HEIDENHAIN

Modular Magnetic Encoders

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 optimized scanning
- 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

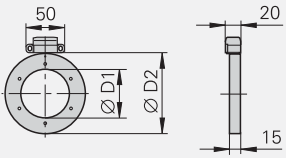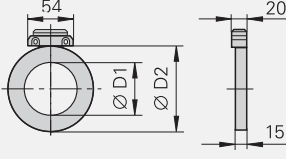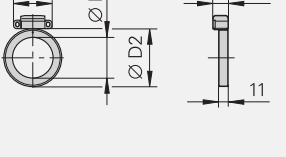is available on request as well as on the Internet at www.heidenhain.de.

Contents

Selection guide

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

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

Mechanically permissible speed	Mounting the scale drum	Interface	Model	Page
14 500 min^{-1} to 3000 min^{-1}	Fastening by axial screws	⌁ 1 V_{PP}	**ERM 2280**	16
19 000 min^{-1} to 3000 min^{-1}	Fastening by axial screws	⎍ TTL	**ERM 220**	18
		⌁ 1 V_{PP}	**ERM 280**	
19 000 min^{-1} to 3000 min^{-1}	Fastening by axial screws	EnDat 2.2/22[1]	**ERM 2410**	20
42 000 min^{-1} to 20 000 min^{-1}	Friction-locked fastening by clamping the drum	⌁ 1 V_{PP}	**ERM 2484**	22
33 000 min^{-1}; 27 000 min^{-1}	Friction-locked fastening by clamping the drum; additional slot for feather key as anti-rotation element	⌁ 1 V_{PP}	**ERM 2485**	
47 000 min^{-1} to 16 000 min^{-1}	Friction-locked fastening by clamping the drum	⌁ 1 V_{PP}	**ERM 2984**	24

ERM 2200
ERM 2410

ERM 200

ERM 2400

ERM 2900

Applications

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. Their large inside diameters offered, their small dimensions and the compact design of the scanning head predestine them for

- the C axis of lathes,
- rotary and tilting axes (e.g. for speed measurement on direct drives or for integration in gear stages), and
- 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 200 series
- Possibly the ERM 2200 series

For years, the ERMs 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, the position error within one signal period, which is approx. 2 μm on a scale drum with 2048 lines and a diameter of 257.5 mm, engenders positioning error of only 0.8 μm on a workpiece with diameter 100 mm. A smaller workpiece diameter will have an even better value.

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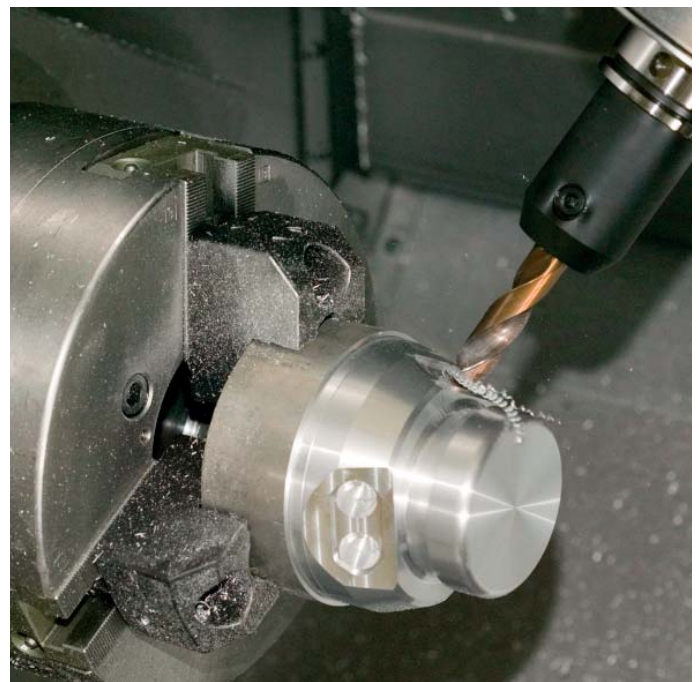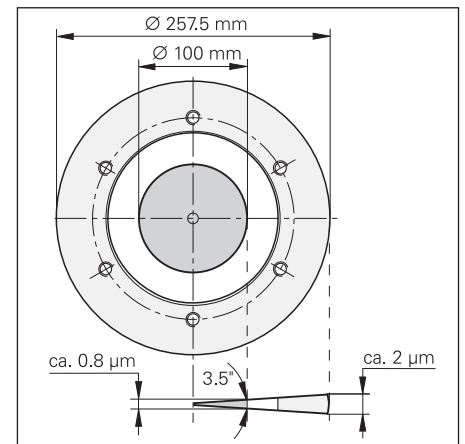
Rotary and tilting tables

Typical requirements:
- Medium to high accuracy
- Large hollow-shaft diameter
- 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 2400 series
- ERM 2900 series

Spindles are among the key components of machine tools and significantly influence their function. The spindle properties are determined by design, drives and bearing systems, but also the encoders make a decisive contribution to performance. They have to permit high rotational speeds and be sufficiently sturdy. Speeds of over 40000 rpm are no problem for the ERM 2900. In addition they 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. On complex workpieces, certain machining movements can be performed only through the interaction of feed axes and spindle positions. For example, when manufacturing a thread, a single-point tool needs to assume a defined angular attitude. Here the ERM 2400 encoders with 400 µm signal period come into use. They have better accuracy behavior and, for example, 600 lines on an outside diameter of 75.44 mm. This is significantly more than gears with comparable dimensions.
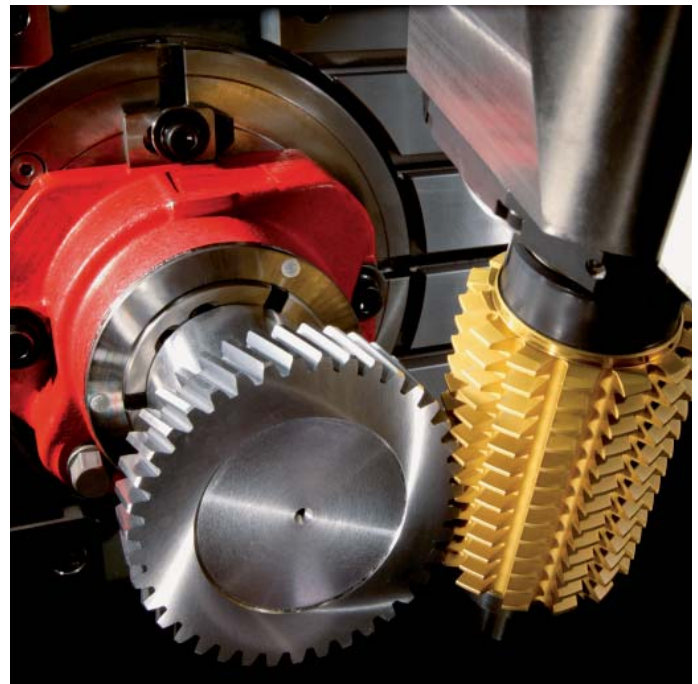
Properties

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 in small installation space
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 circumference. The scanning head is easily positioned with respect to the scale drum by means of a spacer foil. 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 is 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. With the magnetic modular encoders, as with many other HEIDENHAIN encoders, this value is significantly better than 1% of the signal period. For the ERM 2200 and ERM 200 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 determined with the aid of reference marks. A scale drum with distance-coded reference marks is required on these encoders in order to facilitate "homing" the encoder.

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 grating periods are possible on the circumference:
- Approx. 200 µm for ERM 2200
- Approx. 400 µm for ERM 200, ERM 2400, ERM 2410
- Approx. 1000 µm for ERM 2900

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

Magnetic scanning

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

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

A 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.

Incremental measuring method

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

Since an absolute reference is required to ascertain positions, the scale drums are provided with an additional track that bears a **reference mark** or multiple reference marks. The absolute position on the scale, established by the reference mark, is gated with exactly one measuring step. The reference mark must therefore be scanned to establish an absolute reference or to find the last selected datum. The scale drums of the ERM 2200 and ERM 2410 feature distance-coded reference marks. Here the absolute reference is established by scanning two neighboring reference marks (see *Angle for absolute reference* in the Specifications).

Magnetoresistive scanning principle

Magnetoresistive sensors for B+ and B− not shown
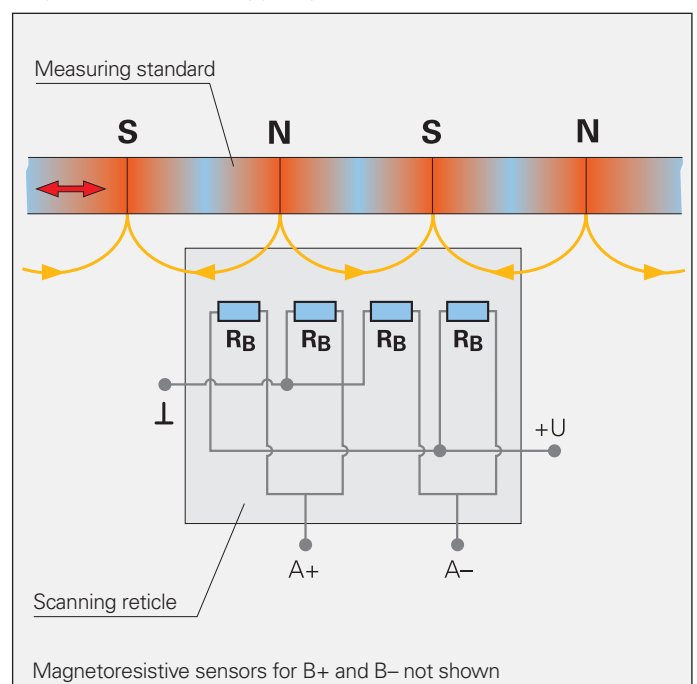
Measuring accuracy

The accuracy of angular measurement is mainly determined by
- the quality of the graduation,
- the 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 error of the bearing, 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 total accuracy.

Encoder-specific error
The encoder-specific error is given in the Specifications:
- Accuracy of graduation
- Position error within one signal period

Accuracy of graduation
The accuracy of the graduation ± a 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 position error at positions that are integral multiples of the signal period.

Position error within one signal period
The position error within one signal period ± u results from the quality of the scanning and—for encoders with integrated pulse-shaping or counter electronics—the quality of the signal-processing electronics. For encoders with sinusoidal output signals, however, the error of signal processing is influenced 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 detectors
- The stability and dynamics of further processing of the analog signals

These factors of influence are to be considered when specifying position error within one signal period.

Position error within one signal period ± u is specified in percent of the signal period. For the ERM magnetic modular encoders with approx. 200 µm or 400 µm, the value is typically better than ± 0.5% of the signal period. You will find the values in the Specifications.

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

Position errors within one revolution

Position error within one signal period
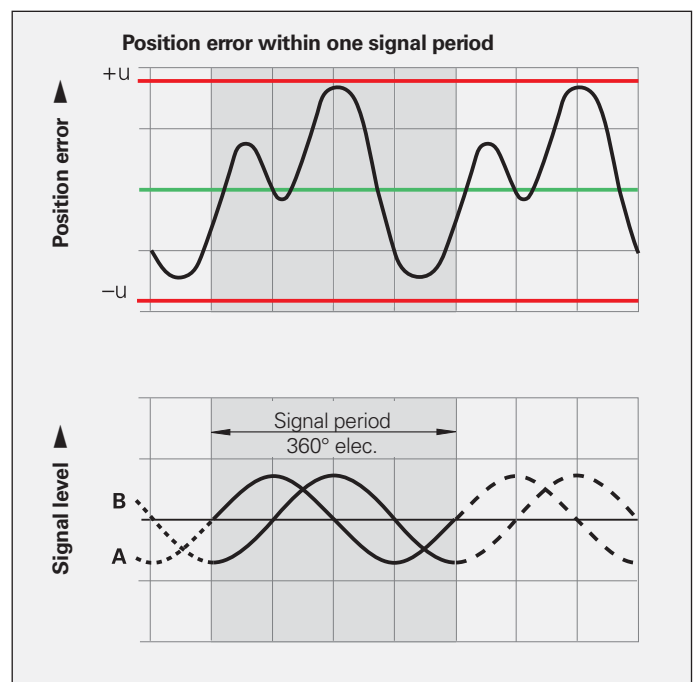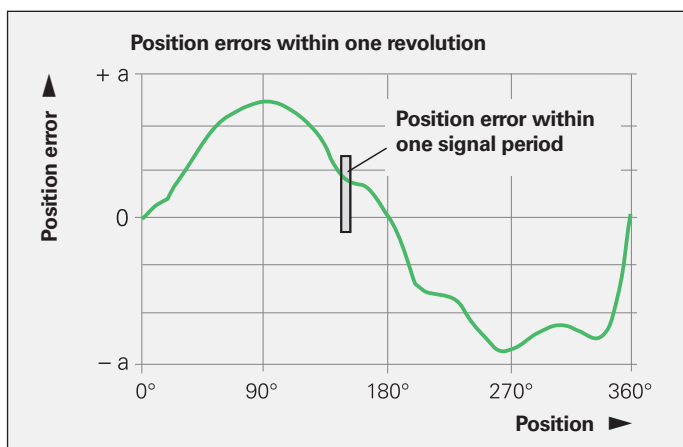
Application-dependent error

The mounting and adjustment of the scanning head drum, 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 total accuracy.

On the other hand, the specified system accuracy for the encoders with integral bearing already includes the error of the bearing and the shaft coupling. (See the *Absolute Angle Encoders with Optimized Scanning* or *Angle Encoders with Integral Bearing* brochures.)

Errors due to eccentricity of the graduation to the bearing

Under normal circumstances, the graduation will have a certain eccentricity relative to the bearing once the ERM's scale drum is mounted. In addition, dimensional and form deviations of the 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 illustration 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 the radial deviation)
D = Scale-drum 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

Error due to deformation of the graduation is not to be ignored. 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 of the ERM 2200, ERM 200 and ERM 2410 are particularly rigid in order to prevent this effect.

Eccentricity of the graduation to the bearing

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

Calibration chart

HEIDENHAIN prepares individual calibration charts and ships them with each of its ERM 2200 series magnetic modular encoders.

The **calibration chart** documents the graduation accuracy including the graduation carrier. It is ascertained through a large number of measuring points during one revolution. All measured values lie within the graduation accuracy listed in the specifications.

The **calibration standard** indicated in the manufacturer's inspection certificate documents and guarantees traceability to recognized national and international standards.

The accuracy data of the calibration chart do not include the position error within one signal period and any error resulting from mounting.

Reversal error

The reversal error is an effect that occurs when the direction of movement changes. It depends on the size of the signal period and the mounting conditions. With 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.

HEIDENHAIN

Teilungstrommel ERM 2200 C
ID 671712-06
SN 38347879

Qualitätsprüf-Zertifikat
DIN 55 350-18-4.2.2

Quality Inspection Certificate
DIN 55 350-18-4.2.2

Positionsabweichung Δφ ["]
Position error Δφ ["]

Nullposition / *Zero Position*

Messposition φ$_M$ [°] / *Measured position* φ$_M$ [°]

Die Messkurve zeigt die Positionsabweichungen der Teilung (inkl. Teilungsträger) bei einer Umdrehung.
Die Strichzahl der Teilungstrommel beträgt 4096.
Kundenseitige Abweichungen durch Anbau und Lagerung sind zusätzlich zu berücksichtigen.

The error curve shows the position errors in one revolution of the graduation (incl. graduation carrier).
The line count of the angle encoder is 4096.
Errors at the costumer resulting from mounting and the bearing must also be accounted for.

Positionsabweichung Δφ des Messgerätes: Δφ = φ$_S$ − φ$_M$
φ$_S$ = Messposition des Vergleichsnormals
φ$_M$ = Messposition des Prüflings

Position error Δφ of the encoder: Δφ = φ$_S$ − φ$_M$
φ$_S$ = position measured by the reference standard
φ$_M$ = position measured by the measured encoder

Maximale Positionsabweichung	
der Messkurve innerhalb 360°	± 1,59″

Maximum position error	
of the error curve within 360°	*± 1.59″*

Unsicherheit der Messmaschine	
0,05″	

Uncertainty of measuring machine	
0.05″	

Messparameter	
Messgeschwindigkeit	3,33 min⁻¹
Anzahl der Messpositionen pro Umdrehung	4096

Measurement parameters	
Measurement velocity	*3.33 min⁻¹*
Number of measurement positions per revolution	*4096*

Dieses Winkelmessgerät wurde unter den strengen HEIDENHAIN-Qualitätsnormen hergestellt und geprüft. Die Positionsabweichung liegt bei einer Bezugstemperatur von 22 °C innerhalb der Genauigkeitsklasse ± 3,5″.

This angle encoder 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 ± 3.5″.

Kalibriernormal	Kalibrierzeichen
ERP 880	091-DKD-K-12901 2009-04

Calibration standard	*Calibration reference*
ERP 880	*091-DKD-K-12901 2009-04*

13.04.2012

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Prüfer/*Inspected by*   H. Knobloch

Mechanical design types and mounting

The ERM modular encoders consist of a circumferential scale drum and the corresponding scanning head. The assemblies 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 data for graduation accuracy and the position error within one signal period can be attained in the application if the requirements are fulfilled (see *Specifications*).

Versions

There are various signal periods available for the ERM modular magnetic encoders (ERM 2200: approx. 200 µm, ERM 200/ 2400: approx. 400 µm, ERM 2900: approx. 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 200 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.
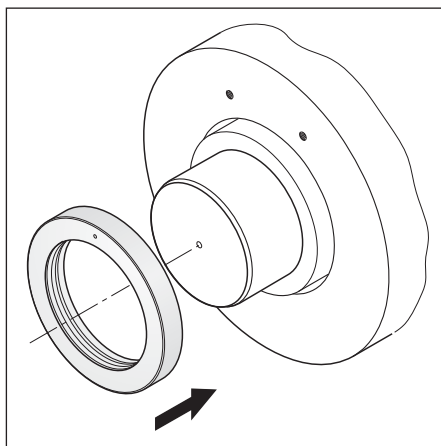
Centering the scale drum

Because the attainable total accuracy is dominated by mounting error (mainly through eccentricity), special attention must be placed on centering the scale drum. Depending on the encoder and mounting method, various methods of centering the scale drums are possible in order to minimize the eccentricity errors that occur in practice.
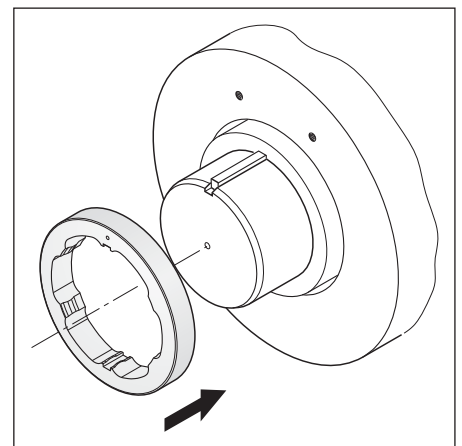
1. Centering by centering collar

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.
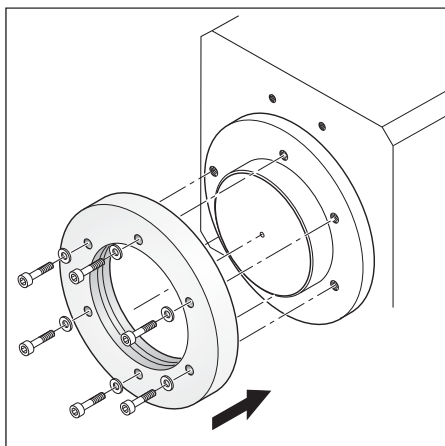
Mounting of the scale drum
TTR ERM 200
TTR ERM 2200

Mounting of the scale drum
TTR ERM 2404
TTR ERM 2904

Mounting of the scale drum
TTR ERM 2405

The scale drum is centered via the centering collar on its inner circumference. HEIDENHAIN recommends a slight oversize of the shaft on which the 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 rotational accuracy before mounting is recommended.

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

2. Centering with two scanning heads

This method is suited for scale drums with screw fastening. Here the graduation or the position value itself serves as reference. The two scanning heads are connected with the subsequent electronics, which form the difference of the two position values. This centering method is recommended when high accuracy is required or when error caused by the shaft geometry or the bearing is to be avoided.

Mounting the scanning head

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

Test film for magnetic graduation

The test film is 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 foils 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

Error 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 Product Information *EIB 1500*).
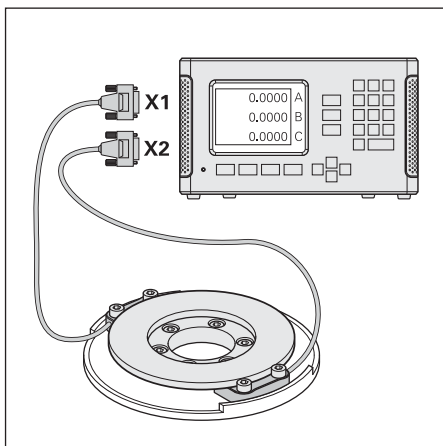
Centering with two scanning heads
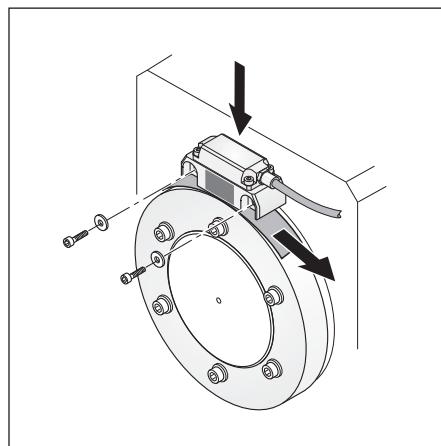
Mounting the scanning head, e.g. AK ERM 280
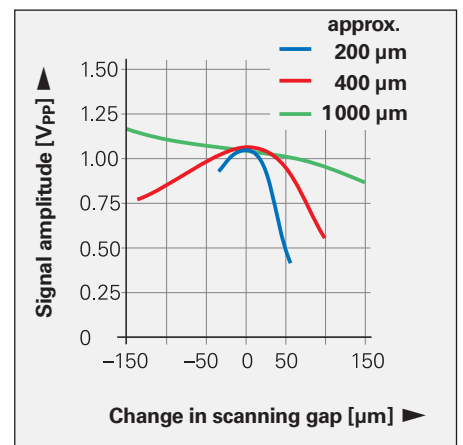
Typical correlation of signal amplitude and scanning gap (mounting clearance)

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** from –30 °C to +70 °C is valid as long as the unit remains in its packaging.

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

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

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

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

The specifications 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 other than the intended applications is at the user's own risk.
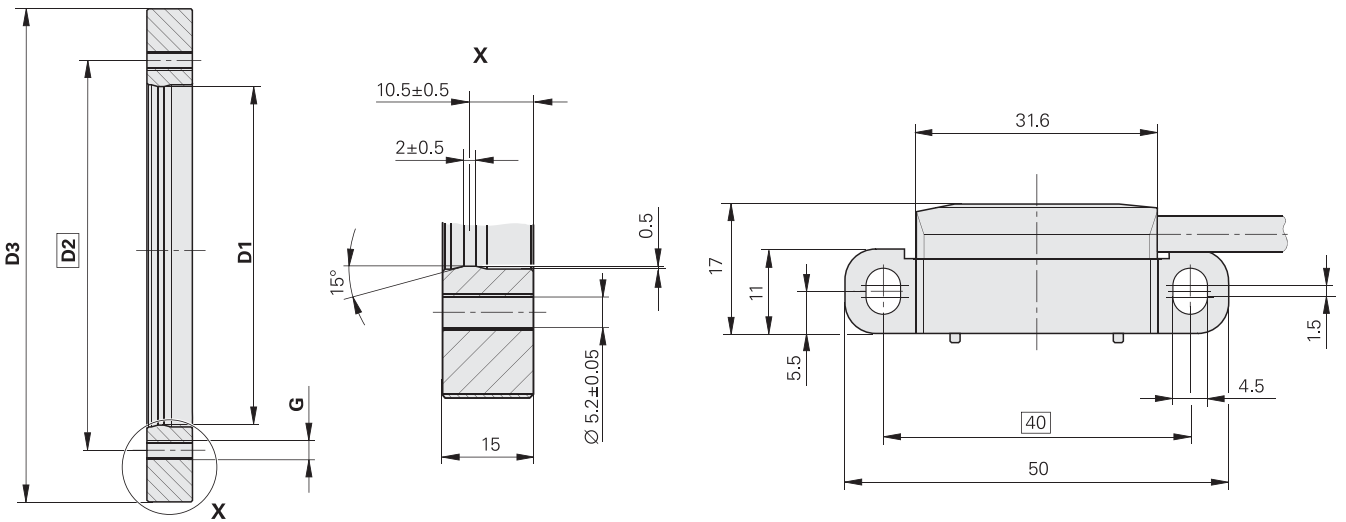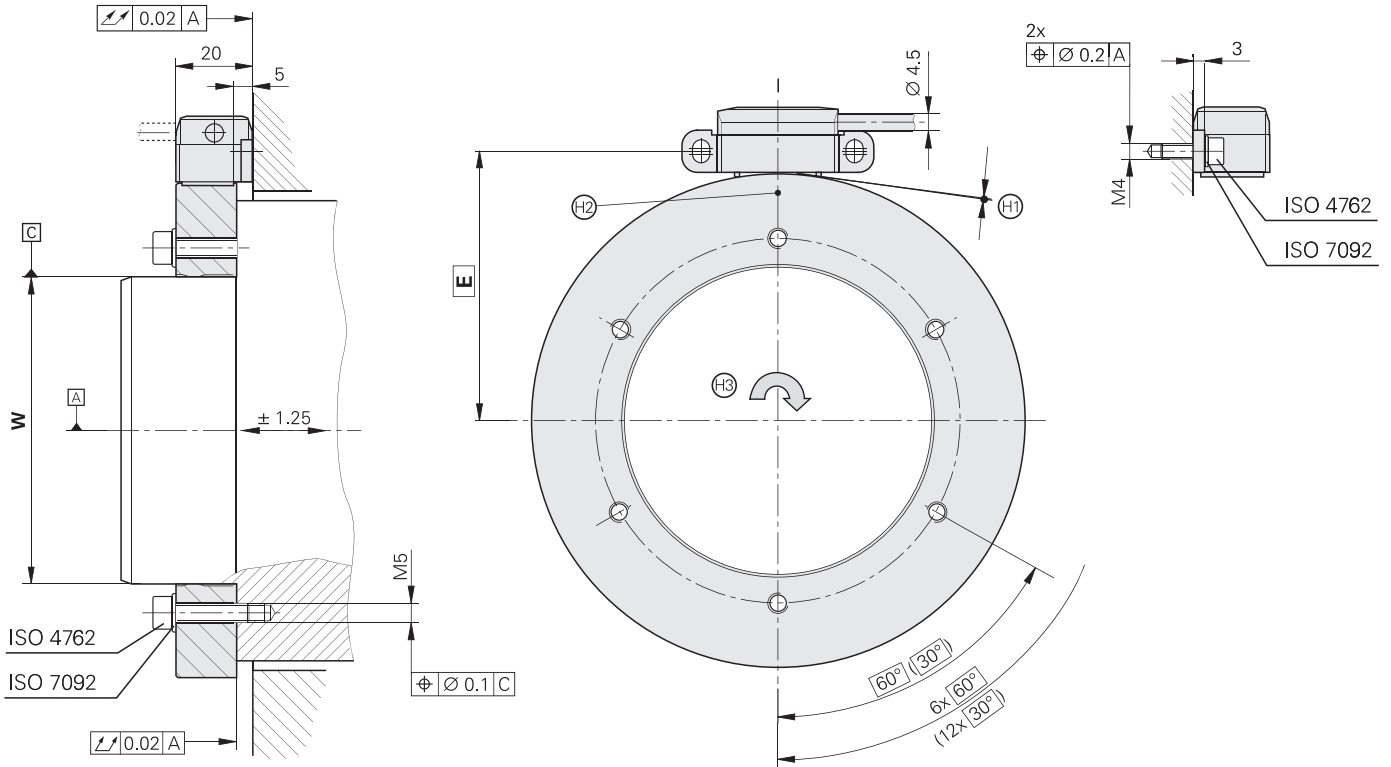In safety-related systems, the higher-level system must verify the position value of the encoder after switch-on.
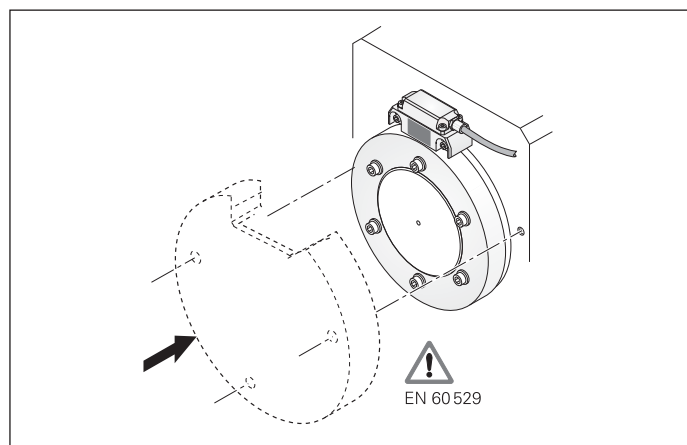
Protection against contact

ERM 2200 series

- **Modular encoders with magnetic scanning principle**
- **Signal period approx. 200 μm (at circumference)**
- **For rotary and tilting tables**

mm

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

Ⓐ = Bearing
Ⓗ1 = Mounting distance of 0.05 mm set with spacer foil
Ⓗ2 = Marker for reference mark, position tolerance with respect to reference mark ± 5°
Ⓗ3 = Direction of shaft rotation for output signals according to interface description

D1	W	D2	D3	E	G
Ø 70 0/–0.008	Ø 70 +0.010/+0.002	Ø 85	Ø 113.16	62.3	6x M6
Ø 80 0/–0.008	Ø 80 +0.010/+0.002	Ø 95	Ø 128.75	70.1	6x M6
Ø 130 0/–0.012	Ø 130 +0.015/+0.003	Ø 145	Ø 176.03	93.7	6x M6
Ø 180 0/–0.012	Ø 180 +0.015/+0.003	Ø 195	Ø 257.50	134.5	6x M6
Ø 260 0/–0.016	Ø 260 +0.020/+0.004	Ø 275	Ø 326.90	169.2	6x M6
Ø 380 0/–0.018	Ø 380 +0.022/+0.004	Ø 395	Ø 452.64	232.0	12x M6

Scanning head	AK ERM 2280
Incremental signals	$\sim$ 1 V$_{PP}$
Cutoff frequency –3 dB	≥ 300 kHz
Signal period	Approx. 200 µm
Line count*	See "Scale drum"
Power supply	5 V DC ± 10 %
Current consumption	≤ 150 mA (without load)
Electrical connection*	Cable 1 m, with or without coupling
Cable length	≤ 150 m (with HEIDENHAIN cable)
Vibration 55 to 2000 Hz Shock 6 ms	≤ 400 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)
Operating temperature	–10 °C to 60 °C
Protection EN 60529	IP 67
Weight	Approx. 0.15 kg (with cable)

Scale drum	TTR ERM 2200 C					
Measuring standard	MAGNADUR graduation; signal period of approx. 200 µm					
Inside diameter*	70 mm	80 mm	130 mm	180 mm	260 mm	380 mm
Outside diameter	113.16 mm	128.75 mm	176.03 mm	257.50 mm	326.90 mm	452.64 mm
Line count*	1800	2048	2800	4096	5200	7200
Position error per signal period [1]	± 5.5″	± 4.5″	± 3.5″	± 2.5″	± 2″	± 1.5″
Accuracy of graduation	± 7″	± 6″	± 5″	± 3.5″	± 3″	± 2.5″
Reference mark	Distance-coded					
Angle for absolute reference	≤ 20°	≤ 22.5°	≤ 14.4°	≤ 11.25°	≤ 13.85°	≤ 8°
Mech. permissible speed	≤ 14500 min^{-1}	≤ 13000 min^{-1}	≤ 9000 min^{-1}	≤ 6000 min^{-1}	≤ 4500 min^{-1}	≤ 3000 min^{-1}
Moment of inertia of the rotor	1.6 · 10^{-3} kgm^2	2.7 · 10^{-3} kgm^2	7.7 · 10^{-3} kgm^2	38 · 10^{-3} kgm^2	76 · 10^{-3} kgm^2	235 · 10^{-3} kgm^2
Permissible axial motion	± 1.25 mm					
Weight approx.	0.69 kg	0.89 kg	1.2 kg	3.0 kg	3.5 kg	5.4 kg

* Please select or indicate when ordering
[1] The position error within one signal period and the accuracy of the graduation result together in the encoder-specific error; for additional error through mounting and the bearing of the measured shaft, see *Measuring accuracy*
Other line counts/dimensions upon request

ERM 200 series

- **Modular encoders with magnetic scanning principle**
- **Signal period approx. 400 µm (at circumference)**
- **For C axis on lathes**

mm

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

Ⓐ = Bearing
⊕1 = Mounting distance of 0.15 mm set with spacer foil
⊕2 = Marker for reference mark, position tolerance with respect to reference mark ±5°
⊕3 = Direction of shaft rotation for output signals according to interface description

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

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

Scale drum	TTR ERM 200								
Measuring standard	MAGNADUR graduation; signal period of approx. 400 µm								
Inside diameter*	40 mm	70 mm	80 mm	120 mm	130 mm	180 mm	220 mm	295 mm	410 mm
Outside diameter	75.44 mm	113.16 mm	128.75 mm	150.88 mm	176.03 mm	257.50 mm	257.50 mm	326.90 mm	452.64 mm
Line count*	600	900	1024	1200	1400	2048	2048	2600	3600
Position error per signal period [1]	± 15.5″	± 10.5″	± 9″	± 8″	± 6.5″	± 4.5″	± 4.5″	± 3.5″	± 3″
Accuracy of graduation	± 11″	± 8″	± 7″	± 6″	± 5.5″	± 4″	± 5″	± 4″	± 3.5″
Reference mark*	*TTR ERM 200:* One *TTR ERM 200C:* Distance-coded								
Mech. permissible speed	≤ 19000 min^{-1}	≤ 14500 min^{-1}	≤ 13000 min^{-1}	≤ 10500 min^{-1}	≤ 9000 min^{-1}	≤ 6000 min^{-1}	≤ 6000 min^{-1}	≤ 4500 min^{-1}	≤ 3000 min^{-1}
Moment of inertia of the rotor	0.34 · 10^{-3} kgm^2	1.6 · 10^{-3} kgm^2	2.7 · 10^{-3} kgm^2	3.5 · 10^{-3} kgm^2	7.7 · 10^{-3} kgm^2	38 · 10^{-3} kgm^2	23 · 10^{-3} kgm^2	44 · 10^{-3} kgm^2	156 · 10^{-3} kgm^2
Permissible axial motion	± 1.25 mm								
Weight approx.	0.35 kg	0.69 kg	0.89 kg	0.72 kg	1.2 kg	3.0 kg	1.6 kg	1.7 kg	3.2 kg

* Please select or indicate when ordering
[1] The position error within one signal period and the accuracy of the graduation result together in the encoder-specific error; for additional error through mounting and the bearing of the measured shaft, see *Measuring accuracy*
Other line counts/dimensions upon request

ERM 2410 series

- **Modular encoders with magnetic scanning principle**
- **For C axis on lathes**
- **Integrated counting function for position-value output**
- **Absolute position value after traverse of two reference marks**

mm

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

Ⓐ = Bearing
Ⓗ1 = Mounting distance of 0.15 mm set with spacer foil
Ⓗ2 = Marker for reference mark, position tolerance with r espect to reference mark ±5°
Ⓗ3 = Direction of shaft rotation for output signals according to interface description

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

Scanning head	AK ERM 2410
Interface	EnDat 2.2 (absolute position value after scanning two reference marks in "position value 2")
Ordering designation	EnDat 22
Integrated interpolation	16384-fold (14 bits)
Clock frequency	≤ 8 MHz
Calculation time t_{cal}	≤ 5 µs
Signal period	Approx. 400 µm
Line count*	See "Scale drum"
Power supply	3.6 to 14 V DC
Power consumption[1]	*At 14 V:* 110 mA; *at 3.6 V:* 300 mA (maximum)
Current consumption (typ.)	*At 5 V:* 90 mA (without load)
Electrical connection	Cable, 1 m, with M12 coupling (8-pin)
Cable length	≤ 150 m (with HEIDENHAIN cable)
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)
Operating temperature	–10 °C to 100 °C
Protection EN 60529	IP 67
Weight	Approx. 0.15 kg (with cable)

| Scale drum	TTR ERM 200C								
Measuring standard	MAGNADUR graduation, signal period approx. 400 µm								
Inside diameter*	40 mm	70 mm	80 mm	120 mm	130 mm	180 mm	220 mm	295 mm	410 mm
Outside diameter	75.44 mm	113.16 mm	128.75 mm	150.88 mm	176.03 mm	257.50 mm	257.50 mm	326.90 mm	452.64 mm
Line count*	600	900	1024	1200	1400	2048	2048	2600	3600
Positions per revolution	9830400	14745600	16777216	19660800	22937600	33554432	33554432	42598400	58982400
Position error per signal period[1]	± 15.5″	± 10.5″	± 9″	± 8″	± 6.5″	± 4.5″	± 4.5″	± 3.5″	± 3″
Accuracy of the graduation[2]	± 11″	± 8″	± 7″	± 6″	± 5.5″	± 4″	± 5″	± 4″	± 3.5″
Reference marks	Distance-coded								
Angle for absolute reference	≤ 36°	≤ 24°	≤ 22.5°	≤ 24°	≤ 18°	≤ 22.5°	≤ 22.5°	≤ 13.85°	≤ 12°
Mech. permiss. speed	≤ 19000 min^{-1}	≤ 14500 min^{-1}	≤ 13000 min^{-1}	≤ 10500 min^{-1}	≤ 9000 min^{-1}	≤ 6000 min^{-1}	≤ 6000 min^{-1}	≤ 4500 min^{-1}	≤ 3000 min^{-1}
Moment of inertia of the rotor	0.34 · 10^{-3} kgm^2	1.6 · 10^{-3} kgm^2	2.7 · 10^{-3} kgm^2	3.5 · 10^{-3} kgm^2	7.7 · 10^{-3} kgm^2	38 · 10^{-3} kgm^2	23 · 10^{-3} kgm^2	44 · 10^{-3} kgm^2	156 · 10^{-3} kgm^2
Permissible axial motion	± 1.25 mm								
Weight approx.	0.35 kg	0.69 kg	0.89 kg	0.72 kg	1.2 kg	3.0 kg	1.6 kg	1.7 kg	3.2 kg

* Please select when ordering
[1] See *General Electrical Information*
[2] The position error within one signal period and the accuracy of the graduation result together in the encoder-specific error; for additional error through mounting and the bearing of the measured shaft, see *Measuring accuracy*
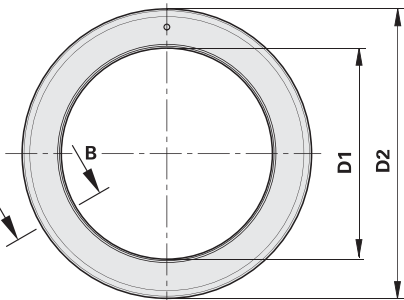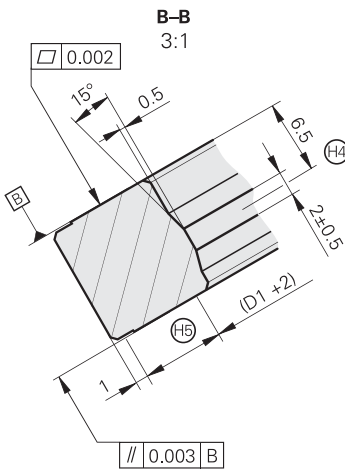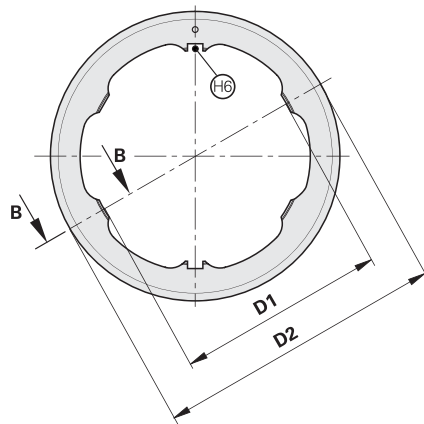Other line counts/dimensions upon request

ERM 2400 series

- **Modular encoders with magnetic scanning principle**
- **Signal period approx. 400 μm (at circumference)**
- **For spindles on milling machines**

A–A
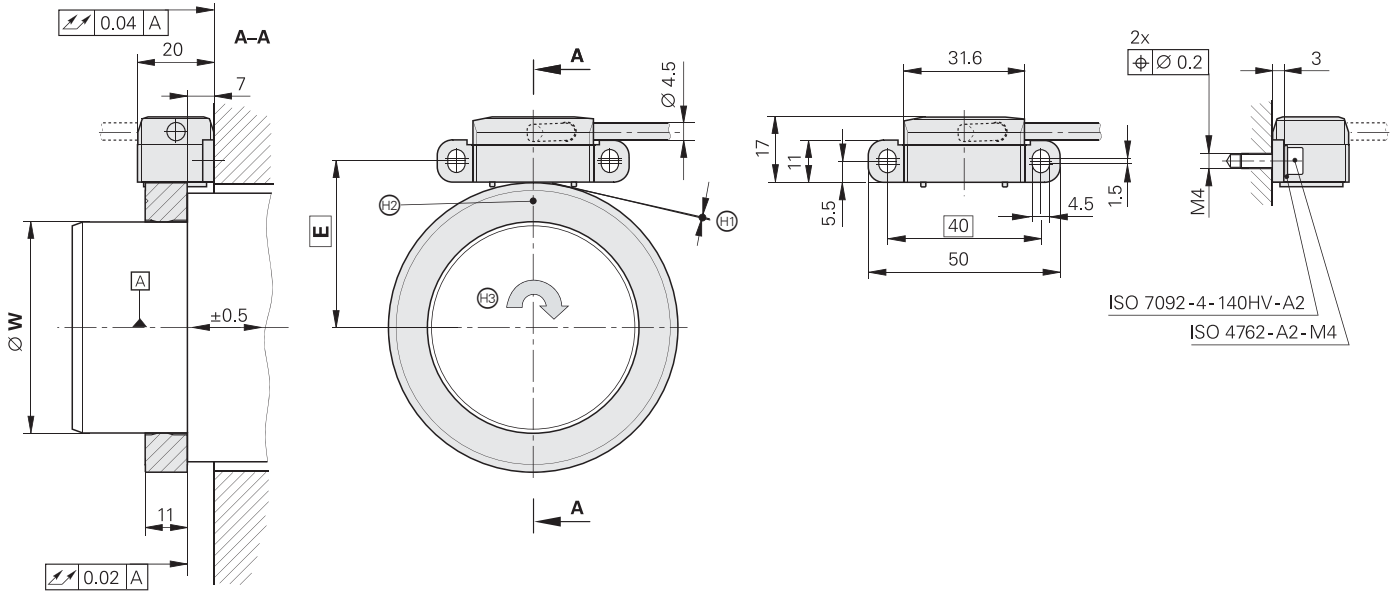
ERM 2404 scale drum

ERM 2405 scale drum

B–B
3:1

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

Ⓐ = Bearing
① = Mounting distance of 0.15 mm set with spacer foil
② = Marker for reference mark, position tolerance with respect
     to reference mark ± 5°
③ = Direction of shaft rotation for output signals as per the interface description
④ = Centering collar
⑤ = Clamping area (applies to both sides)
⑥ = Slot for feather key 4×4×10 (as per DIN 6885 shape A)

D1	W	D2	E
Ø 40 +0.010/+0.002	Ø 40 0/−0.006	Ø 64.37	37.9
Ø 55 +0.010/+0.002	Ø 55 0/−0.006	Ø 75.44	43.4
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

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

Scale drum	ERM 2404				ERM 2405	
Measuring standard	MAGNADUR graduation; signal period of approx. 400 µm					
Inside diameter*	40 mm	55 mm	80 mm	100 mm	40 mm	55 mm
Outside diameter	64.37 mm	75.44 mm	113.16 mm	128.75 mm	64.37 mm	75.44 mm
Line count*	512	600	900	1024	512	600
Position error per signal period[1]	± 18″	± 15.5″	± 10.5″	± 9″	± 18″	± 15.5″
Accuracy of graduation	± 17″	± 14″	± 10	± 9	± 17″	± 14″
Reference mark	One					
Mech. permissible speed	≤ 42000 min^{-1}	≤ 36000 min^{-1}	≤ 22000 min^{-1}	≤ 20000 min^{-1}	≤ 33000 min^{-1}	≤ 27000 min^{-1}
Moment of inertia of the rotor	0.12 · 10^{-3} kgm^2	0.19 · 10^{-3} kgm^2	1.0 · 10^{-3} kgm^2	1.4 · 10^{-3} kgm^2	0.11 · 10^{-3} kgm^2	0.17 · 10^{-3} kgm^2
Permissible axial motion	± 0.5 mm					
Weight approx.	0.17 kg	0.17 kg	0.42 kg	0.43 kg	0.15 kg	0.15 kg

* Please select or indicate when ordering
[1] The position error within one signal period and the accuracy of the graduation result together in the encoder-specific error; for additional error through mounting and the bearing of the measured shaft, see *Measuring accuracy*
Other line counts/dimensions upon request

ERM 2900 series

- **Modular encoders with magnetic scanning principle**
- **Signal period approx. 1000 µm (at circumference)**
- **For spindles on milling machines**

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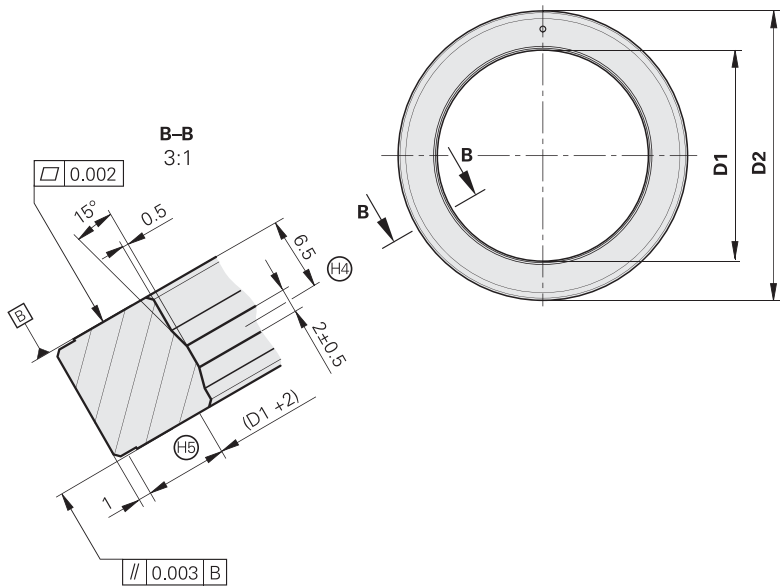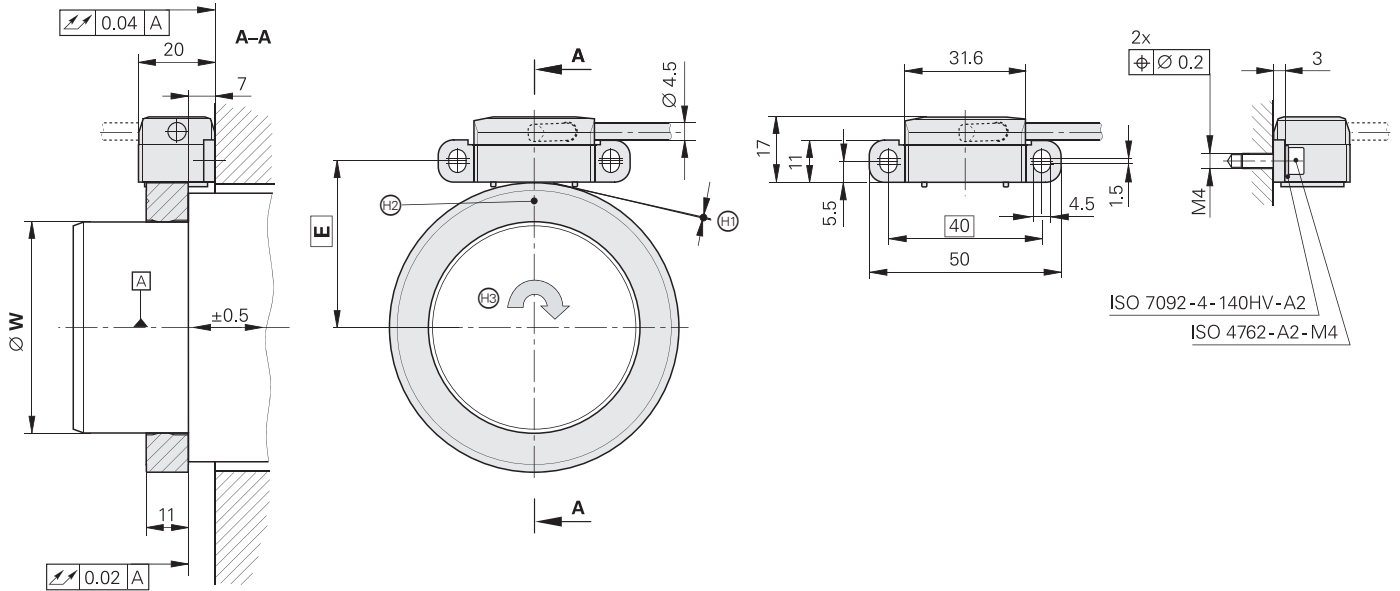
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Ⓐ = Bearing
Ⓗ1 = Mounting distance of 0.30 mm set with spacer foil
Ⓗ2 = Marker for reference mark, position tolerance with respect
  to reference mark ±5°
Ⓗ3 = Direction of shaft rotation for output signals as per the
  interface description
Ⓗ4 = Centering collar
Ⓗ5 = Clamping area (applies to both sides)

D1	W	D2	E
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

Scanning head	AK ERM 2980
Incremental signals	$\sim$ 1 V_{PP}
Cutoff frequency –3 dB	≥ 300 kHz
Signal period	Approx. 1 000 µm
Line count*	See "Scale drum"
Power supply	5 V DC ± 10 %
Current consumption	≤ 150 mA (without load)
Electrical connection*	Cable 1 m, with or without coupling; cable outlet axial or radial
Cable length	≤ 150 m (with HEIDENHAIN cable)
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 400 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)
Operating temperature	–10 °C to 100 °C
Protection EN 60529	IP 67
Weight	Approx. 0.15 kg (with cable)

Scale drum	ERM 2904			
Measuring standard	MAGNADUR graduation; signal period of approx. 1000 µm			
Inside diameter*	40 mm	55 mm	60 mm	100 mm
Outside diameter	58.06 mm	77.41 mm	90.72 mm	120.96 mm
Line count*	192	256	300	400
Position error per signal period [1]	± 68"	± 51"	± 44"	± 33"
Accuracy of graduation	± 68"	± 51"	± 44"	± 33"
Reference mark	One			
Mech. permissible speed	≤ 47000 min^{-1}	≤ 35000 min^{-1}	≤ 29000 min^{-1}	≤ 16000 min^{-1}
Moment of inertia of the rotor	0.07 · 10^{-3} kgm^2	0.22 · 10^{-3} kgm^2	0.45 · 10^{-3} kgm^2	0.92 · 10^{-3} kgm^2
Permissible axial motion	± 0.5 mm			
Weight approx.	0.11 kg	0.19 kg	0,30 kg	0,30 kg

* Please select or indicate when ordering
[1] The position error within one signal period and the accuracy of the graduation result together in the encoder-specific error; for additional error through mounting and the bearing of the measured shaft, see *Measuring accuracy*
Other line counts/dimensions upon request

Interfaces

Incremental signals 〰 1 V_{PP}

HEIDENHAIN encoders with 〰 1 V$_{PP}$ interface provide voltage signals that can be highly interpolated.

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

The **reference mark signal** R has a usable component G of approx. 0.5 V. Next to the reference mark, the output signal can be reduced by up to 1.7 V to a quiescent level H. This must not cause the subsequent electronics to overdrive. Even at the lowered signal level, signal peaks with the amplitude G can also appear.

The data on **signal amplitude** apply when the power supply given in the specifications is connected to the encoder. They refer to a differential measurement at the 120 ohm terminating resistor between the associated outputs. The signal amplitude decreases with increasing frequency. The **cutoff frequency** indicates the scanning frequency at which a certain percentage of the original signal amplitude is maintained:
• –3 dB ≙ 70 % of the signal amplitude
• –6 dB ≙ 50 % of the signal amplitude

The data in the signal description apply to motions at up to 20% of the –3 dB cutoff frequency.

Interpolation/resolution/measuring step
The output signals of the 1 V$_{PP}$ interface are usually interpolated in the subsequent electronics in order to attain sufficiently high resolutions. For **velocity control,** interpolation factors are commonly over 1000 in order to receive usable information even at low rotational or linear velocities.

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

Short-circuit stability
A temporary short circuit of one signal output to 0 V or U$_P$ (except encoders with U$_{Pmin}$ = 3.6 V) does not cause encoder failure, but it is not a permissible operating condition.

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

Interface	Sinusoidal voltage signals 〰 **1 V_{PP}**
Incremental signals	**2 nearly sinusoidal signals A and B**
	Signal amplitude M: 0.6 to 1.2 V$_{PP}$; typically 1 V$_{PP}$
	Asymmetry |P – N|/2M: ≤ 0.065
	Amplitude ratio M$_A$/M$_B$: 0.8 to 1.25
	Phase angle |φ1 + φ2|/2: 90° ± 10° elec.
Reference mark signal	**One or several signal peaks R**
	Usable component G: ≥ 0.2 V
	Quiescent value H: ≤ 1.7 V
	Switching threshold E, F: 0.04 to 0.68 V
	Zero crossovers K, L: 180° ± 90° elec.
Connecting cable	Shielded HEIDENHAIN cable
	For example PUR [4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)]
Cable length	Max. 150 m at 90 pF/m distributed capacitance
Propagation time	6 ns/m

These values can be used for dimensioning of the subsequent electronics. Any limited tolerances in the encoders are listed in the specifications. For encoders without integral bearing, reduced tolerances are recommended for initial operation (see the mounting instructions).

A, B, R measured with oscilloscope in differential mode
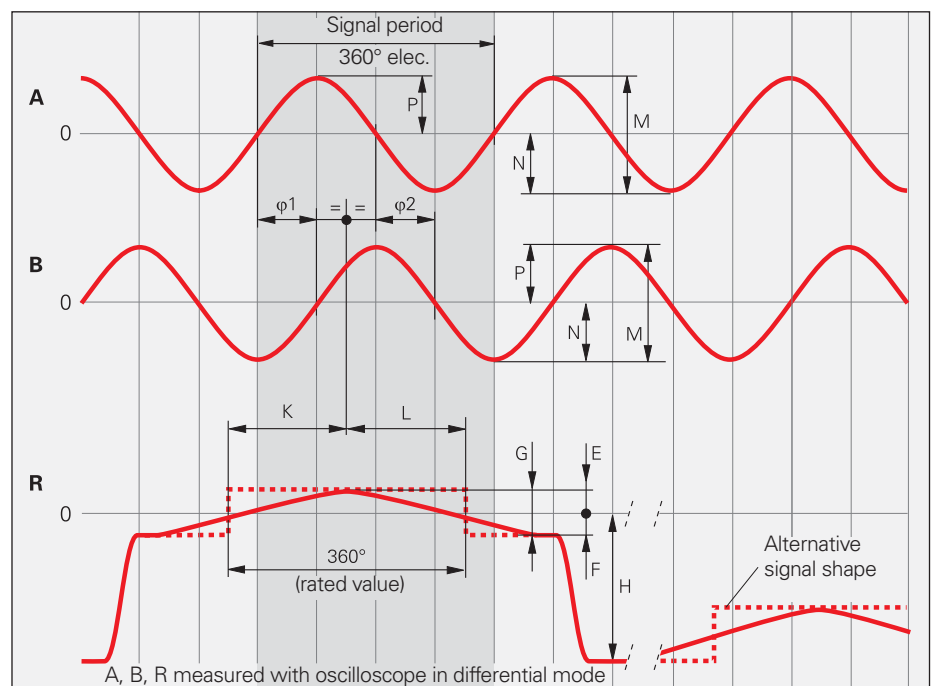
Cutoff frequency
Typical signal amplitude curve with respect to the scanning frequency (depends on encoder)

— –3 dB cutoff frequency
— –6 dB cutoff frequency
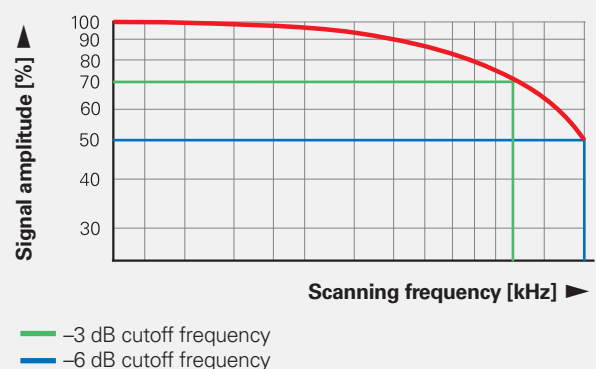
Input circuitry of subsequent electronics

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

–3 dB cutoff frequency of circuitry
Approx. 450 kHz
Approx. 50 kHz with $C_1 = 1000\ pF$
and $C_2 = 82\ pF$
The circuit variant for 50 kHz does reduce the bandwidth of the circuit, but in doing so it improves its noise immunity.
Encoders with **higher signal frequencies** (e.g. LIP 281) require special input circuitry (see the *Exposed Linear Encoders* brochure).

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

Monitoring of the incremental signals
The following thresholds are recommended for monitoring of the signal level M:
Lower threshold: $0.30\ V_{PP}$
Upper threshold: $1.35\ V_{PP}$

Incremental signals
Reference mark signal

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

Pin layout

| | | 12-pin coupling, M23 | | | 12-pin connector, M23 | | |

| | 15-pin D-sub connector | | | | 15-pin D-sub connector | | |
For HEIDENHAIN controls and IK 220 / 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	/
	U_P	Sensor U_P	0 V	Sensor 0 V	A+	A–	B+	B–	R+	R–	**Vacant**	**Vacant**	**Vacant**
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	/	Violet	Yellow

Cable shield connected to housing; **U_P** = Power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!

Interfaces
Incremental signals ⌐⌐TTL

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

The **incremental signals** are transmitted as the square-wave pulse trains U_{a1} and U_{a2}, phase-shifted by 90° elec. The **reference mark signal** consists of one or more reference pulses U_{a0}, which are gated with the incremental signals. In addition, the integrated electronics produce their **inverted signals** $\overline{U_{a1}}$, $\overline{U_{a2}}$ and $\overline{U_{a0}}$ for noise-proof transmission. The illustrated sequence of output signals—with U_{a2} lagging U_{a1}—applies to the direction of motion shown in the dimension drawing.

The **fault-detection signal** $\overline{U_{aS}}$ indicates fault conditions such as breakage of the power line or failure of the light source. It can be used for such purposes as machine shut-off during automated production.

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

The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum **edge separation a** listed in the *Specifications* applies to the illustrated input circuitry with a cable length of 1 m, and refers to a measurement at the output of the differential line receiver. Propagation-time differences in cables additionally reduce the edge separation by 0.2 ns per meter of cable length. To prevent counting errors, design the subsequent electronics to process as little as 90 % of the resulting edge separation.
The max. permissible **shaft speed** or **traversing velocity** must never be exceeded.

The permissible **cable length** for transmission of the TTL square-wave signals to the subsequent electronics depends on the edge separation a. It is at most 100 m, or 50 m for the fault detection signal. This requires, however, that the power supply (see *Specifications*) be ensured at the encoder. The sensor lines can be used to measure the voltage at the encoder and, if required, correct it with an automatic control system (remote sense power supply).

Interface	Square-wave signals ⌐⌐**TTL**
Incremental signals	**2 square-wave signals U_{a1}, U_{a2}** and their inverted signals $\overline{U_{a1}}$, $\overline{U_{a2}}$
Reference mark signal Pulse width Delay time	**1 or more TTL square-wave pulses U_{a0}** and their inverted pulses $\overline{U_{a0}}$ 90° elec. (other widths available on request) $\lvert t_d \rvert \le 50$ ns
Fault-detection signal Pulse width	**1 TTL square-wave pulse $\overline{U_{aS}}$** Improper function: LOW (upon request: U_{a1}/U_{a2} high impedance) Proper function: HIGH $t_S \ge 20$ ms
Signal amplitude	Differential line driver as per EIA standard RS-422 $U_H \ge 2.5$ V at $-I_H = 20$ mA *ERN 1x23:* 10 mA $U_L \le 0.5$ V at $I_L = 20$ mA *ERN 1x23:* 10 mA
Permissible load	$Z_0 \ge 100\ \Omega$ Between associated outputs $\lvert I_L \rvert \le 20$ mA Max. load per output (*ERN 1x23:* 10 mA) $C_{load} \le 1000$ pF With respect to 0 V Outputs protected against short circuit to 0 V
Switching times (10% to 90%)	$t_+ / t_- \le 30$ ns (typically 10 ns) with 1 m cable and recommended input circuitry
Connecting cable Cable length Propagation time	Shielded HEIDENHAIN cable For example PUR [4(2 × 0.14 mm^2) + (4 × 0.5 mm^2)] Max. 100 m ($\overline{U_{aS}}$ max. 50 m) at distributed capacitance 90 pF/m 6 ns/m

Inverse signals $\overline{U_{a1}}$, $\overline{U_{a2}}$, $\overline{U_{a0}}$ are not shown
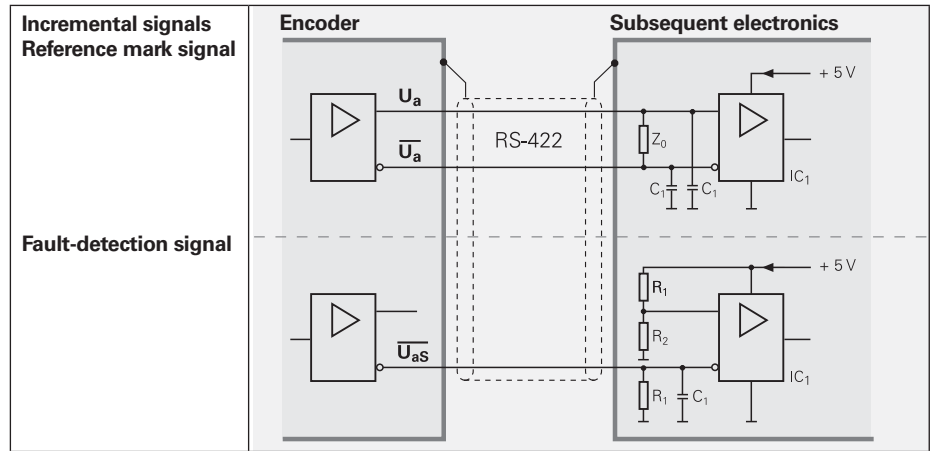
Permissible cable length with respect to the edge separation
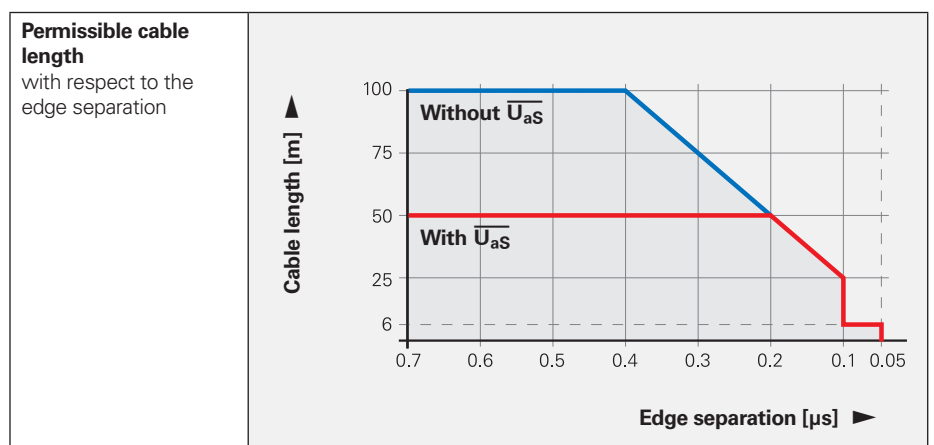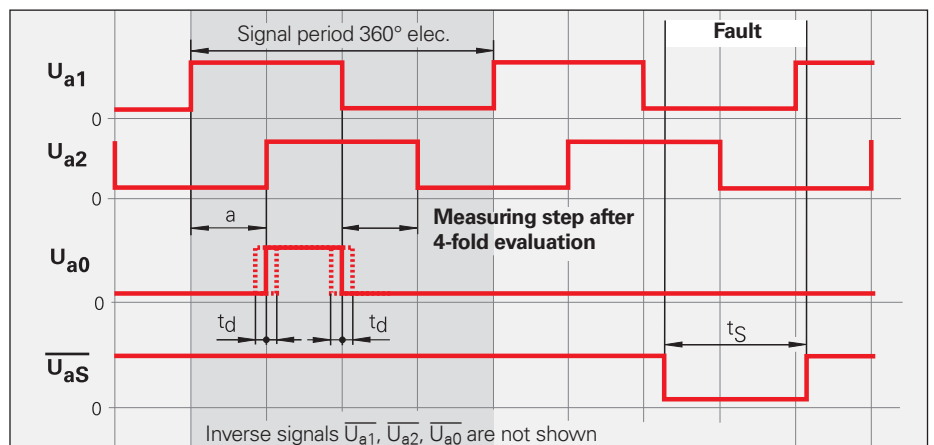
Input circuitry of subsequent electronics
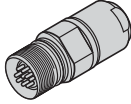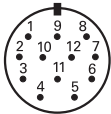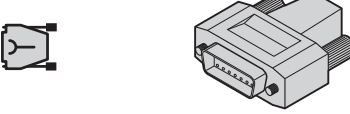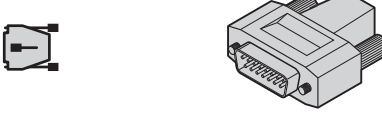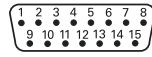
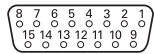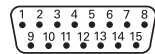### Dimensioning

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

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

Incremental signals Reference mark signal	Encoder		Subsequent electronics

Pin layout

12-pin coupling, M23	**12-pin connector,** M23
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		
coupling/connector	12	2	10	11	5	6	8	1	3	4	7	/	9
D-sub (controls)	1	9	2	11	3	4	6	7	10	12	14	5/8/13	15
D-sub (encoders)	4	12	2	10	1	9	3	11	14	7	13	5/6/8	15
	U_P	Sensor U_P	0 V	Sensor 0 V	U_{a1}	$\overline{U_{a1}}$	U_{a2}	$\overline{U_{a2}}$	U_{a0}	$\overline{U_{a0}}$	$\overline{U_{aS}}$ [1]	Vacant	Vacant [2]
cable	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	Violet	/	Yellow

Cable shield connected to housing; U_P = Power supply voltage

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

Vacant pins or wires must not be used!

[1] **ERO 14xx:** Vacant

[2] **Exposed linear encoders:** Switchover TTL/11 µApp for PWT, otherwise vacant

Interfaces
Absolute position values EnDat

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

For more information, refer to the *EnDat* Technical Information sheet or visit *www.endat.de*.

Position values can be transmitted with or without additional information (e.g. position value 2, temperature sensors, diagnostics, limit position signals).
Besides the position, additional data can be interrogated in the closed loop and functions can be performed with the EnDat 2.2 interface.

Parameters are saved in various memory areas, e.g.:
• Encoder-specific information
• Information of the OEM (e.g. "electronic ID label" of the motor)
• Operating parameters (datum shift, instruction, etc.)
• Operating status (alarm or warning messages)

Monitoring and diagnostic functions of the EnDat interface make a detailed inspection of the encoder possible.
• Error messages
• Warnings
• Online diagnostics based on valuation numbers (EnDat 2.2)

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

Clock frequency and cable length
The clock frequency is variable—depending on the cable length (max. 150 m)—between **100 kHz** and **2 MHz.** With propagation-delay compensation in the subsequent electronics, either clock frequencies **up to 16 MHz** are possible or cable lengths up to 100 m (for other values see *Specifications*).

Interface	EnDat serial bidirectional
Data transfer	Absolute position values, parameters and additional information
Data input	Differential line receiver according to EIA standard RS 485 for the signals CLOCK, $\overline{\text{CLOCK}}$, DATA and $\overline{\text{DATA}}$
Data output	Differential line driver according to EIA standard RS 485 for the signals DATA and $\overline{\text{DATA}}$
Position values	Ascending during traverse in direction of arrow (see dimensions of the encoders)
Incremental signals	$\sim$ 1 V$_{PP}$ (see *Incremental Signals 1 V$_{PP}$*) depending on the unit

Ordering designation	Command set	Incremental signals	Power supply
EnDat 01	EnDat 2.1 or EnDat 2.2	With	See specifications of the encoder
EnDat 21		Without	
EnDat 02	EnDat 2.2	With	Extended range 3.6 to 5.25 V DC or 14 V DC
EnDat 22	EnDat 2.2	Without	

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

EnDat 2.1; EnDat 2.2 without propagation-delay compensation
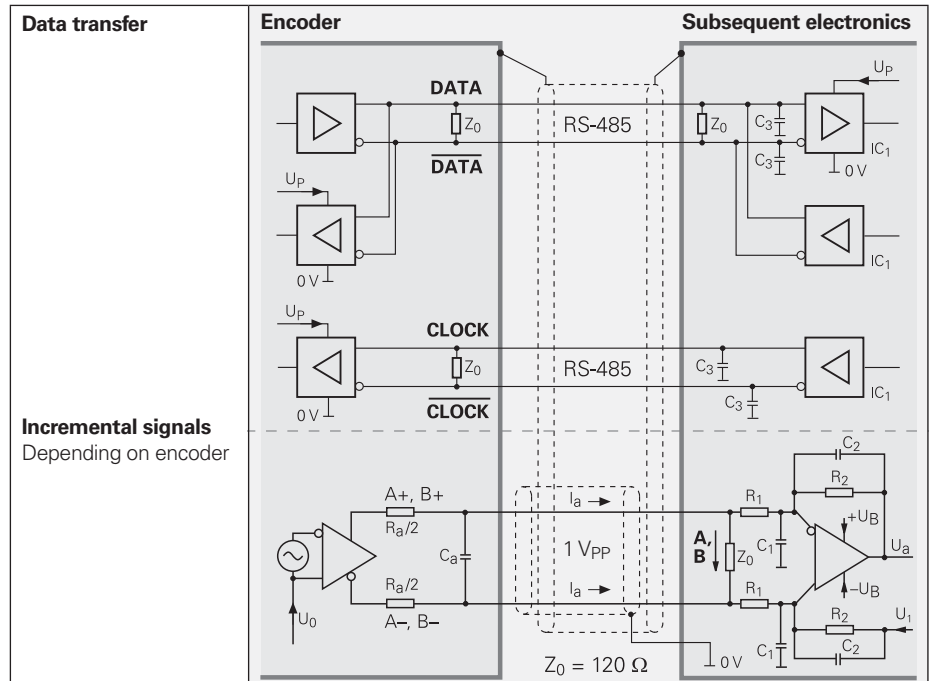EnDat 2.2 with propagation-delay compensation
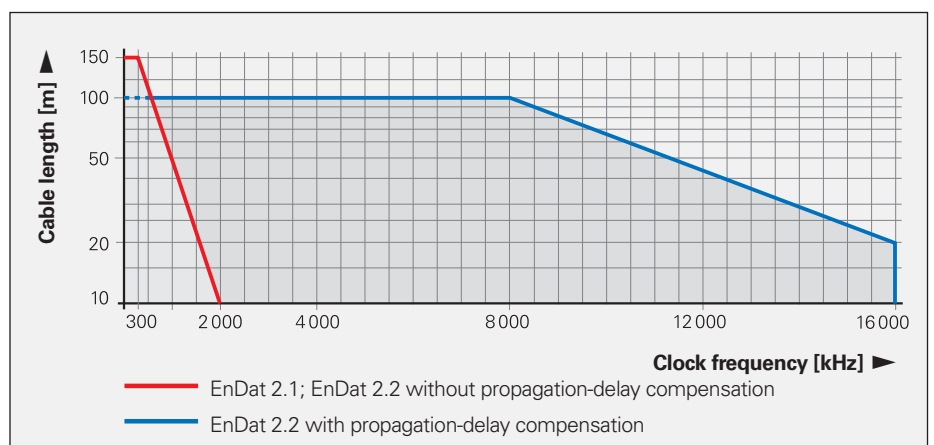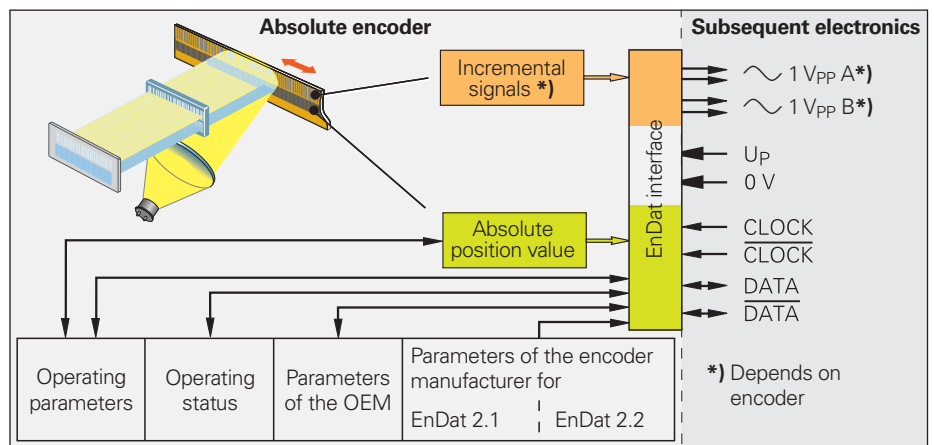
Input circuitry of subsequent electronics

Dimensioning
IC_1 = RS 485 differential line receiver and driver

C_3 = 330 pF
Z_0 = 120 Ω

Pin layout

8-pin coupling, M12

	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 coupling, M23

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

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

Cable shield connected to housing; U_P = Power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.
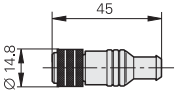Vacant pins or wires must not be used!
[1] Only with ordering designations EnDat 01 and EnDat 02
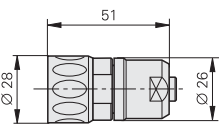
31

Cables and connecting elements

General information

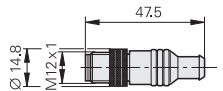**Connector** (insulated): A connecting element with a coupling ring. Available with male or female contacts.
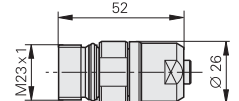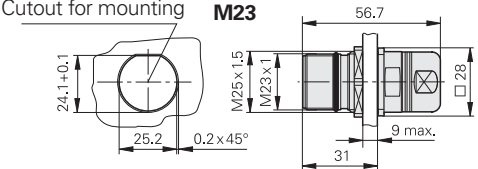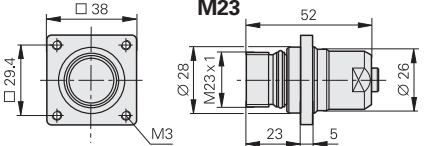
Symbols

M12

M23

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

Symbols

M12

M23

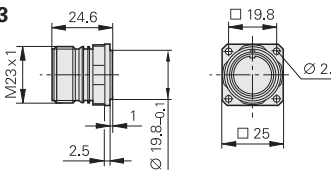**Mounted coupling with central fastening**

Cutout for mounting

M23

Mounted coupling with flange

M23

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

Symbols

M23

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

male or

female contacts.

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

Accessories for flange sockets and M23 mounted couplings
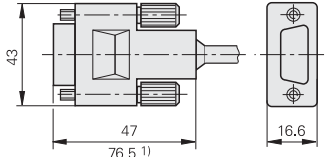
Bell seal
ID 266526-01

Threaded metal dust cap
ID 219926-01

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

Symbols

[1] With integrated interpolation electronics

Connecting cables

<table>
<tr><td></td><td></td><td>8-pin
M12</td><td>17-pin
M23</td></tr>
</table>

		For **EnDat** without incremental signals	For $\sim$ **1 V$_{PP}$** ⊓⊔ **TTL**
PUR connecting cables	**8-pin:** $[(4 \times 0.14 \text{ mm}^2) + (4 \times 0.34 \text{ mm}^2)]$ **12-pin:** $[4(2 \times 0.14 \text{ mm}^2) + (4 \times 0.5 \text{ mm}^2)]$	Ø 6 mm Ø 8 mm	
Complete with connector (female) and coupling (male)		368 330-xx	298 401-xx
Complete with connector (female) and connector (male)		–	298 399-xx
Complete with connector (female) and D-sub connector (female) for IK 220		533 627-xx	310 199-xx
Complete with connector (female) and D-sub connector (male) for IK 115/IK 215		524 599-xx	310 196-xx
With one connector (female)		634 265-xx	309 777-xx
Cable without connectors, Ø 8 mm		–	244 957-01
Mating element on connecting cable to connector on encoder cable	**Connector (female)** for cable Ø 8 mm	–	291 697-05
Connector on connecting cable for connection to subsequent electronics	**Connector (male)** for cable Ø 8 mm Ø 6 mm	–	291 697-08 291 697-07
Coupling on connecting cable	**Coupling (male)** for cable Ø 4.5 mm Ø 6 mm Ø 8 mm	–	291 698-14 291 698-03 291 698-04
Flange socket for mounting on the subsequent electronics	**Flange socket (female)**	–	315 892-08
Mounted couplings	**With flange (female)** Ø 6 mm Ø 8 mm	–	291 698-17 291 698-07
	With flange (male) Ø 6 mm Ø 8 mm	–	291 698-08 291 698-31
	With central fastening (male) Ø 6 to 10 mm	–	741 045-01
Adapter $\sim$ **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)		–	364 914-01

General electrical information

Power supply

Connect HEIDENHAIN encoders only to subsequent electronics whose power supply is generated from PELV systems **(EN 50 178)**. In addition, overcurrent protection and overvoltage protection are required in safety-related applications.

If HEIDENHAIN encoders are to be operated in accordance with IEC 61010-1, power must be supplied from a secondary circuit with current or power limitation as per IEC 61010-1:2001, section 9.3 or IEC 60950-1:2005, section 2.5 or a Class 2 secondary circuit as specified in UL1310.

The encoders require a **stabilized DC voltage U_P** as power supply. The respective *Specifications* state the required power supply and the current consumption. The permissible ripple content of the DC voltage is:
- High frequency interference $U_{PP} < 250$ mV with $dU/dt > 5$ V/µs
- Low frequency fundamental ripple $U_{PP} < 100$ mV

The values apply as measured at the encoder, i.e., without cable influences. The voltage can be monitored and adjusted with the encoder's **sensor lines.** If a controllable power supply is not available, the voltage drop can be halved by switching the sensor lines parallel to the corresponding power lines.

Calculation of the **voltage drop**:

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

where ΔU: Voltage drop in V
1.05: Length factor due to twisted wires
L_C: Cable length in m
I: Current consumption in mA
A_P: Cross section of power lines in mm^2

The voltage actually applied to the encoder is to be considered when **calculating the encoder's power requirement.** This voltage consists of the supply voltage U_P provided by the subsequent electronics minus the line drop in the power lines. For encoders with an expanded supply range, the voltage drop in the power lines must be calculated under consideration of the nonlinear current consumption (see next page).

If the voltage drop is known, all parameters for the encoder and subsequent electronics can be calculated, e.g. voltage at the encoder, current requirements and power consumption of the encoder, as well as the power to be provided by the subsequent electronics.

Switch-on/off behavior of the encoders
The output signals are valid no sooner than after switch-on time $t_{SOT} = 1.3$ s (2 s for PROFIBUS-DP) (see diagram). During time t_{SOT} they can have any levels up to 5.5 V (with HTL encoders up to U_{Pmax}). If an interpolation electronics unit is inserted between the encoder and the power supply, this unit's switch-on/off characteristics must also be considered. If the power supply is switched off, or when the supply voltage falls below U_{min}, the output signals are also invalid. During restart, the signal level must remain below 1 V for the time t_{SOT} before power on. These data apply to the encoders listed in the catalog—customer-specific interfaces are not considered.

Encoders with new features and increased performance range may take longer to switch on (longer time t_{SOT}). If you are responsible for developing subsequent electronics, please contact HEIDENHAIN in good time.

Isolation
The encoder housings are isolated against internal circuits.
Rated surge voltage: 500 V (preferred value as per VDE 0110 Part 1, overvoltage category II, contamination level 2)

Transient response of supply voltage and switch-on/switch-off behavior
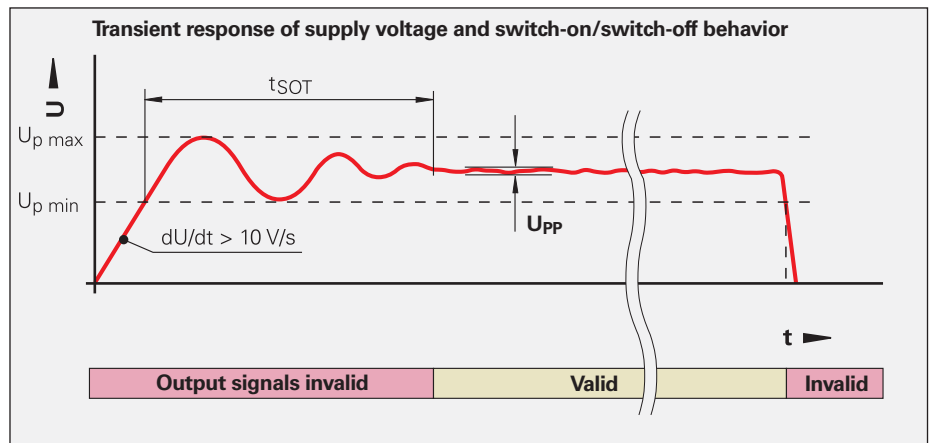
Cable	Cross section of power supply lines A_P			
	1 V_{PP}/TTL/HTL	11 µA_{PP}	EnDat/SSI 17-pin	EnDat[5] 8-pin
Ø 3.7 mm	0.05 mm^2	–	–	0.09 mm^2
Ø 4.3 mm	0.24 mm^2	–	–	–
Ø 4.5 mm EPG	0.05 mm^2	–	0.05 mm^2	0.09 mm^2
Ø 4.5 mm Ø 5.1 mm	0.14/0.09[2] mm^2 0.05[2), 3)] mm^2	0.05 mm^2	0.05/0.14[6] mm^2	0.14 mm^2
Ø 5.5 mm PVC	0.1 mm^2	–	–	–
Ø 6 mm Ø 10 mm[1]	0.19/0.14[2), 4)] mm^2	–	0.08/0.19[6] mm^2	0.34 mm^2
Ø 8 mm Ø 14 mm[1]	0.5 mm^2	1 mm^2	0.5 mm^2	1 mm^2

[1] Metal armor
[4] LIDA 400
[2] Rotary encoders
[5] Also Fanuc, Mitsubishi
[3] Length gauges
[6] RCN, LC adapter cable

Encoders with expanded supply voltage range

For encoders with expanded supply voltage range, the current consumption has a nonlinear relationship with the supply voltage. On the other hand, the power consumption follows a linear curve (see *Current and power consumption* diagram). The maximum power consumption at minimum and maximum supply voltage is listed in the **Specifications**. The maximum power consumption (worst case) accounts for:
• Recommended receiver circuit
• Cable length 1 m
• Age and temperature influences
• Proper use of the encoder with respect to clock frequency and cycle time

The typical current consumption at no load (only supply voltage is connected) for 5 V supply is specified.

The actual power consumption of the encoder and the required power output of the subsequent electronics are measured, while taking the voltage drop on the supply lines into consideration, in four steps:

Step 1: **Resistance of the supply lines**
The resistance values of the supply lines (adapter cable and encoder cable) can be calculated with the following formula:

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

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

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

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

Step 3: **Voltage drop based on the coefficients b and c**

$$\Delta U = -0.5 \cdot (b + \sqrt{b^2 - 4 \cdot c})$$

Where:
U_{Emax},
U_{Emin}: Minimum or maximum supply voltage of the encoder in V
P_{Emin},
P_{Emax}: Maximum power consumption at minimum or maximum power supply, respectively, in W
U_P: Supply voltage of the subsequent electronics in V

Step 4: **Parameters for subsequent electronics and the encoder**
Voltage at encoder:
$U_E = U_P - \Delta U$

Current requirement of encoder:
$I_E = \Delta U / R_L$

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

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

R_L: Cable resistance (for both directions) in ohms
ΔU: Voltage drop in the cable in V
1.05: Length factor due to twisted wires
L_C: Cable length in m
A_P: Cross section of power lines in mm^2

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

	Encoder cable/adapter cable	Connecting cable	Total
1	3 m	/	3 m
2	20 m	/	20 m
3	3 m	17 m	20 m
4	3 m	47 m	50 m
5	3 m	97 m	100 m
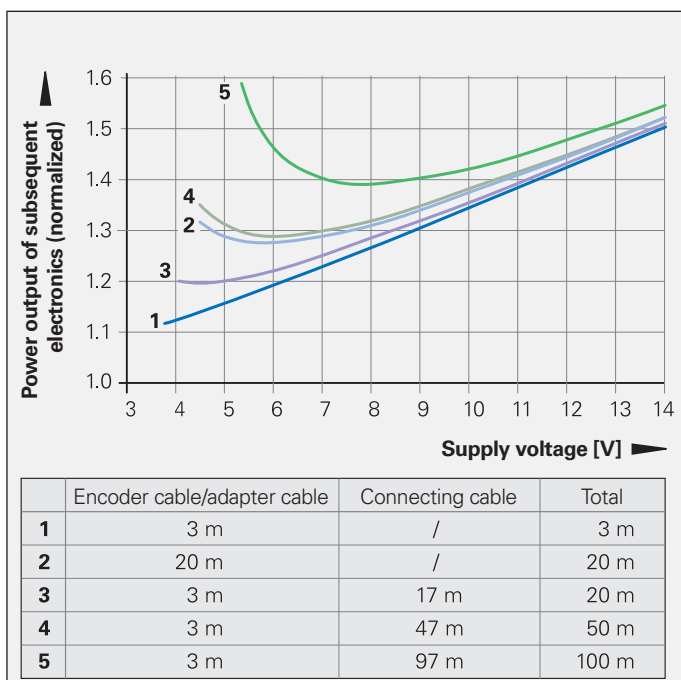
Current and power consumption with respect to the supply voltage (example representation)

Power consumption of encoder (normalized to value at 5 V)

Current requirement of encoder (normalized to value at 5 V)
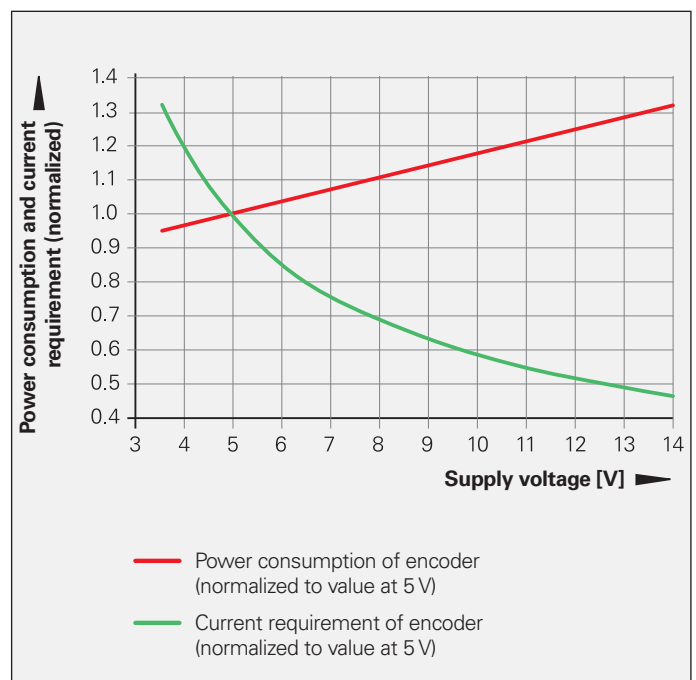
Electrically permissible speed/ traversing speed

The maximum permissible shaft speed or traversing velocity of an encoder is derived from

- the **mechanically** permissible shaft speed/traversing velocity (if listed in the *Specifications*) and
- the **electrically** permissible shaft speed/traversing velocity.
  For encoders with **sinusoidal output signals**, the electrically permissible shaft speed/traversing velocity is limited by the –3 dB/ –6 dB cutoff frequency or the permissible input frequency of the subsequent electronics.
  For encoders with **square-wave signals,** the electrically permissible shaft speed/traversing velocity is limited by
  – the maximum permissible scanning/output frequency f_{max} of the encoder, and
  – the minimum permissible edge separation a for the subsequent electronics.

For angle or rotary encoders

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

For linear encoders

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

Where:
- n_{max}: Elec. permissible speed in min^{-1}
- v_{max}: Elec. permissible traversing velocity in m/min
- f_{max}: Max. scanning/output frequency of encoder or input frequency of subsequent electronics in kHz
- z: Line count of the angle or rotary encoder per 360 °
- SP: Signal period of the linear encoder in µm

Cables

For safety-related applications, use HEIDENHAIN cables and connectors.

Versions
The cables of almost all HEIDENHAIN encoders and all adapter and connecting cables are sheathed in **polyurethane (PUR cables).** Many adapter cables for within motors and a few cables on encoders are sheathed in a **special elastomer (EPG).** Many adapter cables within the motor consist of TPE wires **(special thermoplastic)** in braided sleeving. Individual encoders feature cable with a sleeve of **polyvinyl chloride (PVC).** This cables are identified in the catalog as EPG, TPE or PVC.

Durability
PUR cables are resistant to oil and hydrolysis in accordance with **VDE 0472** (Part 803/test type B) and resistant to microbes in accordance with **VDE 0282** (Part 10). They are free of PVC and silicone and comply with UL safety directives. The **UL certification** "AWM STYLE 20963 80 °C 30 V E63216" is documented on the cable.
EPG cables are resistant to oil in accordance with **VDE 0472** (Part 803/test type B) and to hydrolysis in accordance with **VDE 0282** (Part 10). They are free of PVC, silicone and halogens. In comparison with PUR cables, they are only somewhat resistant to media, frequent flexing and continuous torsion.
PVC cables are oil resistant. The UL certification "AWM E64638 STYLE20789 105C VW-1SC NIKKO" is documented on the cable.
TPE wires with braided sleeving are oil resistant and highly flexible.
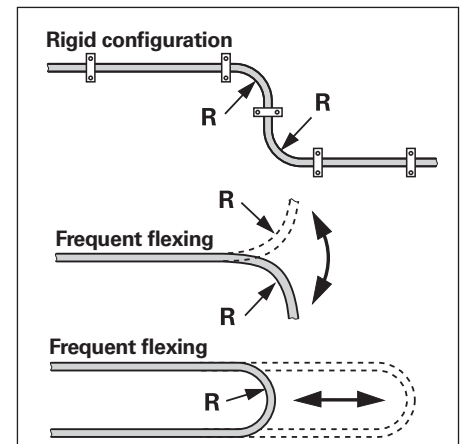
Temperature range

	Rigid configuration	Frequent flexing
PUR	–40 to 80 °C	–10 to 80 °C
EPG TPE	–40 to 120 °C	–
PVC	–20 to 90 °C	–10 to 90 °C

PUR cables with limited resistance to hydrolysis and microbes are rated for up to 100 °C. If needed, please ask for assistance from HEIDENHAIN Traunreut.

Lengths
The **cable lengths** listed in the *Specifications* apply only for HEIDENHAIN cables and the recommended input circuitry of subsequent electronics.

Cable	Bend radius R	
	Rigid configuration	**Frequent flexing**
Ø 3.7 mm	≥ 8 mm	≥ 40 mm
Ø 4.3 mm	≥ 10 mm	≥ 50 mm
Ø 4.5 mm EPG	≥ 18 mm	–
Ø 4.5 mm Ø 5.1 mm Ø 5.5 mm PVC	≥ 10 mm	≥ 50 mm
Ø 6 mm Ø 10 mm[1]	≥ 20 mm ≥ 35 mm	≥ 75 mm ≥ 75 mm
Ø 8 mm Ø 14 mm[1]	≥ 40 mm ≥ 100 mm	≥ 100 mm ≥ 100 mm

[1] Metal armor

Noise-free signal transmission

Electromagnetic compatibility/CE compliance

When properly installed, and when HEIDENHAIN connecting cables and cable assemblies are used, HEIDENHAIN encoders fulfill the requirements for electromagnetic compatibility according to 2004/108/EC with respect to the generic standards for:

- **Noise immunity EN 61000-6-2:**
  Specifically:
  – ESD   EN 61000-4-2
  – Electromagnetic fields   EN 61000-4-3
  – Burst   EN 61000-4-4
  – Surge   EN 61000-4-5
  – Conducted disturbances EN 61000-4-6
  – Power frequency
    magnetic fields   EN 61000-4-8
  – Pulse magnetic fields   EN 61000-4-9
- **Interference EN 61000-6-4:**
  Specifically:
  – For industrial, scientific and medical
    equipment (ISM)   EN 55011
  – For information
    technology equipment   EN 55022

Transmission of measuring signals— electrical noise immunity

Noise voltages arise mainly through capacitive or inductive transfer. Electrical noise can be introduced into the system over signal lines and input or output terminals.
Possible sources of noise include:
- Strong magnetic fields from transformers, brakes and electric motors
- Relays, contactors and solenoid valves
- High-frequency equipment, pulse devices, and stray magnetic fields from switch-mode power supplies
- AC power lines and supply lines to the above devices

Protection against electrical noise

The following measures must be taken to ensure disturbance-free operation:
- Use only original HEIDENHAIN cables. Consider the voltage drop on supply lines.
- Use connecting elements (such as connectors or terminal boxes) with metal housings. Only the signals and power supply of the connected encoder may be routed through these elements. Applications in which additional signals are sent through the connecting element require specific measures regarding electrical safety and EMC.

- Connect the housings of the encoder, connecting elements and subsequent electronics through the shield of the cable. Ensure that the shield has complete contact over the entire surface (360°). For encoders with more than one electrical connection, refer to the documentation for the respective product.
- For cables with multiple shields, the inner shields must be routed separately from the outer shield. Connect the inner shield to 0 V of the subsequent electronics. Do not connect the inner shields with the outer shield, neither in the encoder nor in the cable.
- Connect the shield to protective ground as per the mounting instructions.
- Prevent contact of the shield (e.g. connector housing) with other metal surfaces. Pay attention to this when installing cables.
- Do not install signal cables in the direct vicinity of interference sources (inductive consumers such as contactors, motors, frequency inverters, solenoids, etc.).
  – Sufficient decoupling from interference-signal-conducting cables can usually be achieved by an air clearance of 100 mm or, when cables are in metal ducts, by a grounded partition.
  – A minimum spacing of 200 mm to inductors in switch-mode power supplies is required.
- If compensating currents are to be expected within the overall system, a separate equipotential bonding conductor must be provided. The shield does not have the function of an equipotential bonding conductor.
- Only provide power from PELV systems **(EN 50178)** to position encoders. Provide high-frequency grounding with low impedance **(EN 60204-1 Chap. EMC)**.
- For encoders with 11 µAPP interface: For extension cables, use only HEIDENHAIN cable ID 244955-01. Overall length: max. 30 m.
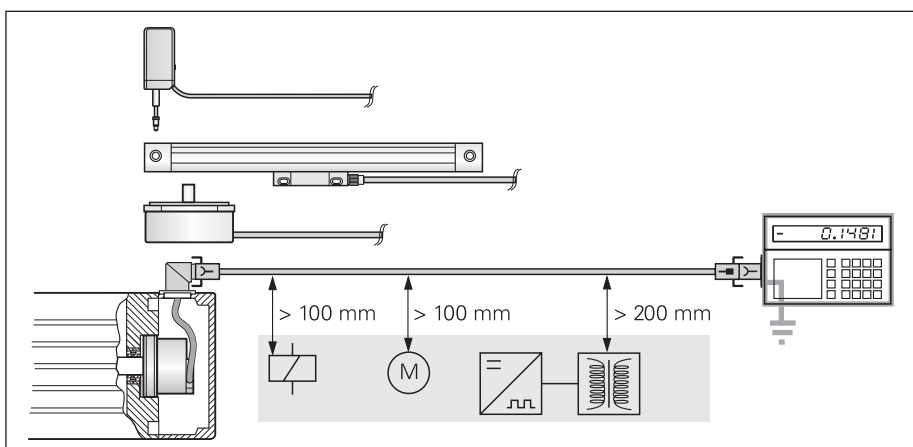
Minimum distance from sources of interference

HEIDENHAIN measuring equipment

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

	PWT 10	PWT 17	PWT 18
Encoder input	$\sim$ 11 µA$_{PP}$	$\sqcap\sqcup$ TTL	$\sim$ 1 V$_{PP}$
Functions	Measurement of signal amplitude Wave-form tolerance Amplitude and position of the reference mark signal		
Power supply	Via power supply unit (included)		
Dimensions	114 mm x 64 mm x 29 mm		

PWM 20

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

	PWM 20
Encoder input	• EnDat 2.1 or EnDat 2.2 (absolute value with/without incremental signals) • DRIVE-CLiQ • Fanuc Serial Interface • Mitsubishi High Speed Serial Interface • SSI • V$_{PP}$/TTL/11 µA$_{PP}$
Interface	USB 2.0
Power supply	100 to 240 V AC or 24 V DC
Dimensions	258 mm x 154 mm x 55 mm

	ATS
Languages	Choice between English or 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	PC (dual-core processor; > 2 GHz); RAM > 1 GB; Windows operating systems XP, Vista, 7 (32-bit/64-bit); 100 MB free space on hard disk

Accessories

EIB 1500

The EIB 1500 external interface box is an interpolation and digitizing unit for digital calculation of the positions of two scanning heads on rotational incremental HEIDENHAIN encoders. Absolute position values are available at the output once the reference marks are traversed. The high interpolation (with some encoders up to 16384-fold) also enables their use in speed control loops.

Specifications	EIB 1512	EIB 1592 F	EIB 1592 M
Input	Incremental signals $\sim$ 1 V$_{PP}$		
Output	EnDat 2.2	Fanuc Serial Interface	Mitsubishi High Speed Serial Interface
Ordering designation	EnDat 22	Fanuc 02	Mit02-4
Subdivision	≤ 16384-fold (depending on the encoder)		
Power supply	3.6 to 14 V DC		

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