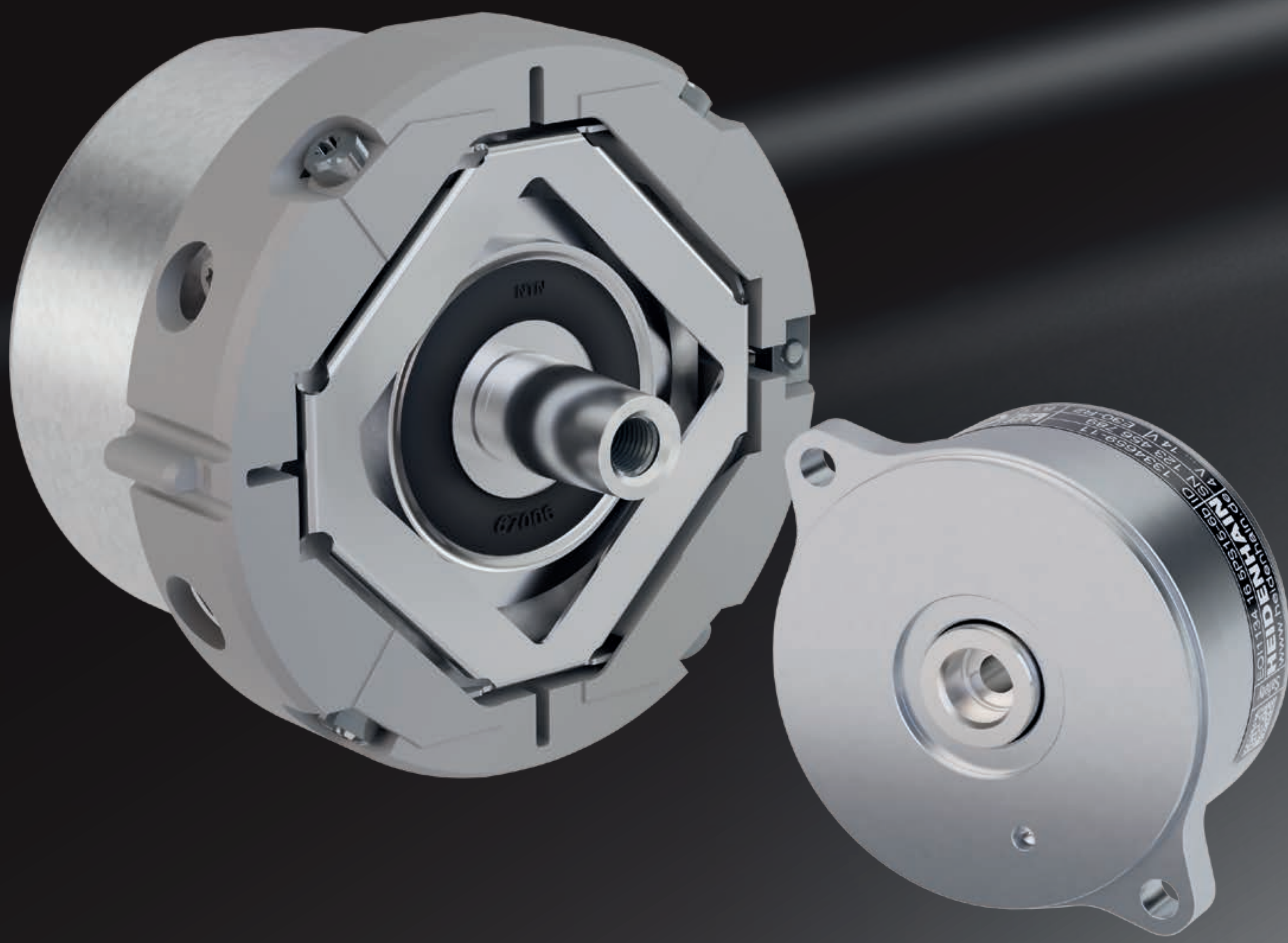
HEIDENHAIN



Encoders for Servo Drives

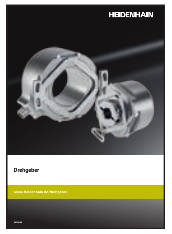
www.heidenhain.com/rotary-encoders

11/2024

This brochure is not an exhaustive overview of HEIDENHAIN products but rather provides a selection of **encoders designed for use on electric motors.**

The **selection tables** provide an overview of all HEIDENHAIN encoders intended for use on electric motors, along with their most relevant specifications. The descriptions of the **technical features** contain basic information on the use of rotary, angular and linear encoders on electric motors.

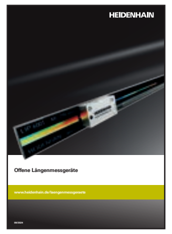
The **mounting information** and detailed **specifications** refer to **rotary encoders** developed specifically for servomotors. For information about other rotary encoders, please refer to the appropriate product documentation.



Brochure
Rotary Encoders

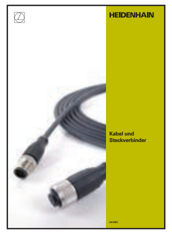
Brochure
Encoders for Elevators

Brochure
Angle Encoders
with Integral Bearing

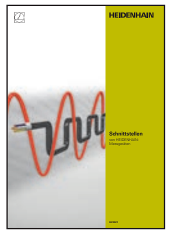


Brochure
Exposed
Linear Encoders

Brochure
Linear encoders
for Numerically Controlled Machine Tools



Brochure
Cables and Connecting Elements



Brochure
Interfaces
of HEIDENHAIN Encoders

Brochure
Modular
Angle Encoders
with Circular Scale

Brochure
Modular Angle Encoders
with Scale Drum or Scale Tape

For more information:

For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure.

This brochure supersedes all previous editions, which thereby become invalid. The basis for ordering from HEIDENHAIN is always the brochure edition and product documentation valid when the order is placed.

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

Contents

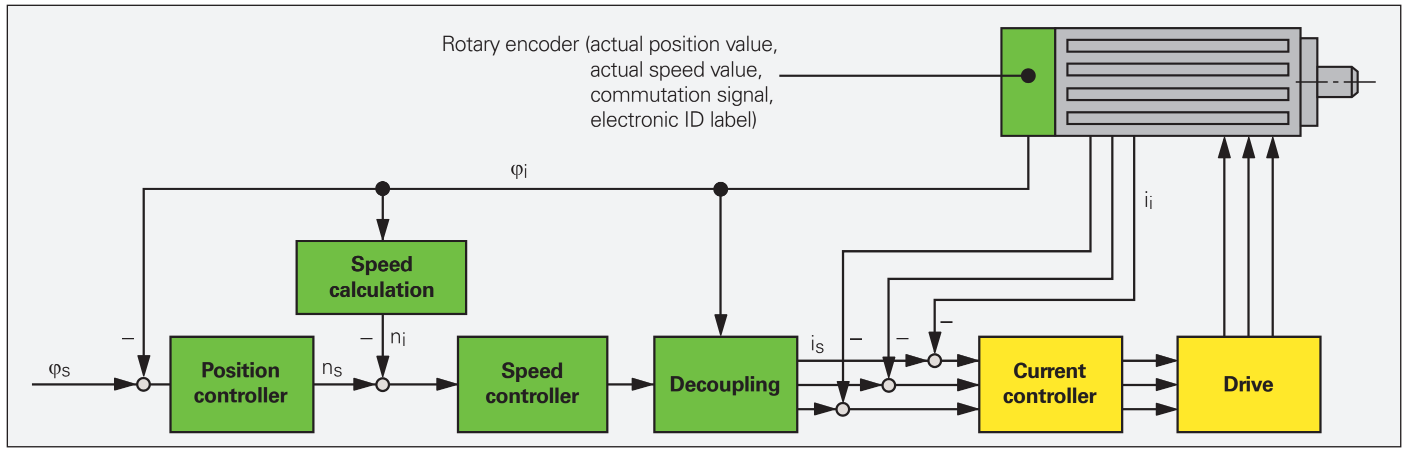
Encoders for servomotors

Controller systems for electric motors require encoders that provide feedback for the position and speed controllers, and for electronic commutation.

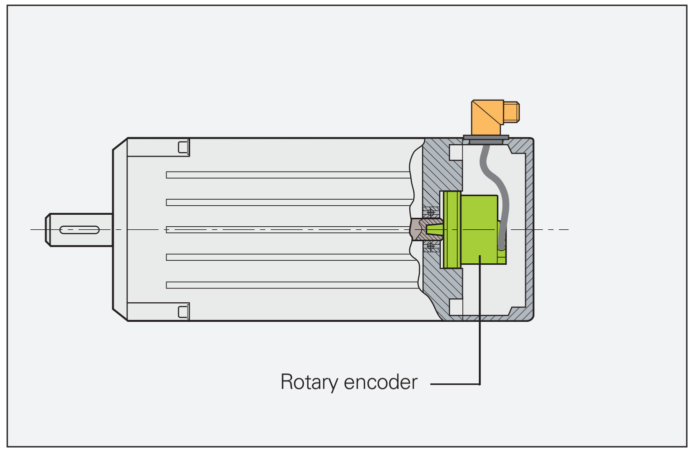
Encoder attributes have a critical impact on important motor characteristics, such as:
- Positioning accuracy
- Speed stability
- Bandwidth, and therefore command and disturbance behavior
- Power dissipation
- Size
- Acoustic noise
- Safety

All of the HEIDENHAIN encoders found in this brochure have been designed to minimize the cabling and installation work required by the motor manufacturer. Overall rotary motor length can also be kept low. Some encoders feature a special design that can even eliminate the need for safety devices such as limit switches.

Digital position control and speed control



Motor for digital drive systems (digital position and speed control)



Linear encoders

HEIDENHAIN provides just the right encoder for different rotary and linear motors in a variety of applications:

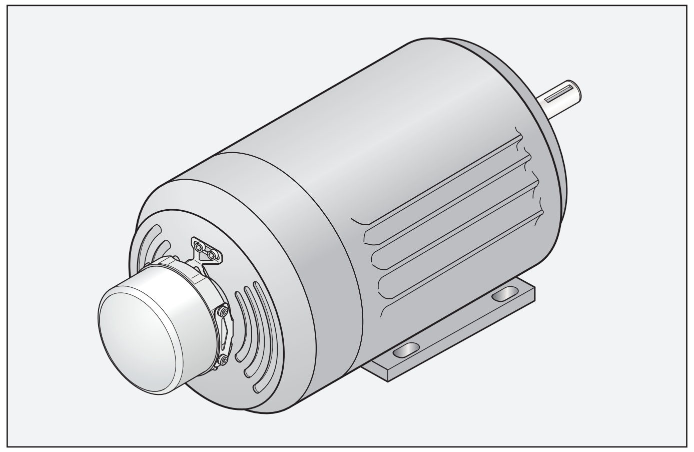
- Absolute and incremental rotary encoders with and without commutation tracks
- Absolute and incremental angle encoders
- Absolute and incremental linear encoders
- Absolute and incremental modular encoders

Rotary encoders

Angle encoders

Rotary encoders for mounting on motors
Rotary encoders for motors with forced-air cooling are either built onto the motor housing or integrated. These rotary encoders are often exposed to the motor's unfiltered forced-air stream and must therefore have a high protection rating of IP64 or better. The permissible operating temperature seldom exceeds 100 °C.

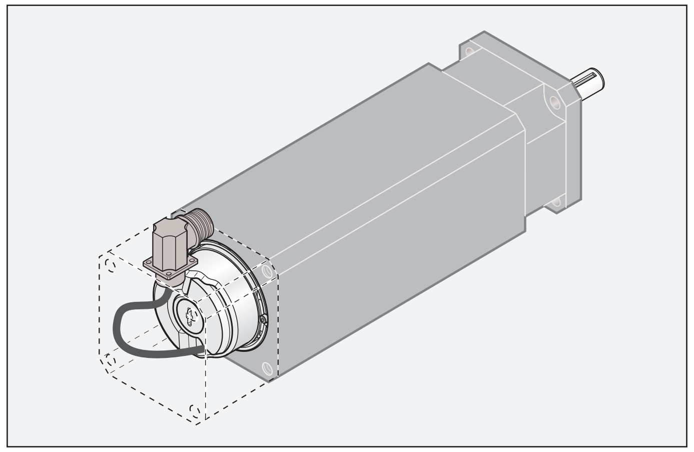
The selection table contains the following encoders:
- Rotary encoders with a mounted stator coupling featuring a high natural frequency (the motor's bandwidth is virtually unlimited)
- Rotary encoders for separate shaft couplings, particularly well suited for electrically isolated mounting
- Absolute rotary encoders with purely digital data transmission or additional sinusoidal TTL or HTL incremental signals
- Incremental rotary encoders with high-quality sinusoidal output signals for digital speed control
- Incremental rotary encoders with TTL- or HTL-compatible output signals
- Information on rotary encoders with **functional safety**, available as safety-related position measurement systems



For the selection table, see page 8

Rotary encoders for mounting inside motors
For motors without forced-air cooling, the rotary encoder is built into the motor housing. As a result, the encoder does not require a high protection rating. Nevertheless, the operating temperature inside the motor housing can reach 100 °C or more.

The selection table contains the following encoders:
- Absolute rotary encoders for operating temperatures of up to 115 °C, and incremental rotary encoders for operating temperatures of up to 120 °C
- Rotary encoders featuring a mounted stator coupling with a high natural frequency
- Absolute rotary encoders with purely digital data transmission (suitable for the HMC 6 and HMC 2 single-cable solutions) or additional sinusoidal incremental signals
- Incremental rotary encoders for digital speed control, featuring high-quality sinusoidal output signals, even under high operating temperatures
- Incremental rotary encoders with an additional commutation signal for BLDC motors
- Information on rotary encoders with **functional safety**, available as safety-related position measurement systems



For the selection table, see page 14

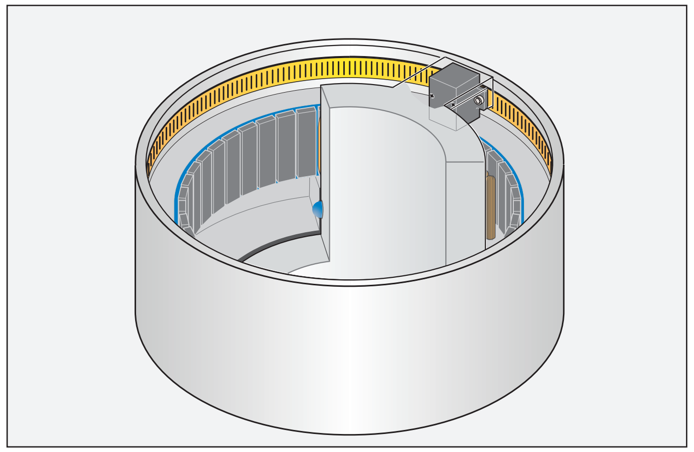
Rotary encoders for robot drive systems and other motors
The inductive KCI and KBI rotary encoders were designed specifically for robot drive systems, providing position feedback directly on the motor shaft or on the gearbox output shaft. These encoders comprise a scanning unit along with either a circular scale or a disk/hub assembly coupled to the mating shaft via a screw connection or via press-fitting, respectively. Connectivity for one external temperature sensor is also provided. If a drive system's motor shaft and output shaft are concentrically integrated, then the D*plus* dual encoders provide a solution that incorporates an additional circular scale or disk/hub assembly.

The selection guide covers the following topics:
- Rotary encoders for operating temperatures of up to 115 °C
- Various form factors for different axis sizes
- Various hub inside diameters for different shafts
- Information on rotary encoders with **functional safety**, available as safety-related position measurement systems

For the selection table, see page 18

Rotary encoders, modular encoders, and angle encoders for built-in and hollow-shaft motors
The rotary encoders and angle encoders for these motors feature **hollow through shafts**, allowing supply lines to be routed through the hollow shaft of both the motor and the encoder. Depending on the operating conditions, these encoders must either have an IP66 rating or be protected from contamination through the machine design (as with optical modular encoders).

- Encoders with high-quality **absolute and/or incremental output signals**
- Angle encoders and modular encoders with their measuring standard on an aluminum or steel drum for **shaft speeds of up to 42 000 rpm**
- Encoders with an integral bearing and a stator coupling, or modular designs
- Encoders with **good acceleration performance** for high control-loop bandwidth



See overview of brochures on page 2

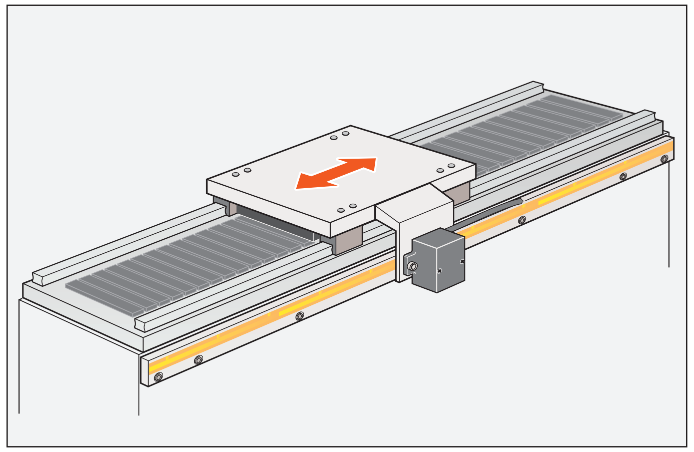
Linear encoders for linear motors
Linear encoders installed on linear motors provide actual-value feedback for the position and speed controllers. These encoders have a critical impact on the linear motor's control characteristics. The linear encoders recommended for this type of application exhibit the following characteristics:
- Low position error during acceleration in the direction of measurement
- High tolerance to acceleration and lateral vibration
- Design suitability for high shaft speeds
- Absolute position information with purely digital data transmission or high-quality sinusoidal incremental signals

Exposed linear encoders feature the following characteristics:
- Higher accuracy grades
- Higher traversing speeds
- Non-contact scanning (i.e., no friction between scanning head and scale)

Exposed linear encoders are suitable for applications in clean environments (e.g., on measuring machines or production equipment in the semiconductor industry).

Sealed linear encoders feature the following characteristics:
- High protection rating
- Easy installation

Sealed linear encoders are thus suitable for applications in high-contamination environments (e.g., on machine tools).

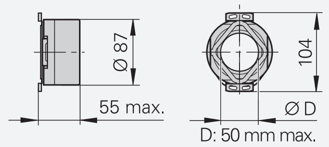
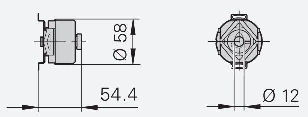
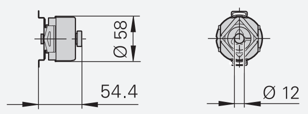
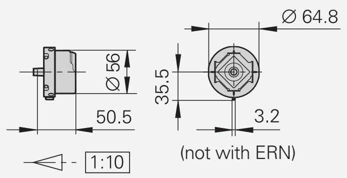
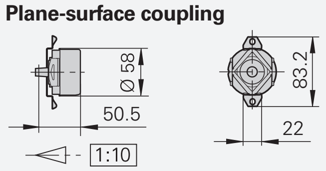


See overview of brochures on page 2

Selection guide

Rotary encoders for mounting on motors

Protection rating: up to IP64 (EN 60529)

Series	Main dimensions	Mechanically permissible shaft speed	Natural frequency f_N (typical) of the coupling	Maximum operating temperature	Supply voltage	Signal periods per revolution	Positions per revolution	Distinguishable revolutions	Interface	Model	Further information
Rotary encoders with integral bearing and mounted stator coupling											
ECN/ERN 100		*Ø ≤ 30 mm:* ≤ 6000 rpm *Ø > 30 mm:* ≤ 4000 rpm	1000 Hz	100 °C	3.6 V to 14 V DC	2048	8192 (13 bits)	–	EnDat 2.2/01 with ∼ 1 V_{PP}	**ECN 113**	**Brochure: *Rotary Encoders***
						–	33554432 (25 bits)		EnDat 2.2/22	**ECN 125**	
					DC 5 V ±0.5 V	1000 to 5000	–		⊓⊔TTL/∼ 1 V_{PP}	**ERN 120/ERN 180**	
				85 °C	10 V to 30 V DC				⊓⊔ HTL	**ERN 130**	
ECN/EQN/ERN 400	**Stator coupling for plane surfaces** 	≤ 6000 rpm *With two shaft clampings (only for hollow through shaft):* ≤ 12000 rpm	*Stator coupling for plane surfaces:* 1500 Hz	100 °C	3.6 V to 14 V DC	512/2048	8192 (13 bits)	–/4096	EnDat 2.2/01 ∼ 1 V_{PP}	**ECN 413/EQN 425**	
						–	33554432 (25 bits)		EnDat 2.2/22	**ECN 425/EQN 437**[1]	
					4.75 V to 30 V DC	512	8192 (13 bits)		SSI	**ECN 413/EQN 425**	
					DC 5 V ±0.5 V	250 to 5000	–		⊓⊔TTL	**ERN 420**	
					10 V to 30 V DC				⊓⊔ HTL	**ERN 430**	
				70 °C					⊓⊔TTL	**ERN 460**	
				100 °C	DC 5 V ±0.5 V	1000 to 5000			∼ 1 V_{PP}	**ERN 480**	
ECN/EQN/ERN 400	**Stator coupling for plane surfaces** 	≤ 6000 rpm *With two shaft clampings (only for hollow through shaft):* ≤ 12000 rpm	*Stator coupling for plane surfaces:* 1500 Hz	100 °C	10 V to 30 V DC	256 to 2048	8192 (13 bits)	–/4096	EnDat H ⊓⊔ HTL SSI 41H ⊓⊔ HTL	**EQN 425**	**Brochure: *Rotary Encoders***
					4.75 V to 30 V DC	512 to 4096			EnDat T ⊓⊔TTL SSI 41T ⊓⊔TTL		
					3.6 V to 14 V DC	–	αi: 33554432 (25 bits)	4096	Fanuc	**ECN 425 F/EQN 437 F**	
					DC 10 V to 28.8 V		16777216 (24 bits)		DRIVE-CLiQ	**ECN 424 S/EQN 436 S**[1]	
ECN/EQN/ERN 400	**Expanding ring coupling**  **Plane-surface coupling** 	≤ 15000 rpm/ ≤ 12000 rpm	*Expanding ring coupling:* 1800 Hz *Plane-surface coupling:* 400 Hz	100 °C	3.6 V to 14 V DC	2048	8192 (13 bits)	–/4096	EnDat 2.2/01 with ∼ 1 V_{PP}	**ECN 413/EQN 425**	**Page 60**
						–	33554432 (25 bits)		EnDat 2.2/22	**ECN 425**[1]**/EQN 437**[1]	
		≤ 15000 rpm			DC 5 V ±0.5 V	1024 to 5000	–		⊓⊔TTL	**ERN 421**	**Product Information document**
					DC 5 V ±0.25 V	2048	Z1 track for sine commutation		∼ 1 V_{PP}	**ERN 487**	

[1] Also available with functional safety

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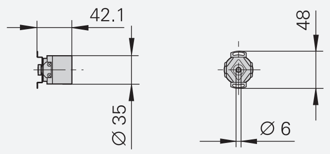
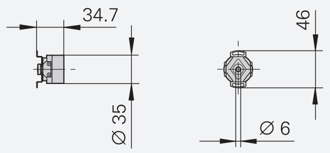
Rotary encoders for mounting on motors

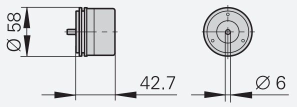
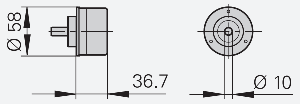
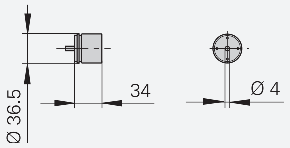
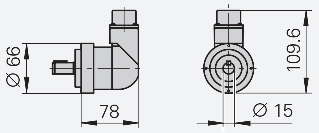
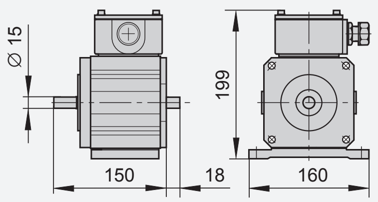
Protection rating: up to IP64 (EN 60529)

Series	Main dimensions	Mechanically permissible shaft speed	Natural frequency f_N (typical) of the coupling	Maximum operating temperature	Supply voltage	Signal periods per revolution	Positions per revolution	Distinguishable revolutions	Interface	Model	Further information
Rotary encoders with integral bearing and mounted stator coupling											
ECN/EQN/ERN 1000	 ERN 1023 	≤ 12000 rpm	1500 Hz	100 °C	3.6 V to 14 V DC	512	8192 (13 bits)	–/4096	EnDat 2.2/01 with ∿ 1 V_{PP}	**ECN 1013/EQN 1025**	**Brochure:** ***Rotary Encoders***
						–	8388608 (23 bits)		EnDat 2.2/22	**ECN 1023/EQN 1035**	
				95 °C	DC 5 V ±0.5 V	100 to 3600	–		⊓⊔TTL/∿ 1 V_{PP}	**ERN 1020/ERN 1080**	
				70 °C	10 V to 30 V DC				⊓⊔ HTLs	**ERN 1030**	
					DC 5 V ±0.25 V	5000 to 36000[1]			⊓⊔TTL	**ERN 1070**	
		≤ 6000 rpm	1600 Hz	90 °C	DC 5 V ±0.5 V	500 to 8192	3 block commutation signals		⊓⊔TTL	**ERN 1023**	**Page 52**

[1] After internal 5-fold or 10-fold interpolation

Rotary encoders for mounting on motors

Protection rating: up to IP64 (EN 60529)

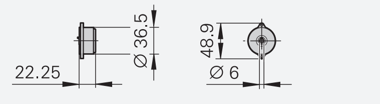
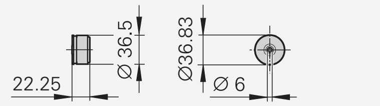
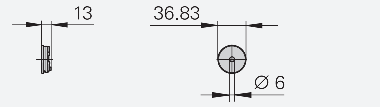
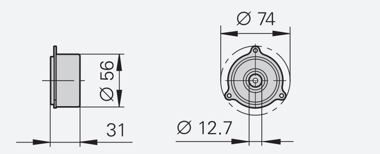
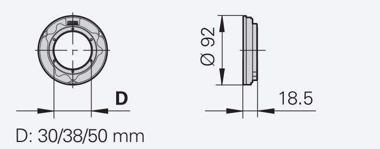
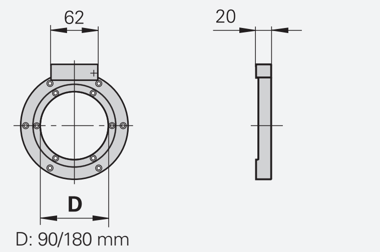
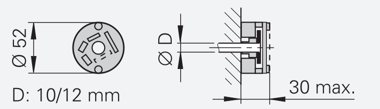
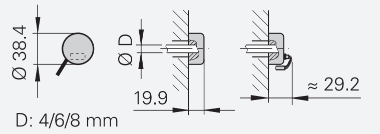
Series	Main dimensions	Mechanically permissible shaft speed	Natural frequency f_N (typical) of the coupling	Maximum operating temperature	Supply voltage	Signal periods per revolution	Positions per revolution	Distinguishable revolutions	Interface	Model	Further information
Rotary encoders with integral bearing for separate shaft coupling											
ROC/ROQ/ROD 400	**synchro flange**  **clamping flange** 	≤ 12000 rpm	–	100 °C	3.6 V to 14 V DC	512/2048	8192 (13 bits)	–/4096	EnDat 2.2/01 with $\sim$ 1 V_{PP}	**ROC 413/ROQ 425**	**Brochure:** ***Rotary Encoders***
						–	33554432 (25 bits)		EnDat 2.2/22	**ROC 425[1]/ROQ 437[1]**	
					4.75 V to 30 V DC	512	8192 (13 bits)	–	SSI	**ROC 413/ROQ 425**	
					10 V to 30 V DC	256 to 2048	8192 (13 bits)	–/4096	EnDat H ⊓⊔ HTL SSI 41H ⊓⊔ HTL	**ROQ 425[3]**	
					4.75 V to 30 V DC	512 to 4096		–	EnDat T ⊓⊔TTL SSI 41T ⊓⊔TTL		
					3.6 V to 14 V DC	–	αi: 33554432 (25 bits)	4096	Fanuc	**ROC 425 F/ROQ 437 F**	
					DC 10 V to 28.8 V		16777216 (24 bits)		DRIVE-CLiQ	**ROC 424 S/EQN 436 S[1]**	
					DC 5 V ±0.5 V	50 to 5000	–	–	⊓⊔TTL	**ROD 426/ROD 420**	
					10 V to 30 V DC	50 to 5000			⊓⊔ HTL	**ROD 436/ROD 430**	
				70 °C		50 to 5000			⊓⊔TTL	**ROD 466**	
				100 °C	DC 5 V ±0.5 V	1000 to 5000			$\sim$ 1 V_{PP}	**ROD 486/ROD 480**	
ROC/ROQ/ROD 1000		≤ 12000 rpm	–	100 °C	3.6 V to 14 V DC	512	8192 (13 bits)	–/4096	EnDat 2.2/01 with $\sim$ 1 V_{PP}	**ROC 1013/ROQ 1025**	**Brochure:** ***Rotary Encoders***
						–	8388608 (23 bits)		EnDat 2.2/22	**ROC 1023/ROQ 1035**	
					DC 5 V ±0.5 V	100 to 3600	–		⊓⊔TTL	**ROD 1020**	
									$\sim$ 1 V_{PP}	**ROD 1080**	
				70 °C	10 V to 30 V DC				⊓⊔HTLs	**ROD 1030**	
					DC 5 V ±0.25 V	5000 to 36000[2]			⊓⊔TTL	**ROD 1070**	
ROD 600		≤ 12000 rpm	–	80 °C	DC 5 V ±0.5 V	512 to 5000	–		⊓⊔TTL	**ROD 620**	
									⊓⊔ HTL	**ROD 630**	
ROD 1900		≤ 4000 rpm	–	70 °C	10 V to 30 V DC	600 to 2400	–		⊓⊔ HTL/HTLs	**ROD 1930**	

1) Also available with functional safety
2) After integrated 5-fold or 10-fold interpolation
3) Only clamping flange

DRIVE-CLiQ is a registered trademark of Siemens AG

Rotary encoders for mounting inside motors

Protection rating: up to IP40 (EN 60529)

Series	Main dimensions	Mechanically permissible shaft speed	Natural frequency f_N (typical) of the coupling	Maximum operating temperature	Supply voltage	Signal periods per revolution	Positions per revolution	Distinguishable revolutions	Interface	Model	Further information
Rotary encoders without integral bearing											
ECI/EQI 1100		≤ 15000 rpm/ ≤ 12000 rpm	–	110 °C	3.6 V to 14 V DC	–	524288 (19 bits)	–/4096	EnDat 2.2/22	**ECI 1119[1]/EQI 1131[1]**	**Page 64 and Product Information document**
					4 V to 14 V DC				EnDat 3/E30-R2		
ECI/EQI 1100 with synchro flange					3.6 V to 14 V DC				EnDat 2.2/22		
ECI/EBI 1100				115 °C			262144 (18 bits)	–/65536[3]		**ECI 1118/EBI 1135**	**Page 72**
ECI/EBI/EQI 1300		≤ 15000 rpm/ ≤ 12000 rpm	–	115 °C	3.6 V to 14 V DC	–	524288 (19 bits)	–/65536/4096[3]	EnDat 2.2/22	**ECI 1319[1]/EQI 1331[1]/ EBI 1335[1)3)]**	**Page 70**
					4 V to 14 V DC			–/4096	EnDat 3/E30-R2	**ECI 1319[1]/EQI 1331[1]**	**Page 72**
				100 °C	DC 10 V to 28.8 V				DRIVE-CLiQ	**ECI 1319 S/EQI 1331 S[1]**	**Page 74**
ECI/EBI 100		≤ 6000 rpm	–	115 °C	3.6 V to 14 V DC	32	524288 (19 bits)	–	EnDat 2.1/01 with ∿ 1 V_{PP}	**ECI 119**	**Page 76**
						–		–/65536[3]	EnDat 2.2/22	**ECI 119/EBI 135**	
ECI/EBI 4000		≤ 6000 rpm	–	115 °C	3.6 V to 14 V DC	–	1048576 (20 bits)	–/65536[3]	EnDat 2.2/22	**ECI 4010[1]/EBI 4010[3]**	**Page 78**
				100 °C	DC 10 V to 28.8 V			–	DRIVE-CLiQ	**ECI 4090 S[1]**	
ERO 1200		≤ 25000 rpm	–	100 °C	DC 5 V ±0.5 V	1024/2048	–		⊓⊔TTL	**ERO 1225**	**Page 82**
									∿ 1 V_{PP}	**ERO 1285**	
ERO 1400		≤ 30000 rpm	–	70 °C	DC 5 V ±0.5 V	512/1000/1024	–		⊓⊔TTL	**ERO 1420**	**Page 84**
					DC 5 V ±0.25 V	5000 to 37500[2]			⊓⊔TTL	**ERO 1470**	
					DC 5 V ±0.5 V	512/1000/1024			∿ 1 V_{PP}	**ERO 1480**	

[1] Also available with functional safety
[2] After internal 5-, 10-, 20-, or 25-fold interpolation
[3] Multiturn function via battery-buffered revolution counter

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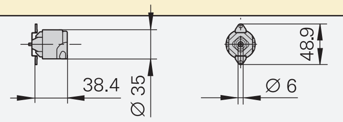
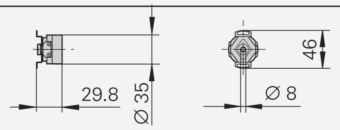
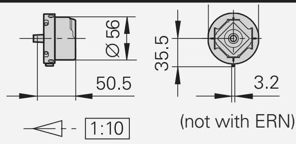
Rotary encoders for mounting inside motors

Protection rating: up to IP40 (EN 60529)

Series	Main dimensions	Mechanically permissible shaft speed	Natural frequency f_N (typical) of the coupling	Maximum operating temperature	Supply voltage	Signal periods per revolution	Positions per revolution	Distinguishable revolutions	Interface	Model	Further information
Rotary encoders with integral bearing and mounted stator coupling											
ECN/EQN/ERN 1100		≤ 12000 rpm	1000 Hz	115 °C	3.6 V to 14 V DC	512	8192 (13 bits)	–/4096	EnDat 2.2/01 with ∼ 1 V_{PP}	**ECN 1113/EQN 1125**	**Page 50**
					3.6 V to 14 V DC	–	8388608 (23 bits)		EnDat 2.2/22	**ECN 1123[1)]/EQN 1135[1)]**	
		≤ 6000 rpm	1600 Hz	90 °C	DC 5 V ±0.5 V	500 to 8192	3 block commutation signals		⊓⊔TTL	**ERN 1123**	**Page 54**
ECN/EQN/ERN 1300	 (not with ERN)	≤ 15000 rpm/ ≤ 12000 rpm	1800 Hz	115 °C	3.6 V to 14 V DC	512/2048	8192 (13 bits)	–/4096	EnDat 2.2/01 with ∼ 1 V_{PP}	**ECN 1313/EQN 1325**	**Page 56**
						–	33554432 (25 bits)		EnDat 2.2/22	**ECN 1325[1)]/EQN 1337[1)]**	
					4 V to 14 V DC				EnDat 3/E30-R2		
				100 °C	DC 10 V to 28.8 V	–	16777216 (24 bits)		DRIVE-CLiQ	**ECN 1324 S/EQN 1336 S**	**Page 58**
		≤ 15000 rpm		120 °C *ERN 1381/4096:* 80 °C	DC 5 V ±0.5 V	1024/2048/4096	–		⊓⊔TTL	**ERN 1321**	**Page 62**
							3 block commutation signals			**ERN 1326**	
						512/2048/4096	–		∼ 1 V_{PP}	**ERN 1381**	
					DC 5 V ±0.25 V	2048	Z1 track for sine commutation			**ERN 1387**	

1) Also available with functional safety

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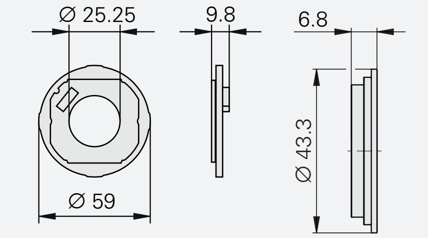
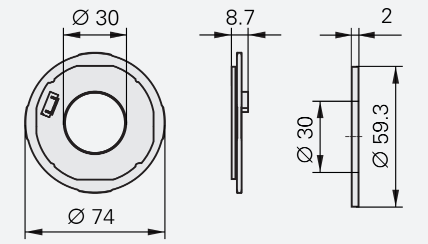
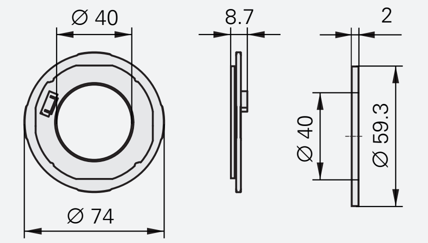
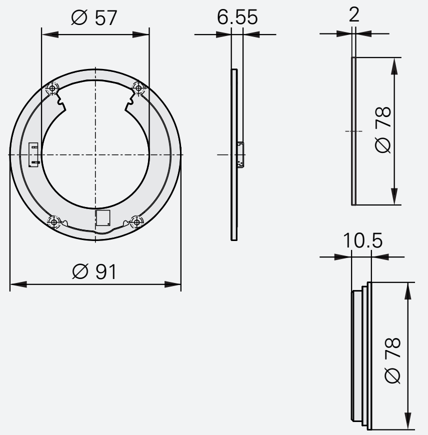
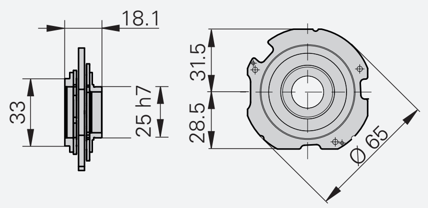
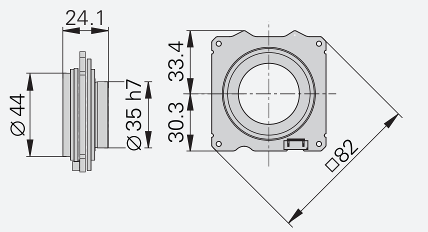
Rotary encoders for robot drive systems and other motors

Protection rating: IP00 (EN 60529)

Series	Main dimensions	Mechanically permissible shaft speed	Natural frequency f_N (typical) of the coupling	Maximum operating temperature	Supply voltage	Signal periods per revolution	Positions per revolution	Distinguishable revolutions[1]	Interface	Model	Further information
KCI/KBI 1300 Hollow shaft diameter: 25 mm		≤ 10000 rpm	–	115 °C	DC 3.6 V to 14 V	–	524288 (19 bits)	–	EnDat 2.2	**KCI 1319**	***Product Information document***
								65536 (16 bits)		**KBI 1335**	
KCI/KBI 100 Hollow shaft diameter: 30 mm		≤ 10000 rpm					1048576 (20 bits)	–		**KCI 120**	
								65536 (16 bits)		**KBI 136**	
KCI/KBI 100 Hollow shaft diameter: 40 mm		≤ 10000 rpm					1048576 (20 bits)	–		**KCI 120**	
								65536 (16 bits)		**KBI 136**	
KCI/KBI 100 Hollow shaft diameter: 55 mm		≤ 10000 rpm					1048576 (20 bits)	–		**KCI 120**	
		≤ 6000 rpm						65536 (16 bits)		**KBI 136**	
KCI/KBI 100 D*plus* AE 04		Motor side: ≤ 15000 rpm Output side: ≤ 6000 rpm					Motor side: 524288 (19 bits) Output side: 1048576 (20 bits)	–		**KCI 120 D*plus***	
								65536 (16 bits)		**KBI 136 D*plus***	
KCI/KBI 100 D*plus* AE 07		Motor side: ≤ 15000 rpm Output side: ≤ 6000 rpm					Motor side: 524288 (19 bits) Output side: 1048576 (20 bits)	–		**KCI 120 D*plus***	

All variants are available with functional safety

[1] Multiturn function via battery-buffered revolution counter

Rotary encoders and angle encoders for DC and three-phase AC motors
General information

Speed stability
In order to obtain **good motor speed stability**, the encoder must provide a **high number of measuring steps per revolution**. For this reason, the HEIDENHAIN product portfolio includes encoders that output a sufficient number of measuring steps per revolution for the required speed stability.

HEIDENHAIN rotary encoders and angle encoders with an integral bearing and stator coupling exhibit particularly beneficial behavior: shaft misalignment within a certain tolerance range does not induce position errors or impair the speed stability (see *Specifications*).

Position errors within one signal period adversely affect the positioning accuracy and speed stability of the motor. At low feed rates, the motor mimics the position error within one signal period.

Transmission of measuring signals
For good dynamic performance with digital speed control, the cycle time of the speed controller should not exceed approximately 125 µs. In addition, the actual values for the position controller and speed controller must be available to the controlling system with the least possible delay.

High clock frequencies are needed to fulfill such demanding time requirements on position-value transmission from the encoder to the controlling system with serial data transmission (see also the *Interfaces of HEIDENHAIN Encoders* brochure). HEIDENHAIN encoders for electric motors therefore output position values over the fast, **purely serial EnDat 2.2 or EnDat 3 interface**, or transmit additional **incremental signals** that are available with virtually no delay to the downstream electronics for speed and position control.

For **standard motors,** manufacturers primarily use the especially robust **ECI/EBI/EQI** encoders without integral bearing or rotary encoders with **TTL** or **HTL compatible output signals**, as well as additional commutation signals for permanent DC motors.

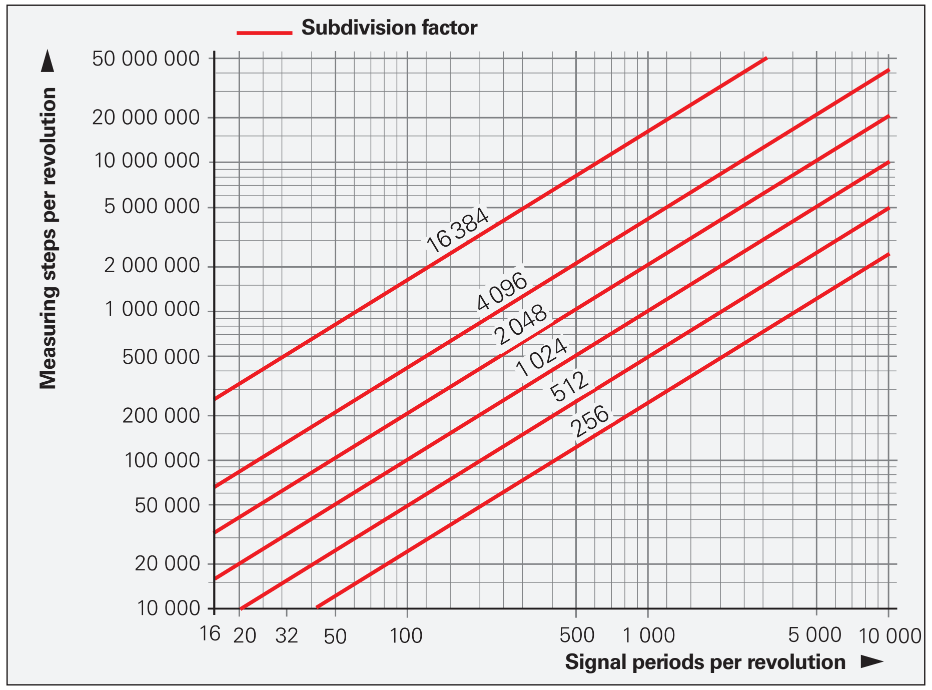
For **digital speed control** on machines with **high dynamic-performance requirements**, a large number of measuring steps are required, usually more than 500 000 per revolution. For applications with standard motors, approximately 60 000 measuring steps per revolution are sufficient (similar to resolvers).

HEIDENHAIN encoders for motors with digital position and speed control are therefore equipped with the **purely serial EnDat22/EnDat 3 interface**, or they output additional **sinusoidal incremental signals** at 1 V_{PP} signal levels (EnDat01).

The high internal resolution of the **EnDat22** and **EnDat 3** encoders permits resolutions of up to 22 bits (4 194 304 measuring steps) in inductive systems and of at least 25 bits (approx. 33 million measuring steps) in photoelectric encoders.

The sinusoidal incremental signals of the **EnDat01** encoders can, due to their high quality, be highly subdivided in the downstream electronics (see Figure 1). Even at speeds of 12 000 rpm, the signal arrives at the input circuit of the controlling system with a frequency of only approximately 400 kHz (see Figure 2). Cable lengths of up to 150 m are possible with 1 V_{PP} incremental signals (see also *1 V_{PP} incremental signals*).

Figure 1:
Signal periods per revolution and the resulting number of measuring steps per revolution as a function of the subdivision factor



HEIDENHAIN absolute encoders for "digital" motors deliver additional sinusoidal incremental signals with the same characteristics as those described above. Absolute encoders from HEIDENHAIN use the EnDat interface (for Encoder Data) for the **serial data transmission** of absolute position feedback and other information for **automatic self-configuration, monitoring and diagnosis.** This makes it possible to use the same downstream electronics and cabling technology for all HEIDENHAIN encoders.

With EnDat22 (HMC 6) and EnDat 3 (HMC 2), the serial data transmission can take place inside the motor cable. Cabling work and costs are thereby significantly reduced.

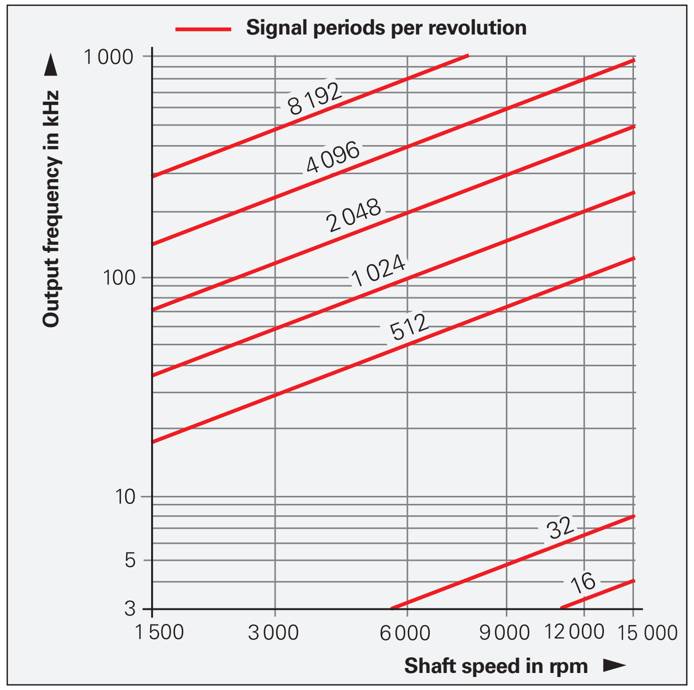
For **automatic configuration**, important **encoder specifications** can be read from the memory of the EnDat encoder, and **motor-specific parameters** can be saved in the encoder's OEM memory area. The usable size of the OEM memory for the rotary encoders listed in the current brochures is at least 1.4 KB (≙ 704 EnDat words).

Most absolute encoders internally subdivide the sinusoidal scanning signals by a factor of 4096 or greater. When these systems are operated with sufficiently **fast transmission** of the absolute position feedback (e.g., at a clock frequency of 2 MHz with EnDat 2.1 or 16 MHz with **EnDat 2.2**) or EnDat 3 (12.5 or 25 Mbit/s), **incremental signal evaluation can be eliminated altogether**.

The benefits of this data transmission technology are **higher noise immunity** along the transmission path and **more cost-efficient connectors and cables.** A large portion of rotary encoders equipped with the EnDat 2.2 or EnDat 3 interface are also able **to evaluate** an external **temperature sensor** (e.g., located in the motor winding). The digitized temperature values are transmitted as part of the EnDat 2.2 or EnDat 3 protocol without an additional line.

Bandwidth
The attainable gain levels for the position and speed control loops, and therefore the bandwidth of the motor with regard to command and disturbance behavior, may be limited by the rigidity of the coupling between the motor shaft and the encoder shaft, as well as by the natural frequency of the stator coupling. HEIDENHAIN therefore offers rotary and angle encoders for high-rigidity shaft couplings.
The stator couplings mounted on the encoder exhibit **high natural frequencies f_N**. With modular and inductive rotary encoders, the stator and rotor are firmly screwed to the motor housing and the shaft (see also *Mechanical design types and mounting*). This mechanical design therefore permits **optimal coupling rigidity**.

Figure 2:
Shaft speed and resulting output frequency as a function of the number of signal periods per revolution



Motor currents
Motors may exhibit impermissible current flowing from the rotor to the stator. This can cause the encoder bearing to overheat, thus shortening its service life. HEIDENHAIN therefore recommends the use of encoders without an integral bearing or encoders with an electrically isolated bearing (hybrid bearing). For more information, please contact HEIDENHAIN.

Fault exclusion for mechanical coupling
HEIDENHAIN encoders designed for functional safety can be mounted in such a way that the rotor or stator fastening does not accidentally loosen.

Size
The higher a motor's permissible operating temperature is, the smaller the motor can be made for a given torque. Since the temperature of the motor also affects the temperature of the encoder, HEIDENHAIN offers encoders for **permissible operating temperatures of up to 120 °C.** These encoders make it possible to implement smaller motors.

Power dissipation and acoustic noise
While the motor is running, encoder position errors within one signal period affect the motor's power dissipation as well as the heat generation and acoustic noise that go along with it. For this reason, rotary encoders with a high signal quality of better than ±1 % of the signal period are preferred (see also *Measuring accuracy*).

Bit error rate
For rotary encoders with a purely serial interface for installation within motors, HEIDENHAIN recommends conducting a type test for the bit error rate.

The use of functionally safe encoders without closed metal housings and/or with cable assemblies that do not comply with the electrical connection directives (see *General electrical information*) always requires the bit error rate to be measured in a type test under application conditions.

Preventive maintenance
Encoders with serial data transfer provide information that enables monitoring of the operating status and thus preventive maintenance:
- Diagnostics
- Clearance gap for optimized and verifiable mounting and application conditions
- Connectable external temperature sensor

HMC 2 and HMC 6
Single-cable solutions for servomotors

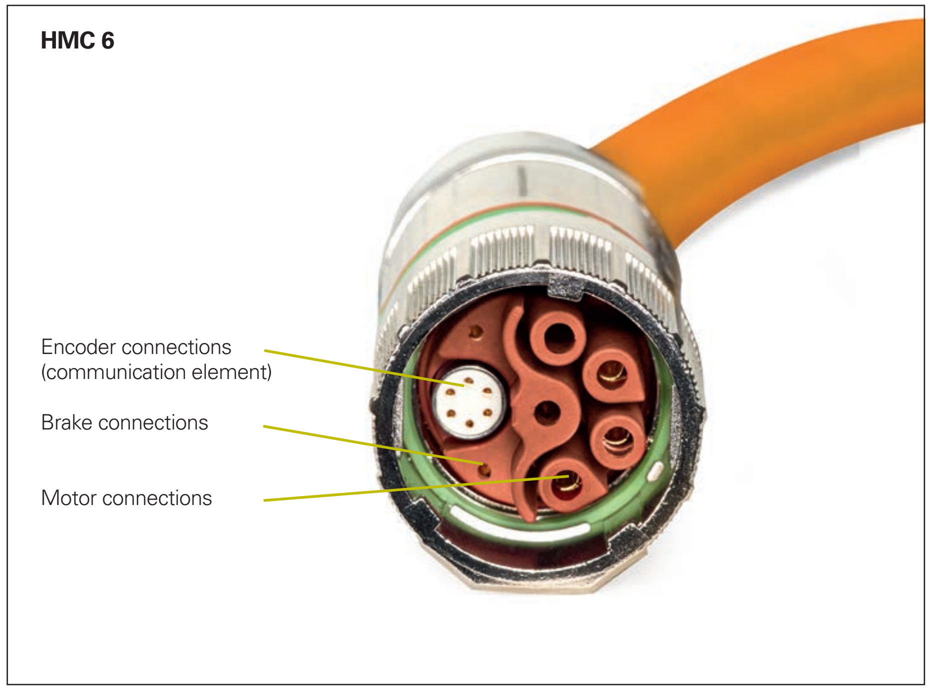
Servomotors normally require two separate pre-assembled cables:
- One cable for the motor encoder
- One cable for motor power

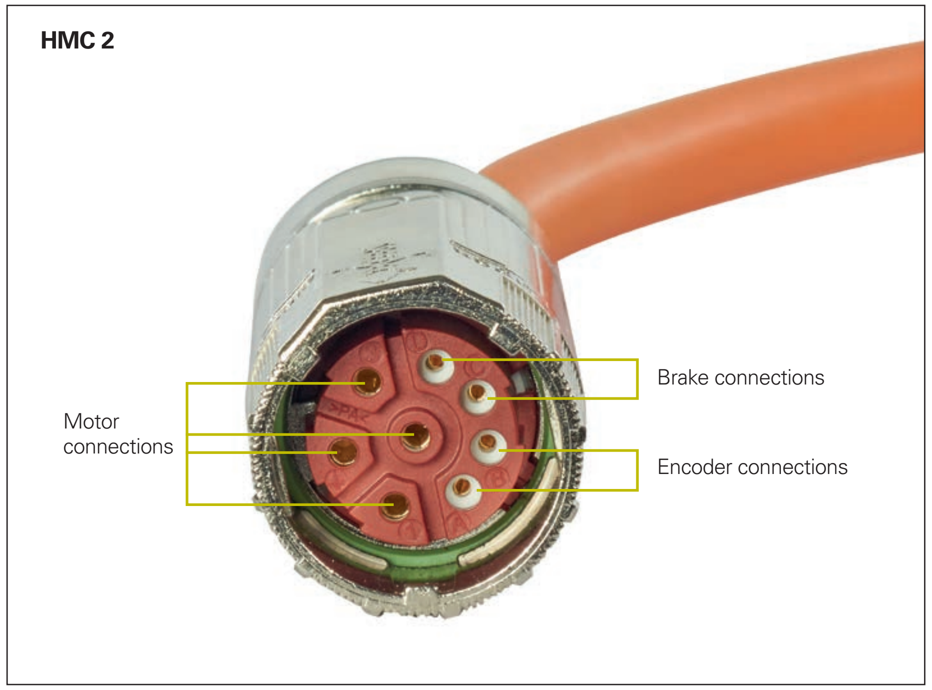
With the **HMC** solution (Hybrid Motor Cable), HEIDENHAIN has integrated the encoder cable into the power cable. Thus, only **one cable** is now needed between the motor and the electrical cabinet.

The HMC 6 single-cable solution was specifically designed for the HEIDENHAIN **EnDat22** interface, and HMC 2 for **EnDat 3**. With purely serial data transmission, cable lengths of up to 100 m can be realized. With HMC 6, all other encoders equipped with a purely serial RS-485 interface (e.g., SSI) can be connected as well. A wide range of encoders can therefore be used without the need for introducing a new interface.

The HMC solution combines the wires for the encoder, motor, and brake into a single cable, which is connected to the motor via a special connector. For connection to the frequency inverter, the cable is split into power connections, brake connections and an encoder connection.

When the components are correctly assembled, the connecting elements attain an IP67 rating.





Advantages
The HMC single-cable solutions offer a series of cost and quality benefits for motor and machine manufacturers:
- Continued utilization of existing interfaces
- Smaller drag chains
- Significant improvement in drag-chain suitability thanks to fewer cables
- Wide range of available encoders for HMC 2 and HMC 6 transmission
- Eliminated separate assignment of power cables and encoder cables in the machine
- Reduced mechanical requirements (flange socket on the motor, cable ducts in the machine housing)
- Reduced logistics for cables and connectors
- Easier and faster installation
- Reduced documentation
- Fewer required servicing components
- Smaller motor profile with cable attached, enabling easier integration into the machine housing
- HEIDENHAIN-tested combination of power and encoder cable

The universal design of the HMC solution gives motor and machine manufacturers high flexibility, letting them use standard components on both the motor and the control.

All HEIDENHAIN encoders with the EnDat22 interface or with purely serial data transfer without battery buffering as per RS-485 are suited for the HMC 6 single-cable solution. This includes motor encoders for servomotors in various sizes, linear and angle encoders used in direct drive motors, and encoders for **functional safety** up to SIL 3.

The HMC 2 single-cable solution can be used with **motor encoders featuring the EnDat 3 interface** (ordering designation: E30-R2) and purely serial data transmission via two wires. The ExI 1100/1300 and ExN 1300 series rotary encoders are available for functional safety applications with up to SIL 3.

For the controlling hardware you can continue to use already deployed frequency inverters or controller units. The HMC cables have been designed for easy assembly of the matching connecting elements. Importantly, this does not impair noise immunity.

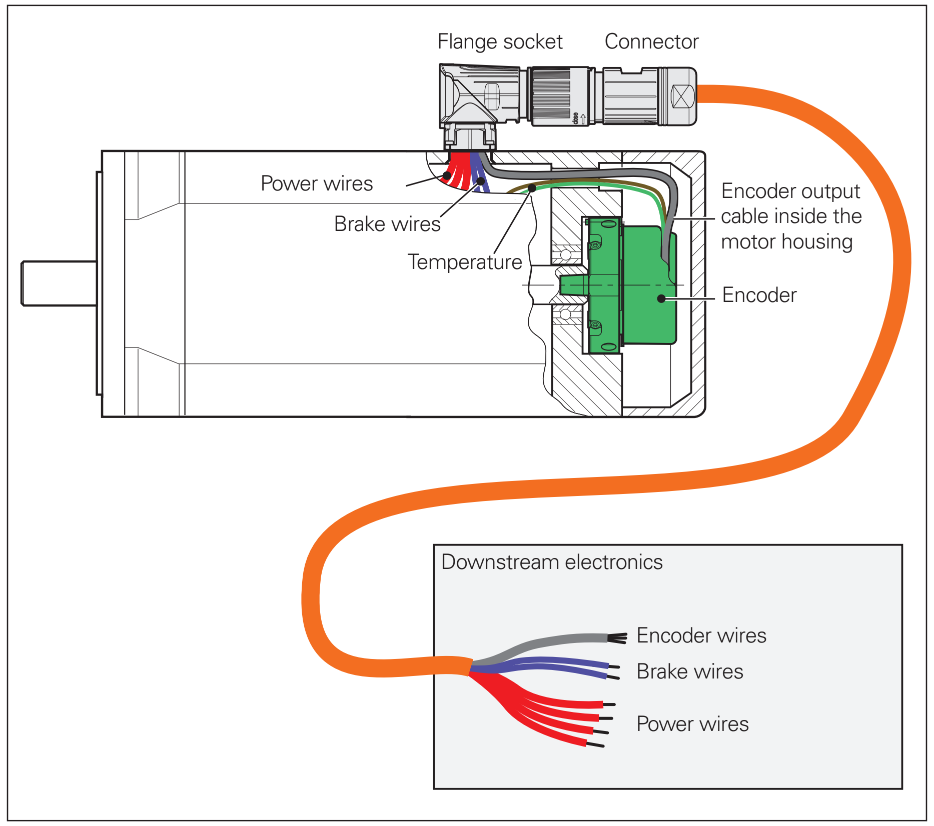
Components
Getting a motor ready for the single-cable solution requires only a handful of components.

Connecting element on the motor
The motor housing is equipped with a standard flange socket for HMC 2 or a special angle flange socket for HMC 6. This angle flange socket brings together the wires for the encoder, motor power and brake.

Crimping tools for the power wires
The crimp contacts for the power and brake wires are assembled with the usual tools.

Output cables inside the motor housing
The rotary encoder is connected by means of the output cables inside the motor housing: your pre-assembled communication element for the HMC 6 or the two contacts for HMC 2 are simply plugged into the angle flange socket.

Cable with hybrid connector
The HMC connecting cable contains the wires for the encoder, power supply, and brake.



For more information:
For more information about HMC 6 and HMC 2, refer to the respective Product Information document and visit *endat.heidenhain.com.*

Safety-related position measuring systems

Functionally safe axes
Driven axes and moving parts can represent a significant hazard for humans. Particularly if the human interacts with the machine (e.g., during workpiece setup), it must be ensured that the machine does not make any uncontrolled movements. This requires position information about the axes in order for a safety function to be implemented.
As an evaluating safety module, the control must be able to detect faulty position information and react accordingly.

Various safety strategies can be pursued depending on the topology of the axis and the evaluation capabilities of the controller. In a single-encoder system, for example, only one encoder per axis is evaluated for the safety function. However, on axes with two encoders, such as a linear axis with a rotary and a linear encoder, the two redundant position values can be compared with each other in the control.
Safe fault detection can be ensured only if the two components (the control and encoder) are properly matched to each other.

Please note that the safety designs of control manufacturers differ from one another.
As a result, the requirements to be fulfilled by the connected encoders may partially differ as well.

Type-examined encoders
Encoders from HEIDENHAIN are used successfully on a variety of controls in widely differing safety designs. This particularly applies to type-examined encoders with EnDat and DRIVE-CLiQ interfaces. The encoders can be operated as single-encoder systems in conjunction with a suitable control in applications with the control category SIL 3 (according to EN 61508) or performance level "e" (of EN ISO 13849).

Unlike incremental encoders, absolute encoders always provide a safe absolute position value, including immediately after switch-on or a power failure. Reliable position transmission is based on two independently generated absolute position values and on error bits provided to the safe control. The purely serial data transmission also provides other benefits, including greater reliability, improved accuracy, diagnostic capabilities and reduced costs through simpler connection technology.

Standard encoders
In addition to those encoders explicitly qualified for safety applications, standard encoders (e.g., with Fanuc interface or $1\ V_{PP}$ signals) can also be used in safe axes. In such cases, the characteristics of the encoders must be matched to the requirements of the given controller. For this purpose, HEIDENHAIN can provide additional data about the individual encoders (failure rate, fault model as per EN 61800-5-2).

For more information:

The safety-related characteristic values are listed in the specifications of the encoders. These characteristic values are explained in the Technical Information document *Safety-Related Position Encoders.*

For the use of standard encoders in safety-related applications, HEIDENHAIN can also provide additional information about individual products (failure rate, fault model as per EN 61800-5-2).

Service life as per ISO 13849
Unless otherwise specified, HEIDENHAIN encoders are designed for a service life of 20 years (as per ISO 13849), which is equivalent to 40 000 operating hours.

Bearing life
The bearing life L_{10mr} as per ISO/TS 16281 at a temperature of 60 °C and maximum bearing loads (maximum permissible shaft offsets for encoders with an integrated stator coupling) is greater than $2 \cdot 10^{10}$ revolutions. Starting at a continuous use temperature of 75 °C, the service life of the grease is limited.

Please contact HEIDENHAIN if you have any questions about the service life of the grease.

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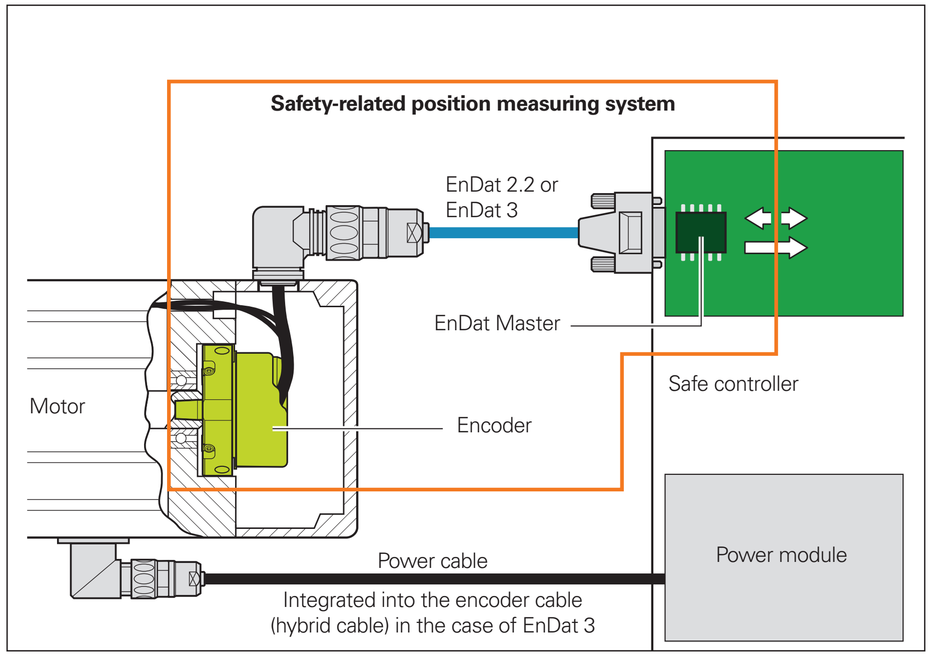


Functionally safe drive system with EnDat 2.2 or EnDat 3

Fault exclusion for the loosening of the mechanical connection
Irrespective of the interface, many safety designs require the safe mechanical connection of the encoder. The standard for electric motors, EN 61800-5-2, requires that the loosening of the mechanical connection between the encoder and the motor be considered as a fault. Because the controller may not be able to detect these errors, fault exclusion is required in many cases. The requirements on a fault exclusion can result in additional constraints in the permissible limit values in the specifications. In addition, fault exclusions for the loosening of the mechanical coupling usually require additional measures during installation of the encoder or in the event of servicing (e.g., anti-rotation lock for screws). These factors must be considered for the selection of a suitable encoder or mounting mode.

For more information:

Adhere to the information in the following documents to ensure the correct and intended operation of the encoder:

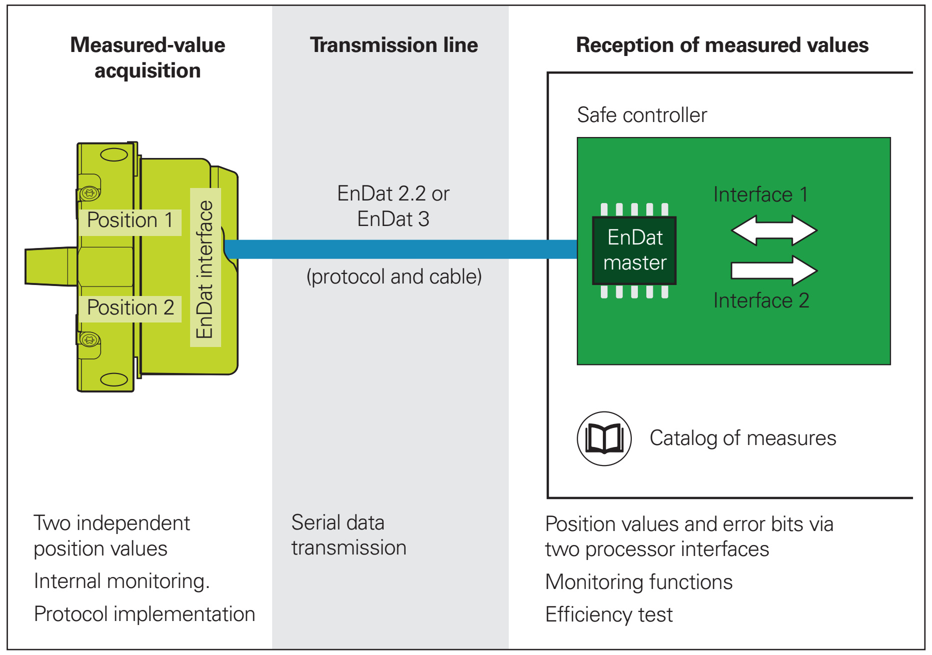
- Mounting instructions
- Operating Instructions
- Product Information document
- Customer information about fault exclusion
- Technical Information document: *Safety-Related Position Measuring Systems* 596632

For implementation in a control with EnDat22:

- Specification for Safe Control 533095

For implementation in a control with EnDat 3:

- *Application Conditions for Functional Safety* 3000003



Safety-related position measurement system with EnDat 2.2 or EnDat 3

Measuring principles
Measuring standard

HEIDENHAIN encoders with optical scanning incorporate measuring standards consisting of periodic structures known as graduations. These graduations are applied to a carrier substrate made of glass or steel. For encoders with large diameters, steel tape is used as the substrate.

HEIDENHAIN manufactures its precision graduations in the following specially developed, photolithographic processes:
- METALLUR: contamination-tolerant graduation consisting of metal lines on gold; typical grating period: 20 µm
- DIADUR: extremely robust chromium lines on glass (typical grating period: 20 µm), or three-dimensional chromium structures (typical grating period: 8 µm) on glass
- SUPRADUR phase grating: optically three-dimensional, planar structure; particularly tolerant to contamination; typical grating period: 8 µm and finer
- OPTODUR phase grating: optically three-dimensional, planar structure with particularly high reflectance; typical grating period: 2 µm and finer

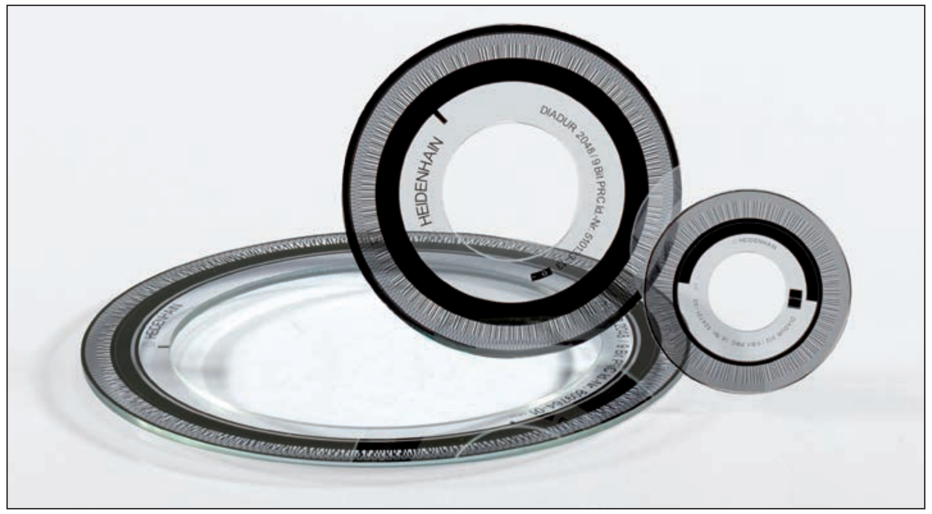
Magnetic encoders use a graduation carrier made of a magnetizable steel alloy. Within it, a graduation consisting of north and south poles is created with a grating period of 400 µm. Due to the short range of electromagnetic interactions and the resulting narrowness of the scanning gap, finer magnetic graduations are not practical.

Encoders that use the **inductive scanning principle** employ metal graduations or copper/nickel-based graduation structures. These graduation structures are applied to a printed-circuit carrier material.

In the **absolute measuring method**, the position value is available immediately upon encoder switch-on and can be requested by the downstream electronics at any time. There is therefore no need to search for the reference position by jogging the axes. This absolute position information is ascertained **from the graduation of the circular scale**, which contains a code structure or consists of multiple parallel graduation tracks.

A separate incremental track, or the track with the finest grating period, is interpolated for the position value and is simultaneously used to generate an optional incremental signal.

In **singleturn encoders,** the absolute position information repeats itself with every revolution. **Multiturn encoders** can distinguish between additional revolutions.

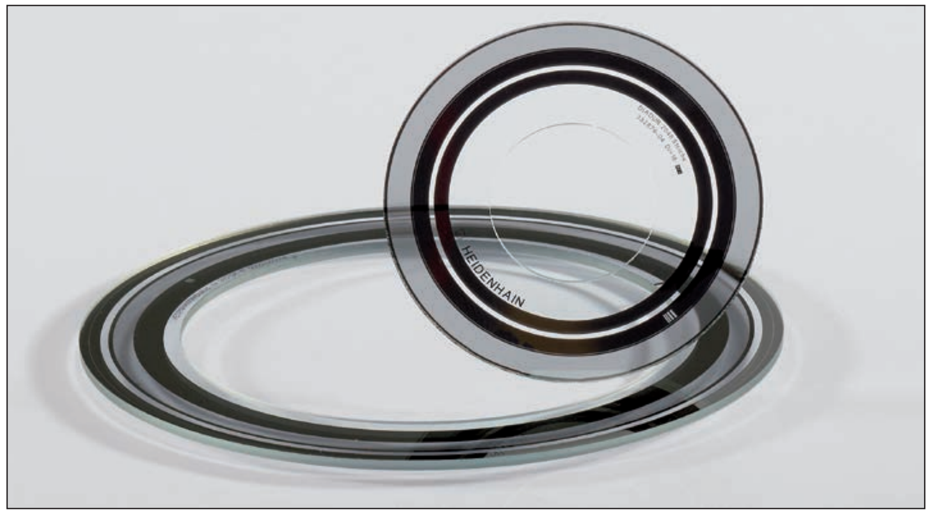


Circular scales of absolute rotary encoders

In the **incremental measuring method**, the graduation is a periodic grating structure. The position information is obtained **through counting** the individual increments (measuring steps) starting at a freely selectable point of origin. Since position ascertainment requires an absolute reference, the circular scales have an additional track containing a **reference mark**.

The absolute position established by the reference mark is assigned to exactly one measuring step.

The reference mark must therefore be traversed before an absolute point of reference can be established or before the most recently selected reference point is refound.



Circular scales of incremental rotary encoders

Scanning methods

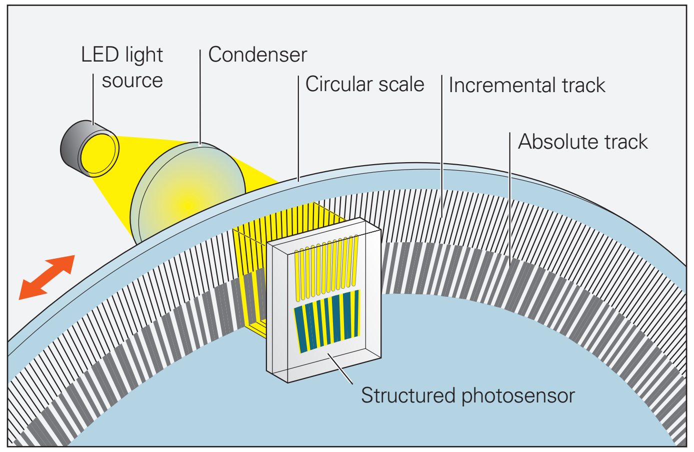
Photoelectric scanning
Most HEIDENHAIN encoders utilize the photoelectric scanning principle. Photoelectric scanning is touchless and therefore does not induce wear. This method detects even extremely fine graduation lines down to a width of only a few micrometers and generates output signals with very small signal periods.

The ERN/ECN/EQN/ERO and ROD/RCN/RQN rotary encoders are designed in accordance with the imaging scanning principle.

Put simply, the imaging scanning principle uses projected-light signal generation: two gratings with equal or similar grating periods (the circular scale and the scanning reticle) are moved relative to each other. The carrier material of the scanning reticle is transparent. The measuring standard's graduation can be applied to transparent or reflective material.

When parallel light passes through a grating structure, light and dark fields are projected at a certain distance. At this location there is an index grating with the same or similar grating period. When the two graduations move relative to each other, the incident light is modulated: if the gaps are aligned, light passes through. If the lines of one grating coincide with the gaps of the other, no light passes through. Photocells or a structured photosensor convert these fluctuations in light into nearly sinusoidal electrical signals. In encoders that use the imaging scanning principle, workable mounting tolerances are attainable starting at a minimum grating period of 10 µm.

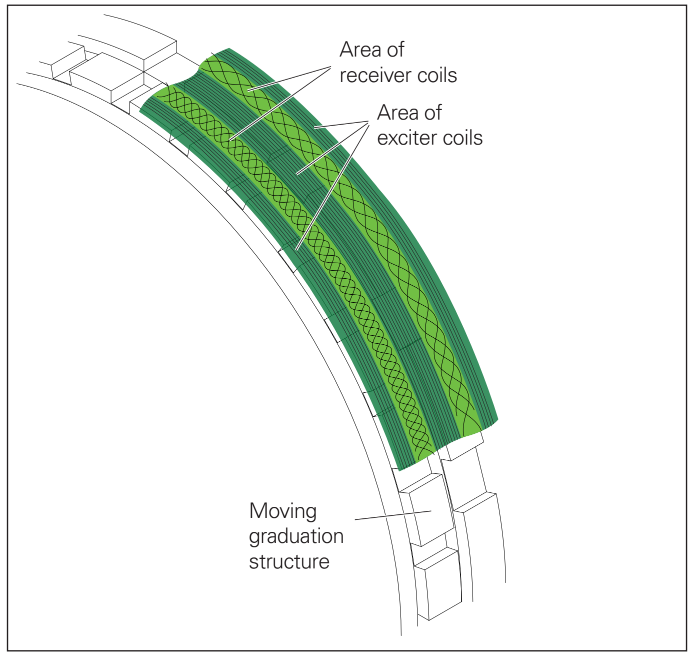
The ECN and EQN absolute rotary encoders with optimized scanning contain a single, large-surface, finely structured photosensor rather than a group of individual photocells. The width of the photosensor's structures is identical to the width of the measuring standard's grating structure. A scanning reticle with a matching structure is therefore not needed.



Photoelectric scanning in accordance with the imaging scanning principle

Other scanning principles
Some encoders operate in accordance with other scanning methods. As their measuring standard, ERM encoders use a permanently magnetized MAGNODUR graduation that is scanned with magnetoresistive sensors.

ECI/EQI/EBI rotary encoders operate according to the inductive measuring principle. Here, moving graduation structures modulate a high-frequency signal in its gain and phase. By means of circumferential scanning, the position value is always generated based on the signals from the receiver coils that are distributed along the circumference. This permits wide mounting tolerances at high resolution.



Inductive scanning

Electronic commutation with position encoders

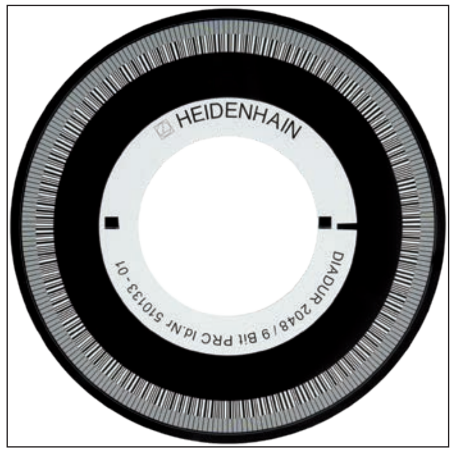
Commutation with permanent-magnet three-phase AC motors
Electronic commutation for a permanent-magnet three-phase AC motor requires the position of the rotor as an absolute value prior to motor start-up. HEIDENHAIN rotary encoders come with different types of rotor position recognition:

- **Absolute rotary encoders** in singleturn and multiturn versions provide the absolute position information immediately after switch-on, allowing the exact position of the rotor to be derived for electronic commutation.

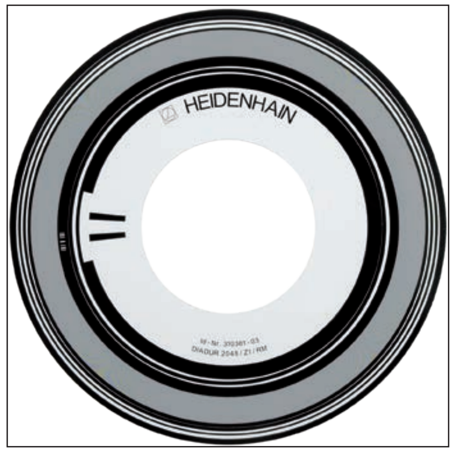
- Along with delivering incremental signals, **incremental rotary encoders with** a second track (the **Z1 track**) provide one sine and one cosine signal (C and D) for each revolution of the motor shaft. For sine commutation, rotary encoders with a Z1 track simply require a subdivision unit and a signal multiplexer in order to obtain the absolute rotor position down to an accuracy of ±5° from the Z1 track and to obtain the position information for speed and position control from the incremental track (see also *Interfaces: Commutation signals*).

- **Incremental rotary encoders with block commutation tracks** also output three commutation signals U, V, and W, which are used to directly drive the power electronics. These rotary encoders are available with various commutation tracks. Typical versions have three signal periods (120° mech.) or four signal periods (90° mech.) per commutation signal and revolution. Irrespective of this, the incremental square-wave signals are used for position and speed control (see also *Interfaces: Commutation signals*).

Commutation of synchronous linear motors
Like absolute rotary and angular encoders, the LIC and LC absolute linear encoder series provide the exact position of the motor's moving component immediately upon switch-on. Maximum holding load is thereby possible even at standstill.



Circular scale with serial code track and incremental track



Circular scale with Z1 track

Circular scale with block commutation tracks

For more information:

Please note the switch-on behavior of the encoders (see the *Interfaces of HEIDENHAIN Encoders* brochure).

Measurement accuracy

The variables influencing the accuracy of **linear encoders** are listed in the *Linear Encoders For Numerically Controlled Machine Tools* and *Exposed Linear Encoders* brochures.

The **angular measurement accuracy** is primarily determined by the following factors:
- The quality of the graduation
- The scanning quality
- The quality of the signal processing electronics
- The eccentricity of the graduation relative to the bearing
- The bearing errors
- The coupling to the measured shaft
- Elasticity of the stator coupling (ERN, ECN, EQN) or shaft coupling (ROD, ROC, ROQ)

These factors can be divided into encoder-specific errors and application-specific factors. For assessment of the attainable **overall accuracy**, all of these individual factors must be taken into account.

Encoder-specific error

In the specifications for rotary encoders, the encoder-specific error is stated as the **system accuracy**.

The extreme values of the total error for any given position relative to their mean lie within the system accuracy of ±a.

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

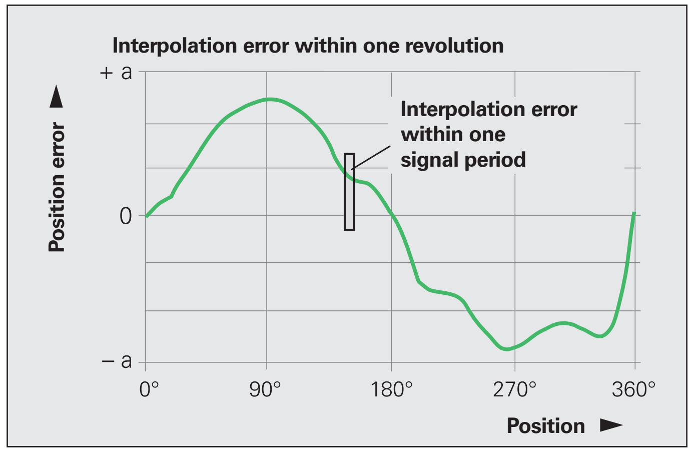
Interpolation error within one signal period
The interpolation error within one signal period is considered separately, since it has an effect even in very small angular movements and in repeated measurements. It particularly causes speed ripples in the speed control loop.

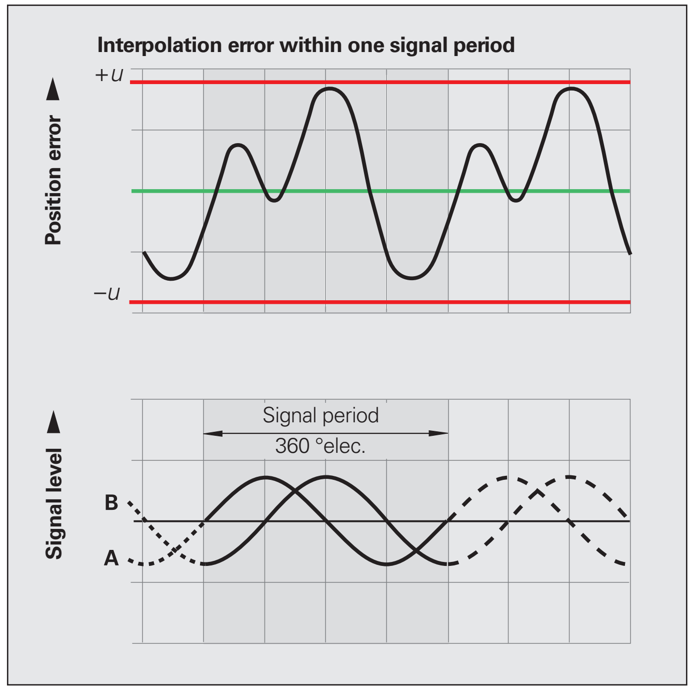
The interpolation error within one signal period ±*u* results from the scanning quality and, for encoders with integrated pulse-shaping or counter electronics, the quality of the signal-processing electronics. For encoders with sinusoidal output signals, however, the error from the signal processing electronics is dictated by the downstream electronics.

The following factors influence the outcome:
- The fineness of the signal period
- The homogeneity and period definition of the graduation
- The quality of scanning filter structures
- The characteristics of the sensors
- The stability and dynamic performance of the analog signal processing

These errors are taken into account in the information about interpolation error within one signal period. For rotary encoders with integral bearing and sinusoidal output signals it is better than ±1% of the signal period or better than ±3% for encoders with square-wave output signals. These signals are suitable for up to 100-fold PLL subdivision.

Due to the higher reproducibility of a position, much smaller measuring steps are still practical.





Application-dependent errors

For **rotary encoders with an integral bearing**, the specified system accuracy already takes the error of the bearing into account. In the case of angle encoders with a separate **shaft coupling** (ROD, ROC, ROQ), the angular error of the coupling must be considered as well (see *Mechanical design types and mounting*). For angle encoders with a **stator coupling** (ERN, ECN, EQN), the system accuracy already includes the error of the shaft coupling.

In contrast, for **encoders without an integral bearing**, the mounting quality and adjustment of the scanning head have a decisive influence on the attainable overall accuracy. Of particular importance are both the mounting eccentricity of the graduation and the radial runout of the measured shaft. Evaluation of the **overall accuracy** of these encoders requires that their application-dependent errors be individually measured and taken into account.

Rotary encoders with photoelectric scanning

In addition to the system accuracy, the mounting quality and adjustment of the scanning head also have a significant effect on the attainable overall accuracy of rotary encoders without an integral bearing but with photoelectric scanning. Particularly important are the mounting eccentricity of the graduation and the radial runout of the measured shaft.

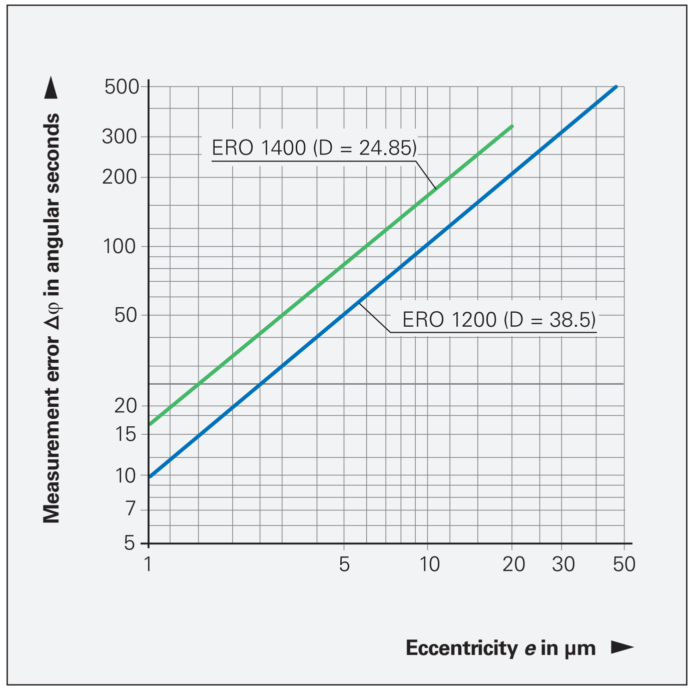
Example
For an ERO 1420 rotary encoder with a mean graduation diameter of 24.85 mm: A radial runout of the measured shaft of 0.02 mm results in a position error of ±330 arc seconds within one revolution.

To evaluate the **accuracy of modular rotary encoders without an integral bearing** (ERO), the relevant errors must be considered individually.

1. Directional errors of the graduation
ERO: The extreme values of the directional errors relative to their mean are listed in the *Specifications* as the accuracy of the graduation. The accuracy of the graduation and the position error within one signal period constitute the system accuracy.

2. Errors due to eccentricity of the graduation relative to the bearing
During mounting of the disk/hub assembly, it is to be expected that the bearing will exhibit radial runout or eccentricity errors. When centering via the centering collar of the hub, bear in mind that HEIDENHAIN guarantees an eccentricity of the graduation relative to the centering collar of less than 5 µm for the encoders listed in this brochure. With modular encoders, this stated accuracy presupposes a diameter error of zero between the motor shaft and the "master shaft."

In the worst-case scenario, if the centering collar is centered relative to the bearing, then the two eccentricity vectors may be cumulative.



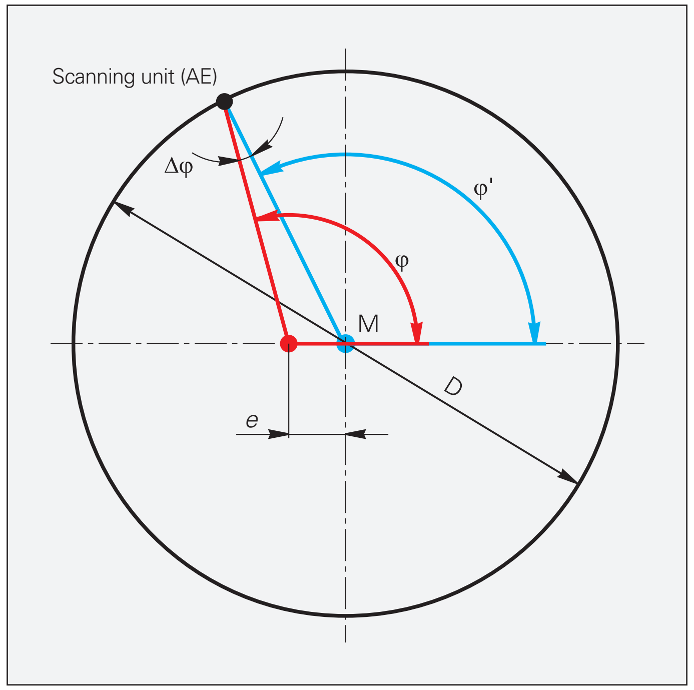
Resultant measuring error Δφ for various eccentricity values *e* as a function of the mean graduation diameter D

The following relationship exists between the eccentricity *e*, the mean graduation diameter D, and the measuring error Δφ (see figure below):

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

$\Delta\varphi$ = Measuring error in " (arc seconds)
e = Eccentricity of the radial grating relative to the bearing in µm
D = Mean graduation diameter in mm

Model	Graduation centerline diameter D	Error per 1 µm of eccentricity
ERO 1420 **ERO 1470** **ERO 1480**	D = 24.85 mm	±16.5"
ERO 1225 **ERO 1285**	D = 38.5 mm	±10.7"



Dependency of the measuring error Δφ on the mean graduation diameter D and the eccentricity *e*.

M = Center of graduation
φ = "True" angle
φ' = Scanned angle

3. Error resulting from radial runout of the bearing
The stated relationship for the measuring error Δφ also applies to the radial runout of the bearing when the eccentricity *e* is replaced by one half of the radial runout (half of the displayed value). The mechanical compliance of the bearing under radial shaft loads causes similar errors.

4. Position error within one signal period $\Delta\varphi_u$
The scanning units of all HEIDENHAIN encoders are adjusted such that, without any further electrical adjustment during mounting, the maximum position error within one signal period (listed below) is not exceeded.

Model	Line count	Position error within one signal period $\Delta\varphi_u$	
		TTL	1 V_{PP}
ERO	2048 1500 1024 1000 512	≤ ±19.0" ≤ ±26.0" ≤ ±38.0" ≤ ±40.0" ≤ ±76.0"	≤ ± 6.5" ≤ ± 8.7" ≤ ±13.0" ≤ ±14.0" ≤ ±25.0"

These values for the position error within one signal period are already included in the system accuracy. Greater error can arise if the mounting tolerances are exceeded.

Rotary encoders with inductive scanning

As with all rotary encoders without an integral bearing, the attainable accuracy of inductive-scanning encoders without an integral bearing depends on the mounting and application conditions. The stated system accuracy assumes a temperature of 20 °C and a low shaft speed. The utilization of all permissible tolerances for the operating temperature, speed, supply voltage, scanning gap, and mounting condition must be taken into account for determining the typical total error.

Since inductive rotary encoders use circumferential scanning, their overall error is generally lower than that of optical rotary encoders without an integral bearing. Because overall error cannot be determined through a simple calculation, these values are provided in the following table.

Model	System accuracy	Total error
ECI 1100 **EBI 1100** **EQI 1100** with EnDat22 or E30-R2	±120"	±280"
ECI 1300 (S) **EQI 1300 (S)** with EnDat22, E30-R2 or DQ01	±65"	±120"
ECI 100 **EBI 100**	±90"	±180"
ECI 4000 (S) **EBI 4000** with 90 mm HW; EnDat22 or DQ01	±25"	±140"
ECI 4000 (S) **EBI 4000** with 180 mm HW; EnDat22 or DQ01	±40"	±150"

Mechanical design types and mounting
Rotary encoders with integral bearing and stator coupling

The **ECN/EQN/ERN** rotary encoders feature integrated bearings and a mounted stator coupling. With these models, the encoder shaft is directly connected to the measured shaft. During angular acceleration of the shaft, the stator coupling must absorb only the torque arising from friction within the bearing. ECN/EQN/ERN rotary encoders thus exhibit excellent dynamic performance and a high natural frequency.

Benefits of the stator coupling:
- No axial mounting tolerance between the shaft and stator housing
- High natural frequency of the coupling
- High torsional rigidity of shaft coupling
- Minimized space requirement for external and internal mounting
- Easy axial mounting

Mounting the ECN/EQN 1100 and ECN/EQN/ERN 1300
The blind hollow shaft or the tapered shaft of the rotary encoder is connected at the encoder's front face to the measured shaft by way of a central screw. Proper centering onto the motor shaft is accomplished via the hollow shaft or tapered shaft. On its stator side, the ECN/EQN 1100 is connected to a plane surface with two clamping screws (without a centering collar). The stator side of the ECN/EQN/ERN 1300 is clamped in a mating hole with an axial screw. The versions with fault exclusion feature an additional nose for a positive lock in the stator.

Mounting accessories

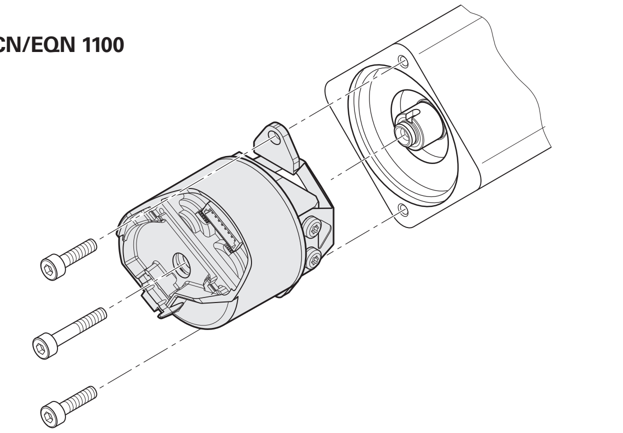
ECN/EQN/ECI/EQI 1100: mounting aid
For turning the encoder shaft from the rear. This facilitates finding the positive-locking connection between the encoder and the measured shaft.
ID 821017-03

ERN/ECN/EQN 1300: inspection tool
For inspecting the shaft connection (fault exclusion for rotor coupling).
ID 680644-01

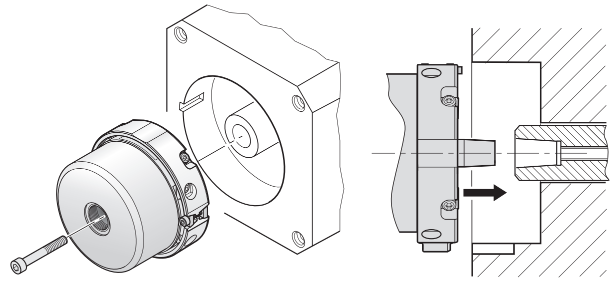
HEIDENHAIN recommends inspecting the holding torque of non-positive-locking shaft connections (e.g., tapered shafts, blind hollow shafts).

The inspection tool is screwed into the M10 back-off thread from the rear of the encoder. Due to the short thread engagement, the fastening screw for the shaft is not touched. With the motor shaft locked in place, the testing torque is applied to the extension by means of a torque wrench (hexagonal, width A/F: 6.3 mm). After any nonrecurring settling, it must be ensured that there is no relative motion between the motor shaft and the encoder shaft.

ECN/EQN 1100



ECN/EQN/ERN 1300



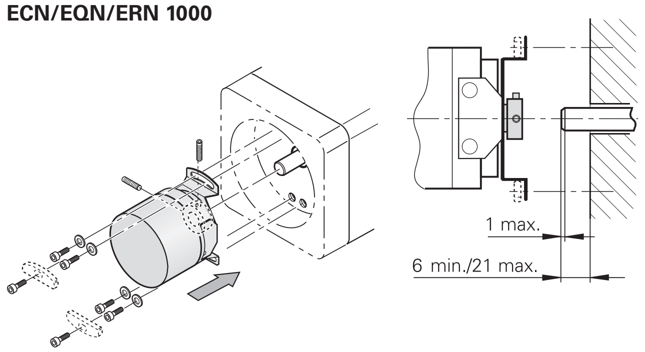
Mounting the ECN/EQN/ERN 1000 and ERN 1x23
The hollow shaft of these rotary encoders is slid onto the measured shaft and clamped on the rotor side with two screws. These encoders are mounted on the stator side without a centering flange onto a plane surface via four clamping screws or via two clamping screws and washers.

The ECN/EQN/ERN 1000 encoders have a blind hollow shaft, but the ERN 1123 has a hollow through shaft.

Accessory for ECN/EQN/ERN 1000

Washer
For increasing the natural frequency f_N when fastening with only two screws.
ID 334653-01 (2 washers)

ECN/EQN/ERN 1000



ECI/EBI/EQI rotary encoders without integral bearing

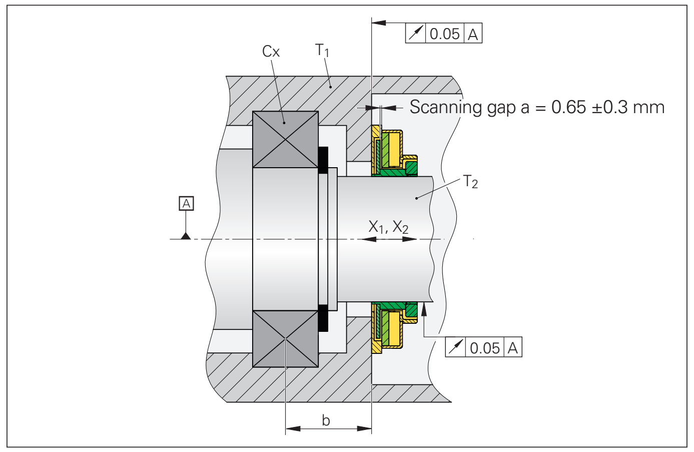
The **ECI/EBI/EQI** inductive encoders have no integral bearing. This means that the mounting and operating conditions influence the encoder's function reserves. It is also essential to ensure that the specified mating dimensions and tolerances are maintained for all operating conditions (see mounting instructions).

The application analysis must yield values within specification for all possible operating conditions (particularly under maximum load and at minimum and maximum operating temperature) and with the signal amplitude taken into account (inspection of the scanning gap and mounting tolerance at room temperature). This particularly applies to the following determined factors:

- Maximum radial runout of the motor shaft
- Maximum axial runout of the motor shaft relative to the mounting surface
- Maximum and minimum scanning gap (a), including in combination with, for example, the following:
  - The length ratio between the motor shaft and the motor housing under the influence of temperature (T_1; T_2; $\alpha1$; $\alpha2$), depending on the position of the fixed bearing (b)
  - The bearing play (C_X)
  - Non-dynamic shaft offsets due to load (X_1)
  - The effect of the motor brakes being engaged (X_2)

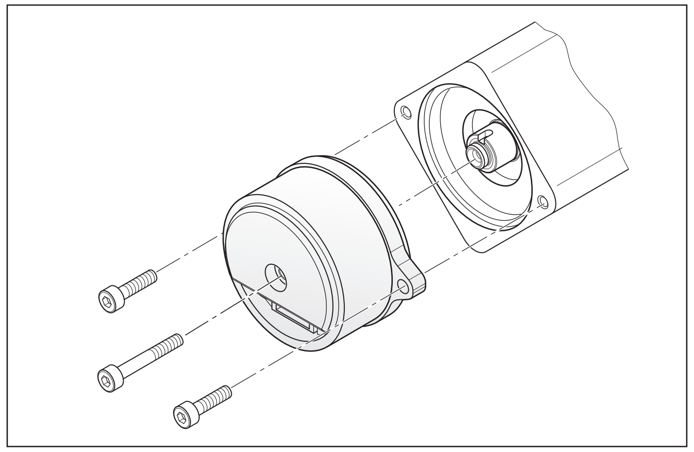
The **ECI/EBI 100** rotary encoders are pre-aligned on a plane surface and, with their hollow shaft locked, are slid onto the measured shaft. Fastening and shaft clamping are achieved with axial screws.

The **ECI/EBI/EQI 1100** inductive rotary encoders are mounted flush on their axis. Their blind hollow shaft is fastened with a central screw. The stator of these rotary encoders is clamped onto a shoulder with two axial screws.



Schematic representation of **ECI/EBI 100**

Mounting the **ECI 119**



Mounting the **ECI/EQI 1100**

Mounting accessories
Mounting aid for removing the PCB connector (see page 38).

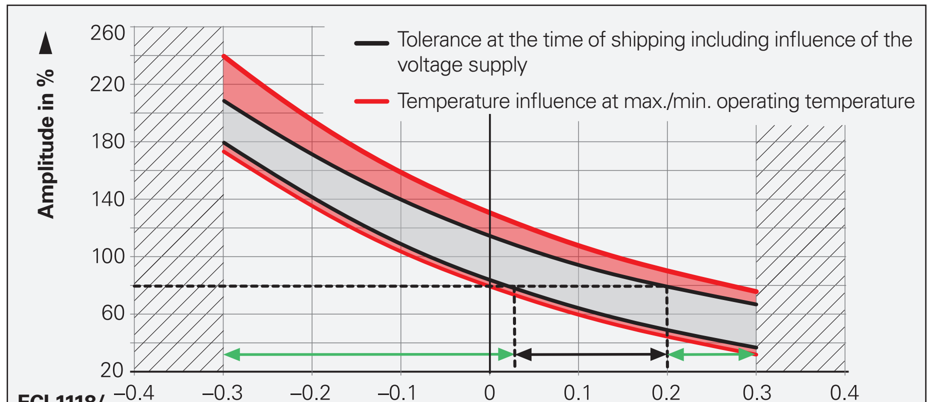
Permissible scanning gap
The size of the scanning gap between the rotor and the stator is dictated by the mounting situation. Later adjustment is possible only through the insertion of shim rings.

The maximum permissible error specified in the mating dimensions applies to both mounting and operation. Thus, the tolerances exploited during mounting are no longer available during operation.

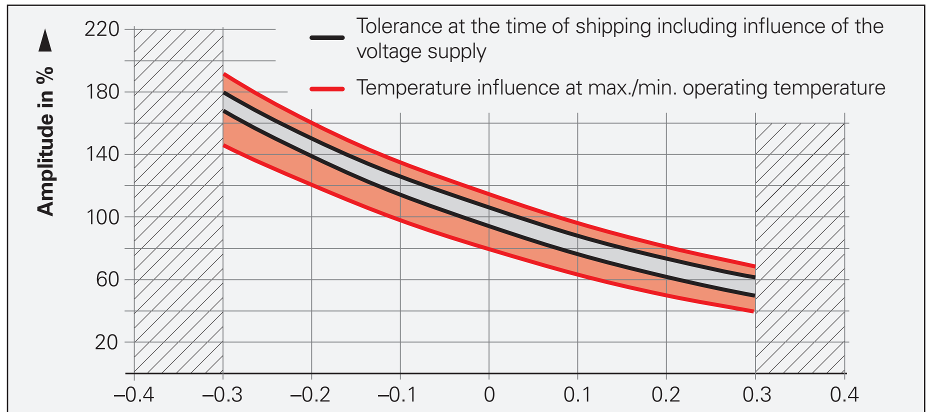
Once the encoder has been mounted, the actual scanning gap between the rotor and the stator can be indirectly measured with the PWM 21 adjusting and testing package using a signal amplitude inside the rotary encoder. The characteristic curves illustrate the relationship between the signal amplitude and the deviation from the ideal scanning gap under different ambient conditions.

The example of the ECI/EBI 1100 shows the resulting deviation from the ideal scanning gap for a signal amplitude of 80% at ideal conditions. Due to tolerances within the rotary encoder, the deviation is between +0.03 mm and +0.2 mm. Thus, the maximum permissible motion of the measured shaft during operation ranges from –0.33 mm to +0.1 mm (green arrows).

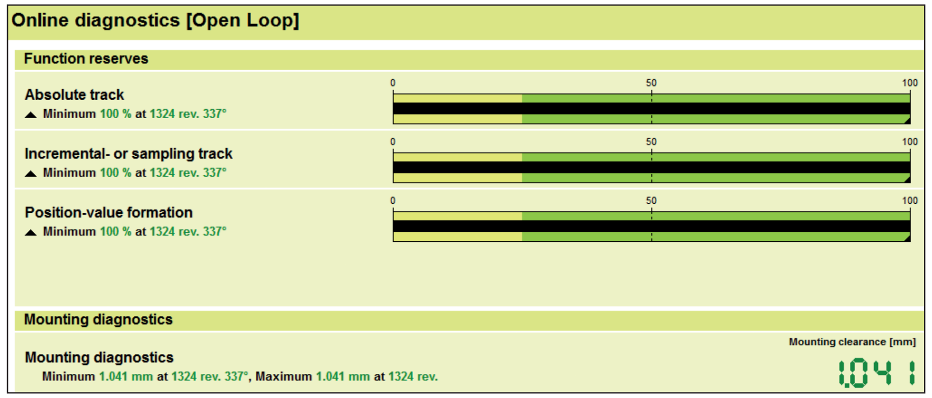
Display of the scanning gap
The latest generation of encoders supports the display of the mounting dimension in the ATS software. This additional data can also be requested by the drive during closed-loop operation.



ECI 1118/ EBI 1135 with EnDat 2.2



ECI/EBI 100

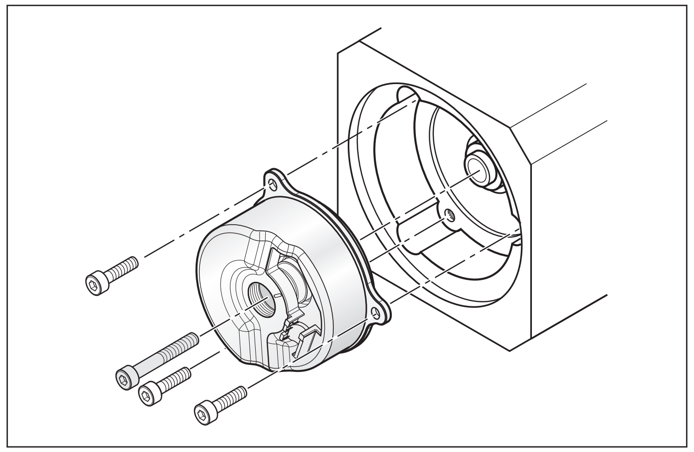


ID	ExI mounting wizard	Mounting interface
728563-xx	✓	
820725-xx	✓	
1164809-xx		✓
1164811-xx		✓
1164812-xx		✓

ID	ExI mounting wizard	Mounting interface
1164813-xx		✓
811811-xx	✓	
811815-xx	✓	
810661-xx		✓
810662-xx		✓
823405-xx	✓	
823406-xx	✓	

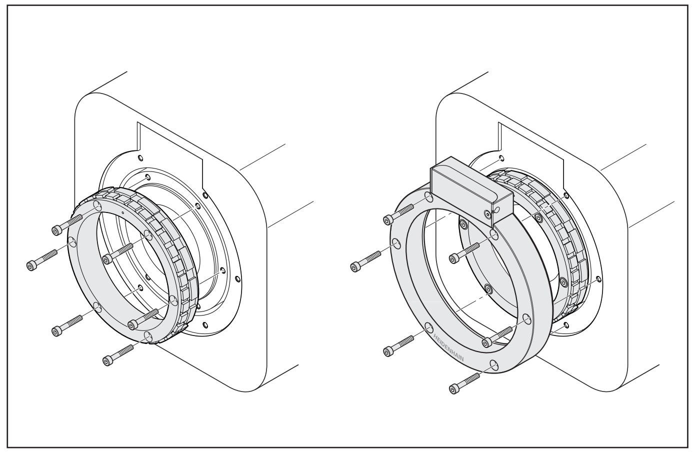
ID	ExI mounting wizard	Mounting interface
823407-xx	✓	
1259551-xx		✓
1259552-xx		✓
1286377-xx		✓
1286388-xx		✓

The **ECI/EBI/EQI 1300** inductive rotary encoders are mounted flush on their axis. Their blind hollow shaft is fastened with a central screw. The stator of these rotary encoders is clamped to a shoulder by three axial screws.



Mounting the **ECI/EQI 1300** with EnDat22 and EnDat 3

The scale drum of the **ECI/EBI 4000** inductive rotary encoders is slid onto the centering collar of the measured shaft and fastened (with/without a key, depending on the version). Then the stator is fastened via an external centering diameter.



Mounting the **ECI/EBI 4000**

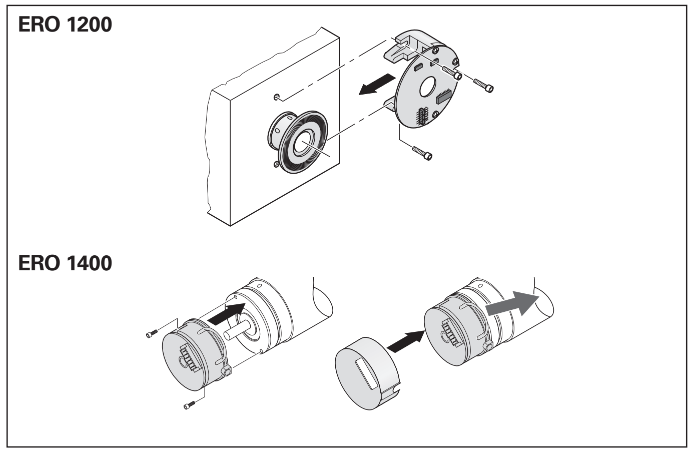
ERO rotary encoders without integral bearing

The **ERO** rotary encoders without an integral bearing consist of a scanning head and a circular scale that must be brought into mutual alignment during mounting. Precise alignment is an important factor in reaching the attainable measuring accuracy.

The **ERO** modular rotary encoders consist of a disk/hub assembly and a scanning unit. These encoders are particularly well suited for limited installation space, low axial offsets, and low radial runout, or for applications where friction of any type must be avoided.

In the **ERO 1200** series, the disk/hub assembly is pressed onto the shaft and aligned to the scanning unit. The scanning unit is aligned on a centering collar and fastened to the mounting surface.

The encoders of the **ERO 1400** series are miniaturized modular rotary encoders. These encoders feature a special built-in **mounting aid** that centers the circular scale relative to the scanning unit and adjusts the gap between the circular scale and the scanning reticle. Short installation time can thus be attained. The encoder comes with a cover cap for protection against extraneous light.

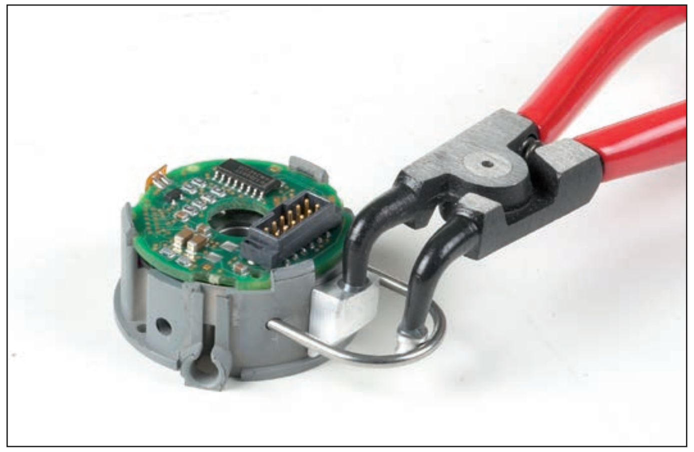


Mounting the **ERO**

Mounting accessories for the ERO 1400

Mounting accessory
Tool for removing the clip in order to achieve optimal encoder mounting.
ID 510175-01

Accessory
Housing for the ERO 14xx with an axial PCB connector and central hole.
ID 331727-23



Mounting accessory for the **ERO 1400**

Mounting and initial setup must be performed with appropriate ESD protection. Do not engage or disengage any connecting element while under power. To avoid overstressing the individual wires during disengagement of the connecting element, HEIDENHAIN recommends using the mounting aid for disconnecting the PCB connector.

Strain relief
Avoid torque or tensile stress, and use strain relief wherever necessary.

Straight M12 flange socket
Retention force of polarizing key:
max. 1 Nm.

Screws
For output cables with standard M12 or M23 flange sockets, use M2.5 screws.

The mounting method with M2.5 screws was designed for the following tightening torques:

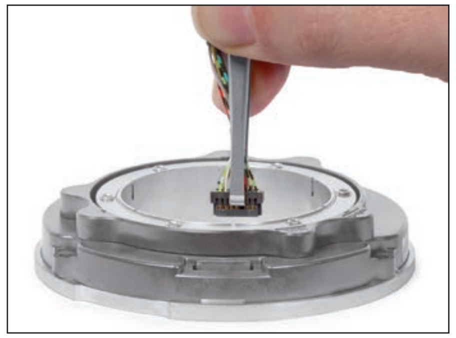
For M12, M23: min. M_d 0.4 Nm
max. M_d 0.5 Nm
Load-bearing thread length: At least 4 mm
Minimum tensile strength of the screws: 800 N/mm^2

To prevent self-loosening of the screws, HEIDENHAIN recommends using a material bonding threadlocker.

Accessories
Mounting aid for disengaging the connector (ID 1075573-01). Suitable for all rotary encoders in this brochure, except for the ERO 1200 series.

To avoid damaging the cable, apply pulling force only to the connector and never to the wires. For other encoders, use tweezers or the mounting aid as needed.

Cable length (rated length)
For output cables with a crimp on the encoder side for strain relief and a shield contact, the cable length is specified up to the crimp sleeve. Exceptions apply, for example, to output cables without a crimp on the encoder side and to those with a sensor connection at the downstream electronics or with a shield connection via a cable clamp. Upon request, binding information (a dimension drawing) can be provided based on the ID number of the output cable (see *Cables and Connectors* brochure).

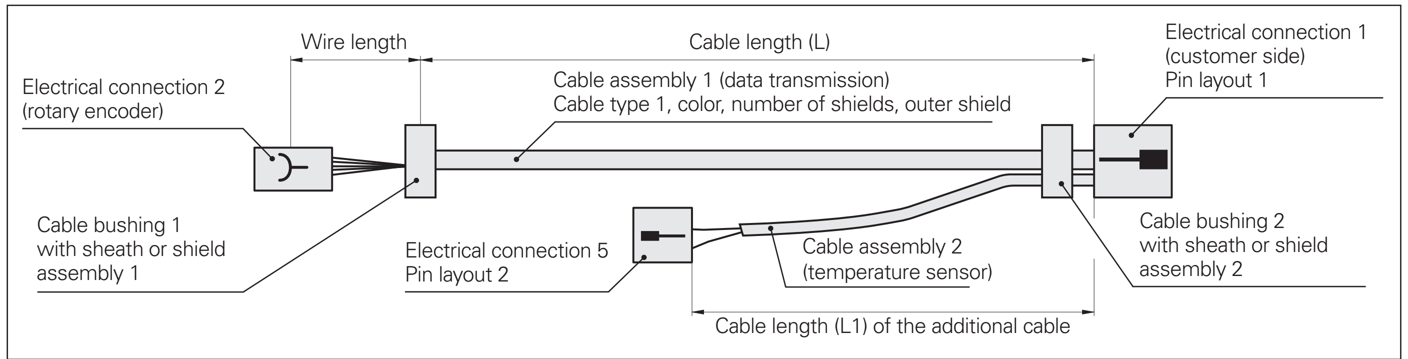


Mounting aid for female connector

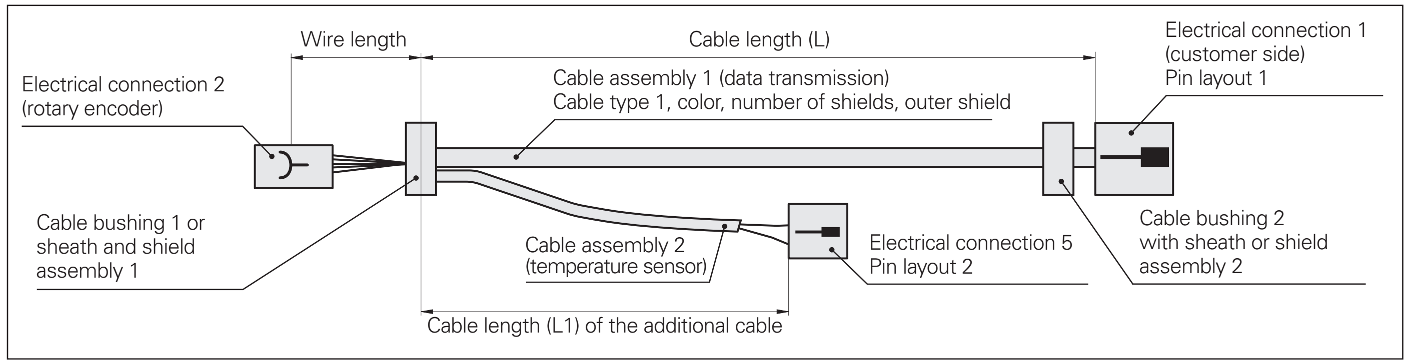
Electromagnetic compatibility
Cables from HEIDENHAIN are tested for electromagnetic compatibility. For output cables with wires for temperature sensors, electromagnetic compatibility must be ensured in the entire system.

Crimp connector
For joining (crimping) the wires of the temperature-sensor output cable to the wires of the temperature sensor inside the motor (ID 1148157-01).

Designation of the cable components



Temperature sensor signals via electrical connection 1



Temperature sensor signals via PCB of rotary encoder

Testing cables for directly connecting a modular rotary encoder to a PWM 21

Testing cable for modular rotary encoders with EnDat (EnDat22, EnDat01, or E30-R2) or SSI interface
Includes three 12-pin adapter connectors and three 15-pin adapter connectors
ID 621742-01

Connecting cable for EnDat or SSI interface
For extending the testing cable; completely assembled with a 15-pin D-sub connector (male) and a 15-pin D-sub connector (female), max. 3 m
ID 675582-xx

Testing cable for modular rotary encoders with DRIVE-CLiQ interface
Includes three 12-pin adapter connectors and three 15-pin adapter connectors
ID 621742-01

Only in connection with:
Adapter cable for DRIVE-CLiQ, Ø 6.8 mm
15-pin D-sub (female) and 6-pin RJ45 Ethernet connector with metal housing (IP20)
ID 1228399-01

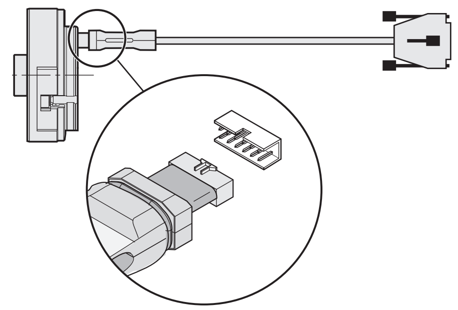
Adapter connector* for ID 621742-01
Quantity of three, for replacement
12-pin: ID 528694-01
15-pin: ID 528694-02
*Adapter connectors should be replaced after 500 connection cycles

Testing cable for the ERN 1387, with commutation signals for sinusoidal commutation
Includes three 14-pin adapter connectors
ID 1118892-02

Connecting cable for ERN 1387
For extending the testing cable
Completely assembled with 15-pin D-sub connector (male) and 15-pin D-sub connector (female), max. 3 m
ID 675582-xx

Adapter connector for ID 1118892-02
Quantity of three, for replacement
ID 528694-04

EnDat 3 adapter (SA 1210)
Adapter for connecting an encoder with EnDat 3 (E30-R2) to the PWM 21
15-pin D-sub connector (male) and 15-pin D-sub connector (female)
ID 1317260-01



Testing cable for modular rotary encoders

EnDat 3 adapter (SA 1210)

Adapter cables for connecting the flange socket on the motor to the PWM 21

For the EnDat22 interface, adapter cable Ø 6 mm
9-pin M23 connector (female) and 8-pin M12 coupling (male)
ID 1136863-xx
(ID 524599-xx is additionally required: 15-pin M12 (female) and 15-pin D-sub connector (male))

Adapter cables, Ø 6 mm/8 mm
8-pin M12 connector (female) and 15-pin D-sub connector (male)
ID 1036526-xx Ø 6 mm
ID 1129753-xx Ø 8 mm

for the DRIVE-CLiQ interface adapter cable Ø 6.8 mm
9-pin M23 connector (female) and 6-pin RJ45 Ethernet connector with IP20 metal housing
ID 1117540-xx

adapter cable Ø 6.8 mm
8-pin M12 connector (female) and 6-pin RJ45 Ethernet connector with IP20 metal housing
ID 1093042-xx

For EnDat01, EnDat Hx, EnDat Tx, or SSI interface with incremental signals

Adapter cable Ø 8 mm
17-pin M23 connector (female) and 15-pin D-sub connector (male)
ID 324544-xx

Adapter cable Ø 8 mm
12-pin M23 connector (female) and 15-pin D-sub connector (male)
ID 310196-xx

Version for HMC 6 adapter cable Ø 13.6 mm
M23 SpeedTEC hybrid connector (female), with five power wires, two brake wires and six communication wires
15-pin D-sub connector (male)
ID 1189174-xx

EnDat 3 interface (E30-R2) for HMC 2, only in combination with EnDat 3 adapter

Adapter cable Ø 9.3 mm
M12 SpeedTEC hybrid connector (female), four power wires, two brake wires, and two communication wires
15-pin D-sub connector (male)
ID 1189174-xx

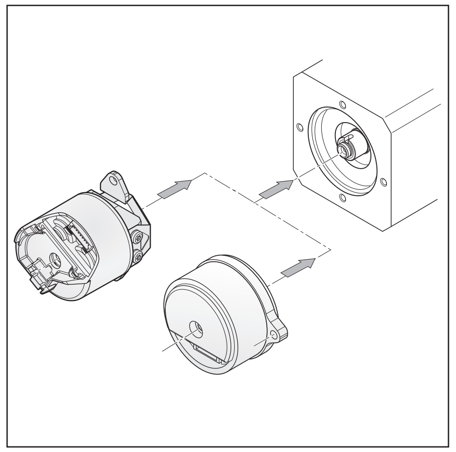
Adapter cable Ø 9.3 mm
M23 SpeedTEC hybrid connector (female), four power wires, two signal wires, and two communication wires
15-pin D-sub connector (male)
ID 1275291-xx

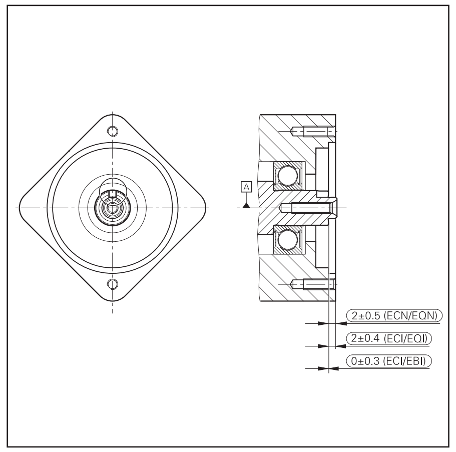
DRIVE-CLiQ is a registered trademark of Siemens AG

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH

Compatible mounting dimensions

Mating dimensions and tolerances must be taken into account during the mounting of rotary encoders. Within some rotary encoder series, the mating dimensions may exhibit only slight differences or even be identical. Certain rotary encoders are therefore mounting-compatible with each other, allowing different encoders to be mounted to the same motor as the requirements dictate.
All dimensions, tolerances, and required mating dimensions are indicated in the dimension drawing of the respective series. Deviating values for rotary encoders with functional safety (FS) are provided in the corresponding Product Information documents.

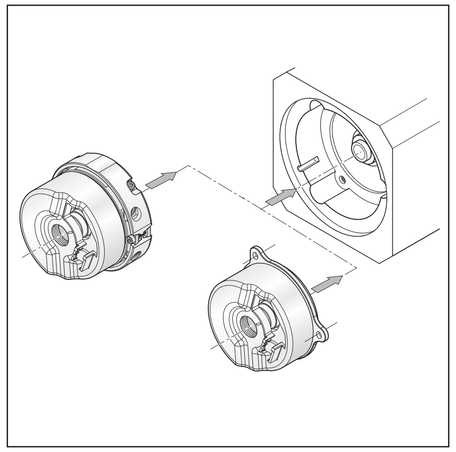




All absolute rotary encoders of the ECN/EQN 1100 FS, ECI/EQI 1100 FS, ECI/EBI 1100, and ECI/EQI 1100 series are mounting-compatible within the respective series, exhibiting only minor differences in the permissible deviation between the shaft surface and coupling surface.

Series	Differences
ECN/EQN 1100 FS	Standard, with slot for FS devices
ECI/EQI 1100 FS	Same as ECN/EQN 1100 FS, but with a different tolerance for the deviation between the shaft and coupling surfaces
ECI 1118/EBI 1135	Same as ECN/EQN 1100 FS, but with a different tolerance for the deviation between the shaft and coupling surfaces
ECI 1119/EQI 1131	Same as ECN/EQN 1100 FS, but with a different tolerance for the deviation between the shaft and coupling surfaces

Some rotary encoders of the ERN 1300, ECN/EQN 1300, ECI/EBI/EQI 1300 FS, and ECN/EQN 400 series are also mounting-compatible with each other and can be mounted to identical motors. Minor differences, such as the anti-rotation element and a limited tolerance for the inside diameter, must be taken into account.



Series	Required mating dimensions			
	ERN 1300	ECN/ EQN 1300 FS	ECI/EBI/ EQI 1300 FS	ECN/ EQN 400 FS
ERN 1300		✓	✓	✓
ECN/EQN 1300 FS			✓	✓
ECI/EQI 1300 FS				
ECN/EQN 400 FS		✓	✓	

Series	Differences
ERN 1300	Standard, deployable for taper shaft
ECN/EQN 1300	Same as ERN 1300, but with an additional ridge as an anti-rotation element (stator coupling)
ECI/EBI/EQI 1300 FS	Same as ERN 1300, but with an anti-rotation element (flange)
ECN/EQN 400	Same as ECN/EQN 1300

Mounting accessories

Screwdriver bits
- For HEIDENHAIN shaft couplings
- For ExN shaft clampings and stator couplings
- For ERO shaft clampings

Width across flats	Length	ID
1.5	70 mm	350378-01
1.5 (spherical head)		350378-02
2		350378-03
2 (spherical head)		350378-04
2.5		350378-05
3 (spherical head)		350378-08
4		350378-07
4 (with dog point)[1]		350378-14
	150 mm	756768-44
TX8	89 mm 152 mm	350378-11 350378-12
TX15	70 mm	756768-42

Screwdriver
When using screwdrivers with adjustable torque, ensure that they comply with DIN EN ISO 6789 and thus meet the required torque tolerances.

Adjustable torque, with accuracy of ±6%
0.2 Nm to 1.2 Nm ID 350379-04
1 Nm to 5 Nm ID 350379-05

[1] For DIN 6912 screws (low head screw with pilot recess)

Screws

Screw	Type of securement	ID
M3x8-8.8 ISO 4762 MKL	Material bonding anti-rotation lock	202264-67
M3x10-8.8 ISO 4762 MKL	Material bonding anti-rotation lock	202264-87
M3x16 A2 ISO 4762 KLF	Self-locking	202264-30
M3x20 A2 ISO 4762 KLF	Self-locking	202264-45
M3x22-8.8 ISO 4762 MKL	Material bonding anti-rotation lock	202264-65
M3x25-8.8 ISO 4762 MKL	Material bonding anti-rotation lock	202264-86
M3x25 A2 ISO 4762 KLF	Self-locking	202264-26
M3x35-8.8 ISO 4762 MKL	Material bonding anti-rotation lock	202264-66
M4x10-8.8 ISO 4762 MKL	Material bonding anti-rotation lock	202264-85
M5x25-8.8 DIN 6912 MKL	Material bonding anti-rotation lock	202264-55
M5x30-8.8 DIN 6912 MKL	Material bonding anti-rotation lock	202264-76
M5x35-8.8 ISO 4762 KLF	Self-locking	202264-80
M5x50-8.8 DIN 6912 KLF	Self-locking	202264-36
M5x50-8.8 DIN 6912 MKL	Material bonding anti-rotation lock	202264-54
Fastener kit • M3 fixing clamp • Spring washer: 3x0.70 DIN 128 A-FS ISO • Screw: M3x10 8.8 DIN EN ISO 4762	Material bonding anti-rotation lock	*20 pieces:* 1264352-01 *200 pieces:* 1264352-02

General information
Alignment of rotor positions between encoders and motors

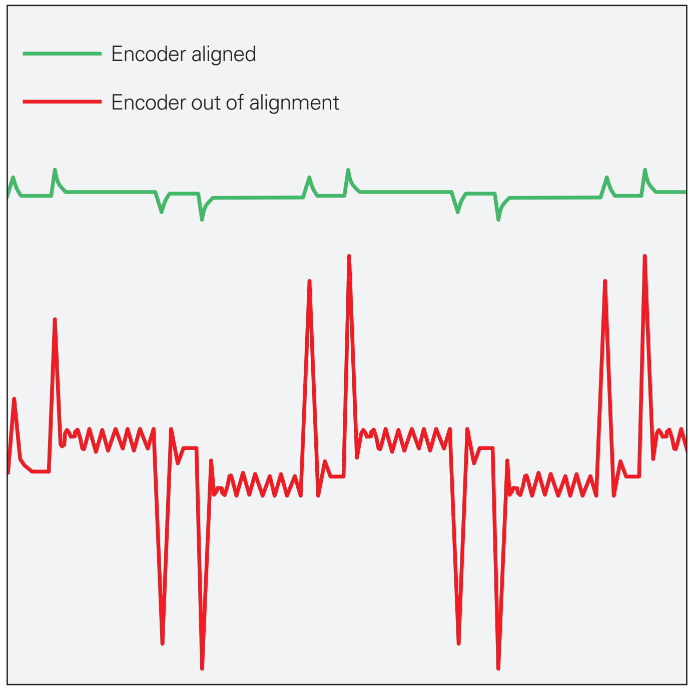
Immediately after a synchronous motor is switched on, information is needed about its absolute rotor position. Rotary encoders with additional commutation signals are suitable for this task but provide comparatively rough position information. Absolute rotary encoders in singleturn or multiturn designs are also well suited, delivering the exact angular position down to an accuracy of a few arc seconds (see also *Electronic commutation with position encoders*). To achieve the most constant motor currents possible, the rotor positions of the motor and of the encoder must be brought into mutual alignment when the encoder is mounted. Inadequate alignment of the rotor positions will cause significant motor noise and high power dissipation.

First, the rotor of the motor is turned to the preferred position through the application of a DC current.

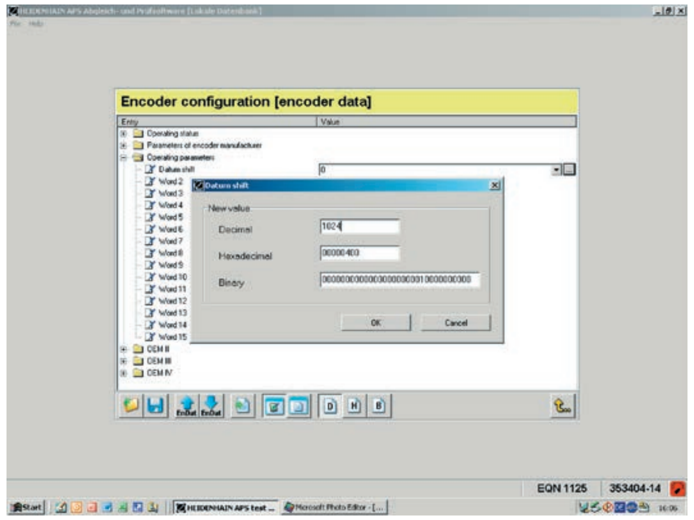
Rotary encoders with commutation signals are then roughly aligned (e.g., using the line markers on the encoder or the reference mark signal) and are mounted to the motor shaft. Fine adjustment is then performed with the PWT 101 testing device (see *Diagnostics, and inspection and testing equipment*): the stator of the rotary encoder is turned until the PWT 101 displays a distance from the reference mark of nearly zero.

Absolute rotary encoders are first completely mounted, after which a datum shift is used to assign the value "zero" to the preferred motor position. This is performed with the adjusting and testing package (see *Diagnostics, and inspection and testing equipment*). This package features complete EnDat functionality, allowing not only datum shifts but also the use of other inspection functions and the setting of write-protection to prevent unintentional changes to saved values.

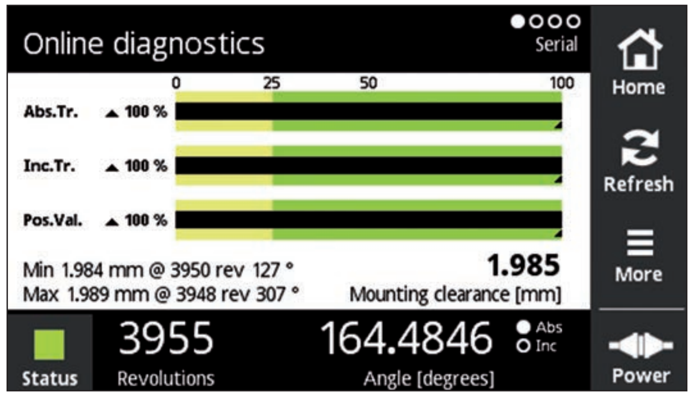
For the ECI/EQI rotary encoders with additional 1 Vpp signals, manual adjustment is possible as well. Please follow the information in the respective mounting instructions.



Motor current of an encoder when aligned vs. significantly out of alignment



Alignment of the rotor positions via the adjusting and testing package



Online diagnostics of the PWT 101

General mechanical information

Certification by an NRTL (Nationally Recognized Testing Laboratory)
All rotary encoders in this brochure comply with the UL safety regulations for the USA and the CSA safety regulations for Canada.

Accelerations
During mounting and operation, encoders are subjected to various types of acceleration.

- **Vibration**
  The encoders are qualified on a test stand under the acceleration values stated in the specifications at frequencies of 55 Hz to 2000 Hz in accordance with EN 60068-2-6[1]. However, if the application or mounting situation causes long-duration resonant vibration, then proper functioning of the encoder may be impaired, or the encoder may incur damage. **Thorough testing of the complete system is therefore required.**
- **Shock**
  The encoders are qualified on a test stand under the acceleration values stated in the specifications and under the exposure times in accordance with EN 60068-2-27 for non-repetitive, semi-sinusoidal shock. **Continuous shock loads** are therefore not covered and **must be tested in the application.**
- The **maximum angular acceleration** is 10^5 rad/s^2. This is the highest permissible rotational acceleration at which the rotor can be accelerated without damage to the encoder. The actual attainable angular acceleration is within the same order of magnitude but can vary depending on the type of shaft connection (for deviating values for the ECN/ERN 100, see the *Specifications*). An adequate safety factor must be determined through system tests.

Deviating values for rotary encoders with functional safety are provided in the corresponding Product Information documents.

[1] Information on values below 55 Hz is available upon request.

Natural frequencies
In conjunction with the stator coupling, the **ECN/EQN/ERN** rotary encoders form an oscillation-capable spring-mass system whose **natural frequency** f_N of the coupling should be as high as possible in the direction of measurement. The natural frequency of the coupling is influenced by the rigidity of the stator coupling and by the customer-side mounting situation. The stated typical natural frequencies may vary depending on the encoder variant (e.g., singleturn or multiturn), production tolerances, and differing mounting conditions. If radial and/or axial acceleration forces also come into play, then the rigidity of the encoder bearing and of the encoder stator has an effect as well. If such loads occur within your application, HEIDENHAIN recommends consulting with the main facility in Traunreut.

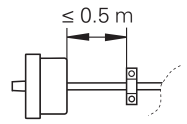
HEIDENHAIN generally recommends determining the natural frequency of the stator coupling within the complete system.

Air humidity
The max. permissible relative humidity is 75%. A relative humidity of 93% is temporarily permissible. Condensation is not permissible.

Magnetic fields
Magnetic fields greater than 30 mT can affect encoder functioning. Please contact HEIDENHAIN in Traunreut, Germany, as needed.

Acoustic noise
Running noise can occur during operation. This is particularly true of encoders with integral bearing and multiturn rotary encoders (with gears). The intensity may vary depending on the mounting situation and shaft speed.

Strain relief
Provide strain relief for the rotary encoder cable.



Starting torque and operating torque
The starting torque is the torque required to put the rotor into motion from standstill. If the rotor is already rotating, then a certain operating torque is acting on the encoder. The starting torque and operating torque are influenced by various factors, such as the temperature, prior standstill time, and the amount of wear on the bearings and seals.

The typical values stated in the specifications are mean values based on encoder-specific test series performed at room temperature and at a stabilized operating temperature. The typical operating torques are also based on constant shaft speeds. For applications in which the torque has a significant influence, HEIDENHAIN recommends consulting with the main facility in Traunreut.

Protection from contact (EN 60529)
After installation of the encoder, all rotating parts must be protected from accidental contact during operation.

Protection (EN 60529)
The ingress of contamination can impair proper functioning of the encoder. Unless otherwise indicated, all of the rotary encoders have an IP64 rating (ExN/ROx 400: IP67) in accordance with EN 60529. These specifications apply to the housing, cable outlet, and flange socket versions when engaged.

The **shaft inlet** meets an IP64 rating. Splash water must not contain any substances that would have harmful effects on the encoder's parts. If the protection rating of the shaft inlet is not sufficient (e.g., due to vertical mounting of the encoder), then the encoders should be additionally protected with labyrinth seals. Many encoders are also available with an IP66 rating for the shaft inlet. Depending on the application, the radial shaft seal rings used for sealing are subjected to wear due to friction.

System tests
Encoders from HEIDENHAIN are usually integrated as components into complete systems. Applications of this type require full-system, **comprehensive testing**, regardless of the encoder's specifications. The specifications provided in this brochure apply only to the encoder and not to the complete system. Any operation of the encoder outside of the specified range or outside of its proper and intended use is solely at the user's own risk.

Mounting
Only the work steps and dimensions in the mounting instructions available for the encoder are to be followed during mounting. All mounting-related information in this brochure is therefore only provisional and non-binding, and will not become the subject matter of a contract.

In addition, the machine manufacturer must define the other required final mounting information for the given application (e.g., tightening torque and the necessity for fault exclusion for screws). The stated tolerance ranges in the product's dimension drawing and mounting instructions must also be considered.

All information on screw connections is based on a mounting temperature of 15 °C to 35 °C.

The specified parameters of the individual products are based on the assumption that steel is used for the mating shaft and that aluminum is used for the mating surface for the stator coupling or stator and that this steel and aluminum have the properties stated in the table below. Any deviations from the information in this table are stated on the respective product page or in separately available Product Information documents. The following material properties and conditions for the mating surfaces are also assumed for the fault exclusion design for functional safety:

	Aluminum	**Steel**
Material	Hardenable wrought aluminum alloy	Unalloyed hardened steel
Tensile strength R_m	≥ 220 N/mm^2	≥ 600 N/mm^2
Yield strength $R_{p0.2}$ or yield point R_e	Not relevant	≥ 400 N/mm^2
Shear strength τ_a	≥ 130 N/mm^2	≥ 390 N/mm^2
Interface pressure p_G	≥ 250 N/mm^2	≥ 660 N/mm^2
Modulus of elasticity E (at 20 °C)	70 kN/mm^2 to 75 kN/mm^2	200 kN/mm^2 to 215 kN/mm^2
Coefficient of thermal expansion α_{therm} (at 20 °C)	≤ 25 · 10^{-6}K^{-1}	10 · 10^{-6}K^{-1} to 17 · 10^{-6}K^{-1}
Surface roughness Rz	≤ 16 µm	
Friction values	Mounting surfaces must be clean and free of grease. Use screws from HEIDENHAIN in their delivery condition.	
Tightening procedure	Use a signal-emitting torque wrench in accordance with DIN EN ISO 6789, with an accuracy of ±6%	
Mounting temperature	15 °C to 35 °C	

Screws with material bonding anti-rotation lock
Mounting screws and central screws from HEIDENHAIN (not included in delivery) feature a coating that, after hardening, provides a material bonding anti-rotation lock. As a result, these screws cannot be reused. The minimum shelf life is two years (storage at ≤ 30 °C and ≤ 65% relative humidity). Their expiration date is printed on the package.

Screw insertion and the application of tightening torque must therefore be completed within five minutes. The required strength is reached at room temperature after six hours. The lower the temperature is, the longer the curing process will take. Curing temperatures below 5 °C are not permissible.

Screws with material bonding anti-rotation lock must not be used more than once. If a replacement becomes necessary, recut the threads and use new screws. On threaded holes, a chamfer is required in order to keep the adhesive coating from being scraped off.

Rotary encoders with functional safety may exert a torque of up to 1 Nm on the mating shaft. In addition, other forces and torques (e.g., from vibrational loads and angular acceleration) must be taken into account. The customer's mechanical elements must be designed for these loads (see also EN 61800-5-2 and EN ISO 13849). The respective Product information documents will describe any other requirements.

Modifications to the encoder
The proper functioning and accuracy of encoders from HEIDENHAIN are ensured only if the encoders have not been modified. Any modification, even a minor one, can impair the proper functioning, reliability, and safety of the encoders, and result in a loss of warranty. This also includes the use of any additional or non-prescribed locking varnishes, lubricants (e.g., for screws), or adhesives. If you are in doubt, we recommend that you consult with HEIDENHAIN in Traunreut, Germany.

Conditions for longer storage periods
HEIDENHAIN recommends the following in order to make storage periods beyond 12 months possible:
- Leave the encoders in their original packaging
- The storage location should be dry, free of dust, and temperature-regulated. It should also be free of vibration, mechanical shock, and chemical environmental influences
- Every twelve months, rotate the shafts of the encoders with integral bearing at low speed and without axial or radial shaft loading so that the bearing lubrication becomes evenly redistributed (e.g., such as when first breaking in an encoder)

Parts subject to wear
Encoders from HEIDENHAIN are designed for a long service life. Preventive maintenance is not required. However, they do contain components that are subject to wear depending on the application and how they are deployed. This especially applies to cables that are subject to frequent flexing.

Other parts subject to wear are the bearings in encoders with integral bearing, the radial shaft seal rings in rotary encoders and angle encoders, and the sealing lips on sealed linear encoders.

In order to avoid damage from current flows, some rotary encoders are available with hybrid bearings. In general, these bearings exhibit greater wear at high temperatures than standard bearings.

Service life
Unless otherwise specified, HEIDENHAIN encoders are designed for a service life of 20 years, equivalent to 40 000 operating hours under typical operating conditions.

Temperature ranges
For encoders still in their packaging, a **storage temperature range** of –30 °C to 65 °C applies (HR 1120: –30 °C to 70 °C). The **operating temperature range** specifies the temperatures that a rotary encoder is permitted to reach during operation in the actual installation environment. Within this range, proper functioning of the rotary encoder is ensured. The operating temperature is measured at the defined measuring point (see dimension drawing) and must not be confused with the ambient temperature.

The temperature of the rotary encoder is influenced by the following factors:
- Installation situation
- Ambient temperature
- Encoder self-heating

An encoder's susceptibility to self-heating depends both on its design characteristics (stator coupling / solid shaft, shaft sealing ring, etc.) and on its operating parameters (shaft speed, supply voltage). A temporary period of heightened self-heating can also occur after very long breaks in operation (of several months). Please allow for a two-minute break-in period at low shaft speeds. The greater susceptibility to self-heating that an encoder exhibits, the lower the ambient temperature needs to be in order to keep the encoder within its permissible operating temperature range.

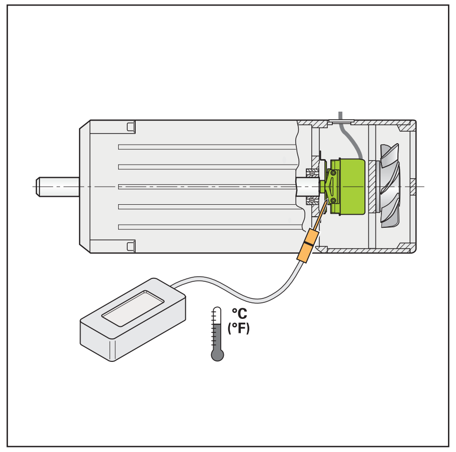
This table shows the approximate self-heating values to be expected for the rotary encoders. In the worst case, the amount of self-heating may be affected by multiple operating parameters, such as a 30 V supply voltage and maximum shaft speed. Thus, if an encoder is being operated close to its maximum permissible specifications, then the actual operating temperature should be measured directly at the encoder. Suitable measures must then be taken (fan, heat sinks, etc.) to sufficiently reduce the ambient temperature so that the maximum permissible operating temperature will not be exceeded during continuous operation.

For high shaft speeds at the maximum permissible ambient temperature, special versions with a reduced protection rating are available (without a radial shaft seal ring and its concomitant frictional heat).

Self-heating at shaft speed n_{max}

ECN/EQN/ ERN 1000	≈ +10 K
ROC/ROQ/ROD Solid shaft	≈ +5 K With IP66 rating: ≈ +10 K
ECN/EQN/ ERN 400/1300 Tapered shaft	≈ +5 K With IP66 rating: ≈ +10 K
ECN/EQN/ ERN 400/1300 Blind hollow shaft	≈ +30 K With IP66 rating: ≈ +40 K
ECN/EQN/ ERN 400 Hollow through shaft	≈ +40 K With IP66 rating: ≈ +50 K
ECN/ERN 100 Hollow through shaft	≈ +50 K
ROD 600	≈ +75 K

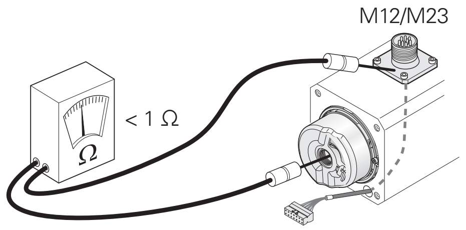
Typical self-heating values of a rotary encoder at maximum permissible shaft speed based on its design characteristics. The relationship between shaft speed and heat generation is nearly linear.



Measuring of the actual operating temperature at the defined measuring point of the rotary encoder (see *Specifications*)

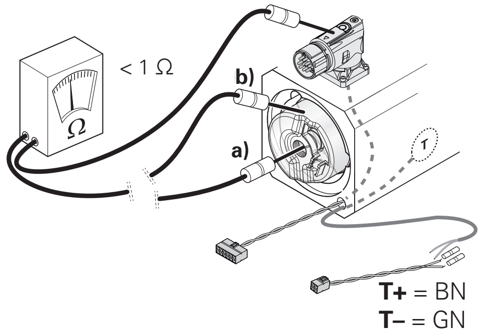
Electrical resistance

Encoders with an integral bearing, pluggable output cable, and standard bearing
Check the resistance between the flange socket and the rotor.
Nominal value: < 1 ohm

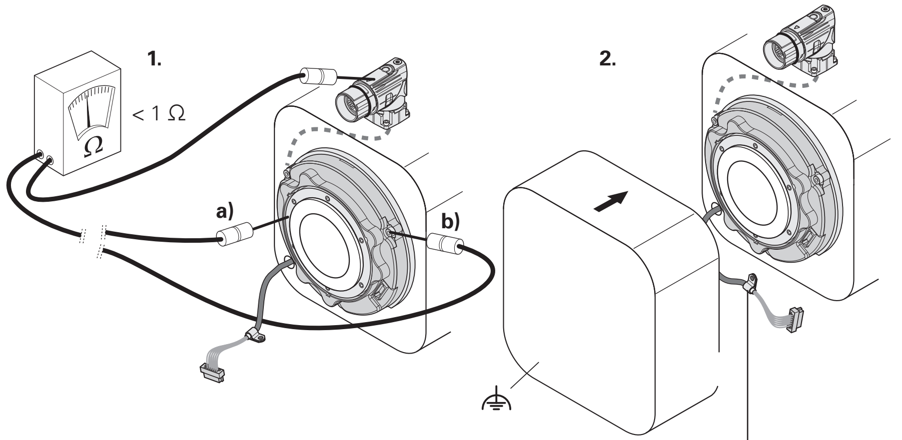


For more information:
When connecting an external temperature sensor, please refer to the information about electromagnetic compatibility in the *General electrical information* section of the *Interfaces of HEIDENHAIN Encoders* brochure.

Encoders with hybrid bearing or EnDat 3 (E30-R2)
Check the resistance between the flange socket and the rotor **a)**, and between the flange socket and the stator (metal housing) **b)**.
Nominal value: < 1 ohm

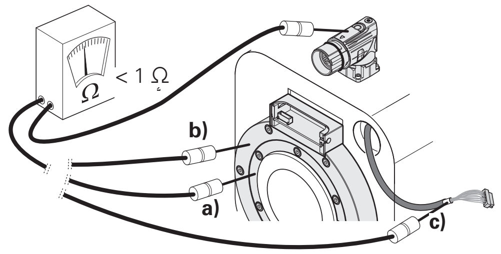


Exposed encoders (ExI 100) without integral bearing but with a pluggable cable
Check the electrical resistance between the flange socket and the rotor **a)**, and between the flange socket and the stator (mounting screw) **b)**.
Nominal value: < 1 ohm

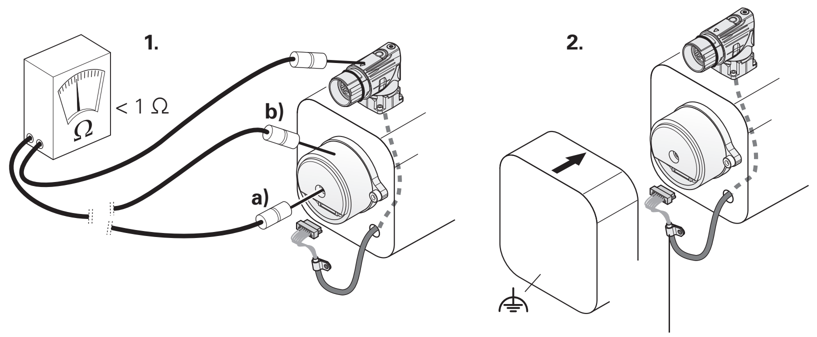


Clamp must be screwed to the motor housing so as to be conductive.

Exposed encoders (ExI 4000) without an integral bearing but with a pluggable output cable
Check the electrical resistance between the flange socket and the rotor **a)**, the flange socket and the stator **b)**, and the flange socket and the crimp sleeve **c)**.
Nominal value: < 1 ohm



Exposed encoders (ExI 1100, ExI 1300) without an integral bearing but with a pluggable output cable
Check the resistance between the flange socket and the rotor **a)**, and between the flange socket and the stator (metal housing) **b)**.
Nominal value: < 1 ohm



Clamp (when present) must be screwed to the motor housing so as to be conductive.

Temperature measurement in motors

Transmission of temperature values
To protect the motor from overloads, the motor manufacturer usually monitors the temperature of the motor winding. In conventional applications, the temperature sensor data are sent via two separate lines to the downstream electronics, where they are then evaluated. Depending on their features, HEIDENHAIN rotary encoders with the **EnDat 2.2, EnDat 3 or DRIVE-CLiQ interface** have an **internal temperature sensor** integrated into the encoder's electronics and an evaluation circuit to which the **external temperature sensor** can be connected. In both cases, the respective digitized measured temperature value is transmitted purely serially over the interface protocol. As a result, no separate lines are needed from the motor to the motor controller.

Signaling of a temperature exceedance
When it comes to the internal temperature sensor, such rotary encoders can support the dual-level cascaded signaling of a temperature exceedance. This signaling consists of a warning (only EnDat) and an error message.

The integrated memory can be read to determine whether the respective encoder supports this warning and error message functionality.

The warning threshold for the internal temperature sensor can be individually adjusted. At the time the encoder is shipped, a default value equivalent to the maximum permissible operating temperature is stored here (temperature at measuring point M1 as per the dimension drawing). The temperature measured by the internal temperature sensor is higher by a device-specific amount than the temperature at measuring point M1.

The encoder features a further, albeit non-adjustable trigger threshold for the internal temperature sensor; an error message is output when this threshold is reached. This trigger threshold is device-specific and, if present, is stated in the specifications.

Encoder	Interface	Internal temperature sensor[1]	External temperature sensor Connection
ECI/EQI 1100	EnDat22	✓ (±1 K)	Possible
	E30-R2		
ECI/EBI 1100	EnDat22	✓ (±5 K)	–
ECN/EQN 1100	EnDat22	✓ (±5 K)	Possible
	EnDat01	–	–
ECN/EQN 1300	EnDat22	✓ (±1 K)	Possible
	E30-R2	✓ (±1 K)	–
	EnDat01	–	–
	DQ01	✓ (±1 K)	Possible
ECN/EQN 400	EnDat22	✓ (±1 K)	Possible
	EnDat01	–	–
ECI/EBI/EQI 1300	EnDat22	✓ (±1 K)	Possible
ECI/EQI 1300	E30-R2	✓ (±1 K)	Possible
ECI/EQI 1300 S	DQ		
ECI/EBI 100	EnDat22	✓ (±4 K)	Possible
	EnDat01	–	–
ECI/EBI 4000	EnDat22	✓ (±1 K)	Possible

[1] In parentheses: accuracy at 125 °C

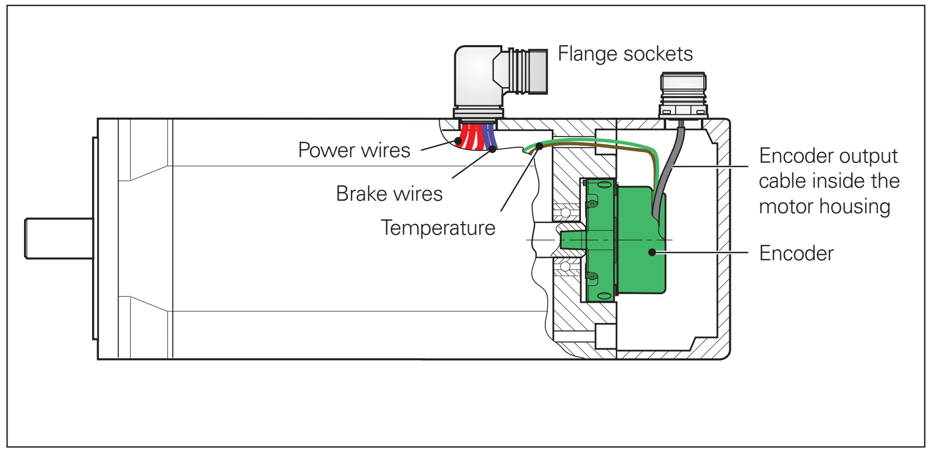
HEIDENHAIN recommends adjusting the warning threshold based on the application such that this threshold is sufficiently below the trigger threshold for the "Temperature exceeded" error message. Compliance with the operating temperature at measuring point M1 is also required for adherence to the encoder's proper and intended use.

For more information on configuring and reading the temperature information, please refer to the respective Application Notes:
EnDat 2.2: Document 722024
EnDat 3: Document 3000005
DRIVE-CLiQ: Document 1236334

For more information:
When connecting an external temperature sensor, please refer to the information about electromagnetic compatibility in the *General electrical information* section of the *Interfaces of HEIDENHAIN Encoders* brochure.

Information on connecting an external temperature sensor

- The external temperature sensor must comply with the following requirements as per EN 61800-5-1:
  – Voltage class A
  – Contamination level 2
  – Overvoltage category 3
- Connect only passive temperature sensors.
- The connections for the temperature sensor are galvanically connected with the encoder electronics.
- Depending on the application, the temperature sensor assembly (sensor + cable assembly) must be mounted such that it is insulated from its environment with double or reinforced insulation.
- The accuracy of the temperature measurement depends on the temperature range.
- Take into account the tolerance of the temperature sensor.
- The transmitted temperature value is not a safe value in terms of functional safety.
- The motor manufacturer is responsible for the quality and accuracy of the temperature sensor, as well as for ensuring electrical safety.
- Use a crimp connector with a suitable temperature range (e.g., up to 150 °C ID 1148157-01).



Cable configuration of the temperature wires in the motor

The accuracy of the temperature measurement depends on the sensor being used and on the temperature range.

	KTY 83-110	KTY 84-130	PT 1000
–40 °C to 80 °C	±6 K	±6 K	±6 K
80.1 °C to 160 °C	±3 K	±3 K	±4 K
160.1 °C to 200 °C	±6 K	±6 K	±6 K

Specifications for the evaluation	
Resolution	0.1 K (with KTY 84-130)
Supply voltage of sensor	3.3 V over dropping resistor R_V = 2 kΩ
Measuring current (typical)	1.3 mA at 595 Ω 1.1 mA at 990 Ω
Total delay of temperature evaluation[1]	160 ms max.
Cable length[2]	≤ 1 m

[1] Filter time constants and conversion time are taken into account; the time constants / response delay of the temperature sensor and the time lag for reading via the encoder interface are not included in this.
[2] Limitation of the cable length due to interference; the measuring error due to the line resistance is negligible.

Connectable temperature sensors

In the case of EnDat 3 encoders with an E30-R2 interface, the encoder can be configured for the connected temperature sensor (KTY 83-110, KTY 84-130 or PT 1000). For encoders with the DRIVE-CLiQ interface, you can choose between the KTY 84-130 or PT 1000. The correct temperature value is then output directly over the interface.

With EnDat22 encoders, the temperature evaluation performed within the rotary encoder is designed for a KTY 84-130 PTC thermistor. For other temperature sensors, the output value (value in additional data 1) must be converted into a temperature value.

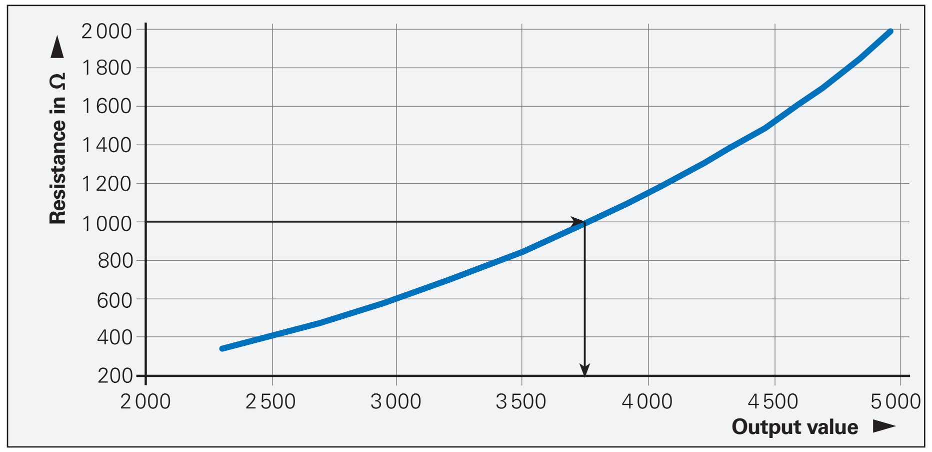


Figure 1: Relationship between the output value and resistance

Example for the KTY 84-130 temperature sensor:
Sensor resistance = 1000 Ω → Output value (temperature value) 3751, which is equal to 375.1 K or 102 °C.

Figure 1 illustrates the relationship between the output value and the resistance of the temperature sensor.
When a KTY 84-130 is used, the temperature value equals the output value. The value has an increment of 0.1 kelvins.

Figure 2 illustrates the relationship for EnDat22 encoders between the output value and the temperature value for a PT 1000. In the graph, the temperature value for the PT 1000 can be determined based on the output value.

General notes on the evaluation:

- Output values ≤ 1151 indicate a short-circuit at the sensor input
- Output values > 6000 indicate a high-impedance sensor input (e.g., due to a broken wire)

Notes on the conversion:
The conversion for the PT 1000 and KTY 83-110 must be performed for encoders that do not inherently support this conversion.

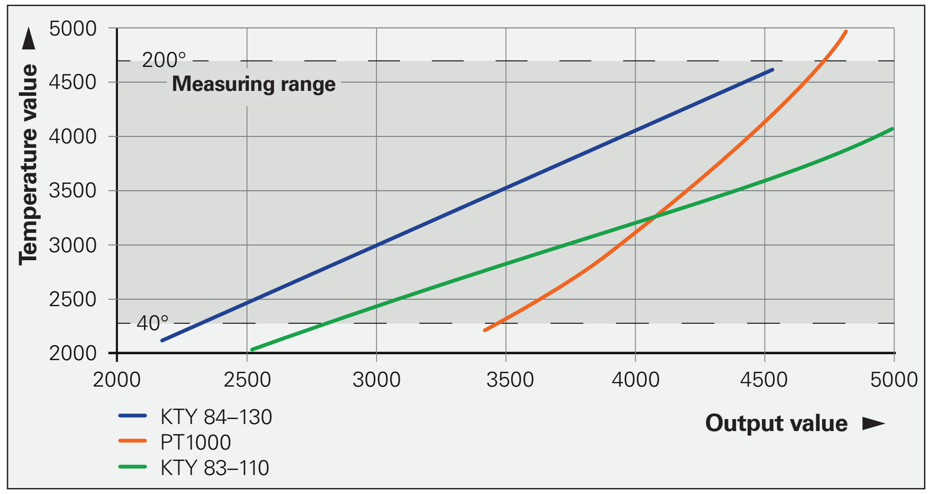


Figure 2: Relationship between the output value and the temperature value using the example of the PT 1000 and KTY 83-110

Example for the PT 1000 temperature sensor:
Output value = 3751 → Temperature value = 2734 (equivalent to 0.3 °C).
The following polynomial can be used to calculate the temperature value:

$$\text{Temperature}_{PT1000} = 1.3823 \cdot 10^{-7} \cdot A^3 - 1.2005 \cdot 10^{-3} \cdot A^2 + 4.6807 \cdot A - 5.2276 \cdot 10^3$$

A = Output value. The PT 1000 polynomial is valid for: 3400 ≤ A ≤ 4810.

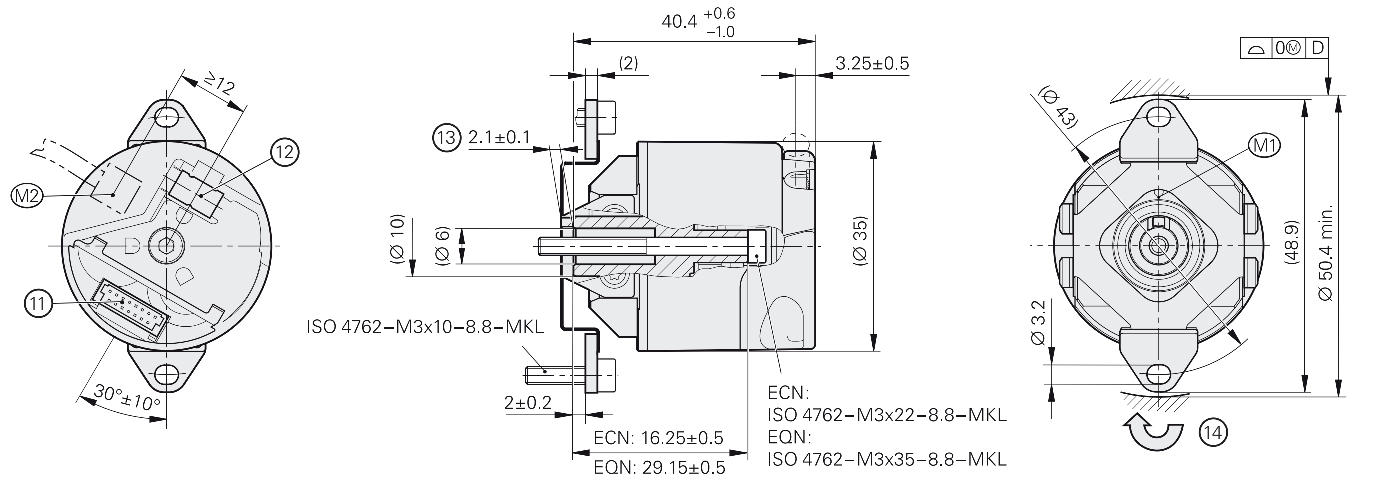
Example for the KTY 83-110 temperature sensor:
Output value = 3751 → Temperature value = 2981 (equivalent to 25.0 °C).
The following polynomial can be used to calculate the temperature value:

$$\text{Temperature}_{KTY83\text{-}110} = 3.007 \cdot 10^{-8} \cdot A^3 - 3.041 \cdot 10^{-4} \cdot A^2 + 1.786 \cdot A - 1.027 \cdot 10^3$$

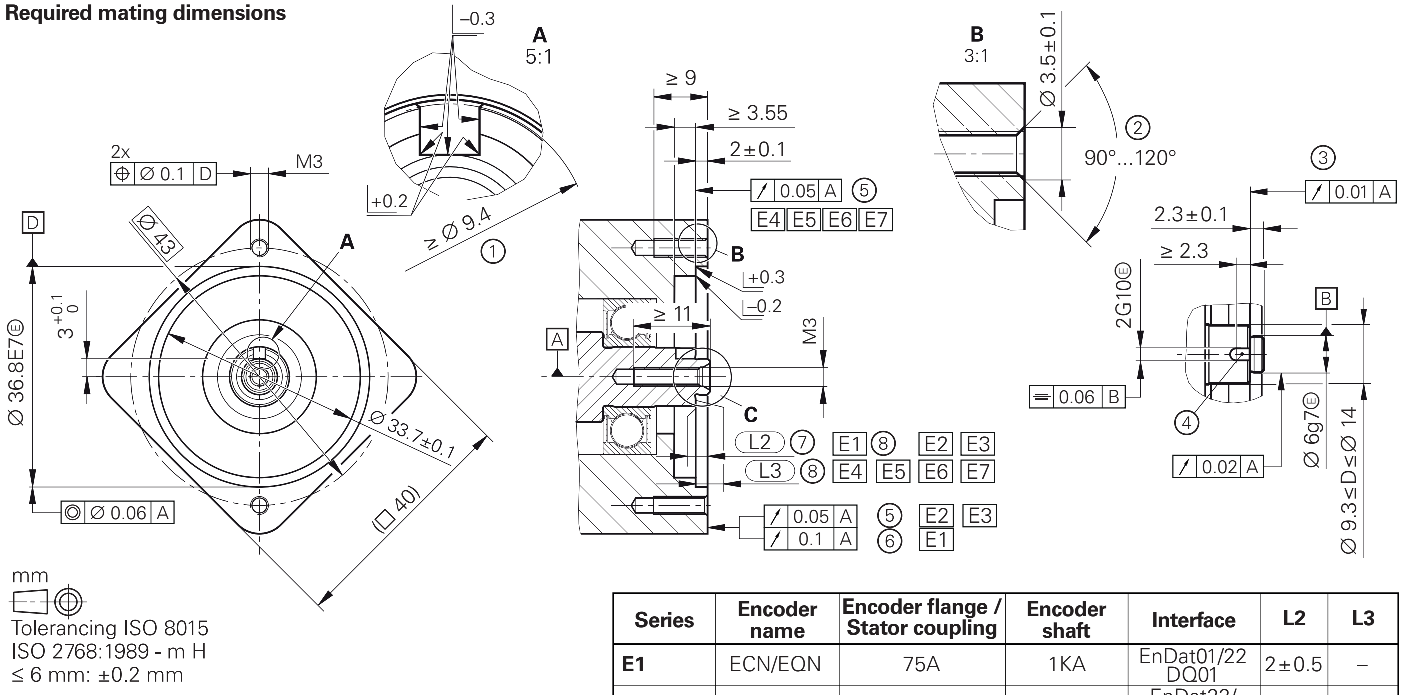
A = Output value. The KTY83-110 polynomial is valid for: 2880 ≤ A ≤ 5460.

ECN/EQN 1100 series

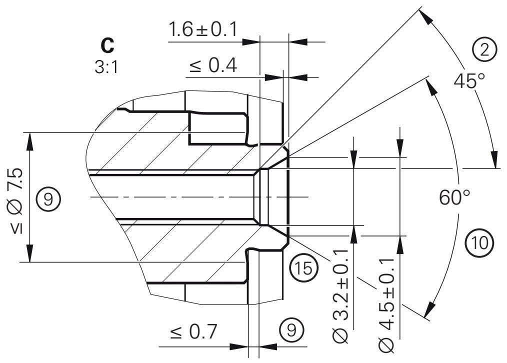
Absolute rotary encoders
- **75A stator coupling for plane surface**
- **Blind hollow shaft**
- **Encoders available with functional safety**



Required mating dimensions



Series	Encoder name	Encoder flange / Stator coupling	Encoder shaft	Interface	L2	L3
E1	ECN/EQN	75A	1KA	EnDat01/22 DQ01	2±0.5	–
E2/E3	ECI/EQI	70C	1KA/82A	EnDat22/ E30-R2	2±0.4	–
E4/E6	ECI/EQI	70F	82A	EnDat22/ E30-R2	–	0±0.4
E5	ECI/EQI	70F	82A	EnDat01	–	0±0.3
E7	ECI/EBI	70E	82C	EnDat22	–	0±0.3



A = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration
1 = Contact surface of slot
2 = Chamfer at start of thread is mandatory for material bonding anti-rotation lock
3 = Shaft surface; ensure full-surface contact!
4 = Slot required only for ECN/EQN and ECI/EQI, WELLA1 = 1KA
5 = EXI flange surface; ensure full-surface contact!
6 = Coupling surface of ECN/EQN
7 = Maximum permissible deviation between the shaft surface and coupling surface; compensation of mounting tolerances and thermal expansion, of which ±0.15 mm of dynamic axial motion is permitted
8 = Maximum permissible deviation between shaft surface and flange surface; compensation of mounting tolerances and thermal expansion
9 = Undercut
10 = Possible centering hole
11 = 15-pin PCB connector
12 = Cable fastener with crimp sleeve; diameter: 4.3 mm ±0.1 mm; length: 7 mm
13 = Positive locking element; ensure correct engagement in Slot 4 (e.g., by measuring the device overhang)
14 = Direction of shaft rotation for ascending position values
15 = Uncoated; shaft coating not permitted

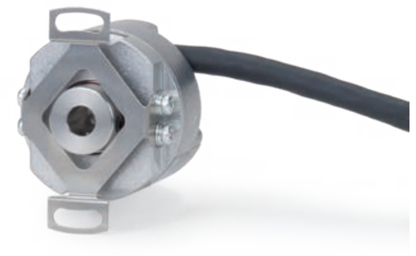
	Absolute			
	ECN 1113	**ECN 1123** Functional Safety	**EQN 1125**	**EQN 1135** Functional Safety
Interface	EnDat 2.2	*ECN 1123:* EnDat 2.2	EnDat 2.2	*EQN 1135:* EnDat 2.2
Ordering designation	EnDat01	*ECN 1123:* EnDat22	EnDat01	*EQN 1135:* EnDat22
Position values per rev.	8192 (13 bits)	8388608 (23 bits)	8192 (13 bits)	8388608 (23 bits)
Revolutions	–		4096 (12 bits)	
Elec. permiss. shaft speed/ deviations[1]	4000 rpm/±1 LSB 12000 rpm/±16 LSB	12000 rpm(for continuous position value)	4000 rpm/±1 LSB 12000 rpm/±16 LSB	12000 rpm (for continuous position value)
Calc. t_{cal} / clock freq.[4]	≤ 9 µs / ≤ 2 MHz	*ECN 1123:* ≤ 7 µs / ≤ 8 MHz	≤ 9 µs / ≤ 2 MHz	*EQN 1135:* ≤ 7 µs / ≤ 8 MHz
Incremental signals	∼ 1 V_{PP}[2]	–	∼ 1 V_{PP}[2]	–
Line count	512	–	512	–
Cutoff frequency –3 dB	≥ 190 kHz	–	≥ 190 kHz	–
System accuracy	±60″			
Electrical connection	15-pin	15-pin[3]	15-pin	15-pin[3]
Supply voltage	3.6 V to 14 V DC	*ECN 1123:* DC 3.6 to 14 V	3.6 V to 14 V DC	*EQN 1135:* DC 3.6 to 14 V
Power consumption (maximum)	*3.6 V:* ≤ 0.6 W *14 V:* ≤ 0.7 W	*ECN 1123:* *3.6 V:* ≤ 0.6 W *14 V:* ≤ 0.7 W	*3.6 V:* ≤ 0.7 W *14 V:* ≤ 0.8 W	*EQN 1135:* *3.6 V:* ≤ 0.7 W *14 V:* ≤ 0.8 W
Current consumption (typical)	*5 V:* 85 mA (without load)	*5 V:* 85 mA (without load)	*5 V:* 105 mA (without load)	*5 V:* 105 mA (without load)
Shaft	1KA blind hollow shaft (Ø 6 mm) with positive-locking element			
Mech. permiss. shaft speed *n*	12000 rpm			
Starting torque (typical)	0.001 Nm (at 20 °C)		0.002 Nm (at 20 °C)	
Moment of inertia of rotor	≈ $0.4 \cdot 10^{-6}$ kgm^2			
Permissible axial motion of measured shaft	±0.5 mm			
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)			
Max. operating temp.	115 °C	*ECN 1123:* 115 °C	115 °C	*EQN 1135:* 115 °C
Min. operating temp.	–40 °C			
Protection EN 60529	IP40 (read about "insulation" under *Electrical safety* in the *Interfaces of HEIDENHAIN Encoders* brochure); contamination from the ingress of fluid must be prevented)			
Mass	≈ 0.1 kg			
Part number	803427-xx	*ECN 1123:* 803429-xx	803428-xx	*EQN 1135:* 803430-xx

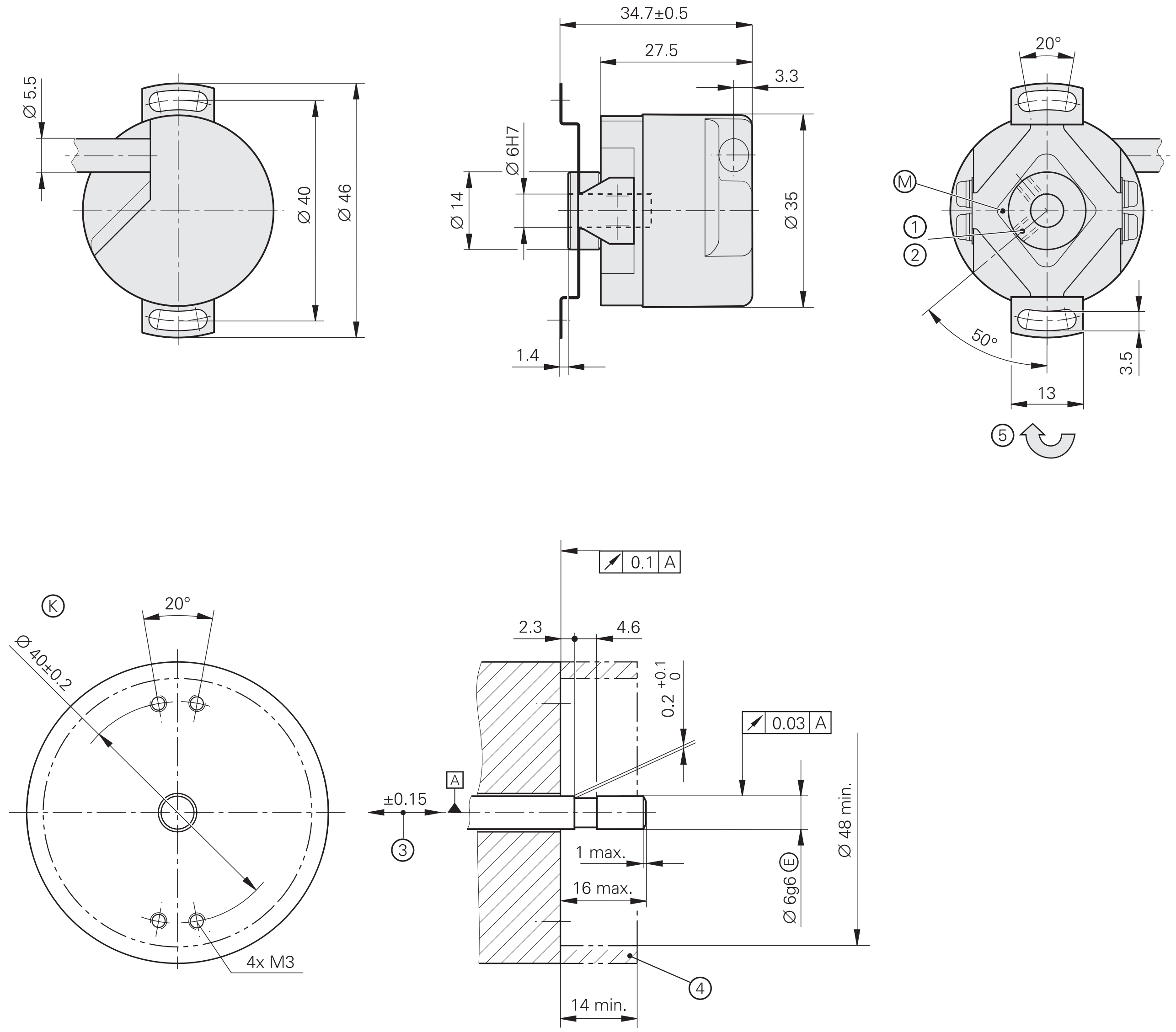
1) Speed-dependent deviations between absolute and incremental signals
2) Deviating tolerances — Signal amplitude: 0.80 V_{PP} to 1.2 V_{PP}; Signal ratio: 0.9 to 1.1 — Asymmetry: 0.05; Phase angle: 90° elec. ±5° elec.
3) See *Temperature measurement in motors*
4) Applies only to EnDat rotary encoders

For dimensions and specifications of encoders with functional safety, see the Product Information document.

ERN 1023

Incremental rotary encoders
- **Stator coupling for plane surface**
- **Blind hollow shaft**
- **Block commutation signals**





mm
Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

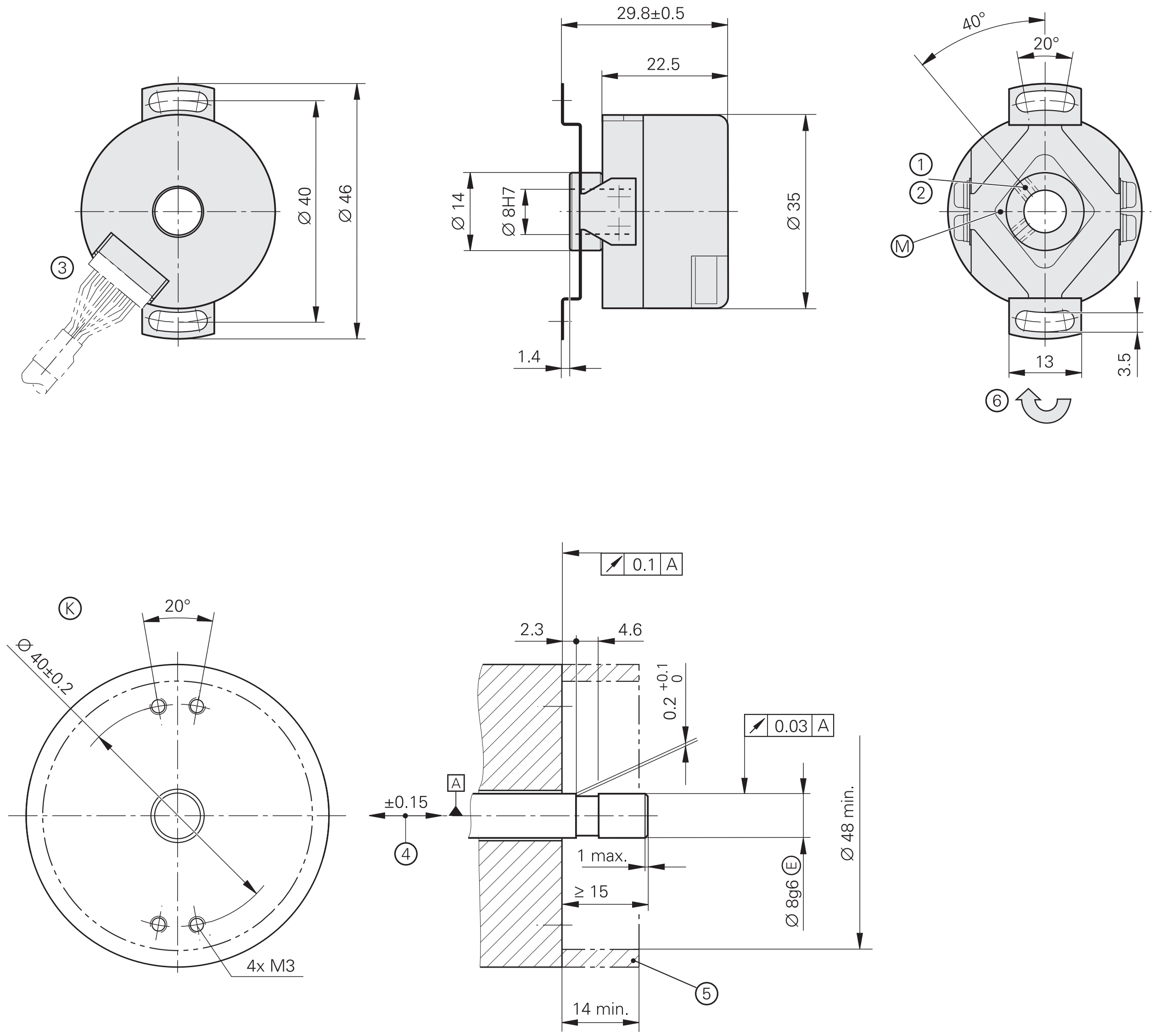
A = Bearing of mating shaft
K = Required mating dimensions
M = Measuring point for operating temperature
1 = Two screws in clamping ring; width A/F 1.5
2 = Reference mark position ±10°
3 = Compensation of mounting tolerances and thermal expansion, no dynamic motion permitted
4 = Ensure protection against contact (EN 60529)
5 = Direction of shaft rotation for output signals according to interface description

	ERN 1023	
Interface	⊓⊔TTL	
Signal periods per revolution*	**500** **512** 600	**1000** **1024** 1250 **2000** **2048** **2500** 4096 5000 8192
Reference mark	One	
Output frequency Edge separation *a*	≤ 300 kHz ≥ 0.41 µs	
Commutation signals[1]	⊓⊔TTL (3 commutation signals U, V, W)	
Width*	2 x 180° (C01); 3 x 120° (C02); **4 x 90° (C03)**	
System accuracy	±260″	±130″
Electrical connection*	Cable **1 m,** 5 m, without coupling	
Supply voltage	DC 5 V ±0.5 V	
Current consumption (without load)	≤ 70 mA	
Shaft	Blind hollow shaft Ø 6 mm	
Mech. permiss. shaft speed *n*	≤ 6000 rpm	
Starting torque (typical)	0.005 Nm (at 20 °C)	
Moment of inertia of rotor	$0.5 \cdot 10^{-6}$ kgm^2	
Permissible axial motion of measured shaft	±0.15 mm	
Vibration 25 Hz to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)	
Max. operating temp.	90 °C	
Min. operating temp.	*Fixed cable:* –20 °C *Moving cable:* –10 °C	
Protection EN 60529	IP64	
Mass	≈ 0.07 kg (without cable)	
Part number	684703-xx	

Bold: This preferred version is available on short notice
* Please select when ordering
1) Three square-wave signals with signal periods with 90°, 120°, or 180° mech. phase shift; see *Commutation signals for block commutation* in the *Interfaces of HEIDENHAIN Encoders* brochure

ERN 1123

Incremental rotary encoders
- **Stator coupling for plane surface**
- **Hollow through shaft**
- **Block commutation signals**



mm
Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

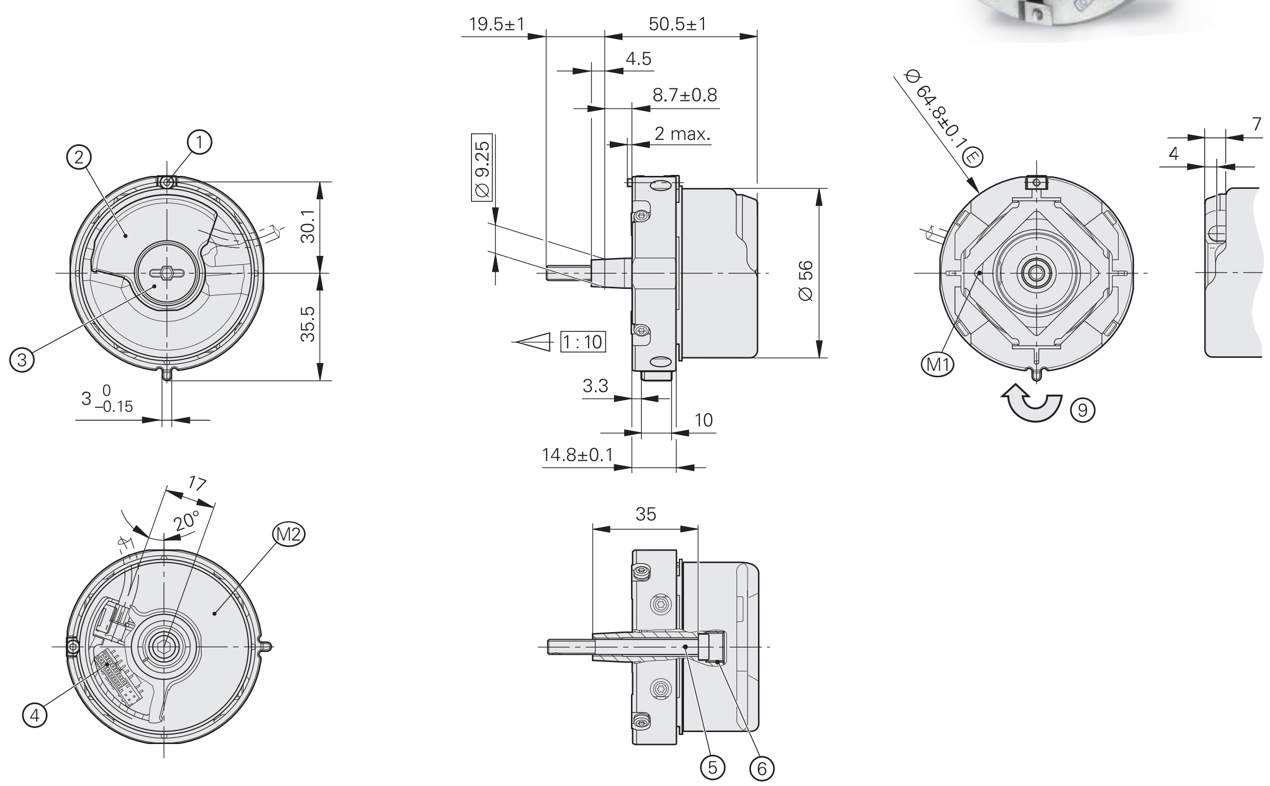
A = Bearing of mating shaft
K = Required mating dimensions
M = Measuring point for operating temperature
1 = Two screws in clamping ring; width A/F 1.5
2 = Reference mark position ±10°
3 = 15-pin PCB connector
4 = Compensation of mounting tolerances and thermal expansion, no dynamic motion permitted
5 = Ensure protection against contact (EN 60529)
6 = Direction of shaft rotation for output signals according to interface description

	ERN 1123	
Interface	⊓⊔TTL	
Signal periods per revolution*	**500** **512** 600	**1000** **1024** 1250 **2000** **2048** **2500** 4096 5000 8192
Reference mark	One	
Output frequency Edge separation *a*	≤ 300 kHz ≥ 0.41 µs	
Commutation signals1)	⊓⊔TTL (3 commutation signals U, V, W)	
Width*	2 x 180° (C01); 3 x 120° (C02); **4 x 90° (C03)**	
System accuracy	±260"	±130"
Electrical connection	15-pin	
Supply voltage	DC 5 V ±0.5 V	
Current consumption (without load)	≤ 70 mA	
Shaft	Hollow through shaft (Ø 8 mm)	
Mech. permiss. shaft speed *n*	≤ 6000 rpm	
Starting torque (typical)	0.005 Nm (at 20 °C)	
Moment of inertia of rotor	$0.5 \cdot 10^{-6}$ kgm^2	
Permissible axial motion of measured shaft	±0.15 mm	
Vibration 25 Hz to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)	
Operating temperature	–20 °C to 90 °C	
Protection EN 60529	IP002)	
Mass	≈ 0.06 kg	
Part number	684702-xx	

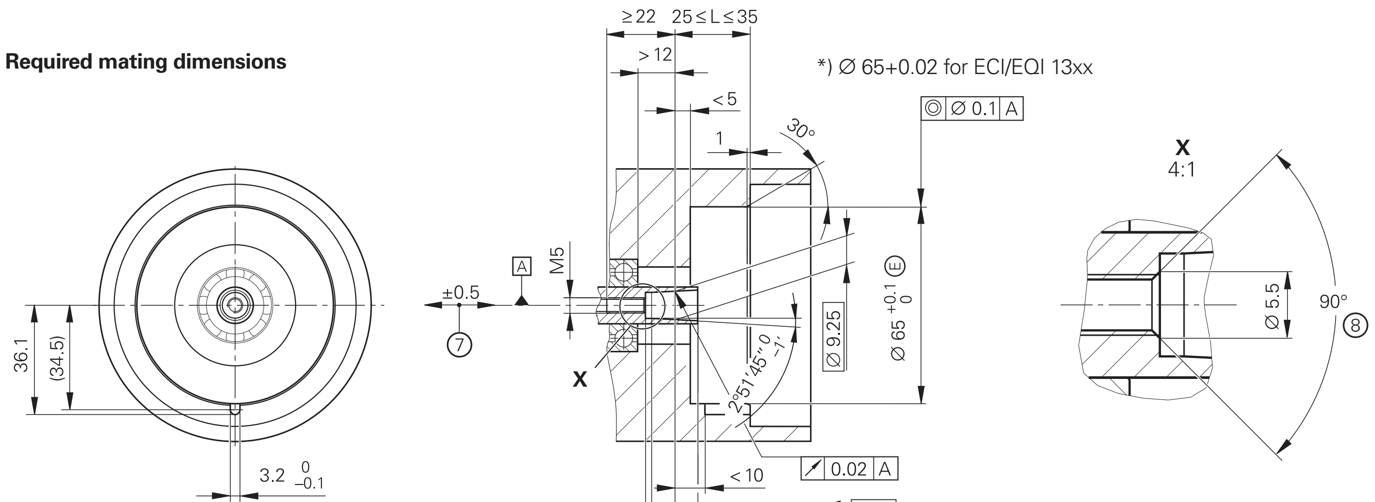
Bold: This preferred version is available on short notice
* Please select when ordering
1) Three square-wave signals with signal periods with 90°, 120°, or 180° mech. phase shift; see *Commutation signals for block commutation* in the *Interfaces of HEIDENHAIN Encoders* brochure
2) Electromagnetic compatibility must be ensured in the entire system

ECN/EQN 1300 series

Absolute rotary encoders
- **07B stator coupling with anti-rotation element for axial mounting**
- **65B tapered shaft**
- **Encoders available with functional safety**
- **Fault exclusion for rotor coupling and stator coupling as per EN 61800-5-2 possible**



Required mating dimensions



mm

Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

A = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration, see D 741714
1 = Clamping screw for coupling ring (width A/F 2)
2 = Die-cast cover
3 = Screw plug: width A/F 3 and 4
4 = 16-pin (12+4-pin) header
5 = Screw: DIN 6912 – M5x50 – 08.8 – MKL; width A/F 4
6 = M10 back-off thread
7 = Compensation of mounting tolerances and thermal expansion, no dynamic motion permitted
8 = Chamfer at start of thread is mandatory for material bonding anti-rotation lock
9 = Direction of shaft rotation for ascending position values

	Absolute **ECN 1313** **EQN 1325**	**ECN 1325** **EQN 1337** Functional Safety	**ECN 1325** **EQN 1337** Functional Safety
Interface	EnDat 2.2		EnDat 3
Ordering designation	EnDat01	EnDat22	E30-R2
Position values per rev.	8192 (13 bits)	33554432 (25 bits)	33554432 (25 bits)
Revolutions	*ECN 1313:* – *EQN 1325:* 4096 (12 bits)	*ECN 1325:* – *EQN 1337:* 4096 (12 bits)	
Elec. permiss. shaft speed/ deviations[2]	*512 lines:* 5000 rpm/±1 LSB 12000 rpm/±100 LSB *2048 lines:* 1500 rpm/±1 LSB 12000 rpm/±50 LSB	15000 rpm (for continuous position value)	
Calc. time t_{cal}/clock freq.	≤ 9 µs/≤ 2 MHz	≤ 7 µs/≤ 8 MHz	–
XEL.time HPFout data rate	–	–	≤ 11 µs at 12.5 Mbit/s; ≤ 8.2 µs at 25 Mbit/s
Incremental signals	∿ 1 V_{PP}[1]	–	
Line count*	512 2048	–	
Cutoff frequency –3 dB	*2048 lines:* ≥ 400 kHz *512 lines:* ≥ 130 kHz	–	
System accuracy	*2048 lines:* ±20″ *512 lines:* ±60″	±20″	
Electrical connection	12-pin	16-pin (12+4-pin); with connection for external temperature sensor[3]	
Supply voltage	3.6 V to 14 V DC		DC 4 V to 14 V (12 V recommended)
Power consumption (maximum)	*ECN 1313 / ECN 1325* *At 3.6 V:* ≤ 0.6 W *At 14 V:* ≤ 0.7 W *EQN 1325 / EQN 1337* *At 3.6 V:* ≤ 0.7 W *At 14 V:* ≤ 0.8 W		*ECN 1325* *At 4 V:* ≤ 700 mW; *At 14 V:* ≤ 750 mW *EQN 1337* *At 4 V:* ≤ 800 mW; *At 14 V:* ≤ 850 mW
Current consumption (typical)	*ECN 1313 / ECN 1325* *At 5 V:* 85 mA (without load) *EQN 1325 / EQN 1337* *At 5 V:* 105 mA (without load)		*ECN 1325* *At 12 V:* 30 mA (w/o communication) *EQN 1337* *At 12 V:* 40 mA (w/o communication)
Shaft	Tapered shaft (Ø 9.25 mm); taper: 1:10		
Mech. permiss. shaft speed *n*	*ECN 1313 / ECN 1325:* ≤ 15000 rpm; *EQN 1325 / EQN 1337:* ≤ 12000 rpm		
Starting torque (typical)	0.01 Nm (at 20 °C)		
Moment of inertia of rotor	$2.6 \cdot 10^{-6}$ kgm^2		
Natural frequency f_N (typical)	1800 Hz		
Permiss. axial motion of measured shaft	±0.5 mm		
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2[2,4] (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)		
Operating temperature	–40 °C to 115 °C		
Protection EN 60529	IP40 when mounted		
Mass	≈ 0.3 kg		
Part number	*ECN 1313:* 768295-xx *EQN 1325:* 827039-xx	*ECN 1325:* 1178019-xx *EQN 1337:* 1178020-xx	*ECN 1325:* 1296522-xx *EQN 1337:* 1296523-xx

* Please select when ordering

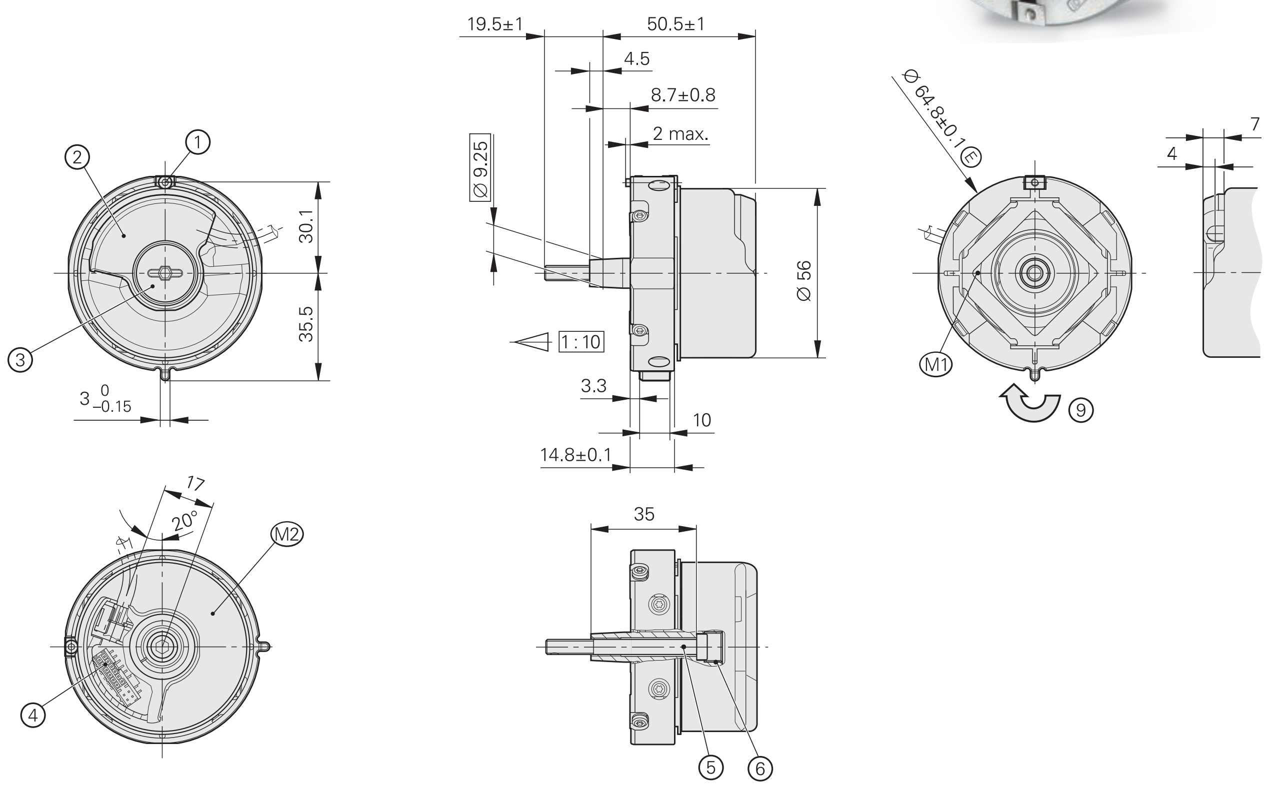
[1] Deviating tolerances
Signal amplitude: 0.8 V_{PP} to 1.2 V_{PP}
Asymmetry: 0.05
Amplitude ratio: 0.9 to 1.1
Phase angle: 90° elec. ±5° elec.
Signal-to-noise ratio E, F: ≥ 100 mV

[2] Speed-dependent deviations between absolute and incremental signals
[3] Evaluation optimized for KTY 84-130 / PT1000 with EnDat 3
[4] Valid as per standard at room temp.; the following applies at operating temps. up to 100 °C: ≤ 300 m/s^2; up to 115 °C: ≤ 150 m/s^2

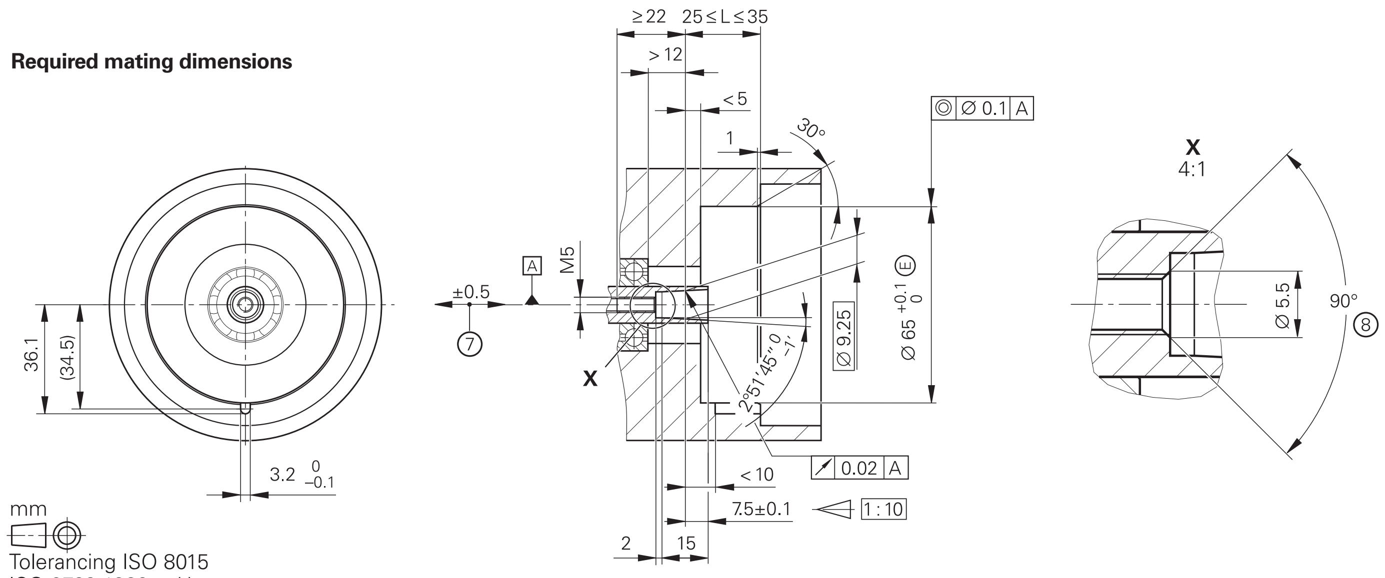
For dimensions and specifications of encoders with functional safety, see the Product Information document.

ECN/EQN 1300 S series

Absolute rotary encoders
- **07B stator coupling with anti-rotation element for axial mounting**
- **65B tapered shaft**
- **Encoders available with functional safety**
- **Fault exclusion for rotor and stator coupling as per EN 61 800-5-2 possible**



Required mating dimensions



mm

Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

A = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration, see D 741714
1 = Clamping screw for coupling ring (width A/F 2)
2 = Die-cast cover
3 = Screw plug: width A/F 3 and 4
4 = 16-pin (12+4-pin) header
5 = Screw: DIN 6912 – M5x50 – 08.8 – MKL; width A/F 4
6 = M10 back-off thread
7 = Compensation of mounting tolerances and thermal expansion, no dynamic motion permitted
8 = Chamfer at start of thread is mandatory for material bonding anti-rotation lock
9 = Direction of shaft rotation for ascending position values

	Absolute	
	ECN 1324 S Functional Safety	**EQN 1336 S** Functional Safety
Interface	DRIVE-CLiQ	
Ordering designation	DQ01	
Position values per rev.	16 777 216 (24 bits)	
Revolutions	–	4096 (12 bits)
Spindle speed	≤ 15 000 rpm (at ≥ 2 position requests per revolution)	≤ 12 000 rpm (at ≥ 2 position requests per revolution)
Calculation time TIME_MAX_ACTVAL	≤ 8 µs	
Incremental signals	–	
System accuracy	±20″	
Electrical connection	16-pin (12+4-pin); with connection for external temperature sensor[1)]	
Supply voltage	10 V to 28 V DC	
Power consumption (maximum)	*10 V:* ≤ 0.9 W *28.8 V:* ≤ 1 W	*10 V:* ≤ 1 W *28.8 V:* ≤ 1.1 W
Current consumption (typical)	*24 V:* 38 mA (without load)	*24 V:* 43 mA (without load)
Shaft	Tapered shaft (Ø 9.25 mm); taper: 1:10	
Starting torque (typical)	0.01 Nm (at 20 °C)	
Moment of inertia of rotor	$2.6 \cdot 10^{-6}$ kgm^2	
Natural frequency f_N (typical)	1800 Hz	
Permissible axial motion of measured shaft	±0.5 mm	
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)	
Operating temperature	–30 °C to 100 °C	
Protection EN 60529	IP40 when mounted	
Mass	≈ 0.25 kg	
Part number	1179144-xx	1179145-xx

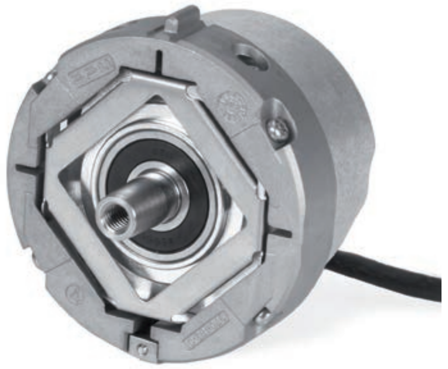
For dimensions and specifications of encoders with functional safety, see the Product Information document.

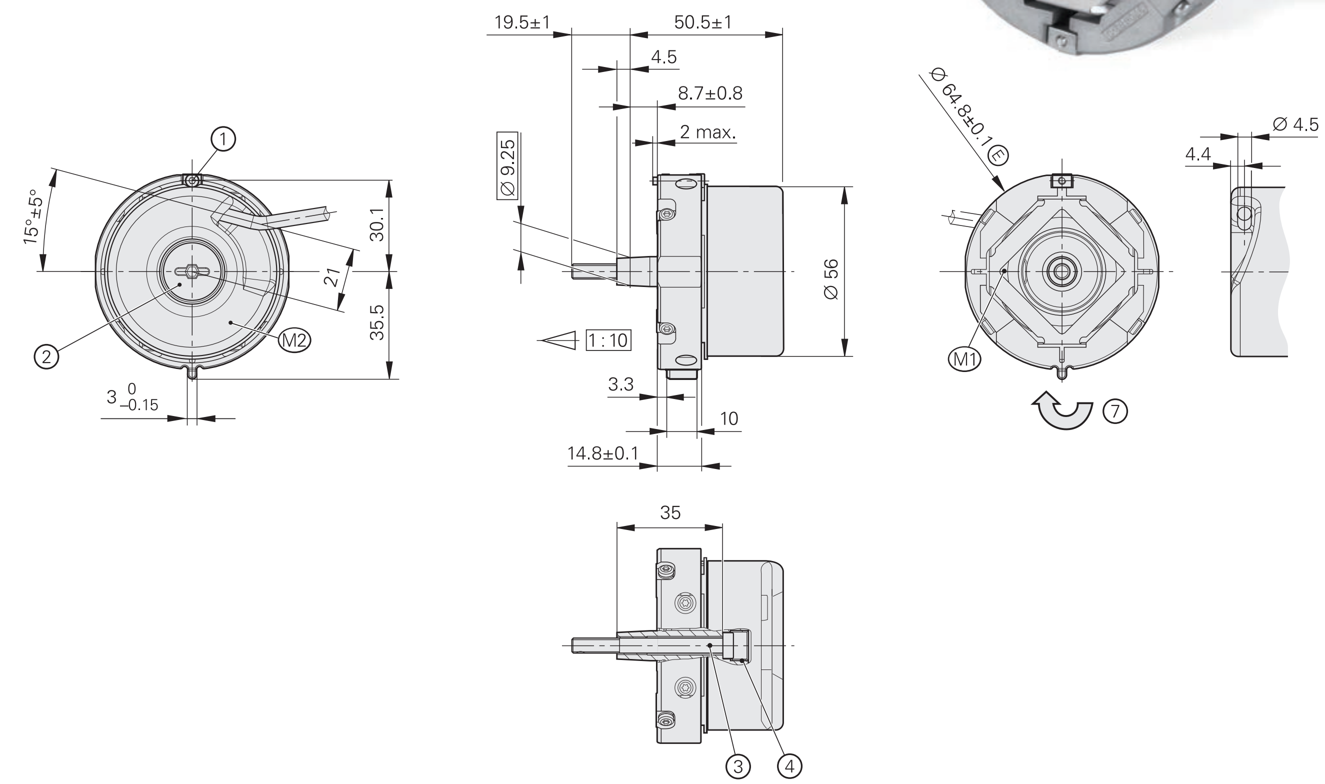
1) Evaluation optimized for the KTY 84-130 and PT 1000 (see *Temperature measurement in motors*)

DRIVE-CLiQ is a registered trademark of Siemens AG

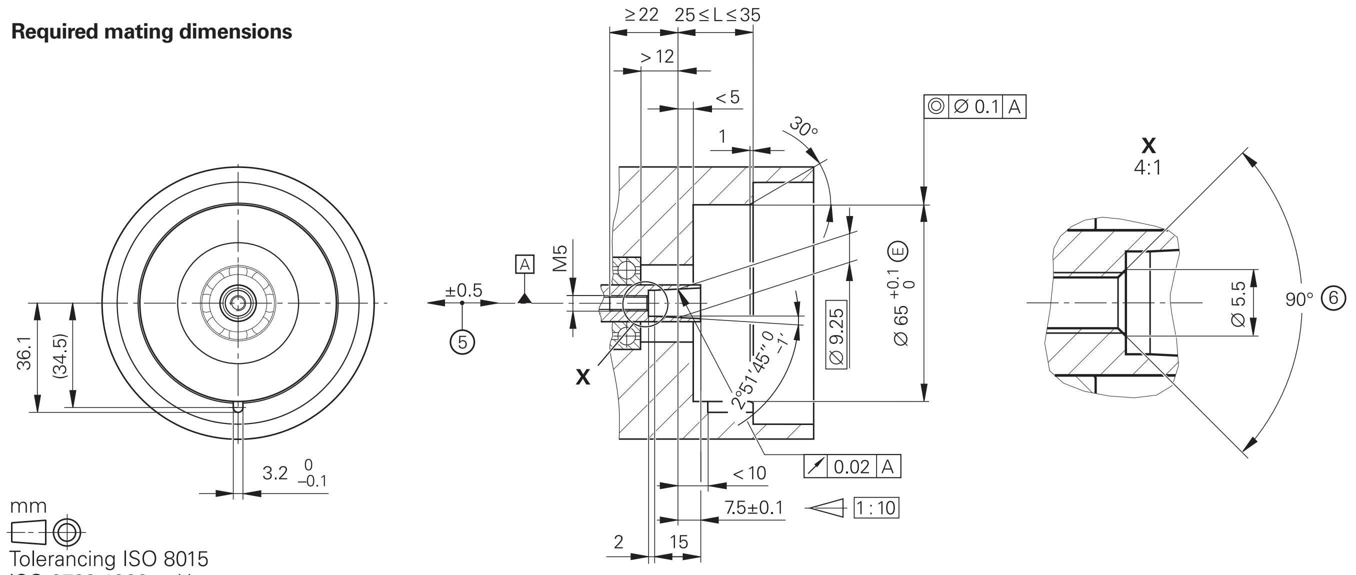
ECN/EQN 400 series

Absolute rotary encoders
- **07B stator coupling with anti-rotation element for axial mounting**
- **65B tapered shaft**
- **Encoders available with functional safety**
- **Fault exclusion for rotor coupling and stator coupling as per EN 61800-5-2 possible**





Required mating dimensions



mm

Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

A = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration, see D 741714
1 = Clamping screw for coupling ring (width A/F 2)
2 = Screw plug: width A/F 3 and 4
3 = Screw: DIN 6912 – M5x50 – 08.8 – MKL; width A/F 4
4 = Back-off thread M10
5 = Compensation of mounting tolerances and thermal expansion; no dynamic movement permitted
6 = Chamfer at start of thread is obligatory for material bonding anti-rotation lock
7 = Direction of shaft rotation for ascending position values

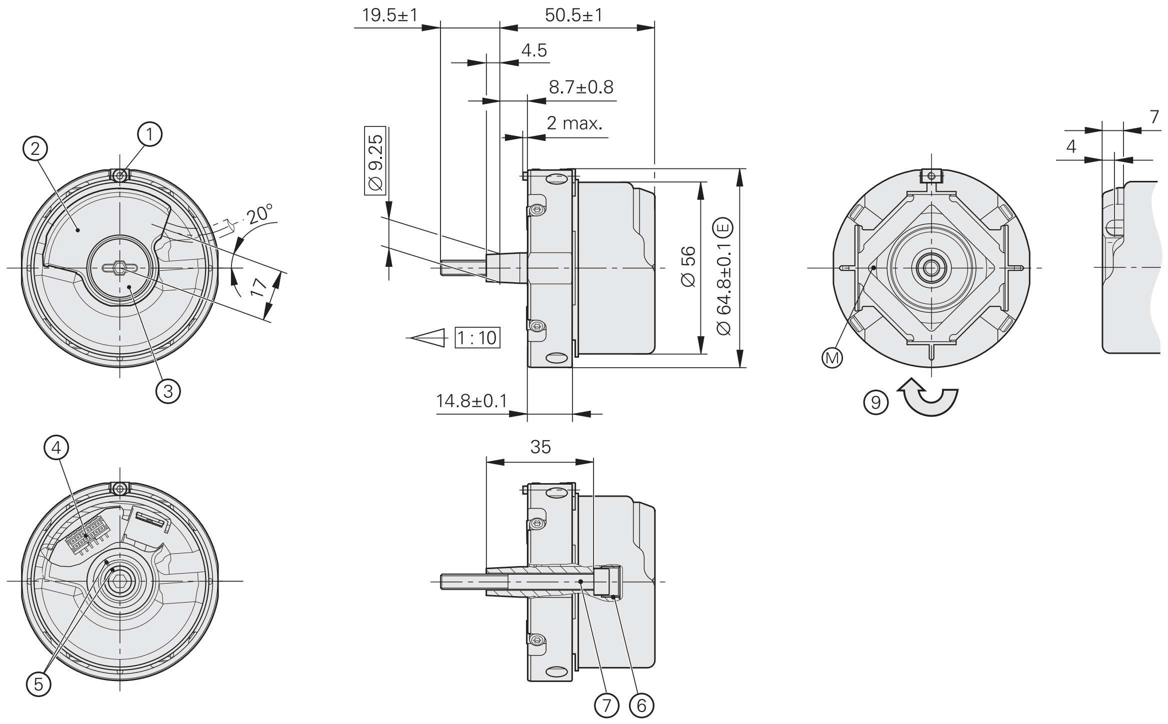
	Absolute			
	ECN 413	**ECN 425** Functional Safety	**EQN 425**	**EQN 437** Functional Safety
Interface	EnDat 2.2			
Ordering designation	EnDat01	EnDat22	EnDat01	EnDat22
Position values per rev.	8192 (13 bits)	33554432 (25 bits)	8192 (13 bits)	33554432 (25 bits)
Revolutions	–		4096 (12 bits)	
Elec. permiss. shaft speed/ deviations[2]	1500 rpm/±1 LSB 12000 rpm/±50 LSB	15000 rpm (for continuous position value)	1500 rpm/±1 LSB 12000 rpm/±50 LSB	15000 rpm (for continuous position value)
Calculation time t_{cal} Clock frequency	≤ 9 µs ≤ 2 MHz	≤ 7 µs ≤ 16 MHz	≤ 9 µs ≤ 2 MHz	≤ 7 µs ≤ 16 MHz
Incremental signals	∼ 1 V_{PP}[1]	–	∼ 1 V_{PP}[1]	–
Line count	2048	–	2048	–
Cutoff frequency –3 dB	≥ 400 kHz	–	≥ 400 kHz	–
System accuracy	±20″			
Electrical connection*	Cable (5 m) with or without M23 coupling	Cable (5 m) with M12 coupling	Cable (5 m) with or without M23 coupling	Cable (5 m) with M12 coupling
Supply voltage	3.6 V to 14 V DC			
Power consumption (maximum)	*3.6 V:* ≤ 0.6 W *14 V:* ≤ 0.7 W		*3.6 V:* ≤ 0.7 W *14 V:* ≤ 0.8 W	
Current consumption (typical)	*5 V:* 85 mA (without load)		*5 V:* 105 mA (without load)	
Shaft	Tapered shaft (Ø 9.25 mm); taper: 1:10			
Mech. permiss. shaft speed *n*	≤ 15000 rpm		≤ 12000 rpm	
Starting torque (typical)	0.01 Nm (at 20 °C)			
Moment of inertia of rotor	$2.6 \cdot 10^{-6}$ kgm^2			
Natural frequency f_N (typical)	1800 Hz			
Permissible axial motion of measured shaft	±0.5 mm			
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)			
Max. operating temp.	100 °C			
Min. operating temp.	*Fixed cable:* –40 °C *Moving cable:* –10 °C			
Protection EN 60529	IP64 when mounted			
Mass	≈ 0.25 kg			
Part number	1065932-xx	683644-xx	1109258-xx	683646-xx

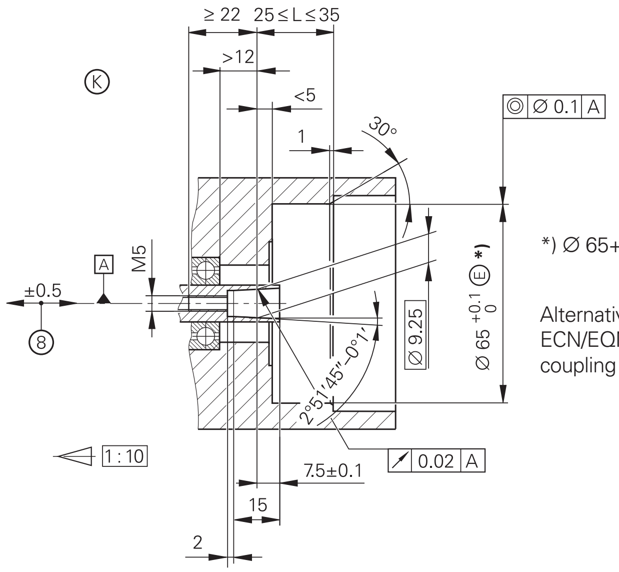
* Please select when ordering
1) Deviating tolerances — Signal amplitude: 0.8 V_{PP} to 1.2 V_{PP}; Asymmetry: 0.05; Amplitude ratio: 0.9 to 1.1; Phase angle: 90° elec. ±5° elec.
2) Speed-dependent deviations between absolute and incremental signals

For dimensions and specifications of encoders with functional safety, see the Product Information document.

ERN 1300 series

Incremental rotary encoders
- **06 stator coupling for axial mounting**
- **65B tapered shaft**





*) Ø 65+0.02 for ECI/EQI 13xx

Alternative:
ECN/EQN 1300 mating dimensions with slot for stator coupling for the anti-rotation element are also usable.

mm
Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

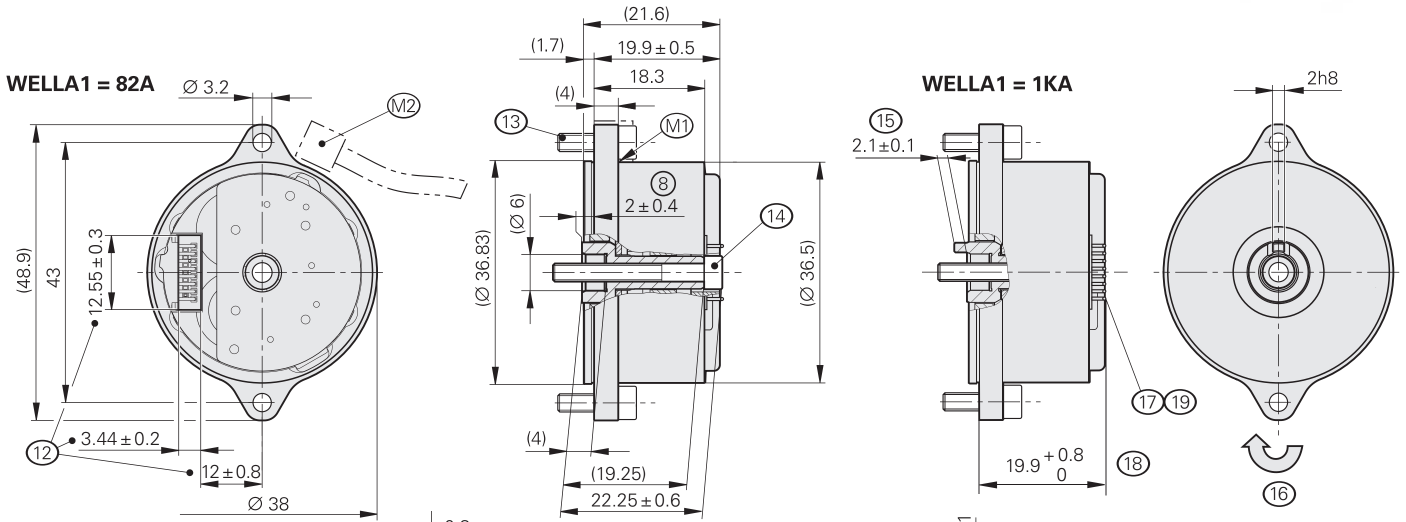
A = Bearing of mating shaft
K = Required mating dimensions
M = Measuring point for operating temperature
1 = Clamping screw for coupling ring (width A/F 2)
2 = Die-cast cover
3 = Screw plug: width A/F 3 and 4
4 = 12-pin, 14-pin or 16-pin PCB connector
5 = Reference mark position on shaft and cap
6 = M10 back-off thread
7 = Self-locking screw: ISO 6912 – M5 x 50 – 08.8; width A/F 4
8 = Compensation of mounting tolerances and thermal expansion; no dynamic movement permitted
9 = Direction of shaft rotation for output signals according to interface description

	Incremental				
	ERN 1321	**ERN 1381**	**ERN 1387**	**ERN 1326**	
Interface	TTL	1 V_{PP} [1]		TTL	
Line count*/ System accuracy	1024/±64″ 2048/±32″ 4096/±16″	512/±60″ 2048/±20″ 4096/±16″	2048/±20″	1024/±64″ 2048/±32″ 4096/±16″	8192/±16″ [5]
Reference mark	One				
Output frequency Edge separation *a* Cutoff frequency –3 dB	≤ 300 kHz ≥ 0.35 µs –	– – ≥ 210 kHz		≤ 300 kHz ≥ 0.35 µs –	≤ 150 kHz ≥ 0.22 µs –
Commutation signals	–		1 V_{PP} [1]	TTL	
Width*	–		Z1 track [2]	3 x 120°; 4 x 90° [3]	
Electrical connection	12-pin		14-pin	16-pin	
Supply voltage	DC 5 V ±0.5 V		DC 5 V ±0.25 V	DC 5 V ±0.5 V	
Current consumption (without load)	≤ 120 mA		≤ 130 mA	≤ 150 mA	
Shaft	Tapered shaft (Ø 9.25 mm); taper: 1:10				
Mech. permiss. shaft speed *n*	≤ 15000 rpm				
Starting torque (typical)	0.01 Nm (at 20 °C)				
Moment of inertia of rotor	$2.6 \cdot 10^{-6}$ kgm^2				
Natural frequency f_N (typical)	1800 Hz				
Permissible axial motion of measured shaft	±0.5 mm				
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2 [2] [4] (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)				
Max. operating temp.	120 °C	120 °C *4096 lines:* 80 °C	120 °C		
Min. operating temp.	–40 °C				
Protection EN 60529	IP40 when mounted				
Mass	≈ 0.25 kg				
Part number	385423-xx	534118-xx	749144-xx	574485-xx	

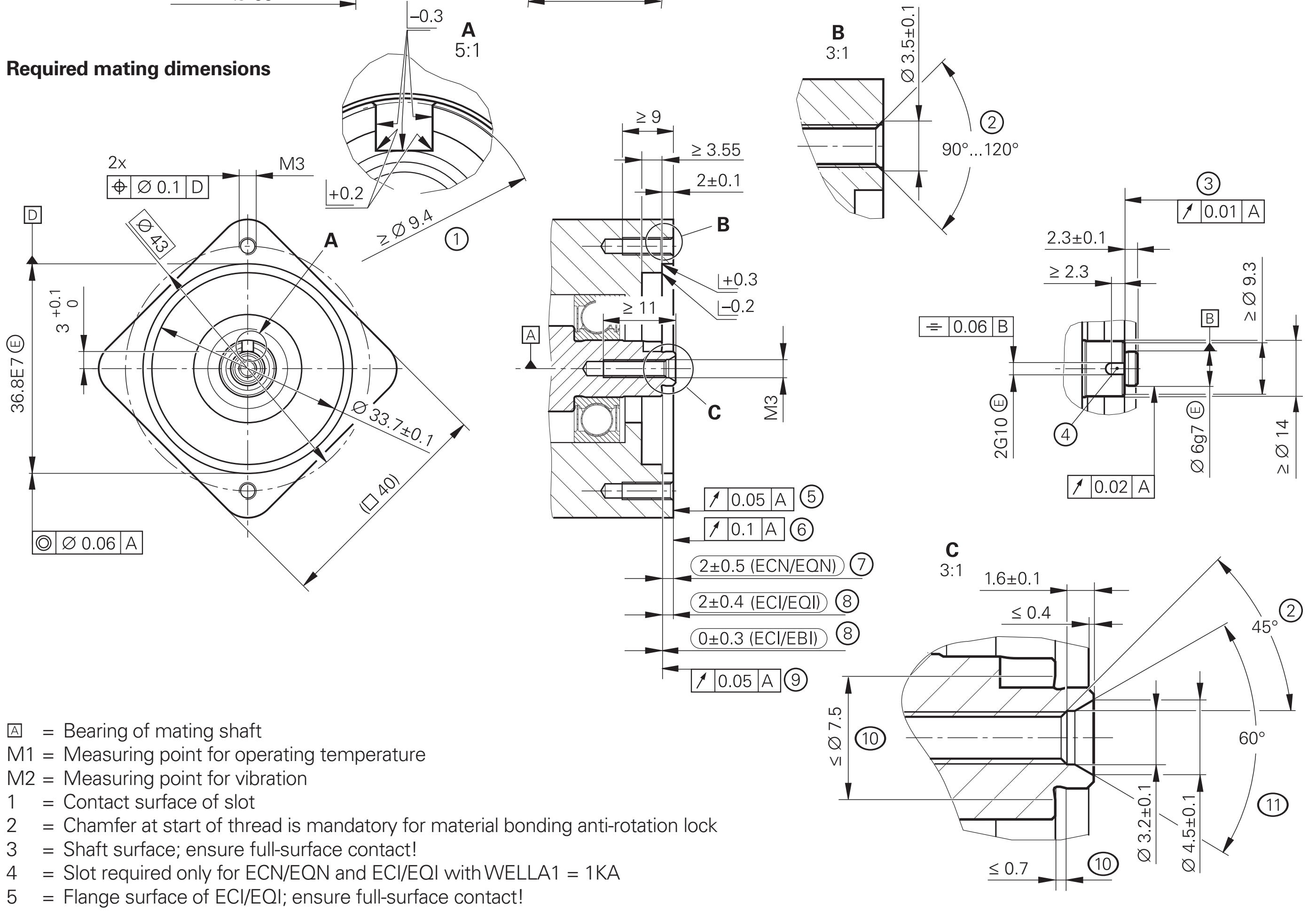
* Please select when ordering
[1] Deviating tolerances
Signal amplitude: 0.8 V_{PP} to 1.2 V_{PP}
Asymmetry: 0.05
Amplitude ratio: 0.9 to 1.1
Phase angle: 90° elec. ±5° elec.
Signal-to-noise ratio E, F: 100 mV
[2] One sine and one cosine signal per revolution; see the *Interfaces of HEIDENHAIN Encoders* brochure
[3] Three square-wave signals with signal periods with 90° or 120° mech. phase shift; see the *Interfaces of HEIDENHAIN Encoders* brochure
[4] Valid as per standard at room temperature; at operating temperatures up to 100 °C: ≤ 300 m/s^2;
up to 120 °C: ≤ 150 m/s^2
[5] Via integrated signal doubling

ECI/EQI 1100 series

Absolute rotary encoders
- **Flange (82A) for axial mounting**
- **Blind hollow shaft Ø 6 mm**
- **Without integral bearing**
- **Simplified mounting dimensions (D1414810) available on request or at *www.heidenhain.com***



Required mating dimensions



A = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration
1 = Contact surface of slot
2 = Chamfer at start of thread is mandatory for material bonding anti-rotation lock
3 = Shaft surface; ensure full-surface contact!
4 = Slot required only for ECN/EQN and ECI/EQI with WELLA1 = 1KA
5 = Flange surface of ECI/EQI; ensure full-surface contact!
6 = Coupling surface of ECN/EQN
7 = Mounting dimension: maximum permissible deviation between the shaft surface and coupling surface; compensation of mounting tolerances and thermal expansion, of which ±0.15 mm of dynamic axial motion is permitted (ECN/EQN)
8 = Maximum permissible deviation between shaft and flange surfaces; compensation of mounting tolerances and thermal expansion; dynamic motion permitted over entire range (ECI/EBI/EQI)
9 = Flange surface of ECI/EBI; ensure full-surface contact!
10 = Undercut
11 = Possible centering hole
12 = Distance to cover; note the opening for header, header connector, and wires
13 = Screw: ISO 4762 – M3x10 – 8.8 – MKL; tightening torque: 1 Nm ±0.1 Nm
14 = Screw: ISO 4762 – M3x25 – 8.8 – MKL; tightening torque: 1 Nm ±0.1 Nm
15 = Positive-locking element; ensure correct engagement in the slot (e.g., by measuring the device overhang)
16 = Direction of shaft rotation for ascending position values
17 = 15-pin header
18 = Dimension for JH standard cable
19 = Ensure installation space for cable

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

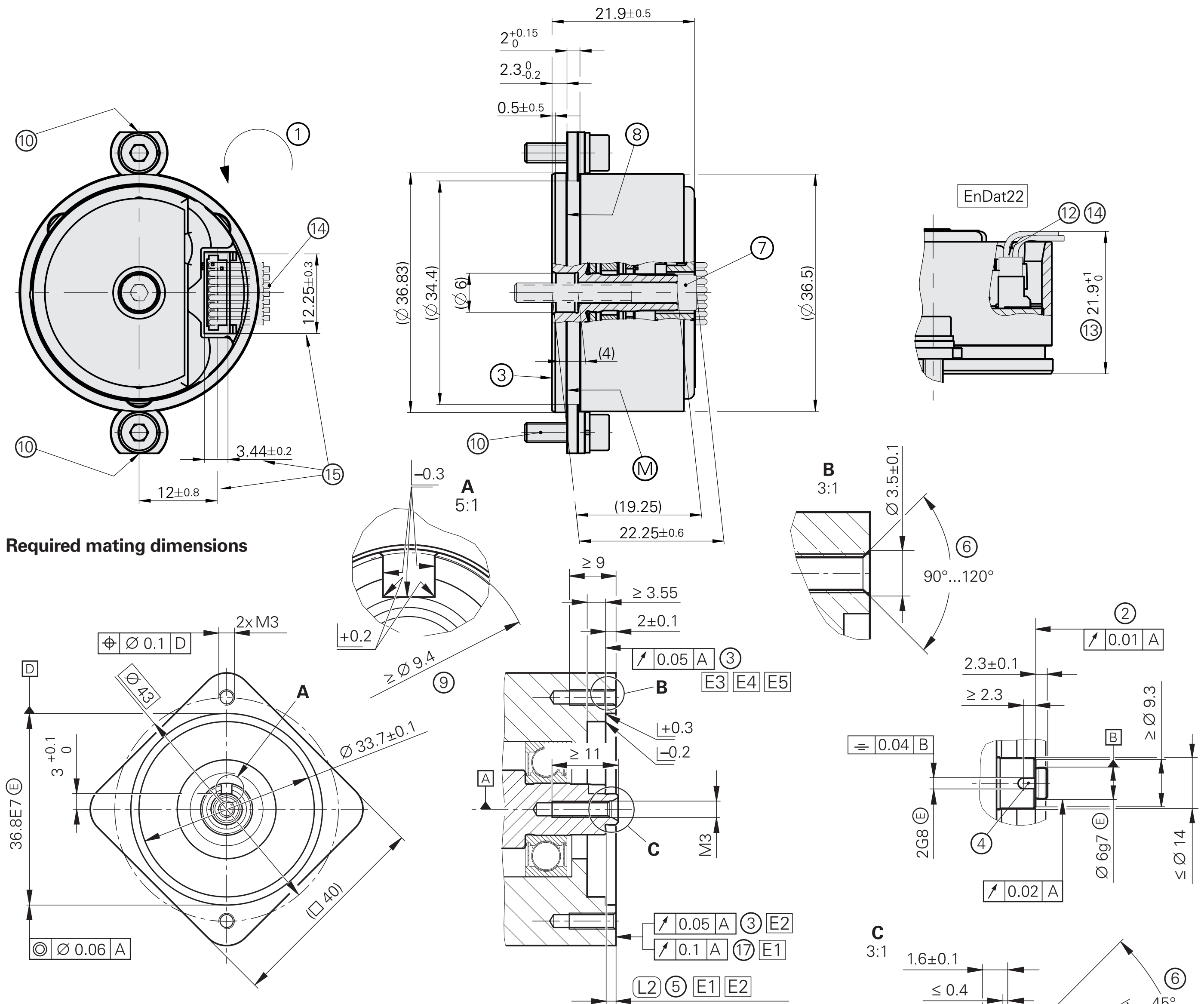
	Absolute **ECI 1119 singleturn** Functional Safety		Absolute **EQI 1131 multiturn** Functional Safety	
Interface	EnDat 2.2	EnDat 3	EnDat 2.2	EnDat 3
Ordering designation	EnDat22	E30-R2	EnDat22	E30-R2
Position values per rev.	524 288 (19 bits)			
Revolutions	–		4096 (12 bits)	
Calculation time t_{cal} Clock frequency	≤ 5 µs ≤ 16 MHz	–	≤ 5 µs ≤ 16 MHz	–
XEL.time HPFout data rate	–	≤ 11 µs at 12.5 Mbit/s ≤ 8.2 µs at 25 Mbit/s	–	≤ 11 µs at 12.5 Mbit/s ≤ 8.2 µs at 25 Mbit/s
Propagation time	–	14 µs (typical)	–	14 µs (typical)
System accuracy	±120"			
Electrical connection	15-pin (with connection for external temperature sensor)1)			
Cable length	*EnDat 3:* ≤ 100 m at 12.5 Mbit/s; ≤ 40 m at 25 Mbit/s *EnDat 2.2:* ≤ 100 m2)			
Supply voltage	3.6 V to 14 V DC			
Power consumption (maximum)	*3.6 V:* ≤ 0.65 W *14 V:* ≤ 0.7 W	*12 V:* 45 mA (without communication)	*3.6 V:* ≤ 0.75 W *14 V:* ≤ 0.85 W	*12 V:* 50 mA (without communication)
Current consumption (typical)	*5 V:* 95 mA (without load)	*4 V:* ≤ 0.85 W; *14 V:* ≤ 0.9 W	*5 V:* 115 mA (without load)	*4 V:* ≤ 0.95 W; *14 V:* ≤ 1 W
Shaft*	Blind hollow shaft for axial clamping Ø 6 mm without positive-locking element (82A) or with positive-locking element (1KA)			
Spindle speed	≤ 15 000 rpm		≤ 12 000 rpm	
Moment of inertia of rotor	$0.2 \cdot 10^{-6}$ kgm^2			
Angular acceleration of rotor	$\leq 1 \cdot 10^5$ rad/s^2			
Permissible axial motion of measured shaft	±0.4 mm			
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	*Stator:* ≤ 400 m/s^2; *rotor:* ≤ 600 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)			
Operating temperature	–40 °C to 110 °C			
Trigger threshold of error message for excessive temperature	125 °C (measuring accuracy of the internal temperature sensor: ±1 K)			
Protection EN 60529	IP00 when mounted3)			
Mass	≈ 0.04 kg			
Part number	1164809-xx	1259551-xx	1164811-xx	1259552-xx

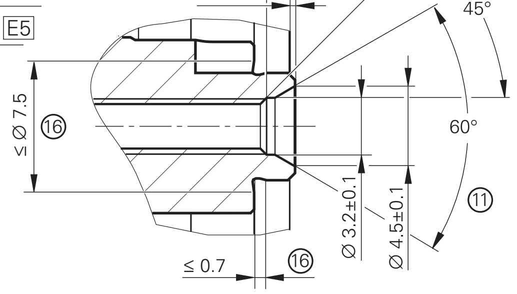
* Please select when ordering
1) *EnDat22:* Evaluation optimized for the KTY 84-130 temperature sensor; *E30-R2:* Evaluation optimized for the KTY 84-130 and PT 1000 (see *Temperature measurement in motors*)
2) Also see the *Interfaces of HEIDENHAIN Encoders* brochure
3) See *Electromagnetic compatibility* under *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure.

For dimensions and specifications of encoders with functional safety, see the Product Information document.

ECI/EQI 1100 series

Absolute rotary encoders
- **70F synchro flange for axial mounting**
- **Blind hollow shaft Ø 6 mm (82A)**
- **Without integral bearing**
- **Other simplified mounting dimensions (D1169667) available on request or at *www.heidenhain.de***





Series	Name	Flange	Shaft	Interface	L2	L3
E1	ECN/EQN	OUA	1KA	EnDat01/22	2±0.5	–
E2	ECI/EQI	70C	1KA/82A	EnDat22	2±0.4	–
E3	ECI/EQI	70F	82A	EnDat22	–	0±0.4
E4	ECI/EQI	70F	82A	EnDat01	–	0±0.3
E5	ECI/EBI	70E	82C	EnDat22	–	0±0.3

A = Bearing of mating shaft
M = Measuring point for operating temperature
1 = Direction of shaft rotation for ascending position values
2 = Shaft surface; ensure full-surface contact!
3 = Flange surface; ensure full-surface contact!
4 = Slot necessary only for 1KA shaft
5 = Mounting dimension: maximum permissible deviation between the shaft surface and flange surface; compensation of mounting tolerances and thermal expansion; ECI/EQI/EBI: dynamic motion permitted over entire range; ECN/EQN: ±0.15 mm dynamic axial motion permitted (with use of ATS software for mounting inspection, the display value for the mounting clearance is shown as 2 mm instead of 0 mm)
6 = Chamfer at start of thread is obligatory for material bonding anti-rotation lock
7 = Shaft fastening screw: DIN EN ISO 4762 – M3x25 – 8.8 with material bonding anti-rotation lock: ID 202264-86; tightening torque: 1 Nm ±0.1 Nm
8 = Clamping surface
9 = Contact surface of slot
10 = Possible flange fastening with fastening kit (ID 1264352-xx); tightening torque: 1 Nm ±0.1 Nm; pay attention to the orientation of the flat!
11 = Possible centering hole
12 = 15-pin header (male)
13 = Dimension for JH standard cable
14 = Ensure space for cable
15 = Distance to cover; note the opening for header, header connector, and wires
16 = Undercut
17 = Coupling surface of ECN/EQN

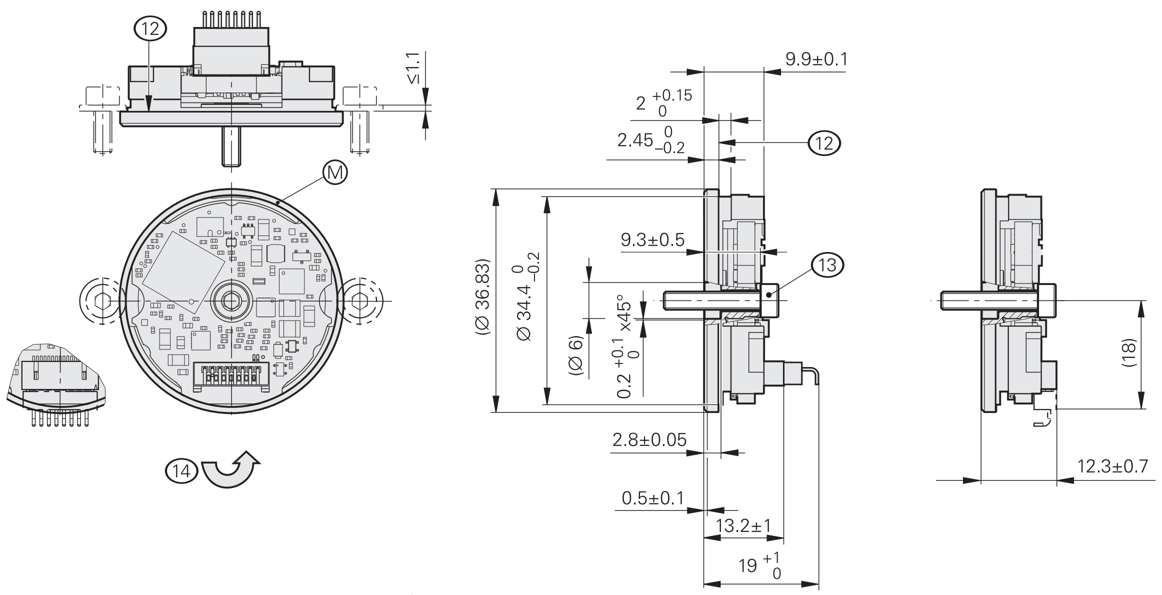
mm
Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

	Absolute	
	ECI 1119 singleturn	**EQI 1131 multiturn**
Interface	EnDat 2.2	
Ordering designation	EnDat22	
Position values per rev.	524288 (19 bits)	
Revolutions	–	4096 (12 bits)
Calculation time t_{cal} Clock frequency	≤ 5 µs ≤ 16 MHz	
System accuracy	±120″	
Electrical connection	15-pin (with connection for external temperature sensor)[1]	
Cable length	≤ 100 m	
Supply voltage	3.6 V to 14 V DC	
Power consumption (maximum)	*3.6 V:* ≤ 0.65 W *14 V:* ≤ 0.7 W	*3.6 V:* ≤ 0.75 W *14 V:* ≤ 0.85 W
Current consumption (typical)	*5 V:* 95 mA (without load)	*5 V:* 115 mA
Shaft	Blind hollow shaft for axial clamping (Ø 6 mm)	
Spindle speed	≤ 15000 rpm	≤ 12000 rpm
Moment of inertia of rotor	0.2 · 10^{-6} kgm^2	
Permissible axial motion of measured shaft	±0.4 mm	
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	*Stator:* ≤ 400 m/s^2; *rotor:* ≤ 600 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)	
Operating temperature	–40 °C to 110 °C	
Protection EN 60529	IP00 when mounted[2]	
Mass	≈ 0.04 kg	
Part number	1164812-xx	1164813-xx

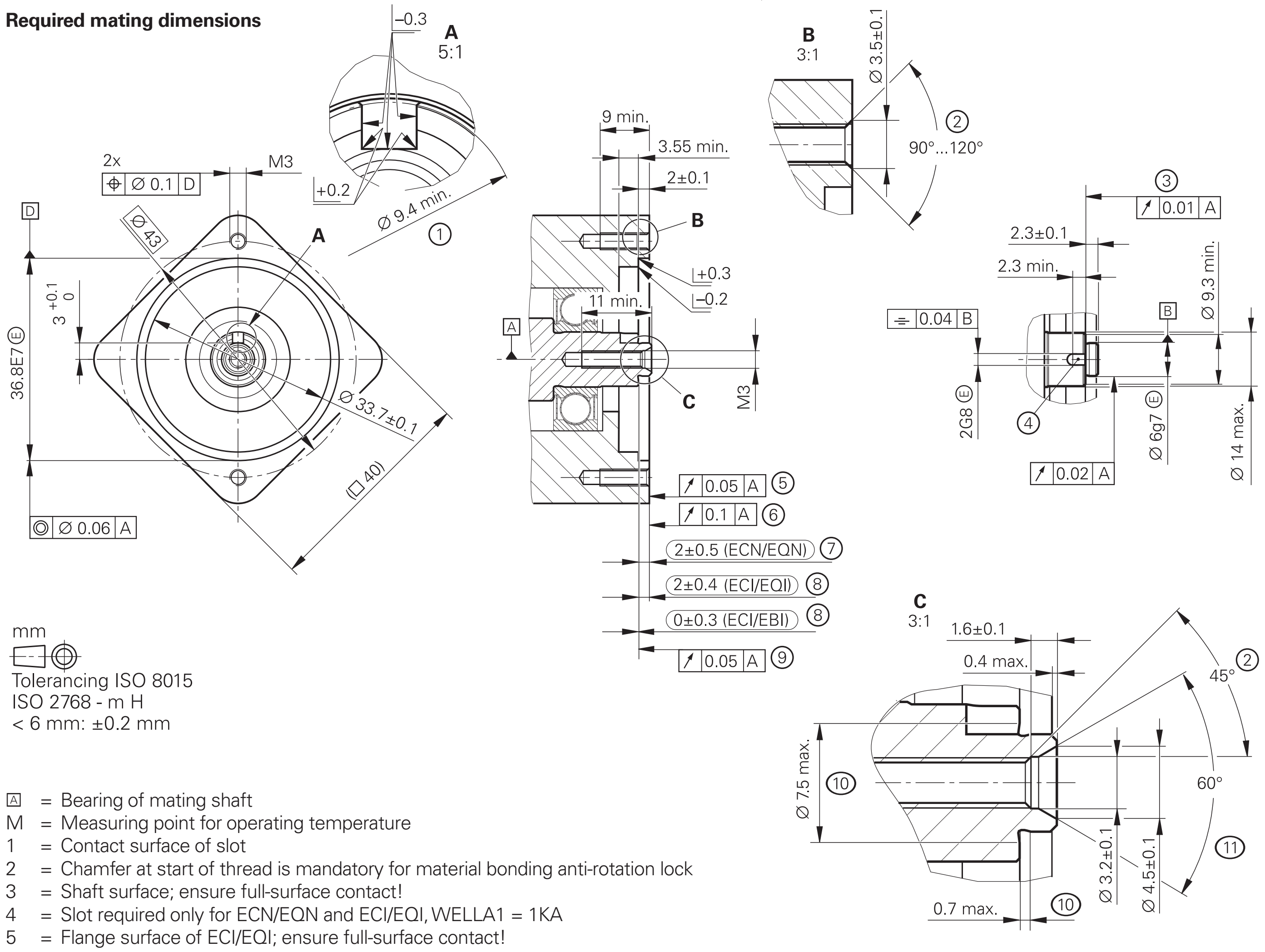
[1] Evaluation optimized for the KTY 84-130 temperature sensor (see *Temperature measurement in motors*)
[2] See *Electromagnetic compatibility* under *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure.

ECI/EBI 1100 series

Absolute rotary encoders
- **Flange (70E) for axial mounting**
- **Blind hollow shaft Ø 6 mm (82C)**
- **Without integral bearing**
- **EBI 1135: multiturn functionality via battery-buffered revolution counter**



Required mating dimensions



mm

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

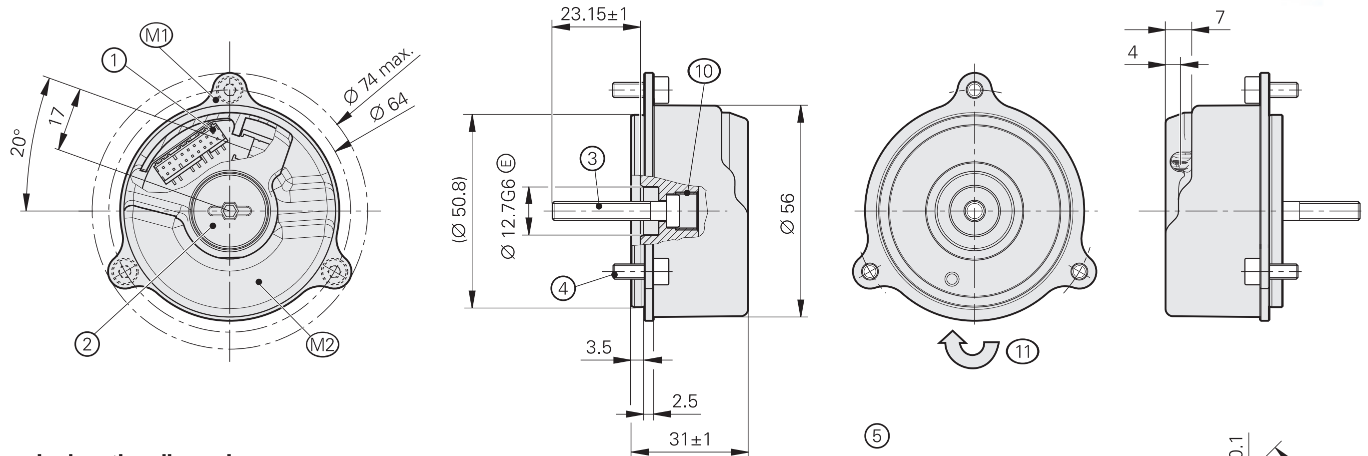
A = Bearing of mating shaft
M = Measuring point for operating temperature
1 = Contact surface of slot
2 = Chamfer at start of thread is mandatory for material bonding anti-rotation lock
3 = Shaft surface; ensure full-surface contact!
4 = Slot required only for ECN/EQN and ECI/EQI, WELLA1 = 1KA
5 = Flange surface of ECI/EQI; ensure full-surface contact!
6 = Coupling surface of ECN/EQN
7 = Maximum permissible deviation between the shaft surface and coupling surface; compensation of mounting tolerances and thermal expansion, of which ±0.15 mm of dynamic axial motion is permitted
8 = Maximum permissible deviation between the shaft surface and flange surface; compensation of mounting tolerances and thermal expansion
9 = Flange surface of ECI/EBI; ensure full-surface contact!
10 = Undercut
11 = Possible centering hole
12 = Clamping surface
13 = Screw: ISO 4762 – M3x16 – 8.8, with materially bonding anti-rotation lock; tightening torque: 1.15 Nm ±0.05 Nm
14 = Direction of shaft rotation for ascending position values

	Absolute	
	ECI 1118 singleturn	**EBI 1135 multiturn**
Interface	EnDat 2.2	
Ordering designation	EnDat22[1]	
Position values per rev.	262 144 (18 bits)	262 144 (18 bits; 19-bit data word length with LSB = 0)
Revolutions	–	65 536 (16 bits)[2]
Calculation time t_{cal} Clock frequency	≤ 6 µs ≤ 8 MHz	
System accuracy	±120"	
Electrical connection	15-pin	
Cable length	≤ 100 m	
Supply voltage	3.6 V to 14 V DC	*Rotary encoder U_P:* DC 3.6 V to 14 V *Backup battery U_{BAT}:* DC 3.6 V to 5.25 V
Power consumption (maximum)	*Normal operation at 3.6 V:* 0.52 W *Normal operation at 14 V:* 0.6 W	
Current consumption (typical)	*5 V:* 80 mA (without load)	*Normal mode at 5 V:* 80 mA (without load) *Buffer mode[3]:* 22 µA (rotating shaft) 12 µA (at standstill)
Shaft	Blind hollow shaft Ø 6 mm, axial clamping	
Mech. permiss. shaft speed *n*	≤ 15 000 rpm	≤ 12 000 rpm
Mech. permiss. acceleration	≤ 10^5 rad/s^2	
Moment of inertia of rotor	0.2 · 10^{-6} kgm^2	
Permissible axial motion of measured shaft	±0.3 mm	
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)	
Operating temperature	–20 °C to 115 °C	
Protection EN 60529	IP00[4]	
Mass	≈ 0.02 kg	
Part number	728563-xx	820725-xx

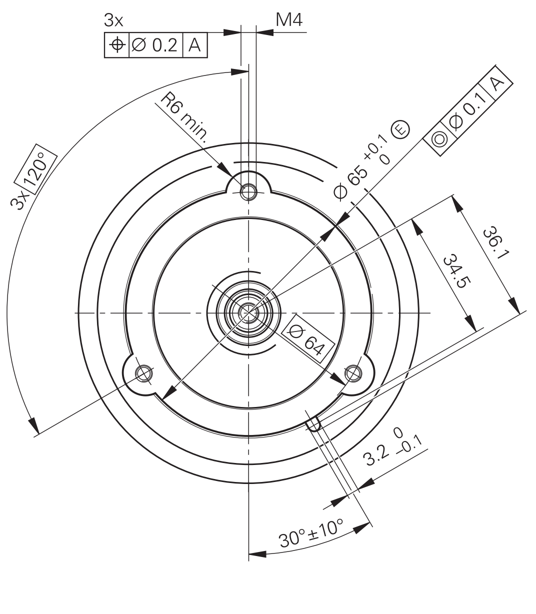
[1] External temperature sensor and online diagnostics are not supported.
[2] Compliance with EnDat Specification 297403 and the EnDat Application Notes 722024, Chapter 13, *Battery-buffered encoders,* is required for correct control of the encoder.
[3] At T = 25 °C; U_{BAT} = 3.6 V
[4] See *Electromagnetic compatibility* under *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure.

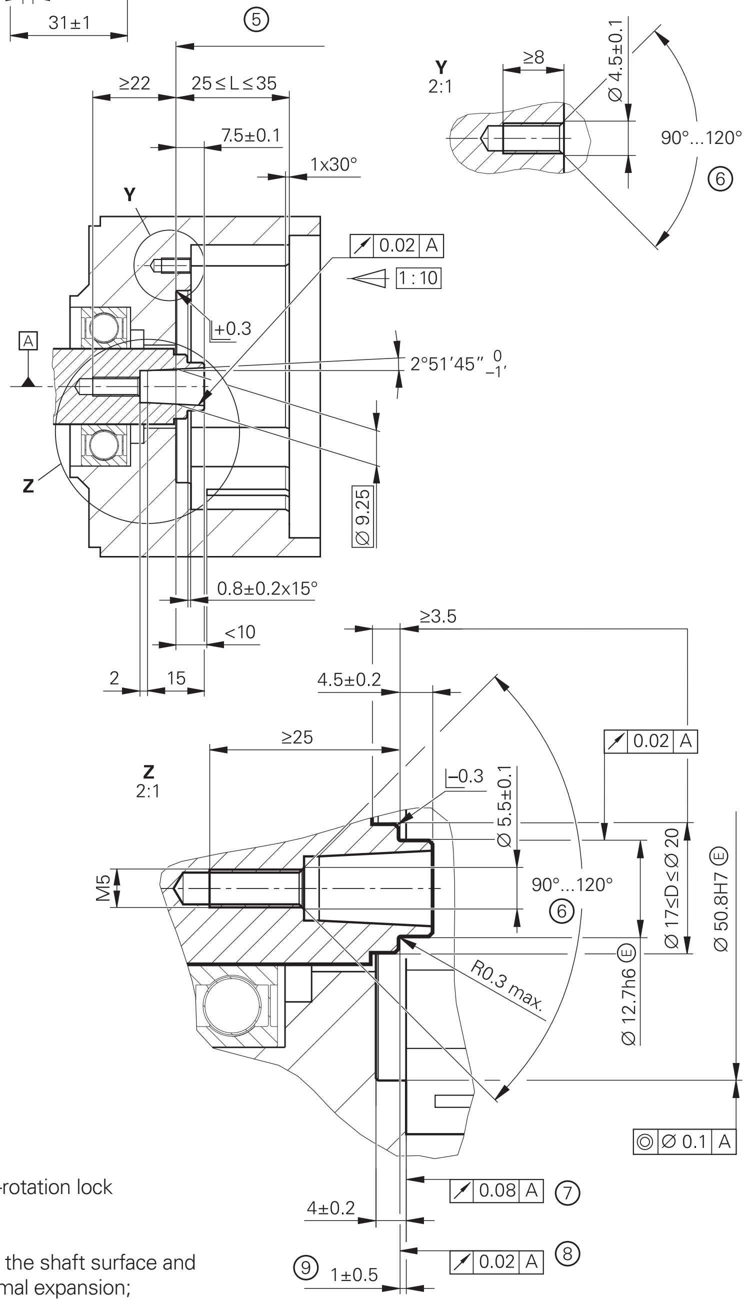
ECI/EBI/EQI 1300 series

Absolute rotary encoders
- **Mounting-compatible with photoelectric rotary encoders with a 07B stator coupling**
- **0YA flange for axial mounting**
- **44C blind hollow shaft Ø 12.7 mm**
- **Without integral bearing**
- **Other simplified mating dimensions available upon request**



Required mating dimensions





D1	D2
Ø 12.7G6 Ⓔ	Ø 12.7h6 Ⓔ

mm
Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

A = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration; see also D 741714
1 = 16-pin PCB connector
2 = Screw plug: width A/F 3 and 4
3 = Screw: ISO 26912 – M5x30 – 08.8 – MKL; width A/F 4
4 = Screw: ISO 4762 – M4x10 – 8.8 – MKL; width A/F 3
5 = Functional diameter of taper for ECN/EQN 13xx
6 = Chamfer at start of thread is obligatory for material bonding anti-rotation lock
7 = Flange surface ExI/resolver; ensure full-surface contact!
8 = Shaft surface; ensure full-surface contact!
9 = *Mounting dimension:* maximum permissible deviation between the shaft surface and flange surface; compensation for mounting tolerances and thermal expansion;
ECI/EQI: dynamic motion permitted over entire range; ECN/EQN: no dynamic motion permitted
10 = Back-off thread M10
11 = Direction of shaft rotation for ascending position values

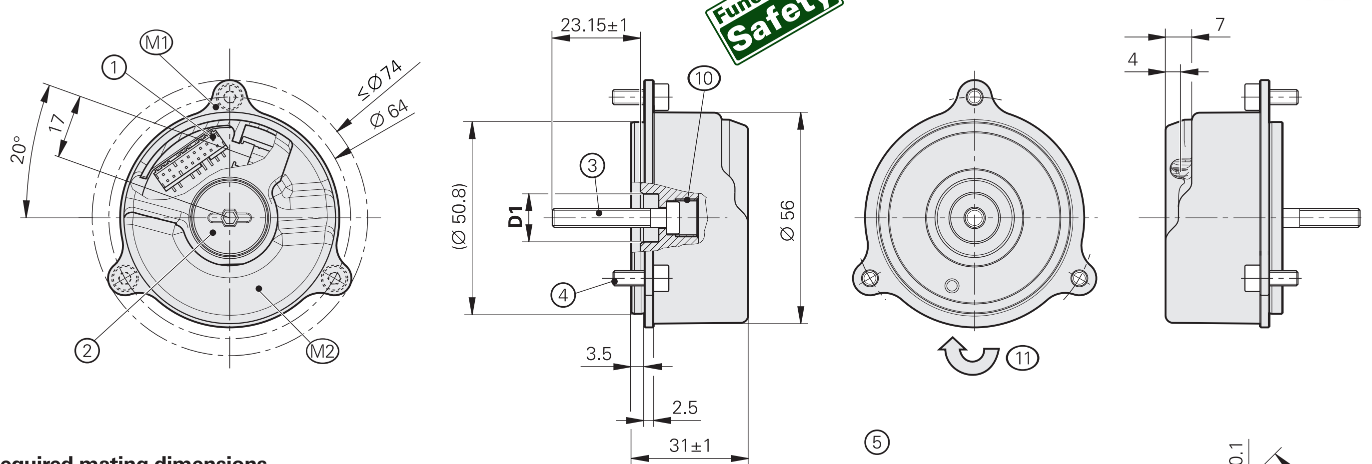
	Absolute **ECI 1319** Functional Safety	**EQI 1331** Functional Safety	**EBI 1335** Functional Safety
Interface	EnDat 2.2		
Ordering designation	EnDat22		
Position values per rev.	524 288 (19 bits)		
Revolutions	–	4096 (12 bits)	65 536 (16 bits)[3]
Elec. permiss. shaft speed/ deviations	≤ 15 000 rpm (for continuous position value)		
Calculation time t_{cal} Clock frequency	≤ 5 µs ≤ 16 MHz		
System accuracy	±65″		
Electrical connection	16-pin with connection for temperature sensor[1]		
Cable length	≤ 100 m		
Supply voltage	3.6 V to 14 V DC		*Rotary encoder U_P:* DC 3.6 V to 14 V *Backup battery U_{BAT}:* DC 3.6 V to 5.25 V
Power consumption (maximum)	*3.6 V:* ≤ 0.65 W *14 V:* ≤ 0.7 W	*3.6 V:* ≤ 0.75 W *14 V:* ≤ 0.85 W	*3.6 V:* ≤ 0.65 W *14 V:* ≤ 0.7 W
Current consumption (typical)	*5 V:* 95 mA (without load)	*5 V:* 115 mA (without load)	*Normal operation at 5 V:* 95 mA (without load) *Backup battery:* 160 µA (rotating shaft)[2] 16 µA (at standstill)
Shaft	Blind hollow shaft for axial clamping (Ø 12.7 mm)		
Mech. permiss. shaft speed *n*	≤ 15 000 rpm	≤ 12 000 rpm	
Moment of inertia of rotor	$2.6 \cdot 10^{-6}$ kgm^2		
Permissible axial motion of measured shaft	±0.5 mm		
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	*Stator:* ≤ 400 m/s^2; *rotor:* ≤ 600 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)		
Operating temperature	–40 °C to 115 °C		
Trigger threshold of error message for excessive temperature	130 °C (measuring accuracy of the internal temperature sensor: ±1 K)		
Protection EN 60529	IP20 when mounted		
Mass	≈ 0.13 kg		
Part number	810661-xx	810662-xx	1230275-xx

[1] Evaluation optimized for KTY 84-130
[2] At T = 25 °C; U_{BAT} = 3.6 V
[3] Compliance with EnDat Specification 297403 and the EnDat Application Notes 722024, Chapter 13, *Battery-buffered encoders,* is required for correct control of the encoder

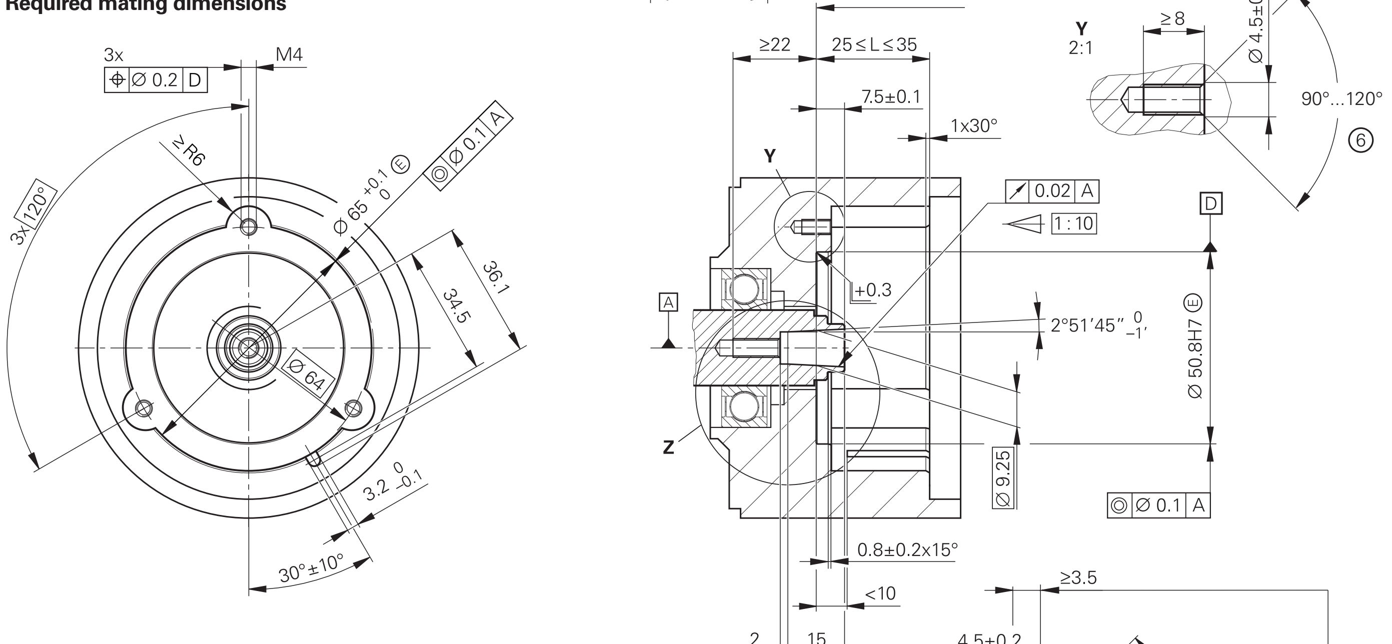
For dimensions and specifications of encoders with functional safety, see the Product Information document.

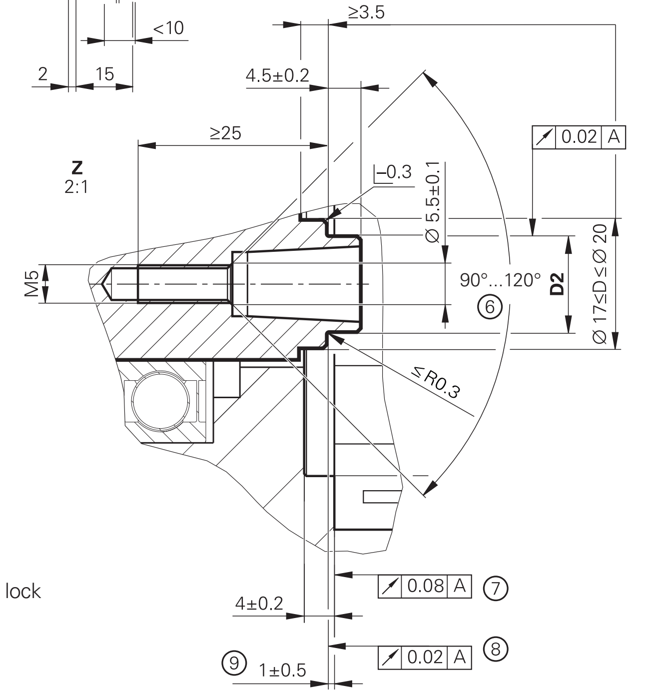
ECI 1319, EQI 1331

Rotary encoders for absolute position measurement with safe singleturn information
- **Robust inductive scanning principle**
- **Mounting-compatible with photoelectric rotary encoders with a 07B stator coupling**
- **0YA mounting flange**
- **Blind hollow shaft for axial clamping Ø 12.7 mm (44C) or Ø 12 mm (44A)**
- **Other simplified mating dimensions available upon request**



Required mating dimensions





D1	D2
Ø 12G6 Ⓔ	Ø 12h6 Ⓔ
Ø 12.7G6 Ⓔ	Ø 12.7h6 Ⓔ

mm

Tolerancing ISO 8015
ISO 2768:1989 - m H
≤ 6 mm: ±0.2 mm

- A = Bearing of mating shaft
- M1 = Measuring point for operating temperature
- M2 = Measuring point for vibration; see also D 741714
- 1 = 16-pin (12+4-pin) PCB connector
- 2 = Screw plug: width A/F 3 and 4
- 3 = Screw: DIN 6912 – M5x30 – 08.8 – MKL; width A/F 4
- 4 = Screw: ISO 4762 – M4x10 – 8.8 – MKL; width A/F 3
- 5 = Functional diameter of taper for ECN/EQN 13xx
- 6 = Chamfer at start of thread is obligatory for material bonding anti-rotation lock
- 7 = ExI/resolver flange surface; ensure full-surface contact!
- 8 = Shaft surface; ensure full-surface contact!
- 9 = Mounting clearance between shaft surface and flange surface; compensation for mounting tolerances and thermal expansion; ECI/EQI: dynamic motion permitted over entire range; ECN/EQN: no dynamic motion permitted
- 10 = Back-off thread M10
- 11 = Direction of shaft rotation for ascending position values

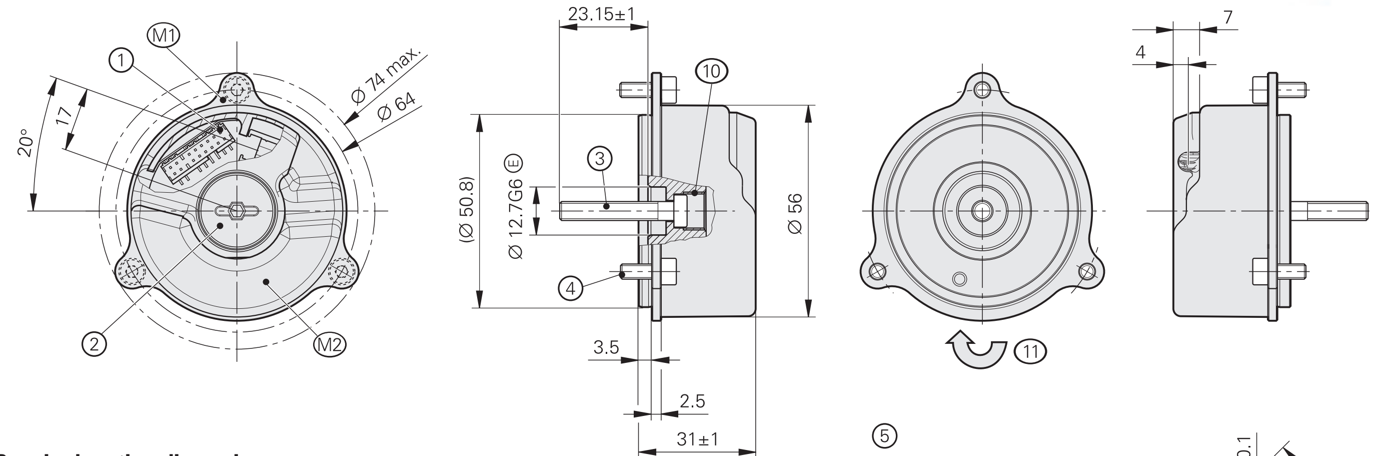
	Absolute ECI 1319 singleturn	 EQI 1331 multiturn
Interface	EnDat 3	
Ordering designation	E30–R2	
Position values per rev.	524288 (19 bits)	
Revolutions	–	4096 (12 bits)
XEL.time HPFout data rate	≤ 11 µs at 12.5 Mbit/s ≤ 8.2 µs at 25 Mbit/s	
Propagation time[1]	14 µs (typical)	
System accuracy	±65″	
Electrical connection	16-pin PCB connector (12+4; with separate connection option for external temperature sensor)[3]	
Cable length	*At 12.5 Mbit/s:* ≤ 100 m; *at 25 Mbit/s:* ≤ 40 m	
Supply voltage	DC 4 V to 14 V (recommended: 12 V)	
Power consumption[2] (maximum)	*4 V:* ≤ 0.85 W *14 V:* ≤ 0.9 W	*4 V:* ≤ 0.95 W *14 V:* ≤ 1 W
Current consumption (typical)	*12 V:* ≤ 45 mA (w/o communication)	*12 V:* ≤ 50 mA (w/o communication)
Shaft	Blind hollow shaft for axial clamping Ø 12.7 mm (44C) or Ø 12 mm (44A)	
Spindle speed	≤ 15000 rpm	≤ 12000 rpm
Moment of inertia of rotor	$2.45 \cdot 10^{-6}$ kgm^2	$2.6 \cdot 10^{-6}$ kgm^2
Angular acceleration of rotor	$\leq 1 \cdot 10^5$ rad/s^2	
Axial motion of measured shaft	≤ ±0.5 mm	
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	*Stator:* ≤ 400 m/s^2; *rotor:* ≤ 600 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)	
Operating temperature	–40 °C to 115 °C	
Trigger threshold of error message for excessive temperature	130 °C (measuring accuracy of the internal temperature sensor: ±1 K)	
Relative humidity	≤ 93 % (40 °C/21 d as per EN 60068-2-78), condensation excluded	
Protection EN 60529	IP20	
Mass	≈ 0.13 kg	
Part number	*44C shaft:* 1286377-01; *44A shaft:* 1286377-06	*44C shaft:* 1286378-01; *44A shaft:* 1286378-06

[1] See *EnDat Application Notes*
[2] See *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure or at *www.heidenhain.com*
[3] Evaluation optimized for the KTY 84-130 and PT 1000 (see *Temperature measurement in motors*)

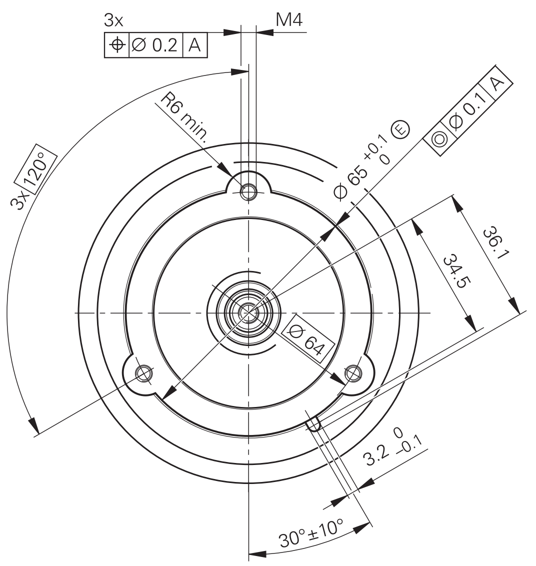
For dimensions and specifications of encoders with functional safety, see the Product Information document.

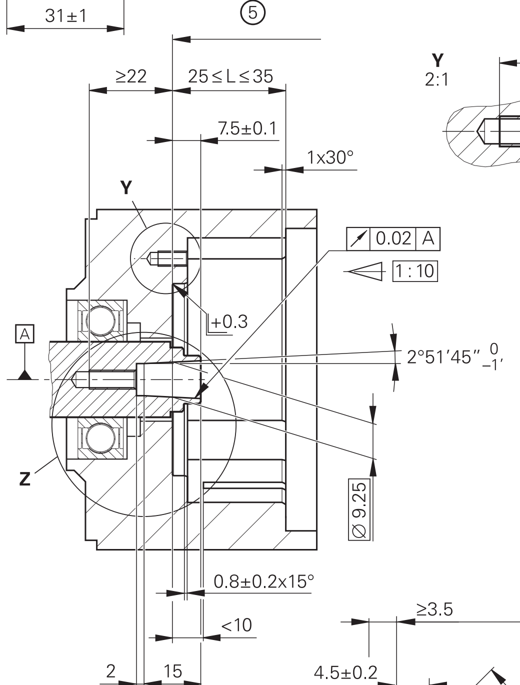
ECI/EQI 1300 S series

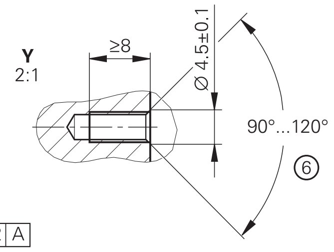
Absolute rotary encoders
- **Mounting-compatible with photoelectric rotary encoders with a 07B stator coupling**
- **0YA flange for axial mounting**
- **44C blind hollow shaft Ø 12.7 mm**
- **Without integral bearing**
- **Other simplified mating dimensions available upon request**



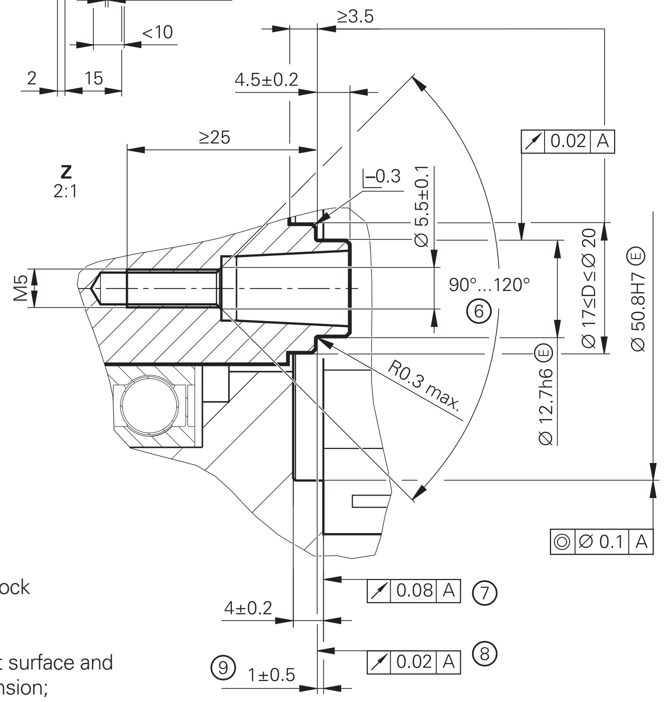
Required mating dimensions







D1	D2
Ø 12.7G6 Ⓔ	Ø 12.7h6 Ⓔ



mm
Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

A = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration; see also D 741714
1 = 16-pin PCB connector
2 = Screw plug: width A/F 3 and 4
3 = Screw: ISO 6912 – M5x30 – 08.8 – MKL; width A/F 4
4 = Screw: ISO 4762 – M4x10 – 8.8 – MKL; width A/F 3
5 = Functional diameter of taper for ECN/EQN 13xx
6 = Chamfer at start of thread is obligatory for material bonding anti-rotation lock
7 = Flange surface ExI/resolver; ensure full-surface contact!
8 = Shaft surface; ensure full-surface contact!
9 = *Mounting dimension:* maximum permissible deviation between the shaft surface and flange surface; compensation for mounting tolerances and thermal expansion; ECI/EQI: dynamic motion permitted over entire range; ECN/EQN: no dynamic motion permitted
10 = Back-off thread M10
11 = Direction of shaft rotation for ascending position values

	Absolute ECI 1319 S Functional Safety	EQI 1331 S Functional Safety
Interface	DRIVE-CLiQ	
Ordering designation	DQ01	
Position values per rev.	524 288 (19 bits)	
Revolutions	–	4096 (12 bits)
Calculation time TIME_MAX_ACTVAL	≤ 12 µs	
System accuracy	±65"	
Electrical connection	16-pin with connection for temperature sensor[1)]	
Cable length	≤ 40 m	
Supply voltage	DC 24 V (10 V to 28.8 V; up to DC 36 V possible without impairing the functional safety)	
Power consumption (maximum)	*10 V:* ≤ 1.1 W *28.8 V:* ≤ 1.25 W	*10 V:* ≤ 1.2 W *28.8 V:* ≤ 1.35 W
Current consumption (typical)	*24 V:* 40 mA (without load)	*24 V:* 45 mA (without load)
Shaft	Blind hollow shaft for axial clamping (Ø 12.7 mm)	
Mech. permiss. shaft speed *n*	≤ 15 000 rpm	≤ 12 000 rpm
Moment of inertia of rotor	$2.6 \cdot 10^{-6}$ kgm^2	
Permissible axial motion of measured shaft	±0.5 mm	
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	*Stator:* ≤ 400 m/s^2; *rotor:* ≤ 600 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)	
Operating temperature	–40 °C to 100 °C	
Trigger threshold of error message for excessive temperature	120 °C (measuring accuracy of the internal temperature sensor: ±1 K)	
Protection EN 60529	IP20 when mounted	
Mass	≈ 0.13 kg	
Part number	1222049-xx	1222051-xx

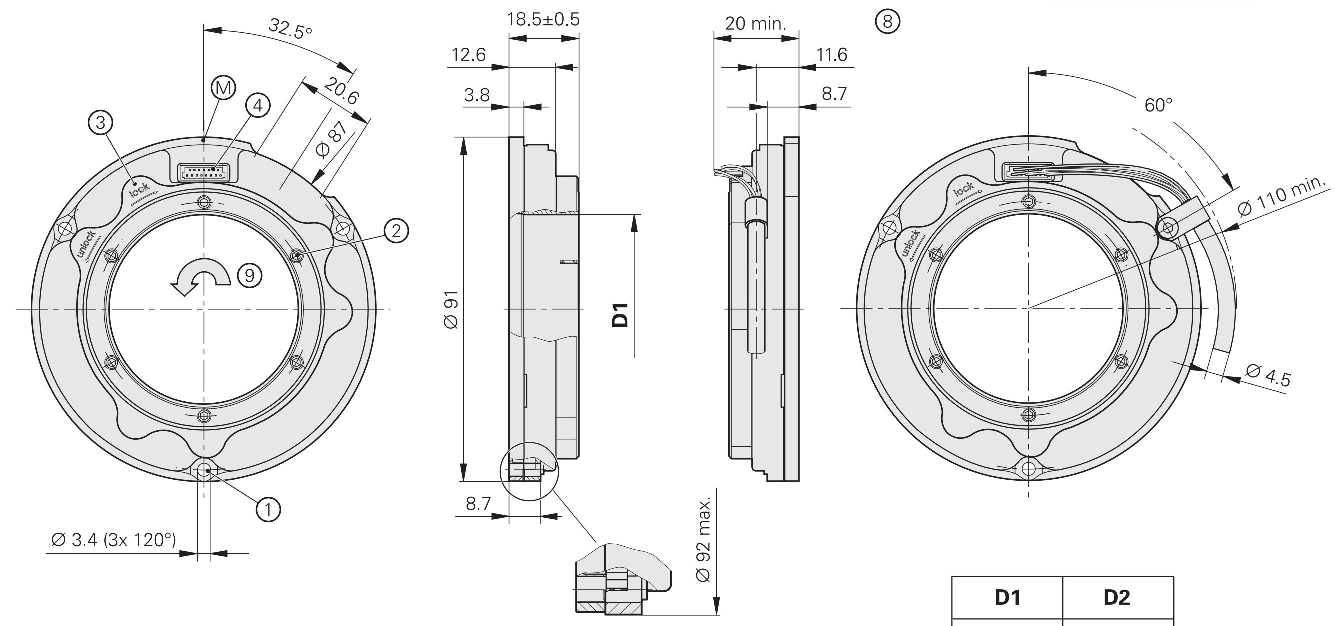
1) Evaluation optimized for the KTY 84-130 and PT 1000 (see *Temperature measurement in motors*)

For dimensions and specifications of encoders with functional safety, see the Product Information document.

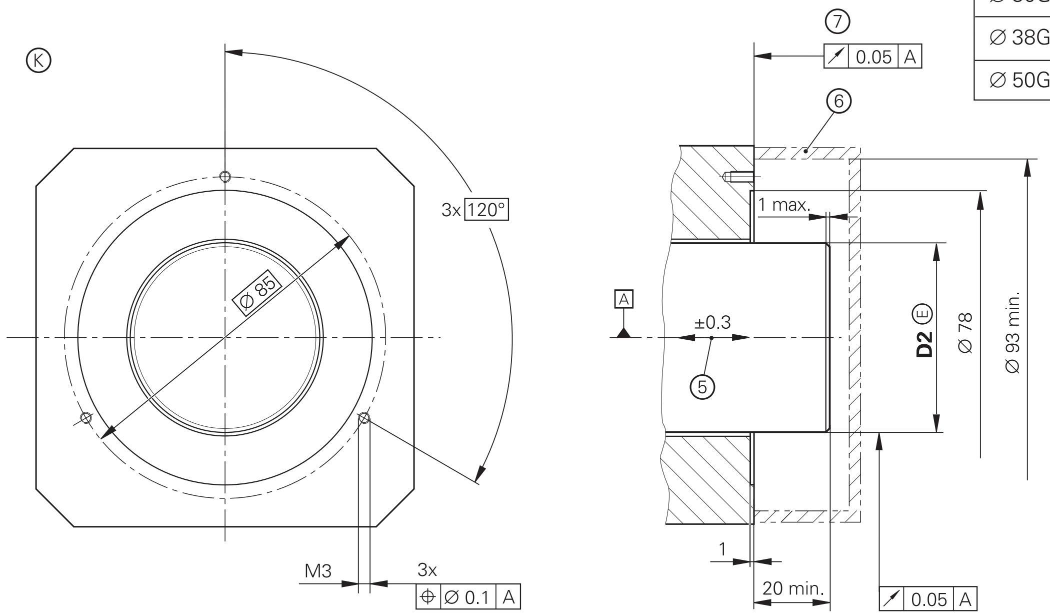
DRIVE-CLiQ is a registered trademark of Siemens AG

ECI/EBI 100 series

Absolute rotary encoders
- **Flange for axial mounting**
- **Hollow through shaft**
- **Without integral bearing**
- ***EBI 135:* multiturn functionality via battery-buffered revolution counter**



D1	D2
Ø 30G6	Ø 30h7
Ø 38G6	Ø 38h7
Ø 50G6	Ø 50h7



mm

Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

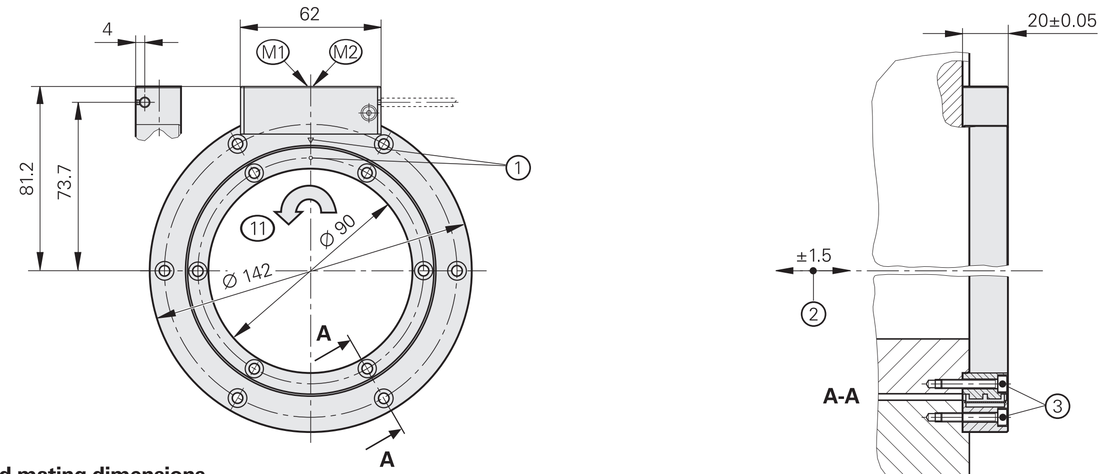
A = Bearing of mating shaft
K = Required mating dimensions
M = Measuring point for operating temperature
1 = Cylinder head screw: ISO 4762-M3 with three ISO 7092 washers
2 = Width A/F 2.0 (6x); tighten evenly crosswise with increasing tightening torque
3 = Shaft detent: for manner of functioning, see the mounting instructions
4 = 15-pin PCB connector
5 = Compensation of mounting tolerances and thermal expansion; no dynamic motion
6 = Protection against contact as per EN 60529
7 = Required up to max. Ø 92 mm
8 = Required mounting frame for output cable with cable clamp (accessory); bending radius of connecting wires: at least R3 mm
9 = Direction of shaft rotation for ascending position values

	Absolute		
	ECI 119 singleturn		**EBI 135 multiturn**
Interface*	EnDat 2.1	EnDat 2.2	EnDat 2.2
Ordering designation	EnDat01	EnDat22[1]	EnDat22[1]
Position values per rev.	524288 (19 bits)		
Revolutions	–		65536 (16 bits)[2]
Elec. permiss. shaft speed/ deviations[3]	≤ 3000 rpm/±128 LSB ≤ 6000 rpm/±256 LSB	≤ 6000 rpm (for continuous position value)	
Calculation time t_{cal} Clock frequency	≤ 8 µs ≤ 2 MHz	≤ 6 µs ≤ 16 MHz	
Incremental signals	∿ 1 V_{PP}	–	–
Line count	32	–	–
Cutoff frequency –3 dB	≥ 6 kHz (typical)	–	–
System accuracy	±90″		
Electrical connection	15-pin	15-pin with connection for temperature sensor[4]	
Cable length	≤ 100m		
Supply voltage	3.6 V to 14 V DC		*Rotary encoder U_P:* DC 3.6 V to 14 V *Backup battery U_{BAT}:* DC 3.6 V to 5.25 V
Power consumption (maximum)	*3.6 V:* ≤ 0.58 W *14 V:* ≤ 0.7 W	*Normal operation at 3.6 V:* 0.53 W *Normal operation at 14 V:* 0.63 W	
Current consumption (typical)	*5 V:* 80 mA (without load)	*5 V:* 75 mA (without load)	*Normal operation at 5 V:* 75 mA (w/o load) *Buffer mode*[5]*:* 25 µA (rotating shaft) 12 µA (at standstill)
Shaft*	Hollow through shaft Ø = 30 mm, 38 mm, 50 mm		
Mech. permiss. shaft speed *n*	≤ 6000 rpm		
Moment of inertia of rotor	*Ø = 30 mm:* 64 · 10^{-6} kgm^2 *Ø = 38 mm:* 58 · 10^{-6} kgm^2 *Ø = 50 mm:* 64 · 10^{-6} kgm^2		
Permissible axial motion of measured shaft	±0.3 mm		
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)		
Operating temperature	–30 °C to 115 °C		
Protection EN 60529	IP20 when mounted[6]		
Mass	*Ø = 30 mm:* ≈ 0.19 kg *Ø = 38 mm:* ≈ 0.16 kg *Ø = 50 mm:* ≈ 0.14 kg		
Part number	823406-xx	823407-xx	823405-xx

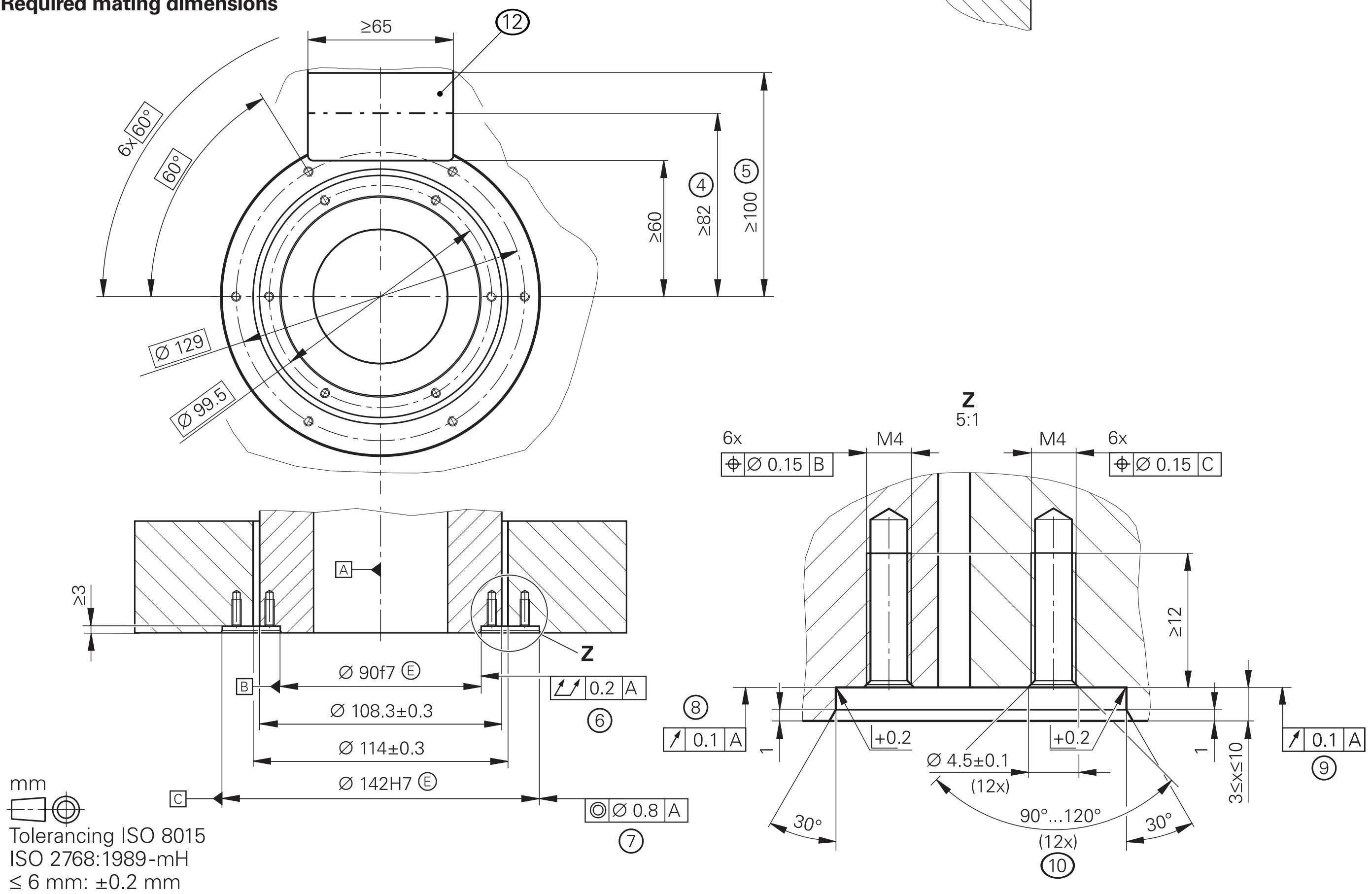
* Please select when ordering
[1] Valuation numbers are not supported
[2] Compliance with EnDat Specification 297403 and the EnDat Application Notes 722024, Chapter 13, *Battery-buffered encoders,* is required for correct control of the encoder
[3] Speed-dependent deviations between absolute and incremental signals
[4] Evaluation optimized for the KTY 84-130 (see *Temperature measurement in motors*)
[5] At T = 25 °C; U_{BAT} = 3.6 V
[6] See *Electromagnetic compatibility* under *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure.

ECI 4010, EBI 4010, ECI 4090 S

Rotary encoders for absolute position values
- **Robust inductive scanning principle**
- **Hollow through shaft (Ø 90 mm)**
- ***EBI 4010:* Multiturn functionality via battery-buffered revolution counter**
- **Consists of a scanning unit and scale drum**



Required mating dimensions



mm
Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

A = Bearing of mating shaft
M1 = Measuring point for operating temperature on housing
M2 = Measuring point for vibration on housing
1 = Position of zero point ±5°
2 = Maximum permissible axial deviation between the shaft surface and flange surface; compensation for mounting tolerances and thermal expansion; dynamic motion permitted over entire range
3 = Use screws with material bonding anti-rotation lock: ISO 4762 – M4 x 25 – 8.8 – MKL as per DIN 267-27 (not included in delivery, ID 202264-88); tightening torque 2.2 Nm ± 0.13 Nm
4 = Space required when encoder cover is closed
5 = Space required for opening the encoder cover
6 = Total runout of mating shaft
7 = Coaxiality of stator mating surface
8 = Bearing surface of rotor
9 = Bearing surface of stator
10 = Chamfer at start of thread is obligatory for material bonding anti-rotation lock
11 = Direction of shaft rotation for ascending position values
12 = This area of the mating surface does not need to be fully covered by the scanning unit

Specifications	ECI 4010 singleturn	EBI 4010 multiturn	ECI 4090 S singleturn
Interface/ordering designation	EnDat 2.2 / EnDat22		DRIVE-CLiQ / DQ01
Position values per rev.	1 048 576 (20 bits)		
Revolutions	–	65 536 (16 bits)	–
Calculation time t_{cal}/ clock frequency	≤ 5 µs/≤ 16 MHz		≤ 11 µs[1]
System accuracy	±25″		
Electrical connection	15-pin with connection for temperature sensor[2]		
Cable length	≤ 100 m		≤ 40 m[3]
Supply voltage	3.6 V to 14 V DC	*Rotary encoder U_P:* DC 3.6 V to 14 V *Buffer battery U_{Bat}:* DC 3.6 to 5.25 V	DC 24 V (10 V to 28.8 V); up to 36 V possible without impairing the functional safety
Power consumption[4] (max.)	*3.6 V:* ≤ 0.63 W; *14 V:* ≤ 0.7 W		*10 V:* ≤ 1.1 W; *28.8 V:* ≤ 1.25 W
Current consumption (typical)	*5 V:* 95 mA (without load)	*Normal operation at 5 V:* 95 mA (w/o load) *Buffer mode[5]:* 220 µA (rotating shaft) 25 µA (shaft at standstill)	*24 V:* 40 mA (without load)
Shaft	Hollow through shaft (Ø 90 mm)		
Spindle speed	≤ 6000 rpm		
Moment of inertia of rotor	$4.26 \cdot 10^{-4}$ kgm^2 (w/o screws)		
Angular acceleration of rotor	$\leq 2 \cdot 10^4$ rad/s^2		
Axial motion of measured shaft	≤ ±1.5 mm		
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	*AE scanning unit:* ≤ 400 m/s^2; *TTR scale drum:* ≤ 600 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)		
Operating temperature	–40 °C to 115 °C (at the measuring point and on the entire scale drum)		–40 °C to 100 °C (at the measuring point and the entire scale drum)
Trigger threshold of error message for excessive temperature	130 °C (measuring accuracy of the internal temperature sensor: ±1 K)		120 °C (measuring accuracy of the internal temperature sensor: ±1 K)
Protection EN 60529	*Complete encoder, mounted:* IP20[6]; *scanning unit:* IP40 (read about insulation under *Electrical safety* in the *Interfaces of HEIDENHAIN Encoders* brochure)		
Mass	*AE scanning unit:* ≈ 0.27 kg; *TTR scale drum:* ≈ 0.17 kg		
Part number	*AE ECI4010 scanning unit:* ID 1130167-xx	*AE EBI4010 scanning unit:* ID 1130173-xx	*AE ECI4090S scanning unit:* ID 1130171-xx
	TTR EXI4000 scale drum: ID 1130175-xx		

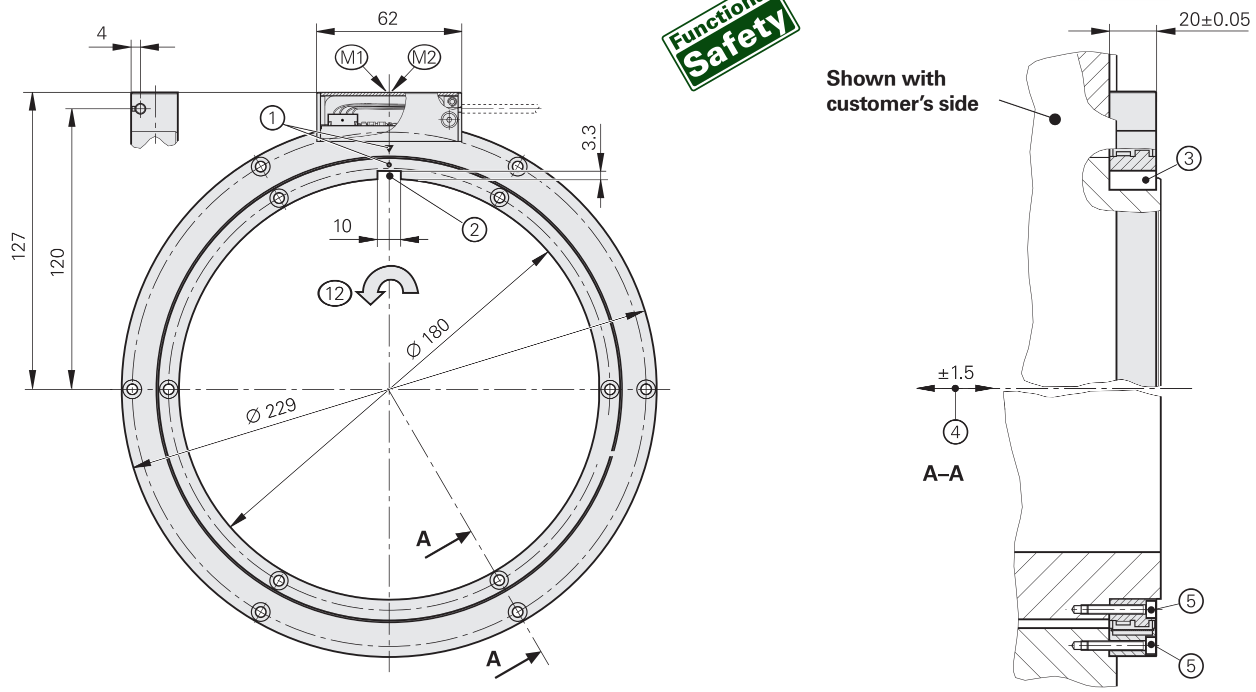
1) Calculation time TIME_MAX_ACTVAL
2) Evaluation optimized for the KTY 84-130, with DQ01 also for the PT 1000 (see *Temperature measurement in motors*)
3) At an output cable length (inside motor) ≤ 1 m
4) See *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure
5) At T = 25 °C; U_{BAT} = 3.6 V
6) The encoder must be protected from abrasive and harmful media in the application; use an appropriate enclosure as needed.

For dimensions and specifications of encoders with functional safety, see the Product Information document.

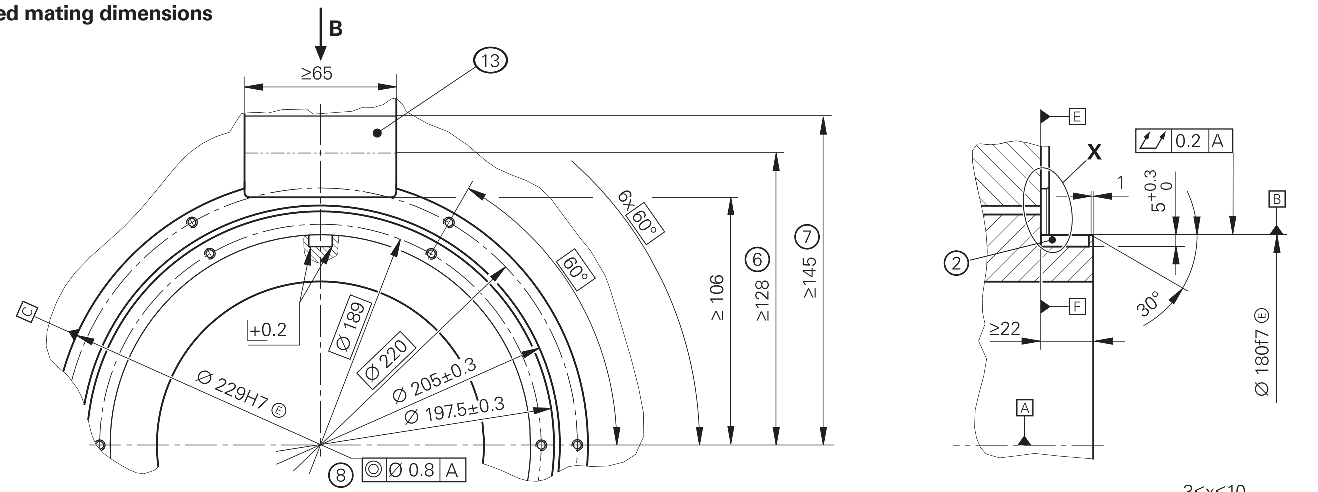
ECI 4010, EBI 4010, ECI 4090 S

Rotary encoders for absolute position values

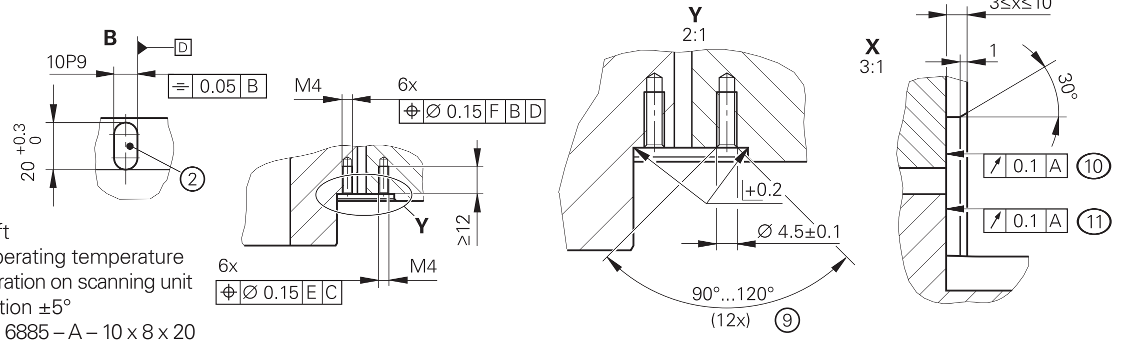
- **Robust inductive scanning principle**
- **Hollow through shaft (Ø 180 mm)**
- ***EBI 4010:* Multiturn functionality via battery-buffered revolution counter**
- **Consists of a scanning unit and scale drum**



Required mating dimensions



mm
Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm



A = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration on scanning unit
1 = Marking of the 0° position ±5°
2 = Slot for feather key DIN 6885 – A – 10 x 8 x 20
3 = Feather key DIN 6885 – A – 10 x 8 x 20
4 = Maximum permissible axial deviation between the shaft surface and flange surface; compensation for mounting tolerances and thermal expansion; dynamic motion permitted over entire range
5 = Fastening screws: ISO 4762 – M4 x 25 – 8.8; a suitable anti-rotation lock must be used for the screw connection (e.g., screw with material bonding anti-rotation lock: ISO 4762 – M4 x 25 – 8.8 MKL as per DIN 267-27, ID 202264-88)
6 = Space required when encoder cover is closed
7 = Space required for opening the encoder cover
8 = Coaxiality of stator mating surface
9 = Chamfer at start of thread is obligatory for material bonding anti-rotation lock
10 = Bearing surface of stator
11 = Bearing surface of rotor
12 = Direction of shaft rotation for ascending position values
13 = This area of the mating surface does not need to be fully covered by the scanning unit

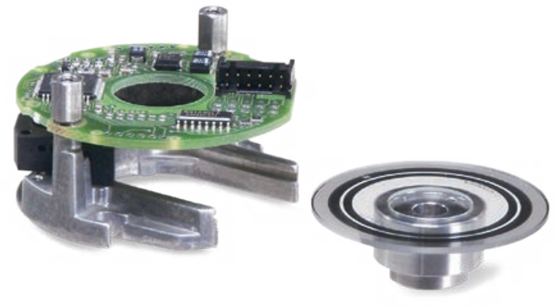
Specifications	**ECI 4010 singleturn** Functional Safety	**EBI 4010 multiturn** Functional Safety	**ECI 4090 S singleturn** Functional Safety
Interface/ordering designation	EnDat 2.2 / EnDat22		DRIVE-CLiQ / DQ01
Position values per rev.	1 048 576 (20 bits)		
Revolutions	–	65 536 (16 bits)	–
Calculation time t_{cal}/ clock frequency	≤ 5 µs/≤ 16 MHz		≤ 11 µs[1]
System accuracy	±40″		
Electrical connection	15-pin with connection for temperature sensor[2]		
Cable length	≤ 100 m		≤ 40 m[3]
Supply voltage	3.6 V to 14 V DC	*Rotary encoder U_P:* DC 3.6 V to 14 V *Buffer battery U_{Bat}:* DC 3.6 to 5.25 V	DC 24 V (10 V to 28.8 V); up to 36 V possible without impairing the functional safety
Power consumption[4] (max.)	*3.6 V:* ≤ 0.63 W; *14 V:* ≤ 0.7 W		*10 V:* ≤ 1.1 W; *28.8 V:* ≤ 1.25 W
Current consumption (typical)	*5 V:* 95 mA (without load)	*Normal operation at 5 V:* 95 mA (w/o load) *Buffer mode[5]:* 220 µA (rotating shaft) 25 µA (shaft at standstill)	*24 V:* 40 mA (without load)
Shaft	Hollow through shaft Ø 180 mm (with keyway)		
Spindle speed	≤ 6000 rpm		
Moment of inertia of rotor	$3.1 \cdot 10^{-3}$ kgm² (without screws, without key)		
Angular acceleration of rotor	$\leq 2 \cdot 10^4$ rad/s²		
Axial motion of measured shaft	≤ ±1.5 mm		
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	*AE scanning unit:* ≤ 400 m/s²; *TTR scale drum:* ≤ 600 m/s² (EN 60068-2-6) ≤ 2000 m/s² (EN 60068-2-27)		
Operating temperature	–40 °C to 115 °C (at the measuring point and on the entire scale drum)		–40 °C to 100 °C (at the measuring point and the entire scale drum)
Trigger threshold of error message for excessive temperature	130 °C (measuring accuracy of the internal temperature sensor: ±1 K)		120 °C (measuring accuracy of the internal temperature sensor: ±1 K)
Protection EN 60529	*Complete encoder, mounted:* IP20[6]; *scanning unit:* IP40 (read about insulation under *Electrical safety* in the *Interfaces of HEIDENHAIN Encoders* brochure)		
Mass	*AE scanning unit:* ≈ 0.39 kg; *TTR scale drum:* ≈ 0.33 kg		
Part number	*AE ECI4010 scanning unit:* ID 1087526-xx	*AE EBI4010 scanning unit:* ID 1097530-xx	*AE ECI4090S scanning unit:* ID 1087527-xx
	TTR EXI4000 scale drum: ID 1113606-xx		

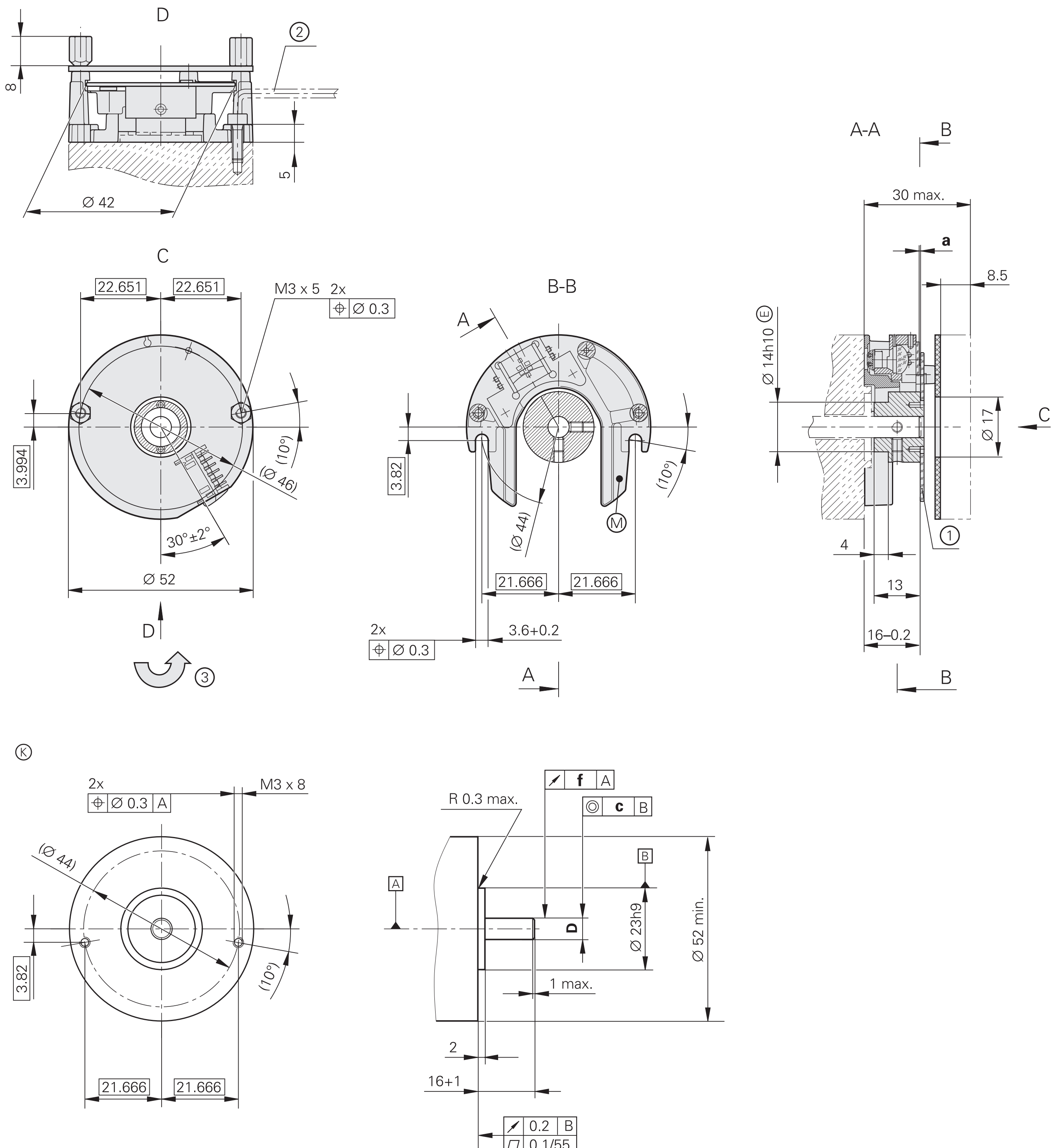
[1] Calculation time TIME_MAX_ACTVAL
[2] Evaluation optimized for the KTY 84-130, with DQ01 also for the PT 1000 (see *Temperature measurement in motors*)
[3] At an output cable length (inside motor) ≤ 1 m
[4] See *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure
[5] At T = 25 °C; U_{BAT} = 3.6 V
[6] The encoder must be protected from abrasive and harmful media in the application; use an appropriate enclosure as needed.

For dimensions and specifications of encoders with functional safety, see the Product Information document.

ERO 1200 series

Incremental rotary encoders
- **Flange for axial mounting**
- **Hollow through shaft**
- **Without integral bearing**





mm
Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

D
Ø 10h6 Ⓔ
Ø 12h6 Ⓔ

	Z	a	f	c
ERO 1225	1024	0.4 ±0.2	0.05	Ø 0.02
	2048	0.2 ±0.05		
ERO 1285	1024 2048	0.2 ±0.03	0.03	Ø 0.02

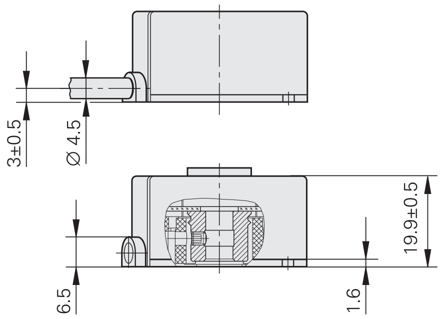
Ⓐ = Bearing of mating shaft
Ⓚ = Required mating dimensions
M = Measuring point for operating temperature
1 = Disk/hub assembly
2 = Offset screwdriver: ISO 2936 – 2.5 (I_2 shortened)
3 = Direction of shaft rotation for output signals according to interface description

	Incremental	
	ERO 1225	**ERO 1285**
Interface	⊓⊔TTL	∼ 1 V_{PP}
Line count*	1024 2048	
Accuracy of graduation[2]	±6″	
Reference mark	One	
Output frequency Edge separation *a* Cutoff frequency –3 dB	≤ 300 kHz ≥ 0.39 µs –	– – ≥ 180 kHz (typical)
System accuracy[1]	*1024 lines:* ±92″ *2048 lines:* ±73″	*1024 lines:* ±67″ *2048 lines:* ±60″
Electrical connection	12-pin	
Supply voltage	DC 5 V ±0.5 V	
Current consumption (without load)	≤ 150 mA	
Shaft*	Hollow through shaft Ø = 10 mm or Ø = 12 mm	
Moment of inertia of rotor	*Shaft Ø 10 mm:* $2.2 \cdot 10^{-6}$ kgm^2 *Shaft Ø 12 mm:* $2.2 \cdot 10^{-6}$ kgm^2	
Mech. permiss. shaft speed *n*	≤ 25 000 rpm	
Permissible axial motion of measured shaft	*1024 lines:* ±0.2 mm *2048 lines:* ±0.05 mm	±0.03 mm
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)	
Operating temperature	–40 °C to 100 °C	
Protection EN 60529	IP00	
Mass	≈ 0.07 kg	
Part number	1037521-xx (scanning unit) 332378-xx (disk/hub assembly)	1037522-xx (scanning unit) 332378-xx (disk/hub assembly)

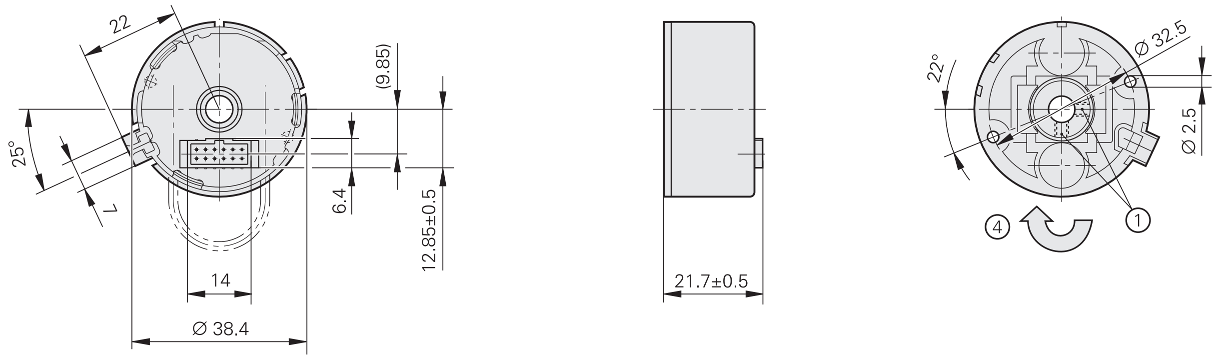
* Please select when ordering
[1] When not mounted; additional deviations due to mounting and bearing of the measured shaft are not taken into account
[2] For other errors, see *Measuring accuracy*

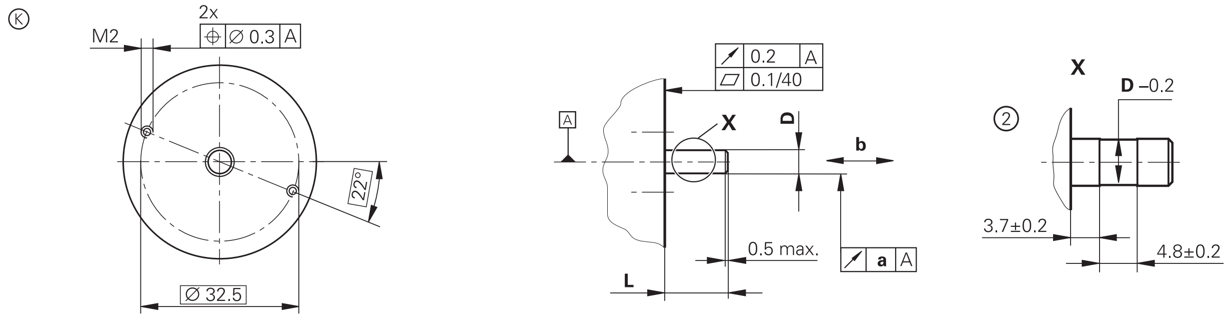
ERO 1400 series

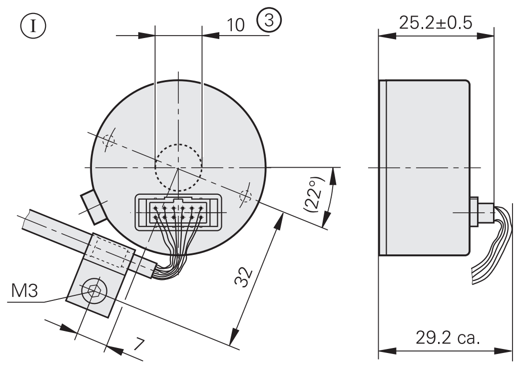
Incremental rotary encoders
- **Flange for axial mounting**
- **Hollow through shaft**
- **Without integral bearing; self-centering**



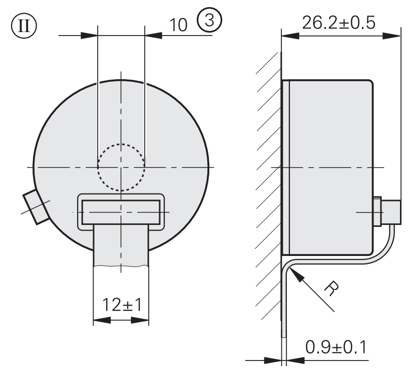
With axial PCB connector



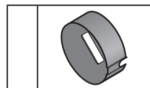
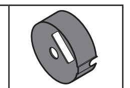




Axial PCB connector and round cable



Axial PCB connector and ribbon cable

		
L	13 +4.5/–3	10 min.

Bend radius R	Rigid configuration	Frequent flexing
Ribbon cable	R ≥ 2 mm	R ≥ 10 mm

	a	b
ERO 1420	0.03	±0.1
ERO 1470	0.02	±0.05
ERO 1480		

D
Ø 4h6 Ⓔ
Ø 6h6 Ⓔ
Ø 8h6 Ⓔ

mm
Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

A = Bearing of mating shaft
K = Required mating dimensions
I = Accessory: round cable
II = Accessory: ribbon cable
1 = Two M3 setscrews offset by 90°; width across flats 1.5
2 = Version for repeated mounting
3 = Version featuring housing with central hole (accessory)
4 = Direction of shaft rotation for output signals according to interface description

	Incremental					
	ERO 1420	**ERO 1470**				**ERO 1480**
Interface	⊓⊔TTL					∿ 1 V_{PP}
Line count*	512 **1000** **1024**	**1000** 1500				512 **1000** **1024**
Integrated interpolation*	–	5-fold	**10-fold**	20-fold	25-fold	–
Signal periods per revolution	512 1000 1024	5000 7500	10000 15000	20000 30000	25000 37500	512 1000 1024
Edge separation *a*	≥ 0.39 µs	≥ 0.47 µs	≥ 0.22 µs	≥ 0.17 µs	≥ 0.07 µs	–
Scanning frequency	≤ 300 kHz	≤ 100 kHz		≤ 62.5 kHz	≤ 100 kHz	–
Cutoff frequency –3 dB	–					≥ 180 kHz
Reference mark	One					
System accuracy[1]	*512 lines:* ±139″ *1000 lines:* ±112″ *1024 lines:* ±112″	*1000 lines:* ±130″ *1500 lines:* ±114″				*512 lines:* ±190″ *1000 lines:* ±163″ *1024 lines:* ±163″
Electrical connection*	12-pin, axial[2]					
Supply voltage	DC 5 V ±0.5 V	DC 5 V ±0.25 V				DC 5 V ±0.5 V
Current consumption (without load)	≤ 150 mA	≤ 155 mA		≤ 200 mA		≤ 150 mA
Shaft*	**Blind hollow shaft** Ø 4 mm, **Ø 6 mm**, or Ø 8 mm, or hollow through shaft in housing with bore (accessory)					
Moment of inertia of rotor	*Shaft Ø 4 mm:* $0.28 \cdot 10^{-6}$ kgm^2 *Shaft Ø 6 mm:* $0.27 \cdot 10^{-6}$ kgm^2 *Shaft Ø 8 mm:* $0.25 \cdot 10^{-6}$ kgm^2					
Mech. permiss. shaft speed *n*	≤ 30000 rpm					
Permissible axial motion of measured shaft	±0.1 mm	±0.05 mm				
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)					
Operating temperature	–10 °C to 70 °C					
Protection EN 60529	*With PCB connector:* IP00 *With cable outlet:* IP40					
Mass	≈ 0.07 kg					
Part number	360731-xx	360736-xx				360737-xx

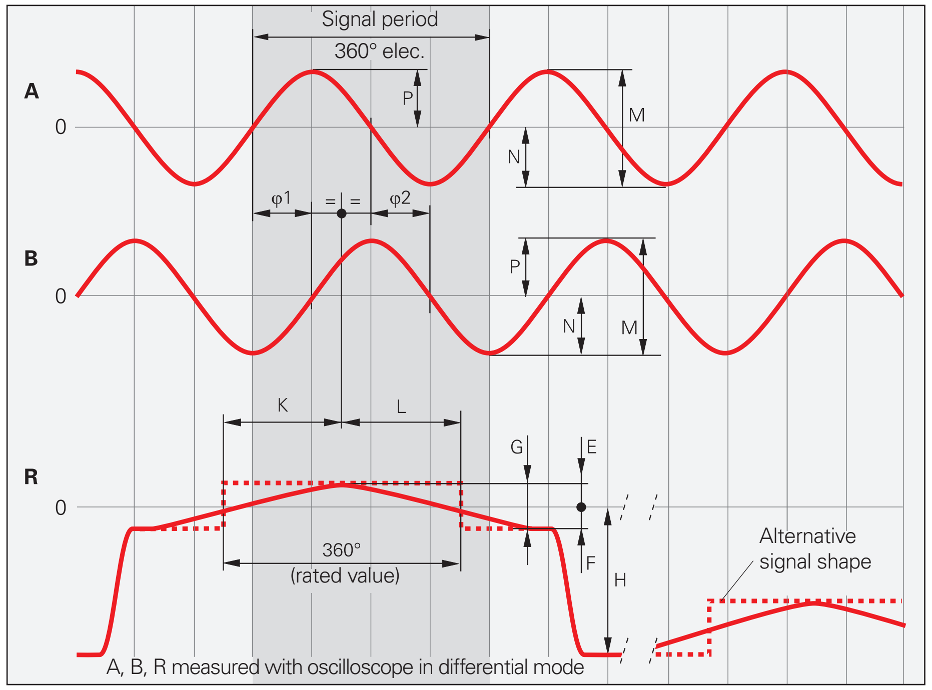
Bold: This preferred version is available on short notice
* Please select when ordering
[1] When not mounted; additional deviations due to mounting and bearing of the measured shaft are not taken into account
[2] Upon request, cable (1 m), radial, unassembled cable end (not for ERO 1470)

Interfaces

1 V_{PP} incremental signals

HEIDENHAIN encoders with the 1 V_{PP} interface provide voltage signals that are highly interpolatable.

The sinusoidal **incremental signals** A and B are phase-shifted by 90° elec. and have a typical amplitude of 1 V_{PP}. The illustrated sequence of output signals, with B lagging A, applies to the direction of motion shown in the dimension drawing. The **reference mark signal** R has a unique assignment to the incremental signals. The output signal may be lower next to the reference mark.

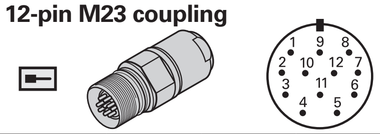


For more information:

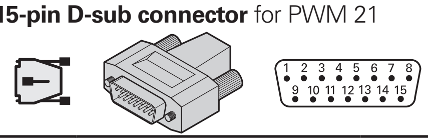
For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure.

Pin layout

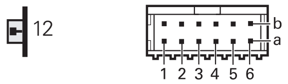
12-pin M23 coupling



15-pin D-sub connector for PWM 21



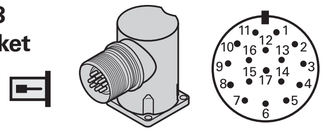
12-pin PCB connector



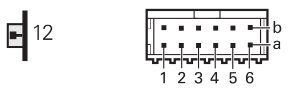
	Supply voltage				Incremental signals						Other signals		
	12	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**9**	**7**	**/**
	4	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**5/6/8/15**	**13**	**/**
12	**2a**	**2b**	**1a**	**1b**	**6b**	**6a**	**5b**	**5a**	**4b**	**4a**	**3b**	**3a**	**/**
	U_P	**Sensor**[1] U_P	**0 V**	**Sensor**[1] 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

Output cable for ERN 1381 inside the motor housing
ID 667343-01

17-pin M23 flange socket



12-pin PCB connector



	Supply voltage				Incremental signals						Other signals		
	7	**1**	**10**	**4**	**15**	**16**	**12**	**13**	**3**	**2**	**5**	**6**	**8/9/11/ 14/17**
12	**2a**	**2b**	**1a**	**1b**	**6b**	**6a**	**5b**	**5a**	**4b**	**4a**	**/**	**/**	**3a/3b**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**T+**[2]	**T–**[2]	**Vacant**
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	Brown[2]	White[2]	/

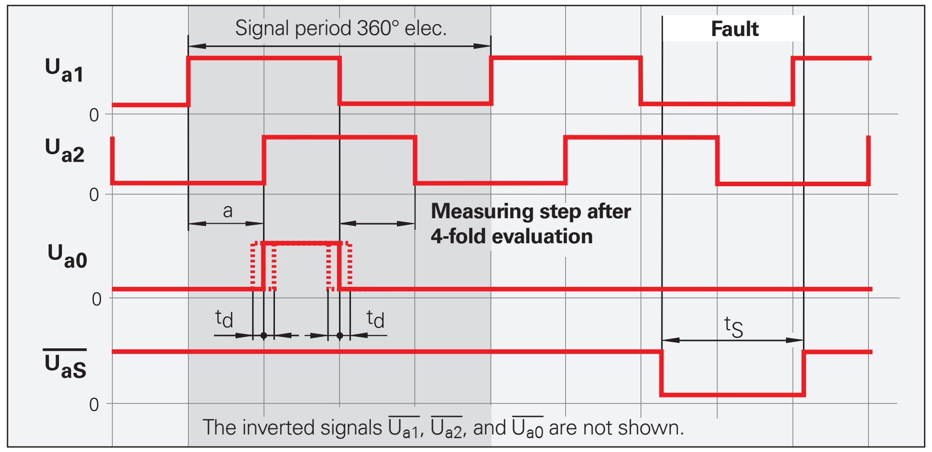
Cable shield connecting with housing; **U_P** = Power supply voltage [1] **LIDA 2xx:** vacant; [2] For connecting a temperature sensor
Sensor: The sense line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!

TTL incremental signals

HEIDENHAIN encoders with the TTL interface contain electronics that digitize sinusoidal scanning signals either with or without interpolation.

The **incremental signals** are output as the square-wave pulse trains U_{a1} and U_{a2} with a 90° elec. phase shift. 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 generate the **inverted signals** $\overline{U_{a1}}$, $\overline{U_{a2}}$, and $\overline{U_{a0}}$ for noise-immune 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 malfunctions such as an interruption in the supply lines, failure of the light source, etc.



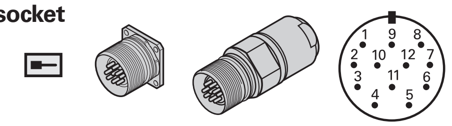
The distance between two successive edges of the incremental signals U_{a1} and U_{a2} through 1-fold, 2-fold, or 4-fold evaluation is one **measuring step.**

For more information:

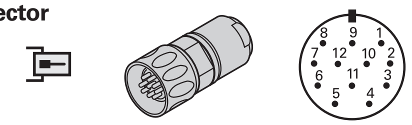
For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure.

Pin layout

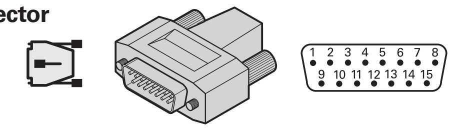
12-pin M23 flange socket or coupling



12-pin M23 connector



15-pin D-sub connector
for IK 215 / PWM 21

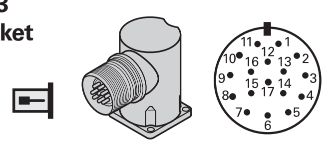
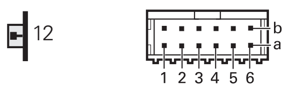


12-pin PCB connector

	Supply voltage				Incremental signals						Other signals		
	12	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**7**	**/**	**9**
	4	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**13**	**5/6/8**	**15**
12	**2a**	**2b**[1]	**1a**	**1b**[1]	**6b**	**6a**	**5b**	**5a**	**4b**	**4a**	**3a**	**3b**	**/**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**U_{a1}**	**$\overline{U_{a1}}$**	**U_{a2}**	**$\overline{U_{a2}}$**	**U_{a0}**	**$\overline{U_{a0}}$**	**$\overline{U_{aS}}$**[1]	**Vacant**	**Vacant**[2]
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	Violet	/	Yellow

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

Pin layout

Output cable for ERN 1321 inside the motor ID 667343-01	17-pin M23 flange socket 	12-pin PCB connector 

	Supply voltage				Incremental signals						Other signals		
(M23)	**7**	**1**	**10**	**4**	**15**	**16**	**12**	**13**	**3**	**2**	**5**	**6**	**8/9/11/14/17**
12	**2a**	**2b**	**1a**	**1b**	**6b**	**6a**	**5b**	**5a**	**4b**	**4a**	**/**	**/**	**3a/3b**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0V	**U_{a1}**	**$\overline{U_{a1}}$**	**U_{a2}**	**$\overline{U_{a2}}$**	**U_{a0}**	**$\overline{U_{a0}}$**	**T+**[1)]	**T–**[1)]	**Vacant**
(cable)	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	Brown[1)]	White[1)]	/

Cable shield connected to housing; **U_P** = Power supply voltage
Sensor: The sense line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!
1) Connections for an external temperature sensor (only for output cables inside the motor, see *Temperature measurement in motors*); if used, please refer to the information about electromagnetic compatibility in the *General electrical information* section of the *Interfaces of HEIDENHAIN Encoders* brochure.

Commutation signals for block commutation

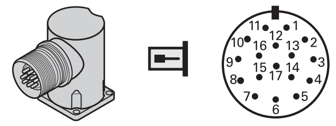
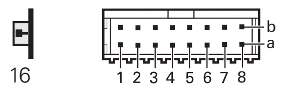
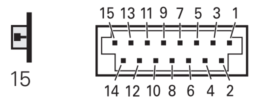
The **block commutation signals U, V, and W** are obtained from three separate absolute tracks. They are transmitted as square-wave signals in TTL levels.

The **ERN 1x23** and **ERN 1326** are rotary encoders with commutation signals for block commutation.

For more information:

For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure.

ERN 1123, ERN 1326 pin layout

17-pin M23 flange socket 	16-pin PCB connector 	15-pin PCB connector 

	Supply voltage				Incremental signals					
(M23)	**7**	**1**	**10**	**11**	**15**	**16**	**12**	**13**	**3**	**2**
16	**1b**	**2b**	**1a**	**/**	**5b**	**5a**	**4b**	**4a**	**3b**	**3a**
15	**13**	**/**	**14**	**/**	**1**	**2**	**3**	**4**	**5**	**6**
	U_P	**Sensor** U_P	**0 V**	**Internal shield**	**U_{a1}**	**$\overline{U_{a1}}$**	**U_{a2}**	**$\overline{U_{a2}}$**	**U_{a0}**	**$\overline{U_{a0}}$**
(cable)	Brown/ Green	Blue	White/ Green	/	Green/ Black	Yellow/ Black	Blue/ Black	Red/ Black	Red	Black

	Other signals						
(M23)	**4**	**5**	**6**	**14**	**17**	**9**	**8**
16	**2a**	**8b**	**8a**	**6b**	**6a**	**7b**	**7a**
15	**/**	**7**	**8**	**9**	**10**	**11**	**12**
	$\overline{U_{aS}}$	**U**	**$\overline{U}$**	**V**	**$\overline{V}$**	**W**	**$\overline{W}$**
(cable)	White	Green	Brown	Yellow	Violet	Gray	Pink

Cable shield connected to housing
U_P = Power supply
Sensor: The sense line is connected in the encoder with the corresponding power line (only with ERN 1326).
Vacant pins or wires must not be used!

Pin layout for ERN 1023

	Supply voltage		Incremental signals						Other signals					
	U_P	**0 V**	**U_{a1}**	**$\overline{U_{a1}}$**	**U_{a2}**	**$\overline{U_{a2}}$**	**U_{a0}**	**$\overline{U_{a0}}$**	**U**	**$\overline{U}$**	**V**	**$\overline{V}$**	**W**	**$\overline{W}$**
(cable)	White	Black	Red	Pink	Olive Green	Blue	Yellow	Orange	Tan	Brown	Green	Gray	Light Blue	Violet

Cable shield connected to housing
U_P = Power supply
Vacant pins or wires must not be used!

Commutation signals for sine commutation

The **commutation signals C and D** are obtained from the Z1 track and are equal to one sine or cosine period per revolution. They have a signal amplitude of 1 V_{PP} (typical) at 1 kΩ.

The input circuit of the downstream electronics is equivalent to the ∿ 1 V_{PP} interface. However, the required terminating impedance Z_0 is 1 kΩ instead of 120 Ω.

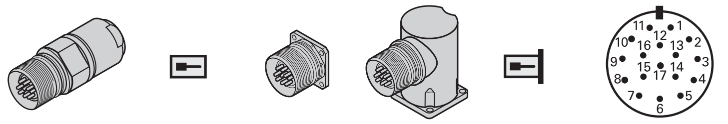
The **ERN 1387** is a rotary encoder with output signals for sinusoidal commutation.

For more information:

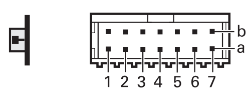
For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure.

Pin layout

17-pin M23 coupling or flange socket



14-pin PCB connector



	Supply voltage					Incremental signals					
	7	**1**	**10**	**4**	**11**	**15**	**16**	**12**	**13**	**3**	**2**
	1b	**7a**	**5b**	**3a**	**/**	**6b**	**2a**	**3b**	**5a**	**4b**	**4a**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Internal shield**	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**
	Brown/Green	Blue	White/Green	White	/	Green/Black	Yellow/Black	Blue/Black	Red/Black	Red	Black

	Other signals					
	14	**17**	**9**	**8**	**5**	**6**
	7b	**1a**	**2b**	**6a**	**/**	**/**
	C+	**C–**	**D+**	**D–**	**T+**[1]	**T–**[1]
	Gray	Pink	Yellow	Violet	Green	Brown

Cable shield connected to housing
U_P = Voltage supply; **T** = Temperature
Sensor: The sense line is connected internally to the respective power line.
Vacant pins or wires must not be used!
1) Connections for an external temperature sensor (only for output cables inside the motor, see *Temperature measurement in motors*); if used, please refer to the information about electromagnetic compatibility in the *General electrical information* section of the *Interfaces of HEIDENHAIN Encoders* brochure.

EnDat 2.2 position feedback

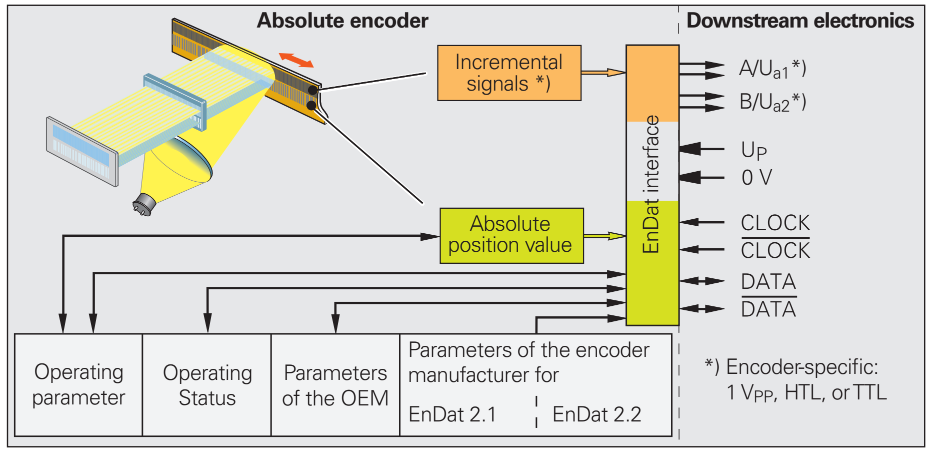
The EnDat interface is a digital, **bidirectional** interface for encoders. It is capable of outputting **position values**, reading information stored in the encoder, updating this information, and storing new information. Because the interface uses **serial transmission**, only **four signal lines** are required. The data (DATA) are transmitted in **synchronism** with the CLOCK signal from the downstream electronics. The type of transmission (position values, parameters, diagnostics, etc.) is selected via mode commands sent to the encoder by the downstream electronics. Some functions are available only with EnDat 2.2 mode commands.

For more information:

For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure.

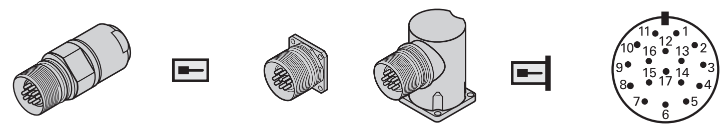
Ordering designation	Command set	Incremental signals
EnDat01 EnDat H EnDat T	EnDat 2.1 or EnDat 2.2	1 V_{PP} HTL TTL
EnDat21		–
EnDat02	EnDat 2.2	1 V_{PP}
EnDat22	EnDat 2.2	–
E30-R2	EnDat 3.0	

Versions of the EnDat interface

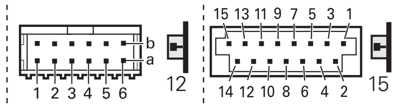


Pin layout for EnDat01/EnDat02

17-pin M23 coupling or flange socket



12-pin PCB connector **15-pin PCB connector**



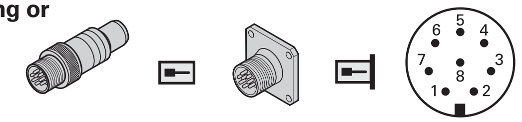
	Supply voltage					Incremental signals[1]				Serial data transmission			
	7	**1**	**10**	**4**	**11**	**15**	**16**	**12**	**13**	**14**	**17**	**8**	**9**
12	**1b**	**6a**	**4b**	**3a**	**/**	**2a**	**5b**	**4a**	**3b**	**6b**	**1a**	**2b**	**5a**
15	**13**	**11**	**14**	**12**	**/**	**1**	**2**	**3**	**4**	**7**	**8**	**9**	**10**
	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

	Other signals	
	5	**6**
12	**/**	**/**
15	**/**	**/**
	T+[2]	**T–**[2]
	Brown[2]	White[2]

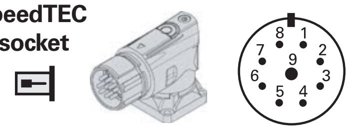
Cable shield connected with housing; **U_P** = Power supply voltage; **T** = Temperature
Sensor: The sense line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!
1) Only with the ordering designations EnDat 01 and EnDat 02
2) Connections for an external temperature sensor (only for output cables inside the motor, see *Temperature measurement in motors*); if used, please refer to the information about electromagnetic compatibility in the *General electrical information* section of the *Interfaces of HEIDENHAIN Encoders* brochure.

EnDat22 pin layout

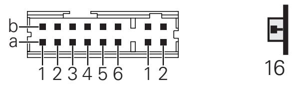
8-pin M12 coupling or flange socket



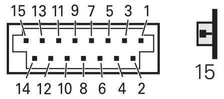
9-pin M23 SpeedTEC angle flange socket



16-pin (12+4-pin) PCB connector



15-pin PCB connector

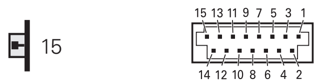


	Supply voltage				Serial data transmission				Other signals	
M12	**8**	**2**	**5**	**1**	**3**	**4**	**7**	**6**	**/**	**/**
M23	**3**	**7**	**4**	**8**	**5**	**6**	**1**	**2**	**/**	**/**
16	**1b**	**6a**	**4b**	**3a**	**6b**	**1a**	**2b**	**5a**	**1a**	**1b**
15	**13**	**11**	**14**	**12**	**7**	**8**	**9**	**10**	**5**	**6**
	U_P	**Sensor**[1] U_P[2]	**0 V**	**Sensor**[1] 0 V[2]	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**	**T+**[3]	**T–**[3]
Cable	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow	Brown	Green

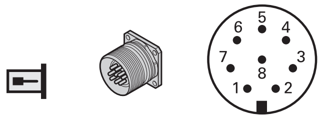
Cable shield connected with housing; **U_P** = Power supply voltage; **T** = Temperature
Sensor: The sense line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!
1) U_{BAT} for EBI 1335; 2) **ECI 1118 EnDat22:** vacant
3) Connections for an external temperature sensor (only EnDat22, except ECI 1118, see *Temperature measurement in motors*); if used, please refer to the information about electromagnetic compatibility in the *General electrical information* section of the *Interfaces of HEIDENHAIN Encoders* brochure.

Pin layout for EBI 135/EBI 1135/EBI 4010

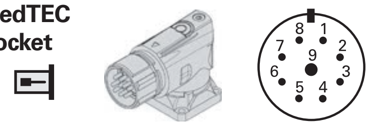
15-pin PCB connector



8-pin M12 flange socket



9-pin M23 SpeedTEC angle flange socket

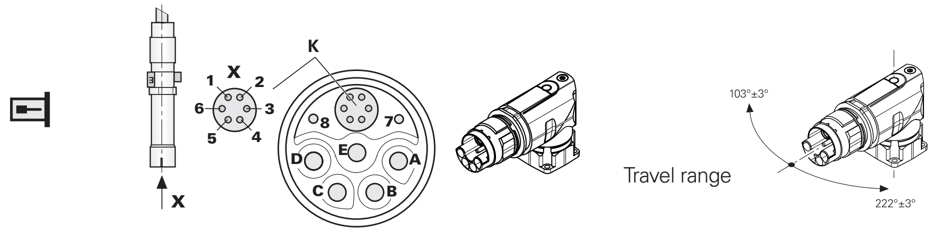


	Supply voltage				Serial data transmission				Other signals[1]	
15	**13**	**11**	**14**	**12**	**7**	**8**	**9**	**10**	**5**	**6**
M12	**8**	**2**	**5**	**1**	**3**	**4**	**7**	**6**	**/**	**/**
M23	**3**	**7**	**4**	**8**	**5**	**6**	**1**	**2**	**/**	**/**
	U_P	**U_{BAT}**	**0 V**[2]	**0 V_{BAT}**[2]	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**	**T+**[3]	**T–**[3]
Cable	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow	Brown	Green

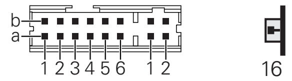
U_P = Power supply; **U_{BAT}** = external buffer battery (false polarity can result in damage to the encoder)
Vacant pins or wires must not be used!
1) Only for EBI 135
2) Connected inside encoder
3) Connections for an external temperature sensor (see *Temperature measurement in motors*); if used, please refer to the information about electromagnetic compatibility in the *General electrical information* section of the *Interfaces of HEIDENHAIN Encoders* brochure.

Pin layout

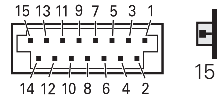
HMC 6 flange socket



16-pin (12+4-pin) PCB connector



15-pin PCB connector



	Encoder							
	Supply voltage		Serial data transmission				Other signals	
Flange socket	**1**	**2**	**3**	**4**	**5**	**6**	**/**	**/**
16	**1b**	**4b**	**6b**	**1a**	**2b**	**5a**	**1a**	**1b**
15	**13**	**14**	**7**	**8**	**9**	**10**	**5**	**6**
	U_P	**0 V**	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**	**T+**[1]	**T–**[1]
Cable	Brown/Green	White/Green	Gray	Pink	Violet	Yellow	Brown	Green

	Motor						
	Brake		Power supply				
Flange socket	**7**	**8**	**A**	**B**	**C**	**D**	**E**
	BRAKE–	**BRAKE+**	**U**	**V**	**W**	**/**	**PE**
Cable	White	White/Black	Blue	Brown	Black	/	Yellow/Green

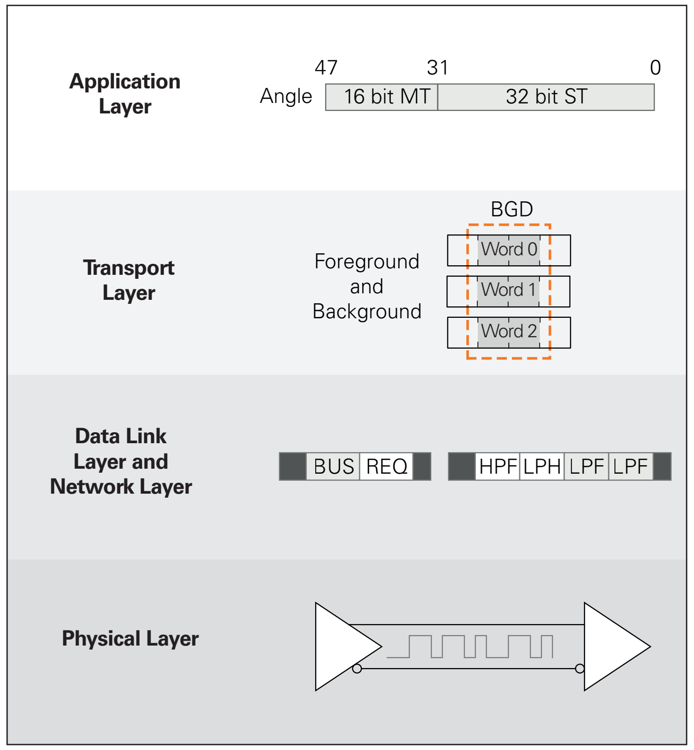
Outer shield of the encoder output cable on housing of communication element **K.**
Vacant pins or wires must not be used!
HMC 6 is not suited for encoders with buffer battery backup (EBI 135, EBI 1335, EBI 1135, EBI 4010)
1) Connections for an external temperature sensor (except ECI 1118, see *Temperature measurement in motors*); if used, please refer to the information about electromagnetic compatibility in the *General electrical information* section of the *Interfaces of HEIDENHAIN Encoders* brochure.

![EnDat 3]

EnDat 3

EnDat 3 combines the features and benefits of EnDat in a new architecture and offers interesting enhanced functions for digital production. EnDat 3 requires two wires for communication. Two other wires are generally used with EnDat 3 for supplying power to the encoder. Since the digital data current has no DC component, it is possible to modulate the communication on the supply wires, and so to reduce the number of wires for certain applications (e.g., hybrid motor cables) to a total of just two wires (HMC 2). The EnDat 3 interface speciation is based on the standardized OSI layer model.

The encoder-end of the interface is called the slave, and the downstream electronics the master. A communication cycle consists of a request from the master followed by a response from the slave.



For more information:

Find out more about EnDat at *endat.heidenhain.com*

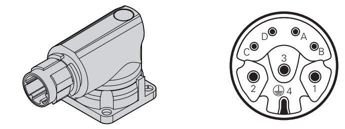
Ordering designations
The ordering designation defines key communication characteristics.

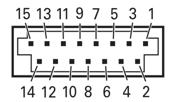
Supported communication types	E30-R2	E30-R4	E30-RB
Communication modulated onto power supply wires	✓	–	–
Communication + separate power supply wires (4 wires)	–	✓	✓
Bus operation	–	–	✓
Sensor box integration	–	✓	✓

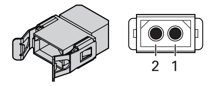
HMC 2 (EnDat 3/E30-R2) M12

Pin layout of ECI, EQI 11xx

8-pin M12 SpeedTEC angle flange socket M12 | **15-pin PCB connector** 15 | 2







	Encoder			
	Power supply / Serial data transfer		Other signals	
M12	**A**	**B**	**/**	**/**
15	**9**	**10**	**5**	**6**
2	**–**	**–**	**2**	**1**
	P_SD+[1)]	**P_SD–**[1)]	**T+**[2)]	**T–**[2)]
	Violet	Yellow	Brown	Green

	Motor					
	Brake		**Power supply**			
M12	**C**	**D**	**1**	**2**	**3**	**4**
	Brake +	**Brake –**	**U**	**V**	**W**	**PE**

1) Power supply and data: P_SD+ includes U_P; P_SD– includes 0 V
2) Connections for an external temperature sensor; evaluation optimized for KTY 84-130, PT 1000 and others (see *Temperature measurement in motors*); if used, please refer to the information about electromagnetic compatibility in the *General electrical information* section of the *Interfaces of HEIDENHAIN Encoders* brochure.

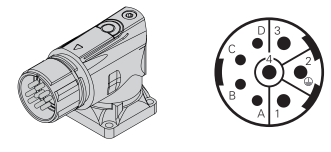
Vacant pins or wires must not be used!

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH

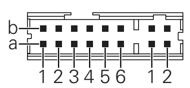
HMC 2 (EnDat 3/E30-R2) M23

Pin layout of ECI, EQI, ECN, EQN 13xx

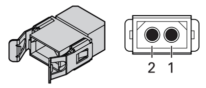
8-pin M23 SpeedTEC
HMC 2 angle flange socket M23



16-pin (12+4-pin)
PCB connector 12 4



2



	Encoder			
	Power supply / Serial data transfer		Other signals	
M23	**A**	**B**	**/**	**/**
12	**2b**	**5a**	**/**	**/**
4	**/**	**/**	**1a**	**1b**
2	**/**	**/**	**2**	**1**
	P_SD+[1]	**P_SD–**[1]	**T+**[2]	**T–**[2]
	Violet	Yellow	Brown	Green

	Motor					
	Brake		**Power supply**			
M23	**C**	**D**	**1**	**4**	**3**	**2**
	Brake +	**Brake –**	**U**	**V**	**W**	**PE**

1) Supply voltage and data: P_SD+ contains U_P (power supply); P_SD– contains 0 V
2) Connections for an external temperature sensor; evaluation optimized for KTY 84-130, PT 1000 and others; (see *Temperature measurement in motors*); if used, please refer to the information about electromagnetic compatibility in the *General electrical information* section of the *Interfaces of HEIDENHAIN Encoders* brochure.

Vacant pins or wires must not be used!

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH

DRIVE-CLiQ interface

HEIDENHAIN encoders with the code letter S after the model designation are suitable for connection to Siemens controls with the **DRIVE-CLiQ interface**
- Ordering designation: DQ01

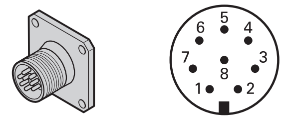
DRIVE-CLiQ is a registered trademark of Siemens AG

For more information:

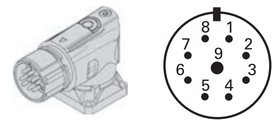
For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure.

Siemens pin layout for encoder cables (AGK)

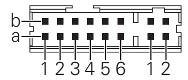
8-pin M12 SPEEDCON flange socket



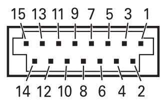
9-pin M23 SpeedTEC angle flange socket



16-pin (12+4-pin) PCB connector 16



15-pin PCB connector 15

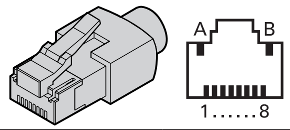


	Supply voltage				Serial data transmission				Other signals	
M12	**8**	**2**	**1**	**5**	**3**	**4**	**7**	**6**	**/**	**/**
M23	**3**	**7**	**8**	**4**	**5**	**6**	**1**	**2**	**/**	**/**
16	**1b**	**6a**	**3a**	**4b**	**6b**	**1a**	**2b**	**5a**	**1a**	**1b**
15	**13**	**11**	**12**	**14**	**7**	**8**	**9**	**10**	**5**	**6**
	–	**–**	**U_P**	**0 V**	**RXP**	**RXN**	**TXP**	**TXN**	**T+**[1]	**T–**[1]
*	Brown/ Green	Blue	White	White/ Green	Gray	Pink	Violet	Yellow	Brown	Green

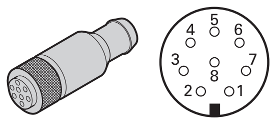
Cable shield connected to housing; **U_P** = Power supply voltage
Vacant pins or wires must not be used!
Output cables with a cable length > 0.5 m require strain relief for the cable
1) Connections for an external temperature sensor (see *Temperature measurement in motors*); if used, please refer to the information about electromagnetic compatibility in the *General electrical information* section of the *Interfaces of HEIDENHAIN Encoders* brochure.

Siemens pin layout for adapter cables (APK) and connecting cables (VBK)

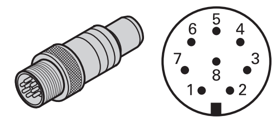
RJ45 connector



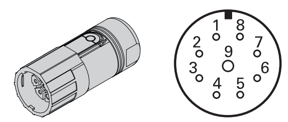
8-pin M12 connector



8-pin M12 coupling



9-pin M23 SpeedTEC connector



	Supply voltage		Serial data transmission			
RJ45	**A**	**B**	**3**	**6**	**1**	**2**
M12	**1**	**5**	**7**	**6**	**3**	**4**
M23	**8**	**4**	**1**	**2**	**5**	**6**
	U_P	**0 V**	**TXP**	**TXN**	**RXP**	**RXN**
*	Red	Black	Green	Yellow	Pink	Blue

* Note how the color assignment of encoder cables differs from adapter cables and connecting cables

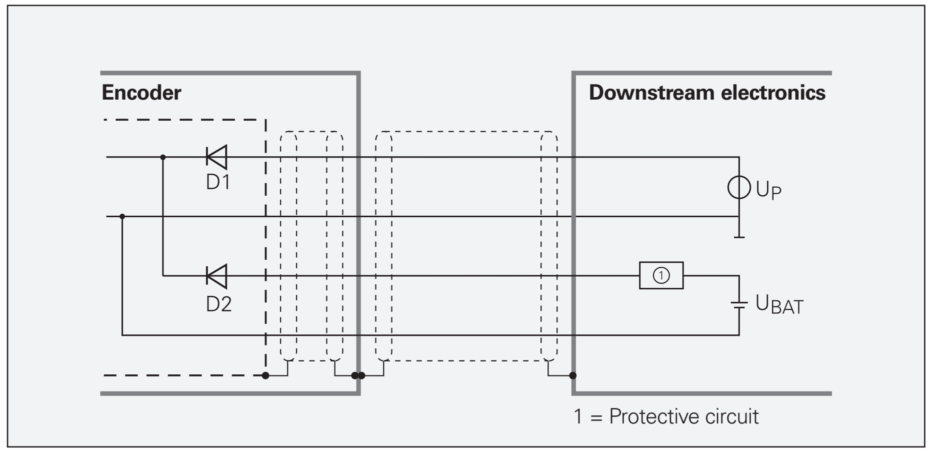
SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH
SPEEDCON is a registered trademark of Phoenix Contact GmbH & Co. KG.

External backup battery for the EBI 1135/EBI 1335/EBI 135/EBI 4010/ KBI 1335/KBI 136 with EnDat 2.2

The multiturn functionality of the inductive rotary encoders is realized via a revolution counter. To ensure that the absolute position information is available after a power failure, the EBI and KBI encoders must be operated with an external backup battery.

A lithium thionyl chloride battery with 3.6 V and 1200 mAh is recommended for the backup battery. The typical battery service life is over nine years (EBI 1135/135) or six years (EBI 4010, EBI 1335) under the right conditions (two ten-hour shifts under normal operation, battery temperature of 25 °C and typical self-discharging). The typical service life of the KBI is stated in the product documentation for each encoder. To reach the typical service life, the main power supply (U_P) must be connected to the encoder during or immediately after connection of the backup battery so that the encoder is fully initialized after being completely without power. Otherwise, the encoder will consume a significantly higher amount of battery current until main power is first supplied.

To prevent damage to the encoder, ensure correct polarity of the backup battery. HEIDENHAIN recommends operating each encoder with a separate battery.



Backup battery connection

If the application requires compliance with DIN EN 60086-4 or UL 1642, then an appropriate protective circuit is required for protection from wiring errors.

If the backup battery voltage falls below certain thresholds, then the encoder will issue the following warnings or error messages transmitted via the EnDat interface:

- **"Battery charge" warning**
  ≤ 2.8 V ±0.2 V
  in normal operating mode
- **"M Power interruption" error message**
  ≤ 2.2 V ±0.2 V
  in battery-buffered mode (encoder must be re-referenced)

A low level of battery current continues to flow even during normal operation of the EBI/KBI. The amount of current depends on the operating temperature. The typical discharge current lies within the µA range and depends on the operating temperature. For more information, please contact HEIDENHAIN.

Please note:
Compliance with EnDat Specification 297403 and the EnDat Application Notes 722024, Chapter 13, *Battery-buffered encoders*, is required for correct control of the encoder.

SSI position values

The **position value** is transmitted, starting with the most significant bit (MSB), over the data lines (DATA) in synchronism with a clock signal (CLOCK) provided by the control. The SSI standard data word length for singleturn encoders is 13 bits, and for multiturn encoders, 25 bits. In addition to the absolute position values, **incremental signals** can be transmitted as well. For a description of the signals, see *1 V_{PP} incremental signals*.

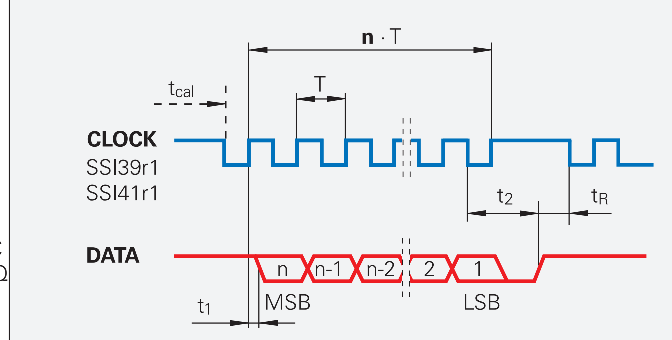
The following **functions** can be activated via programming inputs:

- **Direction of rotation**
- **Zeroing** (setting to zero)

Data transmission

T = 1 to 10 µs
t_{cal} See the specifications
t_1 ≤ 0.4 µs (without cable)
t_2 = 17 to 20 µs
t_R ≥ 5 µs
n = Data word length
13 bits for ECN/ROC
25 bits for EQN/ROQ

$\overline{\text{CLOCK}}$ and $\overline{\text{DATA}}$ not shown

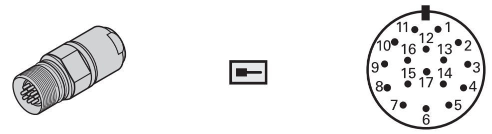


For more information:

For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure.

Pin layout

17-pin M23 coupling



	Supply voltage					Incremental signals				Serial data transmission				Other signals	
	7	**1**	**10**	**4**	**11**	**15**	**16**	**12**	**13**	**14**	**17**	**8**	**9**	**2**	**5**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Internal shield**1)	**A+**	**A–**	**B+**	**B–**	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**	**Dir. of rotation**	**Zeroing**
	Brown/ Green	Blue	White/ Green	White	/	Green/ Black	Yellow/ Black	Blue/ Black	Red/ Black	Gray	Pink	Violet	Yellow	Black	Green

Shield on housing; **U_P** = Power supply voltage
Sensor: With a 5 V supply voltage, the sense line is connected in the encoder with the corresponding power line.
1) Vacant with the ECN/EQN 10xx and ROC/ROQ 10xx

Testing and inspection devices, and diagnostics

HEIDENHAIN encoders provide all of the information needed for setup, monitoring, and diagnostics. The type of information available depends on whether the encoder is incremental or absolute and which interface is being used.

Incremental encoders have 1 V_{PP}, TTL, or HTL interfaces. TTL and HTL encoders monitor their signal amplitudes internally and generate a simple fault-detection signal. With 1 V_{PP} signals, an analysis of the output signals is possible only with external testing devices or through the use of computation resources in the downstream electronics (**analog diagnostic interface**).

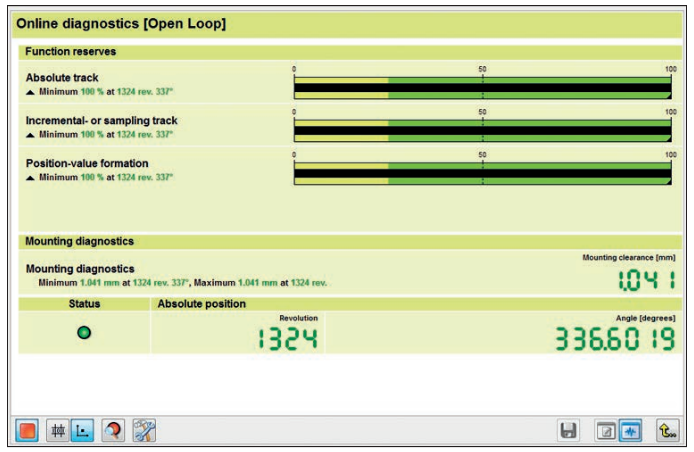
Absolute encoders employ serial data transmission. Depending on the interface, additional 1 V_{PP} incremental signals can be output. The signals are extensively monitored within the encoder. The monitoring results (particularly valuation numbers) can be transmitted to the downstream electronics along with the position values via the serial interface (**digital diagnostic interface**). The following information is available:

- Error message: position value is not reliable
- Warning: an internal functional limit of the encoder has been reached
- Valuation numbers:
  - Detailed information on the encoder's function reserve
  - Identical scaling for all HEIDENHAIN encoders
  - Cyclic reading is possible

This enables the downstream electronics to evaluate the current status of the encoder with little effort, even in Closed Loop mode.

For the analysis of these encoders, HEIDENHAIN offers the appropriate PWM inspection devices and PWT testing units. Based on how these devices are integrated, a distinction is made between two types of diagnostics:

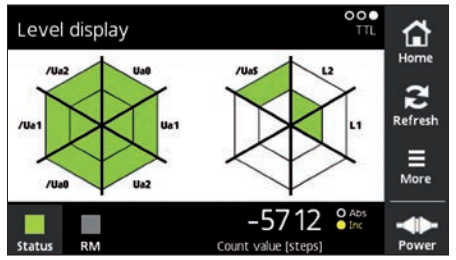
- Encoder diagnostics: the encoder is connected directly to the testing or inspection device, thereby enabling a detailed analysis of encoder functions.
- Monitoring mode: the PWM inspection device is inserted within the closed control loop (via suitable testing adapters as needed). This enables real-time diagnosis of the machine or equipment during operation. The available functions depend on the interface.



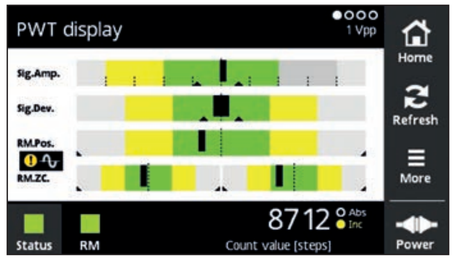
Diagnostics with the PWM 21 and ATS software

Initial setup with the PWM 21 and ATS software

PWT 101
The PWT 101 is a testing device for the functional testing and adjustment of incremental and absolute HEIDENHAIN encoders. Thanks to its compact and rugged design, the PWT 101 is ideal for portable use.



Level display



PWT display

	PWT 101
Encoder input only for HEIDENHAIN encoders	• EnDat • Fanuc Serial Interface • Mitsubishi high speed interface • Panasonic Serial Interface • Yaskawa Serial Interface • 1 V_{PP} • 11 μA_{PP} • TTL
Display	4.3-inch color flat-panel display (touchscreen)
Supply voltage	DC 24 V Power consumption: max. 15 W
Operating temperature	0 °C to 40 °C
Protection EN 60529	IP20
Dimensions	≈ 145 mm × 85 mm × 35 mm

PWM 21
The PWM 21 phase-angle measuring unit, in conjunction with the included ATS adjusting and testing software, serves as an adjusting and testing package for the diagnosis and adjustment of HEIDENHAIN encoders.

For more information, see the *PWM 21, ATS Software* Product Information document.

	PWM 21
Encoder input	• EnDat 2.1, EnDat 2.2, or EnDat 3 (absolute value with or without incremental signals) • DRIVE-CLiQ • Fanuc Serial Interface • Mitsubishi high speed interface • Yaskawa Serial Interface • Panasonic Serial Interface • SSI • 1 V_{PP}/TTL/11 μA_{SS} • HTL (via signal adapter)
Interface	USB 2.0
Supply voltage	AC 100 V to 240 V or DC 24 V
Dimensions	258 mm × 154 mm × 55 mm

	ATS
Languages	German or English (selectable)
Functions	• Position display • Connection dialog • Diagnostics • Mounting wizard for EBI/ECI/EQI, LIP 200, LIC 4000 and others • Additional functions (if supported by the encoder) • Memory contents
System requirements and recommendations	PC (dual-core processor > 2 GHz) RAM > 2 GB Operating systems: Windows 7, 8, and 10 (32-bit / 64-bit) 500 MB of free hard drive space

DRIVE-CLiQ is a registered trademark of Siemens AG

HEIDENHAIN

Mastering nanometer accuracy

HEIDENHAIN

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