# HEIDENHAIN

**SALES & SERVICE:**

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# Exposed Linear Encoders

**March 2012**

# Exposed Linear Encoders

**Linear encoders** measure the position of linear axes without additional mechanical transfer elements. This eliminates a number of potential error sources:

- Positioning error due to thermal behavior of the recirculating ball screw
- Reversal error
- Kinematic error through ball-screw pitch error

Linear encoders are therefore indispensable for machines that must fulfill high requirements for **positioning accuracy** and **machining speed.**

**Exposed linear encoders** are designed for use on machines and installations that require especially high accuracy of the measured value. Typical applications include:

- Measuring and production equipment in the semiconductor industry
- PCB assembly machines
- Ultra-precision machines 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 drives

**Mechanical design**
Exposed linear encoders consist of a scale or scale tape and a scanning head that operate without mechanical contact.
The scale of an exposed linear encoder is fastened directly to a mounting surface. The flatness of the mounting surface is therefore a prerequisite for high accuracy of the encoder.

Information on

- Absolute angle encoders with optimized scanning
- Angle encoders with integral bearing
- Angle encoders without integral bearing
- Magnetic modular encoders
- Rotary encoders
- Encoders for servo drives
- Linear encoders for numerically controlled machine tools
- Interface electronics
- HEIDENHAIN controls

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

# Contents

# Selection Guide

**Absolute position measurement**
The **LIC** exposed linear encoders permit absolute position measurement both over large paths of traverse up to 27 m and at high traversing speed. In their dimensions and mounting, they match the LIDA 400.

**Very high accuracy**
The **LIP** exposed linear encoders are characterized by very small measuring steps together with very high accuracy and repeatability. They operate according to the interferential scanning principle and feature a DIADUR phase grating as the measuring standard (LIP 281: OPTODUR phase grating).

**High accuracy**
The **LIF** exposed linear encoders have a measuring standard manufactured in the SUPRADUR process on a glass substrate and operate on the interferential scanning principle. They feature high accuracy and repeatability, are especially easy to mount, and have limit switches and homing tracks. The special version LIF 481V can be used in high vacuum up to $10^{-7}$ bar (see separate Product Information sheet).

**High traversing speeds**
The **LIDA** exposed linear encoders are specially designed for high traversing speeds up to 10 m/s, and are particularly easy to mount with various mounting possibilities. Steel scale tapes, glass or glass ceramic are used as carriers for METALLUR graduations, depending on the respective encoder. They also feature a limit switch.

**Two-coordinate measurement**
On the **PP** two-coordinate encoder, a planar phase-grating structure manufactured with the DIADUR process serves as the measuring standard, which is scanned interferentially. This makes it possible to measure positions in a plane.

| | Substrate and mounting | Coefficient of expansion $\alpha_{therm}$ | Accuracy grade |
|---|---|---|---|
| **Absolute position measurement** | | | |
| **LIC**<br>For absolute position measurement | Steel scale tape drawn into aluminum extrusions and tensioned | Same as mounting surface | ± 5 µm |
| | Steel scale tape drawn into aluminum extrusions and fixed | $\approx 10 \cdot 10^{-6}K^{-1}$ | ± 15 µm<br>± 5 µm[2)] |
| | Steel scale tape, cemented on mounting surface | $\approx 10 \cdot 10^{-6}K^{-1}$ | ± 15 µm<br>± 5 µm[2)] |
| **Incremental linear measurement** | | | |
| **LIP**<br>For very high accuracy | Zerodur glass ceramic embedded in bolted-on Invar carrier | $\approx 0 \cdot 10^{-6}K^{-1}$ | ± 0.5 µm[3)] |
| | Scale of Zerodur glass ceramic with fixing clamps | $\approx 0 \cdot 10^{-6}K^{-1}$ | ± 3 µm<br>± 1 µm |
| | Scale of Zerodur glass ceramic or glass with fixing clamps | $\approx 0 \cdot 10^{-6}K^{-1}$ or<br>$\approx 8 \cdot 10^{-6}K^{-1}$ | ± 1 µm<br>± 0.5 µm[3)] |
| | Glass scale, fixed with clamps | $\approx 8 \cdot 10^{-6}K^{-1}$ | ± 1 µm |
| **LIF**<br>For high accuracy | Scale of Zerodur glass ceramic or glass, bonded with PRECIMET adhesive film | $\approx 0 \cdot 10^{-6}K^{-1}$ or<br>$\approx 8 \cdot 10^{-6}K^{-1}$ | ± 3 µm |
| **LIDA**<br>For high traversing speeds and large measuring lengths | Glass or glass ceramic scale, bonded to the mounting surface | $\approx 0 \cdot 10^{-6}K^{-1}$ or<br>$\approx 8 \cdot 10^{-6}K^{-1}$ | ± 5 µm[3)] |
| | Steel scale tape drawn into aluminum extrusions and tensioned | Same as mounting surface | ± 5 µm |
| | Steel scale tape drawn into aluminum extrusions and fixed | $\approx 10 \cdot 10^{-6}K^{-1}$ | ± 15 µm<br>± 5 µm[2)] |
| | Steel scale tape, cemented on mounting surface | $\approx 10 \cdot 10^{-6}K^{-1}$ | ± 15 µm<br>± 5 µm[2)] |
| | Steel scale tape drawn into aluminum extrusions and fixed | $\approx 10 \cdot 10^{-6}K^{-1}$ | ± 30 µm |
| | Steel scale tape, cemented on mounting surface | $\approx 10 \cdot 10^{-6}K^{-1}$ | ± 30 µm |
| **PP**<br>For two-coordinate measurement | Glass grid plate, with full-surface bonding | $\approx 8 \cdot 10^{-6}K^{-1}$ | ± 2 µm |

[1)] Signal period of the sinusoidal signals. It is definitive for deviations within one signal period (see *Measuring Accuracy*).

| | Position error per signal period typically | Signal period[1] | Meas. length | Interface | Model | Page |
|---|---|---|---|---|---|---|
| | | | | | | |
| | ± 0.08 µm | – | 140 mm to 27 040 mm | EnDat 2.2/22 | **LIC 4015** | **18** |
| | ± 0.08 µm | – | 240 mm to 6 040 mm | EnDat 2.2/22 | **LIC 4017** | **20** |
| | ± 0.08 µm | – | 70 mm to 1 020 mm | EnDat 2.2/22 | **LIC 4019** | **22** |
| | | | | | | |
| | ± 0.001 µm | 0.128 µm | 70 mm to 270 mm | ⊓⊔TTL<br>∼ 1 $V_{PP}$ | **LIP 372**<br>**LIP 382** | **24** |
| | ± 0.001 µm | 0.512 µm | 20 mm to 3 040 mm | ∼ 1 $V_{PP}$ | **LIP 281** | **26** |
| | ± 0.02 µm | 2 µm | 70 mm to 420 mm | ⊓⊔TTL<br>∼ 1 $V_{PP}$ | **LIP 471**<br>**LIP 481** | **28** |
| | ± 0.04 µm | 4 µm | 70 mm to 1 440 mm | ⊓⊔TTL<br>∼ 1 $V_{PP}$ | **LIP 571**<br>**LIP 581** | **30** |
| | ± 0.04 µm | 4 µm | 70 mm to 1 020 mm | ⊓⊔TTL<br>∼ 1 $V_{PP}$ | **LIF 471**<br>**LIF 481** | **32** |
| | ± 0.2 µm | 20 µm | 240 mm up 3 040 mm | ⊓⊔TTL<br>∼ 1 $V_{PP}$ | **LIDA 473**<br>**LIDA 483** | **34** |
| | ± 0.2 µm | 20 µm | 140 mm to 30 040 mm | ⊓⊔TTL<br>∼ 1 $V_{PP}$ | **LIDA 475**<br>**LIDA 485** | **36** |
| | ± 0.2 µm | 20 µm | 240 mm to 6 040 mm | ⊓⊔TTL<br>∼ 1 $V_{PP}$ | **LIDA 477**<br>**LIDA 487** | **38** |
| | ± 0.2 µm | 20 µm | Up to 6 000 mm[4] | ⊓⊔TTL<br>∼ 1 $V_{PP}$ | **LIDA 479**<br>**LIDA 489** | **40** |
| | ± 2 µm | 200 µm | UP to 10 000 mm[4] | ⊓⊔TTL<br>∼ 1 $V_{PP}$ | **LIDA 277**<br>**LIDA 287** | **42** |
| | ± 2 µm | 200 µm | UP to 10 000 mm[4] | ⊓⊔TTL<br>∼ 1 $V_{PP}$ | **LIDA 279**<br>**LIDA 289** | **44** |
| | | | | | | |
| | ± 0.04 µm | 4 µm | Measuring range 68 x 68 mm[4] | ∼ 1 $V_{PP}$ | **PP 281** | **46** |

[2] After linear length-error compensation in the evaluation electronics
[3] Higher accuracy grades available on request
[4] Other measuring lengths/ranges upon request


**LIC 4015**


**LIC 4017**


**LIP 382**


**LIP 281**


**LIP 581**


**LIF 481**


**LIDA 489**


**LIDA 287**


**PP 281**

# Measuring Principles
## Measuring Standard

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

These graduations are applied to a carrier substrate of glass or steel. The scale substrate for large measuring lengths is a steel tape.

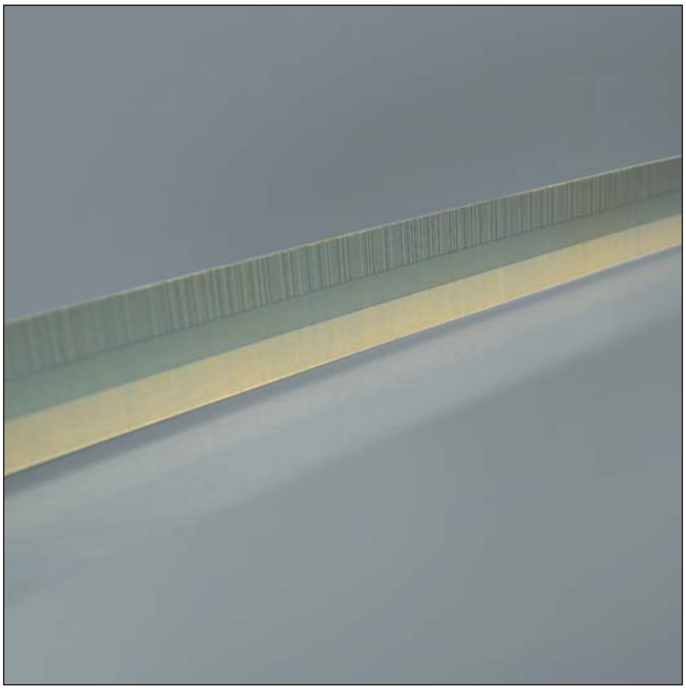
HEIDENHAIN manufactures the precision graduations in specially developed, photolithographic processes.
- AURODUR: matte-etched lines on gold-plated steel tape with typical graduation period of 40 µm
- METALLUR: contamination-tolerant graduation of metal lines on gold, with typical graduation period of 20 µm
- DIADUR: extremely robust chromium lines on glass (typical graduation period of 20 µm) or three-dimensional chrome structures (typical graduation period of 8 µm) on glass
- SUPRADUR phase grating: optically three dimensional, planar structure; particularly tolerant to contamination; typical graduation period of 8 µm and less
- OPTODUR phase grating: optically three dimensional, planar structure with particularly high reflectance, typical graduation period of 2 µm and less

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

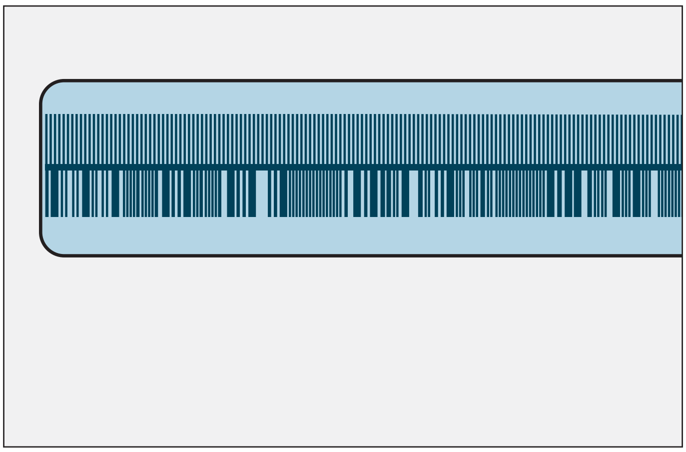
The master graduations are manufactured by HEIDENHAIN on custom-built high-precision ruling machines.

## Absolute Measuring Method

With the absolute measuring method, the position value is available from the encoder immediately upon switch-on and can be called 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 graduated disk**, which is formed from a serial absolute code structure. A separate incremental track is interpolated for the position value and at the same time—depending on the interface version—is used to generate an optional incremental signal.



Graduation of an absolute linear encoder



Schematic representation of an absolute code structure with an additional incremental track (LC 401x as example)

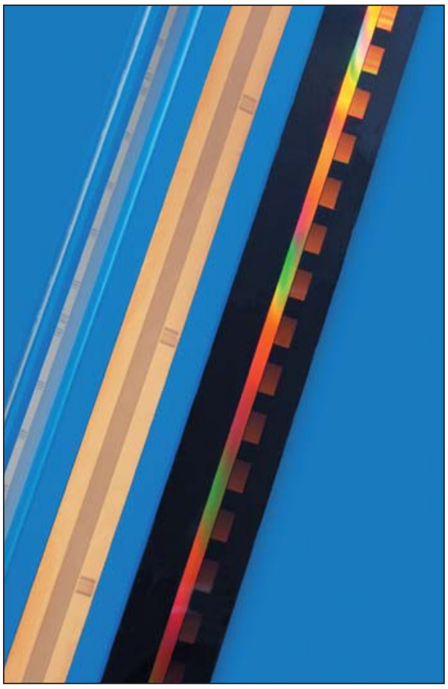
# Incremental Measuring Method

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, established by the reference mark, is gated with exactly one signal period.
The reference mark must therefore be scanned to establish an absolute reference or to find the last selected datum.

In some cases this may necessitate machine movement over large parts of the measuring range. To speed and simplify such "reference runs," many encoders feature **distance-coded reference marks**—multiple reference marks that are individually spaced according to a mathematical algorithm. The subsequent electronics find the absolute reference after traversing two successive reference marks—only a few millimeters traverse (see table).

Encoders with distance-coded reference marks are identified with a "C" behind the model designation (e.g. LIP 581 C).

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



Graduations of incremental linear encoders

$$P_1 = (\text{abs } B - \text{sgn } B - 1) \times \frac{N}{2} + (\text{sgn } B - \text{sgn } D) \times \frac{\text{abs } M_{RR}}{2}$$

where:

$$B = 2 \times M_{RR} - N$$

Where:

$P_1$ = Position of the first traversed reference mark in signal periods

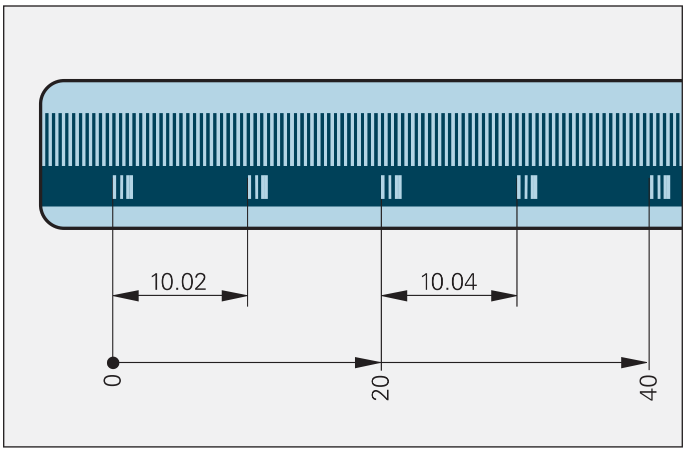
abs = Absolute value

sgn = Algebraic sign function ("+1" or "–1")

$M_{RR}$ = 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 (LIP 5x1 C as example)

| | Signal period | Nominal increment N in signal periods | Maximum traverse |
|---|---|---|---|
| **LIP 5x1 C** | 4 µm | 5000 | 20 mm |
| **LIDA 4x3 C** | 20 µm | 1000 | 20 mm |

Technical Characteristics

# Photoelectric Scanning

Most HEIDENHAIN encoders operate using the principle of photoelectric scanning. Photoelectric scanning of a measuring standard is contact-free, and as such, free of wear. This method detects even very fine lines, no more than a few microns wide, and generates output signals with very small signal periods.

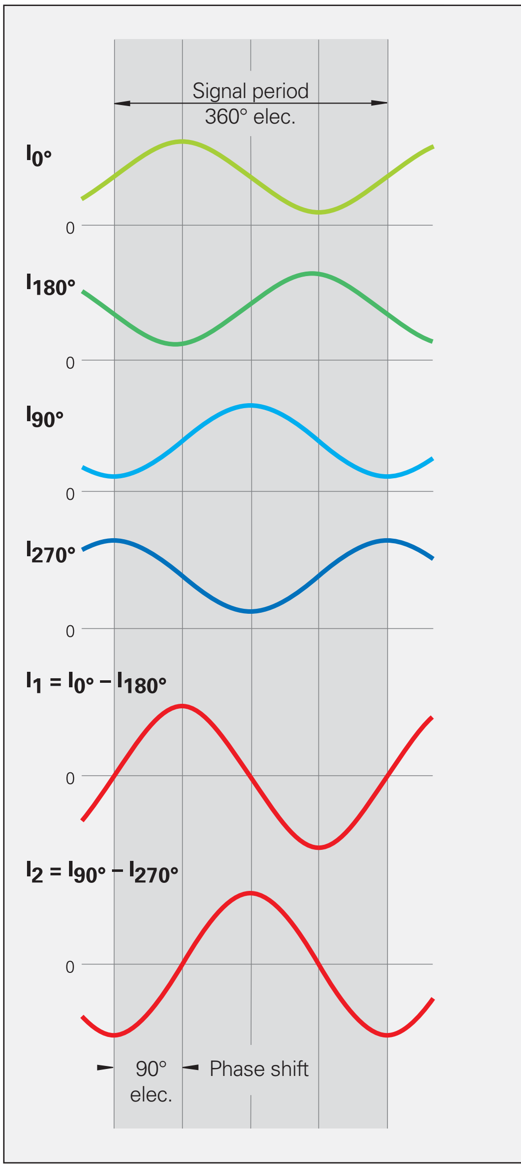
The finer the grating period of a measuring standard is, the greater the effect of diffraction on photoelectric scanning. HEIDENHAIN uses two scanning principles with linear encoders:

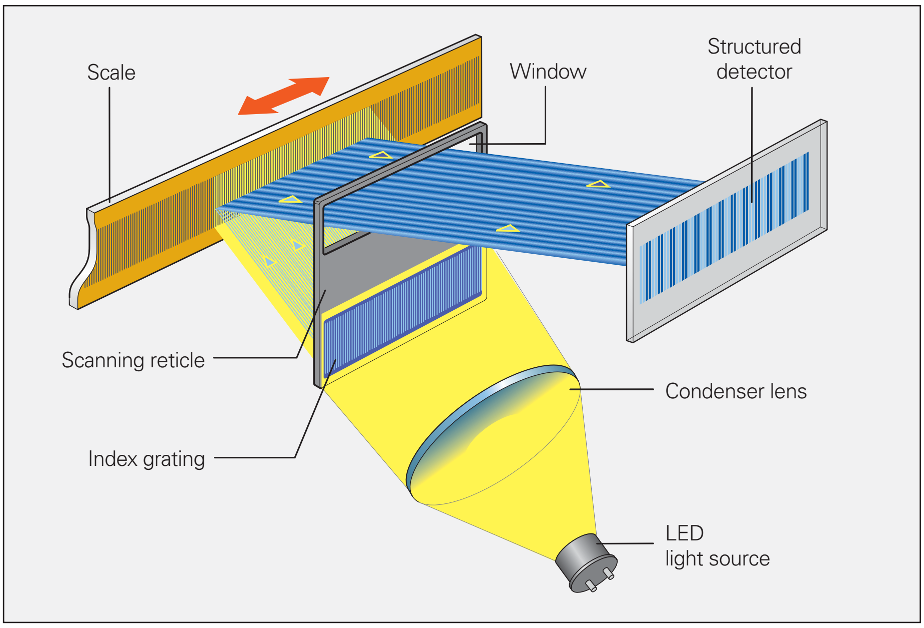
- The **imaging scanning principle** for grating periods from 10 µm to 200 µm.
- The **interferential scanning principle** for very fine graduations with grating periods of 4 µm and smaller.

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

When parallel light passes through a grating, light and dark surfaces are projected at a certain distance. An index grating with the same or similar grating period is located here. When the two gratings move relative to each other, the incident light is modulated. If the gaps in the gratings are aligned, light passes through. If the lines of one grating coincide with the gaps of the other, no light passes through. Photovoltaic cells convert these variations in light intensity into electrical signals. The specially structured grating of the scanning reticle filters the light to generate nearly sinusoidal output signals. The smaller the period of the grating structure is, the closer and more tightly toleranced the gap must be between the scanning reticle and scale. Practical mounting tolerances for encoders with the imaging scanning principle are achieved with grating periods of 10 µm and larger.

The **LIC** and **LIDA** linear encoders operate according to the imaging scanning principle.

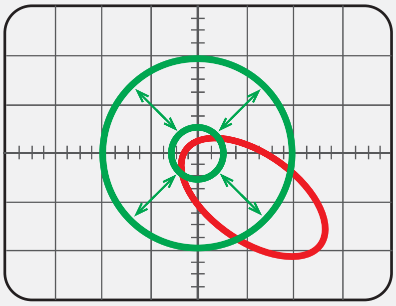



Photoelectric scanning in accordance with the imaging scanning principle with steel scale and single-field scanning (LIDA 400)

The sensor generates four nearly sinusoidal current signals ($I_{0°}$, $I_{90°}$, $I_{180°}$ and $I_{270°}$), electrically phase-shifted to each other by 90°. These scanning signals do not at first lie symmetrically about the zero line. For this reason the photovoltaic cells are connected in a push-pull circuit, producing two 90° phase-shifted output signals $\mathbf{I_1}$ and $\mathbf{I_2}$ in symmetry with respect to the zero line.

In the X/Y representation on an oscilloscope the signals form a Lissajous figure. Ideal output signals appear as a centered circle. Deviations in the circular form and position are caused by position error within one signal period (see *Measuring Accuracy*) and therefore go directly into the result of measurement. The size of the circle, which corresponds with the amplitude of the output signal, can vary within certain limits without influencing the measuring accuracy.



XY representation of the output signals

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

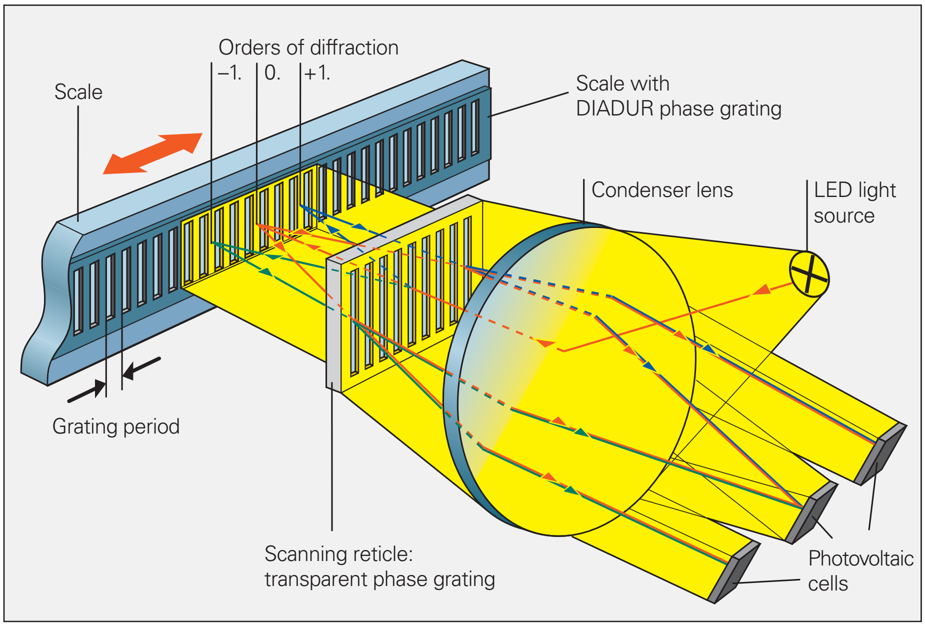
A step grating is used as the measuring standard: reflective lines 0.2 µm high are applied to a flat, reflective surface. In front of that is the scanning reticle—a transparent phase grating with the same grating period as the scale.

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

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

Interferential encoders function with 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 suited for high resolution and high accuracy. Even so, their generous mounting tolerances permit installation in a wide range of applications.

**LIP and LIF** linear encoders and the **PP** two-coordinate encoders operate according to the interferential scanning principle.




Photoelectric scanning in accordance with the interferential scanning principle and single-field scanning

# Measuring Accuracy

The accuracy of linear measurement is mainly determined by
- the quality of the graduation
- the quality of the scanning process,
- the quality of the signal processing electronics,
- the error from the scale guideway relative to the scanning unit.

A distinction is made between position error over relatively large paths of traverse—for example the entire measuring range—and that within one signal period.

**Position error over measuring length**
The accuracy of exposed linear encoders is specified in accuracy grades, which are defined as follows:

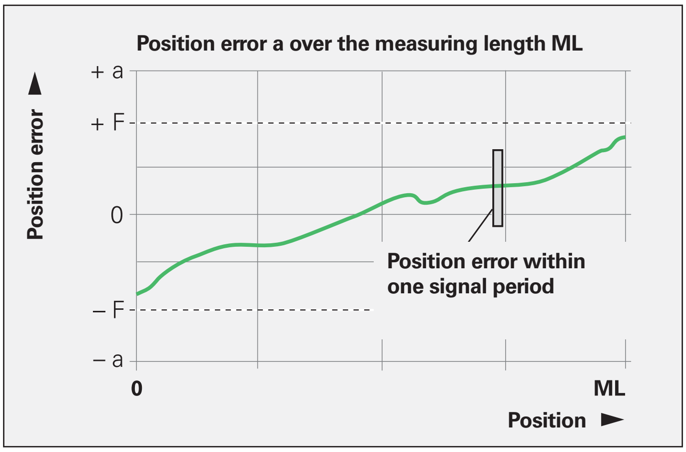
*The extreme values of the total error F of a position lie—with reference to their mean value—over any max. one-meter section of the measuring length within the accuracy grade ±a.*

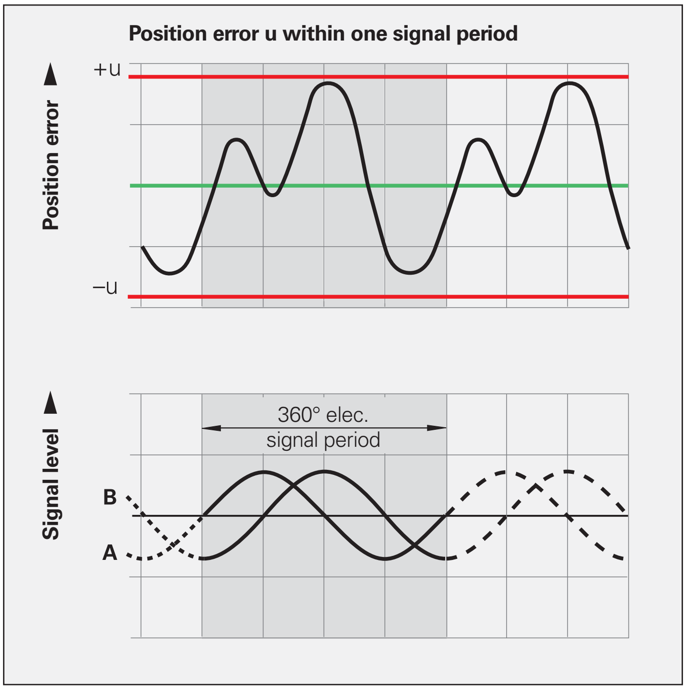
With exposed linear encoders, the above definition of the accuracy grade applies only to the scale. It is then called the scale accuracy.

**Position error within one signal period**
The position error within one signal period is determined by the quality of scanning and the signal period of the encoder. At any position over the entire measuring length of exposed HEIDENHAIN linear encoders it is better than approx. ± 1 % of the signal period.

The smaller the signal period, the smaller the position error within one signal period. It is of critical importance both for accuracy of a positioning movement as well as for velocity control during the slow, even traverse of an axis.

| | Signal period of the scanning signals | Typical position error u within one signal period |
|---|---|---|
| **LIP 3x2** | 0.128 µm | ± 0.001 µm |
| **LIP 281** | 0.512 µm | ± 0.001 µm |
| **LIP 4x1** | 2 µm | ± 0.02 µm |
| **LIP 5x1**<br>**LIF, PP** | 4 µm | ± 0.04 µm |
| **LIC 40xx** | – | ± 0.08 µm |
| **LIDA 4xx** | 20 µm | ± 0.2 µm |
| **LIDA 2xx** | 200 µm | ± 2 µm |



All HEIDENHAIN linear encoders are inspected before shipping for accuracy and proper function.

They are calibrated for accuracy during traverse in both directions. The number of measuring positions is selected to determine very exactly not only the long-range error, but also the position error within one signal period.

The **Manufacturer's Inspection Certificate** confirms the specified system accuracy of each encoder. The **calibration standards** ensure the traceability—as required by EN ISO 9001—to recognized national or international standards.

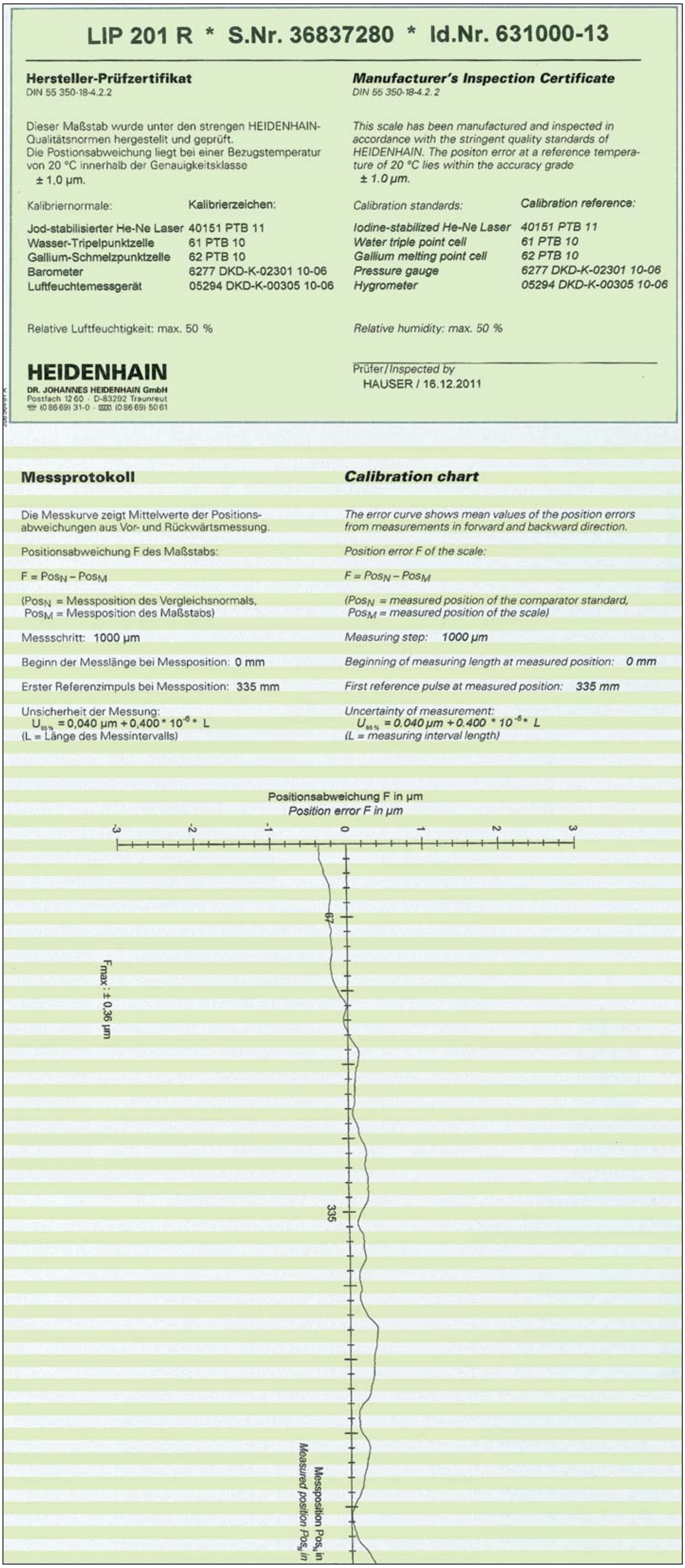
For the encoders of the LIP and PP series, a **calibration chart** documents the position error over the measuring range. It also shows the measuring step and the measuring uncertainty of the calibration measurement.

**Temperature range**
The linear encoders are calibrated at a **reference temperature** of 20 °C. The system accuracy given in the calibration chart applies at this temperature.

The **operating temperature range** indicates the ambient temperature limits between which the linear encoders will function properly.

The **storage temperature range** of –20 °C to +70 °C applies for the unit in its packaging.

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 or scale housing should be mounted at table height on the machine slide. It is important to ensure that the mounting surface is parallel to the machine guideway.



**LIP 201 R * S.Nr. 36837280 * Id.Nr. 631000-13**

**Hersteller-Prüfzertifikat**
DIN 55 350-18-4.2.2

Dieser Maßstab wurde unter den strengen HEIDENHAIN-Qualitätsnormen hergestellt und geprüft. Die Postionsabweichung liegt bei einer Bezugstemperatur von 20 °C innerhalb der Genauigkeitsklasse
± 1,0 µm.

| Kalibriernormale: | Kalibrierzeichen: |
|---|---|
| Jod-stabilisierter He-Ne Laser | 40151 PTB 11 |
| Wasser-Tripelpunktzelle | 61 PTB 10 |
| Gallium-Schmelzpunktzelle | 62 PTB 10 |
| Barometer | 6277 DKD-K-02301 10-06 |
| Luftfeuchtemessgerät | 05294 DKD-K-00305 10-06 |

Relative Luftfeuchtigkeit: max. 50 %

***Manufacturer's Inspection Certificate***
*DIN 55 350-18-4.2.2*

*This scale has been manufactured and inspected in accordance with the stringent quality standards of HEIDENHAIN. The positon error at a reference temperature of 20 °C lies within the accuracy grade*
*± 1.0 µm.*

| *Calibration standards:* | *Calibration reference:* |
|---|---|
| *Iodine-stabilized He-Ne Laser* | *40151 PTB 11* |
| *Water triple point cell* | *61 PTB 10* |
| *Gallium melting point cell* | *62 PTB 10* |
| *Pressure gauge* | *6277 DKD-K-02301 10-06* |
| *Hygrometer* | *05294 DKD-K-00305 10-06* |

*Relative humidity: max. 50 %*

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Prüfer / *Inspected by*
HAUSER / 16.12.2011

**Messprotokoll**

Die Messkurve zeigt Mittelwerte der Positionsabweichungen aus Vor- und Rückwärtsmessung.

Positionsabweichung F des Maßstabs:

$F = Pos_N - Pos_M$

($Pos_N$ = Messposition des Vergleichsnormals,
$Pos_M$ = Messposition des Maßstabs)

Messschritt: 1000 µm

Beginn der Messlänge bei Messposition: 0 mm

Erster Referenzimpuls bei Messposition: 335 mm

Unsicherheit der Messung:
$U_{95\,\%}$ = 0,040 µm + 0,400 * $10^{-6}$ * L
(L = Länge des Messintervalls)

***Calibration chart***

*The error curve shows mean values of the position errors from measurements in forward and backward direction.*

*Position error F of the scale:*

$F = Pos_N - Pos_M$

*($Pos_N$ = measured position of the comparator standard,*
*$Pos_M$ = measured position of the scale)*

*Measuring step: 1000 µm*

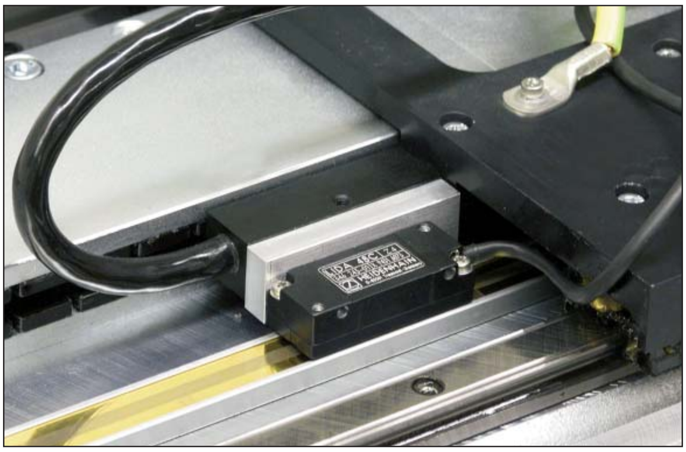
*Beginning of measuring length at measured position: 0 mm*

*First reference pulse at measured position: 335 mm*

*Uncertainty of measurement:*
*$U_{95\,\%}$ = 0.040 µm + 0.400 * $10^{-6}$ * L*
*(L = measuring interval length)*

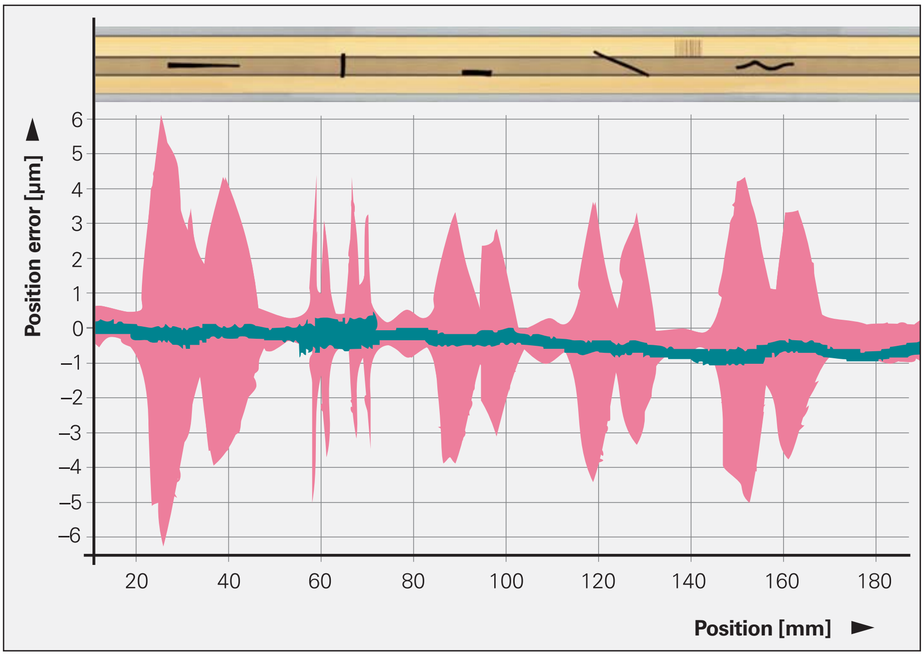
# Reliability

Exposed linear encoders from HEIDENHAIN are optimized for use on fast, precise machines. In spite of the exposed mechanical design they are highly tolerant to contamination, ensure high long-term stability, and are quickly and easily mounted.

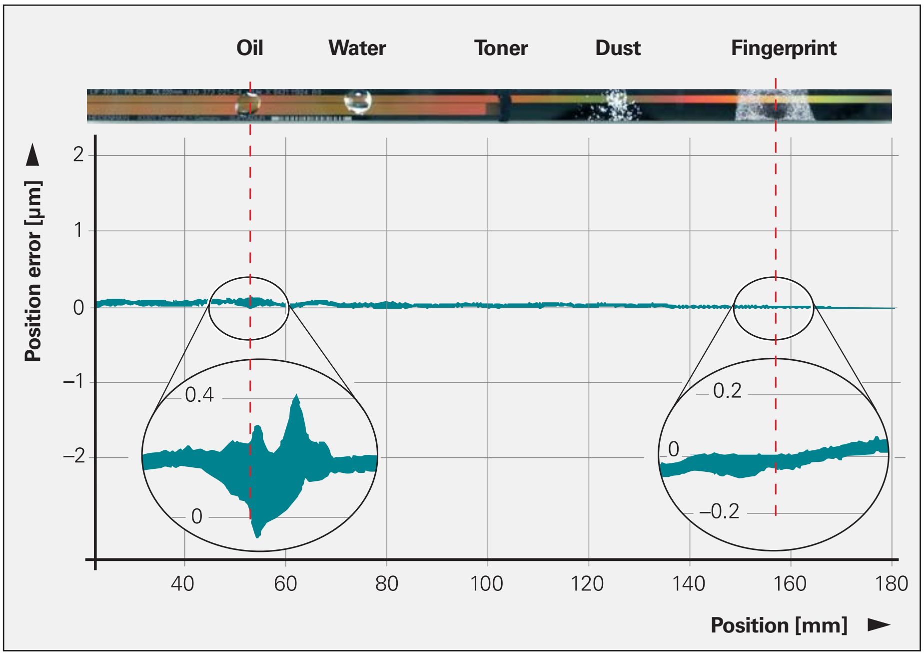


**Lower sensitivity to contamination**
Both the high quality of the grating and the scanning method are responsible for the accuracy and reliability of linear encoders. Exposed linear encoders from HEIDENHAIN operate with **single-field scanning.** Only one scanning field is used to generate the scanning signals. Unlike four-field scanning, with single-field scanning, local contamination on the measuring standard (e.g., fingerprints from mounting or oil accumulation from guideways) influences the light intensity of the signal components, and therefore the scanning signals, in equal measure. The output signals do change in their amplitude, but not in their offset and phase position. They remain highly interpolable, and the position error within one signal period remains small.

The **large scanning field** additionally reduces sensitivity to contamination. In many cases this can prevent encoder failure. This is particularly clear with the LIDA 400 and LIF 400, which in relation to the grating period have a very large scanning surface of 14.5 mm$^2$. Even if the contamination from printer's ink, PCB dust, water or oil is up to 3 mm in diameter, the encoders continue to provide high-quality signals. The position error remains far below the values specified for the accuracy grade of the scale.




Effects of contamination with four-field scanning (red) and single-field scanning (green)




Reaction of the LIF 400 to contamination

**Durable measuring standards**
By the nature of their design, the measuring standards of exposed linear encoders are less protected from their environment. HEIDENHAIN therefore always uses tough gratings manufactured in special processes.

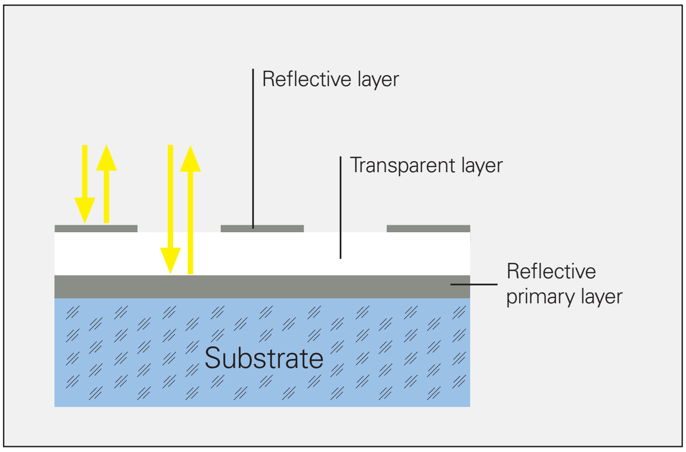
In the DIADUR process, hard chrome structures are applied to a glass or steel carrier.

In the OPTODUR and SUPRADUR process, a transparent layer is applied first over the reflective primary layer. An extremely thin, hard chrome layer is applied to produce an optically three-dimensional phase grating. Graduations that use the imaging scanning principle are produced according to the METALLUR procedure, and have a very similar structure. A reflective gold layer is covered with a thin layer of glass. On this layer are lines of chromium only several nanometers thick, which are semitransparent and act as absorbers. Measuring standards with OPTODUR-, SUPRADUR or METALLUR graduations have proven to be particularly robust and insensitive to contamination because the low height of the structure leaves practically no surface for dust, dirt or water particles to accumulate.

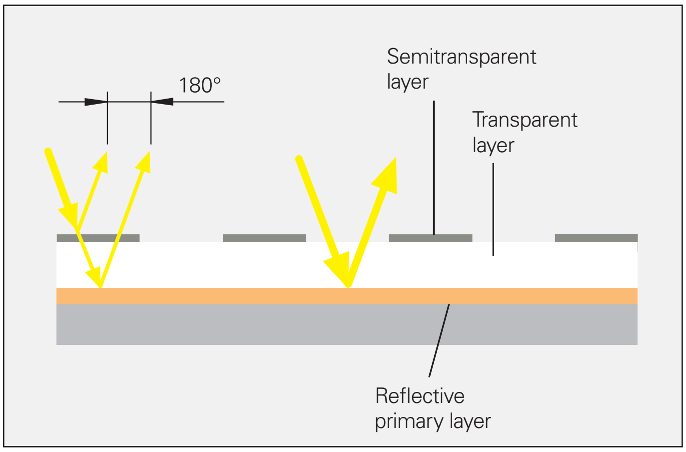
**Application-oriented mounting tolerances**
Very small signal periods usually come with very narrow mounting tolerances for the gap between the scanning head and scale tape. This is the result of diffraction caused by the grating structures. It can lead to a signal attenuation of 50% with a gap change of only ±0.1 mm. Thanks to the interferential scanning principle and innovative index gratings in encoders with the imaging scanning principle it has become possible to provide ample mounting tolerances in spite of the small signal periods.

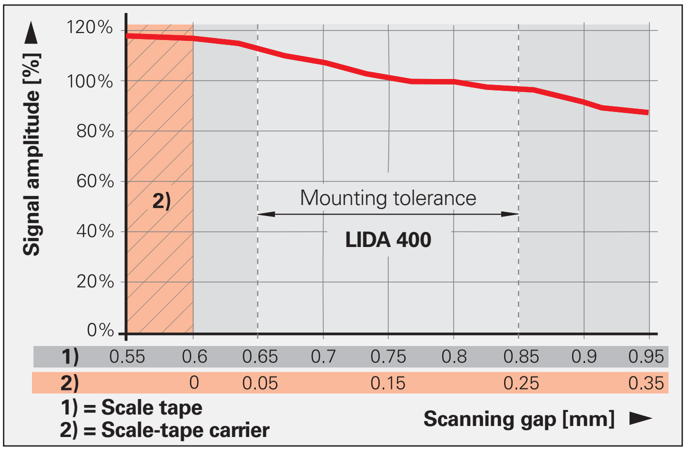
The mounting tolerances of exposed linear encoders from HEIDENHAIN have only a slight influence on the output signals. In particular, the specified tolerance between the scale and scanning head (scanning gap) cause only negligible change in the signal amplitude. This behavior is substantially responsible for the high reliability of exposed linear encoders from HEIDENHAIN. The two diagrams illustrate the correlation between the scanning gap and signal amplitude for the encoders of the LIDA 400 and LIF 400 series.

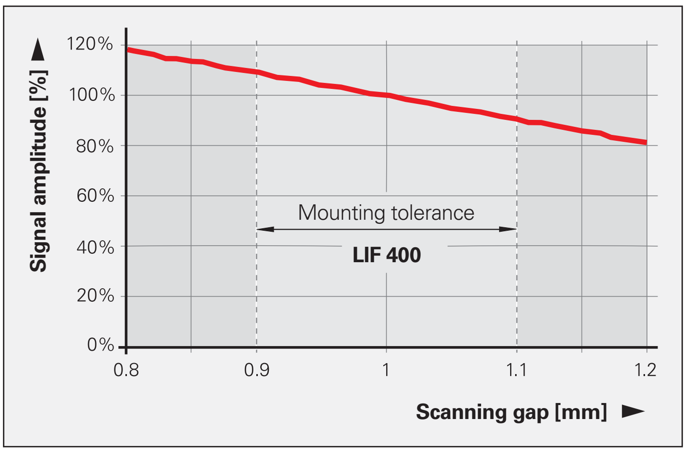
OPTODUR
SUPRADUR




METALLUR



# Mechanical Design Types and Mounting

## Linear Scales

Exposed linear encoders consist of two components: the scanning head and the scale or scale tape. They are positioned to each other solely by the machine guideway. For this reason the machine must be designed from the very beginning to meet the following prerequisites:

- The machine guideway must be designed so that the mounting space for the encoder meets the **tolerances** for the scanning gap (see *Specifications*).
- The bearing surface of the scale must meet requirements for **flatness**.
- To facilitate adjustment of the scanning head to the scale, it should be fastened with a **bracket.**

**Scale versions**
HEIDENHAIN provides the appropriate scale version for the application and accuracy requirements at hand.

**LIP 3x2**
High-accuracy LIP 300 scales feature a graduation substrate of Zerodur, which is cemented in the thermal stress-free zone of a steel carrier. The steel carrier is secured to the mounting surface with screws. Flexible fastening elements ensure reproducible thermal behavior.

**LIP 281**
**LIP 4x1**
**LIP 5x1**
The graduation carriers of Zerodur or glass are fastened onto the mounting surface with clamps and additionally secured with silicone adhesive. The thermal zero point is fixed with epoxy adhesive.

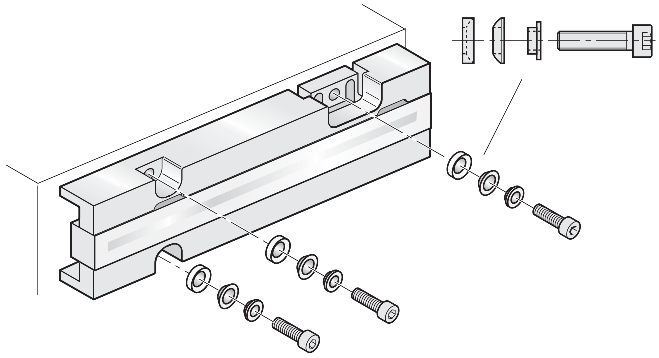
| | |
|---|---|
| *Accessories for LIP 281* | |
| Fixing clamps (6 units) | ID 683609-01 |
| Fixing clamp for thermal fixed point | ID 638611-01 |
| Epoxy adhesive | ID 734360-01 |

| | |
|---|---|
| *Accessories for LIP 4xx/LIP 5xx* | |
| Fixing clamps | ID 270711-04 |
| Silicone adhesive | ID 200417-02 |
| Epoxy adhesive | ID 200409-01 |

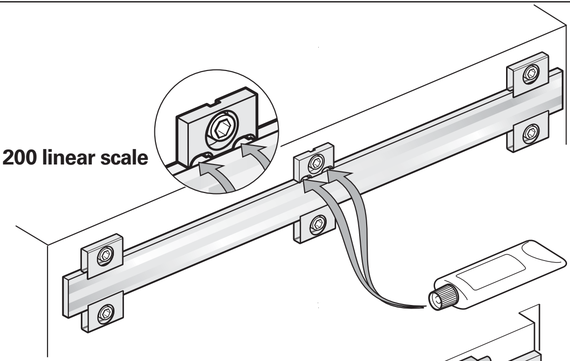
**LIF 4x1**
**LIDA 4x3**
The graduation carriers of glass are glued directly to the mounting surface with PRECIMET adhesive film, and pressure is evenly distributed with a roller.

| | |
|---|---|
| *Accessory* | |
| Roller | ID 276885-01 |

**LIP 302 linear scale**

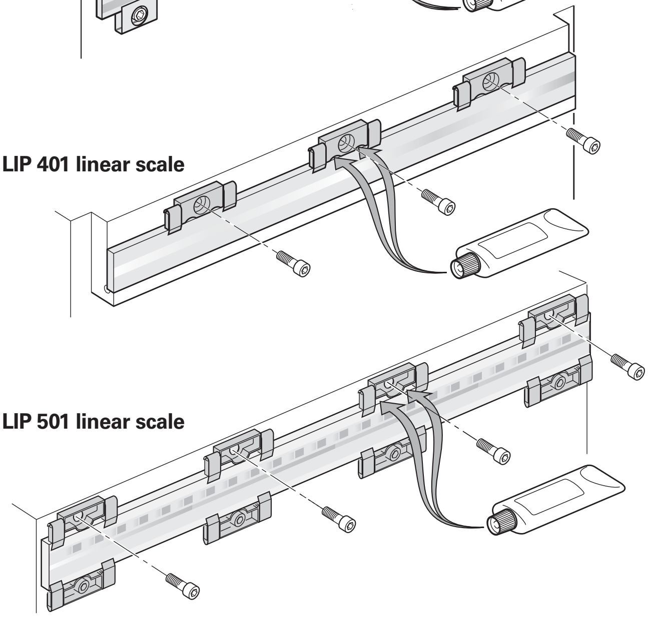


**LIP 200 linear scale**

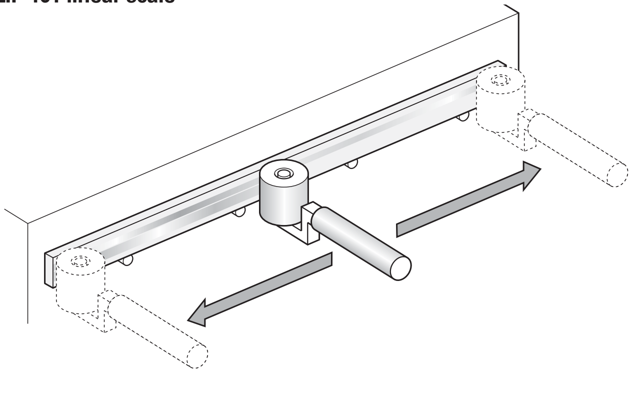


**LIP 401 linear scale**

**LIP 501 linear scale**



**LIF 401 linear scale**



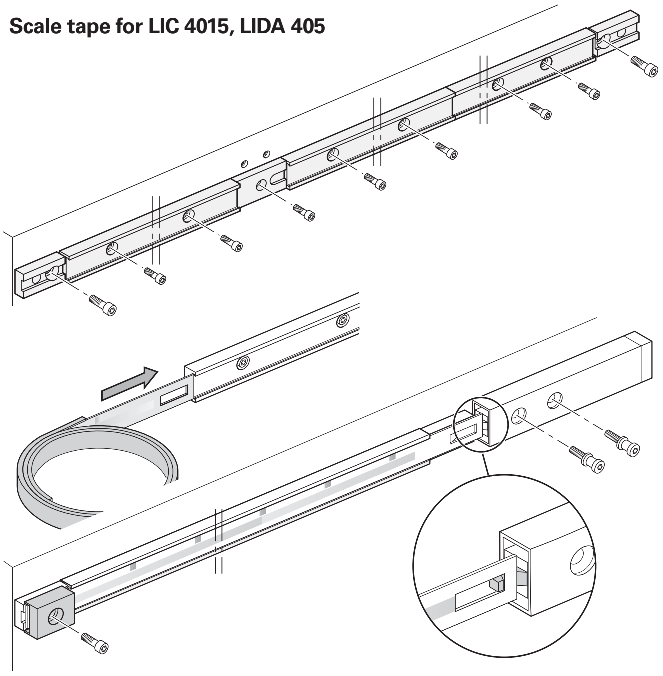
**LIC 4015**
**LIDA 4x5**
Linear encoders of the LIC 4015 and LIDA 4x5 series are specially designed for large measuring lengths. They are mounted with scale carrier sections screwed onto the mounting surface or with PRECIMET adhesive film. Then the one-piece steel scale-tape is pulled into the carrier, **tensioned in a defined manner,** and **secured at its ends** to the machine base. The LIC 40x5 and LIDA 4x5 therefore share the thermal behavior of their mounting surface.

**LIC 4017**
**LIDA 2x7**
**LIDA 4x7**
Encoders of the LIC 4017, LIDA 2x7 and LIDA 4x7 series are also designed for large measuring lengths. The scale carrier sections are secured to the supporting surface with PRECIMET adhesive mounting film; the one-piece scale tape is pulled in and **the midpoint is secured** to the machine bed. This mounting method allows the scale to expand freely at both ends and ensures a defined thermal behavior.

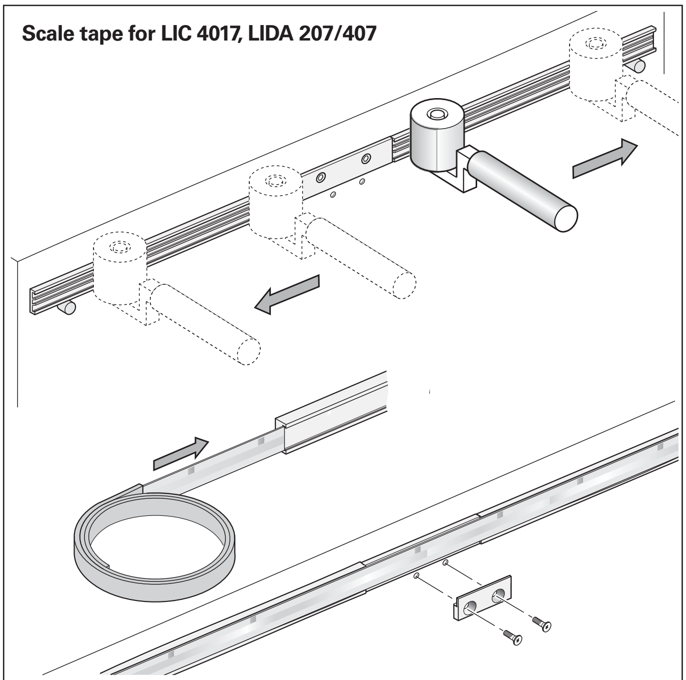
*Accessory* for LIC 4017, LIDA 4x7
Mounting aid ID 373990-01

Mounting aid (for LIC 4017, LIDA 4x7)

**Scale tape for LIC 4015, LIDA 405**



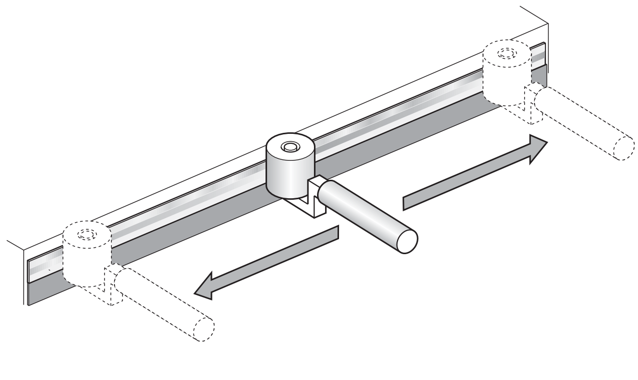
**Scale tape for LIC 4017, LIDA 207/407**



**LIC 4019**
**LIDA 2x9**
**LIDA 4x9**
The steel scale-tape of the graduation is glued directly to the mounting surface with PRECIMET adhesive film, and pressure is evenly distributed with a roller. A ridge or aligning rail 0.3 mm high is to be used for horizontal alignment of the scale tape.

*Accessory* for versions with PRECIMET
Roller ID 276885-01

**Scale tape for LIC 4019, LIDA 209/409**



# Mechanical Design Types and Mounting
## Scanning Heads

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 for simplest and most practical adjustment as well as to ensure the most stable possible construction.

For exact alignment of the scanning head to the scale, it must be adjustable in five axes (see illustration). Because the paths of adjustment are very small, the provision of oblong holes in an angle bracket generally suffices.

**Mounting the LIP 281**
The LIP 281 is mounted from behind or above onto a flat surface (e.g. a bracket). These surfaces have contact areas for thermal connection to optimal heat dissipation. The mounting elements should be made of an effective heat-conducting material.

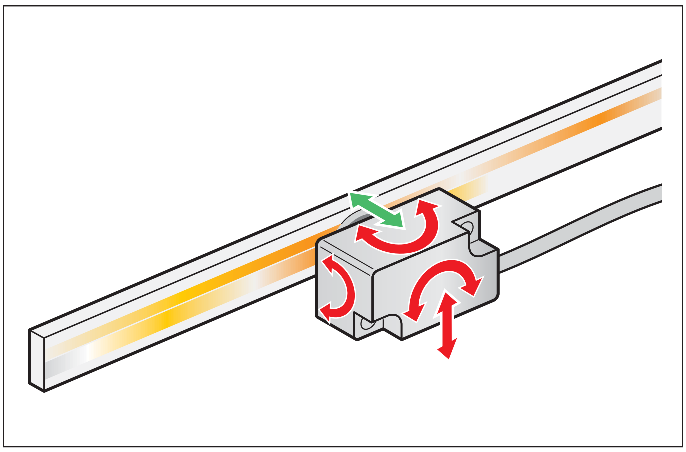
**Mounting the LIP/LIF**
The scanning head features a centering collar that allows it to be rotated in the location hole of the angle bracket and aligned parallel to the scale.

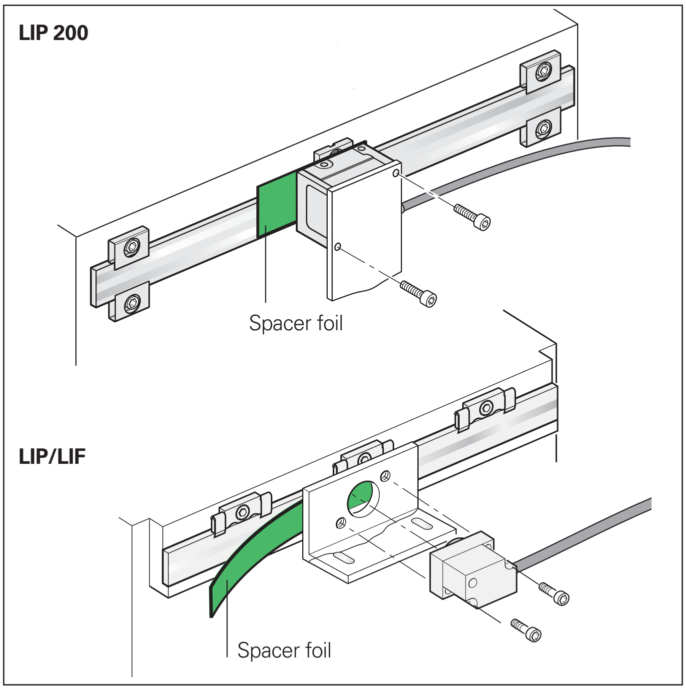
**Mounting the LIC/LIDA**
There are three options for mounting the scanning head (see Dimensions). A spacer foil makes it quite easy to set the gap between the scanning head and the scale or scale tape. It is helpful to fasten the scanning head from behind with a mounting bracket. The scanning head can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

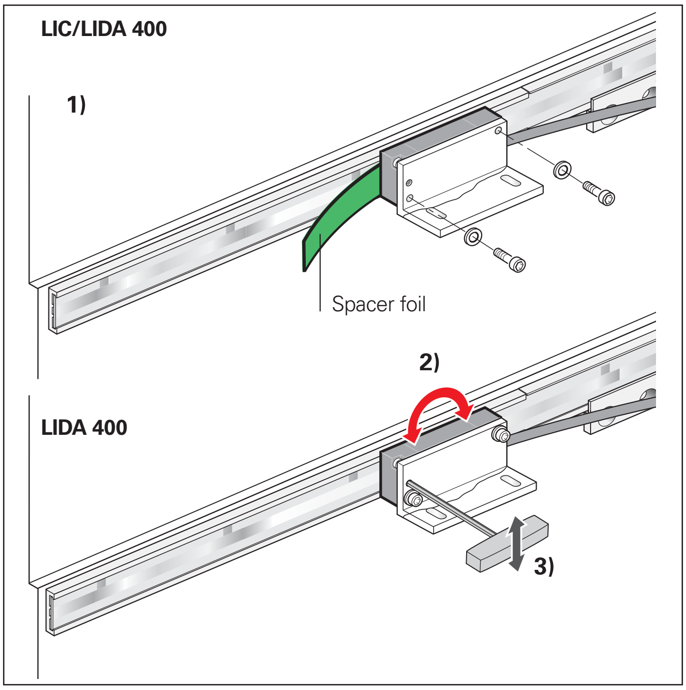
**Adjustment**
The gap between the scale and scanning head is easily adjusted with the aid of a spacer foil.

For the LIC and LIP 281, the signals are adjusted quickly and easily with the aid of the PWM 20 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).

As adjustment aids, HEIDENHAIN offers the appropriate measuring and testing devices (see *HEIDENHAIN Measuring Equipment*).





# General Mechanical Information

**Mounting**
To simplify cable routing, the scanning head is usually screwed onto a stationary machine part, and the scale onto the moving machine part.

The **mounting location** for the linear encoders should be carefully considered in order to ensure both optimum accuracy and the longest possible service life.

- The encoder should be mounted as closely as possible to the working plane to keep the Abbé error small.
- To function properly, linear encoders must not be continuously subjected to strong vibration; the more solid parts of the machine tool provide the best mounting surface in this respect. Encoders should not be mounted on hollow parts or with adapter blocks.
- The linear encoders should be mounted away from sources of heat to avoid temperature influences.

**Temperature range**
The **operating temperature range** indicates the limits of ambient temperature within which the values given in the specifications for linear encoders are maintained.

The **storage temperature range** of –20 °C to 70 °C applies when the unit remains in its packaging.

**Thermal behavior**
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 retract 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 thermal behavior best suited to the application.

**Protection (EN 60529)**
The scanning heads of the LIP, LIF and PP exposed linear encoders feature an IP 50 degree of protection, whereas the LIDA and LIC scanning heads have IP 40. The scales have no special protection. Protective measures must be taken if the possibility of contamination exists.

**Acceleration**
Linear encoders are subjected to various types of acceleration during operation and mounting.

- The indicated maximum values for **vibration** apply for frequencies of 55 to 2000 Hz **(EN 60068-2-6).** Any acceleration exceeding permissible values, for example due to resonance depending on the application and mounting, might damage the encoder. **Comprehensive tests of the entire system are required.**
- The maximum permissible acceleration values (semi-sinusoidal shock) for **shock and impact** are valid for 11 ms, or 6 ms for LIC **(EN 60068-2-27).**

  Under no circumstances should a hammer or similar implement be used to adjust or position the encoder.

**Expendable parts**
Encoders from HEIDENHAIN are designed for a long service life. Preventive maintenance is not required. They contain components that are subject to wear, depending on the application and manipulation. These include in particular cables with frequent flexing.

Other such components are the bearings of encoders with integral bearing, shaft sealing rings on rotary and angle encoders, and sealing lips on sealed linear encoders.

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

The specifications given in this brochure apply to the specific encoder, not to the complete system. Any operation of the encoder outside of the specified range or for any other than the intended applications is at the user's own risk.

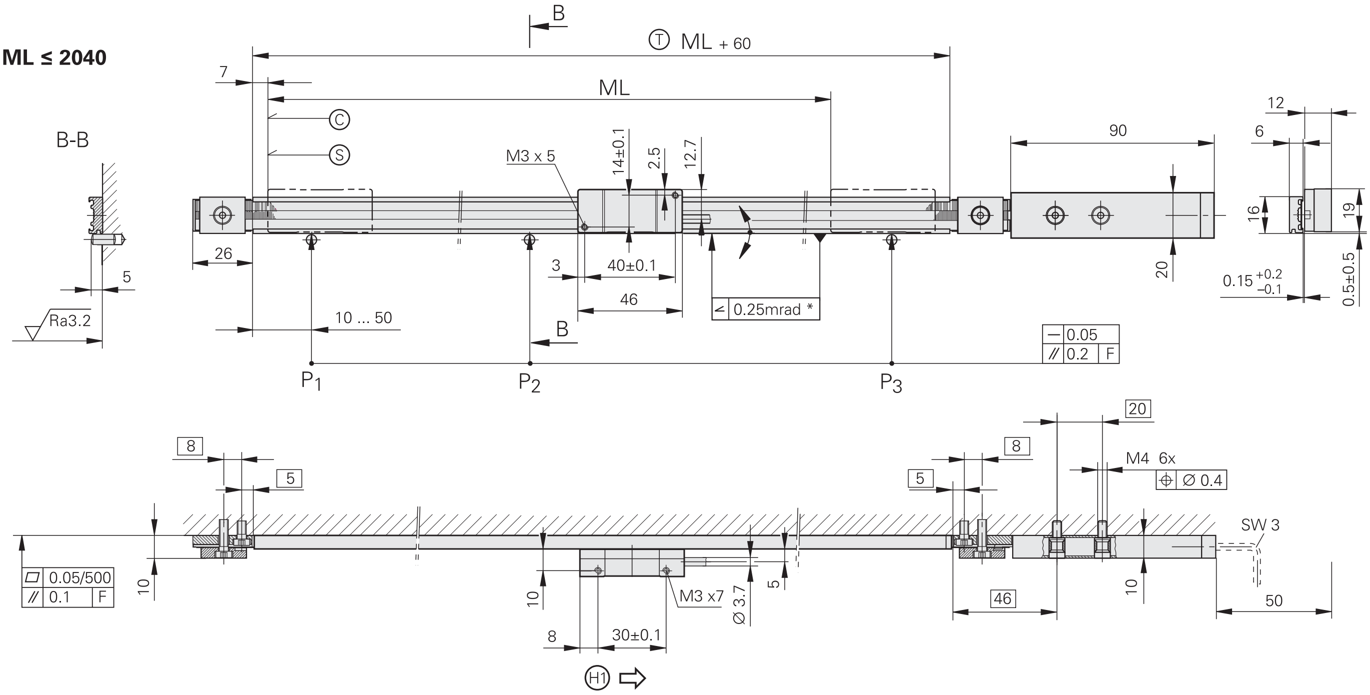
In safety-related systems, the higher-level system must verify the position value of the encoder after switch-on.

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

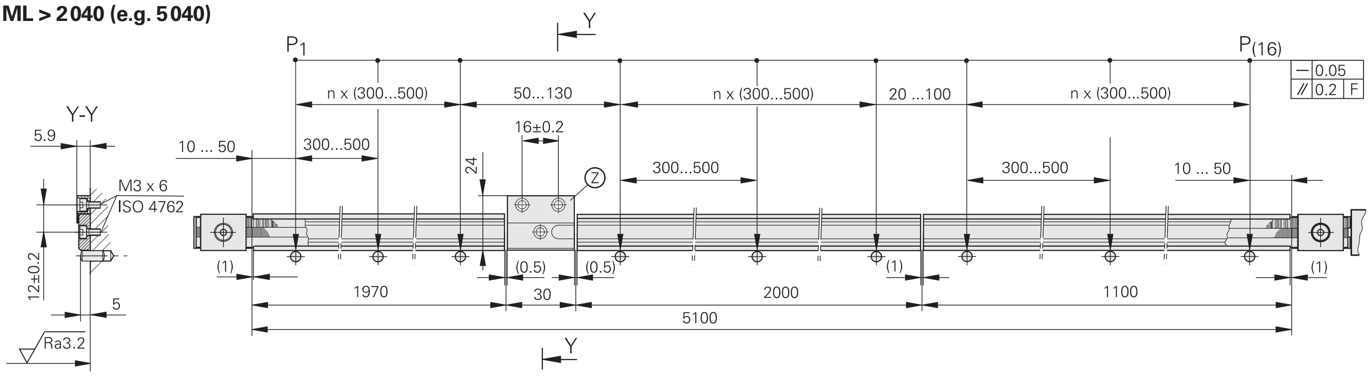
# LIC 4015

**Absolute linear encoder for measuring lengths up to 27 m**
- **For measuring steps to 0.001 µm (1 nm)**
- **Steel scale-tape is drawn into aluminum extrusions and tensioned**

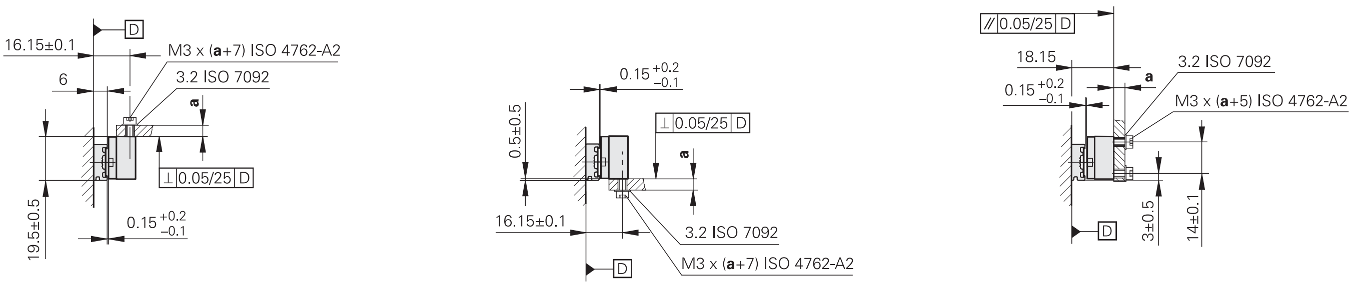
**ML ≤ 2040**




**ML > 2040 (e.g. 5040)**




**Possibilities for mounting the scanning head**




mm

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

F = Machine guideway
P = Gauging points for alignment
* = Max. change during operation
Ⓢ = Beginning of measuring length (ML)
Ⓒ = Code start value: 100 mm
Ⓣ = Carrier length
Ⓩ = Spacer for measuring lengths from 3040 mm
Ⓗ1 = Direction of scanning unit motion for output signals in accordance with interface description

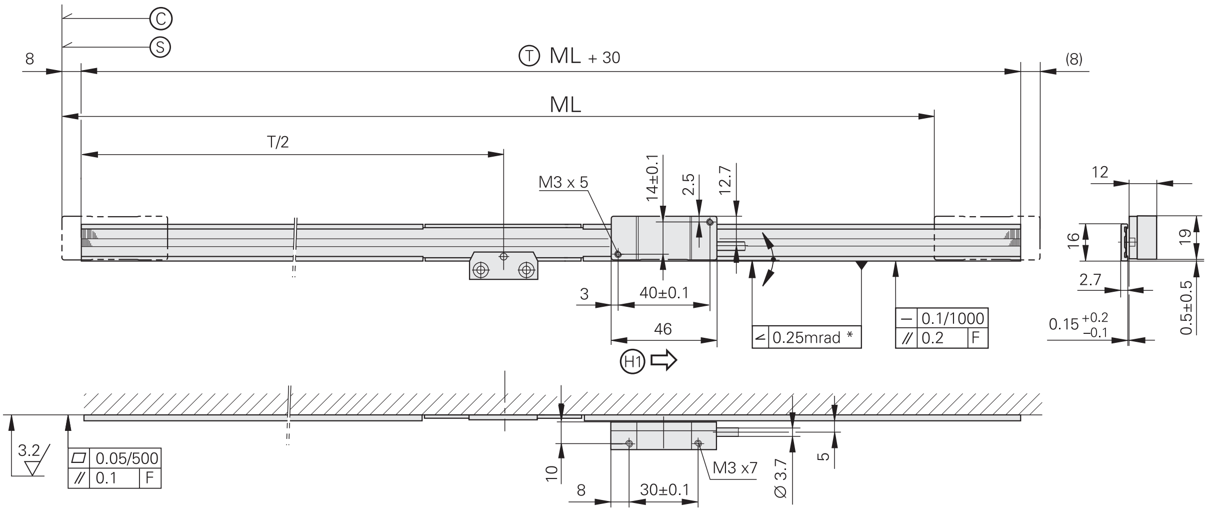
| Specifications | LIC 4015 |
|---|---|
| **Measuring standard**<br>Coefficient of linear expansion | Steel scale tape with METALLUR absolute code track<br>Depends on the mounting surface |
| **Accuracy grade** | ± 5 µm |
| **Measuring length ML***<br>in mm | 140 240 340 440 540 640 740 840 940 1040 1140 1240 1340 1440<br>1540 1640 1740 1840 1940 2040 |
| | Larger measuring lengths up to 27040 mm with a single-section scale tape and individual scale-carrier sections |
| **Absolute position values** | EnDat 2.2 |
| Ordering designation | EnDat 22 |
| Resolution | 0.001 µ m (1 nm) |
| Calculation time $t_{cal}$ | ≤ 6 µs |
| **Power supply** | 3.6 to 14 V DC |
| Power consumption[1] (max.) | *At 14 V:* ≤ 1000 mW<br>*At 3.6 V:* ≤ 800 mW |
| Current consumption (typical) | *At 5 V:* 110 mA |
| **Electrical connection***<br>Cable length | Cable 1 m or 3 m with 8-pin M12 connector (male)<br>≤ 50 m (with HEIDENHAIN cable) |
| **Traversing speed** | ≤ 480 m/min |
| **Vibration** 55 Hz to 2000 Hz<br>**Shock** 6 ms | ≤ 500 m/s² (EN 60068-2-6)<br>≤ 1000 m/s² (EN 60068-2-27) |
| **Operating temperature** | 0 °C to 70 °C |
| **Protection** EN 60529 | IP 40 |
| **Weight** Scanning head<br>Scale tape<br>Parts kit<br>Scale tape carrier<br>Connecting cable<br>Coupling | 16 g (without connecting cable)<br>31 g/m<br>80 g + n[2] × 27 g<br>187 g/m<br>20 g/m<br>32 g |

* Please select when ordering
[1] See *General Electrical Information*
[2] n = 1 for ML 3140 to 5040 mm; n =2 for ML 5140 to 7040 mm; etc.

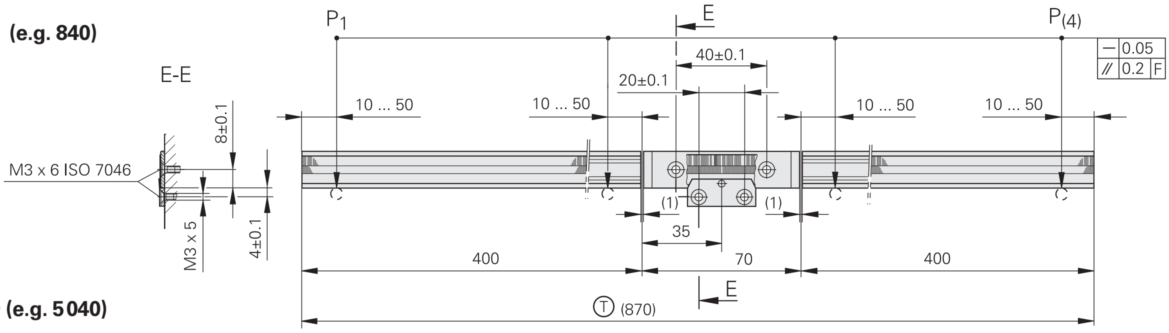
Specifications

# LIC 4017

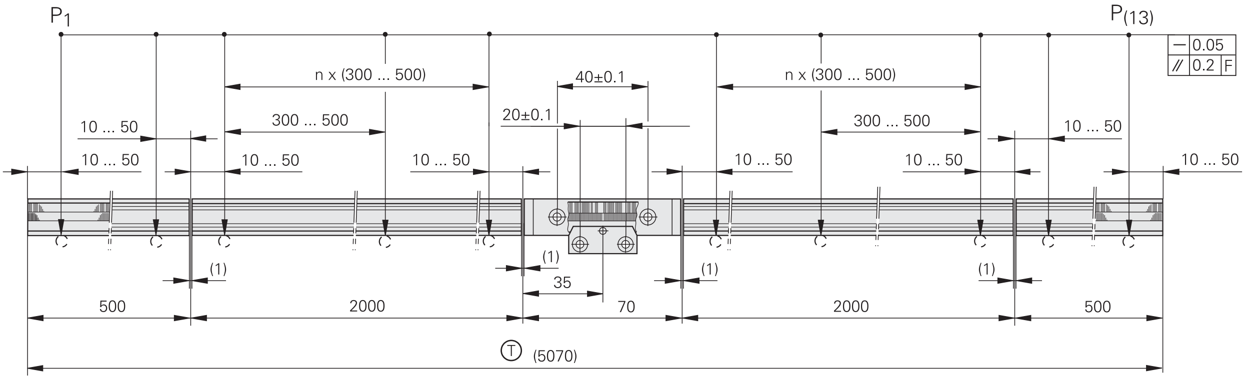
**Absolute linear encoder for measuring lengths up to 6 m**
- **For measuring steps to 0.001 µm (1 nm)**
- **Steel scale-tape is drawn into aluminum extrusions and fixed at center**



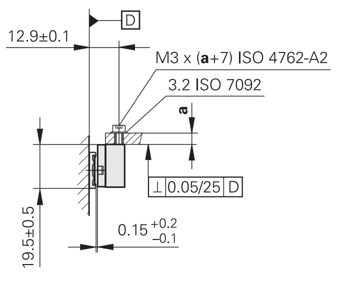

**(e.g. 840)**

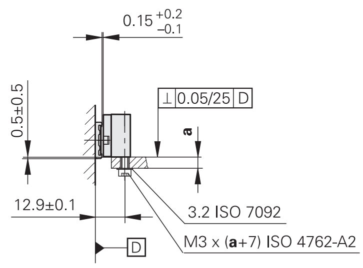


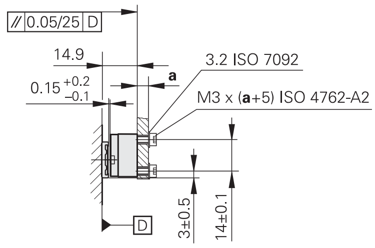

**ML > 2040 (e.g. 5040)**




**Possibilities for mounting the scanning head**




mm

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

F = Machine guideway
P = Gauging points for alignment
* = Max. change during operation
Ⓢ = Beginning of measuring length (ML)
Ⓒ = Code start value: 100 mm

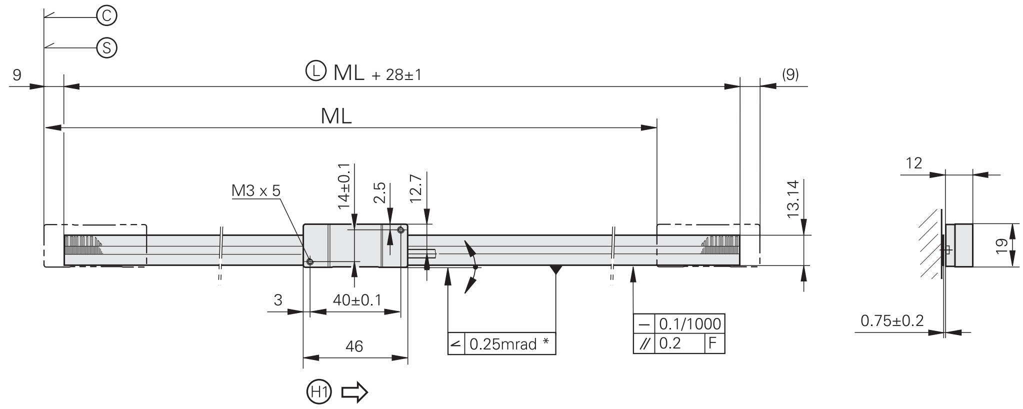
Ⓣ = Carrier length
Ⓩ = Spacer for measuring lengths from 3040
Ⓗ1 = Direction of scanning unit motion for output signals in accordance with interface description

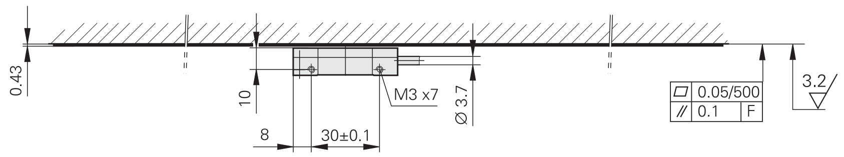
| **Specifications** | **LIC 4017** |
|---|---|
| **Measuring standard**<br>Coefficient of linear expansion | Steel scale tape with METALLUR absolute code track<br>$\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$ |
| **Accuracy grade** | ± 15 µm or ± 5 µm after linear length-error compensation in the subsequent electronics |
| **Measuring length ML***<br>in mm | 240 440 640 840 1040 1240 1440 1640 1840 2040 2240 2440 2640 2840<br>3040 3240 3440 3640 3840 4040 4240 4440 4640 4840 5040 5240 5440 5640<br>5840 6040 |
| **Absolute position values** | EnDat 2.2 |
| Ordering designation | EnDat 22 |
| Resolution | 0.001 µ m (1 nm) |
| Calculation time $t_{cal}$ | ≤ 6 µs |
| **Power supply** | 3.6 to 14 V DC |
| Power consumption[1)] (max.) | *At 14 V:* ≤ 1000 mW<br>*At 3.6 V:* ≤ 800 mW |
| Current consumption (typical) | *At 5 V:* 110 mA |
| **Electrical connection***<br>Cable length | Cable 1 m or 3 m with 8-pin M12 connector (male)<br>≤ 50 m (with HEIDENHAIN cable) |
| **Traversing speed** | ≤ 480 m/min |
| **Vibration** 55 Hz to 2000 Hz<br>**Shock** 6 ms | ≤ 500 $m/s^2$ (EN 60068-2-6)<br>≤ 1000 $m/s^2$ (EN 60068-2-27) |
| **Operating temperature** | 0 °C to 70 °C |
| **Protection** EN 60529 | IP 40 |
| **Weight** Scanning head<br>Scale tape<br>Parts kit<br>Scale tape carrier<br>Connecting cable<br>Coupling | 16 g (without connecting cable)<br>31 g/m<br>20 g<br>68 g/m<br>20 g/m<br>32 g |

***** Please select when ordering
[1)] See *General Electrical Information*

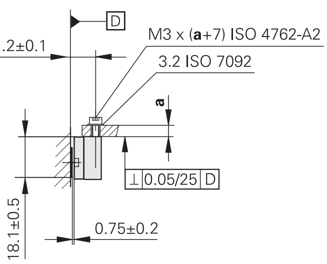
# LIC 4019

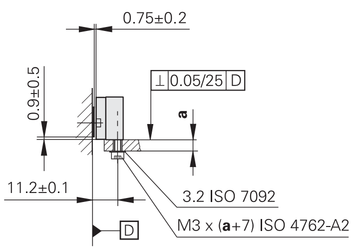
**Absolute linear encoder for measuring lengths up to 1 m**
- **For measuring steps to 0.001 µm (1 nm)**
- **Steel scale tape cemented on mounting surface**

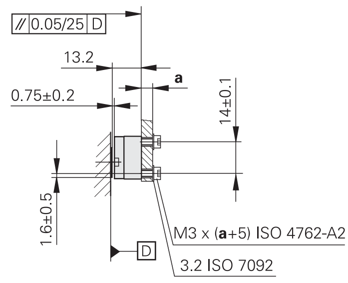



**Possibilities for mounting the scanning head**




mm

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

F = Machine guideway
* = Max. change during operation
C = Code start value: 100 mm
S = Beginning of measuring length (ML)
L = Scale tape length
H1 = Direction of scanning unit motion for output signals in accordance with interface description

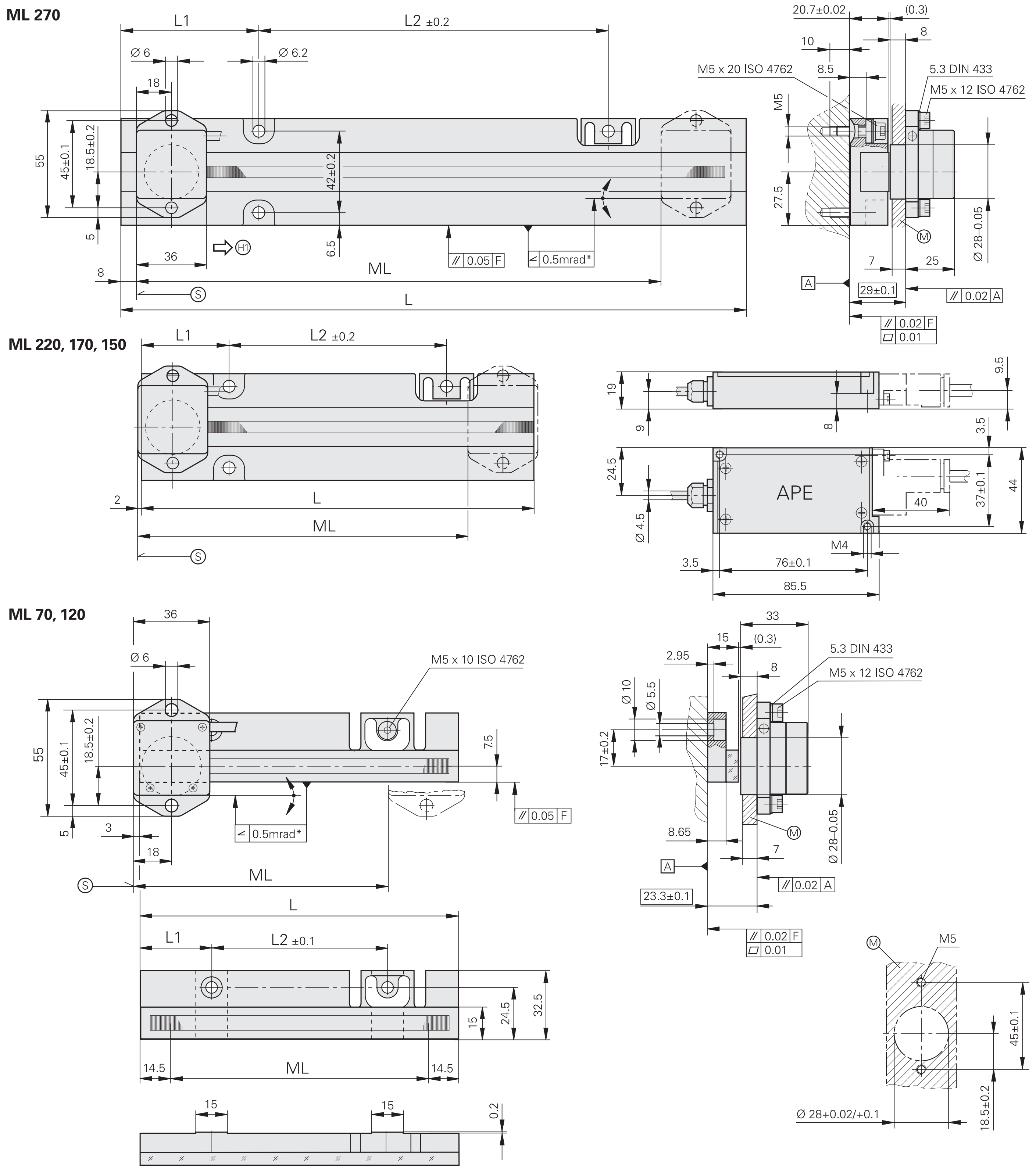
| Specifications | LIC 4019 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Measuring standard**<br>Coefficient of linear expansion | Steel scale tape with METALLUR absolute code track<br>$\alpha_{therm} \approx 10 \cdot 10^{-6}$ K$^{-1}$ | | | | | | | | | | | | | |
| **Accuracy grade** | ± 15 µm or ± 5 µm after linear length-error compensation in the subsequent electronics | | | | | | | | | | | | | |
| **Measuring length ML***<br>in mm | 70 | 120 | 170 | 220 | 270 | 320 | 370 | 420 | 520 | 620 | 720 | 820 | 920 | 1 020 |
| **Absolute position values** | EnDat 2.2 | | | | | | | | | | | | | |
| Ordering designation | EnDat 22 | | | | | | | | | | | | | |
| Resolution | 0.001 µ m (1 nm) | | | | | | | | | | | | | |
| Calculation time $t_{cal}$ | ≤ 6 µs | | | | | | | | | | | | | |
| **Power supply** | 3.6 to 14 V DC | | | | | | | | | | | | | |
| Power consumption[1] (max.) | *At 14 V:* ≤ 1 000 mW<br>*At 3.6 V:* ≤ 800 mW | | | | | | | | | | | | | |
| Current consumption (typical) | *At 5 V:* 110 mA | | | | | | | | | | | | | |
| **Electrical connection***<br>Cable length | Cable 1 m or 3 m with 8-pin M12 connector (male)<br>≤ 50 m (with HEIDENHAIN cable) | | | | | | | | | | | | | |
| **Traversing speed** | ≤ 480 m/min | | | | | | | | | | | | | |
| **Vibration** 55 Hz to 2 000 Hz<br>**Shock** 6 ms | ≤ 500 m/s$^2$ (EN 60 068-2-6)<br>≤ 1 000 m/s$^2$ (EN 60 068-2-27) | | | | | | | | | | | | | |
| **Operating temperature** | 0 °C to 70 °C | | | | | | | | | | | | | |
| **Protection** EN 60 529 | IP 40 | | | | | | | | | | | | | |
| **Weight** Scanning head<br>Scale tape<br>Connecting cable<br>Coupling | 16 g (without connecting cable)<br>31 g/m<br>20 g/m<br>32 g | | | | | | | | | | | | | |

***** Please select when ordering
[1] See *General Electrical Information*

# LIP 372, LIP 382

**Incremental linear encoders with very high accuracy**

- **Measuring steps to 0.001 µm (1 nm)**
- **Measuring standard is fastened by screws**

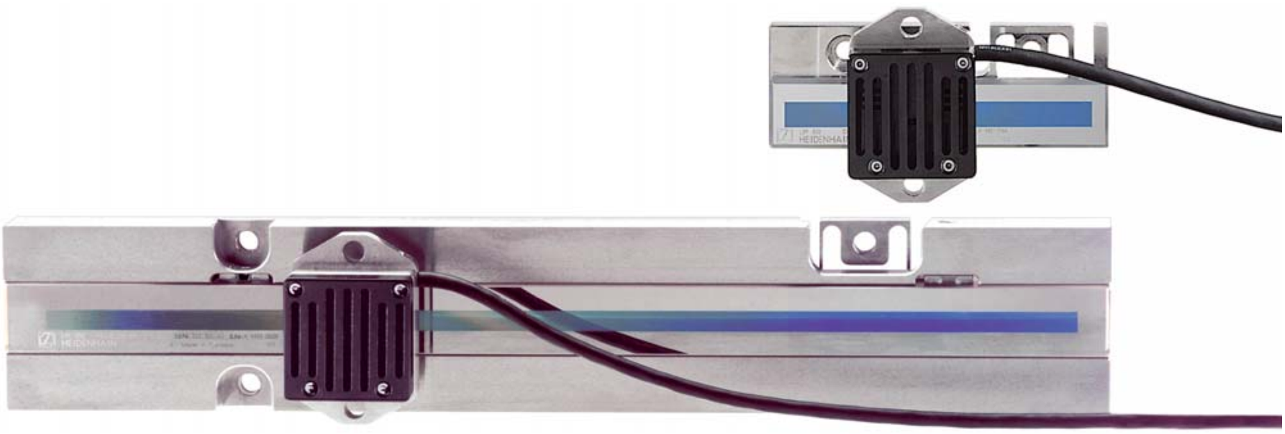



mm

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

* = Max. change during operation
F = Machine guideway
Ⓢ = Beginning of measuring length (ML)
Ⓜ = Mounting surface for scanning head
Ⓗ1 = Direction of scanning unit motion for output signals in accordance with interface description

| ML | L | L1 | L2 |
|---|---|---|---|
| 70 | 100 | 22.5 | 55 |
| 120 | 150 | 33.5 | 83 |
| 150 | 182 | 40 | 102 |
| 170 | 202 | 45 | 112 |
| 220 | 252 | 56 | 140 |
| 270 | 322 | 71 | 180 |

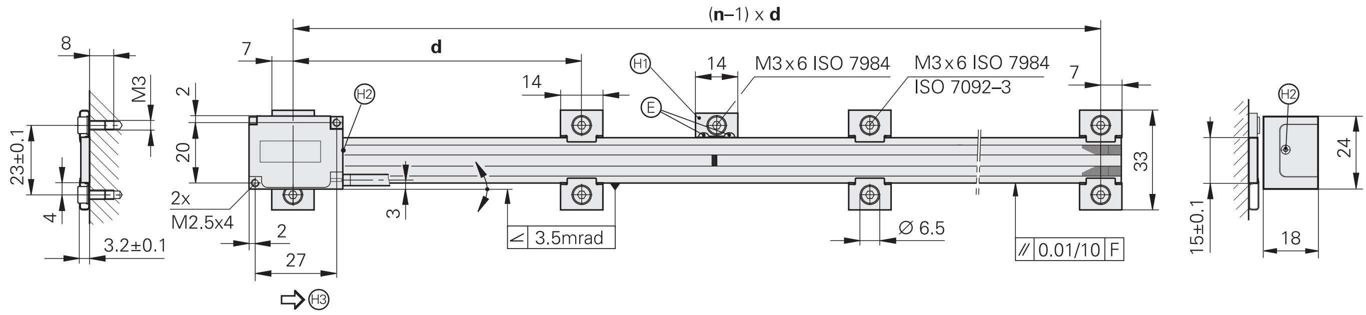


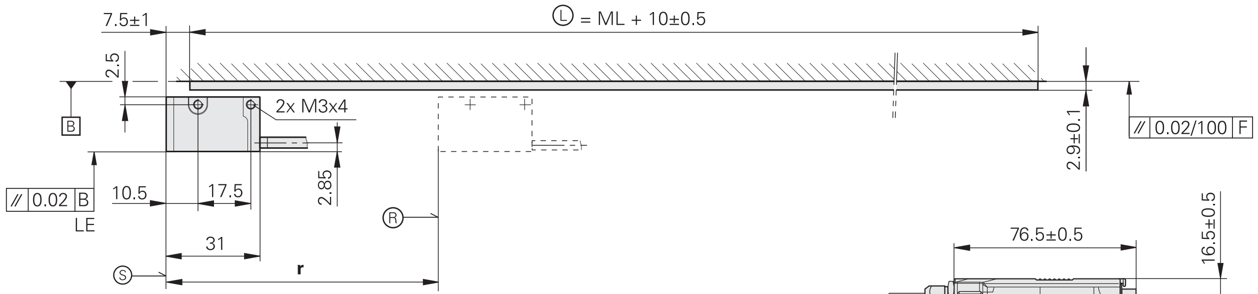
| Specifications | LIP 382 | LIP 372 | | |
|---|---|---|---|---|
| **Measuring standard**<br>Coefficient of linear expansion | DIADUR phase grating on Zerodur glass ceramic<br>$\alpha_{therm} \approx (0 \pm 0.1) \cdot 10^{-6}\ K^{-1}$ | | | |
| **Accuracy grade** | ± 0.5 µm (higher accuracy grades available on request) | | | |
| **Measuring length ML***<br>in mm | 70 120 150 170 220 270 | | | |
| Reference marks | None | | | |
| **Incremental signals** | ∿ 1 $V_{PP}$ | ⊓⊔TTL | | |
| Grating period | 0.512 µm | | | |
| Integrated interpolation<br>Signal period | –<br>0.128 µm | 32-fold<br>0.004 µm | | |
| Cutoff frequency –3 dB | ≥ 1 MHz | – | | |
| Scanning frequency*<br>Edge separation a | – | ≤ 98 kHz<br>≥ 0.055 µs | ≤ 49 kHz<br>≥ 0.130 µs | ≤ 24.5 kHz<br>≥ 0.280 µs |
| **Traversing speed** | ≤ 7.6 m/min | ≤ 0.75 m/min | ≤ 0.38 m/min | ≤ 0.19 m/min |
| **Power supply**<br>Current consumption | 5 V DC ± 5 %<br>< 190 mA | 5 V DC ± 5 %<br>< 250 mA (without load) | | |
| **Electrical connection**<br>Cable length | Cable 0.5 m to interface electronics (APE), sep. adapter cable (1 m/3 m/6 m/9 m) connectable to APE<br>See Interface Description, but ≤ 30 m (with HEIDENHAIN cable) | | | |
| **Vibration** 55 Hz to 2000 Hz<br>**Shock** 11 ms | ≤ 4 $m/s^2$ (EN 60068-2-6)<br>≤ 50 $m/s^2$ (EN 60068-2-27) | | | |
| **Operating temperature** | 0 °C to 40 °C | | | |
| **Weight** Scanning head<br>Interface electronics<br>Scale<br>Connecting cable | 150 g<br>100 g<br>*ML 70 mm:* 260 g, *ML ≥ 150 mm:* 700 g<br>38 g/m | | | |

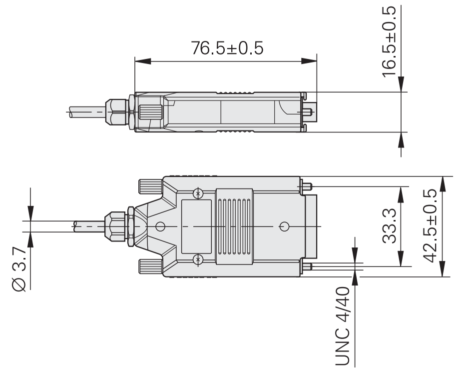
* Please select when ordering

# LIP 281

**Incremental linear encoders for very high accuracy and high position stability**
- **For measuring steps of 0.001 µm (1 nm) and smaller**
- **For high traversing speeds and large measuring lengths**
- **Measuring standard is fastened by fixing clamps**



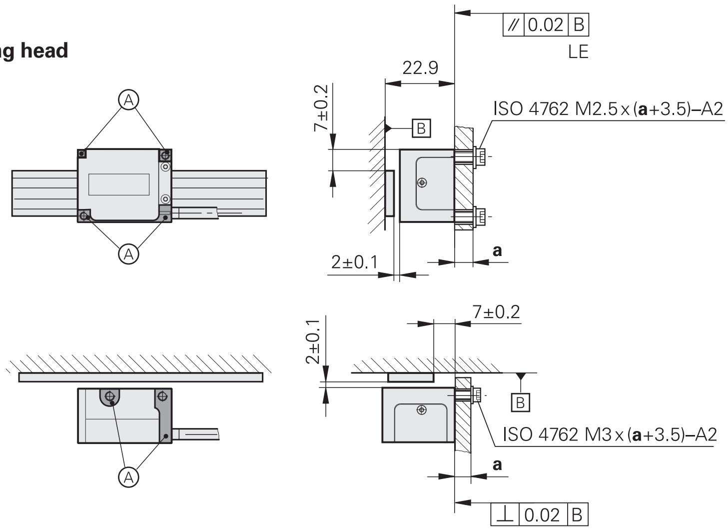

Distance r depends on the scale variant (standard: r = ML/2)
Quantity n of pairs of fixing clamps (mounting with fixing clamps at both ends)

| ML | n |
|---|---|
| ML ≤ 70 | 2 |
| 70 < ML ≤ 100 | 3 |
| 100 < ML ≤ 200 | 4 |
| … | … |

Distance d between fixing clamps:

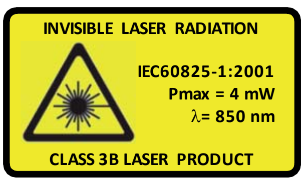
$$\mathbf{d} = \frac{\mathrm{ML} - 4}{\mathbf{n} - 1}$$

**Possibilities for mounting the scanning head**




mm

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




F = Machine guideway
Ⓡ = Reference mark position
Ⓛ = Scale length
Ⓢ = Beginning of measuring length (ML)
Ⓔ = Adhesive according to Mounting Instructions
Ⓐ = Mounting surface
H1 = Mounting element for hard adhesive bond in order to define the thermal fixed point
H2 = Max. protrusion of screw head 0.5 mm
H3 = Direction of scanning unit motion for output signals in accordance with interface description

| Specifications | LIP 281 | |
|---|---|---|
| **Measuring standard**<br>Coefficient of linear expansion | OPTODUR phase grating on Zerodur glass ceramic<br>$\alpha_{therm} \approx (0 \pm 0.1) \times 10^{-6}\ K^{-1}$ | |
| **Accuracy grade*** | ± 1 µm | ± 3 µm (higher accuracy grades available on request) |
| **Measuring length ML***<br>in mm | 20 30 50 70 120<br>170 220 270 320 | 370 420 470 520 570 620 670 720 770<br>820 870 920 970 1020 1140 1240 1340 1440<br>1540 1640 1840 2040 2240 2440 2640 2840 3040 |
| Reference marks | One at midpoint of measuring length | |
| **Incremental signals** | ∿ 1 $V_{PP}$ | |
| Grating period | 2.048 µm | |
| Signal period | 0.512 µm | |
| Cutoff frequency –3 dB | ≥ 3 MHz | |
| **Traversing speed** | ≤ 90 m/min (higher upon request) | |
| **Laser class** | 3B | |
| **Power supply**<br>Current consumption | 5 V DC ± 5 %<br>< 390 mA | |
| **Electrical connection***<br><br>Cable length | Cable 0.5 m, 1 m, 2 m or 3 m with D-sub connector (15-pin)<br>Interface electronics integrated in connector<br>See Interface Description, but ≤ 30 m (with HEIDENHAIN cable) | |
| **Vibration** 55 Hz to 2000 Hz<br>**Shock** 11 ms | ≤ 200 $m/s^2$ (IEC 60068-2-6)<br>≤ 400 $m/s^2$ (IEC 60068-2-27) | |
| **Operating temperature** | 0 °C to 50 °C | |
| **Storage temperature** | –20 °C to 70 °C (in the packaging) | |
| **Weight** Scanning head<br>Connector<br>Scale<br>Connecting cable | 59 g<br>140 g<br>0.11 g/mm overall length<br>22 g/m | |

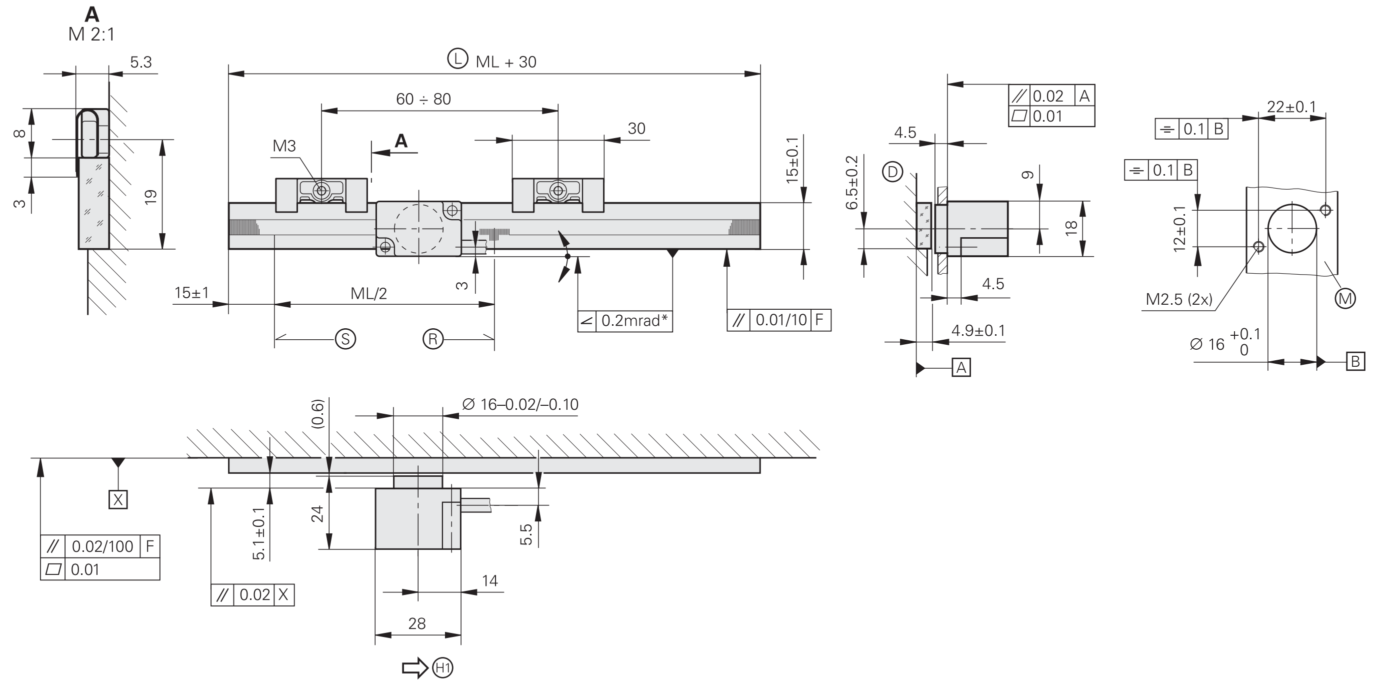
* Please select when ordering

# LIP 471, LIP 481

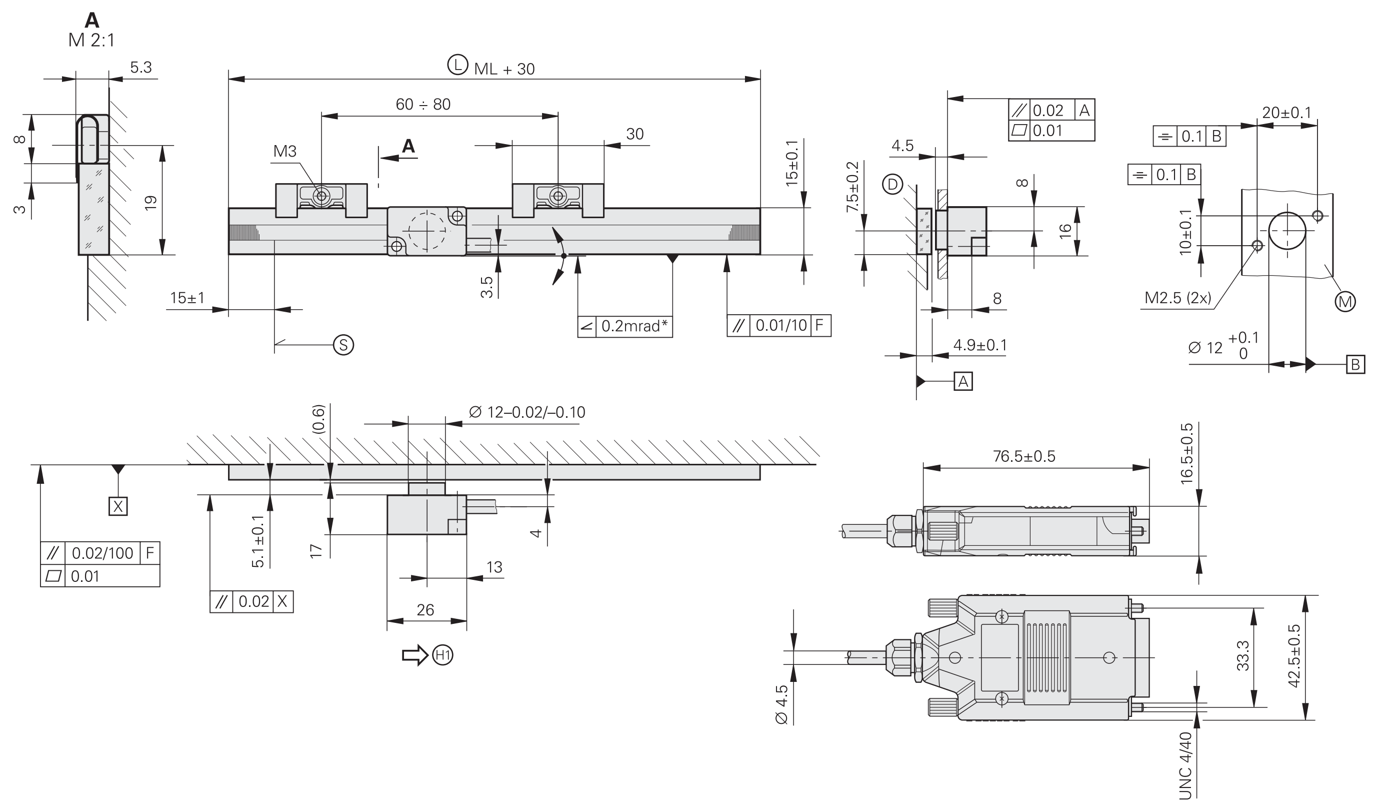
**Incremental linear encoders with very high accuracy**

- **For limited installation space**
- **For measuring steps of 1 µm to 0.005 µm**
- **Measuring standard is fastened by fixing clamps**

**LIP 471 R/LIP 481 R**




**LIP 471 A/LIP 481 A**




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

| | | |
|---|---|---|
| * | = | Max. change during operation |
| F | = | Machine guideway |
| L | = | Scale length |
| D | = | Shown without fixing clamps |
| S | = | Beginning of measuring length (ML) |
| R | = | Reference-mark position on LIP 4x1 R |
| M | = | Mounting surface for scanning head |
| H1 | = | Direction of scanning unit motion for output signals in accordance with interface description |

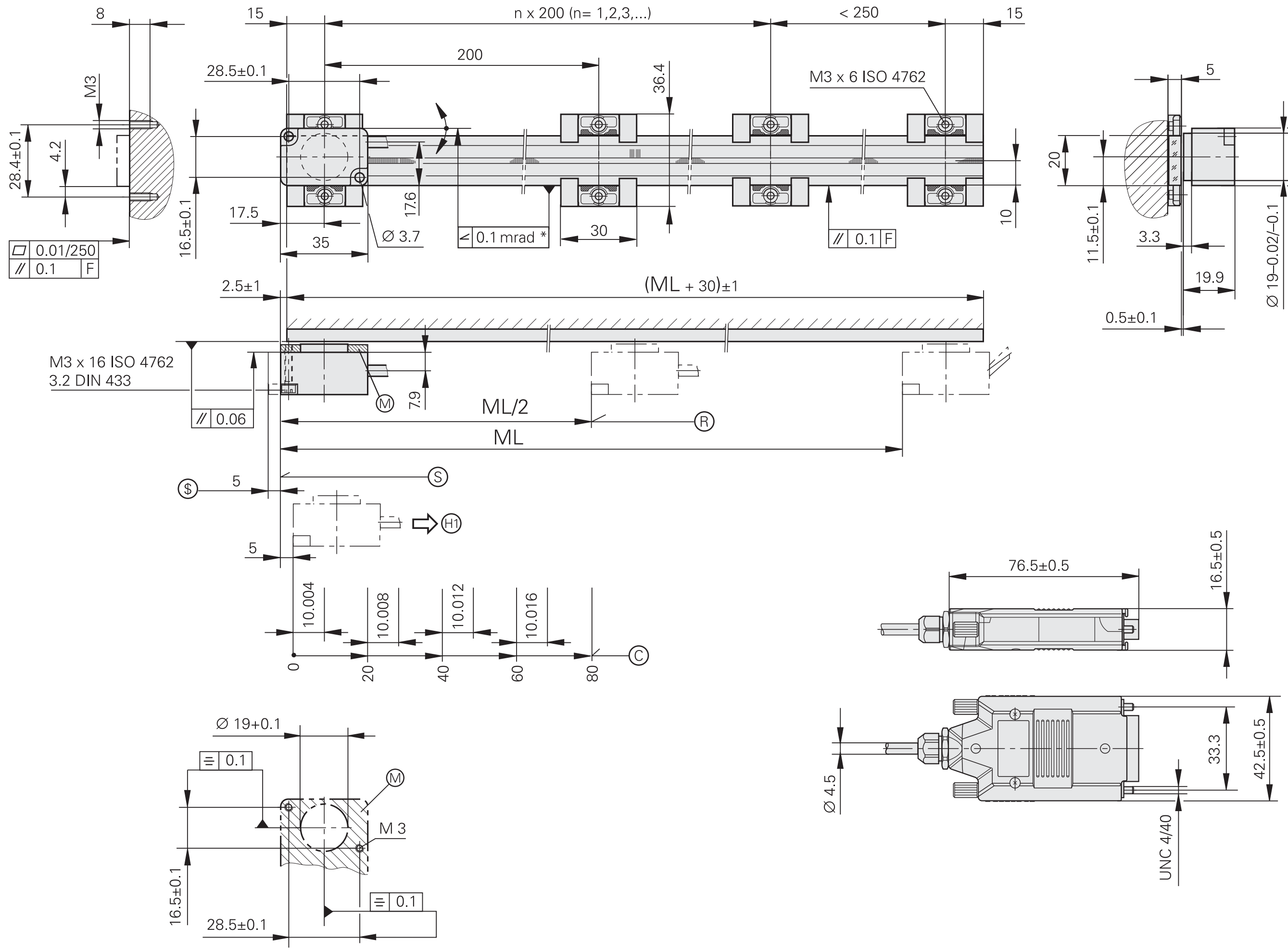

| **Specifications** | **LIP 481** | **LIP 471** | | | | | |
|---|---|---|---|---|---|---|---|
| **Measuring standard***<br>Coefficient of linear expansion | DIADUR phase grating on Zerodur glass ceramic or glass<br>$\alpha_{therm} \approx (0 \pm 0.1) \cdot 10^{-6}\ K^{-1}$ (Zerodur glass ceramic)<br>$\alpha_{therm} \approx 8 \cdot 10^{-6}\ K^{-1}$ (glass) | | | | | | |
| **Accuracy grade*** | ± 1 µm, ± 0.5 µm (higher accuracy grades on request) | | | | | | |
| **Measuring length ML***<br>in mm | 70 120 170 220 270 320 370 420 | | | | | | |
| Reference marks* *LIP 4x1 R*<br>*LIP 4x1 A* | One at midpoint of measuring length<br>None | | | | | | |
| **Incremental signals** | ∿ 1 $V_{PP}$ | ⊓⊔TTL | | | | | |
| Grating period | 4 µm | | | | | | |
| Integrated interpolation*<br>Signal period | –<br>2 µm | 5-fold<br>0.4 µm | | | 10-fold<br>0.2 µm | | |
| Cutoff frequency –3 dB | ≥ 300 kHz | – | | | | | |
| Scanning frequency*<br>Edge separation a | – | ≤ 200 kHz<br>≥ 0.220 µs | ≤ 100 kHz<br>≥ 0.465 µs | ≤50 kHz<br>≥ 0.950 µs | ≤ 100 kHz<br>≥ 0.220 µs | ≤50 kHz<br>≥ 0.465 µs | ≤ 25 kHz<br>≥ 0.950 µs |
| **Traversing speed** | ≤ 36 m/min | ≤ 24 m/min | ≤ 12 m/min | ≤ 6 m/min | ≤ 12 m/min | ≤ 6 m/min | ≤ 3 m/min |
| **Power supply**<br>Current consumption | 5 V DC ± 5 %<br>< 190 mA | 5 V DC ± 5 %<br>< 200 mA (without load) | | | | | |
| **Electrical connection***<br>Cable length | Cable 0.5 m, 1 m, 2 m or 3 m with D-sub connector (15-pin), interface electronics in the connector<br>See Interface Description, but ≤ 30 m (with HEIDENHAIN cable) | | | | | | |
| **Vibration** 55 Hz to 2000 Hz<br>**Shock** 11 ms | ≤ 200 m/s$^2$ (EN 60068-2-6)<br>≤ 500 m/s$^2$ (EN 60068-2-27) | | | | | | |
| **Operating temperature** | 0 °C to 40 °C | | | | | | |
| **Weight** Scanning head<br><br>Scale<br>Connecting cable<br>Connector | *LIP 4x1 A:* 25 g, *LIP 4x1 R:* 50 g<br>(each without cable)<br>5.6 g + 0.2 g/mm measuring length<br>38 g/m<br>140 g | | | | | | |

* Please select when ordering

# LIP 571, LIP 581

**Incremental linear encoders with very high accuracy**

- **For measuring steps of 1 µm to 0.01 µm**
- **Measuring standard is fastened by fixing clamps**




mm

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

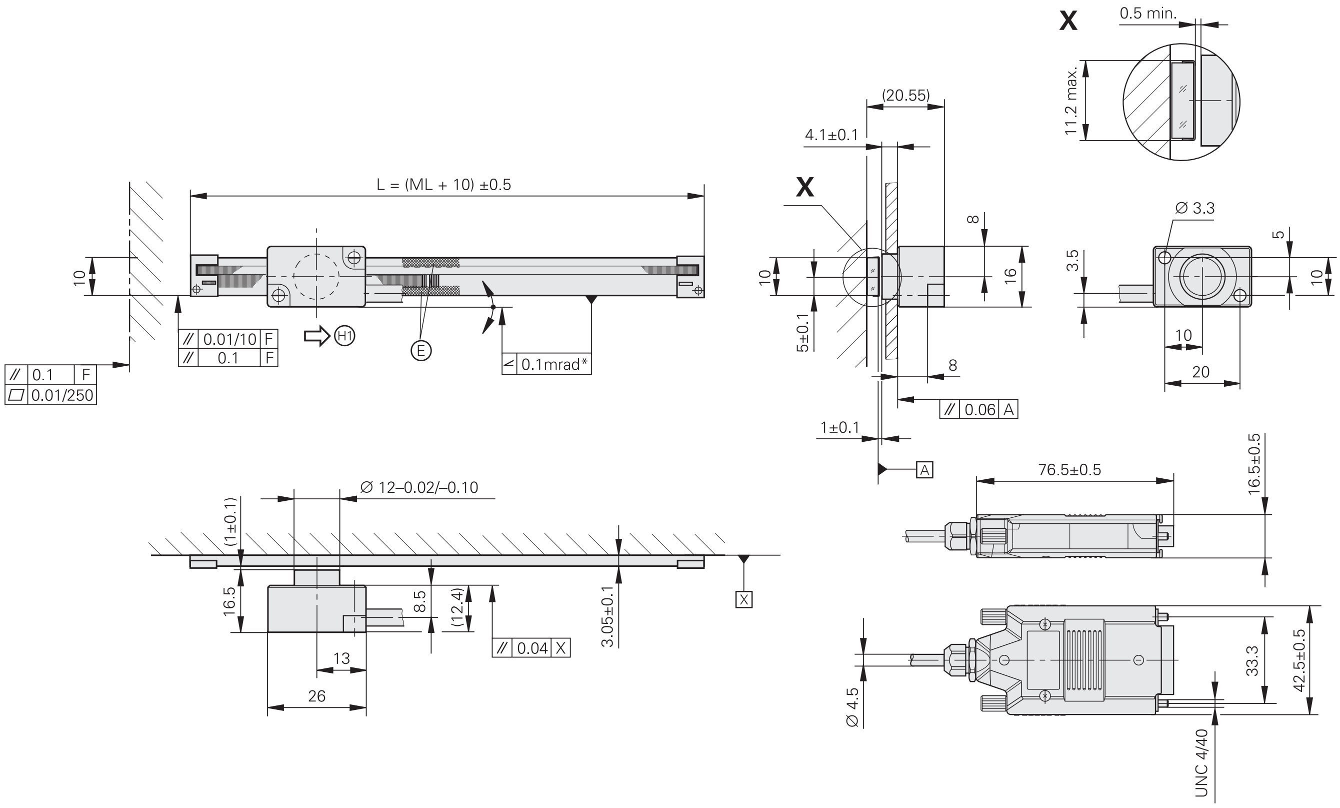
| | | |
|---|---|---|
| * | = | Max. change during operation |
| F | = | Machine guideway |
| Ⓡ | = | Reference-mark position on LIP 5x1 R |
| Ⓒ | = | Reference-mark position on LIP 5x1 C |
| Ⓢ | = | Beginning of measuring length (ML) |
| Ⓢ | = | Permissible overtravel |
| Ⓜ | = | Mounting surface for scanning head |
| Ⓗ1 | = | Direction of scanning unit motion for output signals in accordance with interface description |

| Specifications | LIP 581 | LIP 571 | | | | | |
|---|---|---|---|---|---|---|---|
| **Measuring standard**<br>Coefficient of linear expansion | DIADUR phase grating on glass<br>$\alpha_{therm} \approx 8 \cdot 10^{-6}\ K^{-1}$ | | | | | | |
| **Accuracy grade*** | ± 1 µm | | | | | | |
| **Measuring length ML*** in mm | 70 120 170 220 270 320 370 420 470 520 570 620 670<br>720 770 820 870 920 970 1 020 1 240 1 440 | | | | | | |
| Reference marks* *LIP 5x1 R*<br>*LIP 5x1 C* | One at midpoint of measuring length<br>Distance-coded | | | | | | |
| **Incremental signals** | ∼ 1 $V_{PP}$ | ⊓⊔TTL | | | | | |
| Grating period | 8 µm | | | | | | |
| Integrated interpolation*<br>Signal period | –<br>4 µm | 5-fold<br>0.8 µm | | | 10-fold<br>0.4 µm | | |
| Cutoff frequency –3 dB | ≥ 300 kHz | – | | | | | |
| Scanning frequency*<br>Edge separation a | – | ≤ 200 kHz<br>≥ 0.220 µs | ≤ 100 kHz<br>≥ 0.465 µs | ≤50 kHz<br>≥ 0.950 µs | ≤ 100 kHz<br>≥ 0.220 µs | ≤50 kHz<br>≥ 0.465 µs | ≤ 25 kHz<br>≥ 0.950 µs |
| **Traversing speed** | ≤ 72 m/min | ≤ 48 m/min | ≤ 24 m/min | ≤ 12 m/min | ≤ 24 m/min | ≤ 12 m/min | ≤ 6 m/min |
| **Power supply**<br>Current consumption | 5 V DC ± 5 %<br>< 175 mA | 5 V DC ± 5 %<br>< 175 mA (without load) | | | | | |
| **Electrical connection***<br>Cable length | Cable 0.5 m, 1 m, 2 m or 3 m with D-sub connector (15-pin), interface electronics in the connector<br>See Interface Description, but ≤ 30 m (with HEIDENHAIN cable) | | | | | | |
| **Vibration** 55 Hz to 2 000 Hz<br>**Shock** 11 ms | ≤ 200 $m/s^2$ (EN 60 068-2-6)<br>≤ 500 $m/s^2$ (EN 60 068-2-27) | | | | | | |
| **Operating temperature** | 0 °C to 50 °C | | | | | | |
| **Weight** Scanning head<br>Scale<br>Connecting cable<br>Connector | 25 g (without connecting cable)<br>7.5 g + 0.25 g/mm measuring length<br>38 g/m<br>140 g | | | | | | |

***** Please select when ordering

# LIF 471, LIF 481

**Incremental encoder for simple installation**
- **For measuring steps of 1 µm to 0.01 µm**
- **Position detection through homing track and limit switches**
- **Glass scale fixed with adhesive film**




mm

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

| | | |
|---|---|---|
| * | = | Max. change during operation |
| F | = | Machine guideway |
| ML | = | Measuring length |
| E | = | Epoxy for ML < 170 |
| H1 | = | Direction of scanning unit motion for output signals in accordance with interface description |

| Specifications | LIF 481 | LIF 471 | | | | |
|---|---|---|---|---|---|---|
| **Measuring standard*** <br>Coefficient of linear expansion | SUPRADUR phase grating on Zerodur glass ceramic or glass <br>$\alpha_{therm} \approx (0 \pm 0.1) \cdot 10^{-6}\ K^{-1}$ (Zerodur glass ceramic) <br>$\alpha_{therm} \approx 8 \cdot 10^{-6}\ K^{-1}$ (glass) | | | | | |
| **Accuracy grade** | ± 3 µm | | | | | |
| **Measuring length ML*** <br>in mm | 70 120 170 220 270 320 370 420 470 520 570 620 670 <br>720 770 820 870 920 970 1 020 | | | | | |
| Reference marks | One at midpoint of measuring length | | | | | |
| **Incremental signals** | ∿ 1 $V_{PP}$ | ⊓⊔TTL | | | | |
| Grating period | 8 µm | | | | | |
| Integrated interpolation* <br>Signal period | – <br>4 µm | 5-fold <br>0.8 µm | 10-fold <br>0.4 µm | 20-fold <br>0.2 µm | 50-fold <br>0.08 µm | 100-fold <br>0.04 µm |
| Cutoff frequency –3dB <br>–6dB | ≥ 300 kHz <br>≥ 420 kHz | – | | | | |
| Scanning frequency* | – | ≤ 500 kHz <br>≤ 250 kHz <br>≤ 125 kHz | ≤ 250 kHz <br>≤ 125 kHz <br>≤ 62.5 kHz | ≤ 250 kHz <br>≤ 125 kHz <br>≤ 62.5 kHz | ≤ 100 kHz <br>≤ 50 kHz <br>≤ 25 kHz | ≤ 50 kHz <br>≤ 25 kHz <br>≤ 12.5 kHz |
| Edge separation a[1)] | – | ≥ 0.080 µs <br>≥ 0.175 µs <br>≥ 0.370 µs | ≥ 0.080 µs <br>≥ 0.175 µs <br>≥ 0.370 µs | ≥ 0.040 µs <br>≥ 0.080 µs <br>≥ 0.175 µs | ≥ 0.040 µs <br>≥ 0.080 µs <br>≥ 0.175 µs | ≥ 0.040 µs <br>≥ 0.080 µs <br>≥ 0.175 µs |
| **Traversing speed**[1)] | ≤ 72 m/min <br>≤ 100 m/min | ≤ 120 m/min <br>≤ 60 m/min <br>≤ 30 m/min | ≤ 60 m/min <br>≤ 30 m/min <br>≤ 15 m/min | ≤ 60 m/min <br>≤ 30 m/min <br>≤ 15 m/min | ≤ 24 m/min <br>≤ 12 m/min <br>≤ 6 m/min | ≤ 12 m/min <br>≤ 6 m/min <br>≤ 3 m/min |
| **Position detection** | Homing signal and limit signal, TTL output signals (without line driver) | | | | | |
| **Power supply** <br>Current consumption | 5 V DC ± 5 % <br>< 175 mA | 5 V DC ± 5 % <br>< 180 mA (without load) | | | | |
| **Electrical connection*** <br>Cable length | Cable 0.5 m, 1 m, 2 m or 3 m with D-sub connector (15-pin), interface electronics in the connector <br>See Interface Description, but <br>*Incremental:* ≤ 30 m; *homing, limit:* ≤ 10 m; (with HEIDENHAIN cable) | | | | | |
| **Vibration** 55 Hz to 2 000 Hz <br>**Shock** 11 ms | ≤ 200 $m/s^2$ (EN 60 068-2-6) <br>≤ 500 $m/s^2$ (EN 60 068-2-27) | | | | | |
| **Operating temperature** | 0 °C to 50 °C | | | | | |
| **Weight** Scanning head <br><br><br>Scale <br>Connecting cable <br>Connector | *For scale of Zerodur glass ceramic:* 25 g <br>*For scale of glass:* 9 g <br>(each without cable) <br>0.8 g + 0.08 g/mm measuring length <br>38 g/m <br>140 g | | | | | |

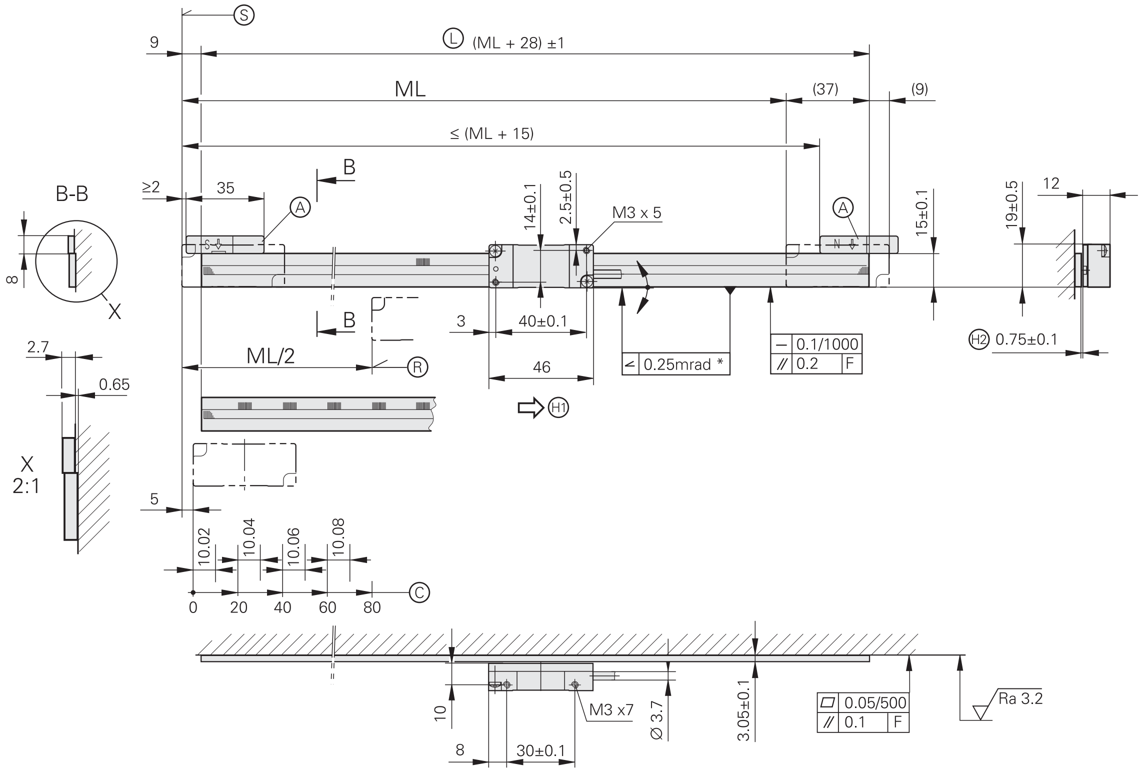
***** Please indicate when ordering

[1)] At the corresponding cutoff or scanning frequency

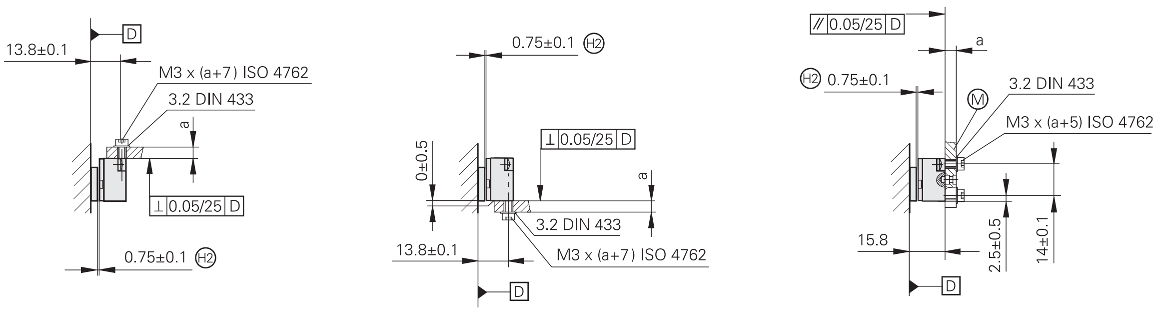
# LIDA 473, LIDA 483

**Incremental linear encoders with limit switches**

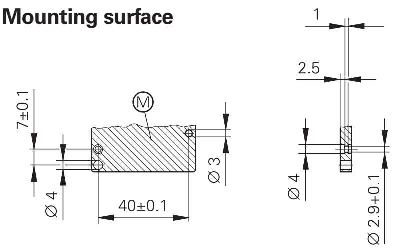
- **For measuring steps of 1 µm to 0.01 µm**
- **Measuring standard of glass or glass ceramic**
- **Glass scale fixed with adhesive film**



**Possibilities for mounting the scanning head**



**Mounting surface**



mm

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

* = Max. change during operation
F = Machine guideway
Ⓛ = Scale length
Ⓐ = Selector magnet for limit switch
Ⓢ = Beginning of measuring length (ML)
Ⓡ = Reference mark position
Ⓜ = Mounting surface for scanning head
H1 = Direction of scanning unit motion for output signals in accordance with interface description
H2 = Adjust or set

| Specifications | LIDA 483 | LIDA 473 | | | |
|---|---|---|---|---|---|
| **Measuring standard**<br>Coefficient of linear expansion* | METALLUR graduation on glass ceramic or glass<br>$\alpha_{therm} \approx 8 \cdot 10^{-6}\ K^{-1}$ (glass)<br>$\alpha_{therm} \approx 0 \cdot 10^{-6}\ K^{-1}$ (ROBAX glass ceramic)<br>$\alpha_{therm} = (0 \pm 0.1) \cdot 10^{-6}\ K^{-1}$ (Zerodur glass ceramic) | | | | |
| **Accuracy grade*** | ± 5 µm, ± 3 µm | | | | |
| **Measuring length ML***<br>in mm | 240 340 440 640 840 1040 1240 1440 1640 1840 2040 2240 2440<br>2640 2840 3040 (ROBAX glass ceramic with up to ML 1640) | | | | |
| Reference marks* *LIDA 4x3*<br>*LIDA 4x3C* | One at midpoint of measuring length<br>Distance-coded | | | | |
| **Incremental signals** | ∿ 1 $V_{PP}$ | ⊓⊔TTL | | | |
| Grating period | 20 µm | | | | |
| Integrated interpolation*<br>Signal period | –<br>20 µm | 5-fold<br>4 µm | 10-fold<br>2 µm | 50-fold<br>0.4 µm | 100-fold<br>0.2 µm |
| Cutoff frequency –3 dB | ≥ 400 kHz | – | | | |
| Scanning frequency* | – | ≤ 400 kHz<br>≤ 200 kHz<br>≤ 100 kHz<br>≤ 50 kHz | ≤ 200 kHz<br>≤ 100 kHz<br>≤ 50 kHz<br>≤ 25 kHz | ≤ 50 kHz<br>≤ 25 kHz<br>≤ 12.5 kHz | ≤ 25 kHz<br>≤ 12.5 kHz<br>≤ 6.25 kHz |
| Edge separation a[1)] | – | ≥ 0.100 µs<br>≥ 0.220 µs<br>≥ 0.465 µs<br>≥ 0.950 µs | ≥ 0.100 µs<br>≥ 0.220 µs<br>≥ 0.465 µs<br>≥ 0.950 µs | ≥ 0.080 µs<br>≥ 0.175 µs<br>≥ 0.370 µs | ≥ 0.080 µs<br>≥ 0.175 µs<br>≥ 0.370 µs |
| **Traversing speed**[1)] | ≤ 480 m/min | ≤ 480 m/min<br>≤ 240 m/min<br>≤ 120 m/min<br>≤ 60 m/min | ≤ 240 m/min<br>≤ 120 m/min<br>≤ 60 m/min<br>≤ 30 m/min | ≤ 60 m/min<br>≤ 30 m/min<br>≤ 15 m/min | ≤ 30 m/min<br>≤ 15 m/min<br>≤ 7.5 m/min |
| **Limit switches** | L1/L2 with two different magnets; *output signals:* TTL (without line driver) | | | | |
| **Power supply**<br>Current consumption | 5 V DC ± 5 %<br>< 100 mA | 5 V DC ± 5 %<br>< 170 mA (without load) | | 5 V DC ± 5 %<br>< 255 mA (without load) | |
| **Electrical connection**<br>Cable length | Cable 3 m with D-sub connector (15-pin), interface electronics for LIDA 473 in the connector<br>See Interface Description, but *limit:* ≤ 20 m (with HEIDENHAIN cable) | | | | |
| **Vibration** 55 Hz to 2000 Hz<br>**Shock** 11 ms | ≤ 200 m/s² (EN 60068-2-6)<br>≤ 500 m/s² (EN 60068-2-27) | | | | |
| **Operating temperature** | 0 °C to 50 °C | | | | |
| **Weight** Scanning head<br>Scale<br>Connecting cable<br>Connector | 20 g (without connecting cable)<br>3 g + 0.1 g/mm measuring length<br>22 g/m<br>*LIDA 483:* 32 g, *LIDA 473:* 140 g | | | | |

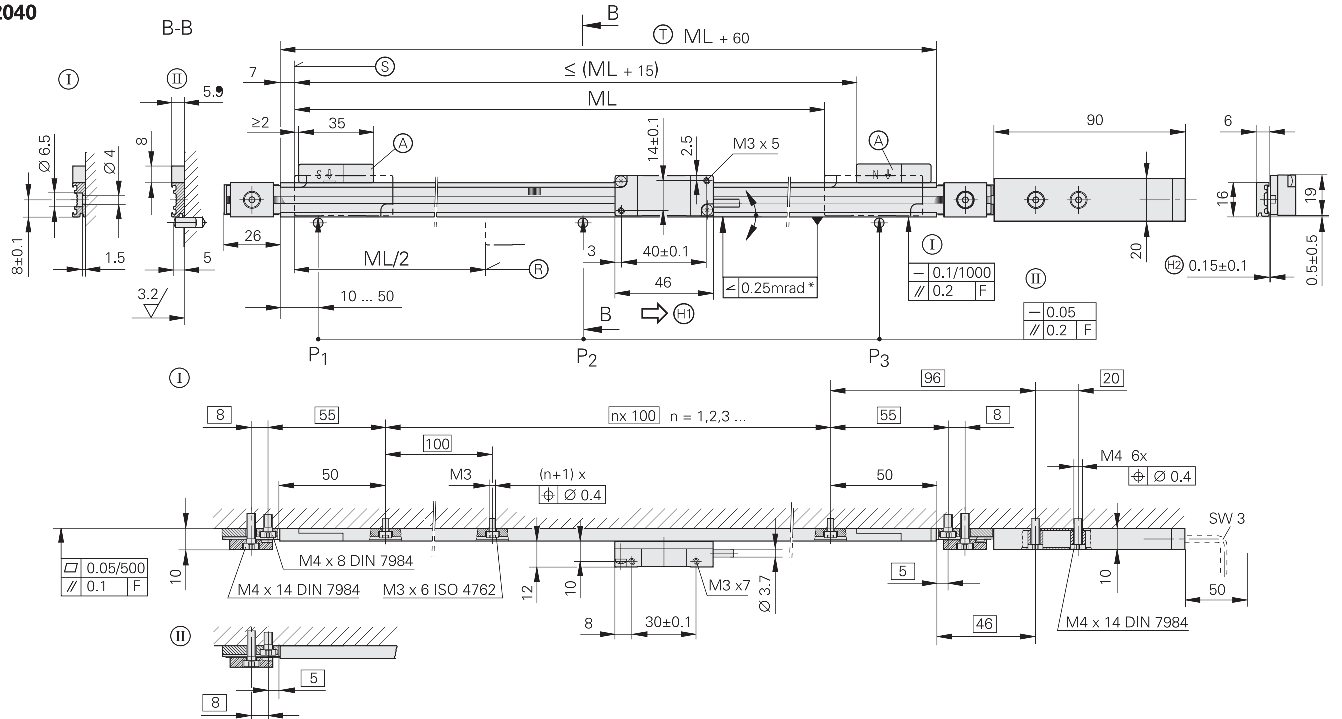
* Please indicate when ordering

1) At the corresponding cutoff or scanning frequency

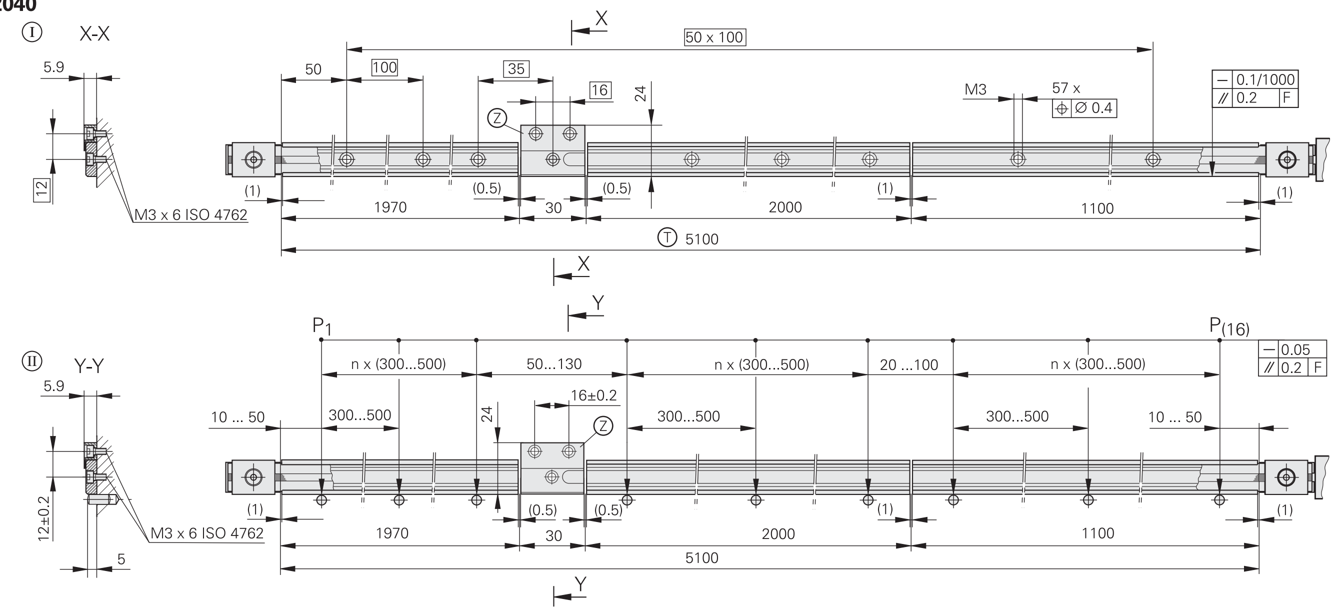
# LIDA 475, LIDA 485

**Incremental linear encoders for measuring lengths up to 30 m**
- **For measuring steps of 1 µm to 0.05 µm**
- **Limit switches**
- **Steel scale-tape is drawn into aluminum extrusions and tensioned**

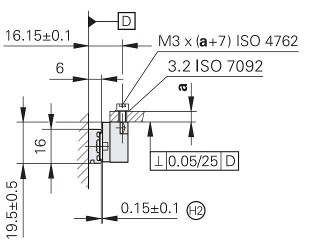
**ML ≤ 2040**

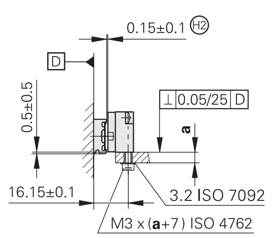


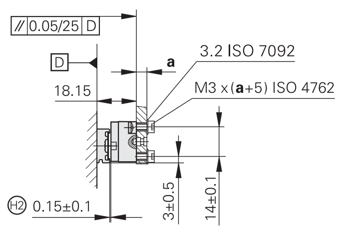

**ML > 2040**




**Possibilities for mounting the scanning head**




mm

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

- Ⓘ = Scale carrier sections fixed with screws
- Ⓘⅈ = Scale carrier sections fixed with PRECIMET
- * = Max. change during operation
- F = Machine guideway
- P = Gauging points for alignment
- Ⓡ = Reference mark position
- Ⓢ = Beginning of measuring length (ML)
- Ⓐ = Selector magnet for limit switch
- Ⓣ = Carrier length
- Ⓩ = Spacer for measuring lengths from 3040 mm
- Ⓗ1 = Direction of scanning unit motion for output signals in accordance with interface description
- Ⓗ2 = Adjust or set


| Specifications | LIDA 485 | LIDA 475 | | | |
|---|---|---|---|---|---|
| **Measuring standard**<br>Coefficient of linear expansion | Steel scale-tape with METALLUR graduation<br>Depends on the mounting surface | | | | |
| **Accuracy grade** | ± 5 µm | | | | |
| **Measuring length ML***<br>in mm | 140 240 340 440 540 640 740 840 940 1 040 1 140 1 240 1 340 1 440<br>1 540 1 640 1 740 1 840 1 940 2 040<br>Larger measuring lengths up to 30 040 mm with a single-section scale tape and individual scale-carrier sections | | | | |
| Reference marks | One at midpoint of measuring length | | | | |
| **Incremental signals** | ∼ 1 $V_{PP}$ | ⊓⊔TTL | | | |
| Grating period | 20 µm | | | | |
| Integrated interpolation*<br>Signal period | –<br>20 µm | 5-fold<br>4 µm | 10-fold<br>2 µm | 50-fold<br>0.4 µm | 100-fold<br>0.2 µm |
| Cutoff frequency –3 dB | ≥ 400 kHz | – | | | |
| Scanning frequency* | – | ≤ 400 kHz<br>≤ 200 kHz<br>≤ 100 kHz<br>≤ 50 kHz | ≤ 200 kHz<br>≤ 100 kHz<br>≤ 50 kHz<br>≤ 25 kHz | ≤ 50 kHz<br>≤ 25 kHz<br>≤ 12.5 kHz | ≤ 25 kHz<br>≤ 12.5 kHz<br>≤ 6.25 kHz |
| Edge separation a[1)] | – | ≥ 0.100 µs<br>≥ 0.220 µs<br>≥ 0.465 µs<br>≥ 0.950 µs | ≥ 0.100 µs<br>≥ 0.220 µs<br>≥ 0.465 µs<br>≥ 0.950 µs | ≥ 0.080 µs<br>≥ 0.175 µs<br>≥ 0.370 µs | ≥ 0.080 µs<br>≥ 0.175 µs<br>≥ 0.370 µs |
| **Traversing speed**[1)] | ≤ 480 m/min | ≤ 480 m/min<br>≤ 240 m/min<br>≤ 120 m/min<br>≤ 60 m/min | ≤ 240 m/min<br>≤ 120 m/min<br>≤ 60 m/min<br>≤ 30 m/min | ≤ 60 m/min<br>≤ 30 m/min<br>≤ 15 m/min | ≤ 30 m/min<br>≤ 15 m/min<br>≤ 7.5 m/min |
| **Limit switches** | L1/L2 with two different magnets; *output signals:* TTL (without line driver) | | | | |
| **Power supply**<br>Current consumption | 5 V DC ± 5 %<br>< 100 mA | 5 V DC ± 5 %<br>< 170 mA (without load) | | 5 V DC ± 5 %<br>< 255 mA (without load) | |
| **Electrical connection**<br>Cable length | Cable 3 m with D-sub connector (15-pin), interface electronics for LIDA 475 in the connector<br>See Interface Description, but *limit:* ≤ 20 m (with HEIDENHAIN cable) | | | | |
| **Vibration** 55 Hz to 2 000 Hz<br>**Shock** 11 ms | ≤ 200 $m/s^2$ (EN 60 068-2-6)<br>≤ 500 $m/s^2$ (EN 60 068-2-27) | | | | |
| **Operating temperature** | 0 °C to 50 °C | | | | |
| **Weight** Scanning head<br>Scale<br>Connecting cable<br>Connector | 20 g (without connecting cable)<br>115 g + 0.25 g/mm measuring length<br>22 g/m<br>*LIDA 485:* 32 g, *LIDA 475:* 140 g | | | | |

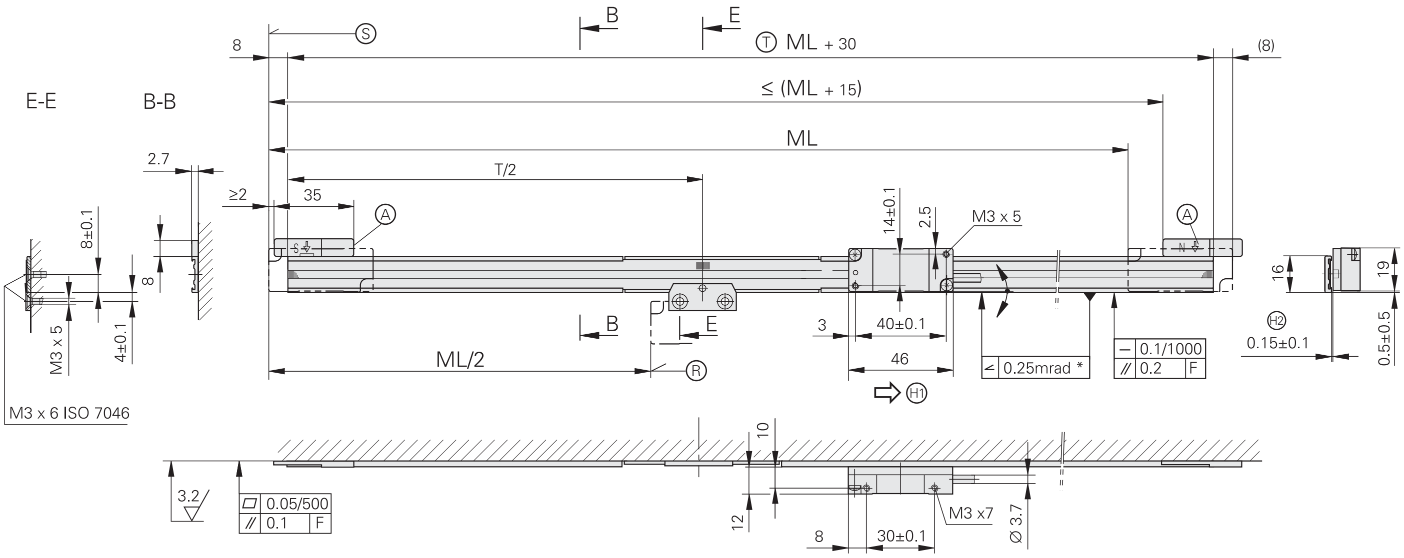
***** Please indicate when ordering

1) At the corresponding cutoff or scanning frequency

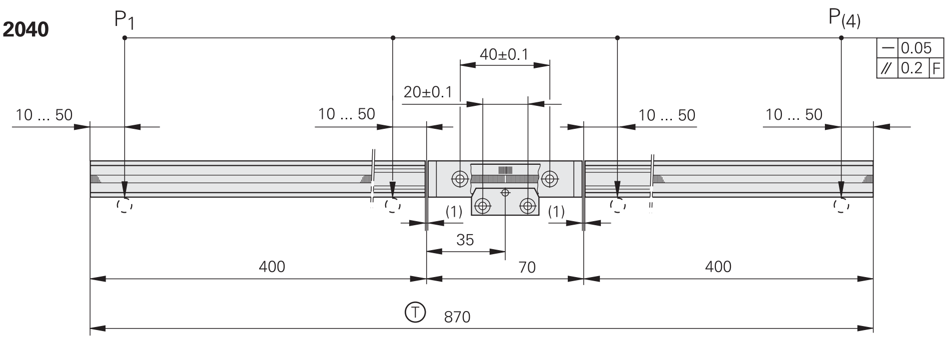
# LIDA 477, LIDA 487

**Incremental linear encoders for measuring ranges up to 6 m**

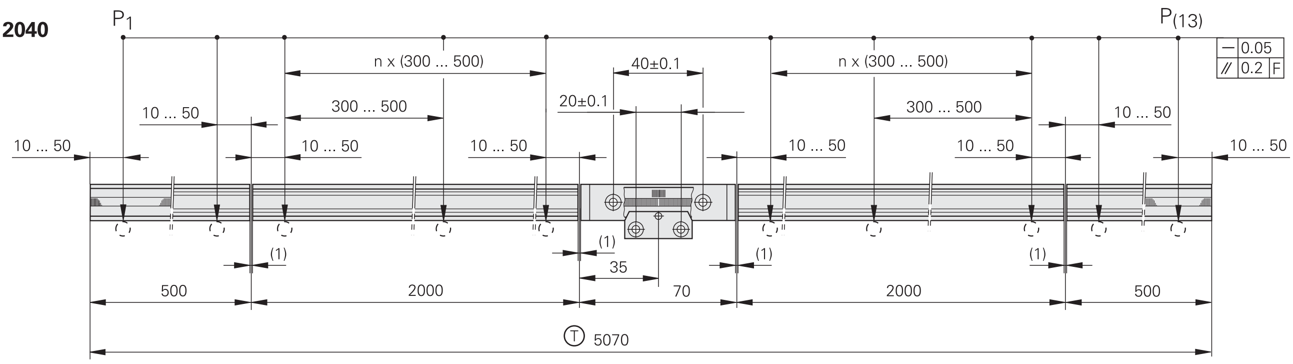
- **For measuring steps of 1 µm to 0.05 µm**
- **Limit switches**
- **Steel scale-tape is drawn into adhesive aluminum extrusions and fixed at center**



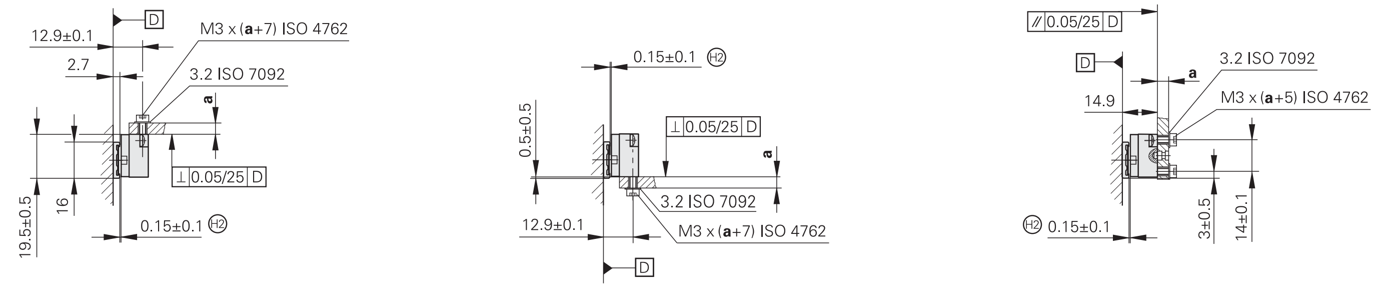

**ML ≤ 2040**




**ML > 2040**




**Possibilities for mounting the scanning head**




mm

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

| | | |
|---|---|---|
| * | = | Max. change during operation |
| F | = | Machine guideway |
| P | = | Gauging points for alignment |
| Ⓡ | = | Reference mark position |
| Ⓢ | = | Beginning of measuring length (ML) |
| Ⓐ | = | Selector magnet for limit switch |
| Ⓣ | = | Carrier length |
| H1 | = | Direction of scanning unit motion for output signals in accordance with interface description |
| H2 | = | Adjust or set |

| Specifications | LIDA 487 | LIDA 477 | | | |
|---|---|---|---|---|---|
| **Measuring standard**<br>Coefficient of linear expansion | Steel scale-tape with METALLUR graduation<br>$\alpha_{therm} \approx 10 \cdot 10^{-6}\,K^{-1}$ | | | | |
| **Accuracy grade** | ± 15 µm or ± 5 µm after linear length-error compensation in the subsequent electronics | | | | |
| **Measuring length ML***<br>in mm | 240 440 640 840 1040 1240 1440 1640 1840 2040 2240 2440 2640 2840<br>3040 3240 3440 3640 3840 4040 4240 4440 4640 4840 5040 5240 5440 5640<br>5840 6040 | | | | |
| Reference marks | One at midpoint of measuring length | | | | |
| **Incremental signals** | ~ 1 $V_{PP}$ | TTL | | | |
| Grating period | 20 µm | | | | |
| Integrated interpolation*<br>Signal period | –<br>20 µm | 5-fold<br>4 µm | 10-fold<br>2 µm | 50-fold<br>0.4 µm | 100-fold<br>0.2 µm |
| Cutoff frequency –3 dB | ≥ 400 kHz | – | | | |
| Scanning frequency* | – | ≤ 400 kHz<br>≤ 200 kHz<br>≤ 100 kHz<br>≤ 50 kHz | ≤ 200 kHz<br>≤ 100 kHz<br>≤ 50 kHz<br>≤ 25 kHz | ≤ 50 kHz<br>≤ 25 kHz<br>≤ 12.5 kHz | ≤ 25 kHz<br>≤ 12.5 kHz<br>≤ 6.25 kHz |
| Edge separation a[1)] | – | ≥ 0.100 µs<br>≥ 0.220 µs<br>≥ 0.465 µs<br>≥ 0.950 µs | ≥ 0.100 µs<br>≥ 0.220 µs<br>≥ 0.465 µs<br>≥ 0.950 µs | ≥ 0.080 µs<br>≥ 0.175 µs<br>≥ 0.370 µs | ≥ 0.080 µs<br>≥ 0.175 µs<br>≥ 0.370 µs |
| **Traversing speed**[1)] | ≤ 480 m/min | ≤ 480 m/min<br>≤ 240 m/min<br>≤ 120 m/min<br>≤ 60 m/min | ≤ 240 m/min<br>≤ 120 m/min<br>≤ 60 m/min<br>≤ 30 m/min | ≤ 60 m/min<br>≤ 30 m/min<br>≤ 15 m/min | ≤ 30 m/min<br>≤ 15 m/min<br>≤ 7.5 m/min |
| **Limit switches** | L1/L2 with two different magnets; *output signals:* TTL (without line driver) | | | | |
| **Power supply**<br>Current consumption | 5 V DC ± 5 %<br>< 100 mA | 5 V DC ± 5 %<br>< 170 mA (without load) | | 5 V DC ± 5 %<br>< 255 mA (without load) | |
| **Electrical connection**<br>Cable length | Cable 3 m with D-sub connector (15-pin), interface electronics for LIDA 477 in the connector<br>See Interface Description, but *limit:* ≤ 20 m (with HEIDENHAIN cable) | | | | |
| **Vibration** 55 Hz to 2000 Hz<br>**Shock** 11 ms | ≤ 200 m/s² (EN 60068-2-6)<br>≤ 500 m/s² (EN 60068-2-27) | | | | |
| **Operating temperature** | 0 °C to 50 °C | | | | |
| **Weight** Scanning head<br>Scale<br>Connecting cable<br>Connector | 20 g (without connecting cable)<br>25 g + 0.1 g/mm measuring length<br>22 g/m<br>*LIDA 487:* 32 g, *LIDA 477:* 140 g | | | | |

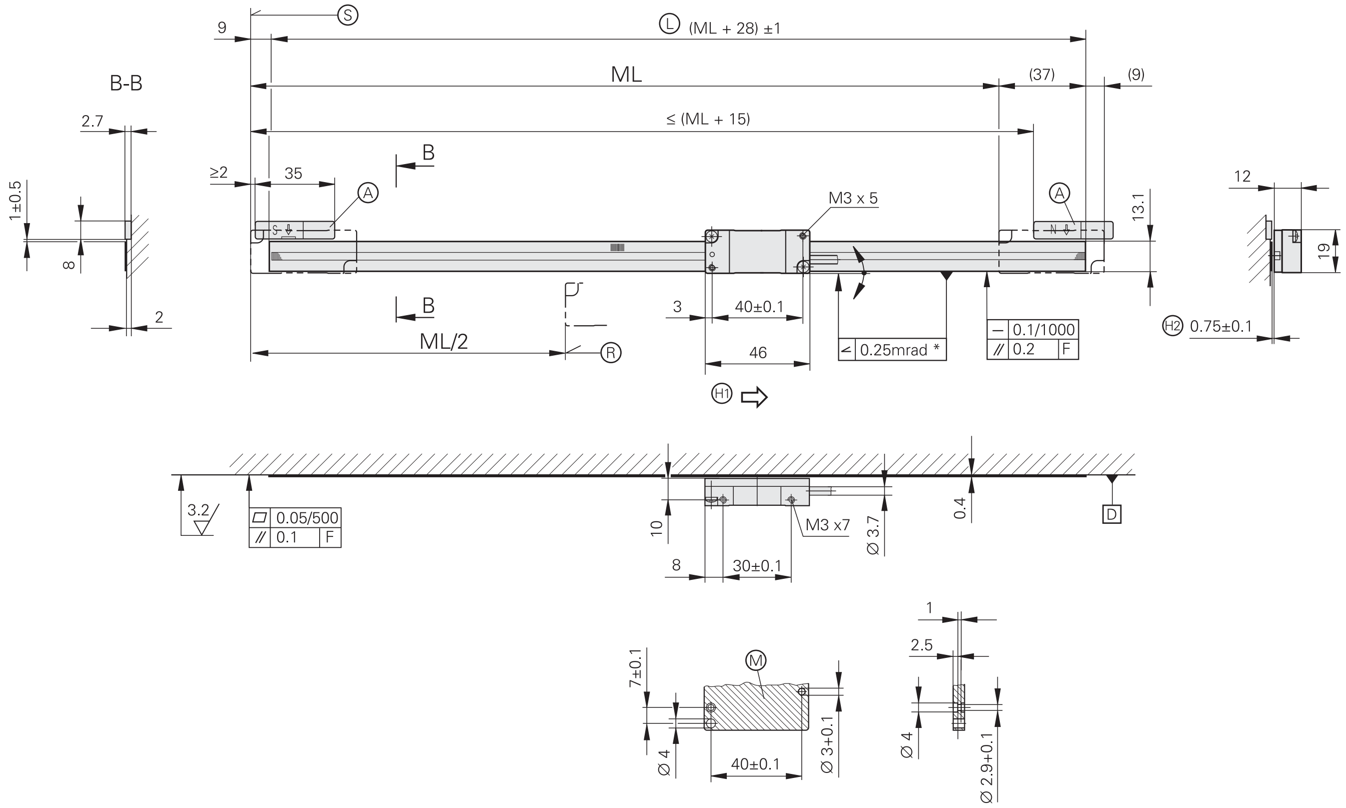
***** Please indicate when ordering

1) At the corresponding cutoff or scanning frequency

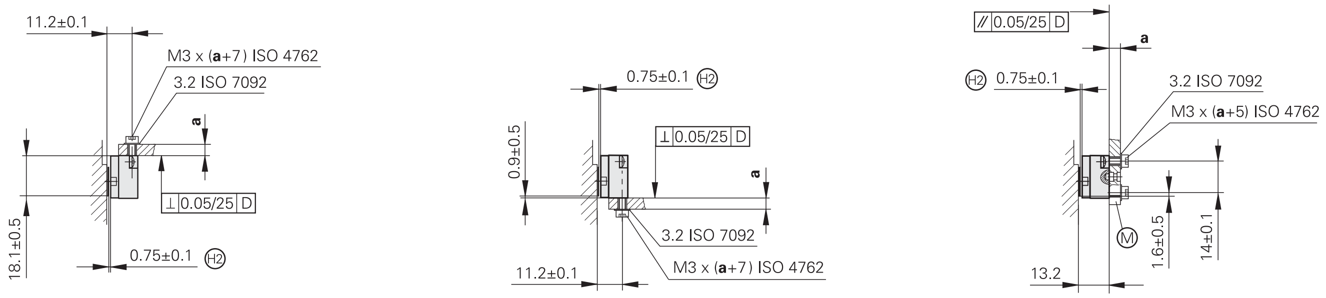
# LIDA 479, LIDA 489

**Incremental linear encoders for measuring ranges up to 6 m**

- **For measuring steps of 1 µm to 0.05 µm**
- **Limit switches**
- **Steel scale tape cemented on mounting surface**




**Possibilities for mounting the scanning head**




mm

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

F = Machine guideway
* = Max. change during operation
Ⓡ = Reference mark position
Ⓢ = Beginning of measuring length (ML)
Ⓐ = Selector magnet for limit switch
Ⓛ = Scale tape length
Ⓜ = Mounting surface for scanning head
H1 = Direction of scanning unit for output signals in accordance with interface description
H2 = Adjust or set


| Specifications | LIDA 489 | LIDA 479 | | | |
|---|---|---|---|---|---|
| **Measuring standard**<br>Coefficient of linear expansion | Steel scale-tape with METALLUR graduation<br>$\alpha_{therm} \approx 10 \cdot 10^{-6}$ K$^{-1}$ | | | | |
| **Accuracy grade** | ± 15 µm or ± 5 µm after linear length-error compensation in the subsequent electronics | | | | |
| **Measuring length ML***<br>in mm | 70 120 170 220 270 320 370 420 520 620 720 820 920 1 020 | | | | |
| Reference marks | One at midpoint of measuring length | | | | |
| **Incremental signals** | ∿ 1 $V_{PP}$ | ⊓⊔TTL | | | |
| Grating period | 20 µm | | | | |
| Integrated interpolation*<br>Signal period | –<br>20 µm | 5-fold<br>4 µm | 10-fold<br>2 µm | 50-fold<br>0.4 µm | 100-fold<br>0.2 µm |
| Cutoff frequency –3 dB | ≥ 400 kHz | – | | | |
| Scanning frequency* | – | ≤ 400 kHz<br>≤ 200 kHz<br>≤ 100 kHz<br>≤ 50 kHz | ≤ 200 kHz<br>≤ 100 kHz<br>≤ 50 kHz<br>≤ 25 kHz | ≤ 50 kHz<br>≤ 25 kHz<br>≤ 12.5 kHz | ≤ 25 kHz<br>≤ 12.5 kHz<br>≤ 6.25 kHz |
| Edge separation a[1)] | – | ≥ 0.100 µs<br>≥ 0.220 µs<br>≥ 0.465 µs<br>≥ 0.950 µs | ≥ 0.100 µs<br>≥ 0.220 µs<br>≥ 0.465 µs<br>≥ 0.950 µs | ≥ 0.080 µs<br>≥ 0.175 µs<br>≥ 0.370 µs | ≥ 0.080 µs<br>≥ 0.175 µs<br>≥ 0.370 µs |
| **Traversing speed**[1)] | ≤ 480 m/min | ≤ 480 m/min<br>≤ 240 m/min<br>≤ 120 m/min<br>≤ 60 m/min | ≤ 240 m/min<br>≤ 120 m/min<br>≤ 60 m/min<br>≤ 30 m/min | ≤ 60 m/min<br>≤ 30 m/min<br>≤ 15 m/min | ≤ 30 m/min<br>≤ 15 m/min<br>≤ 7.5 m/min |
| **Limit switches** | L1/L2 with two different magnets; *output signals:* TTL (without line driver) | | | | |
| **Power supply**<br>Current consumption | 5 V DC ± 5 %<br>< 100 mA | 5 V DC ± 5 %<br>< 170 mA (without load) | | 5 V DC ± 5 %<br>< 255 mA (without load) | |
| **Electrical connection**<br>Cable length | Cable 3 m with D-sub connector (15-pin), interface electronics for LIDA 479 in the connector<br>See Interface Description, but *limit:* ≤ 20 m (with HEIDENHAIN cable) | | | | |
| **Vibration** 55 Hz to 2 000 Hz<br>**Shock** 11 ms | ≤ 200 m/s$^2$ (EN 60 068-2-6)<br>≤ 500 m/s$^2$ (EN 60 068-2-27) | | | | |
| **Operating temperature** | 0 °C to 50 °C | | | | |
| **Weight** Scanning head<br>Scale tape<br>Connecting cable<br>Connector | 20 g (without connecting cable)<br>31 g/m<br>22 g/m<br>*LIDA 489:* 32 g, *LIDA 479:* 140 g | | | | |

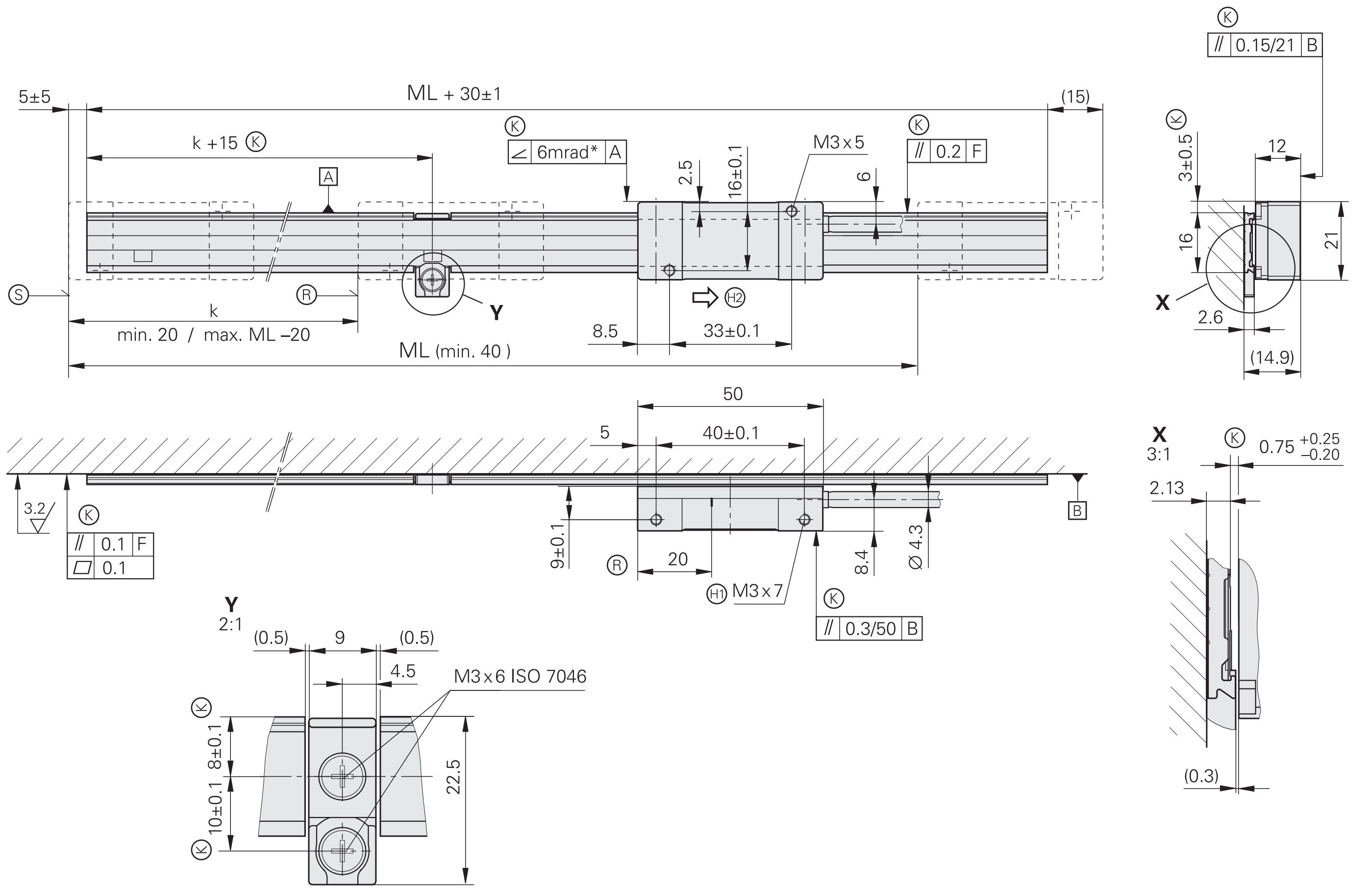
***** Please indicate when ordering

1) At the corresponding cutoff or scanning frequency

# LIDA 277, LIDA 287

**Incremental linear encoder with large mounting tolerance**

- **For measuring steps to 0.5 µm**
- **Scale tape cut from roll**
- **Steel scale-tape is drawn into adhesive aluminum extrusions and fixed**




mm

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

* = Max. change during operation
F = Machine guideway
Ⓚ = Required mating dimensions
Ⓡ = Reference mark
Ⓛ = Scale tape length

Ⓢ = Beginning of measuring length (ML)
Ⓗ1 = Thread at both ends
Ⓗ2 = Direction of scanning unit motion for output signals in accordance with interface description

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

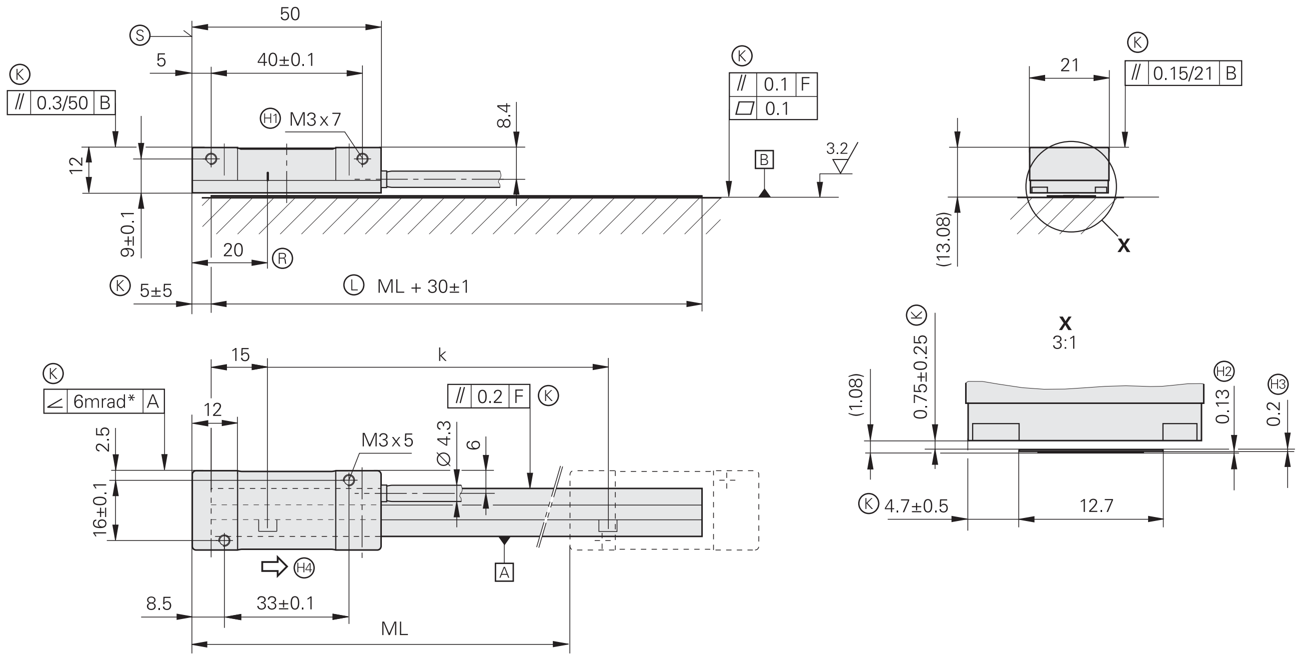

| Specifications | LIDA 287 | LIDA 277 | | |
|---|---|---|---|---|
| **Measuring standard**<br>Coefficient of linear expansion | Steel scale tape<br>$\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$ | | | |
| **Accuracy grade** | ± 30 µm | | | |
| **Scale tape cut from roll*** | 3 m, 5 m, 10 m | | | |
| **Reference marks** | Selectable every 100 mm | | | |
| **Incremental signals** | ∿ 1 $V_{PP}$ | ⊓⊔TTL | | |
| Grating period | 200 µm | | | |
| Integrated interpolation*<br>Signal period | –<br>200 µm | 10-fold<br>20 µm | 50-fold<br>4 µm | 100-fold<br>2 µm |
| Cutoff frequency<br>Scanning frequency<br>Edge separation a | ≥ 50 kHz<br>–<br>– | –<br>≤ 50 kHz<br>≥ 0.465 µs | –<br>≤ 25 kHz<br>≥ 0.175 µs | –<br>≤ 12.5 kHz<br>≥ 0.175 µs |
| **Traversing speed** | ≤ 600 m/min | | ≤ 300 m/min | ≤ 150 m/min |
| **Power supply**<br>Current consumption | 5 V DC ± 5 %<br>< 110 mA | 5 V DC ± 5 %<br>< 140 mA (without load) | | |
| **Electrical connection***<br>Cable length | Cable 1 m or 3 m with D-sub connector (15-pin)<br>See Interface Description, but ≤ 30 m (with HEIDENHAIN cable) | | | |
| **Vibration** 55 Hz to 2000 Hz<br>**Shock** 11 ms | ≤ 200 m/s$^2$ (EN 60068-2-6)<br>≤ 500 m/s$^2$ (EN 60068-2-27) | | | |
| **Operating temperature** | 0 °C to 50 °C | | | |
| **Weight** Scanning head<br>Scale tape<br>Scale-tape carrier<br>Connecting cable<br>Connector | 20 g (without connecting cable)<br>20 g/m<br>70 g/m<br>30 g/m<br>32 g | | | |

***** Please select when ordering

# LIDA 279, LIDA 289

**Incremental linear encoder with large mounting tolerance**

- **For measuring steps to 0.5 µm**
- **Scale tape cut from roll**
- **Steel scale tape cemented on mounting surface**




mm

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

* = Max. change during operation
F = Machine guideway
Ⓚ = Required mating dimensions
Ⓡ = Reference mark
Ⓛ = Scale tape length
Ⓢ = Beginning of measuring length (ML)

H1 = Thread at both ends
H2 = Adhesive tape
H3 = Steel scale tape
H4 = Direction of scanning unit motion for output signals in accordance with interface description

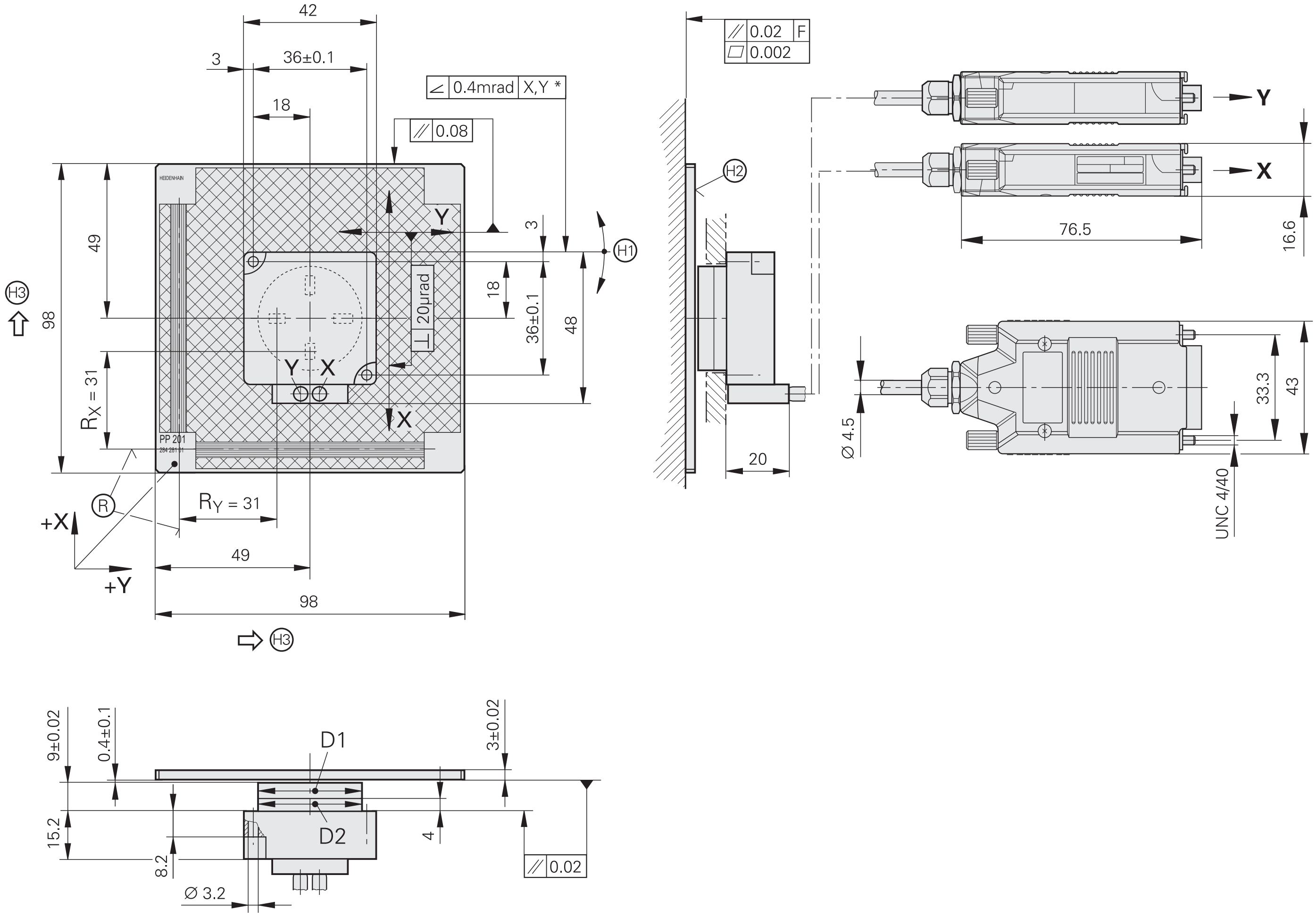
Reference mark:
k = Any position of the selected reference mark starting from the beginning of the measuring length (depends on length of scale blank)


| Specifications | LIDA 289 | LIDA 279 | | |
|---|---|---|---|---|
| **Measuring standard**<br>Coefficient of linear expansion | Steel scale tape<br>$\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$ | | | |
| **Accuracy grade** | ± 30 µm | | | |
| **Scale tape cut from roll*** | 3 m, 5 m, 10 m | | | |
| **Reference marks** | Selectable every 100 mm | | | |
| **Incremental signals** | ∿ 1 $V_{PP}$ | ⊓⊔TTL | | |
| Grating period | 200 µm | | | |
| Integrated interpolation*<br>Signal period | –<br>200 µm | 10-fold<br>20 µm | 50-fold<br>4 µm | 100-fold<br>2 µm |
| Cutoff frequency<br>Scanning frequency<br>Edge separation a | ≥ 50 kHz<br>–<br>– | –<br>≤ 50 kHz<br>≥ 0.465 µs | –<br>≤ 25 kHz<br>≥ 0.175 µs | –<br>≤ 12.5 kHz<br>≥ 0.175 µs |
| **Traversing speed** | ≤ 600 m/min | | ≤ 300 m/min | ≤ 150 m/min |
| **Power supply**<br>Current consumption | 5 V DC ± 5 %<br>< 110 mA | 5 V DC ± 5 %<br>< 140 mA (without load) | | |
| **Electrical connection***<br>Cable length | Cable 1 m or 3 m with D-sub connector (15-pin)<br>See Interface Description, but ≤ 30 m (with HEIDENHAIN cable) | | | |
| **Vibration** 55 Hz to 2000 Hz<br>**Shock** 11 ms | ≤ 200 $m/s^2$ (EN 60068-2-6)<br>≤ 500 $m/s^2$ (EN 60068-2-27) | | | |
| **Operating temperature** | 0 °C to 50 °C | | | |
| **Weight** Scanning head<br>Scale tape<br>Connecting cable<br>Connector | 20 g (without connecting cable)<br>20 g/m<br>30 g/m<br>32 g | | | |

* Please select when ordering

# PP 281 R

**Two-coordinate incremental encoder**
**For measuring steps of 1 µm to 0.05 µm**

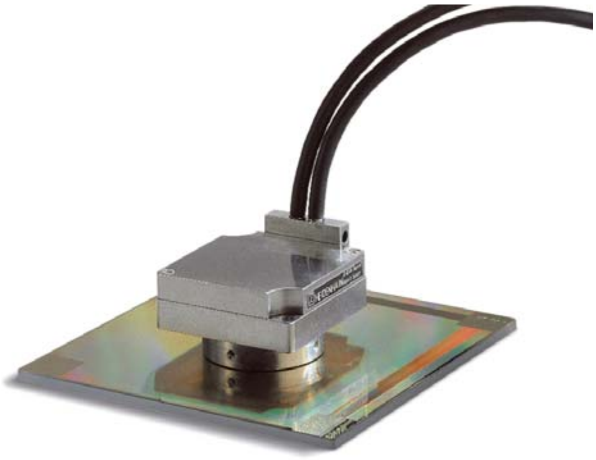



mm

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

* = Max. change during operation
F = Machine guideway
Ⓡ = Reference-mark position relative to center position shown
H1 = Adjusted during mounting
H2 = Graduation side
H3 = Direction of scanning unit motion for output signals in accordance with interface description

| D1 | D2 |
|---|---|
| Ø 32.9 –0.2 | Ø 33 –0.02/–0.10 |



| Specifications | PP 281 R |
|---|---|
| **Measuring standard**<br>Coefficient of linear expansion | Two-coordinate TITANID phase grating on glass<br>$\alpha_{therm} \approx 8 \cdot 10^{-6}\ K^{-1}$ |
| **Accuracy grade** | ± 2 µm |
| **Measuring range** | 68 x 68 mm,<br>other measuring ranges upon request |
| Reference marks[1)] | One reference mark in each axis, 3 mm after beginning of measuring length |
| **Incremental signals** | ∼ 1 $V_{PP}$ |
| Grating period | 8 µm |
| Signal period | 4 µm |
| Cutoff frequency –3 dB | ≥ 300 kHz |
| **Traversing speed** | ≤ 72 m/min |
| **Power supply**<br>Current consumption | 5 V DC ± 5 %<br>< 185 mA per axis |
| **Electrical connection**<br>Cable length | Cable 0.5 m with D-sub connector (15-pin), interface electronics in the connector<br>See Interface Description, but ≤ 30 m (with HEIDENHAIN cable) |
| **Vibration** 55 Hz to 2000 Hz<br>**Shock** 11 ms | ≤ 80 m/s² (EN 60068-2-6)<br>≤ 100 m/s² (EN 60068-2-27) |
| **Operating temperature** | 0 °C to 50 °C |
| **Weight** Scanning head<br>Grid plate<br>Connecting cable<br>Connector | 170 g (without connecting cable)<br>75 g<br>37 g/m<br>140 g |

[1)] The zero crossovers K, L of the reference-mark signal deviate from the interface specification (see the mounting instructions)

# Interfaces
## Incremental Signals ∿ 1 $V_{PP}$

HEIDENHAIN encoders with ∿1 $V_{PP}$ interface provide voltage signals that can be highly interpolated.

The sinusoidal **incremental signals** A and B are phase-shifted by 90° elec. and have amplitudes of typically 1 $V_{PP}$. The illustrated sequence of output signals—with B lagging A—applies for the direction of motion shown in the dimension drawing.

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

The data on **signal amplitude** apply when the power supply given in the specifications is connected to the encoder. They refer to a differential measurement at the 120 ohm terminating resistor between the associated outputs. The signal amplitude decreases with increasing frequency. The **cutoff frequency** indicates the scanning frequency at which a certain percentage of the original signal amplitude is maintained:

- –3 dB ≙ 70 % of the signal amplitude
- –6 dB ≙ 50 % of the signal amplitude

The data in the signal description apply to motions at up to 20% of the –3 dB-cutoff frequency.

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

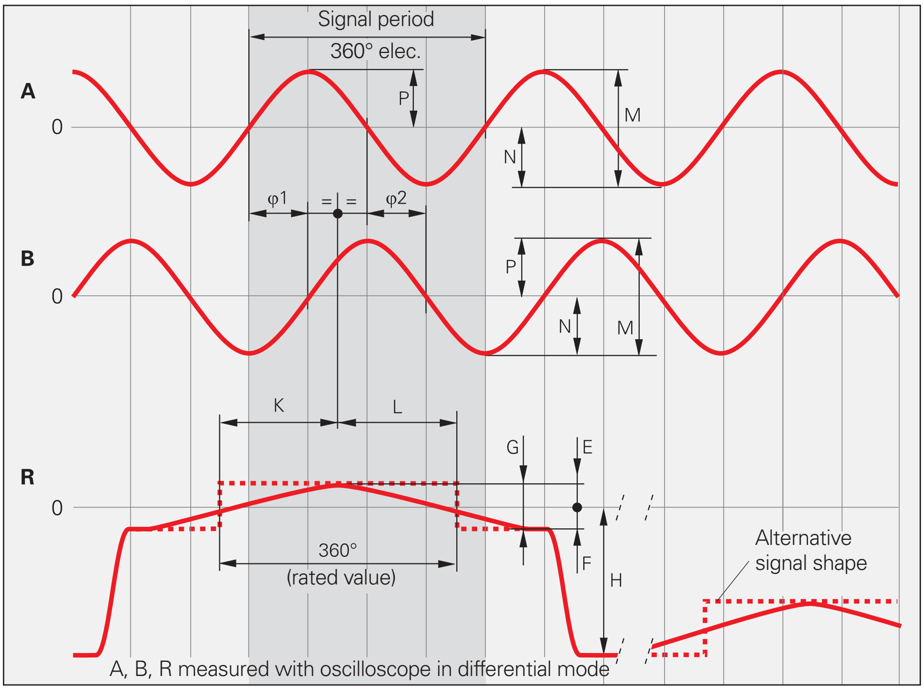
Measuring steps for **position measurement** are recommended in the specifications. For special applications, other resolutions are also possible.

**Short-circuit stability**
A temporary short circuit of one signal output to 0 V or $U_P$ (except encoders with $U_{Pmin}$= 3.6 V) does not cause encoder failure, but it is not a permissible operating condition.

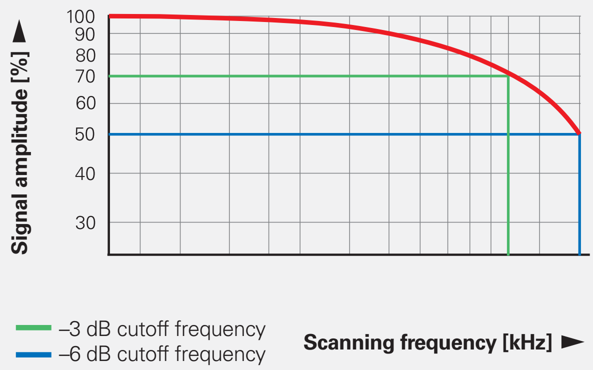
| Short circuit at | 20 °C | 125 °C |
|---|---|---|
| One output | < 3 min | < 1 min |
| All outputs | < 20 s | < 5 s |

| **Interface** | Sinusoidal voltage signals ∿ **1 $V_{PP}$** | |
|---|---|---|
| **Incremental signals** | **2 nearly sinusoidal signals A and B** | |
| | Signal amplitude M: | 0.6 to 1.2 $V_{PP}$; typically 1 $V_{PP}$ |
| | Asymmetry $\|P – N\|/2M$: | ≤ 0.065 |
| | Amplitude ratio $M_A/M_B$: | 0.8 to 1.25 |
| | Phase angle $\|\varphi1 + \varphi2\|/2$: | 90° ± 10° elec. |
| **Reference-mark signal** | **One or several signal peaks R** | |
| | Usable component G: | ≥ 0.2 V |
| | Quiescent value H: | ≤ 1.7 V |
| | Switching threshold E, F: | 0.04 to 0.68 V |
| | Zero crossovers K, L: | 180° ± 90° elec. |
| **Connecting cables** | Shielded HEIDENHAIN cable<br>PUR [4(2 x 0.14 $mm^2$) + (4 x 0.5 $mm^2$)] | |
| Cable length | Max. 150 m at 90 pF/m distributed capacitance | |
| Propagation time | 6 ns/m | |

These values can be used for dimensioning of the subsequent electronics. Any limited tolerances in the encoders are listed in the specifications. For encoders without integral bearing, reduced tolerances are recommended for initial operation (see the mounting instructions).




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



**Monitoring of the incremental signals**
The following thresholds are recommended for monitoring of the signal level M:
Lower threshold: 0.30 $V_{PP}$
Upper threshold: 1.35 $V_{PP}$

## Input Circuitry of Subsequent Electronics

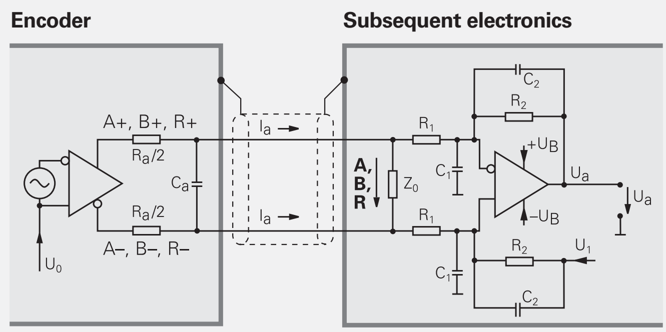
**Dimensioning**
Operational amplifier e.g. MC 34074
$Z_0$ = 120 Ω
$R_1$ = 10 kΩ and $C_1$ = 100 pF
$R_2$ = 34.8 kΩ and $C_2$ = 10 pF
$U_B$ = ±15 V
$U_1$ approx. $U_0$

**–3 dB cutoff frequency of circuitry**
Approx. 450 kHz
Approx. 50 kHz with $C_1$ = 1000 pF
and $C_2$ = 82 pF
The circuit variant for 50 kHz does reduce the bandwidth of the circuit, but in doing so it improves its noise immunity.

**Circuit output signals**
$U_a$ = 3.48 $V_{PP}$ typically
Gain 3.48

**Incremental signals**
**Reference-mark signal**

$R_a$ < 100 Ω,
typically 24 Ω
$C_a$ < 50 pF
$\Sigma I_a$ < 1 mA
$U_0$ = 2.5 V ± 0.5 V
(relative to 0 V of the power supply)




## Input Circuitry of Subsequent Electronics for High Signal Frequencies

For encoders with high signal frequencies (e.g. LIP 281), a special input circuitry is required.

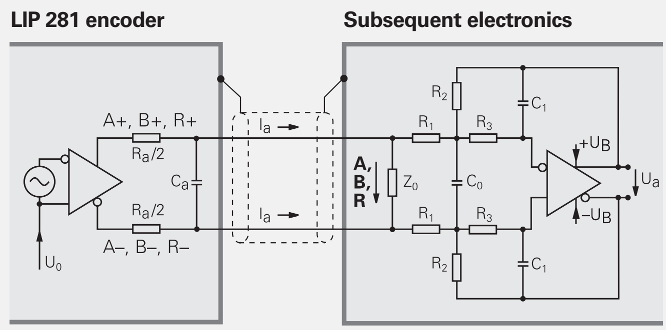
**Dimensioning**
Operational amplifier, e.g. AD 8138
$Z_0$ = 130 Ω
$R_1$ = 681 Ω
$R_2$ = 1 kΩ
$R_3$ = 464 Ω
$C_0$ = 15 pF
$C_1$ = 10 pF
$+U_B$ = 5 V
$-U_B$ = 0 V or –5 V

**–3 dB cutoff frequency of circuitry**
Approx. 10 MHz

**Circuit output signals**
$U_a$ = 1.47 $V_{PP}$ typically
Gain 1.47

**Incremental signals**
**Reference-mark signal**

$R_a$ < 100 Ω,
typically 24 Ω
$C_a$ < 50 pF
$\Sigma I_a$ < 1 mA
$U_0$ = 2.5 V ± 0.5 V
(relative to 0 V of the power supply)



# Interfaces

## Incremental Signals ⊓⊔TTL

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

The **incremental signals** are transmitted as the square-wave pulse trains $U_{a1}$ and $U_{a2}$, phase-shifted by 90° elec. The **reference mark signal** consists of one or more reference pulses $U_{a0}$, which are gated with the incremental signals. In addition, the integrated electronics produce their **inverted signals** $\overline{U_{a1}}$, $\overline{U_{a2}}$ and $\overline{U_{a0}}$ 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** $\overline{U_{aS}}$ indicates fault conditions such as breakage of the power line or failure of the light source. It can be used for such purposes as machine shut-off during automated production.

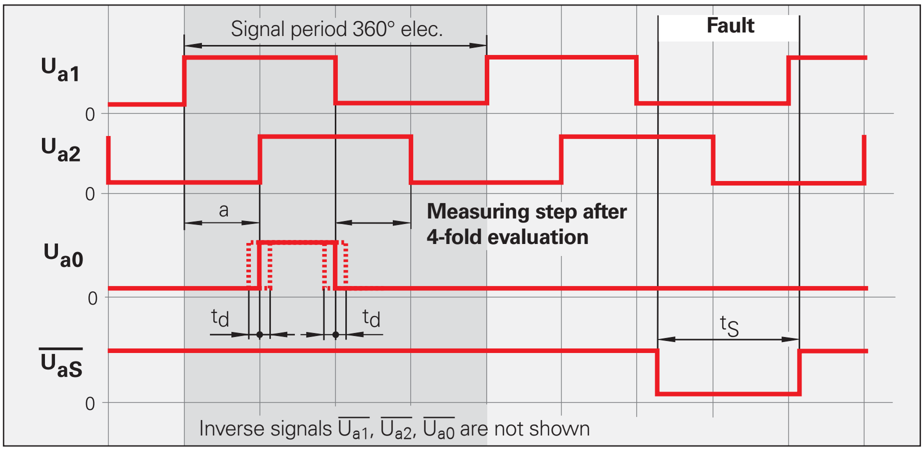
The distance between two successive edges of the incremental signals $U_{a1}$ and $U_{a2}$ through 1-fold, 2-fold or 4-fold evaluation is one **measuring step.**

The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum **edge separation a** listed in the *Specifications* applies for the illustrated input circuitry with a cable length of 1 m, and refers to measurement at the output of the differential line receiver. Cable-dependent differences in the propagation times additionally reduce the edge separation by 0.2 ns per meter of cable. To prevent counting errors, design the subsequent electronics to process as little as 90 % of the resulting edge separation.

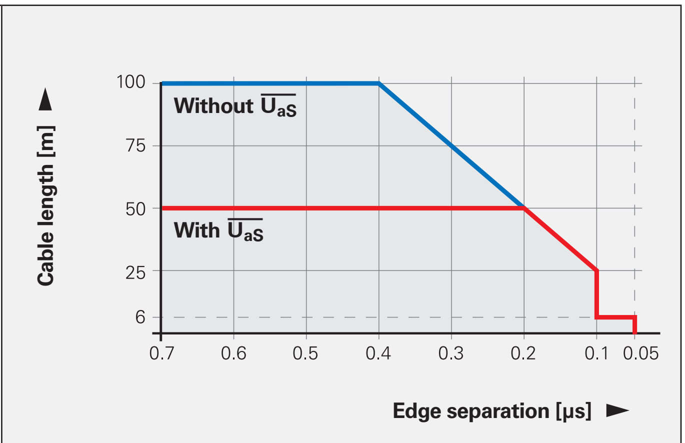
The max. permissible **shaft speed** or **traversing velocity** must never be exceeded.

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

| **Interface** | Square-wave signals **⊓⊔TTL** |
|---|---|
| **Incremental signals** | **2 square-wave signals $U_{a1}$, $U_{a2}$** and their inverted signals **$\overline{U_{a1}}$, $\overline{U_{a2}}$** |
| **Reference-mark signal**<br>Pulse width<br>Delay time | **1 or more TTL square-wave pulses $U_{a0}$** and their inverted pulses **$\overline{U_{a0}}$**<br>90° elec. (other widths available on request); *LS 323:* ungated<br>$\lvert t_d \rvert \leq 50$ ns |
| **Fault-detection signal**<br><br><br>Pulse width | **1 TTL square-wave pulse $\overline{U_{aS}}$**<br>Improper function: LOW (upon request: $U_{a1}/U_{a2}$ high impedance)<br>Proper function: HIGH<br>$t_S \geq 20$ ms |
| **Signal amplitude** | Differential line driver as per EIA standard RS-422<br>$U_H \geq 2.5$ V at $-I_H = 20$ mA    *ERN 1x23:* 10 mA<br>$U_L \leq 0.5$ V at $I_L = 20$ mA    *ERN 1x23:* 10 mA |
| **Permissible load** | $Z_0 \geq 100\ \Omega$    Between associated outputs<br>$\lvert I_L \rvert \leq 20$ mA    Max. load per output (*ERN 1x23:* 10 mA)<br>$C_{load} \leq 1\,000$ pF    With respect to 0 V<br>Outputs protected against short circuit to 0 V |
| **Switching times** (10% to 90%) | $t_+ / t_- \leq 30$ ns (typically 10 ns)<br>with 1 m cable and recommended input circuitry |
| **Connecting cables**<br><br>Cable length<br>Propagation time | Shielded HEIDENHAIN cable<br>PUR [4(2 × 0.14 mm$^2$) + (4 × 0.5 mm$^2$)]<br>Max. 100 m ($\overline{U_{aS}}$ max. 50 m) at distributed capacitance 90 pF/m<br>6 ns/m |




**Permissible cable length**
with respect to the edge separation

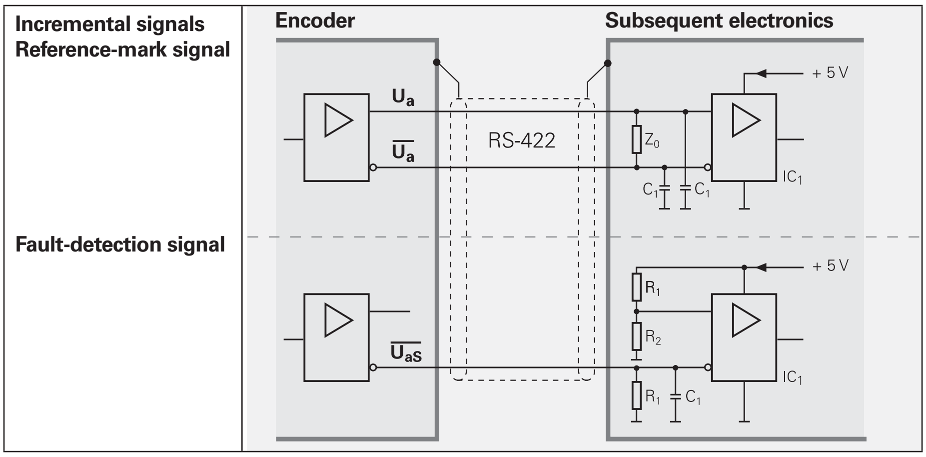


## Input Circuitry of Subsequent Electronics

**Dimensioning**

$IC_1$ = Recommended differential line receiver
DS 26 C 32 AT
Only for a > 0.1 µs:
AM 26 LS 32
MC 3486
SN 75 ALS 193

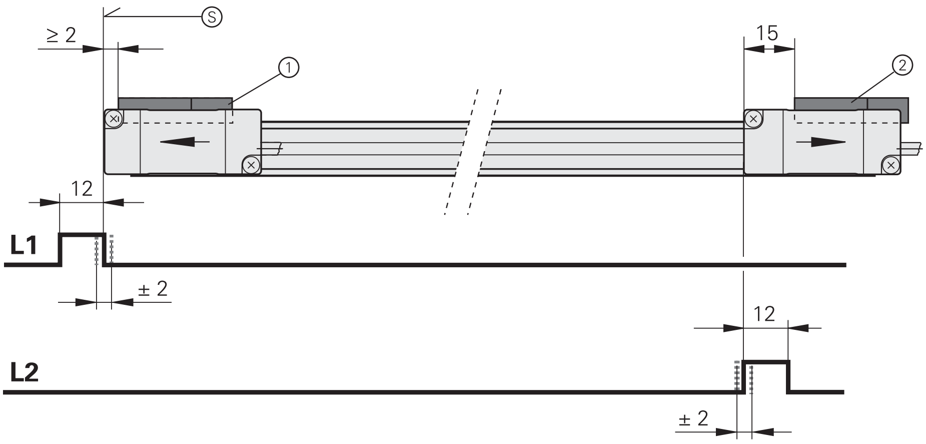
$R_1$ = 4.7 kΩ
$R_2$ = 1.8 kΩ
$Z_0$ = 120 Ω
$C_1$ = 220 pF (serves to improve noise immunity)



# Interfaces
Limit Switches

LIDA 400 encoders are equipped with two limit switches that make limit-position detection and the formation of homing tracks possible. The limit switches are activated by differing adhesive magnets to distinguish between the left or right limit. The magnets can be configured in series to form homing tracks. The signals from the limit switches are sent over separate lines and are therefore directly available. Yet the cable has only a very thin diameter of 3.7 mm in order to keep the forces on movable machine elements to a minimum.

| | | LIDA 47x | LIDA 48x |
|---|---|---|---|
| **Output signals** | | One TTL square-wave pulse from each limit switch L1 and L2; "active high" | |
| **Signal amplitude** | | TTL from push-pull stage (e.g. 74 HCT 1G 08) | TTL from common-collector circuit with load resistance of 10 kΩ against 5 V |
| **Permissible load** | | $I_{aL} \leq 4$ mA<br>$I_{aH} \leq 4$ mA | |
| **Switching times** (10 % to 90 %) | Rise time<br>Fall time | $t_+ \leq 50$ ns<br>$t_- \leq 50$ ns<br>Measured with 3 m cable and recommended input circuitry | $t_+ \leq 10$ µs<br>$t_- \leq 3$ µs<br>Measured with 3 m cable and recommended input circuitry |
| **Permissible cable length** | | Max. 20 m | |



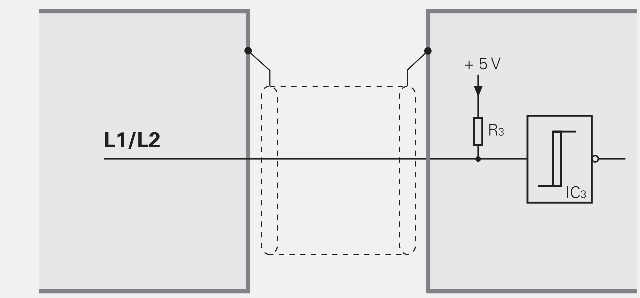

**L1/L2** = Output signals of the limit switches 1 and 2
Tolerance of the switching point: ± 2 mm

Ⓢ = Beginning of measuring length (ML)
① = Magnet N for limit switch 1
② = Magnet S for limit switch 2

**Recommended input circuitry of the subsequent electronics**

**Dimensioning**
$IC_3$ e.g. 74AC14
$R_3$ = 1.5 kΩ

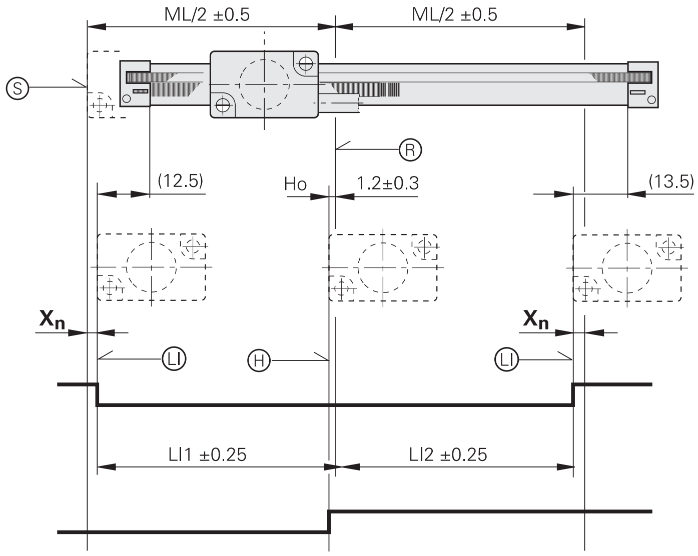
**LIDA 400 limit switches**



# Position Detection

Besides the incremental graduation, the LIF 4x1 features a homing track and limit switches for limit position detection. The signals are transmitted in TTL levels over the separate lines H and L and are therefore directly available. Yet the cable has only a very thin diameter of 4.5 mm in order to keep the forces on movable machine elements to a minimum.

| | **LIF 4x1** |
|---|---|
| **Output signals** | One TTL pulse for homing track H and limit switch L |
| **Signal amplitude** | TTL<br>$U_H \geq 3.8$ V at $-I_H = 8$ mA<br>$U_L \leq 0.45$ V at $I_L = 8$ mA |
| **Permissible load** | $R \geq 680\ \Omega$<br>$\lvert I_L \rvert \leq 8$ mA |
| **Permissible cable length** | Max. 10 m |



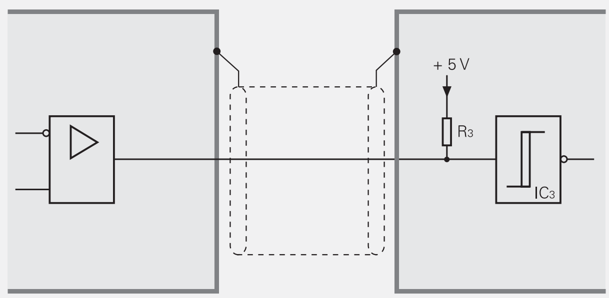

$X_n$ =
Var. 01 $X_1$ = 2 mm
Var. 02 $X_2$ = 14 mm
Var. 03 $X_3$ = 22 mm

Ⓡ = Reference mark position
Ⓢ = Beginning of measuring length (ML)
LI = Limit mark, adjustable
Ⓗ = Switch for homing track
Ho = Trigger point for homing

**Recommended input circuitry of the subsequent electronics**

**Dimensioning**
$IC_3$ e.g. 74AC14
$R_3 = 4.7\ k\Omega$

**Limit switches**
**Homing track**
**LIF 400**



# Interfaces
## Absolute Position Values EnDat

The EnDat interface is a digital, **bidirectional** interface for encoders. It is capable both of transmitting **position values** as well as transmitting or updating information stored in the encoder, or saving new information. Thanks to the **serial transmission method**, only **four signal lines** are required. The data is transmitted in **synchronism** with the clock signal from the subsequent electronics. The type of transmission (position values, parameters, diagnostics, etc.) is selected through mode commands that the subsequent electronics send to the encoder. Some functions are available only with EnDat 2.2 mode commands.

For more information, refer to the *EnDat* Technical Information sheet or visit *www.endat.de*.

**Position values** can be transmitted with or without additional information (e.g. position value 2, temperature sensors, diagnostics, limit position signals).
Besides the position, additional information can be interrogated in the closed loop and functions can be performed with the EnDat 2.2 interface.

**Parameters** are saved in various memory areas, e.g.:
- Encoder-specific information
- Information of the OEM (e.g. “electronic ID label” of the motor)
- Operating parameters (datum shift, instruction, etc.)
- Operating status (alarm or warning messages)

**Monitoring and diagnostic functions** of the EnDat interface make a detailed inspection of the encoder possible.
- Error messages
- Warnings
- Online diagnostics based on valuation numbers (EnDat 2.2)

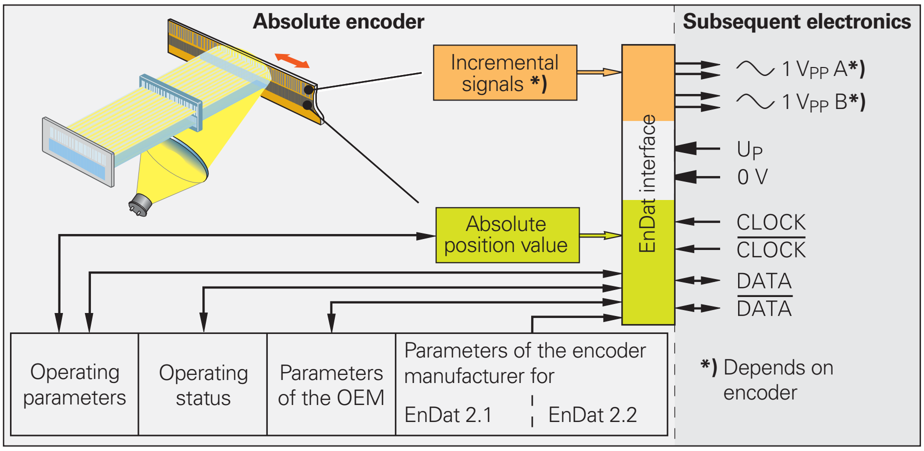
**Incremental signals**
EnDat encoders are available with or without incremental signals. EnDat 21 and EnDat 22 encoders feature a high internal resolution. An evaluation of the incremental signal is therefore unnecessary.

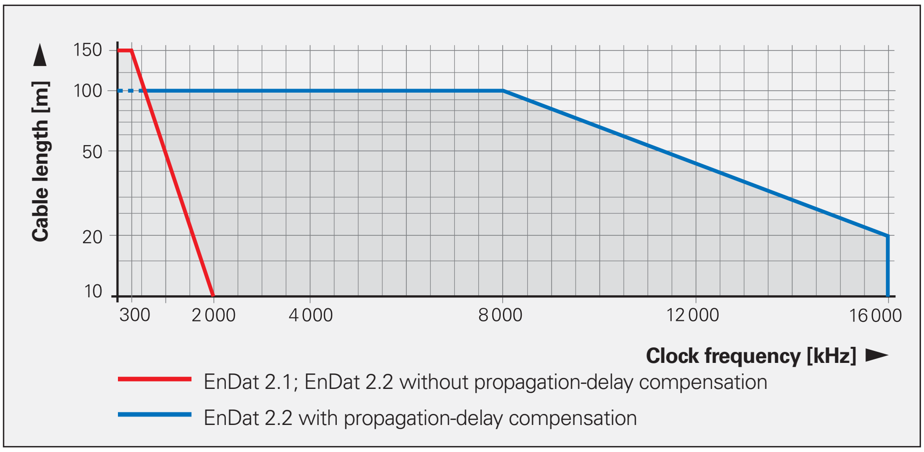
**Clock frequency and cable length**
The clock frequency is variable—depending on the cable length (max. 150 m)—between **100 kHz** and **2 MHz.** With propagation-delay compensation in the subsequent electronics, clock frequencies **up to 16 MHz** at cable lengths up to 100 m are possible (for other values see *Specifications*).

| **Interface** | **EnDat** serial bidirectional |
|---|---|
| **Data transfer** | Absolute position values, parameters and additional information |
| Data input | Differential line receiver according to EIA standard RS 485 for the signals CLOCK, $\overline{\text{CLOCK}}$, DATA and $\overline{\text{DATA}}$ |
| Data output | Differential line driver according to EIA standard RS 485 for DATA and $\overline{\text{DATA}}$ signals. |
| Position values | Ascending during traverse in direction of arrow (see dimensions of the encoders) |
| **Incremental signals** | ~ 1 $V_{PP}$ (see *Incremental signals 1* $V_{PP}$) depending on the unit |

| **Ordering designation** | **Command set** | **Incremental signals** | **Power supply** |
|---|---|---|---|
| **EnDat 01** | EnDat 2.1 or EnDat 2.2 | With | See specifications of the encoder |
| EnDat 21 | | Without | |
| EnDat 02 | EnDat 2.2 | With | Expanded range 3.6 to 5.25 V DC or 14 V DC |
| **EnDat 22** | EnDat 2.2 | Without | |

Versions of the EnDat interface (bold print indicates standard versions)



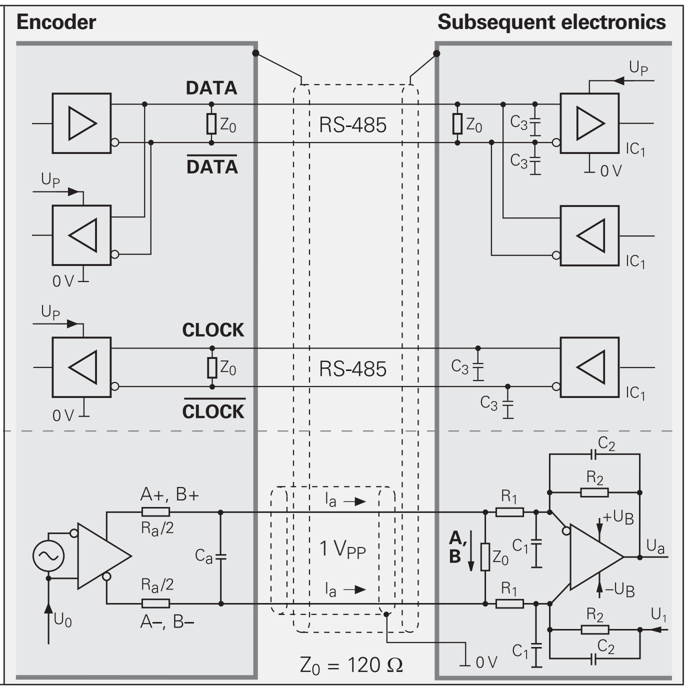
## Input Circuitry of Subsequent Electronics

**Dimensioning**
$IC_1$ = RS 485 differential line receiver and driver

$C_3$ = 330 pF
$Z_0$ = 120 Ω

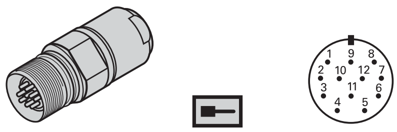
**Data transfer**

**Incremental signals**
Depending on encoder

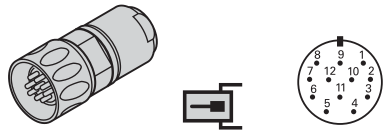


# Interfaces
## Pin Layout 1 $V_{PP}$, TTL, EnDat

**12-pin HEIDENHAIN coupling**



**12-pin HEIDENHAIN connector**

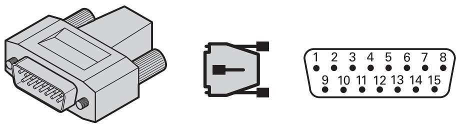


| | Power supply | | | | Incremental signals | | | | | | Other signals | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **12** | **2** | **10** | **11** | **5** | **6** | **8** | **1** | **3** | **4** | **7** | **9** |
| ⊓⊔ **TTL** | $U_P$ | **Sensor** 5 V | **0 V** | **Sensor** 0 V | $U_{a1}$ | $\overline{U_{a1}}$ | $U_{a2}$ | $\overline{U_{a2}}$ | $U_{a0}$ | $\overline{U_{a0}}$ | $\overline{U_{aS}}$ | [1] |
| ∼ **1 $V_{PP}$** | | | | | **A+** | **A–** | **B+** | **B–** | **R+** | **R–** | **L1**[2] | **L2**[2] |
| | Brown/Green | Blue | White/Green | White | Brown | Green | Gray | Pink | Red | Black | Violet | Yellow |

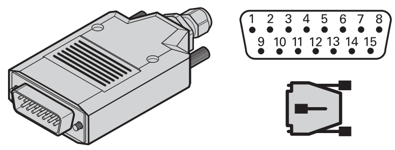
**Shield** on housing; $U_P$ = Power supply voltage
**Sensor:** The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used.

[1] TTL/11 µ$A_{PP}$ conversion for PWT
[2] Only for LIDA 48x;
color assignment applies only to connecting cable

**15-pin D-sub connector**



**15-pin D-sub connector with integrated interface electronics**

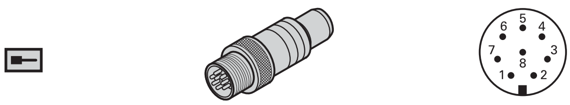


| | Power supply | | | | Incremental signals | | | | | | Other signals | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **4** | **12** | **2** | **10** | **1** | **9** | **3** | **11** | **14** | **7** | **13** | **8** | **6** | **15** |
| ⊓⊔ **TTL** | $U_P$ | **Sensor** 5 V | **0 V** | **Sensor** 0 V | $U_{a1}$ | $\overline{U_{a1}}$ | $U_{a2}$ | $\overline{U_{a2}}$ | $U_{a0}$ | $\overline{U_{a0}}$ | $\overline{U_{aS}}$ | **L1**[2] H[3] | **L2**[2] L[3] | [1] |
| ∼ **1 $V_{PP}$** | | | | | **A+** | **A–** | **B+** | **B–** | **R+** | **R–** | **Vacant** | | | **Vacant** |
| | Brown/Green | Blue | White/Green | White | Brown | Green | Gray | Pink | Red | Black | Violet | Green/Black | Yellow/Black | Yellow |

**Shield** on housing; $U_P$ = Power supply voltage
**Sensor:** The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used.

[1] TTL/11 µ$A_{PP}$ conversion for PWT (not for LIDA 27x)
[2] Only for LIDA 4xx;
color assignment applies only to connecting cable
[3] Only for LIF 481

**8-pin coupling,** M12



| | Power supply | | | | Absolute position values | | | |
|---|---|---|---|---|---|---|---|---|
| | **8** | **2** | **5** | **1** | **3** | **4** | **7** | **6** |
| **EnDat** | $U_P$ | **Sensor** $U_P$ | **0 V** | **Sensor** 0 V | **DATA** | $\overline{\textbf{DATA}}$ | **CLOCK** | $\overline{\textbf{CLOCK}}$ |
| | Brown/Green | Blue | White/Green | White | Gray | Pink | Violet | Yellow |

**Cable shield** connected to housing; $U_P$ = Power supply voltage
**Sensor:** The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!

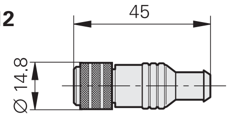
# Cables and Connecting Elements

## General Information

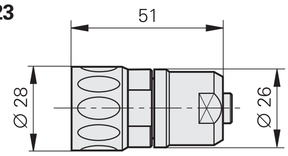
**Connector** (insulated): A connecting element with a coupling ring. Available with male or female contacts.

*Symbols*

**M12**



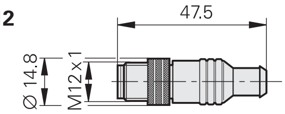

**M23**



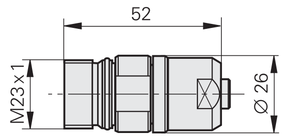

**Coupling** (insulated): Connecting element with external thread; available with male or female contacts.

*Symbols*

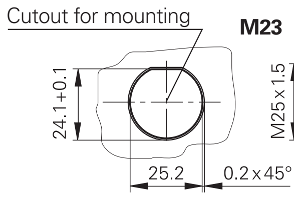
**M12**



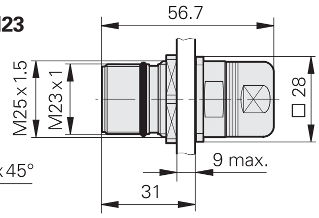

**M23**



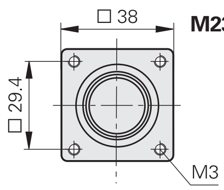

**Mounted coupling with central fastening**



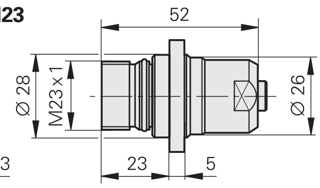

**M23**




**Mounted coupling with flange**



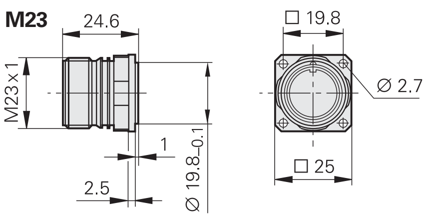

**M23**




**Flange socket:** Permanently mounted on the encoder or a housing, with external thread (like a coupling), available with male or female contacts.

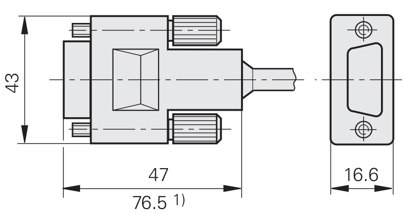
*Symbols*

**M23**




**D-sub connector:** For HEIDENHAIN controls, counters and IK absolute value cards.

*Symbols*




1) Interface electronics integrated in connector

The pins on connectors are **numbered** in the direction opposite to those on couplings or flange sockets, regardless of whether the connecting elements are

male or

female contacts.

When engaged, the connections are **protected** to IP 67 (D-sub connector: IP 50; EN 60529). When not engaged, there is no protection.

**Accessories for flange sockets and M23 mounted couplings**

**Bell seal**
ID 266526-01

**Threaded metal dust cap**
ID 219926-01

# Connecting Cables 1 V<sub></sub>PP, TTL

| | | LIP/LIF/LIDA without limit or homing signals | | For LIF 400/LIDA 400 with limit and homing signals | |
|---|---|---|---|---|---|
| **PUR connecting cable** [6(2 x AWG28) + (4 x 0.14 mm²)] | | | | | Ø 6 mm[1] |
| **PUR connecting cable** [4(2 x 0.14 mm²) + (4 x 0.5 mm²) + 2 x (2 x 0.14 mm²)] | | | | Ø 8 mm | |
| **PUR connecting cable** [6(2 x 0.19 mm²)] | | | Ø 6 mm[1] | | |
| **PUR connecting cable** [4(2 x 0.14 mm²) + (4 x 0.5 mm²)] | | Ø 8 mm | | | |
| **Complete** with D-sub connector (female) and M23 connector (male) | | 331693-xx | 355215-xx | – | – |
| With **one** D-sub connector (female) | | 332433-xx | 355209-xx | 354411-xx | 355398-xx |
| **Complete** with D-sub connectors (female and male) | | 335074-xx | 355186-xx | 354379-xx | 355397-xx |
| **Complete** with D-sub connectors (female) **Pin layout for IK 220** | | 335077-xx | 349687-xx | – | – |
| **Cable only** | | 244957-01 | 291639-01 | 354341-01 | 355241-01 |
| **Adapter cable for LIP 3x2** With M23 coupling (male) | | – | 310128-xx | – | – |
| **Adapter cable for LIP 3x2** with D-sub connector, assignment for IK 220 | | 298429-xx | – | – | – |
| **Adapter cable for LIP 3x2** without connector | | – | 310131-xx | – | – |
| **Complete** with M23 connector (female) and M23 connector (male) | | 298399-xx | – | – | – |
| **With one M23 connector** (female) | | 309777-xx | – | – | – |
| **Connector on connecting cable to connector on encoder cable** | | For cable | Ø 6 mm to Ø 8 mm | 315650-14 | |
| **Connector on connecting cable to mating element on encoder cable** | **M23 connector (female)** | For cable | Ø 8 mm | 291697-05 | |
| **M23 connector** for connection to subsequent electronics | **M23 connector (male)** | For cable | Ø 8 mm<br>Ø 6 mm | 291697-08<br>291697-07 | |
| **M23 flange socket** for mounting on the subsequent electronics | **M23 flange socket (female)** | | | 315892-08 | |
| **Adapter** $\sim$ **1 V**$_{PP}$**/11 µA**$_{PP}$<br>For converting the 1 $V_{PP}$ signals to 11 $\mu A_{PP}$; 12-pin M23 connector (female) and 9-pin M23 connector (male) | | | | 364914-01 | |

[1] Cable length for Ø 6 mm: max. 9 m

# Connecting Cables EnDat

## 8-Pin
## M12

| | | | |
|---|---|---|---|
| | | **EnDat** without incremental signals | |
| **PUR connecting cable** [4 × 2 × 0.09 $mm^2$] | | | |
| **PUR connecting cable** [(4 × 0.14 $mm^2$) + (4 × 0.34 $mm^2$)] | | Ø 6 mm | Ø 3.7 mm |
| **Complete** with connector (female) and coupling (male) |  | 368330-xx | 801142-xx[1)] |
| **Complete** with connector (female) and D-sub connector (female) for IK 220 |  | 533627-xx | – |
| **Complete** with connector (female) and D-sub connector (male) for IK 215/PWM 20 |  | 524599-xx | 801129-xx[1)] |
| With **one** connector (female) |  | 634265-xx | – |

[1)] Max. cable length 6 m

# General Electrical Information

## Power supply

Connect HEIDENHAIN encoders only to subsequent electronics whose power supply is generated from PELV systems **(EN 50178).** In addition, overcurrent protection and overvoltage protection are required in safety-related applications.

If HEIDENHAIN encoders are to be operated in accordance with IEC 61010-1, power must be supplied from a secondary circuit with current or power limitation as per IEC 61010-1:2001, section 9.3 or IEC 60950-1:2005, section 2.5 or a Class 2 secondary circuit as specified in UL1310.

The encoders require a **stabilized DC voltage $U_P$** as power supply. The respective *Specifications* state the required power supply and the current consumption. The permissible ripple content of the DC voltage is:

- High frequency interference
  $U_{PP}$ < 250 mV with dU/dt > 5 V/µs
- Low frequency fundamental ripple
  $U_{PP}$ < 100 mV

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

Calculation of the **voltage drop**:

$$\Delta U = 2 \cdot 10^{-3} \cdot \frac{1.05 \cdot L_C \cdot I}{56 \cdot A_P}$$

where
- $\Delta U$: Voltage drop in V
- 1.05: Length factor due to twisted wires
- $L_C$: Cable length in m
- I: Current consumption in mA
- $A_P$: Cross section of power lines in mm$^2$

The voltage actually applied to the encoder is to be considered when **calculating the encoder's power requirement.** This voltage consists of the supply voltage $U_P$ provided by the subsequent electronics minus the line drop at the encoder. For encoders with an expanded supply range, the voltage drop in the power lines must be calculated under consideration of the nonlinear current consumption (see next page).

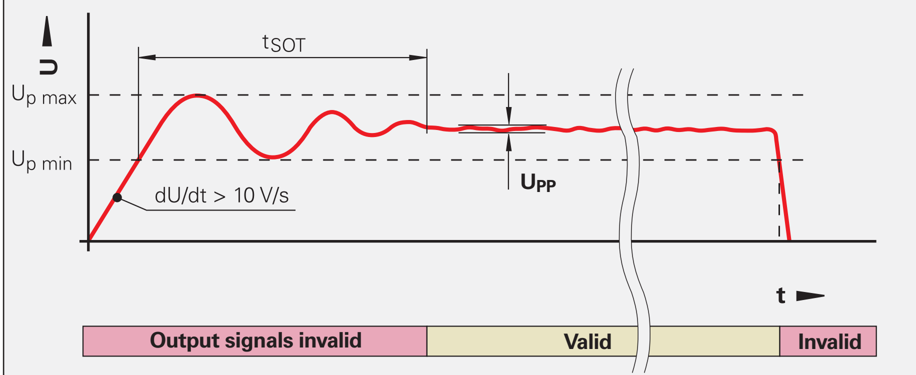
If the voltage drop is known, all parameters for the encoder and subsequent electronics can be calculated, e.g. voltage at the encoder, current requirements and power consumption of the encoder, as well as the power to be provided by the subsequent electronics.

**Switch-on/off behavior of the encoders**
The output signals are valid no sooner than after the switch-on time $t_{SOT}$ = 1.3 s (2 s for PROFIBUS-DP) (see diagram). During the time $t_{SOT}$ they can have any levels up to 5.5 V (with HTL encoders up to $U_{Pmax}$). If an interpolation electronics unit is inserted between the encoder and the power supply, this unit's switch-on/off characteristics must also be considered. If the power supply is switched off, or when the supply voltage falls below $U_{min}$, the output signals are also invalid. During restart, the signal level must remain below 1 V for the time $t_{SOT}$ before power on. These data apply to the encoders listed in the catalog—customer-specific interfaces are not included.

Encoders with new features and increased performance range may take longer to switch on (longer time $t_{SOT}$). If you are responsible for developing subsequent electronics, please contact HEIDENHAIN in good time.

**Insulation**
The encoder housings are isolated against internal circuits.
Rated surge voltage: 500 V
(preferred value as per VDE 0110 Part 1, overvoltage category II, contamination level 2)

**Transient response of supply voltage and switch-on/switch-off behavior**




| Cable | Cross section of power supply lines $A_P$ | | | |
|---|---|---|---|---|
| | **1 $V_{PP}$/TTL/HTL** | **11 µ$A_{PP}$** | **EnDat/SSI** 17-pin | **EnDat**[5] 8-pin |
| **Ø 3.7 mm** | 0.05 mm$^2$ | – | – | 0.09 mm$^2$ |
| **Ø 4.3 mm** | 0.24 mm$^2$ | – | – | – |
| **Ø 4.5 mm EPG** | 0.05 mm$^2$ | – | 0.05 mm$^2$ | 0.09 mm$^2$ |
| **Ø 4.5 mm**<br>**Ø 5.1 mm** | 0.14/0.09[2] mm$^2$<br>0.05[2, 3] mm$^2$ | 0.05 mm$^2$ | 0.05/0.14[6] mm$^2$ | 0.14 mm$^2$ |
| **Ø 5.5 mm PVC** | 0.1 mm$^2$ | – | – | – |
| **Ø 6 mm**<br>**Ø 10 mm**[1] | 0.19/0.14[2, 4] mm$^2$ | – | 0.08/0.19[6] mm$^2$ | 0.34 mm$^2$ |
| **Ø 8 mm**<br>**Ø 14 mm**[1] | 0.5 mm$^2$ | 1 mm$^2$ | 0.5 mm$^2$ | 1 mm$^2$ |

1) Metal armor
2) Rotary encoders
3) Length gauges
4) LIDA 400
5) Also Fanuc, Mitsubishi
6) Adapter cables for RCN, LC

**Encoders with expanded supply voltage range**
For encoders with expanded supply voltage range, the current consumption has a nonlinear relationship with the supply voltage. On the other hand, the power consumption follows a linear curve (see *Current and power consumption* diagram).
The maximum power consumption at minimum and maximum supply voltage is listed in the **Specifications**. The maximum power consumption (worst case) accounts for:
- Recommended receiver circuit
- Cable length 1 m
- Age and temperature influences
- Proper use of the encoder with respect to clock frequency and cycle time

The typical current consumption at no load (only supply voltage is connected) for 5 V supply is specified.

The actual power consumption of the encoder and the required power output of the subsequent electronics are measured, while taking the voltage drop on the supply lines into consideration, in four steps:

***Step 1:* Resistance of the supply lines**
The resistance values of the supply lines (adapter cable and encoder cable) can be calculated with the following formula:

$$R_L = 2 \cdot \frac{1.05 \cdot L_C}{56 \cdot A_P}$$

***Step 2:* Coefficients for calculation of the drop in line voltage**

$$b = -R_L \cdot \frac{P_{Emax} - P_{Emin}}{U_{Emax} - U_{Emin}} - U_P$$

$$c = P_{Emin} \cdot R_L + \frac{P_{Emax} - P_{Emin}}{U_{Emax} - U_{Emin}} \cdot R_L \cdot (U_P - U_{Emin})$$

***Step 3:* Voltage drop based on the coefficients b and c**

$$\Delta U = -0.5 \cdot (b + \sqrt{b^2 - 4 \cdot c})$$

***Step 4:* Parameters for subsequent electronics and the encoder**
Voltage at encoder:
$U_E = U_P - \Delta U$

Current requirement of encoder:
$I_E = \Delta U / R_L$

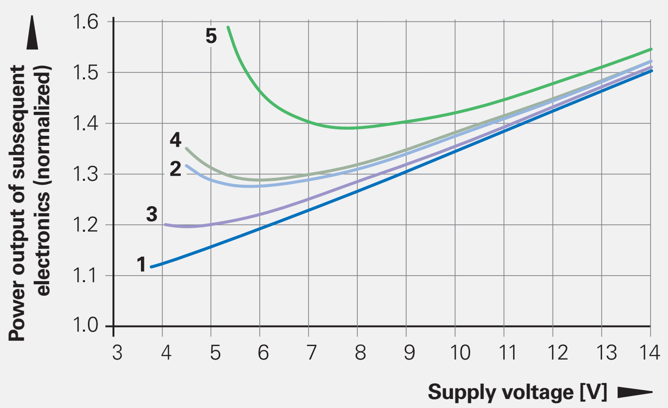
Power consumption of encoder:
$P_E = U_E \cdot I_E$

Power output of subsequent electronics:
$P_S = U_P \cdot I_E$

Where:

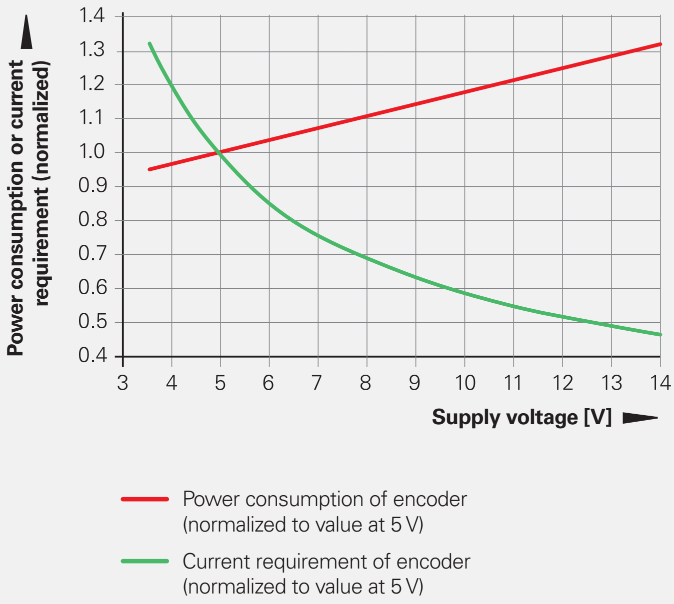
| | |
|---|---|
| $U_{Emax}$, $U_{Emin}$: | Minimum or maximum supply voltage of the encoder in V |
| $P_{Emin}$, $P_{Emax}$: | Maximum power consumption at minimum or maximum power supply, respectively, in W |
| $U_P$: | Supply voltage of the subsequent electronics in V |
| $R_L$: | Cable resistance (for both directions) in ohms |
| $\Delta U$: | Voltage drop in the cable in V |
| 1.05: | Length factor due to twisted wires |
| $L_C$: | Cable length in m |
| $A_P$: | Cross section of power lines in $mm^2$ |

Influence of cable length on the power output of the subsequent electronics (example representation)




| | Encoder cable/adapter cable | Connecting cable | Total |
|---|---|---|---|
| **1** | 3 m | / | 3 m |
| **2** | 20 m | / | 20 m |
| **3** | 3 m | 17 m | 20 m |
| **4** | 3 m | 47 m | 50 m |
| **5** | 3 m | 97 m | 100 m |

Current and power consumption with respect to the supply voltage (example representation)



## Electrically Permissible Speed/ Traversing Speed

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

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

  For encoders with **sinusoidal output signals**, the electrically permissible shaft speed/traversing velocity is limited by the –3 dB/ –6 dB cutoff frequency or the permissible input frequency of the subsequent electronics.

  For encoders with **square-wave signals,** the electrically permissible shaft speed/ traversing velocity is limited by
  – the maximum permissible scanning/ output frequency $f_{max}$ of the encoder, and
  – the minimum permissible edge separation a for the subsequent electronics.

**For angle or rotary encoders**

$$n_{max} = \frac{f_{max}}{z} \cdot 60 \cdot 10^3$$

**For linear encoders**

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

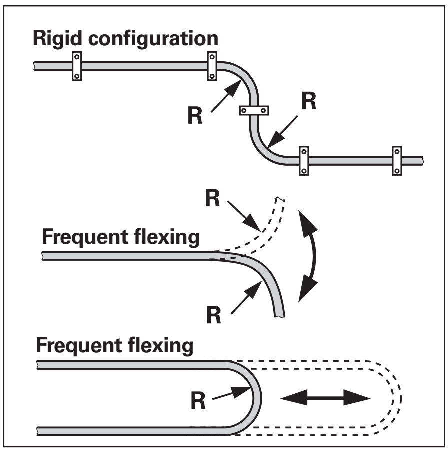
Where:
$n_{max}$: Elec. permissible speed in $min^{-1}$
$v_{max}$: Elec. permissible traversing velocity in m/min
$f_{max}$: Max. scanning/output frequency of encoder or input frequency of subsequent electronics in kHz
z: Line count of the angle or rotary encoder per 360°
SP: Signal period of the linear encoder in µm

## Cable

For safety-related applications, use HEIDENHAIN cables and connectors.

**Versions**
The cables of almost all HEIDENHAIN encoders and all adapter and connecting cables are sheathed in **polyurethane (PUR cables).** Many adapter cables for within motors and a few cables on encoders are sheathed in a **special elastomer (EPG).** Many adapter cables within the motor consist of TPE wires **(special thermoplastic)** in braided sleeving. Individual encoders feature cable with a sleeve of **polyvinyl chloride (PVC).** This cables are identified in the catalog as EPG, TPE or PVC.

**Durability**
**PUR cables** are resistant to oil in accordance with **VDE 0472** (Part 803/test type B) and to hydrolysis and microbes in accordance with **VDE 0282** (Part 10). They are free of PVC and silicone and comply with UL safety directives. The **UL certification** "AWM STYLE 20963 80 °C 30 V E63216" is documented on the cable.
**EPG cables** are resistant to oil in accordance with **VDE 0472** (Part 803/test type B) and to hydrolysis in accordance with **VDE 0282** (Part 10). They are free of silicone and halogens. In comparison with PUR cables, they are only somewhat resistant to media, frequent flexing and continuous torsion.
**PVC cables** are oil resistant. The UL certification "AWM E64638 STYLE20789 105C VW-1SC NIKKO" is documented on the cable.
**TPE wires** with braided sleeving are oil resistant and highly flexible.




**Temperature range**

| | Rigid configuration | Frequent flexing |
|---|---|---|
| PUR | –40 to 80 °C | –10 to 80 °C |
| EPG TPE | –40 to 120 °C | – |
| PVC | –20 to 90 °C | –10 to 90 °C |

PUR cables with limited resistance to hydrolysis and microbes are rated for up to 100 °C. If needed, please ask for assistance from HEIDENHAIN Traunreut.

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

| **Cable** | **Bend radius R** | |
|---|---|---|
| | **Rigid configuration** | **Frequent flexing** |
| **Ø 3.7 mm** | ≥ 8 mm | ≥ 40 mm |
| **Ø 4.3 mm** | ≥ 10 mm | ≥ 50 mm |
| **Ø 4.5 mm EPG** | ≥ 18 mm | – |
| **Ø 4.5 mm**<br>**Ø 5.1 mm**<br>**Ø 5.5 mm PVC** | ≥ 10 mm | ≥ 50 mm |
| **Ø 6 mm**<br>**Ø 10 mm**[1)] | ≥ 20 mm<br>≥ 35 mm | ≥ 75 mm<br>≥ 75 mm |
| **Ø 8 mm**<br>**Ø 14 mm**[1)] | ≥ 40 mm<br>≥ 100 mm | ≥ 100 mm<br>≥ 100 mm |

[1)] Metal armor

## Noise-Free Signal Transmission

**Electromagnetic compatibility/ CE-compliance**
When properly installed, and when HEIDENHAIN connecting cables and cable assemblies are used, HEIDENHAIN encoders fulfill the requirements for electromagnetic compatibility according to 2004/108/EC with respect to the generic standards for:

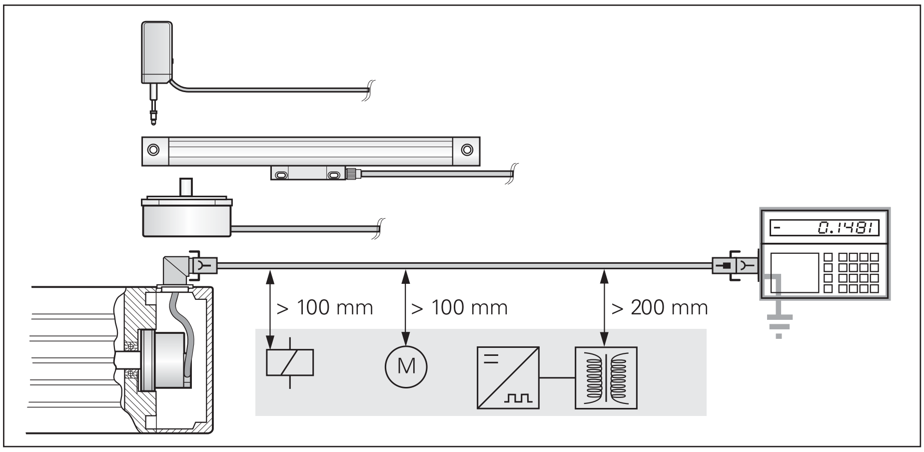
- **Noise immunity EN 61 000-6-2:**
  Specifically:
  - ESD — EN 61 000-4-2
  - Electromagnetic fields — EN 61 000-4-3
  - Burst — EN 61 000-4-4
  - Surge — EN 61 000-4-5
  - Conducted disturbances — EN 61 000-4-6
  - Power frequency magnetic fields — EN 61 000-4-8
  - Pulse magnetic fields — EN 61 000-4-9
- **Interference EN 61 000-6-4:**
  Specifically:
  - For industrial, scientific and medical equipment (ISM) — EN 55 011
  - For information technology equipment — EN 55 022

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

- Strong magnetic fields from transformers, brakes and electric motors
- Relays, contactors and solenoid valves
- High-frequency equipment, pulse devices, and stray magnetic fields from switch-mode power supplies
- AC power lines and supply lines to the above devices

**Protection against electrical noise**
The following measures must be taken to ensure disturbance-free operation:

- Use only original HEIDENHAIN cables. Consider the voltage drop on supply lines.
- Use connecting elements (such as connectors or terminal boxes) with metal housings. Only the signals and power supply of the connected encoder may be routed through these elements. Applications in which additional signals are sent through the connecting element require specific measures regarding electrical safety and EMC.
- Connect the housings of the encoder, connecting elements and subsequent electronics through the shield of the cable. Ensure that the shield has complete contact over the entire surface (360°). For encoders with more than one electrical connection, refer to the documentation for the respective product.
- For cables with multiple shields, the inner shields must be routed separately from the outer shield. Connect the inner shield to 0 V of the subsequent electronics. Do not connect the inner shields with the outer shield, neither in the encoder nor in the cable.
- Connect the shield to protective ground as per the mounting instructions.
- Prevent contact of the shield (e.g. connector housing) with other metal surfaces. Pay attention to this when installing cables.
- Do not install signal cables in the direct vicinity of interference sources (inductive consumers such as contactors, motors, frequency inverters, solenoids, etc.).
  - Sufficient decoupling from interference-signal-conducting cables can usually be achieved by an air clearance of 100 mm or, when cables are in metal ducts, by a grounded partition.
  - A minimum spacing of 200 mm to inductors in switch-mode power supplies is required.
- If compensating currents are to be expected within the overall system, a separate equipotential bonding conductor must be provided. The shield does not have the function of an equipotential bonding conductor.
- Provide power only from PELV systems **(EN 50 178)** to position encoders. Provide high-frequency grounding with low impedance **(EN 60 204-1 Chap. EMC).**
- For encoders with 11 µA$_{PP}$ interface: For extension cables, use only HEIDENHAIN cable ID 244955-01. Overall length: max. 30 m.



Minimum distance from sources of interference

# HEIDENHAIN Measuring and Test Equipment

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


| | PWM 9 |
|---|---|
| **Inputs** | Expansion modules (interface boards) for 11 $\mu A_{PP}$; 1 $V_{PP}$; TTL; HTL; EnDat*/SSI*/commutation signals<br>*No display of position values or parameters |
| **Functions** | • **Measures** signal amplitudes, current consumption, operating voltage, scanning frequency<br>• **Graphically displays** incremental signals (amplitudes, phase angle and on-off ratio) and the reference-mark signal (width and position)<br>• **Displays symbols** for the reference mark, fault detection signal, counting direction<br>• **Universal counter,** interpolation selectable from single to 1 024-fold<br>• **Adjustment support** for exposed linear encoders |
| **Outputs** | • Inputs are connected through to the subsequent electronics<br>• BNC sockets for connection to an oscilloscope |
| **Power supply** | 10 to 30 V DC, max. 15 W |
| **Dimensions** | 150 mm x 205 mm x 96 mm |

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


| | PWT 10 | PWT 17 | PWT 18 |
|---|---|---|---|
| **Encoder input** | ∿ 11 $\mu A_{PP}$ | ⊓⊔ TTL | ∿ 1 $V_{PP}$ |
| **Functions** | Measurement of signal amplitude<br>Wave-form tolerance<br>Amplitude and position of the reference mark signal | | |
| **Power supply** | Via power supply unit (included) | | |
| **Dimensions** | 114 mm x 64 mm x 29 mm | | |

The **APS 27** encoder diagnostic kit is necessary for assessing the mounting tolerances of the LIDA 27x with TTL interface. In order to examine it, the LIDA 27x is either connected to the subsequent electronics via the PS 27 test connector, or is operated directly on the PG 27 test unit.

Green LEDs for the incremental signals and reference pulse, respectively, indicate correct mounting. If they shine red, then the mounting must be checked again.


| | APS 27 |
|---|---|
| **Encoder** | LIDA 277, LIDA 279 |
| **Function** | Good/bad detection of the TTL signals (incremental signals and reference pulse) |
| **Power supply** | Via subsequent electronics or power supply unit (included in items supplied) |
| **Items supplied** | PS 27 test connector<br>PG 27 test unit<br>Power supply unit for PG 27 (110 to 240 V, including adapter plug)<br>Shading films |

The **SA 27** adapter connector serves for tapping the sinusoidal scanning signals of the LIP 372 off the APE. Exposed pins permit connection to an oscilloscope through standard measuring cables.

| | SA 27 |
|---|---|
| **Encoder** | LIP 372 |
| **Function** | Measuring points for the connection of an oscilloscope |
| **Power supply** | Via encoder |
| **Dimensions** | Approx. 30 mm x 30 mm |

The **PWM 20** phase angle measuring unit serves together with the provided ATS adjusting and testing software for diagnosis and adjustment of HEIDENHAIN encoders.

| | PWM 20 |
|---|---|
| **Encoder input** | • EnDat 2.1 or EnDat 2.2 (absolute value with/without incremental signals)<br>• DRIVE-CLiQ<br>• Fanuc Serial Interface<br>• Mitsubishi High Speed Serial Interface<br>• SSI |
| **Interface** | USB 2.0 |
| **Power supply** | 100 to 240 V AC or 24 V DC |
| **Dimensions** | 258 mm 154 mm 55 mm |

| | ATS |
|---|---|
| **Languages** | Choice between English or German |
| **Functions** | • Position display<br>• Connection dialog<br>• Diagnosis<br>• Mounting wizard for EBI/ECI/EQI, LIP 200, LIC 4000<br>• Additional functions (if supported by the encoder)<br>• Memory contents |
| **System requirements** | PC (Dual-Core processor; > 2 GHz)<br>Main memory> 1 GB<br>Windows XP, Vista, 7 (32-bit)<br>100 MB free space on hard disk |

# 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 if additional interpolation of the signals is necessary.

**Input signals of the interface electronics**
Interface electronics from HEIDENHAIN can be connected to encoders with sinusoidal signals of 1 $V_{PP}$ (voltage signals) or 11 $\mu A_{PP}$ (current signals). Encoders with the serial interfaces EnDat or SSI can also be connected to various interface electronics.

**Output signals of the interface electronics**
Interface electronics with the following interfaces to the subsequent electronics are available:

- TTL square-wave pulse trains
- EnDat 2.2
- DRIVE-CLiQ
- Fanuc Serial Interface
- Mitsubishi High Speed Serial Interface
- PCI bus
- Ethernet
- PROFIBUS

**Interpolation of the sinusoidal input signals**
In addition to being converted, the sinusoidal encoder signals are also interpolated in the interface electronics. This results in finer measuring steps, leading to an increased positioning accuracy and higher control quality.

**Formation of a position value**
Some interface electronics have an integrated counting function. Starting from the last reference point set, an absolute position value is formed when the reference mark is traversed, and is output to the subsequent electronics.

**Measured value memory**
Interface electronics with integrated measured value memory can buffer-save measured values:
*IK 220:* Total of 8192 measured values
*EIB 741:* Per input 250000 measured values

**Box design**

**Benchtop design**


**Plug design**

**Version for integration**

**Top-hat rail design**

| Outputs | | Inputs | | Design – protection class | Interpolation[1] or subdivision | Model |
|---|---|---|---|---|---|---|
| Interface | Qty. | Interface | Qty. | | | |
| ⊓⊔TTL | 1 | ∼ 1 $V_{PP}$ | 1 | Box design – IP 65 | 5/10-fold | **IBV 101** |
| | | | | | 20/25/50/100-fold | **IBV 102** |
| | | | | | Without interpolation | **IBV 600** |
| | | | | | 25/50/100/200/400-fold | **IBV 660 B** |
| | | | | Plug design – IP 40 | 5/10/20/25/50/100-fold | **APE 371** |
| | | | | Version for integration – IP 00 | 5/10-fold | **IDP 181** |
| | | | | | 20/25/50/100-fold | **IDP 182** |
| | | ∼ 11 $\mu A_{PP}$ | 1 | Box design – IP 65 | 5/10-fold | **EXE 101** |
| | | | | | 20/25/50/100-fold | **EXE 102** |
| | | | | | Without/5-fold | **EXE 602 E** |
| | | | | | 25/50/100/200/400-fold | **EXE 660 B** |
| | | | | Version for integration – IP 00 | 5-fold | **IDP 101** |
| ⊓⊔TTL/<br>∼ 1 $V_{PP}$<br>Adjustable | 2 | ∼ 1 $V_{PP}$ | 1 | Box design – IP 65 | 2-fold | **IBV 6072** |
| | | | | | 5/10-fold | **IBV 6172** |
| EnDat 2.2 | 1 | ∼ 1 $V_{PP}$ | 1 | Box design – IP 65 | ≤ 16384-fold subdivision | **EIB 192** |
| | | | | Plug design – IP 40 | ≤ 16384-fold subdivision | **EIB 392** |
| DRIVE-CLiQ | 1 | EnDat 2.2 | 1 | Box design – IP 65 | – | **EIB 2391 S** |
| Fanuc Serial Interface | 1 | ∼ 1 $V_{PP}$ | 1 | Box design – IP 65 | ≤ 16384-fold subdivision | **EIB 192 F** |
| | | | | Plug design – IP 40 | ≤ 16384-fold subdivision | **EIB 392 F** |
| Mitsubishi High Speed Serial Interface | 1 | ∼ 1 $V_{PP}$ | 1 | Box design – IP 65 | ≤ 16384-fold subdivision | **EIB 192 M** |
| | | | | Plug design – IP 40 | ≤ 16384-fold subdivision | **EIB 392 M** |
| PCI bus | 1 | ∼ 1 $V_{PP}$<br>∼ 11 $\mu A_{PP}$<br>EnDat 2.1/01<br>SSI<br>Adjustable | 2 | Version for integration – IP 00 | ≤ 4096-fold subdivision | **IK 220** |
| Ethernet | 1 | ∼ 1 $V_{PP}$<br>EnDat 2.1<br>EnDat 2.2<br>∼ 11 $\mu A_{PP}$ upon request<br>Adjustable by software | 4 | Benchtop design – IP 40 | ≤ 4096-fold subdivision | **EIB 741** |
| PROFIBUS DP | 1 | EnDat | 1 | Top-hat rail design | – | **PROFIBUS Gateway** |

[1] Switchable

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