HEIDENHAIN

Angle Encoders
with Integral Bearing

November 2010

Angle encoders with integral bearing
and integrated stator coupling

Angle encoders with integral bearing
for separate shaft coupling

Information on
- Absolute Angle Encoders with Optimized Scanning
- Angle Encoders without Integral Bearing
- Rotary Encoders
- Encoders for Servo Drives
- Exposed Linear Encoders
- Linear Encoders for Numerically Controlled Machine Tools
- Interface Electronics
- HEIDENHAIN controls

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

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

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

Contents

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 10000.

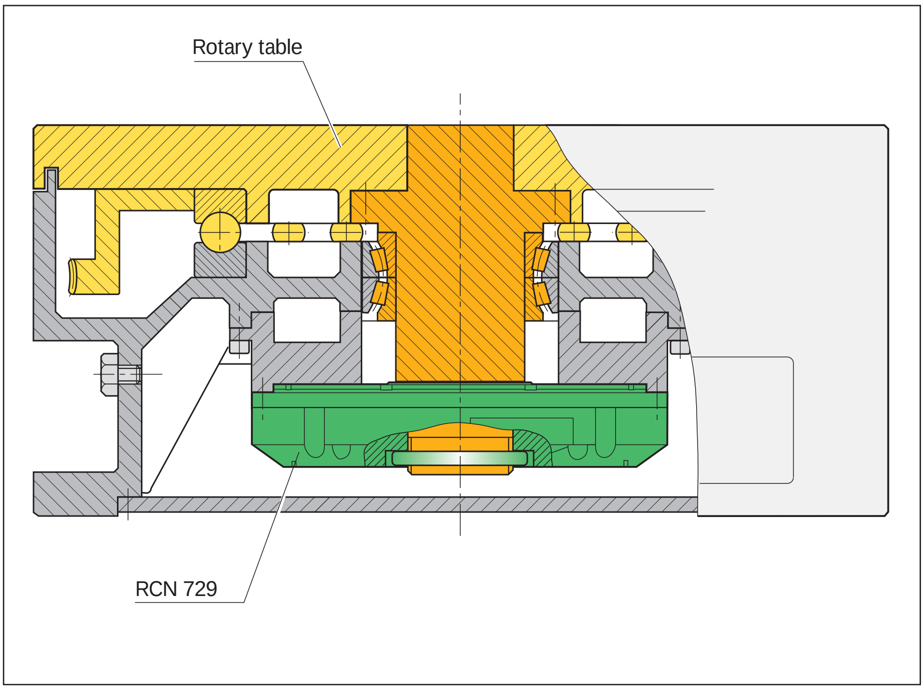
In contrast, rotary encoders are encoders that typically have an accuracy better than ± 10".

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 various applications and meet different requirements.



The **RCN 729** angle encoder mounted on the rotary table of a machine tool

Angle encoders can have one of the following 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 absorb only 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 deviations from the shaft coupling.

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

Selection Guide
For Absolute Angle Encoders
see pages 6/7
For Incremental Angle Encoders
see pages 8/9

RCN 729 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 8/9

ERA 4000 incremental angle encoder

Angle encoders without integral bearing
The **ERP** 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:

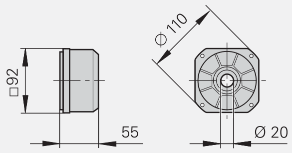
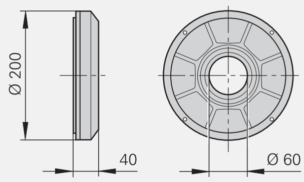
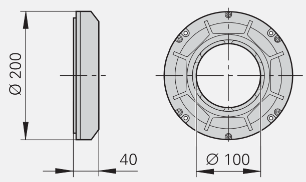
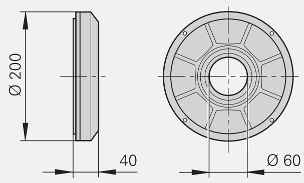
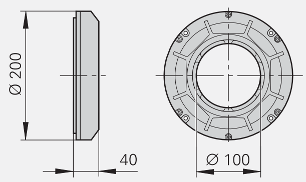
- Large hollow shaft diameters (up to 10 m with a scale tape)
- High shaft speeds up to 20000 min^{-1}
- No additional starting torque from shaft seals
- Segment angles

Selection Guide on pages 10/11

You can find more detailed information on HEIDENHAIN modular angle encoders on the Internet at www.heidenhain.de or in our brochure *Angle Encoders without Integral Bearing.*

Selection Guide

Absolute Angle Encoders with Integral Bearing

Series	**Overall dimensions** in mm	**System accuracy**	**Recommended measuring step**[1]	**Mechanically permissible speed**	**Incremental signals**	**Signal periods/ revolution**
With integrated stator coupling						
RCN 200		± 5“	0.0001°	3000 min^{-1}	∼ 1 V_{PP}	16384
					–	–
					–	–
					–	–
		± 2.5“			∼ 1 V_{PP}	16384
					–	–
					–	–
					–	–
RCN 700		± 2“	0.0001°	1000 min^{-1}	∼ 1 V_{PP}	32768
					–	–
					–	–
					–	–
					∼ 1 V_{PP}	32768
					–	–
					–	–
					–	–
RCN 800		± 1“	0.00005°	1000 min^{-1}	∼ 1 V_{PP}	32768
					–	–
					–	–
					–	–
					∼ 1 V_{PP}	32768
					–	–
					–	–
					–	–

1) For position measurement

For information about the new absolute angle encoders with optimized scanning, visit **www.heidenhain.de** or ask for our catalog: *Absolute Angle Encoders with Optimized Scanning*.

Absolute position values	Absolute positions per revolution	Model	Page
EnDat 2.2 / 02	67 108 864 ≙ 26 bits	**RCN 226**	**24**
EnDat 2.2/22	67 108 864 ≙ 26 bits	**RCN 226**	
Fanuc 02	8 388 608 ≙ 23 bits	**RCN 223 F**	
Mit 02-4	8 388 608 ≙ 23 bits	**RCN 223 M**	
EnDat 2.2 / 02	268 435 456 ≙ 28 bits	**RCN 228**	
EnDat 2.2/22	268 435 456 ≙ 28 bits	**RCN 228**	
Fanuc 02	134 217 728 ≙ 27 bits	**RCN 227 F**	
Mit 02-4	134 217 728 ≙ 27 bits	**RCN 227 M**	
EnDat 2.2 / 02	536 870 912 ≙ 29 bits	**RCN 729**	**30**
EnDat 2.2/22	536 870 912 ≙ 29 bits	**RCN 729**	
Fanuc 02	134 217 728 ≙ 27 bits	**RCN 727 F**	
Mit 02-4	134 217 728 ≙ 27 bits	**RCN 727 M**	
EnDat 2.2 / 02	536 870 912 ≙ 29 bits	**RCN 729**	**32**
EnDat 2.2/22	536 870 912 ≙ 29 bits	**RCN 729**	
Fanuc 02	134 217 728 ≙ 27 bits	**RCN 727 F**	
Mit 02-4	134 217 728 ≙ 27 bits	**RCN 727 M**	
EnDat 2.2 / 02	536 870 912 ≙ 29 bits	**RCN 829**	**30**
EnDat 2.2/22	536 870 912 ≙ 29 bits	**RCN 829**	
Fanuc 02	134 217 728 ≙ 27 bits	**RCN 827 F**	
Mit 02-4	134 217 728 ≙ 27 bits	**RCN 827 M**	
EnDat 2.2 / 02	536 870 912 ≙ 29 bits	**RCN 829**	**32**
EnDat 2.2/22	536 870 912 ≙ 29 bits	**RCN 829**	
Fanuc 02	134 217 728 ≙ 27 bits	**RCN 827 F**	
Mit 02-4	134 217 728 ≙ 27 bits	**RCN 827 M**	

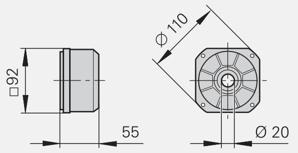
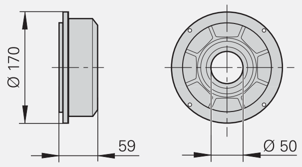
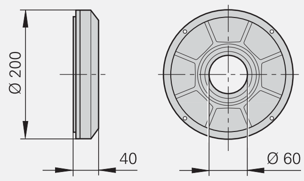
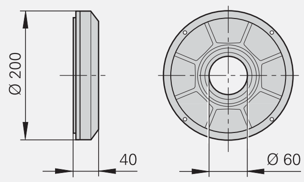
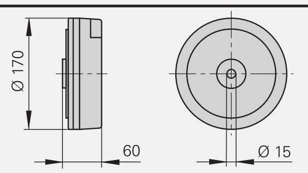
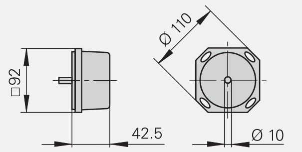
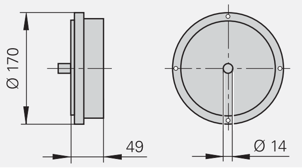
RCN 200

RCN 700
Ø 60 mm

RCN 800
Ø 100 mm

Selection Guide

Incremental Angle Encoders with Integral Bearing

Series	Overall dimensions in mm	System accuracy	Recommended measuring step[1]	Mech. permissible speed
With integrated stator coupling				
RON 200		± 5“	0.005°	3000 min^{-1}
			0.001°/0.0005°	
			0.0001°	
		± 2.5“		
RON 700		± 2“	0.0001°	1000 min^{-1}
				
RON 800 **RPN 800**		± 1“	0.00005°	1000 min^{-1}
			0.00001°	
RON 900		± 0.4“	0.00001°	100 min^{-1}
For separate shaft coupling				
ROD 200		± 5“	0.005°	10000 min^{-1}
			0.0005°	
			0.0001°	
ROD 700		± 2“	0.0001°	1000 min^{-1}
ROD 800		± 1“	0.00005°	1000 min^{-1}

1) For position measurement
2) After integrated interpolation

	Incremental signals	Signal periods/ revolution	Model	Page
	TTL	18000[2)]	**RON 225**	**26**
	TTL	180000/90000[2)]	**RON 275**	
	1 V_{PP}	18000	**RON 285**	
	1 V_{PP}	18000	**RON 287**	
	1 V_{PP}	18000	**RON 785**	**28**
	1 V_{PP}	18000/36000	**RON 786**	**34**
	1 V_{PP}	36000	**RON 886**	**34**
	1 V_{PP}	180000	**RPN 886**	
	11 μA_{PP}	36000	**RON 905**	**36**
	TTL	18000[2)]	**ROD 220**	**38**
	TTL	180000[2)]	**ROD 270**	
	1 V_{PP}	18000	**ROD 280**	
	1 V_{PP}	18000/36000	**ROD 780**	**40**
	1 V_{PP}	36000	**ROD 880**	

RON 285

RON 786

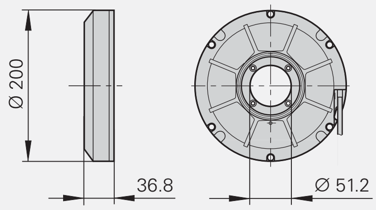
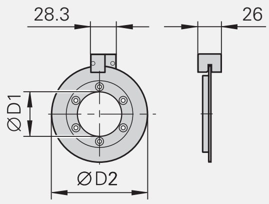
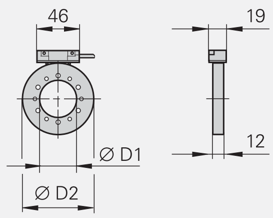
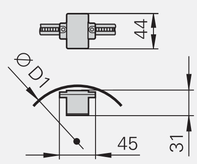
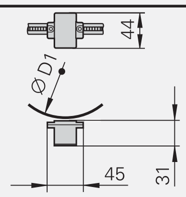
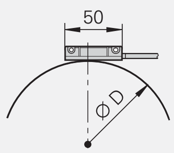
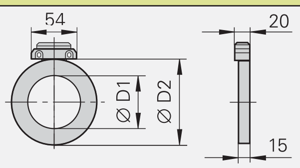
RON 905

ROD 280

ROD 780

Selection Guide

Angle Encoders and Modular Encoders without Integral Bearing

Series	Overall dimensions in mm	Diameter D1/D2	Line count/System accuracy[1]	Recommended measuring step[2]	Mechanically permissible speed
Angle encoders with rigid graduation carrier					
ERP 880 Glass disk with interferential grating		–	90000/± 1“ (180000 signal periods)	0.00001°	≤ 1000 min^{-1}
ERP 8000		D1: 50 mm D2: 108 mm	180000/± 2“ (360000 signal periods)	0.000005°	≤ 100 min^{-1}
ERP 4000		D1: 8 mm D2: 44 mm	65536/± 5” (131072 signal periods)	0.00001°	≤ 300 min^{-1}
ERA 4x80[3] Steel circumferential scale drum with centering collar		D1: 40 mm to 512 mm D2: 76.75 mm to 560.46 mm	3000/± 9.4“ to 52000/± 2.3“	0.002° to 0.00005°	≤ 10000 min^{-1} to ≤ 1500 min^{-1}
Angle encoders with steel scale tape					
ERA 700[3] For inside diameter mounting		458.62 mm 573.20 mm 1146.10 mm	36000/± 3.5“ 45000/± 3.4“ 90000/± 3.2”	0.0002° to 0.00002°	≤ 500 min^{-1}
ERA 800[3] For outside diameter mounting		458.04 mm 572.63 mm	36000/± 3.5“ 45000/± 3.4“	0.0002° to 0.00005°	≤ 100 min^{-1}
ERA 6000		159.07 mm 1146.54 mm	2500/± 80“ to 18000/± 15“		≤ 200 min^{-1} to ≤ 83 min^{-1}
Modular encoders with magnetic graduation					
ERM 200[3]		D1: 40 mm to 410 mm D2: 75.44 mm to 452.64 mm	600/± 36“ to 3600/± 9“		≤ 19000 min^{-1} to ≤ 3000 min^{-1}

1) Before installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft are not included.
2) For position measurement
3) For further versions, see appropriate catalog
4) After integrated interpolation

Incremental signals/ Grating period	Reference marks	Model	For more information
∿ 1 V_{PP}/–	One	**ERP 880**	Catalog: *Angle Encoders without Integral Bearing*
	None	**ERP 8080**	
		ERP 4080	
∿ 1 V_{PP}/20 µm	Distance-coded	**ERA 4280 C**	
∿ 1 V_{PP}/40 µm		**ERA 4480 C**	
∿ 1 V_{PP}/80 µm		**ERA 4880 C**	
∿ 1 V_{PP}/40 µm	Distance-coded (nominal increment of 1 000 grating periods)	**ERA 780 C** full circle	Catalog: *Angle Encoders without Integral Bearing*
∿ 1 V_{PP}/40 µm	Distance-coded (nominal increment of 1 000 grating periods)	**ERA 880 C** full circle	
∿ 1 V_{PP}	Selectable every 100 mm	**ERA 6080**	*ERA 6000 Product Information*
⊓⊔ TTL[4]		**ERA 6070**	
∿ 1 V_{PP}/ Approx. 400 µm		**ERM 280**	Catalog: *Magnetic Modular Encoders*
⊓⊔ TTL/ Approx. 400 µm		**ERM 220**	


ERP 880


ERP 4080


ERA 4000


ERA 780


ERA 880


ERM 280

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 min^{-1}. For higher speeds—up to 20 000 min^{-1}—steel drums are used. The scale substrate for large diameters is a steel tape.

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

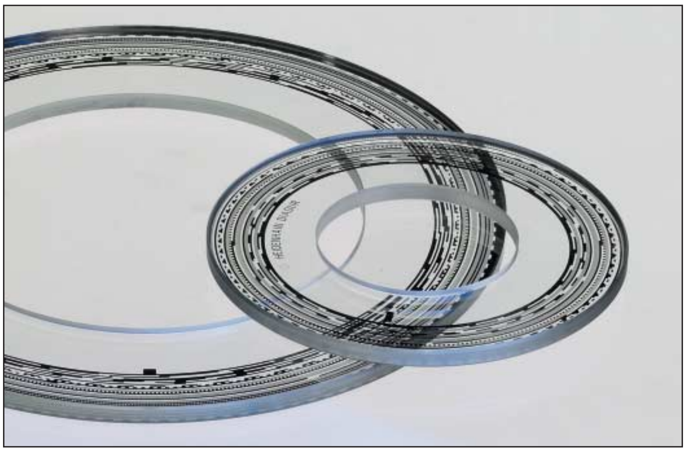
- AURODUR: Matte-etched lines on gold-plated steel tape with grating periods of typically 40 µm
- METALLUR: Contamination-tolerant graduation of metal lines on gold, with typical graduation period of 20 µm
- DIADUR: Extremely robust chromium lines on glass (typical graduation period 20 µm) or three-dimensional chrome structures (typical graduation period of 8 µm) on glass
- SUPRADUR phase grating: optically three dimensional, planar structure; particularly tolerant to contamination; typical graduation period of 8 µm and less
- OPTODUR phase grating: optically three dimensional, planar structure with particularly high reflectance, typical graduation period of 2 µm and less.

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.

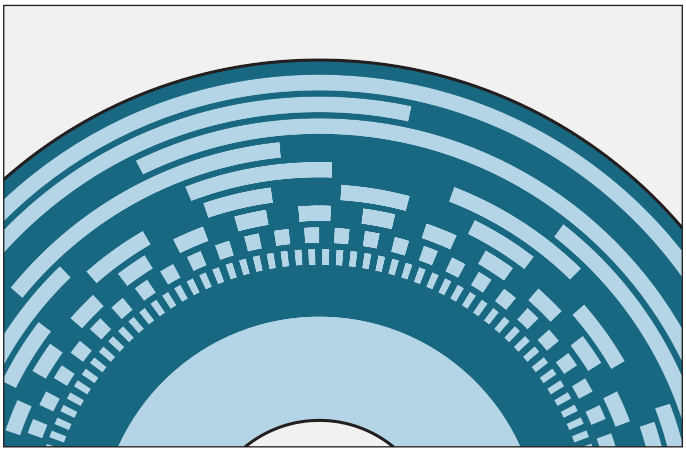
The master graduations are manufactured by HEIDENHAIN on custom-built high-precision ruling machines.

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 the **incremental measuring method**, the graduation consists of a periodic grating structure. The position information is obtained **by counting** the individual increments (measuring steps) from some point of origin. Since an absolute reference is required to ascertain positions, the 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, 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:

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

where:

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

Where:

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")

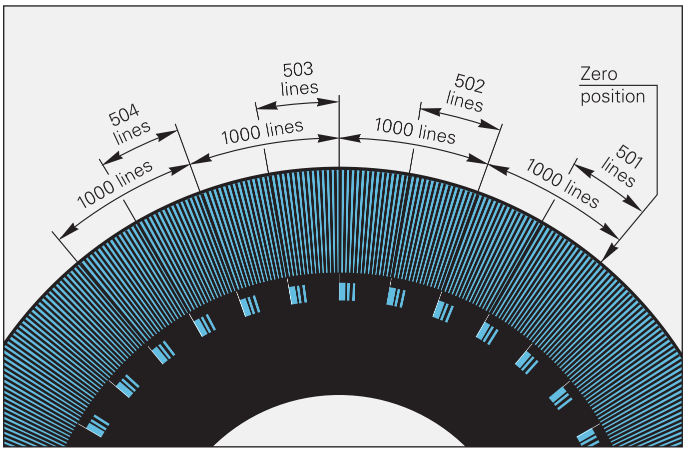
M_{RR} = Measured distance between the traversed reference marks in degrees

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
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

Scanning the Measuring Standard
Photoelectric Scanning

Most HEIDENHAIN encoders operate using the principle of photoelectric scanning. Photoelectric scanning of a measuring standard is contact-free, and as such, free of wear. This method detects even very fine lines, no more than a few 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. 70 µm.
- The **interferential scanning principle** for very fine graduations with grating periods of 4 µm.

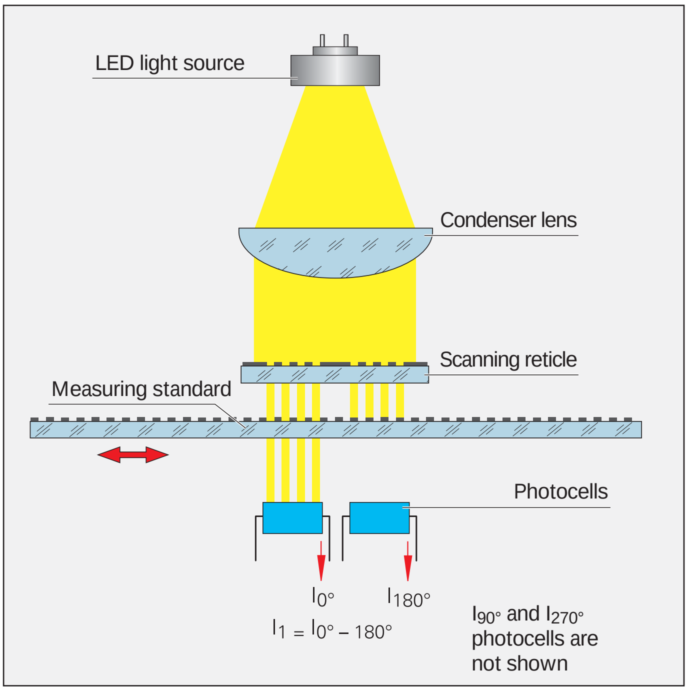
Imaging scanning principle
Put simply, the imaging scanning principle functions by means of projected-light signal generation: two graduations with equal grating periods are moved relative to each other—the scale and the scanning reticle. The carrier material of the scanning reticle is transparent, whereas 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.

Photovoltaic 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 and ROD angle encoders with integral bearing operate according to the imaging scanning principle.

Imaging scanning principle



Interferential scanning principle

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

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

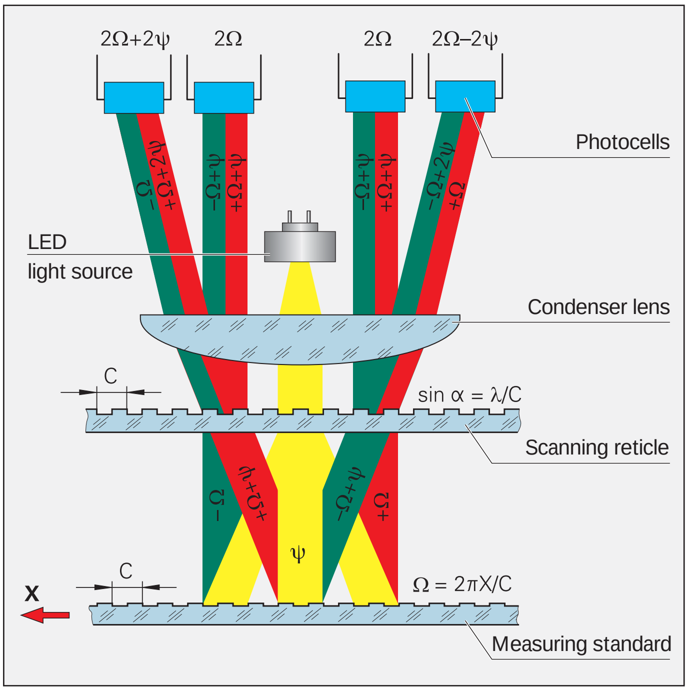
When a light wave passes through the scanning reticle, it is diffracted into three partial waves of the orders –1, 0, and +1, with approximately equal luminous intensity. The waves are diffracted by the scale such that most of the luminous intensity is found in the reflected diffraction orders +1 and –1 These partial waves meet again at the phase grating of the scanning reticle where they are diffracted again and interfere. This produces essentially three waves that leave the scanning reticle at different angles. Photovoltaic cells convert this alternating light intensity into electrical signals.

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

Interferential encoders function with 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 angle encoder with integral bearing operates 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. the quality of the graduation,
2. the quality of the scanning process,
3. the quality of the signal processing electronics,
4. the eccentricity of the graduation to the bearing,
5. the radial runout of the bearing,
6. the 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 error of a position—with respect to the mean value—are within the system accuracy ± a.* The total error is ascertained at constant temperatures (22 °C) 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 catalog: *Angle Encoders without Integral Bearing*). These deviations are not reflected in the system accuracy.

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

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

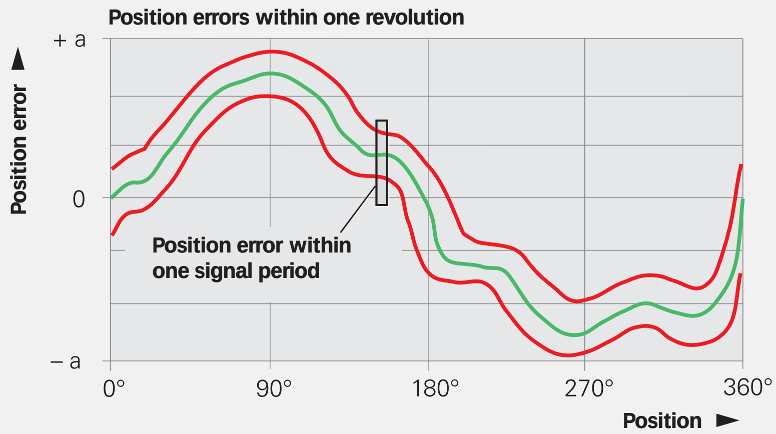
Position deviations within one signal period already become apparent in very small angular motions and in repeated measurements. They especially lead to speed ripples in the speed control loop. These deviations within one signal period are caused by the quality of the sinusoidal scanning signals and their subdivision. The following factors influence the result:

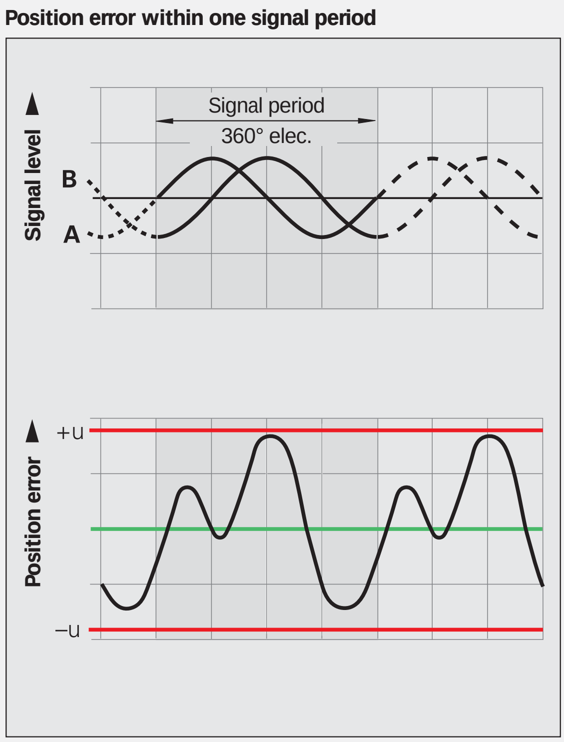
- The size of the signal period
- The homogeneity and edge definition of the graduation
- The quality of the optical filter structures on the scanning reticle
- The characteristics of the photoelectric detectors
- The stability and dynamics during the further processing of the analog signals

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: ± 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".

With a signal quality of ± 1 %, this results in maximum position error within one signal period of approx. ± 0.0001° or ± 0.36".





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 *Mechanical Design Types and Mounting – ROD – Kinematic error of transfer*).

The system 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, in which the reversal error is not included.

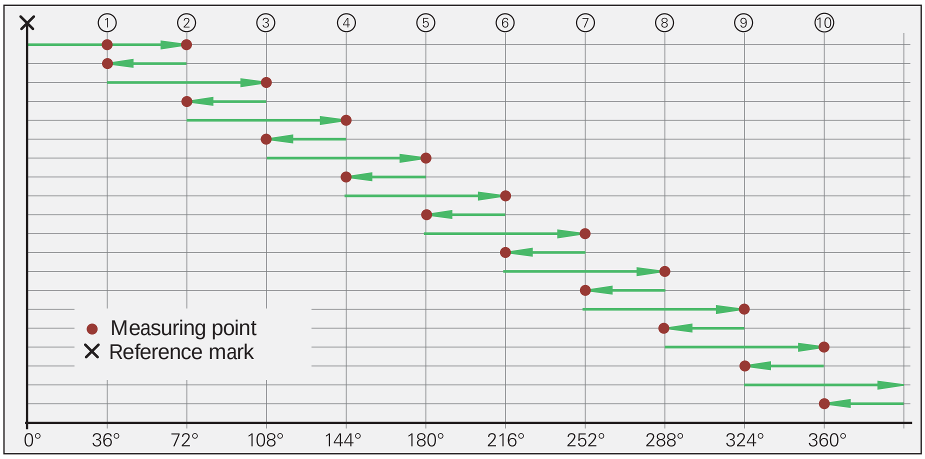
The **reversal error** depends on the shaft coupling. On angle encoders with integral stator coupling it is determined at ten measuring positions in forward and backward steps. The maximum value and arithmetic mean are documented on the calibration chart.

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.

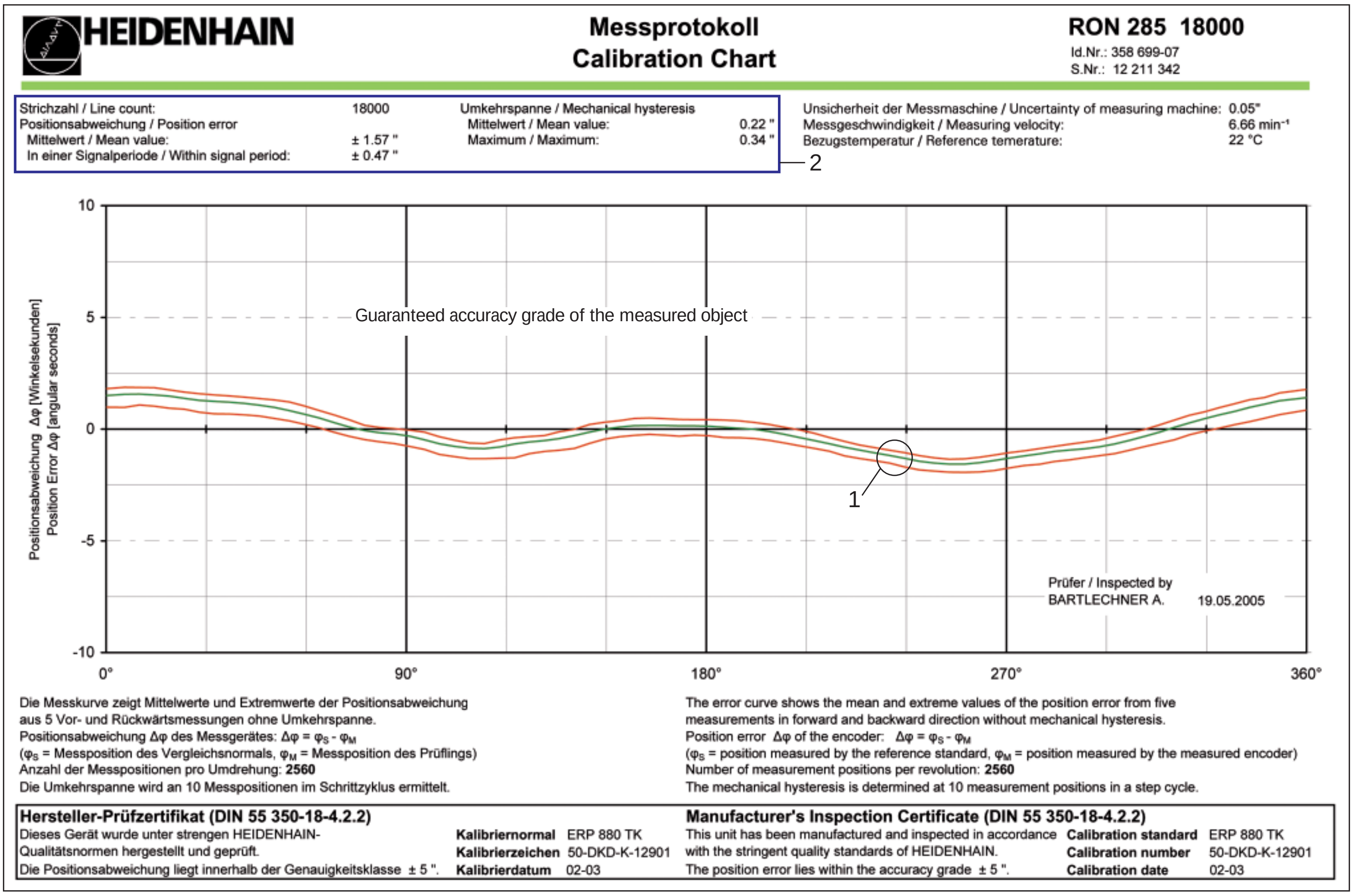
Determination of the reversal error with forward and backward measurements



Calibration chart example: RON 285

1 Graphic representation of error
- Envelope curve
- Mean value curve

2 Results of calibration



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.

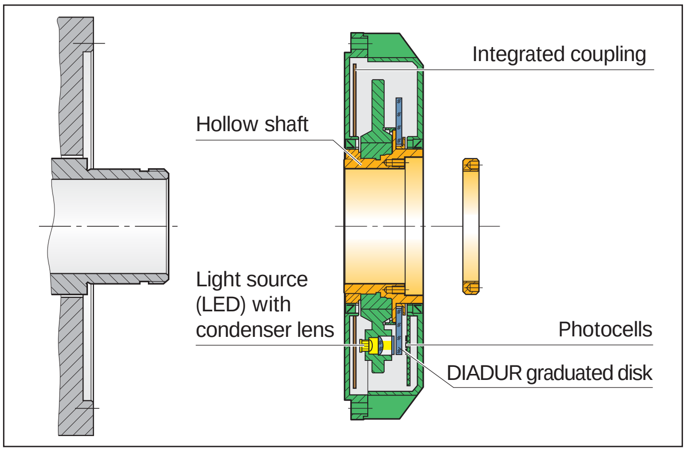
Design: The graduated disk is rigidly affixed to the hollow shaft. The scanning unit rides on the shaft on ball bearings and is connected to the housing with a coupling on the stator side. During angular acceleration of the shaft, the coupling must absorb only that torque caused by friction in the bearing.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

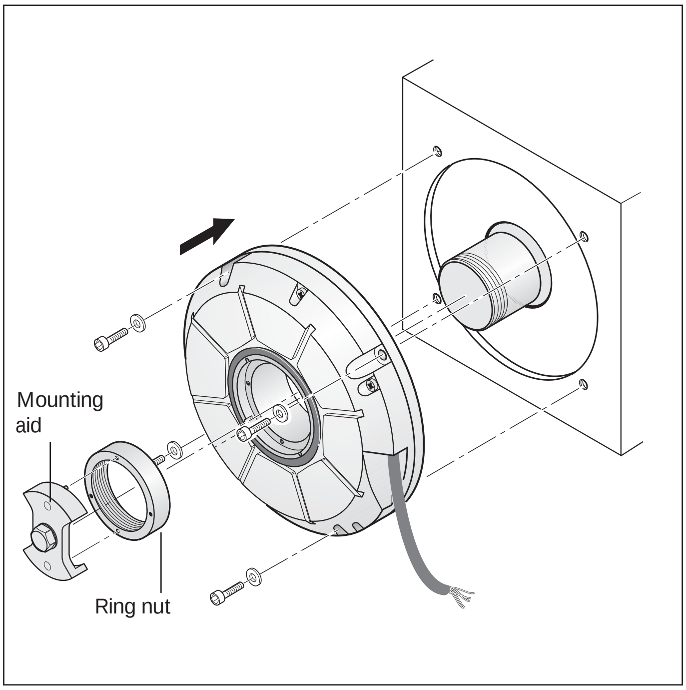
Shaft coupling with ring nut
The RCN, RON and RPN series have a hollow through shaft. For installation, the hollow through shaft of the angle encoder is placed over the machine shaft, and is fixed with a ring nut from the front of the encoder. The ring nut can easily be tightened with the mounting tool.

Front end shaft coupling
It is often helpful, 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 connected by threaded holes on the face with the aid of special mounting elements adapted to the respective 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.

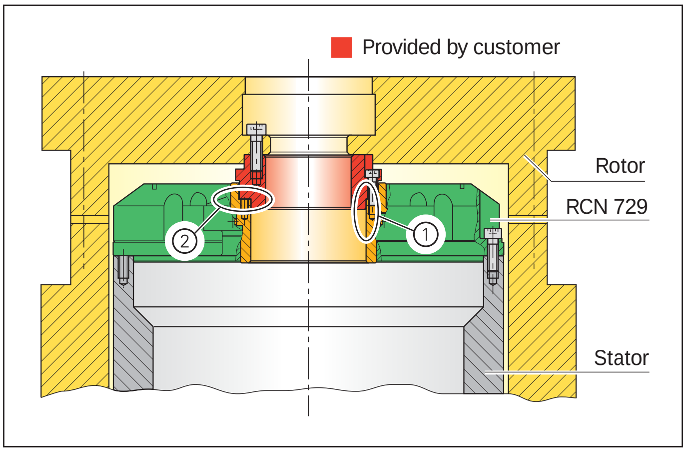
RON 905 shaft coupling
The RON 905 has a blind hollow shaft. The shaft is connected by an axial central screw.



Cross section of the **RON 886** angle encoder



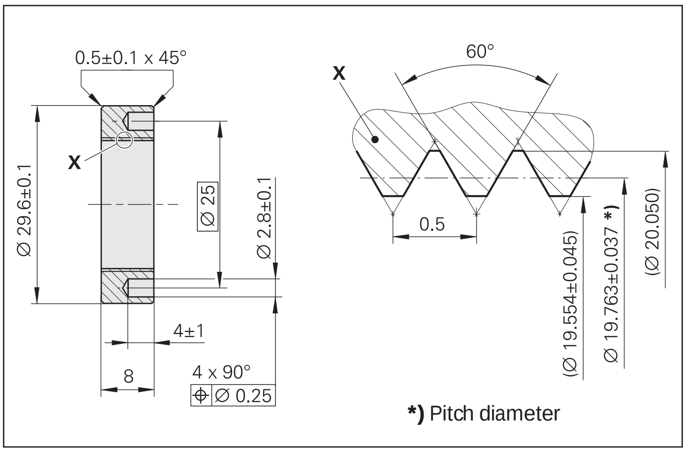
Mounting an angle encoder with hollow through shaft



Front-end shaft coupling with **RCN 729**

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 encoder's hollow shaft.

Ring nut for **Series RxN 200**



Ring nut for RON/RCN 200
Hollow shaft ∅ 20 mm: ID 336 669-03

Ring nut for RON 785
Hollow shaft ∅ 50 mm: ID 336 669-05

Ring nut for RON 786; RON/RPN 886 RCN 72x/RCN 82x
Hollow shaft ∅ 60 mm: ID 336 669-11

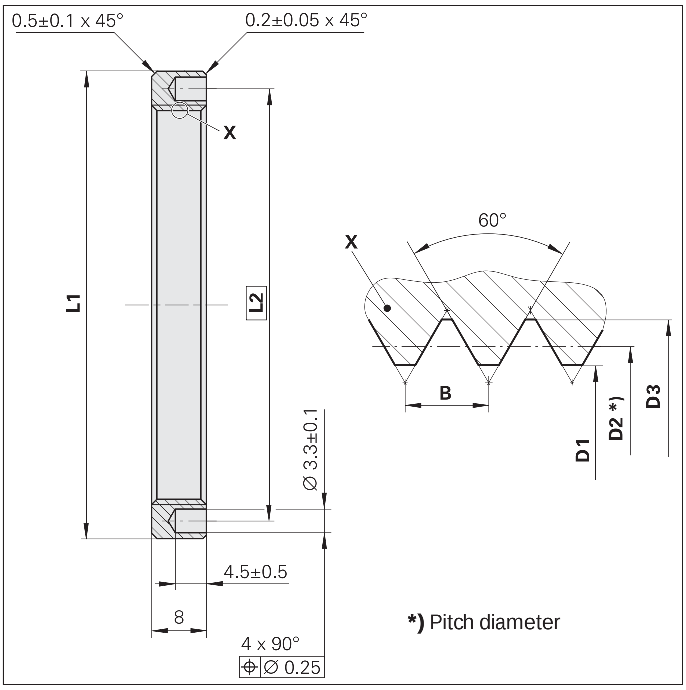
Ring nut for RCN 72x/RCN 82x
Hollow shaft ∅ 100 mm: ID 336 669-16

Mounting tool for HEIDENHAIN ring nuts
The mounting tool is used to tighten the ring nut. Its pins lock into the holes in the ring nuts. A torque wrench provides the necessary tightening torque.

Mounting tool for ring nuts with

Hollow shaft ∅ 20 mm	ID 530 334-03
Hollow shaft ∅ 50 mm	ID 530 334-05
Hollow shaft ∅ 60 mm	ID 530 334-11
Hollow shaft ∅ 100 mm	ID 530 334-16

Ring nut for **RxN 700/800 series**



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

PWW inspection tool for angle encoders
The PWW makes a simple and quick inspection of the most significant mating dimensions possible. The integrated measuring equipment measures position and radial runout regardless of the type of shaft coupling, for example.

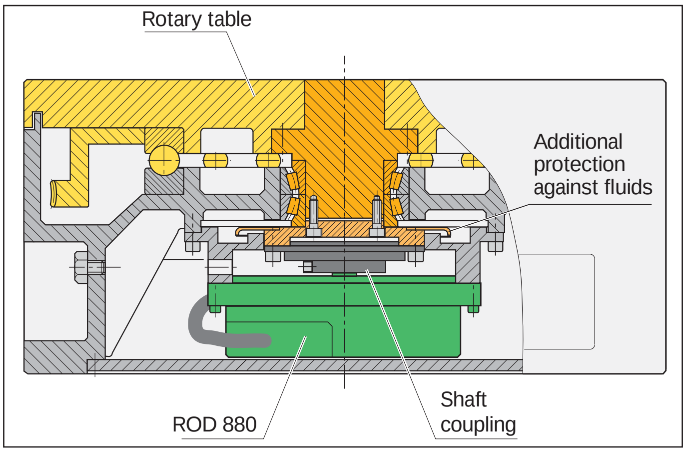
PWW for

Hollow shaft ∅ 20 mm:	ID 516 211-01
Hollow shaft ∅ 50 mm:	ID 516 211-02
Hollow shaft ∅ 60 mm:	ID 516 211-03
Hollow shaft ∅ 100 mm:	ID 516 211-05

Inspection tool PWW

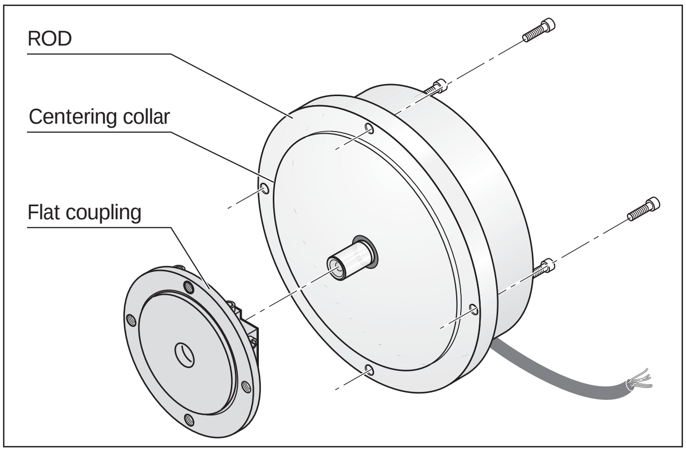
Mechanical Design Types and Mounting
ROD

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 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.



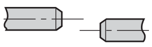
Mounting example ROD 880

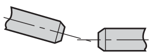
Mounting
ROD angle encoders are provided with an integral mounting flange with centering collar. The encoder shaft is connected to the drive shaft by way of a diaphragm coupling or flat coupling.

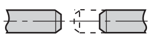


Mounting an ROD

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.

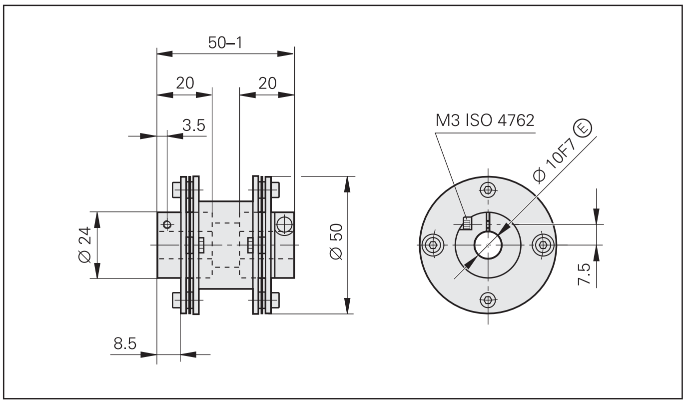
Radial offset λ 

Angular error α 

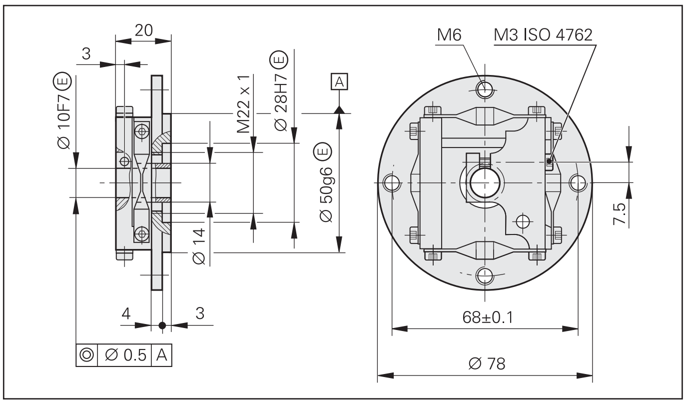
Axial motion δ 

Shaft coupling	ROD 200 Series K 03 Diaphragm coupling	ROD 200 Series K 18 Flat coupling	ROD 700 Series, ROD 800 Series K 01 Diaphragm coupling	ROD 700 Series, ROD 800 Series K 15 Flat coupling	ROD 700 Series, ROD 800 Series K 16 Flat coupling
Hub bore	10 mm		14 mm		
Kinematic transfer error	± 2“ at λ ≤ 0.1 mm and α ≤ 0.09°	± 3“	± 1“	± 0.5“ at λ ≤ 0.05 mm and α ≤ 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			
Perm. radial offset λ	≤ 0.3 mm				
Perm. angular error α	≤ 0.5°			≤ 0.2°	≤ 0.5°
Perm. axial offset 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	10000 min^{-1}	1000 min^{-1}	3000 min^{-1}	1000 min^{-1}	
Torque for locking screws (approx.)	1.2 Nm		2.5 Nm	1.2 Nm	
Weight	100 g	117 g	180 g	250 g	410 g

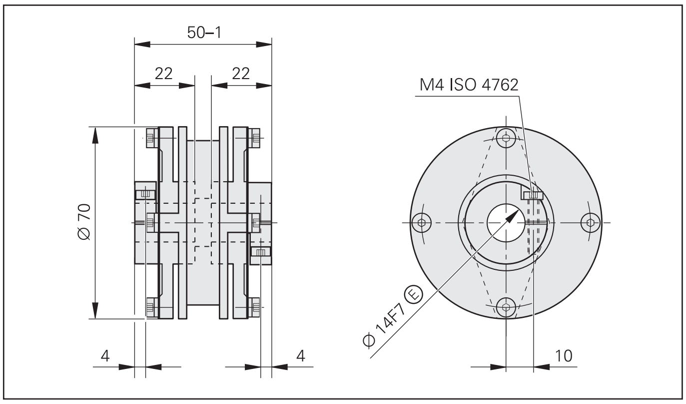
K 03 diaphragm coupling
ID 200 313-04



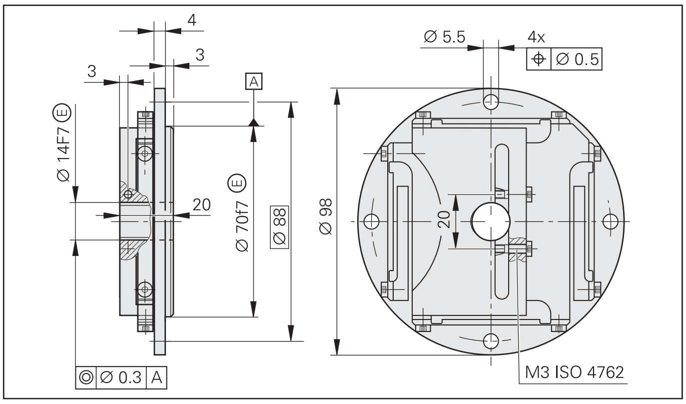
K 18 flat coupling
ID 202 227-01



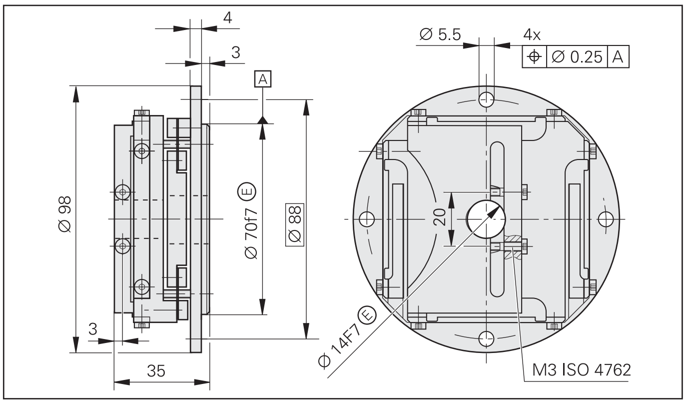
K 01 diaphragm coupling
ID 200 301-02



K 15 flat coupling
ID 255 797-01



K 16 flat coupling
ID 258 878-01



Dimensions in mm

General Mechanical Information

Degree of protection
Unless otherwise indicated, all RCN, RON, RPN and ROD angle encoders meet protection standard IP 67 according to IEC 60529 or EN 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 the 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.

The compressed air introduced directly onto the encoders must be cleaned by a micro filter, and must comply with the following quality classes as per **ISO 8573-1 (2001 edition)**:
- Solid contaminant: Class 1 (max. particle size 0.1 µm and max. particle density 0.1 mg/m^3 at $1 \cdot 10^5$ Pa)
- Total oil content: Class 1 (max. oil concentration 0.01 mg/m^3 at $1 \cdot 10^5$ Pa)
- Maximum pressure dew point: Class 4, but with reference conditions of +3 °C at $2 \cdot 10^5$ Pa

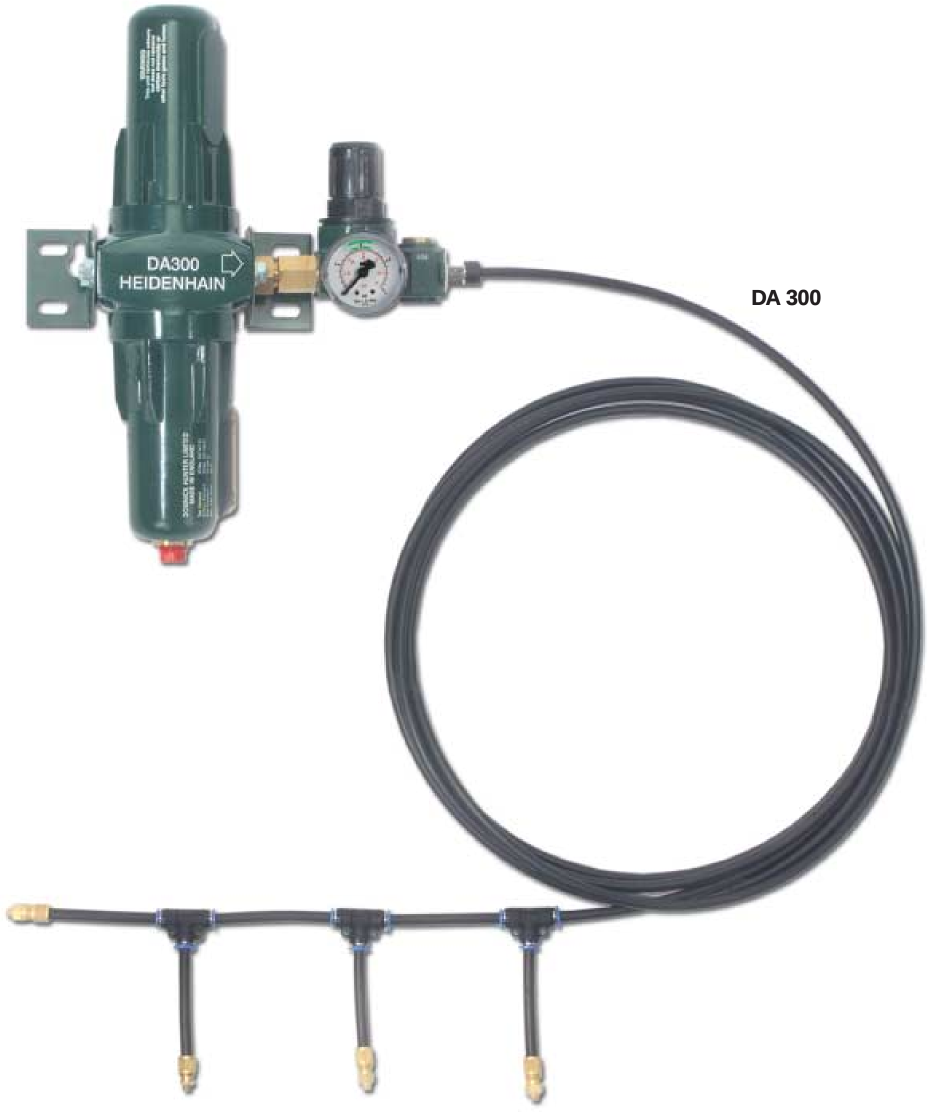
For more information, ask for our *DA 300* Product Information sheet.

For this purpose, HEIDENHAIN offers the **DA 300 compressed air unit** (filter combination with pressure regulator and fittings). The compressed air introduced into the DA 300 must fulfill the requirements of the following quality classes as per ISO 8573-1 (2001 edition):
- 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)
- Maximum pressure dew point:
  No class (+29 °C at $10 \cdot 10^5$ Pa)

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 ∅ 0.3 mm
For air-flow rate from 1 to 4 l/min
ID 207835-04

M5 coupling joint, swiveling
with seal
ID 207834-02



DA 300

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

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

The **storage temperature range** of –30 °C to +80 °C is valid when the unit remains in its packaging. The storage temperature for the RPN 886 may not exceed –10 °C to +50 °C.

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 angle acceleration** for the and encoders
  - RCN/RON 200 series: 1500 rad/s^2
  - RCN/RON 700 series: 3000 rad/s^2
  - RCN/RON/RPN 800 series: 3000 rad/s^2

  For the ROD angle encoders, the permissible angular acceleration varies depending on the shaft coupling and the mating shaft (details upon request).
- The indicated maximum values for **vibration** are valid according to EN 60068-2-6.
- The maximum permissible acceleration values (semi-sinusoidal shock) for **shock and impact** are valid for 6 ms (EN 60068-2-27). Under no circumstances should a hammer or similar implement be used to adjust or position the encoder.

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. For RCN, RON and RPN angle encoders, the frequency ranges given in the respective specifications are those where the natural frequencies of the encoders do not cause any significant position deviations in the measuring direction. 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 handling. These include in particular the following parts:
- LED light source
- Cables with frequent flexing

Additionally for encoders with integral bearing:
- Bearing
- 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-related systems, the higher-level system must verify the position value of the encoder after switch-on.

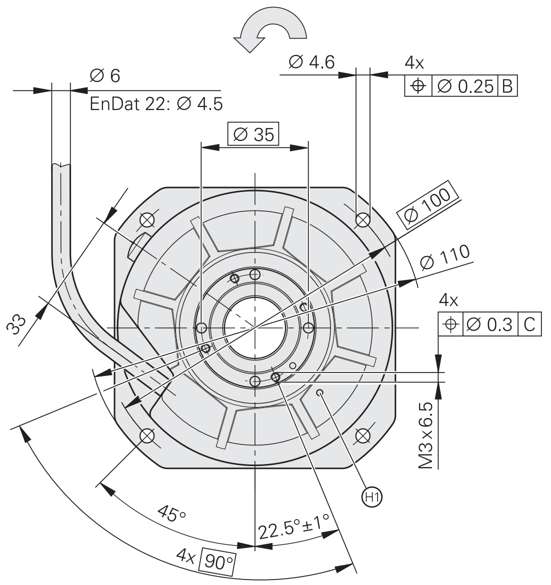
Mounting
Work steps to be performed and dimensions to be maintained during mounting are specified solely in the mounting instructions supplied with the unit. All data in this catalog regarding mounting are therefore provisional and not binding; they do not become terms of a contract.

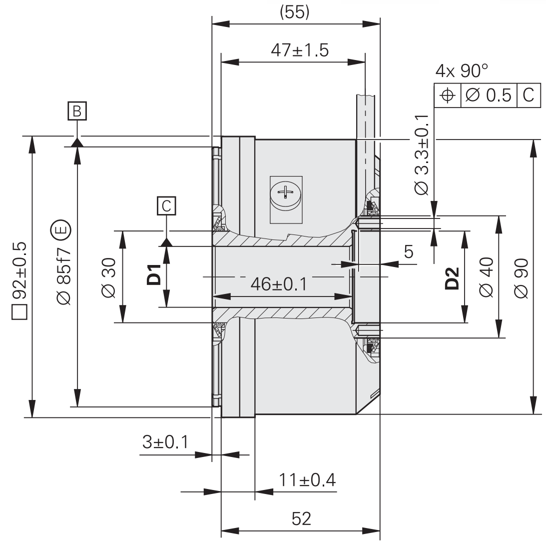
RCN 200 Series

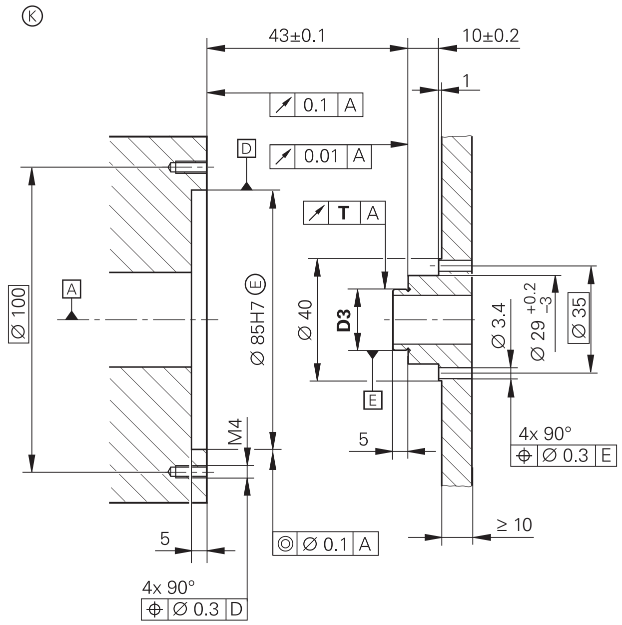
- **Integrated stator coupling**
- **Hollow through shaft Ø 20 mm**
- **System accuracy ± 5“ and ± 2.5“**

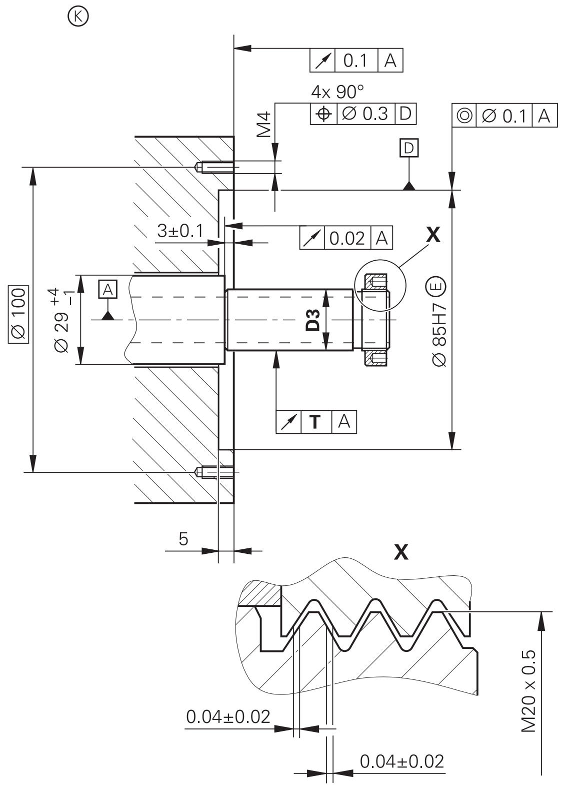
Dimensions in mm

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









Cable radial, also usable axially
A = Bearing
K = Required mating dimensions
H1 = Mark for 0° position (± 5°)
Direction of shaft rotation for output signals as per the interface description

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

	Absolute			
	RCN 228 **RCN 226**		**RCN 227F** **RCN 223F**	**RCN 227M** **RCN 223M**
Absolute position values	EnDat 2.2	EnDat 2.2	Fanuc serial interface	Mitsubishi High Speed Serial Interface
Ordering designation*	EnDat 22	EnDat 02	Fanuc 02	Mit 02-4
Positions per revolution	*RCN 228:* 268435456 (28 bits) *RCN 226:* 67108864 (26 bits)		*RCN 227:* 134217728 (27 bits) *RCN 223:* 8388608 (23 bits)	
Elec. permissible speed	≤ 1500 min^{-1}			
Clock frequency	≤ 8 MHz	≤ 2 MHz	–	
Calculation time t_{cal}	5 µs		–	
Incremental signals	–	∿ 1 V_{PP}	–	
Line count	–	16384	–	
Cutoff frequency –3 dB	–	≥ 180 kHz	–	
Recommended measuring step for position measurement	0.0001°			
System accuracy*	*RCN 228:* ± 2.5“ *RCN 226:* ± 5“		*RCN 227F:* ± 2.5“ *RCN 223F:* ± 5“	*RCN 227M:* ± 2.5“ *RCN 223M:* ± 5“
Power supply Without load	3.6 V to 5.25 V at encoder/max. 350 mA			
Electrical connection	Cable 1 m, with coupling M12	Cable 1 m, with M23 coupling	Cable 1 m, with M23 coupling	
Max. cable length[1)]	150 m		30 m	
Shaft	Hollow through shaft D = 20 mm			
Mech. perm. speed	≤ 3000 min^{-1}			
Starting torque	≤ 0.08 Nm at 20 °C			
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 (EN 60068-2-6) ≤1000 m/s^2 (EN 60068-2-27)			
Operating temperature	*For accuracy of ± 2.5“:* 0 to 50 °C *For accuracy of ± 5“:* *Moving cable* –10 to 70 °C *Stationary cable:* –20 to 70 °C			
Protection EN 60529	IP 64			
Weight	Approx. 0.8 kg			

* Please select when ordering
1) With HEIDENHAIN cable

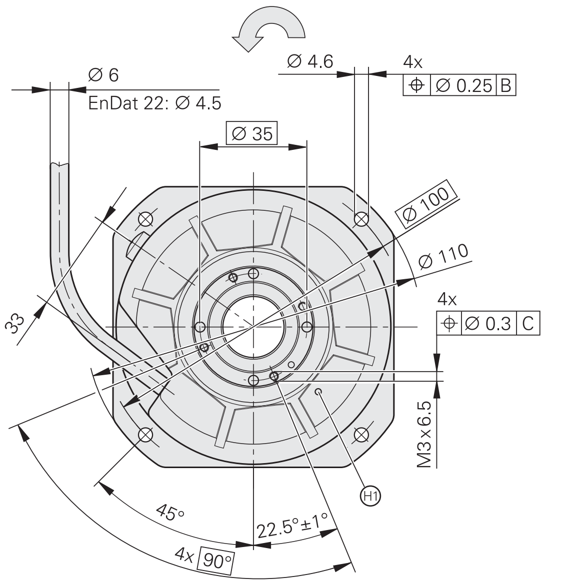
Specifications

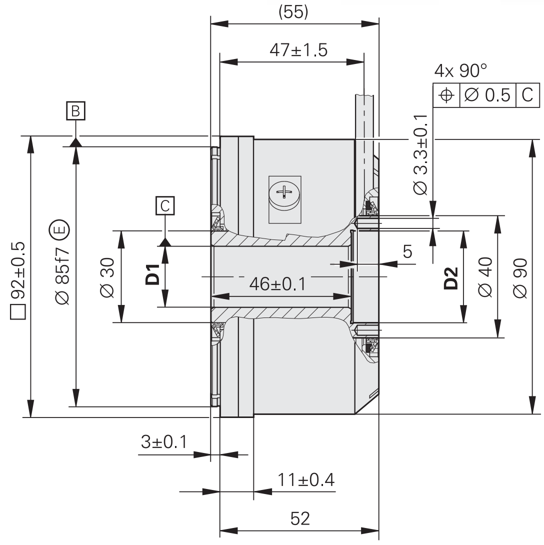
RON 200 Series

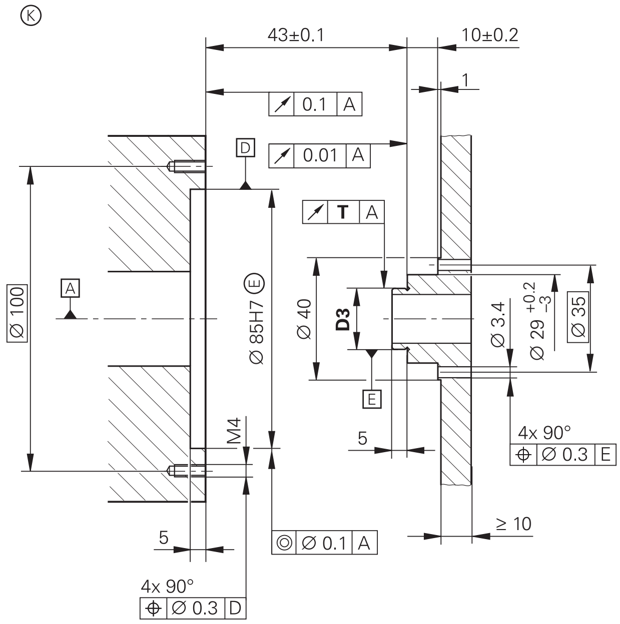
- **Integrated stator coupling**
- **Hollow through shaft Ø 20 mm**
- **System accuracy ± 5“ and ± 2.5“**

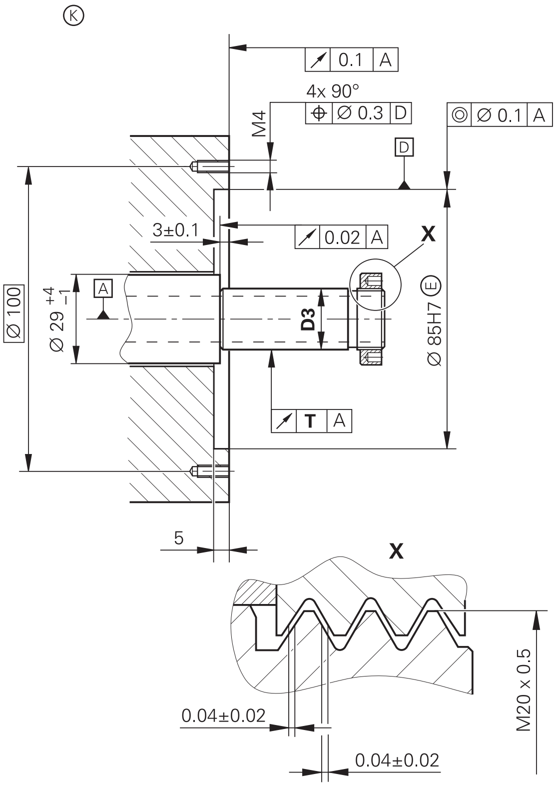
Dimensions in mm

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









Cable radial, also usable axially
A = Bearing
K = Required mating dimensions
H1 = Position of the reference-mark signal (± 5°)
Direction of shaft rotation for output signals as per the interface description

System accuracy	± 2.5“	± 5“
D1	Ø 20H6 E	Ø 20H7 E
D2	Ø 30H6 E	Ø 30H7 E
D3	Ø 20g6 E	Ø 20g7 E
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 2xxC:* One	
Cutoff frequency –3 dB Output frequency Edge separation a	– ≤ 1 MHz ≥ 0.125 µs	– ≤ 250 kHz ≥ 0.96 µs	– ≤ 1 MHz ≥ 0.22 µs	≥ 180 kHz – –	
Elec. permissible speed	–	≤ 166 min^{-1}	≤ 333 min^{-1}	–	
Recommended measuring step for position measurement	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, with or without M23 coupling				
Max. cable length[1)]	50 m			150 m	
Shaft	Hollow through shaft D = 20 mm				
Mech. perm. speed	≤ 3000 min^{-1}				
Starting torque	≤ 0.08 Nm at 20 °C				
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 (EN 60068-2-6) ≤1000 m/s^2 (EN 60068-2-27)				
Operating temperature	*Moving cable:* –10 to 70 °C *Stationary cable:* –20 to 70 °C				0 °C to 50 °C
Protection EN 60529	IP 64				
Weight	Approx. 0.8 kg				

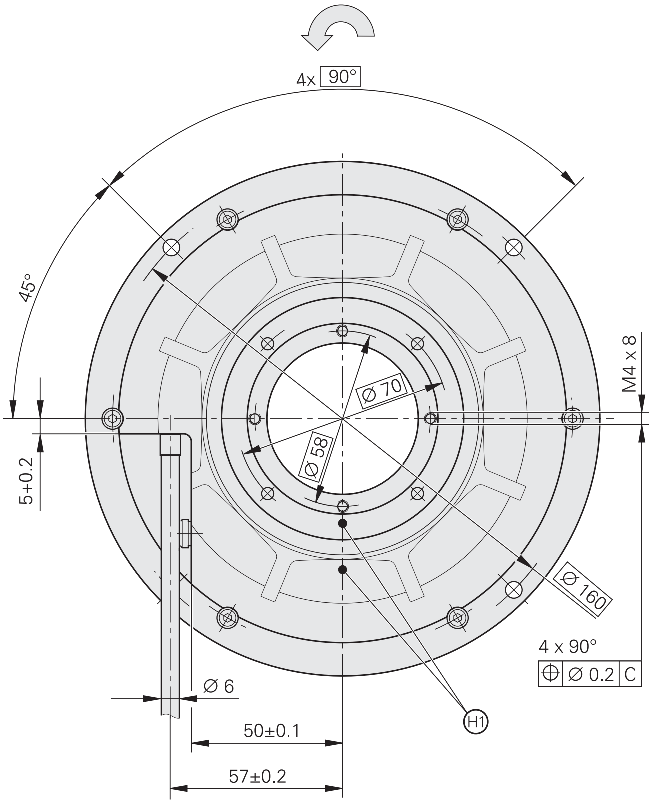
* Please select when ordering
1) With HEIDENHAIN cable

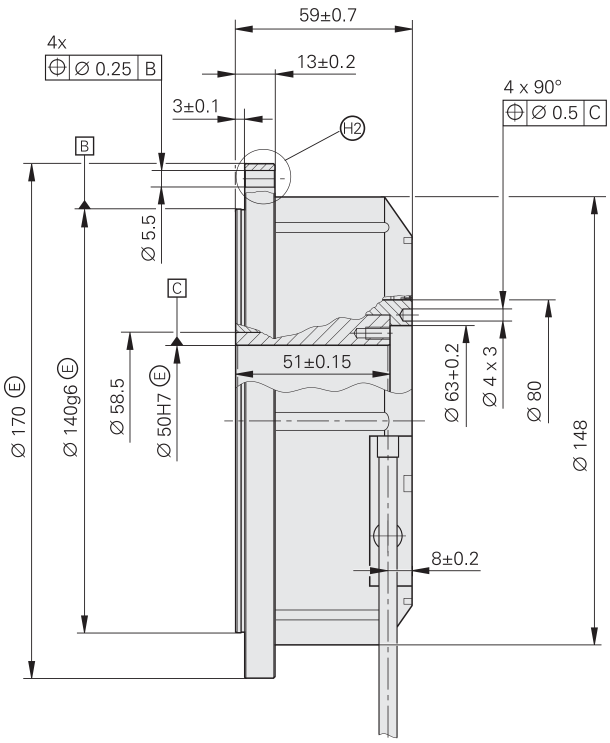
RON 785

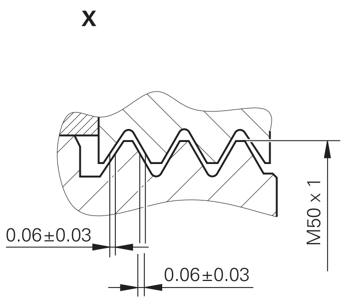
- **Integrated stator coupling**
- **Hollow through shaft Ø 50 mm**
- **System accuracy ± 2“**

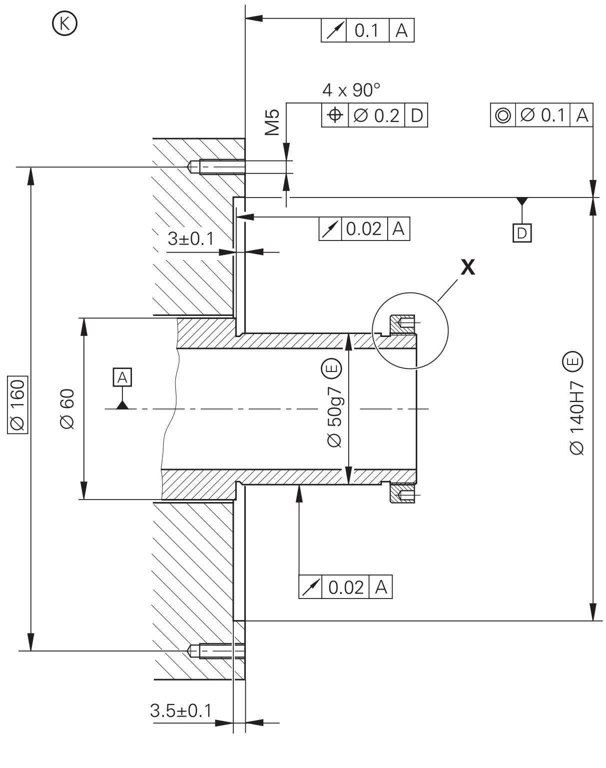
Dimensions in mm

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









Cable radial, also usable axially
A = Bearing
K = Required mating dimensions
H1 = Position of the reference-mark signal (± 5°)
H2 = Shown rotated by 45°
Direction of shaft rotation for output signals as per the interface description

	Incremental RON 785
Incremental signals	∿ 1 V_{PP}
Line count	18000
Reference mark*	*RON 785:* One *RON 785C:* Distance-coded
Cutoff frequency –3 dB	≥ 180 kHz
Recommended measuring step for position measurement	0.0001°
System accuracy	± 2"
Power supply Without load	5 V ± 10 %, max. 150 mA
Electrical connection*	Cable 1 m, with or without M23 coupling
Max. cable length[1)]	150 m
Shaft	Hollow through shaft D = 50 mm
Mech. perm. speed	≤ 1000 min^{-1}
Starting torque	≤ 0.5 Nm at 20 °C
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 (EN 60068-2-6) ≤1000 m/s^2 (EN 60068-2-27)
Operating temperature	0 °C to 50 °C
Protection EN 60529	IP 64
Weight	Approx. 2.5 kg

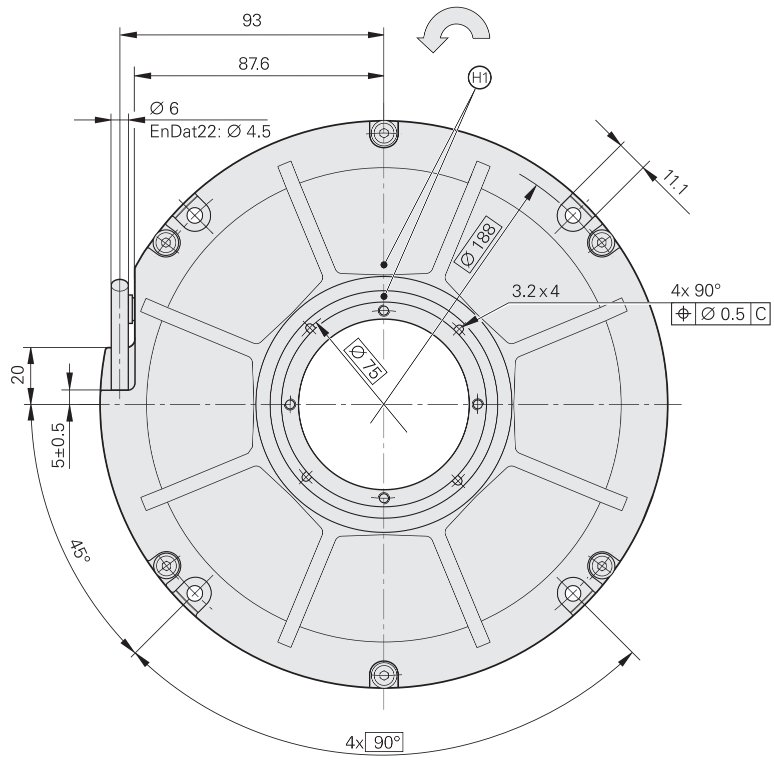
* Please select when ordering
1) With HEIDENHAIN cable

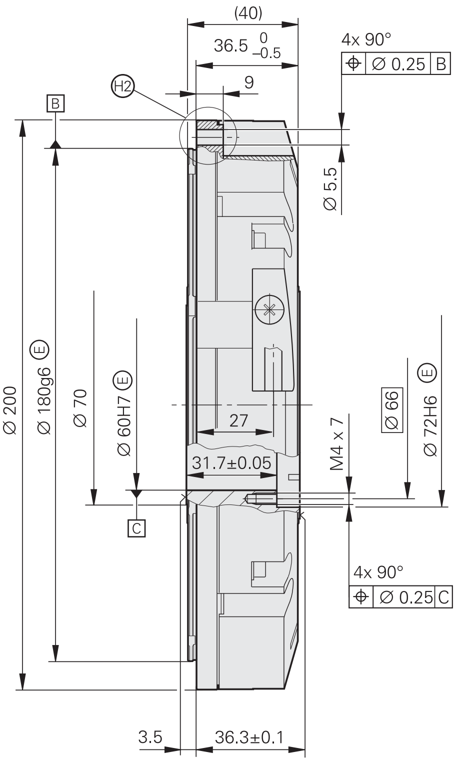
RCN 700/RCN 800 Series

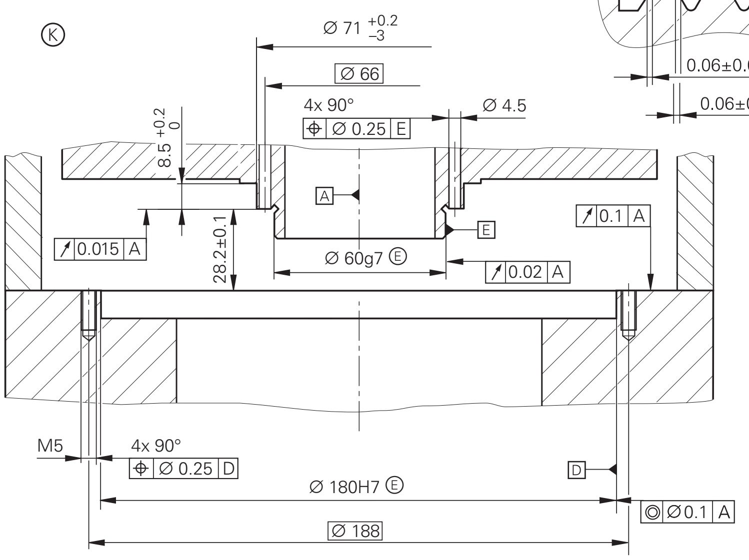
- **Integrated stator coupling**
- **Hollow through shaft Ø 60 mm**
- **System accuracy ± 2“ or ± 1“**

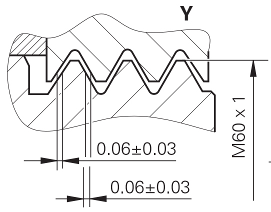
Dimensions in mm

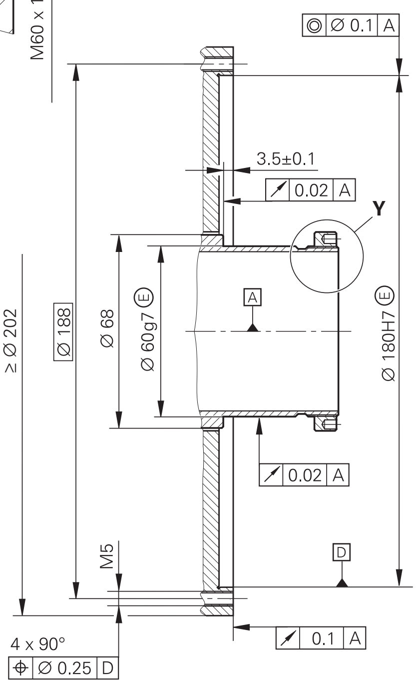
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm











Cable radial, also usable axially
Ⓐ = Bearing
Ⓚ = Required mating dimensions
Ⓗ1 = Mark for 0° position (± 5°)
Ⓗ2 = Shown rotated by 45°
↺ Direction of shaft rotation for output signals as per the interface description

	Absolute			
	RCN 729 **RCN 829**	**RCN 729** **RCN 829**	**RCN 727 F** **RCN 827 F**	**RCN 727 M** **RCN 827 M**
Absolute position values	EnDat 2.2	EnDat 2.2	Fanuc 02 serial interface	Mitsubishi High Speed Serial Interface
Ordering designation*	EnDat 22	EnDat 02	Fanuc 02	Mit 02-4
Positions per revolution	536 870 912 (29 bits)		134 217 728 (27 bits)	
Elec. permissible speed	≤ 300 min^{-1} 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 measurement	*RCN 72x:* 0.0001° *RCN 82x:* 0.00005°			
System accuracy	*RCN 72x:* ± 2“ *RCN 82x:* ± 1“			
Power supply Without load	3.6 to 5.25 V, max. 350 mA			
Electrical connection*	Cable 1 m, with coupling M12	Cable 1 m, with M23 coupling		
Max. cable length[1)]	150 m		30 m	
Shaft	Hollow through shaft D = 60 mm			
Mech. perm. speed	≤ 1000 min^{-1}			
Starting torque	≤ 0.5 Nm at 20 °C			
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 (EN 60068-2-6) ≤1000 m/s^2 (EN 60068-2-27)			
Operating temperature	0 °C to 50 °C			
Protection EN 60529	IP 64			
Weight	Approx. 2.8 kg			

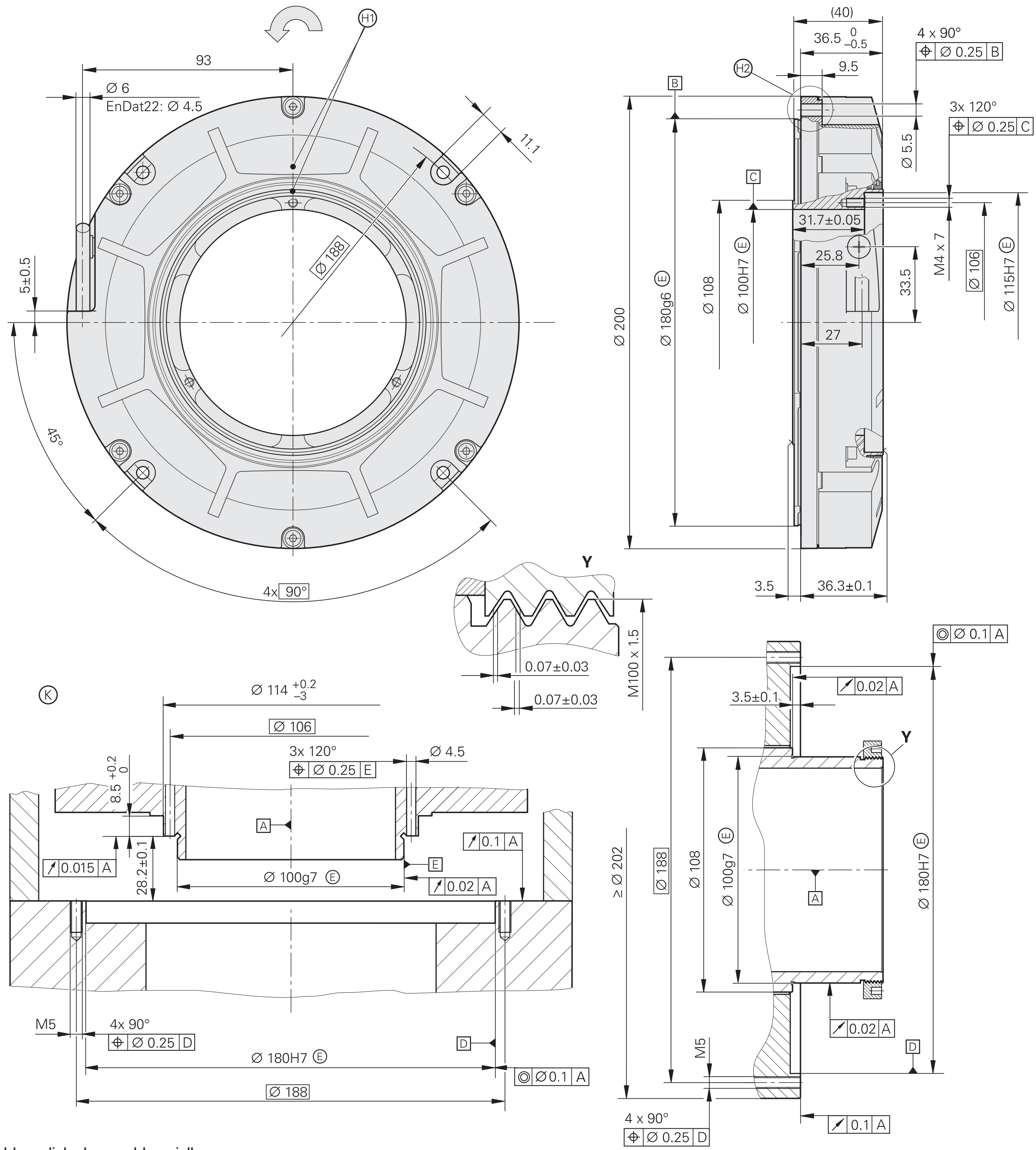
***** Please select when ordering
1) With HEIDENHAIN cable

RCN 700/RCN 800 Series

- **Integrated stator coupling**
- **Hollow through shaft Ø 100 mm**
- **System accuracy ± 2“ or ± 1“**

Dimensions in mm

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



Cable radial, also usable axially
A = Bearing
K = Required mating dimensions
H1 = Mark for 0° position (± 5°)
H2 = Shown rotated by 45°
Direction of shaft rotation for output signals as per the interface description

	Absolute			
	RCN 729 **RCN 829**	**RCN 729** **RCN 829**	**RCN 727 F** **RCN 827 F**	**RCN 727 M** **RCN 827 M**
Absolute position values	EnDat 2.2	EnDat 2.2	Fanuc 02 serial interface	Mitsubishi High Speed Serial Interface
Ordering designation*	EnDat 22	EnDat 02	Fanuc 02	Mit 02-4
Positions per revolution	536 870 912 (29 bits)		134 217 728 (27 bits)	
Elec. permissible speed	≤ 300 min^{-1} 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 measurement	*RCN 72x:* 0.0001° *RCN 82x:* 0.00005°			
System accuracy	*RCN 72x:* ± 2" *RCN 82x:* ± 1"			
Power supply Without load	3.6 to 5.25 V, max. 350 mA			
Electrical connection*	Cable 1 m, with coupling M12	Cable 1 m, with M23 coupling		
Max. cable length[1]	150 m		30 m	
Shaft	Hollow through shaft D = 100 mm			
Mech. perm. speed	≤ 1000 min^{-1}			
Starting torque	≤ 1.5 Nm at 20 °C			
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 (EN 60 068-2-6) ≤ 1000 m/s^2 (EN 60 068-2-27)			
Operating temperature	0 °C to 50 °C			
Protection EN 60 529	IP 64			
Weight	Approx. 2.6 kg			

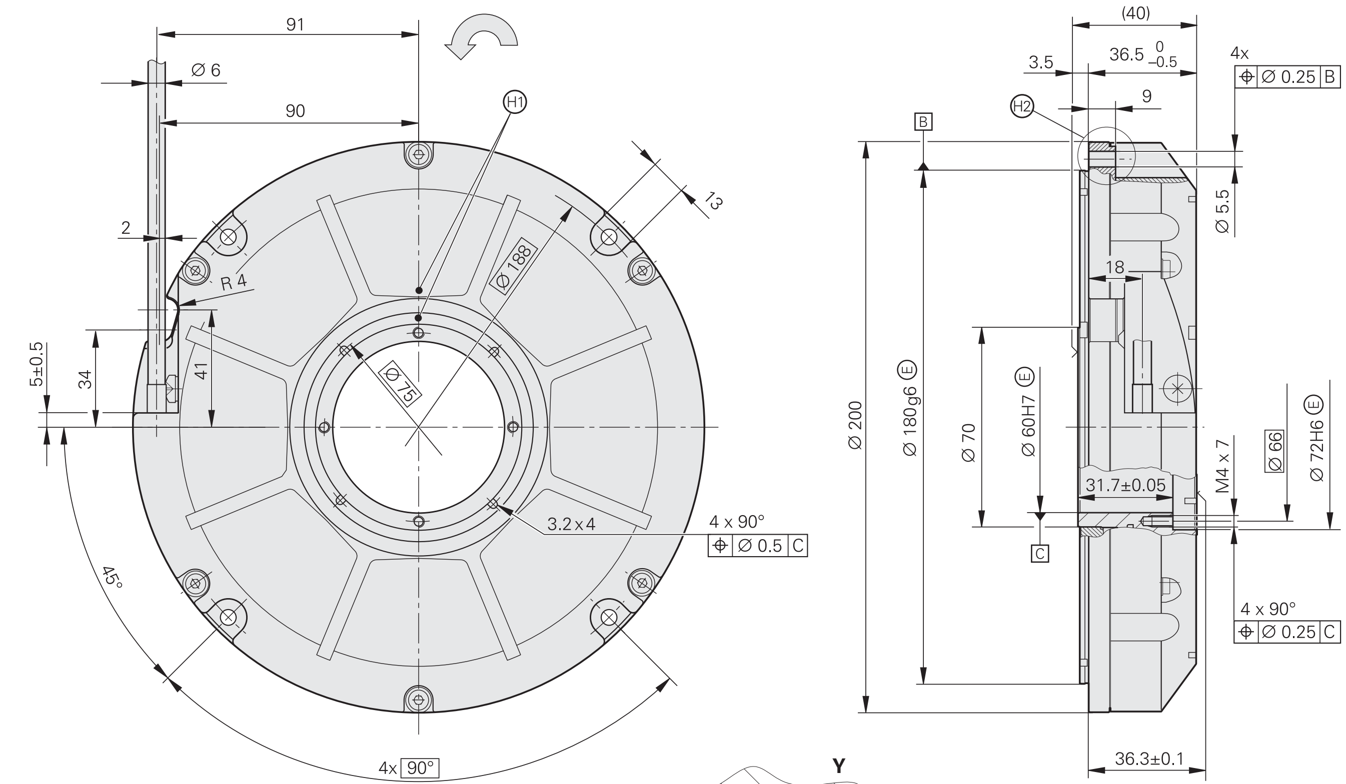
***** Please select when ordering
[1] With HEIDENHAIN cable

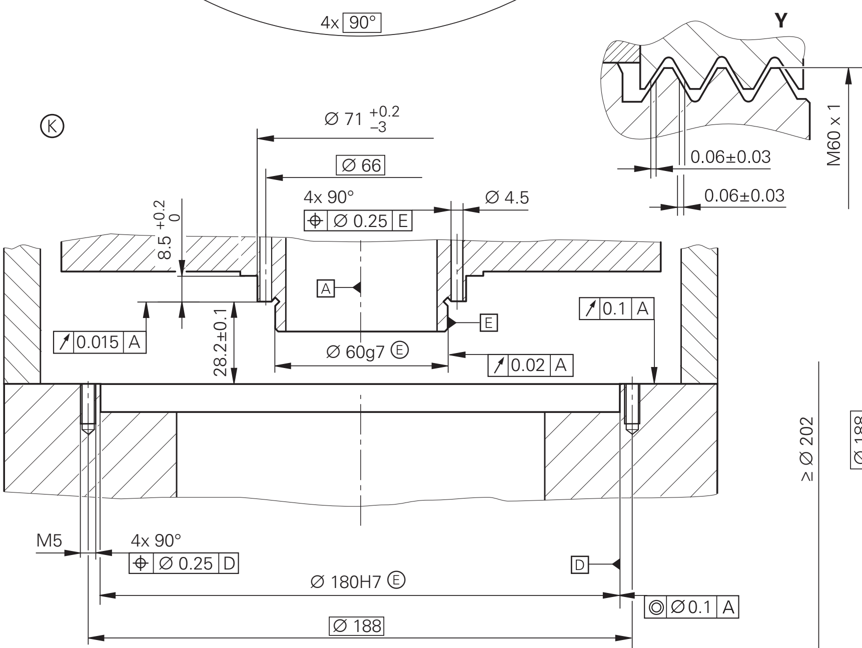
RON 786/RON 886/RPN 886

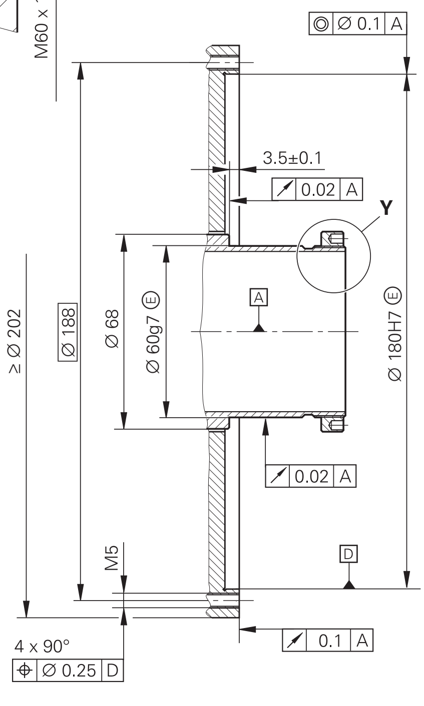
- **Integrated stator coupling**
- **Hollow through shaft Ø 60 mm**
- **System accuracy ± 2“ or ± 1“**

Dimensions in mm

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







Cable radial, also usable axially
A = Bearing
K = Required mating dimensions
H1 = Position of the reference-mark signal (± 5°)
H2 = Shown rotated by 45°
Direction of shaft rotation for output signals as per the interface description

	Incremental		
	RON 786	**RON 886**	**RPN 886**
Incremental signals	∿ 1 V_{PP}		
Line count*	18000 36000	36000	90000 (≙ 180000 signal periods)
Reference mark*	*RON x86:* One *RON x86C:* Distance-coded		One
Cutoff frequency –3 dB –6 dB	≥ 180 kHz		≥ 800 kHz ≥ 1300 kHz
Recommended measuring step for position measurement	0.0001°	0.00005°	0.00001°
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, with or without M23 coupling		
Max. cable length[1)]	150 m		
Shaft	Hollow through shaft D = 60 mm		
Mech. perm. speed	≤ 1000 min^{-1}		
Starting torque	≤ 0.5 Nm at 20 °C		
Moment of inertia of rotor	$1.2 \cdot 10^{-3}$ kgm^2		
Natural frequency	≥ 1000 Hz		≥ 500 Hz
Permissible axial motion of measured shaft	≤ ± 0.1 mm		
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)		≤ 50 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)
Operating temperature	0 °C to 50 °C		
Protection EN 60529	IP 64		
Weight	Approx. 2.5 kg		

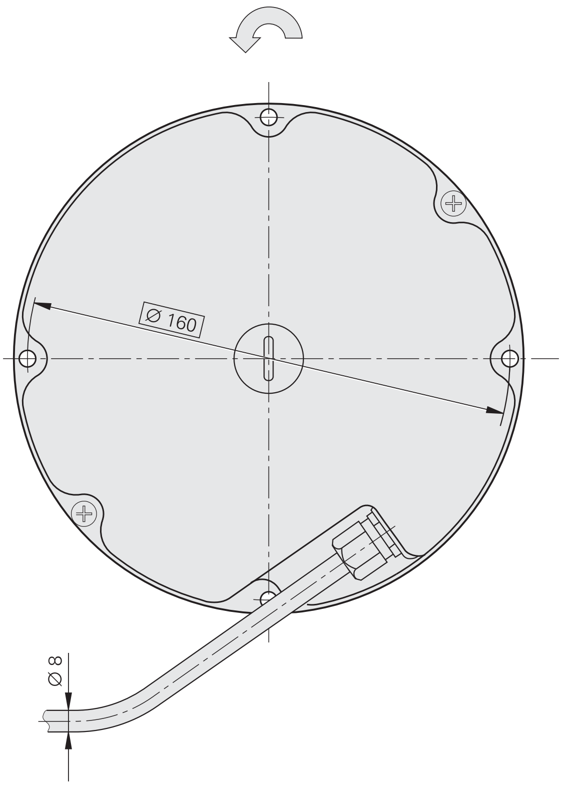
* Please select when ordering
1) With HEIDENHAIN cable

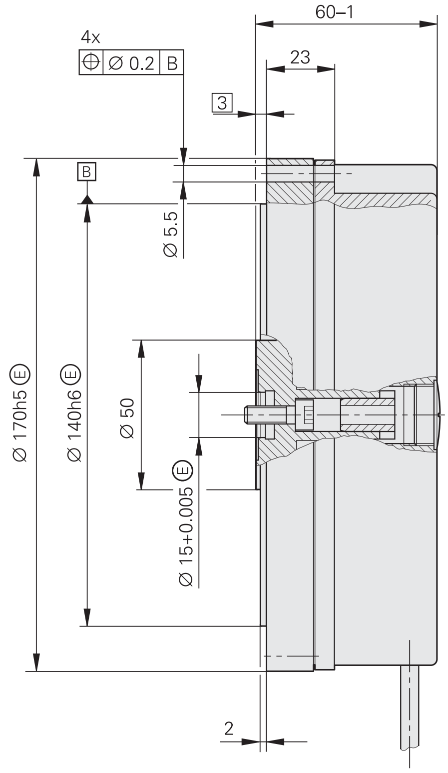
RON 905

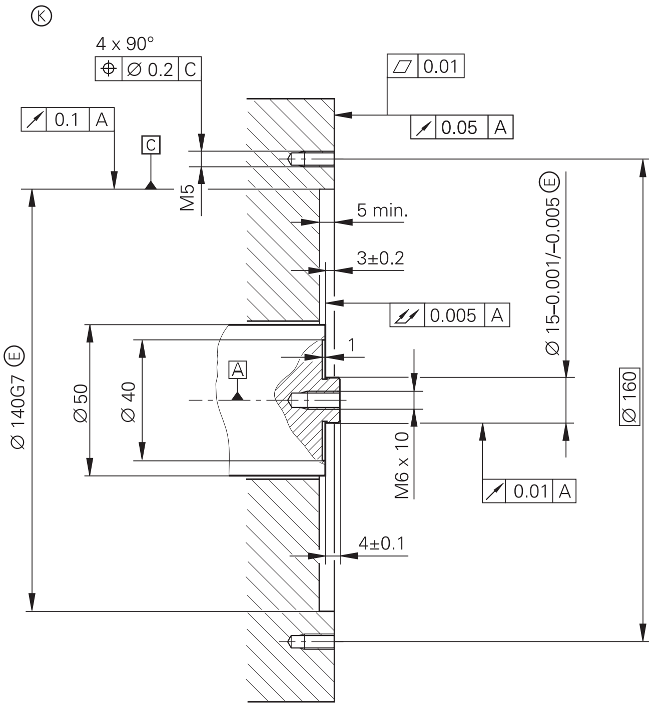
- **Integrated stator coupling**
- **Blind hollow shaft**
- **System accuracy ± 0.4“**

Dimensions in mm

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







Cable radial, also usable axially
A = Bearing
K = Required mating dimensions
Direction of shaft rotation for output signal I_2 lagging I_1

	Incremental **RON 905**
Incremental signals	∼ 11 µA$_{PP}$
Line count	36000
Reference mark	One
Cutoff frequency –3 dB	≥ 40 kHz
Recommended measuring step for position measurement	0.00001°
System accuracy	± 0.4"
Power supply Without load	5 V ± 5 %/max. 250 mA
Electrical connection	Cable 1 m, with M23 connector
Max. cable length[1)]	15 m
Shaft	Blind hollow shaft
Mech. perm. speed	≤ 100 min^{-1}
Starting torque	≤ 0.05 Nm at 20 °C
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 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)
Operating temperature	10 to 30 °C
Protection EN 60529	IP 64
Weight	Approx. 4 kg

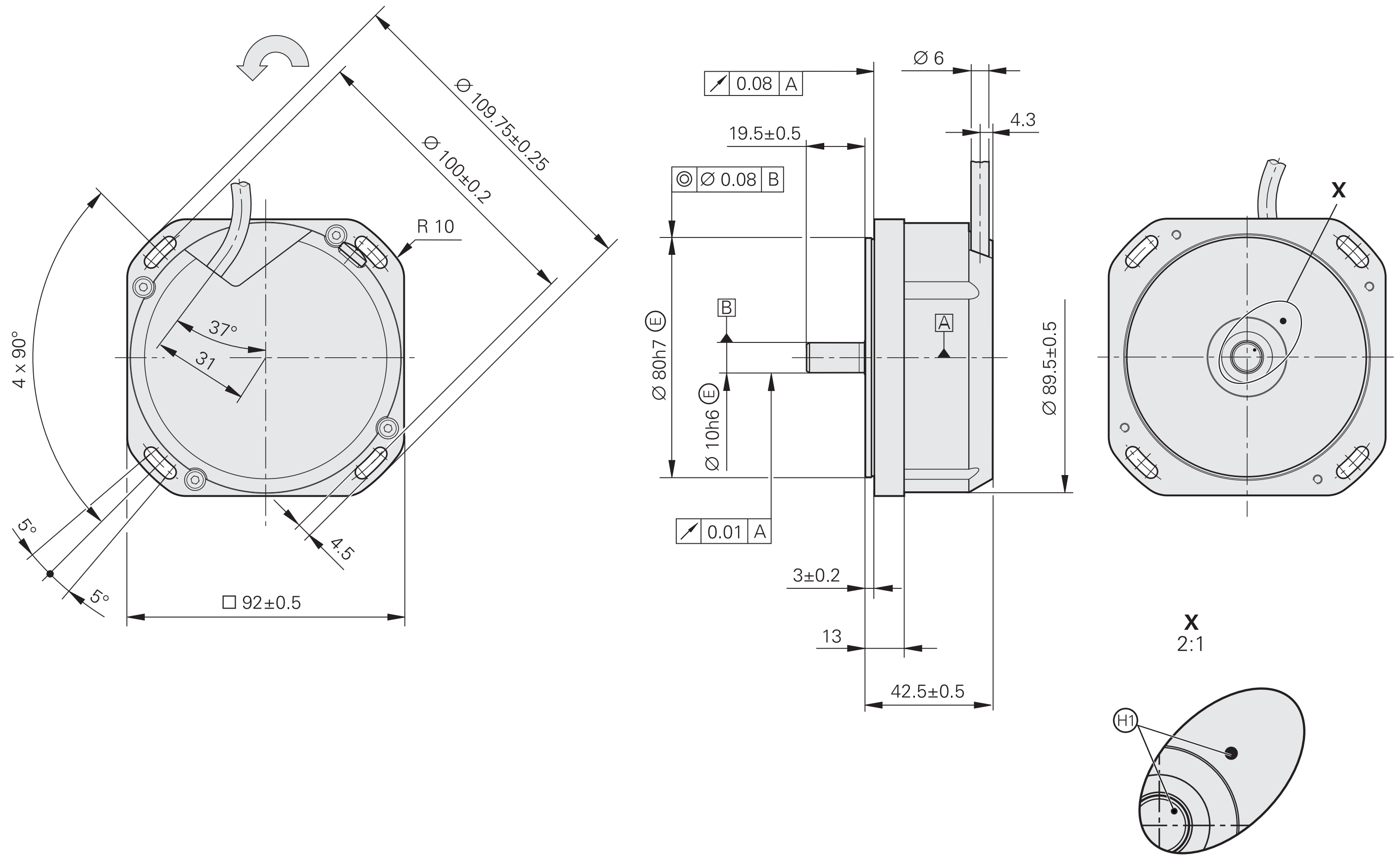
1) With HEIDENHAIN cable

ROD 200 Series

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

Dimensions in mm

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



Cable radial, also usable axially
A = Bearing
H1 = Position of the reference-mark signal
ROD 220/270/280: ±10°
ROD 280C: ±5°
Direction of shaft rotation for output signals as per the interface description

	Incremental		
	ROD 220	ROD 270	ROD 280
Incremental signals	⊓⊔TTL x 2	⊓⊔TTL x 10	∼ 1 V_{PP}
Line count Integrated interpolation Output signals/rev	9000 2-fold 18000	18000 10-fold 180000	18000 – 18000
Reference mark*	One		*ROD 280:* One *RON 280C:* Distance-coded
Cutoff frequency –3 dB Output frequency Edge separation a	– ≤ 1 MHz ≥ 0.125 µs	– ≤ 1 MHz ≥ 0.22 µs	≥ 180 kHz – –
Elec. permissible speed	3333 min^{-1}	≤ 333 min^{-1}	–
Recommended measuring step for position measurement	0.005°	0.0005°	0.0001°
System accuracy	± 5"		
Power supply Without load	5 V ± 10 %, max. 150 mA		
Electrical connection*	Cable 1 m, with or without M23 coupling		
Max. cable length[1]	100 m		150 m
Shaft	Solid shaft D = 10 mm		
Mech. perm. speed	≤ 10000 min^{-1}		
Starting torque	≤ 0.01 Nm at 20 °C		
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 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)		
Operating temperature	*Moving cable:* –10 to 70 °C *Stationary cable:* –20 to 70 °C		
Protection EN 60529	IP 64		
Weight	Approx. 0.7 kg		

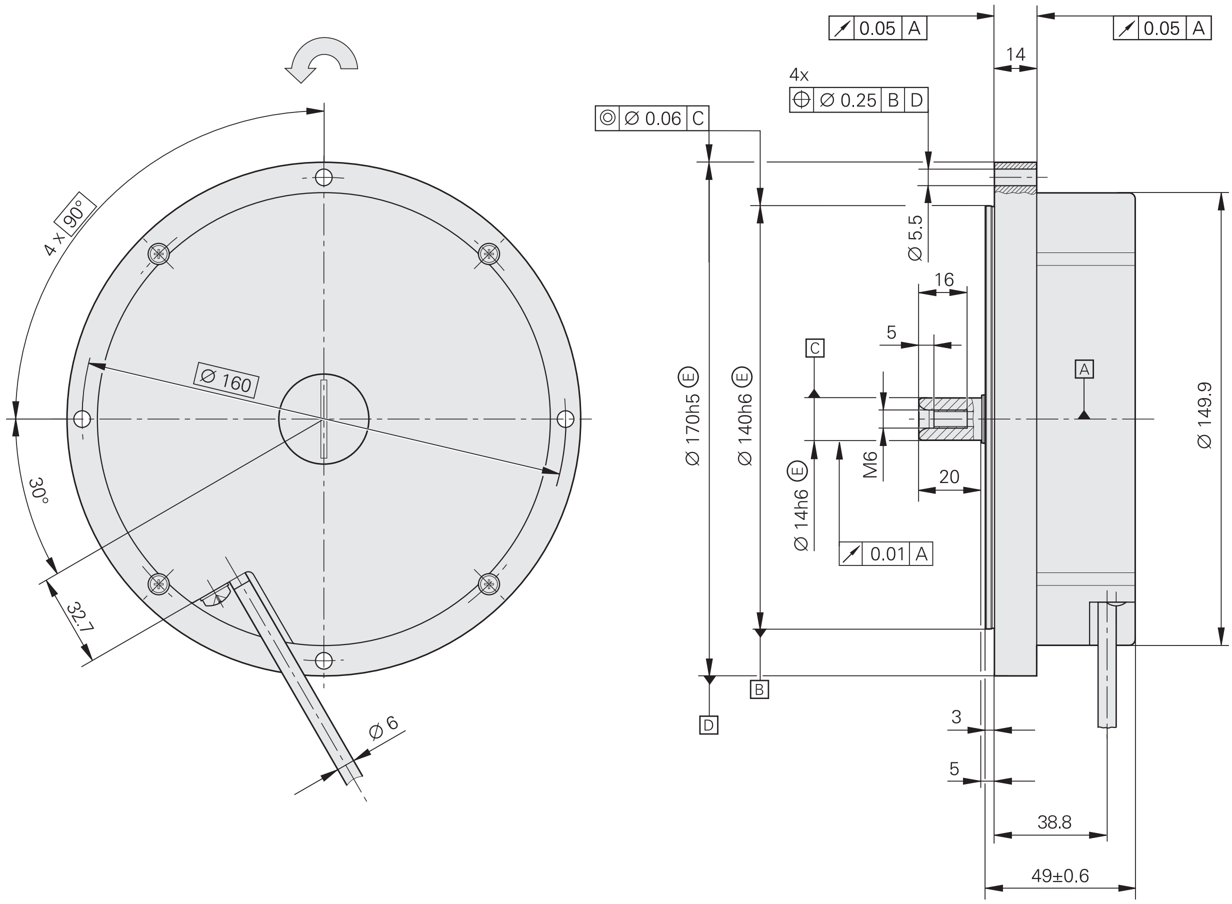
* Please select when ordering
[1] With HEIDENHAIN cable

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
< 6 mm: ±0.2 mm



Cable radial, also usable axially
A = Bearing
H1 = Position of the reference-mark signal (± 5°)
Direction of shaft rotation for output signals as per the interface description

	Incremental	
	ROD 780	**ROD 880**
Incremental signals	∿ 1 V_{PP}	
Line count*	18000 36000	36000
Reference mark*	*ROD x80:* One *RON x80C:* Distance-coded	
Cutoff frequency –3 dB	≥ 180 kHz	
Recommended measuring step for position measurement	0.0001°	0.00005°
System accuracy	± 2"	± 1"
Power supply Without load	5 V ± 10 %, max. 150 mA	
Electrical connection*	Cable 1 m, with or without M23 coupling	
Max. cable length[1)]	150 m	
Shaft	Solid shaft D = 14 mm	
Mech. permissible speed	≤ 1000 min^{-1}	
Starting torque	≤ 0.012 Nm at 20 °C	
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 (EN 60068-2-6) ≤ 300 m/s^2 (EN 60068-2-27)	
Operating temperature	0 °C to 50 °C	
Protection EN 60529	IP 64	
Weight	Approx. 2.4 kg	

***** Please select when ordering
1) With HEIDENHAIN cable

Interfaces
Incremental Signals ∿ 1 V_{PP}

HEIDENHAIN encoders with ∿ 1 V_{PP} interface provide voltage signals that can be highly interpolated.

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

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

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

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

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

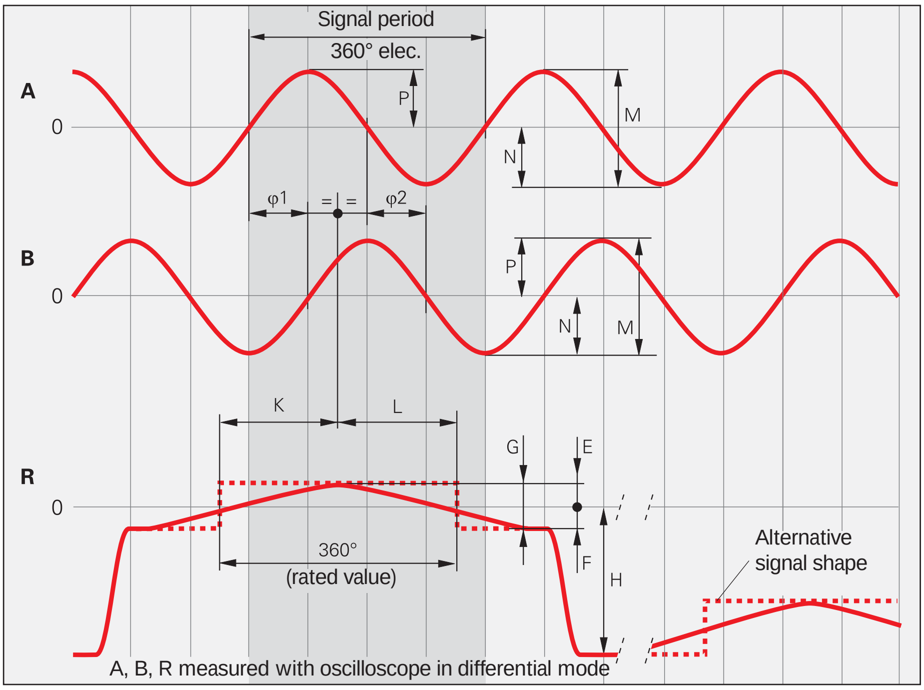
Measuring steps for **position measurement** are recommended in the specifications. For special applications, other resolutions are also possible.

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

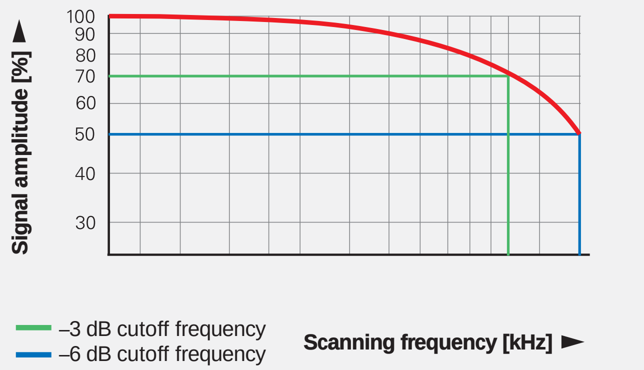
Short circuit at	20 °C	125 °C
One output	< 3 min	< 1 min
All outputs	< 20 s	< 5 s

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

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



Cutoff frequency
Typical signal amplitude curve with respect to the scanning frequency



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

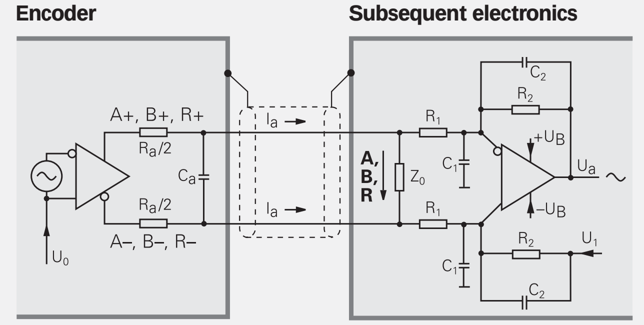
–3 dB cutoff frequency of circuitry
Approx. 450 kHz
Approx. 50 kHz with $C_1 = 1000\ pF$
and $C_2 = 82\ pF$
The circuit variant for 50 kHz does reduce the bandwidth of the circuit, but in doing so it improves its noise immunity.

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

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

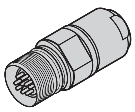
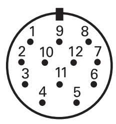
Incremental signals
Reference-mark signal

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

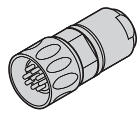
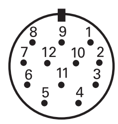


Pin layout

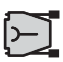
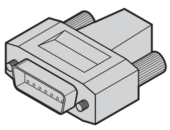
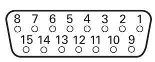
12-pin coupling M23

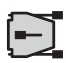
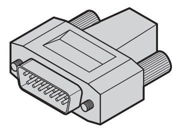
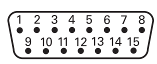
12-pin connector M23

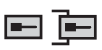
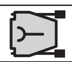
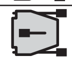




15-pin D-sub connector
For HEIDENHAIN controls and IK 220

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

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

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

Interfaces

Incremental Signals ⊓⊔ TTL

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

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

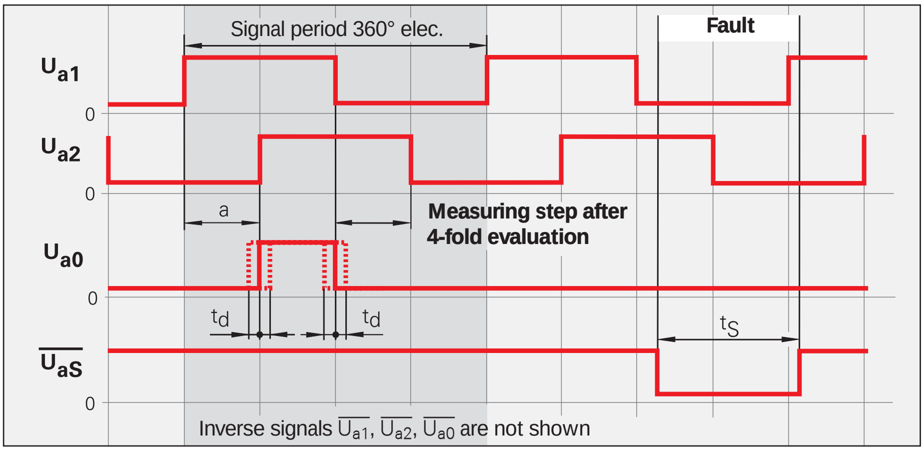
The **fault-detection signal** $\overline{U_{aS}}$ indicates fault conditions such as breakage of the power line or failure of the light source. It can be used for such purposes as machine shut-off during automated production.

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

The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum **edge separation a** listed in the *Specifications* applies to the illustrated input circuitry with a cable length of 1 m, and refers to a measurement at the output of the differential line receiver. Propagation-time differences in cables additionally reduce the edge separation by 0.2 ns per meter of cable length. To prevent counting errors, design the subsequent electronics to process as little as 90 % of the resulting edge separation.

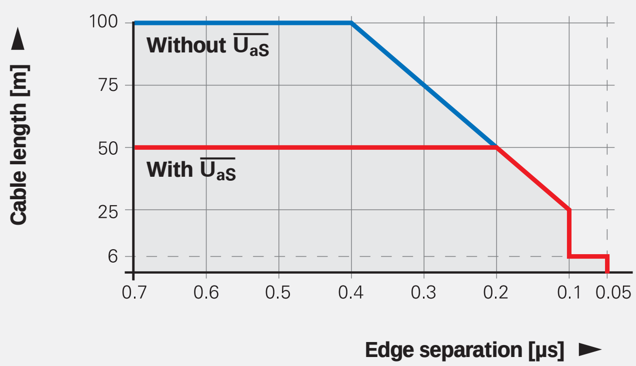
The max. permissible **shaft speed** or **traversing velocity** must never be exceeded.

Interface	Square-wave signals ⊓⊔ **TTL**
Incremental signals	**2 square-wave signals U_{a1}, U_{a2}** and their inverted signals **$\overline{U_{a1}}$, $\overline{U_{a2}}$**
Reference-mark signal Pulse width Delay time	**1 or more TTL square-wave pulses U_{a0}** and their inverted pulses **$\overline{U_{a0}}$** 90° elec. (other widths available on request); *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} high impedance) Proper function: HIGH $t_S \geq 20$ ms
Signal amplitude	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 cables Cable length Propagation time	Shielded HEIDENHAIN cable PUR [4(2 × 0.14 mm^2) + (4 × 0.5 mm^2)] Max. 100 m ($\overline{U_{aS}}$ max. 50 m) at distributed capacitance 90 pF/m 6 ns/m



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

Permissible cable length
with respect to the edge separation

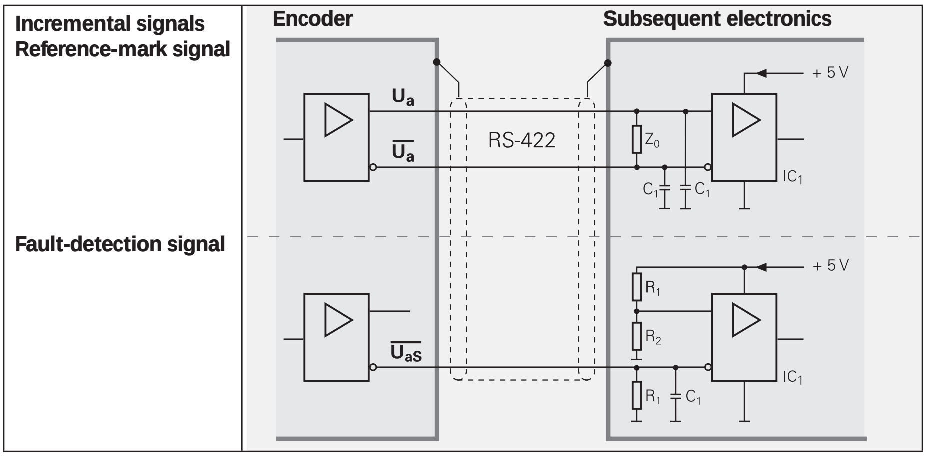


Input circuitry of the subsequent electronics

Dimensioning

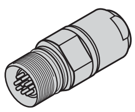
IC_1 = Recommended differential line receiver
DS 26 C 32 AT
Only for a > 0.1 µs:
AM 26 LS 32
MC 3486
SN 75 ALS 193

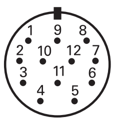
R_1 = 4.7 kΩ
R_2 = 1.8 kΩ
Z_0 = 120 Ω
C_1 = 220 pF (serves to improve noise immunity)



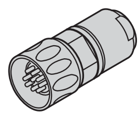
Pin layout

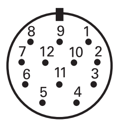
12-pin coupling M23





12-pin connector M23





	Power supply				Incremental signals						Other signals		
	12	2	10	11	5	6	8	1	3	4	7	/	9
	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

Cable shield connected to housing; **U_P** = power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!
[1] **ERO 14xx:** Vacant
[2] **Exposed linear encoders:** Switchover TTL/11 µA_{PP} for PWT, otherwise vacant

Interfaces

Absolute Position Values EnDat

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

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

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

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

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

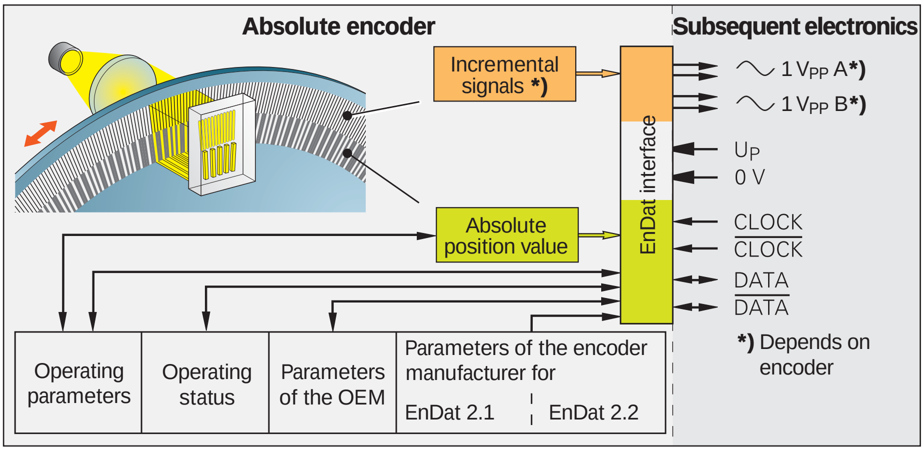
Incremental signals
EnDat encoders are available with or without incremental signals. EnDat 21 and EnDat 22 encoders feature a high internal resolution. An evaluation of the incremental signal is therefore unnecessary.

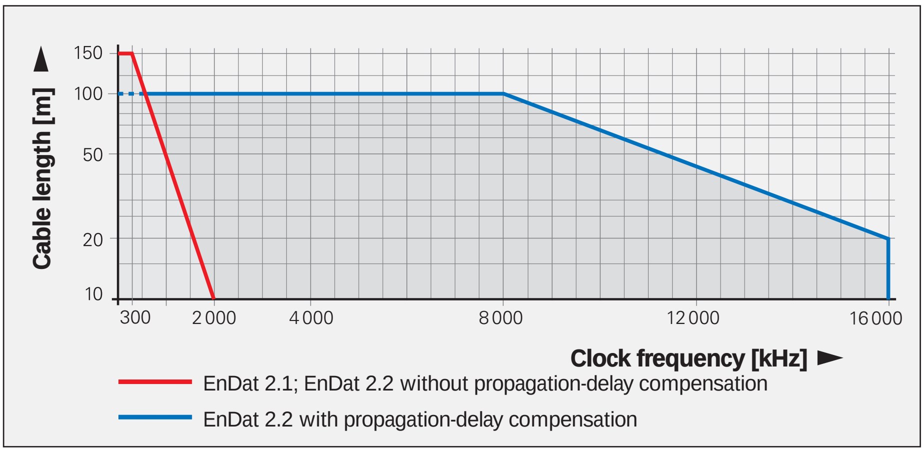
Clock frequency and cable length
The clock frequency is variable—depending on the cable length (max. 150 m)—between **100 kHz** and **2 MHz.** With propagation-delay compensation in the subsequent electronics, clock frequencies up to **16 MHz** at cable lengths up to 100 m are possible.

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

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

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





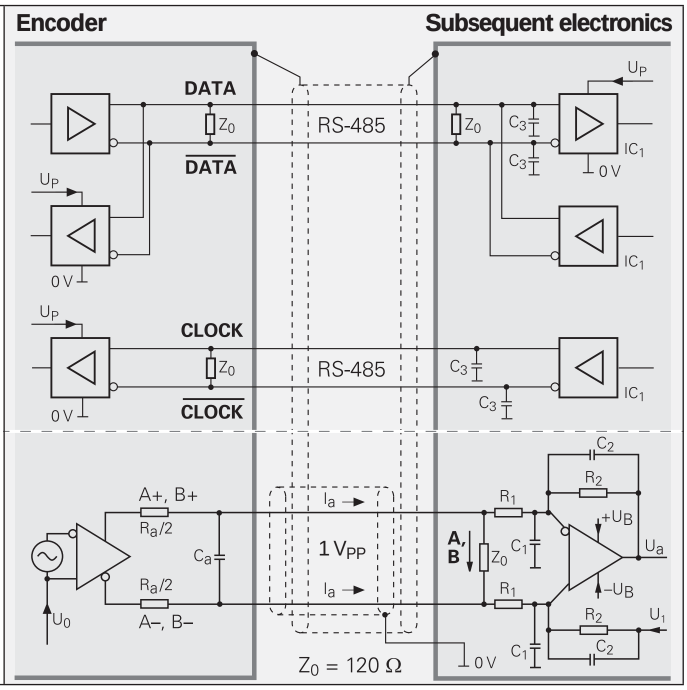
Input circuitry of the subsequent electronics

Dimensioning
IC_1 = RS 485 differential line receiver and driver

C_3 = 330 pF
Z_0 = 120 Ω

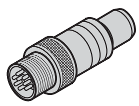
Data transfer

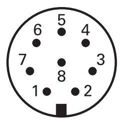
Incremental signals depending on encoder



Pin layout

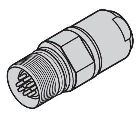
8-pin M12 **coupling**

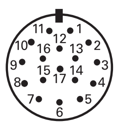




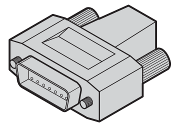
	Power supply				Absolute position values			
	8	2	5	1	3	4	7	6
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

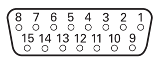
17-pin M23 **coupling**





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





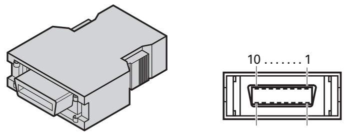
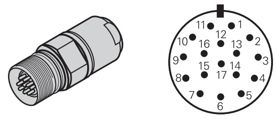
	Power supply					Incremental signals[1]				Absolute position values			
	7	1	10	4	11	15	16	12	13	14	17	8	9
	1	9	2	11	13	3	4	6	7	5	8	14	15
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Internal shield**	**A+**	**A–**	**B+**	**B–**	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**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

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

Interfaces
Fanuc and Mitsubishi Pin Layouts

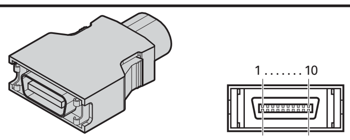
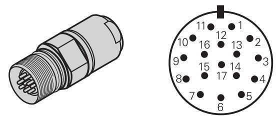
Fanuc pin layout
HEIDENHAIN encoders with the code letter F after the model designation are suited for connection to Fanuc controls with

- **Serial interface Fanuc 01**
  with 1 MHz communication rate
- **Serial interface Fanuc 02**
  with 1 MHz or 2 MHz communication rate

15-pin Fanuc connector 						**17-pin HEIDENHAIN coupling** 			
	Power supply					Absolute position values			
Fanuc connector	**9**	**18/20**	**12**	**14**	**16**	**1**	**2**	**5**	**6**
HEIDENHAIN coupling	**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**	**$\overline{\text{Request}}$**
Cable	Brown/ Green	Blue	White/ Green	White	–	Gray	Pink	Violet	Yellow

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

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.**

10 or 20-pin Mitsubishi connector 					**17-pin HEIDENHAIN coupling** 			
	Power supply				Absolute position values			
Mitsubishi connector **10-pin**	**1**	**–**	**2**	**–**	**7**	**8**	**3**	**4**
Mitsubishi connector **20-pin**	**20**	**19**	**1**	**11**	**6**	**16**	**7**	**17**
HEIDENHAIN coupling	**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**	**$\overline{\text{Request Frame}}$**
Cable	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

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

HEIDENHAIN Measuring Equipment

For Incremental Angle Encoders

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
Functions	• **Measures** signal amplitudes, current consumption, operating voltage, scanning frequency • **Graphically displays** incremental signals (amplitudes, phase angle and on-off ratio) and the reference-mark signal (width and position) • **Displays 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
Dimensions	150 mm × 205 mm × 96 mm

For Absolute Angle Encoders

HEIDENHAIN offers an adjusting and testing package for diagnosis and adjustment of HEIDENHAIN encoders with absolute interface.
- **IK 215** PC expansion board
- **ATS** adjusting and testing software

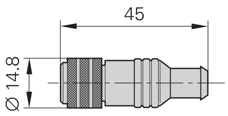
	IK 215
Encoder input	• EnDat 2.1 or EnDat 2.2 (absolute value with/without incremental signals) • FANUC serial interface • Mitsubishi High Speed Serial Interface • SSI
Interface	PCI bus, Rev. 2.1
System requirements	• Operating system: Windows XP (Vista upon request) • Approx. 20 MB free space on the hard disk
Signal subdivision for incremental signals	Up to 65536-fold
Dimensions	100 mm x 190 mm

	ATS
Languages	Choice between English or German
Functions	• Position display • Connection dialog • Diagnostics • Mounting wizard for ECI/EQI • Additional functions (if supported by the encoder) • Memory contents

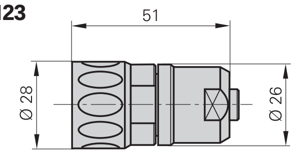
Connector (insulated): A connecting element with a coupling ring. Available with male or female contacts.

Symbols 

M12



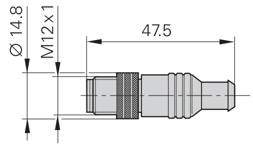
M23



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

Symbols 

M12



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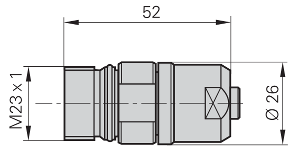
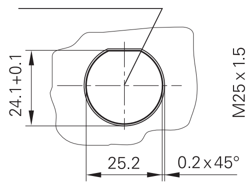


Mounted coupling with central fastening

Cutout for mounting



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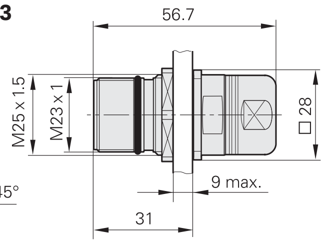
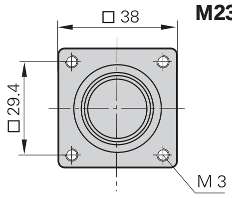
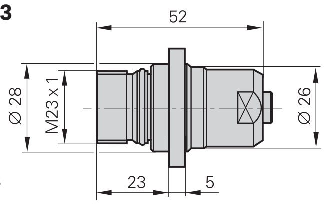


Mounted coupling with flange



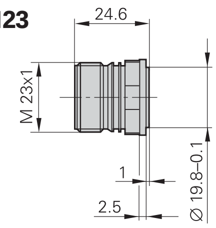
M23

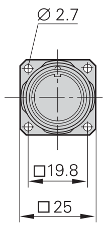


Flange socket: Permanently mounted on the encoder or a housing, with external thread (like a coupling), available with male or female contacts.

Symbols 

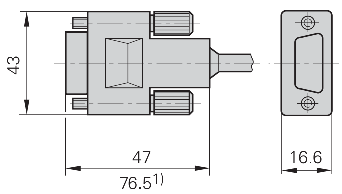
M23





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

Symbols 



[1)] With integrated interpolation electronics

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

male contacts or 

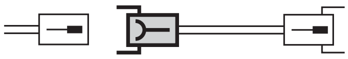
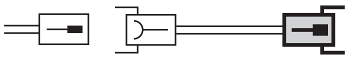
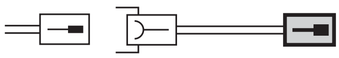
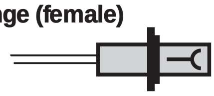
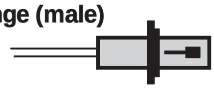
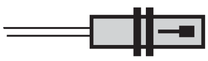
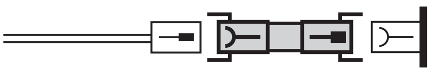
female contacts. 

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

Accessories for flange sockets and M23 mounted couplings

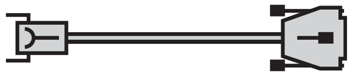
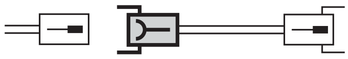
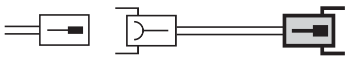
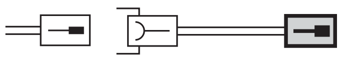
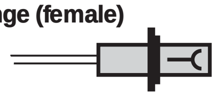
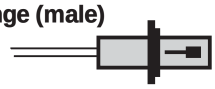
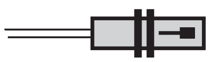
Bell seal
ID 266526-01

Threaded metal dust cap
ID 219926-01

		∿ 1 V_{PP} ⊓⊔ TTL
PUR connecting cables	**12-pin:** [4(2 × 0.14 mm^2) + (4 × 0.5 mm^2)] **Ø 8 mm**	
Complete with connector (female) and coupling (male)		298401-xx
Complete with connector (female) and connector (male)		298399-xx
Complete with connector (female) and D-sub connector (female) for IK 220		310199-xx
Complete with connector (female) and D-sub connector (male) for IK 115/IK 215		310196-xx
With one connector (female)		309777-xx
Cable without connectors, Ø 8 mm		244957-01
Mating element on connecting cable to connector on encoder cable	**Connector (female)** for cable Ø 8 mm 	291697-05
Connector on connecting cable for connection to subsequent electronics	**Connector (male)** for cable Ø 8 mm Ø 6 mm 	291697-08 291697-07
Coupling on connecting cable	**Coupling (male)** for cable Ø 4.5 mm Ø 6 mm Ø 8 mm 	291698-14 291698-03 291698-04
Flange socket for mounting on subsequent electronics	**Flange socket (female)** 	315892-08
Mounted couplings	**With flange (female)** Ø 6 mm Ø 8 mm 	291698-17 291698-07
	With flange (male) Ø 6 mm Ø 8 mm 	291698-08 291698-31
	With central fastening (male) Ø 6 to 10 mm 	741045-01
Adapter ∿ **1 V_{PP}/11 μA_{PP}** For converting the 1 V_{PP} signals to 11 μA_{PP}; 12-pin M23 connector (female) and 9-pin M23 connector (male)		364914-01

EnDat Connecting Cables

8-pin M12 | 17-pin M23

		EnDat without incremental signals	**EnDat** with incremental signals
PUR connecting cables	**8-pin:** [(4 × 0.14 mm^2) + (4 × 0.34 mm^2)] **Ø 6 mm** **17-pin:** [(4 × 0.14 mm^2) + 4(2 × 0.14 mm^2) + (4 × 0.5 mm^2)] **Ø 8 mm**		
Complete with connector (female) and coupling (male)		368330-xx	323897-xx
Complete with connector (female) and D-sub connector (female) for IK 220		533627-xx	332115-xx
Complete with connector (female) and D-sub connector (male) for IK 115/IK 215		524599-xx	324544-xx
With one connector (female)		634265-xx	309778-xx
Cable without connectors, ∅ 8 mm		–	266306-01
Mating element on connecting cable to connector on encoder cable	**Connector (female)** for cable ∅ 8 mm 	–	291697-26
Connector on connecting cable for connection to subsequent electronics	**Connector (male)** for cable ∅ 8 mm ∅ 6 mm 	–	291697-27
Coupling on connecting cable	**Coupling (male)** for cable ∅ 4.5 mm ∅ 6 mm ∅ 8 mm 	–	291698-25 291698-26 291698-27
Flange socket for mounting on subsequent electronics	**Flange socket (female)** 	–	315892-10
Mounted couplings	**With flange (female)** ∅ 6 mm ∅ 8 mm 	**–**	291698-35
	With flange (male) ∅ 6 mm ∅ 8 mm 	–	291698-41 291698-29
	With central fastening (male) ∅ 6 to 10 mm 	–	741045-02

Connecting Cables Fanuc
Mitsubishi

		Cable	Fanuc	Mitsubishi
PUR connecting cables				
Complete with 17-pin M23 connector (female) and Fanuc connector [(2 x 2 x 0.14 mm^2) + (4 x 1 mm^2)]	 Fanuc	∅ 8 mm	534 855-xx	–
Complete with 17-pin M23 connector (female) and 20-pin Mitsubishi connector [(2 x 2 x 0.14 mm^2) + (4 x 0.5 mm^2)]	 Mitsubishi 20-pin	∅ 6 mm	–	367 958-xx
Complete with 17-pin M23 connector (female) and 10-pin Mitsubishi connector [(2 x 2 x 0.14 mm^2) + (4 x 1 mm^2)]	 Mitsubishi 10-pin	∅ 8 mm	–	573 661-xx
Cable without connectors [(2 x 2 x 0.14 mm^2) + (4 x 1 mm^2)]		∅ 8 mm	354 608-01	

General Electrical Information

Power supply

Connect HEIDENHAIN encoders only to subsequent electronics whose power supply is generated from PELV systems **(EN 50178)**. In addition, overcurrent protection and overvoltage protection are required in safety-related applications.

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

The encoders require a **stabilized DC voltage U_P** as power supply. The respective *Specifications* state the required power supply and the current consumption. The permissible ripple content of the DC voltage is:

- High frequency interference U_{PP} < 250 mV with dU/dt > 5 V/µs
- Low frequency fundamental ripple U_{PP} < 100 mV

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

Calculation of the **voltage drop**:

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

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

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

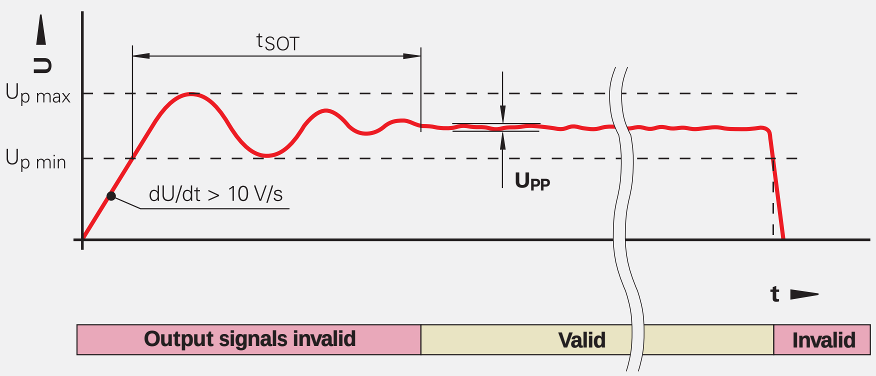
If the voltage drop is known, all parameters for the encoder and subsequent electronics can be calculated, e.g. voltage at the encoder, current requirements and power consumption of the encoder, as well as the power to be provided by the subsequent electronics.

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

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

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

Transient response of supply voltage and switch-on/switch-off behavior



Cable	Cross section of power supply lines A_P			
	1 V_{PP}/TTL/HTL	**11 µA_{PP}**	**EnDat/SSI** 17-pin	**EnDat**[5] 8-pin
Ø 3.7 mm	0.05 mm^2	–	–	0.09 mm^2
Ø 4.3 mm	0.24 mm^2	–	–	–
Ø 4.5 mm EPG	0.05 mm^2	–	0.05 mm^2	0.09 mm^2
Ø 4.5 mm **Ø 5.1 mm**	0.14/0.09[2] mm^2 0.05[2, 3] mm^2	0.05 mm^2	0.05 mm^2	0.14 mm^2
Ø 6 mm **Ø 10 mm**[1]	0.19/0.14[2, 4] mm^2	–	0.08 mm^2	0.34 mm^2
Ø 8 mm **Ø 14 mm**[1]	0.5 mm^2	1 mm^2	0.5 mm^2	1 mm^2

[1] Metal armor [2] Rotary encoders [3] Length gauges [4] LIDA 400
[5] Also Fanuc, Mitsubishi

Encoders with expanded voltage supply range

For encoders with expanded supply voltage range, the current consumption has a nonlinear relationship with the supply voltage. On the other hand, the power consumption follows a linear curve (see *Current and power consumption* diagram). The maximum power consumption at minimum and maximum supply voltage is listed in the **Specifications**. The power consumption at maximum supply voltage (worst case) accounts for:

- Recommended receiver circuit
- Cable length 1 m
- Age and temperature influences
- Proper use of the encoder with respect to clock frequency and cycle time

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

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

Step 1: Resistance of the supply lines

The resistance values of the power lines (adapter cable and encoder cable) can be calculated with the following formula:

$$R_L = 2 \cdot \frac{105 \cdot L_C \cdot I}{56 \cdot A_P}$$

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

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

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

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

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

Step 4: Parameters for subsequent electronics and the encoder

Voltage at encoder:
$U_M = U_P - \Delta U$

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

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

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

Where:

U_{Emax}, U_{Emin}: Minimum or maximum supply voltage of the encoder in V

P_{Emin}, P_{Emax}: Maximum power consumption at minimum or maximum power supply, respectively, in W

U_S: Supply voltage of the subsequent electronics in V

R_L: Cable resistance (for both directions) in ohms

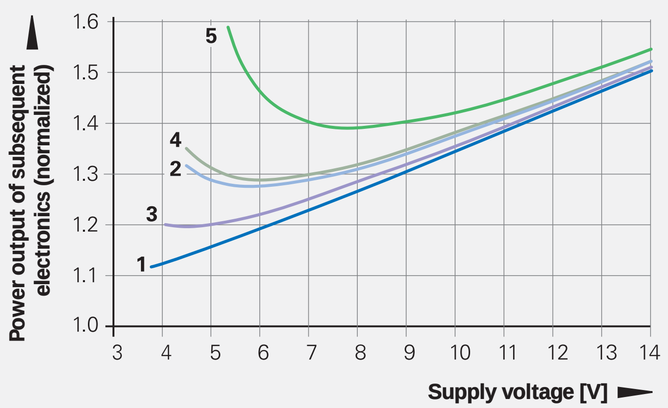
ΔU: Voltage drop in the cable in V

105: Length factor due to twisted wires

L_C: Cable length in m

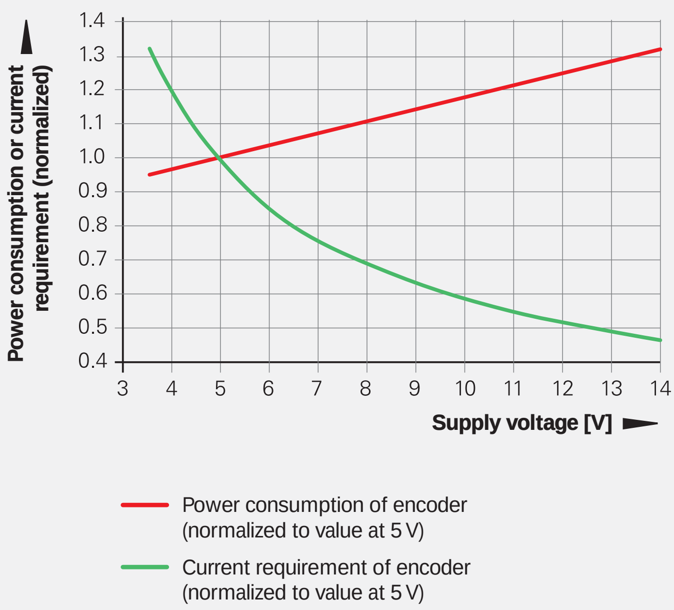
A_P: Cross section of power lines in mm^2

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



	Encoder cable/adapter cable	Connecting cables	Total
1	3 m	/	3 m
2	20 m	/	20 m
3	3 m	17 m	20 m
4	3 m	47 m	50 m
5	3 m	97 m	100 m

Current and power consumption with respect to the supply voltage (example representation)



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

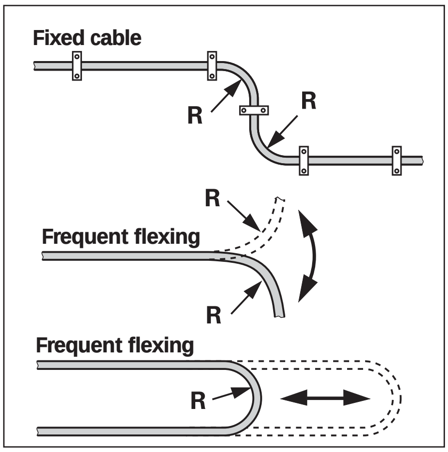
Cable

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

Versions
The cables of almost all HEIDENHAIN encoders and all adapter and connecting cables are sheathed in **polyurethane (PUR cable).** Most adapter cables for within motors and a few cables on encoders are sheathed in a **special elastomer (EPG cable).** These cables are identified in the specifications or in the cable tables with "EPG."

Durability
PUR cables are resistant to oil and hydrolysis in accordance with **VDE 0472** (Part 803/test type B) and resistant to microbes in accordance with **VDE 0282** (Part 10). They are free of PVC and silicone and comply with UL safety directives. The **UL certification** AWM STYLE 20963 80 °C 30 V E63216 is documented on the cable.

EPG cables are resistant to oil in accordance with **VDE 0472** (Part 803/test type B) and to hydrolysis in accordance with **VDE 0282** (Part 10). They are free of silicone and halogens. In comparison with PUR cables, they are only conditionally resistant to media, frequent flexing and continuous torsion.



Temperature range
HEIDENHAIN cables can be used for
Rigid configuration (PUR) –40 to 80 °C
Rigid configuration (EPG) –40 to 120 °C
Frequent flexing (PUR) –10 to 80 °C

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

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

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

[1] Metal armor

Noise-free signal transmission

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

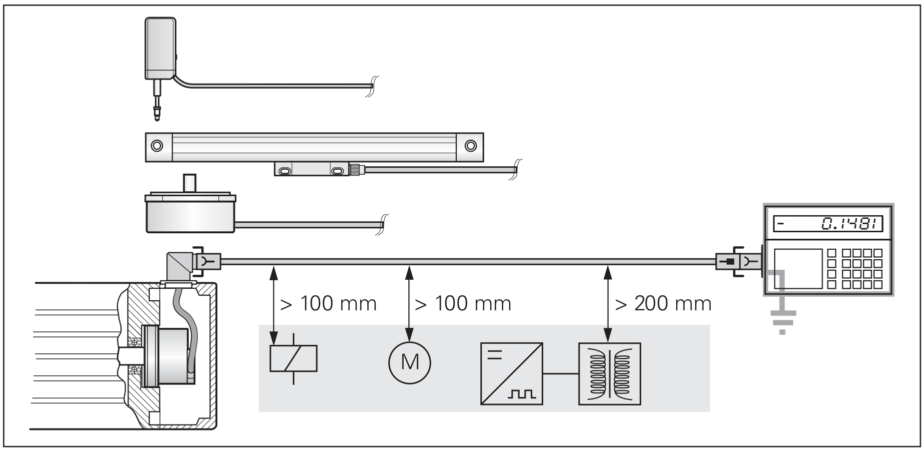
- **Noise immunity EN 61000-6-2:**
  Specifically:
  - ESD EN 61000-4-2
  - Electromagnetic fields EN 61000-4-3
  - Burst EN 61000-4-4
  - Surge EN 61000-4-5
  - Conducted disturbances EN 61000-4-6
  - Power frequency magnetic fields EN 61000-4-8
  - Pulse magnetic fields EN 61000-4-9
- **Interference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

Transmission of measuring signals—electrical noise immunity
Noise voltages arise mainly through capacitive or inductive transfer. Electrical noise can be introduced into the system over signal lines and input or output terminals.
Possible sources of noise include:

- Strong magnetic fields from transformers, brakes and electric motors
- Relays, contactors and solenoid valves
- High-frequency equipment, pulse devices, and stray magnetic fields from switch-mode power supplies
- AC power lines and supply lines to the above devices

Protection against electrical noise
The following measures must be taken to ensure disturbance-free operation:

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



Minimum distance from sources of interference

Evaluation Electronics

IK 220
Universal PC counter card
The IK 220 is an expansion board for 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 document as well as the Product Overview of *Interface Electronics.*

	IK 220			
Input signals (switchable)	∼ 1 V_{PP}	∼ 11 μA_{PP}	EnDat 2.1	SSI
Encoder inputs	Two D-sub connections (15-pin) male			
Input frequency	≤ 500 kHz	≤ 33 kHz	–	
Cable length	≤ 60 m		≤ 50 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			
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			

IBV / APE series
Interpolation and digitizing electronics
Interpolation and digitizing electronics interpolate and digitize the sinusoidal output signals (∼ 1 V_{PP}) from HEIDENHAIN encoders up to 400-fold, and convert them to TTL square-wave pulse trains.

IBV 101

For more information, see the *IBV 100, IBV 600* and *APE 371* Product Information documents, as well as the *Interface Electronics* Product Overview.

	IBV 101	IBV 102	IBV 660	APE 371
Design	Housing			Connector
Degree of protection	IP 65			IP 40
Input	∼ 1 V_{PP}			
Encoder connection	*IBV:* M23 flange socket, 12-pin, female *APE:* D-sub connector 15-pin or M23 connector 12-pin female			
Interpolation switchable	5-fold 10-fold	25-fold 50-fold 100-fold	25-fold 50-fold 100-fold 200-fold 400-fold	5-fold 10-fold 20-fold 25-fold 50-fold 100-fold
Output	• Two ⊓⊔ 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 $\overline{U_{a0}}$ • Fault detection signal $\overline{U_{aS}}$ • Limit and homing signals H, L (for APE 371)			
Power supply	5 V ± 5 %			

ND 200
Digital readouts
HEIDENHAIN encoders with 11 µApp or 1 Vpp signals and EnDat 2.2 interface can be connected to the digital readouts of the ND 200 series. The **ND 280** readout provides the basic functions for simple measuring tasks. The **ND 287** also features other functions such as sorting and tolerance check mode, minimum/maximum value storage, measurement series storage. It calculates the mean value and standard deviations and creates histograms and control charts. The ND 287 permits optional connection of a second encoder for sum/difference measurement or of an analog sensor. The ND 28x feature serial interfaces for measured value transfer.

For more information, see brochure: *Digital Readouts/Linear Encoders.*

	ND 280	ND 287
Input signals[1]	1 x ∿ 11 µApp, ∿ 1 Vpp or EnDat 2.2	
Encoder inputs	D-sub 15-pin female	
Input frequency	∿ *1 Vpp:* ≤ 500 kHz; *11 µApp:* ≤ 100 kHz	
Signal subdivision	Up to 1024-fold (adjustable)	
Display step (adjustable)	*Linear axis:* 0.5 to 0.002 µm *Angular axis:* 0.5° to 0.00001° or 00°00'00.1"	
Functions	• REF reference mark evaluation • 2 datums	
	–	• Sorting and tolerance checking • Measurement series (max. 10000 measured values) • Minimum/maximum value storage • Statistics functions • Sum/difference display (option)
Switching I/O	–	Yes
Interface	V.24/RS-232-C; USB (UART); Ethernet (option for ND 287)	

1) Automatic detection of interface

HEIDENHAIN

DR. JOHANNES HEIDENHAIN GmbH
Dr.-Johannes-Heidenhain-Straße 5
83301 Traunreut, Germany
☏ +49 8669 31-0
FAX +49 8669 5061
E-mail: info@heidenhain.de

www.heidenhain.de

Vollständige und weitere Adressen siehe www.heidenhain.de
For complete and further addresses see www.heidenhain.de

DE **HEIDENHAIN Technisches Büro Nord**
12681 Berlin, Deutschland
☏ 030 54705-240

HEIDENHAIN Technisches Büro Mitte
08468 Heinsdorfergrund, Deutschland
☏ 03765 69544

HEIDENHAIN Technisches Büro West
44379 Dortmund, Deutschland
☏ 0231 618083-0

HEIDENHAIN Technisches Büro Südwest
70771 Leinfelden-Echterdingen, Deutschland
☏ 0711 993395-0

HEIDENHAIN Technisches Büro Südost
83301 Traunreut, Deutschland
☏ 08669 31-1345

AR **NAKASE SRL.**
B1653AOX Villa Ballester, Argentina
www.heidenhain.com.ar

AT **HEIDENHAIN Techn. Büro Österreich**
83301 Traunreut, Germany
www.heidenhain.de

AU **FCR Motion Technology Pty. Ltd**
Laverton North 3026, Australia
E-mail: vicsales@fcrmotion.com

BA Bosnia and Herzegovina → **SL**

BE **HEIDENHAIN NV/SA**
1760 Roosdaal, Belgium
www.heidenhain.be

BG **ESD Bulgaria Ltd.**
Sofia 1172, Bulgaria
www.esd.bg

BR **DIADUR Indústria e Comércio Ltda.**
04763-070 – São Paulo – SP, Brazil
www.heidenhain.com.br

BY **Belarus**
GERTNER Service GmbH
50354 Huerth, Germany
www.gertner.biz

CA **HEIDENHAIN CORPORATION**
Mississauga, OntarioL5T2N2, Canada
www.heidenhain.com

CH **HEIDENHAIN (SCHWEIZ) AG**
8603 Schwerzenbach, Switzerland
www.heidenhain.ch

CN **DR. JOHANNES HEIDENHAIN (CHINA) Co., Ltd.**
Beijing 101312, China
www.heidenhain.com.cn

CZ **HEIDENHAIN s.r.o.**
102 00 Praha 10, Czech Republic
www.heidenhain.cz

DK **TP TEKNIK A/S**
2670 Greve, Denmark
www.tp-gruppen.dk

ES **FARRESA ELECTRONICA S.A.**
08028 Barcelona, Spain
www.farresa.es

FI **HEIDENHAIN Scandinavia AB**
02770 Espoo, Finland
www.heidenhain.fi

FR **HEIDENHAIN FRANCE sarl**
92310 Sèvres, France
www.heidenhain.fr

GB **HEIDENHAIN (G.B.) Limited**
Burgess Hill RH15 9RD, United Kingdom
www.heidenhain.co.uk

GR **MB Milionis Vassilis**
17341 Athens, Greece
www.heidenhain.gr

HK **HEIDENHAIN LTD**
Kowloon, Hong Kong
E-mail: sales@heidenhain.com.hk

HR Croatia → **SL**

HU **HEIDENHAIN Kereskedelmi Képviselet**
1239 Budapest, Hungary
www.heidenhain.hu

ID **PT Servitama Era Toolsindo**
Jakarta 13930, Indonesia
E-mail: ptset@group.gts.co.id

IL **NEUMO VARGUS MARKETING LTD.**
Tel Aviv 61570, Israel
E-mail: neumo@neumo-vargus.co.il

IN **HEIDENHAIN Optics & Electronics India Private Limited**
Chennai – 600 031, India
www.heidenhain.in

IT **HEIDENHAIN ITALIANA S.r.l.**
20128 Milano, Italy
www.heidenhain.it

JP **HEIDENHAIN K.K.**
Tokyo 194-0215, Japan
www.heidenhain.co.jp

KR **HEIDENHAIN Korea LTD.**
Gasan-Dong, Seoul, Korea 153-782
www.heidenhain.co.kr

ME Montenegro → **SL**

MK Macedonia → **BG**

MX **HEIDENHAIN CORPORATION MEXICO**
20235 Aguascalientes, Ags., Mexico
E-mail: info@heidenhain.com

MY **ISOSERVE Sdn. Bhd**
56100 Kuala Lumpur, Malaysia
E-mail: isoserve@po.jaring.my

NL **HEIDENHAIN NEDERLAND B.V.**
6716 BM Ede, Netherlands
www.heidenhain.nl

NO **HEIDENHAIN Scandinavia AB**
7300 Orkanger, Norway
www.heidenhain.no

PH **Machinebanks` Corporation**
Quezon City, Philippines 1113
E-mail: info@machinebanks.com

PL **APS**
02-489 Warszawa, Poland
www.apserwis.com.pl

PT **FARRESA ELECTRÓNICA, LDA.**
4470 - 177 Maia, Portugal
www.farresa.pt

RO **HEIDENHAIN Reprezentanţă Romania**
Braşov, 500338, Romania
www.heidenhain.ro

RS Serbia → **BG**

RU **OOO HEIDENHAIN**
125315 Moscow, Russia
www.heidenhain.ru

SE **HEIDENHAIN Scandinavia AB**
12739 Skärholmen, Sweden
www.heidenhain.se

SG **HEIDENHAIN PACIFIC PTE LTD.**
Singapore 408593
www.heidenhain.com.sg

SK **KOPRETINA TN s.r.o.**
91101 Trencin, Slovakia
www.kopretina.sk

SL **Posredništvo HEIDENHAIN NAVO d.o.o.**
2000 Maribor, Slovenia
www.heidenhain-hubl.si

TH **HEIDENHAIN (THAILAND) LTD**
Bangkok 10250, Thailand
www.heidenhain.co.th

TR **T&M Mühendislik San. ve Tic. LTD. ŞTİ.**
34728 Ümraniye-Istanbul, Turkey
www.heidenhain.com.tr

TW **HEIDENHAIN Co., Ltd.**
Taichung 40768, Taiwan R.O.C.
www.heidenhain.com.tw

UA **Gertner Service GmbH Büro Kiev**
01133 Kiev, Ukraine
www.gertner.biz

US **HEIDENHAIN CORPORATION**
Schaumburg, IL 60173-5337, USA
www.heidenhain.com

VE **Maquinaria Diekmann S.A.**
Caracas, 1040-A, Venezuela
E-mail: purchase@diekmann.com.ve

VN **AMS Co. Ltd**
HCM City, Vietnam
E-mail: davidgoh@amsvn.com

ZA **MAFEMA SALES SERVICES C.C.**
Midrand 1685, South Africa
www.heidenhain.co.za

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