HEIDENHAIN

Encoders for Servo Drives

November 2011

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

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

The **mounting information** and the detailed **specifications** refer to the **rotary encoders** developed specifically for drive technology. Other rotary encoders are described in separate product catalogs.

You will find more detailed information on the **linear and angular encoders** listed in the selection tables, such as mounting information, specifications and dimensions in the respective **product catalogs.**

Contents

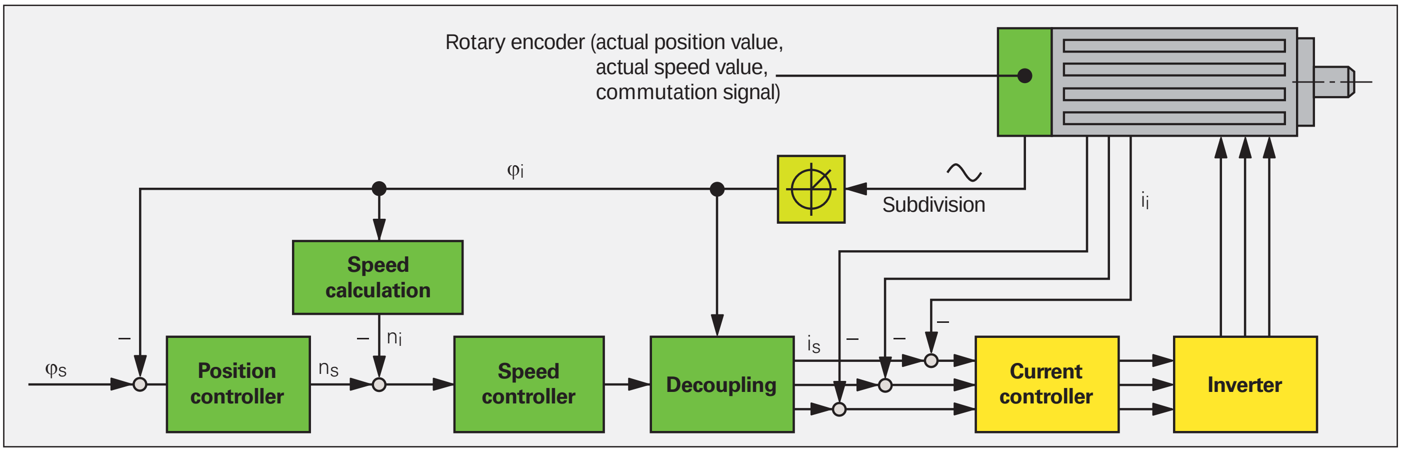
Encoders for Servo Drives

Controlling systems for servo drives require measuring systems that provide feedback for the position and speed controllers and for electronic commutation.

The properties of encoders have decisive influence on important motor qualities such as:

- Positioning accuracy
- Speed stability
- Bandwidth, which determines drive command-signal response and disturbance rejection capability
- Power loss
- Size
- Quietness

Digital position and speed control



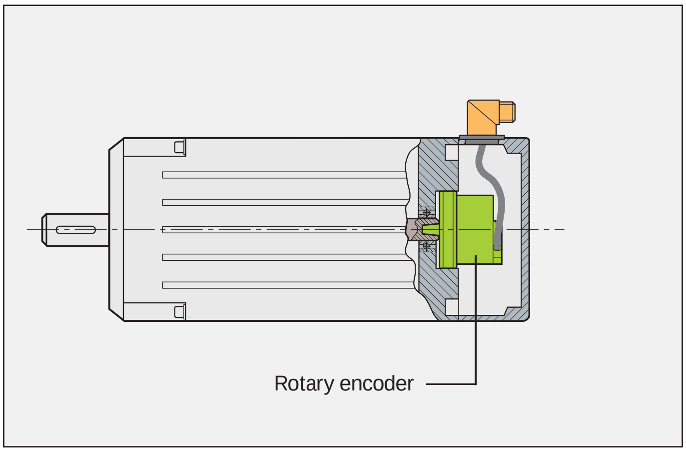
HEIDENHAIN offers the appropriate solution for any of a wide range of applications using both rotary and linear motors:

- Incremental rotary encoders with and without commutation tracks, absolute rotary encoders
- Incremental and absolute angle encoders
- Incremental and absolute linear encoders

Rotary encoder

All the HEIDENHAIN encoders shown in this catalog involve very little cost and effort for the motor manufacturer to mount and wire. Encoders for rotary motors are of short overall length. Some encoders, due to their special design, can perform functions otherwise handled by safety devices such as limit switches.

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



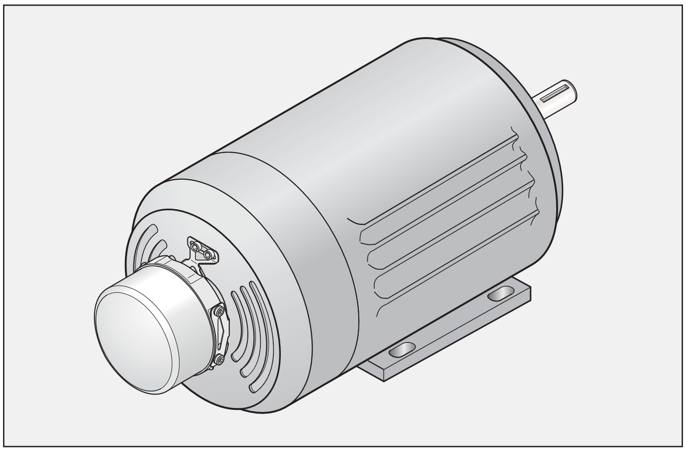
Linear encoders

Angle encoders

Explanation of the Selection Tables

The tables on the following pages list the encoders suited for individual motor designs. The encoders are available with dimensions and output signals to fit specific types of motors (DC or AC).

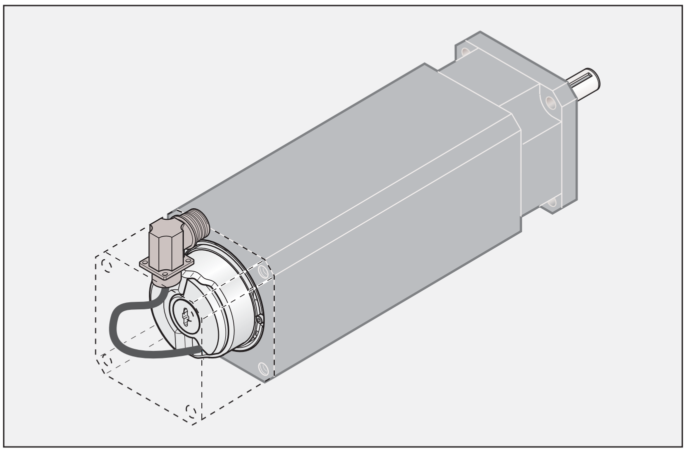
Rotary encoders for mounting on motors
Rotary encoders for motors with forced ventilation are either built onto the motor housing or integrated. As a result, they are frequently exposed to the unfiltered forced-air stream of the motor and must have a high degree of protection, such as IP 64 or better. The permissible operating temperature seldom exceeds 100 °C.



In the selection table you will find
- Rotary encoders with mounted **stator couplings** with high natural frequency—virtually eliminating any limits on the bandwidth of the drive
- Rotary encoders for **separate shaft couplings,** which are particularly suited for **insulated mounting**
- Incremental rotary encoders with high quality **sinusoidal output signals** for digital speed control
- Absolute rotary encoders with purely digital data transfer or complementary sinusoidal incremental signals
- Incremental rotary encoders with **TTL or HTL compatible output signals**

For Selection Table see page 8

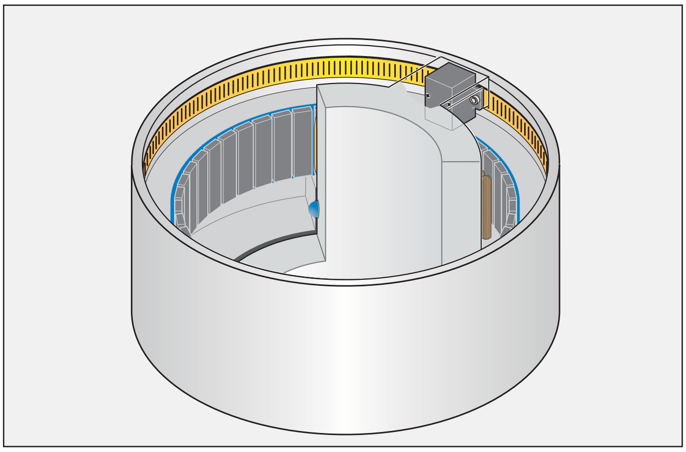
Rotary encoders for integration in motors
For motors without separate ventilation, the rotary encoder is built into the motor housing. This configuration places no stringent requirements on the encoder for a high degree of protection. The operating temperature within the motor housing, however, can reach 100 °C and higher.



In the selection table you will find
- Incremental rotary encoders for **operating temperatures** up to 120 °C, and absolute rotary encoders for operating temperatures up to 115 °C
- Rotary encoders with mounted **stator couplings** with high natural frequency—virtually eliminating any limits on the bandwidth of the drive
- Incremental rotary encoders for digital speed control with **sinusoidal output signals** of high quality—even at high operating temperatures
- Absolute rotary encoders **with purely digital data transfer** or complementary sinusoidal incremental signals
- Incremental rotary encoders with additional **commutation signal** for synchronous motors
- Incremental rotary encoders with **TTL-compatible output signals**

For Selection Table see page 10

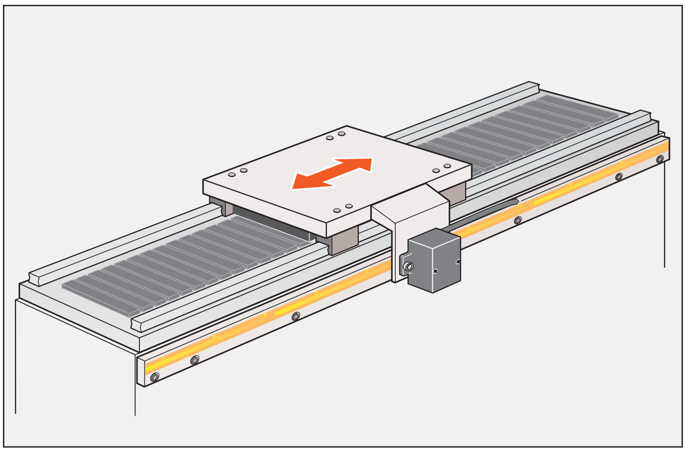
Rotary encoders, modular rotary encoders and angle encoders for integrated and hollow-shaft motors
Rotary encoders and angle encoders for these motors have **hollow through shafts** in order to allow supply lines, for example, to be conducted through the motor shaft—and therefore through the encoder. Depending on the conditions of the application, the encoders must either feature up to IP 66 protection or—for example with modular encoders using optical scanning—the machine must be designed to protect them from contamination.



In the Selection Table you will find
- Angle encoders and modular encoders with the measuring standard on a steel drum for **shaft speeds up to 42 000 min^{-1}**
- Encoders with integral bearing, with stator coupling or modular design
- Encoders with high quality **absolute and/or incremental output signals**
- Encoders with **good acceleration performance** for a broad bandwidth in the control loop

For Selection Table see page 12

Linear encoders for linear motors
Linear encoders on linear motors supply the actual value both for the position controller and the velocity controller. They therefore form the basis for the servo characteristics of a linear drive. The linear encoders recommended for this application
- Have low position deviation during acceleration in the measuring direction
- Have high tolerance to acceleration and vibration in the lateral direction
- Are designed for high velocities
- Provide absolute position information with purely digital data transmission or high-quality sinusoidal incremental signals



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

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

For Selection Table see page 14

Sealed linear encoders are characterized by:
- A high degree of protection
- Simple installation

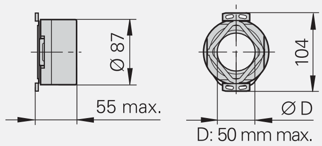
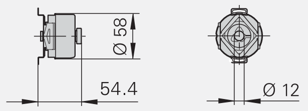
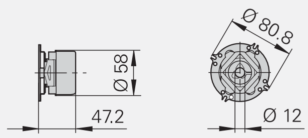
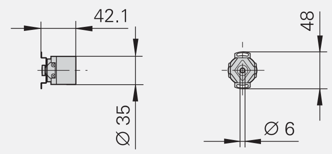
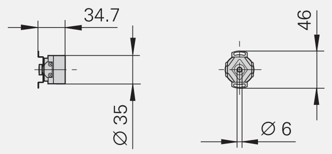
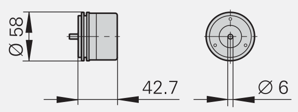
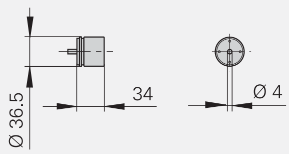
Sealed linear encoders are therefore ideal for applications in environments with airborne liquids and particles, such as on machine tools.

For Selection Table see page 16

Selection Guide

Rotary Encoders for Mounting on Motors

Protection: up to IP 64 (EN 60529)

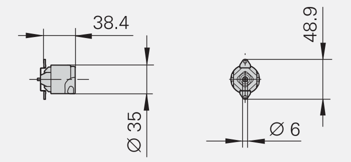
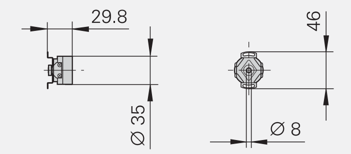
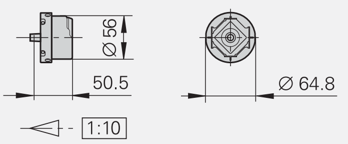
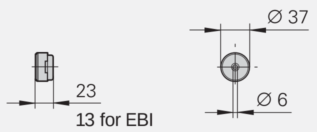
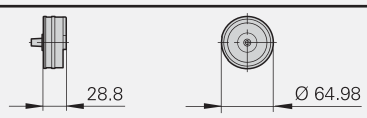
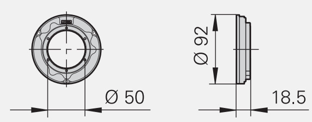
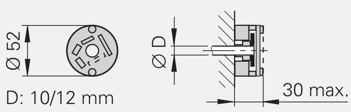
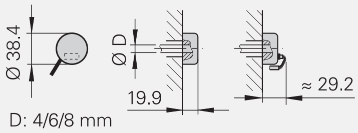
Series	Overall dimensions	Mechanically permissible speed	Natural freq. of the stator connection	Maximum operating temperature	Power supply
Rotary encoders with integral bearing and mounted stator coupling					
ECN/ERN 100		*D ≤ 30 mm:* ≤ 6000 min^{-1} *D > 30 mm:* ≤ 4000 min^{-1}	≥ 1100 Hz	100 °C	5 V DC ± 5 %
					3.6 to 5.25 V DC
					5 V DC ± 10 %
				85 °C	10 to 30 V DC
ECN/EQN/ERN 400	Stator coupling  **Universal stator coupling** 	≤ 6000 min^{-1} *With two shaft clamps (only for hollow through shaft):* ≤ 12000 min^{-1}	*Stator coupling:* ≥ 1500 Hz *Universal stator coupling:* ≥ 1400 Hz	100 °C	3.6 to 14 V DC
					5 V DC ± 10 %
				70 °C	10 to 30 V DC
				100 °C	5 V DC ± 10 %
ECN/EQN/ERN 1000	 ERN 1023 	≤ 12000 min^{-1}	≥ 1500 Hz	100 °C	3.6 to 14 V DC
					5 V DC ± 10 %
				70 °C	10 to 30 V DC
					5 V DC ± 5 %
				100 °C	5 V DC ± 10 %
		≤ 6000 min^{-1}	≥ 1600 Hz	90 °C	
Rotary encoders with integral bearing for separate shaft coupling					
ROC/ROQ/ROD 400		≤ 12000 min^{-1}	–	100 °C	3.6 to 14 V DC
		≤ 16000 min^{-1}			5 V DC ± 10 %
				70 °C	10 to 30 V DC
				100 °C	5 V DC ± 10 %
ROC/ROQ/ROD 1000		≤ 12000 min^{-1}	–	100 °C	3.6 to 14 V DC
					5 V DC ± 10 %
				70 °C	10 to 30 V DC
					5 V DC ± 5 %

	Incremental signals		Absolute position values			Model	More Information
	Output signals	**Signal periods per revolution**	**Positions per revolution**	**Distinguishable revolutions**	**Data interface**		
	∿ 1 V_{PP}	2048	8192	–	EnDat 2.2/01	**ECN 113**	**Catalog:** ***Rotary Encoders***
	–	–	33554432		EnDat 2.2/**22**	**ECN 125**	
	⊓⊔TTL/∿ 1 V_{PP}	1000 to 5000	–			**ERN 120/ERN 180**	
	⊓⊔ HTL					**ERN 130**	
	∿ 1 V_{PP}	512, 2048	8192	–/4096	EnDat 2.2/01	**ECN 413/EQN 425**	
	–	–	33554432		EnDat 2.2/**22**	**ECN 425/EQN 437**	
	⊓⊔TTL	250 to 5000	–			**ERN 420**	
	⊓⊔ HTL					**ERN 430**	
	⊓⊔TTL					**ERN 460**	
	∿ 1 V_{PP}	1000 to 5000				**ERN 480**	
	∿ 1 V_{PP}	512	8192	–/4096	EnDat 2.2/01	**ECN 1013/EQN 1025**	
	–	–	8388608		EnDat 2.2/**22**	**ECN 1023/EQN 1035**	
	⊓⊔TTL/∿ 1 V_{PP}	100 to 3600	–			**ERN 1020/ERN 1080**	
	⊓⊔ HTLs					**ERN 1030**	
	⊓⊔TTL	5000 to 36000[1)]				**ERN 1070**	
	∿ 1 V_{PP}	512, 2048	Z1 track for sine commutation			**ERN 1085**	**Product Info**
	⊓⊔TTL	500 to 8192	3 block commutation signals			**ERN 1023**	**Page 40**
	∿ 1 V_{PP}	512, 2048	8192	–/4096	EnDat 2.2/01	**ROC 413/ROQ 425**	**Catalog:** ***Rotary Encoders***
	–	–	33554432		EnDat 2.2/**22**	**ROC 425/ROQ 437**	
	⊓⊔TTL	50 to 10000	–			**ROD 426**	
	⊓⊔ HTL	50 to 5000				**ROD 436**	
	⊓⊔TTL	50 to 10000				**ROD 466**	
	∿ 1 V_{PP}	1000 to 5000				**ROD 486**	
	∿ 1 V_{PP}	512	8192	–/4096	EnDat 2.2/01	**ROC 1013/ROQ 1025**	
	–	–	8388608		EnDat 2.2/**22**	**ROC 1023/ROQ 1035**	
	⊓⊔TTL/∿ 1 V_{PP}	100 to 3600	–			**ROD 1020/ROD 1080**	
	⊓⊔ HTLs					**ROD 1030**	
	⊓⊔TTL	5000 to 36000[1)]				**ROD 1070**	

1) After internal 5/10-fold interpolation

Selection Guide
Rotary Encoders for Integration in Motors

Protection: up to IP 40 (EN 60529)

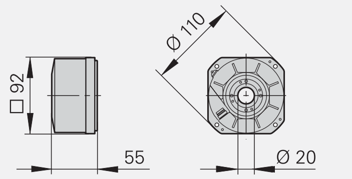
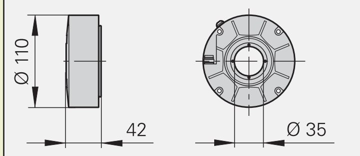
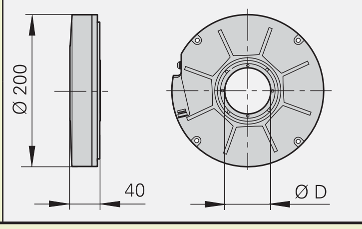
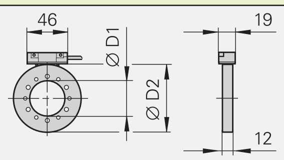
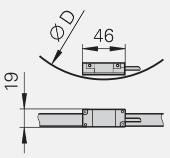
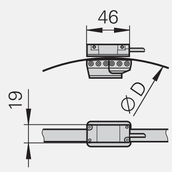
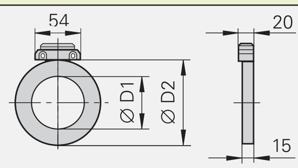
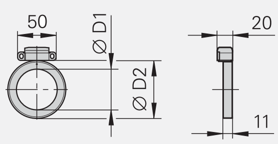
Series	Overall dimensions	Mechanically permissible speed	Natural freq. of the stator connection	Maximum operating temperature	Power supply
Rotary encoders with integral bearing and mounted stator coupling					
ECN/EQN/ ERN 1100		≤ 12000 min^{-1}	≥ 1000 Hz	115 °C	3.6 to 14 V DC
		≤ 6000 min^{-1}	≥ 1600 Hz	90 °C	
ECN/EQN/ ERN 1300		≤ 15000 min^{-1}/ ≤ 12000 min^{-1}	≥ 1800 Hz	115 °C	3.6 to 14 V DC
		≤ 15000 min^{-1}		120 °C *ERN 1381/4096:* 80 °C	5 V DC ± 10%
					5 V DC ± 5%
					5 V DC ± 10%
					5 V DC ± 5%
Rotary encoders without integral bearing					
ECI/EQI 1100		≤ 15000 min^{-1}/ ≤ 12000 min^{-1}	–	115 °C	5 V DC ± 5%
EBI 1100					3.6 to 14 V DC
ECI/EQI 1300		≤ 15000 min^{-1}/ ≤ 12000 min^{-1}	–	115 °C	DC 5 V ± 5% or DC 7 to 10 V
ECI 100		≤ 6000 min^{-1}	–	115 °C	5 V DC ± 5%
ERO 1200		≤ 25000 min^{-1}	–	100 °C	5 V DC ± 10%
ERO 1400		≤ 30000 min^{-1}	–	70 °C	5 V DC ± 10%
					5 V DC ± 5%
					5 V DC ± 10%

1) **Functional Safety** upon request
2) after internal 5/10/20/25-fold interpolation
3) Multiturn function buffered by external battery

	Incremental signals		Absolute position values			Model	More Information
	Output signals	**Signal periods per revolution**	**Positions per revolution**	**Distinguishable revolutions**	**Data interface**		
	∿ 1 V_{PP}	512	8192	–/4096	EnDat 2.2/01	**ECN 1113 / EQN 1125**	**Page 38**
	–	–	8388608		EnDat 2.2/**22**	**ECN 1123/EQN 1135**[1)]	
	⊓⊔TTL	500 to 8192	3 block commutation signals			**ERN 1123**	**Page 42**
	∿ 1 V_{PP}	512/2048/	8192	–/4096	EnDat 2.2/01	**ECN 1313/EQN 1325**	**Page 44**
	–	–	33554432		EnDat 2.2/**22**	**ECN 1325/EQN 1337**[1)]	
	⊓⊔TTL	1024/2048/4096	–			**ERN 1321**	**Page 46**
			3 block commutation signals			**ERN 1326**	
	∿ 1 V_{PP}	512/2048/4096	–			**ERN 1381**	
		2048	Z1 track for sine commutation			**ERN 1387**	
	∿ 1 V_{PP}	16	262144	–/4096	EnDat 2.1/01	**ECI 1118/EQI 1130**	**Page 48**
	–	–			EnDat 2.1 / 21		
				–	EnDat 2.2/**22**	**ECI 1118**	**Page 50**
				65536[3)]	EnDat 2.2/**22**	**EBI 1135**	**Product Info**
	∿ 1 V_{PP}	32	524288	–/ 4096	EnDat 2.1/01	**ECI 1319/EQI 1331**	**Page 52**
					EnDat 2.1 / 21		
	∿ 1 V_{PP}	32	524288	–	EnDat 2.1/01	**ECI 119**	**Page 54**
	–	–			EnDat 2.1 / 21		
	⊓⊔TTL	1024/2048	–			**ERO 1225**	**Page 56**
	∿ 1 V_{PP}					**ERO 1285**	
	⊓⊔TTL	512/1000/1024	–			**ERO 1420**	**Page 58**
	⊓⊔TTL	5000 to 37500[2)]				**ERO 1470**	
	∿ 1 V_{PP}	512/1000/1024				**ERO 1480**	

Selection Guide

Rotary Encoders and Angle Encoders for Integrated and Hollow-Shaft Motors

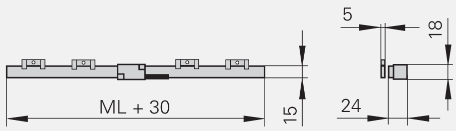
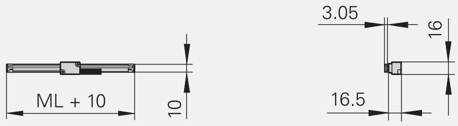
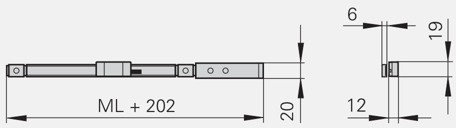
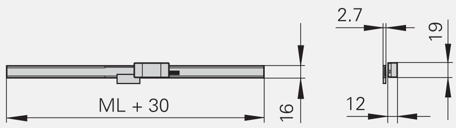
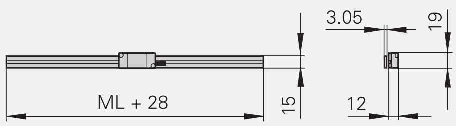
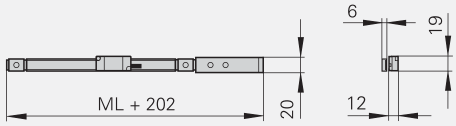
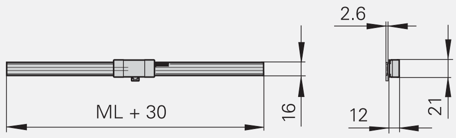
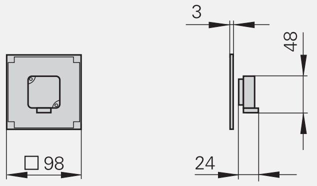
Series	Overall dimensions	Diameter	Mechanically permissible speed	Natural freq. of the stator connection	Maximum operating temperature
Angle encoders with integral bearing and integrated stator coupling					
RCN 2000		–	≤ 1500 min^{-1}	≥ 1000 Hz	*RCN 23xx:* 60 °C *RCN 25xx:* 50 °C
RCN 5000		–	≤ 1500 min^{-1}	≥ 1000 Hz	*RCN 53xx:* 60 °C *RCN 55xx:* 50 °C
RCN 8000		D: 60 mm and 100 mm	≤ 500 min^{-1}	≥ 900 Hz	50 °C
Angle encoders without integral bearing					
ERA 4000 Steel scale drum		D1: 40 to 512 mm D2: 76.75 to 560.46 mm	≤ 10000 min^{-1} to ≤ 1500 min^{-1}	–	80 °C
ERA 7000 For inside diameter mounting		D1: 458.62 mm 573.20 mm 1146.10 mm	≤ 250 min^{-1} ≤ 250 min^{-1} ≤ 220 min^{-1}	–	80 °C
ERA 8000 For outside diameter mounting		D1: 458.11 mm 572.72 mm 1145.73 mm	≤ 50 min^{-1} ≤ 50 min^{-1} ≤ 45 min^{-1}	–	80 °C
Modular encoders without integral bearing with magnetic graduation					
ERM 200		D1: 40 to 410 mm D2: 75.44 to 452.64 mm	≤ 19000 min^{-1} to ≤ 3000 min^{-1}	–	100 °C
ERM 2400		D1: 40/55 mm D2: 64.37/ 75.44 mm	≤ 42000 min^{-1}/ ≤ 36000 min^{-1}	–	100 °C
ERM 2900		D1: 55 mm D2: 77.41 mm	≤ 35000 min^{-1}		

1) Interfaces for Fanuc and Mitsubishi controls upon request

2) Segment solutions upon request

Power supply	System accuracy	Incremental signals		Absolute position values		Model	More Information
		Output signals	Signal periods per revolution	Positions per revolution	Data interface[1]		
3.6 to 14 V DC	± 5“ ± 2.5“	∿ 1 V_{PP}	16384	67108864 ≙ 26 bits 268435456 ≙ 28 bits	EnDat 2.2 / 02	**RCN 2380** **RCN 2580**	**Catalog:** ***Absolute Angle Encoders*** *with Optimized Scanning*
	± 5“ ± 2.5“	–	–	67108864 ≙ 26 bits 268435456 ≙ 28 bits	EnDat 2.2/22	**RCN 2310** **RCN 2510**	
3.6 to 14 V DC	± 5“ ± 2.5“	∿ 1 V_{PP}	16384	67108864 ≙ 26 bits 268435456 ≙ 28 bits	EnDat 2.2 / 02	**RCN 5380** **RCN 5580**	
	± 5“ ± 2.5“	–	–	67108864 ≙ 26 bits 268435456 ≙ 28 bits	EnDat 2.2/22	**RCN 5310** **RCN 5510**	
3.6 to 14 V DC	± 2“ ± 1“	∿ 1 V_{PP}	32768	536870912 ≙ 29 bits	EnDat 2.2 / 02	**RCN 8380** **RCN 8580**	
	± 2“ ± 1“	–	–		EnDat 2.2/22	**RCN 8310** **RCN 8510**	
5 V DC ± 10 %	–	∿ 1 V_{PP}	12000 to 52000	–		**ERA 4280 C**	**Catalog:** ***Angle Encoders*** *without Integral Bearing*
			6000 to 44000			**ERA 4480 C**	
			3000 to 13000			**ERA 4880 C**	
5 V DC ± 5 %	–	∿ 1 V_{PP}	**Full circle**[2] 36000/ 45000/ 90000	–		**ERA 7480 C**	
5 V DC ± 5 %	–	∿ 1 V_{PP}	**Full circle**[2] 36000/ 45000/ 90000	–		**ERA 8480 C**	
5 V DC ± 10 %	± 36“ to ± 9“	⊓⊔ TTL	600 to 3600	–		**ERM 220**	**Catalog:** ***Magnetic Modular Encoders***
		∿ 1 V_{PP}				**ERM 280**	
5 V DC ± 10 %	± 43“/± 36“	∿ 1 V_{PP}	512/600	–		**ERM 2484**	
	± 70“	∿ 1 V_{PP}	256	–		**ERM 2984**	

Selection Guide
Exposed Linear Encoders for Linear Drives

Series	**Overall dimensions**	**Traversing speed**	**Acceleration** in measuring direction	**Accuracy grade**
LIP 400		≤ 30 m/min	≤ 200 m/s^2	To ± 0.5 µm
LIF 400		≤ 72 m/min	≤ 200 m/s^2	± 3 µm
LIC 4000 Absolute linear encoder		≤ 480 m/min	≤ 500 m/s^2	± 5 µm
				± 5 µm[1)]
LIDA 400		≤ 480 m/min	≤ 200 m/s^2	± 5 µm
				± 5 µm[1)]
LIDA 200		≤ 600 m/min	≤ 200 m/s^2	± 30 µm
PP 200 Two-coordinate encoder		≤ 72 m/min	≤ 200 m/s^2	± 2 µm

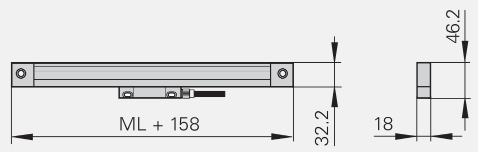
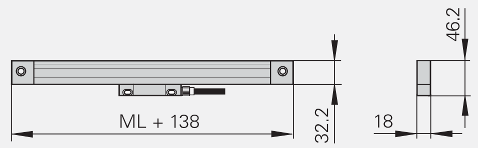
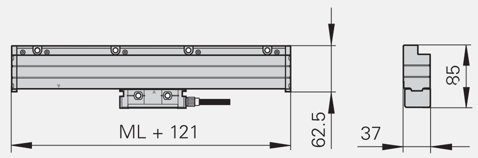
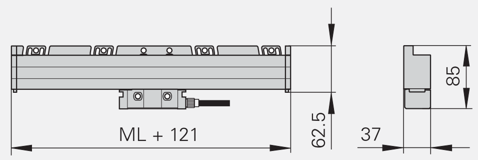
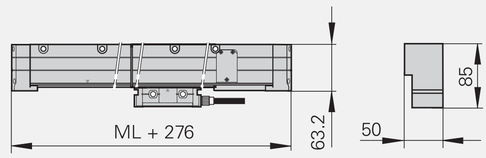
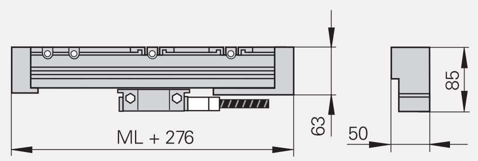
1) After linear error compensation

Measuring lengths	Power supply	Incremental signals		Absolute position values		Model	More Information
		Output signals/ signal period	Cutoff frequency –3 dB	Resolution	Data interface		
70 to 420 mm	5 V DC ± 5 %	∼ 1 V_{PP}/2 µm	≥ 250 kHz	–		**LIP 481**	**Catalog:** ***Exposed Linear Encoders***
70 to 1020 mm	5 V DC ± 5 %	∼ 1 V_{PP}/4 µm	≥ 300 kHz	Homing track Limit switches		**LIF 481**	
140 to 27040 mm	3.6 to 14 V DC	–	–	0.001 µm (1 nm)	EnDat 2.2/22	**LIC 4015**	
140 to 6040 mm						**LIC 4017**	
140 to 30040 mm	5 V DC ± 5 %	∼ 1 V_{PP}/20 µm	≥ 400 kHz	Limit switches		**LIDA 485**	
240 to 6040 mm						**LIDA 487**	
Up to 10000 mm	5 V DC ± 5 %	∼ 1 V_{PP}/200 µm	≥50 kHz	–		**LIDA 287**	
Measuring range 68 mm x 68 mm	5 V DC ± 5 %	∼ 1 V_{PP}/4 µm	≥ 300 kHz	–		**PP 281**	

Selection Guide

Sealed Linear Encoders for Linear Drives

Protection: IP 53 to IP 64[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/s^2	≥ 2000 Hz	50 to 1220 mm
LC Absolute linear encoder		≤ 180 m/min	≤ 100 m/s^2	≥ 2000 Hz	70 to 2040 mm[3]
Linear encoders with full-size scale housing					
LF		≤ 60 m/min	≤ 100 m/s^2	≥ 2000 Hz	140 to 3040 mm
LC Absolute linear encoder		≤ 180 m/min	≤ 100 m/s^2	≥ 2000Hz	140 to 4240 mm 140 to 3040 mm
		≤ 120 m/min (180 m/min upon request)	≤ 100 m/s^2	≥ 780 Hz	4240 to 28040 mm
LB		≤ 120 m/min (180 m/min upon request)	≤ 60 m/s^2	≥ 650 Hz	440 to 30040 mm

[1] After installation according to mounting instructions
[2] Interfaces for Fanuc and Mitsubishi controls upon request
[3] As of 1340 mm measuring length only with mounting spar or tensioning elements

Accuracy grade	Power supply	Incremental signals		Absolute position values		Model	More Information
		Output signals/ signal period	Cutoff frequency –3 dB	Resolution	Data interface[2)]		
± 5 µm	5 V DC ± 5 %	∼ 1 V_{PP}/4 µm	≥ 250 kHz	–		**LF 485**	**Product Info** ***LF 185*** ***LF 485***
± 5 µm	3.6 to 14 V DC	–	–	To 0.01 µm	EnDat 2.2/22	**LC 415**	**Product Info** ***LC 115*** ***LC 415***
± 3 µm				To 0.001 µm			
± 2 µm; ± 3 µm	5 V DC ± 5 %	∼ 1 V_{PP}/4 µm	≥ 250 kHz	–		**LF 185**	**Product Info** ***LF 185*** ***LF 485***
± 5 µm	3.6 to 14 V DC	–	–	To 0.01 µm	EnDat 2.2/22	**LC 115**	**Product Info** ***LC 115*** ***LC 415***
± 3 µm				To 0.001 µm			
± 5 µm	3.6 to 14 V DC	–	–	To 0.01 µm	EnDat 2.2/22	**LC 211**	**Product Info** ***LC 200***
		∼ 1 V_{PP}/40 µm	≥ 250 kHz		EnDat 2.2/02	**LC 281**	
To ± 5 µm	5 V DC ± 5 %	∼ 1 V_{PP}/40 µm	≥ 250 kHz	–		**LB 382**	**Catalog:** ***Linear Encoders*** *for Numerically Controlled Machine Tools*

Rotary Encoders and Angle Encoders for Three-Phase AC and DC Motors
General Information

Speed stability
To ensure **smooth drive performance**, an encoder must provide a **large number of measuring steps per revolution.** The encoders in the HEIDENHAIN product program are therefore designed to supply the necessary numbers of signal periods per revolution to meet the speed stability requirement.

HEIDENHAIN rotary and angular encoders featuring integral bearings and stator couplings provide very good performance: shaft misalignment within certain tolerances (see *Specifications*) do not cause any position error or impair speed stability.

At low speeds, the **position error of the encoder within one signal period** affects speed stability. 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
To ensure the best possible dynamic performance with digitally controlled motors, the sampling time of the speed controller should not exceed approx. 256 µm. The feedback values for the position and speed controller must therefore be available in the controlling system with the least possible delay.

High clock frequencies are needed to fulfill such demanding time requirements on position values transfer from the encoder to the controlling system with a serial data transmission (see also *Interfaces; Absolute Position Values*). HEIDENHAIN encoders for electric drives therefore provide the position values via the fast, purely serial EnDat 2.2 interface, or transmit additional **incremental signals,** which are available immediately for use in the subsequent electronics for speed and position control.

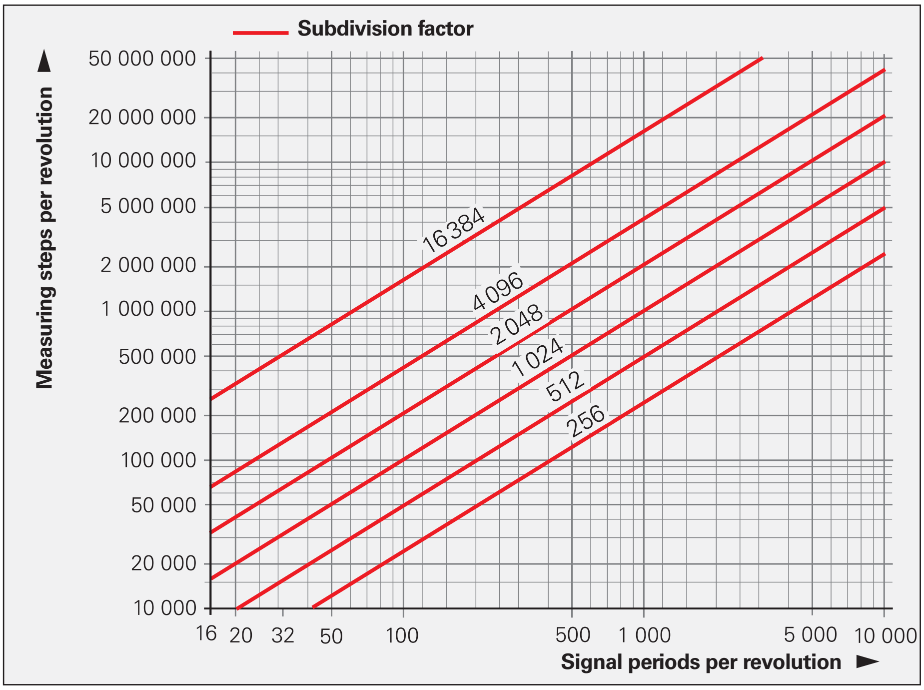
For **standard drives,** manufacturers primarily use HEIDENHAIN absolute encoders without integral bearing (ECI/EQI) or rotary encoders with **TTL** or **HTL compatible output signals**—as well as additional commutation signals for permanent-magnet DC drives.

For **digital speed control** on machines with **high requirements for dynamics,** a large number of measuring steps is required—usually above 500000 per revolution.

For applications with standard drives, as with resolvers, approx. 60000 measuring steps per revolution are sufficient.

HEIDENHAIN encoders for drives with digital position and speed control therefore provide **sinusoidal incremental signals with signal levels of 1 V_{PP}** which, thanks to their high quality, can be highly interpolated in the subsequent electronics (Diagram 1 below). For example, a rotary encoder with 2048 signal periods per revolution and a 1024-fold or 4096-fold subdivision in the subsequent electronics produces approx. **2 or 8 million measuring steps per revolution,** respectively. This corresponds to a resolution of 21 (23) bits. Even at shaft speeds of 12000 min^{-1}, the signal arrives at the input circuit of the controlling system with a frequency of only approx. 400 kHz (Diagram 2). 1-V_{PP} incremental signals permit cable lengths up to 150 m.
(See also *Incremental Signals – 1 V_{PP}*)

Diagram 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 also supply additional sinusoidal incremental signals with the same characteristics as those described above. Absolute encoders from HEIDENHAIN use the EnDat interface (for **En**coder **Dat**a) for the **serial data transmission** of absolute position values and other information for **automatic self-configuration, monitoring and diagnosis.** (See *Absolute Position Values – EnDat*.) This makes it possible to use the same subsequent electronics and cabling technology for all HEIDENHAIN encoders.

Important encoder specifications can be read from the memory of the EnDat encoder for automatic self-configuration, and motor-specific parameters can be saved in the OEM memory area of the encoder. The usable size of the OEM memory on the rotary encoders in the current catalogs is at least 1.4 KB (≙ 704 EnDat words); for the ATEX encoders it is 0.44 KB (≙ 224 EnDat words).

Most absolute encoders themselves already subdivide the sinusoidal scanning signals by a factor of 4096 or greater. If the transmission of absolute positions is fast enough (for example, EnDat 2.1 with 2 MHz or EnDat 2.2 with 8 MHz clock frequency), 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 EnDat2.2 interface offer the additional feature of being able to evaluate an external temperature sensor, located in the motor coil, for example. 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 drives for command response and control reliability, are sometimes limited by the rigidity of the coupling between the motor shaft and encoder shaft as well as by the natural frequency of the coupling. HEIDENHAIN therefore offers rotary and angular encoders for high-rigidity shaft coupling. The stator couplings mounted on the encoders have a **high natural frequency** up to 2 kHz. For the modular and inductive rotary encoders, the stator and rotor are firmly screwed to the motor housing and to the shaft. This means that the rigidity of the motor shaft is of the most significance for the attainable natural frequency. (See also *Mechanical Design and Installation.*)

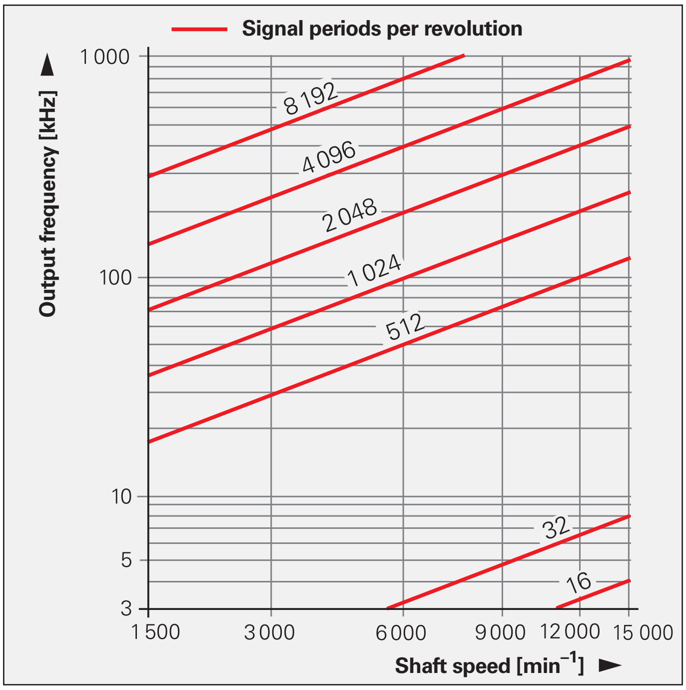
Size

A higher permissible operating temperature permits a smaller motor size for a specific rated torque. Since the temperature of the motor also affects the temperature of the encoder, HEIDENHAIN offers encoders for **permissible operating temperatures up to 120 °C.** These encoders make it possible to design machines with smaller motors.

Power loss and quietness

The power loss of the motor, the accompanying heat generation, and the acoustic noise during operation are influenced by the position error of the encoder within one signal period. For this reason, encoders with a high signal quality of better than ± 1 % of the signal period are preferred. (See also *Measuring Accuracy.*)

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



Linear Encoders for Linear Drives
General Information

Selection criteria for linear encoders
HEIDENHAIN recommends the use of **exposed linear encoders** whenever the severity of contamination inherent in a particular machine environment does not preclude the use of optical measuring systems, and if relatively high accuracy is desired, e.g. for high-precision machine tools and measuring equipment, or for production, testing and inspecting equipment in the semiconductor industry.

Particularly for applications on machine tools that release coolants and lubricants, HEIDENHAIN recommends **sealed linear encoders.** Here the requirements on the mounting surface and on machine guideway accuracy are less stringent than for exposed linear encoders, and therefore installation is faster.

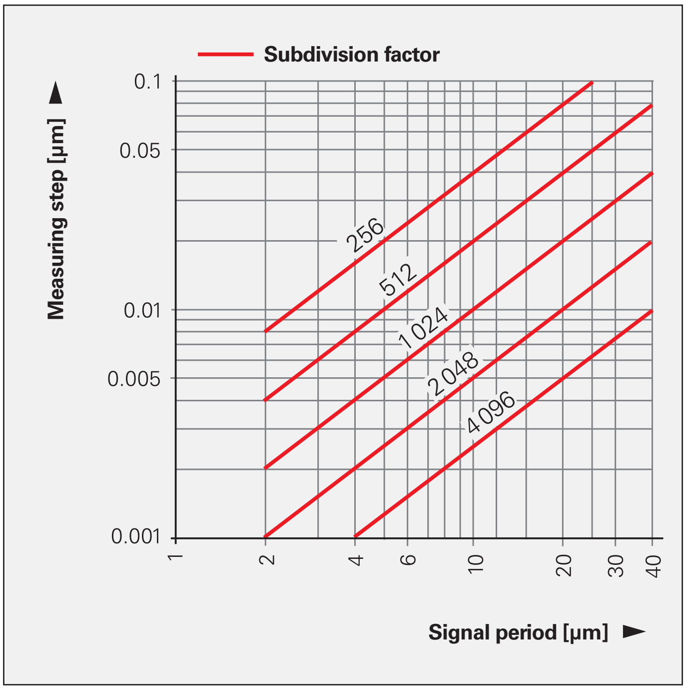
Speed stability
To ensure smooth-running servo performance, the linear encoder must permit a resolution commensurate with the given speed control range:
- On handling equipment, resolutions in the range of several microns are sufficient.
- Feed drives for machine tools need resolutions of 0.1 µm and finer.
- Production equipment in the semiconductor industry requires resolutions of a few nanometers.

At low traversing speeds, the **position 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 function without 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.

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

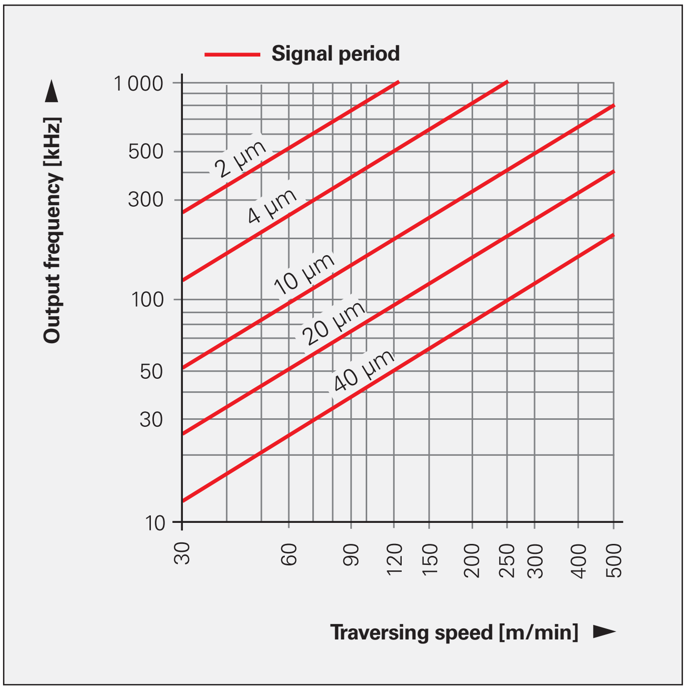
Signal period and resulting measuring step
as a function of the subdivision factor



Transmission of measuring signals
The information above on rotary and angle encoder signal transmission essentially applies also to linear encoders. If, for example, one wishes to traverse at a minimum velocity of 0.01 m/min with a sampling time of 250 µs, and if one assumes that the measuring step should change by at least one measuring step per sampling cycle, then one needs a measuring step of approx. 0.04 µm. To avoid the need for special measures in the subsequent electronics, input frequencies should be limited to less than 1 MHz. Linear encoders with **sinusoidal output signals** or absolute position values according to **EnDat 2.2** are best suited for high traversing speeds and small measuring steps. In particular, sinusoidal voltage signals with levels of **1 V_{PP}** attain a –3 dB cutoff frequency of approx. 200 kHz and more at a permissible cable length of up to 150 m.

The figure below illustrates the relationship between output frequency, traversing speeds, and signal periods of linear encoders. Even at a signal period of 4 µm and a traversing velocity of 70 m/min, the frequency reaches only 300 kHz.

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



Bandwidth
On linear motors, a coupling lacking in rigidity can limit the bandwidth of the position control loop. The manner in which the linear encoder is mounted on the machine has a very significant influence on the rigidity of the coupling. (See *Design Types and Mounting*.)

On sealed linear encoders, the scanning unit is guided along the scale. A coupling connects the scanning carriage with the mounting block and compensates the misalignment between the scale and the machine guideways. This permits relatively large mounting tolerances. The coupling is very rigid in the measuring direction and is flexible in the perpendicular direction. If the coupling is insufficiently rigid in the measuring direction, it could cause low natural frequencies in the position and velocity control loops and limit the bandwidth of the drive.

The sealed linear encoders recommended by HEIDENHAIN for linear motors generally have a **natural frequency of coupling greater than 650 Hz or 2 kHz in the measuring direction,** which in most applications exceeds the mechanical natural frequency of the machine and the bandwidth of the velocity control loop by factors of at least 5 to 10. HEIDENHAIN linear encoders for linear motors therefore have practically no limiting effect on the position and speed control loops.

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

Safety-Related Position Measuring Systems

With the designation **Functional Safety**, HEIDENHAIN offers safety-related position measuring systems that are based on pure serial data transfer via EnDat 2.2 and can be used in safety-oriented applications. A safety-related position measuring system can be used as a single-encoder system in conjunction with a safe control in applications with control category SIL-2 (according to EN 61508/EN 61800-5-2) or performance level "d" (according to EN ISO 13849). Reliable transmission of the position is based on two independently generated absolute position values and on error bits. These are then provided to the safe control.

Basic principle
HEIDENHAIN measuring systems for safety-oriented 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. These standards describe the assessment of safety-oriented systems, for example based on the failure probabilities of integrated components and subsystems.
This modular approach helps manufacturers of safety-oriented systems to implement their complete systems, because they can begin with subsystems that have already been qualified. Safety-related position measuring systems with purely serial data transmission via EnDat 2.2 accommodate this technique. In a safe drive, the safety-related position measuring system is such a subsystem. A **safety-related position measuring system** consists of:

- 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)

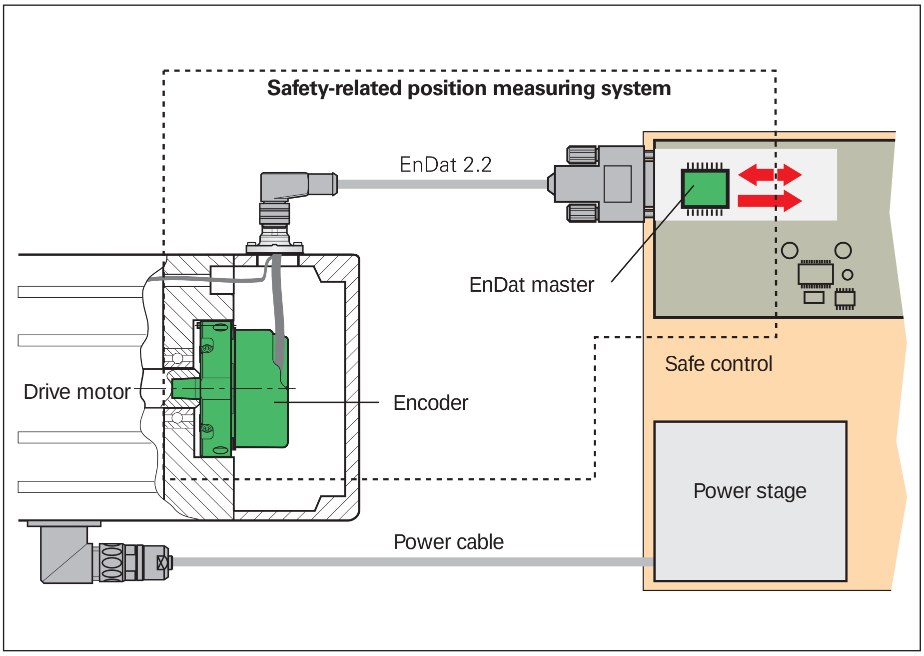
In practice, the **complete "safe servo drive" system** consists of:

- Safety-related position measuring system
- Safety-oriented control (including EnDat master with monitoring functions)
- Power stage with motor power cable and drive
- Physical connection between encoder and drive (e.g. shaft connection/coupling)

Field of application
Safety-related position measuring systems from HEIDENHAIN are designed so that they can be used as single-encoder systems in applications with control category SIL-2 (according to EN 61508). This corresponds to performance level "d" of EN ISO 13849 or category 3 (according to EN 954-1). Also, the functions of the safety-related position measuring system can be used for the safety functions in the complete system (also see EN 61800-5-2) as listed in the table below:

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 according to EN 61 800-5-2



Complete safe drive system

Function
The safety strategy of the position measuring system is based on two mutually independent position values and additional error bits produced in the encoder and transmitted over the EnDat 2.2 protocol to the EnDat master. The EnDat master assumes various monitoring functions with which errors in the encoder and during transmission can be revealed. The two position values are then compared. The EnDat master then makes the data available to the safe control. The control periodically tests the safety-related position measuring system to monitor its correct operation.

The architecture of the EnDat 2.2 protocol makes it possible to process all safety-relevant information and control mechanisms during unconstrained controller operation. This is possible because the safety-relevant information is saved in the additional information. According to EN 61508, the architecture of the position measuring system is regarded as a single-channel tested system.

Documentation on the integration of the position measuring system

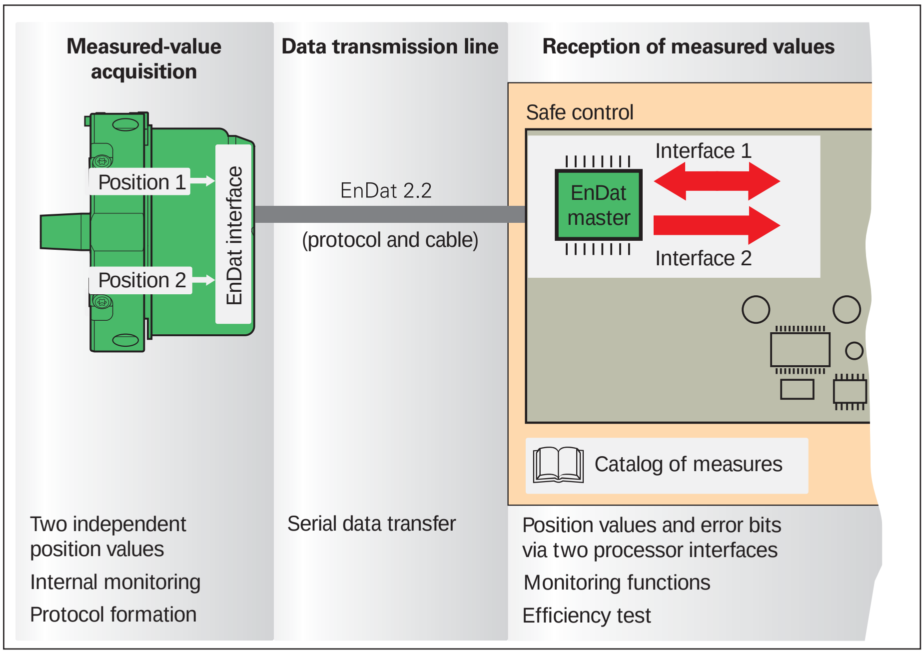
The intended use of position measuring systems places demands on the control, the machine designer, the installation technician, service, etc. The necessary information is provided in the documentation for the position measuring systems.

In order to be able to implement a position measuring system in a safety-oriented application, a suitable control is required. The control assumes the fundamental task of communicating with the encoder and safely evaluating the encoder data.

The requirements for integrating the EnDat master with monitoring functions in the safe control are described in the document **"Specification of the E/E/PES safety requirements for the EnDat master and measures for safe control" (document 533095)**. It contains, for example, specifications on the evaluation and processing of position values and error bits, and on electrical connection and cyclic tests of position measuring systems.

Machine and plant manufacturers need not attend to these details. These functions must be provided by the control. Product information sheets, catalogs and mounting instructions provide information to aid the selection of a suitable encoder. The **product information sheets** and **catalogs** contain general data on function and application of the encoders as well as specifications and permissible ambient conditions. The **mounting instructions** provide detailed information on installing the encoders.

The architecture of the safety system and the diagnostic possibilities 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 is obliged to inform the installation technician and service technicians, for example, of the resulting requirements.



Safety-related position measuring system

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.

Measuring Principles
Measuring Standard

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

HEIDENHAIN manufactures the precision graduations in specially developed, photolithographic processes.
- AURODUR: matte-etched lines on gold-plated steel tape with typical graduation period of 40 µm
- METALLUR: contamination-tolerant graduation of metal lines on gold, with typical graduation period of 20 µm
- DIADUR: extremely robust chromium lines on glass (typical graduation period of 20 µm) or three-dimensional chrome structures (typical graduation period of 8 µm) on glass
- SUPRADUR phase grating: optically three dimensional, planar structure; particularly tolerant to contamination; typical graduation period of 8 µm and less
- OPTODUR phase grating: optically three dimensional, planar structure with particularly high reflectance, typical graduation period of 2 µm and less.

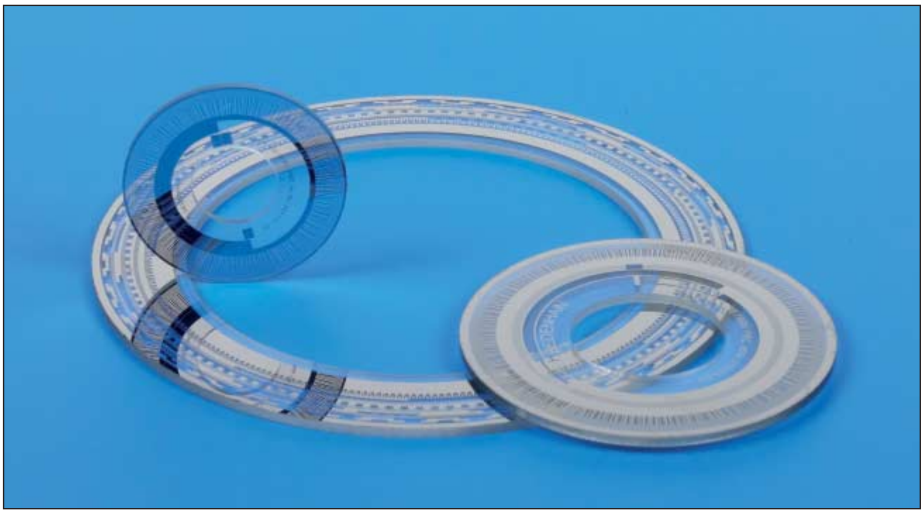
Magnetic encoders use a graduation carrier of magnetizable steel alloy. A graduation consisting of north poles and south poles is formed with a grating period of 400 µm. Due to the short distance of effect of electromagnetic interaction, and the very narrow scanning gaps required, finer magnetic graduations are not practical.

Encoders using the inductive scanning principle have graduation structures of copper. The graduation is applied to a carrier material for printed circuits.

With the **absolute measuring method,** the position value is available from the encoder immediately upon switch-on and can be called at any time by the subsequent electronics. There is no need to move the axes to find the reference position. The absolute position information is read from the **grating on the circular scale,** which is designed as a serial 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 at the same time is used to generate an optional incremental signal.

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



Circular graduations of absolute rotary encoders

With the **incremental measuring method**, the graduation consists of a periodic grating structure. The position information is obtained **by counting** the individual increments (measuring steps) from some point of origin. Since an absolute reference is required to ascertain positions, the graduated disks are provided with an additional track that bears a **reference mark**.

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

The reference mark must therefore be scanned to establish an absolute reference or to find the last selected datum.

Circular graduations of incremental rotary encoders

Scanning Methods

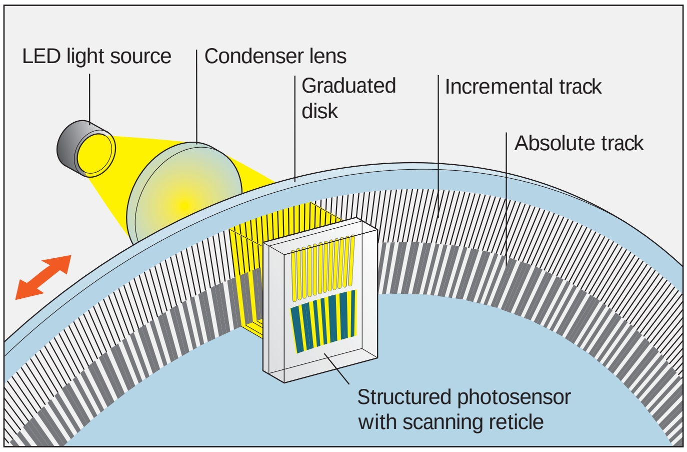
Photoelectric scanning
Most HEIDENHAIN encoders operate using the principle of photoelectric scanning. Photoelectric scanning of a measuring standard is contact-free, and as such, free of wear. This method detects even very fine lines, no more than a few microns wide, and generates output signals with very small signal periods.

The ERN, ECN, EQN, ERO and ROD, RCN, RQN rotary encoders use the imaging scanning principle.

Put simply, the imaging scanning principle functions by means of projected-light signal generation: two graduations with equal or similar grating periods are moved relative to each other—the scale and the scanning reticle. The carrier material of the scanning reticle is transparent, whereas the graduation on the measuring standard may be applied to a transparent or reflective surface.

When parallel light passes through a grating, light and dark surfaces are projected at a certain distance. An index grating with the same or similar grating period is located here. When the two gratings move in relation 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. A structured photosensor or photovoltaic cells convert these variations in light intensity into nearly sinusoidal electrical signals. Practical mounting tolerances for encoders with the imaging scanning principle are achieved with grating periods of 10 µm and larger.

The ECN and EQN absolute rotary encoders with optimized scanning have a single large photosensor instead of a group of individual photoelements. Its structures have the same width as that of the measuring standard. This makes it possible to do without the scanning reticle with matching structure.



Photoelectric scanning according to the imaging scanning principle

Other scanning principles
Some encoders function according to other scanning methods. ERM encoders use a permanently magnetized MAGNODUR graduation that is scanned with magne-toresistive sensors.

ECI/EQI/EBI rotary encoders operate according to the inductive measuring principle. Here, moving graduation structures modulate a high-frequency signal in its amplitude and phase. The position value is always formed by sampling the signals of all receiver coils distributed evenly around the circumference.

Electronic Commutation with Position Encoders

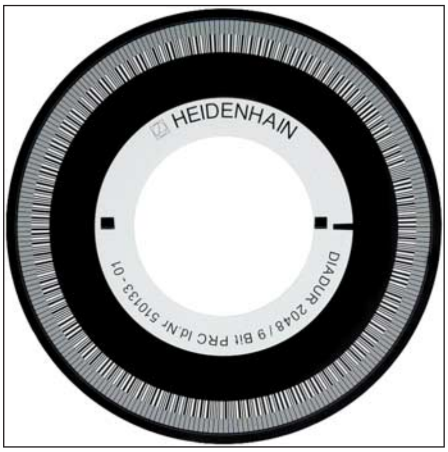
Commutation in permanent-magnet three-phase motors
Before start-up, permanent-magnet three-phase motors must have an absolute position value available for electrical commutation. HEIDENHAIN rotary encoders are available with different types of rotor position recognition:

- **Absolute rotary encoders** in singleturn and multiturn versions provide the absolute position information immediately after switch-on. This makes it immediately possible to derive the exact position of the rotor and use it for electronic commutation.

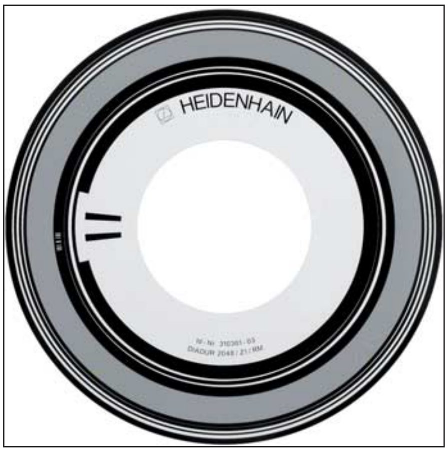
- **Incremental rotary encoders with** a second track—the **Z1 track**—provide one sine and one cosine signal (C and D) for each motor shaft revolution in addition to the incremental signals. For sine commutation, rotary encoders with a Z1 track need only a subdivision unit and a signal multiplexer to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

- **Incremental rotary encoders with block commutation tracks** also output three commutation signals U, V and W. which are used to drive the power electronics directly. These encoders are available with various commutation tracks. Typical versions provide 3 signal periods (120° mech.) or 4 signal periods (90° mech.) per commutation and revolution. Independently of these signals, the incremental square-wave signals serve for position and speed control. (See also *Interfaces—Commutation signals.*)

Commutation of synchronous linear motors
Like absolute rotary and angular encoders, absolute linear encoders of the LIC and LC series provide the exact position of the moving motor part immediately after switch-on. This makes it possible to start with maximum holding load on vertical axes even at a standstill.



Circular scale with serial code track and incremental track



Circular scale with Z1 track

Circular scale with block commutation tracks

Keep in mind the switch-on behavior of the encoders (see *General Electrical Information*).

Measuring Accuracy

The quantities influencing the accuracy of **linear encoders** are listed in the *Linear Encoders for Numerically Controlled Machine Tools* and *Exposed Linear Encoders* catalogs.

The **accuracy of angular measurement** is mainly determined by:

1. Quality of the graduation
2. Scanning quality
3. Quality of the signal processing electronics
4. Eccentricity of the graduation to the bearing
5. Error due to radial error of the bearing
6. Elasticity of the encoder shaft and coupling with the drive shaft
7. Elasticity of the stator coupling (ERN, ECN, EQN) or shaft coupling (ROD, ROC, ROQ)

In positioning tasks, the accuracy of the angular measurement determines the accuracy of the positioning of a rotary axis. The **system accuracy** given in the Specifications applies to a temperature of 20 °C, and is defined as follows:
The extreme values of the total deviations of a position are—referenced to their mean value—within the system accuracy ± a.

- For rotary encoders with integral bearing and integrated stator coupling, this value also includes the deviation due to the shaft coupling.
- For rotary encoders with integral bearing and separate shaft coupling, the angle error of the coupling must be added.
- For rotary encoders without integral bearing, deviations resulting from mounting, from the bearing of the drive shaft, and from adjustment of the scanning head must be expected in addition to the system error (see next page).

The system accuracy reflects position errors within one revolution as well as those within one signal period.

Position error within one revolution becomes apparent in larger angular motions.

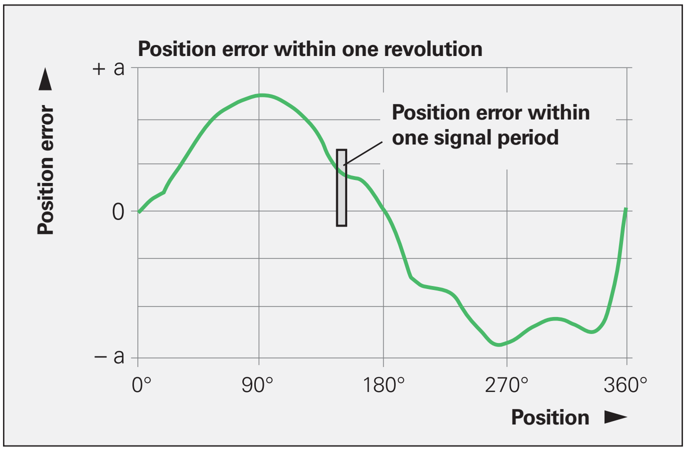
Position errors within one signal period already become apparent in very small angular motions and in repeated measurements. They especially lead to speed ripples in the rotational-speed control loop. HEIDENHAIN rotary encoders with integral bearing permit interpolation of the sinusoidal output signal with subdivision accuracies of better than ± 1 % of the signal period.

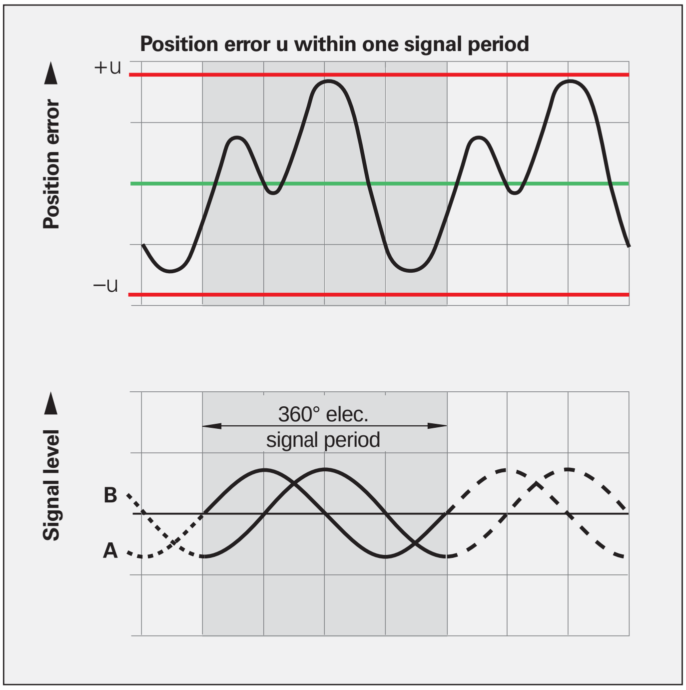
Example
Rotary encoder with 2048 sinusoidal signal periods per revolution:
One signal period corresponds to approx. 600". This results in maximum position deviations within one signal period of approx. ± 6".

The position error of the encoder within one signal period always affects the calculation of the actual speed on the basis of the actual position values of two successive sampling cycles. The position error of the encoder within one revolution is relevant for the speed control loop only if no more than a few actual position values per revolution are being evaluated. For example: a sampling time of 250 µs and a speed of n ≈ 12000 min^{-1} result in only 20 samples per revolution.

Temperatures as high as 120 °C, which can typically be found in motors, cause only a very small position error in HEIDENHAIN encoders.

Encoders with square-wave output signals have a position error of approx. ± 3 % of the signal period. These signals are suitable for up to 100-fold phase-locked loop subdivision.





Measuring Accuracy
Rotary Encoders without Integral Bearing

Rotary Encoders with Photoelectric Scanning

In addition to the system accuracy, the mounting and adjustment of the scanning head normally have a significant effect on the accuracy that can be achieved by rotary encoders without integral bearings with photoelectric scanning. Of particular importance are the mounting eccentricity of the graduation and the radial runout of the measured shaft.

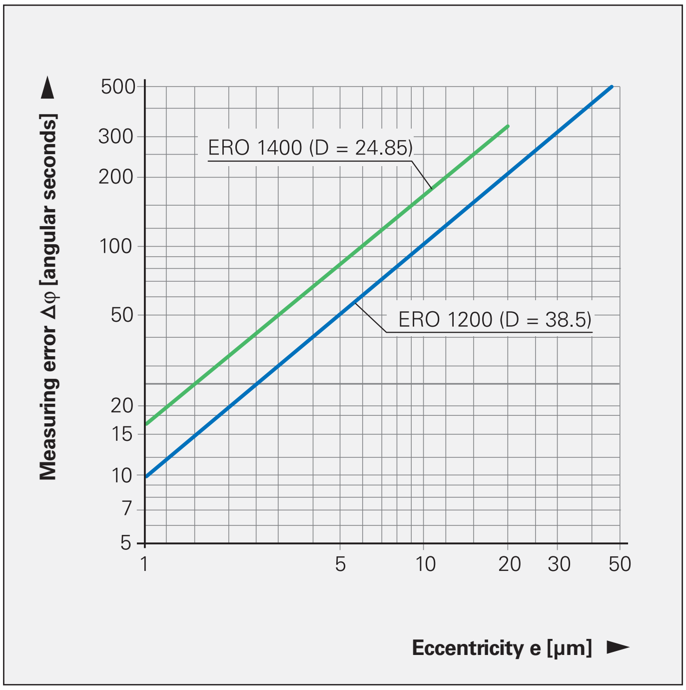
Example
ERO 1420 rotary encoder with a mean graduation diameter of 24.85 mm:
A radial runout of the measured shaft of 0.02 mm results in a position error within one revolution of ± 330 angular seconds.

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

1. Directional deviations of the graduation
ERO: The extreme values of the directional deviation with respect to their mean value are shown in the *Specifications* as the graduation accuracy for each model. The graduation accuracy and the position error within a signal period comprise the system accuracy.

2. Errors due to eccentricity of the graduation to the bearing
Under normal circumstances, the bearing will have a certain amount of radial deviation or geometric error after the disk/hub assembly is mounted. When centering using the centering collar of the hub, please note that, for the encoders listed in this catalog, HEIDENHAIN guarantees an eccentricity of the graduation to the centering collar of under 5 µm. For the modular rotary encoders, this accuracy value presupposes a diameter deviation of zero between the drive shaft and the "master shaft."

If the centering collar is centered on the bearing, then in a worst-case situation both eccentricity vectors could be added together.



Resultant measured deviations Δφ for various eccentricity values e as a function of graduation diameter D

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

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

Δφ = Measuring error in ” (angular seconds)
e = Eccentricity of the radial grating to the bearing in µm
D = Graduation centerline 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. Error due to radial error of the bearing
The equation for the measuring errorΔφ is also valid for radial deviation of the bearing if the value e is replaced with the eccentricity value, i.e. half of the radial deviation (half of the displayed value).
Bearing compliance to radial shaft loading causes similar errors.

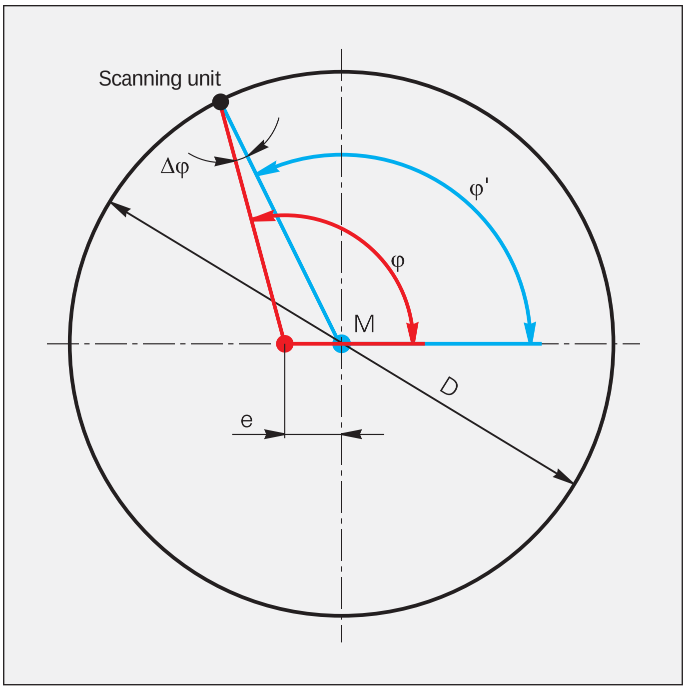
4. Position error within one signal period $\Delta\varphi_u$
The scanning units of all HEIDENHAIN encoders are adjusted so that without any further electrical adjustment being necessary while mounting, the maximum position error values within one signal period will not exceed the values listed below.

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

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

Rotary Encoders with Inductive Scanning

For rotary encoders without integrated bearing with inductive scanning, the attainable accuracy depends on the power supply, the temperature, the rotational speed, the working gap between the rotor and stator, and on the mounting conditions. Further information is available upon request.



Measuring errorΔφ as a function of the mean graduation diameter D and the eccentricity e

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

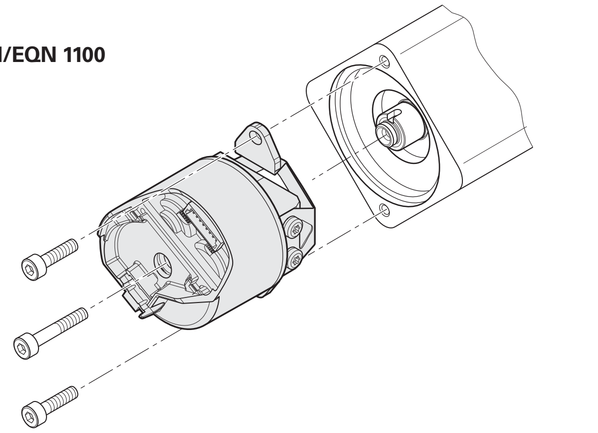
Mechanical Design Types and Mounting
Rotary Encoders with Integral Bearing and Stator Coupling

ECN/EQN/ERN rotary encoders have integrated bearings and a mounted stator coupling. The encoder shaft is directly connected with the shaft to be measured. During angular acceleration of the shaft, the stator coupling must absorb only that torque caused by friction in the bearing. ECN/EQN/ERN rotary encoders therefore provide excellent dynamic performance and a high natural frequency.

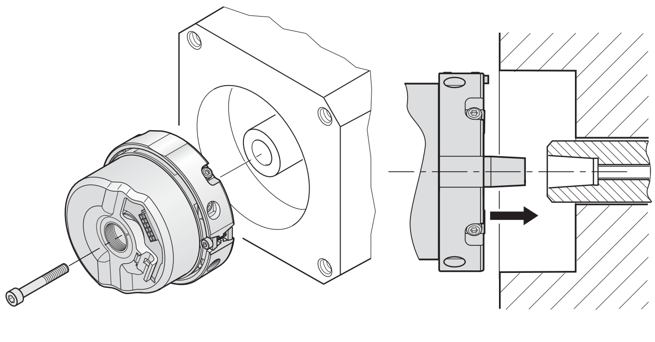
Benefits of the stator coupling:
- No axial mounting tolerances between shaft and stator housing for ExN 1300 and ExN 1100
- High natural frequency of the coupling
- High torsional rigidity of shaft coupling
- Low mounting or installation space requirement
- Simple installation

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

ECN/EQN 1100



ECN/EQN/ERN 1300



Mounting accessories for ExN 1300

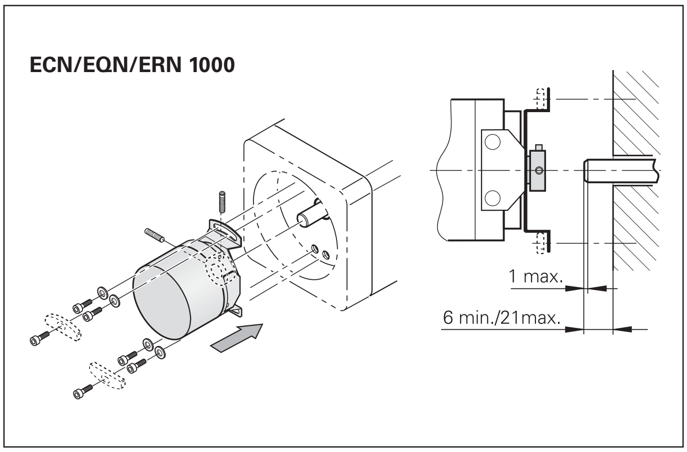
Checking the shaft connection
HEIDENHAIN recommends checking the holding torque of frictional connections (e.g. taper shaft, blind hollow shaft) for 20-fold safety. This is required for functional safety.

The testing tool is screwed in the M10 back-off thread on the back of the encoder. Due to the low screwing depth it does not touch the shaft-fastening screw. When the shaft is locked, the testing torque is applied to the extension by a torque wrench (hexagonal 6.3 mm width across flats). After any nonrecurring settling, there must not be any relative motion between the motor shaft and encoder shaft.

Inspection tool
ID 680644-01

Mounting the ECN/EQN/ERN 1000 and ERN 1x23
The rotary encoder is slid by its hollow shaft onto the measured shaft and fastened by two screws or three eccentric clamps. The stator is mounted without a centering flange to a flat surface with four cap screws or with 2 cap screws and special washers.

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



Accessory ECN/EQN/ERN 1000

Washer
For increasing the natural frequency f_E and mounting with only two screws.
ID 334653-01 (2 pieces)

Mounting accessories

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

Width across flats	Length	ID
1,5	70 mm	350378-01
1.5 (ball head)		350378-02
2		350378-03
2 (ball head)		350378-04
2,5		350378-05
3 (ball head)		350378-08
4		350378-07
4 (with dog point)[1]		350378-14
TX8	89 mm 152 mm	350378-11 350378-12

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

Extraction tool
For pulling off the PCB connector in the ERN 1123
ID 592818-01

Screwdriver
Adjustable torque
0.2 Nm to 1.2 Nm ID 350379-04
1 Nm to 5 Nm ID 350379-05

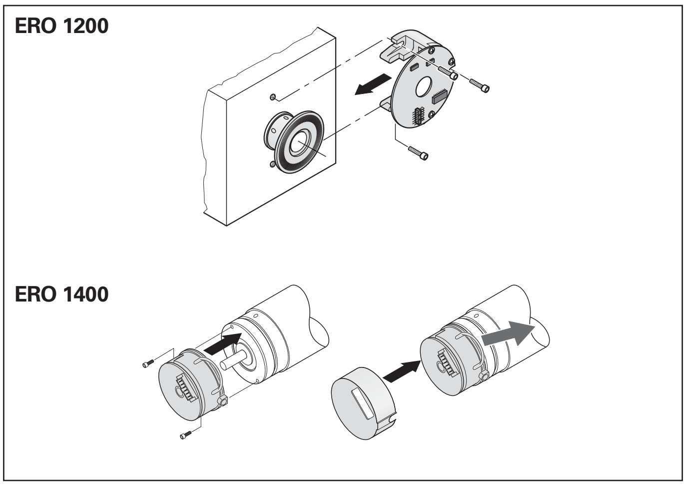
Mechanical Design Types and Mounting
Rotary Encoders without Integral Bearing

The **ERO, ECI/EQI** rotary encoders without integral bearing consist of a scanning head and a graduated disk, which must be adjusted to each other very exactly. A precise adjustment is an important factor for the attainable measuring accuracy.

The **ERO** modular rotary encoders consist of a graduated disk with hub and a scanning unit. They are particularly well suited for applications with limited installation space and negligible 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 adjusted to the scanning unit. The scanning unit is aligned on a centering collar and fastened on the mounting surface.

The **ERO 1400** series consists of miniature modular encoders. These rotary encoders have a special built-in **mounting aid** that centers the graduated disk to the scanning unit and adjusts the gap between the disk and the scanning reticle. This makes it possible to install the encoder in a very short time. The encoder is supplied with a cover cap for protection from extraneous light.



Mounting the **ERO**

Mounting accessories for ERO1400

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

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

Mounting accessories for **ERO 1400**

Special mounting information is to be considered for the **ECI/EQI** inductive rotary encoder without integral bearing. Special mounting training is required.

The **ECI 119** rotary encoder is prealigned on a flat surface and then the locked hollow shaft is slid onto the measured shaft. The encoder is fastened and the shaft clamped by axial screws.

Mounting the **ECI 119**

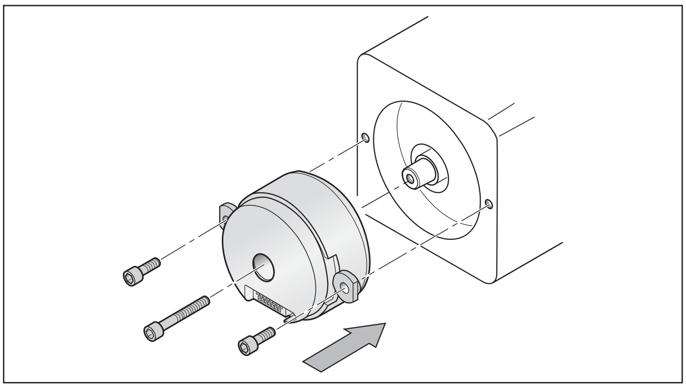
The **ECI/EQI 1100** inductive rotary encoders are mounted as far as possible in axial direction. The blind hollow shaft is attached with a central screw. The stator of the encoder is clamped against a shoulder by two axial screws.

The scanning gap between the rotor and stator is predetermined by the mounting situation. Retroactive adjustment is not possible.

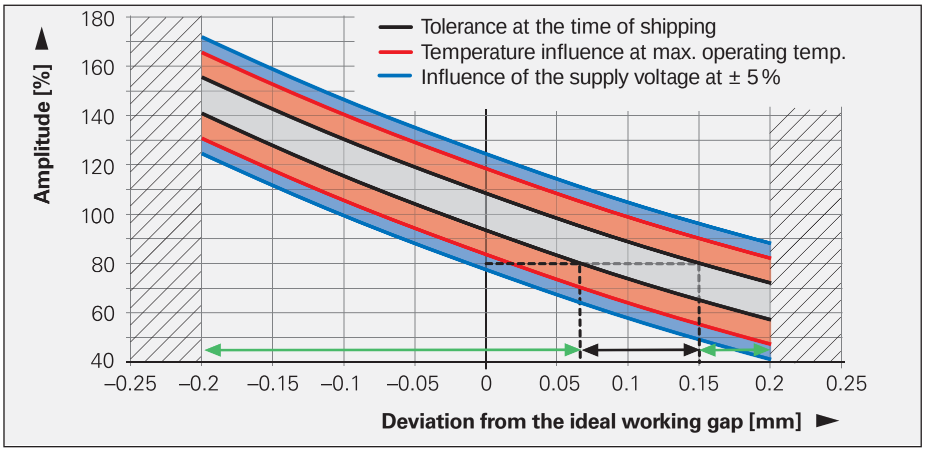
The maximum permitted deviation indicated in the mating dimensions applies to mounting as well as to operation. Tolerances used during mounting are therefore not available for axial motion of the shaft during operation.

Once the encoder has been mounted, the actual working gap between the rotor and stator can be measured indirectly via the signal amplitude in the rotary encoder, using the adjusting and testing package. The characteristic curves show the correlation between the signal amplitude and the deviation from the ideal scanning gap, depending on various ambient conditions.

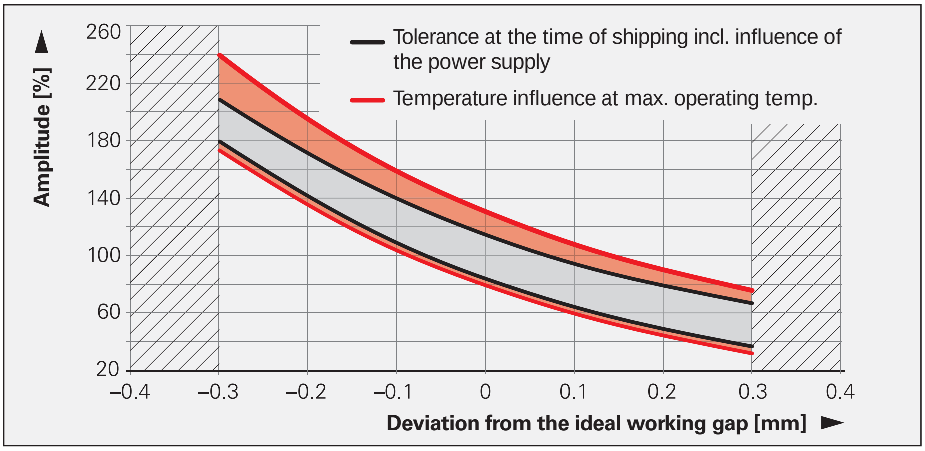
The example of ECI/EQI 1100 shows the resulting deviation from the ideal scanning gap for a signal amplitude of 80 % at ideal conditions. Due to tolerances within the rotary encoder, the deviation is between +0.07 mm and +0.15 mm. This means that the maximum permissible motion of the drive shaft during operation is between –0.27 mm and +0.05 mm (green arrows).



Mounting the **ECI/EQI 1100**

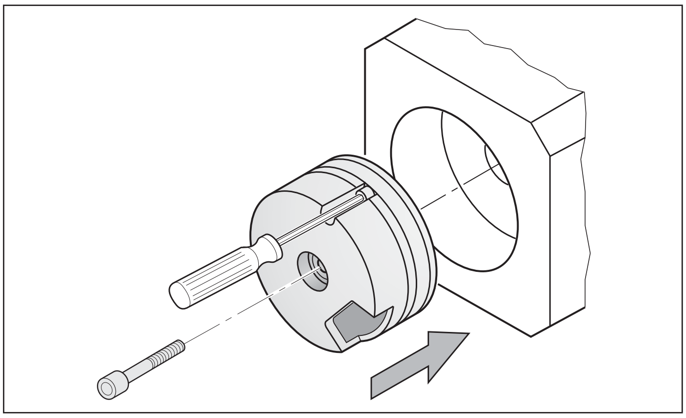


ECI/EQI 1100 with EnDat 2.1



ECI 1118 with EnDat 2.2

The **ECI/EQI 1300** inductive rotary encoders are mechanically compatible with the ExN 1300 photoelectric encoders. The taper shaft (a bottomed hollow shaft is available as an alternative) is fastened with a central screw. The stator of the encoder is clamped by an axially tightened screw in the location hole. The scanning gap between rotor and stator must be set during mounting.



Mounting the **ECI/EQI 1300**

Accessories for ECI/EQI
For inspecting the scanning gap and adjusting the ECI/EQI 1300

Encoder cable
For EIB 741, PWM 20, incl. three 12-pin adapter connectors and three 15-pin adapter connectors
ID 621742-01

Connecting cable
For extending the encoder cable, complete with D-sub connector (male) and D-sub coupling (female), each 15-pin
ID 675582-xx

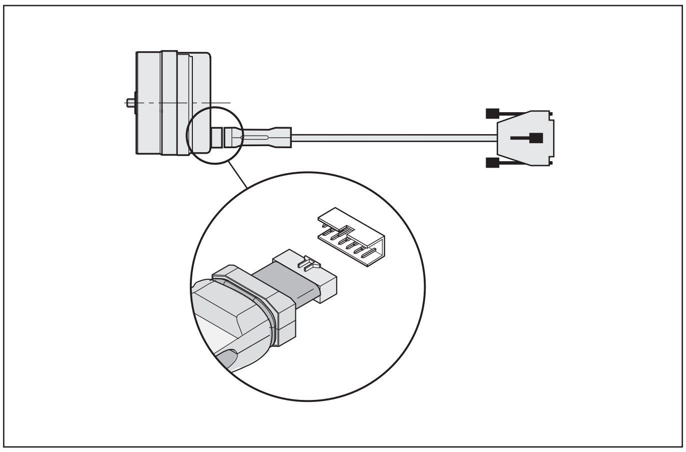
ATS Software
For inspecting the output signals in combination with the adjusting and testing package (see *HEIDENHAIN Measuring and Testing Devices*)
ID 539862-xx

12-pin adapter connector
Three connectors for replacement
ID 528694-01

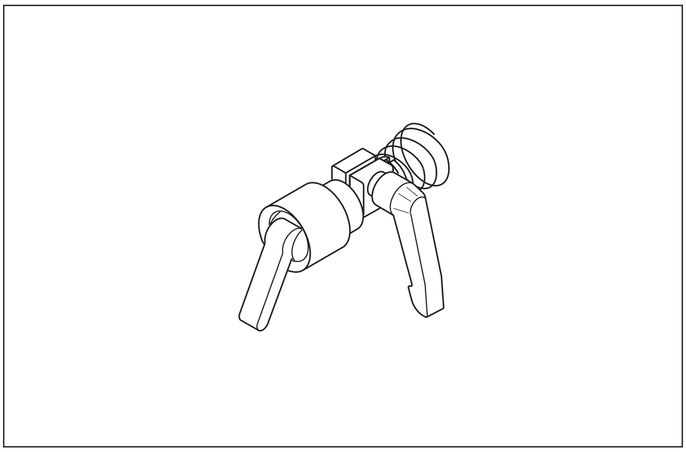
Mounting accessories for ECI/EQI 1300

Adjustment aid for setting the gap
ID 335529-xx

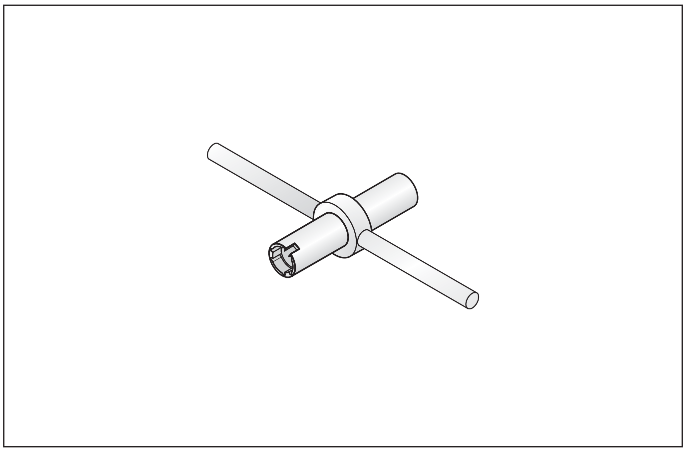
Mounting aid for adjusting the rotor position to the motor EMF
ID 352481-02



Mounting accessories for **ECI/EQI**



Adjustment aid



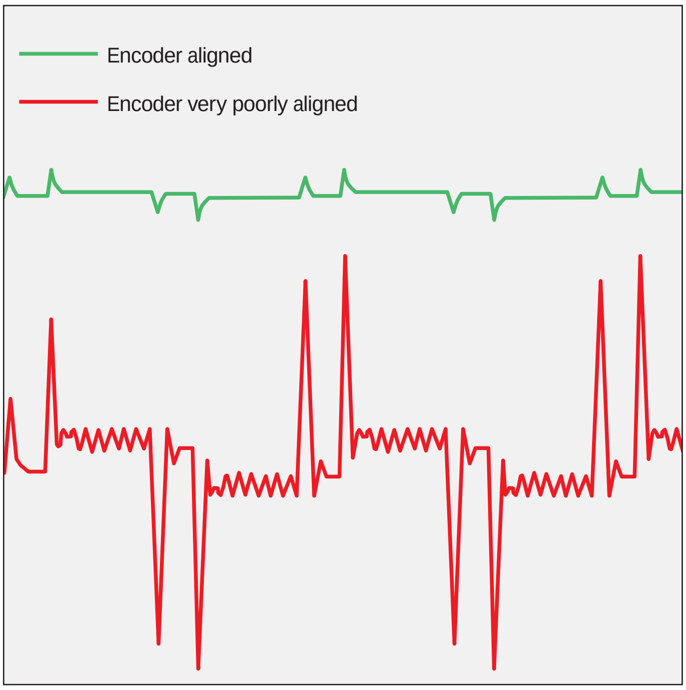
Mounting aid

Aligning the Rotary Encoders to the Motor EMF

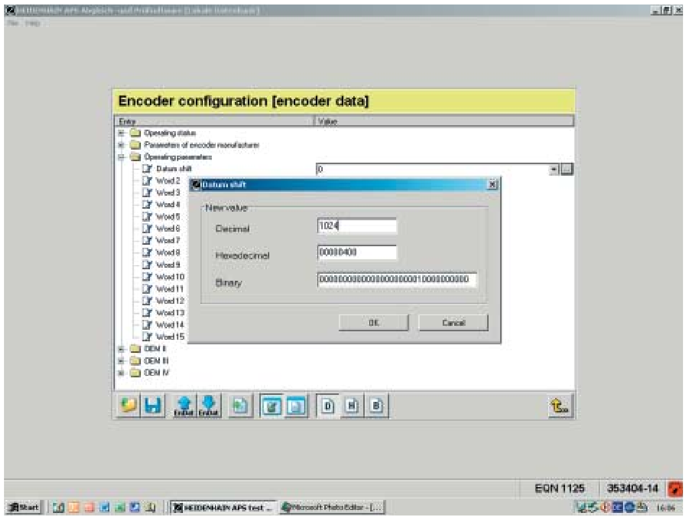
Synchronous motors require information on the rotor position immediately after switch-on. This information can be provided by rotary encoders with additional commutation signals, which provide relatively rough position information. Also suitable are absolute rotary encoders in multiturn and singleturn versions, which transmit the exact position information within a few angular seconds (see also *Electronic Commutation with Position Encoders*). When these encoders are mounted, the rotor positions of the encoder must be assigned to those of the motor in order to ensure the most constant possible motor current. Inadequate assignment to the motor EMF will cause loud motor noises and high power loss.

Rotary encoders with integral bearing
First, the rotor of the motor is brought to a preferred position by the application of a DC current. **Rotary encoders with commutation signals** are aligned approximately—for example with the aid of the line markers on the encoder or the reference mark signal—and mounted on the motor shaft. The fine adjustment is quite easy with a PWM 9 phase angle measuring device (see *HEIDENHAIN Measuring and Testing Devices*): the stator of the encoder is turned until the PWM 9 displays, for example, the value zero as the distance from the reference mark.
Absolute rotary encoders are at first mounted as a complete unit. Then the preferred position of the motor is assigned the value zero. The adjusting and testing package (see *HEIDENHAIN Measuring and Testing Devices*) serve this purpose. They feature the complete range of EnDat functions and make it possible to shift datums, set write protection against unintentional changes in saved values, and use further inspection functions.

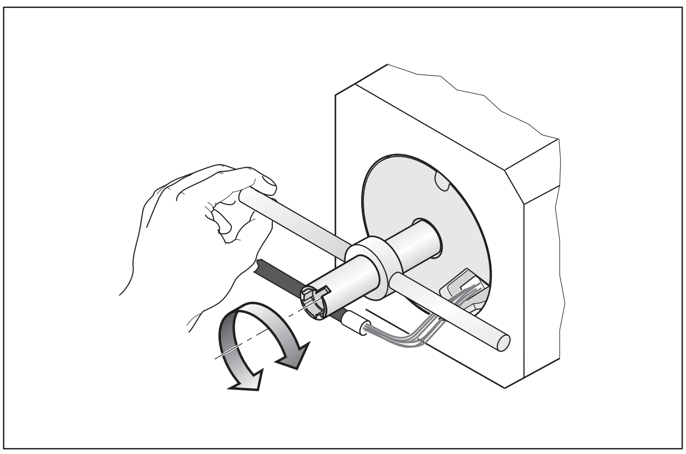
Rotary encoders without integral bearing
ECI/EQI rotary encoders are mounted as complete units and then adjusted with the aid of the adjusting and testing package. For the ECI/EQI with pure serial operation, electronic compensation is also possible: the ascertained compensation value can be saved in the encoder and read out by the control electronics to calculate the position value. ECI/EQI 1300 also permit manual alignment. The central screw is loosened again and the encoder rotor is turned with the mounting aid to the desired position until, for example, an absolute value of approximately zero appears in the position data.



Motor current of adjusted and very poorly adjusted rotary encoder



Aligning the rotary encoder to the motor EMF with the aid of the adjusting and testing software


Manual alignment of ECI/EQI 1300

General Mechanical Information

UL certification
All rotary encoders and cables in this brochure comply with the UL safety regulations for the USA and the "CSA" safety regulations for Canada.

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

- **Vibration**
  The encoders are qualified on a test stand to operate with the specified acceleration values from 55 to 2000 Hz in accordance with EN 60068-2-6. However, if the application or poor mounting cause long-lasting resonant vibration, it can limit performance or even damage the encoder. **Comprehensive tests of the entire system are required.**
- **Shock**
  The encoders are qualified on a test stand to operate with 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 $10^5 rad/s^2$ (DIN 32878). This is the highest permissible acceleration at which the rotor will rotate without damage to the encoder. The angular acceleration actually attainable depends on the shaft connection. A sufficient safety factor is to be determined through system tests.

Humidity
The max. permissible relative humidity is 75 %. 95 % is permissible temporarily. Condensation is not permissible.

Magnetic fields
Magnetic fields > 30 mT can impair proper function of encoders. If required, please contact HEIDENHAIN, Traunreut.

RoHS
HEIDENHAIN has tested the products for harmlessness of the materials as per European Directives 2002/95/EC (RoHS) and 2002/96/EC (WEEE). For a Manufacturer Declaration on RoHS, please refer to your sales agency.

Natural frequencies
The rotor and the couplings of ROC/ROQ/ROD and RIC/RIQ rotary encoders, as also the stator and stator coupling of ECN/EQN/ERN rotary encoders, form a single vibrating spring-mass system.

The **natural frequency f_N** should be as high as possible. A prerequisite for the highest possible natural frequency on **ROC/ROQ/ROD rotary encoders** is the use of a diaphragm coupling with a high torsional rigidity C (see *Shaft Couplings).*

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

f_N: Natural frequency 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 with their stator couplings form a vibrating spring-mass system whose **natural frequency f_N** should be as high as possible. If radial and/or axial acceleration forces are added, the stiffness of the encoder bearings and the encoder stators are also significant. If such loads occur in your application, HEIDENHAIN recommends consulting with the main facility in Traunreut.

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

Protection (EN 60529)
The degree of protection shown in the catalog is adapted to the usual mounting conditions. You will find the respective values in the Specifications. If the given degree of protection is not sufficient (such as when the encoders are mounted vertically), the encoders should be protected by suited measures such as covers, labyrinth seals, or other methods. Splash water must not contain any substances that would have harmful effects on the encoder parts.

Expendable parts
Encoders from HEIDENHAIN are designed for a long service life. Preventive maintenance is not required. They contain components that are subject to wear, depending on the application and manipulation. These include in particular cables with frequent flexing.
Other such components are the bearings of encoders with integral bearing, shaft sealing rings on rotary and angle encoders, and sealing lips on sealed linear encoders.

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

The specifications given in this brochure apply to the specific encoder, not to the complete system. Any operation of the encoder outside of the specified range or for any other than the intended applications is at the user's own risk.

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

Changes to the encoder
The correct operation and accuracy of encoders from HEIDENHAIN is ensured only if they 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 additional retaining compounds, lubricants (e.g. for screws) or adhesives not explicitly prescribed. In case of doubt, we recommend contacting HEIDENHAIN in Traunreut.

Temperature ranges

For the unit in its packaging, the **storage temperature range** is –30 to 80 °C. The **operating temperature range** indicates the temperatures the encoder can reach during operation in the actual installation environment. The function of the encoder is guaranteed within this range (DIN 32878). The operating temperature is measured on the face of the encoder flange (see dimension drawing) and must not be confused with the ambient temperature.

The temperature of the encoder is influenced by:

- Mounting conditions
- The ambient temperature
- Self-heating of the encoder

The self-heating of an encoder depends both on its design characteristics (stator coupling/solid shaft, shaft sealing ring, etc.) and on the operating parameters (rotational speed, power supply). Temporarily increased self-heating can also occur after very long breaks in operation (of several months). Please take a two-minute run-in period at low speeds into account. Higher heat generation in the encoder means that a lower ambient temperature is required to keep the encoder within its permissible operating temperature range.

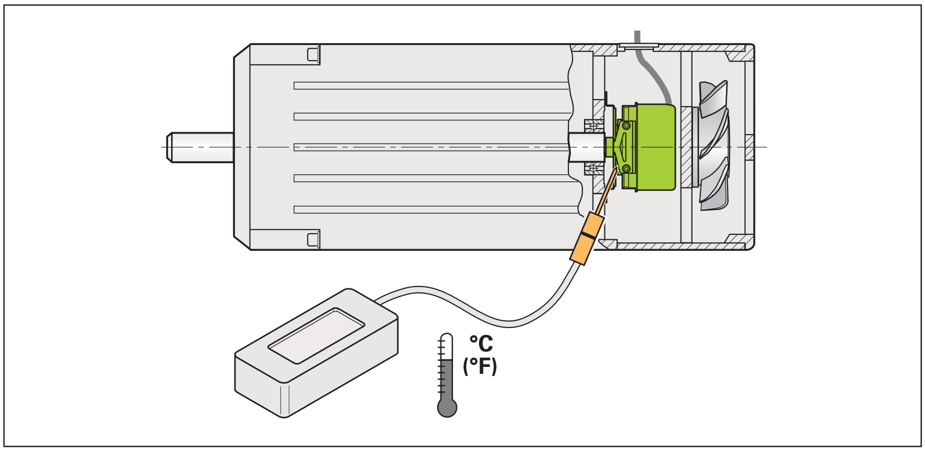
These tables show the approximate values of self-heating to be expected in the encoders. In the worst case, a combination of operating parameters can exacerbate self-heating, for example a 30 V power supply and maximum rotational speed. Therefore, the actual operating temperature should be measured directly at the encoder if the encoder is operated near the limits of permissible parameters. Then suitable measures should be taken (fan, heat sinks, etc.) to reduce the ambient temperature far enough so that the maximum permissible operating temperature will not be exceeded during continuous operation.

For high speeds at maximum permissible ambient temperature, special versions are available on request with reduced degree of protection (without shaft seal and its concomitant frictional heat).

Self-heating at supply voltage (approx.)		**15 V**	**30 V**
	ERN/ROD	+ 5 K	+ 10 K
	ECN/EQN/ROC/ROQ	+ 5 K	+ 10 K

Heat generation at speed n_{max} (approx.)		
Solid shaft	**ROC/ROQ/ROD**	+ 5 K with IP 64 protection + 10 K with IP 66 protection
Blind hollow shaft	**ECN/EQN/ERN 400**	+ 30 K with IP 64 protection + 40 K with IP 66 protection
	ECN/EQN/ERN 1000	+ 10 K
Hollow through shaft	**ECN/ERN 100** **ECN/EQN/ERN 400**	+ 40 K with IP 64 protection + 50 K with IP 66 protection

An encoder's typical self-heating values depend on its design characteristics at maximum permissible speed. The correlation between rotational speed and heat generation is nearly linear.

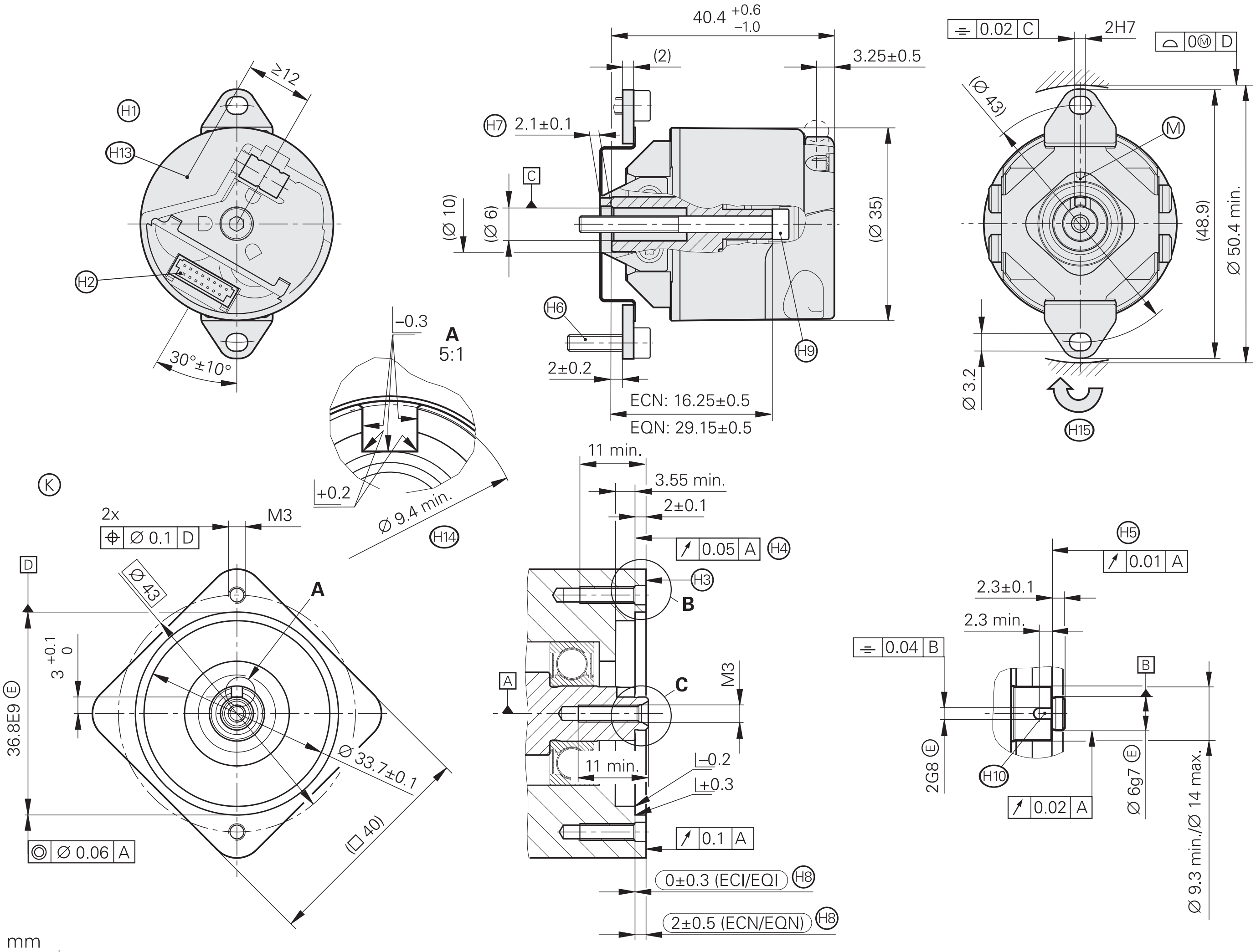


Measuring the actual operating temperature at the defined measuring point of the rotary encoder (see *Specifications*)

ECN/EQN 1100

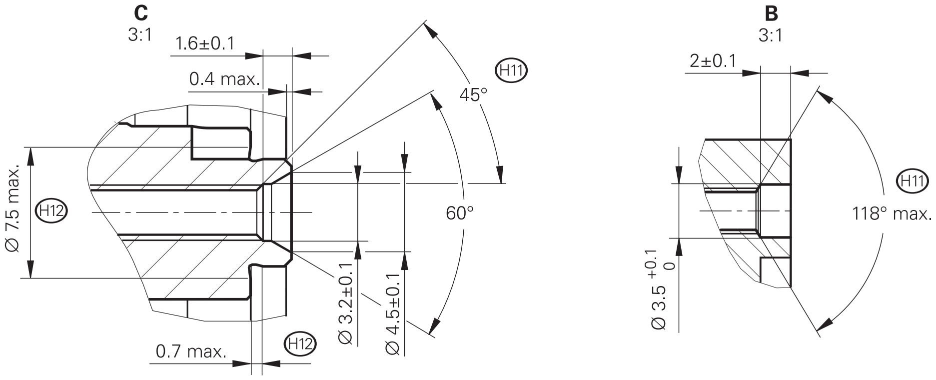
Rotary encoders for absolute position values

- **Mounted stator coupling, 75A**
- **Blind hollow shaft for axial clamping, 1KA**
- **Fault exclusion for loosening of shaft and stator coupling**



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
H1 = Encoder shown without cover
H2 = PCB connector, 15-pin
H3 = Coupling surface
H4 = Flange surface, ECI/EQI 11xx
H5 = Shaft surface
H6 = Screw, ISO 4762–M3x12–8.8 with patch coating (not included in delivery). Tightening torque 1.15±0.05 Nm
H7 = Positive-fit element. Ensure correct engagement in slot H10, e.g. by measuring the device overhang
H8 = Maximum permissible distance between shaft and coupling surface (ECN/EQN) or flange surface (ECI/EQI). Compensation of mounting tolerances and thermal expansion
H9 = ISO 4762 screw with patch coating, ECN: M3x22–8.8, EQN: M3x35–8.8 (not included in delivery). Tightening torque 1.15±0.05 Nm
H10 = Slot for positive fit element (ECN/EQN)
H11 = Chamfer is obligatory at start of thread for materially bonding anti-rotation lock
H12 = Undercut
H13 = Vibration measuring point, see HEIDENHAIN document 741 714
H14 = Contact surface of slot
H15 = 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
Incremental signals	∼ $1\,V_{PP}$[1]	–	∼ $1\,V_{PP}$[1]	–
Line count	512	–	512	–
Cutoff frequency –3 dB	≥ 190 kHz	–	≥ 190 kHz	–
Absolute position values	EnDat 2.2	EnDat 2.2	EnDat 2.2	EnDat 2.2
Ordering designation	EnDat 01	EnDat 22	EnDat 01	EnDat 22
Position values/rev	8 192 (13 bits)	8 388 608 (23 bits)	8 192 (13 bits)	8 388 608 (23 bits)
Revolutions	–	–	4 096 (12 bits)	4 096 (12 bits)
Elec. permissible speed/ Deviation[2]	4 000 min^{-1}/± 1 LSB 12 000 min^{-1}/± 16 LSB	12 000 min^{-1} (for continuous position value)	4 000 min^{-1}/± 1 LSB 12 000 min^{-1}/± 16 LSB	12 000 min^{-1} (for continuous position value)
Calculation time t_{cal}	≤ 9 µs	≤ 7 µs	≤ 9 µs	≤ 7 µs
System accuracy	± 60"	± 60"	± 60"	± 60"
Power supply	3.6 V to 14 V DC	3.6 V to 14 V DC	3.6 V to 14 V DC	3.6 V to 14 V DC
Power consumption (maximum)	*3.6 V:* ≤ 600 mW *14 V:* ≤ 700 mW	*3.6 V:* ≤ 600 mW *14 V:* ≤ 700 mW	*3.6 V:* ≤ 700 mW *14 V:* ≤ 800 mW	*3.6 V:* ≤ 700 mW *14 V:* ≤ 800 mW
Current consumption (typical)	*5 V:* 85 mA (without load)	*5 V:* 85 mA (without load)	*5 V:* 105 mA (without load)	*5 V:* 105 mA (without load)
Electrical connection Via PCB connector	15-pin	15-pin[3]	15-pin	15-pin[3]
Shaft	Blind hollow shaft ∅ 6 mm with positive fit element	Blind hollow shaft ∅ 6 mm with positive fit element	Blind hollow shaft ∅ 6 mm with positive fit element	Blind hollow shaft ∅ 6 mm with positive fit element
Mech. permiss. speed n	12 000 min^{-1}	12 000 min^{-1}	12 000 min^{-1}	12 000 min^{-1}
Starting torque	≤ 0.001 Nm (at 20 °C)	≤ 0.001 Nm (at 20 °C)	≤ 0.002 Nm (at 20 °C)	≤ 0.002 Nm (at 20 °C)
Moment of inertia of rotor	Approx. $0.4 \cdot 10^{-6}$ kgm^2	Approx. $0.4 \cdot 10^{-6}$ kgm^2	Approx. $0.4 \cdot 10^{-6}$ kgm^2	Approx. $0.4 \cdot 10^{-6}$ kgm^2
Permissible axial motion of measured shaft	± 0.5 mm	± 0.5 mm	± 0.5 mm	± 0.5 mm
Vibration 55 Hz to 2 000 Hz **Shock** 6 ms	≤ 200 m/s^2 (EN 60 068-2-6) ≤ 1 000 m/s^2 (EN 60 068-2-27)	≤ 200 m/s^2 (EN 60 068-2-6) ≤ 1 000 m/s^2 (EN 60 068-2-27)	≤ 200 m/s^2 (EN 60 068-2-6) ≤ 1 000 m/s^2 (EN 60 068-2-27)	≤ 200 m/s^2 (EN 60 068-2-6) ≤ 1 000 m/s^2 (EN 60 068-2-27)
Max. operating temp.	115 °C	115 °C	115 °C	115 °C
Min. operating temp.	–40 °C	–40 °C	–40 °C	–40 °C
Protection EN 60 529	IP 40 when mounted	IP 40 when mounted	IP 40 when mounted	IP 40 when mounted
Weight	Approx. 0.1 kg	Approx. 0.1 kg	Approx. 0.1 kg	Approx. 0.1 kg

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

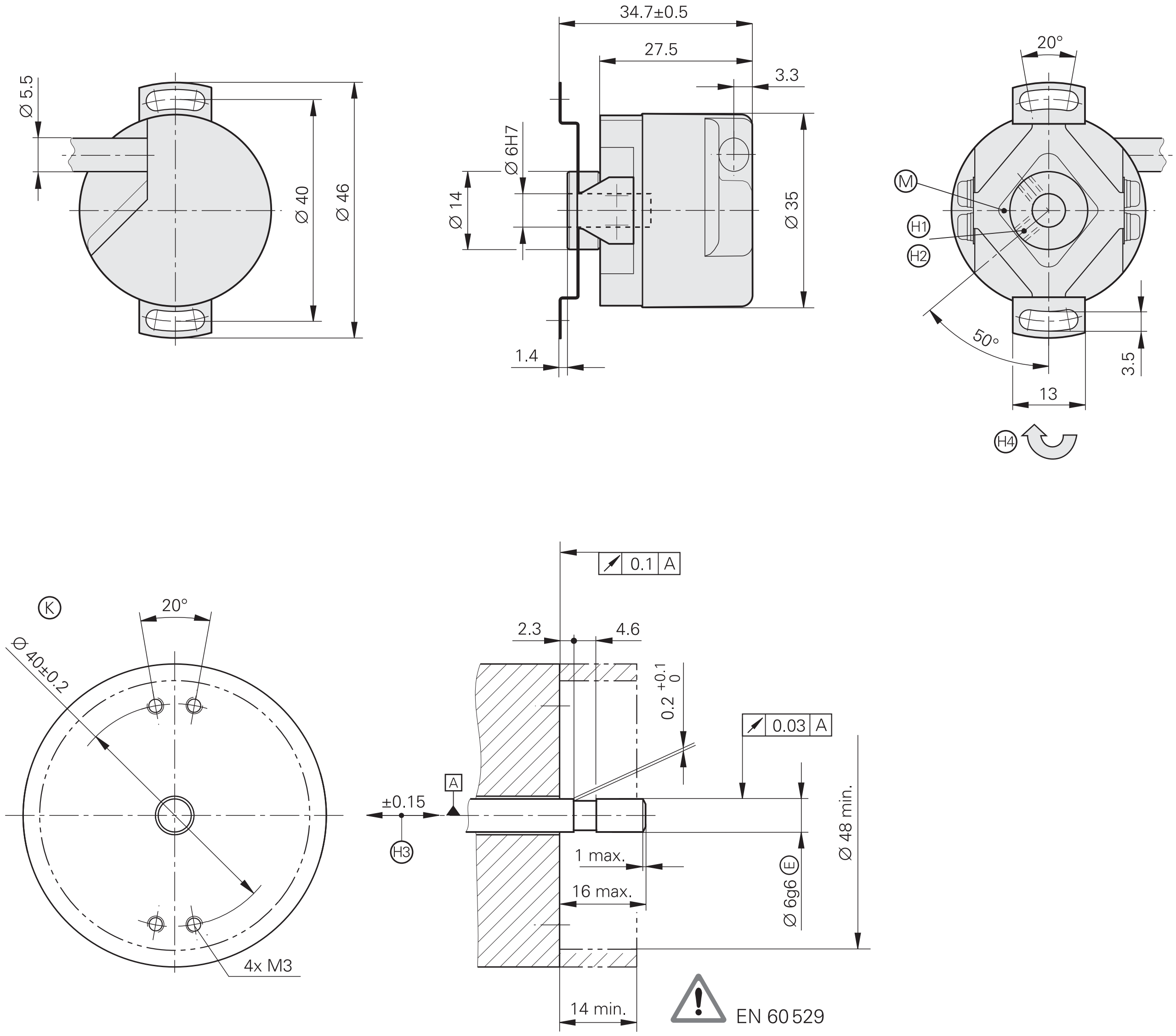
[2] Velocity-dependent deviations between the absolute and incremental signals

[3] With connection for temperature sensor, evaluation optimized for KTY 84-130

Functional Safety for ECN 1123 and EQN 1135 upon request

ERN 1023

Incremental rotary encoders with mounted stator coupling
- **Outside diameter Ø 35 mm**
- **Length 34.7 mm**
- **Blind hollow shaft Ø 6 mm**
- **Block commutation signals**



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

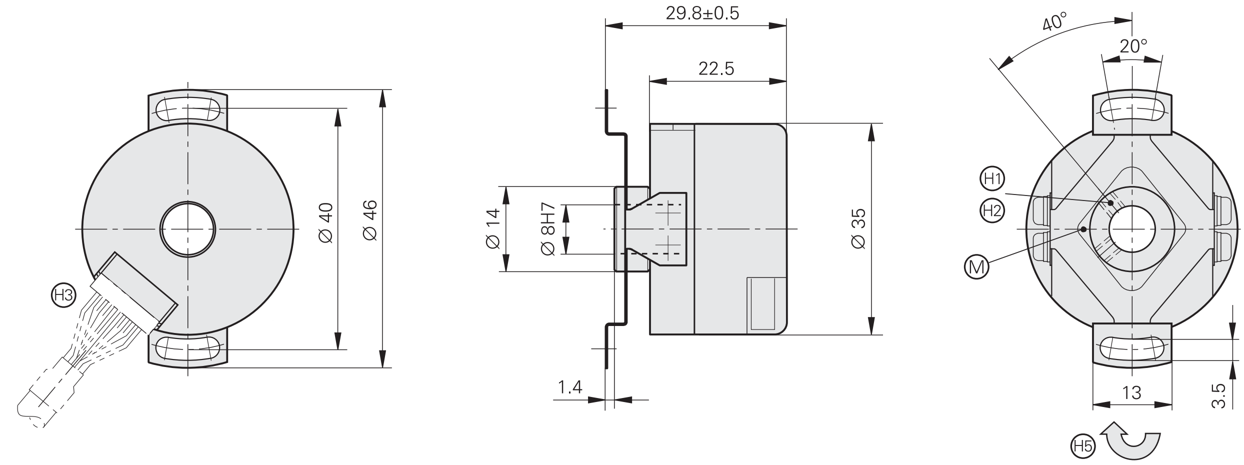
Ⓐ = Bearing of mating shaft
Ⓜ = Measuring point for operating temperature
Ⓚ = Required mating dimensions
Ⓗ1 = 2 screws in clamping ring. Tightening torque: 0.6 ± 0.1 Nm, width A/F: 1.5
Ⓗ2 = Reference mark position ± 10°
Ⓗ3 = Compensation of mounting tolerances and thermal expansion, no dynamic motion permitted
Ⓗ4 = Direction of shaft rotation for output signals according to interface description

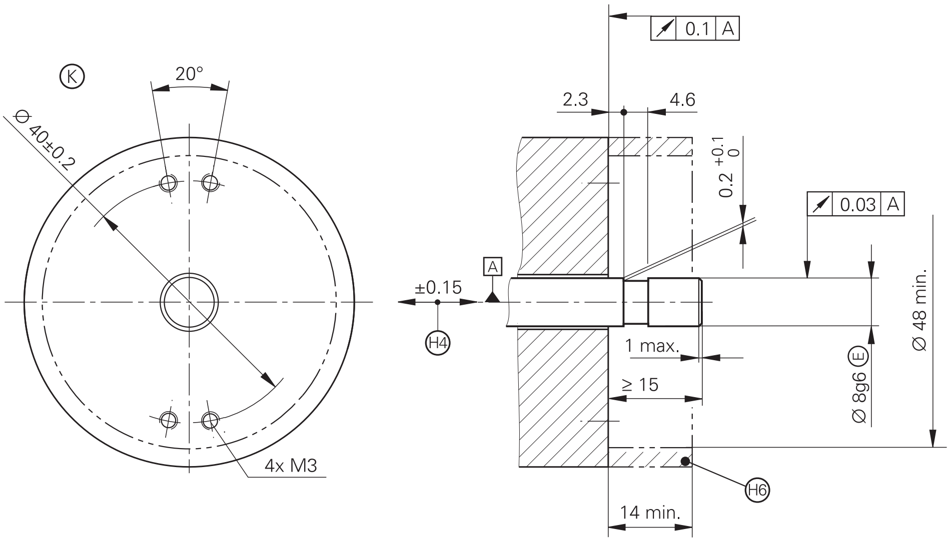
	ERN 1023	
Incremental signals	⊓⊔TTL	
Signal periods/rev*	**500** **512** 600	**1000** **1024** 1250 **2000** **2048** **2500** 4096 5000 8192
Reference mark	One	
Scanning frequency Edge separation *a*	≤ 300 kHz ≥ 0.41 µs	
System accuracy	± 260"	± 130"
Absolute position values	⊓⊔TTL (3 commutation signals U, V, W)	
Commutation signals*	2 x 180° (C01); 3 x 120° (C02); **4 x 90° (C03)**	
Power supply	5 V ± 10 %	
Current consumption Without load	≤ 70 mA	
Electrical connection*	Cable **1 m,** 5 m, without coupling	
Shaft	Blind hollow shaft D = 6 mm	
Mech. permiss. speed n	≤ 6000 min^{-1}	
Starting torque at 20 °C	≤ 0.005 Nm	
Moment of inertia of rotor	$0.5 \cdot 10^{-6}$ kgm^2	
Permissible axial motion of measured shaft	± 0.15 mm	
Vibration 25 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)	
Max. operating temp.	90 °C	
Min. operating temp.	*For fixed cable:* –20 °C *Moving cable:* –10 °C	
Protection EN 60 529	IP 64	
Weight	Approx. 0.07 kg (without cable)	

Bold: Preferred models
* Please select when ordering

ERN 1123

Rotary encoders with integral bearing for integration in motors
- **Mounted stator coupling**
- **Outside diameter Ø 35 mm**
- **Hollow through shaft Ø 8 mm**
- **Block commutation signals**





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

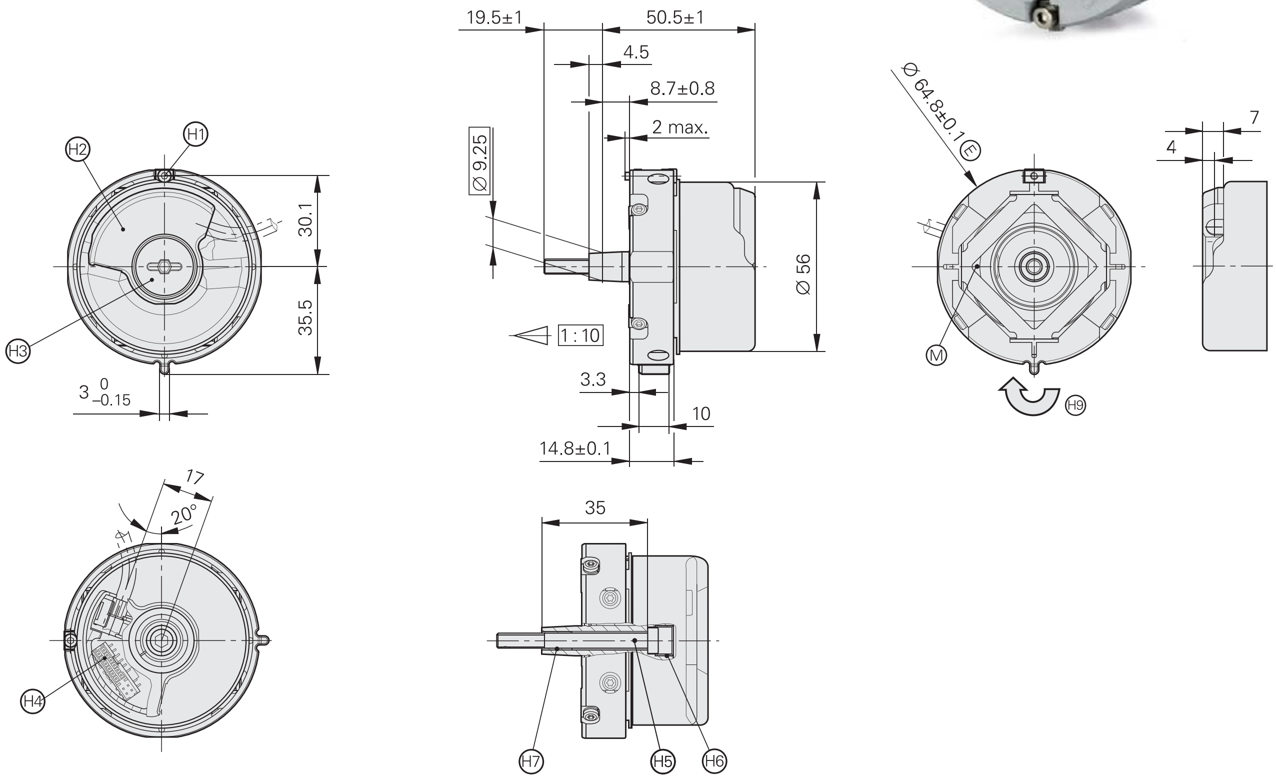
A = Bearing of mating shaft
M = Measuring point for operating temperature
K = Required mating dimensions
H1 = 2 screws in clamping ring. Tightening torque: 0.6 ± 0.1 Nm, width A/F: 1.5
H2 = Reference mark position ± 10°
H3 = 15-pin JAE connector
H4 = Compensation of mounting tolerances and thermal expansion, no dynamic motion permitted
H5 = Direction of shaft rotation for output signals according to interface description
H6 = Protection as per EN 60529

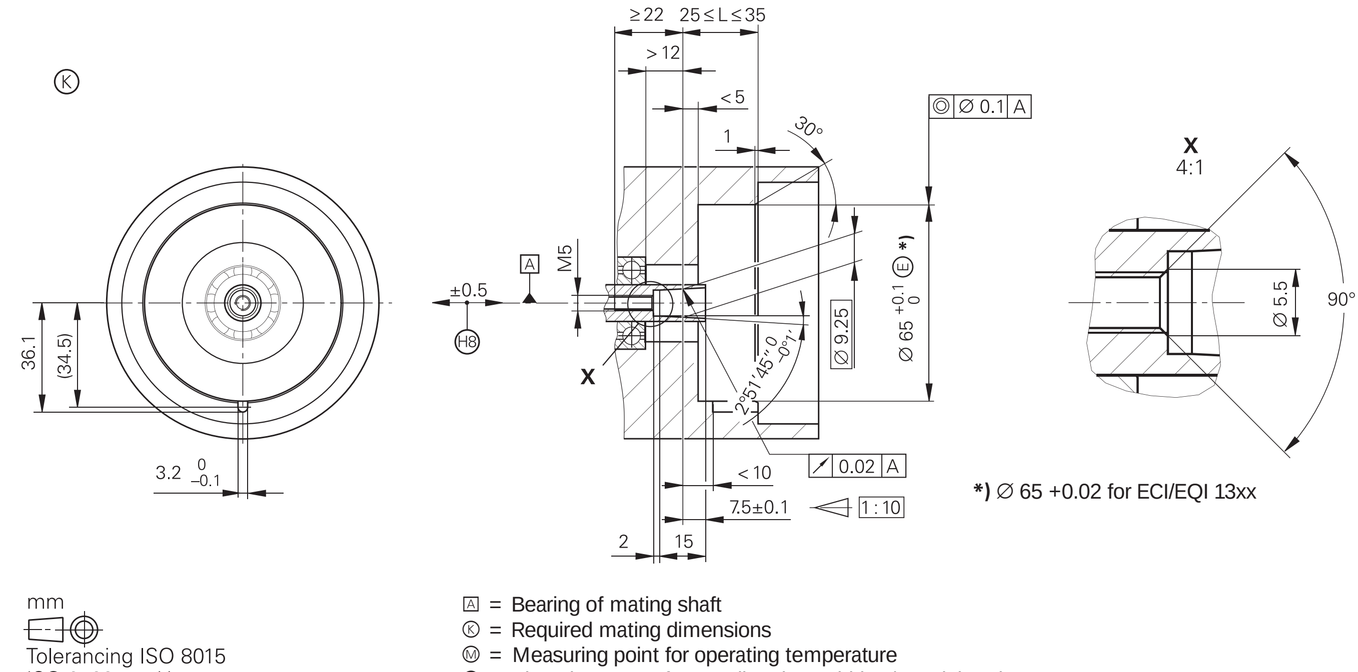
	ERN 1123	
Incremental signals	⊓⊔TTL	
Signal periods/rev*	**500** **512** 600	**1000** **1024** 1250 **2000** **2048** **2500** 4096 5000 8192
Reference mark	One	
Scanning frequency Edge separation *a*	≤ 300 kHz ≥ 0.41 µs	
Absolute position values	⊓⊔TTL (3 commutation signals U, V, W)	
Commutation signals*	2 x 180° (C01); 3 x 120° (C02); **4 x 90° (C03)**[1]	
System accuracy	± 260"	± 130"
Power supply	DC 5 V ± 10 %	
Current consumption (without load)	≤ 70 mA	
Electrical connection	Via PCB connector, 15-pin	
Shaft	Hollow through shaft ∅ 8 mm	
Mech. permiss. speed n	≤ 6000 min^{-1}	
Starting torque	≤ 0.005 Nm (at 20 °C)	
Moment of inertia of rotor	$0.5 \cdot 10^{-6}$ kgm^2	
Permissible axial motion of measured shaft	± 0.15 mm	
Vibration 25 to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)	
Max. operating temp.	90 °C	
Min. operating temp.	–20 °C	
Protection EN 60 529	IP 00[2]	
Weight	Approx. 0.06 kg	

Bold: These preferred versions are available on short notice
* Please select when ordering
[1] Three square-wave signals with signal periods of 90°, 120° or 180° mechanical phase shift, see *Commutation Signals for Block Commutation*
[2] CE compliance of the complete system must be ensured by taking the correct measures during installation.

ECN/EQN 1300 Series

Rotary encoders with integral bearing for integration in motors
- **Mounted stator coupling with anti-rotation element for fault exclusion**
- **Installation diameter 65 mm**
- **Taper shaft**





***)** 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
K = Required mating dimensions
M = Measuring point for operating temperature
H1 = Clamping screw for coupling ring, width A/F 2, tightening torque 1.25–0.2 Nm
H2 = Die-cast cover
H3 = Screw plug, widths A/F 3 and 4, tightening torque 5+0.5 Nm
H4 = PCB connector
H5 = Screw M5 x 50 DIN 6912 width A/F 4 with materially bonding anti-rot. lock, tightening torque 5+0.5 Nm
H6 = M10 back-off thread
H7 = M6 back-off thread
H8 = Compensation of mounting tolerances and thermal expansion, no dynamic motion permitted
H9 = Direction of shaft rotation for output signals as per the interface description

	Absolute			
	ECN 1313	ECN 1325	EQN 1325	EQN 1337
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	–
Absolute position values	EnDat 2.2			
Ordering designation	EnDat 01	EnDat 22	EnDat 01	EnDat 22
Position values/rev	8192 (13 bits)	33554432 (25 bits)	8192 (13 bits)	33554432 (25 bits)
Revolutions	–		4096 (12 bits)	
Elec. permissible speed/ Deviation[2)]	*512 lines:* 5000 min^{-1}/± 1 LSB 12000 min^{-1}/± 100 LSB *2048 lines:* 1500 min^{-1}/± 1 LSB 12000 min^{-1}/± 50 LSB	15000 min^{-1} (for continuous position value)	*512 lines:* 5000 min^{-1}/± 1 LSB 12000 min^{-1}/± 100 LSB *2048 lines:* 1500 min^{-1}/± 1 LSB 12000 min^{-1}/± 50 LSB	15000 min^{-1} (for continuous position value)
Calculation time t_{cal}	≤ 9 µs	≤ 7 µs	≤ 9 µs	≤ 7 µs
System accuracy	*512 lines:* ± 60"; *2048 lines:* ± 20"			
Power supply	3.6 to 14 V DC			
Power consumption (maximum)	*3.6 V:* ≤ 600 mW *14 V:* ≤ 700 mW		*3.6 V:* ≤ 700 mW *14 V:* ≤ 800 mW	
Current consumption (typical)	*5 V:* 85 mA (without load)		*5 V:* 105 mA (without load)	
Electrical connection Via PCB connector	12-pin	*Rotary encoder:* 12-pin *Thermistor*[3)]*:* 4-pin	12-pin	*Rotary encoder:* 12-pin *Thermistor*[3)]*:* 4-pin
Shaft	Taper shaft ∅ 9.25 mm; taper 1:10			
Mech. permiss. speed n	≤15000 min^{-1}		≤ 12000 min^{-1}	
Starting torque At 20 °C	≤ 0.01 Nm			
Moment of inertia of rotor	$2.6 \cdot 10^{-6}$ kgm^2			
Natural frequency of the stator coupling	≥ 1800 Hz			
Permissible axial motion of measured shaft	± 0.5 mm			
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2 [4)] (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)			
Max. operating temp.	115 °C			
Min. operating temp.	–40 °C			
Protection EN 60529	IP 40 when mounted			
Weight	Approx. 0.25 kg			

* Please select when ordering
1) Restricted tolerances

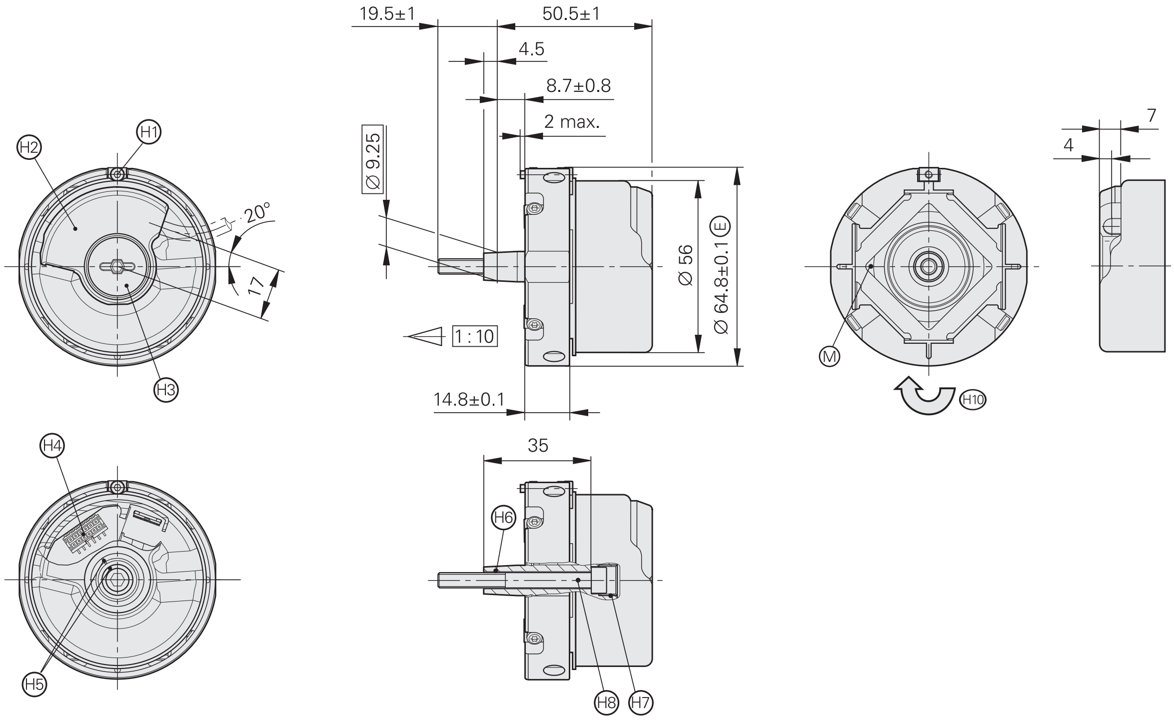
Signal amplitude:	0.8 to 1.2 V_{PP}
Asymmetry:	0.05
Amplitude ratio:	0.9 to 1.1
Phase angle:	90° ± 5° elec.
Signal-to-noise ratio E, F:	100 mV

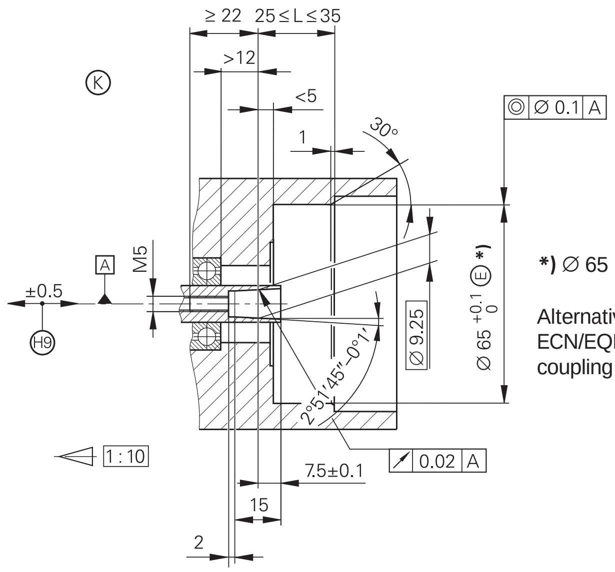
2) Velocity-dependent deviations between the absolute and incremental signals
3) Evaluation optimized for KTY 84-130
4) Valid as per standard at room temperature; Valid at operating temperatures up to 100 °C: ≤ 300 m/s^2; up to 115 °C: ≤ 150 m/s^2

Functional Safety for ECN 1325 and EQN 1337 upon request
For dimensions and specification see the Product Information document

ERN 1300 Series

Rotary encoders with integral bearing for integration in motors
- **Mounted stator coupling**
- **Installation diameter 65 mm**
- **Taper shaft**





***)** Ø 65 +0.02 for ECI/EQI 13xx

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

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
H1 = Clamping screw for coupling ring, width A/F 2. Tightening torque: 1.25 – 0.2 Nm
H2 = Die-cast cover
H3 = Screw plug, width A/F 3 and 4. Tightening torque: 5 + 0.5 Nm
H4 = PCB connector
H5 = Reference mark position indicated on shaft and cap
H6 = M10 back-off thread
H7 = M10 back-off thread
H8 = Self-tightening screw, M5 x 50, DIN 6912, width A/F 4. Tightening torque: 5 + 0.5 Nm
H9 = Compensation of mounting tolerances and thermal expansion, no dynamic motion permitted
H10 = Direction of shaft rotation for output signals as per the interface description

	Incremental				
	ERN 1321	**ERN 1381**	**ERN 1387**	**ERN 1326**	
Incremental signals	⊓⊔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				
Scanning 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
Absolute position values	–		∼ 1 V_{PP}[1]	⊓⊔TTL	
Commutation signals*	–		Z1 track [2]	3 x 120°; 4 x 90°[3]	
Power supply	5 V DC ± 10 %		5 V DC ± 5 %	5 V DC ± 10 %	
Current consumption (w/o load)	≤ 120 mA		≤ 130 mA	≤ 150 mA	
Electrical connection Via PCB connector	12-pin		14-pin	16-pin	
Shaft	Taper shaft ∅ 9.25 mm; taper 1:10				
Mech. permiss. speed n	≤15000 min^{-1}				
Starting torque At 20 °C	≤ 0.01 Nm				
Moment of inertia of rotor	$2.6 \cdot 10^{-6}$ kgm^2				
Natural frequency of the stator coupling	≥ 1800 Hz				
Permissible axial motion of measured shaft	± 0.5 mm				
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 300 m/s^2 [4] (EN 60068-2-6) ≤ 2000 m/s^2 (EN 60068-2-27)				
Max. operating temp.	120 °C	120 °C *4096 lines:* 80 °C	120 °C		
Min. operating temp.	–40 °C				
Protection EN 60529	IP 40 when mounted				
Weight	Approx. 0.25 kg				

* Please select when ordering

[1] Restricted tolerances

Signal amplitude:	0.8 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

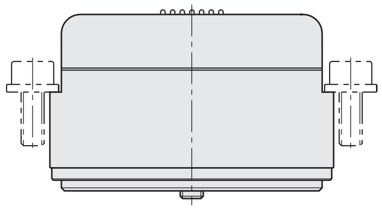
[3] Three square-wave signals with signal periods of 90° or 120° mechanical phase shift; see *Commutation Signals for Block Commutation*

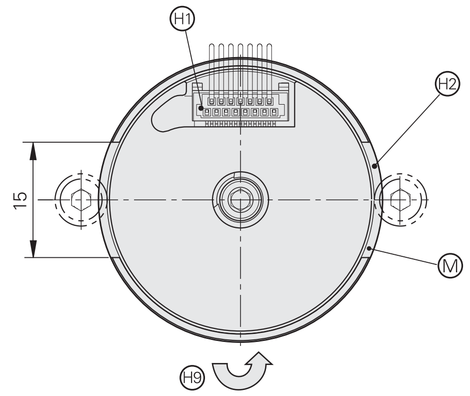
[4] As per standard for room temperature, the following applies for operating temperature: Up to 100 °C: ≤ 300 m/s^2; Up to 120 °C: ≤ 150 m/s^2

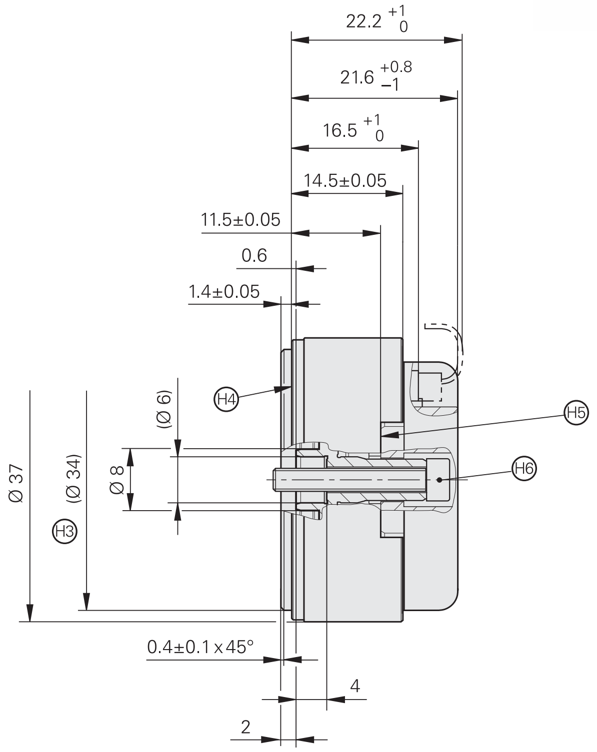
[5] Through integrated signal doubling

ECI/EQI 1100 Series

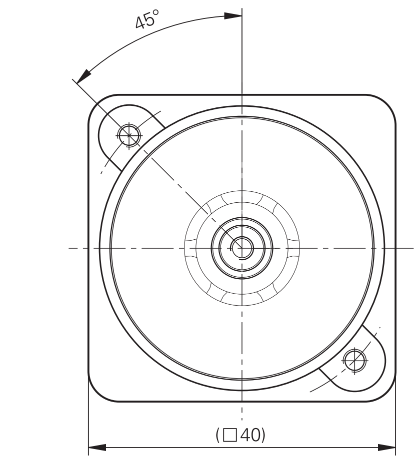
Rotary encoders without integral bearing for integration in motors
- **Installation diameter 37 mm**
- **Blind hollow shaft**

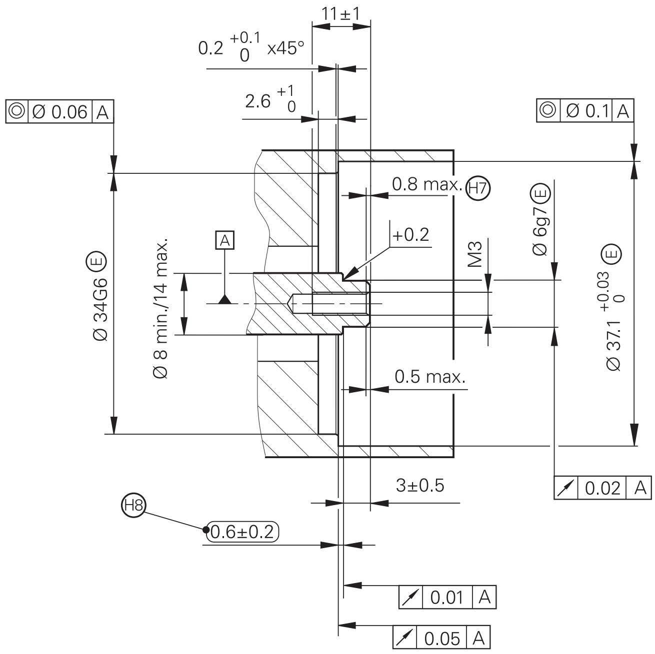






K





mm

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

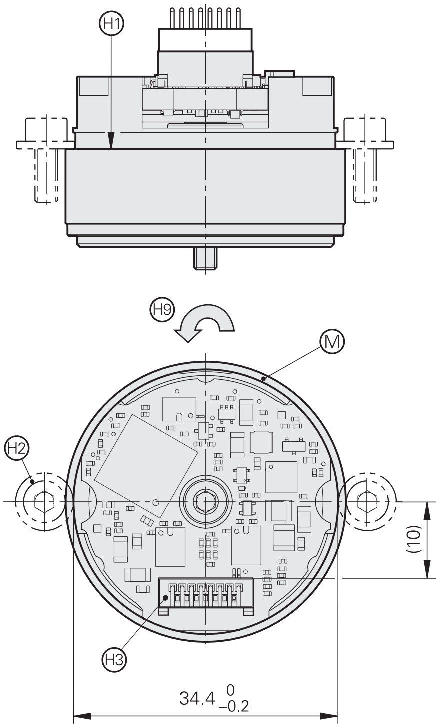
A = Bearing of mating shaft
K = Required mating dimensions
M = Measuring point for operating temperature
H1 = PCB connector, 15-pin
H2 = Permissible surface pressure (material: aluminum 230 N/mm[2])
H3 = Centering collar
H4 = Bearing surface
H5 = Clamping surfaces
H6 = Self-locking screw M3 x 20, ISO 4762, width A/F 2.5, tightening torque: 1.2 ±0.1 Nm
H7 = Start of thread
H8 = Maximum permissible deviation between shaft and flange surfaces.
Compensation of mounting tolerances and thermal expansion, no dynamic motion permitted
H9 = Direction of shaft rotation for output signals as per the interface description

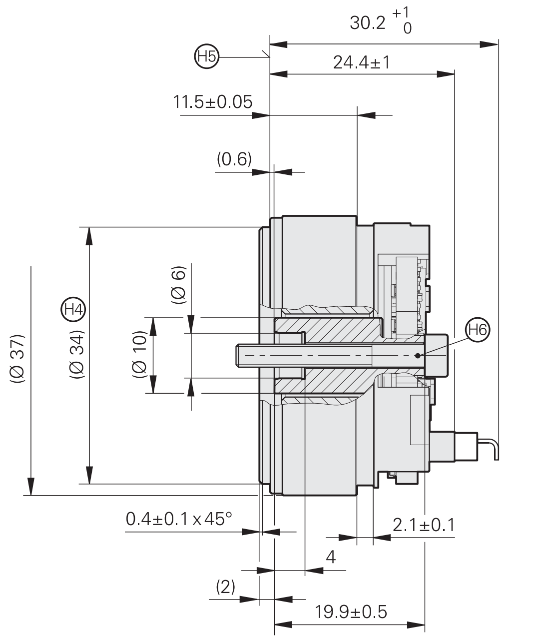
	Absolute			
	ECI 1118		**EQI 1130**	
Incremental signals	∿ 1 V_{PP}	None	∿ 1 V_{PP}	None
Line count	16	–	16	–
Cutoff frequency –3 dB	≥ 6 kHz typical	–	≥ 6 kHz typical	–
Absolute position values	EnDat 2.1			
Ordering designation*	EnDat 01	EnDat 21	EnDat 01	EnDat 21
Position values/rev	262 144 (18 bits)			
Revolutions	–		4 096 (12 bits)	
Elec. permissible speed/ deviations[1)]	4 000 min^{-1}/± 400 LSB 15 000 min^{-1}/± 800 LSB	15 000 min^{-1} (for continuous position value)	4 000 min^{-1}/± 400 LSB 12 000 min^{-1}/± 800 LSB	12 000 min^{-1} (for continuous position value)
Calculation time t_{cal}	≤ 8 µs			
System accuracy	± 280"			
Power supply	5 V DC ± 5 %			
Power consumption (maximum)	≤ 0.85 W		≤ 1.00 W	
Current consumption (typical)	120 mA (without load)		145 mA (without load)	
Electrical connection	Via PCB connector, 15-pin			
Shaft	Blind hollow shaft ∅ 6 mm, axial clamping			
Mech. permiss. speed n	≤15 000 min^{-1}		≤ 12 000 min^{-1}	
Moment of inertia of rotor	$0.76 \cdot 10^{-6}$ kgm^2			
Permissible axial motion of measured shaft	± 0.2 mm			
Vibration 55 Hz to 2 000 Hz **Shock** 6 ms	≤ 300 m/s^2 (EN 60 068-2-6) ≤ 1 000 m/s^2 (EN 60 068-2-27)			
Max. operating temp.	115 °C			
Min. operating temp.	–20 °C			
Protection EN 60 529	IP 20 when mounted			
Weight	Approx. 0.06 kg			

* Please select when ordering
1) Velocity-dependent deviation between the absolute and incremental signals

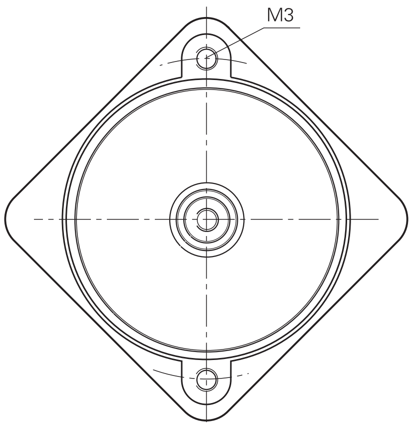
ECI 1118

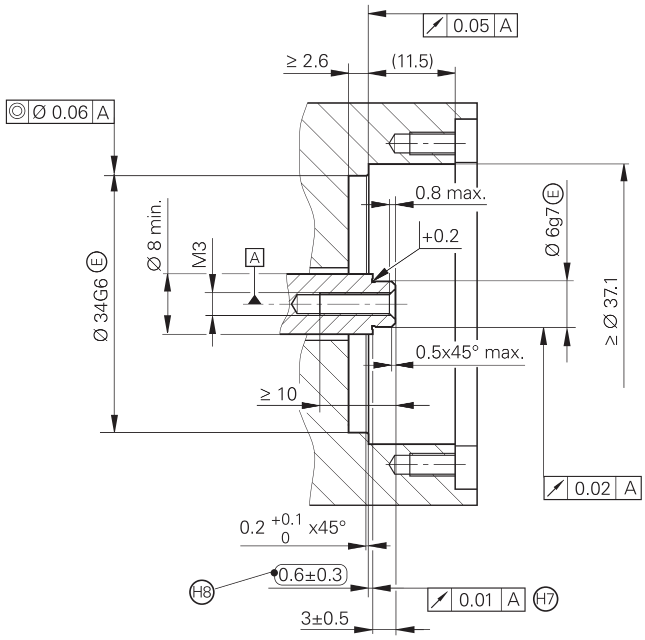
Rotary encoders without integral bearing for integration in motors
- **Installation diameter 37 mm**
- **Blind hollow shaft**





K





mm

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

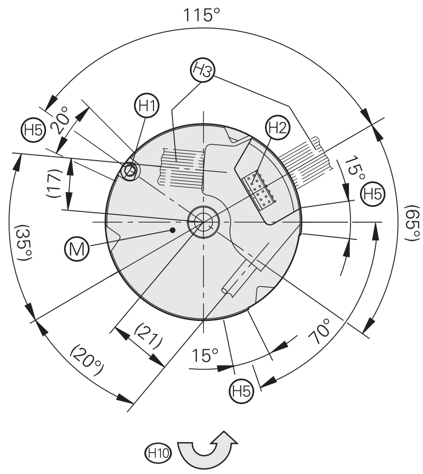
Ⓐ = Bearing of mating shaft
Ⓚ = Required mating dimensions
Ⓜ = Measuring point for operating temperature
H1 = Clamping surface
H2 = Proposed attachment: washer and self-locking screw M3, ISO 4762, width A/F 2.5. Tightening torque: 1.2±0.1 Nm
H3 = PCB connector, 15-pin
H4 = Centering collar
H5 = Bearing surface of stator
H6 = Self-locking screw M3 x 25, ISO 4762, width A/F 2.5, tightening torque: 1.2 ±0.1 Nm
H7 = Shaft surface
H8 = Maximum permissible distance between shaft and bearing surface of stator during mounting and operation
H9 = Direction of shaft rotation for output signals as per the interface description

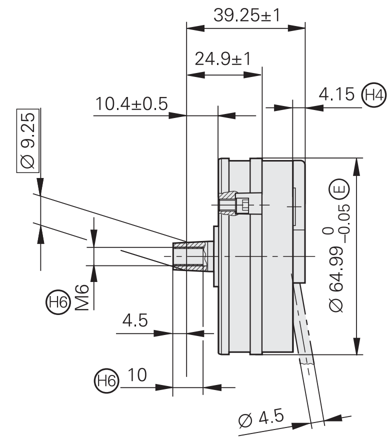
	Absolute **ECI 1118**
Incremental signals	None
Absolute position values	EnDat 2.2
Ordering designation	EnDat 22
Position values/rev	262144 (18 bits)
Revolutions	–
Elec. permissible speed/ deviations[1]	15000 min^{-1} for continuous position value
Calculation time t_{cal}	≤ 6 µs
System accuracy	± 120"
Power supply	3.6 to 14 V DC
Power consumption (maximum)	*3.6 V:* ≤ 520 mW *14 V:* ≤ 600 mW
Current consumption (typical)	*5 V:* 80 mA (without load)
Electrical connection	Via PCB connector, 15-pin
Shaft	Blind hollow shaft ∅ 6 mm, axial clamping
Mech. permiss. speed n	≤ 15000 min^{-1}
Moment of inertia of rotor	$0.14 \cdot 10^{-6}$ 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	IP 00[2]
Weight	Approx. 0.05 kg

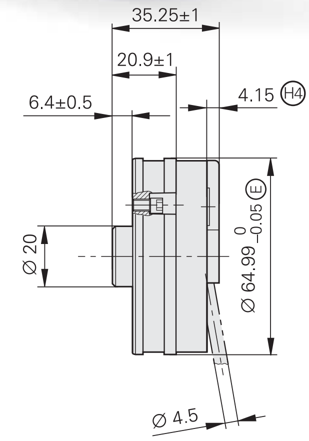
[1] Velocity-dependent deviation between the absolute and incremental signals
[2] CE compliance of the complete system must be ensured by taking the correct measures during installation.

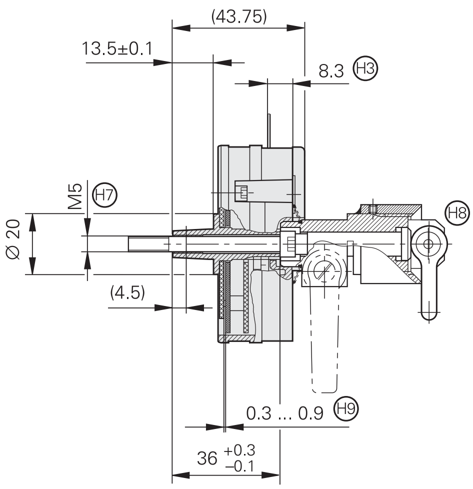
ECI/EQI 1300 Series

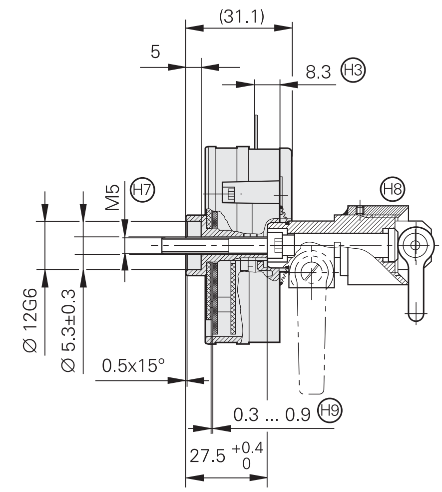
Rotary encoders without integral bearing for integration in motors
- **Installation diameter 65 mm**
- **Taper shaft or blind hollow shaft**

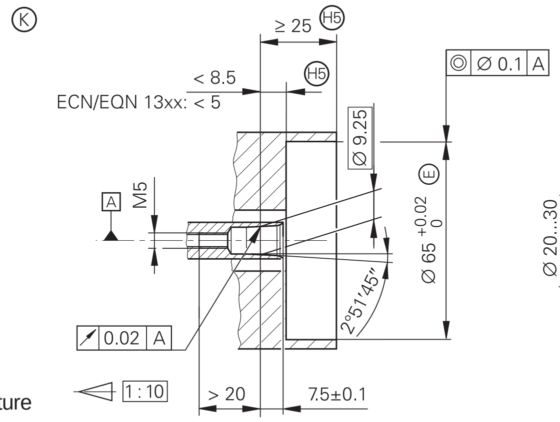


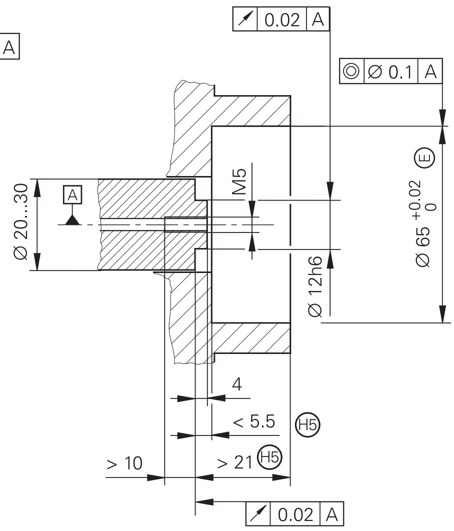












mm

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

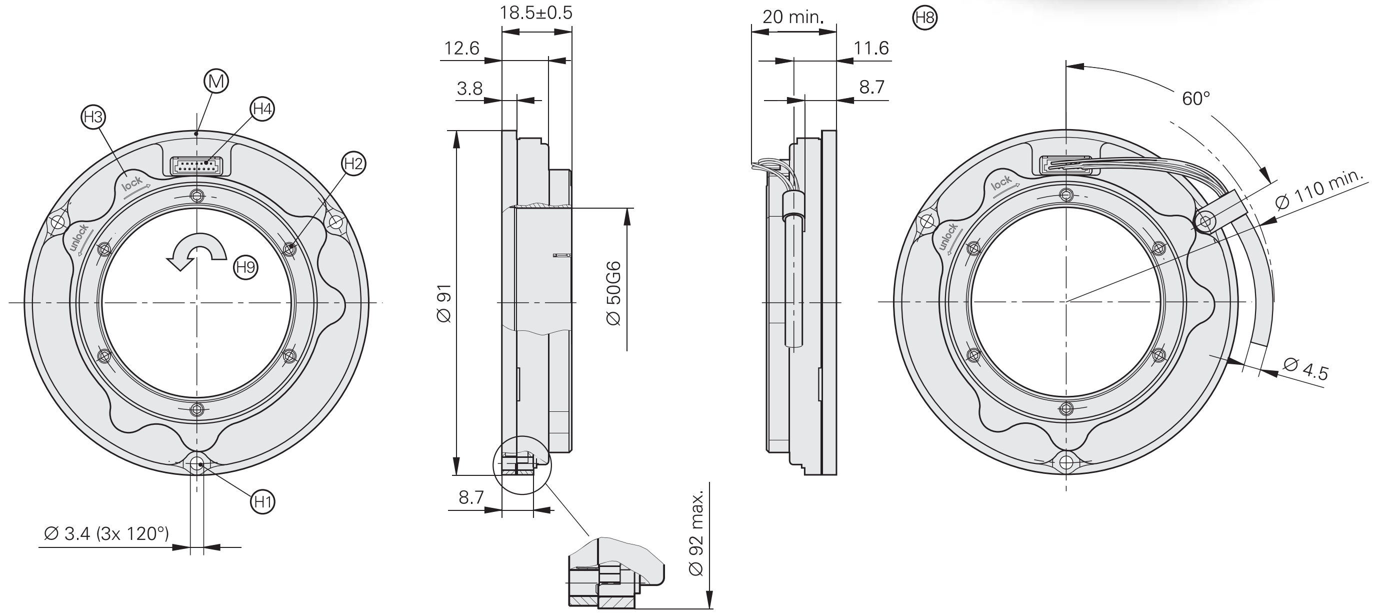
A = Bearing of mating shaft
K = Required mating dimensions
M = Measuring point for operating temperature
H1 = Mounting screw
Turn back by more than one revolution, and tighten with 2-0.5 Nm
H2 = 12-pin PCB connector
H3 = Outlet for ribbon cable
H4 = Cable exit for round cable
H5 = Minimum clamping and support surface; a closed diameter is best
H6 = M6 back-off thread
H7 = Cylinder head screw for hollow shaft: ISO 4762 – M5 x 35-A2, tightening torque 5 Nm
Cylinder head screw for taper shaft: ISO 4762 – M5 x 50-A2, tightening torque 5 Nm
H8 = Setting tool for scanning gap
H9 = Permissible scanning gap range over all operating conditions
H10 = Direction of shaft rotation for output signals as per the interface description

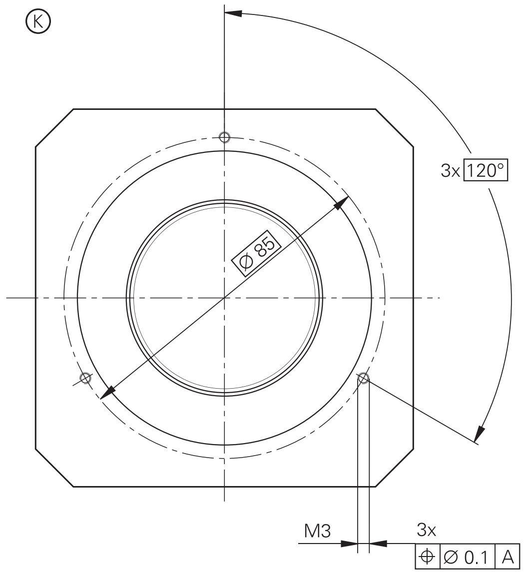
	Absolute			
	ECI 1319		**EQI 1331**	
Incremental signals	∿ 1 V_{PP}	None	∿ 1 V_{PP}	None
Line count	32	–	32	–
Cutoff frequency –3 dB	≥ 6 kHz typical	–	≥ 6 kHz typical	–
Absolute position values	EnDat 2.1			
Ordering designation	EnDat 01	**EnDat 21**	EnDat 01	**EnDat 21**
Position values/rev	524 288 (19 bits)			
Revolutions	–		4 096 (12 bits)	
Elec. permissible speed/ deviations[1)]	≤ 3750 min^{-1}/± 128 LSB ≤ 15000 min^{-1}/± 512 LSB	≤ 15 000 min^{-1} for continuous position value	≤ 4000 min^{-1}/± 128 LSB ≤ 12000 min^{-1}/± 512 LSB	≤ 12 000 min^{-1} for continuous position value
Calculation time t_{cal}	≤ 8 µs			
System accuracy	± 180“			
Power supply*	DC 5 V ± 5 % or DC 7 to 10 V			
Power consumption (maximum)	*5 V:* ≤ 0.7 W *7 V:* ≤ 1.0 W *10 V:* ≤ 1.4 W		*5 V:* ≤ 0.75 W *7 V:* ≤ 1.1 W *10 V:* ≤ 1.55 W	
Current consumption (typical)	100 mA (without load)		110 mA (without load)	
Electrical connection	Via 12-pin PCB connector			
Shaft*/Moment of inertia of rotor	Taper shaft ∅ 9.25 mm; Taper 1:10 /2.2 x 10^{-6} kgm^2 **Blind hollow shaft** ∅ 12.0 mm; Length 5 mm /3.2 x 10^{-6} kgm^2			
Mech. permiss. speed n	≤ 15 000 min^{-1}		≤ 12 000 min^{-1}	
Permissible axial motion of measured shaft	–0.2/+0.4 mm with 0.5 mm scanning gap			
Vibration 55 Hz to 2 000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60 068-2-6) ≤ 1 000 m/s^2 (EN 60 068-2-27)			
Max. operating temp.	115 °C			
Min. operating temp.	–20 °C			
Protection EN 60 529	IP 20 when mounted			
Weight	Approx. 0.13 kg			

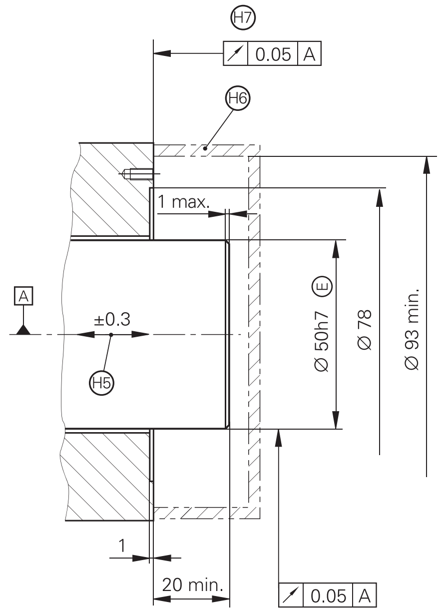
***** Please select when ordering
1) Velocity-dependent deviations between the absolute and incremental signals
Bold: Preferred model

ECI 119

Rotary encoders without integral bearing for integration in motors
- **Hollow through shaft Ø 50 mm**
- **Very flat design**







mm

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

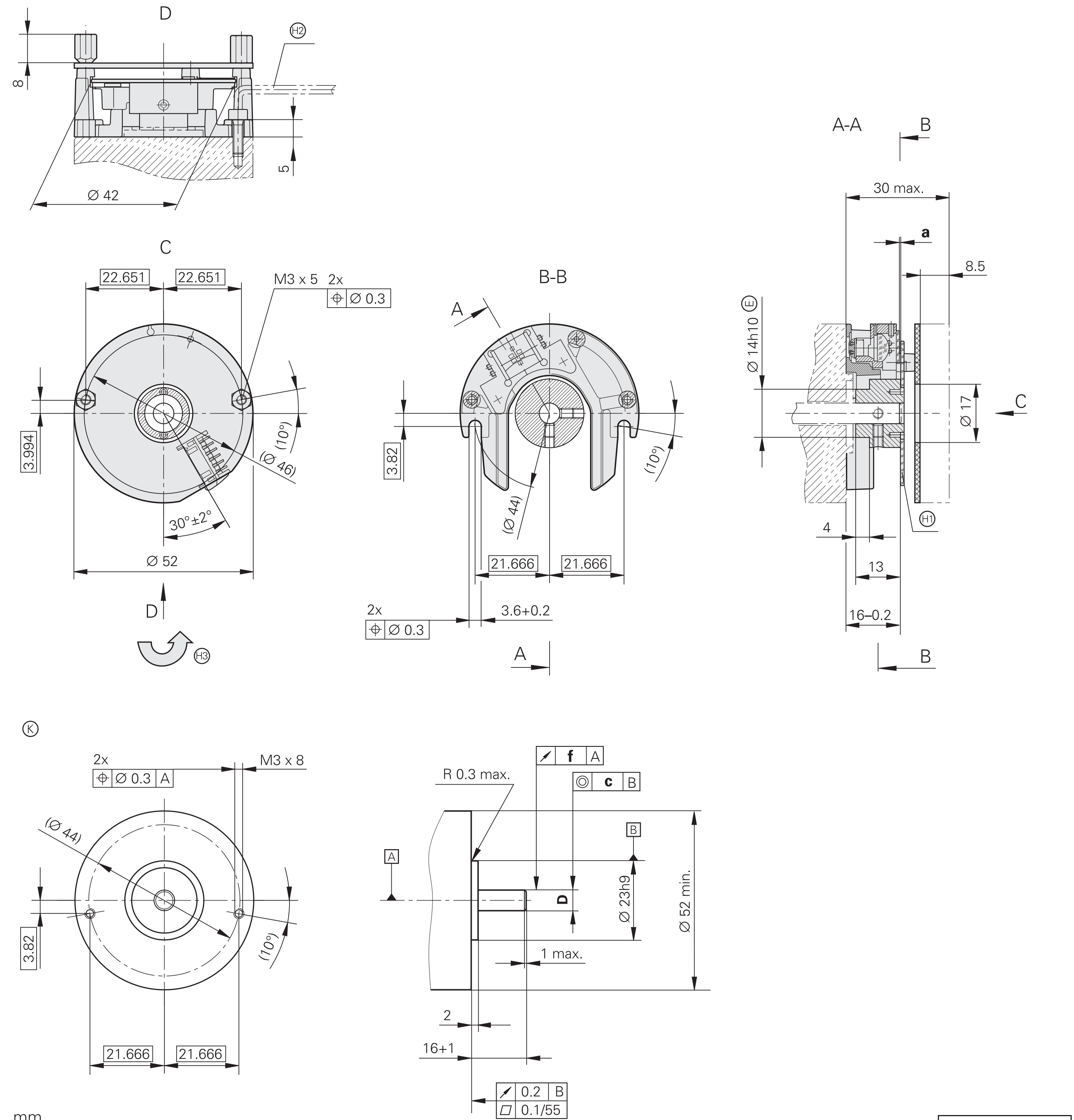
A = Bearing of mating shaft
K = Required mating dimensions
M = Measuring point for operating temperature
H1 = Cylinder head screw ISO 4762-M3 with ISO 7092 (3x) washer. Tightening torque 0.9±0.05 Nm
H2 = SW2.0 (6x). Evenly tighten crosswise with increasing tightening torque; final tightening torque 0.5 ±0.05 Nm
H3 = Shaft detent: For function, see Mounting/Removal
H4 = PCB connector, 15-pin
H5 = Compensation of mounting tolerances and thermal expansion, no dynamic motion
H6 = Protection as per EN 60 529
H7 = Required up to max. Ø 92 mm
H8 = Required mounting frame for output cable with cable clamp (accessory). Bending radius of connecting wires min. R3
H9 = Direction of shaft rotation for output signals as per the interface description

	Absolute ECI 119	
Incremental signals	∿ 1 V_{PP}	–
Line count	32	–
Cutoff frequency –3 dB	≥ 6 kHz typical	–
Absolute position values	**EnDat 2.1**	**EnDat 2.1**
Order designation*	EnDat 01	EnDat 21
Position values/rev	524288 (19 bits)	
Elec. permissible speed/ Deviations[1)]	≤ 3750 min^{-1}/± 128 LSB ≤ 6000 min^{-1}/± 512 LSB	≤ 6000 min^{-1} (for continuous position value)
Calculation time t_{cal}	≤ 8 µs	
System accuracy	± 90"	
Power supply	5 V DC ± 5 %	
Power consumption (maximum)	≤ 0.85 W	
Current consumption (typical)	135 mA (without load)	
Electrical connection	Via PCB connector, 15-pin	
Shaft	Hollow through shaft ∅ 50 mm	
Mech. permiss. speed n	≤ 6000 min^{-1}	
Moment of inertia of rotor	$63 \cdot 10^{-6}$ 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	IP 20 when mounted	
Weight	Approx. 0.14 kg	

* Please select when ordering
1) Velocity-dependent deviation between the absolute and incremental signals

ERO 1200 Series

Rotary encoders without integral bearing for integration in motors
- **Installation diameter 52 mm**
- **Hollow through shaft**



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	0.6 ± 0.2	Ø 0.05	Ø 0.02
	2048	0.2 ± 0.05		
ERO 1285	1024 2048	0.2 ± 0.03	Ø 0.03	Ø 0.02

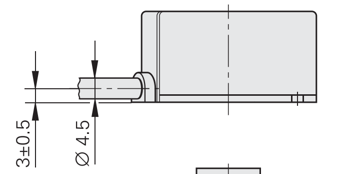
Ⓐ = Bearing
Ⓚ = Required mating dimensions
Ⓗ1 = Disk/hub assembly
Ⓗ2 = Offset screwdriver ISO 2936 – 2.5 (l_2 shortened)
Ⓗ3 = Direction of shaft rotation for output signals as per the interface description

	Incremental	
	ERO 1225	**ERO 1285**
Incremental signals	⊓⊔TTL	∼ 1 V_{PP}
Line count *	1024 2048	
Accuracy of the graduation[2)]	± 6"	
Reference mark	One	
Scanning frequency Edge separation a Cutoff frequency –3 dB	≤ 300 kHz ≥ 0.39 µs –	– – Typically ≥ 180 kHz
System accuracy[1)]	*1024 lines:* ± 92" *2048 lines:* ± 73"	*1024 lines:* ± 67" *2048 lines:* ± 60"
Power supply	5 V DC ± 10 %	
Current consumption (w/o load)	≤ 150 mA	
Electrical connection	Via 12-pin PCB connector	
Shaft*	Hollow through shaft ∅ 10 mm or ∅ 12 mm	
Moment of inertia of rotor	*Shaft ∅ 10 mm:* $2.2 \cdot 10^{-6}$ kgm^2 *Shaft ∅ 12 mm:* $2.15 \cdot 10^{-6}$ kgm^2	
Mech. permiss. speed n	≤25000 min^{-1}	
Permissible axial motion of measured shaft	*1024 lines:* ± 0.2 mm *2048 lines:* ± 0.05 mm	± 0.03 mm
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)	
Max. operating temp.	100 °C	
Min. operating temp.	–40 °C	
Protection EN 60529	IP 00 [3)]	
Weight	Approx. 0.07 kg	

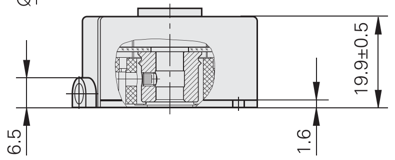
* Please select when ordering
[1)] Before installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft is not included.
[2)] For other errors, see *Measuring Accuracy*
[3)] CE compliance of the complete system must be ensured by taking the correct measures during installation.

ERO 1400 Series

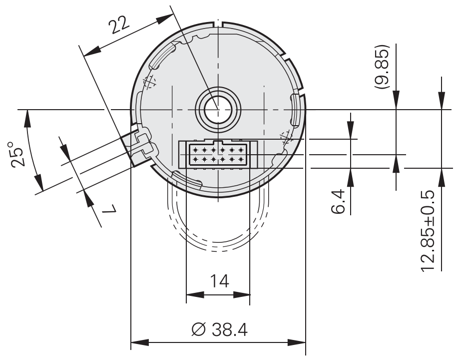
Rotary encoders without integral bearing
- **For integration in motors with PCB connector (protection IP 00)**
- **For mounting on motors with cable outlet (protection IP 40)**
- **Installation diameter 44 mm**

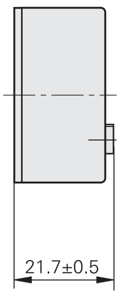


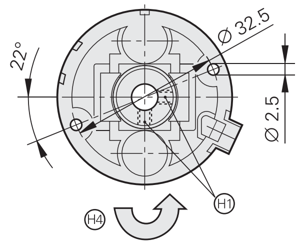
With cable outlet

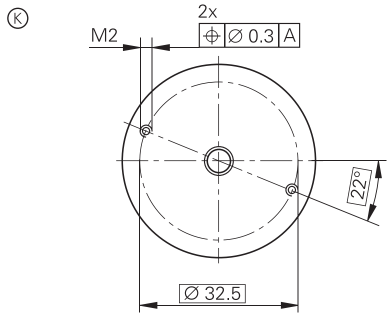


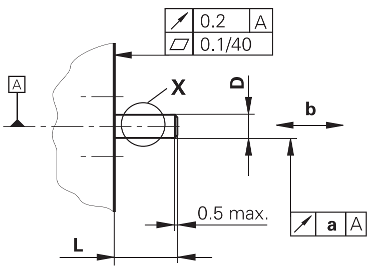
With axial PCB connector

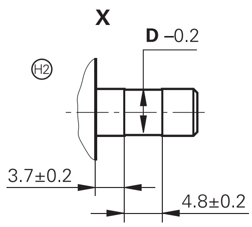


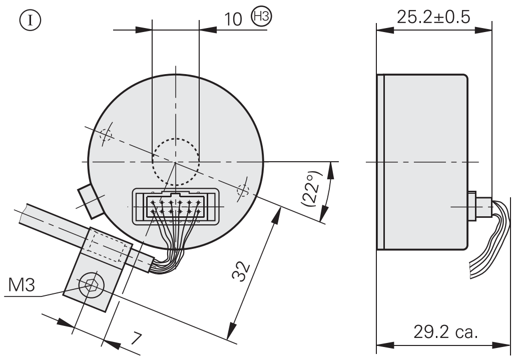




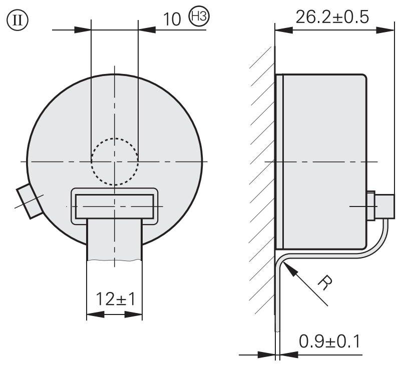




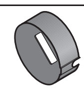
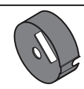




Axial PCB connector and round cable



Axial PCB connector and ribbon cable

		
L	13+4.5/–3	10 min.

mm

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

Ⓐ = Bearing
Ⓚ = Required mating dimensions
Ⓘ = Accessory: Round cable
Ⓘⓘ = Accessory: Ribbon cable
H1 = Setscrew, 2x90° offset, M3, width A/F 1.5 Md = 0.25 ±0.05 Nm
H2 = Version for repeated assembly
H3 = Version featuring housing with central hole (accessory)
H4 = Direction of shaft rotation for output signals as per the interface description

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

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

D
Ø 4h6 Ⓔ
Ø 6h6 Ⓔ
Ø 8h6 Ⓔ

	Incremental					
	ERO 1420	**ERO 1470**				**ERO 1480**
Incremental signals	⊓⊔TTL	⊓⊔TTL x 5	⊓⊔TTL x 10	⊓⊔TTL x 20	⊓⊔TTL x 25	∼ 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/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	*512 lines:* ± 139" *1000 lines:* ± 112" *1024 lines:* ± 112"	*1000 lines:* ± 130" *1500 lines:* ± 114"				*512 lines:* ± 190" *1000 lines:* ± 163" *1024 lines:* ± 163"
Power supply	5 V DC ± 10 %	5 V DC ± 5 %				5 V DC ± 10 %
Current consumption (w/o load)	≤ 150 mA	≤ 155 mA		≤ 200 mA		≤ 150 mA
Electrical connection*	• Over 12-pin axial **PCB connector** • Cable 1 m, radial, without connecting element (not with ERO 1470)					
Shaft*	**Blind hollow shaft** ∅ 4 mm; **∅ 6 mm** or ∅ 8 mm or hollow through shaft in housing with bore (accessory)					
Moment of inertia of rotor	*Shaft ∅ 4 mm:* $0.28 \cdot 10^{-6}$ kgm^2 *Shaft ∅ 6 mm:* $0.27 \cdot 10^{-6}$ kgm^2 *Shaft ∅ 8 mm:* $0.25 \cdot 10^{-6}$ kgm^2					
Mech. permiss. speed n	≤ 30000 min^{-1}					
Permissible axial motion of measured shaft	± 0.1 mm	± 0.05 mm				
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)					
Max. operating temp.	70 °C					
Min. operating temp.	–10 °C					
Protection EN 60529	*With PCB connector:* IP 00[2)] *With cable outlet:* IP 40					
Weight	Approx. 0.07 kg					

Bold: This preferred version is available on short notice
* Please select when ordering
1) Before installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the measured shaft is not included.
2) CE compliance of the complete system must be ensured by taking the correct measures during installation.

Interfaces
Incremental Signals ∼ 1 V_{PP}

HEIDENHAIN encoders with ∼ 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 amplitudes of typically 1 V_{PP}. The illustrated sequence of output signals—with B lagging A—applies for the direction of motion shown in the dimension drawing.

The **reference mark signal** R has a usable component G of approx. 0.5 V. Next to the reference mark, the output signal can be reduced by up to 1.7 V to a quiescent value H. This must not cause the subsequent electronics to overdrive. Even at the lowered signal level, signal peaks with the amplitude G can also appear.

The data on **signal amplitude** apply when the power supply given in the specifications is connected to the encoder. They refer to a differential measurement at the 120 ohm terminating resistor between the associated outputs. The signal amplitude decreases with increasing frequency. The **cutoff frequency** indicates the scanning frequency at which a certain percentage of the original signal amplitude is maintained:

- –3 dB ≙ 70 % of the signal amplitude
- –6 dB ≙ 50 % of the signal amplitude

The data in the signal description apply to motions at up to 20% of the –3 dB-cutoff frequency.

Interpolation/resolution/measuring step
The output signals of the 1 V_{PP} interface are usually interpolated in the subsequent electronics in order to attain sufficiently high resolutions. For **velocity control,** interpolation factors are commonly over 1000 in order to receive usable velocity information even at low speeds.

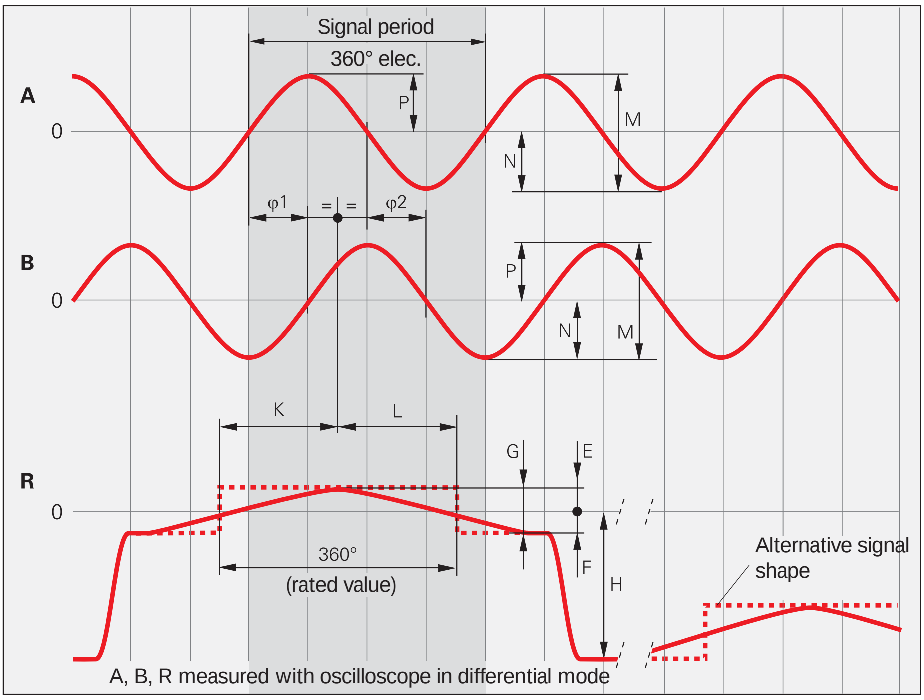
Measuring steps for **position measurement** are recommended in the specifications. For special applications, other resolutions are also possible.

Short-circuit stability
A temporary short circuit of one signal output to 0 V or U_P (except encoders with U_{Pmin}= 3.6 V) does not cause encoder failure, but it is not a permissible operating condition.

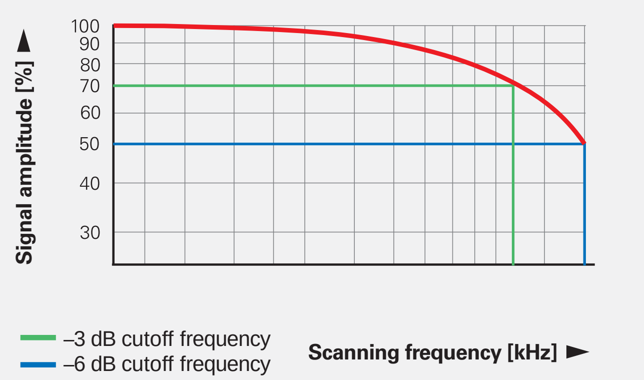
Short circuit at	20 °C	125 °C
One output	< 3 min	< 1 min
All outputs	< 20 s	< 5 s

Interface	Sinusoidal voltage signals ∼ **1 V_{PP}**
Incremental signals	**2 nearly sinusoidal signals A and B** Signal amplitude M: 0.6 to 1.2 V_{PP}; typically 1 V_{PP} Asymmetry |P – N|/2M: ≤ 0.065 Amplitude ratio M_A/M_B: 0.8 to 1.25 Phase angle |φ1 + φ2|/2: 90° ± 10° elec.
Reference-mark signal	**One or several signal peaks R** Usable component G: ≥ 0.2 V Quiescent value H: ≤ 1.7 V Switching threshold E, F: 0.04 to 0.68 V Zero crossovers K, L: 180° ± 90° elec.
Connecting cable Cable length Propagation time	Shielded HEIDENHAIN cable PUR [4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] Max. 150 m at 90 pF/m distributed capacitance 6 ns/m

These values can be used for dimensioning of the subsequent electronics. Any limited tolerances in the encoders are listed in the specifications. For encoders without integral bearing, reduced tolerances are recommended for initial operation (see the mounting instructions).



Cutoff frequency
Typical signal amplitude curve with respect to the scanning frequency



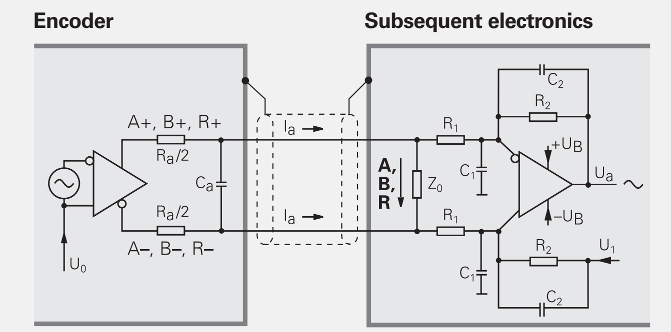
Input Circuitry of the Subsequent Electronics

Dimensioning
Operational amplifier MC 34074
$Z_0 = 120\ \Omega$
$R_1 = 10\ k\Omega$ and $C_1 = 100\ pF$
$R_2 = 34.8\ k\Omega$ and $C_2 = 10\ pF$
$U_B = \pm 15\ V$
U_1 approx. U_0

–3 dB cutoff frequency of circuitry
Approx. 450 kHz
Approx. 50 kHz with $C_1 = 1000\ pF$
and $C_2 = 82\ pF$
The circuit variant for 50 kHz does reduce the bandwidth of the circuit, but in doing so it improves its noise immunity.

Incremental signals
Reference-mark signal

$R_a < 100\ \Omega$, typically $24\ \Omega$
$C_a < 50\ pF$
$\Sigma I_a < 1\ mA$
$U_0 = 2.5\ V \pm 0.5\ V$
(relative to 0 V of the power supply)

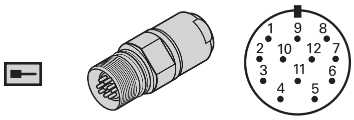


Circuit output signals
$U_a = 3.48\ V_{PP}$ typically
Gain 3.48

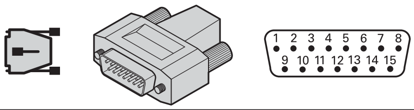
Monitoring of the incremental signals
The following sensitivity levels are recommended for monitoring the signal amplitude M:
Lower threshold: $0.30\ V_{PP}$
Upper threshold: $1.35\ V_{PP}$

Pin Layout

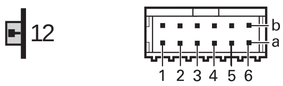
12-pin coupling, M23



15-pin D-sub connector
For IK215/PWM 20



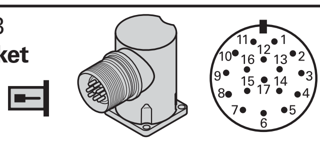
12-pin PCB connector



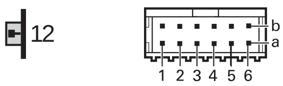
	Power supply				Incremental signals						Other signals		
	12	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**9**	**7**	**/**
	4	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**5/6/8/15**	**13**	**/**
12	**2a**	**2b**	**1a**	**1b**	**6b**	**6a**	**5b**	**5a**	**4b**	**4a**	**3b**	**3a**	**/**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 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 in the motor
ID 667343-01

17-pin M23
flange socket



12-pin PCB connector



	Power supply				Incremental signals						Other signals		
	7	**1**	**10**	**4**	**15**	**16**	**12**	**13**	**3**	**2**	**5**	**6**	**8/9/11/ 14/17**
12	**2a**	**2b**	**1a**	**1b**	**6b**	**6a**	**5b**	**5a**	**4b**	**4a**	**/**	**/**	**3a/3b**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**T+**1)	**T–**1)	**Vacant**
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	Brown1)	White1)	/

Cable shield connected to housing; **U_P** = power supply; 1) Only for encoder cable inside the motor housing
Sensor: The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!

Interfaces
Incremental Signals ⊓⊔ TTL

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

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

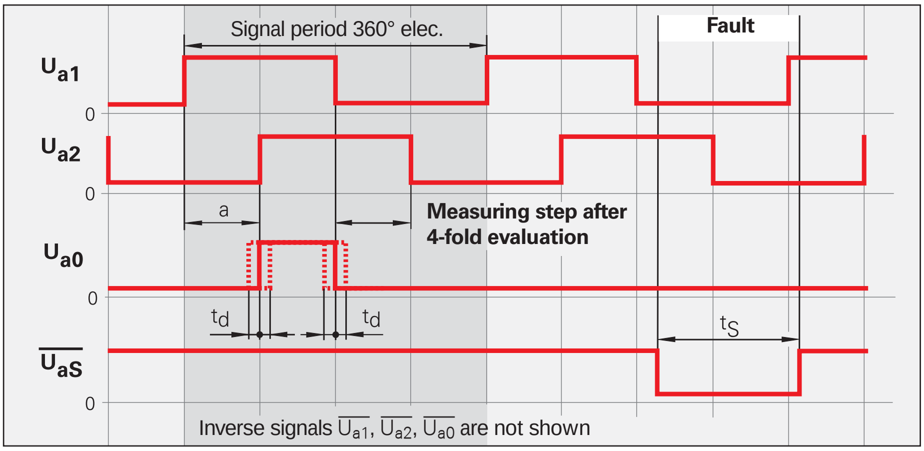
The **fault-detection signal** $\overline{U_{aS}}$ indicates fault conditions such as breakage of the power line or failure of the light source. It can be used for such purposes as machine shut-off during automated production.

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.**

The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum **edge separation a** listed in the *Specifications* applies for the illustrated input circuitry with a cable length of 1 m, and refers to measurement at the output of the differential line receiver. Cable-dependent differences in the propagation times additionally reduce the edge separation by 0.2 ns per meter of cable. To prevent counting errors, design the subsequent electronics to process as little as 90 % of the resulting edge separation.

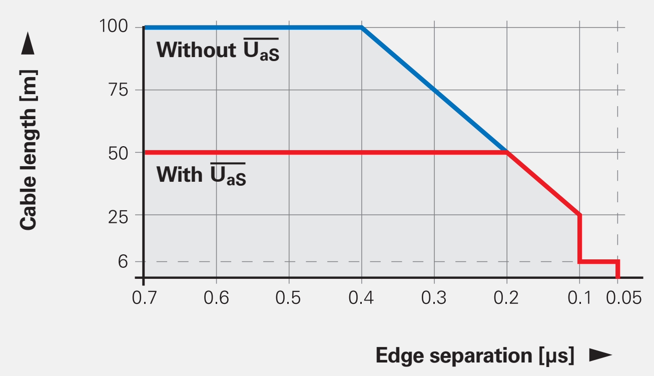
The max. permissible **shaft speed** or **traversing velocity** must never be exceeded.

Interface	Square-wave signals ⊓⊔ **TTL**
Incremental signals	**2 square-wave signals U_{a1}, U_{a2}** and their inverted signals **$\overline{U_{a1}}$, $\overline{U_{a2}}$**
Reference-mark signal Pulse width Delay time	**1 or more TTL square-wave pulses U_{a0}** and their inverted pulses **$\overline{U_{a0}}$** 90° elec. (other widths available on request); *LS 323:* ungated $\|t_d\| \leq 50$ ns
Fault-detection signal Pulse width	**1 TTL square-wave pulse $\overline{U_{aS}}$** Improper function: LOW (upon request: U_{a1}/U_{a2} high impedance) Proper function: HIGH $t_S \geq 20$ ms
Signal amplitude	Differential line driver as per EIA standard RS-422 $U_H \geq 2.5$ V at $-I_H = 20$ mA *ERN 1x23:* 10 mA $U_L \leq 0.5$ V at $I_L = 20$ mA *ERN 1x23:* 10 mA
Permissible load	$Z_0 \geq 100\ \Omega$ Between associated outputs $\|I_L\| \leq 20$ mA Max. load per output (*ERN 1x23:* 10 mA) $C_{load} \leq 1000$ pF With respect to 0 V Outputs protected against short circuit to 0 V
Switching times (10% to 90%)	$t_+ / t_- \leq 30$ ns (typically 10 ns) with 1 m cable and recommended input circuitry
Connecting cable Cable length Propagation time	Shielded HEIDENHAIN cable PUR [4(2 × 0.14 mm²) + (4 × 0.5 mm²)] Max. 100 m ($\overline{U_{aS}}$ max. 50 m) at distributed capacitance 90 pF/m 6 ns/m



The permissible **cable length** for transmission of the TTL square-wave signals to the subsequent electronics depends on the edge separation a. It is at most 100 m, or 50 m for the fault detection signal. This requires, however, that the power supply (see *Specifications*) be ensured at the encoder. The sensor lines can be used to measure the voltage at the encoder and, if required, correct it with an automatic control system (remote sense power supply).

Permissible cable length
with respect to the edge separation

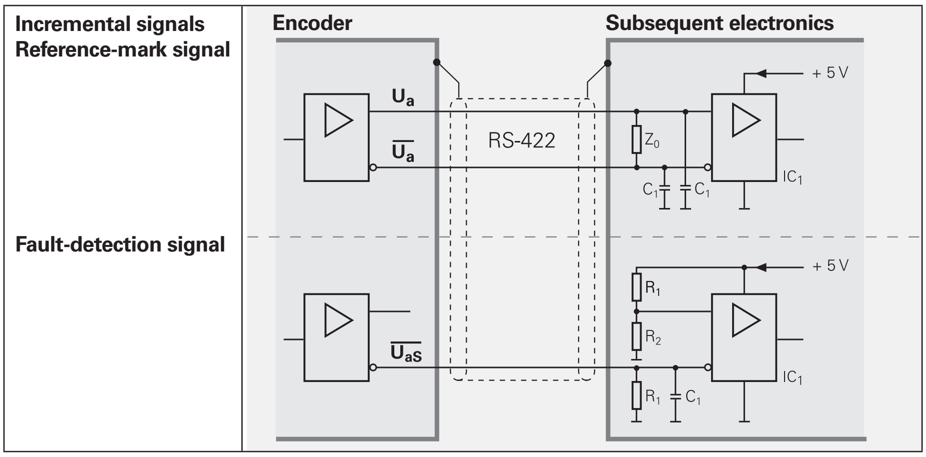


Input Circuitry of the Subsequent Electronics

Dimensioning

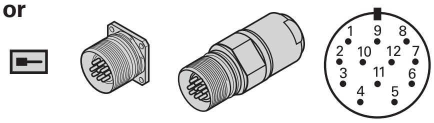
IC_1 = Recommended differential line receiver
DS 26 C 32 AT
Only for a > 0.1 µs:
AM 26 LS 32
MC 3486
SN 75 ALS 193

R_1 = 4.7 kΩ
R_2 = 1.8 kΩ
Z_0 = 120 Ω
C_1 = 220 pF (serves to improve noise immunity)

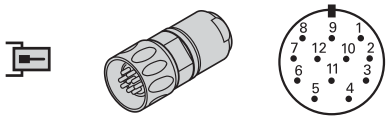


Pin Layout

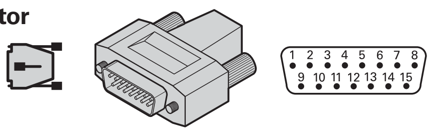
12-pin flange socket or M23 **coupling**



12-pin connector, M23



15-pin D-sub connector
For IK215/PWM 20

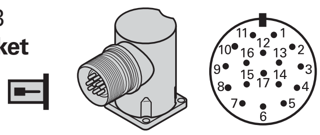


12-pin PCB connector

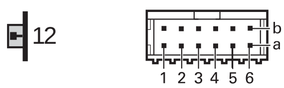
	Power supply				Incremental signals						Other signals		
	12	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**7**	**/**	**9**
	4	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**13**	**5/6/8**	**15**
12	**2a**	**2b**[1]	**1a**	**1b**[1]	**6b**	**6a**	**5b**	**5a**	**4b**	**4a**	**3a**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

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

17-pin M23 **flange socket**



12-pin PCB connector



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

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

1) **ERO 14xx:** Vacant
2) **Exposed linear encoders:** Switchover TTL/11 µAPP for PWT, otherwise vacant
3) Only for encoder cable inside the motor housing

Interfaces

Commutation Signals for Block Commutation

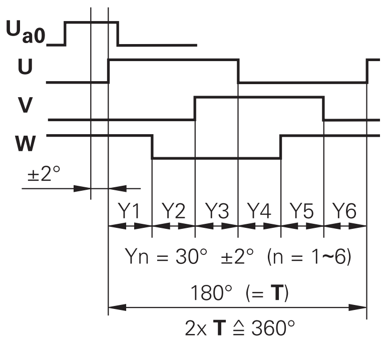
The **block commutation signals U, V and W** are derived from three separate absolute tracks. They are transmitted as square-wave signals in TTL levels.

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

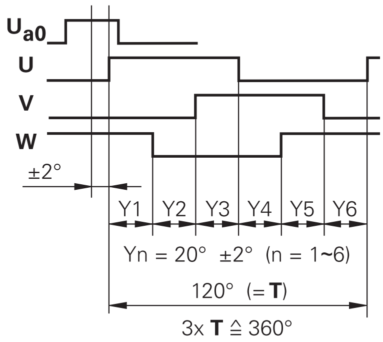
Interface	Square-wave signals ⊓⊔ **TTL**
Commutation signals Width Signal levels	Three square-wave signals U, V, W and their inverse signals $\overline{U}$, $\overline{V}$, $\overline{W}$ 2x180° mech., 3x120° mech. or 4x90° mech. (other versions upon request) See *Incremental Signals* ⊓⊔ *TTL*
Incremental signals	See *Incremental Signals* ⊓⊔ *TTL*
Connecting cable Cable length Propagation time	Shielded HEIDENHAIN cable PUR [6(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] Max. 100 m 6 ns/m

Commutation signals
(Values in mechanical degrees)

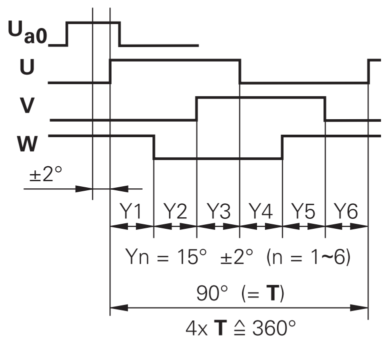
C01



C02

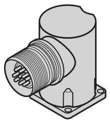


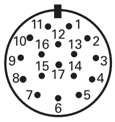
C03



ERN 1123, ERN 1326 Pin Layout

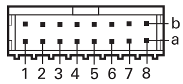
17-pin M23 **flange socket**





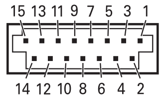
16-pin PCB connector

16



15-pin PCB connector

15



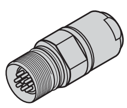
	Power supply				Incremental signals					
	7	**1**	**10**	**11**	**15**	**16**	**12**	**13**	**3**	**2**
16	**1b**	**2b**	**1a**	**/**	**5b**	**5a**	**4b**	**4a**	**3b**	**3a**
15	**13**	**/**	**14**	**/**	**1**	**2**	**3**	**4**	**5**	**6**
	U_P	**Sensor** U_P	**0 V**	**Internal shield**	**U_{a1}**	**$\overline{U_{a1}}$**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

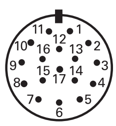
	Other signals						
	4	**5**	**6**	**14**	**17**	**9**	**8**
16	**2a**	**8b**	**8a**	**6b**	**6a**	**7b**	**7a**
15	**/**	**7**	**8**	**9**	**10**	**11**	**12**
	$\overline{U_{aS}}$	**U**	**$\overline{U}$**	**V**	**$\overline{V}$**	**W**	**$\overline{W}$**
	White	Green	Brown	Yellow	Violet	Gray	Pink

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

Pin Layout for ERN 1023

17-pin coupling M23 **or flange socket**





	Power supply		Incremental signals						Other signals					
	7	**10**	**15**	**16**	**12**	**13**	**3**	**2**	**5**	**6**	**14**	**17**	**9**	**8**
	U_P	**0 V**	**U_{a1}**	**$\overline{U_{a1}}$**	**U_{a2}**	**$\overline{U_{a2}}$**	**U_{a0}**	**$\overline{U_{a0}}$**	**U**	**$\overline{U}$**	**V**	**$\overline{V}$**	**W**	**$\overline{W}$**
	White	Black	Red	Pink	Olive Green	Blue	Yellow	Orange	Beige	Brown	Green	Gray	Light Blue	Violet

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

Interfaces

Commutation Signals for Sinusoidal Commutation

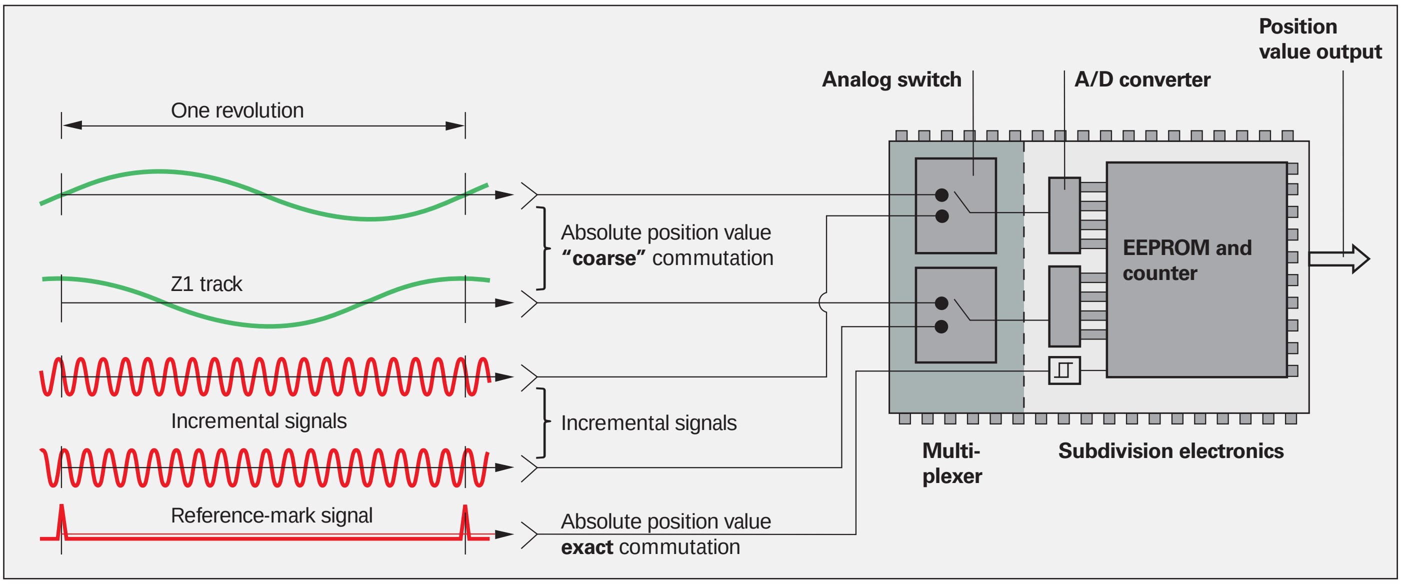
The **commutation signals C and D** are taken from the so-called Z1 track and form one sine or cosine period per revolution. They have a signal amplitude of typically 1 V_{PP} at 1 kΩ.

The input circuitry of the subsequent electronics is the same as for the ∿ 1 V_{PP} interface. The required terminating resistor of Z_0, however, is 1 kΩ instead of 120 Ω.

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

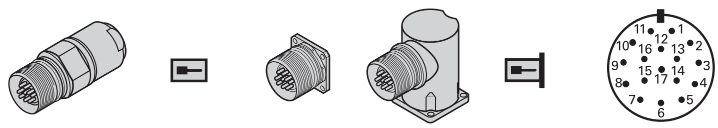
Interface	Sinusoidal voltage signals ∿ **1 V_{PP}**
Commutation signals	**2 nearly sinusoidal signals C and D** See *Incremental Signals* ∿ *1 V_{PP}*
Incremental signals	See *Incremental Signals* ∿ *1 V_{PP}*
Connecting cable Cable length Propagation time	Shielded HEIDENHAIN cable PUR [4(2 x 0.14 mm^2) + (4 x 0.14 mm^2) + (4 x 0.5 mm^2)] Max. 150 m 6 ns/m

Electronic commutation with Z1 track

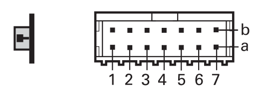


Pin Layout

17-pin coupling or flange socket M23



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[1)]	**0 V**	**Sensor** 0 V[1)]	**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+**[2)]	**T–**[2)]
	Gray	Pink	Yellow	Violet	Green	Brown

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

[1)] Not assigned if a power of 7 to 10 V is supplied via adapter inside the motor housing
[2)] Only for cables inside the motor housing

Absolute Position Values EnDat

The EnDat interface is a digital, **bidirectional** interface for encoders. It is capable both of transmitting **position values** as well as transmitting or updating information stored in the encoder, or saving new information. Thanks to the **serial transmission method**, only **four signal lines** are required. The data is transmitted in **synchronism** with the clock signal from the subsequent electronics. The type of transmission (position values, parameters, diagnostics, etc.) is selected through mode commands that the subsequent electronics send to the encoder. Some functions are available only with EnDat 2.2 mode commands.

For more information, refer to the *EnDat* Technical Information sheet or visit *www.endat.de*.

Position values can be transmitted with or without additional information (e.g. position value 2, temperature sensors, diagnostics, limit position signals).

Besides the position, additional information can be interrogated in the closed loop and functions can be performed with the EnDat 2.2 interface.

Parameters are saved in various memory areas, e.g.:
- Encoder-specific information
- Information of the OEM (e.g. "electronic ID label" of the motor)
- Operating parameters (datum shift, instruction, etc.)
- Operating status (alarm or warning messages)

Monitoring and diagnostic functions of the EnDat interface make a detailed inspection of the encoder possible.
- Error messages
- Warnings
- Online diagnostics based on valuation numbers (EnDat 2.2)

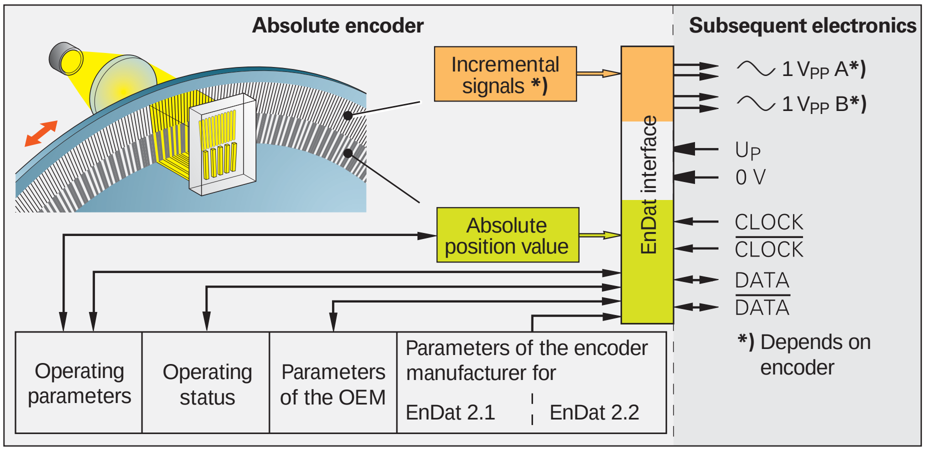
Incremental signals
EnDat encoders are available with or without incremental signals. EnDat 21 and EnDat 22 encoders feature a high internal resolution. An evaluation of the incremental signal is therefore unnecessary.

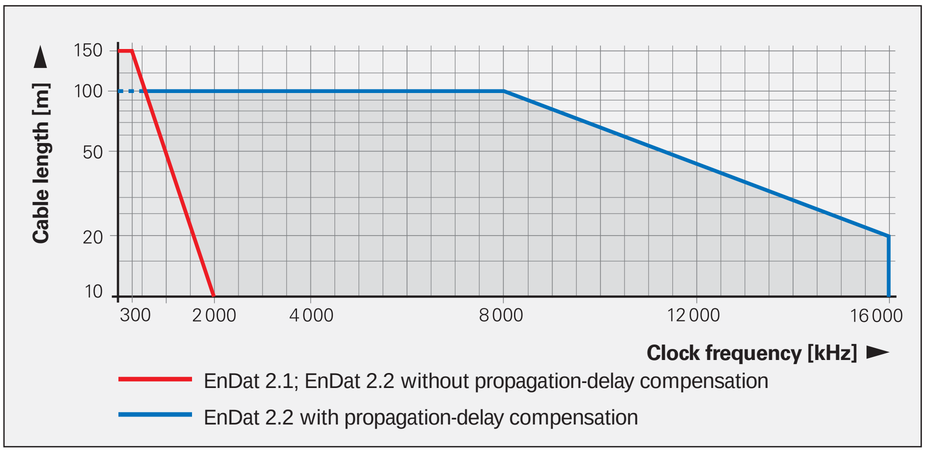
Clock frequency and cable length
The clock frequency is variable—depending on the cable length (max. 150 m)—between **100 kHz** and **2 MHz.** With propagation-delay compensation in the subsequent electronics, clock frequencies up to **16 MHz** at cable lengths up to 100 m are possible.

Interface	**EnDat** serial bidirectional
Data transfer	Absolute position values, parameters and additional information
Data input	Differential line receiver according to EIA standard RS 485 for the signals CLOCK, $\overline{\text{CLOCK}}$, DATA and $\overline{\text{DATA}}$
Data output	Differential line driver according to EIA standard RS 485 for the signals DATA and $\overline{\text{DATA}}$
Position values	Ascending during traverse in direction of arrow (see dimensions of the encoders)
Incremental signals	∿ 1 V_{PP} (see *Incremental signals 1* V_{PP}) depending on the unit

Ordering designation	**Command set**	**Incremental signals**	**Power supply**
EnDat 01	EnDat 2.1 or EnDat 2.2	With	See specifications of the encoder
EnDat 21		Without	
EnDat 02	EnDat 2.2	With	Expanded range 3.6 V to 5.25 V or 14 V DC
EnDat 22	EnDat 2.2	Without	

Versions of the EnDat interface (bold print indicates standard versions)





Input Circuitry of Subsequent Electronics

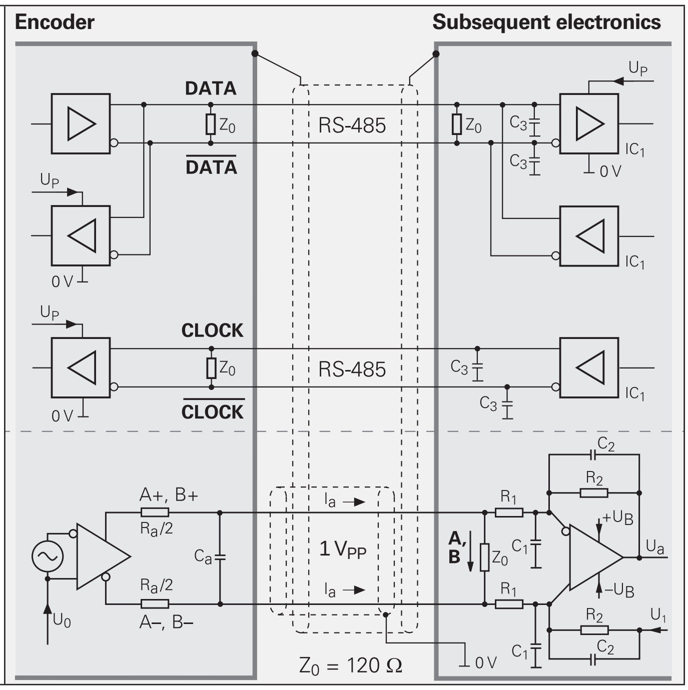
Dimensioning

IC_1 = RS 485 differential line receiver and driver

C_3 = 330 pF
Z_0 = 120 Ω

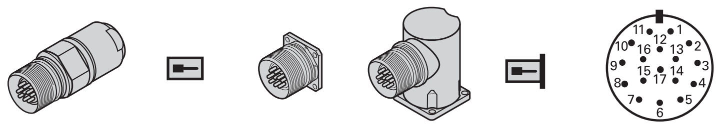
Data transfer

Incremental signals
depending on encoder

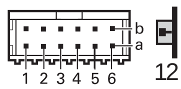


Pin Layout EnDat

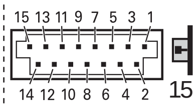
17-pin coupling or flange socket M23



12-pin PCB connector



15-pin PCB connector



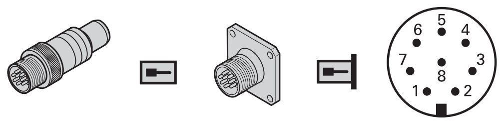
	Power supply					Incremental signals[1]				Absolute position values			
	7	**1**	**10**	**4**	**11**	**15**	**16**	**12**	**13**	**14**	**17**	**8**	**9**
12	**1b**	**6a**	**4b**	**3a**	**/**	**2a**	**5b**	**4a**	**3b**	**6b**	**1a**	**2b**	**5a**
15	**13**	**11**	**14**	**12**	**/**	**1**	**2**	**3**	**4**	**7**	**8**	**9**	**10**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Internal shield**	**A+**	**A–**	**B+**	**B–**	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
	Brown/ Green	Blue	White/ Green	White	/	Green/ Black	Yellow/ Black	Blue/ Black	Red/ Black	Gray	Pink	Violet	Yellow

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

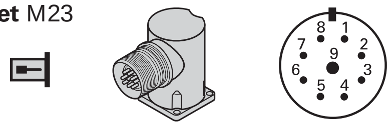
Cable shield connected to housing; **U_P** = power supply voltage; **T** = temperature
Sensor: The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!

1) Only with ordering designations EnDat 01 and EnDat 02
2) Only for cables inside the motor housing
3) Connections for external temperature sensor; connection in the flange socket M23
4) **ECI 1118 EnDat 22:** Vacant
5) Only EnDat 22, except ECI 1118
6) White with M23 flange socket
green with M12 flange socket

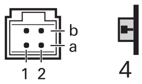
8-pin coupling or flange socket M12



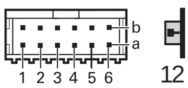
9-pin flange socket M23



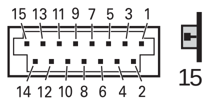
4-pin PCB connector



12-pin PCB connector



15-pin PCB connector

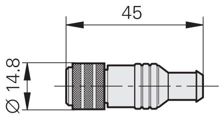


	Power supply				Absolute position values				Other signals[3]			
M12	**8**	**2**	**5**	**1**	**3**	**4**	**7**	**6**	**/**	**/**	**/**	**/**
M23	**3**	**7**	**4**	**8**	**5**	**6**	**1**	**2**	**/**	**/**	**/**	**/**
4	**/**	**/**	**/**	**/**	**/**	**/**	**/**	**/**	**1a**	**1b**	**/**	**/**
12	**1b**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

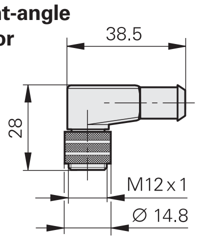
Connector (insulated): A connecting element with a coupling ring. Available with male or female contacts.

Symbols 

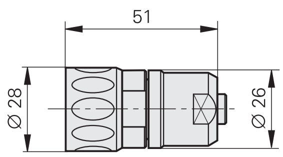
M12



M12 right-angle connector



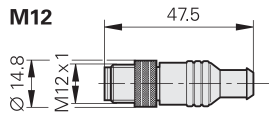
M23



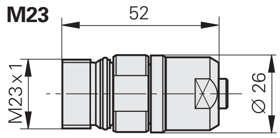
Coupling (insulated): Connecting element with external thread; available with male or female contacts.

Symbols 

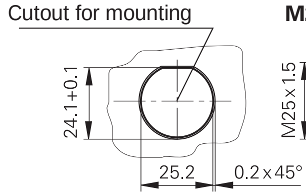
M12



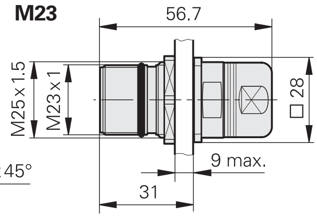
M23



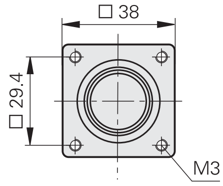
Mounted coupling with central fastening



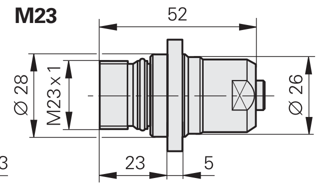
M23



Mounted coupling with flange



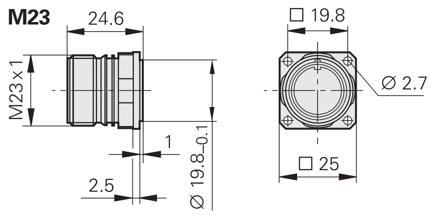
M23



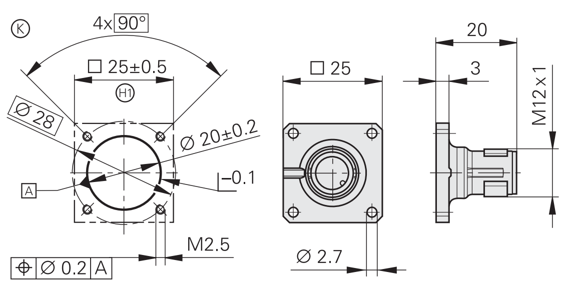
Flange socket: with external thread; permanently mounted on a housing, available with male or female contacts.

Symbols 

M23

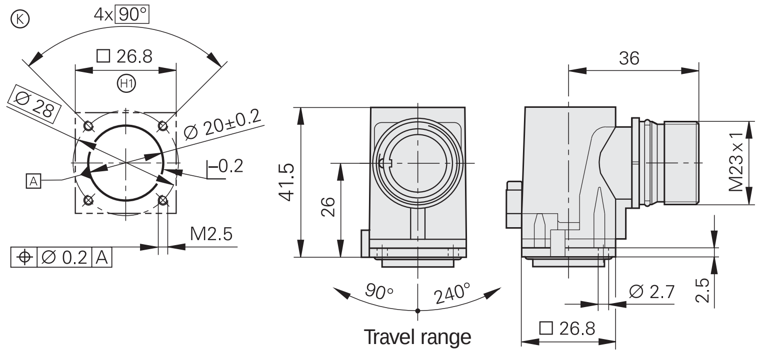


M12 **flange socket**
With motor-internal encoder cable

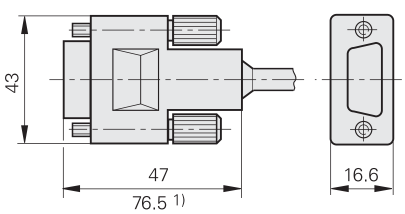


Ⓚ = Mating mounting holes
Ⓗ1 = Flatness 0.05 / Ra3.2

M23 **right-angle flange socket**
(Rotatable) with motor-internal encoder cable



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



1) Interface electronics integrated in connector

The pins on connectors are **numbered** in the direction opposite to those on couplings or flange sockets, regardless of whether the connecting elements are

male or

female.

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

Accessories for flange sockets and M23 mounted couplings

Bell seal
ID 266526-01

Threaded metal dust cap
ID 219926-01

Accessory for M12 connecting element
Insulation spacer
ID 596495-01

Cables inside the Motor Housing

Cables inside the motor housing Cable diameter 4.5 mm or TPE single wire with shrink-wrap or net tubing	PCB connector	Crimp sleeve	**Complete** With PCB connector and right-angle socket M23, 17-pin or *M23 angle socket, 9-pin* 	**With one connector** With PCB connector 	**Complete** With PCB connector and M12, 8-pin flange socket, with net tubing without shield connection 
ECN 1113 **EQN 1125**	15-pin	∅ 4.5 mm	606 079-xx EPG 16xAWG30/7	605 090-xx EPG 16xAWG30/7	–
ECN 1123 **EQN 1135**	15-pin	∅ 4.5 mm	*746 170-xx* *EPG [6(2xAWG28/7)]*	681 161-xx EPG [6(2xAWG28/7)]	746 795-xx TPE 10xAWG26/19
ECI 119	15-pin	∅ 4.5 mm	–	640 067-xx[1] EPG 16xAWG30/7	804 201-xx[3,4] TPE 8xAWG26/19
ECI 1118 **EQI 1130** EnDat 01 EnDat 21	15-pin	–	–	640 030-xx[2] TPE 12xAWG26/19	804 201-xx[3,4] TPE 8xAWG26/19
ECI 1118 EnDat 22	15-pin	–	–	735 784-xx[2] TPE 6xAWG26/19	805 320-xx[3] TPE 6xAWG26/19
ERN 1123	15-pin	–	–	738 976-xx[2] TPE 14xAWG26/19	–
ECN 1313 **EQN 1325** **ECI 1319** **EQI 1331**	12-pin	∅ 6 mm	332 201-xx EPG 16xAWG30/7	332 202-xx EPG 16xAWG30/7	746 820-xx[4] TPE 10xAWG26/19
ECN 1325 **EQN 1337**	12-pin, 4-pin	∅ 6 mm	*746 254-xx* *EPG [6(2xAWG28/7)]*	622 540-xx EPG [6(2xAWG28/7)]	746 820-xx[4] TPE 10xAWG26/19
ERN 1387	14-pin	∅ 6 mm	332 199-xx EPG 16xAWG30/7	332 200-xx EPG 16xAWG30/7	–
ERN 1326	16-pin	∅ 6 mm	341 370-xx[3] EPG 16xAWG30/7	341 369-xx EPG 16xAWG30/7	–
ERN 1321 **ERN 1381**	12-pin	∅ 6 mm	667 343-xx EPG 16xAWG30/7	333 276-xx EPG 16xAWG30/7	–

Italics: Encoder cable with M23, 9-pin angle socket

1) With shield connection clamp
2) Single wires with heat-shrink tubing (without shielding)
3) Without separate connections for temperature sensor
4) Only for EnDat 21/22 (without incremental signals)

CE compliance in the complete system must be ensured for the encoder cable. The shielding connection must be realized on the motor.

Encoder Cables

	Encoder cable		Cable	ID number
ECI 1118 **EQI 1130**	**Complete** With 15-pin PCB connector and M23 coupling (male), 17-pin		EPG 16xAWG30/7 With shield connection ∅ 4.5 mm	675539-xx
ERO 1225 **ERO 1285**	**With one connector** With 12-pin PCB connector		PUR [4(2 × 0.05 mm^2) + (4 × 0.14 mm^2)] With shield connection ∅ 4.5 mm	372164-xx
ERO 1420 **ERO 1470** **ERO 1480**			PUR [4(2 × 0.05 mm^2) + (4 × 0.14 mm^2)] With shield connection ∅ 4.5 mm	346439-xx

CE compliance in the complete system must be ensured for the encoder cable. The shielding connection must be realized on the motor

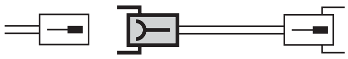
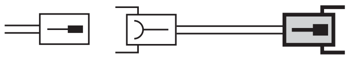
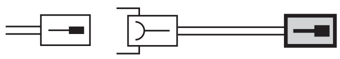
Adapter Cables

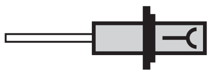
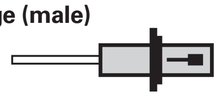
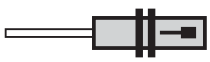
PUR **adapter cable**	[1(4 × 0.14 mm^2) + (4 × 0.34 mm^2)] **Ø 6 mm**	**ID number**
Complete with 9-pin M23 connector (female) and 8-pin M12 coupling (male)		745796-xx
Complete with 9-pin M23 connector (female) and 25-pin D-sub connector (female) for TNC		745813-xx

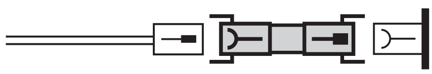
Connecting Cables 1 V_{PP}, TTL

12-Pin M23

PUR connecting cables	**12-pin:** [4(2 × 0.14 mm^2) + (4 × 0.5 mm^2)] **Ø 8 mm**	**For** **∼ 1 V_{PP}** **⊓⊔ TTL**
Complete with connector (female) and coupling (male)		298 401-xx
Complete with connector (female) and connector (male)		298 399-xx
Complete with connector (female) and D-sub connector (female), 15-pin, for TNC		310 199-xx
Complete with connector (female) and D-sub connector (female), 15-pin, for PWM 20/ EIB 741		310 196-xx
With **one** connector (female)		309 777-xx
Cable without connectors, ∅ 8 mm		244 957-01

Mating element on connecting cable to connector on encoder cable	**Connector (female)** for cable ∅ 8 mm 	291 697-05
Connector on connecting cable for connection to subsequent electronics	**Connector (male)** for cable ∅ 8 mm ∅ 6 mm 	291 697-08 291 697-07
Coupling on connecting cable	**Coupling (male)** for cable ∅ 4.5 mm ∅ 6 mm ∅ 8 mm 	291 698-14 291 698-03 291 698-04
Flange socket for mounting on subsequent electronics	**Flange socket (female)** 	315 892-08

Mounted couplings	**With flange (female)** ∅ 6 mm ∅ 8 mm 	291 698-17 291 698-07
	With flange (male) ∅ 6 mm ∅ 8 mm 	291 698-08 291 698-31
	With central fastener (male) ∅ 6 mm to 10 mm 	741 045-01

Adapter ∼ 1 V_{PP}/11 μA_{PP} For converting the 1 V_{PP} signals to 11 μA_{PP}; 12-pin M23 connector (female) and 9-pin M23 connector (male)		364 914-01

EnDat Connecting Cables

8-Pin M12 | **17-Pin M23**

PUR connecting cables **8-pin:** [1(4 × 0.14 mm^2) + (4 × 0.34 mm^2)] **17-pin:** [(4 × 0.14 mm^2) + 4(2 × 0.14 mm^2) + (4 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)		368 330-xx	801 142-xx	323 897-xx *340 302-xx*
Complete with right-angle connector (female) and coupling (male)		373 289-xx	801 149-xx	–
Complete with connector (female) and D-sub connector (female), 15-pin, for TNC (position inputs)		535 627-xx	–	332 115-xx
Complete with connector (female) and D-sub connector (female), 25-pin, for TNC (rotational speed inputs)		*641 926-xx*	–	*336 376-xx*
Complete with connector (female) and D-sub connector (male), 15-pin, for IK 215, PWM 20, EIB 741 etc.		524 599-xx	801 529-xx	350 376-xx
Complete with right-angle connector (female) and D-sub connector (male), 15-pin, for IK 215, PWM 20, EIB 741 etc.		722 025-xx	801 140-xx	–
With **one** connector (female)		559 346-xx	–	309 778-xx 309 779-xx[1)]
With one right-angle connector, (female)		606 317-xx	–	–
Cable only		–	–	266 306-01

Italics: Cable with assignment for “speed encoder“ input (MotEnc EnDat)
[1)] Without incremental signals

General Electrical Information
For Rotary Encoders on Electrical Drives

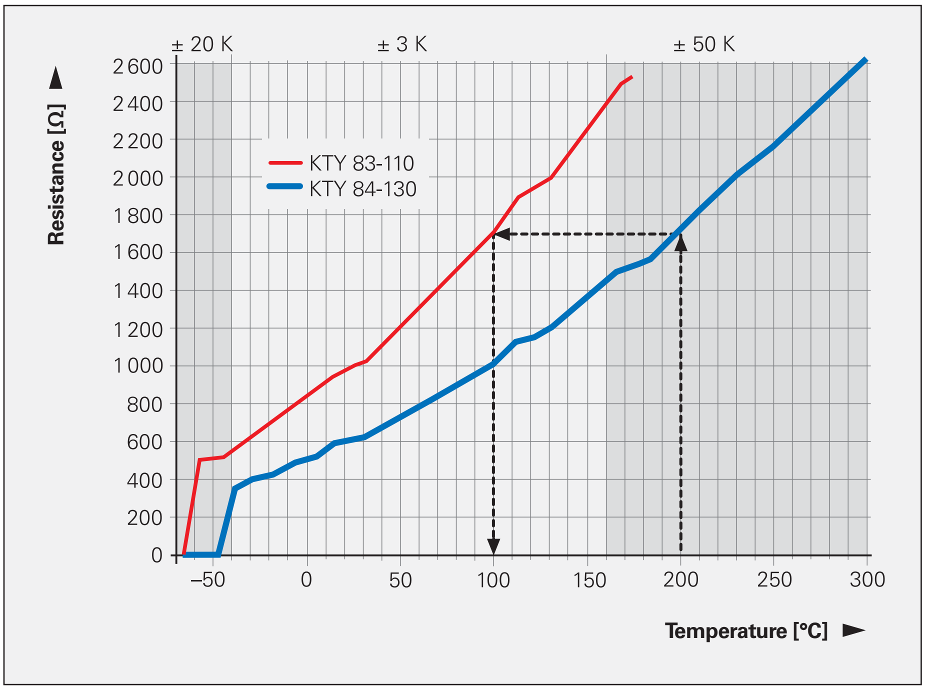
Temperature measurement in motors
In order to protect a motor from an excessive load, the motor manufacturer usually installs a temperature sensor near the motor coil. In classic applications, the values from the temperature sensor are led via two separate lines to the subsequent electronics, where they are evaluated. With HEIDENHAIN encoders for servo drives, the temperature sensor can be connected to the encoder cable inside the motor housing, and the values transmitted via the encoder cable. This means that no separate lines from the motor to the drive controller are necessary.

Integrated temperature evaluation
Besides the integrated temperature sensor (accuracy approx. ± 4 K at 125 °C), encoders with EnDat 22 interface also permit connection of an external temperature sensor (not with ECI 1118). The encoder also evaluates the external sensor signal. The digitized temperature value is transmitted purely serially via the EnDat interface as additional information.

Please note:
- The transmitted temperature value is not a safe value in the sense of functional safety.
- The encoder temperature range permitted at the measuring point on the flange must be complied with independently of the temperature values transmitted over the EnDat interface.

Connectable temperature sensors
The temperature evaluation within the rotary encoder is designed for a KTY 84-130 PTC thermistor. If other temperature sensors are used, then the temperature must be converted according to the resistance curve. In the example shown, the temperature of 200 °C reported via the EnDat interface is actually 100 °C if a KTY 83-110 is used as temperature sensor.

Information for the connection of an external temperature sensor
- Only connect passive temperature sensors
- For electrical separation, use only temperature sensors or reinforced insulation (compare EN 61800-5-1)
- No galvanic separation of the sensor input in the electronics of the rotary encoder
- Accuracy of temperature measurement depends on temperature range. For an ideal sensor:
  – Approx. ± 3 K at –40 °C to 160 °C
  – Approx. ± 20 K at ≤ –40 °C
  – Approx. ± 50 K at ≥ 160 °C
- Note the tolerance of the temperature sensor



Correlation between the temperature and resistance value for KTY 84-130, with conversion example to KTY 83-110

General Electrical Information

Power Supply

Connect HEIDENHAIN encoders only to subsequent electronics whose power supply is generated from PELV systems **(EN 50178).** In addition, overcurrent protection and overvoltage protection are required in safety-related applications.

If HEIDENHAIN encoders are to be operated in accordance with IEC 61010-1, power must be supplied from a secondary circuit with current or power limitation as per IEC 61010-1:2001, section 9.3 or IEC 60950-1:2005, section 2.5 or a Class 2 secondary circuit as specified in UL1310.

The encoders require a **stabilized DC voltage U_P** as power supply. The respective *Specifications* state the required power supply and the current consumption. The permissible ripple content of the DC voltage is:

- High frequency interference $U_{PP} < 250$ mV with $dU/dt > 5$ V/µs
- Low frequency fundamental ripple $U_{PP} < 100$ mV

The values apply as measured at the encoder, i.e., without cable influences. The voltage can be monitored and adjusted with the encoder's **sensor lines.** If a controllable power supply is not available, the voltage drop can be halved by switching the sensor lines parallel to the corresponding power lines.

Calculation of the **voltage drop**:

$$\Delta U = 2 \cdot 10^{-3} \cdot \frac{1.05 \cdot L_C \cdot I}{56 \cdot A_P}$$

where
- ΔU: Voltage drop in V
- 1.05: Length factor due to twisted wires
- L_C: Cable length in m
- I: Current consumption in mA
- A_P: Cross section of power lines in mm^2

The voltage actually applied to the encoder is to be considered when **calculating the encoder's power requirement.** This voltage consists of the supply voltage U_P provided by the subsequent electronics minus the line drop at the encoder. For encoders with an expanded supply range, the voltage drop in the power lines must be calculated under consideration of the nonlinear current consumption (see next page).

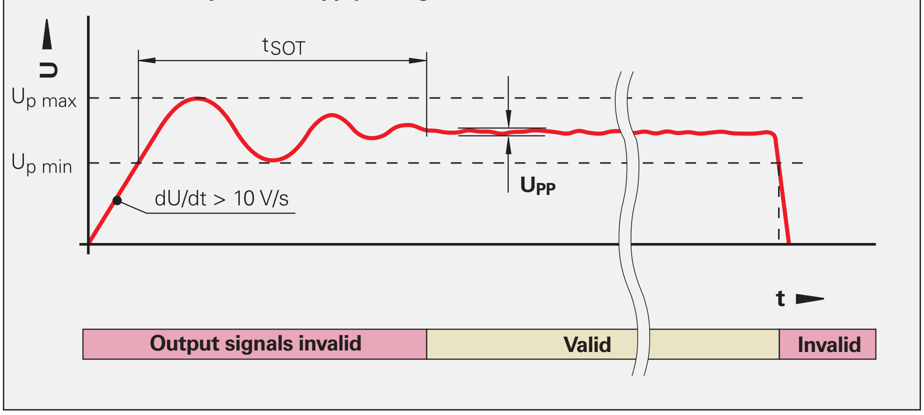
If the voltage drop is known, all parameters for the encoder and subsequent electronics can be calculated, e.g. voltage at the encoder, current requirements and power consumption of the encoder, as well as the power to be provided by the subsequent electronics.

Switch-on/off behavior of the encoders
The output signals are valid no sooner than after the switch-on time t_{SOT} = 1.3 s (2°s for PROFIBUS-DP) (see diagram). During the time t_{SOT} they can have any levels up to 5.5 V (with HTL encoders up to U_{Pmax}). If an interpolation electronics unit is inserted between the encoder and the power supply, this unit's switch-on/off characteristics must also be considered. If the power supply is switched off, or when the supply voltage falls below U_{min}, the output signals are also invalid. During restart, the signal level must remain below 1 V for the time t_{SOT} before power on. These data apply to the encoders listed in the catalog—customer-specific interfaces are not included.

Encoders with new features and increased performance range may take longer to switch on (longer time t_{SOT}). If you are responsible for developing subsequent electronics, please contact HEIDENHAIN in good time.

Insulation
The encoder housings are isolated against internal circuits.
Rated surge voltage: 500 V
(preferred value as per VDE 0110 Part 1, overvoltage category II, contamination level 2)

Transient response of supply voltage and switch-on/switch-off behavior



Cable	Cross section of power supply lines A_P			
	1 V_{PP}/TTL/HTL	**11 µA_{PP}**	**EnDat/SSI** 17-pin	**EnDat**[5] 8-pin
Ø 3.7 mm	0.05 mm^2	–	–	0.09 mm^2
Ø 4.3 mm	0.24 mm^2	–	–	–
Ø 4.5 mm EPG	0.05 mm^2	–	0.05 mm^2	0.09 mm^2
Ø 4.5 mm **Ø 5.1 mm**	0.14/0.09[2] mm^2 0.05[2, 3] mm^2	0.05 mm^2	0.05/0.14[6] mm^2	0.14 mm^2
Ø 5.5 mm PVC	0.1 mm^2	–	–	–
Ø 6 mm **Ø 10 mm**[1]	0.19/0.14[2, 4] mm^2	–	0.08/0.19[6] mm^2	0.34 mm^2
Ø 8 mm **Ø 14 mm**[1]	0.5 mm^2	1 mm^2	0.5 mm^2	1 mm^2

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

Encoders with expanded supply voltage range

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Where:

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

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

U_P: Supply voltage of the subsequent electronics in V

R_L: Cable resistance (for both directions) in ohms

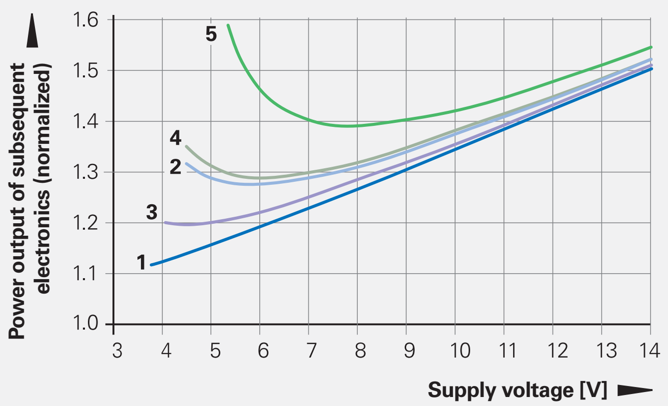
ΔU: Voltage drop in the cable in V

1.05: Length factor due to twisted wires

L_C: Cable length in m

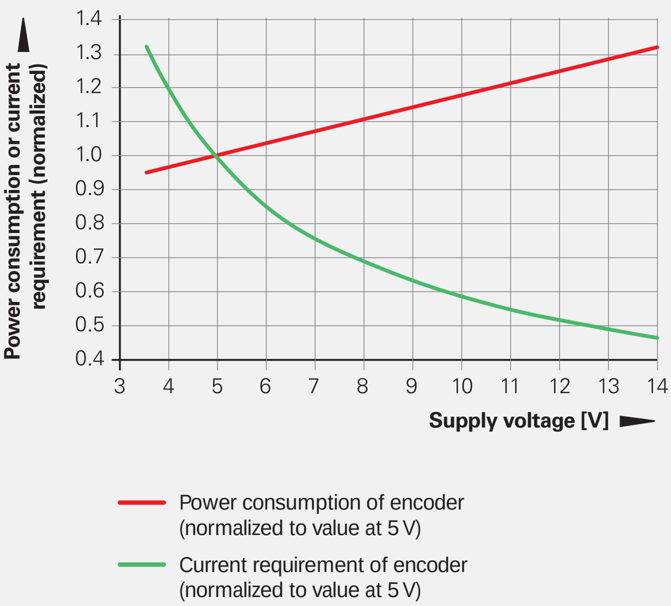
A_P: Cross section of power lines in mm^2

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



	Encoder cable/adapter cable	Connecting cable	Total
1	3 m	/	3 m
2	20 m	/	20 m
3	3 m	17 m	20 m
4	3 m	47 m	50 m
5	3 m	97 m	100 m

Current and power consumption with respect to the supply voltage (example representation)



Electrically Permissible Speed/ Traversing Speed

The maximum permissible shaft speed or traversing velocity of an encoder is derived from

- the **mechanically** permissible shaft speed/traversing velocity (if listed in the *Specifications*)
  and
- the **electrically** permissible shaft speed/traversing velocity.
  For encoders with **sinusoidal output signals**, the electrically permissible shaft speed/traversing velocity is limited by the –3 dB/ –6 dB cutoff frequency or the permissible input frequency of the subsequent electronics.
  For encoders with **square-wave signals,** the electrically permissible shaft speed/traversing velocity is limited by
  – the maximum permissible scanning/output frequency f_{max} of the encoder, and
  – the minimum permissible edge separation a for the subsequent electronics.

For angle or rotary encoders

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

For linear encoders

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

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

Cables

For safety-related applications, use HEIDENHAIN cables and connectors.

Versions
The cables of almost all HEIDENHAIN encoders and all adapter and connecting cables are sheathed in **polyurethane (PUR cables).** Many adapter cables for within motors and a few cables on encoders are sheathed in a **special elastomer (EPG).** Many adapter cables within the motor consist of TPE wires **(special thermo-plastic)** in net tubing. Individual encoders feature cable with a sleeve of **polyvinyl chloride (PVC).** This cables are identified in the catalog as EPG, TPE or PVC.

Durability
PUR cables are resistant to oil in accordance with **VDE 0472** (Part 803/test type B) and to hydrolysis and microbes in accordance with **VDE 0282** (Part 10). They are free of PVC and silicone and comply with UL safety directives. The **UL certification** "AWM STYLE 20963 80 °C 30 V E63216" is documented on the cable.

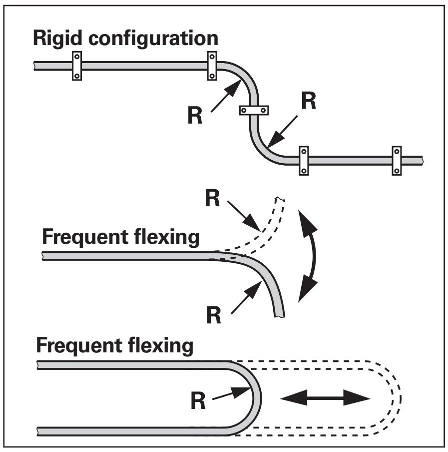
EPG cables are resistant to oil in accordance with **VDE 0472** (Part 803/test type B) and to hydrolysis in accordance with **VDE 0282** (Part 10). They are free of silicone and halogens. In comparison with PUR cables, they are only somewhat resistant to media, frequent flexing and continuous torsion.

PVC cables are oil resistant. The UL certification AWM E64638 STYLE20789 105C VW-1SC NIKKO is documented on the cable.

TPE wires with net tubing are oil resistant and highly flexible

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

[1)] Metal armor



Temperature range

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

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

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

Noise-Free Signal Transmission

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

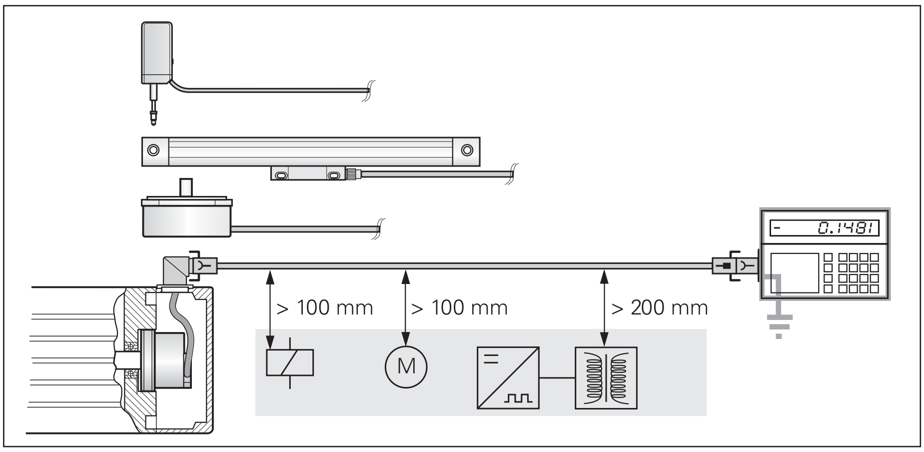
- **Noise immunity EN 61000-6-2:**
  Specifically:
  - ESD EN 61000-4-2
  - Electromagnetic fields EN 61000-4-3
  - Burst EN 61000-4-4
  - Surge EN 61000-4-5
  - Conducted disturbances EN 61000-4-6
  - Power frequency magnetic fields EN 61000-4-8
  - Pulse magnetic fields EN 61000-4-9
- **Interference EN 61000-6-4:**
  Specifically:
  - For industrial, scientific and medical equipment (ISM) EN 55011
  - For information technology equipment EN 55022

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

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

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

- Use only original HEIDENHAIN cables. Consider the voltage drop on supply lines.
- Use connecting elements (such as connectors or terminal boxes) with metal housings. Only the signals and power supply of the connected encoder may be routed through these elements. Applications in which additional signals are sent through the connecting element require specific measures regarding electrical safety and EMC.
- Connect the housings of the encoder, connecting elements and subsequent electronics through the shield of the cable. Ensure that the shield has complete contact over the entire surface (360°). For encoders with more than one electrical connection, refer to the documentation for the respective product.
- For cables with multiple shields, the inner shields must be routed separately from the outer shield. Connect the inner shield to 0 V of the subsequent electronics. Do not connect the inner shields with the outer shield, neither in the encoder nor in the cable.
- Connect the shield to protective ground as per the mounting instructions.
- Prevent contact of the shield (e.g. connector housing) with other metal surfaces. Pay attention to this when installing cables.
- Do not install signal cables in the direct vicinity of interference sources (inductive consumers such as contactors, motors, frequency inverters, solenoids, etc.).
  - Sufficient decoupling from interference-signal-conducting cables can usually be achieved by an air clearance of 100 mm or, when cables are in metal ducts, by a grounded partition.
  - A minimum spacing of 200 mm to inductors in switch-mode power supplies is required.
- If compensating currents are to be expected within the overall system, a separate equipotential bonding conductor must be provided. The shield does not have the function of an equipotential bonding conductor.
- Provide power only from PELV systems **(EN 50178)** to position encoders. Provide high-frequency grounding with low impedance **(EN 60204-1 Chap. EMC).**
- For encoders with 11 µA$_{PP}$ interface: For extension cables, use only HEIDENHAIN cable ID 244955-01. Overall length: max. 30 m.



Minimum distance from sources of interference

HEIDENHAIN Measuring Equipment

For Incremental Encoders

The **PWM 9** is a universal measuring device for checking and adjusting HEIDENHAIN incremental encoders. Expansion modules are available for checking the various types of encoder signals. The values can be read on an LCD monitor. Soft keys provide ease of operation.

	PWM 9
Inputs	Expansion modules (interface boards) for 11 µA$_{PP}$; 1 V$_{PP}$; TTL; HTL; EnDat*/SSI*/commutation signals *No display of position values or parameters
Functions	• **Measures** signal amplitudes, current consumption, operating voltage, scanning frequency • **Graphically displays** incremental signals (amplitudes, phase angle and on-off ratio) and the reference-mark signal (width and position) • **Displays symbols** for the reference mark, fault detection signal, counting direction • **Universal counter,** interpolation selectable from single to 1024-fold • **Adjustment support** for exposed linear encoders
Outputs	• Inputs are connected through to the subsequent electronics • BNC sockets for connection to an oscilloscope
Power supply	10 to 30 V DC, max. 15 W
Dimensions	150 mm × 205 mm × 96 mm

For Absolute Encoders

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

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

DRIVE-CLiQ is a registered trademark of the SIEMENS Corporation.

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

Evaluation Electronics

IK 220
Universal PC counter card
The IK 220 is an expansion board for PCs for recording the measured values of two incremental or absolute HEIDENHAIN encoders. The subdivision and counting electronics subdivide the sinusoidal input signals 4096-fold. A driver software package is included in delivery.

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

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

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

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

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

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

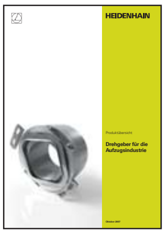
Windows is a registered trademark of the Microsoft Corporation.

More Information
Product Catalogs

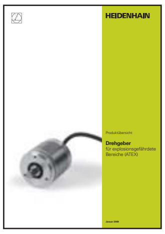
Rotary Encoders

Brochure
Rotary Encoders

Contents:
Absolute Rotary Encoders
ECN, EQN, ROC, ROQ
Incremental Rotary Encoders
ERN, ROD, HR



Product Overview
Rotary Encoders for the Elevator Industry



Product Overview
Rotary Encoders for Potentially Explosive Atmospheres

Angle Encoders and Modular Encoders

Brochure
Absolute Angle Encoders
With Optimized Scanning

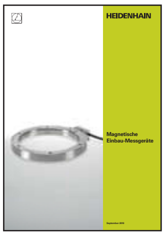
Contents:
Absolute Angle Encoders
RCN 2000, RCN 5000, RCN 8000

Brochure
Angle Encoders without Integral Bearing

Contents:
Incremental Angle Encoders
ERA, ERO, ERP

Brochure
Angle Encoders with Integral Bearing

Contents:
Absolute Angle Encoders
RCN
Incremental Angle Encoders
RON, RPN, ROD



Brochure
Modular Magnetic Encoders

Contents:
Encoders, incremental
ERM

Linear Encoders

Brochure
Linear Encoders
For Numerically Controlled Machine Tools

Contents:
Absolute Linear Encoders
LC
Incremental Linear Encoders
LB, LF, LS

Brochure
Exposed Linear Encoders

Contents:
Absolute Linear Encoders
LIC
Incremental Linear Encoders
LIP, PP, LIF, LIDA

General Information

Further HEIDENHAIN products
- Length gauges
- Measuring systems for machine tool inspection and acceptance testing
- Subsequent electronics
- NC controls for machine tools
- Touch probes

HEIDENHAIN on the Internet
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- The products

Also included:
- Technical articles
- Press releases
- Addresses
- CAD Drawings

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