



HEIDENHAIN



Linear Encoders

For Numerically Controlled
Machine Tools

Further information is available on the Internet at www.heidenhain.de as well as upon request.

Brochures regarding:

- Exposed linear encoders
- Angle encoders with integral bearing
- Angle encoders without integral bearing
- Rotary encoders
- HEIDENHAIN subsequent electronics
- HEIDENHAIN controls
- Measuring devices for machine tool inspection and acceptance testing

Technical information regarding:

- Interfaces of HEIDENHAIN encoders
- Accuracy of feed axes
- Safety-related position measuring systems
- EnDat 2.2—bidirectional interface for position encoders
- Encoders for direct drives

This brochure supersedes all previous editions, which thereby become invalid.

The basis for ordering from HEIDENHAIN is always the brochure edition valid when the order is made.

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



Further information:

For comprehensive descriptions of all available interfaces, as well as general electrical information, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure.

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Specifications

<i>Linear encoders</i>	<i>Series or model</i>	
For absolute position measurement	LC 400 series	22
	LC 100 series	26
For absolute position measurement over large measuring lengths	LC 200 series (single-section housing)	30
	LC 200 series (multi-section housing)	32
For incremental linear measurement with very high repeatability	LF 485	34
	LF 185	36
For incremental linear measurement	LS 400 series	38
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For incremental linear measurement over large measuring lengths	LB 382 (single-section)	42
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Linear encoders for numerically controlled machine tools

Linear encoders from HEIDENHAIN for numerically controlled machine tools can be used nearly everywhere. They are ideal for machines and other equipment whose feed axes are in a closed loop, such as milling machines, machining centers, boring mills, lathes, and grinding machines. The beneficial dynamic behavior of linear encoders, their high permissible traversing speed, and their acceleration in the direction of measurement predestine them for use on highly-dynamic conventional axes as well as on direct drives.

HEIDENHAIN also supplies linear encoders for other applications, such as:

- Manual machine tools
- Presses and bending machines
- Automation and production equipment

Advantages of linear encoders

If a linear encoder is used for measurement of the slide position, the position control loop includes the complete feed mechanics. This is referred to as Closed Loop operation. Transfer errors from the mechanics can be detected by the linear encoder on the feed axis, and corrected by the control electronics. This makes it possible to eliminate a number of potential error sources:

- Positioning error due to heat generation in the recirculating ball screw
- Reversal error
- Kinematic error through the ball-screw pitch error

Linear encoders are therefore indispensable for machine tools on which high **positioning accuracy** and a high **machining rate** are essential.

Mechanical design

Linear encoders for numerically controlled machine tools are sealed measuring devices: an aluminum housing protects the scale, the scanning carriage, and its guide from chips, dust, and splashing water. Downward-oriented elastic lips seal the housing.

The scanning carriage travels along the scale on a low-friction guide. A coupling connects the scanning carriage with the mounting block and compensates the misalignment between the scale and the machine slide.

Depending on the encoder model, lateral and axial offsets of ± 0.2 mm to ± 0.3 mm between the scale and mounting block are permissible.

Thermal characteristics

Increasingly faster machining times with fully encapsulated machines cause ever higher temperatures in the machine's working space. Therefore, the thermal behavior of the linear encoders used becomes increasingly important, since it 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 must expand or contract in a defined, reproducible manner. Linear encoders from HEIDENHAIN are designed for this.

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

Dynamic behavior

Efficiency and performance improvements in machine tools require ever higher feed rates and accelerations. Of course, they must not compromise machining accuracy. In order to transfer rapid and yet exact feed motions, very high demands are placed on rigid machine design as well as on the linear encoders used.

Linear encoders from HEIDENHAIN are characterized by their high rigidity in the measuring direction. This is a very important prerequisite for high-quality contouring accuracy of a machine tool. In addition, the low mass of moving components contributes to their excellent dynamic behavior.

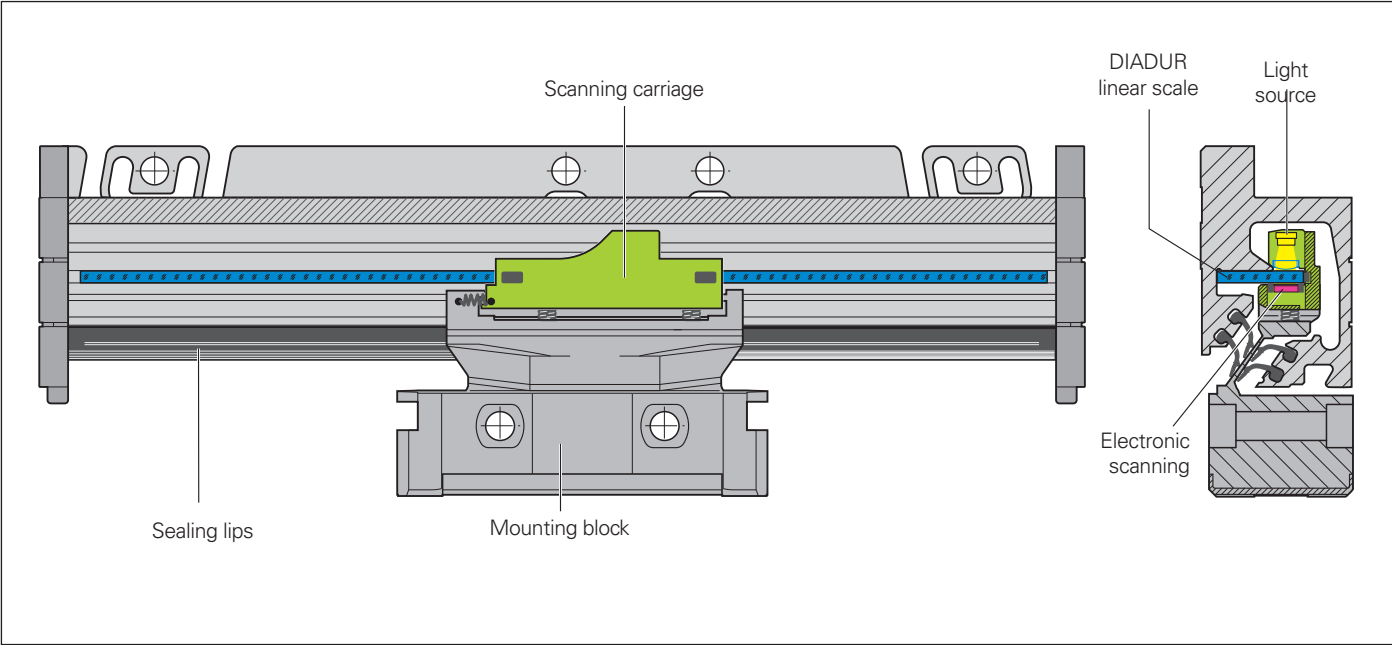
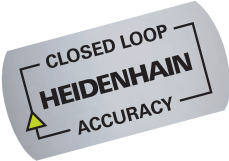
Availability

The feed axes of machine tools travel quite large distances—a typical value is 10000 km in three years. This is why sturdy encoders with good long-term stability are especially important: they ensure the constant availability of the machine.

Due to the details of their design, linear encoders from HEIDENHAIN function properly even after years of operation. A long service life is ensured by the contact-free photoelectric scanning of the measuring standard and by the ball-bearing guidance of the scanning carriage in the scale housing. Thanks to their enclosure, special scanning principles, and—if required—a sealing air connection, the linear encoders are particularly tolerant to contamination. The complete shielding design ensures a high degree of electrical noise immunity.

 **Further information:**

Please request further documentation or inform yourself on the Internet at www.heidenhain.de.

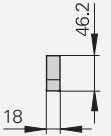
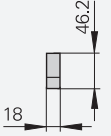
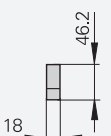


Schematic design of the LC 115 sealed linear encoder

Selection guide

Linear encoders with slimline scale housing

The linear encoders with **slimline scale housing** are designed for **limited installation space**. Larger measuring lengths and higher acceleration loads are possible through the use of a mounting spar or clamping elements.

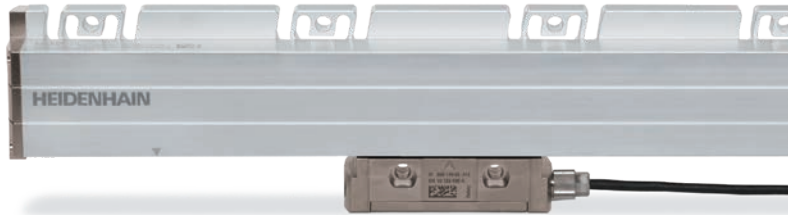
	Cross section	Accuracy grade	Max. interpolation error	Measuring length (ML)	Signal period	Interface	Model	Page
Absolute position measurement Glass scale		±5 µm ±3 µm	±0.1 µm	70 mm to 1240 mm <i>With mounting spar or clamping elements:</i> 70 mm to 2040 mm	–	EnDat 2.2	LC 415 ²⁾	22
					20 µm	EnDat 2.2 with $\sim 1 V_{PP}$	LC 485	
					–	DRIVE-CLiQ	LC 495 S	24
						Fanuc αi	LC 495 F	
						Mitsubishi	LC 495 M	
						Panasonic	LC 495 P	
Incremental linear measurement with very high repeatability - Steel scale - Small signal period		±5 µm ±3 µm	±0.04 µm	50 mm to 1220 mm	4 µm	$\sim 1 V_{PP}$	LF 485	34
Incremental linear measurement Glass scale		±5 µm ±3 µm	±0.2 µm	70 mm to 1240 mm <i>With mounting spar:</i> 70 mm to 2040 mm	20 µm	$\sim 1 V_{PP}$	LS 487	
					–	TTL	LS 477	38



LC 415



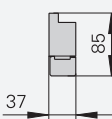
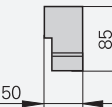
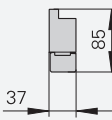
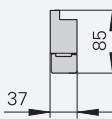
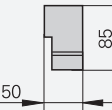
LF 485
LS 487



LC 115

Linear encoders with full-size scale housing

Linear encoders with **full-size scale housing** are characterized by their **sturdy design, high resistance to vibration, and large measuring lengths**. As a connection between the scanning carriage and the mounting block, they have an “oblique web,” which permits **vertical and horizontal mounting** with the same degree of protection.

Absolute position measurement • Glass scale		±5 µm ±3 µm	±0.1 µm ¹⁾	140 mm to 4240 mm	–	EnDat 2.2	LC 115 ²⁾	26
					20 µm	EnDat 2.2 with $\sim 1 V_{PP}$	LC 185	
					–	DRIVE-CLiQ	LC 195 S	28
						Fanuc αi	LC 195 F	
						Mitsubishi	LC 195 M	
	Panasonic	LC 195 P						
Absolute position measurement For large measuring lengths • Steel scale tape		±5 µm	±0.4 µm	440 mm to 28040 mm	–	EnDat 2.2	LC 211	30
					40 µm	EnDat 2.2 with $\sim 1 V_{PP}$	LC 281	
					–	Fanuc αi	LC 291 F	
						Mitsubishi	LC 291 M	
Incremental linear measurement with very high repeatability • Steel scale • Small signal period		±3 µm ±2 µm	±0.04 µm	140 mm to 3040 mm	4 µm	$\sim 1 V_{PP}$	LF 185	36
Incremental linear measurement • Glass scale		±5 µm ±3 µm	±0.2 µm	140 mm to 3040 mm	20 µm	$\sim 1 V_{PP}$	LS 187	40
					–	$\square$ TTL	LS 177	
Incremental linear measurement for large measuring lengths • Steel scale tape		±5 µm	±0.8 µm	440 mm to 30040 mm Up to 72040 mm upon request	40 µm	$\sim 1 V_{PP}$	LB 382	42



LF 185



LC 211

¹⁾ For measuring lengths > 3040 mm: ±0.4 µm at the butt joint (at approx. 3100 mm)

²⁾ Connectable to Yaskawa interface via EIB 3391Y

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 made of glass or steel. For encoders with large measuring lengths, steel tape is used as the scale substrate.

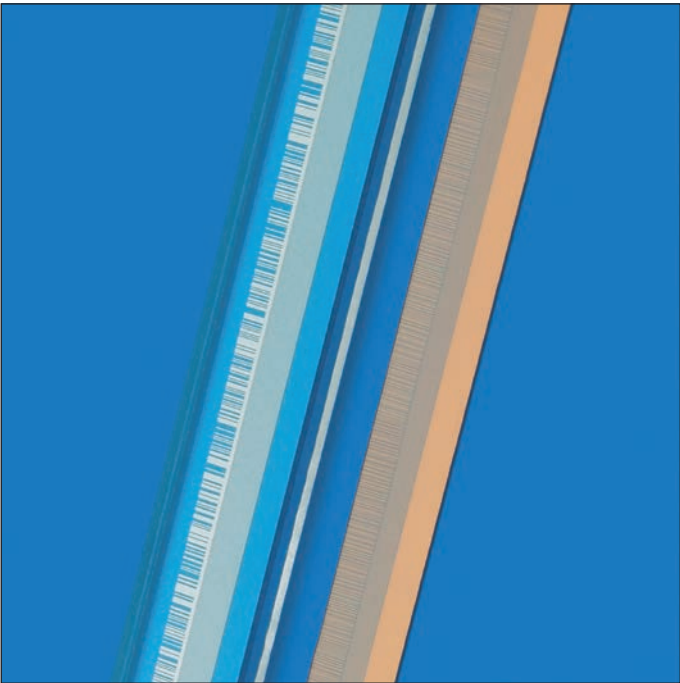
- HEIDENHAIN manufactures the precision graduations in the following specially developed, photolithographic processes:
- METALLUR: contamination-tolerant graduation consisting of metal lines on gold; typical grating period: 40 µm
 - DIADUR: extremely robust chromium lines on glass (typical grating period: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

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

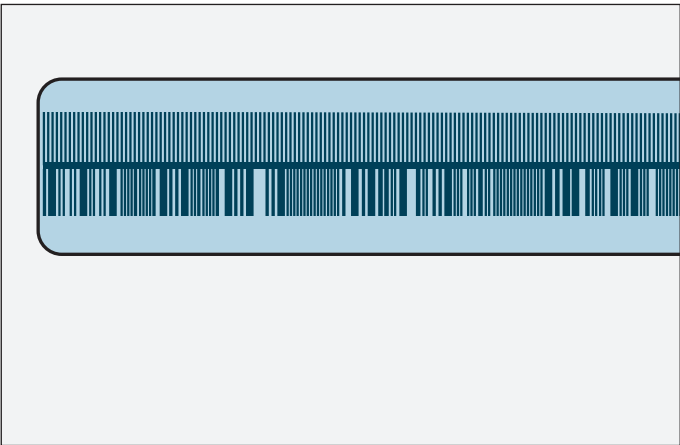
The master graduations are manufactured by HEIDENHAIN on custom-built, high-precision dividing engines.

Absolute measuring method

With the **absolute measuring method**, the position value is immediately available upon switch-on of the encoder and can be requested at any time by the subsequent electronics. There is no need to jog the axes to find the reference position. The absolute position information is read **from the scale graduation**, which is designed as a serial absolute code structure. A separate incremental track is interpolated for the position value and is simultaneously used to generate an optional incremental signal.



Graduations of absolute linear encoders

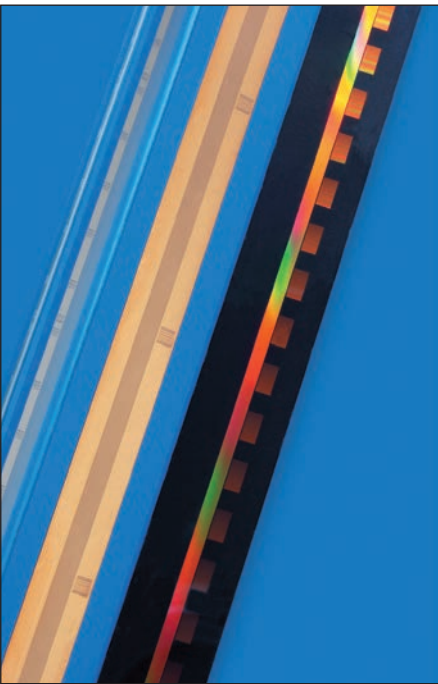


Schematic representation of an absolute code structure with an additional incremental track (LC 485 as example)

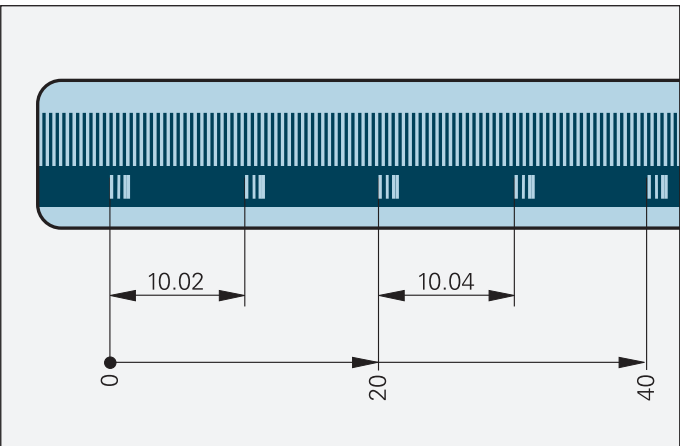
Incremental measuring method

With the **incremental measuring method**, the graduation is arranged as a periodic grating structure. The position information is obtained **through the counting** of individual increments (measuring steps) from any set point of origin. Since the ascertainment of positions requires an absolute reference, the scales or scale tapes feature an additional track bearing 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 traversed before an absolute reference can be established or before the most recently selected reference point is found.



Graduations of incremental linear encoders



Schematic representation of an incremental graduation with distance-coded reference marks (LS encoder as example)

In the most unfavorable case, machine movements over sizeable sections of the measuring range may be necessary. To speed up and simplify such “reference runs,” many HEIDENHAIN encoders feature **distance-coded reference marks**—multiple reference marks that are individually spaced in accordance with a mathematical algorithm. The subsequent electronics find the absolute reference after traversing two successive reference marks—thus after a traverse path of only a few millimeters (see table below).

Encoders with distance-coded reference marks are identified with a “C” following the model designation (e.g., LS 487C). With distance-coded reference marks, the **absolute reference** is calculated by counting the increments between two reference marks and by applying the following formula:

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

and

$$R = 2 \cdot M_{RR} - N$$

- Where:
- | | |
|---|--|
| P_1 = Position of the first traversed reference mark in signal periods | N = Nominal increment between two fixed reference marks in signal periods (see table below) |
| abs = Absolute value | D = Direction of traverse (+1 or -1). Traverse of scanning unit to the right (when properly installed) equals +1 |
| sgn = Algebraic sign function (“+1” or “-1”) | |
| M_{RR} = Number of signal periods between the traversed reference marks | |

	Signal period	Nominal increment N in signal periods	Maximum traverse
LF	4 µm	5000	20 mm
LS	20 µm	1000	20 mm
LB	40 µm	2000	80 mm

Photoelectric scanning

Most HEIDENHAIN encoders utilize the photoelectric scanning principle. Photoelectric scanning is performed without contact and thus does not induce wear. This method detects even extremely fine graduation lines with a width of only a few micrometers 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 linear encoders employ two scanning principles:

- The **imaging scanning principle** for grating periods of 20 µm and 40 µm
- The **interferential scanning principle** for very fine graduations with grating periods of, for example, 8 µm.

Imaging scanning principle

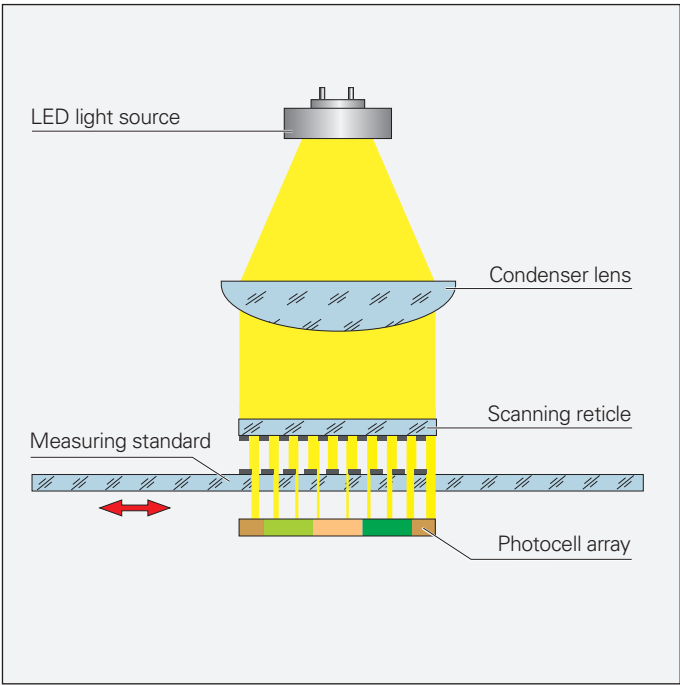
Put simply, the imaging scanning principle uses projected-light signal generation: two gratings with equal or similar grating periods—the scale and the scanning reticle—are moved relative to each other. The carrier material of the scanning reticle is transparent, whereas the graduation of the measuring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

When parallel light passes through a grating, light and dark fields are projected at a particular distance. At this location there is an index grating. When the two gratings move relative to each other, the incident light is modulated: If the gaps are aligned, light passes through. If the lines of one grating coincide with the gaps of the other, no light passes through. An array of photovoltaic cells converts 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 grating period of the grating structure is, the closer and more tightly tolerated the gap must be between the scanning reticle and the scale.

The LC, LS, and LB linear encoders use the imaging scanning principle.

Imaging scanning principle



Interferential scanning principle

The interferential scanning principle exploits the diffraction and interference of light on finely divided gratings in order to produce the signals used to measure displacement.

A step grating is used as the measuring standard: reflective lines with a height of 0.2 µm are applied to a flat, reflective surface. In front of this 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 nearly 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. Photocells convert these alternating light intensities into electrical signals.

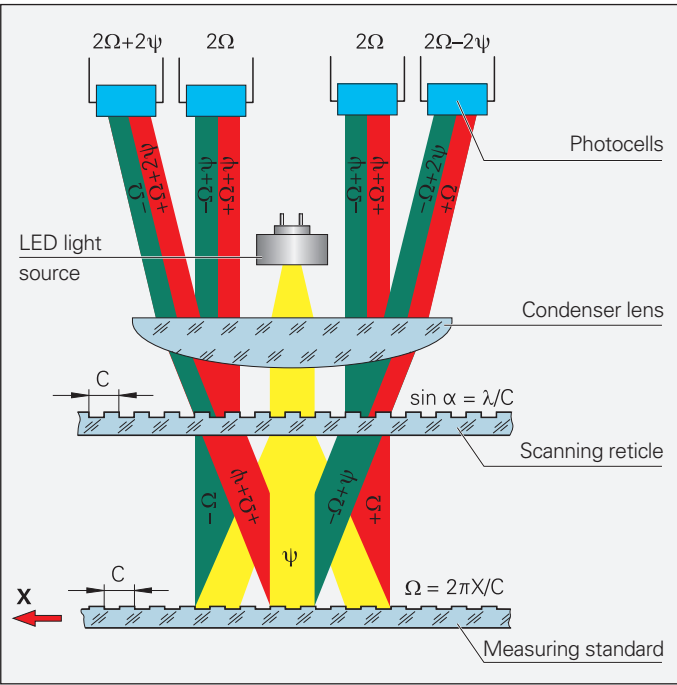
When there is relative motion between the scale and the scanning reticle, the diffracted wavefronts undergo a phase shift: movement by the amount of one grating period shifts the positive first-order diffraction wavefront by one wavelength in the positive direction, while the negative first-order diffraction wavefront is displaced by one wavelength in the negative direction. Since the two waves interfere with each other upon exiting the phase grating, these waves are shifted relative to each other by two wavelengths. This results in two signal periods when there is relative motion of just one grating period.

Interferential encoders use grating periods of, for example, 8 µm, 4 µm, or finer. Their scanning signals are largely free of harmonics and can be highly interpolated. These encoders are therefore especially well suited for small measuring steps and high accuracy.

Sealed linear encoders that use the interferential scanning principle are given the designation LF.

Interferential scanning principle (optics schematics)

- C Grating period
- ψ Phase shift of the light wave when passing through the scanning reticle
- Ω Phase shift of the light wave due to motion X of the scale



Measuring accuracy

The accuracy of the linear measurement is mainly determined by

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

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

Position error over the measuring range

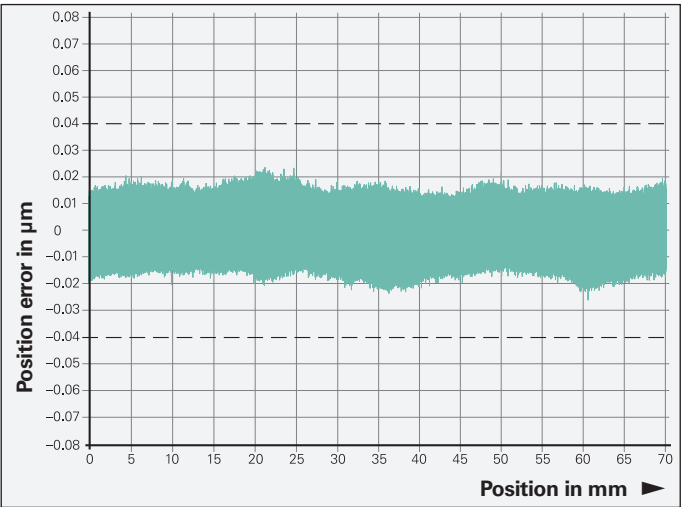
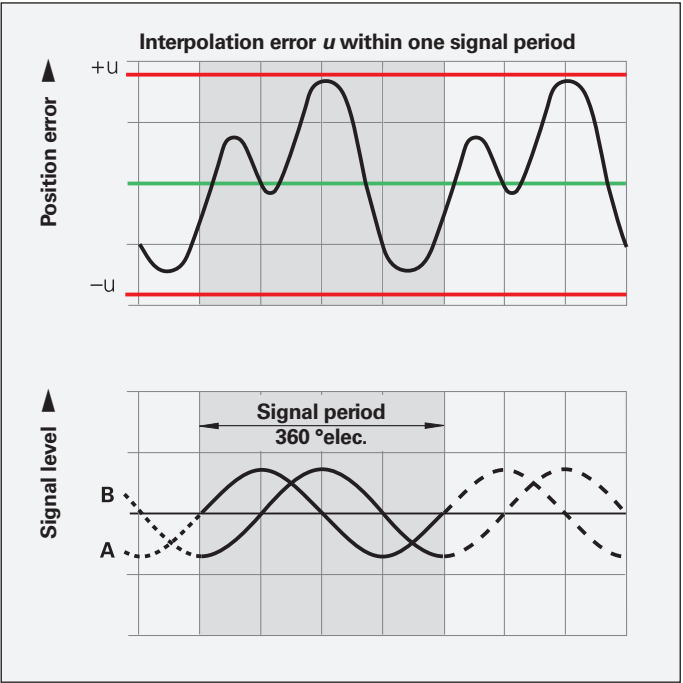
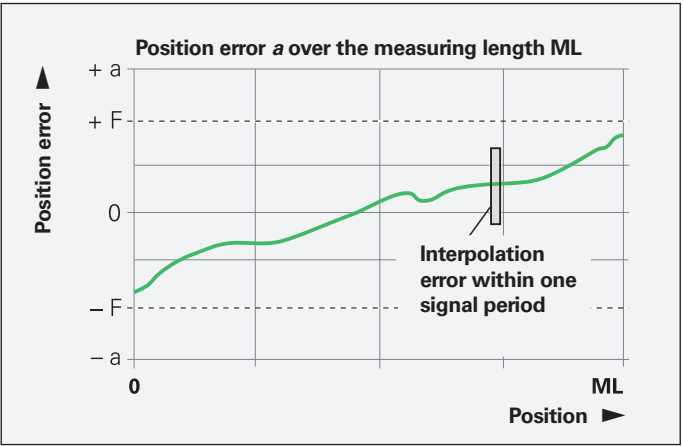
The accuracy of sealed linear encoders is specified in grades, which are defined as follows:

The extreme values $\pm F$ of the measuring curves over any max. one-meter section of the measuring length lie within the accuracy grade $\pm a$. They are measured during the final inspection and documented in the calibration chart.

For sealed linear encoders, this data refers to the scale including the scanning unit, which is then the system accuracy.

Interpolation error within one signal period

The interpolation error within one signal period is determined by the signal period of the encoder, as well as the quality of the graduation and the scanning thereof. At any measuring position, it typically lies at $\pm 2\%$ to $\pm 0.5\%$ of the signal period (see *Selection guide, page 6*). The smaller the signal period, the smaller the interpolation error within one signal period. It is of critical importance both for accuracy of a positioning movement as well as for velocity control during the slow and even traverse of an axis, and therefore for surface quality and the quality of the machined part.



Interpolation error within one signal period for a measuring range of 70 mm for LF encoders

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

The position errors are measured by traversing in both directions, and the averaged curve is shown in the calibration chart.

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

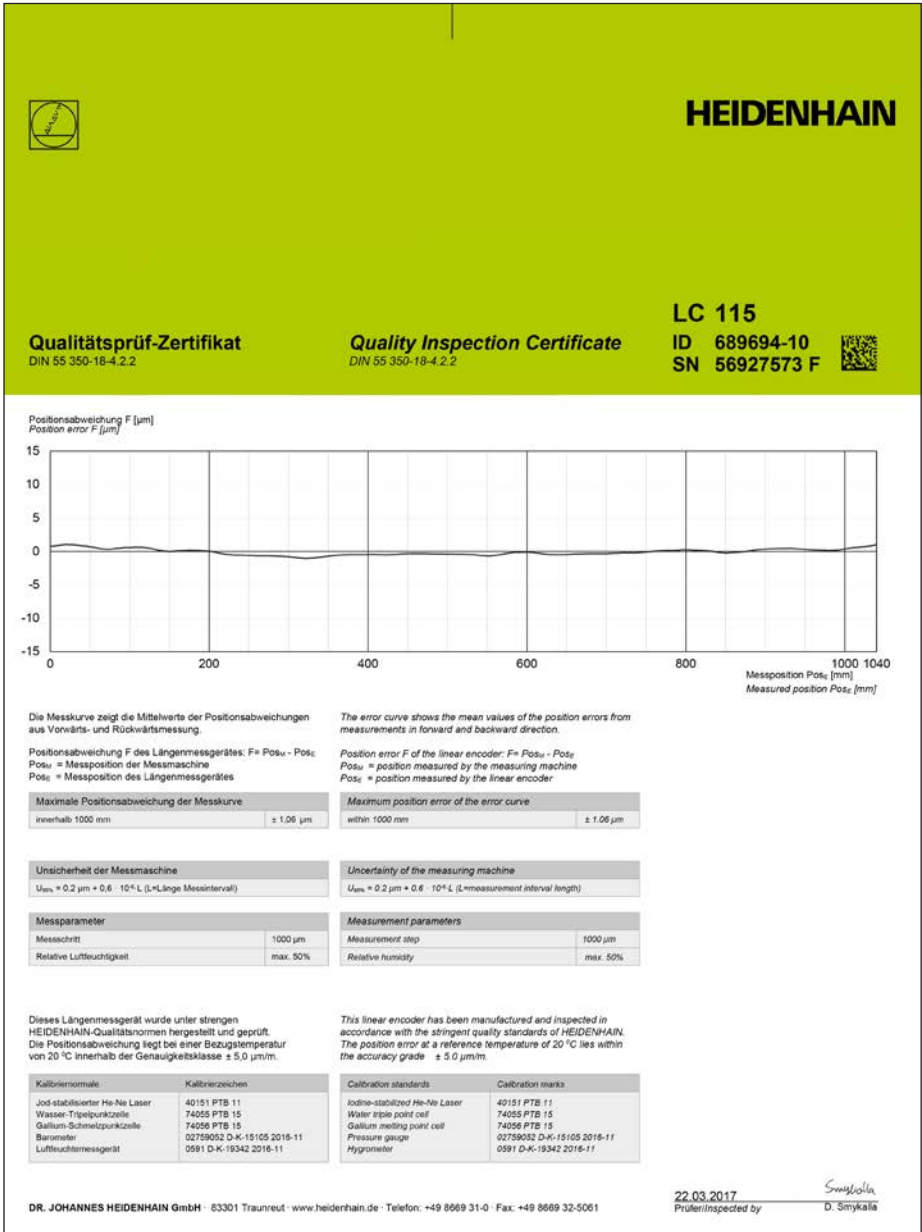
For the LC, LF, and LS series listed in this brochure, a calibration chart documents the **position error** ascertained for the measuring length. It also specifies the measuring parameters and the measurement uncertainty.

Temperature range

The linear encoders are inspected at a **reference temperature** of 20 °C. The system accuracy documented in the calibration chart is valid at this temperature.

The **operating temperature range** states the limits of ambient temperature within which the linear encoder will function properly.

The **storage temperature range** of -20 °C to +70 °C applies when the unit remains in its packaging. Starting from a measuring length of 3240 mm, the permissible storage temperature range for the LC 1x5 encoders is limited to -10 °C to +50 °C.



Example

Mechanical design types and mounting guidelines

Linear encoders with small cross section

The LC, LF, and LS slimline linear encoders should be mounted on a machined surface over the entire length—particularly for high dynamic requirements. Larger measuring lengths and a higher vibration load capacity can be achieved by using a mounting spar or clamping elements (only for LC 4x5).

The slimline linear encoders feature identical mounting dimensions. This makes it possible, for example, to exchange an incremental LS or LF for an absolute LC on a specific machine design (please note that the measuring length of the LF is smaller by 20 mm than that of the LC or LS). In addition, the same mounting spars can also be used, regardless of the encoder version (LC, LF, or LS).

The encoder is mounted such that the sealing lips are directed downward or away from splashing water (also see *General information on page 18*).

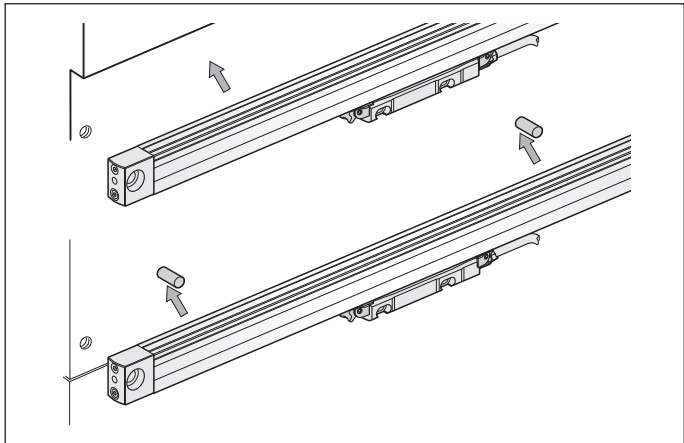
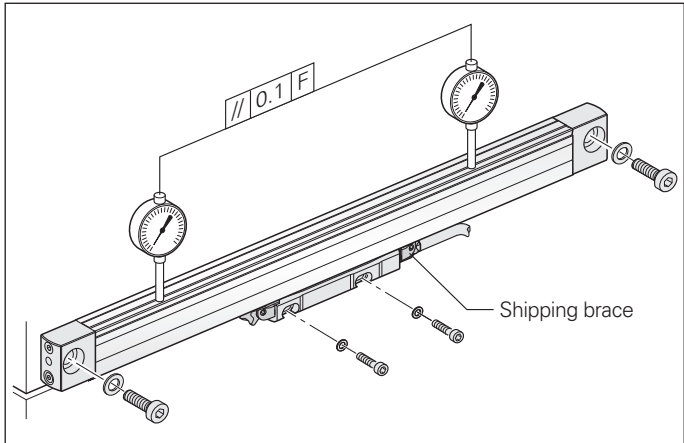
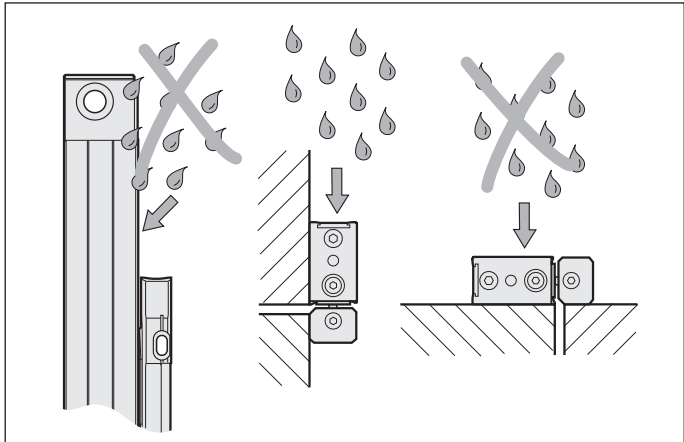
Thermal characteristics

Because they are rigidly fastened using two M8 screws, the linear encoders largely adapt themselves to the mounting surface. When fastened over the mounting spar, the encoder is fixed at its midpoint to the mounting surface. The flexible fastening elements ensure reproducible thermal behavior.

The **LF 485** with its graduation carrier of steel has the same coefficient of thermal expansion as a mounting surface of gray cast iron or steel.

Mounting

It is surprisingly simple to mount the sealed linear encoders from HEIDENHAIN: you need only align the scale unit at several points along the machine guideway. Stop surfaces or stop pins can also be used for this. The shipping brace already sets the proper gap between the scale unit and the scanning unit, as well as the lateral tolerance. If the shipping brace needs to be removed before mounting due to a lack of space, then the mounting gauge is used to set the gap between the scale unit and the scanning unit easily and exactly. Lateral tolerances must also be maintained.



Accessory:
Mounting and test gauges for slimline linear encoders
The **mounting gauge** is used to set the gap between the scale unit and the scanning unit if the shipping brace needs to be removed before mounting. The **test gauges** are used to quickly and easily check the gap of the mounted linear encoder.

Along with the standard procedure of using two M8 screws to mount the scale unit on a plane surface, there are also other mounting possibilities:

Installation with mounting spar
Mounting the encoder with a mounting spar can be especially beneficial. The mounting spar can be fastened as part of the machine assembly process. The encoder is then simply clamped on during final mounting. Easy exchange also facilitates servicing. HEIDENHAIN recommends mounting with the mounting spar when measuring lengths are greater than 620 mm and dynamic requirements are high. The mounting spar is always required for measuring lengths greater than 1240 mm.

For the **MSL 41 mounting spar**, the components required for clamping are already preassembled. This mounting spar is designed for linear encoders with normal or short end blocks. The LC 4x5, LF 4x5, and LS 4x7 can be mounted by either side to enable a cable outlet at either end. The MSL 41 mounting spar must be ordered separately.

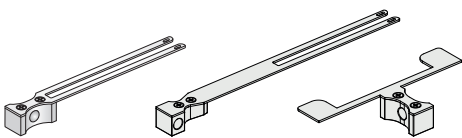
The **mounting aid** is locked onto the mounted spar and therefore simulates an optimally mounted scanning unit. The customer's fastening for the scanning unit can be easily aligned to it. Then the mounting aid is replaced by the linear encoder.

Accessory:
MSL 41 mounting spar
ID 770902-xx

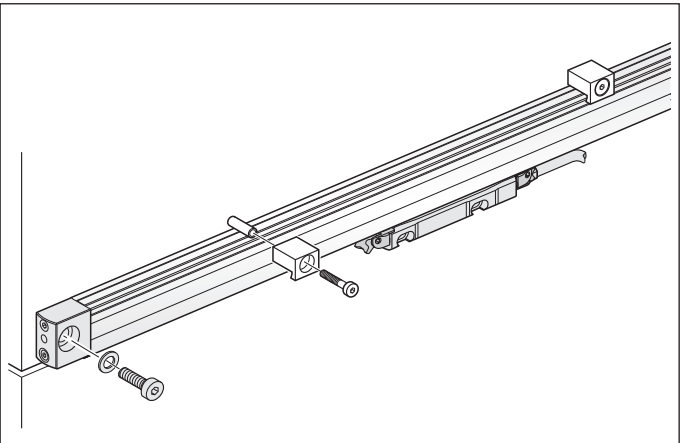
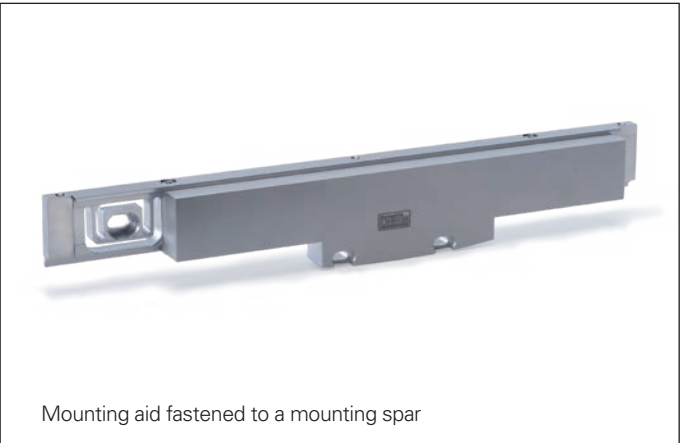
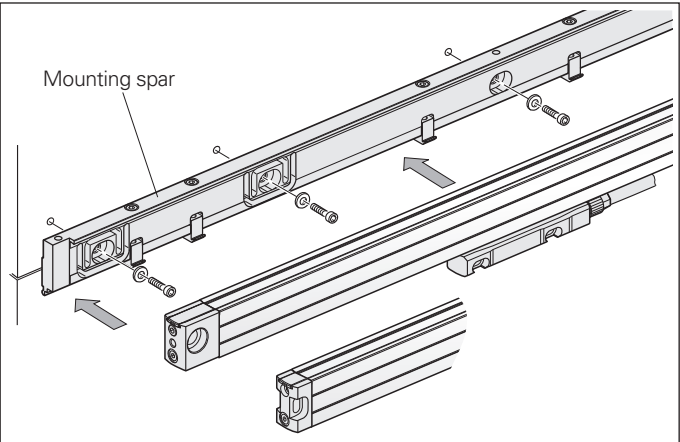
Mounting aid for scanning unit
ID 753853-01

Mounting with clamping elements
If the cable outlet is to the right, the LC 4x5 scanning unit, which is fastened by its end blocks, can additionally be fixed by clamping elements. This eliminates the need of a mounting spar for measuring lengths greater than 620 mm.

Accessory:
Clamping elements
With pin and M5x10 screw
ID 556975-01 (10 per package)



	ID		
Mounting gauge 1.0 mm (gray)	737748-01	1211268-01	1211239-01
Test gauge max.1.3 mm (red)	737748-02	1211268-02	1211239-02
Test gauge min. 0.7 mm (blue)	737748-03	1211268-03	1211239-03



Linear encoders with large cross section

The LB, LC, LF, and LS full-size linear encoders are fastened over their entire length onto a machined surface. This gives them a **high vibration rating**. The oblique arrangement of the sealing lips permits **universal mounting** with vertical or horizontal scale housing with equally high protection rating.

The LC 1x5 features an optimized sealing system with two successive pairs of sealing lips. When cleaned compressed air is introduced into the scale housing, it effectively seals the two pairs of sealing lips against ambient air. This optimally protects the interior of the encoder from contamination.

The flow rate is set through a connecting piece with integrated throttle (see separate accessories under *Protection*, page 18).

Thermal characteristics

The thermal behavior of the LB, LC, LF, and LS 100 full-size linear encoders has been optimized:

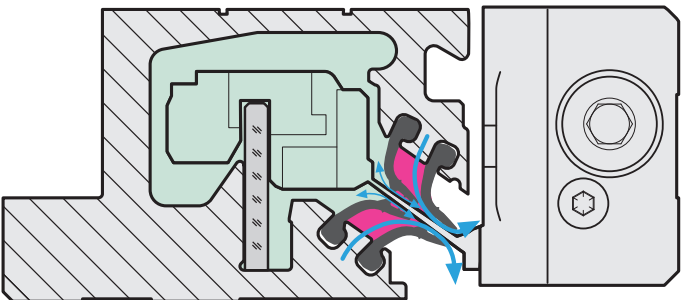
On the **LF**, the steel scale is cemented to a steel carrier that is fastened directly to the machine element.

For the multi-section **LC 200** and **LB**, the steel scale tape is clamped directly onto the machine element. In this way, the encoders are subject to the same thermal changes in length as the bearing surface.

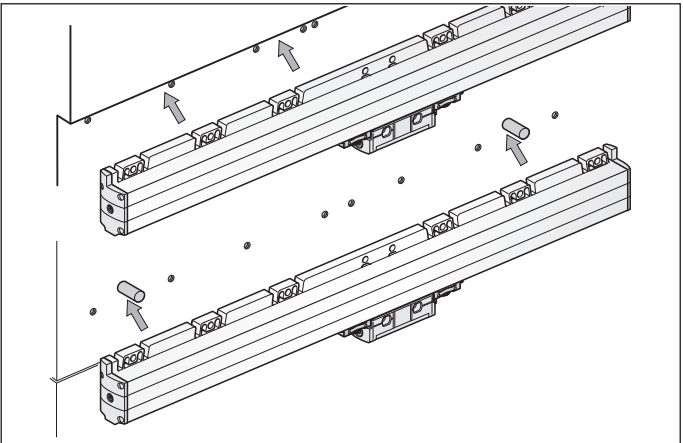
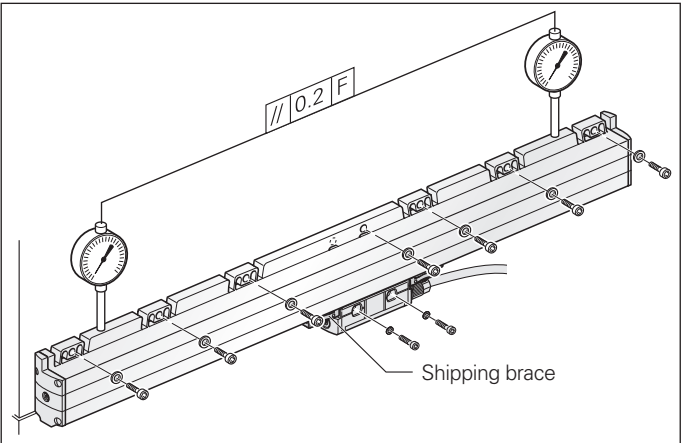
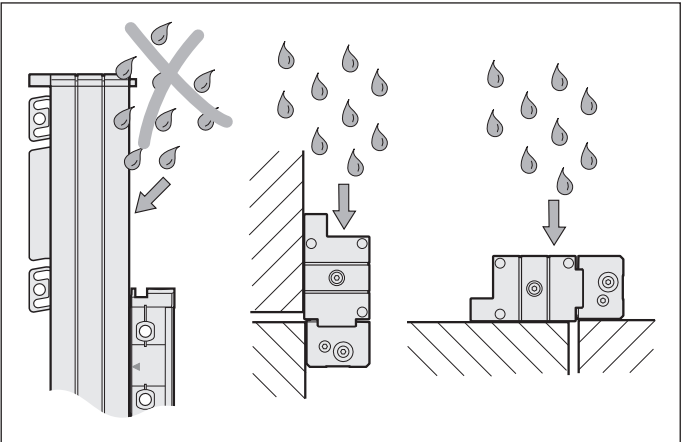
The **LC** and **LS** are fixed to the mounting surface at their midpoint. The flexible fastening elements permit reproducible thermal behavior.

Mounting

It is surprisingly simple to mount the sealed linear encoders from HEIDENHAIN: you need only align the scale unit at several points along the machine guideway. Stop surfaces or stop pins can also be used for this. The shipping brace already sets the proper gap between the scale unit and the scanning unit. The lateral gap is to be set during mounting. If the shipping brace needs to be removed before mounting due to a lack of space, then the mounting gauge is used to set the gap between the scale unit and the scanning unit easily and exactly. Lateral tolerances must also be maintained.



Sealing system of the LC 1x5



Mounting the multi-section LC 2x1 and LB 382

The LC 2x1 and LB 382 with measuring lengths over 3240 mm are mounted on the machine in individual sections:

- Mount and align the individual housing sections
- Pull in the scale tape over the entire length and tension it
- Lubricate the sealing lips and pull them in
- Insert the scanning unit

Adjustment of the scale tape tension enables linear machine error compensation up to $\pm 100 \mu\text{m/m}$.

Accessory:

Mounting aids

- For LC 1x3, LS 1x7 ID 547793-02
- For LC 1x5 ID 1067589-02
- For LC 2x1, LB 382 ID 824039-01

The mounting aid is locked onto the scale unit, simulating an optimally adjusted scanning unit. The customer's fastening for the scanning unit can be easily aligned to it. The mounting aid is then removed and the scanning unit is attached to the mounting bracket.

Accessory:

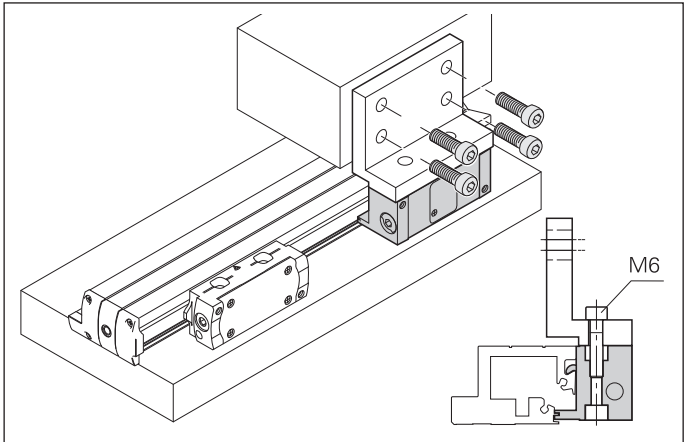
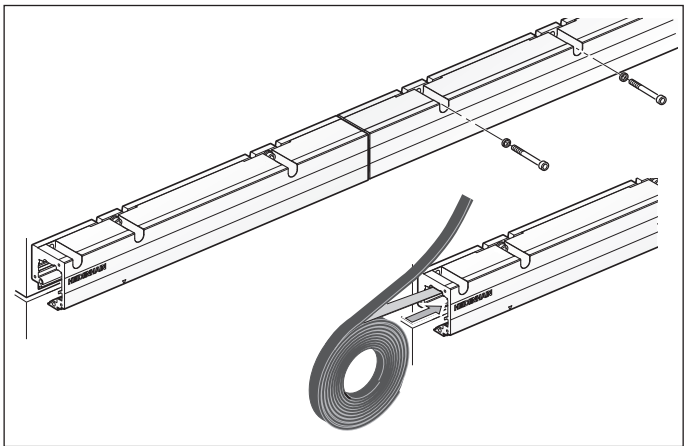
Mounting and test gauges for full-size linear encoders

The **mounting gauge** is used to set the gap between the scale unit and the scanning unit if the shipping brace needs to be removed before mounting. The **test gauges** are used to quickly and easily check the gap of the mounted linear encoder.

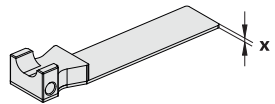
Accessory:

Lubricating device

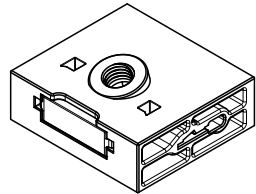
- For LC 2x1, LB 382 sealing lips ID 1104590-05



Example



	LC 1xx, LS 1xx		LB 382/LC 2x1	
	x	ID	x	ID
Mounting gauge (gray)	1,5 mm	575832-11	1,0 mm	772141-11
Test gauge max. (red)	1,8 mm	575832-12	1,3 mm	772141-12
Test gauge min. (blue)	1,2 mm	575832-13	0,7 mm	772141-13



General information

Protection

Sealed **linear encoders** fulfill the requirements for IP53 protection according to **EN 60529** or **IEC 60529** provided that they are mounted with the sealing lips facing away from splash water. If necessary, provide a separate protective cover. If the encoder is exposed to particularly heavy concentrations of coolant and mist, **sealing air** can be used to provide **IP64** protection to more effectively prevent the ingress of contamination. To apply the compressed air for sealing the housing, the LB, LC, LF, and LS sealed linear encoders are therefore equipped with inlets at both end blocks and on the mounting block of the scanning unit.

The compressed air introduced directly onto the encoders must be cleaned by a microfilter and must comply with the following quality classes as per **ISO 8573-1** (2010 edition):

- Solid contaminants: **Class 1**
Particle size No. of particles per m³
0.1 µm to 0.5 µm ≤ 20 000
0.5 µm to 1.0 µm ≤ 400
1.0 µm to 5.0 µm ≤ 10
- Max. pressure dew point: **Class 4**
(pressure dew point at 3 °C)
- Total oil content: **Class 1**
(max. oil concentration 0.01 mg/m³)

For an optimal supply of sealing air to the sealed linear encoders, the required air flow is 7 l/min to 10 l/min per encoder. Ideally, the air flow is regulated by the HEIDENHAIN connecting pieces with integrated throttle. The throttles ensure the prescribed flow quantities at an input pressure of approx. 1 · 10⁵ Pa (1 bar).

Accessory:

Connecting piece

With throttle and gasket, for tube 6x1 for linear encoders (on the end block) ID 226270-02

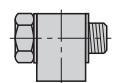
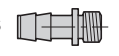
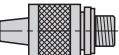
Connecting piece

With throttle and gasket, for tube 6x1 for linear encoders (on the mounting block) ID 275239-01

Also suitable:

Swiveling screw fitting 90°

With seal ID 207834-02



Accessory:

DA 400 compressed air unit ID 894602-01

DA 400

HEIDENHAIN offers the DA 400 compressed-air filter system for purifying the compressed air. It is designed specifically for the introduction of compressed air into encoders.

The DA 400 consists of three filter stages (prefilter, microfilter, and activated carbon filter) and a pressure regulator with manometer. The sealing air function can be effectively monitored using a manometer and pressure switch (available as accessory).

The compressed air introduced into the DA 400 must fulfill the requirements of the following purity classes as per **ISO 8573-1** (2010 edition):

- Solid contaminants: **Class 5**
Particle size No. of particles per m³
0.1 µm to 0.5 µm Not specified
0.5 µm to 1.0 µm Not specified
1.0 µm to 5.0 µm ≤ 100 000
- Max. pressure dew point: **Class 6**
(pressure dew point at 10 °C)
- Total oil content: **Class 4**
(max. oil concentration 5 mg/m³)



Further information:

For more information, ask for our **DA 400 Product Information document**.

Mounting

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

- The encoder should be mounted as closely as possible to the working plane to keep the Abbe error small.
- To function properly, linear encoders must not be continuously subjected to strong vibration; the more solid parts of the machine tool provide the best mounting surface in this respect. Encoders should not be mounted on hollow parts or with adapters. A mounting spar is recommended for sealed linear encoders with small cross section.
- In order to avoid temperature effects, the linear encoders should not be mounted in close proximity to heat sources.
- During cable routing, the minimum bend radius for fixed installation or for frequent flexing must be observed (see table).
- Both the scanning unit and the scale housing are to be connected with low resistance (< 1 Ω) to functional earth.

Cable assembly

Accessory:

1/4" socket wrench

The socket wrench makes it possible to mount the encoder connector to the adapter cable when space is limited. ID 618965-02



Required moving force

The required moving force stated is the maximum force required to move the scale unit relative to the scanning unit.

Acceleration

Linear encoders are subject to various types of acceleration during operation and mounting.

- The indicated maximum values for the **vibration rating** apply for frequencies of 55 Hz to 2000 Hz (**EN 60068-2-6**), except when mechanical resonance arises. **Comprehensive testing of the entire system is therefore required.**
- The maximum permissible acceleration values (semi-sinusoidal shock) for **shock and impact** are valid for 11 ms (**EN 60068-2-27**). Under no circumstances should a hammer or similar implement be used to adjust or position the encoder.

RoHS

HEIDENHAIN has tested its products to ensure the use of non-hazardous materials in accordance with the European Directives 2002/95/EC (RoHS) and 2002/96/EC (WEEE). For a Manufacturer's Declaration on RoHS, please consult your sales agency.

Parts subject to wear

Encoders from HEIDENHAIN are designed for a long service life. Preventive maintenance is not required. However, they do contain components that are subject to wear, depending on the application and how they are deployed. This especially applies to cables subjected to frequent flexing. Other parts subject to wear are the bearings in encoders with integral bearing, the radial shaft seal rings in rotary encoders and angle encoders, and the sealing lips on linear encoders.

System tests

Encoders from HEIDENHAIN are usually integrated as components into complete systems. Such applications require **comprehensive testing of the complete system**, irrespective of the encoder's specifications. 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 outside of its proper and intended use is at the user's own risk.

Mounting

The applicable steps and dimensions that must be complied with during mounting are specified solely in the mounting instructions supplied with the device. All mounting-related information in this brochure is therefore provisional and non-binding; it does not become part of a contract.



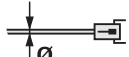
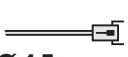
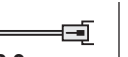
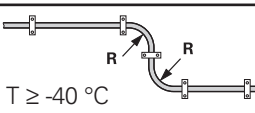
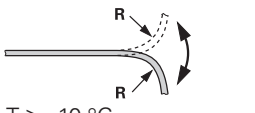
Further information:

Please also pay note the following documents for planning and assembly:

- Brochure: *Cables and Connectors*
- Brochure: *Interfaces of HEIDENHAIN Encoders*
- Mounting instructions for the respective encoder
- Mounting instructions for output and adapter cables



DA 400

	 Ø 3.7 mm	 Ø 4.5 mm	 Ø 6.0 mm Ø 6.8 mm	 Ø 6.6 mm Ø 10 mm	 Ø 8.0 mm
 T ≥ -40 °C	≥ 8 mm	≥ 10 mm	≥ 20 mm	≥ 35 mm	R ₁ ≥ 40 mm
 T ≥ -10 °C	≥ 40 mm	≥ 50 mm	≥ 75 mm	≥ 75 mm	R ₂ ≥ 100 mm

Minimum bend radii for rigid configuration or for frequent flexing

Functional safety

Safe axes

Driven axes on machine tools usually represent a great hazard for humans. Particularly if the human interacts with the machine (e.g., during workpiece setup), it must be ensured that the machine does not make any uncontrolled movements. Here, the position information of axes is needed to conduct a safety function. As an evaluating safety module, the control has the task of detecting faulty position information and reacting to it accordingly.

Various safety strategies can be pursued, depending on the topology of the axis and the evaluation capabilities of the control. In a single-encoder system, for example, only one encoder per axis is evaluated for the safety function. However, on axes with two encoders, such as a linear axis with a rotary and a linear encoder, the two redundant position values can be compared with each other in the control.

Safe fault detection can be ensured only if the two components—control and encoder—are properly adapted to one another. Here, it is to be noted that the safety designs of control manufacturers differ from one another. This also means that the requirements to be fulfilled by the connected encoders can sometimes differ.

Type-examined encoders

Sealed linear encoders from HEIDENHAIN are used successfully on a variety of controls in widely differing safety designs. This applies particularly to the type-examined encoders LC 1x5/LC 4x5 with EnDat and DRIVE-CLiQ interfaces. The encoders can be operated as single-encoder systems in conjunction with a suitable control in applications with the control category SIL 2 (according to EN 61508) or performance level “d” (of EN ISO 13849). Unlike incremental encoders, the absolute LC 1x5/LC 4x5 linear encoders always provide a safe absolute position value—including immediately after switch-on or a power failure. The reliable transmission of the position is based on two independently generated absolute position values and on error bits provided to the safe control. The purely serial data transmission also offers other advantages, such as greater reliability, improved accuracy, diagnostic capabilities, and reduced costs through simpler connection technology.

Standard encoders

In addition to those encoders explicitly qualified for safety applications, standard encoders (e.g., with Fanuc interface or 1 V_{PP} signals) can also be used in safe axes. In these cases, the characteristics of the encoders must be matched to the

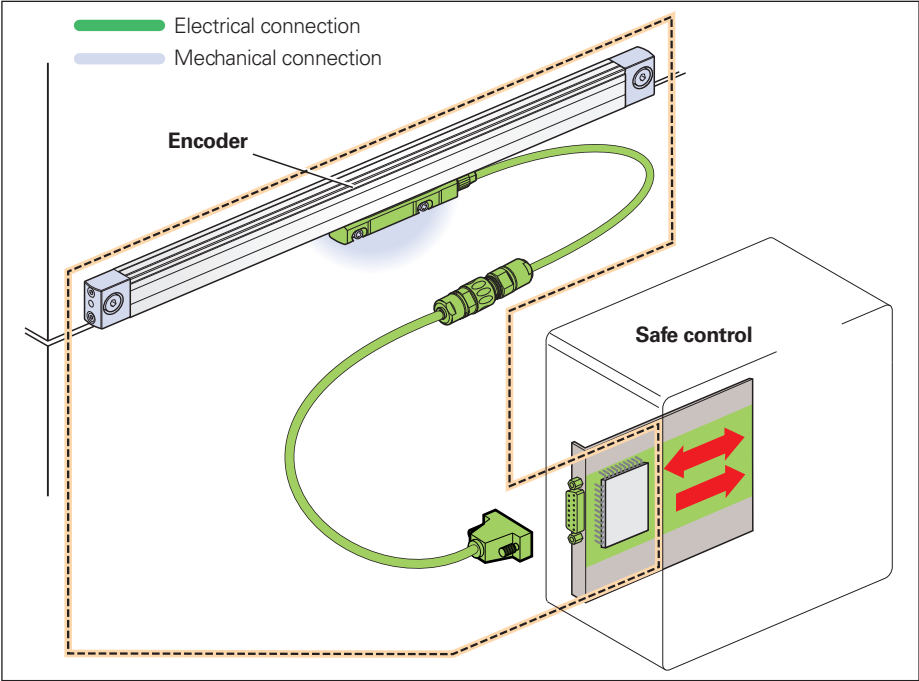
requirements of the respective control. HEIDENHAIN can provide additional data on the individual encoders (failure rate, fault model as per EN 61800-5-2).

Service life

Unless otherwise specified, HEIDENHAIN encoders are designed for a service life of 20 years (in accordance with ISO 13849).

 **Further information:**

The safety-related characteristic values are listed in the specifications of the encoders. The Technical Information document *Safety-Related Position Encoders* provides explanations of the characteristic values. Upon request, HEIDENHAIN can likewise provide additional data about the individual products (failure rate, fault model as per EN 61800-5-2) for the use of standard encoders in safety-related applications.



Encoder with mechanical connection and electrical interface

Fault exclusion for the loosening of the mechanical connection

Irrespective of the interface, many safety designs require the safe mechanical connection of the encoder. The standard for electric drives, EN 61800-5-2, includes the loosening of the mechanical connection between the encoder and the drive as a fault that requires consideration. Since it cannot be guaranteed that the control will detect such errors, fault exclusion is required

in many cases. The requirements on a fault exclusion can result in additional constraints in the permissible limit values in the specifications. In addition, fault exclusions for the loss or loosening of the mechanical coupling usually require additional measures when mounting the encoders or in the event of servicing, e.g. anti-rotation lock for screws. These factors must be considered for the selection of a suitable encoder or a mounting mode.

Fault exclusion for LC 1x5 and LC 4x5 series

There are various mounting options for the LC 1x5/LC 4x5 encoders that offer fault exclusion for the loosening of the mechanical connection. The fault exclusion applies for all LC 4x5 and LC 1x5 encoders, regardless of the interface.

	Mounting	Fastening ²⁾	Safe position for the mechanical connection ¹⁾	Limitation of specifications
LC 1x5				
Housing		M6 ISO 4762 8.8/A70	±0 µm	No
Scanning unit	Mounting options I and II	M6 ISO 4762 8.8/A70	±0 µm	No
LC 4x5				
Housing	Mounting option I End blocks 12A for M8	M8 ISO 4762 8.8/A70 M8 DIN 6912 8.8	±0 µm	No
	Mounting option III MSL 41 mounting spar ID 770902-xx	M6 ISO 4762 8.8/A70	±0 µm	For acceleration in measuring direction up to 60 m/s ²
Scanning unit	All mounting options	M6 ISO 4762 8.8/A70	±0 µm	No

All of the information provided on screw connections assumes a mounting temperature of 15 °C to 35 °C.
¹⁾ Fault exclusions are given only for the explicitly mentioned mounting options
²⁾ A suitable anti-rotation lock must be used for the screw connections (in the case of mounting/servicing)

 **Further information:**

Adhere to the information in the following documents to ensure the correct and intended operation of the encoder:

• Mounting instructions:

LC 115/LC 195S

LC 415/LC 495S (end block 14A)

(end block 12A)

(mounting spar MSL 41)

743390

737907

737908

894918

• Technical Information:

Safety-Related Position Measuring Systems

596632

For implementation in a control:

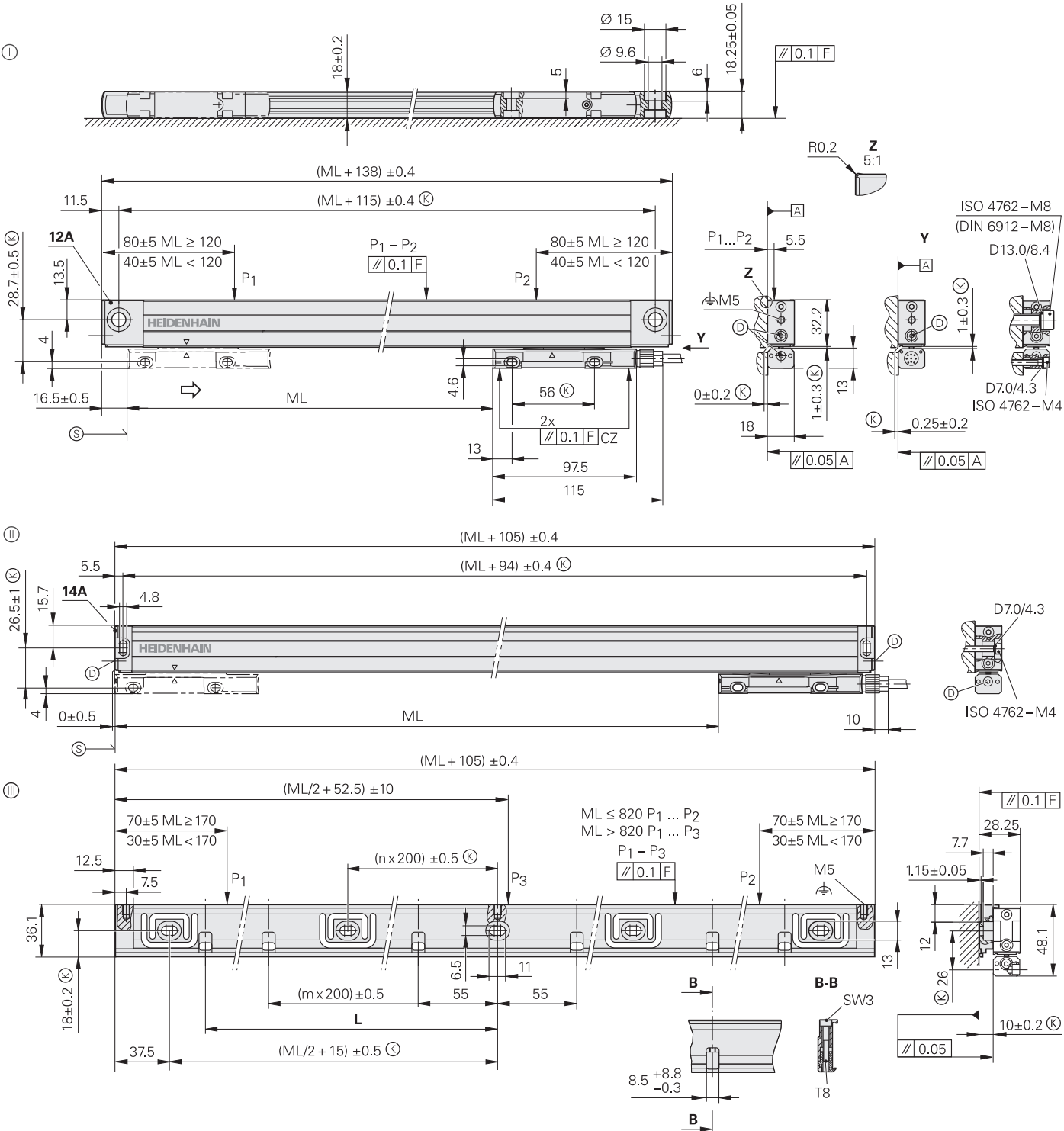
• Specification for Safe Control

533095

LC 400 series

Absolute linear encoders with slimline scale housing

- For limited installation space



ML	70	120	170	220	270	320	370	420	470	520	570	620	670	720	770	820	920	1020	1140	1240	1340	1440	1540	1640	1740	1840	2040
L	37.5	55	75	100	115	140	175	200	225	250	275	300	325	350	375	400	450	500	555	610	655	710	760	810	855	910	1010

- mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm
- ① = End block 12A; for mounting with and without mounting spar
 - ② = End block 14A; for mounting with mounting spar (specifications are restricted if attached directly with M4 screws)
 - ③ = MSL 41 mounting spar
 - F = Machine guideway
 - P = Measuring points for alignment
 - Ⓚ = Required mating dimensions
 - Ⓛ = Compressed air inlet
 - Ⓜ = Beginning of measuring length ML (= 20 mm absolute)
 - = Direction of motion of scanning unit for ascending position values



Specifications	LC 415	LC 415	LC 485
Measuring standard Coefficient of linear expansion	DIADUR glass scale with absolute track and incremental track, grating period: 20 µm $\alpha_{\text{therm}} \approx 8 \cdot 10^{-6} \text{ K}^{-1}$ (mounting mode ①/②); <i>with mounting spar</i> : $\alpha_{\text{therm}} \approx 9 \cdot 10^{-6} \text{ K}^{-1}$ (mounting mode ③)		
Accuracy grade*	±3 µm, ±5 µm		
Measuring length ML* in mm	Mounting spar* or clamping elements* optional up to ML 1240, required as of ML 1340 70 120 170 220 270 320 370 420 470 520 570 620 670 720 770 820 920 1020 1140 1240 1340 1440 1540 1640 1740 1840 2040		
Functional safety for applications with up to	• SIL 2 as per EN 61508 • Category 3, PL “d” as per EN ISO 13849-1:2015		
PFH (per axis)	≤ 15 · 10 ⁻⁹ (up to 6000 m above sea level)		
Safe position ¹⁾	Encoder: ±550 µm (safety-related measuring step SM = 220 µm) <i>Mechanical connection</i> : fault exclusions for the loosening of the housing and scanning unit (page 21)		
Interface	EnDat 2.2		
Ordering designation	EnDat22		EnDat02
Measuring step <i>At ± 3 µm</i> <i>At ± 5 µm</i>	0.001 µm 0.010 µm		0.005 µm 0.010 µm
Clock freq. (calc. time t _{cal})	≤ 16 MHz (≤ 5 µs)		≤ 2 MHz (≤ 5 µs)
Incremental signals	–		~ 1 V _{PP} (20 µm)
Cutoff frequency –3 dB	–		≥ 150 kHz
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable on mounting block		
Cable length	≤ 100 m ²⁾		≤ 150 m ²⁾
Supply voltage	DC 3.6 V to 14 V		
Power consumption (max.)	3.6 V: ≤ 1.1 W; 14 V: ≤ 1.3 W		
Traversing speed	≤ 180 m/min (max. acceleration in measuring direction ≤ 100 m/s ²)		
Required moving force	≤ 5 N		
Vibration 55 Hz to 2000 Hz affecting the	Scanning unit: ≤ 200 m/s ² (EN 60068-2-6) Housing without mounting spar: ≤ 100 m/s ² (EN 60068-2-6) Housing <i>with</i> mounting spar, and cable outlet at right: ≤ 150 m/s ² , left: ≤ 100 m/s ² (EN 60068-2-6)		
Shock 11 ms	≤ 300 m/s ² (EN 60068-2-27)		
Operating temperature	0 °C to 50 °C		
Protection EN 60529 ³⁾	IP53 when installed according to instructions in the brochure, IP64 with sealing air from DA 400		
Mass	Encoder: 0.2 kg + 0.55 kg/m of measuring length; <i>mounting spar</i> : 0.9 kg/m		

* Please select when ordering
1) Further tolerances may occur in subsequent electronics after position value comparison (contact manufacturer of subsequent electronics)
2) With HEIDENHAIN cable (see the *Interfaces of HEIDENHAIN Encoders* brochure)
3) In the application, the LC must be protected from the ingress of particles and liquids

LC 400 series

Absolute linear encoders with slimline scale housing

• For limited installation space

• Identical dimensions for LC 415/LC 485/LC 495



Specifications	LC 495 S	LC 495 S	LC 495 F	LC 495 M	LC 495 P
Measuring standard Coefficient of linear expansion	DIADUR glass scale with absolute track and incremental track, grating period: 20 µm $\alpha_{\text{therm}} \approx 8 \cdot 10^{-6} \text{ K}^{-1}$ (mounting mode ①/②); <i>with mounting spar</i> : $\alpha_{\text{therm}} \approx 9 \cdot 10^{-6} \text{ K}^{-1}$ (mounting mode ③)				
Accuracy grade*	±3 µm, ±5 µm				
Measuring length ML* in mm	Mounting spar* or clamping elements* optional up to ML 1240, required as of ML 1340 70 120 170 220 270 320 370 420 470 520 570 620 670 720 770 820 920 1020 1140 1240 1340 1440 1540 1640 1740 1840 2040				
Functional safety for applications with up to	- SIL 2 as per EN 61508 - Category 3, PL “d” as per EN ISO 13849-1:2015	–			
PFH (per axis)	$25 \cdot 10^{-9}$ (up to 1000 m above sea level NN)	–			
Safe position ¹⁾	<i>Encoder</i> : ±550 µm (safety-related measuring step SM = 220 µm)	–			
	<i>Mechanical connection</i> : fault exclusions for the loosening of the housing and scanning unit (page 21)				
Interface	DRIVE-CLiQ		Fanuc Serial Interface/αi interface	Mitsubishi high speed interface	Panasonic Serial Interface
Ordering designation	DQ01		Fanuc05	Mit03-04	Pana01
Measuring step <i>At ±3 µm</i> <i>At ±5 µm</i>	0.001 µm 0.010 µm		αi interface/α interface 0.00125 µm/0.010 µm 0.0125 µm/0.050 µm	0.001 µm 0.010 µm	
Clock frequency (calculation time t _{cal})	–				
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable on mounting block				
Cable length	≤ 30 m ²⁾		≤ 50 m	≤ 30 m	≤ 50 m
Supply voltage	DC 10 V to 28.8 V		DC 3.6 V to 14 V		
Power consumption (max.)	10 V: ≤ 1.5 W; 28.8 V: ≤ 1.7 W		3.6 V: ≤ 1.1 W; 14 V: ≤ 1.3 W		
Traversing speed	≤ 180 m/min (max. acceleration in measuring direction ≤ 100 m/s ²)				
Required moving force	≤ 5 N				
Vibration 55 Hz to 2000 Hz affecting the	<i>Scanning unit</i> : ≤ 200 m/s ² (EN 60068-2-6) <i>Housing without mounting spar</i> : ≤ 100 m/s ² (EN 60068-2-6) <i>Housing with mounting spar, and cable outlet at right</i> : ≤ 150 m/s ² , <i>left</i> : ≤ 100 m/s ² (EN 60068-2-6)				
Shock 11 ms	≤ 300 m/s ² (EN 60068-2-27)				
Operating temperature	0 °C to 50 °C				
Protection EN 60529 ³⁾	IP53 when installed according to instructions in the brochure, IP64 with sealing air from DA 400				
Mass	<i>Encoder</i> : 0.2 kg + 0.55 kg/m of measuring length; <i>mounting spar</i> : 0.9 kg/m				

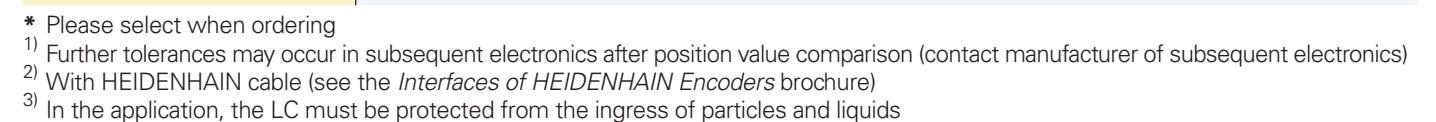
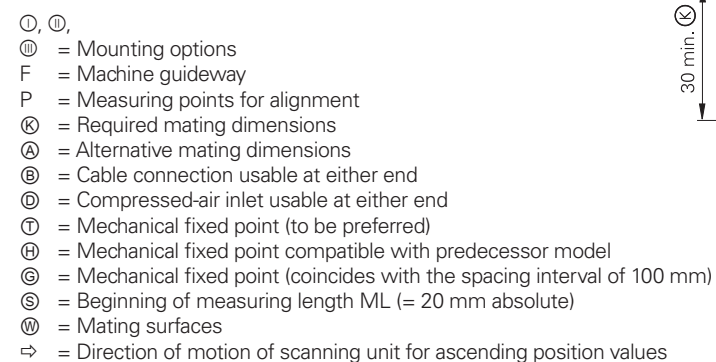
* Please select when ordering

¹⁾ Further tolerances may occur in subsequent electronics after position value comparison (contact manufacturer of subsequent electronics)

²⁾ Greater cable lengths upon request

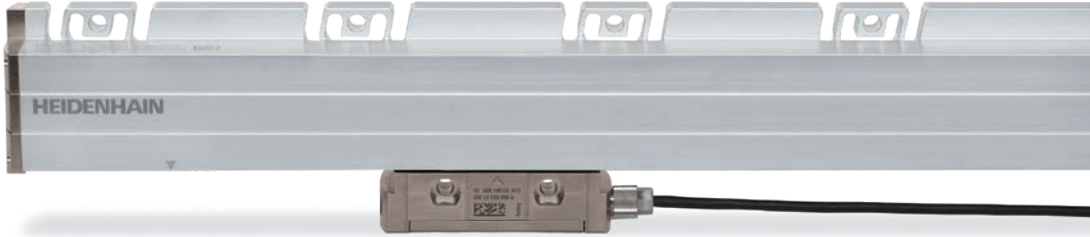
³⁾ In the application, the LC must be protected from the ingress of particles and liquids

- High vibration rating
- Reclining mounting possible
- High reliability through double sealing lips



LC 100 series

- Absolute linear encoders with full-size scale housing
- High vibration rating
 - Reclining mounting possible
 - High reliability through double sealing lips



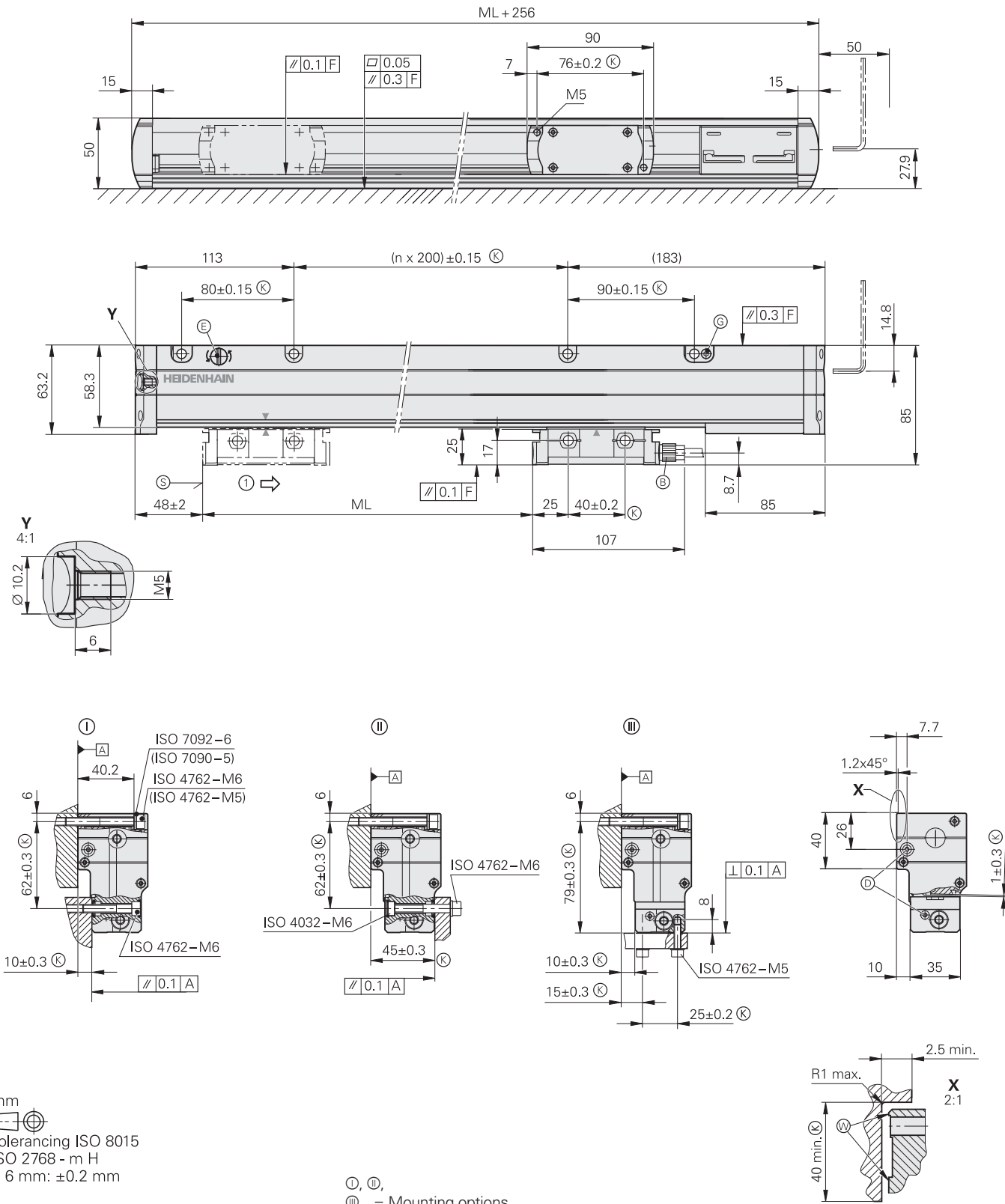
Specifications	LC 195 S	LC 195 S	LC 195 F	LC 195 M	LC 195 P																									
Measuring standard Coefficient of linear expansion	DIADUR glass scale with absolute track and incremental track, grating period: 20 µm $\alpha_{\text{therm}} \approx 8 \cdot 10^{-6} \text{ K}^{-1}$																													
Accuracy grade*	±3 µm up to a measuring length of 3040 mm; ±5 µm			±3 µm up to a measuring length of 2040 mm; ±5 µm	±3 µm up to a measuring length of 3040 mm; ±5 µm																									
Measuring length ML* in mm	140	240	340	440	540	640	740	840	940	1040	1140	1240	1340	1440	1540	1640	1740	1840	2040	2240	2440	2640	2840	3040	3240	3440	3640	3840	4040	4240
Functional safety for applications with up to	- SIL 2 as per EN 61508 - Category 3, PL “d” as per EN ISO 13849-1:2015		–																											
PFH (per axis)	$25 \cdot 10^{-9}$; <i>ML > 3040 mm</i> : $40 \cdot 10^{-9}$ (up to 1000 m above sea level)		–																											
Safe position ¹⁾	<i>Encoder</i> : ±550 µm; <i>ML > 3040 mm</i> : ±2050 µm (safety-related measuring step SM = 220 µm)		–																											
	<i>Mechanical connection</i> : fault exclusions for the loosening of the housing and scanning unit (page 21)																													
Interface	DRIVE-CLiQ										Fanuc Serial Interface/αi interface					Mitsubishi high speed interface					Panasonic Serial Interface									
Ordering designation	DQ01										Fanuc05					Mit03-04					Pana01									
Measuring step <i>At ±3 µm</i> <i>At ±5 µm</i>	0.001 µm 0.010 µm										αi interface/α interface 0.00125 µm/0.010 µm 0.0125 µm/0.050 µm					0.001 µm 0.010 µm														
Clock frequency (calculation time t _{cal})	–																													
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable at either end of mounting block																													
Cable length	≤ 30 m ²⁾										≤ 50 m					≤ 30 m					≤ 50 m									
Supply voltage	DC 10 V to 28.8 V										DC 3.6 V to 14 V																			
Power consumption (max.)	<i>10 V</i> : ≤ 1.5 W; <i>28.8 V</i> : ≤ 1.7 W										<i>3.6 V</i> : ≤ 1.1 W; <i>14 V</i> : ≤ 1.3 W																			
Traversing speed	≤ 180 m/min (max. acceleration ≤ 100 m/s ²)																													
Required moving force	≤ 4 N																													
Vibration 55 Hz to 2000 Hz affecting the Shock 11 ms	<i>Housing</i> : ≤ 200 m/s ² (EN 60068-2-6) <i>Scanning unit</i> : ≤ 200 m/s ² (EN 60068-2-6) ≤ 300 m/s ² (EN 60068-2-27)																													
Operating temperature	0 °C to 50 °C																													
Protection EN 60529 ³⁾	IP53 when installed according to instructions in the brochure, IP64 with sealing air from DA 400																													
Mass	0.55 kg + 2.9 kg/m of measuring length																													

* Please select when ordering
¹⁾ Further tolerances may occur in subsequent electronics after position value comparison (contact manufacturer of subsequent electronics)
²⁾ Greater cable lengths upon request
³⁾ In the application, the LC must be protected from the ingress of particles and liquids

LC 200 series up to 4240 mm (single-section housing)

Absolute linear encoders with full-size scale housing

- Measuring length up to 4240 mm
- Reclining mounting possible
- Also available in mirrored version (mating dimensions upon request)
- Thermal behavior varies depending on the mounting option being used



mm

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

- , ○₁
 III = Mounting options
 F = Machine guideway
 K = Required mating dimensions
 B = Cable connection usable at either end
 D = Compressed-air inlet with integrated throttle usable at either end
 E = Fixed stop
 G = Clamping screw for scale tape
 S = Beginning of measuring length ML (= 100 mm absolute)
 W = Mating surfaces
 → = Direction of motion of scanning unit for ascending position values



Specifications	LC 211				LC 281			LC 291F				LC 291M			
Measuring standard Coefficient of linear expansion	METALLUR steel scale tape with absolute track and incremental track, grating period: 40 µm $\alpha_{\text{therm}} \approx 10 \times 10^{-6} \text{ K}^{-1}$														
Accuracy grade	±5 µm														
Measuring length ML* in mm	440 3240	640 3440	840 3640	1040 3840	1240 4040	1440 4240	1640	1840	2040	2240	2440	2640	2840	3040	
Interface	EnDat 2.2							Fanuc Serial Interface αi interface				Mitsubishi high speed interface			
Ordering designation	EnDat22				EnDat02			Fanuc05				Mit03-04			
Measuring step	0.010 µm							αi interface/α interface 0.0125 µm/0.050 µm				0.010 µm			
Diagnostics interface	Digital														
Clock frequency Calculation time t _{cal}	≤ 16 MHz ≤ 5 µs				≤ 2 MHz ≤ 5 µs			– –							
Incremental signals	–				 1 V _{PP}			–							
Signal period	–				40 µm			–							
Cutoff frequency –3 dB	–				≥ 250 kHz			–							
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable at either end of mounting block														
Cable length ¹⁾	≤ 100 m (at clock frequency ≤ 8 MHz)				≤ 150 m			≤ 50 m				≤ 30 m			
Supply voltage	DC 3.6 V to 14 V														
Power consumption (max.)	At 14 V: ≤ 1.3 W At 3.6 V: ≤ 1.1 W														
Current consumption (typical)	At 5 V: 225 mA (without load)														
Traversing speed	≤ 180 m/min (max. acceleration in measuring direction ≤ 100 m/s ²)														
Required moving force	≤ 15 N														
Vibration 55 Hz bis 2000 Hz affecting the Shock 11 ms	Housing: 200 m/s ² (EN 60068-2-6) Scanning unit: 300 m/s ² (EN 60068-2-6) ≤ 300 m/s ² (EN 60068-2-27)														
Operating temperature	0 °C to 50 °C														
Protection EN 60529	IP53 when installed according to mounting instructions, IP64 with sealing air from DA 400														
Mass	1.3 kg + 3.6 kg/m of measuring length														

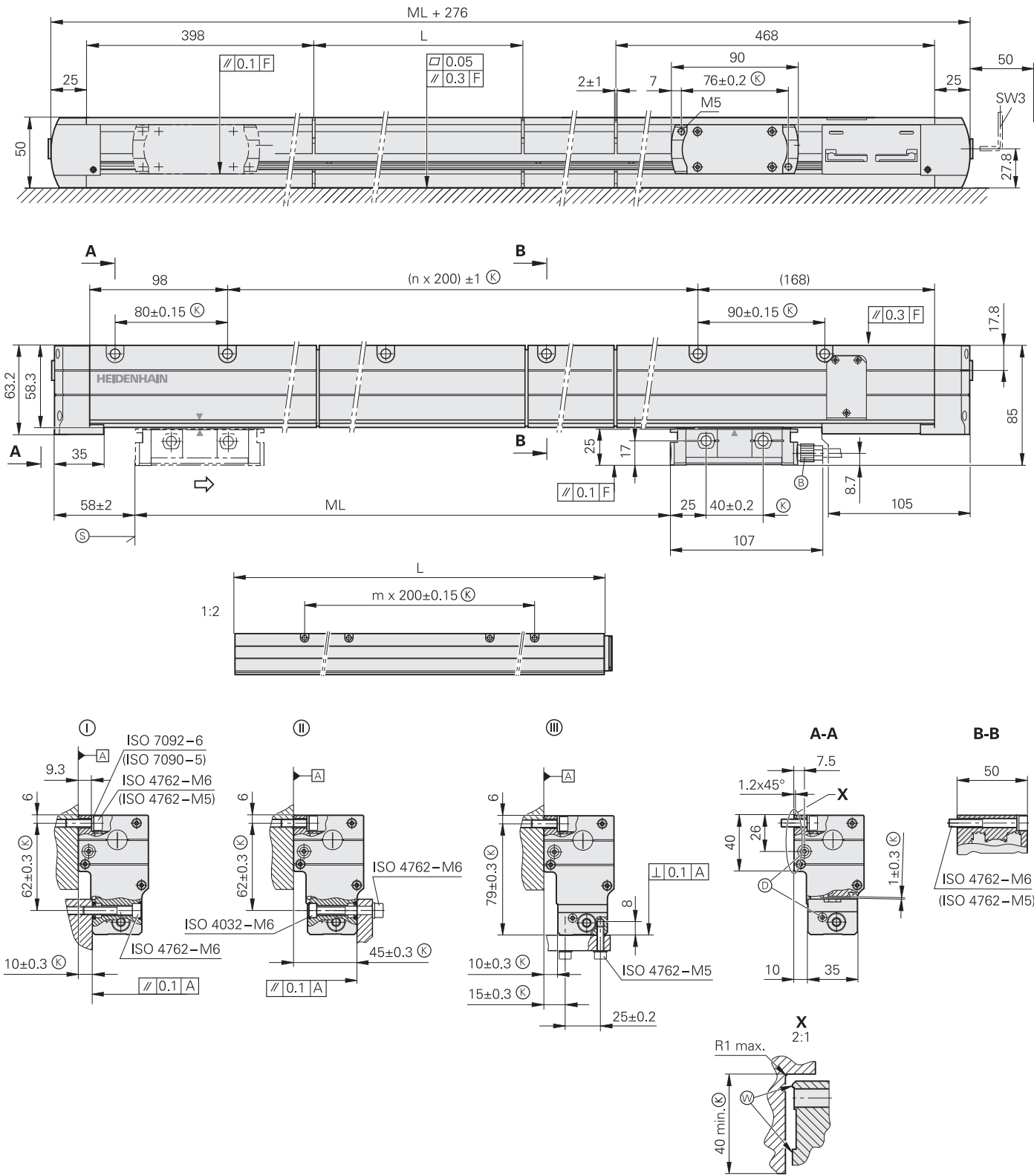
* Please select when ordering

1) With HEIDENHAIN cable

LC 200 series up to 28 040 mm (multi-section housing)

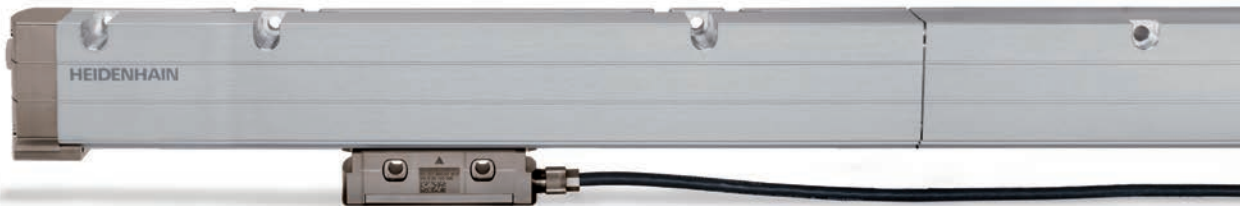
Absolute linear encoders with full-size scale housing

- Measuring lengths up to 28 m
- Simplified mounting (upright or reclining)
- Also available in mirrored version (mating dimensions upon request)



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

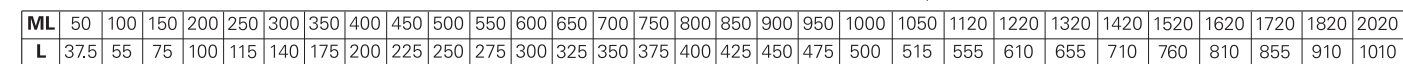
- ①, ②, ③ = Mounting options
- F = Machine guideway
- L = Housing section lengths
- Ⓚ = Required mating dimensions
- Ⓟ = Cable connection usable at either end
- Ⓢ = Compressed-air inlet usable at either end
- Ⓣ = Beginning of measuring length ML (= 100 mm absolute)
- Ⓜ = Mating surfaces
- ⇒ = Direction of motion of scanning unit for ascending position values



Specifications	LC 211	LC 281	LC 291 F	LC 291 M
Measuring standard Coefficient of linear expansion	METALLUR steel scale tape with absolute track and incremental track, grating period: 40 µm Same as machine base (e.g., $\alpha_{\text{therm}} \approx 10 \cdot 10^{-6} \text{ K}^{-1}$ for gray cast iron)			
Accuracy grade	±5 µm			
Measuring length ML* in mm	3240 mm to 28040 mm in steps of 200 mm ²⁾ Kit with single-section METALLUR steel scale tape and housing sections			
Interface	EnDat 2.2		Fanuc Serial Interface αi interface	Mitsubishi high speed interface
Ordering designation	EnDat22	EnDat02	Fanuc05	Mit03-04
Measuring step	0.010 µm		αi interface/α interface 0.0125 µm/0.050 µm	0.010 µm
Diagnostics interface	Digital			
Clock frequency Calculation time t_{cal}	≤ 16 MHz ≤ 5 µs	≤ 2 MHz ≤ 5 µs	–	–
Incremental signals	–	~ 1 V _{pp}	–	–
Signal period	–	40 µm	–	–
Cutoff frequency –3 dB	–	≥ 250 kHz	–	–
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable at either end of mounting block			
Cable length ¹⁾	≤ 100 m (at clock frequency ≤ 8 MHz)	≤ 150 m	≤ 50 m	≤ 30 m
Supply voltage	DC 3.6 V to 14 V			
Power consumption (max.)	At 14 V: ≤ 1.3 W At 3.6 V: ≤ 1.1 W			
Current consumption (typical)	At 5 V: 225 mA (without load)			
Traversing speed	≤ 180 m/min (max. acceleration in measuring direction ≤ 100 m/s ²)			
Required moving force	≤ 15 N			
Vibration 55 Hz to 2000 Hz affecting the Shock 11 ms	Housing: 200 m/s ² (EN 60068-2-6) Scanning unit: 300 m/s ² (EN 60068-2-6) ≤ 300 m/s ² (EN 60068-2-27)			
Operating temperature	0 °C to 50 °C			
Protection EN 60529	IP53 when installed according to mounting instructions, IP64 with sealing air from DA 400			
Mass	1.3 kg + 3.6 kg/m of measuring length			

* Please select when ordering
¹⁾ With HEIDENHAIN cable
²⁾ LC 291 M up to 20040 mm

- Incremental linear encoders with slimline scale housing
- Very high repeatability
- Thermal behavior similar to steel or gray cast iron
- For limited installation space



- ① = End block 12A; for mounting with and without mounting spar
- ② = End block 11A; for mounting with mounting spar
- ③ = Mounting spar MSL 41
- F = Machine guideway
- P = Measuring points for alignment
- Ⓚ = Required mating dimensions

Ⓡ = Reference mark position on LF 485
Two reference marks for measuring lengths

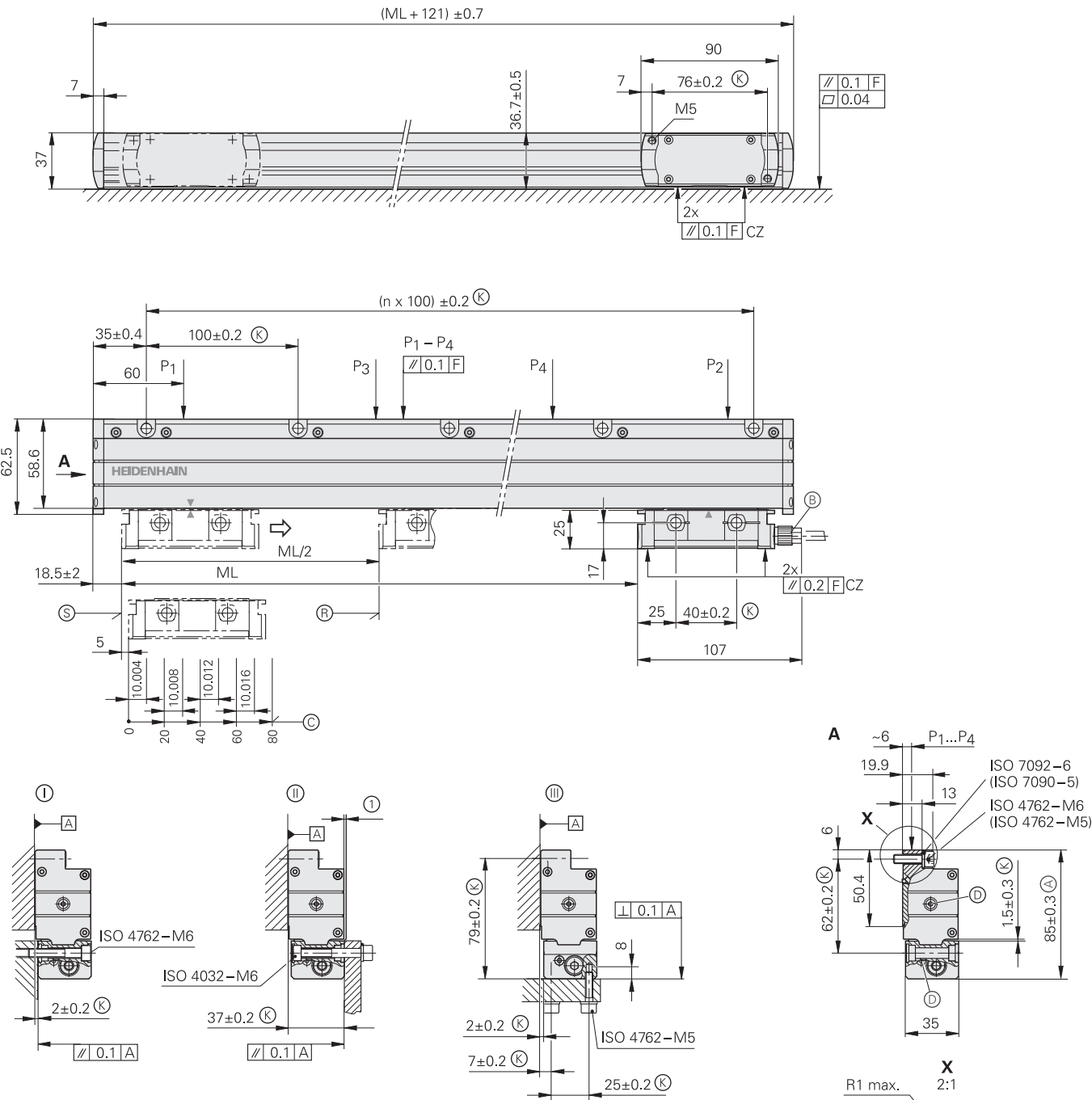
50 ... 1000	1120 ... 1220
$z = 25 \text{ mm}$	$z = 35 \text{ mm}$
$z_1 = ML - 50 \text{ mm}$	$z_1 = ML - 70 \text{ mm}$

Ⓢ = Reference mark position on LF 485 C
Ⓢ = Compressed air inlet
Ⓢ = Beginning of measuring length (ML)
⇒ = Direction of motion of scanning unit for ascending position values

* Please select when ordering

LF 185

- Incremental linear encoders with full-size scale housing
- Very high repeatability
 - Thermal behavior similar to steel or gray cast iron
 - Reclining mounting possible



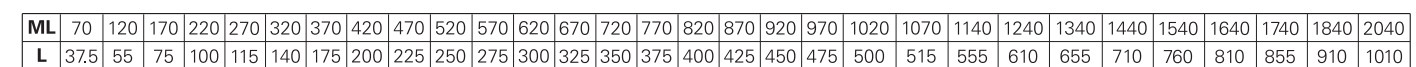
- mm
- Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm
- ①, ②, ③ = Mounting options
F = Machine guideway
P = Measuring points for alignment
ML = Measuring length
Ⓚ = Required mating dimensions
Ⓐ = Alternative mating dimensions
Ⓑ = Cable connection usable at either end
Ⓓ = Compressed-air inlet usable at either end
Ⓔ = Beginning of measuring length (ML)
Ⓕ = Reference mark position on LF 185
Ⓖ = Reference mark position on LF 185C
Ⓜ = Mating surfaces
① = Not an alternative mating dimension, as opposed to LS/LC 100
⇒ = Direction of motion of scanning unit for ascending position values

Specifications	LF 185
Measuring standard Coefficient of linear expansion	SUPRADUR phase grating on steel, grating period: 8 µm $\alpha_{\text{therm}} \approx 10 \cdot 10^{-6} \text{ K}^{-1}$
Accuracy grade*	±3 µm; ±2 µm
Measuring length ML* in mm	140 240 340 440 540 640 740 840 940 1040 1140 1240 1340 1440 1540 1640 1740 1840 2040 2240 2440 2640 2840 3040
Interface	~ 1 V _{PP}
Signal period	4 µm
Reference marks* LF 185 LF 185C	One reference mark at midpoint; other reference mark positions upon request Distance-coded
Diagnostics interface	Analog
Cutoff frequency -3 dB	≥ 250 kHz
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable on mounting block
Cable length	≤ 150 m (with HEIDENHAIN cable)
Supply voltage without load	DC 5 V ±0.25 V/< 150 mA
Traversing speed	≤ 60 m/min (max. acceleration in measuring direction ≤ 100 m/s ²)
Required moving force	≤ 4 N
Vibration 55 Hz to 2000 Hz affecting the Shock 11 ms	Housing: ≤ 150 m/s ² (EN 60068-2-6) Scanning unit: ≤ 200 m/s ² (EN 60068-2-6) ≤ 300 m/s ² (EN 60068-2-27)
Operating temperature	0 °C to 50 °C
Protection EN 60529	IP53 when installed according to instructions in the brochure IP64 with sealing air from DA 400
Mass	0.8 kg + 4.6 kg/m of measuring length

* Please select when ordering

Incremental linear encoders with slimline scale housing

- For limited installation space



® = Reference mark position on LS 4x7
 Two reference marks for measuring lengths

70 ... 1020	1140 ... 2040
$z = 35 \text{ mm}$	$z = 45 \text{ mm}$
$z_1 = \text{ML} - 70 \text{ mm}$	$z_1 = \text{ML} - 90 \text{ mm}$

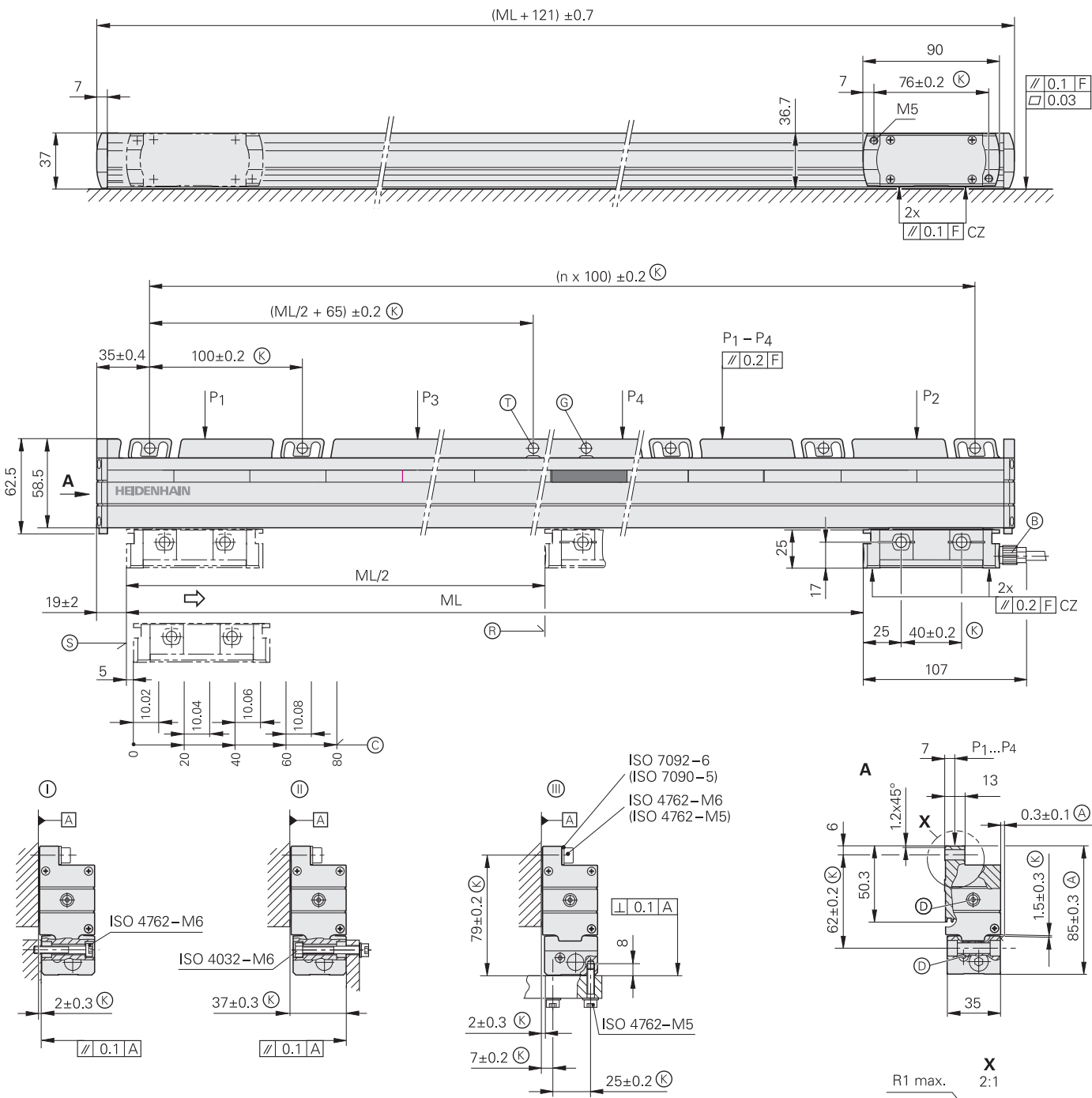
© = Reference mark position on LS 4x7 C
 ® = Compressed air inlet
 Ⓢ = Beginning of measuring length (ML)
 ⇨ = Direction of motion of scanning unit for ascending position values

[illegible]

- * Please select when ordering
- 1) After 4-fold evaluation in the subsequent electronics
- 2) With HEIDENHAIN cable

LS 100 series

- Incremental linear encoders with full-size scale housing
- High vibration rating
 - Reclining mounting possible



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

- ①, ②,
③ = Mounting options
F = Machine guideway
P = Measuring points for alignment
Ⓚ = Required mating dimensions
Ⓐ = Alternative mating dimensions
Ⓢ = Cable connection usable at either end
Ⓣ = Compressed-air inlet usable at either end
Ⓤ = Mechanical fixed point (to be preferred)
Ⓦ = Mechanical fixed point (coincides with the spacing interval of 100 mm)
Ⓡ = Reference mark position on LS 1x7
Ⓢ = Reference mark position on LS 1x7C
Ⓣ = Beginning of measuring length (ML)
Ⓤ = Mating surfaces
⇒ = Direction of motion of scanning unit for ascending position values

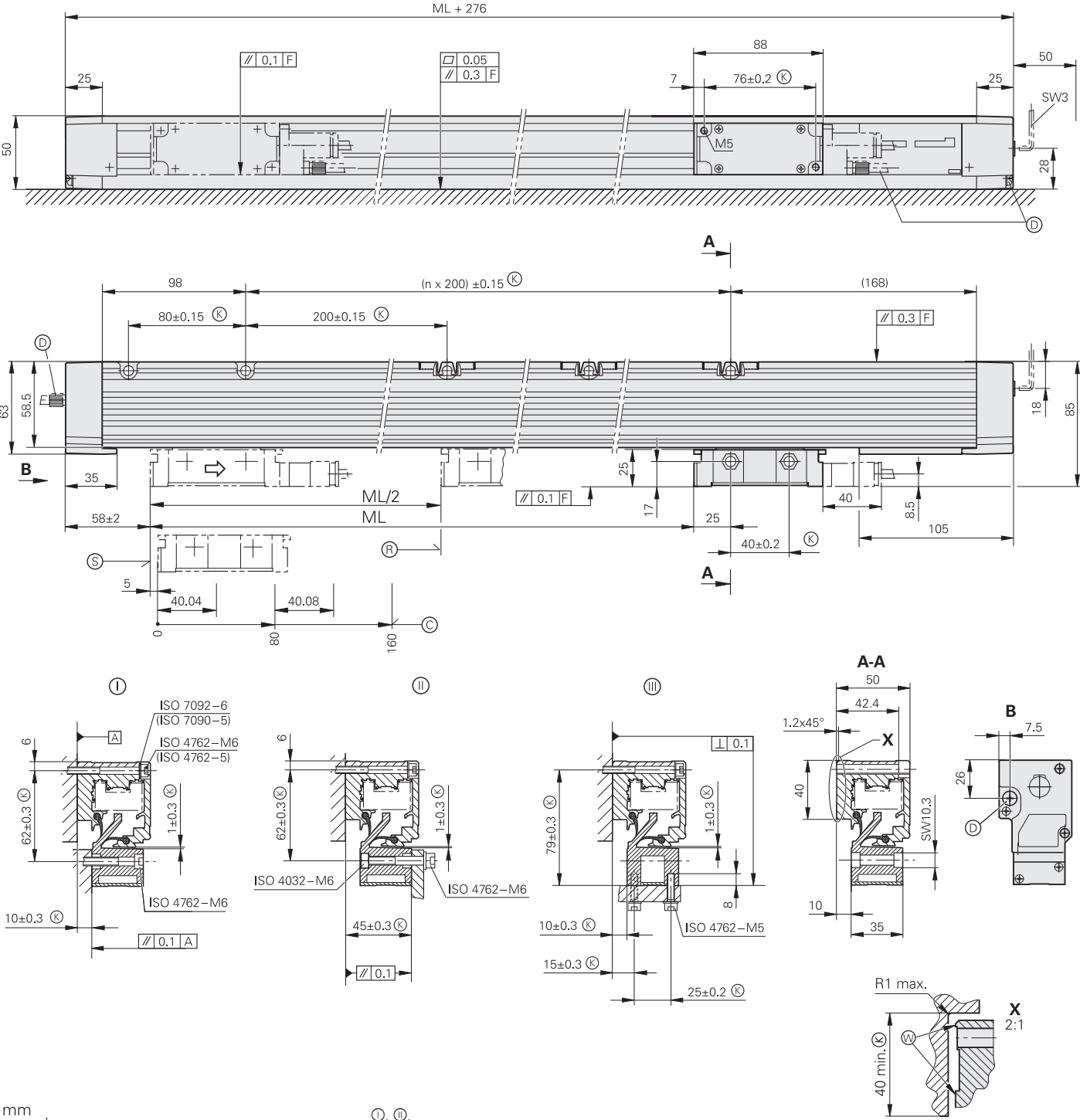
Specifications	LS 187				LS 177													
Measuring standard Coefficient of linear expansion	Glass scale with DIADUR grating, grating period: 20 µm $\alpha_{\text{therm}} \approx 8 \cdot 10^{-6} \text{ K}^{-1}$																	
Accuracy grade*	±5 µm; ±3 µm																	
Measuring length ML* in mm	140 1540	240 1640	340 1740	440 1840	540 2040	640 2240	740 2440	840 2640	940 2840	1040 3040	1140	1240	1340	1440				
Reference marks* LS 1x7 LS 1x7C	Selectable with magnets every 50 mm; standard setting: one reference mark in the center Distance-coded																	
Interface	 1 V _{PP}				 TTL													
Integrated interpolation* Signal period	– 20 µm				5-fold –			10-fold –			20-fold –							
Diagnostics interface	Analog				–													
Cutoff frequency –3 dB	≥ 160 kHz				–			–			–							
Scanning frequency* Edge separation <i>a</i>	–				100 kHz ≥ 0.5 µs		50 kHz ≥ 1 µs		100 kHz ≥ 0.25 µs		50 kHz ≥ 0.5 µs		25 kHz ≥ 1 µs		50 kHz ≥ 0.25 µs		25 kHz ≥ 0.5 µs	
Measuring step	Depends on interpolation				1 µm ¹⁾			0.5 µm ¹⁾			0.25 µm ¹⁾							
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable on mounting block																	
Cable length ²⁾	≤ 150 m				≤ 100 m													
Supply voltage without load	DC 5 V ±0.25 V/< 120 mA				DC 5 V ±0.25 V/< 140 mA													
Traversing speed	≤ 120 m/min				≤ 120 m/min		≤ 60 m/min		≤ 120 m/min		≤ 60 m/min		≤ 30 m/min		≤ 60 m/min		≤ 30 m/min	
Required moving force	≤ 4 N																	
Vibration 55 Hz to 2000 Hz Shock 11 ms Acceleration	≤ 200 m/s ² (EN 60068-2-6) ≤ 400 m/s ² (EN 60068-2-27) ≤ 60 m/s ² in measuring direction																	
Operating temperature	0 °C to 50 °C																	
Protection EN 60529	IP53 when mounted according to the mounting information and instructions IP64 with compressed air from DA 400																	
Mass	0.4 kg + 2.3 kg/m of measuring length																	

* Please select when ordering
1) After 4-fold evaluation in the subsequent electronics
2) With HEIDENHAIN cable

LB 382 up to 3040 mm (single-section housing)

Incremental linear encoders with full-size scale housing

- Reclining mounting possible
- Also available in mirrored version (mating dimensions upon request)



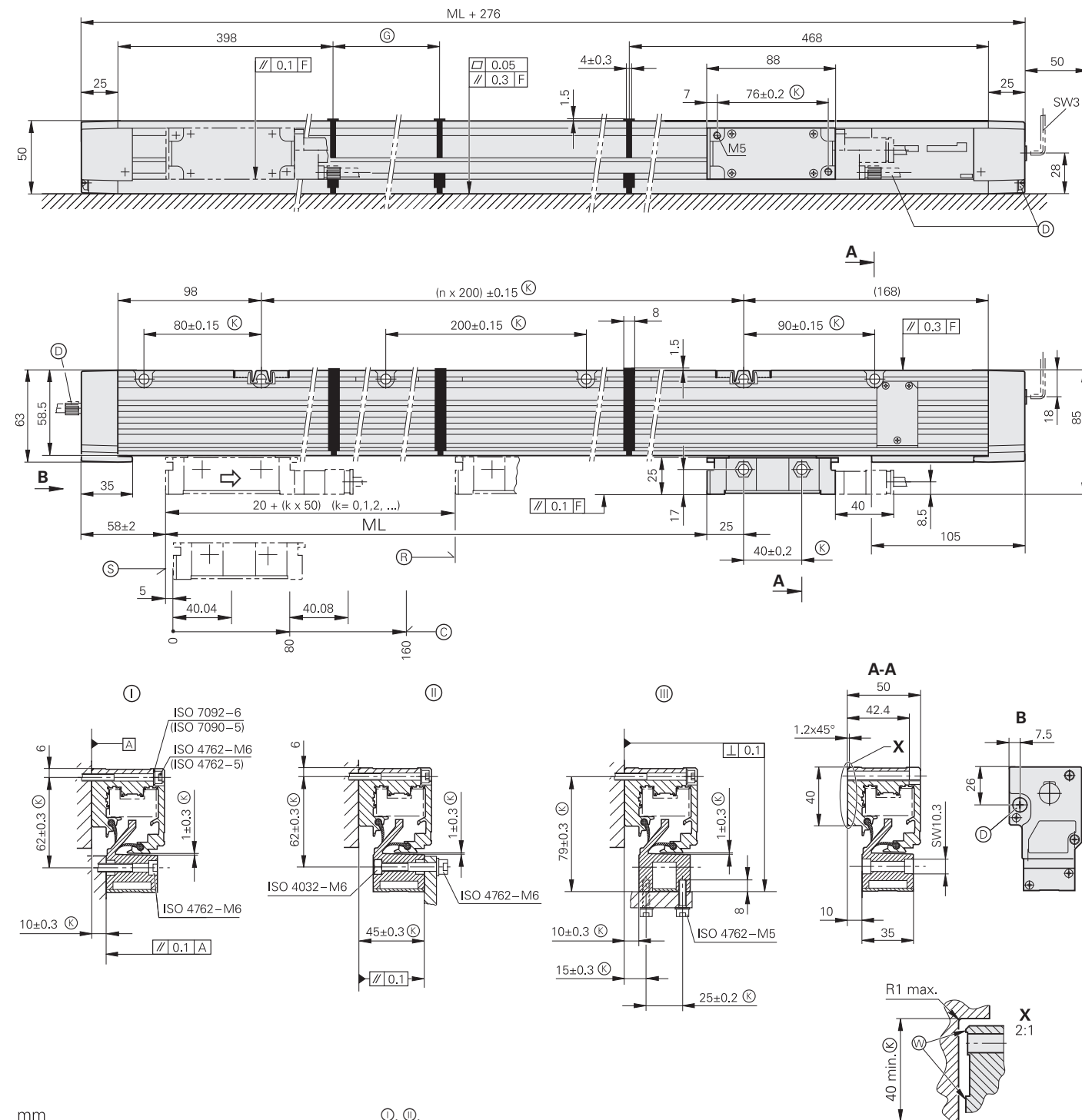
- mm
 Tolerancing ISO 8015
 ISO 2768 - m H
 < 6 mm: ± 0.2 mm
- I, II, III = Mounting options
 F = Machine guideway
 K = Required mating dimensions
 D = Compressed air inlet
 R = Reference mark position on LB 3x2
 C = Reference mark position on LB 3x2 C
 S = Beginning of measuring length (ML)
 W = Mating surfaces
 → = Direction of motion of scanning unit for ascending position values



Specifications	LB 382 up to ML 3040 mm
Measuring standard Coefficient of linear expansion	METALLUR steel scale tape, grating period: 40 µm $\alpha_{\text{therm}} \approx 10 \cdot 10^{-6} \text{ K}^{-1}$
Accuracy grade	$\pm 5 \text{ µm}$
Measuring length ML* in mm	Single-section housing 440 640 840 1040 1240 1440 1640 1840 2040 2240 2440 2640 2840 3040
Reference mark* LB 382 LB 382 C	Selectable by selector plate every 50 mm; standard setting: one reference mark in the center Distance-coded
Interface	$\sim 1 \text{ V}_{\text{PP}}$
Signal period	40 µm
Diagnostics interface	Analog
Cutoff frequency	-3 dB $\geq 250 \text{ kHz}$
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable on mounting block
Cable length ¹⁾	$\leq 150 \text{ m}$
Supply voltage without load	DC 5 V $\pm 0.25 \text{ V}$ / < 150 mA
Traversing speed	$\leq 120 \text{ m/min}$ (max. acceleration in measuring direction $\leq 60 \text{ m/s}^2$)
Required moving force	$\leq 15 \text{ N}$
Vibration 55 Hz to 2000 Hz Shock 11 ms	$\leq 300 \text{ m/s}^2$ (EN 60068-2-6) $\leq 300 \text{ m/s}^2$ (EN 60068-2-27)
Operating temperature	0 °C to 50 °C
Protection EN 60529	IP53 when mounted according to the mounting information and instructions IP64 with compressed air from DA 400
Mass	1.3 kg + 3.6 kg/m of measuring length

* Please select when ordering
 1) With HEIDENHAIN cable

- Measuring lengths up to 30 m (up to 72 m upon request)
- Reclining mounting possible
- Also available in mirrored version (mating dimensions upon request)



mm

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

- ①, ①₁
- Ⓜ = Mounting options
- F = Machine guideway
- Ⓚ = Required mating dimensions
- Ⓓ = Compressed air inlet
- Ⓡ = Reference mark position on LB 3x2
- Ⓒ = Reference mark position on LB 3x2 C
- Ⓢ = Beginning of measuring length (ML)
- Ⓔ = Housing section lengths
- Ⓦ = Mating surfaces
- = Direction of motion of scanning unit for ascending position values

* Please select when ordering
1) With HEIDENHAIN cable

Testing equipment and diagnostics

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

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

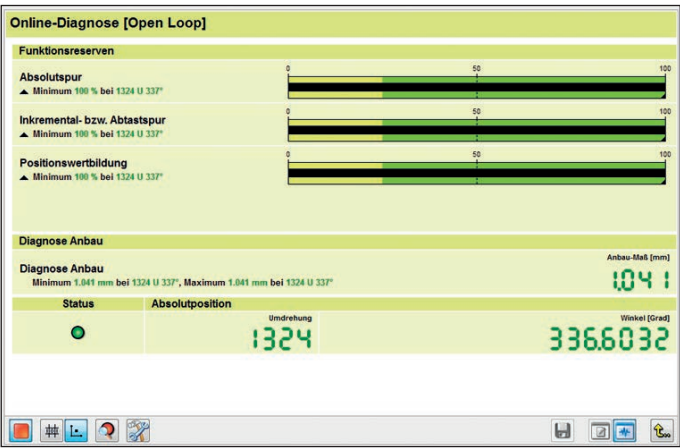
Absolute encoders use serial data transmission. Depending on the interface, additional 1 VPP incremental signals can be output. The signals are comprehensively monitored within the encoder. The monitoring result (particularly in the case of valuation numbers) can be transmitted to the subsequent electronics along with the position values via the serial interface (digital diagnostics interface). The following information is available:

- Error message: position value is not reliable
- Warning: 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 reading is possible

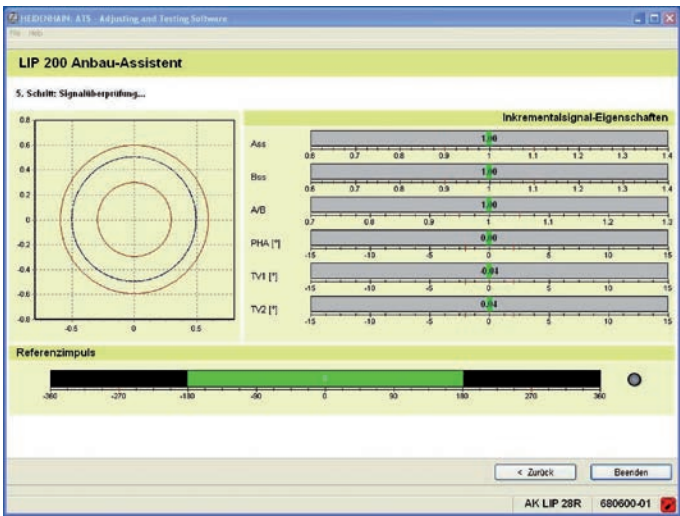
This enables the subsequent electronics to evaluate the current status of the encoder with little effort, even in closed-loop mode.

For the analysis of these encoders, HEIDENHAIN offers the appropriate PWM inspection devices and PWT testing devices. Depending on how these devices are integrated, a differentiation is made between two types of diagnostics:

- Encoder diagnostics: The encoder is connected directly to the testing or inspection device. This makes a detailed analysis of encoder functions possible.
- Monitoring mode: The PWM testing unit is linked into the closed control loop (e.g., via a suitable testing adapter). This enables real-time diagnosis of the machine or system during operation. The available functions depend on the interface.



Diagnostics using PWM 21 and ATS software



Commissioning using PWM 21 and ATS software

Further information:

For comprehensive descriptions of testing equipment and diagnostics, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure.

Related documents

Linear encoders



Brochure
Cables and Connectors

Contents:
Technical properties, cable overviews, and cable lists



Brochure
Interfaces of HEIDENHAIN Encoders

Contents:
Information on serial interfaces, sinusoidal signals, square-wave signals, and commutation signals

Further HEIDENHAIN products



Brochures
TNC 128 Straight-Cut Control
TNC 320 Contouring Control
iTNC 530 Contouring Control
TNC 620 Contouring Control
TNC 640 Contouring Control

Contents:
Information for the user



OEM brochures
TNC 128 Straight-Cut Control
TNC 320 Contouring Control
iTNC 530 Contouring Control
TNC 620 Contouring Control
TNC 640 Contouring Control

Contents:
Information for the machine tool builder



Brochures
MANUALplus 620 Contouring Control
CNC PILOT 640 Contouring Control

Contents:
Information for the user



OEM brochures
MANUALplus 620 Contouring Control
CNC PILOT 640 Contouring Control

Contents:
Information for the machine tool builder



Brochure
Encoders for Servo Drives

Contents:
Rotary encoders
Angle encoders
Linear encoders



Brochure
Angle Encoders with Integral Bearing

Contents:
Absolute angle encoders
RCN, ECN
Incremental angle encoders
RON, RPN, ROD



Brochure
Angle Encoder Modules

Contents:
Angle encoder modules
MRP2000, MRP5000, MRP8000
Angle encoder modules with integrated torque motor **SRP5000, AccurET**



Brochure
Modular Angle Encoders
With Optical Scanning

Contents:
Incremental angle encoders
ERP, ERO, ERA



Brochure
Touch Probes

Contents:
Tool touch probes
TT
Workpiece touch probes
TS



Brochure
Measuring Devices For Machine Tool
Inspection and Acceptance Testing

Contents:
Incremental linear encoders
KGM, VM

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