



# HEIDENHAIN



Product Information

**ECI 4010**

**EBI 4010**

Absolute Rotary Encoders  
with 90 mm Hollow shaft

Suited for Safety-Related  
Applications up to SIL 3  
When Coupled with  
Additional Measures



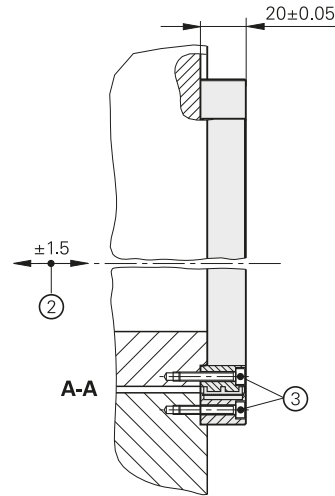
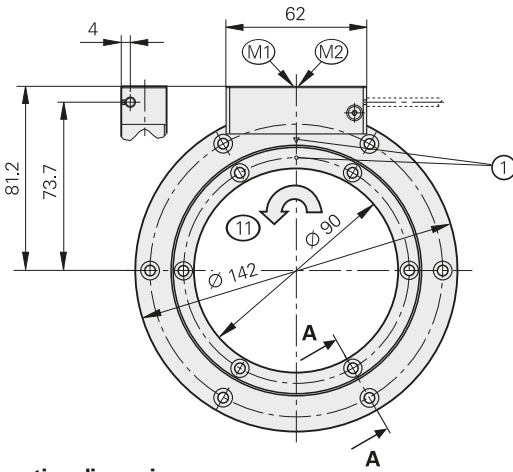
March 2017

# ECI 4010, EBI 4010

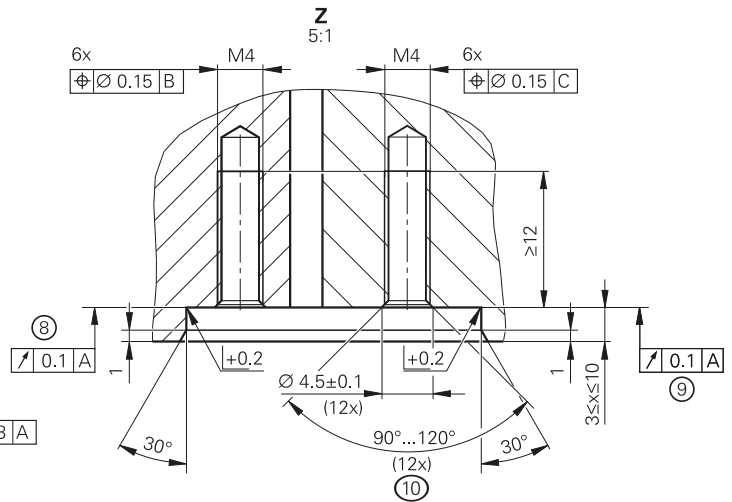
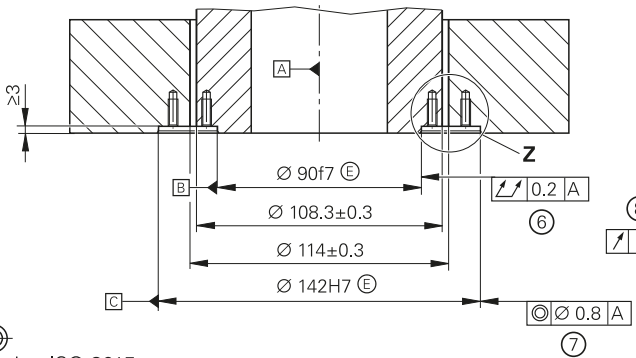
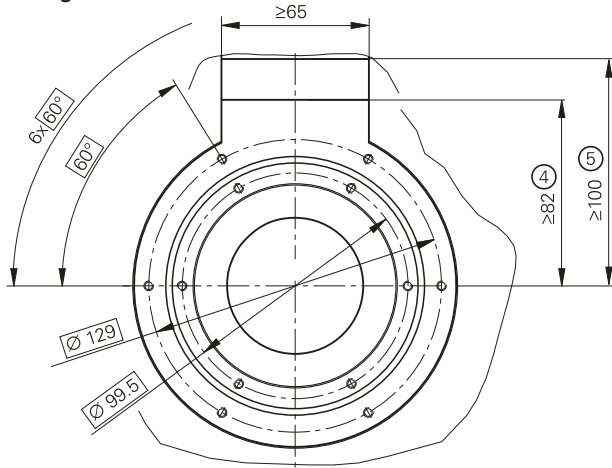
- Rotary encoders for absolute position values with safe singleturn information
- Rugged inductive scanning principle
  - Hollow through shaft  $\varnothing 90$  mm
  - **EBI 4010: Multiturn function through battery-buffered revolution counter**
  - Consists of scanning unit and scale drum



**Functional Safety**



## Required mating dimensions



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

- ☐ = Bearing of mating shaft
- M1 = Measuring point for operating temperature on housing
- M2 = Measuring point for vibration on housing
- 1 = Datum position  $\pm 5^\circ$
- 2 = Maximum permissible axial deviation between shaft and flange surfaces.  
Compensation of mounting tolerances and thermal expansion. Dynamic motion permitted over entire range.
- 3 = Use screws with material bonding anti-rotation lock, ISO 4762 – M4 x 25 – 8.8 – MKL as per DIN 267-27 (not included in delivery, ID 202264-88).  
Tightening torque 2.2 Nm  $\pm 0.13$  Nm
- 4 = Space required when encoder cover is closed
- 5 = Space required for opening the encoder cover
- 6 = Total runout of mating shaft
- 7 = Coaxiality of stator mating surface
- 8 = Bearing surface of rotor
- 9 = Bearing surface of stator
- 10 = Chamfer is obligatory at start of thread for material bonding anti-rotation lock
- 11 = Direction of shaft rotation for output signals according to interface description

Specifications	ECI 4010 – Singleturn	EBI 4010 – Multiturn
Consisting of	AE ECI4010 scanning unit: ID 1130167-02 TTR EXI4000 scale drum: ID 1130175-02	AE EBI4010 scanning unit: ID 1130173-02
<b>Functional safety</b> For applications up to	As single-encoder system for monitoring and closed-loop functions <ul style="list-style-type: none"> <li>• SIL 2 according to EN 61508 (further basis for testing: EN 61800-5-2)</li> <li>• Category 3, PL d according to EN ISO 13849-1:2015</li> </ul> With additional measures as per document 1000344 for safety-related applications up to SIL 3 or category 4, PL e Safe in the singleturn range	
PFH	SIL 2: $\leq 15 \cdot 10^{-9}$ (Probability of dangerous Failure per Hour) SIL 3: $\leq 2 \cdot 10^{-9}$	
Safe position <sup>1)</sup>	Encoder: $\pm 0.44^\circ$ (safety-related measuring step: SM = $0.176^\circ$ ) Fault exclusion for the loosening of AE scanning unit and TTR scale drum, designed for acceleration of AE: $\leq 400 \text{ m/s}^2$ ; of TTR: $\leq 600 \text{ m/s}^2$	
<b>Interface/ordering designation</b>	EnDat 2.2/EnDat22	
Position values/revolution	1 048 576 (20 bits)	
Revolutions	–	65 536 (16 bits)
Calculation time $t_{\text{cal}}$ /clock frequency	$\leq 5 \mu\text{s}/\leq 16 \text{ MHz}$	
<b>System accuracy</b>	$\pm 25''$	
<b>Electrical connection</b>	15-pin PCB connector (with connection for external temperature sensor <sup>2)</sup> )	
Cable length	$\leq 100 \text{ m}$ (see EnDat description in the brochure <i>Interfaces of HEIDENHAIN encoders</i> )	
Voltage supply	DC 3.6 V to 14 V	Rotary encoder $U_P$ : DC 3.6 V to 14 V Buffer battery $U_{BAT}$ : DC 3.6 to 5.25 V
Power consumption <sup>3)</sup> (maximum)	At 3.6 V: $\leq 630 \text{ mW}$ ; at 14 V: $\leq 700 \text{ mW}$	
Current consumption (typical)	At 5 V: 95 mA (without load)	Normal operating at 5 V: 95 mA (without load) Buffer mode <sup>4)</sup> : 220 $\mu\text{A}$ (rotating shaft) 25 $\mu\text{A}$ (at standstill)
<b>Shaft</b>	Hollow through shaft $\varnothing 90 \text{ mm}$	
Speed	$\leq 6000 \text{ rpm}$	
Moment of inertia of rotor	$4.26 \cdot 10^{-4} \text{ kgm}^2$ (without screws)	
Angular acceleration of rotor	$\leq 2 \cdot 10^4 \text{ rad/s}^2$	
Axial motion of measured shaft	$\leq \pm 1.5 \text{ mm}$	
<b>Vibration</b> 55 to 2000 Hz <sup>5)</sup> <b>Shock</b> 6 ms	AE scanning unit: $\leq 400 \text{ m/s}^2$ ; TTR scale drum: $\leq 600 \text{ m/s}^2$ (EN 60068-2-6) $\leq 2000 \text{ m/s}^2$ (EN 60068-2-27)	
<b>Operating temperature</b>	$-40^\circ\text{C}$ to $115^\circ\text{C}$ (at the measuring point and the entire scale drum)	
<b>Trigger threshold</b> of error message for excessive temperature	$130^\circ\text{C}$ (measuring accuracy of internal temperature sensor: $\pm 1 \text{ K}$ )	
<b>Relative humidity</b>	$\leq 93 \%$ ( $40^\circ\text{C}/21 \text{ d}$ as per EN 60068-2-78); without condensation	
<b>Protection</b> EN 60529	Complete encoder in mounted condition: IP20 <sup>6)</sup> ; scanning unit: IP40 (see <i>Insulation</i> under <i>Electrical safety</i> in the brochure <i>Interfaces of HEIDENHAIN Encoders</i> )	
<b>Mass</b>	AE scanning unit: $\approx 0.27 \text{ kg}$ ; TTR scale drum: $\approx 0.17 \text{ kg}$	

<sup>1)</sup> Further tolerances may occur in subsequent electronics after position value comparison (contact manufacturer of subsequent electronics)

<sup>2)</sup> See *Temperature measurement in motors* in the brochure *Encoders for Servo Drives*

<sup>3)</sup> See *General electrical information* in the brochure *Interfaces of HEIDENHAIN Encoders*

<sup>4)</sup> At  $T = 25^\circ\text{C}$ ;  $U_{\text{Bat}} = 3.6 \text{ V}$

<sup>5)</sup> AE: Hz to 55 Hz constant over 6.5 mm distance peak to peak; TTR: 10 Hz to 55 Hz constant over 10 mm distance peak to peak

<sup>6)</sup> The encoder must be protected in use against abrasive and harmful media. Use an appropriate enclosure if required.

# EBI 4010 – external buffer battery

The multifunction of the EBI 4010 is realized through a revolution counter. To prevent loss of the absolute position information during power failure, the EBI must be driven with an external backup battery.

A lithium thionyl chloride battery with 3.6 V and 1200 mAh is recommended as backup battery. The typical service life is over six years with appropriate conditions (two shifts of ten hours each in normal operation; battery temperature 25 °C; typical self-discharging). To achieve this, the main power supply ( $U_P$ ) must be connected to the encoder while connecting the backup battery, or directly thereafter, in order for the encoder to become fully initialized after having been completely powerless. Otherwise the encoder will consume a significantly higher amount of battery current until main power is supplied the first time.

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

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

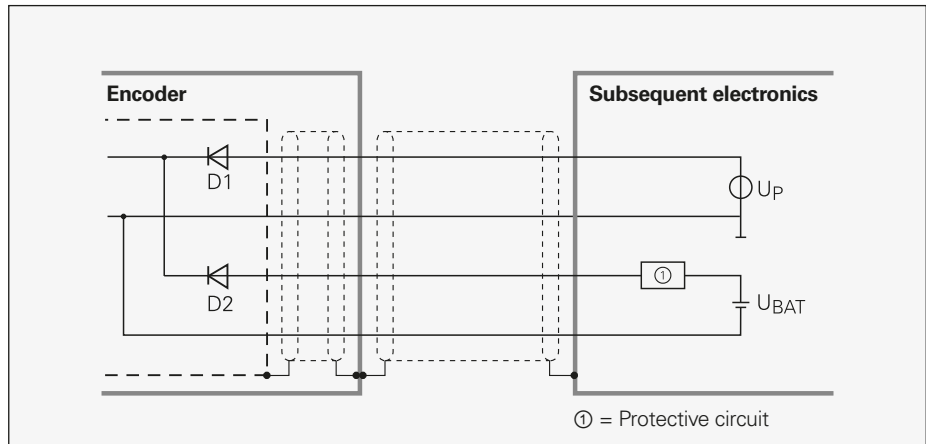
If the voltage of the buffer battery falls below certain thresholds, the encoder will set warning or error messages that are transmitted via the EnDat interface:

- **“Battery charge” warning**  
 $\leq 2.8\text{ V} \pm 0.2\text{ V}$   
 in normal operating mode
- **“M power failure” error message**  
 $\leq 2.2\text{ V} \pm 0.2\text{ V}$  in battery buffered operating mode (encoder must be re-referenced)

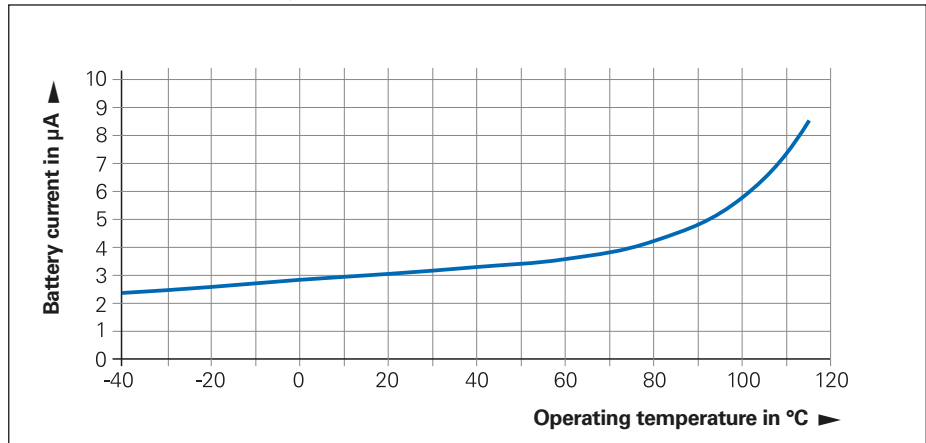
The EBI uses low battery current even during normal operation. The amount of current depends on the operating temperature.

### Please note:

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



Connection to the buffer battery



Typical discharge current in normal operation ( $U_{BAT} = 3.6\text{ V}$ )

# Mounting

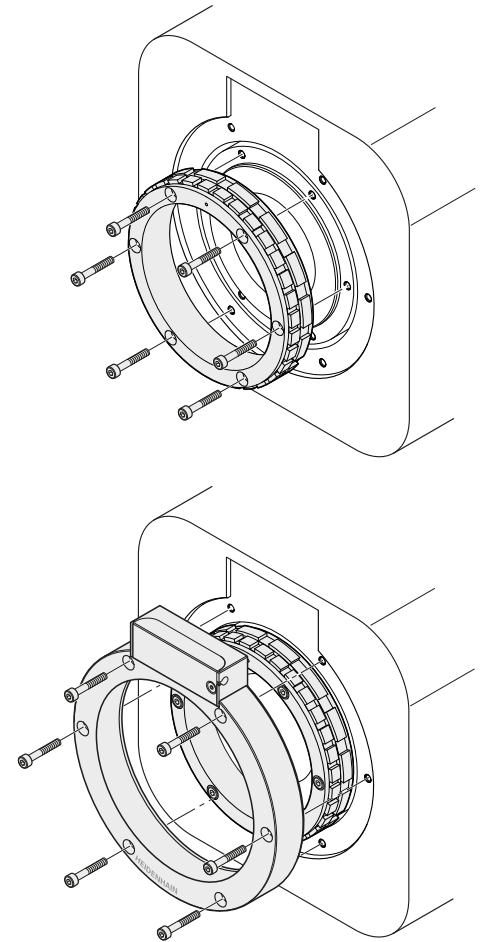
The scale drum of the rotary encoder is slid onto the measured shaft's centering collar and fastened. The stator is mounted via an external centering diameter. In each case, use screws with materially bonding anti-rotation lock (see *Mounting accessories*).

Conditions required on the motor side for a safe mechanical connection:

	Mating shaft/mating stator	
Material	Steel	Aluminum
Tensile strength $R_m$	$\geq 600 \text{ N/mm}^2$	$\geq 220 \text{ N/mm}^2$
Shear strength $\tau_m$	$\geq 390 \text{ N/mm}^2$	$\geq 130 \text{ N/mm}^2$
Interface pressure $P_G$	$\geq 660 \text{ N/mm}^2$	$\geq 250 \text{ N/mm}^2$
Surface roughness $R_z$	$\leq 16 \mu\text{m}$	
Coefficient of thermal expansion $\alpha_{\text{therm}}$ (at 20 °C)	$(10 \text{ to } 17) \cdot 10^{-6} \text{ K}^{-1}$	$\leq 25 \cdot 10^{-6} \text{ K}^{-1}$

## Protection against contact (EN 60529)

After encoder installation, all rotating parts must be protected against accidental contact during operation.



## Mounting accessories

### Screws

Screws are not included in delivery. They can be ordered separately.

ECI 4010/EBI 4010	Screws		Lot size
Mounting screws for stator and rotor	ISO 4762-M4x25-8.8-MKL	ID 202264-88	60 or 300 pieces

<sup>1)</sup> With coating for materially bonding anti-rotation lock

Please note the information on screws from HEIDENHAIN in the catalog titled *Encoders for Servo Drives*, chapter *General mechanical information* under *Rotary encoders with functional safety*.

### Mounting aid

The mounting aid serves to plug and unplug the PCB connector. It prevents damage to the wires and crimp contacts because the strain is applied only to the connector. The wires must not be pulled.


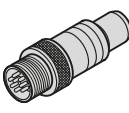


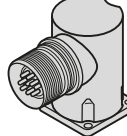
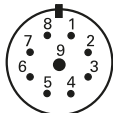

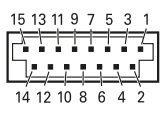
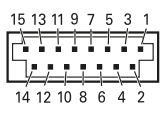




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For further mounting information and mounting aids, refer to the *Encoders for Servo Drives* catalog.


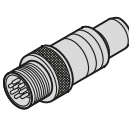
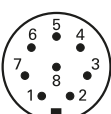

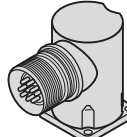
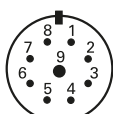

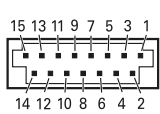
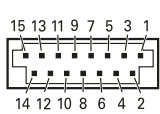






# Electrical connection – Pin layout

## Pin layout of ECI

8-pin coupling, M12											9-pin right-angle socket, M23											15-pin PCB connector										
																																
	Power supply				Serial data transfer				Other signals <sup>1)</sup>																							
 M12	8	2	5	1	3	4	7	6	/	/																						
 M23	3	7	4	8	5	6	1	2	/	/																						
	13	11	14	12	7	8	9	10	5	6																						
	<b>U<sub>P</sub></b>	Sensor <b>U<sub>P</sub></b>	<b>0V</b>	Sensor <b>0V</b>	<b>DATA</b>	<b>DATA</b>	<b>CLOCK</b>	<b>CLOCK</b>	<b>T+</b> <sup>2)</sup>	<b>T-</b> <sup>2)</sup>																						
	Brown/ Green	Blue	White/ Green	White	Gray	Pink	Violet	Yellow	Brown	Green																						

## Pin layout of EBI

8-pin coupling, M12											9-pin right-angle socket, M23											15-pin PCB connector										
																																
	Power supply				Serial data transfer				Other signals <sup>1)</sup>																							
 M12	8	2	5	1	3	4	7	6	/	/																						
 M23	3	7	4	8	5	6	1	2	/	/																						
	13	11	14	12	7	8	9	10	5	6																						
	<b>U<sub>P</sub></b>	<b>U<sub>BAT</sub></b>	<b>0V</b> <sup>3)</sup>	<b>0V BAT</b> <sup>3)</sup>	<b>DATA</b>	<b>DATA</b>	<b>CLOCK</b>	<b>CLOCK</b>	<b>T+</b> <sup>2)</sup>	<b>T-</b> <sup>2)</sup>																						
	Brown/ Green	Blue	White/ Green	White	Gray	Pink	Violet	Yellow	Brown	Green																						

<sup>1)</sup> Only for cables inside the motor housing

<sup>2)</sup> Connections for external temperature sensor (depending on the encoder cable inside the motor); evaluation optimized for KTY 84-130 (see *Temperature measurement in motors* in the *Encoders for Servo Drives* brochure)

<sup>3)</sup> Connected inside encoder

**Cable shield** connected with housing; **U<sub>P</sub>** = 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.





**Note for safety-related applications:** Only completely assembled HEIDENHAIN cables are qualified. Exchange connectors or modify cables only after consultation with HEIDENHAIN Traunreut.

# Electrical connection

## Cables

<b>Encoder cable inside the motor EPG</b> $\varnothing$ 3.7 mm; [(1 · 4 · 0.06) + (4 · 0.06)] mm <sup>2</sup> ; A <sub>P</sub> = 0.06 mm <sup>2</sup> ; wires for TPE [2 · 0.16] mm <sup>2</sup> temperature sensor		
<b>Complete</b> with PCB connector (15-pin) and M23 SpeedTEC right-angle socket (male) 9-pin; wires for temperature sensor		ID 1120940-30 <sup>1)</sup> ; length 0.3 m
<b>Complete</b> with PCB connector (15-pin) and M23 SpeedTEC right-angle socket (male) 9-pin		ID 1121041-03 <sup>1)</sup> ; length 0.3 m

<sup>1)</sup> Operating temperature range (conditional): -20 °C to 120 °C

<b>PUR connecting cable</b> $\varnothing$ 6 m; [(4 · 0.14 mm <sup>2</sup> ) + (4 · 0.34 mm <sup>2</sup> )]; A <sub>P</sub> = 0.34 mm <sup>2</sup>	<b>M12</b> connector, 8-pin	<b>M23</b> connector, 9-pin	
<b>Complete</b> with connector (female) and M12 coupling (male), 8-pin		ID 368330-xx	ID 745796-xx
<b>Complete</b> with M12 connector (female), 8-pin, and D-sub connector (female), 15-pin		ID 533627-xx	–
<b>Complete</b> with M12 connector (female), 8-pin, and D-sub connector (male), 15-pin		ID 524599-xx	–
<b>With one</b> M12 connector (female), 8-pin		ID 634265-xx <sup>1)</sup>	–

A<sub>P</sub>: Cross section of power supply lines

<sup>1)</sup> Connecting element must be suitable for the maximum clock frequency used

**Note for safety-related applications:** Provide bit error rate as per specification 533095!

SpeedTEC is a registered trademark of Intercontec Pfeiffer Industriesteckverbindungen GmbH.

## HEIDENHAIN

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

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

- *Encoders for Servo Drives* brochure: 208922-xx
- *AE ECI4010, EBI4010 Mounting Instructions*: 1152725-xx and *TTR EXI4000*: 1147618-xx
- Technical Information: *Safety-Related Position Measuring Systems*: 596632
- For implementation in a safe control or inverter: Specification: 533095 and *Supplementary Measures Catalog (SIL 3, PL e)*: 1000344
- *Interfaces of HEIDENHAIN Encoders* brochure: 1078628