HEIDENHAIN

Modular Angle Encoders

With Magnetic Scanning

09/2018

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

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

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

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

Comprehensive descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure, ID 1078628-xx.

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

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

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Angle encoders from HEIDENHAIN

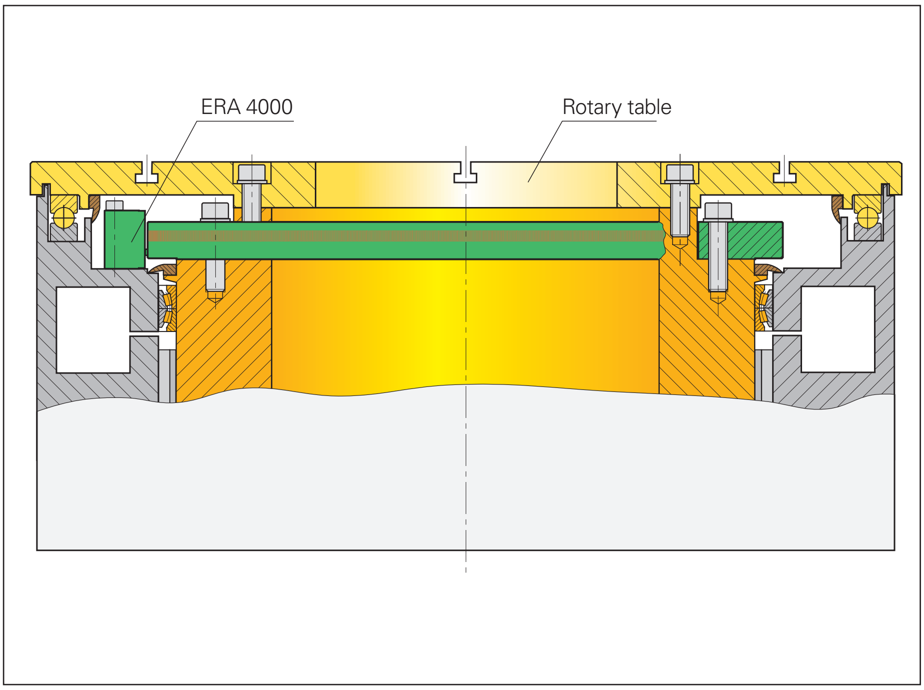
The term angle encoder is typically used to describe encoders that have an accuracy of better than ±5″ and a line count above 10000.

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

etc.

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



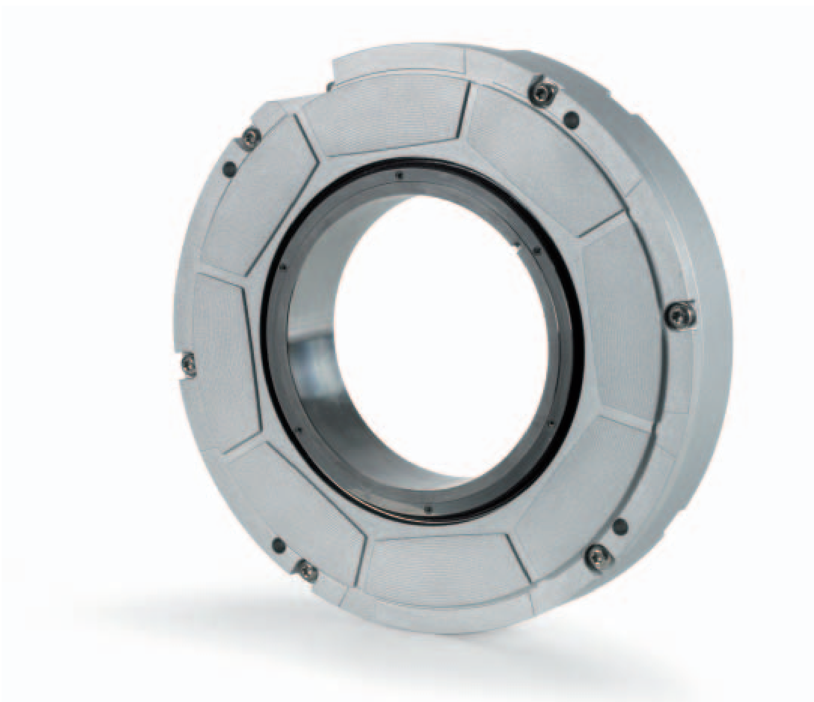
The **ERA 4000** angle encoder mounted onto the rotary table of a machine tool

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 10/11*
- *For incremental angle encoders, see page 12/13*



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

More information:

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

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 12/13

Modular angle encoders with optical scanning

The angle encoders 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 m 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 tape

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

For selection guide see page 8/9

Modular angle encoders with magnetic scanning

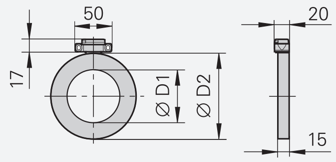
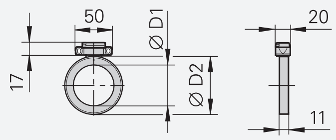
The robust **ERM** encoders are especially suited for use in production machines. The large inside diameters available, their small dimensions, and the compact design of the scanning head predestine them for

- the C axis of lathes,
- 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 6/7

Selection guide

Modular angle encoders with magnetic scanning

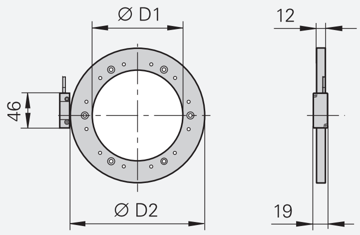
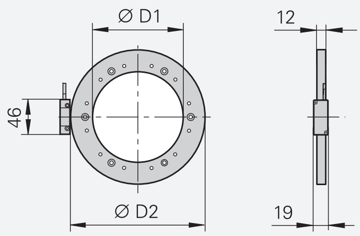
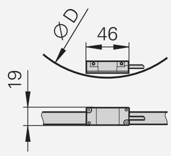
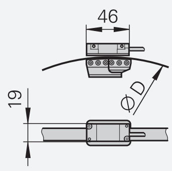
	Overall dimensions in mm	**Diameter**	**Signal periods**	**Grating period**
ERM 2200 series		D1: 40 mm to 410 mm D2: 64.37 mm to 452.64 mm	1024 to 7200	≈ 200 µm
ERM 2400 series		D1: 40 mm to 512 mm D2: 64.37 mm to 603.52 mm	512 to 4800	≈ 400 µm
ERM 2404 series		D1: 30 mm to 100 mm D2: 45.26 mm to 128.75 mm	360 to 1024	≈ 400 µm
ERM 2904 series		D1: 35 mm to 100 mm D2: 45.43 mm to 120.96 mm	180 to 400	≈ 1000 µm
ERM 2405 series		D1: 40 mm; 55 mm D2: 64.37 mm; 75.44 mm	512; 600	≈ 400 µm

Mechanically permissible speed	Mounting the scale drum	Interface	Model	Page
22000 rpm to 3000 rpm	Fastening by screws	∿ $1\,V_{PP}$	**AK ERM 2280** **TTR ERM 2200**	**26-29**
22000 rpm to 1600 rpm	Fastening by screws	⊓⊔TTL	**AK ERM 2420** **TTR ERM 2400**	**26-29**
		∿ $1\,V_{PP}$	**AK ERM 2480** **TTR ERM 2400**	
		EnDat 2.2	**AK ERM 2410** **TTR ERM 2400C**	
60000 rpm to 20000 rpm	Friction-locked fastening by clamping the drum	∿ $1\,V_{PP}$	**AK ERM 2480** **TTR ERM 2404**	**26-31**
50000 rpm to 16000 rpm			**AK ERM 2980** **TTR ERM 2904**	**26-31**
33000 rpm; 27000 rpm	Friction-locked fastening by clamping the drum; additional slot for feather key as anti-rotation element		**AK ERM 2480** **TTR ERM 2405**	**26-31**

ERM 2480

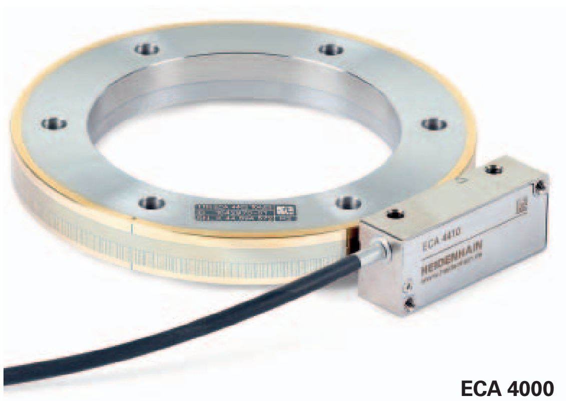
ERM 2485

Selection guide
Modular angle encoders with optical scanning

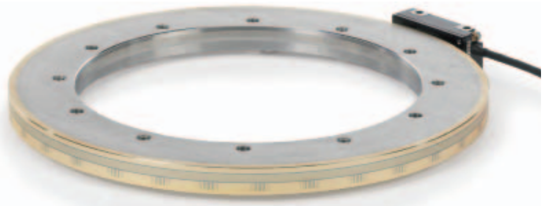
Series	**Version and mounting**	**Overall dimensions** in mm	**Diameter D1/D2**	**Accuracy of graduation**	**Mechanically permissible speed**[1]
Angle encoders with graduation on steel scale drum					
ECA 4000[2)3)]	Steel scale drum with three-point centering		D1: 70 mm to 512 mm D2: 104.63 mm to 560.46 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″	≤ 10000 rpm to ≤ 2500 rpm
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 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 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

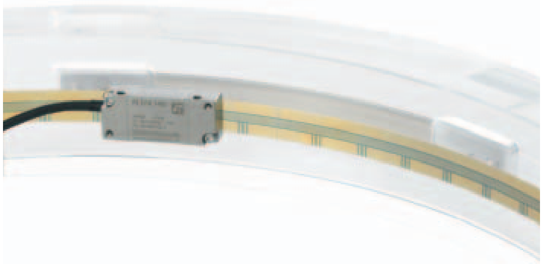
Interface	Signal periods/rev	Reference marks	Model	Further information
EnDat 2.2	–	–	**ECA 4412**	Brochure: *Modular Angle Encoders With Optical Scanning*
Fanuc αi			**ECA 4492 F**	
Mitsubishi			**ECA 4492 M**	
Panasonic			**ECA 4492 P**	
EnDat 2.2			**ECA 4410**	
Fanuc αi			**ECA 4490 F**	
Mitsubishi			**ECA 4490 M**	
Panasonic			**ECA 4490 P**	
∼ 1 V_{PP}	12 000 to 52 000	Distance-coded or one	**ERA 4280 C**	
	6000 to 44 000		**ERA 4480 C**	
	3000 to 13 000		**ERA 4880 C**	
∼ 1 V_{PP}	12 000 to 52 000	Distance-coded or one	**ERA 4282 C**	
∼ 1 V_{PP}	36 000 to 90 000	Distance-coded	**ERA 7480 C**	Brochure: *Modular Angle Encoders With Optical Scanning*
∼ 1 V_{PP}	36 000 to 90 000	Distance-coded	**ERA 8480 C**	



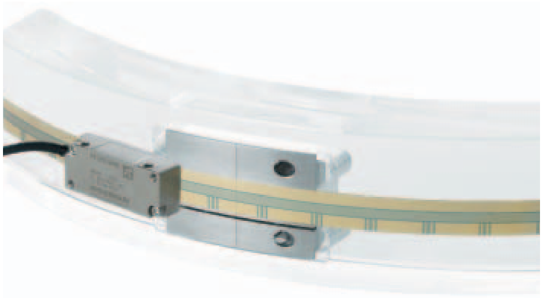
ECA 4000



ERA 4000

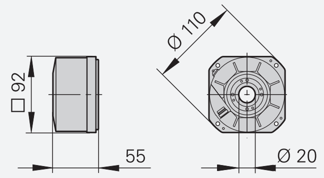
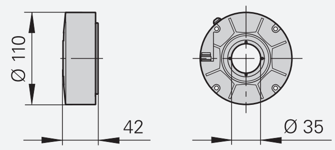
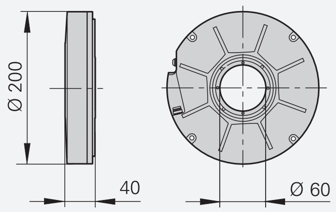
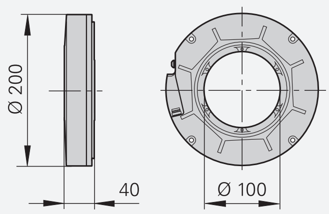
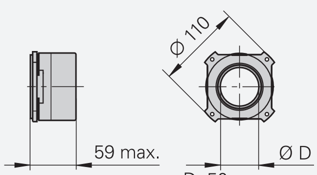


ERA 7480

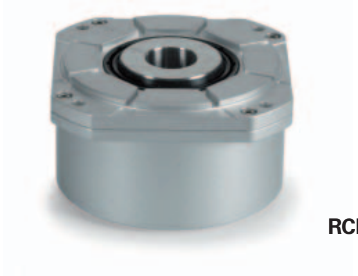


ERA 8480

Selection guide
Absolute sealed angle encoders

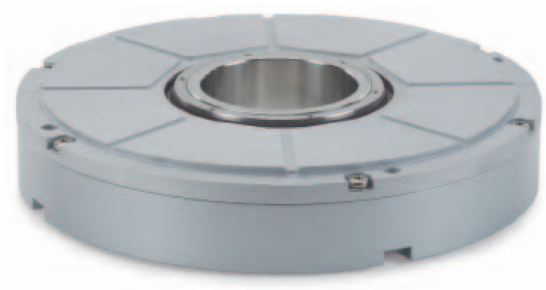
Series	Overall dimensions in mm	System accuracy	Mechanically permissible speed	Position values/ Revolution	Interface
With integrated stator coupling					
RCN 2000		±5″	≤ 1500 rpm	67 108 864 ≙ 26 bits	EnDat 2.2
					EnDat 2.2
					Fanuc αi
					Mitsubishi
		±2.5″		268 435 456 ≙ 28 bits	EnDat 2.2
					EnDat 2.2
					Fanuc αi
					Mitsubishi
RCN 5000		±5″	≤ 1500 rpm	67 108 864 ≙ 26 bits	EnDat 2.2
					EnDat 2.2
					Fanuc αi
					Mitsubishi
		±2.5″		268 435 456 ≙ 28 bits	EnDat 2.2
					EnDat 2.2
					Fanuc αi
					Mitsubishi
RCN 8000		±2″	≤ 500 rpm	536 870 912 ≙ 29 bits	EnDat 2.2
					EnDat 2.2
					Fanuc αi
					Mitsubishi
		±1″			EnDat 2.2
					EnDat 2.2
					Fanuc αi
					Mitsubishi
With mounted stator coupling					
ECN 200	 D: 50 mm max.	±10″	≤ 3000 rpm	33 554 432 ≙ 25 bits	EnDat 2.2
					EnDat 2.2
				8 388 608 ≙ 23 bits	Fanuc α
					Mitsubishi

	Incremental signals	Signal periods/rev	Model	Further information
	$\sim$ 1 V_{PP}	16384	**RCN 2380**	Brochure: *Sealed Angle Encoders*
	–	–	**RCN 2310**	
	–	–	**RCN 2390 F**	
	–	–	**RCN 2390 M**	
	$\sim$ 1 V_{PP}	16384	**RCN 2580**	
	–	–	**RCN 2510**	
	–	–	**RCN 2590 F**	
	–	–	**RCN 2590 M**	
	$\sim$ 1 V_{PP}	16384	**RCN 5380**	
	–	–	**RCN 5310**	
	–	–	**RCN 5390 F**	
	–	–	**RCN 5390 M**	
	$\sim$ 1 V_{PP}	16384	**RCN 5580**	
	–	–	**RCN 5510**	
	–	–	**RCN 5590 F**	
	–	–	**RCN 5590 M**	
	$\sim$ 1 V_{PP}	32768	**RCN 8380**	
	–	–	**RCN 8310**	
	–	–	**RCN 8390 F**	
	–	–	**RCN 8390 M**	
	$\sim$ 1 V_{PP}	32768	**RCN 8580**	
	–	–	**RCN 8510**	
	–	–	**RCN 8590 F**	
	–	–	**RCN 8590 M**	
	$\sim$ 1 V_{PP}	2048	**ECN 225**	Brochure: *Sealed Angle Encoders*
	–	–	**ECN 225**	
	–	–	**ECN 223 F**	
	–	–	**ECN 223 M**	



RCN 2000

RCN 5000

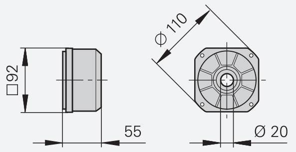
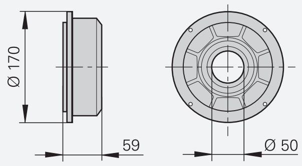
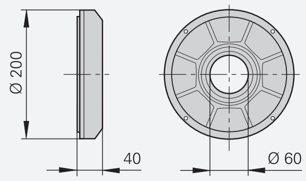
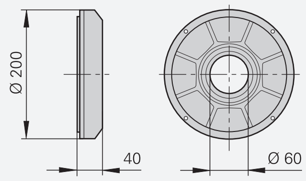
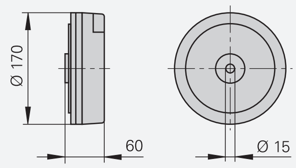
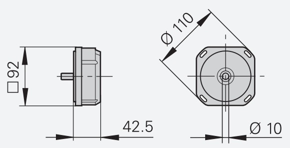
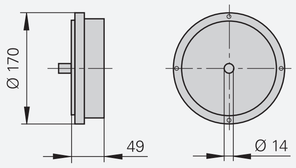


RCN 8000
Ø 60 mm

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
				⊓⊔TTL
				∼ 1 V_{PP}
		±2.5″		∼ 1 V_{PP}
RON 700		±2″	≤ 1000 rpm	∼ 1 V_{PP}
				∼ 1 V_{PP}
RON 800 **RPN 800**		±1″	≤ 1000 rpm	∼ 1 V_{PP}
				∼ 1 V_{PP}
RON 900		±0.4″	≤ 100 min^{-1}	∼ 11 μA_{PP}
For separate shaft coupling				
ROD 200		±5″	≤ 10000 min^{-1}	⊓⊔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	Model	Further information
	18000[2)]	**RON 225**	Brochure: *Sealed Angle Encoders*
	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: *Sealed Angle Encoders*
	180000[2)]	**ROD 270**	
	18000	**ROD 280**	
	18000/36000	**ROD 780**	
	36000	**ROD 880**	

RON 285

RON 786

RON 905

ROD 280

ROD 780

Areas of application

Requirements on productivity and machining quality are steadily increasing. The complexity of workpieces and changing operating conditions due to small batch sizes in part manufacturing are likewise increasing. This must be considered in a production machine's conception and mechanical design in order for such machines to work highly efficiently and precisely.

The robust ERM modular magnetic encoders 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,
- 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.

C axis on lathes

Typical requirements
- Various hollow-shaft diameters
- Resistant to contamination
- Simple installation

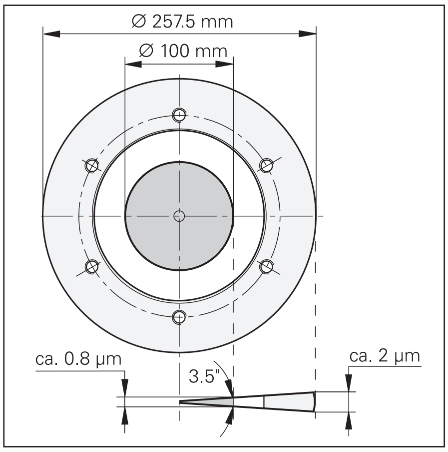
Suitable encoder
- ERM 2400 series
- Possibly the ERM 2200 series

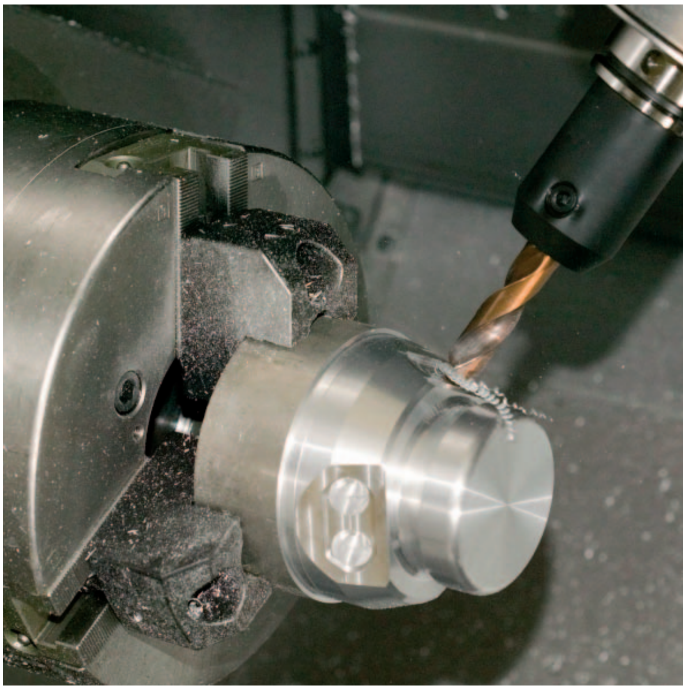
For years, the ERM encoders have been the preferred encoders for C axes on lathes. Besides their high resistance to contamination, the large inside diameters are also important to allow bar material to be machined without limitations.

Because of this design arrangement, the graduation of the ERM is usually on a much larger diameter than the workpiece. Position errors of the encoder therefore affect workpiece accuracy to a correspondingly reduced degree.

For example, on a scale drum with 2048 lines and a diameter of 257.5 mm, the position errors within one signal period are approximately 2 µm. On a workpiece with a diameter of 100 mm this results in a position error of only 0.8 µm. A smaller workpiece diameter will have an even better value.

The accuracy and reproducibility of the ERM encoders therefore also achieve workpiece accuracy values sufficient for milling operations with lathes (classic C-axis machining).





Rotary and tilting axes

Typical requirements
- Medium to high accuracy
- Large hollow-shaft diameters
- Resistant to contamination

Suitable encoder
- ERM 2200 series

Rotary tables and tilting axes require encoders with high signal quality for position and speed control. Encoders with optical measuring standards, for example the RCN series, fulfill these requirements in an ideal way. For medium accuracy requirements, magnetic modular encoders can also be used. Due to their small signal period of 200 µm, the ERM 2200 encoders feature particularly low position error within one signal period and therefore permit relatively high axis speed stability. In addition, the typical advantages of magnetic modular encoders, such as tolerance to contamination and large inside diameters, are very helpful in this application.

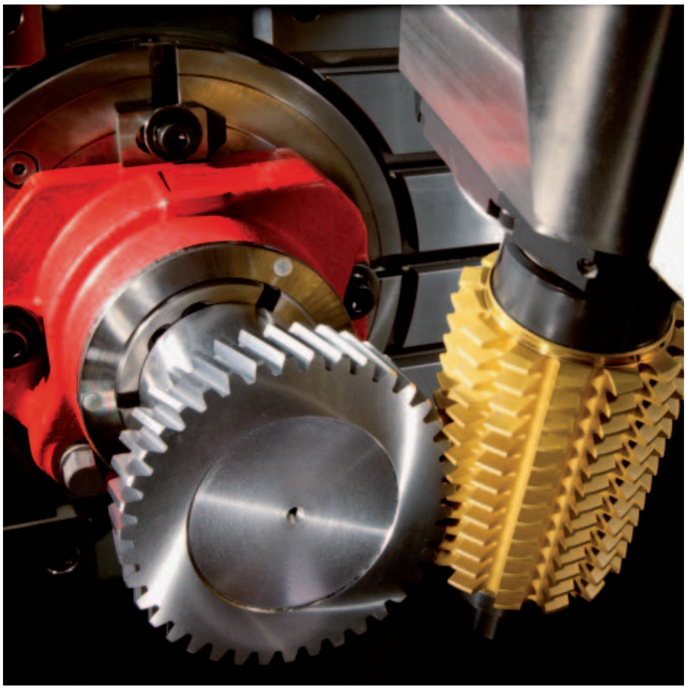
Spindles on milling machines

Typical requirements
- High shaft speeds
- Small mounting space

Suitable encoder
- ERM 2404, ERM 2405 series
- ERM 2904 series

Spindles are among the key components of machine tools and significantly influence their function. Their characteristics are determined by the design, the drive, and the bearing systems. But the encoders being used also make a decisive contribution to performance. They have to permit high rotational speeds and be sufficiently sturdy. Speeds of up to 60 000 rpm are no problem for these encoders. In addition the encoders fulfill the requirement for compact dimensions.

If milling and turning operations are to be performed on one machine, increased requirements for spindle accuracy are the result. Encoders with 400 µm signal period are preferred here.



Properties

The ERM magnetic modular encoders from HEIDENHAIN are characterized by the following properties:

Insensitive to contamination
The encoder in the machine tool is often exposed to heavy loads from cooling lubricants. Particularly with high spindle speeds and large diameters, sealing it becomes very difficult. Here the ERM magnetic modular encoders with their high resistance to contamination are of particular benefit: they can even operate under high humidity, heavy dust loads, and in oily atmospheres.

Large hollow shafts for small installation spaces
ERM encoders are characterized by compact dimensions and large inside diameters of up to 410 mm. Larger diameters are available upon request.

Simple mounting
Mounting the scale drum and scanning head is decidedly simple and requires little adjustment. The scale drum is centered via the centering collar on its inner diameter. The scanning head is easily positioned with respect to the scale drum by means of a spacer shim. If the recommended mounting tolerances are complied with, it is not necessary to inspect the output signals or readjust them.

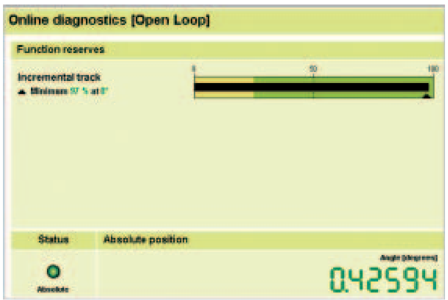
High shaft speeds
The scale drums were specially conceived for high shaft speeds. The maximum permissible speeds shown in the specifications also apply for extreme loads. This allows continuous operation at the maximum permissible speed as well as the more demanding reciprocating traverse. Even reciprocating traverse with ongoing braking and acceleration processes, even with direction reversal, can be performed at the maximum permissible speeds. The reciprocation is based on 10 million load reversals and therefore fulfills the requirements for fatigue strength.

The ERM encoders are completely quiet in operation, even at maximum speeds. Ancillary noises, such as from gear-tooth systems, do not occur.

High signal quality
The output signals of the ERM magnetic modular encoders are characterized by high signal quality: Together with the signal period, signal quality is decisive for position error within one signal period. For the magnetic modular encoders, as well as for many other encoders from HEIDENHAIN, this value is much better than 1 % of the signal period. For the ERM 2200 and ERM 2400 series the position error within one signal period is typically less than 0.5% of the signal period.

Purely serial interface
Besides the incremental output signals, it is possible to transmit the position information as position values over the EnDat 2.2 interface. The sinusoidal scanning signals are highly interpolated in the scanning head and converted to a position value by the integrated counter function. As with all incremental encoders, the absolute reference is established with the aid of reference marks. To speed and simplify the referencing procedure, these encoders have scale drums with distance-coded reference marks.

The EnDat 2.2 interface offers a large number of other benefits besides serial transmission of the position value, such as automatic self-configuration, monitoring and diagnostic functions, and high reliability of data transmission.



Screen showing the valuation numbers as functional reserves (e.g. with ATS software)

ERM scale drums

Measuring principle

Measuring standard
HEIDENHAIN encoders incorporate measuring standards of periodic structures known as graduations.
Magnetic encoders use a graduation carrier of magnetizable steel alloy. A write-head applies strong local magnetic fields in different directions to form a graduation consisting of north poles and south poles (MAGNODUR process).
The following different grating periods are possible on the circumference:

- ≈ 200 µm for the ERM 2200 series
- ≈ 400 µm for the ERM 2400 series
- ≈ 1000 µm for the ERM 2900 series

Due to the short distance of effect of electromagnetic interaction and the very narrow scanning gaps required, finer magnetic graduations have significantly tighter mounting tolerances.

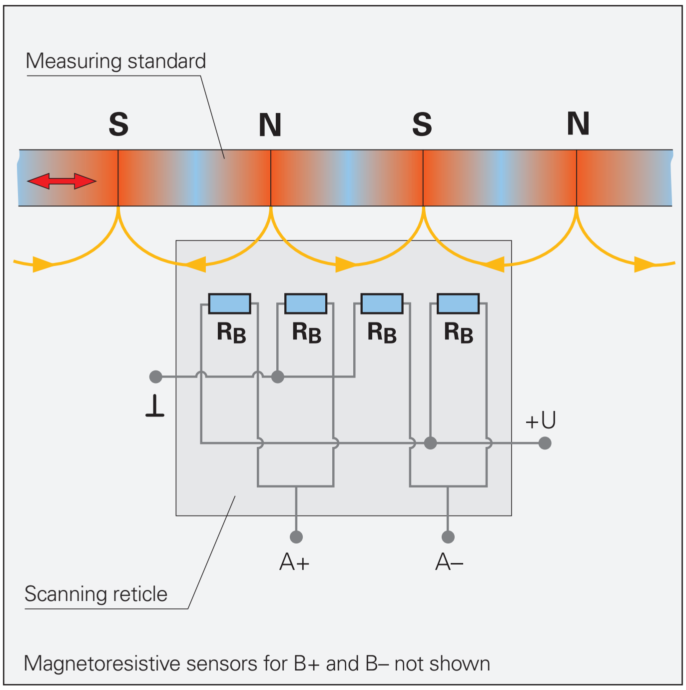
Magnetic scanning
The permanently magnetic MAGNODUR graduation is scanned by magnetoresistive sensors. They consist of resistive tracks whose resistance values change in response to a magnetic field. When a voltage is applied to the sensor and the scale drum moves relative to the scanning head, the flowing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

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

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

Magnetoresistive scanning is typically used for medium-accuracy applications, or for where the diameter of the machined part is relatively small compared to the scale drum.

Magnetoresistive scanning principle



Incremental measuring method
With the incremental measuring method, the graduation consists of a periodic grating structure. The position information is attained **by counting** the individual increments (measuring steps) from some set datum. The shaft speed is determined through mathematical derivation of the change in position over time.

Since an absolute reference is required to ascertain positions, the scale drums are provided with an additional track that bears one **reference mark** or multiple reference marks. The absolute position on the scale, established by the reference mark, is gated with exactly one measuring step. The reference mark must therefore be scanned to establish an absolute reference or to find the last selected datum. For scale drums with distance-coded reference marks, the absolute reference is already established when traversing two neighboring reference marks (see nominal increment *N* in the table).
Scale drums with distance-coded reference marks are identified with a final "C" in the model designation (e.g. TTR ERM 2200 C).

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

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

and

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

Meanings:

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 ($\frac{360°}{\text{Line count}}$)

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

TTR ERM 2200 C

Number of signal periods	Number of reference marks	Nominal increment N
1024	16	45°
1200	24	30°
1440	30	24°
1800	36	20°
2048	32	22.5°
2400	40	18°
2800	50	14.4°
3392	32	22.50°
4096	64	11.25°
5200	52	13.85°
7200	90	8°

TTR ERM 2400 C

Number of signal periods	Number of reference marks	Nominal increment N
512	16	45°
600	20	36°
720	24	30°
900	30	24°
1024	32	22.5°
1200	30	24°
1400	40	18°
1696	32	22.5°
2048	32	22.5°
2600	52	13.85°
3600	60	12°
3850	70	10.3°
4800	80	9°

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 *±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, and
- the stability of the graduation carrier, in order to also ensure accuracy in the mounted condition.

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

Interpolation errors within one signal period

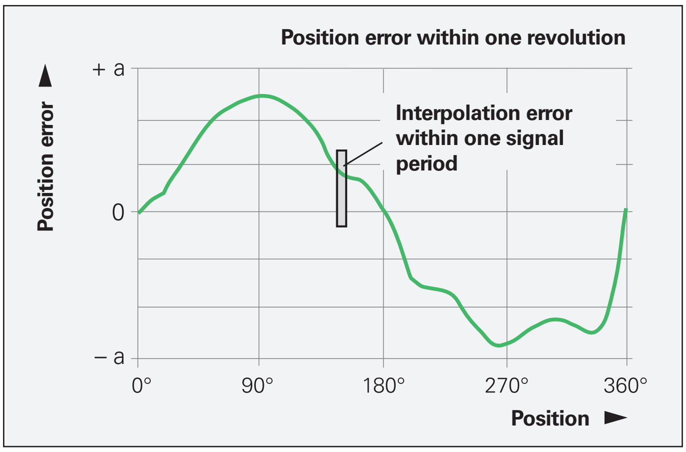
The interpolation errors within one signal period *±u* result from the quality of the scanning and—for encoders with integrated pulse-shaping or counter electronics—the quality of the signal-processing electronics. For encoders with sinusoidal output signals, however, the errors of the signal processing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

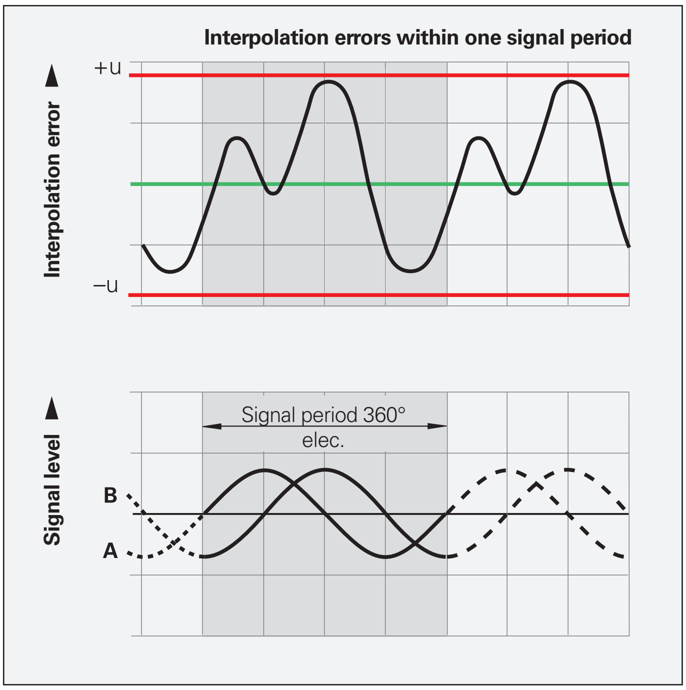
The following individual factors influence the result:
- The size of the signal period
- The homogeneity and period definition of the graduation
- The quality of scanning filter structures
- The characteristics of the sensors
- The stability and dynamics of further processing of the analog signals

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

Interpolation errors within one signal period ± u are specified in percent of the signal period. For the ERM magnetic modular encoders with a signal period of approx. 200 µm or 400 µm, the value is typically better than ±0.5 % of the signal period. 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 the *Angle Encoders with Integral Bearing* brochure).

Errors due to eccentricity of the graduation to the bearing

Under normal circumstances, the graduation will have a certain eccentricity relative to the bearing once the ERM scale drum is mounted. 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 Δφ (see figure below):

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

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

Error due to radial runout of the bearing

The equation for the measuring error Δφ is also valid for radial deviation of the bearing if the value *e* is replaced with the eccentricity value, i.e. half of the radial deviation (half of the displayed value). Bearing compliance to radial shaft loading causes similar errors.

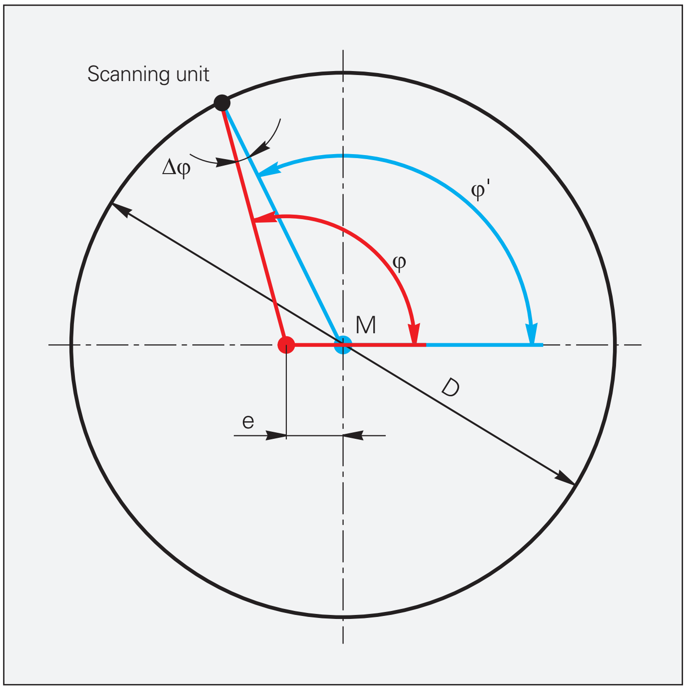
Deformation of the graduation

Errors due to a deformation of the graduation are not to be neglected. It occurs when the graduation is mounted on an uneven, for example convex, surface.

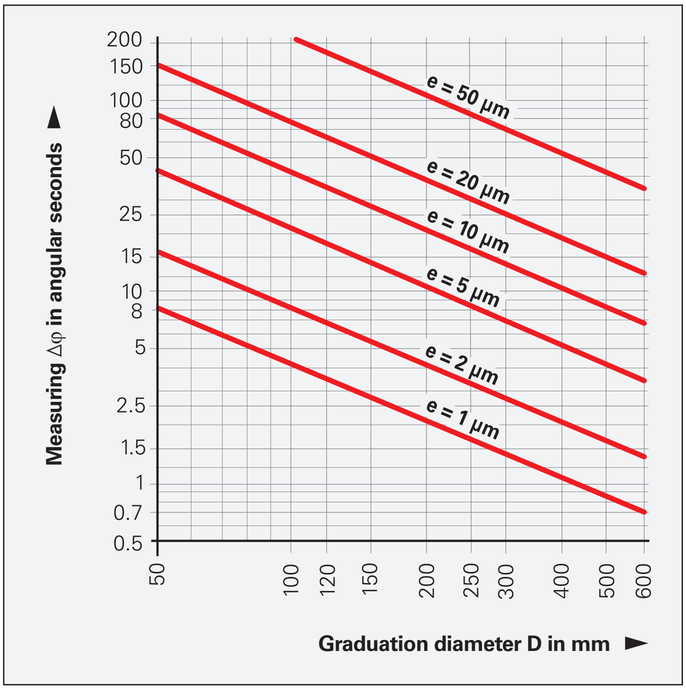
However, the graduation can also be deformed solely by screw tightening torque. The scale drums are particularly rigid in order to prevent this effect.

If there is a change in direction, then hysteresis also has an effect. It depends on the size of the signal period and the mounting conditions. Under ideal mounting conditions it is approx. 0.5 % of the signal period. Deviations of the scanning gap from the nominal value likewise influence the reversal error. HEIDENHAIN therefore recommends measuring the value after mounting for compensation.

Eccentricity of the graduation to the bearing



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



Mechanical design types and mounting

The ERM modular encoders consist of a scale drum and the corresponding scanning head. The position of the scanning head and graduation relative to each other is determined solely via the machine bearing. However, special design features of the ERM modular encoders assure comparably fast mounting and easy adjustment. The values for the graduation accuracy and the interpolation error within one signal period can be attained in the application if the requirements are fulfilled (see the specifications).

Versions
There are various signal periods available for the ERM modular magnetic encoders (ERM 2200: ≈ 200 µm, ERM 2400: ≈ 400 µm, ERM 2900: ≈ 1 mm). This results in different line counts for the same outside diameter.

The scale drums are available in three versions. They differ essentially in the type of mounting. All scale drums feature a centering collar on the inside diameter.

TTR ERM 2200 and TTR ERM 2400 scale drums
For mounting, the scale drums are slid onto the mating shaft and fastened axially with screws.

TTR ERM 2x0x scale drum
The **TTR ERM 2404, TTR ERM 2405,** and **TTR ERM 2904** scale drums are fastened only by a friction-locked connection to the mating surface. The clamping of the scale drum depends on the mounting situation. The clamping force must be applied evenly over the plane surface of the drum. The necessary mounting elements depend on the design of the customer's equipment, and are therefore the responsibility of the customer. The frictional connection must be strong enough to prevent unintentional rotation or skewing in axial and radial directions, even at high speeds and accelerations. The scale drum must not be modified for this purpose, such as by drilling holes or countersinks in it.

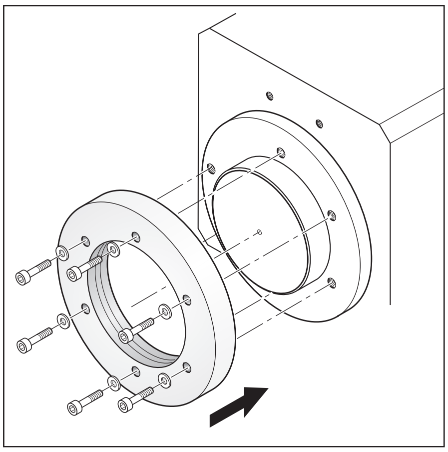
The **TTR ERM 2404** and **TTR ERM 2904** versions feature a smooth inside drum surface. Only a friction-locked connection (clamping of the drum) is to be used to prevent them from rotating unintentionally. The **TTR ERM 2405** scale drums feature a keyway. The feather key is intended only for the prevention of unintentional rotation, and not for the transmission of torque. The special shape of the drum's inside ensures stability even at the maximum permissible speeds.

Designing the mounting elements
The following specifications of the scale drums must be used when designing the mounting elements:

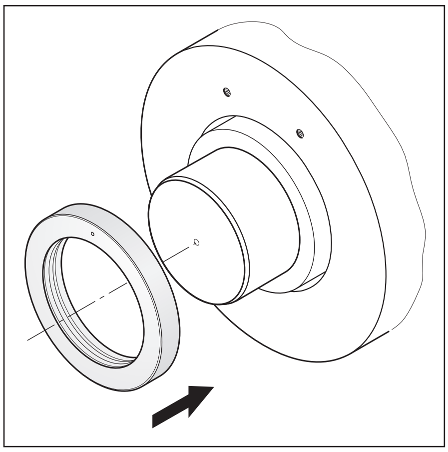
Permissible surface pressure:
$p_{perm} = 100\ \text{N/mm}^2$

Coefficient of thermal expansion:
$\alpha_{therm} = 10 \cdot 10^{-6}\ \text{K}^{-1}$

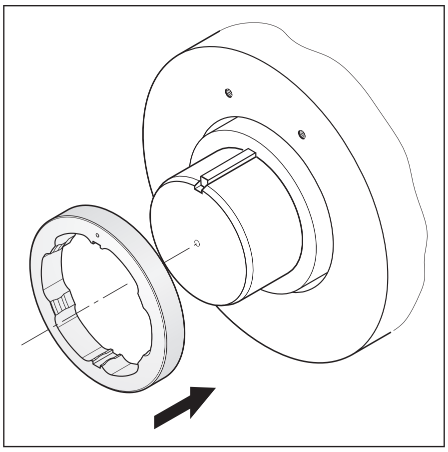
Average surface roughness of the front mating surfaces:
$R_Z \leq 8$ for scale drums with outside diameter < 326.9 mm
$R_Z \leq 16$ for scale drums with outside diameter ≥ 326.9 mm



Mounting of the scale drum
TTR ERM 2400
TTR ERM 2200



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



Mounting of the scale drum
TTR ERM 2405

Centering the scale drum
Because the attainable total accuracy is dominated by mounting error (mainly through eccentricity), special attention must be placed on the centering of the scale drum.

Centering by centering collar
The scale drum is pushed or shrunk onto the shaft. This very simple method requires an exact shaft geometry and bearing quality to meet the corresponding accuracy requirements.

The scale drum is centered via the centering collar on its inner circumference. HEIDENHAIN recommends a slight oversize of the shaft on which the ERM 2x00 scale drum is to be mounted. For easier mounting, the scale drum may be slowly warmed on a heating plate over a period of approx. 10 minutes to a temperature of at most 100 °C. In order to check the radial runout and assess the resulting deviations, testing of the shaft's rotational accuracy before mounting is recommended.

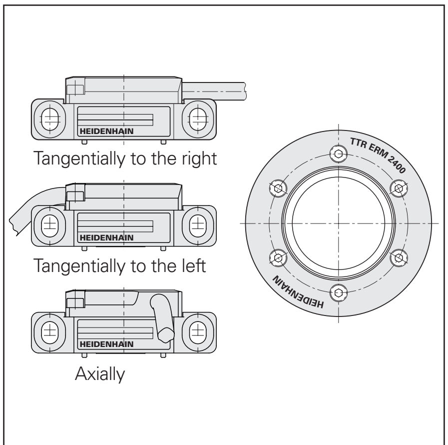
Back-off threads are used for dismounting the scale drums.

Mounting the scanning head
In order to mount the scanning head, the provided spacer shim is applied to the surface of the scale drum. The scanning head is pressed against the shim and fastened by screws, and the shim is removed.

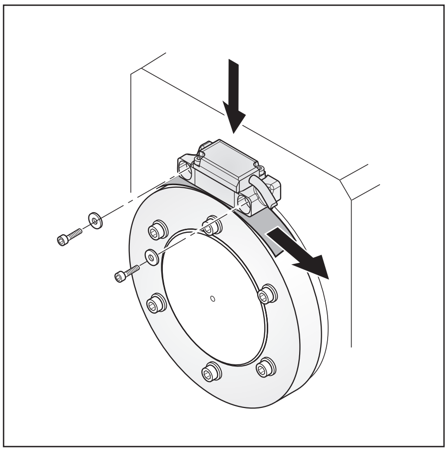
Test film for magnetic graduation
A test film can be used to make the magnetic graduation visible. It enables the user to easily check whether there is any damage to the magnetic graduation, such as demagnetization from a tool. The test film can be "cleaned" with the aid of a demagnetization device and therefore used repeatedly. The test film and demagnetization device are available as accessories.

Mounting clearance
The mounting clearance (gap between scanning head and scale drum) depends on the encoder's signal period. As a result, the spacer shims for mounting the scanning head are of varying thicknesses. Deviations of the scale-to-reticle gap from the ideal value negatively influence the signal amplitude.

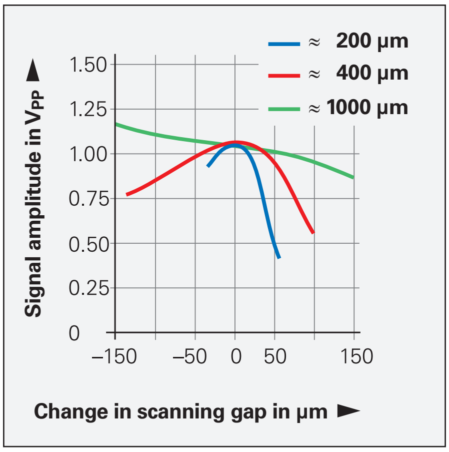
Measuring with two scanning heads
Errors caused by the eccentricity of the graduation to the bearing are compensated with the aid of a second scanning head that is arranged at an angle of 180° ± 5° to the first one. The incremental signals of both scanning heads are digitally offset in an external EIB 1500 interface box with a high subdivision factor and are transmitted as absolute position values after the reference mark is scanned. (See the *EIB 1500* Product Information document).



Possible cable outlets



Mounting the scanning head, e.g. AK ERM 2480



Typical correlation of signal amplitude and scanning gap (mounting clearance)

General mechanical information

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

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

- The indicated maximum values for **vibration** are valid according to EN 60068-2-6
- The maximum permissible acceleration values (semi-sinusoidal shock) for **shock and impact** are valid for 6 ms (EN 60068-2-27)
  Under no circumstances should a hammer or similar implement be used to adjust or position the encoder

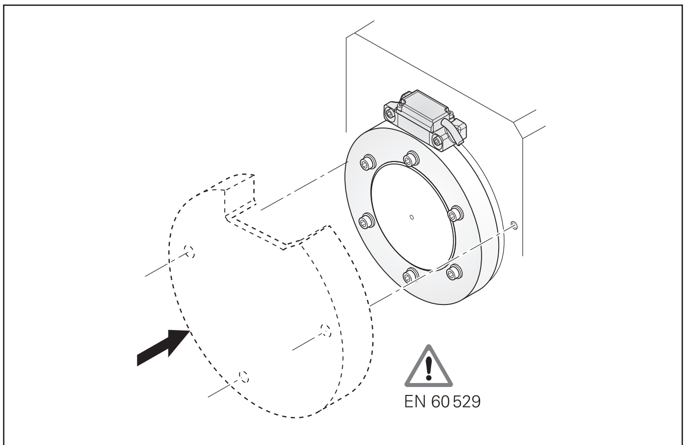
Temperature range
The **operating temperature range** indicates the ambient temperature limits between which the encoders will function properly.
The **storage temperature range** of –30 °C to +70 °C is valid when the unit remains in its packaging.

Shaft speeds
The maximum permissible shaft speeds were determined according to FKM guidelines. This guideline serves as mathematical attestation of component strength with regard to all relevant influences and it reflects the latest state of the art. The requirements for fatigue strength (10^7 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.

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

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

System tests
Encoders from HEIDENHAIN are usually integrated as components in larger systems. Such applications require **comprehensive tests of the entire system** regardless of the specifications of the encoder.
The specifications 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.
In safety-related systems, the encoder's position value must be tested by the higher-level system after switch-on.



Protection against contact

Fault exclusion against loosening of the mechanical connection

In addition to the data interface, the mechanical connection of the encoder to the motor is relevant to safety. The standard for electrical drives, EN 61800-5-2, defines the loss or 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 fault exclusion for the loosening of the mechanical connection is required.

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 ERM 2xx0 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[1]	Restricted characteristic values[2]
Scale drum	Interference fit according to dimension drawing Screw connection:[3] M5 ISO 4762 8.8	±0.025°	• Shock • Maximum angular acceleration • Inside diameter of the drive shaft • Material of drive shaft and stator • Mounting temperature
Scanning head	Screw connection:[3] M4 ISO 4762 8.8		

1) Fault exclusions are given only for the mounting conditions explicitly stated.
2) In comparison to an ERM 2xx0 without fault exclusion
3) Friction coefficient class B as per VDI 2230

Material
The data given in the table for the material of the mating shaft and stator are to be complied with.

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

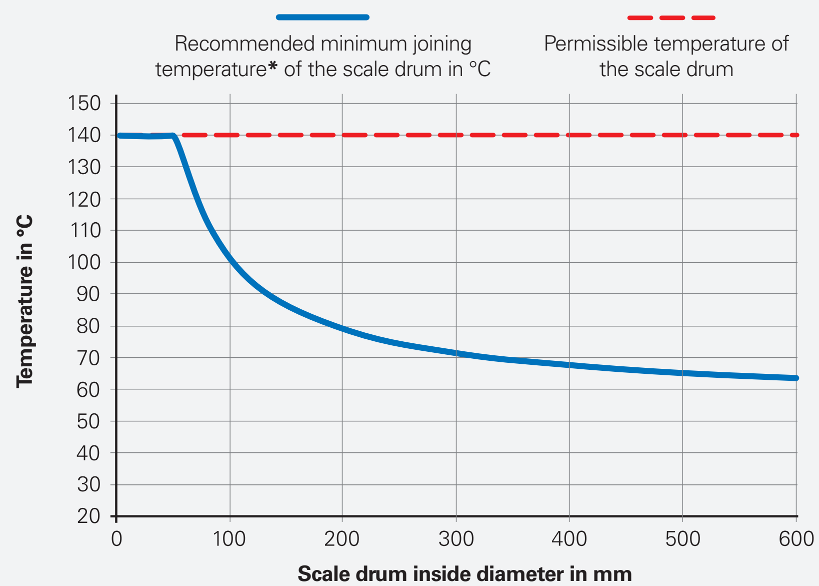
Mounting the scale drum
An oversize of the shaft is required for fault exclusion. The scale drum should preferably be shrunk thermally onto the mating shaft and additionally be fastened with screws. For this purpose, the scale drum must be heated slowly before mounting. Use a heat chamber or a heat plate (but no induction heating sources). The diagram shows the recommended minimum temperatures for the different drum diameters. The maximum temperature should not exceed 140 °C.

During shrink-fitting, make sure that the hole patterns of the scale drum and mating shaft are properly aligned. Appropriate positioning 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 screws used for mounting 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 consecutively until the scale drum comes off the shaft. It is also helpful here to use setscrews inserted into the mating shaft, on which the screws in the back-off threads apply pressure.

Mounting the scanning head
Care must be taken to ensure that the correct scale drum and scanning head are used (correct size and number of signal periods). In order to mount the scanning head, the provided spacer shim is applied to the surface of the circumferential scale drum. The scanning head is pressed against the shim and fastened by screws, and the shim is removed.

	Mating shaft (drum connection)	Mating stator (scanning head connection)
Material	Steel	Steel/cast iron
Tensile strength R_m	≥ 600 N/mm^2	≥ 250 N/mm^2
Shear strength τ_m	≥ 390 N/mm^2	≥ 290 N/mm^2
Elastic modulus E	200 000 N/mm^2 to 215 000 N/mm^2	110 000 N/mm^2 to 215 000 N/mm^2
Coefficient of thermal expansion α_{therm}	$10 \cdot 10^{-6}$ K^{-1} to $13 \cdot 10^{-6}$ K^{-1}	



* The temperature indication refers to an ambient temperature of 20 °C. If the ambient temperature differs, adapt the joining temperature accordingly.

ERM 2200/2400/2900 series

Incremental angle encoder with magnetic scanning
- **Consists of scanning head and scale drum**
- **Various grating periods, corresponding to the accuracy and speed requirements**
- **Different drum shapes for rotary axes and spindles**
- **High variety of drum diameters**

ERM 2200

ERM 2900

Scanning head
Interface
Cutoff frequency (–3dB) Scanning frequency
Integrated interpolation
Clock frequency
Calculation time t_{cal}
Electrical connection
Cable outlet
Power supply
Current consumption (typical)
Power consumption (max.)
Cable length[1]
Vibration 55 Hz to 2000 Hz
Shock 6 ms
Shock 6 ms, with fault exclusion for loosening of the mechanical connection
Operating temperature
Protection EN 60529
Mass Scanning head Connecting cable M23 coupling

	Grating period ≈ 200 µm	Grating period ≈ 400 µm			Grating period ≈ 1000 µm
	AK ERM 2280	**AK ERM 2480**	**AK ERM 2420**	**AK ERM 2410**	**AK ERM 2980**
	$\sim$ 1 V_{PP}	$\sim$ 1 V_{PP}	TTL x 1, TTL x 2	EnDat 2.2[2]	$\sim$ 1 V_{PP}
	≥ 300 kHz –		– ≥ 350 kHz	– –	≥ 300 kHz –
	–			16384 (14 bits)	–
	–			≤ 8 MHz	–
	–			≤ 5 µs	–
	Cable, 1 m, with or without 12-pin M23 coupling			Cable, 1 m, with 8-pin M12 coupling	Cable, 1 m, with or without 12-pin M23 coupling
	Tangentially to the left or right	Tangentially to the left or right, axially		Tangentially to the right	Tangentially to the left or right, axially
	DC 5 V ±0.5 V			DC 3.6 V to 14 V	DC 5 V ±0.5 V
	≤ 150 mA (without load)			At 5 V: ≤ 90 mA (without load)	≤ 150 mA (without load)
				At 3.6 V: 1080 mW; at 14 V: 1300 mW	
	≤ 150 m		≤ 100 m	≤ 150 m	
	≤ 400 m/s² (EN 60068-2-6) ≤ 1000 m/s² (EN 60068-2-27) ≤ 400 m/s² (EN 60068-2-27)			≤ 300 m/s² (EN 60068-2-6) ≤ 1000 m/s² (EN 60068-2-27) ≤ 400 m/s² (EN 60068-2-27)	≤ 400 m/s² (EN 60068-2-6) ≤ 1000 m/s² (EN 60068-2-27) ≤ 400 m/s² (EN 60068-2-27)
	–10 °C to 60 °C	–10 °C to 100 °C			
	IP67				
	≈ 30 g (without connecting cable) ≈ 37 g/m ≈ 50 g				

1) With HEIDENHAIN cable
2) Absolute position value after traverse of two reference marks

Scale drum	TTR ERM 2200 Grating period ≈ 200 µm				
Measuring standard Coefficient of expansion	Steel drum $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$				
Signal periods	1024	1200	1440	1800	2048
Drum inside diameter*	40 mm	40 mm/55 mm	55 mm	70 mm	80 mm/95 mm
Drum outside diameter*	64.37 mm	75.44 mm	90.53 mm	113.16 mm	128.75 mm
Accuracy of graduation	±12″	±10″	±8.5″	±7″	±6″
Interpolation error per signal period	±9″	±8″	±6.5″	±5.5″	±4.5″
Reference mark	One or distance-coded				
Mechanically permissible speed	≤ 22000 rpm	≤ 19000/ 18000 rpm	≤ 18500 rpm	≤ 14500 rpm	≤ 13000/ 12500 rpm
Maximum angular acceleration	50000 rad/s^2	27000 rad/s^2/ 48000 rad/s^2	20000 rad/s^2	9000 rad/s^2	6000 rad/s^2/ 9000 rad/s^2
Moment of inertia	$0.15 \cdot 10^{-3}$ kgm^2	$0.32/0.24 \cdot 10^{-3}$ kgm^2	$0.63 \cdot 10^{-3}$ kgm^2	$1.5 \cdot 10^{-3}$ kgm^2	$2.6/2.1 \cdot 10^{-3}$ kgm^2
Permissible axial movement	≤ ±1.25 mm				
Mass	≈ 0.21 kg	≈ 0.35/0.22 kg	≈ 0.44 kg	≈ 0.69 kg	≈ 0.89/0.65 kg

Scale drum	TTR ERM 2400 Grating period ≈ 400 µm					
Measuring standard Coefficient of expansion	Scale drum $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$					
Signal periods	512	600	720	900	1024	1200
Drum inside diameter*	40 mm	40 mm/55 mm	55 mm	70 mm	80 mm/95 mm	105 mm/120 mm
Drum outside diameter*	64.37 mm	75.44 mm	90.53 mm	113.16 mm	128.75 mm	150.88 mm
Accuracy of graduation	±13″	±11″	±10″	±8″	±7″	±6/8″
Interpolation error per signal period	±18″	±15.5″	±13″	±10.5″	±9″	±8″
Reference mark	One or distance-coded					
Mechanically permissible speed	≤ 22000 rpm	≤ 19000/ 18000 rpm	≤ 18500 rpm	≤ 14500 rpm	≤ 13000/ 12500 rpm	≤ 10500 rpm
Maximum angular acceleration	50000 rad/s^2	27000 rad/s^2/ 48000 rad/s^2	20000 rad/s^2	9000 rad/s^2	6000 rad/s^2/ 9000 rad/s^2	4900 rad/s^2/ 7000 rad/s^2
Moment of inertia	$0.15 \cdot 10^{-3}$ kgm^2	$0.32/0.24 \cdot 10^{-3}$ kgm^2	$0.63 \cdot 10^{-3}$ kgm^2	$1.5 \cdot 10^{-3}$ kgm^2	$2.6/2.1 \cdot 10^{-3}$ kgm^2	$4.4/3.4 \cdot 10^{-3}$ kgm^2
Permissible axial movement	≤ ±1.25 mm					
Mass	≈ 0.21 kg	≈ 0.35/0.22 kg	≈ 0.44 kg	≈ 0.69 kg	≈ 0.89/0.65 kg	≈ 1.0/0.72 kg

* Please select when ordering

2400	2800	3392	4096	5200	7200
105 mm/120 mm	130 mm/140 mm	160 mm	180 mm/220 mm	260 mm/295 mm	380 mm/410 mm
150.88 mm	176.03 mm	213.24 mm	257.50 mm	326.90 mm	452.64 mm
±5.5/7″	±5/6″	±4″	±3.5/4.5″	±3/4″	±2.5/3.5″
±4″	±4″	±3″	±2.5″	±2″	±1.5″
≤ 10500 rpm	≤ 9000/8500 rpm	≤ 7000 rpm	≤ 6000 rpm	≤ 4500 rpm	≤ 3000 rpm
4900 rad/s^2/ 7000 rad/s^2	3300 rad/s^2/ 4400 rad/s^2	1900 rad/s^2	820 rad/s^2/ 1800 rad/s^2	560 rad/s^2/ 1300 rad/s^2	570 rad/s^2/ 960 rad/s^2
4.4/3.4 · 10^{-3} kgm^2	7.4/6.3 · 10^{-3} kgm^2	16 · 10^{-3} kgm^2	37/23 · 10^{-3} kgm^2	76/42 · 10^{-3} kgm^2	240/150 · 10^{-3} kgm^2
≈ 1.0/0.72 kg	≈ 1.2/0.99 kg	≈ 1.8 kg	≈ 3.0/1.6 kg	≈ 3.5/1.7 kg	≈ 5.4/3.2 kg

1400	1696	2048	2600	3600	3850	4800
130 mm/140 mm	160 mm	180 mm/220 mm	260 mm/295 mm	380 mm/410 mm	450 mm	512 mm
176.03 mm	213.24 mm	257.50 mm	326.90 mm	452.64 mm	484.07 mm	603.52 mm
±5.5/7″	±4.5″	±4/5″	±3.5/4″	±3/3.5″	±3.5″	±3″
±6.5″	±5.5″	±4.5″	±3.5″	±3″	±2.5″	±2″
≤ 9000/8500 rpm	≤ 7000 rpm	≤ 6000 rpm	≤ 4500 rpm	≤ 3000 rpm	≤ 3000 rpm	≤ 1600 rpm
3300 rad/s^2/ 4400 rad/s^2	1900 rad/s^2	820 rad/s^2/ 1800 rad/s^2	560 rad/s^2/ 1300 rad/s^2	570 rad/s^2/ 960 rad/s^2	470 rad/s^2	230 rad/s^2
7.4/6.3 · 10^{-3} kgm^2	16 · 10^{-3} kgm^2	37/23 · 10^{-3} kgm^2	76/42 · 10^{-3} kgm^2	235/151 · 10^{-3} kgm^2	153 · 10^{-3} kgm^2	713 · 10^{-3} kgm^2
≈ 1.2/0.99 kg	≈ 1.8 kg	≈ 3.0/1.6 kg	≈ 3.5/1.7 kg	≈ 5.4/3.2 kg	≈ 2.8 kg	≈ 9.1 kg

Scale drum	TTR ERM 2404 Grating period ≈ 400 µm					
Measuring standard Coefficient of expansion	Steel drum $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$					
Signal periods	360	400	512	600	900	1024
Drum inside diameter*	30 mm	30 mm	40 mm/55 mm	55 mm/60 mm	80 mm	100 mm
Drum outside diameter*	45.26 mm	50.29 mm	64.37 mm	75.44 mm	113.16 mm	128.75 mm
Accuracy of graduation	±24″	±21″	±17″	±14″	±10″	±9″
Interpolation error per signal period	±25.5″	±23″	±18″	±15.5″	±10.5″	±9″
Reference mark	One					
Mech. permissible speed	≤ 60000 rpm	≤ 54000 rpm	≤ 42000 rpm ≤ 38000 rpm	≤ 36000 rpm ≤ 30000 rpm	≤ 22000 rpm	≤ 20000 rpm
Moment of inertia	$0.027 \cdot 10^{-3}$ kgm^2	$0.045 \cdot 10^{-3}$ kgm^2	$0.12/0.06 \cdot 10^{-3}$ kgm^2	$0.19/0.16 \cdot 10^{-3}$ kgm^2	$1.0 \cdot 10^{-3}\ kgm^2$	$1.4 \cdot 10^{-3}\ kgm^2$
Permissible axial movement	≤ ±0.5 mm					
Mass	≈ 0.07 kg	≈ 0.10 kg	≈ 0.16 kg/ 0.07 kg	≈ 0.17 kg/ 0.13 kg	≈ 0.42 kg	≈ 0.42 kg

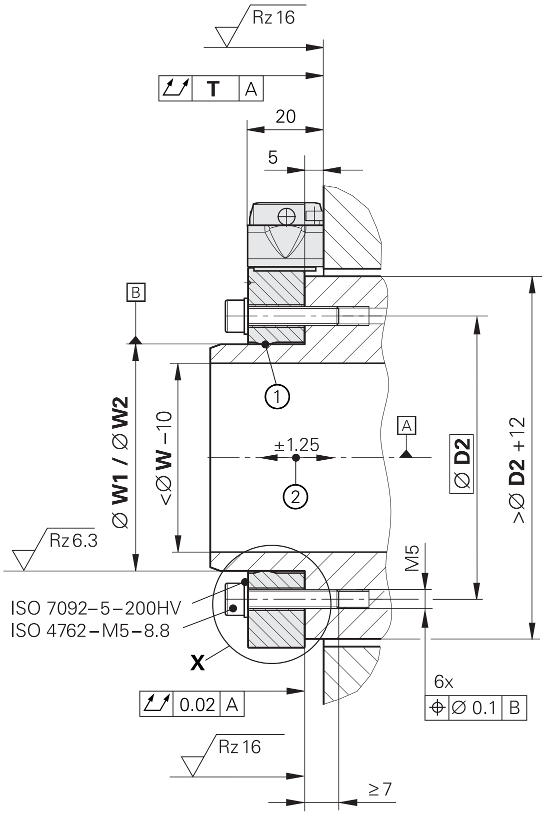
Scale drum	TTR ERM 2904 Grating period ≈ 1000 µm				
Measuring standard Coefficient of expansion	Steel drum $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$				
Signal periods	180	192	256	300	400
Drum inside diameter*	35 mm	40 mm	55 mm	60 mm	100 mm
Drum outside diameter*	54.43 mm	58.06 mm	77.41 mm	90.72 mm	120.96 mm
Accuracy of the graduation	±72″	±68″	±51″	±44″	±33″
Interpolation error per signal period	±72″	±68″	±51″	±44″	±33″
Reference mark	One				
Mech. permissible speed	≤ 50000 rpm	≤ 47000 rpm	≤ 35000 rpm	≤ 29000 rpm	≤ 16000 rpm
Moment of inertia	$0.06 \cdot 10^{-3}\ kgm^2$	$0.07 \cdot 10^{-3}\ kgm^2$	$0.22 \cdot 10^{-3}\ kgm^2$	$0.45 \cdot 10^{-3}\ kgm^2$	$0.93 \cdot 10^{-3}\ kgm^2$
Permissible axial movement	≤ ±0.5 mm				
Mass	≈ 0.11 kg	≈ 0.11 kg	≈ 0.19 kg	≈ 0.30 kg	≈ 0.30 kg

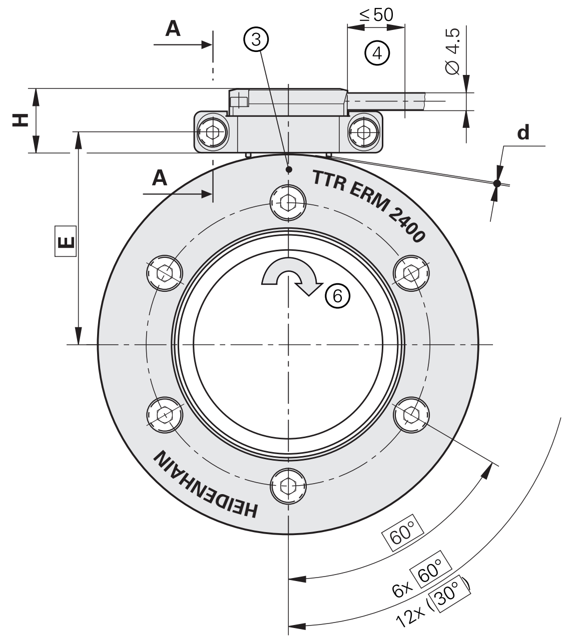
* Please select when ordering

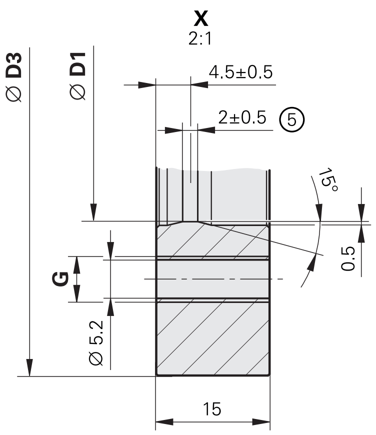
Scale drum	**TTR ERM 2405** Grating period ≈ 400 µm	
Measuring standard Coefficient of expansion	Steel drum $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$	
Signal periods	512	600
Drum inside diameter*	40 mm	55 mm
Drum outside diameter*	64.37 mm	75.44 mm
Accuracy of graduation	±17″	±14″
Interpolation error per signal period	±18″	±15.5″
Reference mark	One	
Mech. permissible speed	≤ 33000 rpm	≤ 27000 rpm
Moment of inertia	$0.11 \cdot 10^{-3}$ kgm^2	$0.16 \cdot 10^{-3}$ kgm^2
Permissible axial movement	≤ ±0.5 mm	
Mass	≈ 0.15 kg	≈ 0.14 kg

***** Please select when ordering

ERM 2200/2400
Dimensions







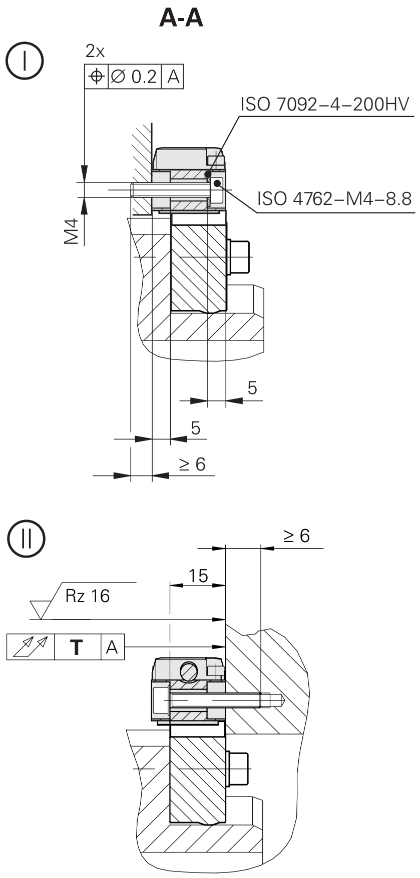
mm

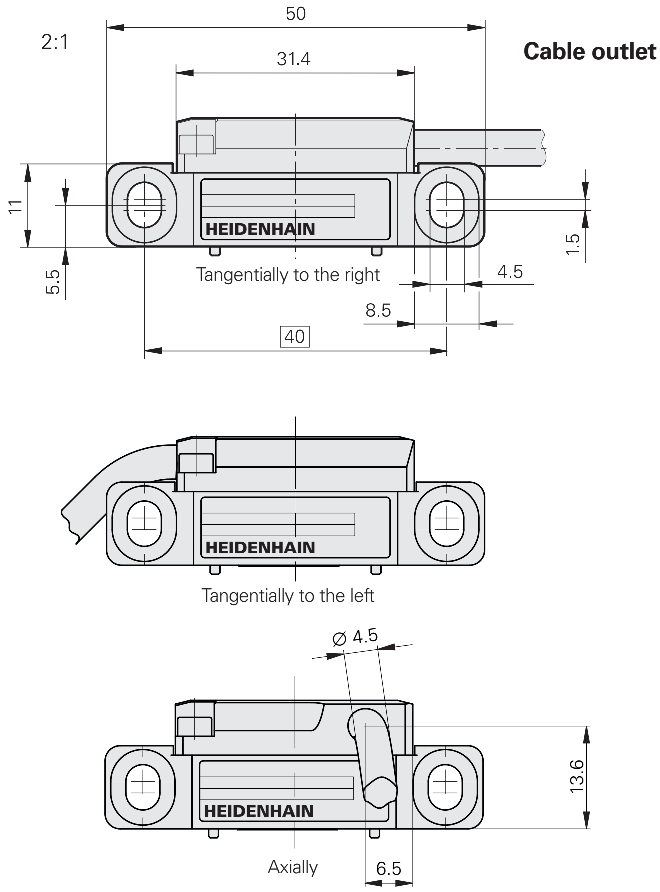
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

W1 = Without mechanical fault exclusion
W2 = With mechanical fault exclusion
Ⓘ, Ⓘⓘ = Mounting possibility for scanning head

A = Bearing of mating shaft
1 = Shaft fit; ensure full-surface contact
2 = Axial tolerance of mating shaft
3 = Reference mark position
4 = Cable support
5 = Centering collar
6 = Direction of rotation for ascending position values

Scanning head	H	T	Mounting clearance **d** (with spacer shim)
AK ERM 2280	17 mm	0.02 mm	0.05 mm
AK ERM 2420/2480	17 mm	0.04 mm	0.15 mm
AK ERM 2410	19.5 mm	0.04 mm	0.15 mm





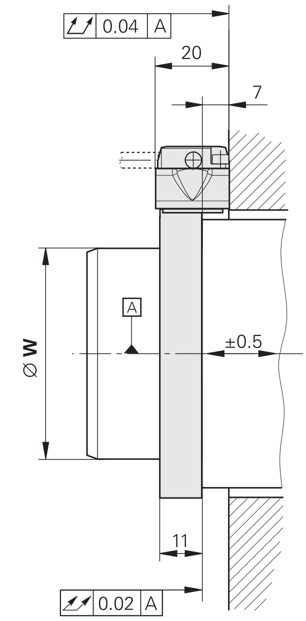
	D1	W1	W2	D2	D3	E	G
TTR ERM 2200 **TTR ERM 2400**	Ø 40 +0/–0.007	Ø 40 +0.009/+0.002	Ø 40 +0.010/+0.003	Ø 50	Ø 64.37	37.9	6x M6
	Ø 40 +0/–0.007	Ø 40 +0.009/+0.002	Ø 40 +0.010/+0.003	Ø 50	Ø 75.44	43.4	6x M6
	Ø 55 +0/–0.008	Ø 55 +0.010/+0.002	Ø 55 +0.015/+0.007	Ø 65	Ø 75.44	43.4	6x M6
	Ø 55 +0/–0.008	Ø 55 +0.010/+0.002	Ø 55 +0.015/+0.007	Ø 70	Ø 90.53	51.0	6x M6
	Ø 70 +0/–0.008	Ø 70 +0.010/+0.002	Ø 70 +0.019/+0.011	Ø 85	Ø 113.16	62.3	6x M6
	Ø 80 +0/–0.008	Ø 80 +0.010/+0.002	Ø 80 +0.022/+0.014	Ø 95	Ø 128.00	70.1	6x M6
	Ø 95 +0/–0.010	Ø 95 +0.013/+0.003	Ø 95 +0.029/+0.019	Ø 110	Ø 128.75	70.1	6x M6
	Ø 105 +0/–0.010	Ø 105 +0.013/+0.003	Ø 105 +0.031/+0.021	Ø 120	Ø 150.88	81.2	6x M6
	Ø 120 +0/–0.010	Ø 120 +0.013/+0.003	Ø 120 +0.036/+0.026	Ø 135	Ø 150.88	81.2	6x M6
	Ø 130 +0/–0.012	Ø 120 +0.015/+0.003	Ø 130 +0.041/+0.029	Ø 145	Ø 176.03	93.7	6x M6
	Ø 140 +0/–0.012	Ø 140 +0.015/+0.003	Ø 140 +0.044/+0.032	Ø 155	Ø 176.03	93.7	6x M6
	Ø 160 +0/–0.012	Ø 160 +0.015/+0.003	Ø 160 +0.049/+0.037	Ø 175	Ø 213.24	112.3	6x M6
	Ø 180 +0/–0.012	Ø 180 +0.015/+0.003	Ø 180 +0.055/+0.043	Ø 195	Ø 257.50	134.5	6x M6
	Ø 220 +0/–0.014	Ø 220 +0.018/+0.004	Ø 220 +0.069/+0.055	Ø 235	Ø 257.50	134.5	6x M6
	Ø 260 +0/–0.016	Ø 260 +0.020/+0.004	Ø 260 +0.082/+0.066	Ø 275	Ø 326.90	169.2	6x M6
	Ø 295 +0/–0.016	Ø 295 +0.020/+0.004	Ø 295 +0.093/+0.077	Ø 310	Ø 326.90	169.2	6x M6
	Ø 380 +0/–0.018	Ø 380 +0.022/+0.005	Ø 380 +0.119/+0.101	Ø 395	Ø 452.64	232.0	12x M6
	Ø 410 +0/–0.020	Ø 410 +0.025/+0.005	Ø 410 +0.130/+0.110	Ø 425	Ø 452.64	232.0	12x M6
	Ø 450 +0/–0.020	Ø 450 +0.025/+0.005	Ø 450 +0.142/+0.122	Ø 465	Ø 484.07	247.7	12x M6
	Ø 512 +0/–0.022	Ø 512 +0.027/+0.005	Ø 512 +0.161/+0.139	Ø 528	Ø 603.52	307.5	12x M6

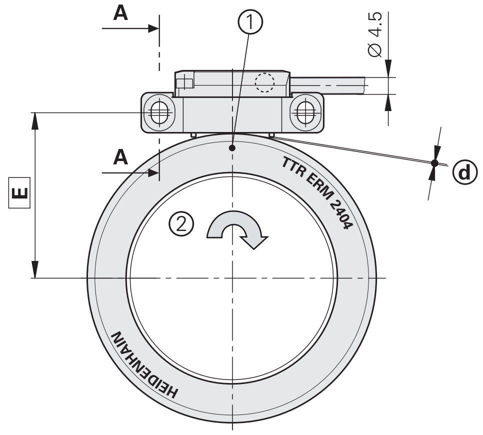
More information:

For CAD data go to *cad.heidenhain.de*

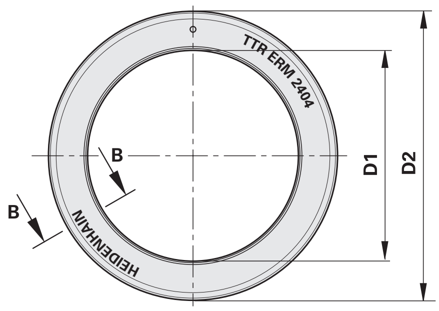
ERM 2404/2405/2904

Dimensions

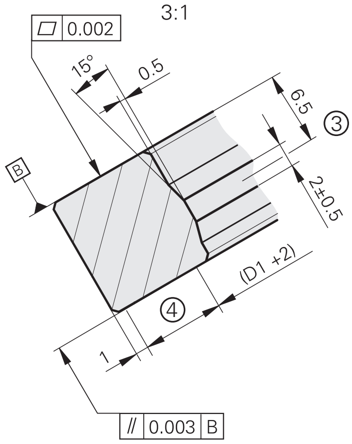




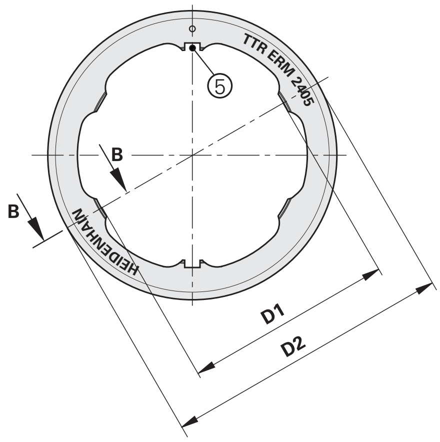
TTR ERM 2404
TTR ERM 2904



B–B
3:1



TTR ERM 2405

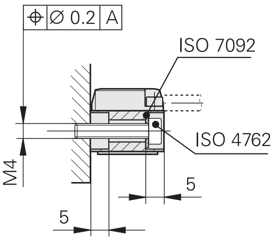


mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

A = Bearing
1 = Marker for reference mark, position tolerance with respect to reference mark ±5°
2 = Direction of rotation for ascending position values
3 = Centering collar
4 = Clamping area (applies to both sides)
5 = Slot for feather key 4 x 4 x 10 (as per DIN 6885 form A)

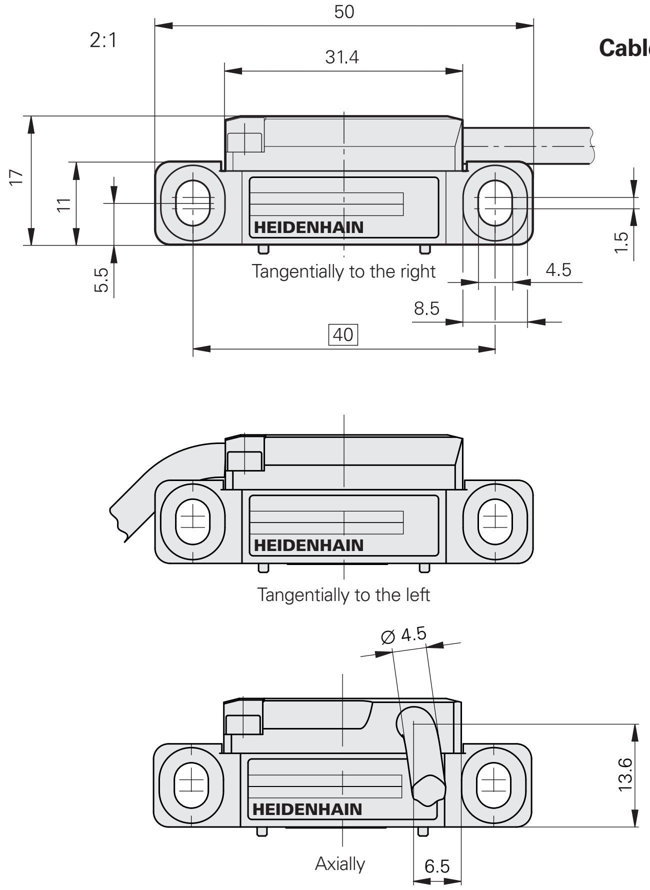
Scanning head	Mounting clearance **d** (with spacer shim)
AK ERM 2480	0.15 mm
AK ERM 2980	0.30 mm

A-A



AK ERM 2480

Cable outlet



	D1	W1	D2	E
TTR ERM 2404 **TTR ERM 2405**	Ø 30 +0.010/+0.002	Ø 30 +0/–0.006	Ø 45.26	28.3
	Ø 30 +0.010/+0.002	Ø 30 +0/–0.006	Ø 50.29	30.9
	Ø 40 +0.010/+0.002	Ø 40 +0/–0.006	Ø 64.37	37.9
	Ø 55 +0.010/+0.002	Ø 55 +0/–0.006	Ø 64.37	37.9
	Ø 55 +0.010/+0.002	Ø 55 +0/–0.006	Ø 75.44	43.4
	Ø 60 +0.010/+0.002	Ø 60 +0/–0.006	Ø 75.44	43.4
	Ø 80 +0.010/+0.002	Ø 80 +0/–0.006	Ø 113.16	62.3
	Ø 100 +0.010/+0.002	Ø 100 +0/–0.006	Ø 128.75	70.0
TTR ERM 2904	Ø 35 +0.010/+0.002	Ø 35 +0/–0.006	Ø 54.43	32.9
	Ø 40 +0.010/+0.002	Ø 40 +0/–0.006	Ø 58.06	34.7
	Ø 55 +0.010/+0.002	Ø 55 +0/–0.006	Ø 77.41	44.4
	Ø 60 +0.010/+0.002	Ø 60 +0/–0.006	Ø 90.72	51.1
	Ø 100 +0.010/+0.002	Ø 100 +0/–0.006	Ø 120.96	66.2

More information:

For CAD data go to *cad.heidenhain.de*

Interfaces

∿ 1 VPP incremental signals

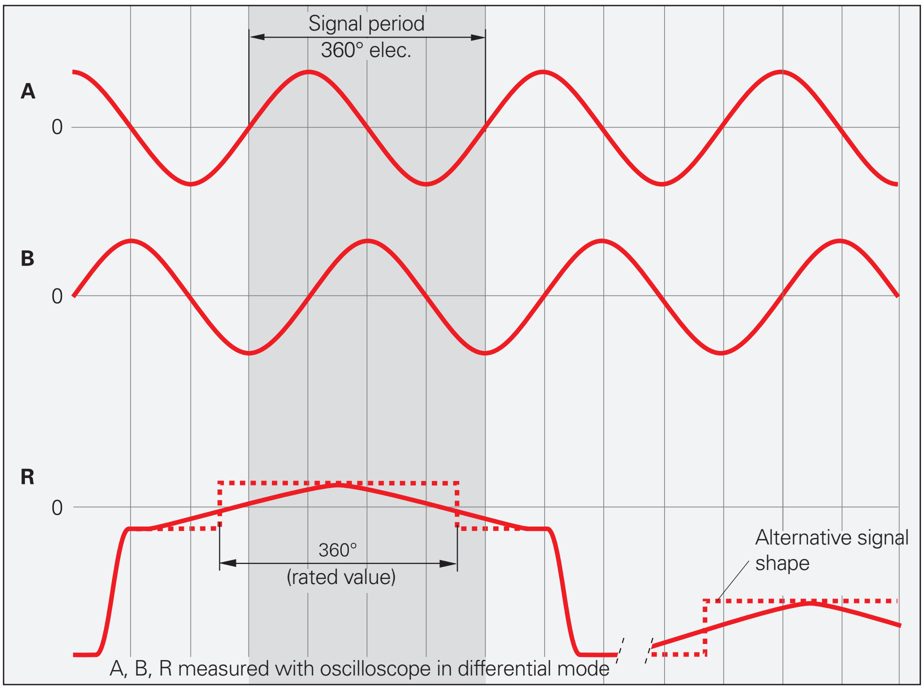
HEIDENHAIN encoders with ∿ 1 VPP interface provide highly interpolable voltage signals.

The sinusoidal **incremental signals** A and B are phase-shifted by 90° elec. and have typical amplitudes of 1 VPP 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.

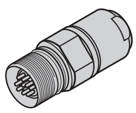
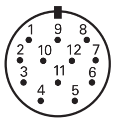
More information:

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

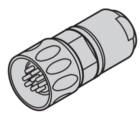
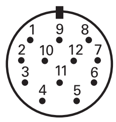


Pin layout

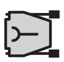
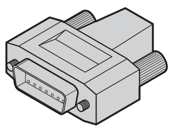
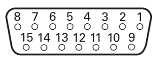
12-pin M23 coupling

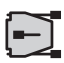
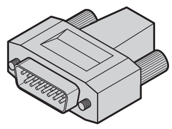
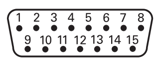
12-pin M23 connector

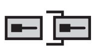
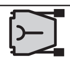
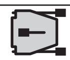




15-pin D-sub connector
For HEIDENHAIN controls and IK 220

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

	Power supply				Incremental signals						Other signals		
	12	2	10	11	5	6	8	1	3	4	9	7	/
	1	9	2	11	3	4	6	7	10	12	5/8/13/15	14	/
	4	12	2	10	1	9	3	11	14	7	5/6/8/15	13	/
	UP	**Sensor** UP	**0 V**	**Sensor** 0 V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**Vacant**	**Vacant**	**Vacant**
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	/	Violet	Yellow

Cable shield connected to housing; UP = 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!

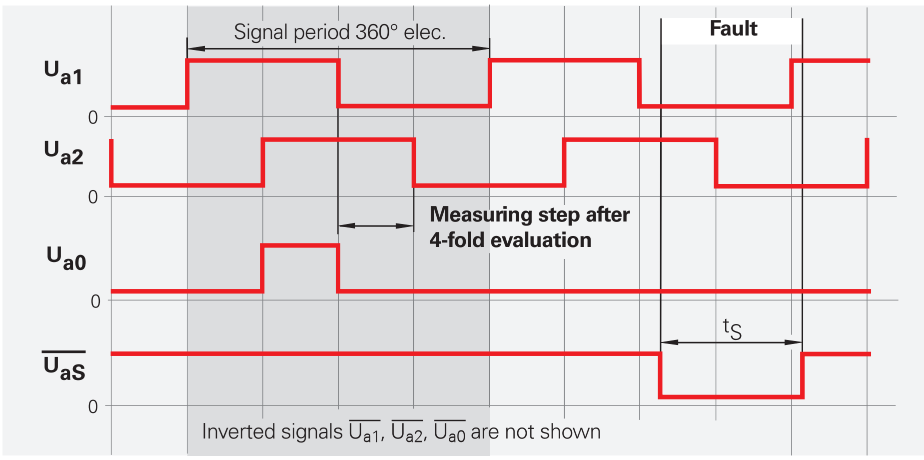
Incremental signals ⊓⊔TTL

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.

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

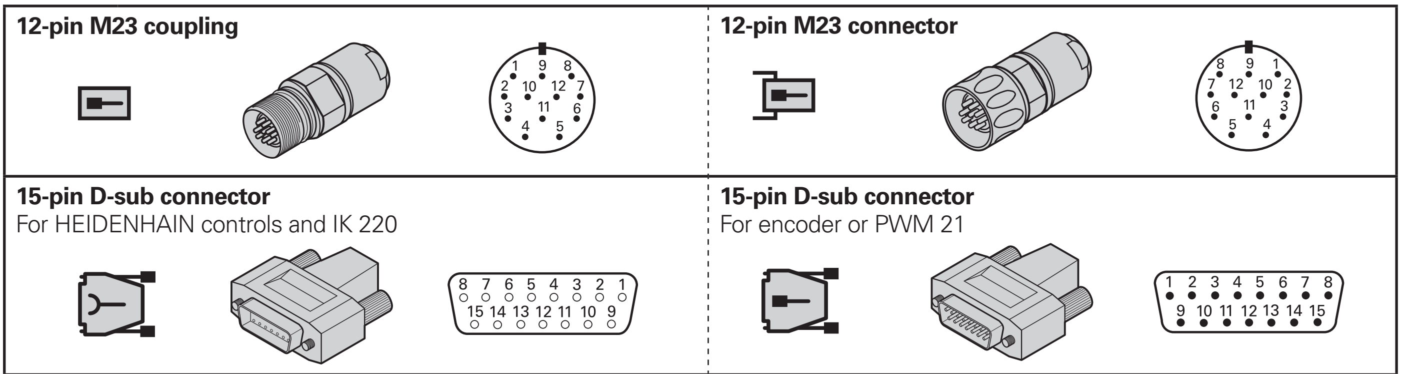
The distance between two successive edges of the incremental signals U_{a1} and U_{a2} through 1-fold, 2-fold or 4-fold evaluation is one **measuring step.**



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



	Power supply				Incremental signals						Other signals		
	12	2	10	11	5	6	8	1	3	4	7	/	9
	1	9	2	11	3	4	6	7	10	12	14	8/13/15	5
	4	12	2	10	1	9	3	11	14	7	13	5/6/8	15
	U_P	Sensor U_P	0 V	Sensor 0 V	U_{a1}	$\overline{U_{a1}}$	U_{a2}	$\overline{U_{a2}}$	U_{a0}	$\overline{U_{a0}}$	$\overline{U_{aS}}$	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 sense line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!

Interfaces
Position values EnDat

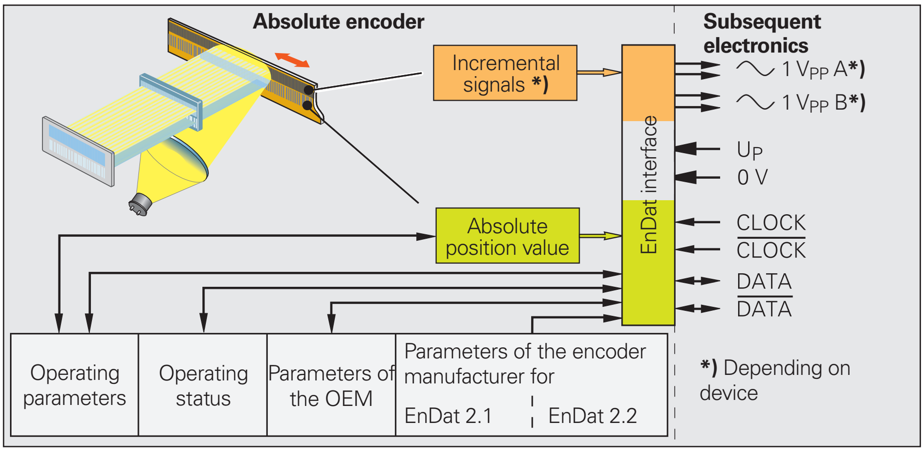
The EnDat interface is a digital, **bidirectional** interface for encoders. It is capable of transmitting **position values,** reading and updating information stored in the encoder, and storing new information. Thanks to the **serial transmission method,** only **four signal lines** are required. The 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.

More information:

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

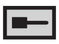
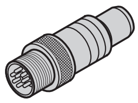
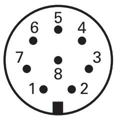
Ordering designation	Command set	Incremental signals
EnDat01	EnDat 2.1 or EnDat 2.2	With
EnDat21		Without
EnDat02	EnDat 2.2	With
EnDat22	EnDat 2.2	Without

Versions of the EnDat interface



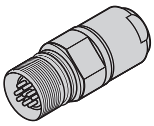
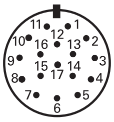
Pin layout

8-pin M12 coupling

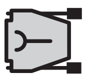
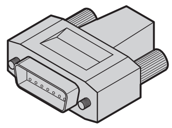
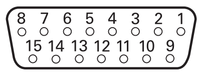




	Power supply				Absolute position values			
	8	**2**	**5**	**1**	**3**	**4**	**7**	**6**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

17-pin M23 coupling

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

	Power supply					Incremental signals[1]				Absolute position values			
	7	**1**	**10**	**4**	**11**	**15**	**16**	**12**	**13**	**14**	**17**	**8**	**9**
	1	**9**	**2**	**11**	**13**	**3**	**4**	**6**	**7**	**5**	**8**	**14**	**15**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Internal shield**	**A+**	**A–**	**B+**	**B–**	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
	Brown/ Green	Blue	White/ Green	White	/	Green/ Black	Yellow/ Black	Blue/ Black	Red/ Black	Gray	Pink	Violet	Yellow

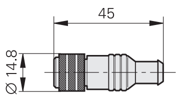
Cable shield connected to housing; **U_P** = Power supply voltage
Sensor: The sense line is connected in the encoder to the respective the power supply line.
Vacant pins or wires must not be used!
[1] Only with ordering designations EnDat01 and EnDat02

Connecting elements and cables
General information

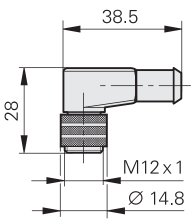
Connector (insulated): A connecting element with a coupling ring. Available with male or female contacts.

Symbols 

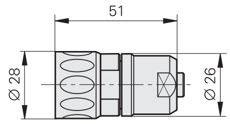
M12



M12 right-angle connector

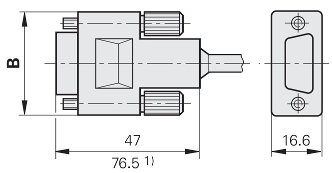


M23



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

Symbols 

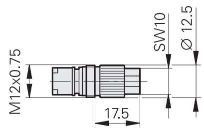


1) With integrated interpolation electronics

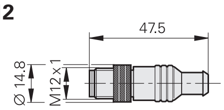
Coupling (insulated):
Connecting element with external thread. Available with male or female contacts.

Symbols 

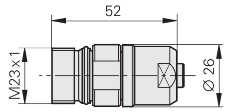
On the adapter cable



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.

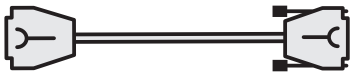
Maximum cable lengths
The maximum achievable cable length is influenced by the supply voltage of the subsequent electronics, the cables used, and the interface. However, commonly used overall lengths of 30 m are usually possible without restrictions.

Accessories for flange sockets and M23 mounted couplings

Threaded metal dust cap
ID 219926-01

Accessory for M12 connecting element
Insulation spacer
ID 596495-01

1 V_{PP} connecting cables

		12-pin M23	
PUR connecting cable	6 × (2 × 0.19 mm²); A_P = 0.19 mm²		
PUR connecting cable	4 × (2 × 0.14 mm²) + (4 × 0.5 mm²); A_P = 0.5 mm²	Ø 8 mm	Ø 6 mm[1)]
Complete with connector (female) and coupling (male)		298401-xx	–
Complete with connector (female) and connector (male)		298399-xx	–
Complete with connector (female) and D-sub connector (female) for IK 220/ND 780		310199-xx	–
Complete with connector (female) and D-sub connector (male), for IK 115/IK 215/ND 280/ND 287/EIB 741		310196-xx	–
With one connector (female)		309777-xx	–
Complete with D-sub connector (female) and M23 connector (male)		331693-xx	355215-xx
With one D-sub connector (female)		332433-xx	355209-xx
Complete with D-sub connector (female) and D-sub connector (male)		335074-xx	355186-xx
Complete with D-sub connector (female) and D-sub connector (female) Assignment 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) mm²; A_P = 0.14 mm²	Ø 4.5 mm	
With one 12-pin PCB connector	Length 1 m 	372164-01	

1) Cable length for Ø 6 mm: max. 9 m
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	∅ 6 mm	∅ 3.7 mm[1)]
Complete with 8-pin M12 connector (female) and 8-pin M12 coupling (male)		1036372-xx	1118858-xx
Complete with 8-pin M12 right-angle connector (female) and 8-pin M12 coupling (male)		1036386-xx	1118863-xx
Complete with 8-pin M12 connector (female) and 15-pin D-sub connector (male), for PWM 20, EIB 74x, etc.		1036526-xx	1118865-xx
Complete with 8-pin M12 right-angle connector (female) and 15-pin D-sub connector (male), for PWM 20, EIB 74x, etc.		1133855-xx	1118867-xx
With one 8-pin M12 connector (female)		1129581-xx	–
With one 8-pin M12 right-angle connector (female)		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	$4 \times (2 \times 0.09\ mm^2)$; $A_P = 0.09\ mm^2$		
PUR connecting cable	$(4 \times 0.14\ mm^2) + (4 \times 0.34\ mm^2)$; $A_P = 0.34\ mm^2$	Ø 6 mm	Ø 3.7 mm[1)]
Complete with 8-pin M12 connector (female) and 8-pin M12 coupling (male)		1036372-xx	1118858-xx
Complete with 8-pin M12 right-angle connector (female) and 8-pin M12 coupling (male)		1036386-xx	1118863-xx
Complete with 8-pin M12 connector (female) and Fanuc connector (female)		1130952-xx	–
With one 8-pin M12 connector (female)		1129581-xx	–
With one 8-pin M12 right-angle connector (female)		1133799-xx	–

[1)] Max. total cable length 6 m
A_P: Cross section of power supply lines

Mitsubishi

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

[1)] Max. total cable length 6 m
A_P: Cross section of power supply lines

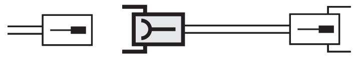
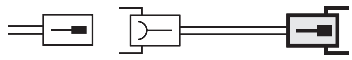
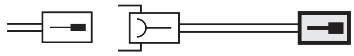
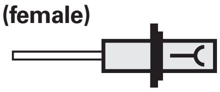
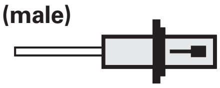
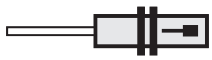
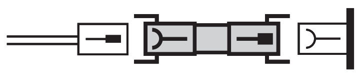
Panasonic connecting cables

Panasonic

PUR connecting cable	$4 \times (2 \times 0.09\ mm^2)$; $A_P = 0.09\ mm^2$		
PUR connecting cable	$(4 \times 0.14\ mm^2) + (4 \times 0.34\ mm^2)$; $A_P = 0.34\ mm^2$	Ø 6 mm	Ø 3.7 mm[1]
Complete with 8-pin M12 connector (female) and 8-pin M12 coupling (male)		1036372-xx	1118858-xx
Complete with 8-pin M12 right-angle connector (female) and 8-pin M12 coupling (male)		1036386-xx	1118863-xx
Complete with 8-pin M12 connector (female) and Fanuc connector (female)		1160268-xx	–
With one 8-pin M12 connector (female)		1129581-xx	–
With one 8-pin M12 right-angle connector (female)		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 ∼ 1 V_{PP}/11 μA_{PP} For converting the 1 V_{PP} signals to 11 μA_{PP}; 12-pin M23 connector (female) and 9-pin M23 connector (male)				364914-01

Diagnostic and testing equipment

HEIDENHAIN encoders provide all information necessary 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 primarily 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 testing devices or through computation in the subsequent electronics **(analog diagnostics interface).**

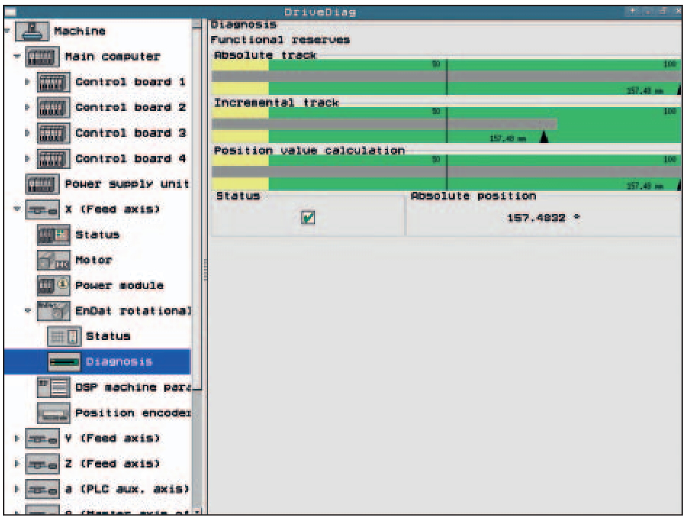
Absolute encoders operate with serial data transfer. Depending on the interface, additional 1 V_{PP} incremental signals can be output. The signals are monitored comprehensively within the encoder. The monitoring result (specifically in the case of valuation numbers) can be transmitted along with the position values to the subsequent electronics over the serial interface **(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

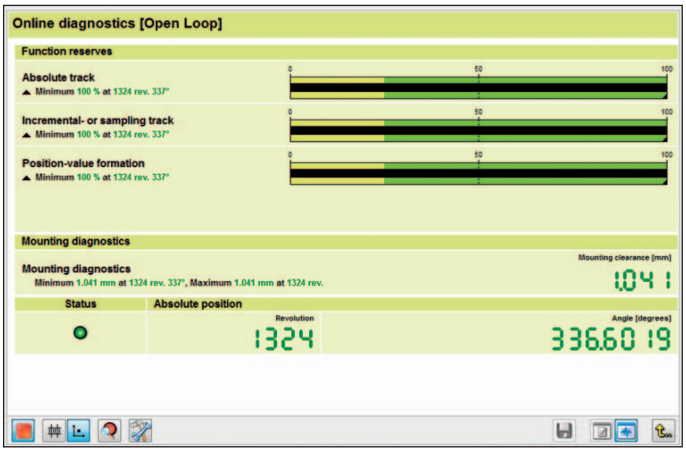
This enables the subsequent electronics to evaluate the current status of the encoder with little effort, even in closed-loop mode.

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

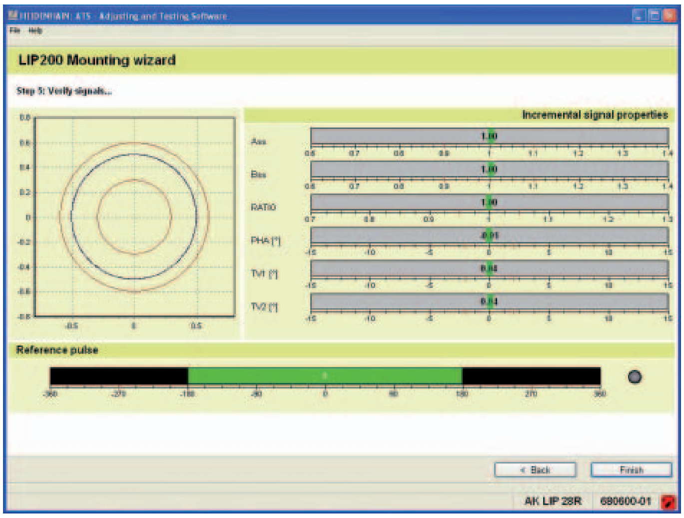
- Encoder diagnostics: The encoder is connected directly to the testing or inspection device. This makes a comprehensive analysis of encoder functions possible.
- Diagnostics in the control loop: The PWM phase meter is looped into the closed control loop (e.g., through a suitable testing adapter). This enables real-time diagnosis of the machine or system 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 21 and ATS software



Commissioning using PWM 21 and ATS software

PWM 21
HEIDENHAIN offers an adjusting and testing package for diagnostics and adjustment of HEIDENHAIN encoders with absolute and incremental interfaces. It consists of the PWM 21 phase angle measuring unit and the ATS adjusting and testing software included in delivery.

	PWM 21
Encoder input	• 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 • Panasonic serial interface • SSI • 1 V_{PP}/TTL/11 μA_{PP} • HTL (via signal adapter)
Interface	USB 2.0
Power supply	AC 100 V to 240 V or DC 24
Dimensions	258 mm × 154 mm × 55 mm

	ATS
Languages	Choice between English and German
Functions	• 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 or recommendations	PC (dual-core processor > 2 GHz) RAM > 2 GB Operating system: Windows XP, Vista, 7 (32-bit/64-bit), 8 200 MB free space on hard disk

DRIVE-CLiQ is a registered trademark of Siemens Aktiengesellschaft

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

	PWT 100
Encoder input Only for HEIDENHAIN encoders	• 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)
Power supply	DC 24 V Power consumption: max. 15 W
Operating temperature	0 °C to 40 °C
Degree of protection EN 60529	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	∿ 1 V_{PP} (signals are connected through)
Design	Cable version with D-sub connector
Function	Switch-off of the signal-error compensation integrated in the scanning head
Power 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 when 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 μA_{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

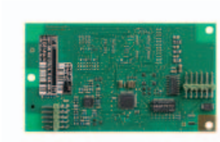
Interpolation of the sinusoidal input signals
In addition to signal conversion, the sinusoidal encoder signals are also interpolated in the interface electronics. This permits finer measuring steps and, as a result, higher control quality and better positioning behavior.

Generation of a position value
Some interface electronics have an integrated counting function. Starting from the last set reference point, an absolute position value is generated when the reference mark is traversed, and it is output 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	Model
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 660 B**
				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	5/10-fold	**EXE 101**
					20/25/50/100-fold	**EXE 102**
					Without/5-fold	**EXE 602 E**
					25/50/100/200/400-fold	**EXE 660 B**
				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[3]	1	Box design – IP65	–	**EIB 2391 S**
Fanuc Serial Interface	1	∼ 1 V_{PP}	1	Box design – IP65	≤ 16384-fold subdivision	**EIB 192 F**
				Plug design – IP40	≤ 16384-fold subdivision	**EIB 392 F**
			2	Box design – IP65	≤ 16384-fold subdivision	**EIB 1592 F**
Mitsubishi High Speed Interface	1	∼ 1 V_{PP}	1	Box design – IP65	≤ 16384-fold subdivision	**EIB 192 M**
				Plug design – IP40	≤ 16384-fold subdivision	**EIB 392 M**
			2	Box design – IP65	≤ 16384-fold subdivision	**EIB 1592 M**
Yaskawa Serial Interface	1	EnDat 2.2[2]	1	Plug design – IP40	–	**EIB 3391 Y**
PROFIBUS DP	1	EnDat 2.1; EnDat 2.2	1	Top-hat rail design	–	**PROFIBUS Gateway**

[1] Switchable
[2] Only for LIC 4100 with 5 nm measuring step, or LIC 2100 with 50 nm or 100 nm measuring steps
[3] Cannot be used for the ERM 2410 series

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