Exposed linear encoders

Linear encoders measure the position of linear axes without additional mechanical transfer elements. A number of potential error sources are thereby eliminated:
- Positioning error due to heat generation in the recirculating ball screw
- Reversal error
- Kinematic error through the ball-screw pitch error

Linear encoders are therefore indispensable for machine tools on which high positioning accuracy and a high machining rate are essential.

Exposed linear encoders are used on machines and equipment that require high measuring accuracy. Typical applications include the following:
- Measuring and production equipment in the semiconductor industry
- PCB assembly machines
- Ultra-precision machines and devices such as diamond lathes for optical components, facing lathes for magnetic storage disks, and grinding machines for ferrite components
- High-accuracy machine tools
- Measuring machines and comparators, measuring microscopes, and other precision measuring devices
- Direct drive motors

Mechanical design
Exposed linear encoders consist of a scale or scale tape and a scanning head that operate without mechanical contact. The scales of exposed linear encoders are fastened to a mounting surface. High flatness of the mounting surface is thus an important requirement for the high accuracy of linear encoders.

Information on the following topics is available upon request or on the Internet at www.heidenhain.com:
- Angle encoders with integral bearing
- Modular angle encoders with optical scanning
- Modular angle encoders with magnetic scanning
- Rotary encoders
- Encoders for servo drives
- Linear encoders for numerically controlled machine tools
- Interface electronics
- HEIDENHAIN controls

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

Standards (ISO, EN, etc.) apply only where explicitly stated in the brochure.

Further information:
For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the Interfaces of HEIDENHAIN Encoders brochure (ID 1078288-xx). For the required cables, please refer to the Cables and Connectors brochure (ID 1208103-xx).

Contents

Overview
Exposed linear encoders 2
Selection guide 4

Technical characteristics
Measuring principles 8
Reliability 12
Measuring accuracy 14
Mechanical design types and mounting 17
General mechanical information 21
Functional safety 22

Specifications
For absolute position measurement
LIC 4113, LIC 4193 24
LIC 4115, LIC 4195 26
LIC 4117, LIC 4197 28
LIC 4119, LIC 4199 30
LIC 4119FS 32
LIC 3117, LIC 3197 34
LIC 3119, LIC 3199 36
LIC 2117, LIC 2197 38
LIC 2119, LIC 2199 40

For high accuracy
LIP 382 42
LIP 216, LIP 281, LIP 291 44
LIP 6071, LIP 6081 46
LIF 471, LIF 481 48

For high traversing speed
LIDA 473, LIDA 483 50
LIDA 475, LIDA 485 52
LIDA 477, LIDA 487 54
LIDA 479, LIDA 489 56
LIDA 277, LIDA 287 58
LIDA 279, LIDA 289 60

For high traversing speed
LIDA 473, LIDA 483 50
LIDA 475, LIDA 485 52
LIDA 477, LIDA 487 54
LIDA 479, LIDA 489 56
LIDA 277, LIDA 287 58
LIDA 279, LIDA 289 60

For two-coordinate measurement
PP 281R 62

Electrical connection
Interfaces 64
Testing equipment and diagnostics 71
Interface electronics 73
### Absolute position measurement

The LIC exposed linear encoders permit absolute position measurement over long traverse paths of up to 28 m at high traversing speed.

### Encoders for use in a vacuum environment

HEIDENHAIN standard encoders are suitable for use in rough or fine vacuums. Encoders used in high and ultrahigh vacuums must meet special requirements. The design and materials used for such encoders must be specifically tailored to these conditions. For more information, please refer to the Linear Encoders for Vacuum Technology Technical Information document.

The LIC 4113V and LIC 4193V linear encoders are specifically designed for use in high vacuums. For more information, please refer to the appropriate Product Information documents.

<table>
<thead>
<tr>
<th>Model</th>
<th>Baseline error</th>
<th>Substrate and mounting</th>
<th>Interpolation error</th>
<th>Measuring length</th>
<th>Interface</th>
<th>Model</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIC 4100</td>
<td>±1 µm1) ±3 µm ±5 µm</td>
<td>Glass or glass ceramic scale, adhesively bonded to the mounting surface or fastened with fixing clamps</td>
<td>±0.020 nm</td>
<td>240 mm to 3040 mm</td>
<td>EnDat 2.2</td>
<td>LIC 4113</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steel scale tape pulled through aluminum extrusions and tensioned</td>
<td>±0.020 nm</td>
<td>140 mm to 28440 mm</td>
<td>EnDat 2.2</td>
<td>LIC 4115</td>
<td>26</td>
</tr>
<tr>
<td>LIC 4113</td>
<td>±5 µm</td>
<td>Steel scale tape, adhesively bonded to mounting surface</td>
<td>±0.020 nm</td>
<td>70 mm to 1020 mm</td>
<td>EnDat 2.2</td>
<td>LIC 4117</td>
<td>28</td>
</tr>
<tr>
<td>LIC 4193</td>
<td>±3 µm ±5 µm ±15 µm2)</td>
<td>Steel scale tape, adhesively bonded to mounting surface</td>
<td>±0.020 nm</td>
<td>70 mm to 1820 mm</td>
<td>EnDat 2.2</td>
<td>LIC 4119</td>
<td>30</td>
</tr>
<tr>
<td>LIC 4115</td>
<td>±1 µm3) ±3 µm ±5 µm ±15 µm4)</td>
<td>Steel scale tape, adhesively bonded to mounting surface</td>
<td>±0.020 nm</td>
<td>Up to 10000 mm</td>
<td>EnDat 2.2</td>
<td>LIC 3117</td>
<td>34</td>
</tr>
<tr>
<td>LIC 4117</td>
<td>±15 µm5)</td>
<td>Steel scale tape, adhesively bonded to mounting surface</td>
<td>±0.020 nm</td>
<td>120 mm to 3020 mm</td>
<td>EnDat 2.2</td>
<td>LIC 2117</td>
<td>38</td>
</tr>
<tr>
<td>LIC 4119</td>
<td>±15 µm6)</td>
<td>Steel scale tape, adhesively bonded to mounting surface</td>
<td>±0.020 nm</td>
<td>120 mm to 3020 mm</td>
<td>EnDat 2.2</td>
<td>LIC 2119</td>
<td>40</td>
</tr>
</tbody>
</table>

1) Up to a measuring length (ML) of 1640 mm
2) For a measuring length (ML) of 1240 mm or greater
3) ±5 µm after linear length-error compensation in the subsequent electronics
4) With HEIDENHAIN Interface electronics
5) Fanuc, a-, Mitsubishi, Panasonic, Yaskawa

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**Note:**

- LIC 41x3, LIC 41x5, LIC 41x7, LIC 31x9, LIC 21x7, LIC 21x9 are available with the indicated models.

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**Selection guide**

**Absolute encoders**

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**Absolute position measurement**

The LIC exposed linear encoders permit absolute position measurement over long traverse paths of up to 28 m at high traversing speed.

**Encoders for use in a vacuum environment**

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The LIC 4113V and LIC 4193V linear encoders are specifically designed for use in high vacuums. For more information, please refer to the appropriate Product Information documents.

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**Baseline error**

- **Accuracy grade:** ±1 µm
- **Interval:** ±0.027 µm
- **Substrate and mounting:** Glass or glass ceramic scale, adhesively bonded to the mounting surface or fastened with fixing clamps
- **Interpolation error:** ±0.020 nm
- **Measuring length:** 240 mm to 3040 mm

**Interface:** EnDat 2.2

**Model:** LIC 4113

**Page:** 24
### Very high accuracy

The LIP exposed linear encoders are characterized by their very small measuring steps combined with extremely high accuracy and repeatability. They utilize the interferential scanning principle and feature an OPTODUR phase grating as their measuring standard. The LIP 211 and LIP 291 linear encoders output the position information as a position value. For this to occur, the sinusalodial scanning signals are highly interpolated in the scanning head and converted into a position value by the integrated counter function. As with all incremental encoders, the absolute reference is established by means of reference marks.

**High accuracy**

The LIF exposed linear encoders utilize the interferential scanning principle and possess a measuring standard made with the SUPRADUR process. They feature high accuracy and repeatability, are particularly easy to mount, and are equipped with limit switches and homing tracks. The special version LIF 481 V can be used in high vacuum chambers of up to 10^-7 mbar (see product information document).

**High traversing speeds**

The LIDA exposed linear encoders are designed for high traversing speeds of up to 10 m/s. Their various mounting options allow for particularly flexible deployment. Depending on the version, steel scale tapes, glass, or glass ceramic are used as the carriers for METALLUR gratings. They also feature limit switches.

**Two-coordinate measurement**

The measuring standard of the PP two-coordinate encoder is an interferentially scanned planar phase grating manufactured with the DIADUR process. Position measurement is thereby possible within a plane.

<table>
<thead>
<tr>
<th>incremental encoder</th>
<th>baseline error</th>
<th>interval</th>
<th>substrate and mounting</th>
<th>interpolation error</th>
<th>signal period</th>
<th>measuring length</th>
<th>interface</th>
<th>model</th>
<th>page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LIP</strong></td>
<td>±0.5 µm</td>
<td>≤0.075 µm</td>
<td>Zerodur glass ceramic embedded within a screw-on linear carrier</td>
<td>±0.01 mm</td>
<td>0.128 µm</td>
<td>70 mm to 270 mm</td>
<td>1 Vpp</td>
<td>LIP 382</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>±0.1 µm</td>
<td>≤0.125 µm</td>
<td>Scale made of Zerodur glass ceramic, fastened with fixing clamps</td>
<td>±0.4 mm</td>
<td>0.512 µm</td>
<td>20 mm to 3040 mm</td>
<td>1 Vpp</td>
<td>LIP 211</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>±0.1 µm</td>
<td>≤0.175 µm</td>
<td>Scale made of Zerodur glass ceramic or glass, adhesively bonded or fastened with fixing clamps</td>
<td>±1 µm</td>
<td>4 µm</td>
<td>70 mm to 3040 mm</td>
<td>1 Vpp</td>
<td>LIP 281</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>±0.25 µm</td>
<td>≤0.225 µm</td>
<td>Scale made of Zerodur glass ceramic or glass, adhesively bonded or fastened with fixing clamps</td>
<td>±12 nm</td>
<td>4 µm</td>
<td>70 mm to 3040 mm</td>
<td>1 Vpp</td>
<td>LIP 6071</td>
<td>46</td>
</tr>
<tr>
<td><strong>LIF</strong></td>
<td>±0.1 µm</td>
<td>≤0.075 µm</td>
<td>Zerodur glass ceramic or glass, adhesively bonded or fastened with fixing clamps</td>
<td>±1 µm</td>
<td>4 µm</td>
<td>70 mm to 3040 mm</td>
<td>1 Vpp</td>
<td>LIF 171</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>±0.1 µm</td>
<td>≤0.175 µm</td>
<td>Scale made of Zerodur glass ceramic or glass, adhesively bonded or fastened with fixing clamps</td>
<td>±12 nm</td>
<td>4 µm</td>
<td>70 mm to 1640 mm</td>
<td>1 Vpp</td>
<td>LIF 471</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>±0.25 µm</td>
<td>≤0.225 µm</td>
<td>Scale made of Zerodur glass ceramic or glass, adhesively bonded or fastened with fixing clamps</td>
<td>±5 µm</td>
<td>4 µm</td>
<td>70 mm to 1640 mm</td>
<td>1 Vpp</td>
<td>LIF 481</td>
<td>41</td>
</tr>
<tr>
<td><strong>LIDA</strong></td>
<td>±0.1 µm</td>
<td>≤0.075 µm</td>
<td>Steel scale tape pulled through aluminum extrusions and tensioned</td>
<td>±1 µm</td>
<td>20 µm</td>
<td>240 mm to 3040 mm</td>
<td>1 Vpp</td>
<td>LIDA 473</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>±0.1 µm</td>
<td>≤0.175 µm</td>
<td>Steel scale tape pulled through aluminum extrusions and secured</td>
<td>±1 µm</td>
<td>20 µm</td>
<td>240 mm to 6040 mm</td>
<td>1 Vpp</td>
<td>LIDA 483</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>±0.1 µm</td>
<td>≤0.25 µm</td>
<td>Steel scale tape, adhesively bonded to mounting surface</td>
<td>±1 µm</td>
<td>20 µm</td>
<td>Up to 6500 mm</td>
<td>1 Vpp</td>
<td>LIDA 479</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>±0.15 µm</td>
<td>≤0.75 µm</td>
<td>Steel scale tape, adhesively bonded to mounting surface</td>
<td>±2 µm</td>
<td>200 µm</td>
<td>Up to 10 000 mm</td>
<td>1 Vpp</td>
<td>LIDA 287</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>±0.15 µm</td>
<td>≤0.75 µm</td>
<td>Steel scale tape, adhesively bonded to mounting surface</td>
<td>±2 µm</td>
<td>200 µm</td>
<td>Up to 10 000 mm</td>
<td>1 Vpp</td>
<td>LIDA 279</td>
<td>60</td>
</tr>
<tr>
<td><strong>PP</strong></td>
<td>±0.2 µm</td>
<td>–</td>
<td>Glass grid plate, secured with full-surface adhesive bond</td>
<td>±12 nm</td>
<td>4 µm</td>
<td>Measuring area: 68 x 68 mm</td>
<td>1 Vpp</td>
<td>PP 281</td>
<td>62</td>
</tr>
</tbody>
</table>

1. At an interval of 1 m or a measuring length < 1 m (accuracy grade)
2. Up to a measuring length of 1020 mm or 1040 mm
3. Higher accuracy grades upon request
4. Other measuring lengths / measuring areas upon request
5. Only for Zerodur glass ceramic up to a measuring length of 1640 mm
6. ±5 µm after linear length error compensation in the subsequent electronics
7. With HEIDENHAIN interface electronics
8. Up to a measuring length of 1640 mm
9. Only for Robax glass ceramic up to a measuring length of 1640 mm
Measuring principles

Measuring standard

HEIDENHAIN encoders with optical scanning incorporate measuring standards consisting of periodic structures known as graduations. These graduations are applied to a carrier substrate made of glass or steel. For encoders with large measuring lengths, steel tape is used as the scale substrate.

HEIDENHAIN manufactures the precision graduations in the following specially developed, photolithographic processes:

• METALLUR: contamination-tolerant graduation consisting of metal lines on gold; typical grating period: 20 µm
• SUPRADUR phase grating: optically three-dimensional, planar structure; particularly tolerant to contamination; typical grating period: 8 µm and finer
• OPTODUR phase grating: optically three-dimensional, planar structure with particularly high reflectance; typical grating period: 2 µm and finer
• TITANID phase grating: exceptionally robust, optically three-dimensional structure with a high degree of reflectance; typical grating period: 8 µm

Along with the very fine grating periods, these processes permit high edge definition and excellent homogeneity of the graduation. In combination with the photoelectric scanning method, these characteristics are crucial for attaining high-quality output signals.

The master graduations are manufactured by HEIDENHAIN on custom-built, high-precision dividing engines.

Absolute measuring method

With the absolute measuring method, the position value is available immediately upon switch-on of the encoder and can be requested at any time by the subsequent electronics. There is no need to move the axes to find the reference position. The absolute position information is read from the graduation on the measuring standard, which is designed as a serial absolute code structure. A separate incremental track is interpolated for the position value and, depending on the interface version, is also used to generate an optional incremental signal.

In the most unfavorable case, machine movements over sizeable sections of the measuring range may be necessary. To speed up and simplify such “reference runs,” many HEIDENHAIN encoders feature distance-coded reference marks—multiple reference marks that are individually spaced in accordance with a mathematical algorithm. The subsequent electronics find the absolute reference after traversing two successive reference marks—thus after a traverse path of only a few millimeters (see table below).

Encoders with distance-coded reference marks are identified with a “C” following the model designation (e.g., LIF 181C).

With distance-coded reference marks, the absolute reference \(R\) is calculated by counting the increments between two reference marks and by applying the following formula:

\[
P_1 = (\text{abs } R - \text{sgn } R - 1) \times N + (\text{sgn } R - \text{sgn } D) \times \text{abs } MRR
\]

\[
R = 2 \times \text{MRR} - N
\]

Where:

- \(P_1\) = Position of the first traversed reference mark in signal periods
- \(\text{abs}\) = Absolute value
- \(\text{sgn}\) = Algebraic sign function (“+1” or “–1”)
- \(MRR\) = Number of signal periods between the traversed reference marks
- \(N\) = Nominal increment between two fixed reference marks in signal periods (see table below)
- \(D\) = Direction of traverse (+1 or –1).

Traverse of scanning unit to the right (when properly installed) equals +1

Schematic representation of an code structure with an additional incremental track (example from the LIC 411x)

Graduations of incremental linear encoders

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 measuring standard is provided with an additional track that bears a reference mark. The absolute position on the scale, which is established by the reference mark, is assigned to exactly one signal period. Thus, before an absolute reference can be established or the most recently selected reference point can be refound, this reference mark must first be traversed.

In the most unfavorable case, machine movements over sizeable sections of the measuring range may be necessary. To speed up and simplify such “reference runs,” many HEIDENHAIN encoders feature distance-coded reference marks—multiple reference marks that are individually spaced in accordance with a mathematical algorithm. The subsequent electronics find the absolute reference after traversing two successive reference marks—thus after a traverse path of only a few millimeters (see table below).

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\]

\[
R = 2 \times \text{MRR} - N
\]

Where:

- \(P_1\) = Position of the first traversed reference mark in signal periods
- \(\text{abs}\) = Absolute value
- \(\text{sgn}\) = Algebraic sign function (“+1” or “–1”)
- \(MRR\) = Number of signal periods between the traversed reference marks
- \(N\) = Nominal increment between two fixed reference marks in signal periods (see table below)
- \(D\) = Direction of traverse (+1 or –1).

Traverse of scanning unit to the right (when properly installed) equals +1

Schematic representation of an incremental graduation with distance-coded reference marks (example from the LIDA 4x3C)
Most HEIDENHAIN encoders utilize the photoelectric scanning principle. Photoelectric scanning is performed contact-free and thus does not induce wear. This method detects even extremely fine graduation lines down to a width of only a few micrometers and generates output signals with very small signal periods.

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

- The **imaging scanning principle** for grating periods from 10 µm to 200 µm
- The **interferential scanning principle** for very fine grating periods of 4 µm and smaller

### Imaging scanning principle

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

When parallel light passes through a grating structure, light and dark fields are projected at a certain interval. At this location there is an index grating with the same or similar grating period. When the two gratings move relative to each other, the incident light is modulated: If the gaps are aligned, light passes through. If the lines of one grating coincide with the gaps of the other, no light passes through.

Photocells convert these light fluctuations into electrical signals. The specially structured grating of the scanning reticle filters the light to generate nearly sinusoidal output signals. The smaller the grating period of the grating structure is, the closer and more tightly tolerated the gap must be between the scanning reticle and the scale. In encoders that use the imaging scanning principle, workable mounting tolerances are attainable starting at a minimum grating period of 10 µm.

The LIC and LIDA linear encoders use the imaging scanning principle.

### Interferential scanning principle

The interferential scanning principle exploits the diffraction and interference of light on finely divided gratings in order to produce the signals used to measure displacement.

A step grating is used as the measuring standard: reflective lines with a height of 0.2 µm are applied to a flat, reflective surface. In front of this 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 nearly 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. Photocells convert these alternating light intensities into electrical signals.

When there is relative motion between the scale and the scanning reticle, the diffracted wavefronts undergo a phase shift: movement by the amount of one grating period shifts the positive first-order diffraction wavefront by one wavelength in the positive direction, while the negative first-order diffraction wavefront is displaced by one wavelength in the negative direction.

Since the two waves interfere with each other upon exiting the phase grating, these waves are shifted relative to each other by two wavelengths. This results in two signal periods when there is relative motion of just one grating period.

Interferential encoders use grating periods of, for example, 8 µm, 4 µm, and finer. Their scanning signals are largely free of harmonics and can be highly interpolated. These encoders are therefore especially well-suited for small measuring steps and high accuracy. They nevertheless feature workable mounting tolerances.

The LIP, LIF, and PP linear encoders use the interferential scanning principle.
Exposed linear encoders from HEIDENHAIN are optimized for use on fast, precise machines. Despite their exposed mechanical design, these encoders are highly insensitive to contamination, ensure high long-term stability, and are quickly and easily mounted.

Lower sensitivity to contamination
Both the high quality of the grating and the scanning method are responsible for the accuracy and reliability of linear encoders. Exposed linear encoders from HEIDENHAIN employ single-field scanning, in which a single large scanning field is used to generate the scanning signals. Local contamination on the measuring standard (e.g., fingerprints from the mounting process or oil residues from guide ways) has only a slight influence on the light intensity of the signal components and thus on the scanning signals. Although this contamination does cause a change in the amplitude of the output signals, their offset and phase position remain unaffected. The signals remain highly interpolation errors and the position error within one single period remains small.

The large scanning field further reduces the sensitivity to contamination. Depending on the nature of the contamination, this feature can even prevent encoder failure. This is particularly true of the LIDA 400 and LIF 400, which feature a very large scanning surface area (14.5 mm²) relative to their grating period. The same goes for the LIC 4100, which has a scanning surface area of 19.5 mm². Even in the case of contamination from printer’s ink, PCB dust, or drops of water or oil of up to 3 mm in diameter, these encoders continue to provide high-quality signals. The position error remains far below the values specified for the accuracy grade of the scale.

The LIDA, LIC, and LID 6000 encoders are equipped with the HSP 1.0 signal processor ASIC from HEIDENHAIN. This ASIC continuously monitors the scanning signal and compensates nearly completely for fluctuations in signal amplitude. If the signal amplitude decreases as the result of contamination on the scanning reticle or measuring standard, the ASIC reacts by increasing the LED current. The ensuing increase in LED light intensity barely raises the noise level, even in the case of strong signal stabilization. As a result, contamination has only a very slight influence on interpolation errors and the position noise.

Durable measuring standards
By nature of their design, the measuring standards of exposed linear encoders are less protected from their environment. For this reason, HEIDENHAIN always uses tough graduations manufactured in special processes.

In the OPTODUR and SUPRADUR processes, a transparent layer is first applied onto the reflective primary layer. For creating an optically three-dimensional phase grating, an extremely thin, hard chromium layer is applied at a thickness of only a few nanometers. The graduations for the imaging scanning principle exhibit a similar design and are manufactured in the METALLUR process. A reflective gold layer is covered with a thin layer of glass. On it are chromium lines acting as absorbers. Since they are only several nanometers thick, these lines are semitransparent. Measuring standards with OPTODUR, SUPRADUR, or METALLUR graduations have proven to be particularly robust and insensitive to contamination because the low height of their structure leaves practically no surface for dust, dirt, or water particles to accumulate.

Workable mounting tolerances
Very small signal periods usually come with very narrow mounting tolerances for the gap between the scanning head and scale tape. This is the result of diffraction caused by the grating structures. Such diffraction can lead to a signal attenuation of 50 % upon a gap change of only ±0.1 mm. The interferential scanning principle and innovative index gratings on encoders that use the imaging principle allow for workable mounting tolerances despite tiny signal periods.

The mounting tolerances of exposed linear encoders from HEIDENHAIN have only a slight influence on the output signals. In particular, the specified distance tolerance between the scale and scanning head (scanning gap) causes only a negligible change in the signal amplitude. During operation, the reliability and stability of the signals are additionally improved by the HSP 1.0. The two diagrams illustrate the correlation between the scanning gap and signal amplitude for the encoders of the LIDA 400 and LIF 400 series.
Measuring accuracy

Accuracy of the measuring standard
The accuracy of the measuring standard is mainly determined by:
- the homogeneity and period definition of the graduation,
- the alignment of the graduation on its carrier, and
- the stability of the graduation carrier.

Encoder-specific position error
Encoder-specific position error includes:
- the accuracy of the measuring standard,
- the accuracy of the interpolation, and
- the position noise.

Accuracy of the interpolation
The accuracy of the interpolation is mainly influenced by:
- the size of the signal period,
- the homogeneity and period definition of the graduation,
- the quality of scanning filter structures,
- the characteristics of the sensors, and
- the quality of the signal processing.

Position noise
Position noise is a random process leading to unpredictable position errors. The position values are grouped around an expected value in the form of a frequency distribution.

Application-dependent position error
In the case of encoders without integral bearing, installing the encoder in the machine has a significant influence on the attainable overall accuracy beyond the specified encoder-specific position error. For assessment of the overall accuracy, the individual application-dependent errors must be measured and taken into account.

Deformation of the graduation
Errors due to a deformation of the graduation are not to be neglected. Such deformation occurs when the measuring standard is mounted on an uneven surface (e.g., a convex surface).

Mounting location
Poor mounting of linear encoders can aggravate the effect of guideway error on measuring accuracy. To keep the resulting Abbé error as small as possible, the scale should ideally be mounted to the machine slide and at the height of the table. It is important to ensure that the mounting surface is parallel to the machine guideway.

Vibration
To function properly, linear encoders must not be continuously subjected to strong vibration. The best mounting surfaces are therefore solid and stable machine elements. Encoders should not be mounted on hollow parts or with adapter blocks, etc.

Influence of temperature
In order to avoid temperature effects, the linear encoders should not be mounted in close proximity to heat sources.
Exposed linear encoders are made up of two separate components: the scanning head and linear scale or scale tape, which are brought together solely over the machine guideway. For this reason, the machine must be designed from the very beginning to meet the following requirements:

- The machine guideway must be designed such that the scanning gap tolerances are complied with at the location where the encoder is installed (see Specifications).
- The mounting surface of the scale must meet the flatness requirements.
- To facilitate adjustment of the scanning head to the scale, the scanning head should be fastened with a mounting bracket.

**Scale versions**

HEIDENHAIN provides the appropriate scale version for the given application and accuracy requirements.

- **LIP 201**
- **LIP 6001**
- **LIC 4003**

The graduation carriers are fastened directly to the mounting surface with clamps. A holder is used to define the thermal fixed point.

**Accessories for the LIC 41x3 and LIP 60x1**

- **Fixing clamps** (ID 1196458-01)
- **Holder for thermal fixed point** (ID 1176475-01)
- **Spacer shims** (ID 1180450-01)
- **Adhesive* (ID 1180444-01)
- **Double-cartridge gun** (ID 1180450-01)
- **Dispensing nozzles and mixing tubes** (ID 1180444-01)

**LIP 6001**

- **LIF 401**
- **LIDA 403**
- **LIC 4003**

The graduation carriers are adhesively bonded directly to the mounting surface with PRECIMET adhesive mounting film, with even pressure applied by means of a roller. A thermal fixed point can be established at a location with epoxy adhesive.

**Accessory**

- **Roller** (ID 276885-01)

* Caution: no transport by air
**dangerous goods**

Trade name: 3M Scotch-Weld
Epoxy Adhesive DP-460 EG
Linear encoders of the LIC 41x5 and LIDA 4x5 series are specially designed for long measuring lengths. They are mounted with scale carrier sections screwed onto the mounting surface or adhesively bonded with PRECIMET adhesive mounting film. The single-piece steel scale tape is then pulled through the carrier sections, tensioned as specified, and secured at its ends to the machine base. The LIC 41x5 and LIDA 4x5 encoders thereby exhibit the same thermal behavior as that of the mounting surface.

The encoders of these series are also designed for long measuring lengths. The scale carrier sections are adhesively bonded to the mounting surface with PRECIMET adhesive mounting film; the single-piece scale tape is pulled through, and the midpoint is secured to the machine base. This mounting method allows the scale tape to expand freely at both ends and ensures a defined thermal behavior.

Accessory for LIC 41x2, LIDA 4x7
Mounting aid ID 373950-01

The steel scale tape of the graduation is adhesively bonded directly to the mounting surface with PRECIMET adhesive mounting film, with pressure applied evenly with a roller. A ridge or aligning rail with a height of 0.3 mm must be provided for the horizontal alignment of the scale tape.

Accessories for versions with PRECIMET
Roller ID 278999-01
Mounting aid, LIDA 2x9 ID 1070297-01
Mounting aid, LIC 21x9 ID 1070802-01

Because exposed linear encoders are assembled on the machine, they must be precisely adjusted after mounting. This adjustment determines the final accuracy of the encoder. It is therefore advisable to design the machine such that this adjustment is as easy and practical as possible, while also ensuring the greatest possible degree of mounting stability.

Mounting the LIP 2x1
The LIP 2x can be fastened from the side as well as from above. The housing cover has a raised contact surface for the thermal connection to ensure optimal heat dissipation. The contact surface is compressed against the mounting element during mounting.

Mounting the LIP 60x1
The LIP 60x can be fastened from the side as well as from above. When mounted from above, it is additionally possible to define a fixed center of rotation by inserting an alignment pin with Ø 2 mm or Ø 3 mm. This facilitates the alignment of the scanning head parallel to the scale. The alignment pin can be removed when mounting is completed.

Mounting the LIP
This scanning head features a centering collar with which the scanning head can be rotated in the location hole of the angle bracket and thereby aligned parallel to the scale.

Mounting the LIC/LIDA
There are three options for mounting the scanning head (see Dimensions). A spacer shim makes it quite easy to set the gap between the scanning head and the scale or scale tape. It is helpful to fasten the scanning head from behind with a mounting bracket. The scanning head can be very precisely adjusted through a hole in the mounting bracket with the aid of a tool.

Adjustment
The gap between the scale and scanning head is easily adjusted with the aid of a spacer shim.

The signals from the LIC, LIP 6000, and LIP 200 can be quickly and easily adjusted with the aid of the PVIM 2021 adjustment and testing package. For all other exposed linear encoders, the incremental and reference mark signals are adjusted through a slight rotation of the scanning head (for the LIDA 400, it is possible with the aid of a tool).

HEIDENHAIN offers the appropriate measuring and testing devices as adjustment aids (see Testing equipment and diagnostics).
Signal-quality indicator

The LIDA, LIF and LIP 6071 linear encoders feature an integrated signal-quality indicator with a multicolor LED, permitting fast and easy signal-quality checks during operation.

This feature provides a number of benefits:
• Scanning-signal quality visualization through a multicolor LED
• Continuous monitoring of incremental signals over the entire measuring length
• Indication of reference-mark signal behavior
• Quick signal-quality checks in the field without additional aids

The built-in signal-quality indicator permits both a reliable assessment of the incremental and reference signals and inspection of the reference mark signal. The quality of the incremental signals is indicated by a range of colors permitting quite detailed signal-quality differentiation. The tolerance conformity of the reference mark signal is shown by means of a pass/fail indicator.

LED indicator for incremental signals

<table>
<thead>
<tr>
<th>LED color</th>
<th>Quality of the scanning signals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Optimal</td>
</tr>
<tr>
<td></td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>Acceptable</td>
</tr>
<tr>
<td></td>
<td>Unsatisfactory</td>
</tr>
</tbody>
</table>

LED indicator for reference-mark-signal (operating check)

When the reference mark is traversed, the LED briefly lights up in red or blue:
• Out of tolerance
• Within tolerance

LED indicator for control margin

A flashing LED that turns dark every 2.5 seconds indicates that the control margin of the scanning ASIC is almost exhausted. In this case, you should clean the measuring standard and the scanning window of the scanning head in compliance with the relevant information in the mounting instructions. The encoder may also need to be rechecked for correct mounting.

Temperature range
The operating temperature range states the limits of ambient temperature within which the specifications of the linear encoder are complied with. The storage temperature range of –20 °C to +70 °C applies when the unit remains in its packaging.

Thermal characteristics
The thermal behavior of the linear encoder is an essential criterion for the working accuracy of the machine. As a general rule, the thermal behavior of the linear encoder should match that of the workpiece or measured object. During temperature changes, the linear encoder should expand or contract in a defined, reproducible manner.

The graduation carriers of HEIDENHAIN linear encoders (see Specifications) have differing coefficients of thermal expansion. This makes it possible to select the linear encoder with the thermal behavior best suited to the application.

Parts subject to wear
Encoders from HEIDENHAIN are designed for a long service life. Preventive maintenance is not required. However, they do contain components that are subject to wear, depending on the application and how they are deployed. This especially applies to cables that are subjected to frequent flexing.

Other parts subject to wear are the bearings in encoders with integral bearing, the radial shaft seal rings in rotary encoders and angle encoders, and the sealing lips on sealed linear encoders.

Protection (EN 60529)
The scanning heads of exposed linear encoders feature the following degrees of protection:

<table>
<thead>
<tr>
<th>Scanning head</th>
<th>Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIC</td>
<td>IP67</td>
</tr>
<tr>
<td>LIDA</td>
<td>IP40</td>
</tr>
<tr>
<td>LIF</td>
<td>IP50</td>
</tr>
<tr>
<td>LIF 300</td>
<td>IP50</td>
</tr>
<tr>
<td>LIP 6000</td>
<td>IP50</td>
</tr>
<tr>
<td>PP</td>
<td>IP20</td>
</tr>
</tbody>
</table>

The scales have no special protection. If the scales are exposed to contamination, protective measures must be taken.

Acceleration
Linear encoders are subject to various types of acceleration during operation and mounting.
• The indicated maximum values for vibration apply to frequencies of 55 Hz to 2000 Hz (EN 60068-2-6). If, depending on the application and the mounting scenario, the permissible acceleration values are exceeded (e.g., in the case of resonances), then the encoder can become damaged. Comprehensive testing of the entire system is therefore required.
• The maximum permissible acceleration values (semi-sinusoidal shock) for shock and impact loads are valid for 11 ms or 6 ms (EN 60068-2-27). Under no circumstances should a hammer or similar implement be used to adjust or position the encoder.

Supradur, Metallur, and Optodur are registered trademarks of Dr. Johannes Heidenhain GmbH, Traunreut, Germany.
Zerodur is a registered trademark of Schott Glaswerke, Mainz, Germany.
Functional safety

With the absolute linear encoders of the LIC 4100 series, HEIDENHAIN offers an ideal solution for position acquisition on linear axes in safety-related applications. In conjunction with a safe control, the encoders can be used as single-encoder systems in applications with control category SIL 2 (as per EN 61508) or performance level “d” (as per EN ISO 13849).

The reliable transmission of the position is based on two independently generated absolute position values and on error bits provided to the safe control. The functions of the encoder can be used for numerous safety functions of the complete system as per EN 61800-5-2. The LIC 4100 linear encoder can provide a safe, absolute position value at any time—including immediately after switch-on. Purely serial data transfer takes place via the bidirectional EnDat 2.2 interface.

In addition to the data interface, the mechanical connection of the encoder to the drive is also safety-relevant. In table D8 of the standard for electrical drive systems, EN 61800-5-2, the loosening of the mechanical connection between the encoder and the motor is listed as a fault that requires consideration. Since it cannot be guaranteed that the control will detect such errors, fault exclusion for the loosening of the mechanical connection is required in many cases.

Unless otherwise specified, HEIDENHAIN encoders are designed for a service life of 20 years (in accordance with ISO 13849).

Fault exclusion for the loosening of the mechanical connection

The machine manufacturer is responsible for the dimensioning of mechanical connections in a drive system. During the mechanical design phase, the OEM will ideally consider the conditions within the application. Verifying a safe connection, however, is both cost- and time-intensive. That’s why HEIDENHAIN has developed a type-examined mechanical fault exclusion for the LIC 4100 series.

Mounting and operating conditions

This fault exclusion has been qualified for a wide range of encoder applications and is ensured for the operating conditions listed below.

In addition to the data interface, the mechanical connection of the encoder to the drive is also safety-relevant. In table D8 of the standard for electrical drive systems, EN 61800-5-2, the loosening of the mechanical connection between the encoder and the motor is listed as a fault that requires consideration. Since it cannot be guaranteed that the control will detect such errors, fault exclusion for the loosening of the mechanical connection is required in many cases.

Unless otherwise specified, HEIDENHAIN encoders are designed for a service life of 20 years (in accordance with ISO 13849).

Material

The material used for the mounting surfaces of the scanning head and measuring standard must comply with the specifications provided in the table.

**Material**

<table>
<thead>
<tr>
<th>Material</th>
<th>Steel</th>
<th>Aluminum</th>
<th>Steel, aluminum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength ( R_m )</td>
<td>( \geq 600 \text{ N/mm}^2 )</td>
<td>( \geq 220 \text{ N/mm}^2 )</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Shear strength ( \tau_y )</td>
<td>( \geq 390 \text{ N/mm}^2 )</td>
<td>( \geq 130 \text{ N/mm}^2 )</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Elastic modulus ( E )</td>
<td>( \geq 200,000 \text{ N/mm}^2 ) to 215,000 \text{ N/mm}^2</td>
<td>( \geq 70,000 \text{ N/mm}^2 ) to 75,000 \text{ N/mm}^2</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Coefficient of thermal expansion ( \alpha_{\text{therm}} )</td>
<td>( 10 \cdot 10^{-6} \text{ K}^{-1} ) to 17 ( \cdot 10^{-6} \text{ K}^{-1} )</td>
<td>25 ( \cdot 10^{-6} \text{ K}^{-1} ) to 25 ( \cdot 10^{-6} \text{ K}^{-1} )</td>
<td></td>
</tr>
</tbody>
</table>
**LIC 4113, LIC 4193**

Absolute linear encoders for measuring lengths of up to 3 m

- Measuring steps of down to 1 nm
- Glass or glass ceramic measuring standard
- Measuring standard secured with adhesive film or fixing clamps
- Consisting of a linear scale and scanning head (with straight or angled cable outlet)
- Version available for use in a high vacuum (see separate Product Information document)

### Linear scale LIC 4003

<table>
<thead>
<tr>
<th>Measuring standard</th>
<th>Coefficient of linear expansion&lt;sup&gt;②&lt;/sup&gt;</th>
<th>METALLUR grating on glass or glass ceramic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient of linear expansion&lt;sup&gt;②&lt;/sup&gt;</td>
<td>$\alpha_{\text{lin}} = 8 \times 10^{-6} , \text{K}^{-1}$ (glass)</td>
<td>$\alpha_{\text{lin}} = (0.05 \pm 0.05) \times 10^{-6} , \text{K}^{-1}$ (Robax glass ceramic)</td>
</tr>
</tbody>
</table>

### Accuracy grade<sup>①</sup>

-±1 µm (only for Robax glass ceramic), ±3 µm, ±5 µm

### Baseline error

$\pm 0.275 \, \mu\text{m}/10 \, \text{mm}$

### Measuring length (ML)<sup>①</sup>

| Measuring length (ML) | 240 | 240 | 240 | 340 | 340 | 340 | 440 | 440 | 440 | 640 | 640 | 640 | 840 | 840 | 840 | 1040 | 1040 | 1040 | 1240 | 1240 | 1240 | 1440 | 1440 | 1440 | 1640 | 1640 | 1640 | 1840 | 1840 | 1840 | 2040 | 2040 | 2040 | 2240 | 2240 | 2240 | 2440 | 2440 | 2440 | 2640 | 2640 | 2640 | 2840 | 2840 | 2840 | 3040 | 3040 | 3040 | 3240 | 3240 | 3240 | 3440 | 3440 | 3440 | 3640 | 3640 | 3640 | 3840 | 3840 | 3840 | 4040 | 4040 | 4040 | 4240 | 4240 | 4240 |

### Mass

$3 \, g + 0.11 \, g/\text{mm of measuring length}$

### Scanning head LIC 411, LIC 419F, LIC 419M, LIC 419P, LIC 419Y

<table>
<thead>
<tr>
<th>Interface</th>
<th>EnDat 2.2</th>
<th>Fanuc Serial Interface ai</th>
<th>Mitsubishi high speed interface</th>
<th>Panasonic Serial Interface</th>
<th>Yaskawa Serial Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordering designation&lt;sup&gt;①&lt;/sup&gt;</td>
<td>EnDat22</td>
<td>Fanuc05</td>
<td>Mto03-4</td>
<td>Mto03-2</td>
<td>Pan@02</td>
</tr>
</tbody>
</table>

### Measuring step<sup>①</sup>

- 10 nm, 5 nm, 1 nm<sup>1) </sup>

### Bit width

36 bits

### Calculation time $t_{\text{cal}}$

- 5 µs
- 16 MHz

### Traversing speed<sup>①</sup>

$\leq 600 \, \text{m/min}$

### Interpolation error

$\pm 20 \, \text{nm}$

### Electrical connection<sup>①</sup>

- Cable (1 m or 3 m) with 8-pin M12 coupling (male) or 15-pin D-sub connector (male)

<table>
<thead>
<tr>
<th>Cable length (with HEIDENHAIN cable)</th>
<th>≤ 100 m</th>
<th>≤ 50 m</th>
<th>≤ 30 m</th>
<th>≤ 50 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage&lt;sup&gt;②&lt;/sup&gt; DC 3.6 V to 14 V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power consumption&lt;sup&gt;②&lt;/sup&gt; (max.)</td>
<td>At 3.6 V: ≤ 700 mW</td>
<td>At 3.6 V: ≤ 850 mW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current consumption (typical)</td>
<td>At 5 V: 75 mA (without load)</td>
<td>At 5 V: 95 mA (without load)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration 85 Hz to 2000 Hz</td>
<td>≤ 500 m/s² (EN 60068-2-6)</td>
<td>≤ 1000 m/s² (EN 60068-2-27)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shock 6 ms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>–10 °C to 70 °C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Mass

| Connector element | ≤ 18 g (without cable) |
| Connecting element | 20 g/mm |
| M12 coupling: 15 g; D-sub connector: 32 g |

---

* Please select when ordering
<sup>①</sup> Mitsubishi: measuring length ≤ 2040 mm
<sup>②</sup> Yaskawa: measuring length ≤ 1840 mm
<sup>③</sup> See General electrical information in the Interfaces of HEIDENHAIN Encoders brochure

Robax is a registered trademark of Schott-Glaswerke, Mainz, Germany.
Absolute linear encoders for measuring lengths of up to 28 m
- For measuring steps of down to 1 nm
- Steel scale tape pulled through aluminum extrusions and tensioned
- Consisting of a linear scale and scanning head (with straight or angled cable outlet)

**Scale LIC 4005**

<table>
<thead>
<tr>
<th>Measuring standard</th>
<th>Steel scale tape with absolute and incremental METALLUR track depending on the mounting surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient of linear expansion</td>
<td>Depends on the mounting surface</td>
</tr>
<tr>
<td>Accuracy grade</td>
<td>±5 µm</td>
</tr>
<tr>
<td>Baseline error</td>
<td>≤ ±0.750 µm/50 mm (typical)</td>
</tr>
<tr>
<td>Measuring length (ML)* in mm</td>
<td>140 240 340 440 540 640 740 840 940 1040 1140 1240 1340 1440 1540 1640 1740 1840 1940 2040</td>
</tr>
<tr>
<td>Greater measuring lengths (up to 28440 mm) with a single-section scale tape and individual scale carrier sections</td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>Scale tape: 31 g/m; Parts kit: 187 g/m; Scale tape carrier: 187 g/m</td>
</tr>
</tbody>
</table>

**Scanning head LIC 4115, LIC 4195**

<table>
<thead>
<tr>
<th>Interface</th>
<th>LIC 411</th>
<th>LIC 419F</th>
<th>LIC 419M</th>
<th>LIC 419P</th>
<th>LIC 419Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordering designation*</td>
<td>EnDat 2.2</td>
<td>Fanuc Serial Interface</td>
<td>Mitsubishi high speed interface</td>
<td>Panasonic Serial Interface</td>
<td>Yaskawa Serial Interface</td>
</tr>
<tr>
<td>Measuring step*</td>
<td>10 nm, 5 nm, 1 nm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bit width</td>
<td>36 bits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculation time tcalc</td>
<td>≤ 5 µs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clock frequency</td>
<td>≤ 16 MHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traversing speed (2)</td>
<td>≤ 600 m/min</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interpolation error</td>
<td>≤0.750 µm/50 mm (typical)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Electrical connection**
- Cable (1 m or 3 m) with 8-pin M12 coupling (male) or 15-pin D-sub connector (male)

<table>
<thead>
<tr>
<th>Cable length (with HEIDENHAIN cable)</th>
<th>≤ 100 m</th>
<th>≤ 50 m</th>
<th>≤ 30 m</th>
<th>≤ 50 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage DC 3.6 V to 14 V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power consumption* (max.)</td>
<td>At 3.6 V: ≤ 700 mW; At 14 V: ≤ 800 mW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current consumption (typical)</td>
<td>At 5 V: 75 mA (without load); At 5 V: 96 mA (without load)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration 65 Hz to 2000 Hz</td>
<td>≤ 500 m/s² (EN 60068-2-7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shock 6 ms</td>
<td>≤ 1000 m/s² (EN 60068-2-27)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mounting options for scanning head**
- Orientation of scale carrier sections:
  - O = Scale carrier sections secured with screws
  - F = Scale carrier sections secured with PRECIMET
  - P = Machine guideway
  - M = Measuring points for alignment
  - E = Mounting error plus dynamic guideway error
  - S = Absolute track start value: 100 mm
  - B = Carrier length
  - M = Mounting surface for scanning head
  - C = Optical centerline
  - G = Mounting clearance between scanning head and extrusion
  - H = Direction of motion of the scanning unit for ascending position values

<table>
<thead>
<tr>
<th>ML ≤ 2040</th>
<th>ML &gt; 2040 (e.g., 5040)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounting options for scanning head</td>
<td></td>
</tr>
</tbody>
</table>

**Mounting error**
- = Mounting error + dynamic guideway error
- = Absolute track start value: 100 mm
- = Carrier length
- = Mounting surface for scanning head
- = Optical centerline
- = Mounting clearance between scanning head and extrusion
- = Direction of motion of the scanning unit for ascending position values

**Dimensions**
- Scale tape: 31 g/m; Parts kit: 187 g/m; Scale tape carrier: 187 g/m

**Scanning head LIC 4115, LIC 4195**

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<td>Yaskawa Serial Interface</td>
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<td></td>
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<td>36 bits</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Calculation time tcalc</td>
<td>≤ 5 µs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clock frequency</td>
<td>≤ 16 MHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traversing speed (2)</td>
<td>≤ 600 m/min</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Interpolation error</td>
<td>≤0.750 µm/50 mm (typical)</td>
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**Electrical connection**
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<tr>
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<th>≤ 50 m</th>
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<tbody>
<tr>
<td>Supply voltage DC 3.6 V to 14 V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power consumption* (max.)</td>
<td>At 3.6 V: ≤ 700 mW; At 14 V: ≤ 800 mW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current consumption (typical)</td>
<td>At 5 V: 75 mA (without load); At 5 V: 96 mA (without load)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration 65 Hz to 2000 Hz</td>
<td>≤ 500 m/s² (EN 60068-2-7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shock 6 ms</td>
<td>≤ 1000 m/s² (EN 60068-2-27)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mounting options for scanning head**
- Orientation of scale carrier sections:
  - O = Scale carrier sections secured with screws
  - F = Scale carrier sections secured with PRECIMET
  - P = Machine guideway
  - M = Measuring points for alignment
  - E = Mounting error plus dynamic guideway error
  - S = Absolute track start value: 100 mm
  - B = Carrier length
  - M = Mounting surface for scanning head
  - C = Optical centerline
  - G = Mounting clearance between scanning head and extrusion
  - H = Direction of motion of the scanning unit for ascending position values
Absolute linear encoders for measuring lengths of up to 6 m
- For measuring steps of down to 1 nm
- Steel scale tape pulled through aluminum extrusions and fastened at center
- Consisting of a linear scale and scanning head (with straight or angled cable outlet)

### Scale LIC 4007

<table>
<thead>
<tr>
<th>Measuring standard</th>
<th>Steel scale tape with absolute and incremental METALLUR track</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient of linear expansion</td>
<td>( a_{\text{linear}} = 10^{-6} \cdot \text{K}^{-1} )</td>
</tr>
<tr>
<td>Accuracy grade*</td>
<td>±3 µm (up to ML 1040), ±5 µm (for ML 1240 or greater), ±15 µm †</td>
</tr>
<tr>
<td>Baseline error</td>
<td>±0.750 µm/50 mm (typical)</td>
</tr>
<tr>
<td>Measuring length (ML)*</td>
<td>240, 440, 640, 840, 1040, 1240, 1440, 1640, 1840, 2040, 2240, 2440, 2640, 2840, 3040, 3240, 3440, 3640, 3840, 4040, 4240, 4440, 4640, 4840, 5040, 5240, 5440, 5640, 5840, 6040</td>
</tr>
</tbody>
</table>

### Mass

| Scale tape | 31 g/m |
| Parts kit | 20 g |
| Scale tape carrier | 68 g/m |

### Scanning head LIC 411, LIC 419F, LIC 419M, LIC 419P, LIC 419Y

| Interface | EnDat 2.2 | Fanuc Serial Interface \( \alpha \) | Mitsubishi high speed interface | Panasonic Serial Interface | Yaskawa Serial Interface |
| Ordering designation* | EnDat22 | Fanuc05 | Mit03-4 | Pan02 | YEC07 |
| Measuring step* | 10 mm, 5 mm, 1 mm† |
| Bit width | 36 bits |
| Calculation time \( t_{\text{calc}} \) | ≤ 5 µs |
| Clock frequency | ≤ 16 MHz |
| Traversing speed3) | ≤ 600 m/min |
| Interpolation error | ±20 nm |
| Electrical connection* | Cable (1 m or 3 m) with 8-pin M12 coupling (male) or 15-pin D-sub connector (male) |

### Cable length

<table>
<thead>
<tr>
<th>(with HEIDENHAIN cable)</th>
<th>≤ 100 m</th>
<th>≤ 50 m</th>
<th>≤ 30 m</th>
<th>≤ 50 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>DC 3.6 V to 14 V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power consumption* (max.)</td>
<td>At 3.6 V: ≤ 700 mW</td>
<td>At 14 V: ≤ 800 mW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current consumption (typical)</td>
<td>At 5 V: 75 mA (without load)</td>
<td>At 5 V: 95 mA (without load)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration 55 Hz to 2000 Hz</td>
<td>≤ 500 m/s² (EN 60068-2-6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shock 6 ms</td>
<td>≤ 1000 m/s² (EN 60068-2-27)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>−10 °C to 70 °C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Mass

| Scanning head | 18 g (without cable) |
| Cable | 20 g/m |
| Connecting element | M12 coupling: 15 g, D-sub connector: 32 g |

* Please select when ordering
† ±5 µm after linear length-error compensation in the subsequent electronics
‡ Mitsubishi: measuring length ≤ 2040 mm
Yaskawa: measuring length ≤ 1840 mm
§ See General electrical information in the Interfaces of HEIDENHAIN Encoders brochure
LIC 4199

Absolute linear encoders for measuring lengths of up to 1 m
• For measuring steps of down to 1 nm
• Steel scale tape adhesively bonded to mounting surface
• Consisting of a linear scale and scanning head (with straight or angled cable outlet)

Scale LIC 4009

<table>
<thead>
<tr>
<th>Measuring standard</th>
<th>Steel scale tape with absolute and incremental METALLUR track</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient of linear expansion</td>
<td>α = 0.000 010 °C⁻¹</td>
</tr>
<tr>
<td>Accuracy grade*</td>
<td>±0.3 mm, ±0.15 µm²</td>
</tr>
<tr>
<td>Baseline error</td>
<td>≤ ±0.750 µm/50 mm (typical)</td>
</tr>
<tr>
<td>Measuring length (ML)*</td>
<td>in mm</td>
</tr>
<tr>
<td>70</td>
<td>120</td>
</tr>
<tr>
<td>Mass</td>
<td>31 g/m</td>
</tr>
</tbody>
</table>

Scanning head LIC 411 LIC 419F LIC 419M LIC 419P LIC 419Y

| Interface | EnDat 2.2 | Fanuc Serial Interface | Mitsubishi high speed interface | Panasonic Serial Interface | Yaskawa Serial Interface |
| Ordering designation* | EnDat22 | Fanuc05 | Mit03-4 | Mit03-2 | Pana02 | YEC07 |
| Measuring step* | 10 nm, 5 nm, 1 nm² |
| Bit width | 36 bits |
| Bit time t_cal | ≤ 5 µs |
| Clock frequency | ≤ 16 MHz |
| Traversing speed³ | ≤ 600 m/min |
| Interpolation error | ±20 nmm |

Electrical connection* Cable (1 m or 3 m) with 8-pin M12 coupling (male) or 15-pin D-sub connector (male)

| Cable length (with HEIDENHAIN cable) | ≤ 100 m¹ | ≤ 50 m | ≤ 30 m | ≤ 50 m |
| Supply voltage | DC 3.6 V to 14 V |
| Power consumption* (max.) | At 3.6 V: ≤ 700 mW | At 14 V: ≤ 800 mW | At 2.6 V: ≤ 850 mW | At 14 V: ≤ 950 mW |
| Current consumption (typical) | At 5 V: 75 mA (without load) | At 5 V: 95 mA (without load) |
| Vibration | 65 Hz to 2000 Hz |
| Shock | 6 ms |
| Operating temperature | –10 °C to 70 °C |
| Mass | Scanning head: ≤ 18 g (without cable) |
| Cable | 20 g/m |
| Connecting element | M12 coupling: 15 g, D-sub connector: 32 g |

* Please select when ordering
¹ ±5 µm after linear length-error compensation in the subsequent electronics
² Mitsubishi: measuring length ≤ 2040 mm
³ Mitsubishi: measuring length ≤ 1840 mm
⁴ Yaskawa: measuring length ≤ 1840 mm

See General electrical information in the Interfaces of HEIDENHAIN Encoders brochure

With LIC 411 FS scanning head: clock frequency: 8 MHz

Mounting options for scanning head

[Diagram showing mounting options for scanning head]

mm

= Absolute track start value
= Unit for distance
= Optical centerline
= Mounting clearance between scanning head and linear scale
= Direction of motion of the scanning unit for ascending positions

Please note:

ISO 9015
ISO 2798: e H
< 6 mm: ±0.2 mm

= Machine guideway
= Mounting error plus dynamic guideway error
= Beginning of measuring length (ML)
= Scale tape length
= Mounting error plus dynamic guideway error
LIC 4119

Absolute linear encoder with high accuracy for safety-related applications

- For measuring steps of down to 1 nm
- Steel scale tape adhesively bonded to mounting surface
- Consisting of a linear scale and scanning head
- Fault exclusion for the loosening of the mechanical connection

**Specifications:**

- **Measuring standard:**
  - Steel scale tape with absolute and incremental METALLUR track
  - **Coefficient of linear expansion:** \( \alpha_{\text{Meas}} = 10 \cdot 10^{-6} \text{ K}^{-1} \)

- **Accuracy grade:** \( \pm 3 \mu \text{m} \)
  - Baseline error: \( \leq \pm 0.75 \mu \text{m} \)
  - Measuring length: \( \leq \pm 70 \mu \text{m} \)

- **Measuring step:**
  - 10 nm, 5 nm, 1 nm

- **Ordering designation:** EnDat 2.2

- **Clock frequency:** 16 MHz

- **Radio interference immunity:**
  - 55 Hz to 2000 Hz

- **Cable length:**
  - 46 m

- **Protection:**
  - IP67

- **Mounting options:**
  - Machine guideway
  - Machine guideway error
  - Scale LIC 4119

- **Additional measuring length:**
  - Only on steel mounting surface

- **Baseline error:**
  - \( \leq \pm 15 \mu \text{m} \)

- **Additional functional safety:**
  - Category 3, PL “d” as per EN ISO 13849-1:2015
  - SIL 2 as per EN 61508 (further basis for testing: EN 61800-5-2)

- **Calculation time:**
  - \( \leq 5 \mu \text{s} \)

- **Protection class:**
  - IP00

- **Scanning head:**
  - LIC 411

- **Interfacing ISO 7889:**
  - \( \pm 6 \text{ mm} \)

- **Tolerancing ISO 8015:**
  - \( \pm 0.2 \text{ mm} \)

- **Clock frequency:**
  - 16 MHz

- **Vibration and shock:**
  - 55 Hz to 2000 Hz

- **Operating temperature:**
  - \( -10 \degree \text{C} \) to \( 70 \degree \text{C} \)

- **Relative air humidity:**
  - \( \leq 93 \% \) at 40 \( \degree \text{C} \) as per EN 60068-2-78; condensation excluded

- **Mass:**
  - \( \leq 18 \text{ g} \) (without cable)

- **Connector:**
  - 26 gpm

- **Cable:**
  - M12 coupling: 15 g/m; D-sub connector: 32 g

* Please select when ordering
1) Up to a measuring length of 1020 mm
2) Up to a measuring length of 2200 mm
3) Additional functional safety only on steel mounting surface
4) In the application, the device must be protected from contamination by solids and liquids. If necessary, use a suitable enclosure with a gasket and sealing air.
5) For the electrical connection, look under LIC 411 without functional safety
6) Further tolerances may occur in subsequent electronics after position value comparison (contact manufacturer of subsequent electronics)
7) See General electrical information in the Interfaces of HEIDENHAIN Encoders brochure
Absolute linear encoders for measuring lengths of up to 10 m

- For measuring steps of down to 10 nm
- Steel scale tape pulled through aluminum extrusions and fastened at center
- Consisting of a linear scale and scanning head

### Scale LIC 3107

**Measuring standard**
Steel scale tape with absolute track and incremental track

**Coefficient of linear expansion**
$\alpha_{\text{linear}} = 10 \cdot 10^{-6} \text{K}^{-1}$

**Accuracy grade**
$\pm 15 \mu m$

**Baseline error**
$\pm 0.750 \mu m/50 \text{ mm} ($typical$)$

**Scale tape cut from roll**
- 3 m, 5 m, 10 m

**Mass**
- Parts kit 31 g
- Scale tape carrier 20 g
- Scale tape cut from roll 68 g

### Scanning head LIC 311 LIC 319F LIC 319M LIC 319P LIC 319Y

**Interface**
- EnDat 2.2
- Fanuc Serial Interface
- Mitsubishi high speed interface
- Panasonic Serial Interface
- Yaskawa Serial Interface

**Ordering designation**
- EnDat 22
- Fanuc 05
- Mit03-4
- Mit03-2
- Pana02
- YEC07

**Measuring step**
$0.01 \mu m (10 \text{ nm})$

**Calculation time**
$\leq 5 \mu s$

**Clock frequency**
$\leq 16 \text{ MHz}$

**Traversing speed**
$\leq 600 \text{ mm/min}$

**Interpolation error**
$\pm 100 \text{ nm}$

**Electrical connection**
- Cable (1 m or 3 m) with 8-pin M12 coupling (male) or 15-pin D-sub connector (male)

**Cable length**
- (with HEIDENHAIN cable) $\leq 100 \text{ m}$
- $\leq 50 \text{ m}$
- $\leq 30 \text{ m}$
- $\leq 50 \text{ m}$

**Supply voltage**
- DC 3.6 V to 14 V

**Power consumption**
- At 3.6 V: $\leq 700 \text{ mW}$
- At 14 V: $\leq 850 \text{ mW}$

**Current consumption**
- At 5 V: $\leq 850 \text{ mW}$
- At 3.6 V: $\leq 950 \text{ mW}$

**Vibration**
- 85 Hz to 2000 Hz
- $\leq 500 \text{ m/s}^2$ (EN 60068-2-6)
- $\leq 1000 \text{ m/s}^2$ (EN 60068-2-27)

**Shock**
- 6 ms
- $\leq 500 \text{ m/s}^2$ (EN 60068-2-6)
- $\leq 1000 \text{ m/s}^2$ (EN 60068-2-27)

**Operating temperature**
- $-10 \degree C$ to $70 \degree C$

**Mass**
- Scanning head 18 g (without cable)
- 20 g (cable)
- Cable 15 g
- Connecting element 32 g

---

*Please select when ordering

1. $\pm 5 \mu m$ after linear length-error compensation in the subsequent electronics
2. See General electrical information in the Interfaces of HEIDENHAIN Encoders brochure
**LIC 3119, LIC 3199**

Absolute linear encoders for measuring lengths of up to 10 m
- For measuring steps of down to 10 nm
- Steel scale tape adhesively bonded to mounting surface
- Consisting of a linear scale and scanning head

<table>
<thead>
<tr>
<th><strong>Scale</strong></th>
<th><strong>LIC 3109</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring standard</td>
<td>Steel scale tape with absolute track and incremental track</td>
</tr>
<tr>
<td>Coefficient of linear expansion</td>
<td>$\alpha_{\text{steel}} = 10 \cdot 10^{-6} , \text{K}^{-1}$</td>
</tr>
<tr>
<td>Accuracy grade</td>
<td>±15 µm</td>
</tr>
<tr>
<td>Baseline error</td>
<td>$\leq 0.750 , \mu\text{m} / 50 , \text{mm}$ (typical)</td>
</tr>
<tr>
<td>Scale tape cut from roll*</td>
<td>3 m, 5 m, 10 m</td>
</tr>
<tr>
<td>Mass</td>
<td>31 g/m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Scanning head</strong></th>
<th><strong>LIC 311</strong></th>
<th><strong>LIC 319F</strong></th>
<th><strong>LIC 319M</strong></th>
<th><strong>LIC 319P</strong></th>
<th><strong>LIC 319Y</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>EnDat 2.2</td>
<td>Fanuc Serial Interface</td>
<td>Mitsubishi high speed interface</td>
<td>Panasonic Serial Interface</td>
<td>Yaskawa Serial Interface</td>
</tr>
<tr>
<td>Ordering designation*</td>
<td>EnDat22</td>
<td>Fanuc 05</td>
<td>MHI53-4</td>
<td>MHI53-2</td>
<td>Pana02</td>
</tr>
<tr>
<td>Measuring step</td>
<td>0.01 µm (10 nm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clock frequency</td>
<td>≤ 5 µs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traversing speed*</td>
<td>≤ 600 m/min</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interpolation error</td>
<td>±100 nm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Electrical connection</strong></th>
<th><strong>LIC 3119</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable length (with HEIDENHAIN cable)</td>
<td>≤ 100 m</td>
</tr>
<tr>
<td>Supply voltage DC</td>
<td>3.6 V to 14 V</td>
</tr>
<tr>
<td>Power consumption*</td>
<td>At 3.6 V: ≤ 700 mW</td>
</tr>
<tr>
<td>Current consumption (typical)</td>
<td>At 3.6 V: ≤ 950 mW</td>
</tr>
<tr>
<td>Vibration 55 Hz to 2000 Hz</td>
<td>≤ 500 m/s² (EN 60068-2-6)</td>
</tr>
<tr>
<td>Shock 6 ms</td>
<td>≤ 1000 m/s² (EN 60068-2-27)</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>–10 °C to 70 °C</td>
</tr>
</tbody>
</table>

* Please select when ordering

1) ±5 µm after linear length error compensation in the subsequent electronics

2) See General electrical information in the Interfaces of HEIDENHAIN Encoders brochure
LIC 2117, LIC 2197

Absolute linear encoders for measuring lengths of up to 3 m
• Measuring step: 100 nm or 50 nm
• Steel scale tape pulled through aluminum extrusions and fastened at center
• Consisting of a linear scale and scanning head

Scale LIC 2107

Measuring standard
Steel scale tape with absolute track

Coefficient of linear expansion
\( a_{\text{Elong}} = 10 \cdot 10^{-6} \text{ K}^{-1} \)

Accuracy grade
\( \pm 15 \mu \text{m} \)

Measuring length (ML)*

<table>
<thead>
<tr>
<th>in mm</th>
<th>120</th>
<th>320</th>
<th>520</th>
<th>770</th>
<th>1020</th>
<th>1520</th>
<th>2020</th>
<th>2420</th>
<th>3020</th>
</tr>
</thead>
<tbody>
<tr>
<td>greater measuring lengths (up to 6020 mm) upon request</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mass

<table>
<thead>
<tr>
<th>Scale tape carrier</th>
<th>20 g/m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>70 g/m</td>
</tr>
</tbody>
</table>

Scanning head LIC 211 LIC 219 F LIC 219 M LIC 219 P LIC 219 Y

Interface

- EnDat 2.2
- Fanuc Serial Interface
- Mitsubishi high speed interface
- Panasonic Serial Interface
- Yaskawa Serial Interface

Ordering designation*

- EnDat22
- Fanuc05
- Mit03-4
- Mit03-2
- Pan02
- YEC07

Measuring step*

- 100 nm, 50 nm

Bit width

- 32 bits

Calculation time \( t_{\text{calc}} \)

- \( \leq 5 \mu \text{s} \)

Clock frequency

- \( \leq 16 \text{ MHz} \)

Traversing speed

- \( \leq 600 \text{ m/min} \)

Interpolation error

- \( \pm 2 \mu \text{m} \)

Electrical connection*

- Cable (1 m or 3 m) with 8-pin M12 coupling (male) or 15-pin D-sub connector (male)

Cable length

- (with HEIDENHAIN cable)

| in m | \( \leq 100 \text{ m} \) | \( \leq 50 \text{ m} \) | \( \leq 30 \text{ m} \) | \( \leq 50 \text{ m} \) |

Supply voltage

- DC 3.6 V to 14 V

Power consumption (max.)

- At 3.6 V: \( \leq 700 \text{ mW} \)
- At 14 V: \( \leq 850 \text{ mW} \)

Current consumption (typical)

- At 5 V: \( \leq 75 \text{ mA} \)
- At 5 V: \( \leq 95 \text{ mA} \) (without load)

Vibration

- 65 Hz to 2000 Hz

Shock

- 6 ms

<table>
<thead>
<tr>
<th>in m/s²</th>
<th>( \leq 500 \text{ m/s}² ) (EN 60068-2-4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \leq 1000 \text{ m/s}² ) (EN 60068-2-27)</td>
</tr>
</tbody>
</table>

Operating temperature

- \(-10 \text{ °C} \) to \(70 \text{ °C} \)

Mass

| Scanning head Cable | \( \leq 18 \text{ g} \) (without cable) |
| Connecting element | 20 g/m |
| M12 coupling | 15 g |
| D-sub connector | 32 g |

* Please select when ordering

1) See General electrical information in the Interfaces of HEIDENHAIN Encoders brochure

** = Machine guideway
* = Maximum change during operation
\( \odot \) = Absolute track start value: 100 mm
\( \ominus \) = Beginning of measuring length (ML)
\( \odot \) = Carrier length
1 = Optical centerline
2 = M3 threaded mating hole; depth: 5 mm
3 = Mounting clearance between scanning head and scale tape
4 = Direction of motion of the scanning unit for ascending position values
LIC 2119, LIC 2199

Absolute linear encoders for measuring lengths of up to 3 m
• Measuring step: 100 nm or 50 nm
• Steel scale tape adhesively bonded to mounting surface
• Consisting of a linear scale and scanning head

Scale LIC 2119

<table>
<thead>
<tr>
<th>Measuring standard</th>
<th>LIC 2119</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel scale tape with absolute track</td>
<td>Steel scale tape with absolute track</td>
</tr>
<tr>
<td>Coefficient of linear expansion</td>
<td>α &lt; 10 · 10⁻⁶ K⁻¹</td>
</tr>
</tbody>
</table>

Accuracy grade

<table>
<thead>
<tr>
<th>Measuring length (ML)* in mm</th>
<th>120</th>
<th>320</th>
<th>520</th>
<th>770</th>
<th>1020</th>
<th>1220</th>
<th>1520</th>
<th>2020</th>
<th>2420</th>
<th>3020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>20 g</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Scanning head LIC 211 LIC 219F LIC 219M LIC 219P LIC 219Y

<table>
<thead>
<tr>
<th>Interface</th>
<th>LIC 211</th>
<th>LIC 219F</th>
<th>LIC 219M</th>
<th>LIC 219P</th>
<th>LIC 219Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>EnDat 2.2 Fanuc Serial interface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitsubishi high speed interface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panasonic Serial interface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yaskawa Serial interface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ordering designation* EnDat22 Fanuc05 Mt03-4 Mt03-2 Pan02 YEC07

Measuring step* 100 nm, 50 nm

Bit width 32 bits

Calculation time tcal ≤ 5 µs ≤ 16 MHz

Traversing speed* ≤ 600 m/min

Interpolation error ≤ 2 µm

Electrical connection* Cable (1 m or 3 m) with 8-pin M12 coupling (male) or 15-pin D-sub connector (male)

Cable length:
- (with HEIDENHAIN cable) ≤ 100 m ≤ 50 m ≤ 30 m ≤ 50 m

Supply voltage DC 3.6 V to 14 V

Power consumption1) (max.)
- At 3.6 V: ≤ 700 mW
- At 14 V: ≤ 860 mW

Current consumption (typical)
- At 5 V: 75 mA (without load)
- At 5 V: 95 mA (without load)

Vibration 55 Hz to 2000 Hz
- ≤ 500 m/s² (EN 60088-2-6)
- ≤ 1000 m/s² (EN 60088-2-27)

Shock 6 ms
- ≤ 500 m/s²
- ≤ 1000 m/s²

Operating temperature −10 °C to 70 °C

Mass
- Scanning head ≤ 18 g (without cable)
- Cable 20 g
- Connecting element M12 coupling: 15 g; D-sub connector: 32 g

* Please select when ordering

1) See General electrical information in the Interfaces of HEIDENHAIN Encoders brochure

Mounting options for scanning head

F = Machine guideway
* = Maximum change during operation
⊙ = Absolute track start value: 100 mm
⊙ = Beginning of measuring length (ML)
⊙ = Scale tape length
1 = Optical centerline
2 = Mounting clearance between scanning head and scale tape
3 = Direction of motion of the scanning unit for ascending position values

Tolerancing ISO 8015
ISO 2768 – m H
< 6 mm: ± 0.2 mm
LIP 382
Incremental linear encoders with very high accuracy
- Measuring steps < 1 nm
- Measuring standard fastened by screws
### LIP 211, LIP 281, LIP 291

Incremental linear encoders for very high accuracy and high position stability

- For measuring steps of 1 nm and smaller
- For high traversing speeds and large measuring lengths
- Measuring standard secured with fixing clamps
- Consisting of a linear scale and scanning head

#### Scale LIP 201

<table>
<thead>
<tr>
<th>Measuring standard</th>
<th>OPTODUR phase grating on Zerodur glass ceramic; grating period 2.048 µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient of linear expansion</td>
<td>$\alpha_{\text{therm}} = (0\pm0.1) \times 10^{-6} \text{ K}^{-1}$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Accuracy grade*</th>
<th>±1 µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>±3 µm (higher accuracy grades upon request)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Baseline error</th>
<th>≤ ±0.125 µm/6 mm</th>
</tr>
</thead>
</table>

| Measuring length (ML)* | 20 30 50 70 120 170 220 |
|------------------------|---|---|---|---|---|---|---|
| in mm                  | 270 | 320 | 370 | 420 | 520 | 570 | 620 |
|                        | 670 | 720 | 770 | 820 | 920 | 970 | 1020 |
|                        | 1070 | 1120 | 1170 | 1220 | 1270 | 1320 | 1370 |
|                        | 1420 | 1470 | 1520 | 1570 | 1620 | 1670 | 1720 |
|                        | 1770 | 1820 | 1870 | 1920 | 1970 | 2020 | 2070 |

| Reference marks | One at midpoint of measuring length |

| Mass | 1.1 g + 0.11 g/mm of measuring length |

#### Scanning head

- **LIP 21, LIP 28, LIP 29**
- **LIP 29M**
- **LIP 28**

<table>
<thead>
<tr>
<th>Interface</th>
<th>EnDat 2.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fanuc Serial Interface</td>
<td>Mitsubishi high speed</td>
</tr>
<tr>
<td>MIO2-4</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ordering designation</th>
<th>EnDat22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fanuc02</td>
<td></td>
</tr>
<tr>
<td>MIO2-4</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Integrated interpolation</th>
<th>16384-fold (14 bits)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clock frequency</th>
<th>≤ 16 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculation time $t_{\text{cal}}$</td>
<td>≤ 5 µs</td>
</tr>
<tr>
<td>Measuring step</td>
<td>0.03125 mm (31.25 pm)</td>
</tr>
<tr>
<td>Signal period</td>
<td>0.512 µm</td>
</tr>
<tr>
<td>Cutoff frequency</td>
<td>-3 dB</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Traversing speed</th>
<th>≥ 120 m/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 90 m/min</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interpolation error RMS position noise</th>
<th>±0.4 nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>±0.12 nm (3 MHz)</td>
<td></td>
</tr>
</tbody>
</table>

| Electrical connection* | Cable (0.5 m or 1 m; 2 m and 3 m for 1 Vpp), with interface electronics in the connector (15-pin D-sub male) |

<table>
<thead>
<tr>
<th>Cable length</th>
<th>See interface description; however, ≤ 15 m (≤ 30 m for 1 Vpp) with HEIDENHAIN cable; during signal adjustment with the PWM 21: ≤ 13 m</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Supply voltage</th>
<th>DC 3.6 V to 14 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power consumption (max.)</td>
<td>At 14 V: 2500 mW; at 3.6 V: 2600 mW</td>
</tr>
<tr>
<td>Current consumption</td>
<td>At 5 V: 300 mA (without load, typical)</td>
</tr>
</tbody>
</table>

| Laser | Mounted scanning head and scale; Class 1; non-mounted scanning head: Class 3B |

<table>
<thead>
<tr>
<th>Vibration 55 Hz to 2000 Hz</th>
<th>≤ 200 m/s²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shock 11 ms</td>
<td>≤ 400 m/s²</td>
</tr>
</tbody>
</table>

| Operating temperature | 0 °C to 50 °C |

| Mass | Scanning head: 59 g; connector: 140 g; cable: 22 g |

---

* Please select when ordering; for measuring lengths < 70 mm, the “adhesively bonded” mounting type is recommended
  1. Absolute position value after traverse of the reference mark in “position value 2”

---

* Note: With HEIDENHAIN interface electronics
LIP 6071, LIP 6081
Incremental linear encoders with very high accuracy
- For limited installation space
- For measuring steps of down to 1 mm
- For high traversing speeds and large measuring lengths
- Position detection through homing track and limit switches
- Measuring standard secured with adhesive or fixing clamps

Scale, clamped

Scale, adheriously bonded

Scanning head and scale clamped / adheriously bonded

Mounting options for scanning head (shown without fixing clamps)

F = Machining guideline
* = Maximum change during operation
IKS = Incremental track
RI = Reference mark track
G = Mounting surface
$= $ Scale length
B = Beginning of measuring length (ML)
D = Fixed point for defining the thermal fixed point
E = Reference mark position
1 = Optical centerline
2 = Mounting clearance of scanning head to scale; adjusted by means of a spacer shim
3 = Scale stop surface
4 = Use additional fixing clamp pair depending on the measuring length (ML)
5 = Adhesive
6 = Direction of motion of the scanning unit for ascending position values
7 = Manual adjustment option 1: alignment pin, Ø 3 mm, possible only with mounting option 3
8 = Manual adjustment option 2: alignment pin, Ø 4 mm
9 = Recommended: GT 3
10 = Adhesive tape (only if the scale is adheriously bonded)

Scale LIP 6001

- Measuring standard*: OPTODUR phase grating on Zerodur glass ceramic or glass, grating period: 8 µm
- Coefficient of linear expansion
  - $\alpha_{\text{glass}} = (0 \pm 0.1) \cdot 10^{-6} \, \text{K}^{-1}$ (Zerodur glass ceramic); $\alpha_{\text{glass}} = 8 \cdot 10^{-6} \, \text{K}^{-1}$ (glass)

- Accuracy grade*
  - $\pm 1 \, \mu\text{m}$ only for Zerodur glass ceramic up to a measuring length of 1020 mm; $\pm 3 \, \mu\text{m}$

- Baseline error
  - $\leq 0.175 \, \mu\text{m} / 5 \, \text{mm}$

- Measuring length (ML)*
  - In mm: 20 30 50 70 120 170 220 270 320 370 420 470 520 570
  - In mm: 620 670 720 770 820 870 920 970 1020 1140 1240 1340 1440 1540

- Reference mark
  - One at midpoint of measuring length

- Mass
  - 1.1 g with 0.1 g/mm of measuring length

Scanning head LIP 6081 LIP 607

- Interface
  - TTL
  - Integrated interpolation*
  - Signal period
    - 4 µm
    - 0.8 µm
    - 0.4 µm
    - 0.16 µm
    - 0.08 µm
    - 0.04 µm
  - 500-fold: 0.008 µm

- Cutoff frequency
  - $\approx -3 \, \text{dB}$
  - $\geq 1 \, \text{kHz}$

- Scanning frequency
  - $\leq 312.5 \, \text{kHz}$
  - $\leq 156.25 \, \text{kHz}$
  - $\leq 62.5 \, \text{kHz}$
  - $\leq 25 \, \text{kHz}$
  - $\leq 12.5 \, \text{kHz}$

- Edge separation a
  - $\geq 0.135 \, \mu\text{m}$
  - $\geq 0.07 \, \mu\text{m}$
  - $\leq 0.135 \, \mu\text{m}$
  - $\leq 0.07 \, \mu\text{m}$

- Traversing speed
  - $\leq 240 \, \text{m/min}$
  - $\leq 75 \, \text{m/min}$
  - $\leq 37 \, \text{m/min}$
  - $\leq 60 \, \text{m/min}$
  - $\leq 30 \, \text{m/min}$
  - $\leq 15 \, \text{m/min}$
  - $\leq 75 \, \text{m/min}$
  - $\leq 15 \, \text{m/min}$
  - $\leq 7.5 \, \text{m/min}$
  - $\leq 3 \, \text{m/min}$

- Interpolation error agreement
  - RMS position noise
  - $\leq 0.04 \, \mu\text{m}$
  - $\leq 0.135 \, \mu\text{m}$

- Electrical connection*
  - Cable outlet on the left or right and straight or angled
  - TTL: cable (0.5 m/1 m) with 15-pin D-sub connector (male)

- Cable length
  - With HEIDENHAIN cable: homing, limit: $\leq 10 \, \text{m}$; only incremental: $\leq 20 \, \text{m}$
  - During signal adjustment with the PWM: $\leq 3 \, \text{m}$

- Supply voltage
  - DC $5 \, \text{V} \pm 0.5 \, \text{V}$

- Current consumption
  - $\leq 150 \, \text{mA}$
  - $\leq 300 \, \text{mA}$ (without load)

- Vibration
  - 55 Hz to 2000 Hz
  - $\leq 500 \, \text{mV} / \text{m/s}^2$ (IEC 60688-2-3)
  - $\leq 1000 \, \text{mV} / \text{m/s}^2$ (IEC 60688-2-27)

- Shock
  - 6 ms
  - $\leq 50 \, \text{m/s}^2$ (IEC 60688-2-2)

- Operating temperature
  - $-10 \, \text{°C}$ to $70 \, \text{°C}$

- Mass
  - Scanning head: 5 g
  - Adhesive tape: 24 g

* Please select when ordering for measuring lengths $< 70 \, \text{mm}$, the “adheriously bonded” mounting type is recommended
† Unlocked TTLx1 possible upon request
‡ With TTL: maximum traversing speed during referencing: 16.8 m/min (70 kHz)
§ $-3 \, \text{dB}$ cutoff frequency of the subsequent electronics
LIF 471, LIF 481
Incremental linear encoders for simple installation
• For measuring steps of down to 2 nm
• Position detection through homing track and limit switches
• Measuring standard secured with adhesive film
• Consisting of a linear scale and scanning head
• Versions available for high vacuum (see Product Information document)
• Interface electronics integrated in the connector

50

<table>
<thead>
<tr>
<th>Scale</th>
<th>LIF 401R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring standard*</td>
<td>SUPRADUR phase grating on Zerodur glass ceramic or glass; grating period: 8 µm</td>
</tr>
<tr>
<td>Coefficient of linear expansion</td>
<td>( a_{\text{therm}} = (0.03 \pm 0.01) \cdot 10^{-6} \text{K}^{-1} ) (Zerodur glass ceramic)</td>
</tr>
<tr>
<td></td>
<td>( a_{\text{therm}} = 8 \cdot 10^{-6} \text{K}^{-1} ) (glass)</td>
</tr>
<tr>
<td>Accuracy grade*</td>
<td>±1 µm (only for Zerodur glass ceramic up to a measuring length of 1020 mm), ±3 µm</td>
</tr>
<tr>
<td>Baseline error</td>
<td>≤ ±0.225 µm/5 mm</td>
</tr>
<tr>
<td>Measuring length (ML)*</td>
<td>70 120 170 220 270 320 370 420 470 520 570 620 670 720 770 820 870 920 970 1020 1140 1240 1340 1440 1540 1640</td>
</tr>
<tr>
<td>Reference marks</td>
<td>One at midpoint of measuring length</td>
</tr>
<tr>
<td>Mass</td>
<td>0.8 g + 0.08 g/mm of measuring length</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scanning head</th>
<th>LIF 48</th>
<th>LIF 47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>( \sim 1 \text{Vpp} )</td>
<td>( \sim \text{TTL} )</td>
</tr>
<tr>
<td>Integrated interpolation*</td>
<td>9-fold 0.8 µm</td>
<td>10-fold 0.4 µm</td>
</tr>
<tr>
<td></td>
<td>20-fold 0.2 µm</td>
<td>50-fold 0.08 µm</td>
</tr>
<tr>
<td></td>
<td>100-fold 0.04 µm</td>
<td></td>
</tr>
<tr>
<td>Cutoff frequency</td>
<td>–3 dB</td>
<td>≥ 1 MHz</td>
</tr>
<tr>
<td>Scanning frequency*</td>
<td>–</td>
<td>≤ 500 kHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 250 kHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 125 kHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 62.5 kHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 250 kHz</td>
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<tr>
<td></td>
<td></td>
<td>≤ 125 kHz</td>
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<tr>
<td></td>
<td></td>
<td>≤ 62.5 kHz</td>
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<tr>
<td></td>
<td></td>
<td>≤ 100 kHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 50 kHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 25 kHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 12.5 kHz</td>
</tr>
<tr>
<td>Edge separation a</td>
<td>–</td>
<td>≥ 0.080 µs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 0.175 µs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 0.370 µs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 0.80 µs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 1.75 µs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 3.70 µs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 8.0 µs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 16.0 µs</td>
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<tr>
<td></td>
<td></td>
<td>≥ 32.0 µs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 64.0 µs</td>
</tr>
<tr>
<td>Traversing speed1</td>
<td>–</td>
<td>≤ 240 m/min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 120 m/min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 60 m/min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 30 m/min</td>
</tr>
<tr>
<td>Interpolation error</td>
<td>RMS position noise</td>
<td>±12 nm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.6 nm (1 MHz2)</td>
</tr>
</tbody>
</table>

Electrical connection*
- Cable (0.5 m/1 m/3 m) with 15-pin D-sub connector (male); interface electronics in the connector
- See interface description; however, incremental: ≤ 30 m; homing, limit: ≤ 10 m; (with HEIDENHAIN cable)

Supply voltage
DC 5 V ±0.25 V

Power consumption (max.)
Scanning head: 130 mW, LIF 48 connector: 840 mW, LIF 47 connector: 720 mW (without load)

Current consumption
< 150 mA
< 165 mA (without load)

Vibration
55 Hz to 2000 Hz
≤ 400 m/s² (EN 60068-2-6)
≤ 500 m/s² (EN 60068-2-27)

Shock
11 m/s²
≤ 400 m/s² (EN 60068-2-6)

Operating temperature
0 °C to 50 °C

Mass
- Scanning head* For scale made of Zerodur glass ceramic: 25 g
- For scale made of glass: 9 g
- Cable: 38 g
- Connector: 75 g

* Please select when ordering
1 With TTL: maximum traversing speed during referencing: 9.6 m/min (40 kHz)
2 –3 dB cutoff frequency of the subsequent electronics

Note:
For more information on the vacuum version, see the LIF-471/481 V Product Information document.

Note:
For distance-coded reference marks or larger measuring lengths, see the LIF 171, LIF 181 Product Information document.
LIDA 473, LIDA 483
Incremental linear encoders with limit switches

- For measuring steps of down to 10 nm
- Glass or glass ceramic measuring standard
- Measuring standard secured with adhesive film

Consisting of a linear scale and scanning head

$F =$ Machine guideway
$* =$ Max. change during operation
(KS: incremental track; RL: Reference mark track)
$\text{ML} =$ Beginning of measuring length (ML)
$\text{R} =$ Reference-mark position on LIDA 4x3
$\text{SC} =$ Reference-mark position on LIDA 4x3 C
$\text{R} =$ Scale length
$\text{M} =$ Selector magnet for limit switch
$\text{S} =$ Mounting surface for scanning head
$\text{m} =$ Signal-quality indicator
$\text{g} =$ Scanning gap
$\text{s} =$ Scale stop surface
$\text{p} =$ Direction of motion of the scanning unit for ascending position values

**Mounting options for scanning head**

<table>
<thead>
<tr>
<th>Scale</th>
<th>LIDA 403</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring standard</td>
<td>METALLUR scale grating on glass or glass ceramic; grating period: 20 µm</td>
</tr>
<tr>
<td>Coefficient of linear expansion*</td>
<td>$\Delta a_{\text{linear}} = 8 \cdot 10^{-6}$ K$^{-1}$ (glass)</td>
</tr>
<tr>
<td>$\Delta a_{\text{linear}} = (0 \pm 0.5) \cdot 10^{-6}$ K$^{-1}$ (Robax glass ceramic)</td>
<td></td>
</tr>
<tr>
<td>Accuracy grade*</td>
<td>±1 µm (only for Robax glass ceramic), ±3 µm, ±5 µm</td>
</tr>
<tr>
<td>Baseline error</td>
<td>≤ ±0.275 µm/10 mm</td>
</tr>
<tr>
<td>Measuring length (ML)*</td>
<td>240  340  440  640  840  1040  1240  1440  1640  1840  2040  2240  2440  2640  2840  3040 (Robax glass ceramic only up to ML of 1640)</td>
</tr>
<tr>
<td>Reference marks*</td>
<td>LIDA 4x3: one at midpoint of measuring length; LIDA 4x3 C: distance-coded</td>
</tr>
<tr>
<td>Mass</td>
<td>3 g + 0.11 g/mm of measuring length</td>
</tr>
</tbody>
</table>

**Scanning head**

<table>
<thead>
<tr>
<th>LIDA 48</th>
<th>LIDA 47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>TTL</td>
</tr>
<tr>
<td>Integrated interpolation*</td>
<td>20 µm</td>
</tr>
<tr>
<td>Signal period</td>
<td>4 µm</td>
</tr>
<tr>
<td>10-fold</td>
<td>0.4 µm</td>
</tr>
<tr>
<td>50-fold</td>
<td>0.2 µm</td>
</tr>
<tr>
<td>Cutoff frequency</td>
<td>&gt; 500 kHz</td>
</tr>
<tr>
<td>Scanning frequency*</td>
<td>&gt; 400 kHz</td>
</tr>
<tr>
<td>Edge separation a)</td>
<td>&gt; 0.200 µs</td>
</tr>
<tr>
<td>Traversing speed 1)</td>
<td>≤ 600 m/min</td>
</tr>
<tr>
<td>Interpolation error</td>
<td>≤ 45 nm</td>
</tr>
<tr>
<td>Limit switches</td>
<td>L1/L2 with two different magnets; output signals: TTL (without line driver)</td>
</tr>
</tbody>
</table>

**Electrical connection**

- Cable (0.5 m/1 m/3 m) with 15-pin D-sub connector (male)
- Cable length: See interface description; however, limit: ≤ 20 m (with HEIDENHAIN cable)
- Supply voltage: DC 5 V ±0.5 V
- Current consumption: < 130 mA ≤ 150 mA (without load)
- Vibration: 65 Hz to 2000 Hz
- Shock: 6 ms
- Operating temperature: +10 °C to 70 °C

**Mass**

- Scanning head: 20 g (without cable)
- Cable: 22 g
- Connector: 32 g

* Please select when ordering
1) At a corresponding cutoff or scanning frequency
Robax is a registered trademark of Schott-Glaswerke, Mainz, Germany
LIDA 475, LIDA 485
Incremental linear encoders for measuring lengths of up to 30 m
- For measuring steps of down to 10 nm
- Limit switches
- Steel scale tape pulled through aluminum extrusions and tensioned
- Consisting of a linear scale and scanning head

ML ≤ 2040

ML > 2040 (e.g., 5040)

Mounting options for scanning head

Scale
- LIDA 405
  - Measuring standard: Steel scale tape with METALLUR scale grating; grating period: 20 µm
  - Coefficient of linear expansion: Depends on the mounting surface
  - Accuracy grade: ±5 µm
  - Baseline error: ±0.750 µm/50 mm (typical)
  - Measuring length (ML)*: 140 240 340 440 540 640 740 840 940 1040 1140 1240 1340 1440 1540 1640 1740 1840 1940 2040
  - Greater measuring lengths (up to 30,040 mm) with a one-piece scale tape and individual scale carrier sections
  - Reference marks: One at midpoint of measuring length
  - Mass: 115 g + 0.25 g/mm of measuring length

Scanning head
- LIDA 48
  - Interface: ~ 1 VPP
- LIDA 47
  - Integrated interpolation*: 5-fold 4 µm, 10-fold 2 µm, 50-fold 0.4 µm, 100-fold 0.2 µm
  - Cutoff frequency: ~500 kHz
  - Scanning frequency*: 400 kHz, 200 kHz, 100 kHz, 50 kHz, 25 kHz, 12.5 kHz, 6.25 kHz
  - Edge separation*: 0.100 µs, 0.220 µs, 0.465 µs, 0.950 µs
  - Traversing speed*: 600 m/min, 480 m/min, 240 m/min, 120 m/min, 60 m/min, 30 m/min
  - Interpolation error: ±45 nm
  - Limit switches: L1/L2 with two different magnets; output signals: TTL (without line driver)
  - Electrical connection: Cable (0.5 m/1 m/3 m) with 15-pin D-sub connector (male)
  - Cable length: See interface description; however, limit: 20 m (with HEIDENHAIN cable)
  - Supply voltage: DC 5 V ±0.5 V
  - Current consumption: < 130 mA (without load)
  - Vibration: 55 Hz to 2000 Hz
  - Shock: 6 ms
  - Operating temperature: −10 °C to 70 °C
  - Mass: Scanning head: 20 g (without cable), Connector: 32 g

* Please select when ordering
1) At a corresponding cutoff or scanning frequency

52

53
LIDA 477, LIDA 487
Incremental linear encoders for measuring ranges of up to 6 m
• For measuring steps of down to 10 nm
• Limit switches
• Steel scale tape pulled through adhesive aluminum extrusions and secured at center
  • Consisting of a linear scale and scanning head

### Mounting options for scanning head
- **F** = Machine guideway
- **P** = Measuring points for alignment
- **G** = Beginning of measuring length (ML)
- **Q** = Reference mark position
- **R** = Selector magnet for limit switch

### Scanning head
- **LIDA 48**
  - Interface: \( \sim 1 \text{ Vpp} \), TTL
  - Integrated interpolation: 5-fold, 10-fold, 50-fold, 100-fold
  - Scanning frequency: \( \sim 400 \text{ kHz} \), \( \sim 200 \text{ kHz} \), \( \sim 100 \text{ kHz} \), \( \sim 50 \text{ kHz} \), \( \sim 25 \text{ kHz} \), \( \sim 12.5 \text{ kHz} \), \( \sim 6.25 \text{ kHz} \)
  - Interpolation error: ±45 nm

- **LIDA 47**
  - Interface: \( \sim 1 \text{ Vpp} \), TTL
  - Integrated interpolation: 5-fold, 10-fold, 50-fold, 100-fold
  - Scanning frequency: \( \sim 400 \text{ kHz} \), \( \sim 200 \text{ kHz} \), \( \sim 100 \text{ kHz} \), \( \sim 50 \text{ kHz} \), \( \sim 25 \text{ kHz} \), \( \sim 12.5 \text{ kHz} \), \( \sim 6.25 \text{ kHz} \)
  - Interpolation error: ±45 nm

### Electrical connection
- Cable: (0.5 m/1 m/3 m) with 15-pin D-sub connector (male)
- Cable length: See interface description, however, limit: \( \leq 20 \text{ m} \) (with HEIDENHAIN cable)

### Supply voltage
- DC 5 V ±0.5 V

### Current consumption
- < 130 mA
- < 150 mA (without load)

### Vibration
- 65 Hz to 2000 Hz
- 6 ms
- \( \leq 500 \text{ m/s}^2 \) (EN 60068-2-6)
- \( \leq 1000 \text{ m/s}^2 \) (EN 60068-2-27)

### Operating temperature
- 10 °C to 70 °C

### Limit switches
- L1/L2 with two different magnets; output signals: TTL (without line driver)

### Mass
- **LIDA 47**
  - Scanning head: 22 g
  - Cable: 32 g

### Scale—LIDA 407
- **Measuring standard**
  - Steel scale tape with METALLUR scale grating; grating period: 20 µm
  - \( \alpha_{\text{therm}} = 10^{-6} \text{ K}^{-1} \)

- **Coefficient of linear expansion**
  - Steel scale tape with METALLUR scale grating

- **Accuracy grade**
  - ±3 µm (up to ML 1040); ±5 µm (for ML 1240 or greater); ±15 µm

- **Baseline error**
  - \( \pm 0.750 \mu m/50 \text{ mm} \) (typical)

- **Measuring length (ML)**
  - ML ≤ 2040 (e.g., 840)
  - ML > 2040 (e.g., 5040)

- **Reference marks**
  - One at midpoint of measuring length

- **Mass**
  - 25 g + 0.1 g/mm of measuring length

---

* Please select when ordering
1) ±5 µm after linear length-error compensation in the subsequent electronics
2) At a corresponding cutoff or scanning frequency

---

**Scale LIDA 407**

**Measuring standard**

- Steel scale tape with METALLUR scale grating, grating period: 20 µm

**Coefficient of linear expansion**

- \( \alpha_{\text{therm}} = 10^{-6} \text{ K}^{-1} \)

**Accuracy grade**

- ±3 µm (up to ML 1040); ±5 µm (for ML 1240 or greater); ±15 µm

**Baseline error**

- \( \pm 0.750 \mu m/50 \text{ mm} \) (typical)

**Measuring length (ML)**

- ML ≤ 2040 (e.g., 840)
  - 240  440  640  840  1040  1240  1440  1640  1840  2040  2240  2440  2640  2840
  - 3040  3240  3440  3640  3840  4040  4240  4440  4640  4840  5040  5240  5440  5640

- ML > 2040 (e.g., 5040)
  - 2840  5840  6040

**Reference marks**

- One at midpoint of measuring length

**Mass**

- 25 g + 0.1 g/mm of measuring length
**LIDA 479, LIDA 489**

Incremental linear encoders for measuring ranges of up to 6 m
- For measuring steps of down to 10 nm
- Limit switches
- Steel scale tape adhesively bonded to mounting surface
- Consisting of a scale tape and scanning head

---

### Scale LIDA 409

<table>
<thead>
<tr>
<th>Scale</th>
<th>LIDA 409</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring standard</td>
<td>Steel scale tape with METALLUR scale grating, grating period: 20 µm</td>
</tr>
<tr>
<td>Coefficient of linear expansion</td>
<td>$a_{	ext{lin}} = 10^{-6} \degree \text{C}^{-1}$</td>
</tr>
<tr>
<td>Accuracy grade</td>
<td>±3 µm, ±15 µm</td>
</tr>
<tr>
<td>Baseline error</td>
<td>±0.750 µm/50 mm (typical)</td>
</tr>
<tr>
<td>Measuring length (ML)</td>
<td>70 120 170 220 270 320 370</td>
</tr>
<tr>
<td>Reference marks</td>
<td>One at midpoint of measuring length Every 50 mm</td>
</tr>
<tr>
<td>Mass</td>
<td>31 g/m</td>
</tr>
</tbody>
</table>

### Scanning head LIDA 48 LIDA 47

<table>
<thead>
<tr>
<th>Interface</th>
<th>LIDA 48</th>
<th>LIDA 47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated interpolation*</td>
<td>5-fold</td>
<td>10-fold</td>
</tr>
<tr>
<td>Signal period</td>
<td>20 µm</td>
<td>0.4 µm</td>
</tr>
<tr>
<td>Cutoff frequency</td>
<td>±3 dB</td>
<td>500 kHz</td>
</tr>
<tr>
<td>Scanning frequency*</td>
<td>≤ 200 kHz</td>
<td>≤ 100 kHz</td>
</tr>
<tr>
<td>Edge separation</td>
<td>≥ 0.100 µs</td>
<td>≥ 0.100 µs</td>
</tr>
<tr>
<td>Traversing speed</td>
<td>± 600 m/min</td>
<td>± 240 m/min</td>
</tr>
<tr>
<td>Interpolation error</td>
<td>±45 nm</td>
<td>±45 nm</td>
</tr>
<tr>
<td>Limit switches</td>
<td>L1/L2 with two different magnets; output signals TTL (without line driver)</td>
<td></td>
</tr>
<tr>
<td>Electrical connection</td>
<td>Cable (0.5 m)/1 m/3 m with 15-pin D-sub connector (male)</td>
<td></td>
</tr>
<tr>
<td>Cable length</td>
<td>See interface description; however, l/min ≤ 20 m (with HEIDENHAIN cable)</td>
<td></td>
</tr>
<tr>
<td>Supply voltage</td>
<td>DC 5 V ±0.5 V</td>
<td></td>
</tr>
<tr>
<td>Current consumption</td>
<td>&lt; 130 mA</td>
<td>&lt; 150 mA (without load)</td>
</tr>
<tr>
<td>Vibration</td>
<td>85 Hz to 2000 Hz</td>
<td>± 500 m/s² (EN 60068-2-6)</td>
</tr>
<tr>
<td>Shock</td>
<td>≤ 1000 m/s² (EN 60068-2-27)</td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>−10 °C to 70 °C</td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>Scanning head 22 g (without cable)</td>
<td></td>
</tr>
<tr>
<td>Connector</td>
<td>32 g</td>
<td></td>
</tr>
</tbody>
</table>

---

* Please select when ordering
1) ±5 µm after linear length-error compensation in the subsequent electronics
2) At a corresponding cutoff or scanning frequency
3) Only one reference mark may be used during operation. Recommended: use the LIDA 4xR special scanning head

---

F = Machine guideway
* = Max. change during operation
IKS: Incremental track, RI: Reference mark track
ML = Beginning of measuring length (ML)
△ = Reference mark position
L = Scale tape length
gages = Scale-tape stop surface
1 = Signal-quality indicator
2 = Scanning gap
3 = Scale-tape stop surface
4 = Direction of motion of the scanning unit for ascending position values

---

**Abbreviations**
- LIDA: Linear Incremental Digital Encoder
- ML: Measuring Length
- Vpp: Volts Peak to Peak
- TTL: Transistor-Transistor Logic
- Hz: Hertz
- µm: Micrometer
- m: Meter
- °C: Degree Celsius

---

**Technical Specifications**
- Measuring Length (ML): 70, 120, 170, 220, 270, 320, 370 mm
- Resolution: ±3 µm, ±15 µm
- Baseline Error: ±0.750 µm/50 mm
- Scale Tape: 2 m, 4 m, 6 m
- Reference Marks: One at midpoint of measuring length Every 50 mm
- Mass: 31 g/m
LIDA 277, LIDA 287
Incremental linear encoder with wide mounting tolerances

- For measuring steps of down to 100 nm
- Scale tape cut from roll
- Steel scale tape pulled through adhesive aluminum extrusions and secured
- Integrated three-color LED signal-quality indicator
- Consisting of a linear scale and scanning head

Reference mark:
k = Any position of the selected reference mark starting from the beginning of the measuring length (depending on the cut)

<table>
<thead>
<tr>
<th>Measuring standard</th>
<th>LIDA 207</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel scale tape, grating period: 200 µm</td>
<td></td>
</tr>
<tr>
<td>Coefficient of linear expansion</td>
<td>( a_{W_{\text{therm}}} = 10 \cdot 10^{-6} \text{ K}^{-1} )</td>
</tr>
</tbody>
</table>

| Accuracy grade | ±15 µm |

| Scale tape from roll* | 3 m, 5 m, 10 m |

| Reference marks | Selectable every 100 mm |

<table>
<thead>
<tr>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale tape</td>
</tr>
<tr>
<td>Scale tape carrier</td>
</tr>
</tbody>
</table>

### Scanning head

<table>
<thead>
<tr>
<th>LIDA 28</th>
<th>LIDA 27</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>(~1 \text{ Vpp}) (\Gamma) (\text{TTL})</td>
</tr>
<tr>
<td>Integrated Interpolation*</td>
<td>200 µm</td>
</tr>
<tr>
<td>Signal period</td>
<td>10-fold</td>
</tr>
<tr>
<td></td>
<td>50-fold</td>
</tr>
<tr>
<td></td>
<td>100-fold</td>
</tr>
<tr>
<td>Cut-off frequency</td>
<td>(\geq 50 \text{ kHz})</td>
</tr>
<tr>
<td></td>
<td>(\geq 50 \text{ kHz})</td>
</tr>
<tr>
<td></td>
<td>(\leq 25 \text{ kHz})</td>
</tr>
<tr>
<td></td>
<td>(\leq 12.5 \text{ kHz})</td>
</tr>
<tr>
<td>Scanning frequency</td>
<td>(\geq 0.465 \text{ µs})</td>
</tr>
<tr>
<td>Edge separation a</td>
<td>(\geq 0.175 \text{ µs})</td>
</tr>
<tr>
<td></td>
<td>(\geq 0.175 \text{ µs})</td>
</tr>
<tr>
<td></td>
<td>(\geq 0.465 \text{ µs})</td>
</tr>
<tr>
<td></td>
<td>(\geq 50 \text{ kHz})</td>
</tr>
<tr>
<td></td>
<td>(\leq 25 \text{ kHz})</td>
</tr>
<tr>
<td></td>
<td>(\leq 12.5 \text{ kHz})</td>
</tr>
<tr>
<td>Traverse speed</td>
<td>(\leq 600 \text{ m/min})</td>
</tr>
<tr>
<td></td>
<td>(\leq 300 \text{ m/min})</td>
</tr>
<tr>
<td></td>
<td>(\leq 150 \text{ m/min})</td>
</tr>
<tr>
<td>Interpolation error</td>
<td>±2 µm</td>
</tr>
<tr>
<td>Electrical connection*</td>
<td>Cable (1 m or 3 m) with 15-pin D-sub connector (male)</td>
</tr>
<tr>
<td>Cable length</td>
<td>See the interface description; however, (\leq 30 \text{ m}) (with HEIDENHAIN cable)</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>DC 5 V ±0.25 V</td>
</tr>
<tr>
<td>Current consumption</td>
<td>&lt; 155 mA</td>
</tr>
<tr>
<td></td>
<td>&lt; 140 mA (without load)</td>
</tr>
<tr>
<td>Vibration 55 Hz to 2000 Hz</td>
<td>≤ 200 m/s² (EN 60068-2-6)</td>
</tr>
<tr>
<td>Shock 11 ms</td>
<td>≤ 500 m/s² (EN 60068-2-27)</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>–10 °C to 70 °C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanning head</td>
</tr>
<tr>
<td>Cable</td>
</tr>
<tr>
<td>Connector</td>
</tr>
</tbody>
</table>

* Please select when ordering
LIDA 279, LIDA 289
Incremental linear encoder with wide mounting tolerances
- For measuring steps of down to 100 nm
- Scale tape cut from roll
- Steel scale tape adhesively bonded to mounting surface
- Integrated three-color LED signal-quality indicator
- Consisting of a linear scale and scanning head

Scale:
- Measuring standard
  - Steel scale tape, grating period: 200 µm
  - Coefficient of linear expansion: $a_{\text{linear}} = 10^{-6} \text{ K}^{-1}$
- Accuracy grade
  - ±15 µm
- Scale tape from roll
  - 3 m, 5 m, 10 m
- Reference marks
  - Selectable every 100 mm
- Mass
  - 20 g/m

Scanning head:
- LIDA 28
- LIDA 27
- Interface
  - » 1 Vpp
  - » TTL
- Integrated Interpolation*
- Signal period
  - 200 µm
  - 10-fold: 20 µm
  - 50-fold: 4 µm
  - 100-fold: 2 µm
- Cut-off frequency
  - ≥ 50 kHz
  - ≥ 50 kHz
  - ≥ 25 kHz
  - ≥ 12.5 kHz
- Scanning frequency
  - ≥ 0.465 µs
  - ≥ 0.175 µs
  - ≥ 0.175 µs
- Traversing speed
  - ≤ 600 m/min
  - ≤ 300 m/min
  - ≤ 150 m/min
- Edge separation
  - a ≤ 0.465 µs
  - a ≤ 0.175 µs
  - a ≤ 0.175 µs

Interpolation error
- ±2 µm

Electrical connection*
- Cable (1 m or 3 m) with 15-pin D-sub connector (male)
- Cable length
  - See the interface description; however, € 30 m (with HEIDENHAIN cable)
- Supply voltage
  - DC 5 V ±0.25 V
- Current consumption
  - < 155 mA
  - < 140 mA (without load)
- Vibration
  - 55 Hz to 2000 Hz
  - ≤ 200 m/s² (EN 60068-2-6)
  - ≤ 500 m/s² (EN 60068-2-27)
- Shock
  - 11 ms
  - 200 m/s² (EN 60068-2-27)
  - 500 m/s² (EN 60068-2-27)
- Operating temperature
  - -10 °C to 70 °C
- Mass
  - Scanning head
    - 20 g (without cable)
  - Connector
    - 32 g

* Please select when ordering
PP 281R

Two-coordinate incremental encoder

- For measuring steps of 1 µm to 0.05 µm

Measuring standard

Coefficient of linear expansion

Two-coordinate TITANID phase grating on glass; grating period: 8 µm

\[ \text{\( \alpha_{\text{grating}} = 8 \cdot 10^{-6} \ \text{K}^{-1} \)} \]

Accuracy grade

±2 µm

Measuring area

68 mm x 68 mm, other measuring areas upon request

Reference marks:

- One reference mark in each axis, 3 mm after beginning of measuring length

Interface

- 1 Vpp

Signal period

4 µm

Cutoff frequency

-3 dB

≥ 300 kHz

Traversing speed

≤ 72 m/min

Interpolation error

RMS position noise

±12 nm

2 nm (450 kHz)

Electrical connection

Cable (0.5 m) with 15-pin D-sub connector (male); interface electronics in the connector

Cable length

See the interface description; however, ≤ 30 m (with HEIDENHAIN cable)

Supply voltage

DC 5 V ±0.25 V

Current consumption

< 185 mA per axis

Vibration

55 Hz to 2000 Hz

≤ 80 m/s² (EN 60068-2-6)

≤ 100 m/s² (EN 60068-2-27)

Shock

11 ms

80 m/s² (EN 60068-2-6)

100 m/s² (EN 60068-2-27)

Operating temperature

0 °C to 50 °C

Mass

- Scanning head: 170 g (without cable)
- Grid plate: 75 g
- Cable: 37 g
- Connector: 140 g

1) The reference mark signal deviates from the interface specification in its zero crossovers K, L (see the mounting instructions)
2) –3 dB cutoff frequency of the subsequent electronics
3) With HEIDENHAIN interface electronics (e.g., EIB 741)
HEIDENHAIN encoders with the \(1\text{ V}_{\text{PP}}\) interface provide voltage signals that are highly interpolatable.

The sinusoidal incremental signals \(A\) and \(B\) are phase-shifted by 90° elec. and have a typical amplitude of \(1\text{ V}_{\text{PP}}\). The illustrated sequence of output signals—with \(B\) lagging \(A\)—applies to the direction of motion shown in the dimension drawing.

The reference mark signal \(R\) has a unique assignment to the incremental signals. The output signal may be lower next to the reference mark.

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

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

The fault detection signal \(U_{a0}^\sim\) indicates fault conditions such as an interruption in the supply lines, failure of the light source, etc.

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

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

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

The fault detection signal \(U_{a0}^\sim\) indicates fault conditions such as an interruption in the supply lines, failure of the light source, etc.

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

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

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

The fault detection signal \(U_{a0}^\sim\) indicates fault conditions such as an interruption in the supply lines, failure of the light source, etc.

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

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

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

The fault detection signal \(U_{a0}^\sim\) indicates fault conditions such as an interruption in the supply lines, failure of the light source, etc.

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

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

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

The fault detection signal \(U_{a0}^\sim\) indicates fault conditions such as an interruption in the supply lines, failure of the light source, etc.

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

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

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

The fault detection signal \(U_{a0}^\sim\) indicates fault conditions such as an interruption in the supply lines, failure of the light source, etc.

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

#### Pin layouts (1 Vpp/TTL)

**LIDA**

15-pin D-sub connector

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

<table>
<thead>
<tr>
<th>FL/TL</th>
<th>Uₚ</th>
<th>Sensor² 5 V</th>
<th>Sensor 0 V</th>
<th>Uₐ₁</th>
<th>Uₐ₂</th>
<th>Uₐ₃</th>
<th>Uₐ₄</th>
<th>Uₐ₅</th>
<th>L₁</th>
<th>L₂</th>
<th>PWT</th>
<th>Vacant</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Vpp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cable shield on housing; Uₚ = Power supply voltage

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

Vacant pins or wires must not be used.

1) TTL/11 µAP conversion for the PWT
2) Color assignment of the connecting cable
3) Valid only for the LIDA 400
4) LIDA 200/300/6000

**LIP 281 and PP 281 R**

15-pin D-sub connector

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

<table>
<thead>
<tr>
<th>FL/TL</th>
<th>Uₚ</th>
<th>Sensor² 5 V</th>
<th>Sensor 0 V</th>
<th>A+</th>
<th>A–</th>
<th>B+</th>
<th>B–</th>
<th>R+</th>
<th>R–</th>
<th>PWT</th>
<th>Vacant</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Vpp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Cable shield on housing; Uₚ = Power supply voltage

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

Vacant pins or wires must not be used.

1) Only for adjusting, do not use in normal operation
2) Color assignment of the connecting cable
3) PP 281 R

**LIF and LIP 6000**

15-pin D-sub connector

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

<table>
<thead>
<tr>
<th>FL/TL</th>
<th>Uₚ</th>
<th>Sensor² 5 V</th>
<th>Sensor 0 V</th>
<th>Uₐ₁</th>
<th>Uₐ₂</th>
<th>Uₐ₃</th>
<th>Uₐ₄</th>
<th>Uₐ₅</th>
<th>H²</th>
<th>L¹</th>
<th>PWT</th>
<th>Vacant</th>
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<tbody>
<tr>
<td>1 Vpp</td>
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<td></td>
<td></td>
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</tbody>
</table>

Cable shield on housing; Uₚ = Power supply voltage

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

Vacant pins or wires must not be used.

1) TTL/11 µAP conversion for the PWT
2) Color assignment of the connecting cable
3) Valid only for the LIP 6000/LIF 400
4) LIDA 200/300/6000

**Alternative: LIDA 400**

12-pin M23 coupling

<table>
<thead>
<tr>
<th></th>
<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>
<td>11</td>
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<tr>
<td>5</td>
<td>6</td>
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<td>3</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>9</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>FL/TL</th>
<th>Uₚ</th>
<th>Sensor² 5 V</th>
<th>Sensor 0 V</th>
<th>Uₐ₁</th>
<th>Uₐ₂</th>
<th>Uₐ₃</th>
<th>Uₐ₄</th>
<th>Uₐ₅</th>
<th>L₁</th>
<th>L₂</th>
<th>PWT</th>
<th>Vacant</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Vpp</td>
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<td></td>
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<td></td>
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</tr>
</tbody>
</table>

Cable shield on housing; Uₚ = Power supply voltage

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

Vacant pins or wires must not be used.

1) TTL/11 µAP conversion for the PWT
2) Color assignment of the connecting cable

Further information:
For detailed descriptions of cables, please refer to the Cables and Connectors brochure.
The EnDat interface is a digital, bidirectional interface for encoders. It is capable of outputting position values, reading and updating information stored in the encoder, and storing new information in the encoder. Thanks to the serial transmission method, only four signal lines are required. The data (DATA) are transmitted in synchronism with the CLOCK signal from the subsequent electronics. The type of transmission (position values, parameters, diagnostics, etc.) is selected via mode commands that the subsequent electronics send to the encoder. Some functions are available only with EnDat 2.2 mode commands.

### Ordering designation
- **EnDat01** EnDat 2.1 or EnDat 2.2 With Incremental signals
- **EnDat21** Without Incremental signals
- **EnDat02** EnDat 2.2 With Incremental signals
- **EnDat22** Without Incremental signals

### Versions of the EnDat interface
- **Absolute encoder**
  - **Subsequent electronics**
    - » 1 Vpp A*
    - » 1 Vpp B*

### Operating parameters
- **Parameters of the OEM**
- **Parameters of the encoder manufacturer for EnDat 2.1**
- **Parameters of the encoder manufacturer for EnDat 2.2**

### Fanuc and Mitsubishi pin layouts

#### Fanuc pin layout
HEIDENHAIN encoders with the code letter F following the model designation are suitable for connection to Fanuc controls and drive systems.

- **Fanuc pin layout**
  - **Ordering designation:** Fanuc05 high speed, one-pair transmission contains the \( \triangleright \) interface (normal and high speed, two-pair transmission)

#### Mitsubishi pin layout
HEIDENHAIN encoders with the code letter M following the model designation are suitable for connection to Mitsubishi controls and drive systems.

- **Mitsubishi pin layout**
  - **Ordering designation:** Mitsu01 two-pair transmission
  - **Ordering designation:** Mit02-4 Generation 1, two-pair transmission
  - **Ordering designation:** Mit03-4 Generation 2, two-pair transmission

#### Fanuc Serial Interface – ci Interface
Ordering designation: Fanuc06 high speed, one-pair transmission contains the ci interface (normal and high speed, two-pair transmission)

#### Mitsubishi high speed interface
- **Ordering designation:** Mit02-2 Generation 1, one-pair transmission
- **Ordering designation:** Mit03-4 Generation 2, two-pair transmission

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

### Further information:
For detailed descriptions of cables, please refer to the Cables and Connectors brochure.
Panasonic and Yaskawa pin layouts

Panasonic pin layout
HEIDENHAIN encoders with the code letter P following the model designation are suitable for connection to Panasonic controls and drive systems.

- Ordering designation: Pana01

Panasonic pin layout
8-pin M12 coupling 15-pin D-sub connector

<table>
<thead>
<tr>
<th>Power supply</th>
<th>Serial data transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>U&lt;sub&gt;p&lt;/sub&gt;</th>
<th>Sensor</th>
<th>0 V</th>
<th>Sensor</th>
<th>Vacant</th>
<th>Vacant</th>
<th>Request Data</th>
<th>Request Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown/Green</td>
<td>Blue</td>
<td>White/Green</td>
<td>White</td>
<td>Gray</td>
<td>Pink</td>
<td>Violet</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

Cable shield connected to housing; U<sub>p</sub> = Power supply voltage
Sensor: The sense line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used.

1) Required for adjustment/testing with the PWM 21

Further information:
For detailed descriptions of cables, please refer to the Cables and Connectors brochure.

Yaskawa pin layout
HEIDENHAIN encoders with the code letter Y following the model designation are suitable for connection to Yaskawa controls and drive systems.

- Ordering designation: YEC07

Yaskawa pin layout
8-pin M12 coupling 15-pin D-sub connector

<table>
<thead>
<tr>
<th>Power supply</th>
<th>Serial data transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>U&lt;sub&gt;p&lt;/sub&gt;</th>
<th>Sensor</th>
<th>0 V</th>
<th>Sensor</th>
<th>Vacant</th>
<th>Vacant</th>
<th>Data</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown/Green</td>
<td>Blue</td>
<td>White/Green</td>
<td>White</td>
<td>Gray</td>
<td>Pink</td>
<td>Violet</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

Cable shield connected to housing; U<sub>p</sub> = Power supply voltage
Sensor: The sense line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used.

1) Required for adjustment/testing with the PWM 21

Further information:
For detailed descriptions of cables, please refer to the Cables and Connectors brochure.

Testing equipment and diagnostics

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

Incremental encoders mainly have 1 Vpp, TTL, or HTL interfaces. TTL and HTL encoders monitor their signal amplitudes internally and generate a simple fault detection signal. With 1 Vpp signals, the analysis of output signals is possible only with external testing devices or via computation in the subsequent electronics (analog diagnostics interface).

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

- Error message: position value is not reliable
- Warning: an internal functional limit of the encoder has been reached
- Valuation numbers:
  - Detailed information about the encoder’s function reserve
  - Identical scaling for all HEIDENHAIN encoders
  - Cyclic reading capability
The subsequent electronics are able to evaluate the current status of the encoder with low resource expenditure, including in closed-loop operation.

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

- Encoder diagnostics: the encoder is connected directly to the inspection or testing device, thereby enabling a detailed analysis of encoder functions.
- Diagnostics in the control loop: the PWM testing unit is linked into the closed control loop (e.g., via a suitable testing adapter). This enables real-time diagnosis of the machine or system during operation. The available functions depend on the interface.
## Testing equipment and diagnostics

### PWM 21

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

<table>
<thead>
<tr>
<th>Encoder input</th>
<th>PWM 21</th>
</tr>
</thead>
<tbody>
<tr>
<td>• EnDat 2.1 or EnDat 2.2 (absolute value with or without incremental signals)</td>
<td></td>
</tr>
<tr>
<td>• DRIVE-CLIQ</td>
<td></td>
</tr>
<tr>
<td>• Fanuc Serial Interface</td>
<td></td>
</tr>
<tr>
<td>• Mitsubishi high speed interface</td>
<td></td>
</tr>
<tr>
<td>• Yaskawa Serial Interface</td>
<td></td>
</tr>
<tr>
<td>• SSI</td>
<td></td>
</tr>
<tr>
<td>• 1 Vpp/TTL/11 µAPP</td>
<td></td>
</tr>
</tbody>
</table>

| Interface | USB 2.0 |
| Supply voltage | AC 100 V to 240 V or DC 24 V |
| Dimensions | 258 mm x 154 mm x 55 mm |

### ATS

| Languages | German or English (selectable) |
| Functions | • Position display |
|           | • Connection dialog |
|           | • Diagnostics |
|           | • Mounting wizard for the EB/EQ/EQI, LIP 200, LIC 4100, and others |
|           | • Additional functions (if supported by the encoder) |
|           | • Memory contents |

| System requirements and recommendations | PC (dual-core processor > 2 GHz) |
|                                          | RAM > 2 GB |
|                                          | Operating system: Windows XP/Vista, 7 (32-bit/64-bit), 8, 10 |

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

### PWT 101

The PWT 101 is a testing device for the functional testing and adjustment of incremental and absolute HEIDENHAIN encoders. Thanks to its compact and rugged design, the PWT 101 is ideal for portable use.

<table>
<thead>
<tr>
<th>Encoder input only for HEIDENHAIN encoders</th>
<th>PWT 101</th>
</tr>
</thead>
<tbody>
<tr>
<td>• EnDat</td>
<td></td>
</tr>
<tr>
<td>• Fanuc Serial Interface</td>
<td></td>
</tr>
<tr>
<td>• Mitsubishi high speed interface</td>
<td></td>
</tr>
<tr>
<td>• Panasonic Serial Interface</td>
<td></td>
</tr>
<tr>
<td>• Yaskawa Serial Interface</td>
<td></td>
</tr>
<tr>
<td>• 1 Vpp with 21 track</td>
<td></td>
</tr>
<tr>
<td>• 1 Vpp</td>
<td></td>
</tr>
<tr>
<td>• 11 µAPP</td>
<td></td>
</tr>
<tr>
<td>• TTL</td>
<td></td>
</tr>
</tbody>
</table>

| Display | 4.3-inch touchscreen |
| Supply voltage | DC 24 V |
| Operating temperature | 0 °C to 40 °C |
| Protection | EN 60529 |
| Dimensions | Approx. 145 mm x 85 mm x 35 mm |

## Interface electronics

### Interface electronics from HEIDENHAIN

Adapt the encoder signals to the interface of the subsequent electronics. They are used when the subsequent electronics cannot directly process the output signals from HEIDENHAIN encoders, or when additional interpolation of the signals is necessary.

<table>
<thead>
<tr>
<th>Encoder input only for HEIDENHAIN encoders</th>
</tr>
</thead>
<tbody>
<tr>
<td>• EnDat</td>
</tr>
<tr>
<td>• Fanuc Serial Interface</td>
</tr>
<tr>
<td>• Mitsubishi high speed interface</td>
</tr>
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</tr>
<tr>
<td>• 1 Vpp with 21 track</td>
</tr>
<tr>
<td>• 1 Vpp</td>
</tr>
<tr>
<td>• 11 µAPP</td>
</tr>
<tr>
<td>• TTL</td>
</tr>
</tbody>
</table>

### Input signals of the interface electronics

Interface electronics from HEIDENHAIN can be connected to encoders with the following sinusoidal signals: 1 Vpp (voltage signals) or 11 µAPP (current signals). Encoders with the EnDat or SSI serial interfaces can also be connected to various interface electronics.

### Output signals of the interface electronics

The interface electronics are available with the following interfaces to the subsequent electronics:

- TTL square-wave pulse trains
- EnDat 2.2
- DRIVE-CLIQ
- Fanuc Serial Interface
- Mitsubishi high speed interface
- Yaskawa Serial Interface
- PROFIBUS

### Interpolation of the sinusoidal input signals

The interface electronics perform signal conversion and interpolate the sinusoidal encoder signals. This permits finer measuring steps, resulting in higher control quality and superior positioning behavior.

### Generation of a position value

Some interface electronics feature an integrated counting function. Starting from the last set reference point, an absolute position value is generated and output to the subsequent electronics when the reference mark is traversed.

### Interface electronics

<table>
<thead>
<tr>
<th>Interface electronics</th>
</tr>
</thead>
<tbody>
<tr>
<td>• TTL square-wave pulse trains</td>
</tr>
<tr>
<td>• EnDat 2.2</td>
</tr>
<tr>
<td>• DRIVE-CLIQ</td>
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<tr>
<td>• Mitsubishi high speed interface</td>
</tr>
<tr>
<td>• Yaskawa Serial Interface</td>
</tr>
<tr>
<td>• PROFIBUS</td>
</tr>
</tbody>
</table>

### Box design

Version for integration

Top-hat rail design

Plug design
<table>
<thead>
<tr>
<th>Outputs Interface</th>
<th>Quantity</th>
<th>Inputs Interface</th>
<th>Quantity</th>
<th>Design – IP rating</th>
<th>Interpolation or subdivision</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTL</td>
<td>1</td>
<td>1 V_{PP}</td>
<td>1</td>
<td>Box design – IP65</td>
<td>5/10-fold</td>
<td>IBV 101</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>20/25/50/100-fold</td>
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<td>Without interpolation</td>
<td>IBV 600</td>
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<td></td>
<td>25/50/100/200/400-fold</td>
<td>IBV 660B</td>
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<td></td>
<td></td>
<td>11 \mu A_{PP}</td>
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<td>5/10-fold</td>
<td>EXE 102</td>
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<td>20/25/50/100-fold</td>
<td>IP 101</td>
</tr>
<tr>
<td>TTL/1 V_{PP}</td>
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<td>1 V_{PP}</td>
<td>1</td>
<td>Box design – IP65</td>
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<td>5/10-fold</td>
<td>IBV 6172</td>
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<td></td>
<td>5/10-fold and</td>
<td>IBV 6272</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>20/25/50/100-fold</td>
<td></td>
</tr>
<tr>
<td>EnDat 2.2</td>
<td>1</td>
<td>1 V_{PP}</td>
<td>1</td>
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<td>≤ 16384-fold subdivision</td>
<td>EIB 192</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Plug design – IP40</td>
<td>≤ 16384-fold subdivision</td>
<td>EIB 392</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>≤ 16384-fold subdivision</td>
<td>EIB 1512</td>
</tr>
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<td>≤ 16384-fold subdivision</td>
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</tr>
<tr>
<td>DRIVE-CLiQ</td>
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<td>EnDat 2.2</td>
<td>1</td>
<td>Box design – IP65</td>
<td>–</td>
<td>EIB 2391S</td>
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<tr>
<td>Fanuc Serial Interface</td>
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<td>1 V_{PP}</td>
<td>1</td>
<td>Box design – IP65</td>
<td>≤ 16384-fold subdivision</td>
<td>EIB 192F</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Plug design – IP40</td>
<td>≤ 16384-fold subdivision</td>
<td>EIB 392F</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>≤ 16384-fold subdivision</td>
<td>EIB 1592F</td>
</tr>
<tr>
<td>Mitsubishi high speed interface</td>
<td>1</td>
<td>1 V_{PP}</td>
<td>1</td>
<td>Box design – IP65</td>
<td>≤ 16384-fold subdivision</td>
<td>EIB 192M</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Plug design – IP40</td>
<td>≤ 16384-fold subdivision</td>
<td>EIB 392M</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>≤ 16384-fold subdivision</td>
<td>EIB 1592M</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 16384-fold subdivision</td>
<td></td>
</tr>
<tr>
<td>Yaskawa Serial Interface</td>
<td>1</td>
<td>EnDat 2.2\textsuperscript{2)}</td>
<td>1</td>
<td>Plug design – IP40</td>
<td>–</td>
<td>EIB 3391Y</td>
</tr>
<tr>
<td>PROFIBUS DP</td>
<td>1</td>
<td>EnDat 2.1, EnDat 2.2</td>
<td>1</td>
<td>Top-hat rail design</td>
<td>–</td>
<td>PROFIBUS gateway</td>
</tr>
</tbody>
</table>

\textsuperscript{1)} Switchable
\textsuperscript{2)} Only for the LIC 4100 with a 5 nm measuring step, or the LIC 2100 with a 50 nm or 100 nm measuring step