Encoders for Servo Drives
This brochure is not an exhaustive overview of HEIDENHAIN products but rather provides a selection of encoders designed for use on electric motors.

The selection tables provide an overview of all HEIDENHAIN encoders intended for use on electric motors, along with their most relevant specifications. The descriptions of the technical features contain basic information on the use of rotary, angular and linear encoders on electric motors.

The mounting information and detailed specifications refer to rotary encoders developed specifically for servomotors. For information about other rotary encoders, please refer to the appropriate product documentation.

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

Encoder attributes have a critical impact on important motor characteristics, such as:

- Positioning accuracy
- Speed stability
- Bandwidth, and therefore command and disturbance behavior
- Power dissipation
- Size
- Acoustic noise
- Safety

All of the HEIDENHAIN encoders found in this brochure have been designed to minimize the cabling and installation work required by the motor manufacturer. Overall rotary motor length can also be kept low. Some encoders feature a special design that can even eliminate the need for safety devices such as limit switches.

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

- Absolute and incremental rotary encoders with and without commutation tracks
- Absolute and incremental angle encoders
- Absolute and incremental linear encoders
- Absolute and incremental modular encoders

Digital position control and speed control

Motor for digital drive systems (digital position and speed control)
Information about the selection tables

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

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

The selection table contains the following encoders:
- Rotary encoders with a mounted stator coupling featuring a high natural frequency (the motor’s bandwidth is virtually unlimited)
- Rotary encoders for separate shaft couplings, particularly well suited to electrically isolated mounting
- Absolute rotary encoders with purely digital data transfer or additional sinusoidal TTL or HTL incremental signals for digital speed control
- Incremental rotary encoders with TTL- or HTL-compatible output signals
- Information on functionally safe rotary encoders available as safety-related position measurement systems

For the selection table, see page 12

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

The selection table contains the following encoders:
- Absolute rotary encoders for operating temperatures of up to 115 °C, and incremental rotary encoders for operating temperatures of up to 120 °C
- Rotary encoders with a mounted stator coupling featuring a high natural frequency (the motor’s bandwidth is virtually unlimited)
- Absolute rotary encoders with purely digital data transmission (suitable for the HMC 6 and HMC 2 single-cable solutions) or additional sinusoidal incremental signals
- Incremental rotary encoders for digital speed control, featuring high-quality sinusoidal output signals, even under high operating temperatures
- Incremental rotary encoders with an additional commutation signal for BLDC motors
- Incremental rotary encoders with TTL-compatible output signals
- Information on functionally safe rotary encoders available as safety-related position measurement systems

For the selection table, see page 8

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

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

For more information, see page 2

Linear encoders for linear motors
Linear encoders installed on linear motors provide actual-value feedback for the position and speed controllers. These encoders have a critical impact on the linear motor’s control characteristics. The linear encoders recommended for this type of application exhibit the following characteristics:
- Low position error during acceleration in the direction of measurement
- High tolerance to acceleration and lateral vibration
- Ability to handle high shaft speeds
- Absolute position information with purely digital data transmission or high-quality sinusoidal incremental signals

For more information, see page 2

Exposed linear encoders are characterized by:
- Higher accuracy grades
- Higher traversing speeds
- Non-contact scanning (i.e., no friction between scanning head and scale)
Exposed linear encoders are suitable for applications in clean environments (e.g., on measuring machines or production equipment in the semiconductor industry).

For more information, see page 2

Sealed linear encoders feature the following characteristics:
- High protection rating
- Easy mounting
Sealed linear encoders are thus suitable for applications in high-contamination environments (e.g., on machine tools).

For more information, see page 2
## Selection guide

**Rotary encoders for mounting inside motors**

Protection rating: up to IP40 (EN 60529)

<table>
<thead>
<tr>
<th>Series</th>
<th>Main dimensions</th>
<th>Mechanically permissible shaft speed</th>
<th>Natural frequency (typical) of the coupling</th>
<th>Maximum operating temperature</th>
<th>Supply voltage</th>
<th>Signal periods per revolution</th>
<th>Positions per revolution</th>
<th>Distinguishable revolutions</th>
<th>Interface</th>
<th>Model</th>
<th>Further information</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECI/EQI 1100</td>
<td></td>
<td></td>
<td></td>
<td>-</td>
<td>DC 3.6 V to 14 V</td>
<td>-</td>
<td>524 288 (19 bits)</td>
<td>-</td>
<td>4096</td>
<td>EnDat 2.2/22</td>
<td>ECI 1119 (1) / EGI 1131 (1)</td>
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<td></td>
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<td>-</td>
<td>DC 3.6 V to 14 V</td>
<td>-</td>
<td>524 288 (19 bits)</td>
<td>-</td>
<td>4096</td>
<td>EnDat 2.2/22</td>
<td>ECI 1319 (1) / EGI 1331 (1)</td>
</tr>
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<td>-</td>
<td>DC 3.6 V to 14 V</td>
<td>-</td>
<td>524 288 (19 bits)</td>
<td>-</td>
<td>4096</td>
<td>EnDat 2.2/22</td>
<td>ECI 1319 (1) / EGI 1331 (1)</td>
</tr>
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<td>ECI/EBI 100</td>
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<td>-</td>
<td>DC 3.6 V to 14 V</td>
<td>-</td>
<td>524 288 (19 bits)</td>
<td>-</td>
<td>4096</td>
<td>EnDat 2.2/22</td>
<td>ECI 1319 (1) / EGI 1331 (1)</td>
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<tr>
<td>ECI/EBI 4000</td>
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<td>-</td>
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<td>1 048 576 (20 bits)</td>
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<td>4096</td>
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<td>ECI 4010 (1) / EBI 4010 (1)</td>
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<td>ERO 1200</td>
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<td></td>
<td>-</td>
<td>DC 5 V ±0.5 V</td>
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<td>1024/2048</td>
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<td>FL/FIL</td>
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<td>ERO 1400</td>
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<td>DC 5 V ±0.5 V</td>
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<td>512/1000/1204</td>
<td>-</td>
<td>FL/FIL</td>
<td>ERO 1420</td>
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</table>

1) Also available with functional safety
2) After internal 5/10/20/25-fold interpolation
3) Multiturn functionality via battery-buffered revolution counter

DRIVE-CLiQ is a registered trademark of Siemens AG.
<table>
<thead>
<tr>
<th>Series</th>
<th>Main dimensions</th>
<th>Mechanically permissible frequency ( f_N ) (typical) of the coupling</th>
<th>Maximum operating temperature</th>
<th>Supply voltage</th>
<th>Signal periods per revolution</th>
<th>Positions per revolution</th>
<th>Distinguishable revolutions</th>
<th>Interface</th>
<th>Model</th>
<th>Further information</th>
</tr>
</thead>
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<tr>
<td>ECN/EGN/ERN 1100</td>
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<td></td>
<td></td>
<td>DC 3.6 V to 14 V</td>
<td>512</td>
<td>8192 (13 bits)</td>
<td>-/4096</td>
<td>EnDat 2.2/01 with 1 Vpp</td>
<td>ECN 1113/EGN 1125</td>
<td>Page 48</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DC 10 V to 28.8 V</td>
<td>-</td>
<td>8788608 (23 bits)</td>
<td>-/4096</td>
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<td></td>
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<td></td>
<td>DC 3.6 V to 14 V</td>
<td>-</td>
<td>-/4096</td>
<td>EnDat 2.2/22</td>
<td>EGN 1123/EGN 1135</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>DC 5 V ±0.5 V</td>
<td>500 to 8192</td>
<td>3 block commutation signals</td>
<td>TTL</td>
<td>ERN 1123</td>
<td>Page 52</td>
<td></td>
</tr>
<tr>
<td>ECN/EGN/ERN 1100</td>
<td></td>
<td>≤ 12 000 rpm</td>
<td>1000 Hz</td>
<td>115 °C</td>
<td>DC 3.6 V to 14 V</td>
<td>512</td>
<td>8192 (13 bits)</td>
<td>-/4096</td>
<td>EnDat 2.2/01 with 1 Vpp</td>
<td>ECN 1113/EGN 1125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 6 000 rpm</td>
<td>1600 Hz</td>
<td>90 °C</td>
<td>DC 5 V ±0.5 V</td>
<td>500 to 8192</td>
<td>3 block commutation signals</td>
<td>TTL</td>
<td>ERN 1123</td>
<td>Page 52</td>
</tr>
<tr>
<td>ECN/EGN/ERN 1300</td>
<td></td>
<td>≤ 15 000 rpm/ ≤ 12 000 rpm</td>
<td>1800 Hz</td>
<td>115 °C</td>
<td>DC 3.6 V to 14 V</td>
<td>512/2048</td>
<td>8192 (13 bits)</td>
<td>-/4096</td>
<td>EnDat 2.2/01 with 1 Vpp</td>
<td>ECN 1313/EGN 1325</td>
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<tr>
<td></td>
<td></td>
<td>≤ 15 000 rpm</td>
<td>1200 Hz</td>
<td>80 °C</td>
<td>DC 5 V ±0.5 V</td>
<td>1024/2048/4096</td>
<td>-</td>
<td>EnDat 2.2/22</td>
<td>ECN 1325S/EGN 1335S</td>
<td>Page 56</td>
</tr>
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<td>DC 5 V ±0.25 V</td>
<td>2048</td>
<td>21 track for sine commutation</td>
<td></td>
<td></td>
<td>ECN 1321</td>
<td>Page 60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DC 4 V to 14 V</td>
<td>-</td>
<td>1024/2048/4096</td>
<td>3 block commutation signals</td>
<td>TTL</td>
<td>ERN 1326</td>
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<tr>
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<td></td>
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<td>DC 10 V to 28.8 V</td>
<td>-</td>
<td>1024/2048/4096</td>
<td>3 block commutation signals</td>
<td>TTL</td>
<td>ERN 1326</td>
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<td>DC 5 V ±0.5 V</td>
<td>1024/2048/4096</td>
<td>-</td>
<td>ERN 1321</td>
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<td></td>
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<td></td>
<td></td>
<td>DC 5 V ±0.25 V</td>
<td>2048</td>
<td>21 track for sine commutation</td>
<td></td>
<td></td>
<td>ERN 1387</td>
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</tbody>
</table>

1) Also available with functional safety

DRIVE-CLIQ is a registered trademark of Siemens AG.
## Rotary encoders for mounting on motors

Protection class: up to IP64 (EN 60529)

<table>
<thead>
<tr>
<th>Series</th>
<th>Main dimensions</th>
<th>Mechanically permissible shaft speed</th>
<th>Natural frequency $f_N$ (typical) of the coupling</th>
<th>Maximum operating temperature</th>
<th>Supply voltage</th>
<th>Signal periods per revolution</th>
<th>Positions per revolution</th>
<th>Distinguishable revolutions</th>
<th>Interface</th>
<th>Model</th>
<th>Further information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotary encoders with integral bearing and mounted stator coupling</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
| **ECN/ERN 100** | ![Diag](diag1.png) | ≤ 300 mm: ≤ 6000 rpm  
> 30 mm: ≤ 4000 rpm | 1000 Hz | 100 °C | DC 3.6 V to 14 V | 2048 | 8192 (13 bits) | – | EnDat 2.2/01 with 1 Vpp | ECN 113 | Brochure: Rotary Encoders |
| | | | | | DC 5 V ±0.5 V | – | 3354432 (25 bits) | | | | |
| | | | | | DC 10 V to 30 V | 1000 to 5000 | – | | | | |
| **ECN/ERN 100** | ![Diag](diag2.png) | ≤ 6000 rpm  
With two shaft clampings only for hollow through shaft: ≤ 12000 rpm | Stator coupling for plane surfaces: 1500 Hz | 100 °C | DC 3.6 V to 14 V | 512/2048 | 8192 (13 bits) | – | EnDat 2.2/01 with 1 Vpp | ECN 125 |
| | | | | | DC 4.75 V to 30 V | 512 | 8192 (13 bits) | – | | |
| | | | | | DC 5 V ±0.5 V | 250 to 5000 | – | | | |
| **ECN/ERN 400** | ![Diag](diag3.png) | ≤ 6000 rpm  
With two shaft clampings only for hollow through shaft: ≤ 12000 rpm | Stator coupling for plane surfaces: 1500 Hz | 100 °C | DC 10 V to 30 V | 256 to 2048 | 8192 (13 bits) | – | EnDat H with 1 Vpp | ECN 425 |
| | | | | | DC 4.75 V to 30 V | 512 to 4096 | – | | | |
| | | | | | DC 3.6 V to 14 V | – | 3354432 (25 bits) | 4096 | Feniuc | ECN 426/F | Brochure: Rotary Encoders |
| | | | | | DC 10 V to 28.8 V | 16777216 (24 bits) | – | | | |
| **ECN/ERN 400** | ![Diag](diag4.png) | ≤ 15000 rpm/ ≤ 12000 rpm | Expanding ring coupling: 1800 Hz  
Plane-surface coupling: 400 Hz | 100 °C | DC 3.6 V to 14 V | 2048 | 8192 (13 bits) | – | EnDat 2.2/01 with 1 Vpp | ECN 425 |
| | | | | | DC 5 V ±0.5 V | – | 3354432 (25 bits) | | | |
| | | | | | DC 5 V ±0.25 V | 1024 to 5000 | – | | | |

1) Also available with functional safety

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## Rotary encoders for mounting on motors

Protection class: up to IP64 (EN 60529)

<table>
<thead>
<tr>
<th>Series</th>
<th>Main dimensions</th>
<th>Mechanically permissible shaft speed</th>
<th>Natural frequency ( f_N ) (typical) of the coupling</th>
<th>Maximum operating temperature</th>
<th>Supply voltage</th>
<th>Signal periods per revolution</th>
<th>Positions per revolution</th>
<th>Distinguishable revolutions</th>
<th>Interface</th>
<th>Model</th>
<th>Further information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rotary encoders with integral bearing and mounted stator coupling</strong></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECN/EGN/ERN 1000</td>
<td>![Diagram]</td>
<td>( \leq 12,000 ) rpm</td>
<td>1500 Hz</td>
<td>100 °C</td>
<td>DC 3.6 V to 14 V</td>
<td>512</td>
<td>8192 (13 bits)</td>
<td>( \leq 4096 )</td>
<td>EnDat 2.2/01 with ( \leq 1 ) Vpp</td>
<td>ECN 1013/EGN 1025</td>
<td>Brochure: Rotary Encoders</td>
</tr>
<tr>
<td></td>
<td>![Diagram]</td>
<td>( 95 ) °C</td>
<td>DC 10 V to 28.8 V</td>
<td>( \leq 4096 )</td>
<td>DC 5 V ±0.5 V</td>
<td>100 to 3000</td>
<td>–</td>
<td>–</td>
<td>EnDat 2.2/22</td>
<td>ECN 1023/EGN 1035</td>
<td></td>
</tr>
<tr>
<td></td>
<td>![Diagram]</td>
<td>( 70 ) °C</td>
<td>DC 10 V to 30 V</td>
<td>–</td>
<td>DC 5 V ±0.5 V</td>
<td>5000 to 36,000(^1)</td>
<td>–</td>
<td>–</td>
<td>DRIVE-CLiQ</td>
<td>ECN 1023S/EGN 1035S</td>
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<tr>
<td></td>
<td>![Diagram]</td>
<td>( \leq 6000 ) rpm</td>
<td>1600 Hz</td>
<td>90 °C</td>
<td>DC 5 V ±0.5 V</td>
<td>500 to 8192</td>
<td>3 block commutation signals</td>
<td>–</td>
<td>TTL/HTLs</td>
<td>ERM 1025/ERM 1080</td>
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<tr>
<td></td>
<td>![Diagram]</td>
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<td>–</td>
<td>TTL</td>
<td>ERM 1030</td>
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<tr>
<td></td>
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<td>HTL</td>
<td>ERM 1070</td>
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\(^1\) After internal 5/10/20/25-fold interpolation
Rotary encoders for mounting on motors
Protection class: up to IP64 (EN 60529)

<table>
<thead>
<tr>
<th>Series</th>
<th>Main dimensions</th>
<th>Mechanically permissible shaft speed</th>
<th>Natural frequency ( f_N ) (typical) of the coupling</th>
<th>Maximum operating temperature</th>
<th>Supply voltage</th>
<th>Signal periods per revolution</th>
<th>Positions per revolution</th>
<th>Distinguishable revolutions</th>
<th>Interface</th>
<th>Model</th>
<th>Further information</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROC/ROQ/ROD 400</td>
<td>Synchro flange</td>
<td>( \leq 12,000 \text{ rpm} )</td>
<td>–</td>
<td>100 °C</td>
<td>DC 3.6 V to 14 V</td>
<td>512/2048</td>
<td>9192 (13 bits)</td>
<td>( \leq 4096 )</td>
<td>EnDat 2.2/01 with ( \leq 1 \text{ Vpp} )</td>
<td>ROC 413/ROQ 425</td>
<td>Brochure: Rotary Encoders</td>
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<tr>
<td></td>
<td>Clamping flange</td>
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<td>–</td>
<td>DC 4.75 V to 30 V</td>
<td>512</td>
<td>9192 (13 bits)</td>
<td>–</td>
<td>–</td>
<td>SSI</td>
<td>ROC 413/ROQ 425</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>–</td>
<td>DC 10 V to 30 V</td>
<td>256 to 2048</td>
<td>9192 (13 bits)</td>
<td>–</td>
<td>( \leq 4096 )</td>
<td>EnDat H ( \leq 1 \text{ Vpp} ) SSI 41H ( \leq 1 \text{ Vpp} )</td>
<td>ROC 425</td>
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<td></td>
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<td>( \leq 12,000 \text{ rpm} )</td>
<td>DC 4.75 V to 30 V</td>
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<td>EnDat T ( \leq 1 \text{ Vpp} ) SSI 41T ( \leq 1 \text{ Vpp} )</td>
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<td>DC 10 V to 28.8 V</td>
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<td>16777216 (24 bits)</td>
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<td></td>
<td></td>
<td></td>
<td>DC 5 V ( \pm 0.5 ) V</td>
<td>50 to 10000</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>( \leq 1 \text{ Vpp} )</td>
<td>ROD 486/ROD 480</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>DC 10 V to 30 V</td>
<td>50 to 5000</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>( \leq 1 \text{ Vpp} )</td>
<td>ROD 486/ROD 480</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>( 70 \text{ °C} )</td>
<td>50 to 10000</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>( \leq 1 \text{ Vpp} )</td>
<td>ROD 486/ROD 480</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>( 100 \text{ °C} )</td>
<td>1000 to 5000</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>( \leq 1 \text{ Vpp} )</td>
<td>ROD 486/ROD 480</td>
<td></td>
</tr>
<tr>
<td>ROC/ROQ/ROD 1000</td>
<td></td>
<td></td>
<td>( \leq 12,000 \text{ rpm} )</td>
<td>100 °C</td>
<td>DC 3.6 V to 14 V</td>
<td>512</td>
<td>9192 (13 bits)</td>
<td>( \leq 4096 )</td>
<td>EnDat 2.2/01 with ( \leq 1 \text{ Vpp} )</td>
<td>ROC 1013/ROQ 1025</td>
<td>Brochure: Rotary Encoders</td>
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<td>95 °C</td>
<td>DC 10 V to 28.8 V</td>
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<td>3388608 (23 bits)</td>
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<td>–</td>
<td>DRIVE-CLiQ</td>
<td>ROC 1023/ROQ 1035</td>
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<tr>
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<td>100 °C</td>
<td>DC 5 V ( \pm 0.5 ) V</td>
<td>100 to 3600</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>( \leq 1 \text{ Vpp} )</td>
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<td>DC 10 V to 30 V</td>
<td>–</td>
<td>( \leq 1 \text{ Vpp} )</td>
<td>ROD 1030</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>( 100 \text{ °C} )</td>
<td>DC 5 V ( \pm 0.5 ) V</td>
<td>1000 to 3600</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>( \leq 1 \text{ Vpp} )</td>
<td>ROD 1070</td>
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<td>ROD 600</td>
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<td>( \leq 12,000 \text{ rpm} )</td>
<td>( 80 \text{ °C} )</td>
<td>DC 5 V ( \pm 0.5 ) V</td>
<td>512 to 5000</td>
<td>–</td>
<td>–</td>
<td>( \leq 1 \text{ Vpp} )</td>
<td>ROD 620</td>
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<tr>
<td>ROD 1900</td>
<td></td>
<td></td>
<td>( \leq 12,000 \text{ rpm} )</td>
<td>( 70 \text{ °C} )</td>
<td>DC 10 V to 30 V</td>
<td>600 to 2400</td>
<td>–</td>
<td>( \leq 1 \text{ Vpp} )</td>
<td>ROD 630</td>
<td></td>
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</tr>
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</table>

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

DRIVE-CLiQ is a registered trademark of Siemens AG.
Rotary encoders and angle encoders for DC and three-phase AC motors

General information

Speed stability
In order to obtain good motor speed stability, the encoder must provide a high number of measuring steps per revolution. For this reason, HEIDENHAIN offers encoders that output a sufficient number of measuring steps per revolution for the required speed stability. HEIDENHAIN rotary encoders and angle encoders with an integral bearing and stator coupling exhibit particularly beneficial shaft misalignment within a certain tolerance range does not induce position errors or impair the speed stability (see Specification notes).

Position errors within one signal period adversely affect the positioning accuracy and speed stability of the motor. At low feed rates, the motor moves in accordance with the position error within one signal period.

Transmission of measuring signals
For good dynamic performance with digital speed control, the pulse time of the speed controller should not exceed approximately 125 μs. In addition, the actual values for the position controller and speed controller must be available to the controlling system with the least possible delay.

High clock frequencies are needed to fulfill such demanding time requirements on position-value transmission from the encoder to the controlling system with serial data transmission (see also the Interfaces of HEIDENHAIN Encoders brochure). HEIDENHAIN encoders for electric motors therefore output position values over the fast, purely serial EnDat 2.2 or EnDat 3 interface or transmit additional incremental signals that are available with virtually no delay to the downstream electronics for speed and position control.

For standard motors, manufacturers primarily use the highly robust ECI/EBI/EQI encoders without integral bearing, or rotary encoders with TTL or HTL compatible output signals—as well as additional commutation signals for permanent DC motors.

For digital speed control on machines with high dynamic-performance requirements, a large number of measuring steps are required—usually more than 500 000 per revolution. For applications with standard motors, approximately 60 000 measuring steps per revolution are sufficient (similar to resolvers).

HEIDENHAIN encoders for motors with digital position and speed control are therefore equipped with the purely serial EnDat 2.2/EnDat 3 interface, or they output additional sinusoidal incremental signals at 1 Vpp signal levels (EnDat 0). The high internal resolution of the EnDat 2.2 and EnDat 3 encoders permits resolutions of up to 22 bits (≈ 194 304 measuring steps) in inductive systems and of at least 25 bits (approx. 33 million measuring steps) in photoelectric encoders.

The sinusoidal incremental signals of the EnDat 10 devices can, due to their high quality, be highly subdivided in the downstream electronics (see Figure 1). Even at speeds of 12 000 rpm, the signal arrives at the input circuit of the controlling system with a frequency of approximately 400 kHz (see Figure 2). Cable lengths of up to 150 m are possible with 1 Vpp incremental signals (see also 1 Vpp incremental signal).

Most absolute encoders internally subdivide the sinusoidal scanning signals by a factor of 4096 or greater. When these systems are operated with sufficiently fast transmission of the absolute position values (e.g., at a clock frequency of 2 MHz with EnDat 2.1 or 16 MHz with EnDat 2.2 or EnDat 3 to 125 Mbit/s or 25 Mbit/s), incremental signal evaluation can be eliminated altogether.

The benefits of this data transmission technology are higher noise immunity along the transmission path and more cost-efficient connectors and cables. A large portion of rotary encoders equipped with the EnDat 2.2 or EnDat 3 interface are also able to evaluate an external temperature sensor (e.g., located in the motor winding). The digitized temperature data is transmitted as part of the EnDat 2.2 or EnDat 3 protocol without an additional line.

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

The stator couplings mounted on the encoder exhibit very high natural frequencies fN. With modular and inductive rotary encoders, the stator and rotor are firmly screwed to the motor housing and the shaft (see also Mechanical design types and mounting). This mechanical design therefore permits optimal coupling rigidity.

Motor currents
Motors may exhibit impermissible current flowing from the rotor to the stator. This can cause the encoder bearing to overheat, thus shortening its service life. HEIDENHAIN therefore recommends the use of encoders without an integral bearing or encoders with an electrically isolated bearing (hybrid bearing). For more information, please contact HEIDENHAIN.

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

Size
The higher a motor’s permissible operating temperature is, the smaller the motor can be made for a given torque. Since the temperature of the motor also affects the temperature of the encoder, HEIDENHAIN offers encoders for permissible operating temperatures of up to 120 °C. These encoders make it possible to implement smaller motors.

Power dissipation and acoustic noise
While the motor is running, encoder position errors within one signal period affect the motor’s power dissipation as well as the heat generation and acoustic noise that go along with it. For this reason, rotary encoders with high signal quality (better than ±1% of the signal period) are preferred (see also Measuring accuracy).

Bit error rate
For rotary encoders with a purely serial interface for installation within motors, HEIDENHAIN recommends conducting a type test for the bit error rate. The use of functionally safe encoders without closed metal housings and/or with cable assemblies that do not comply with the electrical connection directives (see General electrical information) always requires the bit error rate to be measured in a type test under application conditions.

Preventive maintenance
Encoders with serial data transmission provide information that enables monitoring of the operating status and thus preventive maintenance:

- Diagnostics
- Clearance gap for optimized and reliable mounting and application conditions
- Connectable external temperature sensor

Output frequency
For digital motor control, the output frequency of the encoder must not exceed the frequency of the input circuit of the controlling system. For EnDat 2.2, for example, this is a frequency of approximately 400 kHz. For EnDat 3, this frequency is 800 kHz.

The achievable output frequency is limited by the number of measuring steps per revolution and the achievable clock frequency.

Specifications

<table>
<thead>
<tr>
<th>Subdivision factor</th>
<th>Measuring steps per revolution</th>
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<tbody>
<tr>
<td>1</td>
<td>50 000 000</td>
</tr>
<tr>
<td>2</td>
<td>25 000 000</td>
</tr>
<tr>
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<td>12 500 000</td>
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<td>6 250 000</td>
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<tr>
<td>64</td>
<td>781 250</td>
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<td>128</td>
<td>390 625</td>
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<table>
<thead>
<tr>
<th>Signal periods per revolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 000</td>
</tr>
<tr>
<td>Output frequency in kHz</td>
</tr>
<tr>
<td>10 000</td>
</tr>
<tr>
<td>120 000</td>
</tr>
<tr>
<td>1 500 000</td>
</tr>
</tbody>
</table>

Figure 1: Signal periods per revolution and the resulting number of measuring steps per revolution as a function of the subdivision factor

Figure 2: Shaft speed and resulting output frequency as a function of the number of signal periods per revolution
HMC 2 and HMC 6
Single-cable solutions for servomotors

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

With the HMC solution (Hybrid Motor Cable), HEIDENHAIN has integrated the encoder cable into the power cable. Thus, only one cable is now needed between the motor and the electrical cabinet.

The HMC 6 single-cable solution was specifically designed for the HEIDENHAIN EnDat22 interface, and HMC 2 for EnDat3. With purely serial data transmission, cable lengths of up to 100 m can be realized. With HMC 6, all other encoders equipped with a purely serial RS-485 interface (e.g., SSI) can be connected as well. A wide range of encoders can therefore be used without the need for introducing a new interface.

The HMC solution combines the wires for the encoder, motor and brake into a single cable, which is connected to the motor via a special connector. For connection to the drive, the cable is split into power connections, brake connections and an encoder connection.

When the components are correctly assembled, the connecting elements attain an IP67 rating.

Benefits
The HMC single-cable solutions offer a series of cost and quality benefits for motor and machine manufacturers:
• Continued use of existing interfaces
• Realization of smaller drag chains
• Significant improvement in drag-chain suitability thanks to fewer cables
• Wide range of available encoders for HMC 2 and HMC 6 transmission
• Eliminated separate assignment of power cables and encoder cables in the machine
• Reduced mechanical requirements (flange socket on the motor, cable ducts in the machine housing)
• Reduced logistics for cables and connectors
• Easier and faster installation
• Reduced documentation
• Fewer required servicing components
• Smaller motor profile with cable attached, enabling easier integration into the machine housing
• HEIDENHAIN-tested combination of power and encoder cable

The universal design of the HMC solution gives motor and machine manufacturers high flexibility, letting them use standard components on both the motor and the control.

All HEIDENHAIN encoders with the EnDat22 interface or with purely serial data transmission without battery buffering as per RS-485 are suitable for the HMC 6 single-cable solution. This includes motor encoders for servomotors in various sizes, linear and angle encoders used in direct-driven motors, as well as encoders for functional safety up to SIL 3.

The HMC 2 single-cable solution can be used with motor encoders featuring the EnDat 3 interface (ordering designation: E30-R20 and purely serial data transmission via two wires. The ExI 1100/1300 and ExN 1300 series rotary encoders are available for functional safety applications with up to SIL 3.

For the controlling hardware, you can continue to use already deployed frequency inverters or controller units. The HMC cables have been designed for easy assembly of the matching connecting elements. Importantly, this does not impair noise immunity.

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

Connecting element on the motor
The motor housing is equipped with a standard flange socket for HMC 2 or a special angle flange socket for HMC 6. This angle flange socket brings together the wires for the encoder, motor power and brake.

Crimping tools for the power wires
The crimp contacts for the power and brake wires are assembled with the usual tools.

Output cables inside the motor housing
The rotary encoder is connected by means of the output cables inside the motor housing: your pre-assembled communication element for HMC 6 or the two contacts for HMC 2 are simply plugged into the angle flange socket.

Cable with hybrid connector
The HMC connecting cable contains the wires for the encoder, power supply and brake.

Further information:
For more information about HMC 6 and HMC 2, refer to the respective Product Information document, and visit www.endat.de.
Safety-related position measuring systems

Safe axes
Driven axes and moving parts can represent a significant hazard for humans. Particularly if the human interacts with the machine (e.g., during workpiece setup), it must be ensured that the machine does not make any uncontrolled movements. This requires position information about the axes in order for a safety function to be implemented. As an evaluating safety module, the control must be able to detect faulty position information and react accordingly.

Various safety strategies can be pursued, depending on the topology of the axis and the evaluation capabilities of the control. In a single-encoder system, for example, only one encoder per axis is evaluated for the safety function. However, on axes with two encoders, such as a linear axis with a rotary and a linear encoder, the two redundant position values can be compared with each other in the control. Safe fault detection can be ensured only if the two components (the control and encoder) are properly matched to each other. Please note that the safety designs of control manufacturers differ from one another. As a result, the requirements to be fulfilled by the connected encoders may partially differ as well.

Type-examined encoders
Encoders from HEIDENHAIN are used successfully on a variety of controls in widely differing safety designs. This particularly applies to type-examined encoders with EnDat and DRIVE-CLIQ interfaces. These encoders can be operated as single-encoder systems in conjunction with a suitable control in applications with the control category SIL 3 (according to EN 61508) or Performance Level “e” (of EN ISO 13849). Unlike incremental encoders, absolute encoders always provide a safe absolute position value, including immediately after switch-on or a power failure. The reliable transmission of the position is based on two independently generated absolute position values and on error bits provided to the safe control. The purely serial data transmission also provides other benefits, including greater reliability, improved accuracy, diagnostic capabilities and reduced costs through simpler connection technology.

Standard encoders
In addition to encoders explicitly qualified for safety applications, standard encoders (e.g., with Fanuc interface or 1 Vpp signals) can also be used in safe axes. In such cases, the characteristics of the encoders must be matched to the requirements of the respective control. For this purpose, HEIDENHAIN can provide additional data about the individual encoders (failure rate, fault model as per EN 61800-5-2).

Fault exclusion for the loosening of the mechanical connection
Irrespective of the interface, many safety designs require the safe mechanical connection of the encoder. The standard for electric motors, EN 61800-5-2, requires that the loosening of the mechanical connection between the encoder and the motor be considered as a fault. Because the controller may not be able to detect these errors, fault exclusion is required in many cases. The requirements on a fault exclusion can result in additional constraints in the permissible limit values in the specifications. In addition, fault exclusions for the loosening of the mechanical connection usually require additional measures during installation of the encoder or in the event of servicing (e.g., anti-rotation lock for screws). These factors must be considered for the selection of a suitable encoder or mounting mode.

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

Bearing life
The bearing life L_{10hr} as per ISO/TS 16281 at a temperature of 60°C and maximum bearing loads (maximum permissible shaft offsets for encoders with an integrated stator coupling) is greater than 2·10^6 revolutions. Starting at a continuous use temperature of 75°C, the service life of the grease is limited.

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

Further information:
- The safety-related characteristic values are listed in the specifications of the encoders. The Technical Information document Safety-Related Position Encoders provides explanations of the characteristic values.
- For the use of standard encoders in safety-related applications, HEIDENHAIN can also provide additional information about individual products (failure rate, fault model as per EN 61800-5-2).
- For implementation in a control with EnDat2:2:
  - Specification for Safe Control 503035
- For implementation in a control with EnDat3:
  - Application Conditions for Functional Safety 3000003

Measured-value acquisition
Transmission line
Reception of measured values

Position values and error bits via two processor interfaces
Monitoring functions
Efficiency test

Catalog of measures

Further information:
- A advise to the information in the following documents to ensure the correct and intended operation of the encoder:
  - Mounting Instructions
  - Operating Instructions
  - Product Information documents
  - Customer information about fault exclusion
- For implementation in a control with EnDat2:2:
  - Specification for Safe Control 503035
- For implementation in a control with EnDat3:
  - Application Conditions for Functional Safety 3000003

Safety-related position measuring system

Functionally safe drive system with EnDat 2.2 or EnDat 3
Measuring principles

MEASURING STANDARD

The circular scales of absolute rotary encoders

The circular scales of incremental rotary encoders

HEIDENHAIN encoders with optical scanning incorporate measuring standards consisting of periodic structures known as graduations.

These graduations are applied to a substrate of glass or steel. For encoders with large diameters, steeltape is used as the substrate.

HEIDENHAIN manufactures its precision graduations in specially developed, photolithographic processes:

- ALRODUR: matte-etched lines on a gold-plated steel tape; typical grating period: 40 µm
- METALLUR: contamination-tolerant graduation consisting of metal lines on gold; typical grating period: 20 µm
- DIADUR: extremely robust chromium lines on glass (typical grating period: 20 µm), or three-dimensional chromium structures (typical grating period: 8 µm) on glass
- SUPRADUR phase grating: optically three-dimensional, planar structure; particularly tolerant to contamination; typical grating period: 8 µm and finer
- OPTODUR phase grating: optically three-dimensional, planar structure with particularly high reflectance; typical graduation period: 2 µm and finer

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

Encoders that use the inductive scanning principle employ metal graduations or copper/nickel-based graduation structures. These graduation structures are applied to a printed-circuit carrier material.

In the absolute measuring method, the position value is available immediately upon encoder switch-on and can be requested by the downstream electronics at any time. There is no need to move the axes to find the reference position. This absolute position information is ascertained from the graduation of the circular scale, which contains a code structure or consists of multiple parallel graduation tracks.

A separate incremental track, or the track with the finest grating period, is interpolated for the position value and is simultaneously used to generate an optional incremental signal.

Singletum rotary encoders repeat the absolute position information with each revolution. Multitum encoders can distinguish between additional revolutions.

In the incremental measuring method, the graduation consists of a periodic grating structure. Position information is obtained through the counting of individual increments (measuring steps) starting from a freely settable point of origin. Since position ascertainment requires an absolute reference, the circular scales have an additional track containing a reference mark.

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

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

Photoelectric scanning

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

The ERN/ECN/ER0 and ROD/RCN/ RQN rotary encoders are designed in accordance with the imaging scanning principle.

Put simply, the imaging scanning principle uses projected-light signal generation: two gratings with equal or similar grating periods—the circular scale and the scanning reticle—are moved relative to each other. The carrier material of the scanning reticle is transparent, whereas the graduation of the measuring standard may likewise be applied to a transparent material or to a reflective material. When parallel light passes through a grating structure, light and dark fields are projected at a certain distance. At this location there is an index grating with the same or similar grating period. When the two graduations move relative to each other, the incident light is modulated: if the gaps are aligned, light passes through. If the lines of one grating coincide with the gaps of the other, no light passes through. Photocells or a structured photosensor convert these fluctuations in light into nearly sinusoidal electrical signals. In encoders that use the imaging scanning principle, workable mounting tolerances are attainable starting at a minimum grating period of 10 µm.

Other scanning principles

Some encoders operate in accordance with other scanning methods. As their measuring standard, ERN encoders use a permanently magnetized MAGNODUR graduation that is scanned with magnetoresistive sensors.

ECI/EQI/EBI rotary encoders operate according to the inductive measuring principle. In this case, moving graduation structures modulate the gain and phase of a high-frequency signal. By means of circumferential scanning, the position value is always generated based on the signals from the receiver coils that are distributed along the circumference. This permits wide mounting tolerances at high resolution.
Electronic commutation with position encoders

Commutation with permanent-magnet three-phase AC motors

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

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

- Along with delivering incremental signals, incremental rotary encoders with a second track—the Z1 track—provide one sine and one cosine signal (C and D) for each revolution of the motor shaft. For sine commutation, rotary encoders with a Z1 track simply require a subdivision unit and a signal multiplexer in order to obtain the absolute rotor position down to an accuracy of ±0.5° from the Z1 track and to obtain the position information for speed and position control from the incremental track (see also Interfaces: Commutation signals).

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

Commutation of synchronous linear motors

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

Further information:

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

Measuring accuracy

The variables influencing the accuracy of linear encoders are listed in the Linear Encoders For Numerically Controlled Machine Tool and Exposed Linear Encoders brochures.

The angular measurement accuracy is primarily determined by the following factors:

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

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

Encoder-specific error

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

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

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

Interpolation error within one signal period

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

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

The following factors influence the outcome:

- Finesness of the signal period
- Homogenity and period definition of the graduation
- Quality of scanning filter structures
- Characteristics of the sensors
- Stability and dynamic performance of further analog signal processing

These errors are taken into account in the information about interpolation error within one signal period. For rotary encoders with an integral bearing and sinusoidal output signals, these errors are less than ±0.1% of the period signal, and less than ±3% for encoders with square-wave output signals. These signals are suitable for up to 100-fold PLL subdivision.

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

For rotary encoders with an integral bearing, the specified system accuracy already takes the error of the bearing into account. In the case of angle encoders with a separate shaft coupling (ERO, RDC, ROQ), the angular error of the coupling must be considered as well (see Mechanical design types and mounting). For angle encoders with stator coupling (ERN, ECN, EQN), the system accuracy already includes the error of the shaft coupling.

In contrast, for encoders without integral bearing, the mounting, as well as the adjustment of the scanning head, has a decisive influence on the attainable overall accuracy. Of particular importance are the mounting eccentricity of the graduation and the radial runout of the measured shaft. Evaluation of the overall accuracy of these encoders requires that their application-dependent errors be individually measured and taken into account.

Rotary encoders with photoelectric scanning

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

Example

For an ERO 1420 rotary encoder with a mean graduation diameter of 24.85 mm: A radial runout of the measured shaft of 0.02 mm results in a position error of ±30 arc seconds within one revolution.

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

1. Directional errors of the graduation

ERO: The extreme values of the directional errors relative to their mean are listed in the Specifications as the accuracy of the graduation. The system accuracy consists of the graduation accuracy and position error within one signal period.

2. Errors due to eccentricity of the graduation relative to the bearing

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

In the worst-case scenario, if the centering collar is centered relative to the bearing, then the two eccentricity vectors may be cumulative.

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

\[ Δe = \frac{e}{D} \]

3. Radial runout of the bearing

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

4. Position error within one signal period Δpp

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

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

Rotary encoders with inductive scanning

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

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

<table>
<thead>
<tr>
<th>Model</th>
<th>System</th>
<th>Total error</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECI 100</td>
<td>±120°</td>
<td>±280°</td>
</tr>
<tr>
<td>EBI 100</td>
<td>±90°</td>
<td>±180°</td>
</tr>
<tr>
<td>ECI 1100(S)</td>
<td>±45°</td>
<td>±120°</td>
</tr>
<tr>
<td>EBI 490</td>
<td>±25°</td>
<td>±140°</td>
</tr>
<tr>
<td>EnDat22</td>
<td>±40°</td>
<td>±150°</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model</th>
<th>System</th>
<th>Total error</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBI 4000(S)</td>
<td>±57°</td>
<td>±120°</td>
</tr>
<tr>
<td>hollow shaft EnDat22</td>
<td>±40°</td>
<td>±150°</td>
</tr>
</tbody>
</table>

Dependency of the measuring error Δe on the mean graduation diameter D and the eccentricity e:

\[ M = \text{Center of graduation} \]

\[ ψ = \text{‘That’ angle} \]

\[ ψ’ = \text{Scanned angle} \]

Resultant measuring error Δe for various eccentricity values as a function of the mean graduation diameter D.
Mechanical design types and mounting

Rotary encoders with integral bearing and stator coupling

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

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

Mounting the ECN/EQN 1100 and ECN/EQN/ERN 1300

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

Mounting accessories
ECN/EQN/ECI/EQI 1100: Mounting aid
For turning the encoder shaft from the rear. This facilitates finding the positive-locking connection between the encoder and the measured shaft.
ID 821077-03

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

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

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

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

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

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

Accessory for ECN/EQN/ERN 1000

Washer
For increasing the natural frequency fN when fastening with only two screws.
ID 334653-01 (2 washers)
The ECI/EBI/EQI inductive encoders have no integral bearing. This means that the mounting and operating conditions influence the encoder’s function reserves. It is also essential to ensure that the specified mating dimensions and tolerances are maintained for all operating conditions (see mounting instructions).

The application analysis must yield values within specification for all possible operating conditions (particularly under maximum load and at minimum and maximum operating temperature) and with the signal amplitude taken into account (inspection of the scanning gap and mounting tolerance at room temperature). This particularly applies to the following determined factors:

- Maximum radial runout of the motor shaft
- Maximum axial runout of the motor shaft relative to the mounting surface
- Maximum and minimum scanning gap (a), including in combination with, for example, the following:
  - The length ratio between the motor shaft and the motor housing under the influence of temperature (T₁; T₂; α₁; α₂), depending on the position of the fixed bearing (b)
  - The bearing play (Cₓ)
  - Non-dynamic shaft offsets due to load (X₁)
  - The effect of the motor brakes being engaged (X₂)

The ECI/EBI 100 rotary encoders are pre-aligned on a plane surface and, with their hollow shaft locked, are slid onto the measured shaft. Fastening and shaft clamping are achieved with axial screws.

The ECI/EBI/EQI 1100 inductive rotary encoders are mounted flush on their axis. Their blind hollow shaft is fastened with a central screw. The stator of these rotary encoders is clamped onto a shoulder with two axial screws.

The ECI 1118/EBI 1135 with EnDat 2.2

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

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

Once the encoder has been mounted, the actual scanning gap between the rotor and the stator can be indirectly measured with the PVIM 21 adjusting and testing package using a signal amplitude inside the rotary encoder. The characteristic curves illustrate the relationship between the signal amplitude and the deviation from the ideal scanning gap under different ambient conditions.

The example of the ECI/EBI 100 shows the resulting deviation from the ideal scanning gap for a signal amplitude of 80% under ideal conditions. Due to tolerances within the rotary encoder, the deviation is between +0.03 mm and –0.2 mm. Thus, the maximum permissible motion of the measured shaft during operation ranges from –0.33 mm to +0.1 mm (green arrows).

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

### Permissible scanning gap
***

<table>
<thead>
<tr>
<th>Amplitude in %</th>
<th>Deviation from the ideal scanning gap in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>80%</td>
<td>+0.03 mm to –0.2 mm</td>
</tr>
</tbody>
</table>

**Mounting accessory**
Mounting aid for removing the PCB connector (see page 36).
The ECI/EBI/EQI 1300 inductive rotary encoders are mounted flush on their axis. Their blind hollow shaft is fastened with a central screw. The stator of these rotary encoders is clamped to a shoulder by three axial screws.

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

The ERO rotary encoders without an integral bearing consist of a scanning head and a circular scale that must be brought into mutual alignment during mounting. Precise alignment is an important factor in reaching the attainable measuring accuracy.

The ERO modular rotary encoders consist of a disk/hub assembly and a scanning unit. These encoders are particularly well suited for limited installation space, low axial offsets, and low radial runout, or for applications where friction of any type must be avoided.

In the ERO 1200 series, the disk/hub assembly is pressed onto the shaft and brought into alignment with the scanning unit. The scanning unit is aligned on a centering collar and fastened to the mounting surface.

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

Mounting accessories for the ERO 1400

Mounting accessory
Aid for removing the clip in order to achieve optimal encoder mounting. ID 510175.01

Accessory
Housing for the ERO 14xx with an axial PCB connector and central hole. ID 321727.23
Information on output cables

Mounting and commissioning must be performed with appropriate ESD protection. Do not engage or disengage any connecting element while under power. To avoid over-stressing the individual wires during disengagement of the connecting element, HEIDENHAIN recommends using the mounting aid for disconnecting the PCB connector.

Strain relief
Avoid torque or tensile stress, and use strain relief wherever necessary.

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

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

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

For M12, M23:  min. M4 N m, max. M5 N m

Minimum tensile strength of the screws: 800 N/mm²

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

Designation of the cable components

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

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

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

Adapter connectors for directly connecting a modular rotary encoder to a PWM 21

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

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

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

Only in connection with:
Adapter cable for DRIVE-CLiQ, Ø 6.8 mm 15-pin D-sub connector (male) and 6-pin RJ45 EtherCAT connector with metal housing (IP20)
ID 1226399-01

General testing accessories for modular encoders and the PWM 21

For EnDat01, EnDat Hx, EnDat Tx or SSI interface with incremental signals, adapter cable Ø 6.8 mm 17-pin M23 connector (female) and 15-pin D-sub connector (male).
ID 324544-xx

For EnDat, Adapter cable Ø 8 mm 8-pin M12 connector (female) and 15-pin D-sub connector (male).
ID 1129763-xx

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

Adapter connectors for the flange socket on the motor to the PWM 21

For the EnDat22 interface, adapter cable Ø 6 mm 9-pin M23 connector (female) and 8-pin M12 coupling (male).
ID 1136983-xx

(ID 524599-xx is additionally required: 15-pin M23 connector (female) and 15-pin D-sub connector (male)).

Adapter cable Ø 6 mm/8 mm 8-pin M12 connector (female) and 15-pin D-sub connector (male).
ID 1036520-xx

For the DRIVE-CLiQ interface, adapter cable Ø 6.8 mm 9-pin M23 connector (female) and 6-pin RJ45 Ethernet connector with IP20 metal housing.
ID 1117540-xx

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

Adapters for Ethernet 6.8 mm

For ERO 1200 Version 3 (ID 1075573-01)
Cables with IP20 metal housing.

For ERO 1200 Version 4 (ID 1118892-02)
Connectors for replacement 14-pin: ID 526894-04

For ERO 1210 Version 2 (ID 1127260-01)
Connectors for replacement 14-pin: ID 526894-04

Adapters for DRIVE-CLiQ (ID 524599-xx is additionally required: 15-pin D-sub connector (male) and 15-pin D-sub connector (female), max. 3 m
ID 675582-xx

Adapter connector† for ID 621742-01 Three connectors for replacement 15-pin: ID 526894-01
16-pin: ID 526894-02
†Adapter connectors should be replaced after 500 connection cycles

Testing cable for the ERN 1382 with commutation signals for sinusoidal commutation
Includes three 14-pin adapter connectors.
ID 1118892-02

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

Adapter connector for ID 1118892-02 Three connectors for replacement 14-pin: ID 526894-04

EnDat 3 adapter (SA 1210)
Adapter for connecting an encoder with EnDat 3 (E30-R2) to the PWM 21 16-pin D-sub connector (male) and 15-pin D-sub connector (female)
ID 1317260-01

For EnDat1, EnDat Hx, EnDat Tx or SSI interface with incremental signals, adapter cable Ø 8 mm 17-pin M23 connector (female) and 15-pin D-sub connector (male).
ID 324544-xx

For EnDat01, EnDat Hx, EnDat Tx or SSI interface with incremental signals, adapter cable Ø 9.3 mm 15-pin M23 connector (female), four power wires, two brake wires and two communication wires 15-pin D-sub connector (male).
ID 1189174-xx

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

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

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

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

All absolute rotary encoders of the ECN/EQN 1100 FS, ECI/EBI 1100 and EC/EQI 1100 series are mounting-compatible within the respective series, exhibiting only minor differences in the permissible deviation between the shaft surface and coupling surface.

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

### Compatible mounting dimensions

<table>
<thead>
<tr>
<th>Series</th>
<th>Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERN 1300</td>
<td>Standard, deployable for taper shaft</td>
</tr>
<tr>
<td>ECN/EQN 1300 FS</td>
<td>Same as ERN 1300, but with an additional ridge as an anti-rotation element (stator coupling)</td>
</tr>
<tr>
<td>ECI/EQI 1300 FS</td>
<td>Same as ERN 1300, but with an anti-rotation element (flange)</td>
</tr>
</tbody>
</table>

### Mounting accessories

#### Screwdriver bits
- For HEIDENHAIN shaft couplings
- For ExN shaft clampings and stator couplings
- For ERD shaft clampings

<table>
<thead>
<tr>
<th>Width across flats</th>
<th>Length</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>70 mm</td>
<td>350078-01</td>
</tr>
<tr>
<td>15 (spherical head)</td>
<td></td>
<td>350078-02</td>
</tr>
<tr>
<td>4</td>
<td>16 mm</td>
<td>350078-03</td>
</tr>
<tr>
<td>3 (spherical head)</td>
<td></td>
<td>350078-04</td>
</tr>
<tr>
<td>2</td>
<td>13 mm</td>
<td>350078-05</td>
</tr>
<tr>
<td>2 (spherical head)</td>
<td></td>
<td>350078-06</td>
</tr>
<tr>
<td>2</td>
<td>10 mm</td>
<td>350078-07</td>
</tr>
<tr>
<td>2 (spherical head)</td>
<td></td>
<td>350078-08</td>
</tr>
</tbody>
</table>

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

#### Screws

<table>
<thead>
<tr>
<th>Screw</th>
<th>Securing method</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>M3x8 8.8 ISO 4762 MKL</td>
<td>Material bonding anti-rotation lock</td>
<td>202264-67</td>
</tr>
<tr>
<td>M3x10 8.8 ISO 4762 MKL</td>
<td>Material bonding anti-rotation lock</td>
<td>202264-87</td>
</tr>
<tr>
<td>M4x16 A2 ISO 4762 KLF</td>
<td>Self-locking</td>
<td>202264-30</td>
</tr>
<tr>
<td>M6x20 A2 ISO 4762 KLF</td>
<td>Self-locking</td>
<td>202264-45</td>
</tr>
<tr>
<td>M6x22 8.8 ISO 4762 MKL</td>
<td>Material bonding anti-rotation lock</td>
<td>202264-65</td>
</tr>
<tr>
<td>M6x25 8.8 ISO 4762 MKL</td>
<td>Material bonding anti-rotation lock</td>
<td>202264-86</td>
</tr>
<tr>
<td>M6x25 A2 ISO 4762 KLF</td>
<td>Self-locking</td>
<td>202264-26</td>
</tr>
<tr>
<td>M6x36 8.8 ISO 4762 MKL</td>
<td>Material bonding anti-rotation lock</td>
<td>202264-66</td>
</tr>
<tr>
<td>M6x40 8.8 ISO 4762 MKL</td>
<td>Material bonding anti-rotation lock</td>
<td>202264-85</td>
</tr>
<tr>
<td>M6x40 A2 ISO 4762 KLF</td>
<td>Self-locking</td>
<td>202264-55</td>
</tr>
<tr>
<td>M8x25 8.8 DIN 6912 MKL</td>
<td>Material bonding anti-rotation lock</td>
<td>202264-76</td>
</tr>
<tr>
<td>M8x30 8.8 DIN 6912 MKL</td>
<td>Material bonding anti-rotation lock</td>
<td>202264-80</td>
</tr>
<tr>
<td>M8x35 8.8 ISO 4762 KLF</td>
<td>Self-locking</td>
<td>202264-38</td>
</tr>
<tr>
<td>M8x40 8.8 DIN 6912 KLF</td>
<td>Self-locking</td>
<td>202264-54</td>
</tr>
</tbody>
</table>

#### Fastener kit
- M3 fixing clamp
- Spring washer 3x0.70 DIN 126 A FS ISO
- Screw: M3x10 8.8 DIN EN ISO 4762
- Material bonding anti-rotation lock

<table>
<thead>
<tr>
<th>Quantity</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 pieces</td>
<td>1264352-01</td>
</tr>
<tr>
<td>200 pieces</td>
<td>1264352-02</td>
</tr>
</tbody>
</table>
Aligning Rotor Positions Between Encoders and Motors

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

First, the rotor of the motor is turned to the preferred position through the application of a DC current. The rotor encoder is turned until the PWT 101 displays a distance from the reference mark of nearly zero.

Absolute rotary encoders are first completely mounted, after which a datum shift is used to assign the value “zero” to the preferred motor position. This is performed with the adjusting and testing device (see Testing and inspection devices, and diagnosti). The rotor of the encoder is turned until the PWT 101 displays a distance from the reference mark of nearly zero.

For the ECI/EQI rotary encoders in this brochure, it is possible as well. Please follow the instructions.

Certification by NRTL (Nationally Recognized Testing Laboratory) All of the rotary encoders in this brochure comply with the UL safety regulations for the U.S. and the CSA safety regulations for Canada.

Accelerations During mounting and operation, encoders are subjected to various types of acceleration.

- Vibration
- Shock

The encoders are qualified on a test stand under the acceleration values stated in the specifications at frequencies of 55 Hz to 2000 Hz in accordance with EN 60068-2-27 for non-repetitive, sinusoidal shock. Continuous shock loads are therefore not covered and must be tested in the application.

The maximum angular acceleration is \(10^7\) rad/s\(^2\). This is the maximum permissible angular acceleration of the rotor without the encoder incurring damage. The actual attainable angular acceleration is within the same order of magnitude but can vary depending on the type of shaft connection (for deviating values for the ENHERN 100, see the Specifications). An adequate safety factor must be determined through system tests.

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

Natural frequencies

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

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

Humidity

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

Magnetic fields

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

Acoustic noise

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

Starting torque and operating torque

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

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

Protection against contact (EN 60529)

After completed installation, any rotating parts must be sufficiently protected from unintentional contact during operation.

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

The shaft inlet meets an IP66 rating. Splash water must not be allowed to have any harmful effect on the encoder’s parts. If the protection rating of the shaft inlet is not sufficient (e.g., due to vertical mounting of the encoder), then the encoder should be additionally protected with labyrinth seals. Many rotary encoders are also available with an IP66 rating for the shaft inlet. Depending on the application, the radial shaft seal rings used for sealing are subjected to wear due to friction.
Mounting
The work steps and dimensions to be followed during mounting apply only to the mounting instructions available for the encoder. All mounting-related information in this brochure is therefore only provisional and non-binding, and will not become the subject matter of a contract.

In addition, the machine manufacturer must define the other required final mounting information for the given application (e.g., tightening torque, mechanical fault exclusion for screws needed or not). In addition, the stated tolerance ranges in the product’s dimension drawing and mounting instructions must be considered.

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

Material type
Aluminum
Hardened wrought aluminum alloy
Unalloyed hardened steel

Tensile strength Rm
≥ 220 N/mm²
≥ 600 N/mm²

Yield strength Rp 0.2 or yield point Ry
Not applicable
≥ 400 N/mm²

Shear strength τs
≥ 130 N/mm²
≥ 390 N/mm²

Interface pressure pz
≥ 250 N/mm²
≥ 660 N/mm²

Modulus of elasticity E (at 20 °C)
70 kN/mm² to 75 kN/mm²
200 kN/mm² to 215 kN/mm²

Coefficient of thermal expansion α (at 20 °C)
≤ 25 · 10⁻⁶ K⁻¹ to 10 · 10⁻⁶ K⁻¹ to 17 · 10⁻⁶ K⁻¹

Surface roughness Rz
≤ 16 µm

Friction values
Mounting surfaces must be clean and free of grease. Use screws from HEIDENHAIN in their delivery condition.

Tightening procedure
Use a signal-emitting torque wrench in accordance with DIN EN ISO 6789, with an accuracy of ±6%.

Mounting temperature
15 °C to 35 °C

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

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

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

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

**Encoders with an integral bearing, pluggable output cable and standard bearing**

Check the resistance between the flange socket and the rotor. Nominal value: < 1 ohm

**Encoders with hybrid bearing or EnDat 3 (E30-R2)**

Check the resistance between the flange socket and the rotor \(a\), and between the flange socket and the stator (metal housing) \(b\). Nominal value: < 1 ohm

**Exposed encoders (Ex1 100) without integral bearing but with a pluggable output cable**

Check the electrical resistance between the flange socket and the rotor \(a\), and between the flange socket and the stator (mounting screw) \(b\). Nominal value: < 1 ohm

**Exposed encoders (Ex1 4000) without an integral bearing but with a pluggable output cable**

Check the electrical resistance between the flange socket and the rotor \(a\), the flange socket and the stator \(b\), and the flange socket and the crimp sleeve \(c\). Nominal value: < 1 ohm

**Exposed encoders (Ex1 1100, Ex1 1300) without an integral bearing but with a pluggable output cable**

Check the resistance between the flange socket and the rotor \(a\), and between the flange socket and the stator (metal housing) \(b\). Nominal value: < 1 ohm

---

### Temperature measurement in motors

#### Transmission of temperature data

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

#### Signaling of a temperature exceedance

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

- **The integrated memory can be read to determine whether the respective encoder supports this warning and error message functionality.**
- **The warning threshold for the internal temperature sensor can be individually adjusted.**
- **At the time the encoder is shipped, a default value equivalent to the maximum permissible operating temperature is stored here (temperature at measuring point M1 as per the dimension drawing).**
- **The temperature measured by the internal temperature sensor is higher by a device-specific amount than the temperature at measuring point M1.**
- **The encoder features a further, albeit non-adjustable trigger threshold for the internal temperature sensor; an error message is output when this threshold is reached.**
- **This trigger threshold is device-specific and, if present, is stated in the specifications.**

**Further information:**

When connecting an external temperature sensor, please refer to the information about electromagnetic compatibility in the General electrical information section of the Interfaces of HEIDENHAIN Encoders brochure.

#### Interfaces of HEIDENHAIN

- **General electrical information**
  - **Exposed encoders (Ex1 1100, Ex1 1300, Ex1 4000) without an integral bearing but with a pluggable output cable**
    - **Clamp (when present) must be screwed to the motor housing so as to be conductive.**
  - **Transmission of temperature data**
    - **To protect the motor from overloads, the motor manufacturer usually monitors the temperature of the motor winding.**
    - **In conventional applications, the temperature sensor data are sent via two separate lines to the downstream electronics, where they are then evaluated.**
    - **Depending on their features, HEIDENHAIN rotary encoders with the EnDat 2.2, EnDat 3 or DRIVE CLiQ interface have an internal temperature sensor integrated into the encoder’s electronics and an evaluation circuit to which the external temperature sensor can be connected.**
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**Encoders with hybrid bearing or EnDat 3 (E30-R2)**

Check the resistance between the flange socket and the rotor \(a\), and between the flange socket and the stator (metal housing) \(b\). Nominal value: < 1 ohm

**Exposed encoders (Ex1 100) without integral bearing but with a pluggable output cable**

Check the electrical resistance between the flange socket and the stator \(a\), and between the flange socket and the rotor \(b\). Nominal value: < 1 ohm

**Exposed encoders (Ex1 4000) without an integral bearing but with a pluggable output cable**

Check the electrical resistance between the flange socket and the rotor \(a\), the flange socket and the stator \(b\), and the flange socket and the crimp sleeve \(c\). Nominal value: < 1 ohm

**Exposed encoders (Ex1 1100, Ex1 1300) without an integral bearing but with a pluggable output cable**

Check the resistance between the flange socket and the rotor \(a\), and between the flange socket and the stator (metal housing) \(b\). Nominal value: < 1 ohm

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#### Further information:

When connecting an external temperature sensor, please refer to the information about electromagnetic compatibility in the General electrical information section of the Interfaces of HEIDENHAIN Encoders brochure.

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**Further information:**

When connecting an external temperature sensor, please refer to the information about electromagnetic compatibility in the General electrical information section of the Interfaces of HEIDENHAIN Encoders brochure.
Information on connecting an external temperature sensor

- The external temperature sensor must comply with the following requirements as per EN 61800-5-1:
  - Voltage class A
  - Contamination level 2
  - Overvoltage category 3
- Connect only passive temperature sensors.
- The connections for the temperature sensor assembly (sensor + cable assembly) must be mounted such that it is insulated from its environment with double or reinforced insulation.
- The accuracy of the temperature measurement depends on the temperature range.
- Take into account the tolerance of the temperature sensor.
- The transmitted temperature value is not a safe value in terms of functional safety.
- The motor manufacturer is responsible for the quality and accuracy of the temperature sensor, as well as for ensuring electrical safety.
- Use a crimp connector with a suitable cable configuration of the temperature wires in the motor.
- The external temperature sensor must be mounted such that it is insulated from its environment.
- The transmitted temperature value is not a safe value in terms of functional safety.
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Connectable temperature sensors

In the case of EnDat 3 encoders with an E30 RZ interface, the encoder can be configured for the connected temperature sensor (KTY 83-110, KTY 84-130 or PT 1000). For encoders with the DRIVE CLiQ interface, you can choose between the KTY 84-130 or PT 1000. The correct temperature value is then output directly over the interface.

With EnDat22 encoders, the temperature evaluation performed by the rotary encoder is designed for a KTY 84-130 PTC thermistor. For other temperature sensors, the output value (value in additional data 1) must be converted into a temperature value.

Specifications for the evaluation

<table>
<thead>
<tr>
<th>Temperature Range</th>
<th>KTY 83-110</th>
<th>KTY 84-130</th>
<th>PT 1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40 °C to +80 °C</td>
<td>±6 K</td>
<td>±6 K</td>
<td>±6 K</td>
</tr>
<tr>
<td>80.1 °C to 160 °C</td>
<td>±3 K</td>
<td>±3 K</td>
<td>±4 K</td>
</tr>
<tr>
<td>160.1 °C to 200 °C</td>
<td>±6 K</td>
<td>±6 K</td>
<td>±6 K</td>
</tr>
</tbody>
</table>

The accuracy of the temperature measurement depends on the sensor being used and on the temperature range.

- Resolution: 0.1 K (with KTY 84-130)
- Supply voltage of sensor: 3.3 V over dropping resistor RV = 2 kΩ
- Measuring current (typical): 1.3 mA at 505 Ω, 1.1 mA at 990 Ω
- Total delay of temperature evaluation: 160 ms max.
- Cable length: ≤ 1 m

The following polynomial can be used to calculate the temperature value:

\[ T = A + B \cdot A^2 + C \cdot A^3 \]

Where:
- \( T \) is the temperature value in °C
- \( A \) is the output value (temperature value) 3751, which is equal to 375.1 K or 102 °C.

Example for the KTY 84-130 temperature sensor:

Sensor resistance = 1000 Ω → Output value (temperature value) 3751, which is equal to 375.1 K or 102 °C.

Example for the PT 1000 temperature sensor:

Output value = 3751 → Temperature value = 2734 (equivalent to 0.3 °C).

The following polynomial can be used to calculate the temperature value:

\[ T = A + B \cdot A^2 + C \cdot A^3 \]

Where:
- \( T \) is the temperature value in °C
- \( A \) is the output value. The PT 1000 polynomial is valid for: 3400 ≤ A ≤ 4810.

Example for the KTY 83-110 temperature sensor:

Output value = 3751 → Temperature value = 2981 (equivalent to 25.0 °C).

The following polynomial can be used to calculate the temperature value:

\[ T = A + B \cdot A^2 + C \cdot A^3 \]

Where:
- \( T \) is the temperature value in °C
- \( A \) is the output value. The KTY83-110 polynomial is valid for: 2880 ≤ A ≤ 5460.
**ECN/EQN 1100 series**

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

### Required mating dimensions

<table>
<thead>
<tr>
<th>Series</th>
<th>Encoder name</th>
<th>Encoder flange / Stator coupling</th>
<th>Encoder shaft</th>
<th>Interface</th>
<th>L2</th>
<th>L3</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>ENQ/ENQ</td>
<td>76A</td>
<td>1KA</td>
<td>EnDat01</td>
<td>–</td>
<td>0</td>
</tr>
<tr>
<td>E2/E3</td>
<td>ECI/ECI</td>
<td>70C</td>
<td>1KA/82A</td>
<td>EnDat01</td>
<td>–</td>
<td>0</td>
</tr>
<tr>
<td>E4/E6</td>
<td>ENQ/ENQ</td>
<td>70F</td>
<td>82A</td>
<td>EnDat01</td>
<td>–</td>
<td>0</td>
</tr>
<tr>
<td>E5</td>
<td>ENQ/ENQ</td>
<td>70F</td>
<td>82A</td>
<td>EnDat01</td>
<td>–</td>
<td>0</td>
</tr>
<tr>
<td>E7</td>
<td>ENQ/ENQ</td>
<td>70E</td>
<td>82A</td>
<td>EnDat01</td>
<td>–</td>
<td>0</td>
</tr>
</tbody>
</table>

### System accuracy

- ±0.0°

### Electrical connection

- 15-pin

### Supply voltage

- DC 3.6 V to 14 V

### Power consumption (max.)

- 3.6 V: ≤ 0.6 W

### Current consumption (typical)

- 5 V: 85 mA

### Shaft

- 1KA blind hollow shaft (Ø 6 mm) with positive-locking element

### Mech. perm. shaft speed n

- 12 000 rpm

### Vibration

- ≤ 200 m/s² (EN 60068-2-6)

### Protection rating

- EN 60529

For dimensions and specifications of encoders with functional safety, see the Product Information document.
ERN 1023
Incremental rotary encoders
• Stator coupling for plane surface
• Blind hollow shaft
• Block commutation signals

<table>
<thead>
<tr>
<th>Interface</th>
<th>ERN 1023</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal periods per revolution*</td>
<td>500</td>
</tr>
<tr>
<td>Reference mark</td>
<td>One</td>
</tr>
<tr>
<td>Output frequency</td>
<td>≤ 300 kHz</td>
</tr>
<tr>
<td>Edge separation a</td>
<td>≥ 0.41 μs</td>
</tr>
<tr>
<td>Commutation signals (1)</td>
<td>TTL (3 commutation signals U, V, W)</td>
</tr>
<tr>
<td>Width*</td>
<td>2 x 180° (C01); 3 x 120° (C02); 4 x 90° (C03)</td>
</tr>
<tr>
<td>System accuracy</td>
<td>±260” ±130”</td>
</tr>
<tr>
<td>Electrical connection*</td>
<td>Cable 1 m, 5 m, without coupling</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>DC 5 V ±0.5 V</td>
</tr>
<tr>
<td>Current consumption (without load)</td>
<td>≤ 70 mA</td>
</tr>
<tr>
<td>Shaft</td>
<td>Blind hollow shaft Ø 6 mm</td>
</tr>
<tr>
<td>Mech. permis. shaft speed n</td>
<td>≤ 6000 rpm</td>
</tr>
<tr>
<td>Starting torque (typical)</td>
<td>0.005 Nm (at 20 °C)</td>
</tr>
<tr>
<td>Moment of inertia of rotor</td>
<td>0.5 · 10⁻⁶ kgm²</td>
</tr>
<tr>
<td>Permissible axial motion of measured shaft</td>
<td>±0.15 mm</td>
</tr>
<tr>
<td>Vibration</td>
<td>25 Hz to 2000 Hz</td>
</tr>
<tr>
<td>Shock 6 ms</td>
<td>≤ 100 m/s² (EN 60068-2-6)</td>
</tr>
<tr>
<td>Max. operating temperature</td>
<td>90 °C</td>
</tr>
<tr>
<td>Min. operating temperature</td>
<td>Fixed cable: –20 °C</td>
</tr>
<tr>
<td>Moving cable: –10 °C</td>
<td></td>
</tr>
<tr>
<td>Protection</td>
<td>EN 60529 IP64</td>
</tr>
<tr>
<td>Mass</td>
<td>≈ 0.07 kg (without cable)</td>
</tr>
<tr>
<td>ID number</td>
<td>684/703.xx</td>
</tr>
</tbody>
</table>

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

mm:
ISO 8015
ISO 2768 H/H
≤ 6 mm: ±0.2 mm

= Bearing of mating shaft
= Measured mating dimensions
M = Measuring point for operating temperature
1 = Two screws in clamping ring; width A/F 1.5
2 = Reference mark position ±10°
3 = Compensation of mounting tolerances and thermal expansion, no dynamic motion permitted
4 = Ensure protection against contact (EN 60529)
5 = Direction of shaft rotation for output signals as per the interface description
ERN 1123
Incremental rotary encoders
- Stator coupling for plane surface
- Hollow through shaft
- Block commutation signals

**Interface**
- TTL/TTL

**Signal periods per revolution**
- 500
- 512
- 600
- 1000
- 1024
- 1250
- 2000
- 2048
- 2500
- 4096
- 5000
- 8192

**Reference mark**
- One

**Output frequency**
- ≤ 300 kHz
- ≥ 0.41 μs

**Commutation signals**
- TTL/TTL (3 commutation signals U, V, W)

**Width**
- 2 x 180° (C01); 3 x 120° (C02); 4 x 90° (C03)

**System accuracy**
- ±200"
- ±130"

**Electrical connection**
- 15-pin

**Supply voltage**
- DC 5 V ±0.5 V

**Current consumption (without load)**
- ≤ 70 mA

**Shaft**
- Hollow through shaft (Ø 8 mm)

**Mech. permitt. shaft speed n**
- ≤ 6000 rpm

**Starting torque (typical)**
- 0.005 Nm (at 20°C)

**Moment of inertia of rotor**
- 0.5 · 10⁻⁶ kgm²

**Permissible axial motion of measured shaft**
- ±0.15 mm

**Vibration**
- 25 Hz to 2000 Hz
- ≤ 100 mVp/p (EN 60068-2-6)
- ≤ 1000 mVp/p (EN 60068-2-27)

**Shock**
- 6 ms
- ≤ 100 m/s² (EN 60068-2-27)
- ≤ 1000 m/s² (EN 60068-2-6)

**Operating temperature**
- –20°C to 90°C

**Protection**
- EN 60529 IP00

**Mass**
- ≈ 0.06 kg

**ID number**
- 684702-xx

**Notes**
- Bold: This preferred version is available on short notice
- Please select when ordering
- *Please select when ordering
- 1) Three square-wave signals with signal periods with 90°, 120° or 180° mech. phase shift; see Commutation signals for block commutation in the Interfaces of HEIDENHAIN Encoders brochure
- 2) Electromagnetic compatibility must be ensured in the entire system
ECN/EQN 1300 series

Absolute rotary encoders

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

Required mating dimensions

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

Interface

- EnDat 2.2
- EnDat 3
- Position values per revolution
  - ECN 1313: 8192 (13 bits)
  - EQN 1325: 33 554 432 (25 bits)
  - ECN 1325: 33 554 432 (25 bits)
- Revolutions
  - ECN 1313: -
  - EQN 1325: 4096 (12 bits)
- Electric permiss. shaft speed/ deviations
  - 512 lines: 5 000 rpm/±1 LSB
  - 12 000 rpm/±100 LSB
  - 2048 lines: 1500 rpm/±1 LSB
  - 12 000 rpm/±50 LSB

Calculation time tcalc

- 9 µs
- 2 MHz
- 7 µs
- 8 MHz

XEL.time HPFout data rate

- 11 µs at 12.5 Mbit/s
- 8.2 µs at 25 Mbit/s

For dimensions and specifications of encoders with functional safety, see the Product Information document.
ECN/EQN 1300 S series

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

Required mating dimensions

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

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

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

DRIVE-CLiQ is a registered trademark of Siemens AG.
ECN/EQN 400 series

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

Required mating dimensions

<table>
<thead>
<tr>
<th>ID number</th>
<th>Absolute</th>
<th>ECN 425</th>
<th>EQN 425</th>
<th>EQN 437</th>
</tr>
</thead>
<tbody>
<tr>
<td>1065932-xx</td>
<td>ECN 413</td>
<td>EnDat 2.2</td>
<td>EnDat01</td>
<td>EnDat22</td>
</tr>
<tr>
<td>683644-xx</td>
<td>EnDat01</td>
<td>EnDat22</td>
<td>EnDat01</td>
<td>EnDat22</td>
</tr>
<tr>
<td>1109258-xx</td>
<td>81192 (13 bits)</td>
<td>33564432 (25 bits)</td>
<td>81192 (13 bits)</td>
<td>33564432 (25 bits)</td>
</tr>
</tbody>
</table>

Determining signal per revolution

- 1500 rpm/a LSB
- 12 000 rpm/a ±50 LSB

Calculation time (tcalc)

- 7 µs
- 16 MHz
- ±7 µs
- 16 MHz

Line count

- 2048

Cutoff frequency (3 dB)

- 400 kHz
- ±400 kHz

System accuracy

- ±20°

Electrical connection

- Cable 5 m, with or without M23 coupling
- Cable 5 m, with M12 coupling
- Cable 5 m, with or without M23 coupling
- Cable 5 m, with M12 coupling

Supply voltage

- DC 3.6 V to 14 V

Power consumption (maximum)

- 3.6 V: 0.6 W
- 14 V: 0.7 W

Current consumption (typical)

- 3.6 V: 0.6 W
- 14 V: 0.7 W

Supply voltage

- 5 V: 85 mA (without load)
- 5 V: 105 mA (without load)

Shaft

- Tapered shaft
- (9.25 mm); taper: 1:10

Mech. permiss. shaft speed n

- ±15 000 rpm
- ±12 000 rpm

Starting torque (typical)

- 0.01 Nm (at 20 °C)

Moment of inertia of rotor

- 2.6 · 10⁻⁶ kgm²

Natural frequency fN (typical)

- 1800 Hz

Permissible axial motion of measured shaft

- ±0.5 mm

Vibration

- 55 Hz to 2000 Hz
- ≤ 300 m/s² (EN 60068-2-6)
- ≤ 2000 m/s² (EN 60068-2-27)

Max. operating temperature

- 100 °C

Min. operating temperature

- Fixed cable: -40 °C
- Moving cable: -10 °C

Protection

- EN 60068-2-6
- IP64 when mounted

Mass

- ± 0.25 kg

ID number

- 1065932-xx
- 683644-xx
- 1109258-xx
- 683646-xx

* Please select when ordering

1) Deviating tolerances
- Signal amplitude: 0.8 Vpp to 1.2 Vpp
- Asymmetry: ±0.05
- Amplitude ratio: 0.9 to 1.1
- Phase angle: ±5° elec.

2) Speed-dependent deviations between absolute and incremental signals

For dimensions and specifications of encoders with functional safety, see the Product Information document.
ERN 1300 series
Incremental rotary encoders
- 06 stator coupling for axial mounting
- 65B tapered shaft

### Interface

<table>
<thead>
<tr>
<th>Incremental</th>
<th>ERN 1321</th>
<th>ERN 1381</th>
<th>ERN 1387</th>
<th>ERN 1326</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>TTL</td>
<td>TTL</td>
<td>TTL</td>
<td>TTL</td>
</tr>
<tr>
<td>Line count</td>
<td>1024(×16°)</td>
<td>1024(×16°)</td>
<td>1024(×16°)</td>
<td>1024(×16°)</td>
</tr>
<tr>
<td>System accuracy</td>
<td>2048(×32&quot;)</td>
<td>2048(×20&quot;)</td>
<td>2048(×20&quot;)</td>
<td>2048(×20&quot;)</td>
</tr>
<tr>
<td></td>
<td>4096(×16&quot;)</td>
<td>4096(×16&quot;)</td>
<td>4096(×16&quot;)</td>
<td>4096(×16&quot;)</td>
</tr>
</tbody>
</table>

### Reference mark
- One

### Output frequency
- ≤ 300 kHz
- ≥ 0.35 kHz
- ≥ 210 kHz
- ≤ 150 kHz
- ≤ 0.22 kHz

### Commutation signals
- –
- 21 track
- 3 x 120°, 4 x 90°

### Electrical connection
- 12-pin
- 14-pin
- 16-pin

### Supply voltage
- DC 5 V ±0.5 V
- DC 5 V ±2.5 V

### Current consumption (without load)
- ≤ 120 mA
- ≤ 130 mA
- ≤ 150 mA

### Shaft
- Tapered shaft Ø (9.25 mm); taper: 1:10
- Mech. permiss. shaft speed n ≤ 15 000 rpm
- Starting torque (typical) 0.01 Nm (at 20 °C)
- Moment of inertia of rotor 2.6 · 10⁻⁶ kgm²
- Natural frequency fN (typical) 1800 Hz
- Permissible axial motion of measured shaft ±0.5 mm

### Vibration
- 85 Hz to 2000 Hz ≤ 300 m/s² (EN 60068-2-6)
- ≤ 2000 m/s² (EN 60068-2-27)

### Shock
- 6 ms ≤ 300 m/s² (EN 60068-2-6)
- ≤ 150 m/s² (EN 60068-2-27)

### Max. operating temperature
- 120 °C
- 120 °C
- 80 °C

### Min. operating temperature
- -40 °C

### Protection
- EN 60529
- IP40 when mounted

### Mass
- ≤ 0.25 kg

### ID number
- 385423-xx
- 534118-xx
- 749144-xx
- 574485-xx

### Tolerancing
- ISO 8015
- ISO 2768
- ISO 2768

### Notes
- * Please select when ordering
- † Deviating tolerances
  - Signal amplitude: 0.8 Vpp to 1.2 Vpp
  - Asymmetry: 0.05
  - Amplitude ratio: 0.9 to 1.1
  - Phase angle: 90° elec. ±5° elec.
  - Signal-to-noise ratio E, F: 100 mV
- ‡ One sine and one cosine signal per revolution; see the Interfaces of HEIDENHAIN Encoders brochure
- § Three square-wave signals with signal periods with 90° or 120° mech. phase shift; see the Interfaces of HEIDENHAIN Encoders brochure
- § Valid as per standard at room temperature; at operating temperatures up to 100 °C: ≤ 300 m/s²; up to 120 °C: ≤ 150 m/s²
- ¶ Via integrated signal doubling

---

*) Ø 65±0.02 for EC/EQI 13xx

Alternative:
ECN/EQN 1300 mating dimensions with slot for stator coupling for the anti-rotation element are also usable.
ECI/EQI 1100 series

Absolute rotary encoders

- Flange for axial mounting
- Blind hollow shaft
- Without integral bearing

<table>
<thead>
<tr>
<th>Absolute, singleturn (ECI 1119)</th>
<th>Absolute, multiturn (EQI 1131)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>EnDat 2.2</td>
</tr>
<tr>
<td>Ordering designation</td>
<td>EnDat22</td>
</tr>
<tr>
<td>Position values per revolution</td>
<td>524.288B (19 bits)</td>
</tr>
<tr>
<td>Revolutions</td>
<td>-</td>
</tr>
<tr>
<td>Calculation time tcalc</td>
<td>≤ 5 µs</td>
</tr>
<tr>
<td>Clock frequency</td>
<td>≤ 16 MHz</td>
</tr>
<tr>
<td>XEL time HPOut data rate</td>
<td>-</td>
</tr>
<tr>
<td>Propagation time</td>
<td>-</td>
</tr>
<tr>
<td>XEL time</td>
<td>≤ 11 µs at 12.5 Mbit/s</td>
</tr>
<tr>
<td>System accuracy</td>
<td>±120°</td>
</tr>
<tr>
<td>Electrical connection</td>
<td>15-pin (with connection for external temperature sensor) 1)</td>
</tr>
<tr>
<td>Cable length</td>
<td>EnDat 2: ≤ 100 m at 12.5 Mbit/s; ≤ 40 m at 25 Mbit/s</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>DC 3.6 V to 14 V</td>
</tr>
<tr>
<td>Power consumption (maximum)</td>
<td>3.6 V ≤ 0.66 W</td>
</tr>
<tr>
<td>Current consumption (typical)</td>
<td>5 V ≤ 156 mA at room temperature</td>
</tr>
<tr>
<td>Shaft</td>
<td>Blind hollow shaft for axial clamping Ø 6 mm without positive-locking element (82A) or with positive-locking element (1KA)</td>
</tr>
<tr>
<td>Shaft speed</td>
<td>≤ 15 000 rpm</td>
</tr>
<tr>
<td>Moment of inertia of rotor</td>
<td>0.2 · 10^6 kg · m²</td>
</tr>
<tr>
<td>Angular acceleration of rotor</td>
<td>≤ 1 · 10^5 rad/s</td>
</tr>
<tr>
<td>Permissible axial motion of measured shaft</td>
<td>±0.4 mm</td>
</tr>
<tr>
<td>Vibration (55 Hz to 2000 Hz)</td>
<td>860 m/s at 2000 Hz</td>
</tr>
<tr>
<td>Shock 0 m/s</td>
<td>≤ 2000 m/s</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>±40 °C to 110 °C</td>
</tr>
<tr>
<td>Trigger threshold</td>
<td>125 °C (measuring accuracy of the internal temperature sensor: ±1 K)</td>
</tr>
<tr>
<td>Protection</td>
<td>EN 60529</td>
</tr>
<tr>
<td>Mass</td>
<td>0.04 kg</td>
</tr>
<tr>
<td>ID number</td>
<td>1164809-xx</td>
</tr>
</tbody>
</table>

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

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

---

**Required mating dimensions**

| 1 | Contact surface of slot |
| 2 | Shaft surface; ensure full-surface contact |
| 3 | Slotted for ECN/EQN and ECI/EQI with WELLAL = 1KA |
| 4 | ECN/EQI flange surface; ensure full-surface contact |
| 5 | Coupling surface of ECI/EQI |
| 6 | Mounting dimension: maximum permissible deviation between the shaft surface and coupling surface; compensation of mounting tolerances and thermal expansion; of which ±0.15 mm of dynamic axial motion is permitted (ECN/EQN) |
| 7 | Maximum permissible deviation between the shaft surface and flange surface; compensation of mounting tolerances and thermal expansion; dynamic motion permitted over entire range (ECN/EQN) |
| 8 | ECN/EQI flange surface; ensure full-surface contact |
| 9 | ECI/EQI flange surface; ensure full-surface contact |
| 10 | Undercut |
| 11 | Possible centering hole |
| 12 | Distance to cover; note the opening for header, header connector and wires |
| 13 | Screw: ISO 4762 – M3x25 – 8.8 – M6L; tightening torque: 1 Nm ±0.1 Nm |
| 14 | E-COP: ISO 4762 – M3x08 – 8.8 – M6L; tightening torque: 1 Nm ±0.1 Nm |
| 15 | Positive-locking element; ensure correct engagement in the slot (e.g., by measuring the device overhang) |
| 16 | Direction of shaft rotation for ascending position values |
| 17 | 15-pin header |
| 18 | Dimension for JH standard cable |
| 19 | Ensure installation space for cable |

---

1) See Temperature measurement in motors.
2) Please select when ordering.
3) See Electromagnetic compatibility under General electrical information in the Interfaces of HEIDENHAIN Encoders brochure.
ECI/EQI 1100 series

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

Required mating dimensions

<table>
<thead>
<tr>
<th>Series</th>
<th>Name</th>
<th>Flange</th>
<th>Shaft</th>
<th>Interface</th>
<th>L2</th>
<th>L3</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>ECI/EQI</td>
<td>1KA/8DA</td>
<td></td>
<td>EnDat22</td>
<td>2±0.5</td>
<td>–</td>
</tr>
<tr>
<td>E2</td>
<td>ECI/EQI</td>
<td>70C</td>
<td>1KA/8DA</td>
<td>EnDat22</td>
<td>2±0.5</td>
<td>–</td>
</tr>
<tr>
<td>E3</td>
<td>ECI/EQI</td>
<td>70F</td>
<td>82A</td>
<td>EnDat22</td>
<td>–</td>
<td>0±0.3</td>
</tr>
<tr>
<td>E4</td>
<td>ECI/EQI</td>
<td>70F</td>
<td>82A</td>
<td>EnDat22</td>
<td>–</td>
<td>0±0.3</td>
</tr>
<tr>
<td>E5</td>
<td>ECI/EBI</td>
<td>70E</td>
<td>82C</td>
<td>EnDat22</td>
<td>–</td>
<td>0±0.3</td>
</tr>
</tbody>
</table>

1) Evaluation optimized for the KTY 84-130 temperature sensor (see Temperature measurement in motors)
2) See Electromagnetic compatibility under General electrical information in the Interfaces of HEIDENHAIN Encoders brochure.
ECI/EBI/EQI 1300 series

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

---

### Required mating dimensions

1. **D1**
2. **D2**
   - Ø 12.7G6
   - Ø 12.7h6

---

### Electrical connection
- 16-pin with connection for temperature sensor

---

### Interface

<table>
<thead>
<tr>
<th>ECI 1319</th>
<th>EGI 1331</th>
<th>EBI 1335</th>
</tr>
</thead>
<tbody>
<tr>
<td>EnDat 2.2</td>
<td>EnDat22</td>
<td></td>
</tr>
</tbody>
</table>

### Ordering designation
- EnDat22

### Position values per revolution
- 524288 (19 bits)

### Revolutions
- 4096 (12 bits)
- 65536 (16 bits)

### Electric permiss. shaft speed/ deviations
- ≤ 15 000 rpm (for continuous position value)

### Calculation time tcalc
- ≤ 5 µs

### Clock frequency
- ≤ 16 MHz

### System accuracy
- ±65°

### Electrical connection
- 16-pin with connection for temperature sensor
- Cable length ≤ 100 m

### Supply voltage
- DC 3.6 V to 14 V
- DC 3.6 V to 14 V
- DC 3.6 V to 5.25 V

### Power consumption (max.)
- 3.6 V: 0.65 W
- 14 V: 0.75 W
- 14 V: 0.85 W
- 14 V: 0.65 W
- 14 V: 0.7 W

### Current consumption (typical)
- 5 V: 95 mA (without load)
- 5 V: 115 mA (without load)
- Normal operation at 5 V: 95 mA (without load)
- Backup battery: 160 µA (rotating shaft)
- Backup battery: 16 µA (at standstill)

### Shaft
- Blind hollow shaft for axial clamping (Ø 12.7 mm)

### Mech. permiss. shaft speed
- ≤ 15 000 rpm
- ≤ 12 000 rpm

### Moment of inertia of measured rotor
- 2.6 · 10⁻⁶ kgm²

### Permissible axial motion of measured shaft
- ±0.5 mm

### Vibration
- 55 Hz to 2000 Hz
- Shock 0 ms

### Operating temperature
- –40 °C to 115 °C

### Trigger threshold
- of temperature exceedance
- Error message

### Protection
- IP 20 when mounted

### Mass
- 0.13 kg

### ID number
- 810661-xx
- 810662-xx
- 1230275-xx

---

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

For dimensions and specifications of encoders with functional safety, see the Product Information document.
ECI 1319, EQI 1331

Rotary encoders for absolute position values with safe singletum information

- Robust inductive scanning principle
- Mounting-compatible with photoelectric rotary encoders with a 07B stator coupling
- 0Va mounting flange
- Blind hollow shaft for axial clamping Ø 12.7 mm (44C) or Ø 12 mm (44A)
- Cost-optimized mating dimensions upon request

Required mating dimensions

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bearing of mating shaft</td>
</tr>
<tr>
<td>2</td>
<td>Measuring point for operating temperature</td>
</tr>
<tr>
<td>3</td>
<td>Measuring point for vibration (see D741714)</td>
</tr>
<tr>
<td>4</td>
<td>16-pin (12+4-pin) PCB connector</td>
</tr>
<tr>
<td>5</td>
<td>SW3 and SW4 screw plug</td>
</tr>
<tr>
<td>6</td>
<td>Screw: ISO 4762 – M4x10 – 8.8 – MKL SW4</td>
</tr>
<tr>
<td>7</td>
<td>Functional diameter of taper for ECN/EQN 13xx</td>
</tr>
<tr>
<td>8</td>
<td>Chamfer at start of thread is mandatory for material bonding anti-rotation lock</td>
</tr>
<tr>
<td>9</td>
<td>Exholsolve flange surface; ensure full-surface contact</td>
</tr>
<tr>
<td>10</td>
<td>Shaft surface; ensure full-surface contact</td>
</tr>
<tr>
<td>11</td>
<td>Mounting clearance between shaft surface and flange surface; compensation of mounting tolerances and thermal expansion</td>
</tr>
<tr>
<td>12</td>
<td>ECG/EG: dynamic motion permitted over entire range; ECN/EQN: no dynamic motion permitted</td>
</tr>
<tr>
<td>13</td>
<td>M10 back-off thread</td>
</tr>
<tr>
<td>14</td>
<td>Direction of shaft rotation for ascending position values</td>
</tr>
</tbody>
</table>

Absolute

<table>
<thead>
<tr>
<th>Description</th>
<th>ECI 1319 singletum EOI 1319 singletum</th>
<th>EQI 1331 multiturn EOI 1331 multiturn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>EnDat 3</td>
<td>EnDat 3</td>
</tr>
<tr>
<td>Ordering designation</td>
<td>E30-R2</td>
<td>E30-R2</td>
</tr>
<tr>
<td>Position values per revolution</td>
<td>524,288 (19 bits)</td>
<td>4096 (12 bits)</td>
</tr>
<tr>
<td>Revolutions</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>XEL time HP/Out data rate</td>
<td>≤ 11 μs at 12.5 Mbit/s</td>
<td>≤ 8.2 μs at 25 Mbit/s</td>
</tr>
<tr>
<td>Propagation time</td>
<td>14 μs (typical)</td>
<td>14 μs (typical)</td>
</tr>
<tr>
<td>System accuracy</td>
<td>±65°</td>
<td>±65°</td>
</tr>
<tr>
<td>Electrical connection</td>
<td>16-pin PCB connector (12+4; with separate connection option for external temperature sensor)</td>
<td></td>
</tr>
<tr>
<td>Cable length</td>
<td>At 12.5 Mbit/s: ≤ 100 m; at 25 Mbit/s: ≤ 40 m</td>
<td></td>
</tr>
<tr>
<td>Supply voltage</td>
<td>DC 4 V to 14 V (recommended: 12 V)</td>
<td></td>
</tr>
<tr>
<td>Power consumption (maximum)</td>
<td>4 V ≤ 0.85 W</td>
<td>4 V ≤ 0.9 W</td>
</tr>
<tr>
<td>Current consumption (typical)</td>
<td>14 V ≤ 0.9 W</td>
<td>14 V ≤ 1 W</td>
</tr>
<tr>
<td>Shaft speed</td>
<td>≤ 15 000 rpm</td>
<td>≤ 12 000 rpm</td>
</tr>
<tr>
<td>Moment of inertia of rotor</td>
<td>2.45 · 10^6 kNm&lt;sup&gt;2&lt;/sup&gt;</td>
<td>2.6 · 10&lt;sup&gt;6&lt;/sup&gt; kNm&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Angular acceleration of rotor</td>
<td>≤ 1 · 10&lt;sup&gt;5&lt;/sup&gt; rad/s&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Axial motion of measured shaft</td>
<td>≤ ±0.5 mm</td>
<td></td>
</tr>
<tr>
<td>Vibration (65 Hz to 2000 Hz)</td>
<td>Status: ≤ 400 m/s; rotor: ≤ 600 m/s[2]</td>
<td>Status: ≤ 2000 m/s (EN 60068-2-27)</td>
</tr>
<tr>
<td>Shock 0.5 ms</td>
<td>≤ 6 ms</td>
<td>≤ 400 m/s (EN 60068-2-6)</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>–40 °C to 115 °C</td>
<td></td>
</tr>
<tr>
<td>Trigger threshold of temperature exceedance error message</td>
<td>130 °C (measuring accuracy of the internal temperature sensor: ±1 K)</td>
<td></td>
</tr>
<tr>
<td>Relative humidity</td>
<td>≤ 93% 40 °C/21 d as per EN 60068-2-78; condensation excluded</td>
<td></td>
</tr>
<tr>
<td>Protection rating</td>
<td>EN 60529 IP20</td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>0.13 kg</td>
<td></td>
</tr>
<tr>
<td>ID number</td>
<td>44C shaft: 1286377-06; 44A shaft: 1286377-10</td>
<td>44C shaft: 1286378-01; 44A shaft: 1286378-06</td>
</tr>
</tbody>
</table>

1) See EnDat Application Notes
2) See General electrical information in the Interfaces of HEIDENHAIN Encoders brochure or at www.heidenhain.com
3) Evaluation optimized for the KTY 84-130 and PT 1000 (see Temperature measurement in motors)

For dimensions and specifications of encoders with functional safety, see the Product Information document.
ECI/EQI 1300 S series

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

Required mating dimensions

---

### Absolute

#### Interface
- DRIVE-CLIQ

#### Ordering designation
- D001

#### Position values per revolution
- 524,288 (19 bits)

#### Revolutions
- 4096 (12 bits)

#### Calculation time
- TIME_MAX_ACTVAL ≤ 12 µs

#### System accuracy
- ±65°

#### Electrical connection
- 16-pin with connection for temperature sensor

#### Cable length
- ≤ 40 m

#### Supply voltage
- DC 24 V (10 V to 28.8 V; up to DC 36 V possible without impairing the functional safety)

#### Power consumption
- (maximum)
  - 10 V: ≤ 1.1 W
  - 28.8 V: ≤ 1.25 W

#### Current consumption (typical)
- 24 V: 40 mA (without load)
- 24 V: 45 mA (without load)

#### Shaft
- Blind hollow shaft for axial clamping (Ø 12.7 mm)

#### Mech. permiss. shaft speed
- n ≤ 15,000 rpm

#### Moment of inertia of rotor
- 2.6 · 10⁻⁶ kgm²

#### Permissible axial motion of measured shaft
- ± 0.5 mm

#### Vibration
- 55 Hz to 2000 Hz
- Stator: ≤ 400 m/s²; rotor: ≤ 600 m/s² (EN 60068-2-6)
- ≤ 2000 m/s² (EN 60068-2-27)

#### Operating temperature
- -40 °C to 100 °C

#### Trigger threshold of temperature exceedance
- 120 °C (measuring accuracy of the internal temperature sensor: ±1 K)

#### Protection
- EN 600529
- IP20 when mounted

#### Mass
- ≤ 0.13 kg

#### ID number
- 1222049.xx 1222051.xx

---

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

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

DRIVE-CLIQ is a registered trademark of Siemens AG.
ECI/EBI 100 series

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

ECI 119

<table>
<thead>
<tr>
<th>Absolute</th>
<th>ECI 119</th>
<th>EBI 135</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface*</td>
<td>EnDat 2.1</td>
<td>EnDat 2.2</td>
</tr>
<tr>
<td>Ordering designation</td>
<td>EnDat01</td>
<td>EnDat22</td>
</tr>
<tr>
<td>Position values per revolution</td>
<td>524,288 (19 bits)</td>
<td>-</td>
</tr>
<tr>
<td>Revolutions</td>
<td>-</td>
<td>66,536 (16 bits)*</td>
</tr>
<tr>
<td>Electrically permitted shaft speed/ deviations</td>
<td>up to 3,000 rpm ±128 LSB</td>
<td>≤ 6,000 rpm (for continuous position value)</td>
</tr>
<tr>
<td>Calculation time tcalc</td>
<td>≤ 8 µs</td>
<td>≤ 6 µs</td>
</tr>
<tr>
<td>Clock frequency</td>
<td>≤ 2 MHz</td>
<td>-</td>
</tr>
<tr>
<td>Incremental signals</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Line count</td>
<td>52</td>
<td>-</td>
</tr>
<tr>
<td>Incremental frequency</td>
<td>-</td>
<td>≥ 6 kHz (typical)</td>
</tr>
<tr>
<td>System accuracy</td>
<td>±90°</td>
<td>-</td>
</tr>
</tbody>
</table>

Absolute

- Interface: EnDat 2.1, EnDat 2.2, EnDat 2.2
- Ordering designation: EnDat01, EnDat22
- Position values per revolution: 524,288 (19 bits)
- Revolutions: -
- Electrically permitted shaft speed: up to 3,000 rpm ±128 LSB
- Calculation time: tcalc ≤ 8 µs
- Clock frequency: ≤ 2 MHz
- Incremental signals: -
- Line count: 52
- Incremental frequency: ≥ 6 kHz (typical)
- System accuracy: ±90°

EBI 135

- Multiturn functionality via battery-buffered revolution counter
- Position values per revolution: 524,288 (19 bits)
- Revolutions: 66,536 (16 bits)
- Electrically permitted shaft speed: up to 3,000 rpm ±128 LSB
- Calculation time: tcalc ≤ 8 µs
- Clock frequency: ≤ 2 MHz
- Incremental signals: -
- Line count: 52
- Incremental frequency: ≥ 6 kHz (typical)
- System accuracy: ±90°

Electrical connection
- 15-pin connector
- 15-pin connector with connection for temperature sensor

Cable length
- ≤ 100 m

Supply voltage
- DC 3.6 V to 14 V
- Rotary encoder: DC 3.6 V to 14 V
- Backup battery: DC 3.6 V to 9.2 V

Power consumption (max.)
- 3.6 V: ≤ 0.38 W
- 14 V: ≤ 0.7 W
- Normal operation at 3.6 V: 0.53 W
- Normal operation at 14 V: 0.62 W

Current consumption (typical)
- 5 V: 80 mA (without load)
- 5 V: 75 mA (without load)
- Normal operation at 5 V:
  - Buffer mode: 75 mA (without load)
  - 12 µA (at standstill)

Shaft
- Hollow through shaft: Ø = 30 mm, 38 mm, 50 mm

Mechanical permitted shaft speed
- ≤ 6000 rpm

Moment of inertia of rotor
- Ø = 30 mm: 64 · 10⁻⁶ kgm²
- Ø = 38 mm: 59 · 10⁻⁶ kgm²
- Ø = 50 mm: 64 · 10⁻⁶ kgm²

Permissible axial motion of measured shaft
- ±0.3 mm

Vibration
- 55 Hz to 2000 Hz
- ≤ 300 m/s² (EN 60068-2-6)
- ≤ 1000 m/s² (EN 60068-2-27)

Shock
- 5 ms
- ≤ 6 ms
- 300 m/s² (EN 60068-2-6)
- 1000 m/s² (EN 60068-2-27)

Operating temperature
- -30 °C to 115 °C

Protection
- EN 60529
- IP20 when mounted

Mass
- Ø = 30 mm: 0.19 kg
- Ø = 38 mm: 0.16 kg
- Ø = 50 mm: 0.14 kg

ID number
- 823406-xx
- 823407-xx
- 823405-xx

* Please select when ordering
1) Valuation numbers are not supported
2) Compliance with EnDat Specification 297403 and the EnDat Application Notes 722024, Chapter 13, Battery-buffered encoders, is required for correct control of the encoder
3) Speed-dependent deviations between absolute and incremental signals
4) Evaluation optimized for the KTY 84-130 (see Temperature measurement in motors)
5) At T = 25 °C, UBAT = 3.6 V
6) See Electromagnetic compatibility under General electrical information in the Interfaces of HEIDENHAIN Encoders brochure.
Rotary encoders for absolute position values

- Robust inductive scanning principle
- Hollow through shaft (90 mm)
- EBI 4010: multiturn functionality through battery-buffered revolution counter
- Consists of a scanning unit and scale drum

### Specifications

<table>
<thead>
<tr>
<th>ECI 4010 singleturn</th>
<th>EBI 4010 multiturn</th>
<th>ECI 4090 S singleturn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface/ordering designation</td>
<td>EnDat 2.2 / EnDat22</td>
<td>DRIVE-CLiQ / DQ01</td>
</tr>
<tr>
<td>Position values per revolution</td>
<td>1048576 (20 bits)</td>
<td>05038 (16 bits)</td>
</tr>
<tr>
<td>Revolutions</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Calculation time ( t_{\text{cal}} ) ( \Delta f ) clock frequency</td>
<td>( \leq 5 \mu s/16 \text{ MHz} )</td>
<td>( \leq 11 \mu s )</td>
</tr>
<tr>
<td>System accuracy</td>
<td>( \pm 25^\circ )</td>
<td>( \pm 40 \text{ m})</td>
</tr>
<tr>
<td>Electrical connection</td>
<td>15-pin with connection for temperature sensor (^2)</td>
<td>( \leq 6000 \text{ rpm} )</td>
</tr>
<tr>
<td>Cable length</td>
<td>( \leq 100 \text{ m} )</td>
<td>( \leq 2000 \text{ m} ) (^3)</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>DC 3.6 V to 14 V</td>
<td>DC 24 V (10 V to 28.8 V); up to 38 V possible without impairing the functional safety</td>
</tr>
<tr>
<td>Power consumption (^7) (maximum)</td>
<td>3.6 V: 0.83 W; 14 V: 0.7 W</td>
<td>10 V: 0.11 W; 28.8 V: 0.129 W</td>
</tr>
<tr>
<td>Current consumption (typical)</td>
<td>DC 5 V: 96 mA (without load)</td>
<td>Normal operation at 5 V: 95 mA (without load); Buffer mode (^5): 220 ( \mu \text{A} ) (rotating shaft); 26 ( \mu \text{A} ) (shaft at standstill)</td>
</tr>
<tr>
<td>Shaft</td>
<td>Hollow through shaft (90 mm)</td>
<td>( \leq 6000 \text{ rpm} )</td>
</tr>
<tr>
<td>Shaft speed</td>
<td>( \leq 6000 \text{ rpm} )</td>
<td></td>
</tr>
<tr>
<td>Moment of inertia of rotor</td>
<td>4.26 ( \times 10^{-4} \text{ kgm}^2 ) (without screws)</td>
<td>( \leq 2 \times 10^{-4} \text{ rad}^2 )</td>
</tr>
<tr>
<td>Angular acceleration of rotor</td>
<td>( \leq 2 \times 10^4 \text{ rad/s}^2 )</td>
<td></td>
</tr>
<tr>
<td>Axial motion of measured shaft</td>
<td>( \leq \pm 1.5 \text{ mm} )</td>
<td></td>
</tr>
<tr>
<td>Vibration</td>
<td>55 Hz to 2000 Hz</td>
<td>AE scanning unit: ( \leq 400 \text{ m/s}^2 ); TTR scale drum: ( \leq 600 \text{ m/s}^2 ) (EN 60068-2-6)</td>
</tr>
<tr>
<td>Shock</td>
<td>( \leq 2000 \text{ m/s}^2 ) (EN 60068-2-27)</td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>(-40^\circ \text{C} \text{ to } 115^\circ \text{C} ) (at the measuring point and on the entire scale drum)</td>
<td>(-40^\circ \text{C} \text{ to } 100^\circ \text{C} ) (at the measuring point and on the entire scale drum)</td>
</tr>
<tr>
<td>Trigger threshold for exceeded temperature error message</td>
<td>120 ( ^\circ \text{C} ) (measuring accuracy of the internal temperature sensor: ( \pm 1 \text{ K} ))</td>
<td>120 ( ^\circ \text{C} ) (measuring accuracy of the internal temperature sensor: ( \pm 1 \text{ K} ))</td>
</tr>
<tr>
<td>Protection</td>
<td>EN 600529</td>
<td>Complete encoder; mounted: IP20(^6); scanning unit: IP40 (read about insulation under Electrical safety in the Interfaces of HEIDENHAIN Encoders brochure)</td>
</tr>
<tr>
<td>Mass</td>
<td>AE scanning unit: ( \leq 0.22 \text{ kg} ); TTR scale drum: ( \leq 0.17 \text{ kg} )</td>
<td></td>
</tr>
<tr>
<td>ID number</td>
<td>AE ECI4010 scanning unit: ID 1130167-xx</td>
<td>AE EBI4010 scanning unit: ID 1130173-xx</td>
</tr>
<tr>
<td></td>
<td>TTR EXI4000 scale drum: ID 1130175-xx</td>
<td></td>
</tr>
</tbody>
</table>

---

**Notes:**

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

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

DRIVE-CLiQ is a registered trademark of Siemens AG.
**ECI 4010, EBI 4010, ECI 4090 S**

Rotary encoders for absolute position values
- Robust inductive scanning principle
- Hollow through shaft (Ø 180 mm)
- EBI 4010 multiturn functionality through battery-buffered revolution counter
- Consists of a scanning unit and scale drum

<table>
<thead>
<tr>
<th>Specifications</th>
<th>ECI 4010 singleturn</th>
<th>EBI 4010 multiturn</th>
<th>ECI 4090S singleturn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface/ordering designation</td>
<td>EnDat 2.2 / EnDat22</td>
<td>DRIVE-CLiQ / DO21</td>
<td></td>
</tr>
<tr>
<td>Position values per revolution</td>
<td>0348576 (20 bits)</td>
<td>051236 (16 bits)</td>
<td>–</td>
</tr>
<tr>
<td>Revolutions</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Calculation time ( t_{CAL} )</td>
<td>( \geq 5 \mu s / 16 \text{ MHz} )</td>
<td>( \leq 11 \mu s )^7</td>
<td></td>
</tr>
<tr>
<td>System accuracy</td>
<td>( \pm 40&quot; )</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Electrical connection</td>
<td>15-pin with connection for temperature sensor(^2)</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Cable length</td>
<td>( \leq 100 \text{ m} )</td>
<td>( \leq 6 \text{ m} )^6</td>
<td></td>
</tr>
<tr>
<td>Supply voltage</td>
<td>DC 3.6 V to 14 V</td>
<td>Rotary encoder ( U_{U} ): DC 3.6 V to 14 V, Buffer battery ( U_{UB} ): DC 3.6 V to 5.25 V</td>
<td>DC 24 V (10 V to 28.8 V); up to 38 V possible without impairing the functional safety</td>
</tr>
<tr>
<td>Power consumption(^2) (maximum)</td>
<td>3.6 V: ( \leq 0.83 \text{ W} ), 14 V: ( \leq 0.7 \text{ W} )</td>
<td>10 V: ( \leq 1.1 \text{ W} ), 28.8 V: ( \leq 1.29 \text{ W} )</td>
<td></td>
</tr>
<tr>
<td>Current consumption (typical)</td>
<td>5 V: 95 mA (without load), Normal operation at 5 V: 95 mA (without load), Buffer model(^6): 220 ( \mu A ) (rotating shaft), 26 ( \mu A ) (at standstill)</td>
<td>24 ( \mu A ) (without load)</td>
<td></td>
</tr>
<tr>
<td>Shaft</td>
<td>Hollow through shaft (Ø 180 mm with keyway)</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Shaft speed</td>
<td>( \leq 6000 \text{ rpm} )</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Moment of inertia of rotor</td>
<td>( 3.1 \times 10^{-3} \text{ kgm}^2 ) (without screws, without key)</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Angular acceleration of rotor</td>
<td>( \leq 2 \times 10^4 \text{ rad/s}^2 )</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Axial motion of measured shaft</td>
<td>( \leq 1.5 \text{ mm} )</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Vibration 66 Hz to 2000 Hz</td>
<td>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)</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Shock 0 ms</td>
<td>AE scanning unit: ( \leq 400 \text{ m/s}^2 ) (at the measuring point and on the entire scale drum)</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>( -40^\circ \text{ C to } 115^\circ \text{ C} ) (at the measuring point and on the entire scale drum)</td>
<td>( -40^\circ \text{ C to } 100^\circ \text{ C} ) (at the measuring point and on the entire scale drum)</td>
<td></td>
</tr>
<tr>
<td>Trigger threshold for exceeded temperature error message</td>
<td>130 ( ^\circ \text{ C} ) (measuring accuracy of the internal temperature sensor ( \pm 1 \text{ K} ))</td>
<td>120 ( ^\circ \text{ C} ) (measuring accuracy of the internal temperature sensor ( \pm 1 \text{ K} ))</td>
<td></td>
</tr>
<tr>
<td>Protection EN 60529</td>
<td>Complete encoder; mounted: IP20(^6), scanning unit: IP40 (read about insulation under \text{Electrical safety in the Interfaces of HEIDENHAIN Encoders brochure})</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>AE scanning unit: ( \leq 0.39 \text{ kg} ), TTR scale drum: ( \leq 0.33 \text{ kg} )</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>ID number</td>
<td>AE ECI4010 scanning unit: ID 1007526-xx</td>
<td>AE EBI4010 scanning unit: ID 1007530-xx</td>
<td>AE ECI4090S scanning unit: ID 1087527-xx</td>
</tr>
<tr>
<td>TTR ECI4000 scale drum: ID 1110636-xx</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( \mu s \): Microsecond

\(^1\) Calculation time \( \text{TIME}_\text{MAX, ACTUAL} \)
\(^2\) Evaluation optimized for the KTY 84-130, with DO21 also for the PT 1000 (see Temperature measurement in motors)
\(^3\) At an output cable length (inside motor) \( \leq 1 \text{ m} \)
\(^4\) See General electrical information in the Interfaces of HEIDENHAIN Encoders brochure
\(^5\) At \( T = 25^\circ \text{ C}, U_{UB} = 3.6 \text{ V} \)
\(^6\) The encoder must be protected from abrasive and harmful media in the application; use an appropriate enclosure as needed.

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

DRIVE-CLiQ is a registered trademark of Siemens AG.
ERO 1200 series

Incremental rotary encoders

- Flange for axial mounting
- Hollow through shaft
- Without integral bearing

<table>
<thead>
<tr>
<th>Incremental</th>
<th>ERO 1225</th>
<th>ERO 1285</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>TTL, TTL</td>
<td></td>
</tr>
<tr>
<td>Line count*</td>
<td>1024</td>
<td>2048</td>
</tr>
<tr>
<td>Accuracy of graduation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference mark</td>
<td>One</td>
<td></td>
</tr>
<tr>
<td>Output frequency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cutoff frequency –3 dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edge separation a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System accuracy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spacing between signals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System accuracy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Electrical connection

12-pin

Supply voltage

DC 5 V ±0.5 V

Current consumption (without load)

≤ 150 mA

Shaft

- Hollow through shaft Ø = 10 mm or Ø = 12 mm

Moment of inertia of rotor

- Shaft Ø 10 mm: 2.2 · 10⁻⁶ kgm²
- Shaft Ø 12 mm: 2.2 · 10⁻⁶ kgm²

Mech. permiss. shaft speed

≤ 25 000 rpm

Permissible axial motion of measured shaft

- 1024 lines: ±0.2 mm
- 2048 lines: ±0.05 mm

Vibration 55 Hz to 2000 Hz

≤ 100 m/s² (EN 60068-2-6)

Shock 6 ms

≤ 1000 m/s² (EN 60068-2-27)

Operating temperature

-40 °C to 100 °C

Protection EN 60529

IP00

Mass

= 0.07 kg

ID number

1037521-xx (scanning unit)
332378-xx (disk/hub assembly)
1037522-xx (scanning unit)
332378-xx (disk/hub assembly)

* Please select when ordering

1) When not mounted; additional deviations due to mounting and bearing of the measured shaft are not taken into account

2) For other errors, see Measuring accuracy

---

mm

Tolerancing ISO 1015
R0.7/R1.99=R1.99
≤ 6 mm: ±0.2 mm

= Bearing of mating shaft

= Required mating dimensions

M = Measuring point for operating temperature

1 = Disk/hub assembly

2 = Offset screwdriver: ISO 2936 – 2.5 (l shortened)

3 = Direction of shaft rotation for output signals as per the interface description
ERO 1400 series

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

<table>
<thead>
<tr>
<th>Increments</th>
<th>ERO 1420</th>
<th>ERO 1470</th>
<th>ERO 1480</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>TTL</td>
<td>SN5</td>
<td>3.3 V</td>
</tr>
<tr>
<td>Line count</td>
<td>1024</td>
<td>2048</td>
<td>4096</td>
</tr>
<tr>
<td>Integrated interpolation</td>
<td>5-fold</td>
<td>10-fold</td>
<td>20-fold</td>
</tr>
<tr>
<td>Signal periods per revolution</td>
<td>512</td>
<td>1000</td>
<td>1500</td>
</tr>
<tr>
<td>Frequency</td>
<td>≤ 300 kHz</td>
<td>≤ 100 kHz</td>
<td>≤ 62.5 kHz</td>
</tr>
<tr>
<td>Edge separation</td>
<td>≥ 0.39 μs</td>
<td>≥ 0.47 μs</td>
<td>≥ 0.22 μs</td>
</tr>
<tr>
<td>Scanning frequency</td>
<td>≤ 300 kHz</td>
<td>≤ 100 kHz</td>
<td>≤ 62.5 kHz</td>
</tr>
<tr>
<td>Cutoff frequency</td>
<td>300 kHz</td>
<td>100 kHz</td>
<td>62.5 kHz</td>
</tr>
<tr>
<td>Interface</td>
<td>ERO 1420</td>
<td>ERO 1470</td>
<td>ERO 1480</td>
</tr>
<tr>
<td>System accuracy</td>
<td>1 line: ±1.99°</td>
<td>1000 lines: ±1.12°</td>
<td>1000 lines: ±1.14°</td>
</tr>
<tr>
<td>Shaft</td>
<td>Blank hollow shaft</td>
<td>Ø 4 mm, Ø 6 mm or Ø 8 mm, or hollow through shaft in housing with bore (accessory)</td>
<td></td>
</tr>
<tr>
<td>Moment of inertia</td>
<td>Shaft Ø 4 mm: 0.28 · 10⁻⁶ kgm²</td>
<td>Shaft Ø 6 mm: 0.27 · 10⁻⁶ kgm²</td>
<td>Shaft Ø 8 mm: 0.25 · 10⁻⁶ kgm²</td>
</tr>
<tr>
<td>Mech. permiss. shaft speed</td>
<td>30 000 rpm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permissible axial motion of measured shaft</td>
<td>± 0.1 mm</td>
<td>± 0.05 mm</td>
<td></td>
</tr>
<tr>
<td>Vibration</td>
<td>55 Hz to 2000 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shock</td>
<td>0 ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>–10 °C to 70 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protection</td>
<td>EN 60669</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With PCB connector: IP00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With cable outlet: IP40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>0.07 kg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| ID number | 360731-xx | 360736-xx | 360737-xx |

Bold: This preferred version is available on short notice
* Please select when ordering
1) When not mounted; additional deviations due to mounting and bearing of the measured shaft are not taken into account
2) Upon request, cable (1 m), radial, free cable end (not for ERO 1470)
Interfaces

HEIDENHAIN encoders with the \( \sim 1 \text{ V}_{\text{PP}} \) interface provide voltage signals that are highly interpolatable.

The sinusoidal incremental signals A and B are phase-shifted by 90° elec. and have a typical amplitude of 1 Vpp. The illustrated sequence of output signals—with B lagging A—applies to the direction of motion shown in the dimension drawing. The reference mark signal R has a unique assignment to the incremental signals. The output signal may be lower next to the reference mark.

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

Pin layout

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

<table>
<thead>
<tr>
<th>Power supply</th>
<th>Incremental signals</th>
<th>Other signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 2 10 11 5 6 8 1 3 4 9 7</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>4 12 2 10 9 3 11 14 7</td>
<td>5/6/8/15</td>
<td>13</td>
</tr>
</tbody>
</table>

12 1a 1b 6b 6a 5b 5a 4b 4a 3b 3a |

U_p Sensor_0 V | / | |

Brown/Green Blue/White White Brown Green Gray Pink Red Black | | |

Output cable for ERN 1381 inside the motor housing ID 667343.01

12-pin M23 flange socket
12-pin PCB connector

<table>
<thead>
<tr>
<th>Power supply</th>
<th>Incremental signals</th>
<th>Other signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 7 10 4 15 16 12 13 3 2 5 6</td>
<td>8/9 11/14/17</td>
<td></td>
</tr>
<tr>
<td>2a 2b 1a 1b 6b 6a 5b 5a 4b 4a</td>
<td>/</td>
<td></td>
</tr>
</tbody>
</table>

U_p Sensor_0 V | / | |

Brown/Green Blue/White White Brown Green Gray Pink Red Black | | |

Cable shield connecting with housing: \( U_p = \) Power supply voltage
Sensor: The sense line is connected in the encoder with the corresponding power line. Vacant pins or wires must not be used!
1) ERO 14xx: vacant
2) Exposed linear encoders: conversion from TTL to 11 \( \mu \text{A}_{\text{PP}} \) for the PWT, otherwise not assigned

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

1 V_{PP} incremental signals

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

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

The fault detection signal \( U_{\phi} \) indicates malfunctions such as an interruption in the supply lines, failure of the light source, etc.

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

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

TTL incremental signals
### Pin layout for ERN 1023

<table>
<thead>
<tr>
<th>Power supply</th>
<th>Incremental signals</th>
<th>Other signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>2a</td>
<td>2b</td>
</tr>
</tbody>
</table>

- **Sensor U_P**: The sense line is connected in the encoder with the corresponding power line.
- **Vacant pins or wires must not be used!**

### Pin layout for ERN 1123, ERN 1326

<table>
<thead>
<tr>
<th>Power supply</th>
<th>Incremental signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>1b</td>
</tr>
</tbody>
</table>

- **Sensor U_P**: The sense line is connected in the encoder with the corresponding power line.
- **Vacant pins or wires must not be used!**

### Commutation signals for block commutation

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

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

---

Further information:

Detailed descriptions of all available interfaces, as well as general electrical information, can be found in the Interfaces of HEIDENHAIN Encoders brochure.
Commutation signals for sine commutation

The commutation signals C and D are obtained from the Z1 track and are equal to one sine or cosine period per revolution. They have a signal amplitude of 1 Vpp (typical) at 1 kΩ.

The input circuit of the downstream electronics is equivalent to the downstream electronics. However, the required terminating resistance Z0 is 1 kΩ instead of 120 Ω.

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

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

Pin layout

17-pin M23 coupling or flange socket

<table>
<thead>
<tr>
<th>Power supply</th>
<th>Incremental signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>1b</td>
<td>7a</td>
</tr>
</tbody>
</table>

Up Sensor Up
0 V Sensor 0 V
Internal shield A+ A- B+ B- Re+ Re- R- R-

Brown/ 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 | / | /

Cable shield connected to housing:
Up = Voltage supply; T = Temperature
Sensor: The sense line is connected internally to the respective power line. Vacant pins or wires must not be used!

1) Connections for an external temperature sensor (only for output cables inside the motor, see Temperature measurement in motors); if used, please refer to the information about electromagnetic compatibility in the General electrical information section of the Interfaces of HEIDENHAIN Encoders brochure.

Position values EnDat 2.2

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

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

Pin layout for EnDat01/EnDat02

17-pin M23 coupling or flange socket

<table>
<thead>
<tr>
<th>Power supply</th>
<th>Incremental signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>1b</td>
<td>6a</td>
</tr>
</tbody>
</table>

Upp Sensor Up
0 V Sensor 0 V
Internal shield A+ A- B+ B- DATA DATA

Brown/ Green Blue White/ Green White / Green/ Black Yellow/ Black Blue/ Black Red/ Black Red/ Black Grey Pink Violet Yellow

Other signals

| 5 | 6 |
| 12 | / |
| 15 | / |

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

1) Only with the ordering designations EnDat 01 and EnDat 02
2) Connections for an external temperature sensor (only for output cables inside the motor, see Temperature measurement in motors); if used, please refer to the information about electromagnetic compatibility in the General electrical information section of the Interfaces of HEIDENHAIN Encoders brochure.
EnDat22 pin layout

8-pin M12 coupling or flange socket

9-pin M23 SpeedTEC angle flange socket

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

16-pin PCB connector

<table>
<thead>
<tr>
<th>Power supply</th>
<th>Serial data transmission</th>
<th>Other signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>M12</td>
<td>8 2 5 1</td>
<td>3 4 7 6 / /</td>
</tr>
<tr>
<td>M23</td>
<td>3 7 4 8</td>
<td>5 6 1 2 / /</td>
</tr>
<tr>
<td>16</td>
<td>1b 6a 4b 3a 6b 1a 2b 5a 1a 1b</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>13 11 14 12</td>
<td>7 8 9 10 5 6</td>
</tr>
</tbody>
</table>

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

U<sub>p</sub> = Power supply; T = Temperature

Cable shield connected with housing; U<sub>p</sub> = Power supply; U<sub>BAT</sub> = External buffer battery (false polarity can result in damage to the encoder)

Vacant pins or wires must not be used!

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

Pin layout for EBI 135/EBI 1135/EBI 4010

15-pin PCB connector

8-pin M12 flange socket

9-pin M23 SpeedTEC angle flange socket

<table>
<thead>
<tr>
<th>Power supply</th>
<th>Serial data transmission</th>
<th>Other signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>M12</td>
<td>8 2 5 1</td>
<td>3 4 7 6 / /</td>
</tr>
<tr>
<td>M23</td>
<td>3 7 4 8</td>
<td>5 6 1 2 / /</td>
</tr>
<tr>
<td>15</td>
<td>13 11 14 12</td>
<td>7 8 9 10 5 6</td>
</tr>
</tbody>
</table>

U<sub>p</sub>, U<sub>BAT</sub> = Supply voltage

HMC 6 flange socket

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

15-pin PCB connector

<table>
<thead>
<tr>
<th>Encoder</th>
<th>Power supply</th>
<th>Serial data transmission</th>
<th>Other signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 1 2</td>
<td>/ /</td>
<td>/ /</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Motor</th>
<th>Brake</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 8 6 5 4 3 2 1</td>
<td>A B C D E</td>
<td></td>
</tr>
</tbody>
</table>

BRAKE– = Brake; BRAKE+ = Brake

Motor

Cable shield connected with housing; U<sub>p</sub> = Power supply; U<sub>BAT</sub> = External buffer battery (false polarity can result in damage to the encoder)

Vacant pins or wires must not be used!

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

Motor

HMC 6 is not suited for encoders with buffer battery backup (EBI 135, EBI 1335, EBI 1135, EBI 4010)

Connections for an external temperature sensor (except ECI 1118, see Temperature measurement in motors); if used, please refer to the information about electromagnetic compatibility in the General electrical information section of the Interfaces of HEIDENHAIN Encoders brochure.
EnDat 3 combines the features and benefits of EnDat in a new architecture and offers interesting enhanced functions for digital production. EnDat 3 requires two wires for communication. Two other wires are generally used with EnDat 3 for supplying power to the encoder. Since the digital data current has no DC component, it is possible to modulate the communication on the supply wires, and so to reduce the number of wires for certain applications (e.g., hybrid motor cables) to a total of just two wires (HMC 2). The EnDat 3 interface specification is based on the standardized OSI layer model.

The encoder end of the interface is called the slave, and the downstream electronics the master. A communication cycle consists of a request from the master followed by a response from the slave.

Further information:
Find out more about EnDat at www.endat.de

Ordering designations
The ordering designation defines key communication characteristics:

<table>
<thead>
<tr>
<th>Supported communication types</th>
<th>E30-R2</th>
<th>E30-R4</th>
<th>E30-RB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication modulated onto power supply wires</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication + separate power supply wires (4 wires)</td>
<td>–</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Bus operation</td>
<td>–</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>Sensor box integration</td>
<td>–</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Pin layout of ECI, EQI 11xx

<table>
<thead>
<tr>
<th>Encoder</th>
<th>Power supply / Serial data transfer</th>
<th>Other signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>M12</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>15</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>12</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>P_SD+</td>
<td>T+</td>
</tr>
<tr>
<td></td>
<td>P_SD–</td>
<td>T–</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brake</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>D</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>Power</td>
</tr>
<tr>
<td>U</td>
</tr>
<tr>
<td>V</td>
</tr>
<tr>
<td>W</td>
</tr>
<tr>
<td>PE</td>
</tr>
</tbody>
</table>

1 Power supply and data: P_SD+ includes U; P_SD– includes 0V
2 Connections for an external temperature sensor; evaluation optimized for KTY 94-130, PT 1000 and others (see Temperature measurement in motors); if used, please refer to the information about electromagnetic compatibility in the General electrical information section of the Interfaces of HEIDENHAIN Encoders brochure.

Vacant pins or wires must not be used!

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.
HEIDENHAIN encoders with the code letter S after the model designation are suitable for connection to Siemens controls with the DRIVE-CLiQ interface

- Ordering designation: DQ01

DRIVE-CLiQ is a registered trademark of Siemens AG.

Siemens pin layout for encoder cables (AGK)

<table>
<thead>
<tr>
<th>Encoder</th>
<th>Power supply</th>
<th>Serial data transmission</th>
<th>Other signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>M23</td>
<td>A</td>
<td>B</td>
<td>/</td>
</tr>
<tr>
<td>12</td>
<td>2b</td>
<td>5a</td>
<td>/</td>
</tr>
<tr>
<td>4</td>
<td>/</td>
<td>1a</td>
<td>1b</td>
</tr>
<tr>
<td>P_SD+</td>
<td>P_SD–</td>
<td>T+</td>
<td>T–</td>
</tr>
<tr>
<td></td>
<td>Violet</td>
<td>Yellow</td>
<td>Brown</td>
</tr>
</tbody>
</table>

Vacant pins or wires must not be used!

Cable shield connected to housing: Uـ = Power supply voltage Vacant pins or wires must not be used!

Output cables with a cable length > 0.5 m require strain relief for the cable

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

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

<table>
<thead>
<tr>
<th>RJ45 connector</th>
<th>8-pin M12 connector</th>
<th>8-pin M12 coupling</th>
<th>9-pin M23 SpeedTEC connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>Serial data transmission</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RJ45</td>
<td>A</td>
<td>B</td>
<td>3</td>
</tr>
<tr>
<td>M12</td>
<td>1</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>M23</td>
<td>8</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>U~/0V</td>
<td>RXP</td>
<td>TXP</td>
<td>TXN</td>
</tr>
<tr>
<td>Red</td>
<td>Black</td>
<td>Green</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

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

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

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

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

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<th>8-pin M12 connector</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>Serial data transmission</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RJ45</td>
<td>A</td>
<td>B</td>
<td>3</td>
</tr>
<tr>
<td>M12</td>
<td>1</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>M23</td>
<td>8</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>U~/0V</td>
<td>RXP</td>
<td>TXP</td>
<td>TXN</td>
</tr>
<tr>
<td>Red</td>
<td>Black</td>
<td>Green</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

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

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

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

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

<table>
<thead>
<tr>
<th>RJ45 connector</th>
<th>8-pin M12 connector</th>
<th>8-pin M12 coupling</th>
<th>9-pin M23 SpeedTEC connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>Serial data transmission</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RJ45</td>
<td>A</td>
<td>B</td>
<td>3</td>
</tr>
<tr>
<td>M12</td>
<td>1</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>M23</td>
<td>8</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>U~/0V</td>
<td>RXP</td>
<td>TXP</td>
<td>TXN</td>
</tr>
<tr>
<td>Red</td>
<td>Black</td>
<td>Green</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

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

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

Further information:
For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the Interfaces of HEIDENHAIN Encoders brochure.
The multiturn functionality of the EBI 1135, EBI 1335, EBI 135 and EBI 4000 is implemented by means of a revolution counter. In order for the absolute position information to still be available after loss of power, the EBI must be operated with an external backup battery. A lithium thionyl chloride battery with 3.6 V and 1200 mAh is recommended for the backup battery. The typical battery service life is over nine years (EBI 1135/135) or six years (EBI 4010, EBI 1335) under the right conditions (two ten-hour shifts under normal operation, battery temperature of 25 °C and typical self-discharging). To reach the typical service life, the main power supply (UP) must be connected to the encoder during or immediately after connection of the backup battery so that the encoder is fully initialized after being completely without power. Otherwise, the encoder will consume a significantly higher amount of battery current until main power is first supplied.

To prevent damage to the encoder, ensure correct polarity of the backup battery. HEIDENHAIN recommends operating each encoder with its own backup battery. If the application requires compliance with DIN EN 60 086-4 or UL 1642, then an appropriate protective circuit is required for protection from wiring errors.

If the backup battery voltage falls below certain thresholds, then the encoder issues the following warnings or error messages, which are transmitted over the EnDat interface:

- “Battery charge” warning ≤ 2.9 V ±0.2 V in normal operating mode
- “M Power interruption” error message ≤ 2.2 V ±0.2 V in battery-buffered mode (encoder must be re-referenced)

Low battery current continues to flow even during normal operation of the EBI. The amount of current depends on the operating temperature.

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

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

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

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

Output cables: EnDat (EnDat22)

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

Output cables: EnDat (EnDat01)

* SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

1) EPG cable
2) TPE single wires in heat-shrink tubing or braided sleeve (without shield)
3) The TNC does not support any buffer battery backup multifunctions
4) Wires for temperature sensors: 2 TPE single wires in heat-shrink tubing
5) Not for EBI
**Output cables: HMC 2 (E30-R2)**

HMC 2 output cables and power cables with encoder communication

- ECI 1119 (JAE)
- EQI 1131 (JAE)
- ECI 1319 (FCI)
- EQI 1331 (FCI)
- ECN 1325 (FCI)
- EQN 1337 (FCI)

- 1279930-15
- 1302347-xx
- 1302701-30
- 1302763-30
- 1302701-30

- M12
- M23

Further information:
See the HMC 2 Product Information document.

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

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

**Output cables: HMC 6 (EnDat22)**

HMC 6 output cables and power cables with encoder communication

- ECI 1123 (JAE)
- EQI 1135 (JAE)
- ECI 119 (JAE)
- EQI/EQI 11xx (JAE)
- ECI 1319 (FCI)
- EQI 1331 (FCI)
- ECN 1325 (FCI)
- EQN 1337 (FCI)

- 1035967-15
- 1034953-15
- 1072652-02
- 1035387-03
- 1034913-03

- M23

Further information:
For more information about HMC 6, please refer to the HMC 6 Product Information document.

\* SpeedTEC hybrid flange socket is not included in delivery.

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

SpeedTEC is a registered trademark of TE Connectivity Industrial GmbH.

**Output cables: DRIVE-CLiQ**

DRIVE-CLiQ is a registered trademark of Siemens Aktiengesellschaft.

Further information:
See the HMC 2 Product Information document.

- ECI 13245 (FCI)
- EQN 13365 (FCI)
- ECI 40905 (JAE)
- EQI 40905 (JAE)

- 1215636-xx
- 125403-xx
- 125408-xx
- 1160559-01

Further information:
For more information about HMC 6, please refer to the HMC 6 Product Information document.

- ECI 4090S (JAE)
- EQI 4090S (JAE)

- 1217403-xx
- 1181373-xx
- 1160559-01

Further information:
For more information about HMC 6, please refer to the HMC 6 Product Information document.

- ECI 4090S (JAE)
- EQI 4090S (JAE)

- 1121546-xx
- 1121536-xx
- 1125403-N3

Further information:
For more information about HMC 6, please refer to the HMC 6 Product Information document.

- ECI 4090S (JAE)
- EQI 4090S (JAE)

- 1160559-01

Further information:
For more information about HMC 6, please refer to the HMC 6 Product Information document.

- ECI 4090S (JAE)
- EQI 4090S (JAE)

- 1125403-N3

Further information:
For more information about HMC 6, please refer to the HMC 6 Product Information document.

- ECI 4090S (JAE)
- EQI 4090S (JAE)

- 1125403-N3

Further information:
For more information about HMC 6, please refer to the HMC 6 Product Information document.
Output cables: 1 V_pp or TTL

17-pin M23

ERP 880 (Hirose)
ERN 1321 (FCI)
ERN 1381 (FCI)
ERN 1326 (FCI)
ERN 1387 (FCI)
ER 12x6 (Hirose)
ERP B66 (Hirose)
MIR 2080

Testing cables to PWM 21

ERN 1387

15-pin PWM 21

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

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

Incremental encoders have 1 V_pp, TTL, or HTL interfaces. TTL and HTL encoders monitor their signal amplitudes internally and generate a simple fault detection signal. With 1 V_pp signals, an analysis of the output signals is possible only with external testing devices or through the use of computation resources in the downstream electronics (analog diagnostic interface).

Absolute encoders use serial data transmission. Depending on the interface, additional 1 V_pp incremental signals can be output. The signals are extensively monitored within the encoder. The monitoring results (particularly valuation numbers) can be transmitted to the downstream electronics along with the position values via the serial interface (digital diagnostic interface). The following information is available:

- Error message: position value is not reliable
- Warning: an internal functional limit of the encoder has been reached
- Valuation numbers:
  - Detailed information on the encoder’s function reserve
  - Identical scaling for all HEIDENHAIN encoders
  - Cyclic reading is possible

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

For the analysis of these encoders, HEIDENHAIN offers the appropriate PWM inspection devices and PWT testing devices. Based on how these devices are integrated, a distinction is made between two types of diagnostics:

- Encoder diagnostics: the encoder is connected directly to the testing or inspection device, thereby enabling a detailed analysis of encoder functions.
- Monitoring mode: the PWM inspection device is interposed within the closed control loop (via suitable testing adapters as needed). This enables real-time diagnosis of the machine or equipment during operation. The available functions depend on the interface.
### PWT 101
The PWT 101 is a testing device for the functional testing and adjustment of incremental and absolute HEIDENHAIN encoders. Thanks to its compact dimensions and rugged design, the PWT 101 is ideal for portable use.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoder input</td>
<td>only for HEIDENHAIN encoders, including: EnDat, Fanuc Serial Interface, Mitsubishi high speed interface, Panasonic Serial Interface, and Yaskawa Serial Interface.</td>
</tr>
<tr>
<td>Display</td>
<td>4.3-inch color flat-panel display (touchscreen)</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>DC 24 V</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>0 °C to 40 °C</td>
</tr>
<tr>
<td>Protection EN 60529</td>
<td>IP20</td>
</tr>
<tr>
<td>Dimensions</td>
<td>145 mm × 85 mm × 35 mm</td>
</tr>
</tbody>
</table>

### PWM 21
The PWM 21 phase angle measuring unit, in conjunction with the included ATS adjustment and testing software, provides an adjustment and testing package for the diagnosis and adjustment of HEIDENHAIN encoders.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoder input</td>
<td>EnDat 2.1, EnDat 2.2 or EnDat 3 (absolute value with or without incremental signals), DRIVE-CLiQ, Fanuc Serial Interface, Mitsubishi high speed interface, Yaskawa Serial Interface, Panasonic serial interface, SSI, 1 Vpp/TTL/11 µA, or HTL (via signal adapter).</td>
</tr>
<tr>
<td>Interface</td>
<td>USB 2.0</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>AC 100 V to 240 V or DC 24 V</td>
</tr>
<tr>
<td>Dimensions</td>
<td>258 mm × 154 mm × 55 mm</td>
</tr>
</tbody>
</table>

For more information, see the PWM 21, ATS Software Product Information document.

### ATS
- **Languages**: German or English (selectable)
- **Functions**: Position display, Connection dialog, Diagnostics, Mounting wizard for EBI/ECI/EQI, LIP 200, LIC 4000 and others, Additional functions (if supported by the encoder), Memory contents
- **System requirements and recommendations**: PC with dual-core processor > 2 GHz, RAM > 2 GB, Operating systems: Windows 7, 8 and 10 (32-bit / 64-bit), 500 MB of free hard drive space

DRIVE-CLiQ is a registered trademark of Siemens AG.