HEIDENHAIN

Angle Encoders

Angle encoders with integral bearing and integrated stator coupling

Angle encoders with integral bearing for separate shaft coupling

Angle encoders without integral bearing

Information on
• Rotary encoders
• Encoders for servo drives
• Exposed linear encoders
• Sealed linear encoders
• HEIDENHAIN subsequent electronics
• HEIDENHAIN controls
is available on request as well as on the Internet under *www.heidenhain.de*.

Content

HEIDENHAIN Angle Encoders

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

In contrast, rotary encoders are encoders that typically have an accuracy of more than ± 10″.

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 of lathes
- Measuring machines for gears
- Printing units of printing machines
- Spectrometers
- Telescopes

etc.

The tables on the following pages list different types of angle encoders to suit the various applications and meet different requirements.
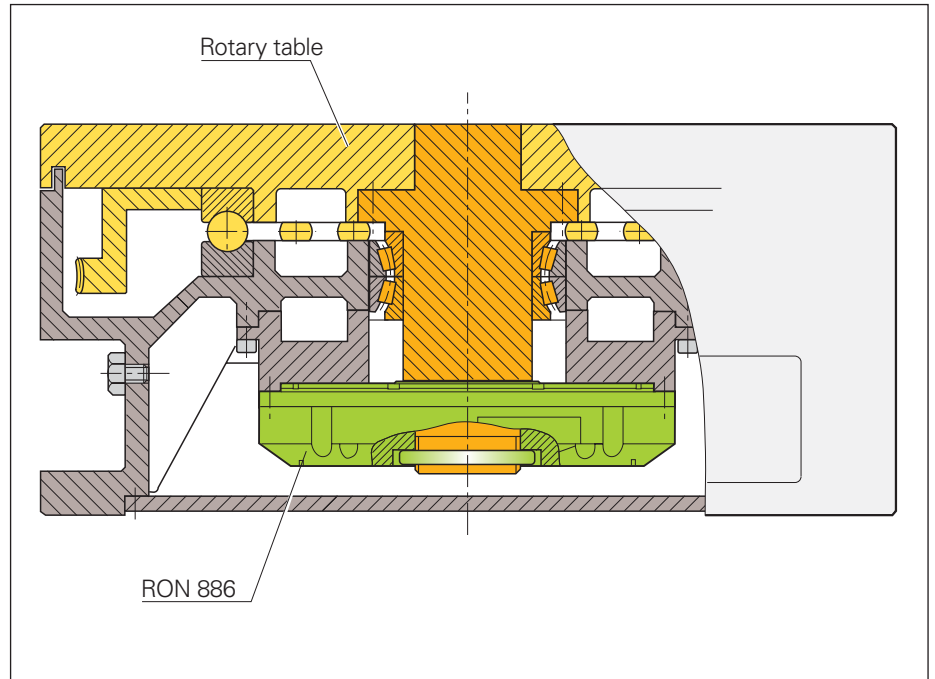
The **RON 886** angle encoder mounted onto the rotary table of a machine tool

Angle encoders can have one of three different mechanical designs:

Angle encoders with integral bearing, hollow shaft and integrated stator coupling

Because of the design and mounting of the stator coupling, it must only absorb that torque caused by friction in the bearing during angular acceleration of the shaft. **RCN, RON** and **RPN** angle encoders therefore provide excellent dynamic performance. With an integrated stator coupling, the stated system accuracy also includes the deviations from the shaft coupling.

Other advantages:
- Compact size for limited installation space
- Hollow shaft diameters up to 100 mm for leading power cables, etc.
- Simple installation

Selection Guide on pages 6/7

RON 886 incremental angle encoder

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

Angle encoders with integral bearing, for separate shaft coupling
ROD angle encoders with solid shaft are particularly suited to applications where higher shaft speeds and larger mounting tolerances are required. The shaft couplings allow axial tolerances of ± 1 mm.

Selection Guide on pages 6/7

ERA 180 incremental angle encoder

Angle Encoders without integral bearing
The **ERP, ERO** and **ERA** angle encoders without integral bearing (modular angle encoders) are intended for integration in machine elements or apparatuses. They are designed to meet the following requirements:
• Large hollow shaft diameter (up to 10 m with a scale tape)
• High shaft speeds up to 40 000 rpm
• No additional starting torque from shaft seals
• Segment angles

Selection Guide on pages 8/9

Selection Guide
Angle Encoders with Integral Bearing

Series	Overall dimensions in mm	System accuracy	Recommended meas. step[1]	Mechanically perm. speed	Incremental signals	Signal periods/rev
With integrated stator coupling						
RCN 200 **RON 200**		± 5″ ± 2.5″	0,0001°	3000 rpm	∿ 1 Vpp	16 384
					–	–
					–	–
		± 5″	0.005°		⊓⊔ TTL	18 000[2]
			0.001°/0.0005°		⊓⊔ TTL	180 000/90 000[2]
			0.0001°		∿ 1 Vpp	9000
		± 2.5″			∿ 1 Vpp	18 000
RCN 700 **RON 700**	 D = 60 mm D = 100 mm for RCN 7xx (F) RCN 8xx (F)	± 2″	0.0001°	1000 rpm	∿ 1 Vpp	18 000
					∿ 1 Vpp	32 768
					–	–
					–	–
					–	–
					∿ 1 Vpp	18 000/36 000
RCN 800 **RON 800** **RPN 800**		± 1″	0.00005°		∿ 1 Vpp	32 768
					–	–
					–	–
					–	–
					∿ 1 Vpp	36 000
			0.00001°		∿ 1 Vpp	180 000
RON 900		± 0.4″	0.00001°	100 rpm	∿ 11 µApp	36 000
For separate shaft coupling						
ROD 200		± 5″	0.005°	10 000 rpm	⊓⊔ TTL	18 000
			0.0005°		⊓⊔ TTL	180 000[2]
			0.0001°		∿ 1 Vpp	18 000
ROD 700		± 2″	0.0001°	1000 rpm	∿ 1 Vpp	18 000/36 000
ROD 800		± 1″	0.00005°		∿ 1 Vpp	36 000

Absolute position values	Absolute positions per revolution	Model	Page
EnDat 2.1/01	67 108 864 ≙ 26 bits	**RCN 226**	**28**
Fanuc01	8 388 608 ≙ 23 bits	**RCN 223 F**	
Mitsu01	8 388 608 ≙ 23 bits	**RCN 223 M**	
–	–	**RON 225**	**30**
–	–	**RON 275**	
–	–	**RON 285**	
–	–	**RON 287**	
–	–	**RON 785**	**32**
EnDat 2.2/02	536 870 912 ≙ 29 bits	**RCN 729**	**34/36**
EnDat 2.2/22	536 870 912 ≙ 29 bits	**RCN 729**	
Fanuc02	134 217 728 ≙ 27 bits	**RCN 727 F**	
Mitsu01	8 388 608 ≙ 23 bits	**RCN 723 M**	
–	–	**RON 786**	**38**
EnDat 2.2/02	536 870 912 ≙ 29 bits	**RCN 829**	**34/36**
EnDat 2.2/22	536 870 912 ≙ 29 bits	**RCN 829**	
Fanuc02	134 217 728 ≙ 27 bits	**RCN 827 F**	
Mitsu01	8 388 608 ≙ 23 bits	**RCN 823 M**	
–	–	**RON 886**	**38**
–	–	**RPN 886**	
–	–	**RON 905**	**40**
–	–	**ROD 260**	**42**
–	–	**ROD 270**	
–	–	**ROD 280**	
–	–	**ROD 780**	**44**
–	–	**ROD 880**	

RON 285

RON 786

RON 905

ROD 285
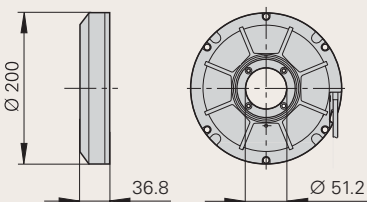
ROD 780

[1] For position capture
[2] With integrated interpolation

Selection Guide
Angle Encoders without Integral Bearing

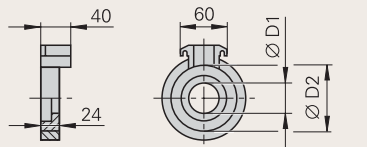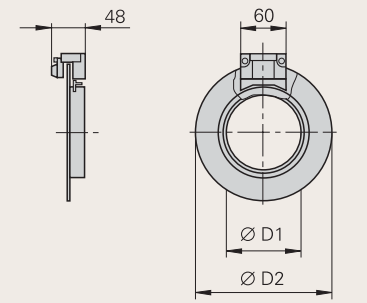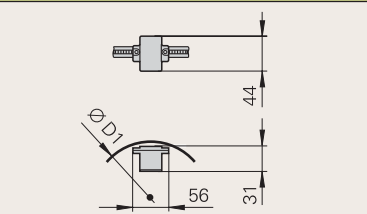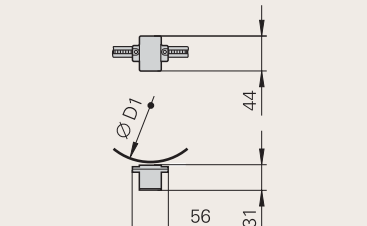| Series	Overall dimensions in mm	Diameter D1/D2	Line count/ System accuracy[1]	Recommended meas. step[3]	Mechanically perm. speed
Grating on solid scale carrier					
ERP 880 Glass disk with interferential grating	Ø 200 36.8 Ø 51.2	–	90 000/± 1″ [1] (180 000 signal periods)	0.000 01°	≤ 1000 rpm
ERA 180 Steel drum with axial grating	40 60 24 Ø D1 Ø D2	D1: 40 to 512 mm D2: 80 to 562 mm	6 000/± 7.5″ to 36 000/± 2.5″ [1]	0.001 5° to 0.000 1°	≤ 40 000 rpm to ≤ 6 000 rpm
ERO 785 Glass disk with radial grating	48 60 Ø D1 Ø D2	D1: 47 mm D2: 129.9 mm	36 000/± 4.2″ to ± 2.2″ [1]	0.000 1°	≤ 8 000 rpm
		D1: 102 mm D2: 182 mm			≤ 6 000 rpm
		D1: 155,1 mm D2: 256.9 mm			≤ 4 000 rpm
Grating on steel tape					
ERA 700 For inside diameter mounting	44 Ø D1 56 31	458.62 mm 573.20 mm 1146.10 mm	**Full circle**[1] 36 000/± 3.5″ 45 000/± 3.4″ 90 000/± 3.2	0.000 1° to 0.000 02°	≤ 500 rpm
		318.58 mm 458.62 mm 573.20 mm	**Segment**[2] 5 000 10 000 20 000		
ERA 800 For outside diameter mounting	44 Ø D1 56 31	458.04 mm 572.63 mm	**Full circle**[1] 36 000/± 3.5″ 45 000/± 3.4″	0.000 1° to 0.000 05°	≤ 100 rpm
		317.99 mm 458.04 mm 572.63 mm	**Segment**[2] 5 000 10 000 20 000		

[1] Without installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft are not included.
[2] Angular segment from 50° to 200°; see *Measuring Accuracy* for the accuracy.
[3] For position capture.

Incremental signals	Reference marks	Model	Page
$\sim$ 1 V$_{PP}$	One	**ERP 880**	**46**
$\sim$ 1 V$_{PP}$	One	**ERA 180**	**48**
$\sim$ 1 V$_{PP}$	One	**ERO 785**	**52**
$\sim$ 1 V$_{PP}$	Distance-coded (nominal increment of 1000 grating periods)	**ERA 780 C** full circle	**54**
		ERA 781 C segment	
$\sim$ 1 V$_{PP}$	Distance-coded (nominal increment of 1000 grating periods)	**ERA 880 C** full circle	**56**
		ERA 881 C segment with tensioning elements	
		ERA 882 C segment without tensioning elements	

ERP 880

ERA 180

ERO 785

ERA 880

Measuring Principles
Measuring Standard

HEIDENHAIN encoders incorporate measuring standards of periodic structures known as graduations.
These graduations are applied to a glass or steel substrate. Glass scales are used primarily in encoders for speeds up to 10 000 rpm. For higher speeds—up to 40 000 rpm—steel drums are used. The scale substrate for large diameters is a steel tape.

These precision graduations are manufactured in various photolithographic processes. Graduations are fabricated from:
• extremely hard chromium lines on glass or gold-plated steel drums,
• matte-etched lines on gold-plated steel tape, or
• three-dimensional structures etched into quartz glass.

These photolithographic manufacturing processes—DIADUR and AURODUR—developed by HEIDENHAIN produce grating periods of:
• 40 µm with AURODUR, and
• 10 µm with DIADUR, and
• 4 µm with etched quartz glass

These processes permit very fine grating periods and are characterized by a high definition and homogeneity of the line edges. Together with the photoelectric scanning method, this high edge definition is a precondition for the high quality of the output signals.

The master graduations are manufactured by HEIDENHAIN on custom-built high-precision ruling machines.

Absolute Measuring Method

Absolute encoders feature multiple coded graduation tracks. The code arrangement provides the absolute position information, which is available immediately after restarting the machine. The track with the finest grating structure is interpolated for the position value and at the same time is used to generate an incremental signal (see *EnDat Interface*).
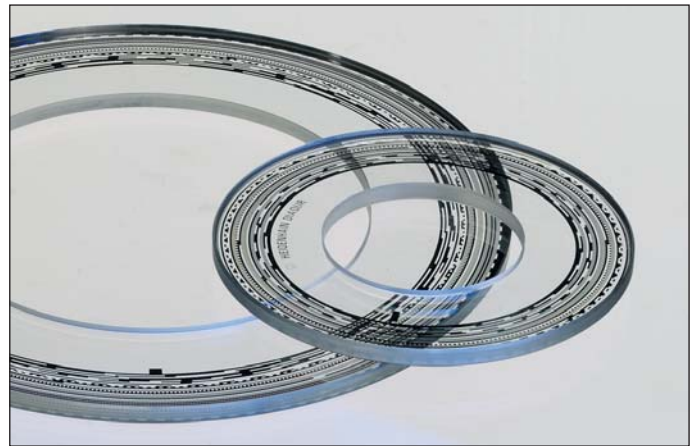
Circular graduations of absolute angle encoders
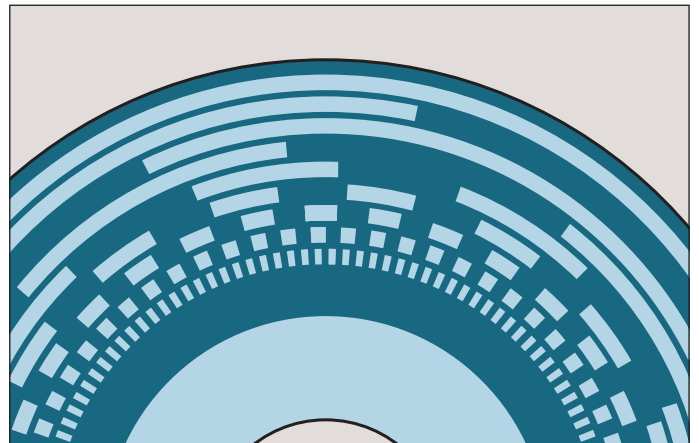
Schematic representation of a circular scale with absolute grating

Incremental Measuring Method

With **incremental measuring methods,** the graduation consists of a periodic grating structure. The position information is obtained **by counting** the individual increments (measuring steps) from some point of origin. Since an absolute reference is required to ascertain positions, the scales or scale tapes are provided with an additional track that bears a **reference mark.** The absolute position on the scale, established by the reference mark, is gated with exactly one measuring step. The reference mark must therefore be scanned to establish an absolute reference or to find the last selected datum.

In some cases, however, this may require a rotation up to nearly 360°. To speed and simplify such "reference runs," many encoders feature **distance-coded reference marks**—multiple reference marks that are individually spaced according to a mathematical algorithm. The subsequent electronics find the absolute reference after traversing two successive reference marks—meaning only a few degrees of traverse (see nominal increment I in the table).
Encoders with distance-coded reference marks are identified with a "C" behind the model designation (e. g. RON 786 C).

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

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

and:

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

and:

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

abs = Absolute value

sgn = Sign function ("+1" or "–1")

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

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

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

D = Direction of rotation (+1 or –1) Rotation to the right (as seen from the shaft side of the angle encoder—see Mating Dimensions) gives "+1"

Line count z	Number of reference marks	Nominal increment I
90 000	180	4°
45 000	90	8°
36 000	72	10°
18 000	36	20°
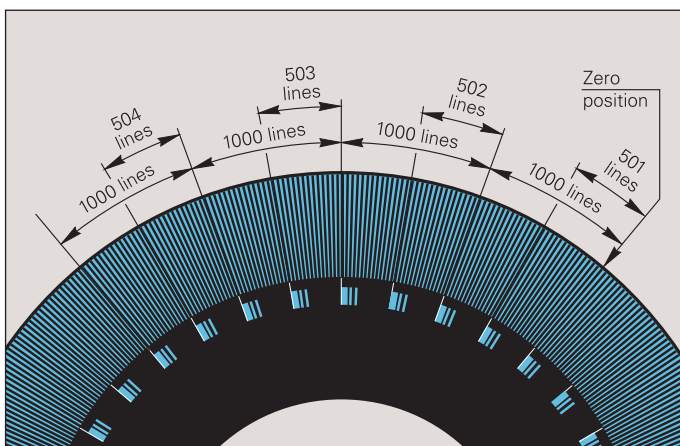
Schematic representation of a circular scale with distance-coded reference marks
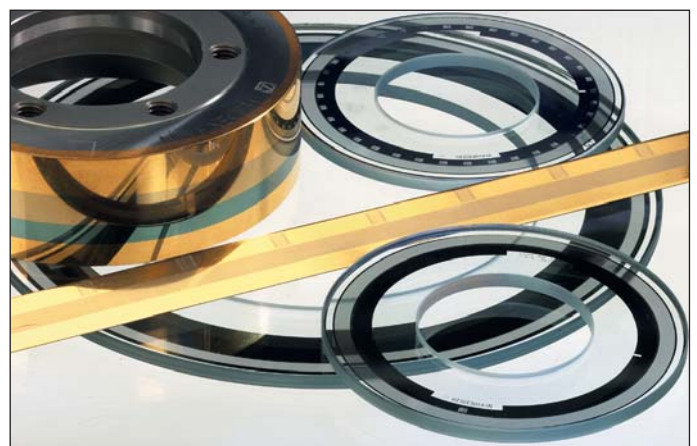
Circular graduations of incremental angle encoders

11

Scanning the Measuring Standard
Photoelectric Scanning

Most HEIDENHAIN encoders operate using the principle of photoelectric scanning. The photoelectric scanning of a measuring standard is contact-free, and therefore without wear. This method detects even very fine lines, no more than a few microns wide, and generates output signals with very small signal periods.

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

- The **imaging scanning principle** for grating periods from 10 μm to approx. 40 μm.
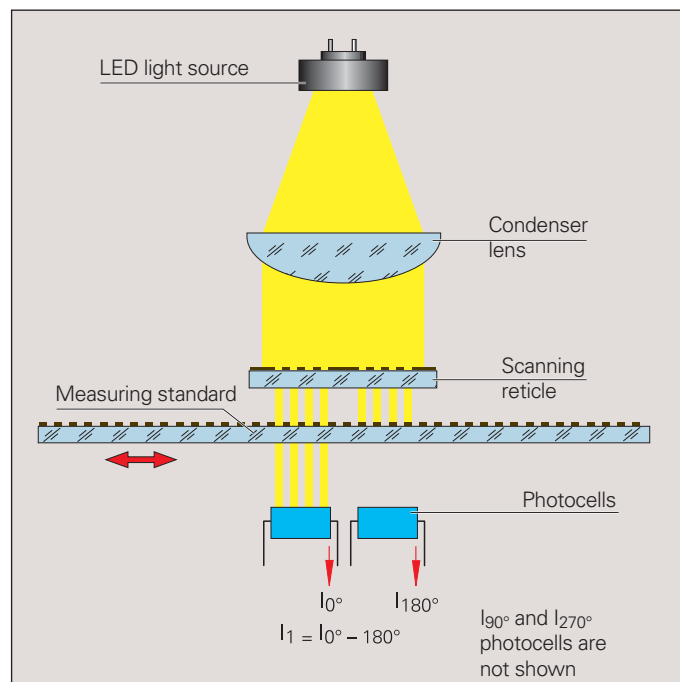- The **interferential scanning principle** for very fine graduations with grating periods of 4 μm.

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

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

The RCN, RON, ROD, ERA and ERO angle encoders operate according to the imaging scanning principle.

Imaging scanning principle

LED light source

Condenser lens

Scanning reticle

Measuring standard

Photocells

$I_{0°}$ $I_{180°}$

$I_1 = I_{0°} - 180°$

$I_{90°}$ and $I_{270°}$ photocells are not shown

Interferential scanning principle

The interferential scanning principle exploits the diffraction and interference of light on a fine graduation to produce signals used to measure displacement.

A step grating is used as the measuring standard: reflective lines 0.2 μm high are applied to a flat, reflective surface. In front of that is the scanning reticle—a transparent phase grating with the same grating period as the scale.

When a light wave passes through the scanning reticle, it is diffracted into three partial waves of the orders –1, 0, and +1, with approximately equal luminous intensity. The waves are diffracted by the scale such that most of the luminous intensity is found in the reflected diffraction orders +1 and –1.

These partial waves meet again at the phase grating of the scanning reticle where they are diffracted again and interfere. This produces essentially three waves that leave the scanning reticle at different angles. Photovoltaic cells convert this alternating light intensity into electrical signals.

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

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

The RPN 886 and ERP 880 angle encoders operate according to the interferential scanning principle.

Interferential scanning principle (optics schematics)
C   Grating period
Ψ   Phase shift of the light wave when passing through the scanning reticle
Ω   Phase shift of the light wave due to motion X of the scale
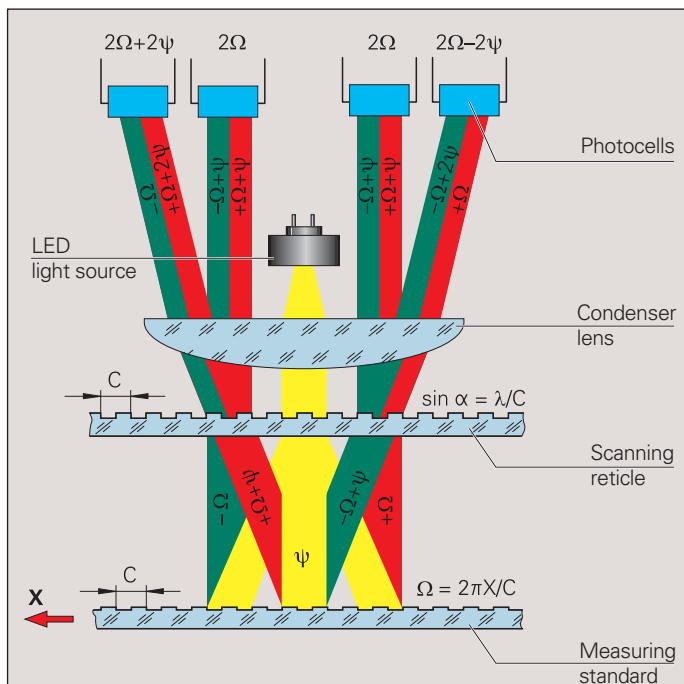
Measuring Accuracy

The accuracy of angular measurement is mainly determined by:
1. Quality of the graduation
2. Quality of the scanning process
3. Quality of the signal processing electronics
4. Eccentricity of the graduation to the bearing
5. Radial runout of the bearing
6. Elasticity of the encoder shaft and its coupling with the drive shaft
7. The elasticity of the stator coupling (RCN, RON, RPN) or shaft coupling (ROD)

In positioning tasks, the accuracy of the angular measurement determines the accuracy of the positioning of a rotary axis. The **system accuracy** given in the *Specifications* is defined as follows: *The extreme values of the total deviations of a position are—referenced to their mean value—within the system accuracy ± a.* They are ascertained during the final inspection, and are indicated on the calibration chart.
- For angle encoders with integral bearing and integrated stator coupling, this value also includes the deviation due to the shaft coupling.

- For angle encoders with integral bearing and separate shaft coupling, the angle error of the coupling must be added (see *Mechanical Design Types and Mounting — ROD*).
- For angle encoders without integral bearing, additional deviations resulting from mounting, errors in the bearing of the drive shaft, and adjustment of the scanning head must be expected (see *Measuring Accuracy — Angle Encoders without Integral Bearing*). These deviations are not reflected in the system accuracy.

The system accuracy reflects position deviations within one revolution as well as those within one signal period.

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

Position deviations within one signal period already become apparent in very small angular motions and in repeated measurements. They especially lead to speed ripples in the speed control loop. These deviations within one signal period are caused by the quality of the sinusoidal

scanning signals and their subdivision. The following factors influence the result:
- The size of the signal period,
- The homogeneity and edge definition of the graduation,
- The quality of the optical filter structures on the scanning reticle,
- The characteristics of the photoelectric detectors, and
- The stability and dynamics during the further processing of the analog signals.

HEIDENHAIN angle encoders take these factors of influence into account, and permit interpolation of the sinusoidal output signal with subdivision accuracies of better than ± 1% of the signal period (RPN/ERP: ± 1.5%). The reproducibility is even better, meaning that useful electric subdivision factors and small signal periods permit small enough measuring steps (see *Specifications*).

Example:
Angle encoder with 36 000 sinusoidal signal periods per revolution
One signal period corresponds to 0.01° or 36″. At a signal quality of ± 1%, this results in maximum position deviations within one signal period of approx. ± 0.0001° or ± 0.36″.

Position deviations within one revolution

Position deviation within one signal period

Position deviations within one signal period
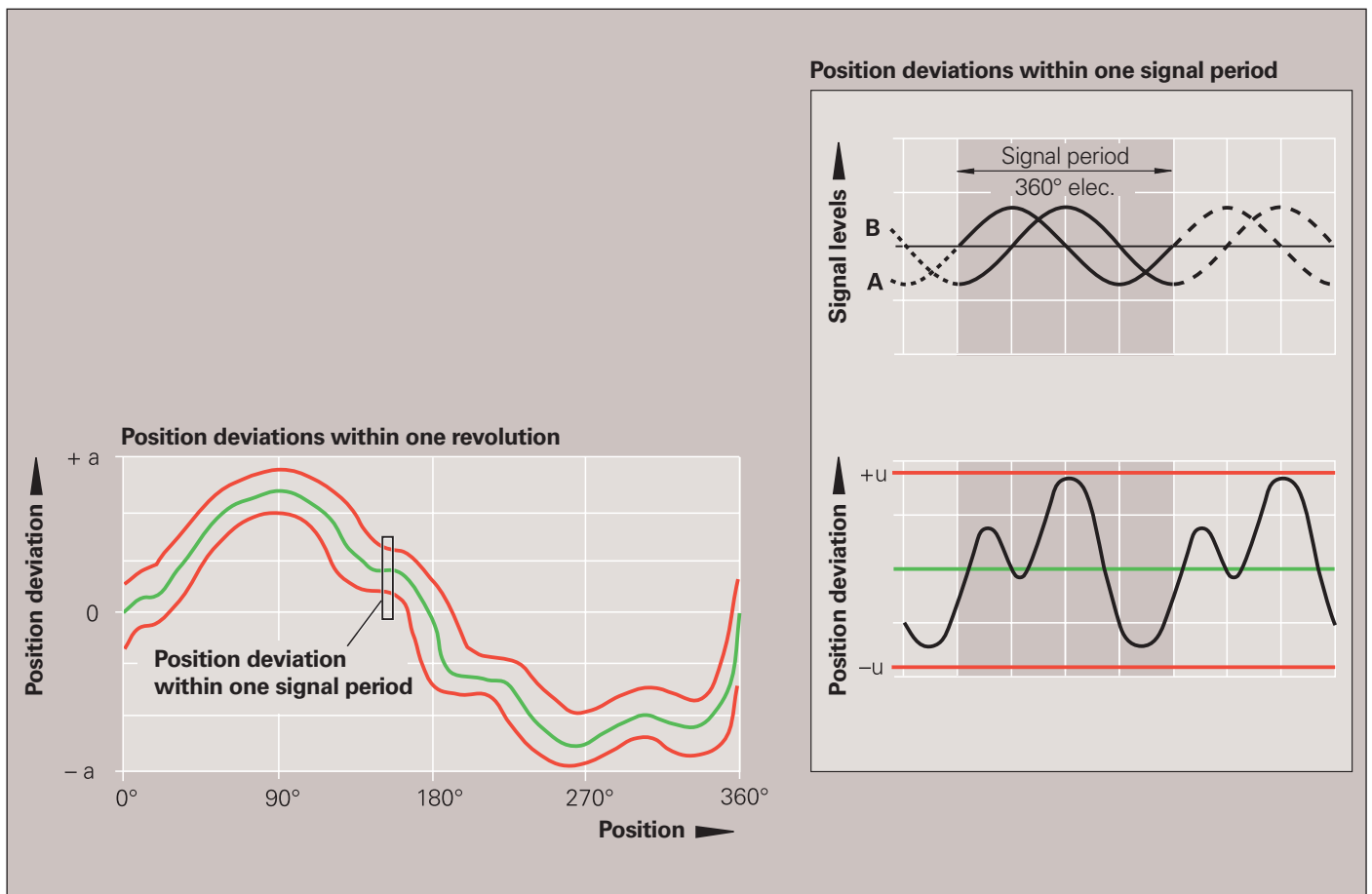
Angle Encoders with Integral Bearing

For its angle encoders with integral bearings, HEIDENHAIN prepares individual calibration charts and ships them with the encoder.
The calibration chart documents the encoder's accuracy and serves as a traceability record to a calibration standard. For the RCN, RON and RPN, which feature an integrated coupling, the accuracy specifications already include the error of the coupling. For angle encoders with separate shaft coupling, however, the error caused by the coupling is not included in the encoder specification and must be added to calculate the total error (see *Kinematic transfer error* under *Mechanical Design Types and Mounting – ROD*).

The accuracy of angle encoders is ascertained through five forward and five backward measurements. The measuring positions per revolution are chosen to determine very exactly not only the long-range error, but also the position error within one signal period.

All measured values determined in this manner lie within or on the graphically depicted **envelope curve**. The **mean value curve** shows the arithmetic mean of the measured values, whereby the reversal error is not included.

The **reversal error** depends on the shaft coupling. On angle encoders with integral stator coupling it is determined at ten measuring positions in forward and backward steps. The maximum value and

arithmetic mean are documented on the calibration chart.
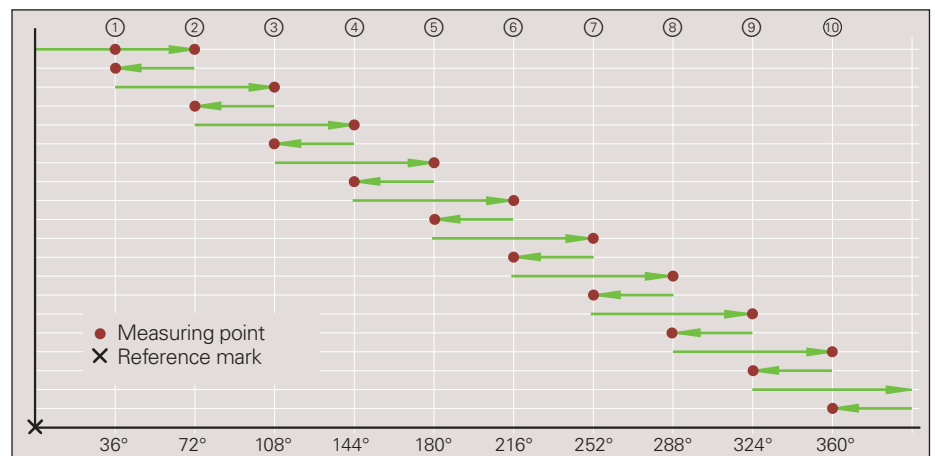The following limits apply to the reversal error:
RCN/RON 2xx: Max. 0.6″
RCN/RON 7xx: Max. 0.4″
RCN/RON/RPN 8xx: Max. 0.4″

The **manufacturer's inspection certificate** certifies the accuracy of the encoder. The **calibration standard** is indicated in order to certify the traceability to the national standard.

Calibration chart example: RON 285
1 Graphic representation of error
 • Envelope curve
 • Mean value curve
2 Results of calibration

Determination of the reversal error with forward and backward measurements

- Measuring point
- × Reference mark

Messprotokoll / Calibration Chart — RON 285 18000
Id.Nr.: 358 699-07
S.Nr.: 12 211 342

| Strichzahl / Line count: | 18000 | Umkehrspanne / Mechanical hysteresis | | Unsicherheit der Messmaschine / Uncertainty of measuring machine: 0.05″ |
| Positionsabweichung / Position error | | Mittelwert / Mean value: | 0.22 ″ | Messgeschwindigkeit / Measuring velocity: 6.66 min⁻¹ |

Position error values:
Mittelwert / Mean value: ± 1.57 ″
In einer Signalperiode / Within signal period: ± 0.47 ″
Maximum / Maximum: 0.34 ″
Bezugstemperatur / Reference temerature: 22 °C

Guaranteed accuracy grade of the measured object

Prüfer / Inspected by
BARTLECHNER A.   19.05.2005

Die Messkurve zeigt Mittelwerte und Extremwerte der Positionsabweichung aus 5 Vor- und Rückwärtsmessungen ohne Umkehrspanne.
Positionsabweichung Δφ des Messgerätes: Δφ = φS - φM
(φS = Messposition des Vergleichsnormals, φM = Messposition des Prüflings)
Anzahl der Messpositionen pro Umdrehung: **2560**
Die Umkehrspanne wird an 10 Messpositionen im Schrittzyklus ermittelt.

The error curve shows the mean and extreme values of the position error from five measurements in forward and backward direction without mechanical hysteresis.
Position error Δφ of the encoder: Δφ = φS - φM
(φS = position measured by the reference standard, φM = position measured by the measured encoder)
Number of measurement positions per revolution: **2560**
The mechanical hysteresis is determined at 10 measurement positions in a step cycle.

| Hersteller-Prüfzertifikat (DIN 55 350-18-4.2.2) | | Manufacturer's Inspection Certificate (DIN 55 350-18-4.2.2) | |
| Dieses Gerät wurde unter strengen HEIDENHAIN-Qualitätsnormen hergestellt und geprüft. Die Positionsabweichung liegt innerhalb der Genauigkeitsklasse ± 5 ″. | Kalibriernormal ERP 880 TK
Kalibrierzeichen 50-DKD-K-12901
Kalibrierdatum 02-03 | This unit has been manufactured and inspected in accordance with the stringent quality standards of HEIDENHAIN. The position error lies within the accuracy grade ± 5 ″. | Calibration standard ERP 880 TK
Calibration number 50-DKD-K-12901
Calibration date 02-03 |

Measuring Accuracy
Angle Encoders without Integral Bearing

In addition to the system accuracy, the mounting and adjustment of the scanning head normally have a significant effect on the accuracy that can be achieved with angle encoders without integral bearings. Of particular importance are the mounting eccentricity and radial runout of the measured shaft.

To evaluate the **accuracy of modular angle encoders without integral bearing** (ERA and ERO), each of the significant errors must be considered individually.

1. Directional deviations of the graduation

ERA 180 and ERO: The extreme values of the directional deviation with respect to their mean value are shown in the *Specifications* as the graduation accuracy for each model. The graduation accuracy and the position error within a signal period comprise the system accuracy.

ERA 700 and ERA 800 series
The extreme values of the directional deviations depend on
- the graduation accuracy,
- the irregular scale-tape expansion during mounting, and
- deviations in the scale-tape butt joints (only for ERA 780 C/ERA 880 C).

The special graduation manufacturing process and the butt joints precisely machined by HEIDENHAIN reduce directional deviations of the graduation to within 3 to 5 angular seconds (with accurate mounting).

ERA 781 C, ERA 881 C, ERA 882 C
In these segment solutions, the additional angular error $\Delta\varphi$ occurs when the nominal scale-tape bearing-surface diameter is not exactly maintained:

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

where
$\Delta\varphi$ = Segment deviation in angular seconds
φ = Segment angle in degrees
D = Nominal scale-tape carrier diameter
D' = Actual scale-tape carrier diameter

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

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

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

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

2. Error due to eccentricity of the graduation to the bearing
Under normal circumstances the bearing will have a certain amount of radial runout or shape deformation after the disk/hub assembly (ERO), circumferential-scale drum (ERA 180) or scale tape (ERA 78xC and ERA 88xC) is mounted. When centering using the centering collar of the hub or the drum, please note that HEIDENHAIN guarantees an eccentricity of the graduation to the centering collar of under 1 µm. For the modular angle encoders, this accuracy value presupposes a diameter deviation of zero between the encoder shaft and the „master shaft." If the centering collar is centered on the bearing, then in a worst-case situation both eccentricity vectors could be added together.

The following relationship exists between the eccentricity *e,* the mean graduation diameter *D* and the measuring error $\Delta\varphi$ (see illustration below):

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

$\Delta\varphi$ = Measuring error in " (angular seconds)
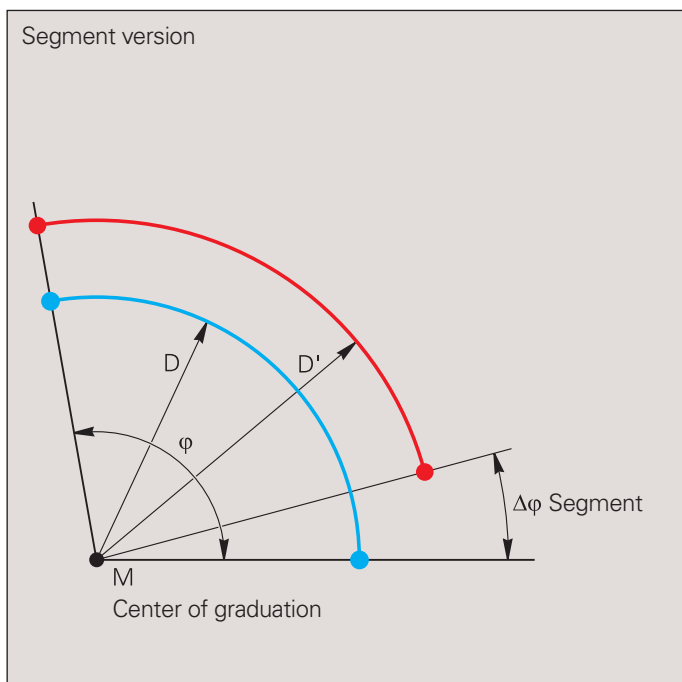e = Eccentricity of the radial grating to the bearing in µm
D = Mean graduation diameter (ERO) or drum outside diameter (ERA 180) and scale-tape carrier diameter (ERA 78xC/ERA 88xC) in mm
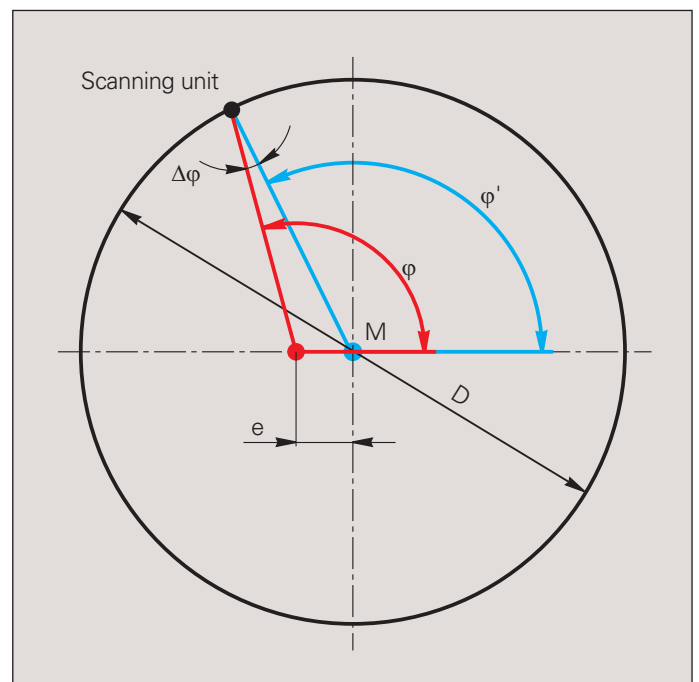M = Center of graduation
φ = "True" angle
φ' = Scanned angle

Angular error due to variations in scale-tape carrier diameter

Eccentricity of the graduation to the bearing

Model	Mean graduation diameter D	Error per 1 µm of eccentricity
ERP 880	$D =$ 126 mm	± 3.3″
ERA 180	$D =$ 80 mm	± 5.2″
	$D =$ 130 mm	± 3.2″
	$D =$ 180 mm	± 2.3″
	$D =$ 250 mm	± 1.6″
	$D =$ 330 mm	± 1.2″
	$D =$ 485 mm	± 0.8″
	$D =$ 562 mm	± 0.7″
ERO 785	$D =$ 110 mm	± 3.7″
	$D =$ 165 mm	± 2.5″
	$D =$ 240 mm	± 1.7″
ERA 78x C	$D =$ 320 mm	± 1.3″
	$D =$ 460 mm	± 0.9″
	$D =$ 570 mm	± 0.7″
	$D =$ 1145 mm	± 0.4″
ERA 88x C	$D =$ 320 mm	± 1.3″
	$D =$ 460 mm	± 0.9″
	$D =$ 570 mm	± 0.7″

3. Error due to radial deviation of the bearing

The equation for the measuring error $\Delta\varphi$ is also valid for radial deviation of the bearing if the value of 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.

4. Position error within one signal period $\Delta\varphi_u$

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

Model	Line count	Position error within one signal period $\Delta\varphi_u$
ERP 880	90 000 ($\triangleq$ 180 000 signal periods)	$\leq$ ± 0.1″
ERA 180	36 000	$\leq$ ± 0.5″
	18 000	$\leq$ ± 1″
	9 000	$\leq$ ± 2″
	6 000	$\leq$ ± 2.5″
ERO 785	36 000	$\leq$ ± 0.5″
ERA 78x C, ERA 88x C	90 000	$\leq$ ± 0.2″
	45 000	$\leq$ ± 0.4″
	36 000	$\leq$ ± 0.5″

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

Resultant measured deviations $\Delta\varphi$ for various eccentricity values e as a function of mean graduation diameter D
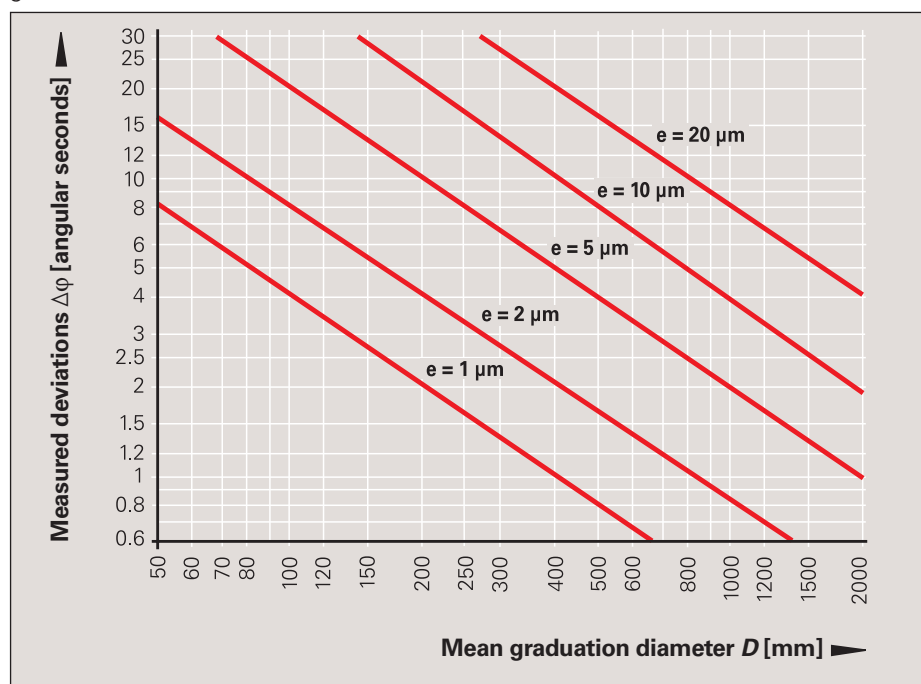
Mechanical Design Types and Mounting
RCN, RON, RPN

RCN, RON and **RPN** angle encoders have an integral bearing, hollow shaft and integrated stator coupling. The measured shaft is directly connected with the shaft of the angle encoder. The reference mark can be assigned to a desired angular position of the measured shaft from the rear of the encoder during mounting.

The graduated disk is rigidly affixed to the hollow shaft. The scanning unit rides on the shaft on ball bearings and is connected to the housing with a coupling on the stator side. During angular acceleration of the shaft, the coupling must absorb only that torque caused by friction in the bearing. Angle encoders with integrated stator coupling therefore provide excellent dynamic performance.

Mounting
The housing of the RCN, RON and RPN is firmly connected to the stationary machine part with an integral mounting flange and a centering collar. Liquids can easily flow away through drainage channels on the flange.

Shaft coupling with ring nut
The RCN, RON and RPN series have a hollow through shaft. For installation, the hollow through shaft of the angle encoder is placed over the machine shaft, and is fixed with a ring nut from the front of the encoder. The ring nut can easily be tightened with the mounting tool.

RON 905 shaft coupling
The RON 905 has a bottomed hollow shaft. The shaft connection is made via an axial central screw.

Front end shaft coupling
It is often advantageous, especially with rotary tables, to integrate the angle encoder in the table so that it is freely accessible when the rotor is lifted. This installation from above reduces mounting times, increases the ease for servicing, and improves the accuracy, since the encoder is located nearer to the rotary table bearing and the measuring or machining plane. The hollow shaft is attached with the threaded holes on the face, using special mounting elements fitted to the individual design (not included in delivery).
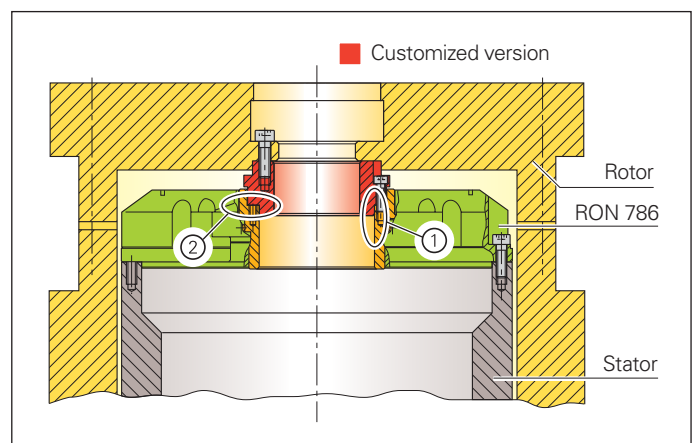
To comply with radial and axial runout specifications, the internal bore ① and the shoulder surface ② are to be used as mounting surfaces for shaft coupling at the face of the encoder.
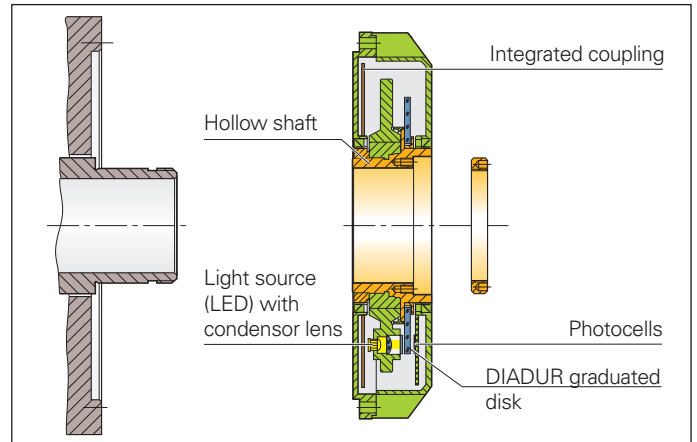
Cross section of the **RON 886** angle encoder
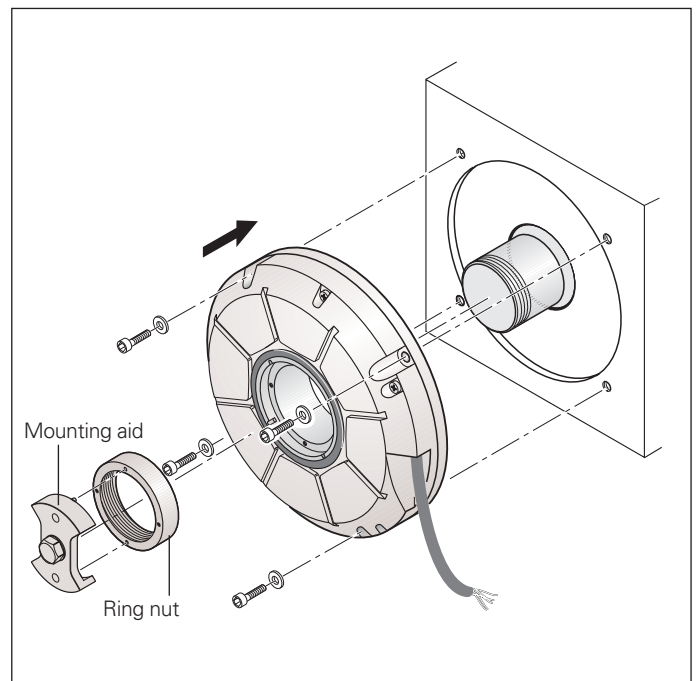
Mounting an angle encoder with hollow through shaft

Front-end shaft coupling with **RON 786**

Ring nuts for RCN, RON and RPN

HEIDENHAIN offers special ring nuts for the RCN, RON and RPN angle encoders with integral bearing and hollow through shaft with integrated coupling. Choose the tolerance of the shaft thread such that the ring nut can be tightened easily, with a minor axial play. This guarantees that the load is evenly distributed on the shaft connection, and prevents distortion of the hollow shaft of the angle encoder.

Ring nut for RON/RCN 200
Hollow shaft ⌀ 20 mm: Id. Nr. 336 669-03

Ring nut for RON 785
Hollow shaft ⌀ 50 mm: Id. Nr. 336 669-05

Ring nut for RON 786; RON/RPN 886
RCN 72x/RCN 82x
Hollow shaft ⌀ 60 mm: Id. Nr. 336 669-01

Ring nut for RCN 72x/RCN 82x
Hollow shaft ⌀ 100 mm: Id. Nr. 336 669-06

Mounting aid for HEIDENHAIN ring nuts

The mounting aid is used to tighten the ring nut. Its pins lock into the bore holes in the ring nuts. A torque screw is used to achieve the necessary tightening torque.

Mounting tool for ring nuts with
Hollow shaft ⌀ 20 mm   Id. Nr. 530 334-03
Hollow shaft ⌀ 50 mm   Id. Nr. 530 334-05
Hollow shaft ⌀ 60 mm   Id. Nr. 530 334-01
Hollow shaft ⌀ 100 mm   Id. Nr. 530 334-06

Ring nut for **RxN 200 series**

*)Thread diameter
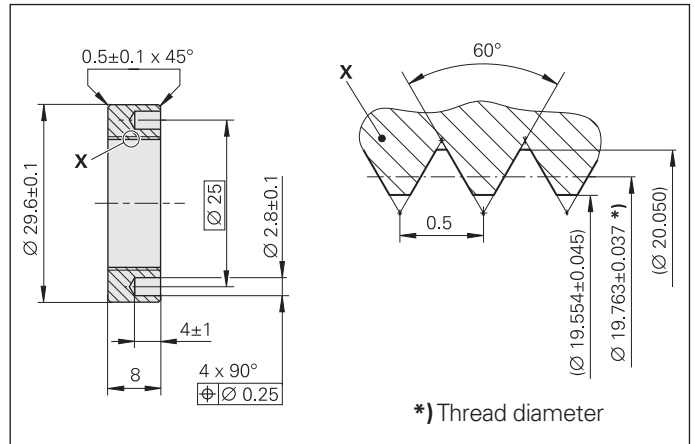
Ring nut for **RxN 700/800 series**

*)Thread diameter
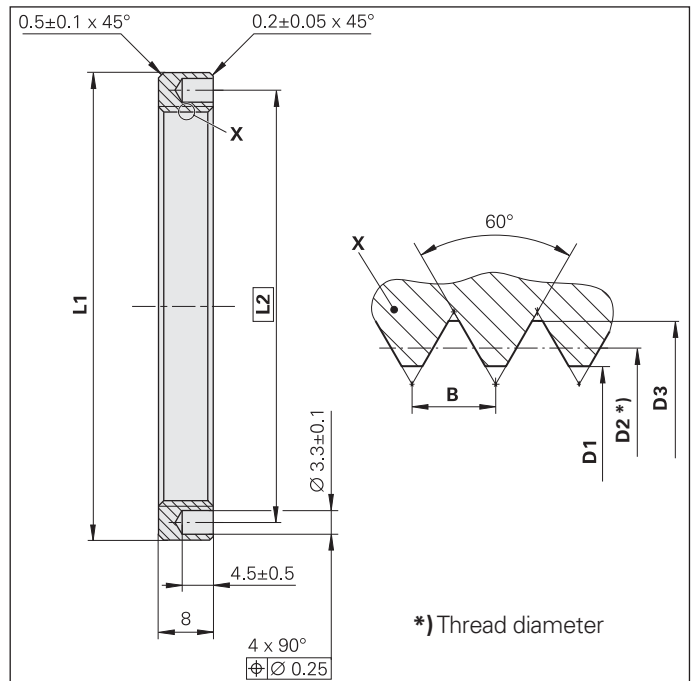
Ring nut for	L1	L2	D1	D2	D3	B
Hollow shaft ⌀ 50	⌀ 62±0.2	⌀ 55	(⌀ 49.052 ±0.075)	⌀ 49.469 ±0.059	(⌀ 50.06)	1
Hollow shaft ⌀ 60	⌀ 70±0.2	⌀ 65	(⌀ 59.052 ±0.075)	⌀ 59.469 ±0.059	(⌀ 60.06)	1
Hollow shaft ⌀ 100	⌀ 114±0.2	⌀ 107	(⌀ 98.538 ±0.095)	(⌀ 99.163 ±0.07)	(⌀ 100.067)	1.5

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Mechanical Design Types and Mounting
ROD

Angle encoders of the **ROD** product family require a separate coupling for connection to the drive shaft. The shaft coupling compensates axial movement and misalignment between the shafts, preventing excessive load on the encoder bearing of the angle encoder. It is important that the encoder shaft and the drive shaft be optimally aligned for high measurement accuracies to be realized. The HEIDENHAIN product program includes diaphragm couplings and flat couplings designed for connecting the shaft of the ROD angle encoder to the drive shaft.

Mounting example
ROD 880
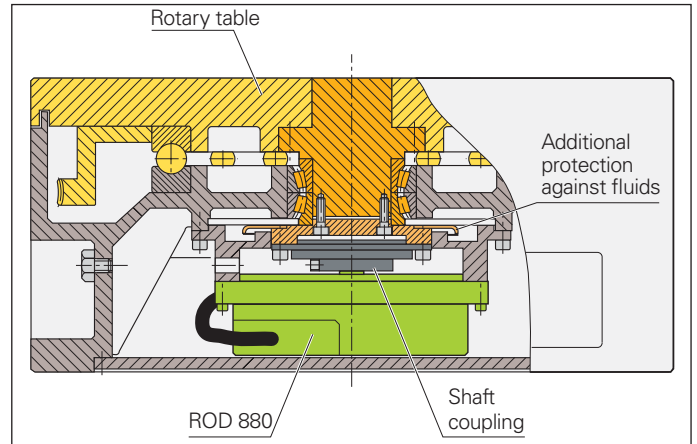
Mounting
ROD angle encoders are provided with an integral mounting flange with centering collar. The encoder shaft is connected to the drive shaft by way of a diaphragm coupling or flat coupling.

Shaft couplings
The shaft coupling compensates axial movement and misalignment between the encoder shaft and the drive shaft, preventing excessive load on the encoder bearing of the angle encoder.
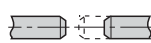
Radial offset λ
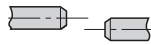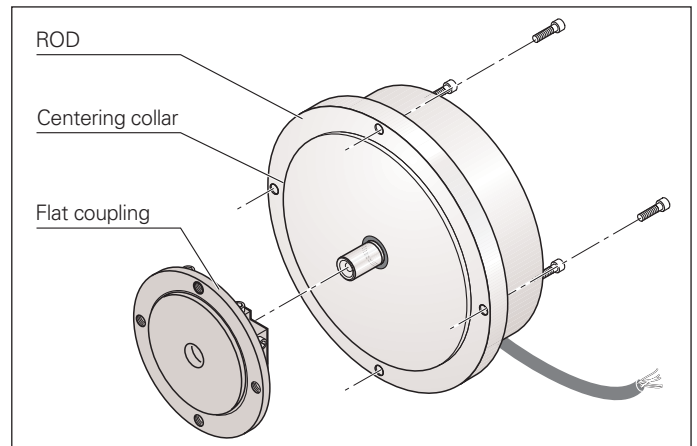
Angular error α
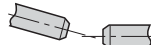
Axial motion δ

Mounting an ROD

| Shaft coupling | ROD 200 Series | | ROD 700 Series, ROD 800 Series | | |
	K 03 Diaphragm coupling	**K 18** Flat coupling	**K 01** Diaphragm coupling	**K 15** Flat coupling	**K 16** Flat coupling
Hub bore	10 mm		14 mm		
Kinematic transfer error	± 2″ at $\lambda \leq 0.1$ mm and $\alpha \leq 0.09°$	± 3″	± 1″	± 0.5″ at $\lambda \leq 0.05$ mm and $\alpha \leq 0.03°$	
Torsional rigidity	1500 Nm/rad	1200 Nm/rad	4000 Nm/rad	6000 Nm/rad	4000 Nm/rad
Permissible torque	0.2 Nm	0.5 Nm			
Permissible radial offset λ	≤ 0.3 mm				
Permissible angular error α	≤ 0.5°			≤ 0.2°	≤ 0.5°
Permissible axial motion δ	≤ 0.2 mm			≤ 0.1 mm	≤ 1 mm
Moment of inertia (approx.)	$20 \cdot 10^{-6}$ kgm^2	$75 \cdot 10^{-6}$ kgm^2	$200 \cdot 10^{-6}$ kgm^2		$400 \cdot 10^{-6}$ kgm^2
Permissible speed	10 000 rpm	1000 rpm	3000 rpm	1000 rpm	
Torque for locking screws (approx.)	1.2 Nm		2.5 Nm	1.2 Nm	
Weight	100 g (0.220 lb)	117 g (0.258 lb)	180 g (0.4 lb)	250 g (0.55 lb)	410 g (0.9 lb)

K 03 diaphragm coupling
Id. Nr. 200 313-04
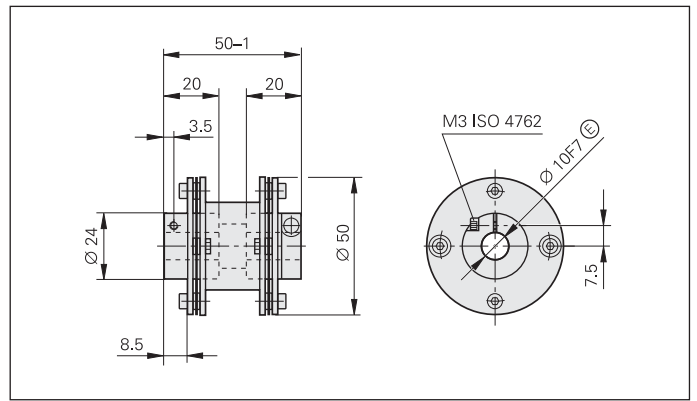
K 18 flat coupling
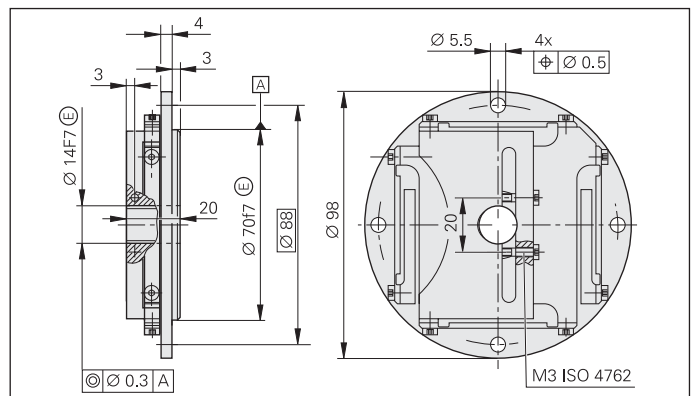Id. Nr. 202 227-01
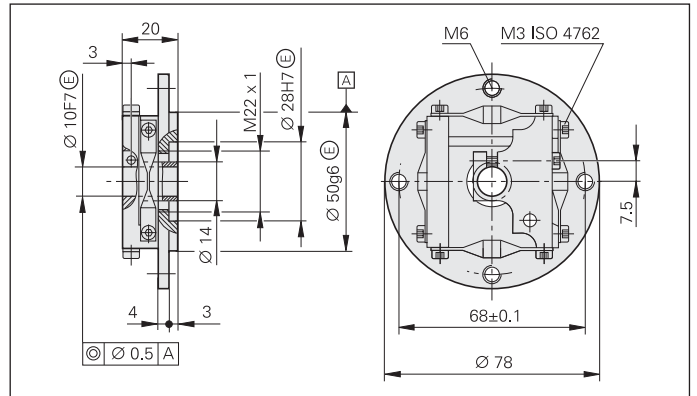
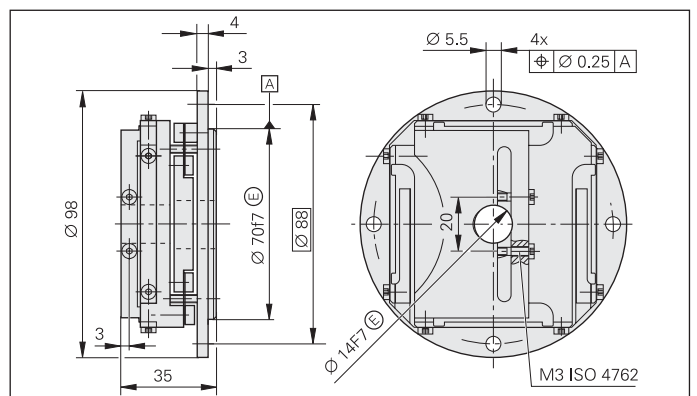**K 01 diaphragm coupling**
Id. Nr. 200 301-02
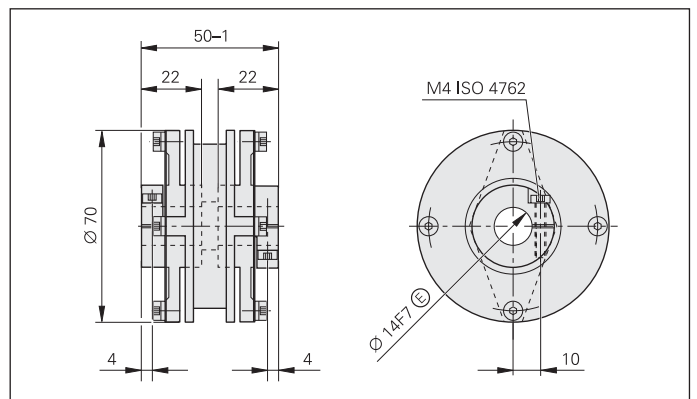
K 15 flat coupling
Id. Nr. 255 797-01

K 16 flat coupling
Id. Nr. 258 878-01

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

Mechanical Design Types and Mounting
ERP

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

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

Mounting the
ERP 880
(in principle)
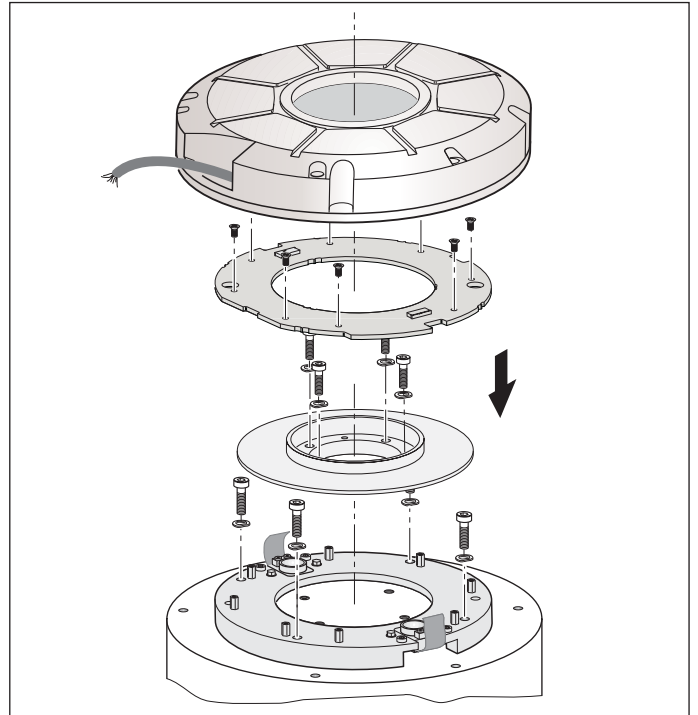
IP 40 cover cap
With sealing ring for IP 40 protection
Cable 1 m with male coupling, 12-pin
Id. Nr. 369 774-01

IP 64 cover cap
With shaft seal for IP 64 protection
Cable 1 m with male coupling, 12-pin
Id.-Nr. 369 774-02

ERA 180, ERO

The **ERA 180** and **ERO** modular angle encoders consist of either a circumferential-scale drum (ERA) or a disk/hub assembly (ERO) and the corresponding scanning unit. Special design features of the modular angular encoders assure comparably fast mounting and easy adjustment.

Mounting the ERA 180
The circumferential scale drum is slid onto the drive shaft and fastened with screws. HEIDENHAIN recommends using a transition fit for mounting the scale drum. For mounting, the scale drum may be slowly warmed on a heating plate over a period of approx. 10 minutes to a temperature of max. 100 °C. The scale drum is centered via the centering collar on its inner circumference. The scanning unit is mounted with the spacer foil attached to the circumferential-scale drum. The scanning unit is pressed against the foil, fastened, and the foil is removed. To protect the ERA 180 from contamination, HEIDENHAIN supplies a protective cover for drum diameters up to 180 mm. For larger diameters, HEIDENHAIN recommends integrating a protective cover into the machine itself.
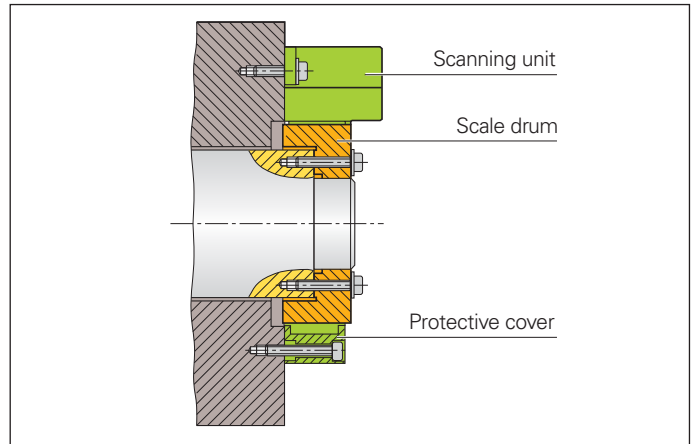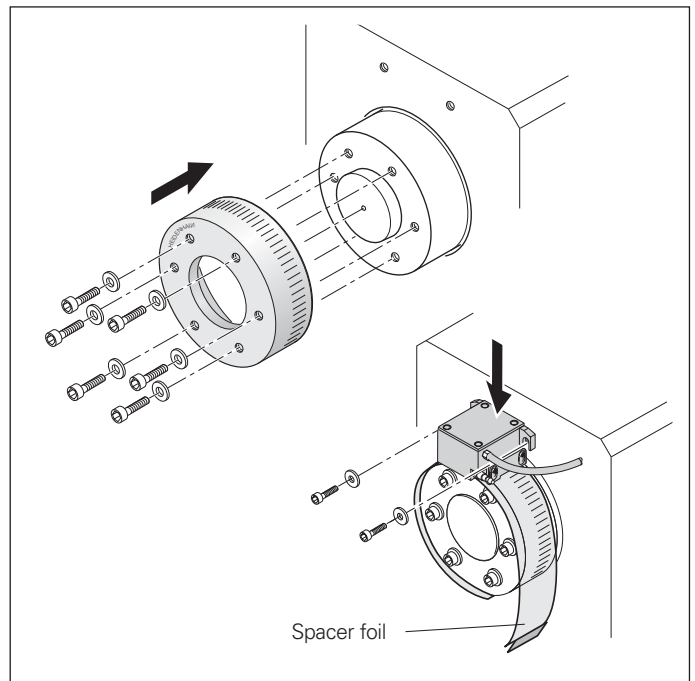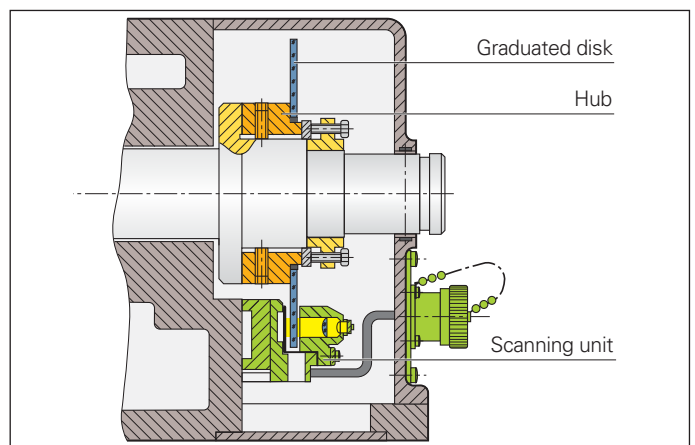
Mounting — ERO
The disk/hub assembly is slid onto the drive shaft, centered, and fastened with screws. The scanning unit is then slid onto the centering collar of the hub and the screws are tightened. The gap between the graduated disk and the scanning unit is set with spacer foils.

Scanning unit
Scale drum
Protective cover

Cross section of
ERA 180

Spacer foil

Mounting the
ERA 180

Graduated disk
Hub
Scanning unit

Cross section of
ERO 785

Mechanical Design Types and Mounting
ERA 700 and ERA 800 Series

The encoders of the ERA 700 and ERA 800 series consist of a scanning unit and a one-piece steel scale tape up to 30 m in length. The tape is mounted on the
- **inside diameter** (ERA 700 series) or
- **outside diameter** (ERA 800 series)

of a machine element.

The ERA 780 C and ERA 880 C angle encoders are designed for **full-circle applications.** Thus, they are particularly suited to hollow shafts with large inside diameters (from approx. 300 mm) and to applications requiring an accurate measurement over a large circumference, e.g. large rotary tables, telescopes, etc.

In applications where there is no full circle, or measurement is not required over 360°, **segment angles** are available for diameters from 300 mm.

Mounting the scale tape for full-circle applications

ERA 780 C: An **internal slot** with a certain diameter is required as scale tape carrier. The tape is inserted starting at the butt joint and is clicked into the slot. The length is cut so that the tape is held in place by its own spring force. To make sure that the scale tape does not move within the slot, it is fixed with adhesive at multiple points in the area of the butt joint.
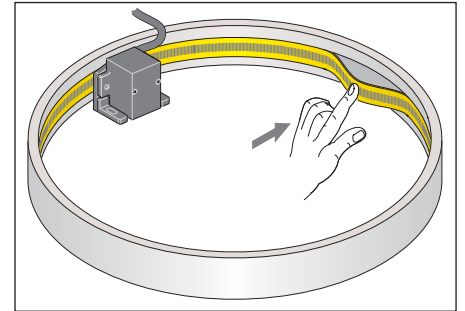
ERA 880 C: The scale tape is supplied with the halves of the tensioning cleat already mounted on the tape ends. An **external slot** is necessary for mounting. The tape is placed in the outside slot of the machine (along slot edge) and is tensioned using the tensioning cleat.
The scale tape ends are manufactured so exactly that only minor signal-form deviations can occur in the area of the butt joint.
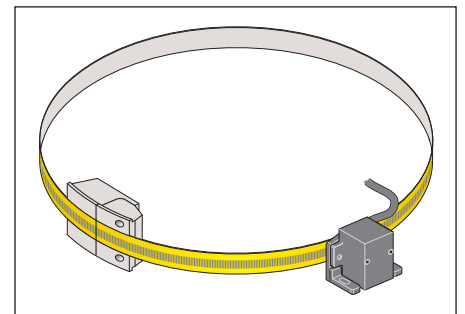

Mounting the scale tape for segment angles

**ERA 781 C:** An internal slot with a certain diameter is required.
Both bearing pieces are fixed in this slot, and are adjusted with cam disks so that the scale can be pressed into the slot while under tension.

Cam disks
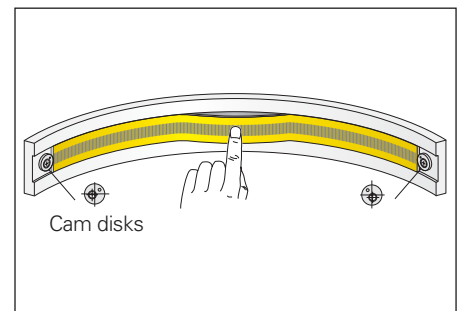
ERA 881 C: The scale tape is supplied with premounted bearing pieces. An external slot with recesses for the bearing pieces is required for placing the scale tape. The scale tape is fitted with tension springs, which create an optimal bearing preload for increasing the accuracy of the scale tape, and evenly distribute the expansion over the entire length of the scale tape.
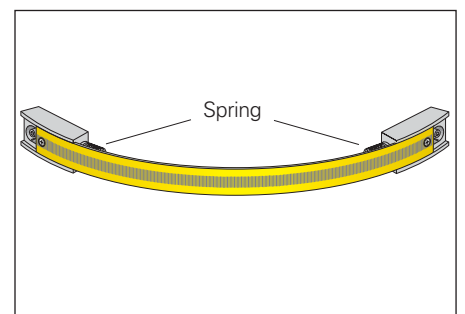
Spring

ERA 882 C: An external slot or one-sided axial stop is recommended for placing the scale tape. The scale tape is supplied without tensioning elements. It must be preloaded with a spring balance, and fixed with the two oblong holes.
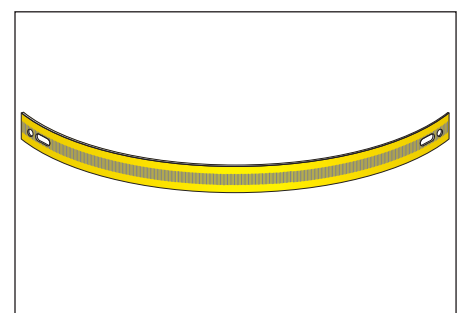
The following must be kept in mind for segment applications:

- **Determining the slot diameter**
  In order to guarantee the correct functioning of the distance-coded reference marks, the circumference of the theoretical full circle must be a multiple of 1000 grating periods. This also facilitates adaptation to the NC control, which mostly can only calculate integer line counts. The connection between the basic slot diameter and the line count can be seen in the table.
- **Segment angles**
  The measuring range available for the segment angle should be a multiple of 1000 signal periods, since these versions are available more quickly.

	Basic slot diameter	Line count projected onto a full circle
ERA 781 C	$318.58 + n \cdot 12.73111$	$25000 + n \cdot 1000$
ERA 881 C/ ERA 882 C	$317.99 + n \cdot 12.73178$	$25000 + n \cdot 1000$

Measuring range

Basic slot diameter

Theoretical full circle
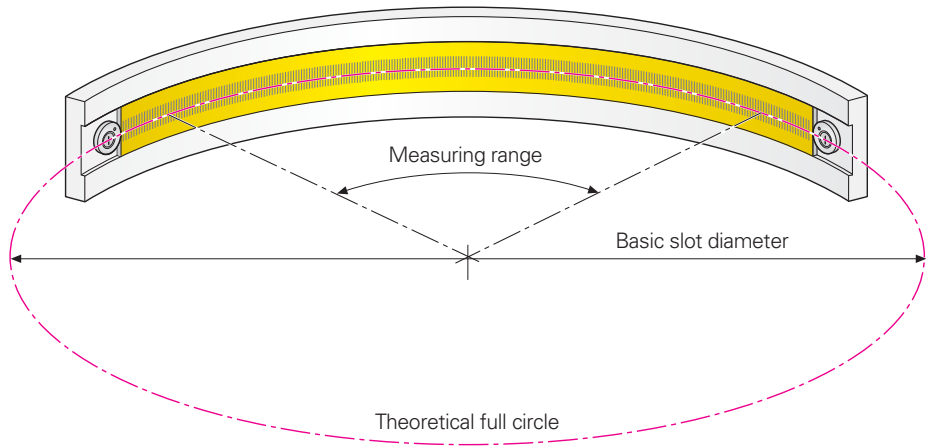
**Mounting the scanning head**
A spacer foil is placed against the scale tape. The scanning head is pushed up against the spacer foil in such a way that the foil is only located between the two mechanical support points on the mounting bracket. The scanning head is secured in this position and the foil is removed.

Spacer foil
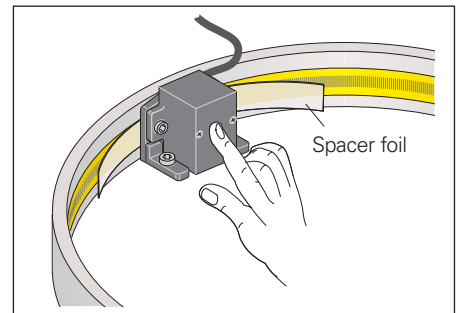
Adjusting the scanning head
Accurate alignment of the scanning head with the scale tape is critical for the ERA 700/800 to provide accurate and reliable measurements (Moiré setting). If the scanning head is not properly aligned, the quality of the output signals will be poor.

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

25
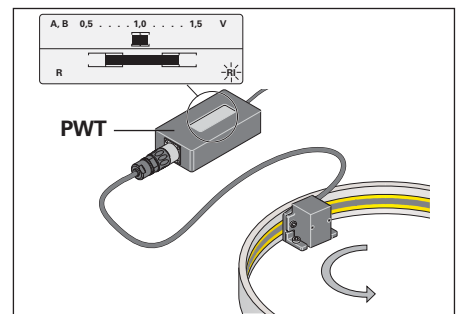
General Mechanical Information

Protection
Unless otherwise indicated, all RCN, RON, RPN and ROD angle encoders meet protection standard IP 67 according to IEC 60529.
This includes housings and cable outlets. The **shaft inlet** provides protection to IP 64.

Splash water should not contain any substances that would have harmful effects on the encoder parts. If protection to IP 64 of the shaft inlet is not sufficient (such as when the angle encoder is mounted vertically), additional labyrinth seals should be provided.

RCN, RON, RPN and ROD angle encoders are equipped with a compressed air inlet. Connection to a source of compressed air slightly above atmospheric pressure provides additional protection against contamination.

For this purpose, HEIDENHAIN offers the **DA 300 compressed air unit** (filter combination with pressure regulator and fittings). The compressed air introduced into the encoder must fulfill the requirements of the following quality classes as per ISO 8573-1:
- Max. particle size and density of solid contaminants:
  Class 4 (max. particle size: 15 µm, max. particle density: 8 mg/m^3)
- Total oil content:
  Class 4 (oil content: 5 mg/m^3)
- Max. pressure dew point:
  Class 4 (+29 °C at $10 \cdot 10^5$ Pa) no classification

The following components are necessary for connection to the RCN, RON, RPN and ROD angle encoders:

M5 connecting piece for RCN/RON/RPN/ROD
with gasket and throttle (Ø 0.3 mm) for air-flow rate from 1 to 4 l/min
Id. Nr. 207 835-04

M5 coupling joint, swiveling
with gasket
Id. Nr. 207 834-02

Temperature range
The **operating temperature range** indicates the limits of ambient temperature within which the values given in the specifications for angle encoders are maintained (DIN 32 878).

The **storage temperature range** of –30 to 80 °C (–22 to 176 °F) is valid when the unit remains in its packaging. The RON 905 should not be stored at temperatures beyond –30 to +50 °C (–22 to +122 °F): exceeding this temperature range could result in irreversible changes of up to 0.05 angular seconds to the unit's accuracy.
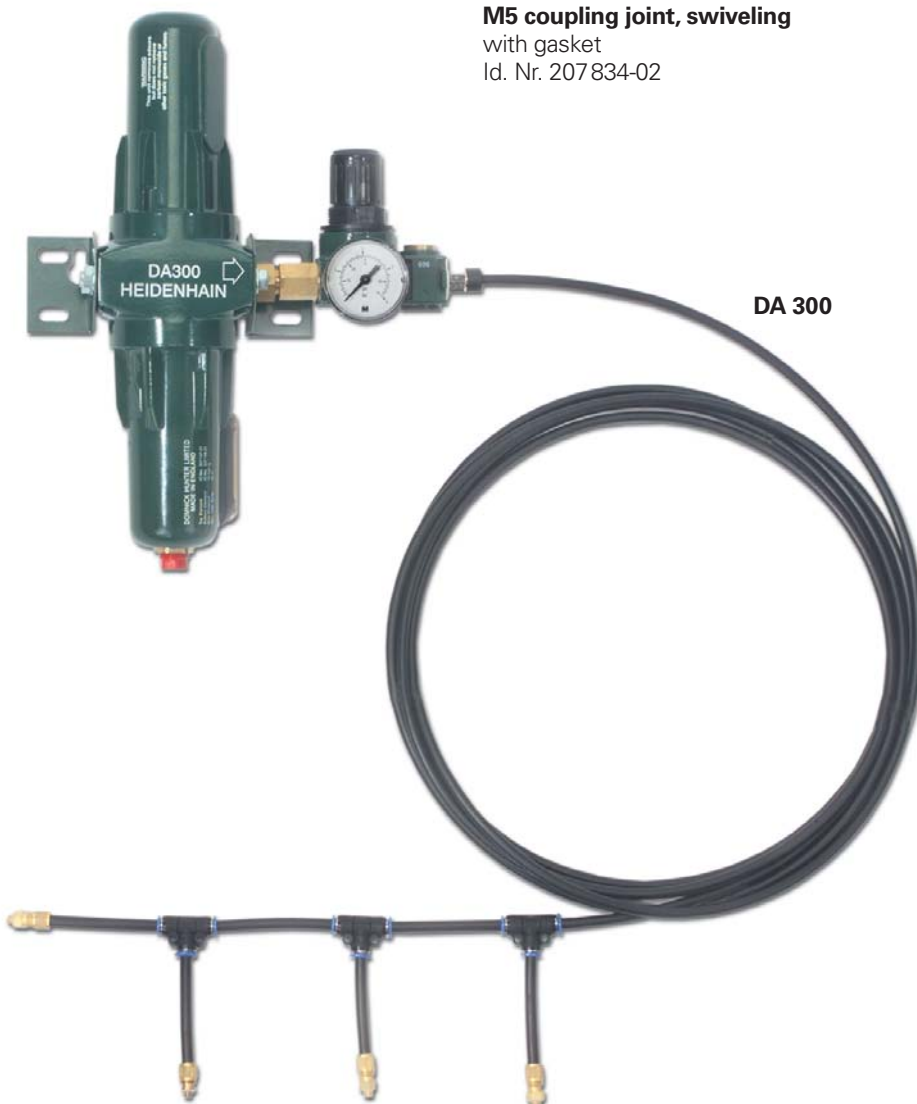
DA 300

Protection against contact

After encoder installation, all rotating parts (coupling on ROD, locking ring on RCN, RON and RPN) must be protected against accidental contact during operation.

Acceleration

Angle encoders are subject to various types of acceleration during operation and mounting.
- The **permissible angular acceleration** for all RCN, RON, RPN and ROD angle encoders is over 10^5rad/s^2.
- The indicated maximum values for **vibration** are valid according to IEC 60068-2-6.
- The maximum permissible acceleration values (semi-sinusoidal shock) for **shock and impact** are valid for 6 ms (IEC 60068-2-27).
  Under no circumstances should a hammer or similar implement be used to adjust or position the encoder.

Natural frequency f_N of coupling

The rotor and shaft coupling of the ROD angle encoders, as well as the stator and stator coupling of the RCN, RON and RPN angle encoders, form a single vibrating spring-mass system.

The **natural frequency f_N** should be as high as possible. With the RCN, RON and RPN angle encoders, the natural frequency f_N is given in the respective specifications. A prerequisite for the highest possible natural frequency on **ROD angle encoders** is the use of a **shaft coupling** with a high torsional rigidity C.

$$f_N = \frac{1}{2 \cdot \pi} \cdot \sqrt{\frac{C}{I}}$$

f_N: Natural frequency in Hz
C: Torsional rigidity of the coupling in Nm/rad
I: Moment of inertia of the rotor in kgm^2

If radial and/or axial acceleration occurs during operation, the effect of the rigidity of the encoder bearing, the encoder stator and the coupling are also significant. If such loads occur in your application, HEIDENHAIN recommends consulting with the main facility in Traunreut.

Expendable parts

HEIDENHAIN encoders contain components that are subject to wear, depending on the application and manipulation. These include in particular the following parts:
- LED light source
- Cables with frequent flexing

Additionally for encoders with integral bearing:
- Bearings
- Shaft sealing rings for rotary and angular encoders
- Sealing lips for sealed linear encoders

System tests

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

The specifications given in the 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-oriented systems, the higher-level system must verify the position value of the encoder after switch-on.

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.
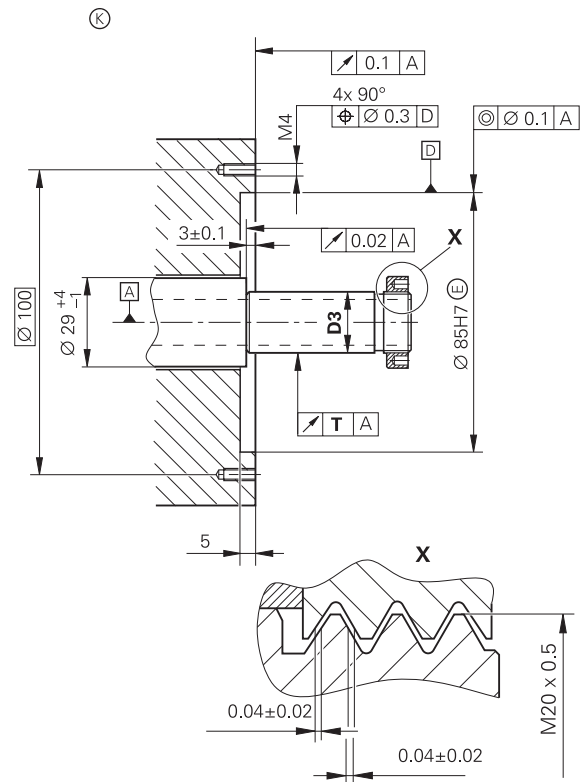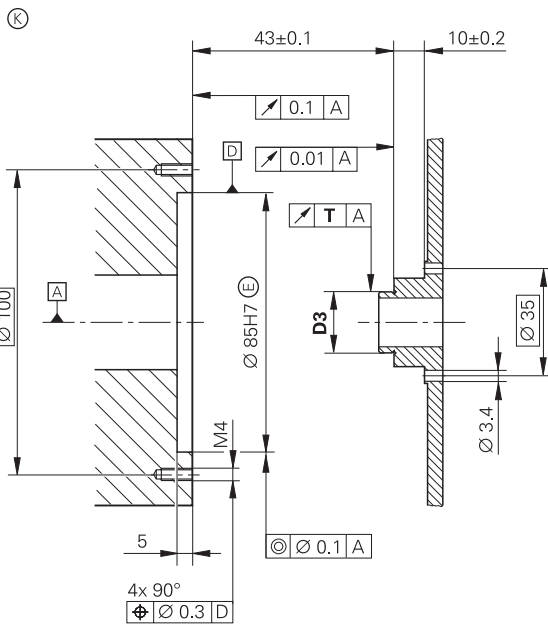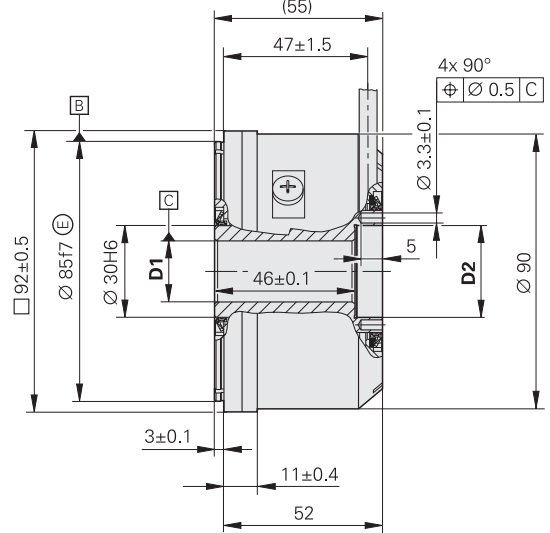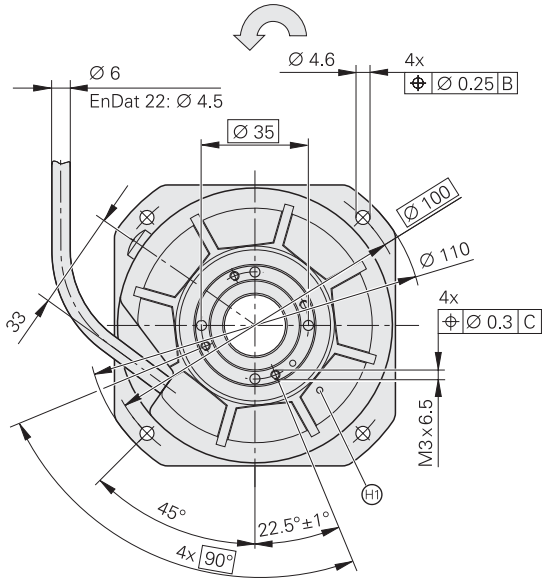
RCN 200 Series

- **Integrated stator coupling**
- **Hollow through shaft, diameter 20 mm**
- **System accuracy ± 5″ and ± 2.5″**

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

Cable radial, also usable axially

Ⓐ = Ball bearing

Ⓚ = Required mating dimensions

↶ Direction of shaft rotation for output signals is described in interface description.

System accuracy	± 2.5″	± 5″
D1	Ø 20H6 Ⓔ	Ø 20H7 Ⓔ
D2	Ø 30H6 Ⓔ	Ø 30H7 Ⓔ
D3	Ø 20g6 Ⓔ	Ø 20g7 Ⓔ
T	0.01	0.02

	Absolute		
	RCN 226	**RCN 223 F**	**RCN 223 M**
Absolute position values	EnDat 2.1	Serial interface – Fanuc 01	Mitsubishi high-speed serial interface
Ordering designation	EnDat 01	Fanuc 01	Mitsu 01
Positions per revolution	67 108 864 (26 bits)	8 388 608 (23 bits)	
Elec. permissible speed	1500 rpm		
Clock frequency	≤ 2 MHz	–	
Calculation time t_{cal}	10 µs	–	
Incremental signals	∿ 1 V_{PP}	–	
Line count	16 384	–	
Cutoff frequency –3 dB	≥ 180 kHz	–	
Recommended meas. step for position capture	0.000 1°		
System accuracy*	± 5″ or ± 2.5″		
Power supply without load	5 V ± 5% max. 350 mA		
Electrical connection*	Cable 1 m (3.3 ft), with M23 coupling		
Max. cable length[1]	150 m	20 m	
Shaft	Hollow through shaft D= 20 mm		
Mech. permissible speed	≤ 3000 rpm		
Starting torque	≤ 0.08 Nm at 20 °C (68 °F)		
Moment of inertia of rotor	$73 \cdot 10^{-6}$ kgm^2		
Natural frequency	≥ 1200 Hz		
Permissible axial motion of measured shaft	± 0.1 mm		
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (IEC 60 068-2-6) ≤ 1000 m/s^2 (IEC 60 068-2-27)		
Operating temperature	*At ± 5″ accuracy:* *Moving cable:* –10 to 70 °C (+14 to 158 °F) *Rigid cable:* –20 to 70 °C (–4 to 158 °F) *At ± 2.5″ accuracy:* 0 to 50 °C (32 to 122 °F)		
Protection IEC 60 529	IP 64		
Weight	Approx. 0.8 kg (1.8 lb)		

* Please indicate when ordering
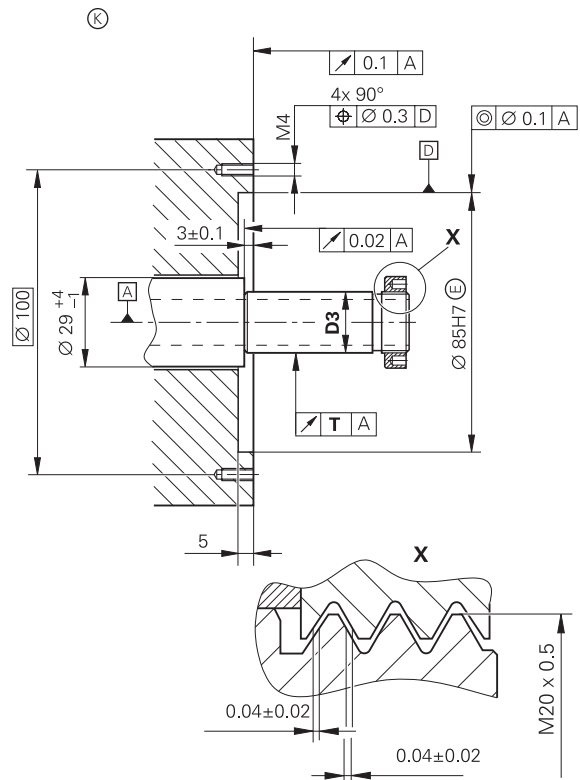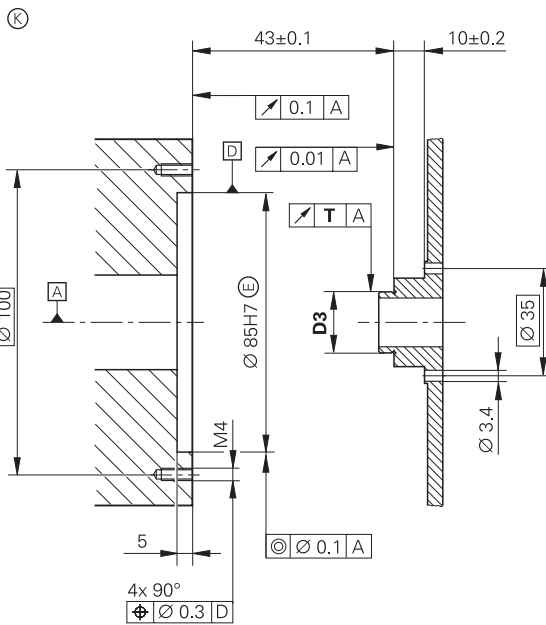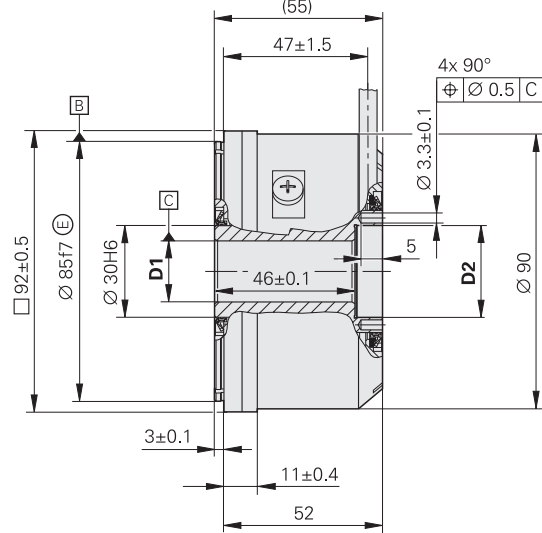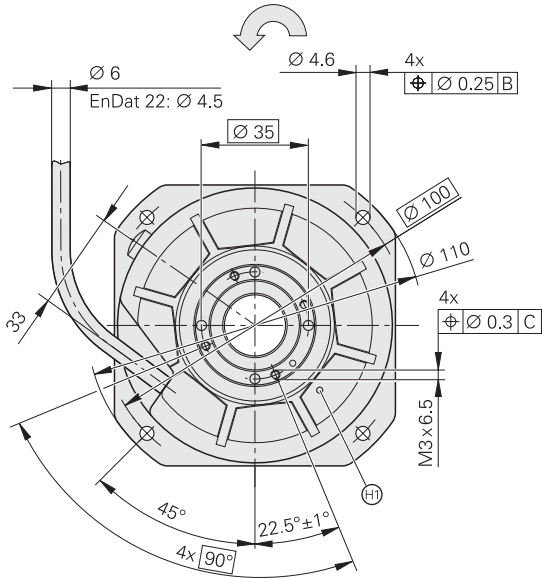[1] With HEIDENHAIN cable

RON 200 Series

- **Integrated stator coupling**
- **Hollow through shaft, diameter 20 mm**
- **System accuracy ± 5″ and ± 2.5″**

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

Cable radial, also usable axially

Ⓐ = Ball bearing

Ⓚ = Required mating dimensions

⟳ Direction of shaft rotation for output signals is described in interface description.

System accuracy	± 2.5″	± 5″
D1	Ø 20H6 Ⓔ	Ø 20H7 Ⓔ
D2	Ø 30H6 Ⓔ	Ø 30H7 Ⓔ
D3	Ø 20g6 Ⓔ	Ø 20g7 Ⓔ
T	0.01	0.02

	Incremental				
	RON 225	**RON 275**	**RON 275**	**RON 285**	**RON 287**
Incremental signals	⊓⊔TTL x 2	⊓⊔TTL x 5	⊓⊔TTL x 10	∿ 1 V$_{PP}$	
Line count Integrated interpolation* Output signals/rev	9000 2-fold/ 18000	18000 5-fold/ 90000	18000 10-fold/ 180000	18000	
Reference mark*	One			*RON 2xx:* One *RON 2xx C:* Distance-coded	
Cutoff frequency (–3 dB) Output frequency Edge separation *a*	– Max. 1 MHz 0.125 µs	– Max. 250 kHz 0.98 µs	– Max. 1 MHz 0.23 µs	≥ 180 kHz – –	
Elec. permissible speed	–	≤ 166 rpm	≤ 333 rpm	–	
Recommended measuring step for position capture	0.005°	0.001°	0.0005°	0.0001°	
System accuracy	± 5″				± 2.5″
Power supply without load	5 V ± 10% max. 150 mA				
Electrical connection*	Cable 1 m (3.3 ft), with or without M23 coupling				
Max. cable length[1]	50 m			150 m	
Shaft	Hollow through shaft D= 20 mm				
Mech. permissible speed	≤ 3000 rpm				
Starting torque	≤ 0.08 Nm at 20 °C (68 °F)				
Moment of inertia of rotor	$73 \cdot 10^{-6}$ kgm^2				
Natural frequency	≥ 1200 Hz				
Permissible axial motion of measured shaft	± 0.1 mm				
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (IEC 60068-2-6) ≤ 1000 m/s^2 (IEC 60068-2-27)				
Operating temperature	*Moving cable:* –10 to 70 °C (+14 to 158 °F) *Rigid cable:* –20 to 70 °C (–4 to 158 °F)				0 to 50 °C (32 °F to 122 °F)
Protection IEC 60529	IP 64				
Weight	Approx. 0.8 kg (1.8 lb)				

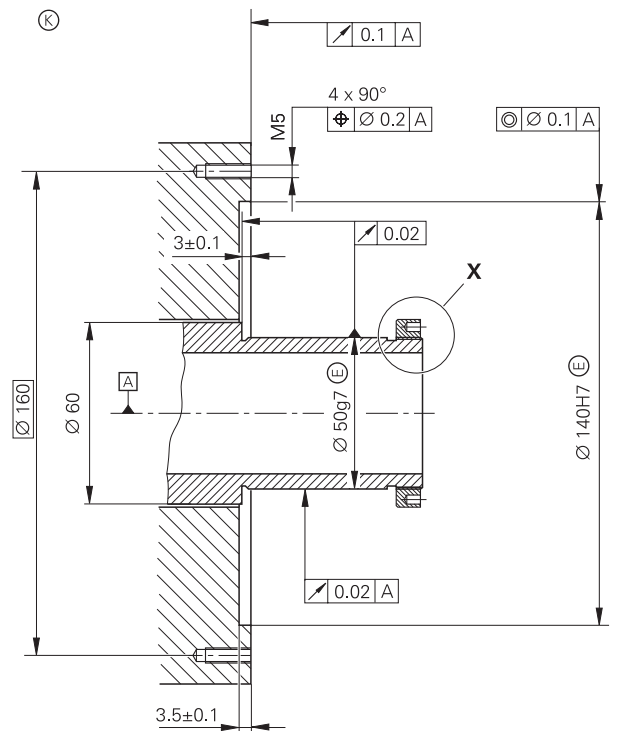* Please indicate when ordering
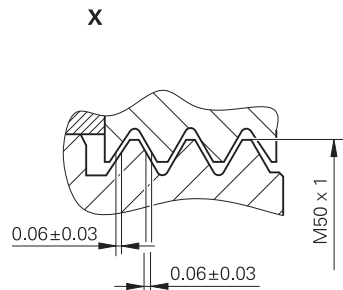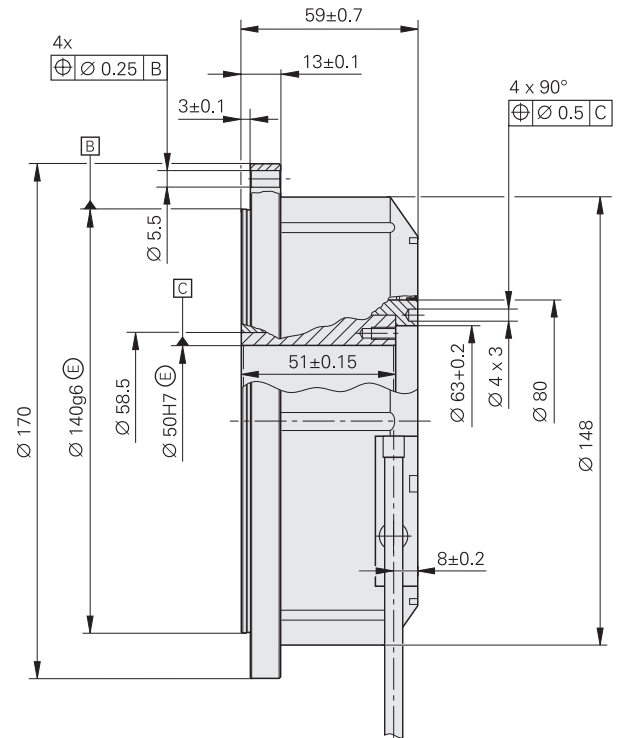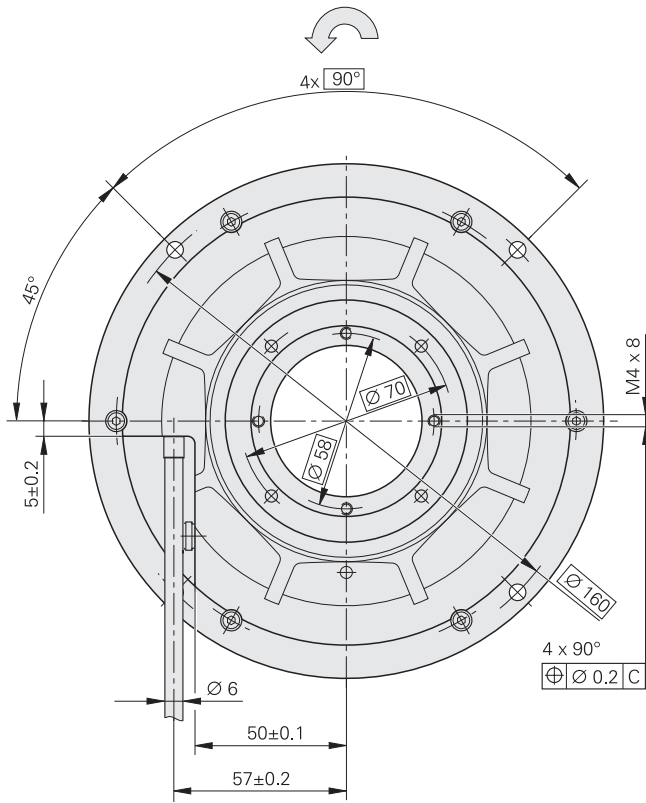[1] With HEIDENHAIN cable

RON 785

- **Integrated stator coupling**
- **Hollow through shaft, diameter 50 mm**
- **System accuracy ± 2"**

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

4x 90°

45°

5±0.2

Ø 70

Ø 58

M4 x 8

Ø 160

Ø 6

50±0.1

57±0.2

4 x 90°
⊕ Ø 0.2 C

4x
⊕ Ø 0.25 B

59±0.7

13±0.1

3±0.1

B

Ø 5.5

C

Ø 170

Ø 140g6 Ⓔ

Ø 58.5

Ø 50H7 Ⓔ

51±0.15

4 x 90°
⊕ Ø 0.5 C

Ø 63+0.2

4 x 3

Ø 80

Ø 148

8±0.2

Ⓚ

X

M50 x 1

0.06±0.03

0.06±0.03

↗ 0.1 A

4 x 90°
⊕ Ø 0.2 A

M5

◎ Ø 0.1 A

3±0.1

↗ 0.02

X

Ø 160

Ø 60

A

Ø 50g7 Ⓔ

Ø 140H7 Ⓔ

↗ 0.02 A

3.5±0.1

Cable radial, also usable axially

Ⓐ = Ball bearing

Ⓚ = Required mating dimensions

Direction of shaft rotation for output signals is described in interface description.

32

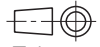|	Incremental **RON 785**
Incremental signals	$\sim$ 1 V$_{PP}$
Line count	18 000
Reference mark*****	*RON 785:* One *RON 785 C:* Distance-coded
Cutoff frequency –3 dB	≥ 180 kHz
Recommended measuring step for position capture	0.000 1°
System accuracy	± 2″
Power supply without load	5 V ± 10% max. 150 mA
Electrical connection*	Cable 1 m (3.3 ft), with or without M23 coupling
Max. cable length[1]	150 m
Shaft	Hollow through shaft D= 50 mm
Mech. permissible speed	≤ 1000 rpm
Starting torque	≤ 0.5 Nm at 20 °C (68 °F)
Moment of inertia of rotor	$1.05 \cdot 10^{-3}$ kgm^2
Natural frequency	≥ 1000 Hz
Permissible axial motion of measured shaft	± 0.1 mm
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (IEC 60 068-2-6) ≤ 1000 m/s^2 (IEC 60 068-2-27)
Operating temperature	0 to 50 °C (32 °F to 122 °F)
Protection IEC 60 529	IP 64
Weight	Approx. 2.5 kg (5.5 lb)

* Please indicate when ordering
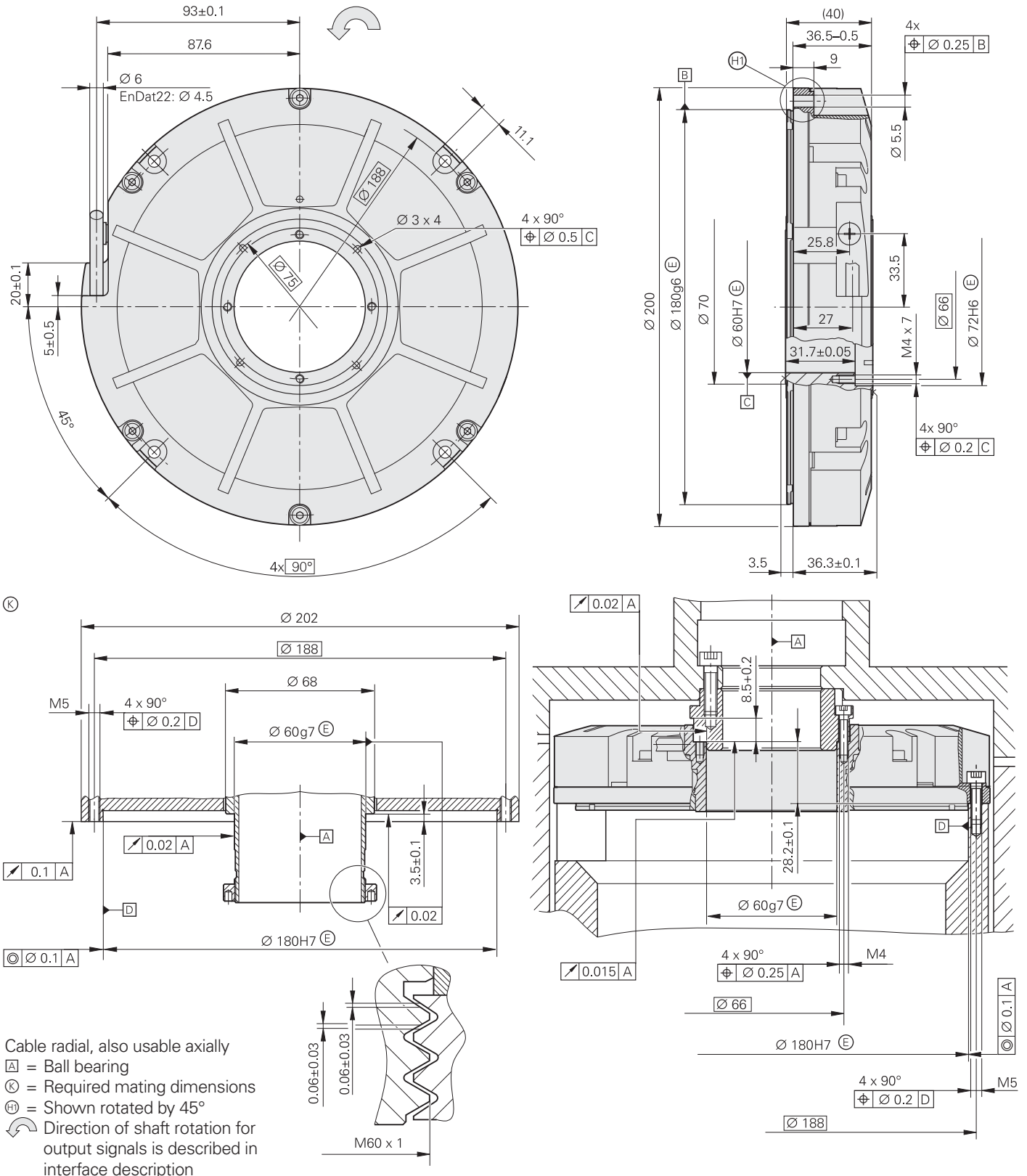[1] With HEIDENHAIN cable

RCN 700/RCN 800 Series

- **Integrated stator coupling**
- **Hollow through shaft, diameter 60 mm**
- **System accuracy ± 2" or ± 1"**

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

93±0.1
87.6
Ø 6
EnDat22: Ø 4.5
20±0.1
5±0.5
45°
Ø 188
Ø 3 x 4
4 x 90°
⊕ Ø 0.5 C
Ø 75
11.1
4x 90°

(40)
36.5–0.5
9
4x
⊕ Ø 0.25 B
B
H
Ø 5.5
Ø 200
Ø 180g6 E
Ø 70
Ø 60H7 E
25.8
33.5
27
31.7±0.05
M4 x 7
Ø 66 E
Ø 72H6 E
C
4x 90°
⊕ Ø 0.2 C
3.5
36.3±0.1

K
Ø 202
Ø 188
Ø 68
M5
4 x 90°
⊕ Ø 0.2 D
Ø 60g7 E
⟋ 0.02 A
A
0.1 A
D
⊚ Ø 0.1 A
3.5±0.1
⟋ 0.02
Ø 180H7 E
M60 x 1
0.06±0.03
0.06±0.03

⟋ 0.02 A
A
8.5+0.2
D
28.2±0.1
Ø 60g7 E
4 x 90°
⊕ Ø 0.25 A
⟋ 0.015 A
Ø 66
Ø 180H7 E
M4
4 x 90°
⊕ Ø 0.2 D
Ø 188
⊚ Ø 0.1 A
M5

Cable radial, also usable axially
Ⓐ = Ball bearing
Ⓚ = Required mating dimensions
Ⓗ = Shown rotated by 45°
⟳ Direction of shaft rotation for output signals is described in interface description

34

	Absolute			
	RCN 729 **RCN 829**	**RCN 729** **RCN 829**	**RCN 727 F** **RCN 827 F**	**RCN 723M** **RCN 823 M**
Absolute position values	EnDat 2.2	EnDat 2.2	Serial Interface Fanuc 02	Mitsubishi high-speed serial interface
Ordering designation*	EnDat 22	EnDat 02	Fanuc 02	Mitsu 01
Positions per revolution	536 870 912 (29 bits)		134 217 728 (27 bits)	8 388 608 (23 bits)
Elec. permissible speed	≤ 300 rpm for continuous position value			
Clock frequency	≤ 8 MHz	≤ 2 MHz	–	
Calculation time t_{cal}	5 µs		–	
Incremental signals	–	◠ 1 V$_{PP}$	–	
Line count*	–	32 768	–	
Cutoff frequency –3 dB	–	≥ 180 kHz	–	
Recommended measuring step for position capture	*RCN 72x: 0.0001°* *RCN 82x: 0.000 05°*			
System accuracy	*RCN 72x: ± 2″* *RCN 82x: ± 1″*			
Power supply without load	3.6 to 5.25 V/Max. 350 mA		5 V ± 5% max. 350 mA	
Electrical connection*	Cable 1 m (3.3 ft), with coupling M12	Cable 1 m (3.3 ft), with or without M23 coupling		
Max. cable length[1]	150 m		30 m	25 m
Shaft	Hollow through shaft D= 60 mm			
Mech. permissible speed	≤ 1000 rpm			
Starting torque	≤ 0.5 Nm at 20 °C (68 °F)			
Moment of inertia of rotor	$1.3 \cdot 10^{-3}$ kgm^2			
Natural frequency	≥ 1000 Hz			
Permissible axial motion of measured shaft	≤ ± 0.1 mm			
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (IEC 60 068-2-6) ≤ 1000 m/s^2 (IEC 60 068-2-27)			
Operating temperature	0 to 50 °C (32 °F to 122 °F)			
Protection IEC 60 529	IP 64			
Weight	Approx. 2.8 kg (6.2 lb)			

* Please indicate when ordering
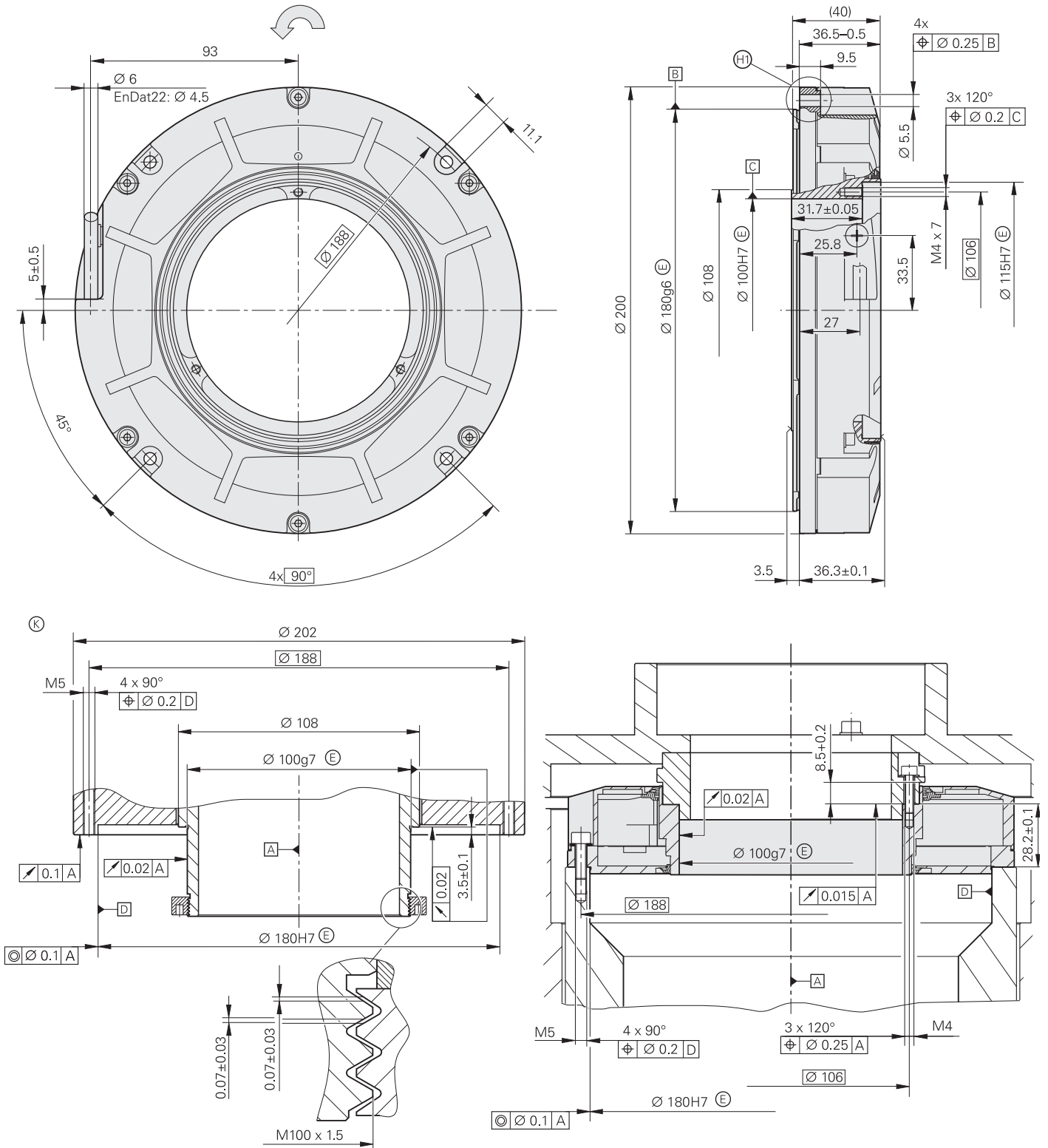[1] With HEIDENHAIN cable

RCN 700/RCN 800 Series

- **Integrated stator coupling**
- **Hollow through shaft, diameter 100 mm**
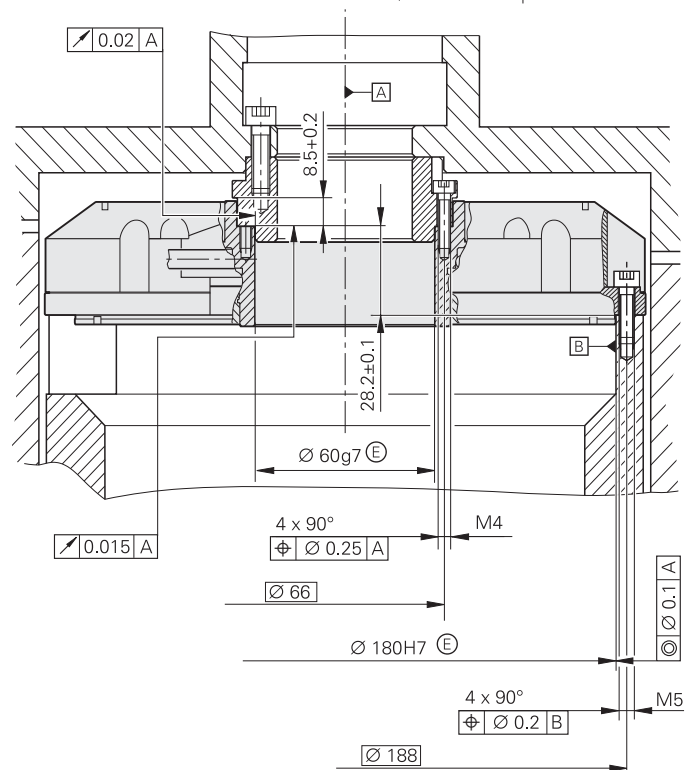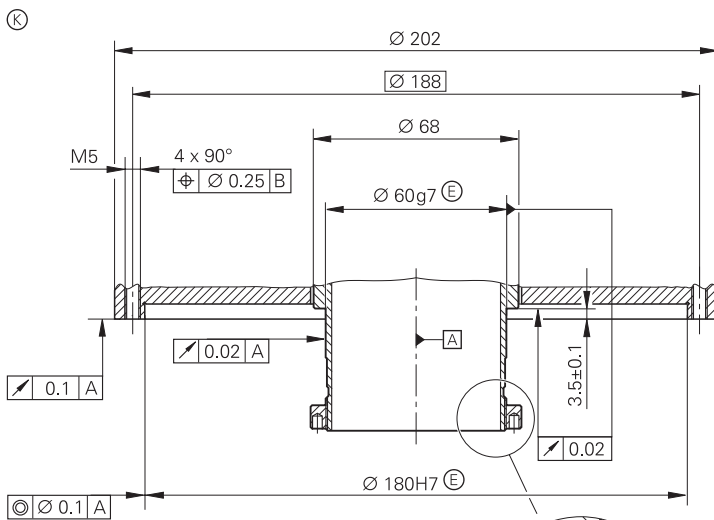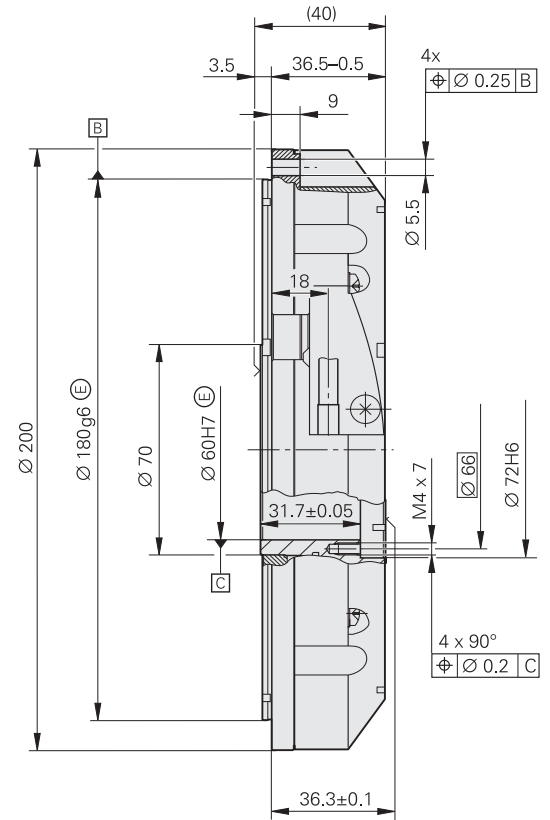- **System accuracy ± 2″ or ± 1″**

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

Cable radial, also usable axially
Ⓐ = Ball bearing
Ⓚ = Required mating dimensions

⊕ = Shown rotated by 45°
↻ = Direction of shaft rotation for output signals
is described in interface description.

	Absolute		
	RCN 729 **RCN 829**	**RCN 729** **RCN 829**	**RCN 727 F** **RCN 827 F**
Absolute position values	EnDat 2.2	EnDat 2.2	Serial Interface Fanuc 02
Ordering designation*	EnDat 22	EnDat 02	Fanuc 02
Positions per revolution	536 870 912 (29 bits)		134 217 728 (27 bits)
Elec. permissible speed	≤ 300 rpm for continuous position value		
Clock frequency	≤ 8 MHz	≤ 2 MHz	–
Calculation time t_{cal}	5 µs		–
Incremental signals	–	$\sim$ 1 V_{PP}	–
Line count*	–	32 768	–
Cutoff frequency –3 dB	–	≥ 180 kHz	–
Recommended measuring step for position capture	*RCN 72x:* 0.000 1° *RCN 82x:* 0.000 05°		
System accuracy	*RCN 72x:* ± 2″ *RCN 82x:* ± 1″		
Power supply without load	3.6 to 5.25 V/Max. 350 mA		5 V ± 5% max. 350 mA
Electrical connection*	Cable 1 m (3.3 ft), with coupling M12	Cable 1 m (3.3 ft), with or without M23 coupling	
Max. cable length[1]	150 m		30 m
Shaft	Hollow through shaft D= 100 mm		
Mech. permissible speed	≤ 1000 rpm		
Starting torque	≤ 1.5 Nm at 20 °C (68 °F)		
Moment of inertia of rotor	$3.3 \cdot 10^{-3}$ kgm^2		
Natural frequency	≥ 900 Hz		
Permissible axial motion of measured shaft	≤ ± 0.1 mm		
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (IEC 60 068-2-6) ≤ 1000 m/s^2 (IEC 60 068-2-27)		
Operating temperature	0 to 50 °C (32 °F to 122 °F)		
Protection IEC 60 529	IP 64		
Weight	Approx. 2.6 kg (5.7 lb)		

* Please indicate when ordering
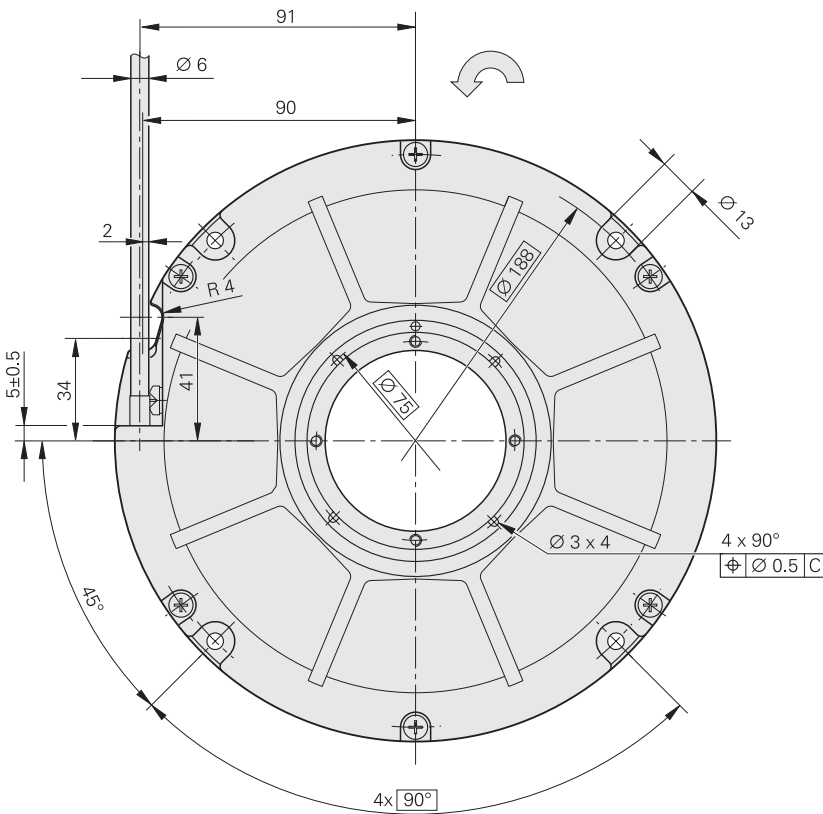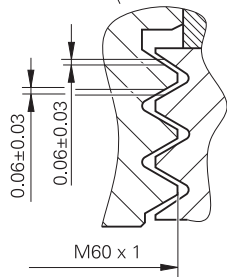[1] With HEIDENHAIN cable

RON 786/RON 886/RPN 886

- **Integrated stator coupling**
- **Hollow through shaft, diameter 60 mm**
- **System accuracy ± 2" or ± 1"**

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

Cable radial, also usable axially
Ⓐ = Ball bearing
Ⓚ = Required mating dimensions
↻ Direction of shaft rotation for
    output signals is described in
    interface description.

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	Incremental		
	RON 786	**RON 886**	**RPN 886**
Incremental signals	$\sim$ 1 V$_{PP}$		
Line count*	18 000 36 000	36 000	90 000 ($\triangleq$ 180 000 signal periods)
Reference mark*	*RON x86:* One *RON x86 C:* Distance-coded		One
Cutoff frequency –3 dB –6 dB	$\geq$ 180 kHz		$\geq$ 800 kHz $\geq$ 1300 kHz
Recommended measuring step for position capture	0.000 1°	0.000 05°	0.000 01°
System accuracy	± 2″	± 1″	
Power supply without load	5 V ± 10% max. 150 mA		5 V ± 10% max. 250 mA
Electrical connection*	Cable 1 m (3.3 ft), with or without M23 coupling		
Max. cable length[1]	150 m		
Shaft	Hollow through shaft D= 60 mm		
Mech. permissible speed	$\leq$ 1000 rpm		
Starting torque	$\leq$ 0.5 Nm at 20 °C (68 °F)		
Moment of inertia of rotor	$1.2 \cdot 10^{-3}$ kgm^2		
Natural frequency	$\geq$ 1000 Hz		$\geq$ 500 Hz
Permissible axial motion of measured shaft	$\leq$ ± 0.1 mm		
Vibration 55 to 2000 Hz **Shock** 6 ms	$\leq$ 100 m/s^2 (IEC 60 068-2-6) $\leq$ 1000 m/s^2 (IEC 60 068-2-27)		$\leq$ 50 m/s^2 (IEC 60 068-2-6) $\leq$ 1000 m/s^2 (IEC 60 068-2-27)
Operating temperature	0 to 50 °C (32 °F to 122 °F)		
Protection IEC 60 529	IP 64		
Weight	Approx. 2.5 kg (5.5 lb)		

* Please indicate when ordering
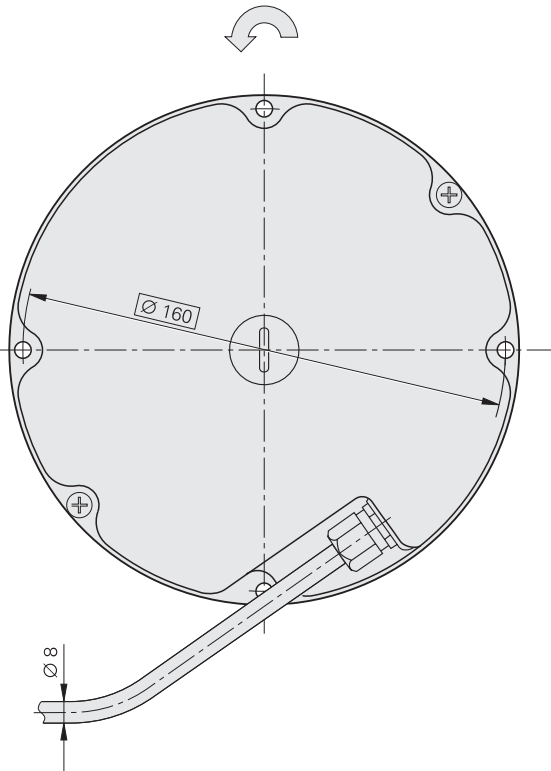[1] With HEIDENHAIN cable

RON 905

- **Integrated stator coupling**
- **Blind hollow shaft**
- **System accuracy ± 0.4"**

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H
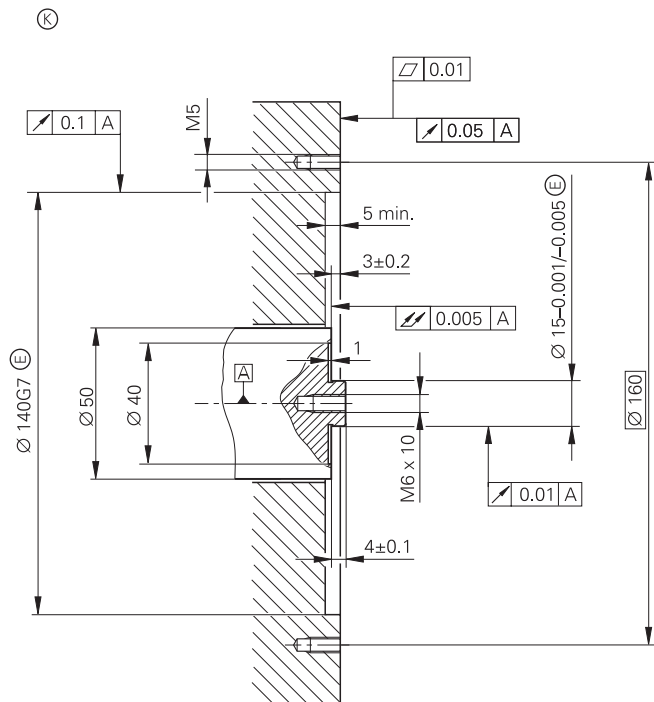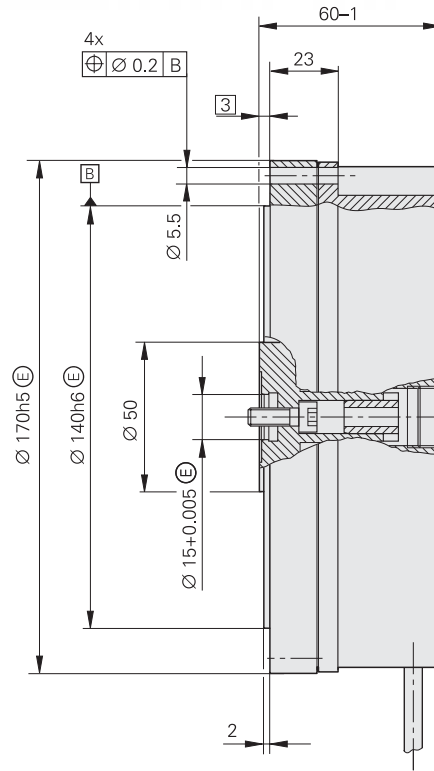
Ø 160

⌀ 8

4x
⊕ | Ø 0.2 | B

60–1

23

3

B

Ø 5.5

Ø 170h5 Ⓔ

Ø 140h6 Ⓔ

Ø 50

Ø 15+0.005 Ⓔ

2

Ⓚ

▱ | 0.01

M5

⟋ | 0.1 | A

⟋ | 0.05 | A

5 min.

3±0.2

⟋⟋ | 0.005 | A

Ø 15−0.001/−0.005 Ⓔ

Ø 140G7 Ⓔ

Ø 50

Ø 40

A

1

Ⓐ

M6 x 10

⟋ | 0.01 | A

Ø 160

4±0.1

Cable radial, also usable axially

Ⓐ = Ball bearing

Ⓚ = Required mating dimensions

Direction of shaft rotation for output signal I_2 laging I_1

	Incremental **RON 905**
Incremental signals	$\sim$ 11 µA$_{PP}$
Line count	36 000
Reference mark	One
Cutoff frequency –3 dB	≥ 40 kHz
Recommended measuring step for position capture	0.00001°
System accuracy	± 0.4"
Power supply without load	5 V ± 5% max. 250 mA
Electrical connection	Cable 1 m (3.3 ft), with M23 connector
Max. cable length[1]	15 m
Shaft	Blind hollow shaft
Mech. permissible speed	≤ 100 rpm
Starting torque	≤ 0.05 Nm at 20 °C (68 °F)
Moment of inertia of rotor	$0.345 \cdot 10^{-3}$ kgm^2
Natural frequency	≥ 350 Hz
Permissible axial motion of measured shaft	≤ ± 0.2 mm
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 50 m/s^2 (IEC 60 068-2-6) ≤ 1000 m/s^2 (IEC 60 068-2-27)
Operating temperature	10 to 30 °C (32 °F to 122 °F)
Protection IEC 60 529	IP 64
Weight	Approx. 4 kg (8.8 lb)

[1] With HEIDENHAIN cable

ROD 200 Series

- **For separate shaft coupling**
- **System accuracy ± 5″**

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

Ø 6

Ø 110–0.5

Ø 100±0.2

R 10

32.5°

33

4 × 90°

5°

5°

□ 92.5–1

4.5

0.08 | A

5

20–1

0.08 | A

B

Ø 80h7

Ø 10h6

A

Ø 90–1

Ø 0.08 | B

0.01 | A

3±0.2

13

42+1

Cable radial, also usable axially

A = Ball bearing

Direction of shaft rotation for output signals is described in interface description.

	Incremental		
	ROD 260	**ROD 270**	**ROD 280**
Incremental signals	⊓⊔TTL	⊓⊔TTL with 10-fold interpolation	∿ 1 V$_{PP}$
Line count	18 000		
Reference mark*	One		*ROD 280:* One *ROD 280 C:* Distance-coded
Cutoff frequency (–3 dB) Output frequency	– Max. 1 MHz		≥ 180 kHz –
Elec. permissible speed	3333 rpm	≤ 333 rpm	–
Recommended measuring step for position capture	0.005°	0.000 5°	0.000 1°
System accuracy	± 5″		
Power supply without load	5 V ± 10% max. 150 mA		
Electrical connection*	Cable 1 m (3.3 ft), with or without M23 coupling		
Max. cable length[1]	100 m		150 m
Shaft	Solid shaft D = 10 mm		
Mech. permissible speed	≤ 10 000 rpm		
Starting torque	≤ 0.01 Nm at 20 °C (68 °F)		
Moment of inertia of rotor	$20 \cdot 10^{-6}$ kgm^2		
Shaft load	*Axial:* 10 N *Radial:* 10 N at shaft end		
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (IEC 60 068-2-6) ≤ 1000 m/s^2 (IEC 60 068-2-27)		
Operating temperature	*Moving cable:* –10 to 70 °C (+14 to 158 °F) *Rigid cable:* –20 to 70 °C (–4 to 158 °F)		
Protection IEC 60 529	IP 64		
Weight	Approx. 0.7 kg (1.5 lb)		

* Please indicate when ordering
[1] With HEIDENHAIN cable

ROD 780/ROD 880

- **For separate shaft coupling**
- **System accuracy ROD 780: ± 2"**
                     ROD 880: ± 1"

Dimensions in mm
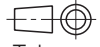
Tolerancing ISO 8015
ISO 2768 - m H
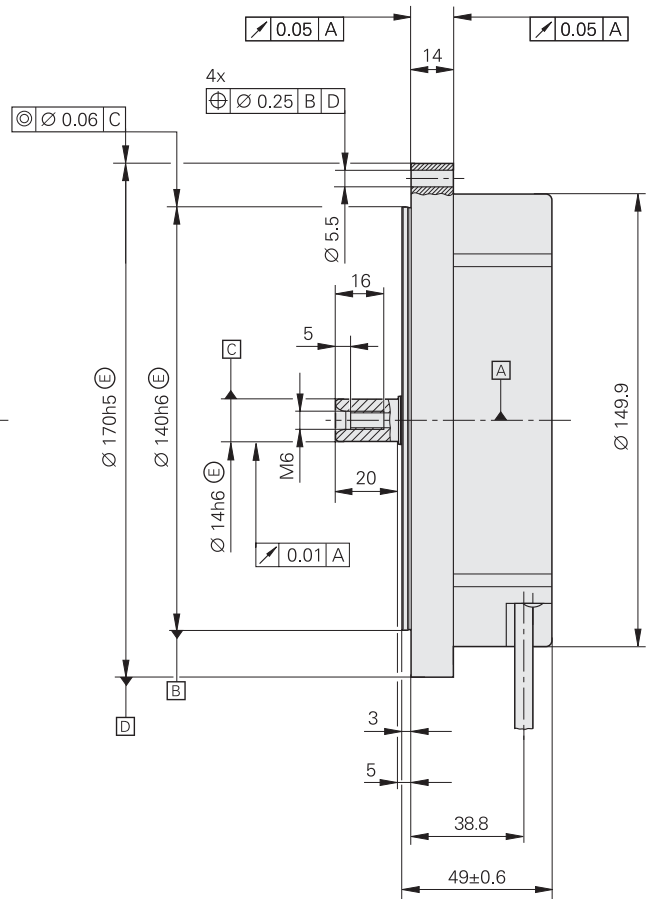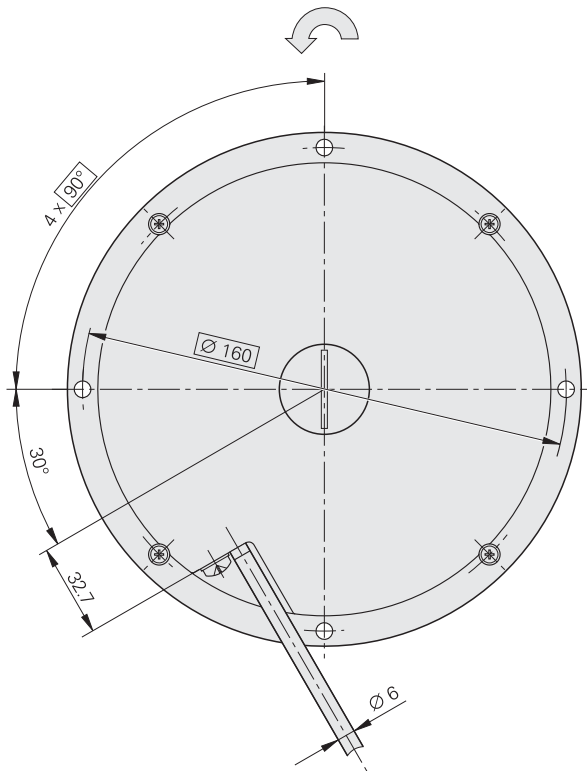
Cable radial, also usable axially

Ⓐ = Ball bearing

⟲ Direction of shaft rotation for output signals is described in interface description.

	Incremental	
	ROD 780	**ROD 880**
Incremental signals	$\sim$ 1 V$_{PP}$	
Line count*	18 000 36 000	36 000
Reference mark*	*ROD x80:* One *ROD x80 C:* Distance-coded	
Cutoff frequency –3 dB	≥ 180 kHz	
Recommended measuring step for position capture	0.000 1°	0.000 05°
System accuracy	± 2"	± 1"
Power supply without load	5 V ± 10% max. 150 mA	
Electrical connection*	Cable 1 m (3.3 ft), with or without M23 coupling	
Max. cable length[1]	150 m	
Shaft	Solid shaft D = 14 mm	
Mech. permissible speed	≤ 1000 rpm	
Starting torque	≤ 0.012 Nm at 20 °C (68 °F)	
Moment of inertia of rotor	$0.36 \cdot 10^{-3}$ kgm^2	
Shaft load	*Axial:* 30 N *Radial:* 30 N at shaft end	
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (IEC 60 068-2-6) ≤ 300 m/s^2 (IEC 60 068-2-27)	
Operating temperature	0 to 50 °C (32 °F to 122 °F)	
Protection IEC 60 529	IP 64	
Weight	Approx. 2.0 kg (4.4 lb)	

* Please indicate when ordering
[1] With HEIDENHAIN cable

ERP 880

- **Modular angle encoder**
- **High accuracy**
  due to interferential scanning principle

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H
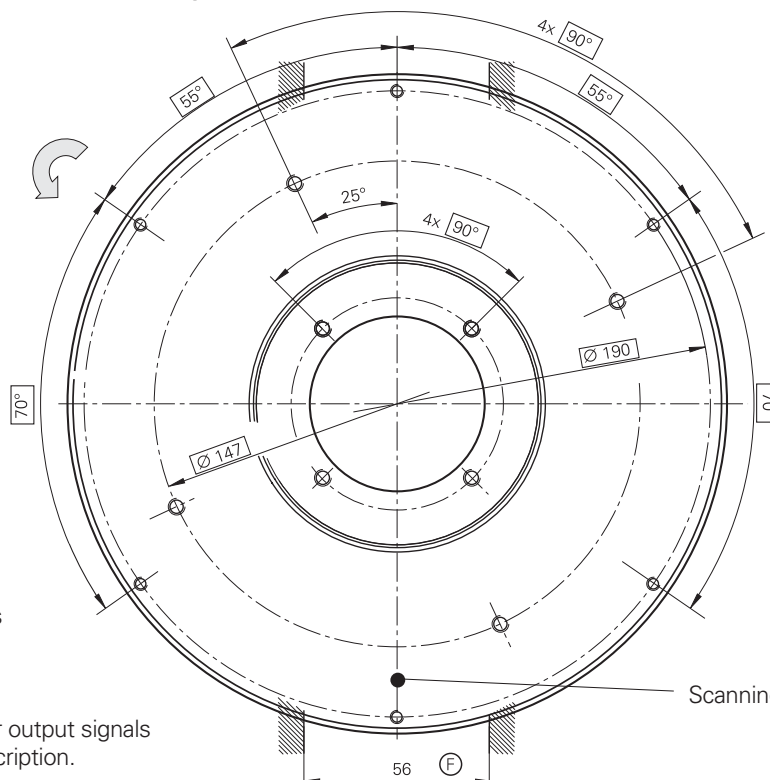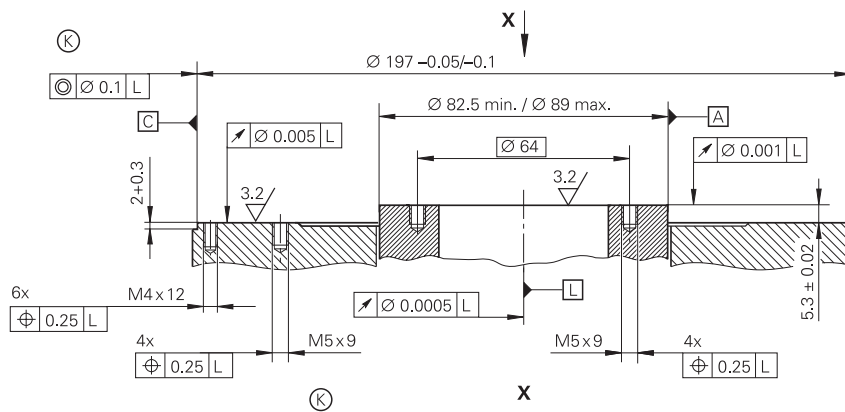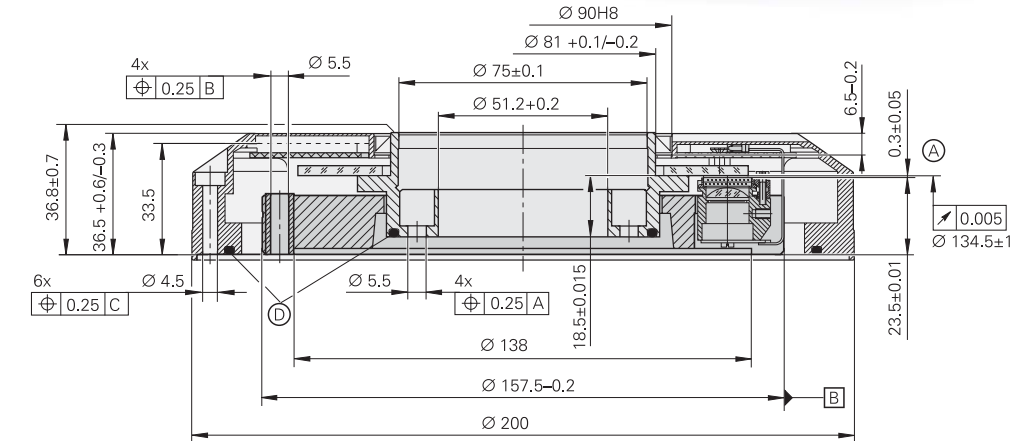
Cable radial, also usable axially

(A) = Disk-to-scanning-reticle gap
(K) = Required mating dimensions
(F) = Space needed for service
(D) = Seal
(L) = Axis of bearing rotation
↻ Direction of shaft rotation for output signals
is described in interface description.

Scanning position A

	Incremental ERP 880		
Incremental signals	$\sim$ 1 V_{PP}		
Line count	90 000 ($\hat{=}$ 180 000 signal periods)		
Reference mark	One		
Cutoff frequency –3 dB –6 dB	≥ 800 kHz ≥ 1.3 MHz		
Recommended measuring step for position capture	0.00001°		
System accuracy[1]	± 1"		
Power supply without load	5 V ± 10% max. 250 mA		
Electrical connection	*With housing:* Cable 1 m (3.3 ft), with M23 coupling *Without housing:* Via 12-pin PCB connector (adapter cable Id. Nr. 372 164-xx)		
Max. cable length[2]	150 m		
Hub inside diameter	51.2 mm		
Mech. permissible speed	≤ 1000 rpm		
Moment of inertia of rotor	$1.2 \cdot 10^{-3}$ kgm^2		
Permissible axial motion of measured shaft	≤ ± 0.05 mm		
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 50 m/s^2 (IEC 60 068-2-6) ≤ 1000 m/s^2 (IEC 60 068-2-27)		
Operating temperature	0 to 50 °C (32 °F to 122 °F)		
Protection* IEC 60 529	*Without housing:* IP 00	*With housing:* IP 40	*With housing and rotary shaft seal:* IP 64
Starting torque	–		0.25 Nm
Weight	3.0 kg (6.6 lb)	3.1 kg (6.8 lb) incl. housing	

* Please indicate when ordering
[1] Without installation. Additional errors caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft are not included.
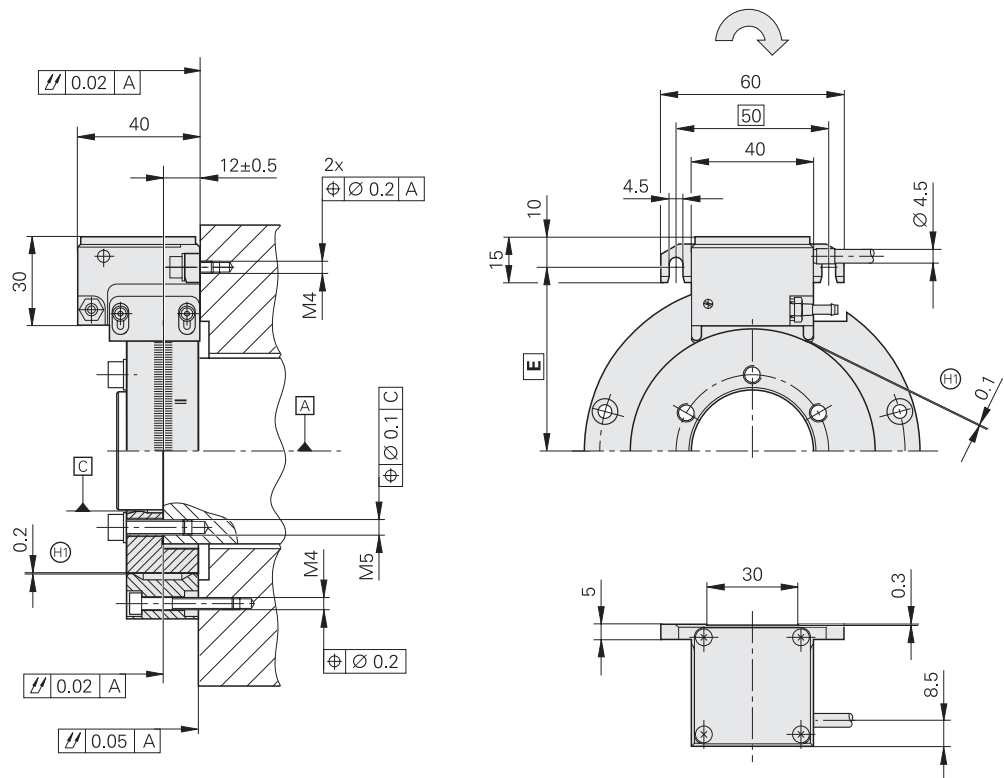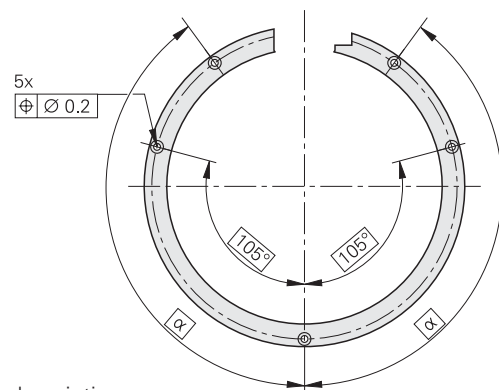[2] With HEIDENHAIN cable

ERA 180

- **Modular angle encoder**
- **Grating on steel drum**

ERA 180

ERA 180

ERA 180 with protective cover

ERA 180 with protective cover

Incremental signals	
Reference mark	
Cutoff frequency –3 dB	
Power supply without load	
Electrical connection	
Max. cable length[1]	
Drum inside diameter*	
Drum outside diameter*	
Line count	
System accuracy[2]	
Accuracy of the graduation[3]	
Recommended measuring step for position capture	
Mech. permissible speed	
Moment of inertia of rotor	
Permissible axial motion of measured shaft	
Vibration 55 to 2000 Hz **Shock** 6 ms	
Operating temperature	
Protection* IEC 60529	
Weight	
Scale drum	
Protective cover	
Scanning head with cable	

Incremental						
ERA 180						
∿ 1 V$_{PP}$						
One						
≥ 500 kHz						
5 V ± 10% max. 150 mA						
Cable 1 m (3.3 ft), with M23 coupling						
150 m						
40 mm	80 mm	120 mm	180 mm	270 mm	425 mm	512 mm
80 mm	130 mm	180 mm	250 mm	330 mm	485 mm	562 mm
6000	9000	9000	18000	18000	36000	36000
± 7.5″	± 5″	± 5″	± 4″	± 4″	± 2.5″	± 2.5″
± 5″	± 3″	± 3″	± 3″	± 3″	± 2″	± 2″
0.0015°	0.001°	0.001°	0.0005°	0.0005°	0.0001°	0.0001°
≤ 40000 rpm	≤ 25000 rpm	≤ 18000 rpm	≤ 13000 rpm	≤ 10000 rpm	≤ 7000 rpm	≤ 6000 rpm
$0.58 \cdot 10^{-3}$ kgm^2	$3.45 \cdot 10^{-3}$ kgm^2	$11.1 \cdot 10^{-3}$ kgm^2	$35.7 \cdot 10^{-3}$ kgm^2	$82.6 \cdot 10^{-3}$ kgm^2	$281.8 \cdot 10^{-3}$ kgm^2	$399.7 \cdot 10^{-3}$ kgm^2
≤ ± 0.5 mm (scale drum relative to scanning head)						
≤ 100 m/s2 (IEC 60068-2-6) ≤ 1000 m/s^2 (IEC 60068-2-27)						
−10 °C to 80 °C (14 °F to 176 °F)						
Without protective cover: IP 00 *With protective cover and compressed air:* IP 40				IP 00		
Approx. 0.5 kg (1.1 lb)	Approx. 1.08 kg (2.38 lb)	Approx. 1.17 kg (2.58 lb)	Approx. 2.85 kg (6.28 lb)	Approx. 3.3 kg (7.3 lb)	Approx. 5 kg (11 lb)	Approx. 5.3 kg (12 lb)
Approx. 0.23 kg (0.51 lb)	Approx. 0.37 kg (0.82 lb)	Approx. 0.51 kg (1.1 lb)	Approx. 0.68 kg (1.5 lb)	–		
Approx. 0.2 kg (0.44 lb)						

* Please indicate when ordering
[1] With HEIDENHAIN cable
[2] Without installation. Additional errors caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft are not included.
[3] For other errors, see *Measuring Accuracy*

ERA 180

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

⊥ | 0.02 | A

40

12±0.5

2x
⊕ | Ø 0.2 | A

30

M4

A

⊕ | Ø 0.1 | C

C

0.2

H1

M4

M5

⊥ | 0.02 | A

⊕ | Ø 0.2

⊥ | 0.05 | A

60

50

40

4.5

10

15

Ø 4.5

E

H1

0.1

30

5

0.3

8.5

Protective cover

Ⓜ

24

Ø 8.4

Ø 4.5

5

5

3x
⊕ | Ø 0.2

105°   105°

D5

D6

D7

5x
⊕ | Ø 0.2

105°   105°

α   α
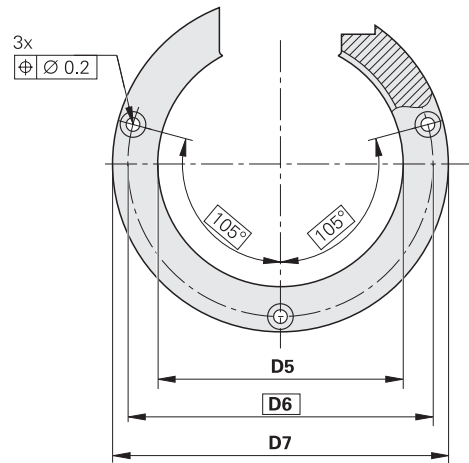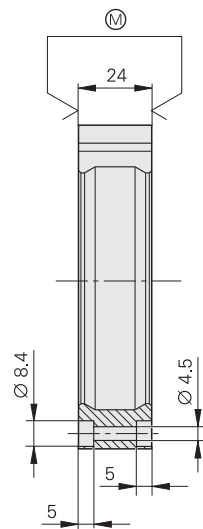
Ⓐ = Bearing
Ⓜ = Mounting surfaces
H1 = Mounting clearance set with spacer foil
H2 = Mounting hole
H3 = Back-off thread
↻ Direction of shaft rotation for output signals is described in interface description.

Scale drum inside diameter

40 mm to 180 mm

6x 60°
60°

M
M
D4 D2 D1 D3 B M6
⊕ Ø 0.1 B
X

X

19
2
12
15°
0.5
24

270 mm

30° 15° D4
Ø 330
D1
Ø 5.5 (Ø 7) 12 x 30° M6 12 x 30°
⊕ Ø 0.3 B   ⊕ Ø 0.3 B
H2   H3

425 mm

30° 15° D4
Ø 485
D1
12 x 30° Ø 6.5 M6 12 x 30°
⊕ Ø 0.2 B   ⊕ Ø 0.2 B
H2   H3

512 mm

20° 5° D4
Ø 562
D1
Ø 7 18 x 20° M8 12 x 30°
⊕ Ø 0.3 B   ⊕ Ø 0.1 B
H2   H3
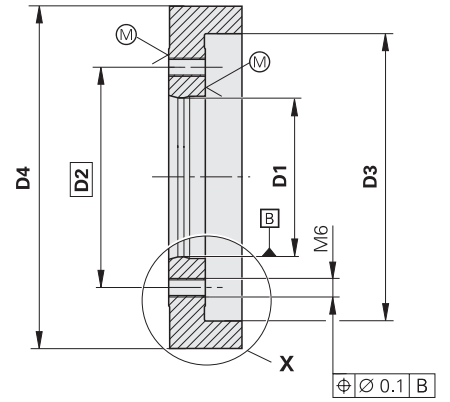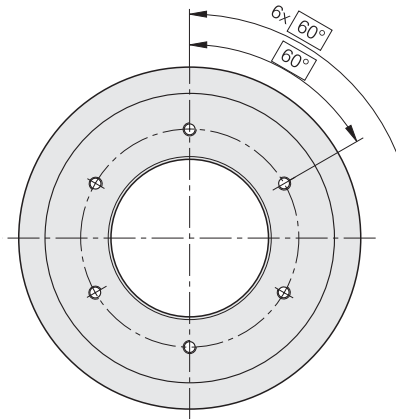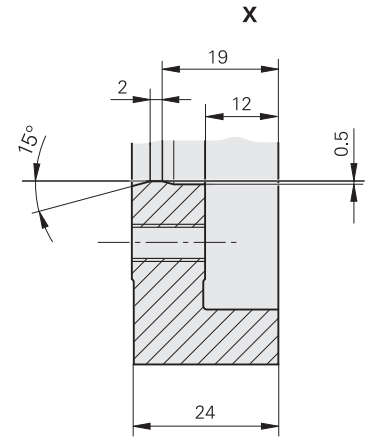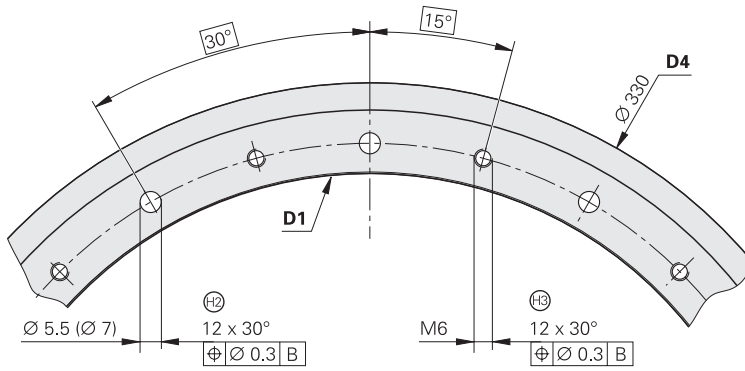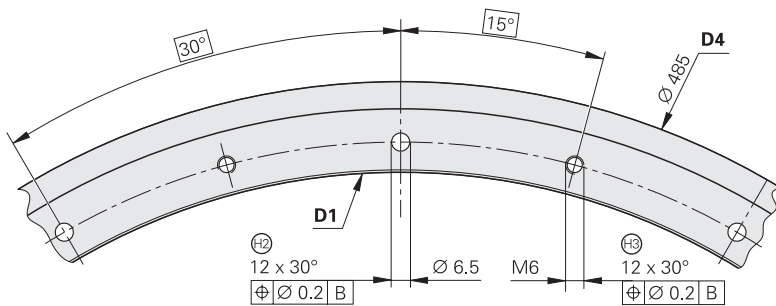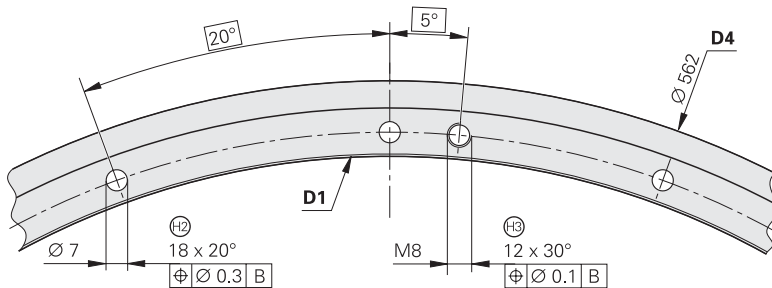
Scale drum inside diameter	D1 Ⓔ	D2	D3	D4	D5	D6	D7	α	E
40 mm	Ø 40 –0.001 –0.005	Ø 50	Ø 64	Ø 80	Ø 80.4	Ø 100	Ø 110	–	60
80 mm	Ø 80 –0.001 –0.005	Ø 95	Ø 112	Ø 130	Ø 130.4	Ø 150	Ø 160	–	85
120 mm	Ø 120 –0.001 –0.008	Ø 140	Ø 162	Ø 180	Ø 180.4	Ø 200	Ø 210	144°	110
180 mm	Ø 180 –0.001 –0.008	Ø 200	Ø 232	Ø 250	Ø 250.4	Ø 270	Ø 280	150°	145
270 mm	Ø 270 –0.01	Ø 290	Ø 312	Ø 330	–	–	–	–	185
425 mm	Ø 425 –0.01	Ø 445	Ø 467	Ø 485	–	–	–	–	262.5
512 mm	Ø 512 –0.015	Ø 528	Ø 544	Ø 562	–	–	–	–	301

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ERO 785

- **Modular angle encoder**
- **Circular scale with hub**

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H
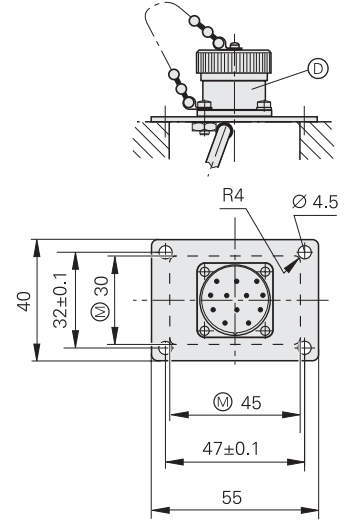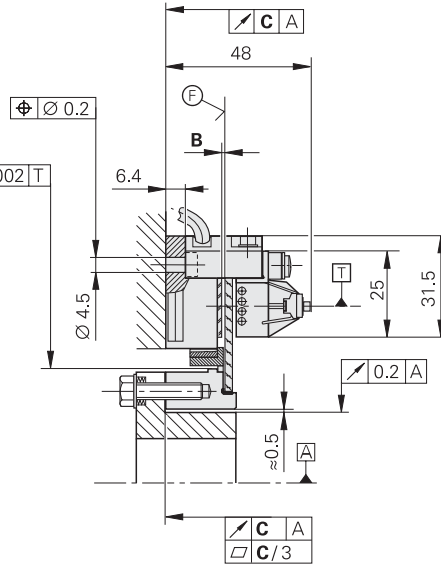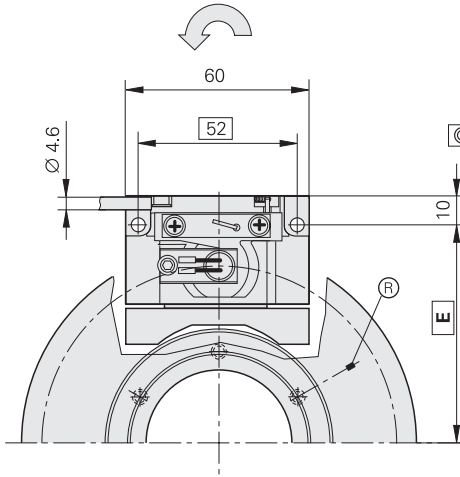
Hub inside diameter
155.1 mm
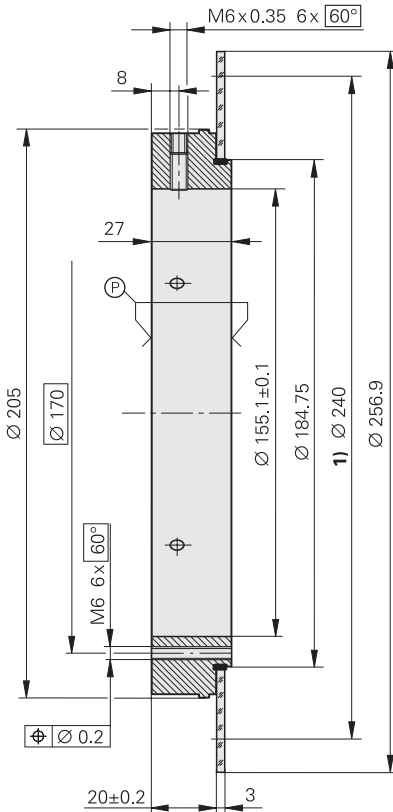
102.2 mm
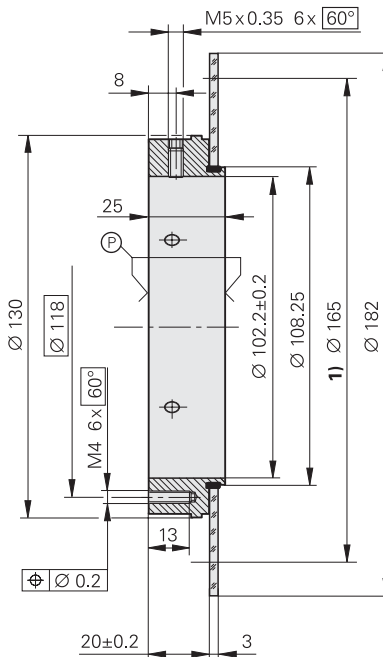
47.2 mm
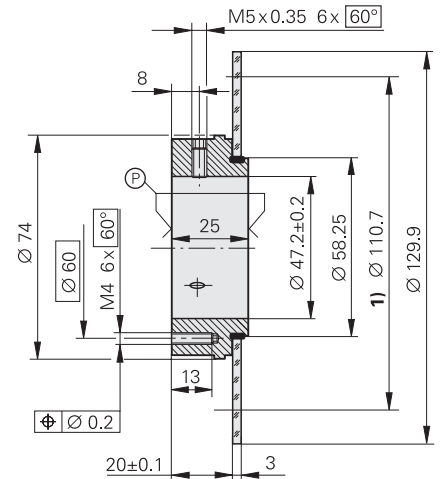
1) Mean graduation diameter
Ⓐ = Bearing
Ⓜ = Cutout for mounting
Ⓡ = Position of the reference mark to an integral mounting thread ± 2°
Ⓣ = Graduation
Ⓕ = Graduation surface
Ⓟ = Mounting surface
Ⓓ = Flange socket
⤹ Direction of shaft rotation for output signals
   is described in interface description.

Hub inside diameter	Line count	E	B	C
155.1	36000	132	0.05 ±0.02	0.02
102.2		94.5	0.20 ±0.02	
47.2		67.35	0.08 ±0.01	0.01

	Incremental ERO 785		
Incremental signals	$\sim$ 1 V$_{PP}$		
Line count	36 000		
Reference mark	One		
Cutoff frequency –3 dB	180 kHz		
Recommended measuring step for position capture	0.000 1°		
System accuracy[1]	± 4.2″	± 3″	± 2.2″
Accuracy of the graduation[2]	± 3.7″	± 2.5″	± 1.7″
Power supply without load	5 V ± 10% max. 150 mA		
Electrical connection	Cable 0.3 m (1 ft) with flange socket (male) M23 on mounting base		
Max. cable length[3]	150 m		
Hub inside diameter*	47.2 mm	102.2 mm	155.1 mm
Mech. permissible speed	≤ 8000 rpm	≤ 6000 rpm	≤ 4000 rpm
Moment of inertia of rotor	620 · 10^{-6} kgm^2	3700 · 10^{-6} kgm^2	26 000 · 10^{-6} kgm^2
Permissible axial motion of measured shaft	See the tolerance of scanning gap "B" in the dimension drawing		
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (IEC 60 068-2-6) ≤ 1000 m/s^2 (IEC 60 068-2-27)		
Operating temperature	0 to 50 °C (32 °F to 122 °F)		
Protection* IEC 60 529	IP 00		
Weight			
Scanning unit	Approx. 0.19 kg (0.42 lb)		
Circular scale with hub	0.46 kg (1.0 lb)	0.87 kg (1.9 lb)	2.6 kg (5.2 lb)

* Please indicate when ordering
[1] Without installation. Additional errors caused by mounting and the bearing of the measured shaft are not included.
[2] For other errors, see *Measuring Accuracy*
[3] With HEIDENHAIN cable

ERA 700 Series

- **Modular angle encoder for inside diameters**
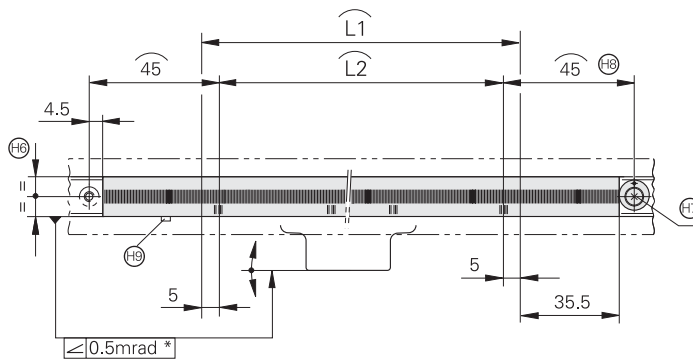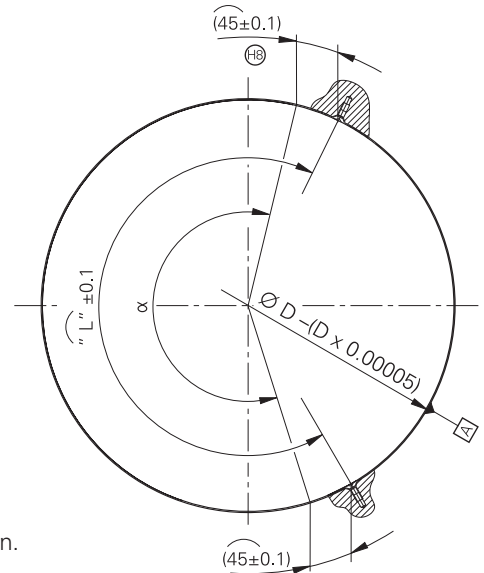- **Full-circle and segment versions**

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H
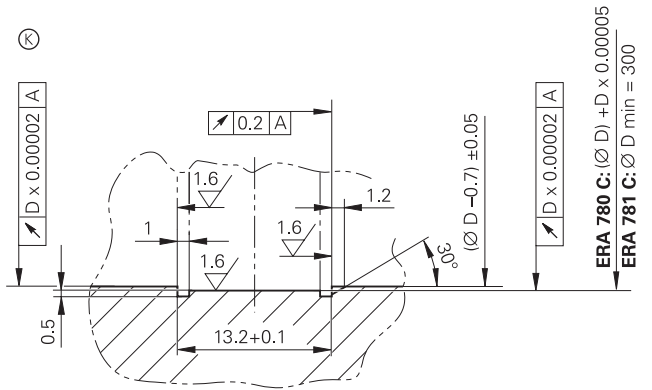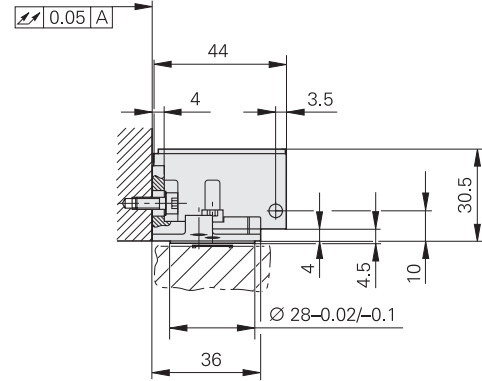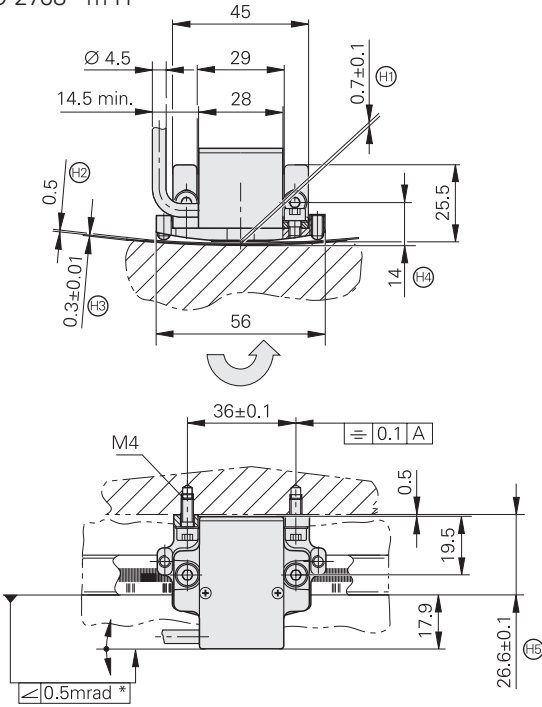
ERA 781 C Scale tape
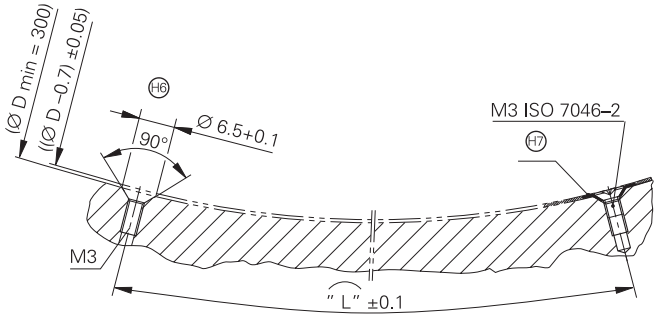
* = Max. change during operation
Ⓐ = Ball bearing
Ⓚ = Required mating dimensions for the scale tape (not to scale)
L⌒ = Distance of the mounting holes
L1⌒ = Traverse path
L2⌒ = Measuring range in radian measure
α = Measuring range in degrees (segment angle)
H1 = Scanning gap (distance between scanning reticle and scale-tape surface)
H2 = Mounting clearance for mounting bracket. Spacer foil 0.5 mm
H3 = Scale-tape thickness
H4 = Distance between floor of scale-tape slot and threaded mounting hole
H5 = Distance between mounting surface and scale-tape slot
H6 = View of customer boring
H7 = Cam disk for tensioning the scale tape
H8 = Position of first reference mark
H9 = Notch for removing scale tape (1 x b = 2 mm)
↺ Direction of shaft rotation for output signals is described in interface description.

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	Incremental **ERA 780 C** Full-circle version **ERA 781 C** Segment version, scale-tape mounting with tensioning elements			
Incremental signals	$\sim$ 1 V_{PP}			
Reference mark	Distance-coded, nominal increment of 1000 grating periods			
Cutoff frequency –3 dB	≥ 180 kHz			
Power supply without load	5 V ± 10% max. 150 mA			
Electrical connection	Cable 3 m (9.9 ft) with coupling M23			
Max. cable length[1]	150 m			
Scale-slot diameter*	318.58 mm	458.62 mm	573.20 mm	1 146.10 mm
Line count				
ERA 780 C full circle	–	36 000	45 000	90 000
ERA 781 C segment*	*72°:* 5 000[4] *144°:* 10 000[4]	*50°:* 5 000 *100°:* 10 000 *200°:* 20 000	*160°:* 20 000	–
Recommended measuring step for position capture	0.000 2°	0.000 1°	0.000 05°	0.000 02°
System accuracy[2]				
ERA 780 C full circle	–	± 3.5″	± 3.4″	± 3.2″
ERA 781 C segment	See *Measuring Accuracy*			
Accuracy of the graduation[3]	± 3″			
Mech. permissible speed	≤ 500 rpm			
Permissible axial motion of measured shaft	± 0.2 mm			
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (IEC 60 068-2-6) ≤ 1000 m/s^2 (IEC 60 068-2-27)			
Operating temperature	–10 to 50 °C (32 °F to 122 °F) (thermal coefficient of expansion of the scale substrate between $9 \cdot 10^{-6}K^{-1}$ and $12 \cdot 10^{-6}K^{-1}$)			
Protection IEC 60 529	IP 00			
Weight				
Scanning unit	Approx. 0.35 kg (0.77 lb)			
Scale tape	Approx. 30 g/m (7.1 oz/m)			

* Please indicate when ordering; other versions available upon request.
[1] With HEIDENHAIN cable
[2] Without installation. Additional errors caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft are not included.
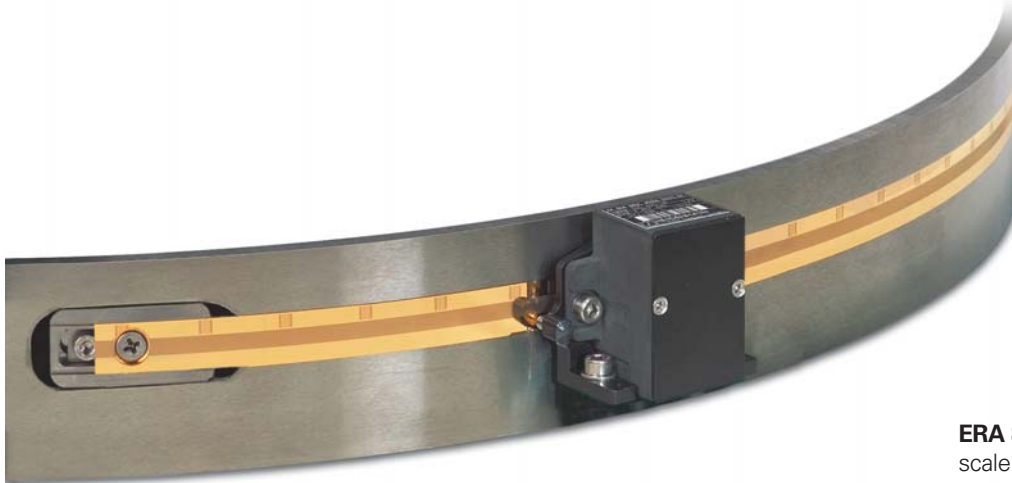[3] For other errors, see *Measuring Accuracy*
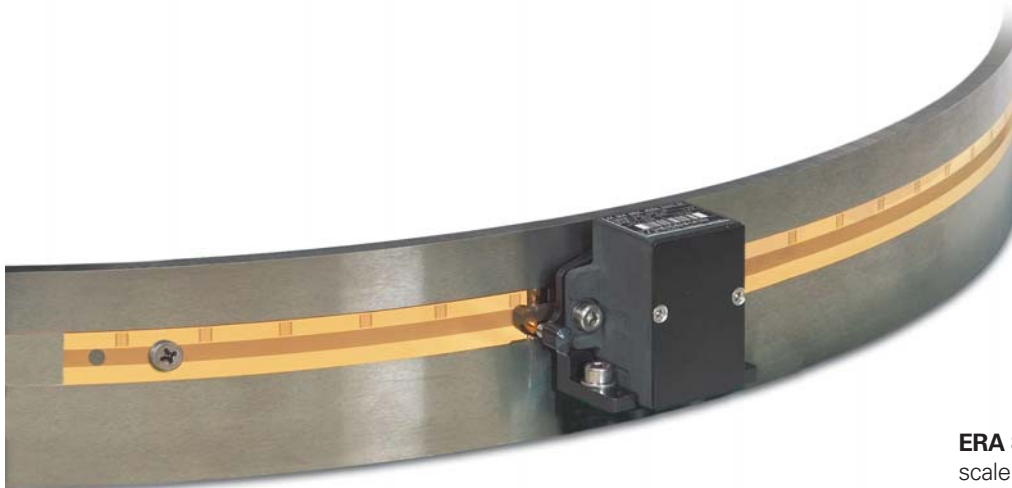[4] Corresponds to 25 000 lines on a full circle

ERA 800 Series

- **Modular angle encoder for outside diameters**
- **Full-circle and segment versions**

ERA 880 C Full-circle version

ERA 881 C Circle-segment version,
scale tape secured with tensioning elements

ERA 882 C Circle-segment version,
scale tape without tensioning elements

	Incremental **ERA 880 C** Full-circle version **ERA 881 C** Circle-segment version, scale-tape mounting via tensioning elements **ERA 882 C** Circle-segment version, scale tape without tensioning elements		
Incremental signals	$\sim$ 1 V$_{PP}$		
Reference mark	Distance-coded, nominal increment of 1000 grating periods		
Cutoff frequency –3 dB	≥ 180 kHz		
Power supply without load	5 V ± 10% max. 150 mA		
Electrical connection	Cable 3 m (9.9 ft) with coupling M23		
Max. cable length[1]	150 m		
Scale-slotdiameter*	317.99 mm	458.04 mm	572.63 mm
Line count			
ERA 880 C full circle	–	36000	45000
ERA 881 C/ ERA 882 C segment*	*72°:* 5000[4] *144°:* 10000[4]	*50°:* 5000 *100°:* 10000 *200°:* 20000	*160°:* 20000
Recommended measuring step for position capture	0.0002°	0.0001°	0.00005°
System accuracy[2]			
ERA 880 C full circle	–	± 3.5″	± 3.4″
ERA 881 C/ ERA 882 C segment	See *Measuring Accuracy*		
Accuracy of the graduation[3]	± 3″		
Mech. permissible speed	≤ 100 rpm		
Permissible axial motion of measured shaft	± 0.2 mm		
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (IEC 60068-2-6) ≤ 1000 m/s^2 (IEC 60068-2-27)		
Operating temperature	–10 to 50 °C (+14 to 122 °F) (thermal coefficient of expansion of the scale substrate between $9 \cdot 10^{-6}K^{-1}$ and $12 \cdot 10^{-6}K^{-1}$)		
Protection IEC 60529	IP 00		
Weight			
Scanning unit	Approx. 0.35 kg (0.77 lb)		
Scale tape	Approx. 30 g/m (7.1 oz/m)		

* Please indicate when ordering; other versions available upon request.
[1] With HEIDENHAIN cable
[2] Without installation. Additional errors caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft are not included.
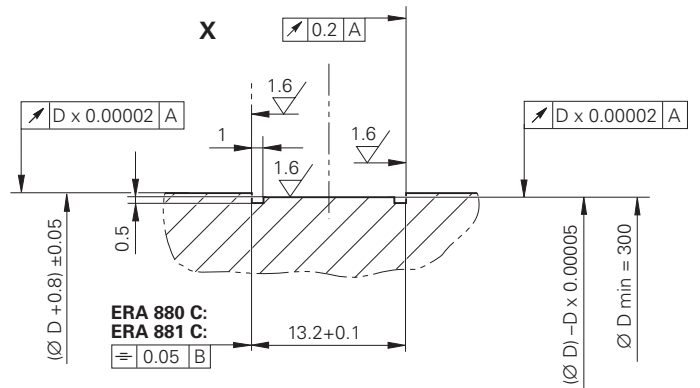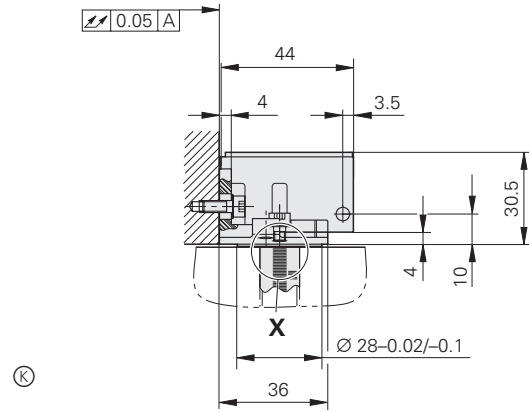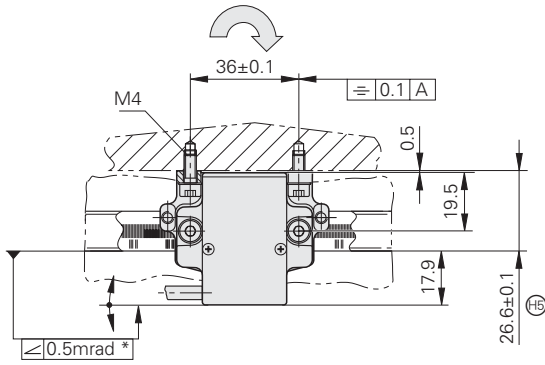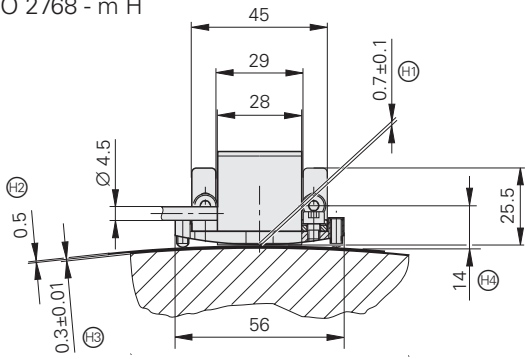[3] For other errors, see *Measuring Accuracy*
[4] Corresponds to 25000 lines on a full circle
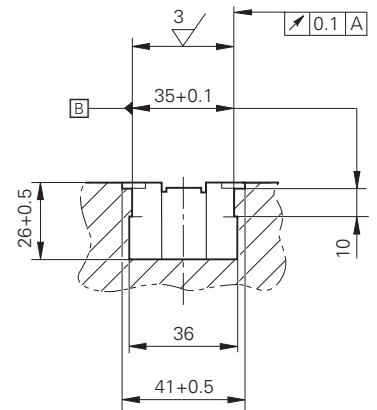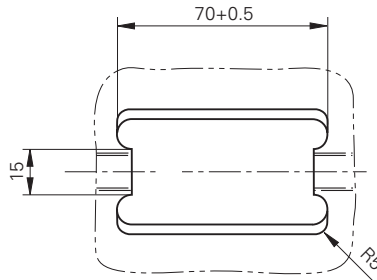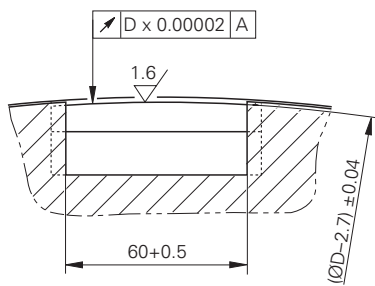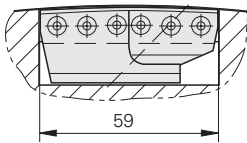
ERA 800 Series

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H

ERA 880 C Scale tape

* = Max. change during operation
Ⓐ = Ball bearing
Ⓚ = Required mating dimensions for the scale tape (not to scale)
⊕1 = Scanning gap (distance between scanning reticle and scale-tape surface)
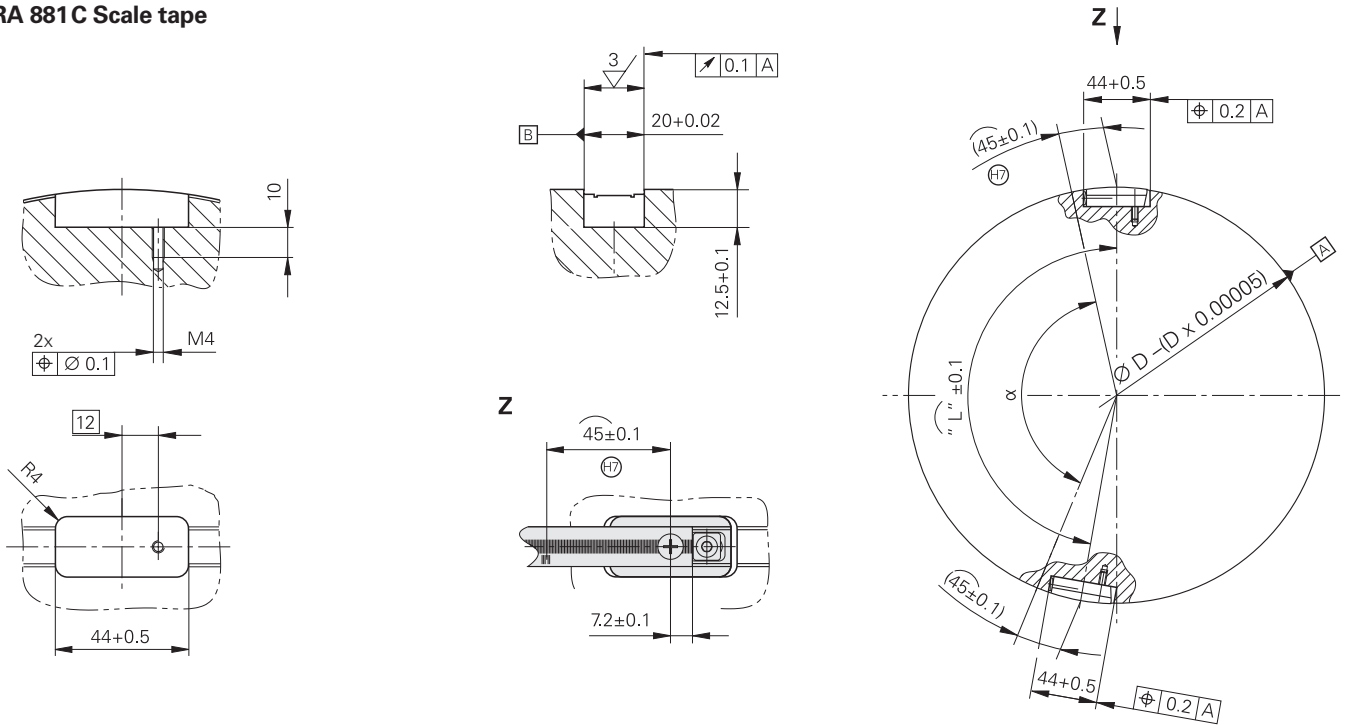⊕2 = Mounting clearance for mounting bracket. Spacer foil 0.5 mm
⊕3 = Scale-tape thickness
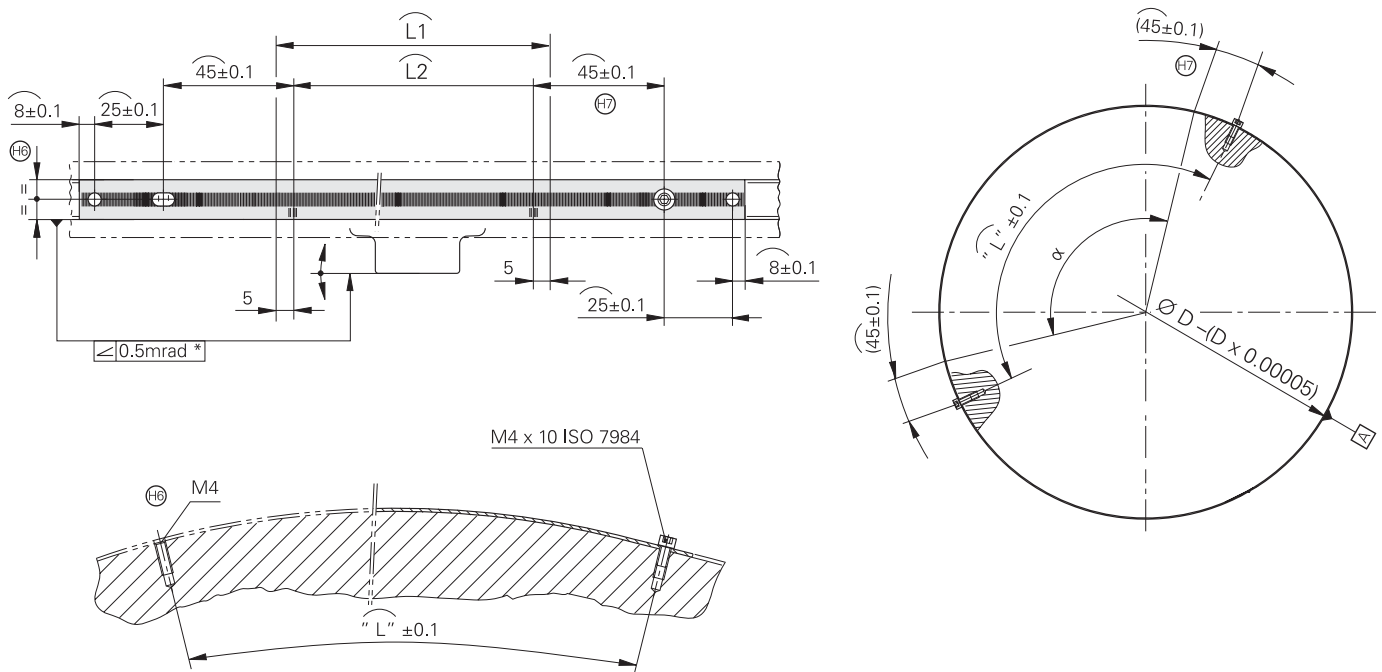⊕4 = Distance between floor of scale-tape slot and threaded mounting hole
⊕5 = Distance between mounting surface and scale-tape slot
↻ Direction of shaft rotation for output signals is described in interface description.

ERA 881 C Scale tape

3

$\nearrow$ | 0.1 | A

B

20+0.02

10

12.5+0.1

2x

M4

$\oplus$ | $\varnothing$ 0.1

12

R4

44+0.5

Z

45±0.1

H7

7.2±0.1

Z ↓

44+0.5

$\oplus$ | 0.2 | A

(45±0.1)

H7

"L" ±0.1

α

$\varnothing$ D –(D x 0.00005)

A

(45±0.1)

44+0.5

$\oplus$ | 0.2 | A

ERA 882 C Scale tape

L1

L2

45±0.1

45±0.1

8±0.1

25±0.1

H7

H6

5

5

8±0.1

25±0.1

$\angle$ | 0.5mrad *

M4 x 10 ISO 7984

H6   M4

"L" ±0.1

(45±0.1)

H7

"L" ±0.1

α

$\varnothing$ D –(D x 0.00005)

A

(45±0.1)

* = Max. change during operation
A = Ball bearing
H6 = View of customer boring
H7 = Position of first reference mark
L = With *ERA 881 C:* Positions of the tensioning elements
      With *ERA 882 C:* Distance of mounting holes
L1 = Traverse path
L2 = Measuring range in radian measure
α = Measuring range in degrees (segment angle)

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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 value *H*. This must not cause the subsequent electronics to overdrive. Even at the lowered signal level, signal peaks with the amplitude *G* can also appear.

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

Interpolation/resolution/measuring step
The output signals of the 1 V_PP interface are usually interpolated in the subsequent electronics in order to attain sufficiently high resolutions. For **velocity control,** interpolation factors are commonly over 1000 in order to receive usable velocity information even at low speeds.

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

Short circuit stability
A temporary short circuit of one signal output to 0 V or 5 V does not cause encoder failure, but it is not a permissible operating condition

Short circuit at	20 °C (68 °F)	125 °C (257 °F)
One output	< 3 min	< 1 min
All outputs	< 20 s	< 5 s

Interface	Sinusoidal voltage signals 〜 **1 V_PP**
Incremental signals	**2 sinusoidal signals A and B**
	Signal level 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	**1 or more signal peaks R**
	Usable component G: 0.2 to 0.85 V
	Quiescent value H: 0.04 V to 1.7 V
	Switching threshold E, F: ≥ 40 mV
	Zero crossovers K, L: 180° ± 90° elec.
Connecting cable **Cable lengths** Propagation time	HEIDENHAIN cable with shielding PUR [4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] Max. 150 m distributed capacitance 90 pF/m 6 ns/m

Any limited tolerances in the encoders are listed in the specifications.

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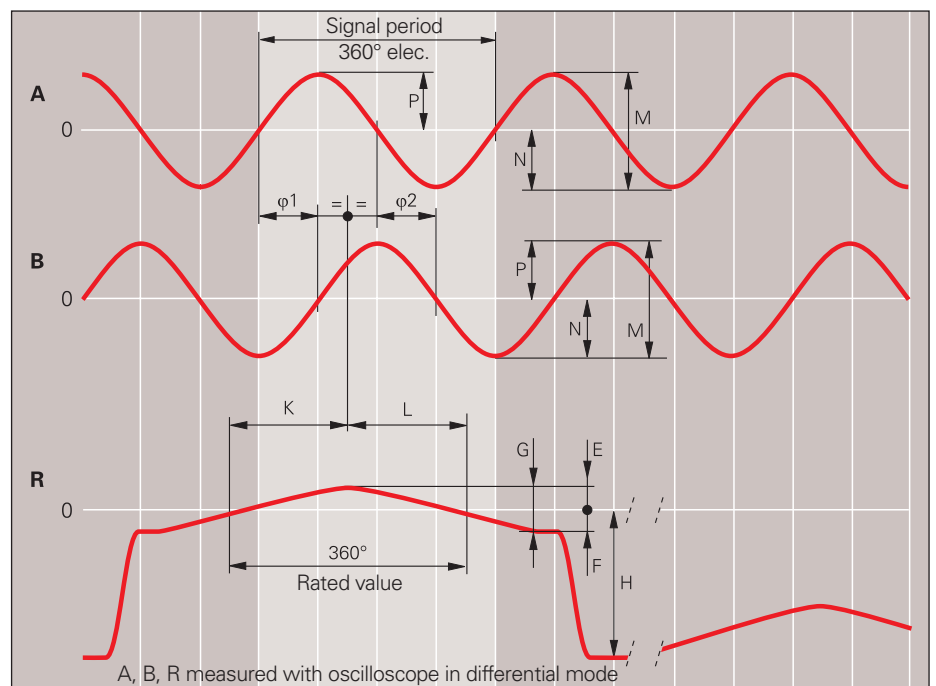
Cutoff frequency
Typical signal amplitude curve with respect to the scanning frequency

— –3dB cutoff frequency
— –6dB cutoff frequency **Scanning frequency [kHz]** ►
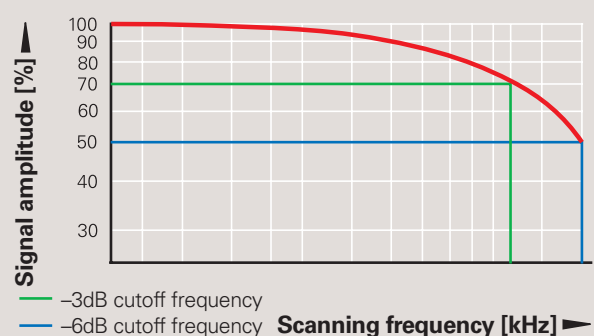
Input circuitry of the subsequent electronics

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

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

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

Signal monitoring
A threshold sensitivity of 250 mV_{PP} is to be provided for monitoring the 1 V_{PP} incremental signals.

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)
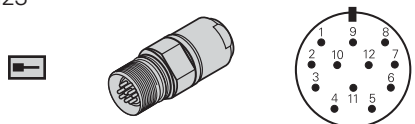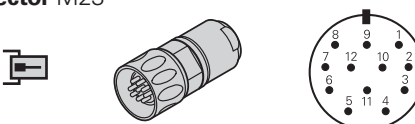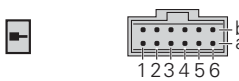
Pin Layout
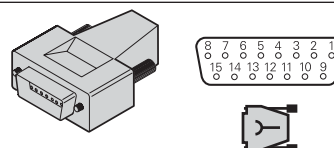

12-pin coupling M23		12-pin connector M23	
12-pin PCB connector to ERP 880		15-pin D-sub connector, female for HEIDENHAIN controls and IK 220	

	Power supply				Incremental signals						Other signals		
▭ ⊏	12	2	10	11	5	6	8	1	3	4	9	7	/
▭	2a	2b	1a	1b	6b	6a	5b	5a	4b	4a	3b	3a	/
⊐	1	9	2	11	3	4	6	7	10	12	5/8/13/15	14	/
	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

Shield on housing; **U_P** = Power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line

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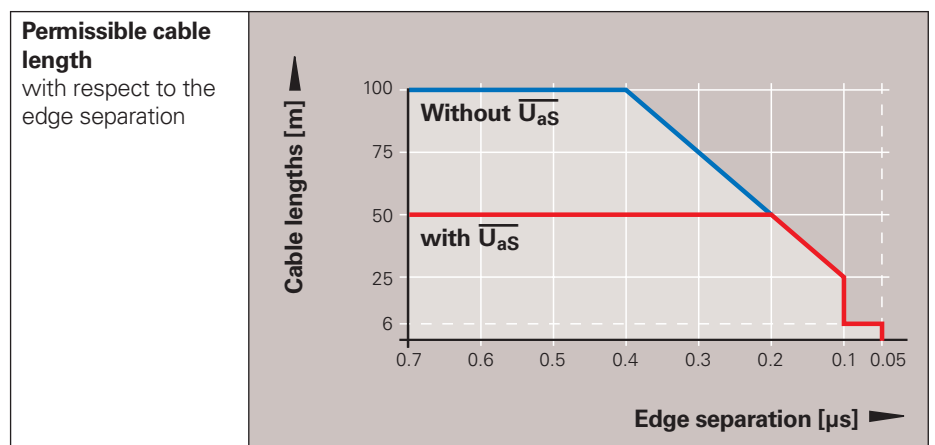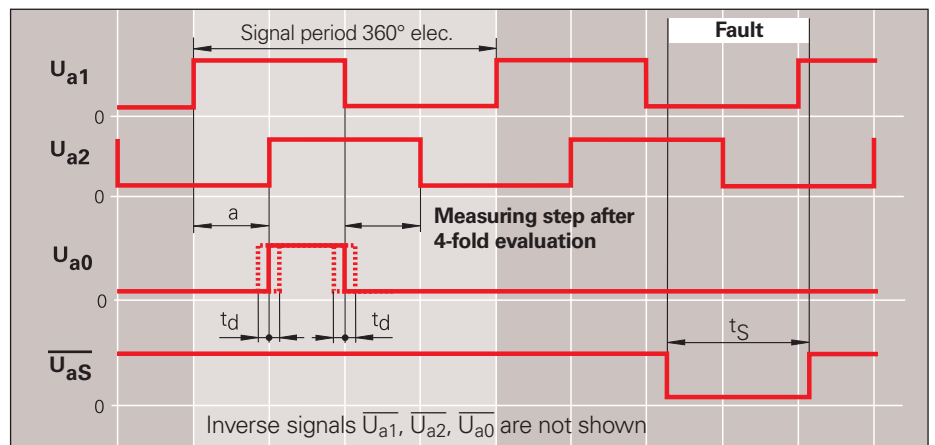
The **fault-detection signal** $\overline{U_{aS}}$ indicates fault conditions such as breakage of the power line or failure of the light source. It can be used for such purposes as machine shut-off during automated production.

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

The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum **edge separation a** listed in the *Specifications* applies for the illustrated input circuitry with a cable length of 1 m, and refers to 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 error, design the subsequent electronics to process even 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 max. 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 system (remote sense power supply).

Interface	Square-wave signals ⊓⊔**TTL**
Incremental signals	**2 TTL 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 square-wave pulses U_{a0}** and their inverted pulses $\overline{U_{a0}}$ 90° elec. (other widths available on request); *LS 323:* ungated $|t_d| \leq 50$ ns
Fault detection signal Pulse width	**1 TTL square-wave pulse $\overline{U_{aS}}$** Improper function: LOW (upon request: U_{a1}/U_{a2} at high impedance) Proper function: HIGH $t_S \geq 20$ ms
Signal level	Differential line driver as per EIA standard RS 422 $U_H \geq 2.5$ V at $-I_H = 20$ mA $U_L \leq 0.5$ V at $I_L = 20$ mA
Permissible load	$Z_0 \geq 100\ \Omega$ between associated outputs $|I_L| \leq 20$ mA max. load per output $C_{load} \leq 1000$ pF with respect to 0 V Outputs protected against short circuit to 0 V
Switching times (10% to 90%)	$t_+ / t_- \leq 30$ ns (typically 10 ns) with 1 m cable and recommended input circuitry
Connecting cable Cable lengths Propagation time	HEIDENHAIN cable with shielding PUR [4(2 × 0.14 mm^2) + (4 × 0.5 mm^2)] Max. 100 m ($\overline{U_{aS}}$ max. 50 m) distributed capacitance 90 pF/m 6 ns/m

Inverse signals $\overline{U_{a1}}$, $\overline{U_{a2}}$, $\overline{U_{a0}}$ are not shown

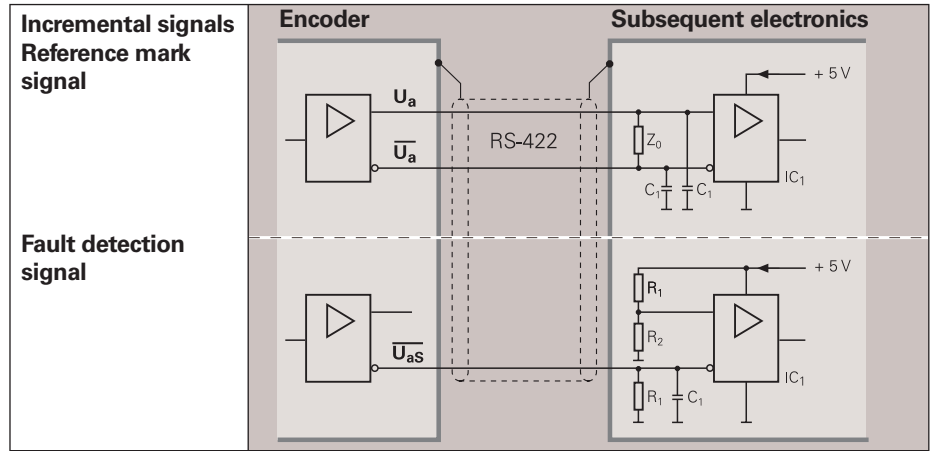**Permissible cable length** with respect to the edge separation
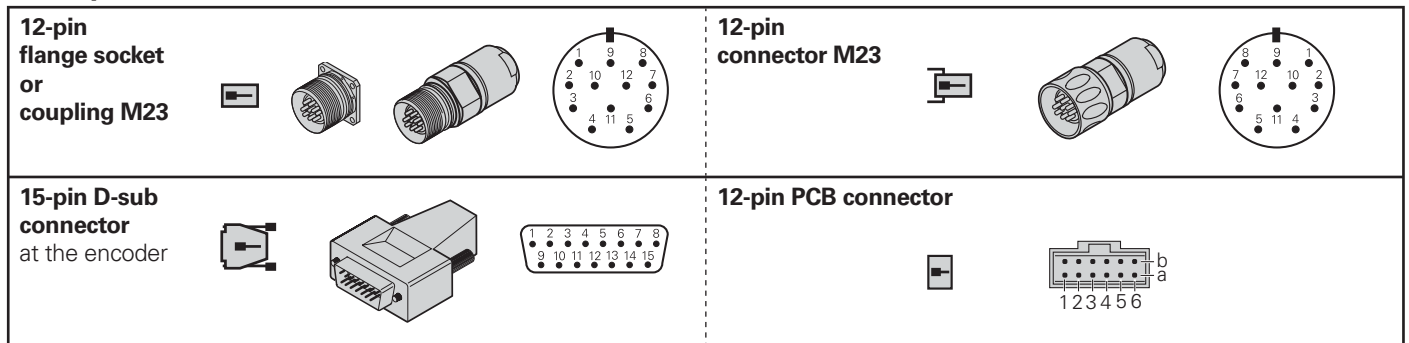
Input circuitry of the subsequent electronics

Dimensioning

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

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

Pin Layout

	Power supply				Incremental signals						Other signals		
▭◼ ▭◻	12	2	10	11	5	6	8	1	3	4	7	/	9
◗◼	4	12	2	10	1	9	3	11	14	7	13	5/6/8	15
◼◻	2a	2b	1a	1b	6b	6a	5b	5a	4b	4a	3a	3b	/
	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]
▭⟍	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	Violet	–	Yellow

Shield on housing; U_P = Power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
[1] **LS 323/ERO 14xx:** Vacant   [2] **Exposed linear encoders:** TTL/11 µA$_{PP}$ conversion for PWT
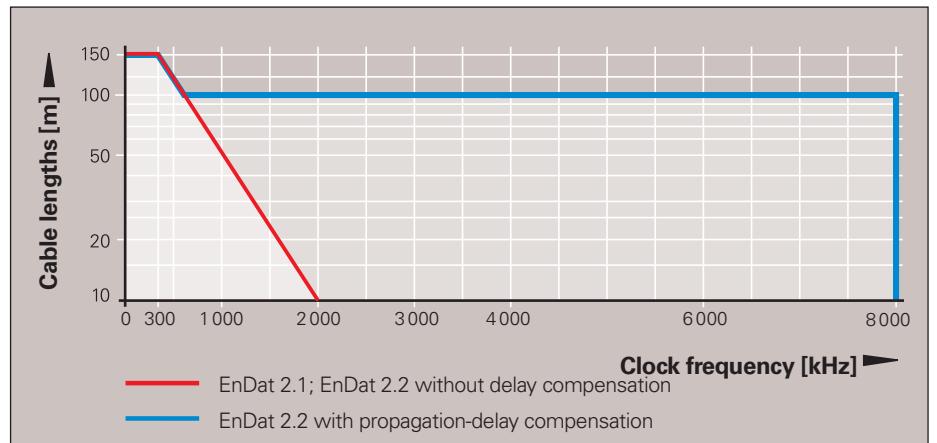
Interfaces
Absolute Position Values EnDat

The EnDat interface is a digital, **bidirectional** interface for encoders. It is capable of transmitting **position values** from both absolute and—with EnDat 2.2—incremental encoders, as well as reading and updating information stored in the encoder, or of saving new information. Thanks to the **serial transmission method** only **four signal lines** are required. The data are 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.

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 CLOCK, $\overline{\text{CLOCK}}$, DATA and $\overline{\text{DATA}}$ signals
Data output	Differential line driver according to EIA standard RS 485 for the DATA and $\overline{\text{DATA}}$ signals
Code	Pure binary code
Position values	Ascending in traverse direction indicated by arrow (see Dimensions)
Incremental signals	$\sim$ 1 V_{PP} (see *Incremental Signals 1 V_{PP}*) depending on unit
Connecting cable With incremental Without signals	HEIDENHAIN cable with shielding PUR [(4 x 0.14 mm^2) + 4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] PUR [(4 x 0.14 mm^2) + (4 x 0.34 mm^2)]
Cable lengths	Max. 150 m
Propagation time	Max. 10 ns; approx. 6 ns/m

Clock frequency and cable length
Without propagation-delay compensation, the **clock frequency**—depending on the cable length—is variable between **100 kHz** and **2 MHz.** Because large cable lengths and high clock frequencies increase the signal run time to the point that they can disturb the unambiguous assignment of data, the delay can be measured in a test run and then compensated. With this **propagation-delay compensation** in the subsequent electronics, clock frequencies up to **8 MHz** at cable lengths up to a maximum of 100 m are possible. To ensure proper function at clock frequencies above 2 MHz, use only original HEIDENHAIN cables.
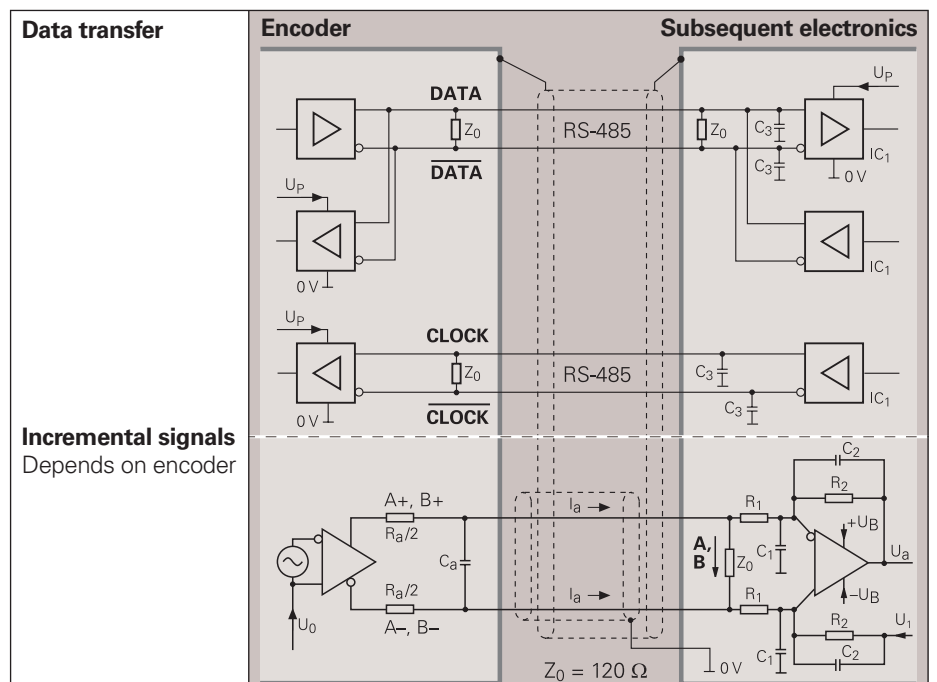
Input circuitry of the subsequent electronics

Dimensioning
IC_1 = RS 485 differential line receiver and driver

C_3 = 330 pF
Z_0 = 120 Ω

— EnDat 2.1; EnDat 2.2 without delay compensation
— EnDat 2.2 with propagation-delay compensation

Versions

The extended EnDat interface version 2.2 is compatible in its communication, command set (i.e. the available mode commands) and time conditions with version 2.1, but also offers significant advantages. It makes it possible, for example, to transfer additional information with the position value without sending a separate request for it. The interface protocol was expanded and the time conditions were optimized.

Both EnDat 2.1 and EnDat 2.2 are available in versions with or without incremental signals. EnDat 2.2 encoders feature a high internal resolution. Therefore, depending on the control technology being used, interrogation of the incremental signals is not necessary. To increase the resolution of EnDat 2.1 encoders, the incremental signals are evaluated in the subsequent electronics.

EnDat 2.2 (includes EnDat 2.1)
- Position values for incremental and absolute encoders
- Additional information on position value
  - Diagnostics and test values
  - Absolute position values after reference run of incremental encoders
  - Parameter upload/download
  - Commutation
  - Acceleration
  - Limit position signal
  - Temperature of the encoder PCB
  - Temperature evaluation of an external temperature sensor (e.g. in the motor winding)

EnDat 2.1
- Absolute position values
- Parameter upload/download
- Reset
- Test command and test values

Interface	Version	Clock frequency	Ordering designation
EnDat 2.1	With incremental signals	≤ 2 MHz	EnDat 01
	Without incremental signals		EnDat 21
EnDat 2.2	With incremental signals	≤ 2 MHz	EnDat 02
	Without incremental signals	≤ 8 MHz	EnDat 22

Benefits of the EnDat Interface
- **Automatic self-configuration:** All information required by the subsequent electronics is already stored in the encoder.
- **High system security** through alarms and messages for monitoring and diagnosis
- **High transmission reliability** through cyclic redundancy checking
- Faster configuration during installation: **Datum shifting** through offsetting by a value in the encoder.

Other benefits of EnDat 2.2
- **A single interface** for all absolute and incremental encoders
- **Additional informationen** (limit switch, temperature, acceleration)
- **Quality improvement:** Position value calculation in the encoder permits shorter sampling intervals (25 µs)

Advantages of purely serial transmission specifically for EnDat-2.2 encoders
- **Simple subsequent electronics** with EnDat receiver chip
- **Simple connection technology:** Standard connecting element (M12; 8-pin), single-shielded standard cable and few wires
- **Minimized transmission times** through adaptation of the data word length to the resolution of the encoder
- **High clock frequencies** up to 8 MHz. Position values available in the subsequent electronics after only approx. 10 µs
- **Support for state-of-the-art machine designs** e.g. direct drive technology

Functions

The EnDat interface transmits absolute position values or additional physical quantities (only EnDat 2.2) in an unambiguous time sequence and serves to read from and write to the encoder's internal memory. Some functions are available only with EnDat 2.2 mode commands.

Position values can be transmitted with or without additional information. The additional information types are selectable over Memory Range Select (MRS) code. Other functions such as parameter reading and writing can also be called after the memory area and address have been selected. Through simultaneous transmission with the position value, additional information can also be requested of axes in the feedback loop, and functions executed with them.

Parameter reading and writing is possible both as a separate function and in connection with the position value. Parameters can be read or written after the memory area and address is selected.

Reset functions serve to reset the encoder in case of malfunction. Reset is possible instead of or during position value transmission.

Servicing diagnosis makes it possible to inspect the position value even at standstill. A test command has the encoder transmit the required test values.

You can find more information in the *Technical Information for EnDat 2.2* document or on the Internet at www.endat.de.

Selecting the Transmission Type

Transmitted data are identified as position values, position values with additional information, or parameters. The type of information to be transmitted is selected by mode commands. **Mode commands** define the content of the transmitted information. Every mode command consists of three bits. To ensure reliable transmission, every bit is transmitted redundantly (inverted or double). If the encoder detects an erroneous mode transmission, it transmits an error message. The EnDat 2.2 interface can also transfer parameter values in the additional information together with the position value. This makes the current position values constantly available for the control loop, even during a parameter request.

Control cycles for transfer of position values

The transmission cycle begins with the first falling **clock edge.** The measured values are saved and the position value calculated. After two clock pulses (2T), to **select the type of transmission** the subsequent electronics transmit the mode command *Encoder transmit position value* (with/without additional information).

After successful calculation of the absolute position value (t_{cal} – see *Specifications*), the **start bit** initiates the data transmission from the encoder to the subsequent electronics. The subsequent **error messages,** error 1 and error 2 (only with EnDat 2.2 commands), are group signals for all monitored functions and serve as failure monitoring.

Beginning with the LSB, the encoder then transmits the absolute **position value** as a complete data word. Its length depends on the encoder being used. The number of required clock pulses for transmission of a position value is saved in the parameters of the encoder manufacturer. The data transmission of the position value is completed with the **Cyclic Redundancy Check** (CRC).

In EnDat 2.2, this is followed by additional information 1 and 2, each also concluded with a CRC. With the end of the data word, the clock must be set to HIGH. After 10 to 30 µs or 1.25 to 3.75 µs (with EnDat 2.2 parameterizable recovery time t_m) the data line falls back to LOW. Then a **new data transmission** can begin by starting the clock.

Mode commands

	EnDat 2.1	EnDat 2.2
• Encoder transmit position values • Selection of the memory area • Encoder receive parameters • Encoder transmit parameters • Encoder receive reset [1] • Encoder transmit test values • Encoder receive test commands	EnDat 2.1	
• Encoder transmit position value with additional information • Encoder transmit position value and receive selection of memory area [2] • Encoder transmit position value and receive parameters [2] • Encoder transmit position value and send parameters [2] • Encoder transmit position value and receive error reset [2] • Encoder transmit position value and receive test command [2] • Encoder receive communication command [3]		EnDat 2.2

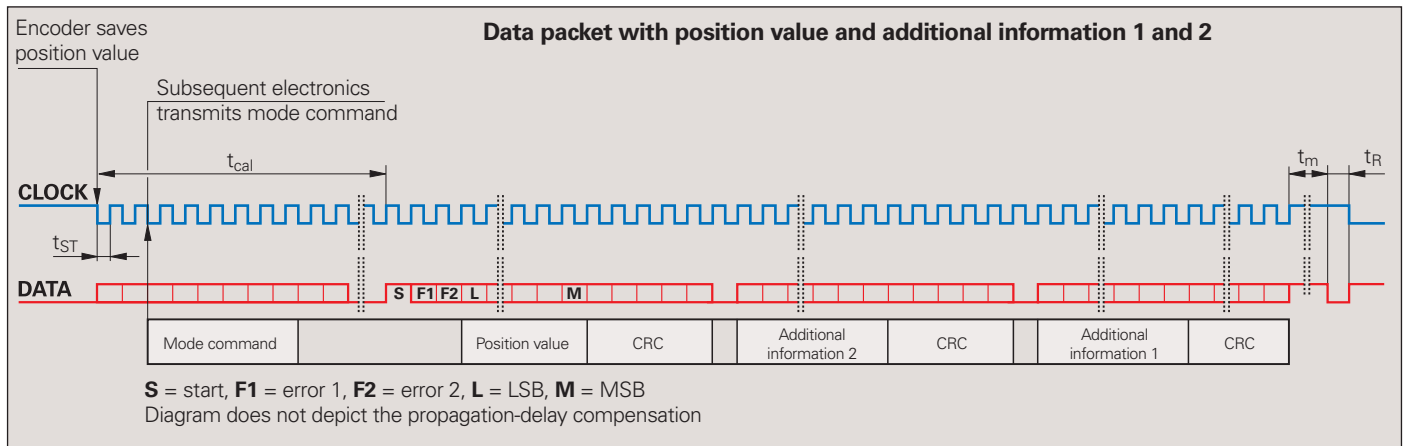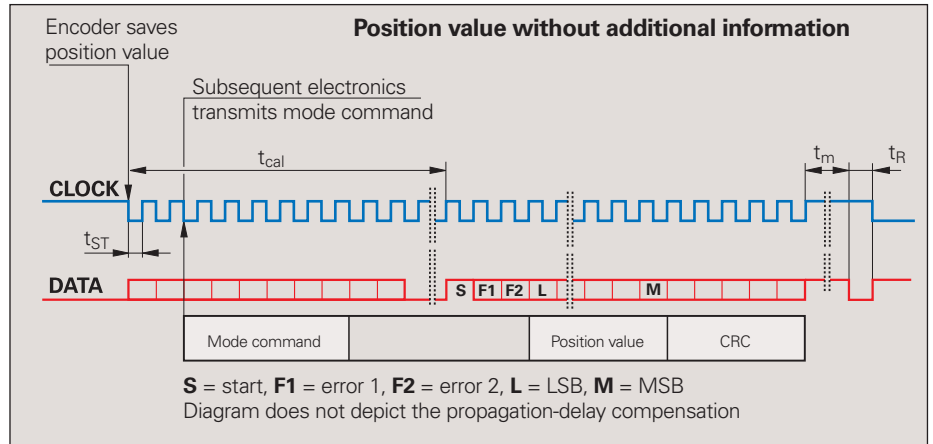[1] Same reaction as switching the power supply off and on
[2] Selected additional additional information is also transmitted
[3] Reserved for encoders that do not support the safety system

		Without delay compensation	With delay compensation
Clock frequency	f_c	100 kHz ... 2 MHz	100 kHz ... 8 MHz
Calculation time for Position value Parameters	t_{cal} t_{ac}	See *Specifications* Max. 12 ms	
Recovery time	t_m	*EnDat 2.1:* 10 to 30 µs *EnDat 2.2:* 10 to 30 µs or 1.25 to 3.75 µs ($f_c \geq$ 1 MHz) (parameterizable)	
	t_R	Max. 500 ns	
	t_{ST}	–	2 to 10 µs
Data delay time	t_D	(0.2 + 0.01 x cable length in m) µs	
Pulse width	t_{HIGH}	0.2 to 10 µs	Pulse width fluctuation HIGH to LOW max. 10%
	t_{LOW}	0.2 to 50 ms/30 µs (with LC)	

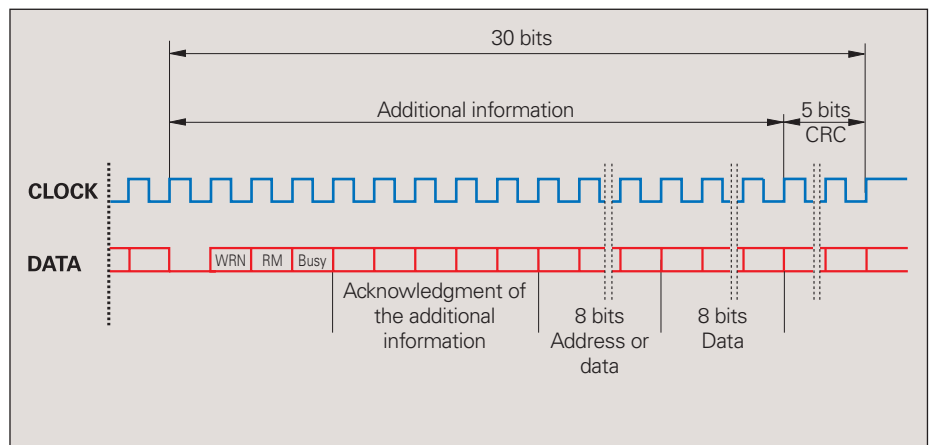## EnDat 2.2 – Transfer of Position Values

EnDat 2.2 can transmit position values selectably with or without additional information.

Position value without additional information

Encoder saves position value

Subsequent electronics transmits mode command

| Mode command | | Position value | CRC |

S = start, **F1** = error 1, **F2** = error 2, **L** = LSB, **M** = MSB
Diagram does not depict the propagation-delay compensation

Data packet with position value and additional information 1 and 2

Encoder saves position value

Subsequent electronics transmits mode command

| Mode command | | Position value | CRC | Additional information 2 | CRC | Additional information 1 | CRC |

S = start, **F1** = error 1, **F2** = error 2, **L** = LSB, **M** = MSB
Diagram does not depict the propagation-delay compensation

Additional information

With EnDat 2.2, one or two additional pieces of information can be appended to the position value. Each additional information is 30 bits long with LOW as first bit, and ends with a CRC check. The additional information supported by the respective encoder is saved in the encoder parameters.

The content of the additional information is determined by the MRS code and is transmitted in the next sampling cycle for additional information. This information is then transmitted with every sampling until a selection of a new memory area changes the content.

The additional information always begin with:	The additional information can contain the following data:	
Status data Warning—WRN Reference mark—RM Parameter request—busy **Acknowledgment** of additional information	**Additional information 1** Diagnosis Position value 2 Memory parameters MRS-code acknowledgment Test values Temperature	**Additional information 2** Commutation Acceleration Limit position signals

EnDat 2.1 – Transfer of Position Values

EnDat 2.1 can transmit position values selectably with interrupted clock pulse (as in EnDat 2.2) or continuous clock pulse.

Interrupted clock

The interrupted clock is intended particularly for time-clocked systems such as closed control loops. At the end of the data word the clock signal is set to HIGH level. After 10 to 30 µs (t_m), the data line falls back to LOW. Then a new data transmission can begin by starting the clock.
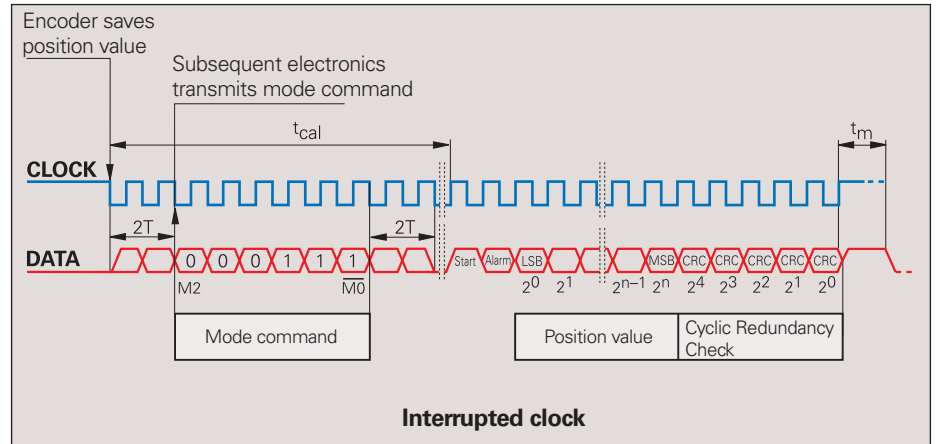
Continuous clock

For applications that require fast acquisition of the measured value, the EnDat interface can have the clock run continuously. Immediately after the last CRC bit has been sent, the data line is switched to high for one clock cycle, and then to low. The new position value is saved with the very next falling edge of the clock and is output in synchronism with the clock signal immediately after the start bit and alarm bit. Because the mode command *Encoder transmit position value* is needed only before the first data transmission, the continuous-clock transfer mode reduces the length of the clock-pulse group by 9 periods per position value.
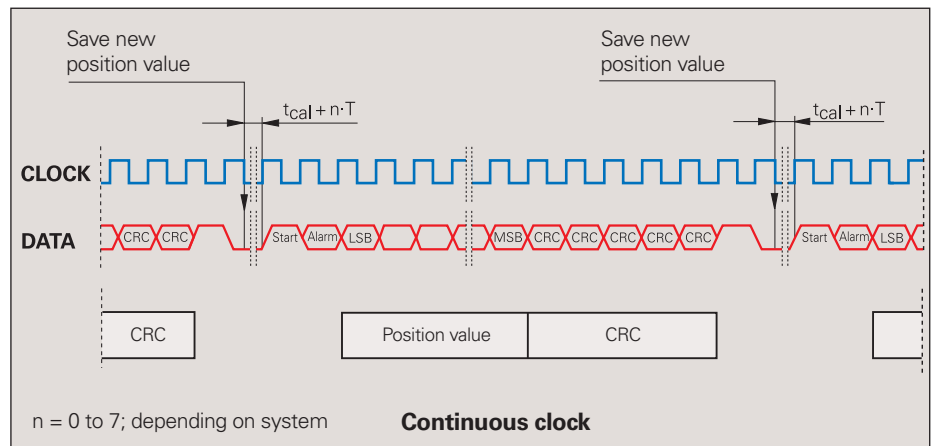
Synchronization of the serially transmitted code value with the incremental signal

Absolute encoders with EnDat interface can exactly synchronize serially transmitted absolute position values with incremental values. With the first falling edge (latch signal) of the CLOCK signal from the subsequent electronics, the scanning signals of the individual tracks in the encoder and counter are frozen, as are also the A/D converters for subdividing the sinusoidal incremental signals in the subsequent electronics.
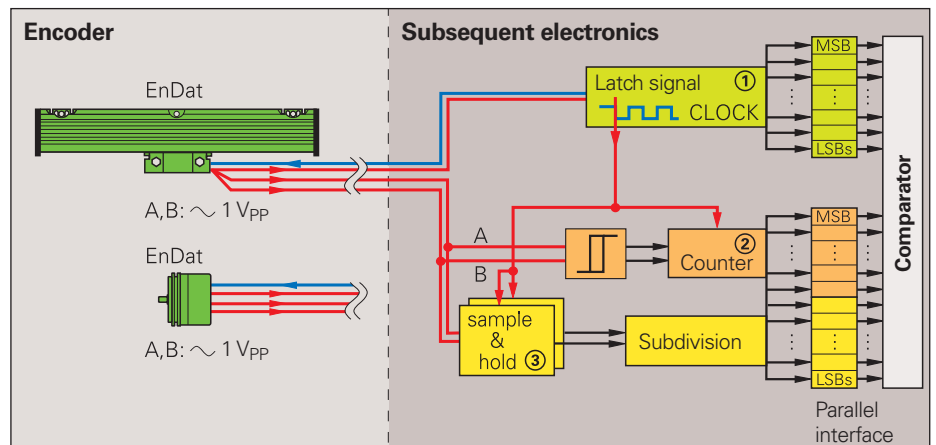
The code value transmitted over the serial interface unambiguously identifies one incremental signal period. The position value is absolute within one sinusoidal period of the incremental signal. The subdivided incremental signal can therefore be appended in the subsequent electronics to the serially transmitted code value.

Interrupted clock

n = 0 to 7; depending on system

Continuous clock

After power on and initial transmission of position values, two redundant position values are available in the subsequent electronics. Since encoders with EnDat interface guarantee a precise synchronization—regardless of cable length—of the serially transmitted absolute value with the incremental signals, the two values can be compared in the subsequent electronics. This monitoring is possible even at high shaft speeds thanks to the EnDat interface's short transmission times of less than 50 µs. This capability is a prerequisite for modern machine design and safety techniques.

Parameters and Memory Areas

The encoder provides several memory areas for parameters. These can be read from by the subsequent electronics, and some can be written to by the encoder manufacturer, the OEM, or even the end user. Certain memory areas can be write-protected.

The parameters, which in most cases are set by the OEM, largely define the function of the encoder and the EnDat interface. When the encoder is exchanged, it is therefore essential that its parameter settings are correct. Attempts to configure machines without including OEM data can result in malfunctions. If there is any doubt as to the correct parameter settings, the OEM should be consulted.

Parameters of the encoder manufacturer

This write-protected memory area contains all **information specific to the encoder,** such as encoder type (linear/angular, singleturn/multiturn, etc.), signal periods, position values per revolution, transmission format of position values, direction of rotation, maximum speed, accuracy dependent on shaft speeds, support of warnings and alarms, part number and serial number. This information forms the basis for **automatic configuration.** A separate memory area contains the parameters typical for EnDat 2.2: Status of additional information, temperature, acceleration, support of diagnostic and error messages, etc.

Parameters of the OEM

In this freely definable memory area, the OEM can store his information, e.g. the "electronic ID label" of the motor in which the encoder is integrated, indicating the motor model, maximum current rating, etc.

Operating parameters

This area is available for a **datum shift** and the configuration of diagnostics. It can be protected against overwriting.

Operating status

This memory area provides detailed alarms or warnings for diagnostic purposes. Here it is also possible to activate write protection for the OEM parameter and operating parameter memory areas and interrogate their status. Once **write protection** is activated, it cannot be removed.

Safety System

The safety system is in preparation. Safety-oriented controls are the planned application for encoders with EnDat 2.2 interface. Refer to IEC 61 800 standard *Adjustable speed electrical power drive systems* Part 5-2.

Monitoring and Diagnostic Functions

The EnDat interface enables comprehensive monitoring of the encoder without requiring an additional transmission line. The alarms and warnings supported by the respective encoder are saved in the "parameters of the encoder manufacturer" memory area.

Diagnosis

Cyclic information on encoder function and additional diagnostic values are transmitted in the additional information.

Error message

An error message becomes active if a **malfunction of the encoder** might result in incorrect position values. The exact cause of the trouble is saved in the encoder's "operating status" memory where it can be interrogated in detail. Errors include:
- Light unit failure
- Signal amplitude too low
- Error in calculation of position value
- Power supply too high/low
- Current consumption is excessive

Here the EnDat interface transmits the error bits, error 1 and error 2 (only with EnDat 2.2 commands). These are group signals for all monitored functions and serve for failure monitoring. The two error messages are generated independently from each other.

Warning

This collective bit is transmitted in the status data of the additional information. It indicates that certain **tolerance limits of the encoder** have been reached or exceeded—such as shaft speed or the limit of light source intensity compensation through voltage regulation—without implying that the measured position values are incorrect. This function makes it possible to issue preventive warnings in order to minimize idle time.
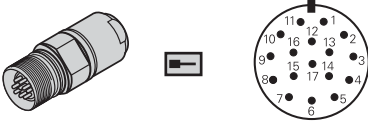
Cyclic Redundancy Check

To ensure **reliability of data transfer,** a cyclic redundancy check (CRC) is performed through the logical processing of the individual bit values of a data word. This 5-bit long CRC concludes every transmission. The CRC is decoded in the receiver electronics and compared with the data word. This largely eliminates errors caused by disturbances during data transfer.

69
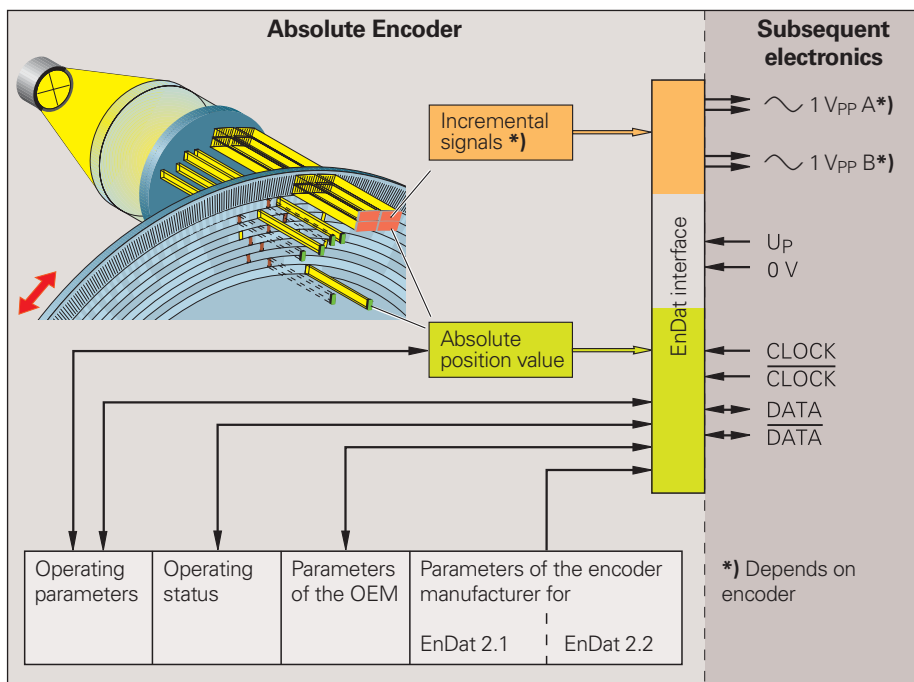
Pin Layout EnDat

17-pin coupling M23													

	Power supply					Incremental signals[1]				Absolute position values			
	7	**1**	**10**	**4**	**11**	**15**	**16**	**12**	**13**	**14**	**17**	**8**	**9**
	U_P	Sensor U_P	0 V	Sensor 0 V	Inside shield	A+	A–	B+	B–	DATA	$\overline{DATA}$	CLOCK	$\overline{CLOCK}$
	Brown/ Green	Blue	White/ Green	White	/	Green/ Black	Yellow/ Black	Blue/ Black	Red/ Black	Gray	Pink	Violet	Yellow
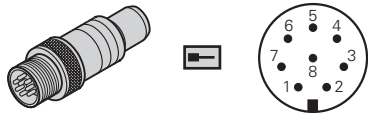
Shield on housing; U_P = Power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!
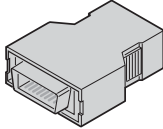[1] Only with ordering designations EnDat 01 and EnDat 02

8-pin coupling M12								
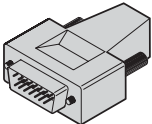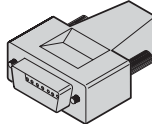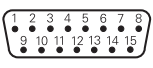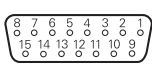
	Power supply				Absolute position values			
	2	**8**	**1**	**5**	**3**	**4**	**7**	**6**
	U_P [1]	U_P	0 V [1]	0 V	DATA	$\overline{DATA}$	CLOCK	$\overline{CLOCK}$
	Blue	Brown/Green	White	White/Green	Gray	Pink	Violet	Yellow

Shield on housing; U_P = Power supply voltage
[1] For power lines configured in parallel
Vacant pins or wires must not be used!

15-pin D-sub connector, male for IK 115/IK 215		**15-pin D-sub connector, female** for HEIDENHAIN controls and IK 220	

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

Shield on housing; U_P = Power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!
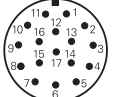[1] Only with ordering designations EnDat 01 and EnDat 02
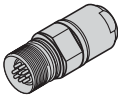
Interfaces
Fanuc and Mitsubishi Pin Layouts

Fanuc pin layout
HEIDENHAIN encoders with the code letter F after the model designation are suited for connection to Fanuc controls with
- **Serial Interface Fanuc 01**
  with 1 MHz communication rate
- **Serial Interface Fanuc 02**
  with 1 MHz or 2 MHz communication rate

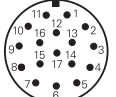| 15-pin Fanu connector					17-pin HEIDENHAIN coupling			
	Power supply				Absolute position values			
9	18/20	12	14	16	1	2	5	6
7	1	10	4	–	14	17	8	9
U_P	Sensor U_P	0 V	Sensor 0 V	Shield	Serial Data	$\overline{\text{Serial Data}}$	Request	$\overline{\text{Request}}$
Brown/ Green	Blue	White/Green	White	–	Gray	Pink	Violet	Yellow
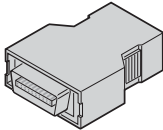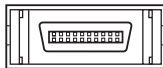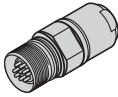
Shield on housing; U_P = Power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!

Mitsubishi pin layout
HEIDENHAIN encoders with the code letter M after the model designation are suited for connection to controls with the **Mitsubishi High Speed Serial Interface.**

20-pin Mitsubishi connector				17-pin HEIDENHAIN coupling			
	Power supply			Absolute position values			
20	19	1	11	6	16	7	17
7	1	10	4	14	17	8	9
U_P	Sensor U_P	0 V	Sensor 0 V	Serial Data	$\overline{\text{Serial Data}}$	Request Frame	$\overline{\text{Request Frame}}$
Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

Shield on housing; U_P = Power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!

HEIDENHAIN Measuring Equipment
for Incremental Angle Encoders

With modular angle encoders the scanning head moves over the graduation without mechanical contact. Thus, to ensure highest quality output signals, the scanning head needs to be aligned very accurately during mounting. HEIDENHAIN offers various measuring and testing equipment for checking the quality of the output signals.

The **PWM 9** is a universal measuring device for checking and adjusting HEIDENHAIN incremental encoders. There are different expansion modules available for checking the different encoder signals. The values can be read on an LCD monitor. Soft keys provide ease of operation.

	PWM 9
Inputs	Expansion modules (interface boards) for 11 µA$_{PP}$; 1 V$_{PP}$; TTL; HTL; EnDat*/SSI*/commutation signals *No display of position values or parameters
Features	• **Measurement** of signal amplitudes, current consumption, operating voltage, scanning frequency • **Graphic display** of incremental signals (amplitudes, phase angle and on-off ratio) and the reference-mark signal (width and position) • **Display symbols** for the reference mark, fault detection signal, counting direction • **Universal counter,** interpolation selectable from single to 1024-fold • **Adjustment support** for exposed linear encoders
Outputs	• Inputs are connected through to the subsequent electronics • BNC sockets for connection to an oscilloscope
Power supply	10 to 30 V, max. 15 W

The **PWT 18** 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 18
Encoder input	1 V$_{PP}$
Features	Measurement of the signal amplitude Tolerance of signal shape Amplitude and position of the reference-mark signal
Power supply	Via power supply unit (included)
Dimensions	114 mm x 64 mm x 29 mm

for Absolute Angle Encoders

The **IK 215** is an adapter card for PCs for inspecting and testing absolute HEIDENHAIN encoders with EnDat or SSI interface. All parameters can be read and written via the EnDat interface.
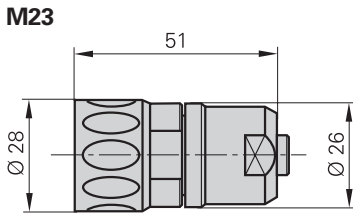
	IK 215	
Encoder input	EnDat (absolute value or incremental signals) or SSI	
Interface	PCI bus, Rev. 2.1	
Application software	**Operating system:**	Windows 2000/XP (Windows 98 in preparation)
	Features:	Position value display Counter for incremental signals EnDat functions
Signal subdivision for incremental signals	Up to 1024-fold	
Dimensions	100 mm x 190 mm	

Connecting Elements and Cables
General Information

Connector insulated: Connecting element with coupling ring, available with male or female contacts.
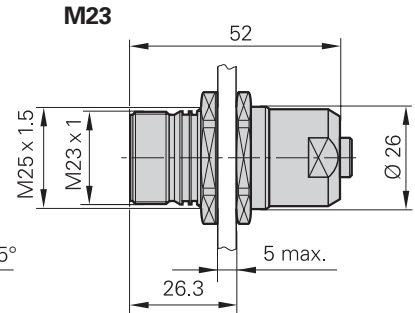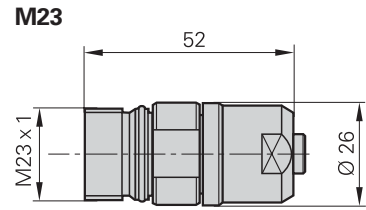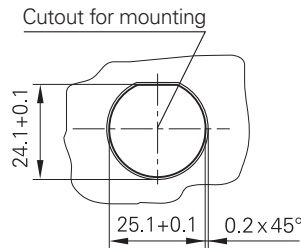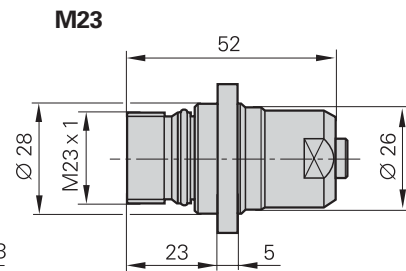
Symbols

M23

51

Ø 28   Ø 26

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

Symbols

M23

24.6

Ø 2.7

M 23×1

□ 19.8

□ 25

1

2.5

Ø 19.8–0.1

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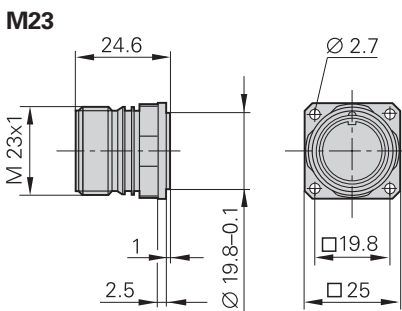
Symbols

X

Y   15.2

X: 42.7   **Y:** 41.7

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

Symbols

M23

52

M23 × 1   Ø 26

Mounted coupling with central fastening

Cutout for mounting

24.1+0.1

25.1+0.1   0.2 × 45°

M23

52

M25 × 1.5   M23 × 1   Ø 26

5 max.

26.3

Mounted coupling with flange

□ 38

□ 29.4

M 3

M23

52

Ø 28   M23 × 1   Ø 26

23   5

The pins on connectors are **numbered** in the direction opposite to those on couplings or flange socket, regardless of whether the connecting elements are
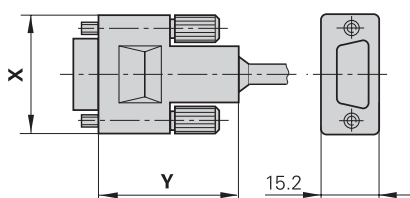
Male contacts or   ●

Female contacts   ○

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

Accessory for flange socket and mounted couplings M23

Bell seal
Id. Nr. 266 526-01

Threaded metal dust cap
Id. Nr. 219 926-01

Connecting Cables $\sim$ 1 V$_{PP}$
$\sqcap\sqcup$ TTL

Polyurethane (PUR) connecting cable dia. 8 mm [4(2 × 0.14 mm2) + (4 × 0.5 mm2)] for encoders with M23 coupling or M23 flange socket			
Complete with M23 connector (female) and M23 connector (male)	298 399-xx	**With one connector** with M23 connector (female)	309 777-xx
Complete with M23 connector (female) and D-sub connector (female) for IK 220	310 199-xx	**Cable only** PUR Ø 8 mm	244 957-01

Adapter cable for ERP 880 dia. 4.5 mm	
With one connector with 12-pin PCB connector with shield connection clamp	372 164-xx

M23 connectors and couplings			
Coupling on encoder cable	**M23 coupling (male),** 12-pin	**Mating element to coupling on encoder cable or flange socket**	**M23 connector (female),** 12-pin
For cable Ø 6 mm Ø 4.5 mm	291 698-03 291 698-14	For connecting cable Ø 8 mm	291 697-05
		Connector for connection to subsequent electronics	**M23 connector (male),** 12-pin
		For connecting cable Ø 8 mm	291 697-08

Couplings and M23 flange socket for mounting			
	M23 flange socket (female), 12-pin		**M23 coupling on mounting base with flange (male),** 12-pin
	315 892-08	For cable Ø 6 mm Ø 8 mm	291 698-08 291 698-31
	M23 coupling on mounting base with central fastening (male), 12-pin		**M23 coupling on mounting base with flange (female),** 12-pin
For cable Ø 6 mm	291 698-33	For cable Ø 6 mm Ø 8 mm	291 698-17 291 698-07

Adapter connector $\sim$ 1 V$_{PP}$/$\sim$ 11 µA$_{PP}$	
For converting the 1-V$_{PP}$ output signals to 11-µA$_{PP}$ input signals for the subsequent electronics; M23 connector (female) 12-pin and M23 connector (male) 9-pin	364 914-01

Connecting Cables   EnDat
Fanuc
Mitsubishi

Polyurethane (PUR) connecting cable dia. 8 mm with M23 connecting element $[(4 \times 0.14 \text{ mm}^2) + 4(2 \times 0.14 \text{ mm}^2) + (4 \times 0.5 \text{ mm}^2)]$			
Complete with M23 connector (female) and M23 coupling (male)	323 897-xx	**Complete** with M23 connector (female) and D-sub connector (male) for IK 115	324 544-xx
With one connector with M23 connector (female)	309 778-xx	**Complete** with M23 connector (female) and D-sub connector (female) for IK 220	332 115-xx
Cable without connectors	266 306-01		

Connecting cable for EnDat 2.2 encoders without incremental signals with M12 connecting element			
Complete with M12 connector (female), 8-pin, and M12 connector (male), 8-pin	368 330-xx	**Complete** with M12 connector (female) and D-sub connector (male) for IK 115/IK 215	524 599-xx

Connectors and couplings M23			
Coupling on encoder cable	**M23 coupling (male),** 17-pin	**Mating connector**	**M23 connector (female),** 17-pin
For cable Ø 6 mm	291 698-26	For connecting cable Ø 8 mm	291 697-26
Connector to subsequent electronics	**M23 connector (male),** 17-pin	**Coupling**	**M23 coupling (male),** 17-pin
For connecting cable Ø 8 mm	291 697-27	For connecting cable Ø 8 mm	291 698-27

Couplings and M23 flange socket for mounting			
	M23 coupling on mounting base with flange (male), 17-pin		**M23 coupling on mounting base with flange (female),** 17-pin
For cable Ø 8 mm	291 698-29	For cable Ø 8 mm	291 698-35
	M23 coupling on mounting base with central fastening (male), 17-pin		**M23 flange socket (female),** 17-pin
For cable Ø 6 mm	291 698-37		315 892-10

PUR adapter cable for Fanuc interface dia. 8 mm		**PUR adapter cable for Mitsubishi interface dia. 8 mm**	
Complete with M23 connector (female), 17-pin, and Fanuc connector $[(2 \times 2 \times 0.14 \text{ mm}^2) + (4 \times 1 \text{ mm}^2)]$	534 855-xx	**Complete with M23 connector (female), 17-pin, and Mitsubishi connector** $[(2 \times 2 \times 0.14 \text{ mm}^2) + (4 \times 0.5 \text{ mm}^2)]$	344 625-xx
Without connectors $[(2 \times 2 \times 0.14 \text{ mm}^2) + (4 \times 1 \text{ mm}^2)]$	354 608-01	**Without connectors** $[(2 \times 2 \times 0.14 \text{ mm}^2) + (4 \times 1 \text{ mm}^2)]$	354 608-01

General Electrical Information

Power supply

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

U_P

5.25 V
5 V
4.75 V

U_{PP}

Typically 500 ms

t

Initial transient response of the supply voltage e..g. 5 V ± 5 %
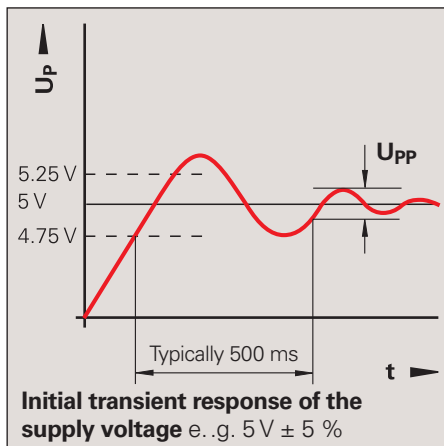
The values apply as measured at the encoder, i. e., without cable influences. The voltage can be monitored and adjusted with the device's **sensor lines.** If a controllable power supply is not available, the voltage drop can be halved by switching the sensor lines parallel to the corresponding power lines.

Calculation of the **voltage drop:**

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

with
ΔU: Voltage attenuation in V
L_C: Cable length in m
I: Current consumption of the encoder in mA (see *Specifications*)
A_P: Cross section of power supply lines in mm^2

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 –3dB/ –6dB 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 angular 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}: Electrically permissible speed in rpm
v_{max}: Electrically permissible speed in m/min
f_{max}: Maximum scanning/output frequency of the encoder or input frequency of the 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

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

Durability
All encoders have polyurethane (PUR) cables. PUR cables are resistant to oil, hydrolysis and microbes in accordance with **VDE 0472.** 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.

Temperature range
HEIDENHAIN cables can be used:
for stationary cables   –40 to 85 °C
for moving cables   –10 to 85 °C

Cables with limited resistance to hydrolysis and microbes are rated for up to 100 °C.

Bending radius
The permissible bending radii R depend on the cable diameter and the configuration:

Stationary cable

R   R

R

Moving cable

R

Moving cable

R
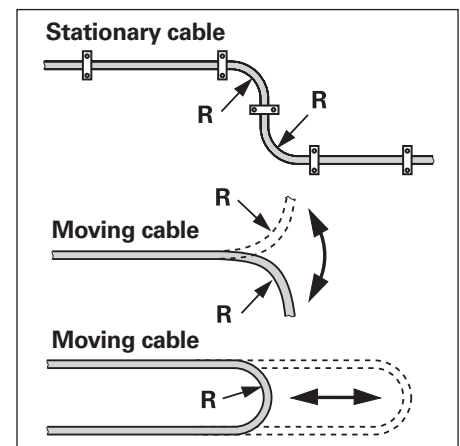
HEIDENHAIN cables	Stationary cable	Moving cable
Ø 3.7 mm	R ≥ 8 mm	R ≥ 40 mm
Ø 4.5 mm Ø 5.1 mm	R ≥ 10 mm	R ≥ 50 mm
Ø 6 mm	R ≥ 20 mm	R ≥ 75 mm
Ø 8 mm	R ≥ 40 mm	R ≥ 100 mm
Ø 10 mm[1]	R ≥ 35 mm	R ≥ 75 mm
Ø 14 mm[1]	R ≥ 50 mm	R ≥ 100 mm

HEIDENHAIN cables	Cross section of power supply lines A_P			
	1 V$_{PP}$/TTL/HTL	11 µA$_{PP}$	EnDat/SSI 17-pin	EnDat 8-pin
Ø 3.7 mm	0.05 mm^2	–	–	–
Ø 4.5/5.1 mm	0.14/0.05[2] mm^2	0.05 mm^2	0.05 mm^2	–
Ø 6/10[1] mm	0.19/ 0.14[3] mm^2	–	0.08 mm^2	0.34 mm^2
Ø 8/14[1] mm	0.5 mm^2	1 mm^2	0.5 mm^2	1 mm^2

[1] Metal armor
[2] Only on length gauges
[3] Only for LIDA 400

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Reliable Signal Transmission

Electromagnetic compatibility/ CE compliance

When properly installed, HEIDENHAIN encoders fulfill the requirements for electromagnetic compatibility according to 89/336/EEC with respect to the generic standards for:

- **Noise immunity EN 61 000-6-2:**
  Specifically:

– ESD	EN 61 000-4-2
– Electromagnetic fields	EN 61 000-4-3
– Burst	EN 61 000-4-4
– Surge	EN 61 000-4-5
– Conducted disturbances	EN 61 000-4-6
– Power frequency magnetic fields	EN 61 000-4-8
– Pulse magnetic fields	EN 61 000-4-9

- **Interference EN 61 000-6-4:**
  Specifically:

– For industrial, scientific and medical (ISM) equipment	EN 55 011
– For information technology equipment	EN 55 022

Transmission of measuring signals— electrical noise immunity

Noise voltages arise mainly through capacitive or inductive transfer. Electrical noise can be introduced into the system over signal lines and input or output terminals.
Possible sources of noise are:
- Strong magnetic fields from transformers 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

Isolation

The encoder housings are isolated against all circuits.
Rated surge voltage: 500 V
(preferred value as per VDE 0110 Part 1)

Protection against electrical noise

The following measures must be taken to ensure disturbance-free operation:
- Use only original HEIDENHAIN cables. Watch for voltage attenuation on the supply lines.
- Use connectors or terminal boxes with metal housings. Do not conduct any extraneous signals.
- Connect the housings of the encoder, connector, terminal box and evaluation electronics through the shield of the cable. Connect the shielding in the area of the cable inlets to be as induction-free as possible (short, full-surface contact).
- Connect the entire shielding system with the protective ground.
- Prevent contact of loose connector housings with other metal surfaces.
- The cable shielding has the function of an equipotential bonding conductor. If compensating currents are to be expected within the entire system, a separate equipotential bonding conductor must be provided.
  Also see **EN 50178**/4.98 Chapter 5.2.9.5 regarding "protective connection lines with small cross section."
- Connect HEIDENHAIN position encoders only to subsequent electronics whose power supply is generated through double or strengthened insulation against line voltage circuits. Also see **IEC 364-4-41:** 1992, modified Chapter 411 regarding "protection against both direct and indirect touch" (PELV or SELV).

- Do not lay signal cables in the direct vicinity of interference sources (inductive consumers such as contacts, motors, frequency inverters, solenoids, etc.).
- Sufficient decoupling from interference-signal-conducting cables can usually be achieved by an air clearance of 100 mm (4 in.) or, when cables are in metal ducts, by a grounded partition.
- A minimum spacing of 200 mm (8 in.) to inductors in switch-mode power supplies is required. Also see **EN 50178**/4.98 Chapter 5.3.1.1 regarding cables and lines, **EN 50 174-2**/09.01, Chapter 6.7 regarding grounding and potential compensation.
- When using **multiturn encoders in electromagnetic fields** greater than 30 mT, HEIDENHAIN recommends consulting with the main facility in Traunreut.

Both the cable shielding and the metal housings of encoders and subsequent electronics have a shielding function. The housings must have the **same potential** and be connected to the main signal ground over the machine chassis or by means of a separate potential compensating line. Potential compensating lines should have a minimum cross section of 6 mm^2 (Cu).
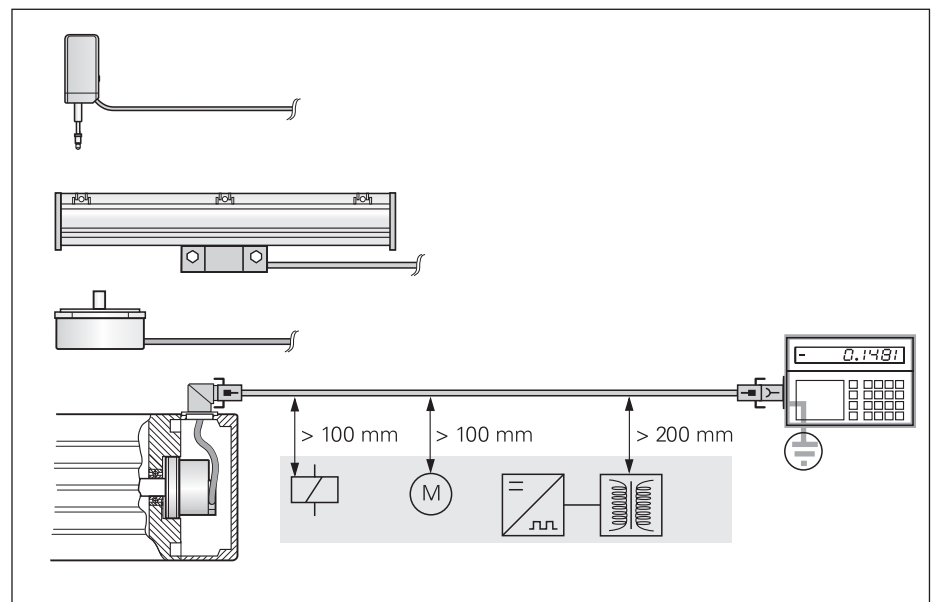
Minimum distance from sources of interference

Evaluation and Display Units

ND 281 B
Position display unit

The ND 281 B position display unit contains special display ranges for angle measurement. You can directly connect incremental angle encoders with $\sim$ 1-V$_{PP}$ output signals and any line count up to 999 999 signal periods per revolution. The display value is available via the RS-232-C/V.24 interface for further processing or print-out.

For more information, see the *Numerical Displays for Length and Angle* catalog.

	ND 281 B	
Input signals	$\sim$ 1 V$_{PP}$	$\sim$ 11 µA$_{PP}$
Encoder inputs	Flange socket, 12-pin female	Flange socket, 9-pin female
Input frequency	Max. 500 kHz	Max. 100 kHz
Max. cable length	60 m	30 m
Signal subdivision	Up to 1024-fold (adjustable)	
Display step (adjustable)	*Decimal degrees:* 0.1° to 0.000 002° *Degrees, minutes, seconds:* to 1"	
Display range (adjustable)	0 to 360° −180° .... 0 ..... +180° 0 to ± max. display range	
Features	Sorting and tolerance check mode with two limit values Display stop Two switching limits Reference-mark evaluation with REF	
External operation	Zero reset, preset and latch command	
Interface	RS-232-C/V.24; max. 38 400 baud	

IBV series
Interpolation and digitizing electronics

Interpolation and digitizing electronics interpolate and digitize the sinusoidal output signals ($\sim$ 1 V$_{PP}$) from HEIDENHAIN encoders up to 100-fold, and convert them to TTL square-wave pulse sequences.

IBV 101

For more information, see the *Interpolation and Digitizing Electronics* brochure for IBV 660 as well as the *IBV 100/EXE 100 product overview.*

	IBV 101	IBV 102	IBV 660
Input signals	$\sim$ 1 V$_{PP}$		
Encoder inputs	Flange socket, 12-pin female		
Interpolation (adjustable)	5-fold 10-fold	25-fold 50-fold 100-fold	25-fold 50-fold 100-fold 200-fold 400-fold
Minimum edge separation	Adjustable from 2 to 0.125 µs, depending on input frequency		Adjustable from 0.8 to 0.1 µs, depending on input frequency
Output signals	• 2 TTL square-wave pulse trains U$_{a1}$ and U$_{a2}$ and their inverted signals $\overline{U_{a1}}$ and $\overline{U_{a2}}$ • Reference pulse U$_{a0}$ and $\overline{U_{a0}}$ • Interference signal $\overline{U_{aS}}$		
Power supply	5 V ± 5%		

IK 220

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

For more information, see the *IK 220* product information sheet.

	IK 220			
Input signals (switchable)	∿ 1 V_{PP}	∿ 11 μA_{PP}	EnDat	SSI
Encoder inputs	Two D-sub connectors (15-pin), male			
Max. input frequency	500 kHz	33 kHz	–	
Max. cable length	60 m		10 m	
Signal subdivision (signal period : meas. step)	Up to 4096-fold			
Data register for measured values (per channel)	48 bits (44 bits used)			
Internal memory	For 8192 position values			
Interface	PCI bus (plug and play)			
Driver software and demonstration program	**For WINDOWS 98/NT/2000/XP** In VISUAL C++, VISUAL BASIC and BORLAND DELPHI			
Dimensions	Approx. 190 mm × 100 mm			