HEIDENHAIN
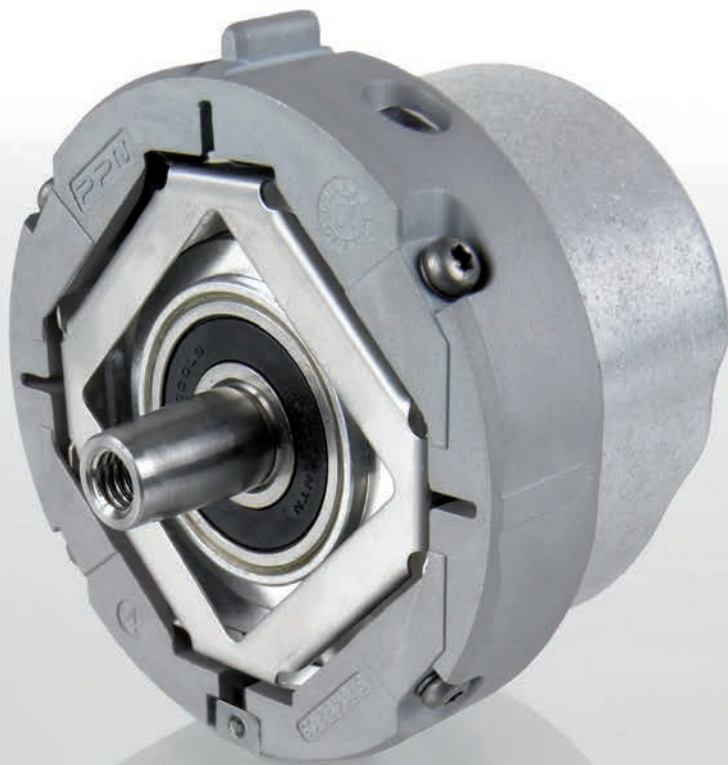
Encoders for
Servo Drives

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.

Further information:

For the **linear encoders and angle encoders** listed in the selection tables, please refer to the respective **product documentation** to find detailed descriptions, including mounting information, specifications and dimensions.

Brochure
Rotary Encoders

Product Overview
Rotary Encoders for the Elevator Industry

Brochure
Angle Encoders
With Integral Bearing

Brochure
Modular
Angle Encoders
With Magnetic Scanning

Brochure
Modular
Angle Encoders
With Optical Scanning

Brochure
Exposed
Linear Encoders

Brochure
Linear Encoders
For Numerically Controlled Machine Tools

Brochure
Cables and Connectors

Brochure
Interfaces
of HEIDENHAIN Encoders

Further information:

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

Table of contents

Encoders for electric motors

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

Rotary encoder (actual position value, actual speed value, commutation signal, electronic ID label)

φ_i

φ_s — Position controller n_s — n_i — Speed calculation — Speed controller — Decoupling i_s — — — Current controller — Drive

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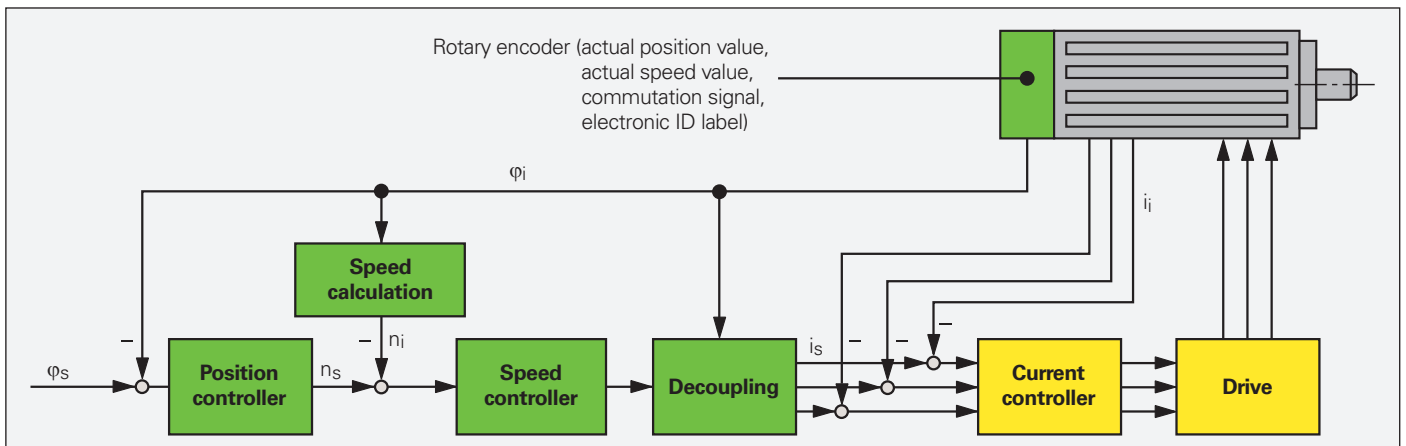
HEIDENHAIN provides just the right encoder for different rotary and linear motors in a variety of applications:

- 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)

Rotary encoder
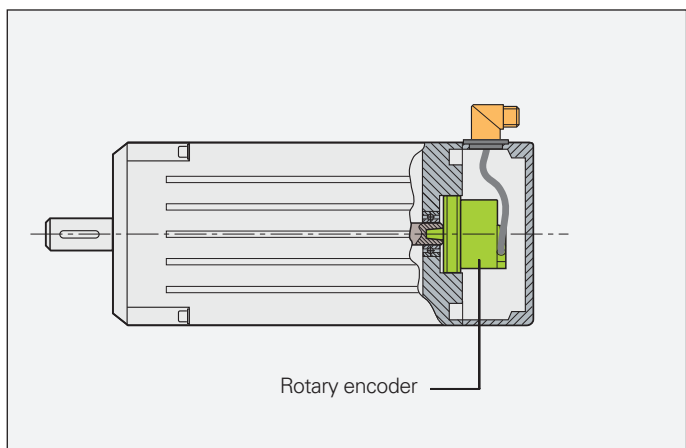
Angle encoders

Linear encoders

Information about the selection tables

The selection tables on the following pages list the encoders that are suitable for each motor design. Each table contains encoders with different dimensions and output signals for the various motor types (DC or three-phase AC motors).

Rotary encoders for mounting on motors

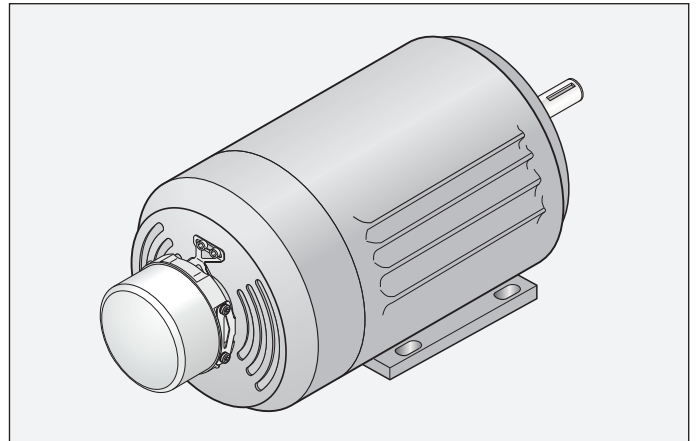Rotary encoders for motors with forced ventilation are either mounted on the motor housing or installed within it. These rotary encoders are often exposed to the motor's unfiltered forced-air stream and must therefore have a high protection rating of IP64 or better. The permissible operating temperature 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 to electrically **isolated mounting**
- **Absolute rotary encoders with purely digital data transfer** 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 functionally safe rotary encoders available as safety-related position measurement systems

*For the selection table, see page 12*

Rotary encoders for mounting inside motors

In motors without forced ventilation, the rotary encoder is installed inside the motor housing. As a result, the encoder does not require a high protection rating. Nevertheless, the operating temperature inside the motor housing can reach 100 °C or more.

The selection table contains the following encoders:
- Absolute rotary encoders for operating temperatures of up to 115 °C, and incremental rotary encoders for **operating temperatures** of up to 120 °C
- Rotary encoders with a mounted **stator coupling** featuring a high natural frequency (the motor's bandwidth is virtually unlimited)
- 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
- Incremental rotary encoders with **TTL-compatible output signals**
- Information on functionally safe rotary encoders available as safety-related position measurement systems

*For the selection table, see page 8*
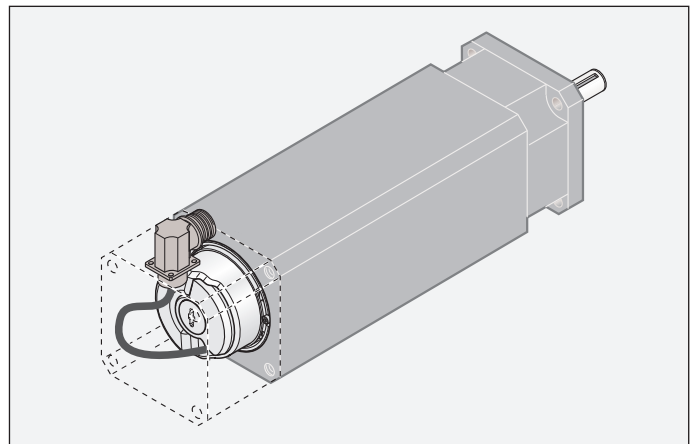
Rotary encoders, modular encoders and angle encoders for built-in and hollow-shaft motors

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

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

For more information, see page 2
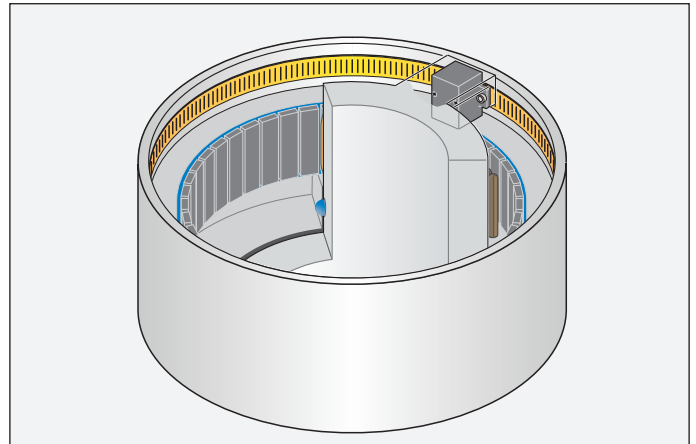
Linear encoders for linear motors

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
- Ability to handle high shaft speeds
- Absolute position information with purely digital data transmission or high-quality sinusoidal incremental signals

For more information, see page 2

Exposed linear encoders are characterized by:
- 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).
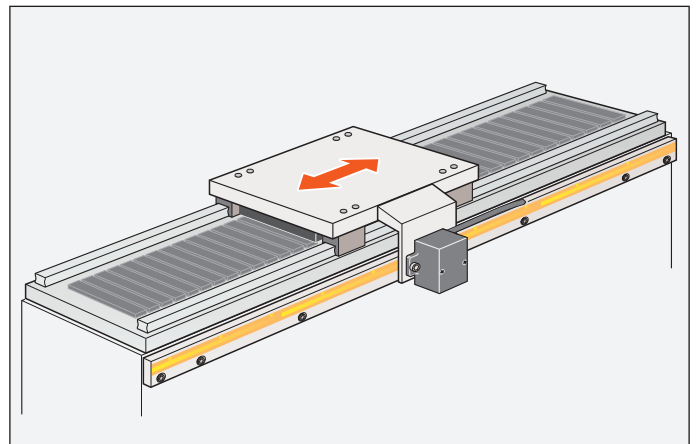
For more information, see page 2

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

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

For more information, see page 2

Selection guide
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		≤ 15 000 rpm/ ≤ 12 000 rpm	–	110 °C	DC 3.6 V to 14 V
					DC 4 V to 14 V
ECI/EQI 1100 with synchro flange					DC 3.6 V to 14 V
ECI/EBI/EQI 1300		≤ 15 000 rpm/ ≤ 12 000 rpm	–	115 °C	DC 3.6 V to 14 V
					DC 4 V to 14 V
				100 °C	DC 10 V to 28.8 V
ECI/EBI 100	D: 30/38/50 mm	≤ 6000 rpm	–	115 °C	DC 3.6 V to 14 V
ECI/EBI 4000	D: 90/180 mm	≤ 6000 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	≤ 25 000 rpm	–	100 °C	DC 5 V ±0.5 V
ERO 1400	D: 4/6/8 mm	≤ 30 000 rpm	–	70 °C	DC 5 V ±0.5 V
					DC 5 V ±0.25 V
					DC 5 V ±0.5 V

[1] Also available with functional safety
[2] After internal 5/10/20/25-fold interpolation
[3] Multiturn functionality 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 62**
			EnDat 3/E30-R2		
			EnDat 2.2/22		
–	524 288 (19 bits)	–/65 536/4096[3]	EnDat 2.2/22	**ECI 1319[1]/EQI 1331[1]/ EBI 1335[1,3]**	**Page 66**
		–/4096	EnDat 3/E30-R2	**ECI 1319[1]/EQI 1331[1]**	**Page 68**
			DRIVE-CLiQ	**ECI 1319 S/EQI 1331 S[1]**	**Page 70**
32	524 288 (19 bits)	–	EnDat 2.1/01 with $\sim$ 1 V$_{PP}$	**ECI 119**	**Page 72**
–		–/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 74**
		–	DRIVE-CLiQ	**ECI 4090 S[1]**	
1024/2048	–		$\sqcap\sqcup$ TTL	**ERO 1225**	**Page 78**
			$\sim$ 1 V$_{PP}$	**ERO 1285**	
512/1000/1024	–		$\sqcap\sqcup$ TTL	**ERO 1420**	**Page 80**
5000 to 37 500[2]			$\sqcap\sqcup$ TTL	**ERO 1470**	
512/1000/1024			$\sim$ 1 V$_{PP}$	**ERO 1480**	

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		≤ 12000 rpm	1000 Hz	115 °C	DC 3.6 V to 14 V
				95 °C	DC 10 V to 28.8 V
				115 °C	DC 3.6 V to 14 V
		≤ 6000 rpm	1600 Hz	90 °C	DC 5 V ±0.5 V
ECN/EQN/ ERN 1300		≤ 15000 rpm/ ≤ 12000 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
		≤ 15000 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

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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 48**
–	8388608 (23 bits)	–/4096	DRIVE-CLiQ	**ECN 1123 S/EQN 1135 S**	
			EnDat 2.2/22	**ECN 1123[1]/EQN 1135[1]**	
500 to 8192	3 block commutation signals		⊓⊔TTL	**ERN 1123**	**Page 52**
512/2048	8192 (13 bits)	–/4096	EnDat 2.2/01 with $\sim$ 1 V_{PP}	**ECN 1313/EQN 1325**	**Page 54**
–	33554432 (25 bits)		EnDat 2.2/22	**ECN 1325[1]/EQN 1337[1]**	
			EnDat 3/E30-R2		
–	16777216 (24 bits)	–/4096	DRIVE-CLiQ	**ECN 1324 S/EQN 1336 S**	**Page 56**
1024/2048/4096	–		⊓⊔TTL	**ERN 1321**	**Page 60**
	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 mounting on motors

Protection class: 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	Ø 87, 104, 55 max., Ø D, D: 50 mm max.	*Ø ≤ 30 mm:* ≤ 6000 rpm *Ø > 30 mm:* ≤ 4000 rpm	1000 Hz	100 °C	DC 3.6 V to 14 V
					DC 5 V ±0.5 V
				85 °C	DC 10 V to 30 V
ECN/EQN/ERN 400	**Stator coupling for plane surfaces** Ø 58, 54.4, Ø 12	≤ 6000 rpm *With two shaft clampings (only for hollow through shaft):* ≤ 12 000 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 ±0.5 V
					DC 10 V to 30 V
				70 °C	
				100 °C	DC 5 V ±0.5 V
ECN/EQN/ERN 400	**Stator coupling for plane surfaces** Ø 58, 54.4, Ø 12	≤ 6000 rpm *With two shaft clampings (only for hollow through shaft):* ≤ 12 000 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** Ø 56, Ø 64.8, 35.5, 50.5, 3.2 (not with ERN), - 1:10 **Plane-surface coupling** Ø 58, 83.2, 50.5, 22, - 1:10	≤ 15 000 rpm/ ≤ 12 000 rpm ≤ 15 000 rpm	*Expanding ring coupling:* 1800 Hz *Plane-surface coupling:* 400 Hz	100 °C	DC 3.6 V to 14 V
					DC 5 V ±0.5 V
					DC 5 V ±0.25 V

[1] Also available with functional safety

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| 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	–		⊓⊔TTL/$\sim$ 1 V_{PP}	**ERN 120/ERN 180**	
			⊓⊔ 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	–		⊓⊔TTL	**ERN 420**	
			⊓⊔ HTL	**ERN 430**	
			⊓⊔TTL	**ERN 460**	
1000 to 5000			$\sim$ 1 V_{PP}	**ERN 480**	
256 to 2048	8192 (13 bits)	–/4096	EnDat H ⊓⊔ HTL SSI 41H ⊓⊔ HTL	**EQN 425**	**Brochure:** *Rotary Encoders*
512 to 4096			EnDat T ⊓⊔TTL SSI 41T ⊓⊔TTL		
–	αi: 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 58**
–	33554432 (25 bits)		EnDat 2.2/22	**ECN 425**[1]**/EQN 437**[1]	
1024 to 5000	–		⊓⊔TTL	**ERN 421**	**Product Information document**
2048	Z1 track for sine commutation		$\sim$ 1 V_{PP}	**ERN 487**	

Rotary encoders for mounting on motors
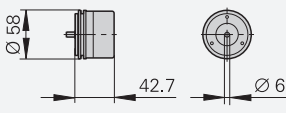
Protection class: up to IP64 (EN 60529)

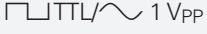| Series	Main dimensions	Mechanically permissible shaft speed	Natural frequency f_N (typical) of the coupling	Maximum operating temperature	Supply voltage
Rotary encoders with integral bearing and mounted stator coupling					
ECN/EQN/ERN 1000	42.1 48 Ø 35 Ø 6 ERN 1023 34.7 46 Ø 35 Ø 6	≤ 12 000 rpm	1500 Hz	100 °C	DC 3.6 V to 14 V
				95 °C	DC 10 V to 28.8 V
					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 5/10/20/25-fold interpolation

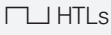| Signal periods per revolution	Positions per revolution	Distinguishable revolutions	Interface	Model	Further information
512	8192 (13 bits)	–/4096	EnDat 2.2/01 with $\sim$ 1 V$_{PP}$	**ECN 1013/EQN 1025**	**Brochure:** *Rotary Encoders*
–	8388608 (23 bits)		EnDat 2.2/22	**ECN 1023/EQN 1035**	
			DRIVE-CLiQ	**ECN 1023 S/EQN 1035 S**	
100 to 3600	–		$\sqcap\sqcup$TTL/$\sim$ 1 V$_{PP}$	**ERN 1020/ERN 1080**	
			$\sqcap\sqcup$ HTLs	**ERN 1030**	
5000 to 36000[1]			$\sqcap\sqcup$TTL	**ERN 1070**	
500 to 8192	3 block commutation signals		$\sqcap\sqcup$TTL	**ERN 1023**	**Page 50**

Rotary encoders for mounting on motors

Protection class: up to IP64 (EN 60529)

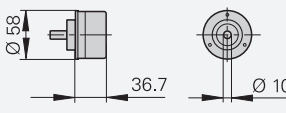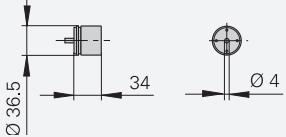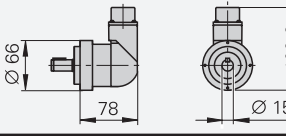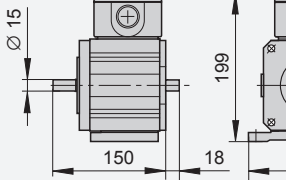| Series	Main dimensions	Mechanically permissible shaft speed	Natural frequency f_N (typical) of the coupling	Maximum operating temperature	Supply voltage
Rotary encoders with integral bearing for separate shaft coupling					
ROC/ROQ/ROD 400	**Synchro flange** Ø 58, 42.7, Ø 6 **Clamping flange** Ø 58, 36.7, Ø 10	≤ 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	DC 5 V ±0.5 V
				100 °C	DC 5 V ±0.5 V
ROC/ROQ/ROD 1000	Ø 36.5, 34, Ø 4	≤ 12 000 rpm	–	100 °C	DC 3.6 V to 14 V
				95 °C	DC 10 V to 28.8 V
				100 °C	DC 5 V ±0.5 V
				70 °C	DC 10 V to 30 V
					DC 5 V ±0.25 V
ROD 600	Ø 66, 78, 109.6, Ø 15	≤ 12 000 rpm	–	80 °C	DC 5 V ±0.5 V
ROD 1900	Ø 15, 199, 150, 18, 160	≤ 4000 rpm	–	70 °C	DC 10 V to 30 V

[1] Also available with functional safety
[2] After integrated 5/10-fold interpolation
[3] Only clamping flange

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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*
–	33 554 432 (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 ⊓⊔ HTL SSI 41 H ⊓⊔ HTL	**ROQ 425**[3]	
512 to 4096			EnDat T ⊓⊔ TTL SSI 41 T ⊓⊔ TTL		
–	αi: 33 554 432 (25 bits)	4096	Fanuc	**ROC 425 F/ROQ 437 F**	
	16 777 216 (24 bits)		DRIVE-CLiQ	**ROC 424 S/EQN 436 S**[1]	
50 to 10 000[2]	–	–	⊓⊔ TTL	**ROD 426/ROD 420**	
50 to 5000			⊓⊔ HTL	**ROD 436/ROD 430**	
50 to 10 000[2]			⊓⊔ 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*
–	8 388 608 (23 bits)		EnDat 2.2/22	**ROC 1023/ROQ 1035**	
			DRIVE-CLiQ	**ROC 1023 S/ROQ 1035 S**	
100 to 3600	–		⊓⊔ TTL	**ROD 1020**	
			$\sim$ 1 V$_{PP}$	**ROD 1080**	
			⊓⊔ HTLs	**ROD 1030**	
5000 to 36 000[2]			⊓⊔ TTL	**ROD 1070**	
512 to 5000	–		⊓⊔ TTL	**ROD 620**	
			⊓⊔ HTL	**ROD 630**	
600 to 2400	–		⊓⊔ HTL/HTLs	**ROD 1930**	

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, HEIDENHAIN offers 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 moves in accordance with 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 highly 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).
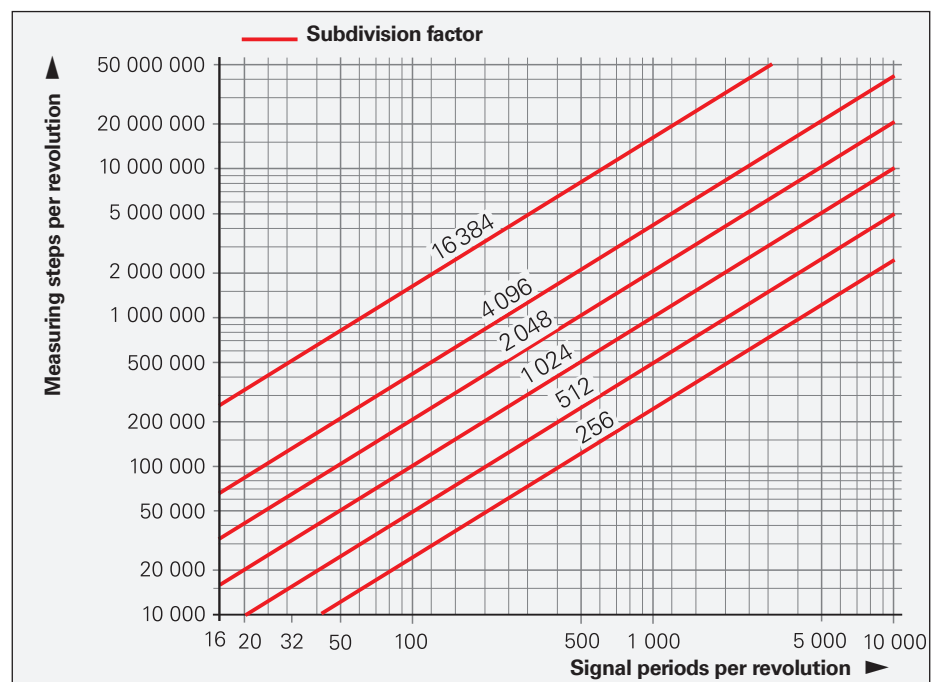
HEIDENHAIN encoders for motors with digital position and speed control are therefore equipped with the **purely serial EnDat22/EnDat3 interface**, or they output additional **sinusoidal incremental signals** at 1 V$_{PP}$ signal levels (EnDat01).

The high internal resolution of the **EnDat22** and **EnDat3** 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** devices 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 (short for Encoder Data) for the **serial data transmission** of absolute position values 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 EnDat 22 (HMC 6) and EnDat 3 (HMC 2), the serial data transmission can take place inside the motor cable. Cabling work and costs are thereby significantly reduced.

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

Most absolute encoders internally subdivide the sinusoidal scanning signals by a factor of 4096 or greater. When these systems are operated with sufficiently **fast transmission** of the absolute position

values (e.g., at a clock frequency of 2 MHz with EnDat 2.1 or 16 MHz with **EnDat 2.2**) or EnDat3 (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 data is 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 high signal quality (better than ±1% of the signal period) are preferred (see also *Measuring accuracy*).

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

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

Preventive maintenance
Encoders with serial data transmission 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
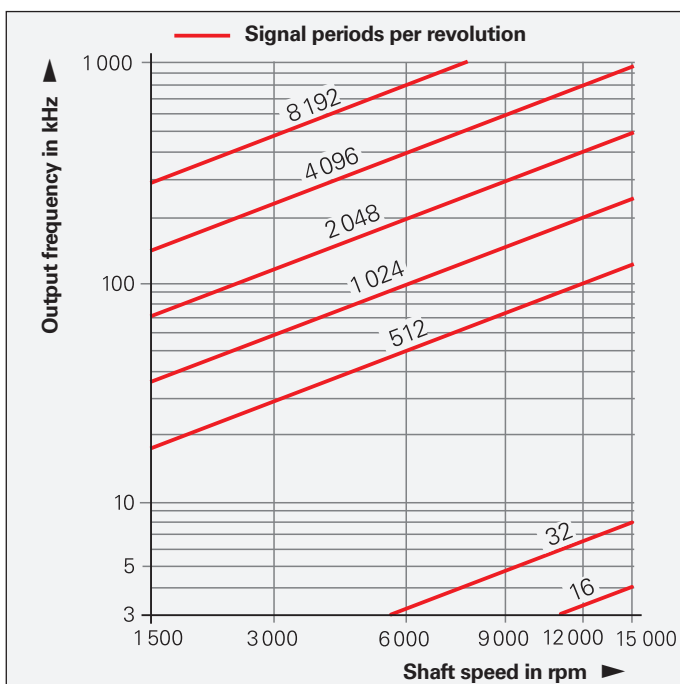
HMC 2 and HMC 6
Single-cable solutions for servomotors

Servomotors normally require two separate connecting cables:
- One encoder cable for the motor encoder
- One power cable for the motor supply

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 **EnDat3**. 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 drive, 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
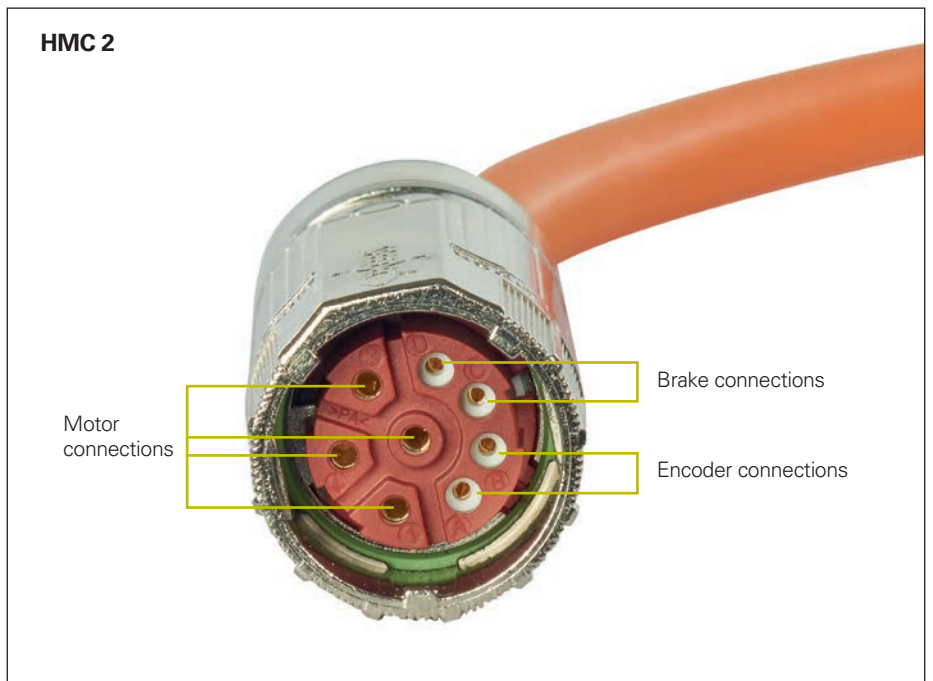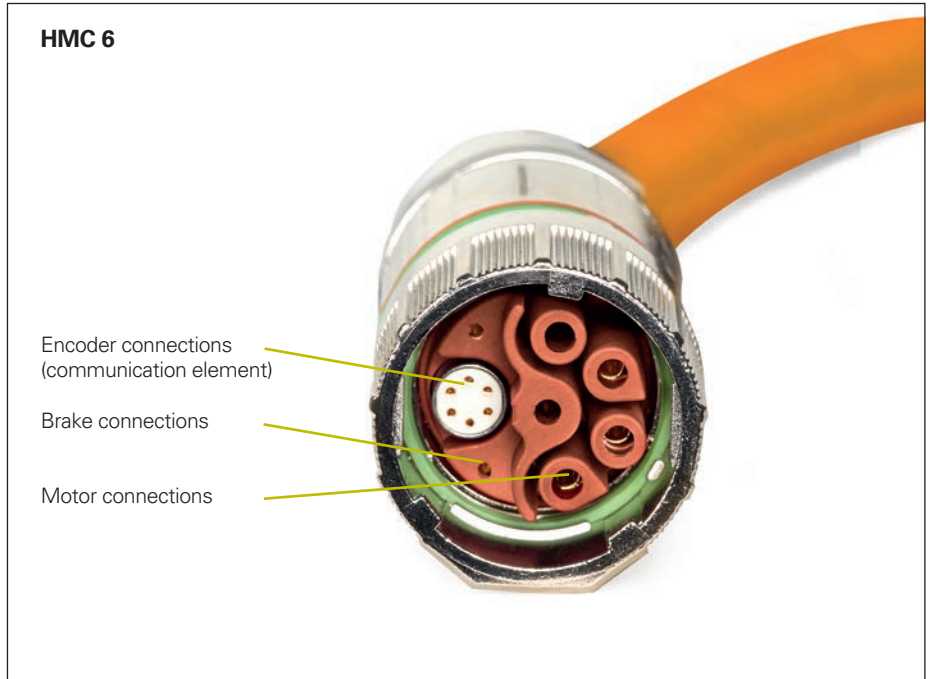
Benefits
The HMC single-cable solutions offer a series of cost and quality benefits for motor and machine manufacturers:
- Continued use of existing interfaces
- Realization of smaller drag chains
- Significant improvement in drag-chain suitability thanks to fewer cables
- Wide range of available encoders 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 transmission without battery buffering as per RS-485 are suitable 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, as well as 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
Preparing a motor 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 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.
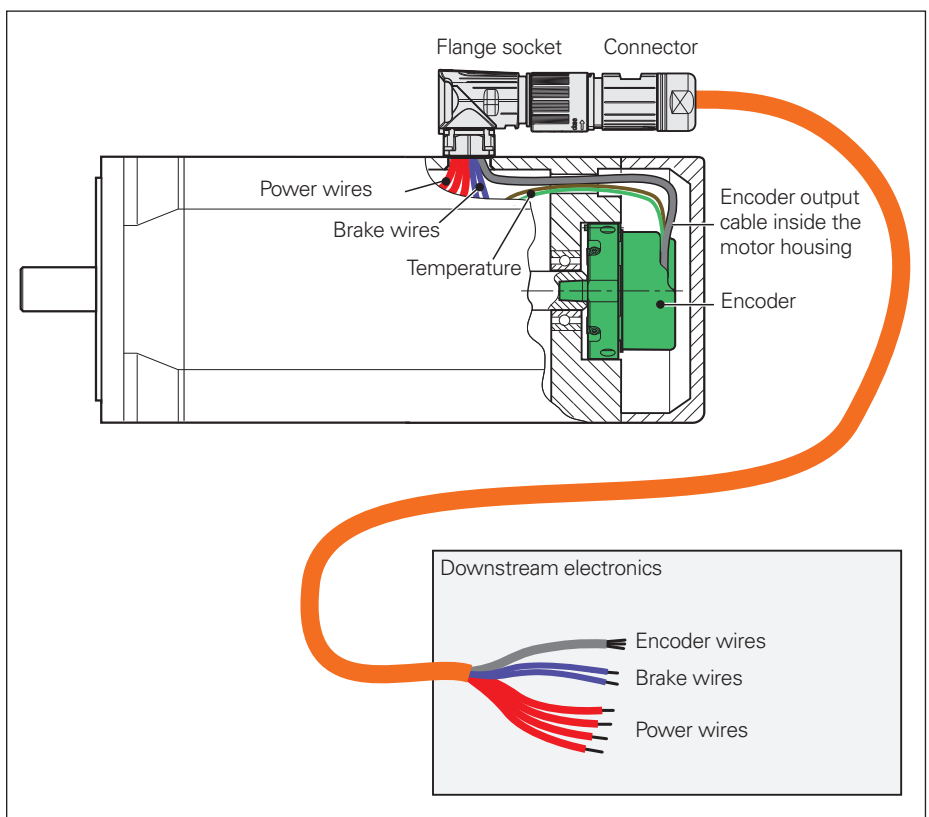
Safety-related position measuring systems

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 control. 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. The reliable transmission of the position 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.
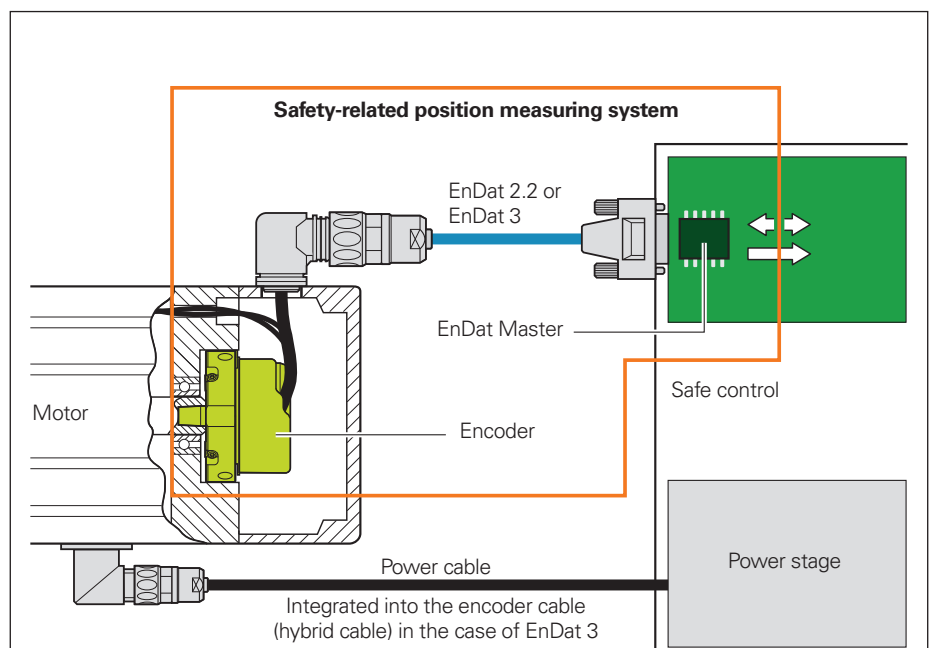
Standard encoders

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 respective control. 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. The Technical Information document *Safety-Related Position Encoders* provides explanations of the characteristic values.

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

Service life as per ISO 13849

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

Bearing life

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

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

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 on a fault exclusion can result in additional constraints in the permissible limit values in the specifications. In addition, fault exclusions for the loosening of the mechanical coupling usually require additional measures during installation of the encoder or in the event of servicing (e.g., anti-rotation lock for screws). These factors must be considered for the selection of a suitable encoder or mounting mode.

📖 **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 EnDat3:
- *Application Conditions for Functional Safety* 3000003
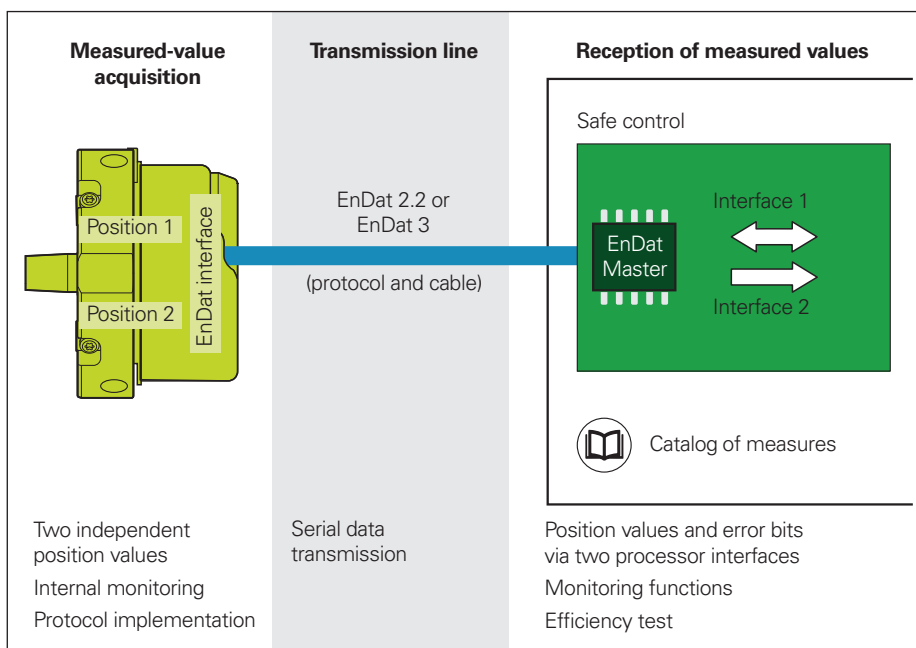
Safety-related position measurement system with EnDat 2.2 or EnDat 3

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 substrate of glass or steel. For encoders with large diameters, steel tape is used as the substrate.

HEIDENHAIN manufactures its precision graduations in specially developed, photolithographic processes:
- AURODUR: matte-etched lines on a gold-plated steel tape; typical grating period: 40 µm
- 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 graduation period: 2 µm and finer

For magnetic encoders, a substrate made of magnetizable steel alloy is used. 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 electro-magnetic 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 no need to move the axes to find the reference position. 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.

Singleturn rotary encoders repeat the absolute position information with each revolution. **Multiturn encoders** can distinguish between additional revolutions.
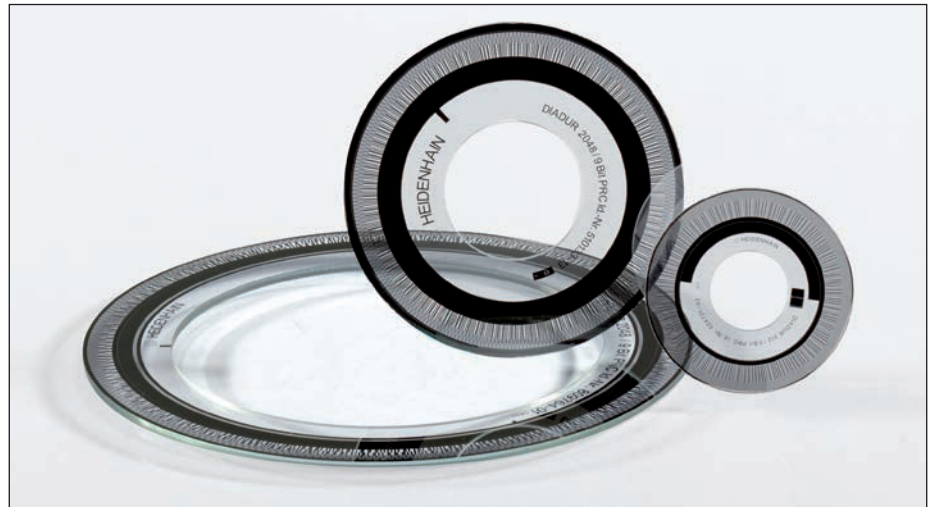
The circular scales of absolute rotary encoders

In the **incremental measuring method**, the graduation consists of a periodic grating structure. Position information is obtained **through the counting** of individual increments (measuring steps) starting from a freely settable 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.

Thus, before an absolute reference can be established or the most recently selected reference point can be refound, this reference mark must first be traversed.

The ciruclar scales of incremental rotary encoders
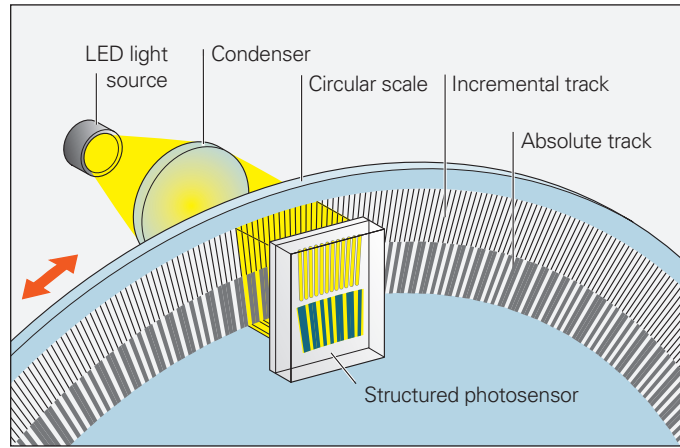
Scanning methods

Photoelectric scanning

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

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

Put simply, the imaging scanning principle uses projected-light signal generation: two gratings with equal or similar grating periods—the circular scale and the scanning reticle—are moved relative to each other. The carrier material of the scanning reticle is transparent, whereas the graduation of the measuring standard may likewise be applied to a transparent material or to a 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 according to 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. In this case, moving graduation structures modulate the gain and phase of a high-frequency signal. By means of circumferential scanning, the position value is always generated based on the signals from the receiver coils that are distributed along the circumference. This permits wide mounting tolerances at high resolution.
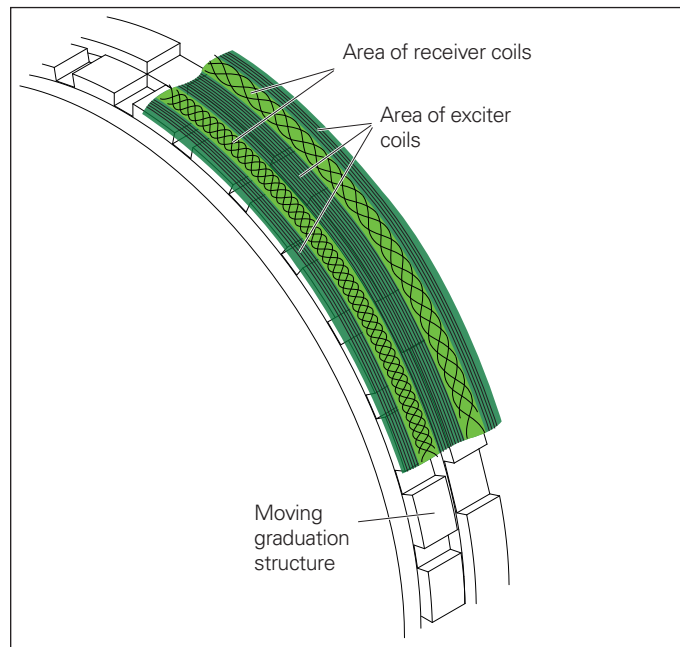
Inductive scanning

# Electronic commutation with position encoders

Commutation with permanent-magnet three-phase AC motors

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

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

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

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

**Commutation of synchronous linear motors**

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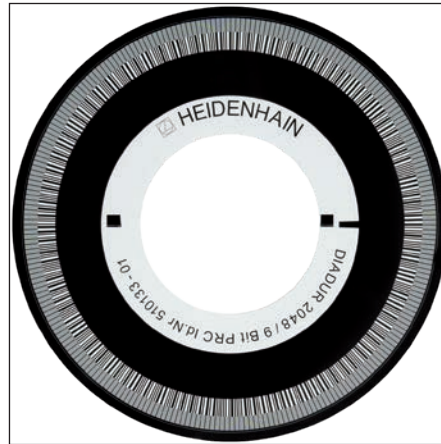
Circular scale with code track and incremental track

Circular scale with Z1 track
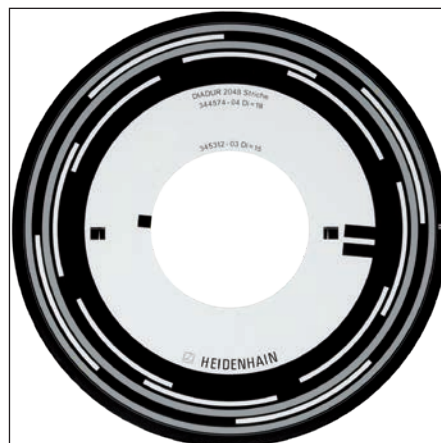
Circular scale with block commutation tracks

📖 **Further information:**

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

Measuring 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:
- Quality of the graduation
- Scanning quality
- Quality of the signal processing electronics
- Eccentricity of the graduation relative to the bearing
- Bearing error
- Coupling with the drive shaft
- Elasticity of the stator coupling (ERN, ECN, EQN) or shaft coupling (ROD, ROC, ROQ)

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

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

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

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

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

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

The following factors influence the outcome:
- Fineness of the signal period
- Homogeneity and period definition of the graduation
- Quality of scanning filter structures
- Characteristics of the sensors
- Stability and dynamic performance of further analog signal processing

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

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

Interpolation error within one revolution

Interpolation error within one signal period
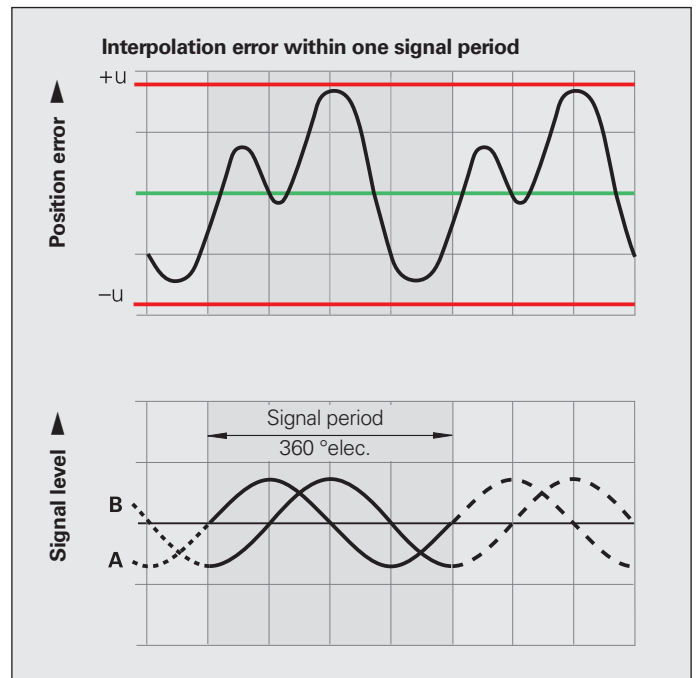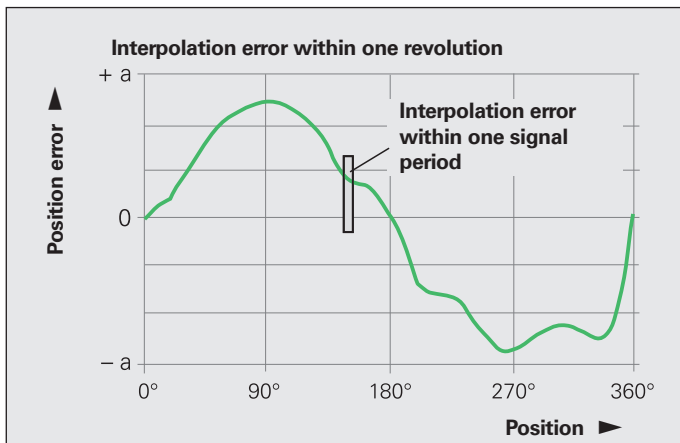
Application-dependent errors

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 **stator coupling** (ERN, ECN, EQN), the system accuracy already includes the error of the shaft coupling.

In contrast, for **encoders without integral bearing**, the mounting, as well as the adjustment of the scanning head, has 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. Of particular importance 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 system accuracy consists of the graduation accuracy and position error within one signal period.

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

In the worst-case scenario, if the centering collar is centered relative to the bearing, then the two eccentricity vectors may be cumulative.
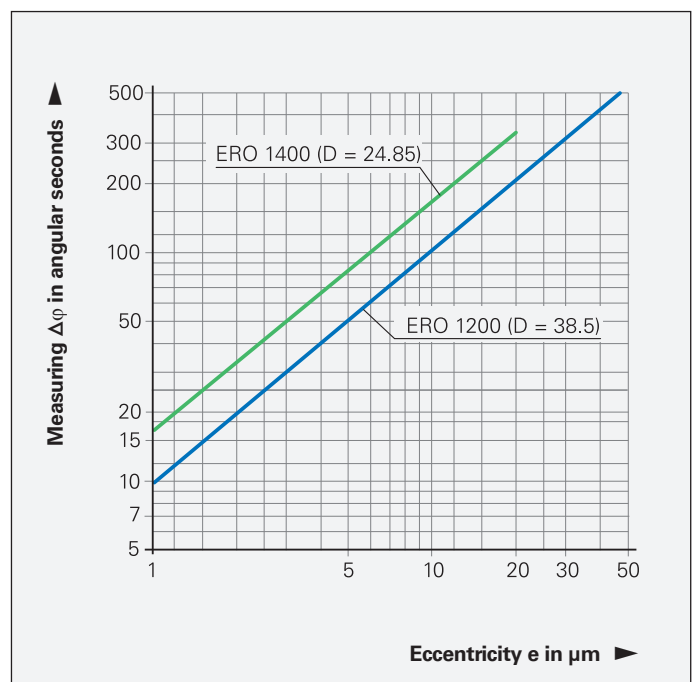
Resultant measuring error Δφ for various eccentricity values e as a function of the mean graduation diameter D

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

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

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

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

3. Radial runout of the bearing

The stated relationship for the measuring error Δφ also applies to the radial runout of the bearing when the eccentricity e is replaced by one half of the radial runout (half of the displayed value).
Bearing compliance under a radial load applied to the shaft causes similar errors.

4. Position error within one signal period Δφ$_u$

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 Δφ$_u$	
		TTL	1 V$_{PP}$
ERO	2048	≤ ±19.0″	≤ ± 6.5″
	1500	≤ ±26.0″	≤ ± 8.7″
	1024	≤ ±38.0″	≤ ±13.0″
	1000	≤ ±40.0″	≤ ±14.0″
	512	≤ ±76.0″	≤ ±25.0″

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

Rotary encoders with inductive scanning

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

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

Model	System accuracy	Total error
ECI 1100 **EBI 1100** **EQI 1100** **EnDat22** **E30-R2**	±120″	±280″
ECI 1300(S) **EQI 1300(S)** **EnDat22** **E30-R2** **DQ01**	±65″	±120″
ECI 100 **EBI 100**	±90″	±180″
ECI 4000(S) **EBI 4000** **90 mm** **hollow shaft** **EnDat22** **DQ01**	±25″	±140″
ECI 4000(S) **EBI 4000** **180 mm** **hollow shaft** **EnDat22** **DQ01**	±40″	±150″
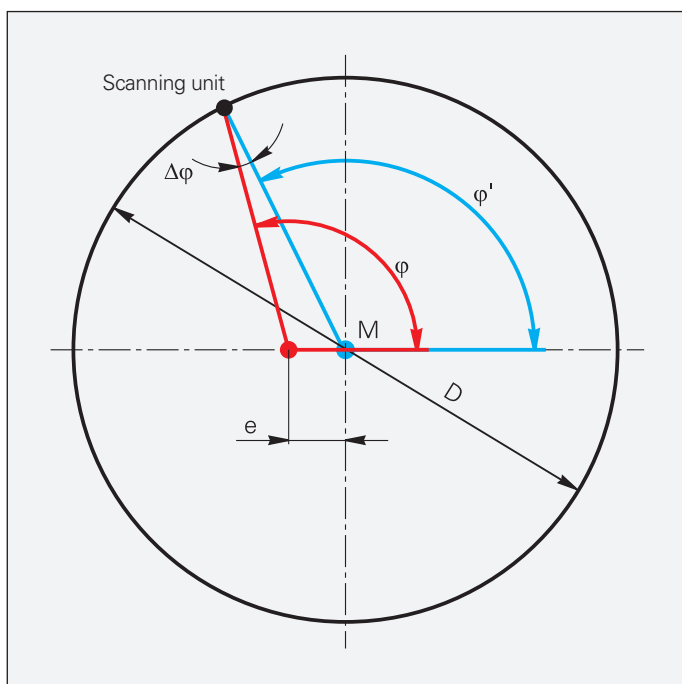
Dependency of the measuring error Δφ on the mean graduation diameter D and the eccentricity e.

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

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

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

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

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

Mounting accessories

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

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

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

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

ECN/EQN 1100
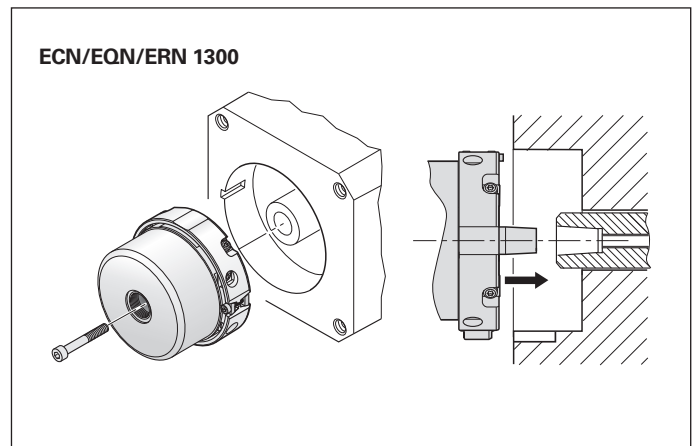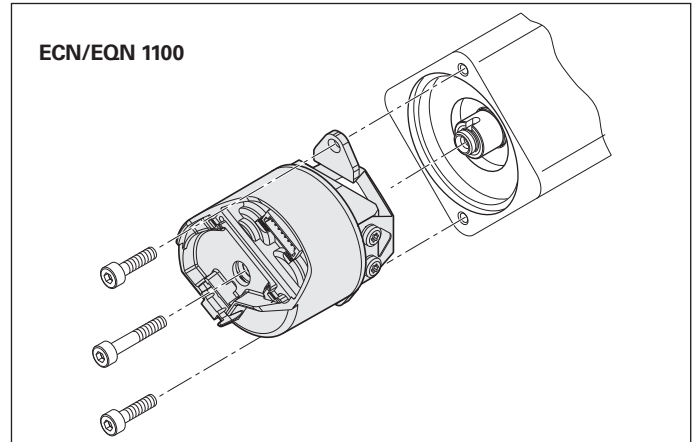
ECN/EQN/ERN 1300

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

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

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

Accessory for ECN/EQN/ERN 1000

Washer

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

ECN/EQN/ERN 1000

1 max.

6 min./21 max.
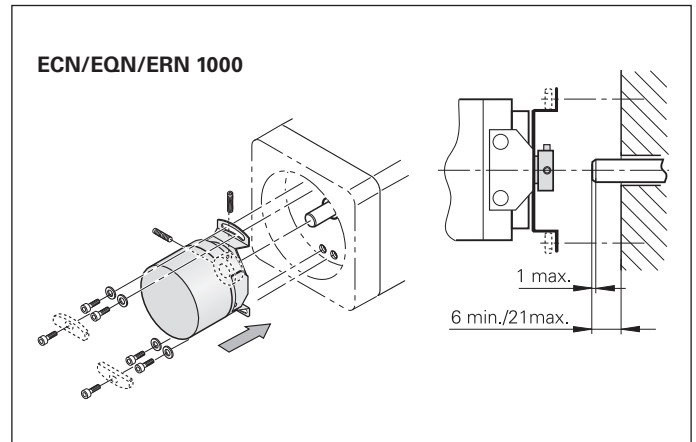
ECI/EBI/EQI rotary encoders without integral bearing

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 accessory
Mounting aid for removing the PCB connector (see page 36).
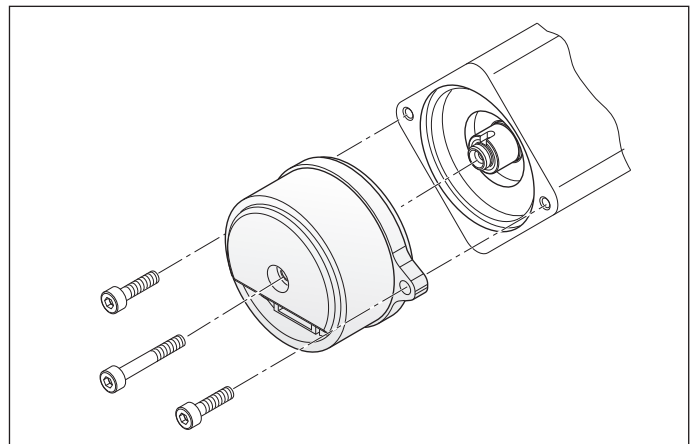

Schematic representation of **ECI/EBI 100**
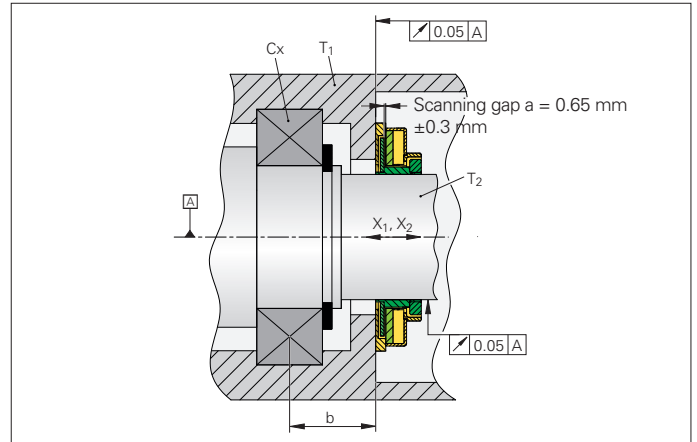
Mounting the **ECI 119**

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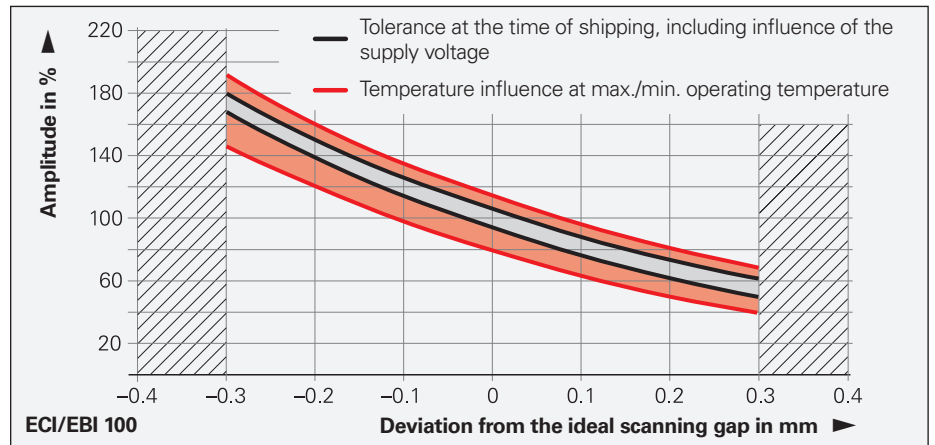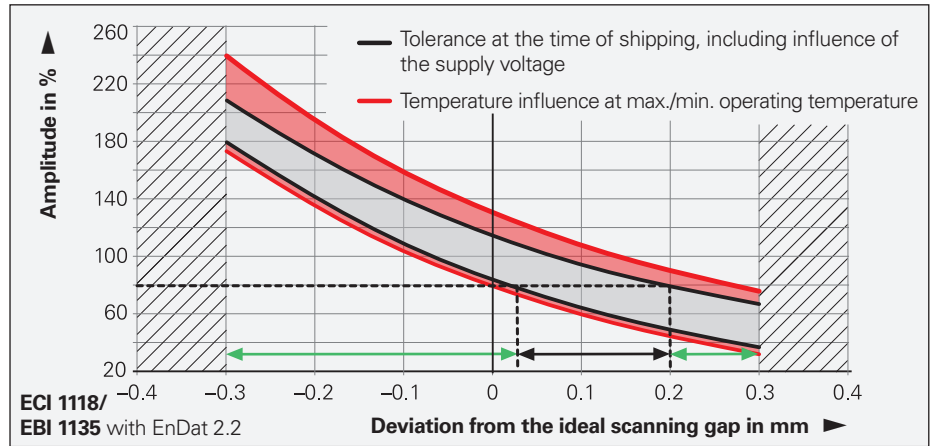
The maximum permissible error specified in the mating dimensions applies to both mounting and operation. Thus, the tolerances exploited during mounting are no longer available during operation.

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% under ideal conditions. Due to tolerances within the rotary encoder, the deviation is between +0.03 mm and +0.2 mm. Thus, the maximum permissible motion of the measured shaft during operation ranges from –0.33 mm to +0.1 mm (green arrows).

Display of the scanning gap

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

ECI 1118/EBI 1135 with EnDat 2.2

- Tolerance at the time of shipping, including influence of the supply voltage
- Temperature influence at max./min. operating temperature

ECI/EBI 100

- Tolerance at the time of shipping, including influence of the supply voltage
- Temperature influence at max./min. operating temperature

Online diagnostics [Open Loop]

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

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

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

The **ECI/EBI/EQI 1300** inductive rotary encoders are mounted flush on their axis. Their blind hollow shaft is fastened with a central screw. The stator of these rotary encoders is clamped to a shoulder by three axial screws.
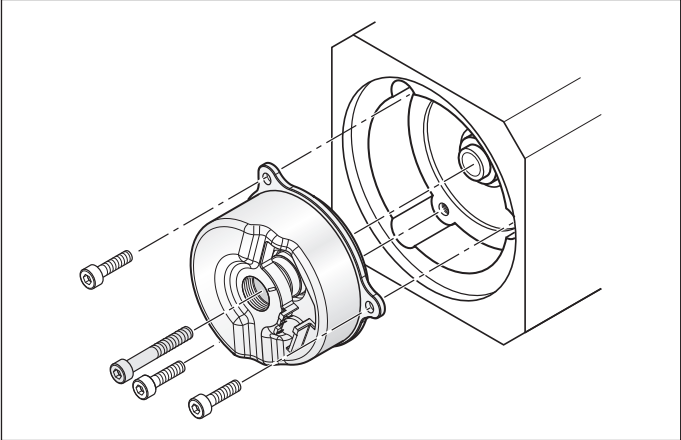
The scale drum of the **ECI/EBI 4000** inductive rotary encoders is slid onto the centering collar of the measured shaft and fastened (with/without a key, depending on the version). Then the stator is fastened via an external centering diameter.
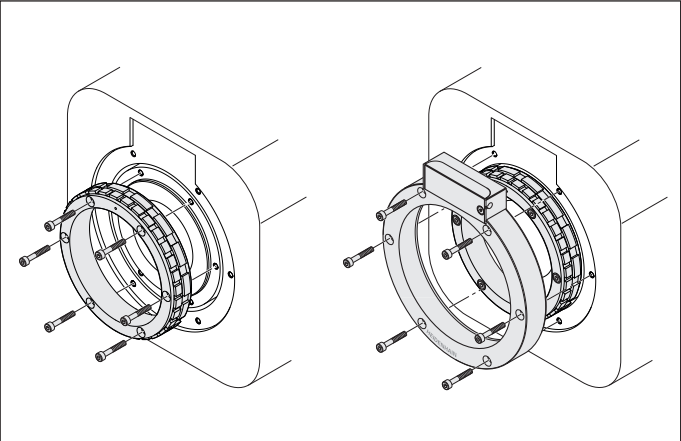
ERO rotary encoders without integral bearing

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 brought into alignment with the scanning unit. The scanning unit is aligned on a centering collar and fastened to the mounting surface.

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

Mounting the **ERO**

ERO 1200

ERO 1400
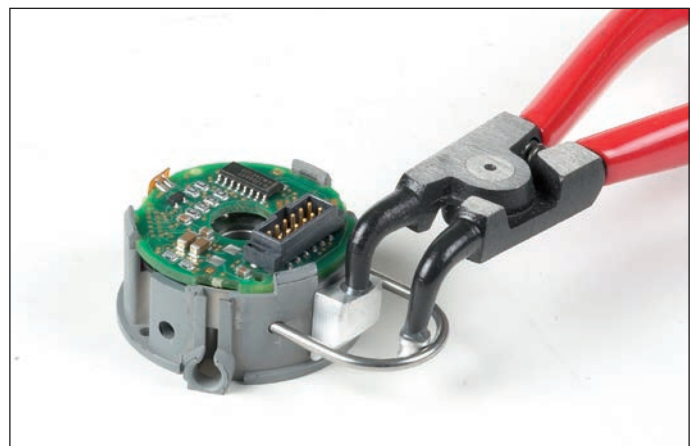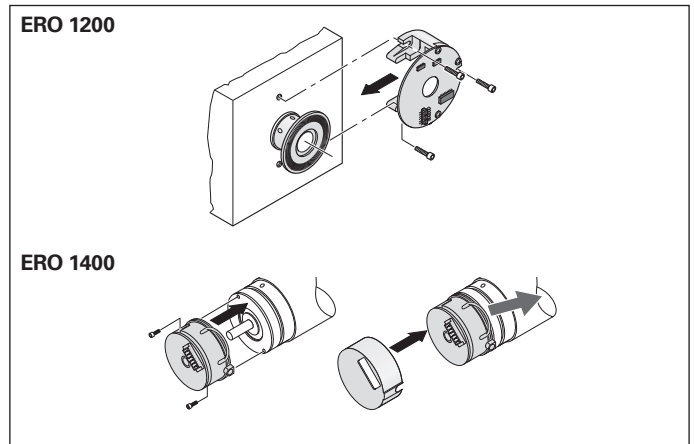
Mounting accessories for the ERO 1400

Mounting accessory
Aid 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 accessories for the **ERO 1400**

35

Information on output cables

Mounting and commissioning 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.

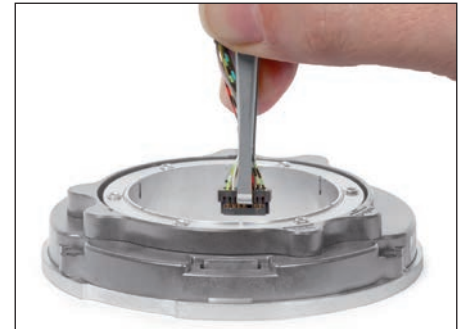The mounting method with M2.5 screws was designed for the following tightening torques:
For M12, M23: min. M_d 0.4 Nm
max. M_d 0.5 Nm
Load-bearing thread length: min. 4 mm
Minimum tensile strength
of the screws: 800 N/mm^2

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

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

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

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

Mounting aid for PCB connector

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

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

Designation of the cable components
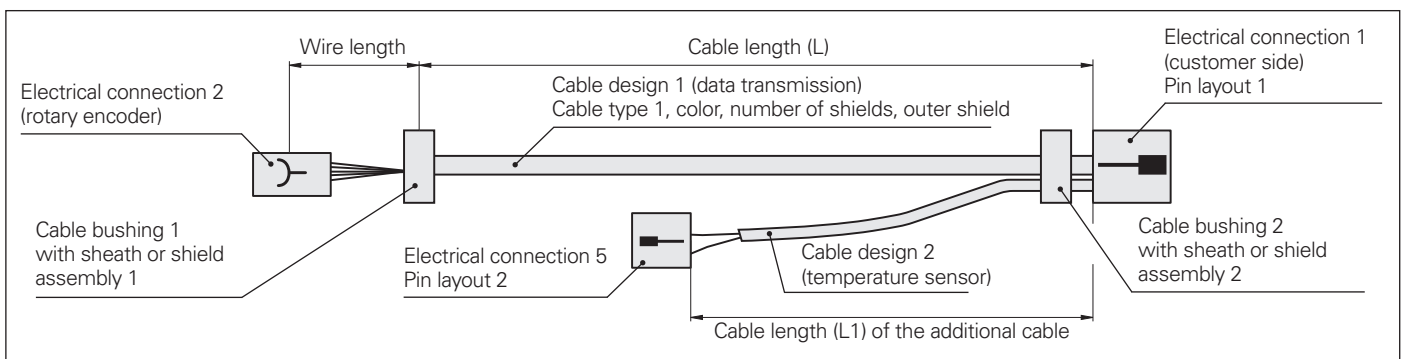
Temperature sensor signals via electrical connection 1

Temperature sensor signals via PCB of rotary encoder

General testing accessories for modular encoders and the PWM 21

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

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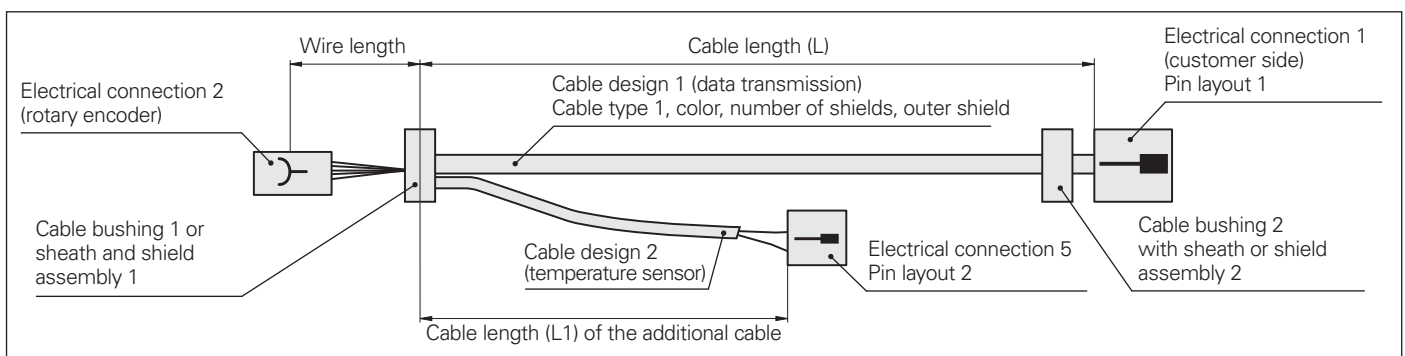Includes three 12-pin adapter connectors and three 15-pin adapter connectors.
ID 621742-01

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

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

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

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

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

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

Adapter connector for ID 1118892-02
Three connectors for replacement
14-pin: ID 528694-04

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

Testing cable for modular rotary encoders

EnDat 3 adapter (SA 1210)

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

For the EnDat22 interface, adapter cable Ø 6 mm
9-pin M23 connector (female)
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)
6-pin RJ45 Ethernet connector
with IP20 metal housing
ID 1117540-xx

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

For EnDat01, EnDat Hx, EnDat Tx or SSI interface with incremental signals, adapter cable Ø 8 mm
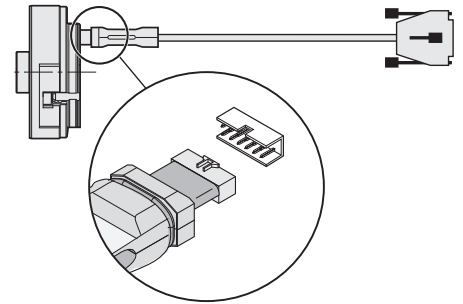17-pin M23 connector (female) and
15-pin D-sub connector (male).
ID 324544-xx

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

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

EnDat 3 interface (E30-R2) for HMC 2, only in combination with EnDat3 adapter Adapter cable Ø 9.3 mm
M12 SpeedTEC hybrid connector (female), four power wires, two brake wires and two communication wires
15-pin D-sub connector (male).
ID 1189174-xx

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

DRIVE-CLiQ is a registered trademark of Siemens AG.

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

Compatible mounting dimensions

Mating dimensions and tolerances must be taken into account during the mounting of rotary encoders. Within some rotary encoder series, the mating dimensions may exhibit only slight differences or even be identical. Certain rotary encoders are therefore mounting-compatible with each other, allowing different encoders to be mounted to the same motor as the requirements dictate.

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

All absolute rotary encoders of the ECN/EQN 1100 FS, ECI/EQI 1100 FS, ECI/EBI 1100 and ECI/EQI 1100 series are mounting-compatible within the respective series, exhibiting only minor differences in the permissible deviation between the shaft surface and coupling surface.
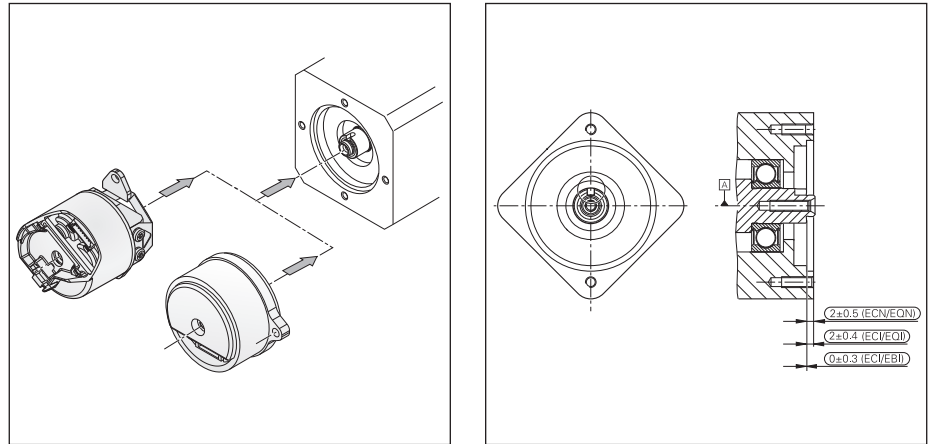
Series	Differences
ECN/EQN 1100 FS	Standard, with slot for FS devices
ECI/EQI 1100 FS	Same as ECN/EQN 1100 FS, but with a different tolerance for the deviation between the shaft and coupling surfaces
ECI 1118/EBI 1135	Same as ECN/EQN 1100 FS, but with a different tolerance for the deviation between the shaft and coupling surfaces
ECI 1119/EQI 1131	Same as ECN/EQN 1100 FS, but with a different tolerance for the deviation between the shaft and coupling surfaces

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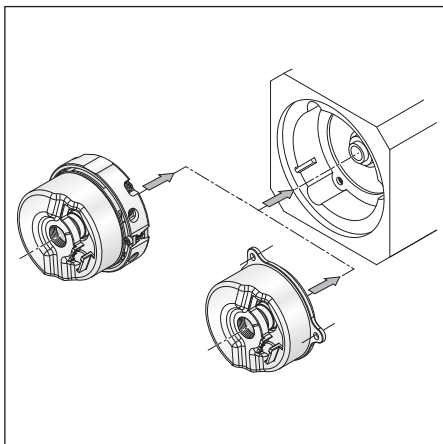
Series	Required mating dimensions			
	ERN 1300	ECN/ EQN 1300 FS	ECI/EBI/ EQI 1300 FS	ECN/ EQN 400 FS
ERN 1300		✓	✓	✓
ECN/EQN 1300 FS			✓	✓
ECI/EQI 1300 FS				
ECN/EQN 400 FS		✓	✓	

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

Mounting accessories

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

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

Screwdriver
When using screwdrivers with adjustable torque, make sure that they comply with DIN EN ISO 6789 for fulfilling the required torque tolerances.

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

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

Screws

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

General information
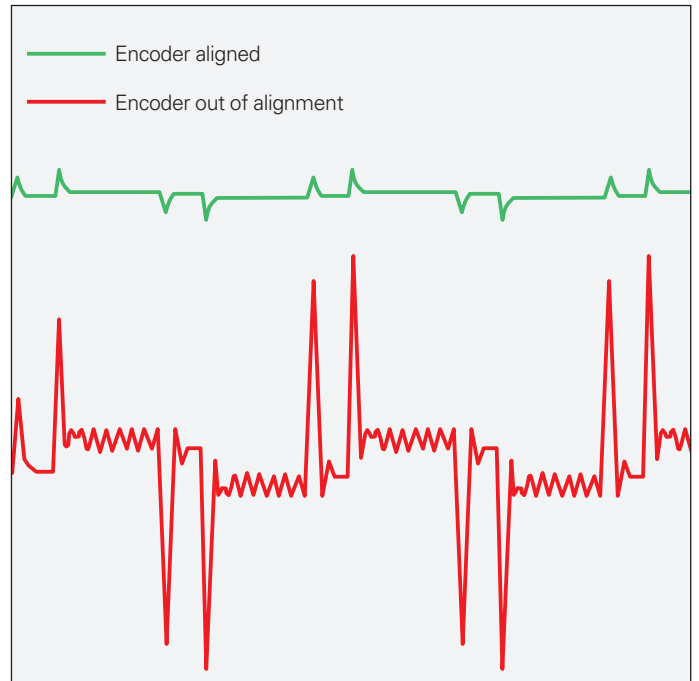## Alignment of rotor positions between encoders and motors

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

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

Rotary encoders with commutation signals are then roughly aligned (e.g., using the line markers on the encoder or the reference mark signal) and are mounted to the motor shaft. Fine adjustment is then performed with the PWT 101 testing device (see *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.

Absolute rotary encoders are first completely mounted, after which a datum shift is used to assign the value "zero" to the preferred motor position. This is performed with the adjusting and testing package (see *Testing and inspection devices, and diagnostics*). This package features complete EnDat functionality, allowing not only datum shifts but also the use of other inspection functions and the setting of write-protection to prevent unintentional changes to saved values.
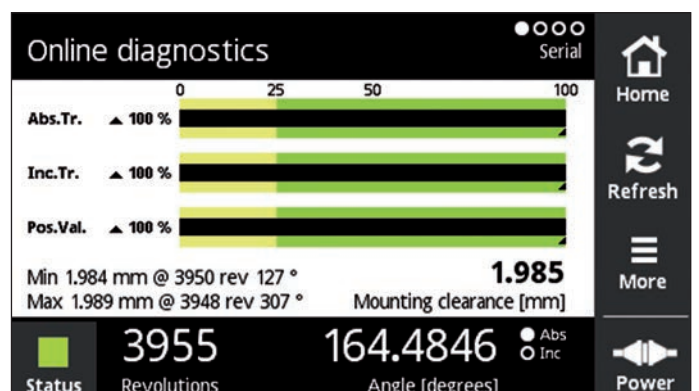
For the ECI/EQI rotary encoders with additional 1 V_{PP} signals, manual adjustment is possible as well. Please follow the information in the respective mounting instructions.

Motor current of aligned encoder and strongly out-of-alignment encoder
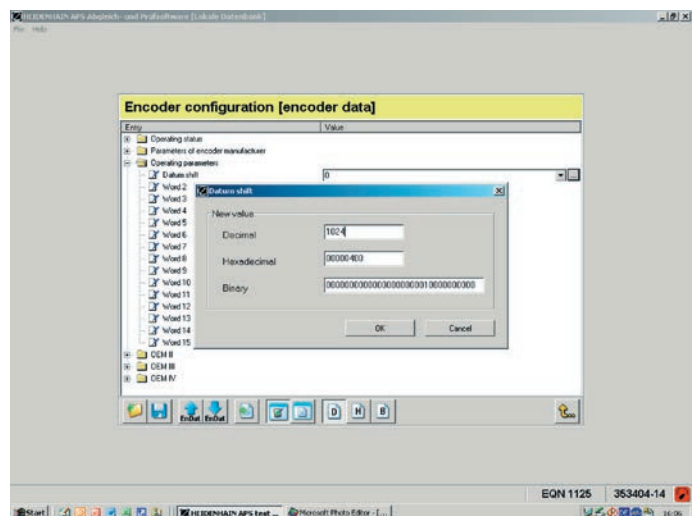
Alignment of the rotor positions by means of the adjusting and testing package

Online diagnostics of the PWT 101

General mechanical information

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

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

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

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

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

Humidity
The maximum permissible relative humidity is 75%. A relative humidity of 93% is temporarily permissible. Condensation is not permissible.

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

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

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

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

Protection against contact (EN 60529)
After completed installation, any rotating parts must be sufficiently protected from unintentional contact during operation.

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

The **shaft inlet** meets an IP64 rating. Splash water must not be allowed to have any harmful effect 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 rotary 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. Such applications require **comprehensive testing of the complete system**, irrespective 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

The work steps and dimensions to be followed during mounting apply only to the mounting instructions available for the encoder. 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, mechanical fault exclusion for screws needed or not). In addition, the stated tolerance ranges in the product's dimension drawing and mounting instructions must be considered.

All provided information on screw connections assumes a mounting temperature of 15 °C to 35 °C.

For the fault exclusion design for functional safety, the following material properties and conditions for the mating surfaces are assumed:

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

Screws with material bonding anti-rotation lock

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

Screw insertion and the application of tightening torque must therefore be completed within five minutes. The required strength is reached at room temperature after six hours. The lower the temperature is, the longer the curing process will take. Curing temperatures below 5 °C are not permissible.
Screws with material bonding anti-rotation lock must not be used more than once. If a replacement becomes necessary, recut the threads and use new screws. On threaded holes, a chamfer is required in order to keep the adhesive coating from being scraped off.

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

Modifications to the encoder

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

Conditions for longer storage periods

For a storage period of twelve months or longer, HEIDENHAIN recommends the following:
- 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 subjected 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, which is equivalent to 40 000 operating hours under typical operating conditions.

Temperature ranges

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

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

An encoder's susceptibility to self-heating depends both on its design characteristics (stator coupling / solid shaft, shaft sealing ring, etc.) and on its operating parameters (shaft speed, supply voltage). A temporary period of intensified 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	$\approx$ +10 K
ROC/ROQ/ROD Solid shaft	$\approx$ +5 K With IP66 rating: $\approx$ +10 K
ECN/EQN/ ERN 400/1300 Tapered shaft	$\approx$ +5 K With IP66 rating: $\approx$ +10 K
ECN/EQN/ ERN 400/1300 Blind hollow shaft	$\approx$ +30 K With IP66 rating: $\approx$ +40 K
ECN/EQN/ ERN 400 Hollow through shaft	$\approx$ +40 K With IP66 rating: $\approx$ +50 K
ECN/ERN 100 Hollow through shaft	$\approx$ +50 K
ROD 600	$\approx$ +75 K

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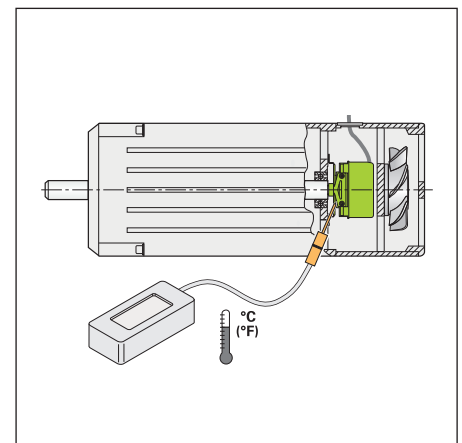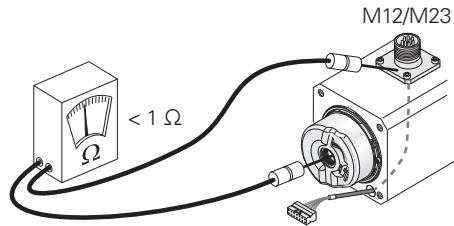

Measuring the actual operating temperature at the defined measuring point of the rotary encoder (see *Specifications*)

Electrical resistance

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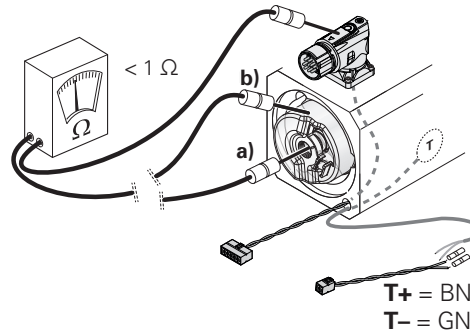Nominal value: < 1 ohm

M12/M23

< 1 Ω

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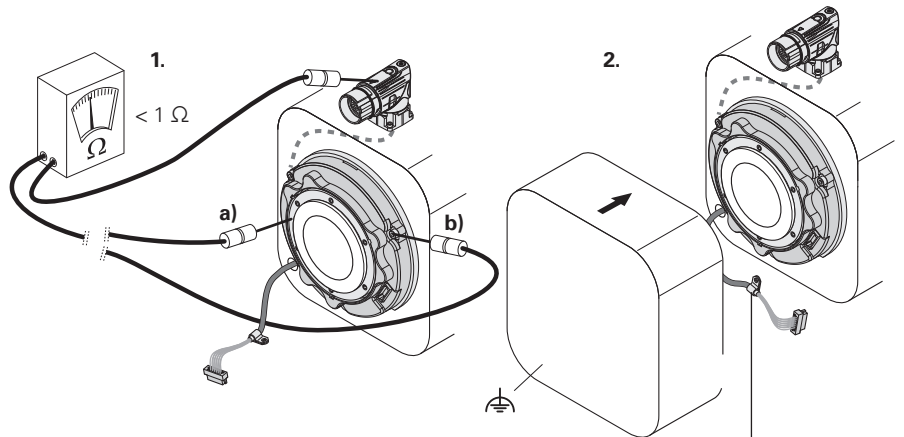
Encoders with hybrid bearing or EnDat 3 (E30-R2)
Check the resistance between the flange socket and the rotor **a)**, and between the flange socket and the stator (metal housing) **b)**.
Nominal value: < 1 ohm

< 1 Ω
b)
a)

T+ = BN
T− = GN

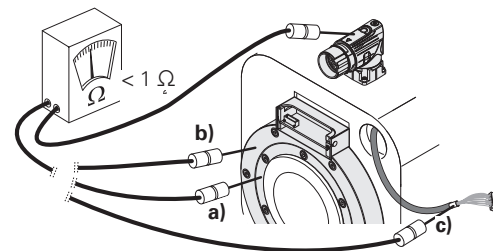**Exposed encoders (Exl 100) without integral bearing but with a pluggable output cable**
Check the electrical resistance between the flange socket and the rotor **a)**, and between the flange socket and the stator (mounting screw) **b)**.
Nominal value: < 1 ohm

1.
< 1 Ω
a)
b)

2.

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 ohm

< 1 Ω
b)
a)
c)

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 ohm

1.
< 1 Ω
b)
a)

2.
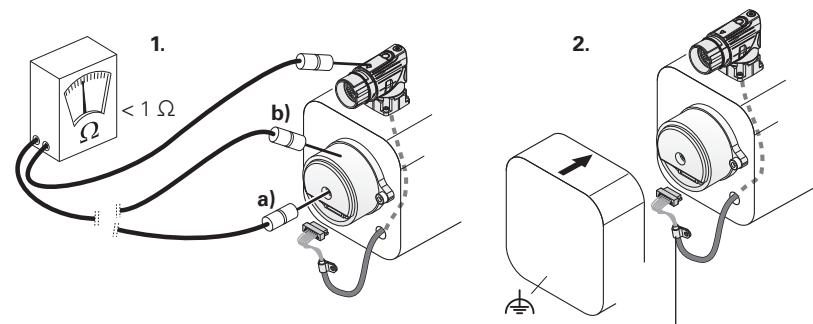
Clamp (when present) must be screwed to the motor housing so as to be conductive.

Temperature measurement in motors

Transmission of temperature data

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

Signaling of a temperature exceedance

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

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

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

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

Encoder	Interface	Internal temperature sensor[1]	External temperature sensor Connection
ECI/EQI 1100	EnDat22	✓ (±1 K)	Possible
	E30-R2		
ECI/EBI 1100	EnDat22	✓ (±5 K)	–
ECN/EQN 1100	EnDat22	✓ (±5 K)	Possible
	EnDat01	–	–
	DQ	✓ (±7 K)	Possible (±7 K)
ECN/EQN 1300	EnDat22	✓ (±4 K)	Possible
	E30-R2	✓ (±1 K)	–
	EnDat01	–	–
	DQ01	✓ (±1 K)	Possible
ECN/EQN 400	EnDat22	✓ (±4 K)	Possible
	EnDat01	–	–
ECI/EBI/EQI 1300	EnDat22	✓ (±1 K)	Possible
ECI/EQI 1300	E30-R2	✓ (±1 K)	Possible
ECI/EQI 1300 S	DQ		
ECI/EBI 100	EnDat22	✓ (±4 K)	Possible
	EnDat01	–	–
ECI/EBI 4000	EnDat22	✓ (±1 K)	Possible

[1] In parentheses: accuracy at 125 °C

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

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

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).
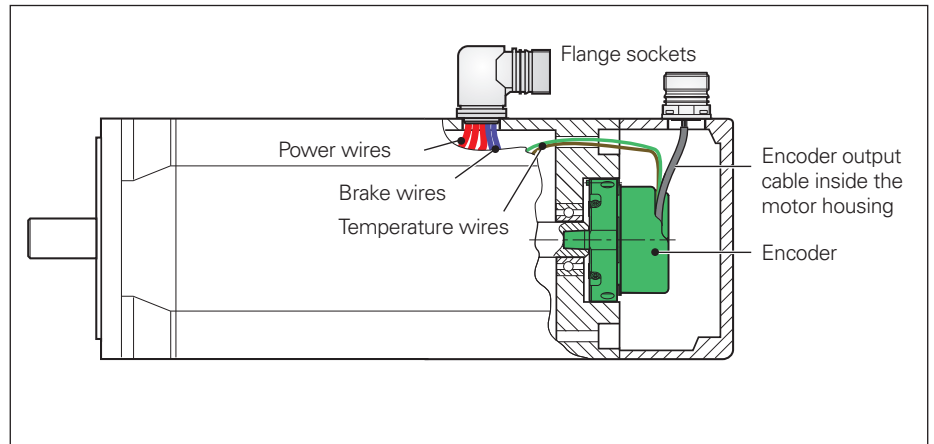
Cable configuration of the temperature wires in the motor

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 $R_V = 2\ k\Omega$
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] With wire cross section of 0.16 mm^2 for TPE, or 0.25 mm^2 for cross-linked polyolefin	≤ 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.
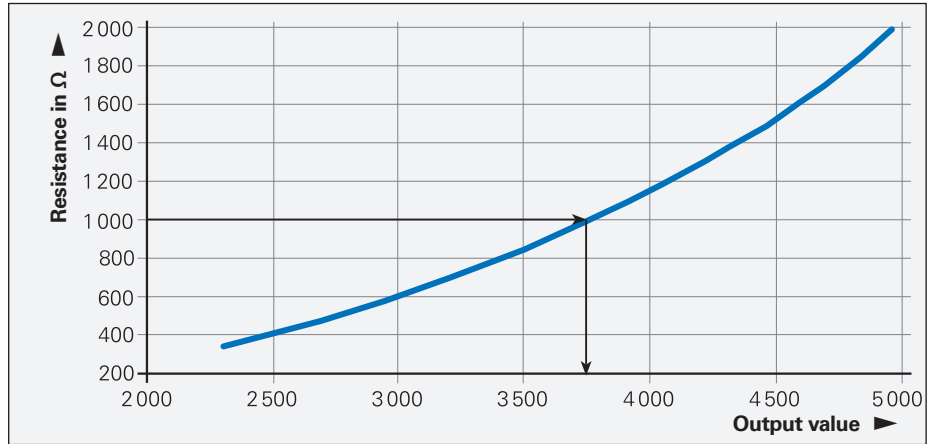
Figure 1: Relationship between the output value and resistance

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.
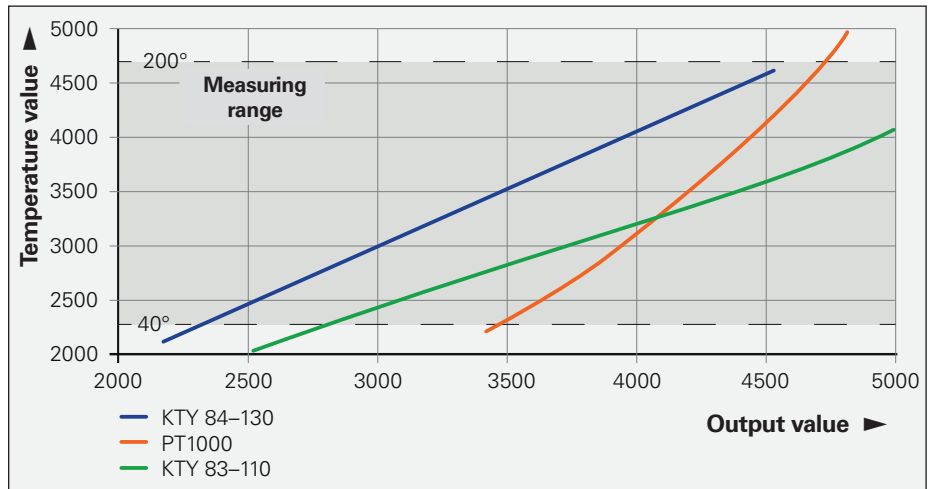
General notes on the evaluation:
- Output signals ≤ 1151 indicate a short-circuit at the sensor input
- Output signals > 6000 indicate a high-impedance sensor input (e.g., due to a broken wire)

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

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

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

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

A = Output value. The PT 1000 polynomial is valid for: $3400 \leq A \leq 4810$.

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

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

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

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ECN/EQN 1100 series

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

Required mating dimensions

mm

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

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

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

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	Absolute			
	ECN 1113	**ECN 1123** **ECN 1123 S** *Functional Safety*	**EQN 1125**	**EQN 1135** **EQN 1135 S** *Functional Safety*
Interface	EnDat 2.2	*ECN 1123:* EnDat 2.2 *ECN 1123 S:* DRIVE-CLiQ	EnDat 2.2	*EQN 1135:* EnDat 2.2 *EQN 1135 S:* DRIVE-CLiQ
Ordering designation	EnDat01	*ECN 1123:* EnDat22 *ECN 1123 S:* DQ01	EnDat01	*EQN 1135:* EnDat22 *EQN 1135 S:* DQ01
Position values per revolution	8192 (13 bits)	8 388 608 (23 bits)	8192 (13 bits)	8 388 608 (23 bits)
Revolutions	–		4096 (12 bits)	
Elec. permiss. shaft speed/ deviations[1]	4000 rpm/±1 LSB 12 000 rpm/±16 LSB	12 000 rpm (for continuous position value)	4000 rpm/±1 LSB 12 000 rpm/±16 LSB	12 000 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
Calculation time TIME_MAX_ACTVAL[5]	–	*ECN 1123 S:* ≤ 8 µs	–	*EQN 1135 S:* ≤ 8 µs
Incremental signals	$\sim$ 1 V_{PP}[2]	–	$\sim$ 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 to 14 V *ECN 1123 S:* DC 10 to 28.8 V	DC 3.6 V to 14 V	*EQN 1135:* DC 3.6 to 14 V *EQN 1135 S:* DC 10 to 28.8 V
Power consumption (max.)	*3.6 V:* ≤ 0.6 W *14 V:* ≤ 0.7 W	*ECN 1123:* *3.6 V:* ≤ 0.6 W *14 V:* ≤ 0.7 W *ECN 1123 S:* *10 V:* ≤ 0.85 W *28.8 V:* ≤ 0.9 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 *EQN 1135 S:* *10 V:* ≤ 0.95 W *28.8 V:* ≤ 1 W
Current consumption (typical)	*5 V:* 85 mA (without load)	*5 V:* 85 mA (without load) *24 V:* 32 mA (without load)	*5 V:* 105 mA (without load)	*5 V:* 105 mA (without load) *24 V:* 35 mA (without load)
Shaft	1KA blind hollow shaft (Ø 6 mm) with positive-locking element			
Mech. permiss. shaft speed n	12 000 rpm			
Starting torque (typical)	0.001 Nm (at 20 °C)		0.002 Nm (at 20 °C)	
Moment of inertia of rotor	$\approx 0.4 \cdot 10^{-6}$ kgm²			
Permissible axial motion of measured shaft	±0.5 mm			
Vibration 55 Hz to 2000 Hz **Shock:** 6 ms	≤ 200 m/s² (EN 60068-2-6) ≤ 1000 m/s² (EN 60068-2-27)			
Max. operating temperature	115 °C	*ECN 1123:* 115 °C *ECN 1123 S:* 95 °C	115 °C	*EQN 1135:* 115 °C *EQN 1135 S:* 95 °C
Min. operating temperature	–40 °C			
Protection rating EN 60529	IP40 (read about insulation under *Electrical safety* in the *Interfaces of HEIDENHAIN Encoders* brochure); contamination from the ingress of fluid must be prevented)			
Mass	≈ 0.1 kg			
ID number	803427-xx	*ECN 1123:* 803429-xx *ECN 1123 S:* 1211015-xx	803428-xx	*EQN 1135:* 803430-xx *EQN 1135 S:* 1211017-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 rotary encoders
[5] Applies only to DRIVE-CLiQ rotary encoders

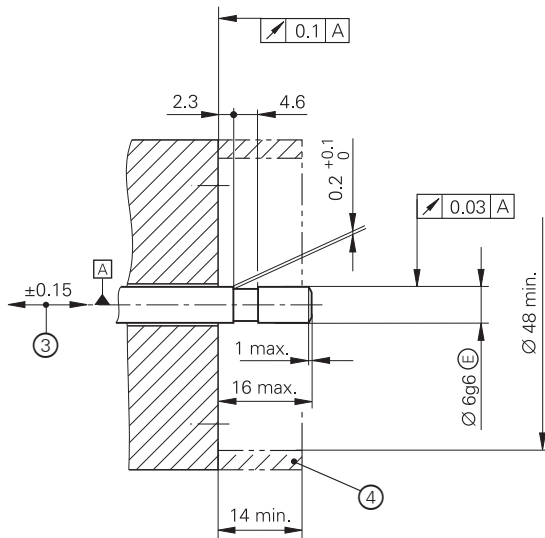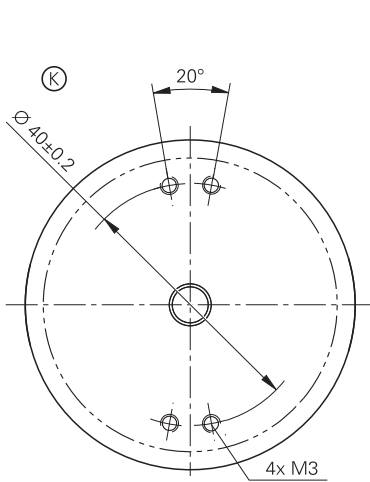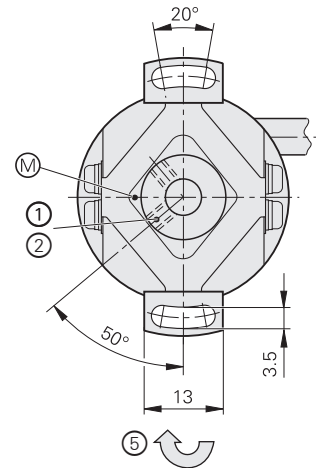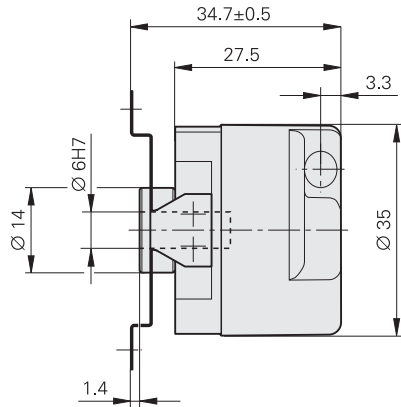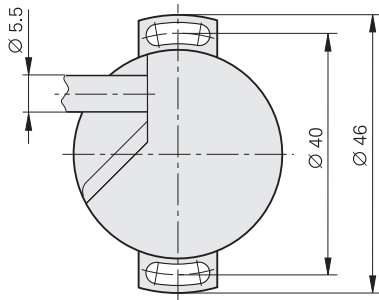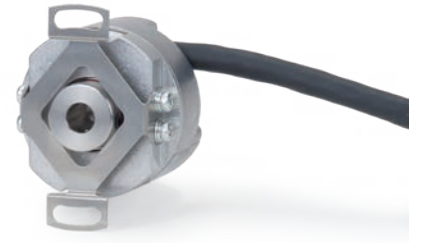For dimensions and specifications of encoders with functional safety, see the Product Information document.

ERN 1023

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

Ø 5.5

34.7±0.5
27.5
3.3
Ø 6H7
Ø 14
Ø 35
1.4

Ø 40
Ø 46

20°
M
1
2
50°
13
3.5
5

Ⓚ
20°
Ø 40±0.2
4x M3

0.1 | A
2.3
4.6
0.2 +0.1 / 0
0.03 | A
A
±0.15
3
1 max.
16 max.
Ø 6g6 Ⓔ
Ø 48 min.
14 min.
4

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

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

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

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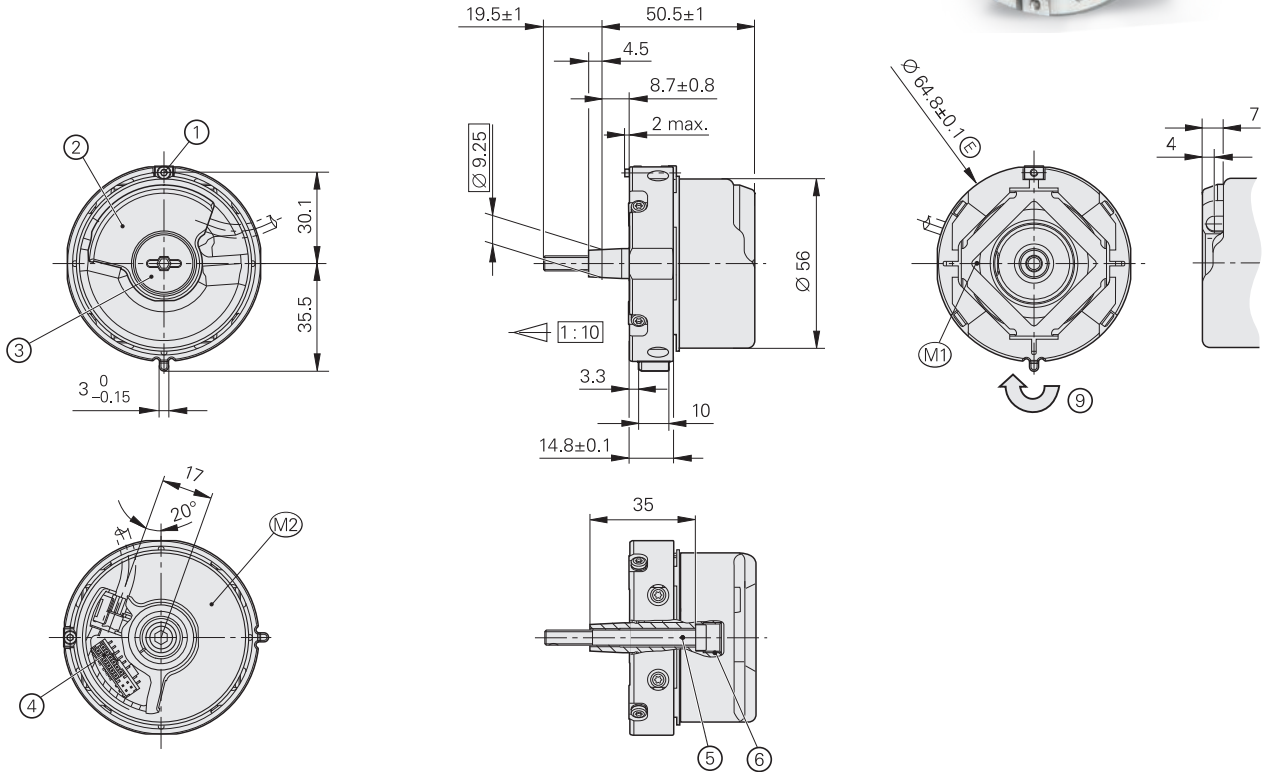* Please select when ordering
[1] Three square-wave signals with signal periods with 90°, 120° or 180° mech. phase shift; see *Commutation signals for block commutation* in the *Interfaces of HEIDENHAIN Encoders* brochure

ERN 1123

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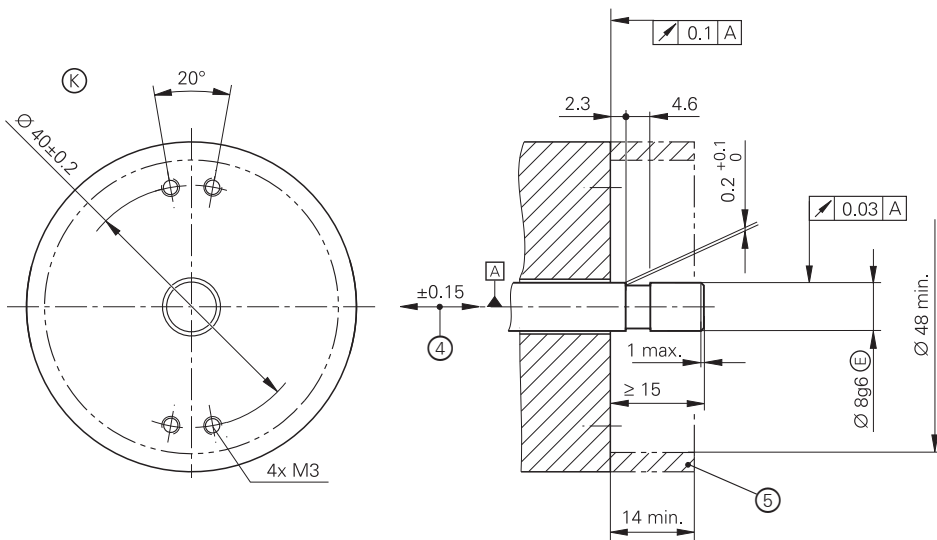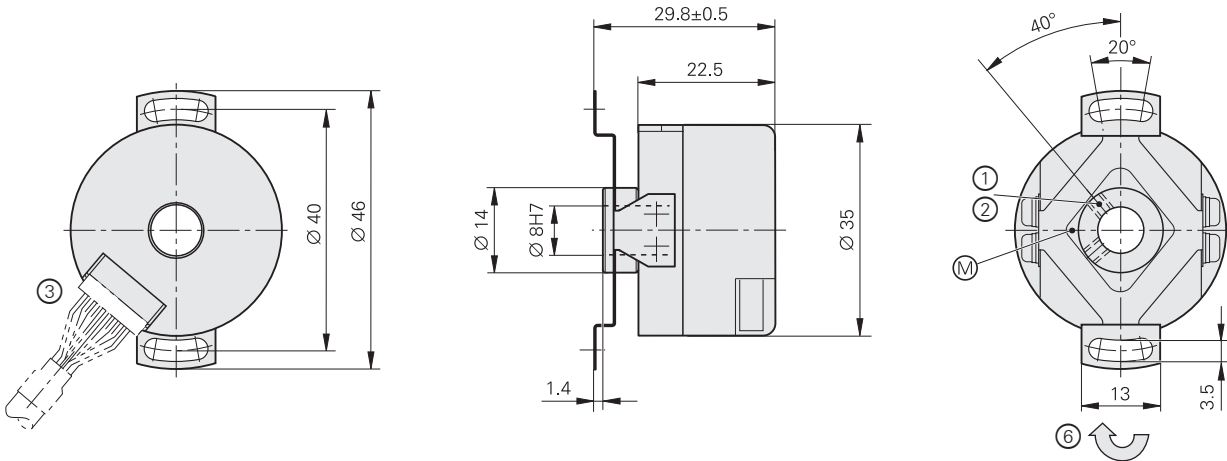
mm

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

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

	ERN 1123											
Interface	⎍TTL											
Signal periods per revolution*	**500**	**512**	600	**1000**	**1024**	1250	**2000**	**2048**	**2500**	4096	5000	8192
Reference mark	One											
Output frequency Edge separation *a*	≤ 300 kHz ≥ 0.41 µs											
Commutation 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 n	≤ 6000 rpm											
Starting torque (typical)	0.005 Nm (at 20 °C)											
Moment of inertia of rotor	$0.5 \cdot 10^{-6}$ kgm^2											
Permissible axial motion of measured shaft	±0.15 mm											
Vibration 25 Hz to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)											
Operating temperature	–20 °C to 90 °C											
Protection EN 60529	IP00[2]											
Mass	≈ 0.06 kg											
ID number	684702-xx											

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

ECN/EQN 1300 series

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

Required mating dimensions

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

*) Ø 65+0.02 for ECI/EQI 13xx

Ⓐ = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration (see D741714)
1   = Clamping screw for coupling ring; width A/F 2
2   = Die-cast cover
3   = Screw plug; widths A/F 3 and 4
4   = 16-pin (12+4-pin) header
5   = Screw: DIN 6912 – M5x50 – 08.8 – MKL SW4
6   = M10 back-off thread
7   = Compensation of mounting tolerances and thermal expansion, no dynamic motion permitted
8   = Chamfer at start of thread is mandatory for material bonding anti-rotation lock
9   = Direction of shaft rotation for ascending position values

	Absolute ECN 1313 EQN 1325	ECN 1325 EQN 1337 **Functional Safety**	ECN 1325 EQN 1337 **Functional Safety**
Interface	EnDat 2.2		EnDat3
Ordering designation	EnDat01	EnDat22	E30-R2
Position values per revolution	8192 (13 bits)	33 554 432 (25 bits)	33 554 432 (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)	
Calculation time t_{cal} Clock frequency	≤ 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	$\sim$ 1 V$_{PP}$[1]	–	
Line count*	512 2048	2048	
Cutoff frequency –3 dB	*2048 lines:* ≥ 400 kHz *512 lines:* ≥ 130 kHz	–	
System accuracy	*512 lines:* ±60″; *2048 lines:* ±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 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 (without communication) *EQN 1337 At 12 V:* 40 mA (without communication)
Shaft	Tapered shaft Ø (9.25 mm); taper: 1:10		
Mech. permiss. shaft speed n	*ECN 1313 / ECN 1325:* ≤ 15000 rpm; *EQN 1325 / EQN 1337:* ≤ 12000 rpm		
Starting torque (typical)	0.01 Nm (at 20 °C)		
Moment of inertia of rotor	$2.6 \cdot 10^{-6}$ kgm^2		
Natural frequency f_N (typical)	1800 Hz		
Permissible 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		
ID 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 EnDat3
[4] Valid as per standard at room temp.; the following applies at operating temps. up to 100 °C: ≤ 300 m/s^2; up to 115 °C: ≤ 150 m/s^2

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

ECN/EQN 1300 S series

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

Required mating dimensions

mm

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

Ⓐ = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration (see D741714)
1 = Clamping screw for coupling ring; width A/F 2
2 = Die-cast cover
3 = Screw plug; widths A/F 3 and 4
4 = 16-pin (12+4-pin) header
5 = Screw: DIN 6912 – M5x50 – 08.8 – MKL SW4
6 = M10 back-off thread
7 = Compensation of mounting tolerances and thermal expansion, no dynamic motion permitted
8 = Chamfer at start of thread is mandatory for material bonding anti-rotation lock
9 = Direction of shaft rotation for ascending position values

	Absolute	
	ECN 1324S Functional Safety	**EQN 1336S** Functional Safety
Interface	DRIVE-CLiQ	
Ordering designation	DQ01	
Position values per revolution	16 777 216 (24 bits)	
Revolutions	–	4096 (12 bits)
Shaft speed	≤ 15 000 rpm (at ≥ 2 position requests per revolution)	≤ 12 000 rpm (at ≥ 2 position requests per revolution)
Calculation time TIME_MAX_ACTVAL	≤ 8 µs	
Incremental signals	–	
System accuracy	±20″	
Electrical connection	16-pin (12+4-pin); with connection for external temperature sensor[1]	
Supply voltage	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	$2.6 \cdot 10^{-6} \ kgm^2$	
Natural frequency f_N (typical)	1800 Hz	
Permissible axial motion of measured shaft	±0.5 mm	
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)	
Operating temperature	–30 °C to 100 °C	
Protection EN 60529	IP40 when mounted	
Mass	≈ 0.25 kg	
ID number	1179144-xx	1179145-xx

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

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

DRIVE-CLiQ is a registered trademark of Siemens AG.

ECN/EQN 400 series

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

Required mating dimensions

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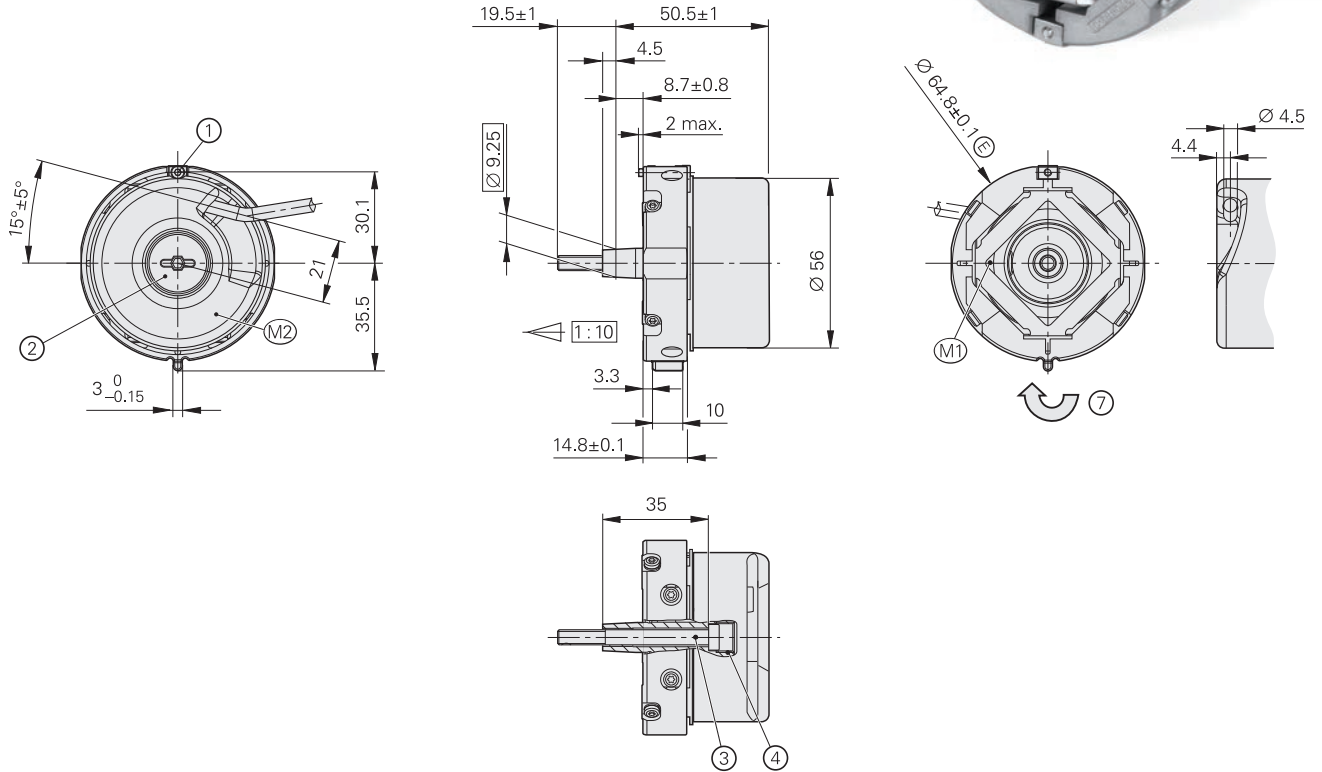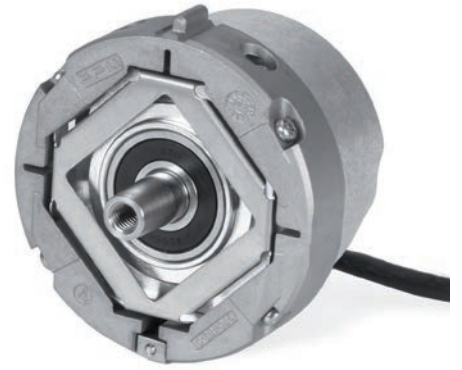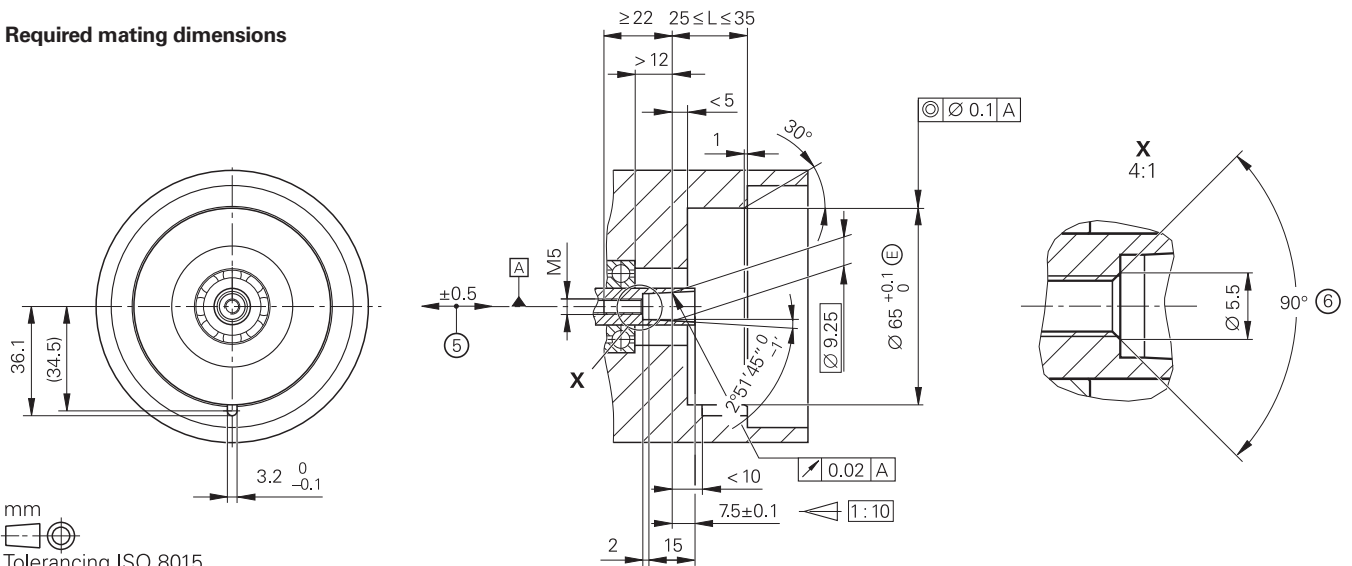
Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

Ⓐ = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration (see D741714)
1 = Clamping screw for coupling ring; width A/F 2
2 = Screw plug; widths A/F 3 and 4
3 = Screw: DIN 6912 – M5x50 – 08.8 – MKL SW4
4 = Back-off thread M10
5 = Compensation of mounting tolerances and thermal expansion; no dynamic movement permitted
6 = Chamfer at start of thread is mandatory for material bonding anti-rotation lock
7 = Direction of shaft rotation for ascending position values

	Absolute			
	ECN 413	**ECN 425** Functional Safety	**EQN 425**	**EQN 437** Functional Safety
Interface	EnDat 2.2			
Ordering designation	EnDat01	EnDat22	EnDat01	EnDat22
Position values per revolution	8192 (13 bits)	33 554 432 (25 bits)	8192 (13 bits)	33 554 432 (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	$\sim$ 1 V_{PP}[1]	–	$\sim$ 1 V_{PP}[1]	–
Line count	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	$2.6 \cdot 10^{-6}$ kgm^2			
Natural frequency f_N (typical)	1800 Hz			
Permissible axial motion of measured shaft	±0.5 mm			
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)			
Max. operating temperature	100 °C			
Min. operating temperature	*Fixed cable*: –40 °C *Moving cable:* –10 °C			
Protection EN 60529	IP64 when mounted			
Mass	≈ 0.25 kg			
ID number	1065932-xx	683644-xx	1109258-xx	683646-xx

* Please select when ordering
[1] Deviating tolerances

Signal amplitude:	0.8 V_{PP} to 1.2 V_{PP}
Asymmetry:	0.05
Amplitude ratio:	0.9 to 1.1
Phase angle:	90° elec. ±5° elec.

[2] Speed-dependent deviations between absolute and incremental signals

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

ERN 1300 series

Incremental rotary encoders
- **06 stator coupling for axial mounting**
- **65B tapered shaft**
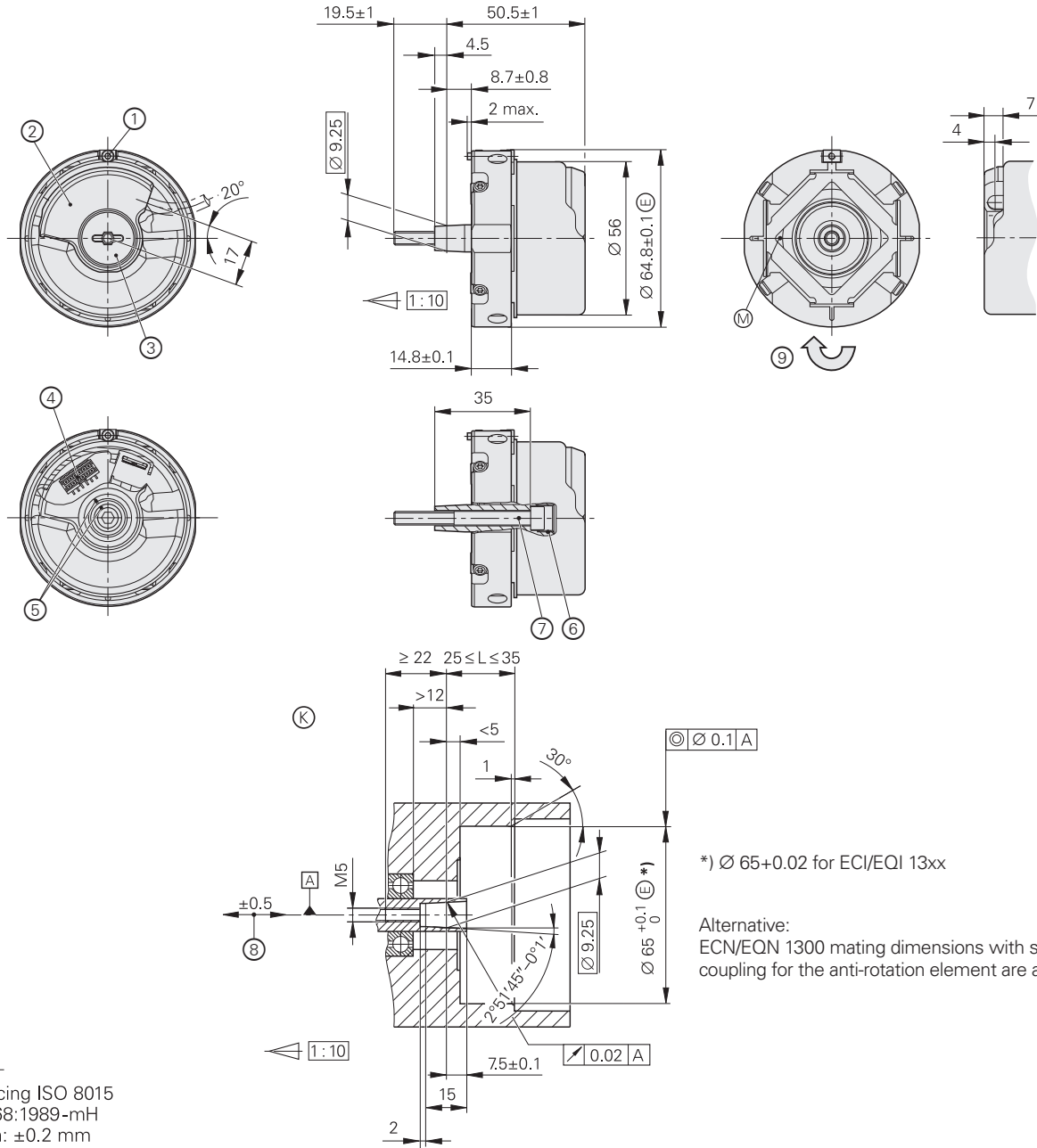
*) Ø 65+0.02 for ECI/EQI 13xx

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

mm

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

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

60

	Incremental				
	ERN 1321	**ERN 1381**	**ERN 1387**	**ERN 1326**	
Interface	⊓⊔ TTL	∿ 1 V_{PP} [1]		⊓⊔ TTL	
Line count*/ System accuracy	1024/±64″ 2048/±32″ 4096/±16″	512/±60″ 2048/±20″ 4096/±16″	2048/±20″	1024/±64″ 2048/±32″ 4096/±16″	8192/±16″ [5]
Reference mark	One				
Output frequency Edge separation a Cutoff frequency –3 dB	≤ 300 kHz ≥ 0.35 µs –	– – ≥ 210 kHz		≤ 300 kHz ≥ 0.35 µs –	≤ 150 kHz ≥ 0.22 µs –
Commutation signals	–		∿ 1 V_{PP} [1]	⊓⊔ TTL	
Width*	–		Z1 track [2]	3 x 120°; 4 x 90° [3]	
Electrical connection	12-pin		14-pin	16-pin	
Supply voltage	DC 5 V ±0.5 V		DC 5 V ±0.25 V	DC 5 V ±0.5 V	
Current consumption (without load)	≤ 120 mA		≤ 130 mA	≤ 150 mA	
Shaft	Tapered shaft ∅ (9.25 mm); taper: 1:10				
Mech. permiss. shaft speed n	≤ 15 000 rpm				
Starting torque (typical)	0.01 Nm (at 20 °C)				
Moment of inertia of rotor	$2.6 \cdot 10^{-6}$ kgm^2				
Natural frequency f_N (typical)	1800 Hz				
Permissible axial motion of measured shaft	±0.5 mm				
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2 [4] (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)				
Max. operating temperature	120 °C	120 °C *4096 lines:* 80 °C	120 °C		
Min. operating temperature	–40 °C				
Protection EN 60529	IP40 when mounted				
Mass	≈ 0.25 kg				
ID number	385423-xx	534118-xx	749144-xx	574485-xx	

* Please select when ordering
[1] Deviating tolerances

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

[2] One sine and one cosine signal per revolution; see the *Interfaces of HEIDENHAIN Encoders* brochure
[3] Three square-wave signals with signal periods with 90° or 120° mech. phase shift; see the *Interfaces of HEIDENHAIN Encoders* brochure
[4] Valid as per standard at room temperature; at operating temperatures up to 100 °C: ≤ 300 m/s^2; up to 120 °C: ≤ 150 m/s^2
[5] Via integrated signal doubling

ECI/EQI 1100 series

Absolute rotary encoders
- **Flange for axial mounting**
- **Blind hollow shaft**
- **Without integral bearing**
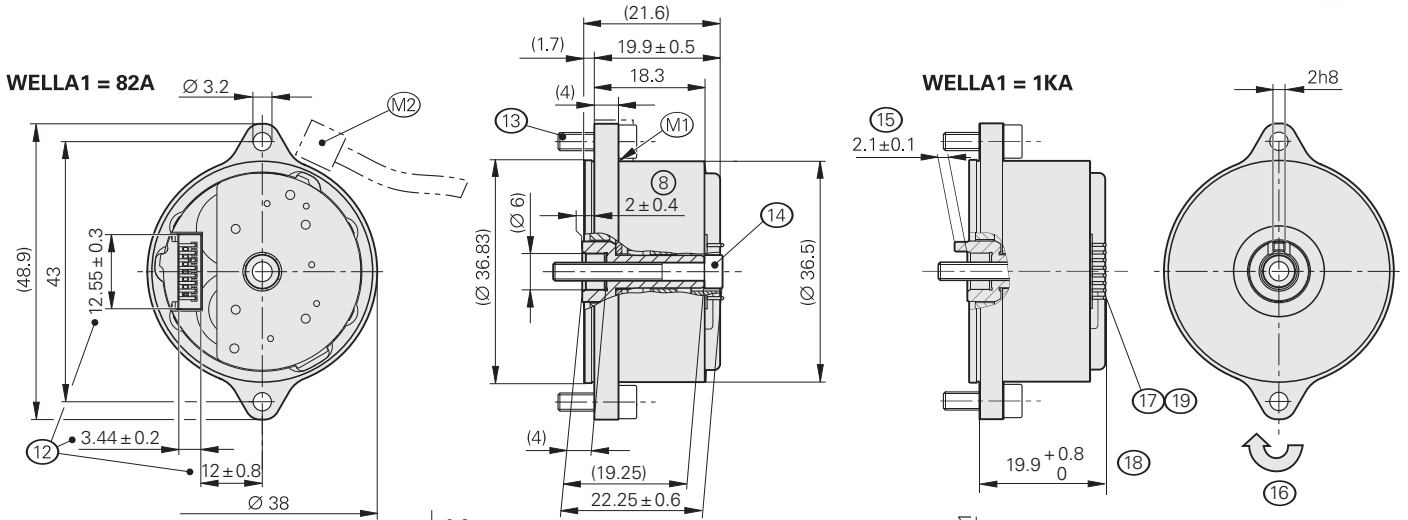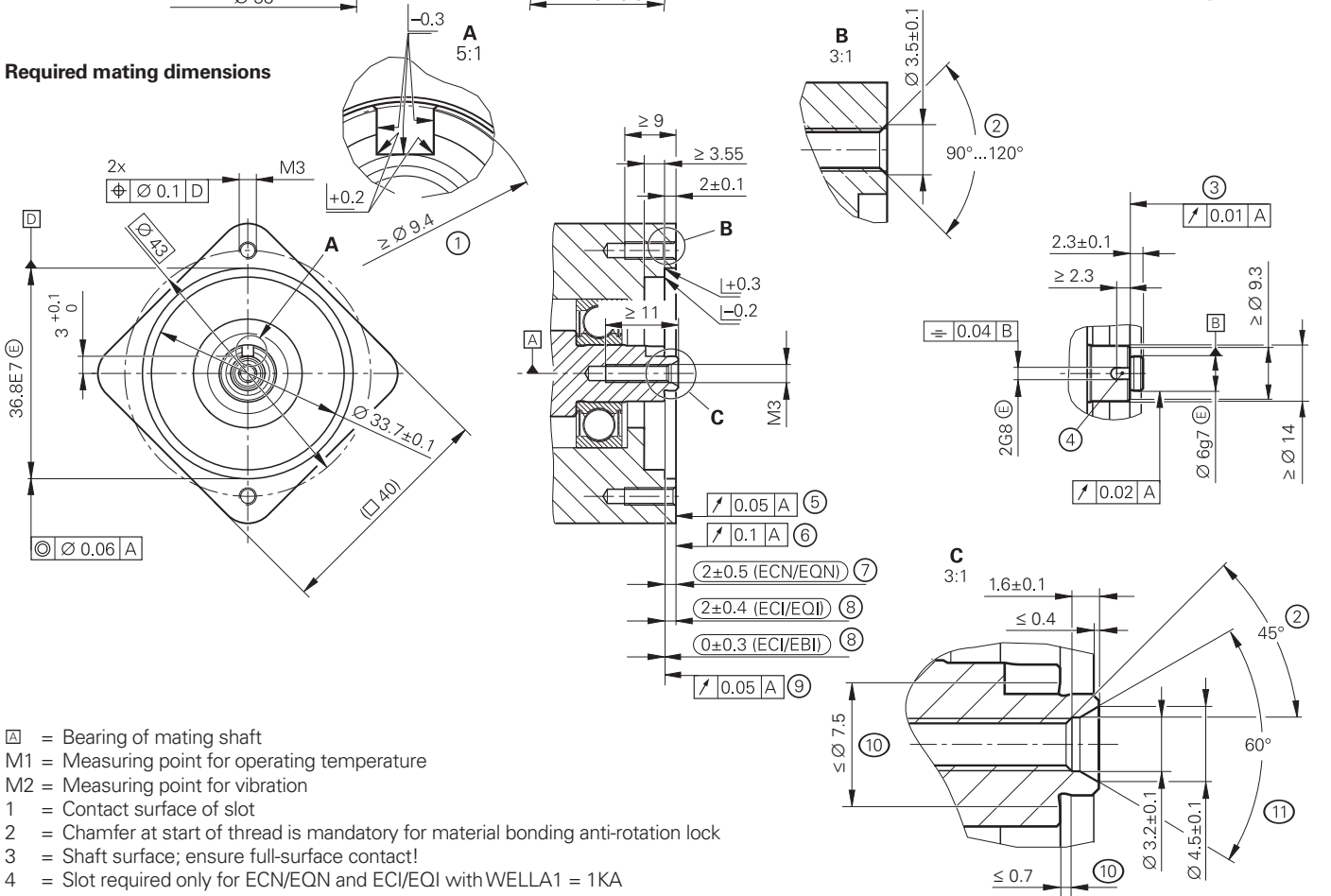
WELLA1 = 82A

WELLA1 = 1KA

Required mating dimensions

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

mm

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

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

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

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

ECI/EQI 1100 series

Absolute rotary encoders
- **70F synchro flange for axial mounting**
- **82A blind hollow shaft**
- **Without integral bearing**
- **Mounting-compatible with ECN/EQN 1100 optical rotary encoders and the ECI/EBI/EQI 1100 inductive series**
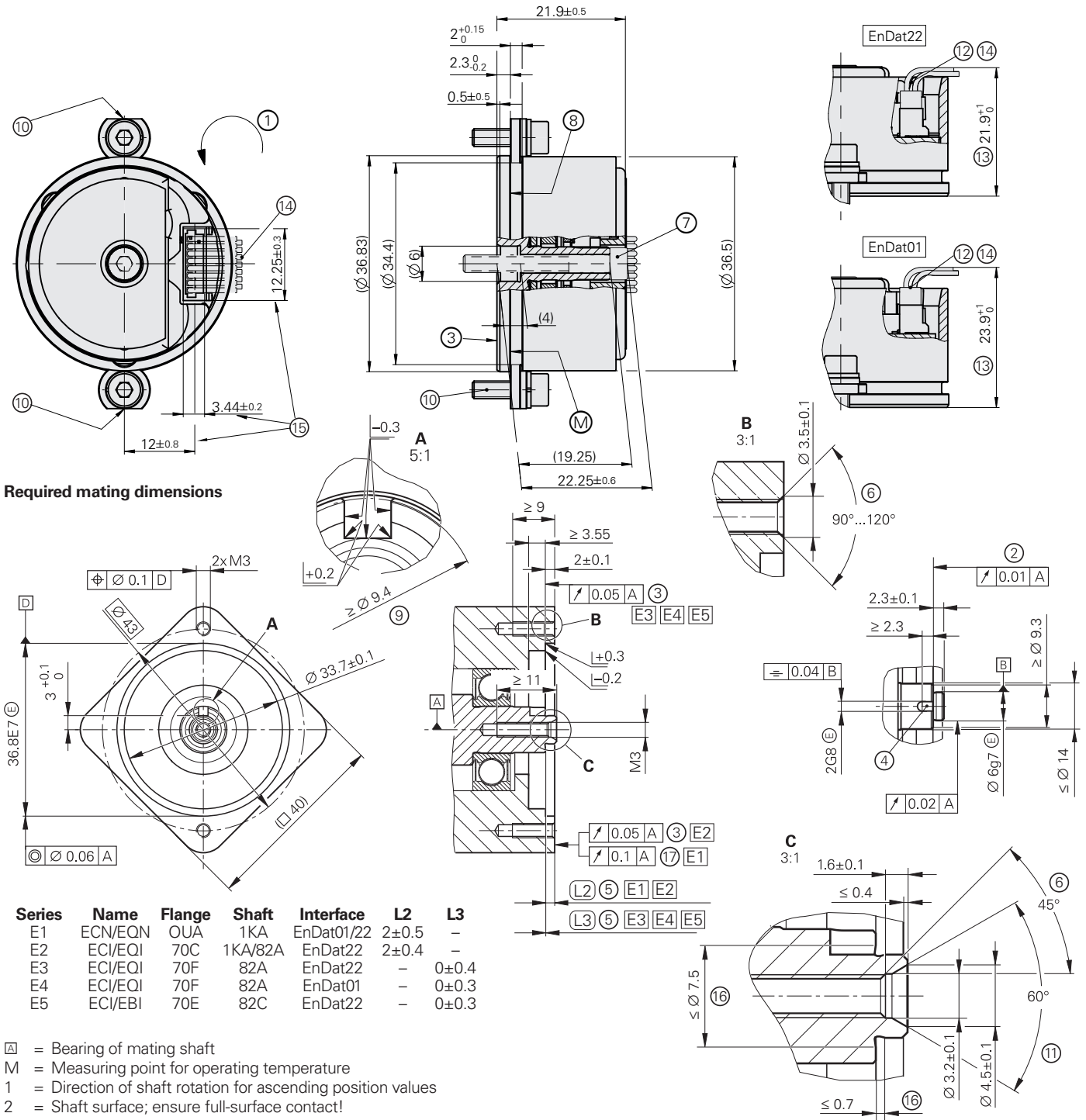
EnDat22

EnDat01

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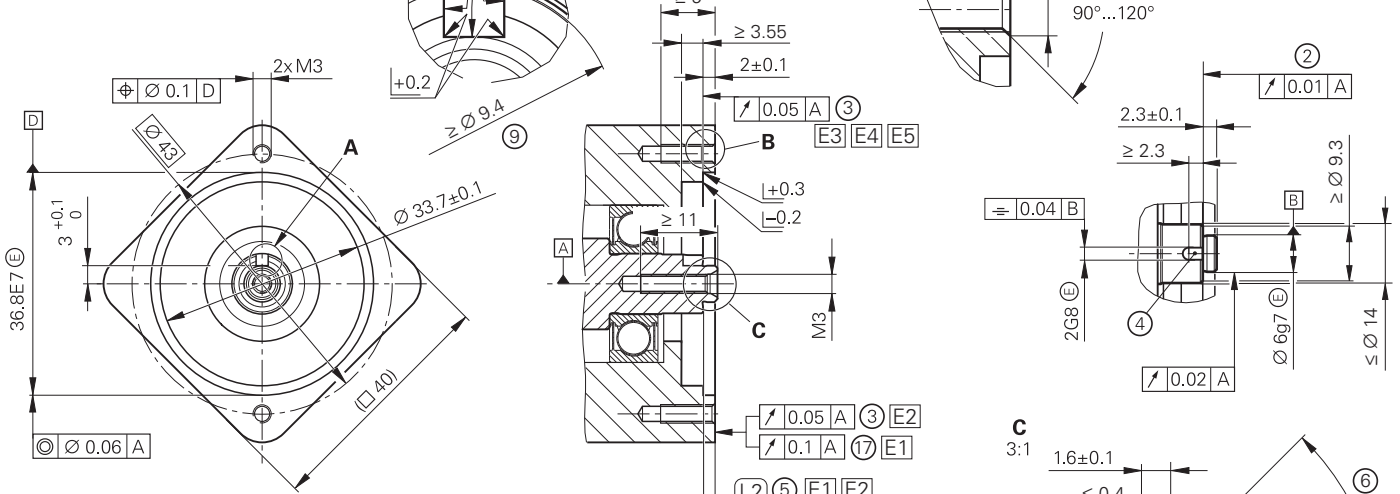
Series	Name	Flange	Shaft	Interface	L2	L3
E1	ECN/EQN	OUA	1KA	EnDat01/22	2±0.5	–
E2	ECI/EQI	70C	1KA/82A	EnDat22	2±0.4	–
E3	ECI/EQI	70F	82A	EnDat22	–	0±0.4
E4	ECI/EQI	70F	82A	EnDat01	–	0±0.3
E5	ECI/EBI	70E	82C	EnDat22	–	0±0.3

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

	Singleturn ECI 1119	Multiturn EQI 1131
Interface	EnDat 2.2	
Ordering designation	EnDat22	
Position values per revolution	524 288 (19 bits)	
Revolutions	–	4096 (12 bits)
Calculation time t_{cal} Clock frequency	≤ 5 µs ≤ 16 MHz	
System accuracy	±120″	
Electrical connection	15-pin (with connection for external temperature sensor)[1]	
Cable length	≤ 100 m	
Supply voltage	DC 3.6 V to 14 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
Current consumption (typical)	*5 V:* 95 mA (without load)	*5 V:* 115 mA
Shaft	Blind hollow shaft for axial clamping Ø 6 mm	
Shaft speed	≤ 15 000 rpm	≤ 12 000 rpm
Moment of inertia of rotor	$0.2 \cdot 10^{-6}$ kgm^2	
Permissible axial motion of measured shaft	±0.4 mm	
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	*Stator:* ≤ 400 m/s^2; *rotor:* ≤ 600 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)	
Operating temperature	–40 °C to 110 °C	
Protection EN 60529	IP00 when mounted[2]	
Mass	≈ 0.04 kg	
ID 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/EQI 1300 series

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

Required mating dimensions

D1	D2
Ø 12.7G6 Ⓔ	Ø 12.7h6 Ⓔ

mm
Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm
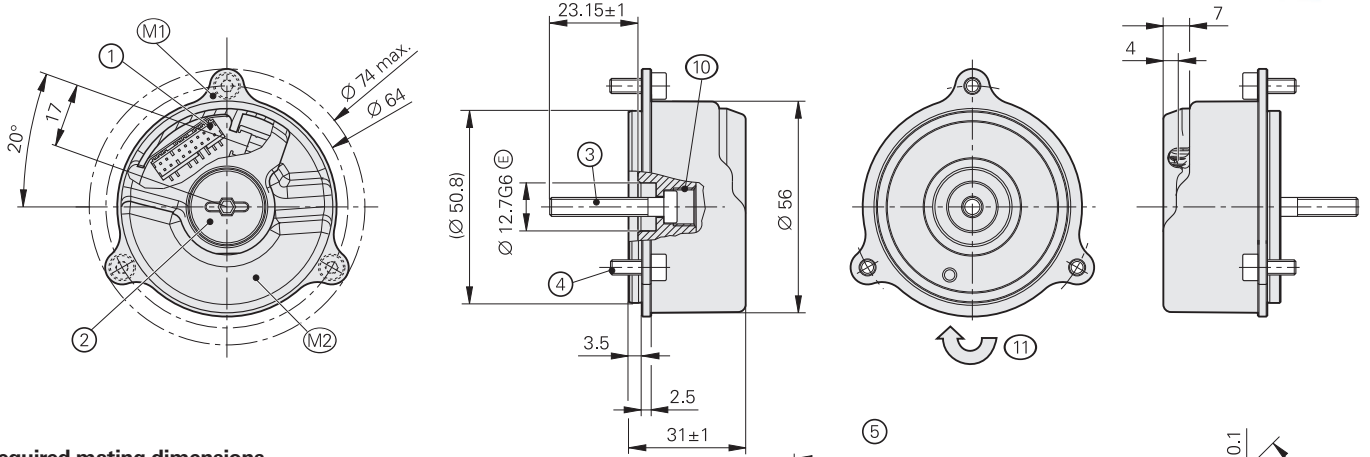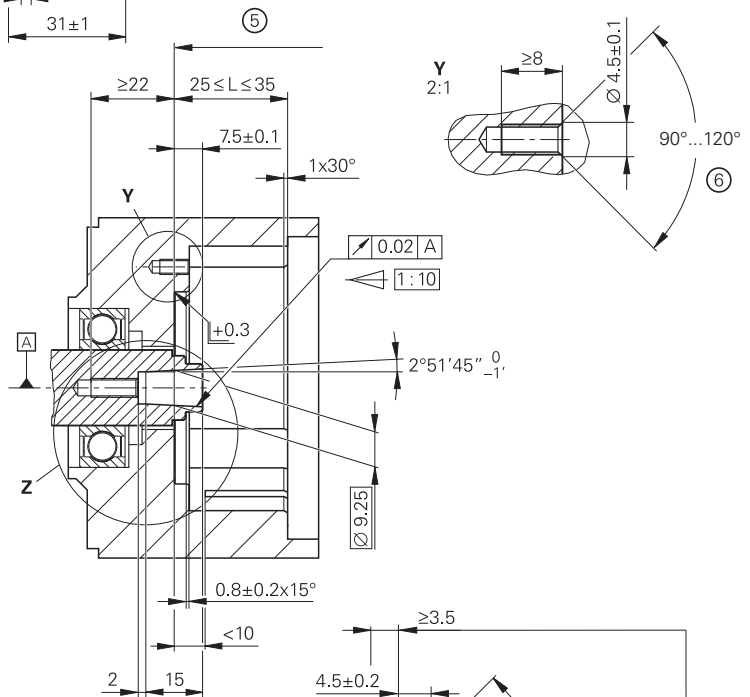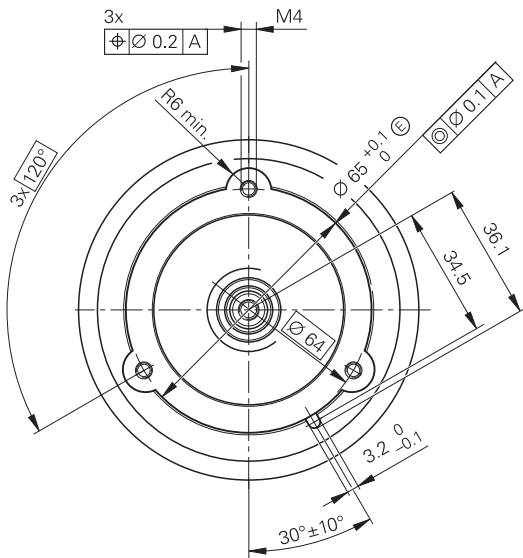
Ⓐ = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration (see D741714)
1 = 16-pin PCB connector
2 = Screw plug; widths A/F 3 and 4
3 = Screw: ISO 26912 – M5x30 – 08.8 – MKL SW4
4 = Screw: ISO 4762 – M4x10 – 8.8 – MKL SW3
5 = Functional diameter of taper for ECN/EQN 13xx
6 = Chamfer at start of thread is mandatory for material bonding anti-rotation lock
7 = Flange surface ExI/resolver; ensure full-surface contact!
8 = Shaft surface; ensure full-surface contact!
9 = *Mounting dimension:* maximum permissible deviation between the shaft surface and flange surface; compensation of mounting tolerances and thermal expansion; ECI/EQI: dynamic motion permitted over entire range; ECN/EQN: no dynamic motion permitted
10 = M10 back-off thread
11 = Direction of shaft rotation for ascending position values

	Absolute		
	ECI 1319 Functional Safety	**EQI 1331** Functional Safety	**EBI 1335** Functional Safety
Interface	EnDat 2.2		
Ordering designation	EnDat22		
Position values per revolution	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 (max.)	*3.6 V:* ≤ 0.65 W *14 V:* ≤ 0.7 W	*3.6 V:* ≤ 0.75 W *14 V:* ≤ 0.85 W	*3.6 V:* ≤ 0.65 W *14 V:* ≤ 0.7 W
Current consumption (typical)	*5 V:* 95 mA (without load)	*5 V:* 115 mA (without load)	*Normal operation at 5 V:* 95 mA (without load) *Backup battery:* 160 µA (rotating shaft)[2] 16 µA (at standstill)
Shaft	Blind hollow shaft for axial clamping (Ø 12.7 mm)		
Mech. permiss. shaft speed n	≤ 15 000 rpm	≤ 12 000 rpm	
Moment of inertia of rotor	$2.6 \cdot 10^{-6}$ kgm^2		
Permissible axial motion of measured shaft	±0.5 mm		
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	*Stator:* ≤ 400 m/s^2; *rotor:* ≤ 600 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)		
Operating temperature	–40 °C to 115 °C		
Trigger threshold of temperature exceedance error message	130 °C (measuring accuracy of the internal temperature sensor: ±1 K)		
Protection EN 60529	IP20 when mounted		
Mass	≈ 0.13 kg		
ID number	810661-xx	810662-xx	1230275-xx

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

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

ECI 1319, EQI 1331

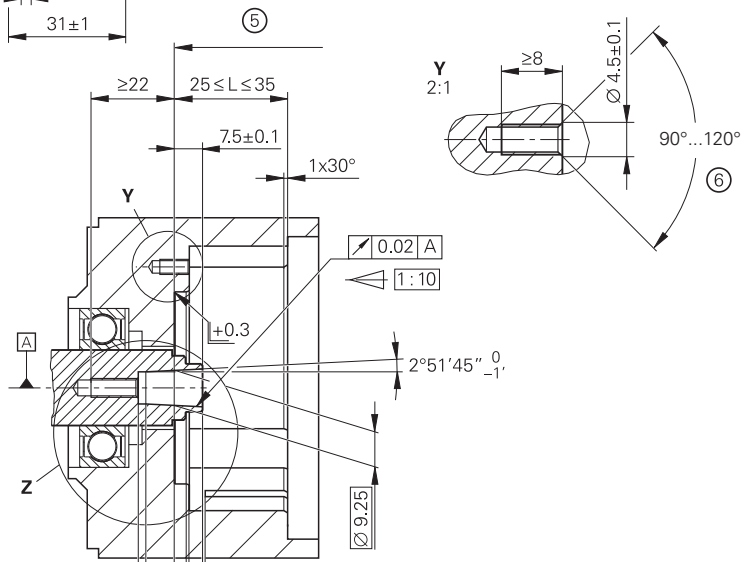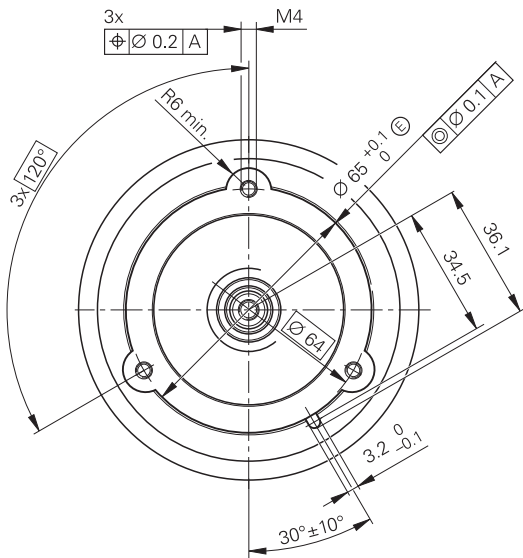Rotary encoders for absolute position values with safe singleturn information
- **Robust inductive scanning principle**
- **Mounting-compatible with photoelectric rotary encoders with a 07B stator coupling**
- **0YA mounting flange**
- **Blind hollow shaft for axial clamping Ø 12.7 mm (44C) or Ø 12 mm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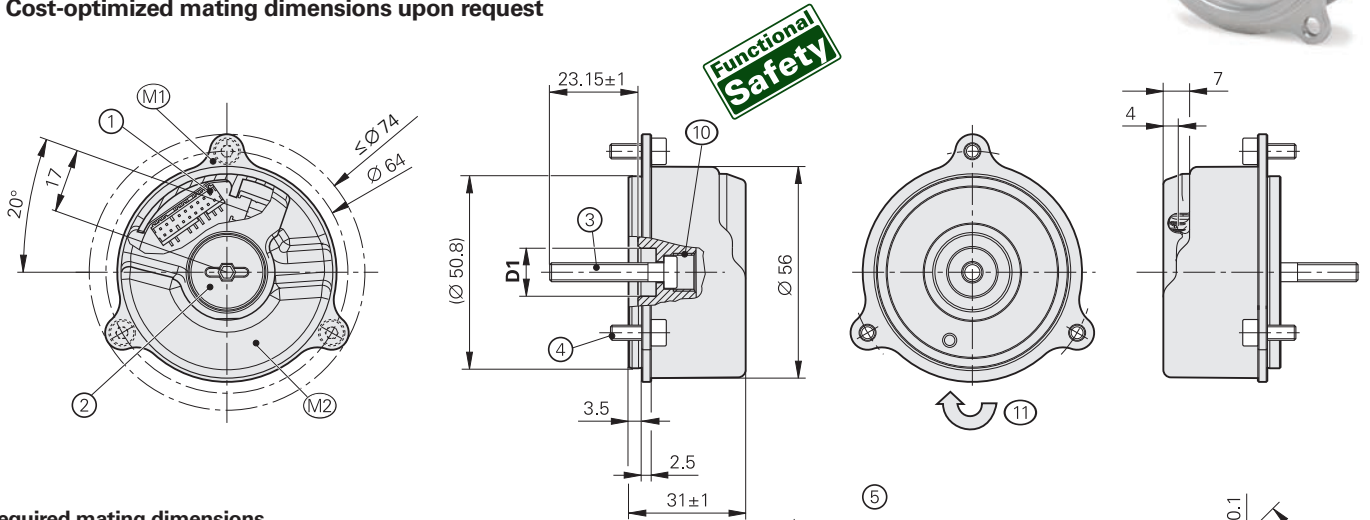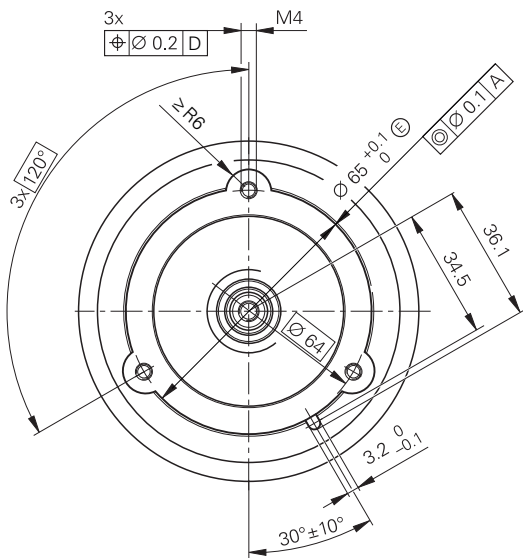
Required mating dimensions

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

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

Ⓐ = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration (see D741714)
1 = 16-pin (12+4-pin) PCB connector
2 = SW3 and SW4 screw plug
3 = Screw: DIN 6912 – M5x30 – 08.8 – MKL SW4
4 = Screw: ISO 4762 – M4x10 – 8.8 – MKL SW3
5 = Functional diameter of taper for ECN/EQN 13xx
6 = Chamfer at start of thread is mandatory for material bonding anti-rotation lock
7 = ExI/resolver flange surface; ensure full-surface contact!
8 = Shaft surface; ensure full-surface contact!
9 = Mounting clearance between shaft surface and flange surface;
    compensation of mounting tolerances and thermal expansion;
    ECI/EQI: dynamic motion permitted over entire range;
    ECN/EQN: no dynamic motion permitted
10 = M10 back-off thread
11 = Direction of shaft rotation for ascending position values
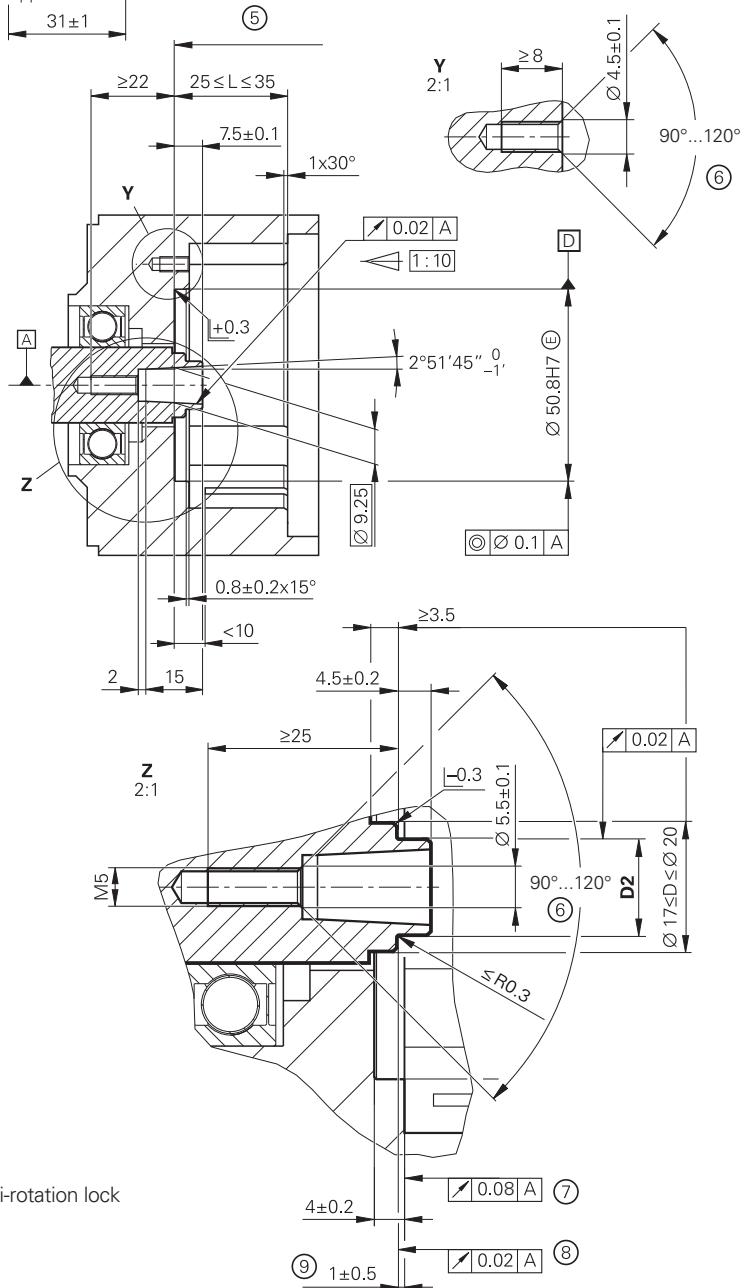
	Absolute	
	ECI 1319 singleturn *Functional Safety*	**EQI 1331 multiturn** *Functional Safety*
Interface	EnDat 3	
Ordering designation	E30–R2	
Position values per revolution	524 288 (19 bits)	
Revolutions	–	4096 (12 bits)
XEL.time HPFout data rate	≤ 11 µs at 12.5 Mbit/s ≤ 8.2 µs at 25 Mbit/s	
Propagation time[1]	14 µs (typical)	
System accuracy	±65″	
Electrical connection	16-pin PCB connector (12+4; with separate connection option for external temperature sensor)[3]	
Cable length	*At 12.5 Mbit/s:* ≤ 100 m; *at 25 Mbit/s:* ≤ 40 m	
Supply voltage	DC 4 V to 14 V (recommended: 12 V)	
Power consumption[2] (maximum)	*4 V:* ≤ 0.85 W *14 V:* ≤ 0.9 W	*4 V:* ≤ 0.95 W *14 V:* ≤ 1 W
Current consumption (typical)	*12 V:* ≤ 45 mA (without communication)	*12 V:* ≤ 50 mA (without communication)
Shaft	Blind hollow shaft for axial clamping Ø 12.7 mm (44C) or Ø 12 mm (44A)	
Shaft speed	≤ 15 000 rpm	≤ 12 000 rpm
Moment of inertia of rotor	$2.45 \cdot 10^{-6}$ kgm^2	$2.6 \cdot 10^{-6}$ kgm^2
Angular acceleration of rotor	$\leq 1 \cdot 10^5$ rad/s^2	
Axial motion of measured shaft	≤ ±0.5 mm	
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	*Stator:* ≤ 400 m/s^2; *rotor:* ≤ 600 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)	
Operating temperature	–40 °C to 115 °C	
Trigger threshold of temperature exceedance error message	130 °C (measuring accuracy of the internal temperature sensor: ±1 K)	
Relative humidity	≤ 93% (40 °C/21 d as per EN 60068-2-78); condensation excluded	
Protection rating EN 60529	IP20	
Mass	≈ 0.13 kg	
ID 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 Ø 12.7 mm**
- **Without integral bearing**
- **Cost-optimized mating dimensions upon request**

Ø 74 max.
Ø 64
20°
17
M1
1
2
M2

23.15±1
Ø 50.8
Ø 12.7G6 (E)
3
10
4
Ø 56
3.5
2.5
31±1
11

7
4

Required mating dimensions

3x
M4
⊕ Ø 0.2 A
R6 min.
3x 120°
Ø 65 +0.1/0 (E)
◎ Ø 0.1 A
36.1
34.5
Ø 64
3.2 0/−0.1
30°±10°

5
≥22
25 ≤ L ≤ 35
7.5±0.1
1x30°
Y
↗ 0.02 A
◁ 1:10
+0.3
2°51'45" 0/−1'
Ø 9.25
0.8±0.2x15°
<10
2
15
A
Z
2:1

Y
2:1
≥8
Ø 4.5±0.1
90°...120°
6

Z
2:1
M5
≥3.5
4.5±0.2
−0.3
Ø 5.5±0.1
90°...120°
6
R0.3 max.
≥25
↗ 0.02 A
Ø 17≤D≤20
Ø 12.7h6 (E)
Ø 50.8H7 (E)
◎ Ø 0.1 A
4±0.2
↗ 0.08 A 7
9 1±0.5
↗ 0.02 A 8
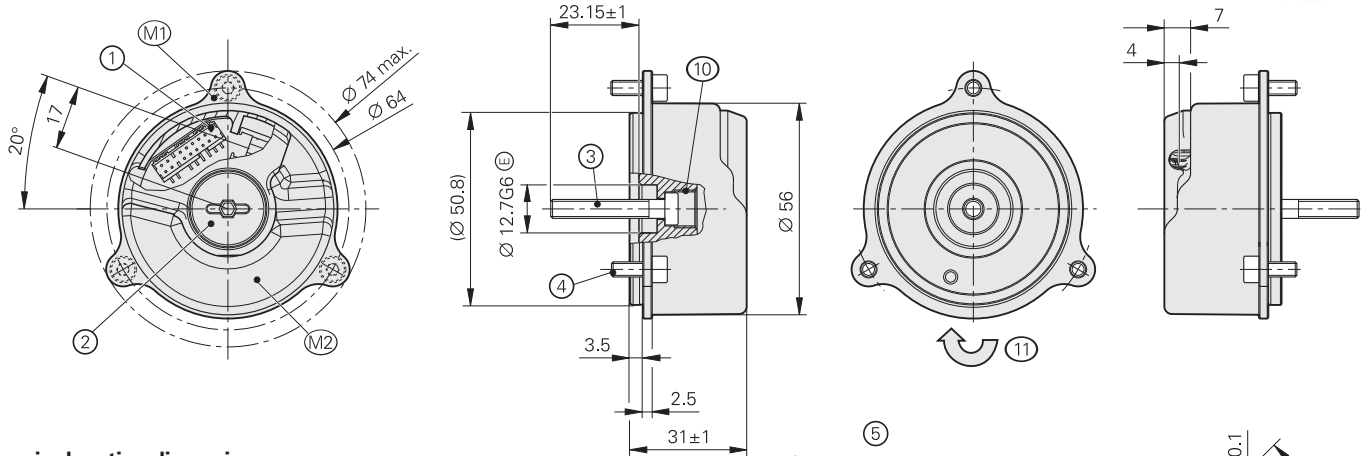
D1	D2
Ø 12.7G6 (E)	Ø 12.7h6 (E)

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

A = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration (see D741714)
1 = 16-pin PCB connector
2 = SW3 and SW4 screw plug
3 = Screw: ISO 6912 – M5x30 – 08.8 – MKL SW4
4 = Screw: ISO 4762 – M4x10 – 8.8 – MKL SW3
5 = Functional diameter of taper for ECN/EQN 13xx
6 = Chamfer at start of thread is mandatory for material bonding anti-rotation lock
7 = Flange surface ExI/resolver; ensure full-surface contact!
8 = Shaft surface; ensure full-surface contact!
9 = *Mounting dimension:* maximum permissible deviation between the shaft surface and
     flange surface; compensation of mounting tolerances and thermal expansion;
     ECI/EQI: dynamic motion permitted over entire range; ECN/EQN: no dynamic motion permitted
10 = M10 back-off thread
11 = Direction of shaft rotation for ascending position values

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

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

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

DRIVE-CLiQ is a registered trademark of Siemens AG.

ECI/EBI 100 series

Absolute rotary encoders
- **Flange for axial mounting**
- **Hollow through shaft**
- **Without integral bearing**
- *EBI 135:* **multiturn functionality via battery-buffered revolution counter**
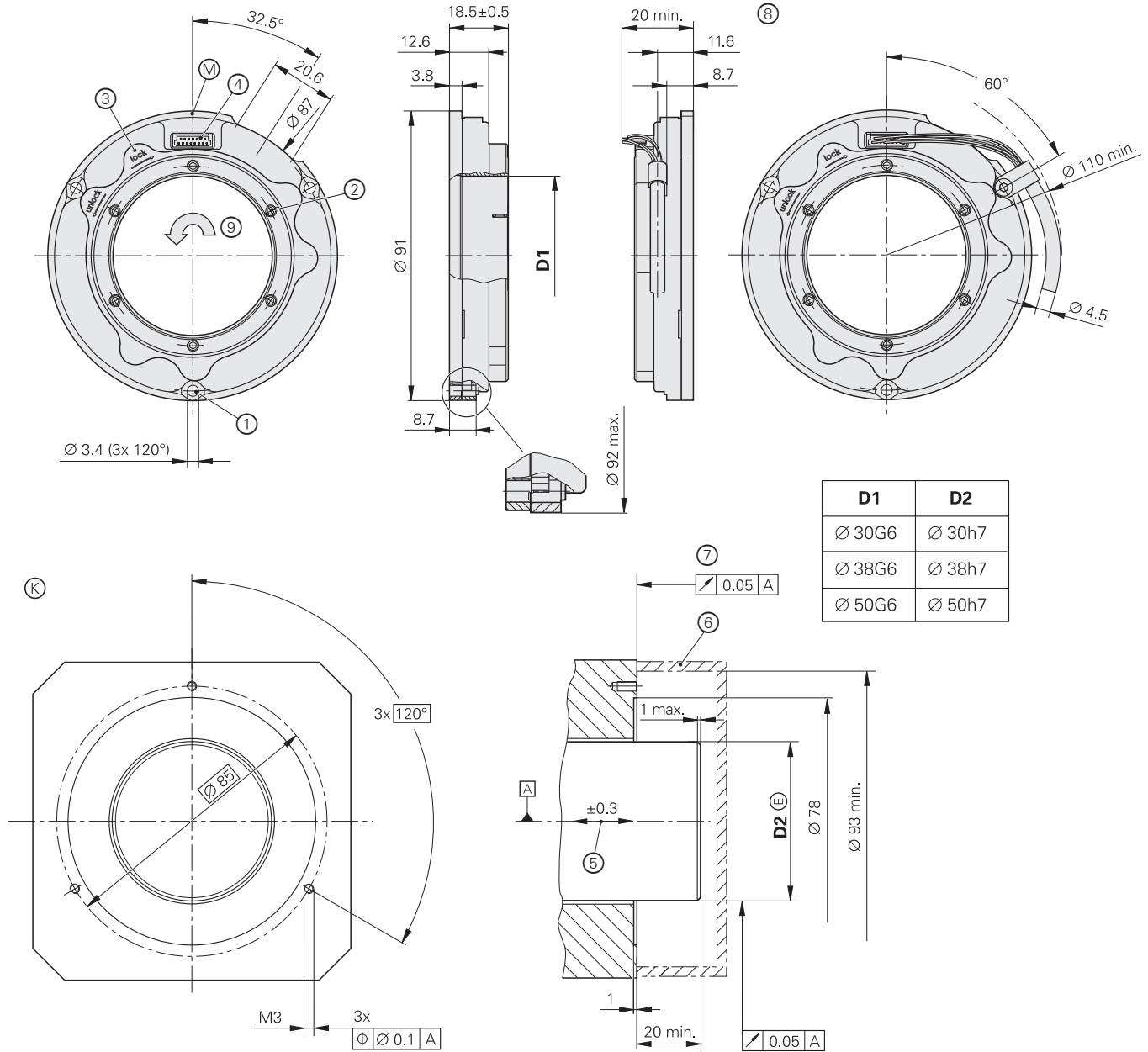
D1	D2
⌀ 30G6	⌀ 30h7
⌀ 38G6	⌀ 38h7
⌀ 50G6	⌀ 50h7

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

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

	Absolute		
	ECI 119		**EBI 135**
Interface*	EnDat 2.1	EnDat 2.2	EnDat 2.2
Ordering designation	EnDat01	EnDat22[1]	EnDat22[1]
Position values per revolution	524 288 (19 bits)		
Revolutions	–		65 536 (16 bits)[2]
Elec. permiss. shaft speed/ deviations[3]	$\leq$ 3000 rpm/±128 LSB $\leq$ 6000 rpm/±256 LSB	$\leq$ 6000 rpm (for continuous position value)	
Calculation time t_{cal} Clock frequency	$\leq$ 8 µs $\leq$ 2 MHz	$\leq$ 6 µs $\leq$ 16 MHz	
Incremental signals	$\sim$ 1 V$_{PP}$	–	–
Line count	32	–	–
Cutoff frequency –3 dB	$\geq$ 6 kHz (typical)	–	–
System accuracy	±90″		
Electrical connection	15-pin	15-pin with connection for temperature sensor[4]	
Cable length	$\leq$ 100m		
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 (max.)	*3.6 V:* $\leq$ 0.58 W *14 V:* $\leq$ 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 $\varnothing$ = 30 mm, 38 mm, 50 mm		
Mech. permiss. shaft speed n	$\leq$ 6000 rpm		
Moment of inertia of rotor	$\varnothing$ = 30 mm: 64 $\cdot$ 10^{-6} kgm^2 $\varnothing$ = 38 mm: 58 $\cdot$ 10^{-6} kgm^2 $\varnothing$ = 50 mm: 64 $\cdot$ 10^{-6} kgm^2		
Permissible axial motion of measured shaft	±0.3 mm		
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	$\leq$ 300 m/s^2 (EN 60068-2-6) $\leq$ 1000 m/s^2 (EN 60068-2-27)		
Operating temperature	–30 °C to 115 °C		
Protection EN 60529	IP20 when mounted[6]		
Mass	$\varnothing$ = 30 mm: $\approx$ 0.19 kg $\varnothing$ = 38 mm: $\approx$ 0.16 kg $\varnothing$ = 50 mm: $\approx$ 0.14 kg		
ID 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.
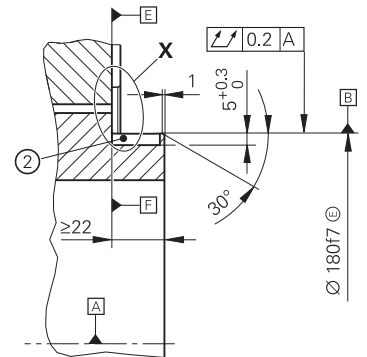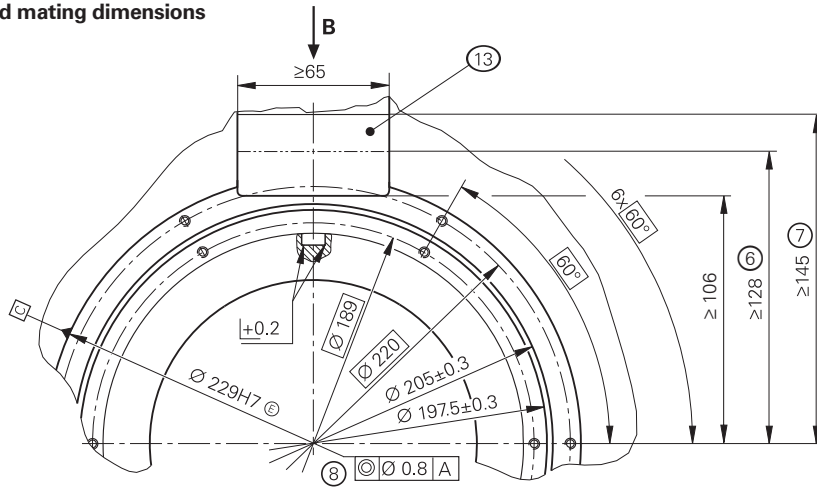
ECI 4010, EBI 4010, ECI 4090 S

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

Required mating dimensions
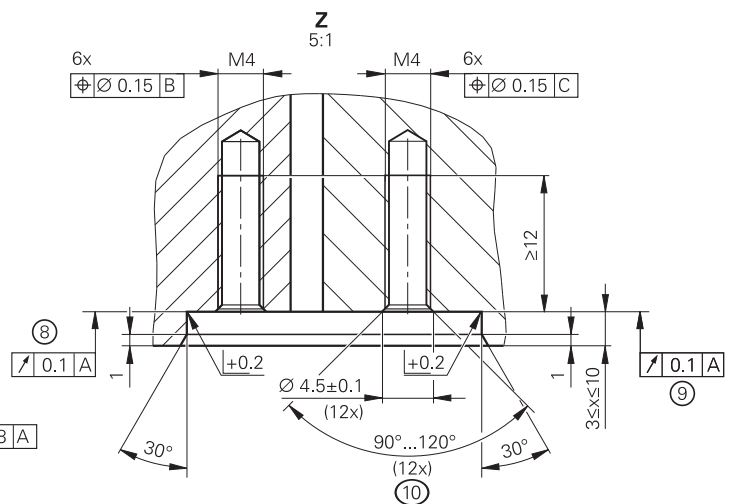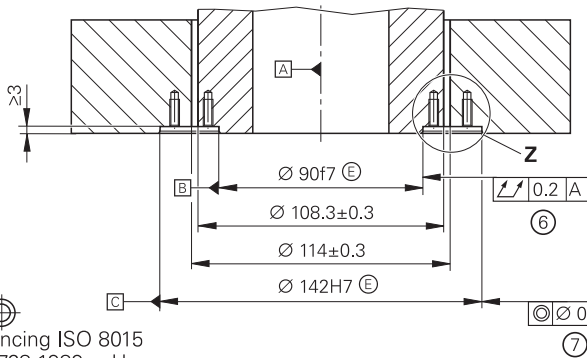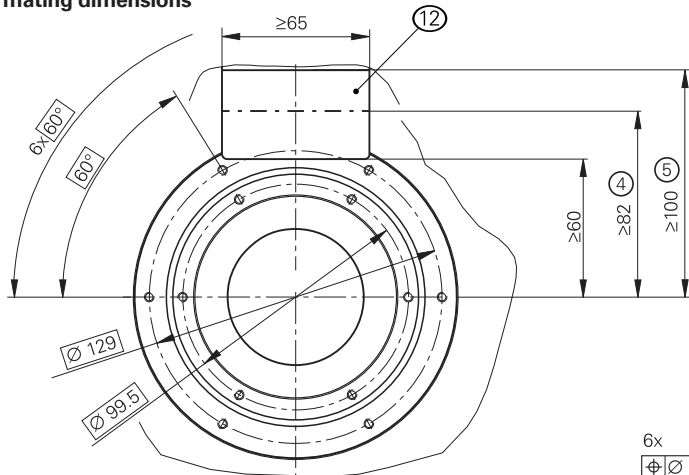
mm

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

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

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

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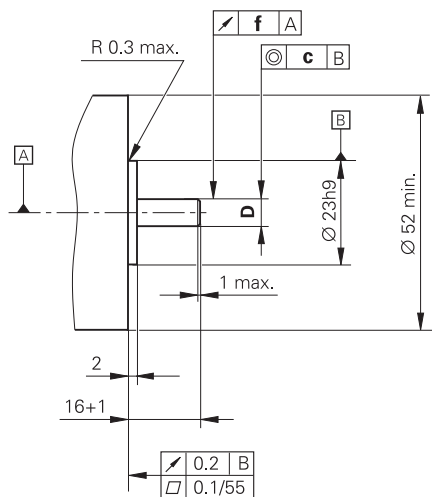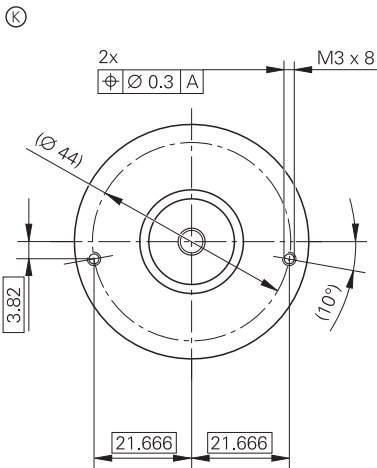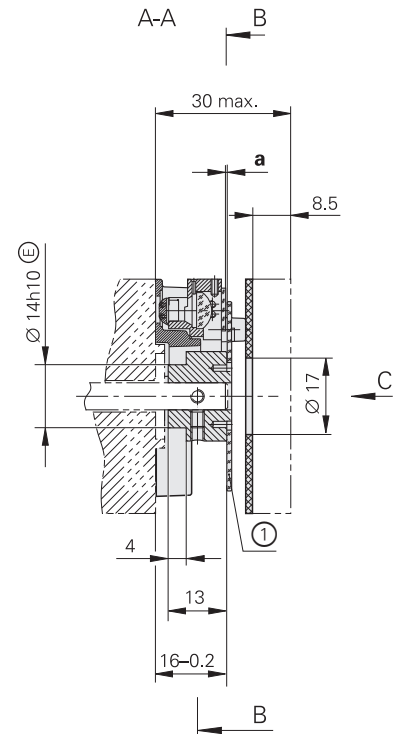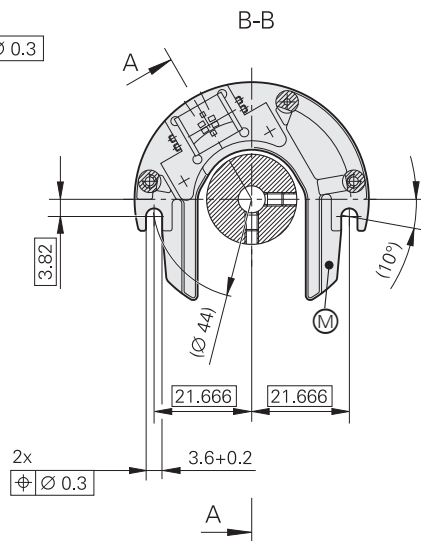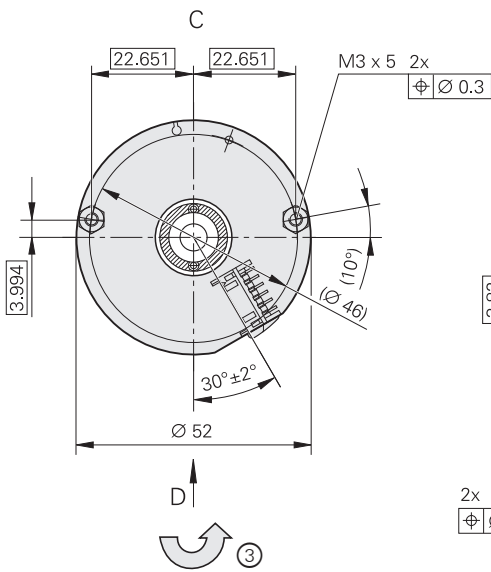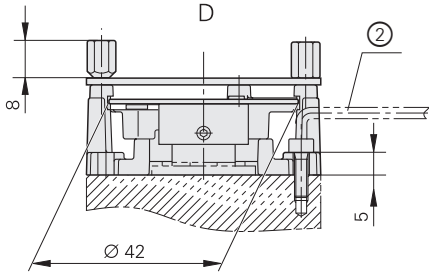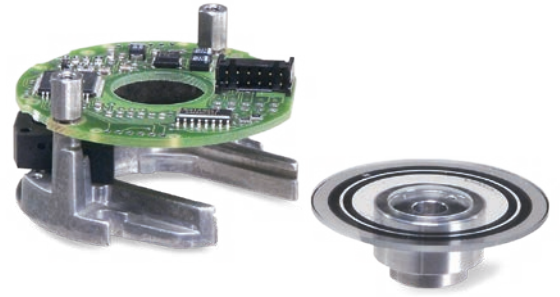
For dimensions and specifications of encoders with functional safety, see the Product Information document.

DRIVE-CLiQ is a registered trademark of Siemens AG.

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 through battery-buffered revolution counter**
- **Consists of a scanning unit and scale drum**

Functional Safety

Shown with customer's side

A–A

Required mating dimensions

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

Y 2:1

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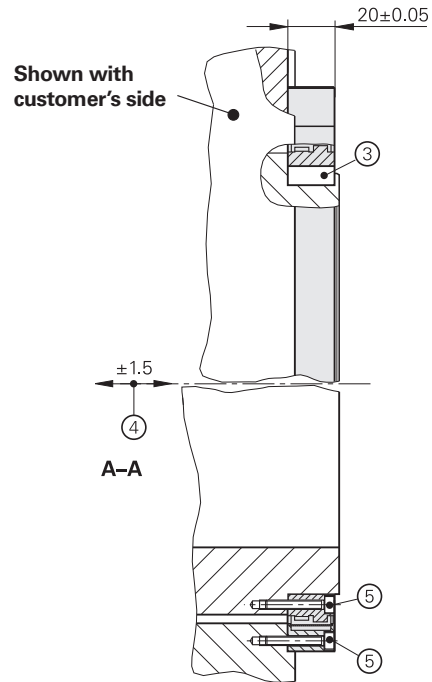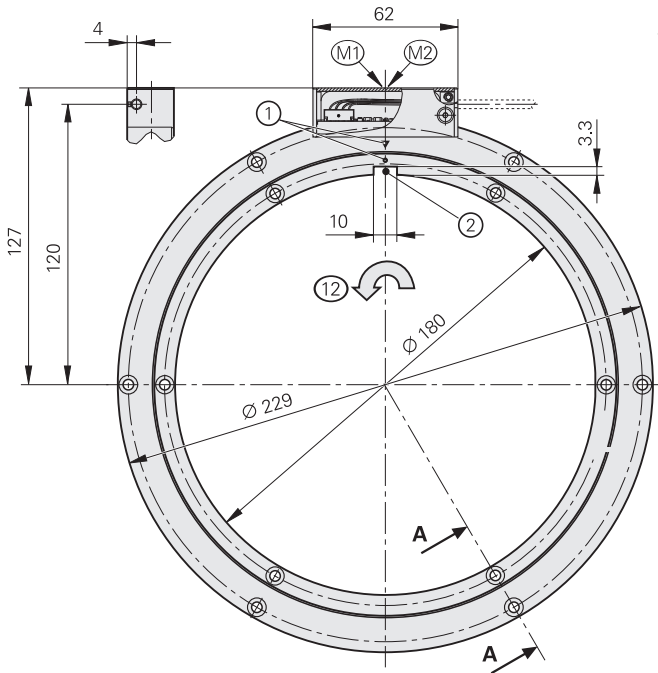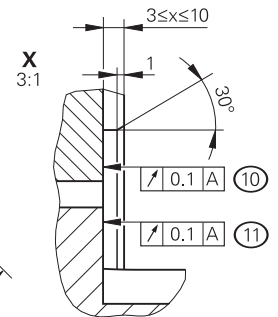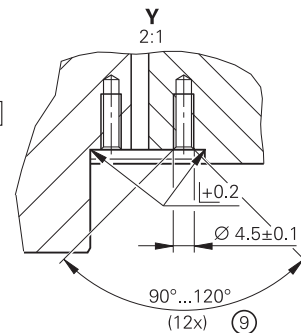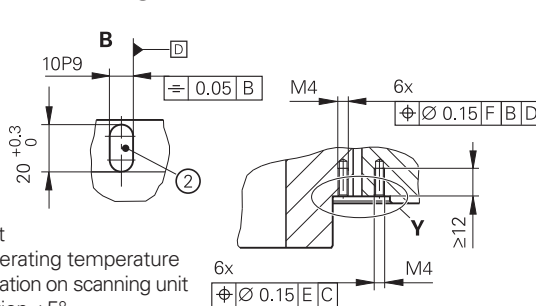
A = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration on scanning unit
1 = Marking of the 0° position ±5°
2 = Slot for feather key DIN 6885 – A – 10 x 8 x 20
3 = Feather key DIN 6885 – A – 10 x 8 x 20
4 = Maximum permissible axial deviation between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

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

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

For dimensions and specifications of encoders with functional safety, see the Product Information document.
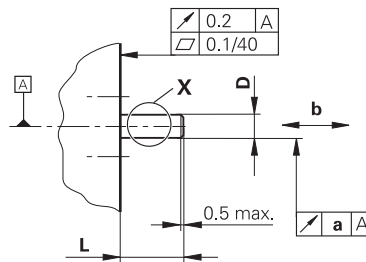
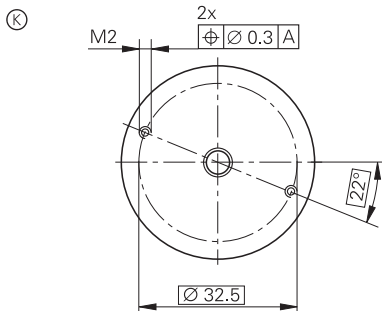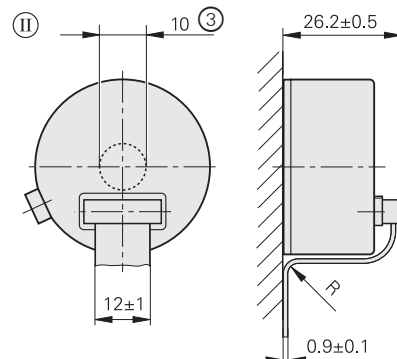DRIVE-CLiQ is a registered trademark of Siemens AG.

ERO 1200 series

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

D

∅ 42

8

5

C

22.651 22.651

M3 x 5 2x
⊕ ∅ 0.3

3.994

(10°)

(∅ 46)

30°±2°

∅ 52

D

③

B-B

A

3.82

(∅ 44)

(10°)

Ⓜ

21.666 21.666

2x
⊕ ∅ 0.3

3.6+0.2

A

②

A-A

B

30 max.

a

8.5

∅ 14h10 Ⓔ

∅ 17

C

4

13

16−0.2

B

①

Ⓚ

2x
⊕ ∅ 0.3 A

M3 x 8

(∅ 44)

3.82

(10°)

21.666 21.666

∅ A

f A

◎ c B

R 0.3 max.

B

∅ 23h9

∅ 52 min.

D

1 max.

2

16+1

∅ 0.2 B

⬜ 0.1/55

mm

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

Ⓐ = Bearing of mating shaft
Ⓚ = Required mating dimensions
M = Measuring point for operating temperature
1 = Disk/hub assembly
2 = Offset screwdriver: ISO 2936 – 2.5 (l_2 shortened)
3 = Direction of shaft rotation for output signals as per the interface description

D
∅ 10h6 Ⓔ
∅ 12h6 Ⓔ

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

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

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

ERO 1400 series

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

With axial PCB connector

3±0.5
Ø 4.5
19.9±0.5
6.5
1.6

22
25°
(9.85)
6.4
12.85±0.5
14
Ø 38.4

21.7±0.5

22°
Ø 32.5
Ø 2.5
④
①

Ⓚ
M2
2x
⌖ Ø 0.3 A
22°
Ø 32.5

0.2 | A
0.1/40
Ⓐ
X
D
b
0.5 max.
a | A
L

X
② D −0.2
3.7±0.2
4.8±0.2

Ⅰ
10 ③
25.2±0.5
(22°)
32
M3
7
29.2 ca.
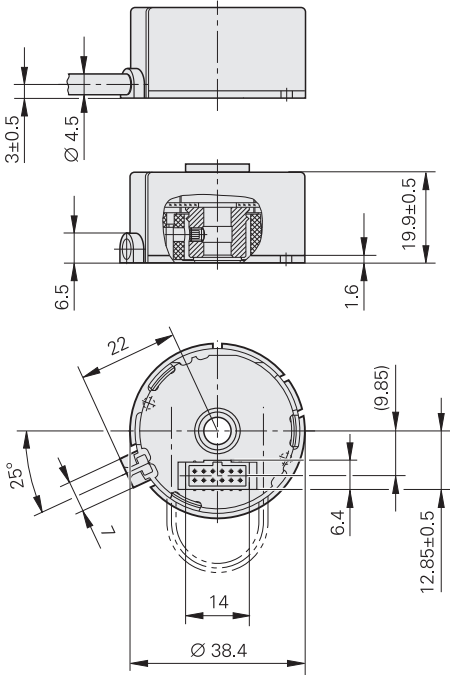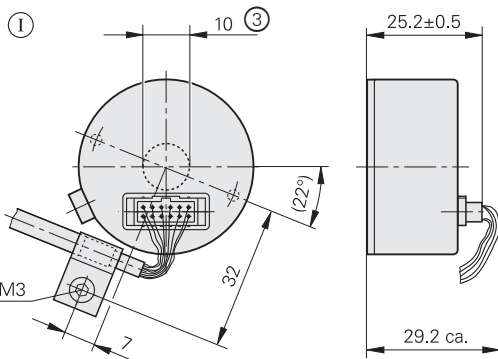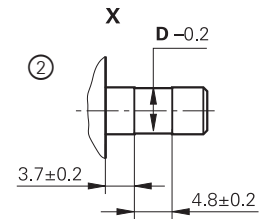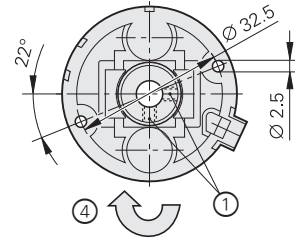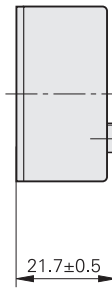
Axial PCB connector and round cable

Ⅱ
10 ③
26.2±0.5
(22°)
12±1
R
0.9±0.1

Axial PCB connector and ribbon cable

| L | 13 +4.5/−3 | 10 min. |

Bend radius R	Fixed cable	Frequent flexing
Ribbon cable	R ≥ 2 mm	R ≥ 10 mm

	a	b		D
ERO 1420	0.03	±0.1		Ø 4h6 Ⓔ
ERO 1470	0.02	±0.05		Ø 6h6 Ⓔ
ERO 1480				Ø 8h6 Ⓔ

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

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

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

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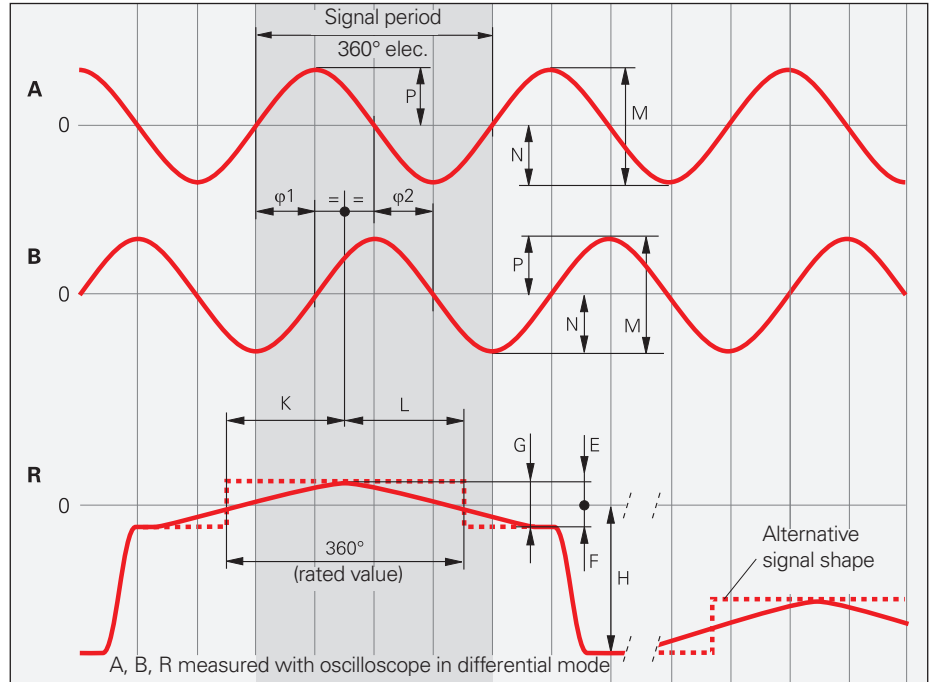
📖 **Further information:**

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

A, B, R measured with oscilloscope in differential mode

Pin layout

12-pin M23 coupling				15-pin D-sub connector for PWM 21				12-pin PCB connector			
	Power supply				Incremental signals					Other signals		
⊡	12	2	10	11	5	6	8	1	3	4	9	7	/
⊡	4	12	2	10	1	9	3	11	14	7	5/6/8/15	13	/
⊡12	2a	2b	1a	1b	6b	6a	5b	5a	4b	4a	3b	3a	/
	U$_P$	Sensor[1] U$_P$	0 V	Sensor[1] 0 V	A+	A–	B+	B–	R+	R–	Vacant	Vacant	Vacant
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	/	Violet	Yellow

Output cable for ERN 1381 inside the motor housing ID 667343-01				17-pin M23 flange socket				12-pin PCB connector			
	Power supply				Incremental signals					Other signals		
⊡	7	1	10	4	15	16	12	13	3	2	5	6	8/9/11/ 14/17
⊡12	2a	2b	1a	1b	6b	6a	5b	5a	4b	4a	/	/	3a/3b
	U$_P$	Sensor U$_P$	0 V	Sensor 0V	A+	A–	B+	B–	R+	R–	T+[2]	T–[2]	Vacant
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	Brown[2]	White[2]	/

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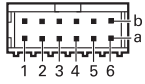**Sensor:** The sense line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!

⊓⊔TTL incremental signals

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

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

The **fault detection signal** $\overline{U_{aS}}$ indicates malfunctions such as an interruption in the supply lines, failure of the light source, etc.

The inverted signals $\overline{U_{a1}}$, $\overline{U_{a2}}$, and $\overline{U_{a0}}$ are not shown.
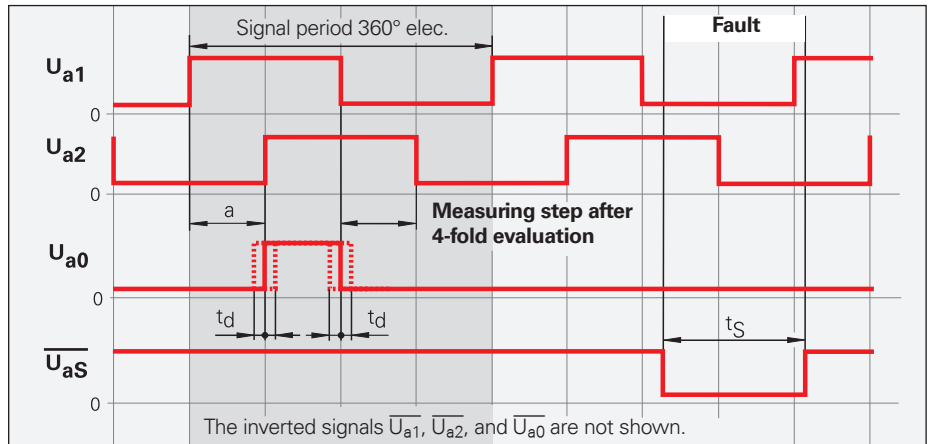
The distance between two successive edges of the incremental signals U_{a1} and U_{a2} through 1-fold, 2-fold or 4-fold evaluation is one **measuring step.**

📖 **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	

	Power supply				Incremental signals						Other signals		
⊏▪ ⊏▪	12	2	10	11	5	6	8	1	3	4	7	/	9
D-sub	4	12	2	10	1	9	3	11	14	7	13	5/6/8	15
PCB 12	2a	2b[1]	1a	1b[1]	6b	6a	5b	5a	4b	4a	3a	3b	/
	U_P	Sensor U_P	0 V	Sensor 0 V	U_{a1}	$\overline{U_{a1}}$	U_{a2}	$\overline{U_{a2}}$	U_{a0}	$\overline{U_{a0}}$	$\overline{U_{aS}}$[1]	Vacant	Vacant[2]
⟵	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	Violet	/	Yellow
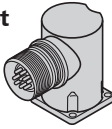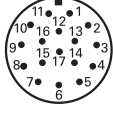
Cable shield connected to housing; U_P = Power supply voltage
Sensor: The sense line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!
[1] **ERO 14xx:** vacant
[2] **Exposed linear encoders:** conversion from TTL to 11 µApp for the PWT, otherwise not assigned

Pin layout

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

		Power supply				Incremental signals						Other signals		
	7	1	10	4	15	16	12	13	3	2	5	6	8/9/11/ 14/17
12	2a	2b	1a	1b	6b	6a	5b	5a	4b	4a	/	/	3a/3b
	U_P	Sensor U_P	0 V	Sensor 0V	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.
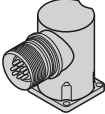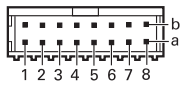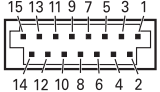
The **ERN 1x23** and **ERN 1326** are rotary encoders with commutation signals for block commutation.

ERN 1123, ERN 1326 pin layout

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

	Power supply				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
	U_P	Sensor U_P	0 V	Internal shield	U_{a1}	$\overline{U_{a1}}$	U_{a2}	$\overline{U_{a2}}$	U_{a0}	$\overline{U_{a0}}$
▭	Brown/ Green	Blue	White/ Green	/	Green/ Black	Yellow/ Black	Blue/ Black	Red/ Black	Red	Black

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

Cable shield connected to housing;
U_P = Power supply
Sensor: The sense line is connected in the encoder with the corresponding power line (only with ERN 1326).

Vacant pins or wires must not be used!

Pin layout for ERN 1023

	Power supply		Incremental signals						Other signals					
	U_P	0 V	U_{a1}	$\overline{U_{a1}}$	U_{a2}	$\overline{U_{a2}}$	U_{a0}	$\overline{U_{a0}}$	U	$\overline{U}$	V	$\overline{V}$	W	$\overline{W}$
▭	White	Black	Red	Pink	Olive Green	Blue	Yellow	Orange	Beige	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 V_{PP} interface. However, the required terminating resistance Z_0 is 1 kΩ instead of 120 Ω.
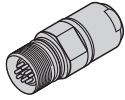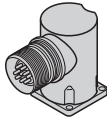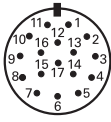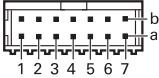
The **ERN 1387** is a rotary encoder with output signals for sinusoidal commutation.

Pin layout

17-pin M23 coupling or flange socket										14-pin PCB connector	

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

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

Cable shield connected to housing;
U_P = Voltage supply; **T** = Temperature
Sensor: The sense line is connected internally to the respective the 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.

Position values EnDat 2.2

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.

📖 **Further information:**

Detailed descriptions of all available interfaces, as well as general electrical information, can be found in the *Interfaces of HEIDENHAIN Encoders* brochure.

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

Versions of the EnDat interface
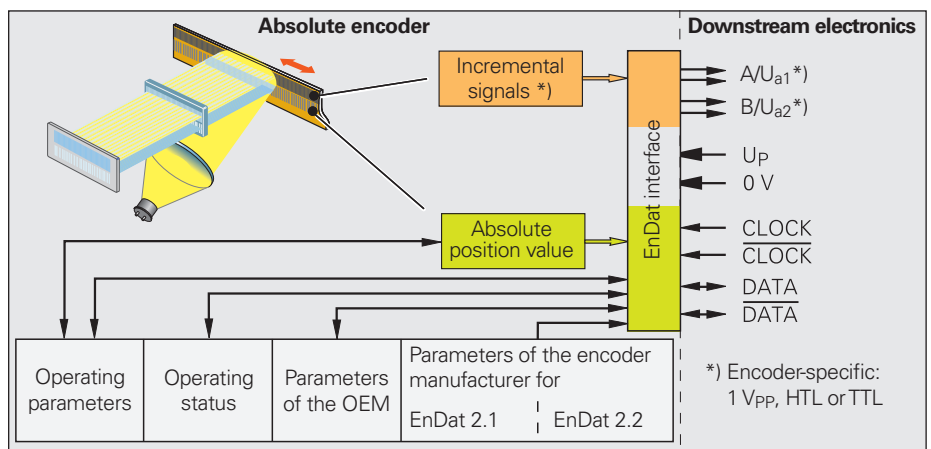
Pin layout for EnDat01/EnDat02
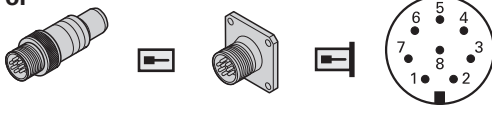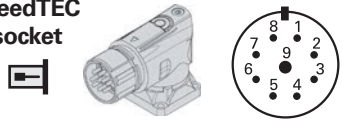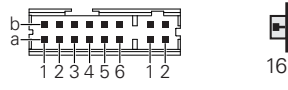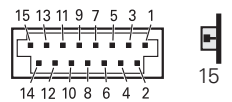
17-pin M23 coupling or flange socket										**12-pin PCB connector**		**15-pin PCB connector**	
	Power supply					Incremental signals[1]				Serial data transmission			
▭ ▭	**7**	**1**	**10**	**4**	**11**	**15**	**16**	**12**	**13**	**14**	**17**	**8**	**9**
▯12	**1b**	**6a**	**4b**	**3a**	/	**2a**	**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	$\overline{DATA}$	CLOCK	$\overline{CLOCK}$
⟍	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

	Power supply				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

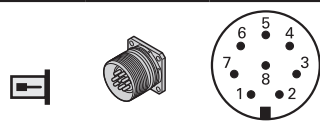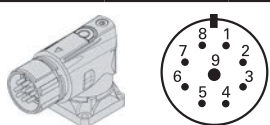**Cable shield** connected with housing; U_P = Power supply; **T** = Temperature

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

Vacant pins or wires must not be used!

[1] U_{BAT} for EBI 1335; [2] **ECI 1118 EnDat22:** vacant

[3] Connections for an external temperature sensor (only EnDat22, except ECI 1118, see *Temperature measurement in motors*); if used, please refer to the information about electromagnetic compatibility in the *General electrical information* section of the *Interfaces of HEIDENHAIN Encoders* brochure.

Pin layout for EBI 135/EBI 1135/EBI 4010

15-pin PCB connector

8-pin M12 flange socket	9-pin M23 SpeedTEC angle flange socket

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

U_P = Power supply; U_{BAT} = External buffer battery (false polarity can result in damage to the encoder)

Vacant pins or wires must not be used!

[1] Only for EBI 135

[2] Connected inside encoder

[3] Connections for an external temperature sensor (see *Temperature measurement in motors*); if used, please refer to the information about electromagnetic compatibility in the *General electrical information* section of the *Interfaces of HEIDENHAIN Encoders* brochure.

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

Pin layout

HMC 6 flange socket

Travel range

103°±3°

222°±3°

16-pin (12+4-pin) PCB connector		15-pin PCB connector

	Encoder							
	Power supply		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	**0 V**	**DATA**	$\overline{\text{DATA}}$	**CLOCK**	$\overline{\text{CLOCK}}$	**T+**[1]	**T–**[1]
⊂	Brown/Green	White/Green	Gray	Pink	Violet	Yellow	Brown	Green

	Motor						
	Brake		Power				
⊟	**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.**
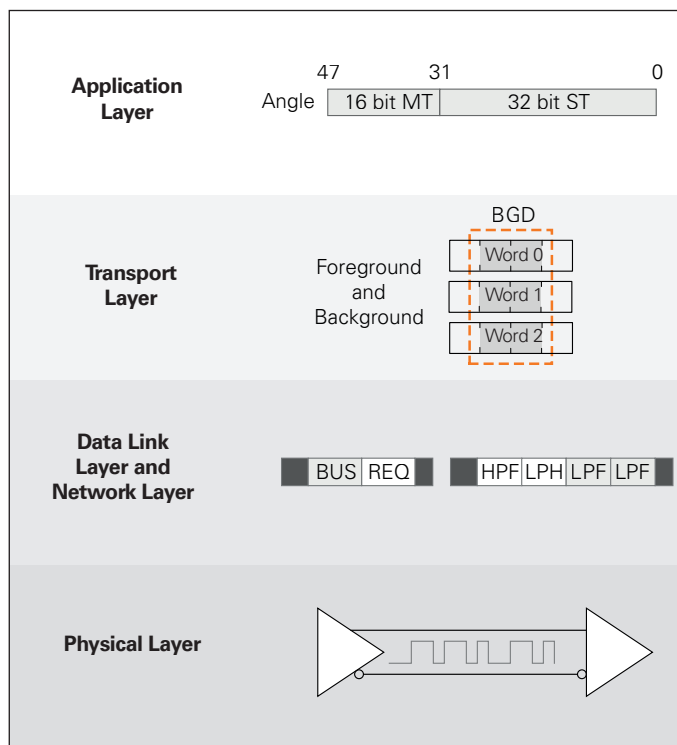Vacant pins or wires must not be used!
HMC 6 is not suited for encoders with buffer battery backup (EBI 135, EBI 1335, EBI 1135, EBI 4010)
[1] Connections for an external temperature sensor (except ECI 1118, see *Temperature measurement in motors*); if used, please refer to the information about electromagnetic compatibility in the *General electrical information* section of the *Interfaces of HEIDENHAIN Encoders* brochure.

EnDat 3

EnDat 3 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
www.endat.de

Application Layer	Angle	47	31	0
Transport Layer	Foreground and Background	BGD Word 0 / Word 1 / Word 2
Data Link Layer and Network Layer	BUS REQ / HPF LPH LPF LPF
Physical Layer	

Application Layer: Angle — 16 bit MT / 32 bit ST

Ordering designations
The ordering designation defines key communication characteristics:

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

HMC 2 (EnDat3/E30-R2) M12

Pin layout of ECI, EQI 11xx

8-pin M12 SpeedTEC angle flange socket		15-pin PCB connector	
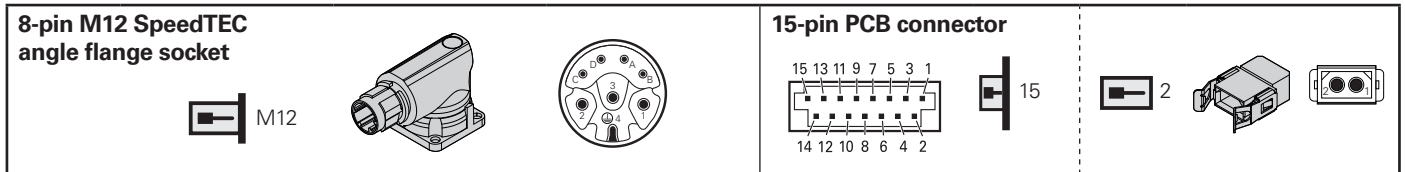
	Encoder			
	Power supply / Serial data transfer		Other signals	
M12	A	B	/	/
15	9	10	5	6
2	–	–	2	1
	P_SD+[1]	**P_SD–**[1]	**T+**[2]	**T–**[2]
	Violet	Yellow	Brown	Green

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

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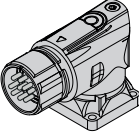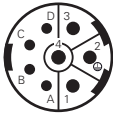
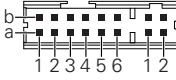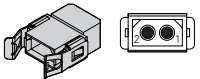[2] Connections for an external temperature sensor; evaluation optimized for KTY 84-130, PT 1000 and others (see *Temperature measurement in motors*); if used, please refer to the information about electromagnetic compatibility in the *General electrical information* section of the *Interfaces of HEIDENHAIN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

Vacant pins or wires must not be used!

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

HMC 2 (EnDat3/E30-R2) M23

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

8-pin M23 SpeedTEC HMC 2 angle flange socket	16-pin (12+4-pin) PCB connector
M23	12 / 4 / 2

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

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

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

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

RJ45 connector		8-pin M12 connector		8-pin M12 coupling		9-pin M23 SpeedTEC connector	
	Power supply			Serial data transmission			
RJ45	A	B	3	6	1	2	
M12	1	5	7	6	3	4	
M23	8	4	1	2	5	6	
	U_P	0 V	TXP	TXN	RXP	RXN	
*	Red	Black	Green	Yellow	Pink	Blue	

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

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

EBI 1135/EBI 1335/EBI 135/EBI 4010: external backup battery

The multiturn functionality of the EBI 1135, EBI 1335, EBI 135 and EBI 4000 is implemented by means of a revolution counter. In order for the absolute position information to still be available after loss of power, the EBI 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). 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 its own backup battery.

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 issues the following warnings or error messages, which are transmitted over the EnDat interface:
- **"Battery charge" warning**
  ≤ 2.8 V ±0.2 V
  in normal operating mode
- **"M Power interruption" error message**
  ≤ 2.2 V ±0.2 V
 in battery-buffered mode (encoder must be re-referenced)

Low battery current continues to flow even during normal operation of the EBI. The amount of current depends on the operating temperature.
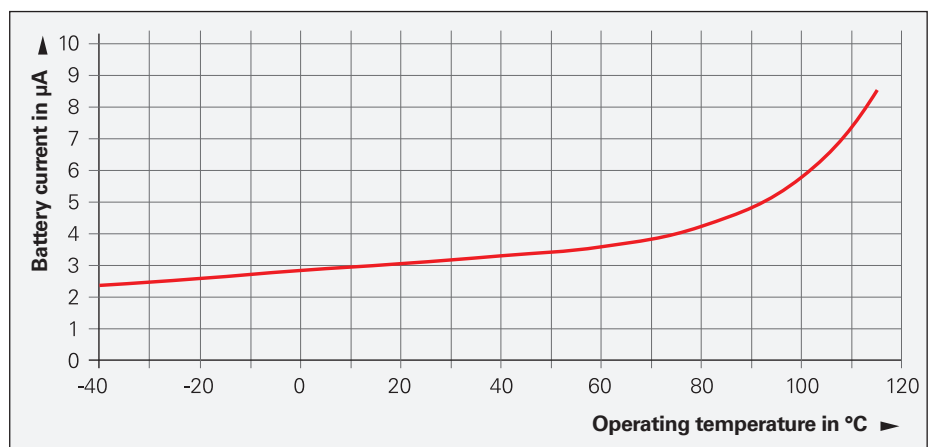
Please note:
Compliance with EnDat Specification 297403 and the EnDat Application Notes 722024, Chapter 13, *Battery-buffered encoders*, is required for correct control of the encoder.
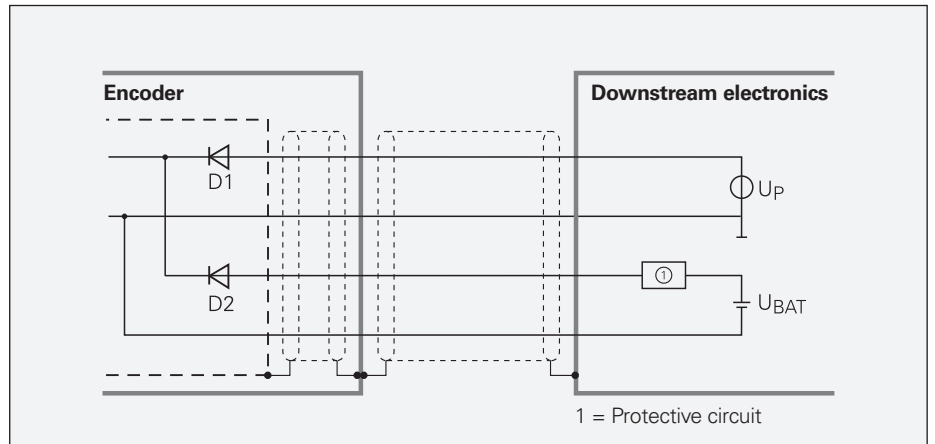
Backup battery connection
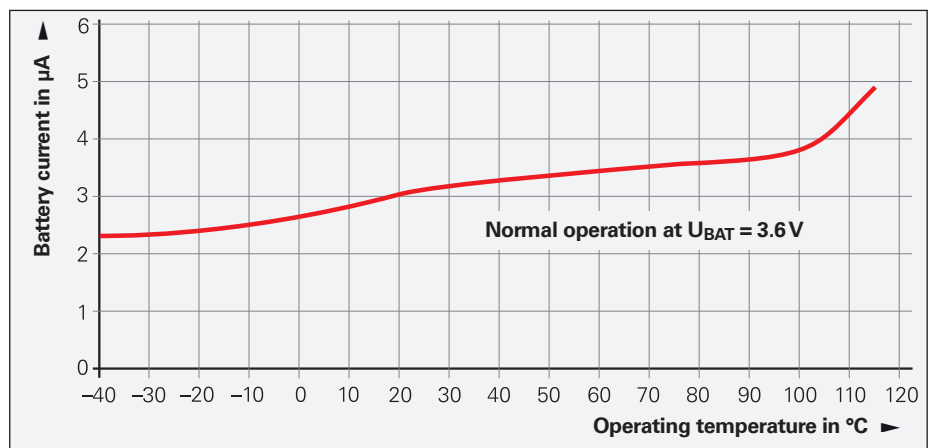
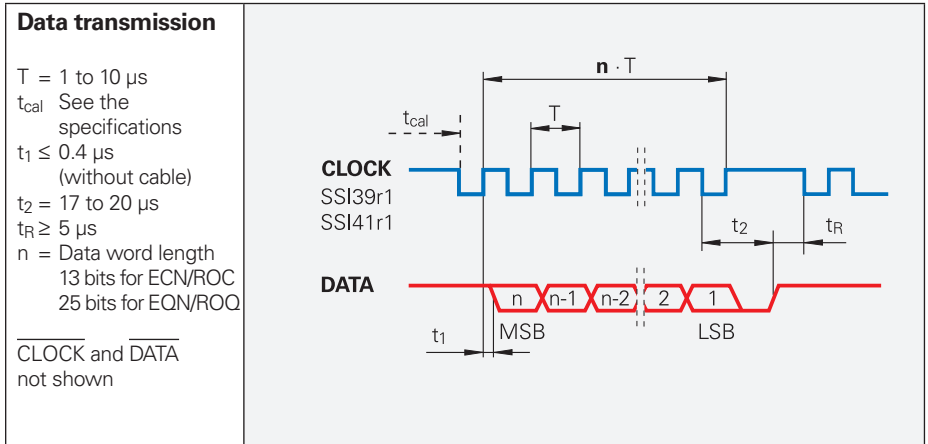*EBI 1135/135:* typical discharge current during normal operation (U_B = 3.6 V)

EBI 4010: typical discharge current during normal operation (U_{BAT} = 3.6 V)

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 transmitted as well. For a description of the signals, see *1 V_{PP} incremental signals*.

The following **functions** can be activated via programming inputs:
- **Direction of rotation**
- **Zeroing** (setting to zero)

Data transmission

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

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

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

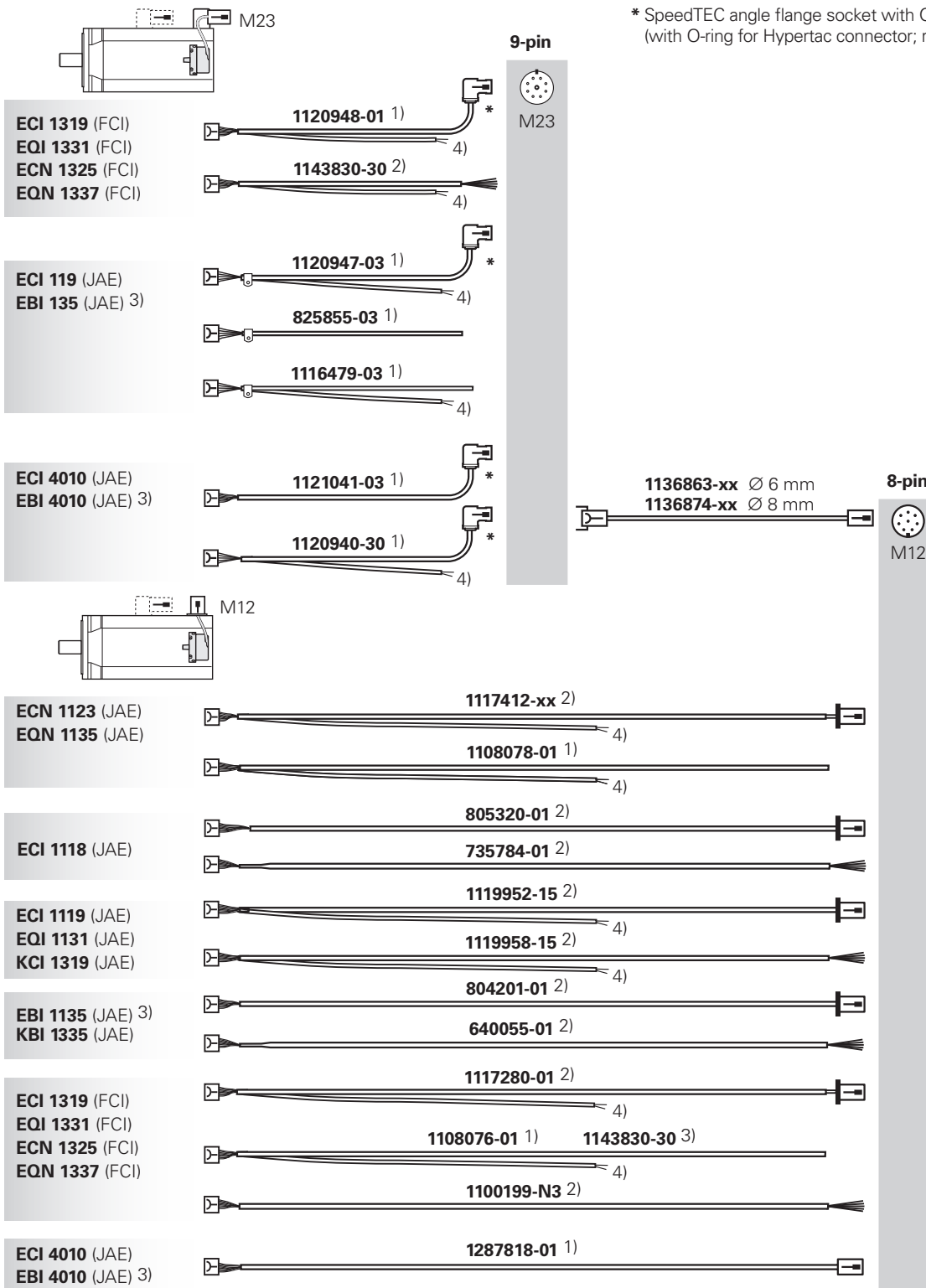| 17-pin M23 coupling															
	Power supply					Incremental signals				Serial data transmission				Other signals	
	7	1	10	4	11	15	16	12	13	14	17	8	9	2	5
	U_P	Sensor U_P	0 V	Sensor 0 V	Internal shield[1]	A+	A–	B+	B–	DATA	$\overline{DATA}$	CLOCK	$\overline{CLOCK}$	Direction of rotation	Zeroing
	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.
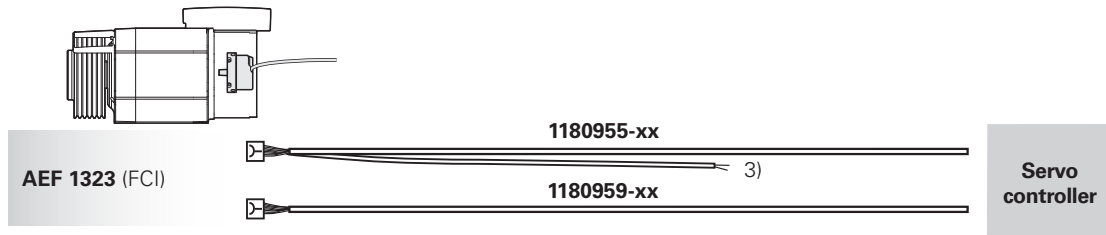[1] Vacant with the ECN/EQN 10xx and ROC/ROQ 10xx

Cables
Output cables: EnDat (EnDat22)

* SpeedTEC angle flange socket with O-ring vibration protection (male) (with O-ring for Hypertac connector; remove O-ring for SpeedTEC)

M23

9-pin

M23

ECI 1319 (FCI)
EQI 1331 (FCI)
ECN 1325 (FCI)
EQN 1337 (FCI)

1120948-01 [1]
4)

1143830-30 [2]
4)

ECI 119 (JAE)
EBI 135 (JAE) [3]

1120947-03 [1] *
4)

825855-03 [1]

1116479-03 [1]
4)

ECI 4010 (JAE)
EBI 4010 (JAE) [3]

1121041-03 [1] *

1120940-30 [1] *
4)

1136863-xx ∅ 6 mm
1136874-xx ∅ 8 mm

8-pin

M12

M12

ECN 1123 (JAE)
EQN 1135 (JAE)

1117412-xx [2]
4)

1108078-01 [1]
4)

ECI 1118 (JAE)

805320-01 [2]

735784-01 [2]

ECI 1119 (JAE)
EQI 1131 (JAE)
KCI 1319 (JAE)

1119952-15 [2]
4)

1119958-15 [2]
4)

EBI 1135 (JAE) [3]
KBI 1335 (JAE)

804201-01 [2]

640055-01 [2]

ECI 1319 (FCI)
EQI 1331 (FCI)
ECN 1325 (FCI)
EQN 1337 (FCI)

1117280-01 [2]
4)

1108076-01 [1]   1143830-30 [3]
4)

1100199-N3 [2]

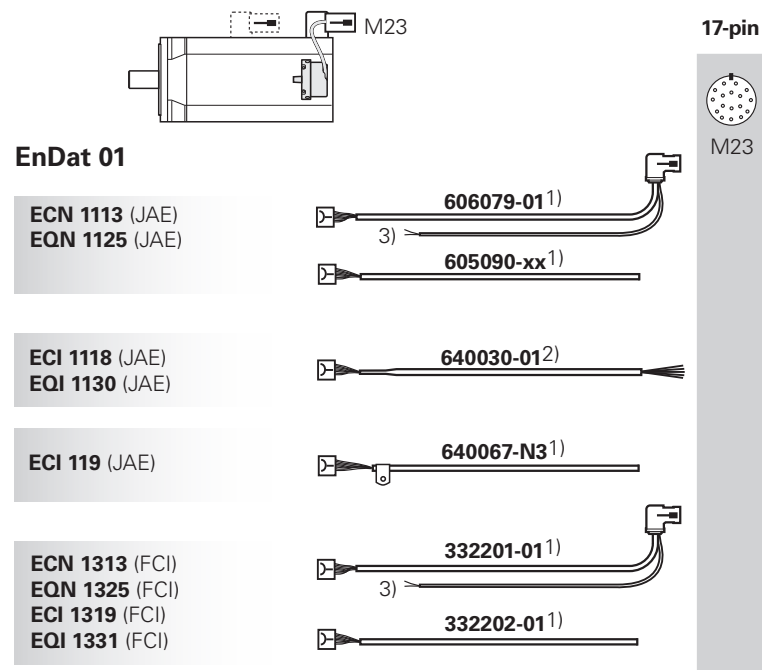**ECI 4010** (JAE)
EBI 4010 (JAE) [3]

1287818-01 [1]

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[1] EPG cable
[2] TPE single wires in heat-shrink tubing or braided sleeve (without shield)
[3] The TNC does not support any buffer battery backup multiturn functions
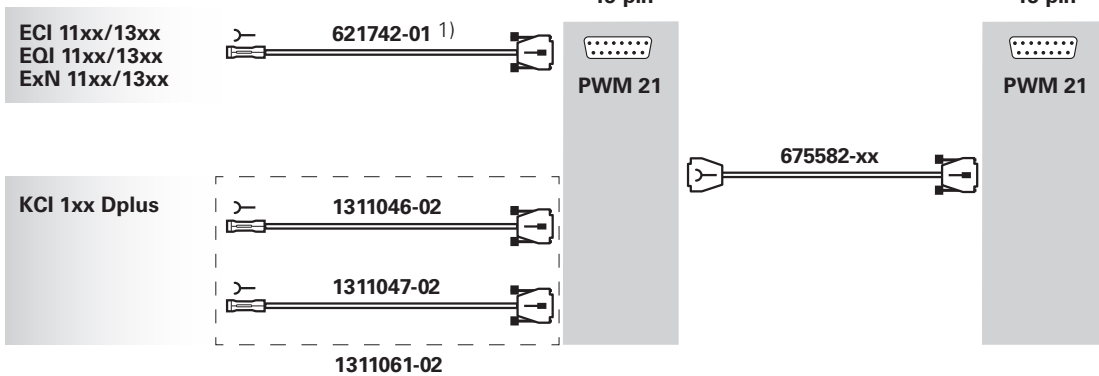[4] Wires for temperature sensors: 2 TPE single wires in heat-shrink tubing
[5] Not for EBI

Output cables: EnDat (EnDat22)

AEF 1323 (FCI)

1180955-xx

3)

1180959-xx

Servo controller

Output cables: EnDat (EnDat01)

M23

17-pin

M23

EnDat 01

ECN 1113 (JAE)
EQN 1125 (JAE)

606079-01[1]

3)

605090-xx[1]

ECI 1118 (JAE)
EQI 1130 (JAE)

640030-01[2]

ECI 119 (JAE)

640067-N3[1]

ECN 1313 (FCI)
EQN 1325 (FCI)
ECI 1319 (FCI)
EQI 1331 (FCI)

332201-01[1]

3)

332202-01[1]

Testing cables to PWM 21

15-pin

15-pin

ECI 11xx/13xx
EQI 11xx/13xx
ExN 11xx/13xx

621742-01 [1]

PWM 21

PWM 21

675582-xx

KCI 1xx Dplus

1311046-02

1311047-02

1311061-02

[1] EPG cable
[2] Cable clamp included
3) Wires for temperature sensors: 2 TPE wires in heat-shrink tubing

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

Output cables: HMC 2 (E30-R2)

HMC 2 output cables and power cables with encoder communication
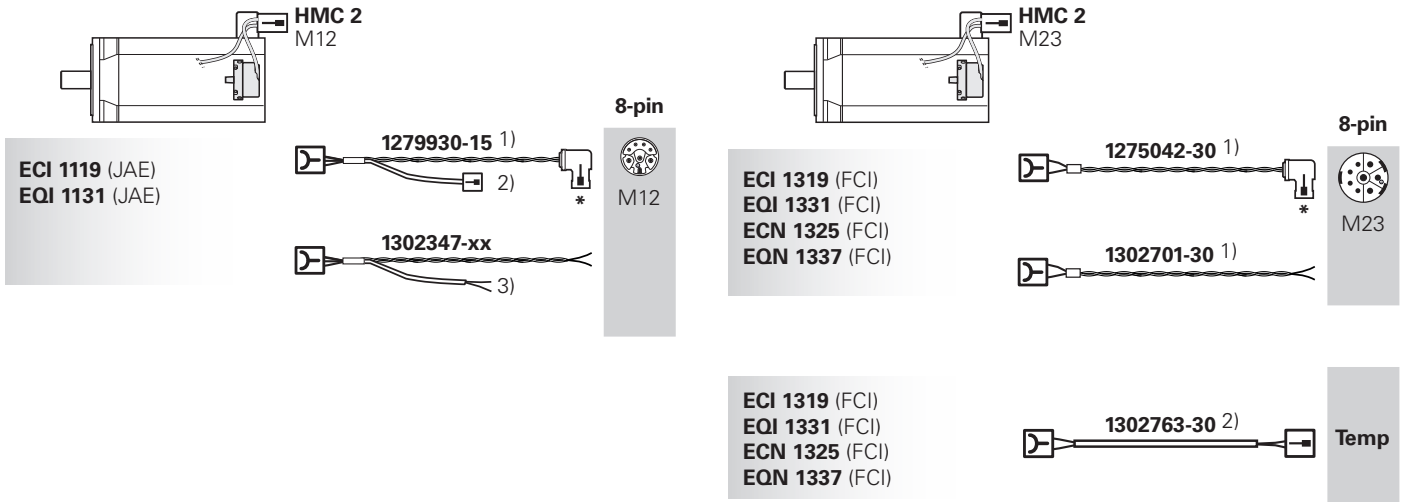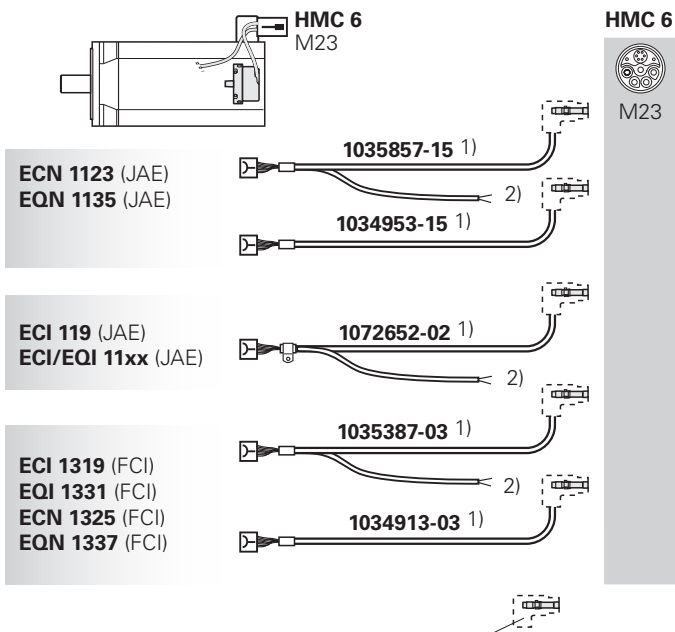

* SpeedTEC angle flange socket
1) ETFE twisted single wires
2) Wires for temperature sensors: 2 ETFE wires in heat-shrink tubing and 2-pin connector (male)
3) Wires for temperature sensors: 2 ETFE wires in heat-shrink tubing
4) Adapter cable to inspection device
5) SA 1210 signal adapter needed for E30-R2

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

Further information:

See the *HMC 2* Product Information document

Output cables: HMC 6 (EnDat22)

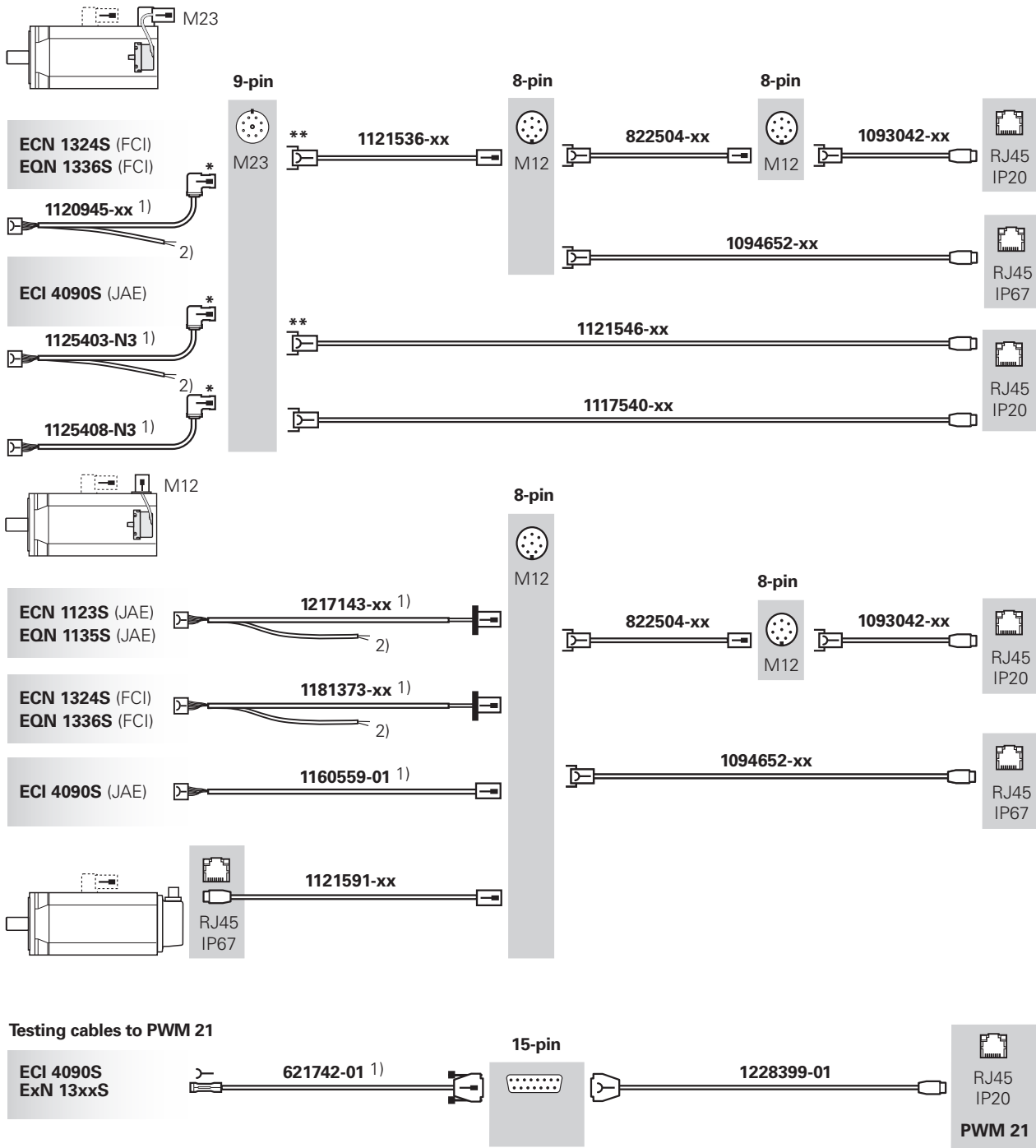**HMC 6 output cables and power cables with encoder communication**

SpeedTEC hybrid flange socket is not included in delivery.

1) EPG cable
2) Wires for temperature sensors: 2 TPE wires in heat-shrink tubing

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

Further information:

For more information about HMC 6, please refer to the *HMC 6* Product Information document.
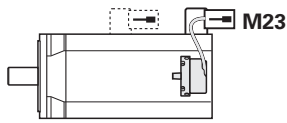
Output cables: DRIVE-CLiQ

M23

9-pin

| ECN 1324S (FCI) | 8-pin | 8-pin | |
| EQN 1336S (FCI) | | | RJ45 IP20 |

M23

** 1121536-xx   M12   822504-xx   M12   1093042-xx   RJ45 IP20

*

1120945-xx 1)

2)

1094652-xx   RJ45 IP67

ECI 4090S (JAE)

*

1125403-N3 1)

2) *

1125408-N3 1)

** 1121546-xx   RJ45 IP20

1117540-xx

M12

8-pin

M12

| ECN 1123S (JAE) | 1217143-xx 1) | 8-pin |
| EQN 1135S (JAE) | 2) | 822504-xx   M12   1093042-xx   RJ45 IP20 |

| ECN 1324S (FCI) | 1181373-xx 1) |
| EQN 1336S (FCI) | 2) |

ECI 4090S (JAE)   1160559-01 1)

1094652-xx   RJ45 IP67

RJ45 IP67   1121591-xx

Testing cables to PWM 21

| ECI 4090S | 15-pin | |
| ExN 13xxS | 621742-01 1) | 1228399-01   RJ45 IP20   **PWM 21** |

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*   SpeedTEC angle flange socket with O-ring vibration protection (male) (with O-ring for Hypertac connector; remove O-ring for SpeedTEC connector)
** SpeedTEC connector (female)
1) EPG cable
2) Wires for temperature sensors: 2 TPE wires in heat-shrink tubing

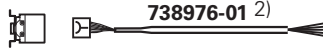DRIVE-CLiQ is a registered trademark of Siemens Aktiengesellschaft.
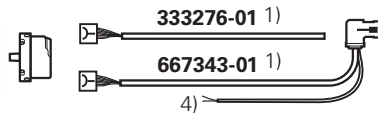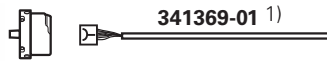
Output cables: 1 V$_{PP}$ or TTL

17-pin

M23

M23

ERN 1123 (JAE)		**738976-01** [2]
ERN 1321 (FCI) **ERN 1381 (FCI)**		**333276-01** [1] **667343-01** [1] [4]
ERN 1326 (FCI)		**341369-01** [1]
ERN 1387 (FCI)		**332200-xx** [1] **332199-01** [1] [4]
ERO 14x0 (FCI)		**346439-01** [3]
ERO 12x5 (Hirose) **ERP 880** (Hirose)		**372164-01** [3]
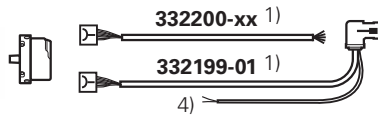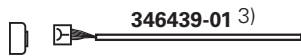
15-pin

MRP 2080		**1160480-xx** [3]
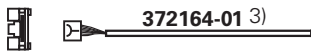
Testing cables to PWM 21
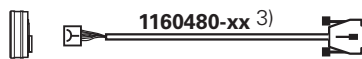
15-pin
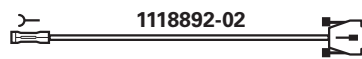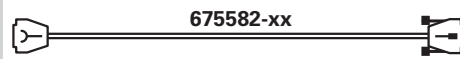
ERN 1387	**1118892-02**	**PWM 21**	**675582-xx**	**PWM 21**

[1] EPG cable
[2] TPE single wires in heat-shrink tubing (without shield)
[3] Cable clamp included
[4] Wires for temperature sensors: 2 polyolefin wires in the heat shrink tubing

Testing and inspection devices, and diagnostics

HEIDENHAIN encoders provide all of the information needed for initial setup, monitoring, and diagnostics. The type of information available depends on whether the encoder is incremental or absolute and on 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 use serial data transmission. Depending on the interface, additional 1 V_{PP} incremental signals can be output. The signals are extensively monitored within the encoder. The monitoring results (particularly valuation numbers) can be transmitted to the downstream electronics along with the position values via the serial interface (**digital diagnostic interface**). The following information is available:
- Error message: position value is not reliable
- Warning: an internal functional limit of the encoder has been reached
- Valuation numbers:
  – Detailed information on the encoder's function reserve
  – Identical scaling for all HEIDENHAIN encoders
  – Cyclic reading is possible

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

For the analysis of these encoders, HEIDENHAIN offers the appropriate PWM inspection devices and PWT testing devices. 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 interposed within the closed control loop (via suitable testing adapters as needed). This enables real-time diagnosis of the machine or equipment during operation. The available functions depend on the interface.
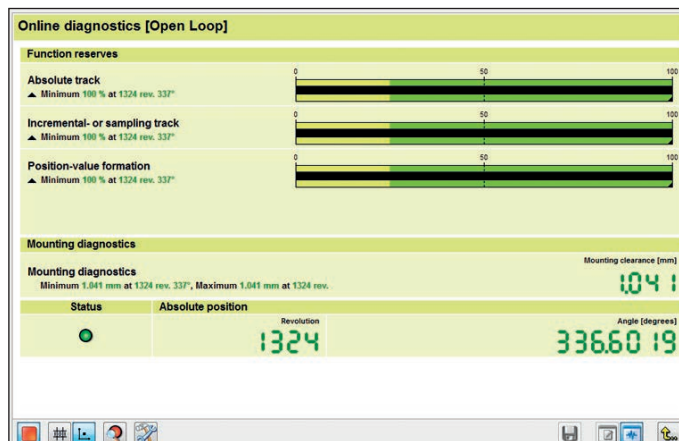
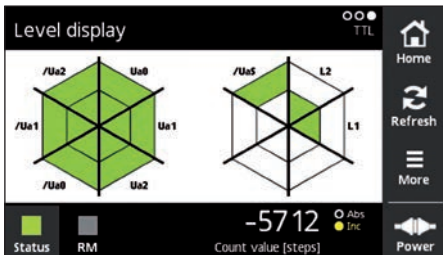
Diagnostics with the PWM 21 and ATS software

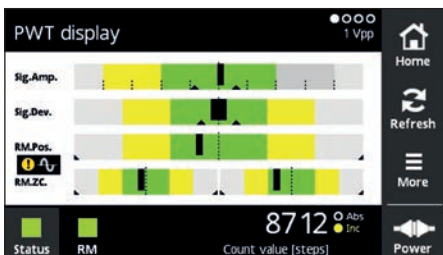Initial setup with the PWM 21 and ATS software

PWT 101

The PWT 101 is a testing device for the functional testing and adjustment of incremental and absolute HEIDENHAIN encoders. Thanks to its compact dimensions 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 adjustment and testing software, provides an adjustment 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.

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Mastering nanometer accuracy

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