HEIDENHAIN

Exposed Linear Encoders

July 2003

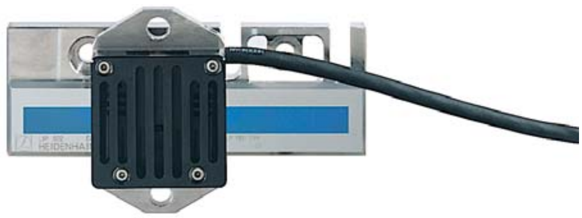
Exposed Linear Encoders

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
- Backlash
- Kinematic error through ball screw pitch error

Linear encoders are therefore indispensable for machines that 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
- Sealed linear encoders
- Angle encoders
- Rotary encoders
- HEIDENHAIN subsequent electronics
- HEIDENHAIN TNC controls
- Machine inspection and calibration

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

A new catalog edition supersedes all previous editions, which thereby become invalid.

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

Contents

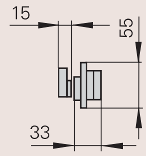
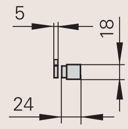
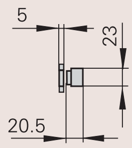
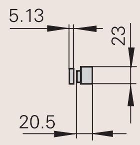
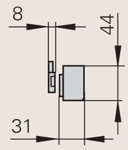
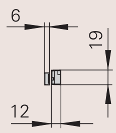
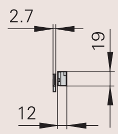
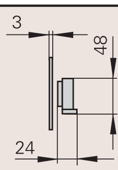
Selection Guide

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 process. They feature **high accuracy** and **repeatability** and are especially easy to mount.

The **LIDA** exposed linear encoders have an AURODUR steel scale tape as measuring standard. They are specially designed for **high traversing speeds** up to 8 m/s and are particularly easy to mount with various mounting possibilities.

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 available on request)*	0.128 µm
	LIP 4x1 R 	± 1 µm ± 0.5 µm *(higher accuracy available on request)*	2 µm
		± 1 µm	4 µm
LIF with PRECIMET® adhesive film • Interferential scanning principle for small signal periods • Limit switches and homing track		± 3 µm	4 µm
For high traversing speeds and large measuring lengths • Steel scale tape cemented on steel carrier or drawn into an aluminum extrusion • Limit switches with LIDA 400		± 5 µm ± 3 µm	40 µm
		± 5 µm	20 µm
		± 15 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

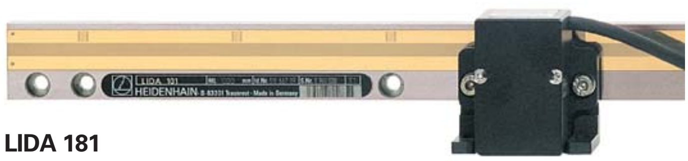
1) Signal period of the sinusoidal signals. It is definitive for deviations within one signal period (see *Measuring Accuracy*).
2) For encoders with TTL interface and integrated interpolation electronics: Measuring step after 4-fold evaluation and with maximum possible interpolation factor (see ⊓⊔ *TTL Interfaces*).

Measuring lengths	Substrate and mounting	Interface/ Meas. step[2]	Model	Page
70 mm to 270 mm (2.7 in. to 10.6 in.)	Zerodur® glass ceramic embedded in bolted-on Invar carrier	TTL *0.001 µm*	**LIP 372**	**18**
		~ 1 V_{PP}	**LIP 382**	
10 mm to 420 mm (0.4 in. to 16.5 in.)	Scale of Zerodur® glass ceramic or glass with bolted-on fixing clamps	TTL *to 0.05 µm*	**LIP 471**	**20**
		~ 1 V_{PP}	**LIP 481**	
70 mm to 1440 mm (2.7 in. to 56 in.)	Glass scale fixed with bolted-on clamps	TTL *to 0.1 µm*	**LIP 571**	**22**
		~ 1 V_{PP}	**LIP 581**	
70 mm to 1020 mm (2.7 in. to 40 in.)	Glass scale fixed with PRECIMET® adhesive film	TTL *to 0.01 µm*	**LIF 471**	**24**
		~ 1 V_{PP}	**LIF 481**	
220 mm to 2040 mm (8.6 in. to 80 in.)	Steel scale tape embedded in steel carrier that is bolted onto a mounting surface	TTL *to 1 µm*	**LIDA 171**	**26**
		~ 1 V_{PP}	**LIDA 181**	
140 mm to 30 040 mm (5.5 in. to 100 ft)	Steel scale tape is drawn into an aluminum extrusion and tensioned	TTL *to 0.05 µm*	**LIDA 475**	**28**
		~ 1 V_{PP}	**LIDA 485**	
240 mm to 6040 mm (9.5 in. to 237 in.) *(other measuring ranges upon request)*	Steel scale tape is drawn into an aluminum extrusion and fixed at center	TTL *to 0.05 µm*	**LIDA 477**	**30**
		~ 1 V_{PP}	**LIDA 487**	
Measuring range 68 mm x 68 mm (2.7 in. x 2.7 in.) *(other measuring ranges upon request)*	Glass grid plate mounted with full-surface adhesion	TTL *to 0.1 µm*	**PP 271**	**32**
		~ 1 V_{PP}	**PP 281**	

LIP 382

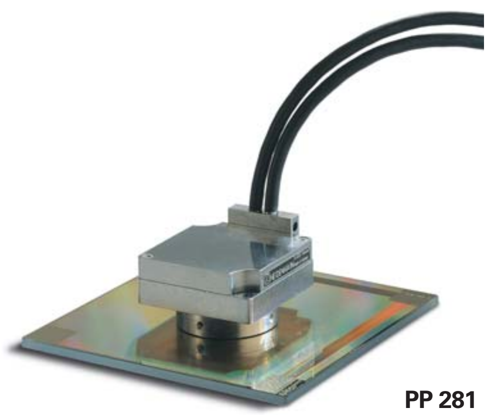
LIP 581

LIF 481



LIDA 181

LIDA 485



PP 281

Measuring Principles
Measuring Standard

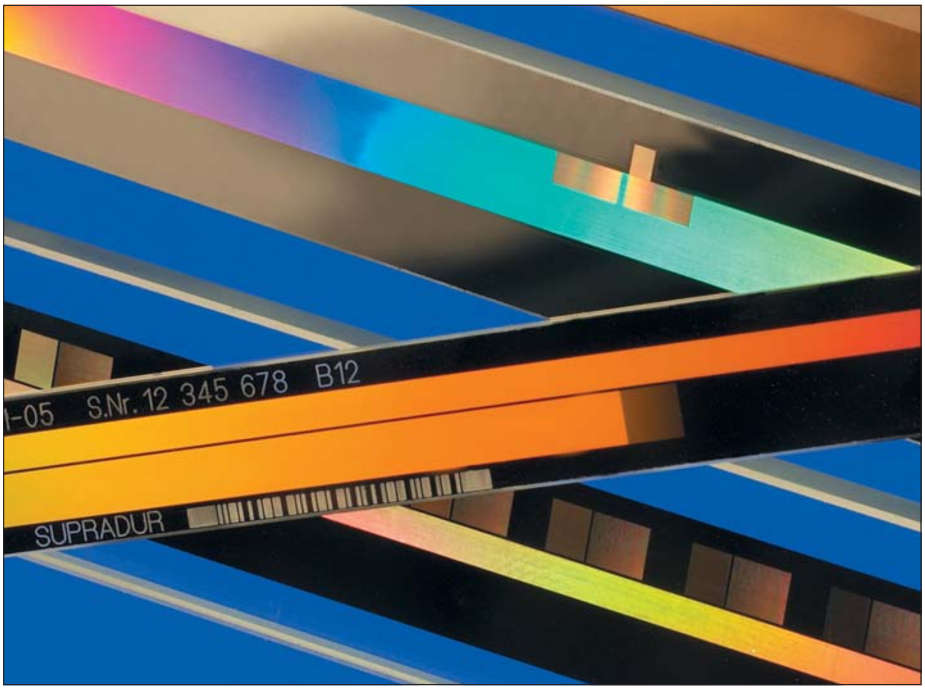
HEIDENHAIN encoders with optical scanning incorporate measuring standards of periodic structures known as graduations. These graduations are applied to a carrier substrate of glass or steel. The scale substrate for large measuring lengths is a steel tape.

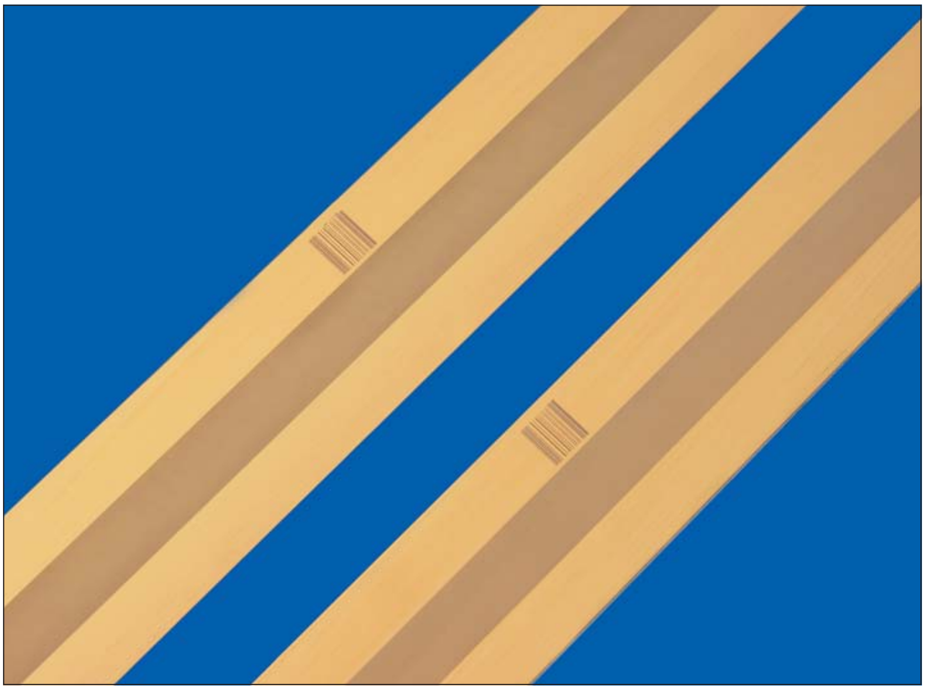
These precision graduations are manufactured in various photolithographic processes. Graduations are fabricated from:
- extremely hard chromium lines on glass,
- matte-etched lines on gold-plated steel tape, or
- three-dimensional structures on glass or steel substrates.

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 **incremental measuring methods,** 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:

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

where:

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

and:

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

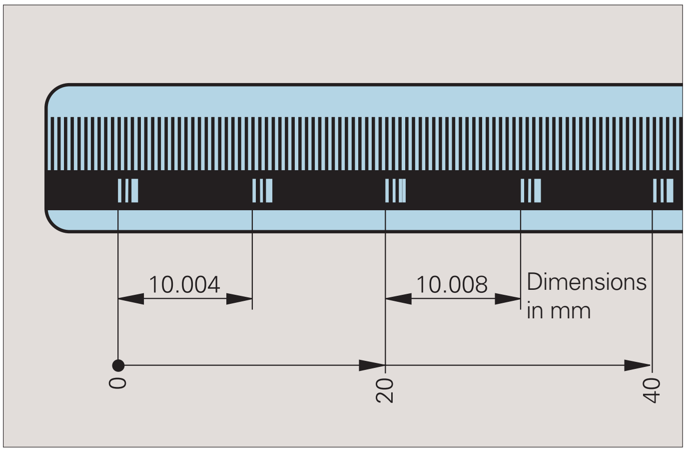
abs = Absolute value

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)

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



Incremental graduation with distance-coded reference marks on an LIP 5x1 C encoder

	Signal period	Nominal increment *N* in signal periods	Max. traverse
LIP 5x1 C	4 µm	5000	20 mm
LIDA 1x1 C	40 µm	2000	80 mm

Photoelectrical Scanning

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

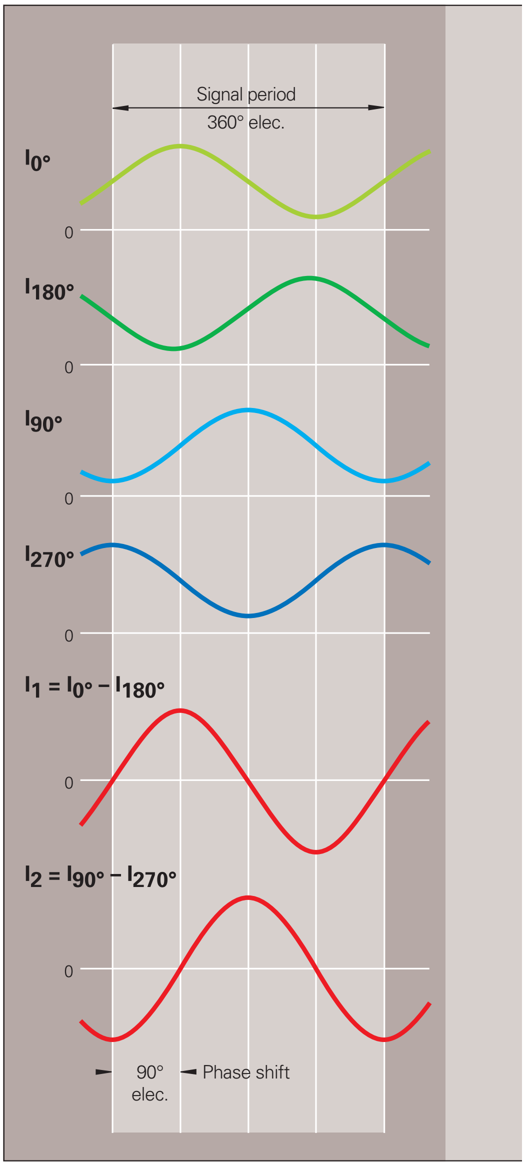
The finer the grating period of a measuring standard is, the greater the effect of diffraction on photoelectric scanning. HEIDENHAIN uses two scanning principles with linear encoders:

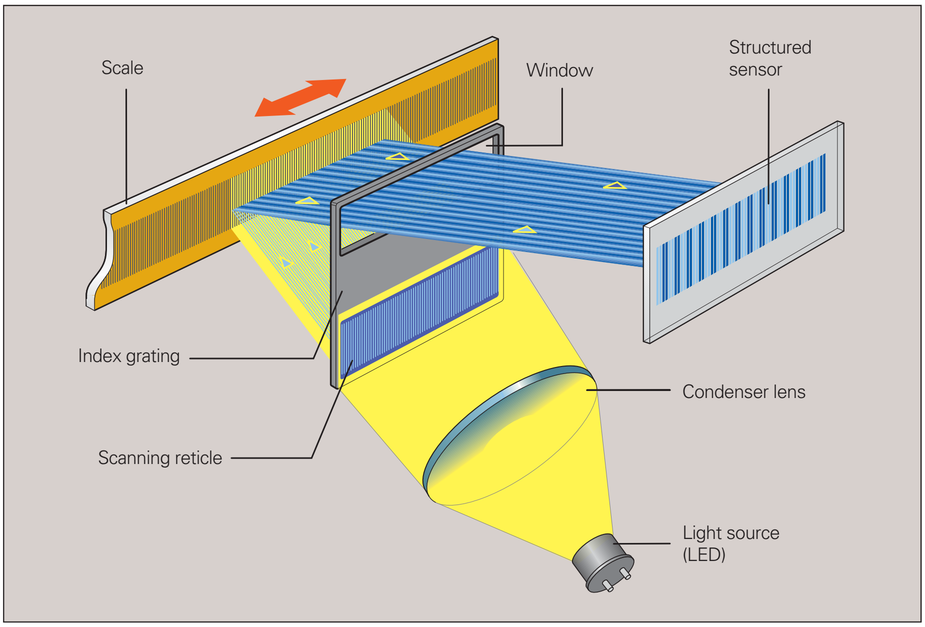
- The **imaging scanning principle** for grating periods from 10 µm to 40 µm.
- The **interferential scanning principle** for very fine graduations with grating periods of 4 µm and smaller.

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

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

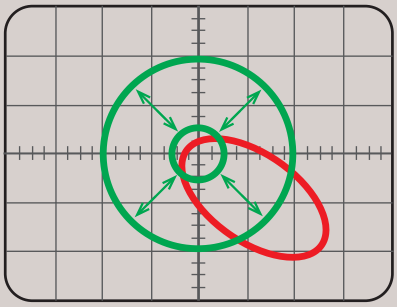




Photoelectric scanning using the imaging scanning principle with steel scale and one scanning field (LIDA 400)

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.



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.

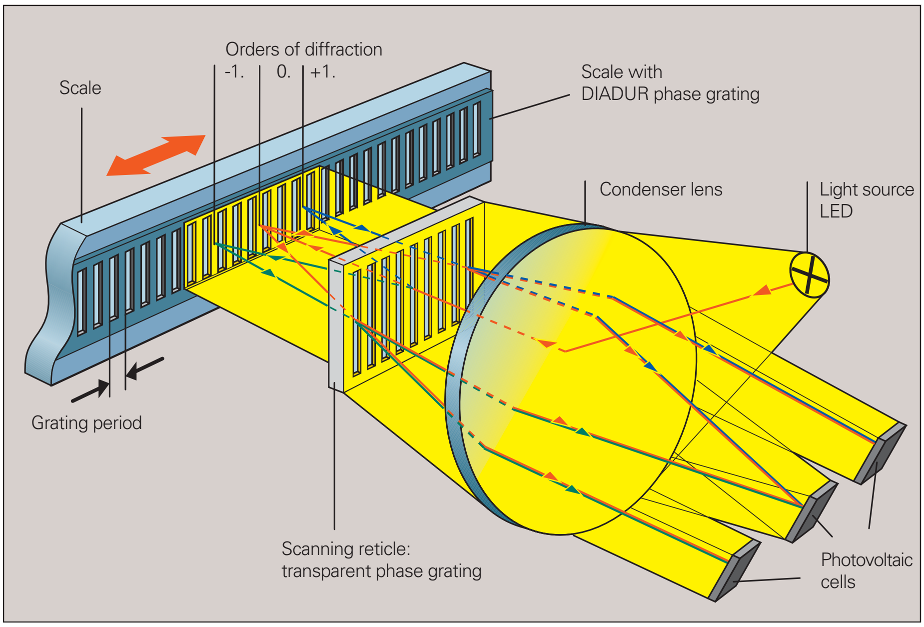
A step grating is used as the measuring standard: reflective lines 0.2 µm high are applied to a flat, reflective surface. In front of that is the scanning reticle—a transparent phase grating with the same grating period as the scale.

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 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.

The linear encoders of the **LIP, LIF** and **PP** product families operate with the interferential scanning principle.



Photoelectric scanning using the interferential scanning principle with one scanning field

Measuring Accuracy

The accuracy of linear measurement is mainly determined by:

- The quality of the graduation
- Quality of the scanning process
- Quality of the signal processing electronics
- The error from the scale guideway over 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 as accuracy grades, which are defined as follows:

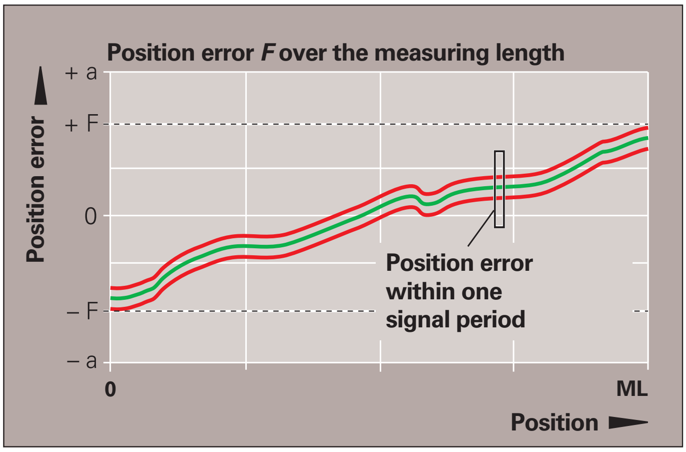
The extreme values of the total error F *of a position lie—with reference to their mean value—over any max. one-meter section of the measuring length within the accuracy grade* ±a.

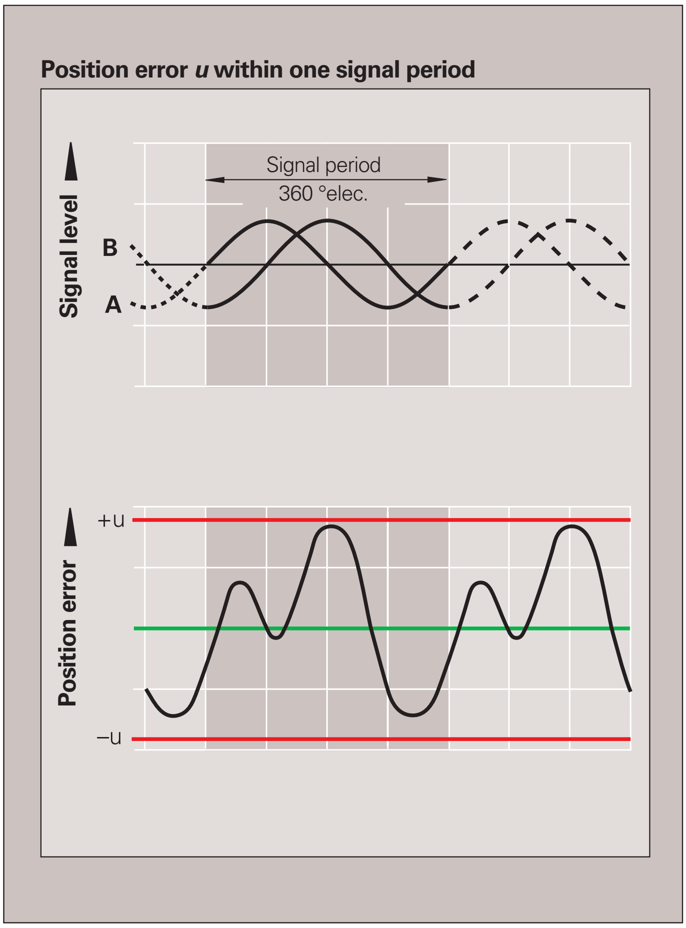
With exposed linear encoders, the above definition of the accuracy grade applies only to the scale. It is then called the scale accuracy.

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	20 µm	0.2 µm
LIDA 1xx	40 µm	0.4 µm





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

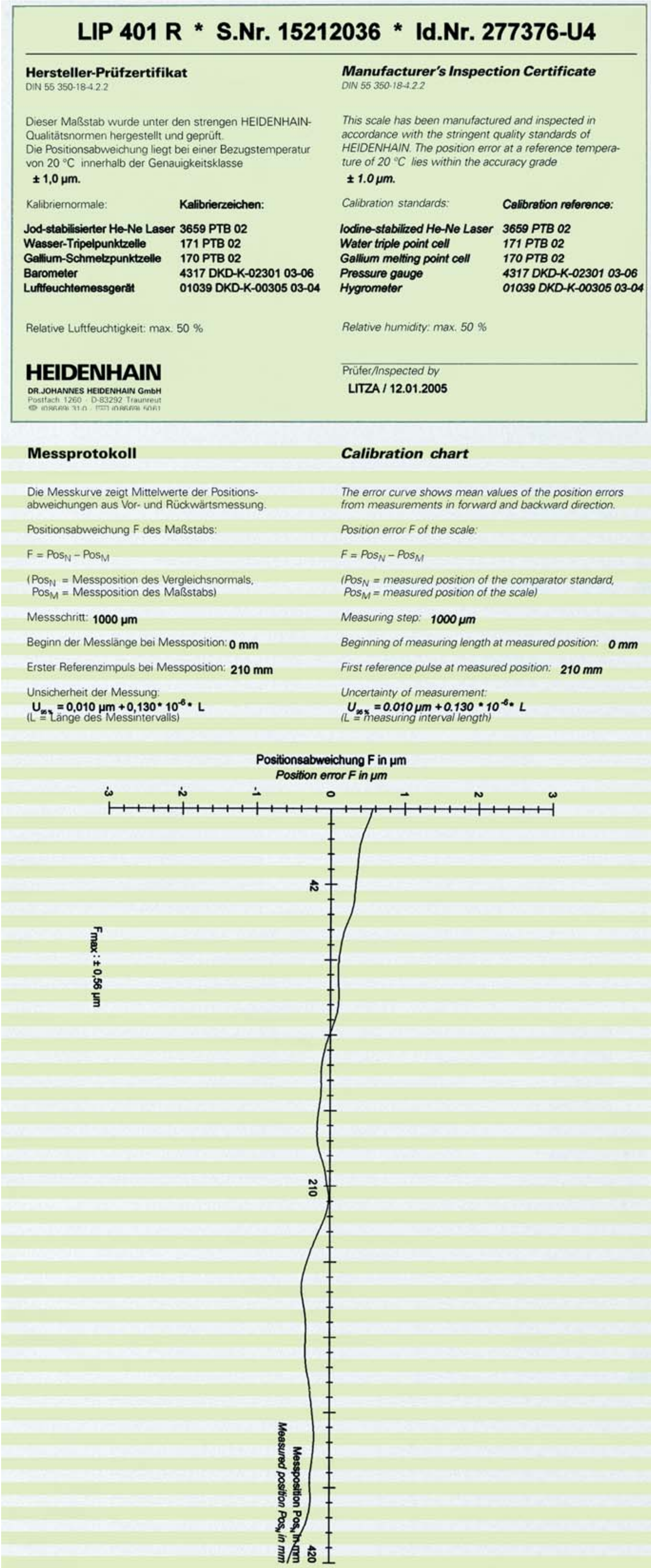
They are calibrated for accuracy during traverse in both directions. The number of measuring positions is selected to determine very exactly not only the long-range error, but also the position error within one signal period.

The **manufacturer's inspection certificate** confirms the specified system accuracy of each length gauge. The **calibration standards** ensure the traceability—as required by ISO 9001—to recognized national or international standards.

For the encoders of the LIP, PP and LIDA 1x1 series, a **calibration chart** documents the position error over the measuring range and also states the measuring step and measuring uncertainty of the calibration.

Temperature range
The length gauges are calibrated at a **reference temperature** of 20 °C (68 °F). The system accuracy given in the calibration chart applies at this temperature. The **operating temperature range** indicates the ambient temperature limits between which the length gauges will function properly. The **storage temperature range** of –20 °C to 70 °C (–4 °F to 158 °F) applies for the device in its packaging.

Poor mounting of linear encoders can aggravate the effect of guideway error on measuring accuracy. To keep the resulting Abbe 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. 15212036 * 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	**171 PTB 02**
Gallium-Schmelzpunktzelle	**170 PTB 02**
Barometer	**4317 DKD-K-02301 03-06**
Luftfeuchtemessgerät	**01039 DKD-K-00305 03-04**

Relative Luftfeuchtigkeit: max. 50 %

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

This scale has been manufactured and inspected in accordance with the stringent quality standards of HEIDENHAIN. The 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	***171 PTB 02***
Gallium melting point cell	***170 PTB 02***
Pressure gauge	***4317 DKD-K-02301 03-06***
Hygrometer	***01039 DKD-K-00305 03-04***

Relative humidity: max. 50 %

HEIDENHAIN
DR. JOHANNES HEIDENHAIN GmbH
Postfach 1260 · D-83292 Traunreut

Prüfer/Inspected by
LITZA / 12.01.2005

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***

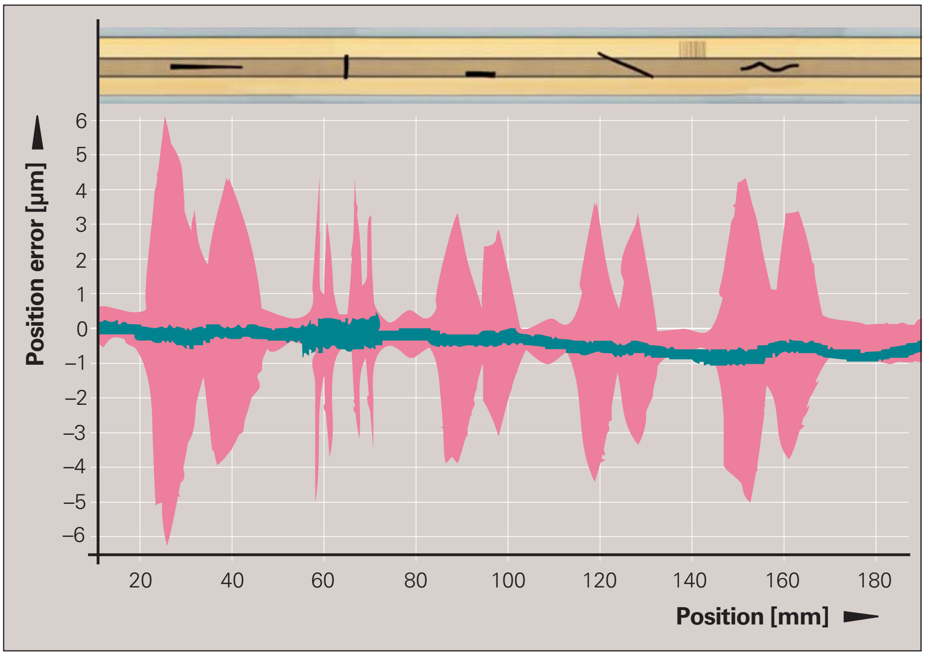
Uncertainty of measurement:
$U_{95\%} = 0.010\ \mu m + 0.130 \cdot 10^{-6} \cdot L$
(L = measuring interval length)

Reliability

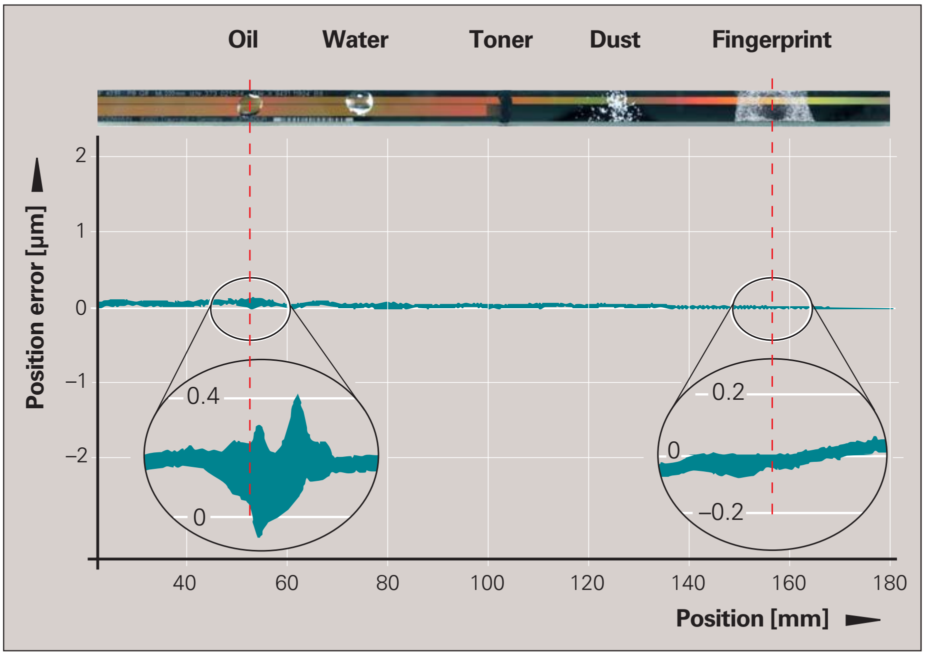
Exposed linear encoders from HEIDENHAIN are optimized for use on fast, precise machines. In spite of the exposed mechanical design they are highly tolerant to contamination, ensure high long-term stability, and are fast and simple to mount.

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.



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

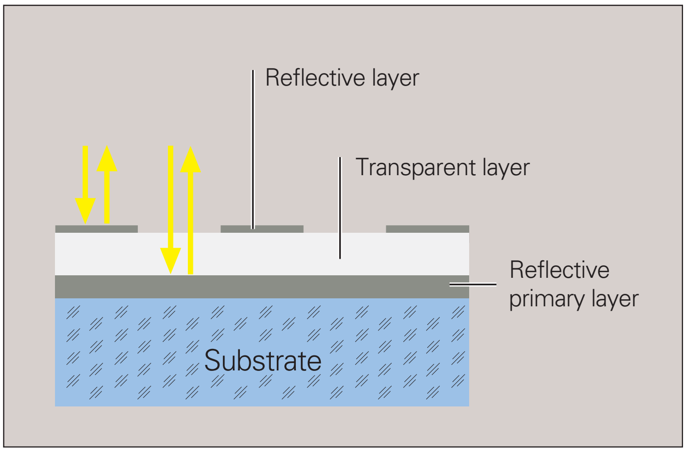


Contamination behavior of LIF 400

Durable measuring standards
By the nature of its 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. The AURODUR process applies gold to a steel strip to produce a scale tape with a hard gold graduation.

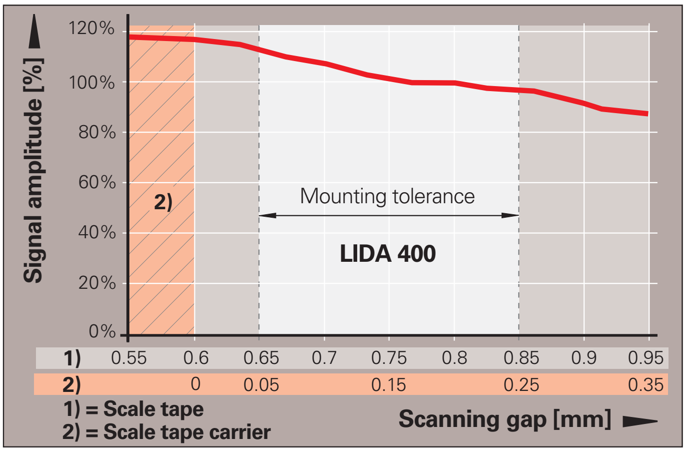
In the SUPRADUR process, a transparent layer is applied first over the reflective primary layer. An extremely thin, hard chrome layer is applied to produce an optically three-dimensional phase grating. Scales with SUPRADUR graduations have proven to be particularly insensitive to contamination because the low height of the structure leaves practically no surface for dust, dirt or water particles to accumulate.

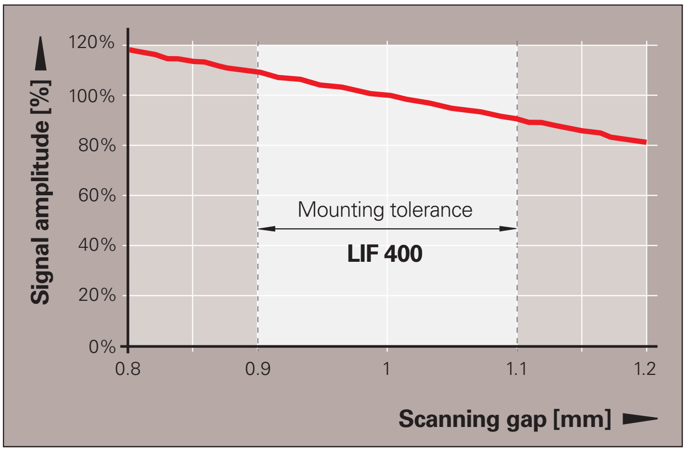


SUPRADUR process: Optically three-dimensional graduation with planar structure

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 measuring 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.





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

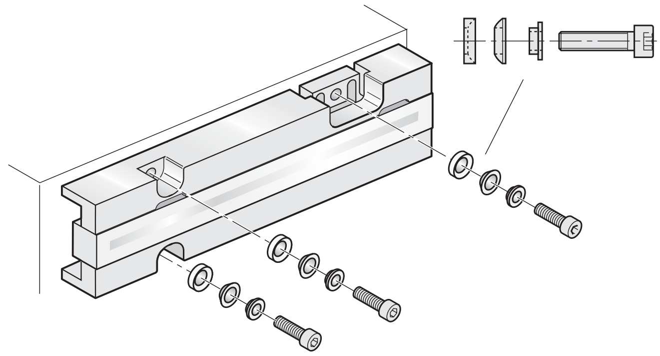
Fixing clamps	Id. Nr. 270711-04
Silicone adhesive	Id. Nr. 200417-02
Epoxy adhesive	Id. Nr. 200409-01

LIF 400 series
The graduation carriers of glass are fastened with PRECIMET® elastic adhesive film, and pressure is evenly distributed with a roller.

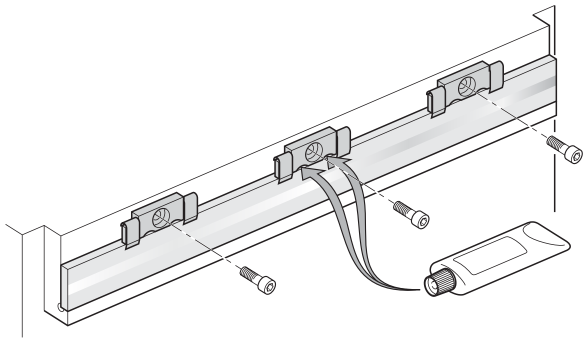
Accessories

Roller	Id. Nr. 276885-01

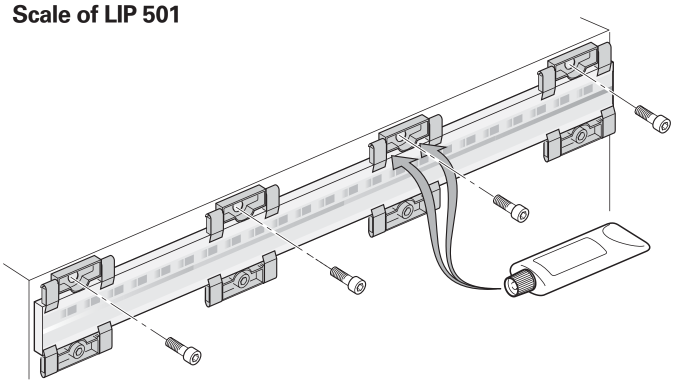
Scale of LIP 302



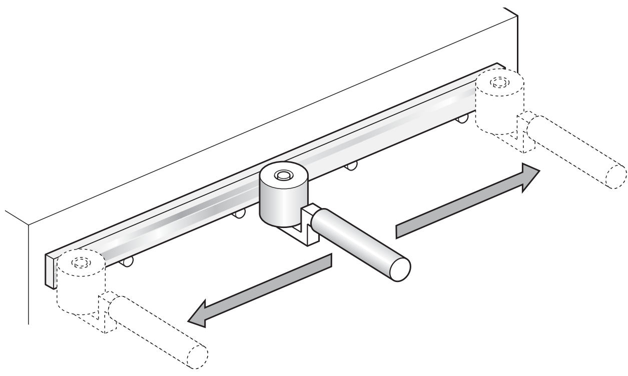
Scale of LIP 401



Scale of LIP 501



Scale of LIF 401



LIDA 1x1 series
The steel scale tape with the graduation is applied to a steel carrier. The steel carrier is secured over its full surface onto the bearing surface. The thermal behavior of the LIDA 100 is the same as that of steel.

LIDA 4x5 series
Linear encoders of the LIDA 405 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.

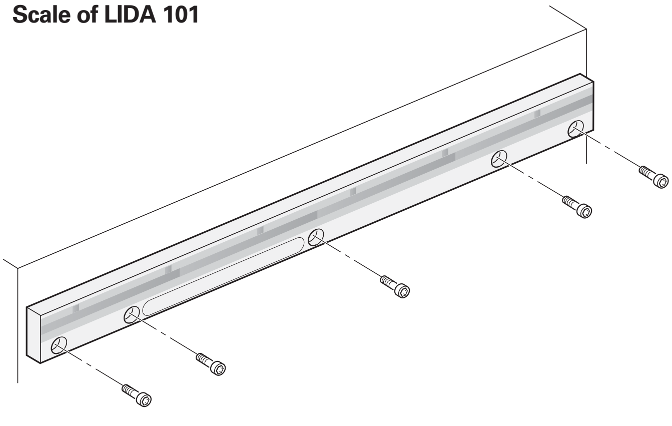
LIDA 4x7 series
Encoders of the LIDA 407 series are also designed for large measuring lengths. The scale carrier sections are fixed to the bearing surface with PRECIMET® adhesive mounting film; the one-piece scale tape is pulled in and **fixed at its midpoint** to the machine bed. This mounting method allows the scale to expanded freely at both ends and ensures a defined thermal behavior.

Accessories for versions with PRECIMET®

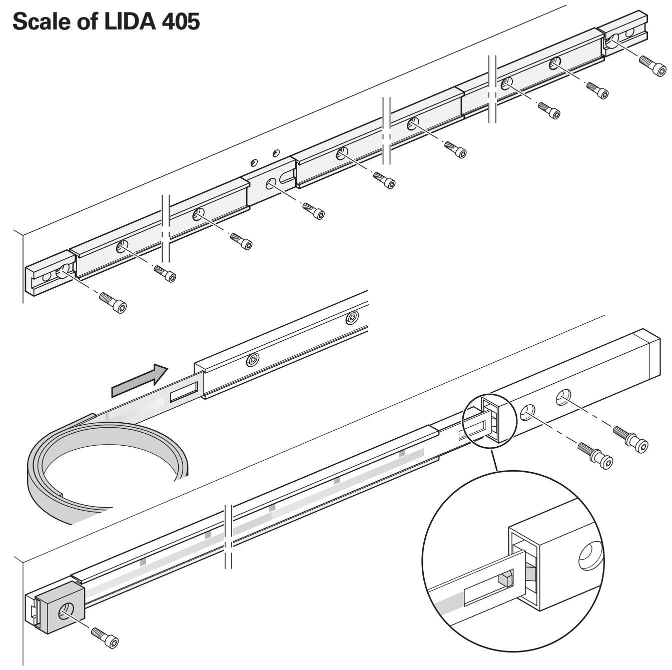
Roller	Id. Nr. 276 885-01
Mounting aid	Id. Nr. 373 990-01

Mounting aid

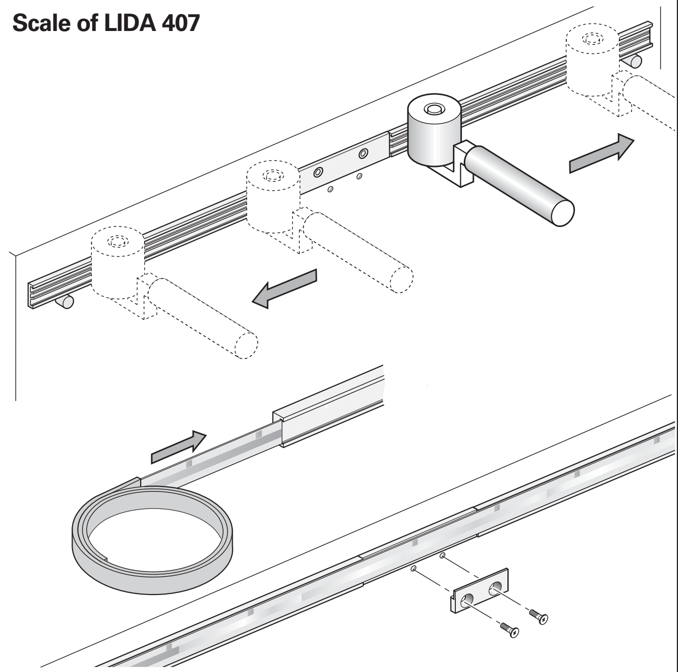
Scale of LIDA 101



Scale of LIDA 405



Scale of LIDA 407



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 the LIP/LIF/LIDA 100
The scanning head features a centering collar that allows it to be rotated in the location hole of the angle bracket and aligned parallel to the scale.

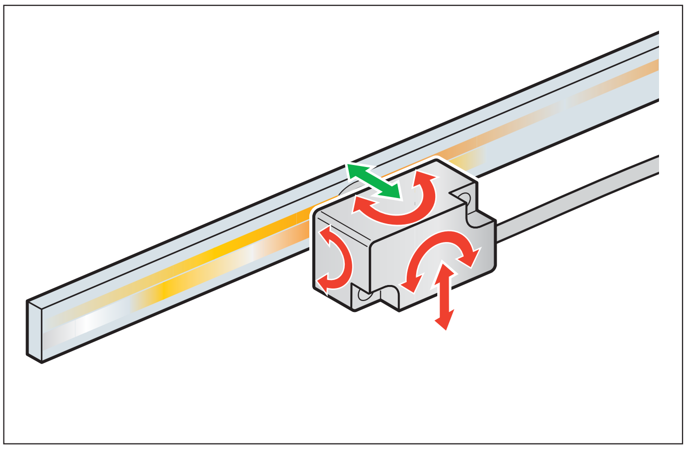
Mounting the LIDA 400
The scanning head is best mounted from behind on the mounting bracket. The scanning head can be very precisely adjusted through a hole in the mounting bracket with the aid of a tool.

Adjustment
To simplify adjustment, HEIDENHAIN recommends the following procedure:

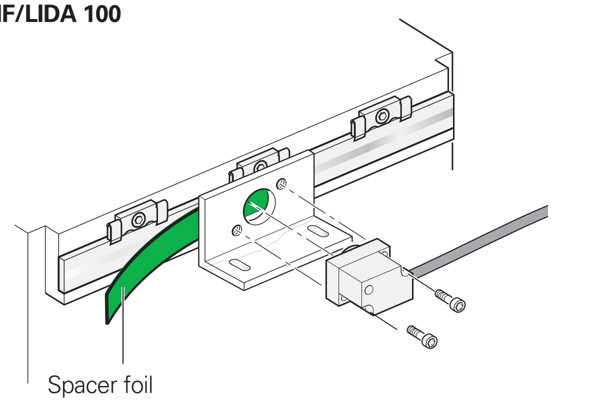
1) Set the scanning gap between the scale and scanning head using the spacer foil.
2) Adjust the incremental signals by rotating the scanning head.
3) Adjust the reference mark signals through further, slight rotation of the scanning head.

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

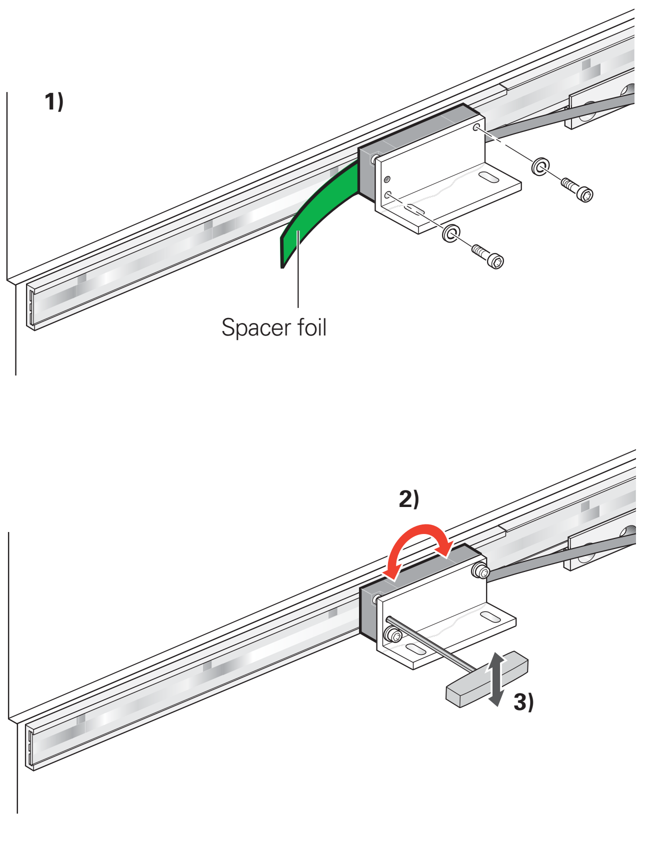
Please note:
Work steps to be performed and dimensions to be maintained during mounting are specified solely in the mounting instructions supplied with the unit. All data in this catalog regarding mounting are therefore provisional and not binding; they do not become terms of a contract.



LIP/LIF/LIDA 100



LIDA 400



General Mechanical Information

Mounting
To simplify cable routing, the scanning head is usually screwed onto a stationary machine part and the scale onto the moving machine part.
The **mounting location** for the linear encoders should be carefully considered in order to ensure both optimum accuracy and the longest possible service life.

- The encoder should be mounted as closely as possible to the working plane to keep the Abbe 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** of –20 °C to 70 °C (–4 °F to 158 °F) 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.

Degree of protection (IEC 60529)
The scanning heads of the exposed linear encoders feature an IP 50 degree of protection. The scales have no special protection. Protective measures must be taken if the possibility of contamination exists.

Acceleration
Linear encoders are subject 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
- Cable

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.

LIP 372
LIP 382

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

Specifications	**LIP 372** **LIP 382**
Measuring standard Grating period Thermal expansion coefficient	DIADUR phase grating on Zerodur® glass ceramic 0.512 µm $\alpha_{therm} \approx 0$ ppm/K
Accuracy grade	±0.5 µm (±0.000 02 in.) (higher accuracy grades available on request)
Measuring length ML* in mm inches	70, 150, 170, 220, 270 2.7, 5.9, 6.7, 8.6, 10.6
Reference mark	None
Max. traversing speed **LIP 372** **LIP 382**	See page 37 7.6 m/min with –3dB cutoff frequency ≥ 1 MHz
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 4 m/s² (IEC 60 068-2-6) ≤ 50 m/s² (IEC 60 068-2-27)
Operating temperature	0 to 40 °C (32 to 122 °F)
Weight Scanning head Interface electronics Scale Cable	150 g 100 g 260 g (ML 70 mm) 700 g (ML ≥ 150 mm) 37 g/m
Power supply **LIP 372** **LIP 382**	5 V ± 5 %/< 160 mA (without load) 5 V ± 5 %/< 160 mA
Incremental signals/ Signal periods **LIP 372** **LIP 382**	⊓⊔ TTL/integr. 32-fold interpolation: 0.004 µm ∿ 1 V_{PP}/0.128 µm
Electrical connection Max. cable length	Cable 0.5 m to interface electronics (APE), sep. adapter cable (1 m/3 m/6 m/9 m) connectable to APE 30 m (98.5 ft)

***** Please indicate when ordering

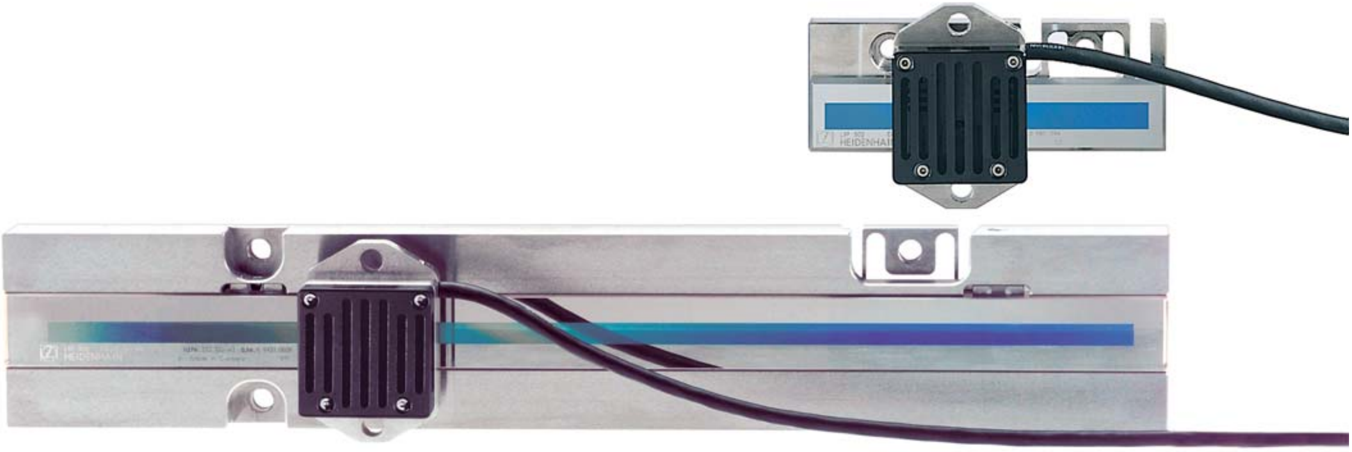
Dimensions

in mm

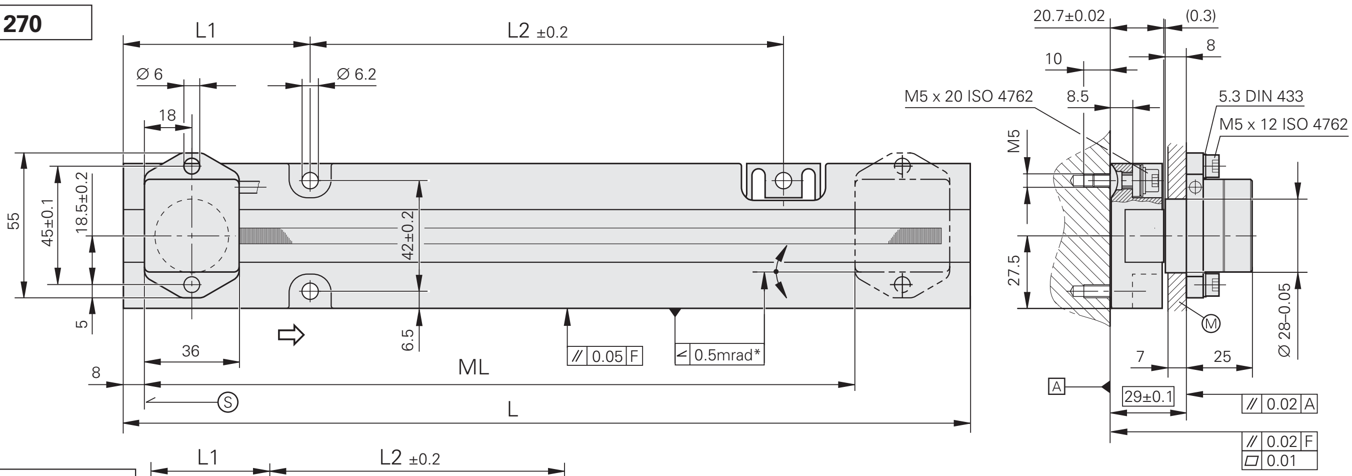
DIN ISO 8015
ISO 2768 - m H

* = 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

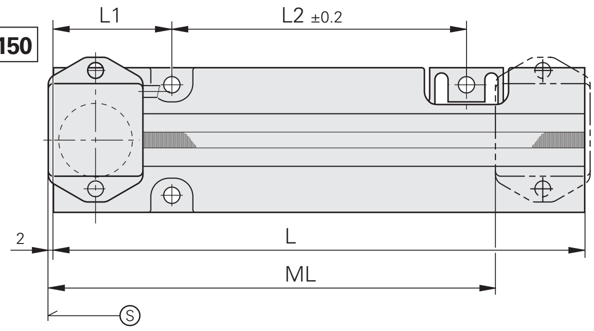
ML	L	L1	L2
150	182	40	102
170	202	45	112
220	252	56	140
270	322	71	180

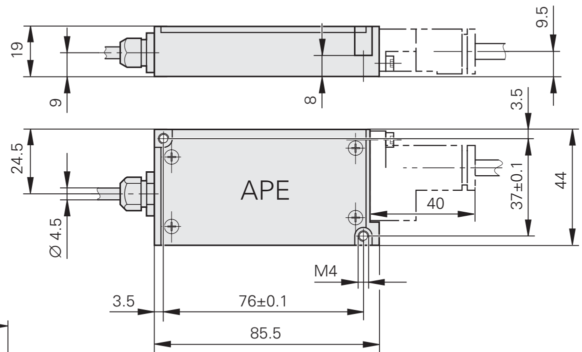


ML 270

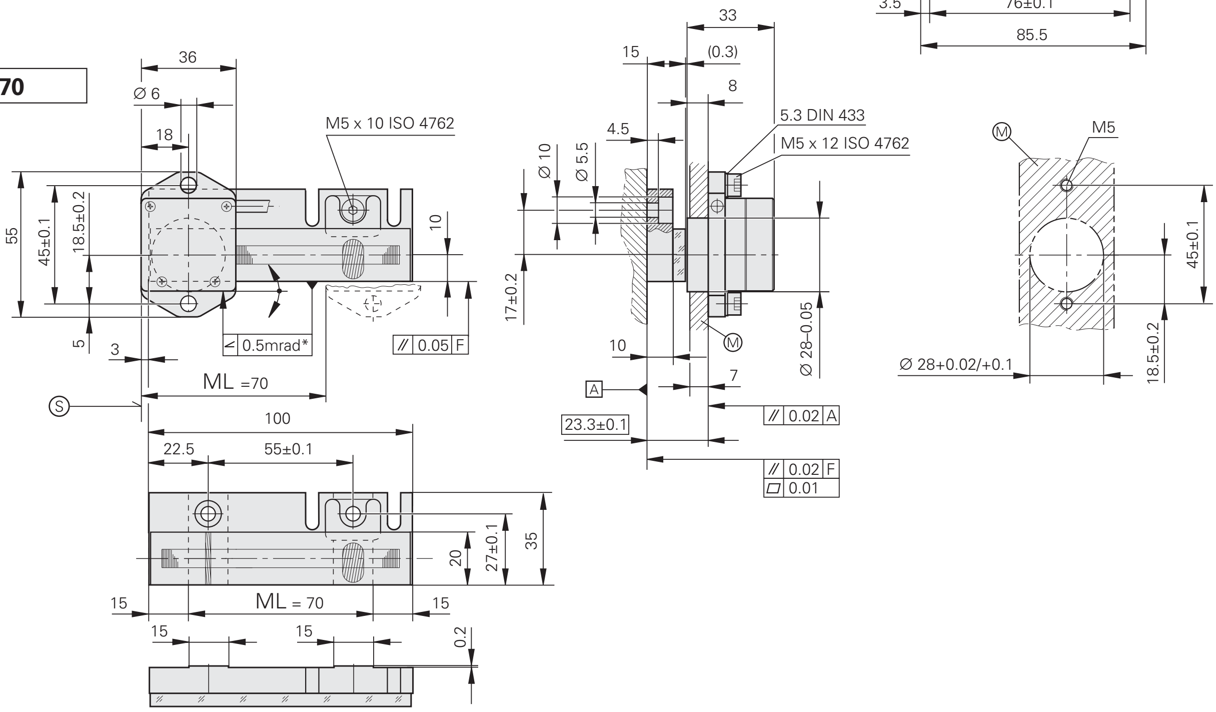


ML 220, 170, 150





ML 70



LIP 471
LIP 481

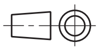
Incremental linear encoders with very high accuracy
- **For limited installation space**
- **For measuring steps of 1 µm to 0.005 µm (0.000 05 in. to 0.000 000 2 in.)**

Specifications		**LIP 471** **LIP 481**
Measuring standard Grating period Thermal expansion coefficient		DIADUR phase grating on Zerodur® glass ceramic or glass 4 µm $\alpha_{therm} \approx$ 0 ppm/K (Zerodur® glass ceramic) $\alpha_{therm} \approx$ 8 ppm/K (glass)
Accuracy grade*		±1 µm (±0.000 04 in.) ±0.5 µm (±0.000 02 in.) (higher accuracy grades on request)
Measuring length ML* in mm inches		70, 120, 170, 220, 270, 320, 2.7, 4.7, 6.7, 8.6, 10.6, 12.6, 370, 420 14.5, 16.5
Reference mark*	**LIP 4x1 R** **LIP 4x1 A**	One at midpoint of measuring length None
Max. traversing speed	**LIP 471** **LIP 481**	See page 37 30 m/min with –3dB cutoff frequency ≥ 250 kHz
Vibration 55 to 2000 Hz **Shock** 11 ms		≤ 200 m/s² (IEC 60 068-2-6) ≤ 500 m/s² (IEC 60 068-2-27)
Operating temperature		0 to 40 °C (32 to 122 °F)
Weight	Scanning head Interface electronics Scale Cable	25 g (LIP 4x1 A), 50 g (LIP 4x1 R), without cable 140 g 5.6 g + 0.2 g/mm measuring length 37 g/m
Power supply	**LIP 471** **LIP 481**	5 V ± 5 %/< 200 mA (without load) 5 V ± 5 %/< 190 mA
Incremental signals/ Signal period	**LIP 471** **LIP 481**	⊓⊔ TTL/integr. 5-fold interpolation: 0.4 µm ⊓⊔ TTL/integr. 10-fold interpolation: 0.2 µm ∼ 1 V_{PP}/2 µm
Electrical connection Max. cable length	 **LIP 471** **LIP 481**	Cable 0.5 m with D-sub connector (15-pin) Interface electronics are integrated in the connector 100 m (329 ft) 150 m (492 ft)

***** Please indicate when ordering

Dimensions

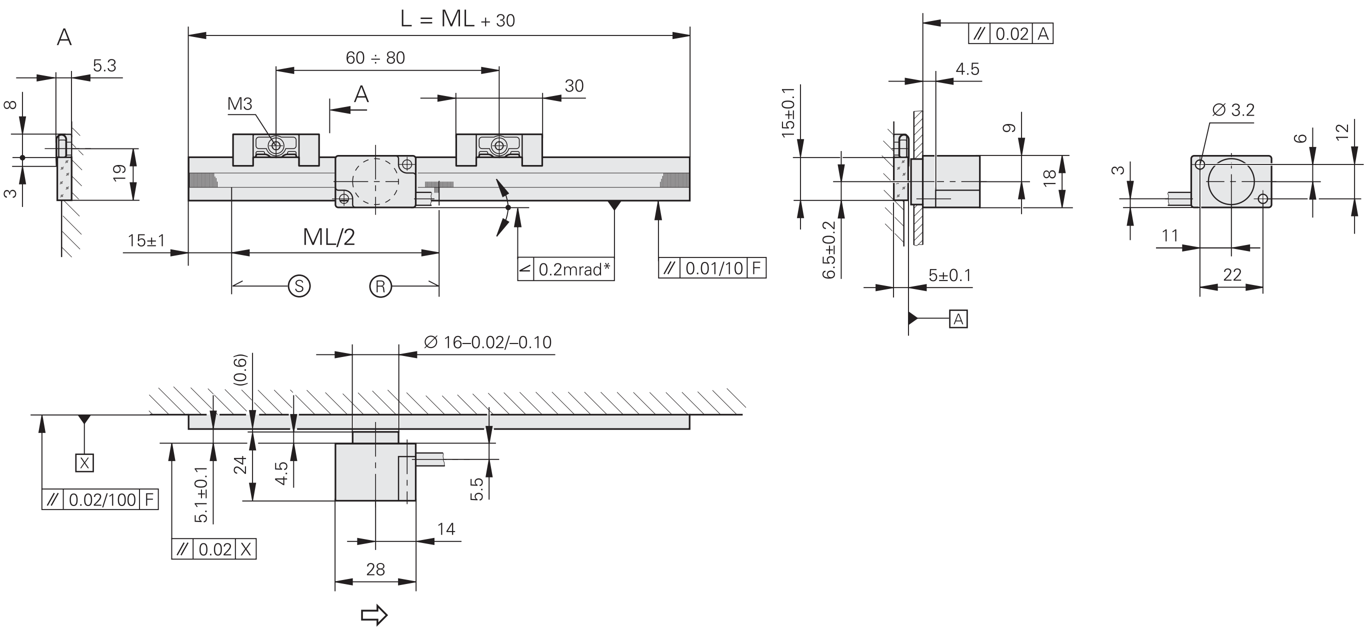
in mm



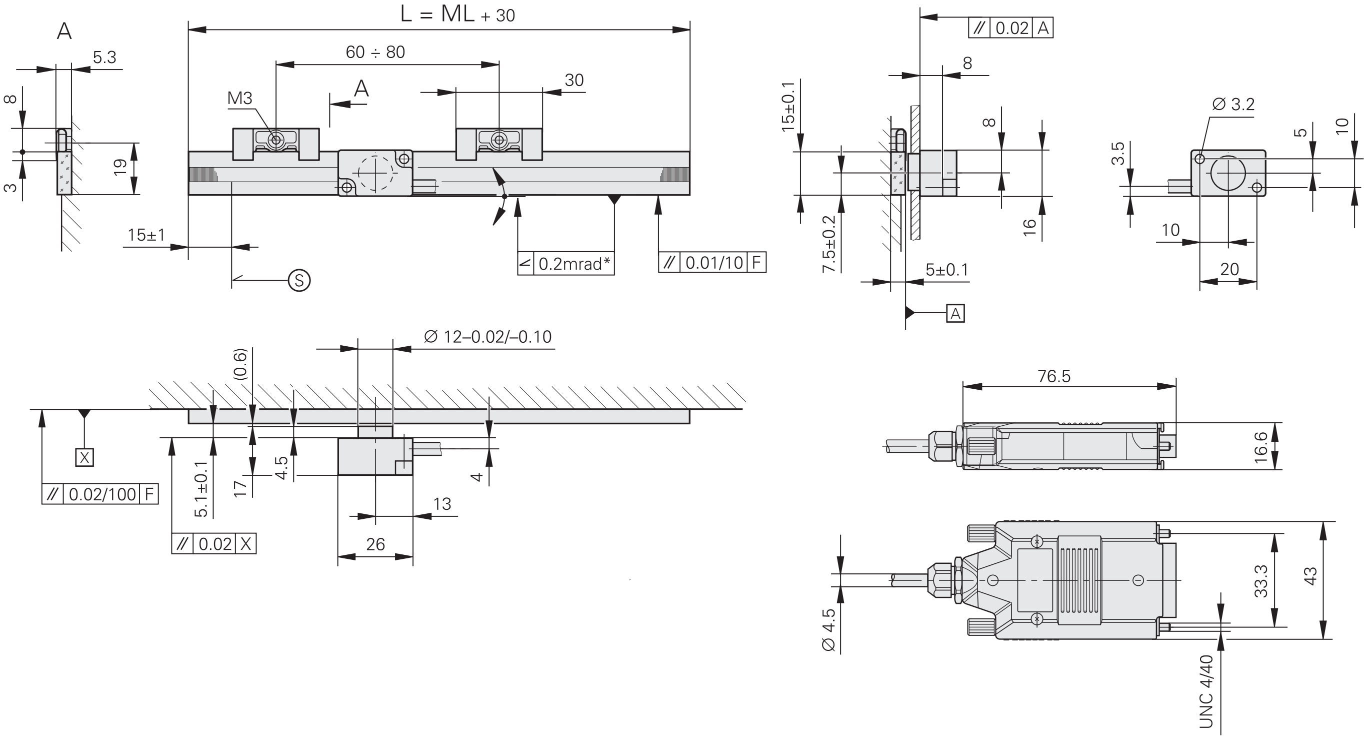
DIN ISO 8015
ISO 2768 - m H

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

LIP 471 R/LIP 481 R



LIP 471 A/LIP 481 A



LIP 571
LIP 581

Incremental linear encoders with very high accuracy
- **For larger measuring lengths**
- **For measuring steps of 1 µm to 0.05 µm (0.000 05 in. to 0.000 002 in.)**

Specifications	**LIP 571** **LIP 581**
Measuring standard Grating period Thermal expansion coefficient	DIADUR phase grating on glass 8 µm $\alpha_{therm} \approx 8$ ppm/K
Accuracy grade	± 1 µm
Measuring length ML* in mm inches	70, 120, 170, 220, 270, 320, 2.7, 4.7, 6.7, 8.6, 10.6, 12.6, 370, 420, 470, 520, 570, 620, 14.5, 16.5, 18.5, 20.5, 22.4, 24.4, 670, 720, 770, 820, 870, 920, 26, 28, 30, 32, 34, 36, 970, 1020, 1240, 1440 38, 40, 48, 56
Reference marks* **LIP 5x1 R** **LIP 5x1 C**	One at midpoint of measuring length Distance-coded; absolute position value available after max. 20 mm traverse
Max. traversing speed **LIP 571** **LIP 581**	See page 37 72 m/min with –3dB cutoff frequency ≥ 300 kHz
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 200 m/s² (IEC 60 068-2-6) ≤ 500 m/s² (IEC 60 068-2-27)
Operating temperature	0 to 50 °C (32 to 122 °F)
Weight Scanning head Interface electronics Scale Cable	20 g (without cable) 140 g 7.2 g +0.24 g/mm measuring length 37 g/m
Power supply **LIP 571** **LIP 581**	5 V ± 5 %/< 220 mA (without load) 5 V ± 5 %/< 210 mA
Incremental signals/ Signal period **LIP 571** **LIP 581**	⊓⊔ TTL/integr. 5-fold interpolation: 0.8 µm ⊓⊔ TTL/integr. 10-fold interpolation: 0.4 µm ∿ 1 V_{PP}/4 µm
Electrical connection* Max. cable length **LIP 571** **LIP 581**	Cable 0.5 m/1 m or 3 m with D-sub connector (15-pin); interface electronics are integrated in the connector 100 m (329 ft) 150 m (492 ft)

***** Please indicate when ordering

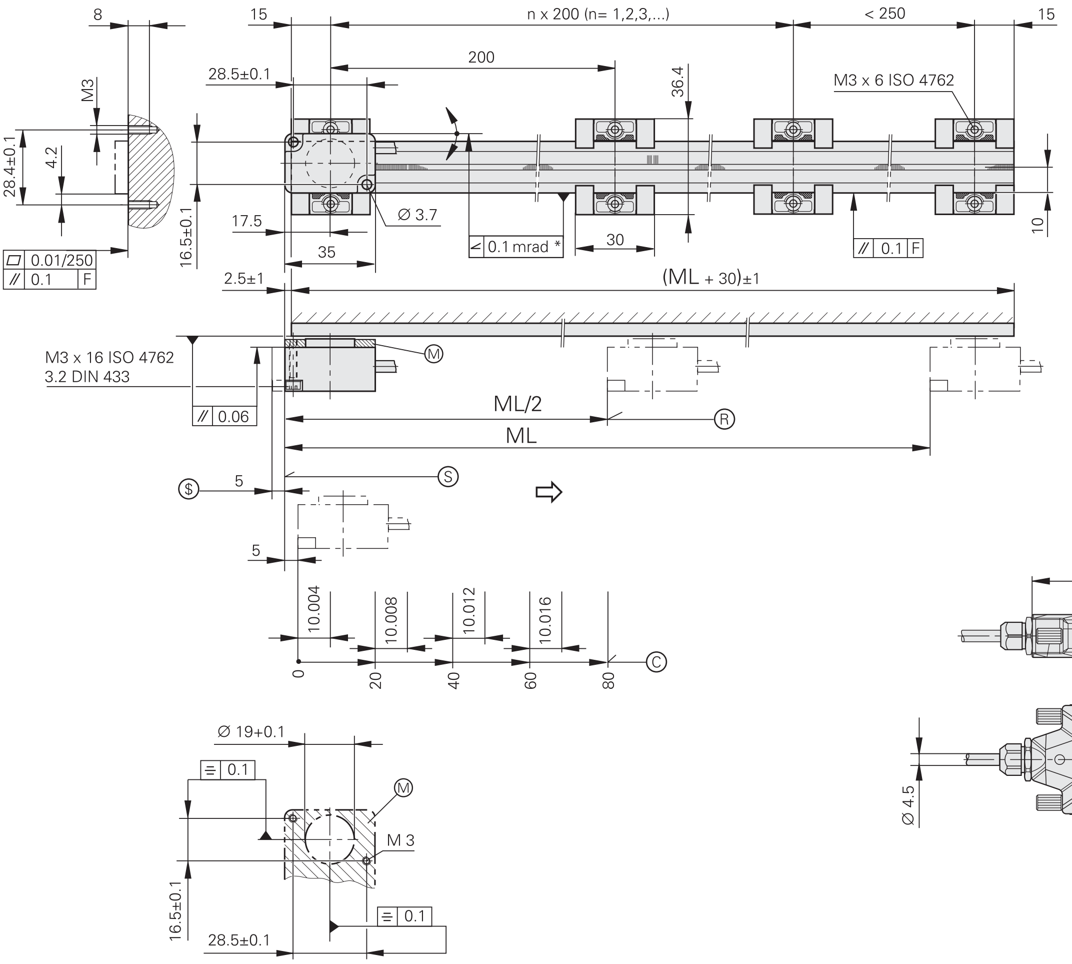
Dimensions

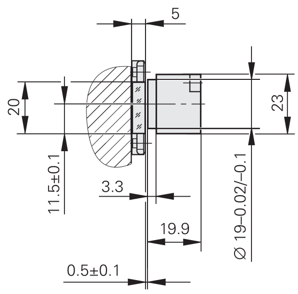
in mm

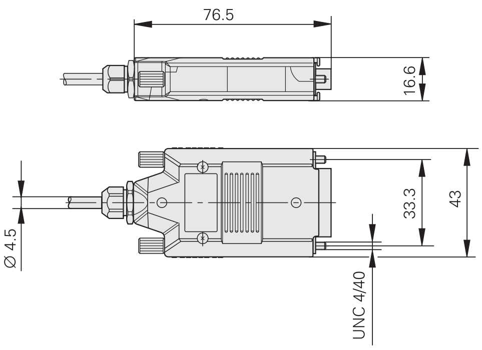
DIN ISO 8015
ISO 2768 - m H

F = Machine guideway
* = Max. change during operation
Ⓡ = Reference mark position LIP 5x1 R
Ⓒ = Reference mark position 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


HEIDENHAIN


8
15
n x 200 (n= 1,2,3,...)
< 250
15
200
28.5±0.1
36.4
M3 x 6 ISO 4762
M3
28.4±0.1
4.2
16.5±0.1
17.5
Ø 3.7
35
0.1 mrad *
30
0.1 F
10
0.01/250
0.1 F
2.5±1
(ML + 30)±1
M3 x 16 ISO 4762
3.2 DIN 433
M
0.06
ML/2
R
ML
5
S
5
10.004
10.008
10.012
10.016
0
20
40
60
80
C
Ø 19+0.1
0.1
M
M 3
0.1
16.5±0.1
28.5±0.1


5
20
23
11.5±0.1
3.3
19.9
Ø 19–0.02/–0.1
0.5±0.1


76.5
16.6
Ø 4.5
33.3
43
UNC 4/40

LIF 471
LIF 481

Incremental linear encoder

- **For measuring steps of 1 µm to 0.1 µm (0.000 05 in. to 0.000 005 in.)**
- **Simple mounting with PRECIMET® adhesive film**
- **Position detection through homing track and limit switches**
- **Relatively insensitive to contamination thanks to SUPRADUR graduation**

Specifications		**LIF 471** **LIF 481**
Measuring standard Up to ML 220 mm From ML 270 mm Grating period Thermal expansion coefficient		 SUPRADUR phase grating on glass DIADUR phase grating on glass 8 µm $\alpha_{therm} \approx$ 8 ppm/K
Accuracy grade		± 3 µm
Measuring length ML* in mm inches		70, 120, 170, 220, 270, 320, 2.7, 4.7, 6.7, 8.6, 10.6, 12.6, 370, 420, 470, 520, 570, 620, 14.5, 16.5, 18.5, 20.5, 22.4, 24.4, 670, 720, 770, 820, 870, 920, 26, 28, 30, 32, 34, 36, 970, 1020 38, 40
Reference marks		One at midpoint of measuring length
Position detection	Output signals	Homing signal and Limit signal TTL (without line driver)
Max. traversing speed	**LIF 471** **LIF 481**	See page 37 72 m/min with –3dB cutoff frequency ≥ 300 kHz 100 m/min with –6dB cutoff frequency ≥ 420 kHz
Vibration 55 to 2000 Hz **Shock** 11 ms		≤ 200 m/s² (IEC 60 068-2-6) ≤ 400 m/s² (IEC 60 068-2-27)
Operating temperature		0 to 50 °C (32 to 122 °F)
Weight	Scanning head Interface electronics Scale Cable	9 g (without cable) 140 g 0.8 g + 0.08 g/mm measuring length 37 g/m
Power supply	**LIF 471** **LIF 481**	5 V ± 5% max. 180 mA (without load) 5 V ± 5%/< 175 mA
Incremental signals/ Signal periods	**LIF 471** **LIF 481**	⊓⊔ TTL/integr. 100-fold interp.: 0.04 µm ⊓⊔ TTL/integr. 50-fold interp.: 0.08 µm ⊓⊔ TTL/integr. 20-fold interp.: 0.2 µm ⊓⊔ TTL/integr. 10-fold interp.: 0.4 µm ⊓⊔ TTL/integr. 5-fold interp.: 0.8 µm ∿ 1 V_{PP}/4 µm
Electrical connection* Max. cable length	 Incremental signals Homing, limit	Cable 0.5 m/1 m or 3 m with D-sub connector (15-pin); interface electronics are integrated in the connector 30 m (98.5 ft) 10 m (32.8 ft)

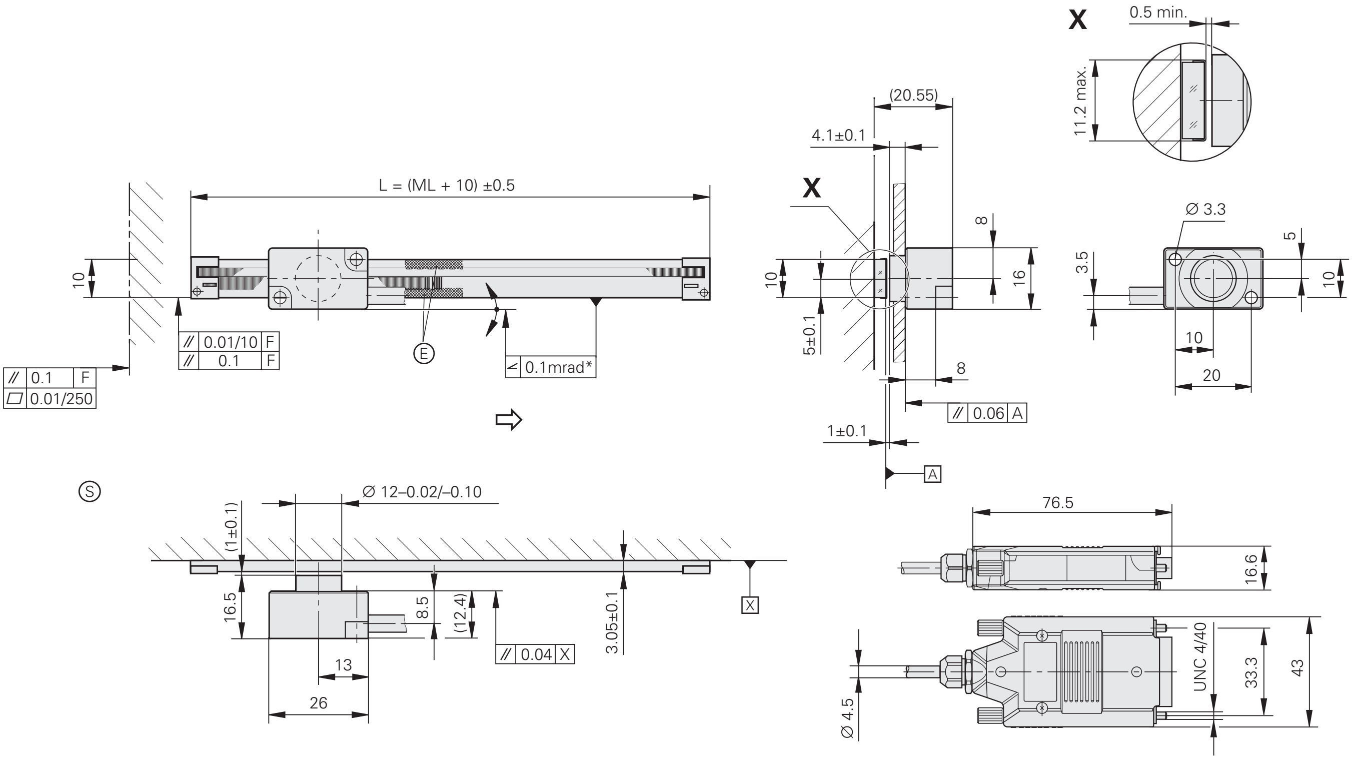
***** Please indicate when ordering

Dimensions

in mm

DIN ISO 8015
ISO 2768 - m H

F = Machine guideway
* = Max. change during operation
Ⓡ = Reference mark position
Ⓔ = Epoxy for ML < 170
Ⓗ = Switch for homing track
Ⓢ = Beginning of measuring length
Ⓛ = Limit mark, adjustable
P = Gauging points for alignment
⇨ = Direction of scanning head motion for output signals in accordance with interface description



L = (ML + 10) ±0.5
10
0.01/10 F
0.1 F
0.1 F
0.01/250
E
0.1mrad*
S
Ø 12–0.02/–0.10
(1±0.1)
16.5
8.5
(12.4)
0.04 X
3.05±0.1
X
13
26
(20.55)
4.1±0.1
X
8
16
5±0.1
8
0.06 A
1±0.1
A
X
0.5 min.
11.2 max.
Ø 3.3
3.5
5
10
10
20
76.5
16.6
UNC 4/40
33.3
43
Ø 4.5

LIDA 171
LIDA 181

Incremental linear encoders for high traversing speeds

- **With steel scale**
- **For measuring steps of 1 µm to 0.1 µm (0.000 05 in. to 0.000 005 in.)**
- **Large mounting tolerances**
- **Mounting variants as for LIDA 400 available on request**

Specifications	**LIDA 171** **LIDA 181**
Measuring standard Grating period Thermal expansion coefficient	Steel tape with AURODUR graduation 40 µm $\alpha_{therm} \approx$ 10 ppm/K
Accuracy grade*	±5 µm (±0.000 2 in.) ±3 µm (±0.000 12 in.)
Measuring length ML* in mm inches	220, 270, 320, 370, 420, 470, 8.6, 10.6, 12.6, 14.5, 16.5, 18.5, 520, 620, 720, 770, 820, 920, 20.5, 24.4, 28, 30, 32, 36, 1020, 1240, 1440, 1640, 1840, 2040 40, 48, 56, 64, 72, 80
Reference marks* **LIDA 1x1** **LIDA 1x1 C**	Selectable by magnet every 50 mm (2 in.) Distance-coded; absolute position value available after max. 80 mm traverse
Max. traversing speed **LIDA 171** **LIDA 181**	See page 37 480 m/min with –3dB cutoff frequency ≥ 200 kHz
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 200 m/s² (IEC 60 068-2-6) ≤ 500 m/s² (IEC 60 068-2-27)
Operating temperature	0 to 50 °C (32 to 122 °F)
Weight Scanning head Selector magnet Scale Cable	70 g (without cable) 10 g Approx. 1.5 kg/m measuring length 37 g/m
Power supply **LIDA 171** **LIDA 181**	5 V ± 5 %/< 200 mA (without load) 5 V ± 5 %/< 150 mA
Incremental signals/ Signal periods **LIDA 171** **LIDA 181**	⊓⊔ TTL/integr. 10-fold interpolation: 4 µm ⊓⊔ TTL/integr. 5-fold interpolation: 8 µm ∿ 1 V_{PP}/40 µm
Electrical connection Max. cable length **LIDA 171** **LIDA 181**	Cable 3 m with connector 100 m (329 ft) 150 m (429 ft)

***** Please indicate when ordering

Dimensions

in mm

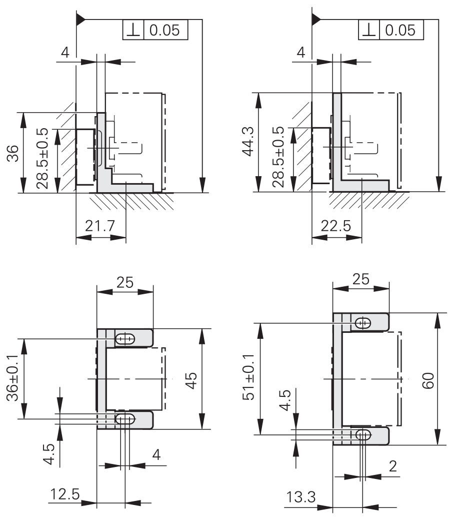
DIN ISO 8015
ISO 2768 - m H

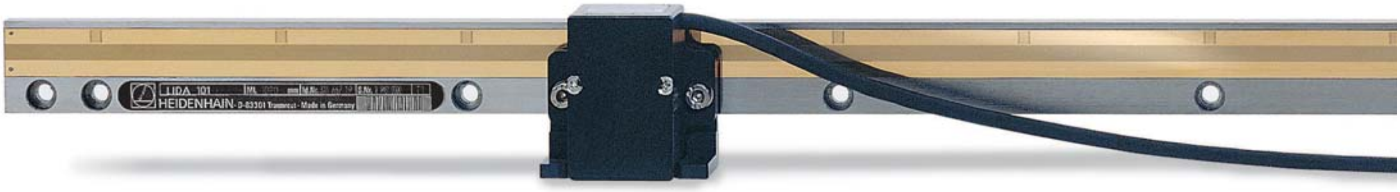
F = Machine guideway
* = Max. change during operation
Ⓡ = Reference mark position with selector magnet LIDA 1x1
Ⓒ = Reference mark position LIDA 1x1 C
Ⓢ = Beginning of measuring length (ML)
Ⓜ = Mounting surface for scanning head
Ⓥ = Mounting bracket (special accessory)
Ⓐ = Selector magnet
Ⓛ = Scale length
▣ = On version Ⓡ no steel permitted in this area
⇨ = Direction of scanning head motion for output signals in accordance with interface description

ML	e
.. 20	25
.. 40	35
.. 70	50

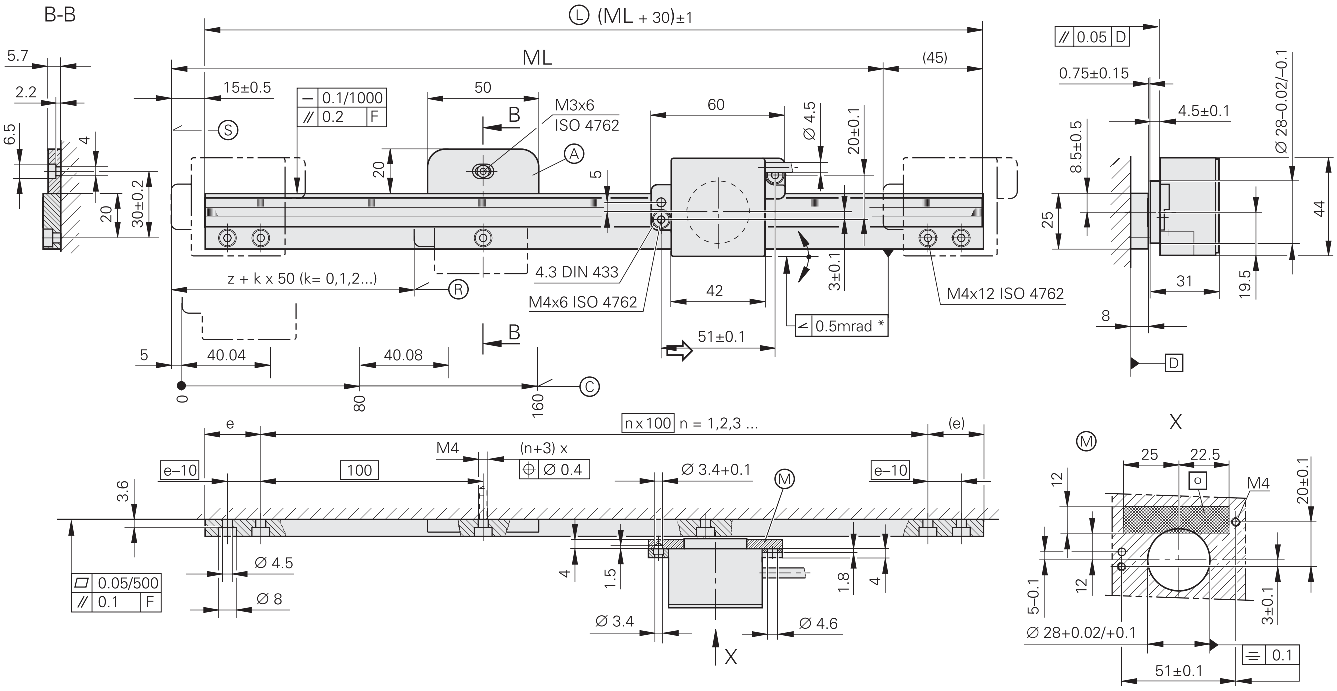
ML	z
≤ 1020	10
> 1020	20

Ⓥ

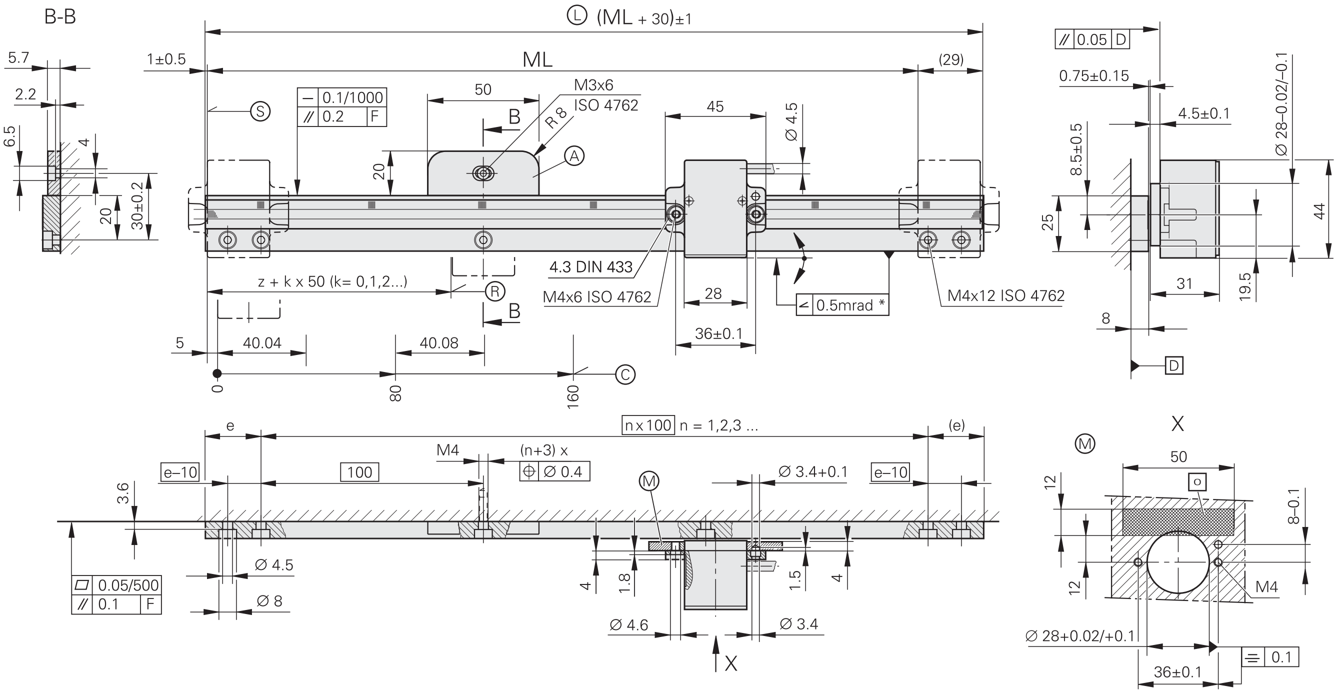




LIDA 171



LIDA 181



LIDA 475
LIDA 485

Incremental linear encoders for limited installation space

- **For large measuring lengths up to 30 m (100 ft)**
- **For measuring steps of 1 µm to 0.1 µm (0.000 05 in. to 0.000 005 in.)**
- **Large mounting tolerances**
- **Limit switches**

Specifications	**LIDA 475** **LIDA 485**
Measuring standard Grating period Thermal expansion coefficient	Steel tape with AURODUR graduation 20 µm Depends on the mounting surface
Accuracy grade	± 5 µm
Measuring length ML* in mm inches	140, 240, 340, 440, 540, 640, 5.5, 9.5, 13.4, 17.3, 21.3, 25, 740, 840, 940, 1040, 1140, 1240, 29, 33, 37, 41, 44, 48, 1340, 1440, 1540, 1640, 1740, 1840, 52, 56, 60, 64, 68, 72, 1940, 2040 76, 80 Larger measuring lengths up to 30 040 mm with a single-section scale tape and individual scale-carrier sections
Reference mark	One at midpoint of measuring length
Limit switches Output signals	L1/L2 with two different magnets TTL (without line driver)
Max. traversing speed **LIDA 475** **LIDA 485**	See page 37 480 m/min with –3dB cutoff frequency ≥ 400 kHz
Vibration 55 to 2000 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 to 50 °C (32 to 122 °F)
Weight Scanning head Scale Cable	20 g (without cable) Approx. 115 g +250 g/m ML 22 g/m
Power supply **LIDA 475** **LIDA 485**	5 V ± 5 %/< 200 mA (without load) 5 V ± 5 %/< 150 mA
Incremental signals/ Signal periods **LIDA 475** **LIDA 485**	⊓⊔ TTL/integr. 5-fold interpolation: 4 µm ⊓⊔ TTL/integr. 10-fold interpolation: 2 µm ∿ 1 V_{PP}/20 µm
Electrical connection Max. cable length	Cable 3 m with D-sub connector (15-pin) For LIDA 475, the interface electronics are integrated in the connector 20 m (66 ft)

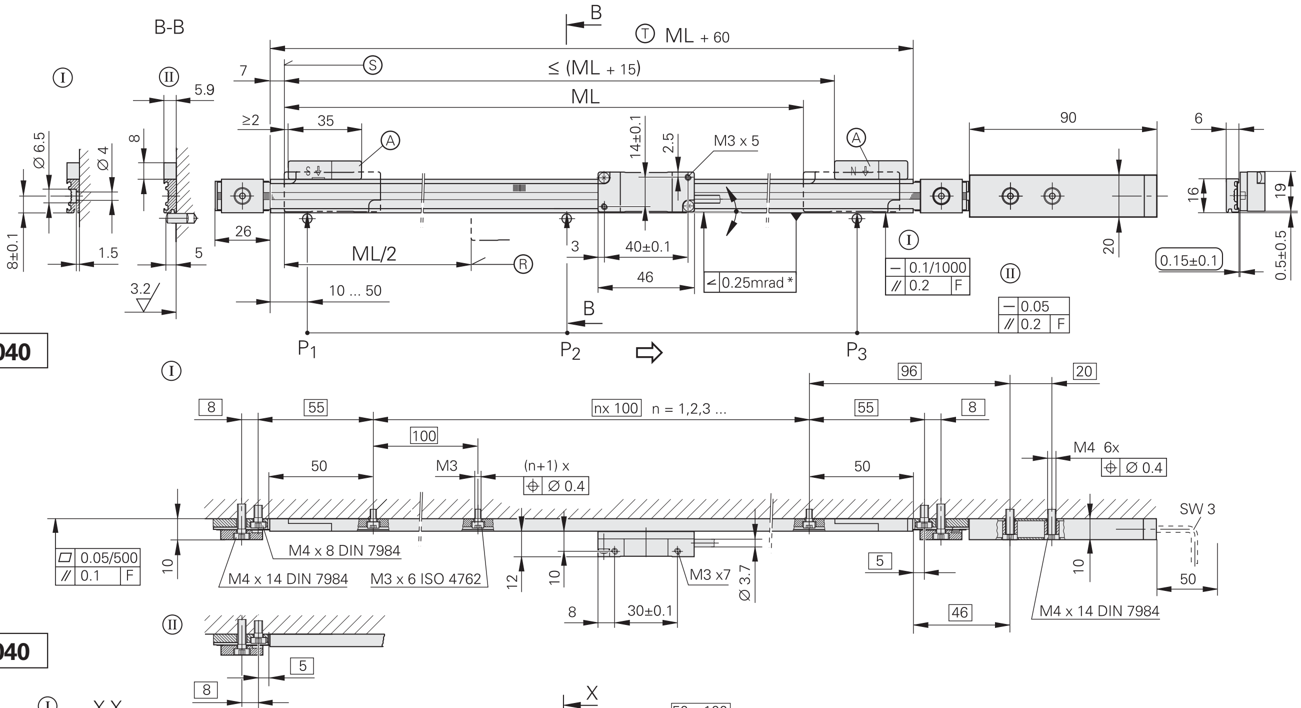
* Please indicate when ordering

Dimensions

in mm

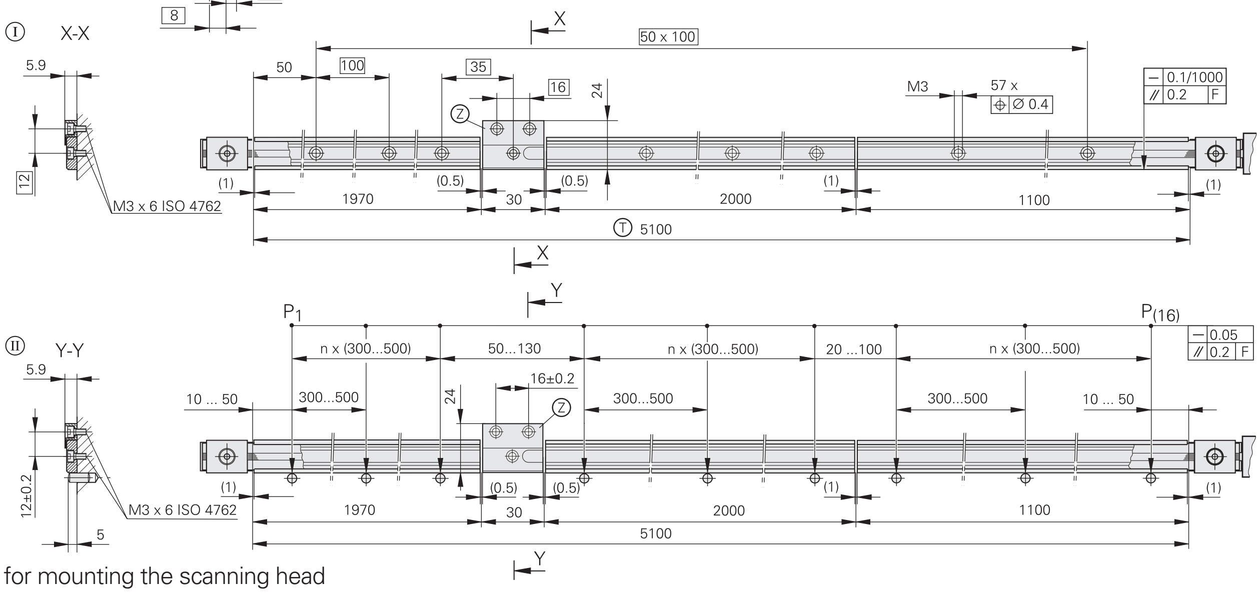
DIN ISO 8015
ISO 2768 - m H

- Ⓘ = 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 switches
- Ⓣ = Carrier length
- Ⓩ = Spacer for measuring lengths from 3040 mm
- ⇨ = Direction of scanning head motion for output signals in accordance with interface description

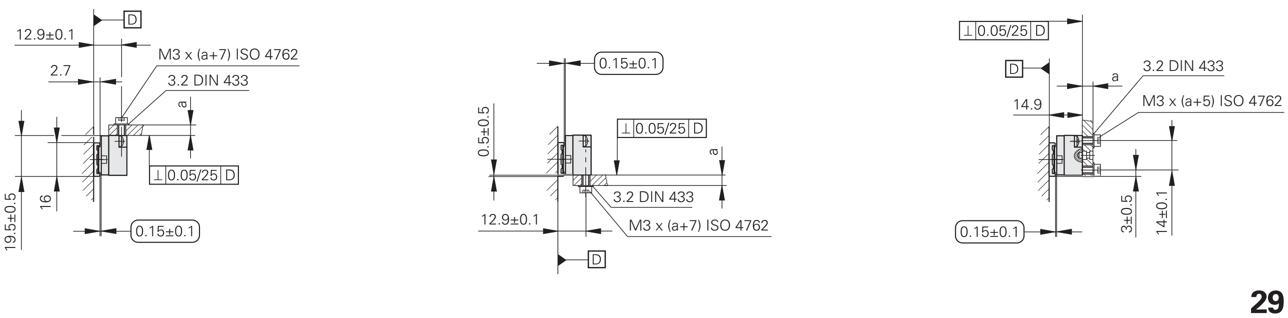


ML ≤ 2040

ML > 2040



Possibilities for mounting the scanning head



LIDA 477
LIDA 487

Incremental linear encoders for limited installation space
- **For measuring ranges up to 6 m**
- **For measuring steps of 1 µm to 0.1 µm (0.000 05 in. to 0.000 005 in.)**
- **Large mounting tolerances**
- **Limit switches**

Specifications	**LIDA 477** **LIDA 487**
Measuring standard Grating period Thermal expansion coefficient	Steel scale tape with AURODUR graduation 20 µm $\alpha_{therm} \approx 10$ ppm/K
Accuracy grade	± 15 µm or ± 5 µm after linear length-error compensation in the evaluation electronics
Measuring length ML* in mm inches	240, 440, 640, 840, 1040, 1240, 9.5, 17.3, 25, 33, 41 48 1440, 1640, 1840, 2040, 2240, 2440, 56, 64, 72, 80, 88, 96, 2640, 2840, 3040, 3240, 3440, 3640, 104, 112, 120, 127, 135, 143, 3840, 4040, 4240, 4440, 4640, 4840, 151, 159, 166, 174, 182, 190, 5040, 5240, 5440, 5640, 5840, 6040 198, 206, 214, 222, 229, 237
Reference marks	One at midpoint of measuring length
Limit switches Output signals	L1/L2 with two different magnets TTL (without line driver)
Max. traversing speed **LIDA 477** **LIDA 487**	See page 37 480 m/min with –3dB cutoff frequency ≥ 400 kHz
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 200 m/s² (IEC 60 068-2-6) ≤ 500 m/s² (IEC 60 068-2-27)
Operating temperature	0 to 50 °C (32 to 122 °F)
Weight Scanning head Scale Cable	20 g (without cable) Approx. 25 g +100 g/m ML 22 g/m
Power supply **LIDA 477** **LIDA 487**	5 V ± 5 %/< 200 mA (without load) 5 V ± 5 %/< 150 mA
Incremental signals/ Signal periods **LIDA 477** **LIDA 487**	⊓⊔ TTL/integr. 5-fold interpolation: 4 µm ⊓⊔ TTL/integr. 10-fold interpolation: 2 µm ∼ 1 V_{PP}/20 µm
Electrical connection Max. cable length	Cable 3 m with D-sub connector (15-pin) For LIDA 477, the interface electronics are integrated in the connector 20 m (66 ft)

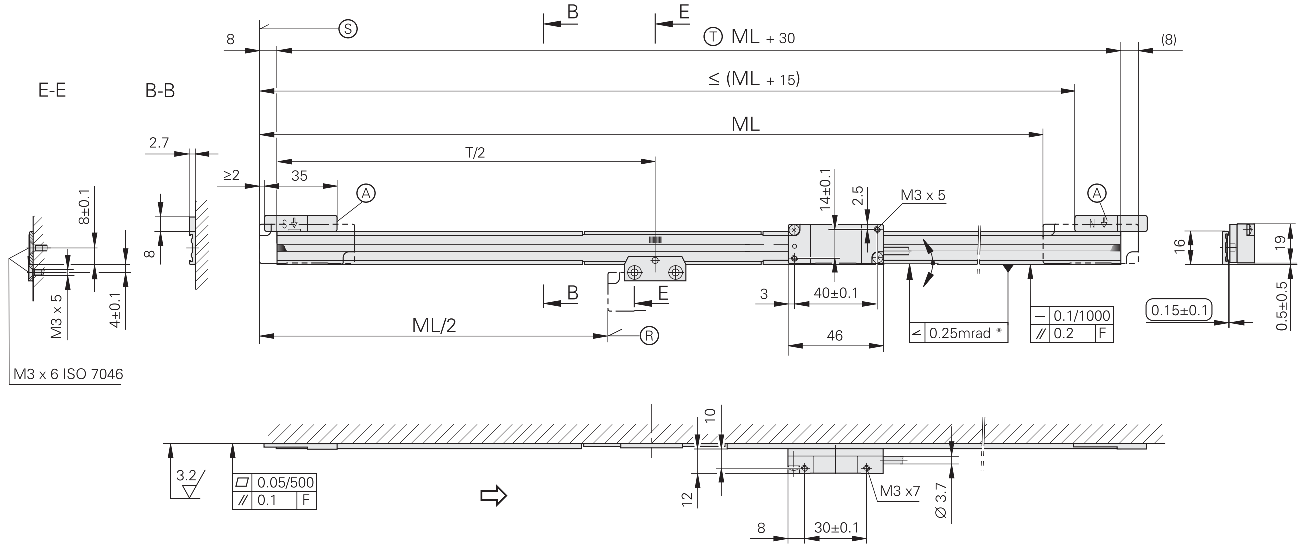
***** Please indicate when ordering

Dimensions

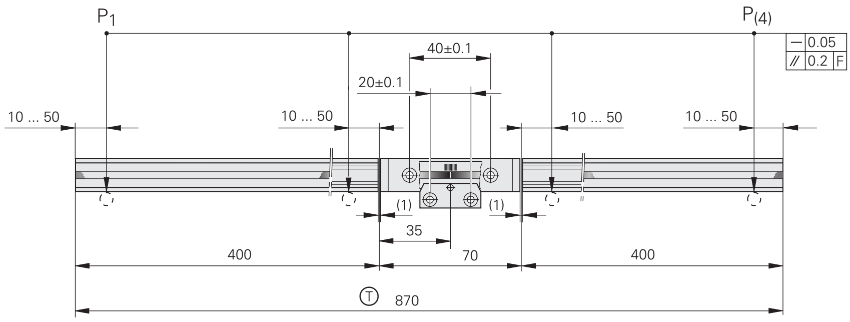
in mm

DIN ISO 8015
ISO 2768 - m H

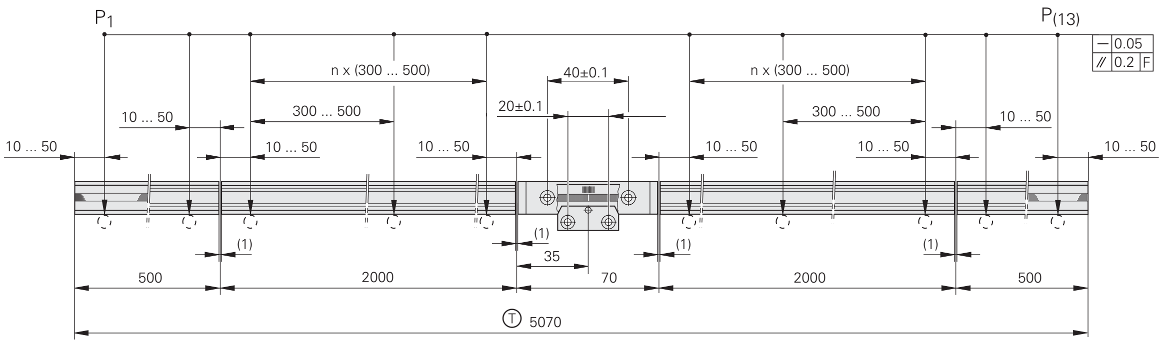
F = Machine guideway
⊂⊃ = Adjust or set
* = Max. change during operation
P = Gauging points for alignment
Ⓡ = Reference mark position
Ⓢ = Beginning of measuring length (ML)
Ⓐ = Selector magnet for limit switches
Ⓣ = Carrier length
⇨ = Direction of scanning head motion for output signals in accordance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



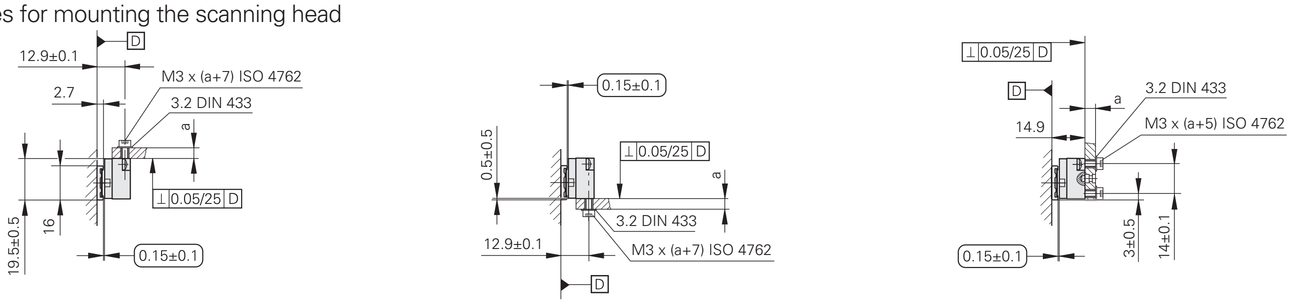
ML ≤ 2040



ML > 2040



Possibilities for mounting the scanning head



PP 271 R
PP 281 R

Incremental two-coordinate encoder
For measuring steps of 1 µm to 0.05 µm (0.000 05 in. to 0.000 002 in.)

Specifications		**PP 271 R** **PP 281 R**
Measuring standard Grating period Thermal expansion coefficient		Two-coordinate TITANID® phase grating on glass 8 µm $\alpha_{therm} \approx$ 8 ppm/K
Accuracy grade		± 2 µm
Measuring range		68 mm x 68 mm (2.7 in x 2.7 in.), (other measuring ranges upon request)
Reference mark		One reference mark each, 3 mm after beginning of measuring length
Max. traversing speed	**PP 271 R** **PP 281 R**	See page 37 60 m/min with –3dB cutoff frequency ≥ 250 kHz
Vibration 55 to 2000 Hz **Shock** 11 ms		≤ 80 m/s² (IEC 60 068-2-6) ≤ 100 m/s² (IEC 60 068-2-27)
Operating temperature		0 to 50 °C (32 to 122 °F)
Weight	Scanning head Interface electronics Grid plate Cable	170 g 140 g 75 g 37 g/m
Power supply	**PP 271 R** **PP 281 R**	5 V ± 5 %/210 mA (without load) 5 V ± 5 %/210 mA
Incremental signals/ Signal period	**PP 271 R** **PP 281 R**	⊓⊔ TTL/integr. 5-fold interpolation: 0.8 µm ⊓⊔ TTL/integr. 10-fold interpolation: 0.4 µm ∼ 1 V_{PP}/4 µm
Electrical connection Max. cable length	 **PP 271 R** **PP 281 R**	Cable 0.5 m with D-sub connector (15-pin) Interface electronics are integrated in the connector 100 m (329 ft) 150 m (492 ft)

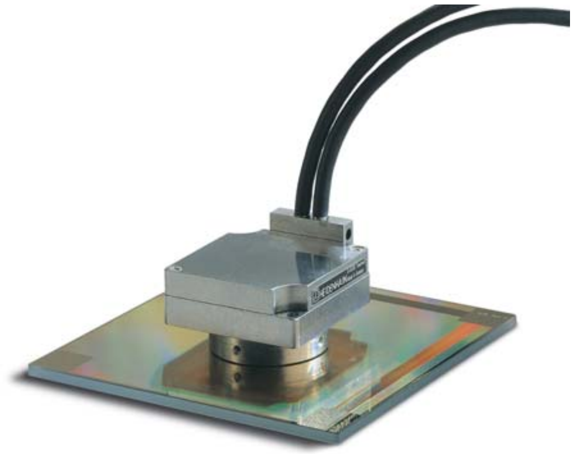
Dimensions

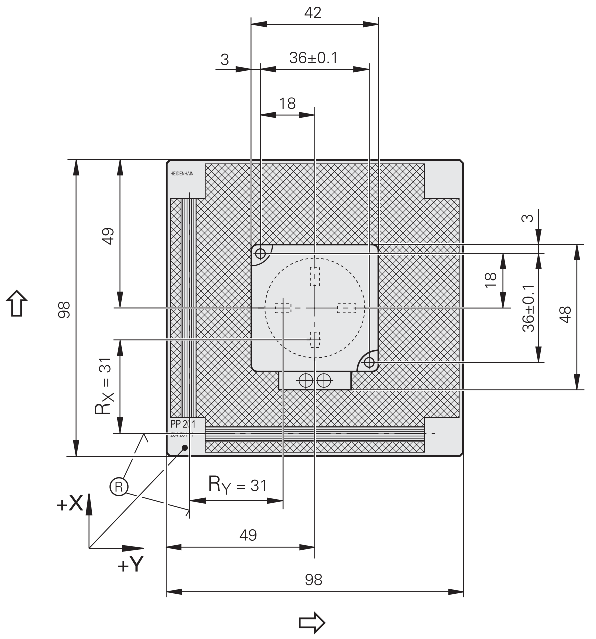
in mm

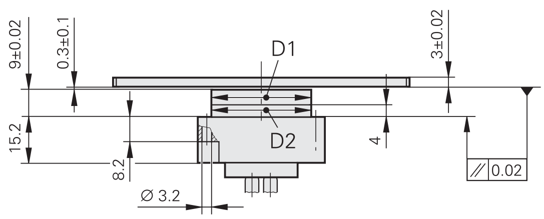
DIN ISO 8015
ISO 2768 - m H

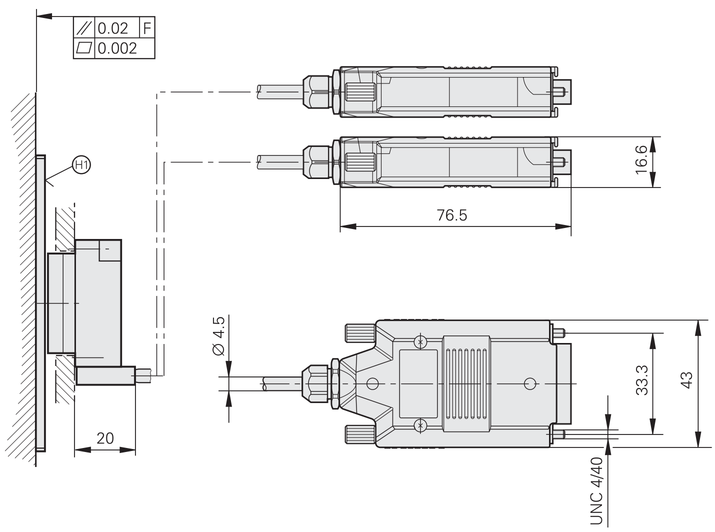
F = Machine guideway
Ⓗ = Side with graduation
Ⓡ = Reference mark position from shown center
⇨ = Direction of scanning head motion for output signals in accordance with interface description

D1	D2
Ø 32,9 –0,2	Ø 33 –0,02/–0,10




42
3
36±0.1
18
98
49
RX = 31
RY = 31
3
18
36±0.1
48
49
98
+X
+Y
R
PP 281
HEIDENHAIN


9±0.02
0.3±0.1
D1
D2
3±0.02
15.2
8.2
4
Ø 3.2
0.02


0.02 F
0.002
H1
20
16.6
76.5
Ø 4.5
33.3
43
UNC 4/40

Interfaces
Incremental signals ∿ 1 V_{PP}

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

The sinusoidal **incremental signals** A and B are phase-shifted by 90° elec. and have 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 an idle level *H*. This must not cause the subsequent electronics to overdrive. In the lowered signal level, signal peaks can also appear with the amplitude *G*.

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:

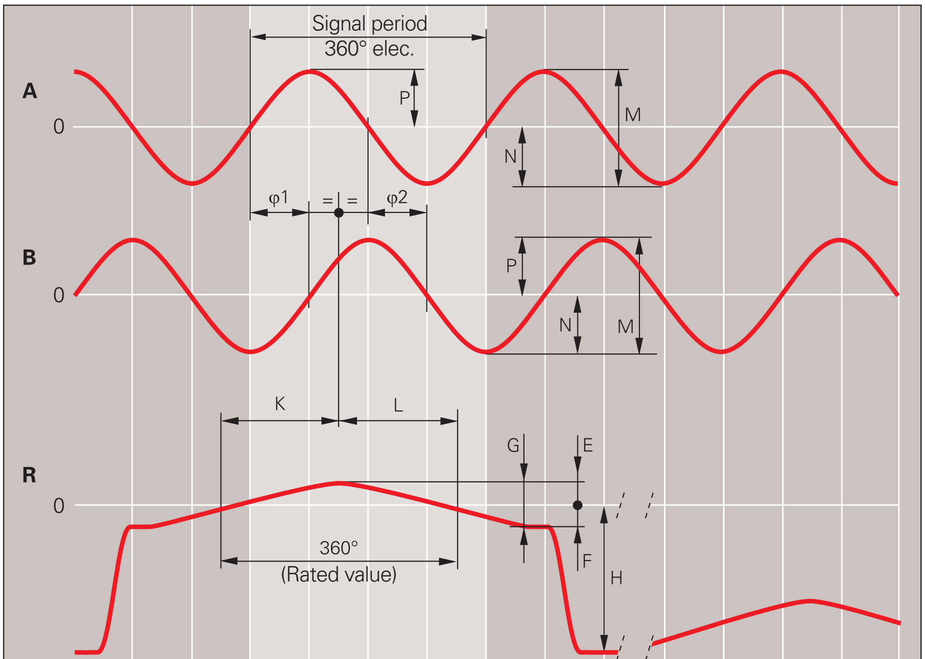
- –3 dB cutoff frequency:
  70 % of the signal amplitude
- –6 dB cutoff frequency:
  50 % of the signal amplitude

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

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

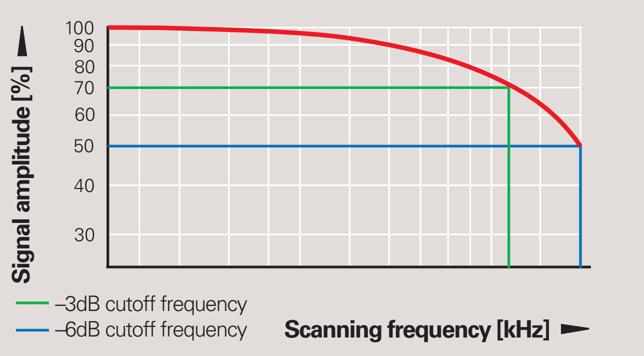
Interface	Sinusoidal voltage signals ∿ **1 V_{PP}**	
Incremental signals	**Two nearly sinusoidal signals A and B**	
	Signal amplitude M:	0.6 to 1.2 V_{PP}; 1 V_{PP} typical
	Asymmetry|P – N|/2M:	≤ 0.065
	Amplitude ratio M_A/M_B:	0.8 to 1.25
	Phase angle |φ1 + φ2|/2:	90° ± 10° elec.
Reference mark signal	**One or more signal peaks R**	
	Usable component G:	0.2 to 0.85 V
	Quiescent value H:	0.04 V to 1.7 V
	Switching threshold E, F:	≥ 40 mV
	Zero crossovers K, L:	180° ± 90° elec.
Connecting cable	HEIDENHAIN cable with shielding PUR [4(2 · 0.14 mm^2) + (4 · 0.5 mm^2)]	
Cable length	Max. 150 m distributed capacitance 90 pF/m	
Propagation time	6 ns/m	

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



A, B and R measured with oscilloscope in differential mode

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



Input circuitry of the subsequent electronics

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

–3dB cutoff frequency of circuitry
Approx. 450 kHz
Approx. 50 kHz with C_1 = 1000 pF
and C_2 = 82 pF

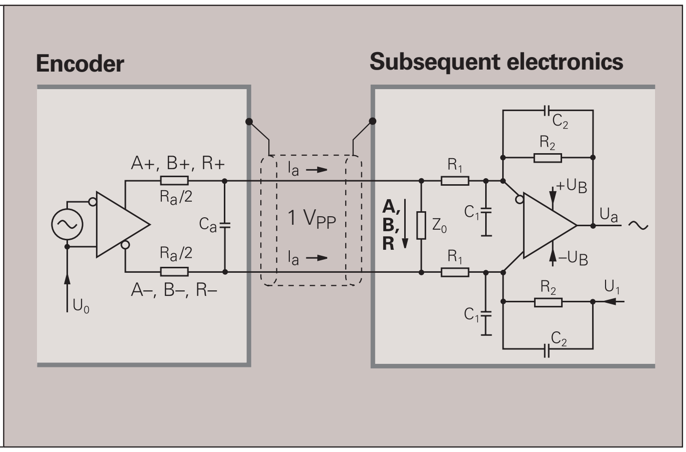
This circuit variant does reduce the bandwidth of the circuit, but in doing so it improves its noise immunity.

Circuit output signals
U_a = 3.48 V_{PP} typical
Gain 3.48

Signal monitoring
A threshold sensitivity of 250 mV_{PP} is to be provided for monitoring the 1 V_{PP} incremental signals.

Incremental signals
Reference mark signal

R_a < 100 Ω,
approx. 24 Ω
C_a < 50 pF
ΣI_a < 1 mA
U_0 = 2.5 V ±0.5 V
(with respect 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.

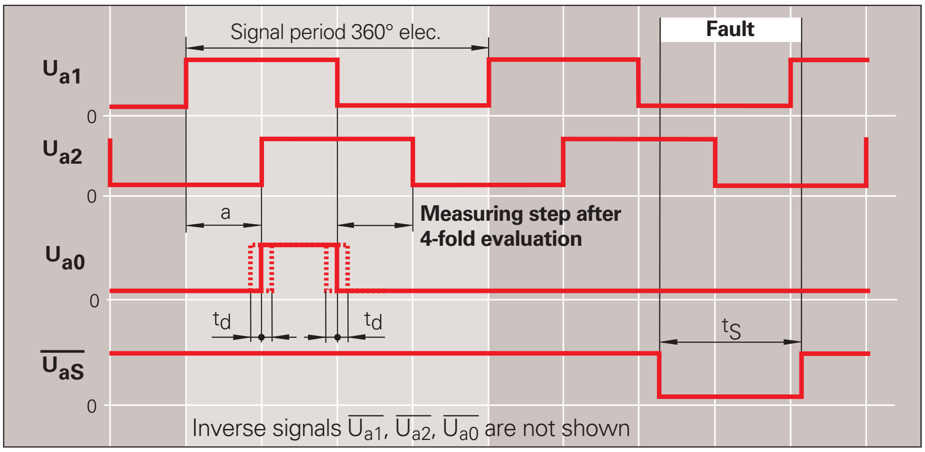
The distance between two successive edges of the incremental signals U_{a1} and U_{a2} through 1-fold, 2-fold or 4-fold evaluation is one **measuring step.**

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.

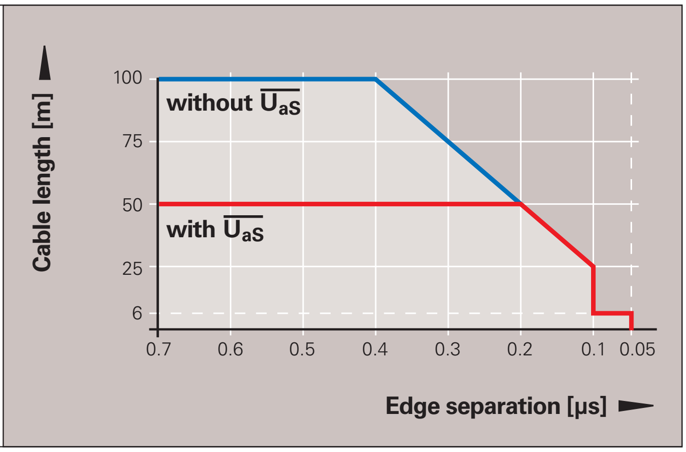
The max. permissible **shaft speed** or **traversing velocity** must never be exceeded.

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).

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	**One or more TTL square-wave pulses U_{a0}** and their inverse pulses $\overline{U_{a0}}$ 90° elec. (other widths available on request); *LS 323:* nongated $\lvert t_d \rvert \leq 50$ ns
Fault detection signal Pulse width	**One TTL square-wave pulse $\overline{U_{aS}}$** Improper function: LOW (on request: U_{a1}/U_{a2} high impedance) Proper function: HIGH $t_S \geq 20$ ms
Signal level	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 $\lvert I_L \rvert \leq 20$ 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 mm^2) + (4 × 0.5 mm^2)] Max. 100 m ($\overline{U_{aS}}$ max. 50 m) with distributed capacitance 90 pF/m 6 ns/m



Permissible cable length with respect to edge separation

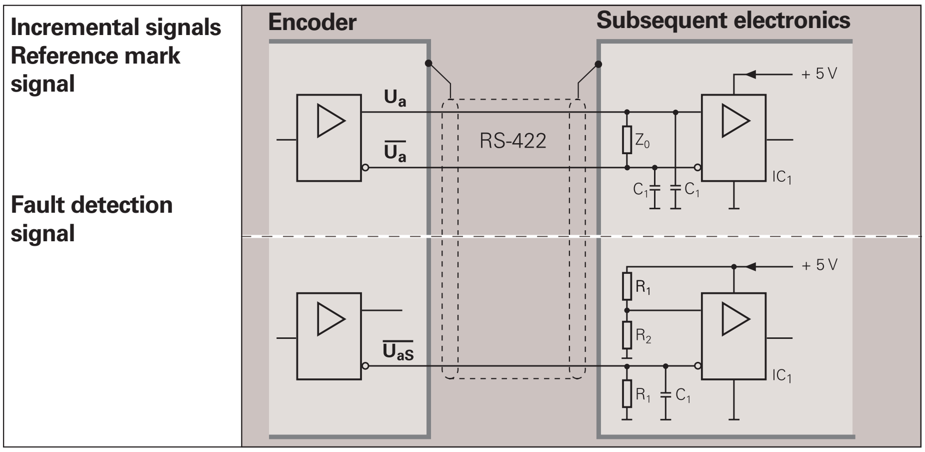


Input circuitry of the subsequent electronics

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)



Relationship between scanning frequency, traversing speed and edge separation.

	Meas. step[1]/ Interpolation*	Scanning frequency*	Traversing speed	Min. edge separation *a*
LIP 372	0.001 µm/ 32-fold	98 kHz 49 kHz 24.5 kHz	≤ 0.75 m/min ≤ 0.38 m/min ≤ 0.19 m/min	≥ 0.055 µs ≥ 0.13 µs ≥ 0.28 µs
LIP 471	0.1 µm/ 5-fold	200 kHz 100 kHz 50 kHz	≤ 24 m/min ≤ 12 m/min ≤ 6 m/min	≥ 0.23 µs ≥ 0.48 µs ≥ 0.98 µs
	0.05 µm/ 10-fold	100 kHz 50 kHz 25 kHz	≤ 12 m/min ≤ 6 m/min ≤ 3 m/min	≥ 0.23 µs ≥ 0.48 µs ≥ 0.98 µs
LIF 471	0.2 µm/ 5-fold	500 kHz 250 kHz 125 kHz	≤ 120 m/min ≤ 60 m/min ≤ 30 m/min	≥ 0.08 µs ≥ 0.18 µs ≥ 0.38 µs
	0.1 µm/ 10-fold	250 kHz 125 kHz 62.5 kHz	≤ 60 m/min ≤ 30 m/min ≤ 15 m/min	≥ 0.08 µs ≥ 0.18 µs ≥ 0.38 µs
	0.05 µm/ 20-fold	250 kHz 125 kHz 62.5 kHz	≤ 60 m/min ≤ 30 m/min ≤ 15 m/min	≥ 0.036 µs ≥ 0.08 µs ≥ 0.18 µs
	0.02 µm/ 50-fold	100 kHz 50 kHz 25 kHz	≤ 24 m/min ≤ 12 m/min ≤ 6 m/min	≥ 0.036 µs ≥ 0.08 µs ≥ 0.18 µs
	0.01 µm/ 100-fold	50 kHz 25 kHz 12.5 kHz	≤ 12 m/min ≤ 6 m/min ≤ 3 m/min	≥ 0.036 µs ≥ 0.08 µs ≥ 0.18 µs

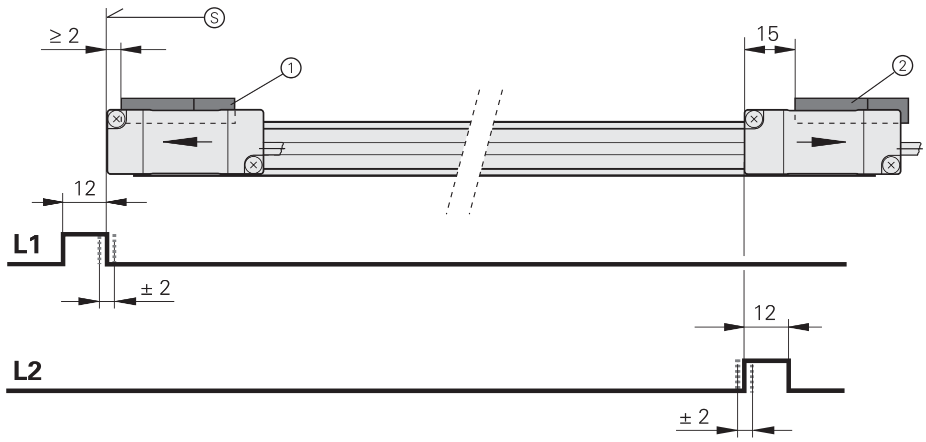
	Meas. step[1]/ Interpolation*	Scanning frequency*	Traversing speed	Min. edge separation *a*
LIP 571, PP 271	0.2 µm/ 5-fold	200 kHz 100 kHz 50 kHz	≤ 48 m/min ≤ 24 m/min ≤ 12 m/min	≥ 0.23 µs ≥ 0.48 µs ≥ 0.98 µs
	0.1 µm/ 10-fold	100 kHz 50 kHz 25 kHz	≤ 24 m/min ≤ 12 m/min ≤ 6 m/min	≥ 0.23 µs ≥ 0.48 µs ≥ 0.98 µs
LIDA 17x	2 µm/ 5-fold	200 kHz 100 kHz 50 kHz	≤ 480 m/min ≤ 240 m/min ≤ 120 m/min	≥ 0.23 µs ≥ 0.48 µs ≥ 0.98 µs
	1 µm/ 10-fold	100 kHz 50 kHz 25 kHz	≤ 240 m/min ≤ 120 m/min ≤ 60 m/min	≥ 0.23 µs ≥ 0.48 µs ≥ 0.98 µs
LIDA 47x	1 µm/ 5-fold	200 kHz 100 kHz 50 kHz	≤ 240 m/min ≤ 120 m/min ≤ 60 m/min	≥ 0.23 µs ≥ 0.48 µs ≥ 0.98 µs
	0.5 µm/ 10-fold	100 kHz 50 kHz 25 kHz	≤ 120 m/min ≤ 60 m/min ≤ 30 m/min	≥ 0.23 µs ≥ 0.48 µs ≥ 0.98 µs
	0.1 µm/ 50-fold	50 kHz 25 kHz 12.5 kHz	≤ 60 m/min ≤ 30 m/min ≤ 15 m/min	≥ 0.08 µs ≥ 0.18 µs ≥ 0.38 µs
	0.05 µm/ 100-fold	25 kHz 12.5 kHz 6.25 kHz	≤ 30 m/min ≤ 15 m/min ≤ 7.5 m/min	≥ 0.08 µs ≥ 0.18 µs ≥ 0.38 µs

***** Please indicate when ordering
[1] After 4-fold evaluation

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 an especially thin diameter of only 3.7 mm to keep forces on moving machine elements low.

		LIDA 47x	LIDA 48x
Output signals		One TTL square-wave pulse from each limit switch L1 and L2; "active high"	
Signal level		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	



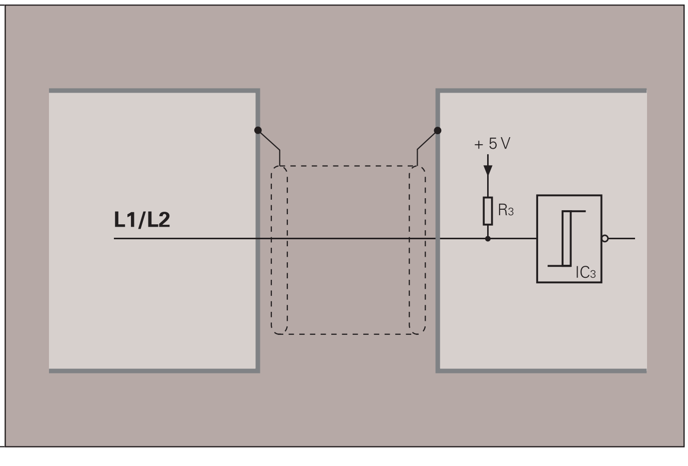
L1/L2 = Output signals of the limit switches 1 and 2
Tolerance of the switching point: ±2 mm

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

Recommended input circuitry of the subsequent electronics

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

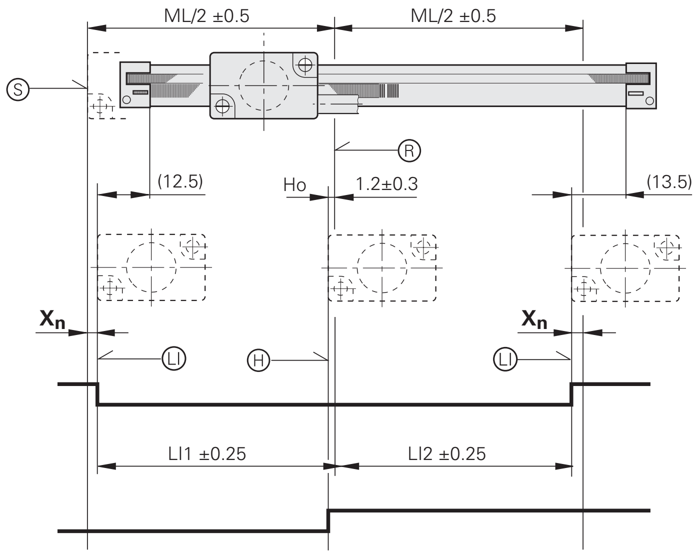
Limit switches LIDA 400



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 an especially thin diameter of only 4.5 mm to keep forces on moving machine elements to a minimum.

	LIF 4x1
Output signals	One TTL pulse for homing track H and limit switches L
Signal level	TTL from common-collector circuit $U_H \geq 3.8$ 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



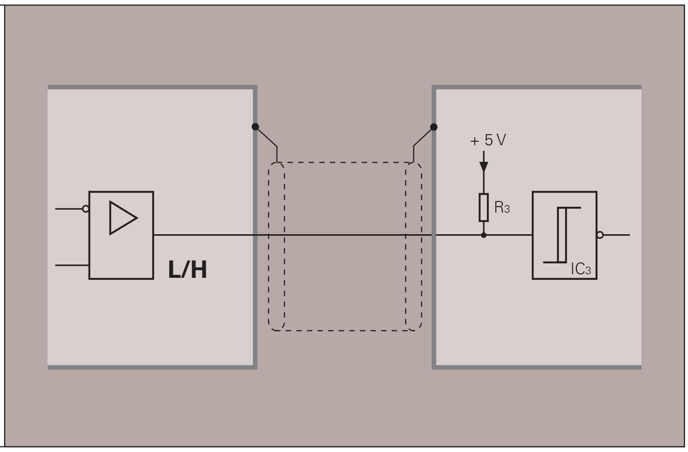
X_n =
Var. 01 **X_1** = 2 mm
Var. 02 **X_2** = 14 mm
Var. 03 **X_3** = 22 mm

Ⓡ = 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



Connecting Elements and Cables

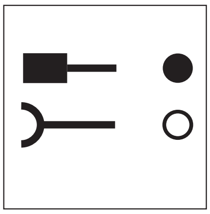
General Information

Pin numbering
The pins on connectors are numbered in directions opposite to those on couplings, regardless of whether the contacts are male or female. Couplings and flange sockets, both with external threads, have the same pin-numbering direction.

Contacts:

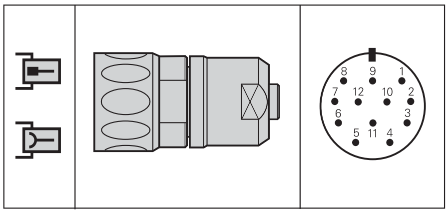
Male contacts

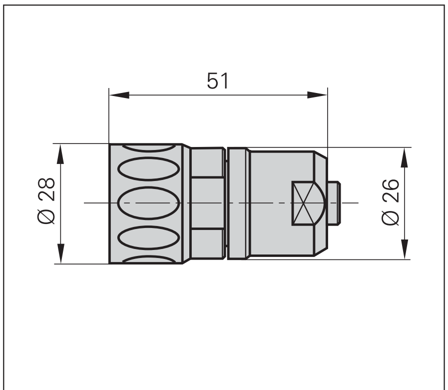
Female contacts



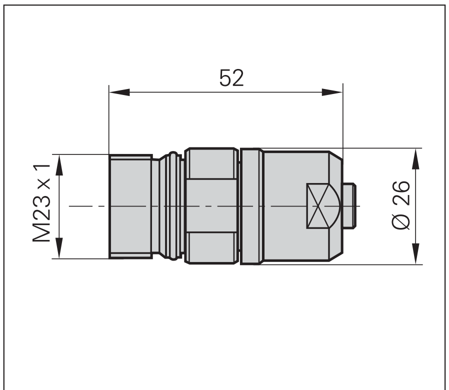
When engaged, the connections provide **protection** to IP 67 (D-sub connector: IP 50; IEC 60529). When not engaged, there is no protection.

Connector: A connecting element with coupling ring, regardless of whether the contacts are male or female.



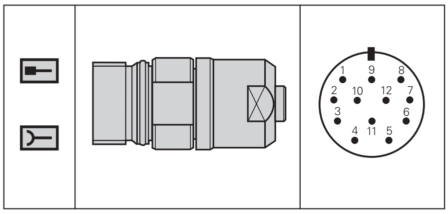


Connector, insulated

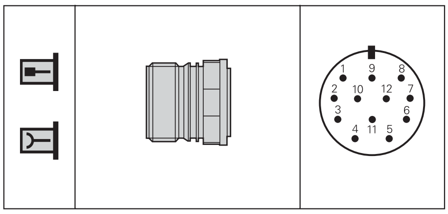


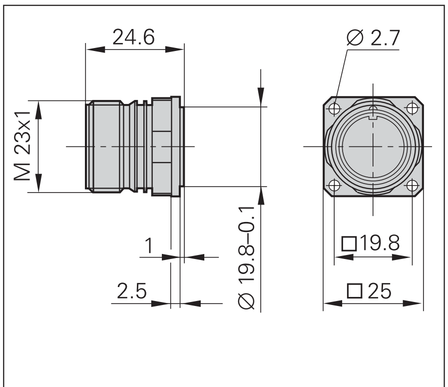
Coupling, insulated

Coupling: A connecting element with external thread, regardless of whether the contacts are male or female.

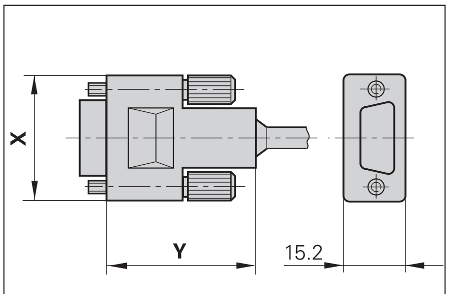


Flange socket: A flange socket is permanently mounted on the encoder or machine housing, has an external thread, and is available with male or female contacts.





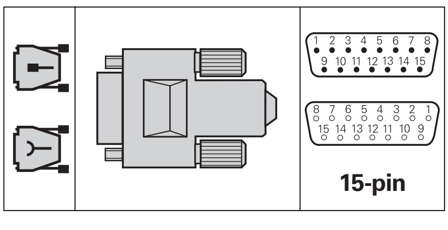
Flange socket

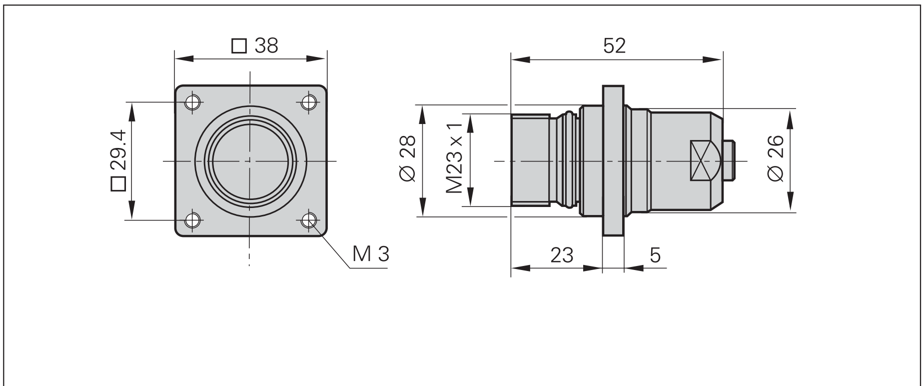


x: 42.7
y: 41.7
88.7 with integrated APE

D-sub connector

D-sub connector: The D-sub connector is used where installation space is limited (e.g., TNC 4xx, IK 220). It is available with an integral APE interface unit.

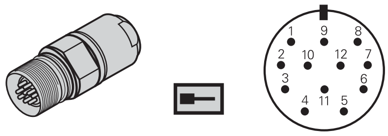




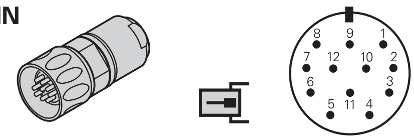
Coupling on mounting base, insulated

Connection

12-pin HEIDENHAIN coupling



12-pin HEIDENHAIN connector

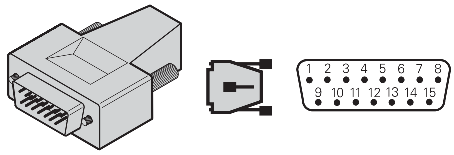


	Power supply				Incremental signals						Other signals	
	12	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**7**	**9**
TTL	**U_P**	**Sensor** 5 V	**0 V**	**Sensor** 0 V	**U_{a1}**	**$\overline{U_{a1}}$**	**U_{a2}**	**$\overline{U_{a2}}$**	**U_{a0}**	**$\overline{U_{a0}}$**	**$\overline{U_{aS}}$**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

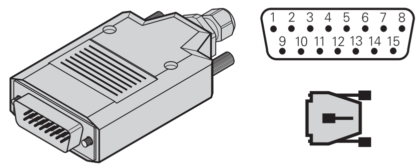
Shield is on housing; **U_P** = Power supply
Sensor: The sensor line is connected internally to the respective power supply

1) Switchover TTL/11 µA$_{PP}$ for PWT.
2) Only with LIDA 48x;
Color assignment applies only to cable

15-pin D-sub connector



15-pin D-sub connector with integrated interface electronics

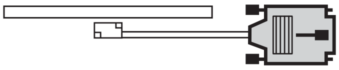
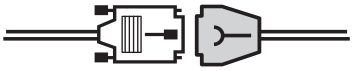
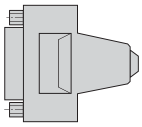


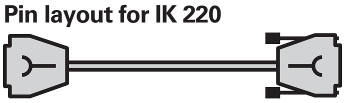
	Power supply				Incremental signals						Other signals			
	4	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**13**	**8**	**6**	**15**
TTL	**U_P**	**Sensor** 5 V	**0 V**	**Sensor** 0 V	**U_{a1}**	**$\overline{U_{a1}}$**	**U_{a2}**	**$\overline{U_{a2}}$**	**U_{a0}**	**$\overline{U_{a0}}$**	**$\overline{U_{aS}}$**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

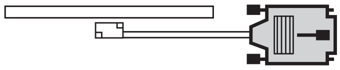
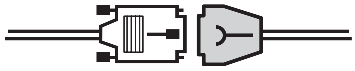
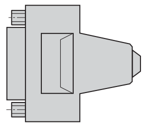
Shield is on housing; **U_P** = Power supply
Sensor: The sensor line is connected internally to the respective power supply

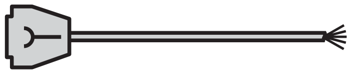
1) Switchover TTL/11 µA$_{PP}$ for PWT.
2) Only with LIDA 4xx;
Color assignment applies only to cable
3) Only with LIF 481

D-Sub Connecting Elements and Cables (15-pin)

Connecting element on LIF/LIP 400/LIP 500/PP 	
Mating element on connecting cable to connector on encoder cable 	**D-sub connector (female),** 15-pin 
For connecting cable Ø 8 mm Ø 6 mm	315650-14

PUR connecting cable Ø 8 mm [4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] Shield on housing **PUR connecting cable Ø 6 mm** [6(2 x 0.19 mm^2)]	Ø 8 mm	Ø 6 mm[1)]
Complete with D-sub connectors (female/male) 	331693-xx	355215-xx
With one connector, D-sub (female) 	332433-xx	355209-xx
Complete with D-sub connectors (female/male) 	335074-xx	355186-xx
Complete with D-sub connectors (female/female) **Pin layout for IK 220** 	335077-xx	349687-xx
Cable without connectors 	244957-01	291639-01

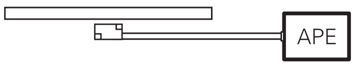
Connecting element on LIDA 400/LIF 400 	
Mating element on connecting cable to connector on encoder cable 	**D-sub connector (female),** 15-pin 
For connecting cable Ø 8 mm Ø 6 mm	315650-14

PUR connecting cable Ø 8 mm [4(2 x 0.14 mm^2) + (4 x 0.5 mm^2) + 2 x (2 x 0.14 mm^2)] Shield on housing **PUR connecting cable Ø 6 mm** [6(2 x AWG28) + (4 x 0.14 mm^2)]	Ø 8 mm	Ø 6 mm[1)]
Complete with D-sub connectors (female/male) 	354379-xx	355397-xx
With one connector, D-sub (female) 	354411-xx	355398-xx
Without connectors 	354341-01	355241-01

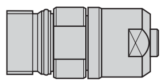
[1)] Cable length for Ø 6 mm max. 9 m (29.6 ft)

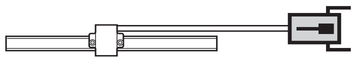
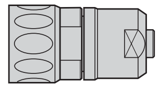
HEIDENHAIN Connecting Elements and Cables (12-pin)

Adapter cable for LIP 300



Adapter cable with coupling (male) 	310128-xx
	Length 1 m/3 m/6 m/9 m
	Diameter 6 mm
Adapter cable without connector 	310131-xx
	Length 1 m/3 m/6 m/9 m
	Diameter 6 mm

Coupling on LIDA 18x 	**Coupling (male),** 12-pin, shield on housing 
For encoder cable Ø 4.5 mm	291698-14

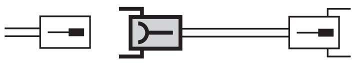
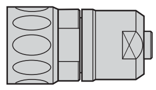
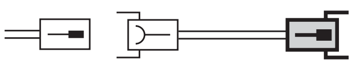
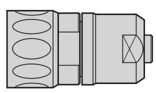
Connector on LIDA 17x 	**Connector (male),** 12-pin, shield on housing 
For encoder cable Ø 4.5 mm	291697-06

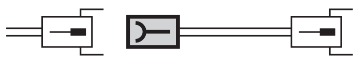
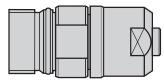
PUR connecting cable Ø 8 mm
[4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] Shield on housing

Complete with connector (female) and connector (male) 	298399-xx
With one connector (female) 	309777-xx
Cable without connectors 	244957-01

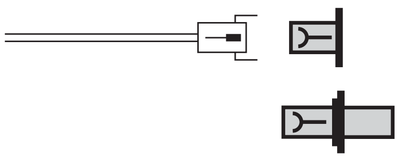
PUR connecting cable Ø 8 mm
[4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] Shield on housing

Complete with coupling (female) and connector (male) 	298400-xx
With one coupling (female) 	298402-xx

Mating element on connecting cable to coupling on encoder cable or flange socket 	**Connector (female),** 12-pin, shield on housing 
For connecting cable Ø 8 mm	291697-05
Connector on cable for connection to subsequent electronics 	**Connector (male),** 12-pin, shield on housing 
For connecting cable Ø 8 mm	291697-08

Mating element on connecting cable to connector on encoder cable 	**Coupling (female),** 12-pin, shield on housing 
For connecting cable Ø 8 mm	291698-02

Flange socket for connecting cable to subsequent electronics



Flange socket (female), 12-pin: 315892-08

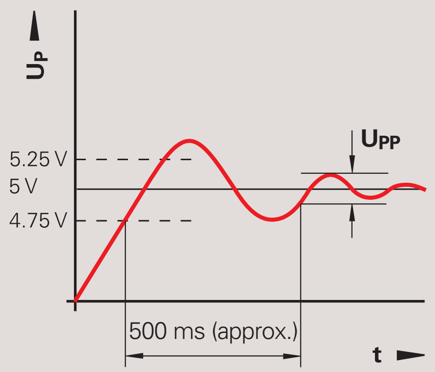
Coupling on mounting base (female), for cable Ø 8 mm, 12-pin: 291698-07

General Electrical Specifications

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



Initial transient response of the supply voltage e. g. 5 V ± 5 %

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

Calculation of the **voltage drop:**

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

where ΔU: Line drop in V
L_C: Cable length in mm
I: Current consumption of the encoder in mA (see *Specifications*)
A_P: Cross section of power lines in mm^2

HEIDENHAIN cables	**Cross section** of power lines A_P		
	1 V_{PP}/TTL/HTL	**11 μA_{PP}**	**EnDat/SSI**
Ø 3.7 mm	0.05 mm^2	–	–
Ø 4.5/5.1 mm	0.14/0.05[2] mm^2	0.05 mm^2	0.05 mm^2
Ø 6/10[1] mm	0.19/ 0.14[3] mm^2	–	0.08 mm^2
Ø 8/14[1] mm	0.5 mm^2	1 mm^2	0.5 mm^2

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/ traversing velocity.
  For encoders with **sinusoidal output signals,** the electrically permissible shaft speed/traversing velocity is limited by the –3dB/ –6dB cutoff frequency or the permissible input frequency of the subsequent electronics.
  For encoders with **square-wave signals,** the electrically permissible shaft speed/ traversing velocity is limited by
  – the maximum permissible scanning/ output frequency f_{max} of the encoder and
  – the minimum permissible edge separation a for the subsequent electronics.

For angular/rotary encoders

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

For linear encoders

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

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

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

Cable

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

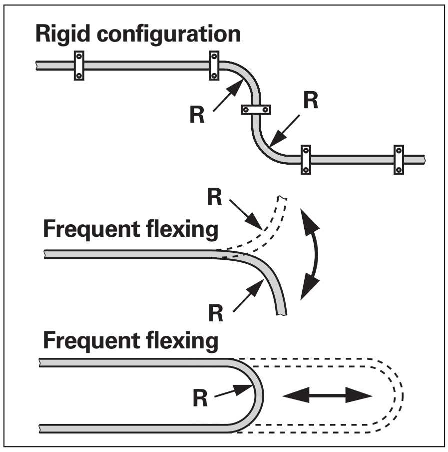
Durability
All encoders use polyurethane (PUR) cables. PUR cables are resistant to oil, hydrolysis and microbes in accordance with **VDE 0472.** They are free of PVC and silicone and comply with UL safety directives. The **UL certification** AWM STYLE 20963 80 °C 30 V E63216 is documented on the cable.

Temperature range
HEIDENHAIN cables can be used:

for rigid configuration	–40 to 85 °C (–40 to 185 °F)
for frequent flexing	–10 to 85 °C (14 to 185 °F)

Cables with limited resistance to hydrolysis and microbes are rated for up to 100 °C.

Bending radius
The permissible bending radii *R* depend on the cable diameter and the configuration:



HEIDENHAIN cables	Rigid configuration	Frequent flexing
Ø 3.7 mm	R ≥ 8 mm	R ≥ 40 mm
Ø 4.5 mm **Ø 5.1 mm**	R ≥ 10 mm	R ≥ 50 mm
Ø 6 mm	R ≥ 20 mm	R ≥ 75 mm
Ø 8 mm	R ≥ 40 mm	R ≥ 100 mm
Ø 10 mm[1]	R ≥ 35 mm	R ≥ 75 mm
Ø 14 mm[1]	R ≥ 50 mm	R ≥ 100 mm

Reliable signal transmission

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

- **IEC 61 000-6-2**
  Electromagnetic compatibility—Immunity for industrial environments
  Specifically:
  - ESD IEC 61 000-4-2
  - Electromagnetic fields IEC 61 000-4-3
  - Burst IEC 61 000-4-4
  - Surge IEC 61 000-4-5
  - Conducted disturbances IEC 61 000-4-6
  - Power frequency magnetic fields IEC 61 000-4-8
  - Pulse magnetic fields IEC 61 000-4-9
- **IEC 61 000-6-4**
  Electromagnetic compatibility—Generic emission standard
  Specifically:
  - for industrial, scientific and medical (ISM) equipment IEC 55 011
  - for information technology equipment IEC 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:

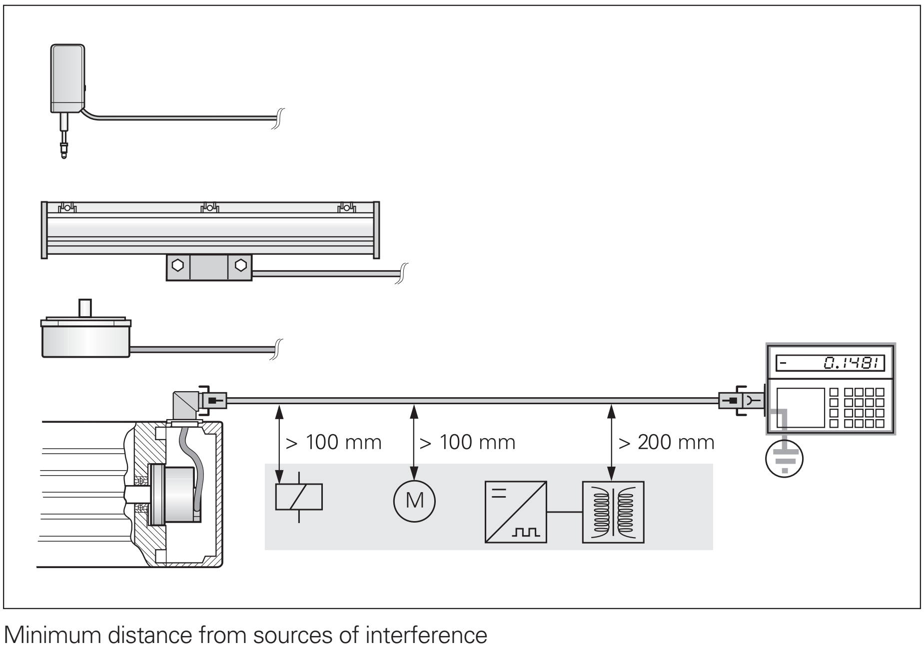
- Strong magnetic fields from transformers and electric motors
- Relays, contactors and solenoid valves
- High-frequency equipment, pulse devices, and stray magnetic fields from switch-mode power supplies
- AC power lines and supply lines to the above devices.

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

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

- Use only original HEIDENHAIN cables. Watch for voltage attenuation on the supply lines.
- Use connectors or terminal boxes with metal housings. Do not conduct any extraneous signals.
- Connect the housings of the encoder, connector, terminal box and evaluation electronics through the shield of the cable. Connect the shielding in the area of the cable inlets to be as induction-free as possible (short, full-surface contact).
- Connect the entire shielding system with the protective ground.
- Prevent contact of loose connector housings with other metal surfaces.
- The cable shielding has the function of an equipotential bonding conductor. If compensating currents are to be expected within the entire system, a separate equipotential bonding conductor must be provided.
  Also see **EN 50 178/**4.98 Chapter 5.2.9.5 regarding "protective connection lines with small cross section."
- Connect HEIDENHAIN position encoders only to subsequent electronics whose power supply is generated through double or strengthened insulation against line voltage circuits. See also **IEC 364-4-41:** 1992, modified Chapter 411 regarding "protection against both direct and indirect touch" (PELV or SELV).
- Do not lay signal cables in the direct vicinity of interference sources (inductive consumers such as contacts, motors, frequency inverters, solenoids, etc.).
- Sufficient decoupling from interference-signal-conducting cables can usually be achieved by an air clearance of 100 mm (4 in.) or, when cables are in metal ducts, by a grounded partition.
- A minimum spacing of 200 mm (8 in.) 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, **EN 50 174-2/**09.01, Chapter 6.7 regarding grounding and potential compensation.
- When using **multiturn encoders in electromagnetic fields** greater than 30 mT, HEIDENHAIN recommends consulting with the main facility in Traunreut.

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



Minimum distance from sources of interference

HEIDENHAIN Measuring and Test Equipment

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

In exposed linear encoders the scanning head moves over the graduation without mechanical contact. Thus, to ensure highest quality output signals, the scanning head needs to be aligned very accurately during mounting. HEIDENHAIN offers various measuring and testing equipment for checking the quality of the output signals.

	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
Features	• **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 length) • **Displays symbols** for reference mark, fault detection signal, counting direction • **Universal counter,** interpolation selectable from 1 to 1024-fold • **Adjustment aid** for exposed encoders
Outputs	• Inputs are fed through for subsequent electronics • BNC sockets for connection to an oscilloscope
Power supply	10 to 30 V, max 15 W
Dimensions	150 mm × 205 mm × 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}
Features	Measuring the signal amplitude Tolerance of signal shape 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

Evaluation Electronics

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** up to **4096-fold.** A driver software package is included in delivery.

For more information see *IK 220* data sheet.

	IK 220			
Input signals (switchable)	$\sim$ 1 V_{PP}	$\sim$ 11 μA_{PP}	EnDat	SSI
Encoder inputs	Two D-sub connectors (15-pin), male			
Input frequency (max.)	500 kHz	33 kHz	–	
Cable lengths (max.)	60 m (197 ft)		10 m (32.8 ft)	
Signal subdivision (signal period: meas. step)	Up to 4096-fold			
Data register for measured values (per channel)	48 bits (44 bits used)			
Internal memory	For 8192 position values			
Interface	PCI bus (plug and play)			
Driver software and demonstration program	**For Windows 95/98/NT/2000/XP** in VISUAL C++, VISUAL BASIC and BORLAND DELPHI			
Dimensions	Approx. 190 mm × 100 mm			