Angle Encoders
with Integral Bearing
Information on
- Angle encoders without integral bearing
- Rotary encoders
- Position encoders for servo drives
- Exposed linear encoders
- Linear encoders for numerically controlled machine tools
- HEIDENHAIN subsequent electronics
- HEIDENHAIN controls

is available on request as well as on the Internet under www.heidenhain.de.

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

Standards (ISO, EN, etc.) apply only where explicitly stated in the catalog.
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  - Angle encoders without integral bearing

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<th>Series or Model</th>
<th>System accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCN 200 series</td>
<td>± 5&quot;/± 2.5&quot;</td>
<td>24</td>
</tr>
<tr>
<td>RON 200 series</td>
<td>± 5&quot;/± 2.5&quot;</td>
<td>26</td>
</tr>
<tr>
<td>RON 785</td>
<td>± 2&quot;</td>
<td>28</td>
</tr>
<tr>
<td>RCN 700/RCN 800 series</td>
<td>± 2&quot;/± 1&quot;</td>
<td>30</td>
</tr>
<tr>
<td>Ø 60 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ø 100 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RON 786/RON 886/RPN 886</td>
<td>± 2&quot;/± 1&quot;</td>
<td>34</td>
</tr>
<tr>
<td>RON 905</td>
<td>± 0.4&quot;</td>
<td>36</td>
</tr>
</tbody>
</table>

- Angle encoders with integral bearing for separate shaft coupling
- ROD 200 series                                               | ± 5"           | 38              |
- ROD 780/ROD 880                                              | ± 2"/± 1"      | 40              |

### Electrical Connection

- **Interfaces and Pin Layouts**
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HEIDENHAIN Angle Encoders

The term angle encoder is typically used to describe encoders that have an accuracy of better than ± 5” and a line count above 10,000.

In contrast, rotary encoders are encoders that typically have an accuracy of more than ± 10”.

Angle encoders are found in applications requiring precision angular measurement to accuracies within several arc seconds.

Examples:
- Rotary tables on machine tools
- Swivel heads on machine tools
- C axes of lathes
- Measuring machines for gears
- Printing units of printing machines
- Spectrometers
- Telescopes
- etc.

The tables on the following pages list different types of angle encoders to suit the various applications and meet different requirements.

Angle encoders can have one of the following mechanical designs:

**Angle encoders with integral bearing, hollow shaft and integrated stator coupling**

Because of the design and mounting of the stator coupling, it must only absorb that torque caused by friction in the bearing during angular acceleration of the shaft. RCN, RON and RPN angle encoders therefore provide excellent dynamic performance. With an integrated stator coupling, the stated system accuracy also includes the deviations from the shaft coupling.

Other advantages:
- Compact size for limited installation space
- Hollow shaft diameters up to 100 mm for leading power cables, etc.
- Simple installation

**Selection Guide**
For absolute angle encoders, see pages 6/7.
For incremental angle encoders, see pages 8/9.
Angle encoders with integral bearing, for separate shaft coupling

ROD angle encoders with solid shaft are particularly suited to applications where higher shaft speeds and larger mounting tolerances are required. The shaft couplings allow axial tolerances of ± 1 mm.

Selection Guide on pages 8/9

Angle encoders without integral bearing

The ERP and ERA angle encoders without integral bearing (modular angle encoders) are intended for integration in machine elements or apparatuses. They are designed to meet the following requirements:

- Large hollow shaft diameter (up to 10 m with a scale tape)
- High shaft speeds up to 20000 rpm
- No additional starting torque from shaft seals
- Segment angles

Selection Guide on pages 10/11

You can find more detailed information on HEIDENHAIN angle encoders for integration on the Internet under www.heidenhain.de or in our Angle Encoders without Integral Bearing brochure.
### Selection Guide

**Absolute Angle Encoders with Integral Bearing**

<table>
<thead>
<tr>
<th>Series</th>
<th>Overall dimensions in mm</th>
<th>System accuracy</th>
<th>Recommd. display step ¹</th>
<th>Mechanically perm. speed</th>
<th>Incremental signals</th>
<th>Signal periods/rev</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>With integrated stator coupling</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**RCN 200**

| ± 5” | 0.0001° | 3000 rpm | ~ 1 Vpp | 16 384 |
| ± 2.5” | ~ | ~ | ~ | ~ |

**RCN 700**

| ± 2” | 0.0001° | 1000 rpm | ~ 1 Vpp | 32 768 |
| ~ | ~ | ~ | ~ | ~ |

**RCN 800**

| ± 1” | 0.00005° | 1000 rpm | ~ 1 Vpp | 32 768 |
| ~ | ~ | ~ | ~ | ~ |

¹) For position measurement
<table>
<thead>
<tr>
<th>Absolute position values</th>
<th>Absolute positions per revolution</th>
<th>Model</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>EnDat 2.2/02</td>
<td>67 108 864 ± 26 bits</td>
<td>RCN 226</td>
<td>24</td>
</tr>
<tr>
<td>EnDat 2.2/22</td>
<td>67 108 864 ± 26 bits</td>
<td>RCN 226</td>
<td>24</td>
</tr>
<tr>
<td>Fanuc 02</td>
<td>8 388 608 ± 23 bits</td>
<td>RCN 223F</td>
<td>24</td>
</tr>
<tr>
<td>Mit 02-4</td>
<td>8 388 608 ± 23 bits</td>
<td>RCN 223M</td>
<td>24</td>
</tr>
<tr>
<td>EnDat 2.2/02</td>
<td>268 435 456 ± 28 bits</td>
<td>RCN 228</td>
<td>30</td>
</tr>
<tr>
<td>EnDat 2.2/22</td>
<td>268 435 456 ± 28 bits</td>
<td>RCN 228</td>
<td>30</td>
</tr>
<tr>
<td>Fanuc 02</td>
<td>134 217 728 ± 27 bits</td>
<td>RCN 227F</td>
<td>30</td>
</tr>
<tr>
<td>Mit 02-4</td>
<td>134 217 728 ± 27 bits</td>
<td>RCN 227M</td>
<td>30</td>
</tr>
<tr>
<td>EnDat 2.2/02</td>
<td>536 870 912 ± 29 bits</td>
<td>RCN 729</td>
<td>32</td>
</tr>
<tr>
<td>EnDat 2.2/22</td>
<td>536 870 912 ± 29 bits</td>
<td>RCN 729</td>
<td>32</td>
</tr>
<tr>
<td>Fanuc 02</td>
<td>134 217 728 ± 27 bits</td>
<td>RCN 727F</td>
<td>32</td>
</tr>
<tr>
<td>Mit 02-4</td>
<td>134 217 728 ± 27 bits</td>
<td>RCN 727M</td>
<td>32</td>
</tr>
<tr>
<td>EnDat 2.2/02</td>
<td>536 870 912 ± 29 bits</td>
<td>RCN 729</td>
<td>32</td>
</tr>
<tr>
<td>EnDat 2.2/22</td>
<td>536 870 912 ± 29 bits</td>
<td>RCN 729</td>
<td>32</td>
</tr>
<tr>
<td>Fanuc 02</td>
<td>134 217 728 ± 27 bits</td>
<td>RCN 727F</td>
<td>32</td>
</tr>
<tr>
<td>Mit 02-4</td>
<td>134 217 728 ± 27 bits</td>
<td>RCN 727M</td>
<td>32</td>
</tr>
<tr>
<td>EnDat 2.2/02</td>
<td>536 870 912 ± 29 bits</td>
<td>RCN 829</td>
<td>30</td>
</tr>
<tr>
<td>EnDat 2.2/22</td>
<td>536 870 912 ± 29 bits</td>
<td>RCN 829</td>
<td>30</td>
</tr>
<tr>
<td>Fanuc 02</td>
<td>134 217 728 ± 27 bits</td>
<td>RCN 827F</td>
<td>30</td>
</tr>
<tr>
<td>Mit 02-4</td>
<td>134 217 728 ± 27 bits</td>
<td>RCN 827M</td>
<td>30</td>
</tr>
<tr>
<td>EnDat 2.2/02</td>
<td>536 870 912 ± 29 bits</td>
<td>RCN 829</td>
<td>32</td>
</tr>
<tr>
<td>EnDat 2.2/22</td>
<td>536 870 912 ± 29 bits</td>
<td>RCN 829</td>
<td>32</td>
</tr>
<tr>
<td>Fanuc 02</td>
<td>134 217 728 ± 27 bits</td>
<td>RCN 827F</td>
<td>32</td>
</tr>
<tr>
<td>Mit 02-4</td>
<td>134 217 728 ± 27 bits</td>
<td>RCN 827M</td>
<td>32</td>
</tr>
</tbody>
</table>
## Selection Guide

Incremental Angle Encoders with Integral Bearing

<table>
<thead>
<tr>
<th>Series</th>
<th>Overall dimensions in mm</th>
<th>System accuracy</th>
<th>Recommended display step</th>
<th>Mechanically perm. speed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>With integrated stator coupling</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RON 200</td>
<td><img src="image1.png" alt="Image" /></td>
<td>± 5”</td>
<td>0.005°</td>
<td>3000 rpm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.001°/0.0005°</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.0001°</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>± 2.5”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RON 700</td>
<td><img src="image2.png" alt="Image" /></td>
<td>± 2”</td>
<td>0.0001°</td>
<td>1000 rpm</td>
</tr>
<tr>
<td>RON 800</td>
<td><img src="image3.png" alt="Image" /></td>
<td>± 1”</td>
<td>0.00005°</td>
<td>1000 rpm</td>
</tr>
<tr>
<td>RPN 800</td>
<td><img src="image4.png" alt="Image" /></td>
<td>± 0.4”</td>
<td>0.00001°</td>
<td>100 rpm</td>
</tr>
<tr>
<td>RON 900</td>
<td><img src="image5.png" alt="Image" /></td>
<td>± 0.4”</td>
<td>0.00001°</td>
<td>100 rpm</td>
</tr>
<tr>
<td><strong>For separate shaft coupling</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROD 200</td>
<td><img src="image6.png" alt="Image" /></td>
<td>± 5”</td>
<td>0.005°</td>
<td>10000 rpm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.0005°</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.0001°</td>
<td></td>
</tr>
<tr>
<td>ROD 700</td>
<td><img src="image7.png" alt="Image" /></td>
<td>± 2”</td>
<td>0.0001°</td>
<td>1000 rpm</td>
</tr>
<tr>
<td>ROD 800</td>
<td><img src="image8.png" alt="Image" /></td>
<td>± 1”</td>
<td>0.00005°</td>
<td>1000 rpm</td>
</tr>
</tbody>
</table>

1) For position measurement
2) After integrated interpolation
<table>
<thead>
<tr>
<th>Incremental signals</th>
<th>Signal periods/rev</th>
<th>Model</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTL</td>
<td>18000&lt;sup&gt;2)&lt;/sup&gt;</td>
<td>RON 225</td>
<td>26</td>
</tr>
<tr>
<td>TTL</td>
<td>180000/90000&lt;sup&gt;2)&lt;/sup&gt;</td>
<td>RON 275</td>
<td></td>
</tr>
<tr>
<td>~ 1 V&lt;sub&gt;pp&lt;/sub&gt;</td>
<td>18000</td>
<td>RON 285</td>
<td></td>
</tr>
<tr>
<td>~ 1 V&lt;sub&gt;pp&lt;/sub&gt;</td>
<td>18000</td>
<td>RON 287</td>
<td></td>
</tr>
<tr>
<td>~ 1 V&lt;sub&gt;pp&lt;/sub&gt;</td>
<td>18000</td>
<td>RON 785</td>
<td>28</td>
</tr>
<tr>
<td>~ 1 V&lt;sub&gt;pp&lt;/sub&gt;</td>
<td>18000/36000</td>
<td>RON 786</td>
<td>34</td>
</tr>
<tr>
<td>~ 1 V&lt;sub&gt;pp&lt;/sub&gt;</td>
<td>36000</td>
<td>RON 886</td>
<td>34</td>
</tr>
<tr>
<td>~ 1 V&lt;sub&gt;pp&lt;/sub&gt;</td>
<td>180000</td>
<td>RPN 886</td>
<td></td>
</tr>
<tr>
<td>~ 11 µA&lt;sub&gt;pp&lt;/sub&gt;</td>
<td>36000</td>
<td>RON 905</td>
<td>36</td>
</tr>
<tr>
<td>TTL</td>
<td>18000&lt;sup&gt;2)&lt;/sup&gt;</td>
<td>ROD 220</td>
<td>38</td>
</tr>
<tr>
<td>TTL</td>
<td>180000&lt;sup&gt;2)&lt;/sup&gt;</td>
<td>ROD 270</td>
<td></td>
</tr>
<tr>
<td>~ 1 V&lt;sub&gt;pp&lt;/sub&gt;</td>
<td>18000</td>
<td>ROD 280</td>
<td></td>
</tr>
<tr>
<td>~ 1 V&lt;sub&gt;pp&lt;/sub&gt;</td>
<td>18000/36000</td>
<td>ROD 780</td>
<td>40</td>
</tr>
<tr>
<td>~ 1 V&lt;sub&gt;pp&lt;/sub&gt;</td>
<td>36000</td>
<td>ROD 880</td>
<td></td>
</tr>
</tbody>
</table>
# Selection Guide

## Angle Encoders without Integral Bearing

<table>
<thead>
<tr>
<th>Series</th>
<th>Overall dimensions in mm</th>
<th>Diameter D1/D2</th>
<th>Line count/ System accuracy</th>
<th>Recommended display step</th>
<th>Mechanically perm. speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERP 880</td>
<td>Glass disk with interferential grating</td>
<td>D1: 40 to 512 mm D2: 80 to 562 mm</td>
<td>90 000/± 1&quot; (180 000 signal periods)</td>
<td>0.000 01°</td>
<td>≤ 1000 rpm</td>
</tr>
<tr>
<td>ERA 180</td>
<td>Steel drum with axial grating</td>
<td>D1: 40 to 512 mm D2: 80 to 562 mm</td>
<td>6 000/± 7.5&quot; to 36 000/± 2.5&quot;</td>
<td>0.001 5° to 0.000 1°</td>
<td>≤ 20 000 rpm to ≤ 3000 rpm</td>
</tr>
</tbody>
</table>

**Grating on steel tape**

<table>
<thead>
<tr>
<th>ERA 700</th>
<th>For inside diameter mounting</th>
<th>Full circle</th>
<th>Segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>458.62 mm 573.20 mm 1146.10 mm</td>
<td>36 000/± 3.5&quot; 45 000/± 3.4&quot; 90 000/± 3.2</td>
<td>0.000 2° to 0.000 02°</td>
<td>≤ 500 rpm</td>
</tr>
<tr>
<td>318.58 mm 458.62 mm 573.20 mm</td>
<td>5 000 10 000 20 000</td>
<td>0.000 2° to 0.000 05°</td>
<td>≤ 500 rpm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ERA 800</th>
<th>For outside diameter mounting</th>
<th>Full circle</th>
<th>Segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>458.04 mm 572.63 mm</td>
<td>36 000/± 3.5&quot; 45 000/± 3.4&quot;</td>
<td>0.000 2° to 0.000 05°</td>
<td>≤ 100 rpm</td>
</tr>
<tr>
<td>317.99 mm 458.04 mm 572.63 mm</td>
<td>5 000 10 000 20 000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

1. Before installation. Additional error caused by mounting inaccuracy and inaccuracy from the bearing of the drive shaft are not included.
2. Angular segment from 50° to 200°; see Measuring Accuracy for the accuracy.
3. For position measurement.
<table>
<thead>
<tr>
<th>Incremental signals</th>
<th>Reference marks</th>
<th>Model</th>
<th>For more information</th>
</tr>
</thead>
<tbody>
<tr>
<td>~ 1 V&lt;sub&gt;PP&lt;/sub&gt;</td>
<td>One</td>
<td>ERP 880</td>
<td><strong>Angle Encoders without Integral Bearing brochure</strong></td>
</tr>
<tr>
<td>~ 1 V&lt;sub&gt;PP&lt;/sub&gt;</td>
<td>One</td>
<td>ERA 180</td>
<td></td>
</tr>
<tr>
<td>~ 1 V&lt;sub&gt;PP&lt;/sub&gt;</td>
<td>Distance-coded</td>
<td>ERA 780C</td>
<td><strong>Angle Encoders without Integral Bearing brochure</strong></td>
</tr>
<tr>
<td></td>
<td>(nominal increment of 1000 grating periods)</td>
<td>ERA 781C segment</td>
<td></td>
</tr>
<tr>
<td>~ 1 V&lt;sub&gt;PP&lt;/sub&gt;</td>
<td>Distance-coded</td>
<td>ERA 880C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(nominal increment of 1000 grating periods)</td>
<td>ERA 881C segment with tensioning elements</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ERA 882C segment without tensioning elements</td>
<td></td>
</tr>
</tbody>
</table>
**Measuring Principles**

**Measuring Standard**

HEIDENHAIN encoders incorporate measuring standards of periodic structures known as graduations. These graduations are applied to a glass or steel substrate. Glass scales are used primarily in encoders for speeds up to 10,000 rpm. For higher speeds—up to 20,000 rpm—steel drums are used. The scale substrate for large diameters is a steel tape.

These precision graduations are manufactured in various photolithographic processes. Graduations are fabricated from:
- extremely hard chromium lines on glass or gold-plated steel drums,
- three-dimensional structures etched into quartz glass, or
- matte-etched lines on gold-plated steel tape.

These photolithographic manufacturing processes—DIADUR and AURODUR—developed by HEIDENHAIN produce grating periods of:
- 40 µm with AURODUR
- 10 µm with DIADUR
- 4 µm with etched quartz glass

These processes permit very fine grating periods and are characterized by a high definition and homogeneity of the line edges. Together with the photoelectric scanning method, this high edge definition is a precondition for the high quality of the output signals.

The master graduations are manufactured by HEIDENHAIN on custom-built high-precision ruling machines.

**Absolute Measuring Method**

**Absolute encoders** feature multiple coded graduation tracks. The code arrangement provides the absolute position information, which is available immediately after restarting the machine. The track with the finest grating structure is interpolated for the position value and at the same time is used to generate an incremental signal (see *EnDat Interface*).

![Circular graduations of absolute angle encoders](image1)

![Schematic representation of a circular scale with absolute grating](image2)
Incremental Measuring Method

With the **incremental measuring method**, the graduation consists of a periodic grating structure. The position information is obtained by counting the individual increments (measuring steps) from some point of origin. Since an absolute reference is required to ascertain positions, the scales or scale tapes are provided with an additional track that bears a reference mark. The absolute position on the scale, established by the reference mark, is gated with exactly one measuring step. The reference mark must therefore be scanned to establish an absolute reference or to find the last selected datum.

In some cases, however, this may require a rotation up to nearly 360°. To speed and simplify such “reference runs,” many encoders feature **distance-coded reference marks**—multiple reference marks that are individually spaced according to a mathematical algorithm. The subsequent electronics find the absolute reference after traversing two successive reference marks—meaning only a few degrees of traverse (see Nominal increment I in the table).

Encoders with distance-coded reference marks are identified with a “C” behind the model designation (e.g. RON 786 C).

With distance-coded reference marks, the **absolute reference** is calculated by counting the signal periods between two reference marks and using the following formula:

\[
\alpha_1 = (\text{abs } A - \text{sgn } A - 1) \times \frac{1}{D} + (\text{sgn } A - \text{sgn } D) \times \frac{\text{abs } M_{RR}}{2}
\]

where:

- \(\alpha_1\) = Absolute angular position of the first traversed reference mark to the zero position in degrees
- \(\text{abs}\) = Absolute value
- \(\text{sgn}\) = Sign function ("+1" or "−1")
- \(M_{RR}\) = Measured distance between the traversed reference marks in degrees
- \(I\) = Nominal increment between two fixed reference marks (see table)
- \(GP\) = Grating period \(\left(\frac{360°}{\text{Line count}}\right)\)
- \(D\) = Direction of rotation (+1 or −1)
  Rotation to the right (as seen from the shaft side of the angle encoder—see Mating Dimensions) gives “+1”

<table>
<thead>
<tr>
<th>Line count z</th>
<th>Number of reference marks</th>
<th>Nominal increment I</th>
</tr>
</thead>
<tbody>
<tr>
<td>36000</td>
<td>72</td>
<td>10°</td>
</tr>
<tr>
<td>18000</td>
<td>36</td>
<td>20°</td>
</tr>
</tbody>
</table>

Schematic representation of a circular scale with distance-coded reference marks

Circular graduations of incremental angle encoders
Most HEIDENHAIN encoders operate using the principle of photoelectric scanning. The photoelectric scanning of a measuring standard is contact-free, and therefore without wear. This method detects even very fine lines, no more than a few microns wide, and generates output signals with very small signal periods.

The finer the grating period of a measuring standard is, the greater the effect of diffraction on photoelectric scanning. HEIDENHAIN uses two scanning principles with angle encoders:

- **The imaging scanning principle** for grating periods from 10 µm to approx. 70 µm.
- **The interferential scanning principle** for very fine graduations with grating periods of 4 µm.

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

When parallel light passes through a grating, light and dark surfaces are projected at a certain distance. An index grating with the same grating period is located here. When the two gratings move relative to each other, the incident light is modulated. If the gaps in the gratings are aligned, light passes through. If the lines of one grating coincide with the gaps of the other, no light passes through.

Photovoltaic cells convert these variations in light intensity into electrical signals. The specially structured grating of the scanning reticle filters the light current to generate nearly sinusoidal output signals. The smaller the period of the grating structure is, the closer and more tightly tolerated the gap must be between the scanning reticle and circular scale. Practical mounting tolerances for encoders with the imaging scanning principle are achieved with grating periods of 10 µm and larger.

The RCN, RON and ROD angle encoders with integral bearing operate according to the imaging scanning principle.
Interferential scanning principle

The interferential scanning principle exploits the diffraction and interference of light on a fine graduation to produce signals used to measure displacement.

A step grating is used as the measuring standard: reflective lines 0.2 µm high are applied to a flat, reflective surface. In front of that is the scanning reticle—a transparent phase grating with the same grating period as the scale.

When a light wave passes through the scanning reticle, it is diffracted into three partial waves of the orders –1, 0, and +1, with approximately equal luminous intensity. The waves are diffracted by the scale such that most of the luminous intensity is found in the reflected diffraction orders +1 and –1. These partial waves meet again at the phase grating of the scanning reticle where they are diffracted again and interfere. This produces essentially three waves that leave the scanning reticle at different angles. Photovoltaic cells convert this alternating light intensity into electrical signals.

A relative motion of the scanning reticle to the scale causes the diffracted wave fronts to undergo a phase shift: when the grating moves by one period, the wave front of the first order is displaced by one wavelength in the positive direction, and the wavelength of diffraction order –1 is displaced by one wavelength in the negative direction. Since the two waves interfere with each other when exiting the grating, the waves are shifted relative to each other by two wavelengths. This results in two signal periods from the relative motion of just one grating period.

Interferential encoders function with average grating periods of 4 µm and finer. Their scanning signals are largely free of harmonics and can be highly interpolated. These encoders are therefore especially suited for high resolution and high accuracy. Even so, their generous mounting tolerances permit installation in a wide range of applications.

The RPN 886 angle encoder with integral bearing operates according to the interferential scanning principle.

Interferential scanning principle (optics schematics)

C Grating period
Ψ Phase shift of the light wave when passing through the scanning reticle
Ω Phase shift of the light wave due to motion X of the scale
The accuracy of angular measurement is mainly determined by:
1. The quality of the graduation
2. The quality of the scanning process
3. The quality of the signal processing electronics
4. Eccentricity of the graduation to the bearing
5. Radial runout of the bearing
6. Elasticity of the encoder shaft and its coupling with the drive shaft
7. The elasticity of the stator coupling (RCN, RON, RPN) or shaft coupling (ROD)

In positioning tasks, the accuracy of the angular measurement determines the accuracy of the positioning of a rotary axis. The system accuracy given in the Specifications is defined as follows:

The extreme values of the total deviations of a position are—referenced to their mean value—within the system accuracy ± a.

The total deviations are ascertained at a constant temperature (22 °C) during the final inspection, and are indicated on the calibration chart.

- For angle encoders with integral bearing and separate shaft coupling, the angle error of the coupling must be added (see Mechanical Design Types and Mounting — ROD).
- For angle encoders without integral bearing, additional deviations resulting from mounting, errors in the bearing of the drive shaft, and adjustment of the scanning head must be expected (see the Angle Encoders without Integral Bearing brochure). These deviations are not reflected in the system accuracy.

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

**Position errors within one revolution** become apparent in larger angular motions.

**Position errors within one signal period** already become apparent in very small angular motions and in repeated measurements. They especially lead to speed ripples in the speed control loop.

These errors within one signal period are caused by the quality of the sinusoidal scanning signals and their subdivision. The following factors influence the result:

- The size of the signal period,
- The homogeneity and edge definition of the graduation,
- The quality of the optical filter structures on the scanning reticle,
- The characteristics of the photoelectric detectors, and
- The stability and dynamics during the further processing of the analog signals.

HEIDENHAIN angle encoders take these factors of influence into account, and permit interpolation of the sinusoidal output signal with subdivision accuracies of better than ±1% of the signal period (RPN: ±1.5%). The reproducibility is even better, meaning that useful electric subdivision factors and small signal periods permit small enough measuring steps (see Specifications).

**Example:**

**Angle encoder with 360000 sinusoidal signal periods per revolution**

One signal period corresponds to 0.01° or 36". At a signal quality of ±1%, this results in maximum position errors within one signal period of approx. ±0.0001° or ±0.36".
For its angle encoders with integral bearings, HEIDENHAIN prepares individual calibration charts and ships them with the encoder.

The calibration chart documents the encoder’s accuracy and serves as a traceability record to a calibration standard. For the RCN, RON and RPN, which feature an integrated coupling, the accuracy specifications already include the error of the coupling. For angle encoders with separate shaft coupling, however, the error caused by the coupling is not included in the encoder specification and must be added to calculate the total error (see Kinematic error of transfer under Mechanical Design Types and Mounting – ROD).

The accuracy of angle encoders is ascertained through five forward and five backward measurements. The measuring positions per revolution are chosen to determine very exactly not only the long-range error, but also the position error within one signal period.

**Calibration chart example: RON 285**

1. Graphic representation of error
   - Envelope curve
   - Mean value curve
2. Results of calibration

All measured values determined in this manner lie within or on the graphically depicted envelope curve. The mean value curve shows the arithmetic mean of the measured values, whereby the reversal error is not included.

The reversal error depends on the shaft coupling. On angle encoders with integral stator coupling it is determined at ten measuring positions in forward and backward steps. The maximum value and arithmetic mean are documented on the calibration chart.

**Determination of the reversal error with forward and backward measurements**

The following limits apply to the reversal error:
- RCN/RON 2xx: Max. 0.6”
- RCN/RON 7xx: Max. 0.4”
- RCN/RON/RPN 8xx: Max. 0.4”

The manufacturer's inspection certificate certifies the accuracy of the encoder. The calibration standard is indicated in order to certify the traceability to the national standard.
**Mechanical Design Types and Mounting**

**RCN, RON, RPN**

**RCN, RON** and **RPN** angle encoders have an integral bearing, hollow shaft and integrated stator coupling. The measured shaft is directly connected with the shaft of the angle encoder. The reference mark can be assigned to a desired angular position of the measured shaft from the rear of the encoder during mounting.

The graduated disk is rigidly affixed to the hollow shaft. The scanning unit rides on the shaft on ball bearings and is connected to the housing with a coupling on the stator side. During angular acceleration of the shaft, the coupling must absorb only that torque caused by friction in the bearing. Angle encoders with integrated stator coupling therefore provide excellent dynamic performance.

**Mounting**

The housing of the RCN, RON and RPN is firmly connected to the stationary machine part with an integral mounting flange and a centering collar. Liquids can easily flow away through drainage channels on the flange.

**Shaft coupling with ring nut**

The RCN, RON and RPN series have a hollow through shaft. For installation, the hollow through shaft of the angle encoder is placed over the machine shaft, and is fixed with a ring nut from the front of the encoder. The ring nut can easily be tightened with the mounting tool.

**RON 905 shaft coupling**

The RON 905 has a bottomed hollow shaft. The shaft connection is made via an axial central screw.

**Front end shaft coupling**

It is often advantageous, especially with rotary tables, to integrate the angle encoder in the table so that it is freely accessible when the rotor is lifted. This installation from above reduces mounting times, increases the ease for servicing, and improves the accuracy, since the encoder is located nearer to the rotary table bearing and the measuring or machining plane. The hollow shaft is attached with the threaded holes on the face, using special mounting elements fitted to the individual design (not included in delivery).

To comply with radial and axial runout specifications, the internal bore \(\text{1}\) and the shoulder surface \(\text{2}\) are to be used as mounting surfaces for shaft coupling at the face of the encoder.
Ring nuts for RCN, RON and RPN
HEIDENHAIN offers special ring nuts for the RCN, RON and RPN angle encoders with integral bearing and hollow through shaft with integrated coupling. Choose the tolerance of the shaft thread such that the ring nut can be tightened easily, with a minor axial play. This guarantees that the load is evenly distributed on the shaft connection, and prevents distortion of the encoder’s hollow shaft.

Ring nut for RON/RCN 200
Hollow shaft Ø 20 mm: Id. Nr. 336669-03

Ring nut for RON 785
Hollow shaft Ø 50 mm: Id. Nr. 336669-05

Ring nut for RON 786; RON/RPN 886
RCN 72x/RCN 82x
Hollow shaft Ø 60 mm: Id. Nr. 336669-01

Ring nut for RCN 72x/RCN 82x
Hollow shaft Ø 100 mm: Id. Nr. 336669-06

Mounting tool for HEIDENHAIN ring nuts
The mounting tool is used to tighten the ring nut. Its pins lock into the bore holes in the ring nuts. A torque wrench provides the necessary tightening torque.

Mounting tool for ring nuts with
Hollow shaft Ø 20 mm  Id. Nr. 530334-03
Hollow shaft Ø 50 mm  Id. Nr. 530334-05
Hollow shaft Ø 60 mm  Id. Nr. 530334-01
Hollow shaft Ø 100 mm  Id. Nr. 530334-06

---

<table>
<thead>
<tr>
<th>Ring nut for</th>
<th>L1</th>
<th>L2</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hollow</td>
<td>62±0.2</td>
<td>70±0.2</td>
<td>69.052±0.075</td>
<td>49.469±0.059</td>
<td>50.06</td>
<td>1</td>
</tr>
<tr>
<td>shaft Ø 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hollow</td>
<td>70±0.2</td>
<td>80±0.2</td>
<td>69.052±0.075</td>
<td>59.469±0.059</td>
<td>60.06</td>
<td>1</td>
</tr>
<tr>
<td>shaft Ø 60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hollow</td>
<td>114±0.2</td>
<td>130±0.2</td>
<td>98.538±0.075</td>
<td>99.163±0.070</td>
<td>100.067</td>
<td>1.5</td>
</tr>
<tr>
<td>shaft Ø 100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Angle encoders of the ROD product family require a separate coupling for connection to the drive shaft. The shaft coupling compensates axial movement and misalignment between the shafts, preventing excessive load on the bearing of the angle encoder. It is important that the encoder shaft and the drive shaft be optimally aligned for high measurement accuracies to be realized. The HEIDENHAIN product program includes diaphragm couplings and flat couplings designed for connecting the shaft of the ROD angle encoder to the drive shaft.

Mounting
ROD angle encoders are provided with an integral mounting flange with centering collar. The encoder shaft is connected to the drive shaft by way of a diaphragm coupling or flat coupling.

Shaft couplings
The shaft coupling compensates axial movement and misalignment between the encoder shaft and the drive shaft, preventing excessive load on the encoder bearing of the angle encoder.

<table>
<thead>
<tr>
<th>Mechanical Design Types and Mounting</th>
<th>ROD 200 series</th>
<th>ROD 700 series, ROD 800 series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaft coupling</td>
<td>K 03 Diaphragm coupling</td>
<td>K 01 Diaphragm coupling</td>
</tr>
<tr>
<td>Hub bore</td>
<td>10 mm</td>
<td>14 mm</td>
</tr>
<tr>
<td>Kinematic transfer error</td>
<td>± 2° at ( \lambda \leq 0.1 \text{ mm} ) and ( \alpha \leq 0.09^\circ )</td>
<td>± 3° at ( \lambda \leq 0.1 \text{ mm} ) and ( \alpha \leq 0.09^\circ )</td>
</tr>
<tr>
<td>Torsional rigidity</td>
<td>1500 Nm/rad</td>
<td>1200 Nm/rad</td>
</tr>
<tr>
<td>Permissible torque</td>
<td>0.2 Nm</td>
<td>0.5 Nm</td>
</tr>
<tr>
<td>Perm. radial offset ( \lambda )</td>
<td>≤ 0.3 mm</td>
<td></td>
</tr>
<tr>
<td>Perm. angular error ( \alpha )</td>
<td>≤ 0.5°</td>
<td>≤ 0.2°</td>
</tr>
<tr>
<td>Perm. axial offset ( \delta )</td>
<td>≤ 0.2 mm</td>
<td>≤ 0.1 mm</td>
</tr>
<tr>
<td>Moment of inertia (approx.)</td>
<td>( 20 \cdot 10^{-6} \text{ kgm}^2 )</td>
<td>( 75 \cdot 10^{-6} \text{ kgm}^2 )</td>
</tr>
<tr>
<td>Permissible speed</td>
<td>10000 rpm</td>
<td>1000 rpm</td>
</tr>
<tr>
<td>Torque for locking screws (approx.)</td>
<td>1.2 Nm</td>
<td>2.5 Nm</td>
</tr>
<tr>
<td>Weight</td>
<td>100 g</td>
<td>117 g</td>
</tr>
</tbody>
</table>
K 03 diaphragm coupling
Id. Nr. 200313-04

K 18 flat coupling
Id. Nr. 202227-01

K 01 diaphragm coupling
Id. Nr. 200301-02

K 15 flat coupling
Id. Nr. 255797-01

K 16 flat coupling
Id. Nr. 258878-01

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H
General Mechanical Information

Protection
Unless otherwise indicated, all RCN, RON, RPN and ROD angle encoders meet protection standard IP 67 according to IEC 60529. This includes housings and cable outlets. The shaft inlet provides protection to IP 64.

Splash water should not contain any substances that would have harmful effects on the encoder parts. If protection to IP 64 of the shaft inlet is not sufficient (such as when the angle encoder is mounted vertically), additional labyrinth seals should be provided.

RCN, RON, RPN and ROD angle encoders are equipped with a compressed air inlet. Connection to a source of compressed air slightly above atmospheric pressure provides additional protection against contamination.

For this purpose, HEIDENHAIN offers the DA 300 compressed air unit (filter combination with pressure regulator and fittings). The compressed air introduced into the encoder must fulfill the requirements of the following quality classes as per ISO 8573-1:
- Max. particle size and density of solid contaminants:
  - Class 4 (max. particle size: 15 µm, max. particle density: 8 mg/m³)
- Total oil content:
  - Class 4 (oil content: 5 mg/m³)
- Max. pressure dew point:
  - (+29 °C at 10 · 10⁵ Pa)

No classification

The following components are necessary for connection to the RCN, RON, RPN and ROD angle encoders:

**M5 connecting piece for RCN/RON/RPN/ROD**
with gasket and throttle Ø 0.3 mm
Id. Nr. 207 835-04

**M5 coupling joint, swiveling**
with seal
Id. Nr. 207 834-02

Temperature range
The angle encoders are inspected at a reference temperature of 22 °C. The system accuracy given in the calibration chart applies at this temperature.

The operating temperature indicates the ambient temperature limits between which the angle encoders will function properly.

The storage temperature range of –30 °C to +80 °C is valid when the unit remains in its packaging. The storage temperature for the RON 905 may not exceed –30 °C to +50 °C.

For more information, ask for our DA 300 product information sheet.
Protection against contact
After encoder installation, all rotating parts (coupling on ROD, locking ring on RCN, RON and RPN) must be protected against accidental contact during operation.

Acceleration
Angle encoders are subject to various types of acceleration during operation and mounting.
- The permissible angular acceleration for all RCN, RON, RPN and ROD angle encoders is over $10^5 \text{rad/s}^2$.
- The indicated maximum values for vibration are valid according to IEC 60068-2-6.
- The maximum permissible acceleration values (semi-sinusoidal shock) for shock and impact are valid for 6 ms (IEC 60068-2-27).
Under no circumstances should a hammer or similar implement be used to adjust or position the encoder.

Natural frequency $f_N$ of coupling
The rotor and shaft coupling of the ROD angle encoders, as well as the stator and stator coupling of the RCN, RON and RPN angle encoders, form a single vibrating spring-mass system.

The natural frequency $f_N$ should be as high as possible. For RCN, RON and RPN angle encoders, the frequency ranges given in the respective specifications are those where the natural frequencies of the encoders do not cause any significant position deviations in the measuring direction. A prerequisite for the highest possible natural frequency on ROD angle encoders is the use of a shaft coupling with a high torsional rigidity $C$.

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

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

If radial and/or axial acceleration occurs during operation, the effect of the rigidity of the encoder bearing, the encoder stator and the coupling are also significant. If such loads occur in your application, HEIDENHAIN recommends consulting with the main facility in Traunreut.

Expendable parts
HEIDENHAIN encoders contain components that are subject to wear, depending on the application and manipulation. These include in particular the following parts:
- LED light source
- Cables with frequent flexing
- Additionally for encoders with integral bearing:
  - Bearings
  - Shaft sealing rings for rotary and angular encoders
  - Sealing lips for sealed linear encoders

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

The specifications given in the brochure apply to the specific encoder, not to the complete system. Any operation of the encoder outside of the specified range or for any other than the intended applications is at the user’s own risk. In safety-oriented systems, the higher-level system must verify the position value of the encoder after switch-on.

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

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RCN 200 Series

- Integrated stator coupling
- Hollow through shaft, diameter 20 mm
- System accuracy ± 5° and ± 2.5°

Dimensions in mm

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

Cable radial, also usable axially

- Bearing
- Required mating dimensions
- Mark for 0° position (± 5°)

Direction of shaft rotation for output signals as per the interface description

System accuracy

<table>
<thead>
<tr>
<th></th>
<th>± 2.5°</th>
<th>± 5°</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>Ø 20H6</td>
<td>Ø 20H7</td>
</tr>
<tr>
<td>D2</td>
<td>Ø 30H6</td>
<td>Ø 30H7</td>
</tr>
<tr>
<td>D3</td>
<td>Ø 20g6</td>
<td>Ø 20g7</td>
</tr>
<tr>
<td>T</td>
<td>0.01</td>
<td>0.02</td>
</tr>
</tbody>
</table>
### Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute RCN 228 RCN 226</th>
<th>RCN 227 F RCN 223 F</th>
<th>RCN 227 M RCN 223 M</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Absolute position values</strong></td>
<td>EnDat 2.2</td>
<td>EnDat 2.2</td>
<td>Fanuc serial interface</td>
</tr>
<tr>
<td><strong>Ordering designation</strong></td>
<td>EnDat 22</td>
<td>EnDat 02</td>
<td>Fanuc 02</td>
</tr>
<tr>
<td><strong>Positions per revolution</strong></td>
<td>RCN 228: 268435456 (28 bits)</td>
<td>RCN 226: 67108864 (26 bits)</td>
<td>RCN 227: 134217728 (27 bits)</td>
</tr>
<tr>
<td><strong>Elec. permissible speed</strong></td>
<td>≤ 1500 rpm</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Clock frequency</strong></td>
<td>≤ 8 MHz</td>
<td>≤ 2 MHz</td>
<td>–</td>
</tr>
<tr>
<td><strong>Calculation time t_cal</strong></td>
<td>5 µs</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Incremental signals</strong></td>
<td>–</td>
<td>1 Vpp</td>
<td>–</td>
</tr>
<tr>
<td><strong>Line count</strong></td>
<td>–</td>
<td>16384</td>
<td>–</td>
</tr>
<tr>
<td><strong>Cutoff frequency ~3 dB</strong></td>
<td>–</td>
<td>≥ 180 kHz</td>
<td>–</td>
</tr>
<tr>
<td><strong>Recommended meas. step</strong></td>
<td>0.0001°</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>System accuracy</strong></td>
<td>RCN 228: ± 2.5°</td>
<td>RCN 227 F: ± 2.5°</td>
<td>RCN 227 M: ± 2.5°</td>
</tr>
<tr>
<td><strong>Power supply</strong></td>
<td>* Without load: 3.6 V to 5.25 V at encoder/max. 350 mA</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Electrical connection</strong></td>
<td>Cable 1 m, with M12 coupling</td>
<td>Cable 1 m, with M23 coupling</td>
<td>Cable 1 m, with M23 coupling</td>
</tr>
<tr>
<td><strong>Max. cable length</strong></td>
<td>150 m</td>
<td>30 m</td>
<td>25 m</td>
</tr>
<tr>
<td><strong>Shaft</strong></td>
<td>Hollow through shaft D= 20 mm</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Mech. permissible speed</strong></td>
<td>≤ 3000 rpm</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Starting torque</strong></td>
<td>≤ 0.08 Nm at 20 °C</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Moment of inertia</strong></td>
<td>73 · 10⁻⁶ kgm²</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Natural frequency</strong></td>
<td>≥ 1200 Hz</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Permissible axial motion of measured shaft</strong></td>
<td>± 0.1 mm</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Vibration</strong></td>
<td>55 to 2000 Hz</td>
<td>≤ 100 m/s² (IEC 60068-2-6)</td>
<td>≤ 1000 m/s² (IEC 60068-2-27)</td>
</tr>
<tr>
<td><strong>Shock</strong></td>
<td>6 ms</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Operating temperature</strong></td>
<td>For accuracy of ± 2.5°: 0 to 50 °C</td>
<td>Moving cable: –10 to 70 °C</td>
<td>Stationary cable: –20 to 70 °C</td>
</tr>
<tr>
<td><strong>Protection</strong></td>
<td>IEC 60529 IP 64</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>Approx. 0.8 kg</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

* Please indicate when ordering

† With HEIDENHAIN cable
RON 200 Series

- Integrated stator coupling
- Hollow through shaft, diameter 20 mm
- System accuracy ± 5" and ± 2.5"

Dimensions in mm

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

<table>
<thead>
<tr>
<th>System accuracy</th>
<th>± 2.5&quot;</th>
<th>± 5&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>Ø 20H6</td>
<td>Ø 20H7</td>
</tr>
<tr>
<td>D2</td>
<td>Ø 30H6</td>
<td>Ø 30H7</td>
</tr>
<tr>
<td>D3</td>
<td>Ø 20g6</td>
<td>Ø 20g7</td>
</tr>
<tr>
<td>T</td>
<td>0.01</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Cable radial, also usable axially

= Bearing

= Required mating dimensions

= Position of the reference-mark signal (± 5")

= Direction of shaft rotation for output signals as per the interface description
<table>
<thead>
<tr>
<th>Incremental</th>
<th>RON 225</th>
<th>RON 275</th>
<th>RON 275</th>
<th>RON 285</th>
<th>RON 287</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incremental signals</td>
<td>TTL x 2</td>
<td>TTL x 5</td>
<td>TTL x 10</td>
<td>~ 1 Vpp</td>
<td></td>
</tr>
<tr>
<td>Line count</td>
<td>9000 2-fold 18000</td>
<td>18000 5-fold 90000</td>
<td>18000 10-fold 180000</td>
<td>18000</td>
<td></td>
</tr>
<tr>
<td>Integrated interpolation*</td>
<td>9000 2-fold 18000</td>
<td>18000 5-fold 90000</td>
<td>18000 10-fold 180000</td>
<td>18000</td>
<td></td>
</tr>
<tr>
<td>Output signals/rev.</td>
<td>One</td>
<td>One</td>
<td>RON 2xx: One</td>
<td>RON 2xx C: Distance-coded</td>
<td></td>
</tr>
<tr>
<td>Reference mark*</td>
<td>One</td>
<td>One</td>
<td>RON 2xx: One</td>
<td>RON 2xx C: Distance-coded</td>
<td></td>
</tr>
<tr>
<td>Cutoff frequency –3 dB</td>
<td>~ ≤ 1 MHz ≥ 0.125 µs</td>
<td>~ ≤ 250 kHz ≥ 0.96 µs</td>
<td>~ ≤ 1 MHz ≥ 0.22 µs</td>
<td>≥ 180 kHz</td>
<td></td>
</tr>
<tr>
<td>Output frequency</td>
<td>1 MHz</td>
<td>250 kHz</td>
<td>1 MHz</td>
<td>180 kHz</td>
<td></td>
</tr>
<tr>
<td>Edge separation a</td>
<td>~</td>
<td>~</td>
<td>~</td>
<td>~</td>
<td></td>
</tr>
<tr>
<td>Elec. permissible speed</td>
<td>~</td>
<td>≤ 166 rpm</td>
<td>≤ 333 rpm</td>
<td>~</td>
<td></td>
</tr>
<tr>
<td>Recommended meas. step for position capture</td>
<td>0.005°</td>
<td>0.001°</td>
<td>0.0005°</td>
<td>0.0001°</td>
<td></td>
</tr>
<tr>
<td>System accuracy</td>
<td>± 5”</td>
<td>± 2.5”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power supply without load</td>
<td>5 V ±10% max. 150 mA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical connection*</td>
<td>Cable 1 m, with or without M23 coupling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. cable length 1)</td>
<td>50 m</td>
<td>150 m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shaft</td>
<td>Hollow through shaft D= 20 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mech. permissible speed</td>
<td>≤ 3000 rpm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starting torque</td>
<td>≤ 0.08 Nm at 20 °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moment of inertia of rotor</td>
<td>73 · 10⁻⁶ kgm²</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural frequency</td>
<td>≥ 1200 Hz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permissible axial motion of measured shaft</td>
<td>± 0.1 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration 55 to 2000 Hz</td>
<td>≤ 100 m/s² (IEC 60068-2-6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shock 6 ms</td>
<td>≤ 1000 m/s² (IEC 60068-2-27)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>Moving cable: –10 to 70 °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stationary cable: –20 to 70 °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protection</td>
<td>IEC 60529</td>
<td>IP 64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>Approx. 0.8 kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Please indicate when ordering
1) With HEIDENHAIN cable
RON 785

- Integrated stator coupling
- Hollow through shaft, diameter 50 mm
- System accuracy ± 2"

Dimensions in mm

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

Cable radial, also usable axially

= Bearing
= Required mating dimensions
= Shown rotated by 45°

Direction of shaft rotation for output signals as per the interface description
<table>
<thead>
<tr>
<th><strong>Incremental signals</strong></th>
<th>1 Vpp</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Line count</strong></td>
<td>18,000</td>
</tr>
<tr>
<td><strong>Reference mark</strong></td>
<td>RON 785: One RON 785C. Distance-coded</td>
</tr>
<tr>
<td><strong>Cutoff frequency -3 dB</strong></td>
<td>≥ 180 kHz</td>
</tr>
<tr>
<td><strong>Recommended meas. step for position capture</strong></td>
<td>0.0001°</td>
</tr>
<tr>
<td><strong>System accuracy</strong></td>
<td>± 2”</td>
</tr>
<tr>
<td><strong>Power supply without load</strong></td>
<td>5 V ±10% max. 150 mA</td>
</tr>
<tr>
<td><strong>Electrical connection</strong></td>
<td>Cable 1 m, with or without M23 coupling</td>
</tr>
<tr>
<td><strong>Max. cable length</strong></td>
<td>150 m</td>
</tr>
<tr>
<td><strong>Shaft</strong></td>
<td>Hollow through shaft D= 50 mm</td>
</tr>
<tr>
<td><strong>Mech. permissible speed</strong></td>
<td>≤ 1000 rpm</td>
</tr>
<tr>
<td><strong>Starting torque</strong></td>
<td>≤ 0.5 Nm at 20 °C</td>
</tr>
<tr>
<td><strong>Moment of inertia of rotor</strong></td>
<td>1.05 · 10⁻³ kgm²</td>
</tr>
<tr>
<td><strong>Natural frequency</strong></td>
<td>≥ 1000 Hz</td>
</tr>
<tr>
<td><strong>Permissible axial motion of measured shaft</strong></td>
<td>± 0.1 mm</td>
</tr>
<tr>
<td><strong>Vibration</strong> 55 to 2000 Hz</td>
<td>≤ 100 m/s² (IEC 60068-2-6)</td>
</tr>
<tr>
<td><strong>Shock 6 ms</strong></td>
<td>≤ 1000 m/s² (IEC 60068-2-27)</td>
</tr>
<tr>
<td><strong>Operating temperature</strong></td>
<td>0 to 50 °C</td>
</tr>
<tr>
<td><strong>Protection</strong> IEC 60529</td>
<td>IP 64</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>Approx. 2.5 kg</td>
</tr>
</tbody>
</table>

* Please indicate when ordering
1) With HEIDENHAIN cable
RCN 700/RCN 800 Series

- Integrated stator coupling
- Hollow through shaft, diameter 60 mm
- System accuracy ± 2" or ± 1"

Dimensions in mm

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

Cable radial, also usable axially
= Bearing
= Required mating dimensions
= Shown rotated by 45°
= Direction of shaft rotation for output signals as per the interface description
<table>
<thead>
<tr>
<th>Absolute</th>
<th>RCN 729</th>
<th>RCN 829</th>
<th>RCN 727 F</th>
<th>RCN 827 M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute position values</td>
<td>EnDat 2.2</td>
<td>EnDat 2.2</td>
<td>Fanuc 02 serial interface</td>
<td>Mitsubishi high-speed serial interface</td>
</tr>
<tr>
<td>Ordering designation*</td>
<td>EnDat 22</td>
<td>EnDat 02</td>
<td>Fanuc 02</td>
<td>Mit 02-4</td>
</tr>
<tr>
<td>Positions per revolution</td>
<td>536870912 (29 bits)</td>
<td>134217728 (27 bits)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elec. permissible speed</td>
<td>≤ 300 rpm (for continuous position value)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clock frequency</td>
<td>≤ 8 MHz</td>
<td>≤ 2 MHz</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Calculation time t_{cal}</td>
<td>5 µs</td>
<td></td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Incremental signals</td>
<td>–</td>
<td>≥ 1 Vpp</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Line count*</td>
<td>–</td>
<td>32768</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Cutoff frequency –3 dB</td>
<td>–</td>
<td>≥ 180 kHz</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td><strong>Recommended meas. step</strong> for position capture</td>
<td>RCN 72x: 0.0001°</td>
<td>RCN 82x: 0.00005°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System accuracy</td>
<td>RCN 72x: ± 2”</td>
<td>RCN 82x: ± 1”</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Power supply</strong></td>
<td>3.6 to 5.25 V/Max. 350 mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>without load</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical connection*</td>
<td>Cable 1 m, with M12 coupling</td>
<td>Cable 1 m, with or without M23 coupling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. cable length(^1)</td>
<td>150 m</td>
<td>30 m</td>
<td>25 m</td>
<td></td>
</tr>
<tr>
<td><strong>Shaft</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hollow through shaft D= 60 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mech. permissible speed</strong></td>
<td>≤ 1000 rpm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Starting torque</strong></td>
<td>≤ 0.5 Nm at 20 °C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Moment of inertia</strong> of rotor</td>
<td>1.3 · 10^{-3} kgm^2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Natural frequency</strong></td>
<td>≥ 1000 Hz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Permissible axial motion of measured shaft</strong></td>
<td>≤ ± 0.1 mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vibration</strong> 55 to 2000 Hz Shock 6 ms</td>
<td>≤ 100 m/s^2 (IEC 60068-2-6)</td>
<td>≤ 1000 m/s^2 (IEC 60068-2-27)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>0 to 50 °C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Protection</strong></td>
<td>IEC 60529</td>
<td>IP 64</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>Approx. 2.8 kg</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Please indicate when ordering
\(^1\) With HEIDENHAIN cable
RCN 700/RCN 800 Series

- Integrated stator coupling
- Hollow through shaft, diameter 100 mm
- System accuracy ± 2° or ± 1°

Dimensions in mm

Cable radial, also usable axially
= Bearing
= Required mating dimensions
θ = Shown rotated by 45°
= Direction of shaft rotation for output signals as per the interface description

Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm
<table>
<thead>
<tr>
<th>Absolute</th>
<th>RCN 729 RCN 829</th>
<th>RCN 729 RCN 829</th>
<th>RCN 727 F RCN 827 F</th>
<th>RCN 727 M RCN 827 M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute position values</td>
<td>EnDat 2.2</td>
<td>EnDat 2.2</td>
<td>Fanuc 02 serial interface</td>
<td>Mitsubishi high-speed serial interface</td>
</tr>
<tr>
<td>Ordering designation*</td>
<td>EnDat 22</td>
<td>EnDat 02</td>
<td>Fanuc 02</td>
<td>Mit 02-4</td>
</tr>
<tr>
<td>Positions per revolution</td>
<td>536 870 912 (29 bits)</td>
<td></td>
<td>134 217 728 (27 bits)</td>
<td></td>
</tr>
<tr>
<td>Elec. permissible speed</td>
<td>≤ 300 rpm (for continuous position value)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clock frequency</td>
<td>≤ 8 MHz</td>
<td>≤ 2 MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculation time $t_{cal}$</td>
<td>5 µs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incremental signals</td>
<td>–</td>
<td>1 Vpp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line count*</td>
<td>–</td>
<td>32 768</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cutoff frequency –3 dB</td>
<td>–</td>
<td>≥ 180 kHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Recommended meas. step for position capture</strong></td>
<td>( RCN 72x: 0.0001^\circ )</td>
<td>( RCN 82x: 0.00005^\circ )</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>System accuracy</strong></td>
<td>( RCN 72x: ± 2^\circ )</td>
<td>( RCN 82x: ± 1^\circ )</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Power supply without load</strong></td>
<td>3.6 to 5.25 V/MAX. 350 mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Electrical connection</strong>*</td>
<td>Cable 1 m, with M12 coupling</td>
<td>Cable 1 m, with or without M23 coupling</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Max. cable length(^1)</strong></td>
<td>150 m</td>
<td>30 m</td>
<td>25 m</td>
<td></td>
</tr>
<tr>
<td><strong>Shaft</strong></td>
<td>Hollow through shaft D= 100 mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mech. permissible speed</strong></td>
<td>≤ 1000 rpm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Starting torque</strong></td>
<td>≤ 1.5 Nm at 20 °C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Moment of inertia of rotor</strong></td>
<td>( 3.3 \cdot 10^{-3} \text{ kgm}^2 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Natural frequency</strong></td>
<td>≥ 900 Hz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Permissible axial motion of measured shaft</strong></td>
<td>≤ ± 0.1 mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vibration</strong></td>
<td>( 55 \text{ to } 2000 \text{ Hz} ) ( 6 \text{ ms} )</td>
<td>≤ 100 m/s(^2) (IEC 60068-2-6) ( \leq 1000 \text{ m/s}^2) (IEC 60068-2-27)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Shock</strong></td>
<td>0 to 50 °C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Protection</strong></td>
<td>IEC 60529</td>
<td>IP 64</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>Approx. 2.6 kg</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Please indicate when ordering
\(^1\) With HEIDENHAIN cable
RON 786/RON 886/RPN 886

- Integrated stator coupling
- Hollow through shaft, diameter 60 mm
- System accuracy ± 2° or ± 1°

Dimensions in mm

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

Cable radial, also usable axially

- Bearing
- Required mating dimensions
- Shown rotated by 45°
- Direction of shaft rotation for output signals as per the interface description
<table>
<thead>
<tr>
<th>Incremental</th>
<th>RON 786</th>
<th>RON 886</th>
<th>RPN 886</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incremental signals</td>
<td>1 Vpp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line count*</td>
<td>18000 36000</td>
<td>36000</td>
<td>90000 (± 180 000 signal periods)</td>
</tr>
<tr>
<td>Reference mark*</td>
<td>RON x86: One RON x86C: Distance-coded</td>
<td>One</td>
<td></td>
</tr>
<tr>
<td>Cutoff frequency –3 dB</td>
<td>≥ 180 kHz</td>
<td></td>
<td>≥ 800 kHz</td>
</tr>
<tr>
<td>–6 dB</td>
<td></td>
<td></td>
<td>≥ 1300 kHz</td>
</tr>
<tr>
<td>Recommended meas. step</td>
<td>0.0001°</td>
<td>0.00005°</td>
<td>0.00001°</td>
</tr>
<tr>
<td>for position capture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System accuracy</td>
<td>± 2”</td>
<td>± 1”</td>
<td></td>
</tr>
<tr>
<td>Power supply without load</td>
<td>5 V ±10% max. 150 mA</td>
<td></td>
<td>5 V ±10% max. 250 mA</td>
</tr>
<tr>
<td>Electrical connection*</td>
<td>Cable 1 m, with or without M23 coupling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. cable length 1)</td>
<td>150 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shaft</td>
<td>Hollow through shaft D= 60 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mech. permissible speed</td>
<td>≤ 1000 rpm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starting torque</td>
<td>≤ 0.5 Nm at 20 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moment of inertia of rotor</td>
<td>1.2 · 10⁻³ kgm²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural frequency</td>
<td>≥ 1000 Hz</td>
<td></td>
<td>≥ 500 Hz</td>
</tr>
<tr>
<td>Permissible axial motion of measured shaft</td>
<td>≤ ± 0.1 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration 55 to 2000 Hz Shock 6 ms</td>
<td>≤ 100 m/s² (IEC 60068-2-6)</td>
<td>≤ 1000 m/s² (IEC 60068-2-27)</td>
<td>≤ 50 m/s² (IEC 60068-2-6)</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>0 to 50 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protection</td>
<td>IEC 60529 IP 64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>Approx. 2.5 kg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Please indicate when ordering
1) With HEIDENHAIN cable
RON 905

- Integrated stator coupling
- Blind hollow shaft
- System accuracy ± 0.4"

Dimensions in mm

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

Cable radial, also usable axially

= Bearing

= Required mating dimensions

= Direction of shaft rotation for output signal $I_2$ lagging $I_1$
<table>
<thead>
<tr>
<th><strong>Incremental RON 905</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Incremental signals</strong></td>
<td>11 µAPP</td>
</tr>
<tr>
<td>Line count</td>
<td>36000</td>
</tr>
<tr>
<td>Reference mark</td>
<td>One</td>
</tr>
<tr>
<td>Cutoff frequency –3 dB</td>
<td>≥ 40 kHz</td>
</tr>
<tr>
<td><strong>Recommended meas. step</strong> for position capture</td>
<td>0.00001°</td>
</tr>
<tr>
<td><strong>System accuracy</strong></td>
<td>± 0.4”</td>
</tr>
<tr>
<td><strong>Power supply without load</strong></td>
<td>5 V ± 5% max. 250 mA</td>
</tr>
<tr>
<td><strong>Electrical connection</strong></td>
<td>Cable 1 m, with M23 connector</td>
</tr>
<tr>
<td><strong>Max. cable length</strong></td>
<td>15 m</td>
</tr>
<tr>
<td><strong>Shaft</strong></td>
<td>Blind hollow shaft</td>
</tr>
<tr>
<td><strong>Mech. permissible speed</strong></td>
<td>≤ 100 rpm</td>
</tr>
<tr>
<td><strong>Starting torque</strong></td>
<td>≤ 0.05 Nm at 20 °C</td>
</tr>
<tr>
<td><strong>Moment of inertia of rotor</strong></td>
<td>0.345 · 10⁻³ kgm²</td>
</tr>
<tr>
<td><strong>Natural frequency</strong></td>
<td>≥ 350 Hz</td>
</tr>
<tr>
<td><strong>Permissible axial motion of measured shaft</strong></td>
<td>≤ ± 0.2 mm</td>
</tr>
<tr>
<td><strong>Vibration</strong> 55 to 2000 Hz</td>
<td>≤ 50 m/s² (IEC 60068-2-6)</td>
</tr>
<tr>
<td><strong>Shock 6 ms</strong></td>
<td>≤ 1000 m/s² (IEC 60068-2-27)</td>
</tr>
<tr>
<td><strong>Operating temperature</strong></td>
<td>10 to 30 °C</td>
</tr>
<tr>
<td><strong>Protection</strong></td>
<td>IEC 60529 IP 64</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>Approx. 4 kg</td>
</tr>
</tbody>
</table>

1) With HEIDENHAIN cable
ROD 200 Series

- For separate shaft coupling
- System accuracy ± 5"

Dimensions in mm

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

Cable radial, also usable axially

= Bearing

= Position of the reference mark,
  ROD 220/270/280: ±10°
  ROD 280C: ±5°

= Direction of shaft rotation for output signals as per the interface description
<table>
<thead>
<tr>
<th>Incremental</th>
<th>ROD 220</th>
<th>ROD 270</th>
<th>ROD 280</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Incremental signals</strong></td>
<td>TTL x 2</td>
<td>TTL x 10</td>
<td>1 Vpp</td>
</tr>
<tr>
<td><strong>Line count</strong></td>
<td>9000</td>
<td>18000</td>
<td>18000</td>
</tr>
<tr>
<td><strong>Integrated interpolation</strong></td>
<td>2-fold</td>
<td>10-fold</td>
<td>10-fold</td>
</tr>
<tr>
<td><strong>Output signals/revolution</strong></td>
<td>18000</td>
<td>180000</td>
<td>180000</td>
</tr>
<tr>
<td><strong>Reference mark</strong></td>
<td>One</td>
<td>One</td>
<td>ROD 280: One</td>
</tr>
<tr>
<td><strong>OD 280C: Distance-coded</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cutoff frequency –3 dB</strong></td>
<td>–</td>
<td>–</td>
<td>≥ 180 kHz</td>
</tr>
<tr>
<td><strong>Output frequency</strong></td>
<td>≤ 1 MHz</td>
<td>≤ 1 MHz</td>
<td>–</td>
</tr>
<tr>
<td><strong>Edge separation a</strong></td>
<td>≥ 0.125 µs</td>
<td>≥ 0.22 µs</td>
<td>0.22 µs</td>
</tr>
<tr>
<td><strong>Electrical permissible speed</strong></td>
<td>3333 rpm</td>
<td>≤ 333 rpm</td>
<td>–</td>
</tr>
<tr>
<td><strong>Recommended meas. step</strong></td>
<td>0.005°</td>
<td>0.0005°</td>
<td>0.0001°</td>
</tr>
<tr>
<td><strong>for position capture</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>System accuracy</strong></td>
<td>± 5”</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Power supply</strong></td>
<td>5 V ±10% max. 150 mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>without load</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Electrical connection</strong></td>
<td>Cable 1 m, with or without M23 coupling</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Max. cable length</strong></td>
<td>100 m</td>
<td>150 m</td>
<td></td>
</tr>
<tr>
<td><strong>Shaft</strong></td>
<td>Solid shaft D = 10 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mech. permissible speed</strong></td>
<td>≤ 10,000 rpm</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Starting torque</strong></td>
<td>≤ 0.01 Nm at 20 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Moment of inertia of rotor</strong></td>
<td>20 · 10⁻⁶ kgm²</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Shaft load</strong></td>
<td>Axial: 10 N</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Radial: 10 N at shaft end</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vibration</strong></td>
<td>55 to 2000 Hz</td>
<td>≤ 100 m/s² (IEC 60068-2-6)</td>
<td>≤ 1000 m/s² (IEC 60068-2-27)</td>
</tr>
<tr>
<td><strong>Shock</strong></td>
<td>6 ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Operating temperature</strong></td>
<td>Moving cable: –10 to 70 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stationary cable: –20 to 70 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Protection</strong></td>
<td>IEC 60529 IP 64</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>Approx. 0.7 kg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Please indicate when ordering

1) With HEIDENHAIN cable
ROD 780/ROD 880

- For separate shaft coupling
- System accuracy ROD 780: ± 2"
  ROD 880: ± 1"

Dimensions in mm

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

Cable radial, also usable axially

= Bearing

Direction of shaft rotation for output signals as per the interface description
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Incremental ROD 780</th>
<th>Incremental ROD 880</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incremental signals</td>
<td>~1 Vpp</td>
<td></td>
</tr>
<tr>
<td>Line count*</td>
<td>18,000 36,000</td>
<td></td>
</tr>
<tr>
<td>Reference mark*</td>
<td>ROD x80: One ROD x80C: Distance-coded</td>
<td></td>
</tr>
<tr>
<td>Cutoff frequency –3 dB</td>
<td>≥ 180 kHz</td>
<td></td>
</tr>
<tr>
<td>Recommended meas. step for position capture</td>
<td>0.0001° 0.00005°</td>
<td></td>
</tr>
<tr>
<td>System accuracy</td>
<td>± 2”</td>
<td>± 1”</td>
</tr>
<tr>
<td>Power supply without load</td>
<td>5 V ±10% max. 150 mA</td>
<td></td>
</tr>
<tr>
<td>Electrical connection*</td>
<td>Cable 1 m, with or without M23 coupling</td>
<td></td>
</tr>
<tr>
<td>Max. cable length 1)</td>
<td>150 m</td>
<td></td>
</tr>
<tr>
<td>Shaft</td>
<td>Solid shaft D = 14 mm</td>
<td></td>
</tr>
<tr>
<td>Mech. permissible speed</td>
<td>≤ 1000 rpm</td>
<td></td>
</tr>
<tr>
<td>Starting torque</td>
<td>≤ 0.012 Nm at 20 °C</td>
<td></td>
</tr>
<tr>
<td>Moment of inertia of rotor</td>
<td>0.36 · 10⁻³ kgm²</td>
<td></td>
</tr>
<tr>
<td>Shaft load</td>
<td>Axial: 30 N Radial: 30 N at shaft end</td>
<td></td>
</tr>
<tr>
<td>Vibration 55 to 2000 Hz Shock 6 ms</td>
<td>≤ 100 m/s² (IEC 60068-2-6) ≤ 300 m/s² (IEC 60068-2-27)</td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>0 to 50 °C</td>
<td></td>
</tr>
<tr>
<td>Protection IEC 60529</td>
<td>IP 64</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>Approx. 2.0 kg</td>
<td></td>
</tr>
</tbody>
</table>

* Please indicate when ordering
1) With HEIDENHAIN cable
HEIDENHAIN encoders with \( \sim 1 \text{V}_{\text{PP}} \) interface provide voltage signals that can be highly interpolated.

The sinusoidal incremental signals A and B are phase-shifted by 90° elec. and have an amplitude of typically 1 Vpp. The illustrated sequence of output signals—with B lagging A—applies for the direction of motion shown in the dimension drawing.

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

The data on signal amplitude apply when the power supply given in the specifications is connected to the encoder. They refer to a differential measurement at the 120-ohm terminating resistor between the associated outputs. The signal amplitude decreases with increasing frequency. The cutoff frequency indicates the scanning frequency at which a certain percentage of the original signal amplitude is maintained:
- \( –3 \text{ dB cutoff frequency:} \) 70 % of the signal amplitude
- \( –6 \text{ dB cutoff frequency:} \) 50 % of the signal amplitude

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

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

**Short-circuit stability**
A temporary short circuit of one signal output to 0 V or UP does not cause encoder failure, but it is not a permissible operating condition.

<table>
<thead>
<tr>
<th>Short circuit at</th>
<th>( 20 \ ^{\circ} \text{C} )</th>
<th>( 125 \ ^{\circ} \text{C} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>One output</td>
<td>&lt; 3 min</td>
<td>&lt; 1 min</td>
</tr>
<tr>
<td>All outputs</td>
<td>&lt; 20 s</td>
<td>&lt; 5 s</td>
</tr>
</tbody>
</table>

**Interface**
Sinusoidal voltage signals \( \sim 1 \text{V}_{\text{PP}} \)

<table>
<thead>
<tr>
<th>Incremental signals</th>
<th>2 nearly sinusoidal signals A and B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal amplitude M:</td>
<td>0.6 to 1.2 \text{V}<em>{\text{PP}}, typ. 1 \text{V}</em>{\text{PP}}</td>
</tr>
<tr>
<td>Asymmetry (</td>
<td>P – N</td>
</tr>
<tr>
<td>Signal ratio ( M_A/M_B</td>
<td>≤ 1.25</td>
</tr>
<tr>
<td>Phase angle (</td>
<td>\varphi_1 + \varphi_2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reference mark signal</th>
<th>1 or more signal peaks R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usable component G:</td>
<td>0.2 to 0.85 V</td>
</tr>
<tr>
<td>Quiescent value H:</td>
<td>0.04 V to 1.7 V</td>
</tr>
<tr>
<td>Switching threshold E, F:</td>
<td>≥ 40 mV</td>
</tr>
<tr>
<td>Zero crossovers K, L:</td>
<td>180° ± 90° elec.</td>
</tr>
</tbody>
</table>

**Connecting cable**
HEIDENHAIN cable with shielding
PUR \([4(2 \times 0.14 \text{mm}^2) + (4 \times 0.5 \text{mm}^2)]\)
Max. 150 m distributed capacitance 90 pF/m
6 ns/m

Any limited tolerances in the encoders are listed in the specifications.

---

### Cutoff Frequency

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

- \( –3 \text{ dB cutoff frequency} \)
- \( –6 \text{ dB cutoff frequency} \)

**Cut-off frequency**

Typical signal amplitude curve with respect to the scanning frequency
Input circuitry of the subsequent electronics

**Dimensioning**
Operational amplifier MC 34074

\[ Z_0 = 120 \, \Omega \]
\[ R_1 = 10 \, k\Omega \text{ and } C_1 = 100 \, pF \]
\[ R_2 = 34.8 \, k\Omega \text{ and } C_2 = 10 \, pF \]
\[ U_B = \pm 15 \, V \]
\[ U_1 \approx U_0 \]

-3dB cutoff frequency of circuitry
Approx. 450 kHz

Approx. 50 kHz and \( C_1 = 1000 \, pF \)
and \( C_2 = 82 \, pF \)

This circuit variant does reduce the bandwidth of the circuit, but in doing so it improves its noise immunity.

**Circuit output signals**
\[ U_a = 3.48 \, V_{PP} \text{ typical} \]
Gain 3.48

**Signal monitoring**
A threshold sensitivity of 250 m\( V_{PP} \) is to be provided for monitoring the 1 \( V_{PP} \) incremental signals.

---

**Incremental signals**
Reference mark signal
\( R_a < 100 \, \Omega \), approx. 24 \( \Omega \)
\( C_a < 50 \, pF \)
\( \Sigma I_a < 1 \, mA \)
\( U_2 = 2.5 \, V \pm 0.5 \, V \)
(relative to 0V of the power supply)

**Pin Layout**

12-pin M23 coupling
12-pin M23 connector
15-pin D-sub connector, female for HEIDENHAIN controls and IK 220

<table>
<thead>
<tr>
<th>Power supply</th>
<th>Incremental signals</th>
<th>Other signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 2 10 11</td>
<td>5 6 8 1 3 4</td>
<td>7/9</td>
</tr>
<tr>
<td>1 9 2 11</td>
<td>3 4 6 7 10 12</td>
<td>5/8/13/14/15</td>
</tr>
<tr>
<td>( U_P ) Sensor ( U_P ) 0 V Sensor 0 V</td>
<td>A+ A– B+ B– R+ R–</td>
<td>Vacant Vacant Vacant</td>
</tr>
<tr>
<td>Brown/ Green Blue White/ Green</td>
<td>Brown Green Gray Pink Red Black</td>
<td>/ Violet Yellow</td>
</tr>
</tbody>
</table>

**Shield** on housing; \( U_P \) = power supply voltage
**Sensor:** The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!
HEIDENHAIN encoders with TTL interface incorporate electronics that digitize sinusoidal scanning signals with or without interpolation.

The incremental signals are transmitted as the square-wave pulse trains \( U_{a1} \) and \( U_{a2} \), phase-shifted by 90° elec. The reference mark signal consists of one or more reference pulses \( U_{a0} \), which are gated with the incremental signals. In addition, the integrated electronics produce their inverse signals \( U_{a1} \), \( U_{a2} \), and \( U_{a0} \) for noise-proof transmission.

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

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

The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum edge separation \( a \) listed in the Specifications applies for the illustrated input circuitry with a cable length of 1 m, and refers to a measurement at the output of the differential line receiver. Propagation-time differences in cables additionally reduce the edge separation by 0.2 ns per meter of cable length. To prevent counting error, design the subsequent electronics to process as little as 90% of the resulting edge separation. The max. permissible shaft speed or traversing velocity must never be exceeded.

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

<table>
<thead>
<tr>
<th>Interface</th>
<th>Square-wave signals ( \text{TTL} )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Incremental signals</strong></td>
<td>2 TTL square-wave signals ( U_{a1}, U_{a2} ) and their inverted signals ( U_{a1}, U_{a2} )</td>
</tr>
<tr>
<td><strong>Reference mark signal</strong></td>
<td>1 or more square-wave pulses ( U_{a0} ) and their inverted pulses ( U_{a0} )</td>
</tr>
<tr>
<td>Pulse width</td>
<td>90° elec. (other widths available on request); LS 323: ungated ( t_d ) ≤ 50 ns</td>
</tr>
<tr>
<td>Delay time</td>
<td></td>
</tr>
<tr>
<td><strong>Fault detection signal</strong></td>
<td>1 TTL square-wave pulse ( U_{aS} )</td>
</tr>
<tr>
<td>Improper function: LOW (upon request: ( U_{a1}/U_{a2} ) high impedance)</td>
<td></td>
</tr>
<tr>
<td>Proper function: HIGH</td>
<td></td>
</tr>
<tr>
<td>Pulse width</td>
<td>( t_S ) ≥ 20 ms</td>
</tr>
<tr>
<td><strong>Signal level</strong></td>
<td>Differential line driver as per EIA standard RS 422</td>
</tr>
<tr>
<td>( U_H ) ≥ 2.5 V at ( -I_H ) = 20 mA</td>
<td></td>
</tr>
<tr>
<td>( U_L ) ≤ 0.5 V at ( -I_L ) = 20 mA</td>
<td></td>
</tr>
<tr>
<td><strong>Permissible load</strong></td>
<td>( Z_0 ) ≥ 100 Ω between associated outputs</td>
</tr>
<tr>
<td>(</td>
<td>I_L</td>
</tr>
<tr>
<td>( C_{load} ) ≤ 1000 pF with respect to 0 V</td>
<td></td>
</tr>
<tr>
<td>Outputs protected against short circuit to 0 V</td>
<td></td>
</tr>
<tr>
<td><strong>Switching times</strong> (10% to 90%)</td>
<td>( t_+/t_- ) ≤ 30 ns (typically 10 ns)</td>
</tr>
<tr>
<td>with 1 m cable and recommended input circuitry</td>
<td></td>
</tr>
<tr>
<td><strong>Connecting cable</strong></td>
<td>HEIDENHAIN cable with shielding</td>
</tr>
<tr>
<td>Cable length</td>
<td>PUR ( [4(2 \times 0.14 \text{ mm}^2) + (4 \times 0.5 \text{ mm}^2)] )</td>
</tr>
<tr>
<td>Max. 100 m (( U_{aS} ) max. 50 m) distributed capacitance 90 pF/m</td>
<td></td>
</tr>
<tr>
<td>6 m/s</td>
<td></td>
</tr>
</tbody>
</table>

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

**Dimensioning**

IC₁ = Recommended differential line receivers
- DS 26 C 32 AT
- AM 26 LS 32
- MC 3486
- SN 75 ALS 193

R₁ = 4.7 kΩ
R₂ = 1.8 kΩ
Z₀ = 120 Ω
C₁ = 220 pF (serves to improve noise immunity)

---

Pin Layout

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

<table>
<thead>
<tr>
<th>Power supply</th>
<th>Incremental signals</th>
<th>Other signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Uₚ</td>
<td>Sensor Uₚ</td>
<td>0 V</td>
</tr>
</tbody>
</table>

- Brown/Green | Blue | White/Green | White | Brown | Green | Gray | Pink | Red | Black | Violet | Yellow² |

**Shield** on housing; Uₚ = power supply voltage

**Sensor:** The sensor line is connected internally with the corresponding power line

¹) LS 323/ERO 14xx: Vacant
²) Exposed linear encoders: TTL/11 μAₚₚ conversion for PWT, otherwise vacant

Vacant pins or wires must not be used!
The EnDat interface is a digital, bidirectional interface for encoders. It is capable of transmitting position values from both absolute and—in with EnDat 2.2—incremental encoders, as well as reading and updating information stored in the encoder, or of saving new information. Thanks to the serial transmission method only four signal lines are required. The data are transmitted in synchronism with the clock signal from the subsequent electronics. The type of transmission (position values, parameters, diagnostics, etc.) is selected by mode commands that the subsequent electronics send to the encoder.

Clock frequency and cable length

Without propagation-delay compensation, the clock frequency—depending on the cable length—is variable between 100 kHz and 2 MHz.

Because large cable lengths and high clock frequencies increase the signal run time to the point that they can disturb the unambiguous assignment of data, the delay can be measured in a test run and then compensated. With this propagation-delay compensation in the subsequent electronics, clock frequencies up to 8 MHz at cable lengths up to a maximum of 100 m are possible. The maximum clock frequency is mainly determined by the cables and connecting elements used. To ensure proper function at clock frequencies above 2 MHz, use only original ready-made HEIDENHAIN cables.

Input circuitry of the subsequent electronics

Dimensioning

IC1 = RS 485 differential line receiver and driver

$C_3 = 330 \text{ pF}$

$Z_0 = 120 \Omega$
Versions

The extended EnDat interface version 2.2 is compatible in its communication, command set and time conditions with version 2.1, but also offers significant advantages. It makes it possible, for example, to transfer additional information with the position value without sending a separate request for it. The interface protocol was expanded and the time conditions (clock frequency, processing time, recovery time) were optimized. In addition, encoders with ordering designations EnDat 02 or EnDat 22 have an extended power supply range.

Both EnDat 2.1 and EnDat 2.2 are available in versions with or without incremental signals. EnDat 2.2 encoders feature a high internal resolution. Therefore, depending on the control technology being used, interrogation of the incremental signals is not necessary. To increase the resolution of EnDat 2.1 encoders, the incremental signals are evaluated in the subsequent electronics.

Command set

The command set is the sum of all available mode commands. The EnDat 2.2 command set includes EnDat 2.1 mode commands. When a mode command from the EnDat 2.2 command set is transmitted to EnDat 01 subsequent electronics, the encoder or the subsequent electronics may generate an error message.

EnDat 2.2 command set (includes EnDat 2.1 command set)

- Position values for incremental and absolute encoders
- Additional information on position value
  - Diagnostics and test values
  - Absolute position values after reference run of incremental encoders
  - Parameter upload/download
  - Commutation
  - Acceleration
  - Limit position signal
  - Temperature of the encoder PCB
  - Temperature evaluation of an external temperature sensor (e.g. in the motor winding)

EnDat 2.1 command set

- Absolute position values
- Parameter upload/download
- Reset
- Test command and test values

Benefits of the EnDat Interface

- **Automatic self-configuration**: All information required by the subsequent electronics is already stored in the encoder
- **High system security** through alarms and messages for monitoring and diagnosis
- **High transmission reliability** through cyclic redundancy checking
- Faster configuration during installation: Datum shifting through offsetting by a value in the encoder

Other benefits of EnDat 2.2

- **A single interface** for all absolute and incremental encoders
- **Additional information** (limit switch, temperature, acceleration)
- **Quality improvement**: Position value calculation in the encoder permits shorter sampling intervals (25 µs)

Advantages of purely serial transmission specifically for EnDat 2.2 encoders

- **Simple subsequent electronics** with EnDat receiver chip
- **Simple connection technology**: Standard connecting elements (M12 — 8-pin) single-shielded standard cable and low wiring costs
- **Minimized transmission times** through adaptation of the data word length to the resolution of the encoder
- **High clock frequencies** up to 8 MHz.
  Position values available in the subsequent electronics after only approx. 10 µs
- **Support for state-of-the-art machine designs** e.g. direct drive technology

Functions

The EnDat interface transmits absolute position values or additional physical quantities (only EnDat 2.2) in an unambiguous time sequence and serves to read from and write to the encoder’s internal memory. Some functions are available only with EnDat 2.2 mode commands.

Position values can be transmitted with or without additional information. The additional information types are selectable via the Memory Range Select (MRS) code. Other functions such as parameter reading and writing can also be called after the memory area and address have been selected. Through simultaneous transmission with the position value, additional information can also be requested of axes in the feedback loop, and functions executed with them.

Parameter reading and writing is possible both as a separate function and in connection with the position value. Parameters can be read or written after the memory area and address is selected.

Reset functions serve to reset the encoder in case of malfunction. Reset is possible instead of or during position value transmission.

Servicing diagnostics make it possible to inspect the position value even at a standstill. A test command has the encoder transmit the required test values.

You can find more information in the Technical Information document for EnDat 2.2 or on the Internet at www.endat.de.
Selecting the Transmission Type

Transmitted data are identified as either position values, position values with additional information, or parameters. The type of information to be transmitted is selected by mode commands. **Mode commands** define the content of the transmitted information. Every mode command consists of three bits. To ensure reliable transmission, every bit is transmitted redundantly (inverted or double). If the encoder detects an erroneous mode transmission, it transmits an error message. The EnDat 2.2 interface can also transfer parameter values in the additional information together with the position value. This makes the current position values constantly available for the control loop, even during a parameter request.

Control cycles for transfer of position values

The transmission cycle begins with the first falling clock edge. The measured values are saved and the position value calculated. After two clock pulses (2T), to select the type of transmission the subsequent electronics transmit the mode command “Encoder transmit position value” (with/without additional information).

After successful calculation of the absolute position value (t_{cal}—see table), the start bit begins the data transmission from the encoder to the subsequent electronics. The subsequent error messages, error 1 and error 2 (only with EnDat 2.2 commands), are group signals for all monitored functions and serve as failure monitors.

Beginning with the LSB, the encoder then transmits the absolute position value as a complete data word. Its length varies depending on which encoder is being used. The number of required clock pulses for transmission of a position value is saved in the parameters of the encoder manufacturer. The data transmission of the position value is completed with the **Cyclic Redundancy Check** (CRC).

In EnDat 2.2, this is followed by additional information 1 and 2, each also concluded with a CRC. With the end of the data word, the clock must be set to HIGH. After 10 to 30 μs or 1.25 to 3.75 μs (with EnDat 2.2 parameterizable recovery time t_{R}), the data line falls back to LOW. Then a new data transmission can begin by starting the clock.

### Mode commands

<table>
<thead>
<tr>
<th>EnDat 2.1</th>
<th>EnDat 2.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoder transmit position value</td>
<td>Encoder transmit position value with additional information</td>
</tr>
<tr>
<td>Selection of the memory area</td>
<td>Encoder transmit position value and receive selection of memory area</td>
</tr>
<tr>
<td>Encoder receive parameters</td>
<td>Encoder transmit position value and receive parameters</td>
</tr>
<tr>
<td>Encoder transmit parameters</td>
<td>Encoder transmit position value and transmit parameters</td>
</tr>
<tr>
<td>Encoder receive reset</td>
<td>Encoder transmit position value and receive error reset</td>
</tr>
<tr>
<td>Encoder transmit test values</td>
<td>Encoder transmit position value and receive test command</td>
</tr>
<tr>
<td>Encoder receive test commands</td>
<td>Encoder receive communication command</td>
</tr>
</tbody>
</table>

1) Same reaction as switching the power supply off and on
2) Selected additional information is also transmitted
3) Reserved for encoders that do not support the safety system

The time absolute linear encoders need for calculating the position values t_{cal} differs depending on whether EnDat 2.1 or EnDat 2.2 mode commands are transmitted (see Specifications in the Linear Encoders for Numerically Controlled Machine Tools brochure). If the incremental signals are evaluated for axis control, then the EnDat 2.1 mode commands should be used. Only in this manner can an active error message be transmitted synchronously to the currently requested position value. EnDat 2.1 mode commands should not be used for pure serial position-value transfer for axis control.

<table>
<thead>
<tr>
<th>Without delay compensation</th>
<th>With delay compensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clock frequency f_c</td>
<td>100 kHz ... 2 MHz</td>
</tr>
<tr>
<td>Calculation time for Position value Parameters t_{cal} t_{ac}</td>
<td>See Specifications Max. 12 ms</td>
</tr>
<tr>
<td>Recovery time</td>
<td>EnDat 2.1: 10 to 30 μs EnDat 2.2: 10 to 30 μs or 1.25 to 3.75 μs (f_c ≥ 1 MHz) (parameterizable)</td>
</tr>
<tr>
<td>( \tau_R )</td>
<td>Max. 500 ns</td>
</tr>
<tr>
<td>( \tau_ST )</td>
<td>– 2 to 10 μs</td>
</tr>
<tr>
<td>Data delay time ( \tau_D )</td>
<td>(0.2 + 0.01 x cable length in m) μs</td>
</tr>
<tr>
<td>Pulse width ( t_{HI} )</td>
<td>0.2 to 10 μs Pulse width fluctuation HIGH to LOW max. 10%</td>
</tr>
<tr>
<td>( t_{LO} )</td>
<td>0.2 to 50 ms/30 μs (with LC)</td>
</tr>
</tbody>
</table>
EnDat 2.2 – Transfer of Position Values

EnDat 2.2 can transmit position values with or without additional information.

Encoder saves position value

Subsequent electronics transmit mode command

Diagram does not depict the propagation-delay compensation

Data packet with position value and additional information 1 and 2

Encoder saves position value

Subsequent electronics transmit mode command

Diagram does not depict the propagation-delay compensation

Additional information

With EnDat 2.2, one or two pieces of additional information can be appended to the position value. Each additional information is 30 bits long with LOW as first bit, and ends with a CRC check. The additional information supported by the respective encoder is saved in the encoder parameters.

The content of the additional information is determined by the MRS code and is transmitted in the next sampling cycle for additional information. This information is then transmitted with every sampling until a selection of a new memory area changes the content.

The additional information always begins with:

<table>
<thead>
<tr>
<th>Status data</th>
<th>Additional information 1</th>
<th>Additional information 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warning – WRN</td>
<td>Diagnosis</td>
<td>Commutation</td>
</tr>
<tr>
<td>Reference mark – RM</td>
<td>Position value 2</td>
<td>Acceleration</td>
</tr>
<tr>
<td>Parameter request – Busy</td>
<td>Memory parameters</td>
<td>Limit position signals</td>
</tr>
<tr>
<td>Acknowledgment of additional information</td>
<td>MRS-code acknowledgment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Test values</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Temperature</td>
<td></td>
</tr>
</tbody>
</table>

The additional information can contain the following data:

- Status data
- Additional information 1
- Additional information 2
EnDat 2.1 – Transmission of Position Values

EnDat 2.1 can transmit position values with interrupted clock pulse (as in EnDat 2.2) or continuous clock pulse.

**Interrupted clock**

The interrupted clock is intended particularly for time-clocked systems such as closed control loops. At the end of the data word the clock signal is set to HIGH level. After 10 to 30 µs (tm), the data line falls back to LOW. A new data transmission can then begin when started by the clock.

**Continuous clock**

For applications that require fast acquisition of the measured value, the EnDat interface can have the clock run continuously. Immediately after the last CRC bit has been sent, the data line is switched to high for one clock cycle, and then to low. The new position value is saved with the very next falling edge of the clock and is output in synchronism with the clock signal immediately after the start bit and alarm bit. Because the mode command Encoder transmit position value is needed only before the first data transmission, the continuous-clock transfer mode reduces the length of the clock-pulse group by 10 periods per position value.

Synchronization of the serially transmitted code value with the incremental signal

Absolute encoders with EnDat interface can exactly synchronize serially transmitted absolute position values with incremental values. With the first falling edge (latch signal) of the CLOCK signal from the subsequent electronics, the scanning signals of the individual tracks in the encoder and counter are frozen, as are the A/D converters for subdividing the sinusoidal incremental signals in the subsequent electronics.

The code value transmitted over the serial interface unambiguously identifies one incremental signal period. The position value is absolute within one sinusoidal period of the incremental signal. The subdivided incremental signal can therefore be appended in the subsequent electronics to the serially transmitted code value.

After power on and initial transmission of position values, two redundant position values are available in the subsequent electronics. Since encoders with EnDat interface guarantee a precise synchronization—regardless of cable length—of the serially transmitted absolute value with the incremental signals, the two values can be compared in the subsequent electronics. This monitoring is possible even at high shaft speeds thanks to the EnDat interface’s short transmission times of less than 50 µs. This capability is a prerequisite for modern machine design and safety systems.
**Parameters and Memory Areas**

The encoder provides several memory areas for parameters. These can be read from by the subsequent electronics, and some can be written to by the encoder manufacturer, the OEM, or even the end user. Certain memory areas can be write-protected.

The parameters, which in most cases are set by the OEM, largely define the function of the encoder and the EnDat interface. When the encoder is exchanged, it is therefore essential that its parameter settings are correct. Attempts to configure machines without including OEM data can result in malfunctions. If there is any doubt as to the correct parameter settings, the OEM should be consulted.

**Parameters of the OEM**

In this freely definable memory area, the OEM can store his information, e.g. the “electronic ID label” of the motor in which the encoder is integrated, indicating the motor model, maximum current rating, etc.

**Operating parameters**

This area is available for a datum shift and the configuration of diagnostics. It can be protected against overwriting.

**Operating status**

This memory area provides detailed alarms or warnings for diagnostic purposes. Here it is also possible to activate write protection for the OEM parameter and operating parameter memory areas, and to interrogate their status. Once write protection is activated, it cannot be removed.

**Safety System**

The safety system is in preparation. Safety-oriented controls are the planned application for encoders with EnDat 2.2 interface. The ISO 13849-1 (previously EN 954-1) and IEC 61508 standards serve as the foundation for this.

**Monitoring and Diagnostic Functions**

The EnDat interface enables comprehensive monitoring of the encoder without requiring an additional transmission line. The alarms and warnings supported by the respective encoder are saved in the “parameters of the encoder manufacturer” memory area.

**Error message**

An error message becomes active if a malfunction of the encoder might result in incorrect position values. The exact cause of the disturbance is saved in the “operating status” memory and can be interrogated in detail. Errors include, for example,

- Light unit failure
- Signal amplitude too low
- Error in calculation of position value
- Power supply too high/low
- Current consumption is excessive

Here the EnDat interface transmits the error bits, error 1 and error 2 (only with EnDat 2.2 commands). These are group signals for all monitored functions and serve for failure monitoring. The two error messages are generated independently from each other.

**Warning**

This collective bit is transmitted in the status data of the additional information. It indicates that certain tolerance limits of the encoder have been reached or exceeded—such as shaft speed or the limit of light source intensity compensation through voltage regulation—without implying that the measured position values are incorrect. This function makes it possible to issue preventive warnings in order to minimize idle time.

**Cyclic Redundancy Check**

To ensure reliability of data transfer, a cyclic redundancy check (CRC) is performed through the logical processing of the individual bit values of a data word. This 5-bit long CRC concludes every transmission. The CRC is decoded in the receiver electronics and compared with the data word. This largely eliminates errors caused by disturbances during data transfer.
Pin Layout EnDat

17-pin M23 coupling

<table>
<thead>
<tr>
<th>Power supply</th>
<th>Incremental signals</th>
<th>Absolute position values</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>U_P</td>
<td>Sensor</td>
<td>0 V</td>
</tr>
<tr>
<td>Brown/ Green</td>
<td>Blue</td>
<td>White/ Green</td>
</tr>
</tbody>
</table>

Shield on housing; U_P = power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!

1) Only with ordering designations EnDat 01 and EnDat 02

8-pin M12 coupling

<table>
<thead>
<tr>
<th>Power supply</th>
<th>Absolute position values</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>U_P</td>
<td>U_P</td>
</tr>
<tr>
<td>Blue</td>
<td>Brown/Green</td>
</tr>
</tbody>
</table>

Shield on housing; U_P = power supply voltage
Vacant pins or wires must not be used!

1) For parallel supply lines

15-pin D-sub connector, male
for IK 115/IK 215

<table>
<thead>
<tr>
<th>Power supply</th>
<th>Incremental signals</th>
<th>Absolute position values</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>U_P</td>
<td>Sensor</td>
<td>0 V</td>
</tr>
<tr>
<td>Brown/ Green</td>
<td>Blue</td>
<td>White/ Green</td>
</tr>
</tbody>
</table>

Shield on housing; U_P = power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!

1) Only with ordering designations EnDat 01 and EnDat 02

15-pin D-sub connector, female
for HEIDENHAIN controls and IK 220
Interfaces
Fanuc and Mitsubishi Pin Layouts

Fanuc pin layout
HEIDENHAIN encoders with the code letter F after the model designation are suited for connection to Fanuc controls with

- **Fanuc 01 serial interface**
  - with 1 MHz communication rate
- **Fanuc 02 serial interface**
  - with 1 MHz or 2 MHz communication rate

<table>
<thead>
<tr>
<th>15-pin Fanuc connector</th>
<th>17-pin HEIDENHAIN coupling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>Absolute Position Values</td>
</tr>
<tr>
<td>9 18/20 12 14 16</td>
<td>1 2 5 6</td>
</tr>
<tr>
<td>7 1 10 4 –</td>
<td>14 17 8 9</td>
</tr>
<tr>
<td>Brown/Green</td>
<td>Gray Pink Violet Yellow</td>
</tr>
</tbody>
</table>

Shield on housing; \( U_P \) = power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!

Mitsubishi pin layout
HEIDENHAIN encoders with the code letter M after the model designation are suited for connection to controls with the Mitsubishi high-speed serial interface.

<table>
<thead>
<tr>
<th>10 or 20-pin Mitsubishi connector</th>
<th>17-pin HEIDENHAIN coupling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>Absolute Position Values</td>
</tr>
<tr>
<td>10-pin</td>
<td>1 2 7 8 3 4</td>
</tr>
<tr>
<td>20-pin</td>
<td>20 19 1 11 6 16 7 17</td>
</tr>
<tr>
<td>Brown/Green</td>
<td>Gray Pink Violet Yellow</td>
</tr>
</tbody>
</table>

Shield on housing; \( U_P \) = power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!
The pins on connectors are numbered in the direction opposite to those on couplings or flange socket, regardless of whether the contacts are male contacts or female contacts.

When engaged, the connections provide protection to IP 67 (D-sub connector: IP 50; IEC 60529). When not engaged, there is no protection.
### Connecting Cables ~ 1\,V_{PP} \quad \begin{array}{c} \text{TTL} \\ \text{M23} \end{array}

**12-pin**

<table>
<thead>
<tr>
<th>Description</th>
<th>Connector (female)</th>
<th>Connector (male)</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Complete with connector (female) and coupling (male)</strong></td>
<td><img src="connector1.png" alt="Connector Diagram" /></td>
<td><img src="coupling1.png" alt="Coupling Diagram" /></td>
<td>298401-xx</td>
</tr>
<tr>
<td><strong>Complete with connector (female) and connector (male)</strong></td>
<td><img src="connector2.png" alt="Connector Diagram" /></td>
<td><img src="connector2.png" alt="Connector Diagram" /></td>
<td>298399-xx</td>
</tr>
<tr>
<td><strong>Complete with connector (female) and D-sub connector (female) for IK 220</strong></td>
<td><img src="connector3.png" alt="Connector Diagram" /></td>
<td><img src="connector4.png" alt="Connector Diagram" /></td>
<td>310199-xx</td>
</tr>
<tr>
<td><strong>Complete with connector (female) and D-sub connector (male) for IK 115/IK 215</strong></td>
<td><img src="connector5.png" alt="Connector Diagram" /></td>
<td><img src="connector6.png" alt="Connector Diagram" /></td>
<td>310196-xx</td>
</tr>
<tr>
<td><strong>With one connector (female)</strong></td>
<td><img src="connector7.png" alt="Connector Diagram" /></td>
<td></td>
<td>309777-xx</td>
</tr>
<tr>
<td><strong>Cable only, Ø 8 mm</strong></td>
<td></td>
<td></td>
<td>244957-01</td>
</tr>
</tbody>
</table>

**Mating element on connecting cable to connector on encoder cable**

<table>
<thead>
<tr>
<th>Description</th>
<th>Connector (female)</th>
<th>Connector (male)</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Connector on cable for connection to subsequent electronics</strong></td>
<td><img src="connector8.png" alt="Connector Diagram" /></td>
<td><img src="connector9.png" alt="Connector Diagram" /></td>
<td>291697-05</td>
</tr>
<tr>
<td><strong>Connector on cable for connection to subsequent electronics</strong></td>
<td><img src="connector10.png" alt="Connector Diagram" /></td>
<td><img src="connector11.png" alt="Connector Diagram" /></td>
<td>291697-08</td>
</tr>
<tr>
<td><strong>Connector on cable for connection to subsequent electronics</strong></td>
<td><img src="connector12.png" alt="Connector Diagram" /></td>
<td><img src="connector13.png" alt="Connector Diagram" /></td>
<td>291697-07</td>
</tr>
<tr>
<td><strong>Coupling on connecting cable</strong></td>
<td><img src="coupling14.png" alt="Coupling Diagram" /></td>
<td><img src="connector15.png" alt="Connector Diagram" /></td>
<td>291698-14</td>
</tr>
<tr>
<td><strong>Coupling on connecting cable</strong></td>
<td><img src="coupling16.png" alt="Coupling Diagram" /></td>
<td><img src="connector17.png" alt="Connector Diagram" /></td>
<td>291698-03</td>
</tr>
<tr>
<td><strong>Coupling on connecting cable</strong></td>
<td><img src="coupling18.png" alt="Coupling Diagram" /></td>
<td><img src="connector19.png" alt="Connector Diagram" /></td>
<td>291698-04</td>
</tr>
<tr>
<td><strong>Flange socket for mounting on the subsequent electronics</strong></td>
<td><img src="flange1.png" alt="Flange Socket Diagram" /></td>
<td></td>
<td>315892-08</td>
</tr>
</tbody>
</table>

**Mounted couplings**

<table>
<thead>
<tr>
<th>Description</th>
<th>With flange (female)</th>
<th>With flange (male)</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>With flange (female)</strong></td>
<td><img src="coupling20.png" alt="Coupling Diagram" /></td>
<td><img src="connector21.png" alt="Connector Diagram" /></td>
<td>291698-17</td>
</tr>
<tr>
<td><strong>With flange (male)</strong></td>
<td><img src="coupling22.png" alt="Coupling Diagram" /></td>
<td><img src="connector23.png" alt="Connector Diagram" /></td>
<td>291698-07</td>
</tr>
<tr>
<td><strong>With flange (male)</strong></td>
<td><img src="coupling24.png" alt="Coupling Diagram" /></td>
<td><img src="connector25.png" alt="Connector Diagram" /></td>
<td>291698-08</td>
</tr>
<tr>
<td><strong>With flange (male)</strong></td>
<td><img src="coupling26.png" alt="Coupling Diagram" /></td>
<td><img src="connector27.png" alt="Connector Diagram" /></td>
<td>291698-31</td>
</tr>
<tr>
<td><strong>With central fastening (male)</strong></td>
<td><img src="coupling28.png" alt="Coupling Diagram" /></td>
<td><img src="connector29.png" alt="Connector Diagram" /></td>
<td>291698-33</td>
</tr>
</tbody>
</table>

**Adapter connector ~ 1\,V_{PP}/11\,\mu A_{PP}**

For converting the 1\,V_{PP} signals to 11\,\mu A_{PP}; M23 connector (female) 12-pin and M23 connector (male) 9-pin

<table>
<thead>
<tr>
<th>Description</th>
<th><img src="adapter.png" alt="Adapter Connector Diagram" /></th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adapter connector ~ 1,V_{PP}/11,\mu A_{PP}</strong></td>
<td><img src="adapter.png" alt="Adapter Connector Diagram" /></td>
<td>364914-01</td>
</tr>
</tbody>
</table>
## Connecting Cables EnDat

<table>
<thead>
<tr>
<th>8-pin</th>
<th>17-pin</th>
</tr>
</thead>
<tbody>
<tr>
<td>M12</td>
<td>M23</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PUR connecting cable</th>
<th>8-pin: [(4 × 0.14 mm²) + (4 × 0.34 mm²)]</th>
<th>Ø 6 mm</th>
<th>17-pin: [(4 × 0.14 mm²) + (2 × 0.14 mm²) + (4 × 0.5 mm²)]</th>
<th>Ø 8 mm</th>
<th>EnDat without Incremental signals</th>
<th>EnDat with incremental signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete with connector (female) and coupling (male)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>368330-xx</td>
</tr>
<tr>
<td>Complete with connector (female) and D-sub connector (female) for IK 220</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>530627-xx</td>
</tr>
<tr>
<td>Complete with connector (female) and D-sub connector (male) for IK 115/IK 215</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>524599-xx</td>
</tr>
<tr>
<td>With one connector (female)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>559346-xx</td>
</tr>
<tr>
<td>Cable only, Ø 8 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Mating element on connecting cable to connector on encoder cable | Connector (female) for cable Ø 8 mm | | | | | 291697-26 |
| Connectors on cable for connection to subsequent electronics | Connector (male) for cable Ø 8 mm Ø 6 mm | | | | | 291697-27 |
| Coupling on connecting cable | Coupling (male) for cable Ø 4.5 mm Ø 6 mm Ø 8 mm | | | | | 291698-25 291698-26 291698-27 |
| Flange socket for mounting on the subsequent electronics | Coupling (female) | | | | | 315892-10 |

| Mounted couplings | With flange (female) Ø 6 mm Ø 8 mm | | | | | 291698-35 |
| | With flange (male) Ø 6 mm Ø 8 mm | | | | | 291698-41 291698-29 |
| | With central fastening (male) Ø 6 mm | | | | | 291698-37 |
## Connecting Cables Fanuc Mitsubishi

<table>
<thead>
<tr>
<th>PUR connecting cable</th>
<th>Fanuc</th>
<th>Mitsubishi</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Complete</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with M23 connector (female), 17-pin and Fanuc connector</td>
<td>Ø 8 mm</td>
<td>534855-xx</td>
</tr>
<tr>
<td></td>
<td></td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Complete</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with M23 connector (female), 17-pin and Mitsubishi connector, 20-pin</td>
<td>Ø 6 mm</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>367958-xx</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Complete</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with M23 connector (female), 17-pin and Mitsubishi connector, 10-pin</td>
<td>Ø 8 mm</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>573661-xx</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cable only</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ø 8 mm</td>
<td>354608-01</td>
</tr>
</tbody>
</table>
General Electrical Information

Power supply

The encoders require a stabilized dc voltage $U_p$ as power supply. The respective specifications state the required power supply and the current consumption. The permissible ripple content of the dc voltage is:

- High frequency interference:
  \[ U_{pp} \leq 250 \text{ mV with } \frac{dU}{dt} > 5 \text{ V/µs} \]
- Low frequency fundamental ripple:
  \[ U_{pp} \leq 100 \text{ mV} \]

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

Calculation of the voltage drop:

\[ \Delta U = 2 \cdot 10^{-3} \cdot \frac{L_c \cdot I}{56 \cdot A_p} \]

where

- $\Delta U$: Line drop in V
- $L_c$: Cable length in m
- $I$: Current consumption of the encoder in mA (see Specifications)
- $A_p$: Cross section of power lines in mm²

Electrically permissible speed/Traversing speed

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

- the mechanically permissible shaft speed/traversing velocity (if listed in Specifications)
- the electrically permissible shaft speed or traversing velocity.

For encoders with sinusoidal output signals, the electrically permissible shaft speed or traversing velocity is limited by:

- the maximum permissible scanning frequency $f_{max}$ of the encoder and
- the minimum permissible edge separation $a$ for the subsequent electronics.

For encoders with square-wave signals, the electrically permissible shaft speed or traversing velocity is limited by:

- the maximum permissible scanning frequency $f_{max}$ and
- the minimum permissible edge separation $a$ for the subsequent electronics.

For angular or rotary encoders

\[ n_{max} = f_{max} \cdot z \cdot 60 \cdot 10^3 \]

For linear encoders

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

where

- $n_{max}$: Electrically permissible speed in rpm,
- $v_{max}$: Electrically permissible speed in m/min
- $f_{max}$: Maximum scanning/output frequency of the encoder or input frequency of the subsequent electronics in kHz,
- $z$: Line count of the angle or rotary encoder per 360°
- $SP$: Signal period of the linear encoder in µm

HEIDENHAIN cables

<table>
<thead>
<tr>
<th>Cross section of power supply lines $A_p$</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1V_{pp}$/TTL/HTL</td>
<td>$11 \mu A_{pp}$</td>
</tr>
<tr>
<td>Ø 3.7 mm</td>
<td>0.06 mm²</td>
</tr>
<tr>
<td>Ø 4.5/5.1 mm</td>
<td>0.14/0.05² mm²</td>
</tr>
<tr>
<td>Ø 6/10¹ mm</td>
<td>0.19/0.14³ mm²</td>
</tr>
<tr>
<td>Ø 8/14¹ mm</td>
<td>0.5 mm²</td>
</tr>
</tbody>
</table>

¹) Metal armor
²) Only on length gauges
³) Only for LIDA 400

Cables

Lengths

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

Durability

All encoders have polyurethane (PUR) cables. PUR cables are resistant to oil, hydrolysis and microbes in accordance with VDE 0472. They are free of PVC and silicone and comply with UL safety directives. The UL certification AWM STYLE 20963 80 °C 30 V E63216 is documented on the cable.

Temperature range

HEIDENHAIN cables can be used:

- for rigid configuration: -40 to 85 °C
- for moving cables: -10 to 85 °C

Bending radius

The permissible bending radii $R$ depend on the cable diameter and the configuration:

<table>
<thead>
<tr>
<th>Stationary cable</th>
<th>Moving cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø 3.7 mm</td>
<td>R ≥ 8 mm</td>
</tr>
<tr>
<td>Ø 4.5 mm</td>
<td>R ≥ 10 mm</td>
</tr>
<tr>
<td>Ø 5.1 mm</td>
<td>R ≥ 10 mm</td>
</tr>
<tr>
<td>Ø 6 mm</td>
<td>R ≥ 20 mm</td>
</tr>
<tr>
<td>Ø 8 mm</td>
<td>R ≥ 40 mm</td>
</tr>
<tr>
<td>Ø 10 mm</td>
<td>R ≥ 35 mm</td>
</tr>
<tr>
<td>Ø 14 mm¹⁾</td>
<td>R ≥ 50 mm</td>
</tr>
</tbody>
</table>

¹⁾ Only for LIDA 400
Reliable Signal Transmission

Electromagnetic compatibility/CE compliance
When properly installed, HEIDENHAIN encoders fulfill the requirements for electromagnetic compatibility according to 89/336/EEC with respect to the generic standards for:

• Noise immunity (IEC 61000-6-2)
  Specifically:
  – ESD EN 61000-4-2
  – Electromagnetic fields EN 61000-4-3
  – Burst EN 61000-4-4
  – Surge EN 61000-4-5
  – Conducted disturbances EN 61000-4-6
  – Power frequency magnetic fields EN 61000-4-8
  – Pulse magnetic fields EN 61000-4-9

• Interference (EN 61000-6-4):
  Specifically:
  – For industrial, scientific and medical (ISM) equipment EN 55011
  – For information technology equipment EN 55022

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

Possible sources of noise are:
• Strong magnetic fields from transformers and electric motors
• Relays, contactors and solenoid valves
• High-frequency equipment, pulse devices, and stray magnetic fields from switch-mode power supplies
• AC power lines and supply lines to the above devices

Isolation
The encoder housings are isolated against all circuits.
Rated surge voltage: 500 V (preferred value as per VDE 0110 Part 1)

Protection against electrical noise
The following measures must be taken to ensure disturbance-free operation:
• Use only original HEIDENHAIN cables. Watch for voltage attenuation on the supply lines.
• Use connectors or terminal boxes with metal housings. Do not conduct any extraneous signals.
• Connect the housings of the encoder, connector, terminal box and evaluation electronics through the shield of the cable. Connect the shielding in the area of the cable inlets to be as induction-free as possible (short, full-surface contact).
• Connect the entire shielding system with the protective ground.
• Prevent contact of loose connector housings with other metal surfaces.
• The cable shielding has the function of an equipotential bonding conductor. If compensating currents are to be expected within the entire system, a separate equipotential bonding conductor must be provided. Also see EN 50178/4.98 Chapter 5.2.9.5 regarding “protective connection lines with small cross section.”
• Connect HEIDENHAIN position encoders only to subsequent electronics whose power supply is generated through double or strengthened insulation against line voltage circuits. Also see IEC 364-4-41: 1992, modified Chapter 411 regarding “protection against both direct and indirect touch” (PELV or SELV).

Do not lay signal cables in the direct vicinity of interference sources (inductive consumers such as contacts, motors, frequency inverters, solenoids, etc.).

Sufficient decoupling from interference-signal-conducting cables can usually be achieved by an air clearance of 100 mm or, when cables are in metal ducts, by a grounded partition.

A minimum spacing of 200 mm to inductors in switch-mode power supplies is required. Also see EN 50178/4.98 Chapter 5.3.1.1 regarding cables and lines, EN 50174-2/09.01, Chapter 6.7 regarding grounding and potential compensation.

When using multiturn encoders in electromagnetic fields greater than 30 mT, HEIDENHAIN recommends consulting with the main facility in Traunreut.

Both the cable shielding and the metal housings of encoders and subsequent electronics have a shielding function. The housings must have the same potential and be connected to the main signal ground over the machine chassis or by means of a separate potential compensating line. Potential compensating lines should have a minimum cross section of 6 mm² (Cu).

Minimum distance from sources of interference
**Evaluation and Display Units**

**ND 281 B Position Display Unit**
The ND 281 B position display unit contains special display ranges for angle measurement. You can directly connect incremental angle encoders with 1-Vpp output signals and any line count up to 999,999 signal periods per revolution. The display value is available via the RS-232-C/V.24 interface for further processing or print-out.

For more information, see the *Numerical Displays for Length and Angle* catalog.

<table>
<thead>
<tr>
<th><strong>Input signals</strong></th>
<th><strong>ND 281 B</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoder inputs</td>
<td>Flange socket, 12-pin female</td>
</tr>
<tr>
<td>Input frequency</td>
<td>Max. 500 kHz</td>
</tr>
<tr>
<td>Max. cable length</td>
<td>60 m</td>
</tr>
<tr>
<td><strong>Signal subdivision</strong></td>
<td>Up to 1024-fold (adjustable)</td>
</tr>
<tr>
<td><strong>Display step</strong> (adjustable)</td>
<td>Decimal degrees: 0.1° to 0.000002°</td>
</tr>
<tr>
<td><strong>Display range</strong> (adjustable)</td>
<td>0 to 360°</td>
</tr>
<tr>
<td><strong>Features</strong></td>
<td>Sorting and tolerance check mode with two limit values</td>
</tr>
<tr>
<td><strong>External operation</strong></td>
<td>Zero reset, preset and latch command</td>
</tr>
<tr>
<td><strong>Interface</strong></td>
<td>RS-232-C/V.24; max. 38400 baud</td>
</tr>
</tbody>
</table>

**IBV Series Interpolation and Digitizing Electronics**
Interpolation and digitizing electronics interpolate and digitize the sinusoidal output signals (1 Vpp) from HEIDENHAIN encoders up to 100-fold, and convert them to TTL square-wave pulse sequences.

For more information, see the *Interpolation and Digitizing Electronics* brochure for IBV 660 as well as the *IBV 100/EXE 100* product overview.

<table>
<thead>
<tr>
<th><strong>Input signals</strong></th>
<th><strong>IBV 101</strong></th>
<th><strong>IBV 102</strong></th>
<th><strong>IBV 660</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoder inputs</td>
<td>Flange socket, 12-pin female</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Interpolation</strong> (adjustable)</td>
<td>5-fold</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10-fold</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-fold</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50-fold</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100-fold</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>200-fold</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>400-fold</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Minimum edge separation</strong></td>
<td>Adjustable from 2 to 0.125 µs, depending on input frequency</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adjustable from 0.8 to 0.1 µs, depending on input frequency</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Output signals</strong></td>
<td>Two TTL square-wave pulse trains ( U_a1 ) and ( U_a2 ) and their inverted signals ( \overline{U_a1} ) and ( \overline{U_a2} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reference pulse ( U_{r0} ) and ( \overline{U_{r0}} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fault detection signal ( U_{s3} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Power supply</strong></td>
<td>5 V ± 5%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**IK 220
Universal PC Counter Card**
The IK 220 is an expansion board for AT-compatible PCs for recording the measured values of two incremental or absolute linear or angle encoders. The subdivision and counting electronics subdivide the sinusoidal input signals to generate up to 4096 measuring steps per input signal period. A driver software package is included in delivery.

<table>
<thead>
<tr>
<th><strong>Input signals</strong> (switchable)</th>
<th>IK 220</th>
</tr>
</thead>
<tbody>
<tr>
<td>– 1 V&lt;sub&gt;PP&lt;/sub&gt;</td>
<td>– 11 μA&lt;sub&gt;PP&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Encoder inputs</strong></th>
<th>Two D-sub connectors (15-pin), male</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Max. input frequency</strong></td>
<td>500 kHz 33 kHz –</td>
</tr>
<tr>
<td><strong>Max. cable length</strong></td>
<td>60 m 10 m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Signal subdivision</strong> (signal period to meas. step)</th>
<th>Up to 4096-fold</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data register for measured values</strong> (per channel)</td>
<td>48 bits (44 bits used)</td>
</tr>
<tr>
<td><strong>Internal memory</strong></td>
<td>For 8192 position values</td>
</tr>
<tr>
<td><strong>Interface</strong></td>
<td>PCI bus (plug and play)</td>
</tr>
<tr>
<td><strong>Driver software and demonstration program</strong></td>
<td>For WINDOWS 98/NT/2000/XP In VISUAL C++, VISUAL BASIC and BORLAND DELPHI</td>
</tr>
</tbody>
</table>

| **Dimensions**                                      | Approx. 190 mm × 100 mm |

For more information, see the IK 220 Product Information sheet.
HEIDENHAIN Measuring Equipment
For Incremental Angle Encoders

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

<table>
<thead>
<tr>
<th>PWM 9</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inputs</strong></td>
</tr>
<tr>
<td>Expansion modules (interface boards) for 11 µA&lt;sub&gt;PP&lt;/sub&gt;; 1 V&lt;sub&gt;PP&lt;/sub&gt;; TTL; HTL; EnDat*/SSI*/commutation signals</td>
</tr>
<tr>
<td>*No display of position values or parameters</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>• <strong>Measures</strong> signal amplitudes, current consumption, operating voltage, scanning frequency</td>
</tr>
<tr>
<td>• <strong>Graphically displays</strong> incremental signals (amplitudes, phase angle and on-off ratio) and the reference-mark signal (width and position)</td>
</tr>
<tr>
<td>• <strong>Displays symbols</strong> for the reference mark, fault detection signal, counting direction</td>
</tr>
<tr>
<td>• <strong>Universal counter</strong>, interpolation selectable from single to 1024-fold</td>
</tr>
<tr>
<td>• <strong>Adjustment support</strong> for exposed linear encoders</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Inputs are connected through to the subsequent electronics</td>
</tr>
<tr>
<td>• BNC sockets for connection to an oscilloscope</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 to 30 V, max. 15 W</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 mm x 205 mm x 96 mm</td>
</tr>
</tbody>
</table>

The **PWT** is a simple adjusting aid for HEIDENHAIN incremental encoders. In a small LCD window the signals are shown as bar charts with reference to their tolerance limits.

<table>
<thead>
<tr>
<th>PWT 10</th>
<th>PWT 17</th>
<th>PWT 18</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Encoder input</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>~ 11 µA&lt;sub&gt;PP&lt;/sub&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TTL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>~ 1 V&lt;sub&gt;PP&lt;/sub&gt;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement of signal amplitude</td>
</tr>
<tr>
<td>Wave-form tolerance</td>
</tr>
<tr>
<td>Amplitude and position of the reference mark signal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via power supply unit (included)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>114 mm x 64 mm x 29 mm</td>
</tr>
</tbody>
</table>

For Absolute Angle Encoders

The **IK 215** is an adapter card for PCs for inspecting and testing absolute HEIDENHAIN encoders with EnDat or SSI interface. Parameters can be read and written via the EnDat interface.

<table>
<thead>
<tr>
<th>IK 215</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Encoder inputs</strong></td>
</tr>
<tr>
<td>EnDat 2.1 (absolute value or incremental signals) or SSI</td>
</tr>
</tbody>
</table>

| Interface |
| PCI bus, Rev. 2.1 |

| Application software |
| Operating system: Windows 2000/XP |
| Display of position value |
| Counter for incremental signals |
| EnDat functions |
| Mounting software for ExI 1100/1300 |

| Signal subdivision for incremental signals |
| Up to 1024-fold |

| Dimensions |
| 100 mm x 190 mm |