



**HEIDENHAIN**



**Modular Angle  
Encoders**  
With Circular Scale

# Modular angle encoders with circular scale

**Modular angle encoders with a circular scale** are deployed on machines and automated systems requiring high measurement accuracy. Typical applications include the following:

- Production and measurement equipment in the semiconductor industry
- PCB assembly machines
- Ultra-precision equipment such as diamond lathes for optical components
- High-accuracy machine tools
- Measuring machines, comparators, measuring microscopes, and other precision measuring devices
- Direct drive motors

## Mechanical design

Modular angle encoders consist of a circular scale and a scanning head that operate without mechanical contact. For high accuracy, the mounting surface for the circular scale must exhibit high flatness.



Information about the following topics is available upon request or online at [www.heidenhain.com](http://www.heidenhain.com):

- Angle encoders with integral bearing
- Modular angle encoders with scale drum or scale tape
- Rotary encoders
- Encoders for servo drives
- Linear encoders for numerically controlled machine tools
- Signal converters
- HEIDENHAIN controls

*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 placed.*

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

## Further information:

For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure (ID 1078628-xx).

For the required cables, please refer to the *Cables and Connectors* brochure (ID 1206103-xx).

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# Angle encoders from HEIDENHAIN

Angle encoders are found in applications requiring precision angular measurement at 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
- Spectrometers
- Telescopes
- Laser trackers
- Rotary tables on measuring machines
- Rotary tables on wafer-handling machines
- etc.

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



Angle encoders differ in terms of the following physical design characteristics:

## Sealed angle encoders with a hollow shaft and stator coupling

The stator coupling is designed so that the coupling absorbs only the torque arising from bearing friction, especially during angular acceleration of the shaft. These angle encoders therefore provide excellent dynamic performance. Due to the stator coupling, the stated 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 benefits:

- Compact size for limited installation space
- Hollow shaft diameters of up to 100 mm
- Easy installation
- Also available with functional safety



RCN 8000 absolute angle encoder



ECA 4000 absolute angle encoder with scale drum



ERO 2000 incremental angle encoder with scale drum



ECM 2000 absolute angle encoder

## Modular angle encoders with optical scanning

The ERP, ERO, ERA and ECA modular angle encoders are particularly well suited for high-accuracy applications with low installation space. Particular benefits:

- Wide hollow-shaft diameter (of up to 10 m with a scale tape)
- High shaft speeds of up to 20000 rpm
- No additional starting torque from shaft seals
- Segment solutions
- 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 these angle encoders do not come with an enclosure, the required degree of protection must be ensured through proper installation.

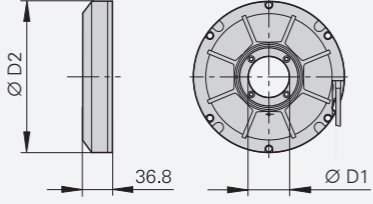
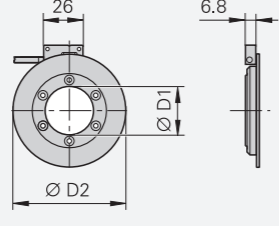
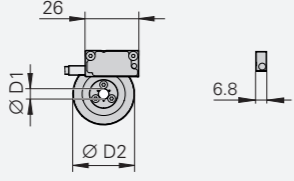
## Modular angle encoder with magnetic scanning

Thanks to their robust design, the ERM and ECM modular angle encoders are highly immune to cooling lubricant and contamination in production machines. They are ideal for medium to high accuracy requirements and low installation space:

- Large shaft diameters
- High shaft speeds of up to 60000 rpm
- No additional starting torque from shaft seals
- High immunity to contamination
- Available with functional safety

# Selection guide

## Modular angle encoders with optical scanning and scale drum

Series	Version and mounting	Overall dimensions in mm	Diameter D1/D2	Accuracy of graduation	Mechanically permissible speed <sup>1)</sup>	Signal periods per revolution	Reference marks	Interface	Model	Page
<b>Angle encoders with graduation on circular scale</b>										
<b>ERP 880</b>	Phase grating on glass disk with hub; screwed onto front of shaft		D1: 51.2 mm D2: 200 mm	±0.9"	≤ 1000 rpm	180 000	One	~ 1 V <sub>PP</sub>	<b>ERP 880</b>	<b>24</b>
<b>ERP 1000</b>	OPTODUR graduation on glass disk with hub; screwed onto front of shaft		D1: 104 mm D2: 151 mm	±0.9"/1.5"	≤ 950 rpm	63 000	One	~ 1 V <sub>PP</sub> TTL EnDat 2.2	<b>ERP 1080</b> <b>ERP 1070</b> <b>ERP 1010</b>	<b>26</b>
			D1: 62 mm D2: 109 mm	±1.8"	≤ 1200 rpm	50 000				
			D1: 32 mm D2: 75 mm	±3"	≤ 2000 rpm	30 000				
			D1: 13 mm D2: 57 mm	±4"	≤ 2600 rpm	23 000				
<b>ERO 2000</b>	SUPRADUR graduation on glass		D1: 5 mm D2: 30 mm	±8"	≤ 14 000 rpm	4096	One	~ 1 V <sub>PP</sub>	<b>ERO 2080</b>	<b>32</b>
			D1: - D2: 18.6 mm	±10"	≤ 24 000 rpm	2500				



ERP 880



ERP 1000



ERO 2000

<sup>1)</sup> May be limited during operation due to electrically permissible shaft speed

<sup>2)</sup> Through integrated interpolation



# 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 made of glass or steel. For encoders with long measuring lengths, steel tape is used as the scale substrate.

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

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

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.

## Absolute measuring method

In the **absolute measuring method**, the position value is available immediately upon encoder switch-on and can be requested by the downstream electronics at any time. There is therefore no need to search for the reference position by jogging the axes.

The absolute position information is read from the **circular scale**, which is designed with 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.

## Incremental measuring method

In the **incremental measuring method**, the graduation is a periodic grating structure. The position information is obtained **through counting** the individual increments (measuring steps) starting at a freely selectable point of origin. Since position measurement requires an absolute point of reference, the measuring standard features an additional track containing 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 traversed before an absolute point of reference can be established or before the most recently selected reference point is refound.

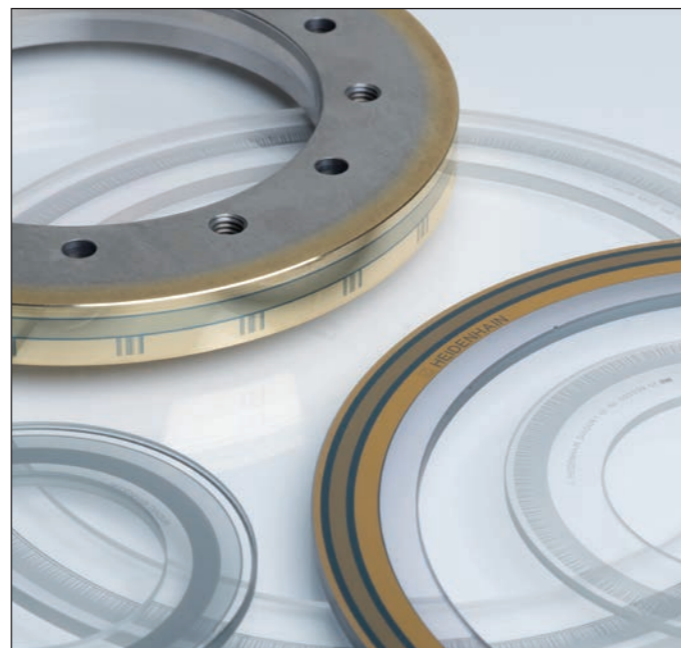
In some cases, this may require rotation by up to 360°. To simplify reference runs, many HEIDENHAIN encoders feature **distance-coded reference marks**: the reference-mark track has multiple reference marks at different defined distances. The downstream electronics determine the absolute reference point after just two neighboring reference marks have been traversed; in other words, after just a few degrees of rotational motion (see "Nominal increment N" in the table).

With distance-coded reference marks, the **absolute reference** is determined by counting the increments between two reference marks.

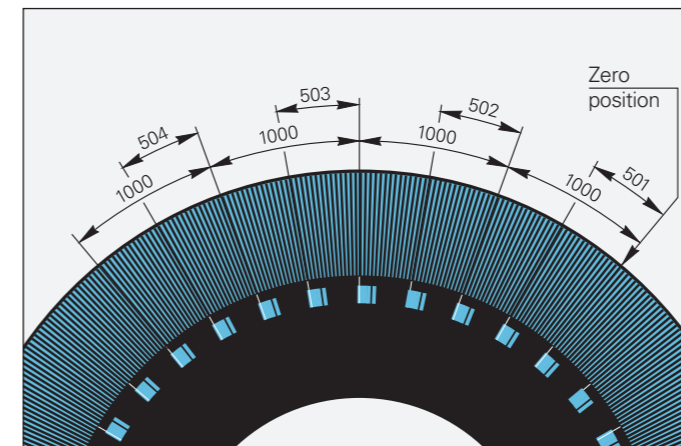
Line count z	Number of reference marks	Nominal increment N
36 000	72	10°
18 000	36	20°



Circular scale with serial absolute track and incremental track



Absolute and incremental circular scales and scale drums



Schematic representation of a circular scale with distance-coded reference marks

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

# Photoelectric scanning

Most HEIDENHAIN encoders utilize the photoelectric scanning principle. Photoelectric scanning is touchless and therefore does not induce wear. This method detects even extremely fine graduation lines down to a width of only a few micrometers 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 of 20  $\mu\text{m}$  and 40  $\mu\text{m}$
- The **interferential scanning principle** for very fine grating periods of, for example, 8  $\mu\text{m}$

## Imaging scanning principle

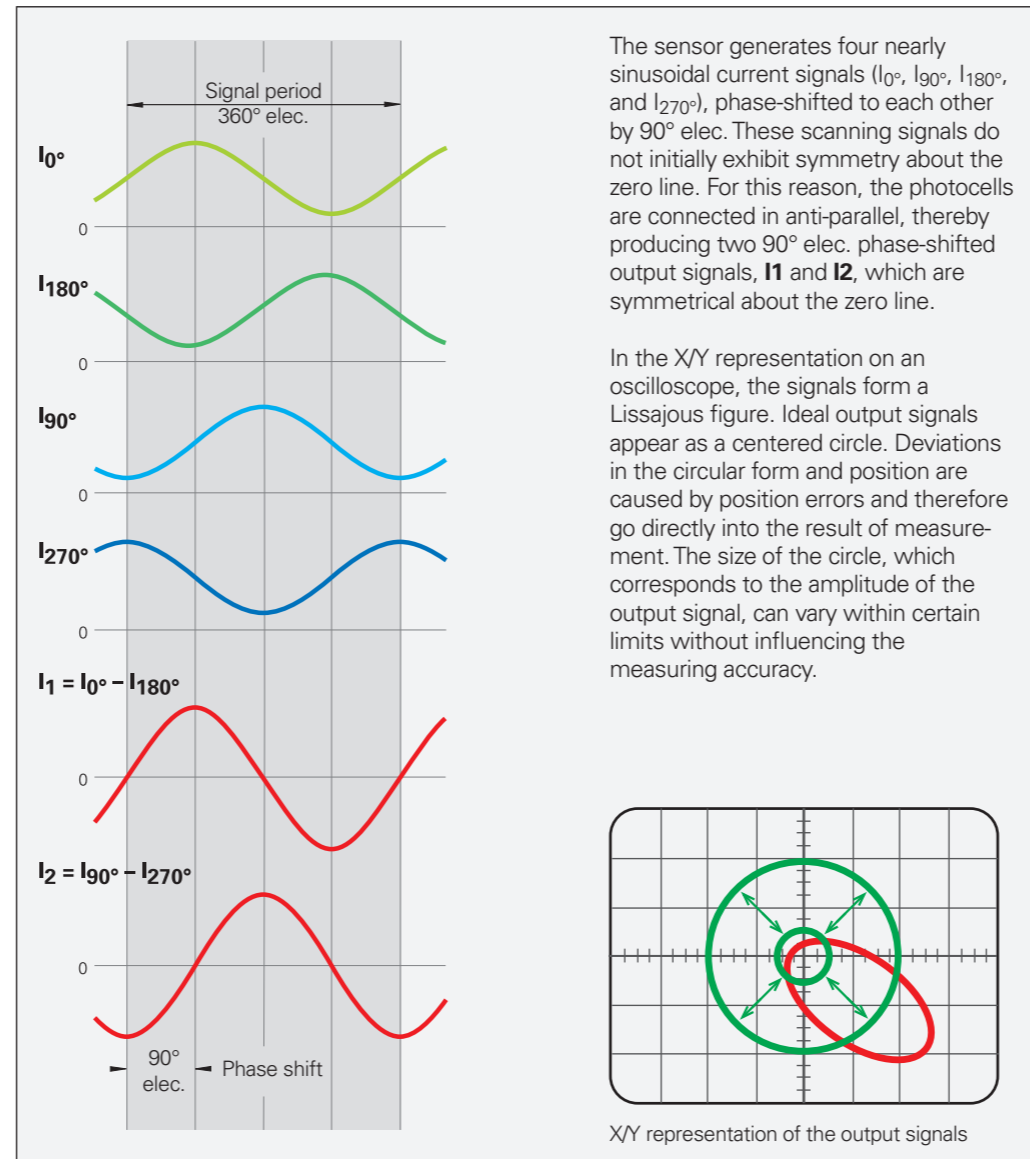
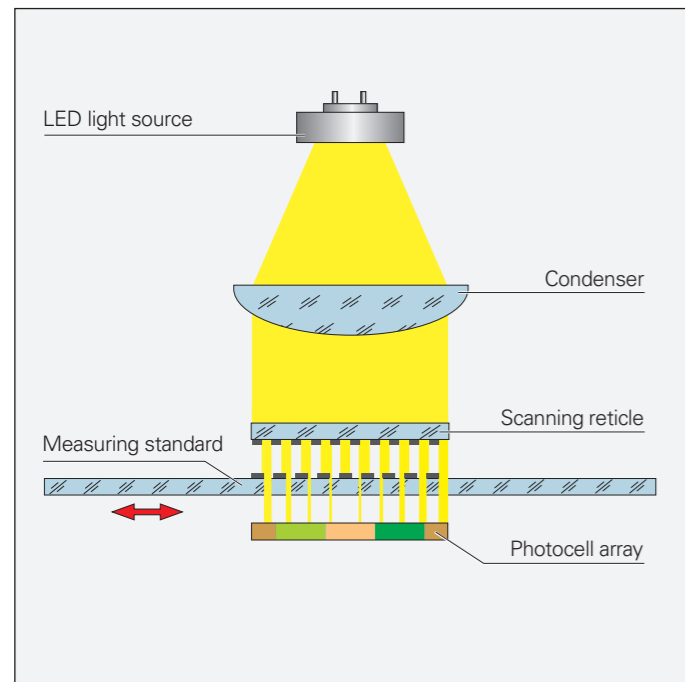
Put simply, the imaging scanning principle uses projected-light signal generation: two gratings with equal or similar grating periods—the scale and the scanning reticle—are moved relative to each other. The carrier material of the scanning reticle is transparent, whereas the graduation of the measuring standard may be applied to a transparent material or to a reflective material.

When parallel light passes through a grating structure, light and dark fields are projected at a certain distance. At this location there is an index grating. When the two gratings move relative to each other, the incident light is modulated: If the gaps are aligned, light passes through. If the lines of one grating coincide with the gaps of the other, no light passes through. A photocell array 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 graduation period of the grating structure, the closer and more tightly tolerated the gap must be between the scanning reticle and the scale. In encoders that use the imaging scanning principle, workable mounting tolerances are attainable starting at a minimum grating period of 10  $\mu\text{m}$ .

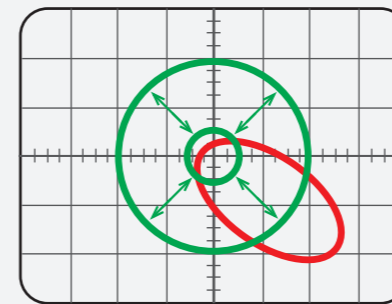
The ERO angle encoders, for example, operate according to the imaging scanning principle.

Imaging scanning principle



The sensor generates four nearly sinusoidal current signals ( $I_{0^\circ}$ ,  $I_{90^\circ}$ ,  $I_{180^\circ}$ , and  $I_{270^\circ}$ ), phase-shifted to each other by 90° elec. These scanning signals do not initially exhibit symmetry about the zero line. For this reason, the photocells are connected in anti-parallel, thereby producing two 90° elec. phase-shifted output signals, **I1** and **I2**, which are symmetrical about the zero line.

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



X/Y representation of the output signals

## Interferential scanning principle

The interferential scanning principle uses the diffraction and interference of light on finely divided gratings in order to produce the signals from which motion is measured.

A step grating is used as the measuring standard: reflective lines with a height of 0.2  $\mu\text{m}$  are applied to a flat, reflective surface. In front of this 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 nearly 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. Photocells convert these alternating light intensities into electrical signals.

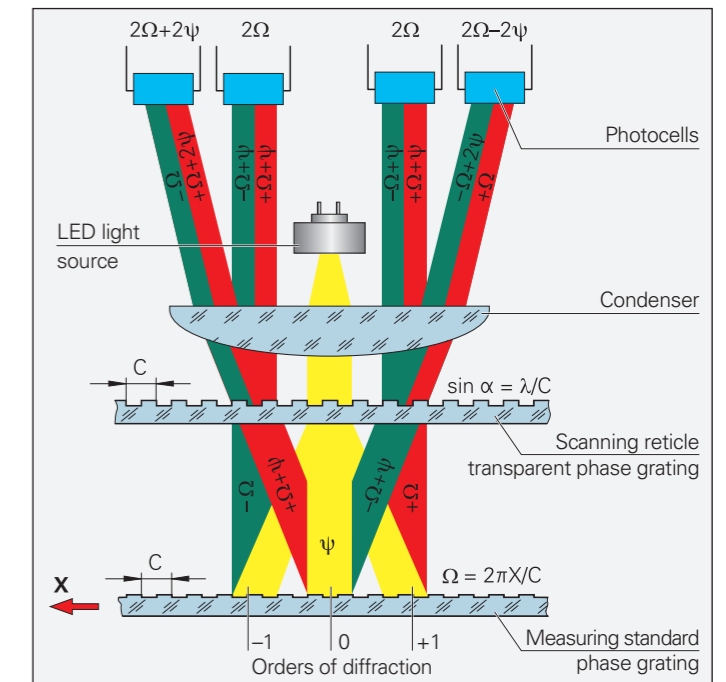
When there is relative motion between the scale and the scanning reticle, the diffracted wavefronts undergo a phase shift: movement by the amount of one grating period shifts the positive first-order diffraction wavefront by one wavelength in the positive direction, while the negative first-order diffraction wavefront is displaced by one wavelength in the negative direction. Since the two waves interfere with each other upon exiting the phase grating, these waves are shifted relative to each other by two wavelengths. This results in two signal periods when there is relative motion of just one grating period.

Interferential encoders use grating periods of, for example, 8  $\mu\text{m}$ , 4  $\mu\text{m}$ , or 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 (optical diagram)

- C Grating period
- $\psi$  Phase shift of the light wave when passing through the scanning reticle
- $\Omega$  Phase shift of the light wave due to motion X of the scale



# Measurement accuracy

The accuracy of angular measurement is mainly determined by:

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

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

The accuracy of the graduation is indicated by the uncompensated maximum value of the **baseline error**. This accuracy is ascertained under ideal conditions via measurement of the position error by means of a serially produced scanning head. The distance between the measuring points is equivalent to the integer multiple of the signal period. As a result, the interpolation error has no effect. The accuracy of the graduation  $a$  defines the upper limit of the baseline error within any section of up to  $360^\circ$ . For special encoders, an additional baseline error is stated for defined angular intervals of the graduation.

## Encoder-specific error

The encoder-specific error is given in the Specifications:

- The graduation accuracy
- The Interpolation error within one signal period
- The position noise

## The graduation accuracy

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 the graduation carrier
- The stability of the graduation carrier, in order to also ensure accuracy in the mounted condition

## Interpolation error within one signal period

The interpolation error within one signal periods  $\pm u$  is primarily influenced by:

- The fineness of the signal period
- The homogeneity and period definition of the graduation
- The quality of the scanning filter structures
- The characteristics of the sensors
- The quality of the signal processing electronics

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.

## Position noise

Position noise is a random process leading to unpredictable position errors. The position values are grouped around an expected value in the form of a frequency distribution.

The amount of position noise depends on the signal processing bandwidths necessary for forming the position values. It is ascertained within a defined time interval and is stated as a product-specific RMS value.

In the speed control loop, position noise influences the speed stability at low rotational speeds.

## Application-dependent error

The quality of the mounting and adjustment of the scanning head, in addition to the given encoder-specific error, normally has 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 the *Angle Encoders with Integral Bearing* brochure).

## Error due to eccentricity of the graduation relative to the bearing

Mounting-related eccentricity between the graduation and the bearing can be expected during mounting of the disk/hub assembly. In addition, dimensional and form error 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 figure below):

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

- $\Delta\varphi$  = Measurement error in " (arc seconds)
- $e$  = Eccentricity of the scale drum relative to the bearing in  $\mu\text{m}$  (1/2 radial runout)
- $D$  = Graduation diameter in mm
- $M$  = Center of graduation
- $\varphi$  = "True" angle
- $\varphi'$  = Scanned angle

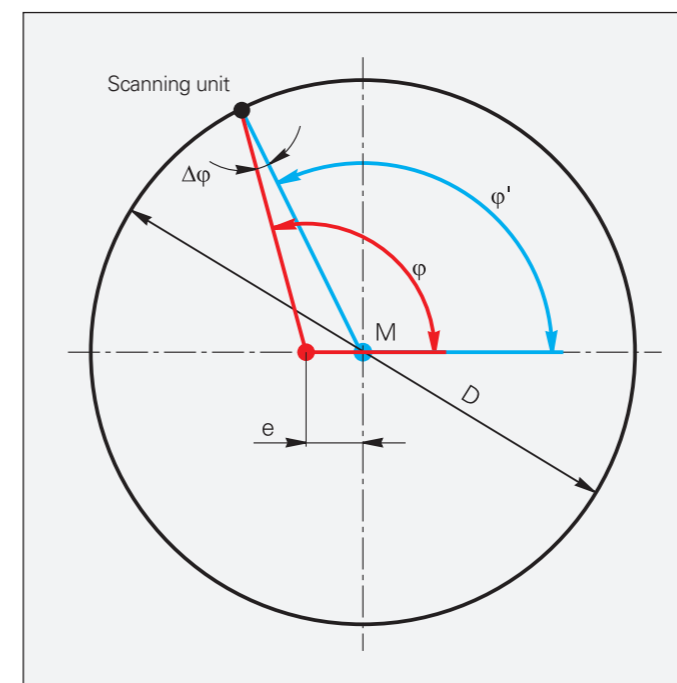
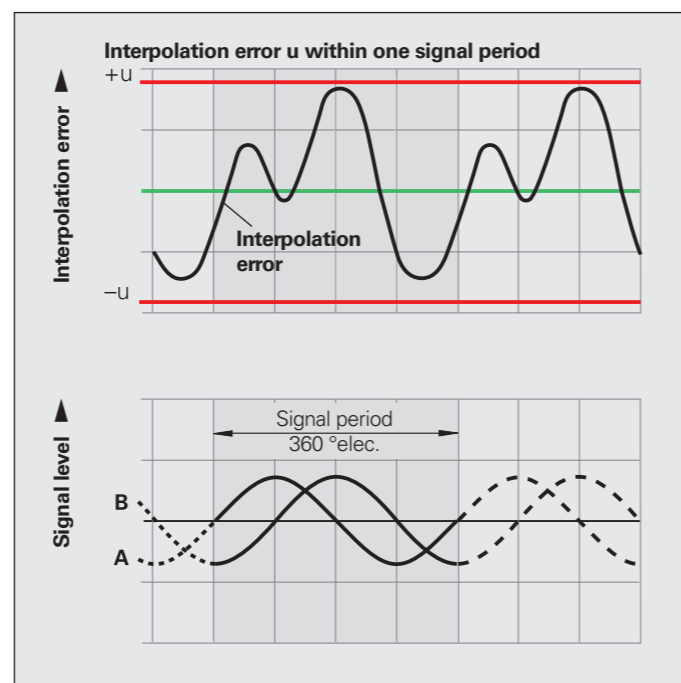
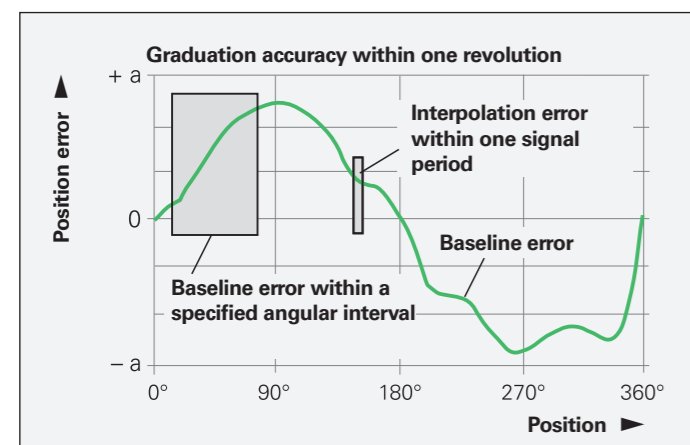
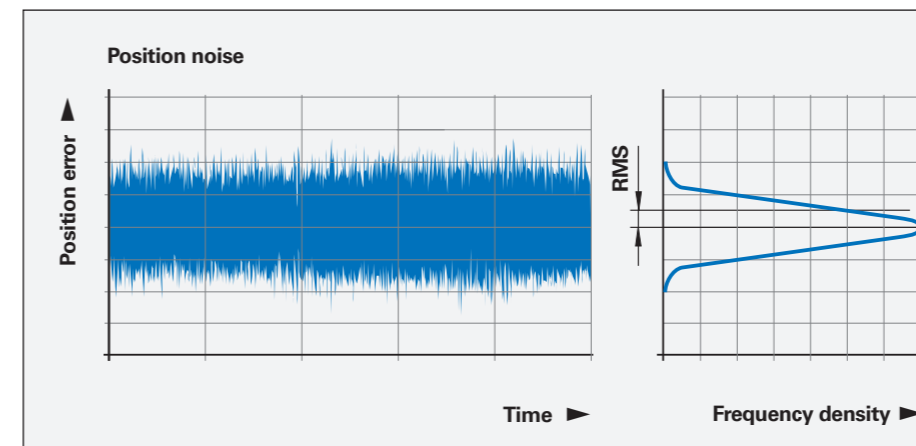
## Calculation example:

ERP 1000 angle encoder with drum diameter of 146.5 mm, radial runout of the disk/hub assembly  $2 \mu\text{m}$  ( $\triangleq$  eccentricity of  $1 \mu\text{m}$ )

$$\Delta\varphi = \pm 412 \cdot \frac{1}{146.5} \approx \pm 2.8''$$

## Graduation diameter $D$ for:

<b>ERP 880</b>	$D = 126 \text{ mm}$
<b>ERP 1000</b>	$D = 52.5 \text{ mm}$ $D = 71 \text{ mm}$ $D = 104.5 \text{ mm}$ $D = 146.5 \text{ mm}$
<b>ERO 2000</b>	$D = 26.7 \text{ mm}$ $D = 16.3 \text{ mm}$



The eccentricity of the graduation relative to the bearing



### Radial runout error of the bearing

The function for finding the measurement error  $\Delta\varphi$  also applies to the radial runout error of the bearing when the eccentricity (half of the displayed radial runout error) is entered for  $e$ . The mechanical compliance of the bearing under radial shaft loads causes similar errors.

### Deformation of the graduation resulting from mounting

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

### Geometric and diameter errors of the bearing surface (for TKN ERP 1002)

Geometric errors of the bearing surface can affect the attainable system accuracy.

The segment solutions exhibit additional angular error  $\Delta\varphi$  if the nominal mounting diameter is not precisely complied with:

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

Where

$\Delta\varphi$  = Error for segment in arc seconds

$\varphi$  = Segment angle in degrees

$D$  = Nominal mounting diameter

$D'$  = Actual mounting diameter

This error can be eliminated if the signal period per  $360^\circ z'$  that is valid for the actual mounting diameter  $D'$  can be entered into the controller. The following relationship is valid:

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

where  $z$  = Nominal signal period per  $360^\circ$

$z'$  = Actual signal period per  $360^\circ$

The angle actually traversed in segment solutions should be measured with a comparative encoder, such as an angle encoder with an 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 error. A common and effective method of eliminating this error is to mount two or even more scanning heads at equal distances around the graduation carrier. The downstream 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.

## 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.

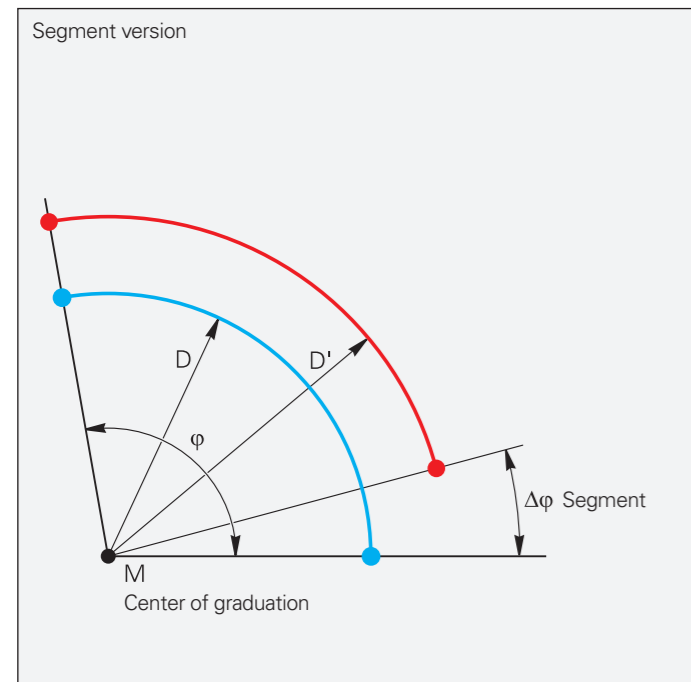
The **Quality Inspection Document** confirms the specified graduation accuracy of each encoder. The **calibration standards** ensure the traceability—as required by EN ISO 9001—to recognized national or international standards.

For the ERP and ERO encoder series, a calibration chart documents the ascertained **position error**. It also specifies the measuring parameters and the measurement uncertainty.

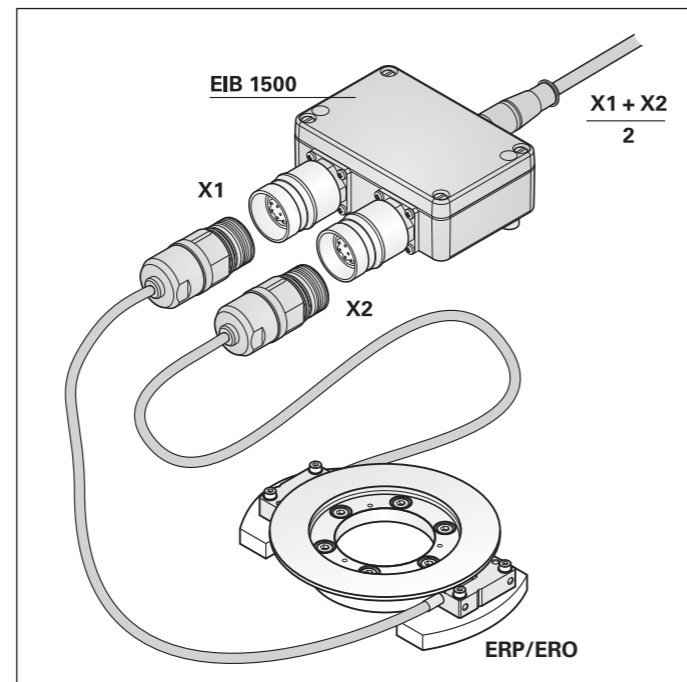
### Temperature range

The angle encoders are inspected at a **reference temperature** of 22 °C. This is the temperature at which the system accuracy provided in the calibration chart is valid.

Angular error resulting from variations in the mounting diameter



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



For testing and calibration purposes, modular angle encoders with circular scale 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.

**HEIDENHAIN**

**TKN ERP 1000**

ID 1126369-06

SN 639539006

Qualitätsprüfbescheinigung

Quality Inspection Document

Position error  $\Delta\text{Pos}$  in Winkelsekunden

Position error  $\Delta\text{Pos}$  in angular seconds

Die Messkurve zeigt die Positionsabweichungen des Teilkreises (mit Nabe) bei einer Umdrehung.

The error curve shows the position error of the disk/hub assembly over one revolution.

Die Anzahl der Signalperioden des Teilkreises (mit Nabe) beträgt 63000.

The disk/hub assembly has 63000 signal periods.

Positionenabweichung  $\Delta\text{Pos}$  des Teilkreises (mit Nabe):  $\Delta\text{Pos} = \text{Pos}_i - \text{Pos}_k$   
 $\text{Pos}_i$  = Position des Vergleichsmaßes  
 $\text{Pos}_k$  = Position des Prüfings

Position error  $\Delta\text{Pos}$  of the disk/hub assembly:  $\Delta\text{Pos} = \text{Pos}_i - \text{Pos}_k$   
 $\text{Pos}_i$  = position measured by the reference standard  
 $\text{Pos}_k$  = position measured by the measured encoder

Maximale Positionsabweichung der Messkurve innerhalb 360°	± 0,51"
---	---------

Maximum position error of the error curve within 360°	± 0,51"
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Unsicherheit der Messmaschine	0,05"
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Uncertainty of the measuring machine	0,05"
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Messgeschwindigkeit	5 mm/s
Anzahl der Messpositionen pro Umdrehung	8064

Measuring velocity	5 mm/s
Number of measuring positions per revolution	8064

Dieser Teilkreis (mit Nabe) wurde unter strengsten HEIDENHAIN-Qualitätsnormen hergestellt und geprüft. Die Positionsabweichung liegt bei einer Bezugs-temperatur von 22 °C innerhalb der Genauigkeitsklasse ± 0,5".

This disk/hub assembly has been manufactured and inspected in accordance with the stringent quality standards of HEIDENHAIN. The position error at a reference temperature of 22 °C lies within the accuracy grade ± 0,5".

In der Applikation entstehen zusätzliche Positionsabweichungen. Beachten Sie hierzu die Angaben im Prospekt.

Additional position errors arise in the application. Please note the information about this in the brochure.

Kalibrierfirma	Kalibrierzeichen
ERP 880	8702-K-19057-01-00 2021-08

Kalibrierstandard	Kalibriermark
ERP 880	8702-K-19057-01-00 2021-08

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26.09.2022  
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### Calibration chart using the example of the ERP 1000 scale drum

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



# Reliability

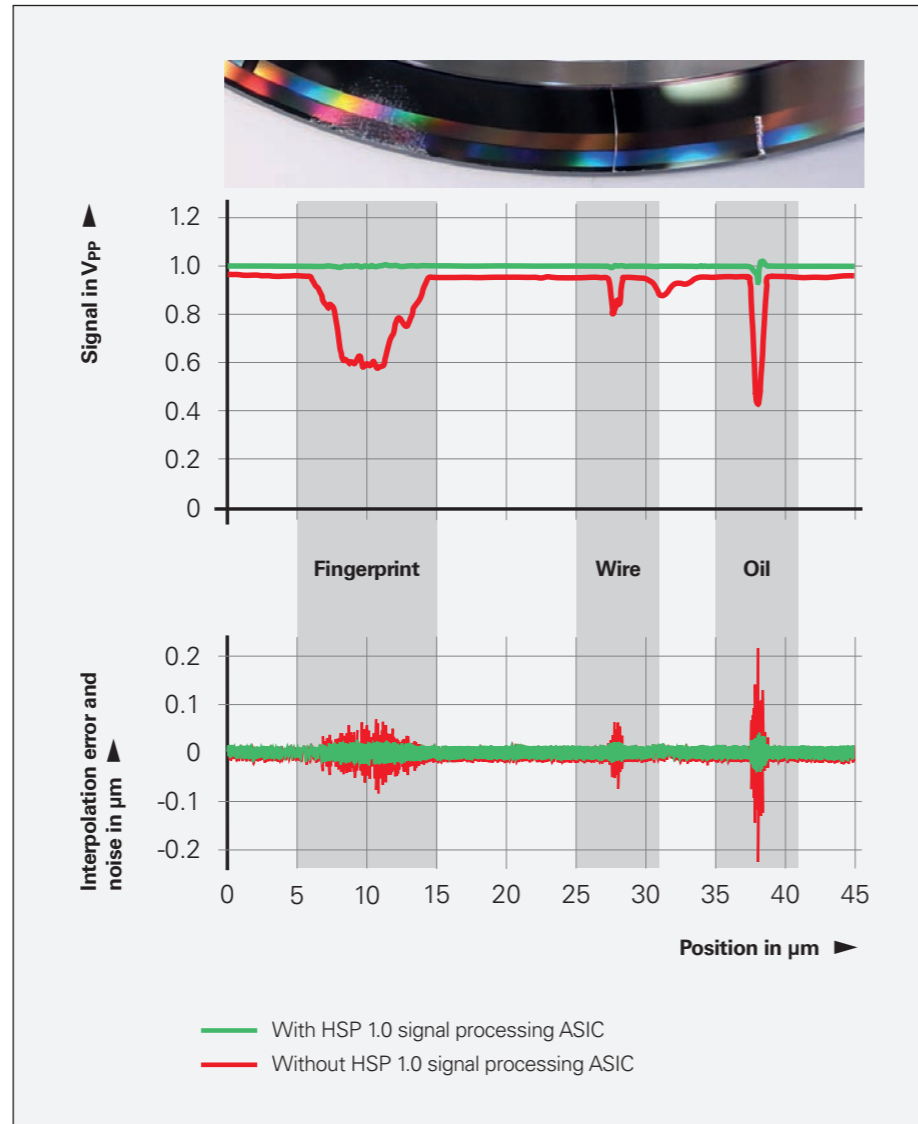
Modular angle encoders with optical scanning from HEIDENHAIN are optimized for use on fast, precise machines. Even with their exposed mechanical design, these encoders are highly immune to contamination, ensure high long-term stability and are fast and easy to mount.

## Low 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. The signals remain highly interpolable, and the position error per signal period remains small.

The **large scanning field** further reduces the sensitivity to contamination. Depending on the nature of the contamination, this feature can even prevent encoder failure. The encoders continue to provide high-quality signals even if the contamination comes from printer's ink, PCB dust, water or oil and is up to 3 mm in diameter. The position errors per revolution remain far below the specified accuracy.

The ERP 1000 and ERO 2000 encoders are equipped with the HSP 1.0 signal processor ASIC from HEIDENHAIN. This ASIC continuously monitors the scanning signal and compensates nearly completely for fluctuations in signal amplitude. If the signal amplitude decreases as the result of contamination on the scanning reticle or measuring standard, the ASIC reacts by increasing the LED current. The ensuing increase in LED light intensity barely raises the noise level, even in the case of strong signal stabilization. As a result, contamination has only a very slight influence on interpolation errors and the position noise.



Measuring standard with contamination and the associated signal amplitudes with conventional scanning and scanning with the HSP 1.0 signal processing ASIC

## Durable measuring standards

Due to their exposed design, the measuring standards of modular angle encoders with circular scale are less protected from their environment. For this reason, HEIDENHAIN always uses tough graduations manufactured in special processes.

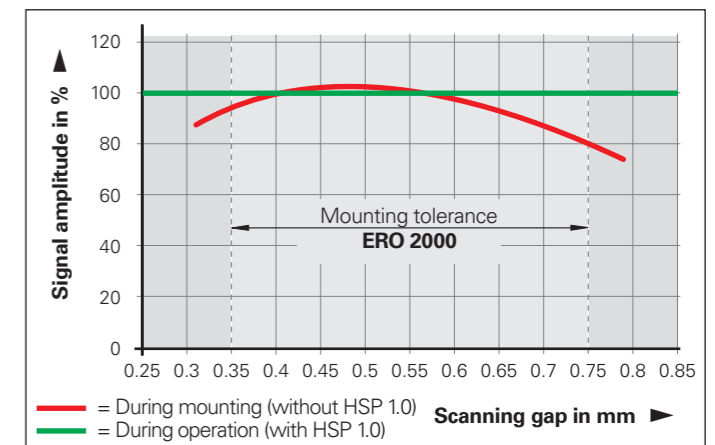
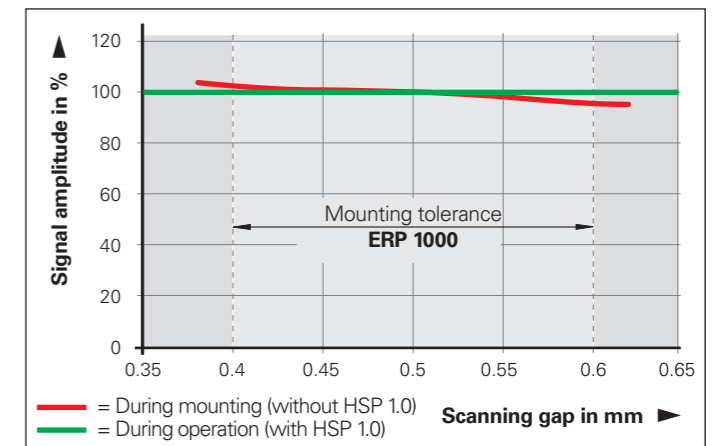
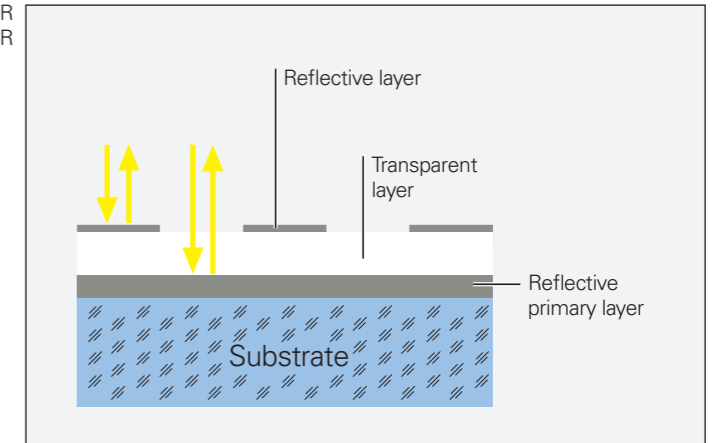
In the OPTODUR and SUPRADUR processes, a transparent layer is first applied onto the reflective primary layer. For creating an optically three-dimensional phase grating, an extremely thin, hard chromium layer is applied at a thickness of only a few nanometers. Measuring standards with OPTODUR or SUPRADUR graduations have proven to be particularly robust and insensitive to contamination because the low height of their structure leaves practically no surface for dust, dirt, or water particles to accumulate.

## Workable mounting tolerances

Very small signal periods usually come with very narrow mounting tolerances for the gap between the scanning head and scale tape. This is the result of diffraction caused by the grating structures. Such diffraction can lead to a signal attenuation of 50% upon a gap change of only  $\pm 0.1$  mm. The interferential scanning principle and innovative index gratings on encoders that use the imaging principle allow for workable mounting tolerances despite tiny signal periods.

The mounting tolerances of modular angle encoders with circular scale from HEIDENHAIN have minimal influence on the output signals. In particular, the specified distance tolerance between the circular scale and scanning head (scanning gap) causes only negligible change in the signal amplitude. During operation, the reliability and stability of the signals are additionally improved by the HSP 1.0. The two diagrams illustrate the correlation between the scanning gap and signal amplitude for the encoders of the ERP 1000 and ERO 2000 series.

OPTODUR  
SUPRADUR



## Signal-quality indicator

The ERP 1010 and ERP 1070 modular angle encoders feature an integrated signal-quality indicator with a multicolor LED, permitting fast and easy signal-quality checks during operation.

This feature provides a number of benefits:

- Scanning-signal quality visualization via a multicolor LED
- Continuous monitoring of incremental signals over the entire angular measurement range
- Indication of the reference-mark signal behavior
- Quick signal-quality checks in the field without additional aids

The built-in signal-quality indicator permits both a reliable assessment of the incremental signals and inspection of the reference mark signal. The quality of the **incremental signals** is indicated by different colors. A blue LED indicates traversal of the **reference mark**.

### LED indicator for incremental signals

LED color	Quality of the scanning signals
●	Optimal
●	Acceptable
●	Unsatisfactory

In the encoders with a serial interface (ERP 1010), an error bit is set when a red LED is displayed. Error bits can be displayed and cleared with the ATS mounting wizard.

### LED indicator for the reference mark signal

When the reference mark is traversed, the LED briefly switches to blue. In the ERP 1070 encoders, the LED can also be used for checking the reference mark signal:

- Out of tolerance
- In tolerance

### LED indicator for control margin

In the encoders with a TTL interface (ERP 1070), a flashing LED (goes briefly dark every 2.5 s) indicates when the control margin of the scanning ASIC (HSP) is nearly exhausted. Clean the measuring standard and the scanning window of the scanning head in compliance with the relevant information in the mounting instructions. The encoder may also need to be checked for correct mounting.



ERP 1010 and ERP 1070:  
Signal-quality indicator in the interface electronics

## Mechanical design types and mounting

The modular angle encoders with circular scale consist of a scanning head and a disk/hub assembly. The position of the scanning head and graduation relative to each other is determined solely via the machine guideway. For this reason, the machine must be designed from the very beginning to meet the following prerequisites:

- The **bearing** must be designed such that it meets the accuracy requirements of the axis and the scanning-gap tolerances of the encoder, even during operation (see the *Specifications*).
- The **mounting surface** for the graduation carrier must meet the flatness, roundness, radial runout and diameter requirements of the given encoder.
- To facilitate **adjustment** of the scanning head relative to the graduation, the scanning head should be fastened via a mounting bracket or via appropriate fixed stops.

All modular angle encoders with circular scale are designed such that the specified accuracy can be reached in the actual application. The various mounting designs 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. Three-point centering

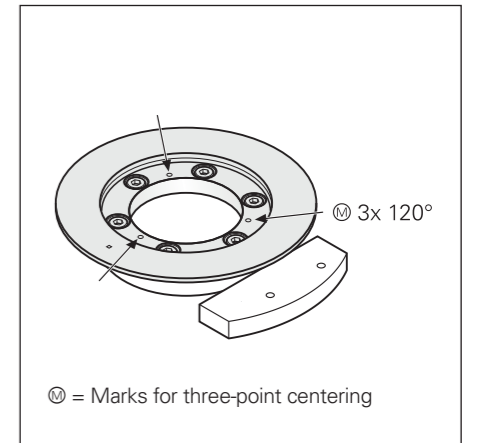
The graduation carrier is centered via three positions marked on the graduation carrier at 120° increments. As a result, any roundness errors of the surface on which the carrier is to be centered do not affect the exact alignment of the axis center point.

#### 2. Optical centering

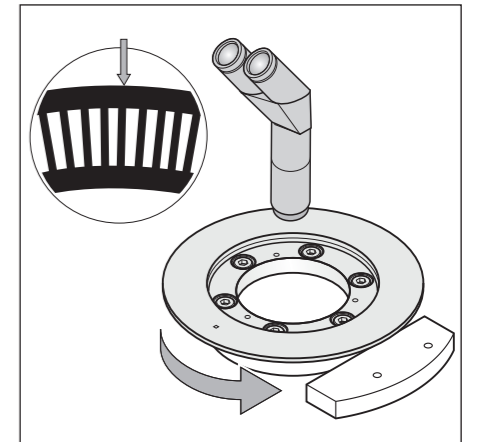
Graduation carriers made from glass are often centered with the aid of a microscope. This method uses the clear and unambiguous reference edges or centering rings on the graduation carriers.

#### 3. Centering with two scanning heads

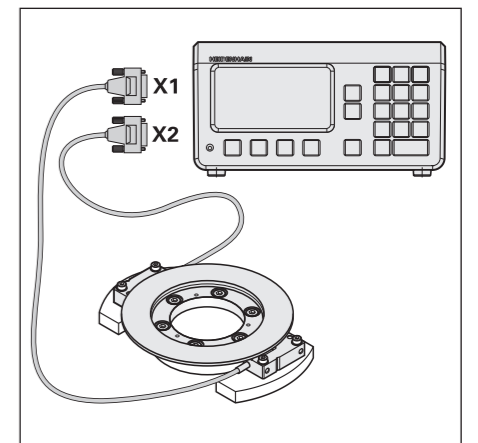
This strategy is suited for all modular angle encoders with circular scale. Because HEIDENHAIN graduations exhibit a long-range characteristic error, and because the graduation or the position value itself serves as the reference with this centering method, this is the most accurate centering method.



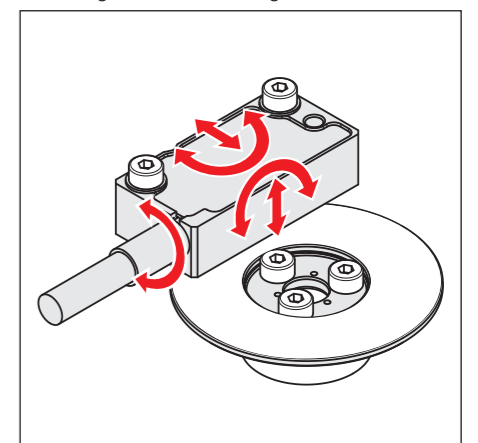
Three-point centering



Optical centering



Centering with two scanning heads



### Scanning heads

Since final assembly of the modular angle encoders with circular scale takes place on the machine, exact mounting of the scanning head is necessary once the graduation carrier has been mounted. In order for the scanning head to be exactly aligned, 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 wide mounting tolerances.

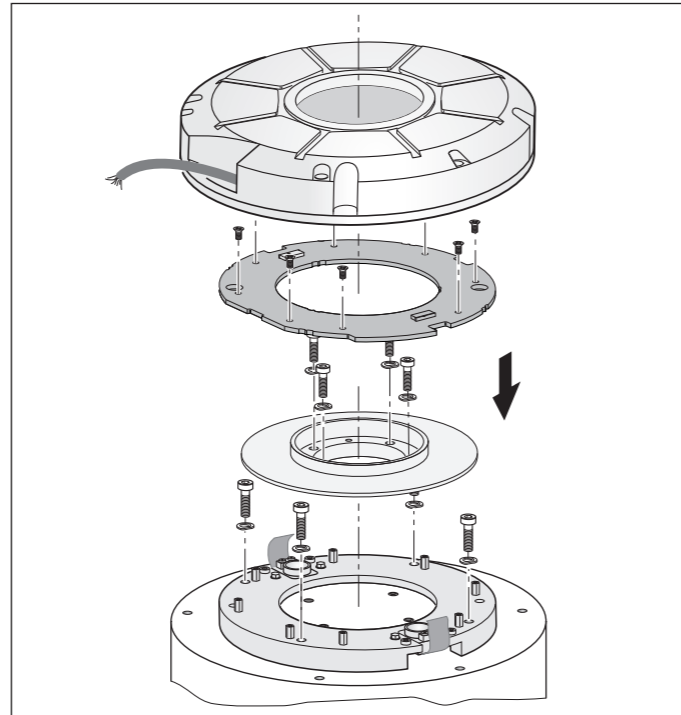
## ERP 880

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 PWM 9 (see *HEIDENHAIN measuring equipment*) and an oscilloscope. A housing can protect the ERP 880 from contamination.

Mounting the ERP 880 (in principle)



### IP40 housing

With sealing ring for IP40 protection  
Cable, 1 m, with 12-pin coupling (male)  
ID 369774-01

### IP64 housing

With shaft sealing ring for IP64 protection  
Cable, 1 m, with 12-pin coupling (male)  
ID 369774-02



## ERP 1000 ERO 2000

The ERP 1000 and ERO 2000 modular angle encoders consist of a scanning head and a disk/hub assembly or a circular scale with pin. These are positioned and adjusted relative to each other on the machine.

### Mounting the disk/hub assembly

The disk/hub assembly is pressed onto the shaft axially, 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 graduation track integrated in the circular scale, or electrically with the aid of a second, diametrically opposed scanning head.

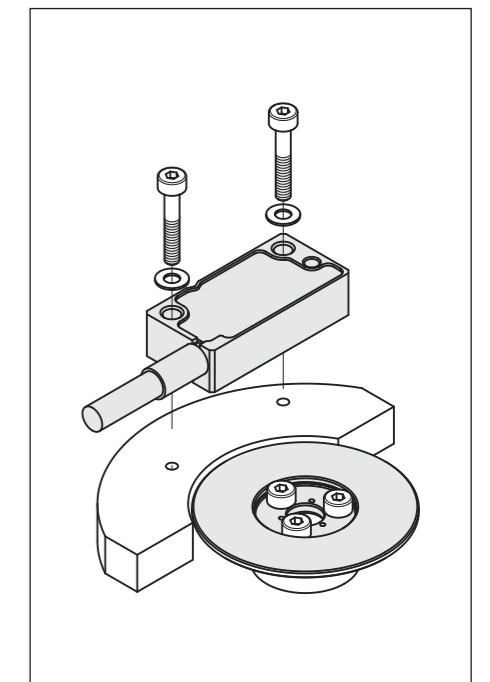
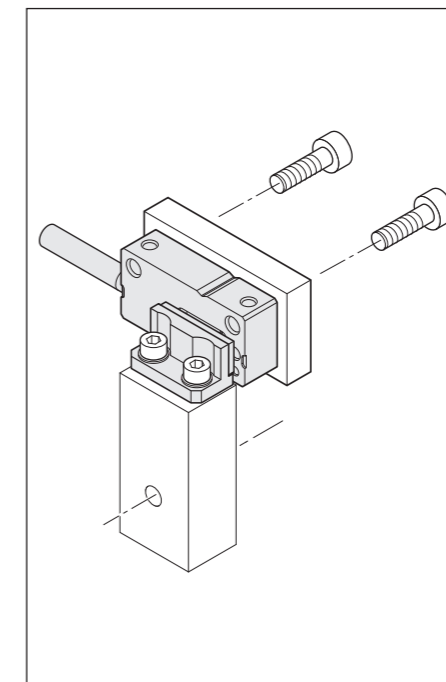
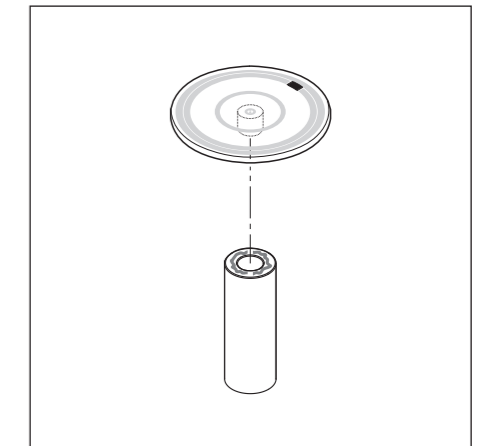
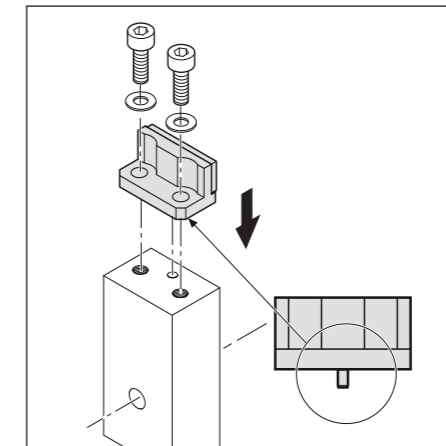
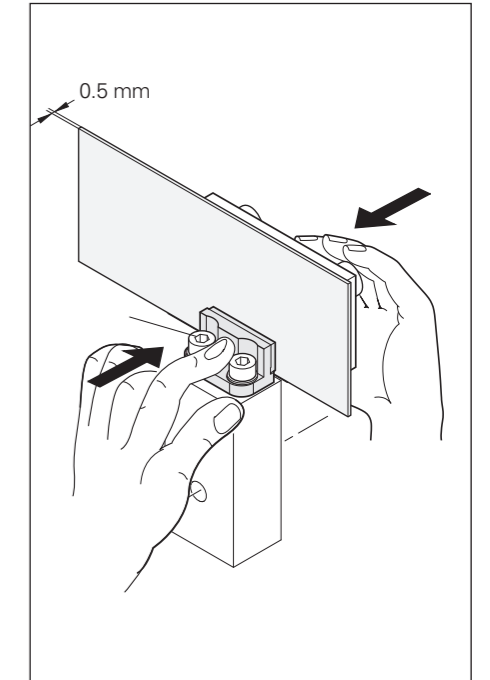
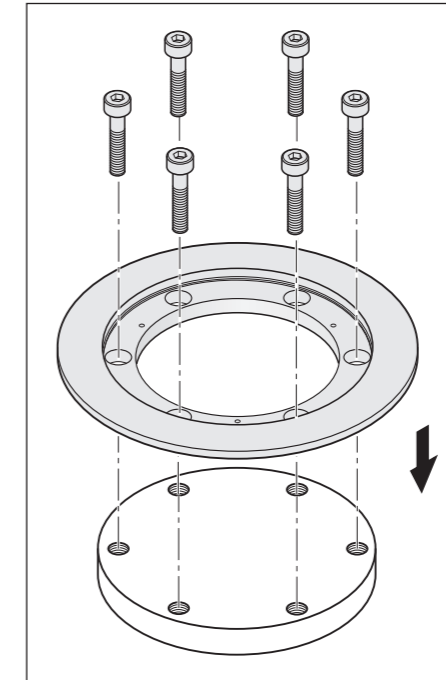
### Mounting the disk/hub assembly with a centering pin

The TKN ERP 1002 segments feature a centering pin for easy mounting to the mating component. This procedure is sufficient for application where only small angles need to be measured. The gap to the scanning head is adjusted with the aid of a spacer shim (0.5 mm). Each segment features two threaded holes for attaching.

The TKN ERO 2000 full circles as well as the TKN ERO 2002 segments feature an H7 fitting hole for quick and easy mounting. To increase accuracy, the circular scale can also be centered optically. For this purpose, the hole in the mating component must have a larger diameter. The measuring standard and the mating component must be connected through an adhesive bond. A UV-curing adhesive is recommended.

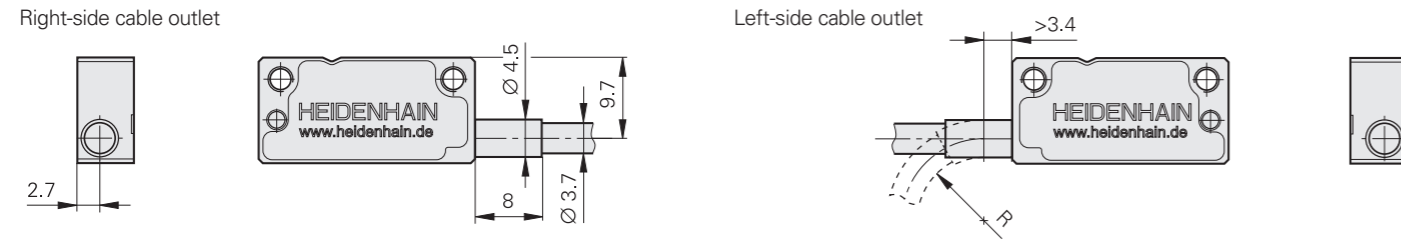
### Mounting the scanning head

The modular angle encoders must be precisely adjusted after being installed on the machine. This adjustment determines the final accuracy of the encoder. It is therefore advisable to design the machine such that this adjustment is as easy and practical as possible, while also ensuring the greatest possible degree of mounting stability. The scanning heads of the ERP 10x0 and ERO 2080 be fastened from the side as well as from above.

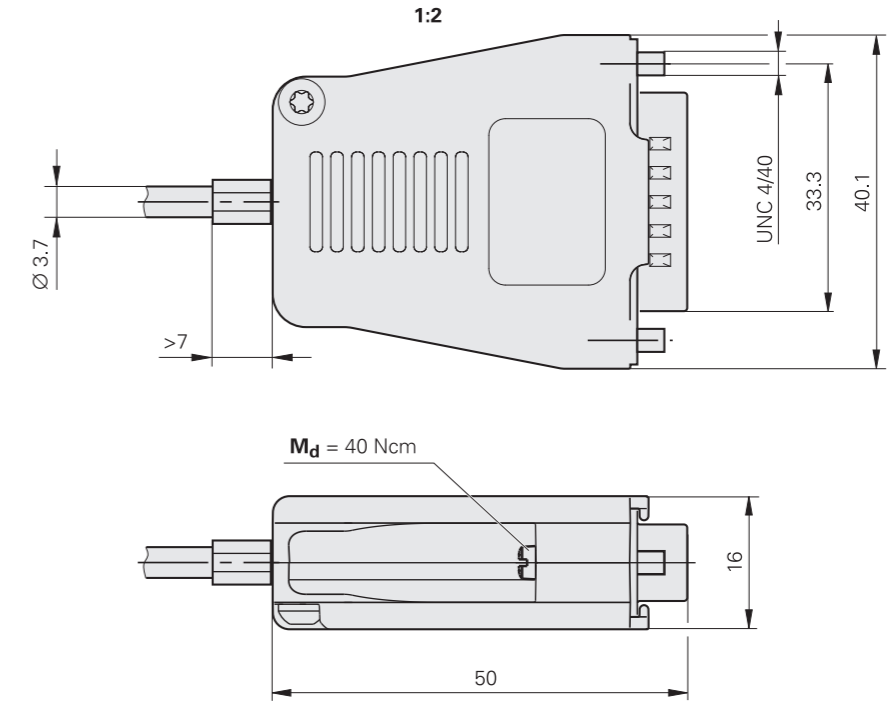


# Cable outlets and connectors for ERP 1000 and ERO 2000

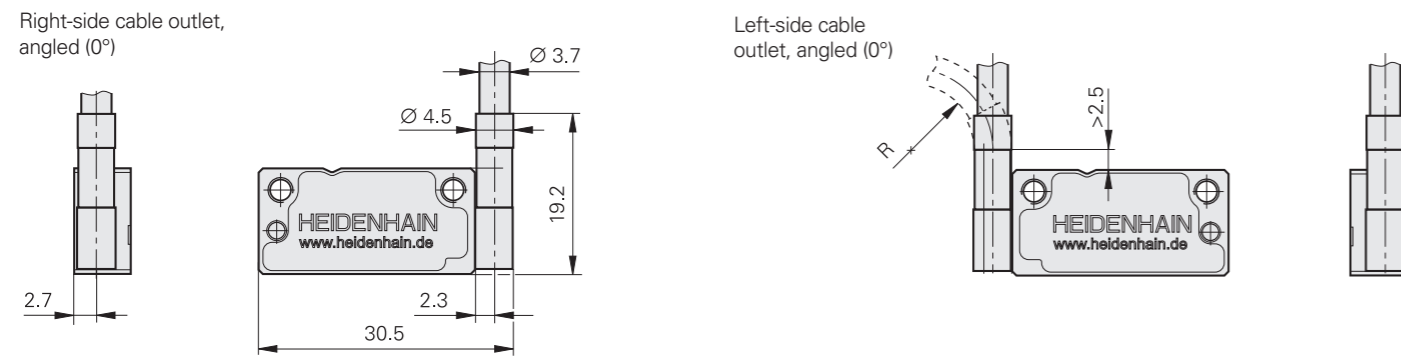
## Cable outlet, straight



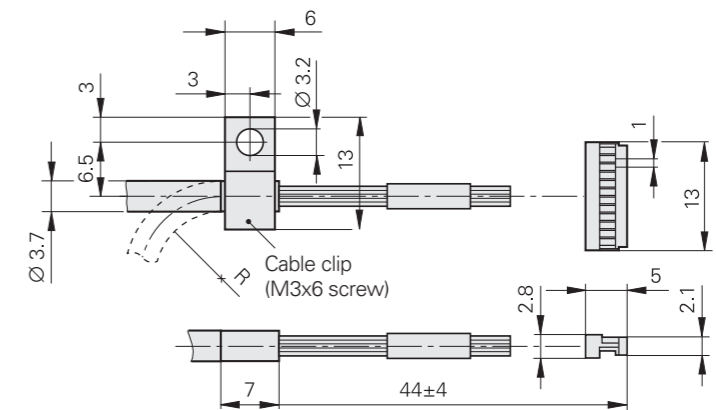
## D-sub connector $\sim 1 V_{PP}$ , TTL, EnDat



## Cable outlet, angled



## SHR-12V-S connector $\sim 1 V_{PP}$



Cable bend radius **R**

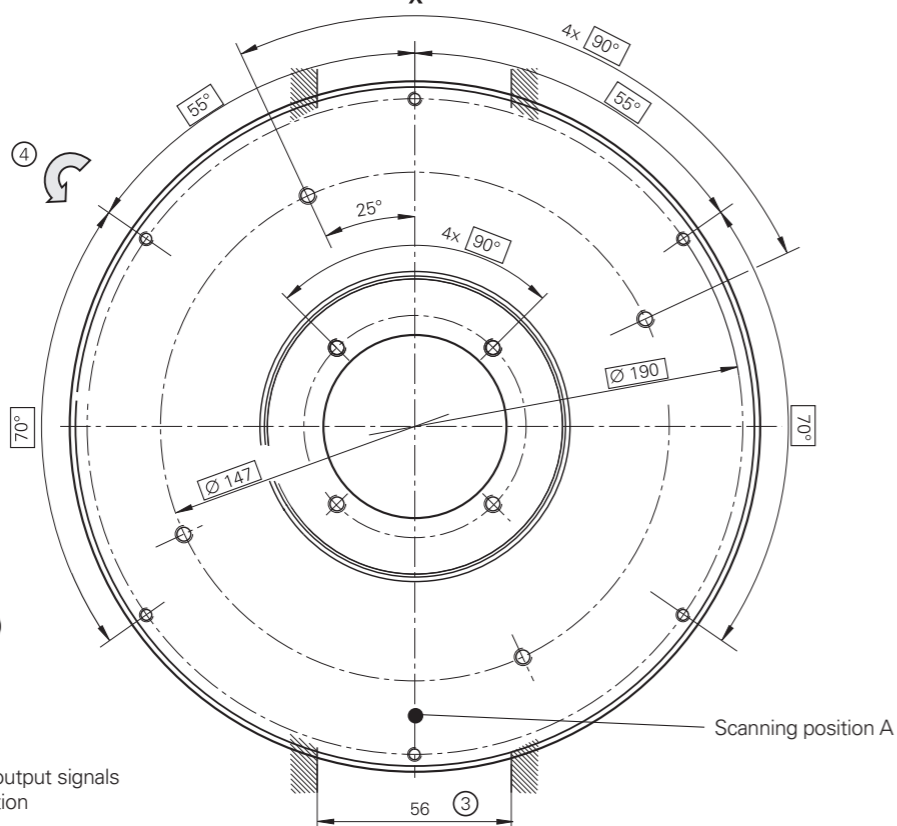
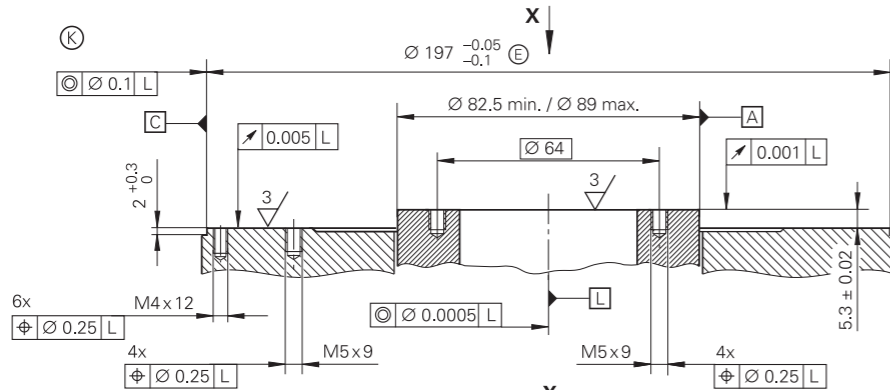
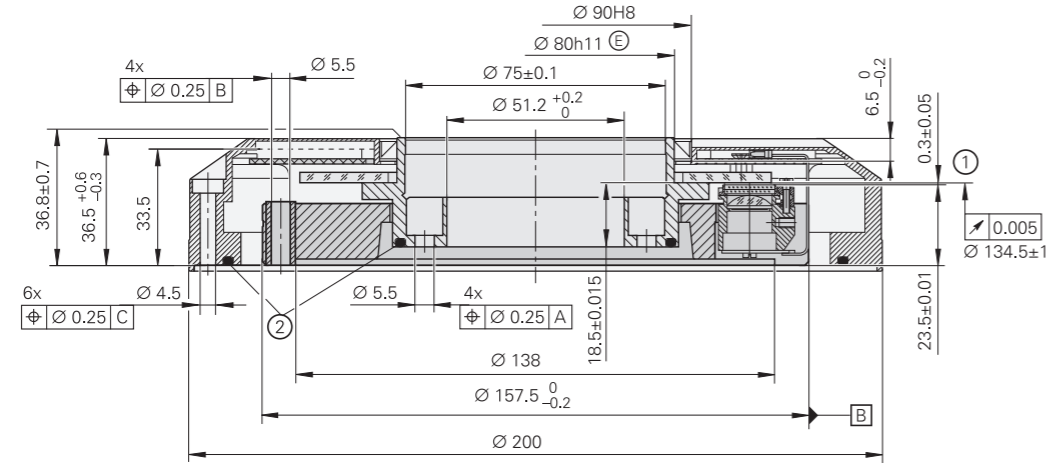
Ø 3.7 mm		
<b>R<sub>1</sub> ≥ 8 mm</b>		
<b>R<sub>2</sub> ≥ 40 mm</b>		



# 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

- Radial cable (can also be used 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

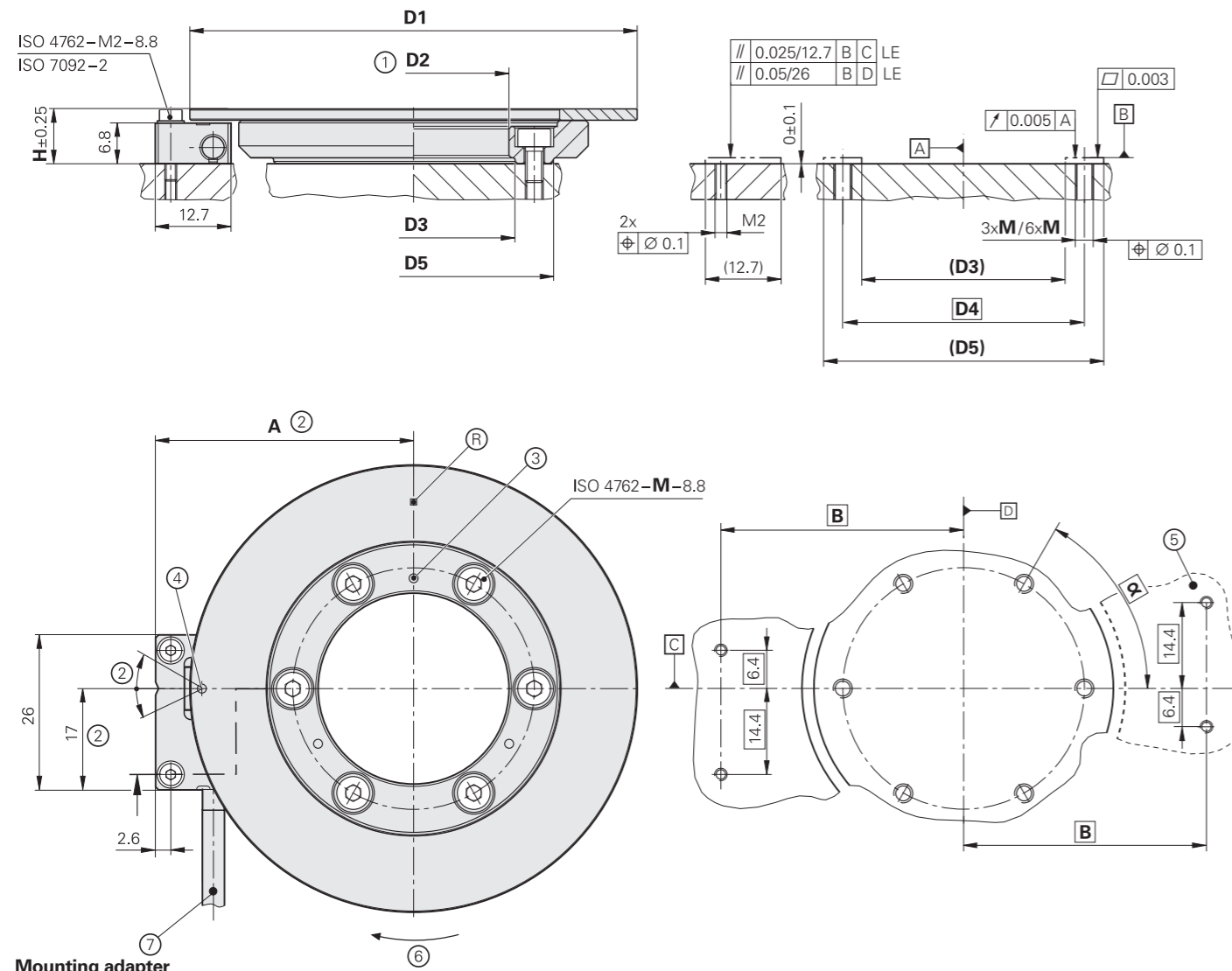
ERP 880	
<b>Measuring standard</b>	DIADUR phase grating on glass
Signal periods	180000
<b>Accuracy of graduation</b>	±0.9"
<b>Position error per signal period<sup>1)</sup></b>	±0.1"
<b>Reference marks</b>	One
<b>Hub inside diameter</b>	51.2 mm
Mech. permissible speed	≤ 1000 rpm
Moment of inertia	1.2 · 10 <sup>-3</sup> kgm <sup>2</sup>
Permissible axial motion of measured shaft	≤ ±0.05 mm
<b>Interface</b>	~ 1 V <sub>PP</sub>
Cutoff frequency	-3 dB ≥ 800 kHz -6 dB ≥ 1.3 MHz
<b>Electrical connection</b>	<i>With cover:</i> Cable (1 m) with M23 coupling <i>Without housing:</i> Via 12-pin PCB connector (adapter cable ID 372164-xx)
Cable length	≤ 150 m (with HEIDENHAIN cable)
Supply voltage	DC 5 V ±0.5 V
Current consumption	≤ 250 mA (without load)
<b>Vibration</b> 55 Hz to 2000 Hz	≤ 50 m/s <sup>2</sup> (EN 60068-2-6)
<b>Shock</b> 6 ms	≤ 1000 m/s <sup>2</sup> (EN 60068-2-27)
<b>Operating temperature</b>	0 °C to 50 °C
<b>Protection*</b> EN 60529	<i>Without housing:</i> IP00 <i>With housing:</i> IP40 <i>With housing and shaft seal:</i> IP64
<b>Starting torque</b>	-      0.25 Nm
<b>Mass</b>	3.0 kg      3.1 kg incl. housing

\* Please select when ordering

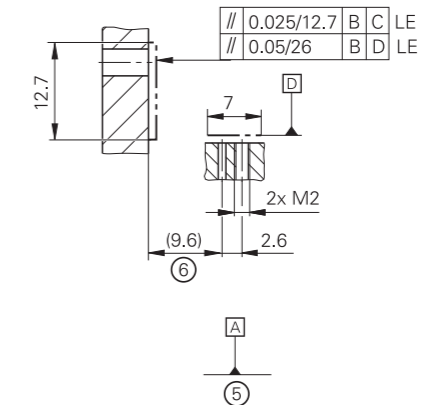
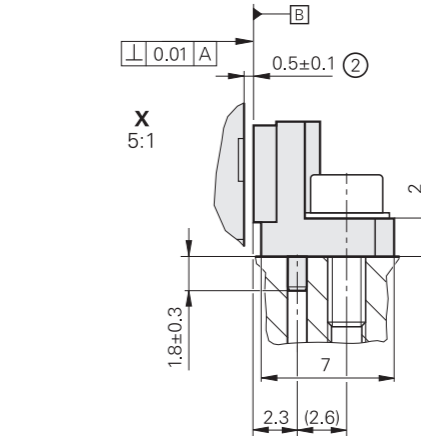
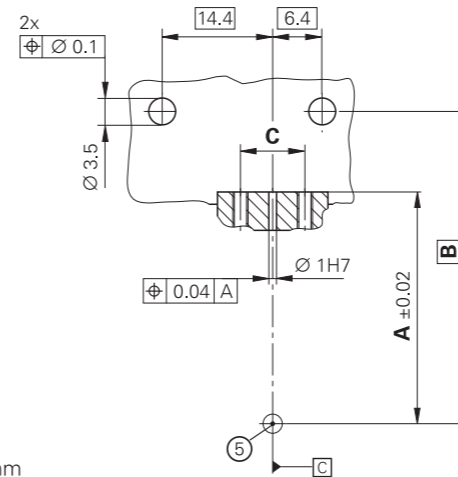
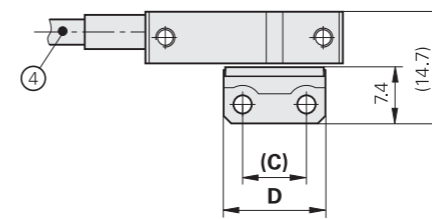
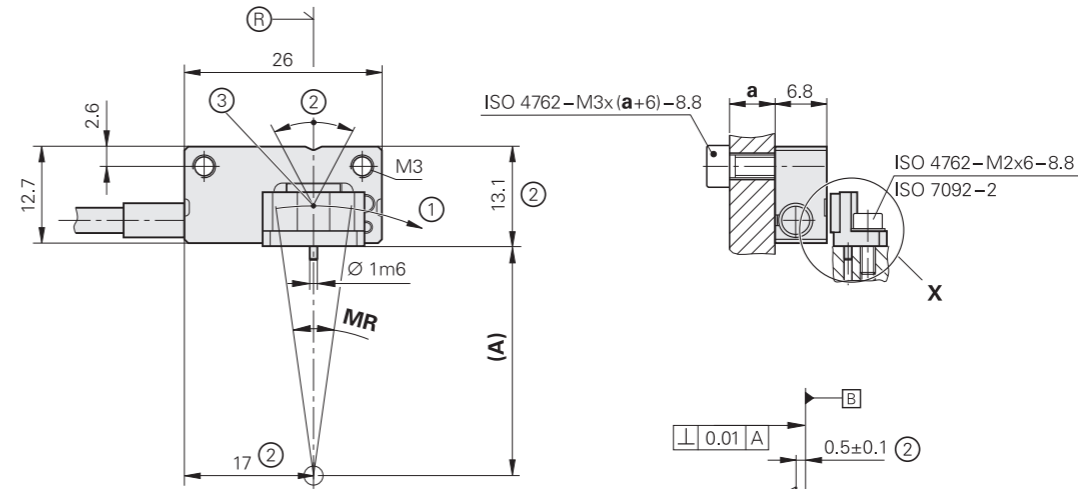
<sup>1)</sup> The position error per signal period and the accuracy of the graduation together yield the encoder-specific error; for additional errors arising from installation and the bearing of the measured shaft, see *Measurement accuracy*

# ERP 1000 series

- Very high resolution and accuracy
- Low mass and low mass moment of inertia
- Consisting of an AK scanning head and TKN circular scale



Mounting adapter



SP/360°	23000	30000	50000	63000
<b>A</b>	34.08	43.3	60.05	81.05
<b>B</b>	31.48	40.7	57.45	78.45
<b>D1</b>	Ø 57	Ø 75	Ø 109	Ø 151
<b>D2</b>	Ø 13H6	Ø 32H6	Ø 62H6	Ø 104H6
<b>D3</b>	Ø 15.1	Ø 34.1	Ø 64.5	Ø 106.5
<b>D4</b>	Ø 21.5	Ø 40.5	Ø 72	Ø 114
<b>D5</b>	Ø 27.9	Ø 46.9	Ø 79.5	Ø 121.5
<b>H</b>	9.2	9.2	10.2	10.2
<b>α</b>	3 x 120° = 360°	6 x 60° = 360°	6 x 60° = 360°	6 x 60° = 360°
<b>M</b>	M3	M3	M4	M4

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

- ▢ = Bearing
- Ⓜ = Reference mark
- 1 = Centering collar
- 2 = Fine adjustment of the scanning head for attainment of optimal incremental signals
- 3 = Marks for circular scale centering (3x120°)
- 4 = Optical centering point
- 5 = For centering of circular scale with two scanning heads
- 6 = Positive direction of rotation
- 7 = Alternative cable outlet and connector are available

LE = Line element (ISO 1101: 2008)  
 SP = Signal periods

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

- ▢ = Bearing
- Ⓜ = Position of the reference mark
- 1 = Positive direction of rotation
- 2 = Fine adjustment of the scanning head for attainment of optimal incremental signals
- 3 = Optical center point
- 4 = Alternative cable outlet and connector are available
- 5 = Center of rotation
- 6 = Adjustable

LE = Line element (ISO 1101: 2008)  
 SP = Signal periods  
 MR = Measuring range  
 MR\* = Required range for electronic fine adjustment

SP/360°	23000			30000			50000			63000		
<b>MR</b>	10°	23°	36°	8°	16°	31°	5°	11°	21°	4°	8°	15°
<b>MR*</b>	6.6°			5.2°			3.2°			2.4°		
<b>A</b>	20.98			30.2			46.95			67.95		
<b>B</b>	31.48			40.7			57.45			78.45		
<b>C</b>	5	8.4	13	5	8.4	13	5	8.4	13	5	8.4	13
<b>D</b>	10	13.4	22.9	10	13.4	22.9	10	13.4	22.9	10	13.4	22.9

# Specifications

Scanning head	AK ERP 1070							
Interface	□□TTL							
Reference mark signal	Square-wave pulse							
Integrated interpolation*	1-fold <sup>1)</sup>	5-fold	10-fold	25-fold	50-fold	100-fold	500-fold	1000-fold
Scanning frequency <sup>2)</sup>	≤ 450 kHz	≤ 312.5 kHz		≤ 250 kHz	≤ 125 kHz	≤ 62.5 kHz	≤ 12.5 kHz	≤ 6.25 kHz
Edge separation <i>a</i>	≥ 0.125 μs	≥ 0.135 μs	≥ 0.07 μs	≥ 0.03 μs				
Electrical connection*	15-pin D-sub connector (male) with 0.5 m/1 m/1.5 m cable, interface electronics in the connector; cable outlet: left or right and straight or angled							
Cable length	With HEIDENHAIN cable: ≤ 20 m; during signal adjustment with the PWM 21: ≤ 3 m							
Supply voltage	DC 5 V ±0.5 V							
Current consumption	≤ 300 mA (without load)							

Scanning head	AK ERP 1080	
Interface	~ 1 V <sub>PP</sub>	
Reference mark signal	Square-wave pulse	
Cutoff frequency -3 dB	≥ 1 MHz	
Electrical connection*	15-pin D-sub connector (male) with 0.5 m/1 m/1.5 m/3 m cable; 12-pin SHR-12V-S connector (female) with 0.5 m/1 m/1.5 m/3 m cable; cable outlet: left or right and straight or angled	
Cable length	With HEIDENHAIN cable: ≤ 20 m; during signal adjustment with the PWM 21: ≤ 3 m	
Supply voltage	DC 5 V ±0.5 V	
Current consumption	≤ 150 mA (without load)	

\* Please select when ordering

<sup>1)</sup> Suitable for applications that measure the time between individual TTL output signal clock edges; non-clocked output signals keep edge jitter low

<sup>2)</sup> Maximum scanning frequency during referencing: 70 kHz

Scanning head	AK ERP 1010	
Interface	EnDat 2.2 <sup>1)</sup>	
Ordering designation	EnDat22	
Clock frequency	≤ 16 MHz	
Calculation time <i>t<sub>cal</sub></i>	≤ 5 μs	
Electrical connection*	15-pin D-sub connector (male) with 0.5 m/1 m/1.5 m/3 m cable; interface electronics inside the connector; cable outlet: left or right and straight or angled	
Cable length	With HEIDENHAIN cable: ≤ 100 m; during signal adjustment with the PWM 21: ≤ 3 m	
Supply voltage	DC 3.6 V to 14 V	
Power consumption (max.)	At 3.6 V: 1220 mW; at 14 V: 1430 mW	
Current consumption (typical)	At 5 V: 175 mA (without load)	

<sup>1)</sup> Absolute position value after crossing of the reference mark in "Position value 2"

Scanning head	Generally valid (AK ERP 1070 / AK ERP 1080 / AK ERP 1010)	
Vibration 55 Hz to 2000 Hz Shock 6 ms	≤ 500 m/s <sup>2</sup> (EN 60068-2-6) ≤ 1000 m/s <sup>2</sup> (EN 60068-2-27)	
Operating temperature	-10 °C to 70 °C	
Protection	IP50	
Mass	Scanning head Connector Cable	≈ 5 g (without cable) ≈ 75 g ≈ 22 g/m

Circular scale	TKN ERP 1000 (full circle)			
Measuring standard	OPTODUR graduation on glass			
Signal periods*	23000	30000	50000	63000
Accuracy of graduation <sup>1)</sup>	±4"	±3"	±1.8"	±1.5" or ±0.9"
Baseline error <sup>2)</sup>	≤ ±0.8"/10°		≤ ±0.6"/10°	≤ ±0.5"/10° or ≤ ±0.4"/10°
Position error per signal period <sup>3)</sup>	±0.06"	±0.04"	±0.025"	±0.02"
Position noise RMS (1 MHz)	0.006"	0.004"	0.003"	0.002"
Positions/revolution <sup>4)</sup>	376832000	491520000	819200000	1032192000
Measuring step <sup>4)</sup>	0.0034"	0.0026"	0.0016"	0.0013"
Reference marks	One			
Hub inside diameter (D1)	13 mm	32 mm	62 mm	104 mm
Hub outside diameter (D2)	57 mm	75 mm	109 mm	151 mm
Mech. permissible speed	≤ 2600 rpm	≤ 2000 rpm	≤ 1200 rpm	≤ 950 rpm
Elec. permiss. shaft speed <sup>4)5)</sup>	≤ 2600 rpm	≤ 2000 rpm	≤ 1200 rpm	≤ 950 rpm
Moment of inertia	1.6 · 10 <sup>-5</sup> kgm <sup>2</sup>	5.7 · 10 <sup>-5</sup> kgm <sup>2</sup>	3.1 · 10 <sup>-4</sup> kgm <sup>2</sup>	1.1 · 10 <sup>-3</sup> kgm <sup>2</sup>
Protection EN 60529	Complete, mounted encoder: IP00			
Mass	≈ 57 g	≈ 92 g	≈ 185 g	≈ 289 g

\* Please select when ordering

<sup>1)</sup> When centered with two scanning heads

<sup>2)</sup> For mechanical centering as per the mounting instructions

<sup>3)</sup> The position error per signal period and the accuracy of the graduation together yield the encoder-specific error; for additional errors arising from installation and the bearing of the measured shaft, see *Measurement accuracy*

<sup>4)</sup> With serial interface

<sup>5)</sup> With TTL serial interface and depending on the selected interpolation

Circular scale	TKN ERP 1002 (segment)			
Measuring standard	OPTODUR graduation on glass			
Signal periods*	23000	30000	50000	63000
Position error per signal period	±0.06"	±0.04"	±0.025"	±0.02"
Position noise RMS (1 MHz)	0.006"	0.004"	0.003"	0.002"
Positions/rev. <sup>1)</sup> over 360°	376832000	491520000	819200000	1032192000
Measuring step <sup>1)</sup>	0.0034"	0.0026"	0.0016"	0.0013"
Reference marks	One			
Measuring range	10°/23°/36°	8°/16°/31°	5°/11°/21°	4°/8°/15°
Elec. permiss. shaft speed <sup>1)2)</sup>	≤ 2600 rpm	≤ 2000 rpm	≤ 1200 rpm	≤ 950 rpm
Protection EN 60529	Complete, mounted encoder: IP00			
Mass	≈ 0.6 g/1 g/1.7 g			

\* Please select when ordering

<sup>1)</sup> With serial interface

<sup>2)</sup> With TTL serial interface and depending on the selected interpolation

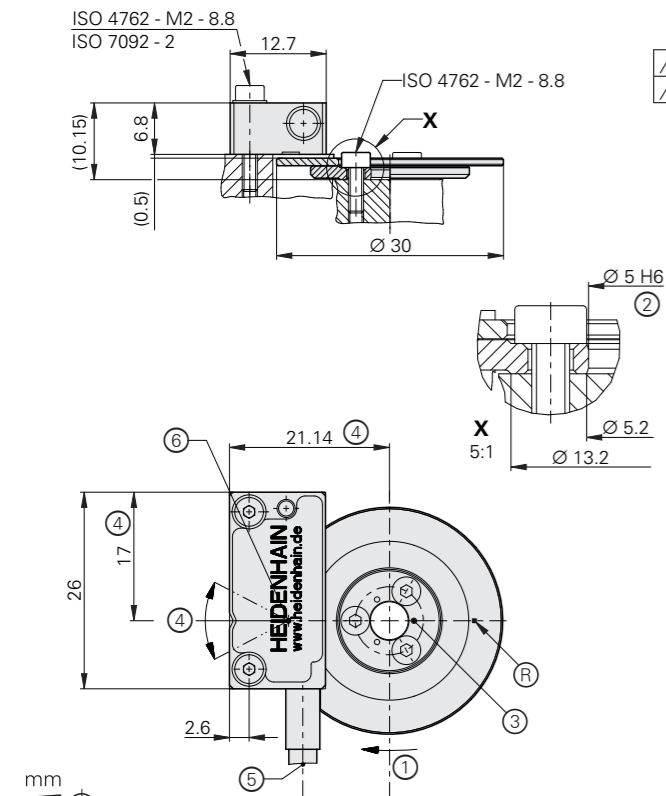


# ERO 2000 series

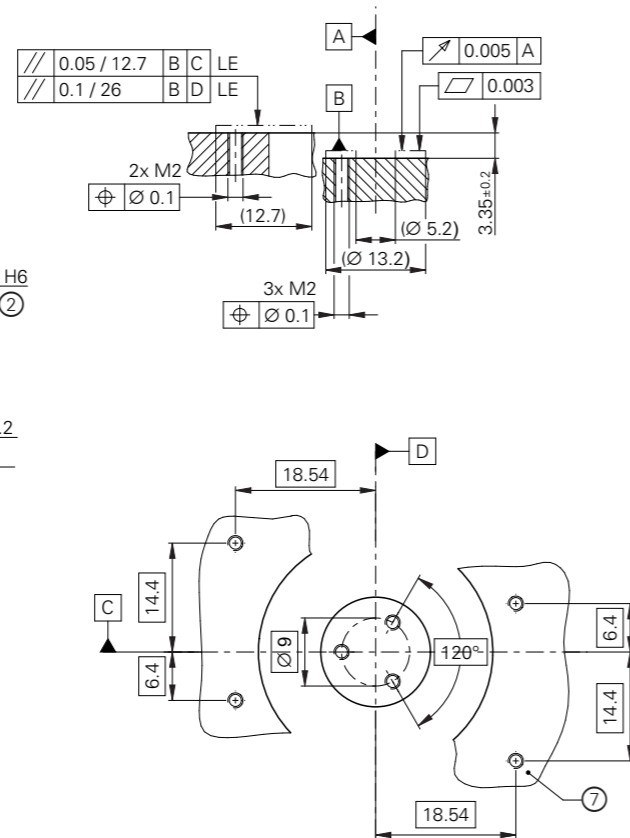
- High resolution and accuracy
- Low mass and low mass moment of inertia
- Consisting of an AK scanning head and TKN circular scale
- TKN segment versions with position detection via homing track



## Graduation carrier Ø 30 mm



## Required mating dimensions



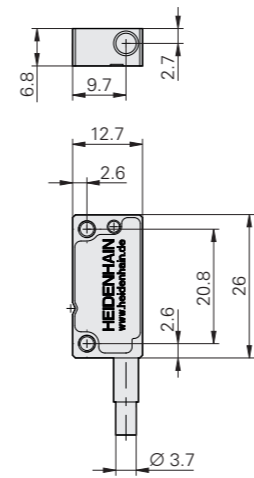
mm  
Tolerancing ISO 8015  
ISO 2768 - m H  
< 6 mm: ±0.2 mm

- ⊠ = Bearing
- Ⓜ = Reference mark
- 1 = Positive direction of rotation
- 2 = Centering collar
- 3 = Marks for circular scale centering (3x120°)
- 4 = Fine adjustment of the scanning head for obtaining optimal incremental signals
- 5 = Alternative cable outlet and connector are available
- 6 = Optical center point
- 7 = For centering of circular scale with two scanning heads

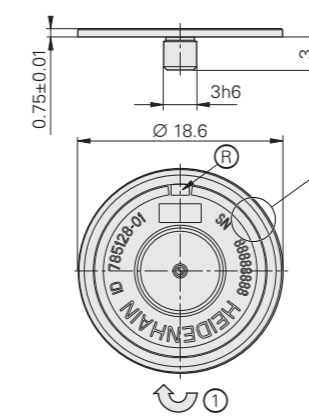
LE = Line element (ISO 1101: 2008)

## Graduation carrier Ø 18.6 mm (segment version: 18.6 mm x 9 mm)

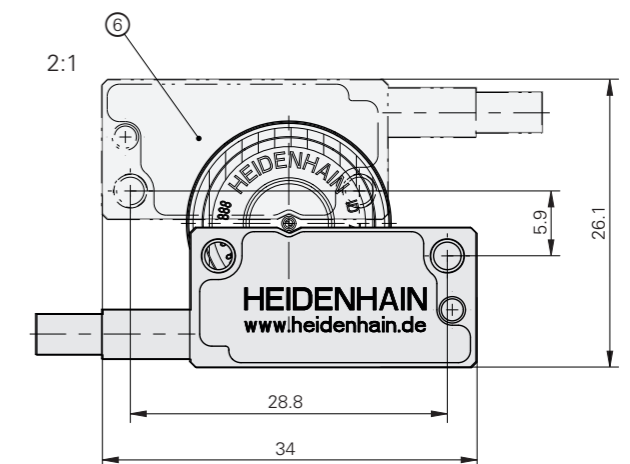
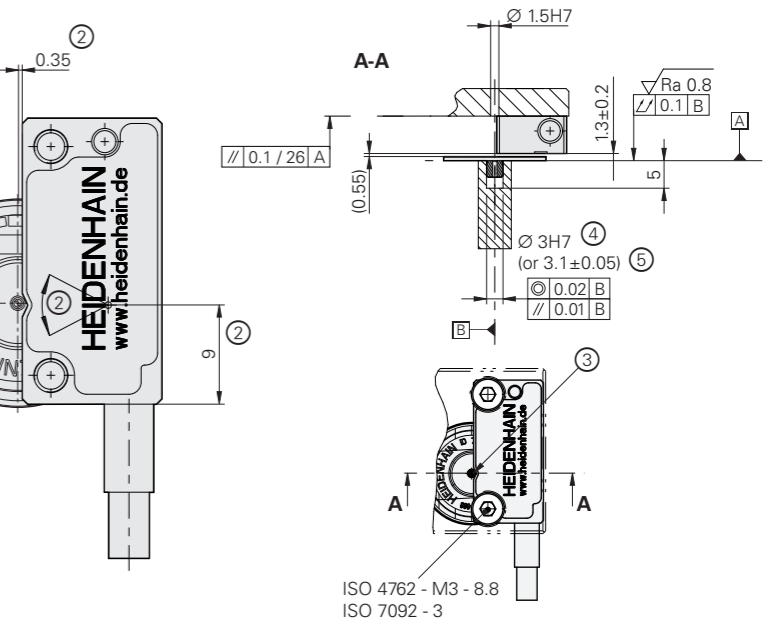
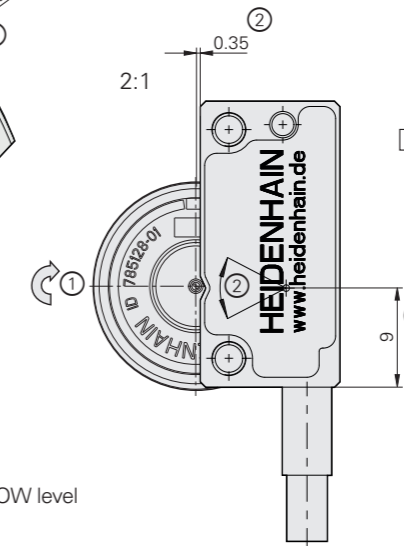
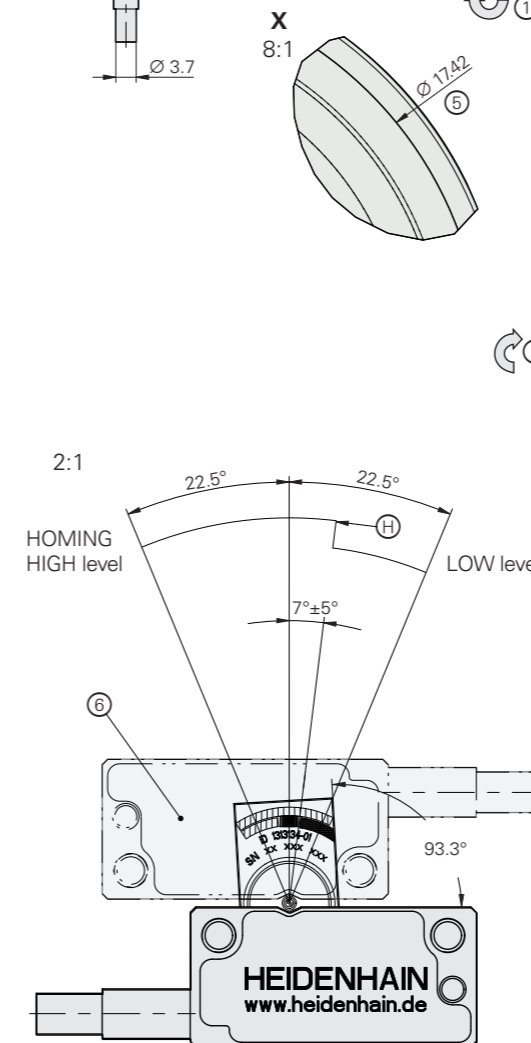
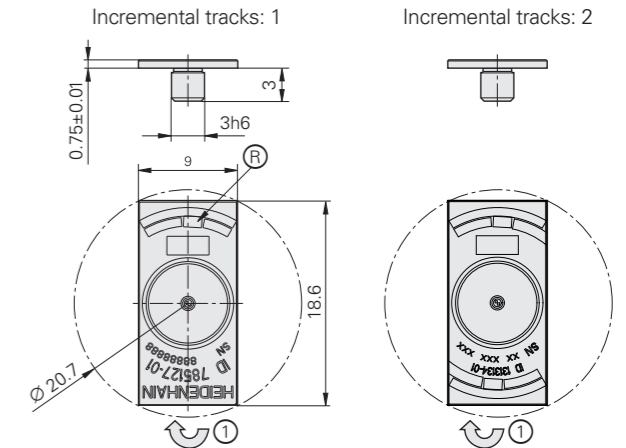
### AK ERO 20x0



### TKN ERO 2000 2:1



### TKN ERO 2002 2:1



- ⊠ = Bearing of mating shaft
- Ⓜ = Signal edge of the homing track
- R = Position of the reference mark
- 1 = Direction of shaft rotation for ascending position values
- 2 = Fine adjustment of the scanning head for optimal incremental signals
- 3 = Cylindrical pin for positioning and Moiré adjustment (must be removed after positioning)
- 4 = Dimension for alignment of the circular scale via the centering pin of the circular scale
- 5 = Dimension for mounting the circular scale via optical alignment; do not use the outer glass edge of the circular scale
- 6 = Optional: mounting with two scanning heads

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

# Specifications

<b>Scanning head</b>	<b>AK ERO 2080</b>
<b>Interface</b>	~ 1 V <sub>PP</sub>
Reference mark signal	Square-wave pulse
Cutoff frequency -3 dB <sup>1)</sup>	≥ 1 MHz
<b>Electrical connection*</b>	15-pin D-sub connector (male) with 0.5 m/1 m/1.5 m/3 m cable 12-pin SHR-12V-S connector (female) with 0.5 m/1 m/1.5 m/3 m cable Cable outlet on the left or right and straight or angled
Cable length	With HEIDENHAIN cable: ≤ 20 m; during signal adjustment with the PWM 21: ≤ 3 m
Supply voltage	DC 5 V ±0.5 V
Current consumption	≤ 150 mA (without load)
<b>Vibration</b> 55 Hz to 2000 Hz <b>Shock</b> 6 ms	≤ 500 m/s <sup>2</sup> (EN 60068-2-6) ≤ 1000 m/s <sup>2</sup> (EN 60068-2-27)
<b>Operating temperature</b>	-10 °C to 70 °C
<b>Protection</b>	IP50
<b>Mass</b>	Scanning head ≈ 5 g (without cable) Connector ≤ 75 g Cable ≈ 22 g/m

\* Please select when ordering

<sup>1)</sup> Maximum frequency during referencing: 500 kHz

Circular scale	TKN ERO 2000 (full circle)		TKN ERO 2002 <sup>1)</sup> (segment)	
<b>Measuring standard</b>	SUPRADUR graduation on glass			
<b>Measuring range</b>	360°		45°	
<b>Signal periods</b>	4096	2500	2500 over 360°	
<b>Accuracy of graduation</b> <sup>2)</sup>	±8"	±10"	-	-
<b>Baseline error</b> <sup>3)</sup>	≤ ±2"/10°			
<b>Position error per signal period</b> <sup>4)</sup>	±0.3"	±0.5"	±0.5"	
<b>RMS position noise</b> (1 MHz)	0.03"	0.04"	0.04"	
<b>Reference marks</b>	One		One	One on every side
<b>Inside diameter of hub</b>	5 mm	-	-	
<b>Dimensions of graduation carrier</b>	Ø 30 mm	Ø 18.6 mm	18.6 mm x 9 mm	
<b>Centering pin</b>	-	3 mm	3 mm	
Mech. permissible shaft speed	≤ 14000 rpm		≤ 24000 rpm	
Moment of inertia	4.1 · 10 <sup>-7</sup> kgm <sup>2</sup>	2.2 · 10 <sup>-8</sup> kgm <sup>2</sup>	1.1 · 10 <sup>-8</sup> kgm <sup>2</sup>	
<b>Protection</b> EN 60529	Complete, mounted encoder: IP00			
<b>Mass</b>	≈ 5.2 g	≈ 0.56 g	≈ 0.36 g	

<sup>1)</sup> Along with their incremental graduation, the TKN ERO 2002 segment versions feature a homing track for position detection (see @ in mating dimensions). The signal for position detection from the scanning head is transmitted in the TTL level via a separate line and is therefore directly available. The incremental signals correspond to the V<sub>PP</sub> interface.

<sup>2)</sup> When centered with two scanning heads

<sup>3)</sup> For mechanical centering as per the mounting instructions

<sup>4)</sup> The position error per signal period and the accuracy of the graduation together yield the encoder-specific error; for additional errors arising from installation and the bearing of the measured shaft, see *Measurement accuracy*

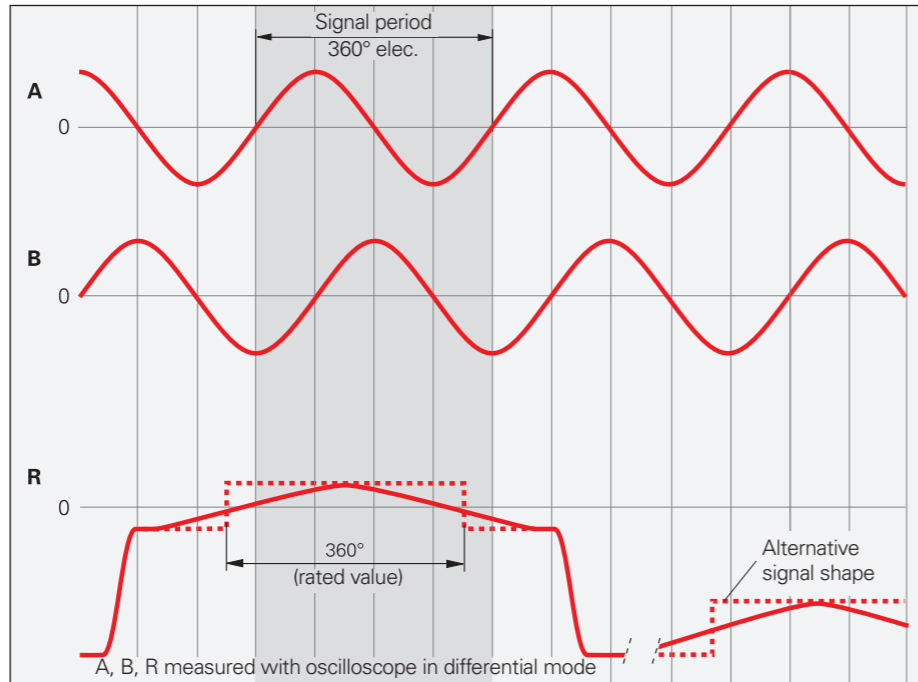
# Interfaces

## ~ 1 V<sub>PP</sub> incremental signals

HEIDENHAIN encoders with ~ 1 V<sub>PP</sub> interface provide highly interpolable voltage signals.

The sinusoidal **incremental signals** A and B are phase-shifted by 90° elec. and have a typical amplitude of 1 V<sub>PP</sub>. The illustrated sequence of output signals—with B lagging A—applies to the direction of motion shown in the dimension drawing.

The **reference mark signal** R has a unique assignment to the incremental signals. The output signal may be lower next to the reference mark.



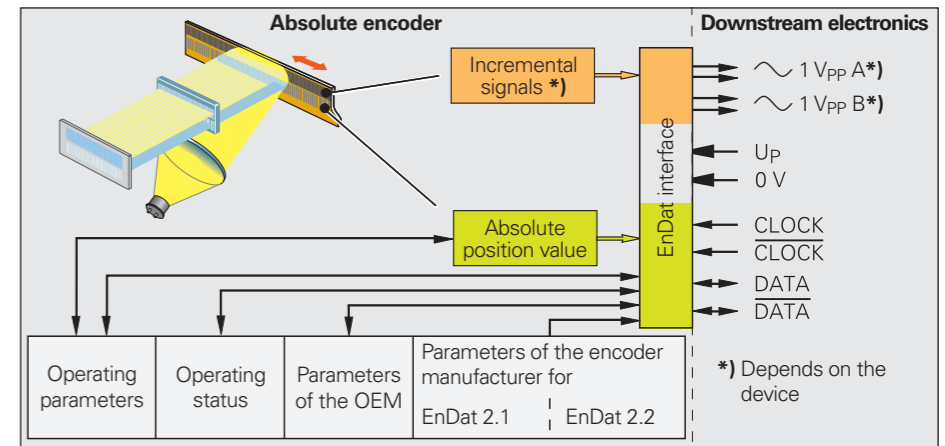
**Further information:**  
For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure.

## EnDat position values

The EnDat interface is a digital **bidirectional** interface for encoders. It is capable of outputting **position values**, reading and updating information stored in the encoder, and storing new information in the encoder. Thanks to the **serial transmission method**, only **four signal lines** are required. The data (DATA) are transmitted in **synchronism** with the CLOCK signal from the downstream electronics. The type of transmission (position values, parameters, diagnostics, etc.) is selected via mode commands sent to the encoder by the downstream electronics. Some functions are available only with EnDat 2.2 mode commands.

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

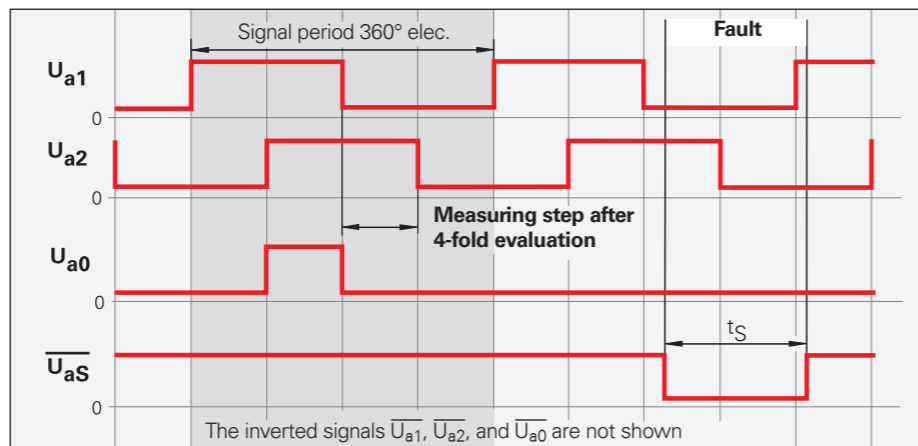
Versions of the EnDat interface



## Incremental signals □TTL

HEIDENHAIN encoders with the □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.



**Further information:**  
For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure.

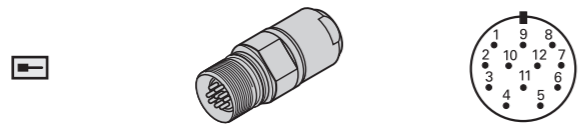




The **fault detection signal**  $\overline{U_{aS}}$  indicates fault conditions such as an interruption in the supply lines, failure of the light source, etc.

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**.

**Further information:**  
For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure.

# Pin layout

## ERP 880




12-pin M23 coupling													
													
12-pin PCB connector on ERP 880													
													
	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	/
	U <sub>P</sub>	Sensor U <sub>P</sub>	0V	Sensor 0V	A+	A-	B+	B-	R+	R-	Vacant	Vacant	Vacant
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	/	Violet	Yellow

**Cable shield** connected to housing; **U<sub>P</sub>** = Power supply voltage

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

Vacant pins or wires must not be used!

## ERP 1000

15-pin D-sub connector (male)					12-pin SHR-12V-S connector (female)										
	Power supply				Incremental signals						Serial data transmission/ other signals				
	4	12	2	10	1	9	3	11	14	7	13	15	5	6	8
	1	-	2	-	3	4	6	5	8	7	9	11	12	10	/
EnDat	U <sub>P</sub>	Sensor U <sub>P</sub>	0V	Sensor 0V	/	/	/	/	/	/	DATA	CLOCK	DATA	Vacant	CLOCK
TTL	● — ●		● — ●		U <sub>a1</sub>	U <sub>a1</sub>	U <sub>a2</sub>	U <sub>a2</sub>	U <sub>a0</sub>	U <sub>a0</sub>	U <sub>aS</sub>	Vacant	Va- cant <sup>1)</sup>	Va- cant <sup>1)</sup>	Va- cant <sup>1)</sup>
~ 1V <sub>PP</sub>					A+	A-	B+	B-	R+	R-	Va- cant <sup>1)</sup>	Va- cant <sup>1)</sup>	Vacant	Vacant	Vacant
	Brown/ Green	/	White/ Green	/	Brown	Green	Gray	Pink	Red	Black	Violet	Yellow	/	/	/

**Shield** lies on housing; **U<sub>P</sub>** = Power supply voltage

**Sensor:** The sense line is connected in the connector with the corresponding power line.

Vacant wires and pins must not be used.

<sup>1)</sup> Required for signal adjustment with the PWM 21



# Testing equipment and diagnostics

## ERO 2000

15-pin D-sub connector (male)					12-pin SHR-12V-S connector (female)										
Power supply					Incremental signals						Other signals				
	4	12	2	10	1	9	3	11	14	7	13	8	6	15	
	1	-	2	-	3	4	6	5	8	7	9	12	10	11	
	1V <sub>PP</sub>	U <sub>P</sub>	Sensor U <sub>P</sub>	0V	Sensor 0V	A+	A-	B+	B-	R+	R-	Va-cant <sup>1)</sup>	H	/	Vacant <sup>1)</sup>
	Brown/ Green	/	White/ Green	/	Brown	Green	Gray	Pink	Red	Black	Violet	Green/ Black	Yellow/ Black	Yellow	

**Shield** on housing; **U<sub>P</sub>** = Power supply voltage

**Sensor:** The sense line is connected in the connector with the corresponding power line.

Vacant pins or wires must not be used.

<sup>1)</sup> Required for signal adjustment with the PWM 21

HEIDENHAIN encoders provide all of the information needed for commissioning, monitoring, and diagnostics. The type of information available depends on whether the encoder is incremental or absolute and on which interface is being used.

Incremental encoders mainly have 1 V<sub>PP</sub>, TTL, or HTL interfaces. TTL and HTL encoders monitor their signal amplitudes internally and generate a simple fault detection signal. With 1 V<sub>PP</sub> signals, an analysis of the output signals is possible only with external testing devices or through the use of computation resources in the downstream electronics (analog diagnostic interface).

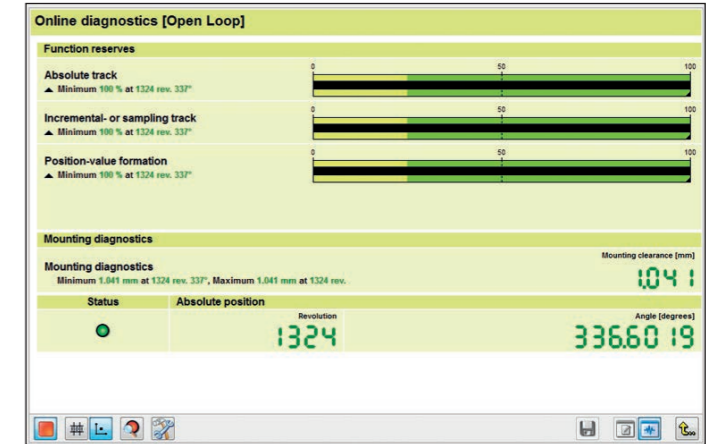
Absolute encoders use serial data transmission. Depending on the interface, additional 1 V<sub>PP</sub> incremental signals can be output. The signals are extensively monitored within the encoder. The monitoring results (particularly valuation numbers) can be transmitted to the downstream electronics along with the position values via the serial interface (digital diagnostic 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 about the encoder's function reserve
  - Identical scaling for all HEIDENHAIN encoders
  - Cyclic reading capability

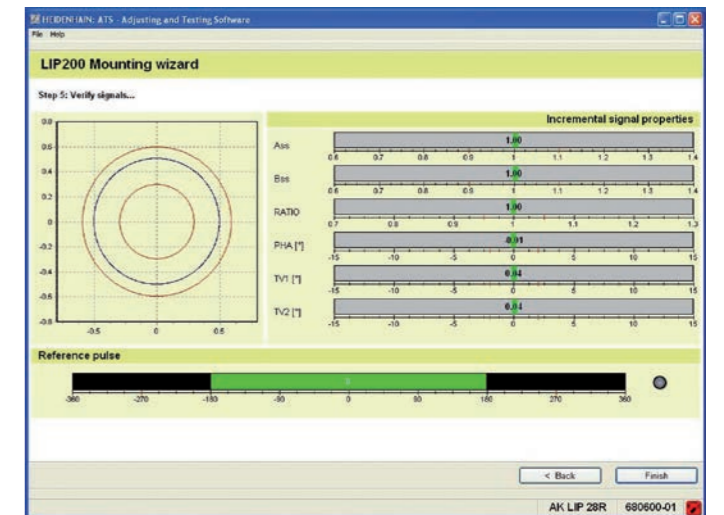
This enables the downstream electronics to evaluate the current status of the encoder with little effort, even in closed-loop mode.

For the analysis of these encoders, HEIDENHAIN offers the appropriate PWM inspection devices and PWT testing devices. Based on how these devices are integrated, a distinction is made between two types of diagnostics:

- Encoder diagnostics: the encoder is connected directly to the testing or inspection device, thereby enabling a detailed analysis of encoder functions.
- Diagnostics in the control loop: the PWM testing unit is linked into the closed control loop (e.g., via a suitable testing adapter). This enables real-time diagnosis of the machine or system during operation. The available functions depend on the interface.



Diagnostics with the PWM 21 and ATS software



Initial setup with the PWM 21 and ATS software

### PWT 101

The PWT 101 is a testing device for the functional testing and adjustment of incremental and absolute HEIDENHAIN encoders. Thanks to its compact and rugged design, the PWT 101 is ideal for portable use.



#### Further information:

For a detailed description, refer to the *PWT 101* Product Information document.

PWT 101	
<b>Encoder input</b> only for HEIDENHAIN encoders	<ul style="list-style-type: none"> <li>• EnDat</li> <li>• Fanuc Serial Interface</li> <li>• Mitsubishi high speed interface</li> <li>• Panasonic Serial Interface</li> <li>• Yaskawa Serial Interface</li> <li>• 1 V<sub>PP</sub></li> <li>• 11 μA<sub>PP</sub></li> <li>• TTL</li> </ul>
<b>Display</b>	4.3-inch color flat-panel display (touchscreen)
<b>Supply voltage</b>	DC 24 V Power consumption: max. 15 W
<b>Operating temperature</b>	0 °C to 40 °C
<b>Protection EN 60529</b>	IP20
<b>Dimensions</b>	≈ 145 mm × 85 mm × 35 mm

### PWM 21

The PWM 21 phase-angle measuring unit, in conjunction with the included ATS adjusting and testing software, serves as an adjusting and testing package for the diagnosis and adjustment of HEIDENHAIN encoders.



#### Further information:

For detailed descriptions, refer to the *PWM 21/ATS Software* Product Information document.

PWM 21	
<b>Encoder input</b>	<ul style="list-style-type: none"> <li>• EnDat 2.1, EnDat 2.2, or EnDat 3 (absolute value with or without incremental signals)</li> <li>• DRIVE-CLiQ</li> <li>• Fanuc Serial Interface</li> <li>• Mitsubishi high speed interface</li> <li>• Yaskawa Serial Interface</li> <li>• Panasonic serial interface</li> <li>• SSI</li> <li>• 1 V<sub>PP</sub>/TTL/11 μA<sub>PP</sub></li> <li>• HTL (via signal adapter)</li> </ul>
<b>Interface</b>	USB 2.0
<b>Supply voltage</b>	AC 100 V to 240 V or DC 24 V
<b>Dimensions</b>	258 mm × 154 mm × 55 mm

ATS	
<b>Languages</b>	German or English (selectable)
<b>Functions</b>	<ul style="list-style-type: none"> <li>• Position display</li> <li>• Connection dialog</li> <li>• Diagnostics</li> <li>• Mounting wizard for the EBI/ECI/EQI, ERP 1000, ERO 2000, and others</li> <li>• Additional functions (if supported by the encoder)</li> <li>• Memory contents</li> </ul>
<b>System requirements and recommendations</b>	PC (dual-core processor > 2 GHz) RAM > 2 GB Operating systems: Windows 7, 8, and 10 (32-bit / 64-bit) 500 MB of free hard drive space

DRIVE-CLiQ is a registered trademark of Siemens Aktiengesellschaft.

# HEIDENHAIN

Mastering nanometer accuracy



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