HEIDENHAIN

Exposed Linear Encoders

May 2011

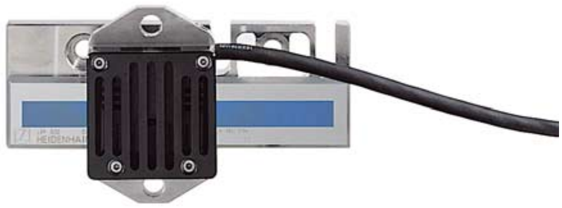
Exposed Linear Encoders

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*

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

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

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.

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 limit switches.

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 interferentially scanned. This makes it possible to measure positions in a plane.

	Substrate and mounting	Coefficient of expansion α_{therm}	Accuracy grade
Absolute position measurement			
LIC 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 ± 5 µm[2)]
	Steel scale tape, cemented on mounting surface	$\approx 10 \cdot 10^{-6}K^{-1}$	± 15 µm ± 5 µm[2)]
Incremental linear measurement			
LIP 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 or glass with fixing clamps	$\approx 0 \cdot 10^{-6}K^{-1}$ or $\approx 8 \cdot 10^{-6}K^{-1}$	± 1 µm ± 0.5 µm[3)]
	Glass scale, fixed with clamps	$\approx 8 \cdot 10^{-6}K^{-1}$	± 1 µm
LIF For high accuracy	Scale of Zerodur glass ceramic or glass, bonded with PRECIMET adhesive film	$\approx 0 \cdot 10^{-6}K^{-1}$ or $\approx 8 \cdot 10^{-6}K^{-1}$	± 3 µm
LIDA 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 $\approx 8 \cdot 10^{-6}K^{-1}$	± 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 ± 5 µm[2)]
	Steel scale tape, cemented on mounting surface	$\approx 10 \cdot 10^{-6}K^{-1}$	± 15 µm ± 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 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*).
2) After linear length-error compensation in the evaluation electronics
3) Higher accuracy grades available on request
4) other measuring lengths/ranges upon request

	Position error per signal period typically	Signal period[1)]	Measuring length	Interface	Model	Page
	± 0.08 µm	–	140 mm to 27040 mm	EnDat 2.2/22	**LIC 4015**	**18**
	± 0.08 µm	–	240 mm to 6040 mm	EnDat 2.2/22	**LIC 4017**	**20**
	± 0.08 µm	–	70 mm to 1020 mm	EnDat 2.2/22	**LIC 4019**	**22**
	± 0.001 µm	0.128 µm	70 mm to 270 mm	⊓⊔TTL ∿ 1 V_{PP}	**LIP 372** **LIP 382**	**24**
	± 0.02 µm	2 µm	70 mm to 420 mm	⊓⊔TTL ∿ 1 V_{PP}	**LIP 471** **LIP 481**	**26**
	± 0.04 µm	4 µm	70 mm to 1440 mm	⊓⊔TTL ∿ 1 V_{PP}	**LIP 571** **LIP 581**	**28**
	± 0.04 µm	4 µm	70 mm to 1020 mm	⊓⊔TTL ∿ 1 V_{PP}	**LIF 471** **LIF 481**	**30**
	± 0.2 µm	20 µm	140 mm to 3040 mm	⊓⊔TTL ∿ 1 V_{PP}	**LIDA 473** **LIDA 483**	**32**
	± 0.2 µm	20 µm	140 mm to 30040 mm	⊓⊔TTL ∿ 1 V_{PP}	**LIDA 475** **LIDA 485**	**34**
	± 0.2 µm	20 µm	240 mm to 6040 mm	⊓⊔TTL ∿ 1 V_{PP}	**LIDA 477** **LIDA 487**	**36**
	± 0.2 µm	20 µm	Up to 6000 mm[4)]	⊓⊔TTL ∿ 1 V_{PP}	**LIDA 479** **LIDA 489**	**38**
	± 2 µm	200 µm	UP to 10000 mm[4)]	⊓⊔TTL ∿ 1 V_{PP}	**LIDA 277** **LIDA 287**	**40**
	± 2 µm	200 µm	UP to 10000 mm[4)]	⊓⊔TTL ∿ 1 V_{PP}	**LIDA 279** **LIDA 289**	**42**
	± 0.04 µm	4 µm	Measuring range 68 x 68 mm[4)]	∿ 1 V_{PP}	**PP 281**	**44**

LIC 4015

LIC 4017

LIP 382

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.

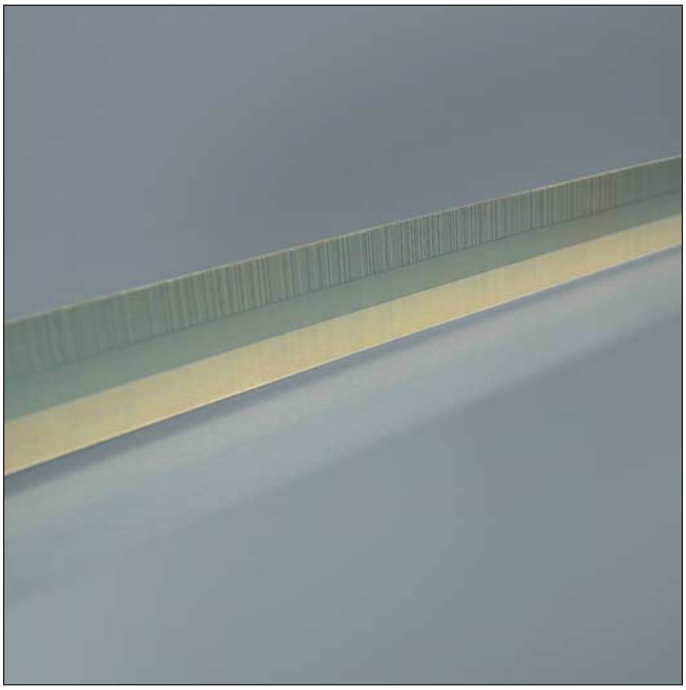
HEIDENHAIN manufactures the precision graduations in specially developed, photolithographic processes.
- AURODUR: Matte-etched lines on gold-plated steel tape with grating periods of typically 40 µm
- METALLUR: Contamination-tolerant graduation of metal lines on gold, with typical graduation period of 20 µm
- DIADUR: Extremely robust chromium lines on glass (typical graduation period 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.

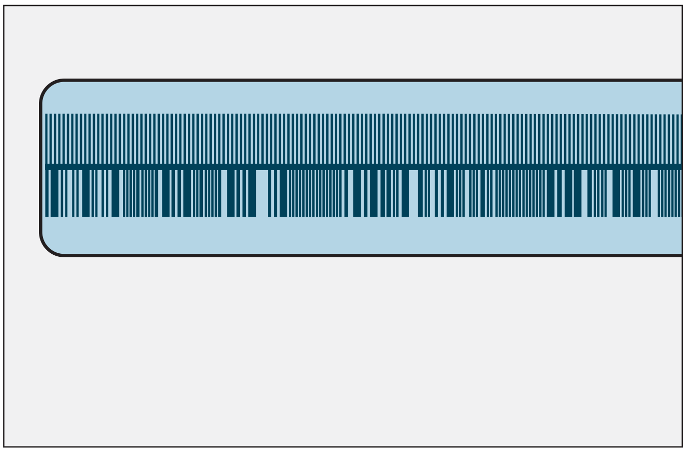
The master graduations are manufactured by HEIDENHAIN on custom-built high-precision ruling machines.

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

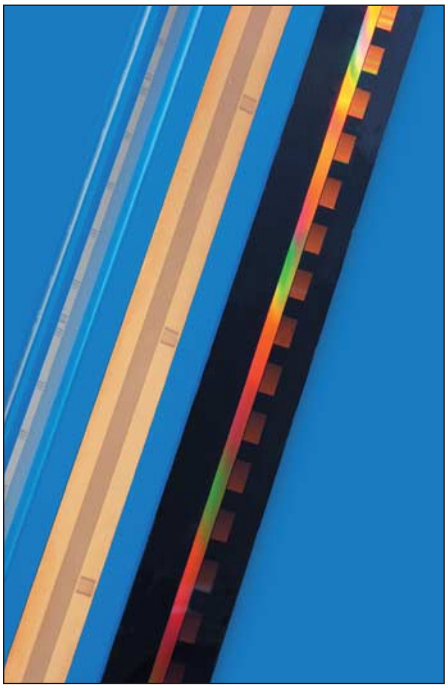
With the incremental measuring method, the graduation consists of a periodic grating structure. The position information is obtained **by counting** the individual increments (measuring steps) from some point of origin. Since an absolute reference is required to ascertain positions, the measuring standard 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 581C).

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

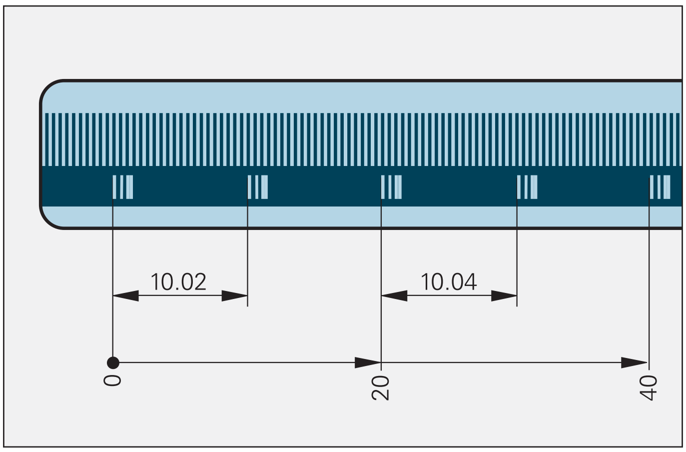
abs = Absolute value

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 5x1C as example)

	Signal period	Nominal increment N in signal periods	Maximum traverse
LIP 5x1C	4 µm	5000	20 mm

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.

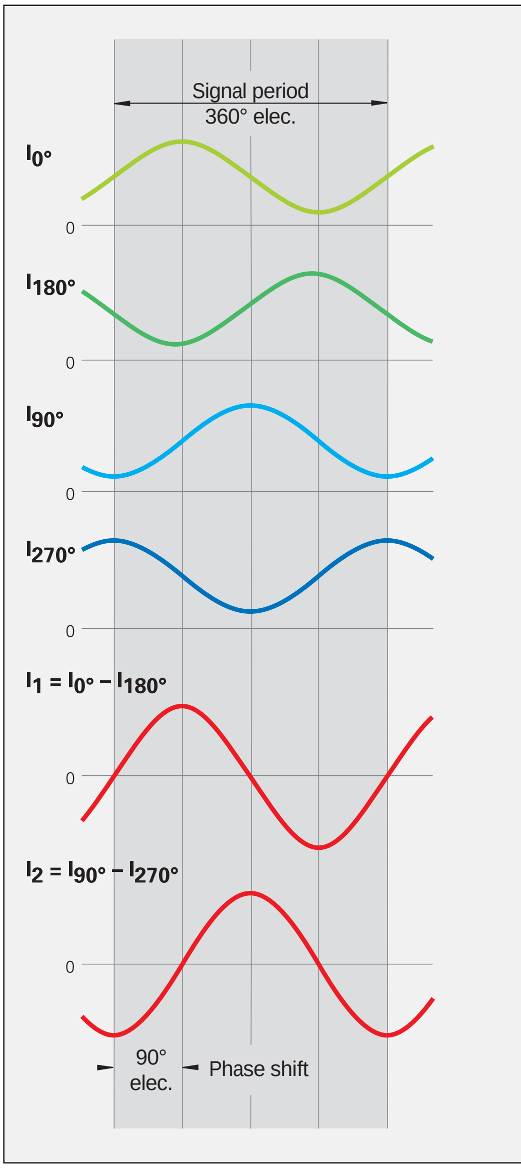
The finer the grating period of a measuring standard is, the greater the effect of diffraction on photoelectric scanning. HEIDENHAIN uses two scanning principles with linear encoders:

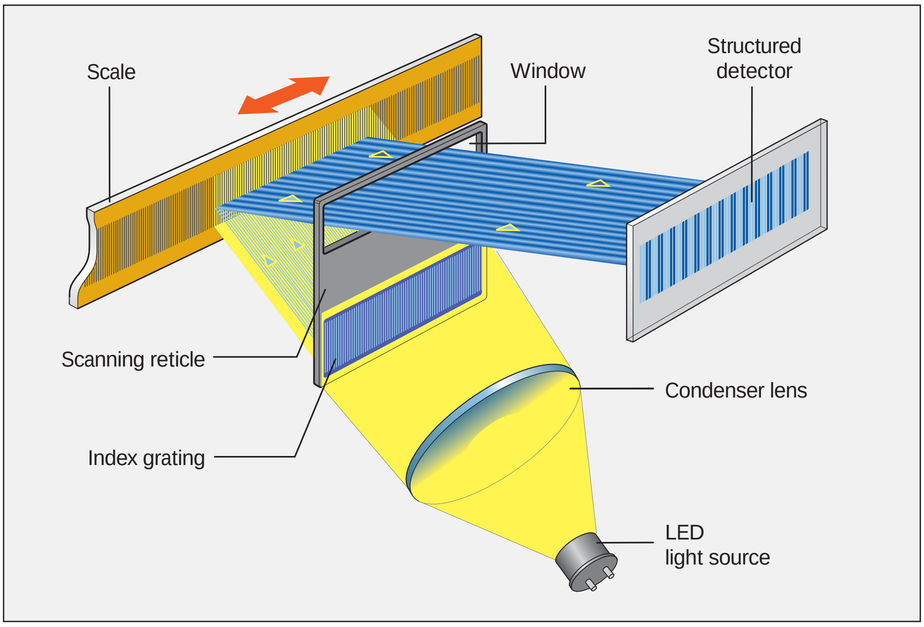
- The **imaging scanning principle** for grating periods from 10 µm to 200 µm.
- The **interferential scanning principle** for very fine graduations with grating periods of 4 µm and smaller.

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 current 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.

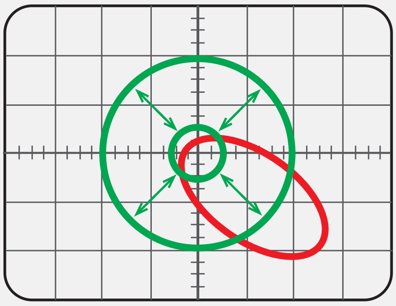




Photoelectric scanning in accordance with the imaging scanning principle with steel scale and single-field scanning (LIDA 400)

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 concentric inner 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.

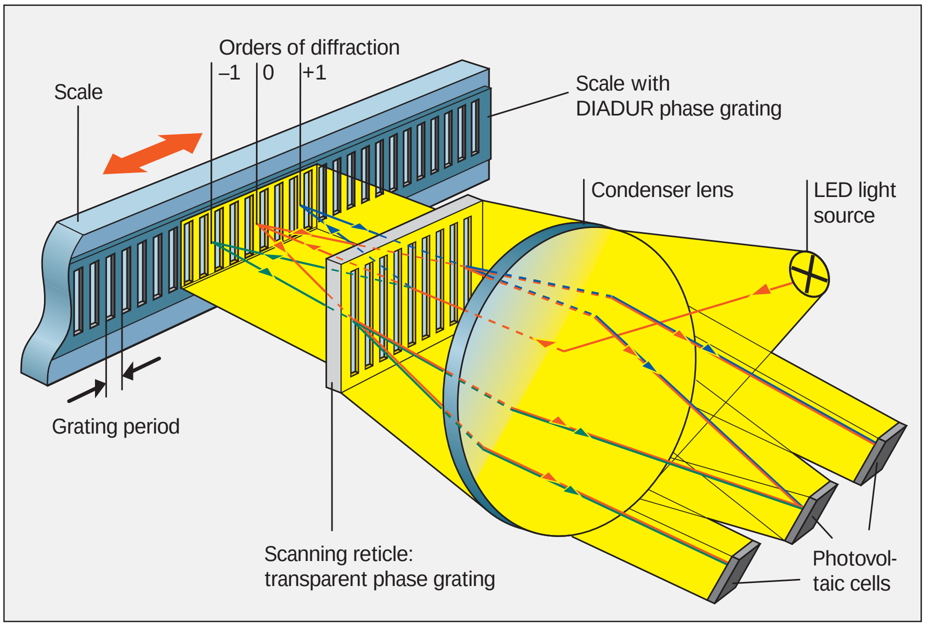
A step grating is used as the measuring standard: reflective lines 0.2 µm high are applied to a flat, reflective surface. In front of that is the scanning reticle—a transparent phase grating with the same grating period as the scale.

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

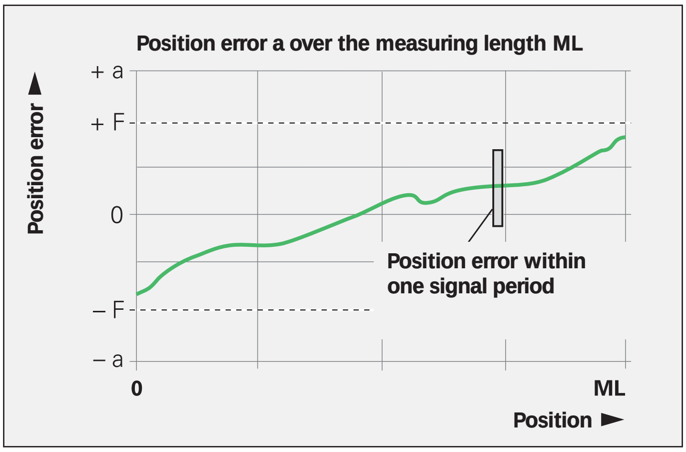
The accuracy of linear measurement is mainly determined by:
- the quality of the graduation
- the quality of the scanning process
- the quality of the signal processing electronics
- the error from the scale guideway relative to the scanning unit.

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:

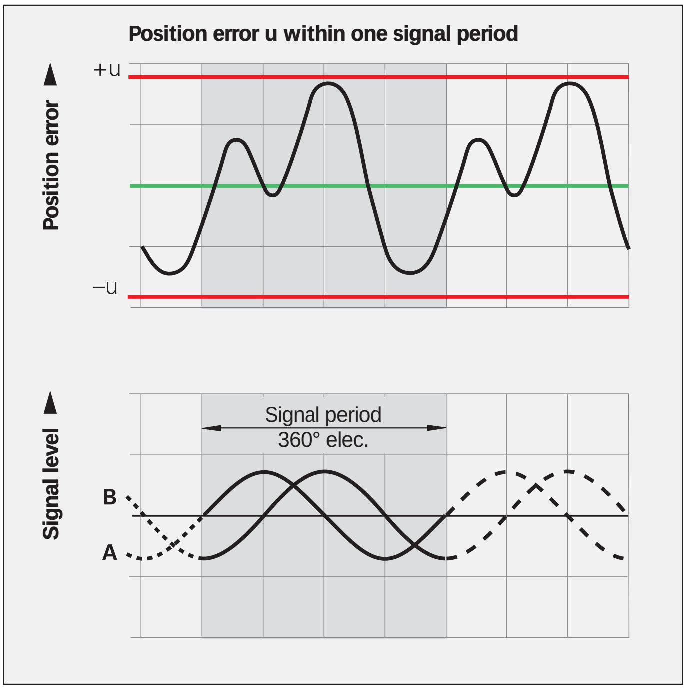
The extreme values of the total error F of a position lie—with reference to their mean value—over any max. one-meter section of the measuring length within the accuracy grade ±a.

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 does not exceed 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 4x1	2 µm	± 0.02 µm
LIP 5x1 **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 401 R * S.Nr. 19702302 * Id.Nr. 277376-U4

Hersteller-Prüfzertifikat
DIN 55 350-18-4.2.2

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

Kalibriernormale:	Kalibrierzeichen:
Jod-stabilisierter He-Ne Laser	3659 PTB 02
Wasser-Tripelpunktzelle	66 PTB 05
Gallium-Schmelzpunktzelle	67 PTB 05
Barometer	4945 DKD-K-02301 05-09
Luftfeuchtemessgerät	01758 DKD-K-00305 05-05

Relative Luftfeuchtigkeit: max. 50 %

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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 position 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	*3659 PTB 02*
Water triple point cell	*66 PTB 05*
Gallium melting point cell	*67 PTB 05*
Pressure gauge	*4945 DKD-K-02301 05-09*
Hygrometer	*01758 DKD-K-00305 05-05*

Relative humidity: max. 50 %

Prüfer/Inspected by
Flatscher / 02.02.2007

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: **210 mm**

Unsicherheit der Messung:
$U_{95\%}$ = 0,010 µm + 0,130 * 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:

$F = Pos_N – Pos_M$

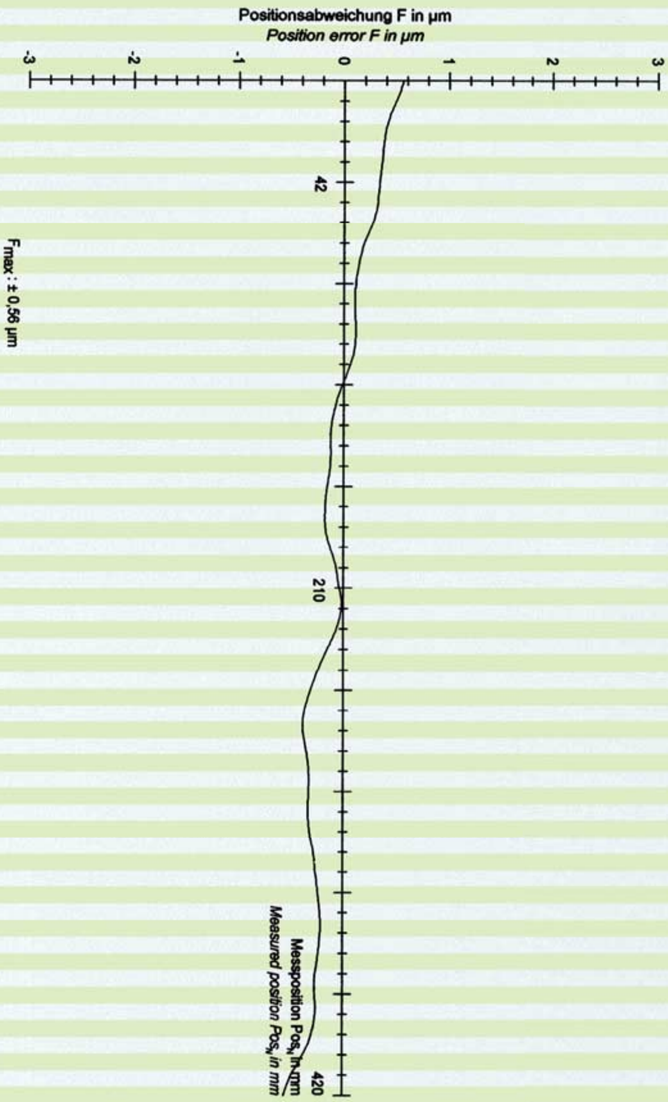
(Pos_N = measured position of the comparator standard,
Pos_M = measured position of the scale)

Measuring step: ***1000 µm***

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

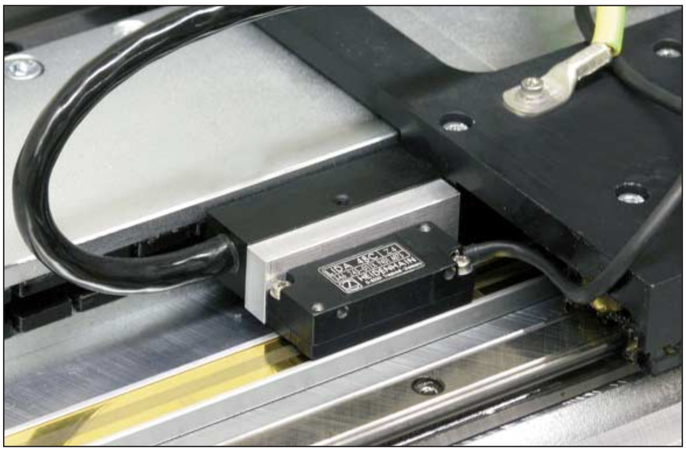
First reference pulse at measured position: ***210 mm***

Uncertainty of measurement:
$U_{95\%}$ = 0.010 µm + 0.130 * 10^{-6} * L
(L = measuring interval length)



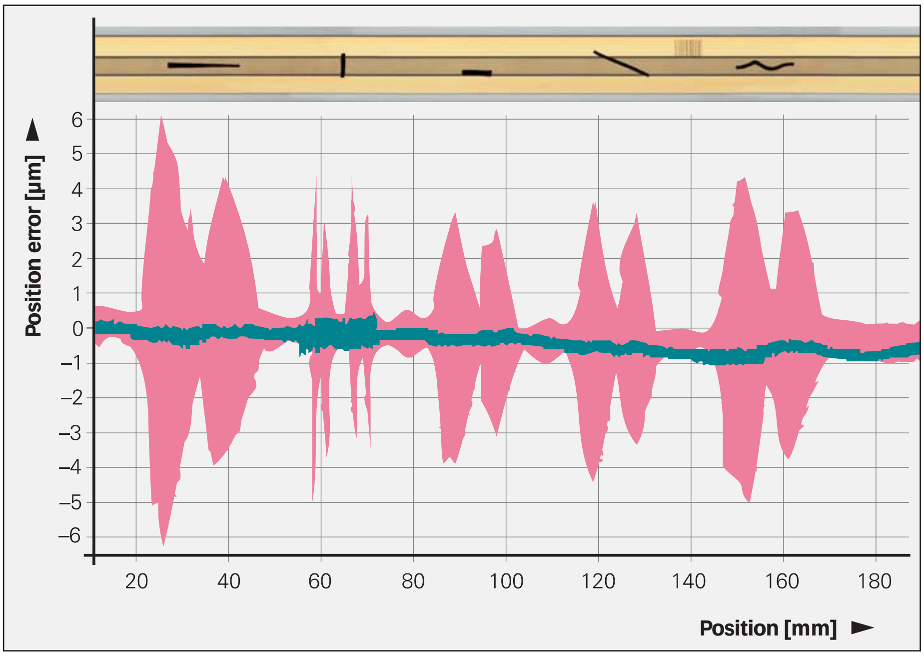
Reliability

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.

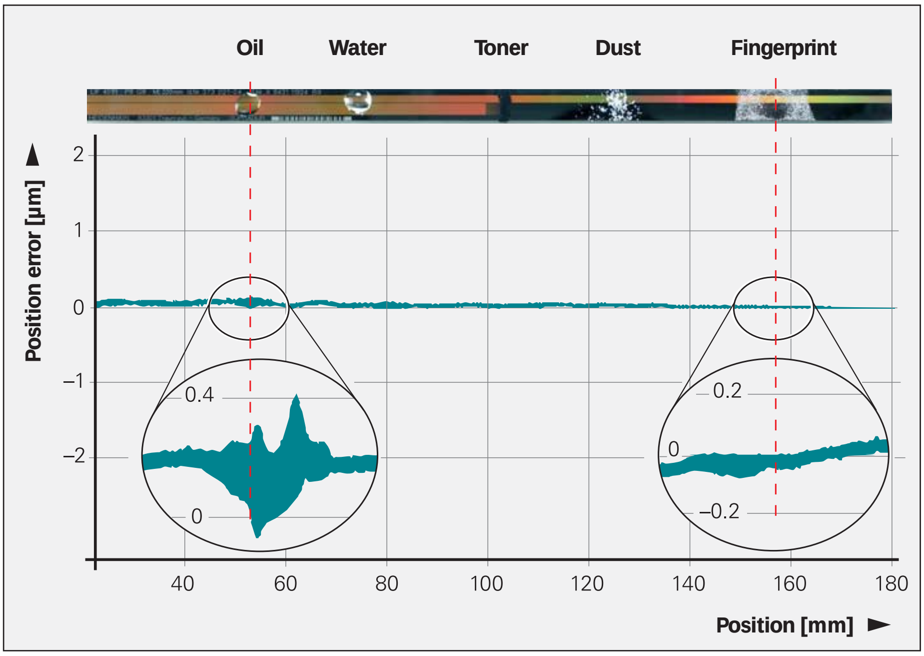


Lower sensitivity to contamination
Both the high quality of the grating and the scanning method are responsible for the accuracy and reliability of linear encoders. Exposed linear encoders from HEIDENHAIN operate with **single-field scanning.** Only one scanning field is used to generate the scanning 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 with contamination from printer's ink, PCB dust, water or oil with 3 mm 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.

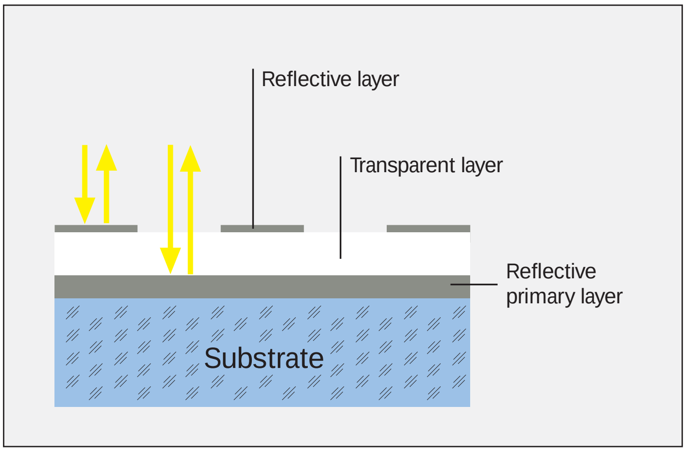
In the DIADUR process, hard chrome structures are applied to a glass or steel carrier.

In the 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 like absorbers. Measuring standards with 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.

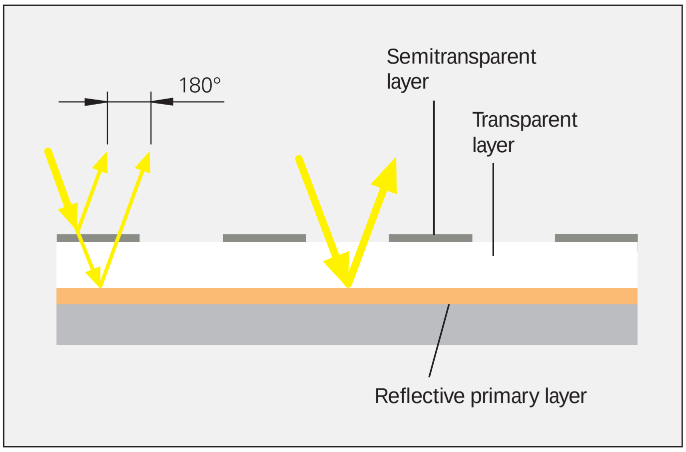
Application-oriented mounting tolerances
Very small signal periods usually come with very narrow mounting tolerances for the gap between the scanning head and scale tape. This is the result of diffraction caused by the grating structures. It can lead to a signal attenuation of 50% with a gap change of 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.

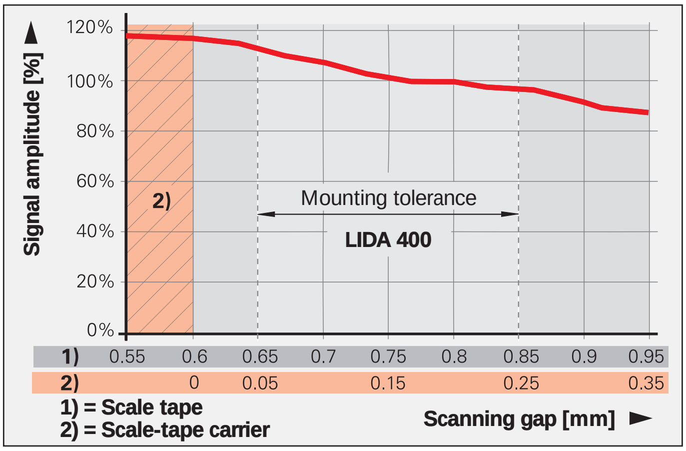
The mounting tolerances of exposed linear encoders from HEIDENHAIN have only a slight influence on the output signals. In particular the specified gap tolerance between the scale and scanning head (scanning gap) causes only negligible change in the signal amplitude. This behavior is substantially responsible 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.

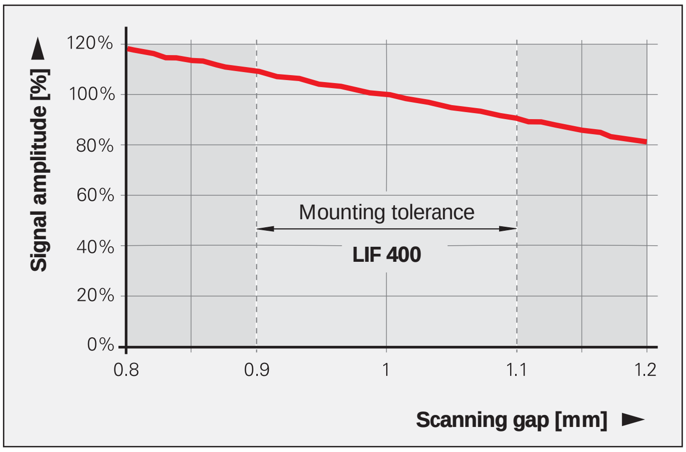
SUPRADUR



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 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.

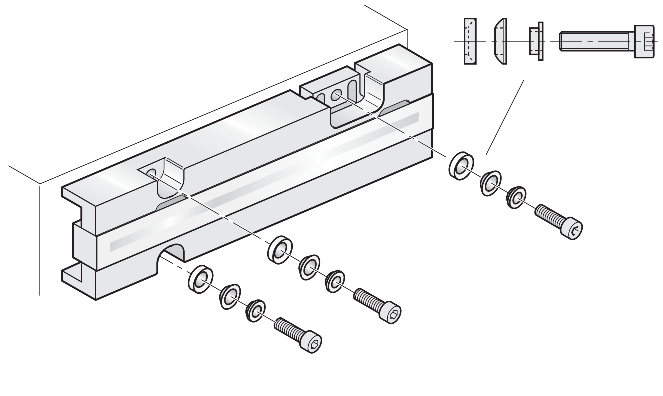
Accessory

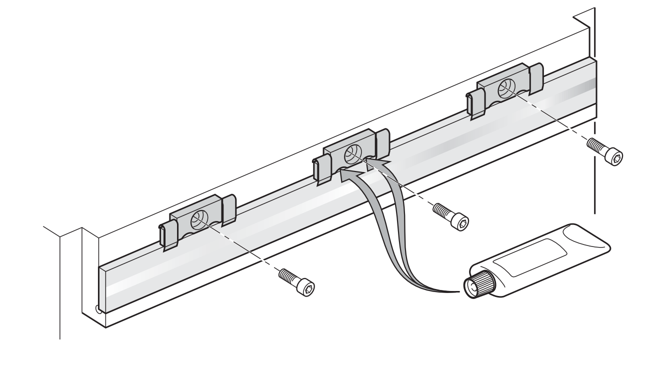
Fixing clamps	ID 270711-04
Silicone adhesive	ID 200417-02
Epoxy adhesive	ID 200409-01

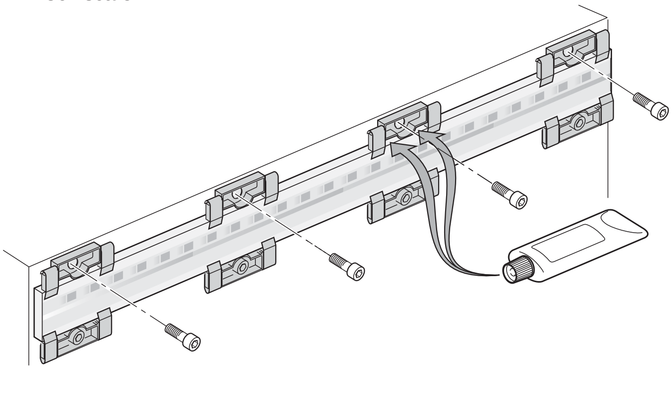
LIF 4x1
LIDA 4x3
The graduation carriers of glass are glued directly to the mounting surface with PRECIMET adhesive film, and pressure is evenly distributed with a roller.

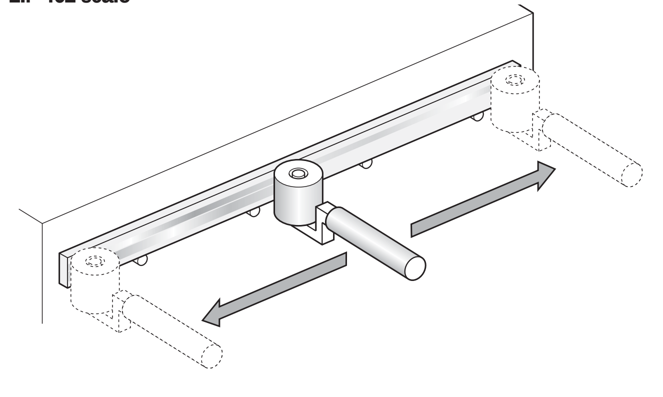
Accessory

Roller	ID 276885-01


LIP 302 scale


LIP 401 scale


LIP 501 scale


LIF 401 scale

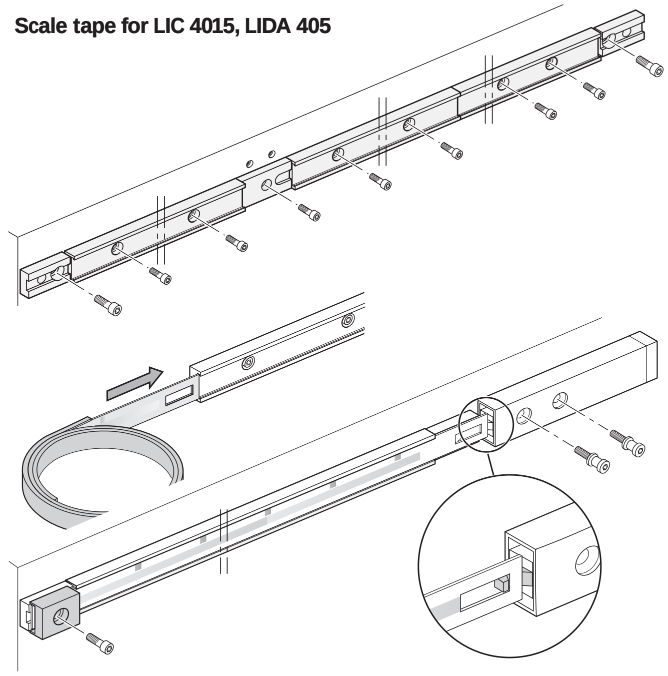
LIC 4015
LIDA 4x5
Linear encoders of the LIC 4015 and LIDA 4x5 series are specially designed for large measuring lengths. They are mounted with scale carrier sections screwed onto the mounting surface or with PRECIMET adhesive film. Then the one-piece steel scale-tape is pulled into the carrier, **tensioned 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.

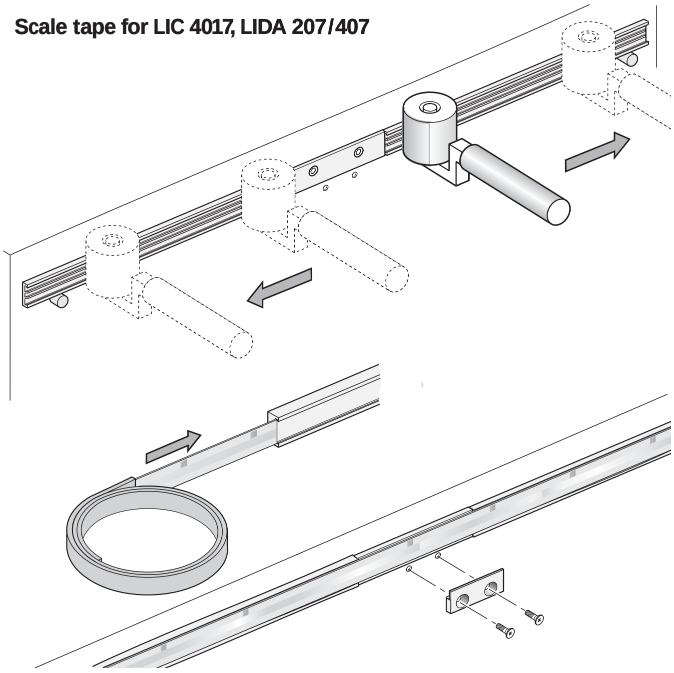
Accessory for LIC 4017, LIDA 4x7
Mounting aid ID 373990-01

Mounting aid (for LIC 4017, LIDA 4x7)

Scale tape for LIC 4015, LIDA 405



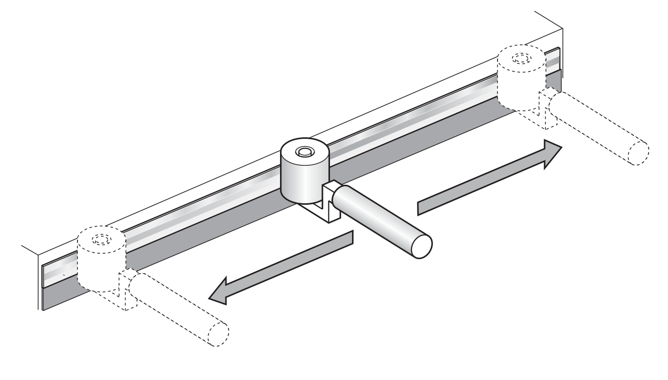
Scale tape for LIC 4017, LIDA 207/407



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.

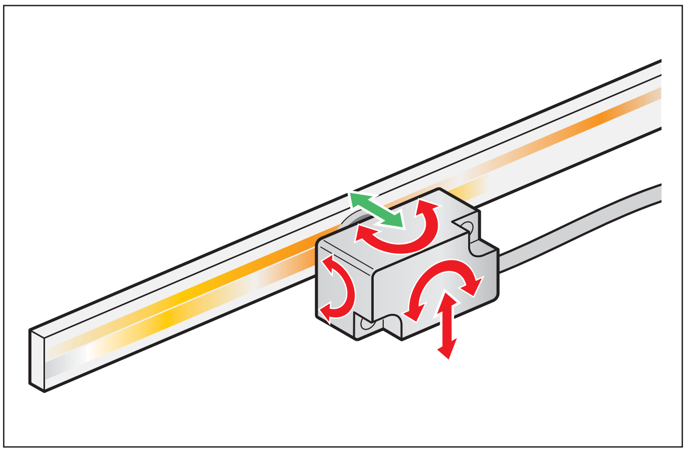
Mounting of LIP/LIF
The scanning head features a centering collar that allows it to be rotated in the location hole of the angle bracket and aligned parallel to the scale.

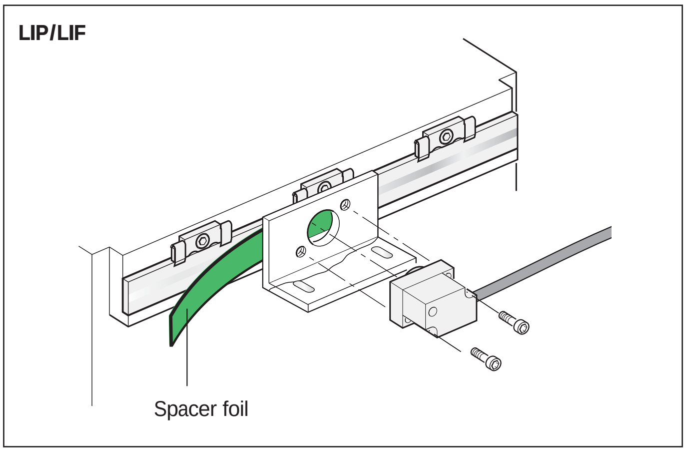
Mounting the LIC/LIDA
There are three options for mounting the scanning head (see Dimensions). A spacer foil makes it quite easy to set the gap between the scanning head and the scale or scale tape. It is helpful to fasten the scanning head from behind with a mounting bracket. The scanning head can be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

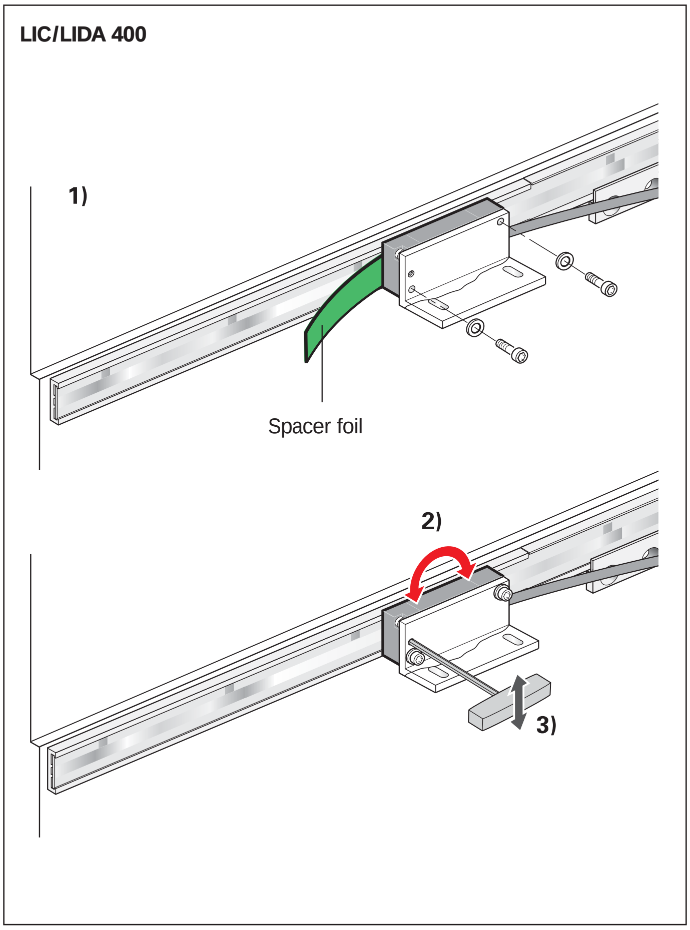
Adjustment
To simplify adjustment, HEIDENHAIN recommends the following procedure:

1) Set the scanning gap between the scale and scanning head using the spacer foil.
2) Adjust the incremental signals by rotating the scanning head.
3) Adjust the reference mark signal through further, slight rotation of the scanning head (a tool can be used for the LIDA 400).

As adjustment aids, HEIDENHAIN offers the PWM or PWT measuring and testing devices (see *HEIDENHAIN Measuring and Test 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 moving cables.

On encoders with integral bearing, other such components are the bearings, 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 the brochure apply to the specific encoder, not to the complete system. Any operation of the encoder outside of the specified range or for any other than the intended applications is at the user's own risk.

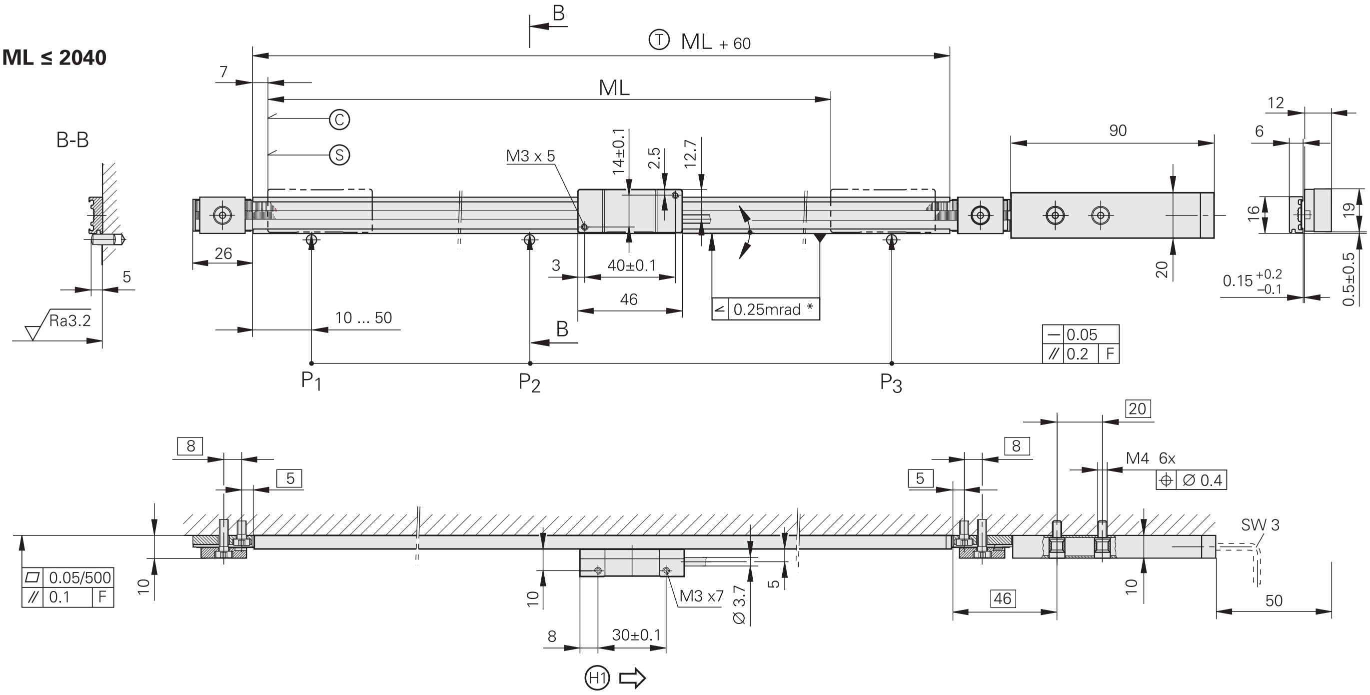
In safety-related systems, the higher-level system must verify the position value of the encoder after switch-on.

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.

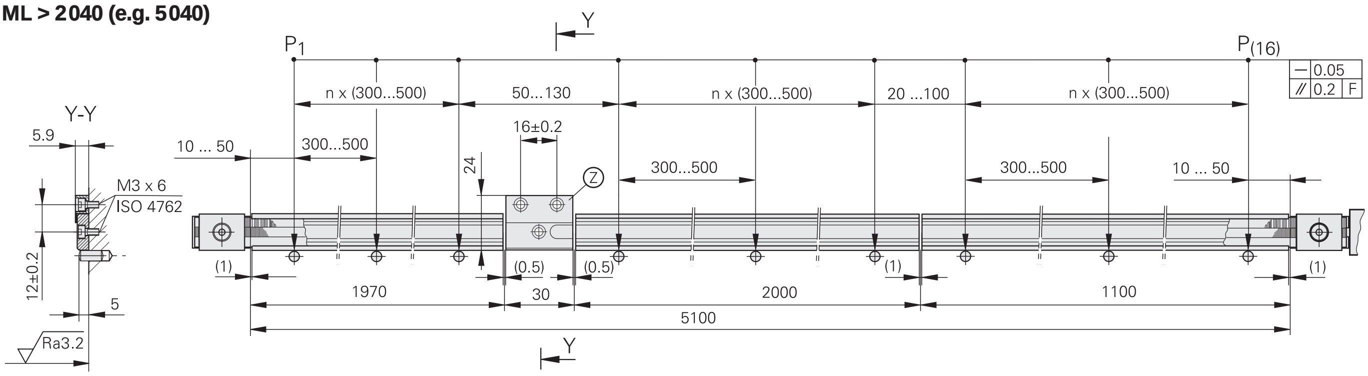
LIC 4015

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**

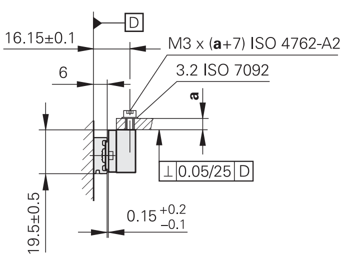
ML ≤ 2040

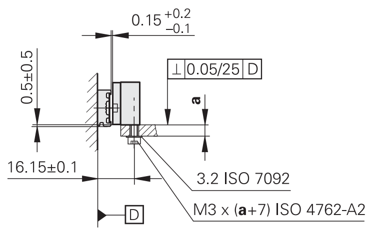


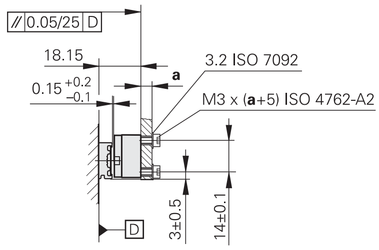
ML > 2040 (e.g. 5040)



Possibilities for mounting the scanning head







mm

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

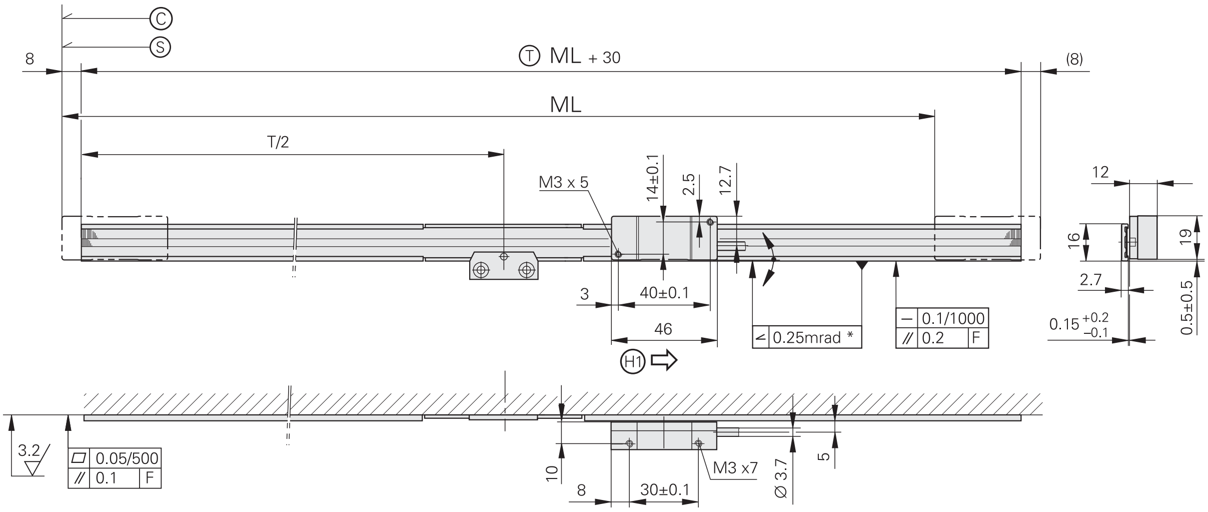
F = Machine guideway
P = Gauging points for alignment
* = Max. change during operation
Ⓢ = Beginning of measuring length (ML)
Ⓒ = Code start value: 100 mm
Ⓣ = Carrier length
Ⓩ = Spacer for measuring lengths from 3040 mm
Ⓗ1 = Direction of scanning unit motion for output signals in accordance with interface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

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

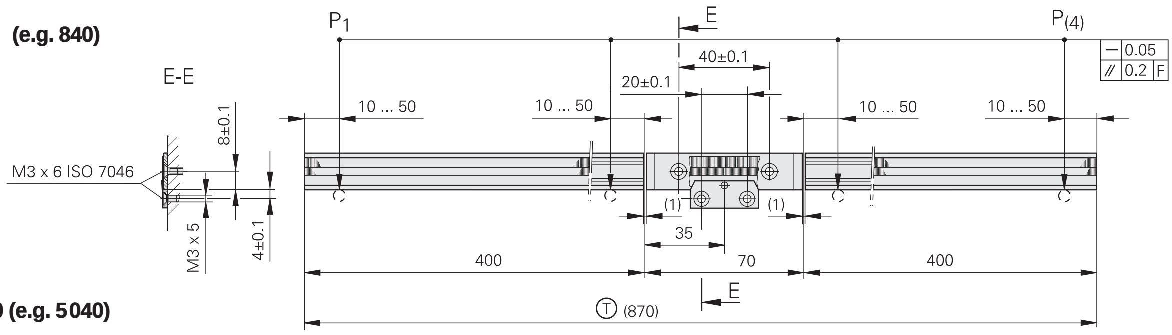
* Please select when ordering
[1] See *General Electrical Information*
[2] n = 1 for ML 3140 to 5040 mm; n =2 for ML 5140 to 7040 mm; etc.

LIC 4017

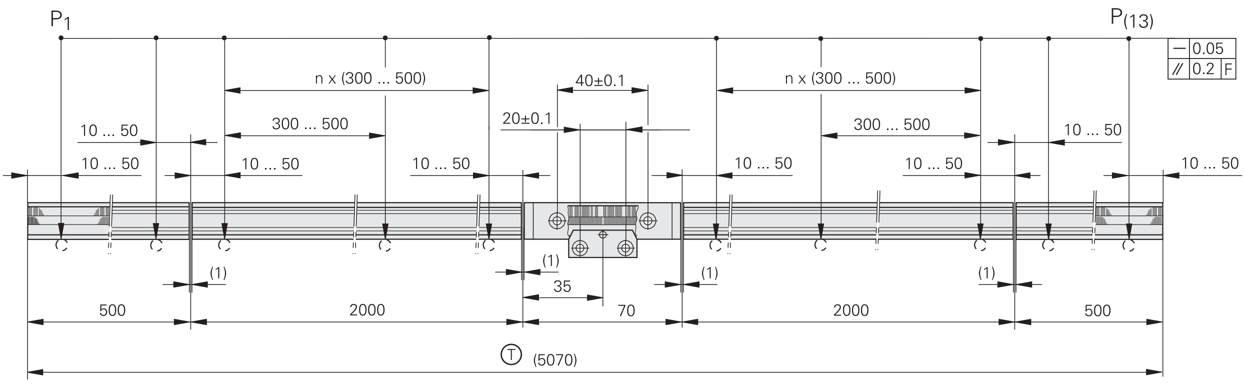
Absolute linear encoder for measuring lengths up to 6 m
- **For measuring steps to 0.001 µm (1 nm)**
- **Steel scale-tape is drawn into aluminum extrusions and fixed at center**



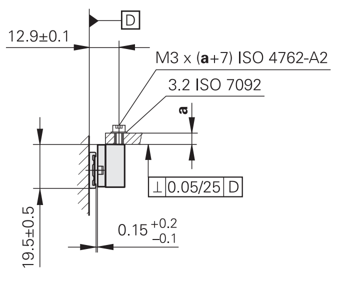
(e.g. 840)

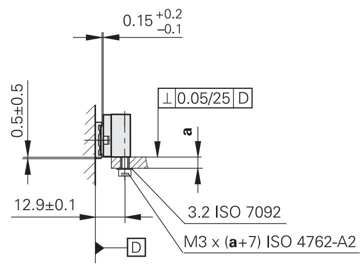


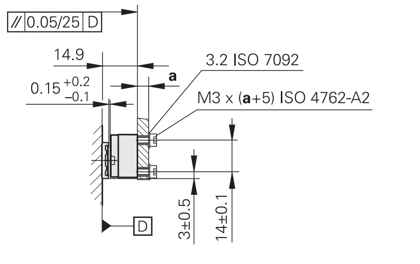
ML > 2040 (e.g. 5040)



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

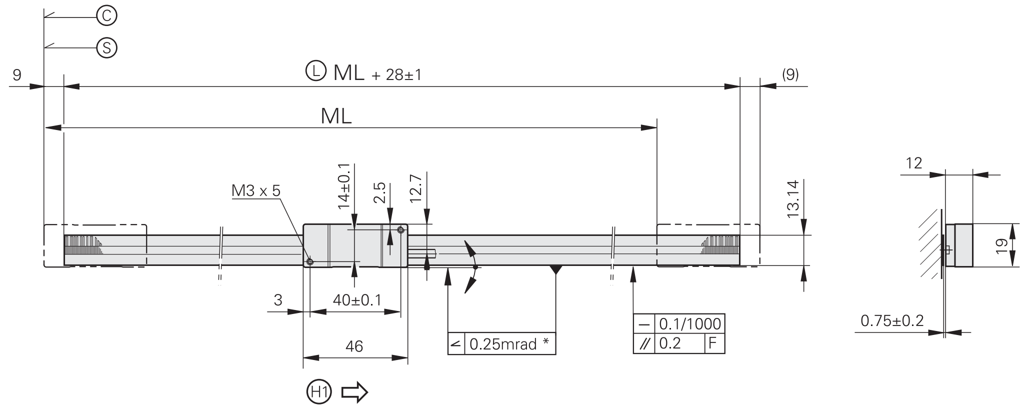
Ⓣ = Carrier length
Ⓩ = Spacer for measuring lengths from 3040
Ⓗ1 = Direction of scanning unit motion for output signals in accordance with interface description

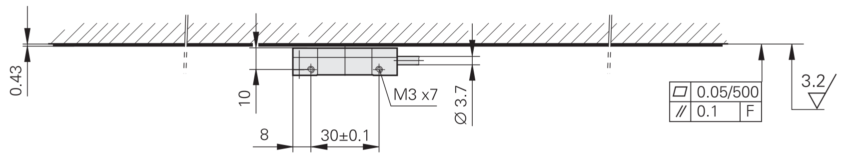
Specifications	LIC 4017
Measuring standard Coefficient of linear expansion	Steel scale tape with METALLUR absolute code track $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$
Accuracy grade	± 15 µm or ± 5 µm after linear length-error compensation in the evaluation electronics
Measuring length ML* in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

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

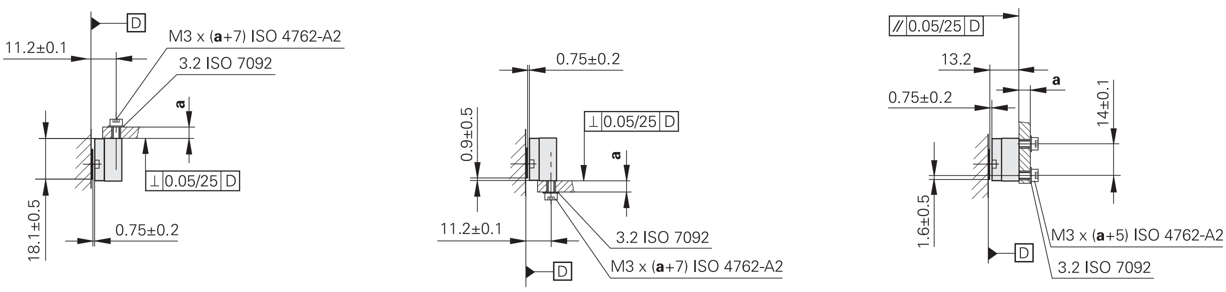
LIC 4019

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
Ⓒ = Code start value: 100 mm
Ⓢ = Beginning of measuring length (ML)
Ⓛ = Scale tape length
Ⓗ1 = Direction of scanning unit motion for output signals in accordance with interface description

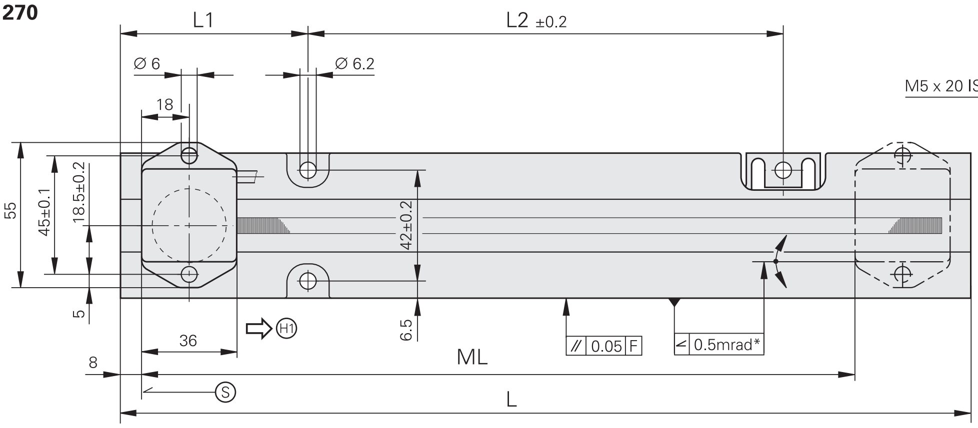
Specifications	LIC 4019
Measuring standard Coefficient of linear expansion	Steel scale tape with METALLUR absolute code track $\alpha_{therm} \approx 10 \cdot 10^{-6}$ K^{-1}
Accuracy grade	± 15 µm or ± 5 µm after linear length-error compensation in the subsequent electronics
Measuring length ML* in mm	70 120 170 220 270 320 370 420 520 620 720 820 920 1020
Absolute position values	EnDat 2.2
Ordering designation	EnDat 22
Resolution	0.001 µm (1 nm)
Calculation time t_{cal}	≤ 6 µs
Power supply	DC 3.6 to 14 V
Power consumption[1)] (max.)	*At 14 V:* ≤ 1000 mW *At 3.6 V:* ≤ 800 mW
Current consumption (typical)	*At 5 V:* 110 mA
Electrical connection* Cable length	Cable 1 m or 3 m with 8-pin M12 connector (male) ≤ 50 m (with HEIDENHAIN cable)
Traversing speed	≤ 480 m/min
Vibration 55 to 2000 Hz **Shock** 6 ms	≤ 500 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)
Operating temperature	0 °C to 70 °C
Protection EN 60529	IP 40
Weight Scanning head Scale tape Connecting cable Coupling	16 g (without connecting cable) 31 g/m 20 g/m 32 g

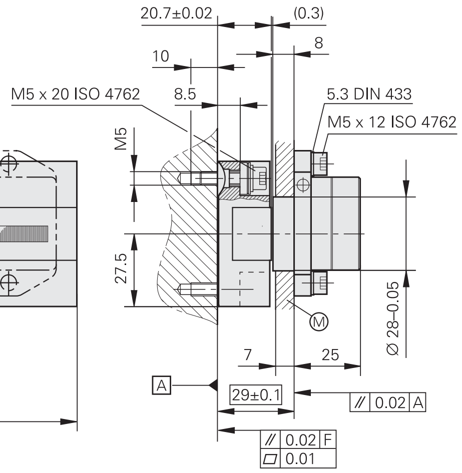
***** Please select when ordering
1) See *General Electrical Information*

LIP 372, LIP 382

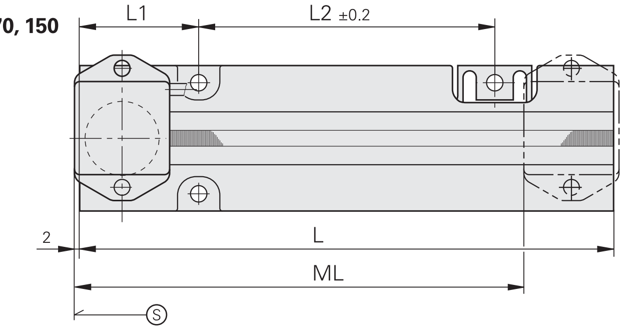
Incremental linear encoders with very high accuracy
- **Measuring steps to 0.001 µm (1 nm)**
- **Measuring standard is fastened by screws**

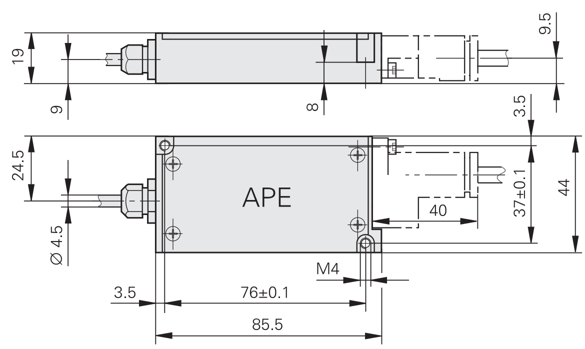
ML 270



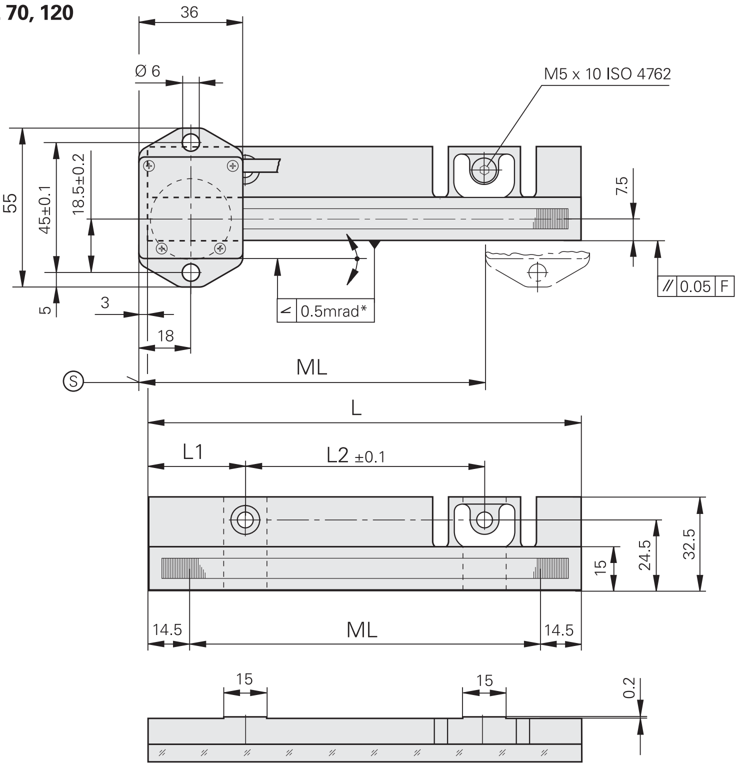


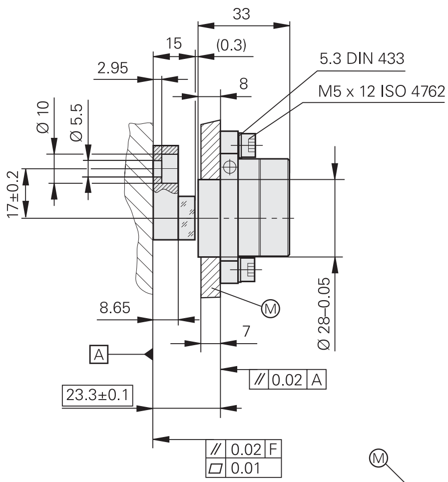
ML 220, 170, 150

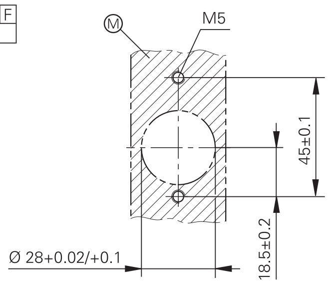




ML 70, 120





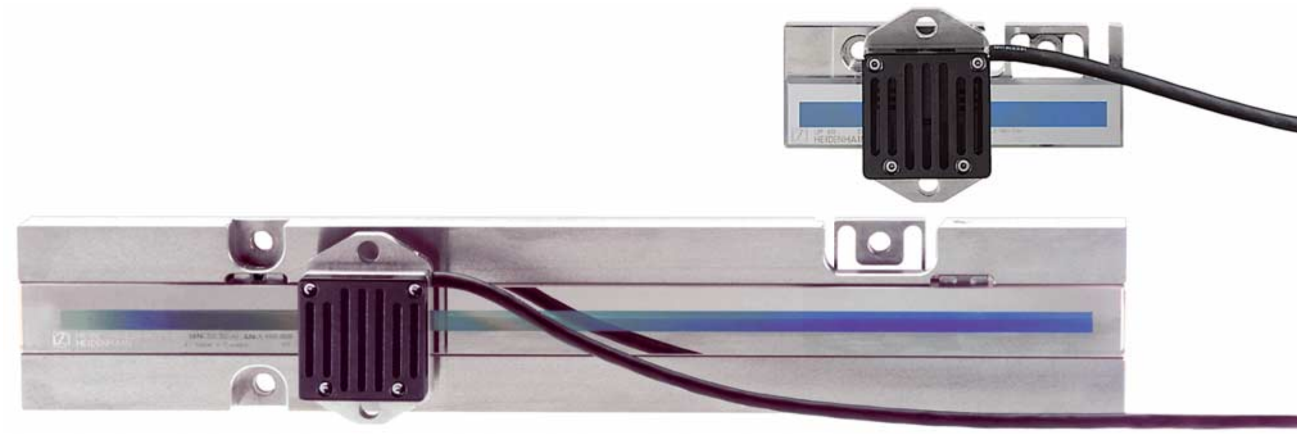


mm

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

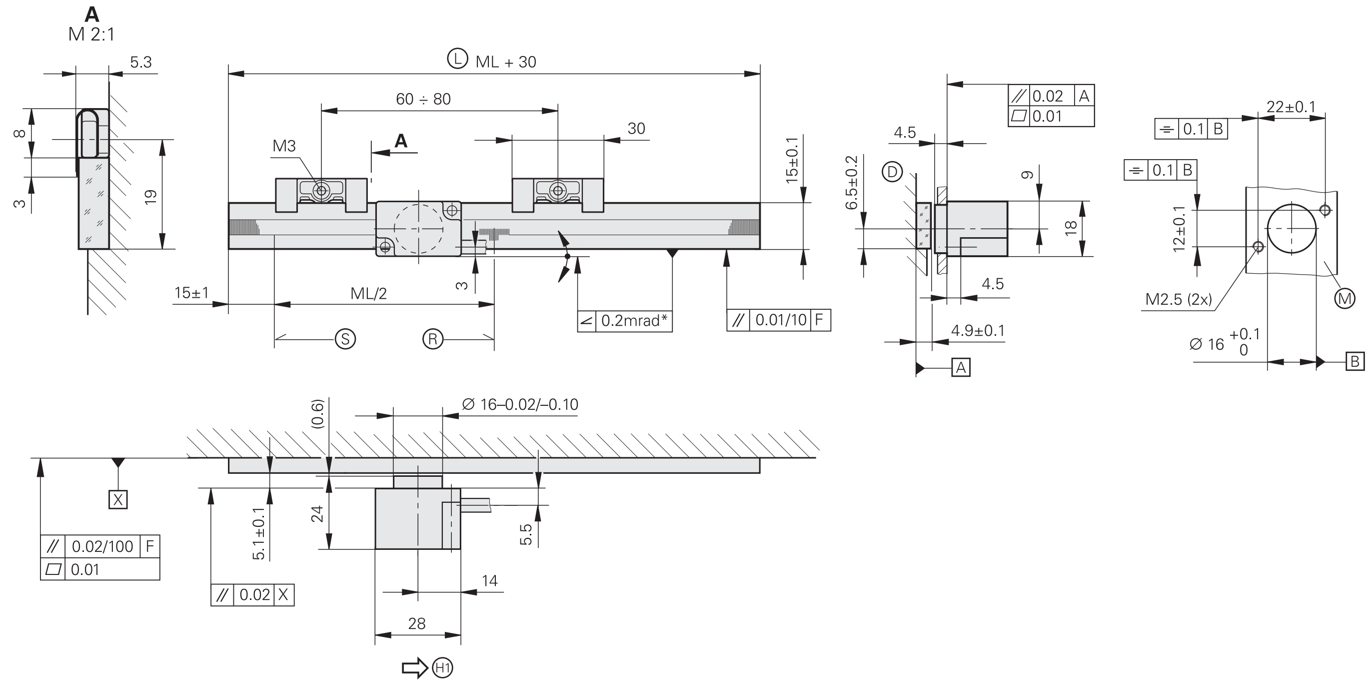
* Please select when ordering

LIP 471, LIP 481

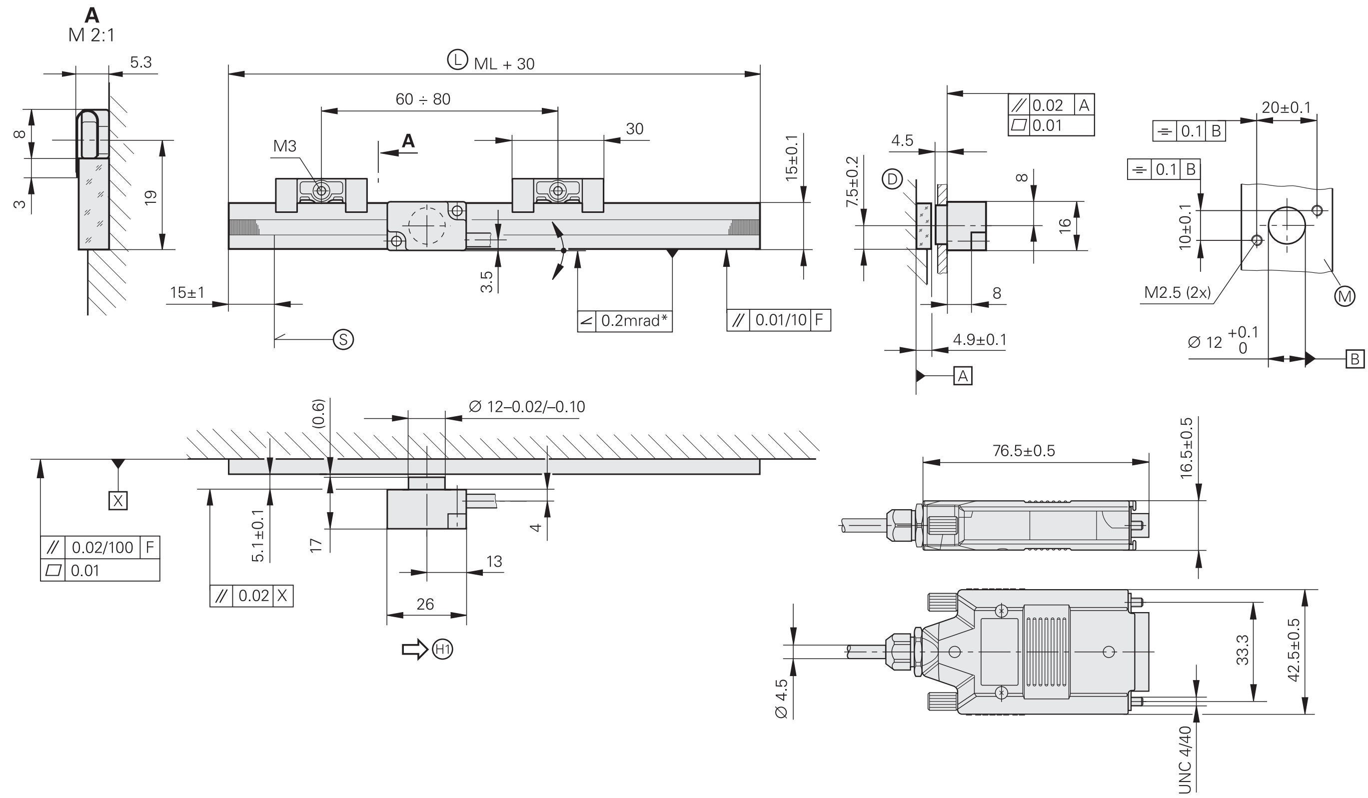
Incremental linear encoders with very high accuracy

- **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
Ⓛ	=	Scale length
Ⓓ	=	Shown without fixing clamps
Ⓢ	=	Beginning of measuring length (ML)
Ⓡ	=	Reference-mark position on LIP 4x1 R
Ⓜ	=	Mounting surface for scanning head
Ⓗ1	=	Direction of scanning unit motion for output signals in accordance with interface description

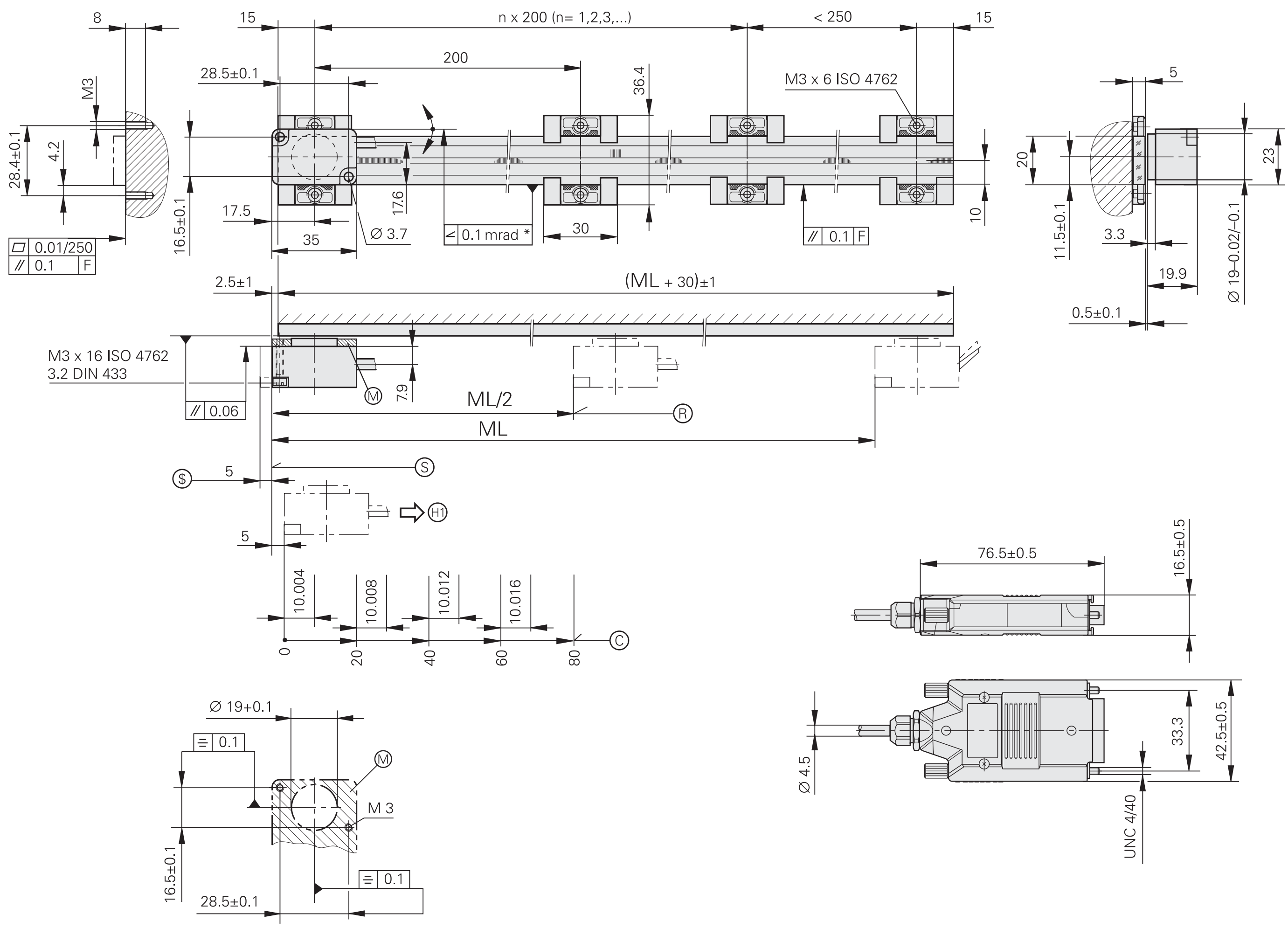
Specifications	LIP 481	LIP 471					
Measuring standard* Coefficient of linear expansion	DIADUR phase grating on Zerodur glass ceramic or glass $\alpha_{therm} \approx (0 \pm 0.1) \cdot 10^{-6}\ K^{-1}$ (Zerodur glass ceramic) $\alpha_{therm} \approx 8 \cdot 10^{-6}\ K^{-1}$ (glass)						
Accuracy grade*	± 1 µm, ± 0.5 µm (higher accuracy grades on request)						
Measuring length ML* in mm	70 120 170 220 270 320 370 420						
Reference marks* *LIP 4x1 R* *LIP 4x1 A*	One at midpoint of measuring length None						
Incremental signals	∿ 1 V_{PP}	⊓⊔TTL					
Grating period	4 µm						
Integrated interpolation* Signal period	– 2 µm	5-fold 0.4 µm			10-fold 0.2 µm		
Cutoff frequency –3dB	≥ 250 kHz	–					
Scanning frequency* Edge separation a	–	≤ 200 kHz ≥ 0.220 µs	≤ 100 kHz ≥ 0.465 µs	≤ 50 kHz ≥ 0.950 µs	≤ 100 kHz ≥ 0.220 µs	≤ 50 kHz ≥ 0.465 µs	≤ 25 kHz ≥ 0.950 µs
Traversing speed	≤ 30 m/min	≤ 24 m/min	≤ 12 m/min	≤ 6 m/min	≤ 12 m/min	≤ 6 m/min	≤ 3 m/min
Power supply Current consumption	DC 5 V ± 5% < 190 mA	DC 5 V ± 5% < 200 mA (without load)					
Electrical connection* Cable length	Cable 0.5 m, 1 m, 2 m or 3 m with D-sub connector (15-pin), interface electronics in the connector ≤ 30 m (with HEIDENHAIN cable)						
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 500 m/s^2 (EN 60068-2-27)						
Operating temperature	0 °C to 40 °C						
Weight Scanning head Scale Connecting cable Connector	*LIP 4x1 A:* 25 g, *LIP 4x1 R:* 50 g (each without cable) 5.6 g + 0.2 g/mm measuring length 38 g/m 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 5x1R
Ⓒ = Reference-mark position on LIP 5x1C
Ⓢ = 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

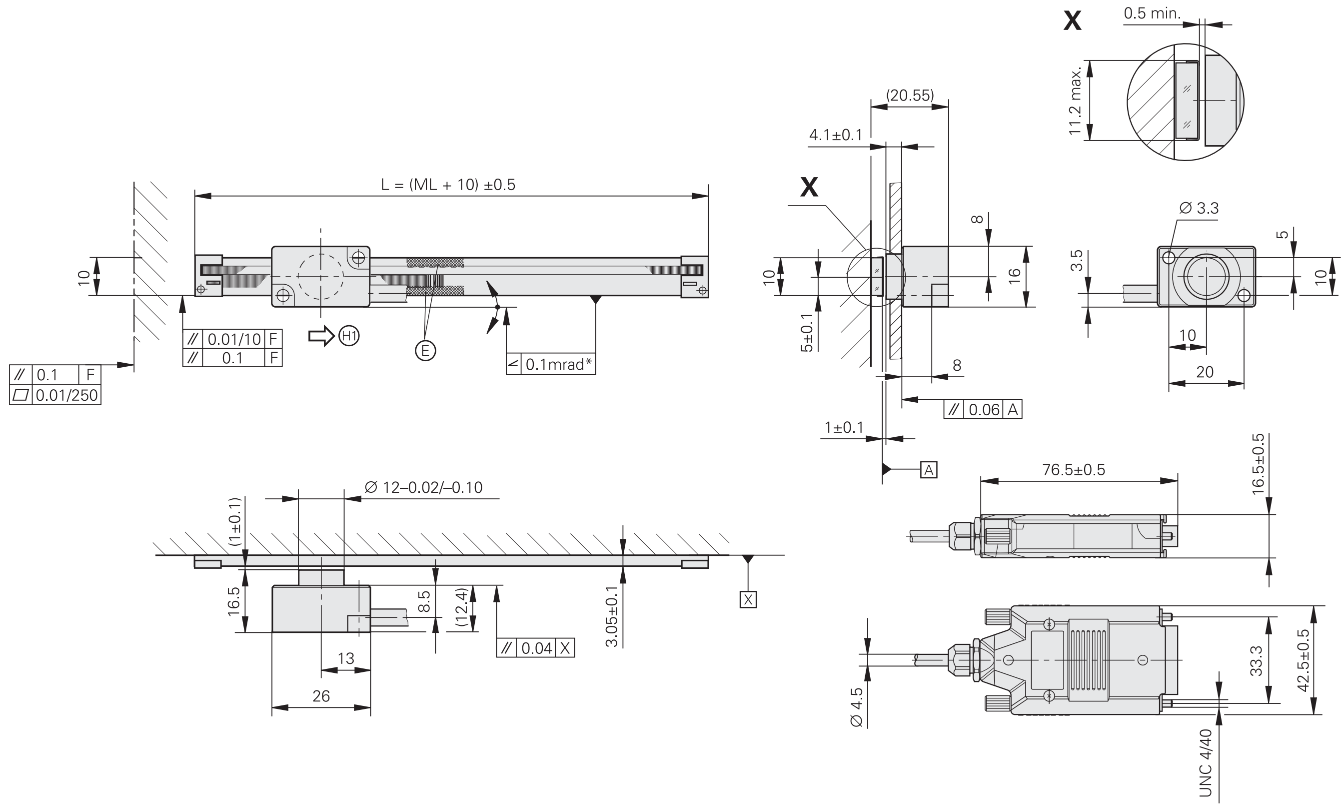
Specifications	LIP 581	LIP 571					
Measuring standard Coefficient of linear expansion	DIADUR phase grating on glass $\alpha_{therm} \approx 8 \cdot 10^{-6} K^{-1}$						
Accuracy grade*	± 1 µm						
Measuring length ML* in mm	70 120 170 220 270 320 370 420 470 520 570 620 670 720 770 820 870 920 970 1020 1240 1440						
Reference marks* *LIP 5x1 R* *LIP 5x1 C*	One at midpoint of measuring length Distance-coded						
Incremental signals	∼ 1 V_{PP}	⊓⊔ TTL					
Grating period	8 µm						
Integrated interpolation* Signal period	– 4 µm	5-fold 0.8 µm			10-fold 0.4 µm		
Cutoff frequency –3dB	≥ 300 kHz	–					
Scanning frequency* Edge separation a	–	≤ 200 kHz ≥ 0.220 µs	≤ 100 kHz ≥ 0.465 µs	≤ 50 kHz ≥ 0.950 µs	≤ 100 kHz ≥ 0.220 µs	≤ 50 kHz ≥ 0.465 µs	≤ 25 kHz ≥ 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 Current consumption	DC 5 V ± 5% < 175 mA	DC 5 V ± 5% < 175 mA (without load)					
Electrical connection* Cable length	Cable 0.5 m, 1 m, 2 m or 3 m with D-sub connector (15-pin), interface electronics in the connector ≤ 30 m (with HEIDENHAIN cable)						
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 500 m/s^2 (EN 60068-2-27)						
Operating temperature	0 °C to 50 °C						
Weight Scanning head Scale Connecting cable Connector	25 g (without connecting cable) 7.5 g + 0.25 g/mm measuring length 38 g/m 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
Ⓔ = Epoxy for ML < 170
Ⓗ1 = Direction of scanning unit motion for output signals in accordance with interface description

Specifications	**LIF 481**	**LIF 471**				
Measuring standard* Coefficient of linear expansion	SUPRADUR phase grating on Zerodur glass ceramic or glass $\alpha_{therm} \approx (0\pm0.1) \cdot 10^{-6}\ K^{-1}$ (Zerodur glass ceramic) $\alpha_{therm} \approx 8 \cdot 10^{-6}\ K^{-1}$ (glass)					
Accuracy grade	± 3 µm					
Measuring length ML* in mm	70 120 170 220 270 320 370 420 470 520 570 620 670 720 770 820 870 920 970 1020					
Reference marks	One at midpoint of measuring length					
Incremental signals	∿ 1 V_{PP}	⊓⊔ TTL				
Grating period	8 µm					
Integrated interpolation* Signal period	– 4 µm	5-fold 0.8 µm	10-fold 0.4 µm	20-fold 0.2 µm	50-fold 0.08 µm	100-fold 0.04 µm
Cutoff frequency –3dB –6dB	≥ 300 kHz ≥ 420 kHz	–				
Scanning frequency*	–	≤ 500 kHz ≤ 250 kHz ≤ 125 kHz	≤ 250 kHz ≤ 125 kHz ≤ 62.5 kHz	≤ 250 kHz ≤ 125 kHz ≤ 62.5 kHz	≤ 100 kHz ≤ 50 kHz ≤ 25 kHz	≤ 50 kHz ≤ 25 kHz ≤ 12.5 kHz
Edge separation a[1)]	–	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs	≥ 0.040 µs ≥ 0.080 µs ≥ 0.175 µs	≥ 0.040 µs ≥ 0.080 µs ≥ 0.175 µs	≥ 0.040 µs ≥ 0.080 µs ≥ 0.175 µs
Traversing speed[1)]	≤ 72 m/min ≤ 100 m/min	≤ 120 m/min ≤ 60 m/min ≤ 30 m/min	≤ 60 m/min ≤ 30 m/min ≤ 15 m/min	≤ 60 m/min ≤ 30 m/min ≤ 15 m/min	≤ 24 m/min ≤ 12 m/min ≤ 6 m/min	≤ 12 m/min ≤ 6 m/min ≤ 3 m/min
Position detection	Homing signal and limit signal, TTL output signals (without line driver)					
Power supply Current consumption	DC 5 V ± 5 % < 175 mA	DC 5 V ± 5 % < 180 mA (without load)				
Electrical connection* Cable length	Cable 0.5 m, 1 m, 2 m or 3 m with D-sub connector (15-pin), interface electronics in the connector *Incremental:* ≤ 30 m; *homing, limit:* ≤ 10 m; (with HEIDENHAIN cable)					
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 500 m/s^2 (EN 60068-2-27)					
Operating temperature	0 °C to 50 °C					
Weight Scanning head Scale Connecting cable Connector	*For scale of Zerodur glass ceramic:* 25 g *For scale of glass:* 9 g (each without cable) 0.8 g + 0.08 g/mm measuring length 38 g/m 140 g					

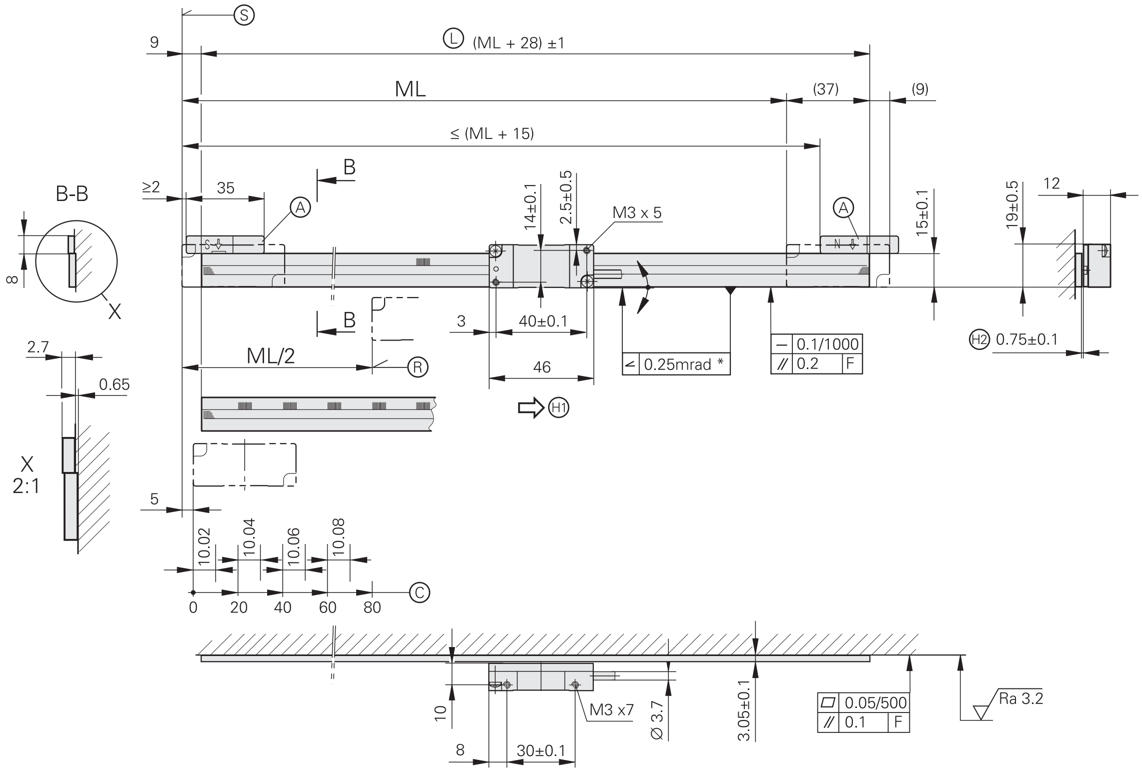
***** Please indicate when ordering

1) At the corresponding cutoff or scanning frequency

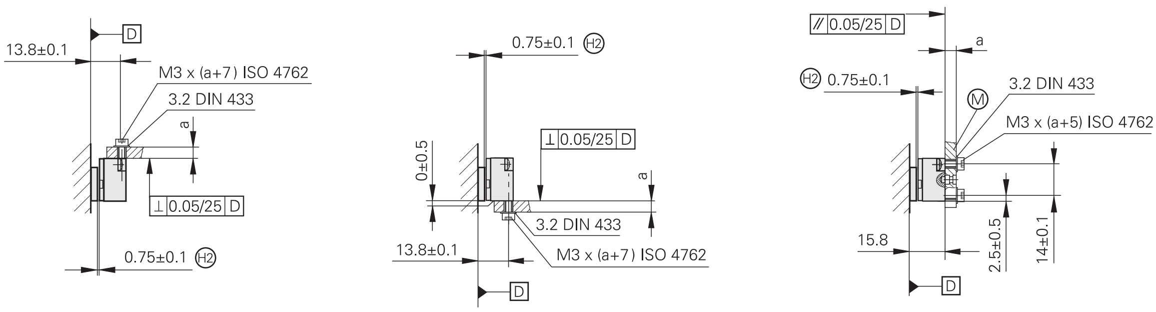
LIDA 473, LIDA 483

Incremental linear encoders with limit switches

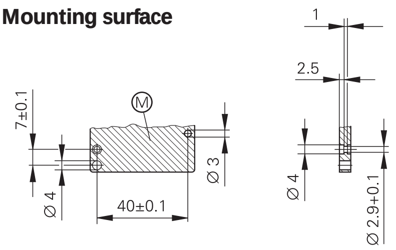
- **For measuring steps of 1 µm to 0.01 µm**
- **Measuring standard of glass or glass ceramic**
- **Glass scale fixed with adhesive film**



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

* Please indicate when ordering

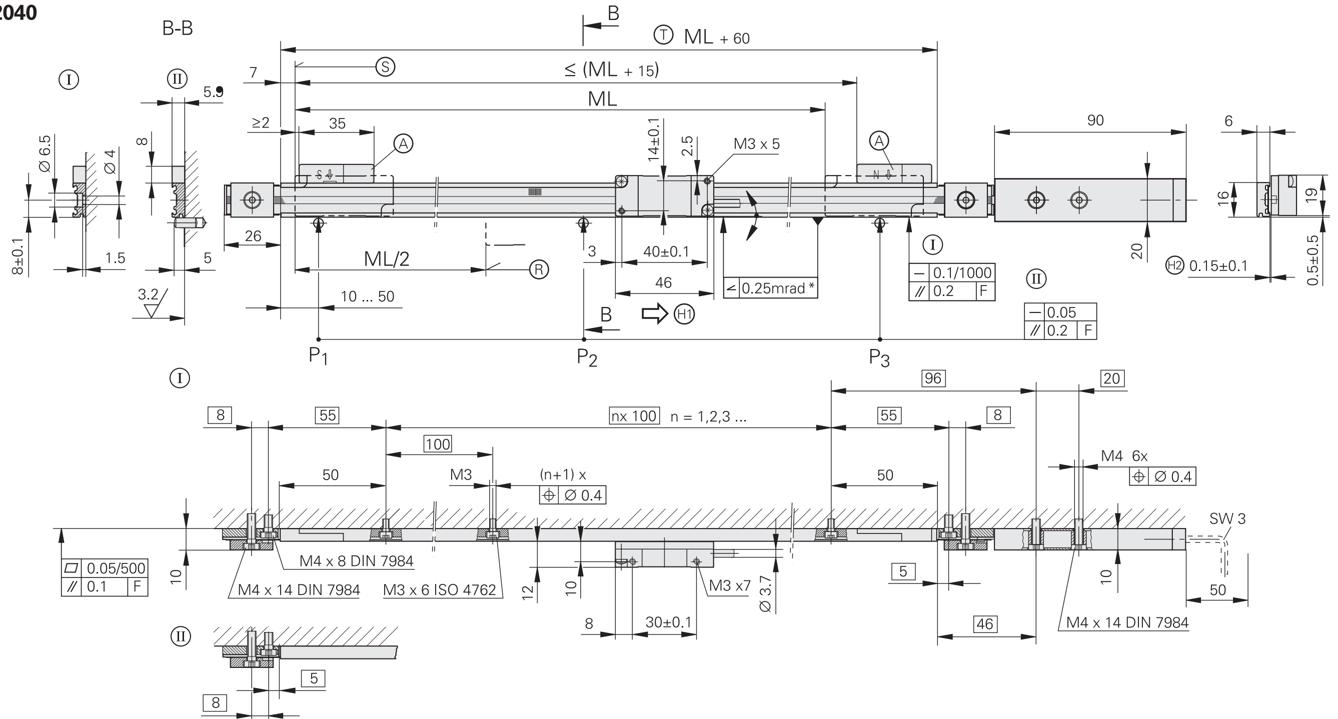
1) At the corresponding cutoff or scanning frequency

LIDA 475, LIDA 485

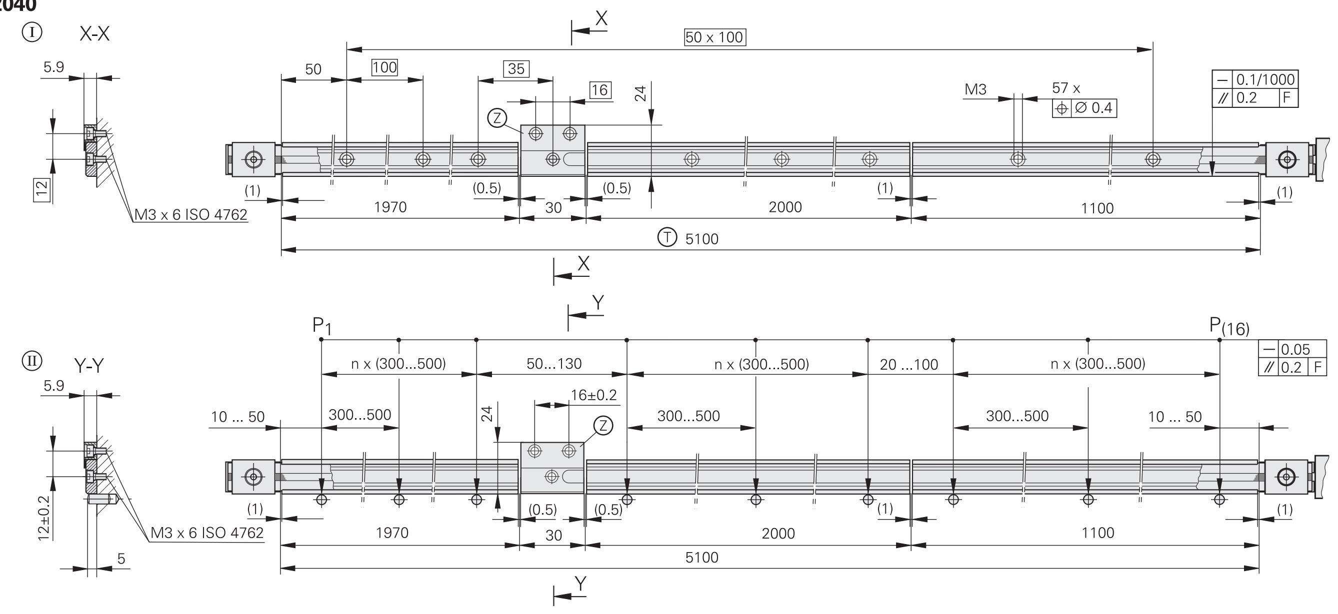
Incremental linear encoders for measuring lengths up to 30 m

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

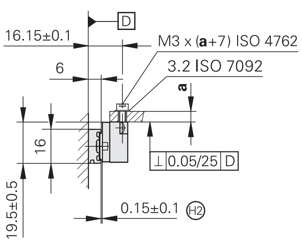
ML ≤ 2040

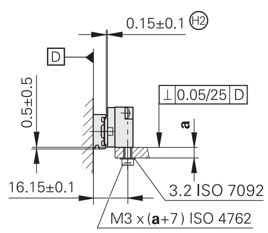


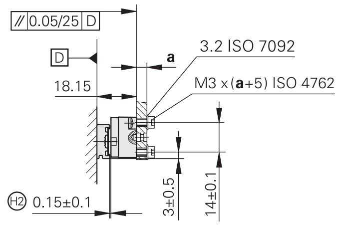
ML > 2040



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
Ⓘⓘ = Scale carrier sections fixed with PRECIMET glue
* = 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
H1 = Direction of scanning unit motion for output signals in accordance with interface description
H2 = Adjust or set

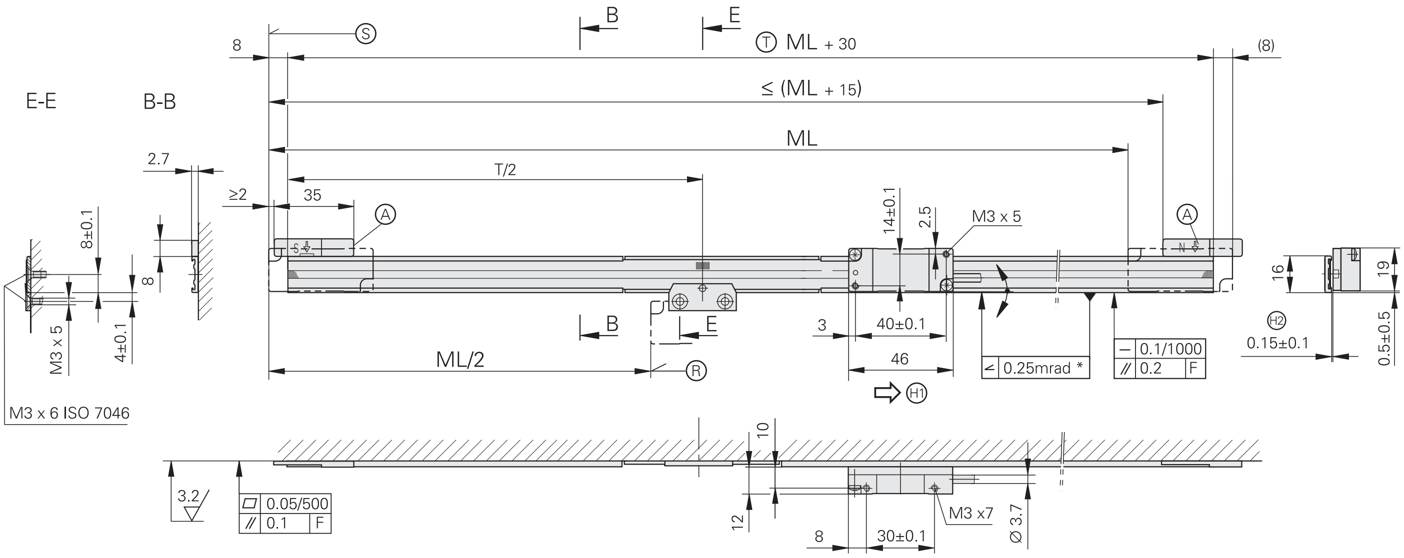
Specifications	LIDA 485	LIDA 475			
Measuring standard Coefficient of linear expansion	Steel scale tape with METALLUR graduation Depends on the mounting surface				
Accuracy grade	± 5 µm				
Measuring length ML* in mm	140 240 340 440 540 640 740 840 940 1040 1140 1240 1340 1440 1540 1640 1740 1840 1940 2040				
	Larger measuring lengths up to 30040 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* Signal period	– 20 µm	5-fold 4 µm	10-fold 2 µm	50-fold 0.4 µm	100-fold 0.2 µm
Cutoff frequency –3dB	≥ 400 kHz	–			
Scanning frequency*	–	≤ 400 kHz ≤ 200 kHz ≤ 100 kHz ≤ 50 kHz	≤ 200 kHz ≤ 100 kHz ≤ 50 kHz ≤ 25 kHz	≤ 50 kHz ≤ 25 kHz ≤ 12.5 kHz	≤ 25 kHz ≤ 12.5 kHz ≤ 6.25 kHz
Edge separation a[1)]	–	≥ 0.100 µs ≥ 0.220 µs ≥ 0.465 µs ≥ 0.950 µs	≥ 0.100 µs ≥ 0.220 µs ≥ 0.465 µs ≥ 0.950 µs	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs
Traversing speed[1)]	≤ 480 m/min	≤ 480 m/min ≤ 240 m/min ≤ 120 m/min ≤ 60 m/min	≤ 240 m/min ≤ 120 m/min ≤ 60 m/min ≤ 30 m/min	≤ 60 m/min ≤ 30 m/min ≤ 15 m/min	≤ 30 m/min ≤ 15 m/min ≤ 7.5 m/min
Limit switches	L1/L2 with two different magnets; *output signals:* TTL (without line driver)				
Power supply Current consumption	DC 5 V ± 5% < 100 mA	DC 5 V ± 5% < 170 mA (without load)		DC 5 V ± 5% < 255 mA (without load)	
Electrical connection Cable length	Cable 3 m with D-sub connector (15-pin), interface electronics for LIDA 475 in the connector ≤ 20 m (with HEIDENHAIN cable)				
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 500 m/s^2 (EN 60068-2-27)				
Operating temperature	0 °C to 50 °C				
Weight Scanning head Scale Connecting cable Connector	20 g (without connecting cable) 115 g + 0.25 g/mm measuring length 22 g/m *LIDA 485:* 32 g, *LIDA 475:* 140 g				

***** Please indicate when ordering

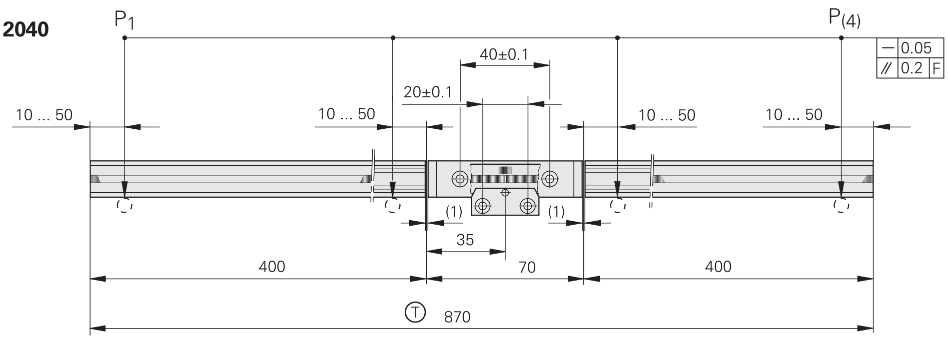
1) At the corresponding cutoff or scanning frequency

LIDA 477, LIDA 487

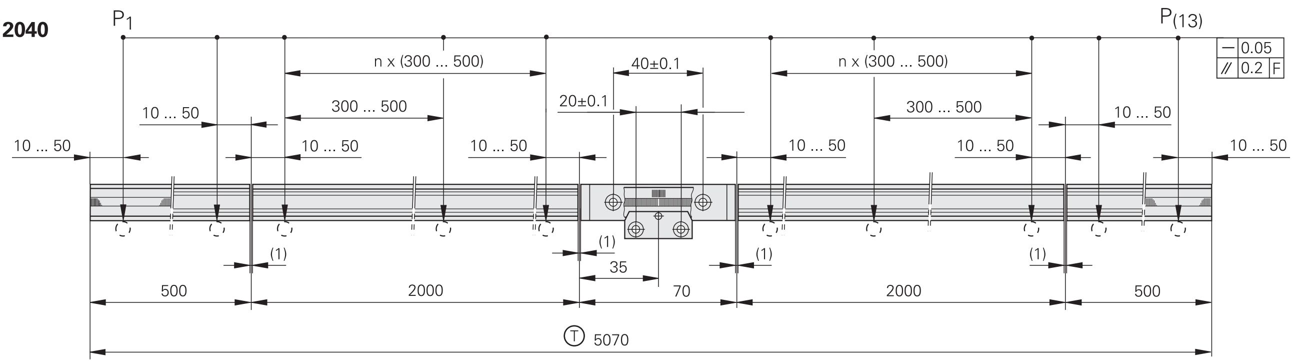
Incremental linear encoders for measuring ranges up to 6 m
- **For measuring steps of 1 µm to 0.05 µm**
- **Limit switches**
- **Steel scale-tape is drawn into adhesive aluminum extrusions and fixed at center**



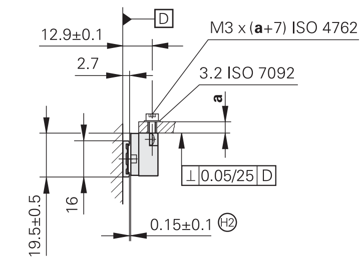
ML ≤ 2040

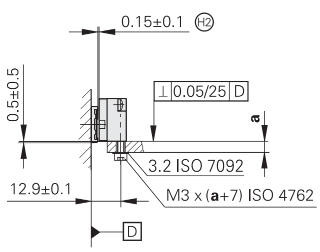


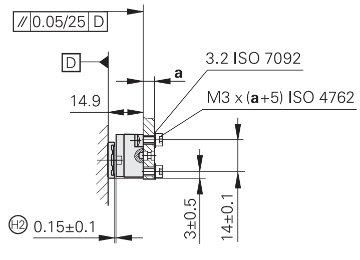
ML > 2040



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

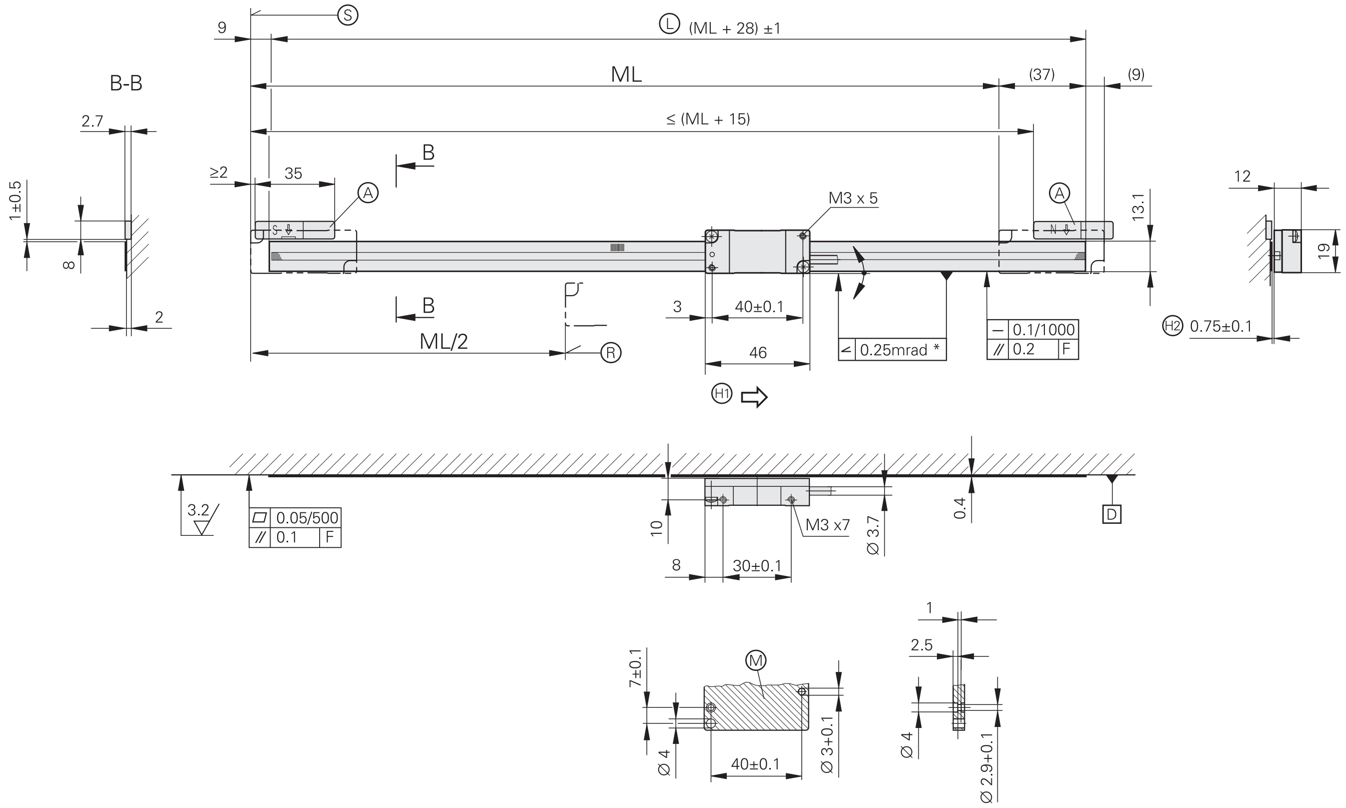
***** Please indicate when ordering

[1] At the corresponding cutoff or scanning frequency

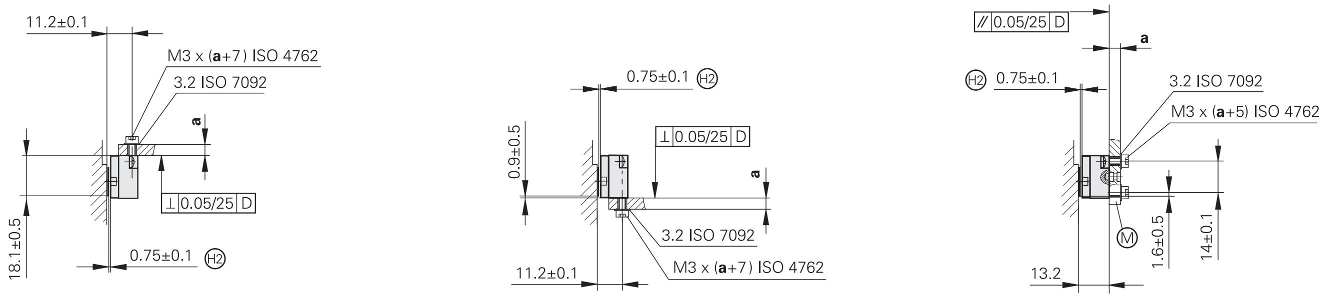
LIDA 479, LIDA 489

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 motion for output signals in accordance with interface description
H2 = Adjust or set

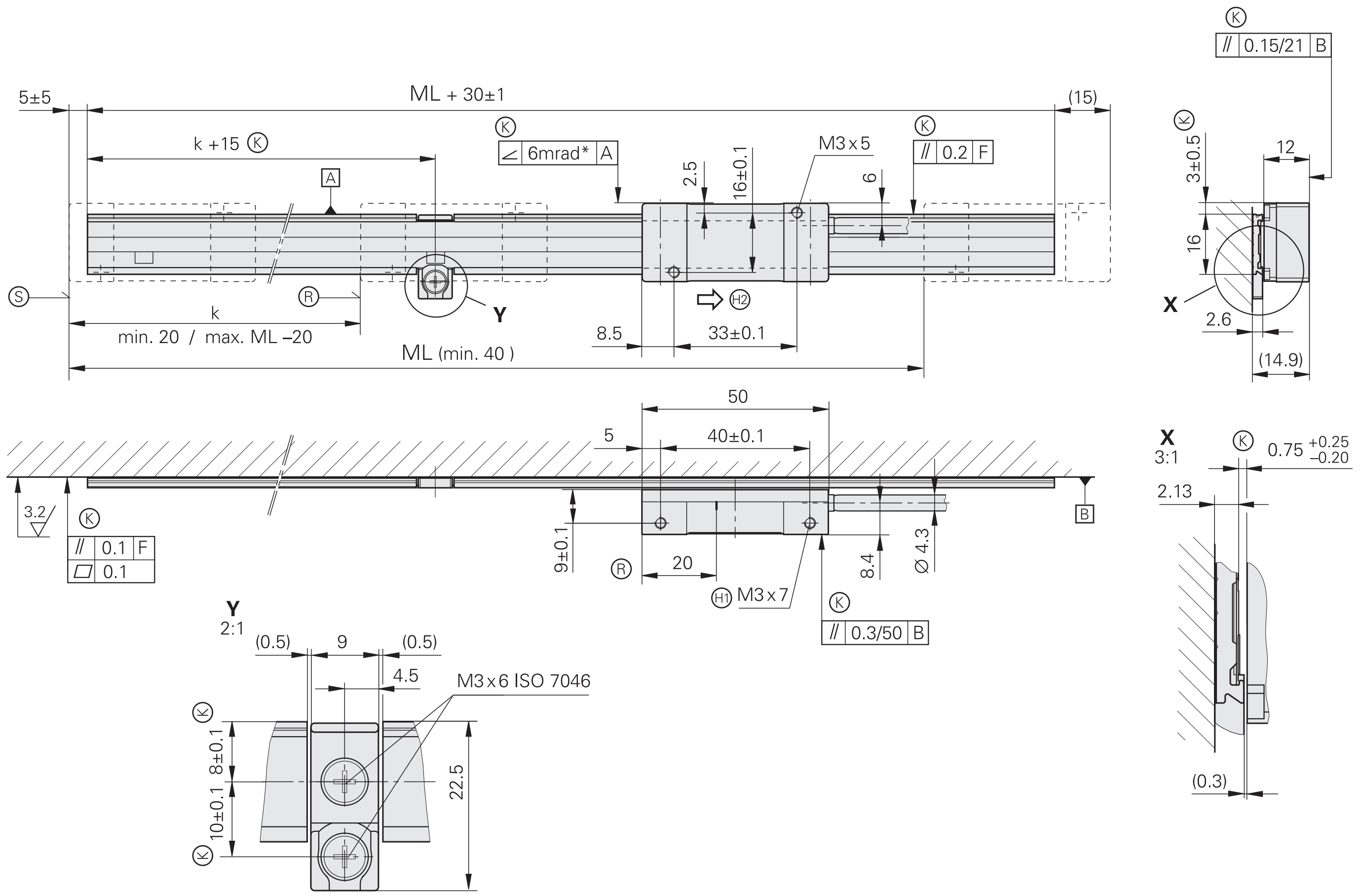
Specifications	LIDA 489	LIDA 479			
Measuring standard Coefficient of linear expansion	Steel scale-tape with METALLUR graduation $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$				
Accuracy grade	± 15 µm or ± 5 µm after linear length-error compensation in the subsequent electronics				
Measuring length ML* in mm	70 120 170 220 270 320 370 420 520 620 720 820 920 1020				
Reference marks	One at midpoint of measuring length				
Incremental signals	∿ 1 V_{PP}	⊓⊔ TTL			
Grating period	20 µm				
Integrated interpolation* Signal period	– 20 µm	5-fold 4 µm	10-fold 2 µm	50-fold 0.4 µm	100-fold 0.2 µm
Cutoff frequency –3dB	≥ 400 kHz	–			
Scanning frequency*	–	≤ 400 kHz ≤ 200 kHz ≤ 100 kHz ≤ 50 kHz	≤ 200 kHz ≤ 100 kHz ≤ 50 kHz ≤ 25 kHz	≤ 50 kHz ≤ 25 kHz ≤ 12.5 kHz	≤ 25 kHz ≤ 12.5 kHz ≤ 6.25 kHz
Edge separation a[1)]	–	≥ 0.100 µs ≥ 0.220 µs ≥ 0.465 µs ≥ 0.950 µs	≥ 0.100 µs ≥ 0.220 µs ≥ 0.465 µs ≥ 0.950 µs	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs
Traversing speed[1)]	≤ 480 m/min	≤ 480 m/min ≤ 240 m/min ≤ 120 m/min ≤ 60 m/min	≤ 240 m/min ≤ 120 m/min ≤ 60 m/min ≤ 30 m/min	≤ 60 m/min ≤ 30 m/min ≤ 15 m/min	≤ 30 m/min ≤ 15 m/min ≤ 7.5 m/min
Limit switches	L1/L2 with two different magnets; *output signals:* TTL (without line driver)				
Power supply Current consumption	DC 5 V ± 5 % < 100 mA	DC 5 V ± 5 % < 170 mA (without load)		DC 5 V ± 5 % < 255 mA (without load)	
Electrical connection Cable length	Cable 3 m with D-sub connector (15-pin), interface electronics for LIDA 479 in the connector ≤ 20 m (with HEIDENHAIN cable)				
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 200 m/s² (EN 60068-2-6) ≤ 500 m/s² (EN 60068-2-27)				
Operating temperature	0 °C to 50 °C				
Weight Scanning head Scale tape Connecting cable Connector	20 g (without connecting cable) 31 g/m 22 g/m *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	=	Adhesive tape
Ⓗ3	=	Steel scale tape
Ⓗ4	=	Direction of scanning unit motion for output signals in accordance with interface description

Reference mark:
k = Position of 1st reference mark from the beginning of the measuring length, depending on the cut
j = Additional reference marks every 100 mm

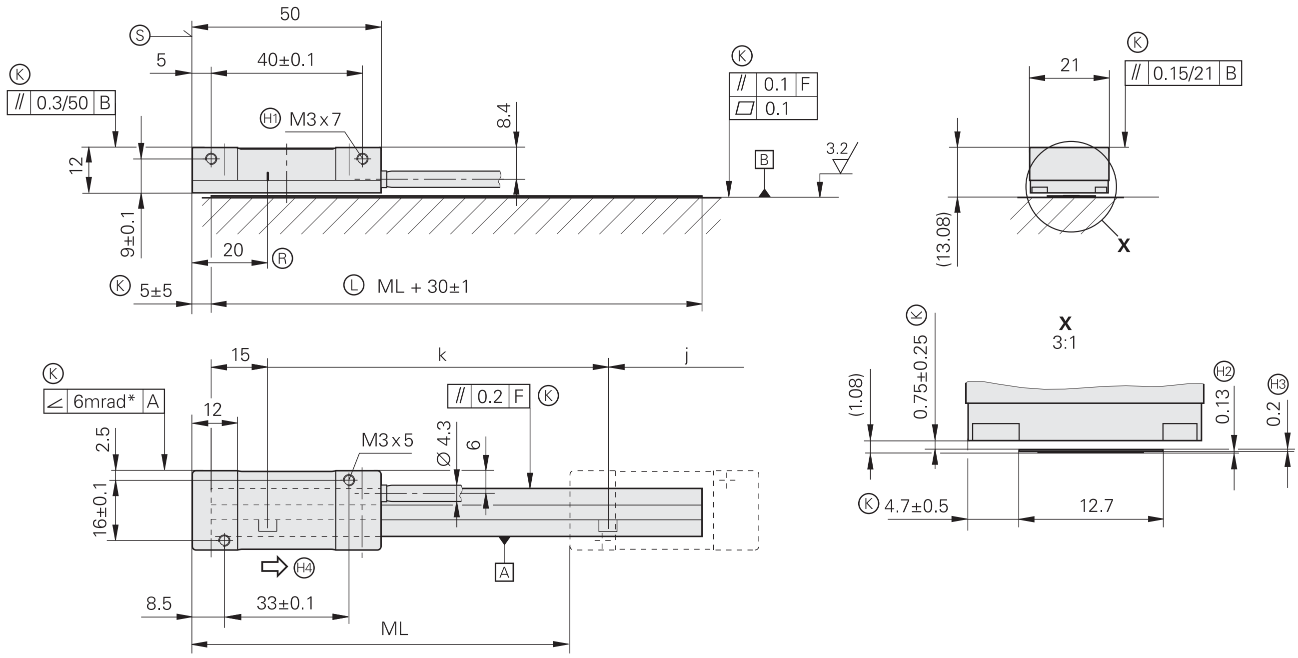
Specifications	**LIDA 287**	**LIDA 277**		
Measuring standard Coefficient of linear expansion	Steel scale tape $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$			
Accuracy grade	± 30 µm			
Scale tape cut from roll*	3 m, 5 m, 10 m			
Reference marks	Selectable every 100 mm			
Incremental signals	∿ 1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

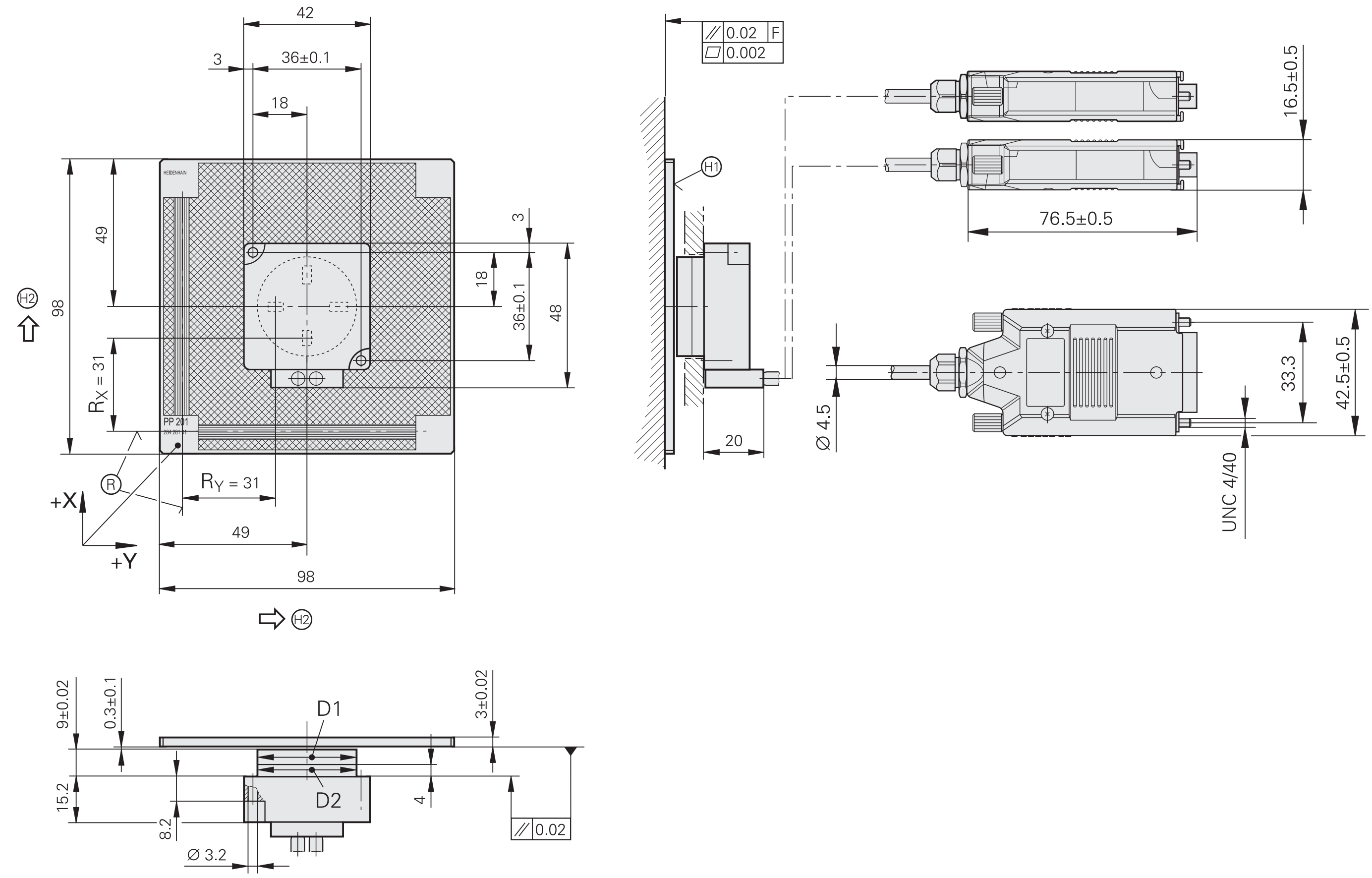
Reference mark:
k = Position of 1st reference mark from the beginning of the measuring length, depending on the cut
j = Additional reference marks every 100 mm

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

***** Please select when ordering

PP 281 R

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

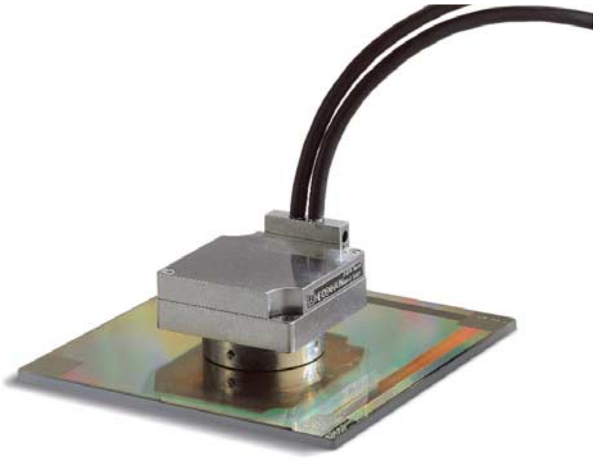


mm

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

F = Machine guideway
(R) = Reference-mark position relative to center position shown
(H1) = Graduation side
(H2) = 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 Coefficient of linear expansion	Two-coordinate TITANID phase grating on glass $\alpha_{therm} \approx 8 \cdot 10^{-6}\,K^{-1}$
Accuracy grade	± 2 µm
Measuring range	68 x 68 mm, 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 –3dB	≥ 300 kHz
Traversing speed	≤ 72 m/min
Power supply Current consumption	DC 5 V ± 5 % < 185 mA per axis
Electrical connection Cable length	Cable 0.5 m with D-sub connector (15-pin), interface electronics in the connector ≤ 30 m (with HEIDENHAIN cable)
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 80 m/s^2 (EN 60068-2-6) ≤ 100 m/s^2 (EN 60068-2-27)
Operating temperature	0 °C to 50 °C
Weight Scanning head Grid plate Connecting cable Connector	170 g (without connecting cable) 75 g 37 g/m 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 $1\text{-}V_{PP}$ 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.

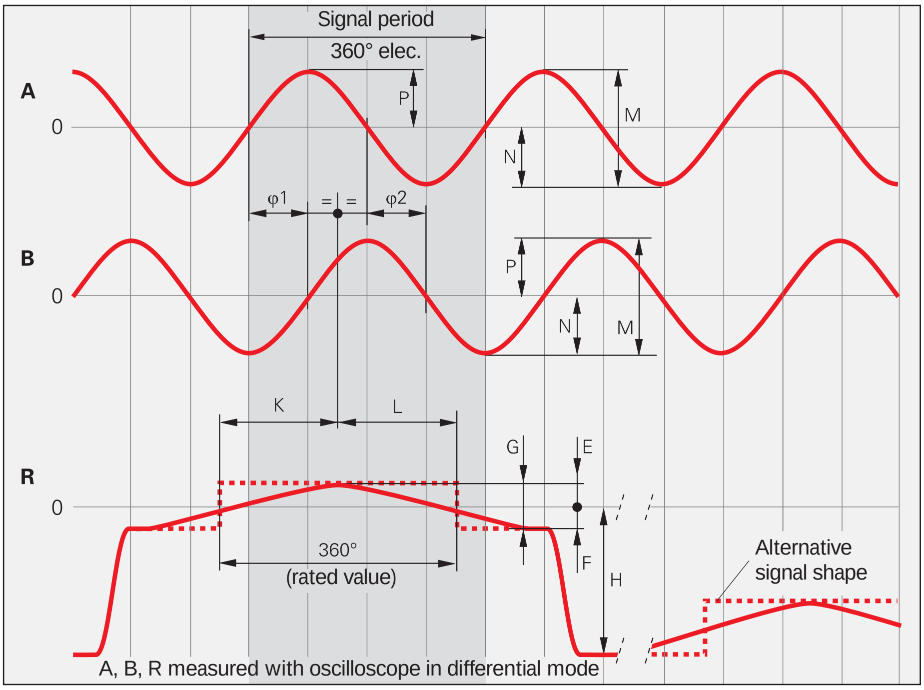
Measuring steps for **position measurement** are recommended in the specifications. For special applications, other resolutions are also possible.

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.

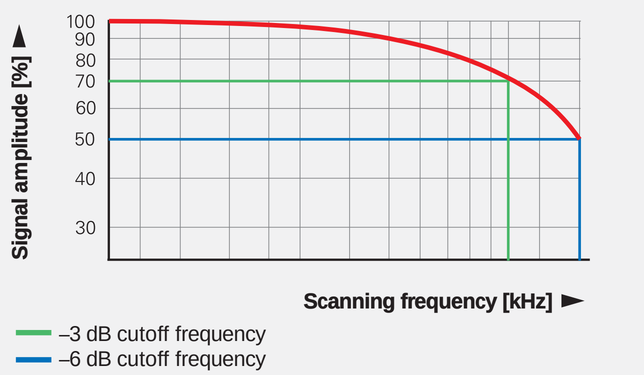
Short circuit at	20 °C	125 °C
One output	< 3 min	< 1 min
All outputs	< 20 s	< 5 s

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 |φ1 + φ2|/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 Cable length Propagation time	Shielded HEIDENHAIN cable PUR [4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] max. 150 m with 90 pF/m distributed capacitance 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



Input circuitry of the subsequent electronics

Dimensioning
Operational amplifier 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

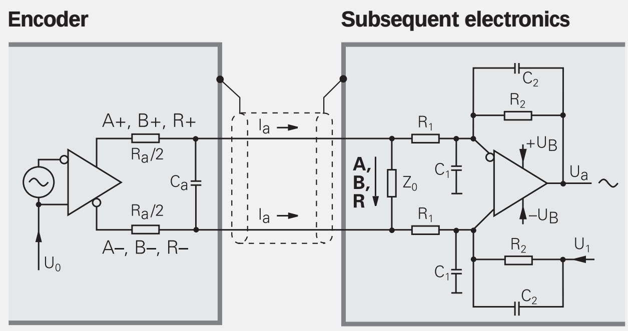
–3dB cutoff frequency of circuitry
Approx. 450 kHz
Approx. 50 kHz with C_1 = 1000 pF
and C_2 = 82 pF
The circuit variant for 50 kHz does reduce the bandwidth of the circuit, but in doing so it improves its noise immunity.

Output signals of the circuit
U_a = 3.48 V_{PP} typically
Gain 3.48

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}

Incremental signals
Reference-mark signal

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



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 for the direction of motion shown in the dimension drawing.

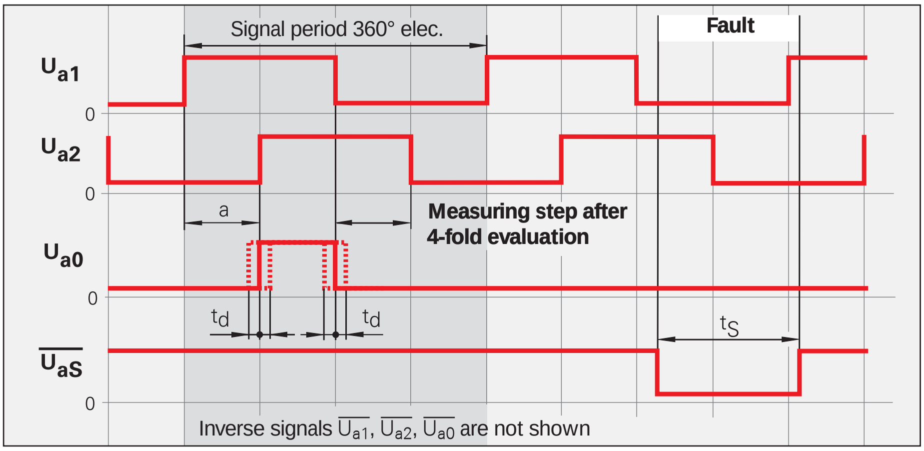
The **fault-detection signal** $\overline{U_{aS}}$ indicates fault conditions such as breakage of the power line or failure of the light source. It can be used for such purposes as machine shut-off during automated production.

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.**

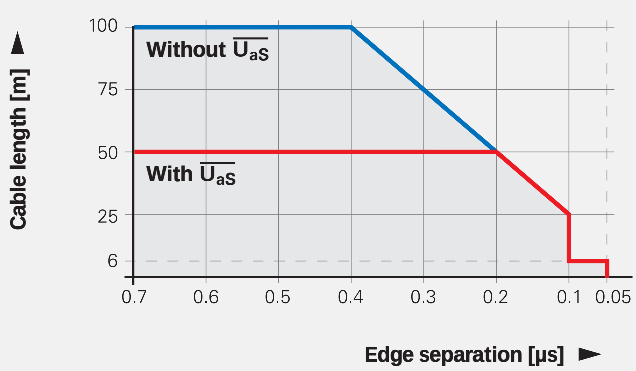
The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum **edge separation a** listed in the *Specifications* applies for the illustrated input circuitry with a cable length of 1 m, and refers to a measurement at the output of the differential line receiver. 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.

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 Pulse width Delay time	**1 or more TTL square-wave pulses U_{a0}** and their inverted pulses **$\overline{U_{a0}}$** 90° elec. (other widths available on request); *LS 323:* ungated $\|t_d\| \leq 50$ ns
Fault-detection signal Pulse width	**1 TTL square-wave pulse $\overline{U_{aS}}$** Improper function: LOW (upon request: U_{a1}/U_{a2} high impedance) Proper function: HIGH $t_S \geq 20$ ms
Signal amplitude	Differential line driver as per EIA standard RS 422 $U_H \geq 2.5$ V at $-I_H = 20$ mA *ERN 1x23:* 10 mA $U_L \leq 0.5$ V at $I_L = 20$ mA *ERN 1x23:* 10 mA
Permissible load	$Z_0 \geq 100\ \Omega$ between associated outputs $\|I_L\| \leq 20$ mA max. load per output (*ERN 1x23:* 10 mA) $C_{load} \leq 1000$ pF with respect to 0 V Outputs protected against short circuit to 0 V
Switching times (10% to 90%)	$t_+ / t_- \leq 30$ ns (typically 10 ns) with 1 m cable and recommended input circuitry
Connecting cables Cable length Propagation time	Shielded HEIDENHAIN cable PUR [4(2 × 0.14 mm^2) + (4 × 0.5 mm^2)] Max. 100 m ($\overline{U_{aS}}$ max. 50 m) at distributed capacitance 90 pF/m 6 ns/m



Permissible cable length
with respect to the edge separation



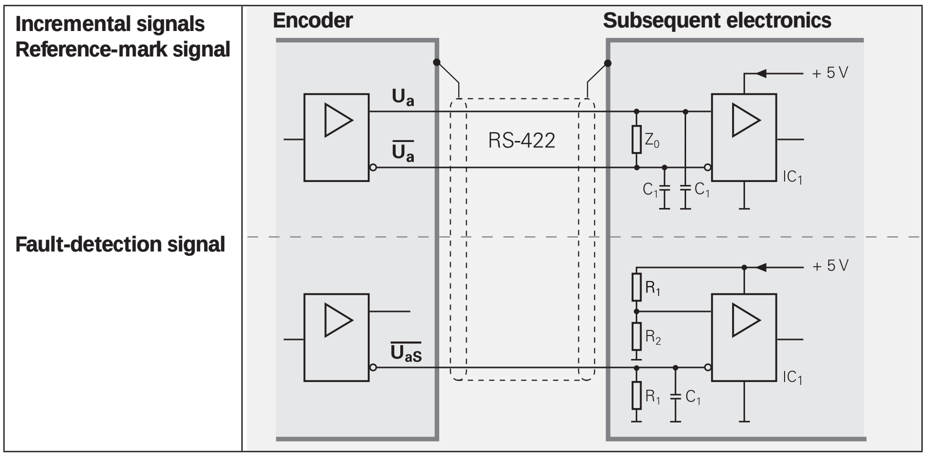
The permissible **cable length** for transmission of the TTL square-wave signals to the subsequent electronics depends on the edge separation a. It is at most 100 m, or 50 m for the fault detection signal. This requires, however, that the power supply (see *Specifications*) be ensured at the encoder. 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).

Input circuitry of the 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

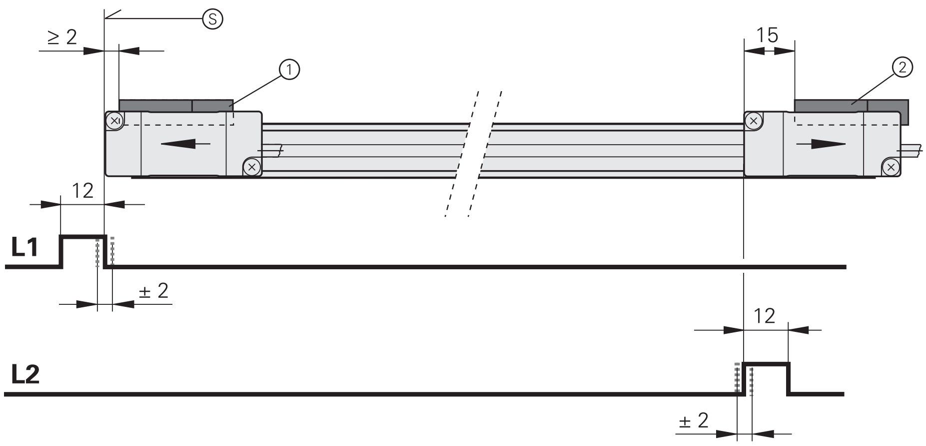
R_1 = 4.7 kΩ
R_2 = 1.8 kΩ
Z_0 = 120 Ω
C_1 = 220 pF (serves to improve noise immunity)



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 $I_{aH} \leq 4$ mA	
Switching times (10 % to 90 %) Rise time / Fall time	$t_+ \leq 50$ ns $t_- \leq 50$ ns Measured with 3 m cable and recommended input circuitry	$t_+ \leq 10$ µs $t_- \leq 3$ µs Measured with 3 m cable and recommended input circuitry
Permissible cable length	Max. 20 m	



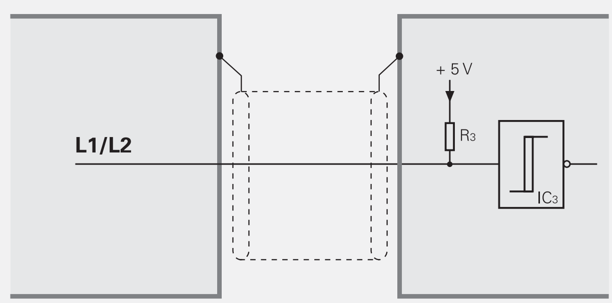
L1/L2 = Output signals of the limit switches 1 and 2
Tolerance of the switching point: ±2 mm

Ⓢ = 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

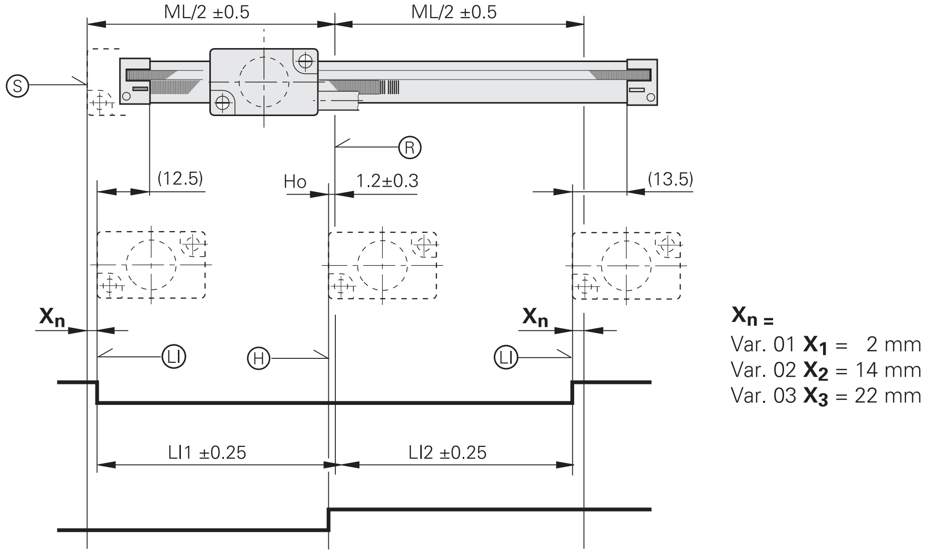
LIDA 400 limit switches



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 $U_H \geq 3.8$ V at $-I_H = 8$ mA $U_L \leq 0.45$ V at $I_L = 8$ mA
Permissible load	$R \geq 680\ \Omega$ $\lvert I_L \rvert \leq 8$ mA
Permissible cable length	Max. 10 m



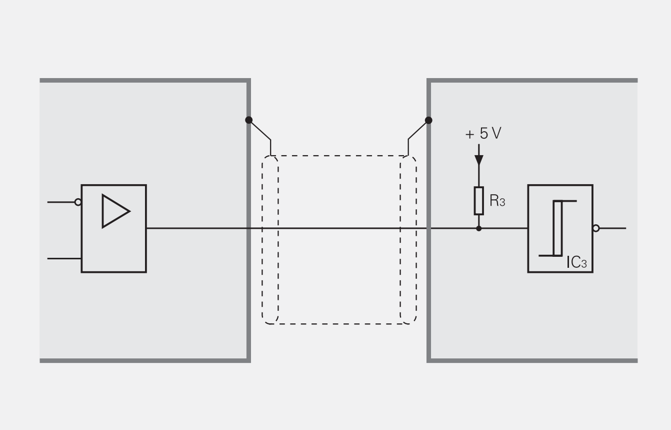
X_n =
Var. 01 X_1 = 2 mm
Var. 02 X_2 = 14 mm
Var. 03 X_3 = 22 mm

Ⓡ = Reference mark position
Ⓢ = Beginning of measuring length (ML)
Ⓛ = 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.

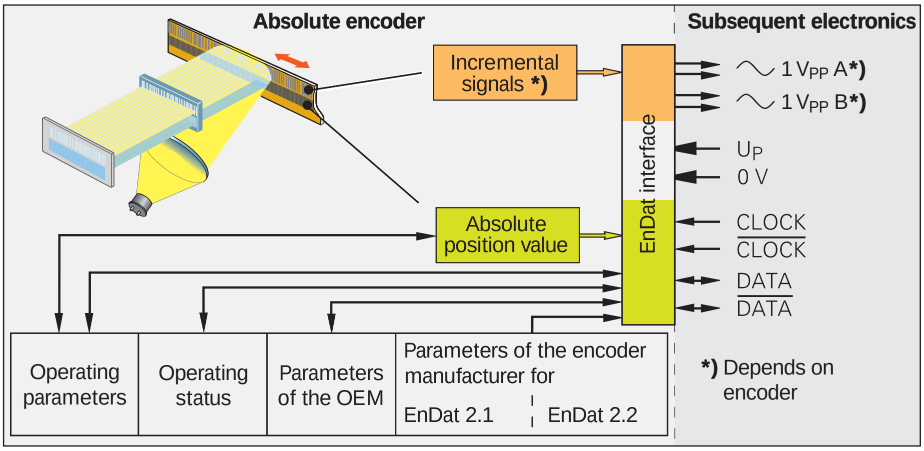
Clock frequency and cable length

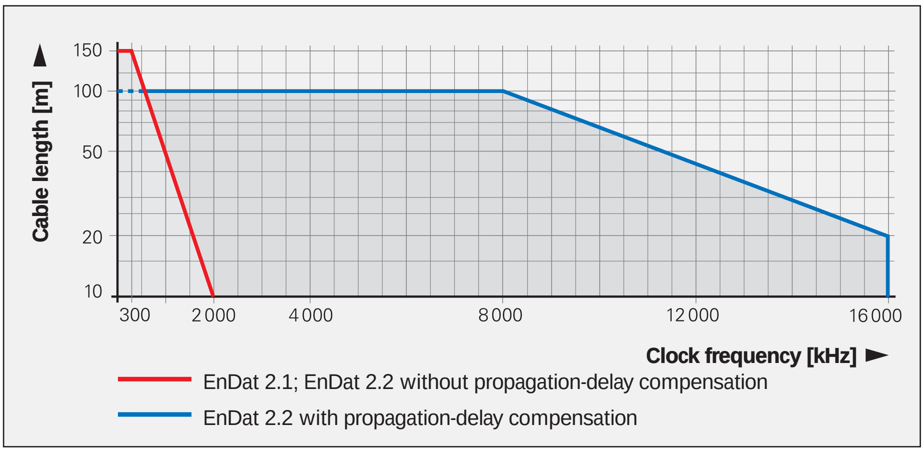
The clock frequency is variable—depending on the cable length (max. 150 m)—between **100 kHz** and **2 MHz.** With propagation-delay compensation in the subsequent electronics, clock frequencies **up to 16 MHz** at cable lengths up to 100 m are possible (for other values see *Specifications*).

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 the signals DATA and $\overline{\text{DATA}}$
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 V to 5.25 V or 14 V DC
EnDat 22	EnDat 2.2	Without	

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



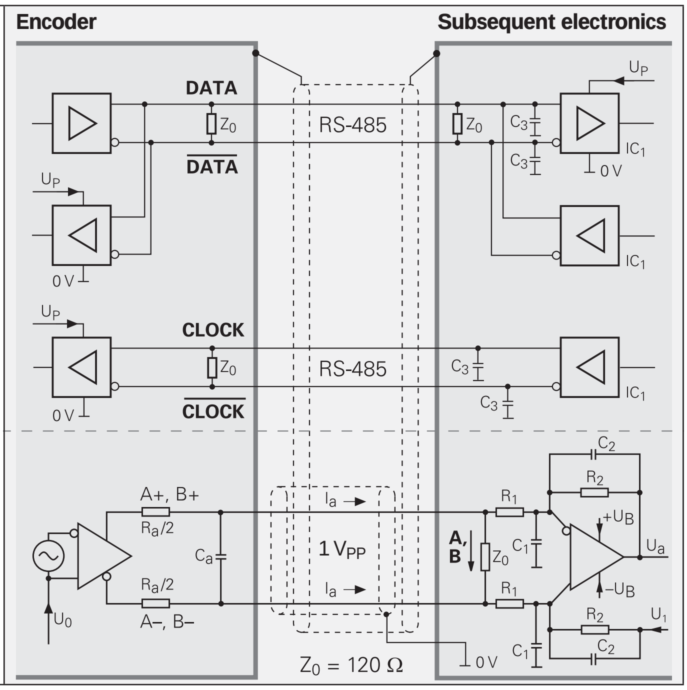


Input circuitry of the subsequent electronics

Dimensioning
IC_1 = RS 485 differential line receiver and driver

C_3 = 330 pF
Z_0 = 120 Ω

Data transfer

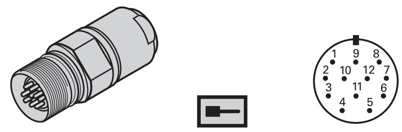


Incremental signals
depending on encoder

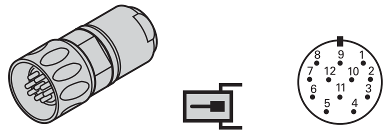
Interfaces

Pin Layout 1 V_{PP}, TTL, EnDat

12-pin HEIDENHAIN coupling



12-pin HEIDENHAIN connector

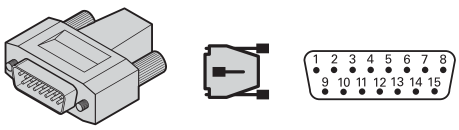


	Power supply				Incremental signals						Other signals	
	12	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**7**	**9**
TTL	**U_P**	**Sensor** 5 V	**0 V**	**Sensor** 0 V	**U_{a1}**	**$\overline{U_{a1}}$**	**U_{a2}**	**$\overline{U_{a2}}$**	**U_{a0}**	**$\overline{U_{a0}}$**	**$\overline{U_{aS}}$**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

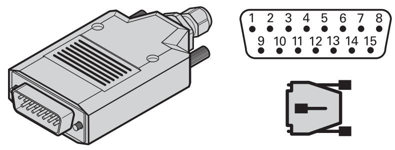
Shield on housing; **U_P** = Power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used.

1) TTL/11 µA_{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**
Cable	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 µA_{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 M12 **coupling**

	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**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
Cable	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

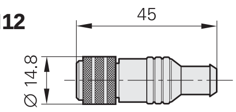
Cable shield connected to housing; **U_P** = power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!

Cables and Connecting Elements
General Information

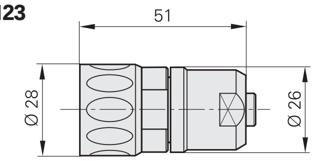
Connector (insulated): A connecting element with a coupling ring. Available with male or female contacts.

Symbols

M12



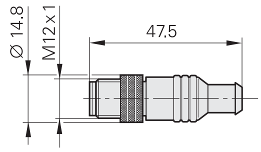
M23



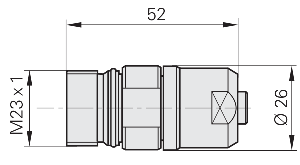
Coupling (insulated): Connecting element with external thread; available with male or female contacts.

Symbols

M12

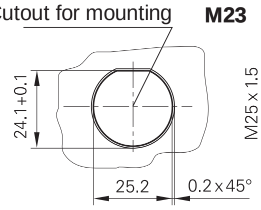


M23

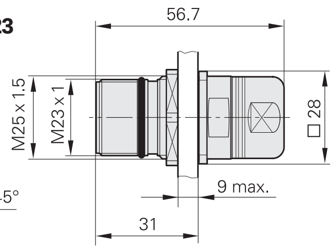


Mounted coupling with central fastening

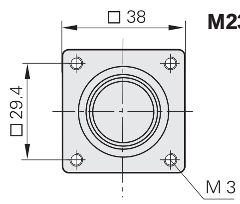
Cutout for mounting



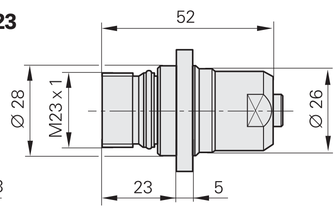
M23



Mounted coupling with flange



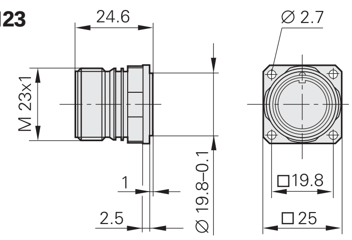
M23



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

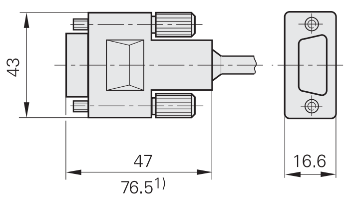
Symbols

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 contacts or

female contacts.

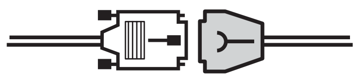
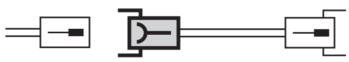
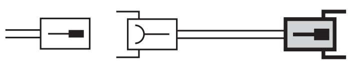
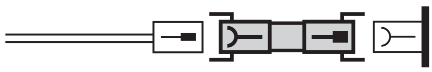
When engaged, the connections are **protected** to IP 67 (D-sub connector: IP 50; EN 60529). When not engaged, there is no protection.

Accessories for flange sockets and M23 mounted couplings

Bell seal
ID 266526-01

Threaded metal dust cap
ID 219926-01

Connecting Cable 1 V_{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 mm^2)]					
PUR connecting cable [4(2 x 0.14 mm^2) + (4 x 0.5 mm^2) + 2 x (2 x 0.14 mm^2)]					
PUR connecting cable [6(2 x 0.19 mm^2)]					
PUR connecting cable [4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)]		Ø 8 mm	Ø 6 mm[1)]	Ø 8 mm	Ø 6 mm[1)]
Complete with D-sub connector (female) and M23 connector (male)		331 693-xx	355 215-xx	–	–
With **one** D-sub connector (female)		332 433-xx	355 209-xx	354 411-xx	355 398-xx
Complete with D-sub connectors (female and male)		335 074-xx	355 186-xx	354 379-xx	355 397-xx
Complete with D-sub connectors (female) **Pin assignment for IK 220**		335 077-xx	349 687-xx	–	–
Cable without connectors		244 957-01	291 639-01	354 341-01	355 241-01
Adapter cable for LIP 3x2 with M23 coupling (male)		–	310 128-xx	–	–
Adapter cable for LIP 3x2 with D-sub connector, assignment for IK 220		298 429-xx	–	–	–
Adapter cable for LIP 3x2 without connector		–	310 131-xx	–	–
Complete with M23 connector (female) and M23 connector (male)		298 399-xx	–	–	–
With one M23 connector (female)		309 777-xx	–	–	–
Connector on connecting cable to connector on encoder cable		For cable	Ø 6 mm to Ø 8 mm	315 650-14	
Connector on connecting cable to mating element on encoder cable	**M23 connector (female)** 	For cable	Ø 8 mm	291 697-05	
M23 connector for connection to subsequent electronics	**M23 connector (male)** 	For cable	Ø 8 mm Ø 6 mm	291 697-08 291 697-07	
M23 flange socket for mounting on the subsequent electronics	**M23 flange socket (female)** 			315 892-08	
Adapter ∿ 1 V_{PP}/11 µA_{PP} For converting the 1 V_{PP} signals to 11 µA_{PP}; 12-pin M23 connector (female) and 9-pin M23 connector (male)				364 914-01	

1) Cable length for Ø 6 mm: max. 9 m

Connecting Cables EnDat

8-Pin M12

		For **EnDat** without incremental signals
PUR connecting cables	**8-pin:** [(4 × 0.14 mm^2) + (4 × 0.34 mm^2)] **Ø 6 mm**	
Complete with connector (female) and coupling (male)		368330-xx
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
With one connector (female)		559346-xx

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
- ΔU: Voltage attenuation 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).

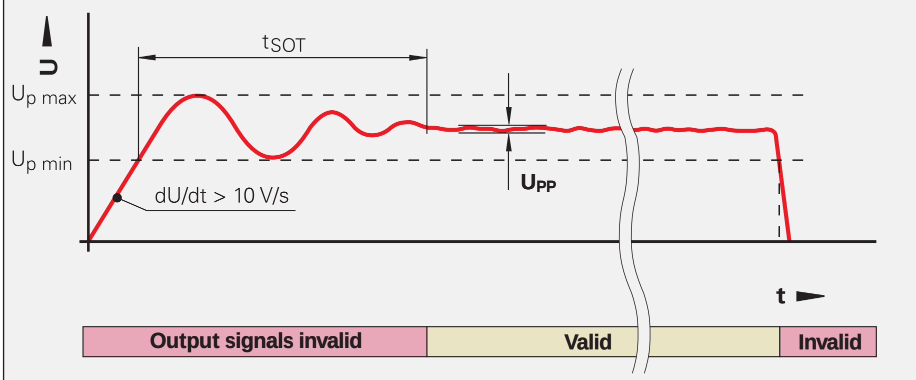
If the voltage drop is known, all parameters for the encoder and subsequent electronics can be calculated, e.g. voltage at the encoder, current requirements and power consumption of the encoder, as well as the power to be provided by the subsequent electronics.

Switch-on/off behavior of the encoders
The output signals are valid no sooner than after switch-on time t_{SOT} = 1.3 s (2 s for PROFIBUS-DP) (see diagram). During 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.

Isolation
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



Cables	Cross section of power supply lines A_P			
	1 V_{PP}/TTL/HTL	11 μA_{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 Ø 5.1 mm	0.14/0.09[2] mm^2 0.05[2), 3)] mm^2	0.05 mm^2	0.05/0.14[6] mm^2	0.14 mm^2
Ø 6 mm 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 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) RCN, LC adapter cables

Encoders with expanded voltage supply 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 power consumption at maximum supply voltage (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 in four steps:

***Step 1:* Resistance of the supply lines**

The resistance values of the power lines (adapter cable and encoder cable) can be calculated with the following formula:

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

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

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

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

***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:
$U_E = U_S - \Delta U$

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:
$P_S = U_S \cdot I_E$

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_S: Supply voltage of the subsequent electronics in V

R_L: Cable resistance (for both directions) in ohms

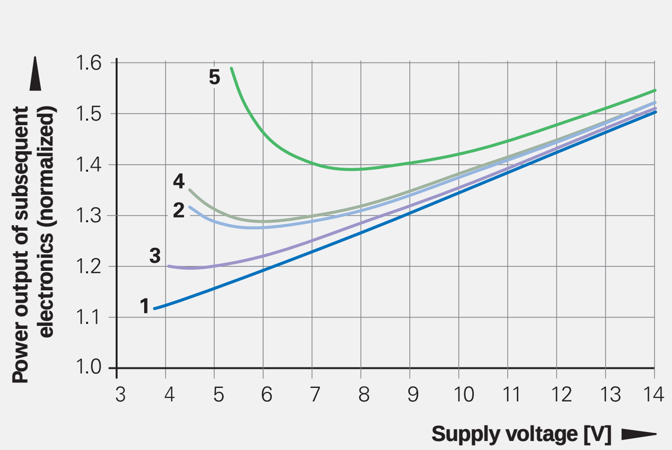
ΔU: Voltage drop in the cable in V

1.05: Length factor due to twisted wires

L_C: Cable length in m

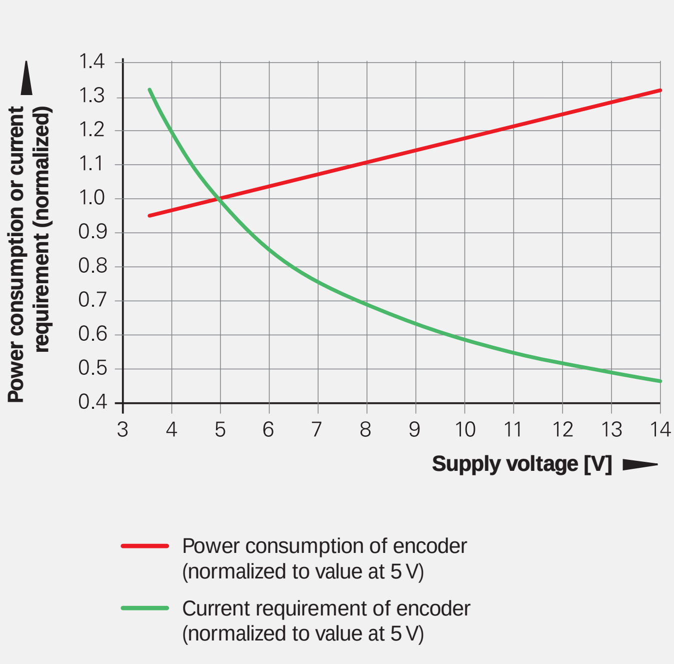
A_P: Cross section of power lines in mm^2

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



	Encoder cable/adapter cable	Connecting cables	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 –3dB/ –6dB 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 frequency f_{max} of the encoder
    and
  - the minimum permissible edge separation a for the subsequent electronics.

For angular 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

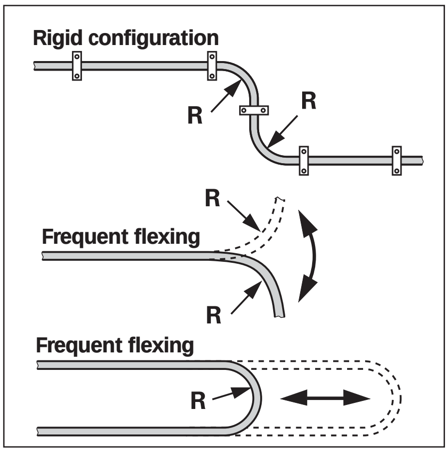
Cables

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 cable).** Most adapter cables for within motors and a few cables on encoders are sheathed in a **special elastomer (EPG cable).** These cables are identified in the specifications or in the cable tables with "EPG."

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 conditionally resistant to media, frequent flexing and continuous torsion.



Temperature range
HEIDENHAIN cables can be used for

rigid configuration (PUR)	–40 to 80 °C
rigid configuration (EPG)	–40 to 120 °C
Frequent flexing (PUR)	–10 to 80 °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.

Cables	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 **Ø 5.1 mm**	≥ 10 mm	≥ 50 mm
Ø 6 mm **Ø 10 mm**[1)]	≥ 20 mm ≥ 35 mm	≥ 75 mm ≥ 75 mm
Ø 8 mm **Ø 14 mm**[1)]	≥ 40 mm ≥ 100 mm	≥ 100 mm ≥ 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:

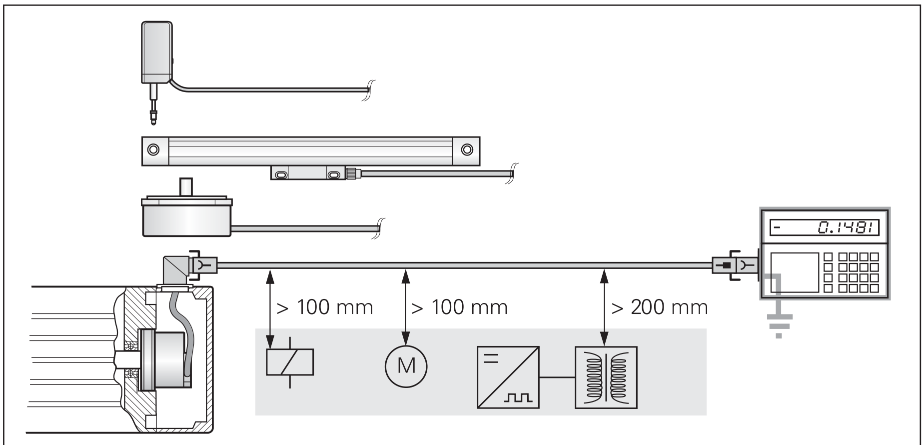
- **Noise EN 61 000-6-2:**
  Specifically:
  - ESD EN 61 000-4-2
  - Electromagnetic fields EN 61 000-4-3
  - Burst EN 61 000-4-4
  - Surge EN 61 000-4-5
  - Conducted disturbances EN 61 000-4-6
  - Power frequency magnetic fields EN 61 000-4-8
  - Pulse magnetic fields EN 61 000-4-9
- **Interference 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 are:

- 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 attenuation on supply lines.
- Use connecting elements (such as connectors or terminal boxes) with metal housings. Only the signals of and power supply for 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 µAPP interface: For extension cables, use only HEIDENHAIN cable ID 244 955-01. 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. There are different expansion modules available for checking the different encoder signals. The values can be read on an LCD monitor. Soft keys provide ease of operation.

	PWM 9
Inputs	Expansion modules (interface boards) for 11 μA_{PP}; 1 V_{PP}; TTL; HTL; EnDat*/SSI*/commutation signals *No display of position values or parameters
Functions	• **Measures** signal amplitudes, current consumption, operating voltage, scanning frequency • **Graphically displays** incremental signals (amplitudes, phase angle and on-off ratio) and the reference-mark signal (width and position) • **Displays symbols** for the reference mark, fault detection signal, counting direction • **Universal counter,** interpolation selectable from single to 1 024-fold • **Adjustment support** for exposed linear encoders
Outputs	• Inputs are connected through to the subsequent electronics • BNC sockets for connection to an oscilloscope
Power supply	DC 10 to 30 V, 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 μA_{PP}	⊓⊔TTL	∿ 1 V_{PP}
Functions	Measurement of signal amplitude Wave-form tolerance 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 PG 27 test unit Power supply unit for PG 27 (110 to 240 V, including adapter plug) 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) • DRIVE-CLiQ • Fanuc Serial Interface • Mitsubishi High Speed Serial Interface • SSI
Interface	USB 2.0
Power supply	AC 100 to 240 V or DC 24 V
Dimensions	258 mm 154 mm 55 mm

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

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