PP}
				~ 1 V _{PP}
RON 800 RPN 800		± 1"	≤ 1000 rpm	~ 1 V _{PP}
RON 900		± 0.4"	≤ 100 rpm	~ 11 μA _{PP}
For separate shaft coupling				
ROD 200		± 5"	≤ 10000 rpm	□ TTL
				□ TTL
				~ 1 V _{PP}
ROD 700		± 2"	≤ 1000 rpm	~ 1 V _{PP}
ROD 800		± 1"	≤ 1000 rpm	~ 1 V _{PP}

¹⁾ Possibly restricted in operation by the electrically permissible speed

²⁾ With integrated interpolation

	Signal periods/rev	Type	Further Information
	18000 ²⁾	RON 225	Brochure: <i>Sealed Angle Encoders</i>
	180000/90000 ²⁾	RON 275	
	18000	RON 285	
	18000	RON 287	
	18000	RON 785	
	18000/36000	RON 786	
	36000	RON 886	
	180000	RPN 886	
	36000	RON 905	

	18000 ²⁾	ROD 220	Brochure: <i>Sealed Angle Encoders</i>
	180000 ²⁾	ROD 270	
	18000	ROD 280	
	18000/36000	ROD 780	
	36000	ROD 880	



RON 285



RON 786



RON 905



ROD 280



ROD 780

Measuring principles

Measuring standard

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

These graduations are applied to a carrier substrate of glass or steel. The scale substrate for large measuring lengths 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 chromium 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 finer
- OPTODUR phase grating: optically three dimensional, planar structure with particularly high reflectance, typical graduation period of 2 µm and less

Along with these very fine grating periods, these processes permit 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 dividing engines.

DIADUR, AURODUR and METALLUR are registered trademarks of DR. JOHANNES HEIDENHAIN GmbH, Traunreut.

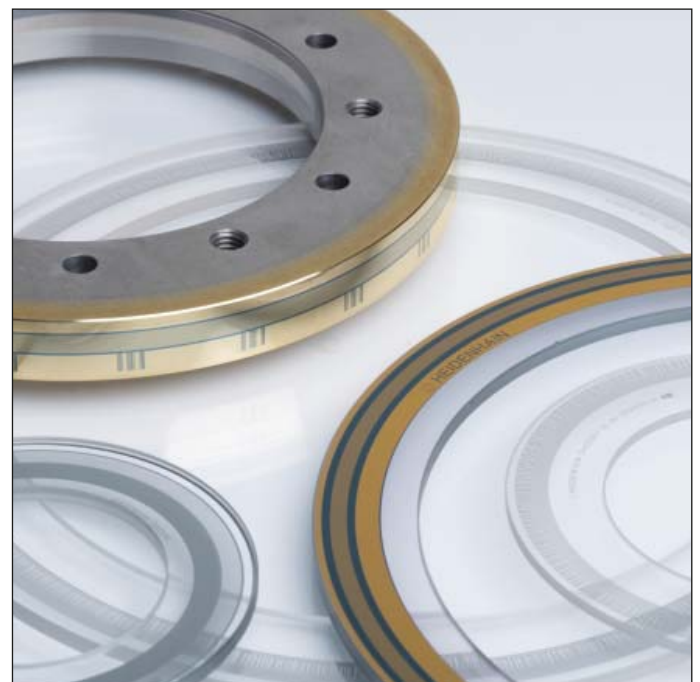
Absolute measuring method

With the absolute measuring method, the position value is available from the encoder immediately upon switch-on and can be called at any time by the subsequent electronics. There is no need to move the axes to find the reference position.

The absolute position information is read from the **graduated disk** which is formed from a serial absolute code structure. The code structure is unique over one revolution. A separate incremental track is read with the single-field scanning principle and interpolated for the position value.



Graduated disk with serial absolute code track and incremental track



Absolute and incremental circular scales and scale drums

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 HEIDENHAIN 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—only a few degrees of rotation (see nominal increment N in table below).

Encoders with distance-coded reference marks are identified with a "C" ending 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:

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

where:

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

Where:

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

abs = Absolute value

sgn = Algebraic sign function (= "+1" or "-1")

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

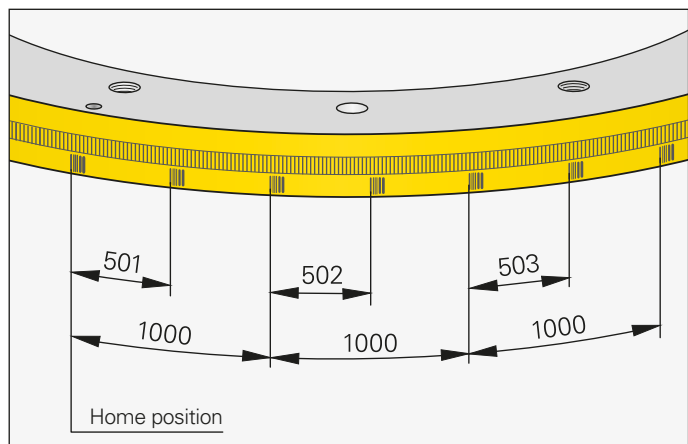
N = Nominal increment between two fixed reference marks (see tables)

GP = Grating period ($\frac{360^\circ}{\text{Signal period}}$)

D = Direction of rotation (+1 or -1)
The rotation as per mating dimensions result in "+1"

ERA 7480C, ERA 8480C

Signal period z	Number of reference marks	Nominal increment N
36000	72	10°
45000	90	8°
90000	180	4°



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

ERA 4000C

Signal period with grating period			Number of reference marks	Nominal increment N
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°

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 micrometers 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 angle encoders use two scanning principles:

- The **imaging scanning principle** for grating periods from 20 μm and 40 μm
- The **interferential scanning principle** for very fine graduations with grating periods of, for example, 8 μm .

Imaging principle

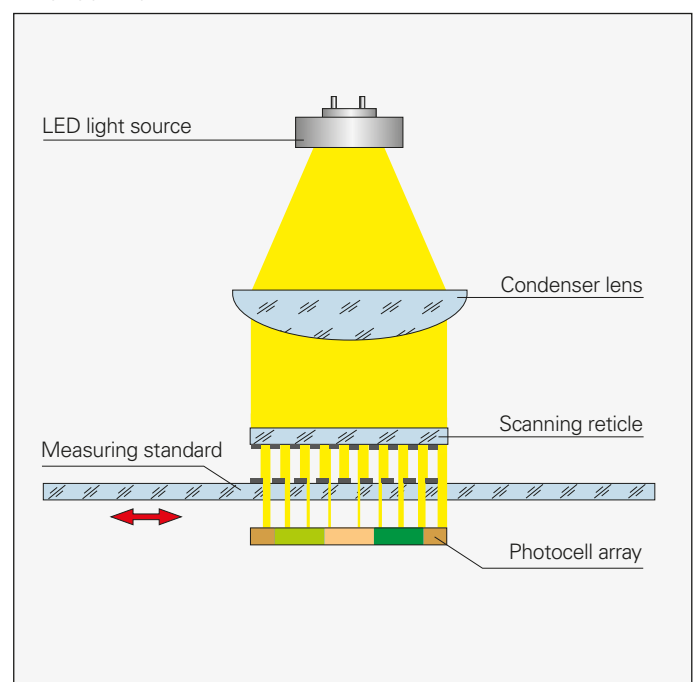
To put it simply, the imaging scanning principle functions by means of projected-light signal generation: Two scale gratings with equal or similar grating periods are moved relative to each other—the measuring standard and the scanning reticle. The carrier material of the scanning reticle is transparent, 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 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. An array of photovoltaic cells converts 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 tolerated the gap must be between the scanning reticle and 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.

Imaging principle



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.

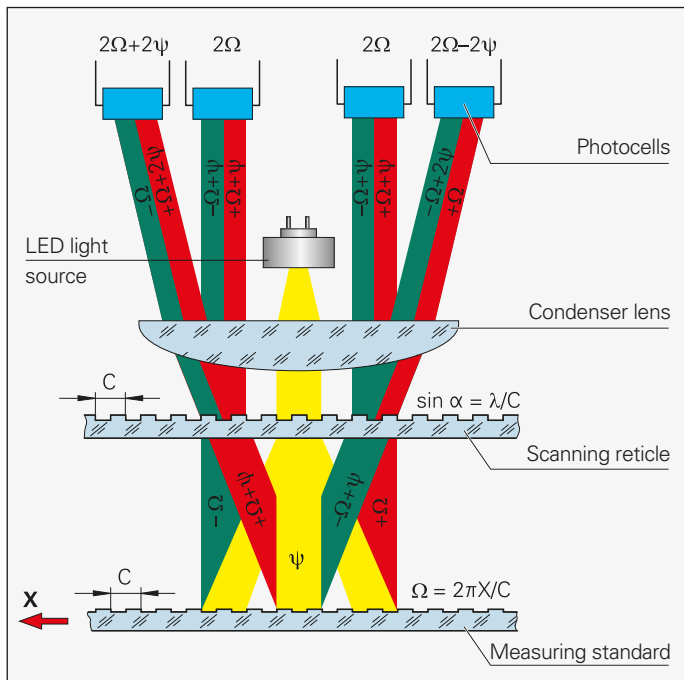
A relative motion of the scanning reticle to the scale causes the diffracted wave fronts to undergo a phase shift: When the grating moves by one period, the wave front of the first order is displaced by one wavelength in the positive direction, and the wavelength of diffraction order -1 is displaced 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 grating periods of, for example, 8 μm, 4 μm and finer. Their scanning signals are largely free of harmonics and can be highly interpolated. These encoders are therefore especially suited for small measuring steps and high accuracy.

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

Interferential scanning principle (optics schematics)

- C Grating period
- ψ Phase shift of the light wave when passing through the scanning reticle
- Ω Phase shift of the light wave due to motion X of the scale



Measuring accuracy

The accuracy of angular measurement is mainly determined by

- the quality of the graduation,
- the stability of the graduation carrier,
- the quality of the scanning process,
- the quality of the signal processing electronics,
- the eccentricity of the graduation to the bearing,
- the bearing error, and
- the coupling to the measured shaft.

These factors of influence are comprised of encoder-specific error and application-dependent issues. All individual factors of influence must be considered in order to assess the attainable overall accuracy.

Encoder-specific error

The encoder-specific error is given in the Specifications:

- Accuracy of graduation
- Interpolation errors within one signal period

Accuracy of graduation

The accuracy $\pm a$ of the graduation results from its quality. This includes

- the homogeneity and period definition of the graduation,
- the alignment of the graduation on its carrier,
- *for encoders with solid graduation carriers*: the stability of the graduation carrier in order to also ensure accuracy in the mounted state,
- *for encoders with steel scale tape*: the error due to irregular scale-tape expansion during mounting, as well as the error at the scale-tape butt joints with full circle applications.

The accuracy of the graduation $\pm a$ is ascertained under ideal conditions by using a series-produced scanning head to measure interpolation error at positions that are integral multiples of the signal period.

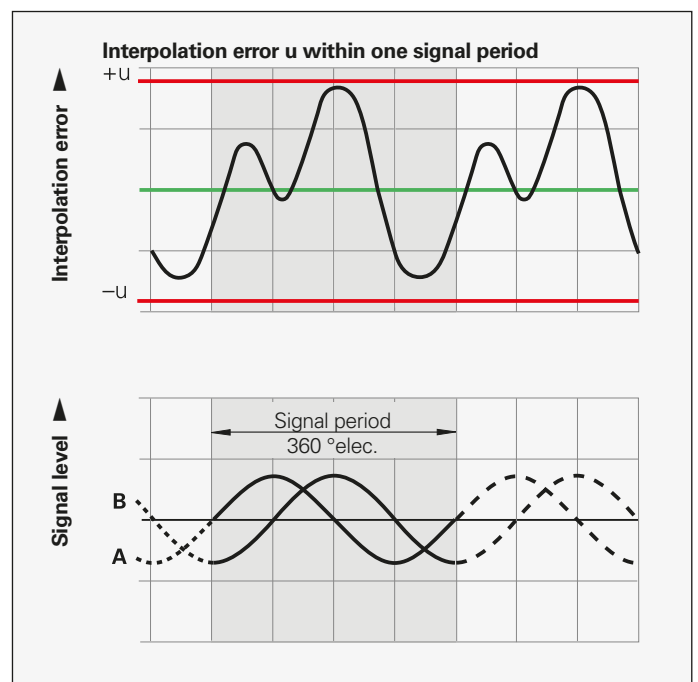
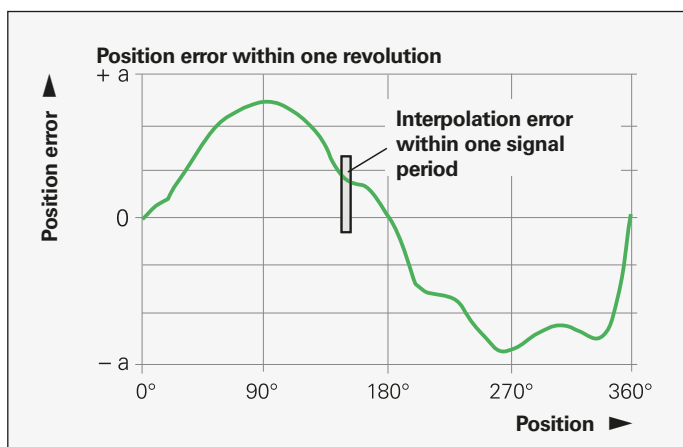
Interpolation errors within one signal period

The interpolation errors within one signal period $\pm u$ results from the quality of the scanning and—for encoders with integrated pulse-shaping or counter electronics—the quality of the signal-processing electronics. For encoders with sinusoidal output signals, however, the errors are determined by the signal processing circuitry of the subsequent electronics.

The following individual factors influence the result:

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

These influences are to be considered when specifying interpolation error within one signal period.



Interpolation errors within one signal period $\pm u$ is specified in percent of the signal period. For modular angle encoders without integral bearing the value is typically better than $\pm 1\%$ of the signal period (ERP 880: $\pm 1.5\%$). You will find the specified values in the Specifications.

Interpolation errors within one signal period already become apparent in very small rotational motions and in repeated measurements. They especially lead to speed ripples in the speed control loop.

Application-dependent error

The mounting and adjustment of the scanning head, in addition to the given encoder-specific error, normally have a significant effect on the accuracy that can be achieved by **encoders without integral bearings**. Of particular importance are the mounting eccentricity of the graduation and the radial runout of the measured shaft. The application-dependent error values must be measured and calculated individually in order to evaluate the overall accuracy.

In contrast, the specified system accuracy for encoders with integral bearing already includes the error of the bearing and the shaft coupling (see brochure *Angle Encoders with Integral Bearing*).

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 steel scale tape is mounted. In addition, dimensional and form errors of the customer's shaft can result in added eccentricity. The following relationship exists between the eccentricity e , the graduation diameter D and the measuring error $\Delta\varphi$ (see illustration below):

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

$\Delta\varphi$ = Measurement error in " (angular seconds)

e = Eccentricity of the scale drum to the bearing in μm (1/2 radial runout)

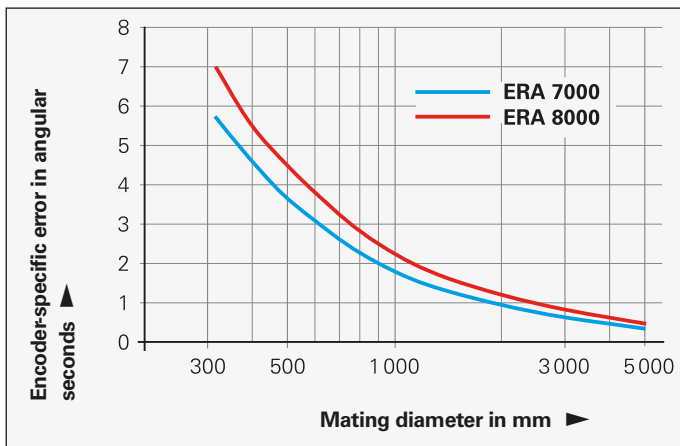
D = Mean graduation diameter in mm

M = Center of graduation

φ = "True" angle

φ' = Scanned angle

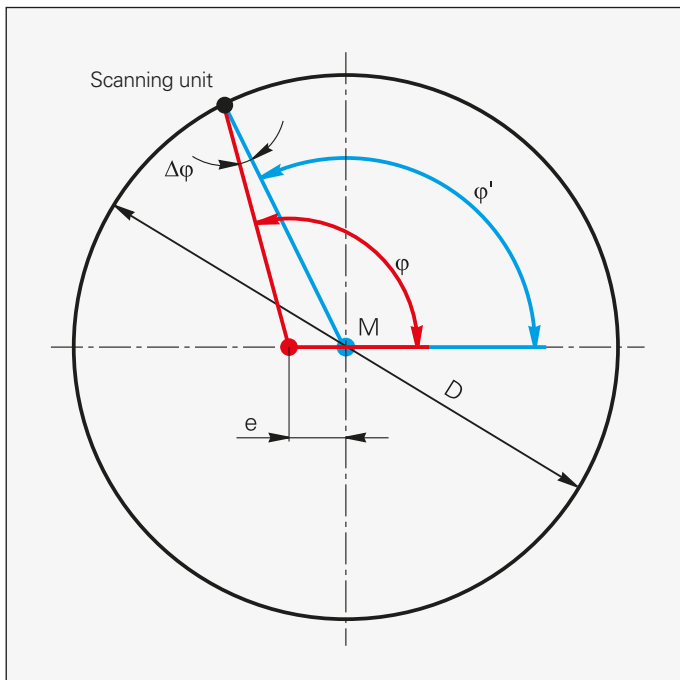
Encoder-specific errors with ERA 7000 and ERA 8000



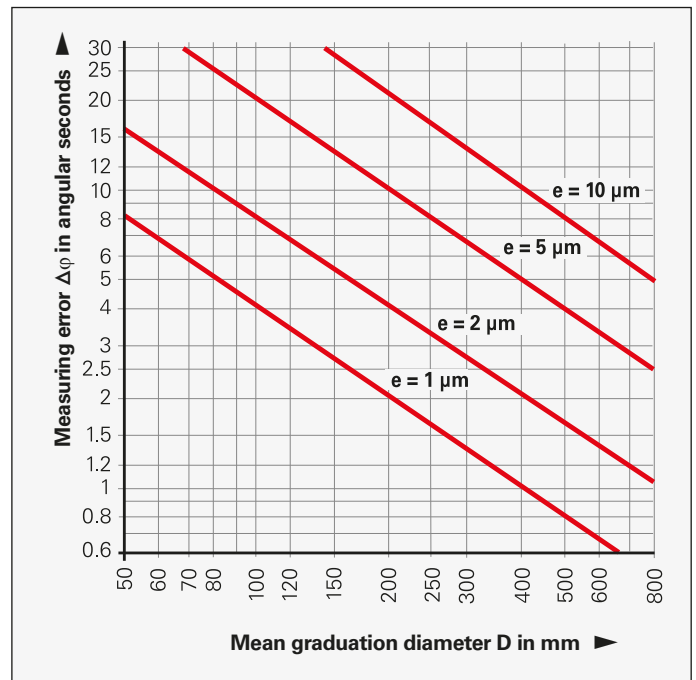
Mean graduation diameter D for:

ERP 880	$D = 126 \text{ mm}$
ERP 4000	$D = 40 \text{ mm}$
ERP 8000	$D = 104 \text{ mm}$
ERO 6000	$D = 64 \text{ mm or } 142 \text{ mm}$
ERO 6100	$D = 64 \text{ mm}$
ERA 4000	$D \triangleq \text{Drum outside diameter}$
ECA 4000	$D \triangleq \text{Drum outside diameter}$
ERA 7000	$D \triangleq \text{Scale mating diameter}$
ERA 8000	$D \triangleq \text{Scale mating diameter}$

Eccentricity of the graduation to the bearing



Resultant measurement error $\Delta\varphi$ for various eccentricity values e as a function of graduation diameter D



Error due to radial runout of the bearing

The equation for the measuring error $\Delta\phi$ 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.

Deformation of the graduation resulting from mounting

The profile, reference surfaces, position of the graduation relative to the mounting surface, mounting holes, etc. of the scale drums and disk/hub assemblies are all designed so that the mounting and operation only marginally influence the accuracy of the encoders.

Shape and diameter error of the bearing surface (for ERA 7000 and ERA 8000)

Shape errors of the bearing surface can impair the attainable system accuracy.

In the segment solutions, the additional angular error $\Delta\phi$ occurs if the nominal scale-tape bearing-surface diameter is not exactly maintained:

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

where

$\Delta\phi$ = 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 signal period 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 signal period per 360°

z' = Actual signal period per 360°

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

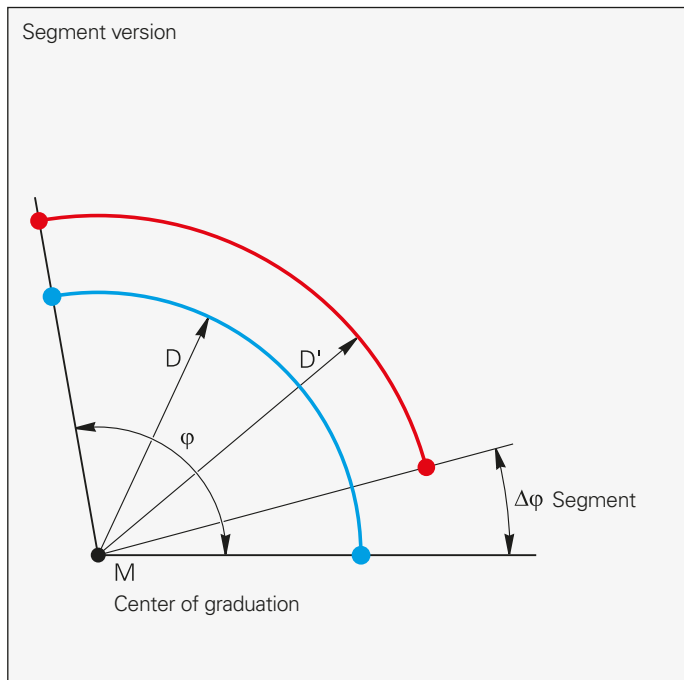
Compensation possibilities

The mounting eccentricity of the graduation and the radial runout of the measured shaft cause a large share of the application-dependent errors. A common and effective method of eliminating these errors is to mount two or even more scanning heads at equal distances around the graduation carrier. The subsequent electronics mathematically combine the individual position values.

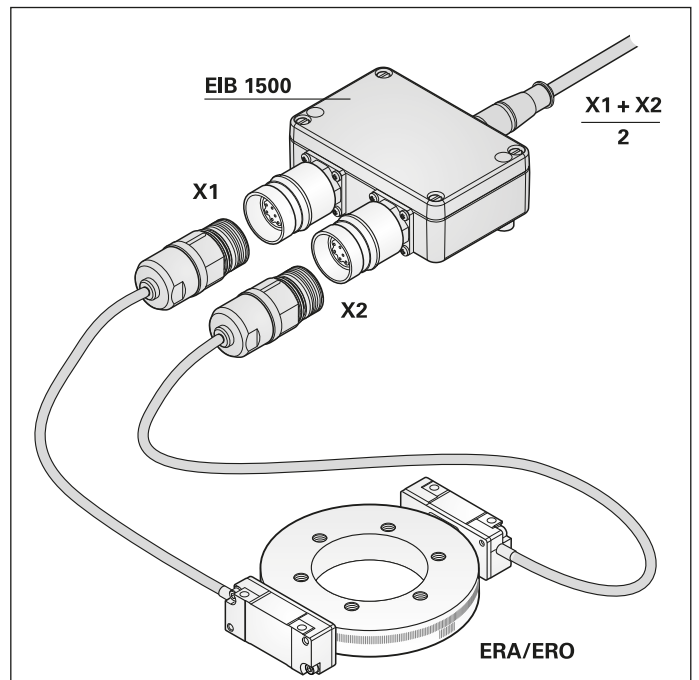
The EIB 1500 from HEIDENHAIN is an electronics unit suitable for mathematically combining the position values from two scanning heads in real time and without negative influences on the control loop (see *Evaluation and display units*).

The accuracy improvement actually attained by this in practice strongly depends on the installation situation and the application. In principle, all eccentricity errors (reproducible errors due to mounting errors, non-reproducible errors due to radial eccentricity of the bearing) as well as all uneven harmonics of the graduation error are eliminated.

Angular error due to variations in scale-tape carrier diameter



Position calculation of two scanning heads in order to compensate for eccentricity and radial runout



Calibration chart

For all angle encoders from HEIDENHAIN, proper function is checked and accuracy is measured before delivery. The accuracy of the angle encoders is determined during traverse over one revolution. The number of measuring positions is selected to determine very exactly not only the long-range error, but also the interpolation error within one signal period. Errors resulting from mounting are not included.

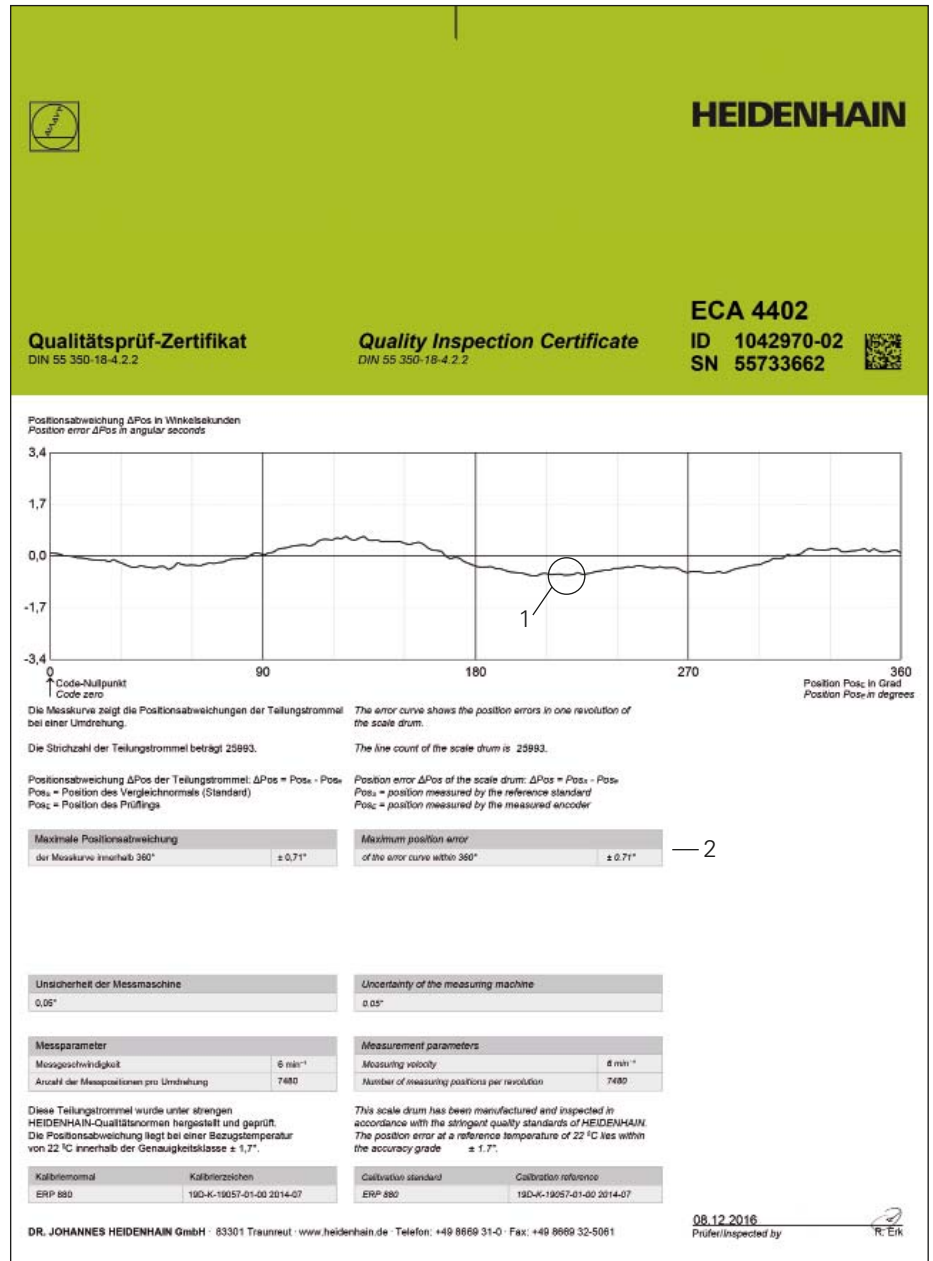
The **Quality Inspection Certificate** confirms the specified **graduation accuracy** of each encoder. The **calibration standards** ensure the traceability—as required by EN ISO 9001—to recognized national or international standards.

For the ERP, ERO 6000, ERA 4000, and ECA 4000 series, a calibration chart also documents the ascertained **position error**. It also indicates the measuring parameters and the uncertainty of the calibration measurement.

Temperature range

The angle encoders are inspected at a **reference temperature** of 22 °C. The system accuracy given in the calibration chart applies at this temperature.

For testing and calibration purposes, modular angle encoders with solid graduation carriers are mounted at HEIDENHAIN in exactly the same way as in the application later. This ensures that it is possible to apply the accuracy determined at HEIDENHAIN exactly to the machine.



Calibration chart using the example of the ECA 4402 scale drum

- 1 Graphic representation of the graduation error
- 2 Result of calibration

Reliability

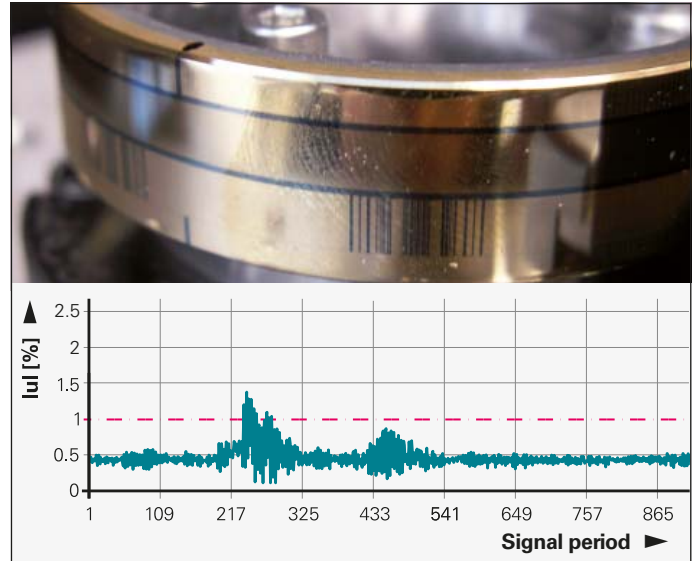
Modular angle encoders with optical scanning from HEIDENHAIN are optimized for use on fast, precise machines. In spite of the exposed mechanical design, they are highly tolerant to contamination, ensure high long-term stability, and are quickly and easily mounted.

Lower sensitivity to contamination

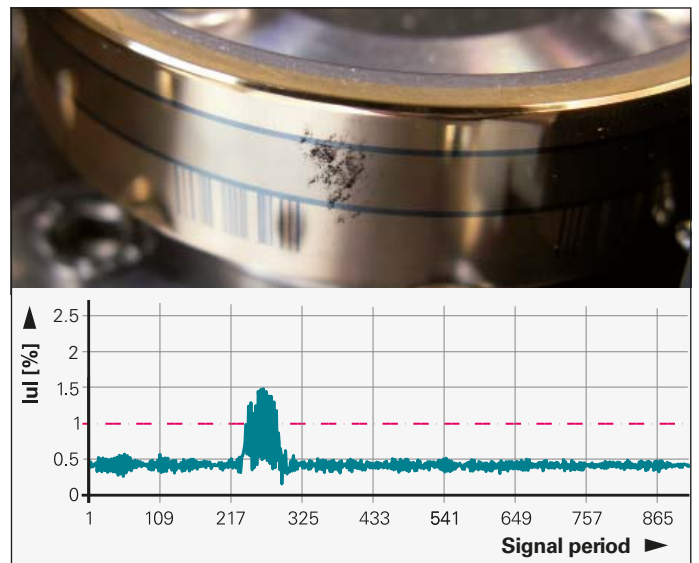
Both the high quality of the grating and the scanning method are responsible for the accuracy and reliability of the encoders. Encoders from HEIDENHAIN operate with **single-field scanning**. Only one scanning field is used to generate the scanning signals. Local contamination on the measuring standard (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 interpolation error 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 interpolation errors within one revolution remain far below the specified accuracy.

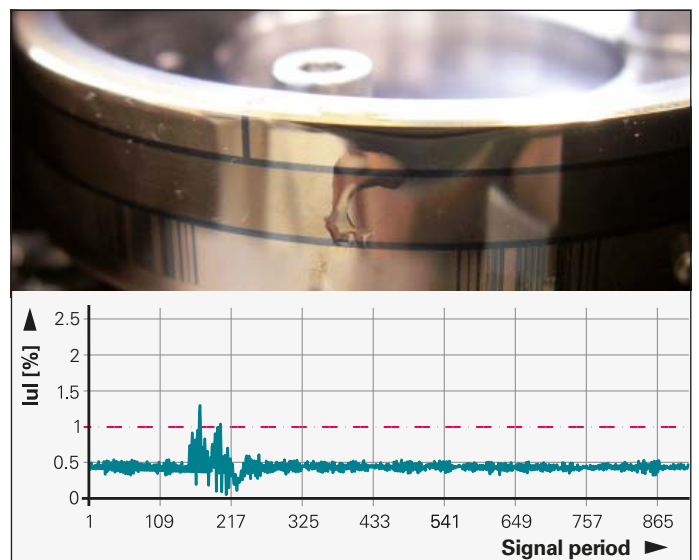
The figures at right show the results of contamination tests with ERA 4000 encoders. The maximum interpolation errors within one signal period $|u|$ are indicated. Despite significant contamination, the specified value of $\pm 1\%$ is exceeded only slightly.



Contamination by fingerprint



Contamination by toner dust



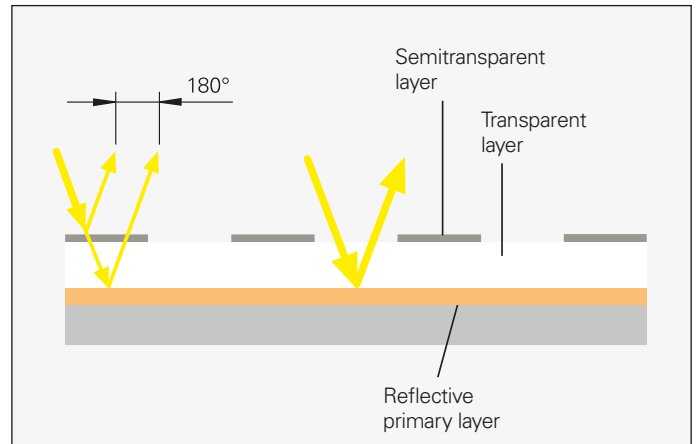
Contamination by water drops

Durable measuring standards

By the nature of their exposed design, the measuring standards of modular angle encoders with optical scanning 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.

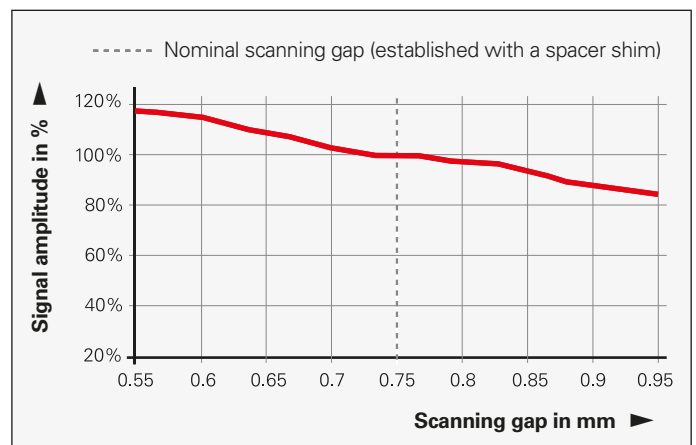
In the METALLUR process a reflective gold layer is covered with a thin layer of glass. On this layer are lines of chrome only several nanometers thick, which are semitransparent and act as absorbers. Measuring standards with METALLUR graduations have proven to be particularly robust and insensitive to 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 modular angle encoders from HEIDENHAIN have only a slight influence on the output signals. In particular, a variation in the scanning gap between the graduation carrier and scanning head causes only negligible change in the signal amplitude, and barely affect the interpolation 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

Modular angle encoders with optical scanning consist of a scanning head and a graduation carrier. The graduation carrier can either be a scale tape or a solid component, such as a scale drum or disk/hub assembly. The position 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 so designed 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, the scanning head should be fastened to a bracket or by using appropriate fixed stops.

All modular angle encoders with optical scanning and **solid graduation carriers** are designed so that the specified accuracy can actually be achieved in the application. The mounting methods and alignment strategies ensure the highest possible reproducibility.

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

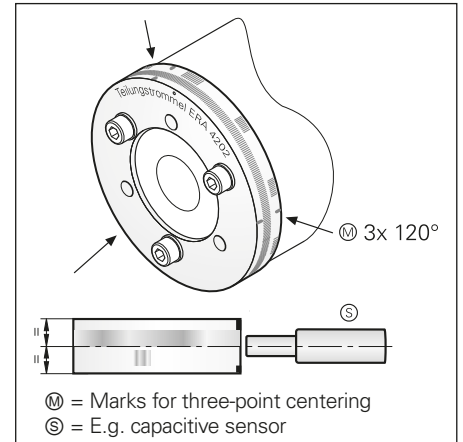
Graduation carriers made from glass are often centered with the aid of a microscope. This method uses the clear and unambiguous reference edges or centering rings on the graduation carriers.

4. Centering with two scanning heads

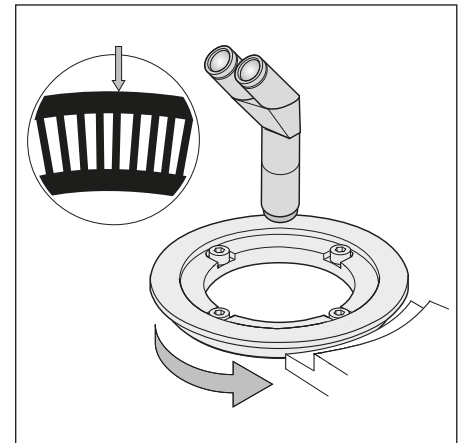
This strategy is suited for all angle encoders without integral bearing with solid graduation carriers. Since HEIDENHAIN graduations typically have long-range error characteristics, and the graduation or position value itself is used as reference here, this is the most exact of all centering strategies.

Scanning heads

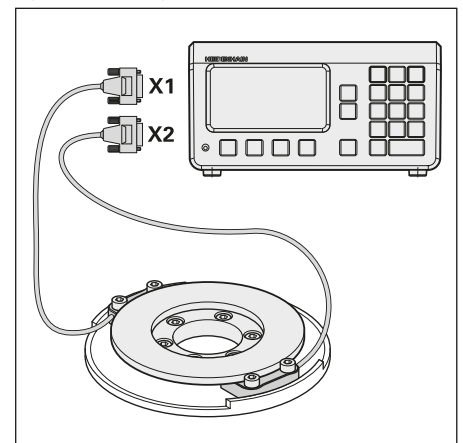
Since final assembly of the modular angle encoders with optical scanning takes place on the machine, exact mounting of the scanning head is necessary once the graduation carrier has been mounted. For exact alignment of the scanning head to the scale, it must in principle be aligned and adjustable in 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.



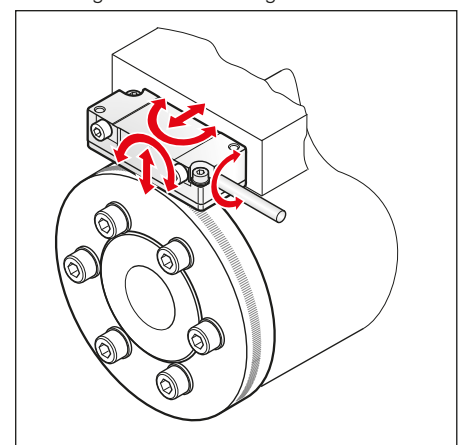
Three-point centering



Optical centering



Centering with two scanning heads

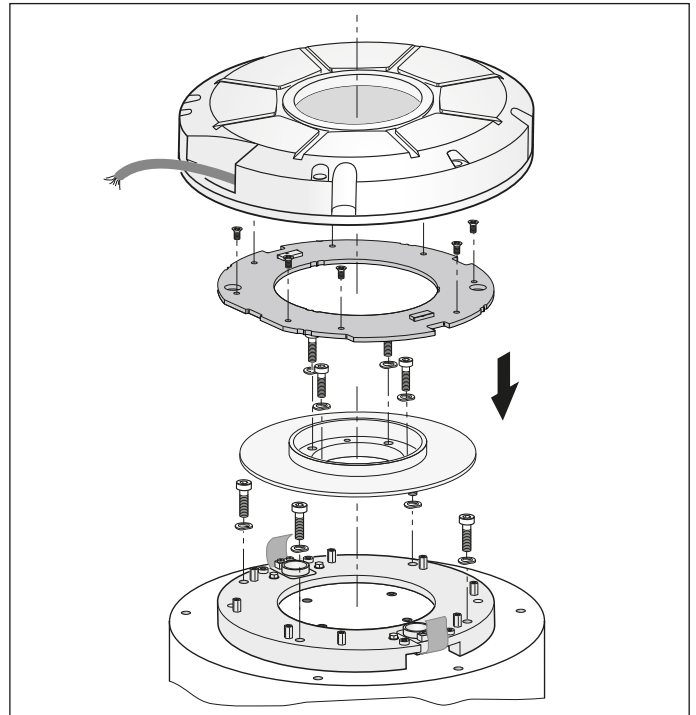


ERP 880

The ERP 880 modular angle encoder consists of the following components: scanning unit, disk/hub assembly, and PCB. Housings 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 $\pm 1.5 \mu\text{m}$. Then the disk/hub assembly is screwed onto the front of the shaft, and is also aligned with a maximum eccentricity of $\pm 1.5 \mu\text{m}$ to the scanning unit. Then the PCB is attached and connected to the scanning unit. Fine adjustment takes place with "electrical centering" using the PVM 9 (see *HEIDENHAIN measuring equipment*) and an oscilloscope. A housing can protect the ERP 880 from contamination.



Mounting
the ERP 880
(in principle)

IP 40 housing

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

IP 64 housing

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



ERP 4080/ERP 8080

The ERP 4080 and ERP 8080 modular angle encoders are intended for measuring tasks requiring utmost precision and resolution. They operate on the principle of interferentially scanning a phase grating. They consist of a scanning head and a disk/hub assembly.

Determining the axial mounting tolerance

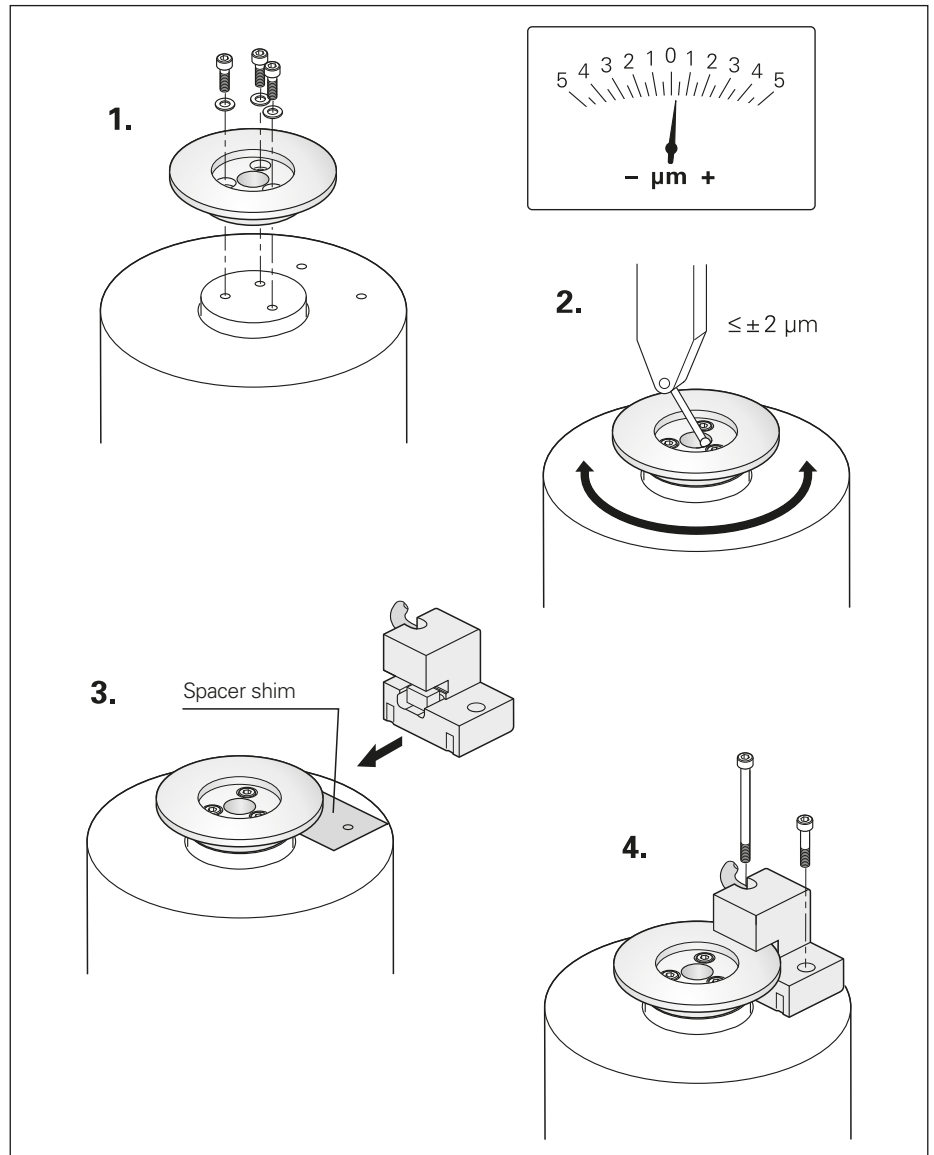
To attain the greatest possible accuracy, it is important to ensure that the wobble of the shaft and the wobble of the disk/hub assembly do not add to each other. The positions of the maximum and minimum wobble of the hub are marked. The wobble of the shaft must be measured and the maximum and minimum 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 $\geq 0.9 V_{PP}$.



Optional accessories

Mounting aid

For adjusting the scanning head
ID 622976-02

Adapter for length gauges

For measuring the mounting tolerances
ID 627142-01

Spacer shims

For axial position adjustment

10 μm	ID 619943-01
20 μm	ID 619943-02
30 μm	ID 619943-03
40 μm	ID 619943-04
50 μm	ID 619943-05
60 μm	ID 619943-06
70 μm	ID 619943-07
80 μm	ID 619943-08
90 μm	ID 619943-09
100 μm	ID 619943-10

Set (one shim each from
10 μm to 100 μm): ID 619943-11

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

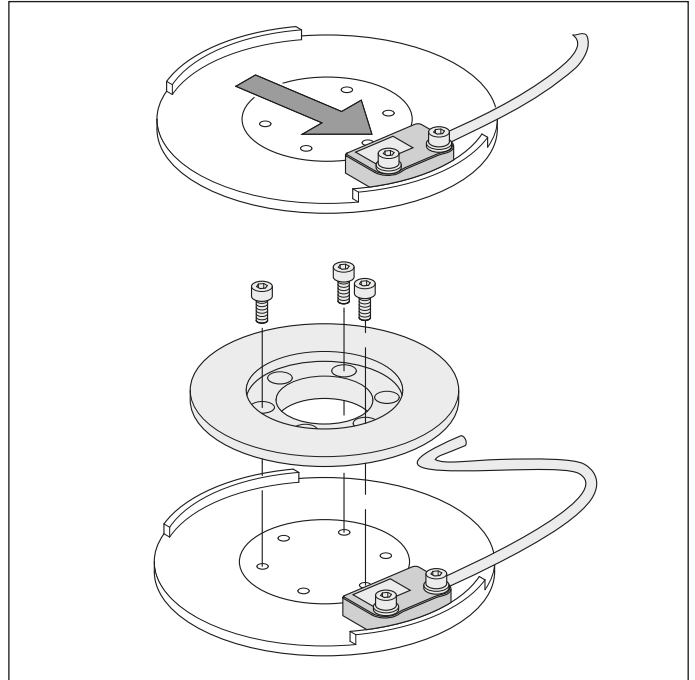
A mating surface with fixed stop and defined inside diameter is advantageous for simple mounting of the scanning head. The scanning head is pressed against this mounting surface and secured with two screws. No further alignment is necessary. Then the disk/hub assembly is screwed onto the front of the 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

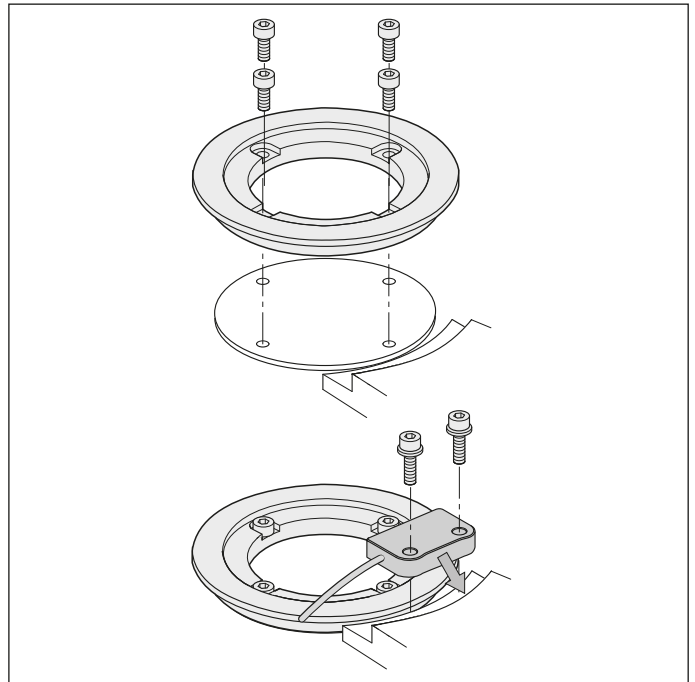
The disk/hub assembly is mounted on the shaft axially and centered optically. A mounting bracket with stop edge and defined inside diameter, and that can be adjusted axially, is advantageous for simple mounting of the scanning head. The scanning head is pressed against the stop surfaces of the mounting bracket and then secured with two screws. The included spacer shim 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



ERA 4000/ECA 4000 series

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

The scale drums are available in the versions with centering collar and with three-point centering.

The ERA 4x80 versions are available with various grating periods depending on the accuracy requirements. The appropriate scanning heads for specific scale drums are shown in the table at right. Furthermore, the correspondence between the diameters or the number of signal peaks of the graduation drum and the scanning head must be taken into account. Special design measures are required to protect the ERA and ECA 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 and ECA modular angular encoders assure comparatively fast mounting and easy adjustment.

Mounting the ERA 4x00/ECA 4400 scale drums

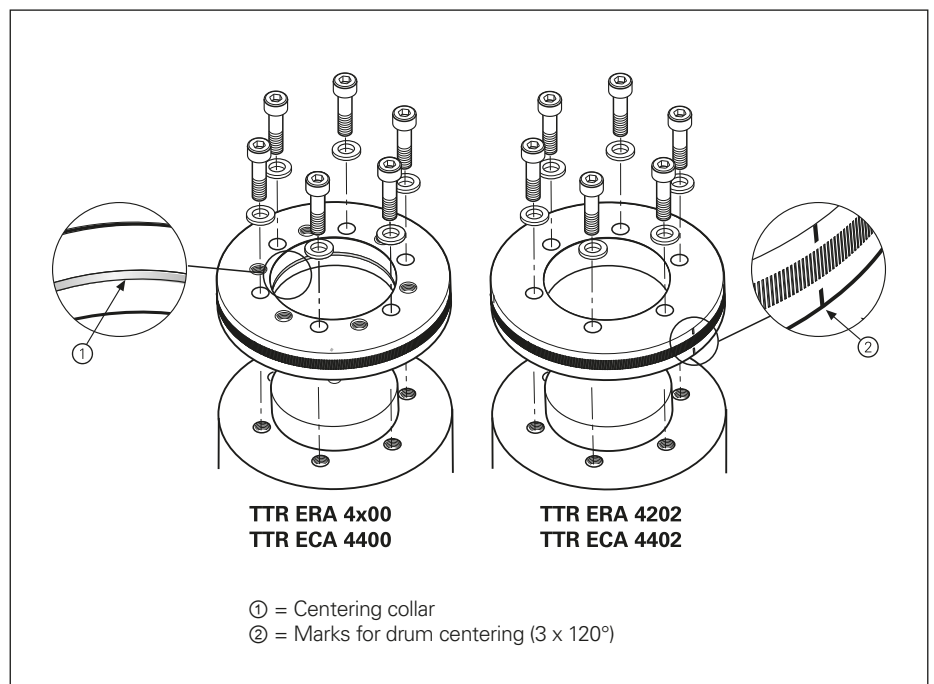
The scale drum is centered via the centering collar on its inner circumference. Two centering methods are possible:

- a) The graduation drum is slid onto the receiving shaft or thermally shrunk (see also the Functional Safety section) and fastened with screws. The drum does not need to be adjusted. The scale drums can or should be heated for assembly.
- b) The scale drums are centered on the inner diameter via the centering collar.

Mounting the ERA 4202/ECA 4402 scale drums

The scale drums are 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. Centering via the inside diameter is not possible.

Design of the scale drum	Centering methods	Model of scale drum	Appropriate scanning head
With centering collar	<ul style="list-style-type: none"> • Slid or heat-shrunk onto shaft • Centering on the inside diameter 	TTR ERA 4200	AK ERA 4280
		TTR ERA 4400	ERA 4480 scanning head
		TTR ERA 4800	ERA 4880 scanning head
		TTR ECA 4400 scale drum	AK ECA 4410 AK ECA 4490
With three-point centering	<ul style="list-style-type: none"> • Centering on the outside diameter 	TTR ERA 4202	AK ERA 4280
		TTR ERA 4402	AK ECA 4410 AK ECA 4490

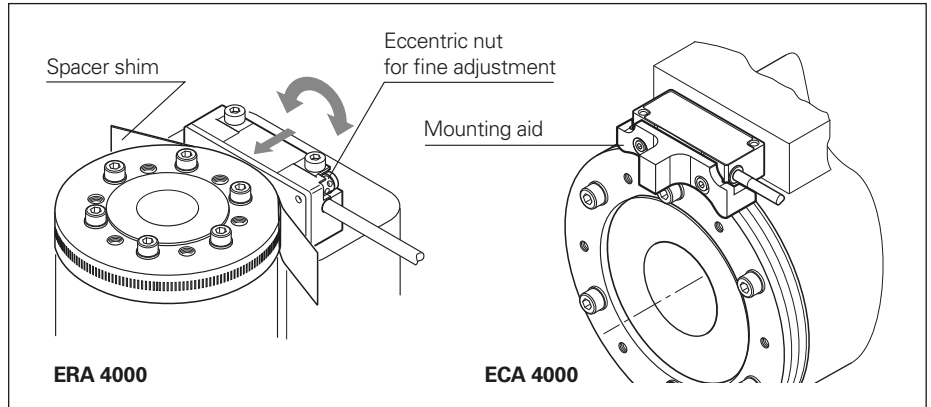


Mounting the scale drums

In addition to the encoder-specific centering methods, centering with two scanning heads is possible.

Mounting the scanning head

To mount the scanning head, a spacer shim or a mounting aid is placed between the surface of the scale drum and the scanning head. The scanning head is pressed against them, fastened, and the shim or mounting aid is removed. ERA 4000 encoders with 20 µm grating period also feature an eccentric bushing for fine adjustment of the scanning field.

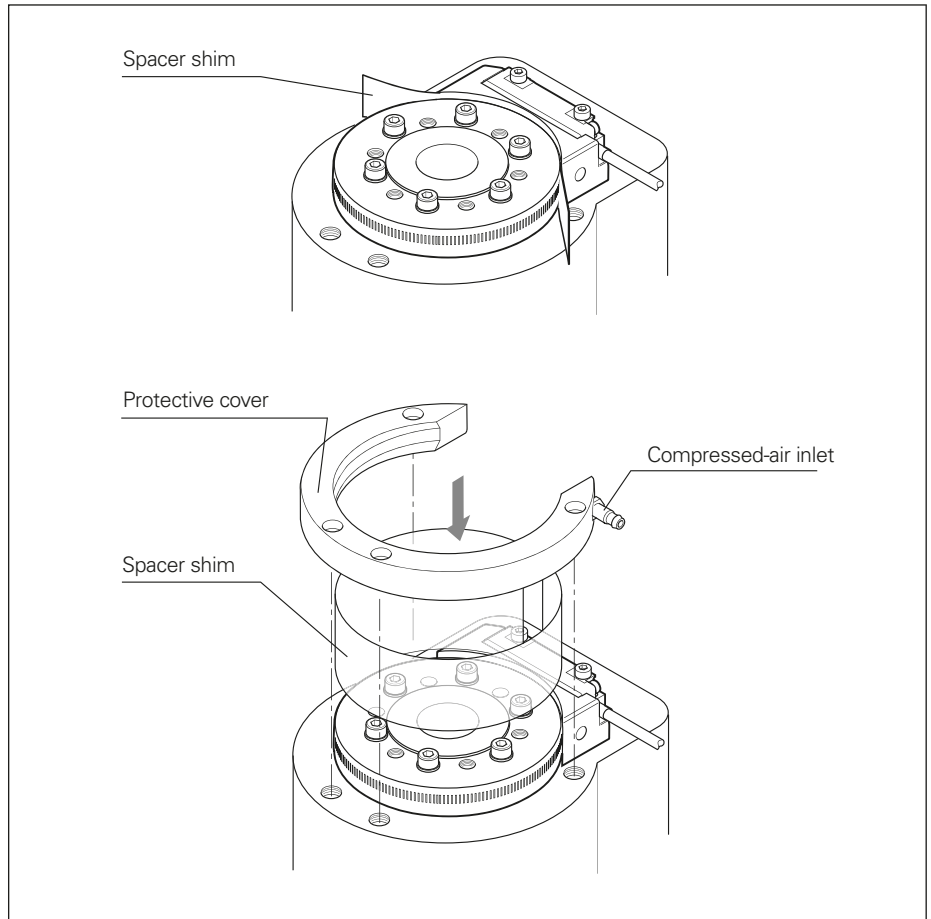


Mounting the scanning head

Mounting the protective cover

Some variants of the ERA 4000 angle encoders are optionally available with protective covers. 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 shim 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 shim is removed. For information about the compressed-air inlet see *General mechanical information*.



Mounting an ERA 4480 with protective cover

ERA 7000 and ERA 8000 series

The ERA 7000 and ERA 8000 series of 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

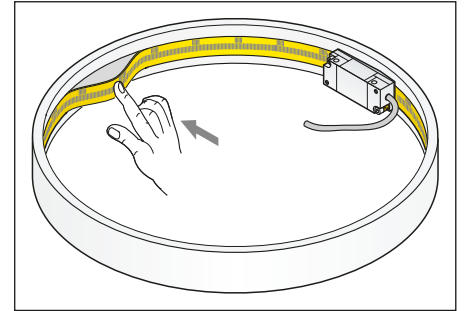
- the **inside diameter** (ERA 7000 series)
 - the **outside diameter** (ERA 8000 series)
- of a machine element.

The ERA 74x0C and ERA 84x0C angle encoders are designed for **full-circle applications**. They are therefore 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.

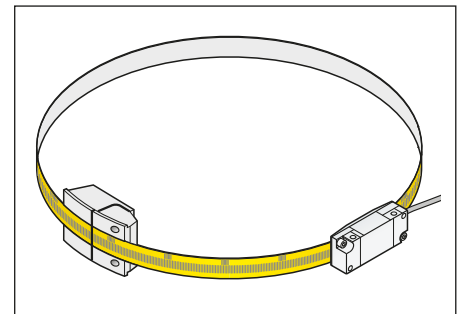
For applications where there is no full circle, or measurement is not required over 360°, **circle segment versions** are available.

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.



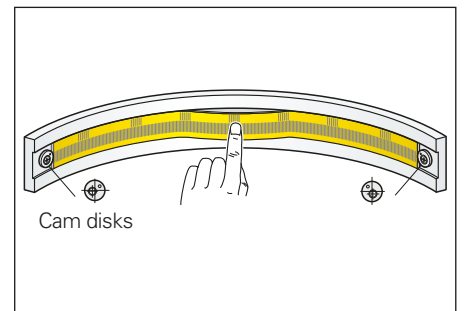
ERA 84x0C: The scale tape is supplied with the halves of the tensioning cleat already mounted on the tape ends. An **external slot** is necessary for mounting. A recess must also be provided for the tensioning cleat. After the scale tape has been inserted, it is fastened aligned along the slot edge and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



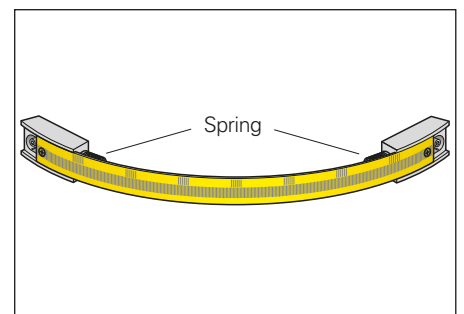
The scale tape ends are manufactured so exactly that only minor signal-form deviations can occur in the area of the butt joint. To make sure that the scale tape does not move within the slot, it is fixed with adhesive at multiple points in the area of the butt joint.

Mounting the scale tape for circle segment versions

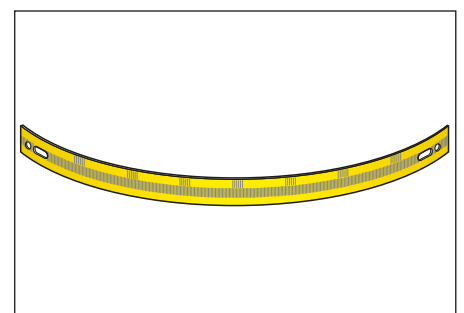
ERA 74x1C: An internal slot with a specified diameter is required. The two cam disks fixed in this slot are adjusted so that the scale can be snapped into the slot under pressure.



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.



Determining the mating diameter

In order to guarantee the correct functioning of the distance-coded reference marks, the circumference must be a multiple of 1000 grating periods. The association between the mating diameter and the signal period can be seen in the table.

Specification of segment angle

For segment versions, the angle available as measuring range must be a multiple of 1000 grating periods. Also, the circumference of the theoretical full circle must be a multiple of 1000 grating periods, since this often simplifies integration with the numerical control.

Mounting the scanning head

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

Checking the output signals at the butt joint

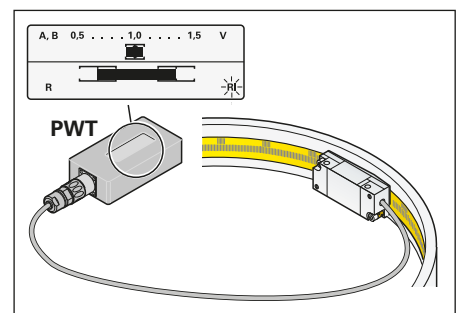
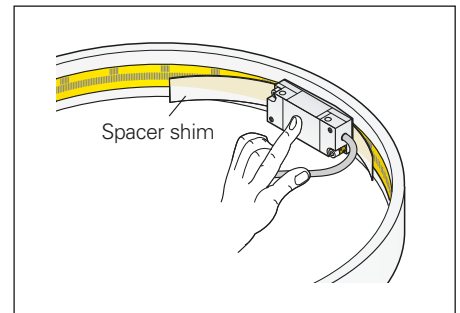
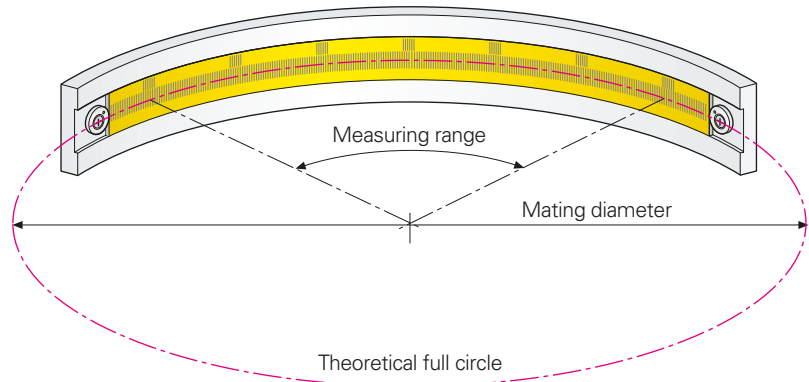
In order to check whether the scale tapes of the ERA 74x0 C and ERA 84x0 C have been mounted correctly, the output signals should be checked at the butt joint—before the adhesive has hardened.

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 and testing devices*).

	Mating diameter in mm	Measuring range in degrees for segment versions
ERA 7000 C	$n \cdot 0.01273112 + 0.3$	$n_1 \cdot 4.583204 : (D - 0.3)$
ERA 8000 C	$n \cdot 0.0127337 - 0.3$	$n_1 \cdot 4.584121 : (D + 0.3)$

n = signal period of full circle; n_1 = signal period of measuring range
 D = mating diameter [mm]



General information

Protection

Modular angle encoders with optical scanning must be protected against contamination by solids or liquids. If necessary, a suitable encapsulation is to be provided by seals and sealing air.

The scanning heads themselves partially fulfill the IP40 degree of protection (ERA) and IP67 (ECA) according to EN 60 529 or IEC 60 529.

For several variants of the ERA 4000 angle encoders, optional protective covers are available. This can increase the degree of protection to IP40. Connection to a source of compressed air slightly above atmospheric pressure provides additional protection against condensation. Due to its design, the protective cover is not designed as protection against contamination by moisture or dust. In many applications, however, the protective cover provides reliable protection. Constructive marginal and operating conditions have a decisive influence.

At a pressure of approx. $1 \cdot 10^5$ Pa (1 bar), a flow rate of approx. 33 liters/min is established with the HEIDENHAIN connecting pieces with integrated reactor. This configuration provides good protection against dust in most cases.

A tried and tested method of avoiding contamination under difficult ambient conditions both during operation and at a standstill is to adequately cover the area where the encoder is installed in addition to the protective cover and to flush it with clean compressed air or to generate a slight overpressure.

The compressed air introduced directly onto the encoders must be cleaned by a microfilter and must comply with the following quality classes as per **ISO 8573-1** (2010 edition):

- Solid contaminants: **Class 1**
Particle size Number of particles per m³
0.1 µm to 0.5 µm ≤ 20 000
0.5 µm to 1.0 µm ≤ 400
1.0 µm to 5.0 µm ≤ 10
- Max. pressure dew point: **Class 4**
(pressure dew point at 3 °C)
- Total oil content: **Class 1**
(max. oil concentration 0.01 mg/m³)

Accessory:

DA 400 compressed air unit
ID 894602-01

DA 400

HEIDENHAIN offers the DA 400 compressed-air filter system for purifying the compressed air. It is designed specifically for the introduction of compressed air into encoders.

The DA 400 consists of three filter stages (pre-filter, microfilter and activated carbon filter) and a pressure regulator with manometer. The sealing air function can be effectively monitored using a manometer and pressure switch (available as accessory).

The compressed air introduced into the DA 400 must fulfill the requirements of the following purity classes as per **ISO 8573-1** (2010 edition):

- Solid contaminants: **Class 5**
Particle size No. of particles per m³
0.1 µm to 0.5 µm Not specified
0.5 µm to 1.0 µm Not specified
1.0 µm to 5.0 µm ≤ 100 000
- Max. pressure dew point: **Class 6**
(pressure dew point at 10 °C)
- Total oil content: **Class 4**
(max. oil concentration 5 mg/m³)



For more information:

For more information, ask for our *DA 400 Product Information Sheet*.



DA 400

Temperature range

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

The **storage temperature range** of $-20\text{ }^{\circ}\text{C}$ to $70\text{ }^{\circ}\text{C}$ applies to the device in the packaging (ERP 4080 / ERP 8080: $0\text{ }^{\circ}\text{C}$ to $60\text{ }^{\circ}\text{C}$).

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 resistance** 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.

Shaft speeds

The maximum permissible shaft speeds for the ERA 4000/ECA 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 million reversals of load) were considered in the calculation of the permissible shaft speeds. Because installation has a significant influence, all requirements and directions in the specifications and mounting instructions must be followed for the shaft-speed data to be valid.

RoHS

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

Expendable parts

Encoders from HEIDENHAIN are designed for a long service life. Preventive maintenance is not required. However, they contain components that are subject to wear, depending on the application and manipulation. These include in particular cables with frequent flexing.

Other such components are the bearings of encoders with integral bearing, shaft sealing rings on rotary and angle encoders, and sealing lips on sealed linear encoders.

System tests

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

The specifications shown in this brochure apply to the specific encoder, not to the complete system. Any operation of the encoder outside of the specified range or for any applications 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 brochure regarding mounting are therefore provisional and not binding; they do not become terms of a contract.

Functional safety

With the absolute angle encoder of the ECA 4410 series, HEIDENHAIN offers an ideal solution for position acquisition for rotational axes in safety-related applications. In conjunction with a safe control, the encoders can be used as single-encoder systems for applications with control category SIL 2 (as per EN 61 508) and performance level "d" (as per EN ISO 13 849).

Reliable transmission of the position is based on two independently generated absolute position values and on error bits, which are then provided to the safe control. The functions of the encoder can be used for numerous safety functions in the complete system as per EN 61 800-5-2.

The ECA 4410 angle encoder provides a safe absolute position value at all times—including immediately after switch-on. Purely serial data transfer takes place via the bidirectional EnDat 2.2 interface.

In addition to the data interface, the mechanical connection of the encoder to the motor is also relevant to safety. Table

D16 of the standard for electrical drives, EN 61 800-5-2, defines the loosening of the mechanical connection between the encoder and drive as a fault that requires consideration. Since it cannot be guaranteed that the control will detect such errors, in many cases a fault exclusion for the loosening of the mechanical connection is required.

Fault exclusion against loosening of the mechanical connection

The machine manufacturer is responsible for the dimensioning of mechanical connections in a drive system. The OEM should ideally consider the application conditions for the mechanical design. Providing objective evidence of a safe connection is time-consuming, however.

For this reason, HEIDENHAIN has developed a mechanical fault exclusion for the ECA 4410 series and confirmed it by way of a type examination.

The qualification of the mechanical fault exclusion was performed for a broad application range of the encoders. This means that fault exclusion is ensured under the operating conditions listed below. The great range of temperatures in combination with the multitude of material characteristics, as well as the maximum permissible shaft speeds and accelerations require an interference fit of the drum. The dimensioning of the interference fit, taking into account all safety factors, makes it necessary to shrink-fit the scale drum and directly influences the required assembly temperatures.

Mounting with mechanical fault exclusion is to be seen as an option. If no mechanical fault exclusion is required for the safety strategy, the drum can also be fastened without interference fitting (see **W1** under *Dimensions*).

Both mounting options and the prerequisites are described in the documentation.

Mechanical connection	Fastening	Safe position for the mechanical coupling ³⁾	Restricted characteristic values ⁴⁾
Scale drum	Interference fit according to dimension drawing: Screw connection: ^{1) 2)} M5x20 ISO 4762 8.8 screws M6x25 ISO 4762 8.8 screws	Drum outside diameter 104.63 mm to 127.64 mm: ±0.015°	See <i>Specifications</i> : • Vibration • Shock • Maximum angular acceleration • Operating temperature
	Mounting option I: Screw connection: ²⁾ M3x25 ISO 4762 8.8 screws	Drum outside diameter 148.2 mm or more: ±0.0°	See <i>Dimensions</i> : • Mounting tolerances
Mounting option II: Screw connection: ²⁾ M3x20 ISO 4762 8.8 screws	See <i>Mounting</i> : • Usable materials • Mounting conditions		

¹⁾ A material bonding anti-rotation lock is to be used for the screw connections of the scale drums (mounting or service)

²⁾ Friction class B according to VDI 2230

³⁾ Fault exclusions are given only for the mounting conditions explicitly stated

⁴⁾ Compared with ECA 44x2

Material

For the material of the mating shaft and stator, the data given in the table is to be observed.

Mounting temperature

All information on screw connections is given with respect to a mounting temperature of 15 °C to 35 °C.

Mounting the scale drum

An oversize of the shaft is required for fault exclusion. The ECA 4400 scale drum should preferably be shrunk thermally onto the mating shaft and additionally be fastened with screws. For this purpose, the scale drum must be heated slowly before mounting. Ideally, this is done using an oven or heating plate. The diagram shows the recommended minimum temperatures for the different drum diameters. The maximum temperature must not exceed 140 °C.

During shrink-fitting, make sure that the hole patterns of the scale drum and mating shaft are properly aligned. Appropriate centering aids (setscrews) can facilitate mounting. When the scale drum has cooled down, all mounting screws have to be tightened again with the correct torque. The mounting screws used for the assembly of the scanning head and scale drum must be used only to secure the scanning head and the scale drum. Do not additionally fasten any other components with these screws.

Removing the scale drum

The scale drum is removed using the corresponding back-off threads in the drum. To do so, fasten greased screws and tighten them in a row until the scale drum comes off the shaft.

Mounting the scanning head

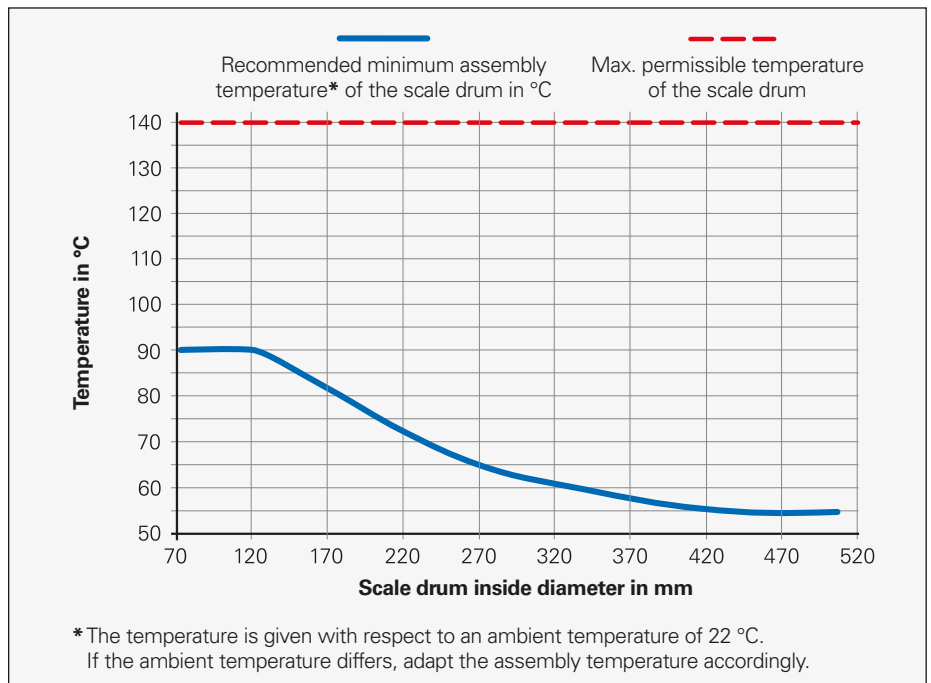
Ensure that the diameter specifications for all components of the encoder (scale drum, scanning head, mounting aid) match. The relevant information is indicated on the ID labels. A mounting wizard in the ATS software helps to ensure that the scanning head and the scale drum are properly aligned.

Accessory:

- Mounting aid (corresponding to drum diameter)
- Mounting wizard in ATS software

Mating shaft/mating stator	
Material	Steel
Tensile strength R_m	$\geq 600 \text{ N/mm}^2$
Shear strength τ_m	$\geq 390 \text{ N/mm}^2$
Elastic modulus E	$\geq 200\,000 \text{ N/mm}^2$ to $215\,000 \text{ N/mm}^2$
Coefficient of thermal expansion α_{therm}	$(10 \text{ to } 13) \cdot 10^{-6} \text{ K}^{-1} \text{ } ^{1)}$

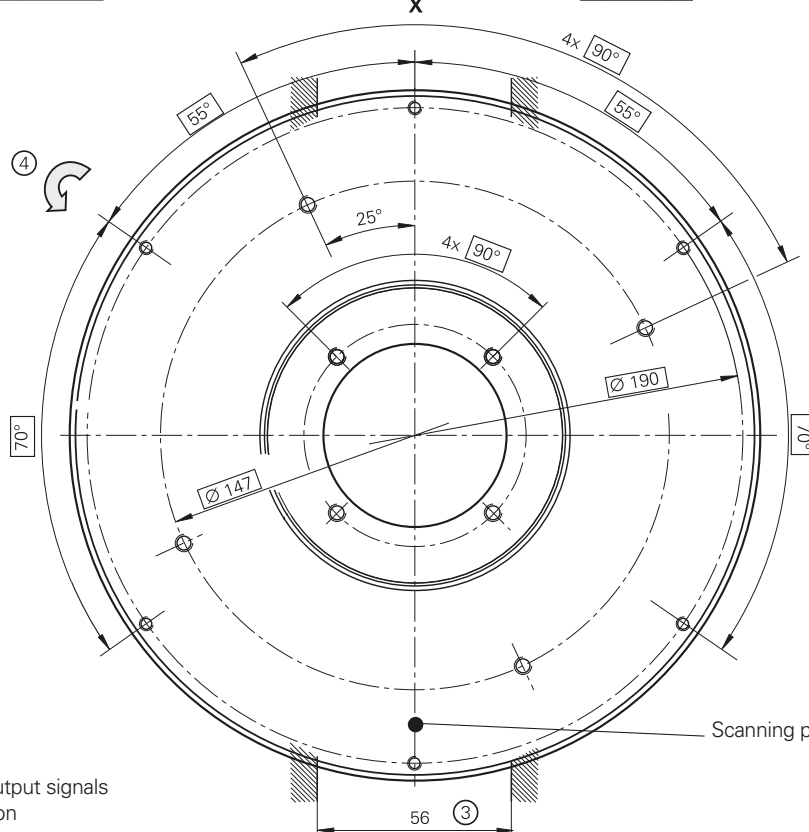
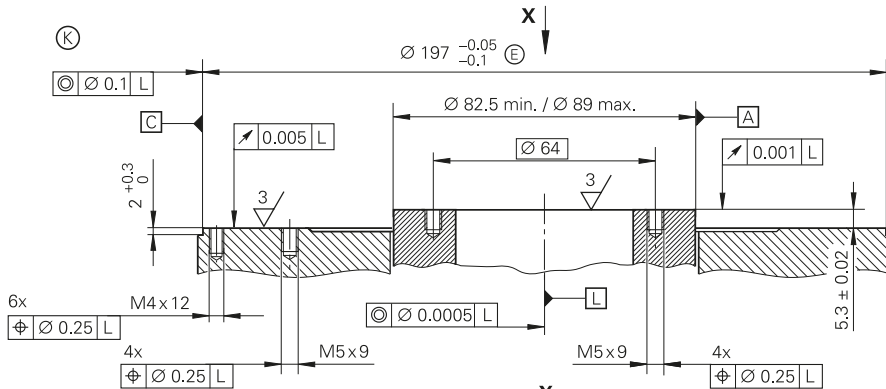
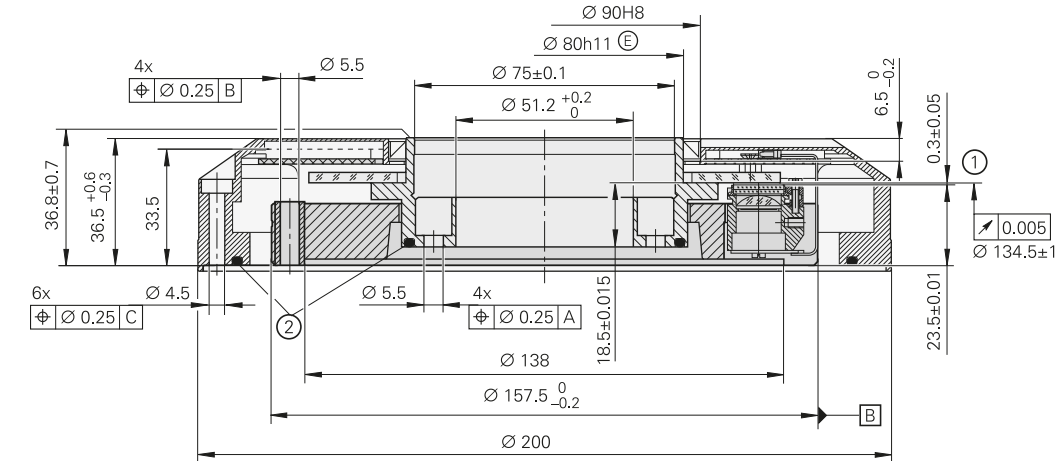
¹⁾ More available on request



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

- = Axis of bearing rotation
- ⊗ = Required mating dimensions

- 1 = Disk-to-scanning-reticle gap
- 2 = Seal
- 3 = Space required for service

- 4 = Direction of shaft rotation for output signals according to interface description

ERP 880	
Measuring standard	DIADUR phase grating on glass
Signal periods	180 000
Accuracy of graduation	±0.9"
Interpolation error per signal period¹⁾	±0.1"
Reference marks	One
Hub inside diameter	51.2 mm
Mech. permissible speed	≤ 1000 rpm
Moment of inertia	$1.2 \cdot 10^{-3} \text{ kgm}^2$
Permissible axial motion of measured shaft	≤ ±0.05 mm
Interface	 1 V _{PP}
Cutoff frequency	-3 dB ≥ 800 kHz -6 dB ≥ 1.3 MHz
Electrical connection	<i>With housing:</i> Cable 1 m, with M23 coupling <i>Without housing:</i> Via PCB connector, 12-pin (adapter cable ID 372164-xx)
Cable length	≤ 150 m (with HEIDENHAIN cable)
Voltage supply	DC 5 V ±0.5 V
Current consumption	≤ 250 mA (without load)
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	<i>Without housing:</i> IP 00 <i>With housing:</i> IP 40 <i>With housing and shaft seal:</i> IP 64
Starting torque	– 0.25 Nm
Mass	3.0 kg 3.1 kg incl. housing

* Please select when ordering

¹⁾ Interpolation error within one signal period and the accuracy of the graduation together result in the encoder-specific error; for additional error from mounting and bearing of the measured shaft, see *Measuring accuracy*

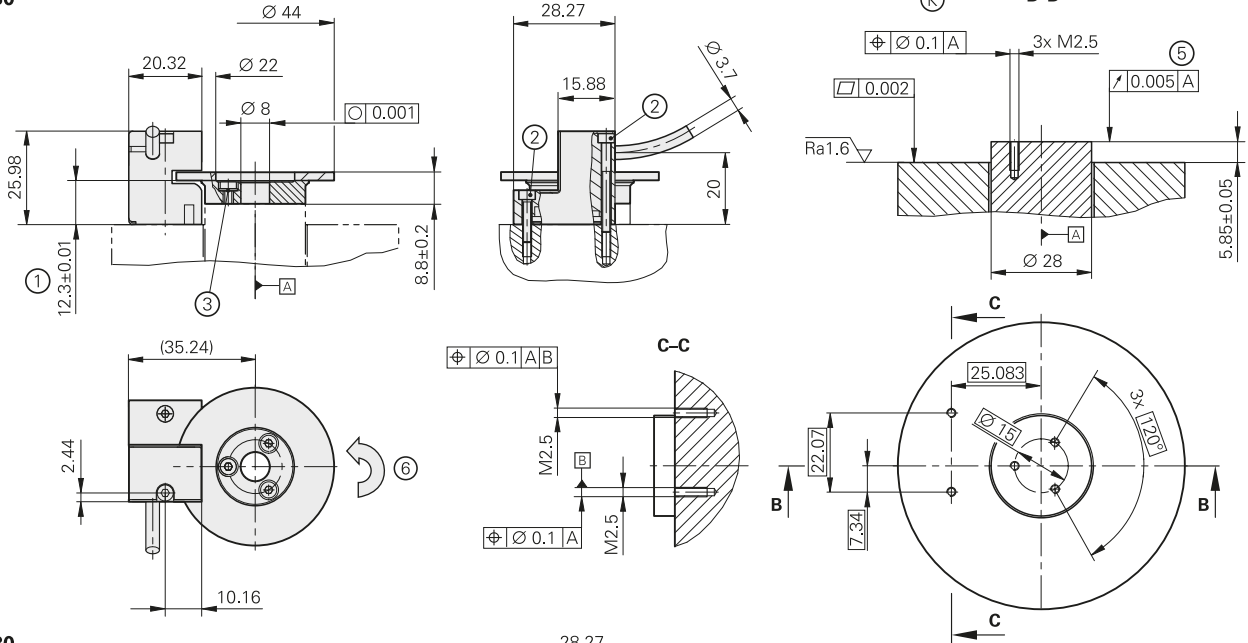
ERP 4080/ERP 8080

Incremental angle encoder for high accuracy

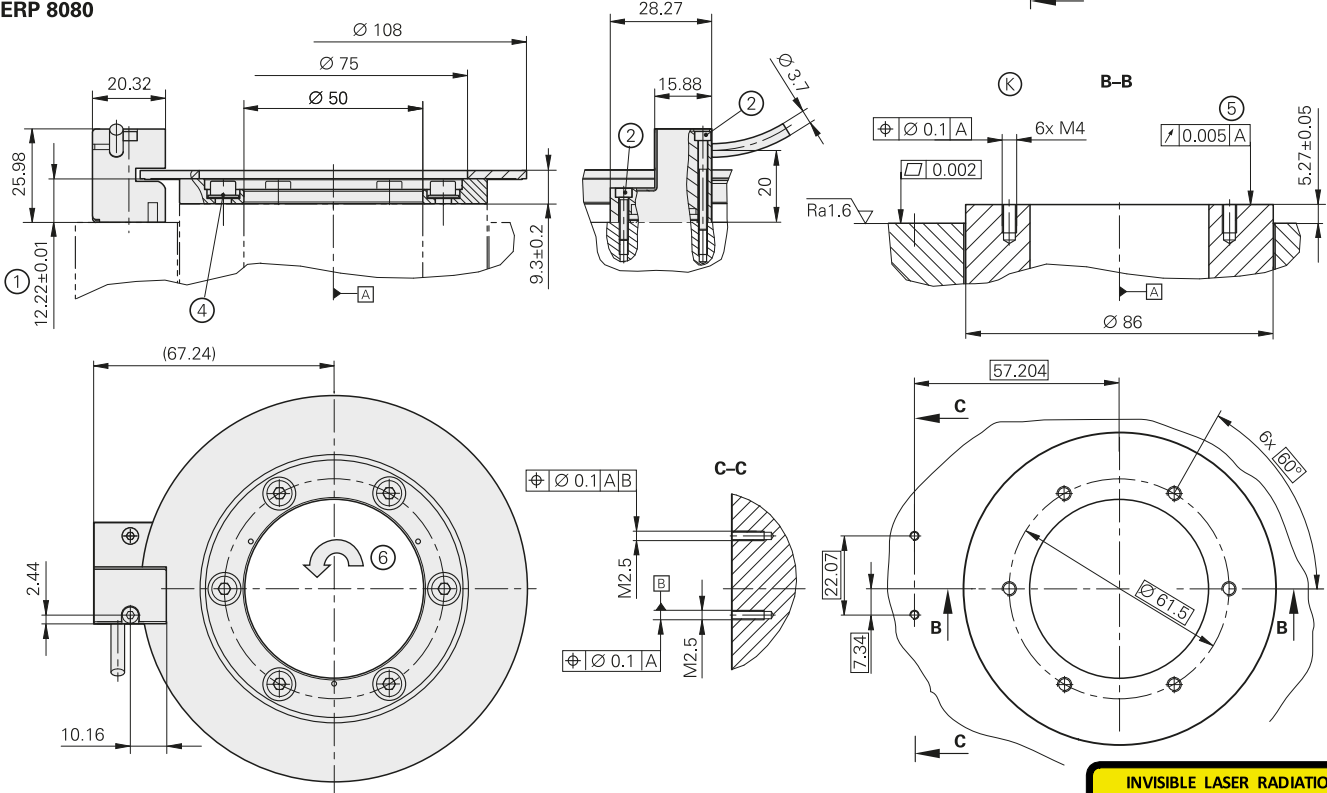
- Very high resolution
- Consists of scanning head and disk/hub assembly



ERP 4080

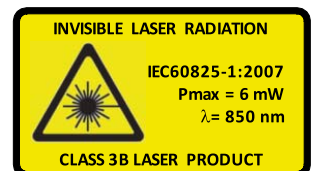


ERP 8080



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

- ⊠ = Bearing
- ⊗ = Required mating dimensions
- 1 = Mounting clearance set with spacer shim
- 2 = Cylinder head screw, ISO 4762-A2-M2.5
- 3 = Cylinder head screw, ISO 4762-A2-M2.5, and washer, ISO 7089-2.5-140HV-A2
- 4 = Cylinder head screw ISO 4762-A2-M4 and washer ISO 7089-4-140HV-A2
- 5 = Bearing surface not convex
- 6 = Direction of shaft rotation for output signals according to interface description



Scanning head	AK ERP 4080	AK ERP 8080
Interface	~ 1 V _{pp}	
Cutoff frequency -3 dB	≥ 250 kHz	
Electrical connection	Cable 1 m, with D-sub connector (15-pin)	
Cable length	≤ 30 m (with HEIDENHAIN cable)	
Voltage supply	DC 5 V ±0.25 V	
Current consumption	≤ 150 mA (without load)	
Laser	<i>Scanning head and graduated disk mounted: Class 1</i> <i>Scanning head not mounted: Class 3B</i> <i>Laser diode used: Class 3B</i>	
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	
Mass	≈ 33 g (without cable)	

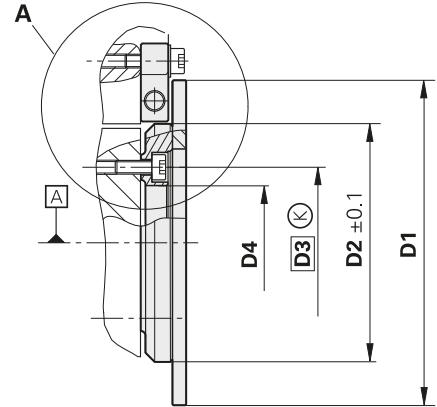
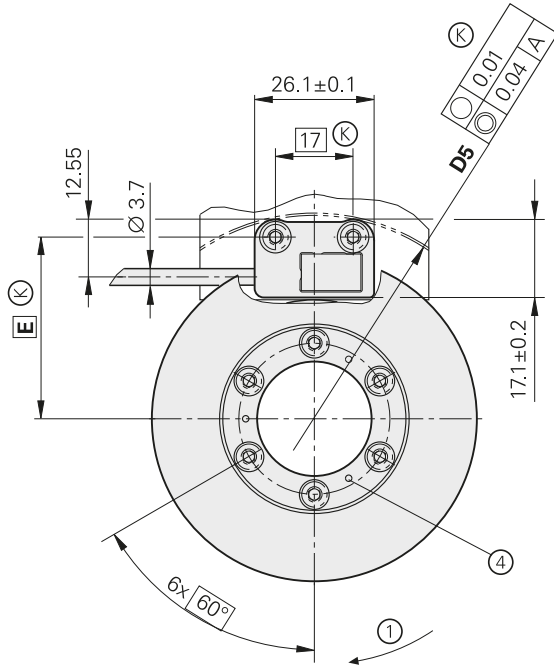
Circular scale	TKN ERP 4000 (scale)	TKN ERP 8000 (scale)
Measuring standard	Phase grating on glass	
Signal periods	131 072	360 000
Accuracy of graduation	±2"	±1"
Interpolation error per signal period ¹⁾	±0.1"	±0.05"
Reference marks	None	
Hub inside diameter	8 mm	50 mm
Mech. permissible speed	≤ 300 rpm	≤ 100 rpm
Moment of inertia	5 · 10 ⁻⁶ kgm ²	250 · 10 ⁻⁶ kgm ²
Permissible axial motion of measured shaft	≤ ±0.01 mm (incl. wobble)	
Protection EN 60529	<i>Complete encoder in mounted condition: IP00 (for clean room applications)</i>	
Mass	≈ 36 g	≈ 180 g

¹⁾ Interpolation error within one signal period and the accuracy of the graduation together result in the encoder-specific error; for additional error from mounting and bearing of the measured shaft, see *Measuring accuracy*

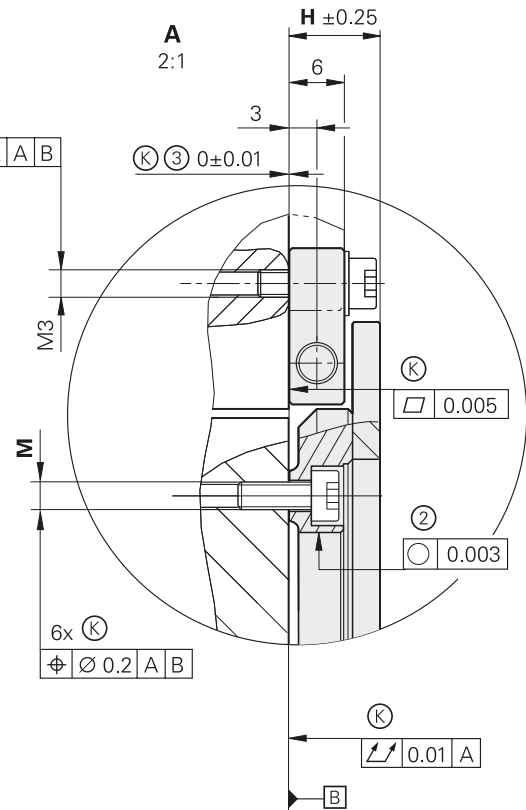
ERO 6000 series

Incremental angle encoder for high accuracy

- Compact design
- Low mass, low moment of inertia
- Consists of scanning head and disk/hub assembly


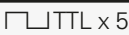




D1	D2	D3	D4	D5	E	H	M
∅ 71	∅ 52	∅ 33	∅ 25H6	∅ 88.9H6	39.7	9.9	M3
∅ 150	∅ 130	∅ 107	∅ 95 $^{+0.015}_0$	∅ 166H6	78.7	10.2	M4



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

- ▣ = Bearing
- ⊗ = Required mating dimensions
- 1 = Positive direction of rotation
- 2 = Centering collar
- 3 = Mounting tolerance between mounting surface of scanning head and disk/hub assembly
- 4 = Marks for circular scale centering (3x 120°)

Scanning head	AK ERO 6080		AK ERO 6070	
Interface	 1 V _{pp}	 x 5	 x 10	 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 <i>a</i>	–	≥ 0.220 μs	≥ 0.220 μs	≥ 0.175 μs
Electrical connection	3 m cable with 15-pin D-sub connector (male); on ERO 6070 interface electronics in the connector			
Cable length	≤ 30 m			
Voltage supply	DC 5 V ±0.25 V			
Current consumption	< 100 mA (without load)	< 200 mA (without load)		
Vibration 55 to 2000 Hz Shock 6 ms	≤ 200 m/s ² (EN 60068-2-6) ≤ 500 m/s ² (EN 60068-2-27)			
Operating temperature	0 °C to 50 °C (32 °F to 122 °F)			
Mass	Scanning head Connector Cable	≈ 6 g (without cable) ≈ 32 g ≈ 22 g/m	≈ 6 g (without cable) ≈ 140 g ≈ 22 g/m	

Circular scale	TKN ERO 6000	
Measuring standard	METALLUR graduation on glass	
Signal periods*	9000	18000
Accuracy of graduation	±5"	±3.5"
Interpolation error per signal period ¹⁾	±2"	±1"
Reference marks	One	
Hub inside diameter	25 mm	95 mm
Circular scale outside diameter	71 mm	150 mm
Mech. permissible speed	≤ 1600 rpm	≤ 800 rpm
Moment of inertia	44 × 10 ⁻⁶ kgm ²	1.1 × 10 ⁻³ kgm ²
Permissible axial motion	≤ 0.1 mm	
Protection EN 60529	<i>Complete encoder in mounted condition: IP00</i>	
Mass	≈ 84 g	≈ 323 g

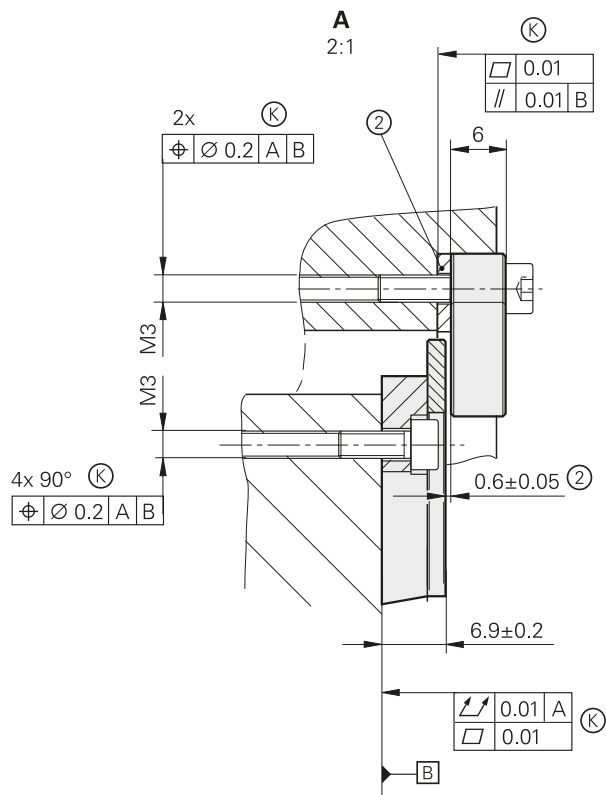
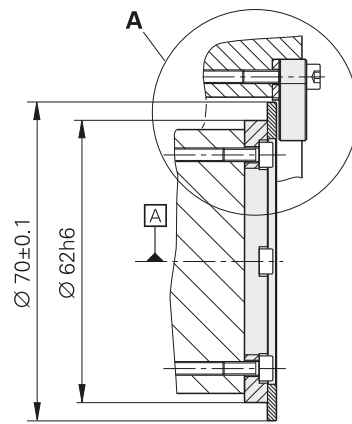
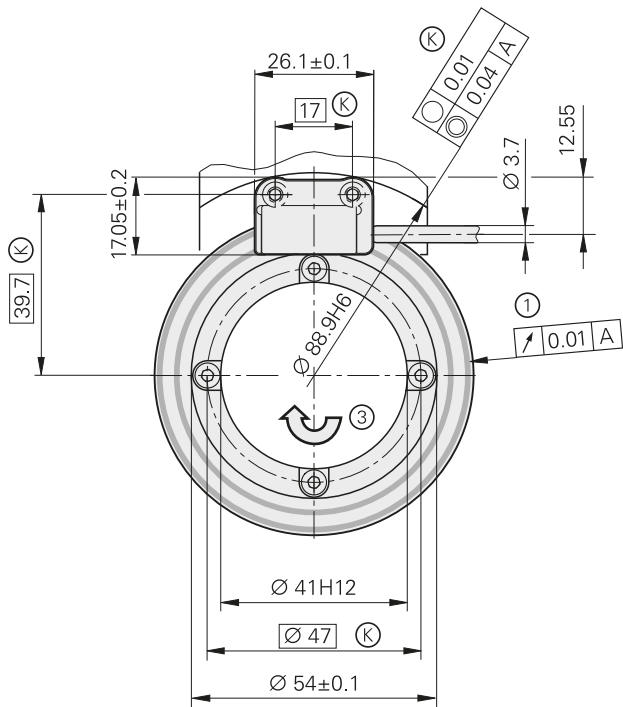
* Please select when ordering

¹⁾ Interpolation error within one signal period and the accuracy of the graduation together result in the encoder-specific error; for additional error from mounting and bearing of the measured shaft, see *Measuring accuracy*

ERO 6180

incremental angle encoder

- Compact design
- Low mass, 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

- ▣ = Bearing
- ⊙ = Required mating dimensions
- 1 = Customer's centering of the TKN (disk/hub assembly) through the graduation
- 2 = Use shim to adjust the scanning gap
- 3 = Direction of scanning unit motion for output signals in accordance with interface description

Scanning head	AK ERO 6180
Interface	$\sim 1 V_{pp}$
Reference mark signal	Square-wave pulse
Cutoff frequency -3 dB	≥ 200 kHz
Electrical connection	Cable 3 m with D-sub connector (male), 15-pin
Cable length	≤ 30 m
Voltage supply	DC 5 V ± 0.25 V
Current consumption	< 100 mA (without load)
Vibration 55 to 2000 Hz Shock 6 ms	≤ 200 m/s ² (EN 60 068-2-6) ≤ 500 m/s ² (EN 60 068-2-27)
Operating temperature	0 °C to 50 °C (32 °F to 122 °F)
Mass	Scanning head ≈ 6 g (without cable) Connector ≈ 32 g Cable ≈ 22 g/m

Circular scale	TKN ERO 6100
Measuring standard	Chrome graduation on glass
Signal periods	4096
Accuracy of graduation	$\pm 10''$
Interpolation error per signal period¹⁾	$\pm 5''$
Reference marks	One
Hub inside diameter	41 mm
Circular scale outside diameter	70 mm
Mech. permissible speed	≤ 3500 rpm
Moment of inertia	50×10^{-6} kgm ²
Permissible axial motion	≤ 0.1 mm
Protection EN 60529	Complete encoder in mounted position: IP00
Mass	≈ 71 g

¹⁾ Interpolation error within one signal period and the accuracy of the graduation together result in the encoder-specific error; for additional error from mounting and bearing of the measured shaft, see *Measuring accuracy*

ECA 4400 series


Absolute angle encoder with high accuracy

- Steel scale drum with three-point centering or centering collar
- Consists of scanning head and scale drum
- Also for safety-related applications



ECA 4000

Scanning head	
Interface	
Ordering designation	
Clock frequency	
Calculation time t_{cal}	
Functional safety For applications up to	
PFH	
Electrical connection	
Cable length ¹⁾	
Voltage supply	
Power consumption (max.)	
Current consumption (typical)	
Vibration 55 to 2000 Hz Shock 6 ms	
Operating temperature	
Protection EN 60529 ³⁾	
Mass	Scanning head Connecting cable Coupling (M12)

AK ECA 4410 	AK ECA 4410	AK ECA 4490F	AK ECA 4490M	AK ECA 4490P
EnDat 2.2		Fanuc Serial Interface; xi Interface	Mitsubishi high speed interface	Panasonic Serial Interface
EnDat22		Fanuc05	Mit03-4	Pana01
≤ 16 MHz		-		
≤ 5 μs		-		
<ul style="list-style-type: none"> SIL 2 according to EN 61 508 (further basis for testing: EN 61 800-5-2) Category 3, PL "d" as per EN ISO 13849-1:2015 	-			
≤ 20 · 10 ⁻⁹ (up to 6000 m above sea level)	-			
Cable, 1 m or 3 m with 8-pin M12 coupling (male) or 15-pin D-sub connector				
≤ 100 m		≤ 50 m	≤ 30 m	≤ 50 m
DC 3.6 V to 14 V				
At 3.6 V: 700 mW At 14 V: 800 mW		At 3.6 V: 850 mW At 14 V: 950 mW		
At 5 V: 90 mA (without load)		At 5 V: 100 mA (without load)		
≤ 200 m/s ² (EN 60 068-2-6) ≤ 200 m/s ² (EN 60 068-2-27)	≤ 500 m/s ² (EN 60 068-2-6) ≤ 1000 m/s ² (EN 60 068-2-27)			
-10 °C to 70 °C ²⁾	-10 °C to 70 °C			
IP67				
18 g (without cable) 20 g/m 15 g				

¹⁾ With HEIDENHAIN cable; clock frequency ≤ 8 MHz

²⁾ With drum outside diameter of 104.63 mm: 10 °C to 70 °C

³⁾ In the application the device must be protected from contamination by solids and liquids. If necessary, use a suitable enclosure with seal and sealing air

Scale drum	TTR ECA 4400 scale drum								
Measuring standard Coefficient of expansion	Steel drum $\alpha_{\text{therm}} \approx 10.4 \cdot 10^{-6} \text{ K}^{-1}$								
Drum inside diameter*	70 mm	80 mm	120 mm	120 mm	150 mm	180 mm	270 mm	425 mm	512 mm
Drum outside diameter*	104.63 mm	127.64 mm	148.2 mm	178.55 mm	208.89 mm	254.93 mm	331.31 mm	484.07 mm	560.46 mm
Safe position ^{1) 2)}	±0.88°		±0.44°				±0.22°		±0.11°
Safety-related measuring step SM	0.352° (10 bits)		0.176° (11 bits)				0.088° (12 bits)		0.044° (13 bits)
Mech. permissible speed	≤ 8500 rpm	≤ 6250 rpm	≤ 5250 rpm	≤ 4500 rpm	≤ 4250 rpm	≤ 3250 rpm	≤ 2500 rpm	≤ 1800 rpm	≤ 1500 rpm
Max. angular acceleration	14 000 rad/s ²	6600 rad/s ²	7900 rad/s ²	2700 rad/s ²	1800 rad/s ²	1000 rad/s ²	1300 rad/s ²	900 rad/s ²	1200 rad/s ²
Elec. permissible speed	≤ 7000 rpm	≤ 5750 rpm	≤ 4400 rpm	≤ 3000 rpm	≤ 2550 rpm	≤ 2100 rpm	≤ 900 rpm	≤ 600 rpm	≤ 550 rpm
Moment of inertia	$0.81 \cdot 10^{-3} \text{ kgm}^2$	$1.9 \cdot 10^{-3} \text{ kgm}^2$	$2.3 \cdot 10^{-3} \text{ kgm}^2$	$7.1 \cdot 10^{-3} \text{ kgm}^2$	$12 \cdot 10^{-3} \text{ kgm}^2$	$28 \cdot 10^{-3} \text{ kgm}^2$	$59 \cdot 10^{-3} \text{ kgm}^2$	$195 \cdot 10^{-3} \text{ kgm}^2$	$258 \cdot 10^{-3} \text{ kgm}^2$
Permissible axial movement	≤ ±0.4 mm (scale drum relative to the scanning head)								
Positions per revolution	134217728 (27 bits)					268435456 (28 bits)		536870912 (29 bits)	
Measuring step	0.0097"					0.0048"		0.0024"	
Signal periods	8195	10 010	11 616	14 003	16 379	19 998	25 993	37 994	44 000
Accuracy of graduation	±3.7"	±3.0"	±2.8"	±2.5"	±2.5"	±2.5"	±2.5"	±2.0"	±2.0"
Interpolation error per signal period RMS(1δ)	±0.20" 0.040"	±0.16" 0.032"	±0.14" 0.028"	±0.12" 0.023"	±0.10" 0.020"	±0.08" 0.016"	±0.06" 0.012"	±0.04" 0.009"	±0.04" 0.007"
Protection EN 60529 ³⁾	Complete encoder in mounted condition: IP00								
Mass	≈ 0.40 kg	≈ 0.68 kg	≈ 0.51 kg	≈ 1.2 kg	≈ 1.5 kg	≈ 2.3 kg	≈ 2.6 kg	≈ 3.8 kg	≈ 3.6 kg

* Please select when ordering

¹⁾ Further tolerances may occur in subsequent electronics after position value comparison (contact manufacturer of subsequent electronics)

²⁾ *Mechanical connection*: fault exclusions for loosening of the scanning head and scale drum (page 36)

³⁾ In the application the device must be protected from contamination by solids and liquids. If necessary, use a suitable enclosure with seal and sealing air

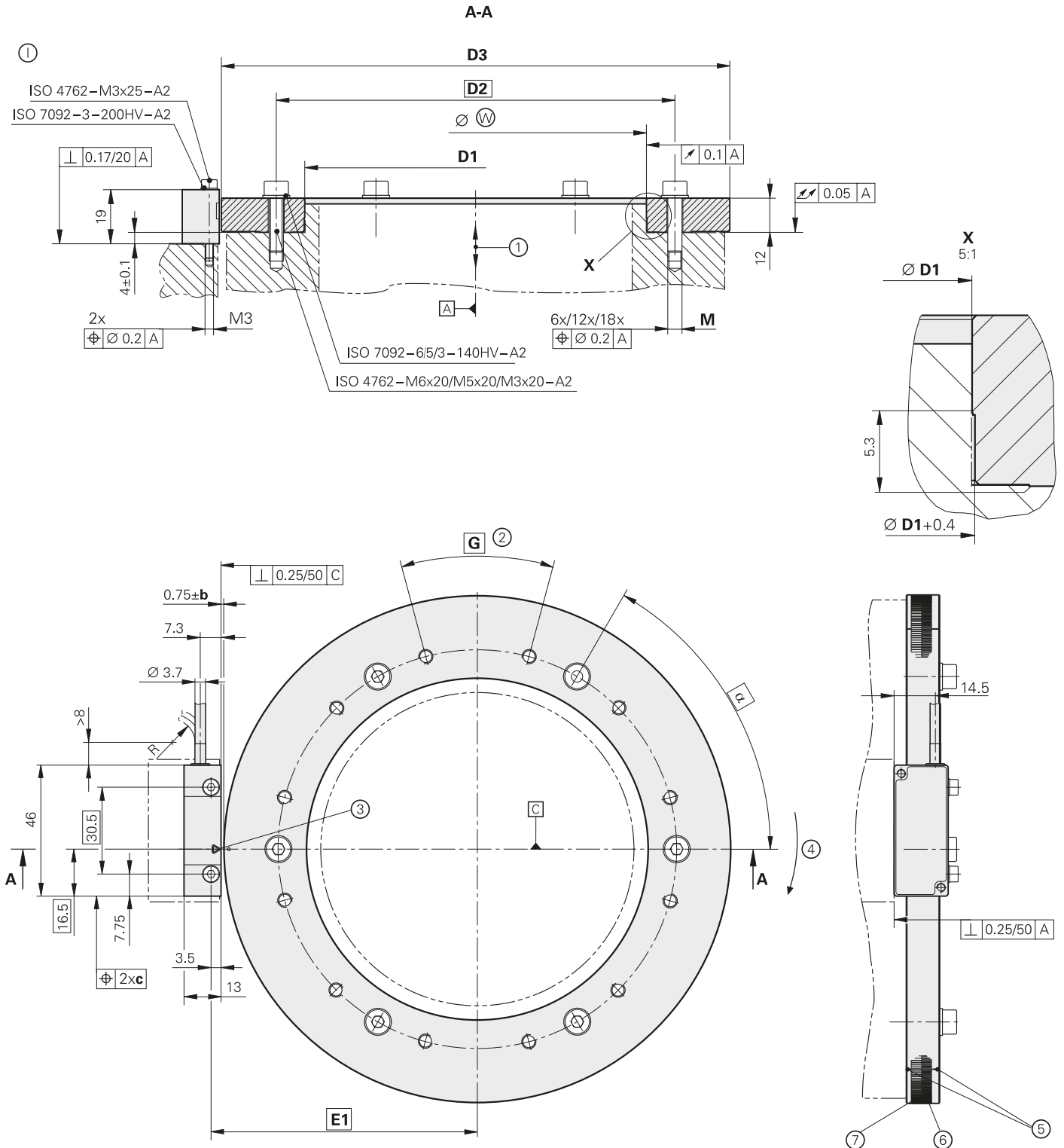
Scale drum	TTR ECA 4402 (ECA 4402 scale drum)								
Measuring standard Coefficient of expansion	Steel drum $\alpha_{\text{therm}} \approx 10.4 \cdot 10^{-6} \text{ K}^{-1}$								
Drum inside diameter*	70 mm	80 mm	120 mm/ 150 mm	130 mm	150 mm/ 185 mm	180 mm/ 210 mm	270 mm	425 mm	512 mm
Drum outside diameter*	104.63 mm	127.64 mm	178.55 mm	148.20 mm	208.89 mm	254.93 mm	331.31 mm	484.07 mm	560.46 mm
Mech. permissible speed	≤ 8500 rpm	≤ 6250 rpm	≤ 4500 rpm	≤ 5250 rpm	≤ 4250 rpm	≤ 3250 rpm	≤ 2500 rpm	≤ 1800 rpm	≤ 1500 rpm
Electrically permissible speed	≤ 7000 rpm	≤ 5750 rpm	≤ 3000 rpm	≤ 4400 rpm	≤ 2550 rpm	≤ 2100 rpm	≤ 900 rpm	≤ 600 rpm	≤ 550 rpm
Moment of inertia	$0.83 \cdot 10^{-3} \text{ kgm}^2$	$2.0 \cdot 10^{-3} \text{ kgm}^2$	7.1/ $4.5 \cdot 10^{-3} \text{ kgm}^2$	$1.7 \cdot 10^{-3} \text{ kgm}^2$	12/ $6.5 \cdot 10^{-3} \text{ kgm}^2$	28/ $20 \cdot 10^{-3} \text{ kgm}^2$	$59 \cdot 10^{-3} \text{ kgm}^2$	$199 \cdot 10^{-3} \text{ kgm}^2$	$263 \cdot 10^{-3} \text{ kgm}^2$
Permissible axial movement	≤ ±0.4 mm (scale drum relative to the scanning head)								
Positions per revolution	134217728 (27 bits)					268435456 (28 bits)		536870912 (29 bits)	
Measuring step	0.0097"					0.0048"		0.0024"	
Signal periods	8195	10010	14003	11616	16379	19998	25993	37994	44000
Accuracy of graduation	±3"	±2.5"	±2"	±2.3"	±1.9"	±1.8"	±1.7"	±1.5"	±1.5"
Interpolation error per signal period RMS (1σ)	±0.20" 0.040"	±0.16" 0.032"	±0.12" 0.023"	±0.14" 0.028"	±0.10" 0.020"	±0.08" 0.016"	±0.06" 0.012"	±0.04" 0.009"	±0.04" 0.007"
Protection EN 60529 ¹⁾	Complete encoder in mounted condition: IP00								
Mass Scale drum	≈ 0.42 kg	≈ 0.69 kg	≈ 1.2 kg/ 0.66 kg	≈ 0.35 kg	≈ 1.5 kg/ 0.66 kg	≈ 2.3 kg/ 1.5 kg	≈ 2.6 kg	≈ 3.8 kg	≈ 3.7 kg

* Please select when ordering

¹⁾ In the application the device must be protected from contamination by solids and liquids. If necessary, use a suitable enclosure with seal and sealing air

ECA 4412, ECA 4492

Dimensions

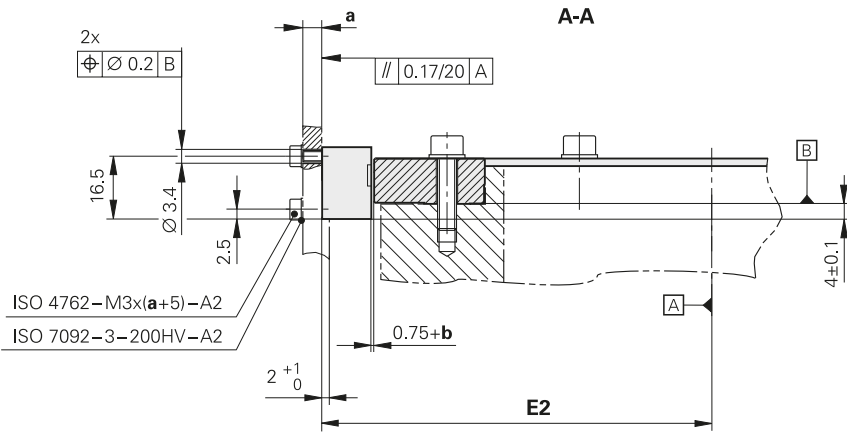


mm

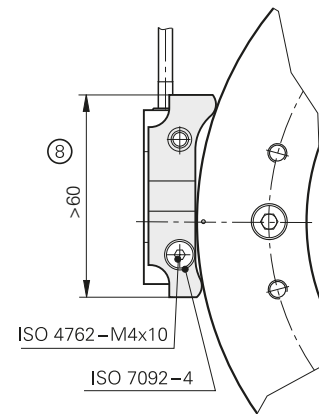
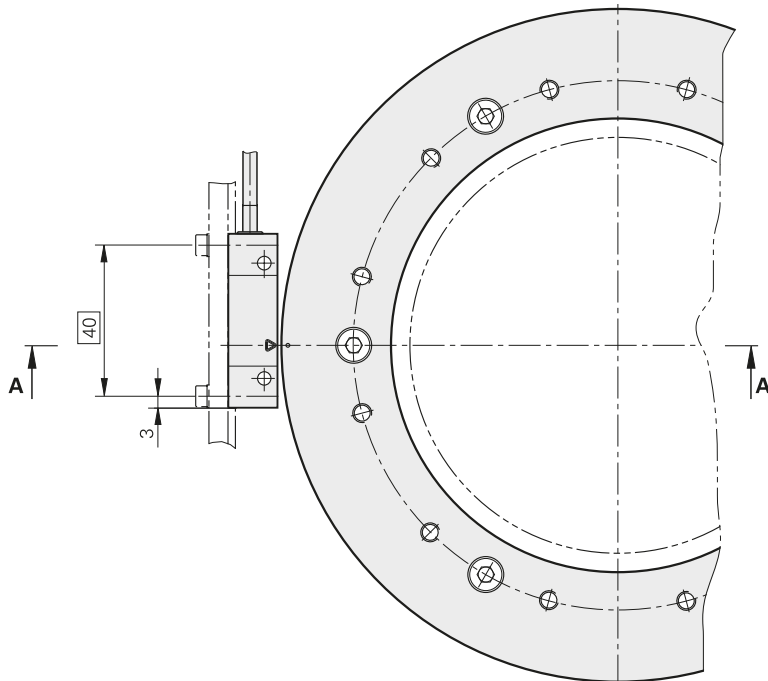
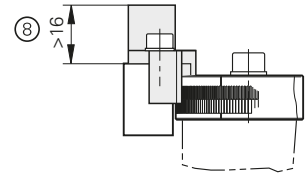
 Tolerancing ISO 8015
 ISO 2768 - m H
 ≤ 6 mm: ±0.2 mm

- ①, ② = Mounting options
- ▢ = Bearing
- ⊕ = Mating diameter (shaft)
- 1 = Permissible axial motion of measured shaft: ≤ ±0.4 mm
- 2 = Not permitted for drum fastening
- 3 = Optical centerline and mark for 0° position
- 4 = Positive direction of rotation
- 5 = Marks for drum centering (3x120°)
- 6 = Incremental track
- 7 = Code track
- 8 = Space for mounting aid

II



Accessory: Mounting aid



D1	\textcircled{V}	D2	D3	E1	E2	α	M	G	b [mm]	c [mm]
$\varnothing 70 +0.05/+0.07$	$\varnothing \leq 70$	$\varnothing 85$	$\varnothing 104.63$	56.57	66.07	$6 \times 60^\circ = 360^\circ$	6x M5	/	± 0.07	0.3
$\varnothing 80 +0.05/+0.07$	$\varnothing \leq 80$	$\varnothing 95$	$\varnothing 127.64$	68.07	77.57	$6 \times 60^\circ = 360^\circ$	6x M5	/	± 0.07	0.3
$\varnothing 120 +0.05/+0.07$	$\varnothing \leq 120$	$\varnothing 140$	$\varnothing 178.55$	93.52	103.02	$6 \times 60^\circ = 360^\circ$	6x M5	/	± 0.10	0.3
$\varnothing 130 +0.05/+0.07$	$\varnothing \leq 130$	$\varnothing 139$	$\varnothing 148.20$	78.35	87.85	$12 \times 30^\circ = 360^\circ$	12x M3	/	± 0.07	0.3
$\varnothing 150 +0.05/+0.07$	$\varnothing \leq 150$	$\varnothing 163$	$\varnothing 178.55$	93.52	103.02	$12 \times 30^\circ = 360^\circ$	12x M3	/	± 0.10	0.3
$\varnothing 150 +0.05/+0.07$	$\varnothing \leq 150$	$\varnothing 165$	$\varnothing 208.89$	108.69	118.19	$6 \times 60^\circ = 360^\circ$	6x M5	/	± 0.12	0.5
$\varnothing 180 +0.05/+0.07$	$\varnothing \leq 180$	$\varnothing 200$	$\varnothing 254.93$	131.71	141.21	$6 \times 60^\circ = 360^\circ$	6x M5	/	± 0.12	0.5
$\varnothing 185 +0.05/+0.07$	$\varnothing \leq 185$	$\varnothing 197$	$\varnothing 208.89$	108.69	118.19	$12 \times 30^\circ = 360^\circ$	12x M3	/	± 0.12	0.5
$\varnothing 210 +0.05/+0.07$	$\varnothing \leq 210$	$\varnothing 230$	$\varnothing 254.93$	131.71	141.21	$12 \times 30^\circ = 360^\circ$	12x M3	/	± 0.12	0.5
$\varnothing 270 +0.05/+0.07$	$\varnothing \leq 270$	$\varnothing 290$	$\varnothing 331.31$	169.90	179.40	$12 \times 30^\circ = 360^\circ$	12x M5	/	± 0.15	1.0
$\varnothing 425 +0.05/+0.07$	$\varnothing \leq 425$	$\varnothing 445$	$\varnothing 484.07$	246.29	255.79	$12 \times 30^\circ = 360^\circ$	12x M6	12x M6	± 0.15	1.0
$\varnothing 512 +0.05/+0.07$	$\varnothing \leq 512$	$\varnothing 528$	$\varnothing 560.46$	284.48	293.98	$18 \times 20^\circ = 360^\circ$	18x M6	12x M8	± 0.15	1.0

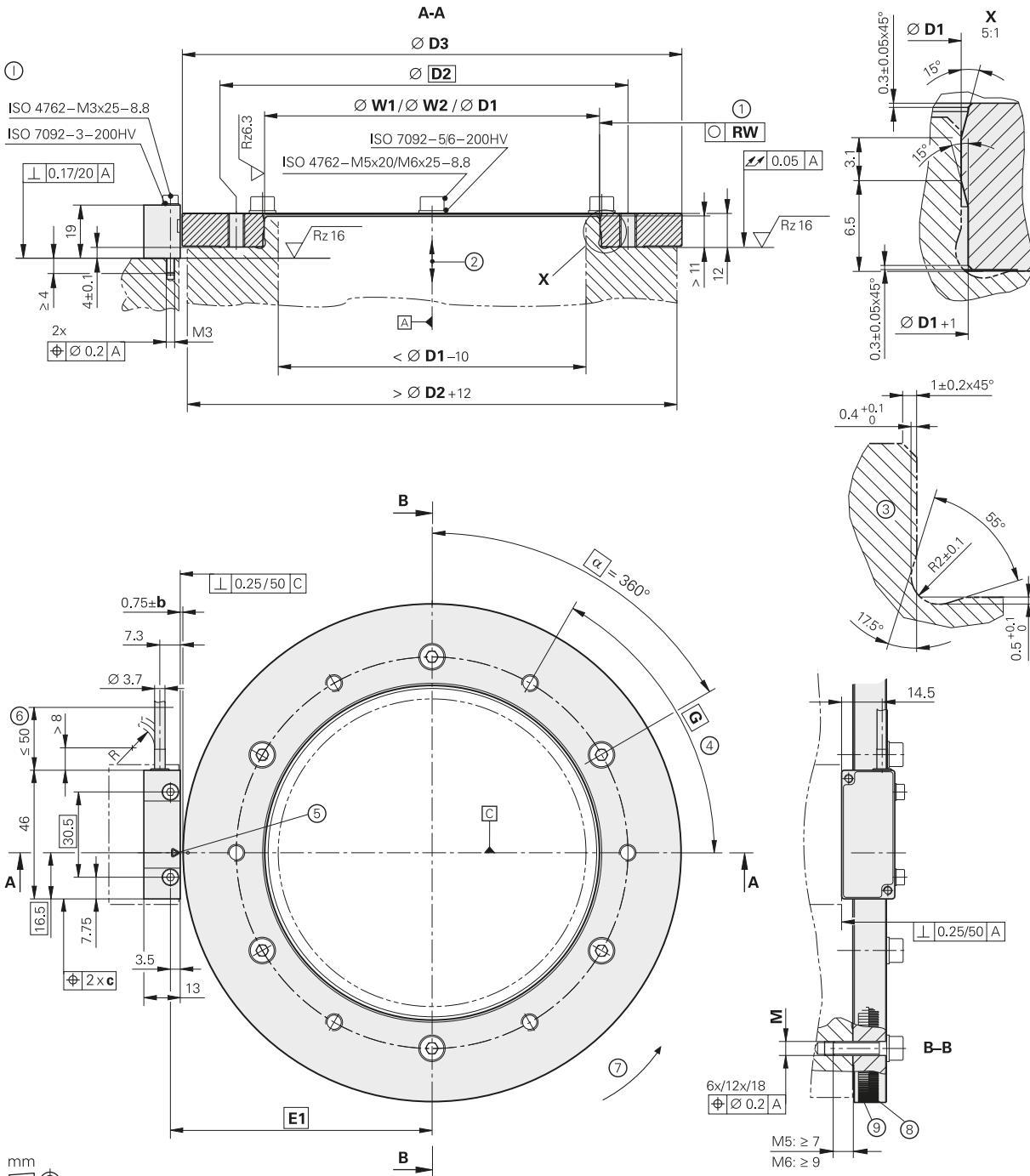


For more information:

For CAD data go to cad.heidenhain.de

ECA 4410

Dimensions



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

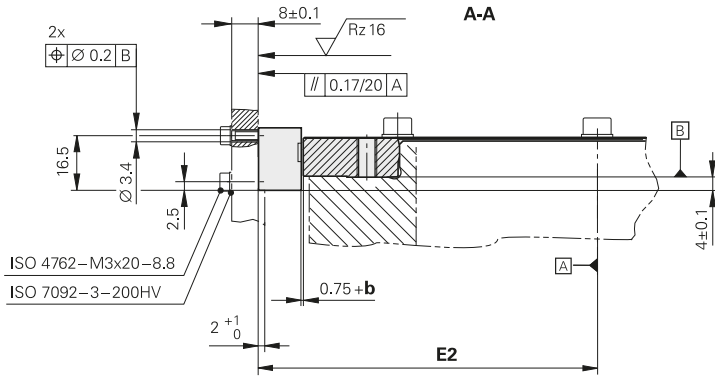
W1 = Without mechanical fault exclusion
W2 = With mechanical fault exclusion

⊙, ⊕ = Mounting options
 = Bearing of mating shaft
 W = Mating diameter (shaft)
 1 = Circularity of mating diameter (shaft)
 2 = Permissible axial motion of measured shaft:
 ≤ ±0.4 mm

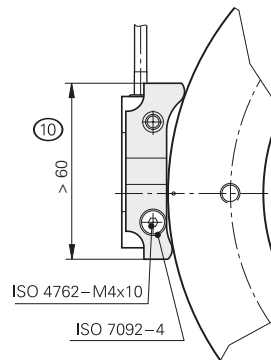
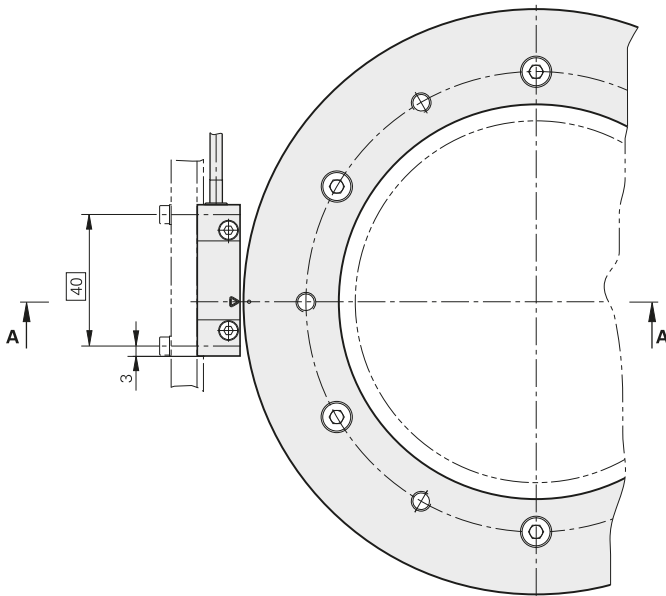
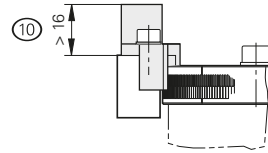
3 = Design proposal for undercut
 4 = Back-off thread, not permitted for drum fastening
 5 = Optical centerline
 6 = Cable support
 7 = Positive direction of rotation
 8 = Incremental track
 9 = Code track
 10 = Space for mounting aid

	b [mm]	c [mm]
∅ 70	±0.05	0.3
∅ 80	±0.07	0.3
∅ 120	±0.07	0.3
∅ 120	±0.10	0.3
∅ 150	±0.12	0.5
∅ 180	±0.12	0.5
∅ 270	±0.15	1.0
∅ 425	±0.15	1.0
∅ 512	±0.15	1.0

II



Accessory: Mounting aid



D1	W1	W2	RW	D2	D3	E1	E2	α	M	G
∅ 70 -0.001/-0.005	∅ 70 +0.005	∅ 70 +0.007/+0.002	0.001	∅ 85	∅ 104.63	56.57	66.07	6x60°	6x M5	6x M6
∅ 80 -0.001/-0.005	∅ 80 +0.006	∅ 80 +0.009/+0.003	0.0015	∅ 95	∅ 127.64	68.07	77.57	6x60°	6x M5	6x M6
∅ 120 -0.001/-0.008	∅ 120 +0.008	∅ 120 +0.040/+0.022	0.002	∅ 134	∅ 148.20	78.35	87.85	6x60°	6x M5	6x M6
∅ 120 -0.001/-0.008	∅ 120 +0.008	∅ 120 +0.040/+0.022	0.002	∅ 140	∅ 178.55	93.52	103.02	6x60°	6x M5	6x M6
∅ 150 -0.001/-0.008	∅ 150 +0.008	∅ 150 +0.046/+0.028	0.002	∅ 165	∅ 208.89	108.69	118.19	6x60°	6x M5	6x M6
∅ 180 -0.001/-0.008	∅ 180 +0.010	∅ 180 +0.050/+0.030	0.003	∅ 200	∅ 254.93	131.71	141.21	6x60°	6x M5	6x M6
∅ 270 0/-0.01	∅ 270 +0.012	∅ 270 +0.067/+0.044	0.003	∅ 290	∅ 331.31	169.90	179.40	12x30°	12x M5	12x M6
∅ 425 0/-0.01	∅ 425 +0.015	∅ 425 +0.094/+0.067	0.006	∅ 445	∅ 484.07	246.29	255.79	12x30°	12x M6	12x M6
∅ 512 0/-0.015	∅ 512 +0.016	∅ 512 +0.109/+0.076	0.007	∅ 528	∅ 560.46	284.48	293.98	18x20°	18x M6	12x M8



For more information:

For CAD data go to cad.heidenhain.de

ERA 4280C, ERA 4480C, ERA 4880C

Incremental angle encoder for high accuracy

- Steel scale drum with centering collar
- Protective cover optional for ERA 4480C
- Consists of scanning head and scale drum



ERA 4000



ERA 4000 with protective cover

Scanning head

Interface

Cutoff frequency -3 dB

Electrical connection

Cable length

Voltage supply

Current consumption

Vibration 55 to 2000 Hz

Shock 6 ms

Operating temperature

Mass

Scanning head

Scale drum

Measuring standard

Coefficient of expansion

Signal periods/ ERA 4200

Interpolation error ERA 4400

per signal period¹⁾ ERA 4800

Accuracy of graduation

Reference marks

Drum inside diameter*

Drum outside diameter*

Mech. permissible speed

Moment of inertia

Permissible axial movement

Protection* EN 60529

Without protective cover

With protective cover²⁾ and compressed air

Mass

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								
$\sim 1 V_{PP}$								
$\geq 350 \text{ kHz}$								
Cable 1 m with M23 coupling (12-pin)								
$\leq 150 \text{ m}$ (with HEIDENHAIN cable)								
DC 5 V $\pm 0.5 \text{ V}$								
$< 100 \text{ mA}$ (without load)								
$\leq 200 \text{ m/s}^2$ (EN 60068-2-6) $\leq 1000 \text{ m/s}^2$ (EN 60068-2-27)								
$-10 \text{ }^\circ\text{C}$ to $80 \text{ }^\circ\text{C}$								
$\approx 20 \text{ g}$; scanning head for protective cover: $\approx 35 \text{ g}$ (each without cable)								

TTR ERA 4200C graduation period 20 μm TTR ERA 4400C graduation period 40 μm TTR ERA 4800C graduation period 80 μm								
Steel drum $\alpha_{\text{therm}} \approx 10.4 \cdot 10^{-6} \text{ K}^{-1}$								
12000/ ± 1.1 "	16384/ ± 0.8 "	20000/ ± 0.7 "	28000/ ± 0.5 "	32768/ ± 0.4 "	40000/ ± 0.4 "	52000/ ± 0.3 "	–	–
6000/ ± 2.2 "	8192/ ± 1.6 "	10000/ ± 1.3 "	14000/ ± 1.0 "	16384/ ± 0.8 "	20000/ ± 0.7 "	26000/ ± 0.5 "	38000/ ± 0.4 "	44000/ ± 0.3 "
3000/ ± 4.4 "	4096/ ± 3.2 "	5000/ ± 2.6 "	7000/ ± 1.9 "	8192/ ± 1.6 "	10000/ ± 1.3 "	13000/ ± 1.0 "	–	–
± 5 "	± 3.7 "	± 3 "	± 2.5 "				± 2 "	
Distance-coded or one								
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
10000 rpm	8500 rpm	6250 rpm	4500 rpm	4250 rpm	3250 rpm	2500 rpm	1800 rpm	1500 rpm
$0.27 \cdot 10^{-3} \text{ kgm}^2$	$0.81 \cdot 10^{-3} \text{ kgm}^2$	$1.9 \cdot 10^{-3} \text{ kgm}^2$	$7.1 \cdot 10^{-3} \text{ kgm}^2$	$12 \cdot 10^{-3} \text{ kgm}^2$	$28 \cdot 10^{-3} \text{ kgm}^2$	$59 \cdot 10^{-3} \text{ kgm}^2$	$195 \cdot 10^{-3} \text{ kgm}^2$	$258 \cdot 10^{-3} \text{ kgm}^2$
$\leq \pm 0.5 \text{ mm}$ (scale drum relative to the scanning head)								
Complete encoder in mounted condition:								
IP00								
IP40	IP40	IP40	IP40	IP40	IP40	IP40	–	–
$\approx 0.28 \text{ kg}$	$\approx 0.41 \text{ kg}$	$\approx 0.68 \text{ kg}$	$\approx 1.2 \text{ kg}$	$\approx 1.5 \text{ kg}$	$\approx 2.3 \text{ kg}$	$\approx 2.6 \text{ kg}$	$\approx 3.8 \text{ kg}$	$\approx 3.6 \text{ kg}$
$\approx 0.07 \text{ kg}$	$\approx 0.1 \text{ kg}$	$\approx 0.12 \text{ kg}$	$\approx 0.17 \text{ kg}$	$\approx 0.22 \text{ kg}$	$\approx 0.26 \text{ kg}$	$\approx 0.35 \text{ kg}$	–	–

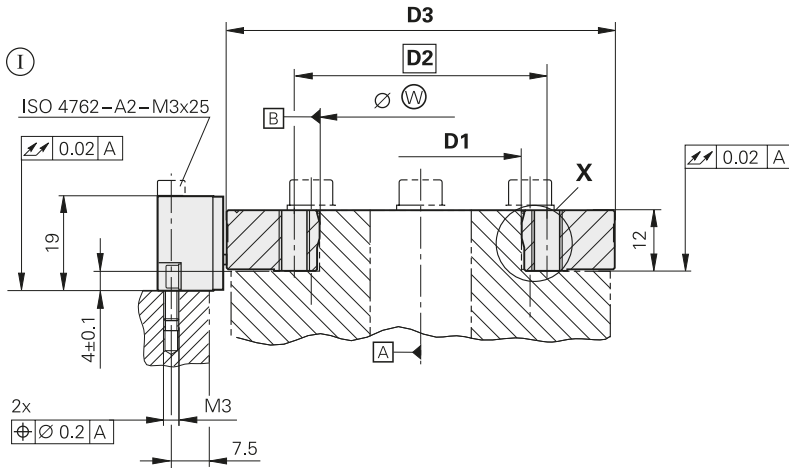
* Please select when ordering

¹⁾ Interpolation error within one signal period and the accuracy of the graduation together result in the encoder-specific error; for additional error from mounting and bearing of the measured shaft, see *Measuring accuracy*

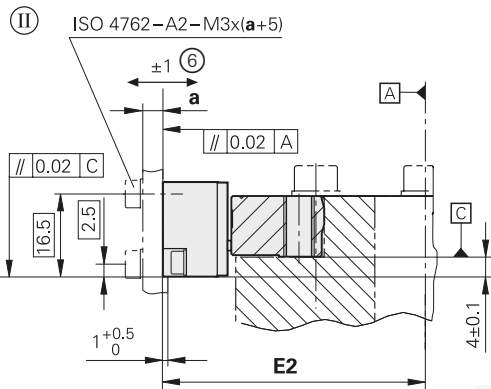
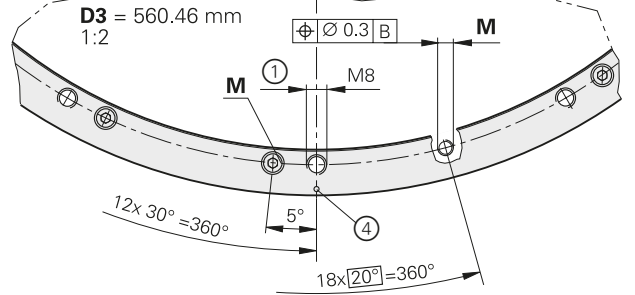
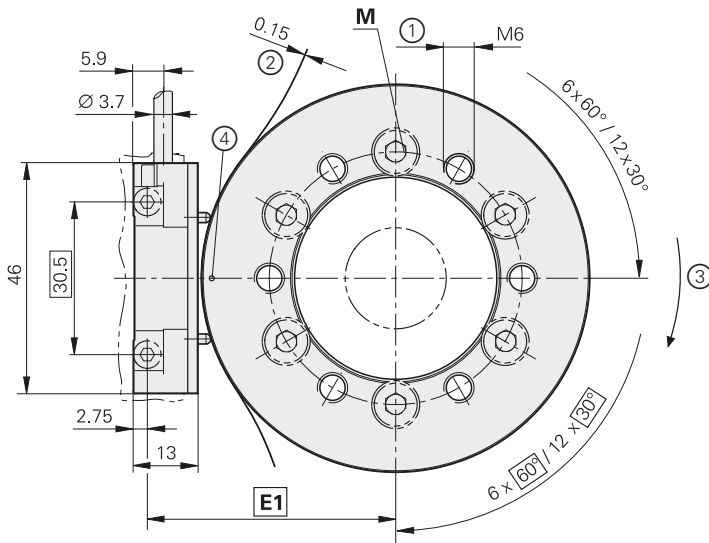
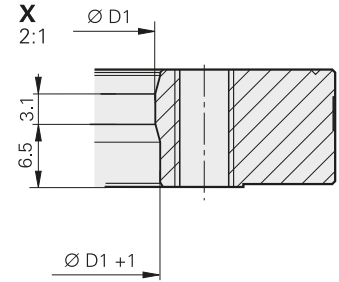
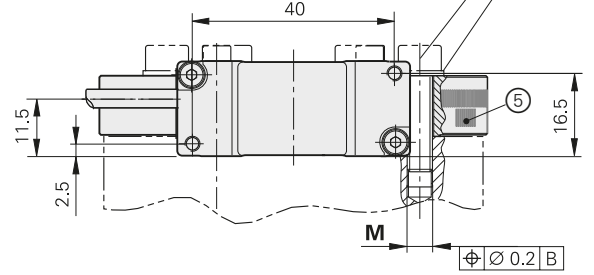
²⁾ Possible only with ERA 4480; please order protective cover separately

ERA 4280C, ERA 4480C, ERA 4880C

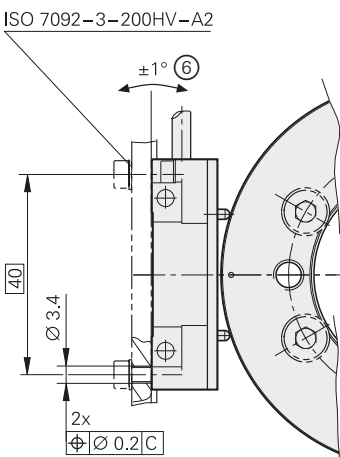
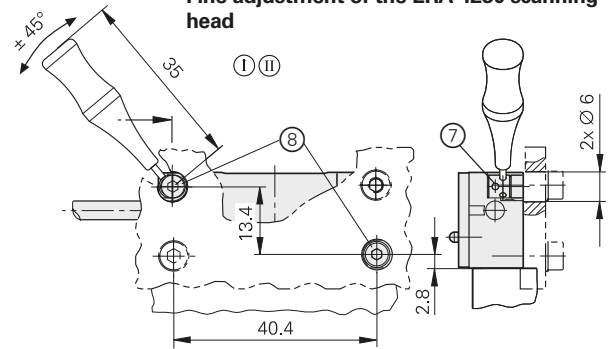
Without protective cover



ISO 7092-5-140HV-A2
D3: $\varnothing 484.07/\varnothing 560.46 = \text{ISO 7092-6-140HV-A2}$
 ISO 4762-A2-M5x20
D3: $\varnothing 484.07/\varnothing 560.46 = \text{ISO 4762-A2-M6x22}$



Fine adjustment of the ERA 4280 scanning head



For more information:

For CAD data go to cad.heidenhain.de

mm



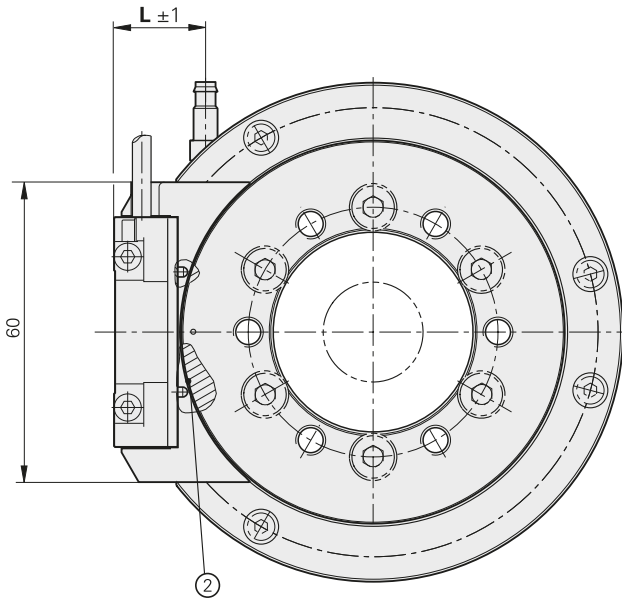
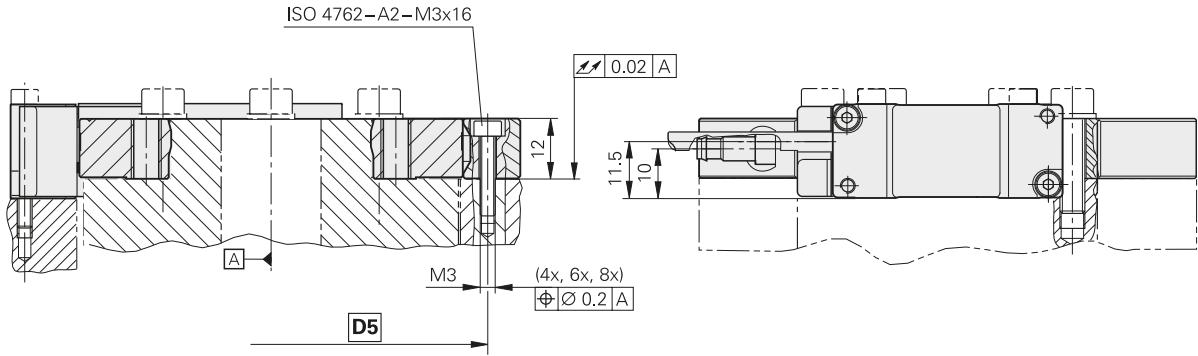
Tolerancing ISO 8015
 ISO 2768 - m H
 ≤ 6 mm: ±0.2 mm

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

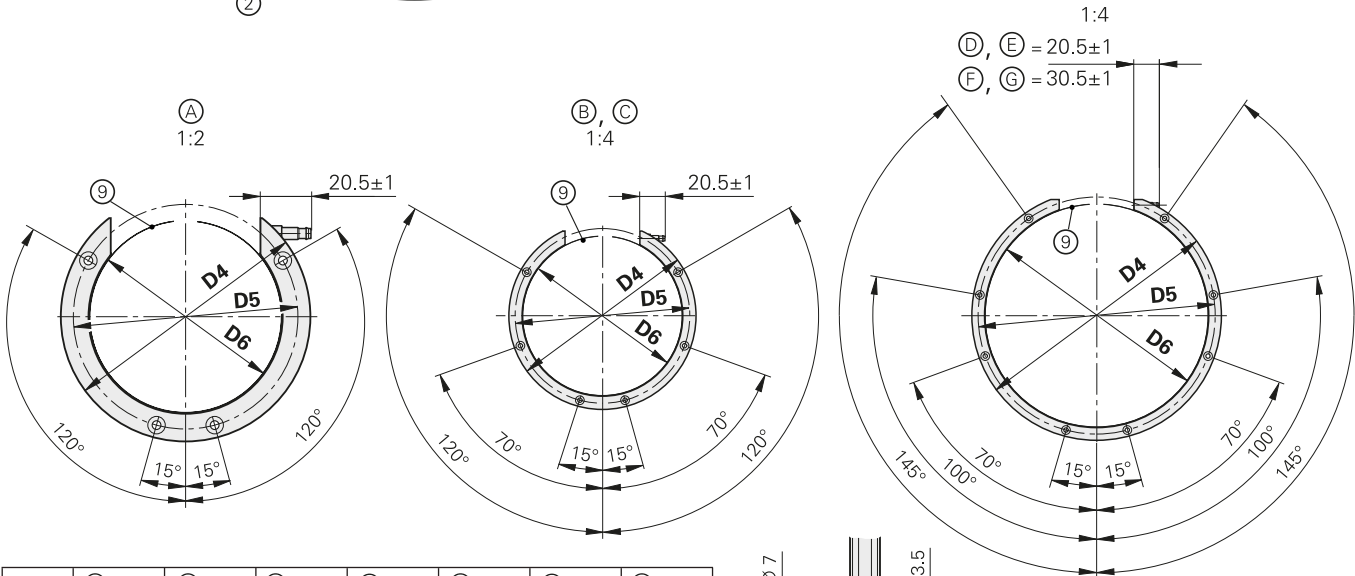
*) Circularity of mating diameter (shaft)

ERA 4480C

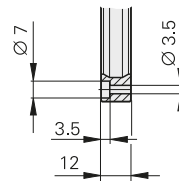
With protective cover



- ⊙, ⊗ = Mounting options
- M = Mounting screws
- ▣ = Bearing
- ⊗ = mating shaft
- 1 = Back-off thread
- 2 = Mounting clearance (spacer shim)
- 3 = Positive direction of shaft rotation for output signals according to interface description
- 4 = Marker for reference mark, position tolerance with respect to reference mark ± 1.0 mm
- 5 = Reference mark
- 6 = Ensure adjustability of mounting surface for scanning head
- 7 = Eccentric bushing
- 8 = Holes required for fine adjustment
- 9 = Mounting clearance 0.15 mm (protective cover)



	(A)	(B)	(C)	(D)	(E)	(F)	(G)
D3	∅ 76.75	∅ 104.63	∅ 127.64	∅ 178.55	∅ 208.89	∅ 254.93	∅ 331.31
D4	∅ 100	∅ 127	∅ 150	∅ 200	∅ 232	∅ 278	∅ 354
D5	∅ 90	∅ 117	∅ 140	∅ 190	∅ 222	∅ 268	∅ 344
D6	∅ 77.2	∅ 105.2	∅ 128.2	∅ 179.1	∅ 209.4	∅ 255.6	∅ 332
L	18.6	16.5	15.5	14.5	13.2	12.7	12.1



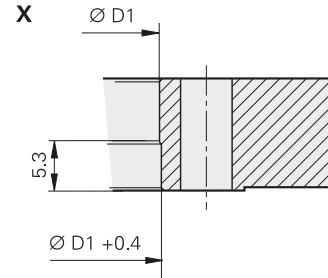
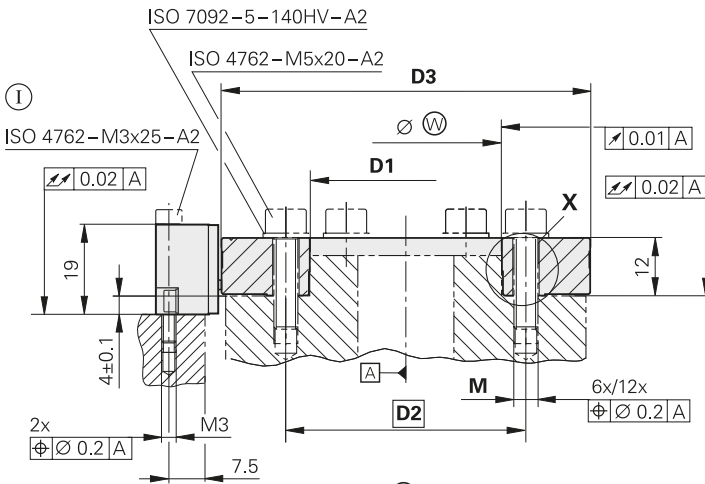
For more information:

For CAD data go to cad.heidenhain.de

ERA 4282 C

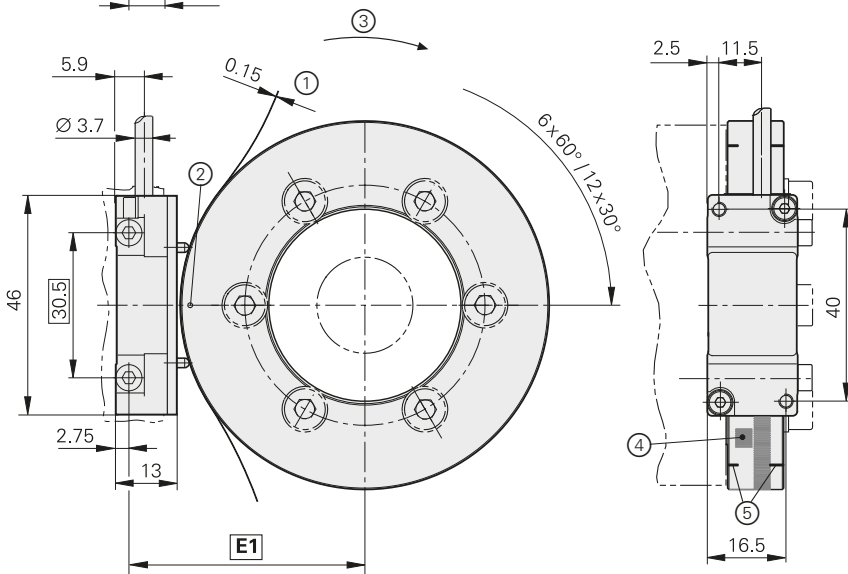
Incremental angle encoder for high accuracy

- Steel scale drum with three-point centering
- Consists of scanning head and scale drum

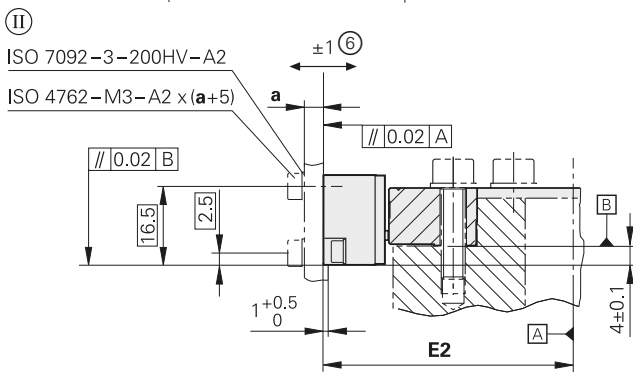


mm

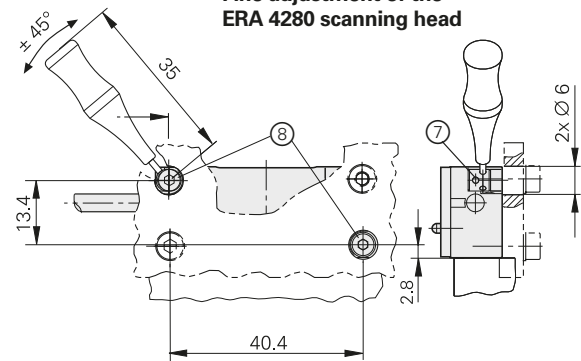
 Tolerancing ISO 8015
 ISO 2768 - m H
 ≤ 6 mm: ±0.2 mm



- ⊙, ⊕ = Mounting options
- ⊠ = Bearing
- ⊗ = mating shaft
- 1 = Mounting clearance (spacer shim)
- 2 = Mark for reference mark
- 3 = Positive direction of rotation for output signals as per interface description
- 4 = Reference mark
- 5 = Marks for drum centering (3 x 120°)
- 6 = Ensure adjustability of mounting surface for scanning head
- 7 = Eccentric bushing
- 8 = Required holes for fine adjustment (only for ERA 4280 scanning head)

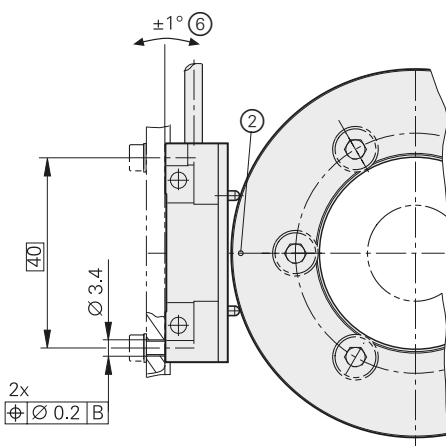


Fine adjustment of the ERA 4280 scanning head



For more information:

For CAD data go to cad.heidenhain.de



D1	⊗	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 163	Ø 178.55	100.24	102.98	M3 12x
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
Interface	$\sim 1 V_{pp}$
Cutoff frequency -3 dB	≥ 350 kHz
Electrical connection	Cable 1 m with M23 coupling (12-pin)
Cable length	≤ 150 m (with HEIDENHAIN cable)
Voltage supply	DC 5 V ± 0.5 V
Current consumption	< 100 mA (without load)
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
Mass	≈ 20 g (without cable)

Scale drum	TTR ERA 4202 C						
Measuring standard Grating period Coefficient of expansion	Steel drum 20 μ m $\alpha_{therm} \approx 10.4 \cdot 10^{-6} K^{-1}$						
Signal periods	12000	16384	20000	28000	32768	40000	52000
Accuracy of graduation	$\pm 4''$	$\pm 3''$	$\pm 2.5''$	$\pm 2''$	$\pm 1.9''$	$\pm 1.8''$	$\pm 1.7''$
Interpolation error per signal period¹⁾	$\pm 1.1''$	$\pm 0.8''$	$\pm 0.7''$	$\pm 0.5''$	$\pm 0.4''$	$\pm 0.4''$	$\pm 0.3''$
Reference marks	Distance-coded						
Drum inside diameter*	40 mm	70 mm	80 mm	120 mm/ 150 mm	150 mm/ 185 mm	180 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	331.31 mm
Mech. permissible speed	10000 rpm	8500 rpm	6250 rpm	4500 rpm	4250 rpm	3250 rpm	2500 rpm
Moment of inertia	$0.28 \cdot 10^{-3}$ kgm ²	$0.83 \cdot 10^{-3}$ kgm ²	$2.0 \cdot 10^{-3}$ kgm ²	$7.1/4.5 \cdot 10^{-3}$ kgm ²	$12/6.5 \cdot 10^{-3}$ kgm ²	$28/20 \cdot 10^{-3}$ kgm ²	$59 \cdot 10^{-3}$ kgm ²
Permissible axial movement	$\leq \pm 0.5$ mm (scale drum relative to the scanning head)						
Protection EN 60529	Complete encoder in mounted condition: IP00						
Mass	≈ 0.30 kg	≈ 0.42 kg	≈ 0.69 kg	≈ 1.2 kg/ 0.66 kg	≈ 1.5 kg/ 0.66 kg	≈ 2.3 kg/ 1.5 kg	≈ 2.6 kg

* Please select when ordering

¹⁾ Interpolation error within one signal period and the accuracy of the graduation together result in the encoder-specific error; for additional error from mounting and bearing of the measured shaft, 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
Interface	$\sim 1 V_{pp}$
Cutoff frequency -3 dB	≥ 350 kHz
Electrical connection	Cable 1 m with M23 coupling (12-pin)
Cable length	≤ 150 m (with HEIDENHAIN cable)
Voltage supply	DC 5 V ± 0.5 V
Current consumption	< 100 mA (without load)
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
Mass	≈ 20 g (without cable)

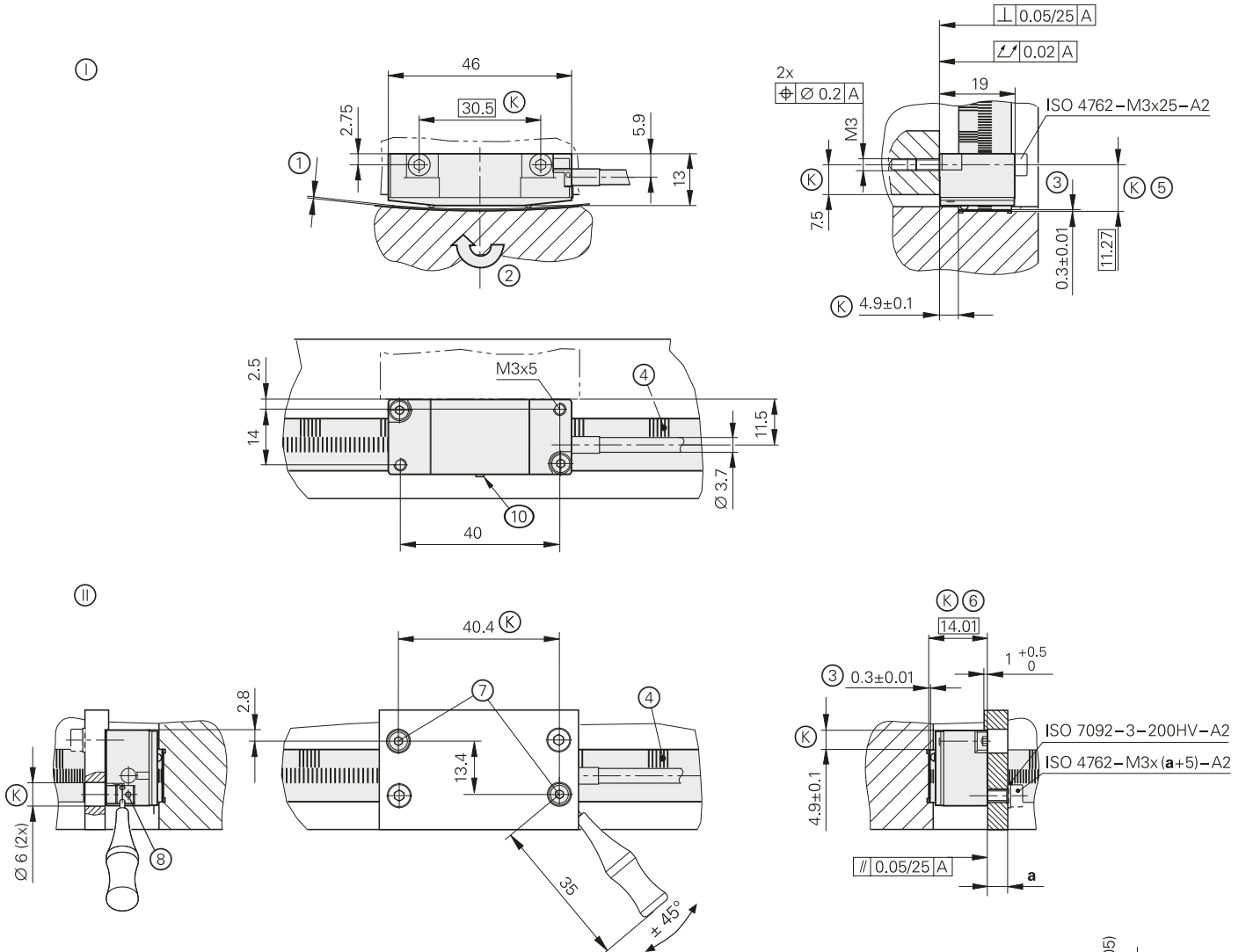
Scale Tape	MSB ERA 7400C full circle version MSB ERA 7401C segment version			
Measuring standard Grating period Coefficient of expansion	Steel scale-tape with METALLUR graduation 40 μ m $\alpha_{therm} \approx 10.5 \cdot 10^{-6} K^{-1}$			
Signal periods ¹⁾	36000	45000	90000	
Accuracy of graduation ²⁾	$\pm 3.9''$	$\pm 3.2''$	$\pm 1.6''$	
Interpolation error per signal period ²⁾	$\pm 0.4''$	$\pm 0.3''$	$\pm 0.1''$	
Accuracy of the scale tape	± 3 μ m/m of tape length			
Reference marks	Distance-coded			
Scale-slot diameter*	Full circle	458.62 mm	573.20 mm	1146.10 mm
	Segment	≥ 400 mm		
Mech. permissible speed	≤ 250 rpm	≤ 250 rpm	≤ 220 rpm	
Permissible 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	Complete encoder in mounted condition: IP00			
Mass	≈ 30 g/m			

* Please select when ordering, additional diameters up to max. 3 m upon request

¹⁾ Validity for full circle version; for segment versions depending on the mating diameter and the tape length

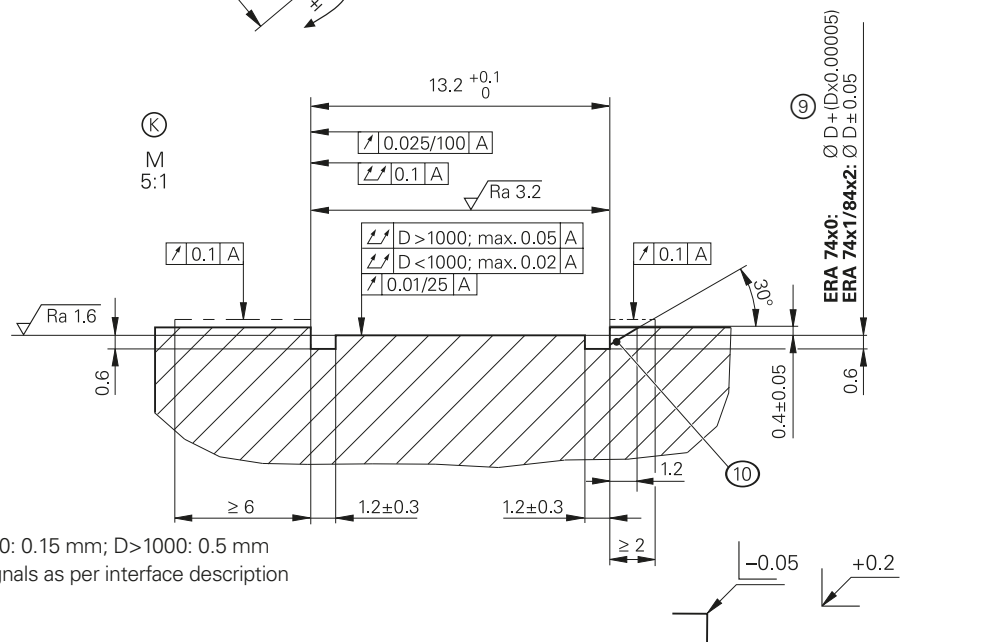
²⁾ Accuracy of the graduation and interpolation error within one signal period result in the encoder-specific error; for additional error from mounting and bearing of the measured shaft, see *Measuring accuracy*

ERA 7000 series



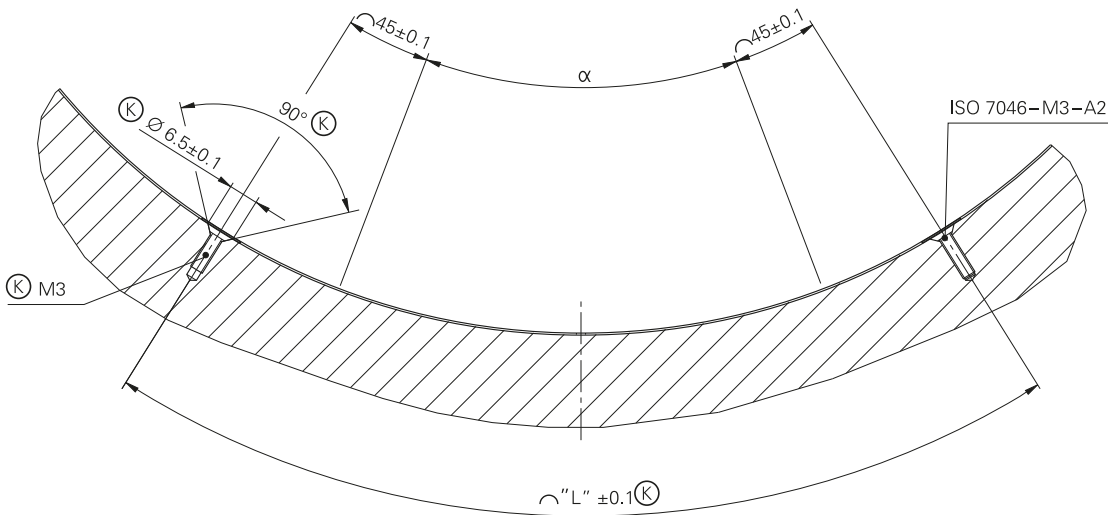
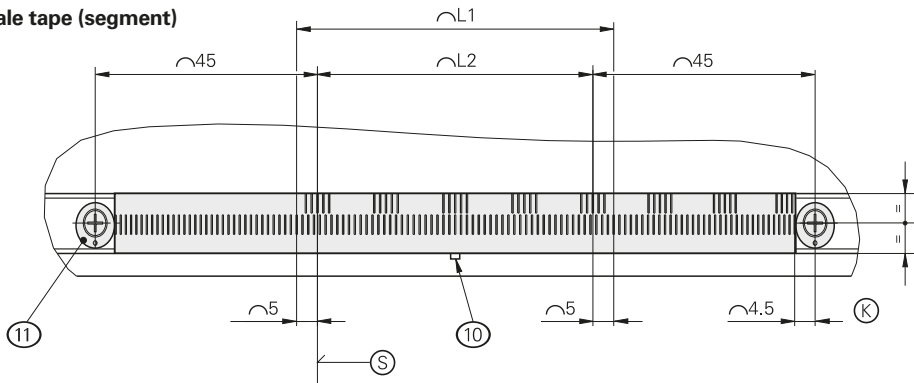
mm

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



- ⓪, ① = Mounting options
- Ⓜ = Bearing
- Ⓚ = Required mating dimensions
- 1 = Mounting clearance (spacer shim) D<1000: 0.15 mm; D>1000: 0.5 mm
- 2 = Positive direction of rotation for output signals as per interface description
- 3 = Scale tape thickness
- 4 = Reference mark
- 5 = Distance between floor of scale-tape slot 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 = Eccentric bushing (moiré setting)
- 9 = Scale tape slot floor $\varnothing D$
- 10 = Notch for scale tape disassembly (b = 2 mm)

ERA 74x1 scale tape (segment)



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

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

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

- ⊗ = Required mating dimensions
- Ⓢ = Beginning of measurement
- 10 = Notch for scale tape disassembly (b = 2 mm)
- 11 = Cam disk for tensioning the scale tape
- ∩ = Length of the arc in the stress-free zone, pay attention to the scale-tape thickness
- ∩L = Position of the threaded mounting holes
- ∩L1 = Traverse path
- ∩L2 = Measuring range in the arc

- n = Signal period
- D = Slot-floor diameter
- α = Measuring range in degrees (segment angle)
- π = 3.14159...

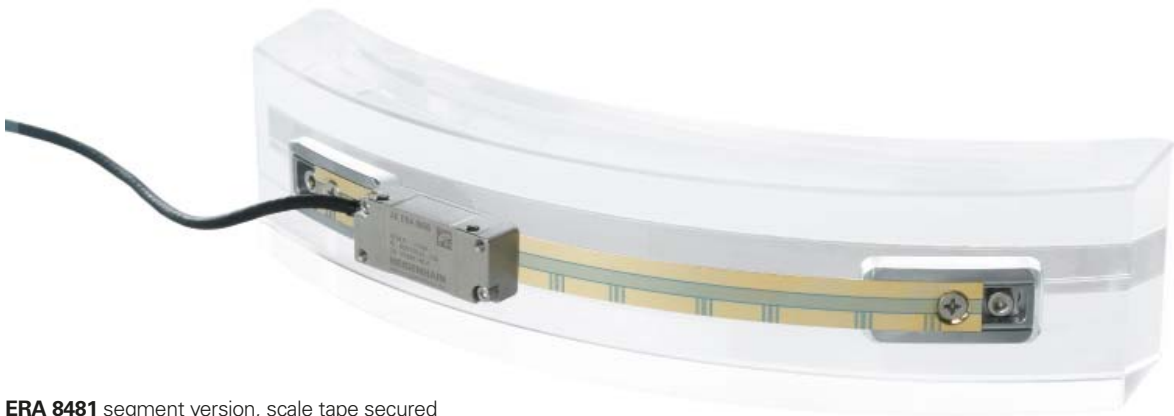
ERA 8000 series

Incremental angle encoder for high accuracy

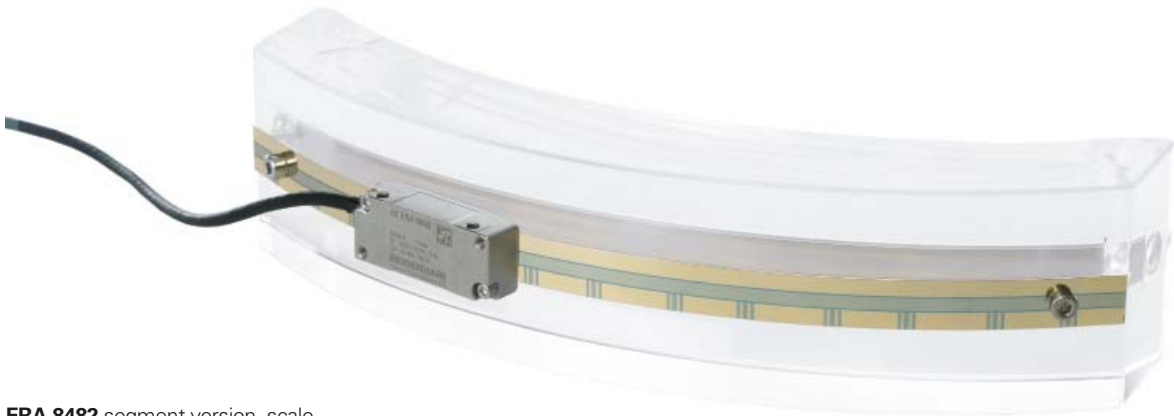
- Steel scale tape for external mounting
- Full-circle and segment versions, also for very large diameters
- Consists of scanning head and scale tape



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
Interface	$\sim 1 V_{pp}$
Cutoff frequency -3 dB	≥ 350 kHz
Electrical connection	Cable 1 m with M23 coupling (12-pin)
Cable length	≤ 150 m (with HEIDENHAIN cable)
Voltage supply	DC 5 V ± 0.5 V
Current consumption	< 100 mA (without load)
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
Mass	≈ 20 g (without cable)

Scale Tape	MSB ERA 8400C full circle version MSB ERA 8401C segment version with tensioning elements MSB ERA 8402C segment version without tensioning elements		
Measuring standard Grating period Coefficient of expansion	Steel scale-tape with METALLUR graduation 40 μ m $\alpha_{therm} \approx 10.5 \cdot 10^{-6} K^{-1}$		
Signal periods ¹⁾	36000	45000	90000
Accuracy of graduation ²⁾	$\pm 4.7''$	$\pm 3.9''$	$\pm 1.9''$
Interpolation error per signal period ²⁾	$\pm 0.4''$	$\pm 0.3''$	$\pm 0.1''$
Accuracy of the scale tape	± 3 μ m/m of tape length		
Reference marks	Distance-coded		
Scale-slot diameter*	Full circle	458.11 mm	572.72 mm
	Segment	≥ 400 mm	
Mech. permissible speed	≤ 50 rpm	≤ 50 rpm	≤ 45 rpm
Permissible 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	Complete encoder in mounted condition: IP00		
Mass	≈ 30 g/m		

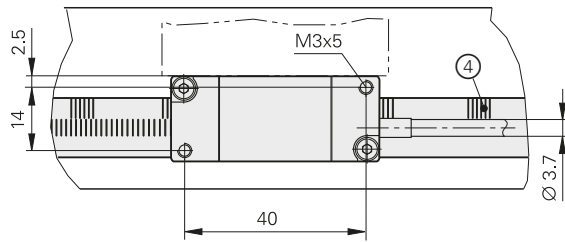
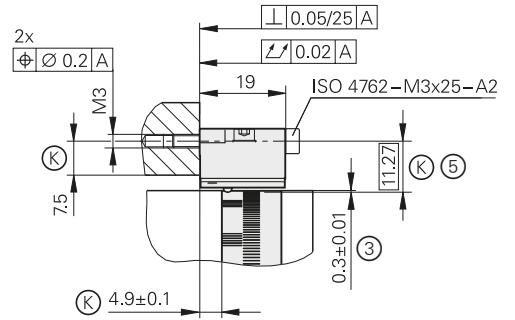
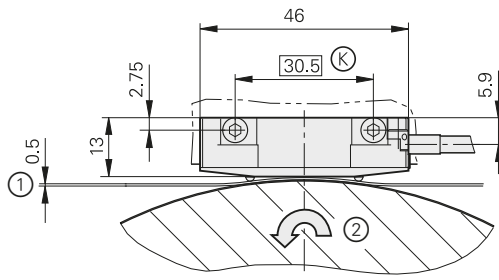
* Please select when ordering, additional diameters up to max. 3 m upon request

¹⁾ Validity for full circle version; for segment versions depending on the mating diameter and the tape length

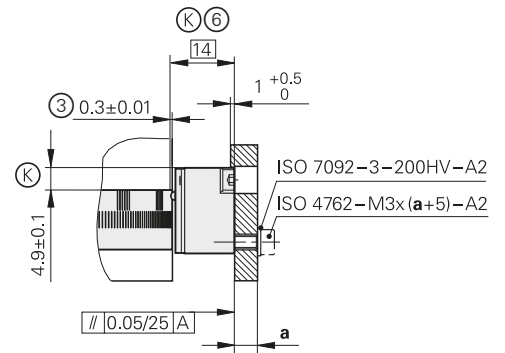
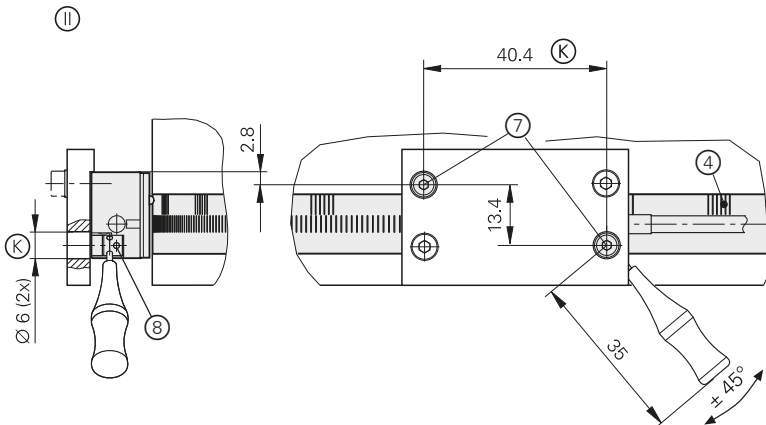
²⁾ Accuracy of the graduation and interpolation error within one signal period result in the encoder-specific error; for additional error from mounting and bearing of the measured shaft, see *Measuring accuracy*

ERA 8000 series

①

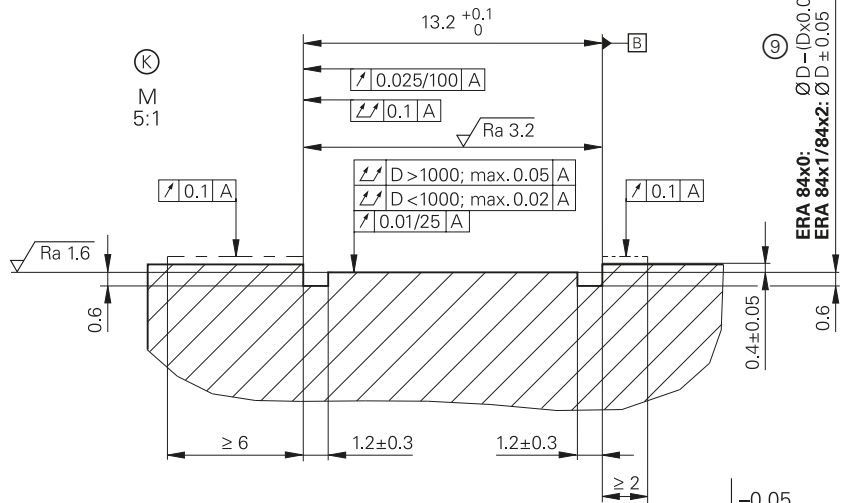


②

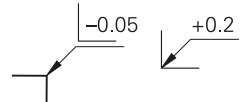


mm

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



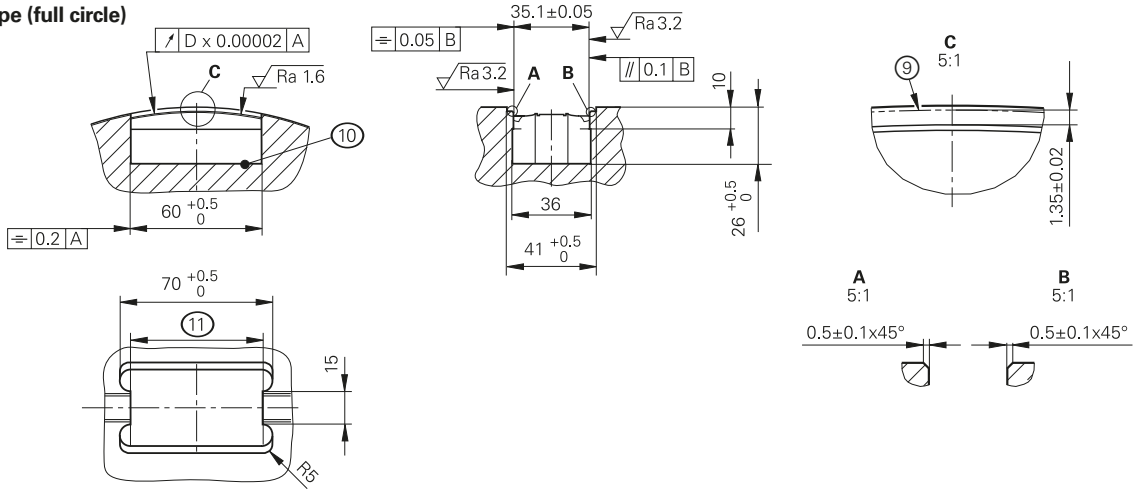
ERA 84x0: Ø D - (D x 0.00005)
 ERA 84x1/84x2: Ø D ± 0.05



- ①, ② = Mounting options
- ▣ = Bearing
- ⊗ = Required mating dimensions
- ⊙ = Beginning of measurement
- 1 = Mounting clearance (spacer shim)
- 2 = Positive direction of rotation for output signals as per interface description
- 3 = Scale tape thickness
- 4 = Reference mark
- 5 = Distance between floor of scale-tape slot 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 = Eccentric bushing (moiré setting)
- 9 = Scale tape slot floor Ø D
- 10 = Floor of pocket is ferromagnetic for fixing the tensioning cleat
- 11 = Length of the chamfer >60 mm

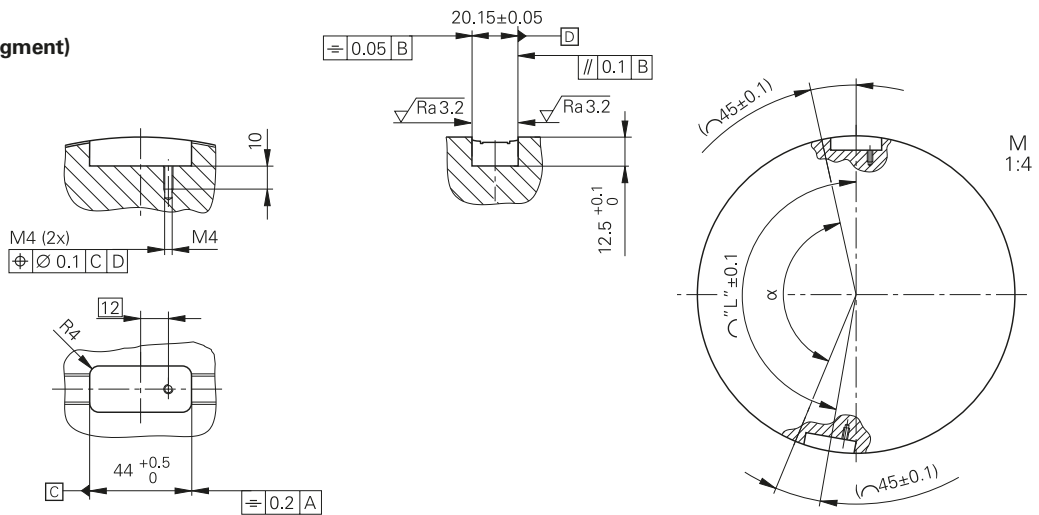
ERA 84x0 scale tape (full circle)

Ⓚ
M
1:2



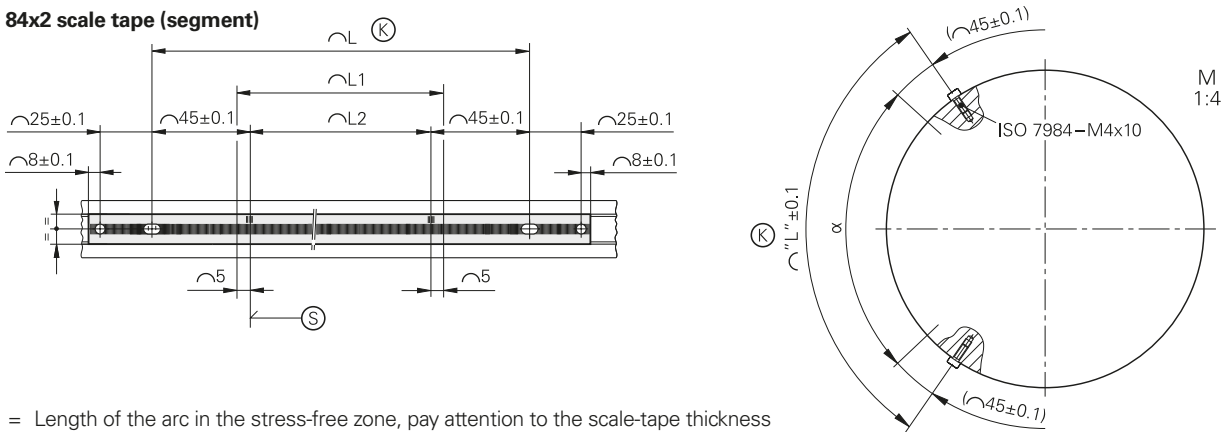
ERA 84x1 scale tape (segment)

Ⓚ
M
1:2



ERA 84x2 scale tape (segment)

M
1:2



- ⌒ = Length of the arc in the stress-free zone, 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 the arc

- n = Signal period
- D = Slot-floor diameter
- α = Measuring range in degrees (segment angle)
- π = 3.14159...

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

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

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

Interfaces

Incremental signals $\sim 1 V_{PP}$

HEIDENHAIN encoders with $\sim 1 V_{PP}$ interface provide highly interpolable voltage signals.

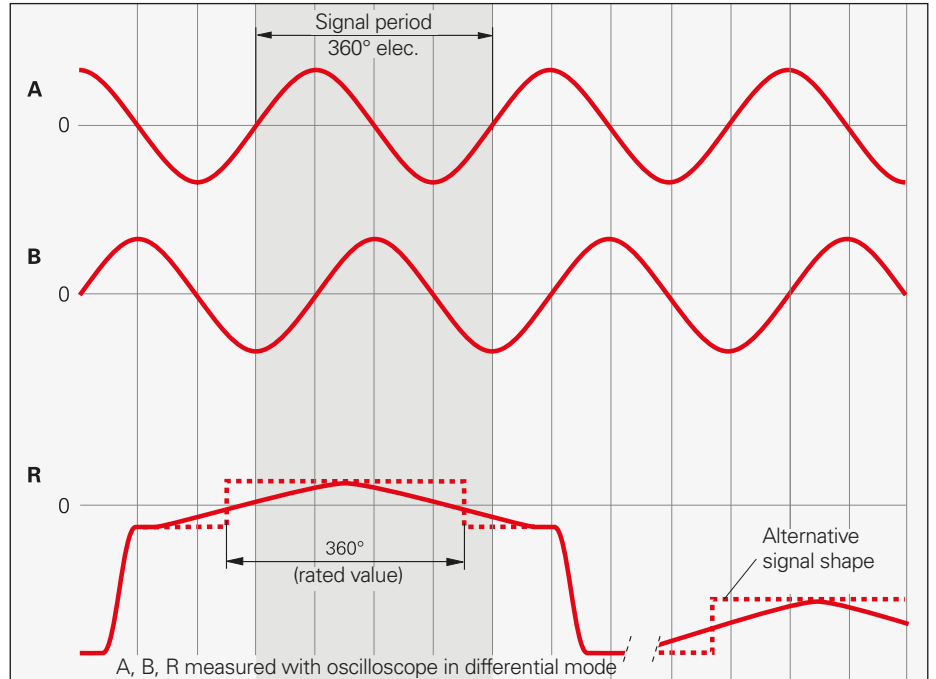
The sinusoidal **incremental signals** A and B are phase-shifted by 90° elec. and have amplitudes of typically $1 V_{PP}$. The illustrated sequence of output signals—with B lagging A—applies for the direction of motion shown in the dimension drawing.

The **reference mark signal** R has an unambiguous assignment to the incremental signals. The output signal might be somewhat lower next to the reference mark.


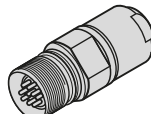
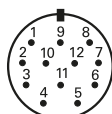

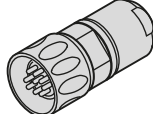
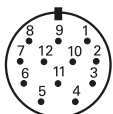

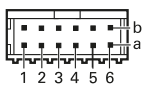

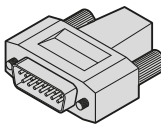
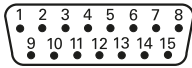






For more information:

Comprehensive descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.



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	2	10	11	5	6	8	1	3	4	9	7	/
	2a	2b	1a	1b	6b	6a	5b	5a	4b	4a	3b	3a	/
	4	12	2	10	1	9	3	11	14	7	5/6/8	13	15
	U_P	Sensor U_P	0V	Sensor 0V	A+	A-	B+	B-	R+ ¹⁾	R- ¹⁾	Vacant	Vacant	Vacant
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	/	Violet	Yellow

Cable shield connected to housing; U_P = Power supply voltage
Sensor: The sensor cable is connected to the respective voltage supply in the encoder (ERO 6xxx and ERA in the encoder connector)
 Vacant pins or wires must not be used.

¹⁾ ERP 4080/ERP 8080: Vacant

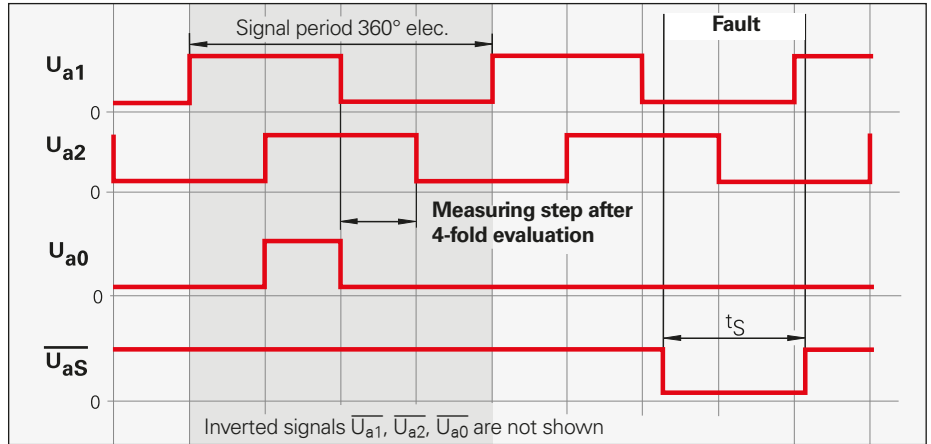
Incremental signals \square TTL

HEIDENHAIN encoders with \square 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 an interruption in the supply lines, failure of the light source, etc.

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**.



For more information:

Comprehensive descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

Pin layout

15-pin D-sub connector					15-pin D-sub connector with integrated interface electronics									
	Voltage 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	0V	Sensor 0V	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 cable is connected to the respective voltage supply in the encoder (ERO 6xxx and ERA in the encoder connector)
 Vacant pins or wires must not be used.

¹⁾ ERO 6x70: Switchover TTL/11 μA_{PP} for PWT, otherwise vacant

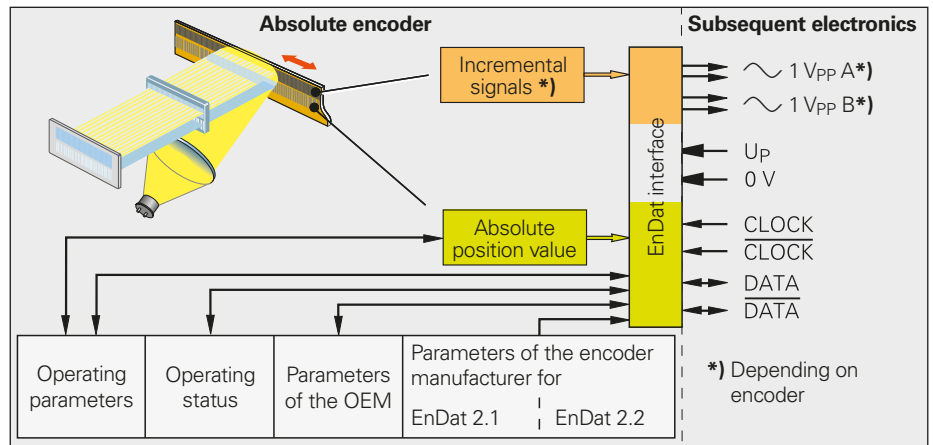
Interfaces

Position values

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

Ordering designation	Command set	Incremental signals
EnDat01	EnDat 2.1 or EnDat 2.2	With
EnDat21		Without
EnDat02	EnDat 2.2	With
EnDat22	EnDat 2.2	Without


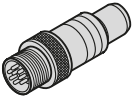


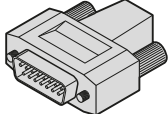




Versions of the EnDat interface



For more information:

Comprehensive descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

EnDat pin layout

8-pin coupling, M12					15-pin D-sub connector				
									
	Voltage supply				Absolute position values				
	8	2	5	1	3	4	7	6	
	4	12	2	10	5	13	8	15	
	Up	Sensor Up	0V	Sensor 0V	DATA	DATA	CLOCK	CLOCK	
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow	

Cable shield connected to housing; **Up** = Power supply voltage

Sensor: The sensor line is connected in the encoder with the corresponding power line. Vacant pins or wires must not be used.

Fanuc, Mitsubishi and Panasonic pin layout

Fanuc pin layout

HEIDENHAIN encoders with the code letter F after the model designation are suited for connection to Fanuc controls and drive systems.


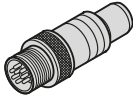


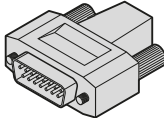
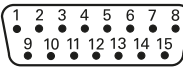



• Fanuc Serial Interface – α Interface

Ordering designation: Fanuc02 normal and high speed, two-pair transmission

• Fanuc Serial Interface – αi interface

Ordering designation: Fanuc05 high speed, one-pair transmission contains α interface (normal and high speed, two-pair transmission)

Fanuc pin layout

8-pin coupling, M12					15-pin D-sub connector				
									
	Voltage supply				Absolute position values				
	8	2	5	1	3	4	7	6	
	4	12	2	10	5	13	8	15	
	Up	Sensor Up	0V	Sensor 0V	Serial Data	Serial Data	Request	Request	
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow	

Cable shield connected to housing; **Up** = Power supply voltage

Sensor: The sensor line is connected in the encoder with the corresponding power line.

Vacant pins or wires must not be used.

Mitsubishi pin layout


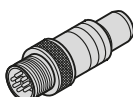
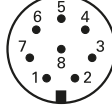

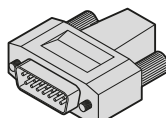
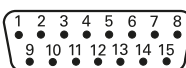



HEIDENHAIN encoders with the code letter M after the model designation are suited for connection to Mitsubishi controls and drive systems.

Mitsubishi high speed interface

- Ordering designation: Mitsu01 Two-pair transmission
- Ordering designation: Mit02-4 Generation 1, two-pair transmission

- Ordering designation: Mit02-2 Generation 1, one-pair transmission
- Ordering designation: Mit03-4 Generation 2, two-pair transmission

Mitsubishi pin layout

8-pin coupling, M12					15-pin D-sub connector				
									
	Voltage supply				Absolute position values				
	8	2	5	1	3	4	7	6	
	4	12	2	10	5	13	8	15	
Mit03-4	Up	Sensor Up	0V	Sensor 0V	Serial Data	Serial Data	Request Frame	Request Frame	
Mit02-2					Vacant	Vacant	Request/ Data	Request/ Data	
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow	

Cable shield connected to housing; **Up** = Power supply voltage

Sensor: The sensor line is connected in the encoder with the corresponding power line.


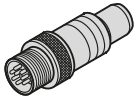


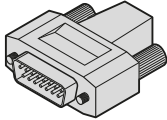
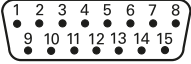



Vacant pins or wires must not be used.

Panasonic pin layout

HEIDENHAIN encoders with the code letter P after the model designation are suited for connection to Panasonic controls and drive systems.

- Ordering designation: Pana01

Panasonic pin layout

8-pin coupling, M12					15-pin D-sub connector			
								
	Voltage supply				Absolute position values			
	8	2	5	1	3	4	7	6
	4	12	2	10	5	13	8	15
	U_P	Sensor U _P	0V	Sensor 0V	Vacant ¹⁾	Vacant ¹⁾	Request Data	Request Data
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

Cable shield connected to housing; **U_P** = Power supply voltage

Sensor: The sensor line is connected in the encoder with the corresponding power line.

Vacant pins or wires must not be used.

¹⁾ Required for adjustment/inspection by PWM 20

Connecting elements and cables

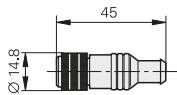
General information

Connector (insulated): Connecting element with coupling ring; available with male or female contacts.

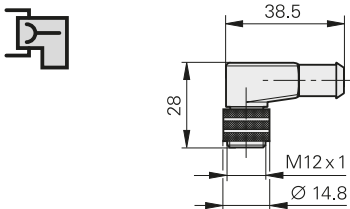
Symbols



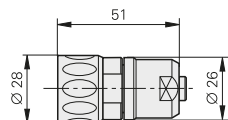
M12



M12 right-angle connector

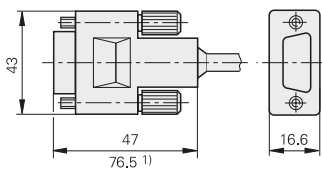


M23



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

Symbols



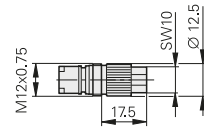
¹⁾ With integrated interpolation electronics

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

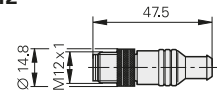
Symbols



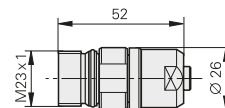
On the adapter cable



M12



M23



The **pin numbering** on connectors is in the direction opposite to those on couplings or flange sockets, regardless of whether the connecting elements have

male contacts or



female contacts.



When engaged, the connections provide **protection** to IP67 (D-sub connector: IP50; RJ-45: IP20; EN 60529). When not engaged, there is no protection.

Maximum cable lengths

The maximum achievable cable length is influenced by the supply voltage of the subsequent electronics, the cables used, and the interface. However, commonly used overall lengths of 30 m are usually possible without restrictions.





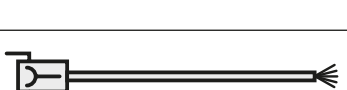








For more information:

Brochure: *Cables and Connectors for HEIDENHAIN Controls*







1 V_{PP} connecting cables

12-pin M23

PUR connecting cable		[6(2 × 0.19 mm ²); A _P = 0.19 mm ²]	
PUR connecting cable		∅ 8 mm	∅ 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), 15-pin, for IK 115/IK 215/ND 280/ND 287/EIB 741		310196-xx	–
With one Connector (female)		309777-xx	–
Complete With D-sub connector (male) and M23 connector (male)		331693-xx	355215-xx
With one D-sub connector(female)		332433-xx	355209-xx
Complete With D-sub connector (male) and D-sub connector (male)		335074-xx	355186-xx
Complete With D-sub connector (female) and D-sub connector (female) pin layout for IK 220/ND 780		335077-xx	349687-xx
Cable only		816317-xx	816323-xx
Encoder cable for ERP 880	PUR [4(2 × 0.05) + (4 × 0.14)] mm ² ; A _P = 0.14 mm ²	∅ 4.5 mm	
With one PCB connector, 12-pin	Length 1 m 	372164-01	

¹⁾ Cable length for ∅ 6 mm max. 9 m
A_P: Cross section of power supply lines

EnDat connecting cables






PUR connecting cable [(4 (2 × 0.09 mm ²)); A _P = 0.09 mm ²]			
PUR connecting cable [(4 × 0.14 mm ²) + (4 × 0.34 mm ²); A _P = 0.34 mm ²]		Ø 6 mm	Ø 3.7 mm ¹⁾
Complete With M12 connector (female) and M12 coupling (male), 8 pins each		1036372-xx	1118858-xx
Complete With M12 right-angle connector (female) and M12 coupling (male), 8-pin each		1036386-xx	1118863-xx
Complete With M12 connector (female), 8-pin and D-sub connector (male), 15-pin, for PWM 20, EIB 74x etc.		1036526-xx	1118865-xx
Complete With M12 right-angle connector (female), 8-pin and D-sub connector (male), 15-pin, for PWM 20, EIB 74x etc.		1133855-xx	1118867-xx
With one M12 connector (female), 8-pin		1129581-xx	–
With one M12 right-angle connector (female), 8-pin		1133799-xx	–

¹⁾ Max. total cable length 6 m

A_P: Cross section of power supply lines

Connecting cables Fanuc Mitsubishi







Fanuc

PUR connecting cable	$[4 \times (2 \times 0.09 \text{ mm}^2)]; A_P = 0.09 \text{ mm}^2$		
PUR connecting cable	$[(4 \times 0.14 \text{ mm}^2) + (4 \times 0.34 \text{ mm}^2)]; A_P = 0.34 \text{ mm}^2$	Ø 6 mm	Ø 3.7 mm ¹⁾
Complete With M12 connector (female) and M12 coupling (male), 8-pin		1036372-xx	1118858-xx
Complete With M12 right-angle connector (female) and M12 coupling (male), 8-pin		1036386-xx	1118863-xx
Complete With M12 connector (female), 8-pin, and Fanuc connector (female)		1130952-xx	–
With one connector With M12 connector (female), 8-pin		1129581-xx	–
With one connector With M12 right-angle connector (female), 8-pin		1133799-xx	–

¹⁾ Max. total cable length 6 m

A_P: Cross section of power supply lines

Mitsubishi






PUR connecting cable	$[(4 \times 0.14 \text{ mm}^2) + (4 \times 0.34 \text{ mm}^2)]; A_P = 0.34 \text{ mm}^2$	Ø 6 mm	Ø 3.7 mm ¹⁾
Complete With M12 connector (female) and M12 coupling (male), 8-pin		1036372-xx	1118858-xx
Complete With M12 right-angle connector (female) and M12 coupling (male), 8-pin		1036386-xx	1118863-xx
Complete With M12 connector (female), 8-pin, and Mitsubishi connector, 20-pin	 Mitsubishi 20-pin	1132594-xx	–
Complete With M12 connector (female), 8-pin, and Mitsubishi connector, 10-pin	 Mitsubishi 10-pin	1132621-xx	–
With one connector With M12 connector (female), 8-pin		1129581-xx	–
With one connector With M12 right-angle connector (female), 8-pin		1133799-xx	–

¹⁾ Max. total cable length 6 m

A_P: Cross section of power supply lines

Panasonic connecting cable

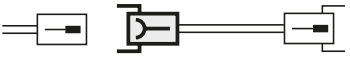
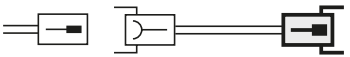
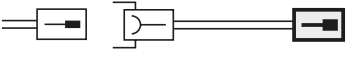

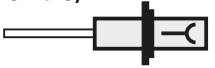
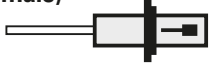
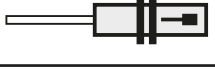
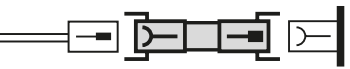
Panasonic

PUR connecting cable [4 × (2 × 0.09 mm ²); A _P = 0.09 mm ²			
PUR connecting cable [(4 × 0.14 mm ²) + (4 × 0.34 mm ²); A _P = 0.34 mm ²		Ø 6 mm	Ø 3.7 mm ¹⁾
Complete With M12 connector (female) and M12 coupling (male), 8-pin		1036372-xx	1118858-xx
Complete With M12 right-angle connector (female) and M12 coupling (male), 8-pin		1036386-xx	1118863-xx
Complete With M12 connector (female), 8-pin, and Fanuc connector (female)		1160268-xx	–
With one connector With M12 connector (female), 8-pin		1129581-xx	–
With one connector With M12 right-angle connector (female), 8-pin		1133799-xx	–

¹⁾ Max. total cable length 6 m

A_P: Cross section of power supply lines

Connecting elements

			12-pin M23
Mating element on connecting cable to connecting element on encoder	Connector (female) 	For cable Ø 8 mm	291697-05
Connector for connection to subsequent electronics	Connector (male) 	For cable Ø 8 mm Ø 6 mm	291697-08 291697-07
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	291698-14 291698-14 291698-03 291698-04
Flange socket for mounting on subsequent electronics	Flange socket (female) 		315892-08
Mounted couplings	With flange (female) 	Ø 6 mm Ø 8 mm	291698-17 291698-07
	With flange (male) 	Ø 6 mm Ø 8 mm	291698-08 291698-31
	With central fastening (male) 	Ø 6 mm to 10 mm	741045-01
Adapter $\sim 1V_{PP}/11\mu A_{PP}$ For converting the $1V_{PP}$ signals to $11\mu A_{PP}$; M23 connector (female), 12-pin and M23 connector (male), 9-pin			364914-01

Diagnostic and testing equipment

HEIDENHAIN encoders are provided with all information necessary for commissioning, monitoring and diagnostics. The type of available information depends on whether the encoder is incremental or absolute and which interface is used.

Incremental encoders mainly have 1 V_{PP}, TTL or HTL interfaces. TTL and HTL encoders monitor their signal amplitudes internally and generate a simple fault detection signal. With 1 V_{PP} signals, the analysis of output signals is possible only in external test devices or through computation in the subsequent electronics (analog diagnostics interface).

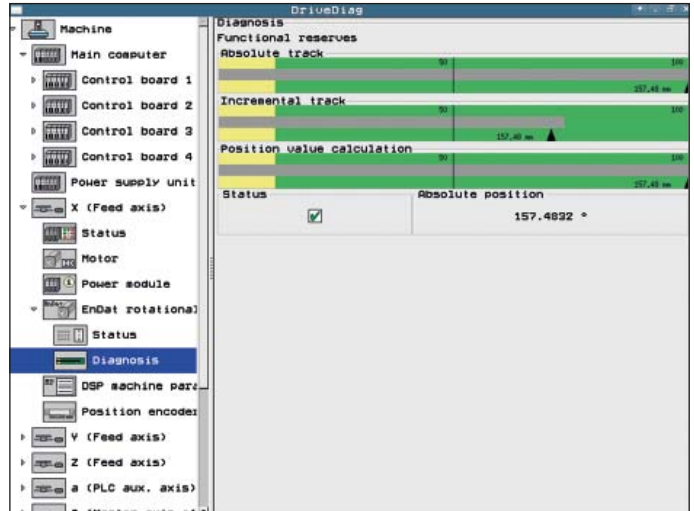
Absolute encoders operate with serial data transfer. Depending on the interface, additional 1 V_{PP} incremental signals can be output. The signals are monitored comprehensively within the encoder. The monitoring result (especially with valuation numbers) can be transferred along with the position values through the serial interface to the subsequent electronics (digital diagnostics interface). The following information is available:

- Error message: Position value is not reliable.
- Warning: An internal functional limit of the encoder has been reached
- Valuation numbers:
 - Detailed information on the encoder's functional reserve
 - Identical scaling for all HEIDENHAIN encoders
 - Cyclic output is possible

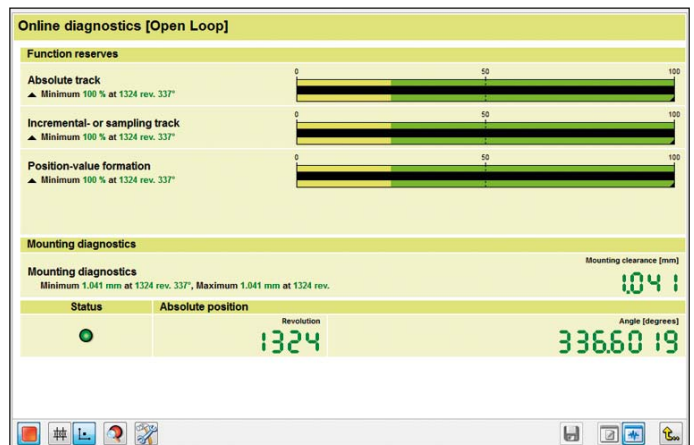
This enables the subsequent electronics to evaluate the current status of the encoder with little effort even in closed-loop mode.

HEIDENHAIN offers the appropriate PWM inspection devices and PWT test devices for encoder analysis. There are two types of diagnostics, depending on how the devices are integrated:

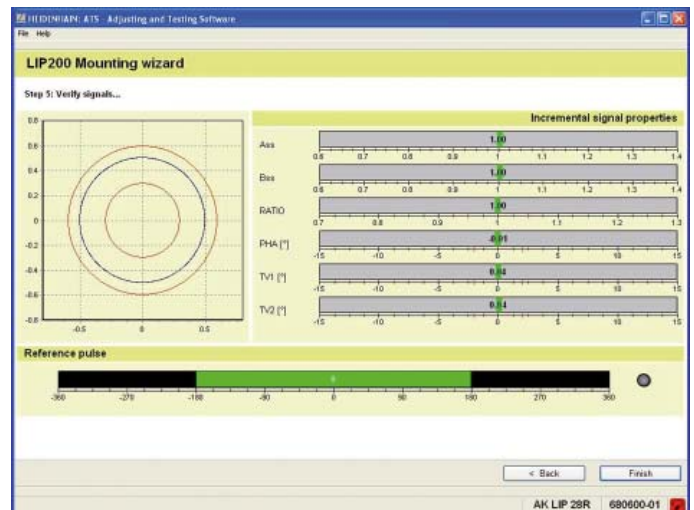
- Encoder diagnostics: The encoder is connected directly to the test or inspection device. This makes a comprehensive analysis of encoder functions possible.
- Diagnostics in the control loop: The PWM phase meter is looped into the closed control loop (e.g. through a suitable testing adapter). This makes a real-time diagnosis of the machine or system possible during operation. The functions depend on the interface.



Diagnostics in the control loop on HEIDENHAIN controls with display of the valuation number or the analog encoder signals



Diagnostics using PWM 20 and ATS software



Commissioning using PWM 20 and ATS software

PWM 20

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



	PWM 20
Encoder input	<ul style="list-style-type: none"> • EnDat 2.1 or EnDat 2.2 (absolute value with or without incremental signals) • DRIVE-CLiQ • Fanuc Serial Interface • Mitsubishi high speed interface • Yaskawa serial interface • SSI • 1 V_{PP}/TTL/11 μA_{PP}
Interface	USB 2.0
Voltage supply	100 V to 240 V AC or 24 V DC
Dimensions	258 mm x 154 mm x 55 mm

	ATS
Languages	Choice between English and German
Functions	<ul style="list-style-type: none"> • Position display • Connection dialog • Diagnostics • Mounting wizard for EBI/ECI/EQI, LIP 200, LIC 4000 and others • Additional functions (if supported by the encoder) • Memory contents
System requirements and recommendations	PC (dual-core processor > 2 GHz) RAM > 2 GB Operating system: Windows XP, Vista, 7, 8 and 10 (32-bit/64-bit) 500 MB free space on hard disk

DRIVE-CLiQ is a registered trademark of SIEMENS AG.

PWT 100

The PWT 100 is a testing device for checking the function and adjustment of incremental and absolute HEIDENHAIN encoders. Thanks to its compact dimensions and robust design, the PWT 100 is ideal for mobile use.



	PWT 100
Encoder input Only for HEIDENHAIN encoders	<ul style="list-style-type: none"> • EnDat • Fanuc Serial Interface • Mitsubishi high speed interface • Panasonic Serial Interface • Yaskawa Serial Interface • 1 V_{PP} • 11 μA_{PP} • TTL
Display	4.3" color flat-panel display (touch screen)
Voltage supply	24 V DC Power consumption: max. 15 W
Operating temperature	0 °C to 40 °C
Protection EN 60 529	IP20
Dimensions	≈ 145 mm x 85 mm x 35 mm

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	$\sim 1 V_{PP}$ (signals are connected through)
Design	Cable with D-sub connector
Function	Switch-off of the signal-error compensation integrated in the scanning head
Voltage supply	Via subsequent electronics

Interface electronics

Interface electronics from HEIDENHAIN adapt the encoder signals to the interface of the subsequent electronics. They are used when the subsequent electronics cannot directly process the output signals from HEIDENHAIN encoders, or if additional interpolation of the signals is necessary.

Input signals of the interface electronics

Interface electronics from HEIDENHAIN can be connected to encoders with sinusoidal signals of $1 V_{PP}$ (voltage signals) or $11 \mu A_{PP}$ (current signals). Encoders with the serial interfaces EnDat or SSI can also be connected to various interface electronics.

Output signals of the interface electronics

Interface electronics with the following interfaces to the subsequent electronics are available:

- TTL square-wave pulse trains
- EnDat 2.2
- DRIVE-CLiQ
- Fanuc Serial Interface
- Mitsubishi high speed interface
- Yaskawa Serial Interface
- Profibus

Interpolation of the sinusoidal input signals

In addition to being converted, the sinusoidal encoder signals are also interpolated in the interface electronics. This permits finer measuring steps and, as a result, higher control quality and better positioning behavior.

Formation of a position value

Some interface electronics have an integrated counting function. Starting from the last reference point set, an absolute position value is formed when the reference mark is traversed, and is transferred to the subsequent electronics.

Box design



Plug design



Version for integration



Top-hat rail design



Outputs		Inputs		Design – degree of protection	Interpolation ¹⁾ or subdivision	Type	
Interface	Qty.	Interface	Qty.				
□TTL	1	~ 1 V _{PP}	1	Box design – IP65	5/10-fold	IBV 101	
					20/25/50/100-fold	IBV 102	
					Without interpolation	IBV 600	
					25/50/100/200/400-fold	IBV 660B	
				Plug design – IP40	5/10/20/25/50/100-fold	APE 371	
				Version for integration – IP00	5/10-fold	IDP 181	
		20/25/50/100-fold	IDP 182				
		~ 11 μA _{PP}	1	Box design – IP65	1	5/10-fold	EXE 101
						20/25/50/100-fold	EXE 102
						Without/5-fold	EXE 602E
25/50/100/200/400-fold	EXE 660B						
Version for integration – IP00	5-fold	IDP 101					
	□TTL/ ~ 1 V _{PP} Adjustable	2	~ 1 V _{PP}	1	Box design – IP65	2-fold	IBV 6072
5/10-fold						IBV 6172	
5/10-fold and 20/25/50/100-fold						IBV 6272	
EnDat 2.2	1	~ 1 V _{PP}	1	Box design – IP65	≤ 16384-fold subdivision	EIB 192	
				Plug design – IP40	≤ 16384-fold subdivision	EIB 392	
				2	Box design – IP65	≤ 16384-fold subdivision	EIB 1512
DRIVE-CLiQ	1	EnDat 2.2	1	Box design – IP65	–	EIB 2391S	
Fanuc Serial Interface	1	~ 1 V _{PP}	1	Box design – IP65	≤ 16384-fold subdivision	EIB 192F	
				Plug design – IP40	≤ 16384-fold subdivision	EIB 392F	
				2	Box design – IP65	≤ 16384-fold subdivision	EIB 1592F
Mitsubishi high speed interface	1	~ 1 V _{PP}	1	Box design – IP65	≤ 16384-fold subdivision	EIB 192M	
				Plug design – IP40	≤ 16384-fold subdivision	EIB 392M	
				2	Box design – IP65	≤ 16384-fold subdivision	EIB 1592M
Yaskawa serial interface	1	EnDat 2.2 ²⁾	1	Plug design – IP40	–	EIB 3391Y	
PROFIBUS-DP	1	EnDat 2.1; EnDat 2.2	1	Top-hat rail design	–	PROFIBUS Gateway	

¹⁾Switchable

²⁾ Only LIC 4100 with 5 nm measuring step, LIC 2100 with 50 nm and 100 nm measuring steps

Evaluation electronics

For measuring and testing tasks

Evaluation electronics from HEIDENHAIN combine measured value acquisition with intelligent, application-specific further processing. They are used in many metrological applications, ranging from simple measuring stations to complex inspection systems with multiple measuring points.

Evaluation units feature interfaces for various encoder signals. They include units with integrated display—which can be used independently—and units that require a PC for operation.

The overview table lists evaluation electronics for measuring and testing tasks. You can find comprehensive information, including on other evaluation units for 2-D and 3-D measuring tasks, on the Internet under www.heidenhain.de or in the brochure *Evaluation Electronics for Metrology Applications*.

Digital readouts for manual machine tools optimally support the operator with cycles for milling, drilling and turning. You can find these digital readouts on the Internet at www.heidenhain.de or in the brochure *Digital Readouts and Linear Encoders for Manually Operated Machine Tools*.



Unit with integrated display –
e.g. ND 2100G GAGE-CHEK



Modular design – MSE 1000



Table-top design – EIB 700



Version for integration – IK 220

ND 200

Evaluation unit for

- Measurement equipment
- Adjustment and inspection equipment
- SPC inspection stations

ND 1100 QUADRA-CHEK

Evaluation electronics for

- Positioning equipment
- Measuring fixtures

ND 2100G GAGE-CHEK

Evaluation electronics for

- Multipoint inspection apparatuses
- SPC inspection stations

MSE 1000

Modular evaluation electronics for

- Multipoint inspection apparatuses
- SPC inspection stations

EIB 700

Evaluation electronics for












- Testing stations
- Multipoint inspection apparatuses
- Mobile data acquisition

IK 220

Evaluation electronics for installation in computer systems with PCI interface for

- Measuring and testing stations

¹⁾ Optional for ND 287

Functions	Input		Interpolation or subdivision	Output Interface	Type
	Interface	Qty.			
<ul style="list-style-type: none"> • Metrological and statistical functions (sorting and tolerance checking, measurement series, SPC) • Second encoder¹⁾ for sum/difference display, temperature compensation 	 1 V _{PP}  11 μA _{PP} EnDat	1	4096-fold	RS-232-C/V-24 USB Ethernet ¹⁾	ND 280
		Up to 2			ND 287
<ul style="list-style-type: none"> • Measurement series with min./max. value storage • Connection for touch probe 	 1 V _{PP}  TTL	2	10-fold (at 1 V _{PP})	RS-232-C/V-24 USB	ND 1102
		3			ND 1103
		4			ND 1104
<ul style="list-style-type: none"> • Programming of up to 100 parts • Graphic display of measurement results • Sorting and tolerance checking using tolerance and warning limits • Measurement series with min./max. value storage • Entry of formulas and combinations • Functions for statistical process control (SPC) 	 1 V _{PP}  TTL EnDat	4	10-fold (at 1 V _{PP})	RS-232-C/V-24 USB	ND 2104 G
		8			ND 2108 G
<ul style="list-style-type: none"> • Modular design • Configurable as desired • Various interfaces • Fast communication with higher-level computer system • Universal outputs 	 1 V _{PP}  TTL EnDat Analog	Up to 250	4096-fold	Ethernet	MSE 1000
<ul style="list-style-type: none"> • Precise position measurement up to 50 kHz updating rate • Programmable measured-value inputs • Internal and external measured-value triggers • Measured-value memory for approx. 250 000 measured values per channel • Connection over standard Ethernet interface to higher-level computer systems 	 1 V _{PP}	4	4096-fold	Ethernet	EIB 741 EIB 742
<ul style="list-style-type: none"> • Programmable measured-value inputs • Internal and external measured-value triggers • Measured-value memory for 8192 measured values per channel • Optional assemblies for encoder outputs and external inputs/outputs 	 1 V _{PP}  11 μA _{PP} EnDat SSI	2	4096-fold	PCI bus	IK 220

For more information

DR. JOHANNES HEIDENHAIN GmbH develops and manufactures linear and angle encoders, rotary encoders, digital readouts, touch probes and numerical controls. HEIDENHAIN supplies its products to manufacturers of machine tools, and of automated machines and systems, in particular for semiconductor and electronics manufacturing.

HEIDENHAIN worldwide

HEIDENHAIN is represented in all industrialized countries—usually with wholly owned subsidiaries. Sales engineers and service technicians support the user on-site with technical information and servicing.

HEIDENHAIN on the Internet

At www.heidenhain.de you will find not only our brochures in various languages, but also a great deal of further up-to-date information on the company and its products. Our web site also includes:

- Technical articles
- Press releases
- Addresses
- TNC training programs

Length measurement



Brochure
Linear Encoders
For Numerically Controlled Machine Tools

Contents:
Absolute linear encoders
LC
Incremental linear encoders
LB, LF, LS



Brochure
Length Gauges

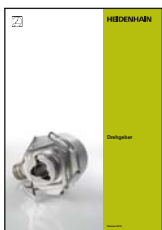
Contents:
HEIDENHAIN-ACANTO
HEIDENHAIN-SPECTO
HEIDENHAIN-METRO
HEIDENHAIN-CERTO



Brochure
Exposed Linear Encoders

Contents:
Absolute linear encoders
LIC
Incremental linear encoders
LIP, PP, LIF, LIDA

Angle measurement



Brochure
Rotary Encoders

Contents:
Absolute rotary encoders
ECN, EQN, ROC, ROQ
Incremental rotary encoders
ERN, ROD



Brochure
Angle Encoders with Integral Bearing

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



Brochure
Encoders for Servo Drives

Contents:
Rotary encoders
Angle encoders
Linear encoders



Brochure
Modular Angle Encoders
With Magnetic Scanning

Contents:
Incremental encoders
ERM

Machine tool control



Brochures
TNC 128 Straight Cut Control
TNC 320 Contouring Control
iTNC 530 Contouring Control
TNC 620 Contouring Control
TNC 640 Contouring Control

Contents:
 Information for the user



OEM brochures
TNC 128 Straight Cut Control
TNC 320 Contouring Control
iTNC 530 Contouring Control
TNC 620 Contouring Control
TNC 640 Contouring Control

Contents:
 Information for the machine tool builder



Brochures
MANUALplus 620 Contouring Control
CNC Pilot 640 Contouring Control

Contents:
 Information for the user



OEM brochures
MANUALplus 620 Contouring Control
CNC Pilot 640 Contouring Control

Contents:
 Information for the machine tool builder

Setup and measurement



Brochure
Touch Probes

Contents:
 Tool touch probes
TT, TL
 Workpiece touch probes
TS



Brochure
Evaluation Electronics
For Metrology Applications

Contents:
ND 100, ND 287, ND 1100, ND 1200, ND 1300, ND 1400, QUADRA-CHEK 3000, ND 2100G, MSE 1000, EIB 700, IK 220, IK 5000



Brochure
Measuring Devices for Machine Tool Inspection and Acceptance Testing

Contents:
 Incremental linear encoders
KGM, VM



Brochure
Digital Readouts/Linear Encoders
For Manually Operated Machine Tools

Contents:
 Digital readouts
ND 280, ND 500, ND 700, POSITIP, ND 1200R
 Linear encoders
LS 300, LS 600



Product overview
Interface Electronics



Product Information
QUADRA-CHEK 3000

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