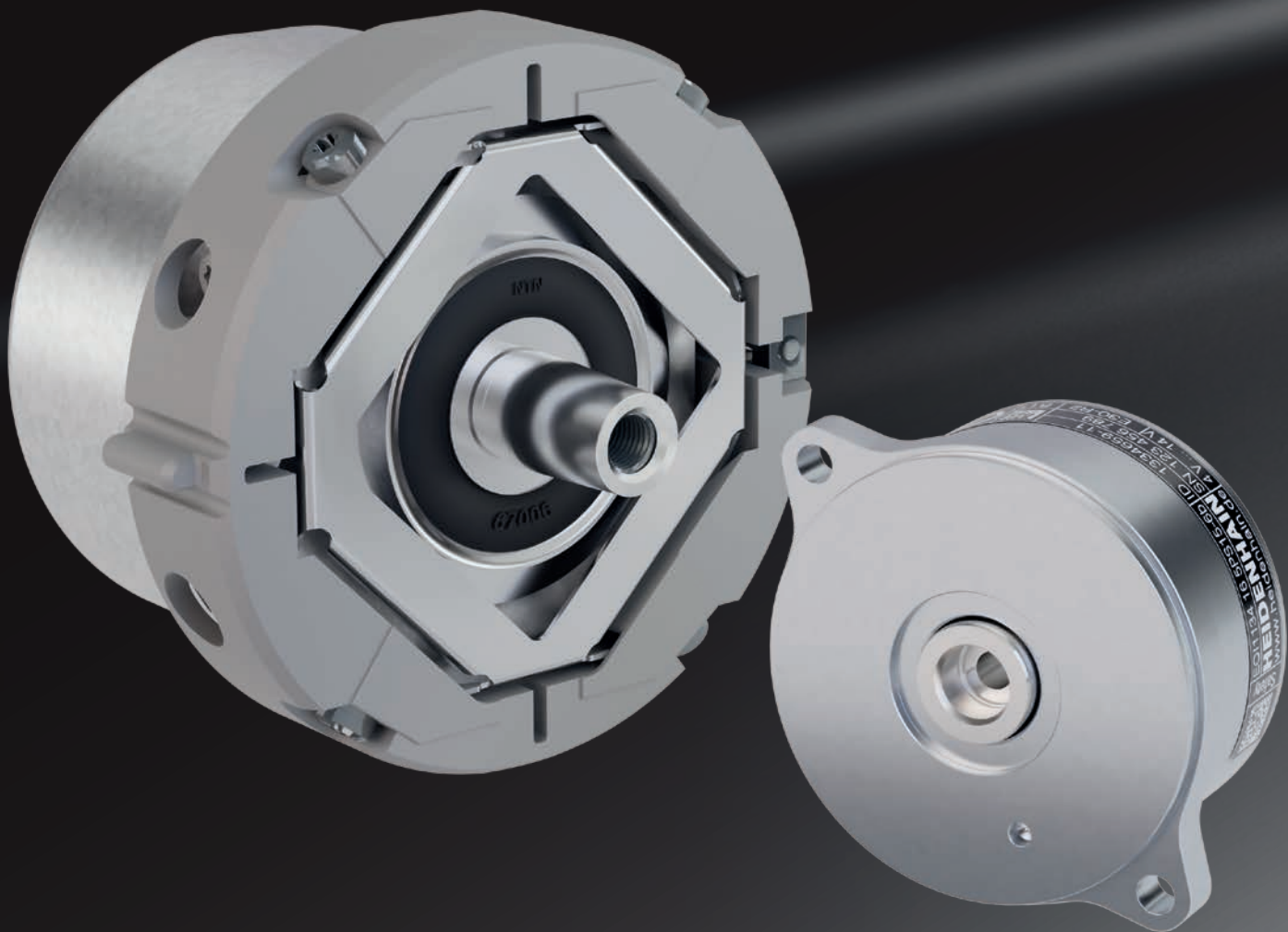




Encoders for Servo Drives

www.heidenhain.com/rotary-encoders

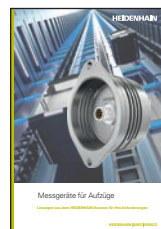
This brochure is not an exhaustive overview of HEIDENHAIN products but rather provides a selection of **encoders designed for use on electric motors**.

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



Further 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.

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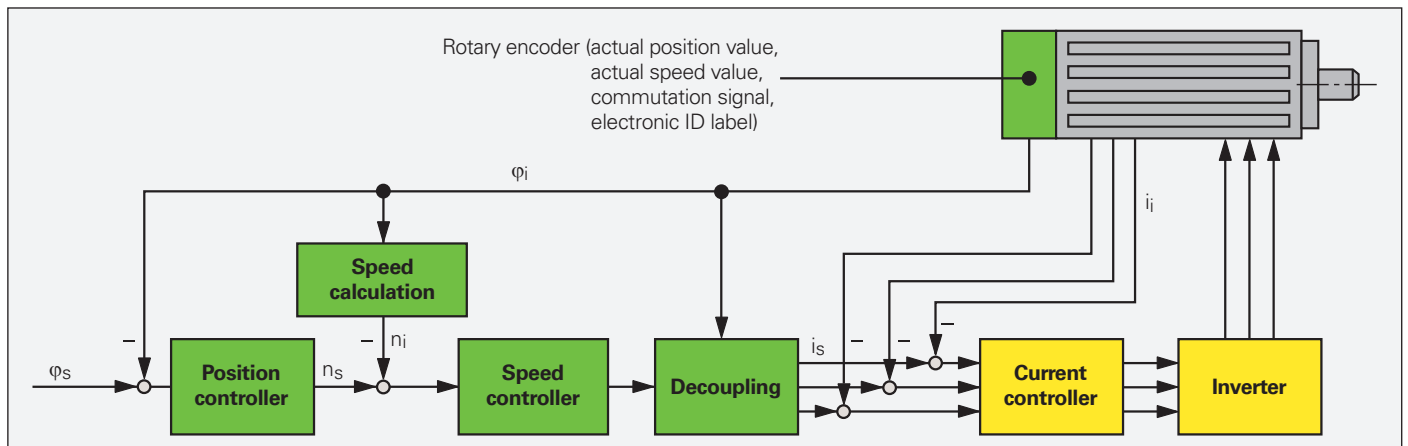
Encoders for servomotors

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

Digital position control and speed control



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

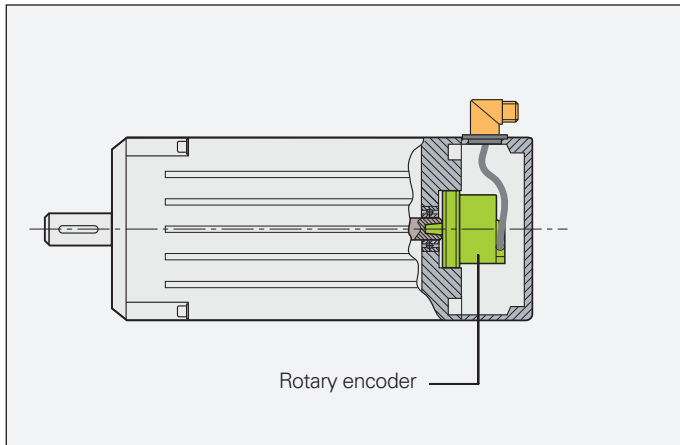
- Absolute and incremental rotary encoders with and without commutation tracks
- Absolute and incremental angle encoders
- Absolute and incremental linear encoders
- Absolute and incremental modular encoders



Rotary encoders

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.

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



Angle encoders



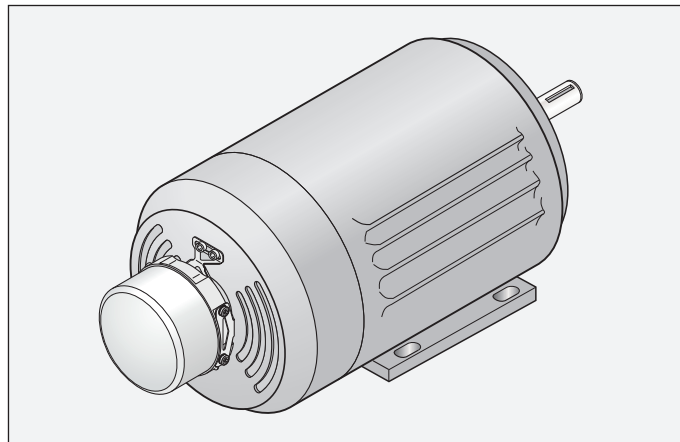
Linear encoders

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



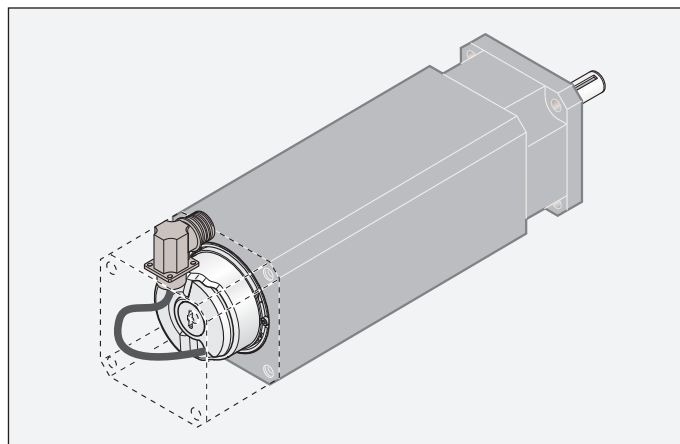
For the selection table, see page 8

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. However, 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 *Dplus* 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

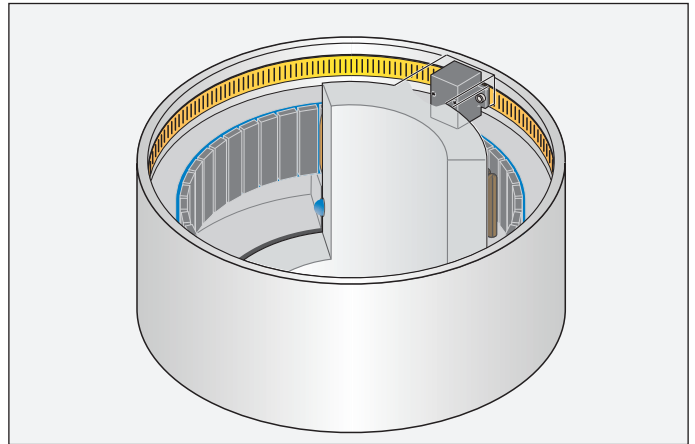


For the selection table, see page 18

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 42000 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:

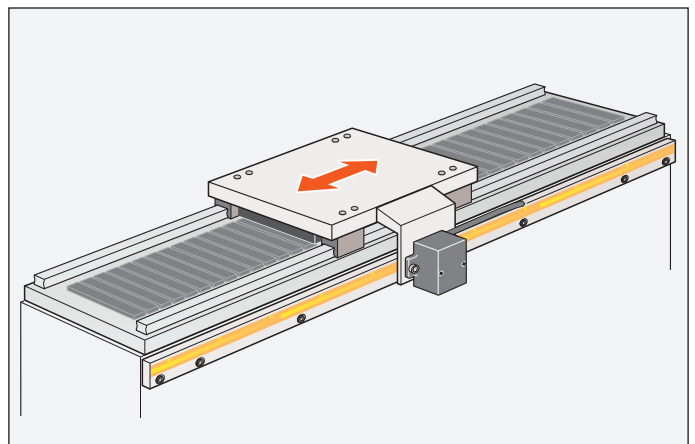
- Higher accuracy grades
- Higher traversing speeds
- Non-contact scanning (i.e., no friction between scanning head and scale)

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).

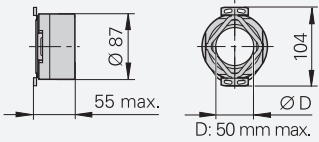
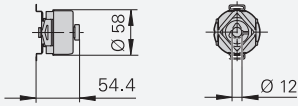
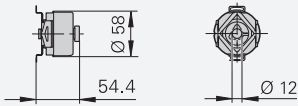
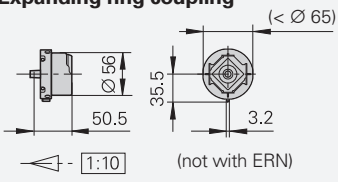
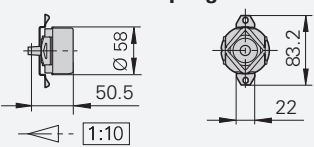


See overview of brochures on page 2

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
Rotary encoders with integral bearing and mounted stator coupling					
ECN/ERN 100		$\varnothing \leq 30 \text{ mm:}$ $\leq 6000 \text{ rpm}$ $\varnothing > 30 \text{ mm:}$ $\leq 4000 \text{ rpm}$	1000 Hz	100 °C	DC 3.6 V to 14 V
					DC 5 V $\pm 0.5 \text{ V}$
				85 °C	DC 10 V to 30 V
ECN/EQN/ERN 400	Stator coupling for plane surfaces 	$\leq 6000 \text{ rpm}$ With two shaft clampings (only for hollow through shaft): $\leq 12000 \text{ rpm}$	Stator coupling for plane surfaces: 1500 Hz	100 °C	DC 3.6 V to 14 V
					DC 4.75 V to 30 V
					DC 5 V $\pm 0.5 \text{ V}$
					DC 10 V to 30 V
				70 °C	
ECN/EQN/ERN 400	Stator coupling for plane surfaces 	$\leq 6000 \text{ rpm}$ With two shaft clampings (only for hollow through shaft): $\leq 12000 \text{ rpm}$	Stator coupling for plane surfaces: 1500 Hz	100 °C	DC 10 V to 30 V
					DC 4.75 V to 30 V
					DC 3.6 V to 14 V
					DC 10 V to 28.8 V
ECN/EQN/ERN 400	Expanding ring coupling  Plane-surface coupling 	$\leq 15000 \text{ rpm/}$ $\leq 12000 \text{ rpm}$	Expanding ring coupling: 1800 Hz Plane-surface coupling: 400 Hz	100 °C	DC 3.6 V to 14 V
		$\leq 15000 \text{ rpm}$			DC 5 V $\pm 0.5 \text{ V}$
					DC 5 V $\pm 0.25 \text{ V}$

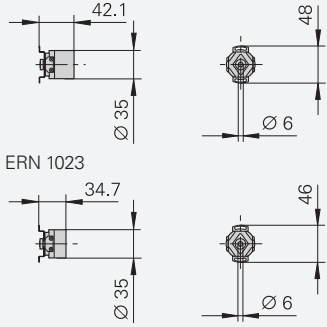
¹⁾ Also available with functional safety

DRIVE-CLiQ is a registered trademark of Siemens AG

	Signal periods per revolution	Positions per revolution	Distinguishable revolutions	Interface	Model	Further information
	2048	8192 (13 bits)	–	EnDat 2.2/01 with $\sim 1 V_{pp}$	ECN 113	Brochure: Rotary Encoders
	–	33554432 (25 bits)		EnDat 2.2/22	ECN 125	
	1000 to 5000	–		$\square\square$ TTL/ $\sim 1 V_{pp}$	ERN 120/ERN 180	
				$\square\square$ HTL	ERN 130	
	512/2048	8192 (13 bits)	–/4096	EnDat 2.2/01 $\sim 1 V_{pp}$	ECN 413/EQN 425	
	–	33554432 (25 bits)		EnDat 2.2/22	ECN 425/EQN 437 ¹⁾	
	512	8192 (13 bits)		SSI	ECN 413/EQN 425	
	250 to 5000	–		$\square\square$ TTL	ERN 420	
				$\square\square$ HTL	ERN 430	
				$\square\square$ TTL	ERN 460	
	1000 to 5000			$\sim 1 V_{pp}$	ERN 480	
	256 to 2048	8192 (13 bits)	–/4096	EnDat H $\square\square$ HTL SSI 41H $\square\square$ HTL	EQN 425	Brochure: Rotary Encoders
	512 to 4096			EnDat T $\square\square$ TTL SSI 41T $\square\square$ TTL		
	–	α i: 33554432 (25 bits)	4096	Fanuc	ECN 425 F/EQN 437 F	
		16777216 (24 bits)		DRIVE-CLiQ	ECN 424 S/EQN 436 S ¹⁾	
	2048	8192 (13 bits)	–/4096	EnDat 2.2/01 with $\sim 1 V_{pp}$	ECN 413/EQN 425	Page 60
	–	33554432 (25 bits)		EnDat 2.2/22	ECN 425 ¹⁾ /EQN 437 ¹⁾	
	1024 to 5000	–		$\square\square$ TTL	ERN 421	Product Information document
	2048	Z1 track for sine commutation		$\sim 1 V_{pp}$	ERN 487	

Rotary encoders for mounting on motors

Protection rating: up to IP64 (EN 60529)

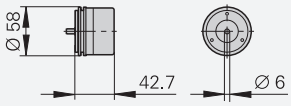
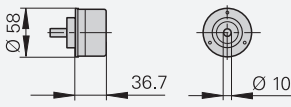
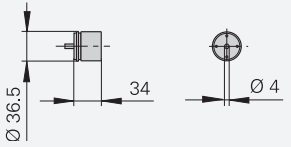
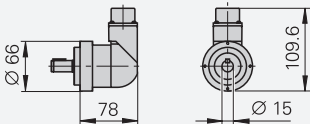
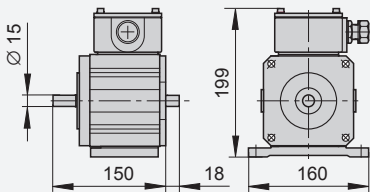
Series	Main dimensions	Mechanically permissible shaft speed	Natural frequency f_N (typical) of the coupling	Maximum operating temperature	Supply voltage
Rotary encoders with integral bearing and mounted stator coupling					
ECN/EQN/ERN 1000		≤ 12000 rpm	1500 Hz	100 °C	DC 3.6 V to 14 V
				95 °C	DC 5 V ± 0.5 V
				70 °C	DC 10 V to 30 V DC 5 V ± 0.25 V
		≤ 6000 rpm	1600 Hz	90 °C	DC 5 V ± 0.5 V

¹⁾ After internal 5-fold or 10-fold interpolation

	Signal periods per revolution	Positions per revolution	Distinguishable revolutions	Interface	Model	Further information
	512	8192 (13 bits)	–/4096	EnDat 2.2/01 with $\sim$ 1 V _{pp}	ECN 1013/EQN 1025	Brochure: Rotary Encoders
	–	8388608 (23 bits)		EnDat 2.2/22	ECN 1023/EQN 1035	
	100 to 3600	–		 1 V _{pp}	ERN 1020/ERN 1080	
				 HTLs	ERN 1030	
	5000 to 36000 ¹⁾			 TTL	ERN 1070	
	500 to 8192	3 block commutation signals		 TTL	ERN 1023	Page 52

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
Rotary encoders with integral bearing for separate shaft coupling					
ROC/ROQ/ROD 400	Synchro flange  Clamping flange 	$\leq 12\,000$ rpm	–	100 °C	DC 3.6 V to 14 V
					DC 4.75 V to 30 V
					DC 10 V to 30 V
					DC 4.75 V to 30 V
					DC 3.6 V to 14 V
					DC 10 V to 28.8 V
					DC 5 V ± 0.5 V
					DC 10 V to 30 V
				70 °C	
				100 °C	DC 5 V ± 0.5 V
ROC/ROQ/ROD 1000		$\leq 12\,000$ rpm	–	100 °C	DC 3.6 V to 14 V
					DC 5 V ± 0.5 V
				70 °C	DC 10 V to 30 V
					DC 5 V ± 0.25 V
ROD 600		$\leq 12\,000$ rpm	–	80 °C	DC 5 V ± 0.5 V
ROD 1900		$\leq 4\,000$ rpm	–	70 °C	DC 10 V to 30 V

¹⁾ Also available with functional safety

²⁾ After integrated 5-fold or 10-fold interpolation

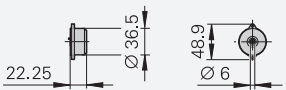
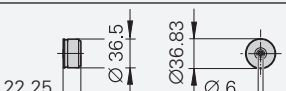
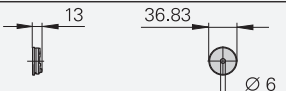
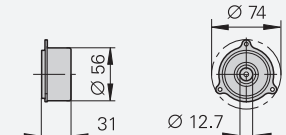
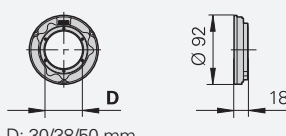
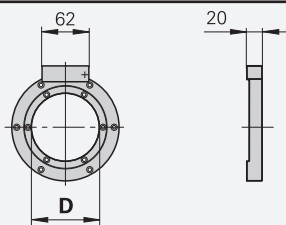
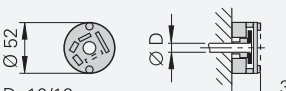
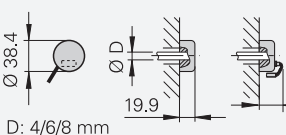
³⁾ Only clamping flange

DRIVE-CLiQ is a registered trademark of Siemens AG

	Signal periods per revolution	Positions per revolution	Distinguishable revolutions	Interface	Model	Further information
	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⁾	
	512	8192 (13 bits)	–	SSI	ROC 413/ROQ 425	
	256 to 2048	8192 (13 bits)	–/4096	EnDat H $\square$ HTL SSI 41H $\square$ HTL	ROQ 425 ³⁾	
	512 to 4096		–	EnDat T $\square$ TTL SSI 41T $\square$ TTL		
	–	α i: 33554432 (25 bits)	4096	Fanuc	ROC 425 F/ROQ 437 F	
		16777216 (24 bits)		DRIVE-CLiQ	ROC 424 S/EQN 436 S ¹⁾	
	50 to 5000	–	–	$\square$ TTL	ROD 426/ROD 420	
	50 to 5000			$\square$ HTL	ROD 436/ROD 430	
	50 to 5000			$\square$ TTL	ROD 466	
	1000 to 5000			$\sim 1 V_{pp}$	ROD 486/ROD 480	
	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	
	100 to 3600	–		$\square$ TTL	ROD 1020	
				$\sim 1 V_{pp}$	ROD 1080	
				$\square$ HTLs	ROD 1030	
	5000 to 36000 ²⁾			$\square$ TTL	ROD 1070	
	512 to 5000			$\square$ TTL	ROD 620	
				$\square$ HTL	ROD 630	
	600 to 2400			–	$\square$ HTL/HTLs	

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
Rotary encoders without integral bearing					
ECI/EQI 1100		$\leq 15000 \text{ rpm}$ $\leq 12000 \text{ rpm}$	–	110 °C	DC 3.6 V to 14 V
					DC 4 V to 14 V
					DC 3.6 V to 14 V
ECI/EBI 1100				115 °C	
ECI/EBI/EQI 1300		$\leq 15000 \text{ rpm}$ $\leq 12000 \text{ rpm}$	–	115 °C	DC 3.6 V to 14 V
				100 °C	DC 4 V to 14 V
ECI/EBI 100	 D: 30/38/50 mm	$\leq 6000 \text{ rpm}$	–	115 °C	DC 3.6 V to 14 V
ECI/EBI 4000	 D: 90/180 mm	$\leq 6000 \text{ rpm}$	–	115 °C	DC 3.6 V to 14 V
				100 °C	DC 10 V to 28.8 V
ERO 1200	 D: 10/12 mm	$\leq 25000 \text{ rpm}$	–	100 °C	DC 5 V $\pm 0.5 \text{ V}$
ERO 1400	 D: 4/6/8 mm	$\leq 30000 \text{ rpm}$	–	70 °C	DC 5 V $\pm 0.5 \text{ V}$
					DC 5 V $\pm 0.25 \text{ V}$
					DC 5 V $\pm 0.5 \text{ V}$

¹⁾ Also available with functional safety

²⁾ After internal 5-, 10-, 20-, or 25-fold interpolation

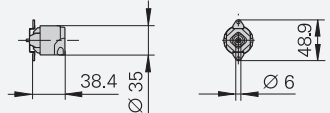
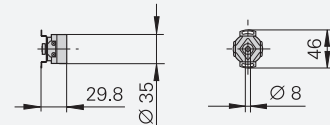
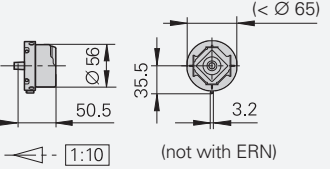
³⁾ Multiturn function via battery-buffered revolution counter

DRIVE-CLiQ is a registered trademark of Siemens AG

	Signal periods per revolution	Positions per revolution	Distinguishable revolutions	Interface	Model	Further information
	–	524 288 (19 bits)	–/4096	EnDat 2.2/22	ECI 1119 ¹⁾ /EQI 1131 ¹⁾	Page 64 and Product Information document
				EnDat 3/E30-R2		
				EnDat 2.2/22		Page 66
		262 144 (18 bits)	–/65 536 ³⁾		ECI 1118/EBI 1135	Page 72
	–	524 288 (19 bits)	–/65 536/4096 ³⁾	EnDat 2.2/22	ECI 1319 ¹⁾ /EQI 1331 ¹⁾ / EBI 1335 ¹⁾³⁾	Page 70
			–/4096	EnDat 3/E30-R2		Page 72
				DRIVE-CLiQ		Page 74
	32	524 288 (19 bits)	–	EnDat 2.1/01 with $\sim 1 V_{PP}$	ECI 119	Page 76
	–		–/65 536 ³⁾	EnDat 2.2/22	ECI 119/EBI 135	
	–	1 048 576 (20 bits)	–/65 536 ³⁾	EnDat 2.2/22	ECI 4010 ¹⁾ /EBI 4010 ³⁾	Page 78
			–	DRIVE-CLiQ	ECI 4090S ¹⁾	
	1024/2048	–		 TTL	ERO 1225	Page 82
				$\sim 1 V_{PP}$	ERO 1285	
	512/1000/1024	–		 TTL	ERO 1420	Page 84
	5000 to 37 500 ²⁾			 TTL	ERO 1470	
	512/1000/1024			$\sim 1 V_{PP}$	ERO 1480	

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
Rotary encoders with integral bearing and mounted stator coupling					
ECN/EQN/ERN 1100		$\leq 12\,000$ rpm	1000 Hz	115 °C	DC 3.6 V to 14 V
					DC 3.6 V to 14 V
		$\leq 6\,000$ rpm	1600 Hz	90 °C	DC 5 V ± 0.5 V
ECN/EQN/ERN 1300		$\leq 15\,000$ rpm/ $\leq 12\,000$ rpm	1800 Hz	115 °C	DC 3.6 V to 14 V
					DC 4 V to 14 V
				100 °C	DC 10 V to 28.8 V
		$\leq 15\,000$ rpm		120 °C ERN 1381/4096: 80 °C	DC 5 V ± 0.5 V
					DC 5 V ± 0.25 V

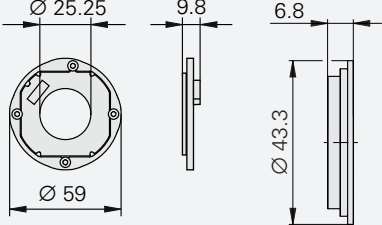
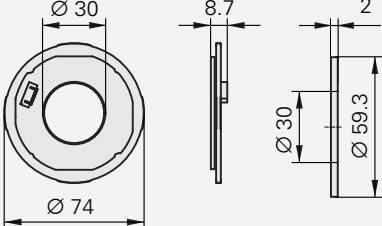
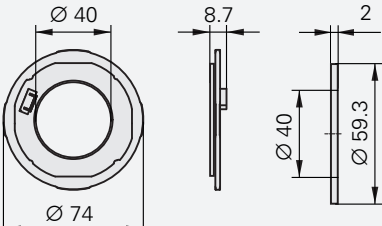
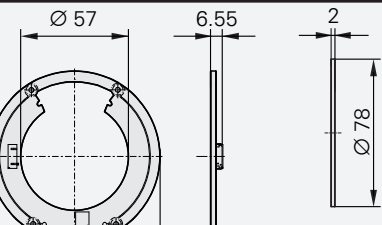
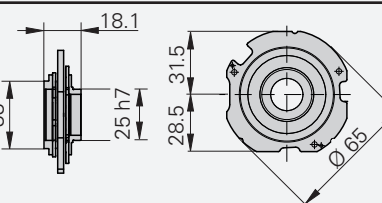
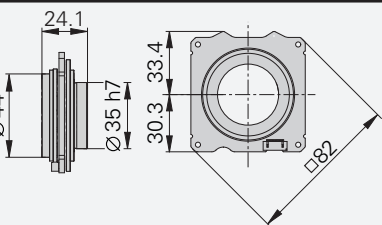
¹⁾ Also available with functional safety

DRIVE-CLiQ is a registered trademark of Siemens AG

	Signal periods per revolution	Positions per revolution	Distinguishable revolutions	Interface	Model	Further information
	512	8192 (13 bits)	–/4096	EnDat 2.2/01 with $\sim 1 V_{PP}$	ECN 1113/EQN 1125	Page 50
	–	8388608 (23 bits)		EnDat 2.2/22	ECN 1123¹⁾/EQN 1135¹⁾	
	500 to 8192	3 block commutation signals		$\square$ TTL	ERN 1123	Page 54
	512/2048	8192 (13 bits)	–/4096	EnDat 2.2/01 with $\sim 1 V_{PP}$	ECN 1313/EQN 1325	Page 56
	–	33554432 (25 bits)		EnDat 2.2/22	ECN 1325¹⁾/EQN 1337¹⁾	
				EnDat 3/E30-R2		
	–	16777216 (24 bits)		DRIVE-CLiQ	ECN 1324S/EQN 1336S	Page 58
	1024/2048/4096	–		$\square$ TTL	ERN 1321	Page 62
		3 block commutation signals			ERN 1326	
	512/2048/4096	–		$\sim 1 V_{PP}$	ERN 1381	
	2048	Z1 track for sine commutation			ERN 1387	

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
KCI/KBI 1300 Hollow shaft diameter: 25 mm		≤ 10000 rpm	–	115 °C	DC 3.6 V to 14 V
KCI/KBI 100 Hollow shaft diameter: 30 mm		≤ 10000 rpm			
KCI/KBI 100 Hollow shaft diameter: 40 mm		≤ 10000 rpm			
KCI/KBI 100 Hollow shaft diameter: 55 mm		≤ 10000 rpm			
		≤ 6000 rpm			
KCI/KBI 100 Dplus AE 04		Motor side: ≤ 15000 rpm Output side: ≤ 6000 rpm			
KCI/KBI 100 Dplus AE 07		Motor side: ≤ 15000 rpm Output side: ≤ 6000 rpm			

All variants are available with functional safety

¹⁾ Multiturn function via battery-buffered revolution counter

	Signal periods per revolution	Positions per revolution	Distinguishable revolutions ¹⁾	Interface	Model	Further information
	–	524 288 (19 bits)	–	EnDat 2.2	KCI 1319	Product Information documents
			65 536 (16 bits)		KBI 1335	
		1 048 576 (20 bits)	–		KCI 120	
			65 536 (16 bits)		KBI 136	
		1 048 576 (20 bits)	–		KCI 120	
			65 536 (16 bits)		KBI 136	
		1 048 576 (20 bits)	–		KCI 120	
			65 536 (16 bits)		KBI 136	
		Motor side: 524 288 (19 bits) Output side: 1 048 576 (20 bits)	–		KCI 120 <i>Dplus</i>	
			65 536 (16 bits)		KBI 136 <i>Dplus</i>	
		Motor side: 524 288 (19 bits) Output side: 1 048 576 (20 bits)	–		KCI 120 <i>Dplus</i>	

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).

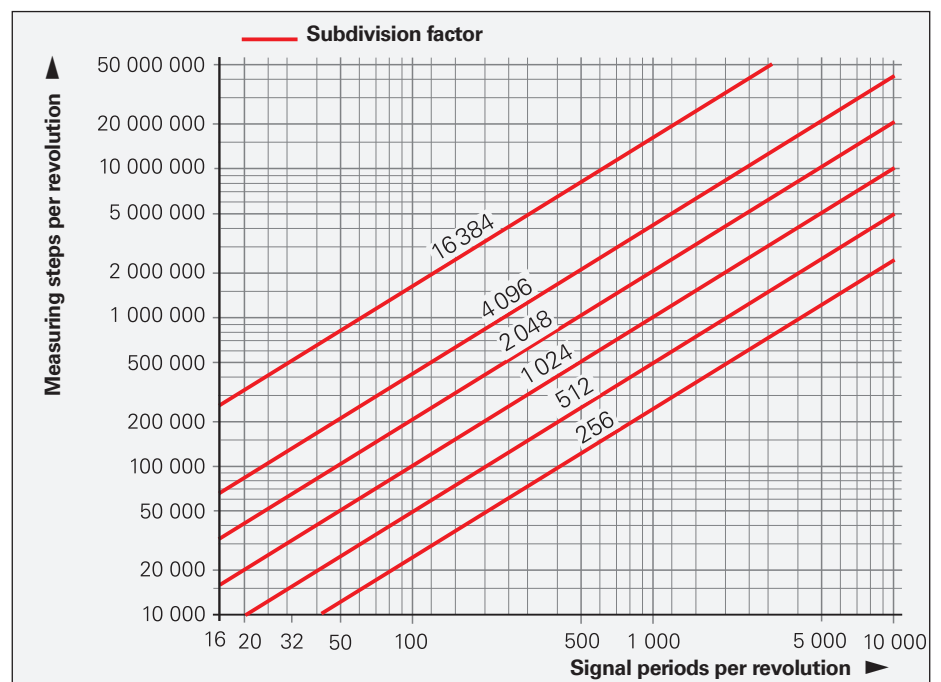
HEIDENHAIN encoders for motors with digital position and speed control are therefore equipped with the **purely serial EnDat22/EnDat 3 interface**, or they output additional **sinusoidal incremental signals** at 1 V_{PP} signal levels (EnDat01).

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 ($\triangleq$ 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**.

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 $\pm 1\%$ 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.

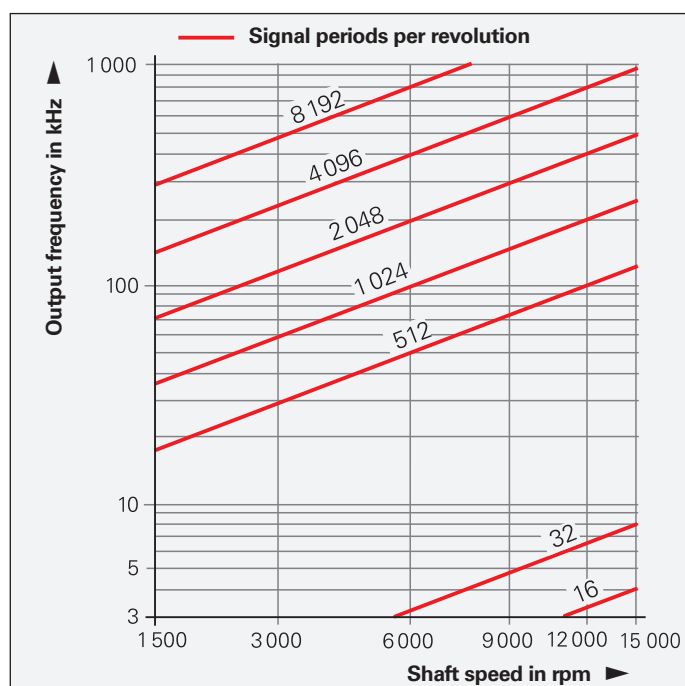
The use of functionally safe encoders without closed metal housings and/or with cable assemblies that do not comply with the electrical connection directives (see *General electrical information*) always requires the bit error rate to be measured in a type test under application conditions.

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

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



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.

HMC 6

Encoder connections
(communication element)

Brake connections

Motor connections

HMC 2

Motor
connections

Brake connections

Encoder connections

Benefits

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

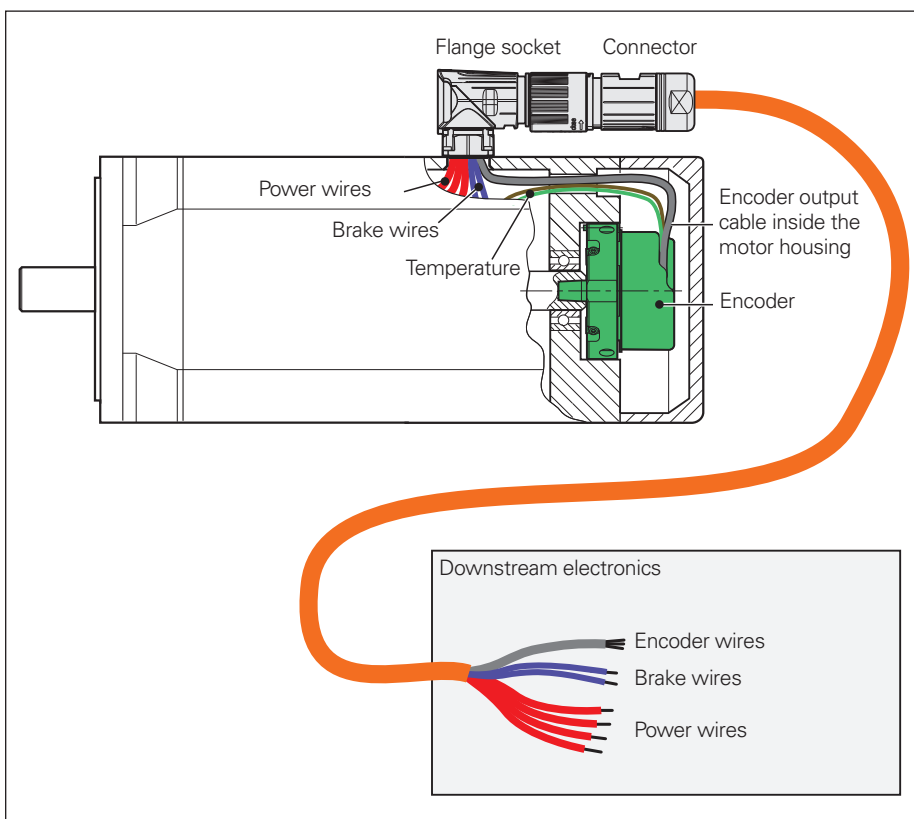
The crimp contacts for the power and brake wires are assembled with the usual tools.

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.



Further 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. These 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 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).



Further 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).

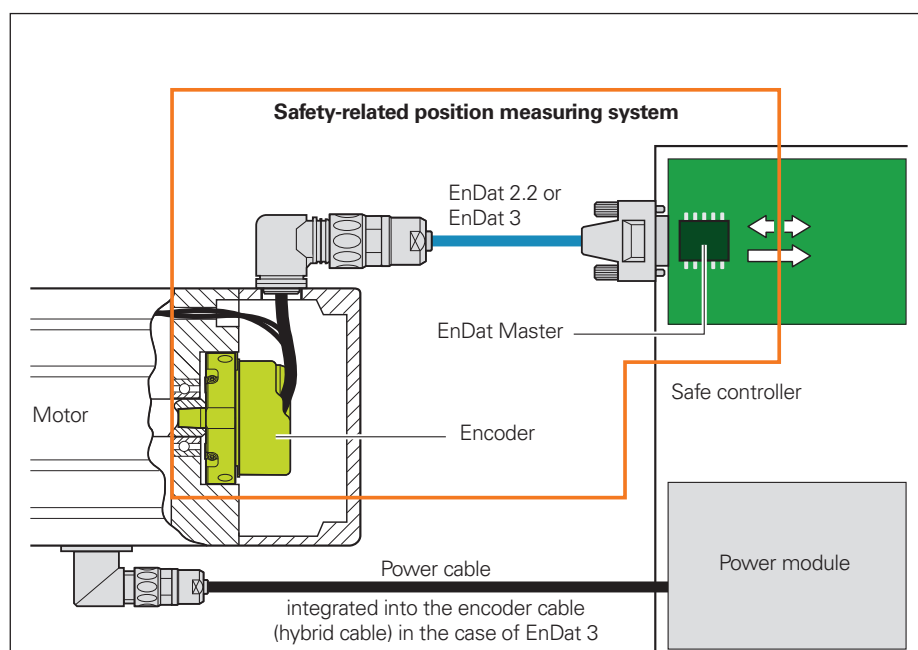
Service life as per ISO 13849

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. At a continuous use temperature of 75 °C or above, the service life of the grease is limited. Please contact HEIDENHAIN if you have any questions about the service life of the grease.

DRIVE-CLiQ is a registered trademark of Siemens AG



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 for 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.



Further information:

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

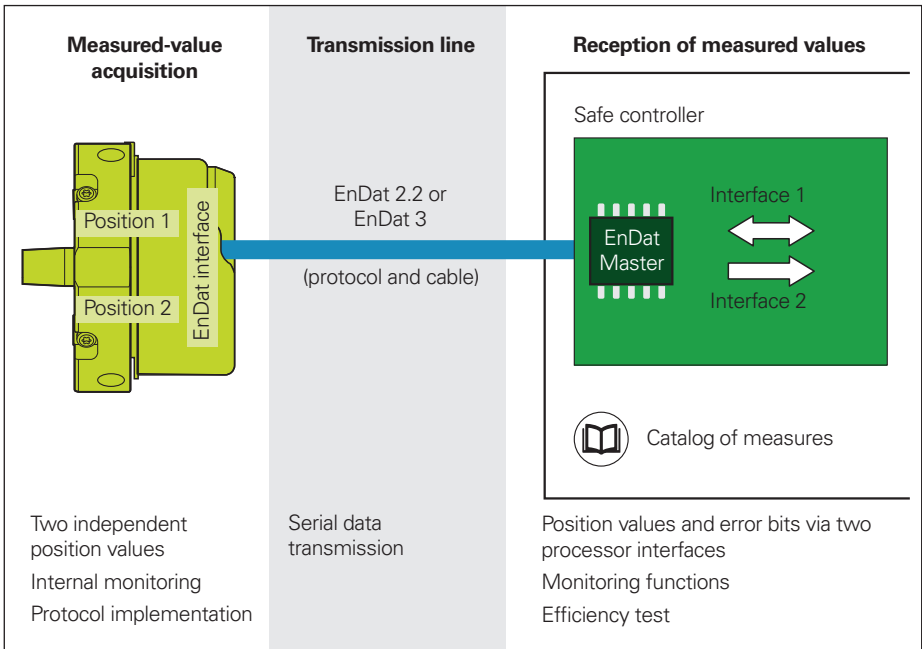
- Mounting instructions
- Operating Instructions
- Product Information documents
- Customer information about fault exclusion
- Technical Information document: *Safety-Related Position Measuring Systems* 596632

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

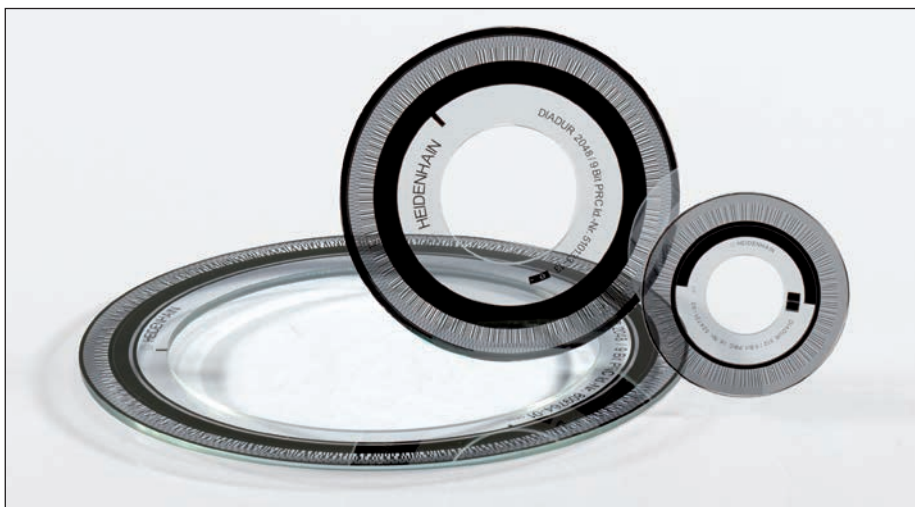
Magnetic encoders use a graduation carrier made of a magnetizable steel alloy. Within it, a graduation consisting of north and south poles is created with a grating period of 400 μm . Due to the short range of electromagnetic interactions and the resulting narrowness of the scanning gap, finer magnetic 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.



The circular scales of incremental rotary encoders

Scanning methods

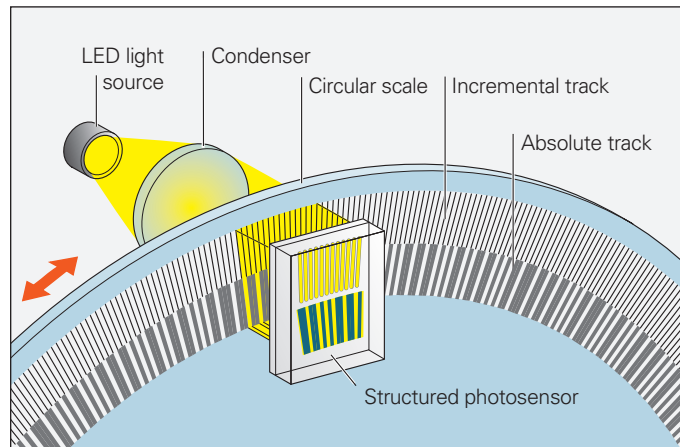
Photoelectric scanning

Most HEIDENHAIN encoders utilize the photoelectric scanning principle. Photoelectric scanning is non-contact 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.

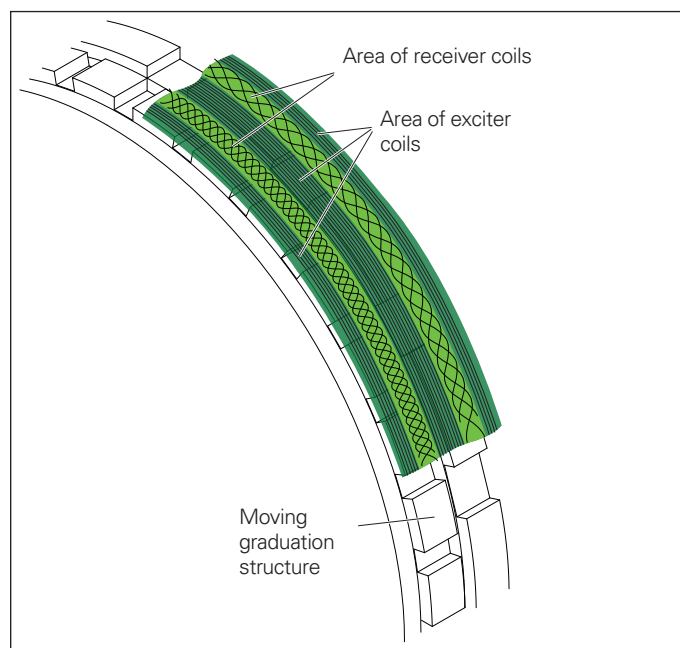


Photoelectric scanning in accordance with the imaging scanning principle

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

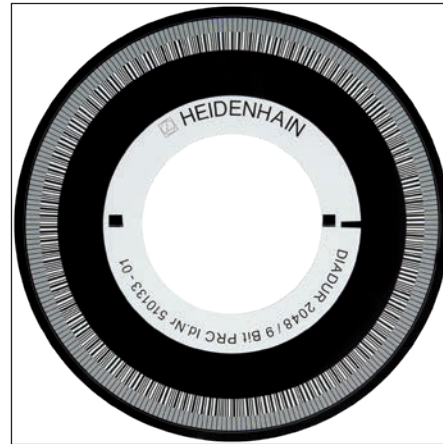
Commutation with permanent-magnet three-phase AC motors

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 $\pm 5^\circ$ 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

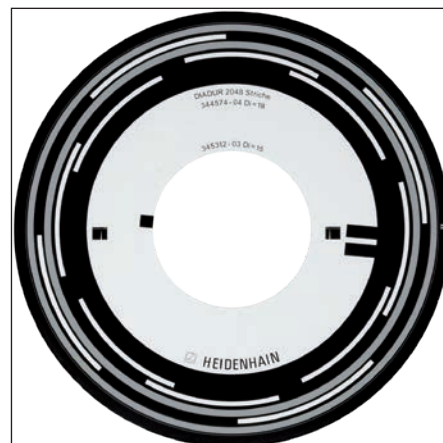
Like absolute rotary and angular encoders, the LIC and LC absolute linear encoder series provide the exact position of the motor's moving component immediately upon switch-on. Maximum holding load is thereby possible even at standstill.



Circular scale with absolute code track and incremental track



Circular scale with Z1 track



Circular scale with block commutation tracks



Further 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-related error
- 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 $\pm a$.

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.

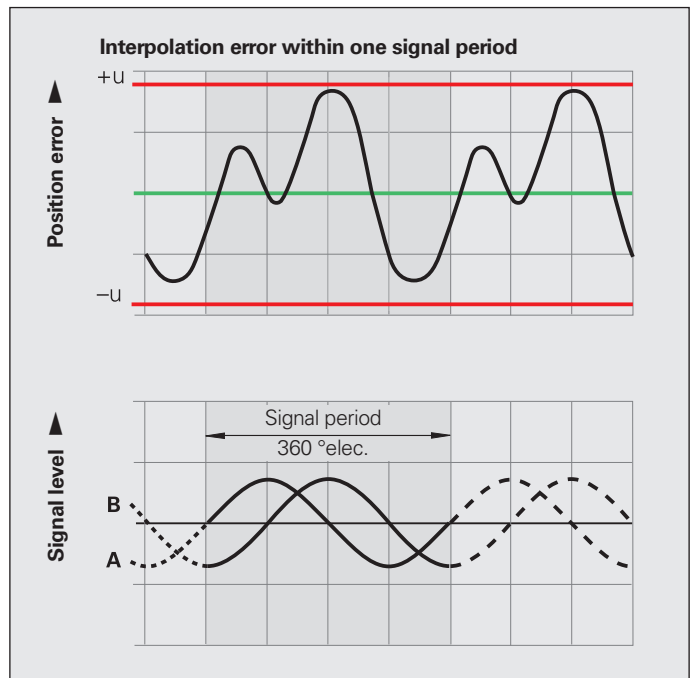
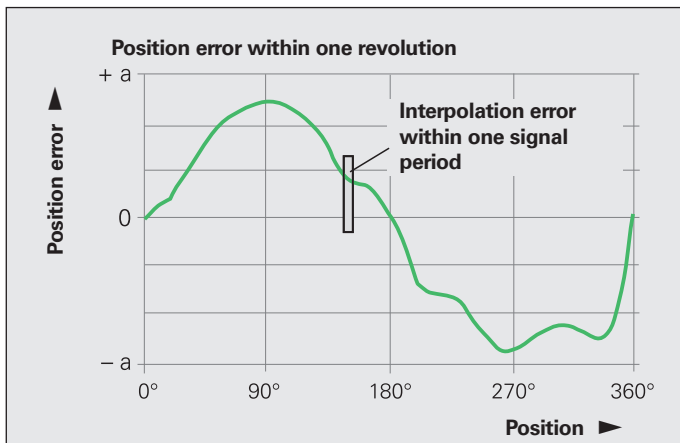
The interpolation error within one signal period $\pm u$ results from the scanning quality and, for encoders with integrated pulse-shaping or counter electronics, the quality of the signal-processing electronics. For encoders with sinusoidal output signals, however, the error from the signal processing 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 $\pm 1\%$ of the signal period or better than $\pm 3\%$ 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

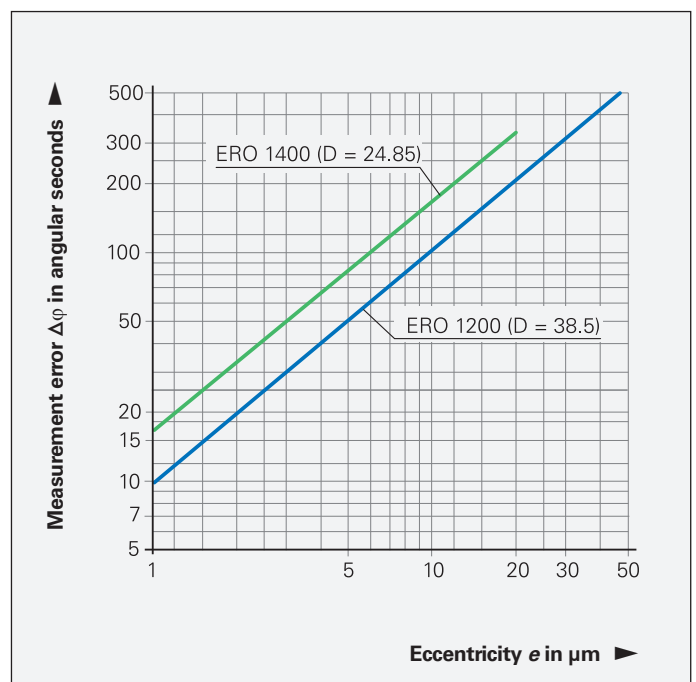
ERO: The extreme values of the directional errors relative to their mean are listed in the *Specifications* as the accuracy of the graduation. The accuracy of the graduation and the position error within one signal period constitute the system accuracy.

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 $\Delta\varphi$ 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 $\Delta\varphi$ (see figure below):

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

- $\Delta\varphi$ = 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	$\pm 16.5''$
ERO 1225 ERO 1285	D = 38.5 mm	$\pm 10.7''$

3. Error resulting from radial runout of the bearing

The stated relationship for the measuring error $\Delta\varphi$ 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	$\leq \pm 19.0''$	$\leq \pm 6.5''$
	1500	$\leq \pm 26.0''$	$\leq \pm 8.7''$
	1024	$\leq \pm 38.0''$	$\leq \pm 13.0''$
	1000	$\leq \pm 40.0''$	$\leq \pm 14.0''$
	512	$\leq \pm 76.0''$	$\leq \pm 25.0''$

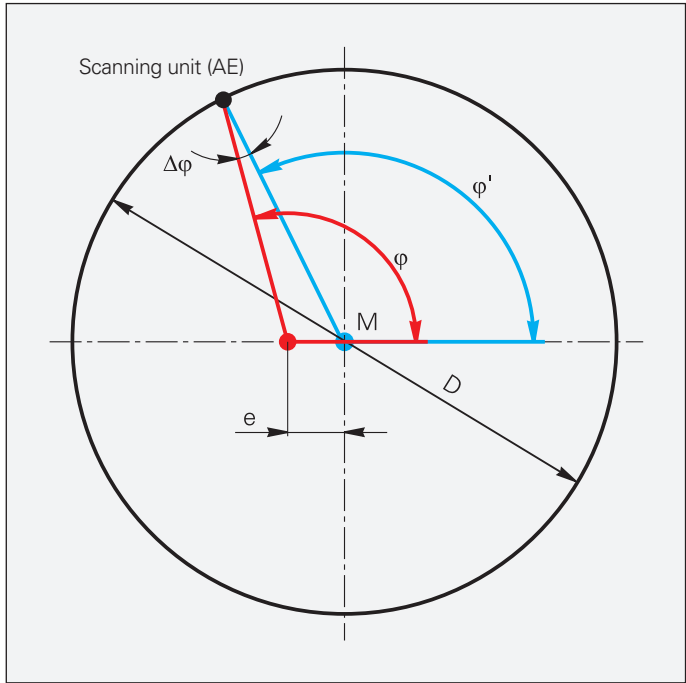
These values for the position error within one signal period are already included in the system accuracy. Greater error can arise if the mounting tolerances are exceeded.

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	$\pm 120''$	$\pm 280''$
ECI 1300(S) EQI 1300(S) with EnDat22, E30-R2 or DQ01	$\pm 65''$	$\pm 120''$
ECI 100 EBI 100	$\pm 90''$	$\pm 180''$
ECI 4000(S) EBI 4000 with 90-mm hollow shaft; EnDat22 or DQ01	$\pm 25''$	$\pm 140''$
ECI 4000(S) EBI 4000 with 180-mm hollow shaft; EnDat22 or DQ01	$\pm 40''$	$\pm 150''$



Dependency of the measuring error $\Delta\varphi$ on the mean graduation diameter D and the eccentricity e .

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

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

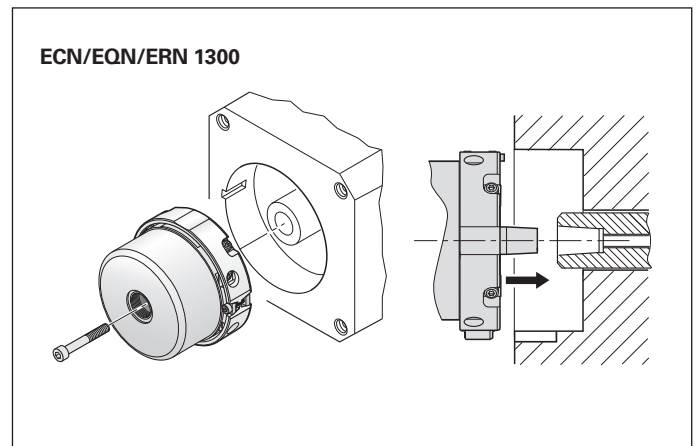
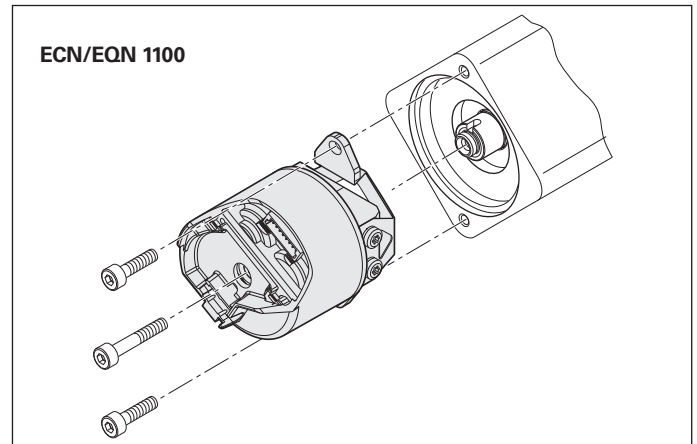
ERN/ECN/EQN 1300: inspection tool

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.



Mounting the ECN/EQN/ERN 1000 and ERN 1x23

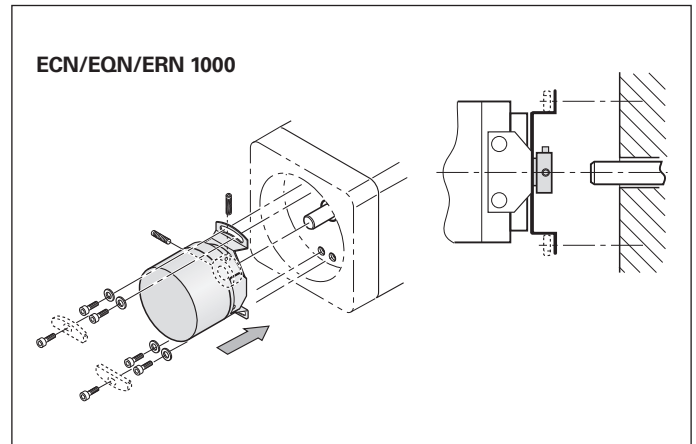
The hollow shaft of these rotary encoders is slid onto the measured shaft and clamped on the rotor side with two screws. These encoders are mounted on the stator side without a centering flange onto a plane surface via four clamping screws or via two clamping screws and washers.

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)



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 ($T_1; T_2; \alpha_1; \alpha_2$), 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)

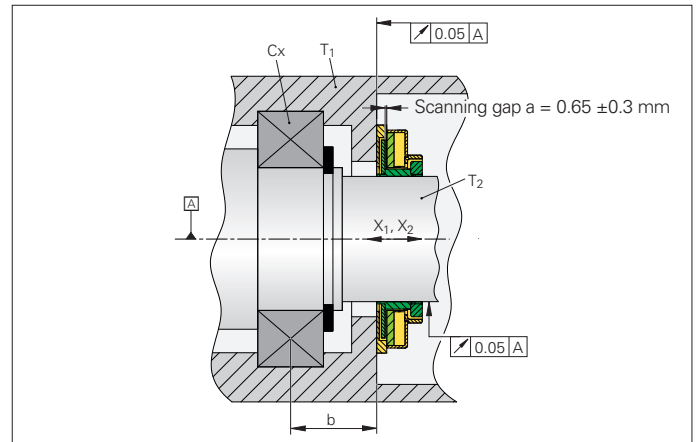
The **ECI/EBI 100** rotary encoders are pre-aligned on a plane surface and, with their hollow shaft locked, are slid onto the measured shaft. Fastening and shaft clamping are achieved with axial screws.

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.

Mounting accessories

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

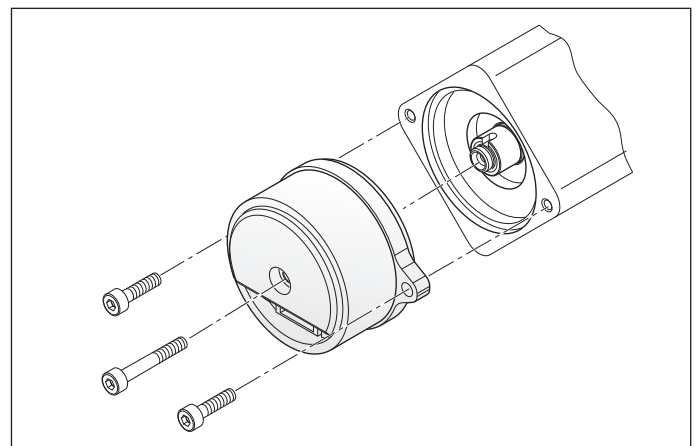
Schematic representation of **ECI/EBI 100**



Mounting the **ECI 119**



Mounting the **ECI/EQI 1100**



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.

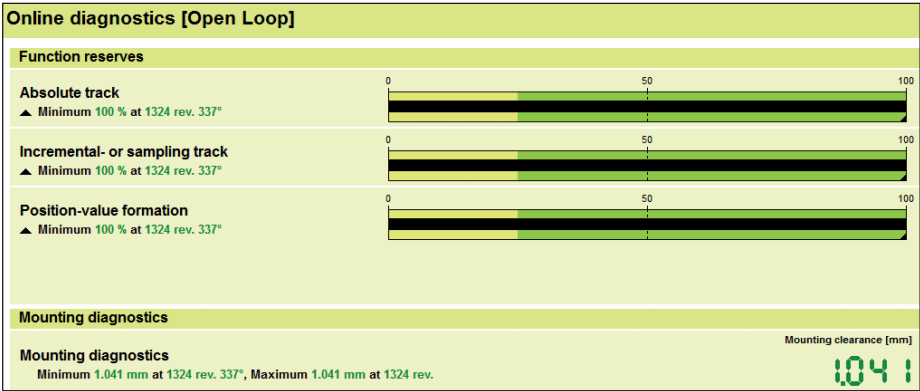
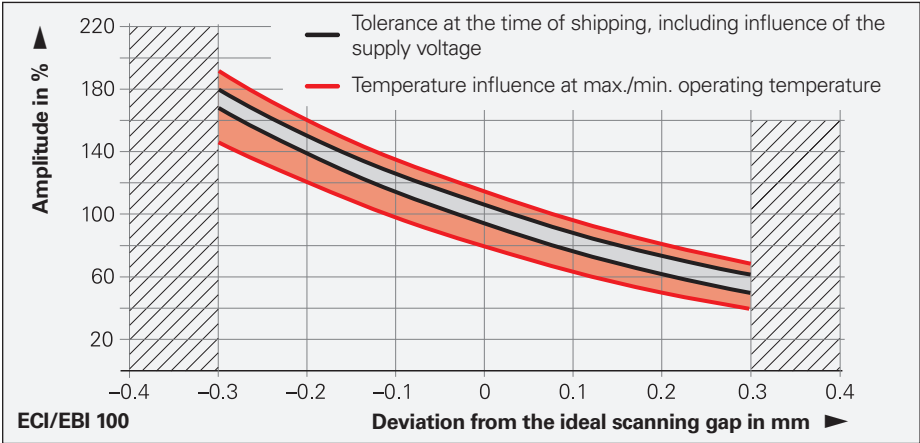
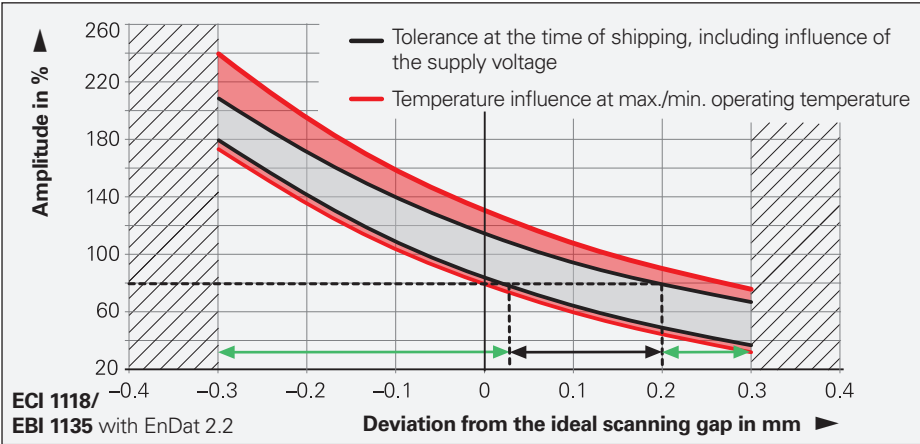
The maximum permissible error specified in the mating dimensions applies to both mounting and operation. Thus, the tolerances exploited during mounting are no longer available during operation.

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.



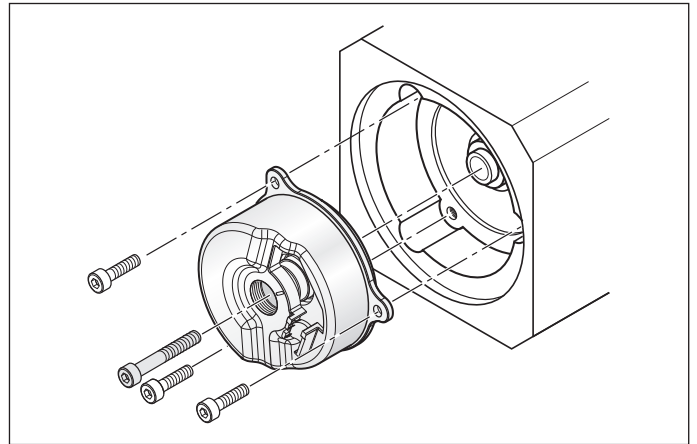
ID	Exl mount- ing wizard	Mounting interface
728563-xx	✓	
820725-xx	✓	
1164809-xx		✓
1164811-xx		✓
1164812-xx		✓
1164813-xx		✓

ID	Exl mount- ing wizard	Mounting interface
811811-xx	✓	
811815-xx	✓	
810661-xx		✓
810662-xx		✓
823405-xx	✓	
823406-xx	✓	
823407-xx	✓	

ID	Exl mount- ing wizard	Mounting interface
1259551-xx		✓
1259552-xx		✓
1286377-xx		✓
1286378-xx		✓
1334662-xx		✓
1334664-xx		✓
1391210-xx		✓
1391216-xx		✓

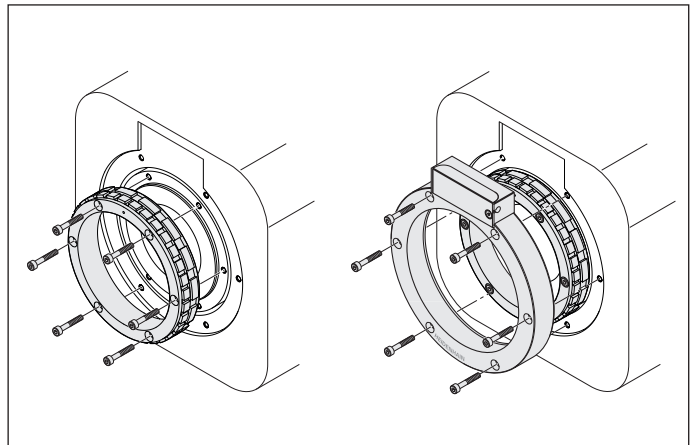
The **ECI/EBI/EQI 1300** inductive rotary encoders are mounted flush on their axis. Their blind hollow shaft is fastened with a central screw. The stator of these rotary encoders is clamped to a shoulder by three axial screws.

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 accessories for the ERO 1400

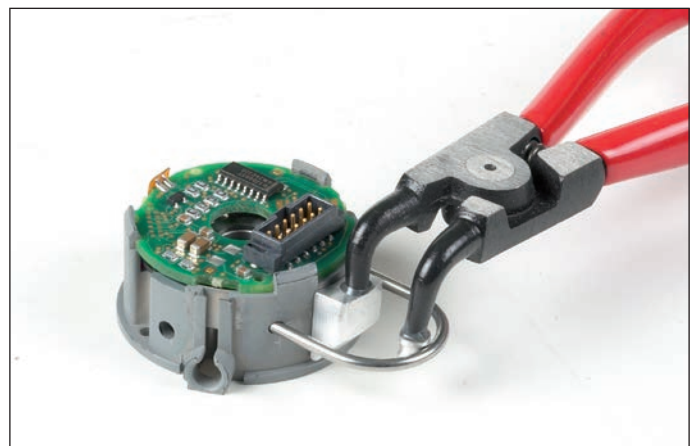
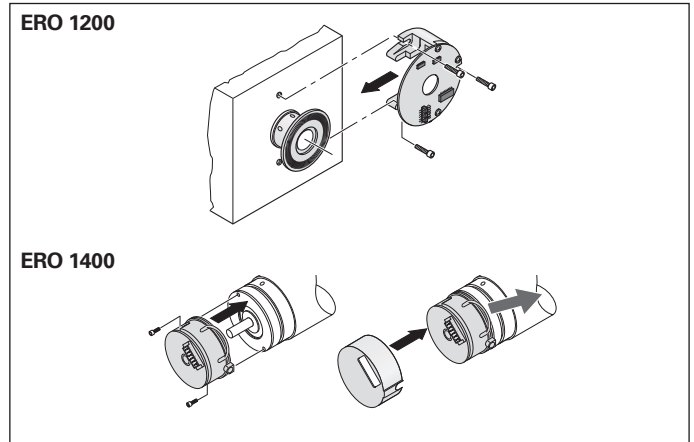
Mounting accessory

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 the **ERO**



Mounting accessory for the **ERO 1400**

Information on output cables

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:

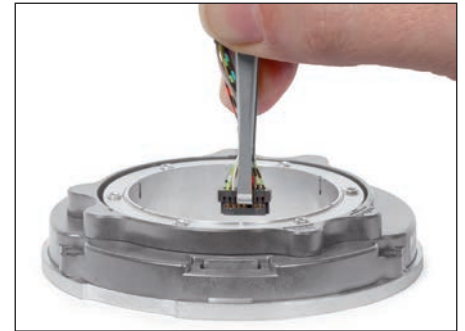
For M12, M23:	min. M_d	0.4 Nm
	max. M_d	0.5 Nm
Load-bearing thread length:	At least 4 mm	
Minimum tensile strength of the screws:	800 N/mm ²	

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.



Mounting aid for female connector

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).

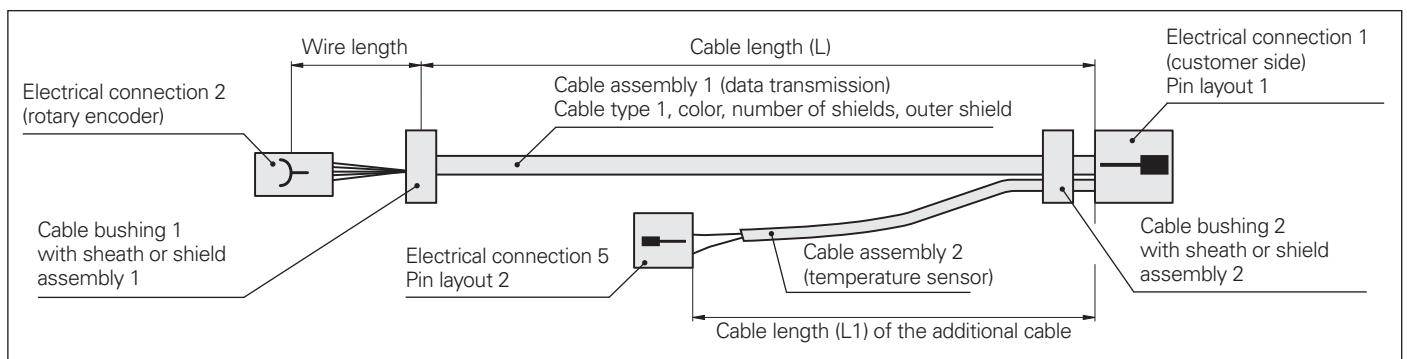
Electromagnetic compatibility

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.

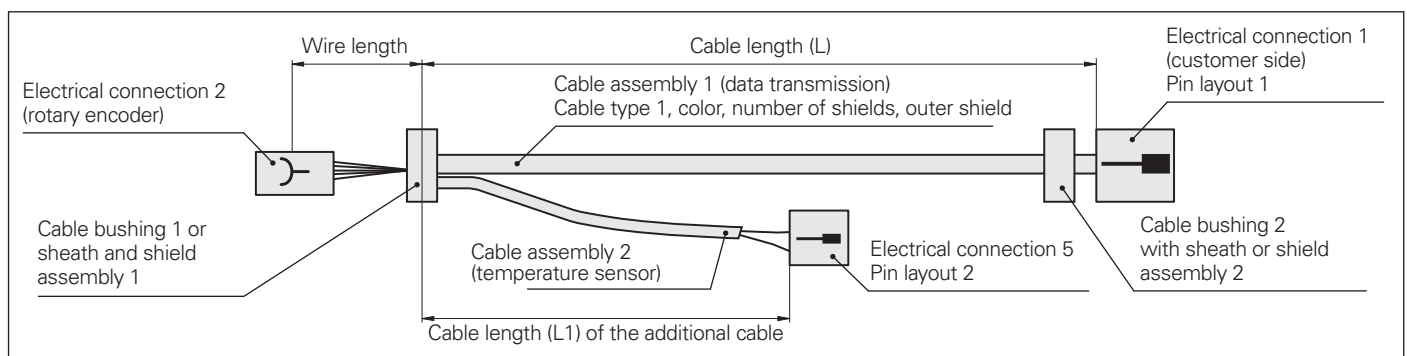
Crimp connector

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

General testing accessories for modular encoders and the PWM 21

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
15-pin D-sub connector (male) and
15-pin D-sub connector (female), max. 3 m

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 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

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
Completely assembled with
15-pin D-sub connector (male) and
15-pin D-sub connector (female), max. 3 m

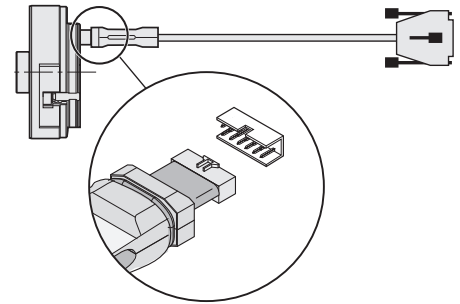
Adapter connector for ID 1118892-02
Quantity of three, for replacement
ID 528694-04

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

**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



Testing cable for modular rotary encoders



EnDat 3 adapter (SA 1210)

**For 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 11 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

adapter cable Ø 15.8 mm
M23 SpeedTEC hybrid connector (female),
four power wires, two signal wires, and
two communication wires
15-pin D-sub connector (male)
ID 1352456-xx

DRIVE-CLiQ is a registered trademark of
Siemens AG

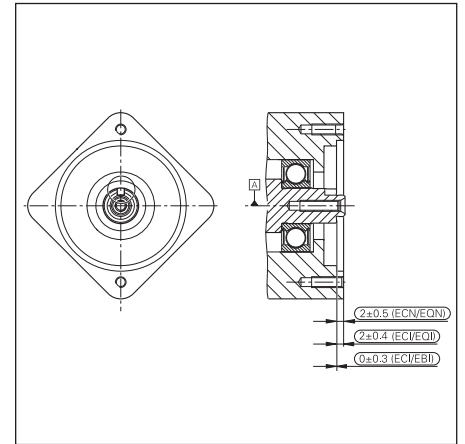
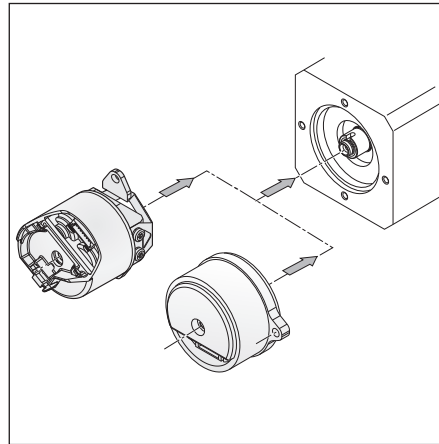
SpeedTEC is a registered trademark of TE
Connectivity Industrial GmbH

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.

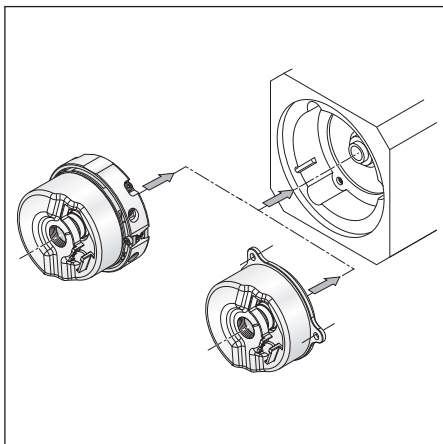
All dimensions, tolerances, and required mating dimensions are indicated in the dimension drawing of the respective series. Deviating values for rotary encoders with functional safety (FS) are provided in the corresponding Product Information documents.

All absolute rotary encoders of the ECN/EQN 1100FS, ECI/EQI 1100FS, 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 1100FS	Standard, with slot for FS devices
ECI/EQI 1100FS	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 1300FS, 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 1300FS	ECI/EBI/ EQI 1300FS	ECN/ EQN 400FS
ERN 1300		✓	✓	✓
ECN/EQN 1300FS			✓	✓
ECI/EQI 1300FS				
ECN/EQN 400FS		✓	✓	

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 1300FS	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 $\pm 6\%$
 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

Alignment of rotor positions between encoders and motors

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

using the line markers on the encoder (Fig. 10-10) and are mounted to the motor shaft. Fine adjustment is then performed with the PWT 101 testing device (see *Testing and inspection devices, and diagnostics*): the stator of the rotary encoder is turned until the PWT 101 displays a distance from the reference mark of nearly zero.

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



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 U.S. 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 60068-2-6¹⁾. 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 ECI/EBI 4000, see the *Specifications*; ERO 1200 and ERO 1400 are available upon request). 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

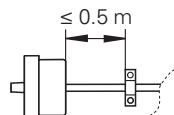
Magnetic fields greater than 30 mT can affect proper encoder functioning. Please contact HEIDENHAIN in Traunreut, Germany, as needed.

Acoustic noise

Running noise can occur during operation. This is particularly true of encoders with an integral bearing and of 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, Germany.

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 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.

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.

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.

Conditions for storage

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 mounting by the customer 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	$\geq 220 \text{ N/mm}^2$	$\geq 600 \text{ N/mm}^2$
Yield strength $R_{p0.2}$ or yield point R_e	Not relevant	$\geq 400 \text{ N/mm}^2$
Shear strength τ_a	$\geq 130 \text{ N/mm}^2$	$\geq 390 \text{ N/mm}^2$
Interface pressure p_G	$\geq 250 \text{ N/mm}^2$	$\geq 660 \text{ N/mm}^2$
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)	$\leq 25 \cdot 10^{-6} \text{ K}^{-1}$	$10 \cdot 10^{-6} \text{ K}^{-1}$ to $17 \cdot 10^{-6} \text{ K}^{-1}$
Surface roughness R_z	$\leq 16 \text{ }\mu\text{m}$	
Friction values	Mounting surfaces must be clean and free of grease. Screws and washers are assumed to be in the same condition as delivered.	
Tightening procedure	Use a signal-emitting torque wrench in accordance with DIN EN ISO 6789, with an accuracy of $\pm 6\%$	
Mounting temperature	15 °C to 35 °C	

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.

Supplementary information:
For rotary encoders of the ECN/EQN/ERN 4xx/13xx series with a hollow shaft, a maximum of 2 Nm is permissible when being operated in the temperature range of $-30 \text{ }^\circ\text{C}$ to $-40 \text{ }^\circ\text{C}$.

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 $\leq 30 \text{ }^\circ\text{C}$ and $\leq 65\%$ relative humidity). Their expiration date is printed on the package.

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.

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, the longer the curing process will take. Curing temperatures below $5 \text{ }^\circ\text{C}$ are not permissible.

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 an encoder in its packaging, the applicable **storage temperature range** is -30 °C to 65 °C. The **operating temperature range** specifies the temperature of the rotary encoder that is permissible during operation under actual installation conditions. 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.

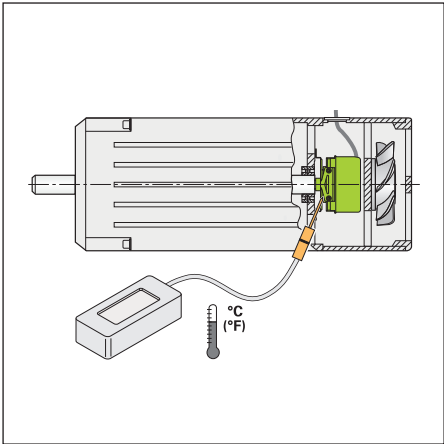
This table shows the approximate self-heating values to be expected for the rotary encoders. In the worst case, the amount of self-heating may be affected by multiple operating parameters, such as a 30 V supply voltage and maximum shaft speed. Thus, if an encoder is being operated close to its maximum 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	≈ +40 K With IP64 rating: ≈ +50 K
ROD 600	≈ +75 K
ROD 1900	≈ +40 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.



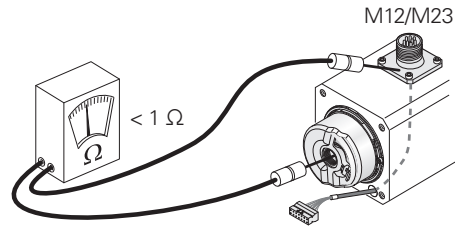
Measuring of the actual operating temperature at the defined measuring point of the rotary encoder (see *Specifications*)

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: $< 1 \text{ ohm}$



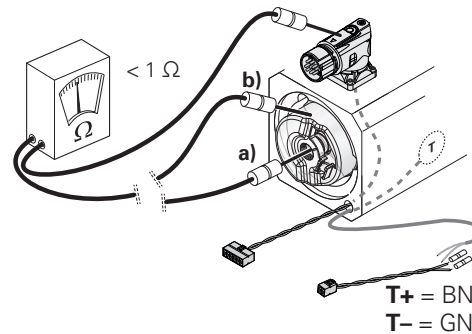
Further information:

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)**.

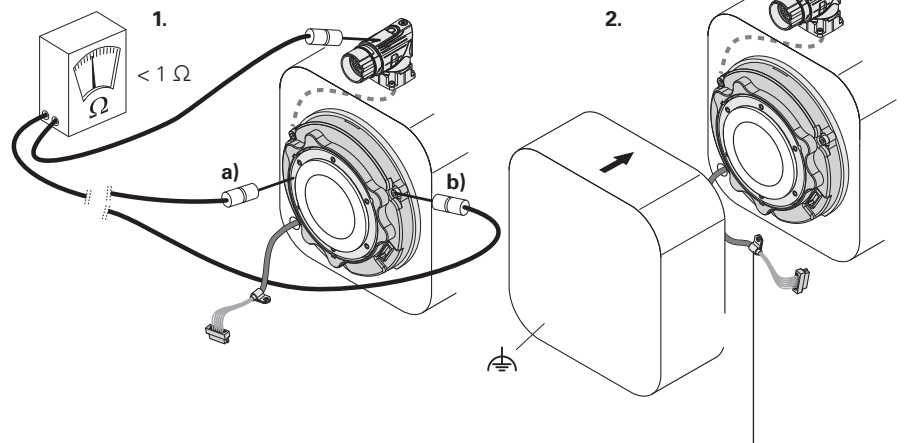
Nominal value: $< 1 \text{ ohm}$



Exposed encoders (Exl 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: $< 1 \text{ ohm}$

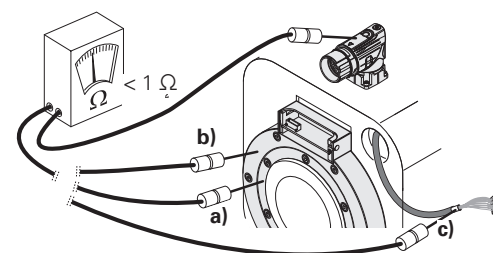


Clamp must be screwed to the motor housing so as to be conductive.

Exposed encoders (Exl 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)**.

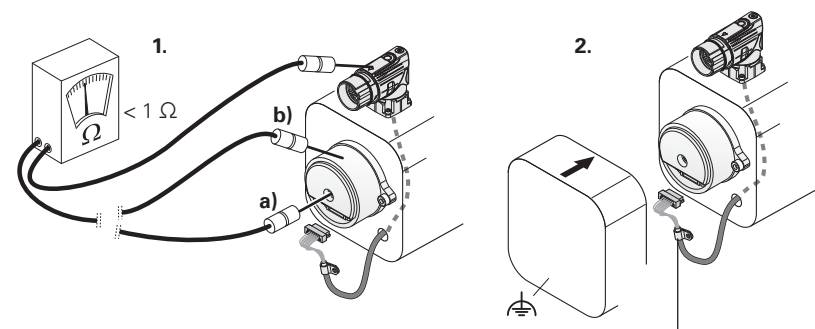
Nominal value: $< 1 \text{ ohm}$



Exposed encoders (Exl 1100, Exl 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: $< 1 \text{ ohm}$



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.

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.

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 1300S	DQ		
ECI/EBI 100	EnDat22	✓ (±4 K)	Possible
	EnDat01	–	–
ECI/EBI 4000	EnDat22	✓ (±1 K)	Possible
KCI/KBI 1100	EnDat22	✓ (±1 K)	Possible
KCI/KBI 1300	EnDat22	✓ (±1 K)	Possible
KCI/KBI 100	EnDat22	✓ (±1 K)	Possible
KCI/KBI 100 Dplus	EnDat22	✓ (±1 K)	–

¹⁾ In parentheses: accuracy at 125 °C

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

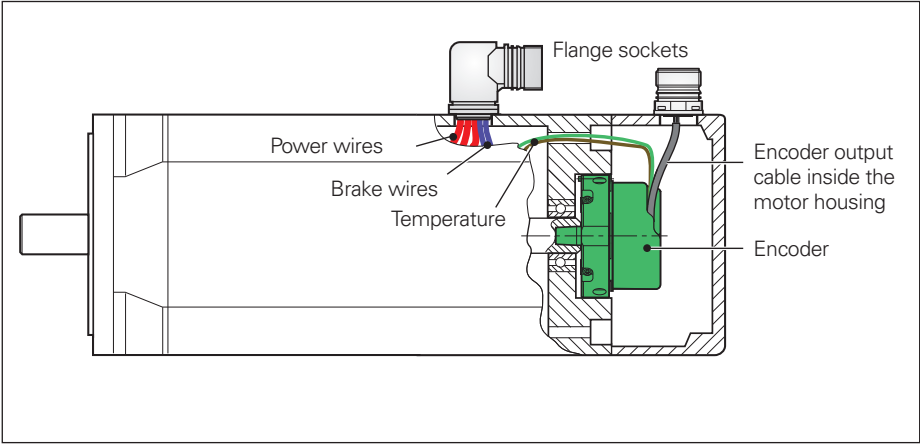


Further information:

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 $R_V = 2\text{ k}\Omega$
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.

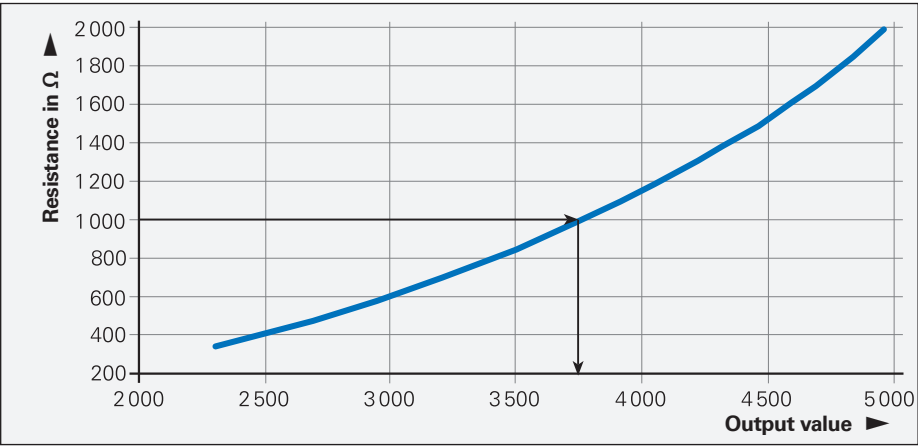


Figure 1: Relationship between the output value and resistance

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.

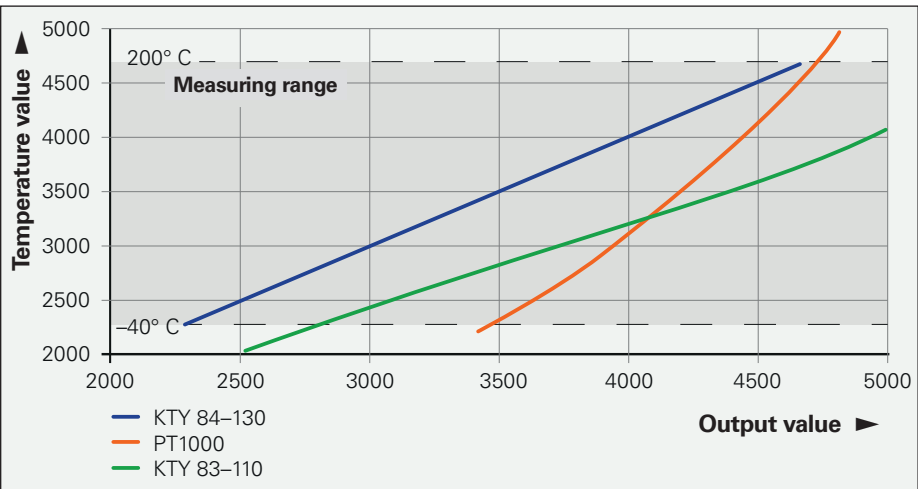


Figure 2: Relationship between the output value and the temperature value using the example of the PT 1000 and KTY 83-110

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:

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

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:

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

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

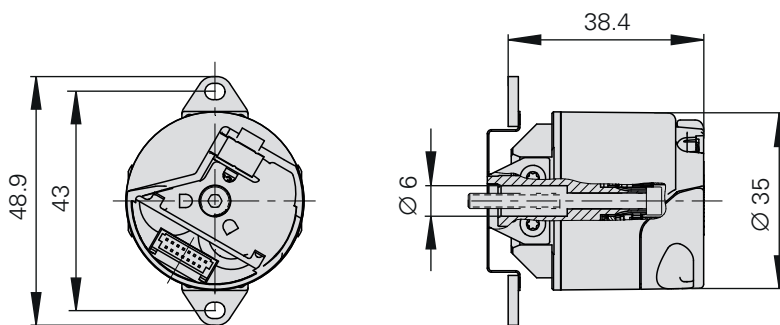
ECN/EQN 1100 series

Absolute rotary encoders

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



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions for ECN/EQN 1100

[ID 1459415](#)



Mating dimensions for ECN/EQN/ECI/EBI/EQI 1100

[ID 747859](#)

	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/revolution	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	DC 3.6 V to 14 V	ECN 1123: DC 3.6 V to 14 V	DC 3.6 V to 14 V	EQN 1135: DC 3.6 V 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 <i>n</i>	12000 rpm			
Starting torque (typical)	0.001 Nm (at 20 °C)		0.002 Nm (at 20 °C)	
Moment of inertia of rotor	≈ 0.4 · 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 <i>Electrical safety</i> in the <i>Interfaces of HEIDENHAIN Encoders</i> 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} Asymmetry: 0.05
Signal ratio: 0.9 to 1.1 Phase angle: 90° elec. ±5° elec.

³⁾ See *Temperature measurement in motors*

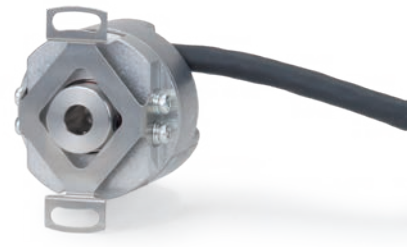
⁴⁾ Applies only to EnDat encoders

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

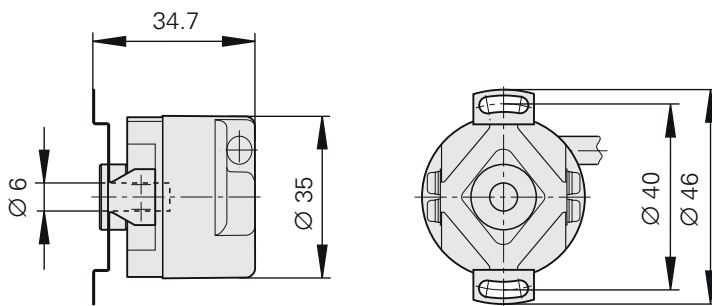
ERN 1023

Incremental rotary encoders

- Stator coupling for plane surface
- Blind hollow shaft
- Block commutation signals



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions
[ID 684703](#)

	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 <i>a</i>	≤ 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 <i>n</i>	≤ 6000 rpm												
Starting torque (typical)	0.005 Nm (at 20 °C)												
Moment of inertia of rotor	0.5 · 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 For frequent flexing: -10 °C												
Protection rating 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

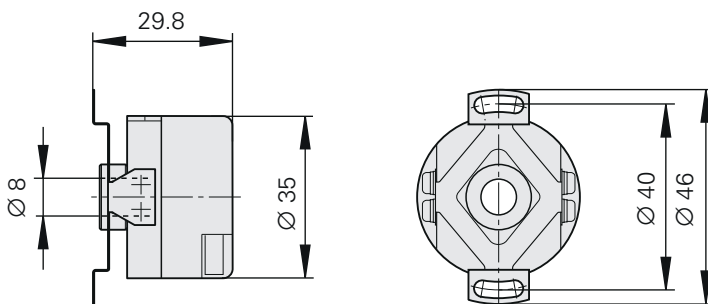
ERN 1123

Incremental rotary encoders

- Stator coupling for plane surface
- Hollow through shaft
- Block commutation signals



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions
[ID 1041991](#)

	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 <i>a</i>	≤ 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	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 <i>n</i>	≤ 6000 rpm												
Starting torque (typical)	0.005 Nm (at 20 °C)												
Moment of inertia of rotor	0.5 · 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	IP00 ²⁾												
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

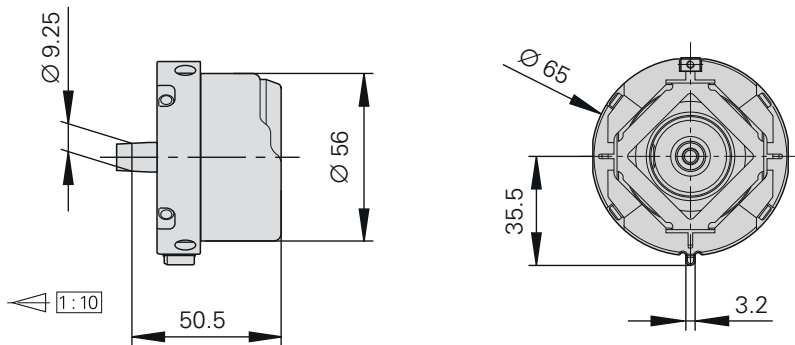
ECN/EQN 1300 series

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



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions for ECN/EQN 1300
[ID 735268](#)



Mating dimensions for ECN/EQN/ECI/EQI/EBI 1300
[ID 650136](#)

	Absolute		
	ECN 1313 EQN 1325	ECN 1325 EQN 1337 	ECN 1325 EQN 1337 
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	DC 3.6 V to 14 V		DC 4.0 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	$2.6 \cdot 10^{-6} \text{ kgm}^2$		
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 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/s²;
up to 115 °C: ≤ 150 m/s²

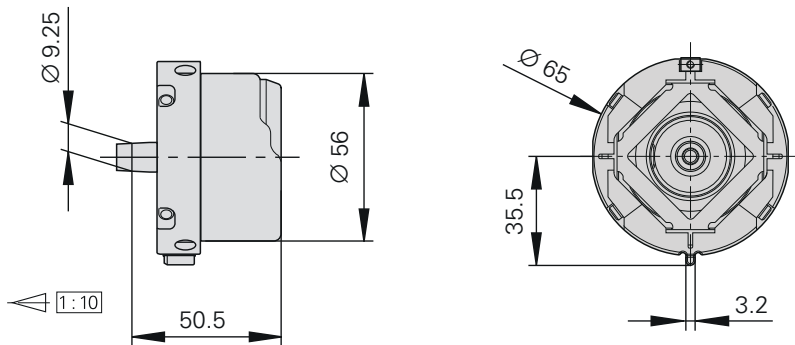
ECN/EQN 1300 S series

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 61800-5-2 possible



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions for ECN/EQN 1300
[ID 735268](#)



Mating dimensions for ECN/EQN/ECI/EQI/EBI 1300
[ID 650136](#)

	Absolute	
	ECN 1324S 	EQN 1336S 
Interface	DRIVE-CLiQ	
Ordering designation	DQ01	
Position values per rev.	16777216 (24 bits)	
Revolutions	–	4096 (12 bits)
Spindle speed	≤ 15000 rpm (at ≥ 2 position requests per revolution)	≤ 12000 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	DC 10 V to 28 V	
Power consumption (max.)	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	$2.6 \cdot 10^{-6} \text{ kgm}^2$	
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 (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	≈ 0.3 kg	
Part number	1179144-xx	1179145-xx

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

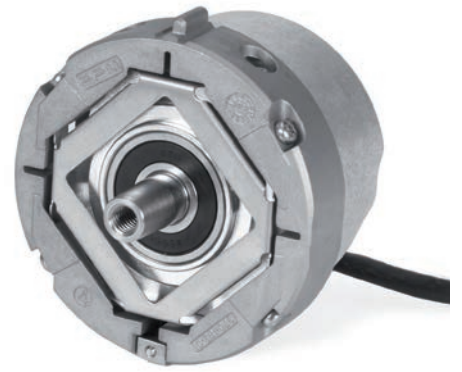
¹⁾ Evaluation optimized for the KTY 84-130 and PT 1000 (see *Temperature measurement in motors*)

DRIVE-CLiQ is a registered trademark of Siemens AG

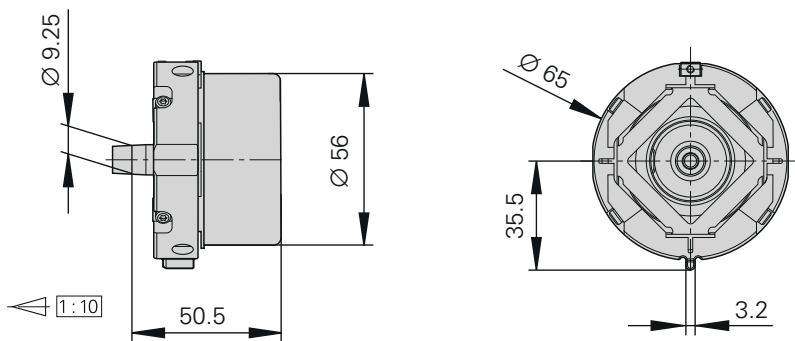
ECN/EQN 400 series

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



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions
[ID 1351634](#)

	Absolute			
	ECN 413	ECN 425 	EQN 425	EQN 437 
Interface	EnDat 2.2			
Ordering designation	EnDat01	EnDat22	EnDat01	EnDat22
Position values per rev.	8192 (13 bits)	33554 432 (25 bits)	8192 (13 bits)	33554 432 (25 bits)
Revolutions	–		4096 (12 bits)	
Elec. permiss. shaft speed/ deviations ²⁾	1500 rpm/±1 LSB 12 000 rpm/±50 LSB	15 000 rpm (for continuous position value)	1500 rpm/±1 LSB 12 000 rpm/±50 LSB	15 000 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	DC 3.6 V to 14 V			
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	≤ 15 000 rpm		≤ 12 000 rpm	
Starting torque (typical)	0.01 Nm (at 20 °C)			
Moment of inertia of rotor	2.6 · 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 (EN 60068-2-6) ≤ 2000 m/s ² (EN 60068-2-27)			
Max. operating temp.	100 °C			
Min. operating temp.	Fixed cable: –40 °C For frequent flexing: –10 °C			
Protection EN 60529	IP64 when mounted			
Mass	≈ 0.3 kg			
Part number	1065932-xx	1178024-xx	1109258-xx	1178025-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.

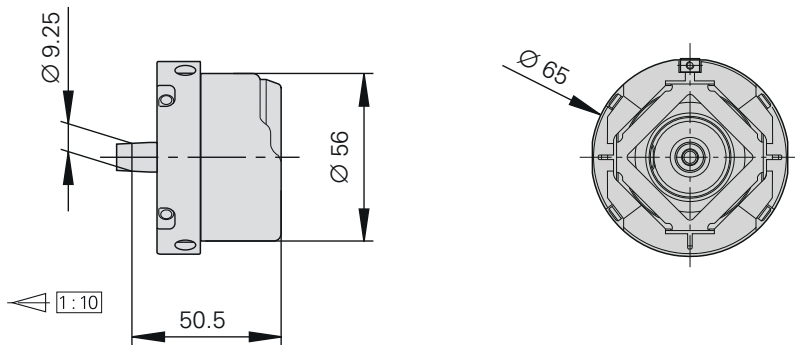
ERN 1300 series

Incremental rotary encoders

- 06 stator coupling for axial mounting
- 65B tapered shaft



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions
[ID 374033](#)

	Incremental				
	ERN 1321	ERN 1381	ERN 1387	ERN 1326	
Interface		 1 V _{PP} ¹⁾			
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	≤ 300 kHz	–		≤ 300 kHz	≤ 600 kHz
Edge separation <i>a</i>	≥ 0.35 μs	–		≥ 0.35 μs	≥ 0.12 μs
Cutoff frequency –3 dB	–	≥ 210 kHz		–	–
Commutation signals	–		 1 V _{PP} ¹⁾		
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 <i>n</i>	≤ 15000 rpm				
Starting torque (typical)	0.01 Nm (at 20 °C)				
Moment of inertia of rotor	2.6 · 10 ^{–6} kgm ²				
Natural frequency <i>f</i> _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 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	≈ 0.3 kg				
Part number	385423-xx	534118-xx	749144-xx	574485-xx	

* Please select when ordering

- ¹⁾ Deviating tolerances
- | | |
|-----------------------------|---|
| Signal amplitude: | 0.75 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/s²;
up to 120 °C: ≤ 150 m/s²

⁵⁾ Via integrated signal doubling

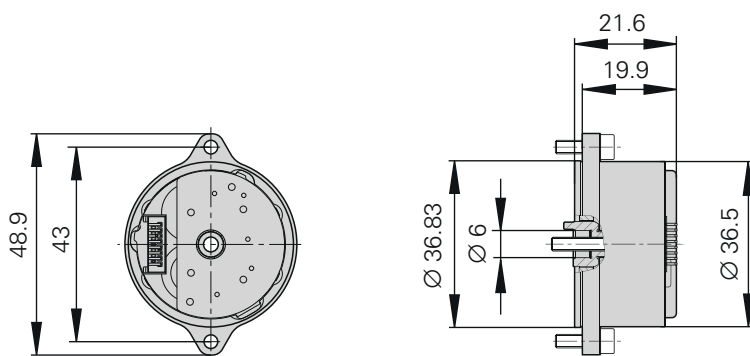
ECI/EQI 1100 series

Absolute rotary encoders

- 70C flange for axial mounting
- Blind hollow shaft $\varnothing$ 6 mm
- Without integral bearing



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions for ECI/EQI 1100 (70C flange)

[ID 1414810](#)



Mating dimensions for ECN/EQN/ECI/EQI/EBI 1100

[ID 747859](#)

	Absolute ECI 1119 singletum 		Absolute EQI 1131 multitum 	
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	–
Availability of position value	–	≤ 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 m ²⁾			
Supply voltage	EnDat 2.2: DC 3.6 V to 14 V EnDat 3: DC 4 V to 14 V			
Power consumption (maximum)	3.6 V: ≤ 0.65 W 14 V: ≤ 0.7 W	4 V: ≤ 0.53 W; 14 V: ≤ 0.9 W	3.6 V: ≤ 0.75 W 14 V: ≤ 0.85 W	4 V: ≤ 0.66 W; 14 V: ≤ 1 W
Current consumption (typical)	5 V: 95 mA (without load)	12 V: 27 mA (without communication)	5 V: 115 mA (without load)	12 V: 33 mA (without communication)
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 · 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			
Trigger threshold of error message for excessive temperature	125 °C (measuring accuracy of the internal temperature sensor: ±1 K)			
Protection EN 60529	IP00 when mounted ³⁾			
Mass	≈ 0.04 kg			
Part number	1164809-xx	1391210-xx	1164811-xx	1391216-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.

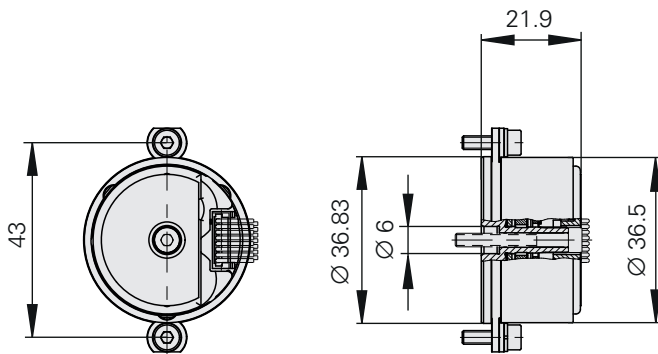
For dimensions and specifications of encoders with functional safety, see the Product Information document.

ECI/EQI 1100 series

Absolute rotary encoders

- 70F synchro flange for axial mounting
- Blind hollow shaft $\varnothing$ 6 mm (82A)
- Without integral bearing

Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions for ECI/EQI 1100 (70F flange)
[ID 1169667](#)



Mating dimensions for ECN/EQN/ECI/EQI/EBI 1100
[ID 747859](#)

	Absolute	
	ECI 1119 singletum	EQI 1131 multitum
Interface	EnDat 2.2	
Ordering designation	EnDat22	
Position values per rev.	524 288 (19 bits)	
Revolutions	–	4096 (12 bits)
Calculation time t_{cal} Clock frequency	$\leq 5 \mu\text{s}$ $\leq 16 \text{ MHz}$	
System accuracy	$\pm 120''$	
Electrical connection	15-pin (with connection for external temperature sensor) ¹⁾	
Cable length	$\leq 100 \text{ m}$	
Supply voltage	DC 3.6 V to 14 V	
Power consumption (maximum)	3.6 V: $\leq 0.65 \text{ W}$ 14 V: $\leq 0.7 \text{ W}$	3.6 V: $\leq 0.75 \text{ W}$ 14 V: $\leq 0.85 \text{ W}$
Current consumption (typical)	5 V: 95 mA (without load)	5 V: 115 mA
Shaft	Blind hollow shaft for axial clamping ($\varnothing 6 \text{ mm}$)	
Spindle speed	$\leq 15000 \text{ rpm}$	$\leq 12000 \text{ rpm}$
Moment of inertia of rotor	$0.2 \cdot 10^{-6} \text{ kgm}^2$	
Permissible axial motion of measured shaft	$\pm 0.4 \text{ mm}$	
Vibration 55 Hz to 2000 Hz Shock 6 ms	Stator: $\leq 400 \text{ m/s}^2$; rotor: $\leq 600 \text{ m/s}^2$ (EN 60068-2-6) $\leq 2000 \text{ m/s}^2$ (EN 60068-2-27)	
Operating temperature	$-40 \text{ }^\circ\text{C}$ to $110 \text{ }^\circ\text{C}$	
Protection EN 60529	IP00 when mounted ²⁾	
Mass	$\approx 0.04 \text{ kg}$	
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.

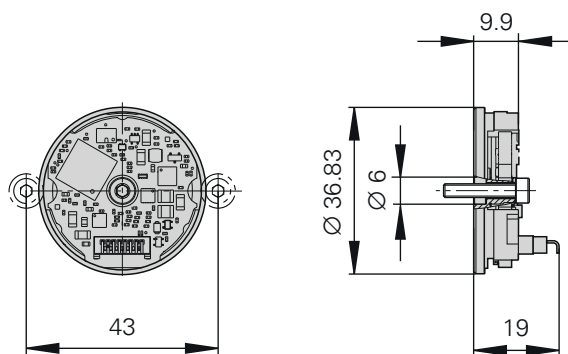
ECI/EBI 1100 series

Absolute rotary encoders

- 70E flange for axial mounting
- Blind hollow shaft $\varnothing$ 6 mm (82C)
- Without integral bearing
- EBI 1135: multiturn functionality via battery-buffered revolution counter



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions for ECI/EBI 1100 (70E flange)
[ID 683612](#)



Mating dimensions for ECN/EQN/ECI/EQI/EBI 1100
[ID 747859](#)

	Absolute	
	ECI 1118 singletum	EBI 1135 multitum
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	$\leq 6 \mu s$ $\leq 8 \text{ MHz}$	
System accuracy	$\pm 120''$	
Electrical connection	15-pin	
Cable length	$\leq 100 \text{ m}$	
Supply voltage	DC 3.6 V to 14 V	U _P for rotary encoder: 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 operation at 5 V: 80 mA (without load) Buffer mode ³⁾ : 22 μA (rotating shaft) 12 μA (at standstill)
Shaft	Blind hollow shaft $\varnothing 6 \text{ mm}$, axial clamping	
Mech. permiss. shaft speed n	$\leq 15000 \text{ rpm}$	$\leq 12000 \text{ rpm}$
Mech. permiss. acceleration	$\leq 10^5 \text{ rad/s}^2$	
Moment of inertia of rotor	$0.2 \cdot 10^{-6} \text{ kgm}^2$	
Permissible axial motion of measured shaft	$\pm 0.3 \text{ mm}$	
Vibration 55 Hz to 2000 Hz Shock 6 ms	$\leq 300 \text{ m/s}^2$ (EN 60068-2-6) $\leq 1000 \text{ m/s}^2$ (EN 60068-2-27)	
Operating temperature	$-20 \text{ }^\circ\text{C}$ to $115 \text{ }^\circ\text{C}$	
Protection EN 60529	IP00 ⁴⁾	
Mass	$\approx 0.02 \text{ kg}$	
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 $T = 25 \text{ }^\circ\text{C}$; $U_{BAT} = 3.6 \text{ V}$

⁴⁾ See *Electromagnetic compatibility* under *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure.

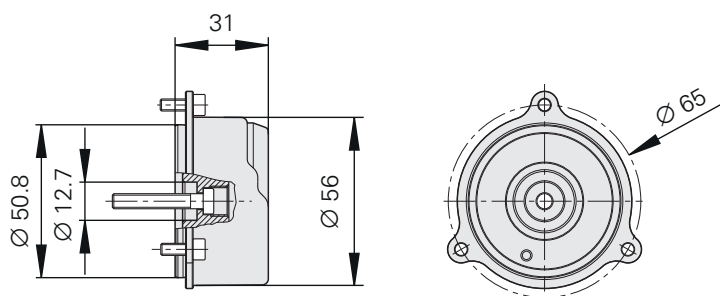
ECI/EBI/EQI 1300 series

Absolute rotary encoders

- Mounting-compatible with photoelectric rotary encoders with a 07B stator coupling
- 0YA flange for axial mounting
- 44C blind hollow shaft $\varnothing 12.7$ mm
- Without integral bearing



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions for ECI/EQI/EBI 1300 (0YA flange)
[ID 758331](#)



Mating dimensions for ECN/EQN/ECI/EQI/EBI 1300
[ID 650136](#)

	Absolute		
	ECI 1319 	EQI 1331 	EBI 1335 
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	DC 3.6 V to 14 V		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) Buffer mode: 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 · 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 $T = 25 \text{ °C}$; $U_{BAT} = 3.6 \text{ V}$

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.

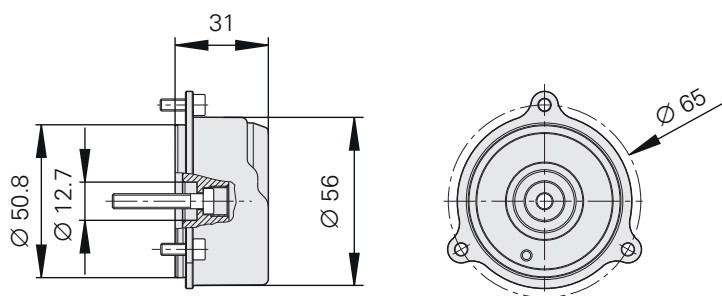
ECI 1319, EQI 1331

Rotary encoders for absolute position measurement with safe singletum 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 $\varnothing 12.7$ mm (44C) or $\varnothing 12$ mm (44A)



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions for ECI/EQI 1300 (0YA flange)
[ID 758331](#)



Mating dimensions for ECN/EQN/ECI/EQI 1300
[ID 650136](#)

	Absolute	
	ECL 1319 singleturn 	ECL 1331 multiturn 
Interface	EnDat 3	
Ordering designation	E30-R2	
Position values per rev.	524 288 (19 bits)	
Revolutions	–	4096 (12 bits)
XEL.time HPFout data rate	$\leq 11 \mu\text{s}$ at 12.5 Mbit/s $\leq 8.2 \mu\text{s}$ at 25 Mbit/s	
Propagation time ¹⁾	14 μs (typical)	
System accuracy	$\pm 65''$	
Electrical connection	16-pin PCB connector (12+4; with separate connection option for external temperature sensor) ³⁾	
Cable length	At 12.5 Mbit/s: $\leq 100 \text{ m}$; at 25 Mbit/s: $\leq 40 \text{ m}$	
Supply voltage	DC 4 V to 14 V (recommended: 12 V)	
Power consumption ²⁾ (maximum)	4 V: $\leq 0.85 \text{ W}$ 14 V: $\leq 0.9 \text{ W}$	4 V: $\leq 0.95 \text{ W}$ 14 V: $\leq 1 \text{ W}$
Current consumption (typical)	12 V: $\leq 45 \text{ mA}$ (w/o communication)	12 V: $\leq 50 \text{ mA}$ (w/o communication)
Shaft	Blind hollow shaft for axial clamping $\varnothing 12.7 \text{ mm}$ (44C) or $\varnothing 12 \text{ mm}$ (44A)	
Spindle speed	$\leq 15000 \text{ rpm}$	$\leq 12000 \text{ rpm}$
Moment of inertia of rotor	$2.45 \cdot 10^{-6} \text{ kgm}^2$	$2.6 \cdot 10^{-6} \text{ kgm}^2$
Axial motion of measured shaft	$\leq \pm 0.5 \text{ mm}$	
Vibration 55 Hz to 2000 Hz Shock 6 ms	Stator: $\leq 400 \text{ m/s}^2$; rotor: $\leq 600 \text{ m/s}^2$ (EN 60068-2-6) $\leq 2000 \text{ m/s}^2$ (EN 60068-2-27)	
Operating temperature	$-40 \text{ }^\circ\text{C}$ to $115 \text{ }^\circ\text{C}$	
Trigger threshold of error message for excessive temperature	$130 \text{ }^\circ\text{C}$ (measuring accuracy of the internal temperature sensor: $\pm 1 \text{ K}$)	
Relative humidity	$\leq 93 \%$ ($40 \text{ }^\circ\text{C}/21 \text{ d}$ as per EN 60068-2-78), condensation excluded	
Protection EN 60529	IP20	
Mass	$\approx 0.13 \text{ kg}$	
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.

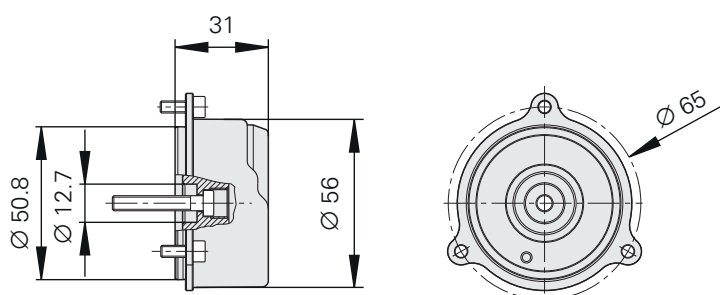
ECI/EQI 1300S series

Absolute rotary encoders

- Mounting-compatible with photoelectric rotary encoders with a 07B stator coupling
- 0YA flange for axial mounting
- 44C blind hollow shaft $\varnothing 12.7$ mm
- Without integral bearing



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions for ECI/EQI 1300 (0YA flange)
[ID 758331](#)



Mating dimensions for ECN/EQN/ECI/EQI 1300
[ID 650136](#)

	Absolute	
	ECI 1319 S 	EQI 1331 S 
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 <i>n</i>	≤ 15 000 rpm	≤ 12 000 rpm
Moment of inertia of rotor	$2.6 \cdot 10^{-6} \text{ kgm}^2$	
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.

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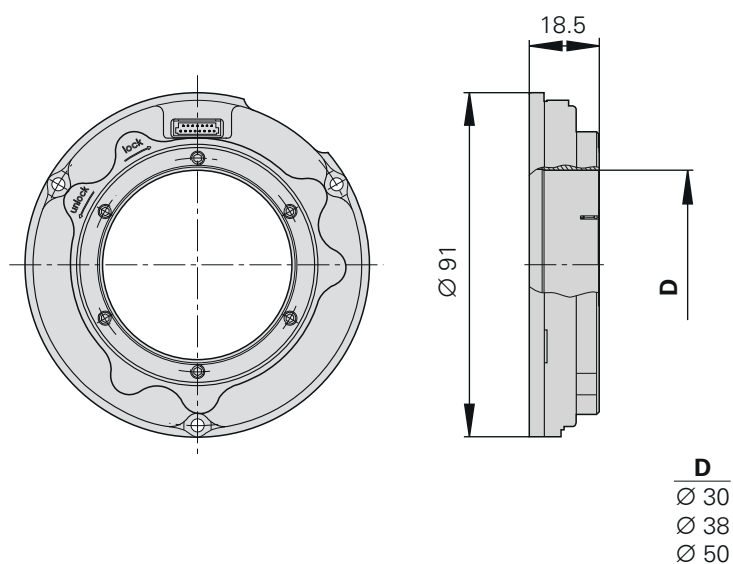
ECI/EBI 100 series

Absolute rotary encoders

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



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions
[ID 1032000](#)

	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.	524 288 (19 bits)		
Revolutions	–		65 536 (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	DC 3.6 V to 14 V		U _P for rotary encoder: 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 (without 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.

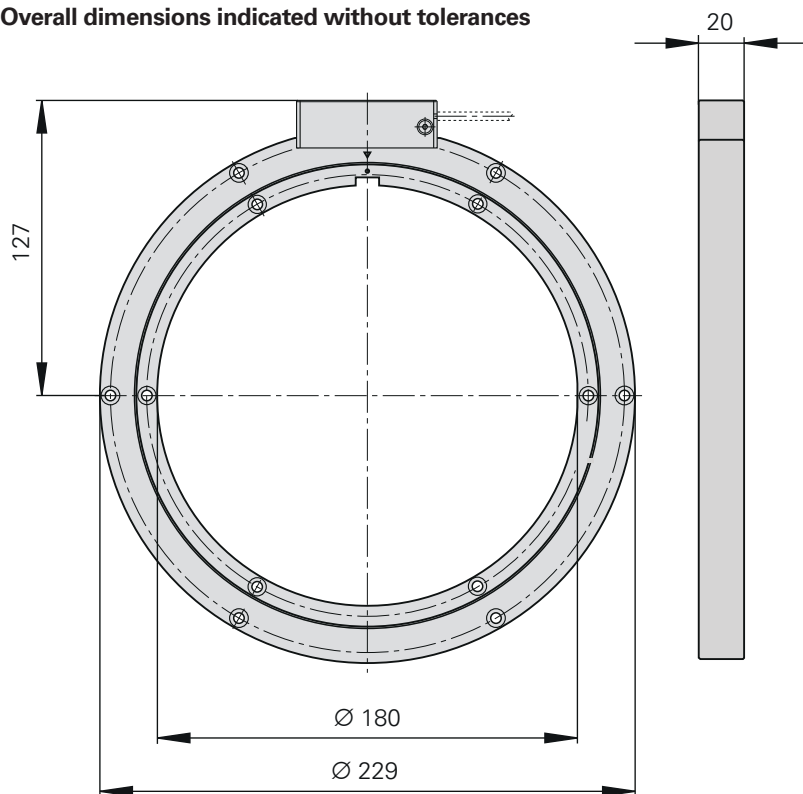
ECI 4010, EBI 4010, ECI 4090 S

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



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions
[ID 1128521](#)

Specifications	ECI 4010 singleturn 	EBI 4010 multiturn 	ECI 4090S 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	$\leq 5 \mu\text{s}/\leq 16 \text{ MHz}$		$\leq 11 \mu\text{s}^{1)}$
System accuracy	$\pm 25''$		
Electrical connection	15-pin with connection for temperature sensor ²⁾		
Cable length	$\leq 100 \text{ m}$		$\leq 40 \text{ m}^{3)}$
Supply voltage	DC 3.6 V to 14 V	U _P for rotary encoder: DC 3.6 V to 14 V Backup 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: $\leq 0.63 \text{ W}$; 14 V: $\leq 0.7 \text{ W}$		10 V: $\leq 1.1 \text{ W}$; 28.8 V: $\leq 1.25 \text{ W}$
Current consumption (typical)	5 V: 95 mA (without load)	Normal operation at 5 V: 95 mA (without load) Buffer mode ⁵⁾ : 220 μA (rotating shaft) 25 μA (shaft at standstill)	24 V: 40 mA (without load)
Shaft	Hollow through shaft ($\varnothing 90 \text{ mm}$)		
Spindle speed	$\leq 6000 \text{ rpm}$		
Moment of inertia of rotor	$4.26 \cdot 10^{-4} \text{ kgm}^2$ (w/o screws)		
Angular acceleration of rotor	$\leq 2 \cdot 10^4 \text{ rad/s}^2$		
Axial motion of measured shaft	$\leq \pm 1.5 \text{ mm}$		
Vibration 55 Hz to 2000 Hz Shock 6 ms	AE scanning unit: $\leq 400 \text{ m/s}^2$; TTR scale drum: $\leq 600 \text{ m/s}^2$ (EN 60068-2-6) $\leq 2000 \text{ m/s}^2$ (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: $\pm 1 \text{ K}$)		120°C (measuring accuracy of the internal temperature sensor: $\pm 1 \text{ K}$)
Protection EN 60529	Complete encoder, mounted: IP20 ⁶⁾ ; scanning unit: IP40 (read about insulation under <i>Electrical safety</i> in the <i>Interfaces of HEIDENHAIN Encoders</i> brochure)		
Mass	AE scanning unit: $\approx 0.27 \text{ kg}$; TTR scale drum: $\approx 0.17 \text{ kg}$		
Part number	AE ECI 4010 scanning unit: ID 1130167-xx	AE EBI 4010 scanning unit: ID 1130173-xx	AE ECI 4090S scanning unit: ID 1130171-xx
	TTR EXI 4000 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) $\leq 1 \text{ m}$

⁴⁾ See *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure

⁵⁾ At $T = 25^\circ\text{C}$; $U_{\text{BAT}} = 3.6 \text{ V}$

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.

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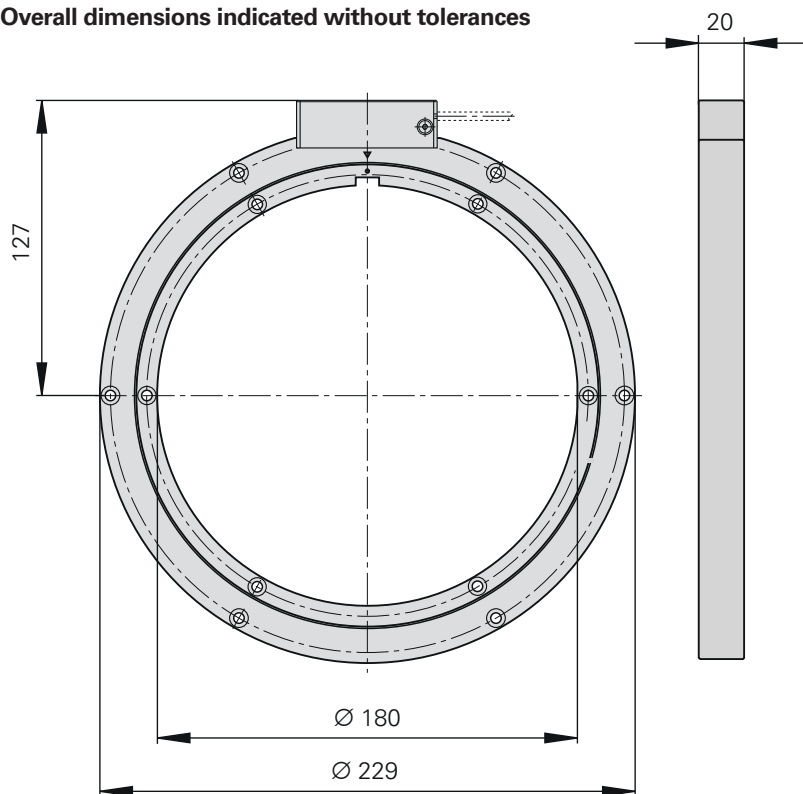
ECI 4010, EBI 4010, ECI 4090 S

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



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions
[ID 1100243](#)

Specifications	ECI 4010 singleturn 	EBI 4010 multiturn 	ECI 4090S 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	$\leq 5 \mu\text{s}/\leq 16 \text{ MHz}$		$\leq 11 \mu\text{s}^{1)}$
System accuracy	$\pm 40''$		
Electrical connection	15-pin with connection for temperature sensor ²⁾		
Cable length	$\leq 100 \text{ m}$		$\leq 40 \text{ m}^{3)}$
Supply voltage	DC 3.6 V to 14 V	U _P for rotary encoder: DC 3.6 V to 14 V Backup 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: $\leq 0.63 \text{ W}$; 14 V: $\leq 0.7 \text{ W}$		10 V: $\leq 1.1 \text{ W}$; 28.8 V: $\leq 1.25 \text{ W}$
Current consumption (typical)	5 V: 95 mA (without load)	Normal operation at 5 V: 95 mA (without load) Buffer mode ⁵⁾ : 220 μA (rotating shaft) 25 μA (shaft at standstill)	24 V: 40 mA (without load)
Shaft	Hollow through shaft $\varnothing 180 \text{ mm}$ (with keyway)		
Spindle speed	$\leq 6000 \text{ rpm}$		
Moment of inertia of rotor	$3.1 \cdot 10^{-3} \text{ kgm}^2$ (without screws, without key)		
Angular acceleration of rotor	$\leq 2 \cdot 10^4 \text{ rad/s}^2$		
Axial motion of measured shaft	$\leq \pm 1.5 \text{ mm}$		
Vibration 55 Hz to 2000 Hz Shock 6 ms	AE scanning unit: $\leq 400 \text{ m/s}^2$; TTR scale drum: $\leq 600 \text{ m/s}^2$ (EN 60068-2-6) $\leq 2000 \text{ m/s}^2$ (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: $\pm 1 \text{ K}$)		120°C (measuring accuracy of the internal temperature sensor: $\pm 1 \text{ K}$)
Protection EN 60529	Complete encoder, mounted: IP20 ⁶⁾ ; scanning unit: IP40 (read about insulation under <i>Electrical safety</i> in the <i>Interfaces of HEIDENHAIN Encoders</i> brochure)		
Mass	AE scanning unit: $\approx 0.39 \text{ kg}$; TTR scale drum: $\approx 0.33 \text{ kg}$		
Part number	AE ECI 4010 scanning unit: ID 1087526-xx	AE EBI 4010 scanning unit: ID 1097530-xx	AE ECI 4090S scanning unit: ID 1087527-xx
	TTR EXI 4000 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) $\leq 1 \text{ m}$

⁴⁾ See *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure

⁵⁾ At $T = 25^\circ\text{C}$; $U_{\text{BAT}} = 3.6 \text{ V}$

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.

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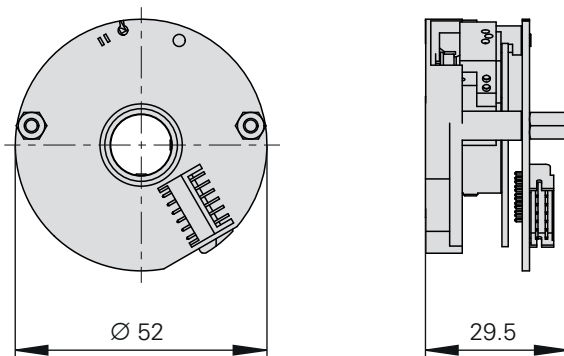
ERO 1200 series

Incremental rotary encoders

- Flange for axial mounting
- Hollow through shaft
- Without integral bearing



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions
[ID 332878](#)

	Incremental	
	ERO 1225	ERO 1285
Interface	□□TTL	~ 1 V _{PP}
Line count*	1024 2048	
Accuracy of graduation ²⁾	±6"	
Reference mark	One	
Output frequency	≤ 300 kHz	–
Edge separation <i>a</i>	≥ 0.39 μs	–
Cutoff frequency –3 dB	–	≥ 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 <i>n</i>	≤ 25000 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*

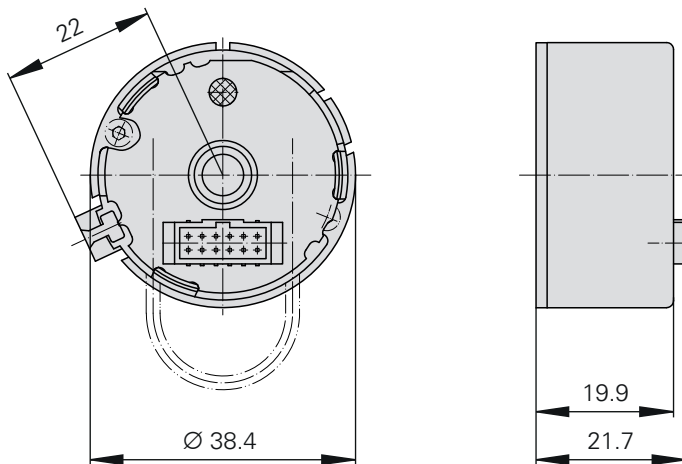
ERO 1400 series

Incremental rotary encoders

- Flange for axial mounting
- Hollow through shaft
- Without integral bearing; self-centering



Overall dimensions indicated without tolerances



For technical drawings, visit: www.heidenhain.com/documentation



Mating dimensions
[ID 339431](#)

	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	10 000 15 000	20 000 30 000	25 000 37 500	512 1000 1024
Edge separation <i>a</i>	≥ 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 PCB connector, 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 · 10 ^{–6} kgm ² Shaft Ø 6 mm: 0.27 · 10 ^{–6} kgm ² Shaft Ø 8 mm: 0.25 · 10 ^{–6} kgm ²					
Mech. permiss. shaft speed <i>n</i>	≤ 30 000 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 ²⁾					
Mass	≈ 0.07 kg					
Part number	360732-xx	360736-xx				360738-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

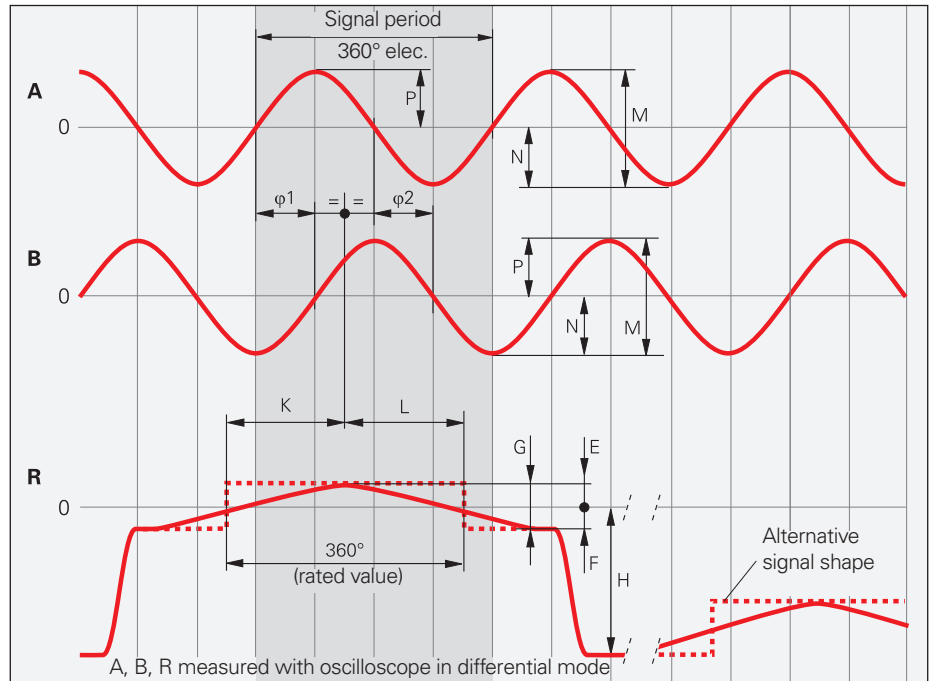
HEIDENHAIN encoders with the ~ 1 V_{PP} interface provide voltage signals that are highly interpolatable.

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.



Further 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	/
	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
	2a	2b	1a	1b	6b	6a	5b	5a	4b	4a	/	/	3a/3b
	U _P	Sensor U _P	0 V	Sensor 0 V	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⁾	/

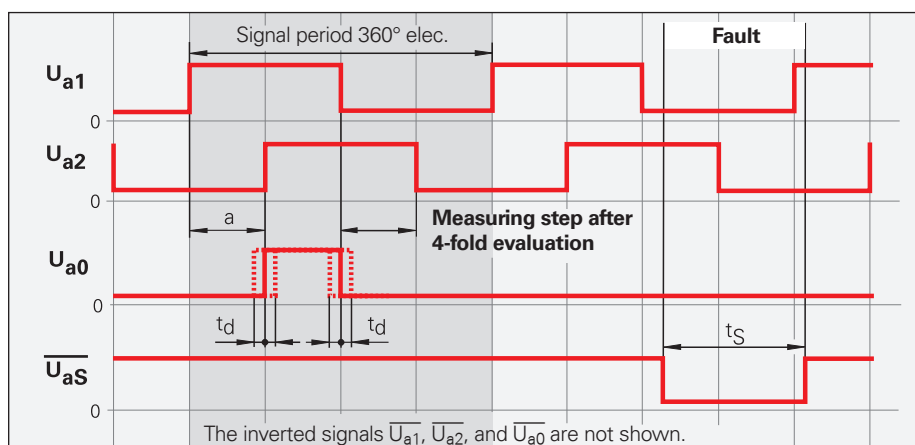
Cable shield connecting with housing; U_P = Power supply voltage ¹⁾ LIDA 2xx: vacant; ²⁾ For connecting a temperature sensor
Sensor: The sense line is connected in the encoder with the corresponding power line.
 Vacant pins or wires must not be used!

TTL incremental signals

HEIDENHAIN encoders with the  TTL interface incorporate electronics that digitize sinusoidal scanning signals 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.



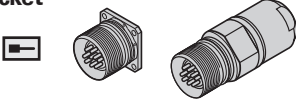
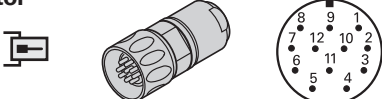
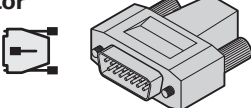
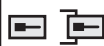
The distance between two successive edges of the incremental signals U_{a1} and U_{a2} through 1-fold, 2-fold, or 4-fold evaluation is one **measuring step**.



Further 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
	2a	2b ¹⁾	1a	1b ¹⁾	6b	6a	5b	5a	4b	4a	3a	3b	/
	U_P	Sensor U_P	0V	Sensor 0V	U_{a1}	$\overline{U_{a1}}$	U_{a2}	$\overline{U_{a2}}$	U_{a0}	$\overline{U_{a0}}$	$\overline{U_{aS}}$¹⁾	Vacant	Vacant²⁾
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	Violet	/	Yellow

Cable shield connected to housing; **U_P** = Power supply voltage

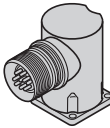
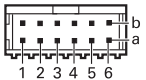
Sensor: The sense line is connected in the encoder with the corresponding power line.

Vacant pins or wires must not be used!

¹⁾ **ERO 14xx:** vacant

²⁾ **Exposed linear encoders:** conversion from TTL to 11 μ App 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			
	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	0V 	Sensor 0V	U_{a1}	$\overline{U_{a1}}$	U_{a2}	$\overline{U_{a2}}$	U_{a0}	$\overline{U_{a0}}$	$T_+^{1)}$	$T_-^{1)}$	Vacant	
	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.

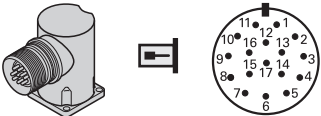
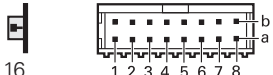
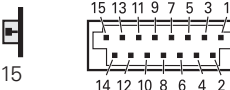
The **ERN 1x23** and **ERN 1326** are rotary encoders with commutation signals for block commutation.



Further 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						
	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	
	Up	Sensor Up	0V	Internal shield	Ua1	Ua1	Ua2	Ua2	Ua0	Ua0	
	Brown/ Green	Blue	White/ Green	/	Green/Black	Yellow/Black	Blue/Black	Red/Black	Red	Black	

Other signals							

Cable shield connected to housing
U_P = Power supply voltage
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	0V	U _{a1}	$\overline{U_{a1}}$	U _{a2}	$\overline{U_{a2}}$	U _{a0}	$\overline{U_{a0}}$	U	$\overline{U}$	V	$\overline{V}$	W	$\overline{W}$
	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 $\sim 1\text{ V}_{PP}$ interface. However, the required terminating impedance Z₀ is 1 kΩ instead of 120 Ω.

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



Further 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 = Power supply voltage; **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

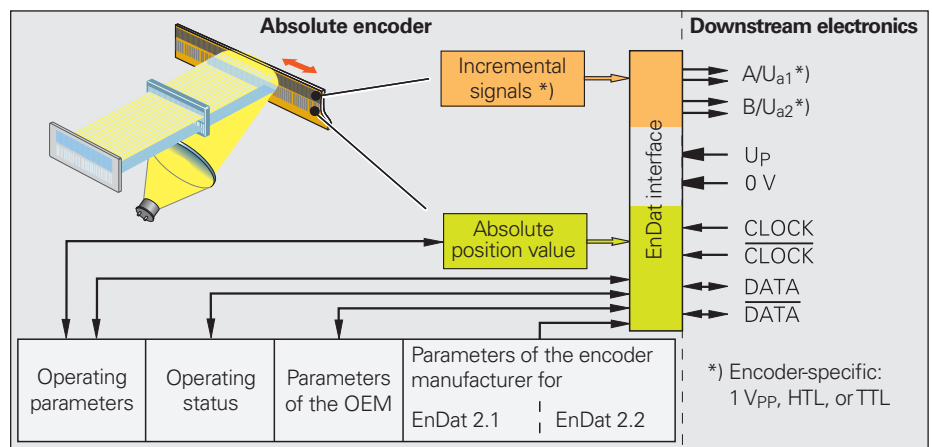
The EnDat interface is a digital, **bidirectional** interface for encoders. It is capable of outputting **position values**, reading information stored in the encoder, updating this information, and storing new information. Because the interface uses **serial transmission**, only **four signal lines** 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.

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	–

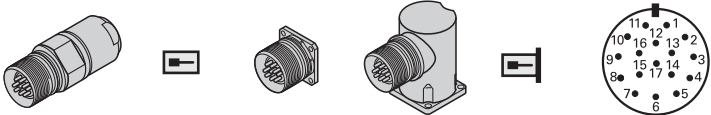
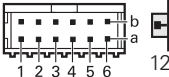
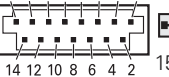
Versions of the EnDat interface with the EnDat 2.1 and 2.2 command sets

Further 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 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

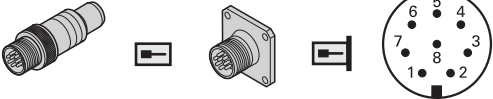
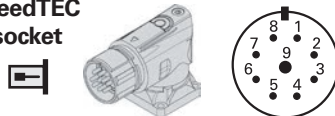
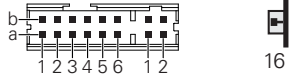
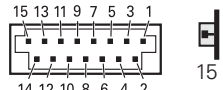
Other signals			
	5	6	
	12	/	/
	15	/	/
	$T_+^{(2)}$	$T_-^{(2)}$	
	Brown ²⁾	White ²⁾	

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⁾
	Brown/ Green	Blue	White/ Green	White	Gray	Pink	Violet	Yellow	Brown	Green

Cable shield connected with housing; **U_P** = Power supply voltage; **T** = Temperature

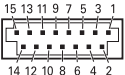
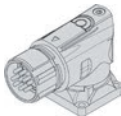
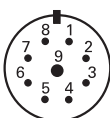
Sensor: The sense line is connected in the encoder with the corresponding power line.

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										
 15										
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}	0V ²⁾	0V _{BAT} ²⁾	DATA	DATA	CLOCK	CLOCK	T ³⁾	T ^{- 3)}
	Brown/ Green	Blue	White/ Green	White	Gray	Pink	Violet	Yellow	Brown	Green

U_P = Power supply voltage; **U_{BAT}** = external backup battery (false polarity can result in damage to the encoder)

Vacant pins or wires must not be used!

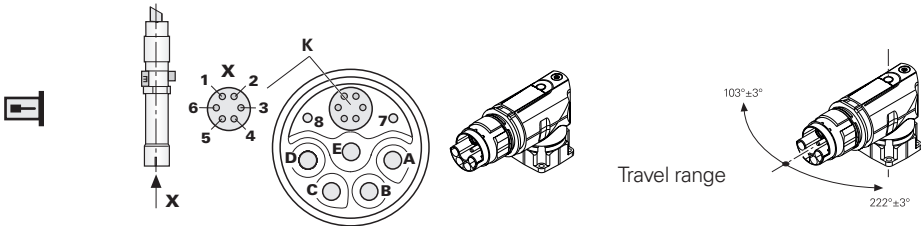
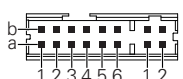
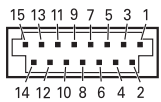
¹⁾ Only for EBI 135

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.

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH

Pin layout

HMC 6 flange socket 								
16-pin (12+4-pin) PCB connector   16				15-pin PCB connector   15				
	Encoder							
	Supply voltage		Serial data transmission				Other signals	
	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	0V	DATA	DATA	CLOCK	CLOCK	T₊¹⁾	T₋¹⁾
	Brown/Green	White/Green	Gray	Pink	Violet	Yellow	Brown	Green

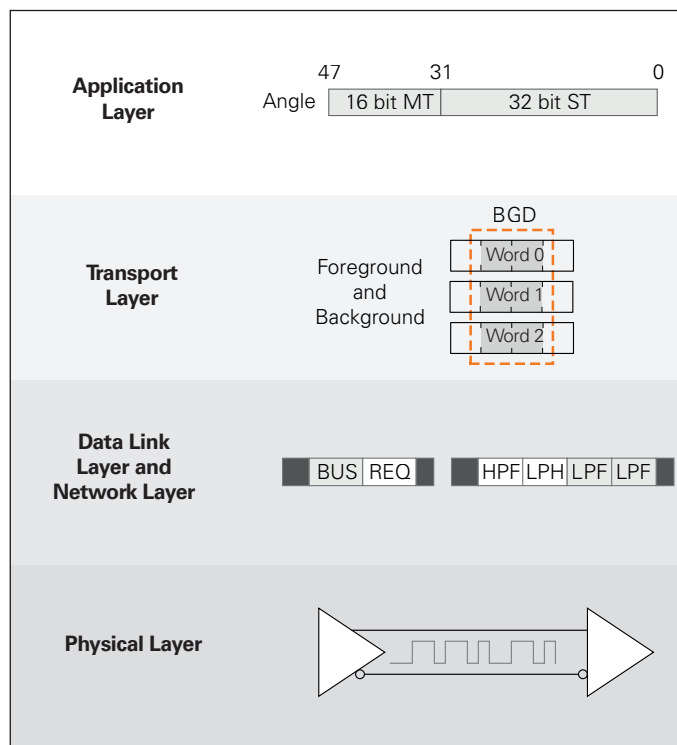
	Motor						
	Brake		Power supply				
	7	8	A	B	C	D	E
	BRAKE-	BRAKE+	U	V	W	/	PE
	White	White/Black	Blue	Brown	Black	/	Yellow/Green

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 backup 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 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 specification 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.



Further information:

Find out more about EnDat at endat.heidenhain.com

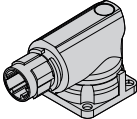
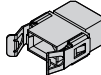
Ordering designations

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	–	✓	✓
EnDat 3.0 command set	✓	✓	✓

HMC 2 (EnDat 3/E30-R2) M12

Pin layout of ECI, EQI 11xx

8-pin M12 SpeedTEC angle flange socket		15-pin PCB connector					
 M12			 15	 2			
	Encoder						
	Supply voltage / 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
	Brake +	Brake –	U	V	W

¹⁾ Supply voltage and data: P_SD+ includes Up; P_SD– includes 0 V

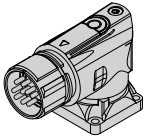
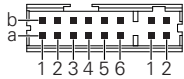
²⁾ Connections for an external temperature sensor; evaluation optimized for KTY 84-130, PT 1000 and others (see *Temperature measurement in motors*); if used, please refer to the information about electromagnetic compatibility in the *General electrical information* section of the *Interfaces of HEIDENHAIN 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 PCB connector (12+4-pin)    12  4  2  2 1				
Encoder				
Supply voltage / 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

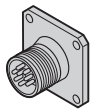
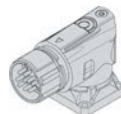
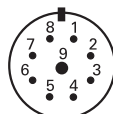
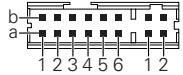
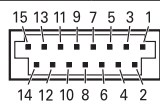
DRIVE-CLiQ is a registered trademark of Siemens AG



Further 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  					15-pin PCB connector  					
	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	0V	RXP	RXN	TXP	TXN	T ⁺ ¹⁾	T [–] ¹⁾
 *	Brown/ Green	Blue	White	White/ Green	Gray	Pink	Violet	Yellow	Brown	Green

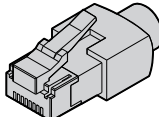
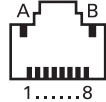
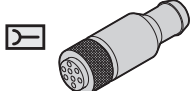
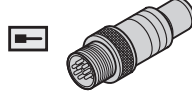
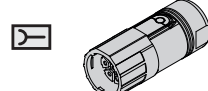
Cable shield connected to housing; **U_P** = Power supply voltage

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	
	Up	0V	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

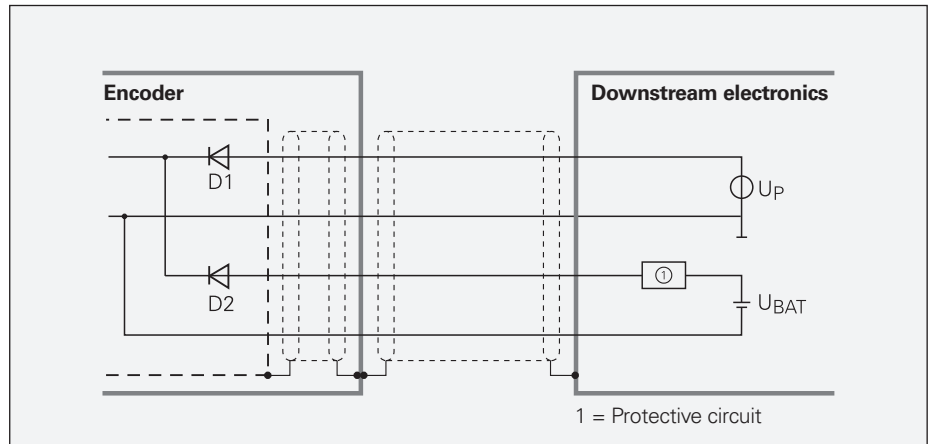
SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH
SPEEDCON is a registered trademark of Phoenix Contact GmbH & Co. KG.

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**
 $\leq 2.8 \text{ V} \pm 0.2 \text{ V}$
in normal operating mode
- **"M Power interruption" error message**
 $\leq 2.2 \text{ V} \pm 0.2 \text{ V}$
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:

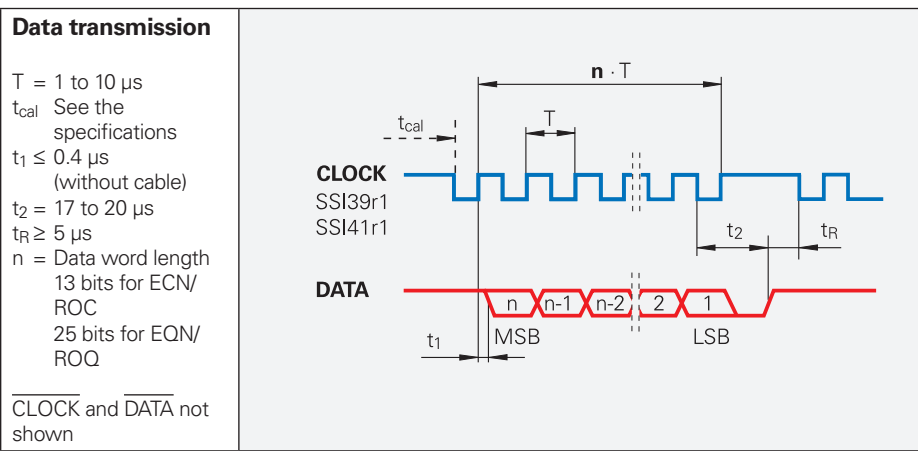
Compliance with EnDat Specification 297403 and the EnDat Application Notes 722024, Chapter 13, *Battery-buffered encoders*, is required for correct control of the encoder.

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:

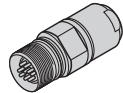
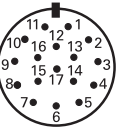
- **Direction of rotation**
- **Zeroing** (setting to zero)



Further 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	DATA	CLOCK	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**).

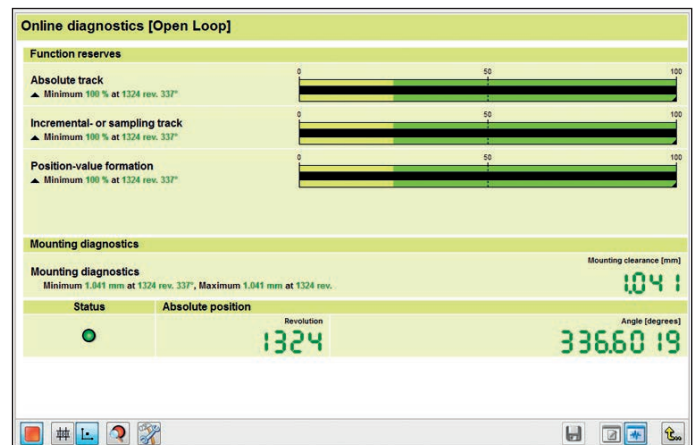
Absolute encoders employ serial data transmission. Depending on the interface, 1 V_{PP} incremental signals can also be output. The signals are extensively monitored within the encoder. The monitoring results (particularly valuation numbers) can be transmitted to the downstream electronics along with 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

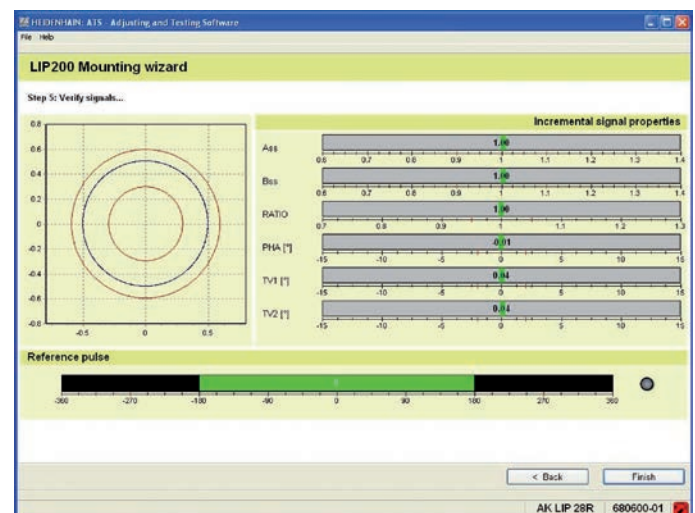
This enables the downstream electronics to evaluate the current status of the encoder with little effort, even in closed-loop mode.

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



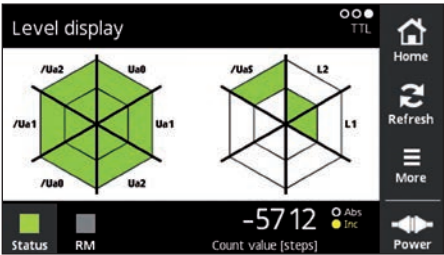
Initial setup with the PWM 21 and ATS software

PWT 101

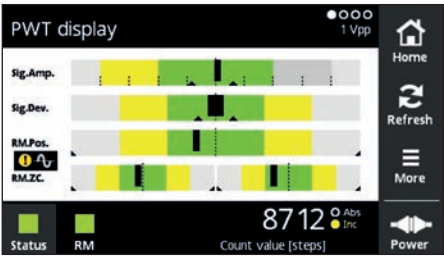
The PWT 101 is a testing device for the functional testing and adjustment of absolute and incremental HEIDENHAIN encoders. Thanks to its compact and rugged design, the PWT 101 is ideal for portable use.



	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



Level display



PWT display

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_{PP} • 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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