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HEIDENHAIN

Exposed Linear Encoders

September 2008

Exposed Linear Encoders

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

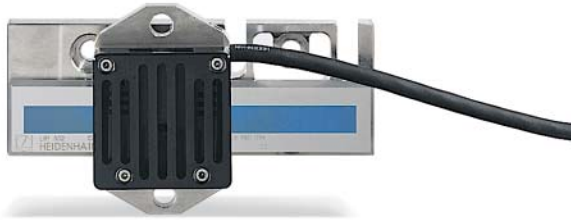
- Positioning error due to thermal behavior of the recirculating ball screw
- Reversal error
- Kinematic error through ball-screw pitch error

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
- Angle encoders with integral bearing
- Angle encoders without integral bearing
- 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.

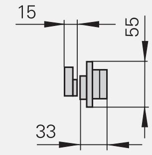
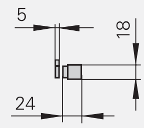
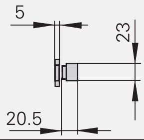
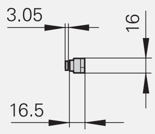
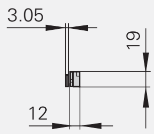
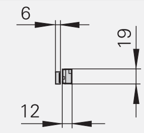
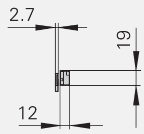
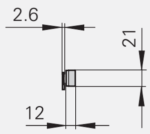
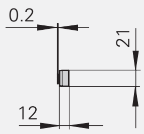
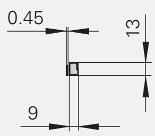
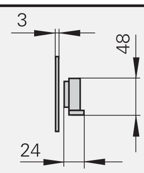
Contents

Selection Guide

The **LIP** exposed linear encoders are characterized by very small measuring steps together with very high **accuracy** and **repeatability.** As the measuring standard they feature a DIADUR phase grating applied to a graduation carrier of glass ceramic or glass.

The **LIF** exposed linear encoders have a measuring standard on a glass substrate manufactured in the DIADUR or SUPRDAUR processes. They feature high **accuracy** and **repeatability,** and are especially easy to mount.
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.

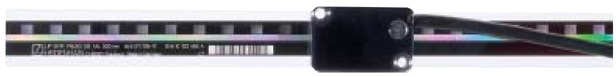
The **PP** two-coordinate encoders feature as measuring standard a planar phase-grating structure manufactured with the DIADUR process on a glass substrate. This makes it possible to measure **positions in a plane.**

	Cross section	Accuracy grades	Signal period[1)]
LIP for very high accuracy • Scale of glass ceramic or glass • Interferential scanning principle for small signal periods		± 0.5 µm *(higher accuracy grades available on request)*	0.128 µm
	LIP 4x1R 	± 1 µm ± 0.5 µm *(higher accuracy grades available on request)*	2 µm
		± 1 µm	4 µm
LIF for high accuracy • With PRECIMET adhesive film • Interferential scanning principle for small signal periods • Limit switches and homing track		± 3 µm	4 µm
LIDA with thermally adapted graduation carriers • Linear coefficient of expansion selectable via graduation carrier • Limit switches		± 5 µm *(higher accuracy grades available on request)*	20 µm
LIDA for high traversing speeds and large measuring lengths • Steel scale tape drawn into aluminum extrusion or cemented to mounting surface • Limit switches with LIDA 400		± 5 µm	20 µm
		± 15 µm	20 µm
		± 30 µm	200 µm
		± 30 µm	200 µm
LIDA for very limited installation space • Small scanning head • Simple installation		± 5 µm	20 µm
PP for two-coordinate measuring • Common scanning point for both coordinates • Interferential scanning principle for small signal periods		± 2 µm	4 µm

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

Measuring lengths	Substrate and mounting	Interface	Model	Page
70 mm to 270 mm	Zerodur glass ceramic embedded in bolted-on Invar carrier	TTL	**LIP 372**	**18**
		1 V_{PP}	**LIP 382**	
70 mm to 420 mm	Scale of Zerodur glass ceramic or glass with bolted-on fixing clamps	TTL	**LIP 471**	**20**
		1 V_{PP}	**LIP 481**	
70 mm to 1440 mm	Glass scale fixed with bolted-on clamps	TTL	**LIP 571**	**22**
		1 V_{PP}	**LIP 581**	
70 mm to 1020 mm	Glass scale fixed with PRECIMET adhesive film	TTL	**LIF 471**	**24**
		1 V_{PP}	**LIF 481**	
240 mm to 3040 mm	Glass or glass ceramic scale is cemented to the mounting surface	TTL	**LIDA 473**	**26**
		1 V_{PP}	**LIDA 483**	
140 mm to 30040 mm	Steel scale tape drawn into aluminum extrusion and tensioned	TTL	**LIDA 475**	**28**
		1 V_{PP}	**LIDA 485**	
240 mm to 6040 mm	Steel scale tape drawn into aluminum extrusion and fixed at center	TTL	**LIDA 477**	**30**
		1 V_{PP}	**LIDA 487**	
Up to 10000 mm	Steel scale tape drawn into aluminum extrusion and fixed at center	TTL	**LIDA 277**	**32**
		1 V_{PP}	**LIDA 287**	
Up to 10000 mm	Steel scale tape cemented on mounting surface	TTL	**LIDA 279**	**32**
		1 V_{PP}	**LIDA 289**	
70 mm to 1020 mm	Glass scale fixed with PRECIMET adhesive film	TTL	**LIDA 573**	**34**
		1 V_{PP}	**LIDA 583**	
Measuring range 68 x 68 mm *(other measuring ranges upon request)*	Glass grid plate mounted with full-surface adhesion	TTL	**PP 271**	**36**
		1 V_{PP}	**PP 281**	

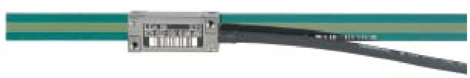

LIP 382

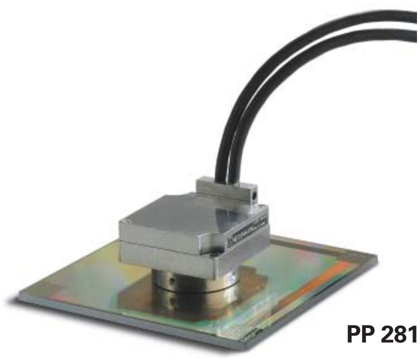

LIP 581


LIF 481


LIDA 485


LIDA 279


LIDA 583


PP 281

Measuring Principles
Measuring Standard

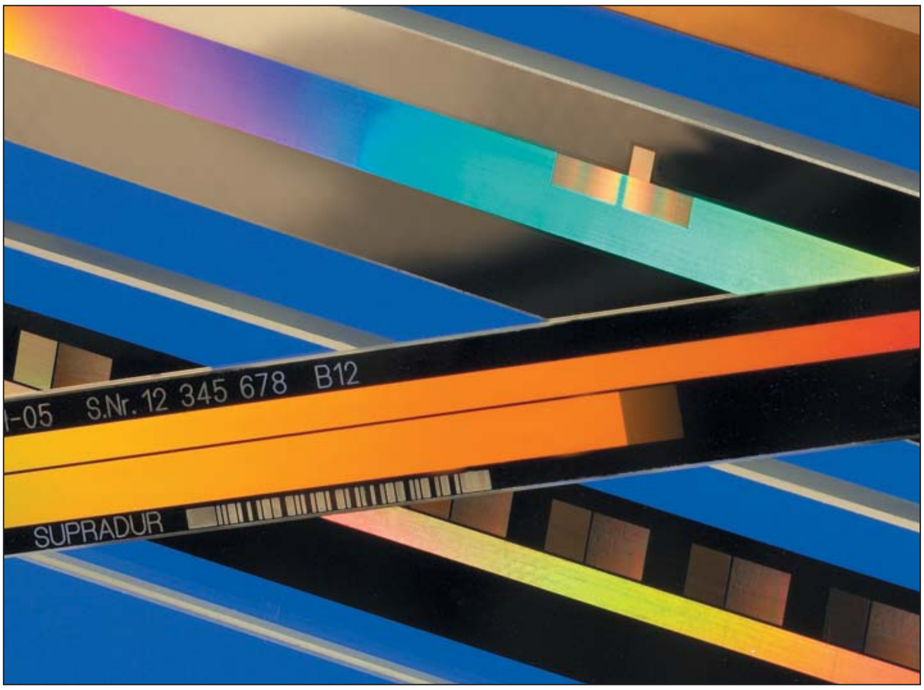
HEIDENHAIN encoders with optical scanning incorporate measuring standards of periodic structures known as graduations. These graduations are applied to a carrier substrate of glass or steel. The scale substrate for large measuring lengths is a steel tape.

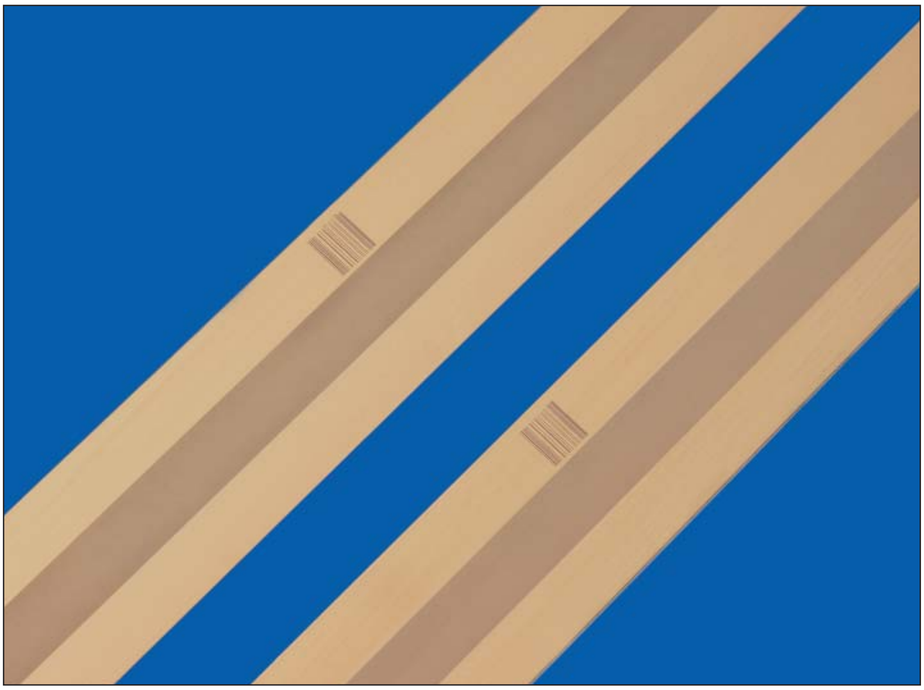
These precision graduations are manufactured in various photolithographic processes. Graduations are fabricated from:
- extremely hard chromium lines on glass,
- matte-etched lines on gold-plated steel tape, or
- three-dimensional structures on glass or steel substrates.

The photolithographic manufacturing processes developed by HEIDENHAIN produce grating periods of typically 40 µm to under 1 µm.

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

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





Incremental Measuring Method

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

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

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

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

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

where:

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

and:

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

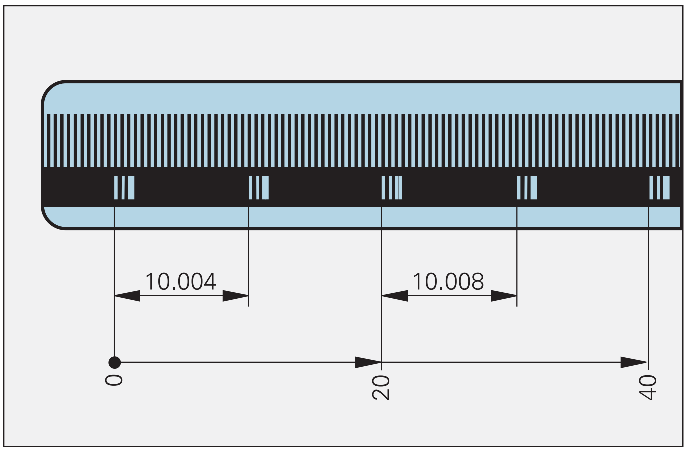
abs = Absolute value

sgn = Sign function ("+1" or "–1")

M_{RR} = Number of signal periods between the traversed reference marks

N = Nominal increment between two fixed reference marks in signal periods (see table below)

D = Direction of traverse (+1 or –1) Traverse of scanning unit to the right (when properly installed) equals +1.



Schematic representation of an incremental graduation with distance-coded reference marks (LIP 5x1 C as example)

	Signal period	Nominal increment N in signal periods	Maximum traverse
LIP 5x1 C	4 µm	5000	20 mm

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.

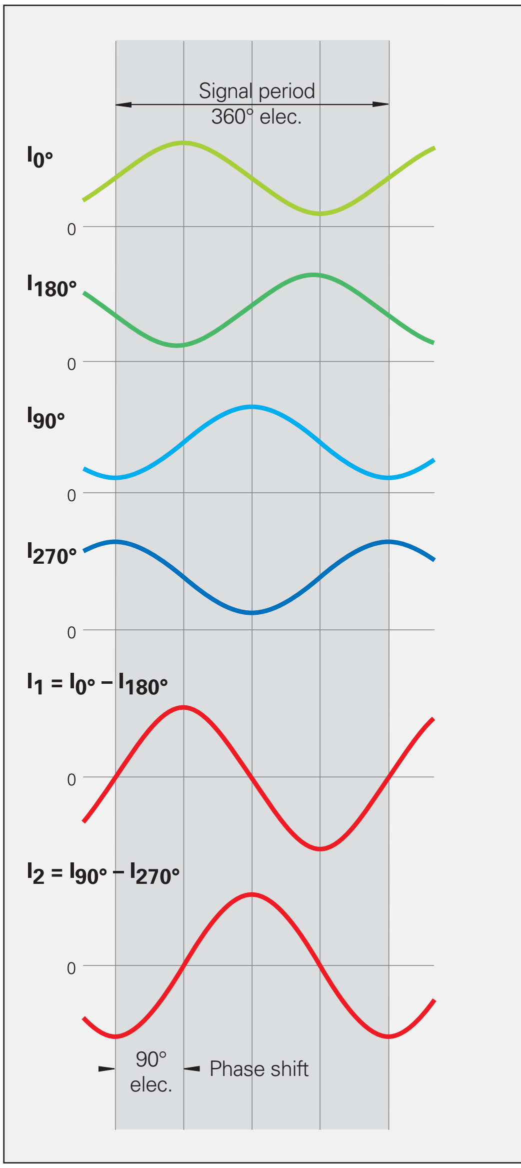
The finer the grating period of a measuring standard is, the greater the effect of diffraction on photoelectric scanning. HEIDENHAIN uses two scanning principles with linear encoders:

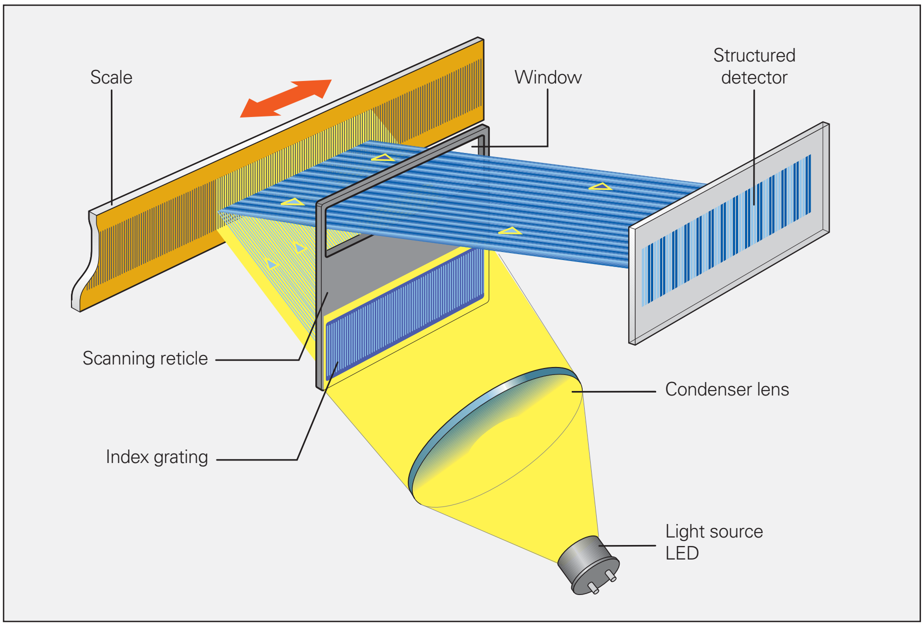
- The **imaging scanning principle** for grating periods from 10 µm to 200 µm.
- The **interferential scanning principle** for very fine graduations with grating periods of 4 µm and smaller.

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

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

LIDA linear encoders operate according to the imaging scanning principle.

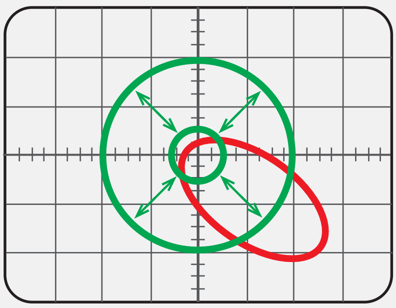




Photoelectric scanning in accordance with the imaging scanning principle with steel scale and single-field scanning (LIDA 400)

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 XY 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.



X/Y graph 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.

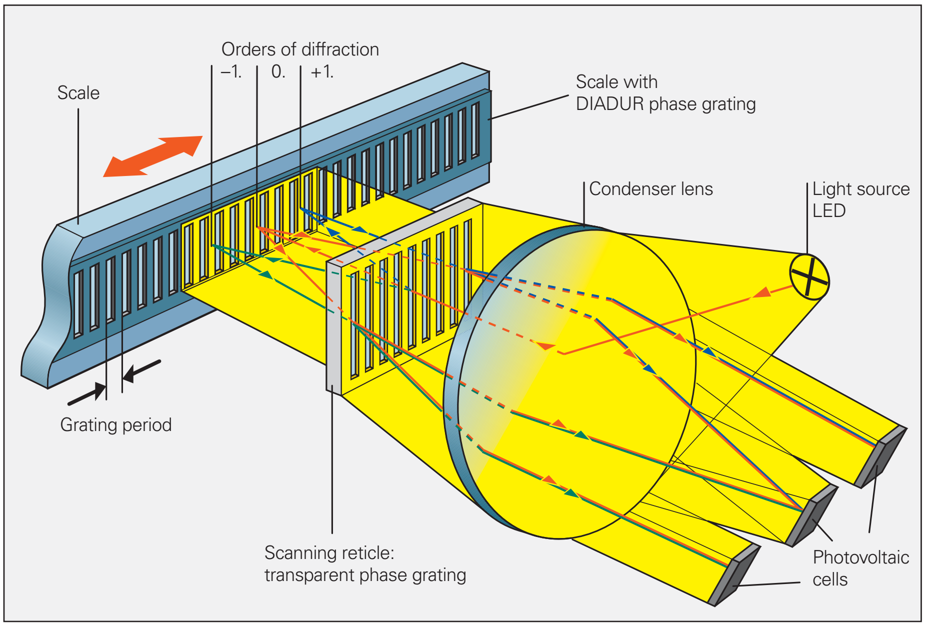
A step grating is used as the measuring standard: reflective lines 0.2 µm high are applied to a flat, reflective surface. In front of that is the scanning reticle—a transparent phase grating with the same grating period as the scale.

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

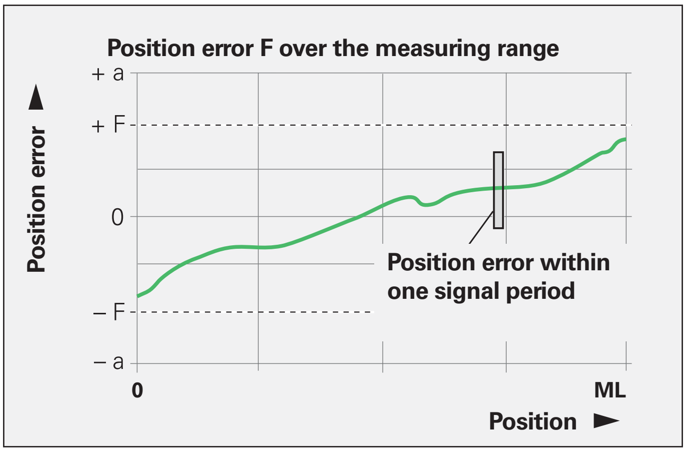
Measuring Accuracy

The accuracy of linear measurement is mainly determined by:

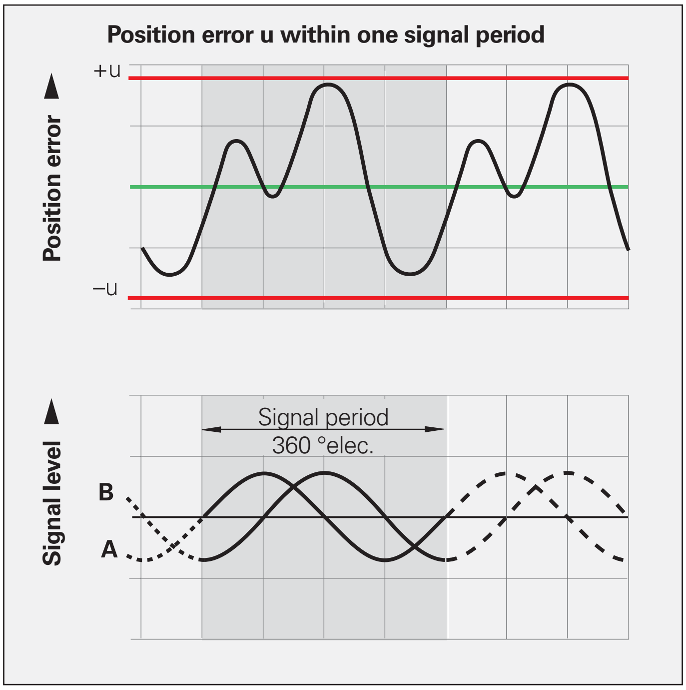
- The quality of the graduation
- The quality of the scanning process
- The quality of the signal processing electronics
- The error from the scale guideway relative to the scanning unit

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 an 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 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
LIDA 4xx **LIDA 5xx**	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 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.

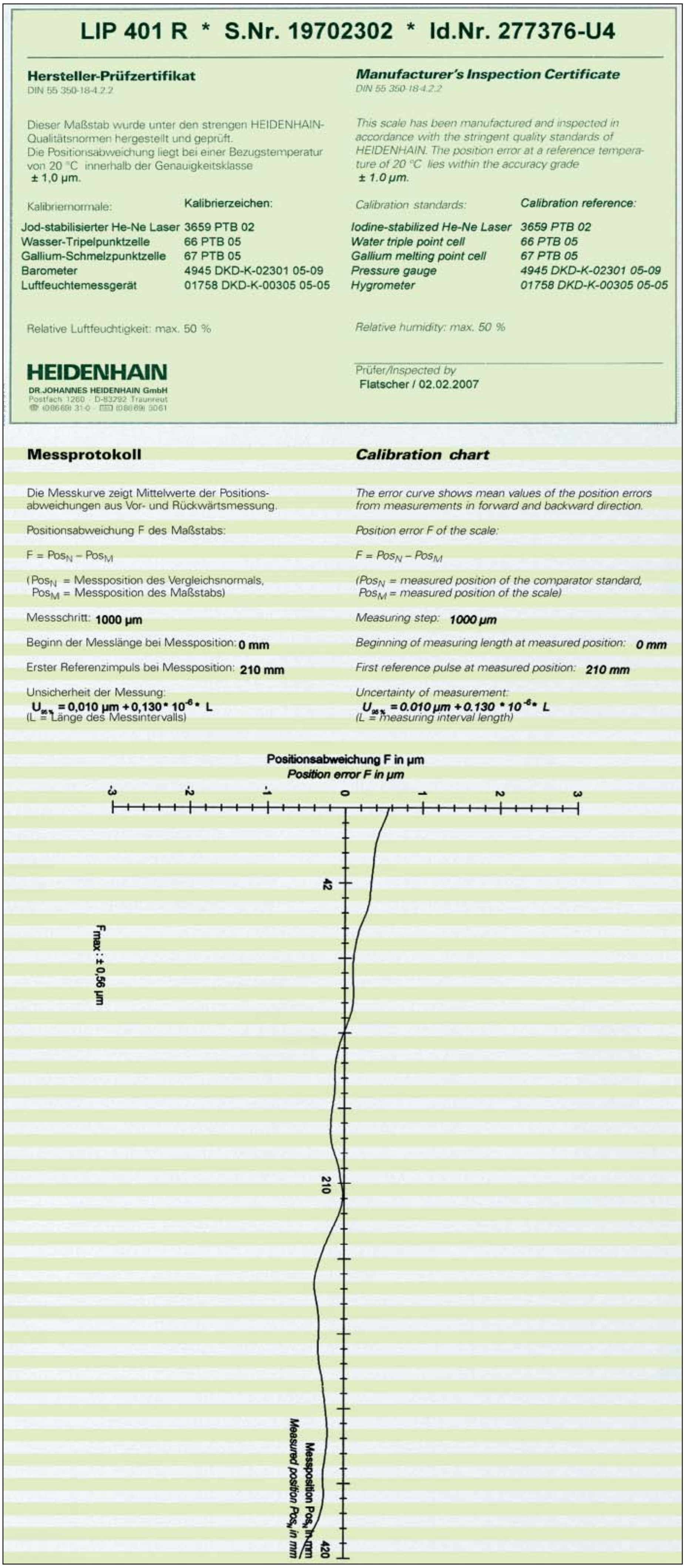
Temperature range

The length gauges 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:
$U_{95\%} = 0{,}010\ \mu m + 0{,}130 \cdot 10^{-6} \cdot L$
(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***

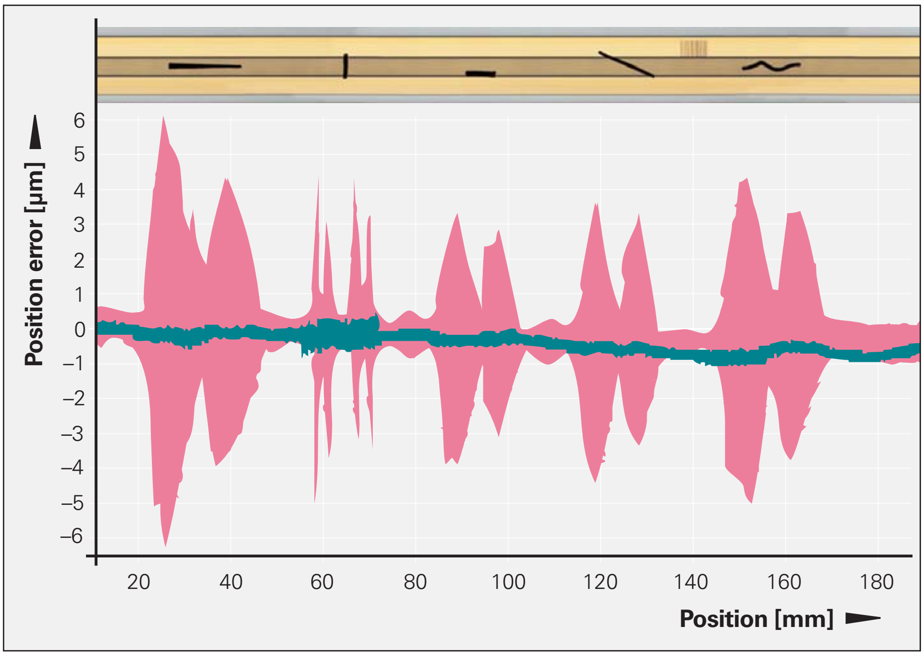
Uncertainty of measurement:
$U_{95\%} = 0.010\ \mu m + 0.130 \cdot 10^{-6} \cdot L$
(L = measuring interval length)

Reliability

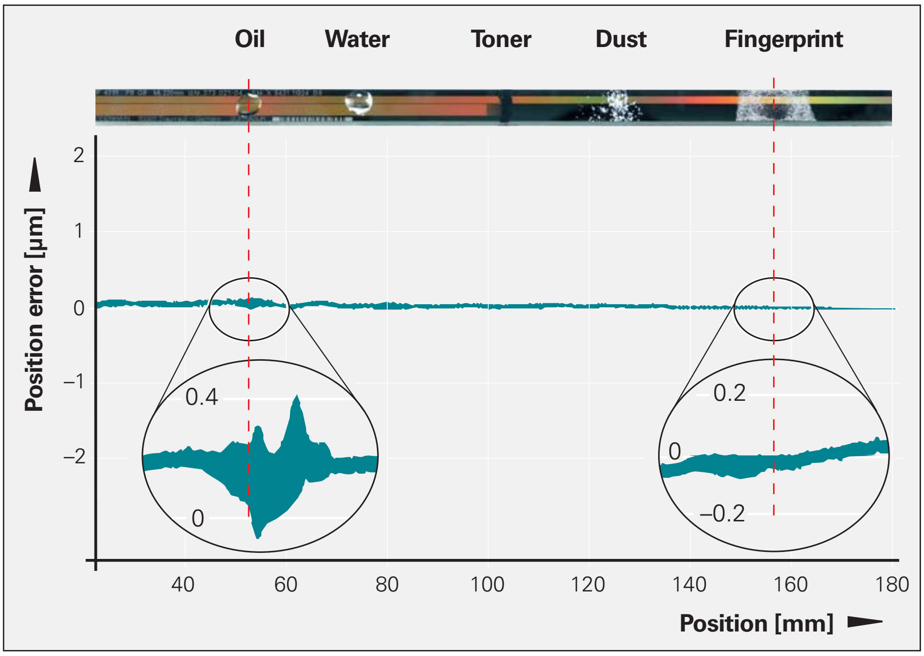
Exposed linear encoders from HEIDENHAIN are optimized for use on fast, precise machines. In spite of the exposed mechanical design they are highly tolerant to contamination, ensure high long-term stability, and are fast and simple to mount.

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.

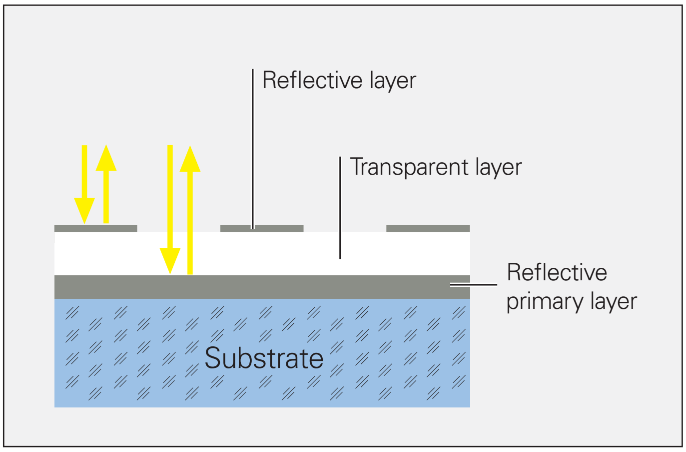
In the DIADUR process, hard chrome structures are applied to a glass or steel carrier.

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.

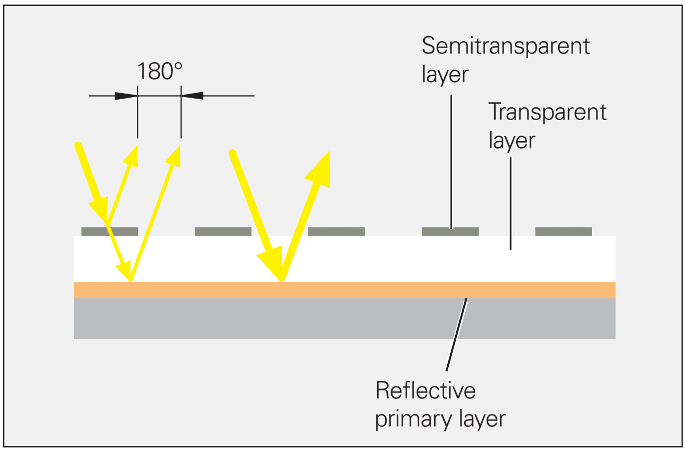
Application-oriented mounting tolerances
Very small signal periods usually come with very narrow mounting tolerances for the gap between the scanning head and scale tape. This is the result of diffraction caused by the grating structures. It can lead to a signal attenuation of 50% with a gap change of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

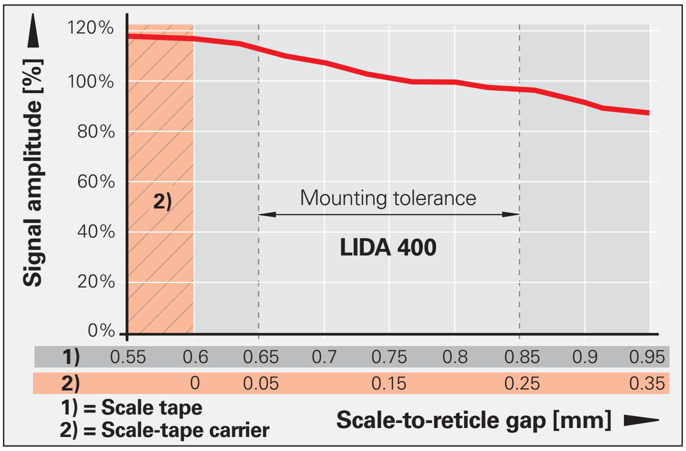
The mounting tolerances of exposed linear encoders from HEIDENHAIN have only a slight influence on the output signals. In particular the specified gap tolerance between the scale and scanning head (scanning gap) causes only negligible change in the signal amplitude. This behavior is substantially responsible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

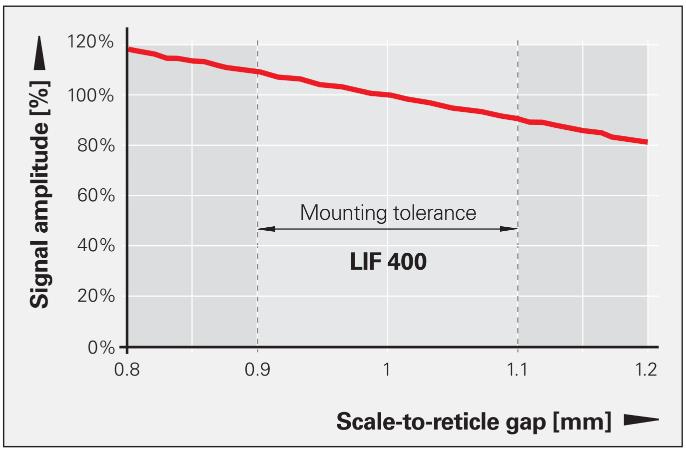
SUPRADUR



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 **tolerances** in the mounting space for the encoder are met (see *Specifications*).
- The bearing surface of the scale must meet requirements for **evenness.**
- 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 300 series
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 fixed with screws onto the bearing surface. Flexible fastening elements ensure reproducible thermal behavior.

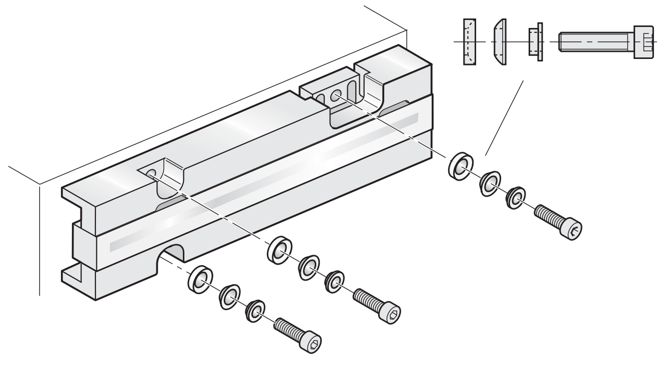
LIP 400 and LIP 500 series
The graduation carriers of Zerodur or glass are fastened onto the bearing surface with clamps and additionally secured with silicone adhesive. The thermal zero point is fixed with epoxy adhesive.

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

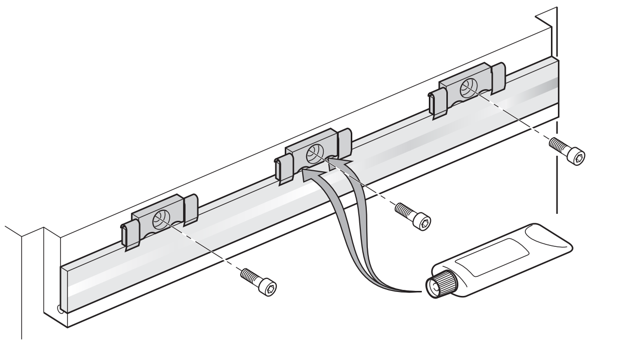
LIF 400 series
LIDA 4x3 series
LIDA 500 series
The graduation carriers of glass are glued directly to the bearing surface with PRECIMET adhesive film, and pressure is evenly distributed with a roller.

Accessory	
Roller	ID 276885-01

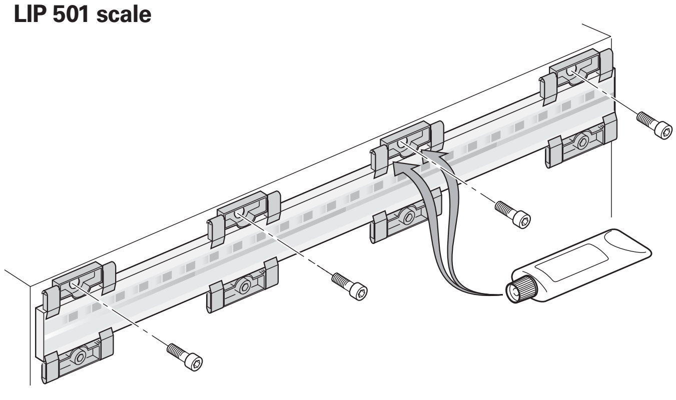
LIP 302 scale



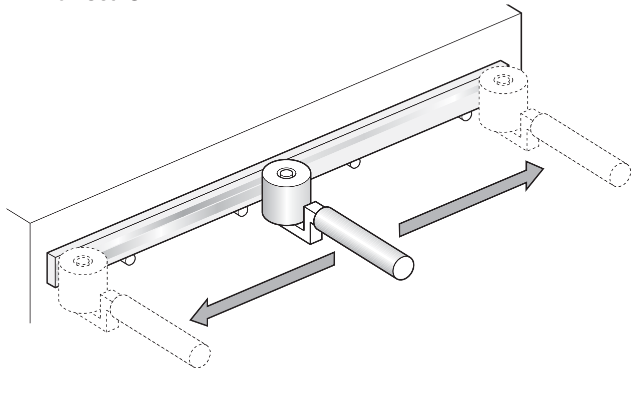
LIP 401 scale



LIP 501 scale



LIF 401 scale



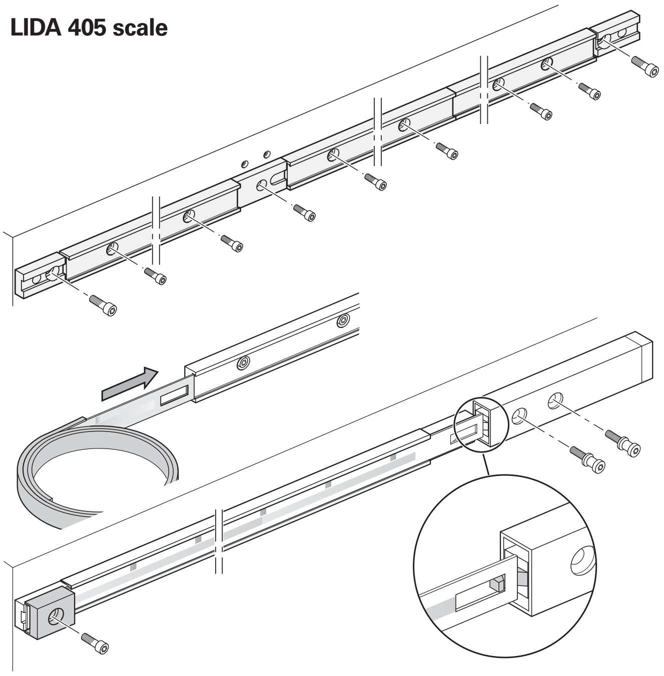
LIDA 4x5 series
Linear encoders of the LIDA 4x5 series are specially designed for large measuring lengths. They are mounted with scale carrier sections screwed onto the bearing surface or with PRECIMET adhesive film. Then the one-piece steel scale tape is pulled into the carrier, **tensioned,** and **fixed at its ends** to the machine bed. The LIDA 405 therefore shares the thermal behavior of its mounting surface.

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

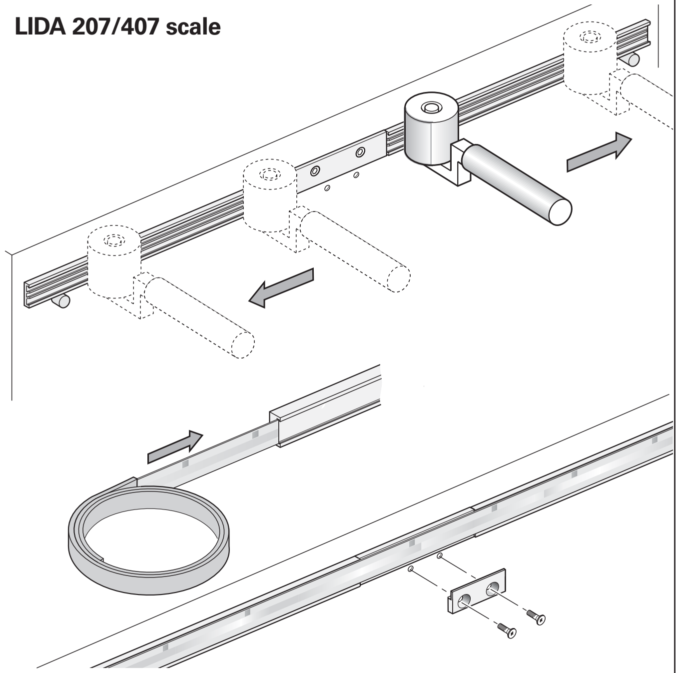
Accessory for LIDA 4x7
Mounting aid ID 373990-01

Mounting aid
(for LIDA 407)

LIDA 405 scale



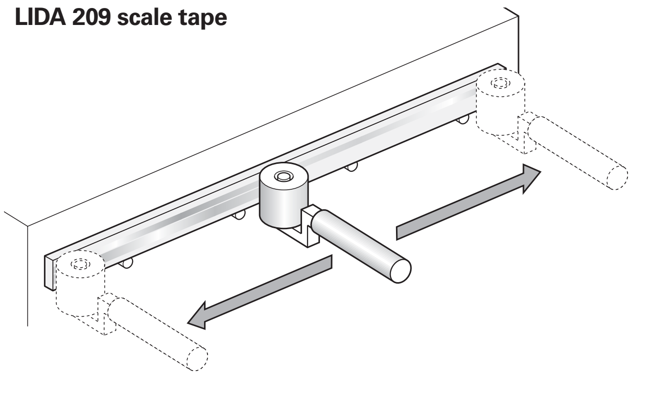
LIDA 207/407 scale



LIDA 2x9 series
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 3 mm high is to be used for horizontal alignment of the scale tape.

Accessory for versions with PRECIMET
Roller ID 276885-01

LIDA 209 scale tape



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, it is generally sufficient to provide oblong holes in an angle bracket.

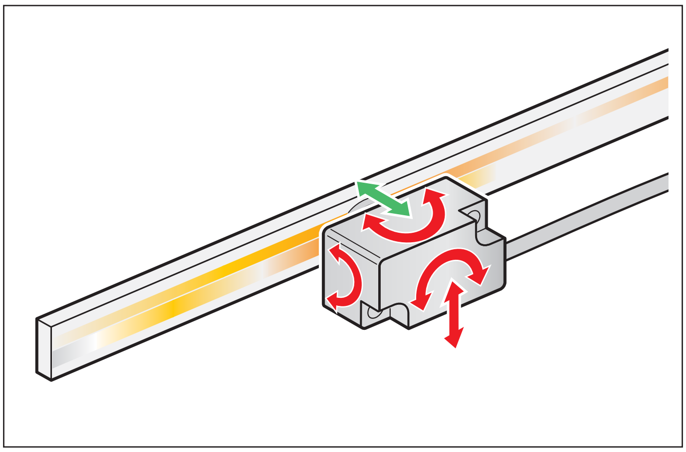
Mounting of LIP/LIF
The scanning head features a centering collar that allows it to be rotated in the location hole of the angle bracket and aligned parallel to the scale.

Mounting of LIDA
The scanning head is best mounted from behind on the mounting bracket. The LIDA 400 scanning head can be very precisely adjusted through a hole in the mounting bracket with the aid of a tool.

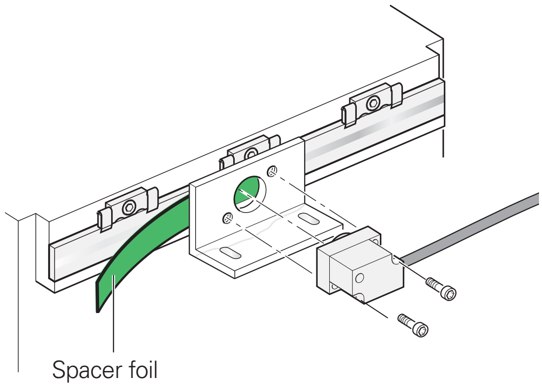
Adjustment
To simplify adjustment, HEIDENHAIN recommends the following procedure:

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).

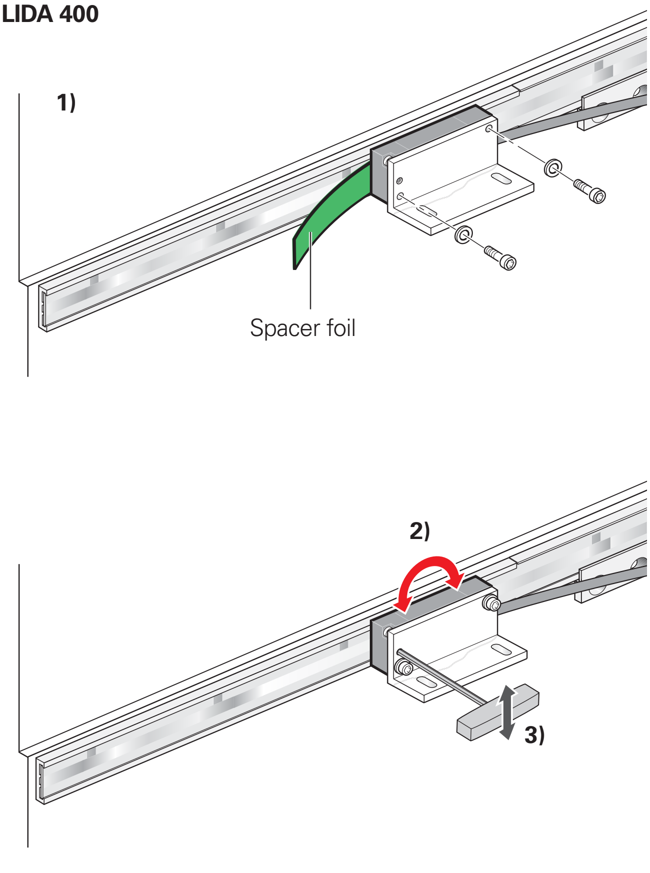
As adjustment aids, HEIDENHAIN offers the PWM 9 or PWT measuring and testing devices (see *HEIDENHAIN Measuring and Test Equipment*).



LIP/LIF



LIDA 400



General Mechanical Information

Mounting
To simplify cable routing, the scanning head is usually screwed onto a stationary machine part, 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 elements of the machine tool provide the best mounting surfaces in this respect; encoders should not be mounted on hollow parts or with adapter pieces.
- 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** from –20 °C to +70 °C is valid 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 (IEC 60529)
The scanning heads of the LIP, LIF and PP exposed linear encoders feature an IP 50 degree of protection, whereas the LIDA 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 **(IEC 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 **(IEC 60068-2-27).**
  Under no circumstances should a hammer or similar implement be used to adjust or position the encoder.

Expendable parts
In particular the following parts in encoders from HEIDENHAIN are subject to wear:

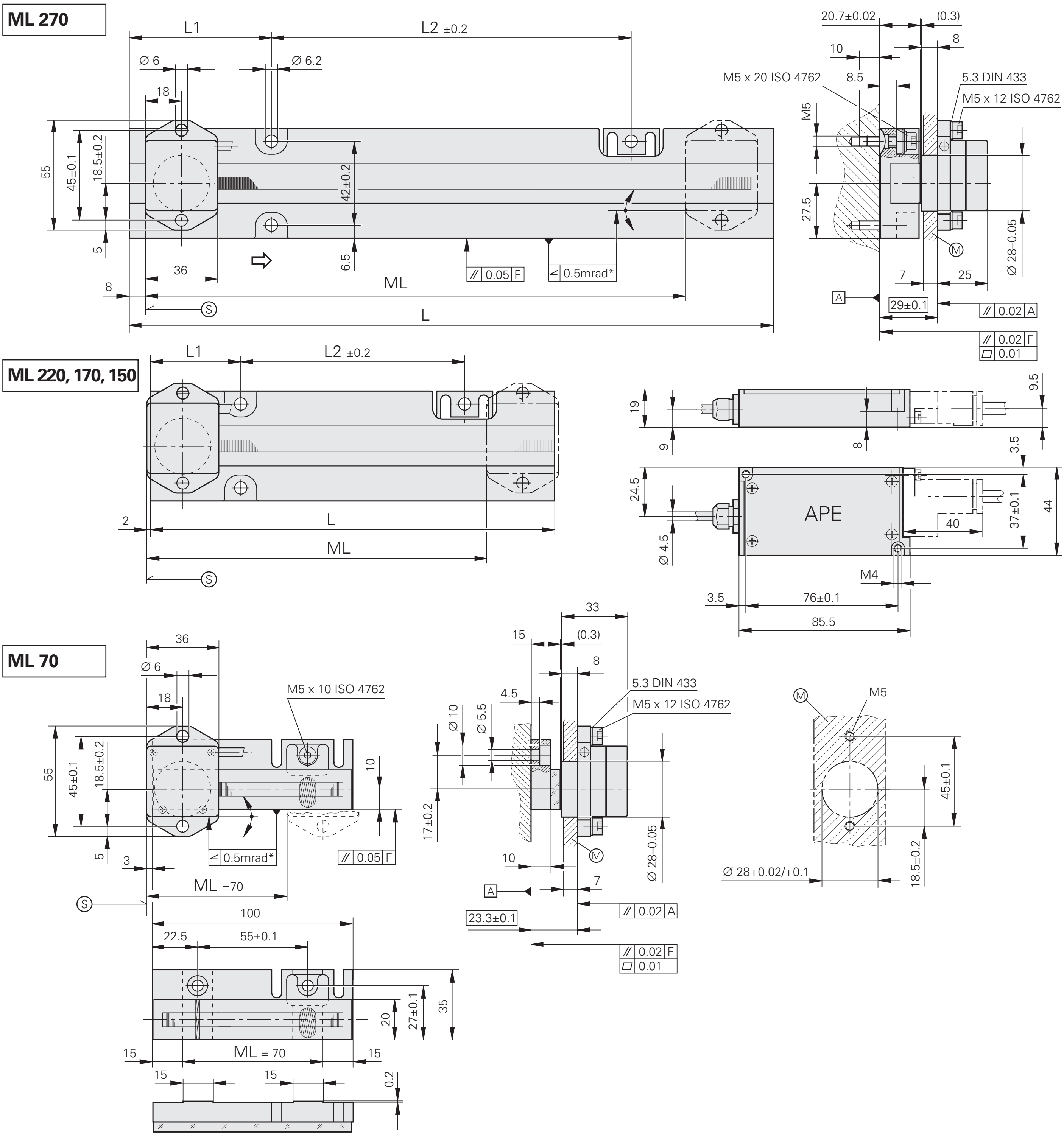
- LED light source
- Cables

System tests
Encoders from HEIDENHAIN are usually integrated as components in larger systems. Such applications require **comprehensive tests of the entire system** regardless of the specifications of the encoder.
The specifications given in the brochure apply to the specific encoder, not to the complete system. Any operation of the encoder outside of the specified range or for any other than the intended applications is at the user's own risk.
In safety-oriented systems, the higher-level system must verify the position value of the encoder after switch-on.

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

LIP 300 Series

Incremental linear encoders for very high accuracy
For measuring steps to 0.001 µm (1 nm)

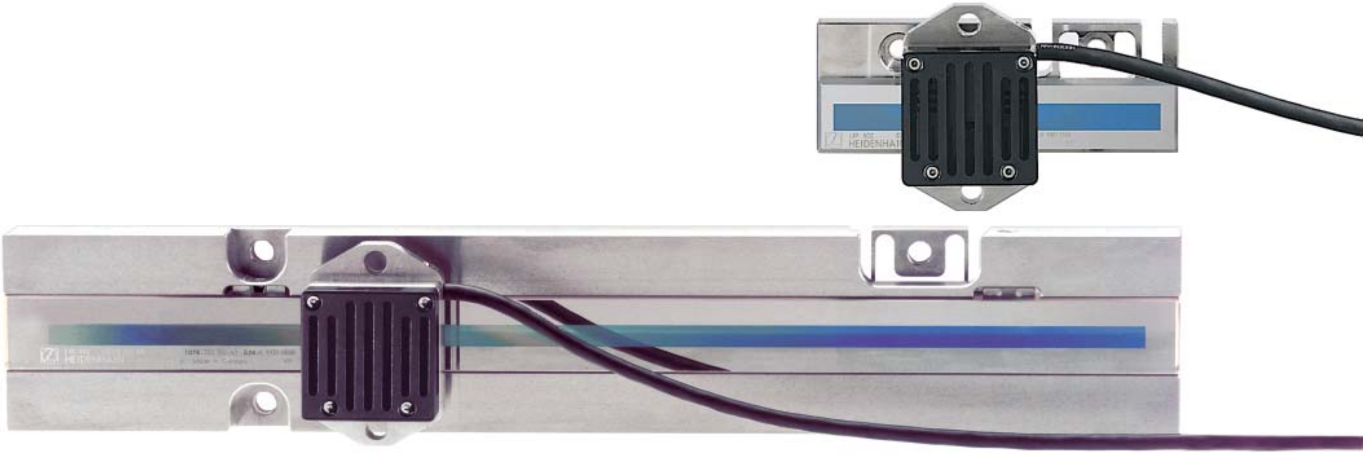


Dimensions in mm

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
⇨ = Direction of scanning head motion for output signals in accordance with interface description

ML	L	L1	L2
150	182	40	102
170	202	45	112
220	252	56	140
270	322	71	180



Specifications	LIP 382	LIP 372		
Measuring standard Expansion coefficient	DIADUR phase grating on Zerodur glass ceramic $\alpha_{therm} \approx 0 \cdot 10^{-6}\,K^{-1}$			
Accuracy grade	± 0.5 µm (higher accuracy grades available on request)			
Measuring length ML* in mm	70 150 170 220 270			
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 **Power consumption**	5 V ± 5% < 190 mA	5 V ± 5% < 250 mA (without load)		
Electrical connection	Cable 0.5 m to interface electronics (APE), sep. adapter cable (1 m/3 m/6 m/9 m) connectable to APE			
Cable length[1)]	≤ 30 m			
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 4 m/s^2 (IEC 60068-2-6) ≤ 50 m/s^2 (IEC 60068-2-27)			
Operating temperature	0 °C to 40 °C			
Weight Scanning head Interface electronics Scale Connecting cable	 150 g 100 g 260 g (ML 70 mm) 700 g (ML ≥ 150 mm) 38 g/m			

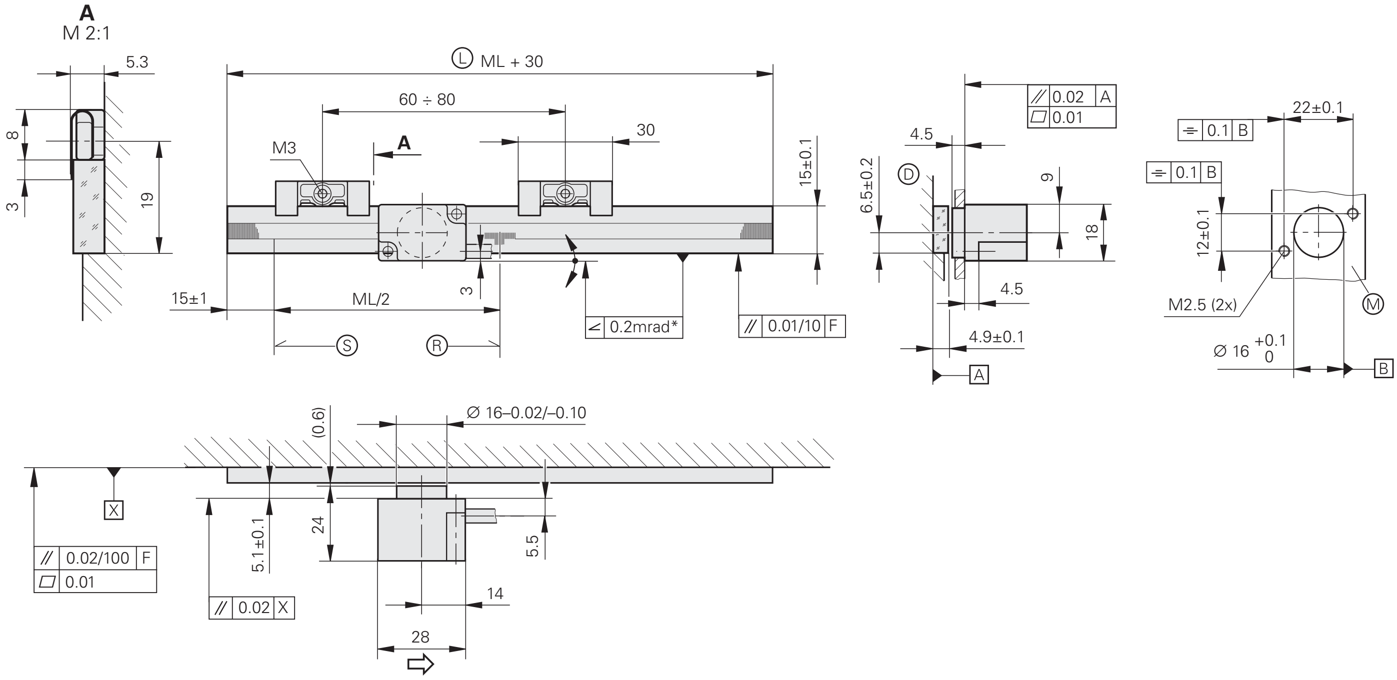
***** Please indicate when ordering
1) With HEIDENHAIN cable

LIP 400 Series

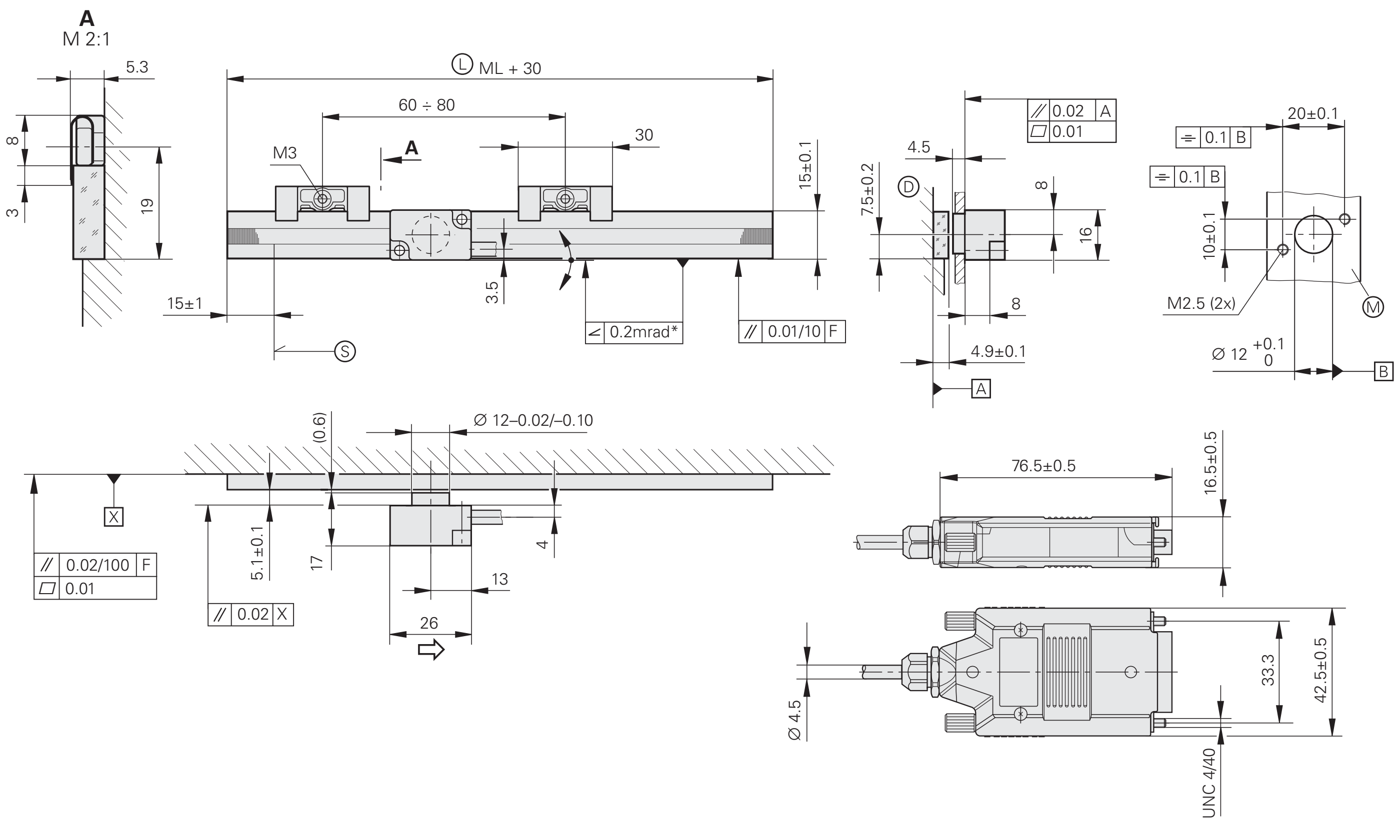
Incremental linear encoders for very high accuracy

- **For limited installation space**
- **For measuring steps of 1 µm to 0.005 µm**

LIP 471 R/LIP 481 R



LIP 471A/LIP 481A



Dimensions in mm

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

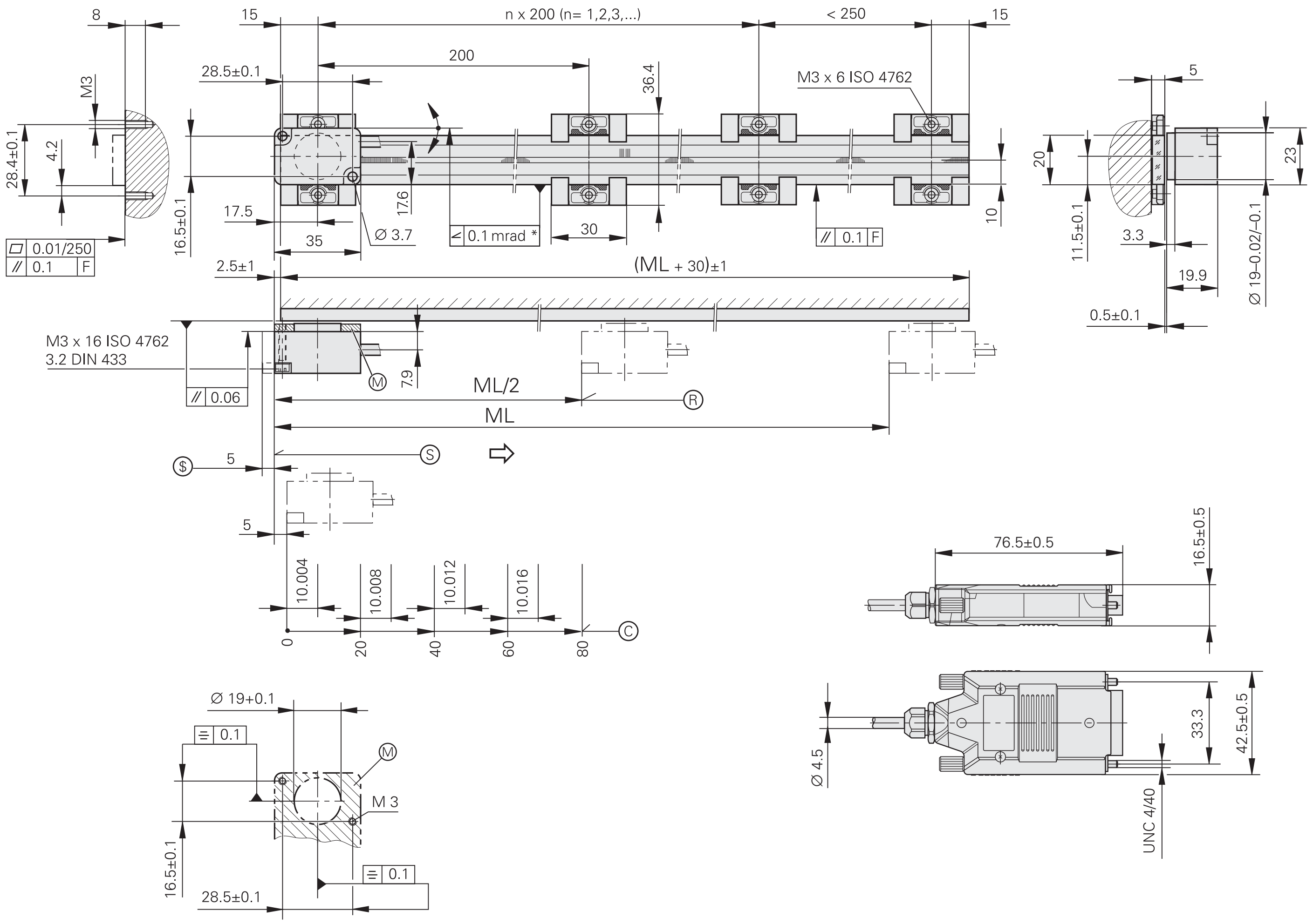
F = Machine guideway
* = Max. change during operation
Ⓡ = Reference-mark position on LIP 4x1 R
Ⓢ = Beginning of measuring length (ML)
⇨ = Direction of scanning head motion for output signals in accordance with interface description

Specifications	LIP 481	LIP 471					
Measuring standard* Expansion coefficient	DIADUR phase grating on Zerodur glass ceramic or glass $\alpha_{therm} \approx 0 \cdot 10^{-6}\ K^{-1}$ (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 **Power consumption**	5 V ± 5% < 190 mA	5 V ± 5% < 200 mA (without load)					
Electrical connection	Cable 0.5 m with D-sub connector (15-pin), interface electronics integrated in the connector						
Cable length[1)]	≤ 30 m	≤ 30 m					
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 200 m/s^2 (IEC 60068-2-6) ≤ 500 m/s^2 (IEC 60068-2-27)						
Operating temperature	0 °C to 40 °C						
Weight Scanning head Connector Scale Connecting cable	 25 g (LIP 4x1 A), 50 g (LIP 4x1 R), each without connecting cable 140 g 5.6 g + 0.2 g/mm measuring length 38 g/m						

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

LIP 500 Series

Incremental linear encoders for very high accuracy
- **For larger measuring lengths**
- **For measuring steps of 1 µm to 0.01 µm**



Dimensions in mm

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

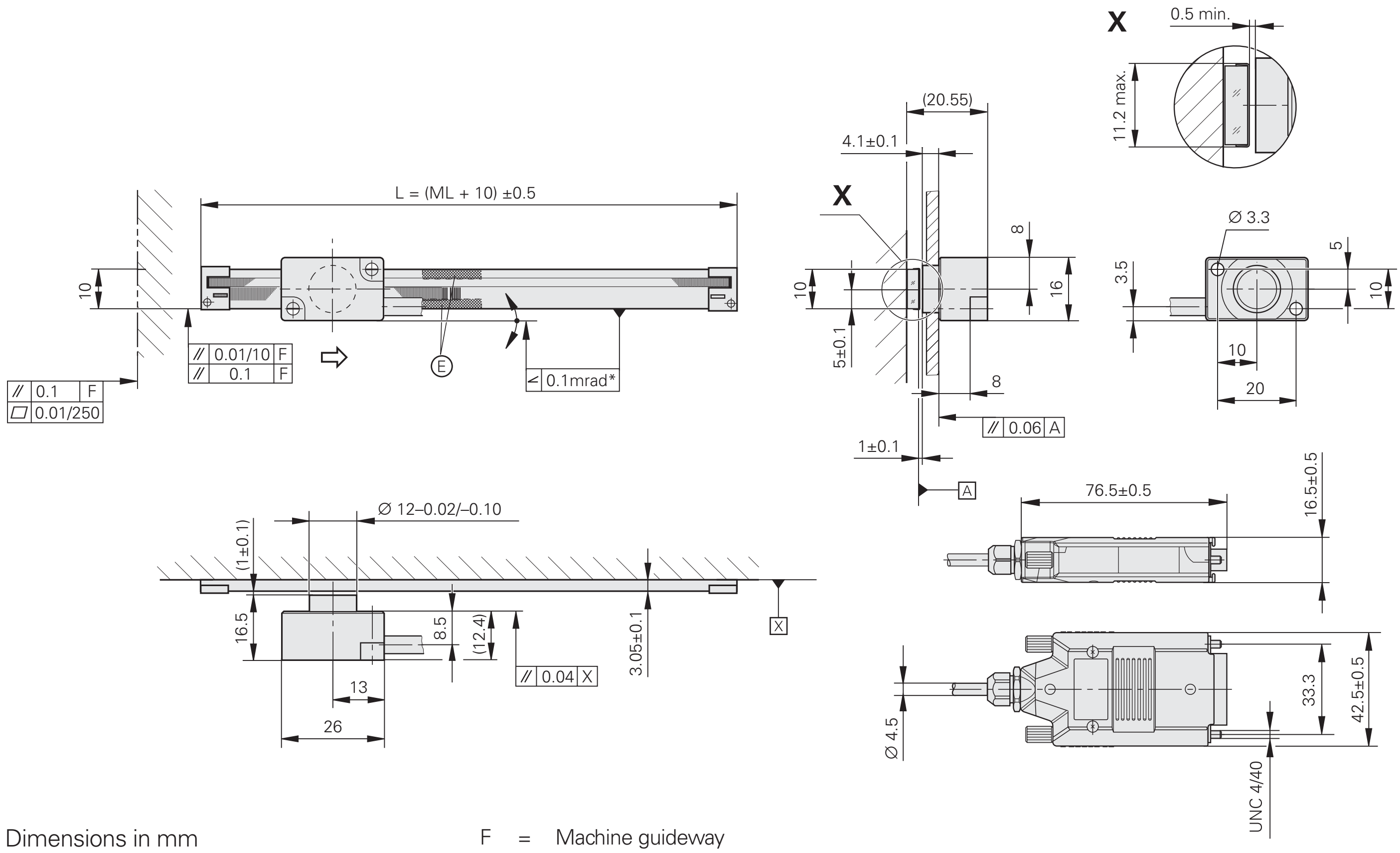
F = Machine guideway
* = Max. change during operation
Ⓡ = Reference-mark position on LIP 5x1 R
Ⓒ = Reference-mark position on LIP 5x1 C
Ⓢ = Beginning of measuring length (ML)
Ⓢ = Permissible overtravel
Ⓜ = Mounting surface for scanning head
⇨ = Direction of scanning head motion for output signals in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

Specifications	LIP 581	LIP 571					
Measuring standard Expansion coefficient	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 1 020 1 240 1 440						
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 **Power consumption**	5 V ± 5% < 175 mA	5 V ± 5% < 175 mA (without load)					
Electrical connection	Cable 0.5 m, 1 m, 2 m or 3 m with D-sub connector (15-pin), interface electronics integrated in connector						
Cable length[1)]	≤ 30 m						
Vibration 55 to 2 000 Hz **Shock** 11 ms	≤ 200 m/s² (IEC 60 068-2-6) ≤ 500 m/s² (IEC 60 068-2-27)						
Operating temperature	0 °C to 50 °C						
Weight Scanning head Connector Scale Connecting cable	 25 g (without connecting cable) 140 g 7.5 g + 0.25 g/mm measuring length 38 g/m						

* Please indicate when ordering
1) With HEIDENHAIN cable

LIF 400 Series

Incremental linear encoders for simple mounting with PRECIMET adhesive film
- **For measuring steps of 1 µm to 0.1 µm**
- **Position detection through homing track and limit switches**



Dimensions in mm

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

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

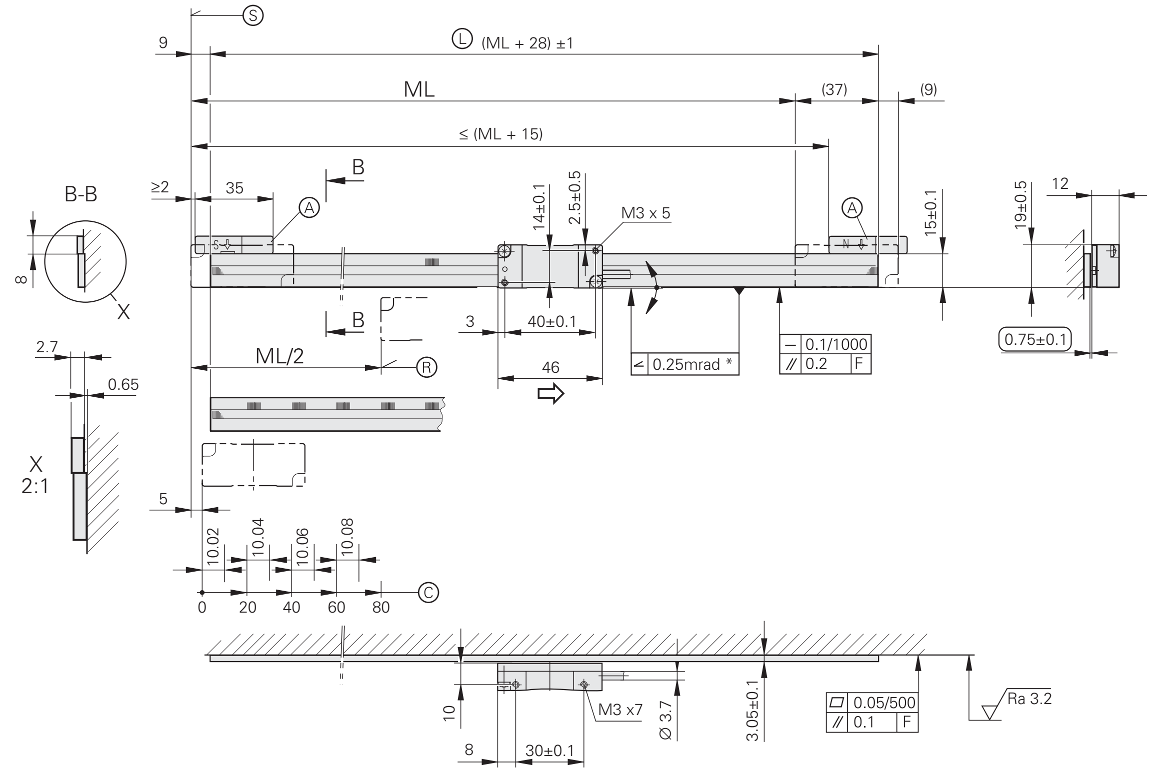
Specifications	LIF 481	LIF 471				
Measuring standard Expansion coefficient	SUPRADUR phase grating on glass $\alpha_{therm} \approx 8 \cdot 10^{-6}\ K^{-1}$					
Accuracy grade	± 3 µm					
Measuring length ML* in mm	70 120 170 220 270 320 370 420 470 520 570 620 670 720 770 820 870 920 970 1 020					
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 **Power consumption**	5 V ± 5% < 175 mA	5 V ± 5% < 180 mA (without load)				
Electrical connection*	Cable 0.5 m, 1m or 3 m with D-sub connector (15-pin), interface electronics integrated in the connector					
Cable length[2)]	*Incremental:* ≤ 30 m, *homing, limit:* ≤ 10 m					
Vibration 55 to 2 000 Hz **Shock** 11 ms	≤ 200 m/s² (IEC 60 068-2-6) ≤ 500 m/s² (IEC 60 068-2-27)					
Operating temperature	0 °C to 50 °C					
Weight Scanning head Connector Scale Connecting cable	 9 g (without connecting cable) 140 g 0.8 g + 0.08 g/mm measuring length 38 g/m					

***** Please indicate when ordering
1) At the corresponding cutoff or scanning frequency
2) With HEIDENHAIN cable

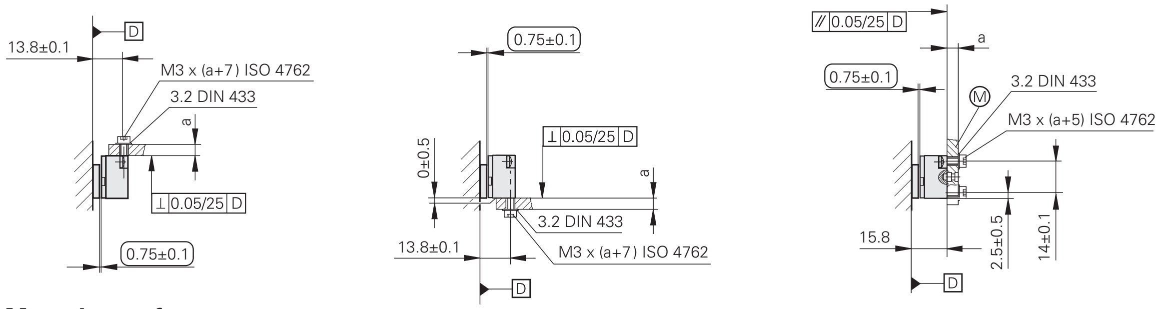
LIDA 4x3 Series

Incremental linear encoders with measuring standard of glass ceramic or glass

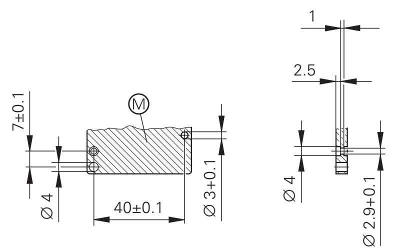
- **For measuring steps of 1 µm to 0.1 µm**
- **Measuring standard is fastened with adhesive to the mounting surface**
- **Limit switches**



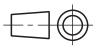
Possibilities for mounting the scanning head



Mounting surface



Dimensions in mm



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

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

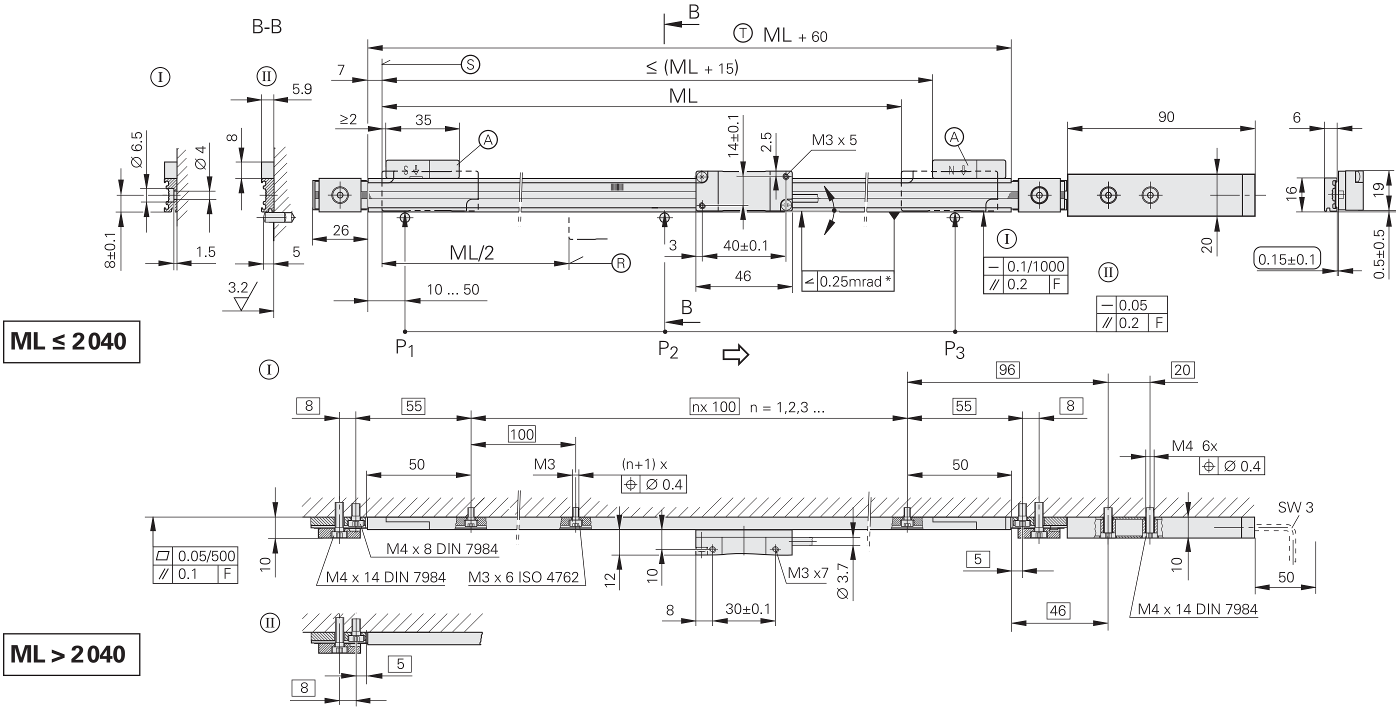
Specifications	LIDA 483	LIDA 473			
Measuring standard Expansion coefficient*	METALLUR graduation on glass ceramic or glass $\alpha_{therm} \approx 8 \cdot 10^{-6}$ K^{-1} (glass) $\alpha_{therm} \approx 0 \cdot 10^{-6}$ K^{-1} (ROBAX glass ceramic) $\alpha_{therm} = (0 \pm 0.1) \cdot 10^{-6}$ K^{-1} (Zerodur glass ceramic)				
Accuracy grade	± 5 µm (higher accuracy grades available on request)				
Measuring length ML* in mm	240 340 440 640 840 1 040 1 240 1 440 1 640 1 840 2 040 2 240 2 440 2 640 2 840 3 040 (ROBAX glass ceramic up to ML 1 640)				
Reference marks* *LIDA 4x3* *LIDA 4x3 C*	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*	–	≤ 200 kHz ≤ 100 kHz ≤ 50 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)	–	≥ 0.220 µs ≥ 0.465 µs ≥ 0.950 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	≤ 240 m/min ≤ 120 m/min ≤ 60 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 **Power consumption**	5 V ± 5% < 100 mA	5 V ± 5% < 170 mA (without load)		5 V ± 5% < 255 mA (without load)	
Electrical connection	Cable 3 m with D-sub connector (15-pin), interface electronics for LIDA 473 integrated in the connector				
Cable length 2)	≤ 20 m				
Vibration 55 to 2 000 Hz **Shock** 11 ms	≤ 200 m/s^2 (IEC 60 068-2-6) ≤ 500 m/s^2 (IEC 60 068-2-27)				
Operating temperature	0 °C to 50 °C				
Weight Scanning head Connector Scale Connecting cable	 20 g (without connecting cable) *LIDA 483:* 32 g, *LIDA 473:* 140 g 3 g + 0.1 g/mm measuring length 22 g/m				

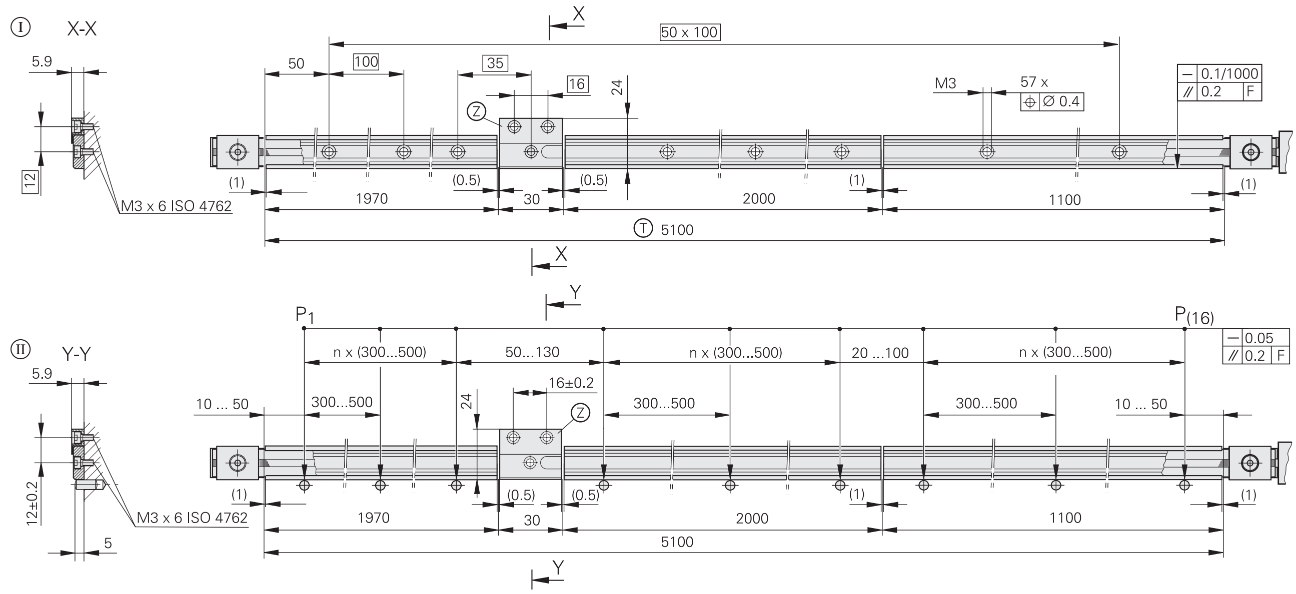
***** Please indicate when ordering 1) At the corresponding cutoff or scanning frequency 2) With HEIDENHAIN cable

LIDA 4x5 Series

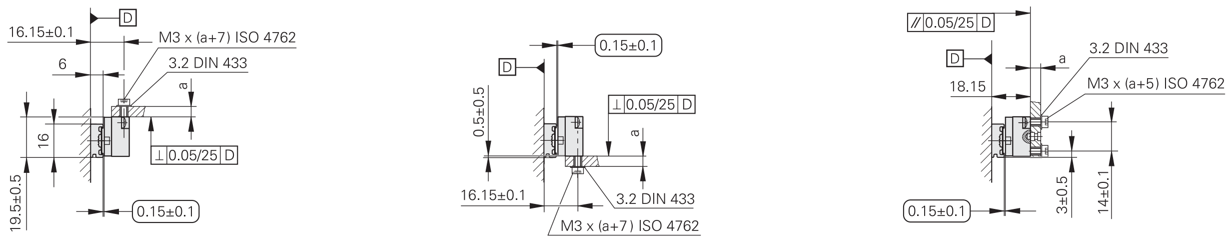
Incremental linear encoders for long measuring ranges up to 30 m

- **For measuring steps of 1 µm to 0.1 µm**
- **Large mounting tolerances**
- **Limit switches**





Possibilities for mounting the scanning head



Dimensions in mm

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

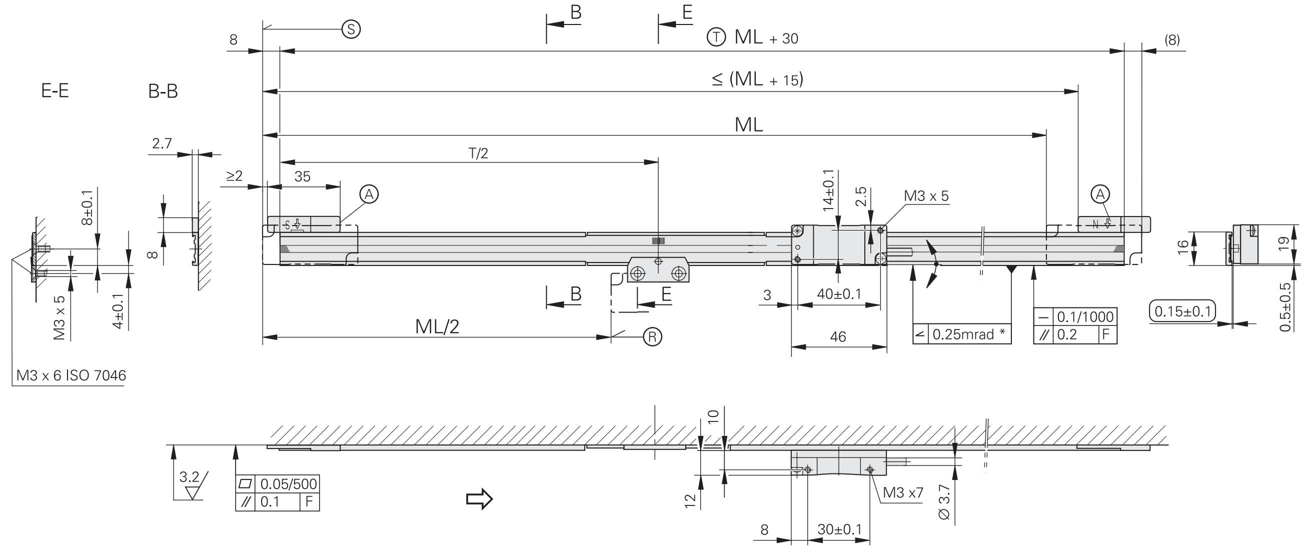
Ⓘ = Scale carrier sections fixed with screws
Ⓘⓘ = Scale carrier sections fixed with PRECIMET
F = Machine guideway
⬭ = Adjust or set
* = Max. change during operation
P = Gauging points for alignment
Ⓡ = Reference mark position
Ⓢ = Beginning of measuring length (ML)
Ⓐ = Selector magnet for limit switch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

Specifications	LIDA 485	LIDA 475			
Measuring standard Expansion coefficient	Steel scale tape with METALLUR graduation Depending on the mounting surface				
Accuracy grade	± 5 µm				
Measuring length ML* in mm	140 240 340 440 540 640 740 840 940 1 040 1 140 1 240 1 340 1 440 1 540 1 640 1 740 1 840 1 940 2 040				
	Larger measuring lengths up to 30 040 mm with a single-section scale tape and individual scale-carrier sections				
Reference marks	One at midpoint of measuring length				
Incremental signals	∿ 1 V_{PP}	⊓⊔ TTL			
Grating period	20 µm				
Integrated interpolation* 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*	–	≤ 200 kHz ≤ 100 kHz ≤ 50 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)]	–	≥ 0.220 µs ≥ 0.465 µs ≥ 0.950 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	≤ 240 m/min ≤ 120 m/min ≤ 60 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 **Power consumption**	5 V ± 5% < 100 mA	5 V ± 5% < 170 mA (without load)		5 V ± 5% < 255 mA (without load)	
Electrical connection	Cable 3 m with D-sub connector (15-pin), interface electronics for LIDA 475 integrated in the connector				
Cable length[2)]	≤ 20 m				
Vibration 55 to 2 000 Hz **Shock** 11 ms	≤ 200 m/s^2 (IEC 60 068-2-6) ≤ 500 m/s^2 (IEC 60 068-2-27)				
Operating temperature	0 °C to 50 °C				
Weight Scanning head Connector Scale Connecting cable	 20 g (without connecting cable) *LIDA 485:* 32 g, *LIDA 475:* 140 g 115 g + 0.25 g/mm measuring length 22 g/m				

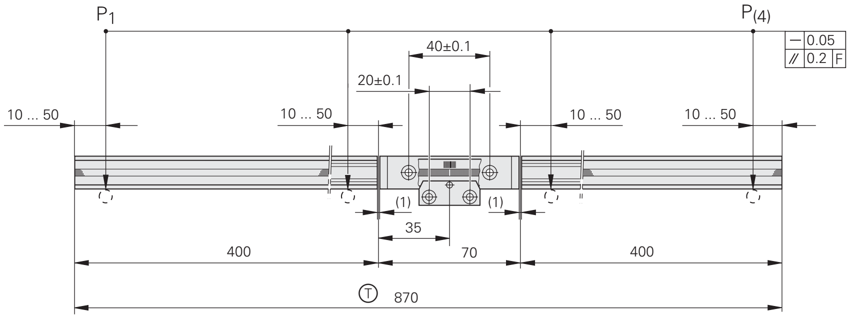
***** Please indicate when ordering [1)] At the corresponding cutoff or scanning frequency [2)] With HEIDENHAIN cable

LIDA 4x7 Series

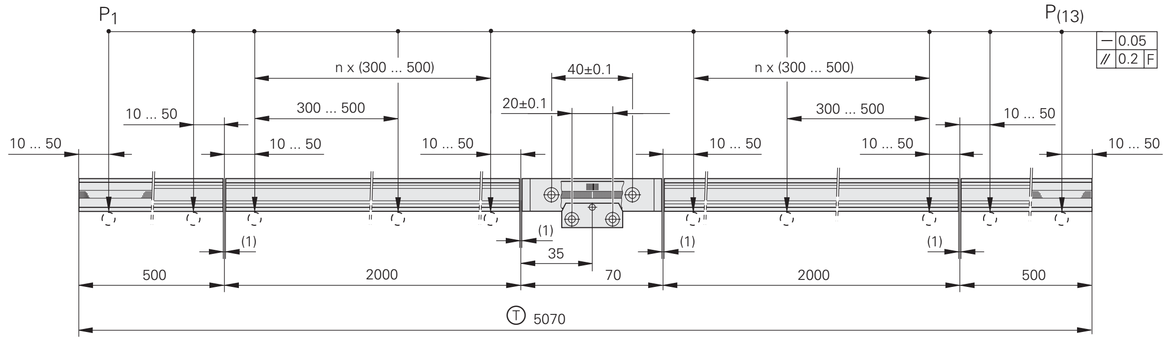
Incremental linear encoders for measuring ranges up to 6 m
- **For measuring steps of 1 µm to 0.1 µm**
- **Large mounting tolerances**
- **Limit switches**



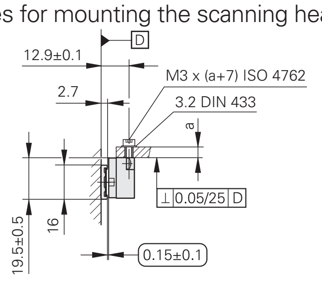
ML ≤ 2040

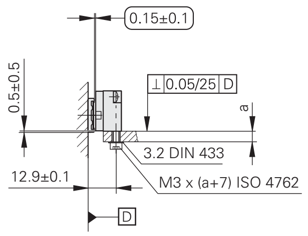


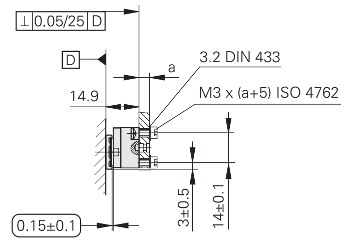
ML > 2040



Possibilities for mounting the scanning head







Dimensions in mm

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

F = Machine guideway
⬭ = Adjust or set
* = Max. change during operation
P = Gauging points for alignment
Ⓡ = Reference mark position
Ⓢ = Beginning of measuring length (ML)
Ⓐ = Selector magnet for limit switch
Ⓣ = Carrier length

⇨ = Direction of scanning head motion for output signals in accordance with interface description

Specifications	LIDA 487	LIDA 477			
Measuring standard Expansion coefficient	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 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				
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*	–	≤ 200 kHz ≤ 100 kHz ≤ 50 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)	–	≥ 0.220 µs ≥ 0.465 µs ≥ 0.950 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	≤ 240 m/min ≤ 120 m/min ≤ 60 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 **Power consumption**	5 V ± 5% < 100 mA	5 V ± 5% < 170 mA (without load)		5 V ± 5% < 255 mA (without load)	
Electrical connection	Cable 3 m with D-sub connector (15-pin), interface electronics for LIDA 477 integrated in the connector				
Cable length 2)	≤ 20 m				
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 200 m/s^2 (IEC 60068-2-6) ≤ 500 m/s^2 (IEC 60068-2-27)				
Operating temperature	0 °C to 50 °C				
Weight Scanning head Connector Scale Connecting cable	 20 g (without connecting cable) *LIDA 487:* 32 g, *LIDA 477:* 140 g 25 g + 0.1 g/mm measuring length 22 g/m				

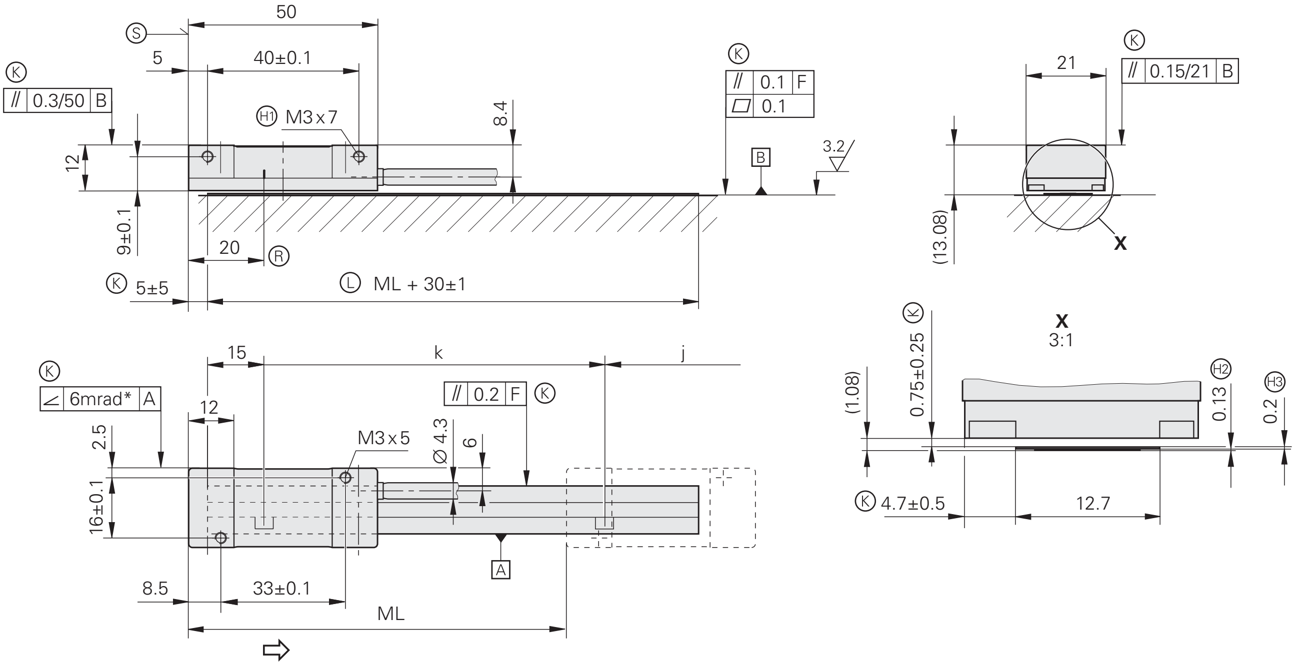
***** Please indicate when ordering
1) At the corresponding cutoff or scanning frequency
2) With HEIDENHAIN cable

LIDA 200 Series

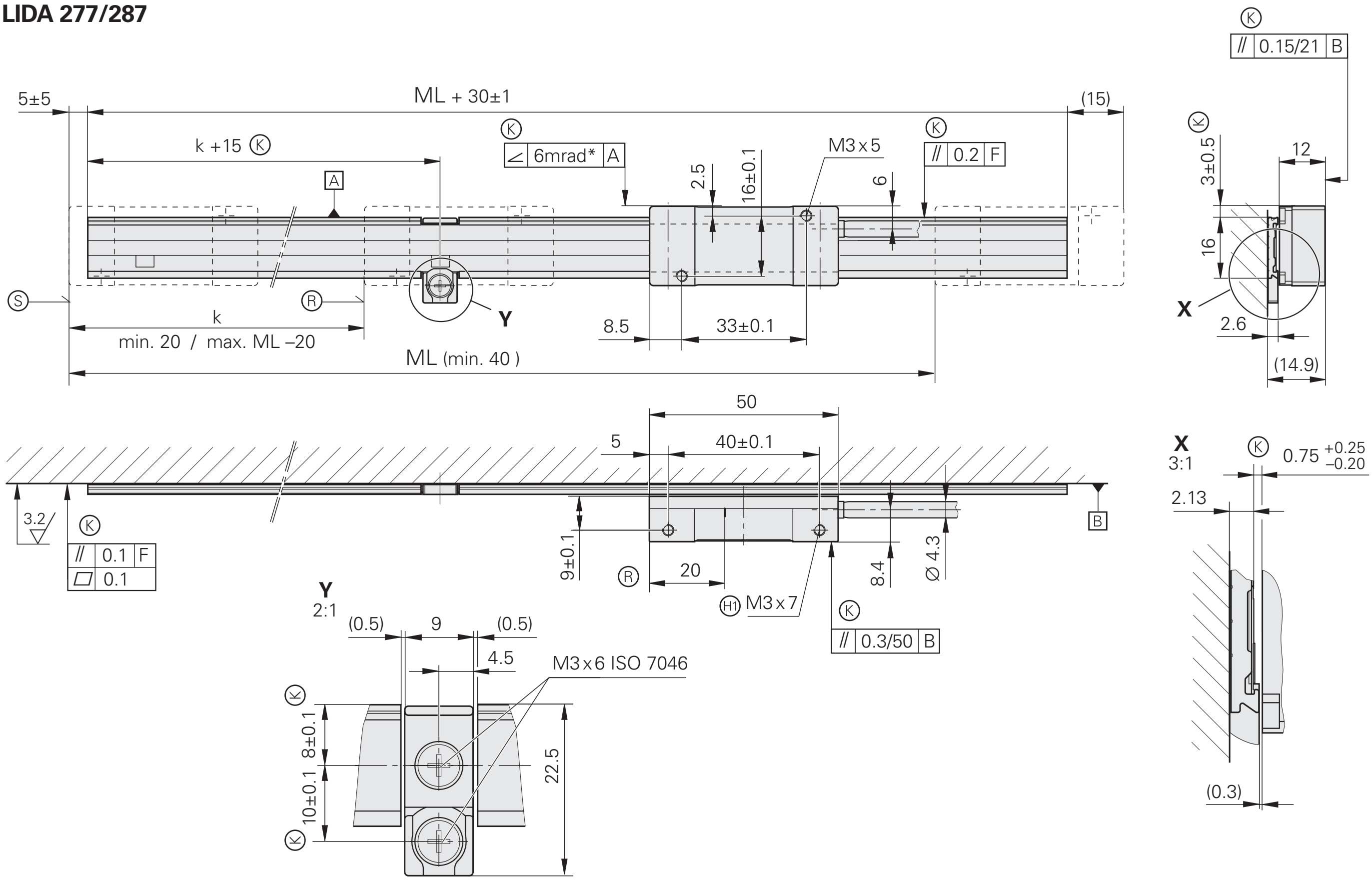
Incremental linear encoder with large mounting tolerance

- **For measuring steps to 0.5 µm**
- **Scale tape cut from roll**
- **Scale tape attached via cementable scale-tape carrier (LIDA 2x7) or by cementing to the mounting surface (LIDA 2x9)**
- **Reference marks at regular intervals**

LIDA 279/289



LIDA 277/287



Dimensions in mm

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

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
⇨ = Direction of scanning head 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

LIDA 279

LIDA 277

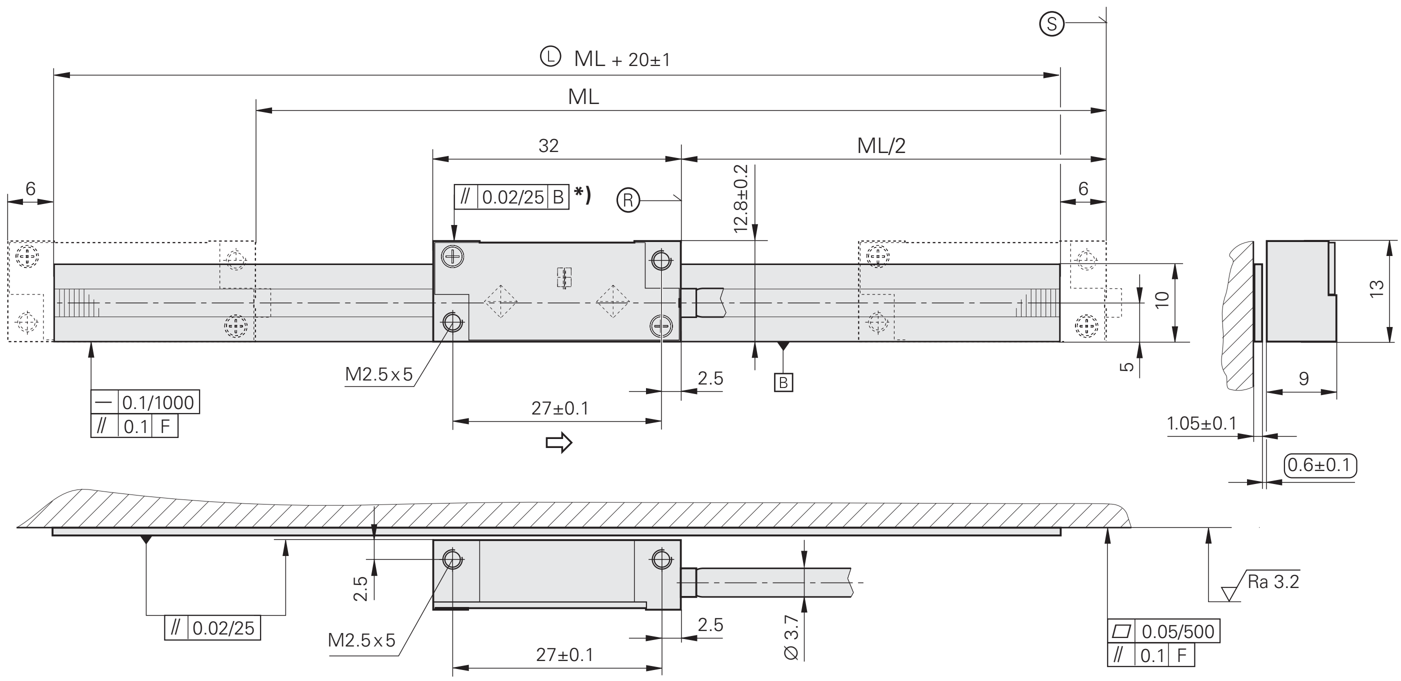
Specifications	**LIDA 287** **LIDA 289**	**LIDA 277** **LIDA 279**		
Measuring standard Expansion coefficient	Steel scale tape $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$			
Accuracy grade	± 30 µm			
Scale tape cut from roll*	3 m, 5 m, 10 m			
Reference marks	Selectable every 100 mm			
Incremental signals	∿ 1 V_{PP}	TTL x10	TTL x 50	TTL x 100
Grating period Integrated interpolation* Signal period	200 µm – 200 µm	200 µm 10-fold 20 µm	200 µm 50-fold 4 µm	200 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	
Power supply **Power consumption**	5 V ± 5% < 110 mA	5 V ± 5% < 140 mA (without load)		
Electrical connection	Cable 3 m with D-sub connector (15-pin)			
Cable length[1)]	≤ 30 m			
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 200 m/s^2 (IEC 60068-2-6) ≤ 500 m/s^2 (IEC 60068-2-27)			
Operating temperature	0 °C to 50 °C			
Weight Scanning head Scale tape Scale-tape carrier Connector Cable	 20 g (without cable) 20 g/m 70 g/m (only for LIDA 2x7) 32 g 30 g/m			

* Please indicate when ordering
[1)] With HEIDENHAIN cable

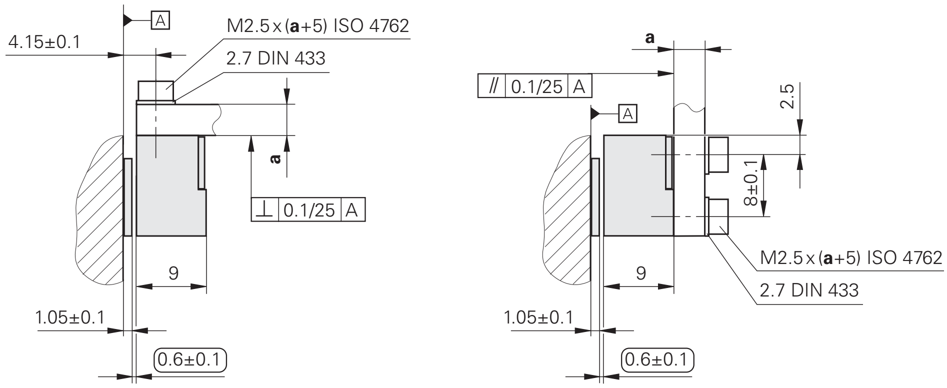
LIDA 500 Series

Incremental linear encoders for limited installation space

- **For measuring steps of 1 µm to 0.1 µm**
- **Simple mounting with PRECIMET adhesive film**
- **Large mounting tolerances**



Possibilities for mounting the scanning head

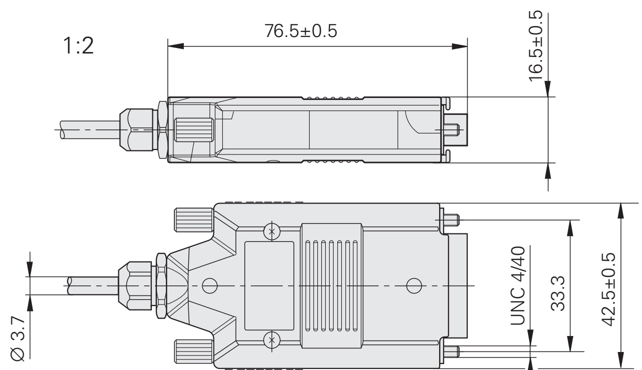


F = Machine guideway
Ⓡ = Reference mark
Ⓛ = Scale tape length
Ⓢ = Beginning of measuring length (ML)
⬭ = Adjust
*) = Or adjust to max. signal or reference mark position
⇨ = Direction of scanning head motion for output signals in accordance with interface description

Dimensions in mm

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

D-sub connector for LIDA 573

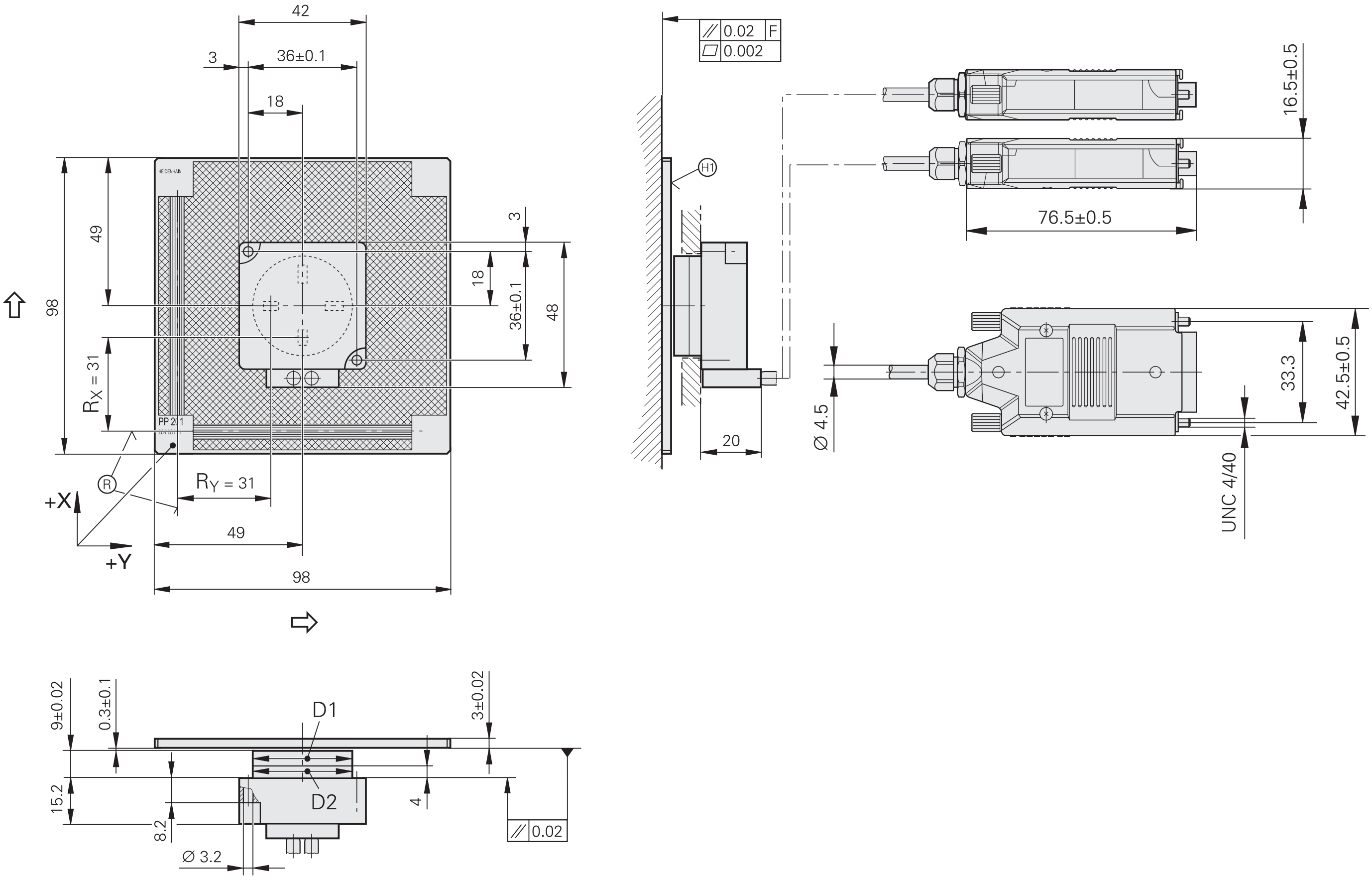


Specifications	LIDA 583	LIDA 573			
Measuring standard Expansion coefficient	METALLUR graduation on glass $\alpha_{therm} \approx 8 \cdot 10^{-6}\ K^{-1}$				
Accuracy grade	± 5 µm				
Measuring length ML* in mm	70 120 170 220 270 320 370 420 470 520 570 620 670 720 770 820 870 920 970 1 020				
Reference marks	One at midpoint of measuring length				
Incremental signals	∿ 1 V_{PP}	⊓⊔ TTL x 5	⊓⊔ TTL x 10	⊓⊔ TTL x 25	⊓⊔ TTL x 50
Grating period Integrated interpolation* Signal period	20 µm – 20 µm	20 µm 5-fold 4 µm	20 µm 10-fold 2 µm	20 µm 25-fold 0.8 µm	20 µm 50-fold 0.4 µm
Cutoff frequency Scanning frequency Edge separation a	≥ 250 kHz – –	– ≤ 200 kHz ≥ 0.220 µs	– ≤ 100 kHz ≥ 0.220 µs	– ≤ 50 kHz ≥ 0.175 µs	– ≤ 25 kHz ≥ 0.175 µs
Traversing speed	≤ 300 m/min	≤ 240 m/min	≤ 120 m/min	≤ 60 m/min	≤ 30 m/min
Power supply **Power consumption**	5 V ± 5% < 100 mA	5 V ± 5% < 200 mA (without load)			
Electrical connection	Cable 3 m with D-sub connector (15-pin), *LIDA 573:* interface electronics integrated in the connector				
Cable length[1)]	≤ 30 m				
Vibration 55 to 2 000 Hz **Shock** 11 ms	200 m/s^2 500 m/s^2				
Operating temperature	0 °C to 50 °C				
Weight Scanning head Scale tape Connector Cable	 6 g (without cable) 26 g/m *LIDA 583:* 32 g, *LIDA 573:* 140 g 22 g/m				

* Please indicate when ordering
1) With HEIDENHAIN cable

PP 200 Series

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

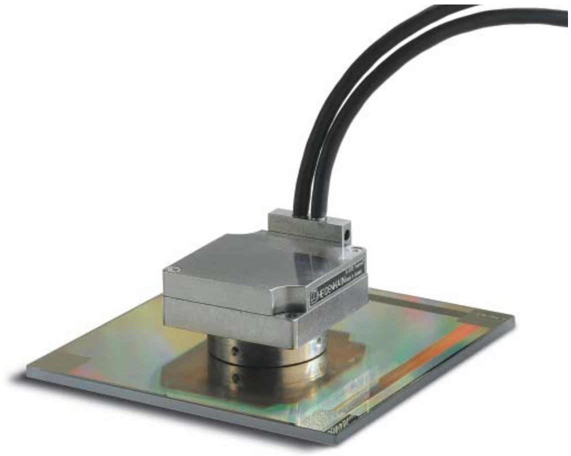


Dimensions in mm

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

F = Machine guideway
H1 = Graduation side
R = Reference mark position relative to center position shown
⇨ = Direction of scanning head 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	PP 271 R					
Measuring standard Expansion coefficient	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}	⊓⊔ 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 **Power consumption**	5 V ± 5% < 185 mA per axis	5 V ± 5% < 240 mA per axis (without load)					
Electrical connection	Cable 0.5 m with D-sub connector (15-pin), interface electronics integrated in the connector						
Cable length[2]	≤ 30 m	≤ 30 m					
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 80 m/s² (IEC 60068-2-6) ≤ 100 m/s² (IEC 60068-2-27)						
Operating temperature	0 °C to 50 °C						
Weight Scanning head Connector Grid plate Connecting cable	 170 g 140 g 75 g 37 g/m						

***** Please indicate when ordering
[1] The zero crossovers K, L of the reference-mark signal deviate from the interface specification (see the mounting instructions)
[2] With HEIDENHAIN cable

Interfaces

Incremental Signals ~ $1\,V_{PP}$

HEIDENHAIN encoders with ~ $1\text{-}V_{PP}$ interface provide voltage signals that can be highly interpolated.

The sinusoidal **incremental signals** A and B are phase-shifted by 90° elec. and have an amplitude 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.

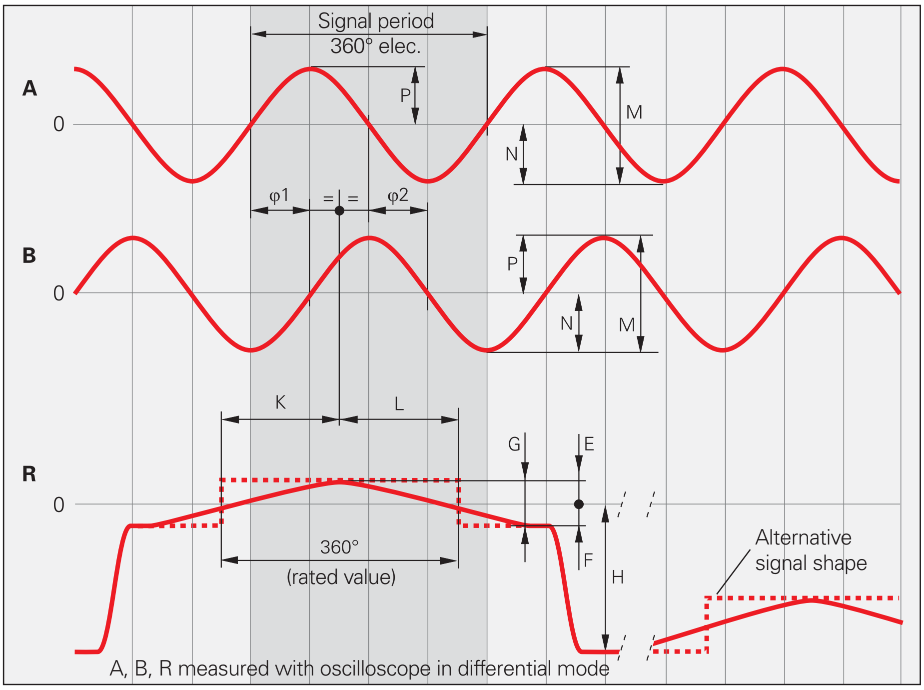
Measuring steps for **position measurement** are recommended in the specifications. For special applications, other resolutions are also possible.

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.

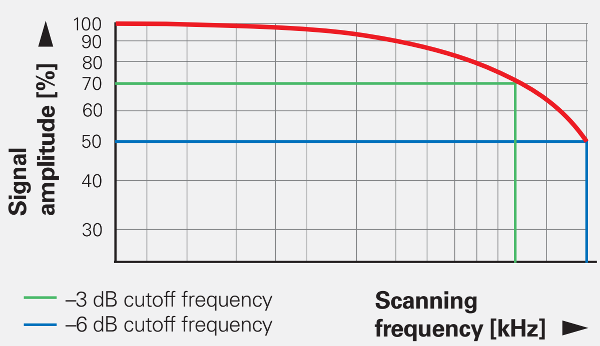
Short circuit at	20 °C	125 °C
One output	< 3 min	< 1 min
All outputs	< 20 s	< 5 s

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
	Signal 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	HEIDENHAIN cable with shielding PUR [4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)]	
Cable length	max. 150 m with 90 pF/m distributed capacitance	
Propagation time	6 ns/m	

These values can be used for dimensioning of the subsequent electronics. Any limited tolerances in the encoders are listed in the specifications. For encoders without integral bearing, reduced tolerances are recommended for initial servicing (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
$Z_0 = 120\ \Omega$
$R_1 = 10\ k\Omega$ and $C_1 = 100\ pF$
$R_2 = 34.8\ k\Omega$ and $C_2 = 10\ pF$
$U_B = \pm 15\ V$
U_1 approx. U_0

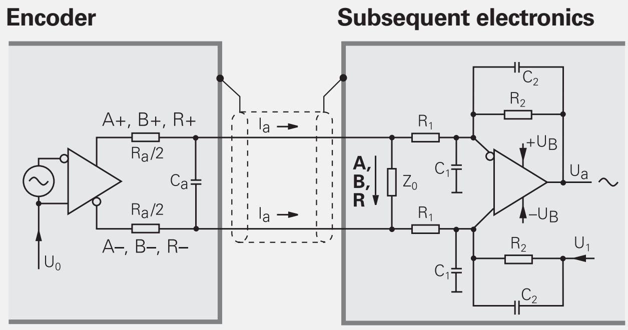
–3dB cutoff frequency of circuitry
Approx. 450 kHz
Approx. 50 kHz and $C_1 = 1000\ pF$
and $C_2 = 82\ pF$
The circuit variant for 50 kHz does reduce the bandwidth of the circuit, but in doing so it improves its noise immunity.

Output signals of the circuit
$U_a = 3.48\ V_{PP}$ typical
Gain 3.48

Monitoring the incremental signals
The following threshold sensitivities are recommended for signal monitoring:
Minimum signal amplitude M: $0.30\ V_{PP}$
Maximum signal amplitude M: $1.35\ V_{PP}$

Incremental signals
Reference-mark signal

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



Interfaces
Incremental Signals ⊓⊔ TTL

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

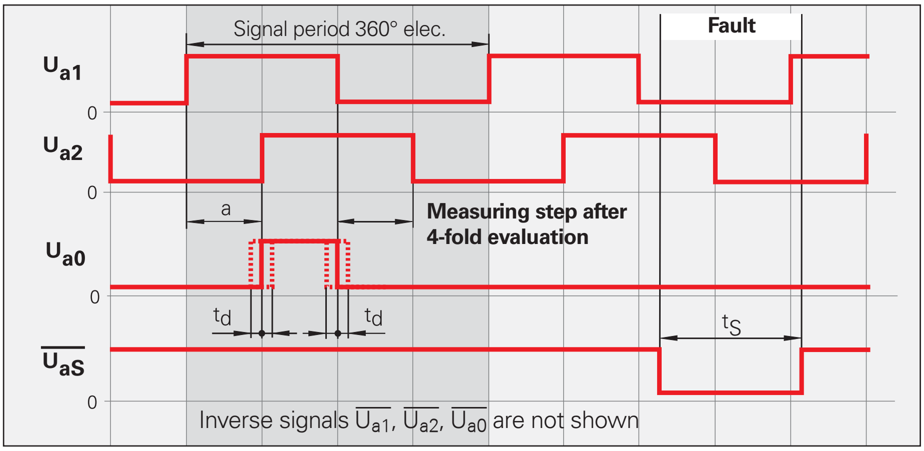
The **incremental signals** are transmitted as the square-wave pulse trains U_{a1} and U_{a2}, phase-shifted by 90° elec. The **reference mark signal** consists of one or more reference pulses U_{a0}, which are gated with the incremental signals. In addition, the integrated electronics produce their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

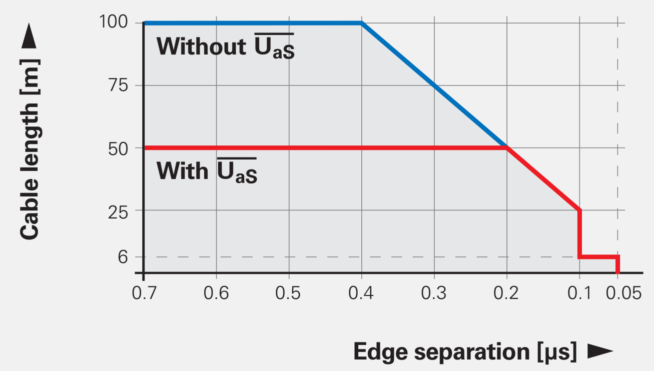
The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum **edge separation a** listed in the *Specifications* applies for the illustrated input circuitry with a cable length of 1 m, and refers to a measurement at the output of the differential line receiver.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

Interface	Square-wave signals **⊓⊔ TTL**
Incremental signals	**2 TTL 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 $U_L \leq 0.5$ V at $I_L = 20$ mA
Permissible load	$Z_0 \geq 100\ \Omega$ between associated outputs $\|I_L\| \leq 20$ mA max. load per output $C_{load} \leq 1000$ 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 cable Cable length Propagation time	HEIDENHAIN cable with shielding PUR [4(2 × 0.14 mm²) + (4 × 0.5 mm²)] Max. 100 m ($\overline{U_{aS}}$ max. 50 m) with 90 pF/m distributed capacitance 6 ns/m



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

Permissible cable length
with respect to the edge separation

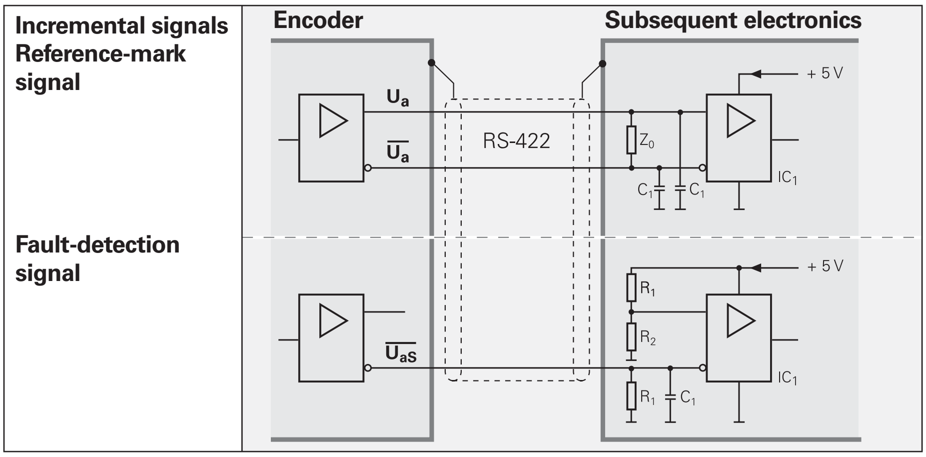


Input circuitry of the subsequent electronics

Dimensioning

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

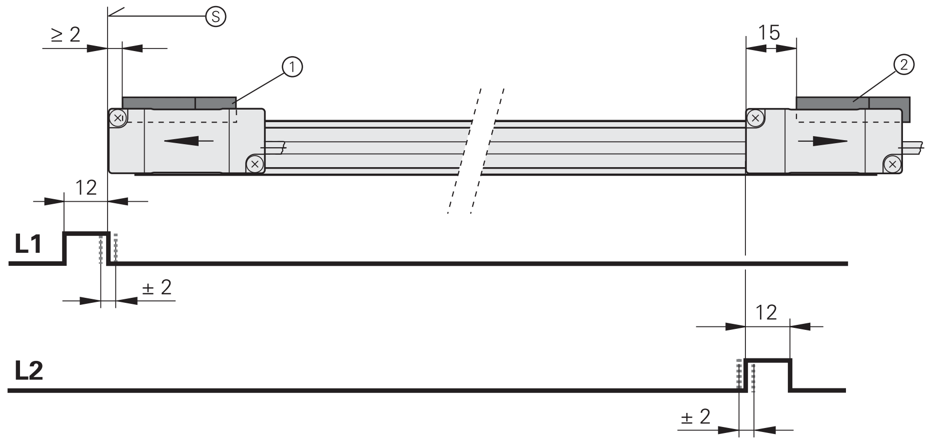
R_1 = 4.7 kΩ
R_2 = 1.8 kΩ
Z_0 = 120 Ω
C_1 = 220 pF (serves to improve noise immunity)



Interfaces
Limit Switches

LIDA 400 encoders are equipped with limit switches that make limit-position detection and the design 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 10 kΩ load resistance 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	



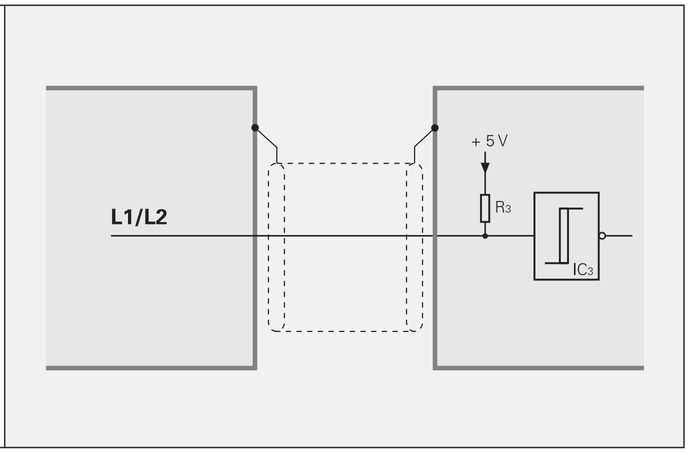
L1/L2 = Output signals from limit switches 1 and 2
Tolerance of the trigger edge: ± 2 mm

Ⓢ = 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

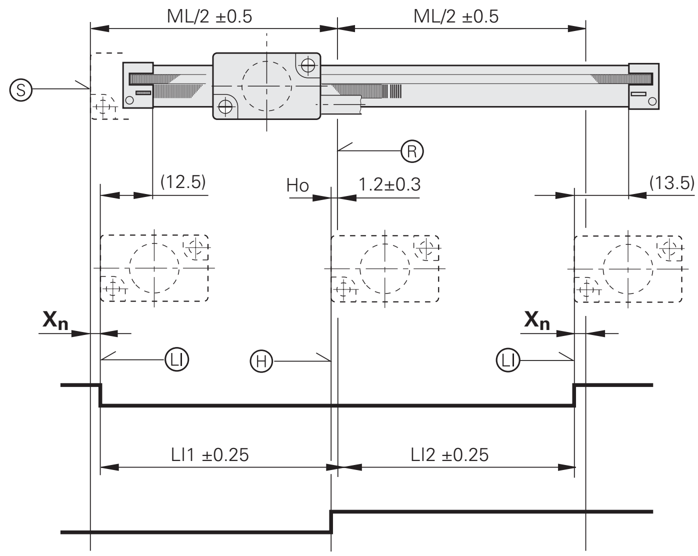
Limit switches LIDA 400



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



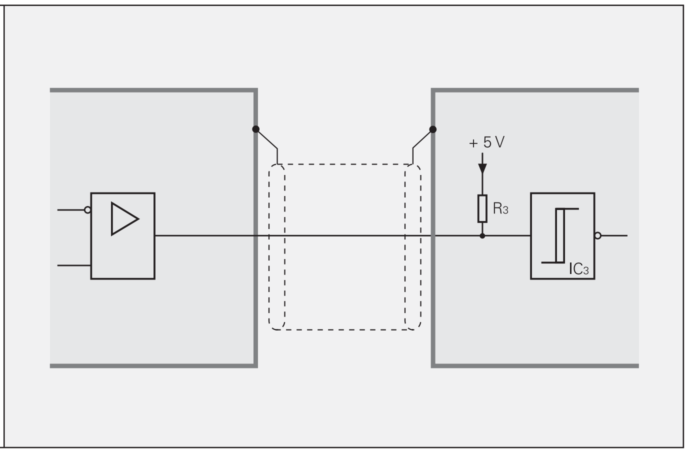
X_n =
Var. 01 **X_1** = 2 mm
Var. 02 **X_2** = 14 mm
Var. 03 **X_3** = 22 mm

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

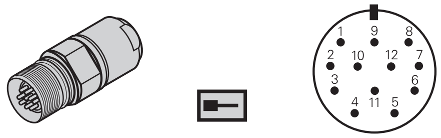
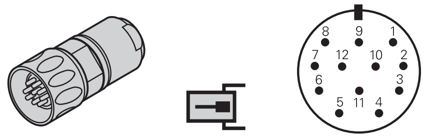
Recommended input circuitry of the subsequent electronics

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

Limit switches
Homing track
LIF 400



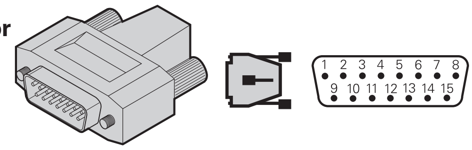
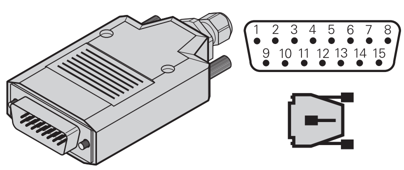
Interfaces
Electrical Connection

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 internally 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 internally with the corresponding power line
Vacant pins or wires must not be used

1) TTL/11 µA_{PP} conversion for PWT. Not with LIDA 27x
2) Only for LIDA 4xx;
Color assignment applies only to connecting cable
3) Only for LIF 481

IK 220
Universal PC counter card
The IK 220 is an expansion board for AT-compatible PCs for recording the measured values of **two incremental or absolute linear or angle encoders.** The subdivision and counting electronics **subdivide** the **sinusoidal input signals** to generate up to **4096 measuring steps.** A driver software package is included in delivery.

For more information, see the *IK 220 Product Information* sheet.

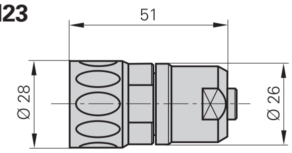
	IK 220			
Input signals (switchable)	∼ 1 V_{PP}	∼ 11 μA_{PP}	EnDat 2.1	SSI
Encoder inputs	2 D-sub connections (15-pin) male			
Max. input frequency	500 kHz	33 kHz	–	
Max. cable length	60 m		10 m	
Signal subdivision (signal period : meas. step)	Up to 4 096-fold			
Data register for measured values (per channel)	48 bits (44 bits used)			
Internal memory	For 8 192 position values			
Interface	PCI bus (plug and play)			
Driver software and demonstration program	**For Windows 98/NT/2000/XP** in VISUAL C++, VISUAL BASIC and BORLAND DELPHI			
Dimensions	Approx. 190 mm × 100 mm			

Cables and Connecting Elements
General Information

Connector (insulated): Connecting element with coupling ring; available with male or female contacts.

Symbols

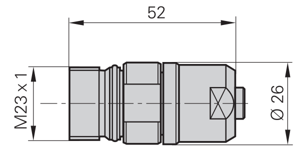
M23



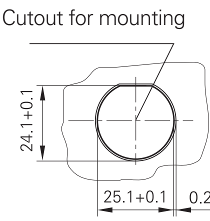
Coupling (insulated): Connecting element with external thread; available with male or female contacts.

Symbols

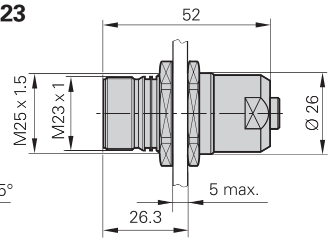
M23



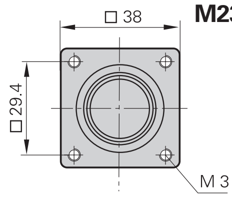
Mounted coupling with central fastening



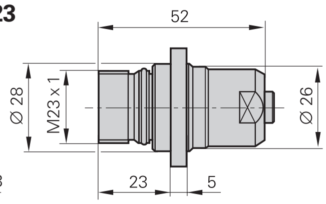
M23



Mounted coupling with flange



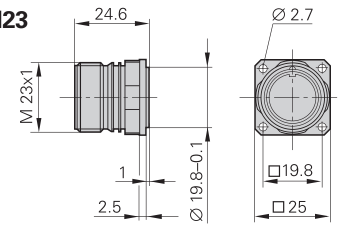
M23



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

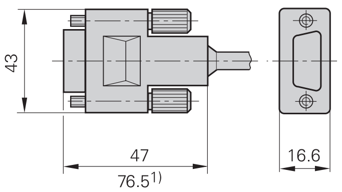
Symbols

M23



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

Symbols



1) with integrated interpolation electronics

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

male contacts or

female contacts.

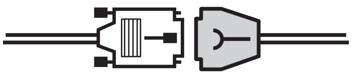
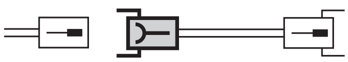
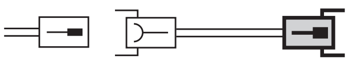
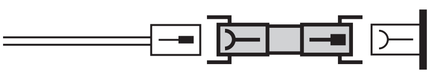
When engaged, the connections provide **protection** to IP 67 (D-sub connector: IP 50; IEC 60529). When not engaged, there is no protection.

Accessories for flange sockets and M23 mounted couplings

Bell seal
ID 266526-01

Threaded metal dust cap
ID 219926-01

Connecting Cables

		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)		331693-xx	355215-xx	–	–
With **one** D-sub connector (female)		332433-xx	355209-xx	354411-xx	355398-xx
Complete with D-sub connectors (female and male)		335074-xx	355186-xx	354379-xx	355397-xx
Complete with D-sub connectors (female) **Assignment for IK 220**		335077-xx	349687-xx	–	–
Cable without connectors		244957-01	291639-01	354341-01	355241-01
Adapter cable for LIP 3x2 with M23 coupling (male)		–	310128-xx	–	–
Adapter cable for LIP 3x2 with D-sub connector, assignment for IK 220		298430-xx	–	–	–
Adapter cable for LIP 3x2 without connector		–	310131-xx	–	–
Complete with M23 connectors (female/male)		298399-xx	–	–	–
With **one** M23 connector (female)		309777-xx	–	–	–
Connector on connecting cable to connector on encoder cable		For cable	Ø 8 mm Ø 6 mm	315650-14	
Connector on connecting cable to mating element on encoder cable	**M23 connector (female)** 	For cable	Ø 8 mm	291697-05	
M23 connector for connection to subsequent electronics	**M23 connector (male)** 	For cable	Ø 8 mm Ø 6 mm	291697-08 291697-07	
M23 flange socket for mounting on the subsequent electronics	**M23 flange socket (female)**			315892-08	
Adapter connector ∼ 1 V_{PP}/11 μA_{PP} For converting the 1 V_{PP} signals to 11 μA_{PP}; M23 connector (female) 12-pin and M23 connector (male) 9-pin				364914-01	

[1] Cable length for Ø 6 mm: max. 9 m

General Electrical Information

Power Supply

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

- High frequency interference $U_{PP} < 250$ 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 **line drop:**

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

where
ΔU: Line drop in V
L_C: Cable length in m
I: Current consumption in mA
A_P: Cross section of power lines in mm^2

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, the 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. This data applies to the encoders listed in the catalog—customized interfaces are not considered.

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)

Cables

HEIDENHAIN cables are mandatory for **safety-related applications.**
The **cable lengths** listed in the *Specifications* apply only to HEIDENHAIN cables and the recommended input circuitry of the subsequent electronics.

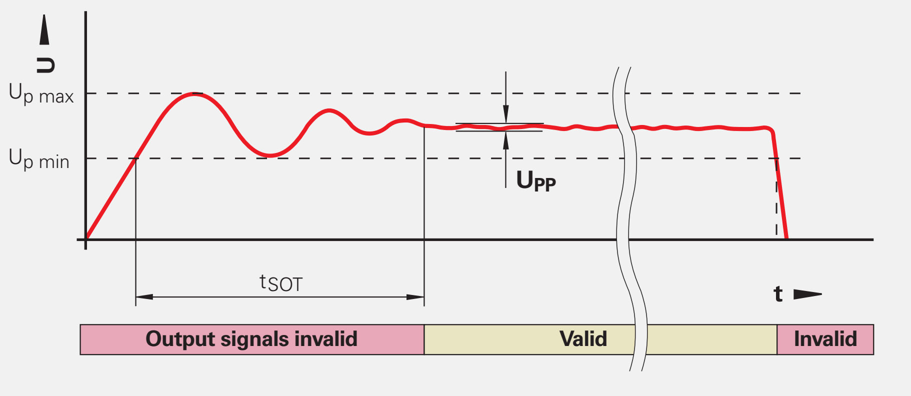
Durability
All encoders have polyurethane (PUR) cables. PUR cables are resistant to oil, hydrolysis and microbes in accordance with **VDE 0472.** They are free of PVC and silicone and comply with UL safety directives. The **UL certification** AWM STYLE 20963 80 °C 30 V E63216 is documented on the cable.

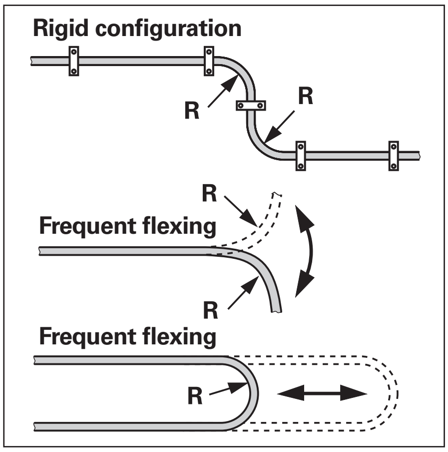
Temperature range
HEIDENHAIN cables can be used for
- rigid configuration –40 °C to 85 °C
- frequent flexing –10 °C to 85 °C

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

Bend radius
The permissible bend radii R depend on the cable diameter and the configuration:

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





Connect HEIDENHAIN position encoders only to subsequent electronics whose power supply is generated through double or strengthened insulation against line voltage circuits. Also see **IEC 364-4-41:** 1992, modified Chapter 411 regarding "protection against both direct and indirect touch" (PELV or SELV). If position encoders or electronics are used in safety-related applications, they must be operated with protective extra-low voltage (PELV) and provided with overcurrent protection or, if required, with overvoltage protection.

Cable	Cross section of power supply lines A_P				Bend radius R	
	1 V_{PP}/TTL/HTL	**11 μA_{PP}**	**EnDat/SSI** 17-pin	**EnDat**[4] 8-pin	**Rigid configuration**	**Frequent flexing**
Ø 3.7 mm	0.05 mm^2	–	–	–	≥ 8 mm	≥ 40 mm
Ø 4.3 mm	0.24 mm^2	–	–	–	≥ 10 mm	≥ 50 mm
Ø 4.5 mm **Ø 5.1 mm**	0.14/0.05[2] mm^2	0.05 mm^2	0.05 mm^2	0.14 mm^2	≥ 10 mm	≥ 50 mm
Ø 6 mm **Ø 10 mm**[1]	0.14/0.19[2] mm[3]	–	0.08 mm^2	0.34 mm^2	≥ 20 mm ≥ 35 mm	≥ 75 mm ≥ 75 mm
Ø 8 mm **Ø 14 mm**[1]	0.5 mm^2	1 mm^2	0.5 mm^2	1 mm^2	≥ 40 mm ≥ 100 mm	≥ 100 mm ≥ 100 mm

[1] Metal armor [2] Length gauges [3] LIDA 400 [4] Also Fanuc, Mitsubishi

Electrically Permissible Speed/ Traversing Speed

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

- the **mechanically** permissible shaft speed/traversing velocity (if listed in *Specifications*)
  and
- the **electrically** permissible shaft speed or traversing velocity.
  For encoders with **sinusoidal output signals,** the electrically permissible shaft speed or traversing velocity is limited by the –3 dB/ –6 dB cutoff frequency or the permissible input frequency of the subsequent electronics.
  For encoders with **square-wave signals,** the electrically permissible shaft speed/ traversing velocity is limited by
  – the maximum permissible scanning 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

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

and:

n_{max}: Electrically permissible speed in rpm
v_{max}: Electrically 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

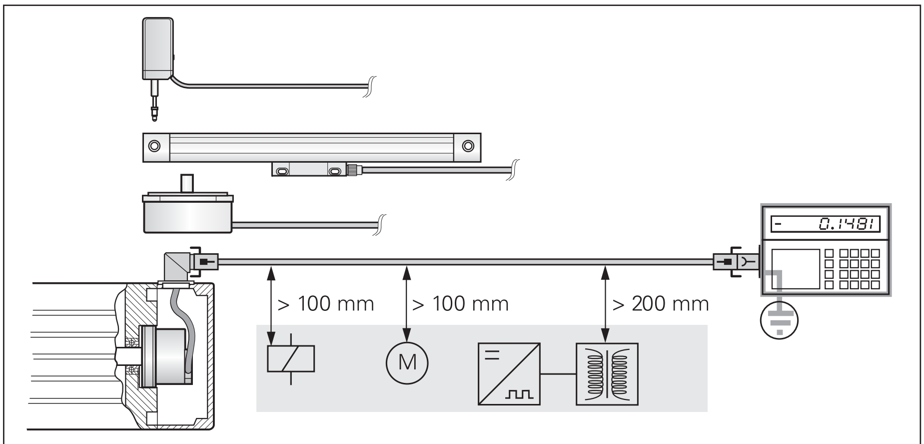
Noise-Free Signal Transmission

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

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

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



Minimum distance from sources of interference

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

- Use only HEIDENHAIN cables.
- Use connectors or terminal boxes with metal housings. Do not conduct any extraneous signals.
- Connect the housings of the encoder, connector, terminal box and evaluation electronics through the shield of the cable. Connect the shielding in the area of the cable outlets to be as induction-free as possible (short, full-surface contact).
- Connect the entire shielding system with the protective ground.
- Prevent contact of loose connector housings with other metal surfaces.
- The cable shielding has the function of an equipotential bonding conductor. If compensating currents are to be expected within the entire system, a separate equipotential bonding conductor must be provided. See also **EN 50 178**/ 4.98 Chapter 5.2.9.5 regarding "protective connection lines with small cross section."
- Do not lay signal cables in the direct vicinity of interference sources (inductive consumers such as contacts, motors, frequency inverters, solenoids, etc.).
- Sufficient decoupling from cables conducting interference signals 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. See also **EN 50 178**/4.98 Chapter 5.3.1.1, regarding cables and lines, as well as **EN 50 174-2**/09.01, Chapter 6.7, regarding grounding and potential compensation.
- When using **rotary encoders in electromagnetic fields** greater than 30 mT, HEIDENHAIN recommends consulting with the main facility in Traunreut.

Both the cable shielding and the metal housings of encoders and subsequent electronics have a shielding function. The housings must have the **same potential** and be connected to the main signal ground over the machine chassis or by means of a separate potential compensating line. Potential compensating lines should have a minimum cross section of 6 mm^2 (Cu).

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	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 **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 **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

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