Product Information

ECI 4010
EBI 4010
Absolute Rotary Encoders with 180 mm Hollow shaft

Suited for Safety-Related Applications up to SIL 3 when Coupled with Additional Measures
ECI 4010, EBI 4010

Rotary encoders for absolute position values with safe singletum information
- Rugged inductive scanning principle
- Hollow through shaft Ø 180 mm
- EBI 4010: Multiturn function through battery-buffered revolution counter
- Consists of scanning unit and scale drum

Functional Safety

View of customer’s side

Required mating dimensions

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

1 = Bearing of mating shaft
M1 = Measuring point for operating temperature
M2 = Measuring point for vibration on scanning unit
① = Mark for 0° position ±5°
② = Slot for machine key DIN 6885–A–10x8x20
③ = Machine key as per DIN 6885–A–10x8x20
④ = Maximum permissible axial deviation between shaft and flange surfaces. Compensation of mounting tolerances and thermal expansion. Dynamic motion permitted over entire range.
⑤ = Mounting screws: ISO 4762–M4x25–8.8. Tightening torque 2.2 Nm ±0.13 Nm. A suitable anti-rotation lock is to be used for the screw connection (e.g. screw with material bonding anti-rotation lock, ISO 4762–M4x25–8.8 MKL as per DIN 267-27 ID 202264-88).
⑥ = Space necessary when encoder cover is closed
⑦ = Space required when encoder cover is open
⑧ = Coaxiality of stator mating surface
⑨ = Chamfer at start of thread is obligatory for materially bonding anti-rotation lock
⑩ = Bearing surface of stator
⑪ = Bearing surface of rotor
⑫ = Direction of shaft rotation for output signals according to interface description
### Specifications

<table>
<thead>
<tr>
<th>ECI 4010 – Singleturn</th>
<th>EBI 4010 – Multiturn</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consisting of</strong></td>
<td>AE ECI4010 scanning unit: ID 1087526-02</td>
</tr>
<tr>
<td></td>
<td>TTR EXI4000 scale drum: ID 1113606-02</td>
</tr>
</tbody>
</table>

#### Functional safety

For applications up to

- SIL 2 according to EN 61 508 (further basis for testing: EN 61 800-5-2)
- Category 3, PL d according to EN ISO 13849-1:2015

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 position¹**

- Encoder: ± 0.44° (safety-related measuring step: SM = 0.176°)
- Mechanical coupling: ±0.5° (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: \( \leq 600 \text{ m/s}^2 \))

### Interface/ordering designation

- EnDat 2.2/EnDat22

### Position values/revolution

- 1048576 (20 bits)
- 65536 (16 bits)

### Calculation time \( t_{cal} / \) clock frequency

- \( \leq 5 \mu s / 16 \text{ MHz} \)

### System accuracy

- ±40" (safety-related measuring step)

### Electrical connection

- 15-pin PCB connector (with connection for external temperature sensor²)

#### 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 consumption³ (maximum)

- At 3.6 V: \( \leq 630 \text{ mW} \), at 14 V: \( \leq 700 \text{ mW} \)
- Normal operating at 5 V: 95 mA (without load)
- Buffer mode⁴: 95 mA (without load)
- 220 µA (rotating shaft)
- 25 µA (at standstill)

### Shaft

- Hollow through shaft Ø 180 mm (with keyway)

### Speed

- \( \leq 6000 \text{ rpm} \)

### Moment of inertia of rotor

- \( 3.1 \cdot 10^{-3} \text{ kgm}^2 \) (without screws, without machine key)

### Angular acceleration of rotor

- \( \leq 2 \cdot 10^4 \text{ rad/s}^2 \)

### Axial motion of measured shaft

- \( \leq \pm 1.5 \text{ mm} \)

### Vibration

- 55 to 2000 Hz⁵
- Shock: 6 ms

### Operating temperature

- –40°C to 115°C (at the measuring point and the entire scale drum)

### Trigger threshold of error message for excessive temperature

- 130°C (measuring accuracy of internal temperature sensor: \( \pm 1 \text{ K} \))

### Relative humidity

- \( \leq 93\% \) (40°C/21 d as per EN 60068-2-78); without condensation

### Protection

- EN 60529: Complete encoder in mounted condition: IP20⁶, scanning unit: IP40 (see Insulation under Electrical safety in the brochure Interfaces of HEIDENHAIN Encoders)

### Mass

- AE scanning unit: \( \approx 0.39 \text{ kg} \)
- TTR scale drum: \( \approx 0.33 \text{ kg} \)

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¹ Further tolerances may occur in subsequent electronics after position value comparison (contact manufacturer of subsequent electronics)
² See Temperature measurement in motors in the brochure Encoders for Servo Drives
³ See General electrical information in the brochure Interfaces of HEIDENHAIN Encoders
⁴ At \( T = 25^\circ \text{C} \); \( U_{BAT} = 3.6 \text{ V} \)
⁵ 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
⁶ The encoder must be protected in use against abrasive and harmful media. Use an appropriate enclosure if required.
The multifunction function 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 (UP) 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 60885-4 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
  \[ \text{Current} \leq 2.8 \text{ V} \pm 0.2 \text{ V} \]
  in normal operating mode

- “M power failure” error message
  \[ \text{Current} \leq 2.2 \text{ V} \pm 0.2 \text{ V} \] 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.
The scale drum of the rotary encoder is slid onto the centering collar of the measured shaft with machine key 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:

<table>
<thead>
<tr>
<th>Material</th>
<th>Mating shaft/mating stator</th>
</tr>
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<tbody>
<tr>
<td>Steel</td>
<td>Aluminum</td>
</tr>
<tr>
<td>Tensile strength Rm</td>
<td>≥ 600 N/mm²</td>
</tr>
<tr>
<td>Shear strength τm</td>
<td>≥ 390 N/mm²</td>
</tr>
<tr>
<td>Interface pressure PG</td>
<td>≥ 660 N/mm²</td>
</tr>
<tr>
<td>Surface roughness Rz</td>
<td>≤ 16 µm</td>
</tr>
<tr>
<td>Coefficient of thermal expansion αtherm (at 20 °C)</td>
<td>(10 to 17) · 10⁻⁶ K⁻¹</td>
</tr>
</tbody>
</table>

### 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.

<table>
<thead>
<tr>
<th>ECI 4010/EBI 4010</th>
<th>Screws</th>
<th>Lot size</th>
</tr>
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<tbody>
<tr>
<td>Mounting screws</td>
<td>ISO 4762 M4×25 8.8 MKL</td>
<td>ID 202264-88 60 or 300 pieces</td>
</tr>
</tbody>
</table>

1) 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.

**Machine key**

The machine keys are not included in delivery.

**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.

ID 1075573-01

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

<table>
<thead>
<tr>
<th>M12</th>
<th>M23</th>
<th>Power supply</th>
<th>Serial data transfer</th>
<th>Other signals</th>
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<tbody>
<tr>
<td>8</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
<td>1</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Brown/Green</td>
<td>Sensor</td>
<td>Blue</td>
<td>White/Green</td>
<td>White</td>
</tr>
</tbody>
</table>

#### Power supply
- UP
- Brown/Green
- Blue
- White/Green
- White

#### Serial data transfer
- Sensor 0 V
- 0 V
- DATA
- CLOCK

#### Other signals
- T+
- T–

### Pin layout of EBI

#### 8-pin coupling
**M12**

#### 9-pin right-angle socket
**M23**

#### 15-pin PCB connector

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</tr>
<tr>
<td>Brown/Green</td>
<td>UBAT</td>
<td>Blue</td>
<td>White/Green</td>
<td>White</td>
</tr>
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#### Power supply
- UP
- Brown/Green
- Blue
- White/Green
- White

#### Serial data transfer
- Sensor 0 V
- 0 V
- DATA
- CLOCK

#### Other signals
- T+
- T–

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1) Only for cables inside the motor housing
2) Connections for external temperature sensor (depending on the encoder cable inside the motor); evaluation optimized for KTY B4-130 (see Temperature measurement in motors in the Encoders for Servo Drives brochure)
3) Connected inside encoder

**Cable shield**: connected with housing; **UP** = 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

**Encoder cable inside the motor EPG** Ø 3.7 mm; [(1 x 4 x 0.06) + (4 x 0.06)] mm²; \( A_P = 0.06 \text{ mm}^2 \); wires for TPE temperature sensor [2 · 0.16] mm²

<table>
<thead>
<tr>
<th>Complete</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Complete</strong> with PCB connector (15-pin) and M23 SpeedTEC right-angle socket (male) 9-pin; wires for temperature sensor</td>
<td>![Diagram]</td>
<td>ID 1120940-30 (^{1)}); length 0.3 m</td>
</tr>
<tr>
<td><strong>Complete</strong> with PCB connector (15-pin) and M23 SpeedTEC right-angle socket (male) 9-pin</td>
<td>![Diagram]</td>
<td>ID 1121041-03 (^{1)}); length 0.3 m</td>
</tr>
</tbody>
</table>

CE compliance of the complete system must be documented.

\(^{1)}\) Operating temperature range (conditional): –20 \(^{\circ}\)C to 120 \(^{\circ}\)C

**PUR connecting cable** Ø 6 m; [(4 x 0.14 mm²) + (4 x 0.34 mm²)]; \( A_P = 0.34 \text{ mm}^2 \)

<table>
<thead>
<tr>
<th>Complete</th>
<th><strong>M12 connector, 8-pin</strong></th>
<th><strong>M23 connector, 9-pin</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Complete</strong> with connector (female) and M12 coupling (male), 8-pin</td>
<td>![Diagram]</td>
<td>ID 368330-xx ID 745796-xx</td>
</tr>
<tr>
<td><strong>Complete</strong> with M12 connector (female), 8-pin, and D-sub connector (female), 15-pin</td>
<td>![Diagram]</td>
<td>ID 533627-xx –</td>
</tr>
<tr>
<td><strong>Complete</strong> with M12 connector (female), 8-pin, and D-sub connector (male), 15-pin</td>
<td>![Diagram]</td>
<td>ID 524599-xx –</td>
</tr>
<tr>
<td><strong>With one</strong> M12 connector (female), 8-pin</td>
<td>![Diagram]</td>
<td>ID 634265-xx (^{1)}) –</td>
</tr>
</tbody>
</table>

\( A_P \): Cross section of power supply lines

\(^{1)}\) Connecting element must be suitable for the maximum clock frequency used

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

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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.

**For more information:**

Comply with the requirements described in the following documents to ensure the correct operation of the encoder:

- **Encoders for Servo Drives brochure:** 208922-xx
- **AE ECI4010, EBI4010 Mounting Instructions:** 1214405-xx and **TTR EXI4000:** 1214404-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