HEIDENHAIN

Exposed Linear Encoders

November 2014

Exposed linear encoders

Linear encoders measure the position of linear axes without additional mechanical transfer elements. This eliminates a number of potential error sources:
- Positioning error due to thermal behavior of the recirculating ball screw
- Reversal error
- Kinematics error through ball-screw pitch error

Therefore, linear encoders are indispensable for machine tools on which high **positioning accuracy** and a high **machining rate** are essential.

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

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

Information on
- Angle encoders with integral bearing
- Angle encoders without integral bearing
- Modular magnetic encoders
- Rotary encoders
- Encoders for servo drives
- Linear encoders for numerically controlled machine tools
- Interface electronics
- HEIDENHAIN controls

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

The *Interfaces of HEIDENHAIN Encoders* brochure, ID 1078628-xx, includes comprehensive descriptions of all available interfaces as well as general electrical information.

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

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

Contents

Selection guide

Absolute encoders and encoders with position value output

Absolute position measurement
The **LIC** exposed linear encoders permit absolute position measurement both over large paths of traverse up to 28 m and at high traversing speed.

Incremental encoder with position value output
The LIP 211 and LIP 291 incremental linear encoders output the position information as a position value. The sinusoidal scanning signals are highly interpolated in the scanning head and converted to a position value by the integrated counter function. As with all incremental encoders, the absolute reference is determined with the aid of reference marks.

	Substrate and mounting	**Coefficient of expansion α_{therm}**	**Accuracy grade**
LIC 4100 For high accuracy and high traversing speed	Glass or glass ceramic scale, bonded to the mounting surface	$\approx (0\pm0.1) \cdot 10^{-6}K^{-1}$ $\approx 8 \cdot 10^{-6}K^{-1}$	± 3 µm[2)] ± 5 µm
	Steel scale tape drawn into aluminum extrusions and tensioned	Same as mounting surface	± 5 µm
	Steel scale tape drawn into aluminum extrusions and fixed	$\approx 10 \cdot 10^{-6}K^{-1}$	± 3 µm[3)] ± 5 µm[4)] ± 15 µm[5)]
	Steel scale tape, bonded to the mounting surface	$\approx 10 \cdot 10^{-6}K^{-1}$	± 3 µm ± 15 µm[5)]
LIC 2100 For high traversing speed	Steel scale tape drawn into aluminum extrusions and fixed	$\approx 10 \cdot 10^{-6}K^{-1}$	± 15 µm
	Steel scale tape, bonded to the mounting surface	$\approx 10 \cdot 10^{-6}K^{-1}$	± 15 µm
LIP 200 For very high accuracy	Scale of Zerodur glass ceramic with fixing clamps	$\approx (0\pm0.1) \cdot 10^{-6}K^{-1}$	± 1 µm[3)] ± 3 µm

1) Signal period of the sinusoidal signals. It is definitive for deviations within one signal period (see *Measuring accuracy*).
2) Higher accuracy grades available on request

Position error per signal period typically	Signal period[1]	Measuring length	Interface	Model	Page
± 0.04 µm	–	240 mm to 3 040 mm	EnDat 2.2	**LIC 4113**	**22**
			Fanuc αi	**LIC 4193 F**	
			Mitsubishi	**LIC 4193 M**	
			Panasonic	**LIC 4193 P**	
± 0.04 µm	–	140 mm to 28 440 mm	EnDat 2.2	**LIC 4115**	**24**
			Fanuc αi	**LIC 4195 F**	
			Mitsubishi	**LIC 4195 M**	
			Panasonic	**LIC 4195 P**	
± 0.04 µm	–	240 mm to 6 040 mm	EnDat 2.2	**LIC 4117**	**26**
			Fanuc αi	**LIC 4197 F**	
			Mitsubishi	**LIC 4197 M**	
			Panasonic	**LIC 4197 P**	
± 0.04 µm	–	70 mm to 1 020 mm	EnDat 2.2	**LIC 4119**	**28**
			Fanuc αi	**LIC 4199 F**	
			Mitsubishi	**LIC 4199 M**	
			Panasonic	**LIC 4199 P**	
± 1.5 µm	–	120 mm to 3 020 mm	EnDat 2.2	**LIC 2117**	**30**
			Fanuc αi	**LIC 2197 F**	
			Mitsubishi	**LIC 2197 M**	
			Panasonic	**LIC 2197 P**	
± 1.5 µm	–	120 mm to 3 020 mm	EnDat 2.2	**LIC 2119**	**32**
			Fanuc αi	**LIC 2199 F**	
			Mitsubishi	**LIC 2199 M**	
			Panasonic	**LIC 2199 P**	
± 0.001 µm	0.512 µm	20 mm to 3 040 mm	EnDat 2.2	**LIP 211**	**36**
			Fanuc αi	**LIC 291 F**	
			Mitsubishi	**LIC 291 M**	

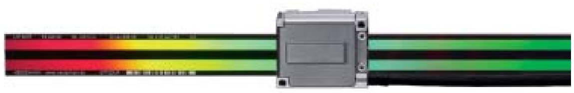
LIC 41x3

LIC 41x5

LIC 41x7

LIC 21x7

LIC 21x9



LIP 211

3) Up to measuring length ML = 1 020 mm or 1 040 mm
4) As of measuring length ML = 1 240 mm
5) ± 5 µm after linear length-error compensation in the subsequent electronics

Selection guide
Incremental encoders

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

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

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

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

Encoders for application in vacuum
Our standard encoders are suitable for use in a rough or fine vacuum. Encoders used for applications in a high or ultrahigh vacuum need to fulfill special requirements. The design and materials used have to be specially adapted for it. For more information, refer to the Technical Information document *Linear Encoders for Vacuum Technology*.

The following exposed linear encoders are specially adapted for use in high and ultrahigh vacuum environments:
- High vacuum: LIP 481V and LIF 481V
- Ultrahigh vacuum: LIP 481U

For more information, please refer to the appropriate product information documents.

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

1) Signal period of the sinusoidal signals. It is definitive for deviations within one signal period (see *Measuring accuracy*).
2) Up to measuring lengths 1 020 mm or 1 040 mm
3) Higher accuracy grades available on request

Position error per signal period typically	Signal period[1]	Measuring length	Interface	Model	Page
± 0.001 µm	0.128 µm	70 mm to 270 mm	TTL	**LIP 372**	**34**
			~ 1 V_{PP}	**LIP 382**	
± 0.001 µm	0.512 µm	20 mm to 3040 mm	~ 1 V_{PP}	**LIP 281**	**36**
± 0.02 µm	2 µm	70 mm to 420 mm	TTL	**LIP 471**	**38**
			~ 1 V_{PP}	**LIP 481**	
± 0.04 µm	4 µm	70 mm to 1440 mm	TTL	**LIP 571**	**40**
			~ 1 V_{PP}	**LIP 581**	
± 0.04 µm	4 µm	70 mm to 1020 mm[4]	TTL	**LIF 471**	**42**
			~ 1 V_{PP}	**LIF 481**	
± 0.2 µm	20 µm	240 mm to 3040 mm	TTL	**LIDA 473**	**44**
			~ 1 V_{PP}	**LIDA 483**	
± 0.2 µm	20 µm	140 mm to 30040 mm	TTL	**LIDA 475**	**46**
			~ 1 V_{PP}	**LIDA 485**	
± 0.2 µm	20 µm	240 mm to 6040 mm	TTL	**LIDA 477**	**48**
			~ 1 V_{PP}	**LIDA 487**	
± 0.2 µm	20 µm	Up to 6000 mm[4]	TTL	**LIDA 479**	**50**
			~ 1 V_{PP}	**LIDA 489**	
± 2 µm	200 µm	Up to 10000 mm[4]	TTL	**LIDA 277**	**52**
			~ 1 V_{PP}	**LIDA 287**	
± 2 µm	200 µm	Up to 10000 mm[4]	TTL	**LIDA 279**	**54**
			~ 1 V_{PP}	**LIDA 289**	
± 0.04 µm	4 µm	Measuring range 68 x 68 mm[4]	~ 1 V_{PP}	**PP 281**	**56**
± 0.02 µm	2 µm	70 mm to 420 mm	~ 1 V_{PP}	**LIP 481V** **LIP 481U**	**Product Information**
± 0.04 µm	4 µm	70 mm to 1020 mm		**LIF 481V**	

[4] Other measuring lengths/ranges upon request
[5] Only for Zerodur glass ceramics, with LIDA 4x3 up to ML 1640 mm
[6] ± 5 µm after linear length-error compensation in the subsequent electronics

LIP 382

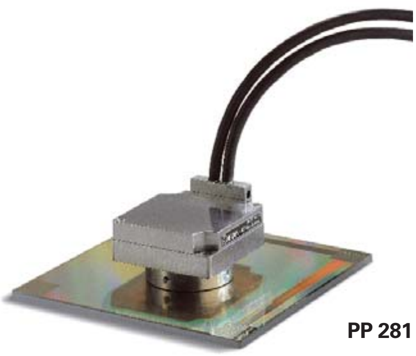
LIP 281

LIP 581

LIF 481

LIDA 489

LIDA 287



PP 281

Measuring principles

Measuring standard

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

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

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

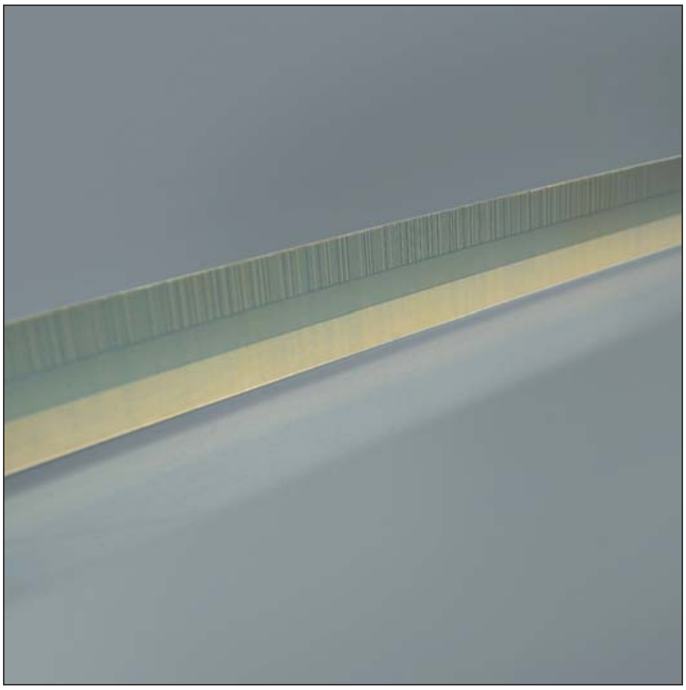
- AURODUR: matte-etched lines on gold-plated steel tape with typical graduation period of 40 µm
- METALLUR: contamination-tolerant graduation of metal lines on gold, with typical graduation period of 20 µm
- DIADUR: extremely robust chromium lines on glass (typical graduation period of 20 µm) or three-dimensional chromium structures (typical graduation period of 8 µm) on glass
- SUPRADUR phase grating: optically three dimensional, planar structure; particularly tolerant to contamination; typical graduation period of 8 µm and finer
- OPTODUR phase grating: optically three dimensional, planar structure with particularly high reflectance, typical graduation period of 2 µm and finer

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

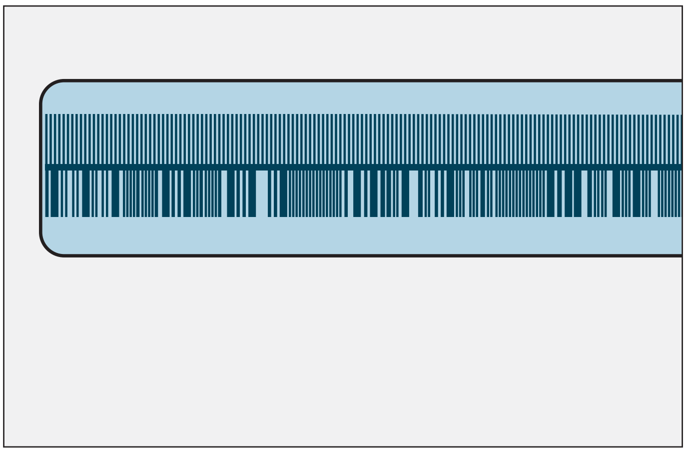
The master graduations are manufactured by HEIDENHAIN on custom-built high-precision dividing engines.

Absolute measuring method

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



Graduations of absolute linear encoders



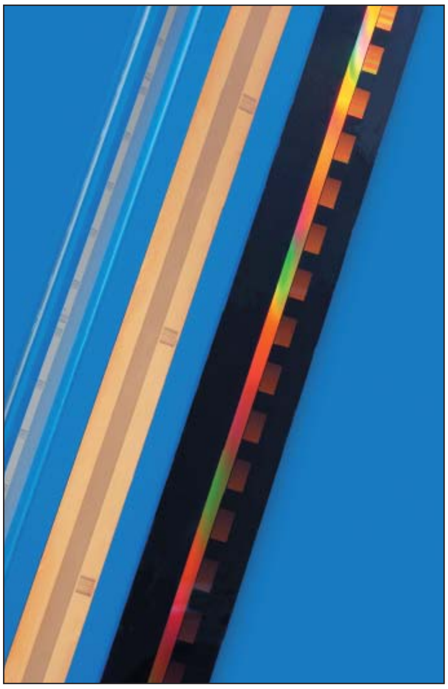
Schematic representation of an absolute code structure with an additional incremental track (LC 401x as example)

Incremental measuring method

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

In the most unfavorable case this may necessitate machine movements over large lengths of the measuring range. To speed and simplify such "reference runs," many HEIDENHAIN encoders feature **distance-coded reference marks**—multiple reference marks that are individually spaced according to a mathematical algorithm. The subsequent electronics find the absolute reference after traversing two successive reference marks—only a few millimeters traverse (see table). Encoders with distance-coded reference marks are identified with a "C" behind the model designation (e.g. LIP 581 C).

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



Graduations of incremental linear encoders

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

and

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

Where:

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

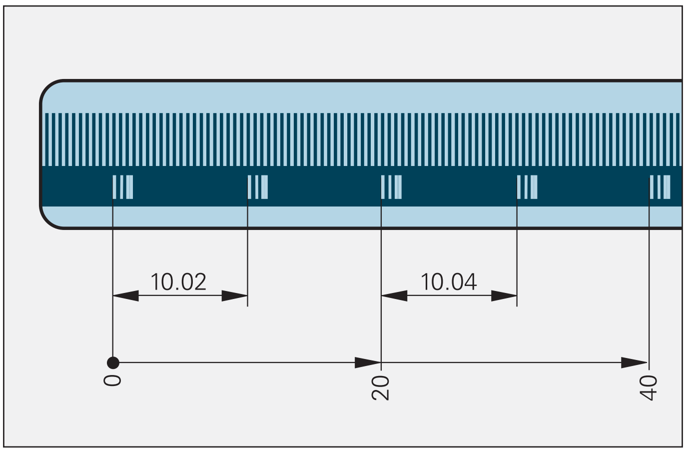
abs = Absolute value

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

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

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

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



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

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

Photoelectric scanning

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

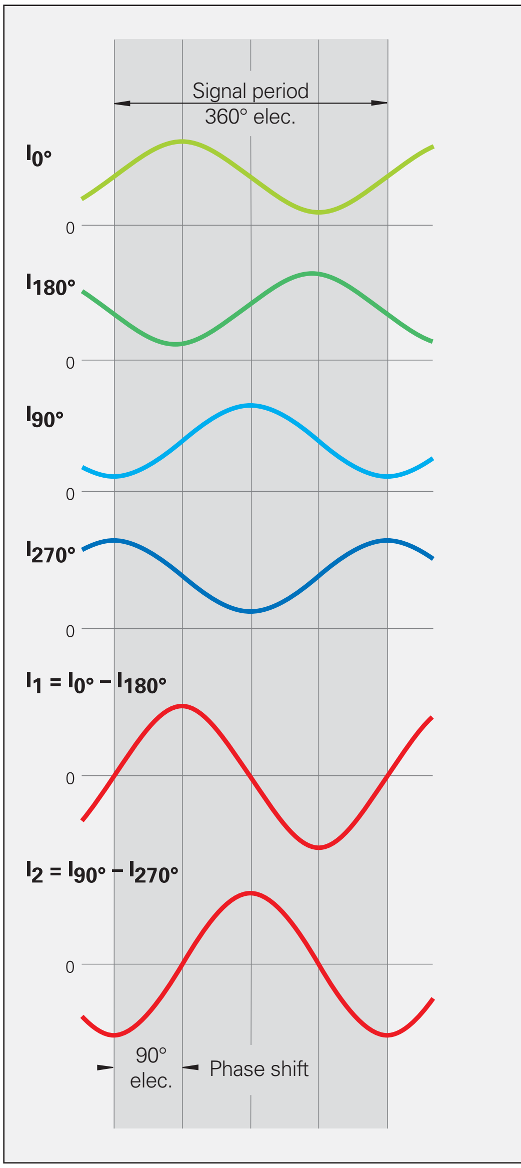
The finer the grating period of a measuring standard is, the greater the effect of diffraction on photoelectric scanning. HEIDENHAIN uses two scanning principles with linear encoders:

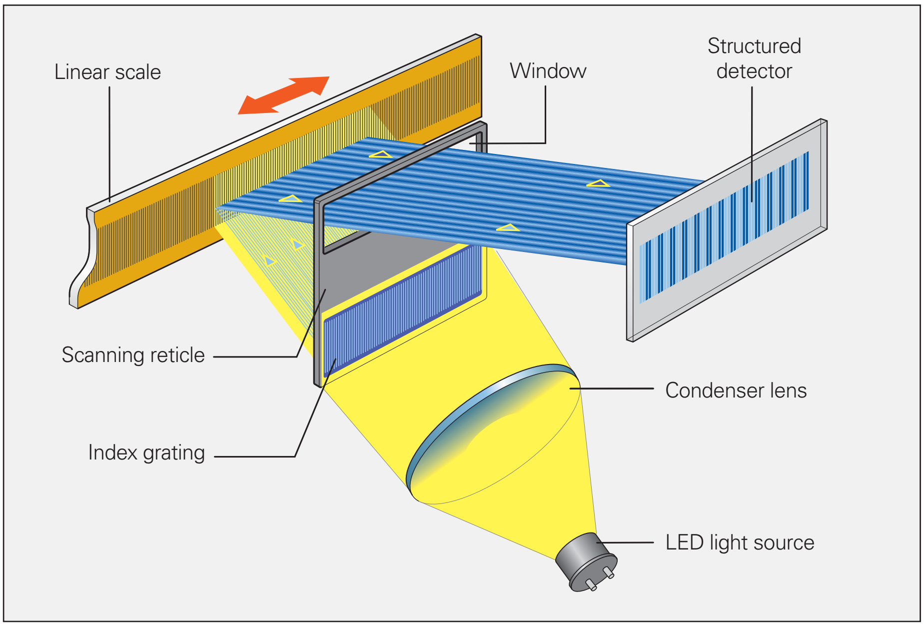
- The **imaging scanning principle** for grating periods from 10 µm to 200 µm.
- The **interferential scanning principle** for very fine graduations with grating periods of 4 µm and smaller.

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

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

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

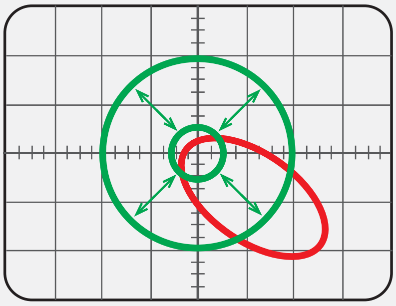




Photoelectric scanning according to the imaging scanning principle with steel scale and single-field scanning (LIDA 400)

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

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



X/Y representation of the output signals

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

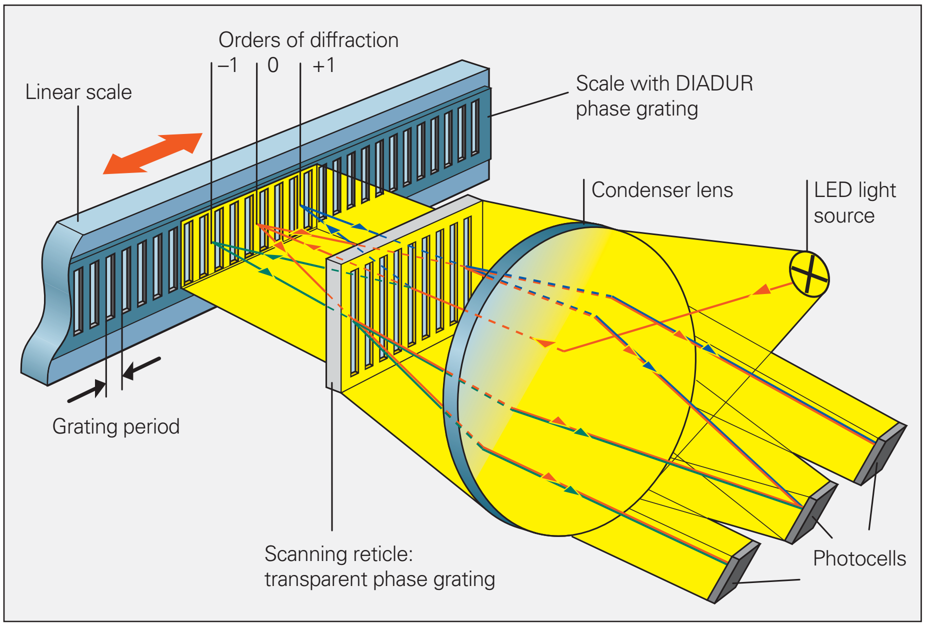
A step grating is used as the measuring standard: reflective lines 0.2 µm high are applied to a flat, reflective surface. In front of that is the scanning reticle—a transparent phase grating with the same grating period as the scale.

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

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

Interferential encoders function with grating periods of, for example, 8 µm, 4 µm and finer. Their scanning signals are largely free of harmonics and can be highly interpolated. These encoders are therefore especially suited for high resolution and high accuracy. Even so, their generous mounting tolerances permit installation in a wide range of applications.

LIP, LIF and **PP** linear encoders operate according to the interferential scanning principle.



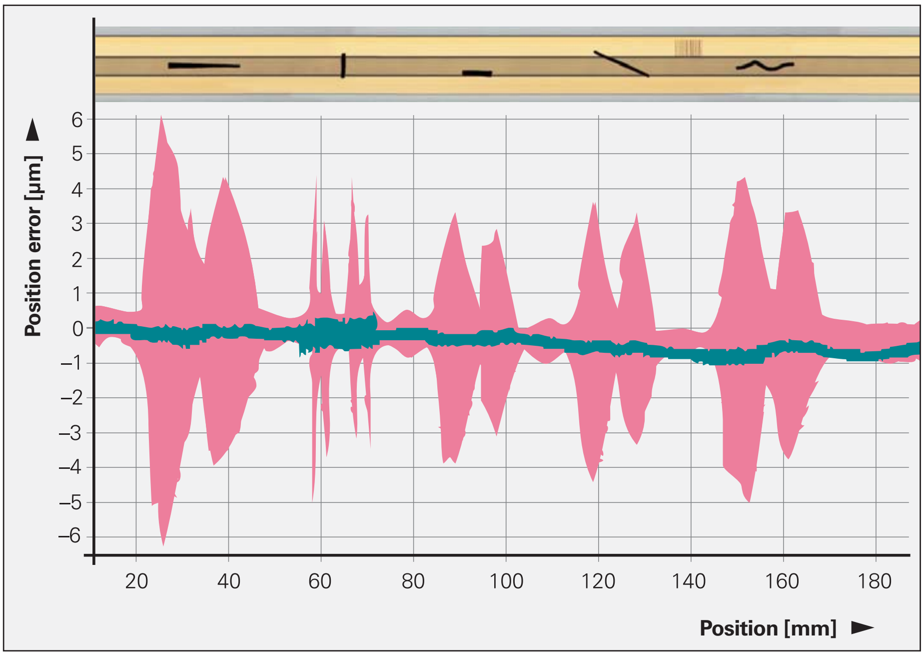
Photoelectric scanning according to the interferential scanning principle and single-field scanning

Reliability

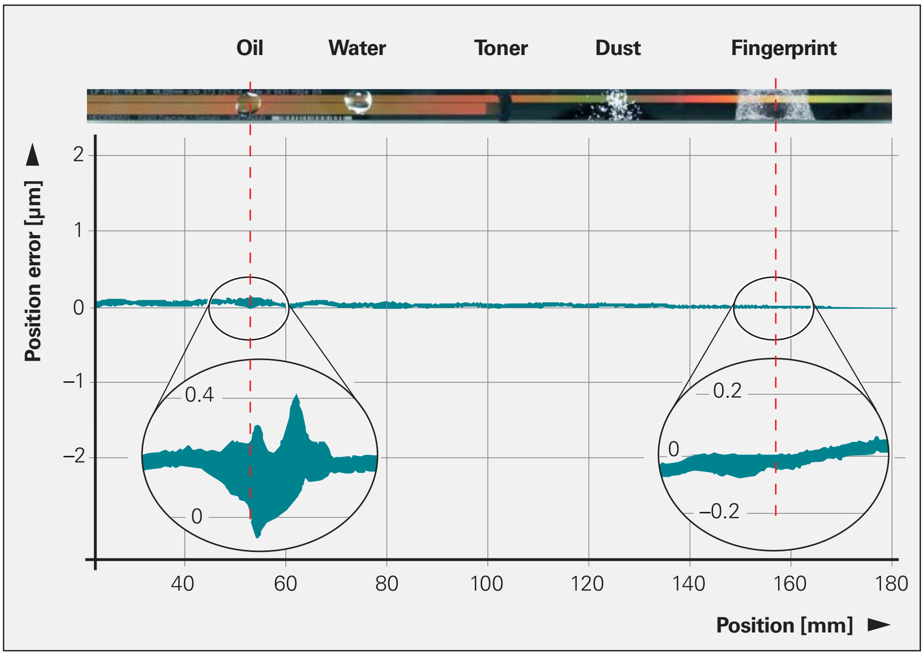
Exposed linear encoders from HEIDENHAIN are optimized for use on fast, precise machines. In spite of the exposed mechanical design, they are highly tolerant to contamination, ensure high long-term stability, and are quickly and easily mounted.

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

The **large scanning field** additionally reduces sensitivity to contamination. In many cases this can prevent encoder failure. This is particularly clear with the LIDA 400 and LIF 400, which in relation to the grating period have a very large scanning surface of 14.5 mm^2 as well as the LIC 4100 with 15.5 mm^2. Even if the contamination from printer's ink, PCB dust, water or oil is up to 3 mm in diameter, the encoders continue to provide high-quality signals. The position error remains far below the values specified for the accuracy grade of the scale.



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



Reaction of the LIF 400 to contamination

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

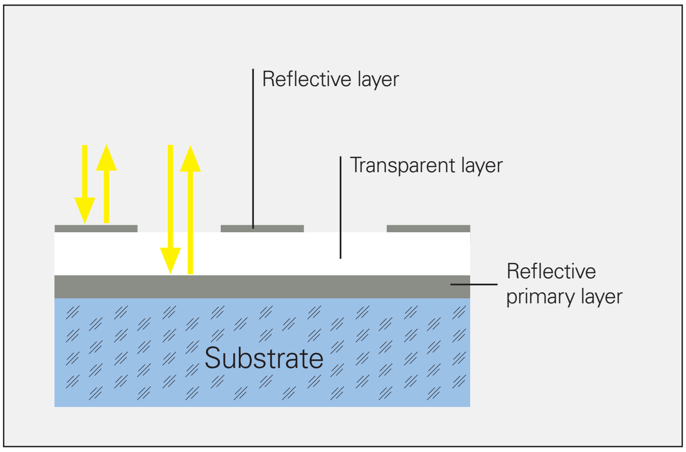
In the DIADUR process, chrome structures are applied to a glass or steel carrier.

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

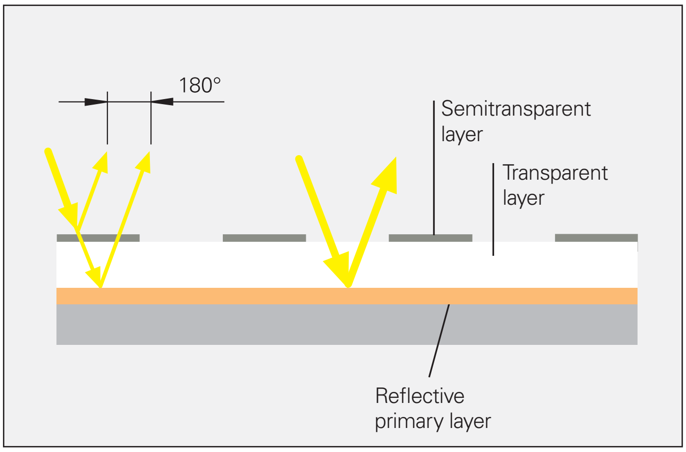
Application-oriented mounting tolerances
Very small signal periods usually come with very narrow mounting tolerances for the gap between the scanning head and scale tape. This is the result of diffraction caused by the grating structures. It can lead to a signal attenuation of 50 % with a gap change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

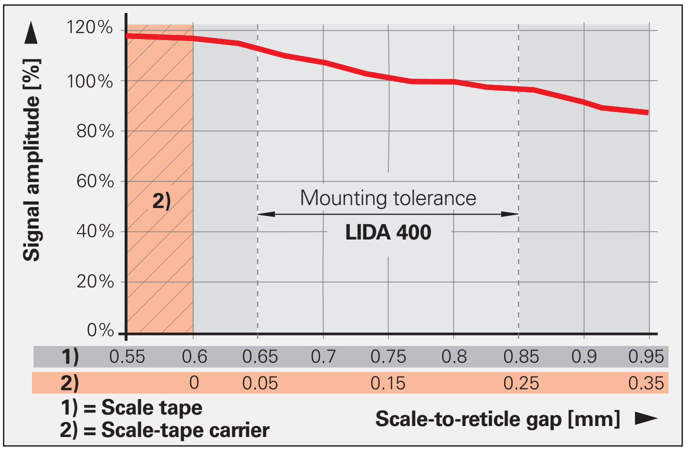
The mounting tolerances of exposed linear encoders from HEIDENHAIN have only a slight influence on the output signals. In particular, the specified tolerance between the scale and scanning head (scanning gap) cause only negligible change in the signal amplitude. This behavior is substantially responsible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

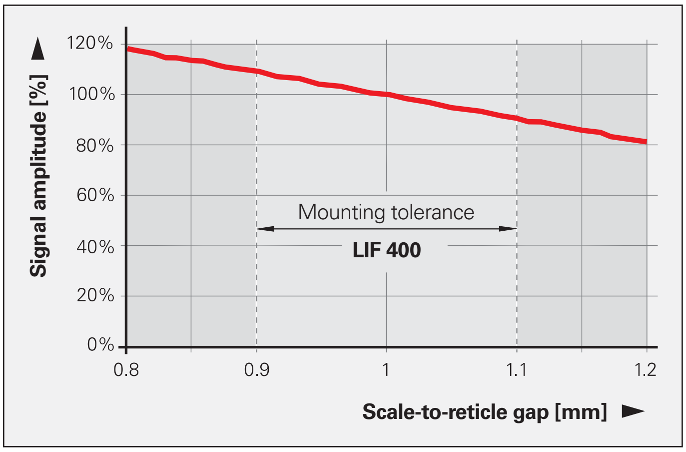
OPTODUR
SUPRADUR



METALLUR







Measuring accuracy

The accuracy of linear measurement is mainly influenced by
- the quality of the graduation,
- the quality of the graduation carrier,
- the quality of the scanning process,
- the quality of the signal processing electronics, and
- the bearing error.

These factors of influence are comprised of encoder-specific error and application-dependent issues. All individual factors of influence must be considered in order to assess the attainable overall accuracy.

Error specific to the measuring device

The encoder-specific errors include
- Accuracy of the graduation (listed in the Specifications as the accuracy grade)
- Position error within one signal period

Accuracy of graduation

The accuracy of the graduation ± a results from its quality. This includes
- The homogeneity and period definition of the graduation
- The alignment of the graduation on its carrier
- *For encoders with massive graduation carriers:* the stability of the graduation carrier, in order to also ensure accuracy in the mounted condition
- *For encoders with steel scale tape:* the error due to irregular scale-tape expansion during mounting

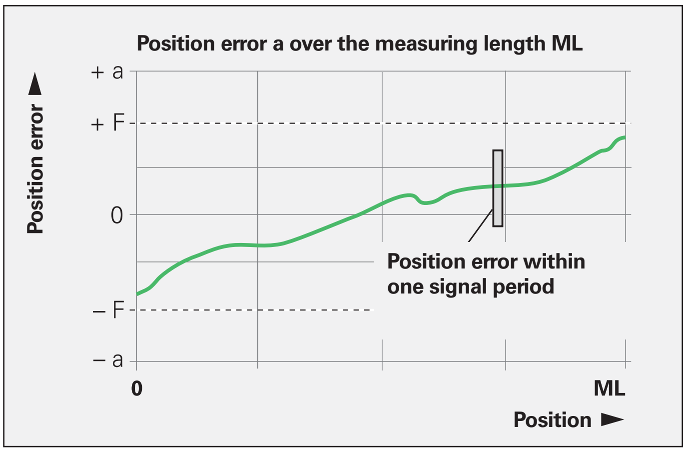
The accuracy of the graduation ± a is ascertained under ideal conditions by using a series-produced scanning head to measure position error at positions that are integral multiples of the signal period. The respectively determined position error F lies—with reference to its mean value—within the accuracy grade ±a over any max. one-meter section of the measuring length.

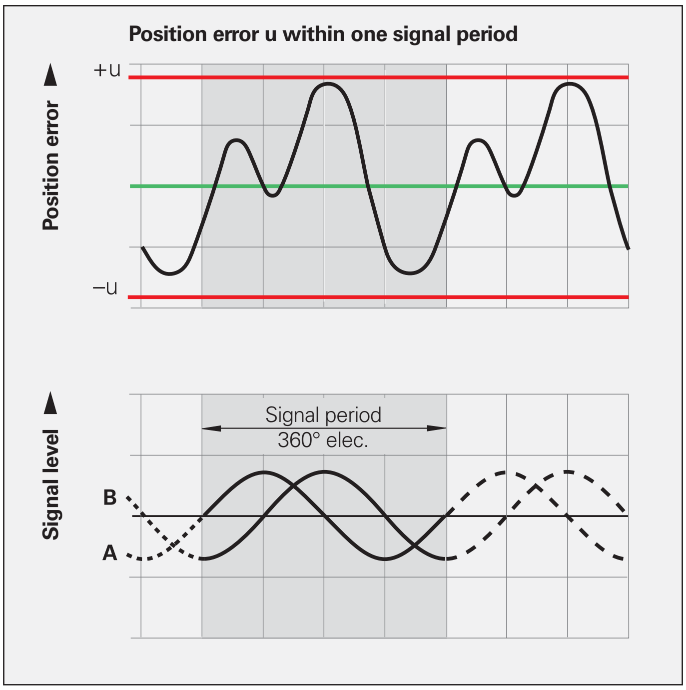
Position error within one signal period

Position errors within one signal period ± u result from the quality of the scanning and—for encoders with integrated pulse-shaping or counter electronics—the quality of the signal-processing electronics. For encoders with sinusoidal output signals, however, the errors of the signal processing electronics are determined by the subsequent electronics.

The following individual factors influence the result:
- The size of the signal period
- The homogeneity and period definition of the graduation
- The quality of scanning filter structures
- The characteristics of the sensors
- The stability and dynamics of further processing of the analog signals

These factors of influence are to be considered when specifying position error within one signal period.





Position error within one signal period ± u is specified in relation to the signal period. For exposed linear encoders, the value is typically better than ± 1 % of the signal period. You will find the specific values in the table below.

Position errors within one signal period already become apparent in very small paths of traverse and in repeated measurements. They especially lead to fluctuations in traversing speed in the speed control loop.

Application-dependent error

The mounting and adjustment of the scanning head, in addition to the given encoder-specific error, normally have a significant effect on the accuracy that can be achieved by encoders without integral bearings. The application-dependent error values must be measured and calculated individually in order to evaluate the **overall accuracy.**

Deformation of the graduation
Error due to deformation of the graduation is not to be ignored. It occurs when the graduation is mounted on an uneven, for example convex, surface.

Mounting location
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 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.

Vibration
To function properly, linear encoders must not be continuously subjected to strong vibration; the more solid parts of the machine tool provide the best mounting surface in this respect. Encoders should not be mounted on hollow parts or with adapter blocks.

Temperature influence
The linear encoders should be mounted away from sources of heat to avoid temperature influences.

	Signal period of the scanning signals	Typical position error u within one signal period
LIP 3x2	0.128 µm	± 0.001 µm
LIP 2x1	0.512 µm	± 0.001 µm
LIP 4x1	2 µm	± 0.02 µm
LIP 5x1 **LIF, PP**	4 µm	± 0.04 µm
LIC 41xx	–	± 0.04 µm
LIDA 4xx	20 µm	± 0.2 µm
LIC 21xx	–	± 1.5 µm
LIDA 2xx	200 µm	± 2 µm

Calibration chart

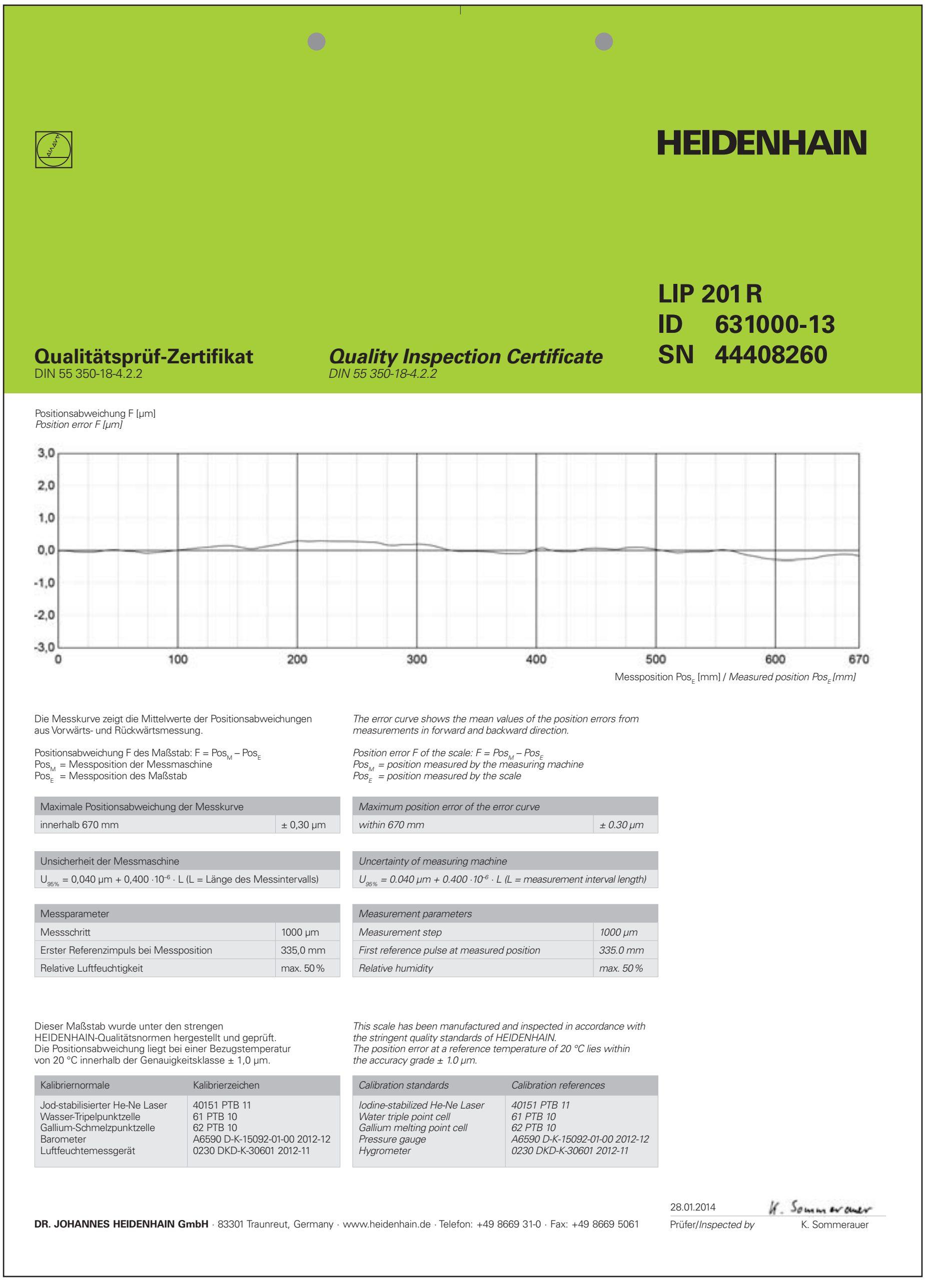
All HEIDENHAIN linear encoders are inspected before shipping for accuracy and proper function.

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

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

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


HEIDENHAIN

LIP 201 R
ID 631000-13
SN 44408260

Qualitätsprüf-Zertifikat
DIN 55 350-18-4.2.2

Quality Inspection Certificate
DIN 55 350-18-4.2.2

Die Messkurve zeigt die Mittelwerte der Positionsabweichungen aus Vorwärts- und Rückwärtsmessung.

Positionsabweichung F des Maßstab: $F = Pos_M - Pos_E$
Pos_M = Messposition der Messmaschine
Pos_E = Messposition des Maßstab

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

Position error F of the scale: $F = Pos_M - Pos_E$
Pos_M = position measured by the measuring machine
Pos_E = position measured by the scale

Maximale Positionsabweichung der Messkurve	
innerhalb 670 mm	± 0,30 µm

Maximum position error of the error curve	
within 670 mm	*± 0.30 µm*

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

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

Messparameter	
Messschritt	1000 µm
Erster Referenzimpuls bei Messposition	335,0 mm
Relative Luftfeuchtigkeit	max. 50 %

Measurement parameters	
Measurement step	*1000 µm*
First reference pulse at measured position	*335.0 mm*
Relative humidity	*max. 50 %*

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.

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.

Kalibriernormale	Kalibrierzeichen
Jod-stabilisierter He-Ne Laser	40151 PTB 11
Wasser-Tripelpunktzelle	61 PTB 10
Gallium-Schmelzpunktzelle	62 PTB 10
Barometer	A6590 D-K-15092-01-00 2012-12
Luftfeuchtemessgerät	0230 DKD-K-30601 2012-11

Calibration standards	*Calibration references*
Iodine-stabilized He-Ne Laser	*40151 PTB 11*
Water triple point cell	*61 PTB 10*
Gallium melting point cell	*62 PTB 10*
Pressure gauge	*A6590 D-K-15092-01-00 2012-12*
Hygrometer	*0230 DKD-K-30601 2012-11*

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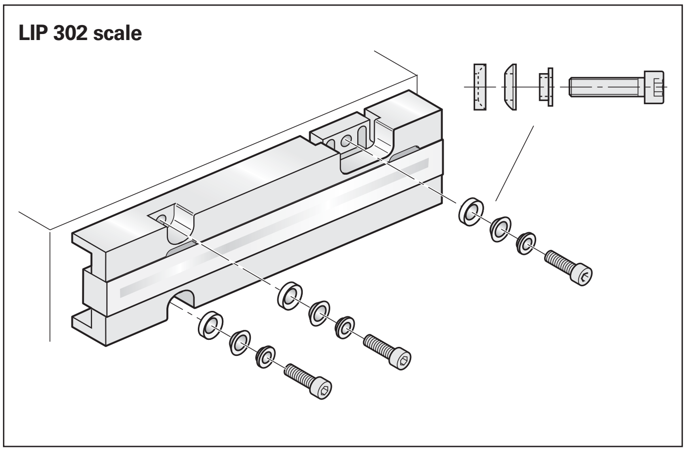
28.01.2014 K. Sommerauer
Prüfer/*Inspected by* K. Sommerauer

Mechanical design types and mounting

Linear scales

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

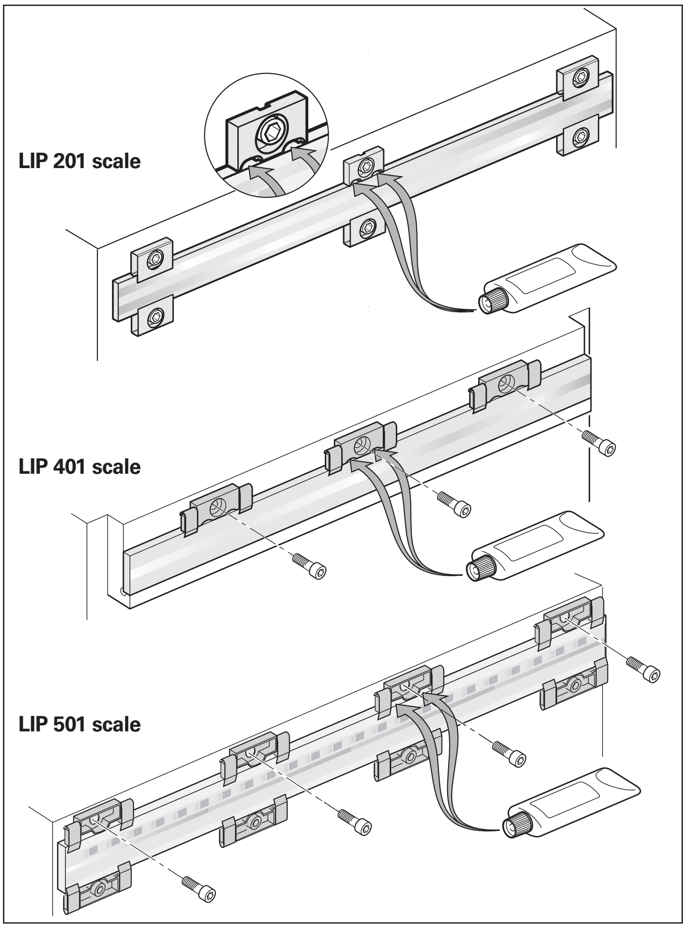
- The machine guideway must be designed so that the mounting space for the encoder meets the **tolerances** for the scanning gap (see *Specifications*).
- The bearing surface of the scale must meet requirements for **flatness.**
- To facilitate adjustment of the scanning head to the scale, it should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



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

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

LIP 2x1
LIP 4x1
LIP 5x1
The graduation carriers of Zerodur or glass are fastened onto the mounting surface with clamps and additionally secured with silicone adhesive. The thermal zero point is fixed with epoxy adhesive.



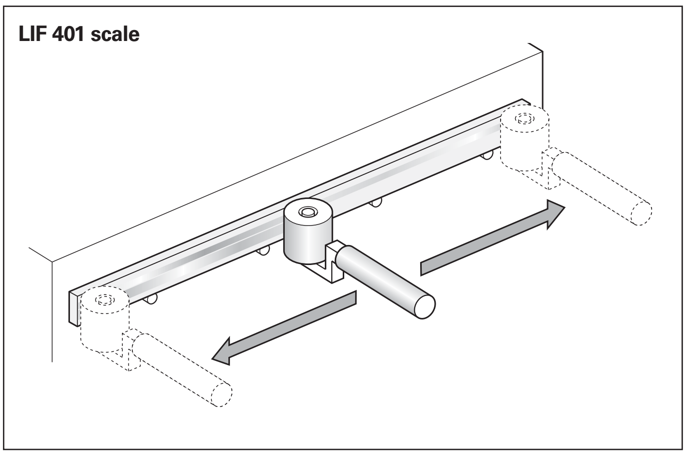
Accessories for the LIP 2x1

Fixing clamps (6x)	ID 683609-01
Fixing clamp for thermal fixed point	ID 683611-01
Epoxy adhesive	ID 734360-01

Accessories for LIP 4xx/LIP 5xx

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

LIC 41x3
LIF 4x1
LIDA 4x3
The graduation carriers of glass are glued directly to the mounting surface with PRECIMET adhesive film, and pressure is evenly distributed with a roller.



Accessories

Roller	ID 276885-01

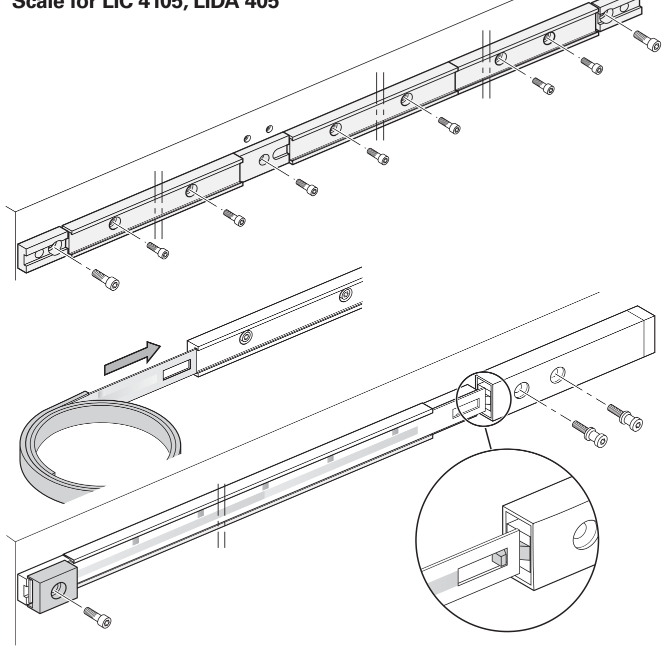
LIC 41x5
LIDA 4x5
Linear encoders of the LIC 41x5 and LIDA 4x5 series are specially designed for large measuring lengths. They are mounted with scale carrier sections screwed onto the mounting surface or cemented with PRECIMET adhesive film. Then the one-piece steel scale-tape is pulled into the carrier, **tensioned in a defined manner,** and **secured at its ends** to the machine base. The LIC 41x5 and LIDA 4x5 therefore share the thermal behavior of their mounting surface.

LIC 21x7
LIC 41x7
LIDA 2x7
LIDA 4x7
Encoders of the LIC 41x7, LIC 21x7, LIDA 2x7 and LIDA 4x7 series are also designed for large measuring lengths. The scale carrier sections are secured to the supporting surface with PRECIMET adhesive mounting film; the one-piece scale tape is pulled in and **the midpoint is secured** to the machine bed. This mounting method allows the scale to expand freely at both ends and ensures a defined thermal behavior.

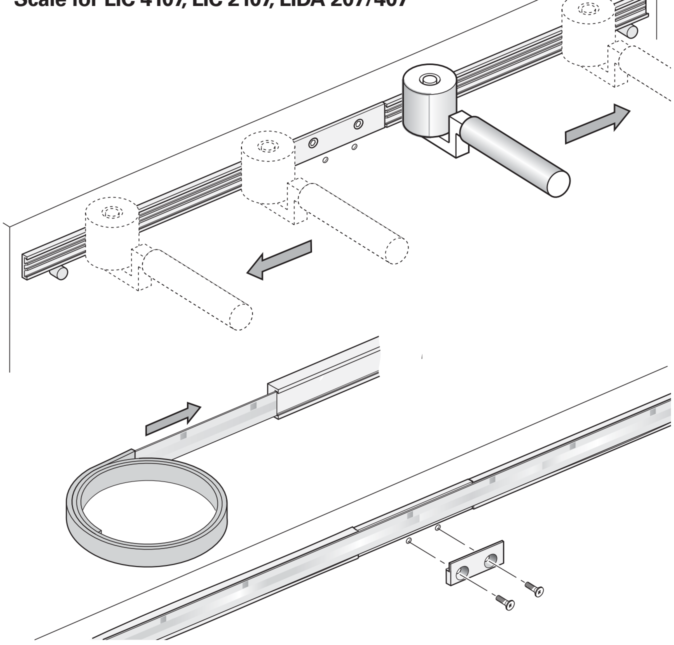
Accessory for LIC 41x7, LIDA 4x7
Mounting aid ID 373990-01


Mounting aid
(for LIC 41x7, LIDA 4x7)

Scale for LIC 4105, LIDA 405



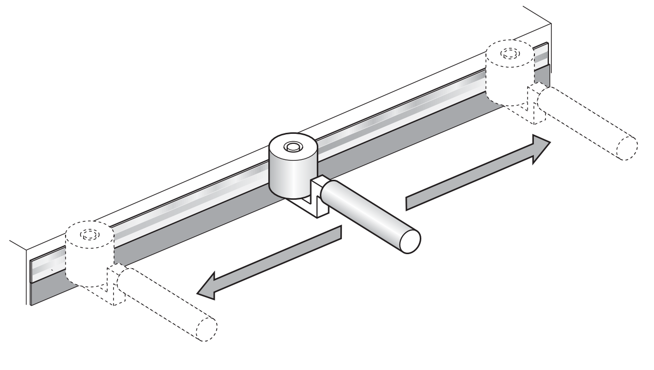
Scale for LIC 4107, LIC 2107, LIDA 207/407



LIC 21x9
LIC 41x9
LIDA 2x9
LIDA 4x9
The steel scale-tape of the graduation is cemented directly to the mounting surface with PRECIMET adhesive film, and pressure is evenly distributed with a roller. A ridge or aligning rail 0.3 mm high is to be used for horizontal alignment of the scale tape.

Accessory for versions with PRECIMET
Roller ID 276885-01

Scale for LIC 4109, LIC 2109, LIDA 209/409



Mechanical design types and mounting
Scanning heads

Because exposed linear encoders are assembled on the machine, they must be precisely adjusted after mounting. This adjustment determines the final accuracy of the encoder. It is therefore advisable to design the machine for simplest and most practical adjustment as well as to ensure the most stable possible construction.

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

Mounting the LIP 2x1
The LIP 2x is mounted from behind or above onto a flat surface (e.g. a bracket). These surfaces have contact areas for thermal connection to ensure optimal heat dissipation. The mounting elements should be made of an effective heat-conducting material.

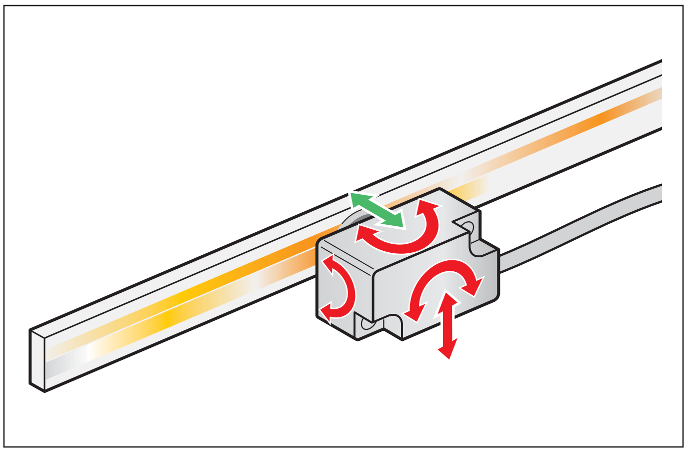
Mounting the LIP/LIF
The scanning head features a centering collar that allows it to be rotated in the location hole of the angle bracket and aligned parallel to the scale.

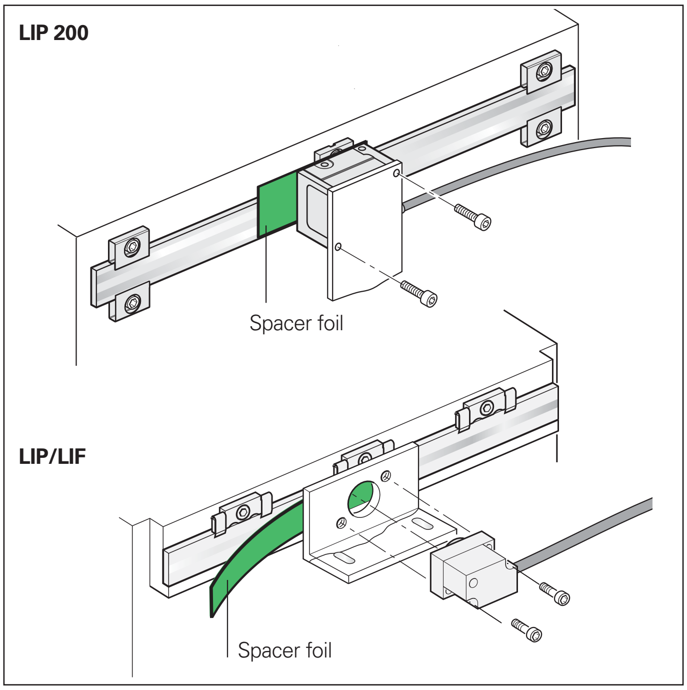
Mounting the LIC/LIDA
There are three options for mounting the scanning head (see Dimensions). A spacer foil makes it quite easy to set the gap between the scanning head and the scale or scale tape. It is helpful to fasten the scanning head from behind with a mounting bracket. The scanning head can be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

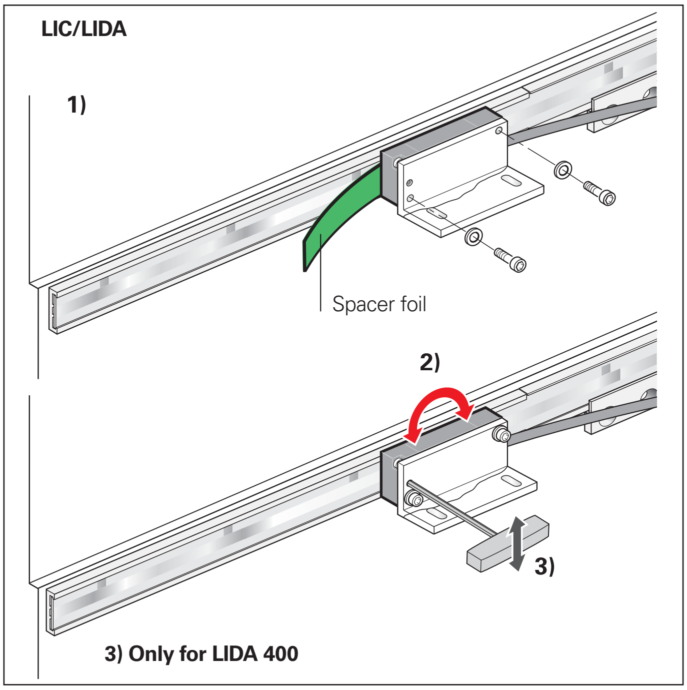
Adjustment
The gap between the scale and scanning head is easily adjusted with the aid of a spacer foil.

For the LIC and LIP 2x1, the signals are adjusted quickly and easily with the aid of the PWM 20 adjustment and testing package. For all other exposed linear encoders, the incremental and reference-mark signals are adjusted through a slight rotation of the scanning head (for the LIDA 400 it is possible with the aid of a tool).

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







Scanning heads – LIDA 200 status display

The LIDA 200 features an integrated status display with a multicolor LED. This makes the mounting quality visible at a glance during mounting. No further aids are required. The status display also makes it possible to quickly and easily check the signal quality during normal operation.

The status display offers a number of benefits:

- Easy mounting without test unit or oscilloscope
- Quality of scanning signals displayed by three-color LED
- Continuous monitoring of incremental signals over entire measuring length
- Status of reference mark signal displayed during mounting
- Quick check of correct operation in the field without technical aids

The integrated status display permits both a qualified judgment of the incremental signals as well as a check of the reference mark signal. The quality of the **incremental signals** is clarified by shades of color as well as the blinking of the LED. This makes a very detailed gradation of signal quality possible. The **reference mark signal's** compliance to tolerances is shown by a pass/fail display.

Note
The status display of the reference mark signal is switched off at velocities over approx. 150 mm/s in order to prevent permanent blinking. The information on the incremental signals would otherwise no longer be displayed. The reference mark signal display is not activated until the power supply is switched back on.

LED display of incremental signals

Amplitude range	LED blinks	LED color	Mounting quality
1.35 V ... 1.45 V	5x	🟠	Unsatisfactory
1.25 V ... 1.35 V	4x	🟡	
1.15 V ... 1.25 V	3x	🟢	Acceptable
1.05 V ... 1.15 V	2x	🟢	Good
0.95 V ... 1.05 V	1x	🟢	Optimum
0.85 V ... 0.95 V	2x	🟢	Good
0.75 V ... 0.85 V	3x	🟢	Acceptable
0.65 V ... 0.75 V	4x	🟡	Unsatisfactory
0.55 V ... 0.65 V	5x	🟠	
0.45 V ... 0.55 V	6x	🟠	
0.35 V ... 0.45 V	7x	🟠	
0.25 V ... 0.35 V	8x	🔴	
0.15 V ... 0.25 V	8x	🔴	
0.00 V ... 0.15 V	8x	🔴	

LED reference-mark-signal display (function check)
When the reference mark is scanned, the LED lights up briefly in blue or red.
🟠 Out of tolerance
🔵 Within tolerance
○ Incorrect measurement! The reference mark was scanned too quickly.

General mechanical information

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

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

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

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

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

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

Protection (EN 60 529)
The scanning heads of exposed linear encoders feature the following degrees of protection:

Scanning head	Protection
LIC	IP 67
LIDA	IP 40
LIF	IP 50
LIP 200	IP 30
LIP 300 **LIP 400** **LIP 500**	IP 50
PP	IP 50

The scales have no special protection. Protective measures must be taken if the possibility of contamination exists.

Acceleration
Linear encoders are subjected to various types of acceleration during operation and mounting.
- The indicated maximum values for **vibration** apply for frequencies of 55 Hz to 2000 Hz **(EN 60068-2-6).** Any acceleration exceeding permissible values, for example due to resonance depending on the application and mounting, might damage the encoder. **Comprehensive tests of the entire system are required.**
- The maximum permissible acceleration values (semi-sinusoidal shock) for **shock and impact** are valid for 11 ms, or 6 ms for the LIC **(EN 60068-2-27).** Under no circumstances should a hammer or similar implement be used to adjust or position the encoder.

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.

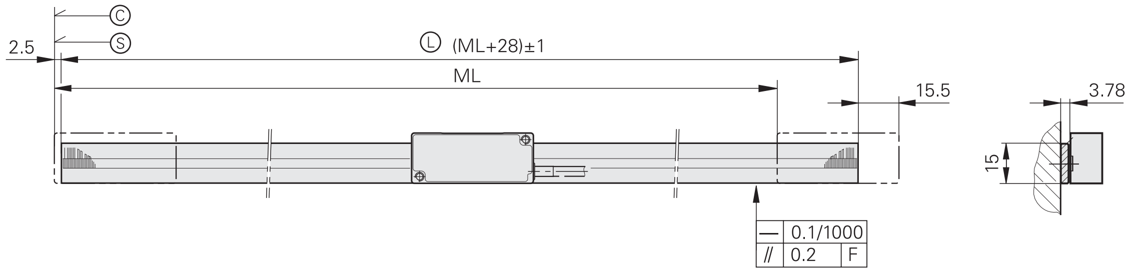
The specifications shown in this brochure apply to the specific encoder, not to the complete system. Any operation of the encoder outside of the specified range or for any other than the intended applications is at the user's own risk.

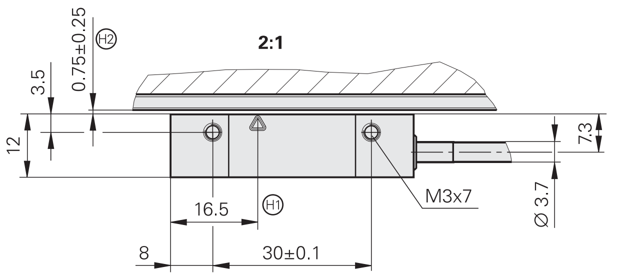
In safety-related systems, the higher-level system must verify the position value of the encoder after switch-on.

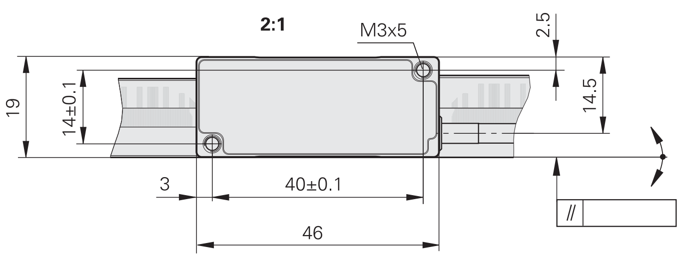
Mounting
Work steps to be performed and dimensions to be maintained during mounting are specified solely in the mounting instructions supplied with the unit. All data in this catalog regarding mounting are therefore provisional and not binding; they do not become terms of a contract.

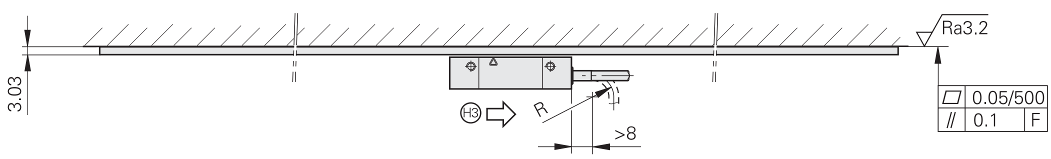
LIC 4113, LIC 4193

Absolute linear encoder for measuring lengths up to 3 m
- **Measuring steps to 0.001 µm**
- **Measuring standard of glass or glass ceramic**
- **Glass scale cemented with adhesive film**
- **Consists of scale and scanning head**

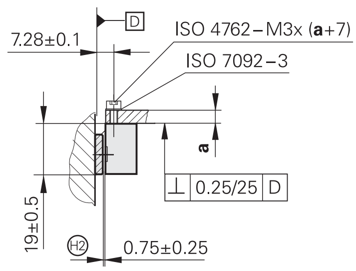


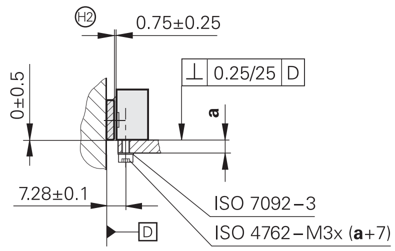


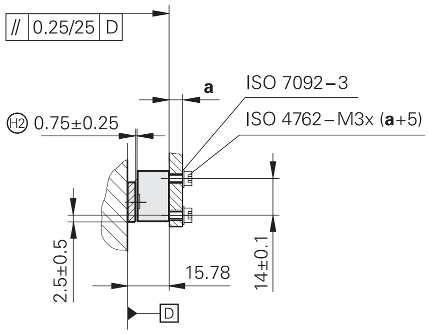




Possibilities for mounting the scanning head







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

F = Machine guideway
* = Mounting error plus dynamic guideway error
Ⓒ = Code start value: 100 mm
Ⓢ = Beginning of measuring length (ML)
Ⓛ = Scale length
H1 = Optical centerline
H2 = Mounting clearance between scanning head and scale
H3 = Direction of scanning unit motion for output signals in accordance with interface description

Linear scale	LIC 4003
Measuring standard Coefficient of linear expansion*	METALLUR absolute and incremental track on glass or glass ceramic $\alpha_{therm} \approx 8 \cdot 10^{-6}\ K^{-1}$ (glass) $\alpha_{therm} = (0 \pm 0.1) \cdot 10^{-6}\ K^{-1}$ (Zerodur glass ceramic)
Accuracy grade*	± 3 µm, ± 5 µm (higher accuracy grades on request)
Measuring length ML* in mm	240 340 440 640 840 1 040 1 240 1 440 1 640 1 840 2 040 2 240 2 440 2 640 2 840 3 040
Weight	3 g + 0.1 g/mm measuring length

Scanning head	AK LIC 411	AK LIC 419 F	AK LIC 419 M	AK LIC 419 P
Interface	EnDat 2.2	Fanuc Serial Interface αi interface	Mitsubishi high speed interface	Panasonic Serial Interface
Ordering designation*	EnDat22	Fanuc05	Mit03-4 Mit02-2	Pana01
Resolution*	0.01 µm (10 nm) 0.005 µm (5 nm) 0.001 µm (1 nm)			
Calculation time t_{cal} Clock frequency	≤ 5 µs 16 MHz	–		
Traversing speed[1)]	≤ 600 m/min			
Electrical connection*	Cable, 1 m or 3 m with 8-pin M12 coupling (male) or 15-pin D-sub connector (male)			
Cable length (with HEIDENHAIN cable)	≤ 100 m	≤ 50 m	≤ 30 m	≤ 50 m
Voltage supply	3.6 V to 14 V DC			
Power consumption[1)] (max.)	*At 3.6 V:* ≤ 800 mW *At 14 V:* ≤ 900 mW	*At 3.6 V:* ≤ 950 mW *At 14 V:* ≤ 1 050 mW		
Current consumption (typical)	*At 5 V:* 75 mA (without load)	*At 5 V:* 95 mA (without load)		
Vibration 55 Hz to 2 000 Hz **Shock** 6 ms	≤ 500 m/s² (EN 60 068-2-6) ≤ 1 000 m/s² (EN 60 068-2-27)			
Operating temperature	–10 °C to 70 °C			
Weight Scanning head Connecting cable Connector	≤ 18 g (without connecting cable) 20 g/m *M12 coupling:* 15 g; *D-sub connector:* 32 g			

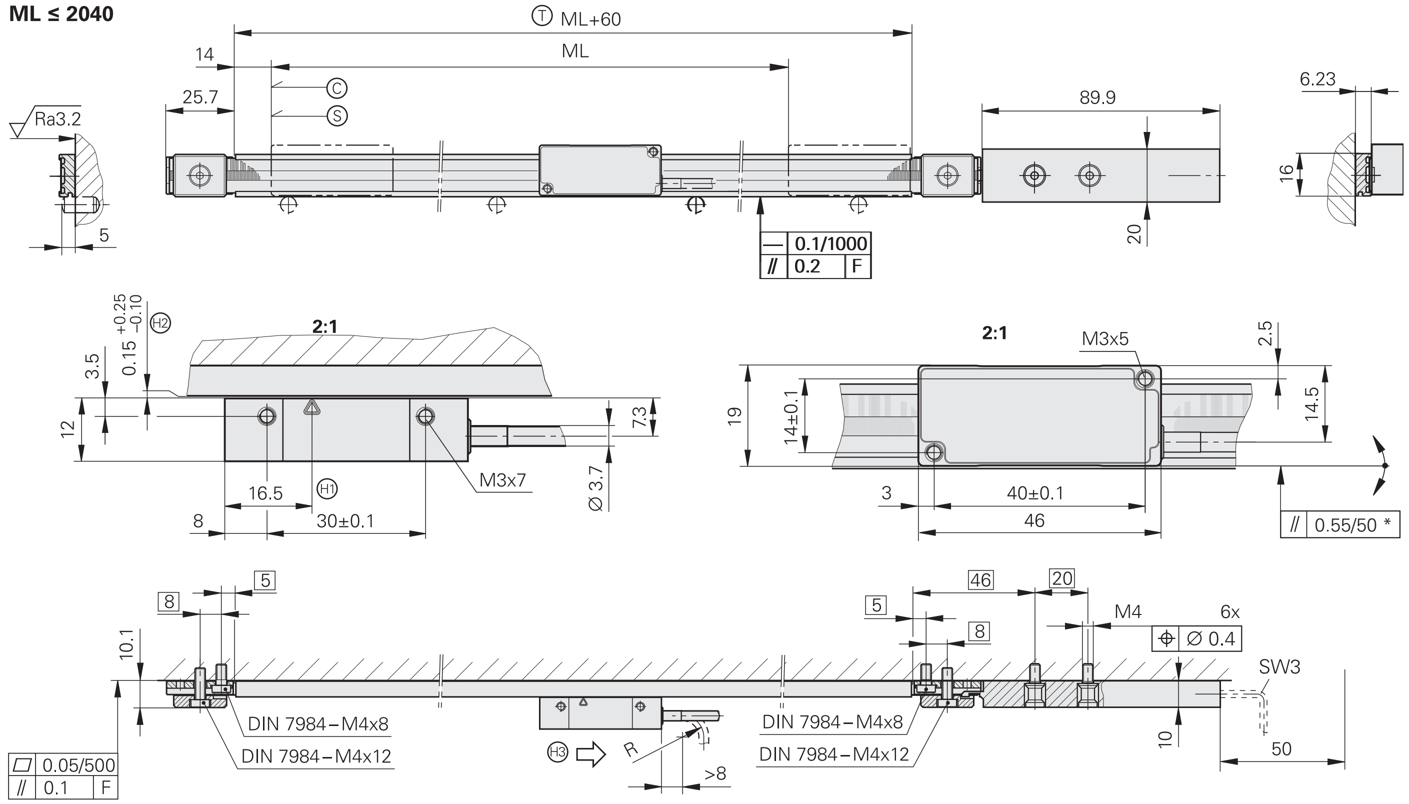
* Please select when ordering
1) See *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure

LIC 4115, LIC 4195

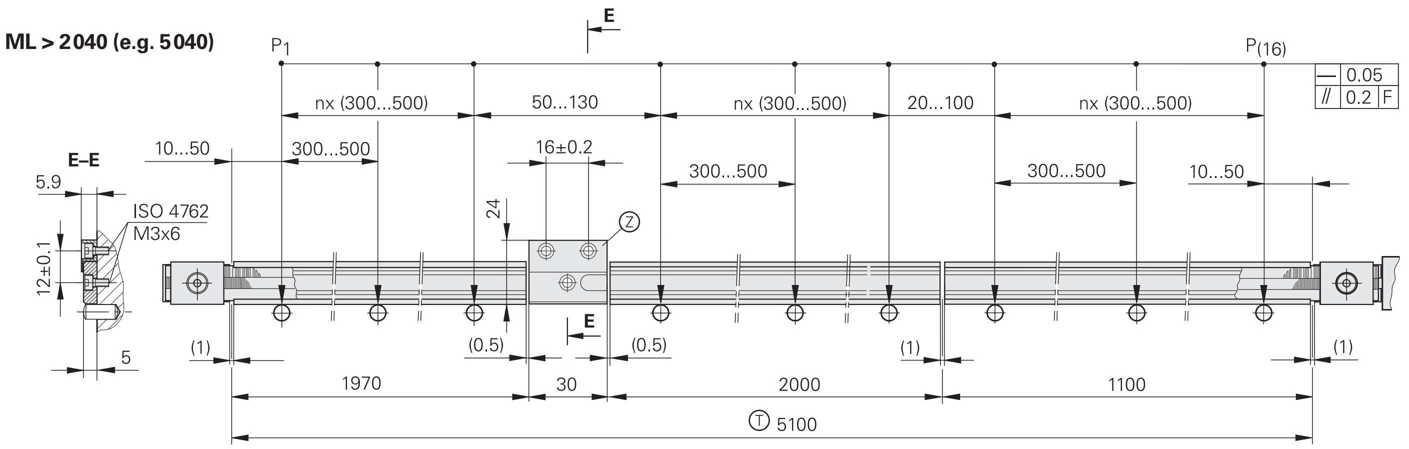
Absolute linear encoder for measuring lengths up to 28 m

- **For measuring steps as fine as 0.001 µm (1 nm)**
- **Steel scale-tape is drawn into aluminum extrusions and tensioned**
- **Consists of scale and scanning head**

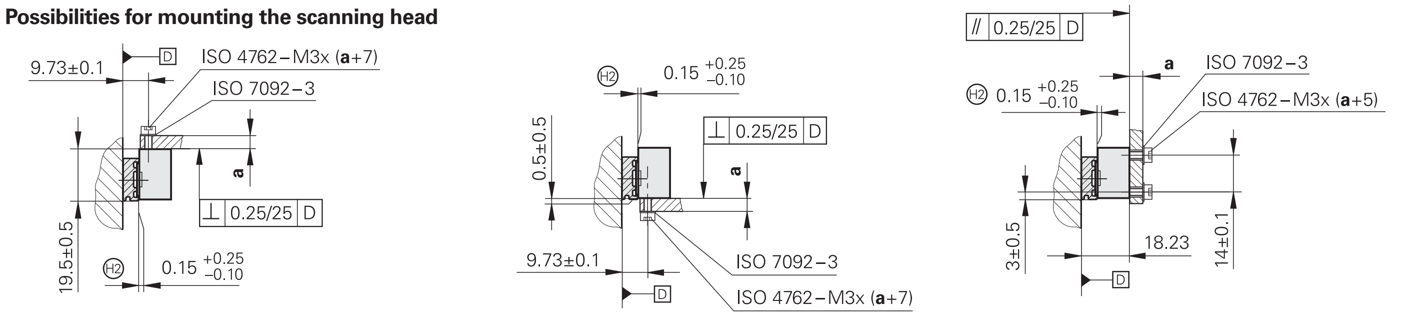
ML ≤ 2040



ML > 2040 (e.g. 5040)



Possibilities for mounting the scanning head



mm

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

F = Machine guideway
P = Gauging points for alignment
* = Mounting error plus dynamic guideway error
Ⓒ = Code start value: 100 mm
Ⓢ = Beginning of measuring length (ML)
Ⓣ = Carrier length
Ⓩ = Spacer for measuring lengths from 3040 mm
Ⓗ1 = Optical centerline
Ⓗ2 = Mounting clearance between scanning head and scale
Ⓗ3 = Direction of scanning unit motion for output signals in accordance with interface description

Linear scale	LIC 4005
Measuring standard Coefficient of linear expansion	Steel scale tape with METALLUR absolute and incremental track Depends on the mounting surface
Accuracy grade	± 5 µm
Measuring length ML* in mm	140 240 340 440 540 640 740 840 940 1 040 1 140 1 240 1 340 1 440 1 540 1 640 1 740 1 840 1 940 2 040
	Larger measuring lengths up to 28 440 mm with a single-section scale tape and individual scale-carrier sections
Weight Scale tape Parts kit Scale-tape carrier	31 g/m 80 g + n[4] × 27 g 187 g/m

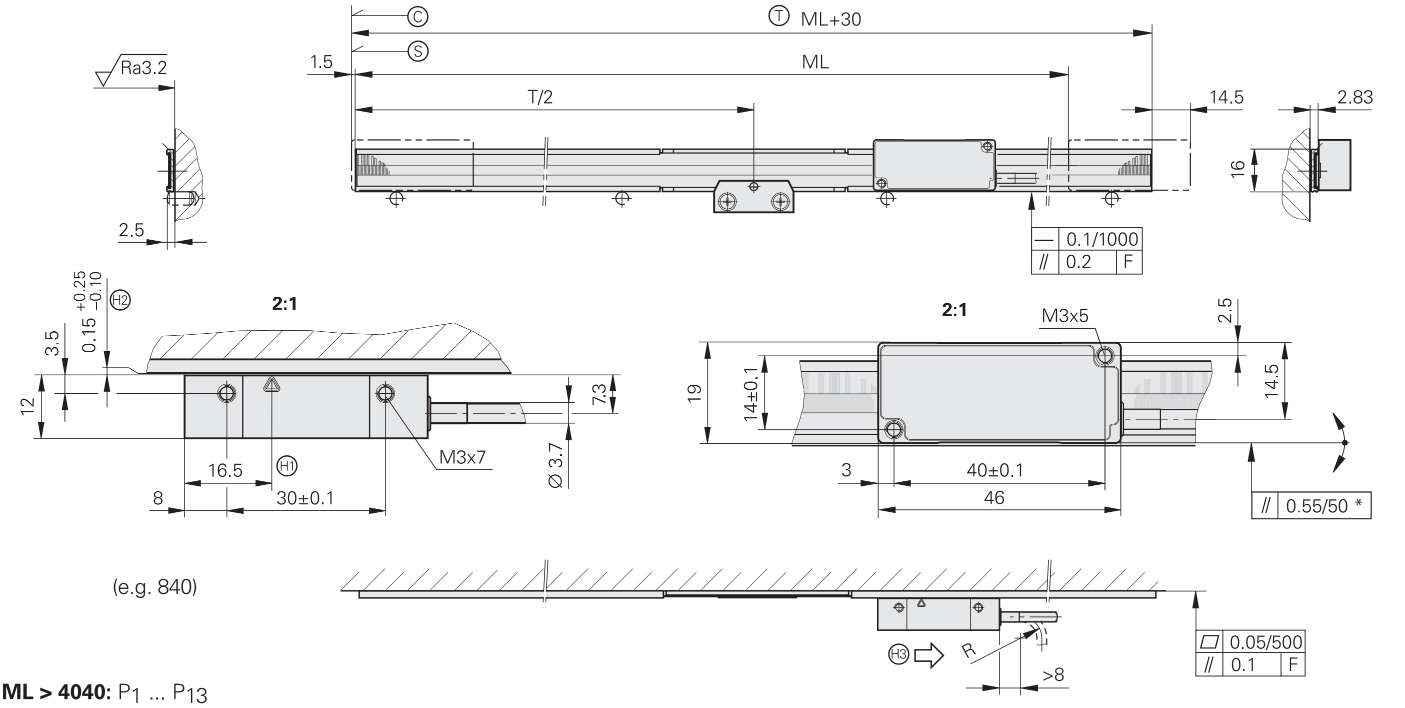
Scanning head	AK LIC 411	AK LIC 419 F	AK LIC 419 M	AK LIC 419 P
Interface	EnDat 2.2	Fanuc Serial Interface αi interface	Mitsubishi high speed interface	Panasonic Serial Interface
Ordering designation*	EnDat22	Fanuc05	Mit03-4 Mit02-2	Pana01
Resolution*	0.01 µm (10 nm) 0.005 µm (5 nm) 0.001 µm (1 nm)		0.01 µm (10 nm) 0.005 µm (5 nm)[2] 0.001 µm (1 nm)[3]	0.01 µm (10 nm) 0.005 µm (5 nm) 0.001 µm (1 nm)
Calculation time t_{cal} Clock frequency	≤ 5 µs 16 MHz	–		
Traversing speed[1]	≤ 600 m/min			
Electrical connection*	Cable, 1 m or 3 m with 8-pin M12 coupling (male) or 15-pin D-sub connector (male)			
Cable length (with HEIDENHAIN cable)	≤ 100 m	≤ 50 m	≤ 30 m	≤ 50 m
Voltage supply	3.6 V to 14 V DC			
Power consumption[1] (max.)	*At 3.6 V:* ≤ 800 mW *At 14 V:* ≤ 900 mW	*At 3.6 V:* ≤ 950 mW *At 14 V:* ≤ 1 050 mW		
Current consumption (typical)	*At 5 V:* 75 mA (without load)	*At 5 V:* 95 mA (without load)		
Vibration 55 Hz to 2 000 Hz **Shock** 6 ms	≤ 500 m/s^2 (EN 60 068-2-6) ≤ 1 000 m/s^2 (EN 60 068-2-27)			
Operating temperature	–10 °C to 70 °C			
Weight Scanning head Connecting cable Connector	≤ 18 g (without connecting cable) 20 g/m *M12 coupling:* 15 g; *D-sub connector:* 32 g			

* Please select when ordering
[1] See *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure
[2] Up to measuring length ML ≤ 21 040
[3] Up to measuring length ML ≤ 4 140
[4] n = 1 for ML 3 140 mm to 5 040 mm; n = 2 for ML 5 140 mm to 7 040 mm; etc.*

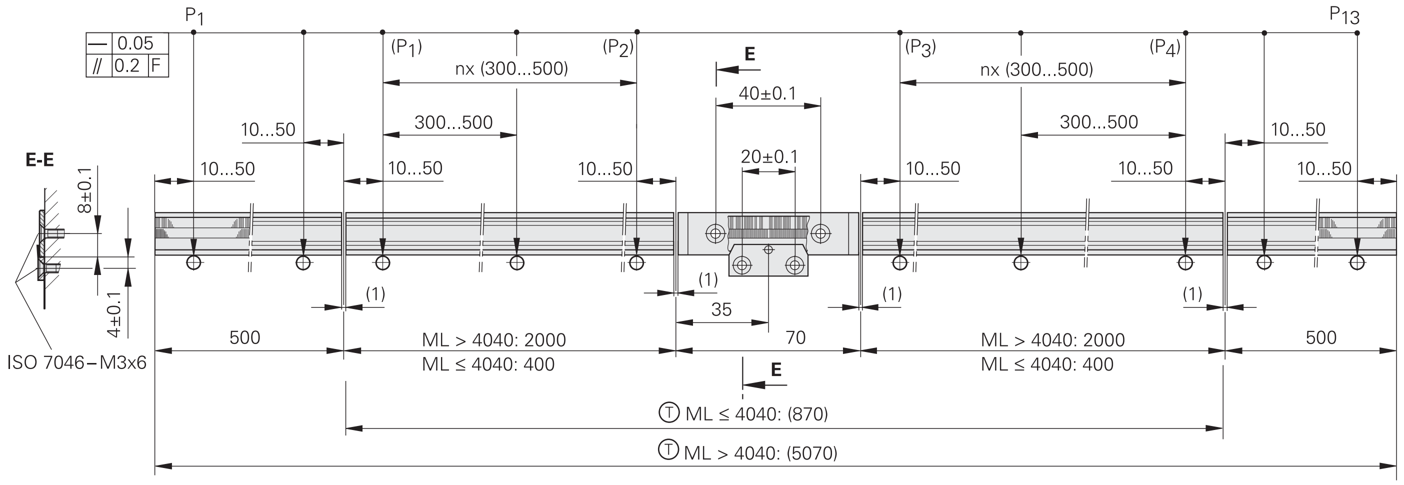
LIC 4117, LIC 4197

Absolute linear encoder for measuring lengths up to 6 m

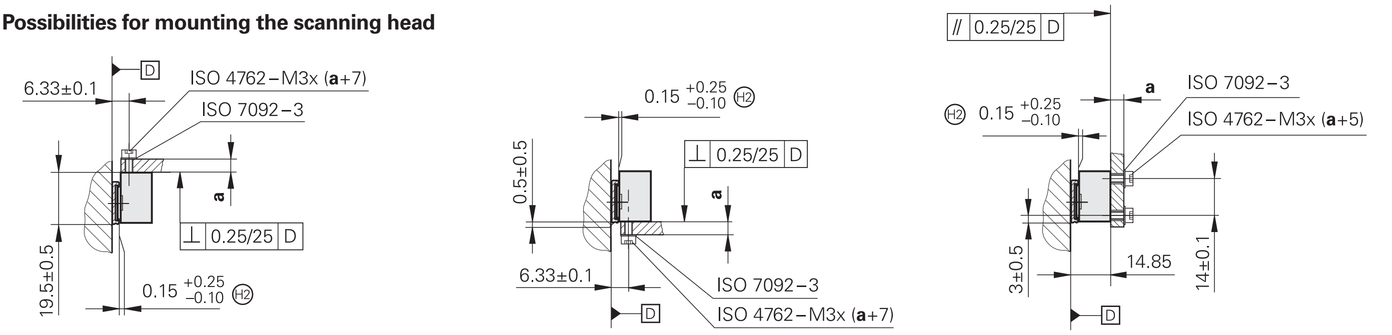
- **For measuring steps as fine as 0.001 µm (1 nm)**
- **Steel scale-tape is drawn into aluminum extrusions and fixed at center**
- **Consists of scale and scanning head**



ML > 4040: P1 ... P13
ML ≤ 4040: (P1 ... P4)



Possibilities for mounting the scanning head



mm

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

F = Machine guideway
P = Gauging points for alignment
* = Mounting error plus dynamic guideway error
Ⓒ = Code start value: 100 mm
Ⓢ = Beginning of measuring length (ML)
Ⓣ = Carrier length
H1 = Optical centerline
H2 = Mounting clearance between scanning head and scale
H3 = Direction of scanning unit motion for output signals in accordance with interface description

Linear scale	LIC 4007
Measuring standard Coefficient of linear expansion	Steel scale tape with METALLUR absolute and incremental track $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$
Accuracy grade*	± 3 µm (up to ML 1 040 mm), ± 5 µm (as of ML 1 240), ± 15 µm[1]
Measuring length ML* in mm	240 440 640 840 1 040 1 240 1 440 1 640 1 840 2 040 2 240 2 440 2 640 2 840 3 040 3 240 3 440 3 640 3 840 4 040 4 240 4 440 4 640 4 840 5 040 5 240 5 440 5 640 5 840 6 040
Weight Scale tape Parts kit Scale-tape carrier	31 g/m 20 g 68 g/m

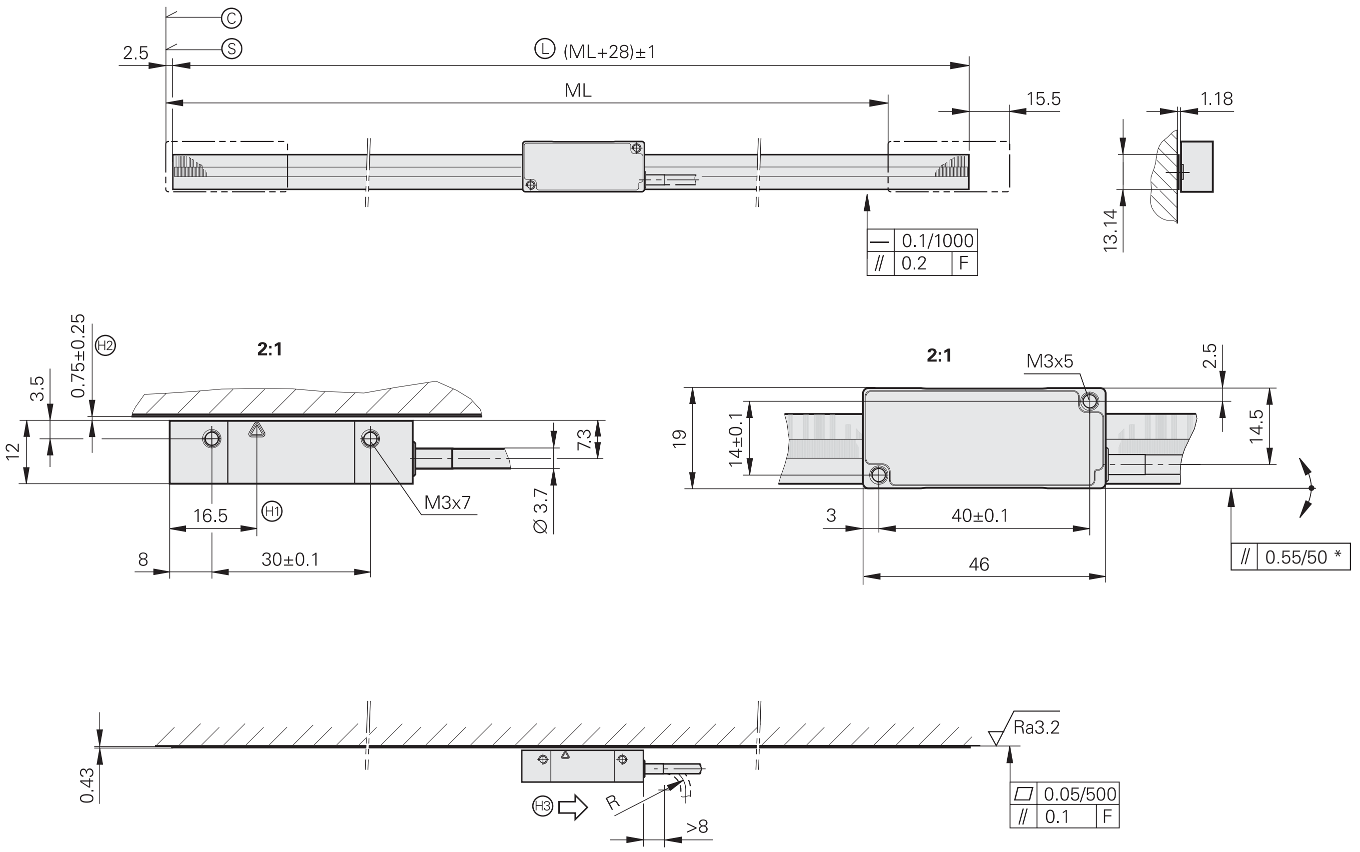
Scanning head	AK LIC 411	AK LIC 419 F	AK LIC 419 M	AK LIC 419 P
Interface	EnDat 2.2	Fanuc Serial Interface αi interface	Mitsubishi high speed interface	Panasonic Serial Interface
Ordering designation*	EnDat22	Fanuc05	Mit03-4 Mit02-2	Pana01
Resolution*	0.01 µm (10 nm) 0.005 µm (5 nm) 0.001 µm (1 nm)		0.01 µm (10 nm) 0.005 µm (5 nm) 0.001 µm (1 nm)[3]	0.01 µm (10 nm) 0.005 µm (5 nm) 0.001 µm (1 nm)
Calculation time t_{cal} Clock frequency	≤ 5 µs 16 MHz	–		
Traversing speed[2]	≤ 600 m/min			
Electrical connection*	Cable, 1 m or 3 m with 8-pin M12 coupling (male) or 15-pin D-sub connector (male)			
Cable length (with HEIDENHAIN cable)	≤ 100 m	≤ 50 m	≤ 30 m	≤ 50 m
Voltage supply	3.6 V to 14 V DC			
Power consumption[2] (max.)	*At 3.6 V:* ≤ 800 mW *At 14 V:* ≤ 900 mW	*At 3.6 V:* ≤ 950 mW *At 14 V:* ≤ 1 050 mW		
Current consumption (typical)	*At 5 V:* 75 mA (without load)	*At 5 V:* 95 mA (without load)		
Vibration 55 Hz to 2 000 Hz **Shock** 6 ms	≤ 500 m/s^2 (EN 60 068-2-6) ≤ 1 000 m/s^2 (EN 60 068-2-27)			
Operating temperature	–10 °C to 70 °C			
Weight Scanning head Connecting cable Connector	≤ 18 g (without connecting cable) 20 g/m *M12 coupling:* 15 g; *D-sub connector:* 32 g			

* Please select when ordering
[1] ± 5 µm after linear length-error compensation in the subsequent electronics
[2] See *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure
[3] Up to measuring length ML ≤ 4 140

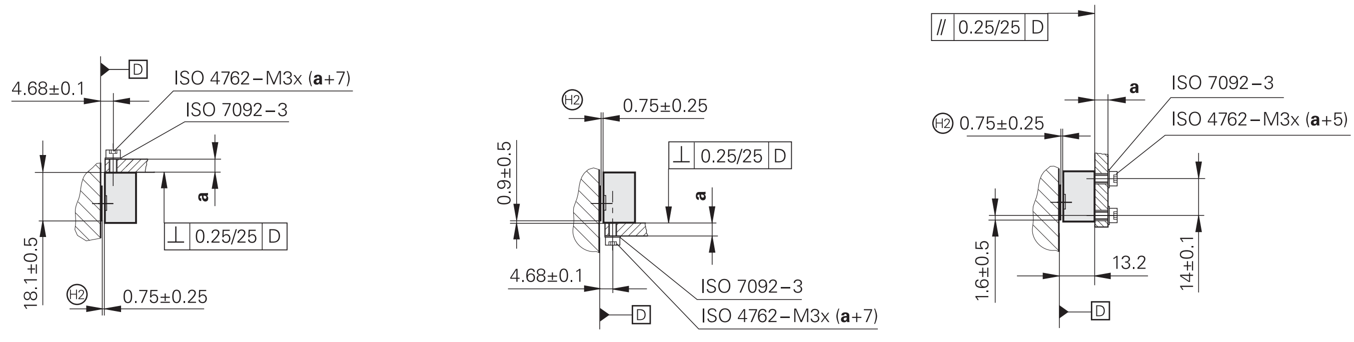
LIC 4119, LIC 4199

Absolute linear encoder for measuring lengths up to 1 m

- **For measuring steps as fine as 0.001 µm (1 nm)**
- **Steel scale tape cemented on mounting surface**
- **Consists of scale and scanning head**



Possibilities for mounting the scanning head



mm

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

F = Machine guideway
* = Mounting error plus dynamic guideway error
Ⓒ = Code start value: 100 mm
Ⓢ = Beginning of measuring length (ML)
Ⓛ = Scale tape length
Ⓗ1 = Optical centerline
Ⓗ2 = Mounting clearance between scanning head and scale
Ⓗ3 = Direction of scanning unit motion for output signals in accordance with interface description

Linear scale	LIC 4009
Measuring standard Coefficient of linear expansion	Steel scale tape with METALLUR absolute and incremental track $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$
Accuracy grade*	± 3 µm, ± 15 µm[1)]
Measuring length ML* in mm	70 120 170 220 270 320 370 420 520 620 720 820 920 1 020
Weight	31 g/m

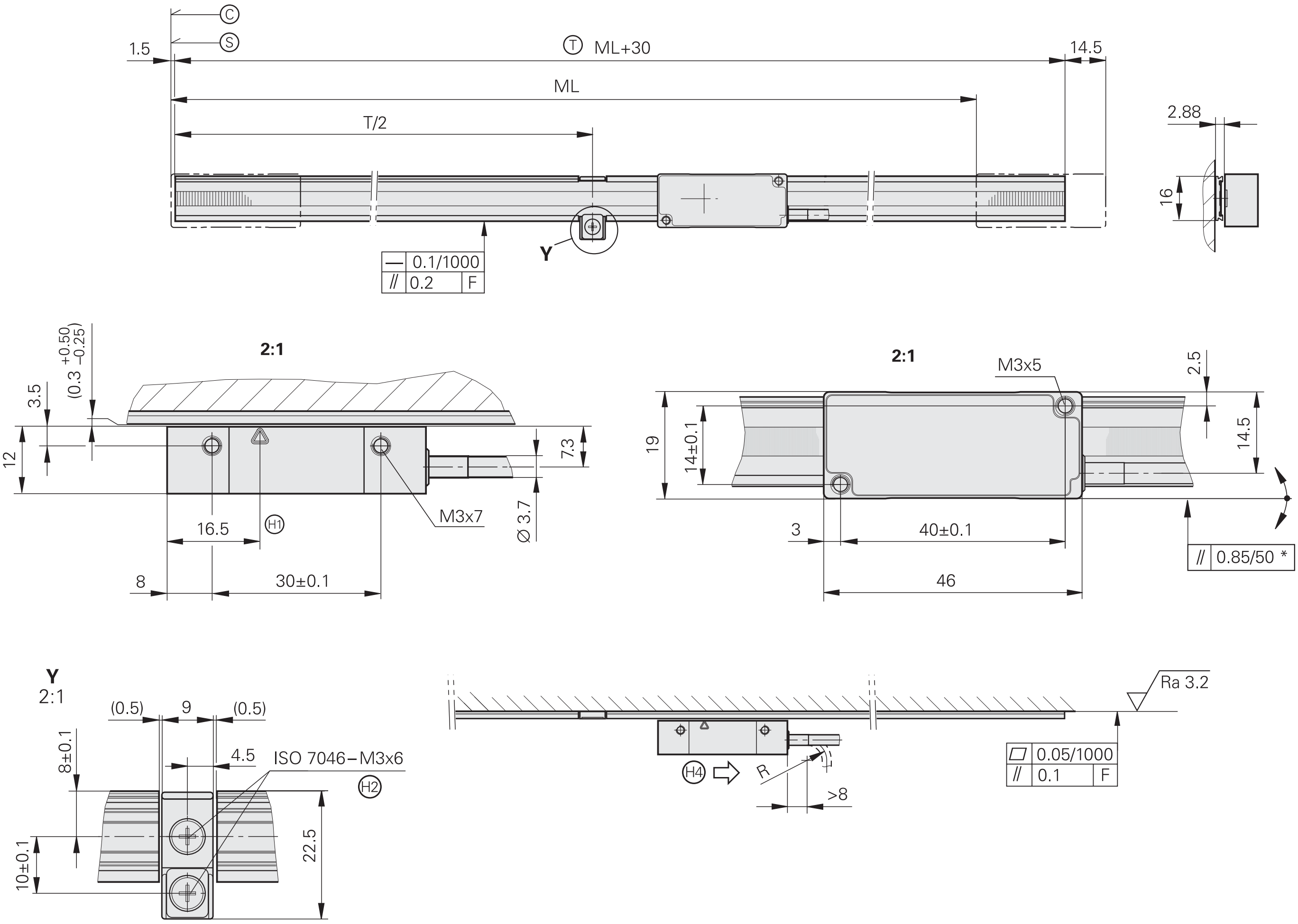
Scanning head	AK LIC 411	AK LIC 419F	AK LIC 419M		AK LIC 419P
Interface	EnDat 2.2	Fanuc Serial Interface αi interface	Mitsubishi high speed interface		Panasonic Serial Interface
Ordering designation*	EnDat22	Fanuc05	Mit03-4	Mit02-2	Pana01
Resolution*	0.01 µm (10 nm) 0.005 µm (5 nm) 0.001 µm (1 nm)				
Calculation time t_{cal} Clock frequency	≤ 5 µs 16 MHz	–			
Traversing speed[2)]	≤ 600 m/min				
Electrical connection*	Cable, 1 m or 3 m with 8-pin M12 coupling (male) or 15-pin D-sub connector (male)				
Cable length (with HEIDENHAIN cable)	≤ 100 m	≤ 50 m	≤ 30 m		≤ 50 m
Voltage supply	3.6 V to 14 V DC				
Power consumption[2)] (max.)	*At 3.6 V:* ≤ 800 mW *At 14 V:* ≤ 900 mW	*At 3.6 V:* ≤ 950 mW *At 14 V:* ≤ 1 050 mW			
Current consumption (typical)	*At 5 V:* 75 mA (without load)	*At 5 V:* 95 mA (without load)			
Vibration 55 Hz to 2 000 Hz **Shock** 6 ms	≤ 500 m/s^2 (EN 60 068-2-6) ≤ 1 000 m/s^2 (EN 60 068-2-27)				
Operating temperature	–10 °C to 70 °C				
Weight Scanning head Connecting cable Connector	≤ 18 g (without connecting cable) 20 g/m *M12 coupling:* 15 g; *D-sub connector:* 32 g				

* Please select when ordering
1) ± 5 µm after linear length-error compensation in the subsequent electronics
2) See *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure

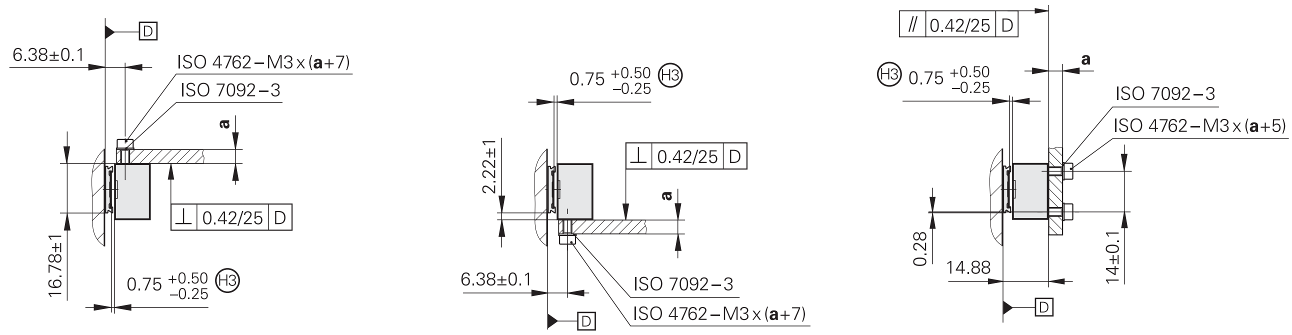
LIC 2117, LIC 2197

Absolute linear encoder for measuring lengths up to 3 m

- **Measuring step 0.1 µm or 0.05 µm**
- **Steel scale-tape is drawn into aluminum extrusions and fixed at center**
- **Consists of scale and scanning head**



Possibilities for mounting the scanning head



mm

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

F = Machine guideway
* = Max. change during operation
Ⓒ = Code start value: 100 mm
Ⓢ = Beginning of measuring length (ML)
Ⓣ = Carrier length
H1 = Optical centerline
H2 = Mating threaded hole, M3, 5 mm deep
H3 = Mounting clearance between scanning head and scale tape
H4 = Direction of scanning unit motion for output signals in accordance with interface description

Linear scale	**LIC 2107**
Measuring standard Coefficient of linear expansion	Steel scale tape with absolute track $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$
Accuracy grade	± 15 µm
Measuring length ML* in mm	120 320 520 770 1 020 1 220 1 520 2 020 2 420 3 020 (Larger measuring lengths up to 6 020 mm available on request)
Weight Scale tape Scale-tape carrier	20 g/m 70 g/m

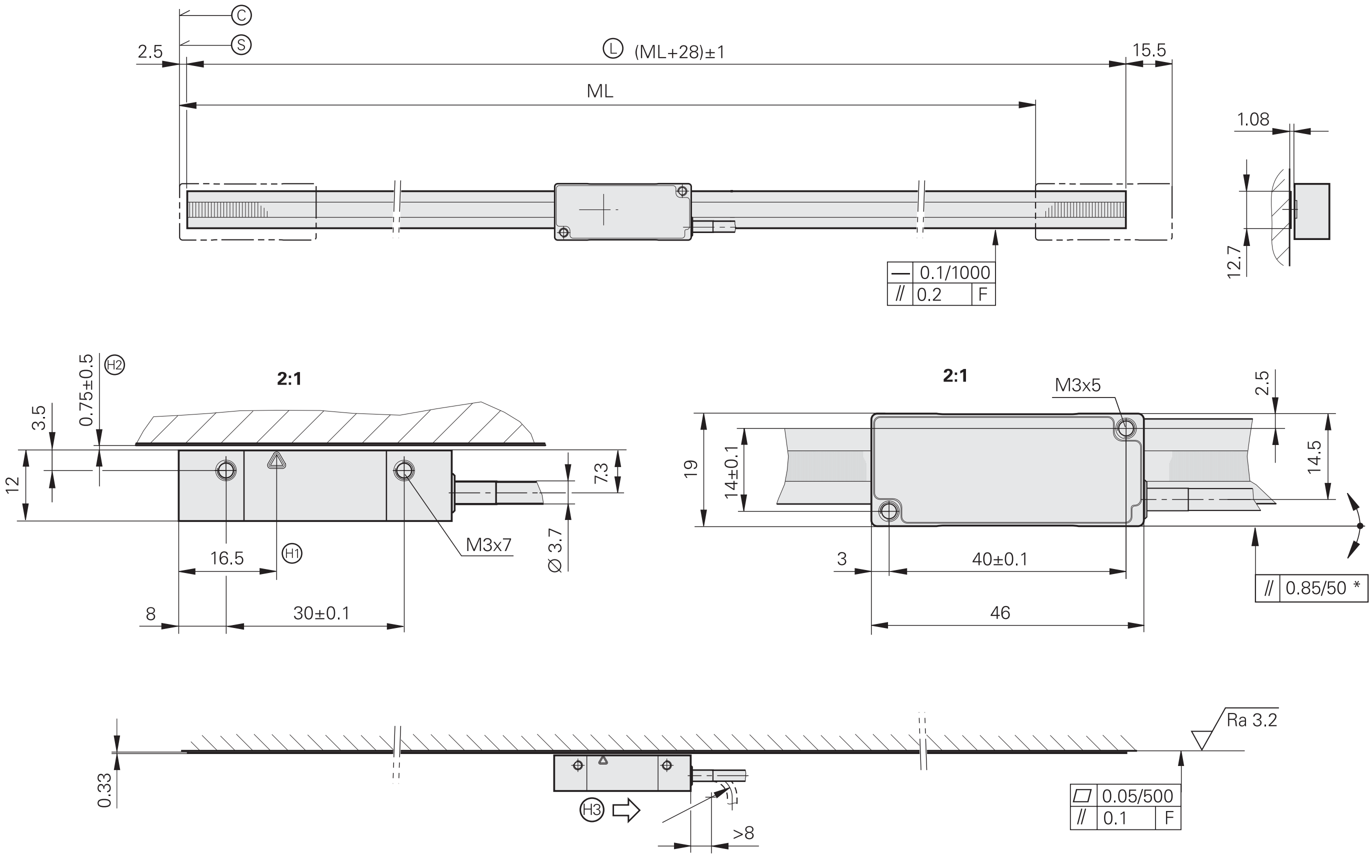
Scanning head	**AK LIC 211**	**AK LIC 219F**	**AK LIC 219M**	**AK LIC 219P**
Interface	EnDat 2.2	Fanuc Serial Interface αi interface	Mitsubishi high speed interface	Panasonic Serial Interface
Ordering designation*	EnDat22	Fanuc05	Mit03-4 / Mit02-2	Pana01
Resolution*	0.1 µm or 0.05 µm			
Calculation time t_{cal} Clock frequency	≤ 5 µs ≤ 16 MHz	– –		
Traversing speed[1]	≤ 600 m/min			
Electrical connection*	Cable, 1 m or 3 m with 8-pin M12 coupling (male) or 15-pin D-sub connector (male)			
Cable length (with HEIDENHAIN cable)	≤ 100 m	≤ 50 m	≤ 30 m	≤ 50 m
Voltage supply	3.6 V to 14 V DC			
Power consumption[1] (max.)	*At 3.6 V:* ≤ 800 mW *At 14 V:* ≤ 900 mW	*At 3.6 V:* ≤ 950 mW *At 14 V:* ≤ 1 050 mW		
Current consumption (typical)	*At 5 V:* 75 mA (without load)	*At 5 V:* 95 mA (without load)		
Vibration 55 Hz to 2 000 Hz **Shock** 6 ms	≤ 500 m/s² (EN 60 068-2-6) ≤ 1 000 m/s² (EN 60 068-2-27)			
Operating temperature	–10 °C to 70 °C			
Weight Scanning head Connecting cable Connector	≤ 18 g (without connecting cable) 20 g/m *M12 coupling:* 15 g; *D-sub connector:* 32 g			

* Please select when ordering
[1] See *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure

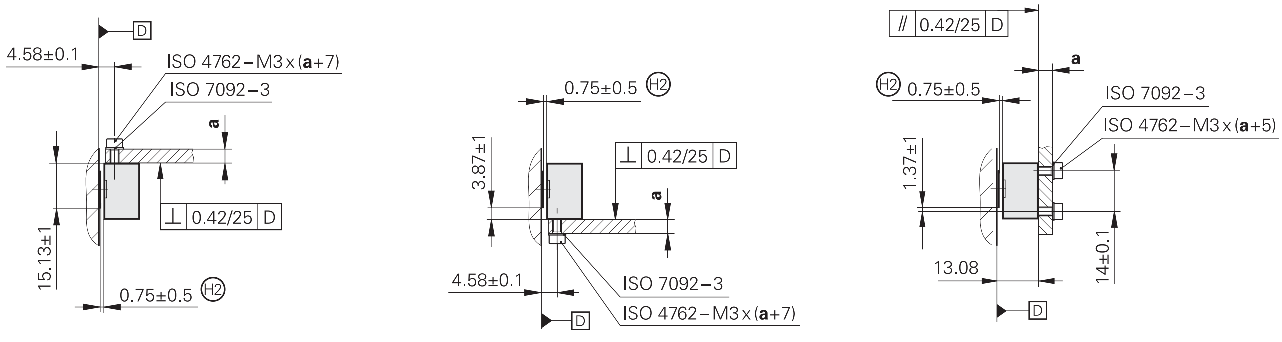
LIC 2119, LIC 2199

Absolute linear encoder for measuring lengths up to 3 m

- **Measuring step 0.1 µm or 0.05 µm**
- **Steel scale tape cemented on mounting surface**
- **Consists of scale and scanning head**



Possibilities for mounting the scanning head



mm

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

F = Machine guideway
* = Max. change during operation
Ⓒ = Code start value: 100 mm
Ⓢ = Beginning of measuring length (ML)
Ⓛ = Scale tape length
Ⓗ1 = Optical centerline
Ⓗ2 = Mating threaded hole, M3, 5 mm deep
Ⓗ3 = Mounting clearance between scanning head and scale tape
Ⓗ4 = Direction of scanning unit motion for output signals in accordance with interface description

Linear scale	**LIC 2109**
Measuring standard Coefficient of linear expansion	Steel scale tape with absolute track $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$
Accuracy grade	± 15 µm
Measuring length ML* in mm	120 320 520 770 1 020 1 220 1 520 2 020 2 420 3 020 (Larger measuring lengths up to 6 020 mm available on request)
Weight	20 g/m

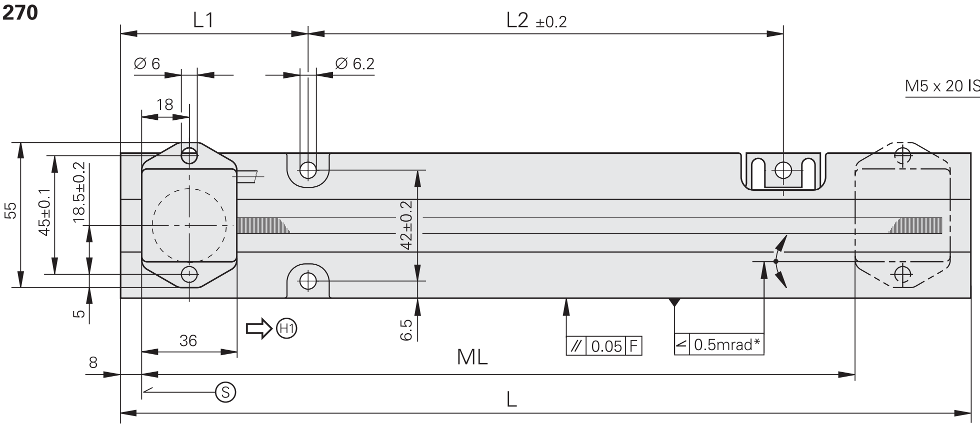
Scanning head	**AK LIC 211**	**AK LIC 219 F**	**AK LIC 219 M**	**AK LIC 219 P**
Interface	EnDat 2.2	Fanuc Serial Interface αi interface	Mitsubishi high speed interface	Panasonic Serial Interface
Ordering designation*	EnDat22	Fanuc05	Mit03-4 Mit02-2	Pana01
Resolution*	0.1 µm or 0.05 µm			
Calculation time t_{cal} Clock frequency	≤ 5 µs ≤ 16 MHz	– –		
Traversing speed[1)]	≤ 600 m/min			
Electrical connection*	Cable, 1 m or 3 m with 8-pin M12 coupling (male) or 15-pin D-sub connector (male)			
Cable length (with HEIDENHAIN cable)	≤ 100 m	≤ 50 m	≤ 30 m	≤ 50 m
Voltage supply	3.6 V to 14 V DC			
Power consumption[1)] (max.)	*At 3.6 V:* ≤ 800 mW *At 14 V:* ≤ 900 mW	*At 3.6 V:* ≤ 950 mW *At 14 V:* ≤ 1 050 mW		
Current consumption (typical)	*At 5 V:* 75 mA (without load)	*At 5 V:* 95 mA (without load)		
Vibration 55 Hz to 2 000 Hz **Shock** 6 ms	≤ 500 m/s^2 (EN 60 068-2-6) ≤ 1 000 m/s^2 (EN 60 068-2-27)			
Operating temperature	–10 °C to 70 °C			
Weight Scanning head Connecting cable Connector	≤ 18 g (without connecting cable) 20 g/m *M12 coupling:* 15 g; *D-sub connector:* 32 g			

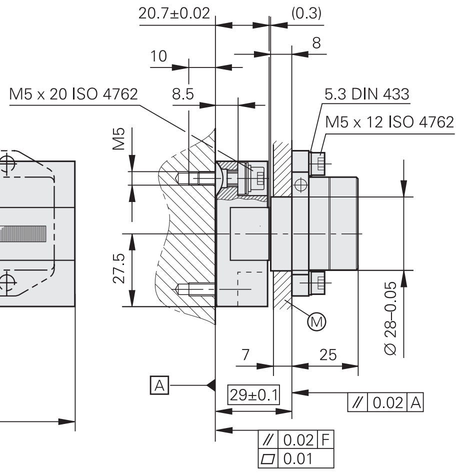
* Please select when ordering
1) See *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure

LIP 372, LIP 382

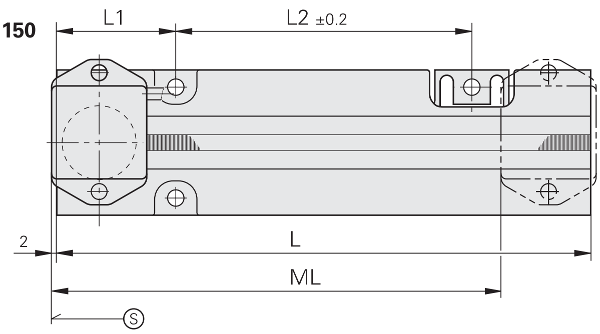
Incremental linear encoders with very high accuracy
- **Measuring steps to 0.001 µm (1 nm)**
- **Measuring standard is fastened by screws**

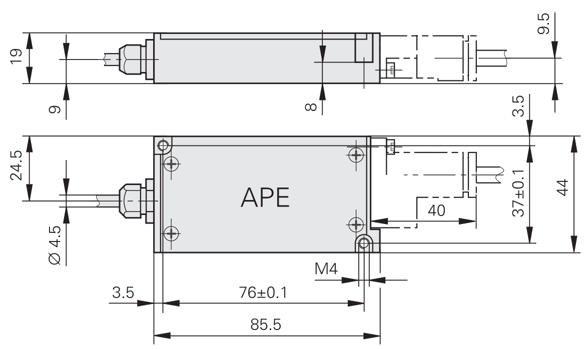
ML 270



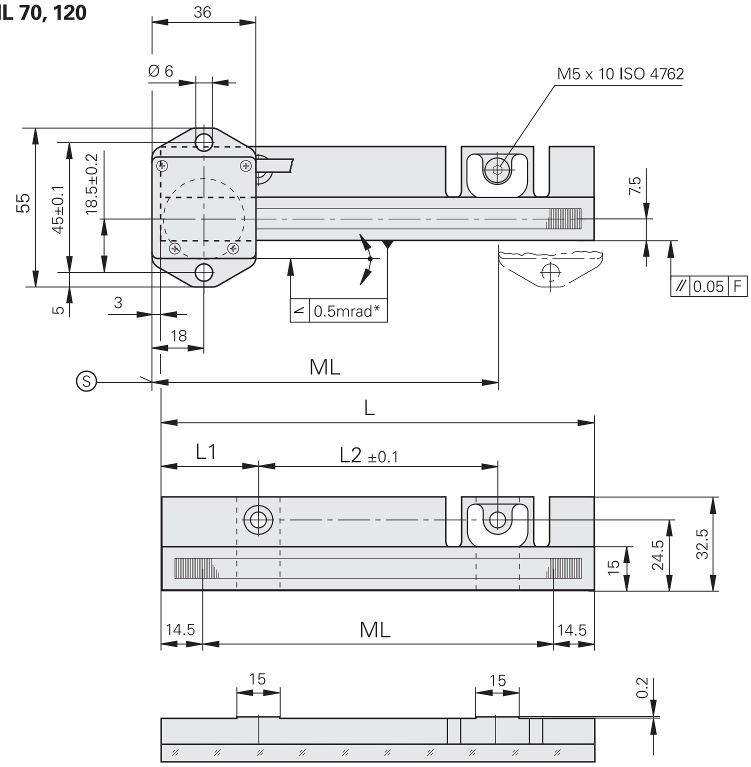


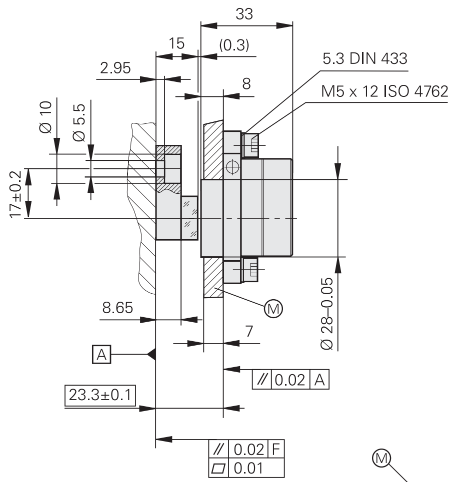
ML 220, 170, 150

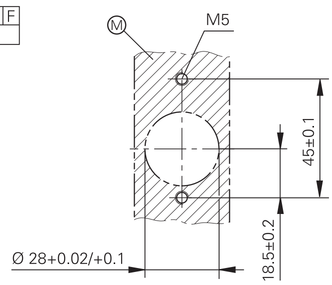




ML 70, 120

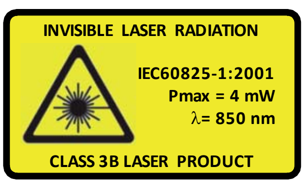






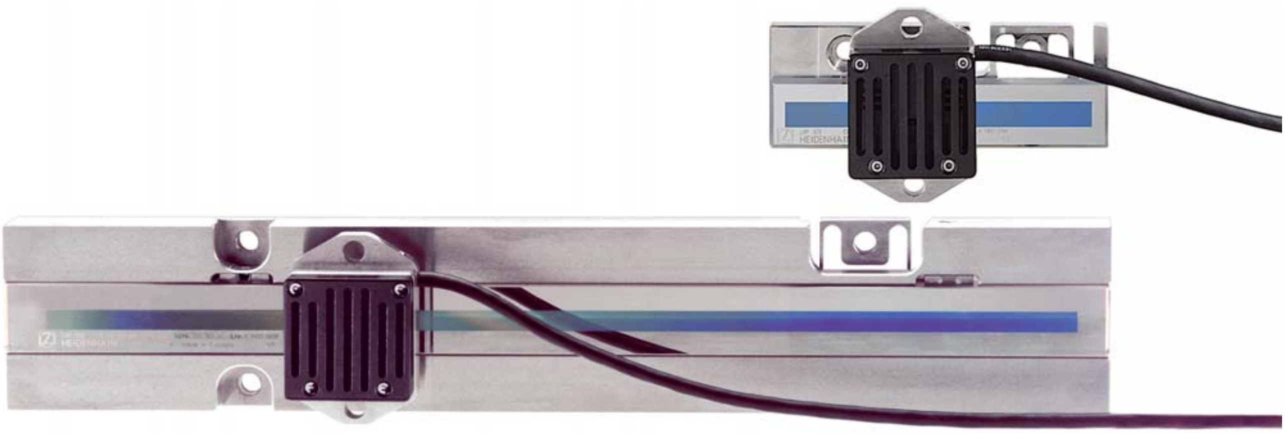
mm

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



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

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

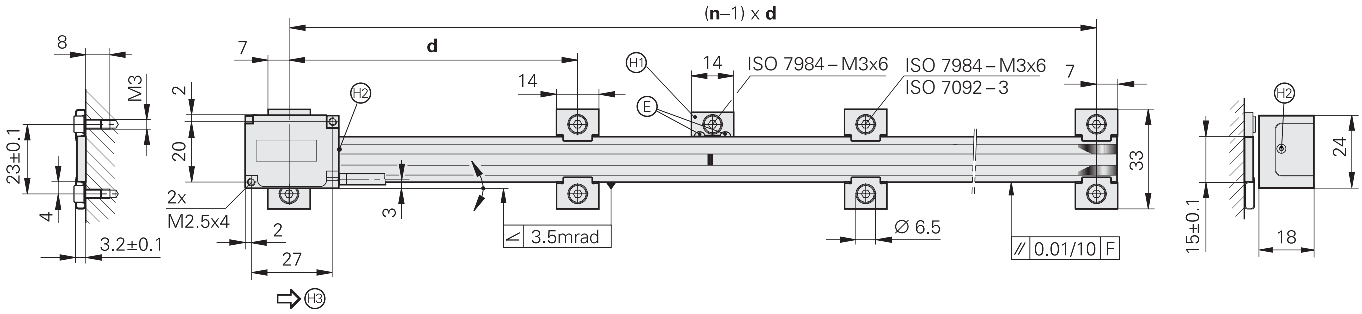


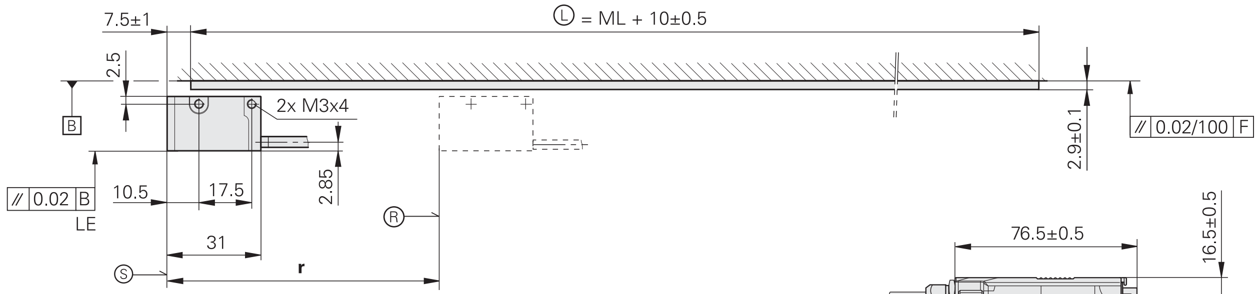
	LIP 382	LIP 372		
Measuring standard Coefficient of linear expansion	DIADUR phase grating on Zerodur glass ceramic; grating period 0.512 µm $\alpha_{therm} \approx (0 \pm 0.1) \cdot 10^{-6}\ K^{-1}$			
Accuracy grade	± 0.5 µm (higher accuracy grades available on request)			
Measuring length ML* in mm	70 120 150 170 220 270			
Reference marks	None			
Interface	∿ 1 V_{PP}	⊓⊔TTL		
Integrated interpolation Signal period	– 0.128 µm	32-fold 0.004 µm		
Cutoff frequency –3 dB	≥ 1 MHz	–		
Scanning frequency* Edge separation a	–	≤ 98 kHz ≥ 0.055 µs	≤ 49 kHz ≥ 0.130 µs	≤ 24.5 kHz ≥ 0.280 µs
Traversing speed	≤ 7.6 m/min	≤ 0.75 m/min	≤ 0.38 m/min	≤ 0.19 m/min
Laser	*Scanning head and scale mounted:* Class 1 *Scanning head not mounted:* Class 3B *Laser diode used:* Class 3B			
Electrical connection	Cable 0.5 m to interface electronics (APE), sep. adapter cable (1 m/3 m/6 m/9 m) connectable to APE			
Cable length	See interface description, but ≤ 30 m (with HEIDENHAIN cable)			
Voltage supply	5 V DC ± 0.25 V	5 V DC ± 0.25 V		
Current consumption	< 190 mA	< 250 mA (without load)		
Vibration 55 Hz to 2000 Hz **Shock** 11 ms	≤ 4 m/s^2 (EN 60068-2-6) ≤ 50 m/s^2 (EN 60068-2-27)			
Operating temperature	0 °C to 40 °C			
Weight Scanning head Interface electronics Linear scale Connecting cable	150 g 100 g *ML 70 mm:* 260 g, *ML ≥ 150 mm:* 700 g 38 g/m			

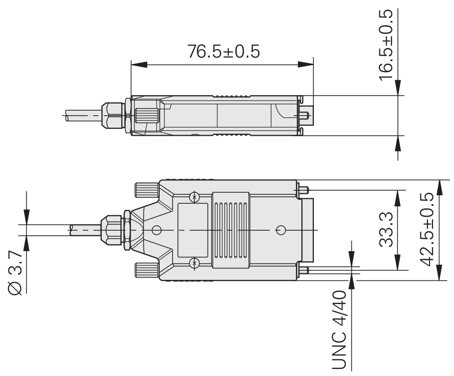
***** Please select when ordering

LIP 211, LIP 281, LIP 291

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







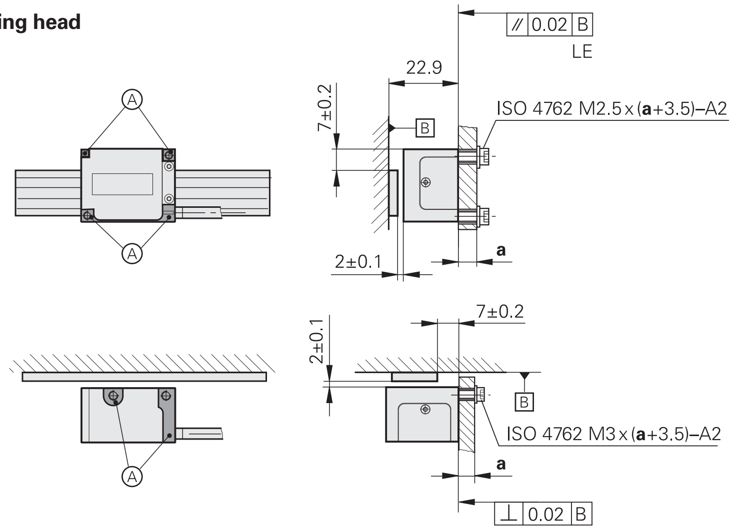
Distance r depends on the scale variant (standard: r = ML/2)
Quantity n of pairs of fixing clamps (mounting with fixing clamps at both ends)

ML	n
ML ≤ 70	2
70 < ML ≤ 100	3
100 < ML ≤ 200	4
...	...

Distance d between fixing clamps:

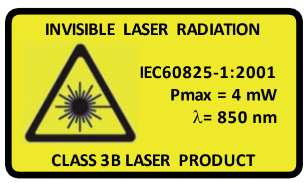
$$\mathbf{d} = \frac{ML - 4}{\mathbf{n} - 1}$$

Possibilities for mounting the scanning head



mm

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



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

Linear scale	LIP 201	
Measuring standard Coefficient of linear expansion	OPTODUR phase grating on Zerodur glass ceramic; grating period 2.048 µm $\alpha_{therm} \approx (0 \pm 0.1) \times 10^{-6}\ K^{-1}$	
Accuracy grade*	± 1 µm	± 3 µm (higher accuracy grades available on request)
Measuring length ML* in mm	20 30 50 70 120 170 220 270 320 370 420 470 520 570 620 670 720 770 820 870 920 970 1 020	370 420 470 520 570 620 670 720 770 820 870 920 970 1 020 1 140 1 240 1 340 1 440 1 540 1 640 1 840 2 040 2 240 2 440 2 640 2 840 3 040
Reference marks	One at midpoint of measuring length	
Weight	0.11 g/mm overall length	

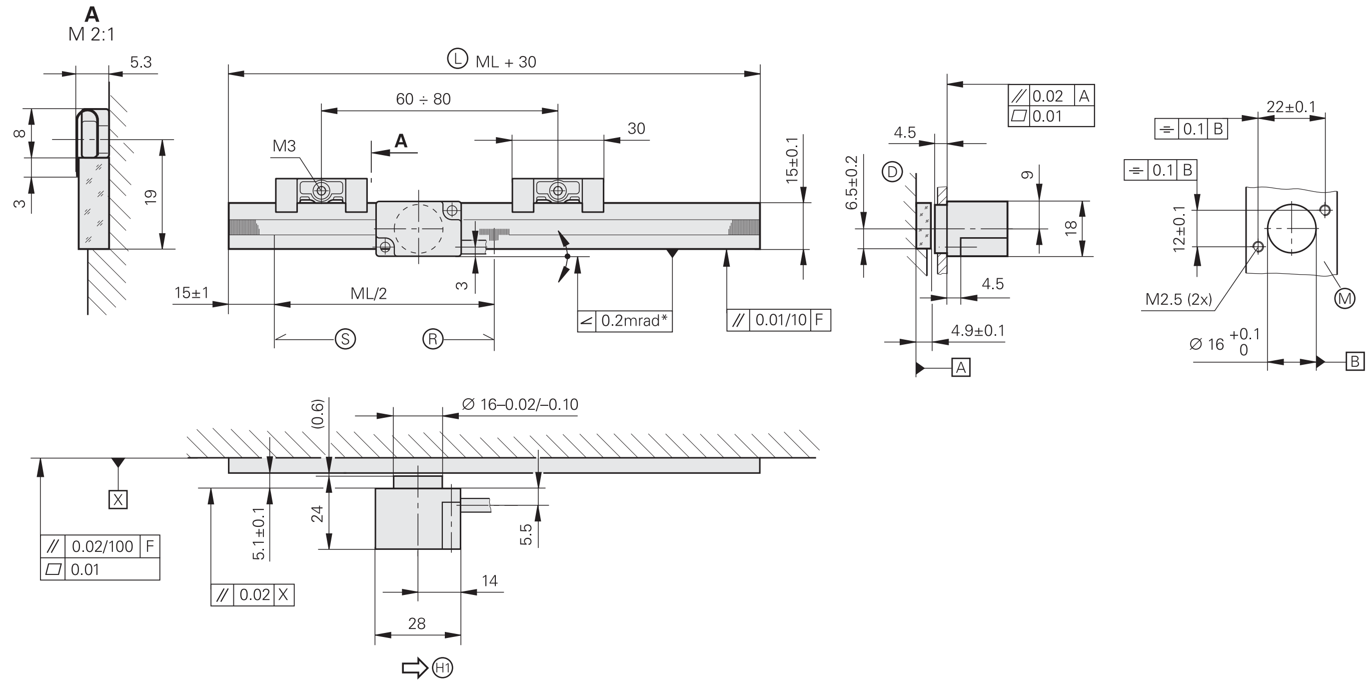
Scanning head	AK LIP 21	AK LIP 29 F	AK LIP 29 M		AK LIP 28
Interface	EnDat 2.2[1]	Fanuc Serial Interface αi Interface[1]	Mitsubishi high speed Interface[1]		∼ 1 V_{PP}
Ordering designation	EnDat 22	Fanuc05	Mit03-4	Mit02-2	–
Integrated interpolation	16 384-fold (14 bits)				–
Clock frequency	≤ 8 MHz	–			–
Calculation time t_{cal}	≤ 5 µs	–			–
Resolution	0.03125 nm (31.25 pm)				–
Signal period	–				0.512 µm
Cutoff frequency –3 dB	–				≥ 3 MHz
Traversing speed	≤ 120 m/min				≤ 90 m/min (higher upon request)
Electrical connection*	Cable 0.5 m, 1 m, 2 m, or 3 m with 15-pin D-sub connector (male); interface electronics in the connector				
Cable length	See interface description, but ≤ 30 m (with HEIDENHAIN cable)				
Voltage supply	3.6 V to 14 V DC				5 V DC ± 0.25 V
Power consumption[2] (max.)	*At 14 V:* 2150 mW; *At 3.6 V:* 2200 mW				–
Current consumption	*At 5 V:* 300 mA (without load, typical)				≤ 390 mA
Laser	*Scanning head and scale mounted:* Class 1 *Scanning head not mounted:* Class 3B *Laser diode used:* Class 3B				
Vibration 55 Hz to 2 000 Hz **Shock** 11 ms	≤ 200 m/s^2 (IEC 60 068-2-6) ≤ 400 m/s^2 (IEC 60 068-2-27)				
Operating temperature	0 °C to +50 °C				
Weight Scanning head Connector Connecting cable	59 g 140 g 22 g/m				

* Please select when ordering
1) Absolute position value after scanning the reference marks in "position value 2"
2) See *General electrical information* in the *Interfaces of HEIDENHAIN Encoders* brochure

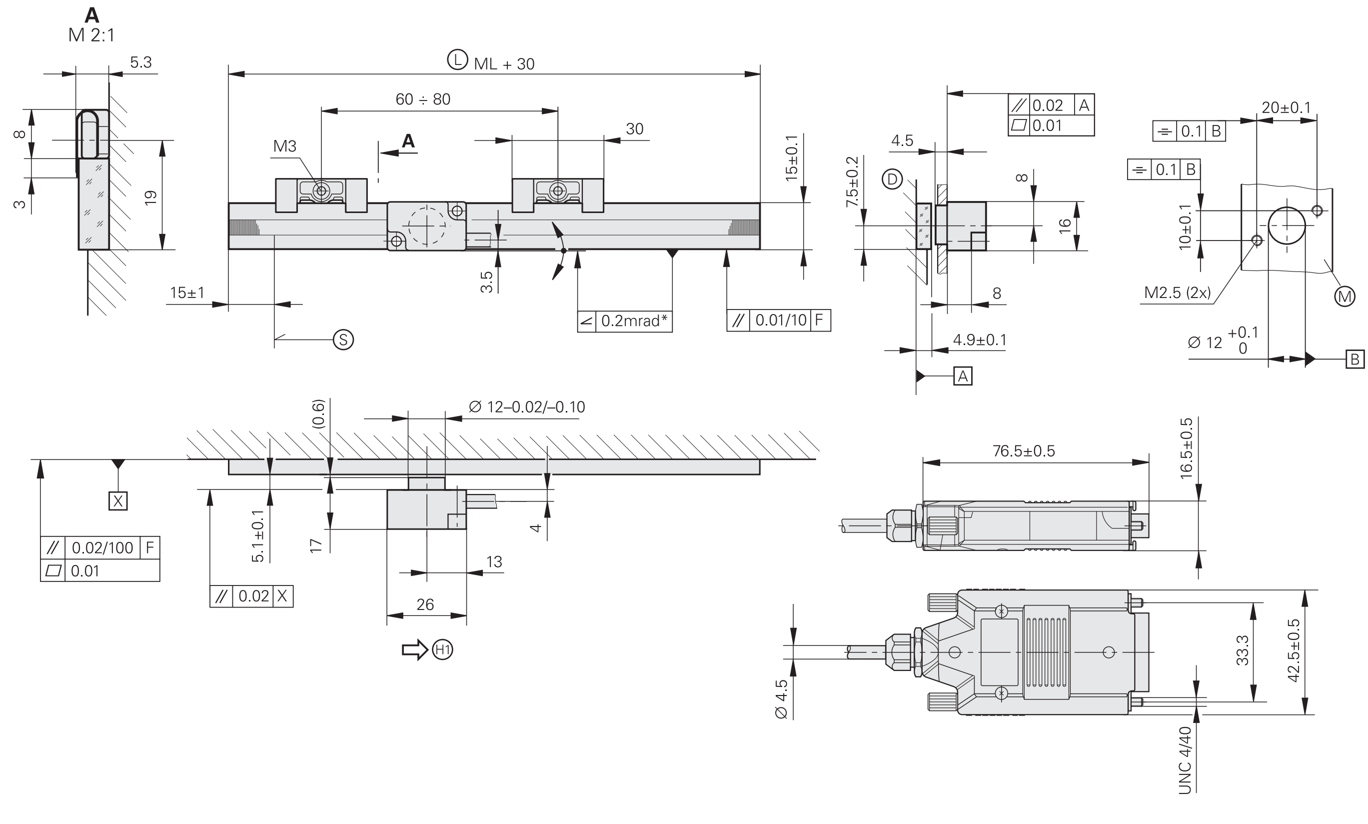
LIP 471, LIP 481

Incremental linear encoders with very high accuracy
- **For limited installation space**
- **For measuring steps of 1 µm to 0.005 µm**
- **Measuring standard is fastened by fixing clamps**

LIP 471 R/LIP 481 R



LIP 471 A/LIP 481 A



mm

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

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

	LIP 481	LIP 471					
Measuring standard* Coefficient of linear expansion	DIADUR phase grating on Zerodur glass ceramic or glass; grating period 4 µm $\alpha_{therm} \approx (0 \pm 0.1) \cdot 10^{-6}\ K^{-1}$ (Zerodur glass ceramic) $\alpha_{therm} \approx 8 \cdot 10^{-6}\ K^{-1}$ (glass)						
Accuracy grade*	± 1 µm (higher accuracy grades available on request) ± 0.5 µm						
Measuring length ML* in mm	70 120 170 220 270 320 370 420						
Reference marks*	*LIP 4x1 R:* One at midpoint of measuring length *LIP 4x1 A:* None						
Interface	∿ 1 V_{PP}	⊓⊔TTL					
Integrated interpolation* Signal period	– 2 µm	5-fold 0.4 µm			10-fold 0.2 µm		
Cutoff frequency –3 dB	≥ 300 kHz	–					
Scanning frequency* Edge separation a	–	≤ 200 kHz ≥ 0.220 µs	≤ 100 kHz ≥ 0.465 µs	≤ 50 kHz ≥ 0.950 µs	≤ 100 kHz ≥ 0.220 µs	≤ 50 kHz ≥ 0.465 µs	≤ 25 kHz ≥ 0.950 µs
Traversing speed	≤ 36 m/min	≤ 24 m/min	≤ 12 m/min	≤ 6 m/min	≤ 12 m/min	≤ 6 m/min	≤ 3 m/min
Electrical connection*	Cable 0.5 m, 1 m, 2 m, or 3 m with 15-pin D-sub connector (male); interface electronics in the connector						
Cable length	See interface description, but ≤ 30 m (with HEIDENHAIN cable)						
Voltage supply	5 V DC ± 0.25 V	5 V DC ± 0.25 V					
Current consumption	< 190 mA	< 200 mA (without load)					
Vibration 55 Hz to 2000 Hz **Shock** 11 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 500 m/s^2 (EN 60068-2-27)						
Operating temperature	0 °C to 40 °C						
Weight Scanning head Linear scale Connecting cable Connector	*LIP 4x1 A:* 25 g, *LIP 4x1 R:* 50 g (each without cable) 5.6 g + 0.2 g/mm measuring length 38 g/m 140 g						

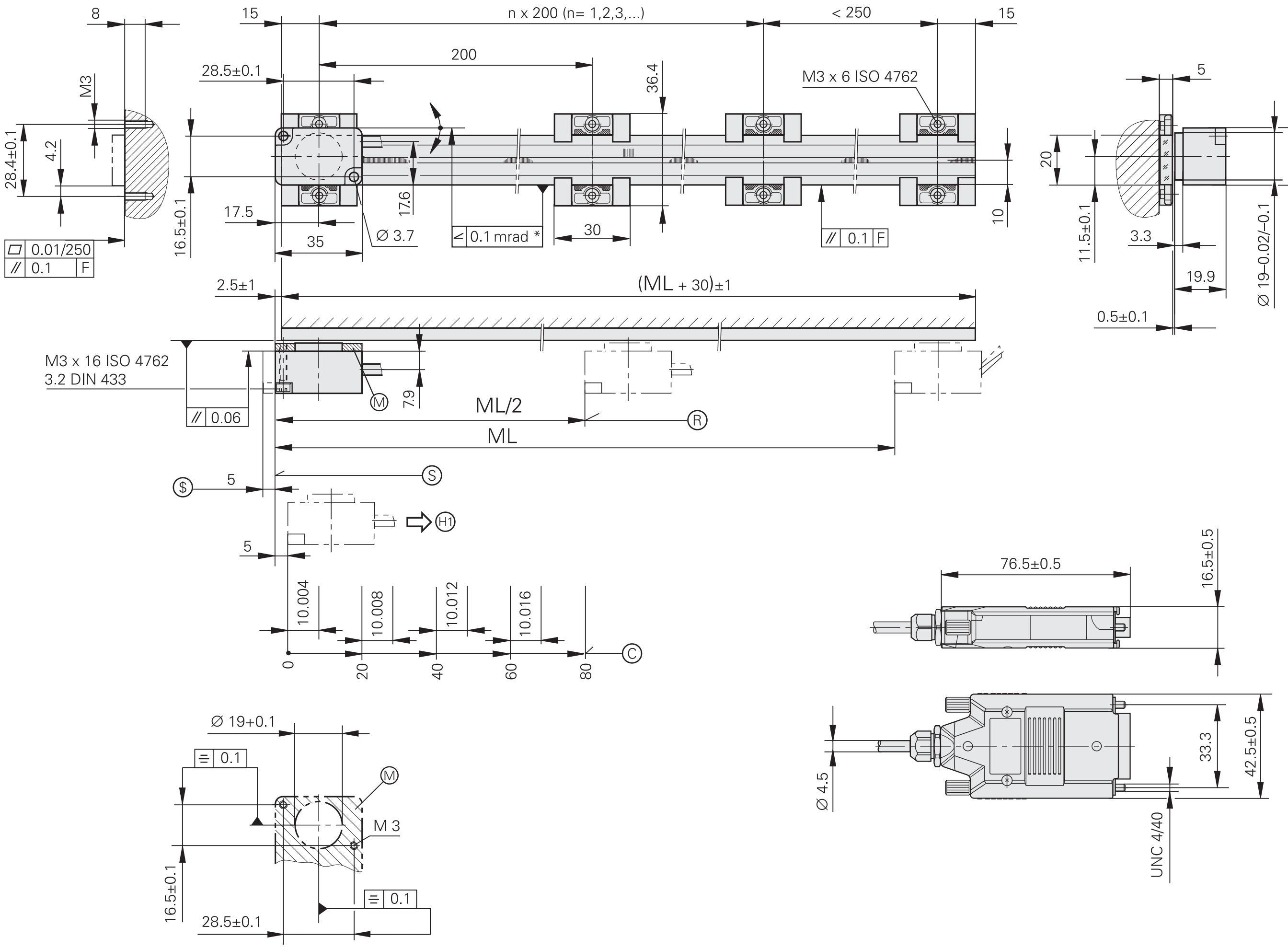
***** Please select when ordering

Versions available for **high vacuum LIP 481 V** and **ultrahigh vacuum LIP 481 U** (see Product Information).

LIP 571, LIP 581

Incremental linear encoders with very high accuracy

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



mm

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

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

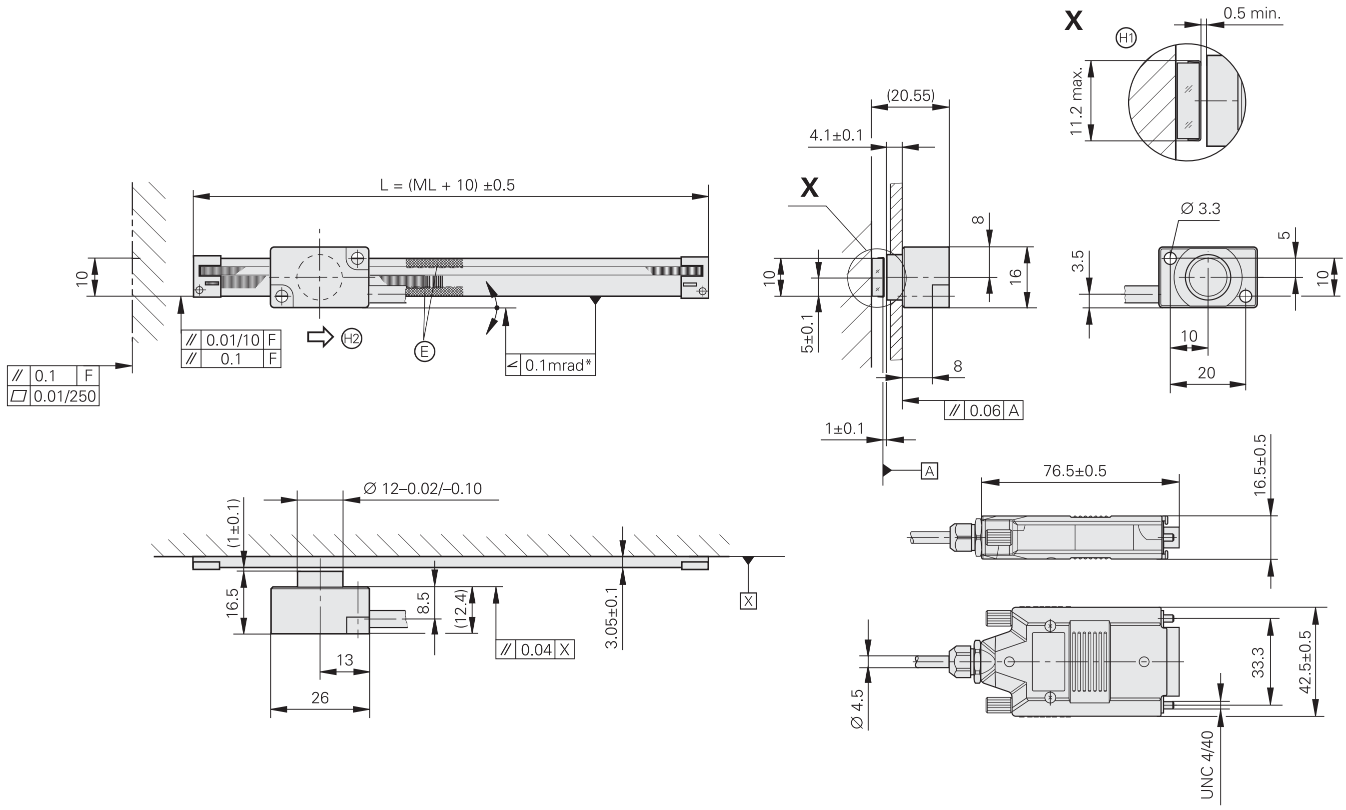
	LIP 581	LIP 571					
Measuring standard Coefficient of linear expansion	DIADUR phase grating on glass; grating period 8 µm $\alpha_{therm} \approx 8 \cdot 10^{-6}\ K^{-1}$						
Accuracy grade	± 1 µm						
Measuring length ML* in mm	70 120 170 220 270 320 370 420 470 520 570 620 670 720 770 820 870 920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

***** Please select when ordering

LIF 471, LIF 481

Incremental linear encoders for simple installation

- **For measuring steps of 1 µm to 0.01 µm**
- **Position detection through homing track and limit switches**
- **Glass scale cemented with adhesive film**
- **Consists of scale and scanning head**



mm

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

* = Max. change during operation
F = Machine guideway
ML = Measuring length
Ⓔ = Epoxy for ML < 170
H1 = Dimensions of limit plate
H2 = Direction of scanning unit motion for output signals in accordance with interface description

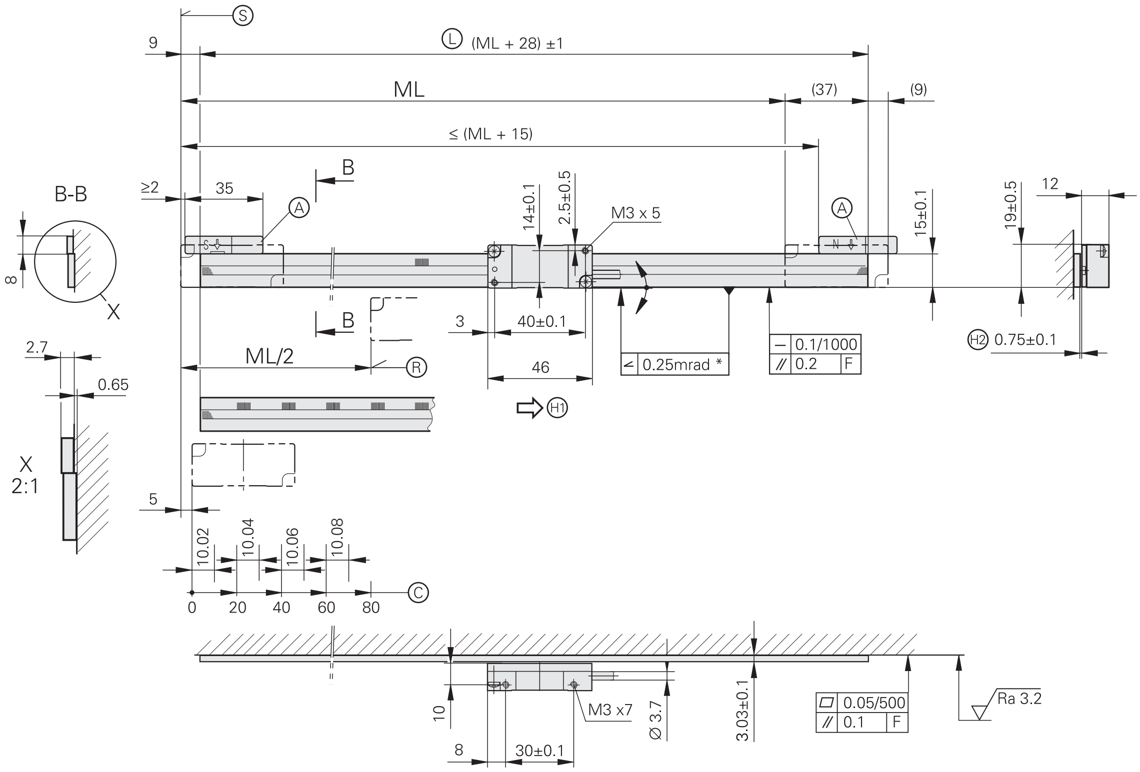
Linear scale	LIF 401 R
Measuring standard* Coefficient of linear expansion	SUPRADUR phase grating on Zerodur glass ceramic or glass; grating period 8 µm $\alpha_{therm} \approx (0\pm0{,}1) \cdot 10^{-6}\,K^{-1}$ (Zerodur glass ceramic) $\alpha_{therm} \approx 8 \cdot 10^{-6}\,K^{-1}$ (glass)
Accuracy grade*	± 1 µm (only for Zerodur glass ceramic), ± 3 µm
Measuring length ML* in mm	70 120 170 220 270 320 370 420 470 520 570 620 670 720 770 820 870 920 970 1 020
Reference marks	One at midpoint of measuring length
Weight	0.8 g + 0.08 g/mm measuring length

Scanning head	AK LIF 48	AK LIF 47				
Interface	∼ 1 V_{PP}	⊓⊔TTL				
Integrated interpolation* Signal period	– 4 µm	5-fold 0.8 µm	10-fold 0.4 µm	20-fold 0.2 µm	50-fold 0.08 µm	100-fold 0.04 µm
Cutoff frequency –3 dB –6 dB	≥ 300 kHz ≥ 420 kHz	–				
Scanning frequency*	–	≤ 500 kHz ≤ 250 kHz ≤ 125 kHz	≤ 250 kHz ≤ 125 kHz ≤ 62.5 kHz	≤ 250 kHz ≤ 125 kHz ≤ 62.5 kHz	≤ 100 kHz ≤ 50 kHz ≤ 25 kHz	≤ 50 kHz ≤ 25 kHz ≤ 12.5 kHz
Edge separation a[1)]	–	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs	≥ 0.040 µs ≥ 0.080 µs ≥ 0.175 µs	≥ 0.040 µs ≥ 0.080 µs ≥ 0.175 µs	≥ 0.040 µs ≥ 0.080 µs ≥ 0.175 µs
Traversing speed[1)]	≤ 72 m/min ≤ 100 m/min	≤ 120 m/min ≤ 60 m/min ≤ 30 m/min	≤ 60 m/min ≤ 30 m/min ≤ 15 m/min	≤ 60 m/min ≤ 30 m/min ≤ 15 m/min	≤ 24 m/min ≤ 12 m/min ≤ 6 m/min	≤ 12 m/min ≤ 6 m/min ≤ 3 m/min
Position detection	Homing signal and limit signal; TTL output signals (without line driver)					
Electrical connection*	Cable 0.5 m, 1 m, 2 m, or 3 m with 15-pin D-sub connector (male); interface electronics in the connector					
Cable length	See interface description, but *incremental:* ≤ 30 m; *homing, limit:* ≤ 10 m; (with HEIDENHAIN cable)					
Voltage supply	5 V DC ± 0.25 V	5 V DC ± 0.25 V				
Current consumption	< 175 mA	< 180 mA (without load)				
Vibration 55 Hz to 2 000 Hz **Shock** 11 ms	≤ 200 m/s^2 (EN 60 068-2-6) ≤ 500 m/s^2 (EN 60 068-2-27)					
Operating temperature	0 °C to 50 °C					
Weight Scanning head* Connecting cable Connector	*For scale of Zerodur glass ceramic:* 25 g *For scale of glass:* 9 g (each without cable) 38 g/m 140 g					

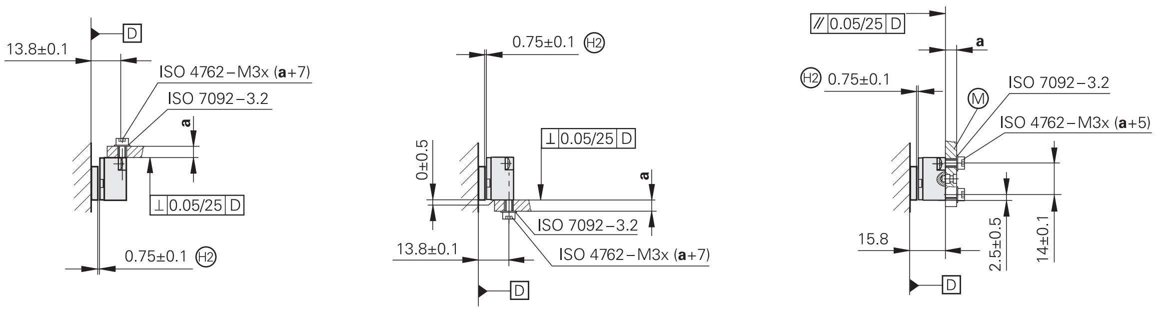
* Please select when ordering
1) At the corresponding cutoff or scanning frequency
Versions available for **high vacuum LIP 481 V** (see Product Information).

LIDA 473, LIDA 483

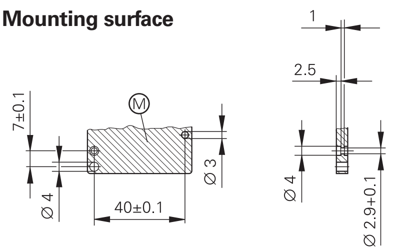
Incremental linear encoders with limit switches
- **For measuring steps of 1 µm to 0.01 µm**
- **Measuring standard of glass or glass ceramic**
- **Glass scale cemented with adhesive film**
- **Consists of scale and scanning head**



Possibilities for mounting the scanning head



Mounting surface



mm

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

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

Linear scale	LIDA 403
Measuring standard Coefficient of linear expansion*	METALLUR scale grating on glass ceramic or glass; grating period 20 µm $\alpha_{therm} \approx 8 \cdot 10^{-6}\ K^{-1}$ (glass) $\alpha_{therm} = (0 \pm 0.1) \cdot 10^{-6}\ K^{-1}$ (Zerodur glass ceramic)
Accuracy grade*	± 1 µm (only for Zerodur glass ceramic up to ML 1640), ± 3 µm, ± 5 µm
Measuring length ML* in mm	240 340 440 640 840 1040 1240 1440 1640 1840 2040 2240 2440 2640 2840 3040
Reference marks*	*LIDA 4x3:* One at midpoint of measuring length *LIDA 4x3C:* Distance-coded
Weight	3 g + 0.1 g/mm measuring length

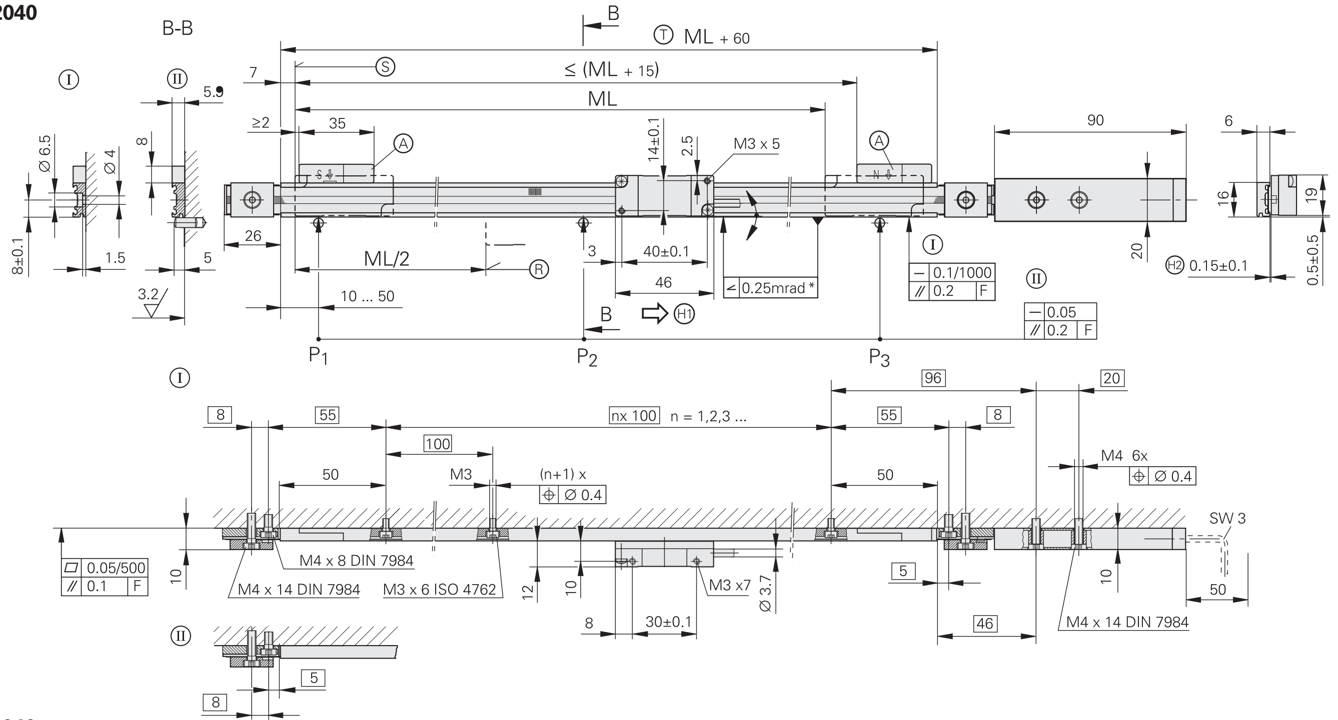
Scanning head	AK LIDA 48	AK LIDA 47			
Interface	∿ 1 V_{PP}	⊓⊔TTL			
Integrated interpolation* Signal period	– 20 µm	5-fold 4 µm	10-fold 2 µm	50-fold 0.4 µm	100-fold 0.2 µm
Cutoff frequency –3 dB	≥ 400 kHz	–			
Scanning frequency*	–	≤ 400 kHz ≤ 200 kHz ≤ 100 kHz ≤ 50 kHz	≤ 200 kHz ≤ 100 kHz ≤ 50 kHz ≤ 25 kHz	≤ 50 kHz ≤ 25 kHz ≤ 12.5 kHz	≤ 25 kHz ≤ 12.5 kHz ≤ 6.25 kHz
Edge separation a[1)]	–	≥ 0.100 µs ≥ 0.220 µs ≥ 0.465 µs ≥ 0.950 µs	≥ 0.100 µs ≥ 0.220 µs ≥ 0.465 µs ≥ 0.950 µs	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs
Traversing speed[1)]	≤ 480 m/min	≤ 480 m/min ≤ 240 m/min ≤ 120 m/min ≤ 60 m/min	≤ 240 m/min ≤ 120 m/min ≤ 60 m/min ≤ 30 m/min	≤ 60 m/min ≤ 30 m/min ≤ 15 m/min	≤ 30 m/min ≤ 15 m/min ≤ 7.5 m/min
Limit switches	L1/L2 with two different magnets; *output signals:* TTL (without line driver)				
Electrical connection	Cable, 3 m with 15-pin D-sub connector (male); interface electronics in connector for AK LIDA 47				
Cable length	See interface description, but *limit:* ≤ 20 m (with HEIDENHAIN cable)				
Voltage supply	5 V DC ± 0.25 V	5 V DC ± 0.25 V		5 V DC ± 0.25 V	
Current consumption	< 100 mA	< 170 mA (without load)		< 255 mA (without load)	
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 500 m/s² (EN 60068-2-6) ≤ 1000 m/s² (EN 60068-2-27)				
Operating temperature	–10 °C to 70 °C				
Weight Scanning head Connecting cable Connector	20 g (without connecting cable) 22 g/m *LIDA 483:* 32 g, *LIDA 473:* 140 g				

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

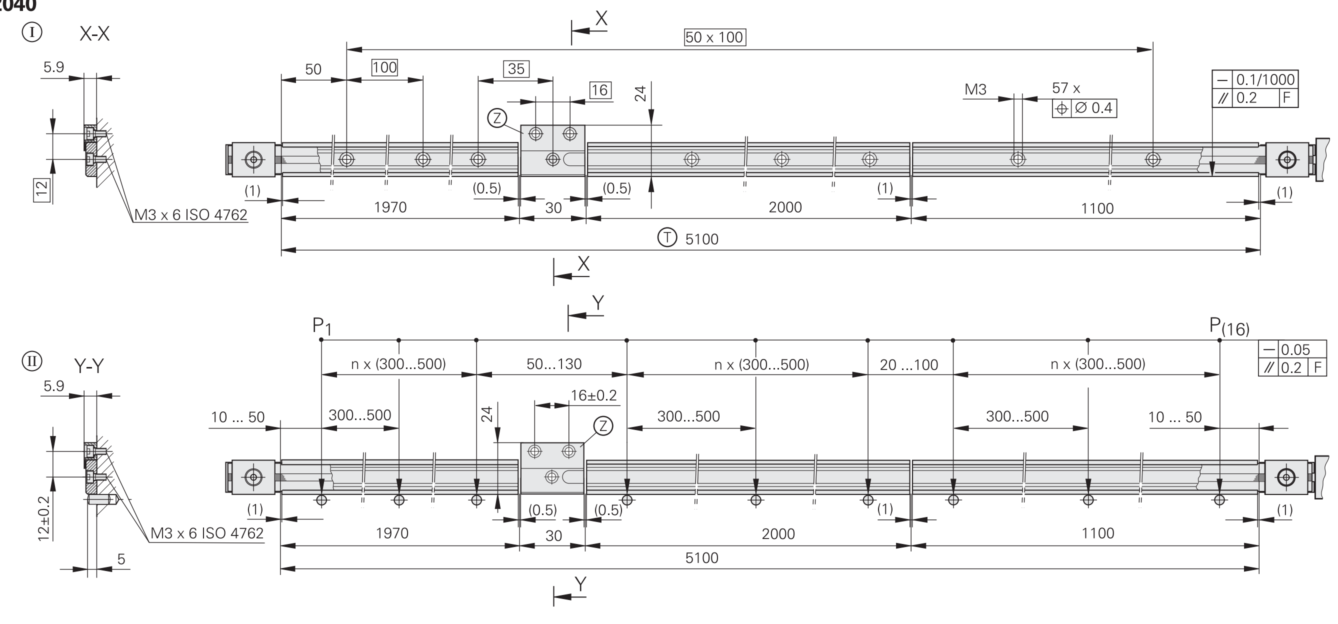
LIDA 475, LIDA 485

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

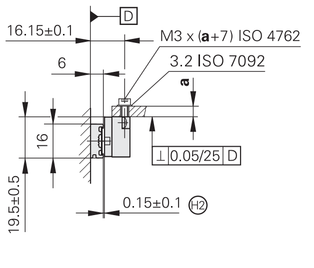
ML ≤ 2040

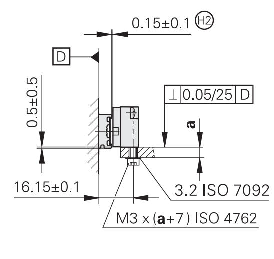


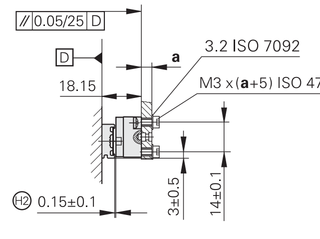
ML > 2040



Possibilities for mounting the scanning head







mm

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

Ⓘ = Scale carrier sections fixed with screws
Ⓘⓘ = Scale carrier sections fixed with PRECIMET
* = Max. change during operation
F = Machine guideway
P = Gauging points for alignment
Ⓡ = Reference mark position
Ⓢ = Beginning of measuring length (ML)

Ⓐ = Selector magnet for limit switch
Ⓣ = Carrier length
Ⓩ = Spacer for measuring lengths from 3040 mm
H1 = Direction of scanning unit motion for output signals in accordance with interface description
H2 = Adjust or set

Linear scale	**LIDA 405**
Measuring standard Coefficient of linear expansion	Steel scale tape with METALLUR scale grating; grating period 20 µm Depends on the mounting surface
Accuracy grade	± 5 µm
Measuring length ML* in mm	140 240 340 440 540 640 740 840 940 1 040 1 140 1 240 1 340 1 440 1 540 1 640 1 740 1 840 1 940 2 040
	Larger measuring lengths up to 30 040 mm with a single-section scale tape and individual scale-carrier sections
Reference marks	One at midpoint of measuring length
Weight	115 g + 0.25 g/mm measuring length

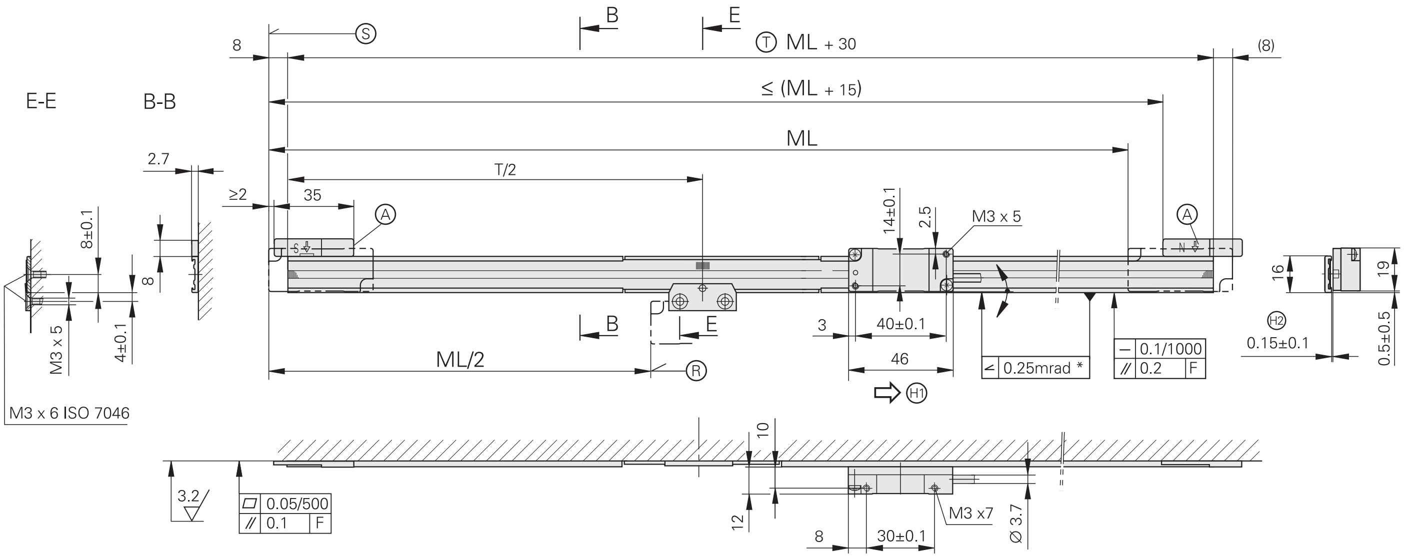
Scanning head	**AK LIDA 48**	**AK LIDA 47**			
Interface	∿ 1 V_{PP}	⊓⊔TTL			
Integrated interpolation* Signal period	– 20 µm	5-fold 4 µm	10-fold 2 µm	50-fold 0.4 µm	100-fold 0.2 µm
Cutoff frequency –3 dB	≥ 400 kHz	–			
Scanning frequency*	–	≤ 400 kHz ≤ 200 kHz ≤ 100 kHz ≤ 50 kHz	≤ 200 kHz ≤ 100 kHz ≤ 50 kHz ≤ 25 kHz	≤ 50 kHz ≤ 25 kHz ≤ 12.5 kHz	≤ 25 kHz ≤ 12.5 kHz ≤ 6.25 kHz
Edge separation a[1)]	–	≥ 0.100 µs ≥ 0.220 µs ≥ 0.465 µs ≥ 0.950 µs	≥ 0.100 µs ≥ 0.220 µs ≥ 0.465 µs ≥ 0.950 µs	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs
Traversing speed[1)]	≤ 480 m/min	≤ 480 m/min ≤ 240 m/min ≤ 120 m/min ≤ 60 m/min	≤ 240 m/min ≤ 120 m/min ≤ 60 m/min ≤ 30 m/min	≤ 60 m/min ≤ 30 m/min ≤ 15 m/min	≤ 30 m/min ≤ 15 m/min ≤ 7.5 m/min
Limit switches	L1/L2 with two different magnets; *output signals:* TTL (without line driver)				
Electrical connection	Cable, 3 m with 15-pin D-sub connector (male); interface electronics in connector for AK LIDA 47				
Cable length	See interface description, but *limit:* ≤ 20 m (with HEIDENHAIN cable)				
Voltage supply	5 V DC ± 0.25 V	5 V DC ± 0.25 V		5 V DC ± 0.25 V	
Current consumption	< 100 mA	< 170 mA (without load)		< 255 mA (without load)	
Vibration 55 Hz to 2 000 Hz **Shock** 6 ms	≤ 500 m/s^2 (EN 60 068-2-6) ≤ 1 000 m/s^2 (EN 60 068-2-27)				
Operating temperature	–10 °C to 70 °C				
Weight Scanning head Connecting cable Connector	20 g (without connecting cable) 22 g/m *LIDA 485:* 32 g, *LIDA 475:* 140 g				

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

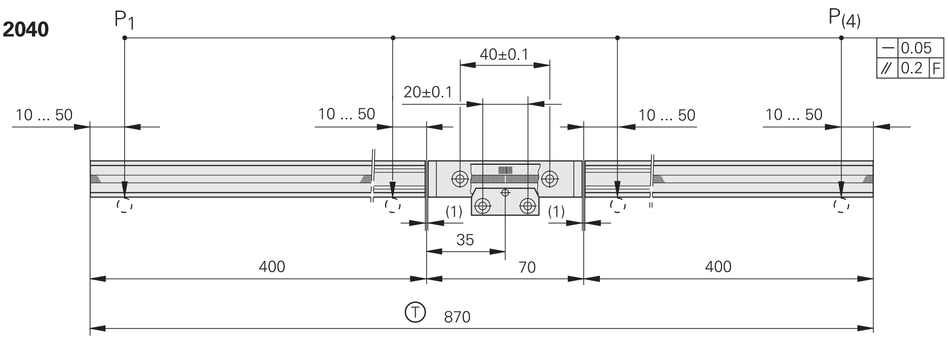
LIDA 477, LIDA 487

Incremental linear encoders for measuring ranges up to 6 m

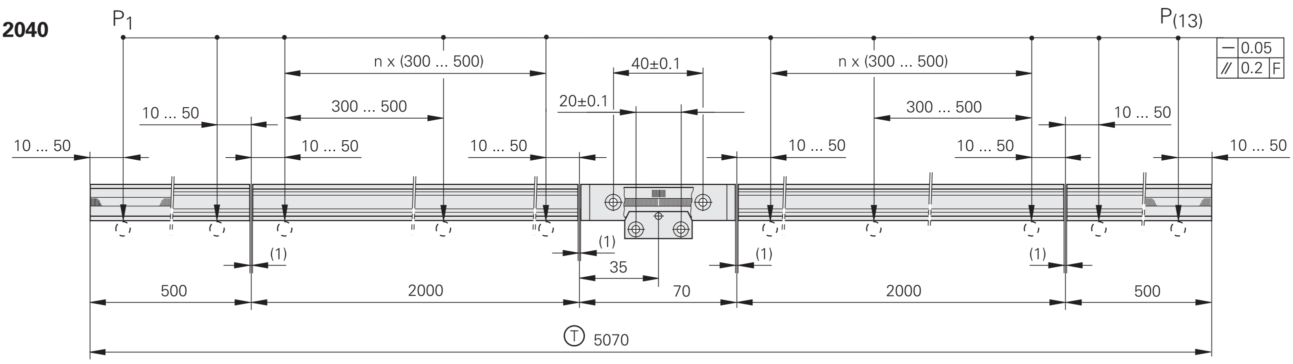
- **For measuring steps of 1 µm to 0.05 µm**
- **Limit switches**
- **Steel scale-tape is drawn into adhesive aluminum extrusions and fixed at center**
- **Consists of scale and scanning head**



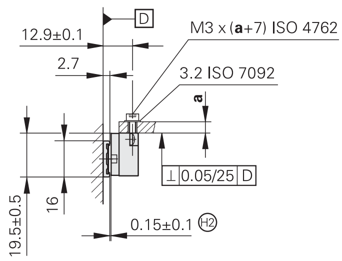
ML ≤ 2040

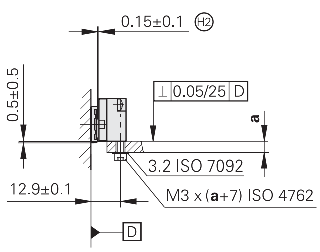


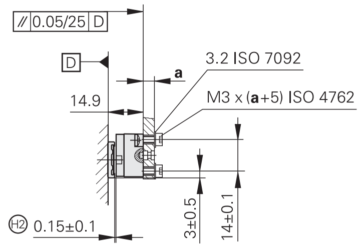
ML > 2040



Possibilities for mounting the scanning head







mm

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

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

H1 = Direction of scanning unit motion for output signals in accordance with interface description
H2 = Adjust or set

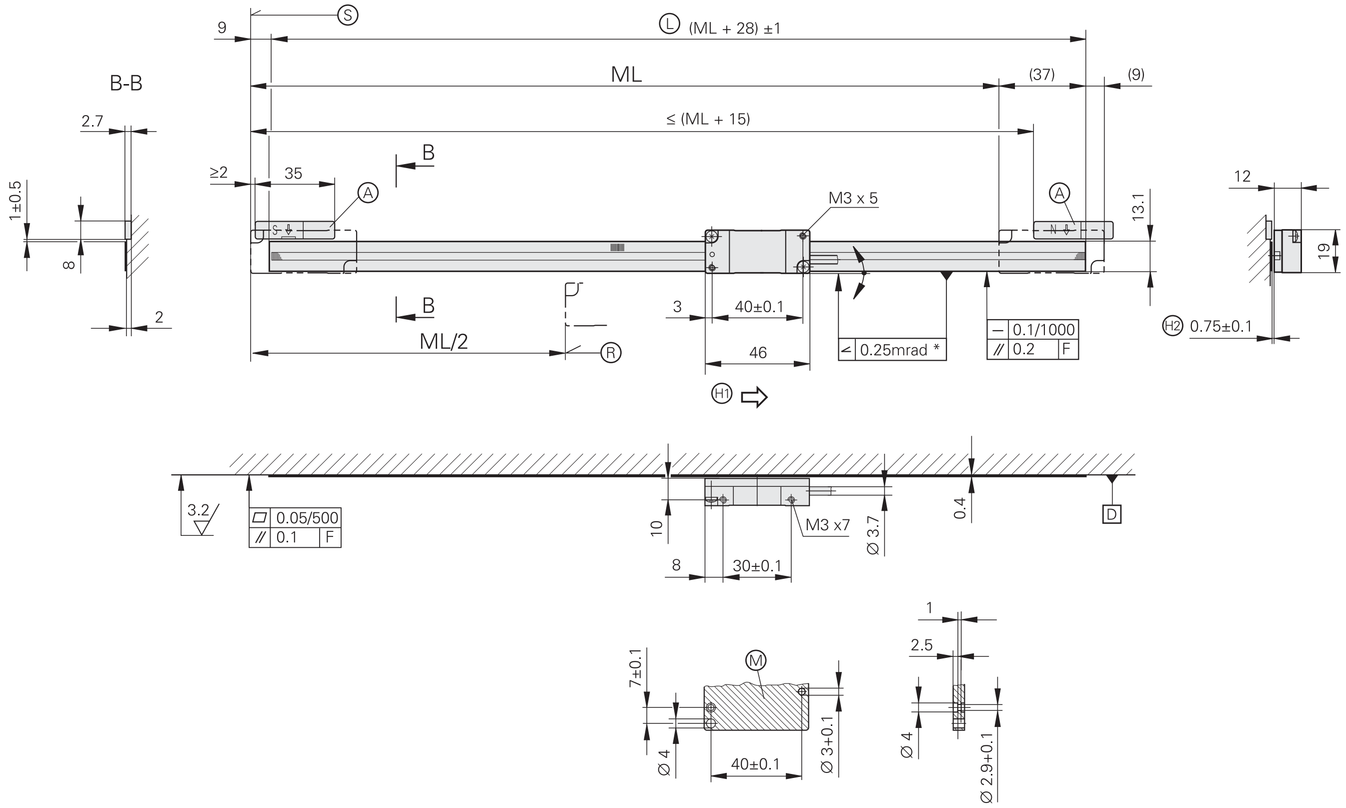
Linear scale	LIDA 407
Measuring standard Coefficient of linear expansion	Steel scale tape with METALLUR scale grating; grating period 20 µm $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$
Accuracy grade*	± 3 µm (up to ML 1 040) ± 5 µm (as of ML 1 240) ± 15 µm[1)]
Measuring length ML* in mm	240 440 640 840 1 040 1 240 1 440 1 640 1 840 2 040 2 240 2 440 2 640 2 840 3 040 3 240 3 440 3 640 3 840 4 040 4 240 4 440 4 640 4 840 5 040 5 240 5 440 5 640 5 840 6 040
Reference marks	One at midpoint of measuring length
Weight	25 g + 0.1 g/mm measuring length

Scanning head	AK LIDA 48	AK LIDA 47			
Interface	∿ 1 V_{PP}	⊓⊔TTL			
Integrated interpolation* Signal period	– 20 µm	5-fold 4 µm	10-fold 2 µm	50-fold 0.4 µm	100-fold 0.2 µm
Cutoff frequency –3 dB	≥ 400 kHz	–			
Scanning frequency*	–	≤ 400 kHz ≤ 200 kHz ≤ 100 kHz ≤ 50 kHz	≤ 200 kHz ≤ 100 kHz ≤ 50 kHz ≤ 25 kHz	≤ 50 kHz ≤ 25 kHz ≤ 12.5 kHz	≤ 25 kHz ≤ 12.5 kHz ≤ 6.25 kHz
Edge separation a[2)]	–	≥ 0.100 µs ≥ 0.220 µs ≥ 0.465 µs ≥ 0.950 µs	≥ 0.100 µs ≥ 0.220 µs ≥ 0.465 µs ≥ 0.950 µs	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs
Traversing speed[2)]	≤ 480 m/min	≤ 480 m/min ≤ 240 m/min ≤ 120 m/min ≤ 60 m/min	≤ 240 m/min ≤ 120 m/min ≤ 60 m/min ≤ 30 m/min	≤ 60 m/min ≤ 30 m/min ≤ 15 m/min	≤ 30 m/min ≤ 15 m/min ≤ 7.5 m/min
Limit switches	L1/L2 with two different magnets; *output signals:* TTL (without line driver)				
Electrical connection	Cable, 3 m with 15-pin D-sub connector (male); interface electronics in connector for AK LIDA 47				
Cable length	See interface description, but *limit:* ≤ 20 m (with HEIDENHAIN cable)				
Voltage supply	5 V DC ± 0.25 V	5 V DC ± 0.25 V		5 V DC ± 0.25 V	
Current consumption	< 100 mA	< 170 mA (without load)		< 255 mA (without load)	
Vibration 55 Hz to 2 000 Hz **Shock** 6 ms	≤ 500 m/s^2 (EN 60 068-2-6) ≤ 1 000 m/s^2 (EN 60 068-2-27)				
Operating temperature	–10 °C to 70 °C				
Weight Scanning head Connecting cable Connector	20 g (without connecting cable) 22 g/m *LIDA 487:* 32 g, *LIDA 477:* 140 g				

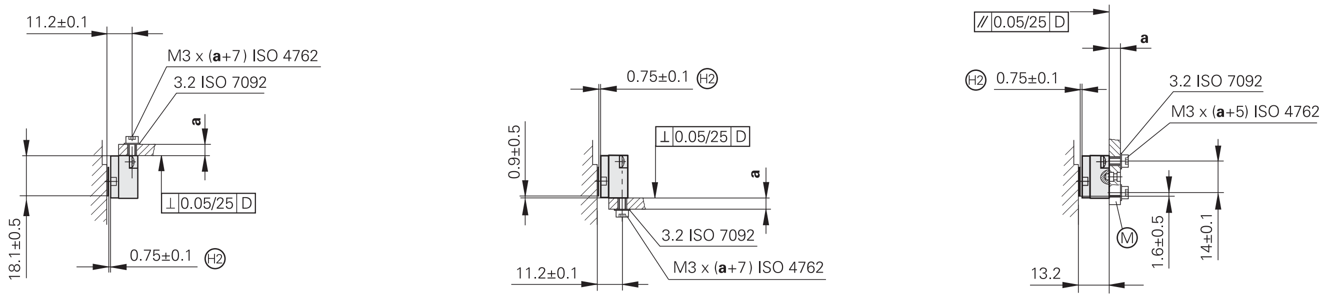
* Please select when ordering
1) ± 5 µm after linear length-error compensation in the subsequent electronics
2) At the corresponding cutoff or scanning frequency

LIDA 479, LIDA 489

Incremental linear encoders for measuring ranges up to 6 m
- **For measuring steps of 1 µm to 0.05 µm**
- **Limit switches**
- **Steel scale tape cemented on mounting surface**
- **Consists of scale and scanning head**



Possibilities for mounting the scanning head



mm

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

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

Linear scale	LIDA 409	
Measuring standard Coefficient of linear expansion	Steel scale tape with METALLUR scale grating; grating period 20 µm $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$	
Accuracy grade*	± 3 µm, ± 15 µm[1]	
Measuring length ML* in mm	70 120 170 220 270 320 370 420 520 620 720 820 920 1 020	Scale tape cut from roll: 2 m, 4 m, 6 m
Reference marks	One at midpoint of measuring length	Every 50 mm
Weight	31 g/m	

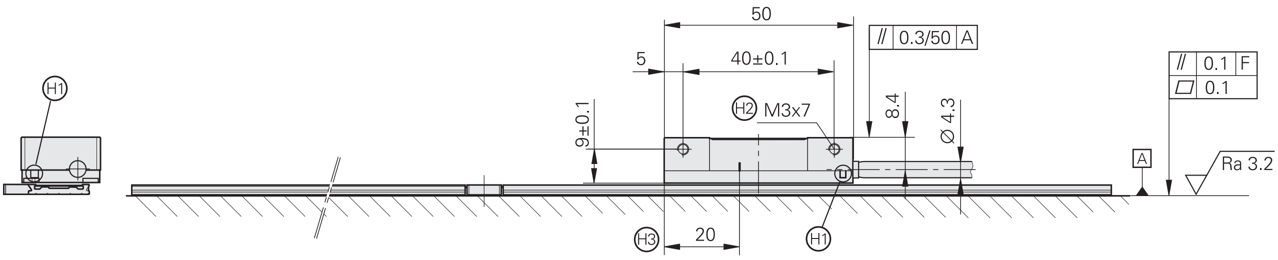
Scanning head	AK LIDA 48	AK LIDA 47			
Interface	∿ 1 V_{PP}	⊓⊔TTL			
Integrated interpolation* Signal period	– 20 µm	5-fold 4 µm	10-fold 2 µm	50-fold 0.4 µm	100-fold 0.2 µm
Cutoff frequency –3 dB	≥ 400 kHz	–			
Scanning frequency*	–	≤ 400 kHz ≤ 200 kHz ≤ 100 kHz ≤ 50 kHz	≤ 200 kHz ≤ 100 kHz ≤ 50 kHz ≤ 25 kHz	≤ 50 kHz ≤ 25 kHz ≤ 12.5 kHz	≤ 25 kHz ≤ 12.5 kHz ≤ 6.25 kHz
Edge separation a[2]	–	≥ 0.100 µs ≥ 0.220 µs ≥ 0.465 µs ≥ 0.950 µs	≥ 0.100 µs ≥ 0.220 µs ≥ 0.465 µs ≥ 0.950 µs	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs
Traversing speed[2]	≤ 480 m/min	≤ 480 m/min ≤ 240 m/min ≤ 120 m/min ≤ 60 m/min	≤ 240 m/min ≤ 120 m/min ≤ 60 m/min ≤ 30 m/min	≤ 60 m/min ≤ 30 m/min ≤ 15 m/min	≤ 30 m/min ≤ 15 m/min ≤ 7.5 m/min
Limit switches	L1/L2 with two different magnets; *output signals:* TTL (without line driver)				
Electrical connection	Cable, 3 m with 15-pin D-sub connector (male); interface electronics in connector for AK LIDA 47				
Cable length	See interface description, but *limit:* ≤ 20 m (with HEIDENHAIN cable)				
Voltage supply	5 V DC ± 0.25 V	5 V DC ± 0.25 V		5 V DC ± 0.25 V	
Current consumption	< 100 mA	< 170 mA (without load)		< 255 mA (without load)	
Vibration 55 Hz to 2 000 Hz **Shock** 6 ms	≤ 500 m/s^2 (EN 60 068-2-6) ≤ 1 000 m/s^2 (EN 60 068-2-27)				
Operating temperature	–10 °C to 70 °C				
Weight Scanning head Connecting cable Connector	20 g (without connecting cable) 22 g/m *LIDA 489:* 32 g, *LIDA 479:* 140 g				

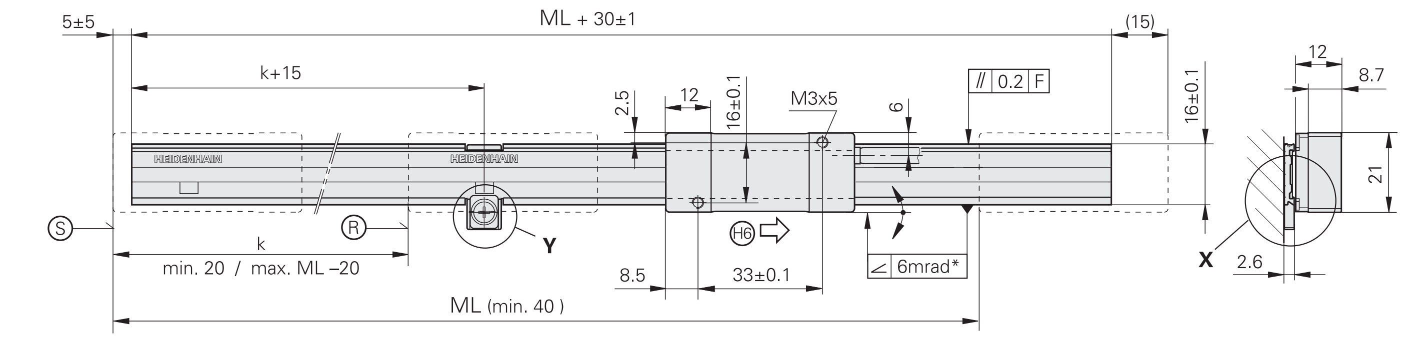
* Please select when ordering
[1] ± 5 µm after linear length-error compensation in the subsequent electronics
[2] At the corresponding cutoff or scanning frequency

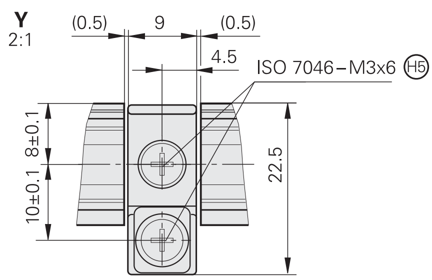
LIDA 277, LIDA 287

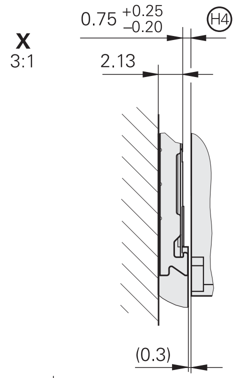
Incremental linear encoder with large mounting tolerance

- **For measuring steps to 0.5 µm**
- **Scale tape cut from roll**
- **Steel scale-tape is drawn into adhesive aluminum extrusions and fixed**
- **Integrated status display with three-color LED**
- **Consists of scale and scanning head**

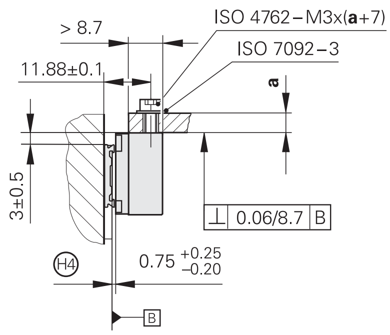


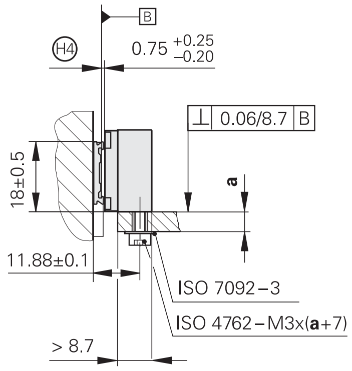


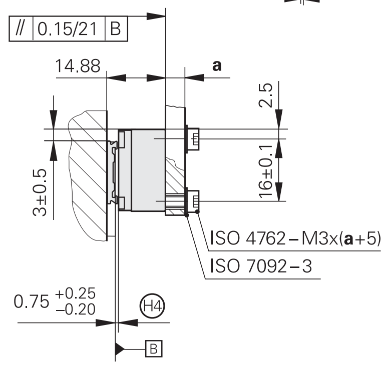




Possibilities for mounting the scanning head







mm

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

* = Max. change during operation
F = Machine guideway
Ⓡ = Reference mark
Ⓛ = Scale tape length
Ⓢ = Beginning of measuring length (ML)
(H1) = LED (integrated checking of the mounting)
(H2) = Thread at both ends
(H3) = Position of reference mark relative to scanning head
(H4) = Mounting clearance between scale and scanning head
(H5) = Mating threaded hole, M3, 5 mm deep
(H6) = Direction of scanning unit motion for output signals in accordance with interface description

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

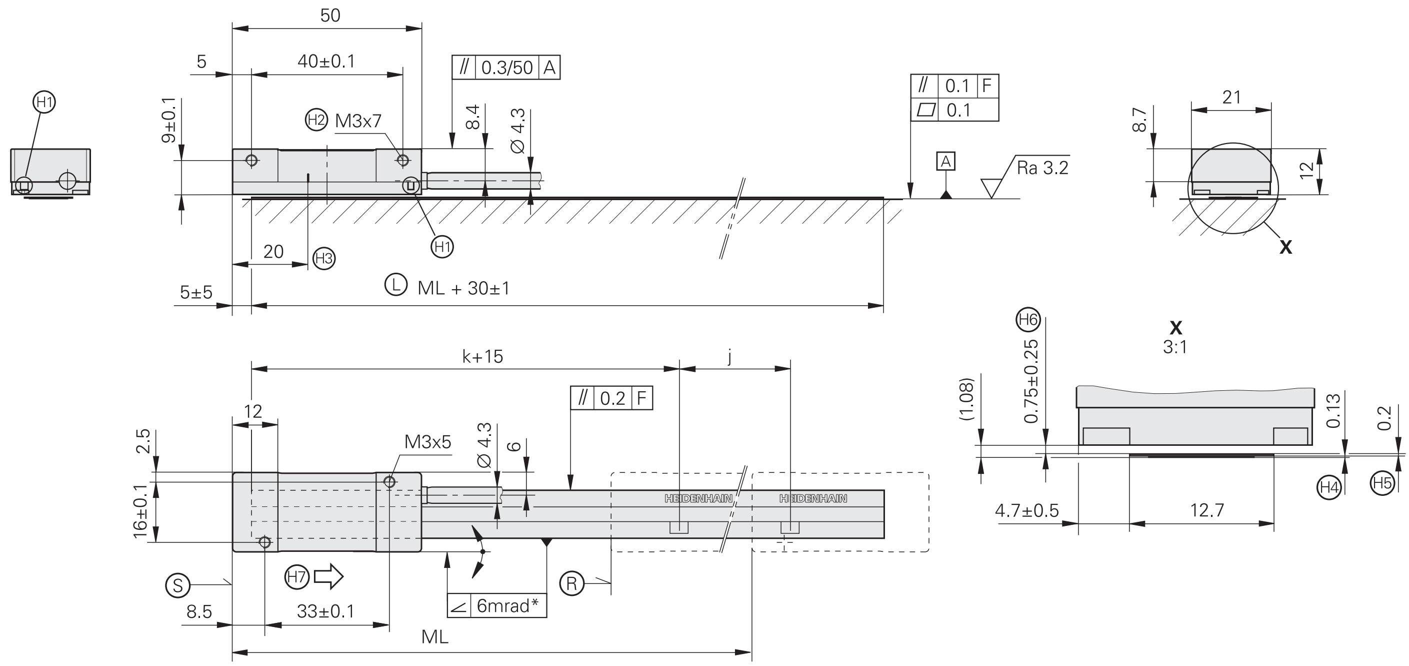
Linear scale	LIDA 207
Measuring standard Coefficient of linear expansion	Steel scale tape; grating period 200 µm $\alpha_{therm} \approx 10 \cdot 10^{-6}$ K^{-1}
Accuracy grade	± 15 µm
Scale tape cut from roll*	3 m, 5 m, 10 m
Reference marks	Selectable every 100 mm
Weight Scale tape Scale-tape carrier	20 g/m 70 g/m

Scanning head	AK LIDA 28	AK LIDA 27		
Interface	∿ 1 V_{PP}	⊓⊔TTL		
Integrated interpolation* Signal period	– 200 µm	10-fold 20 µm	50-fold 4 µm	100-fold 2 µm
Cut-off frequency Scanning frequency Edge separation a	≥ 50 kHz – –	– ≥ 50 kHz ≥ 0.465 µs	– ≤ 25 kHz ≥ 0.175 µs	– ≤ 12.5 kHz ≥ 0.175 µs
Traversing speed	≤ 600 m/min		≤ 300 m/min	≤ 150 m/min
Electrical connection*	Cable, 1 m or 3 m with 15-pin D-sub connector (male)			
Cable length	See interface description, but ≤ 30 m (with HEIDENHAIN cable)			
Voltage supply	5 V DC ± 0.25 V	5 V DC ± 0.25 V		
Current consumption	< 155 mA	< 165 mA (without load)		
Vibration 55 Hz to 2 000 Hz **Shock** 11 ms	≤ 200 m/s^2 (EN 60 068-2-6) ≤ 500 m/s^2 (EN 60 068-2-27)			
Operating temperature	–10 °C to 70 °C			
Weight Scanning head Connecting cable Connector	20 g (without connecting cable) 30 g/m 32 g			

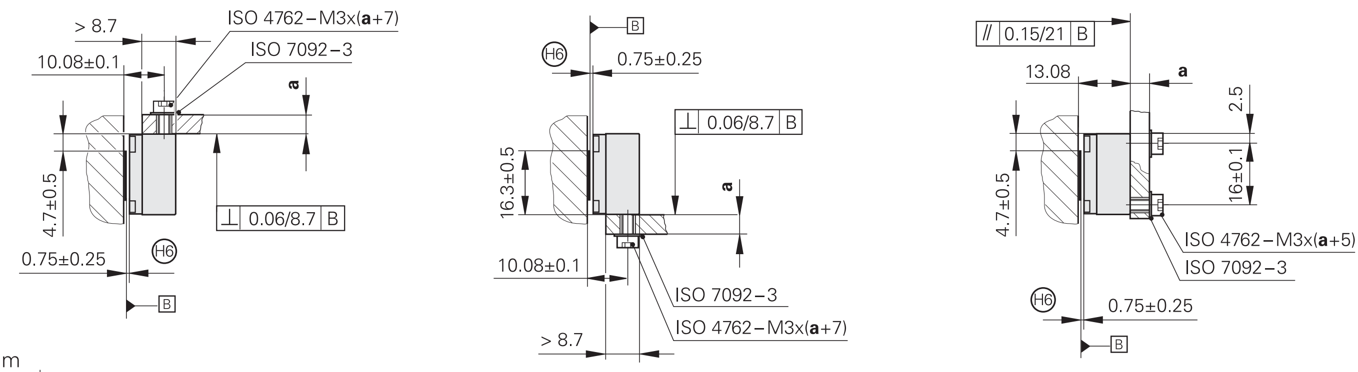
***** Please select when ordering

LIDA 279, LIDA 289

Incremental linear encoder with large mounting tolerance
- **For measuring steps to 0.5 µm**
- **Scale tape cut from roll**
- **Steel scale tape cemented on mounting surface**
- **Integrated status display with three-color LED**
- **Consists of scale and scanning head**



Possibilities for mounting the scanning head



mm

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

* = Max. change during operation
F = Machine guideway
Ⓡ = Reference mark
Ⓛ = Scale tape length
Ⓢ = Beginning of measuring length (ML)
H1 = LED (integrated checking of the mounting)
H2 = Thread at both ends
H3 = Position of reference mark relative to scanning head
H4 = Adhesive tape
H5 = Steel scale tape
H6 = Mounting clearance between scale and scanning head
H7 = Direction of scanning unit motion for output signals in accordance with interface description

Reference mark:
k = Any position of the selected reference mark starting from the beginning of the measuring length (depends on the length of cut)
j = Additional reference marks spaced every n x 100 mm

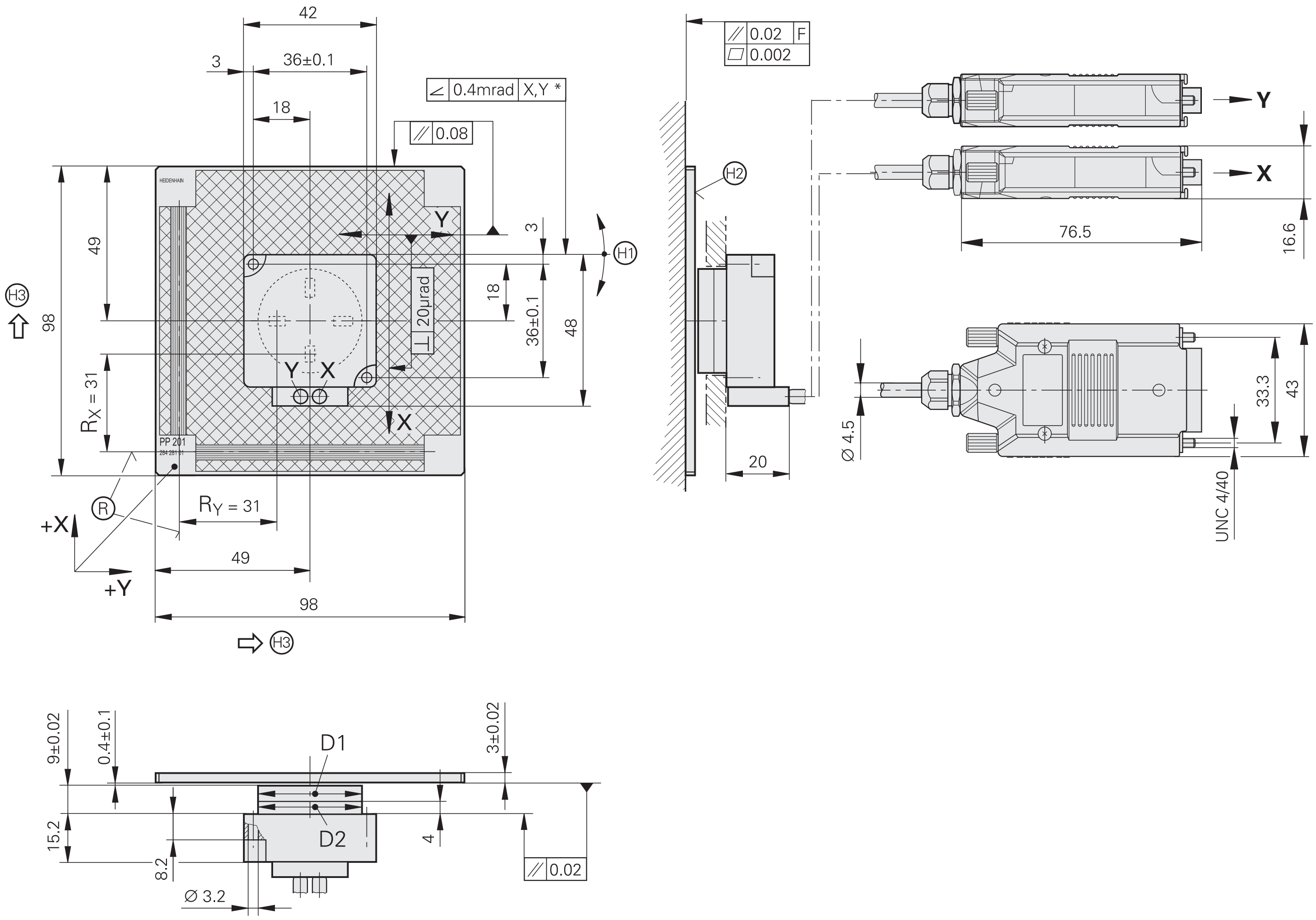
Linear scale	**LIDA 209**
Measuring standard Coefficient of linear expansion	Steel scale tape; grating period 200 µm $\alpha_{therm} \approx 10 \cdot 10^{-6}\ K^{-1}$
Accuracy grade	± 15 µm
Scale tape cut from roll*	3 m, 5 m, 10 m
Reference marks	Selectable every 100 mm
Weight	20 g/m

Scanning head	**AK LIDA 28**	**AK LIDA 27**		
Interface	∼ 1 V_{PP}	⊓⊔TTL		
Integrated interpolation* Signal period	– 200 µm	10-fold 20 µm	50-fold 4 µm	100-fold 2 µm
Cut-off frequency Scanning frequency Edge separation a	≥ 50 kHz – –	– ≥ 50 kHz ≥ 0.465 µs	– ≤ 25 kHz ≥ 0.175 µs	– ≤ 12.5 kHz ≥ 0.175 µs
Traversing speed	≤ 600 m/min		≤ 300 m/min	≤ 150 m/min
Electrical connection*	Cable, 1 m or 3 m with 15-pin D-sub connector (male)			
Cable length	See interface description, but ≤ 30 m (with HEIDENHAIN cable)			
Voltage supply	5 V DC ± 0.25 V	5 V DC ± 0.25 V		
Current consumption	< 155 mA	< 165 mA (without load)		
Vibration 55 Hz to 2 000 Hz **Shock** 11 ms	≤ 200 m/s^2 (EN 60 068-2-6) ≤ 500 m/s^2 (EN 60 068-2-27)			
Operating temperature	–10 °C to 70 °C			
Weight Scanning head Connecting cable Connector	20 g (without connecting cable) 30 g/m 32 g			

* Please select when ordering

PP 281 R

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

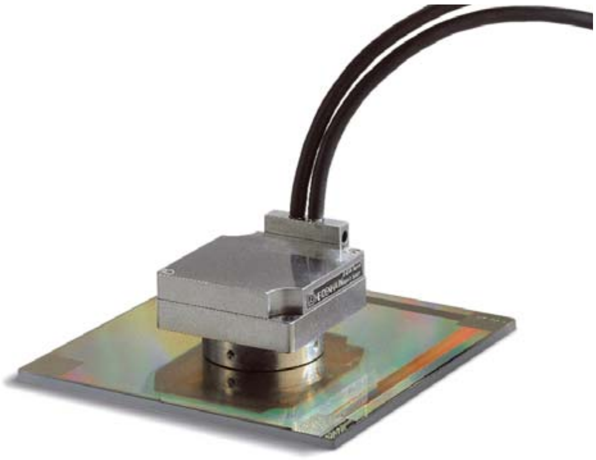


mm

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

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

D1	D2
Ø 32.9 –0.2	Ø 33 –0.02/–0.10



	PP 281 R
Measuring standard Coefficient of linear expansion	Two-coordinate TITANID phase grating on glass; grating period 8 µm $\alpha_{therm} \approx 8 \cdot 10^{-6}$ K^{-1}
Accuracy grade	± 2 µm
Measuring range	68 mm x 68 mm, other measuring ranges upon request
Reference marks[1)]	One reference mark in each axis, 3 mm after beginning of measuring length
Interface	∿ 1 V_{PP}
Signal period	4 µm
Cutoff frequency –3 dB	≥ 300 kHz
Traversing speed	≤ 72 m/min
Electrical connection	Cable, 0.5 m with 15-pin D-sub connector (male); with interface electronics in the connector
Cable length	See interface description, but ≤ 30 m (with HEIDENHAIN cable)
Voltage supply	5 V DC ± 0.25 V
Current consumption	< 185 mA per axis
Vibration 55 Hz to 2000 Hz **Shock** 11 ms	≤ 80 m/s^2 (EN 60068-2-6) ≤ 100 m/s^2 (EN 60068-2-27)
Operating temperature	0 °C to 50 °C
Weight Scanning head Grid plate Connecting cable Connector	170 g (without connecting cable) 75 g 37 g/m 140 g

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

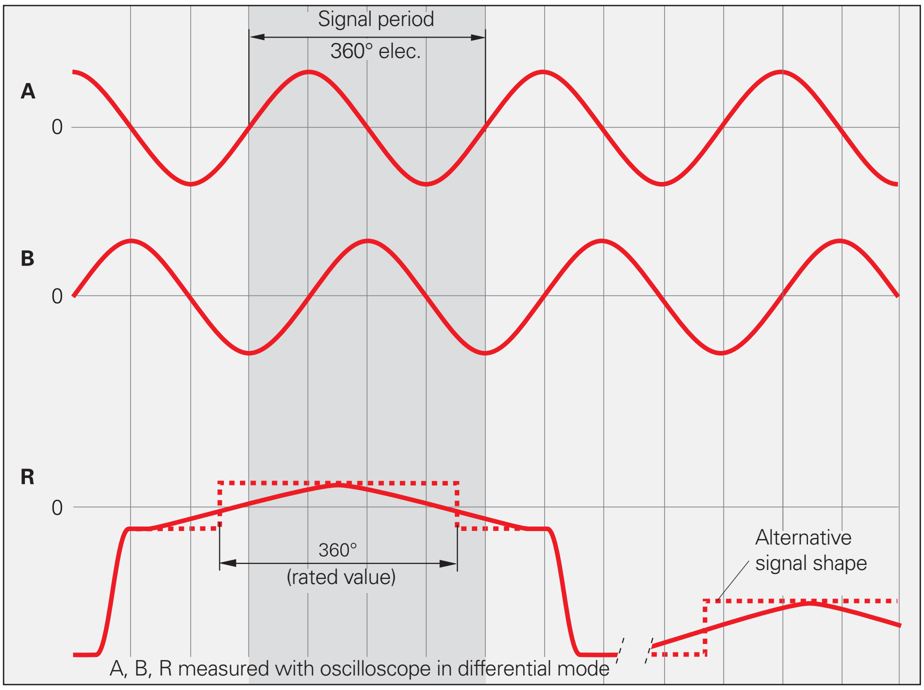
Interfaces
Incremental signals ∿ 1 V_{PP}

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

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

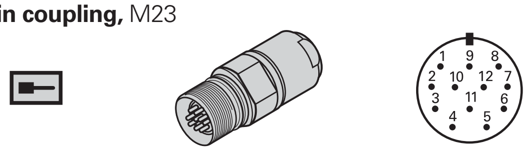
The **reference mark signal** R has an unambiguous assignment to the incremental signals. The output signal might be somewhat lower next to the reference mark.

Comprehensive descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

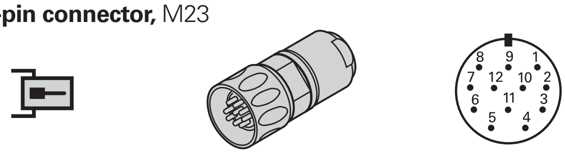


Pin layout

12-pin coupling, M23

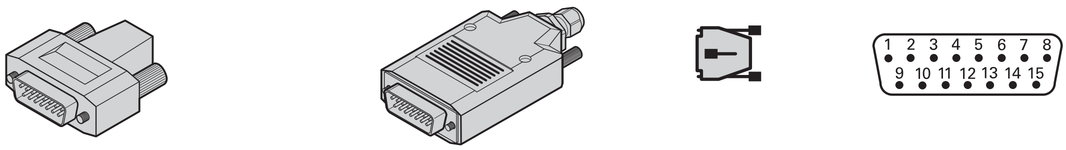


12-pin connector, M23



15-pin D-sub connector
For encoder or PWM 20/EIB 74x

Interface electronics integrated



	Voltage supply				Incremental signals						Other signals		
	12	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**9**	**7**	**/**
	4	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**5/6/8/15**	**13**	**/**
	U_P	**Sensor**[1)] U_P	**0 V**	**Sensor**[1)] 0 V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**Vacant**	**Vacant**	**Vacant**
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	/	Violet	Yellow

Cable shield connected to housing; **U_P** = Power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!
[1)] **LIDA 2xx:** Vacant

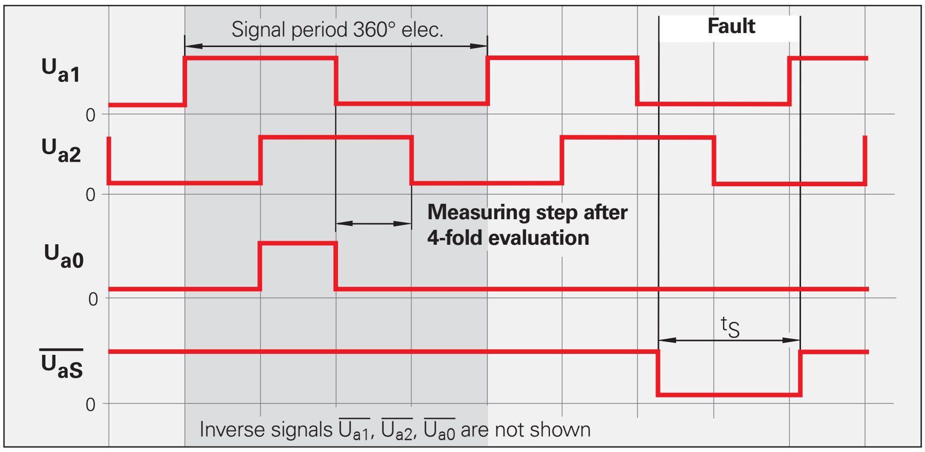
Incremental signals ⊓⊔TTL

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 to the direction of motion shown in the dimension drawing.

The **fault detection signal** $\overline{U_{aS}}$ indicates fault conditions such as an interruption in the supply lines, failure of the light source, etc.

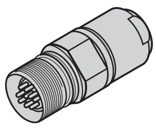
The distance between two successive edges of the incremental signals U_{a1} and U_{a2} through 1-fold, 2-fold or 4-fold evaluation is one **measuring step.**

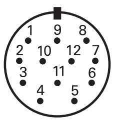


Comprehensive descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

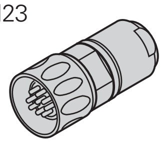
Pin layout

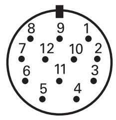
12-pin coupling, M23



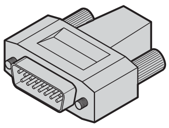


12-pin connector, M23

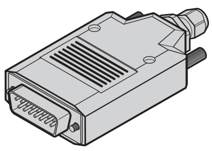


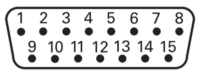


15-pin D-sub connector
For encoder or PWM 20/EIB 74x



Interface electronics integrated





	Voltage supply				Incremental signals						Other signals		
12-pin coupling / connector	12	2	10	11	5	6	8	1	3	4	7	/	9[3]
15-pin D-sub	4	12	2	10	1	9	3	11	14	7	13	5/6/8	15[3]
	U_P	**Sensor**[1] U_P	**0 V**	**Sensor**[1] 0 V	**U_{a1}**	**$\overline{U_{a1}}$**	**U_{a2}**	**$\overline{U_{a2}}$**	**U_{a0}**	**$\overline{U_{a0}}$**	**$\overline{U_{aS}}$**[2]	**Vacant**	**Vacant**
Cable	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	Violet	/	Yellow

Cable shield connected to housing; **U_P** = Power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!
1) **LIDA 2xx:** Vacant 2) **ERO 14xx:** Vacant
3) **Exposed linear encoders:** TTL/11 µApp switchover for PWT (not with LIDA 27x), otherwise vacant

Interfaces
Limit switches

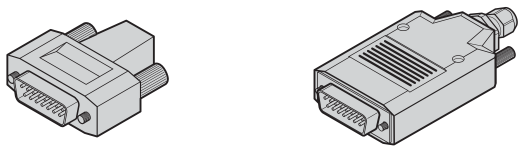
LIDA 400 encoders are equipped with two limit switches that make limit-position detection and the formation of homing tracks possible. The limit switches are activated by differing adhesive magnets to enable switching between the left or right limit. The magnets can be configured in series to form homing tracks. The **signals from the limit switches L1** and **L2** are transmitted over separate lines and are therefore directly available. Nevertheless, the cable has only a very thin diameter of 3.7 mm in order to keep the forces on movable machine elements to a minimum.

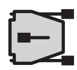
The incremental signals conform with the 1 V_{PP} or TTL interfaces.

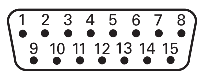
Comprehensive descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

LIDA 4xx pin layout

15-pin D-sub connector Interface electronics integrated







	Voltage 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]	**L2**[2]	[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

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

[1] TTL/11 µA_{PP} switchover for PWT (not for LIDA 27x)
[2] Color assignment applies only to connecting cable

Position detection

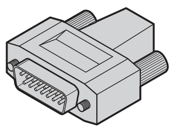
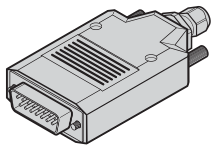
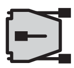
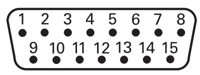
Besides the incremental graduation, the **LIF 4x1** features a homing track and limit switches for limit position detection.
The **signals for position detection H** and **L** are transmitted in TTL level over the separate lines H and L and are therefore directly available. Yet the cable has only a very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

Comprehensive descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

The incremental signals conform with the 1 V_{PP} or TTL interfaces.

LIF 4x1 pin layout

15-pin D-sub connector Interface electronics integrated

	Voltage 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}**	**$\overline{U_{a0}}$**	**$\overline{U_{aS}}$**	**H**	**L**	**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

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

1) TTL/11 µA_{PP} switchover for PWT

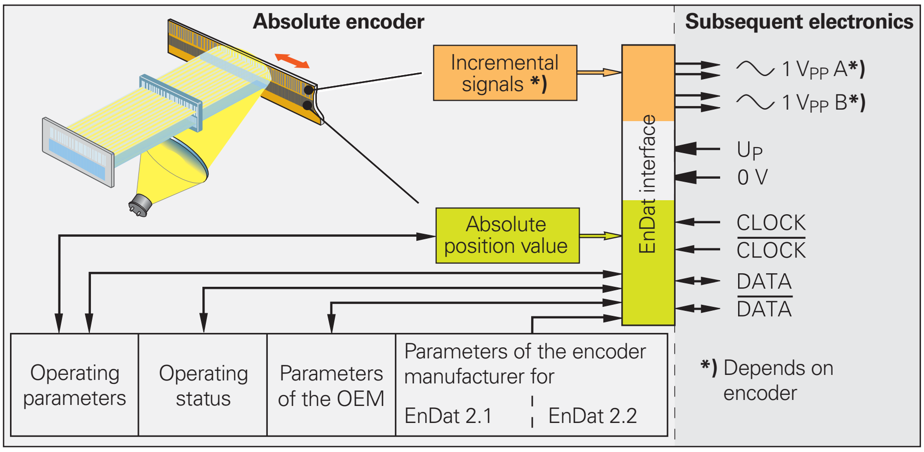
Interfaces
Position values EnDat

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

Comprehensive descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

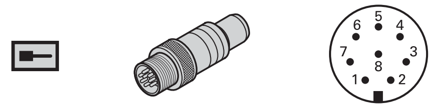
Ordering designation	Command set	Incremental signals
EnDat01	EnDat 2.1 or EnDat 2.2	With
EnDat21		Without
EnDat02	EnDat 2.2	With
EnDat22	EnDat 2.2	Without

Versions of the EnDat interface

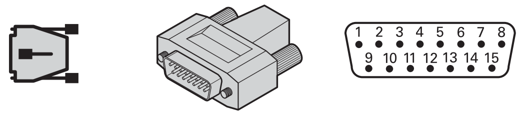


EnDat pin layout

8-pin coupling, M12



15-pin D-sub connector



	Voltage supply				Absolute position values			
8-pin coupling	**8**	**2**	**5**	**1**	**3**	**4**	**7**	**6**
15-pin D-sub	**4**	**12**	**2**	**10**	**5**	**13**	**8**	**15**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
Cable	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

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

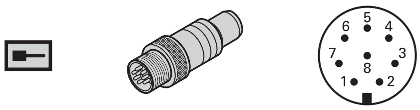
Fanuc and Mitsubishi pin layouts

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

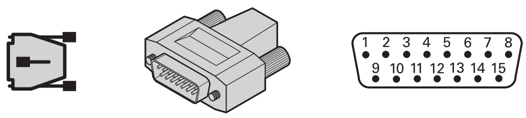
- **Fanuc Serial Interface – α Interface**
  Ordering designation: Fanuc02
  Normal and high speed, two-pair transmission
- **Fanuc Serial Interface – αi interface**
  Ordering designation: Fanuc05
  High speed, one-pair transmission
  Includes α interface (normal and high speed, two-pair transmission)

Fanuc pin layout

8-pin coupling, M12



15-pin D-sub connector



	Voltage supply				Absolute position values			
	8	**2**	**5**	**1**	**3**	**4**	**7**	**6**
	4	**12**	**2**	**10**	**5**	**13**	**8**	**15**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Serial Data**	**$\overline{\text{Serial Data}}$**	**Request**	**$\overline{\text{Request}}$**
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

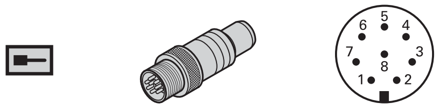
Cable shield connected to housing; **U_P** = Power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power supply.
Vacant pins or wires must not be used!

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

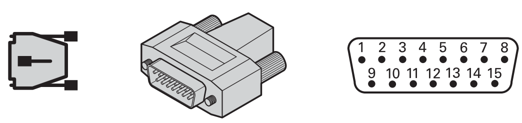
Mitsubishi high speed interface
- Ordering designation: Mitsu01
  Two-pair transmission
- Ordering designation: Mit02-4
  Generation 1, two-pair transmission
- Ordering designation: Mit02-2
  Generation 1, one-pair transmission
- Ordering designation: Mit03-4
  Generation 2, two-pair transmission

Mitsubishi pin layout

8-pin coupling, M12



15-pin D-sub connector



	Voltage supply				Absolute position values			
	8	**2**	**5**	**1**	**3**	**4**	**7**	**6**
	4	**12**	**2**	**10**	**5**	**13**	**8**	**15**
Mit03-4	**U_P**	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Serial Data**	**$\overline{\text{Serial Data}}$**	**Request Frame**	**$\overline{\text{Request Frame}}$**
Mit02-2					**Vacant**	**Vacant**	**Request/ Data**	**$\overline{\text{Request/ Data}}$**
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

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

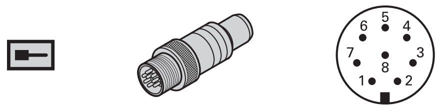
Panasonic pin layout

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

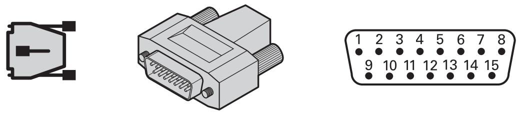
- Ordering designation: Pana01

Panasonic pin layout

8-pin coupling, M12



15-pin D-sub connector



	Voltage supply				Absolute position values			
	8	**2**	**5**	**1**	**3**	**4**	**7**	**6**
	4	**12**	**2**	**10**	**5**	**13**	**8**	**15**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Vacant**[1]	**Vacant**[1]	**Request Data**	**$\overline{\text{Request Data}}$**
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

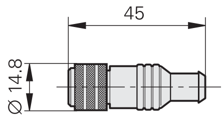
Cable shield connected to housing; **U_P** = Power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power supply.
Vacant pins or wires must not be used!
[1] Required for adjustment/inspection with PWM 20

Connecting elements and cables
General information

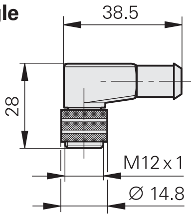
Connector (insulated): Connecting element with coupling ring; available with male or female contacts (see symbols).

Symbols

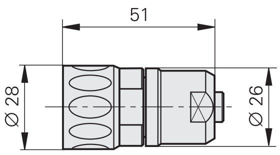
M12



M12 right-angle connector



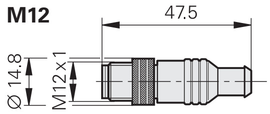
M23



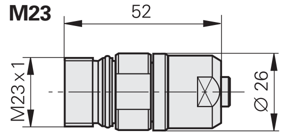
Coupling (insulated): Connecting element with external thread; available with male or female contacts (see symbols).

Symbols

M12

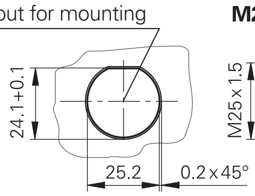


M23

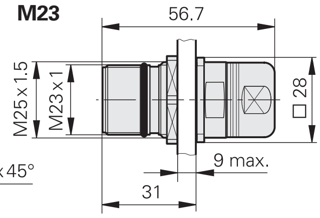


Mounted coupling with central fastening

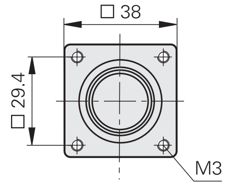
Cutout for mounting



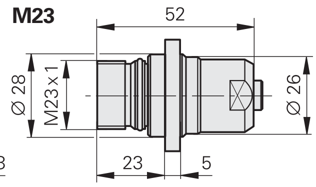
M23



Mounted coupling with flange



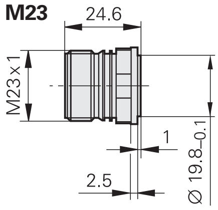
M23

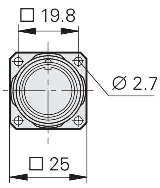


Flange socket with external thread; permanently mounted on a housing, available with male or female contacts.

Symbols

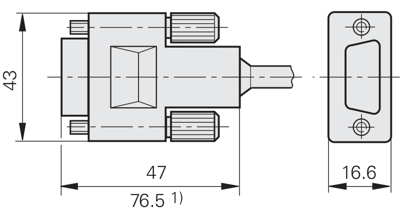
M23





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

Symbols



1) Interface electronics integrated in connector

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

male contacts or

female contacts.

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

Accessory for flange sockets and M23 mounted couplings

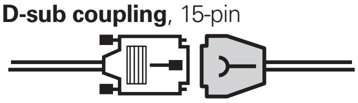
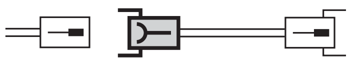
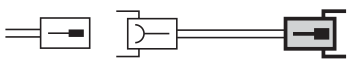
Threaded metal dust cap
ID 219926-01

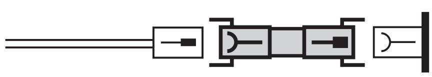
Accessory for M12 connecting element
Insulation spacer
ID 596495-01

Connecting cables for 1 V_{PP}, TTL

		LIP/LIF/LIDA **Without limit or homing signals**		LIF 400/LIDA 400 **With limit and homing signals**	
PUR connecting cable [6(2 x AWG28) + (4 x 0.14 mm²)]; A_P = 0.14 mm²					
PUR connecting cable [4(2 x 0.14 mm²) + (4 x 0.5 mm²) + 2 x (2 x 0.14 mm²)] A_P = 0.5 mm²					
PUR connecting cable [6(2 x 0.19 mm²)] A_P = 0.19 mm²					
PUR connecting cable [4(2 x 0.14 mm²) + (4 x 0.5 mm²)] A_P = 0.5 mm²		Ø 8 mm	Ø 6 mm[1]	Ø 8 mm	Ø 6 mm[1]
Complete with 15-pin D-sub connector (female), and 12-pin M23 connector (male)		331693-xx	355215-xx	–	–
With one 15-pin D-sub connector (female)		332433-xx	355209-xx	354411-xx	355398-xx
Complete with 15-pin D-sub connectors (female and male)		335074-xx	355186-xx	354379-xx	355397-xx
Complete with 15-pin D-sub connectors (female and female) **Pin layout for IK 220**		335077-xx	349687-xx	–	–
Cable only		816317-xx	816323-xx	354341-01	355241-01

Adapter cable for LIP 3x2 With 12-pin M23 coupling (male)		–	310128-xx	–	–
Adapter cable for LIP 3x2 With 15-pin D-sub connector, pin layout for IK 220		298429-xx	–	–	–
Adapter cable for LIP 3x2 without connectors		–	310131-xx	–	–
Complete with 12-pin M23 connectors (female and male)		298399-xx	–	–	–
With one 12-pin M23 connector (female)		309777-xx	–	–	–

Connector on connecting cable to connector on encoder cable	**D-sub coupling**, 15-pin 	For cable	Ø 6 mm To Ø 8 mm	315650-14
Connector on connecting cable to mating element on encoder cable	**M23 connector (female),** 12-pin 	For cable	Ø 8 mm	291697-05
M23 connector for connection to subsequent electronics	**M23 connector (male),** 12-pin 	For cable	Ø 8 mm Ø 6 mm	291697-08 291697-07
M23 flange socket for installation in the subsequent electronics	**M23 flange socket (female),** 12-pin			315892-08

Adapter ∼ 1 V_{PP}/11 μA_{PP} For converting the 1 V_{PP} signals to 11 μA_{PP}; 12-pin M23 connector (female) and 9-pin M23 connector (male)		364914-01

[1] Cable length for Ø 6 mm: max. 9 m

A_P: Cross section of power supply lines

EnDat connecting cables

PUR connecting cable [4(2 x 0.09 mm^2)]; A_P = 0.09 mm^2			
PUR connecting cable [(4 × 0.14 mm^2) + (4 × 0.34 mm^2)]; A_P = 0.34 mm^2		Ø 6 mm	Ø 3.7 mm[1)]
Complete with 8-pin connector (female) and coupling (male)		368330-xx	801142-xx
Complete with 8-pin right-angle connector (female) and coupling (male)		373289-xx	801149-xx
Complete with 8-pin connector (female) and 15-pin D-sub connector (male), for PWM 20, EIB 74x etc.		524599-xx	801129-xx
Complete with 8-pin right-angle connector (female) and 15-pin D-sub connector (male), for PWM 20, EIB 74x etc.		722025-xx	801140-xx
With one 8-pin connector (female)		634265-xx	–
With one 8-pin right-angle connector (female)		606317-xx	–

1) Maximum total cable length 6 m
A_P: Cross section of power supply lines

Connecting cables Fanuc Mitsubishi

Fanuc

PUR connecting cable [4 × (2 × 0.09 mm²)]; A_P = 0.09 mm²			
PUR connecting cable [(4 × 0.14 mm²) + (4 × 0.34 mm²)]; A_P = 0.34 mm²		Ø 6 mm	Ø 3.7 mm[1)]
Complete With M12 connector (female) and M12 coupling (male), 8 pins each		368330-xx	801142-xx
Complete With M12 right-angle connector (female) and M12 coupling (male), 8 pins each		373289-xx	801149-xx
Complete With 8-pin M12 connector (female) and Fanuc connector (female)		646807-xx	–
With one connector With 8-pin M12 connector (female)		634265-xx	–
With one connector With 8-pin M12 right-angle connector (female)		606317-xx	–

1) Maximum total cable length 6 m
A_P: Cross section of power supply lines

Mitsubishi

PUR connecting cable [(1 × 4 × 0.14 mm²) + (4 × 0.34 mm²)]; A_P = 0.34 mm²		Ø 6 mm
Complete With 8-pin M12 connector (female) and 20-pin Mitsubishi connector		646806-xx
Complete With 8-pin M12 connector (female) and 10-pin Mitsubishi connector		647314-xx
With one connector With 8-pin M12 connector (female)		634265-xx
With one connector With 8-pin M12 right-angle connector (female)		606317-xx

A_P: Cross section of power supply lines

Diagnostic and testing equipment

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

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

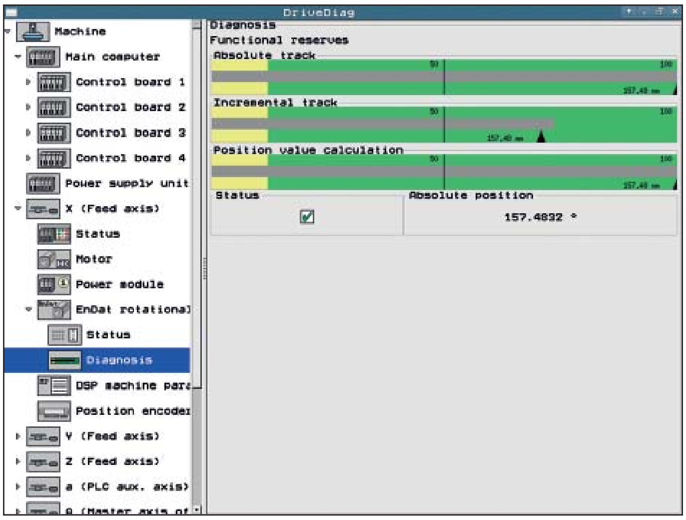
Absolute encoders operate with serial data transfer. Depending on the interface, additional 1 V_{PP} incremental signals can be output. The signals are monitored comprehensively within the encoder. The monitoring result (especially with valuation numbers) can be transferred along with the position value through the serial interface to the subsequent electronics (digital diagnostics interface). The following information is available:

- Error message: Position value is not reliable.
- Warning message: An internal functional limit of the encoder has been reached.
- Valuation numbers:
  - Detailed information on the encoder's functional reserve
  - Identical scaling for all HEIDENHAIN encoders
  - Cyclic output is possible

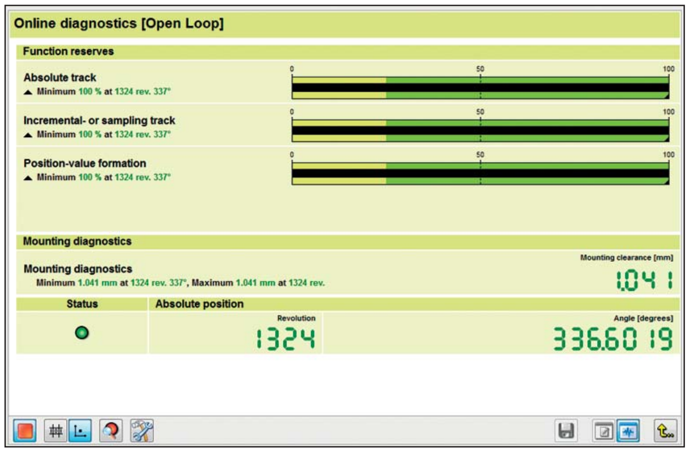
This enables the subsequent electronics to evaluate the current status of the encoder with little effort even in closed-loop mode.

HEIDENHAIN offers the appropriate PWM inspection devices and PWT test devices for encoder analysis. There are two types of diagnostics, depending on how they are integrated:

- Encoder diagnostics: The encoder is connected directly to the test or inspection device. This makes a comprehensive analysis of encoder functions possible.
- Diagnostics in the control loop: The PWM 20 is looped into the closed control loop (e.g. through a suitable testing adapter). This makes a real-time diagnosis of the machine or system possible during operation. The functions depend on the interface.



Diagnostics in the control loop on HEIDENHAIN controls with display of the valuation number or the analog encoder signals



Diagnostics using PWM 20 and ATS software

Commissioning using PWM 20 and ATS software

Diagnostic and testing equipment

PWM 20
Together with the included ATS adjusting and testing software, the PWM 20 phase angle measuring unit serves for diagnosis and adjustment of HEIDENHAIN encoders.

For more information, see the *PWM 20 / ATS Software* Product Information sheet.

	PWM 20
Encoder input	• EnDat 2.1 or EnDat 2.2 (absolute value with/without incremental signals) • DRIVE-CLiQ • Fanuc Serial Interface • Mitsubishi high speed interface • Yaskawa Serial Interface • SSI • $1\ V_{PP}$/TTL/$11\ \mu A_{PP}$
Interface	USB 2.0
Voltage supply	100 V to 240 V AC or 24 V DC
Dimensions	258 mm x 154 mm x 55 mm

	ATS
Languages	Choice between English and German
Functions	• Position display • Connection dialog • Diagnostics • Mounting wizard for EBI/ECI/EQI, LIP 200, LIC 4100 and others • Additional functions (if supported by the encoder) • Memory contents
System requirements and recommendations	PC (dual-core processor, > 2 GHz) RAM > 2 GB Windows operating systems XP, Vista, 7 (32-bit/64-bit), 8 200 MB free space on hard disk

DRIVE-CLiQ is a registered trademark of Siemens Aktiengesellschaft

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

	PWM 9
Inputs	Expansion modules (interface boards) for $11\ \mu A_{PP}$; $1\ V_{PP}$; TTL; HTL; EnDat*/SSI*/commutation signals *No display of position values or parameters
Functions	• **Measures** signal amplitudes, current consumption, operating voltage, scanning frequency • **Graphically displays** incremental signals (amplitudes, phase angle and on-off ratio) and the reference-mark signal (width and position) • **Displays symbols** for the reference mark, fault-detection signal, counting direction • **Universal counter,** interpolation selectable from single to 1024-fold • **Adjustment support** for exposed linear encoders
Outputs	• Inputs are connected through to the subsequent electronics • BNC sockets for connection to an oscilloscope
Voltage supply	10 V to 30 V DC, 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	$\sim$ 11 μA_{PP}	⊓⊔ TTL	$\sim$ 1 V_{PP}
Functions	Measurement of signal amplitude Wave-form tolerance Amplitude and position of the reference mark signal		
Voltage supply	Via power supply unit (included)		
Dimensions	114 mm x 64 mm x 29 mm		

The **APS 27** encoder diagnostic kit can be used in addition to the integrated functional display for assessing the mounting tolerances of the LIDA 27x with TTL interface. To examine them, the LIDA 27x is either connected to the subsequent electronics via the PS 27 test connector, or is operated directly on the PG 27 test unit.

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

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

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

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

Interface electronics

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

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

Output signals of the interface electronics
Interface electronics with the following interfaces to the subsequent electronics are available:
- TTL square-wave pulse trains
- EnDat 2.2
- DRIVE-CLiQ
- Fanuc Serial Interface
- Mitsubishi high speed interface
- Yaskawa Serial Interface
- Profibus

Interpolation of the sinusoidal input signals
In addition to being converted, the sinusoidal encoder signals are also interpolated in the interface electronics. This permits finer measuring steps and, as a result, higher control quality and better positioning behavior.

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

Box design

Plug design

Version for integration

Top-hat rail design

Outputs		Inputs		Design – degree of protection	Interpolation[1] or subdivision	Model
Interface	Qty.	Interface	Qty.			
⊓⊔TTL	1	∼ 1 V_{PP}	1	Box design – IP 65	5/10-fold	**IBV 101**
					20/25/50/100-fold	**IBV 102**
					Without interpolation	**IBV 600**
					25/50/100/200/400-fold	**IBV 660 B**
				Plug design – IP 40	5/10/20/25/50/100-fold	**APE 371**
				Version for integration – IP 00	5/10-fold	**IDP 181**
					20/25/50/100-fold	**IDP 182**
		∼ 11 μA_{PP}	1	Box design – IP 65	5/10-fold	**EXE 101**
					20/25/50/100-fold	**EXE 102**
					Without/5-fold	**EXE 602 E**
					25/50/100/200/400-fold	**EXE 660 B**
				Version for integration – IP 00	5-fold	**IDP 101**
⊓⊔TTL/ ∼ 1 V_{PP} Adjustable	2	∼ 1 V_{PP}	1	Box design – IP 65	2-fold	**IBV 6072**
					5/10-fold	**IBV 6172**
					5/10-fold and 20/25/50/100-fold	**IBV 6272**
EnDat 2.2	1	∼ 1 V_{PP}	1	Box design – IP 65	≤ 16384-fold subdivision	**EIB 192**
				Plug design – IP 40	≤ 16384-fold subdivision	**EIB 392**
			2	Box design – IP 65	≤ 16384-fold subdivision	**EIB 1512**
DRIVE-CLiQ	1	EnDat 2.2	1	Box design – IP 65	–	**EIB 2391 S**
Fanuc Serial Interface	1	∼ 1 V_{PP}	1	Box design – IP 65	≤ 16384-fold subdivision	**EIB 192 F**
				Plug design – IP 40	≤ 16384-fold subdivision	**EIB 392 F**
			2	Box design – IP 65	≤ 16384-fold subdivision	**EIB 1592 F**
Mitsubishi high speed interface	1	∼ 1 V_{PP}	1	Box design – IP 65	≤ 16384-fold subdivision	**EIB 192 M**
				Plug design – IP 40	≤ 16384-fold subdivision	**EIB 392 M**
			2	Box design – IP 65	≤ 16384-fold subdivision	**EIB 1592 M**
Yaskawa Serial Interface	1	EnDat 2.2[2]	1	Plug design – IP 40	–	**EIB 3391 Y**
PROFIBUS-DP	1	EnDat 2.1; EnDat 2.2	1	Top-hat rail design	–	**PROFIBUS Gateway**

[1] Switchable

[2] Only LIC 4100 with 5 nm measuring step, LIC 2100 with 50 nm and 100 nm measuring steps

For more information

DR. JOHANNES HEIDENHAIN GmbH develops and manufactures linear and angle encoders, rotary encoders, digital readouts, touch probes and numerical controls. HEIDENHAIN supplies its products to manufacturers of machine tools, and of automated machines and systems, in particular for semiconductor and electronics manufacturing.

HEIDENHAIN worldwide
HEIDENHAIN is represented in all industrialized countries—usually with wholly owned subsidiaries. Sales engineers and service technicians support the user on-site with technical information and servicing.

HEIDENHAIN on the Internet
At www.heidenhain.de you will find not only our brochures in various languages, but also a great deal of further up-to-date information on the company and its products. Our web site also includes:

- Technical articles
- Press releases
- Addresses
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Brochure
General Catalog

Contents:
Product program

Brochure
Interfaces of HEIDENHAIN Encoders

Contents:
Descriptions of interfaces
General electrical information

Length measurement

Brochure
Linear Encoders
For Numerically Controlled Machine Tools

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Absolute linear encoders
LC
Incremental linear encoders
LB, LF, LS

Brochure
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LIP, PP, LIF, LIDA

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iTNC 530 Contouring Control
TNC 640 Contouring Control

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Information for the user

Brochures
TNC 128 Straight Cut Control
TNC 320 Contouring Control
TNC 620 Contouring Control

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Information for the user

Brochures
MANUALplus 620 Contouring Control
CNC Pilot 640 Contouring Control

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Brochure
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ECN, EQN, ROC, ROQ
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ERN, ROD

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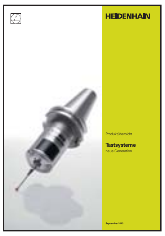

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Linear encoders
LS 300, LS 600

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