Absolute Angle Encoders

With Optimized Scanning

April 2012

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With Optimized Scanning

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

Angle encoders are found in applications that require the highly accurate measurement of angles in the range of a few angular seconds, e.g. in rotary tables and swivel heads on machine tools, C axes on lathes, but also in measuring equipment and telescopes.

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

This catalog describes absolute angle encoders with optimized scanning. They feature integral bearings, hollow shafts and integrated stator couplings and are distinguished in particular by:
- Small position error within one signal period
- Large mounting tolerances
- High permissible shaft speeds
- Plug-in cables
- Functional safety (option, in preparation)

You will find further incremental and absolute angle encoders in the corresponding product catalogs *Angle Encoders with Integral Bearing* and *Angle Encoders without Integral Bearing*.

Information on
- Angle Encoders with Integral Bearing
- Angle Encoders without Integral Bearing
- Rotary Encoders
- Encoders for Servo Drives
- Exposed Linear Encoders
- Linear Encoders for Numerically Controlled Machine Tools
- HEIDENHAIN Controls

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

Contents

Advantages
of Absolute Angle Encoders with Optimized Scanning

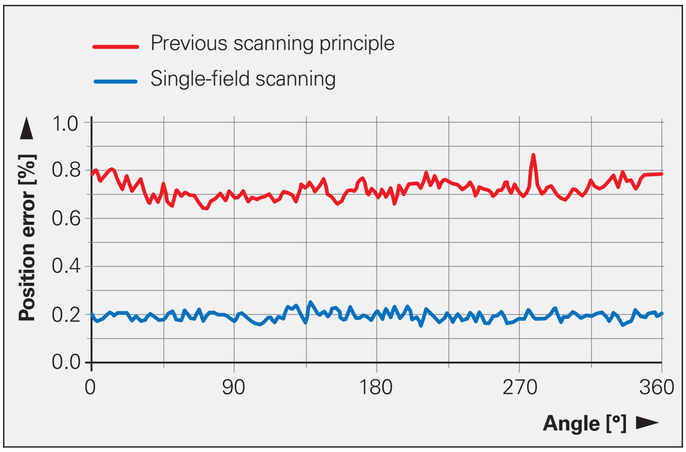
High signal quality thanks to optimized scanning
- Only two graduation tracks (previously up to 24 parallel graduation tracks)
- Absolute track with serial code structure
- Incremental track with single-field scanning
- Relatively insensitive to contamination thanks to a large scanning surface
- Scanning signals with high signal quality through special optical filtering
- Significantly reduced position error within one signal period

Large mounting tolerances through
- Optimized integrated stator coupling with improved torsional rigidity
- Revised shaft sealing for large axial and radial movements between the rotor and stator

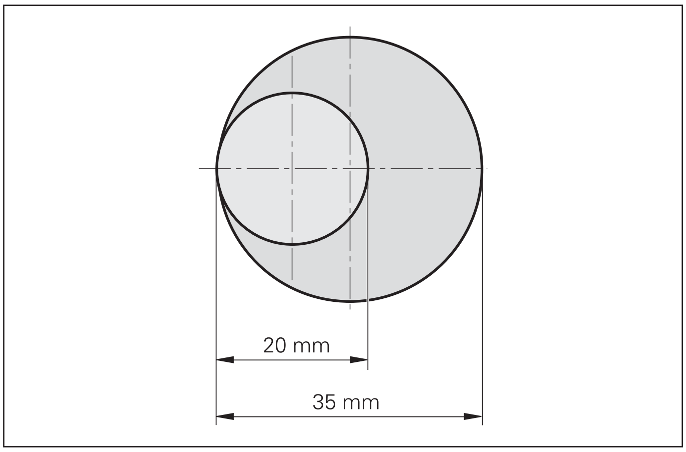
RCN 5000: Large hollow shaft with small mounting space
- Stator can be mounted to the same mating dimensions as the RCN 2000 (110 mm flange diameter)
- Hollow shaft with ∅ 35 mm has more than three times the cross section of the RCN 2000
- More space for stiffer shafts or hydraulic lines
- Reduced overall height of 42 mm for the RCN 5000 instead of 55 mm for the RCN 2000

Plug-in electrical connection enables
- Selectable lengths of connecting cable through separately ordered cable assemblies
- Simple connection through quick disconnects (no tools required)
- High tightness level of IP 67

New scanning and evaluation electronics for
- High shaft speeds up to 3000 min^{-1} with purely serial data transmission
- Increased power-supply range of 3.6 V to 14 V DC
- Encoder monitoring and diagnostics without an additional line



Position error within one signal period (example: RCN 2580, 1 % position error ≙ 0.8")



Large hollow shaft of RCN 5000

Plug-in cable

Measuring Principles

Measuring standard
HEIDENHAIN encoders with optical scanning incorporate measuring standards of periodic structures known as graduations. These graduations are applied to a carrier substrate of glass or steel. The scale substrate for large measuring lengths is a steel tape.

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

- AURODUR: matte-etched lines on gold-plated steel tape with typical graduation period of 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 of 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

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

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

Absolute measuring method
With the absolute measuring method, the position value is available from the encoder immediately upon switch-on and can be called at any time by the subsequent electronics. There is no need to move the axes to find the reference position.

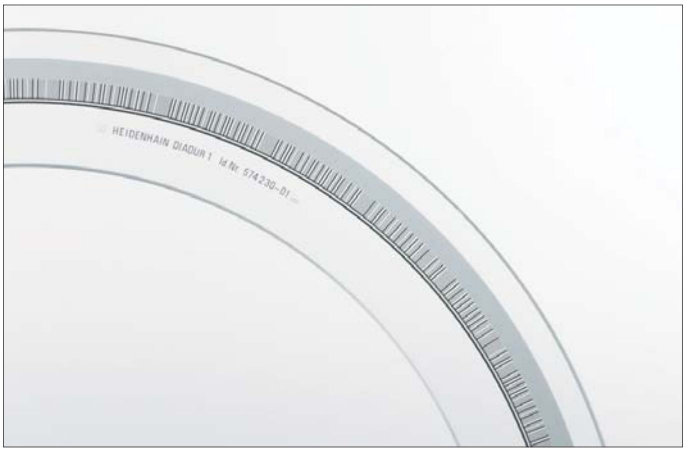
The absolute position information is read from the graduated disk which is formed from a serial absolute code structure. The code structure is unique over one revolution. A separate incremental track is read with the single-field scanning principle and interpolated for the position value.

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 in the micrometer range and less, and generates output signals with very small signal periods.

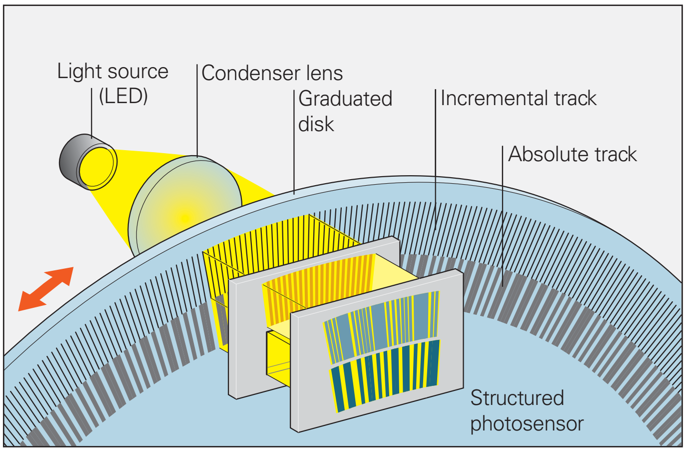
The RCN angle encoders with integral bearing operate using the imaging scanning principle.

Put simply, the imaging scanning principle functions by means of projected-light signal generation: two graduations with equal or similar grating periods—the scale and the scanning reticle—are moved relative to each other. The carrier material of the scanning reticle is transparent. The graduation on the measuring standard can likewise be applied to a transparent surface, but also a 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 or similar 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. A large, finely structured photosensor converts these variations in light intensity into electrical signals. Its structures have the same width as that of the measuring standard. The special structure filters the light to generate nearly sinusoidal output signals.



Graduated disk with serial code track and incremental track



Single-field scanning principle

Measuring Accuracy

The accuracy of angular measurement is mainly determined by

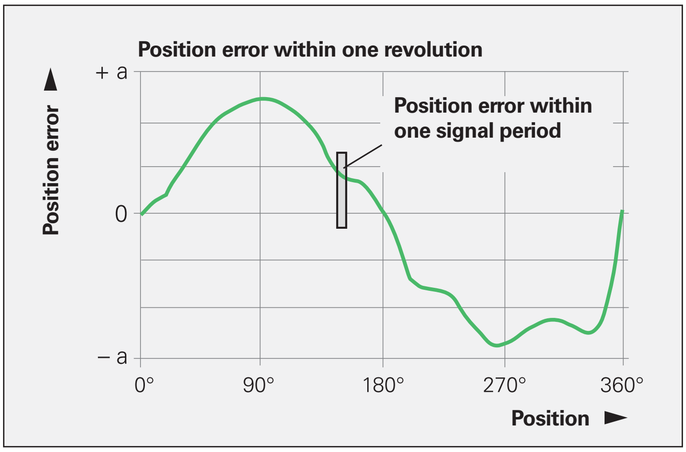
1. the quality of the graduation,
2. the quality of the scanning process,
3. the quality of the signal processing electronics,
4. the eccentricity of the graduation to the bearing,
5. the radial runout of the bearing,
6. the elasticity of the encoder shaft and its coupling with the drive shaft,
7. and the elasticity of the stator coupling.

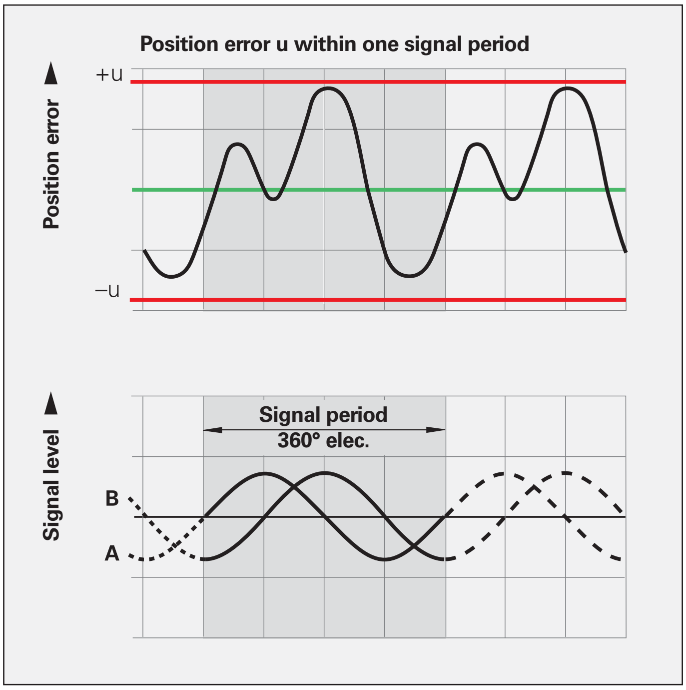
Position errors within one revolution
The **system accuracy** given in the *Specifications* is defined as follows:
The extreme values of the total deviations of a position are—referenced to their mean value—within the system accuracy ± a.
The total errors are ascertained at constant temperature (22 °C) during the final inspection and are recorded on the quality inspection certificate.

The system accuracy reflects position errors within one revolution as well as those within one signal period and—for angle encoders with integral bearing and integral stator coupling—the errors of the shaft coupling.

Position error within one signal period
Position errors within one signal period already become apparent in very small angular motions and in repeated measurements. They especially lead to speed ripples in the speed control loop. These errors within one signal period are caused by the quality of the graduation and its scanning. The smaller the signal period, the smaller the errors.

HEIDENHAIN RCN angle encoders with optimized scanning permit interpolation of the sinusoidal output signals with subdivision accuracies of better than ± 0.5 % of the signal period. The reproducibility is even better, meaning that useful electric subdivision factors and small signal periods permit small enough measuring steps.





For its angle encoders with integral bearings, HEIDENHAIN prepares individual quality inspection certificates and ships them with the encoder. The quality inspection certificate documents the encoder's accuracy and serves as a traceability record to a calibration standard.

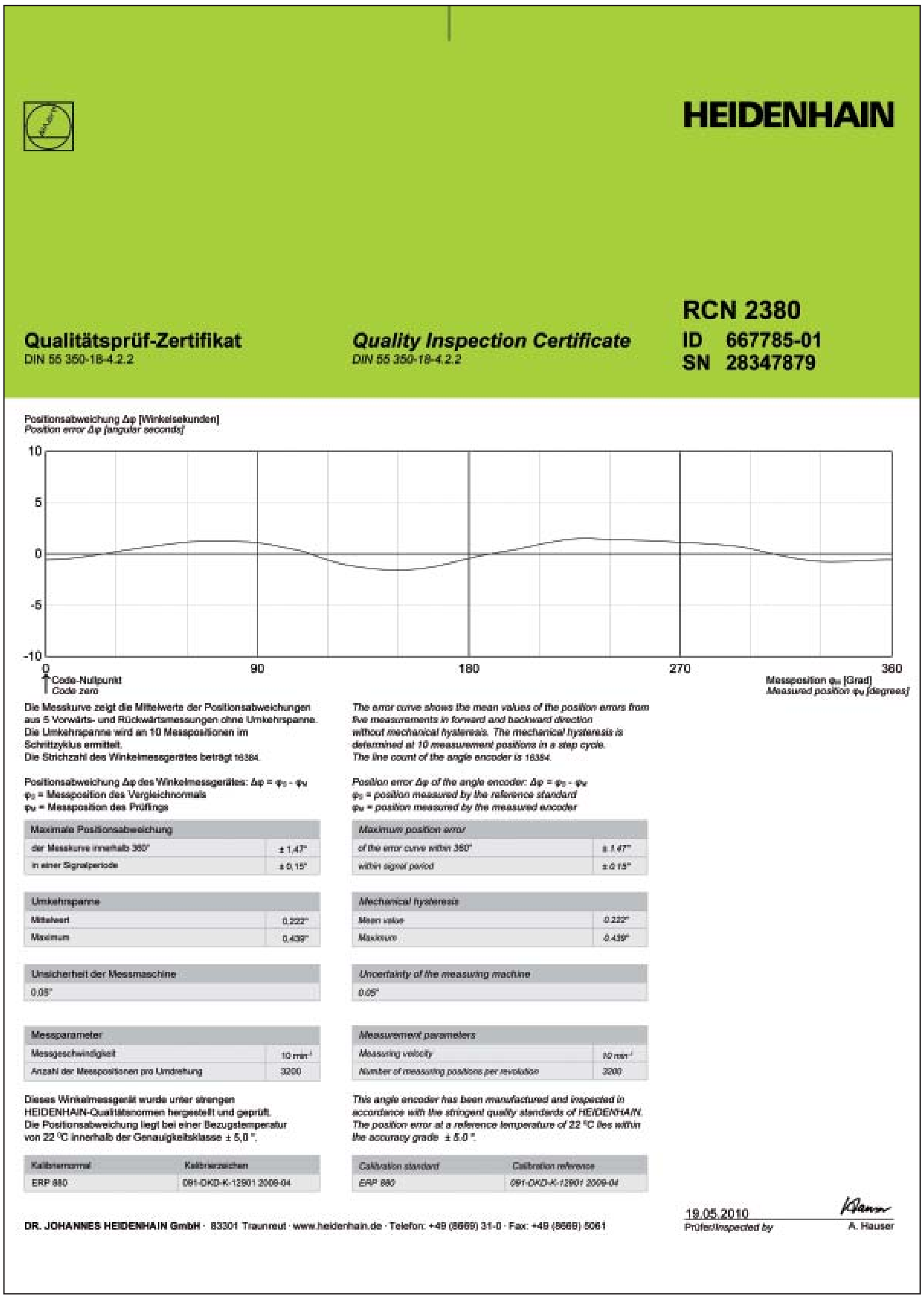
The system accuracy of angle encoders is ascertained through five forward and five backward measurements. The measuring positions per revolution are chosen to determine very exactly not only the long range error, but also the position error within one signal period.

The **mean value curve** shows the arithmetic mean of the measured values, in which the reversal error is not included.

The **reversal error** is ascertained with forward and backward measurements at ten positions. The maximum value and arithmetic mean are documented on the calibration chart. The following limits apply to the reversal error:

RCN 2xxx: Max. 0.6″
RCN 5xxx: Max. 0.6″
RCN 8xxx: Max. 0.4″

The **calibration standard** is indicated in order to certify the traceability to the national standard.



HEIDENHAIN

Qualitätsprüf-Zertifikat
DIN 55 350-18-4.2.2

Quality Inspection Certificate
DIN 55 350-18-4.2.2

RCN 2380
ID 667785-01
SN 28347879

Positionsabweichung Δφ [Winkelsekunden]
Position error Δφ [angular seconds]

Die Messkurve zeigt die Mittelwerte der Positionsabweichungen aus 5 Vorwärts- und Rückwärtsmessungen ohne Umkehrspanne. Die Umkehrspanne wird an 10 Messpositionen im Schrittzyklus ermittelt. Die Strichzahl des Winkelmessgerätes beträgt 16384.

The error curve shows the mean values of the position errors from five measurements in forward and backward direction without mechanical hysteresis. The mechanical hysteresis is determined at 10 measurement positions in a step cycle. The line count of the angle encoder is 16384.

Positionsabweichung Δφ des Winkelmessgerätes: $Δφ = φ_0 - φ_M$
$φ_0$ = Messposition des Vergleichnormals
$φ_M$ = Messposition des Prüflings

Position error Δφ of the angle encoder: $Δφ = φ_0 - φ_M$
$φ_0$ = position measured by the reference standard
$φ_M$ = position measured by the measured encoder

Maximale Positionsabweichung	
der Messkurve innerhalb 360°	± 1,47″
in einer Signalperiode	± 0,15″

Maximum position error	
of the error curve within 360°	*± 1.47″*
within signal period	*± 0.15″*

Umkehrspanne	
Mittelwert	0.222″
Maximum	0.439″

Mechanical hysteresis	
Mean value	*0.222″*
Maximum	*0.439″*

Unsicherheit der Messmaschine
0.05″

Uncertainty of the measuring machine
0.05″

Messparameter	
Messgeschwindigkeit	10 min⁻¹
Anzahl der Messpositionen pro Umdrehung	3200

Measurement parameters	
Measuring velocity	*10 min⁻¹*
Number of measuring positions per revolution	*3200*

Dieses Winkelmessgerät wurde unter strengen HEIDENHAIN-Qualitätsnormen hergestellt und geprüft. Die Positionsabweichung liegt bei einer Bezugstemperatur von 22 °C innerhalb der Genauigkeitsklasse ± 5,0 ″.

This angle encoder has been manufactured and inspected in accordance with the stringent quality standards of HEIDENHAIN. The position error at a reference temperature of 22 °C lies within the accuracy grade ± 5.0 ″.

Kalibriernormal	Kalibrierzeichen
ERP 880	081-DKD-K-12901 2009-04

Calibration standard	*Calibration reference*
ERP 880	*081-DKD-K-12901 2009-04*

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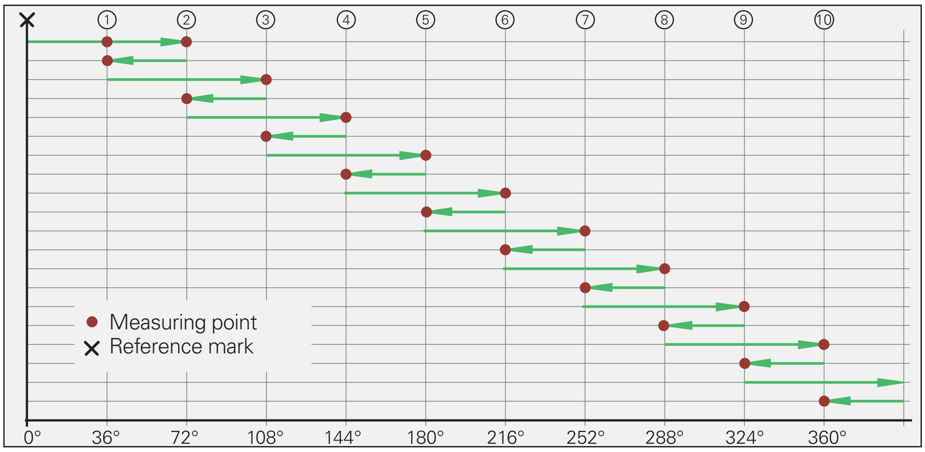
19.05.2010
Prüfer/*Inspected by*
A. Hauser

Example

Determination of the reversal error with forward and backward measurements



RCN angle encoders feature an integral bearing, a hollow shaft and a stator coupling. The measured shaft is directly connected with the shaft of the angle encoder.

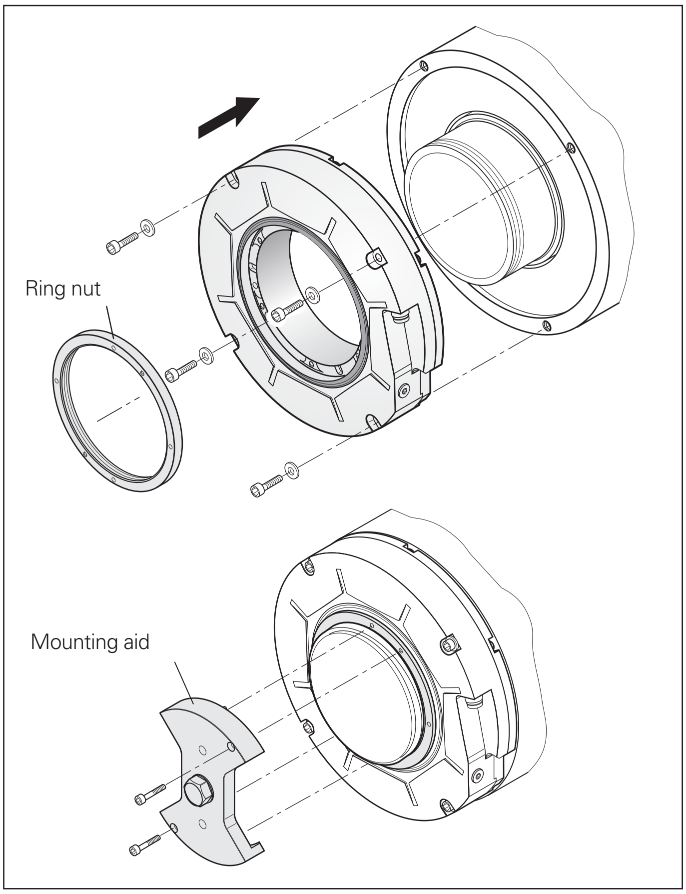
Design
The graduated disk is rigidly affixed to the hollow shaft. The scanning unit rides on the shaft on ball bearings and is connected to the housing with a coupling on the stator side. The stator coupling and the sealing design of the RCN with optimized scanning greatly compensate axial and radial mounting errors without restricting function or accuracy. This permits relatively large mounting tolerances to facilitate mounting. 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 RCN housing is firmly connected to the stationary machine part with an integral mounting flange and a centering collar.

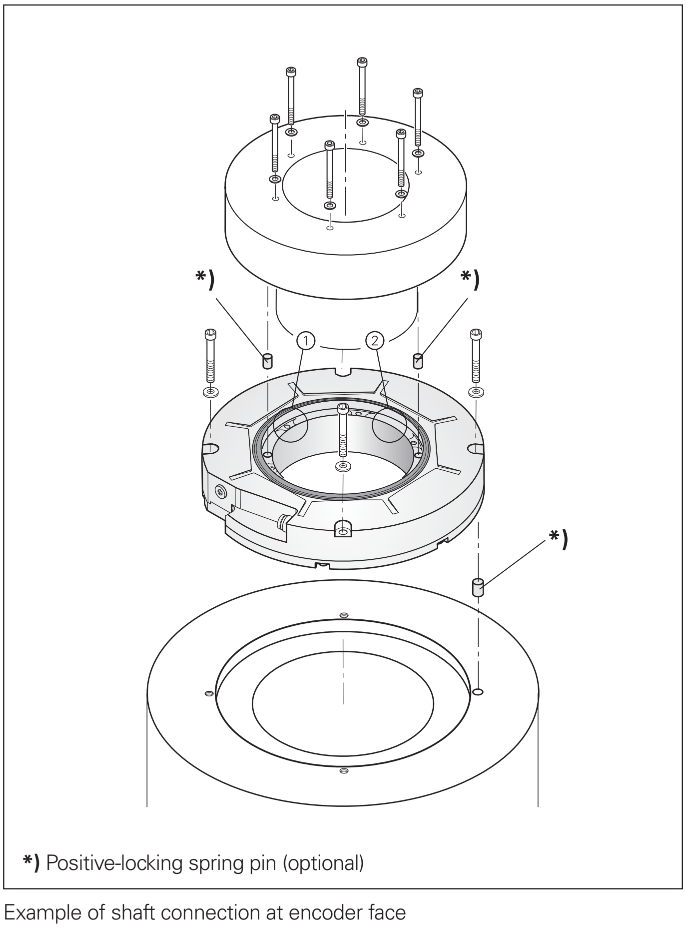
Shaft coupling with ring nut
The shaft of the RCN is designed as a hollow through shaft. For installation, the hollow through shaft of the angle encoder is placed over the machine shaft, and is fixed with a ring nut from the front of the encoder. The ring nut can easily be tightened with the mounting 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. The hollow shaft is connected by threaded holes on the front end 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 front of the encoder. In addition, positive-locking spring pins can be used on the rotor or stator side.

Materials to be used
The machine shaft and the fastening components must be made of steel. The machine shaft material must have a coefficient of expansion of $\alpha < 16 \times 10^{-6}\ K^{-1}$ and a creep limit $R_{P0.2} > 370\ N/mm^2$.



Mounting an angle encoder with hollow through shaft



Example of shaft connection at encoder face

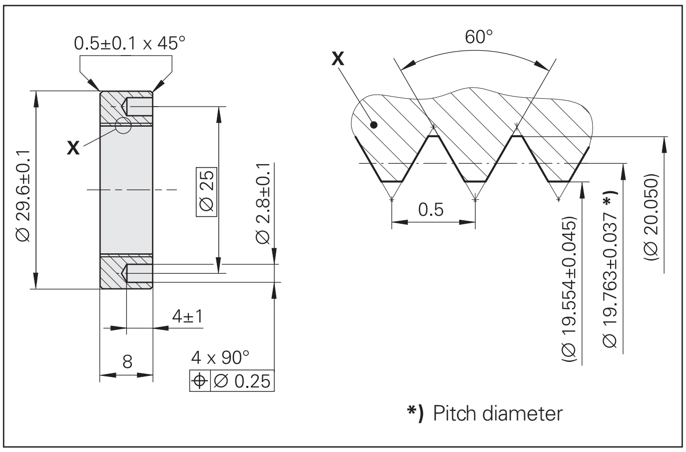
Ring nuts for the RCN

HEIDENHAIN offers special ring nuts for RCN angle encoders. 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.

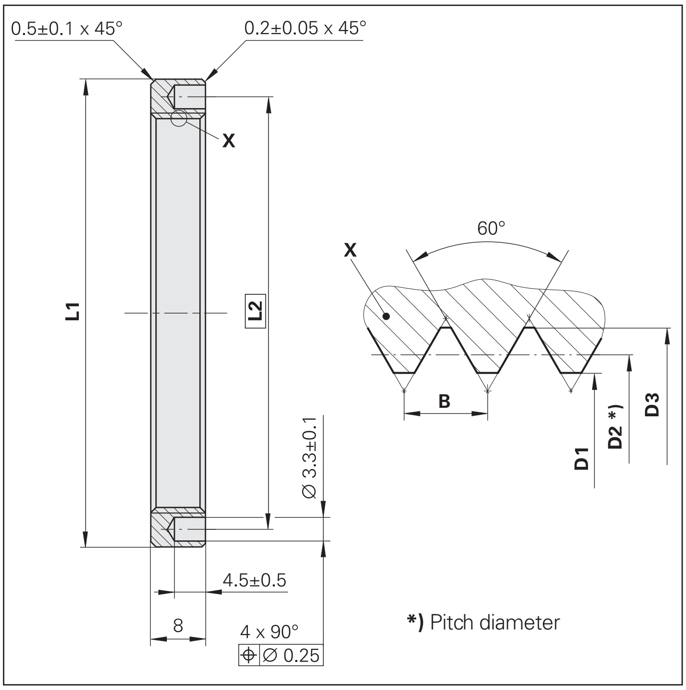
Ring nut for the RCN 2xxx
Hollow shaft Ø 20 mm: ID 336669-03

Ring nut for the RCN 5xxx
Hollow shaft Ø 35 mm: ID 336669-17

Ring nut for the RCN 8xxx
Hollow shaft Ø 60 mm: ID 336669-11
Hollow shaft Ø 100 mm: ID 336669-16



Ring nut for **RCN 2000 series**



Ring nut for **RCN 5000/8000 series**

Ring nut for	L1	L2	D1	D2	D3	B
Hollow shaft Ø 35	Ø 46±0.2	Ø 40	(Ø 34.052 ±0.075)	Ø 34.463 ±0.053	(Ø 35.24)	1
Hollow shaft Ø 60	Ø 70±0.2	Ø 65	(Ø 59.052 ±0.075)	Ø 59.469 ±0.059	(Ø 60.06)	1
Hollow shaft Ø 100	Ø 114±0.2	Ø 107	(Ø 98.538 ±0.095)	(Ø 99.163 ±0.07)	(Ø 100.067)	1.5

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 Ø 20 mm	ID 530334-03
Hollow shaft Ø 35 mm	ID 530334-17
Hollow shaft Ø 60 mm	ID 530334-11
Hollow shaft Ø 100 mm	ID 530334-16

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 516211-01
Hollow shaft 35 mm: ID 516211-06
Hollow shaft 60 mm: ID 516211-03
Hollow shaft 100 mm: ID 516211-05

General Mechanical Information

Degree of protection
Unless otherwise indicated, all RCN 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 angle encoders are equipped with a compressed air inlet. Connection to a source of compressed air slightly above atmospheric pressure generates **sealing air** and 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** (2010 edition):

- Particles: **Class 1**
  Particle size — Number of particles per m^3
  0.1 µm to 0.5 µm ≤ 20000
  0.5 µm to 1.0 µm ≤ 400
  1.0 µm to 5.0 µm ≤ 10
- Max. pressure dewpoint: **Class 4**
  (pressure dewpoint at 3 °C)
- Total oil content: **Class 1**
  (max. oil concentration: 0.01 mg/m^3)

For optimum supply of sealing air to the angle encoders with integral bearing, the required air flow is 1 to 4 l/min per encoder. Ideally the air flow is regulated by the HEIDENHAIN connecting pieces with integrated throttle (see *Accessories*). At an inlet pressure of approx. $1 \cdot 10^5$ Pa (1 bar), the throttles ensure the prescribed volume of airflow.

For more information, ask for our *DA 400* Product Information sheet.

Accessory:
DA 400 compressed air unit
ID 894602-01

DA 400
HEIDENHAIN offers the DA 400 compressed-air filter system for purifying the compressed air. It is designed specifically for the introduction of compressed air into encoders.

The DA 400 consists of three filter stages (prefilter, fine filter and activated carbon filter) and a pressure regulator with pressure gauge. The pressure gauge and automatic pressure switch (available as accessories) effectively monitor the sealing air.

The compressed air introduced into the DA 400 must fulfill the requirements of the following purity classes as per DIN/ISO 8573-1 (2010 edition):

- Particles: **Class 5**
  Particle size — Number of particles per m^3
  0.1 µm to 0.5 µm Not specified
  0.5 µm to 1.0 µm Not specified
  1.0 µm to 5.0 µm ≤ 100000
- Max. pressure dewpoint: **Class 6**
  (pressure dewpoint at 10 °C)
- Total oil content: **Class 4**
  (max. oil concentration: 5 mg/m^3)

The following components are necessary for connection to the RCN angle encoders:

M5 connecting piece for RCN
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 gasket, without throttle
ID 207834-02

DA 400

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 –20 °C to 70 °C applies when the unit remains in its packaging.

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

Acceleration
Angle encoders are subject to various types of acceleration during operation and mounting.

- The **permissible angular acceleration** for the angle encoders
  – *RCN 2000 series:* 15 000 rad/s^2
  – *RCN 5000 series:* 10 000 rad/s^2
  – *RCN 8000 series:* 3 000 rad/s^2
- The indicated maximum values for **vibration** are valid according to EN 60 068-2-6.
- The maximum permissible acceleration values (semi-sinusoidal shock) for **shock and impact** are valid for 6 ms (EN 60 068-2-27).

  Under no circumstances should a hammer or similar implement be used to adjust or position the encoder.

Natural frequency f_N of coupling
Together, the stator and stator coupling of RCN angle encoders form a single vibrating spring-mass system.

The **natural frequency f_N** should be as high as possible. 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.

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

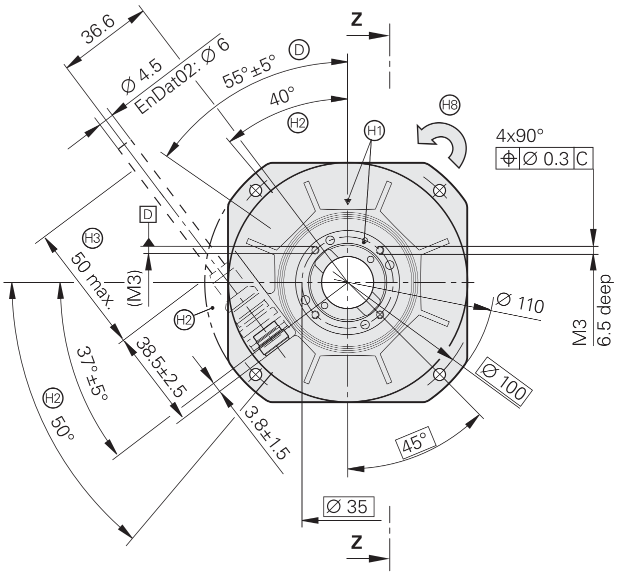
System tests
Encoders from HEIDENHAIN are usually integrated as components in larger systems. Such applications require **comprehensive tests of the entire system** regardless of the specifications of the encoder.

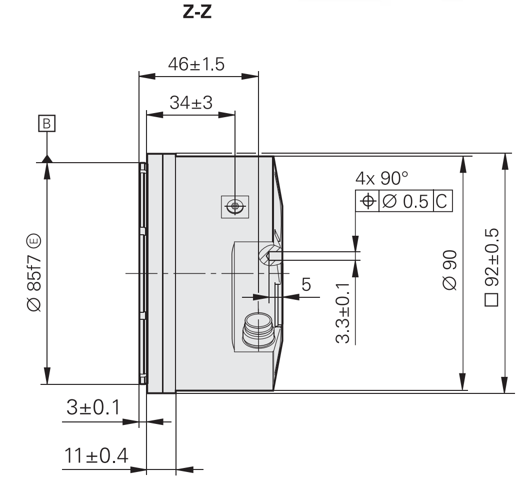
The specifications given in this brochure apply to the specific encoder, not to the complete system. Any operation of the encoder outside of the specified range or for any other than the intended applications is at the user's own risk.
In safety-related systems, the higher-level system must verify the position value of the encoder after switch-on.

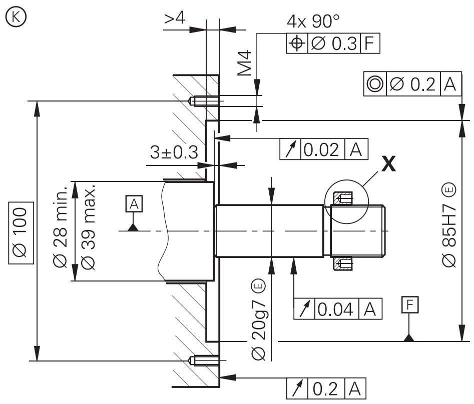
Mounting
Work steps to be performed and dimensions to be maintained during mounting are specified solely in the mounting instructions supplied with the unit. All data in this catalog regarding mounting are therefore provisional and not binding; they do not become terms of a contract.

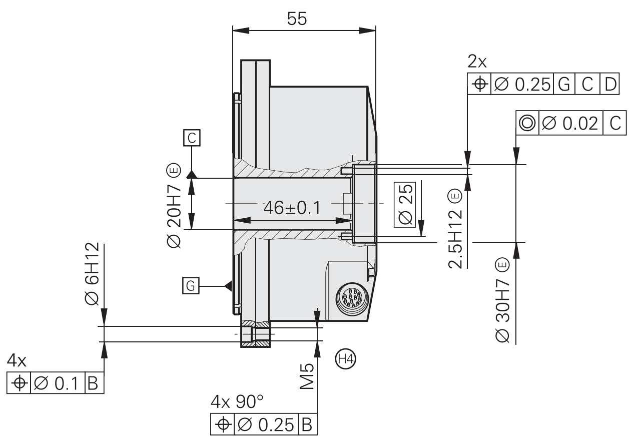
RCN 2000 Series

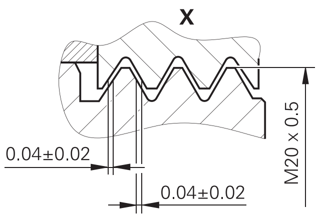
- Integrated stator coupling
- Hollow through shaft Ø 20 mm
- System accuracy ± 2.5" and ± 5"



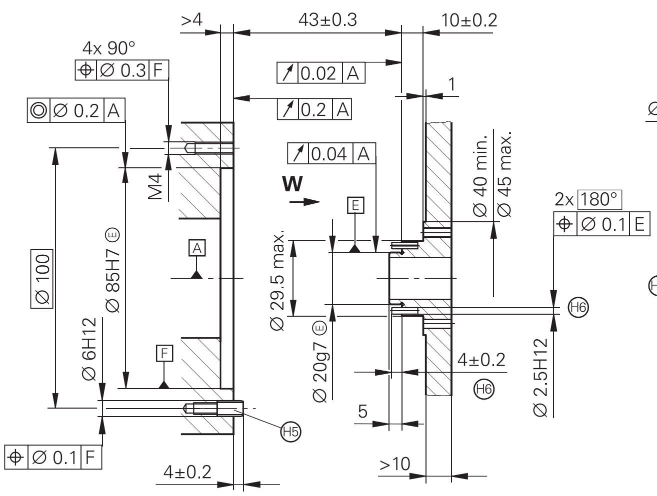


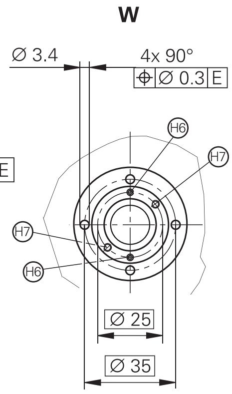






Ⓚ Alternative mounting option





mm

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

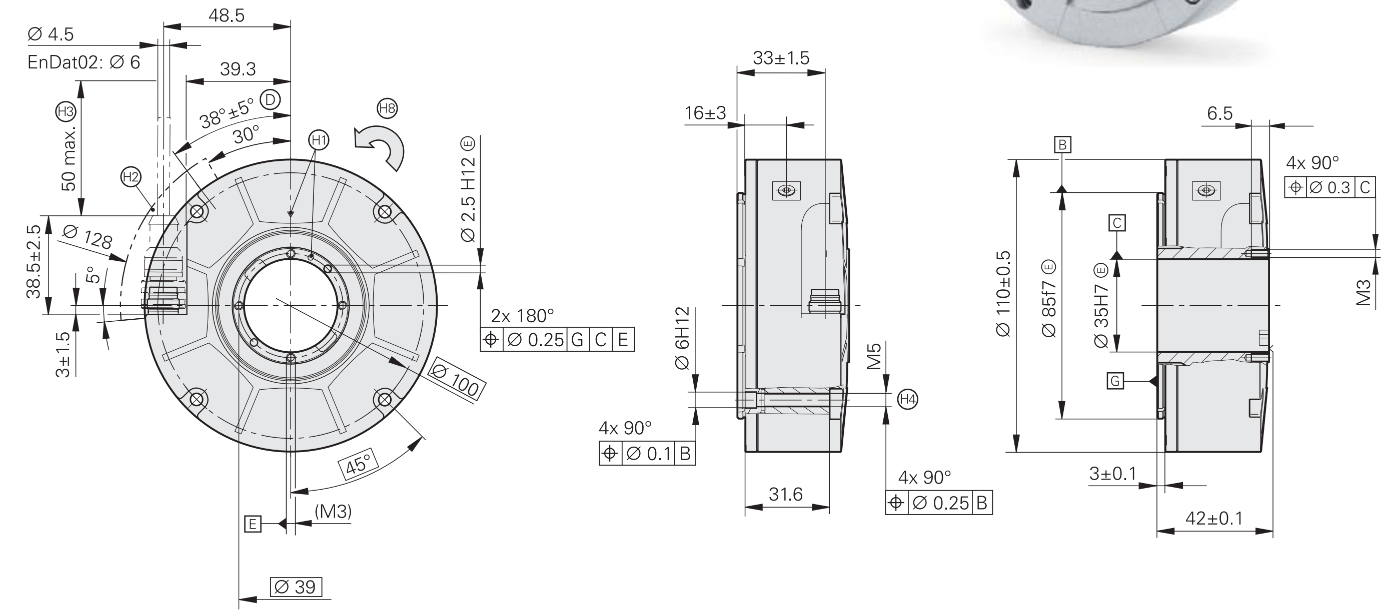
Ⓐ = Bearing of mating shaft
Ⓓ = Compressed air inlet
Ⓚ = Required mating dimensions
H1 = Mark for 0° position ± 5°
H2 = Free space for customer
H3 = Cable support
H4 = M5 back-off thread for dismounting, core hole diameter Ø 4.6 mm
H5 = 1x positive-locking spring pin, ISO 13337 – 6x10 – ST (optional)
H6 = 2x positive-locking spring pin, ISO 8752 – 2.5x10 – ST (optional)
H7 = Recommendation: When using a spring pin, provide additional back-off threads
H8 = Direction of shaft rotation for output signals as per the interface description

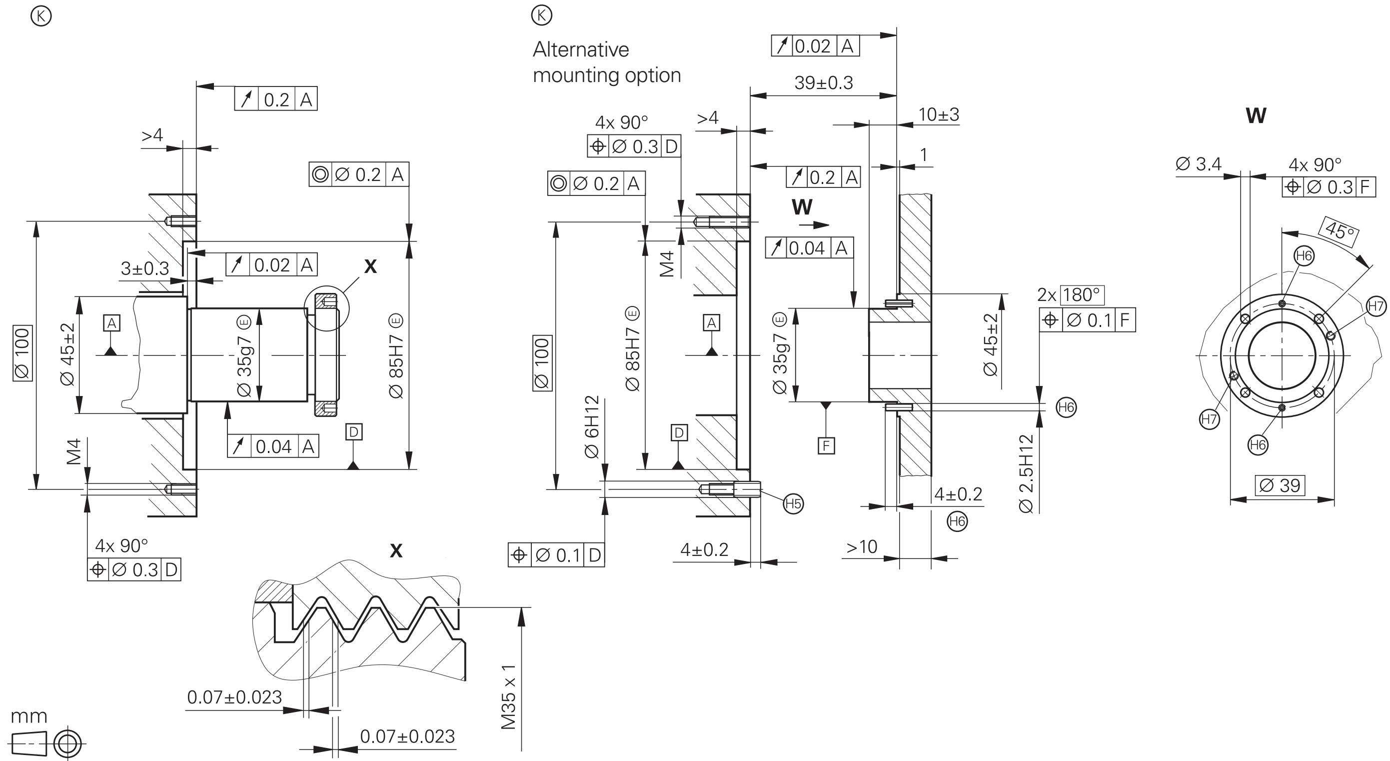
	Absolute **RCN 2510 RCN 2310**	**RCN 2580 RCN 2380**	**RCN 2590 F RCN 2390 F**	**RCN 2590 M RCN 2390 M**
Measuring standard	DIADUR circular scale with absolute and incremental track (16384 lines)			
System accuracy	*RCN 25x0:* ± 2.5" *RCN 23x0:* ± 5"			
Position error per signal period	*RCN 25x0:* ≤ ± 0.3" *RCN 23x0:* ≤ ± 0.4"	*RCN 25x0:* ≤ ± 0.4" *RCN 23x0:* ≤ ± 0.4"		
Absolute position values	EnDat 2.2		Fanuc Serial Interface αi Interface (incl. α Interface)	Mitsubishi High Speed Serial Interface
Ordering designation	EnDat 22	EnDat 02	Fanuc 05	Mit 03-4
Positions per revolution	*RCN 25x0:* 268435456 (28 bits) *RCN 23x0:* 67108864 (26 bits)			
Elec. permissible speed	≤ 3000 min^{-1} for continuous position value	≤ 1500 min^{-1} for continuous position value	≤ 3000 min^{-1} for continuous position value	
Clock frequency	≤ 16 MHz	≤ 2 MHz	–	
Calculation time t_{cal}	≤ 5 µs (at 8 MHz clock frequency)		–	
Incremental signals	–	∿ 1 V_{PP}	–	
Cutoff frequency –3 dB	–	≥ 400 kHz	–	
Electrical connection	Separate adapter cable connectable to encoder via quick disconnect			
Power supply	3.6 to 14 V DC			
Power consumption[1)] (maximum)	*3.6 V:* ≤ 1.1 W *14 V:* ≤ 1.4 W			
Current consumption (typical)	*5 V:* ≤ 225 mA (without load)			
Shaft	Hollow through shaft D = 20 mm			
Mech. permissible speed	≤ 1500 min^{-1}; *temporary:* ≤ 3000 min^{-1} (speeds over 1500 min^{-1} require consultation)			
Starting torque	≤ 0.08 Nm at 20 °C			
Moment of inertia of rotor	$188 \cdot 10^{-6}$ kgm^2			
Permissible axial motion of measured shaft	± 0.3 mm			
Natural frequency	≥ 1000 Hz			
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)			
Operating temperature	*RCN 25xx:* 0 °C to 50 °C *RCN 23xx:* –20 °C to 60 °C			
Protection EN 60529	IP 64			
Weight	Approx. 1.0 kg			

1) See *General Electrical Information*

RCN 5000 Series

- **Integrated stator coupling**
- **Hollow through shaft Ø 35 mm**
- **System accuracy ± 2.5" and ± 5"**





mm

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

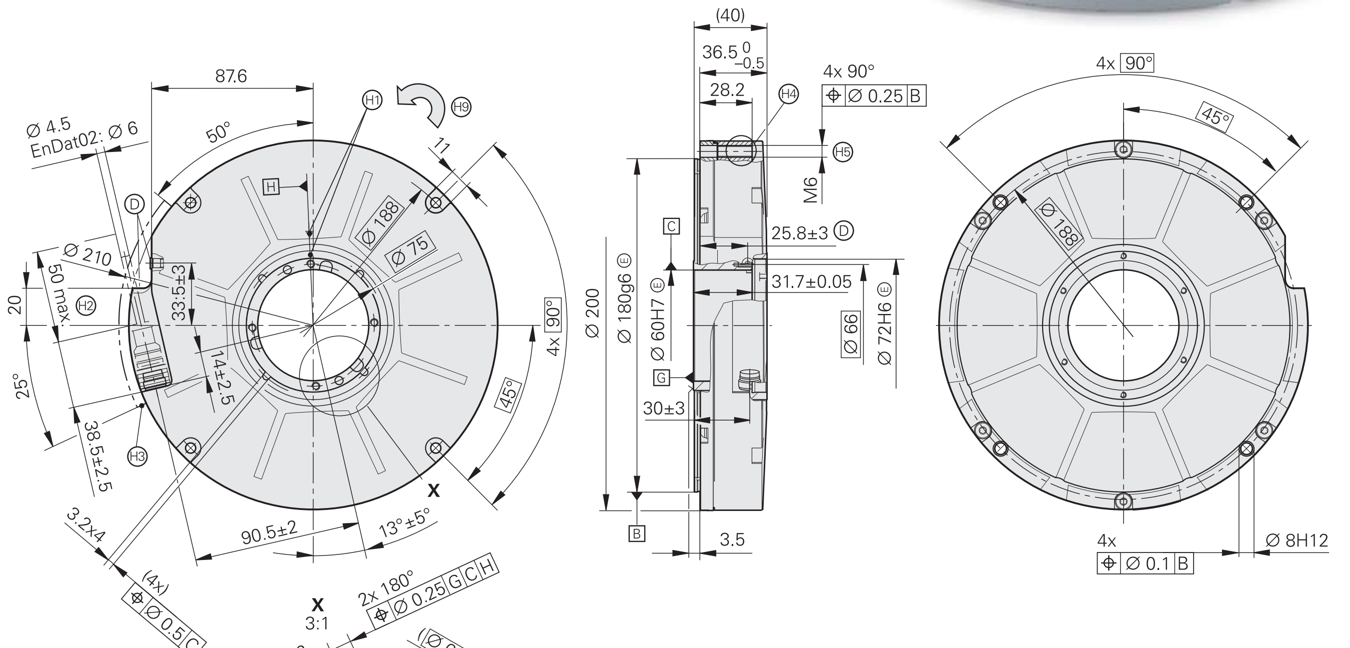
A = Bearing of mating shaft
D = Compressed air inlet
K = Required mating dimensions
H1 = Mark for 0° position ± 5°
H2 = Free space for customer
H3 = Cable support
H4 = M5 back-off thread for dismounting, core hole diameter Ø 4.6 mm
H5 = 1x positive-locking spring pin, ISO 13337 – 6x10 – ST (optional)
H6 = 2x positive-locking spring pin, ISO 8752 – 2.5x10 – ST (optional)
H7 = Recommendation: When using a spring pin, provide additional back-off threads
H8 = Direction of shaft rotation for output signals as per the interface description

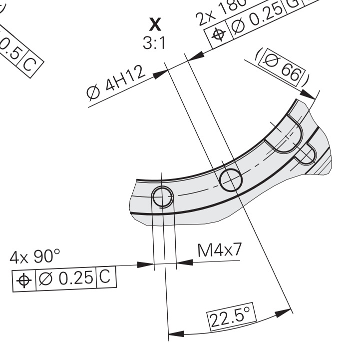
	Absolute **RCN 5510** **RCN 5310**	**RCN 5580** **RCN 5380**	**RCN 5590 F** **RCN 5390 F**	**RCN 5590 M** **RCN 5390 M**
Measuring standard	DIADUR circular scale with absolute and incremental track (16384 lines)			
System accuracy	*RCN 55x0:* ± 2.5" *RCN 53x0:* ± 5"			
Position error per signal period	*RCN 55x0:* ≤ ± 0.3" *RCN 53x0:* ≤ ± 0.4"	*RCN 55x0:* ≤ ± 0.4" *RCN 53x0:* ≤ ± 0.4"		
Absolute position values	EnDat 2.2		Fanuc Serial Interface αi Interface (incl. α Interface)	Mitsubishi High Speed Serial Interface
Ordering designation	EnDat 22	EnDat 02	Fanuc 05	Mit 03-4
Positions per revolution	*RCN55x0:* 268435456 (28 bits) *RCN53x0:* 67108864 (26 bits)			
Elec. permissible speed	≤ 3000 min^{-1} for continuous position value	≤ 1500 min^{-1} for continuous position value	≤ 3000 min^{-1} for continuous position value	
Clock frequency	≤ 16 MHz	≤ 2 MHz	–	
Calculation time t_{cal}	≤ 5 µs (at 8 MHz clock frequency)		–	
Incremental signals	–	∿ 1 V_{PP}	–	
Cutoff frequency –3 dB	–	≥ 400 kHz	–	
Electrical connection	Separate adapter cable connectable to encoder via quick disconnect			
Power supply	3.6 to 14 V DC			
Power consumption[1)] (maximum)	*3.6 V:* ≤ 1.1 W *14 V:* ≤ 1.4 W			
Current consumption (typical)	*5 V:* ≤ 225 mA (without load)			
Shaft	Hollow through shaft D = 35 mm			
Mech. permissible speed	≤ 1500 min^{-1}; *temporary:* ≤ 3000 min^{-1} (speeds over 1500 min^{-1} require consultation)			
Starting torque	≤ 0.08 Nm at 20 °C			
Moment of inertia of rotor	$140 \cdot 10^{-6}$ kgm^2			
Permissible axial motion of measured shaft	± 0.3 mm			
Natural frequency	≥ 1000 Hz			
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)			
Operating temperature	*RCN 55xx:* 0 °C to 50 °C *RCN 53xx:* –20 °C to 60 °C			
Protection EN 60529	IP 64			
Weight	Approx. 0.9 kg			

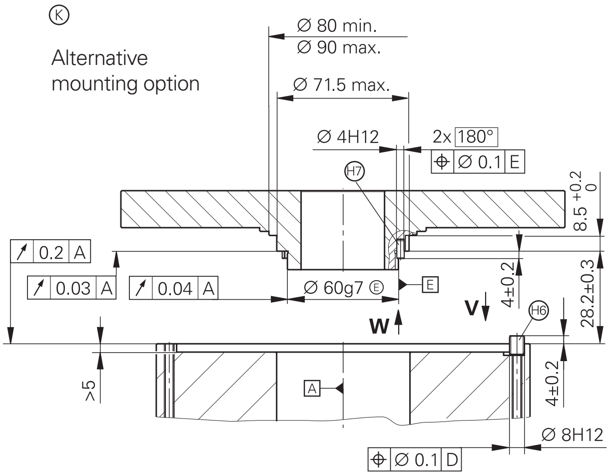
[1)] See *General Electrical Information*

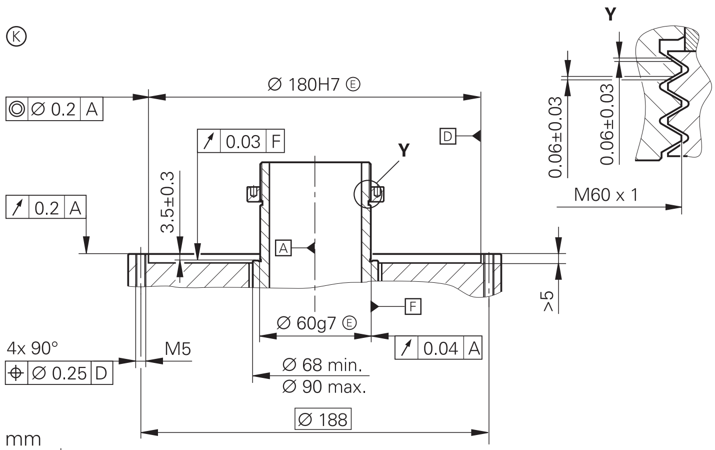
RCN 8000 Series

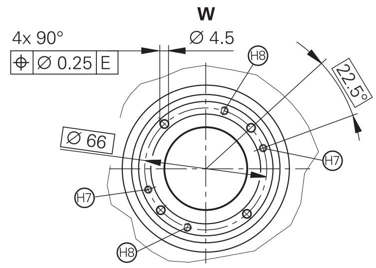
- **Integrated stator coupling**
- **Hollow through shaft Ø 60 mm**
- **System accuracy ± 1" and ± 2"**

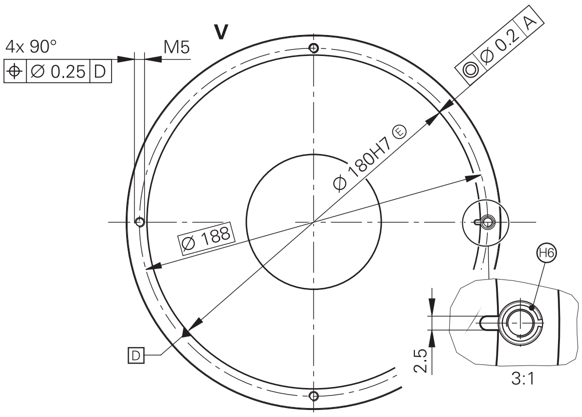












mm

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

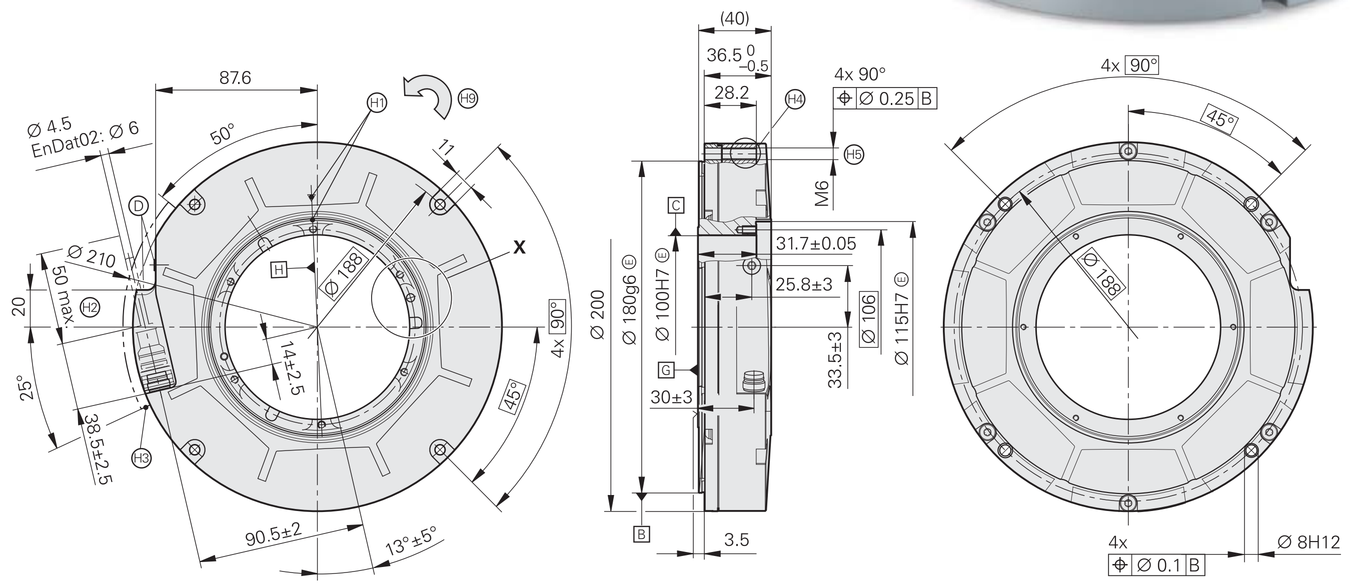
- A = Bearing of mating shaft
- D = Compressed air inlet
- K = Required mating dimensions
- H1 = Mark for 0° position ± 5°
- H2 = Cable support
- H3 = Free space for customer
- H4 = Shown rotated by 45°
- H5 = Back-off thread M6 for dismounting, core hole diameter Ø 5.5 mm
- H6 = 1x positive-locking spring pin, ISO 13337 – 8x10 – ST (optional)
- H7 = 2x positive-locking spring pin, ISO 8752 – 4x10 – ST (optional)
- H8 = Recommendation: When using a spring pin, provide additional back-off threads
- H9 = Direction of shaft rotation for output signals as per the interface description

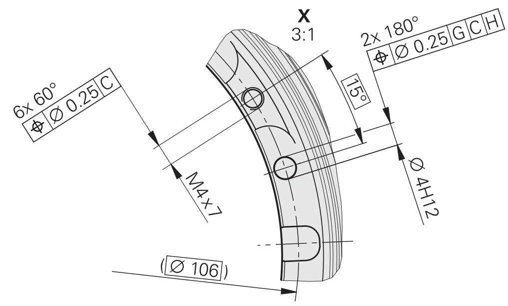
	Absolute RCN 8510 RCN 8310	RCN 8580 RCN 8380	RCN 8590 F RCN 8390 F	RCN 8590 M RCN 8390 M
Measuring standard	DIADUR circular scale with absolute and incremental track (32 768 lines)			
System accuracy	*RCN 85x0:* ± 1″ *RCN 83x0:* ± 2″			
Position error per signal period	*RCN 85x0:* ≤ ± 0.15″ *RCN 83x0:* ≤ ± 0.2″	*RCN 85x0:* ≤ ± 0.2″ *RCN 83x0:* ≤ ± 0.2″		
Absolute position values	EnDat 2.2		Fanuc Serial Interface αi Interface (incl. α Interface)	Mitsubishi High Speed Serial Interface
Ordering designation	EnDat 22	EnDat 02	Fanuc 05	Mit 03-4
Positions per revolution	536 870 912 (29 bits)			
Elec. permissible speed	≤ 1 500 min^{-1} for continuous position value	≤ 750 min^{-1} for continuous position value	≤ 1 500 min^{-1} for continuous position value	
Clock frequency	≤ 16 MHz	≤ 2 MHz	–	
Calculation time t_{cal}	≤ 5 µs (at 8 MHz clock frequency)		–	
Incremental signals	–	∼ 1 V_{PP}	–	
Cutoff frequency –3 dB	–	≥ 400 kHz	–	
Electrical connection	Separate adapter cable connectable to encoder via quick disconnect			
Power supply	3.6 to 14 V DC			
Power consumption[1] (maximum)	*3.6 V:* ≤ 1.1 W *14 V:* ≤ 1.4 W			
Current consumption (typical)	*5 V:* ≤ 225 mA (without load)			
Shaft	Hollow through shaft D = 60 mm			
Mech. permissible speed	≤ 500 min^{-1}; *temporary:* ≤ 1 500 min^{-1} (speeds over 500 min^{-1} require consultation)			
Starting torque	≤ 0.7 Nm at 20 °C			
Moment of inertia of rotor	$1.3 \cdot 10^{-6}$ kgm^2			
Permissible axial motion of measured shaft	± 0.3 mm			
Natural frequency	≥ 900 Hz			
Vibration 55 Hz to 2 000 Hz **Shock** 6 ms	≤ 200 m/s^2 (EN 60 068-2-6) ≤ 1 000 m/s^2 (EN 60 068-2-27)			
Operating temperature	0 °C to 50 °C			
Protection EN 60 529	IP 64			
Weight	Approx. 2.8 kg			

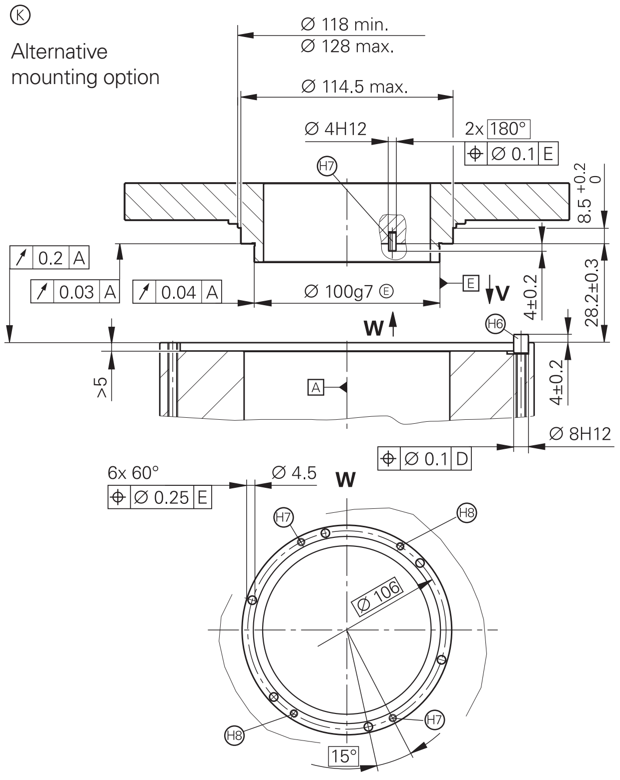
[1] See *General Electrical Information*

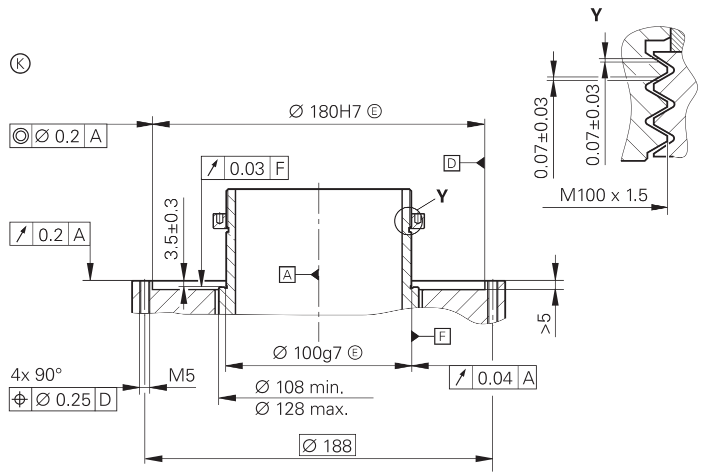
RCN 8000 Series

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



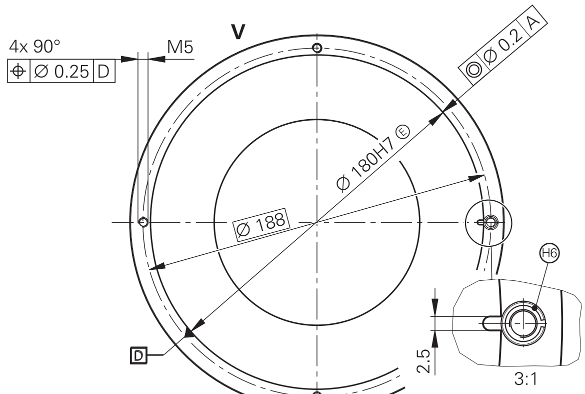






mm

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



Ⓐ = Bearing of mating shaft
Ⓓ = Compressed air inlet
Ⓚ = Required mating dimensions
H1 = Mark for 0° position ± 5°
H2 = Cable support
H3 = Free space for customer
H4 = Shown rotated by 45°
H5 = Back-off thread M6 for dismounting, core hole diameter Ø 5.5 mm
H6 = 1x positive-locking spring pin, ISO 13337 – 8x10 – ST (optional)
H7 = 2x positive-locking spring pin, ISO 8752 – 4x10 – ST (optional)
H8 = Recommendation: When using a spring pin, provide additional back-off threads
H9 = Direction of shaft rotation for output signals as per the interface description

	Absolute **RCN 8510** **RCN 8310**	**RCN 8580** **RCN 8380**	**RCN 8580 F** **RCN 8380 F**	**RCN 8580 M** **RCN 8380 M**
Measuring standard	DIADUR circular scale with absolute and incremental track (32 768 lines)			
System accuracy	*RCN 85x0:* ± 1" *RCN 83x0:* ± 2"			
Position error per signal period	*RCN 85x0:* ≤ ± 0.15" *RCN 83x0:* ≤ ± 0.2"	*RCN 85x0:* ≤ ± 0.2" *RCN 83x0:* ≤ ± 0.2"		
Absolute position values	EnDat 2.2		Fanuc Serial Interface αi Interface (incl. α Interface)	Mitsubishi High Speed Serial Interface
Ordering designation	EnDat 22	EnDat 02	Fanuc 05	Mit 03-4
Positions per revolution	536 870 912 (29 bits)			
Elec. permissible speed	≤ 1 500 min^{-1} for continuous position value	≤ 750 min^{-1} for continuous position value	≤ 1 500 min^{-1} for continuous position value	
Clock frequency	≤ 16 MHz	≤ 2 MHz	–	
Calculation time t_{cal}	≤ 5 µs (at 8 MHz clock frequency)		–	
Incremental signals	–	∿ 1 V_{PP}	–	
Cutoff frequency –3 dB	–	≥ 400 kHz	–	
Electrical connection	Separate adapter cable connectable to encoder via quick disconnect			
Power supply	3.6 to 14 V DC			
Power consumption[1)] (maximum)	*3.6 V:* ≤ 1.1 W *14 V:* ≤ 1.4 W			
Current consumption (typical)	*5 V:* ≤ 225 mA (without load)			
Shaft	Hollow through shaft D = 100 mm			
Mech. permissible speed	≤ 500 min^{-1}; *temporary:* ≤ 1 500 min^{-1} (speeds over 500 min^{-1} require consultation)			
Starting torque	≤ 1.5 Nm at 20 °C			
Moment of inertia of rotor	$3.3 \cdot 10^{-6}$ kgm^2			
Permissible axial motion of measured shaft	± 0.3 mm			
Natural frequency	≥ 900 Hz			
Vibration 55 Hz to 2 000 Hz **Shock** 6 ms	≤ 200 m/s^2 (EN 60 068-2-6) ≤ 1 000 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			

1) See *General Electrical Information*

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, instruction, etc.)
- Operating status (alarm or warning messages)

Monitoring and diagnostic functions of the EnDat interface make a detailed inspection of the encoder possible.

- Error messages
- Warnings
- Online diagnostics based on valuation numbers (EnDat 2.2)

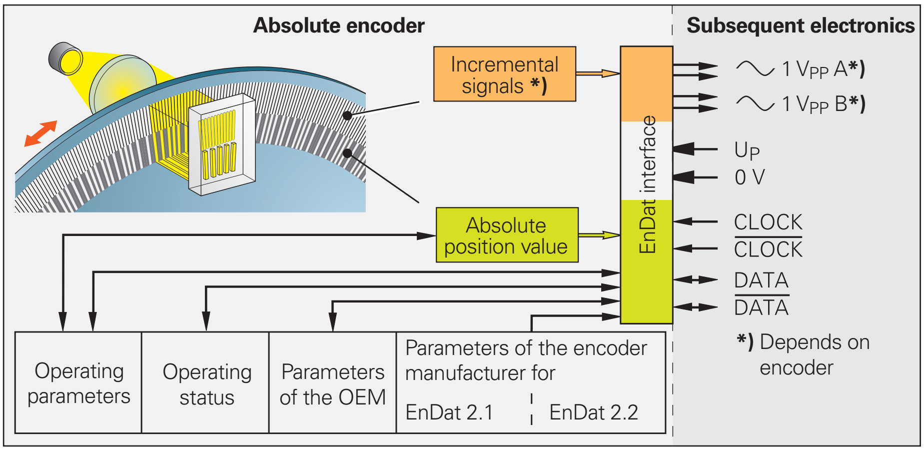
Incremental signals
EnDat encoders are available with or without incremental signals. EnDat 21 and EnDat 22 encoders feature a high internal resolution. An evaluation of the incremental signal is therefore unnecessary.

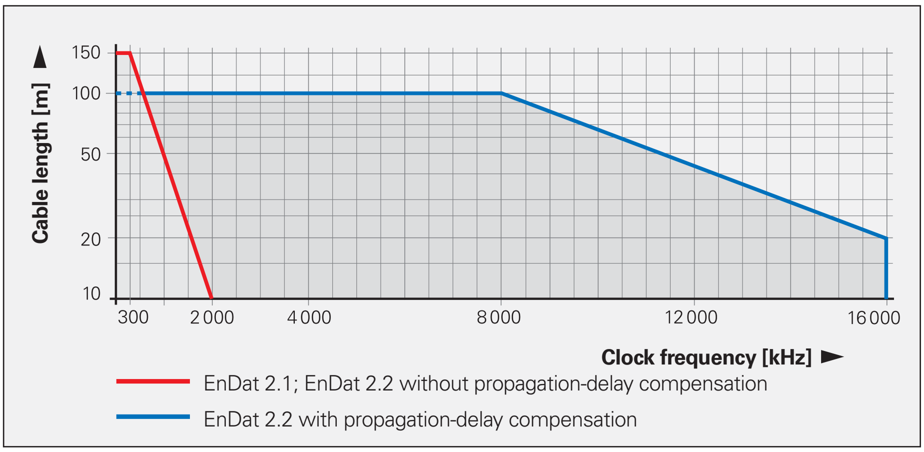
Clock frequency and cable length
The clock frequency is variable—depending on the cable length (max. 150 m)—between **100 kHz** and **2 MHz.** With propagation-delay compensation in the subsequent electronics, clock frequencies up to **16 MHz** at cable lengths up to 100 m are possible.

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 DATA and $\overline{\text{DATA}}$ signals.
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	Extended 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)



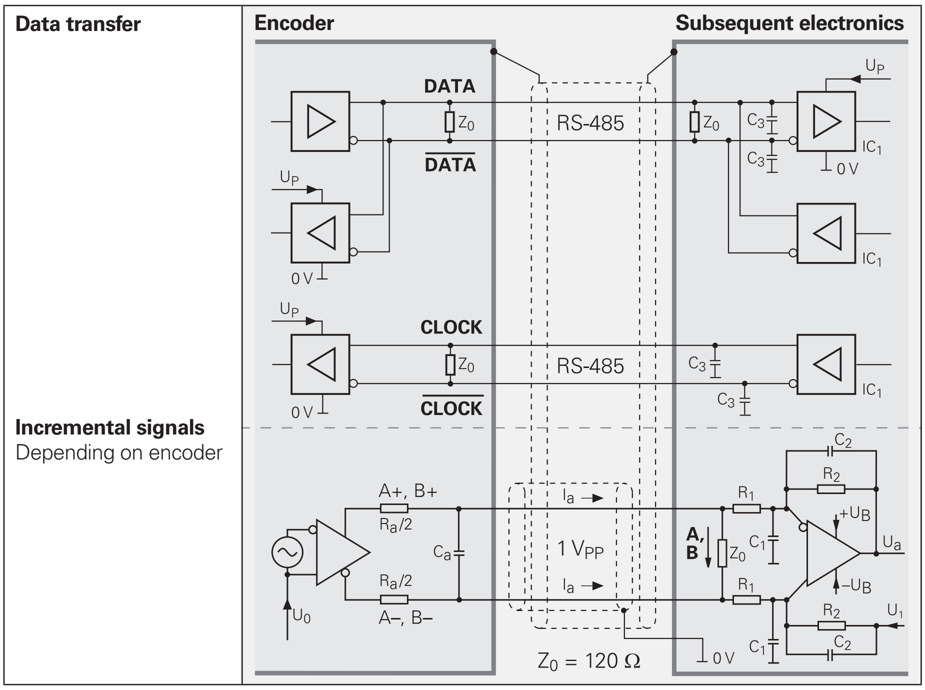


Input Circuitry of Subsequent Electronics

Dimensioning
IC_1 = RS 485 differential line receiver and driver

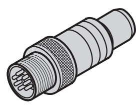
C_3 = 330 pF
Z_0 = 120 Ω

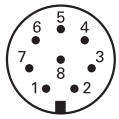
For a description of the 1 V_{PP} incremental signals see catalog: *Angle Encoders with Integral Bearing*.



Pin layout

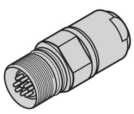
8-pin coupling, M12

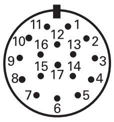




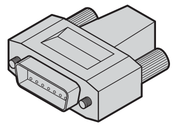
	Power supply				Absolute position values			
	8	**2**	**5**	**1**	**3**	**4**	**7**	**6**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

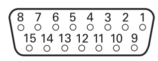
17-pin M23 **coupling**





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





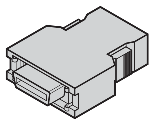
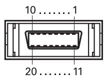
	Power supply					Incremental signals[1]				Absolute position values			
	7	**1**	**10**	**4**	**11**	**15**	**16**	**12**	**13**	**14**	**17**	**8**	**9**
	1	**9**	**2**	**11**	**13**	**3**	**4**	**6**	**7**	**5**	**8**	**14**	**15**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Internal shield**	**A+**	**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

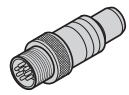
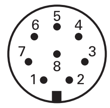
Interfaces
Fanuc and Mitsubishi Pin Layouts

Fanuc pin layout
HEIDENHAIN encoders with the code letter F after the model designation are suited for connection to Fanuc controls with **Fanuc Serial Interface – αi Interface**
- αi interface (high speed, one-pair transmission) includes α interface (normal and high speed, two-pair transmission)
- Ordering designation for Fanuc05

20-pin Fanuc connector

8-pin M12 coupling

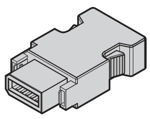
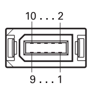



	Power supply					Absolute position values			
20-pin Fanuc connector	**9**	**18/20**	**12**	**14**	**16**	**1**	**2**	**5**	**6**
8-pin M12 coupling	**8**	**2**	**5**	**1**	**–**	**3**	**4**	**7**	**6**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Shield**	**Serial Data**	**$\overline{\text{Serial Data}}$**	**Request**	**$\overline{\text{Request}}$**
Cable	Brown/Green	Blue	White/Green	White	–	Gray	Pink	Violet	Yellow

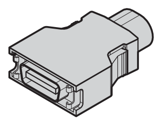
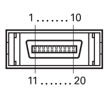
Cable shield connected to housing; **U_P** = power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!

Mitsubishi pin layout
HEIDENHAIN encoders with the code letter M after the model designation are suited for connection to controls with **Mitsubishi high-speed serial interface.**
- Transmission rate 2.5 MHz and 5 MHz (two-pair transmission)
- Ordering designation Mit03-4

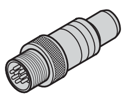
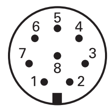
10-pin Mitsubishi connector

20-pin Mitsubishi connector

8-pin M12 coupling

	Power supply				Absolute position values			
10-pin	**1**	**–**	**2**	**–**	**7**	**8**	**3**	**4**
20-pin	**20**	**19**	**1**	**11**	**6**	**16**	**7**	**17**
8-pin M12 coupling	**8**	**2**	**5**	**1**	**3**	**4**	**7**	**6**
	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

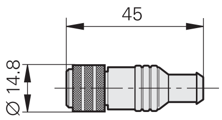
Cable shield connected to housing; **U_P** = power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!

Cables and Connecting Elements
General Information

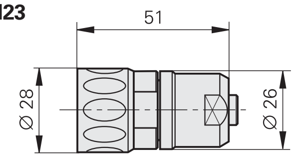
Connector (insulated): Connecting element with coupling ring; available with male or female contacts.

Symbols 

M12



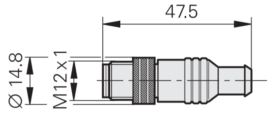
M23



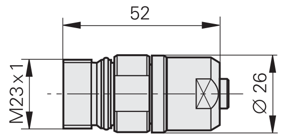
Coupling (insulated): Connecting element with external thread; available with male or female contacts.

Symbols 

M12

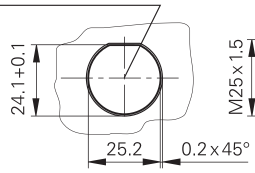


M23

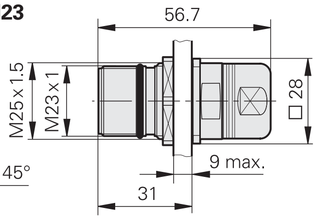


Mounted coupling with central fastening

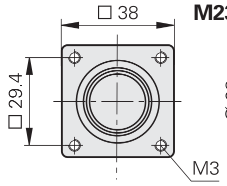
Cutout for mounting



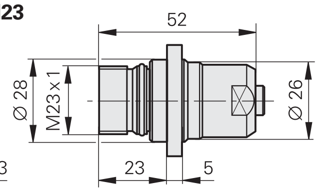
M23



Mounted coupling with flange



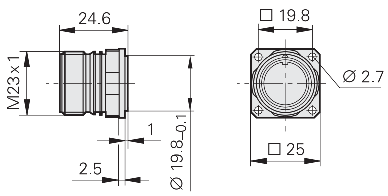
M23



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

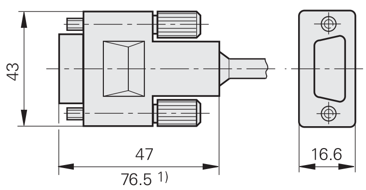
Symbols 

M23



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

Symbols 



1) with integrated interface 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 or

female contacts.

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

Accessories for flange sockets and M23 mounted couplings

Bell seal
ID 266526-01

Threaded metal dust cap
ID 219926-01

EnDat Connecting Cables

8-pin M12 | 17-pin M23

		EnDat without incremental signals	**EnDat** with incremental signals
PUR adapter cable			
Complete with 17-pin M23 coupling (male)	Ø 6 mm	–	ID 643450-xx
Complete with 15-pin D-sub connector (female)	Ø 4.5 mm Ø 6 mm	ID 735987-xx –	– ID 727658-xx
Complete with 8-pin M12 coupling (male)	Ø 4.5 mm	ID 679671-xx	–
PUR connecting cables	**8-pin:** [(4 × 0.14 mm²) + (4 × 0.34 mm²)] **Ø 6 mm** **17-pin:** [(4 × 0.14 mm²) + 4(2 × 0.14 mm²) + (4 × 0.5 mm²)] **Ø 8 mm**		
Complete with connector (female) and coupling (male)		ID 368330-xx	ID 323897-xx
Complete with connector (female) and D-sub connector (female) for IK 220		ID 533627-xx	ID 332115-xx
Complete with connector (female) and D-sub connector (male) for IK 115/IK 215		ID 524599-xx	ID 324544-xx
With **one connector (female)**		ID 634265-xx	ID 309778-xx
Cable only, Ø 8 mm		–	ID 266306-01
Mating element on connecting cable to connector on encoder cable	**Connector (female)** for cable Ø 8 mm	–	ID 291697-26
Connector on cable for connection to subsequent electronics	**Connector (male)** for cable Ø 8 mm Ø 6 mm	–	ID 291697-27
Coupling on connecting cable	**Coupling (male)** for cable Ø 4.5 mm Ø 6 mm Ø 8 mm	–	ID 291698-25 ID 291698-26 ID 291698-27
Flange socket for mounting on subsequent electronics	**Flange socket (female)**	–	ID 315892-10
Mounted couplings	**With flange (female)** Ø 6 mm Ø 8 mm	–	ID 291698-35
	With flange (male) Ø 6 mm Ø 8 mm	–	ID 291698-41 ID 291698-29
	With central fastening Ø 6 mm to 10 mm **(male)**	–	ID 741045-02

Connecting Cables Fanuc
Mitsubishi

			Fanuc	Mitsubishi
PUR adapter cable				
Complete with 8-pin M12 coupling (male)		Ø 4.5 mm	679671-xx	
Complete with Fanuc connector (female)		Ø 4.5 mm	770967-xx	–
Complete with 10-pin Mitsubishi connector (female)		Ø 4.5 mm	–	770968-xx
Complete with 20-pin Mitsubishi connector (male)		Ø 4.5 mm	–	770966-xx
PUR connecting cables	[(4 x 0.14 mm²) + (4 x 0.34 mm²)]			
Complete with M12 connector (female) 8-pin and M12 coupling (male) 8-pin		Ø 6 mm	368330-xx	
Complete with M12 connector (female) 8-pin and M23 coupling (male) 17-pin		Ø 6 mm	582333-xx	
Complete with M12 connector (female) 8-pin and Fanuc connector (female)	 Fanuc	Ø 6 mm	646807-xx	–
Complete with M12 connector (female) 8-pin and Mitsubishi connector (female) 10-pin	 Mitsubishi 10-pin	Ø 6 mm	–	647314-xx
Complete with M12 connector (female) 8-pin and Mitsubishi connector (male) 20-pin	 Mitsubishi 20-pin	Ø 6 mm	–	646806-xx
Cable without connectors [(2 x 2 x 0.14 mm²) + (4 x 1 mm²)]		Ø 8 mm	354608-01	

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 drop in V
- 1.05: Length factor due to twisted wires
- L_C: Cable length in m
- I: Current consumption in mA
- A_P: Cross section of power lines in mm²

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).

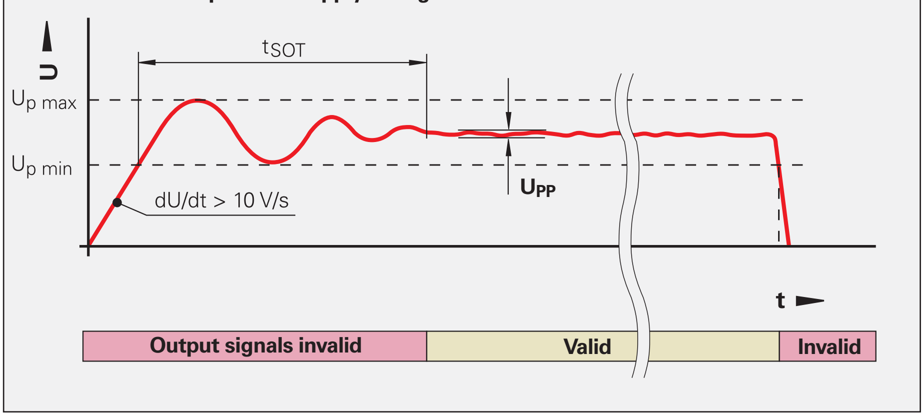
If the voltage drop is known, all parameters for the encoder and subsequent electronics can be calculated, e.g. voltage at the encoder, current requirements and power consumption of the encoder, as well as the power to be provided by the subsequent electronics.

Switch-on/off behavior of the encoders
The output signals are valid no sooner than after the switch-on time t_{SOT} = 1.3 s (2 s for PROFIBUS-DP) (see diagram). During the 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.

Insulation
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 mm²	–	–	0.09 mm²
Ø 4.3 mm	0.24 mm²	–	–	–
Ø 4.5 mm EPG	0.05 mm²	–	0.05 mm²	0.09 mm²
Ø 4.5 mm **Ø 5.1 mm**	0.14/0.09[2] mm² 0,05[2), 3)] mm²	0.05 mm²	0.05/0.14[6] mm²	0.14 mm²
Ø 5.5 mm PVC	0.1 mm²	–	–	–
Ø 6 mm **Ø 10 mm**[1]	0.19/0.14[2), 4)] mm²	–	0.08/0.19[6] mm²	0.34 mm²
Ø 8 mm **Ø 14 mm**[1]	0.5 mm²	1 mm²	0.5 mm²	1 mm²

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

Encoders with expanded supply voltage range

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

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

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

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

***Step 1:* Resistance of the supply lines**

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

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

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

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

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

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

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

***Step 4:* Parameters for subsequent electronics and the encoder**

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

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

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

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

Where:

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

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

U_P: Supply voltage of the subsequent electronics in V

R_L: Cable resistance (for both directions) in ohms

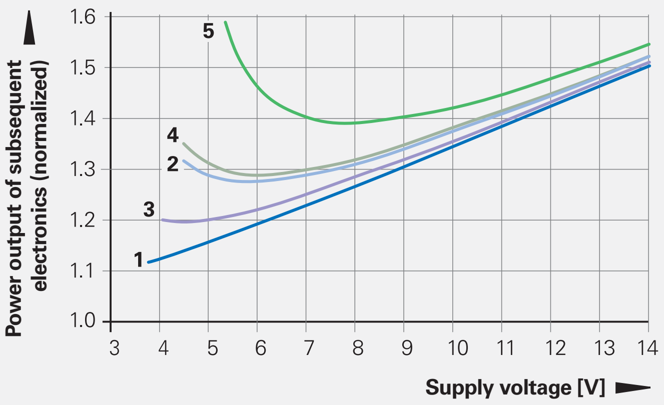
ΔU: Voltage drop in the cable in V

1.05: Length factor due to twisted wires

L_C: Cable length in m

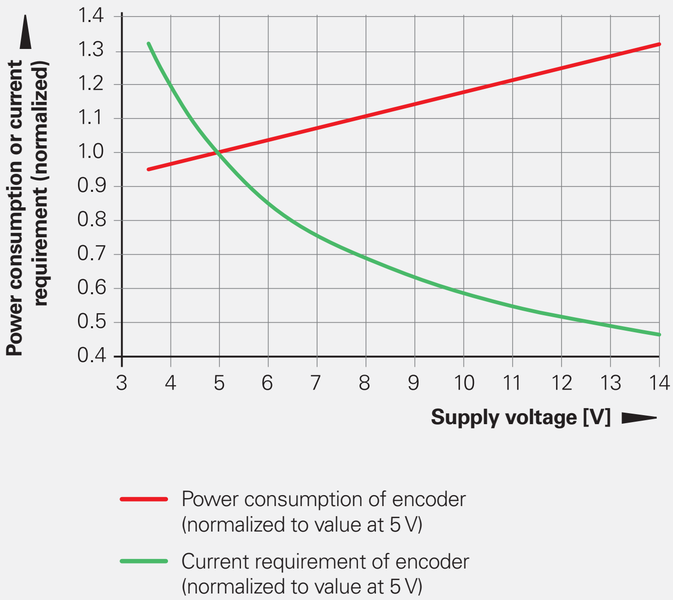
A_P: Cross section of power lines in mm^2

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



	Encoder cable/adapter cable	Connecting 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 –3 dB/ –6 dB cutoff frequency or the permissible input frequency of the subsequent electronics.

  For encoders with **square-wave signals,** the electrically permissible shaft speed/ traversing velocity is limited by
  – the maximum permissible scanning/ output frequency f_{max} of the encoder, and
  – the minimum permissible edge separation a for the subsequent electronics.

For angle or rotary encoders

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

For linear encoders

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

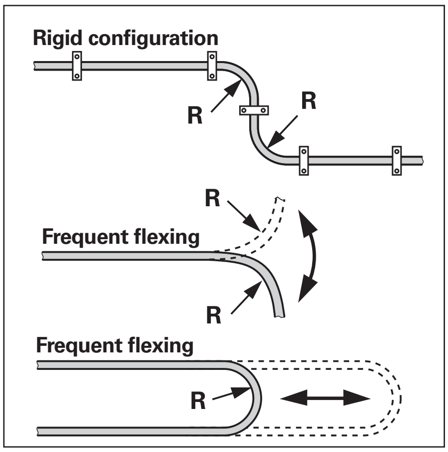
Where:
n_{max}: Elec. permissible speed in min^{-1}
v_{max}: Elec. permissible traversing velocity in m/min
f_{max}: Max. scanning/output frequency of encoder or input frequency of subsequent electronics in kHz
z: Line count of the angle or rotary encoder per 360°
SP: Signal period of the linear encoder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

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

Durability
PUR cables are resistant to oil in accordance with **VDE 0472** (Part 803/test type B) and to hydrolysis and 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 somewhat resistant to media, frequent flexing and continuous torsion.
PVC cables are oil resistant. The UL certification "AWM E64638 STYLE20789 105C VW-1SC NIKKO" is documented on the cable.
TPE wires with braided sleeving are oil resistant and highly flexible.



Temperature range

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

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

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

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

[1)] Metal armor

Noise-Free Signal Transmission

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

- **Noise immunity EN 61 000-6-2:** Specifically:
  - ESD — EN 61 000-4-2
  - Electromagnetic fields — EN 61 000-4-3
  - Burst — EN 61 000-4-4
  - Surge — EN 61 000-4-5
  - Conducted disturbances — EN 61 000-4-6
  - Power frequency magnetic fields — EN 61 000-4-8
  - Pulse magnetic fields — EN 61 000-4-9
- **Interference EN 61 000-6-4:** Specifically:
  - For industrial, scientific and medical equipment (ISM) — EN 55 011
  - For information technology equipment — EN 55 022

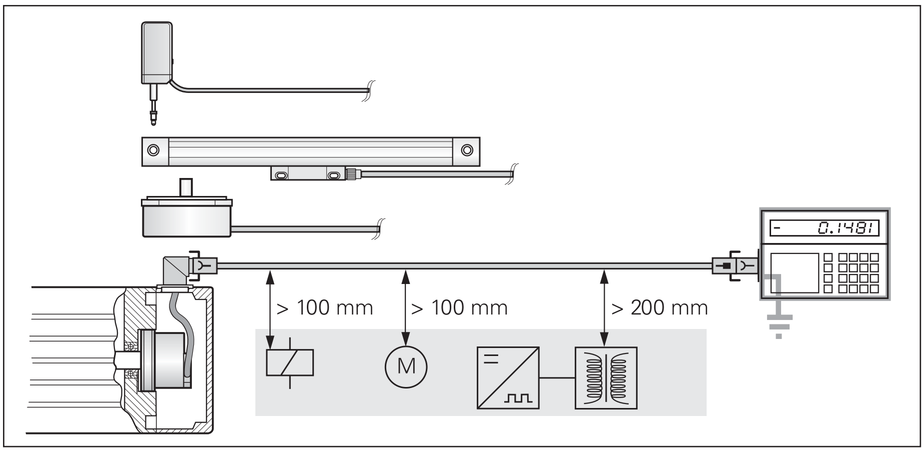
Transmission of measuring signals—electrical noise immunity
Noise voltages arise mainly through capacitive or inductive transfer. Electrical noise can be introduced into the system over signal lines and input or output terminals.

Possible sources of noise include:

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

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

- Use only original HEIDENHAIN cables. Consider the voltage drop on supply lines.
- Use connecting elements (such as connectors or terminal boxes) with metal housings. Only the signals and power supply of the connected encoder may be routed through these elements. Applications in which additional signals are sent through the connecting element require specific measures regarding electrical safety and EMC.
- Connect the housings of the encoder, connecting elements and subsequent electronics through the shield of the cable. Ensure that the shield has complete contact over the entire surface (360°). For encoders with more than one electrical connection, refer to the documentation for the respective product.
- For cables with multiple shields, the inner shields must be routed separately from the outer shield. Connect the inner shield to 0 V of the subsequent electronics. Do not connect the inner shields with the outer shield, neither in the encoder nor in the cable.
- Connect the shield to protective ground as per the mounting instructions.
- Prevent contact of the shield (e.g. connector housing) with other metal surfaces. Pay attention to this when installing cables.
- Do not install signal cables in the direct vicinity of interference sources (inductive consumers such as contactors, motors, frequency inverters, solenoids, etc.).
  - Sufficient decoupling from interference-signal-conducting cables can usually be achieved by an air clearance of 100 mm or, when cables are in metal ducts, by a grounded partition.
  - A minimum spacing of 200 mm to inductors in switch-mode power supplies is required.
- If compensating currents are to be expected within the overall system, a separate equipotential bonding conductor must be provided. The shield does not have the function of an equipotential bonding conductor.
- Provide power only from PELV systems **(EN 50 178)** to position encoders. Provide high-frequency grounding with low impedance **(EN 60 204-1 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 HEIDENHAIN encoders. The subdivision and counting electronics subdivide the sinusoidal input signals 4096-fold. A driver software package is included in delivery.

For more information, see the *IK 220 Product Information sheet.*

	IK 220			
Encoder inputs switchable	∼ 1 V_{PP}	∼ 11 μA_{PP}	EnDat 2.1	SSI
Connection	Two D-sub connections (15-pin, male)			
Input frequency	≤ 500 kHz	≤ 33 kHz	–	
Signal subdivision	4096-fold		–	
Internal memory	8192 position values per input			
Interface	PCI bus (plug and play)			
Driver software and demo program	**For Windows 2000/XP/Vista/7** in VISUAL C++, VISUAL BASIC and BORLAND DELPHI			

EIB 741
External interface box
The EIB 741 is ideal for applications requiring high resolution, fast measured-value acquisition, mobile data acquisition or data storage.

Up to four incremental or absolute HEIDENHAIN encoders can be connected to the EIB 741. The data is output over a standard Ethernet interface.

For more information, see the *EIB 741 Product Information sheet.*

	EIB 741		
Encoder inputs switchable	∼ 1 V_{PP}	EnDat 2.1	EnDat 2.2
Connection	Four D-sub connections (15-pin, female)		
Input frequency	≤ 500 kHz	–	
Signal subdivision	4096-fold	–	
Internal memory	Typically 250000 position values per input		
Interface	Ethernet as per IEEE 802.3 (≤ 1 gigabit)		
Driver software and demo program	**For Windows, Linux, LabView** Program examples		

HEIDENHAIN Measuring Equipment

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

For more information, see the *PWM 20, ATS Software Product Information sheet.*

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

	ATS
Languages	Choice between English or German
Functions	• Position display • Connection dialog • Diagnosis • Mounting wizard for EBI/ECI/EQI, LIP 200, LIC 4000 • Additional functions (if supported by the encoder) • Memory contents
System requirements	PC (dual-core processor; > 2 GHz); RAM > 1 GB; Windows XP, Vista, 7 (32 bits) operating system; 100 MB free space on hard disk

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