Encoders for Servo Drives

01/2019

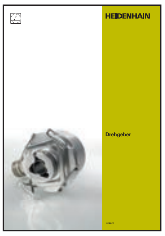
This brochure is not intended as an overview of the HEIDENHAIN product program. Rather it presents a selection of **encoders for use on electric drives**.

In the **selection tables** you will find an overview of all HEIDENHAIN encoders for use on electric drives, along with the most important specifications. The **technical features** descriptions contain basic information on the use of rotary, angle, and linear encoders on electric drives.

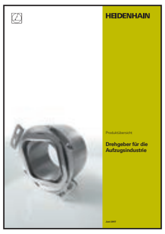
The **mounting information** and detailed **specifications** refer to **rotary encoders** developed specifically for drive technology. You will find more encoders in the corresponding product documentation.

Further information:

For the **linear and angle encoders** also listed in the selection tables, you will find more detailed information, specifications, and dimensions in the respective **product documentation.**

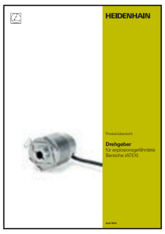


Brochure
Rotary Encoders



Product Overview
Rotary Encoders for the Elevator Industry

Brochure
Angle Encoders with Integral Bearing



Product Overview
Rotary Encoders for Potentially Explosive Atmospheres

Brochure
Modular Angle Encoders
With Optical Scanning

Brochure
Modular Encoders
With Magnetic Scanning

Brochure
Linear Encoders
For Numerically Controlled Machine Tools

Brochure
Exposed Linear Encoders

Further information:

Detailed descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

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

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

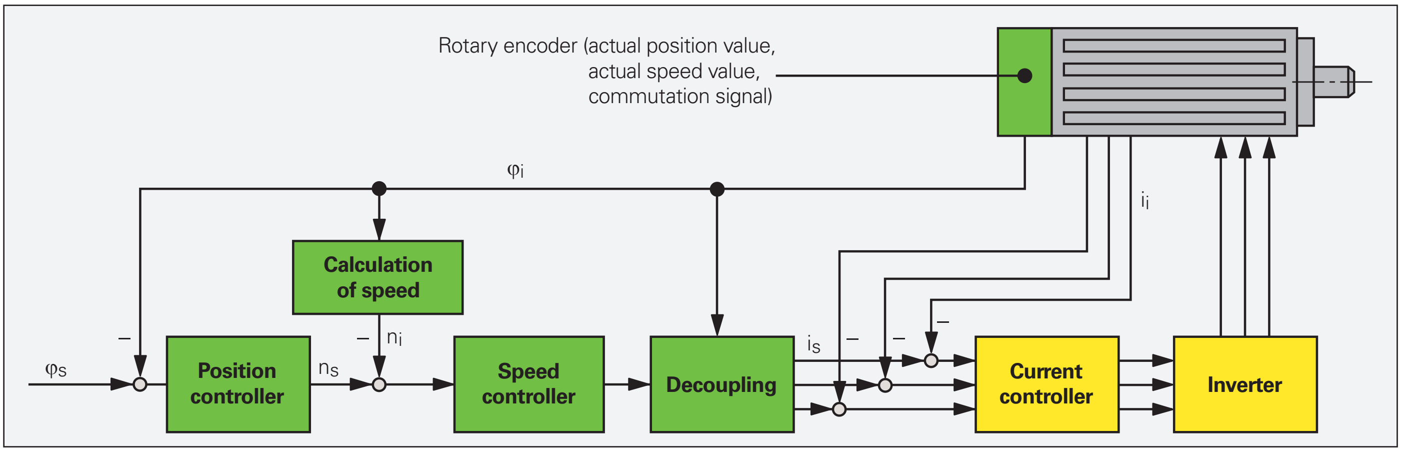
Contents

Encoders for servo drives

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

The characteristics of an encoder have a decisive influence on important motor qualities such as the following:
- Positioning accuracy
- Speed stability
- Bandwidth, and therefore the command and disturbance behavior of the drive
- Power loss
- Size
- Noise emission
- Safety

Digital position and speed control



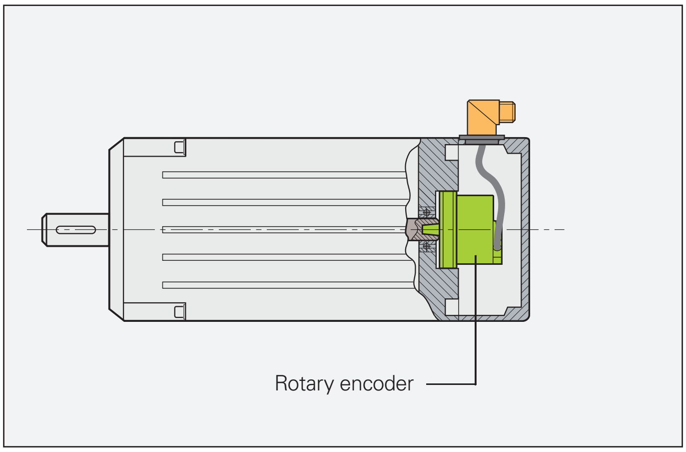
For rotary and linear motors used in a wide variety of applications, HEIDENHAIN has just the right solution:

- 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 encoder

For all of the HEIDENHAIN encoders featured in this brochure, the cost and effort required by the drive manufacturer for mounting and wiring has been kept to a minimum. At the same time, the overall length of rotary motors can be kept low. Even safety devices such as limit switches can be eliminated thanks to the special design of certain encoders.

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



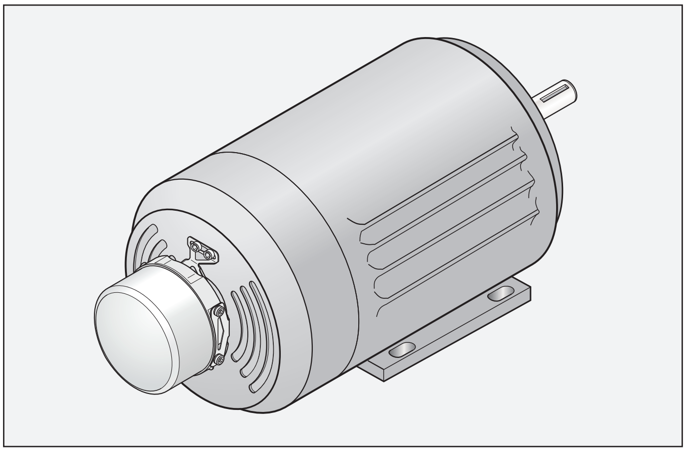
Linear encoders

Angle encoders

Explanation of the selection tables

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

Rotary encoders for mounting on motors
Rotary encoders for motors with forced ventilation are either mounted onto the motor housing or installed inside it. These encoders are frequently exposed to the unfiltered forced-air stream of the motor and must therefore exhibit a high protection rating of IP64 or better. The permissible operating temperature seldom exceeds 100 °C.

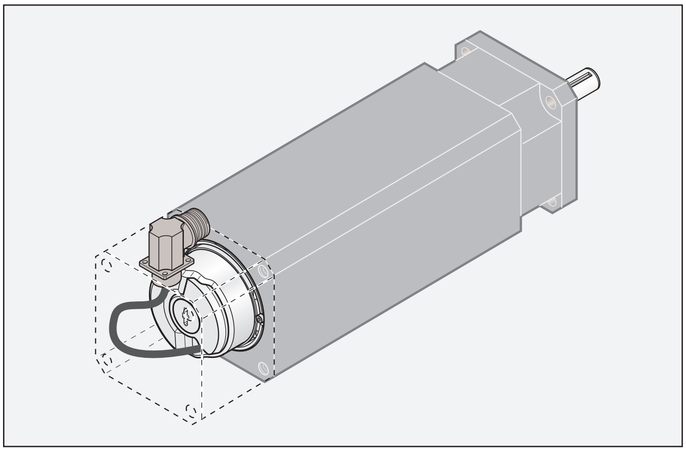


In the selection table you will find the following:

- Rotary encoders featuring a mounted **stator coupling** with a high natural frequency—the bandwidth of the drive is practically unlimited
- Rotary encoders for **separate shaft couplings**; these encoders are particularly well suited for **insulated mounting**
- Absolute rotary encoders with purely digital data transmission or additional sinusoidal TTL or HTL incremental signals
- Incremental rotary encoders with **sinusoidal output signals** featuring high signal quality for digital speed control
- Incremental encoders with **TTL- or HTL-compatible output signals**
- Information on rotary encoders with the "functional safety" designation that are available as safety-related position encoders

For the selection table, see page 12

Rotary encoders for integration in motors
For motors without forced ventilation, the rotary encoder is installed within the motor housing. As a result, the encoder does not require a high degree of protection. The operating temperature within the motor housing, however, can reach 100 °C and higher.

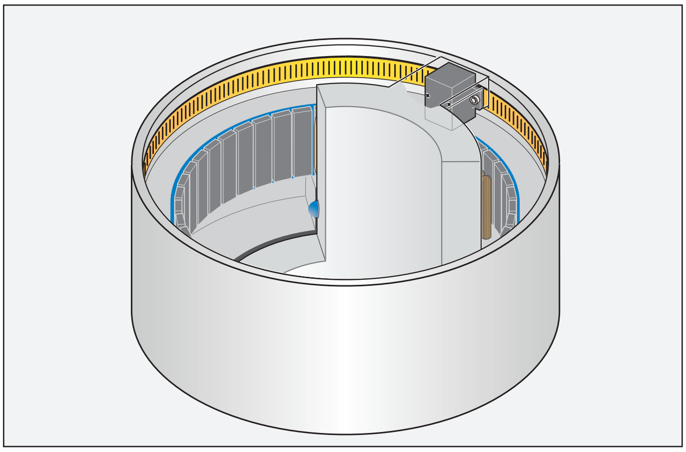


In the selection table you will find the following:

- Absolute rotary encoders for operating temperatures of up to 115 °C and incremental rotary encoders for **operating temperatures** of up to 120 °C
- Rotary encoders featuring a mounted **stator coupling** with a high natural frequency—the bandwidth of the drive is practically unlimited
- Absolute rotary encoders with **purely digital data transmission**—suitable for the **HMC 6** single-cable solution—or with additional sinusoidal incremental signals
- Incremental rotary encoder for digital speed control with **sinusoidal output signals** featuring high signal quality, even at high temperatures
- Incremental rotary encoders with an additional **commutation signal** for synchronous motors
- Incremental rotary encoders with **TTL-compatible output signals**
- Information on rotary encoders with the "functional safety" designation that are available as safety-related position encoders

For the selection table, see page 8

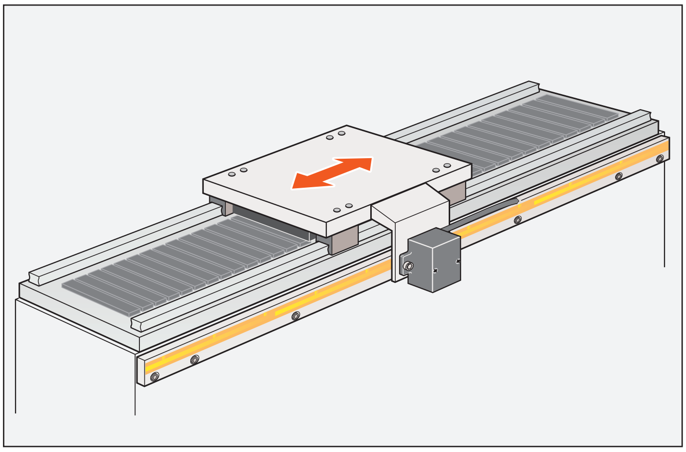
Rotary encoders, modular encoders, and angle encoders for integrated and hollow-shaft motors
Rotary encoders and angle encoders for these motors feature **hollow through shafts** for the purpose of allowing supply lines, for example, to be wired through the hollow shaft of the motor and thus also through the encoder. Depending on the application conditions, these encoders exhibit either an IP66 protection rating or must be protected from contamination by the machine design (such as for modular encoders with optical scanning).



In the selection table you will find the following:
- Encoders with **absolute and/or incremental output signals** featuring high signal quality
- Angle encoders and modular encoders with measuring standards on aluminum or steel drums for **speeds of up to 42 000 rpm**
- Encoders with integral bearing and stator coupling, or modular versions
- Encoders with **good acceleration behavior** for high bandwidth in the control loop

For the selection table, see page 18

Linear encoders for linear motors
Linear encoders on linear motors provide the actual value for both the position controller and the speed controller. These encoders thus have a decisive influence on the control characteristics of a linear drive. The linear encoders recommended for this type of application



- feature low position deviation during acceleration in the measuring direction,
- can tolerate acceleration and vibration in the lateral direction,
- are designed for high velocities, and
- provide absolute position information with purely digital data transmission or high-quality sinusoidal incremental signals.

Exposed linear encoders are characterized by the following:
- Higher accuracy grades
- Higher traversing speeds
- Contact-free scanning (i.e., no friction between scanning head and scale)

Exposed linear encoders are well suited for applications in clean environments, such as on measuring machines or production equipment in the semiconductor industry.

For the selection table, see page 20

Sealed linear encoders are characterized by the following:
- A high degree of protection
- Easy installation

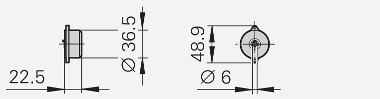
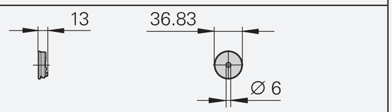
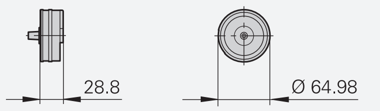
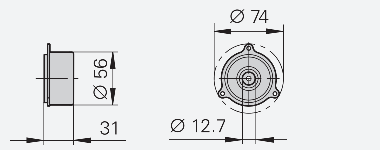
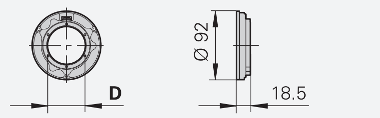
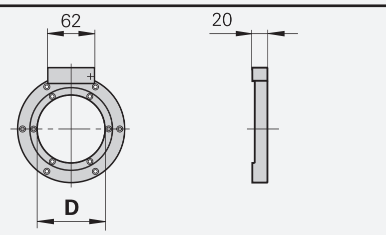
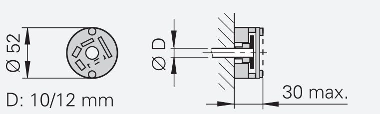
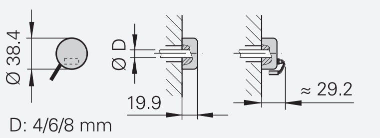
Sealed linear encoders are therefore ideal for applications in environments with airborne liquids and particles, such as on machine tools.

For the selection table, see page 22

Selection guide

Rotary encoders for integration in motors

Protection: up to IP40 (EN 60529)

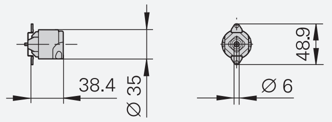
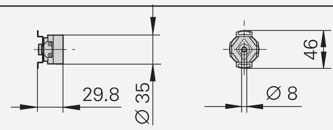
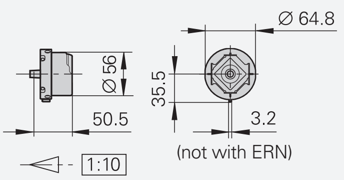
Series	Overall dimensions	Mechanically permissible speed	Natural frequency of the stator coupling (typical)	Maximum operating temperature	Supply voltage
Rotary encoders without integral bearing					
ECI/EQI 1100		≤ 15000 rpm/ ≤ 12000 rpm	–	110 °C	DC 3.6 V to 14 V
ECI/EBI 1100				115 °C	
ECI/EQI 1300		≤ 15000 rpm/ ≤ 12000 rpm	–	115 °C	DC 4.75 V to 10 V
					DC 3.6 V to 14 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	≤ 25000 rpm	–	100 °C	DC 5 V ±0.5 V
ERO 1400	 D: 4/6/8 mm	≤ 30000 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

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 74**
	262 144 (18 bits)	–/65 536[3]		**ECI 1118/EBI 1135**	**Page 76**
32	524 288 (19 bits)	–/4096	EnDat 2.2/01 with ∼ 1 V_{PP}	**ECI 1319[1]/EQI 1331[1]**	**Page 78**
–			EnDat 2.2/22		**Page 80**
32	524 288 (19 bits)	–	EnDat 2.1/01 with ∼ 1 V_{PP}	**ECI 119**	**Page 82**
–		–/65 536[3]	EnDat 2.2/22	**ECI 119/EBI 135**	
–	1 048 576 (20 bits)	–/65 536[3]	EnDat 2.2/22	**ECI/EBI 4010[1]**	**Page 84**
		–	DRIVE-CLiQ	**ECI 4090 S[1]**	
1024/2048	–		⊓⊔TTL	**ERO 1225**	**Page 88**
			∼ 1 V_{PP}	**ERO 1285**	
512/1000/1024	–		⊓⊔TTL	**ERO 1420**	**Page 90**
5000 to 37 500[2]			⊓⊔TTL	**ERO 1470**	
512/1000/1024			∼ 1 V_{PP}	**ERO 1480**	

[3] Multiturn function via battery-buffered revolution counter

Series	Overall dimensions	Mechanically permissible speed	Natural frequency of the stator coupling (typical)	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
		≤ 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
		≤ 15000 rpm		120 °C *ERN 1381/4096:* 80 °C	DC 5 V ±0.5 V
					DC 5 V ±0.25 V
					DC 10 V to 28.8 V

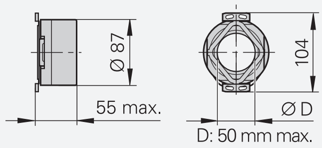
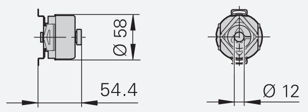
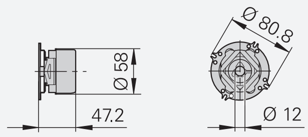
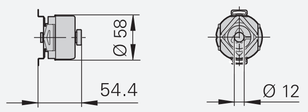
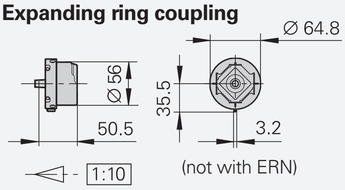
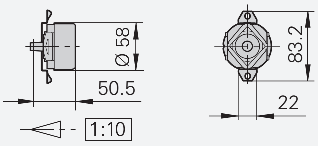
[1] Also available with functional safety

DRIVE-CLiQ is a registered trademark of Siemens AG.

Signal periods per revolution	Positions per revolution	Distinguishable revolutions	Interface	Model	Further information
512	8192 (13 bits)	–/4096	EnDat 2.2/01 with ∿ 1 V_{PP}	**ECN 1113/EQN 1125**	**Page 56**
–	8388608 (23 bits)		EnDat 2.2/22	**ECN 1123[1)]/EQN 1135[1)]**	
500 to 8192	3 block commutation signals		⎍ TTL	**ERN 1123**	**Page 60**
512/2048	8192 (13 bits)	–/4096	EnDat 2.2/01 with ∿ 1 V_{PP}	**ECN 1313/EQN 1325**	**Page 62**
–	33554432 (25 bits)		EnDat 2.2/22	**ECN 1325[1)]/EQN 1337[1)]**	
1024/2048/4096	–		⎍ TTL	**ERN 1321**	**Page 68**
	3 block commutation signals			**ERN 1326**	
512/2048/4096	–		∿ 1 V_{PP}	**ERN 1381**	
2048	Z1 track for sine commutation			**ERN 1387**	
–	16777216 (24 bits)	–/4096	DRIVE-CLiQ	**ECN 1324S/EQN 1336S**	**Page 64**

Rotary encoders for mounting on motors

Protection: up to IP64 (EN 60529)

Series	Overall dimensions	Mechanically permissible speed	Natural frequency of the stator coupling (typical)	Maximum operating temperature	Supply voltage
Rotary encoders with integral bearing and mounted stator coupling					
ECN/ERN 100		*D ≤ 30 mm:* ≤ 6000 rpm *D > 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**  **Universal stator coupling** 	≤ 6000 rpm *With 2 shaft clamps (only for hollow through shaft):* ≤ 12 000 rpm	*Stator coupling for plane surfaces:* 1500 Hz *Universal stator coupling:* 1400 Hz	100 °C	DC 3.6 V to 14 V
					DC 4.75 V to 30 V
					DC 5 V ±0.5 V
				70 °C	DC 10 V to 30 V
				100 °C	DC 5 V ±0.5 V
ECN/EQN/ERN 400	**Stator coupling for plane surfaces** 	≤ 6000 rpm *With 2 shaft clamps (only for hollow through shaft):* ≤ 12 000 rpm	*Stator coupling for plane surfaces:* 1500 Hz *Universal stator coupling:* 1400 Hz	100 °C	DC 10 V to 30 V
					DC 4.75 V to 30 V
					DC 3.6 V to 14 V
					DC 10 V to 28.8 V
ECN/EQN/ERN 400	**Expanding ring coupling**  **Plane-surface coupling** 	≤ 15 000 rpm/ ≤ 12 000 rpm	*Expanding ring coupling:* 1800 Hz *Plane-surface coupling:* 400 Hz	100 °C	DC 3.6 V to 14 V
		≤ 15 000 rpm			DC 5 V ±0.5 V
					DC 5 V ±0.25 V

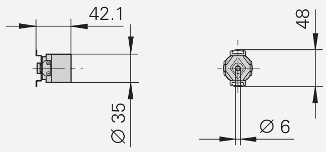
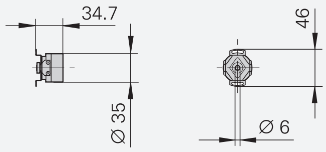
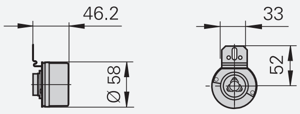
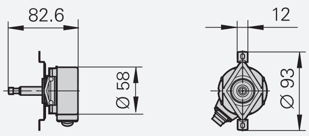
1) Also available with functional safety

DRIVE-CLiQ is a registered trademark of Siemens AG.

Signal periods per revolution	Positions per revolution	Distinguishable revolutions	Interface	Model	Further information
2048	8192 (13 bits)	–	EnDat 2.2/01 with ∼ 1 V_{PP}	**ECN 113**	**Brochure:** ***Rotary Encoders***
–	33 554 432 (25 bits)		EnDat 2.2/22	**ECN 125**	
1000 to 5000	–		⊓⊔TTL/∼ 1 V_{PP}	**ERN 120/ERN 180**	
			⊓⊔ HTL	**ERN 130**	
512/2048	8192 (13 bits)	–/4096	EnDat 2.2/01 ∼ 1 V_{PP}	**ECN 413/EQN 425**	
–	33 554 432 (25 bits)		EnDat 2.2/22	**ECN 425/EQN 437**	
512	8192 (13 bits)		SSI	**ECN 413/EQN 425**	
250 to 5000	–		⊓⊔TTL	**ERN 420**	
			⊓⊔ HTL	**ERN 430**	
			⊓⊔TTL	**ERN 460**	
1000 to 5000			∼ 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: 33 554 432 (25 bits)	4096	Fanuc	**ECN 425 F/EQN 437 F**	
	33 554 432 (25 bits)/ 8 388 608 (23 bits)		Mitsubishi	**ECN 425 M/EQN 435 M**	
	16 777 216 (24 bits)		DRIVE-CLIQ	**ECN 424 S/EQN 436 S**	
2048	8192 (13 bits)	–/4096	EnDat 2.2/01 with ∼ 1 V_{PP}	**ECN 413/EQN 425**	**Page 66**
–	33 554 432 (25 bits)		EnDat 2.2/22	**ECN 425[1)]/EQN 437[1)]**	
1024 to 5000	–		⊓⊔TTL	**ERN 421**	**Product Information**
2048	Z1 track for sine commutation			**ERN 487**	

Rotary encoders for mounting on motors

Protection: up to IP64 (EN 60529)

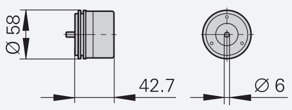
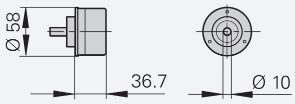
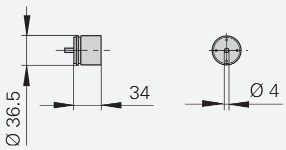
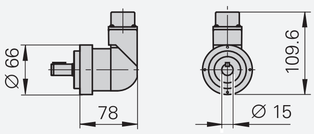
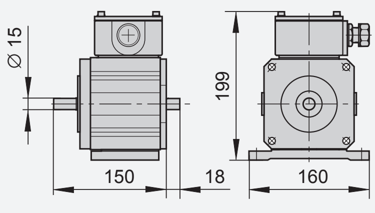
Series	Overall dimensions	Mechanically permissible speed	Natural frequency of the stator coupling (typical)	Maximum operating temperature	Supply voltage
Rotary encoders with integral bearing and mounted stator coupling					
ECN/EQN/ERN 1000	 ERN 1023 	≤ 12000 rpm	1500 Hz	100 °C	DC 3.6 V to 14 V
					DC 4.75 V to 30 V
					DC 3.6 V to 14 V
					DC 5 V ±0.5 V
				70 °C	DC 10 V to 30 V
					DC 5 V ±0.25 V
		≤ 6000 rpm	1600 Hz	90 °C	DC 5 V ±0.5 V
Rotary encoders with integral bearing and torque support for Siemens drives					
EQN/ERN 400		≤ 6000 rpm	–	100 °C	DC 3.6 V to 14 V
					DC 10 V to 30 V
					DC 5 V ±0.5 V
					DC 10 V to 30 V
ERN 401		≤ 6000 rpm	–	100 °C	DC 5 V ±0.5 V
					DC 10 V to 30 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 ∼ 1 V_{PP}	**ECN 1013/EQN 1025**	**Brochure:** ***Rotary Encoders***
				SSI		
	–	8388608 (23 bits)		EnDat 2.2/22	**ECN 1023/EQN 1035**	
	100 to 3600	–		⊓⊔TTL/∼ 1 V_{PP}	**ERN 1020/ERN 1080**	
				⊓⊔ HTLs	**ERN 1030**	
	5000 to 36000[1)]			⊓⊔TTL	**ERN 1070**	
	500 to 8192	3 block commutation signals		⊓⊔TTL	**ERN 1023**	**Page 58**
	2048	8192 (13 bits)	4096	EnDat 2.1/01 with ∼ 1 V_{PP}	**EQN 425**	**Page 70**
				SSI		
	1024	–		⊓⊔TTL	**ERN 420**	
				⊓⊔ HTL	**ERN 430**	
	1024			⊓⊔TTL	**ERN 421**	**Page 72**
				⊓⊔ HTL	**ERN 431**	

Rotary encoders for mounting on motors

Protection: up to IP64 (EN 60529)

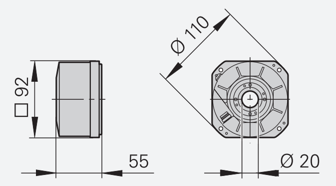
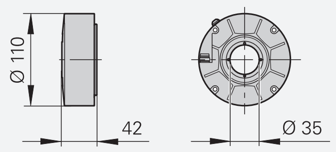
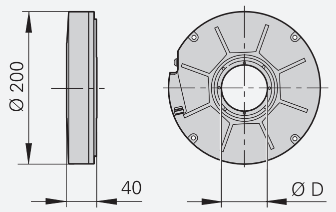
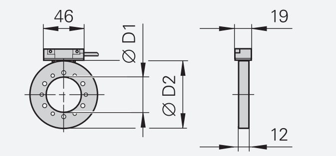
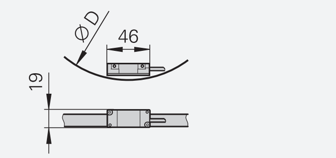
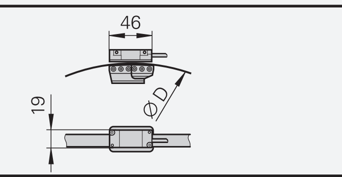
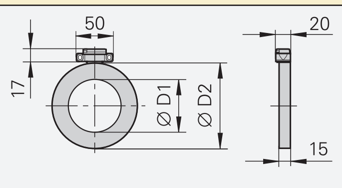
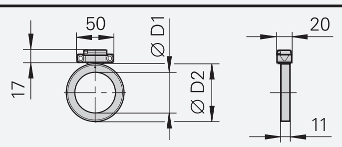
Series	Overall dimensions	Mechanically permissible speed	Natural frequency of the stator coupling (typical)	Maximum operating temperature	Supply voltage
Rotary encoders with integral bearing for separate shaft coupling					
ROC/ROQ/ROD 400 **RIC/RIQ**	**Synchro flange**  **Clamping flange** 	≤ 12000 rpm	–	100 °C	DC 3.6 V to 14 V
					DC 5 V
					DC 4.75 V to 30 V
					DC 10 V to 30 V
					DC 4.75 V to 30 V
					DC 3.6 V to 14 V
					DC 10 V to 28.8 V
					DC 5 V ±0.5 V
					DC 10 V to 30 V
				70 °C	
				100 °C	DC 5 V ±0.5 V
ROC/ROQ/ROD 1000		≤ 12000 rpm	–	100 °C	DC 3.6 V to 14 V
					DC 4.75 V to 30 V
					DC 3.6 V to 14 V
					DC 5 V ±0.5 V
				70 °C	DC 10 V to 30 V
					DC 5 V ±0.25 V
ROD 600		≤ 12000 rpm	–	80 °C	DC 5 V ±0.5 V
ROD 1900		≤ 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

DRIVE-CLiQ is a registered trademark of Siemens AG.

Signal periods per revolution	Positions per revolution	Distinguishable revolutions	Interface	Model	Further information
512/2048	8192 (13 bits)	–/4096	EnDat 2.2/01 with ∿ 1 V_{PP}	**ROC 413/ROQ 425**	**Brochure:** ***Rotary Encoders***
–	33554432 (25 bits)		EnDat 2.2/22	**ROC 425**[1]**/ROQ 437**[1]	
16	262144 (18 bits)		EnDat 2.1/01	**RIC 418/RIQ 430**	
512	8192 (13 bits)		SSI	**ROC 413/ROQ 425**	
256 to 2048	8192 (13 bits)	–/4096	EnDat H ⊓⊔ HTL SSI 41H ⊓⊔ HTL	**ROQ 425**[3]	
512 to 4096			EnDat T ⊓⊔ TTL SSI 41T ⊓⊔ TTL		
–	αi: 33554432 (25 bits)	4096	Fanuc	**ROC 425F/ROQ 437F**	
	33554432 (25 bits)/ 8388608 (23 bits)		Mitsubishi	**ROC 425M/ROQ 435M**	
	16777216 (24 bits)		DRIVE-CLIQ	**ROC 424S/EQN 436S**	
50 to 10000[2]	–	–	⊓⊔ TTL	**ROD 426/ROD 420**	
50 to 5000			⊓⊔ HTL	**ROD 436/ROD 430**	
50 to 10000[2]			⊓⊔ TTL	**ROD 466**	
1000 to 5000			∿ 1 V_{PP}	**ROD 486/ROD 480**	
512	8192 (13 bits)	–/4096	EnDat 2.2/01 with ∿ 1 V_{PP}	**ROC 1013/ROQ 1025**	**Brochure:** ***Rotary Encoders***
			SSI		
–	8388608 (23 bits)		EnDat 2.2/22	**ROC 1023/ROQ 1035**	
100 to 3600	–		⊓⊔ TTL	**ROD 1020**	
			∿ 1 V_{PP}	**ROD 1080**	
			⊓⊔ HTLs	**ROD 1030**	
5000 to 36000[2]			⊓⊔ TTL	**ROD 1070**	
512 to 5000	–		⊓⊔ TTL	**ROD 620**	
			⊓⊔ HTL	**ROD 630**	
600 to 2400	–		⊓⊔ HTL/HTLs	**ROD 1930**	

Angle encoders for integrated and hollow-shaft motors

Series	Overall dimensions	Diameter	Mechanically permissible speed	Natural frequency of the stator coupling (typical)	Maximum operating temperature
Angle encoders with integral bearing and integrated stator coupling					
RCN 2000		–	≤ 1500 rpm	1000 Hz	*RCN 23xx:* 60 °C *RCN 25xx:* 50 °C
RCN 5000		–	≤ 1500 rpm	1000 Hz	*RCN 53xx:* 60 °C *RCN 55xx:* 50 °C
RCN 8000		D: 60 mm and 100 mm	≤ 500 rpm	900 Hz	50 °C
Modular angle encoders with optical scanning					
ERA 4000 Steel scale drum		D1: 40 mm to 512 mm D2: 76.75 mm to 560.46 mm	≤ 10000 rpm to ≤ 1500 rpm	–	80 °C
ERA 7000 For mounting on inside diameter		D: 458.62 mm to 1146.10 mm	≤ 250 rpm to ≤ 220 rpm	–	80 °C
ERA 8000 For mounting on inside diameter		D: 458.11 mm to 1145.73 mm	≤ 50 rpm to ≤ 45 rpm	–	80 °C
Modular angle encoders with magnetic scanning					
ERM 2200 Signal period of approx. 200 µm **ERM 2400** Signal period of approx. 400 µm		D1: 40 mm to 410 mm D2: 75.44 mm to 452.64 mm	≤ 19000 rpm to ≤ 3000 rpm	–	100 °C
ERM 2400 Signal period of approx. 400 µm		D1: 40 mm to 100 mm D2: 64.37 mm to 128.75 mm	≤ 42000 rpm to ≤ 20000 rpm	–	100 °C
ERM 2900 Signal period of approx. 1000 µm		D1: 40 mm to 100 mm D2: 58.06 mm to 120.96 mm	≤ 35000 rpm/ ≤ 16000 rpm		

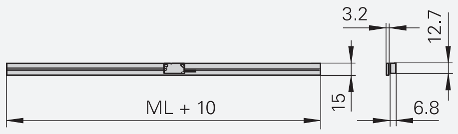
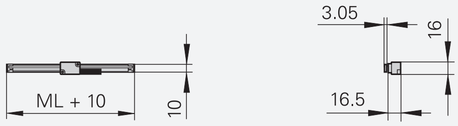
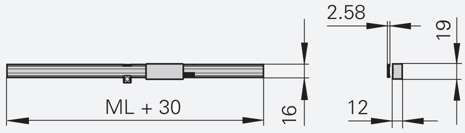
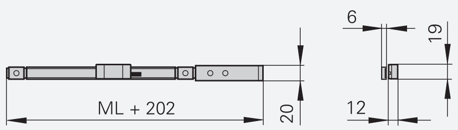
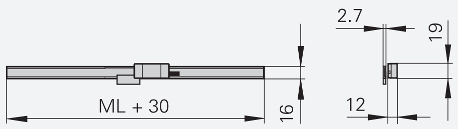
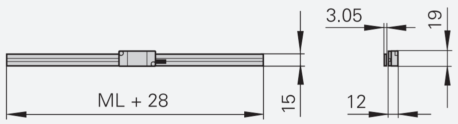
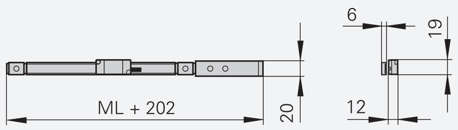
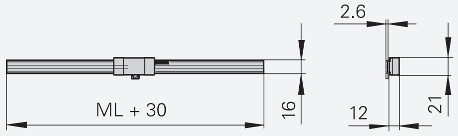
1) Interfaces for Fanuc and Mitsubishi controls available upon request

2) Segment solutions upon request

Supply voltage	System accuracy	Signal periods per revolution	Positions per revolution	Interface[1]	Model	Further information
DC 3.6 V to 14 V	±5″ ±2.5″	16384	67108864 (26 bits) 268435456 (28 bits)	EnDat 2.2/02 with ∿ 1 V_{PP}	**RCN 2380** **RCN 2580**	**Brochure:** ***Angle Encoders*** *With integral bearing*
	±5″ ±2.5″	–	67108864 (26 bits) 268435456 (28 bits)	EnDat 2.2/22	**RCN 2310**[3] **RCN 2510**[3]	
DC 3.6 V to 14 V	±5″ ±2.5″	16384	67108864 (26 bits) 268435456 (28 bits)	EnDat 2.2/02 with ∿ 1 V_{PP}	**RCN 5380** **RCN 5580**	
	±5″ ±2.5″	–	67108864 (26 bits) 268435456 (28 bits)	EnDat 2.2/22	**RCN 5310**[3] **RCN 5510**[3]	
DC 3.6 V to 14 V	±2″ ±1″	32768	536870912 (29 bits)	EnDat 2.2/02 with ∿ 1 V_{PP}	**RCN 8380** **RCN 8580**	
	±2″ ±1″	–		EnDat 2.2 / 22	**RCN 8310**[3] **RCN 8510**[3]	
DC 5 V ±0.5 V	–	12000 to 52000	–	∿ 1 V_{PP}	**ERA 4280 C**	**Brochure:** ***Modular Angle Encoders*** *With Optical Scanning*
		6000 to 44000			**ERA 4480 C**	
		3000 to 13000			**ERA 4880 C**	
DC 5 V ±0.25 V	–	**Full circle**[2] 36000 to 90000	–	∿ 1 V_{PP}	**ERA 7480 C**	
DC 5 V ±0.25 V	–	**Full circle**[2] 36000 to 90000	–	∿ 1 V_{PP}	**ERA 8480 C**	
DC 5 V ±0.5 V	–	600 to 3600	–	⊓⊔TTL	**ERM 2420**	**Brochure:** ***Modular Angle Encoders*** *With Magnetic Scanning*
				∿ 1 V_{PP}	**ERM 2280** **ERM 2480**	
DC 5 V ±0.5 V	–	512 to 1024	–	∿ 1 V_{PP}	**ERM 2484**	
		256/400	–		**ERM 2984**	

3) Also available with functional safety

Exposed linear encoders for linear drives

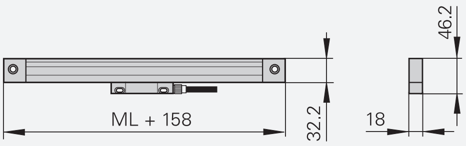
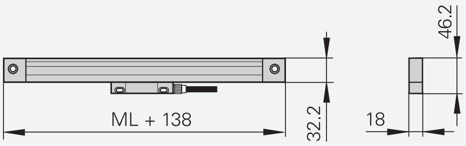
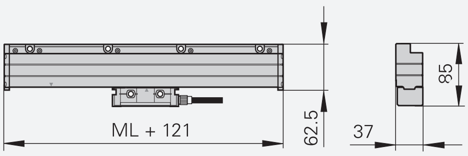
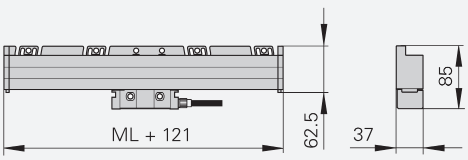
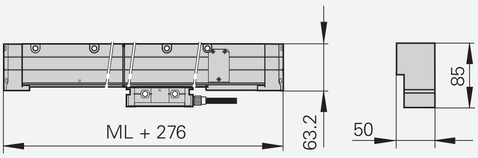
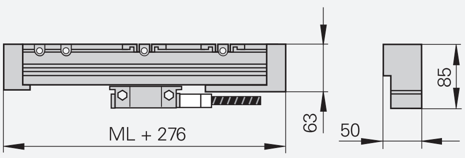
Series	Overall dimensions	Traversing speed	Acceleration in measuring direction	Accuracy grade
LIP 6000		240 m/min	500 m/s^2	Down to ±1μm[1)]
LIF 400		≤ 72 m/min	≤ 200 m/s^2	±1 μm[1)]
LIC 2100 Absolute linear encoder		≤ 600 m/min	≤ 200 m/s^2	±15 μm
LIC 4100[2)] Absolute linear encoder		≤ 600 m/min	≤ 500 m/s^2	±5 μm
				±5 μm[3)]
LIDA 400		≤ 480 m/min	≤ 500 m/s^2	±5 μm
				±5 μm[1)]
LIDA 200		≤ 600 m/min	≤ 200 m/s^2	±30 μm

1) With Zerodur glass ceramic up to a measuring length of 1020 mm
2) Also available with Fanuc, Mitsubishi, and Panasonic interfaces
3) After linear error compensation

Measuring lengths	Supply voltage	Signal period	Cutoff frequency –3 dB	Switching output	Interface	Model	Further information
20 mm to 3040 mm	DC 5 V ±0.5 V	4 µm	≥ 1 MHz	Homing track Limit switch	∿ 1 V_{PP}	**LIP 6081**	**Brochure:** ***Exposed Linear Encoders***
					⊓⊔TTL	**LIP 6071**	
70 mm to 1020 mm	DC 5 V ±0.25 V	4 µm	≥ 300 kHz	Homing track Limit switch	∿ 1 V_{PP}	**LIF 481**	
					⊓⊔TTL	**LIF 471**	
120 mm to 3020 mm	DC 3.6 V to 14 V	–	–	–	EnDat 2.2/22 Resolution 0.05 µm	**LIC 2107**	
140 mm to 27 040 mm	DC 3.6 V to 14 V	–	–	–	EnDat 2.2/22 Resolution 0.001 µm	**LIC 4115**	
140 mm to 6040 mm						**LIC 4117**	
140 mm to 30 040 mm	DC 5 V ±0.25 V	20 µm	≥ 400 kHz	Limit switch	∿ 1 V_{PP}	**LIDA 485**	
					⊓⊔TTL	**LIDA 475**	
240 mm to 6040 mm					∿ 1 V_{PP}	**LIDA 487**	
					⊓⊔TTL	**LIDA 477**	
Up to 10 000 mm	DC 5 V ±0.25 V	200 µm	≥ 50 kHz	–	∿ 1 V_{PP}	**LIDA 287**	
					⊓⊔TTL	**LIDA 277**	

Sealed linear encoders for linear drives

Protection: IP53 to IP64[1)] (EN 60529)

Series	**Overall dimensions**	**Traversing speed**	**Acceleration** in measuring direction	**Natural frequency of coupling**	**Measuring lengths**
Linear encoders with slimline scale housing					
LF		≤ 60 m/min	≤ 100 m/s²	≥ 2000 Hz	50 mm to 1220 mm
LC Absolute linear encoder		≤ 180 m/min	≤ 100 m/s²	≥ 2000 Hz	70 mm to 2040 mm[3)]
Linear encoders with full-size scale housing					
LF		≤ 60 m/min	≤ 100 m/s²	≥ 2000 Hz	140 mm to 3040 mm
LC Absolute linear encoder		≤ 180 m/min	≤ 100 m/s²	≥ 2000Hz	140 mm to 4240 mm
					140 mm to 3040 mm
					140 mm to 4240 mm
					140 mm to 3040 mm
		≤ 120 m/min (180 m/min upon request)	≤ 100 m/s²	≥ 780 Hz	3240 mm to 28040 mm
LB		≤ 120 m/min (180 m/min upon request)	≤ 60 m/s²	≥ 650 Hz	440 mm to 30040 mm (up to 72040 mm upon request)

1) After mounting in accordance with mounting instructions
2) Interfaces for Siemens, Fanuc, and Mitsubishi controls available upon request
3) At or above a measuring length of 1340 mm: only with mounting spar or clamping elements
4) Also available with functional safety

Accuracy grade	Supply voltage	Signal period	Cutoff frequency –3 dB	Resolution	Interface[2)]	Model	Further information
±5 µm	DC 5 V ±0.25 V	4 µm	≥ 250 kHz	–	∿ 1 V_{PP}	**LF 485**	**Brochure:** ***Linear Encoders*** *For Numerically Controlled Machine Tools*
±5 µm	DC 3.6 V to 14 V	–	–	Down to 0.01 µm	EnDat 2.2/22	**LC 415**[4)]	
±3 µm				Down to 0.001 µm			
±5 µm		20 µm	≥ 150 kHz	Down to 0.01 µm	EnDat 2.2/02	**LC 485**	
±3 µm				Down to 0.05 µm			
±2 µm; ±3 µm	DC 5 V ±0.25 V	4 µm	≥ 250 kHz	–	∿ 1 V_{PP}	**LF 185**	**Brochure:** ***Linear Encoders*** *For Numerically Controlled Machine Tools*
±5 µm	DC 3.6 V to 14 V	–	–	Down to 0.01 µm	EnDat 2.2/22	**LC 115**[4)]	
±3 µm				Down to 0.001 µm			
±5 µm		20 µm	≥ 150 kHz	Down to 0.01 µm	EnDat 2.2/02	**LC 185**	
±3 µm				Down to 0.05 µm			
±5 µm	DC 3.6 V to 14 V	–	–	Down to 0.01 µm	EnDat 2.2/22	**LC 211**	
		40 µm	≥ 250 kHz		EnDat 2.2/02 with ∿ 1 V_{PP}	**LC 281**	
Down to ±5 µm	DC 5 V ±0.25 V	40 µm	≥ 250 kHz	–	∿ 1 V_{PP}	**LB 382**	

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

Speed stability
For **good speed stability** of the drive, a **high number of measuring steps per revolution** is required. The encoders in the HEIDENHAIN product program are thus designed to output the necessary number of measuring steps per revolution to meet the required speed stability.

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

At low speeds, the speed stability is affected by the **position errors within an individual signal period.** In encoders with purely serial data transmission, the LSB (Least Significant Bit) goes into the speed stability (see also *Measuring accuracy*).

Transmission of measuring signals
For the best possible 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 in order to meet these tight time requirements for the serial data transmission of the position value from the encoder to the controlling system (see also the *Interfaces of HEIDENHAIN Encoders* brochure). This is why HEIDENHAIN encoders for servo drives output the position values over the fast, **purely serial EnDat 2.2 interface** or transmit additional **incremental signals** that are available virtually without delay for speed and position control in the subsequent electronics.

For **standard drives**, manufacturers primarily use the especially rugged **ECI/EQI** absolute encoders without integral bearing or rotary encoders with **TTL-** or **HTL-compatible output signals**—with additional commutation signals for permanent-magnet DC drives.

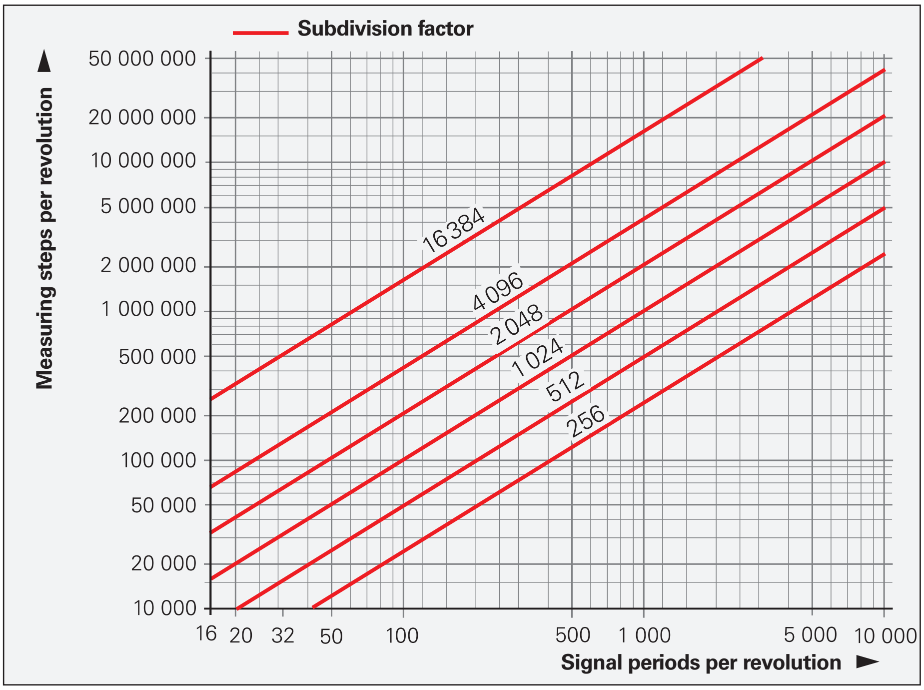
For **digital speed control** on machines with **high dynamic requirements**, a high number of measuring steps is needed—usually more than 500 000 per revolution. For applications with standard drives, approximately 60 000 measuring steps per revolution are sufficient (similarly to resolvers).

HEIDENHAIN encoders for servo drives with digital position and speed control are therefore either equipped with the **purely serial EnDat22 interface** or additionally output **sinusoidal incremental signals** with 1 V_{PP} signal levels (EnDat01).

The high internal resolution of the **EnDat22** encoders permits resolutions of up to 19 bits (524 288 measuring steps) with inductive systems, and at least 23 bits (approximately 8 million measuring steps) with photoelectric encoders.

Thanks to their high signal quality, the sinusoidal incremental signals of the **EnDat01** encoders can be highly subdivided in the subsequent 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" drives additionally supply sinusoidal incremental signals with the same characteristics as those described above. Absolute encoders from HEIDENHAIN use the EnDat interface (**En**coder **Dat**a) for the **serial data transmission** of encoded position values and of other information for **automatic self-configuration, monitoring, and diagnostics** (see *EnDat position values*). As a result, the same subsequent electronics and cabling technology can always be used for HEIDENHAIN encoders.

For automatic commissioning, 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).

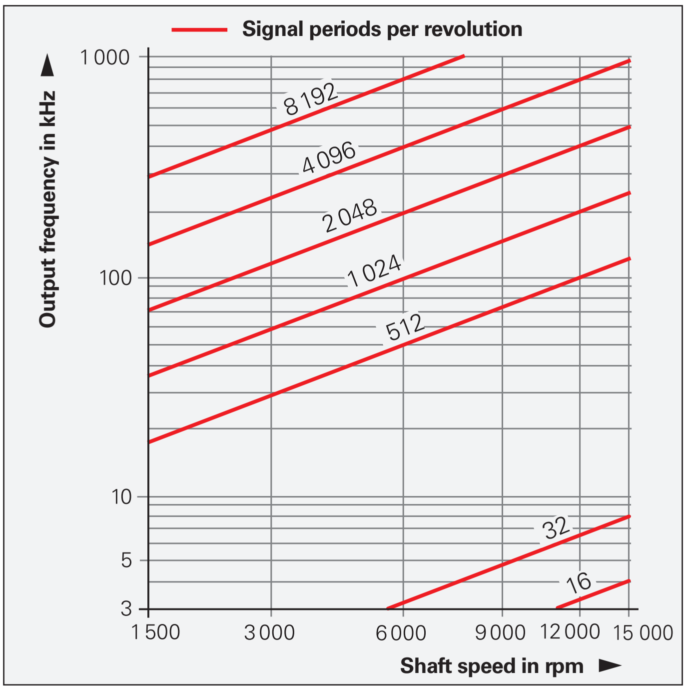
Most absolute encoders already subdivide the sinusoidal scanning signals by a factor of 4096 or greater in the encoder itself. If the **data transmission** of the absolute position values is fast enough (e.g., EnDat 2.1 with 2 MHz or **EnDat 2.2** with 16 MHz clock frequency), then these systems can **do without incremental signal evaluation**.

Benefits of this data transmission technology include **greater noise immunity** of the transmission path and **less expensive connectors and cables**. Rotary encoders with the EnDat 2.2 interface offer the additional feature of being able to **evaluate** an external **temperature sensor** located, for example, in the motor winding. The digitized temperature values are transmitted as part of the EnDat 2.2 protocol without an additional line.

Bandwidth
The attainable gain for the position and speed control loops, and therefore the bandwidth of the drive for command and disturbance behavior, may be limited by the rigidity of the coupling of the motor shaft to the encoder shaft as well as by the natural frequency of the stator coupling. HEIDENHAIN therefore offers rotary and angular encoders for high-rigidity shaft couplings.

The stator couplings mounted on the encoder have a **high natural frequency** of 1800 Hz (typical). For the 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 design therefore permits optimal rigidity of the coupling.

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



Motor currents
Motors are sometimes subjected to impermissible current from the rotor to the stator. This can result in overheating in the encoder bearing and reduce its service life. HEIDENHAIN therefore recommends the use of encoders without integral bearing or encoders with insulating bearing (hybrid bearing). For more information, please contact HEIDENHAIN.

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

Size
A higher permissible operating temperature permits a smaller motor size 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**. This feature allows for the implementation of motors that are smaller in size.

Power loss and noise emission
The power loss of the motor, in addition to the accompanying heat generation and acoustic noise, is affected during operation by the position errors of the encoder within one signal period. For this reason, rotary encoders with a high signal quality of better than ±1 % of the signal period are preferred (see also *Measuring accuracy*).

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

When 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*) are used, it is always necessary that the bit error rate be measured in a type test under application conditions.

HMC 6
Single-cable solution for servo drives

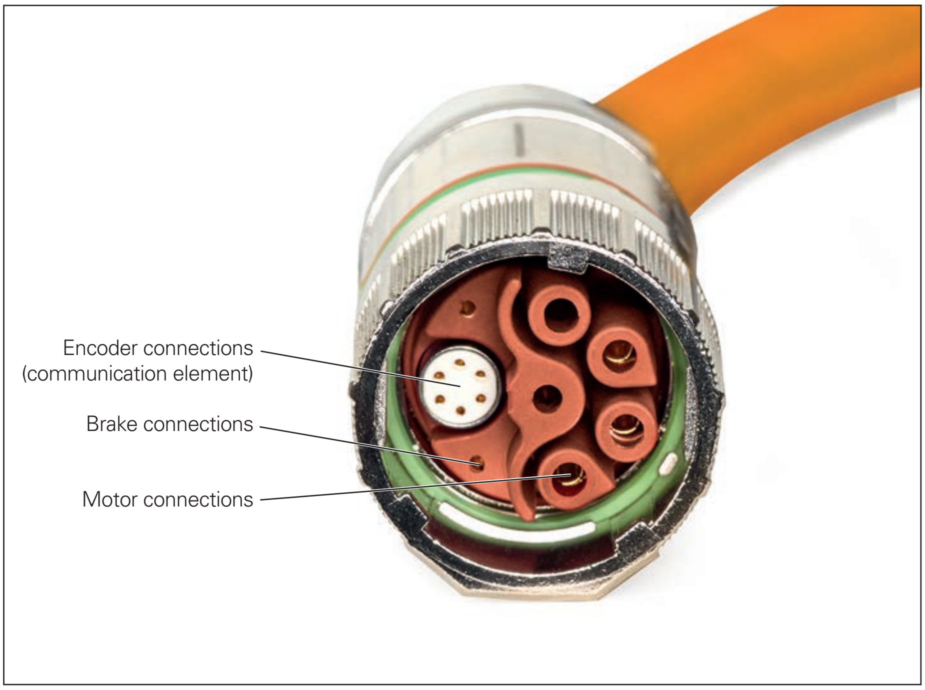
Motors normally need two separate cables:
- one cable for the motor encoder, and
- one cable for the motor power supply.

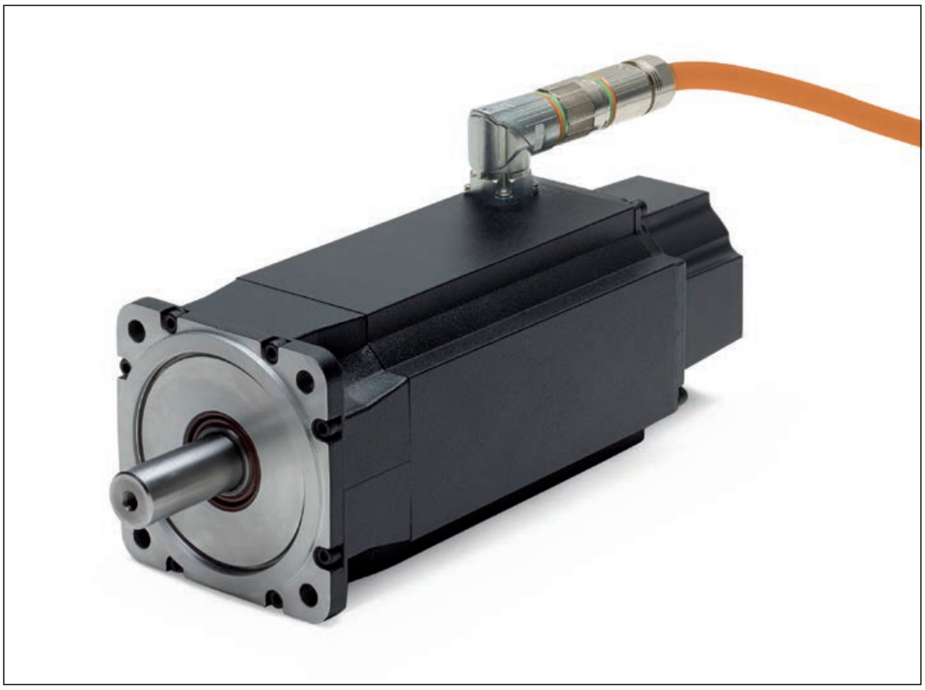
With its Hybrid Motor Cable **HMC 6**, HEIDENHAIN has integrated the encoder cable into the power cable. Thus, only **one cable** is needed between the motor and electrical cabinet.

The HMC 6 single-cable solution has been specially designed for the HEIDENHAIN **EnDat22** interface with purely serial transmission over cable lengths up to 100 m. However, all other encoders with purely serial RS-485 interfaces (e.g., SSI) can also be connected. This makes a broad range of encoders available without a new interface needing to be introduced.

The HMC 6 solution integrates the lines for the encoder, motor, and brake within a single cable. This cable is connected to the motor via a special connector. For connection to the inverter, the cable is split into power connections, brake connections, and an encoder connector. Thus, all of the already existing components on the control side can still be used.

When the components are correctly mounted, the connections achieve an IP67 rating. A quick-release lock, as well as vibration protection against the loosening of coupling joints, is integrated into the connector.





Advantages
The HMC 6 single-cable solution offers a series of cost and quality benefits for both the motor manufacturer and the machine tool builder:
- Continued use of existing interfaces
- Possible use of smaller drag chains
- Significant improvement in drag-chain suitability thanks to fewer cables
- Availability of wide range of encoders for HMC 6 transmission
- Eliminated need to separately assign power cables and encoder cables in the machine
- Reduced mechanical requirements (flange socket on the motor, cable ducts in the machine housing)
- Reduced logistical cost and effort for cables and connectors
- Simpler and faster installation
- Reduced documentation work
- Fewer servicing components required
- Smaller motor profile with cable attached, and thus easier integration into the machine housing
- HEIDENHAIN-tested power- and encoder-cable combination

The universal design of the HMC 6 gives you—as motor manufacturer or machine tool builder—exceptional flexibility because you can use standard components on both the motor side and the control side.

A particular advantage is the fact that the HMC 6 single-cable solution can be used with **all HEIDENHAIN encoders featuring the EnDat22 interface** or with purely serial data transmission without battery buffering in accordance with RS-485. Compatible encoders include drive encoders for servomotors in various sizes, as well as linear and angle encoders used in direct drives. Also included, of course, are encoders for **functional safety** up to SIL 3.

The control side is also easy to handle, since you can use the same inverter systems or controller units as before. The HMC 6 cable has been designed to make assembly of the proper connecting elements easy. And most importantly, noise immunity is not thereby impaired.

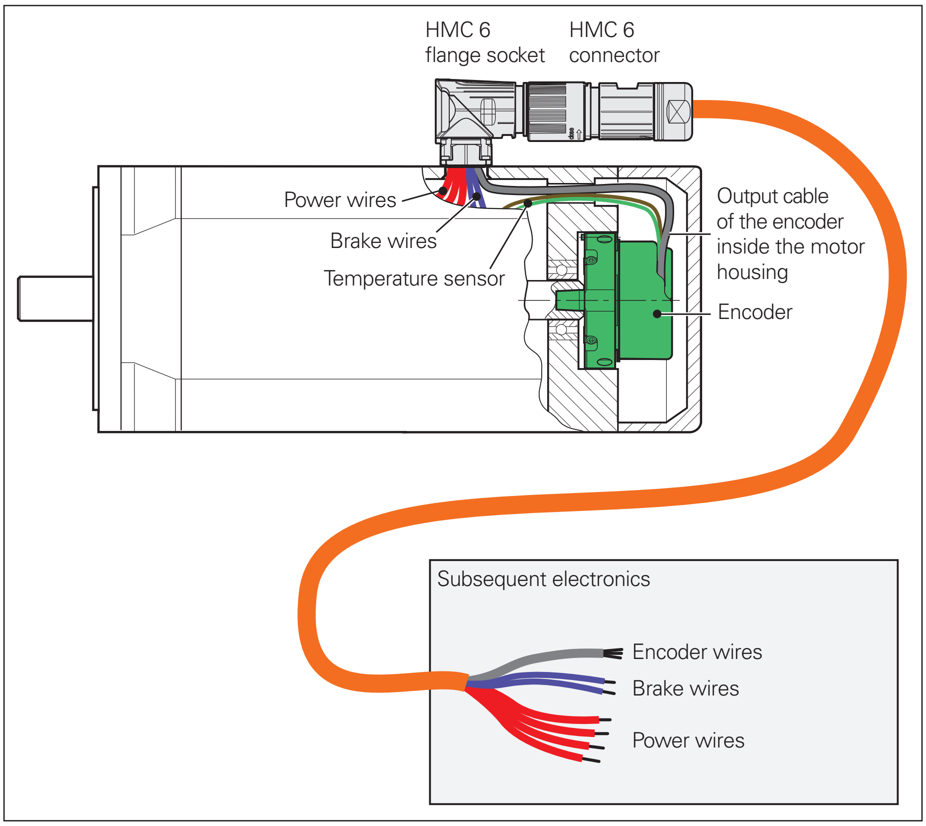
Components
Preparing your motor for the single-cable solution requires only a handful of components.

Connecting element on the motor
The motor housing must be equipped with a special angle flange socket in which the wires for the encoder, the motor power supply, and the brake are gathered together.

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 via the output cable inside the motor housing: your pre-assembled communication element is simply plugged into the angle flange socket.

Cable with hybrid connector
The HMC 6 connecting cable contains not only the encoder lines but also the power and brake wires. A hybrid connector is assembled to one end of the cable.



Further information:
For more about the HMC 6 solution, refer to the *HMC 6* product information document.

Linear encoders for linear drives
General information

Selection criteria for linear encoders
HEIDENHAIN recommends the use of **exposed linear encoders** if contamination within the machine is inconsequential for optical systems and if relatively high accuracy is desired (e.g., for high-precision machine tools and measuring equipment, as well as for production and testing equipment in the semiconductor industry).

Particularly for applications on cutting machine tools that operate with cooling lubricants, HEIDENHAIN recommends **sealed linear encoders**. With these encoders, the requirements for the mounting surface and machine guideway accuracy are less stringent than in the case of exposed linear encoders. Installation is therefore faster.

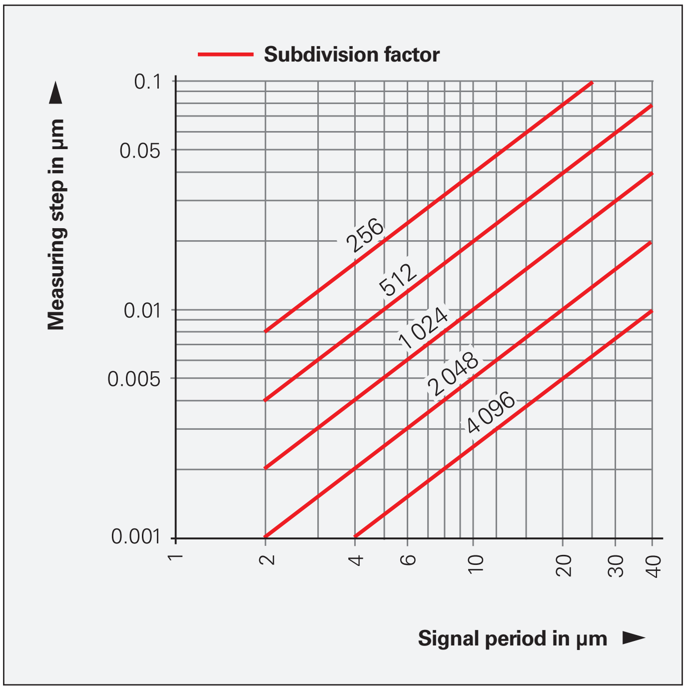
Speed stability
In order for linear drives to attain good speed stability, the linear encoder must enable a sufficiently fine resolution for the given speed control range:
- On handling equipment, resolutions in the range of several microns are sufficient
- Feed drives for machine tools need resolutions of 0.1 µm and finer
- Production equipment in the semiconductor industry requires resolutions in the range of a few nanometers

At low traversing speeds, the **interpolation error within one signal period** has a decisive influence on the speed stability of linear motors (see also *Measuring accuracy*).

Traversing speeds
Exposed linear encoders operate without mechanical contact between the scanning head and the scale. The maximum permissible traversing speed is limited only by the cutoff frequency (–3 dB) of the output signals.

In the case of sealed linear encoders, the scanning unit is guided along the scale on ball bearings. Sealing lips protect the scale and scanning unit from contamination. The ball bearings and sealing lips permit mechanical traversing speeds of up to **180 m/min**.

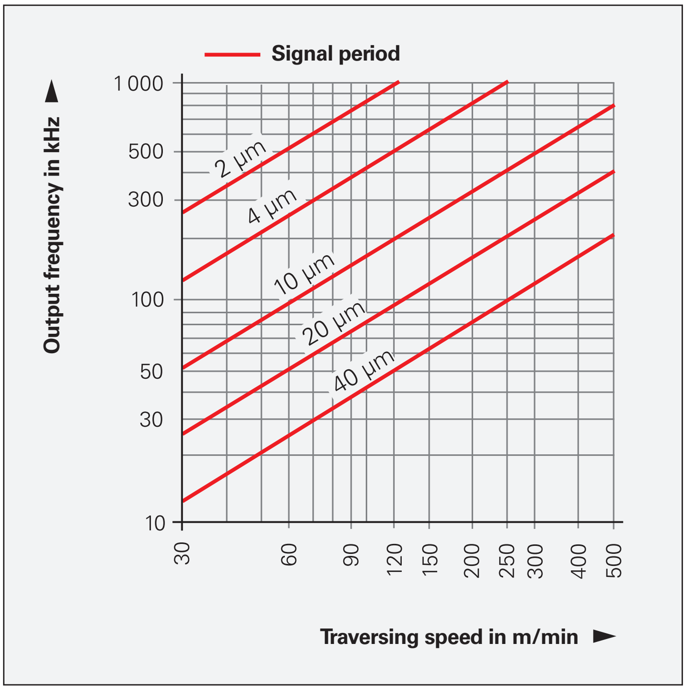
Signal period and resulting measuring step as a function of the subdivision factor



Transmission of measuring signals
The information provided on rotary and angle encoder signal transmission essentially applies to linear encoders as well. For example, if you desire a minimum traversing speed of 0.01 m/min at a cycle time of 250 µs, and if a change of at least one measuring step is to occur per scanning cycle, then a measuring step of approximately 0.04 µm is required. To avoid the need for special measures in the subsequent electronics, input frequencies should be limited to less than 1 MHz. Thus, for high traversing speeds and small measuring steps, linear encoders with **sinusoidal output signals** or absolute position values in accordance with **EnDat 2.2** are best suited. In particular, sinusoidal voltage signals with **1 V$_{PP}$** levels permit a –3 dB cutoff frequency of approximately 200 kHz and more at a permissible cable length of up to 150 m.

The figure below illustrates the relationship between the output frequency, traversing speed, and signal period of a linear encoder. Even with a signal period of 4 µm and at traversing speeds of up to 70 m/min, frequencies of only 300 kHz are reached.

Traversing speed and resulting output frequency as a function of the signal period



Bandwidth
On linear motors, a non-rigid coupling of the linear encoder to the machine can limit the bandwidth of the position control loop. The manner in which the linear encoder is mounted on the machine has a significant influence on the rigidity of the coupling (see *Design types and mounting*).

In a sealed linear encoder, the scanning unit is guided along the scale. A coupling connects the scanning carriage with the mounting block and compensates for the misalignment between the scale and the machine slides. Relatively large mounting tolerances can thereby be attained. The coupling is very rigid in the measuring direction and is movable in the perpendicular direction. If the coupling is insufficiently rigid in the measuring direction, then the feedback for the position and speed control loops exhibits low natural frequencies that can limit the bandwidth of the drive.

The couplings of the sealed linear encoders recommended by HEIDENHAIN for linear motors generally have a **natural frequency of more than 650 Hz or over 2 kHz in the measuring direction**, which in most applications exceeds the first-order mechanical natural frequency of the machine and the bandwidth of the speed control loop by factors of at least five to ten. HEIDENHAIN linear encoders for linear motors therefore have virtually no limiting effect on the position control loops and speed control loops.

Further information:
For more information on linear encoders for linear drives, refer to our brochures *Exposed Linear Encoders* and *Linear Encoders for Numerically Controlled Machine Tools*.

Safety-related position measuring systems

Under the "functional safety" designation, HEIDENHAIN offers encoders that can be used in safety-related applications. These encoders operate as single-encoder systems with purely serial data transmission via EnDat 2.2 or DRIVE-CLiQ. The reliable transmission of the position is based on two independently generated absolute position values and on error bits provided to the safe control.

Basic principle
HEIDENHAIN measuring systems for safety-related applications are tested for compliance with EN ISO 13849-1 (successor to EN 954-1) as well as EN 61508 and EN 61800-5-2. In these standards, the assessment of safety-related systems is based on, among other things, the failure probabilities of integrated components and subsystems. This modular approach makes it easier for the manufacturers of safety-related systems to implement their complete systems, allowing them to build upon subsystems that have already been qualified. Safety-related position measuring systems with purely serial data transmission via EnDat 2.2 or DRIVE-CLiQ are accommodative to this approach. In a functionally safe drive, the safety-related position measuring system represents such a subsystem. The **safety-related position measuring system** consists of the following (e.g., with EnDat 2.2):

- Encoder with EnDat 2.2 transmission component
- Data transfer line with EnDat 2.2 communication and HEIDENHAIN cable
- EnDat 2.2 receiver component with monitoring function (EnDat master)

The **complete "safe servo drive" system** consists of the following (e.g., with EnDat 2.2):

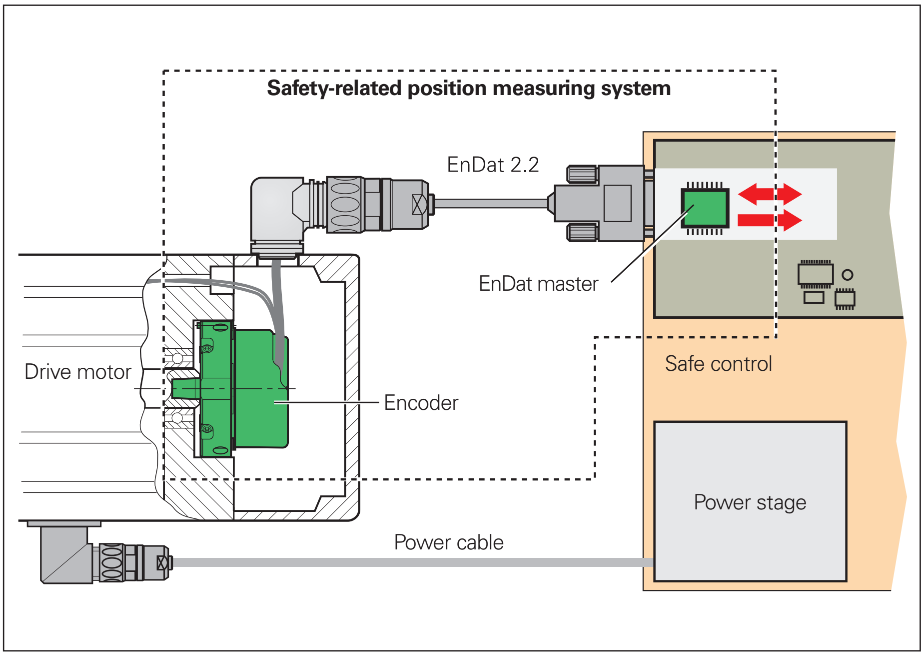
- Safety-related position measuring system
- Safety-related control (including EnDat master with monitoring functions)
- Power stage with motor power cable and drive
- Mechanical connection between encoder and drive (e.g., rotor/stator connection)

Area of application
Safety-related position measuring systems from HEIDENHAIN are designed such that they can be used as single-encoder systems in applications with control category SIL 2 (in accordance with EN 61508), PL d, category 3 (in accordance with EN ISO 13849).

Through additional measures taken in the control, certain encoders can be used in applications with up to SIL 3, PL e, category 4. The suitability of these encoders is indicated accordingly in the documentation (brochures / product information documents). The functions of the safety-related position measuring system can be used for the following safety functions in the complete system (also see EN 61800-5-2):

SS1	Safe Stop 1
SS2	Safe Stop 2
SOS	Safe Operating Stop
SLA	Safely Limited Acceleration
SAR	Safe Acceleration Range
SLS	Safely Limited Speed
SSR	Safe Speed Range
SLP	Safely Limited Position
SLI	Safely Limited Increment
SDI	Safe Direction
SSM	Safe Speed Monitor

Safety functions as per EN 61800-5-2



Complete safe servo-drive system with EnDat 2.2

DRIVE-CLiQ is a registered trademark of Siemens AG.

Method of operation

The safety design of the position measuring system is based on two mutually independent position values generated in the encoder, and on additional error bits. With EnDat 2.2, for example, these are transmitted to the EnDat Master via the EnDat 2.2 protocol.

The EnDat master performs various monitoring functions by which errors in the encoder and data transmission can be detected. A comparison is made, for example, between the two position values. The EnDat master then makes the data available to the safe control. The control monitors the functionality of the safety-related position measuring system through periodically triggered tests.

The architecture of the EnDat 2.2 protocol makes possible the processing of all safety-related information or control mechanisms during unimpaired normal operation. This is possible because the safety-related information is contained in the additional data. According to EN 61508, the architecture of the position measuring system is regarded as a single-channel tested system.

Documentation regarding integration of the position measuring system

The proper use of a position measuring system places demands on the control, the machine designer, the installation technician, servicing personnel, etc. The needed information is provided in the documentation for the position measuring systems.

In order to be able to implement a position measuring system in a safety-related application, a suitable control is required. The control performs the essential tasks of carrying out communication with the encoder and reliably evaluating the encoder data.

The requirements for integrating the EnDat master with monitoring functions into the safe control are described in HEIDENHAIN document 533095. This document contains, for example, requirements pertaining to the electrical connection, cyclic tests of the position measuring system, and the evaluation and further processing of position values.
Supplementing this, document 1000344 describes measures that enable the use of suitable encoders in applications up to SIL 3, PL e, category 4.

Machine and equipment manufacturers need not attend to these details themselves. This functionality must be provided by the control. Product information documents, brochures, and mounting instructions provide information to aid in the selection of a suitable encoder. **Product information documents** and **brochures** contain general information on the functionality and use of the encoders, as well as information on permissible ambient conditions and specifications. The **mounting instructions** provide detailed information about installing the encoders.

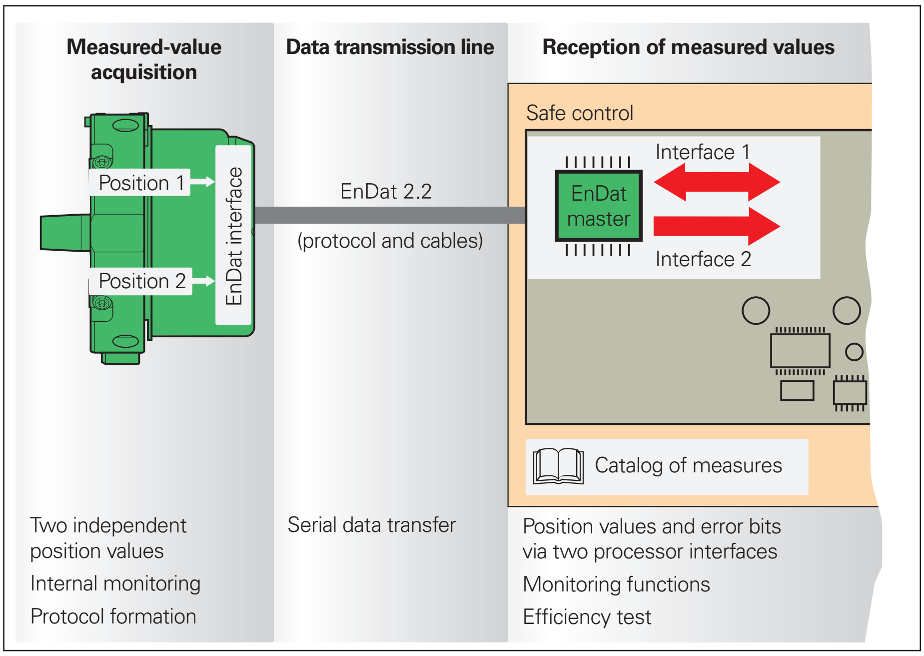
The architecture of the safety system and the diagnostic capabilities of the control may call for further requirements. **For example, the operating instructions of the control must explicitly state whether fault exclusion is required for the loosening of the mechanical connection between the encoder and the drive.** The machine designer must pass on the resulting requirements to installation and servicing technicians, for example.

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 drives, EN 61800-5-2, includes the loosening of the mechanical connection between the encoder and the drive as a fault that requires consideration. In many cases, fault exclusion is required because the control is not necessarily capable of detecting such errors.

Standard encoders

In addition to those encoders explicitly qualified for safety applications, standard encoders (e.g., with 1 V_{PP} signals) can also be used in safe applications. In these cases, the characteristics of the encoders must be matched to the requirements of the respective control. HEIDENHAIN can provide additional data on the individual encoders (failure rate, fault model as per EN 61800-5-2).



Safety-related position encoder with EnDat 2.2

Further information:

For more information on the topic of functional safety, refer to the technical information documents *Safety-Related Position Measuring Systems* and *Safety-Related Control Technology* as well as the product information document of the functional safety encoders and the customer information documents on fault exclusion.

Measuring principles
Measuring standard

HEIDENHAIN encoders with optical scanning use 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 graduation period: 40 µm
- METALLUR: contamination-tolerant graduation consisting of metal lines on gold; typical graduation period: 20 µm
- DIADUR: extremely robust chromium lines on glass (typical graduation period: 20 µm) or three-dimensional chromium structures (typical graduation period: 8 µm) on glass
- SUPRADUR phase grating: optically three dimensional, planar structure; particularly tolerant to contamination; typical graduation period: 8 µm and finer
- OPTODUR phase grating: optically three dimensional, planar structure with particularly high reflectance; typical graduation period: 2 µm and finer

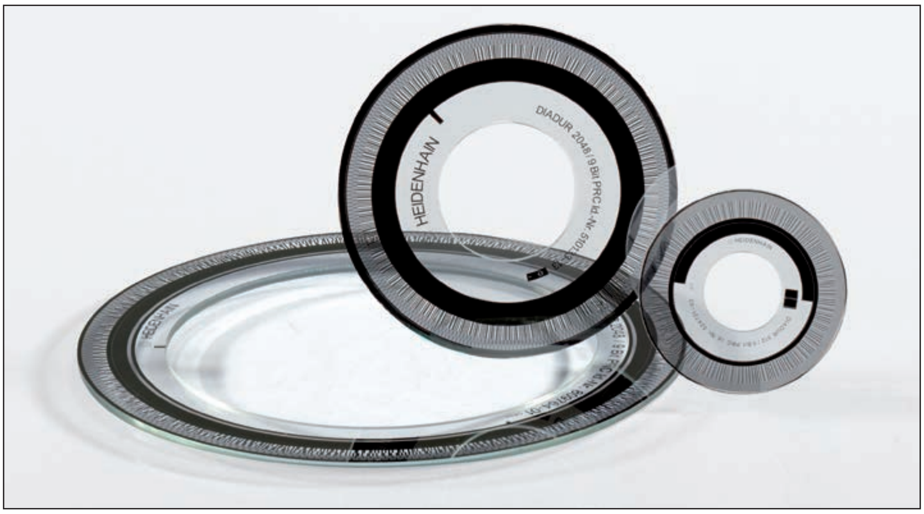
For magnetic encoders, a substrate made of magnetizable steel alloy is used. Within this alloy, a graduation consisting of north poles and south poles is created with a grating period of 400 µm. Due to the short range of electromagnetic interaction and the narrow scanning gap that is therefore required, finer magnetic graduations are not practical.

Encoders that employ the **inductive scanning principle** use metal graduations or graduation structures based on copper/nickel. The graduation structures are applied to a carrier material for printed circuits.

With the **absolute measuring method,** the position value is immediately available upon encoder switch-on and can be fetched at any time by the subsequent electronics. There is no need to jog the axes to find the reference position. This absolute position information is obtained **from the graduation on the circular scale**, which is arranged as a code structure or consists of several 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 also distinguish between revolutions.



Circular graduations of absolute rotary encoders

With the **incremental measuring method,** the graduation is arranged as a periodic grating structure. The position information is obtained **through the counting** of individual increments (measuring steps) from any set point of origin. Since the ascertainment of positions requires an absolute reference, the circular scales feature an additional track bearing a **reference mark.**

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

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

Circular graduations of incremental rotary encoders

Scanning methods

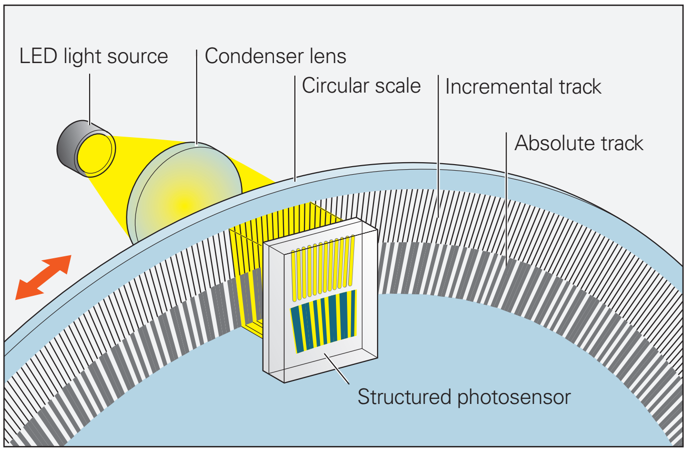
Photoelectric scanning principle
Most HEIDENHAIN encoders operate based on the principle of photoelectric scanning. Photoelectric scanning is performed without contact and thus does not induce wear. This method detects even extremely fine graduation lines with a width of only a few micrometers and generates output signals with very small signal periods.

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

Put simply, the projected light principle uses shadow-optical signal generation: two scale gratings with the same or similar grating periods (the graduated disk and the scanning reticle) are moved relative to each other. The carrier material of the scanning reticle is transparent, whereas the graduation on the measuring standard may be applied to a transparent or reflective material.

When parallel light passes through a grating, light and dark fields are projected at a particular interval. An index grating with the same or similar grating period is located here. 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. Photovoltaic cells or a structured photosensor convert these changes in light into nearly sinusoidal electrical signals. Practical mounting tolerances for encoders with the projected light principle are achieved with grating periods of 10 µm and larger.

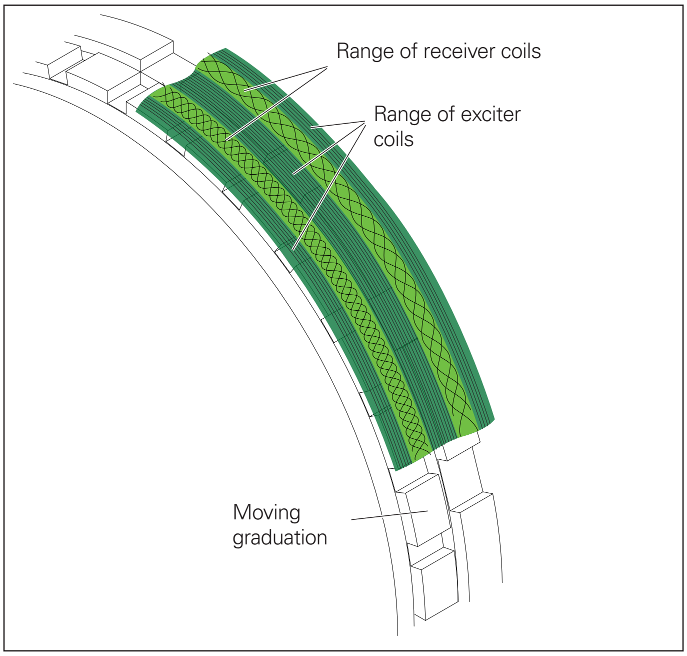
The ECN and EQN absolute rotary encoders with optimized scanning contain a single large-surface, finely structured photosensor rather than a group of individual photocells. The width of the photosensor's structures and the width of the grating structure of the measuring standard are the same. As a result, the scanning reticle with the index grating can be eliminated.



Photoelectric scanning in accordance with the projected light 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 and RIC/RIQ rotary encoders operate in accordance with the inductive measuring principle. In this case, moving graduation structures modulate a high-frequency signal in its amplitude and phase. Through circumferential scanning, the position value is always determined based on the signals of all of the receiver coils distributed evenly around the circumference. This permits wide mounting tolerances at high resolution.



Inductive scanning

Electronic commutation with position encoders

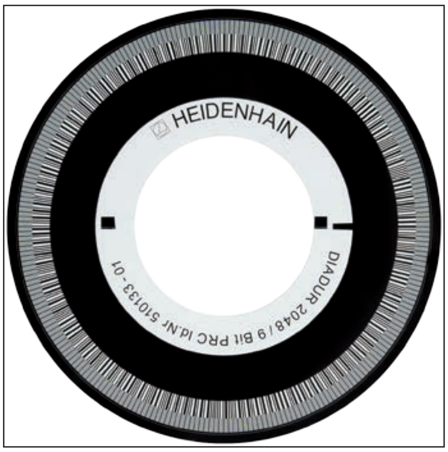
Commutation with permanent-magnet three-phase motors
Before a permanent-magnet, three-phase AC drive is started, its rotor position must be available as an absolute value for electronic commutation. HEIDENHAIN rotary encoders are available with different types of rotor position detection:

- **Absolute rotary encoders** in singleturn and multiturn versions provide absolute position information immediately upon switch-on. Thus, the exact position of the rotor can be instantly derived and used for electronic commutation.

- **Incremental rotary encoders** with a second **Z1 track** provide an additional sine and cosine signal (C and D) per motor shaft revolution. For signal commutation, electronics for signal period subdivision and a signal multiplexer are the only things you need in order to obtain both the absolute rotor position at an accuracy of ±5° from the Z1 track as well as the position information for speed and position control from the incremental track (see also *Interfaces – Commutation signals*.

- **Incremental rotary encoders with block commutation tracks** additionally provide three commutation signals (U, V, and W), which are used to directly control the power electronics. These 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, absolute linear encoders from the LIC and LC series provide the exact position of the movable motor part immediately upon switch-on. Maximum holding load is thereby possible even at standstill.



Circular scale with serial code track and incremental track

Circular scale with Z1 track

Circular scale with block commutation tracks

Further information:

Please pay attention to the switch-on behavior of the encoder (see the *Interfaces of HEIDENHAIN Encoders* brochure).

Measuring accuracy

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

The **accuracy of the angular measurement** is primarily influenced by the following factors:

- The quality of the graduation
- The scanning quality
- The quality of the signal processing electronics
- The eccentricity of the graduation relative to the bearing
- The errors of the bearing
- The coupling to the measured shaft
- The elasticity of the stator coupling (ERN, ECN, EQN) or shaft coupling (ROD, ROC, ROQ, RIC, RIQ)

These factors can be divided into encoder-specific errors and application-dependent factors. For assessment of the attainable **overall accuracy**, every single factor must be taken into account.

Encoder-specific errors

For rotary encoders, the encoder-specific errors are provided in the specifications as the **system accuracy**.

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

The system accuracy encompasses the position errors within a single revolution as well as the position errors within one signal period and, for rotary encoders with stator coupling, the errors of the shaft coupling.

Position errors within one signal period
Position errors within one signal period are considered separately since they have an effect even in very small angular movements and in repeated measurements. In particular, they cause speed ripples in the speed control loop.

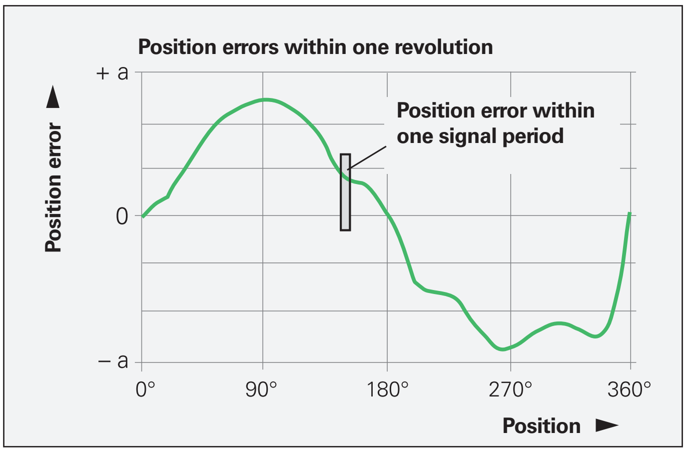
The position errors within one signal period ±u result from the scanning quality and, for encoders with integrated pulse-shaping or counter electronics, from the quality of the signal-processing electronics. For encoders with sinusoidal output signals, however, the errors of the signal processing electronics are determined by the subsequent electronics.

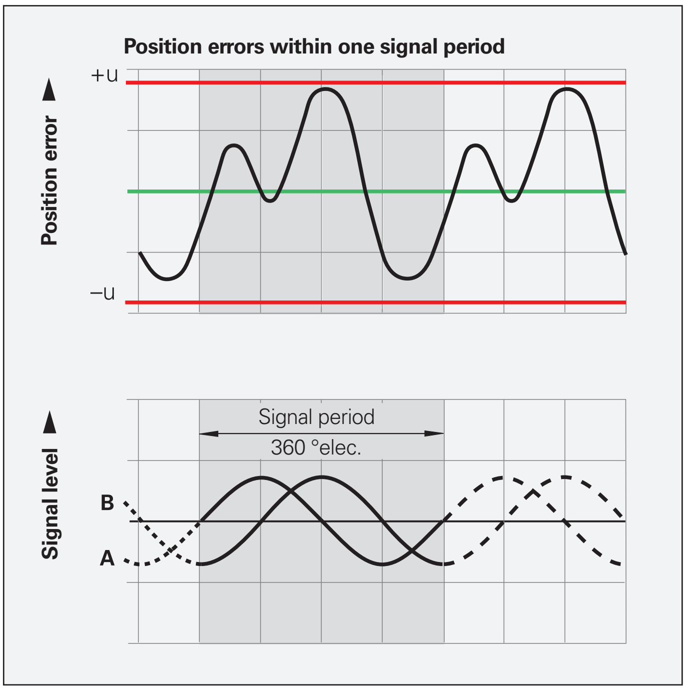
The following individual factors influence the result:

- The fineness of the signal period
- The homogeneity and period definition of the graduation
- The quality of scanning filter structures
- The characteristics of the sensors
- The stability and dynamics of the further processing of the analog signals

These errors are taken into account in the information regarding the position error within one signal period. For rotary encoders with integral bearing and sinusoidal output signals, these errors are less than ±1 % of the signal period, or 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.





Application-dependent errors

For **rotary encoders with integral bearing**, the specified system accuracy already includes the errors of the bearing. For rotary encoders with separate **shaft coupling** (ROD, ROC, ROQ, RIC, RIQ), the angular error of the coupling must also be taken into account (see *Mechanical design types and mounting*). For angle encoders with **stator coupling** (ERN, ECN, EQN), the system accuracy already includes the errors of the shaft coupling.

In contrast, for **encoders without integral bearing**, the mounting situation and the adjustment of the scanning head have a decisive influence on the attainable overall accuracy. Of particular importance are the mounting eccentricity of the graduation and the radial runout of the measured shaft. For the assessment of the **overall accuracy** of these devices, the application-dependent errors must be individually determined and taken into account.

Rotary encoders with photoelectric scanning

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

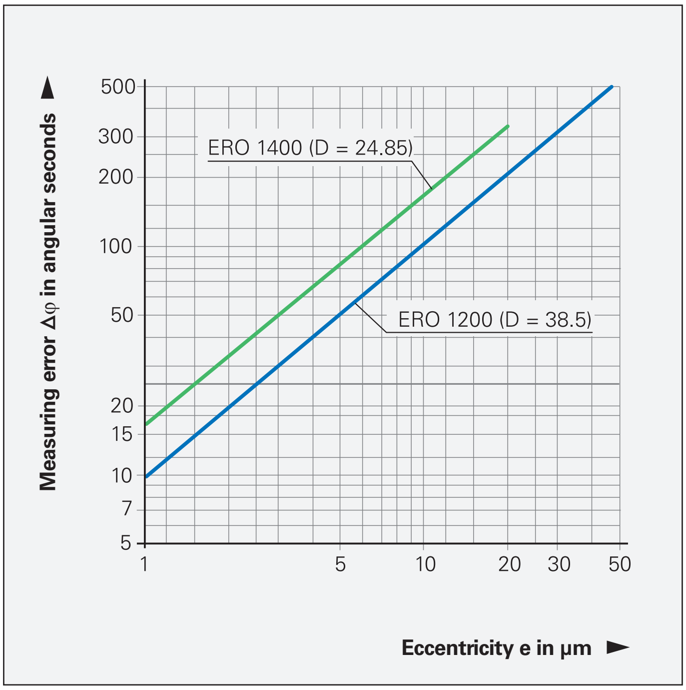
Example
An ERO 1420 rotary encoder with a mean graduation diameter of 24.85 mm:
A radial runout of the measured shaft of 0.02 mm results in a position error of ±330 angular seconds within one revolution.

For evaluation of the **accuracy of modular rotary encoders without integral bearing** (ERO), each of the significant errors must be considered individually.

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

2. Errors due to eccentricity of the graduation relative to the bearing
During mounting, it must usually be assumed that the bearing will have radial runout or eccentricity errors. When centering with the centering collar of the hub, be sure to take into account the fact that HEIDENHAIN guarantees an eccentricity of the graduation relative to the centering collar of under 5 µm for the encoders listed in this brochure. For the modular rotary encoders, this accuracy value presupposes a diameter error of zero between the motor shaft and the “master shaft.”

If the centering collar is centered relative to the bearing, the two eccentricity vectors could add up in the worst-case scenario.



Resultant measurement errors Δφ for various eccentricity values e as a function of mean graduation diameter D

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

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

Δφ = Measurement error in ″ (angular seconds)
e = Eccentricity of the radial grating relative to the bearing in µm
D = Mean graduation diameter in mm

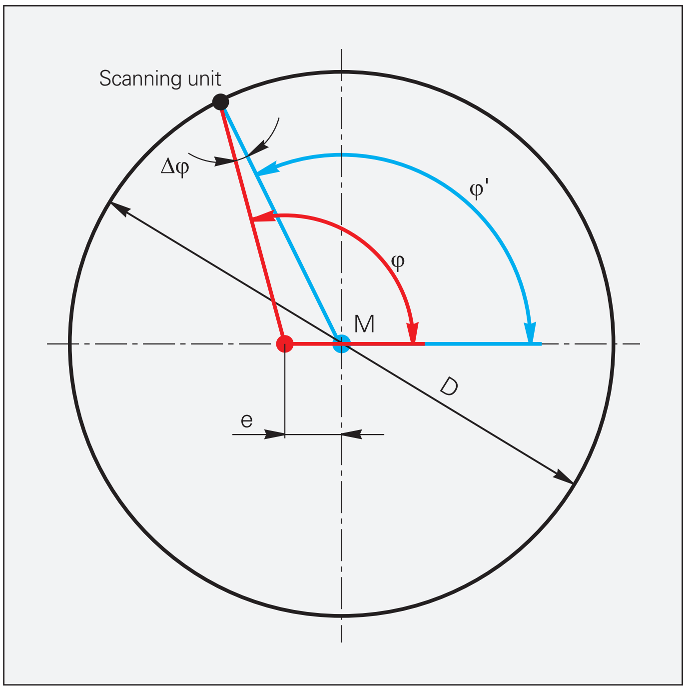
Model	Mean graduation diameter D	Error per 1 µm of eccentricity
ERO 1420 **ERO 1470** **ERO 1480**	D = 24.85 mm	±16.5″
ERO 1225 **ERO 1285**	D = 38.5 mm	±10.7″

3. Radial runout of the bearing
The relationship provided for the measurement 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). Similar errors are caused when the bearing gives under radial loading of the shaft.

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

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

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



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

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

Rotary encoders with inductive scanning

As with all rotary encoders without integral bearing, the attainable accuracy for devices with inductive scanning depends on the mounting and application conditions. The system accuracy is given for a temperature of 20 °C and rotation at low 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.

Thanks to the circumferential scanning of the inductive rotary encoders, the total error is less than that of optical rotary encoders without integral bearing. Because the total error cannot be determined through a simple calculation rule, the values are provided in the following table.

Model	System accuracy	Total error
ECI 1100 **EBI 1100** **EQI 1100** **EnDat22**	±120″	±280″
ECI 1300 **EQI 1300** **EnDat22**	±65″	±120″
ECI 1300 **EQI 1300** **EnDat01**	±180″	±280″
ECI 100 **EBI 100**	±90″	±180″
ECI 4000 **EBI 4000** **90 mm hollow shaft** **EnDat22**	±25″	±140″
ECI 4000 **EBI 4000** **180 mm hollow shaft** **EnDat22**	±40″	±150″

Mechanical design types and mounting

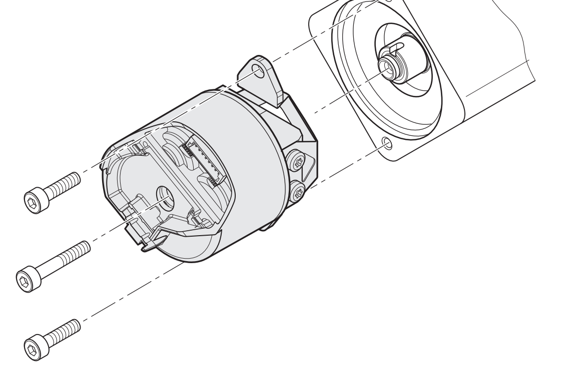
Rotary encoders with integral bearing and stator coupling

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

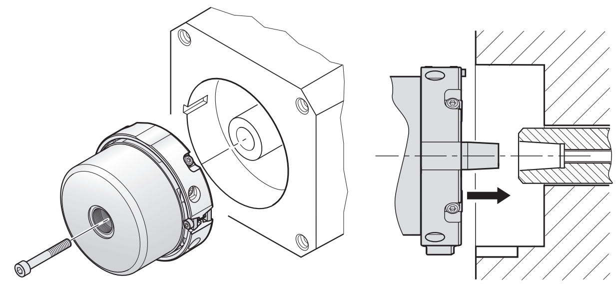
Benefits of the stator coupling:
- No axial mounting tolerances between shaft and stator housing for ExN 1300
- High natural frequency of the coupling
- High torsional rigidity of shaft coupling
- Low required space for external or internal mounting
- Simple axial mounting

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 its front end to the measured shaft by way of a central screw. The encoder is centered on the motor shaft by means of the hollow shaft or tapered shaft. The stator of the ECN/EQN 1100 is connected to a flat surface with two clamping screws without the use of a centering collar. The stator of the ECN/EQN/ERN 1300 is screwed into a mating hole by way of an axially tightened screw.

ECN/EQN 1100



ECN/EQN/ERN 1300



Mounting accessories

ECN 1100: Mounting aid
For disengaging the PCB connector
(see page 44)

ECN/EQN/ECI/EQI 1100: Mounting aid
For turning the encoder shaft from the rear side so that the positive-locking connection between the encoder and measured shaft can be found
ID 821017-03

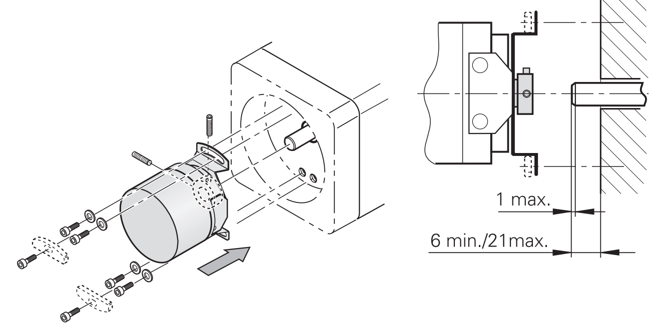
ERN/ECN/EQN 1300: Inspection tool
For inspecting the shaft connection (fault exclusion for rotor coupling)
ID 680644-01

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 low thread engagement, the shaft-fastening screw is not touched. When the motor shaft is locked, the testing torque is applied to the extension with a torque wrench (hexagonal, 6.3 mm width across flats). After any nonrecurring settling, it must be ensured that there is no relative motion between the motor shaft and the encoder shaft.

Mounting the ECN/EQN/ERN 1000 and ERN 1x23
The hollow shaft of the rotary encoder is slid onto the measured shaft and clamped on the rotor side with two screws. The stator is mounted without a centering flange to a flat surface with four clamping screws or with two clamping screws and special washers.

The ECN/EQN/ERN 1000 encoders feature a blind hollow shaft; the ERN 1123 features a hollow through shaft.

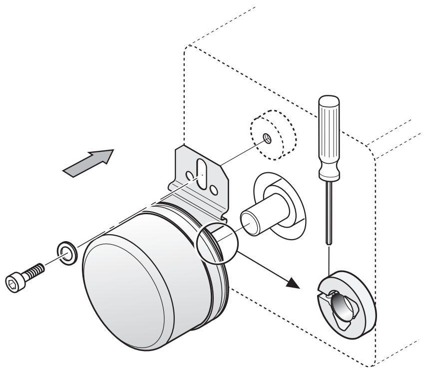


Accessory for ECN/EQN/ERN 1000

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

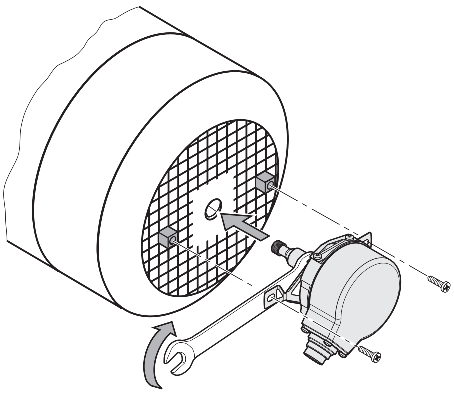
Mounting the EQN/ERN 400
The EQN/ERN 400 encoders are designed for use on Siemens asynchronous motors and serve as replacements for existing Siemens rotary encoders.

The hollow shaft of the rotary encoder is slid onto the measured shaft and fastened on the rotor side with the shaft clamping ring. On the stator side, the encoder's anti-rotation element is fastened to a plane surface.



Mounting the EQN/ERN 401
The ERN 401 encoders are designed for use on Siemens asynchronous motors and serve as replacements for existing Siemens rotary encoders.

This rotary encoder features a solid shaft with an M8 external thread, centering taper, and width A/F 8. While being screwed in, the shaft centers itself relative to the motor shaft. The stator coupling is fastened to the motor's ventilation grille by means of special fastening clips.



Rotary encoders without integral bearing – ECI/EBI/EQI

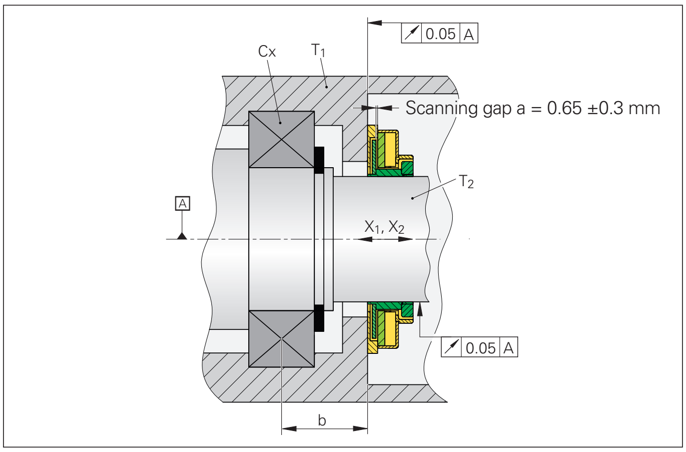
The **ECI/EBI/EQI** inductive rotary encoders do not have integral bearings. This means that mounting and operating conditions influence the functional reserves of the encoder. Another key factor is compliance with the specified mating dimensions and tolerances (see the mounting instructions) in all operating conditions.

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 applies particularly 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 relationship between the motor shaft and motor housing subject to temperature (T_1; T_2; α1; α2) based on the position of the fixed bearing (b)
  - The bearing play (C_X)
  - Non-dynamic shaft offsets due to load (X_1)
  - The effect from the engaging of the motor brakes (X_2)

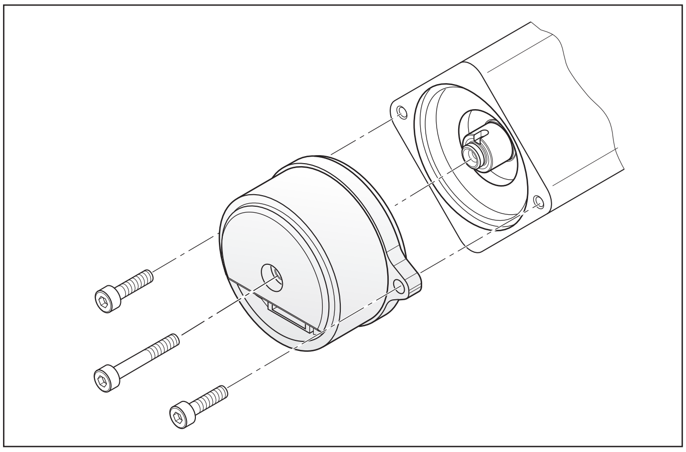
The **ECI/EBI 100** rotary encoders are prealigned on a flat surface. The locked hollow shaft is then slid onto the measured shaft. Axial screws are used to fasten the encoder and clamp the shaft.

The **ECI/EBI/EQI 1100** inductive rotary encoders are mounted axially up to the surface of the encoder. The blind hollow shaft is fastened with a central screw. The stator of the rotary encoder is clamped onto a shoulder with two axial screws.



Schematic representation of **ECI/EBI 100**

Mounting the **ECI 119**



Mounting the **ECI/EQI 1100**

Mounting accessory

Mounting aid for removing the PCB connector (see page 44).

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

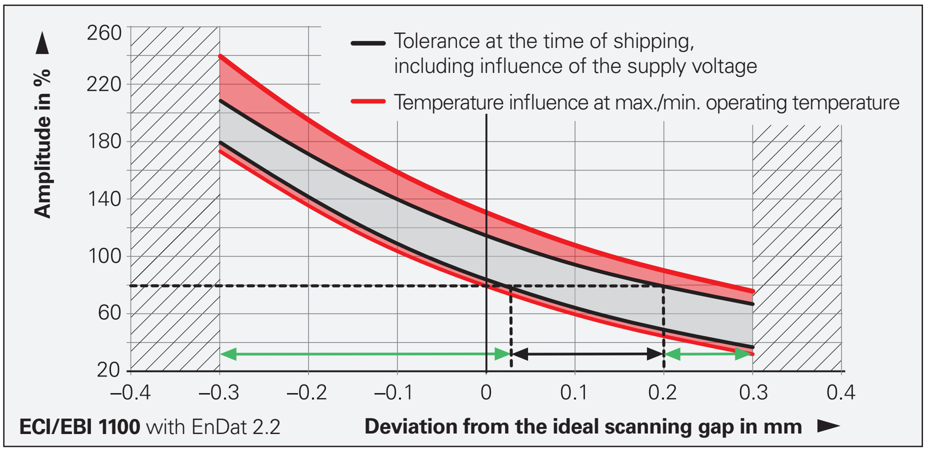
The maximum permitted error specified in the mating dimensions applies to mounting as well as to operation. The tolerances used during mounting are therefore no longer available for the axial motion of the shaft during operation.

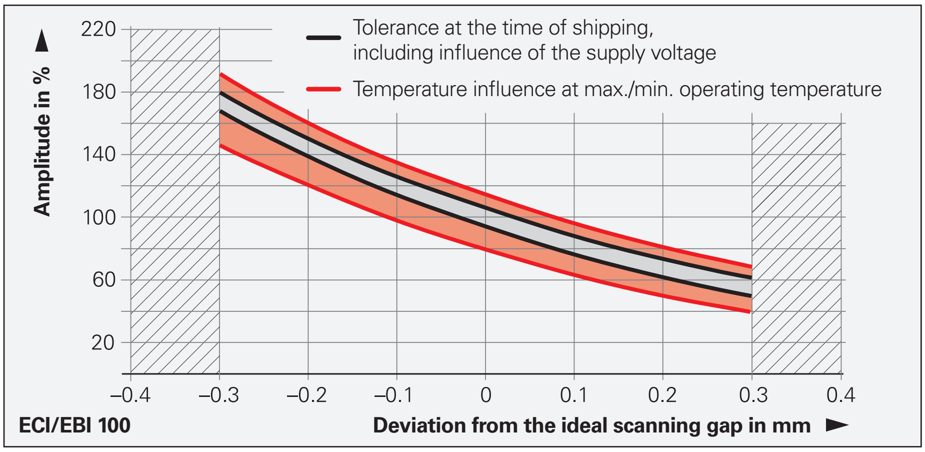
Once the encoder has been mounted, the actual scanning gap between the rotor and stator can be measured indirectly with the PWM 21 testing package via a signal amplitude in the rotary encoder. The characteristic curves show the correlation between the signal amplitude and the deviation from the ideal scanning gap under various ambient conditions.

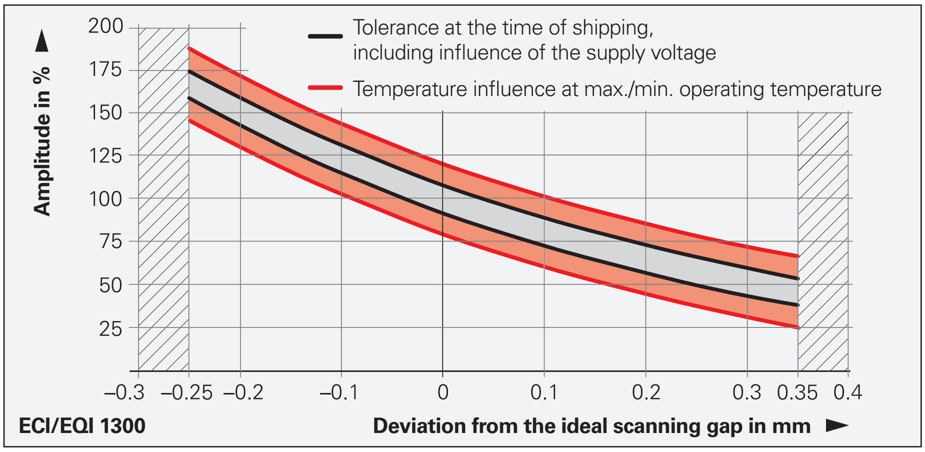
The example of the ECI/EBI 1100 shows the resulting deviation from the ideal scanning gap for a signal amplitude of 80 % under ideal conditions. Due to tolerances within the rotary encoder, the deviation is between +0.03 mm and +0.2 mm. Thus, the maximum permissible motion of the measured shaft during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

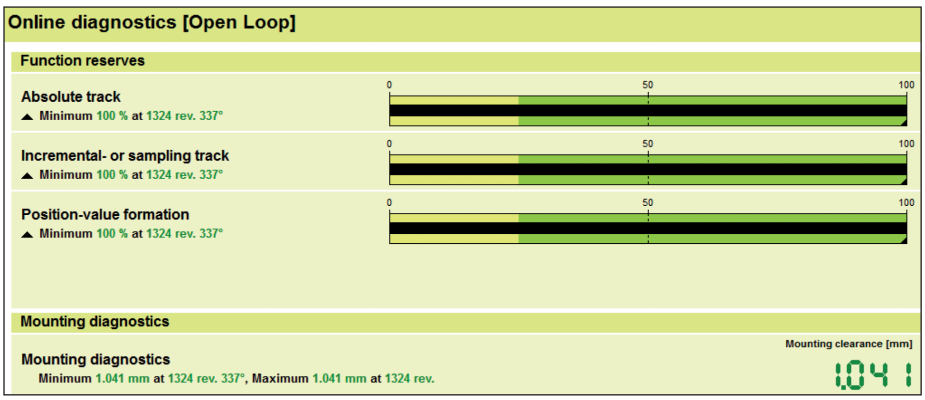
Display of the scanning gap
The latest generation of encoders supports the display of the mounting dimension in the ATS software. This additional data can also be called by the inverter during closed-loop mode.

ID	ExI mounting wizard	Mounting interface
728563-xx	✔	
820725-xx	✔	
826930-xx		✔
826980-xx		✔
811811-xx	✔	
811815-xx	✔	
810661-xx		✔
810662-xx		✔
823406-xx	✔	
823407-xx	✔	
823405-xx	✔	

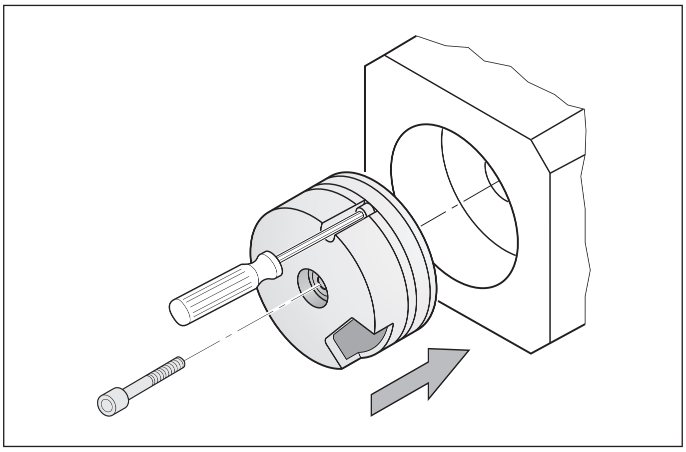






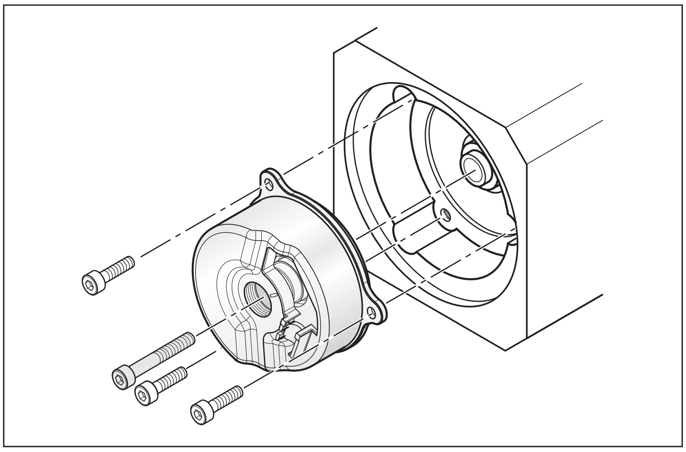


The **ECI/EQI 1300** inductive rotary encoders with EnDat01 are mechanically compatible with the ExN 1300 photoelectric encoders. Their tapered shaft (a blind hollow shaft is available as an alternative) is fastened with a central screw. The stator of the rotary encoder is clamped with an axially tightened bolt in the mating hole. The scanning gap between the rotor and stator must be adjusted during mounting.



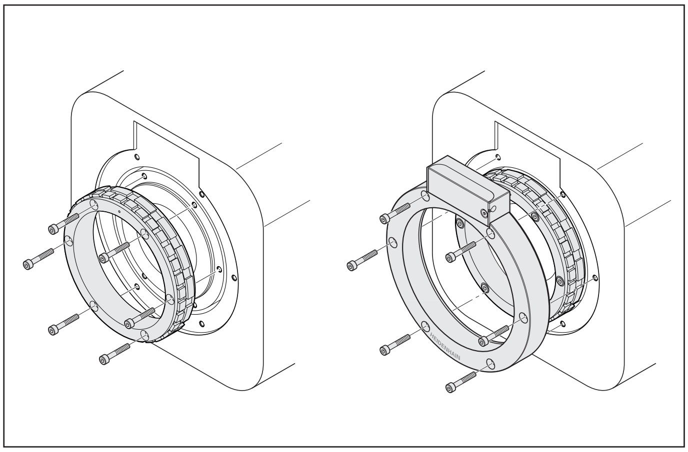
Mounting the
ECI/EQI 1300 EnDat01

The **ECI/EQI 1300** inductive rotary encoders with EnDat22 are mounted axially up to the surface of the encoder. The blind hollow shaft is fastened with a central screw. The stator of the rotary encoder is clamped to a shoulder by three axial screws.



Mounting the
ECI/EQI 1300 EnDat22

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



Mounting the
ECI/EBI 4000

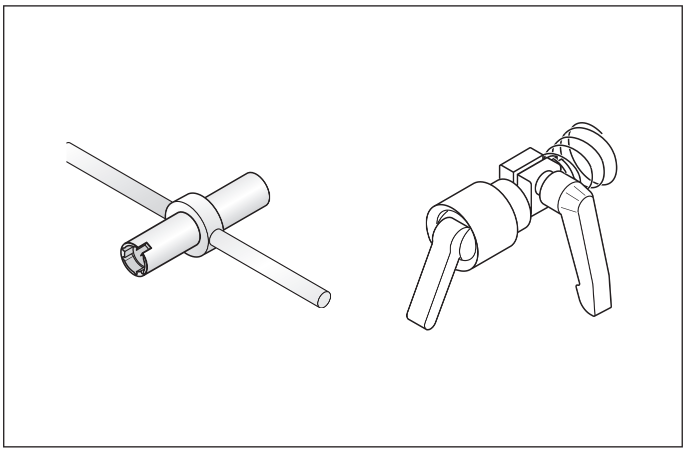
Mounting accessories for the
ECI/EQI 1300 EnDat01

Adjustment aid for adjusting the scanning gap
ID 335529-xx

Mounting aid for adjusting the position of the rotor to the EMF of the motor
ID 352481-02

Accessory for ECI/EQI for checking the scanning gap and adjusting the ECI/EQI 1300

Mounting aid for removing the PCB connector (see page 44)



Mounting and adjusting aids for the **ECI/EQI 1300** EnDat01

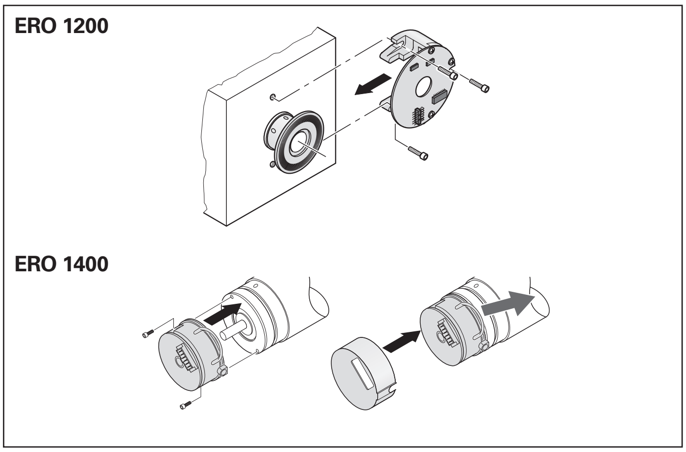
ERO rotary encoders without integral bearing

The **ERO** rotary encoders without integral bearing consist of both a scanning head and a graduated disk that must be mutually aligned. Precise alignment is an important factor for 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 applications with limited installation space as well as those with low axial and radial runout, or for applications where friction of any type must be avoided.

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

The encoders of the **ERO 1400** series are miniaturized modular rotary encoders. These encoders feature a special built-in **mounting aid** that centers the graduated disk relative to the scanning unit and adjusts the gap between the graduated disk and the scanning reticle. Short installation times are thereby attainable. The encoder comes with a cover cap for protection against extraneous light.

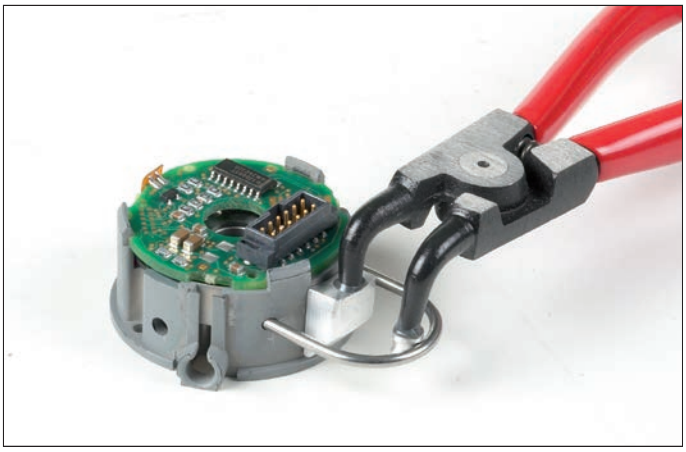


Mounting the **ERO**

Mounting accessories for the ERO 1400

Mounting accessory
Aid for removing the clip for achieving optimal encoder mounting.
ID 510175-01

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



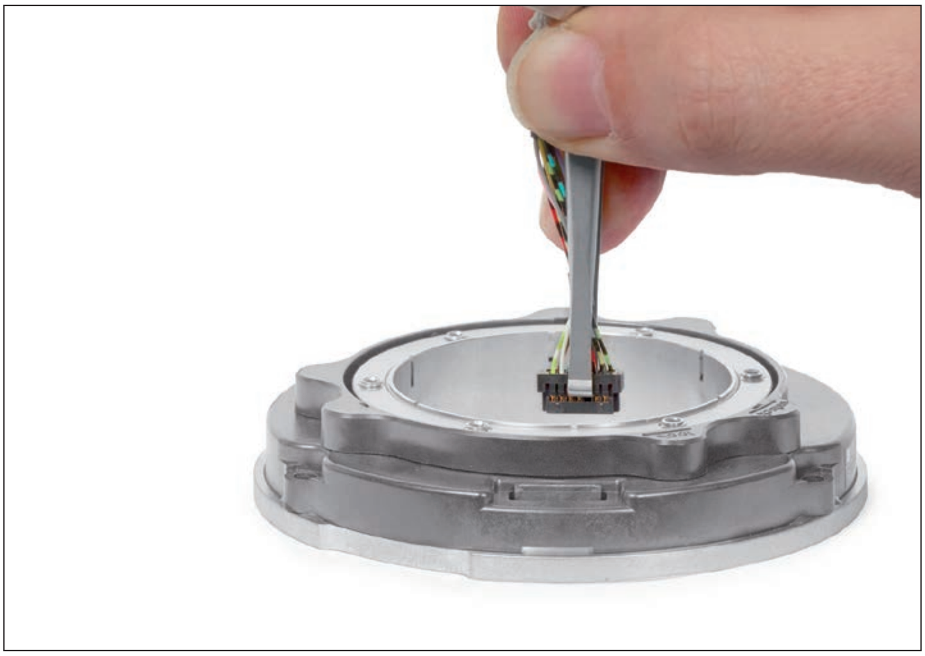
Mounting accessories for the **ERO 1400**

Information on output cables

Mounting and commissioning must be performed only with appropriate ESD protection. Do not engage or disengage the connecting element when it is under power. To avoid overstressing the individual wires when disengaging a connecting element, HEIDENHAIN recommends using the mounting aid to disconnect the PCB connector.

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



Mounting aid for PCB connector

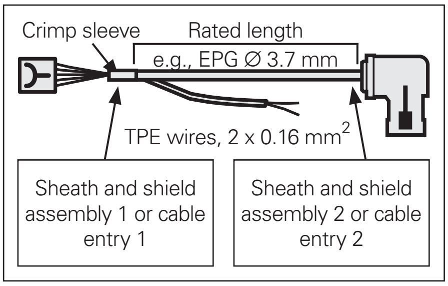
Screws
For output cables with standard M12 or M23 flange sockets, use M2.5 screws.

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

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

To prevent the screws from loosening on their own, HEIDENHAIN recommends using a materially bonding threadlocker.

Cable length (rated length)
For output cables with crimping on the encoder side for strain relief and shield contacting, the cable length up to the crimp sleeve is specified.



The rated wire length for temperature sensors is the same as the rated cable length for standard output cables. Exceptions include output cables without crimping on the encoder side or a shield connection by way of a cable clamp. On request, you can receive binding information (a dimension drawing) upon providing the corresponding output cable ID number (see the cable list).

Electromagnetic compatibility
Cables from HEIDENHAIN are tested for electromagnetic compatibility. For output cables containing wires for temperature sensors, conformity with the EMC Directive in the overall system must be documented.

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

You will find information on the appropriate crimping tools in the *HMC 6* product information document.

Strain relief
Avoid torque or tensile stress; use strain relief when needed.

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

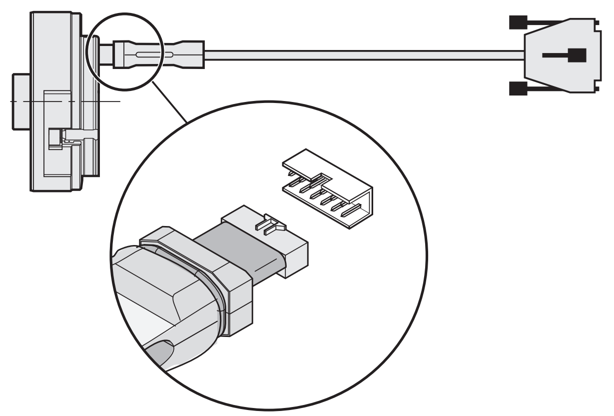
General testing accessories for modular encoders and the PWM 21

Testing cable for modular rotary encoders with the EnDat22, EnDat01, SSI, and DRIVE-CLiQ interfaces
Includes three 12-pin adapter connectors and three 15-pin adapter connectors.
ID 621742-01

Adapter connectors
Three connectors for replacement
12-pin: ID 528694-01
15-pin: ID 528694-02

Connecting cable for the EnDat22, EnDat01, and SSI interfaces
For extending the testing cable.
Complete with 15-pin D-sub connector (male) and 15-pin D-sub connector (female)
(max. 3 m)
ID 1080091-xx

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



Testing cable for modular rotary encoders

Testing cable for ERN 138xx with commutation signals for sinusoidal commutation
Includes three 14-pin adapter connectors.
ID 1118892-02

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

Connecting cable
For extending the testing cable.
Complete with 15-pin D-sub connector (male) and 15-pin D-sub connector (female)
(max. 3 m).
ID 675582-xx

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

EnDat22 interface
Adapter cable Ø 6 mm
9-pin M23 connector (female)
8-pin M12 coupling (male)
ID 1136863-xx
(in addition, ID 524599-xx M12 (female) to 15-pin D-sub connector (male) is needed)

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

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

EnDat01, EnDat Hx, EnDat Tx, or SSI interface with incremental signals
Adapter cable Ø 8 mm
17-pin M23 connector (female)
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), five power wires, two brake wires, and six communication wires
15-pin D-sub connector (male)
ID 1189174-xx

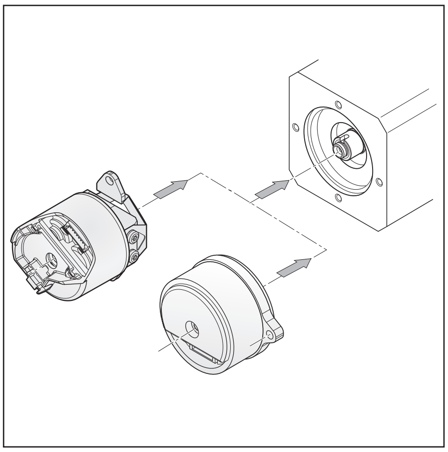
DRIVE-CLiQ is a registered trademark of Siemens AG.

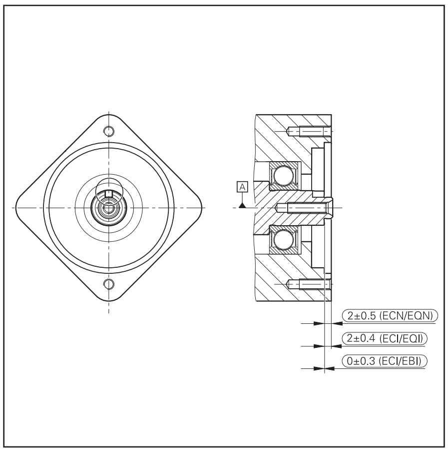
SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

Shared mounting dimensions

Mating dimensions and tolerances must be taken into consideration for the mounting of rotary encoders. Within a given rotary encoder series, the mating dimensions may vary partially, minimally, or even not at all. Thus, certain rotary encoders share the same mounting dimensions and, depending on the given requirements, can be mounted to identical mating dimensions.

All dimensions and tolerances, as well as the required mating dimensions, are specified in the dimension drawing of the respective encoder series. For the differing values for rotary encoders with functional safety (FS), please refer to the relevant product information document.

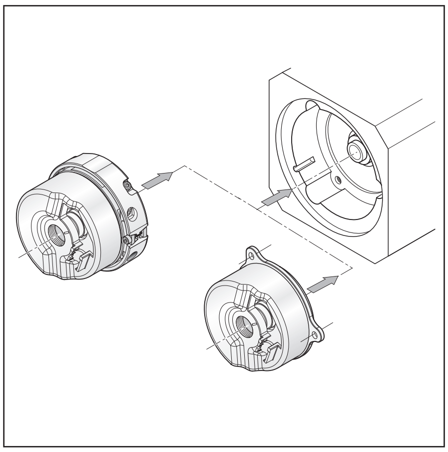




All 1100 series absolute rotary encoders have mutually compatible mounting dimensions. Slight differences exist in the given permissible deviation between the shaft surface and coupling surface.

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

Some rotary encoders of the 1300 series and the ECN/EQN 400 series are mutually mounting-compatible and can therefore be mounted to identical mating dimensions. Slight differences, such as in the anti-rotation element and the restricted tolerance for the inside diameter, must still be taken into account.



Series	Required mating dimensions				
	ERN 1300	**ECN/EQN 1300 FS**	**ECI/EQI 1300**	**ECI/EQI 1300 FS**	**ECN/EQN 400 FS**
ERN 1300		✔	✔	✔	✔
ECN/EQN 1300 FS				✔	✔
ECI/EQI 1300	✔	✔			✔
ECI/EQI 1300 FS					
ECN/EQN 400 FS		✔		✔	

Series	Differences
ERN 1300	Standard, usable for tapered shaft
ECN/EQN 1300	Same as ERN 1300, with additional nose as anti-rotation element (stator coupling)
ECI/EQI 1300	Same as ERN 1300, with tolerance for the inside 65 mm diameter restricted to 0.02 mm, and as additional variant for hollow shaft
ECI/EQI 1300 FS	Same as ERN 1300, with anti-rotation element (flange)
ECN/EQN 400	Same as ECN/EQN 1300

Mounting accessories

Screwdriver bit
- For HEIDENHAIN shaft couplings
- For ExN shaft clamps and stator couplings
- For ERO shaft clamps

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

1) For screws as per DIN 6912 (low head screw with pilot recess)

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

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

Screws

Screw	Securing method	ID
M3x8 8.8 ISO 4762 MKL	Materially bonding anti-rotation lock	202264-67
M3x10 8.8 ISO 4762 MKL	Materially 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	Materially bonding anti-rotation lock	202264-65
M3x25 8.8 ISO 4762 MKL	Materially bonding anti-rotation lock	202264-86
M3x25 A2 ISO 4762 KLF	Self-locking	202264-26
M3x35 8.8 ISO 4762 MKL	Materially bonding anti-rotation lock	202264-66
M4x10 8.8 ISO 4762 MKL	Materially bonding anti-rotation lock	202264-85
M5x30 8.8 DIN 6912 MKL	Materially 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	Materially bonding anti-rotation lock	202264-54

General information
Aligning the rotary encoders to the EMF of the motor

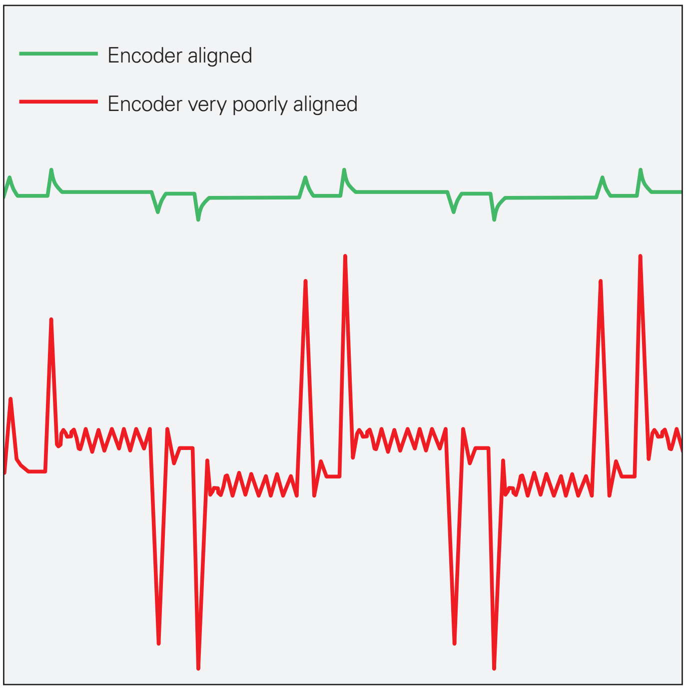
Synchronous motors require information on the absolute rotor position immediately upon switch-on. Rotary encoders with additional commutation signals, which provide relatively rough position information, are well suited for this, as are absolute singleturn or multiturn rotary encoders that output the exact angular position at an accuracy of a few angular seconds (see also *Electronic commutation with position encoders*). During the mounting process for these encoders, the rotor positions of the encoder must be assigned to those of the motor in order to ensure the most constant possible motor currents. Inadequate assignment to the EMF of the motor will cause significant motor noise and high power loss.

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

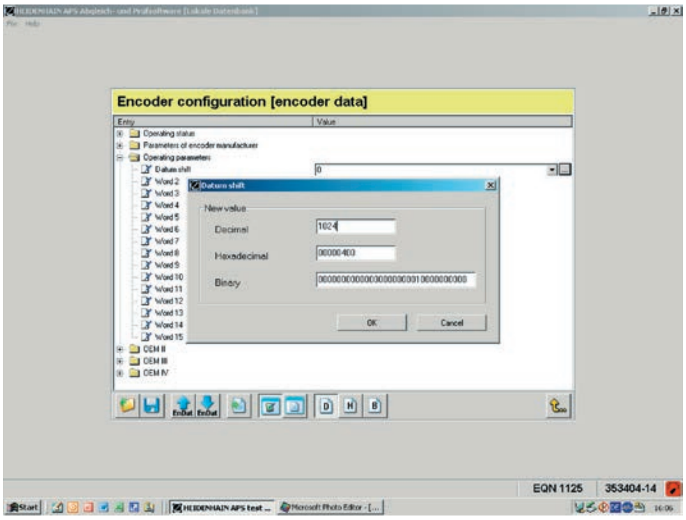
Rotary encoders with commutation signals are then roughly aligned—for example, with the aid of the line markers on the encoder or by means of the reference mark signal—and then mounted to the motor shaft. The fine adjustment can be performed very easily with the PWT 100 testing device (see *Testing equipment and diagnostics*): the stator of the rotary encoder is turned until the PWT 100 shows that the distance from the reference mark is approximately zero.

Absolute rotary encoders are first completely mounted. Then, via a datum shift, the preferred position of the motor is assigned the value zero. The adjusting and testing package is used as an aid (see *Testing equipment and diagnostics*). It features the complete range of EnDat functions, thus making it possible to shift datums, configure write-protection against unintentional changes to saved values, and to utilize further inspection functions.

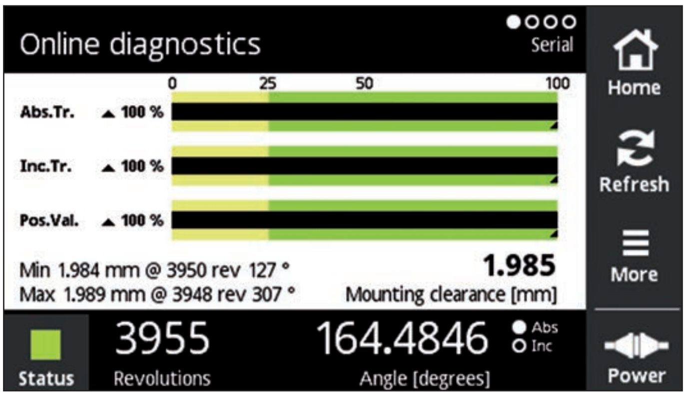
Manual adjustment is also possible for the ECI/EQI rotary encoders with additional 1 V_{PP} signals. Please follow the information in the respective mounting instructions.



Motor current of a well-aligned and a very poorly aligned rotary encoder



Aligning a rotary encoder to the EMF of the motor with the help of the adjusting and testing package



Online diagnostics of the PWT 100

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 with the CSA safety regulations for Canada.

Types of acceleration
Encoders are subject to various types of acceleration during operation and mounting.

- **Vibration**
  With a test bench, the encoders are qualified under the specified acceleration values at frequencies ranging from 55 Hz to 2000 Hz in accordance with EN 60068-2-6. However, if sustained resonances are induced by the application or due to poor mounting, the encoder may exhibit limited performance or even become damaged. **Comprehensive tests of the complete system are therefore required.**
- **Shock**
  With a test bench, the encoders are qualified for non-repetitive semi-sinusoidal shock under the specified acceleration values and duration in accordance with EN 60068-2-27. This does not include **permanent shock loads,** which **must be tested in the application.**
- The **maximum angular acceleration** is 10^5 rad/s^2. This is the highest permissible rotational acceleration at which the rotor may be accelerated without the encoder incurring damage. The actually attainable angular acceleration is in the same order of magnitude (for deviating values for ECN/ERN 100, see *Specifications)* but depends on the type of shaft connection. A sufficient safety factor is to be determined through system tests.

Other values for rotary encoders with functional safety are provided in the corresponding product information documents.

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

Magnetic fields
Magnetic fields of > 30 mT can affect the functioning of encoders. If required, please contact HEIDENHAIN in Traunreut, Germany.

RoHS
HEIDENHAIN has tested its products to ensure the use of non-hazardous materials in accordance with the European Directives "RoHS" and "WEEE." For a Manufacturer's Declaration on RoHS, please consult your sales agency.

Natural frequencies
In the case of the ROC/ROQ/ROD and RIC/RIQ rotary encoders, the rotor and the shaft coupling together form an oscillation-capable spring-mass system. The same is also true of the stator and stator coupling of the ECN/EQN/ERN rotary encoders. The **natural frequency f_N** should be as high as possible. A prerequisite for the highest possible natural frequency in the case of **ROC/ROQ/ROD/RIC/RIQ rotary encoders** is the use of a diaphragm coupling with a high torsional rigidity C (see *Shaft couplings*).

$$f_N = \frac{1}{2 \times \pi} \cdot \sqrt{\frac{C}{I}}$$

f_N: Natural frequency of the coupling in Hz
C: Torsional rigidity of the coupling in Nm/rad
I: Moment of inertia of the rotor in kgm^2

ECN/EQN/ERN rotary encoders, in conjunction with their stator coupling, represent an oscillation-capable spring-mass system whose **natural frequency f_N of the coupling** should be as high as possible. The natural frequency of the coupling is influenced by the natural frequency of the stator coupling and the customer-side mounting situation. The specified typical natural frequencies of the stator coupling can vary depending on the rotary encoder variant (e.g., singleturn vs. multiturn), the production tolerances, and the mounting conditions. If radial and/or axial acceleration forces are applied, then the rigidity of the encoder bearing and that of the encoder stator also have an effect. If such loads occur in your application, HEIDENHAIN recommends that you consult the main office in Traunreut.

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

Starting torque and operating torque
The starting torque is required in order for the rotor to start rotating from a standstill. If the rotor is already rotating, then the encoder is affected by the operating torque. The starting torque and operating torque are influenced by various factors such as temperature, standstill time, and wear on the bearings and seals.

The typical values provided in the specifications are mean values based on encoder-specific test series at room temperature and a settled temperature state. The typical operating torques are also based on constant rotational speeds. For applications in which the torque has a significant influence, HEIDENHAIN recommends that you consult the main office in Traunreut.

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

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

The **shaft inlet** has an IP64 rating. Splash water must not be permitted to have any harmful effects on the encoder's parts. If the degree of protection of the shaft inlet is not sufficient (e.g., when the encoders are mounted vertically), then the encoders should be additionally protected with labyrinth seals. Many encoders are also available with an IP66 protection rating for the shaft inlet. The radial shaft seal rings that are used for sealing are, due to their friction, subject to a certain amount wear depending on the application.

Noise emission
Operating noise can occur, particularly in the case of encoders with integral bearing or multiturn rotary encoders (with gears). The intensity may vary depending on the mounting conditions and the speed.

System tests
Encoders from HEIDENHAIN are usually integrated as components into larger systems. In such cases, **the complete system must be thoroughly tested**, regardless of the encoder's specifications.

The specifications provided in this brochure apply to the encoder in particular, and not to the complete system. Any use of the encoder outside of the specified range or intended use is at the user's own risk.

Mounting
The applicable steps and dimensions that must be complied with during mounting are specified solely in the mounting instructions supplied with the device. All mounting-related information in this brochure is therefore provisional and non-binding and will not become the subject matter of a contract.

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

Screws with materially bonding anti-rotation lock
Mounting screws and central screws from HEIDENHAIN (not included in delivery) feature a coating which, after hardening, provides a materially bonding anti-rotation lock. Therefore, 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, the longer the curing process will take. Curing temperatures below 5 °C are not permitted.

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

The following material properties and conditions must be complied with for the customer-side mounting design:

	Mating stator	**Mating shaft**
Material type	Hardenable wrought aluminum alloys	Unalloyed hardened steel
Tensile strength R_m	≥ 220 N/mm^2	≥ 600 N/mm^2
Yield strength $R_{p,0.2}$ 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
Elastic modulus E (at 20 °C)	70 kN/mm^2 to 75 kN/mm^2	200 kN/mm^2 to 215 kN/mm^2
Coefficient of thermal expansion α_{therm} (at 20 °C)	≤ 25 · 10^{-6}K^{-1}	10 · 10^{-6}K^{-1} to 17 · 10^{-6}K^{-1}
Surface roughness Rz	≤ 16 µm	
Friction values	Mounting surfaces must be clean and free of grease. Use screws from HEIDENHAIN in 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	

Changes to the encoder
The correct operation and accuracy of encoders from HEIDENHAIN are ensured only if the encoders have not been modified. Any changes, even minor ones, can impair the operation and reliability 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 consulting with HEIDENHAIN in Traunreut, Germany.

Conditions for longer storage times
For a storage period of over twelve months, 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 vibrations, mechanical shock, and chemical environmental influences
- Every twelve months, rotate the shafts of encoders with integral bearing at low speed and without axial or radial shaft loading (e.g., such as when breaking in an encoder) so that the bearing lubrication becomes evenly redistributed

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 handled. These parts especially include cables that undergo 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 linear encoders.

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

Insulation
The encoder housings are insulated against internal circuits.
Rated surge voltage: 500 V
Preferred value as per DIN EN 60664-1
Overvoltage category II
Contamination level 2
(no electrically conductive contamination)

Temperature ranges
For the device in its packaging, a **storage temperature range** of –30 °C to 65 °C (HR 1120: –30 °C to 70 °C) applies. The **operating temperature range** specifies the temperatures that the rotary encoder is permitted to reach during operation under actual mounting conditions. Within this range, the 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 encoder is influenced by the following:
- Mounting conditions
- Ambient temperature
- Self-heating of the rotary encoder

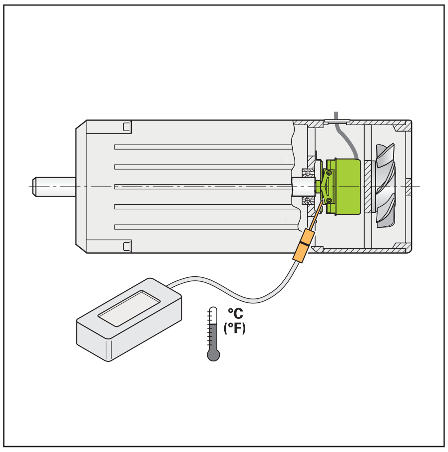
The amount of encoder self-heating depends both on its design characteristics (stator coupling/solid shaft, radial shaft seal ring, etc.) and on its operating parameters (rotational speed, supply voltage). A temporary increase in self-heating can also occur after very long breaks in operation (of several months). Please allow for a two-minute run-in period at low speeds. Greater self-heating by the encoder means that a lower ambient temperature is required 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, a combination of operating parameters can exacerbate self-heating, such as a 30 V supply voltage combined with maximum rotational speed. Thus, if the encoder is operated close to the maximum permissible specifications, then the actual operating temperature should be measured directly at the encoder. In this case, suitable measures should then be taken (fan, heat sinks, etc.) to reduce the ambient temperature to the point that the maximum permissible operating temperature will not be exceeded, including during continuous operation.

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

Self-heating at shaft speed n_{max}	
Solid shaft/tapered shaft **ROC/ROQ/ROD/ RIC/RIQ/ ExN 400/1300**	≈ +5 K ≈ +10 K with IP66 protection
ROD 600	≈ +75 K
ROD 1900	≈ +10 K
Blind hollow shaft **ECN/EQN/ ERN 400/1300**	≈ +30 K ≈ +40 K with IP66 protection
ECN/EQN/ ERN 1000	≈ +10 K
Hollow through shaft **ECN/ERN 100 ECN/EQN/ERN 400**	≈ +40 K with IP64 protection ≈ +50 K with IP66 protection

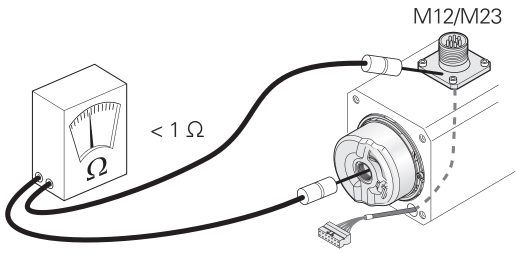
Typical self-heating values of an encoder at maximum permissible speed depending on its design charactersistics. The correlation between rotational speed and heat generation is nearly linear.



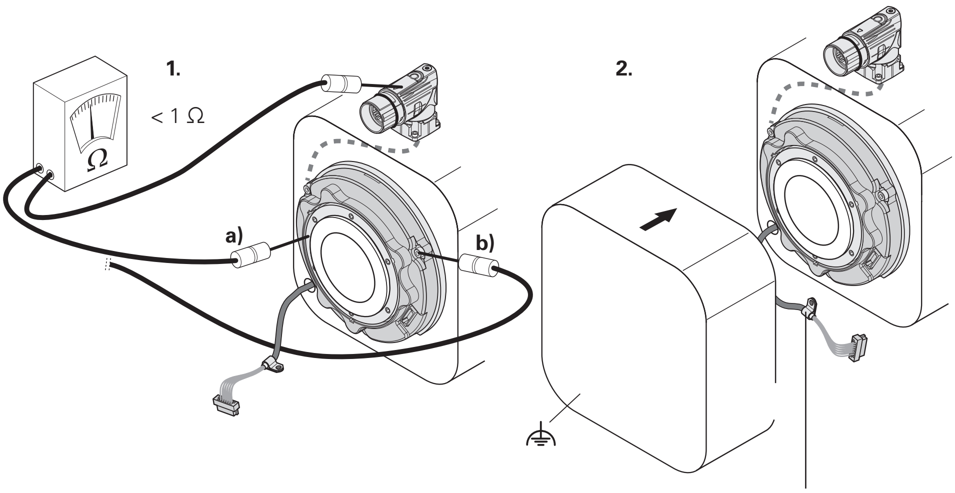
Measuring of the actual operating temperature at the defined measuring point of the rotary encoder (see *Specifications*)

Electrical resistance

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

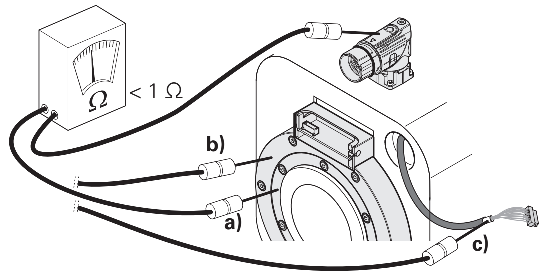


Exposed encoders (ExI 100) without integral bearing and with pluggable output cable
Check the electrical resistance between the flange socket and the rotor **a)**, and stator (mounting screw) **b)**.
Nominal value: < 1 ohm

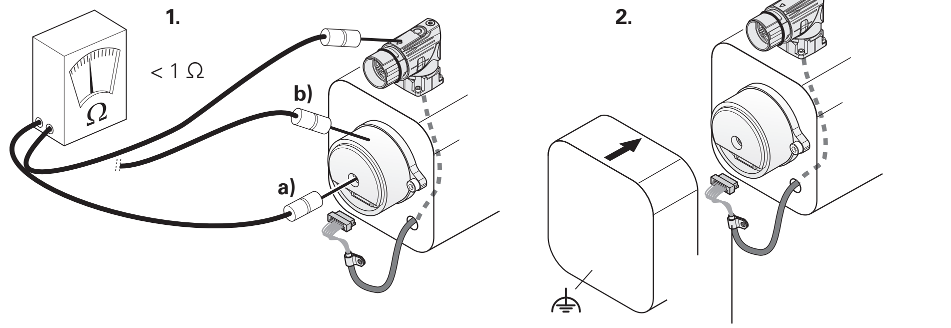


Clamp must be screwed conductively to the motor housing. Conformity with the EMC Directive must be ensured in the complete system.

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



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



Clamp (if present) must be screwed conductively to the motor housing. Conformity with the EMC Directive must be ensured in the complete system.

Temperature measurement in motors

Transmission of temperature values

To protect the motor from overload, the motor manufacturer usually monitors the temperature of the motor winding. In classic applications, the temperature sensor data is sent via two separate lines to the subsequent electronics, where they are evaluated. Depending on their version, HEIDENHAIN rotary encoders with the EnDat 2.2 interface feature an internal temperature sensor integrated into the encoder electronics as well as an evaluation circuit to which an external temperature sensor can be connected. In both cases, the respective digitalized measured temperature value is transmitted purely serially via the EnDat protocol (as part of the additional data). As a result, no separate lines from the motor to the drive controller are needed.

Signaling of an exceeded temperature

With regard to the internal temperature sensor, such rotary encoders can support the dual-level cascaded signaling of an exceeded temperature. This signaling consists of an EnDat warning and an EnDat error message.

Whether or not the respective encoder supports this warning and error message can be read from the following addresses in the integrated memory:

- EnDat warning for *exceeded temperature:* EnDat memory area *Parameters of the encoder manufacturer,* word 36 – *Support of warnings,* bit 2^1 – *Temperature exceeded*
- EnDat error message for *exceeded temperature:* EnDat memory area *Parameters of the encoder manufacturer for EnDat 2.2,* word 35 – *Support of operating condition error sources,* bit 2^6 – *Temperature exceeded*

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

[1] Value in parenthesis: accuracy at 125 °C

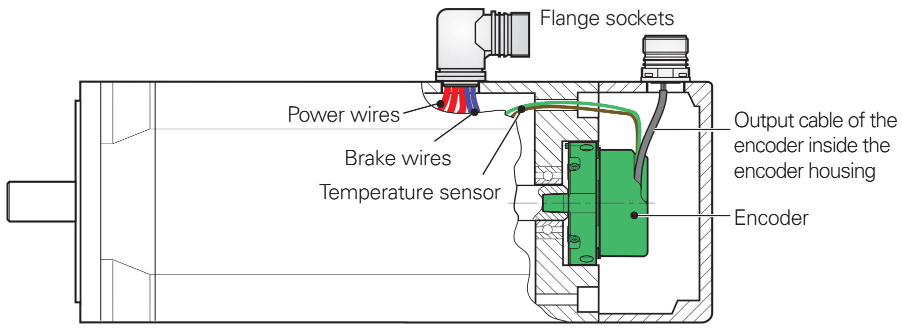
In accordance with the EnDat specification, when the warning threshold for an exceeded temperature of the internal temperature sensor is reached, an **EnDat warning** is output (EnDat memory area *Operating status,* word 1 – *Warning,* bit 2^1 – *Temperature exceeded*). This warning threshold for the internal temperature sensor is stored in the EnDat memory area *Operating parameters,* word 6 – *Trigger threshold of the warning bit for excessive temperature*, and can be individually configured. 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 rotary encoder features a further, albeit non-adjustable, trigger threshold of the internal temperature sensor. When this threshold is reached, an **EnDat error message** is output (EnDat memory area *Operating status,* word 0 – *Error messages,* bit 2^2 – *Position* and, in additional data 2, *Operating status error sources,* bit 2^6 – *Temperature exceeded).* The value for this trigger threshold depends on the device and is shown in the specifications (if there is a trigger threshold).

HEIDENHAIN recommends adjusting the warning threshold based on the application such that the threshold is sufficiently below the trigger threshold for the *exceeded temperature* EnDat error message. For compliance with the intended use of the encoder, it is also important that the operating temperature at the measuring point M1 be maintained.

Information for the connection of an external temperature sensor

- The external temperature sensor must comply with the following prerequisites as per EN 61800-5-1:
  – Voltage class A
  – Contamination level 2
  – Overvoltage category 3
- Only connect passive temperature sensors
- The connections for the temperature sensor are galvanically connected to 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 that electrical safety is ensured
- 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.

	KTY84-130	PT1000
–40 °C to +80 °C	±6 K	±6 K
80.1 °C to 160 °C	±3 K	±4 K
160.1 °C to 200 °C	±6 K	±6 K

Specifications of the evaluation	
Resolution	0.1 K (with KTY84-130)
Supply voltage for sensor	3.3 V over dropping resistor R_V = 2 kΩ
Measuring current (typical)	1.2 mA at 595 Ω 1.0 mA at 990 Ω
Total delay of the 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 polyolefine	≤ 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 the reading of the data via the device 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
The temperature evaluation 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 illustrates the relationship between the output value and the resistance of the temperature sensor.
For the KTY 84-130, the temperature value equals the output value. The value's unit of measure is 0.1 kelvin.

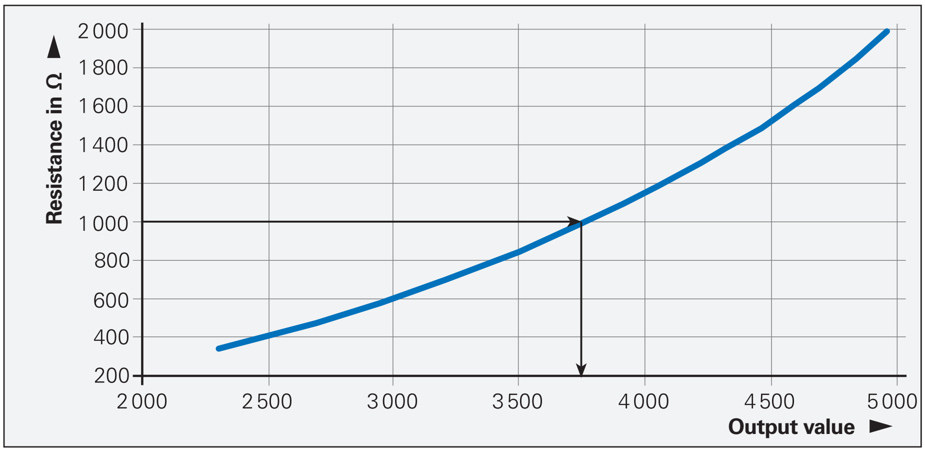


Figure 1: Relationship between output value and resistance

Example for the KTY 84-130 temperature sensor:
Sensor resistance = 1000 Ω → output value (temperature value):
3751, which corresponds to 375,1 K, or 102 °C.

Figure 2 shows the relationship between the output value and the temperature value for a PT1000. In the graph, the temperature value for the PT1000 can be determined based on the output value.

For more information, see page 44.

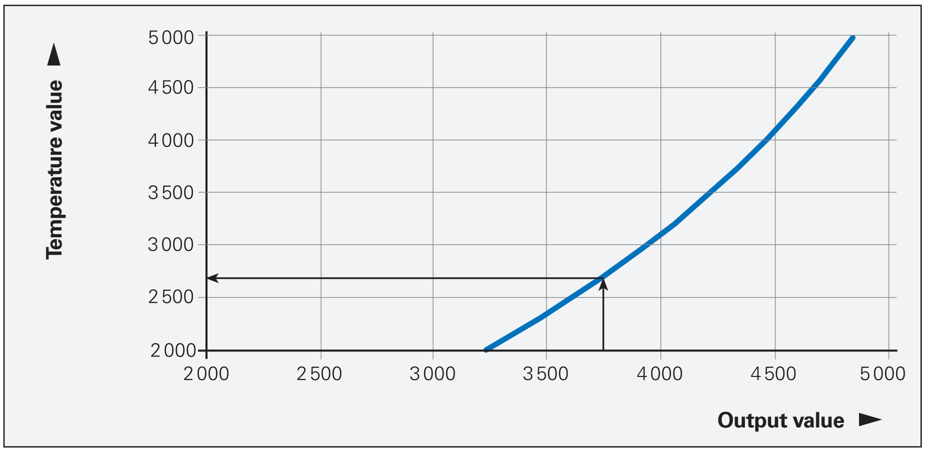


Figure 2: Relationship between output value and temperature value with the example of the PT1000

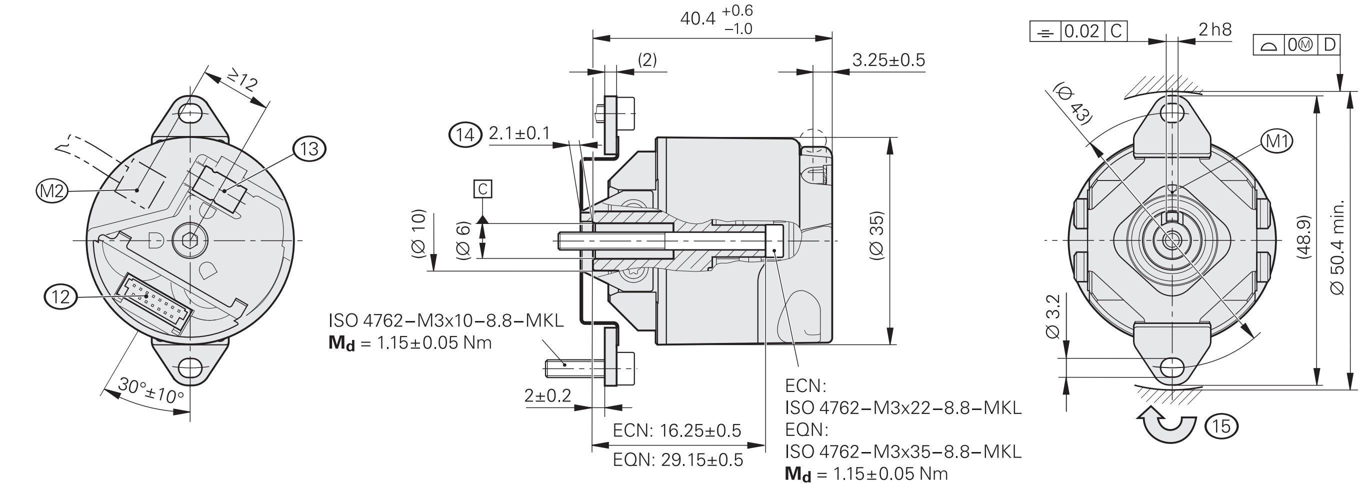
Example with temperature sensor PT1000:
Output value = 3751 → temperature value = 2734 (corresponds to 0.3 °C).
The following polynomial can be used to calculate the temperature value:

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

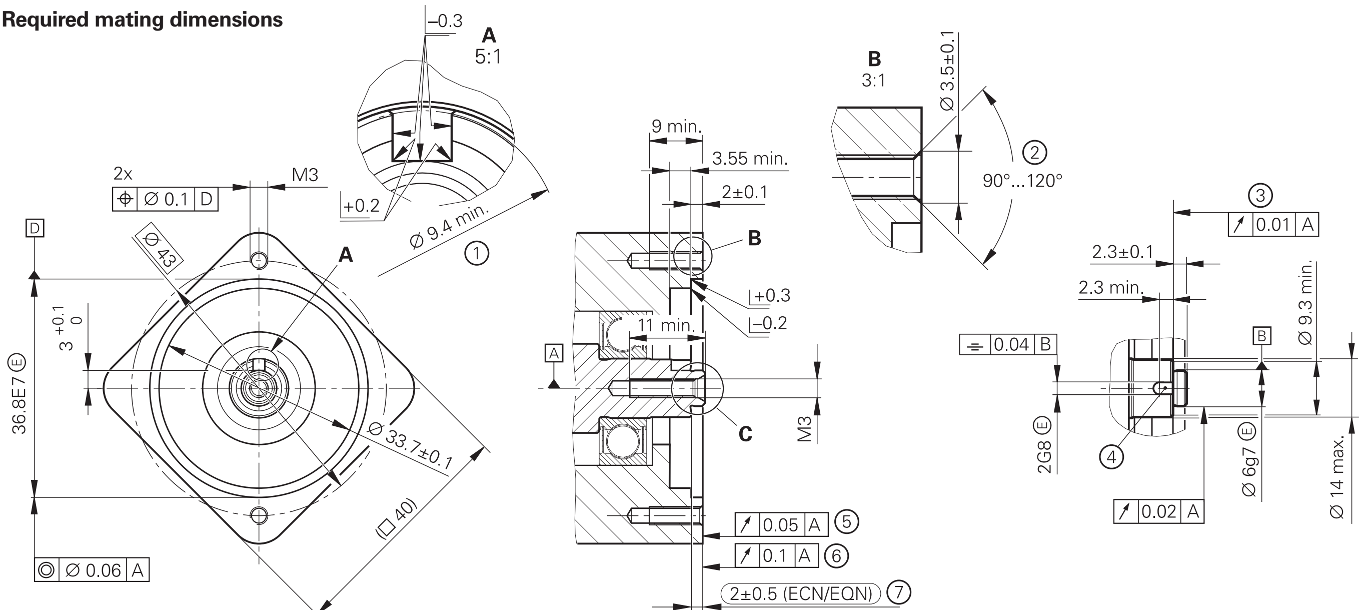
A = Output value. The PT1000 polynomial is valid for: $3400 \leq A \leq 4810$.

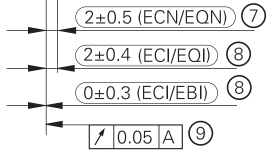
ECN/EQN 1100 series

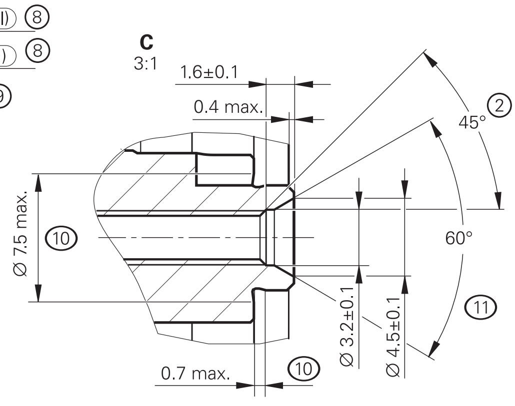
Absolute rotary encoders
- **75A stator coupling for plane surface**
- **Blind hollow shaft**
- **Encoders available with functional safety**



Required mating dimensions







mm

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

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 materially bonding anti-rotation lock
3 = Shaft surface; ensure full-surface contact!
4 = Slot required only for ECN/EQN and ECI/EQI, WELLA1 = 1KA
5 = Flange surface of ECI/EQI FS; ensure full-surface contact!
6 = Coupling surface of ECN/EQN
7 = Maximum permissible deviation between the shaft surface and coupling surface. Compensation of mounting tolerances and thermal expansion, of which ±0.15 mm of dynamic axial motion is permitted
8 = Maximum permissible deviation between the shaft surface and flange surface. Compensation of mounting tolerances and thermal expansion
9 = Flange surface of ECI/EBI; ensure full-surface contact!
10 = Undercut
11 = Possible centering hole
12 = 15-pin PCB connector
13 = Cable gland with crimp sleeve; diameter: 4.3 ±0.1 mm; length: 7 mm
14 = Positive-locking element. Ensure correct engagement in slot 4 (e.g., by measuring the device overhang)
15 = Direction of shaft rotation for output signals as per the interface description

	Absolute			
	ECN 1113	**ECN 1123** Functional Safety	**EQN 1125**	**EQN 1135** Functional Safety
Interface	EnDat 2.2			
Ordering designation	EnDat01	EnDat22	EnDat01	EnDat22
Position values per rev.	8192 (13 bits)	8388608 (23 bits)	8192 (13 bits)	8388608 (23 bits)
Revolutions	–		4096 (12 bits)	
Elec. permissible speed/ Deviations[2]	4000 rpm/±1 LSB 12000 rpm/±16 LSB	12000 rpm (for continuous position value)	4000 rpm/±1 LSB 12000 rpm/±16 LSB	12000 rpm (for continuous position value)
Calculation time t_{cal} Clock frequency	≤ 9 µs ≤ 2 MHz	≤ 7 µs ≤ 8 MHz	≤ 9 µs ≤ 2 MHz	≤ 7 µs ≤ 8 MHz
Incremental signals	∼ 1 V_{PP}[1]	–	∼ 1 V_{PP}[1]	–
Line count	512	–	512	–
Cutoff frequency –3 dB	≥ 190 kHz	–	≥ 190 kHz	–
System accuracy	±60"			
Electrical connection via PCB connector	15-pin	15-pin[3]	15-pin	15-pin[3]
Supply voltage	DC 3.6 V to 14 V			
Power consumption (max.)	*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	Blind hollow shaft ∅ 6 mm with positive-locking element			
Mech. permiss. speed *n*	12000 rpm			
Starting torque (typical)	0.001 Nm (at 20 °C)		0.002 Nm (at 20 °C)	
Moment of inertia of rotor	≈ $0.4 \cdot 10^{-6}$ kgm^2			
Permiss. axial motion of measured shaft	±0.5 mm			
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)			
Max. operating temperature	115 °C			
Min. operating temperature	–40 °C			
Protection EN 60529	IP40 when mounted			
Mass	≈ 0.1 kg			
Valid for ID	803427-xx	803429-xx	803428-xx	803430-xx

1) Restricted tolerances
Signal amplitude: 0.80 V_{PP} to 1.2 V_{PP}
Asymmetry: 0.05
Amplitude ratio: 0.9 to 1.1
Phase angle: 90° ±5° elec.

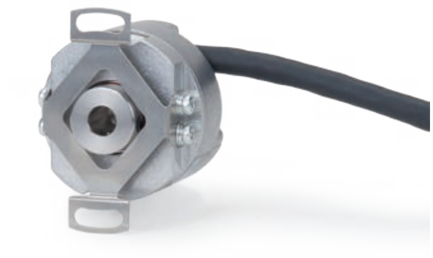
2) Speed-dependent deviations between absolute and incremental signals

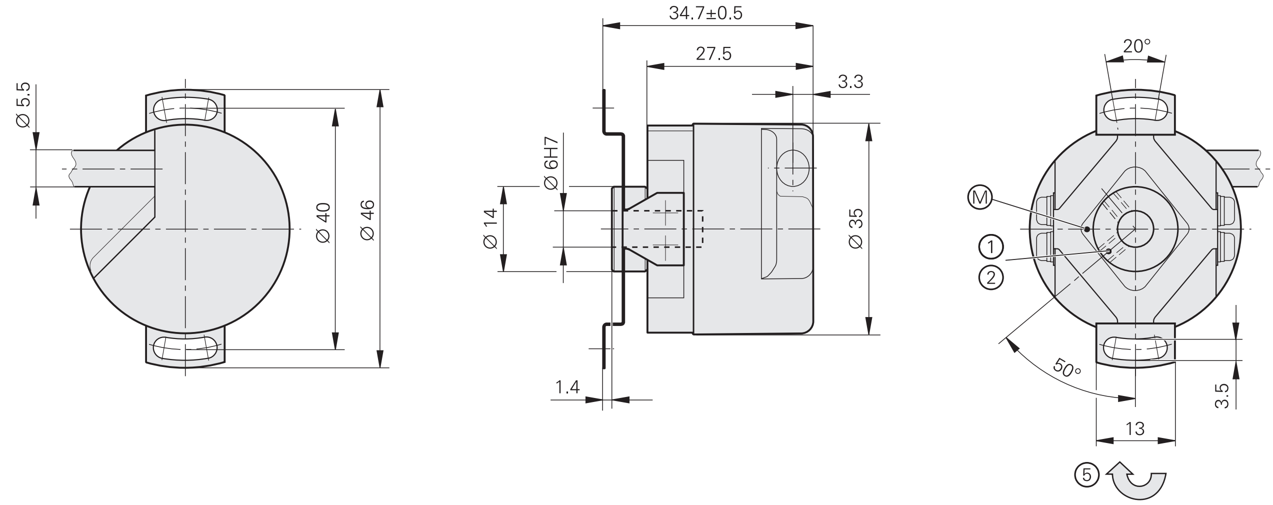
3) With connection for temperature sensor; evaluation optimized for KTY 84-130

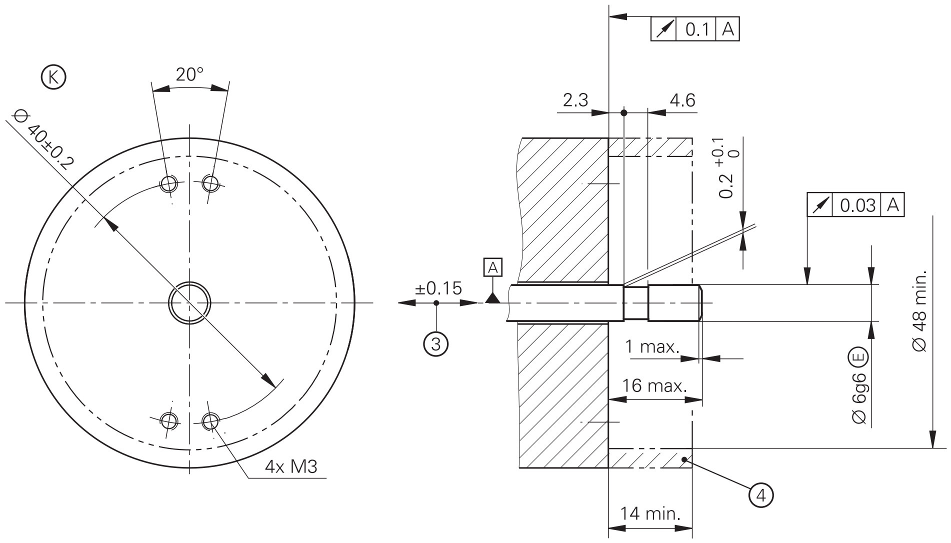
Functional safety is available for ECN 1123 and EQN 1135. For dimensions and specifications, see the product information document.

ERN 1023

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







mm

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

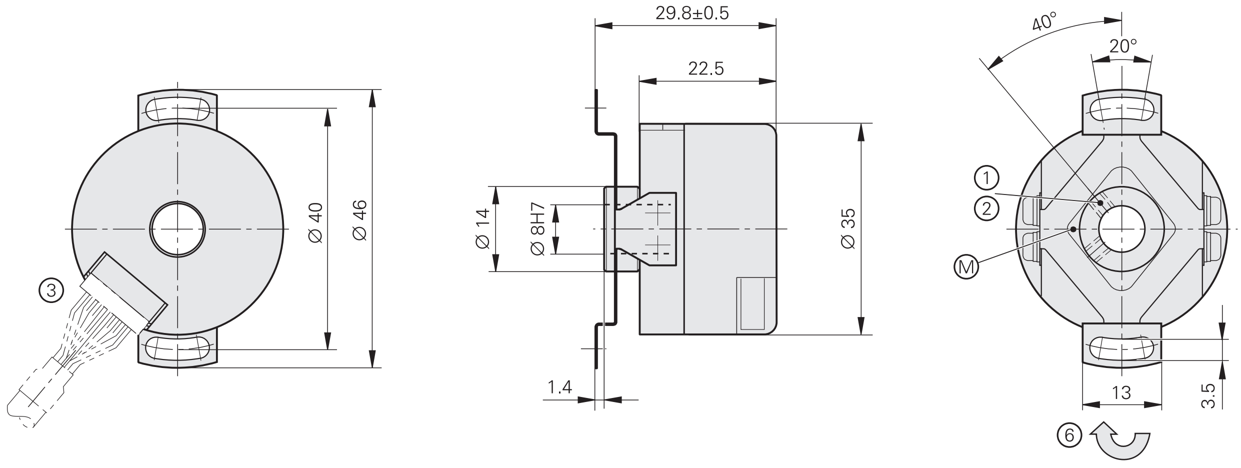
A = Bearing of mating shaft
K = Required mating dimensions
M = Measuring point for operating temperature
1 = 2 screws in clamping ring; tightening torque: 0.6 Nm ±0.1 Nm; width A/F 1.5
2 = Reference mark position ±10°
3 = Compensation of mounting tolerances and thermal expansion; no dynamic motion permitted
4 = Ensure protection against contact (EN 60529)
5 = Direction of shaft rotation for output signals as per the interface description

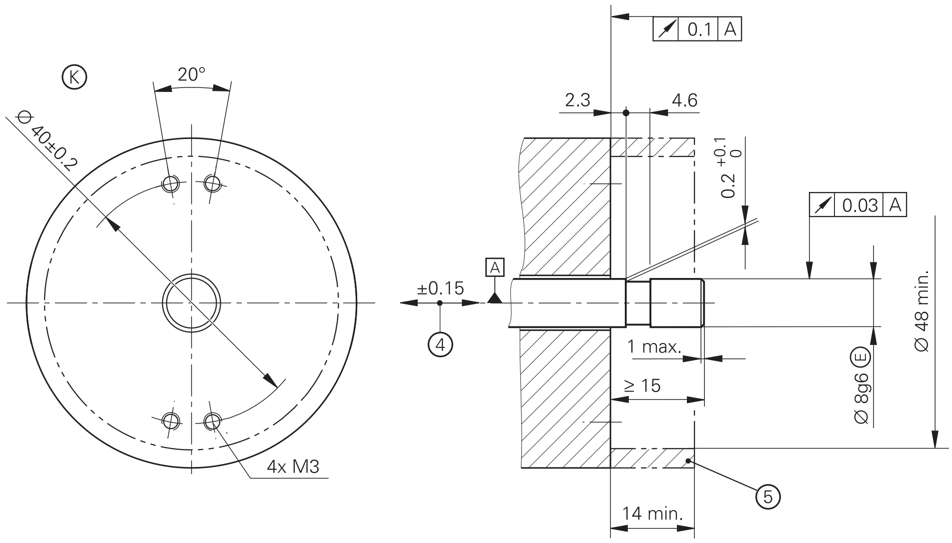
	ERN 1023		
Interface	⊓⊔TTL		
Signal periods per rev.*	**500** **512** 600	**1000** **1024** 1250 **2000** **2048** **2500** 4096 5000 8192	
Reference mark	One		
Output frequency Edge separation *a*	≤ 300 kHz ≥ 0.41 µs		
Commutation signals[1)]	⊓⊔TTL (3 commutation signals U, V, W)		
Width*	2 x 180° (C01); 3 x 120° (C02); **4 x 90° (C03)**		
System accuracy	±260″	±130″	
Electrical connection*	Cable: **1 m**, or 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. 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		
Permiss. 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)		
Valid for ID	684703-xx		

Boldface: This preferred version is available on short notice
* Please select when ordering
1) Three square-wave 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 encoder
- **Stator coupling for plane surface**
- **Hollow through shaft**
- **Block commutation signals**





mm

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

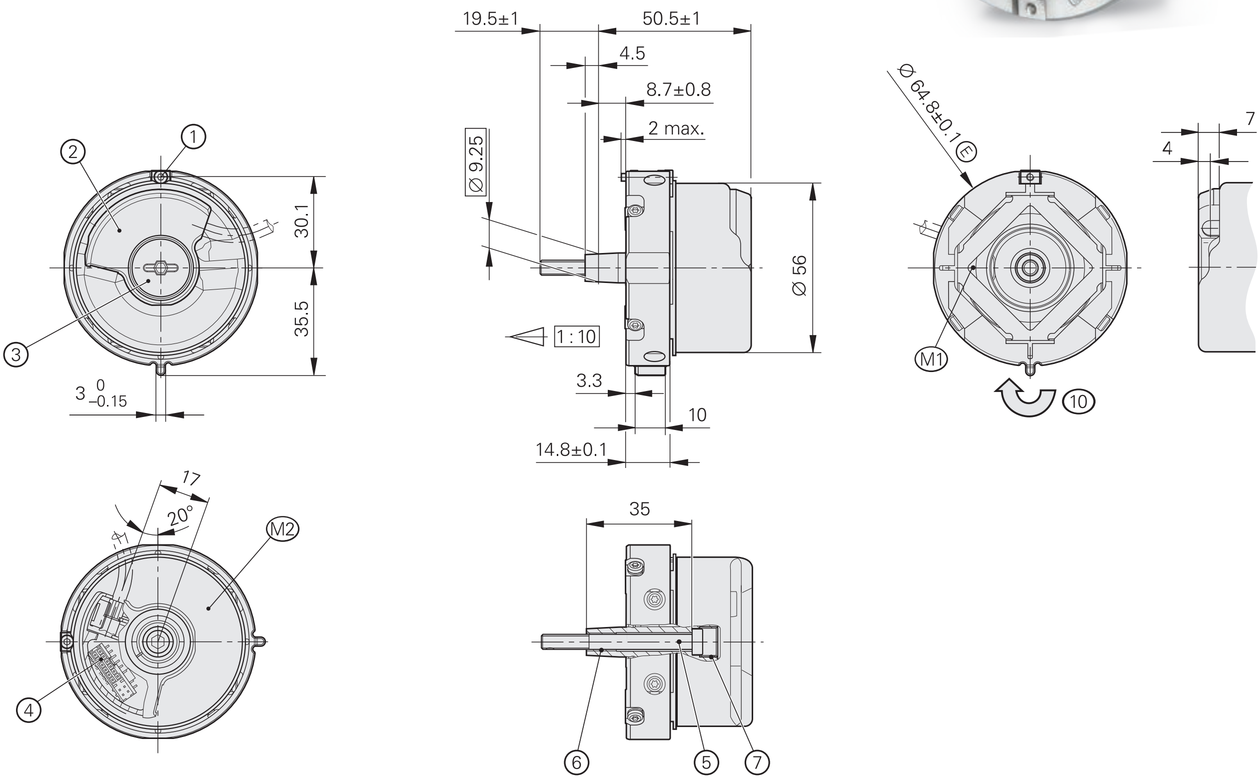
A = Bearing of mating shaft
K = Required mating dimensions
M = Measuring point for operating temperature
1 = 2 screws in clamping ring; tightening torque: 0.6 Nm ±0.1 Nm; width A/F 1.5
2 = Reference mark position ±10°
3 = 15-pin JAE connector
4 = Compensation of mounting tolerances and thermal expansion; no dynamic motion permitted
5 = Ensure protection against contact (EN 60529)
6 = Direction of shaft rotation for output signals as per the interface description

	ERN 1123	
Interface	⊓⊔TTL	
Signal periods per rev.*	**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 via PCB connector	15-pin	
Supply voltage	DC 5 V ±0.5 V	
Current consumption (without load)	≤ 70 mA	
Shaft	Hollow through shaft ∅ 8 mm	
Mech. permiss. 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	
Permiss. 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	–20 °C	
Protection EN 60529	IP00[2]	
Mass	≈ 0.06 kg	
Valid for ID	684702-xx	

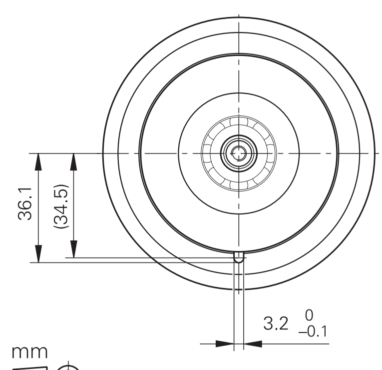
Boldface: This preferred version is available on short notice
* Please select when ordering
1) Three square-wave signal periods with 90°, 120°, or 180° mech. phase shift; see *Commutation signals for block commutation* in the *Interfaces of HEIDENHAIN Encoders* brochure
2) Conformity with the EMC Directive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

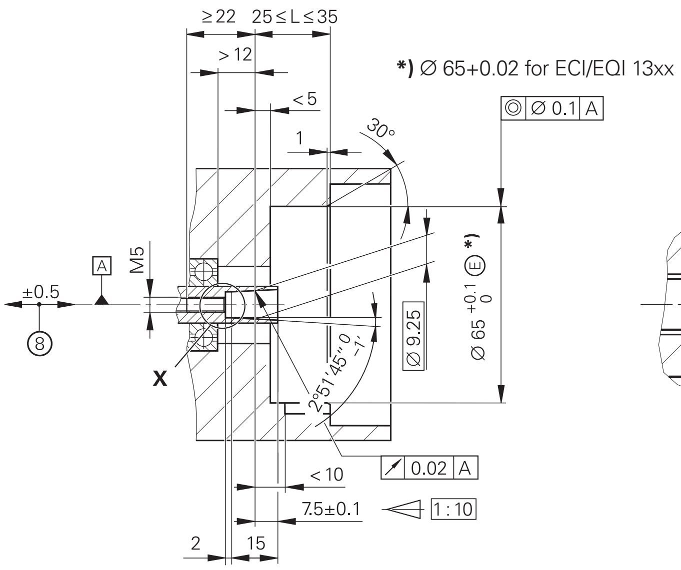
ECN/EQN 1300 series

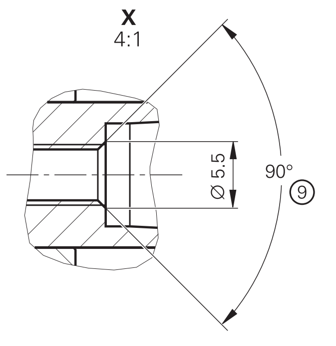
Absolute rotary encoders
- **07B stator coupling with anti-rotation element for axial mounting**
- **65B tapered shaft**
- **Encoders available with functional safety**
- **Fault exclusion possible for rotor coupling and stator coupling as per EN 61800-5-2**



Required mating dimensions







mm

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

Ⓐ = Bearing of mating shaft
Ⓚ = Required mating dimensions
Ⓜ1 = Measuring point for operating temperature
Ⓜ2 = Measuring point for vibration, see D 741714
1 = Clamping screw for coupling ring: width A/F 2; tightening torque: 1.25 Nm –0.2 Nm
2 = Die-cast cover
3 = Screw plug: width A/F 3 and 4; tightening torque: 5 Nm +0.5 Nm
4 = 12-pin or 16-pin PCB connector
5 = Screw: DIN 6912 – M5x50 – 08.8 – MKL; width A/F 4; tightening torque: 5 Nm +0.5 Nm
6 = M6 back-off thread
7 = M10 back-off thread
8 = Compensation of mounting tolerances and thermal expansion; no dynamic motion permitted
9 = Chamfer at start of thread is mandatory for materially bonding anti-rotation lock
10 = Direction of shaft rotation for output signals as per the interface description

	Absolute			
	ECN 1313	**ECN 1325** Functional Safety	**EQN 1325**	**EQN 1337** Functional Safety
Interface	EnDat 2.2			
Ordering designation	EnDat01	EnDat22	EnDat01	EnDat22
Position values per rev.	8192 (13 bits)	33554432 (25 bits)	8192 (13 bits)	33554432 (25 bits)
Revolutions	–		4096 (12 bits)	
Elec. permissible 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)	*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	≤ 9 µs ≤ 2 MHz	≤ 7 µs ≤ 8 MHz
Incremental signals	∼ 1 V_{PP}[1]	–	∼ 1 V_{PP}[1]	–
Line count*	512 2048	2048	512 2048	2048
Cutoff frequency –3 dB	*2048 lines:* ≥ 400 kHz *512 lines:* ≥ 130 kHz	–	*2048 lines:* ≥ 400 kHz *512 lines:* ≥ 130 kHz	–
System accuracy	*512 lines:* ±60"; *2048 lines:* ±20"			
Electrical connection via PCB connector	12-pin	16-pin with connection for temperature sensor[3]	12-pin	16-pin with connection for temperature sensor[3]
Supply voltage	DC 3.6 V to 14 V			
Power consumption (max.)	*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. speed *n*	≤ 15000 rpm		≤ 12000 rpm	
Starting torque (typical)	0.01 Nm (at 20 °C)			
Moment of inertia of rotor	$2.6 \cdot 10^{-6}$ kgm²			
Natural frequency of the stator coupling (typical)	1800 Hz			
Permiss. axial motion of measured shaft	±0.5 mm			
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 300 m/s² [4] (EN 60068-2-6) ≤ 2000 m/s² (EN 60068-2-27)			
Max. operating temp.	115 °C			
Min. operating temp.	–40 °C			
Protection EN 60529	IP40 when mounted			
Mass	≈ 0.25 kg			
Valid for ID	768295-xx	683643-xx	827039-xx	683645-xx

* Please select when ordering

1) Restricted 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° ±5° elec.
- Signal-to-noise ratio E, F: ≥ 100 mV

2) Speed-dependent deviations between absolute and incremental signals

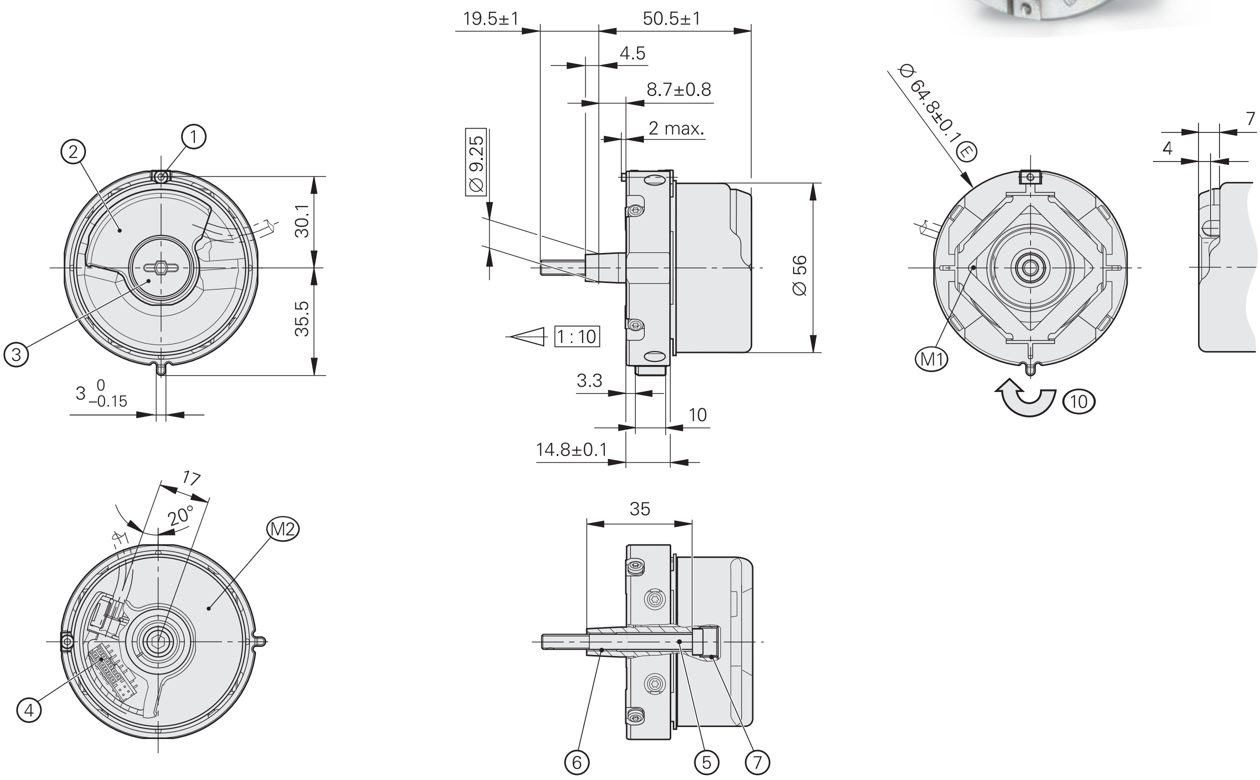
3) Evaluation optimized for KTY 84-130

4) Valid in accordance with standard at room temperature; at operating temperature, the following applies: Up to 100 °C: ≤ 300 m/s²; Up to 115 °C: ≤ 150 m/s²

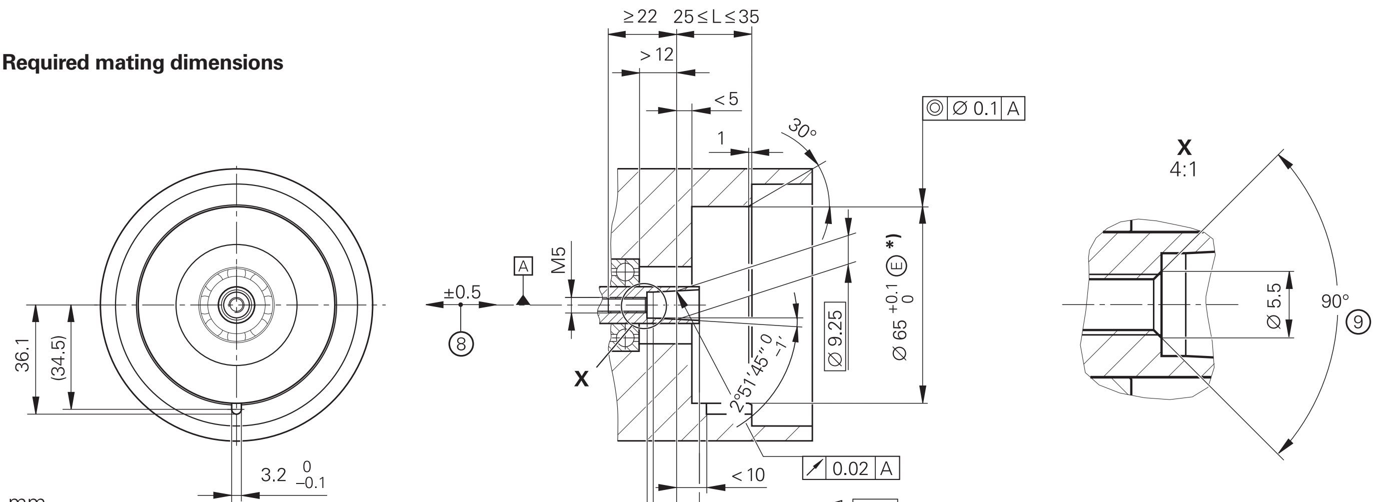
Functional safety is available for the ECN 1325 and EQN 1337. For dimensions and specifications, see the product information document.

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 possible for rotor coupling and stator coupling as per EN 61800-5-2**



Required mating dimensions



mm

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

A = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration, see D 741714
1 = Clamping screw for coupling ring: width A/F 2; tightening torque: 1.25 Nm –0.2 Nm
2 = Die-cast cover
3 = Screw plug: width A/F 3 and 4; tightening torque: 5 Nm +0.5 Nm
4 = 16-pin PCB connector
5 = Screw: DIN 6912 – M5x50 – 08.8 – MKL; width A/F 4; tightening torque: 5 Nm +0.5 Nm
6 = M6 back-off thread
7 = M10 back-off thread
8 = Compensation of mounting tolerances and thermal expansion; no dynamic motion permitted
9 = Chamfer at start of thread is mandatory for materially bonding anti-rotation lock
10 = Direction of shaft rotation for output signals as per the interface description

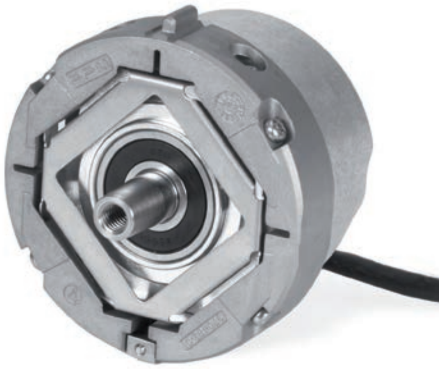
	Absolute	
	ECN 1324 S Functional Safety	**EQN 1336 S** Functional Safety
Interface	DRIVE-CLiQ	
Ordering designation	DQ01	
Position values per rev.	16 777 216 (24 bits)	
Revolutions	–	4096 (12 bits)
Speed[1)]	≤ 15 000 rpm (at ≥ 2 position requests/rev.)	≤ 12 000 rpm (at ≥ 2 position requests/rev.)
Calculation time$_{TIME_MAX_ACTVAL}$	≤ 8 µs	
Incremental signals	–	
System accuracy	±20″	
Electrical connection via PCB connector	16-pin with connection for 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)	*At 24 V:* 38 mA (without load)	*At 24 V:* 43 mA (without load)
Shaft	Tapered shaft ∅ 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 of the stator coupling (typical)	1800 Hz	
Permissible axial motion of measured shaft	±0.5 mm	
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)	
Max. operating temp.	100 °C	
Min. operating temp.	–30 °C	
Protection EN 60529	IP40 when mounted	
Mass	≈ 0.25 kg	
Valid for ID	1042274-xx	1042276-xx

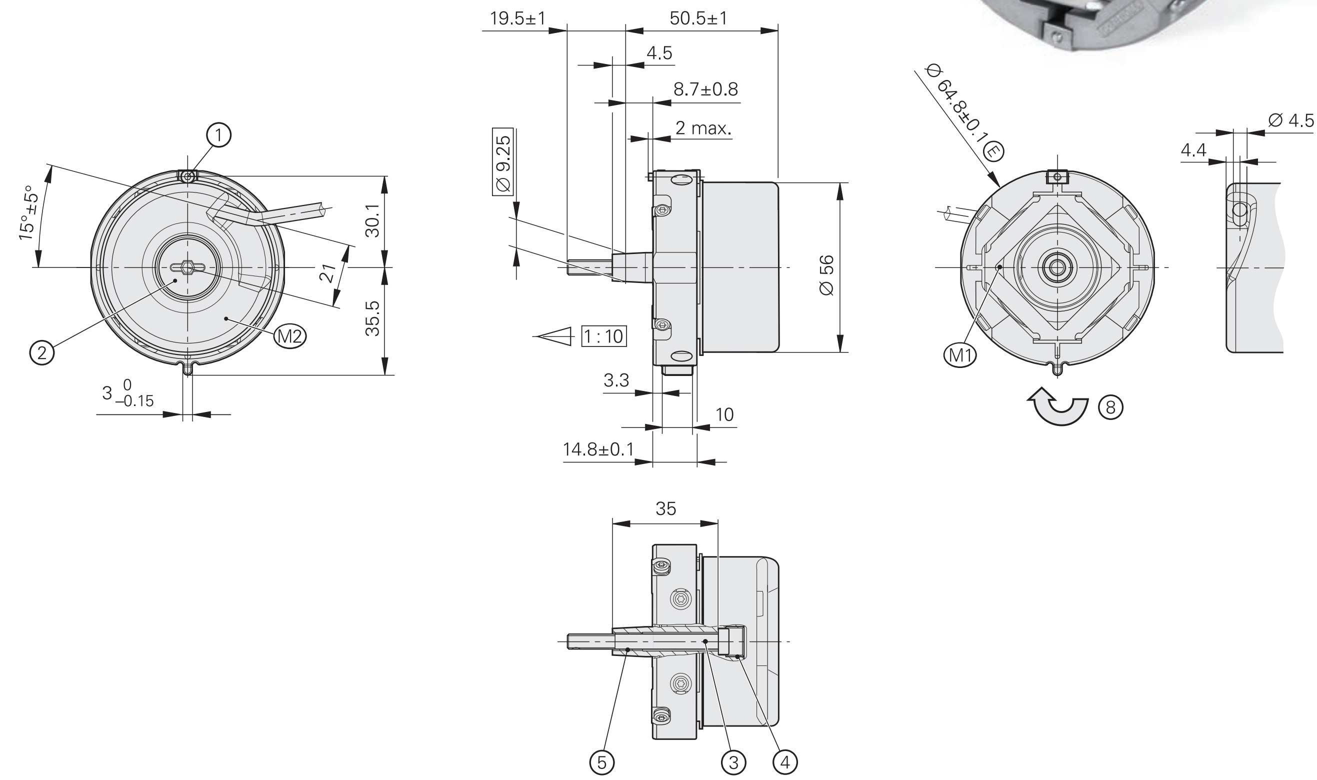
1) Evaluation optimized for KTY 84-130

Functional safety available for ECN 1324 S and EQN 1336 S. For dimensions and specifications, see the product information document.

ECN/EQN 400 series

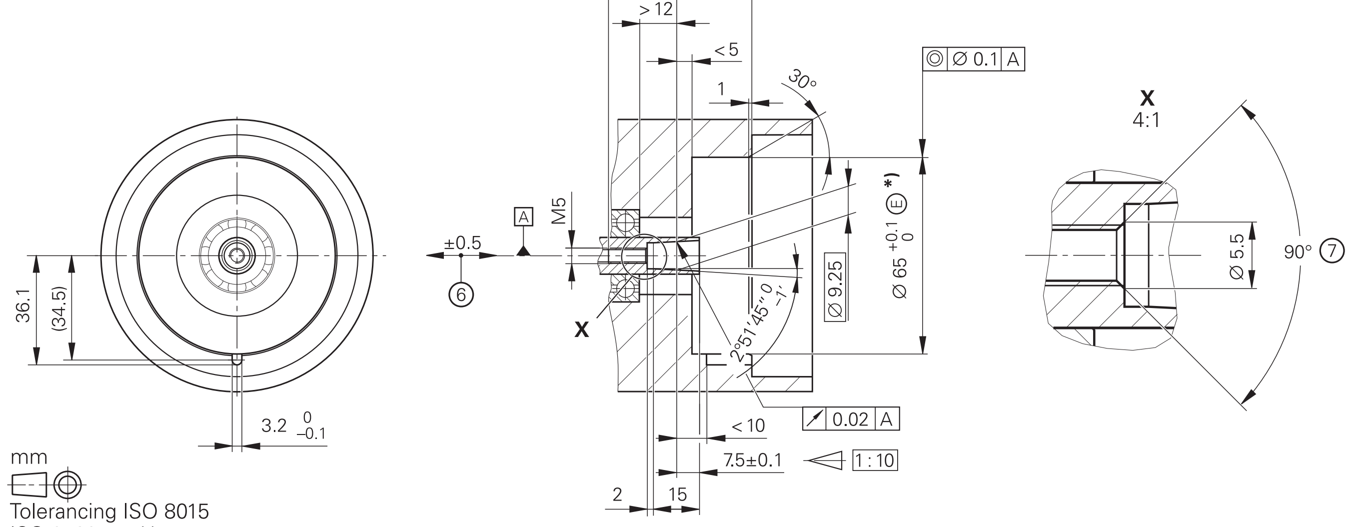
Absolute rotary encoders
- **07B stator coupling with anti-rotation element for axial mounting**
- **65B tapered shaft**
- **Encoders available with functional safety**
- **Fault exclusion possible for rotor coupling and stator coupling as per EN 61800-5-2**





Required mating dimensions

***)** Ø 65+0.02 for ECI/EQI 13xx



mm

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

A = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration, see D 741714
1 = Clamping screw for coupling ring: width A/F 2; tightening torque: 1.25 Nm –0.2 Nm
2 = Screw plug: width A/F 3 and 4; tightening torque: 5 Nm +0.5 Nm
3 = Screw: DIN 6912 – M5x50 – 08.8 – MKL; width A/F 4; tightening torque: 5 Nm +0.5 Nm
4 = M10 back-off thread
5 = M6 back-off thread
6 = Compensation of mounting tolerances and thermal expansion; no dynamic motion permitted
7 = Chamfer at start of thread is mandatory for materially bonding anti-rotation lock
8 = Direction of shaft rotation for output signals as per the interface description

	Absolute			
	ECN 413	**ECN 425** Functional Safety	**EQN 425**	**EQN 437** Functional Safety
Interface	EnDat 2.2			
Ordering designation	EnDat01	EnDat22	EnDat01	EnDat22
Position values per rev.	8192 (13 bits)	33554432 (25 bits)	8192 (13 bits)	33554432 (25 bits)
Revolutions	–		4096 (12 bits)	
Elec. permissible speed/ Deviations[2]	1500 rpm/±1 LSB 12000 rpm/±50 LSB	15000 rpm (for continuous position value)	1500 rpm/±1 LSB 12000 rpm/±50 LSB	15000 rpm (for continuous position value)
Calculation time t_{cal} Clock frequency	≤ 9 µs ≤ 2 MHz	≤ 7 µs ≤ 16 MHz	≤ 9 µs ≤ 2 MHz	≤ 7 µs ≤ 16 MHz
Incremental signals	∿ 1 V_{PP}[1]	–	∿ 1 V_{PP}[1]	–
Line count	2048			
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 (max.)	*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	Taper shaft Ø 9.25 mm; taper 1:10			
Mech. permiss. speed *n*	≤ 15000 rpm		≤ 12000 rpm	
Starting torque (typical)	0.01 Nm (at 20 °C)			
Moment of inertia of rotor	$2.6 \cdot 10^{-6}$ kgm²			
Natural frequency of the stator coupling (typical)	1800 Hz			
Permissible axial motion of measured shaft	±0.5 mm			
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 300 m/s² (EN 60068-2-6) ≤ 2000 m/s² (EN 60068-2-27)			
Max. operating temp.	100 °C			
Min. operating temperature	*Fixed cable:* –40 °C *Moving cable:* –10 °C			
Protection EN 60529	IP64 when mounted			
Mass	≈ 0.25 kg			
Valid for ID	1065932-xx	683644-xx	1109258-xx	683646-xx

* Please select when ordering

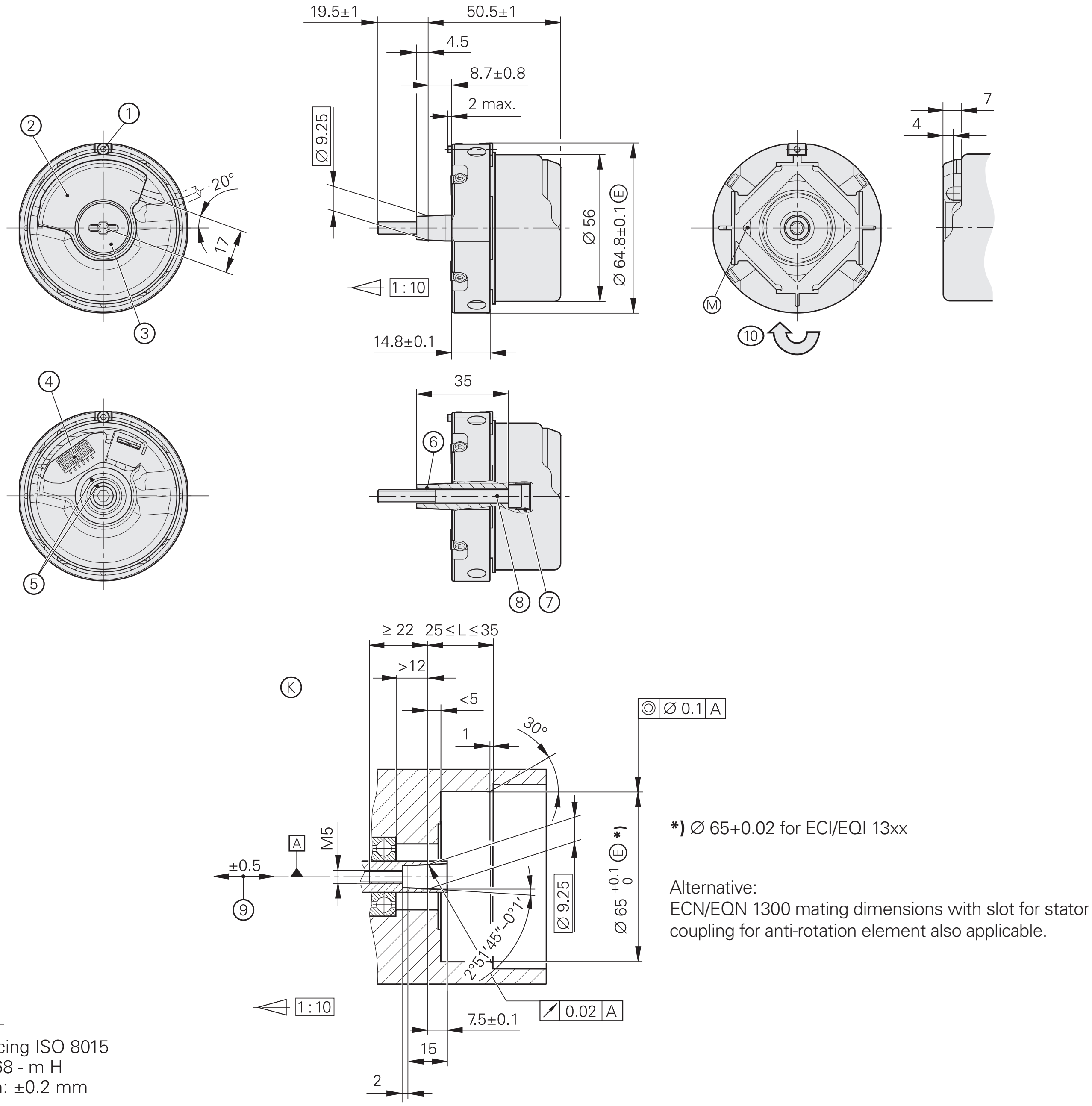
[1] Restricted tolerances
Signal amplitude: 0.8 V_{PP} to 1.2 V_{PP}
Asymmetry: 0.05
Amplitude ratio: 0.9 to 1.1
Phase angle: 90° ±5° elec.

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

Functional safety is available for the ECN 425 and EQN 437. For dimensions and specifications, see the product information document.

ERN 1300 series

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



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

Ⓐ = Bearing of mating shaft
Ⓚ = Required mating dimensions
Ⓜ = Measuring point for operating temperature
1 = Clamping screw for coupling ring: width A/F 2; tightening torque: 1.25 Nm –0.2 Nm
2 = Die-cast cover
3 = Screw plug: width A/F 3 and 4; tightening torque: 5 Nm +0.5 Nm
4 = 12-pin, 14-pin, or 16-pin PCB connector
5 = Reference mark position on shaft and cap
6 = M6 back-off thread
7 = M10 back-off thread
8 = Self-locking screw: M5x50 DIN 6912; width A/F 4; tightening torque: 5 Nm +0.5 Nm
9 = Compensation of mounting tolerances and thermal expansion; no dynamic motion permitted
10 = Direction of shaft rotation for output signals as per the interface description

	Incremental				
	ERN 1321	**ERN 1381**	**ERN 1387**	**ERN 1326**	
Interface	⊓⊔TTL	∼ 1 V_{PP}[1]		⊓⊔TTL	
Line count*/ System accuracy	1024/±64″ 2048/±32″ 4096/±16″	512/±60″ 2048/±20″ 4096/±16″	2048/±20″	1024/±64″ 2048/±32″ 4096/±16″	8192/±16″[5]
Reference mark	One				
Output frequency Edge separation *a* Cutoff frequency –3 dB	≤ 300 kHz ≥ 0.35 µs –	– ≥ 210 kHz		≤ 300 kHz ≥ 0.35 µs –	≤ 150 kHz ≥ 0.22 µs
Commutation signals	–		∼ 1 V_{PP}[1]	⊓⊔TTL	
Width*	–		Z1 track[2]	3 x 120°; 4 x 90°[3]	
Electrical connection via PCB connector	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	Taper shaft Ø 9.25 mm; taper 1:10				
Mech. permiss. speed *n*	≤ 15000 rpm				
Starting torque (typical)	0.01 Nm (at 20 °C)				
Moment of inertia of rotor	$2.6 \cdot 10^{-6}$ kgm^2				
Natural frequency of the stator coupling (typical)	1800 Hz				
Permiss. axial motion of measured shaft	±0.5 mm				
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2 [4] (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)				
Max. operating temp.	120 °C	120 °C *4096 lines:* 80 °C	120 °C		
Min. operating temp.	–40 °C				
Protection EN 60529	IP40 when mounted				
Mass	≈ 0.25 kg				
Valid for ID	385423-xx	534118-xx	749144-xx	574485-xx	

* Please select when ordering

1) Restricted 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° ±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* brochur

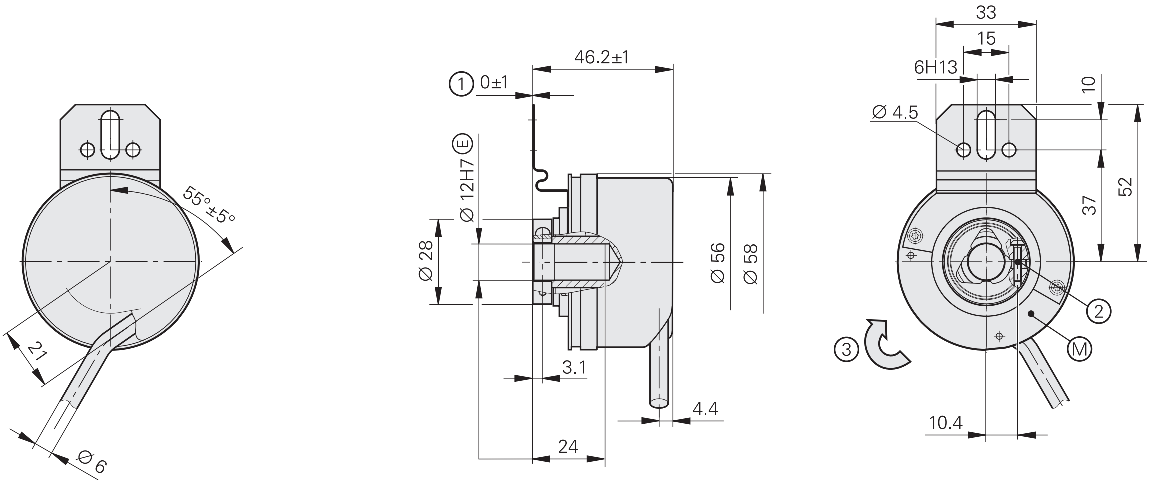
3) Three square-wave signals with signals periods with 90° or 120° mech. phase shift; see the *Interfaces of HEIDENHAIN Encoders* brochure

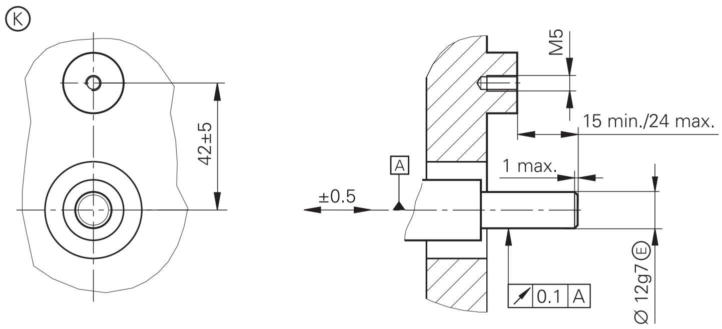
4) Valid in accordance with standard at room temperature; at operating temperature, the following applies: Up to 100 °C: ≤ 300 m/s^2
Up to 120 °C: ≤ 150 m/s^2

5) Through integrated signal doubling

EQN/ERN 400 series

Absolute and incremental rotary encoders
- **Torque support**
- **Blind hollow shaft**
- **Replacement for Siemens 1XP8000**





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

Siemens model	Replacement model		ID	Design
1XP8012-10	ERN 430[1)]	HTL	597331-76	Cable (0.8 m) with mounted coupling and 17-pin M23 central fastening
1XP8032-10	ERN 430	HTL		
1XP8012-20	ERN 420[1)]	TTL	597330-74	
1XP8032-20	ERN 420	TTL		
1XP8014-10	EQN 425[1)]	EnDat	649989-74	Cable (1 m) with 17-pin M23 coupling
1XP8024-10	EQN 425	EnDat		
1XP8014-20	EQN 425[1)]	SSI	649990-73	
1XP8024-20	EQN 425	SSI		

1) Original Siemens encoder has a 17-pin M23 flange socket

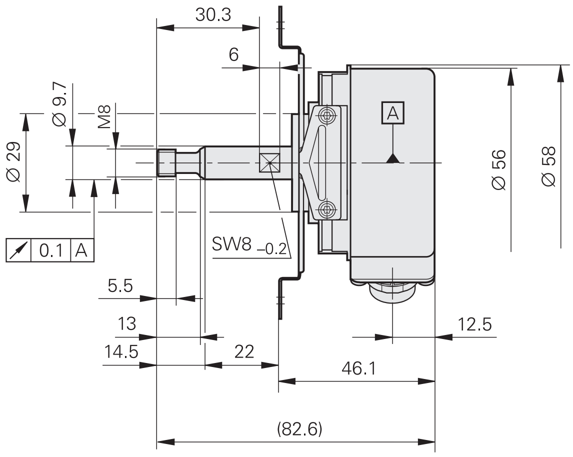
Ⓐ = Bearing of mating shaft
Ⓚ = Required mating dimensions
Ⓜ = Measuring point for operating temperature
1 = Distance from clamping ring to coupling
2 = Clamping screw with X8 hexalobular socket: tightening torque: 1.1 Nm ±0.1 Nm
3 = Direction of shaft rotation for output signals as per the interface description

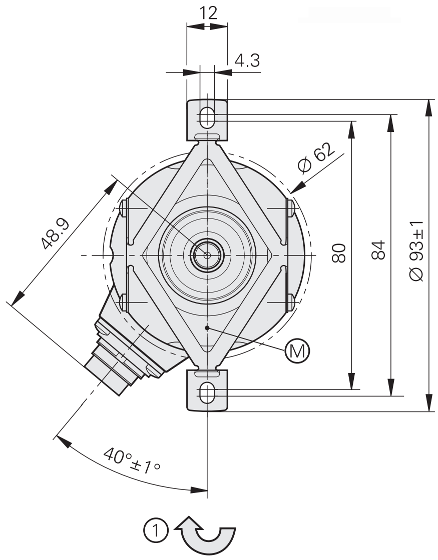
	Absolute		Incremental	
	EQN 425		**ERN 420**	**ERN 430**
Interface*	EnDat 2.2	SSI	⊓⊔TTL	⊓⊔HTL
Ordering designation	EnDat01	SSI41r1	–	–
Positions per revolution	8192 (13 bits)		–	–
Revolutions	4096		–	–
Code	Pure binary	Gray	–	–
Elec. permissible speed Deviations[1]	≤ 1500/10000 rpm ±1 LSB/±50 LSB	≤ 12000 rpm ±12 LSB	–	–
Calculation time t_{cal} Clock frequency	≤ 9 µs ≤ 2 MHz	≤ 5 µs –	–	–
Incremental signals	∼ 1 V_{PP}[2]		⊓⊔TTL	⊓⊔HTL
Line count	2048	512	1024	
Cutoff frequency –3 dB Output frequency Edge separation *a*	≥ 400 kHz – –	≥ 130 kHz – –	– ≤ 300 kHz ≥ 0.39 µs	
System accuracy	±20″	±60″	1/20 of grating period	
Electrical connection	Cable (1 m) with M23 coupling		Cable 0.8 m with mounted coupling and central fastening	
Supply voltage	DC 3.6 V to 14 V	DC 10 V to 30 V	DC 5 V ±0.5 V	DC 10 V to 30 V
Power consumption (max.)	*3.6 V:* ≤ 0.7 W *14 V:* ≤ 0.8 W	*10 V:* ≤ 0.75 W *30 V:* ≤ 1.1 W	–	–
Current consumption (typical, without load)	*5 V:* 105 mA	*5 V:* 120 mA *24 V:* 28 mA	≤ 120 mA	≤ 150 mA
Shaft	Blind hollowed shaft ∅ 12 mm			
Mech. permiss. speed *n*	≤ 6000 rpm			
Starting torque (typical)	0.05 Nm at 20 °C			
Moment of inertia of rotor	≤ $4.6 \cdot 10^{-6}$ kgm^2			
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) ≤ 1000 m/s^2 (EN 60068-2-27)			
Max. operating temp.	100 °C			
Min. operating temperature	*Fixed cable*: –40 °C *Moving cable:* –10 °C			
Protection EN 60529	IP66			
Mass	≈ 0.3 kg			
Valid for ID	649989-xx	649990-xx	597330-xx	597331-xx

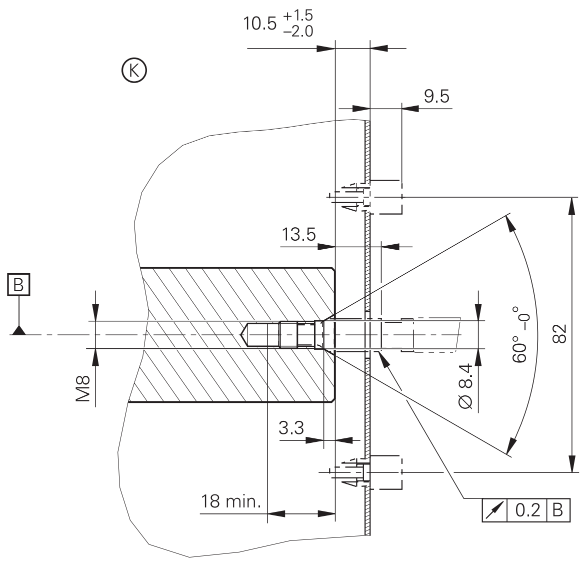
* Please select when ordering
1) Velocity-dependent deviations between the absolute value and incremental signals
2) Restricted tolerances: signal amplitudes of 0.8 V_{PP} to 1.2 V_{PP}

ERN 401 series

Incremental rotary encoders
- **Stator coupling via fastening clips**
- **Blind hollow shaft**
- **Replacement for Siemens 1XP8000**
- **Including mounting set with housing**







mm

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

Siemens model	Replacement model	ID
1XP8001-2	ERN 421	538724-71
1XP8001-1	ERN 431	538725-02

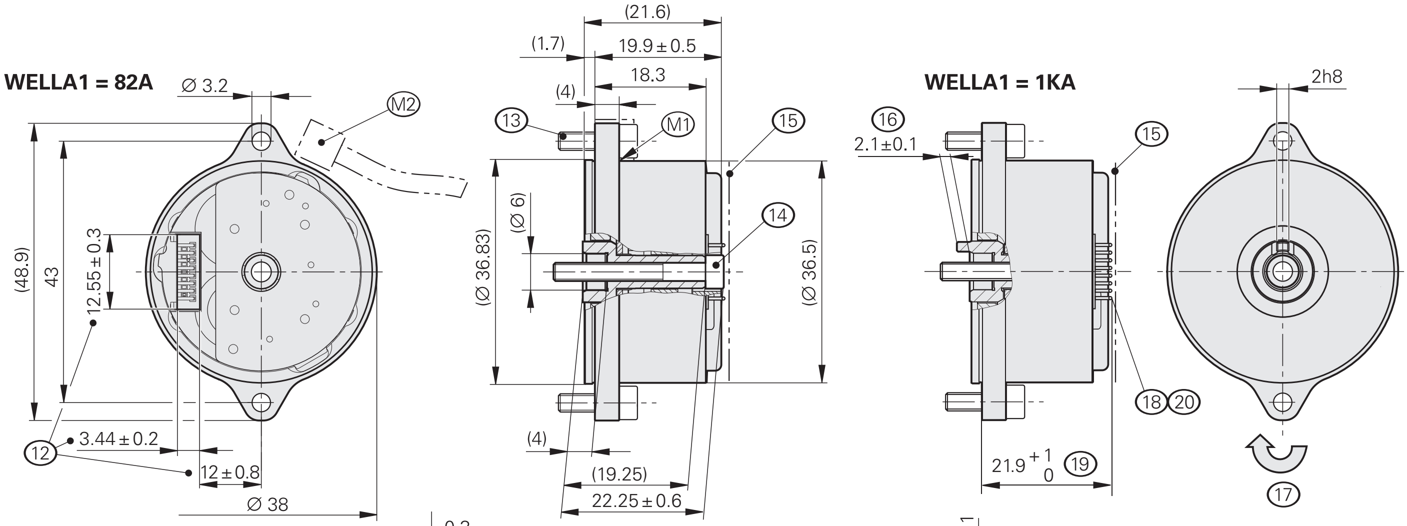
A = Encoder bearing
B = Bearing of mating shaft
K = Required mating dimensions
M = Measuring point for operating temperature
1 = Direction of shaft rotation for output signals as per the interface description

	Incremental	
	ERN 421	ERN 431
Interface	⊓⊔ TTL	⊓⊔ HTL
Line count	1024	
Reference mark	One	
Output frequency Edge separation *a*	≤ 300 kHz ≥ 0.39 µs	
System accuracy	1/20 of grating period	
Electrical connection	M16 flange socket (female)	
Supply voltage	DC 5 V ±0.5 V	DC 10 V to 30 V
Current consumption without load	≤ 120 mA	≤ 150 mA
Shaft	Solid shaft with M8 external thread, 60° centering taper	
Mech. permiss. speed *n*[1)]	≤ 6000 rpm	
Starting torque (typical)	0.025 Nm (at 20 °C)	
Moment of inertia of rotor	$\leq 4.3 \cdot 10^{-6}$ kgm^2	
Permissible axial motion of measured shaft	±1 mm	
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60068-2-6); higher values upon request ≤ 1000 m/s^2 (EN 60068-2-27)	
Max. operating temp.	100 °C	
Min. operating temperature	–40 °C	
Protection EN 60529	IP66	
Mass	≈ 0.3 kg	
Valid for ID	538724-xx	538725-xx

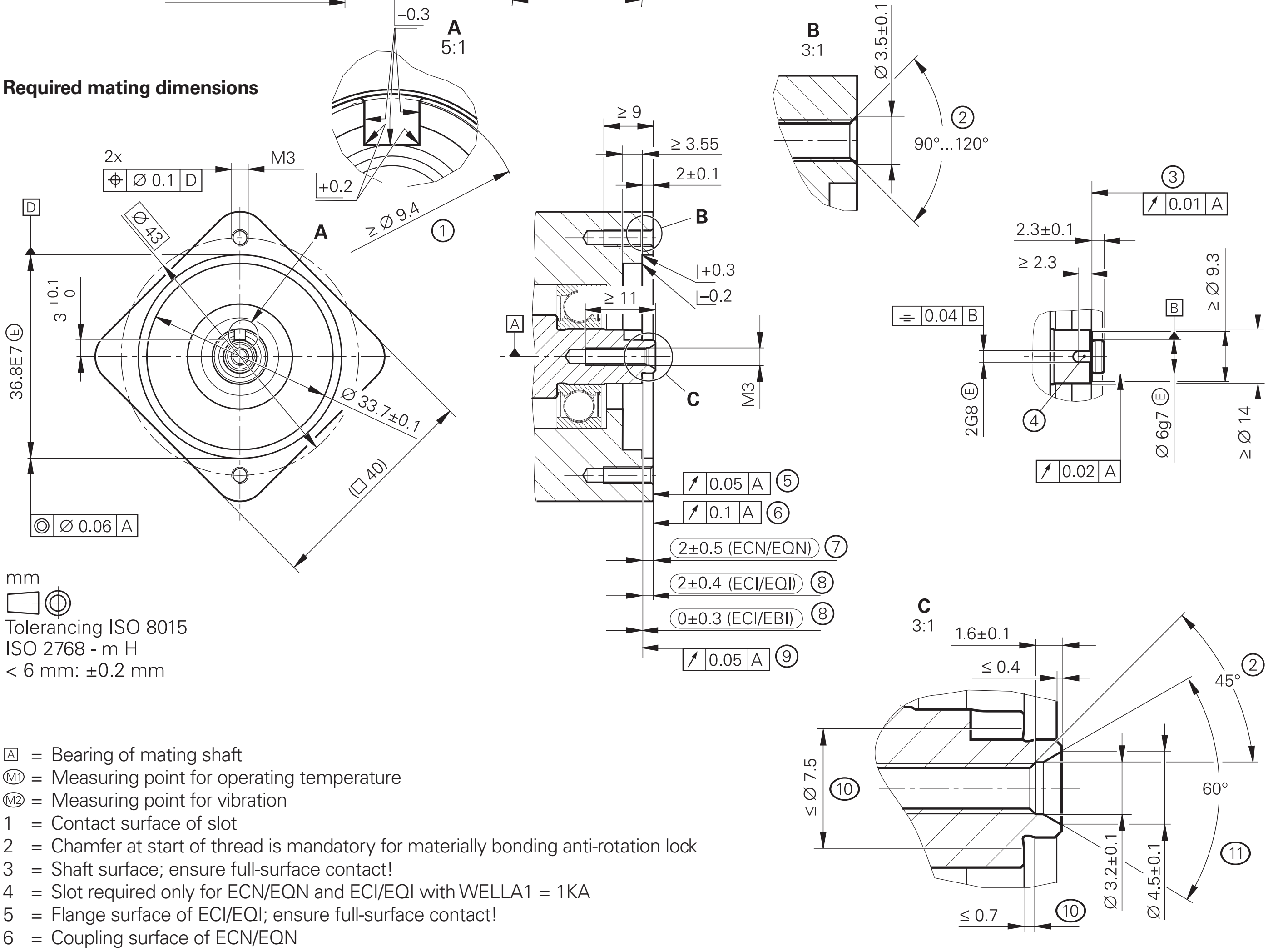
1) For the relationship between the operating temperature and the shaft speed or supply voltage, see the *General mechanical information*

ECI/EQI 1100 series

Absolute rotary encoders
- **Flange for axial mounting**
- **Blind hollow shaft**
- **Without integral bearing**



Required mating dimensions



mm

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

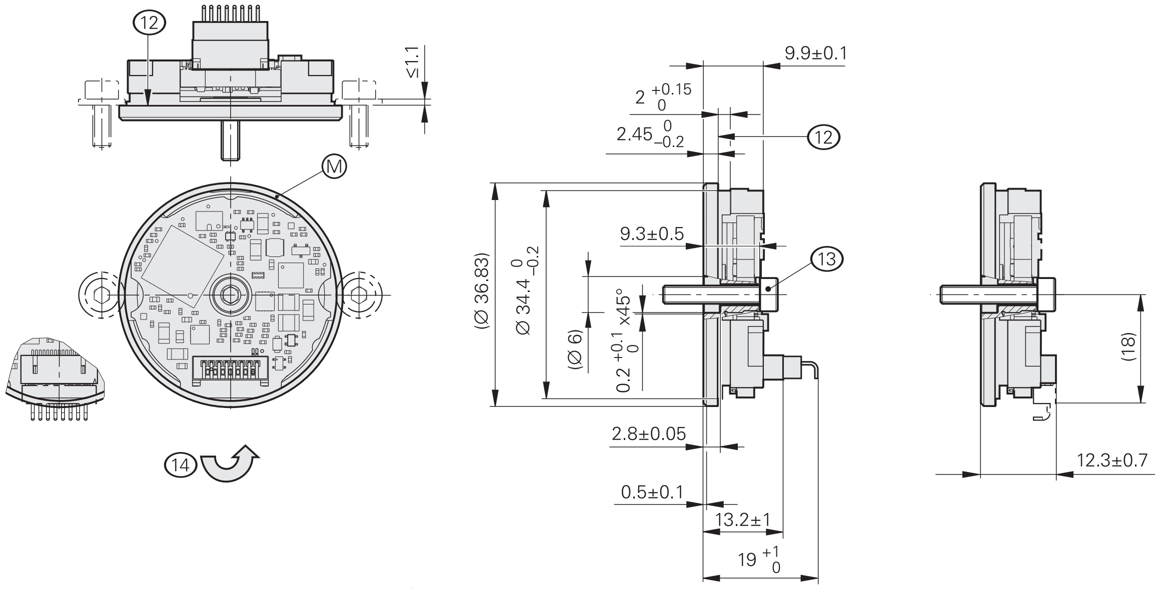
- A = Bearing of mating shaft
- M1 = Measuring point for operating temperature
- M2 = Measuring point for vibration
- 1 = Contact surface of slot
- 2 = Chamfer at start of thread is mandatory for materially bonding anti-rotation lock
- 3 = Shaft surface; ensure full-surface contact!
- 4 = Slot required only for ECN/EQN and ECI/EQI with WELLA1 = 1KA
- 5 = Flange surface of ECI/EQI; ensure full-surface contact!
- 6 = Coupling surface of ECN/EQN
- 7 = Maximum permissible deviation between the shaft surface and coupling surface. Compensation of mounting tolerances and thermal expansion, of which ±0.15 mm of dynamic axial motion is permitted
- 8 = Maximum permissible deviation between the shaft surface and flange surface. Compensation of mounting tolerances and thermal expansion
- 9 = Flange surface of ECI/EBI; ensure full-surface contact!
- 10 = Undercut
- 11 = Possible centering hole
- 12 = Opening for PCB connector at least 1.5 mm circumferentially larger
- 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 = Ensure at least 1 mm of clearance from the cover. Note the opening for the connector!
- 16 = Positive-locking element. Ensure correct engagement in slot 4
- 17 = Direction of shaft rotation for output signals as per the interface description

	Absolute	
	ECI 1119 Functional Safety	EQI 1131 Functional Safety
Interface	EnDat 2.2	
Ordering designation	EnDat22	
Position values per rev.	524288 (19 bits)	
Revolutions	–	4096 (12 bits)
Calculation time t_{cal} Clock frequency	≤ 5 µs ≤ 16 MHz	
System accuracy	±120″	
Electrical connection via PCB connector	15-pin	
Supply voltage	DC 3.6 V to 14 V	
Power consumption (max.)	*3.6 V:* ≤ 0.65 W *14 V:* ≤ 0.7 W	*3.6 V:* ≤ 0.7 W *14 V:* ≤ 0.85 W
Current consumption (typical)	*5 V:* 95 mA (without load)	*5 V:* 115 mA (without load)
Shaft*	Blind hollow shaft for axial clamping ∅ 6 mm, without positive-locking element (82A) or with positive-locking element (1KA)	
Mech. permiss. speed *n*	≤ 15000 rpm	≤ 12000 rpm
Moment of inertia of rotor	$0.3 \cdot 10^{-6}$ kgm^2	
Permissible axial motion of measured shaft	±0.4 mm	
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 400 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)	
Max. operating temp.	110 °C	
Min. operating temp.	–40 °C	
Trigger threshold for exceeded temperature error message	125 °C (measuring accuracy of internal temperature sensor: ±1 K)	
Protection EN 60529	IP00 when mounted[1)]	
Mass	≈ 0.04 kg	
Valid for ID	826930-xx	826980-xx

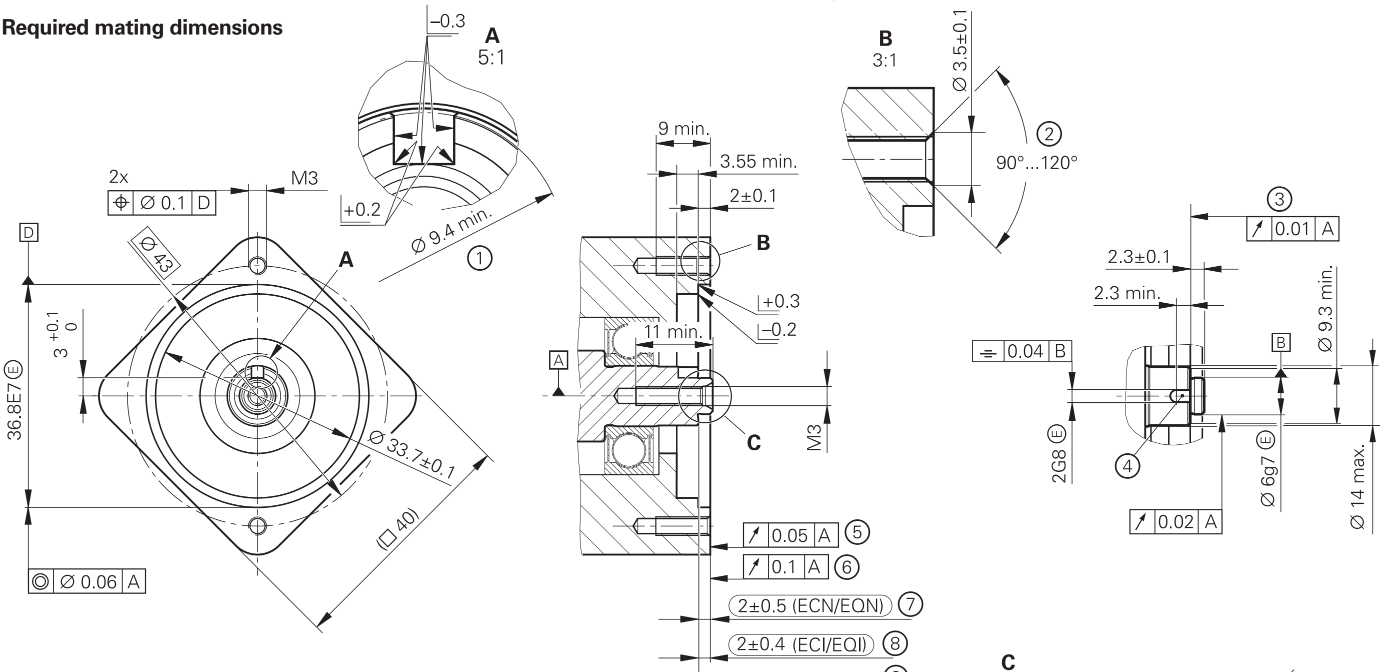
***** Please select when ordering
Functional safety available. For dimensions and specifications, see the product information document.
[1)] See the *Electrical safety* section in the chapter *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure; conformity with the EMC Directive must be ensured in the complete system

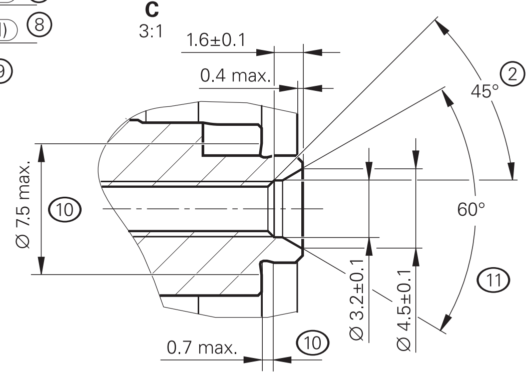
ECI/EBI 1100 series

Absolute rotary encoders
- **Flange for axial mounting**
- **Blind hollow shaft**
- **Without integral bearing**
- **EBI 1135: multiturn functionality via battery-buffered revolution counter**



Required mating dimensions





mm

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

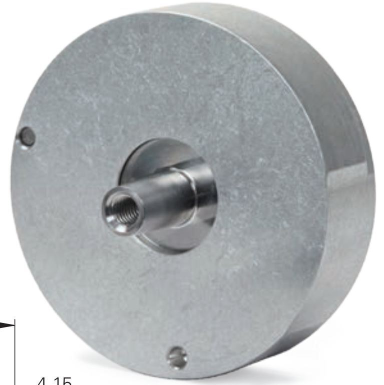
Ⓐ = Bearing of mating shaft
Ⓜ = Measuring point for operating temperature
1 = Contact surface of slot
2 = Chamfer at start of thread is mandatory for materially bonding anti-rotation lock
3 = Shaft surface; ensure full-surface contact!
4 = Slot required only for ECN/EQN and ECI/EQI with WELLA1 = 1KA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

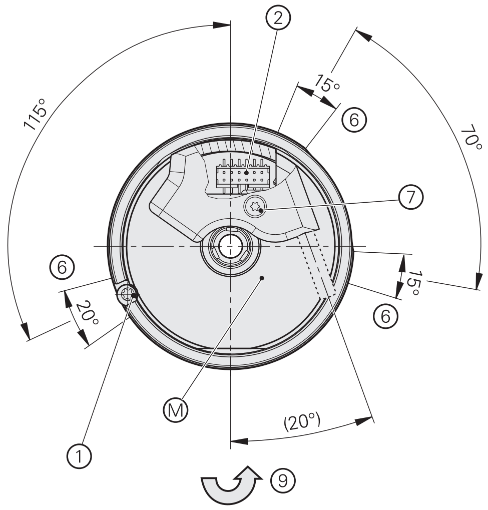
	Absolute	
	ECI 1118	**EBI 1135**
Interface	EnDat 2.2	
Ordering designation	EnDat22[1)]	
Position values per rev.	262 144 (18 bits)	262 144 (18 bits; 19-bit data word length with LSB = 0)
Revolutions	–	65 536 (16 bits)
Calculation time t_{cal} Clock frequency	≤ 6 µs ≤ 8 MHz	
System accuracy	±120"	
Electrical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

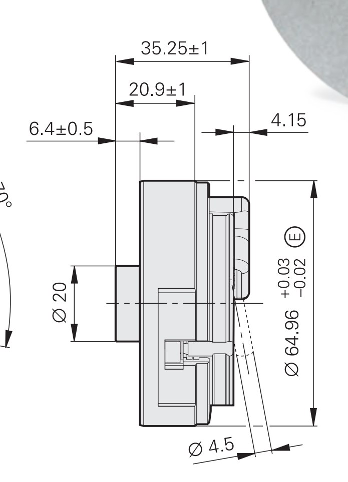
1) External temperature sensor and online diagnostics are not supported. Compliance with the EnDat specification 297403 and the EnDat Application Notes 722024, chapter 13, *Battery-buffered encoders*, is required for correct control of the rotary encoder
2) At T = 25 °C; U_{BAT} = 3.6 V
3) Conformity with the EMC Directive must be ensured in the complete system

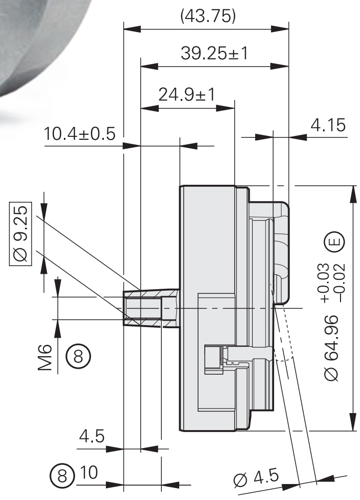
ECI/EQI 1300 series

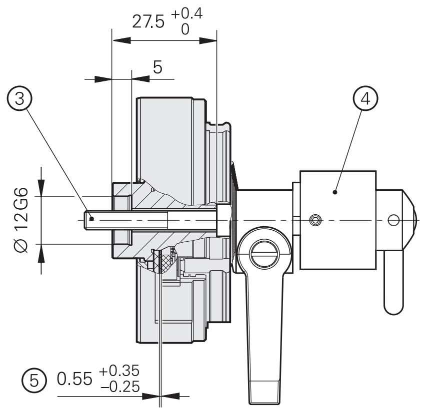
Absolute rotary encoders
- **Flange for axial mounting; adjusting tool required**
- **Tapered shaft or blind hollow shaft**
- **Without integral bearing**

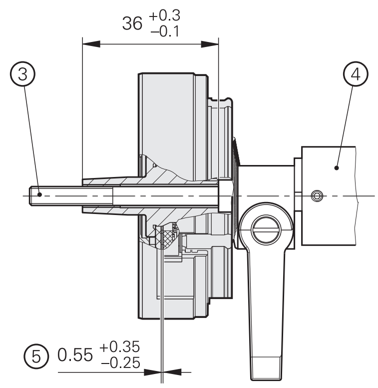






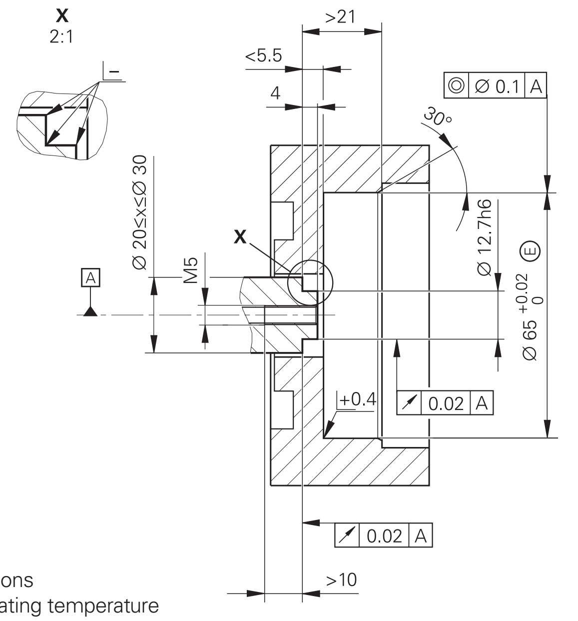


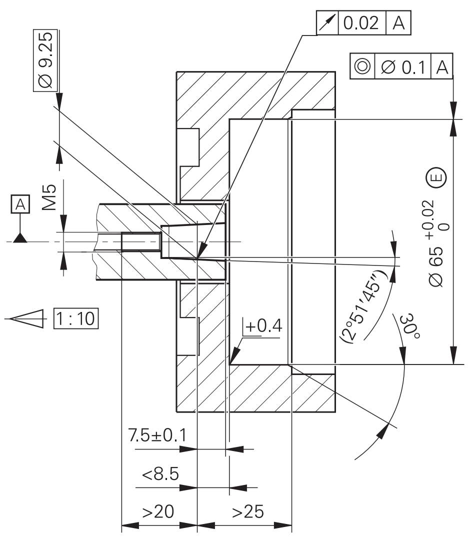




All dimensions under operating conditions

K





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

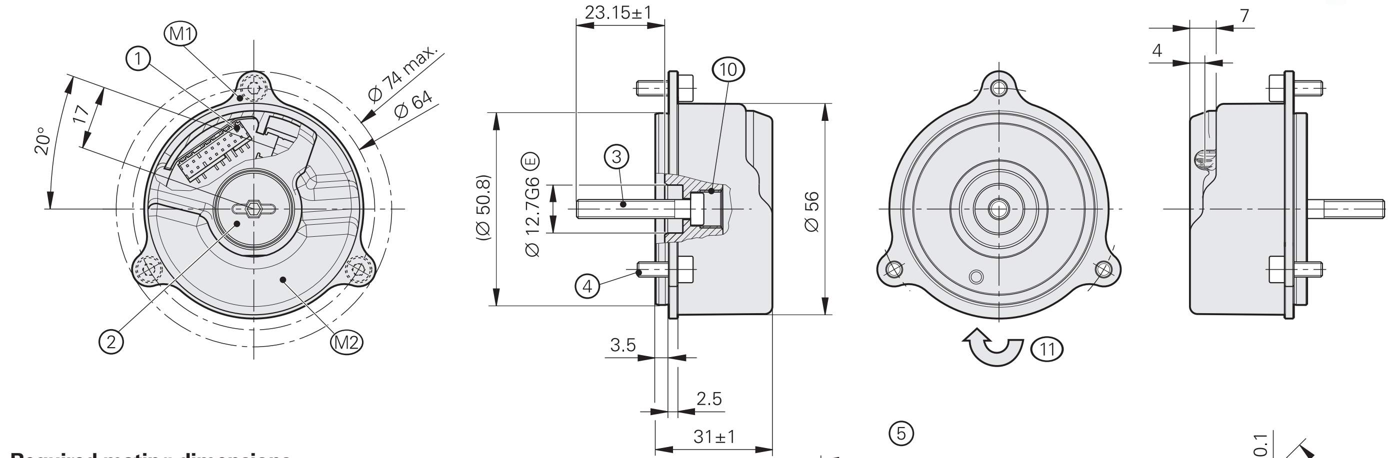
A = Bearing
K = Required mating dimensions
M = Measuring point for operating temperature
1 = Eccentric bolt; for mounting: turn back and tighten with 2 Nm –0.5 Nm torque (Torx 15)
2 = 12-pin PCB connector
3 = Cylinder head screw: ISO 4762 – M5x35 – 8.8; tightening torque: 5 Nm +0.5 Nm for blind hollow shaft
Cylinder head screw: ISO 4762 – M5x50 – 8.8; tightening torque: 5 Nm +0.5 Nm for tapered shaft
4 = Adjusting tool for scanning gap
5 = Permissible scanning gap range under all conditions
6 = Minimum clamping surface and support surface; a closed diameter is best
7 = Fastening screw for cable cover: M2.5 Torx 8; tightening torque: 0.4 Nm ±0.1 Nm
8 = M6 back-off thread
9 = Direction of shaft rotation for output signals as per the interface description

	Absolute	
	ECI 1319	**EQI 1331**
Interface	EnDat 2.2	
Ordering designation	EnDat01	
Position values per rev.	524288 (19 bits)	
Revolutions	–	4096 (12 bits)
Elec. permissible speed/ Deviations[1]	≤ 3750 rpm/±128 LSB ≤ 15000 rpm/±512 LSB	≤ 4000 rpm/±128 LSB ≤ 12000 rpm/±512 LSB
Calculation time t_{cal} Clock frequency	≤ 8 µs ≤ 2 MHz	
Incremental signals	∿ 1 V_{PP}	
Line count	32	
Cutoff frequency –3 dB	≥ 6 kHz (typical)	
System accuracy	±180"	
Electrical connection via PCB connector	12-pin	
Supply voltage	DC 4.75 V to 10 V	
Power consumption (max.)	*4.75 V:* ≤ 0.62 W *10 V:* ≤ 0.63 W	*4.75 V:* ≤ 0.73 W *10 V:* ≤ 0.74 W
Current consumption (typical)	*5 V:* 85 mA (without load)	*5 V:* 102 mA (without load)
Shaft*	Tapered shaft Ø 9.25 mm; taper 1:10 Blind hollow shaft Ø 12.0 mm; length: 5 mm	
Moment of inertia of rotor	*Tapered shaft:* $2.1 \cdot 10^{-6}$ kgm^2 *Hollow shaft:* $2.8 \cdot 10^{-6}$ kgm^2	
Mech. permiss. speed *n*	≤ 15000 rpm	≤ 12000 rpm
Permiss. axial motion of measured shaft	–0.2/+0.4 mm with 0.5 mm scanning gap	
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)	
Max. operating temp.	115 °C	
Min. operating temp.	–20 °C	
Protection EN 60529	IP20 when mounted	
Mass	≈ 0.13 kg	
Valid for ID	811811-xx	811814-xx

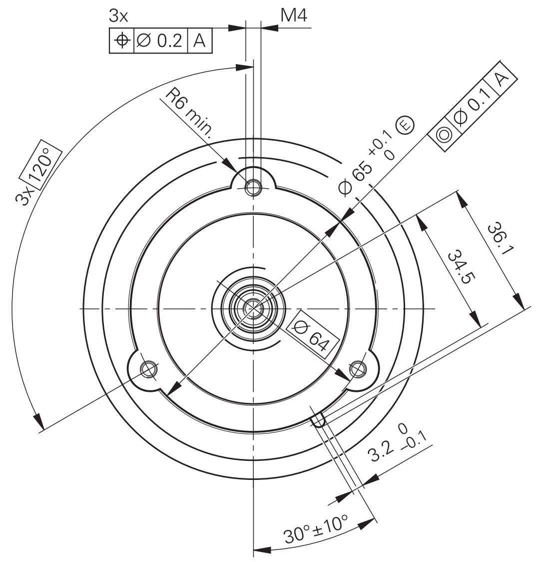
***** Please select when ordering
[1] Speed-dependent deviations between the absolute and incremental signals

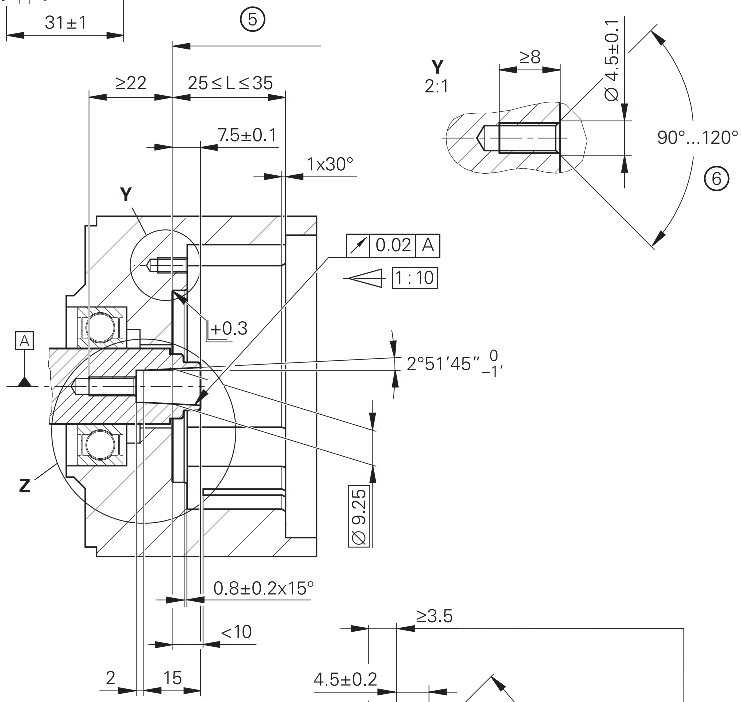
ECI/EQI 1300 series

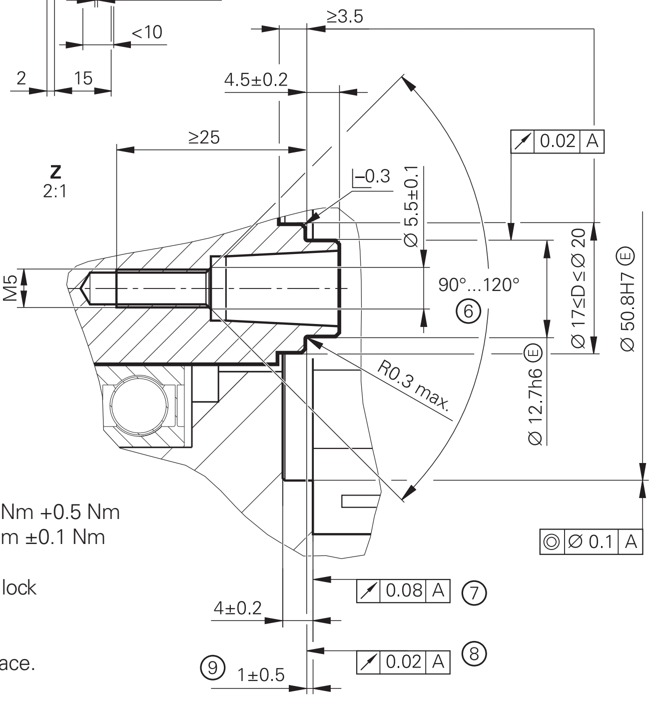
Absolute rotary encoders
- **Mounting-compatible with photoelectric rotary encoders with 07B stator coupling**
- **0YA flange for axial mounting**
- **44C blind hollow shaft Ø 12.7 mm**
- **Without integral bearing**
- **Cost-optimized mating dimensions upon request**



Required mating dimensions







D1	D2
Ø 12.7G6 Ⓔ	Ø 12.7h6 Ⓔ

mm

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

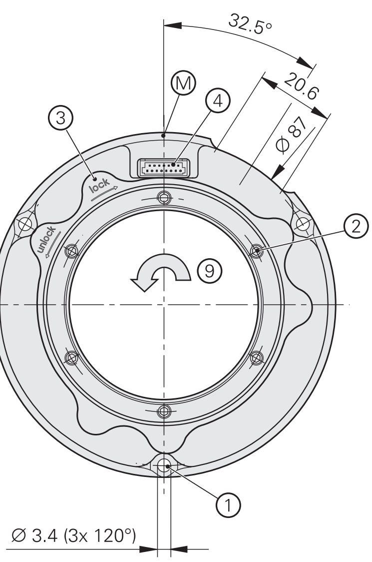
A = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration, see also D 741714
1 = 16-pin PCB connector
2 = Screw plug: width A/F 3 and 4; tightening torque: 5 Nm +0.5 Nm
3 = Screw: DIN 6912 – M5x30 – 08.8 – MKL; width A/F 4, tightening torque: 5 Nm +0.5 Nm
4 = Screw: ISO 4762 – M4x10 – 8.8 – MKL; width A/F 3; tightening torque: 2 Nm ±0.1 Nm
5 = Functional diameter of taper for ECN/EQN 13xx
6 = Chamfer at start of thread is mandatory for materially bonding anti-rotation lock
7 = ExI/resolver flange surface; ensure full-surface contact!
8 = Shaft surface; ensure full-surface contact!
9 = 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 output signals as per the interface description

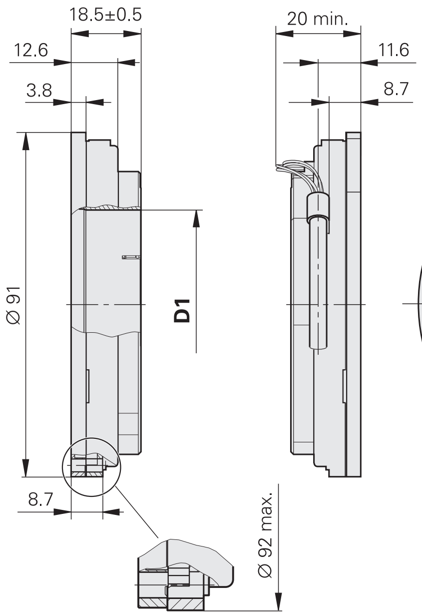
	Absolute	
	ECI 1319 Functional Safety	EQI 1331 Functional Safety
Interface	EnDat 2.2	
Ordering designation	EnDat22	
Position values per rev.	524 288 (19 bits)	
Revolutions	–	4096 (12 bits)
Elec. permissible speed/ Deviations	≤ 15 000 rpm (for continuous position value)	
Calculation time t_{cal} Clock frequency	≤ 5 µs ≤ 16 MHz	
System accuracy	±65″	
Electrical connection via PCB connector	16-pin with connection for temperature sensor[1)]	
Cable length	≤ 100 m	
Supply voltage	DC 3.6 V to 14 V	
Power consumption (max.)	*At 3.6 V:* ≤ 0.65 W *At 14 V:* ≤ 0.7 W	*At 3.6 V:* ≤ 0.75 W *At 14 V:* ≤ 0.85 W
Current consumption (typical)	*At 5 V:* 95 mA (without load)	*At 5 V:* 115 mA (without load)
Shaft	Blind hollow shaft for axial clamping ∅ 12.7 mm	
Mech. permiss. speed *n*	≤ 15 000 rpm	≤ 12 000 rpm
Moment of inertia of rotor	$2.6 \cdot 10^{-6}$ kgm²	
Permiss. axial motion of measured shaft	±0.5 mm	
Vibration 55 Hz to 2000 Hz[2)] **Shock** 6 ms	*Stator:* ≤ 400 m/s²; *rotor:* ≤ 600 m/s² (EN 60068-2-6) ≤ 2000 m/s² (EN 60068-2-27)	
Max. operating temp.	115 °C	
Min. operating temp.	–40 °C	
Trigger threshold for exceeded temperature error message	130 °C (measuring accuracy of internal temperature sensor: ±1 K)	
Protection EN 60529	IP20 when mounted	
Mass	≈ 0.13 kg	
Valid for ID	810661-xx	810662-xx

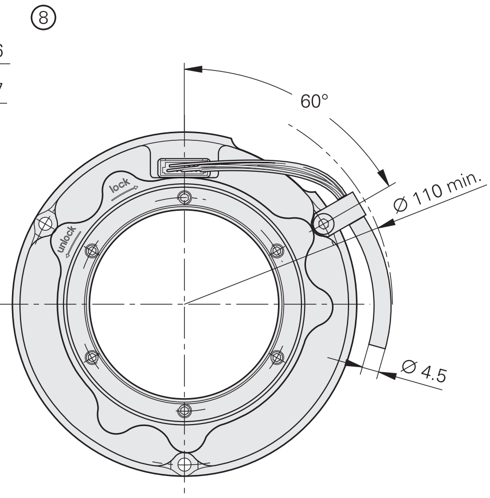
1) Evaluation optimized for KTY 84-130
2) 10 Hz to 55 Hz constant over 4.9 mm peak to peak
Functional safety available. For dimensions and specifications, see the product information document.

ECI/EBI 100 series

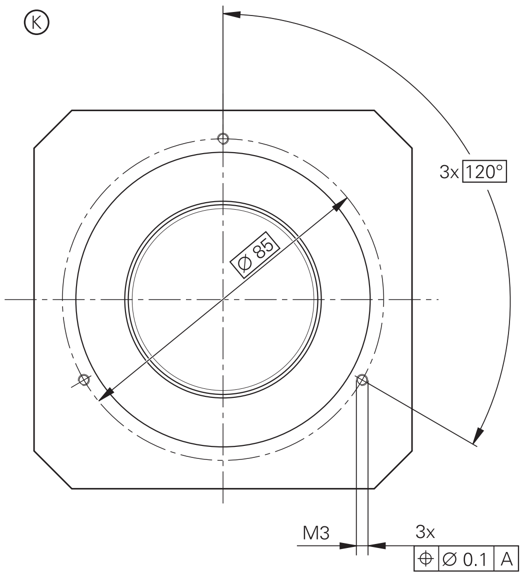
Absolute rotary encoders
- **Flange for axial mounting**
- **Hollow through shaft**
- **Without integral bearing**
- ***EBI 135:* multiturn functionality via battery-buffered revolution counter**

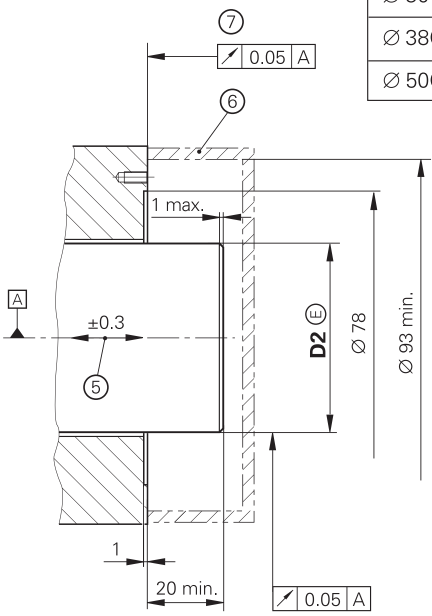






D1	D2
Ø 30G6	Ø 30h7
Ø 38G6	Ø 38h7
Ø 50G6	Ø 50h7





mm

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

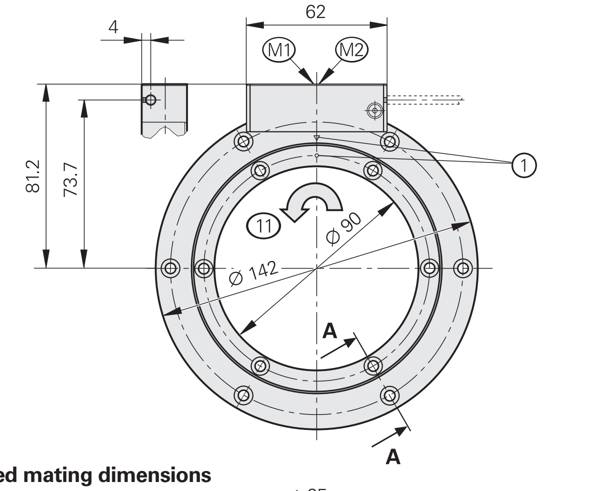
Ⓐ = Bearing of mating shaft
Ⓚ = Required mating dimensions
Ⓜ = Measuring point for operating temperature
1 = Cylinder head screw: ISO 4762-M3, with three ISO 7092 washers; tightening torque: 0.9 Nm ±0.05 Nm
2 = Width A/F 2.0 (6x); tighten evenly crosswise with increasing tightening torque; final tightening torque: 0.5 Nm ±0.05 Nm
3 = Shaft detent: for manner of functioning, see Mounting Instructions
4 = 15-pin PCB connector
5 = Compensation of mounting tolerances and thermal expansion; no dynamic motion
6 = Protection against contact as per EN 60529
7 = Required up to max. Ø 92 mm
8 = Required mounting frame for output cable with cable clamp (accessory). Bending radius of connecting wires: at least R3
9 = Direction of shaft rotation for output signals as per the interface description

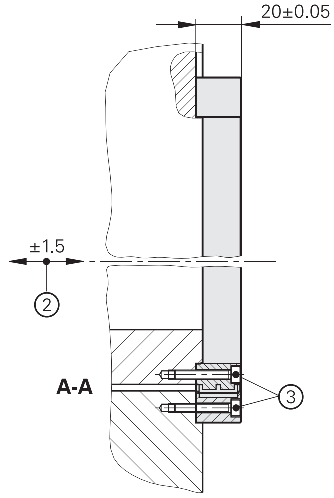
	Absolute		
	ECI 119		**EBI 135**
Interface*	EnDat 2.1	EnDat 2.2	EnDat 2.2
Ordering designation	EnDat01	EnDat22[1]	EnDat22[1]
Position values per rev.	524 288 (19 bits)		
Revolutions	–		65 536 (16 bits)[2]
Elec. permissible speed/ Deviations[3]	≤ 3000 rpm/±128 LSB ≤ 6000 rpm/±256 LSB	≤ 6000 rpm (for continuous position value)	
Calculation time t_{cal} Clock frequency	≤ 8 µs ≤ 2 MHz	≤ 6 µs ≤ 16 MHz	
Incremental signals	∼ 1 V_{PP}	–	–
Line count	32	–	–
Cutoff frequency –3 dB	≥ 6 kHz (typical)	–	–
System accuracy	±90"		
Electrical connection via PCB connector	15-pin	15-pin with connection for temperature sensor[5]	
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:* ≤ 0.58 W *14 V:* ≤ 0.7 W	*Normal operation at 3.6 V:* 0.53 W *Normal operation at 14 V:* 0.63 W	
Current consumption (typical)	*5 V:* 80 mA (without load)	*5 V:* 75 mA (without load)	*Normal operation at 5 V:* 75 mA (without load) *Buffer operation*[4]: 25 µA (with rotating shaft) 12 µA (at standstill)
Shaft*	Hollow through shaft: D = 30 mm, 38 mm, 50 mm		
Mech. permiss. speed *n*	≤ 6000 rpm		
Moment of inertia of rotor	*D = 30 mm:* $64 \cdot 10^{-6}$ kgm^2 *D = 38 mm:* $58 \cdot 10^{-6}$ kgm^2 *D = 50 mm:* $64 \cdot 10^{-6}$ kgm^2		
Permissible axial motion of measured shaft	±0.3 mm		
Vibration 55 Hz to 2000 Hz[6] **Shock** 6 ms	≤ 300 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)		
Max. operating temp.	115 °C		
Min. operating temp.	–30 °C		
Protection EN 60529	IP20 when mounted[7]		
Mass	*D = 30 mm:* ≈ 0.19 kg *D = 38 mm:* ≈ 0.16 kg *D = 50 mm:* ≈ 0.14 kg		
Valid for ID	823406-xx	823407-xx	823405-xx

* Please select when ordering
1) Valuation numbers are not supported
2) Compliance with the 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 the absolute and incremental signals
4) At T = 25 °C; U_{BAT} = 3.6 V
5) Evaluation optimized for KTY 84-130
6) 10 to 55 Hz constant over 4.9 mm peak to peak
7) Conformity with the EMC Directive must be ensured in the complete system

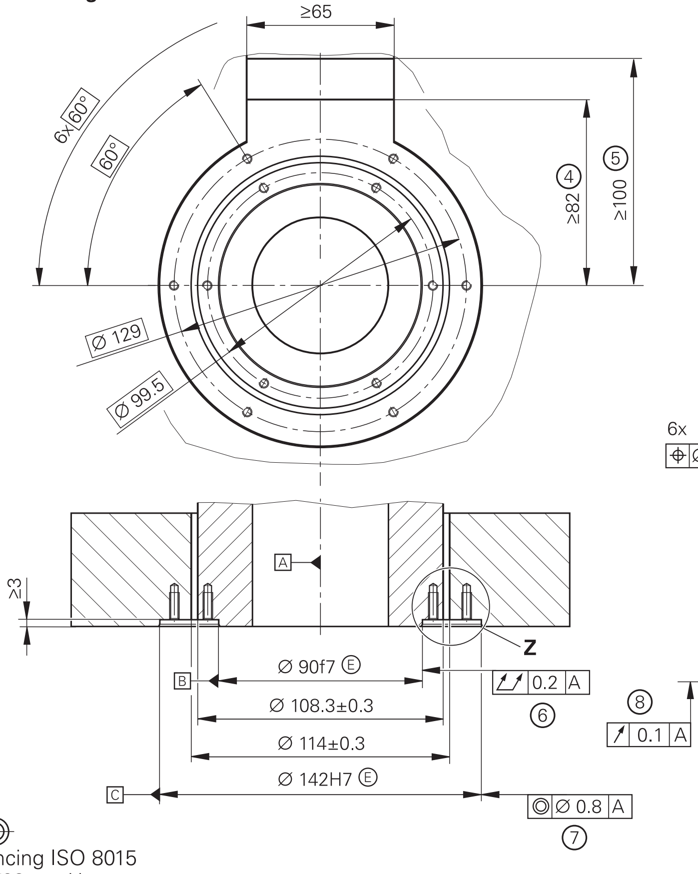
ECI 4010, EBI 4010, ECI 4090 S

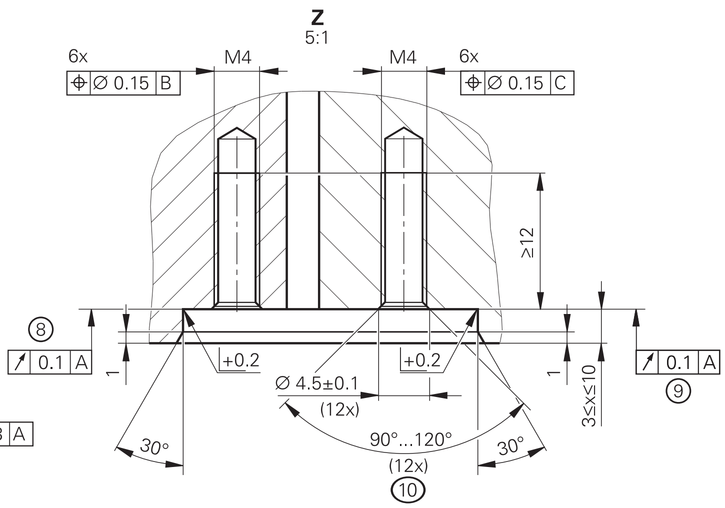
Rotary encoders for absolute position values
- **Rugged inductive scanning principle**
- **Hollow through shaft Ø 90 mm**
- ***EBI 4010:* multiturn functionality via battery-buffered revolution counter**
- **Made up of scanning unit and scale drum**





Required mating dimensions





mm

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

A = Bearing of mating shaft
M1 = Measuring point for operating temperature on housing
M2 = Measuring point for vibration on housing
1 = Datum position ±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 is mandatory at start of thread for materially bonding anti-rotation lock
11 = Direction of shaft rotation for output signals as per the interface description

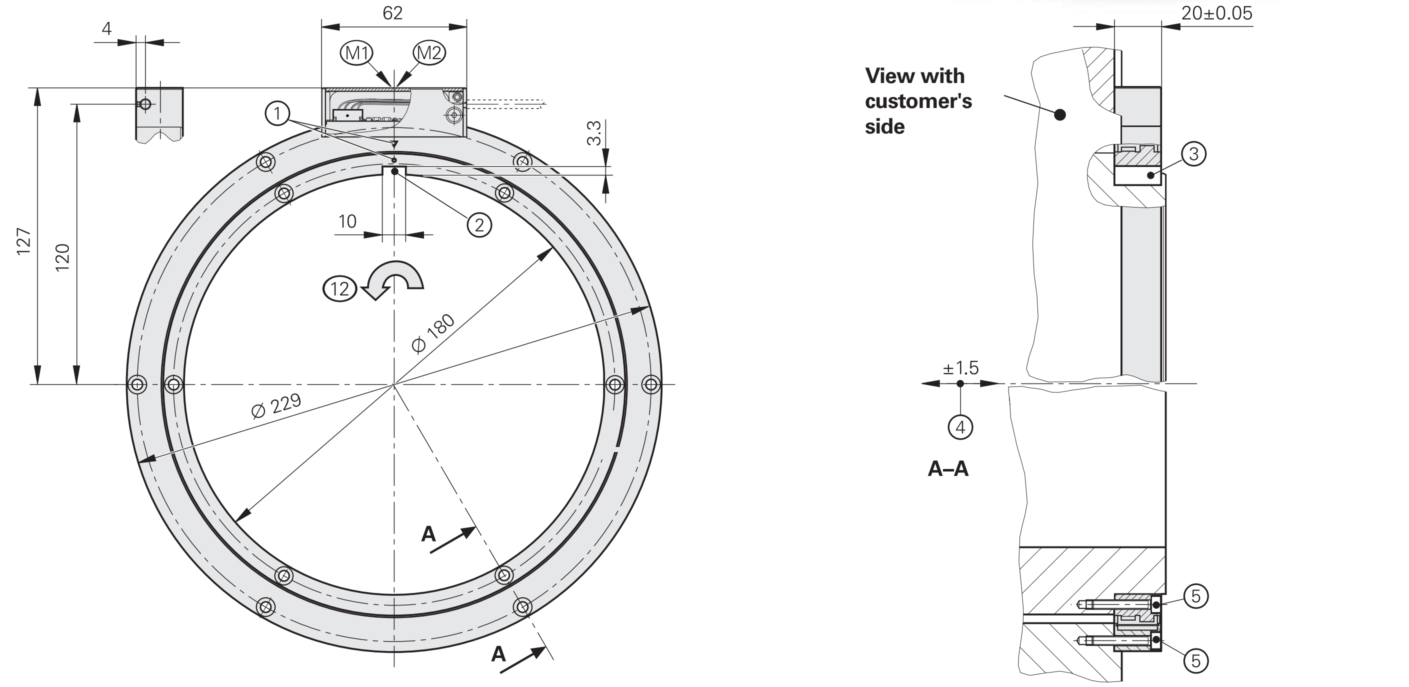
Specifications	**ECI 4010 – singleturn** Functional Safety	**EBI 4010 – multiturn** Functional Safety	**ECI 4090 S – singleturn** Functional Safety
Interface/ ordering designation	EnDat 2.2 / EnDat22		DRIVE-CLiQ / DQ01
Position values per rev.	1048576 (20 bits)		
Revolutions	–	65536 (16 bits)	–
Calculation time t_{cal}/ clock frequency	≤ 5 µs/≤ 16 MHz		≤ 11 µs[1]
System accuracy	±25″		
Electrical connection via PCB connector	15-pin with connection for temperature sensor[2]		
Cable length	≤ 100 m (see EnDat description in the *Interfaces of HEIDENHAIN Encoders* brochure)		≤ 40 m[3] (see description in the *Interfaces of HEIDENHAIN Encoders* brochure)
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 to 5.25 V	DC 24 V (10 V to 28.8 V); up to 36 V possible without limiting the functional safety
Power consumption[4] (maximum)	*At 3.6 V:* ≤ 630 mW; *at 14 V:* ≤ 700 mW		*At 10 V:* ≤ 1100 mW; *At 28.8 V:* ≤ 1250 mW
Current consumption (typical)	*At 5 V:* 95 mA (without load)	*Normal operation at 5 V:* 95 mA (without load) *Buffer mode*[5]*:* 220 µA (rotating shaft) 25 µA (at standstill)	*At 24 V:* 40 mA (without load)
Shaft	Hollow through shaft ∅ 90 mm		
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[6] **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 internal temperature sensor: ±1 K)		120 °C (measuring accuracy of internal temperature sensor: ±1 K)
Protection EN 60529	*Complete encoder when mounted:* IP20[7]; *scanning unit:* IP40 (see *Insulation* under *Electrical safety* in the *Interfaces of HEIDENHAIN Encoders* brochure)		
Mass	*AE scanning unit:* ≈ 0.27 kg; *TTR scale drum:* ≈ 0.17 kg		
Consisting of	*AE ECI 4010 scanning unit:* ID 1130167-xx	*AE EBI4010 scanning unit:* ID 1130173-xx	*AE ECI4090S:* ID 1130171-02
	TTR EXI4000 scale drum: ID 1130175-xx		

1) Computing time TIME_MAX_ACTVAL
2) See *Temperature measurement in motors*
3) With output cable length (inside the 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) *AE:* 10 Hz to 55 Hz constant over 6.5 mm peak to peak; *TTR:* 10 Hz to 55 Hz constant over 10 mm peak to peak
7) The encoder must be protected from abrasive and harmful media in the application. Use an appropriate enclosure as needed.

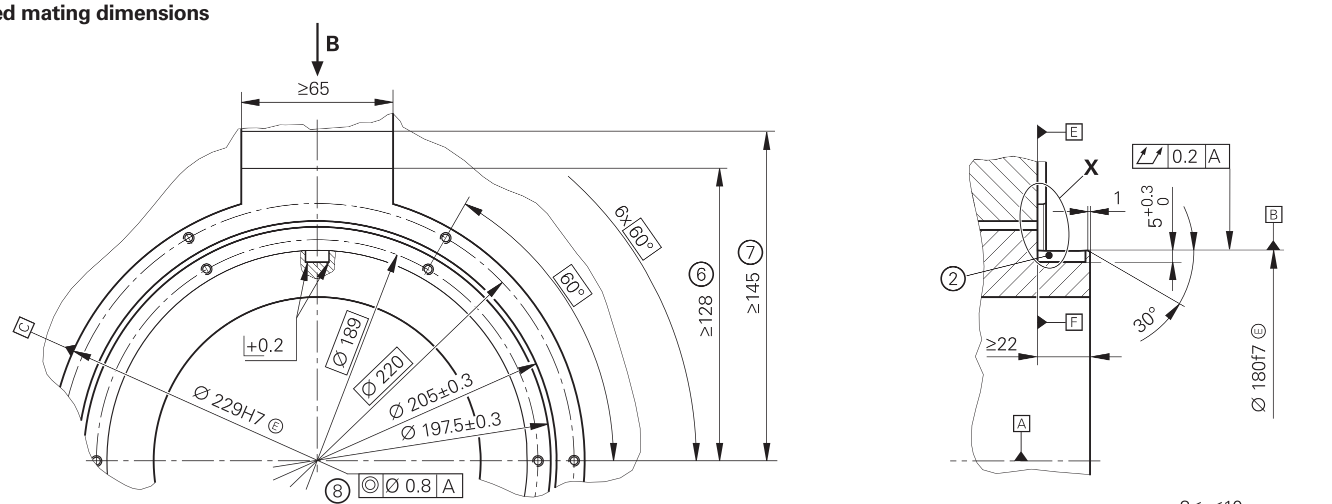
Functional safety available. For dimensions and specifications, see the product information document.

ECI 4010, EBI 4010, ECI 4090 S

Rotary encoders for absolute position values
- **Rugged inductive scanning principle**
- **Hollow through shaft Ø 180 mm**
- ***EBI 4010:* multiturn functionality via battery-buffered revolution counter**
- **Made up of scanning unit and scale drum**

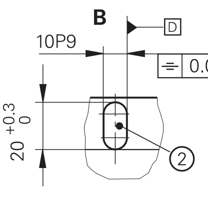


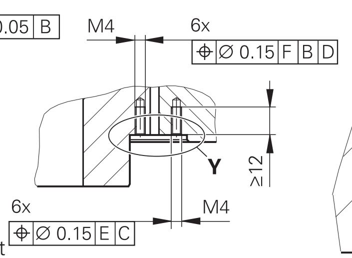
Required mating dimensions

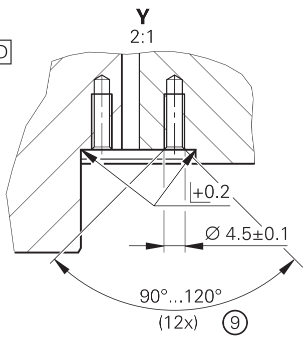


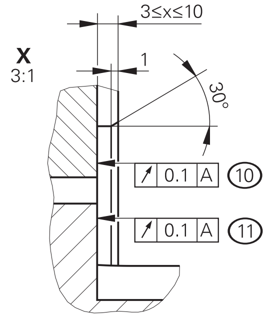
mm

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









A = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration on scanning unit
1 = Mark for 0° position ±5°
2 = Slot for machine key: DIN 6885–A–10x8x20
3 = Machine key: DIN 6885–A–10x8x20
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–M4x25–8.8; tightening torque 2.2 Nm ±0.13 Nm; a suitable anti-rotation lock is to be used for the screw connection (e.g., screw with material bonding anti-rotation lock: ISO 4762–M4x25–8.8 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 materially bonding anti-rotation lock
10 = Bearing surface of stator
11 = Bearing surface of rotor
12 = Direction of shaft rotation for output signals as per the interface description

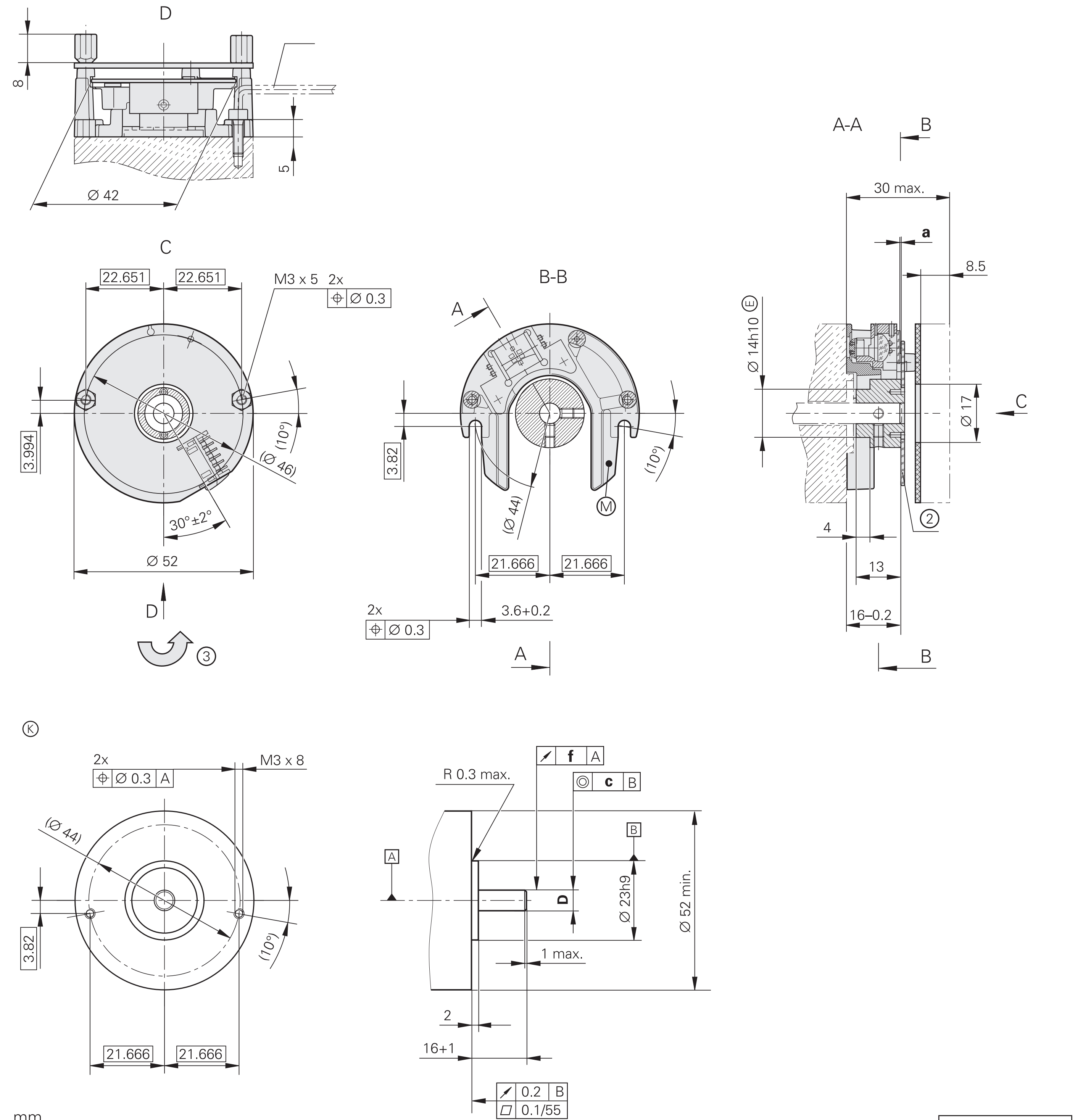
Specifications	ECI 4010 – singleturn	EBI 4010 – multiturn	ECI 4090 S – singleturn
Interface/ ordering designation	EnDat 2.2/EnDat22		DRIVE-CLiQ / DQ01
Position values per rev.	1048576 (20 bits)		
Revolutions	–	65536 (16 bits)	–
Calculation time t_{cal}/clock frequency	≤ 5 µs/≤ 16 MHz		≤ 11 µs[1]
System accuracy	±40″		
Electrical connection via PCB connector	15-pin with connection for temperature sensor[2]		
Cable length	≤ 100 m (see EnDat description in the *Interfaces of HEIDENHAIN Encoders* brochure)		≤ 40 m[3] (see description in the *Interfaces of HEIDENHAIN Encoders* brochure)
Supply voltage	DC 3.6 V to 14 V	*Encoder* U_P*:* DC 3.6 V to 14 V *Backup battery* U_{BAT}*:* DC 3.6 to 5.25 V	DC 24 V (10 V to 28.8 V); up to 36 V possible without limiting the functional safety
Power consumption[4] (maximum)	*At 3.6 V:* ≤ 630 mW; *at 14 V:* ≤ 700 mW		*At 10 V:* ≤ 1100 mW; *At 28.8 V:* ≤ 1250 mW
Current consumption (typical)	*At 5 V:* 95 mA (without load)	*Normal operation at 5 V:* 95 mA (without load) *Buffer mode*[5]*:* 220 µA (rotating shaft) 25 µA (at standstill)	*At 24 V:* 40 mA (without load)
Shaft	Hollow through shaft ∅ 180 mm (with keyway)		
Speed	≤ 6000 rpm		
Moment of inertia of rotor	$3.1 \cdot 10^{-3}$ kgm^2 (without screws, without machine 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[6] **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 internal temperature sensor: ±1 K)		120 °C (measuring accuracy of internal temperature sensor: ±1 K)
Protection EN 60529	*Complete encoder when mounted:* IP20[7]; *scanning unit:* IP40 (see *Insulation* under *Electrical safety* in the *Interfaces of HEIDENHAIN Encoders* brochure)		
Mass	*AE scanning unit:* ≈ 0.39 kg; *TTR scale drum:* ≈ 0.33 kg		
Consisting of	*AE ECI 4010 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) Computing time TIME_MAX_ACTVAL
2) See *Temperature measurement in motors*
3) With output cable length (inside the 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) *AE:* Hz to 55 Hz constant over 6.5 mm peak to peak; *TTR:* 10 Hz to 55 Hz constant over 10 mm peak to peak
7) The encoder must be protected from abrasive and harmful media in the application. Use an appropriate enclosure as needed.

Functional safety available. For dimensions and specifications, see the product information document.

ERO 1200 series

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



mm

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

D
Ø 10h6 Ⓔ
Ø 12h6 Ⓔ

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

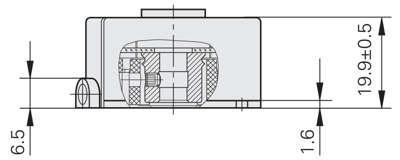
Ⓐ = Bearing
Ⓚ = Required mating dimensions
Ⓜ = Measuring point for operating temperature
1 = Disk/hub assembly
2 = Offset screwdriver: ISO 2936 – 2.5 (l_2 shortened)
3 = Direction of shaft rotation for output signals as per the interface description

	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 via PCB connector	12-pin	
Supply voltage	DC 5 V ±0.5 V	
Current consumption (without load)	≤ 150 mA	
Shaft*	Hollow through shaft D = 10 mm or D = 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. speed *n*	≤ 25000 rpm	
Permiss. 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)	
Max. operating temp.	100 °C	
Min. operating temperature	–40 °C	
Protection EN 60529	IP00[3)]	
Mass	≈ 0.07 kg	
Valid for ID	1037519-xx	1037520-xx

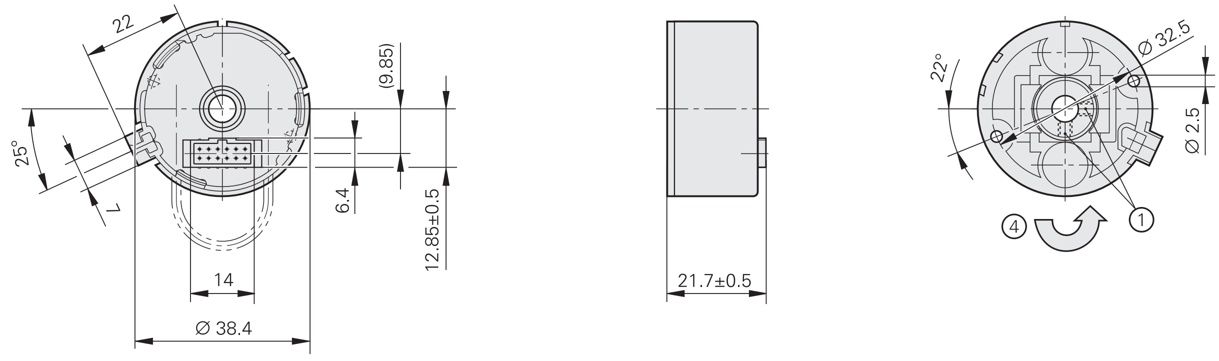
* Please select when ordering
1) When not mounted. Additional deviations due to mounting and bearing of the drive shaft must be taken into account
2) For other errors, see *Measuring accuracy*
3) Compliance with the EMC Directive must be ensured in the complete system via appropriate measures taken for mounting

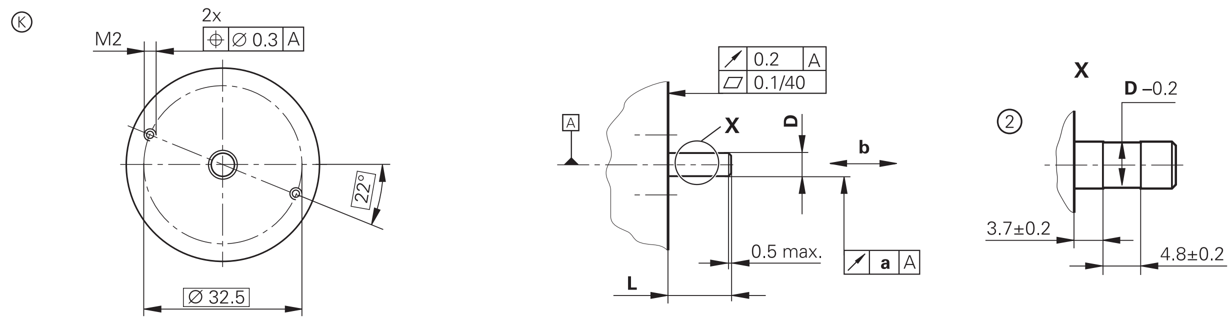
ERO 1400 series

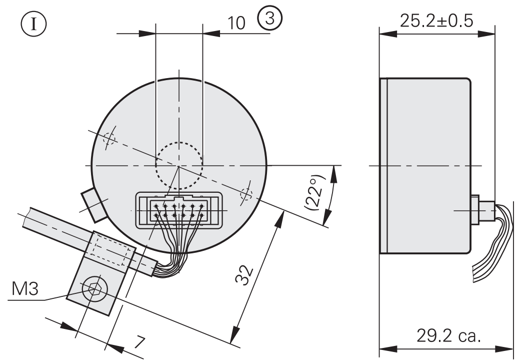
Incremental rotary encoders
- **Flange for axial mounting**
- **Hollow through shaft**
- **Without integral bearing; self-centering**



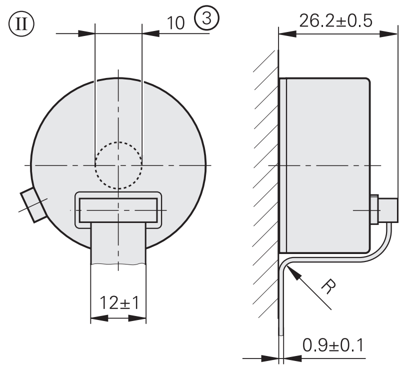
With axial PCB connector







Axial PCB connector and round cable



Axial PCB connector and ribbon cable

mm

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

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 Ⓔ

Ⓐ = Bearing of mating shaft
Ⓚ = Required mating dimensions
Ⓘ = Accessory: Round cable
Ⓘⓘ = Accessory: Ribbon cable
1 = 2x M3 setscrews offset by 90°; width A/F 1.5; Md = 0.25 Nm ±0.05 Nm
2 = Version for repeated mounting
3 = Version featuring housing with central hole (accessory)
4 = Direction of shaft rotation for output signals as per the 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 rev.	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* via PCB connector	12-pin, axial[3)]					
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** D= 4 mm; **D = 6 mm** or D= 8 mm, or hollow through shaft in housing with bore (accessory)					
Moment of inertia of rotor	*Shaft Ø 4 mm:* 0.28 · 10^{-6} kgm^2 *Shaft Ø 6 mm:* 0.27 · 10^{-6} kgm^2 *Shaft Ø 8 mm:* 0.25 · 10^{-6} kgm^2					
Mech. permiss. speed *n*	≤ 30000 rpm					
Permiss. 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)					
Max. operating temp.	70 °C					
Min. operating temp.	–10 °C					
Protection EN 60529	*With PCB connector:* IP00[2)] *With cable outlet:* IP40					
Mass	≈ 0.07 kg					
Valid for ID	360731-xx	360736-xx				360737-xx

Boldface: 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 drive shaft must be taken into account
2) Conformity with the EMC Directive must be ensured in the complete system
3) Cable 1 m, radial, free cable end (not with ERO 1470) upon request

Interfaces

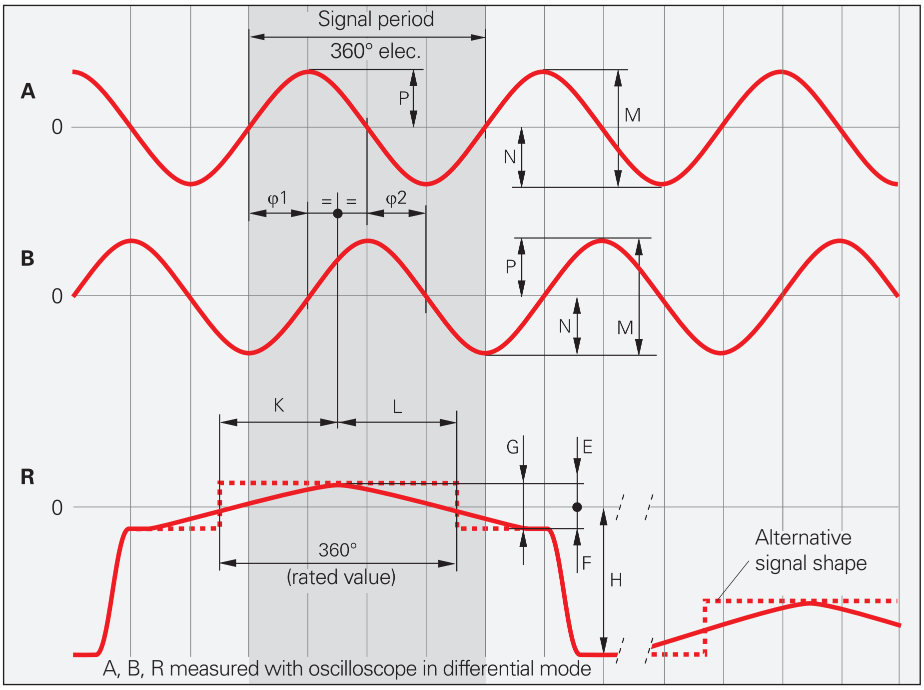
1 V_{PP} incremental signals

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

The sinusoidal **incremental signals** A and B are phase-shifted by 90° elec. and have a typical signal 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 an unambiguous assignment to the incremental signals. The output signal may be somewhat lower next to the reference mark.

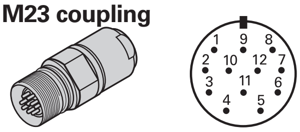
Further information:

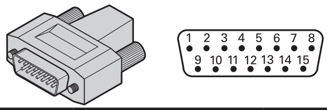
Detailed descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

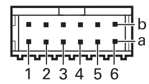


Pin layout

12-pin M23 coupling | **15-pin D-sub connector,** for PWM 21 | **12-pin PCB connector** 12



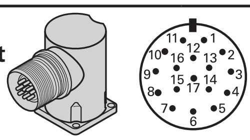


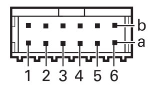


	Power supply				Incremental signals						Other signals		
	12	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**9**	**7**	**/**
	4	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**5/6/8/15**	**13**	**/**
12	**2a**	**2b**	**1a**	**1b**	**6b**	**6a**	**5b**	**5a**	**4b**	**4a**	**3b**	**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** 12





	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)]	/

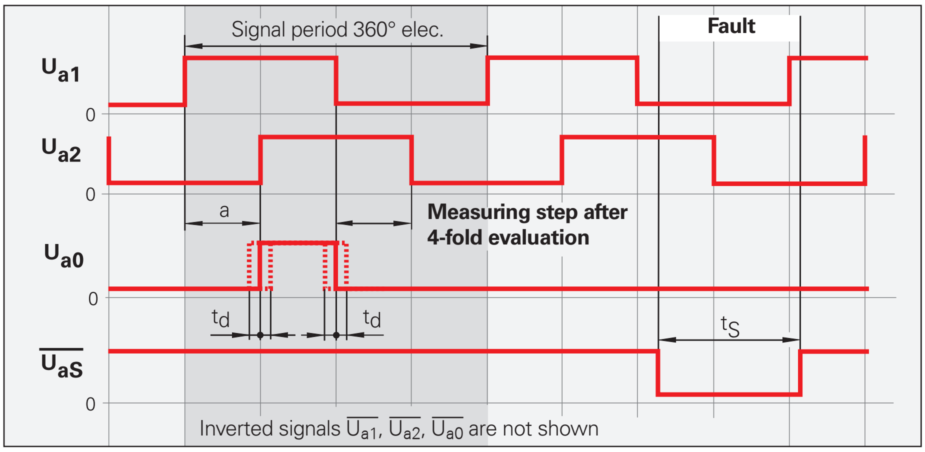
Cable shield connected with housing; **U_P** = Power supply;[1)] **LIDA 2xx:** vacant;[2)] Only for output cable inside the motor housing
Sensor: the sense line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!

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

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



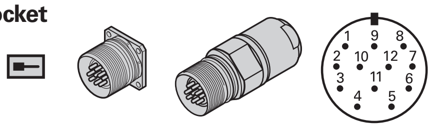
The distance between two successive edges of the incremental signals U_{a1} and U_{a2} through 1-fold, 2-fold, or 4-fold evaluation is one **measuring step.**

Further information:

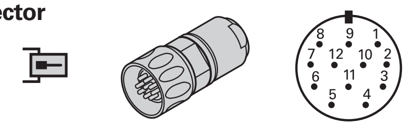
Detailed descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

Pin layout

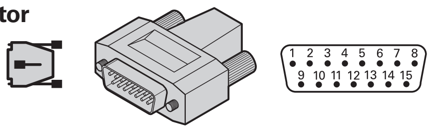
12-pin M23 flange socket or coupling



12-pin M23 connector



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



12-pin PCB connector

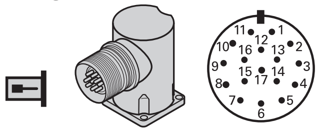
	Power supply				Incremental signals						Other signals		
M23 flange socket / M23 connector	**12**	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**7**	**/**	**9**
D-sub	**4**	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**13**	**5/6/8**	**15**
PCB 12	**2a**	**2b**[1]	**1a**	**1b**[1]	**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]
Cable	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:** TTL/11 µApp switchover for PWT, otherwise vacant

Pin layout

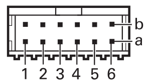
Output cable for ERN 1321 inside the motor
ID 667343-01

17-pin M23 flange socket



12-pin PCB connector

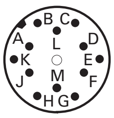
12



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

ERN 421 pin layout

12-pin M16 flange socket (female)



	Power supply				Incremental signals						Other signals	
(M16)	**M**	**B**	**K**	**L**	**E**	**F**	**H**	**A**	**C**	**D**	**G**	**J**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**U_{a1}**	**$\overline{U_{a1}}$**	**U_{a2}**	**$\overline{U_{a2}}$**	**U_{a0}**	**$\overline{U_{a0}}$**	**$\overline{U_{aS}}$**	**Vacant**
(cable)	Brown/Green	Blue	White/Green	White	Brown	Green	Gray	Pink	Red	Black	Violet	Yellow

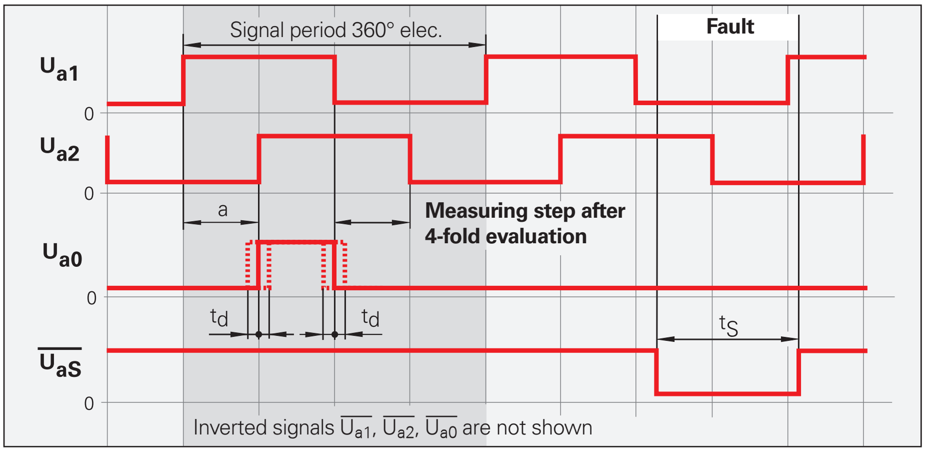
Cable shield connected to housing; **U_P** = Power supply voltage
Sensor: The sense line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!
[1] Only for output cables inside the motor housing

⊓⊔ HTL, HTLs incremental signals

HEIDENHAIN encoders with the ⊓⊔ HTL 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} with a 90° elec. phase shift. The **reference mark signal** consists of one or more reference pulses U_{a0}, which are gated with the incremental signals. In addition, the integrated electronics produce their **inverted signals** $\overline{U_{a1}}$, $\overline{U_{a2}}$, and $\overline{U_{a0}}$ for noise-proof transmission (not with HTLs). The illustrated sequence of output signals—with U_{a2} lagging U_{a1}—applies to the direction of motion shown in the dimension drawing.

The **fault detection signal** $\overline{U_{aS}}$ indicates fault conditions such as a failure of the light source.



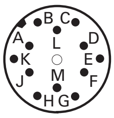
The distance between two successive edges of the incremental signals U_{a1} and U_{a2} through 1-fold, 2-fold, or 4-fold evaluation is one **measuring step.**

Further information:

Detailed descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

ERN 431 pin layout

12-pin M16 flange socket (female)



	Power supply				Incremental signals						Other signals	
	M	**B**	**K**	**L**	**E**	**F**	**H**	**A**	**C**	**D**	**G**	**J**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**U_{a1}**	**$\overline{U_{a1}}$**	**U_{a2}**	**$\overline{U_{a2}}$**	**U_{a0}**	**$\overline{U_{a0}}$**	**$\overline{U_{aS}}$**	**Vacant**
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	Violet	Yellow

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

Commutation signals for block commutation

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

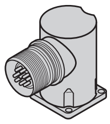
Rotary encoders with commutation signals for block commutation are the **ERN 1x23** and **ERN 1326**.

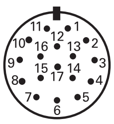
Further information:

Detailed descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

ERN 1123, ERN 1326 pin layout

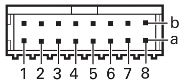
17-pin M23 flange socket





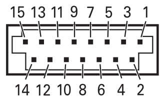
16-pin PCB connector

16



15-pin PCB connector

15



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

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

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

Pin layout for ERN 1023

	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**	**$\overline{W}$**
Cable	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 derived from the Z1 track and are equivalent to one sine period or cosine period per revolution. They have a signal amplitude of 1 V_{PP} (typ.) at 1 kΩ.
The input circuitry of the subsequent electronics is the same as that of the ∼ 1 V_{PP} interface. However, the required terminating resistance Z_0 is 1 kΩ instead of 120 Ω.

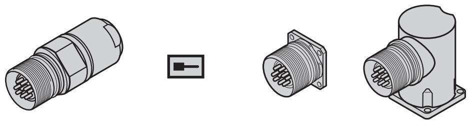
The **ERN 1387** is a rotary encoder with output signals for sinusoidal commutation.

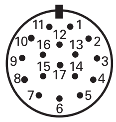
Further information:

Detailed descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

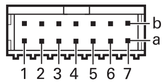
Pin layout

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 = Power supply; **T** = Temperature
Sensor: The sense line is connected internally to the respective the power supply.
Vacant pins or wires must not be used!
1) Only for output cables inside the motor housing

EnDat position values

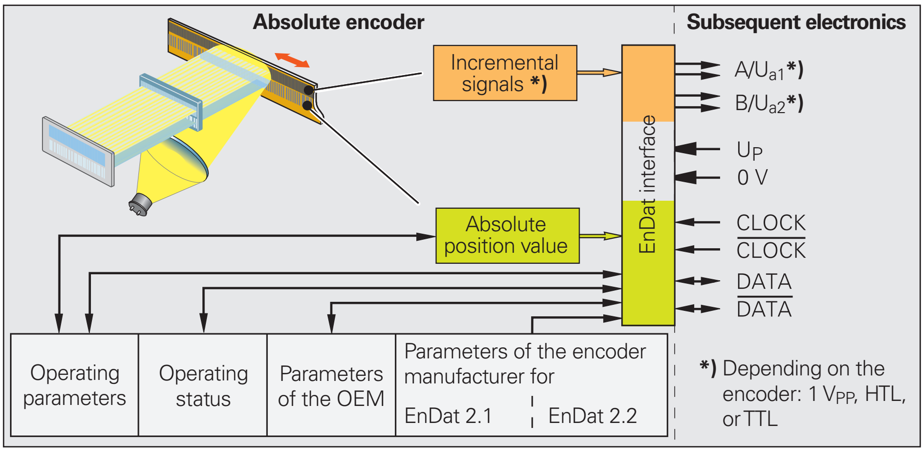
The EnDat interface is a digital, **bidirectional** interface for encoders. It is capable of transmitting **position values,** reading and updating information stored in the encoder, and storing new information. Thanks to the **serial transmission method,** only **four signal lines** are required. The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

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

Versions of the EnDat interface

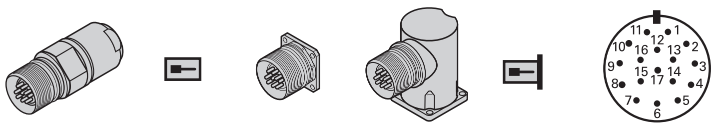
Further information:

Detailed descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

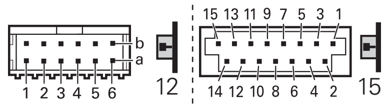


Pin layout for EnDat01/EnDat02

17-pin M23 coupling or flange socket



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



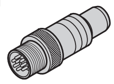
	Power supply					Incremental signals[1]				Serial data transfer			
M23	**7**	**1**	**10**	**4**	**11**	**15**	**16**	**12**	**13**	**14**	**17**	**8**	**9**
12	**1b**	**6a**	**4b**	**3a**	**/**	**2a**	**5b**	**4a**	**3b**	**6b**	**1a**	**2b**	**5a**
15	**13**	**11**	**14**	**12**	**/**	**1**	**2**	**3**	**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**	**$\overline{CLOCK}$**
Cable	Brown/ Green	Blue	White/ Green	White	/	Green/ Black	Yellow/ Black	Blue/ Black	Red/ Black	Gray	Pink	Violet	Yellow

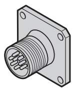
	Other signals	
M23	**5**	**6**
12	**/**	**/**
15	**/**	**/**
	T+[2]	**T–**[2]
Cable	Brown[2]	White[2]

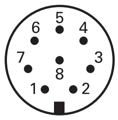
Cable shield connected to housing; **U_P** = Power supply; **T** = Temperature
Sensor: The sense line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!
[1] Only with ordering designations EnDat01 and EnDat02
[2] Only for output cables inside the motor housing

EnDat22 pin layout

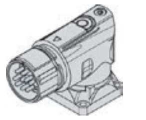
8-pin M12 coupling or flange socket

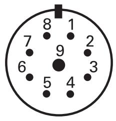




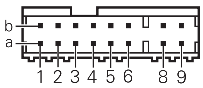


9-pin M23 SpeedTEC angle flange socket



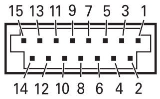


16-pin PCB connector



16

15-pin PCB connector



15

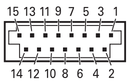
	Power supply				Serial data transfer				Other signals	
M12	**8**	**2**	**5**	**1**	**3**	**4**	**7**	**6**	**/**	**/**
M23	**3**	**7**	**4**	**8**	**5**	**6**	**1**	**2**	**/**	**/**
16	**1b**	**6a**	**4b**	**3a**	**6b**	**1a**	**2b**	**5a**	**8a**	**8b**
15	**13**	**11**	**14**	**12**	**7**	**8**	**9**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

Cable shield connected to 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] **ECI 1118 EnDat22:** vacant [2] Only EnDat22, except for ECI 1118

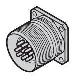
Pin layout for EBI 135/EBI 1135/EBI 4010

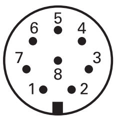
15-pin PCB connector

15

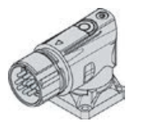


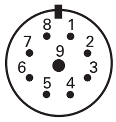
8-pin M12 flange socket





9-pin M23 SpeedTEC angle flange socket



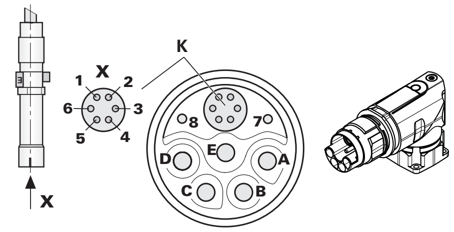


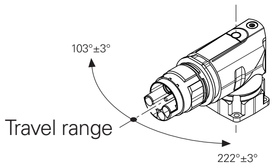
	Voltage supply				Serial data transfer				Other signals[1]	
15	**13**	**11**	**14**	**12**	**7**	**8**	**9**	**10**	**5**	**6**
M12	**8**	**2**	**5**	**1**	**3**	**4**	**7**	**6**	**/**	**/**
M23	**3**	**7**	**4**	**8**	**5**	**6**	**1**	**2**	**/**	**/**
	U_P	**U_{BAT}**	**0 V**[2]	**0 V_{BAT}**[2]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

U_P = Power supply; **U_{BAT}** = External backup battery (false polarity can result in damage to the encoder)
Vacant pins or wires must not be used!
[1] Only for EBI 135
[2] Connected inside encoder

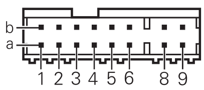
Pin layout

HMC 6 flange socket



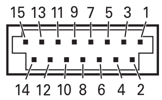


16-pin PCB connector



16

15-pin PCB connector



15

	Encoder							
	Voltage supply		Serial data transfer				Other signals	
	1	**2**	**3**	**4**	**5**	**6**	**/**	**/**
16	**1b**	**4b**	**6b**	**1a**	**2b**	**5a**	**8a**	**8b**
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

External shield of the encoder output cable on the housing of communication element **K.**
Vacant pins or wires must not be used!
1) Except for ECI 1118

DRIVE-CLiQ interface

HEIDENHAIN encoders with the code letter S after the model designation are suitable for connection to controls from Siemens featuring the **DRIVE-CLiQ interface**.

- Ordering designation: DQ01

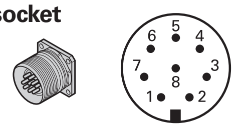
DRIVE-CLiQ is a registered trademark of Siemens AG.

Further information:

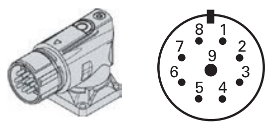
Detailed descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

Siemens pin layout

8-pin M12 flange socket

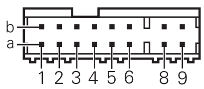


9-pin M23 SpeedTEC angle flange socket



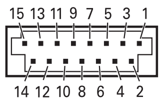
16-pin PCB connector

16



15-pin PCB connector

15



	Power supply				Serial data transfer				Other signals[1]	
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**	**8a**	**8b**
15	**13**	**11**	**12**	**14**	**7**	**8**	**9**	**10**	**5**	**6**
	–	**–**	**U_P**	**0 V**	**RXP**	**RXN**	**TXP**	**TXN**	**T+**[2]	**T–**[2]
	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] Only for output cables inside the motor housing
[2] Connections for external temperature sensor; evaluation optimized for KTY 84-130 (see *Temperature measurement in motors*)

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

EBI 1135/EBI 135/EBI 4010 – external backup battery

The multiturn functionality of the EBI 1135, EBI 135, and EBI 4000 is implemented via 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 service life is over nine years (EBI 1135/135) or six years (EBI 4010) under appropriate conditions (two shifts of ten hours each in normal operation; battery temperature of 25 °C; typical self-discharging). In order for this to be achieved, the main power supply (U_P) must be connected to the encoder during connection of the backup battery or immediately afterward 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 supplied for the first time.

Ensure correct polarity of the backup battery in order to avoid damage to the encoder. HEIDENHAIN recommends operating each encoder with its own backup battery.

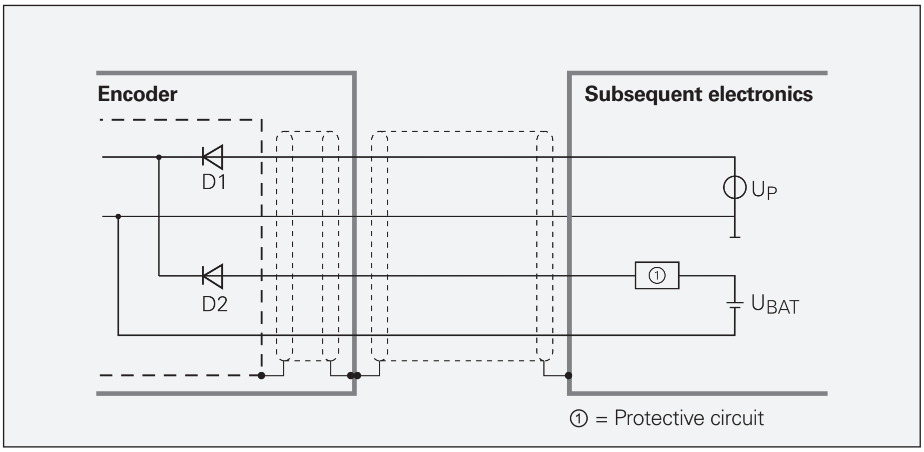
If the application requires compliance with DIN EN 60086-4 or UL 1642, an appropriate protective circuit is required for protection from wiring errors.

If the voltage of the backup battery falls below certain thresholds, the encoder will set warning or error messages that are transmitted via the EnDat interface:

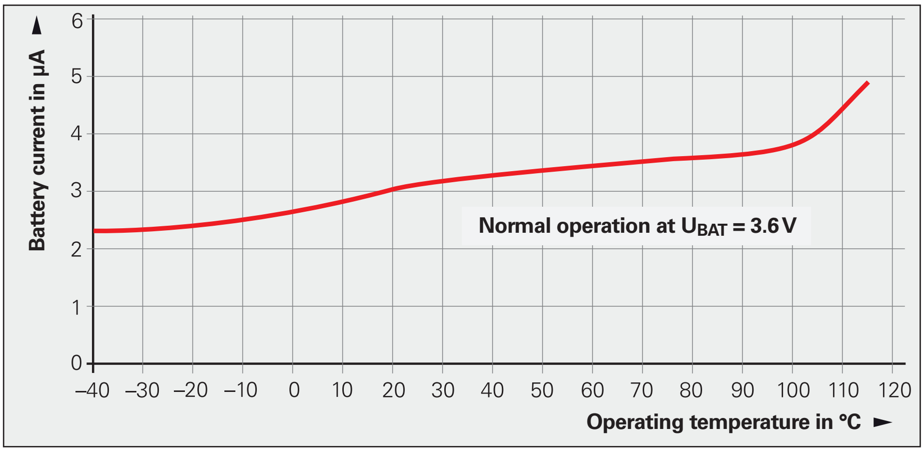
- **"Battery charge" warning message**
  ≤ 2.8 V ±0.2 V
  in normal operating mode
- **"M power interruption" error message**
  ≤ 2.2 V ±0.2 V
  in battery-buffered mode (encoder must be re-referenced)

The EBI uses low battery current even during normal operation. The amount of current depends on the operating temperature.

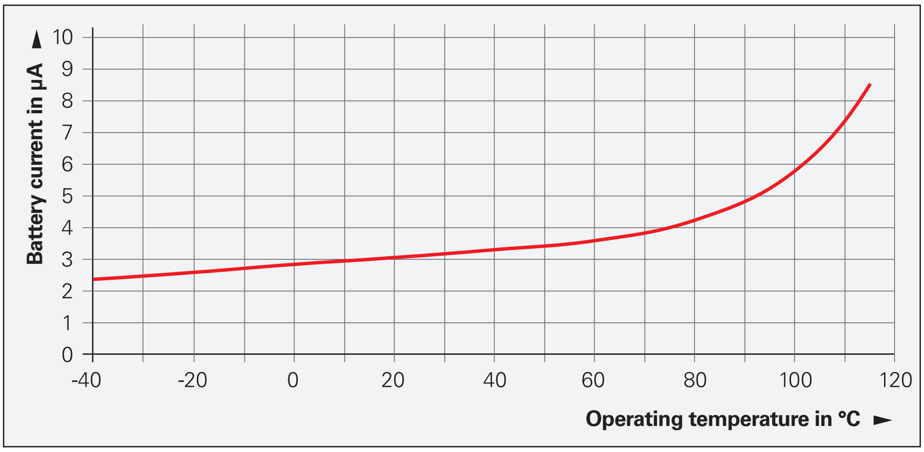
Please note:
Compliance with the EnDat specification 297403 and the EnDat Application Notes 722024, chapter 13 *Battery-buffered encoders*, is required for correct control of the encoder.



Connection to the backup battery



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

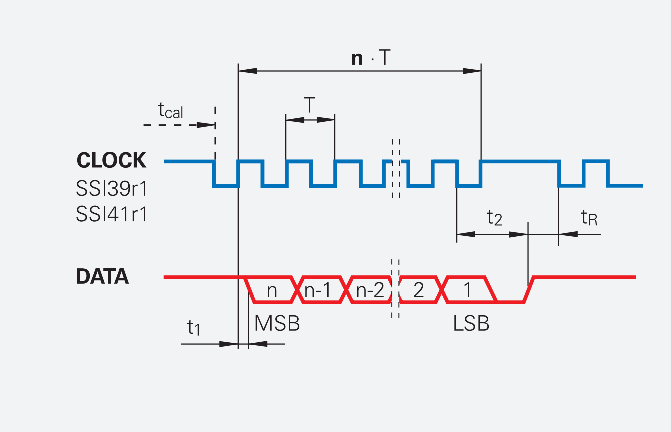
The **position value**, beginning with the most significant bit (MSB), is transferred over the data lines (DATA) in synchronism with a CLOCK signal provided by the control. The SSI standard data word length for singleturn encoders is 13 bits, and for multiturn encoders 25 bits. In addition to the absolute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

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

Data transfer

T = 1 to 10 µs
t_{cal} See *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

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

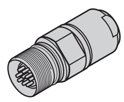


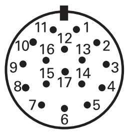
Further information:

Detailed descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

Pin layout

17-pin M23 coupling





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

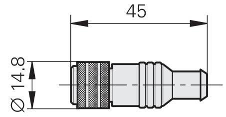
Shield on housing; **U_P** = Power supply voltage
Sensor: In the case of a 5 V supply voltage, the sense line is connected in the encoder with the corresponding power line.
[1] Vacant for ECN/EQN 10xx and ROC/ROQ 10xx

Cables and connecting elements
General information and dimensions

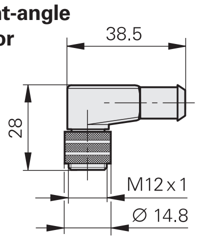
Plastic-insulated connector: Connecting element with coupling ring; available with male or female contacts (see symbols).

Symbols

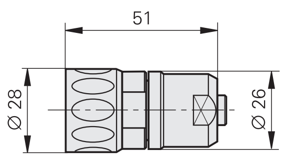
M12



M12 right-angle connector



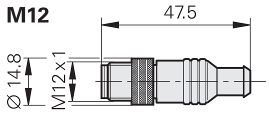
M23



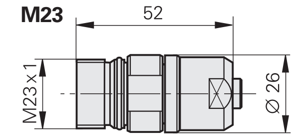
Plastic-insulated coupling: Connecting element with outside thread; available with male or female contacts (see symbols).

Symbols

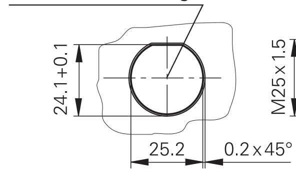
M12



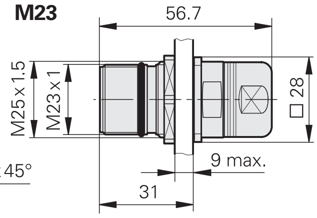
M23



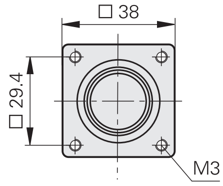
Mounted coupling with central fastening



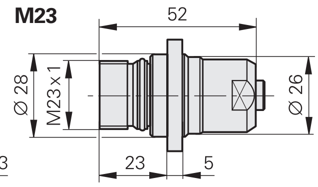
M23



Mounted coupling with flange



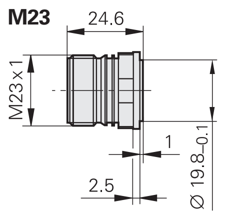
M23

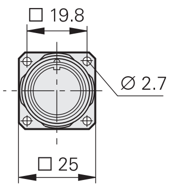


Flange socket with external thread; is permanently mounted on a housing; available with male or female contacts.

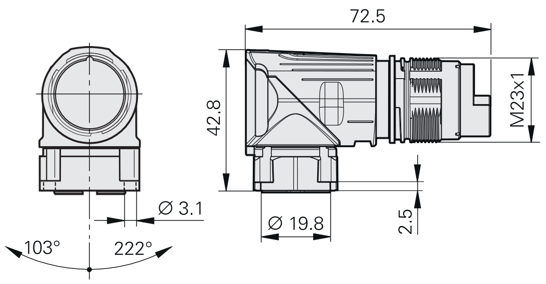
Symbols

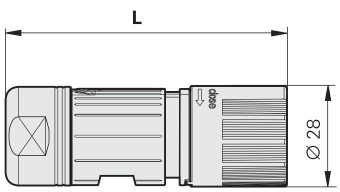
M23



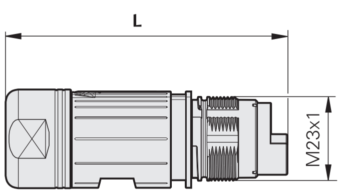


HMC 6



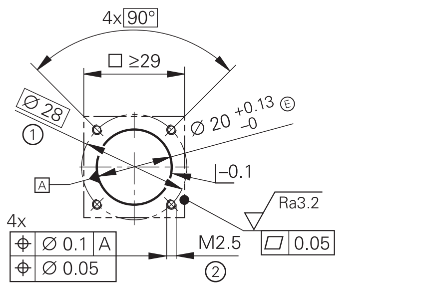


	L
Ø 9.5 mm – Ø 14.5 mm	78
Ø 14 mm – Ø 17 mm	80.5



	L
Ø 9.5 mm – Ø 14.5 mm	78
Ø 14 mm – Ø 17 mm	80.5

Required mating dimensions for flange socket

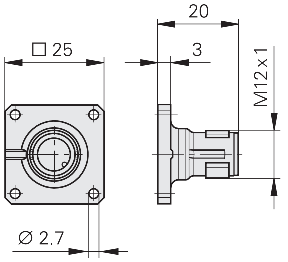


① = Bolt circle diameter
② = At least 4 mm load-bearing thread length

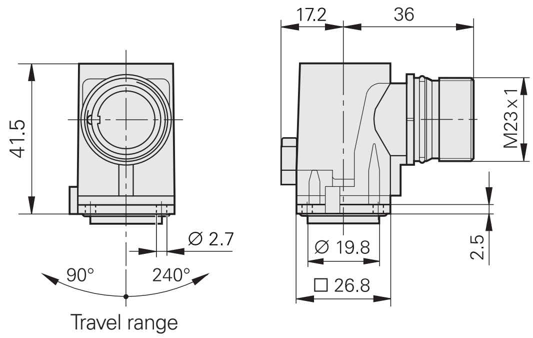
mm

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

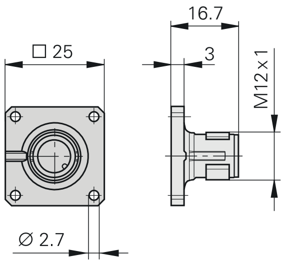
M12 flange socket
with output cable inside the motor.
For EnDat21/22 interface



M23 angle flange socket
(rotatable) with output cable inside the motor

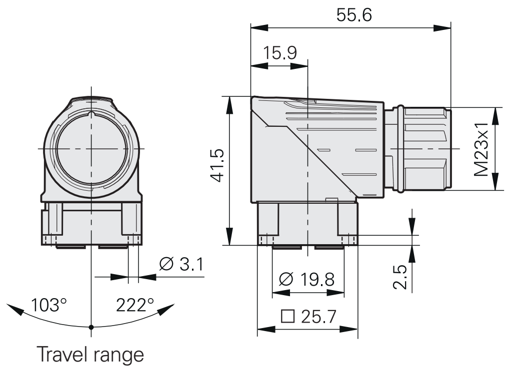


M12 flange socket
with output cable inside the motor.
For DRIVE-CLiQ interface

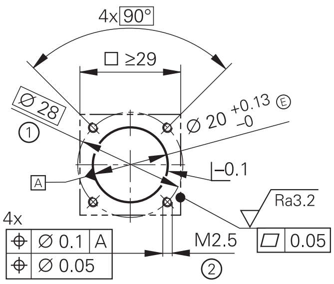


DRIVE-CLiQ is a registered trademark of Siemens AG.

M23 SpeedTEC angle flange socket
(rotatable) with output cable inside the motor



Required mating dimensions for M12 and M23 flange socket



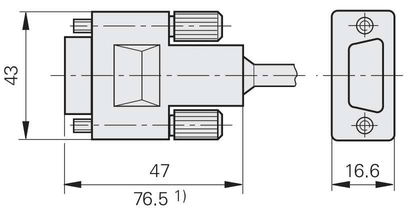
① = Bolt circle diameter
② = At least 4 mm load-bearing thread length

Output cables with SpeedTEC angle flange socket are always delivered with a mounted O-ring for vibration protection. As a result, usage is possible for a connecting cable with either a threaded connector (with O-ring) or a SpeedTEC connector (O-ring needs to be removed).

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

D-sub connector for HEIDENHAIN controls, counters, and IK absolute-value cards

Symbols



1) Interface electronics integrated into the connector

The **pin numbering** on connectors is in the direction opposite to those on couplings or flange sockets, regardless of whether the connecting elements have

male contacts or

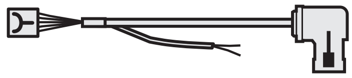
female contacts.

The **degree of protection** of the connecting elements is IP67 when connected (D-sub connector: IP50; EN 60529). When not connected, there is no protection.

Accessories for flange sockets and M23 mounted couplings

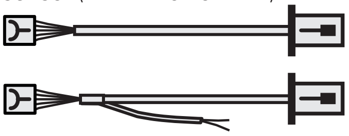
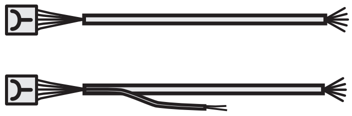
Threaded dust cap made of metal
ID 219926-01

Output cables inside the motor housing

Output cables inside the motor housing Cable diameters: 4.5 mm or 3.7 mm; TPE single wires with shrink-wrap or braided sleeve				**Complete** with PCB connector and 17-pin M23 angle flange socket, with wires for temperature sensor (cross-linked polyolefin 2 x 0.25 mm^2) 	**Complete** with PCB connector and 9-pin M23 angle flange socket, with wires for temperature sensor (TPE 2 x 0.16 mm^2) 
Rotary encoder	**Interface**	**PCB connector**	**Crimp sleeve**		
ECI 119	**EnDat01**	**15-pin**	**–**	–	–
ECI 119	**EnDat22**	**15-pin**	**–**	–	1120947-xx[1) 4)] EPG 1 x (4 x 0.06 mm^2) + 4 x 0.06 mm^2
EBI 135	**EnDat22**	**15-pin**	–	–	
ECI 1119 **EQI 1131**	**EnDat22**	**15-pin**	**–**	–	–
ECI 1118	**EnDat22**	**15-pin**	**–**	–	–
EBI 1135	**EnDat22**	**15-pin**	**–**	–	–
ECI 1319 **EQI 1331**	**EnDat01**	**12-pin**	**Ø 6 mm**	332201-xx EPG 16 x 0.06 mm^2	–
	EnDat22	**16-pin or** **12-pin + 4-pin**	**Ø 6 mm**	–	1120948-xx[4)] EPG 1 x (4 x 0.06 mm^2) + 4 x 0.06 mm^2
ECN 1113 **EQN 1125**	**EnDat01**	**15-pin**	**Ø 4.5 mm**	606079-xx EPG 16 x 0.06 mm^2	–
ECN 1123 **EQN 1135**	**EnDat22**	**15-pin**	**Ø 4.5 mm**	–	–
ECN 1313 **EQN 1325**	**EnDat01**	**12-pin**	**Ø 6 mm**	332201-xx EPG 16 x 0.06 mm^2	–

Attention: For output cables, conformity with the EMC Directive must be ensured in the complete system. The shield connection must be realized on the motor.

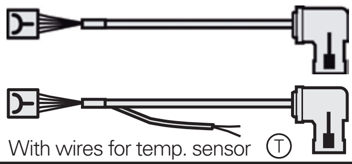
SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

Complete with PCB connector and 8-pin M12 flange socket (TPE single wires with braided sleeve and without shield), with wires for temperature sensor (TPE 2 x 0.16 mm^2)  With wires for temperature sensor (T)	**Assembled on one end** with PCB connector (other end free: stripped or unstripped), with wires for temperature sensor (TPE 2 x 0.16 mm^2)  With wires for temperature sensor (T)	**Completely assembled for HMC 6** with PCB connector and communication element, with wires for temperature sensor (TPE 2 x 0.16 mm^2) 
–	640067-xx[1)] EPG 16 x 0.06 mm^2	–
–	825855-xx[1)] EPG 4 x 2 x 0.16 mm^2	1072652-xx[1)] EPG 1 x (4 x 0.06 mm^2) + 4 x 0.06 mm^2
–	1116479-xx[1)] (T) EPG 1 x (4 x 0.06 mm^2) + 4 x 0.06 mm^2	–
1119952-xx (T) TPE 8 x 0.16 mm^2	1119958-xx (T) TPE 8 x 0.16 mm^2	1072652-xx[1)] EPG 1 x (4 x 0.06 mm^2) + 4 x 0.06 mm^2
805320-xx TPE 6 x 0.16 mm^2	735784-xx[2)] TPE 6 x 0.16 mm^2	
804201-xx TPE 8 x 0.16 mm^2	640055-xx[2)] TPE 8 x 0.16 mm^2	–
–	332202-xx EPG 16 x 0.06 mm^2	–
1117280-xx (T) TPE 8 x 0.16 mm^2	1108076-xx (T) EPG 1 x (4 x 0.06 mm^2) + 4 x 0.06 mm^2 1100199-xx TPE 8 x 0.16 mm^2 1143830-xx (T) TPE 8 x 0.16 mm^2	1035387-xx EPG 1 x (4 x 0.06 mm^2) + 4 x 0.06 mm^2
–	605090-xx EPG 16 x 0.06 mm^2	–
1117412-xx (T) TPE 8 x 0.16 mm^2	1108078-xx (T) EPG 1 x (4 x 0.06 mm^2) + 4 x 0.06 mm^2	1035857-xx EPG 1 x (4 x 0.06 mm^2) + 4 x 0.06 mm^2
–	332202-xx EPG 16 x 0.06 mm^2	–

1) With cable clamp for shield connection
2) Single wires with heat-shrink tubing, without shield
3) Pay attention to the maximum temperature (see the *Interfaces of HEIDENHAIN Encoders* brochure)
4) SpeedTEC angle flange socket (male) with O-ring for vibration protection (for threaded connector with O-ring; for SpeedTEC connector, remove O-ring)

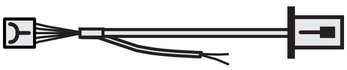
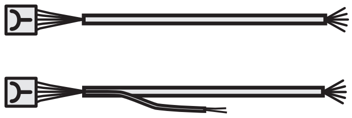
Further information:

For more information about the HMC 6 solution, please refer to the *HMC 6* product information document.

Output cables inside the motor housing Cable diameters: 4.5 mm or 3.7 mm; TPE single wires with shrink-wrap or braided sleeve				**Complete** with PCB connector and 17-pin M23 angle flange socket, with wires for temperature sensor (cross-linked polyolefin 2 x 0.25 mm^2) 	**Complete** with PCB connector and 9-pin M23 angle flange socket, with wires for temperature sensor (TPE 2 x 0.16 mm^2) 
Rotary encoder	**Interface**	**PCB connector**	**Crimp sleeve**		
ECN 1324 S **EQN 1336 S**	**DRIVE-CLiQ**	**16-pin or** **12-pin + 4-pin**	**Ø 6 mm**	–	1120945-xx[4] EPG 2 x (2 x 0.06 mm^2) + 4 x 0.06 mm^2
ECN 1325 **EQN 1337**	**EnDat22**	**16-pin or** **12-pin + 4-pin**	**Ø 6 mm**	–	1120948-xx[4] EPG 1 x (4 x 0.06 mm^2) + 4 x 0.06 mm^2
ERN 1123	**TTL**	**15-pin**	**–**	–	–
ERN 1321 **ERN 1381**	**TTL** **1 V_{PP}**	**12-pin**	**Ø 6 mm**	667343-xx EPG 16 x 0.06 mm^2	–
ERN 1326	**TTL**	**16-pin**	**Ø 6 mm**	–	–
ERN 1387	**1 V_{PP}**	**14-pin**	**Ø 6 mm**	332199-xx EPG 16 x 0.06 mm^2	–
ERO 1225 **ERO 1285**	**TTL** **1 V_{PP}**	**12-pin**	**Ø 4.5 mm**	–	–
ERO 1420 **ERO 1470** **ERO 1480**	**TTL** **TTL** **1 V_{PP}**	**12-pin**	**Ø 4.5 mm**	–	–
ECI 4010 **EBI 4010**	**EnDat22**	**15-pin**	**Ø 4.5 mm**	–	1121041-xx[4] EPG 1 x (4 x 0.06 mm^2) + 4 x 0.06 mm^2 1120940-xx[4] Ⓣ EPG 1 x (4 x 0.06 mm^2) + 4 x 0.06 mm^2
ECI 4090 S	**DRIVE-CLiQ**	**15-pin**	**Ø 4.5 mm**	–	1125408-xx[4] EPG 2 x (2 x 0.06 mm^2) + 4 x 0.06 mm^2 1125403-xx[4] Ⓣ EPG 2 x (2 x 0.06 mm^2) + 4 x 0.06 mm^2

Attention: For output cables, conformity with the EMC Directive must be ensured in the complete system. The shield connection must be realized on the motor.

DRIVE-CLiQ is a registered trademark of Siemens AG.
SpeedTEC is a registered trademark of TE connectivity.

Complete with PCB connector and 8-pin M12 flange socket (TPE single wires with braided sleeve and without shield), with wires for temperature sensor (TPE 2 x 0.16 mm^2) 	**Assembled on one end** with PCB connector (other end free: stripped or unstripped), with wires for temperature sensor (TPE 2 x 0.16 mm^2)  With wires for temperature sensor Ⓣ	**Completely assembled for HMC 6** with PCB connector and communication element, with wires for temperature sensor (TPE 2 x 0.16 mm^2) 
1181373-xx[5)] EPG 2 x (2 x 0.06 mm^2) + 4 x 0.06 mm^2	–	–
1117280-xx TPE 8 x 0.16 mm^2	1108076-xx Ⓣ EPG 1 x (4 x 0.06 mm^2) + 4 x 0.06 mm^2 1100199-xx TPE 8 x 0.16 mm^2 1143830-xx TPE 8 x 0.16 mm^2	1035387-xx EPG 1 x (4 x 0.06 mm^2) + 4 x 0.06 mm^2
–	738976-xx[2)] TPE 14 x 0.16 mm^2	–
–	333276-xx EPG 16 x 0.06 mm^2	–
–	341369-xx EPG 16 x 0.06 mm^2	–
–	332200-xx EPG 16 x 0.06 mm^2	–
–	372164-xx[3)] PUR [4(2 x 0.05 mm^2) + (4 x 0.16 mm^2)]	–
–	346439-xx[3)] PUR [4(2 x 0.05 mm^2) + (4 x 0.16 mm^2)]	–
–	–	–
–	–	–

1) With cable clamp for shield connection
2) Single wires with heat-shrink tubing, without shield
3) Pay attention to maximum temperature (see the *Interfaces of HEIDENHAIN Encoders* brochure)
4) SpeedTEC angle flange socket (male) with O-ring for vibration protection (for threaded connector with O-ring; for SpeedTEC connector, remove O-ring)
5) EPG cable with one-sided shield connection

Further information:

For more information about the HMC 6 solution, please refer to the *HMC 6* product information document.

1 VPP, TTL adapter cables and connecting cables

12-pin M23

PUR connecting cables and adapter cables 4(2 x 0.14 mm²) + (4 x 0.5 mm²); AP = 0.5 mm²	Ø 8 mm			∿ 1 VPP / ⊓⊔ TTL
Complete with connector (female) and coupling (male)				298401-xx
Complete with connector (female) and connector (male)				298399-xx
Complete with connector (female) and 15-pin D-sub connector (female) for TNC				310199-xx
Complete with connector (female) and 15-pin D-sub connector (male) for PWM 21/EIB 741				310196-xx
With one connector (female)				309777-xx
Cable only				816317-xx
Mating element on connecting cable for connection to encoder connector	**Connector (female)**	For cable	Ø 8 mm	291697-05
Connector on connecting cable for connection to subsequent electronics	**Connector (male)**	For cable	Ø 8 mm Ø 6 mm	291697-08 291697-07
Coupling on connecting cable	**Coupling (male)**	For cable	Ø 4.5 mm Ø 6 mm Ø 8 mm	291698-14 291698-03 291698-04
Flange socket for integration in the subsequent electronics	**Flange socket (female)**			315892-08
Mounted couplings	**With flange (female)**		Ø 6 mm Ø 8 mm	291698-17 291698-07
	With flange (male)		Ø 6 mm Ø 8 mm	291698-08 291698-31
	With central fastening (male)		Ø 6 to 10 mm	741045-01
∿ 1 VPP/11 µAPP adapter For conversion from 1 VPP to 11 µAPP signals; 12-pin M23 connector (female) 9-pin M23 connector (male)				364914-01

AP: Cross section of power supply lines

EnDat adapter cables and connecting cables 8-pin M12 17-pin M23

PUR connecting cables and adapter cables **8-pin, Ø 3.7 mm:** 1(4 x 0,06 mm^2) + (4 x 0,06 mm^2); A_P = 2 x 0.06 mm^2 **8-pin, Ø 6 mm:** 2(2 x 0.09 mm^2) + 2(2 x 0.16 mm^2); A_P = 2 x 0.16 mm^2 **17-pin, Ø 8 mm:** (4 x 0.16 mm^2) + 4(2 x 0.16 mm^2) + (4 x 0.5 mm^2); A_P = 2 x 0.5 mm^2		**EnDat** without incremental signals		**EnDat** with **SSI** incremental signals
	Cable diameter	6 mm	3.7 mm	8 mm
Complete with connector (female) and coupling (male)		1036372-xx	1118858-xx	323897-xx *340302-xx*
Complete with right-angle connector (female) and coupling (male)		1036386-xx	1118863-xx	–
Complete with connector (female) and 15-pin D-sub connector (female) for TNC (position inputs)		1036521-xx	–	332115-xx
Complete with connector (female) and 25-pin D-sub connector (female) for TNC (speed inputs)		1133104-xx	–	*336376-xx* 509667-xx
Complete with connector (female) and 15-pin D-sub connector (male) for IK 215, PWM 21, EIB 741, etc.		1036526-xx	1118865-xx	324544-xx
Complete with right-angle connector (female) and 15-pin D-sub connector (male) for IK 215, PWM 21, EIB 741, etc.		1133855-xx	1118867-xx	–
With one connector (female)		1129581-xx[1)]	–	309778-xx
With one right-angle connector (female)		1133799-xx[1)]	–	–
Cable only		1150200-xx	–	816322-xx

Italics: Cable with layout for "speed encoder" input (MotEnc EnDat)
1) Use the connecting element for 8 MHz signal transmission
A_P: Cross section of power supply lines
For more adapter cables and connecting cables, please refer to the *Cables and Connectors* brochure.

EnDat adapter cables

8-pin M12 | 9-pin M23

PUR adapter cables 1(4 x 0.14 mm²) + (4 x 0.34 mm²); A_P = 0.34 mm²		**EnDat** without incremental signals
Complete with 9-pin M23 connector (female) and 8-pin M12 coupling (male)	 Ø 6 mm Ø 8 mm	1136863-xx 1136874-xx
Complete with 9-pin M23 connector (female) and 15-pin D-sub connector (female) for PWM 21	 Ø 6 mm	1173166-xx

A_P: Cross section of power supply lines

HMC 6 connecting cable

PUR connecting cable Communication and supply: 2 x (2 x 0.09 mm²) + 2 x 0.24 mm² Power and PE: 1 x (3 x 1.5 mm²) + 1 x 1.5 mm²		1.5 mm²	4 mm²
With one HMC 6 hybrid connecting element with power wires		1188098-xx	1188099-xx

Further information:

For more information about the HMC 6 solution, please refer to the *HMC 6* product information document.

Siemens connecting cables

PUR connecting cables ∅ 6.8 m; 2 x (2 x 0.17 mm^2) + (2 x 0.24 mm^2); A_P = 0.24 mm^2		
Complete with 8-pin M12 connector (female) and 8-pin M12 coupling (male)		822504-xx
Complete with 8-pin M12 connector (female) and RJ45 Siemens connector (IP67)		1094652-xx
Complete with 8-pin M12 connector (female) and RJ45 Siemens connector (IP20)		1093042-xx
Complete with 9-pin M23 SpeedTEC connector (female) and RJ45 Siemens connector (IP20)		1121546-xx
Complete with 9-pin M23 connector (female) and RJ45 Siemens connector (IP20)		1117540-xx
Complete with 8-pin M23 SpeedTEC connector (female) and 8-pin M12 coupling (male)		1121536-xx

A_P: Cross section of power supply lines

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

Interface electronics

Interface electronics from HEIDENHAIN adapt the encoder signals to the interface of the subsequent electronics. They are used when the subsequent electronics cannot directly process the output signals from HEIDENHAIN encoders or when additional interpolation of the signals is necessary.

Input signals of the interface electronics
Interface electronics from HEIDENHAIN can be connected to encoders with the following sinusoidal signals: 1 V_{PP} (voltage signals) or 11 μA_{PP} (current signals). Encoders with the EnDat or SSI serial interfaces can also be connected to various interface electronics.

Output signals of the interface electronics
There are interface electronics with the following interfaces to the subsequent electronics:
- TTL square-wave pulse trains
- EnDat 2.2
- DRIVE-CLiQ
- Fanuc serial interface
- Mitsubishi high-speed interface
- Yaskawa serial interface
- PROFIBUS

Interpolation of the sinusoidal input signals
In addition to performing signal conversion, the interface electronics interpolate the sinusoidal encoder signals. This permits finer measuring steps and, as a result, higher control quality and better positioning behavior.

Formation of a position value
Some interface electronics have an integrated counting function. Starting from the last set reference point, an absolute position value is generated and output to the subsequent electronics when the reference mark is traversed.

Box design

Plug design

Version for integration

Top-hat rail design

DRIVE-CLiQ is a registered trademark of Siemens AG.

Outputs		Inputs		Design – degree of protection	Interpolation[1] or subdivision	Model
Interface	Quantity	Interface	Quantity			
⊓⊔TTL	1	∼ 1 V_{PP}	1	Box design – IP65	5/10-fold	**IBV 101**
					20/25/50/100-fold	**IBV 102**
					Without interpolation	**IBV 600**
					25/50/100/200/400-fold	**IBV 660 B**
				Plug design – IP40	5/10-fold	**IBV 3171**
					20/25/50/100-fold	**IBV 3271**
				Version for integration – IP00	5/10-fold	**IDP 181**
					20/25/50/100-fold	**IDP 182**
		∼ 11 μA_{PP}	1	Box design – IP65	5/10-fold	**EXE 101**
					20/25/50/100-fold	**EXE 102**
				Version for integration – IP00	5-fold	**IDP 101**
⊓⊔TTL/ ∼ 1 V_{PP} Adjustable	2	∼ 1 V_{PP}	1	Box design – IP65	2-fold	**IBV 6072**
					5/10-fold	**IBV 6172**
					5/10-fold and 20/25/50/100-fold	**IBV 6272**
EnDat 2.2	1	∼ 1 V_{PP}	1	Box design – IP65	≤ 16384-fold subdivision	**EIB 192**
				Plug design – IP40	≤ 16384-fold subdivision	**EIB 392**
			2	Box design – IP65	≤ 16384-fold subdivision	**EIB 1512**
DRIVE-CLiQ	1	EnDat 2.2	1	Box design – IP65	–	**EIB 2391 S**
				Cable design – IP65	–	**EIB 3392 S**
Fanuc serial interface	1	∼ 1 V_{PP}	1	Box design – IP65	≤ 16384-fold subdivision	**EIB 192 F**
				Plug design – IP40	≤ 16384-fold subdivision	**EIB 392 F**
			2	Box design – IP65	≤ 16384-fold subdivision	**EIB 1592 F**
Mitsubishi high-speed interface	1	∼ 1 V_{PP}	1	Box design – IP65	≤ 16384-fold subdivision	**EIB 192 M**
				Plug design – IP40	≤ 16384-fold subdivision	**EIB 392 M**
			2	Box design – IP65	≤ 16384-fold subdivision	**EIB 1592 M**
Yaskawa serial interface	1	EnDat 2.2	1	Plug design – IP40	–	**EIB 3391Y**
PROFIBUS DP	1	EnDat 2.2	1	Top-hat rail design	–	**PROFIBUS Gateway**
PROFINET IO	1	EnDat 2.2	1	Top-hat rail design	–	**PROFINET Gateway**

[1] Switchable
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Testing equipment and diagnostics

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

Incremental encoders primarily 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, the analysis of output signals is possible only with external testing devices or via computation in the subsequent electronics (analog diagnostics interface).

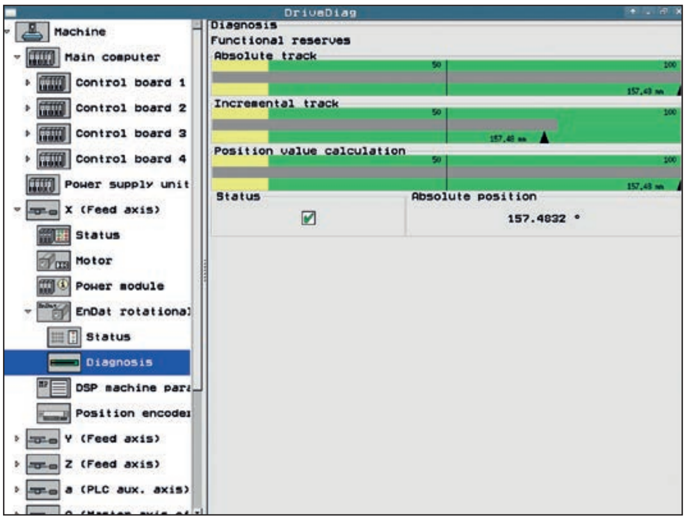
Absolute encoders operate with serial data transmission. Depending on the interface, additional 1 V_{PP} incremental signals can be output. The signals are comprehensibly monitored within the encoder. The monitoring result (particularly in the case of valuation numbers) can be transmitted to the subsequent electronics along with the position values via the serial interface (digital diagnostics 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 functional reserve
  - Identical scaling for all HEIDENHAIN encoders
  - Cyclic reading is possible

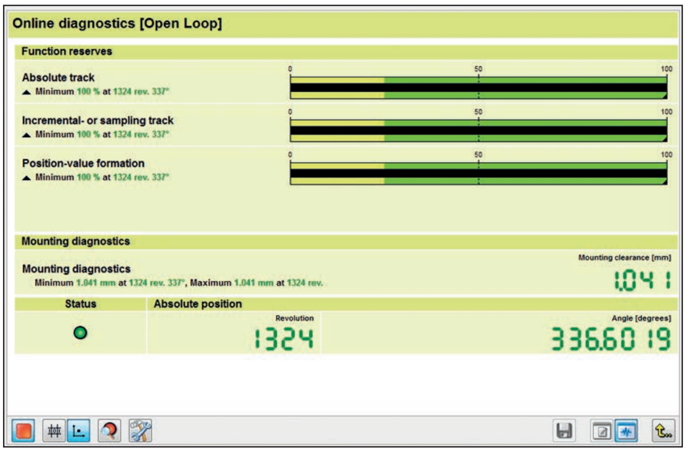
This enables the subsequent electronics to evaluate the current status of the encoder with little effort, even in closed-loop mode.

HEIDENHAIN offers the appropriate PWM inspection devices and PWT testing devices for encoder analysis. Depending on how these devices are integrated, a differentiation is made between two types of diagnostics:

- Encoder diagnostics: The encoder is connected directly to the testing or inspection device. This makes a detailed analysis of encoder functions possible.
- Diagnostics in the control loop: The PWM testing unit is connected into the closed control loop (e.g., via a suitable testing adapter). This enables real-time diagnosis of the machine or system during operation. The available functions depend on the interface.



Diagnostics in the control loop on HEIDENHAIN controls with display of the valuation number or the analog encoder signals



Diagnostics via the PWM 21 and ATS software

Commissioning via the PWM 21 and ATS software

PWM 21
In conjunction with the ATS adjusting and testing software included in delivery, the PWM 21 phase angle measuring unit is used as 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 or EnDat 2.2 (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 can be selected
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 Vista (32-bit), 7, 8, and 10 (32-bit/64-bit) 500 MB free space on hard disk

DRIVE-CLiQ is a registered trademark of Siemens AG.

PWT 100
The PWT 100 is a testing device for the functional testing and adjustment of incremental and absolute HEIDENHAIN encoders. Thanks to its compact dimensions and robust design, the PWT 100 is ideal for portable use.

	PWT 100
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

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