



# HEIDENHAIN



## Linear Encoders

For Numerically Controlled  
Machine Tools

June 2017



Further information is available on the Internet at [www.heidenhain.de](http://www.heidenhain.de) as well as upon request.

Brochures:

- 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 brochures:

- 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:**

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

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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 servo loop, such as milling machines, machining centers, boring machines, 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 slide, and corrected by the control electronics. This makes it possible to eliminate 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.

## Mechanical design

Linear encoders for servo-controlled machine tools are sealed measuring devices: an aluminum housing protects the scale, the scanning carriage and its guide against 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 guideways.

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



### Further information:

Please request further documentation or inform yourself on the Internet at [www.heidenhain.de](http://www.heidenhain.de)



### 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 thermal expansion (see *Specifications*). This makes it possible to select the linear encoder whose thermal behavior is best suited to the application.

### Dynamic behavior

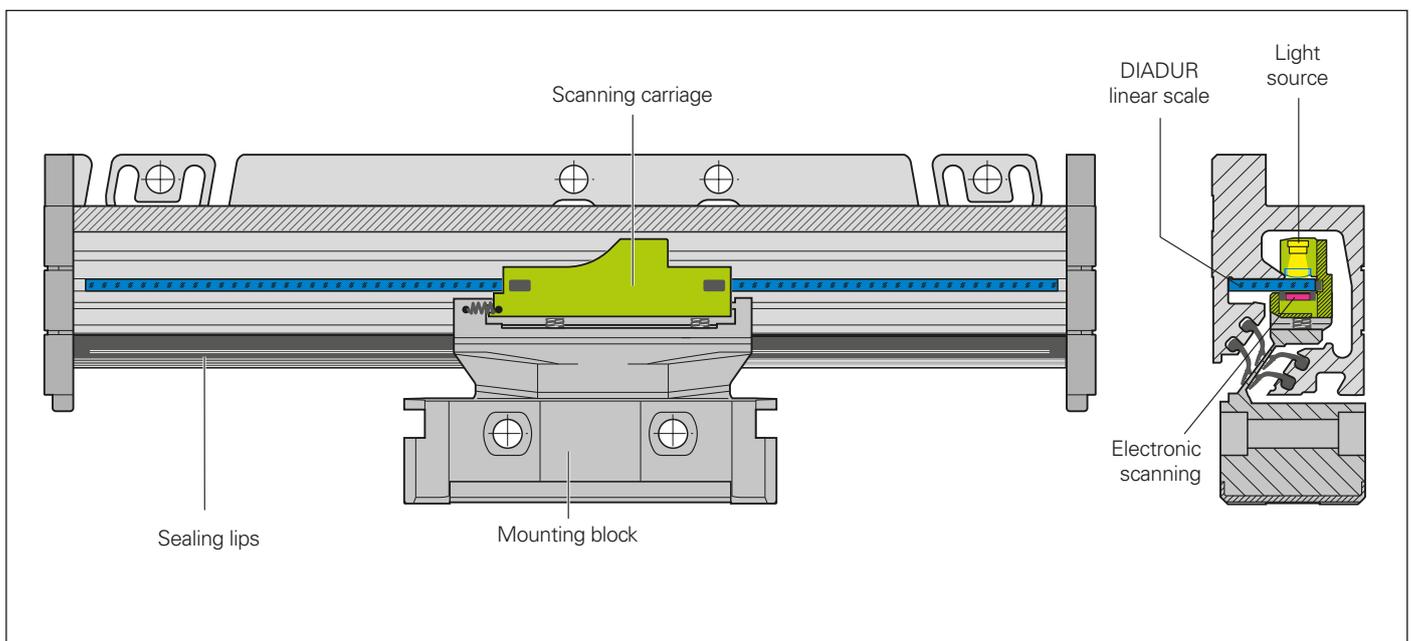
Efficiency and performance improvements in machine tools require ever higher feed rates and accelerations. Of course, they must not compromise machining accuracy. In order to transfer rapid and yet exact feed motions, very high demands are placed on rigid machine design as well as on the linear encoders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

Linear encoders from HEIDENHAIN are characterized by their high rigidity in the measuring direction. This is a very important prerequisite for high-quality path accuracies on 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. Therefore, robust 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. The contact-free principle of photoelectrically scanning the measuring standard, as well as the ball-bearing guidance of the scanning carriage in the scale housing ensure a long lifetime. Through 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.

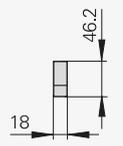
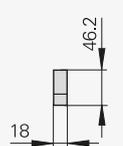
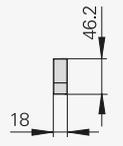


Schematic design of the **LC 115** sealed linear encoder

# Selection guide

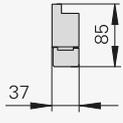
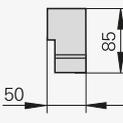
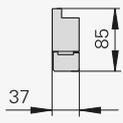
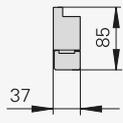
## Linear encoders with slimline scale housing

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)
<b>Absolute position measurement</b> <ul style="list-style-type: none"> <li>Glass scale</li> </ul>		± 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
<b>Incremental linear measurement with very high repeatability</b> <ul style="list-style-type: none"> <li>Steel scale</li> <li>Small signal period</li> </ul>		± 5 µm ± 3 µm	± 0.04 µm	50 mm to 1220 mm
<b>Incremental linear measurement</b> <ul style="list-style-type: none"> <li>Glass scale</li> </ul>		± 5 µm ± 3 µm	± 0.2 µm	70 mm to 1240 mm <i>with mounting spar:</i> 70 mm to 2040 mm

## Linear encoders with full-size scale housing

Linear encoders with **full-size scale housing** are characterized by their **sturdy construction, 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.

<b>Absolute position measurement</b> <ul style="list-style-type: none"> <li>Glass scale</li> </ul>		± 5 µm ± 3 µm	±0.1 µm <sup>1)</sup>	140 mm to 4240 mm
<b>Absolute position measurement</b> For large measuring lengths <ul style="list-style-type: none"> <li>Steel scale tape</li> </ul>		± 5 µm	±0.4 µm	3240 mm to 28040 mm
<b>Incremental linear measurement with very high repeatability</b> <ul style="list-style-type: none"> <li>Steel scale</li> <li>Small signal period</li> </ul>		± 3 µm ± 2 µm	± 0.04 µm	140 mm to 3040 mm
<b>Incremental linear measurement</b> <ul style="list-style-type: none"> <li>Glass scale</li> </ul>		± 5 µm ± 3 µm	± 0.2 µm	140 mm to 3040 mm
<b>Incremental linear measurement for large measuring lengths</b> <ul style="list-style-type: none"> <li>Steel scale tape</li> </ul>		± 5 µm	±0.8 µm	440 mm to 30040 mm Up to 72040 mm upon request

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

Signal period	Interface	Type	Page
–	EnDat 2.2	LC 415 <sup>2)</sup>	22
20 μm	EnDat 2.2 with $\sim 1 V_{PP}$	LC 485	
–	DRIVE-CLiQ	LC 495 S	24
	Fanuc $\alpha$ i	LC 495 F	
	Mitsubishi	LC 495 M	
	Panasonic	LC 495 P	
4 μm	$\sim 1 V_{PP}$	LF 485	32
20 μm	$\sim 1 V_{PP}$	LS 487	36
–	$\square$ TTL	LS 477	
–	EnDat 2.2	LC 115 <sup>2)</sup>	26
20 μm	EnDat 2.2 with $\sim 1 V_{PP}$	LC 185	
–	DRIVE-CLiQ	LC 195 S	28
	Fanuc $\alpha$ i	LC 195 F	
	Mitsubishi	LC 195 M	
	Panasonic	LC 195 P	
–	EnDat 2.2	LC 211	30
40 μm	EnDat 2.2 with $\sim 1 V_{PP}$	LC 281	
–	Fanuc $\alpha$ i	LC 291 F	
–	Mitsubishi	LC 291 M	
4 μm	$\sim 1 V_{PP}$	LF 185	34
20 μm	$\sim 1 V_{PP}$	LS 187	38
–	$\square$ TTL	LS 177	
40 μm	$\sim 1 V_{PP}$	LB 382	40



LC 415



LF 485  
LS 487



LC 115



LF 185



LC 211

<sup>2)</sup> Connectable to Yaskawa interface via EIB 3391 Y

# 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.

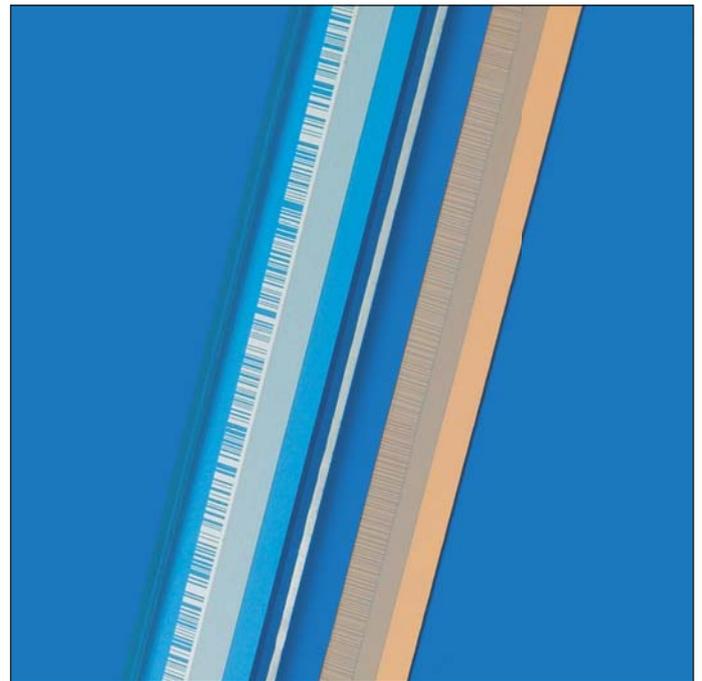
- AURODUR: matte-etched lines on gold-plated steel tape with typical graduation period of 40  $\mu\text{m}$
- METALLUR: contamination-tolerant graduation of metal lines on gold, with typical graduation period of 20  $\mu\text{m}$
- DIADUR: extremely robust chromium lines on glass (typical graduation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

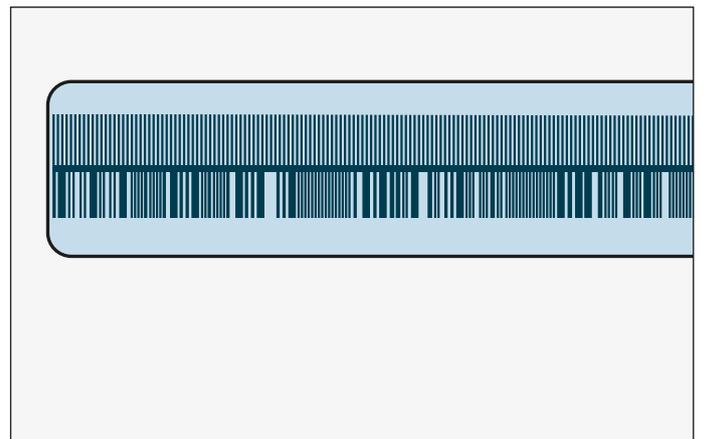
The master graduations are manufactured by HEIDENHAIN on custom-built high-precision dividing engines.

## 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 scale graduation**, which is formed from a serial absolute code structure. A separate incremental track is interpolated for the position value and at the same time is used to generate an optional incremental signal.



Graduations of absolute linear encoders



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

# Incremental measuring method

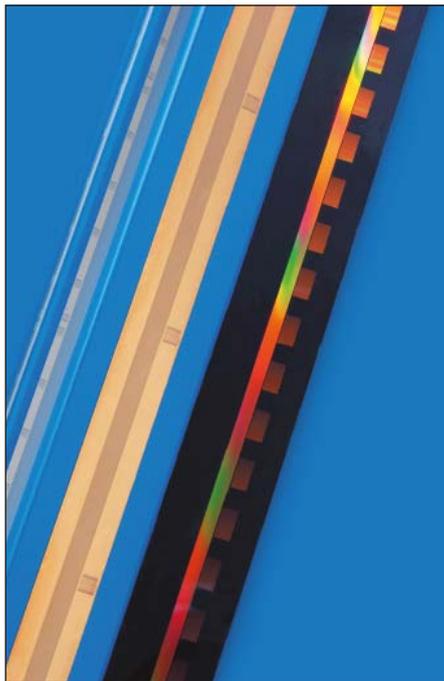
With the **incremental measuring method**, the graduation consists of a periodic grating structure. The position information is obtained **by counting** the individual increments (measuring steps) from some point of origin. Since an absolute reference is required to ascertain positions, the scales or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

Encoders with distance-coded reference marks are identified with a "C" ending the model designation (e.g. LS 487 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

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

and

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

Where:

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

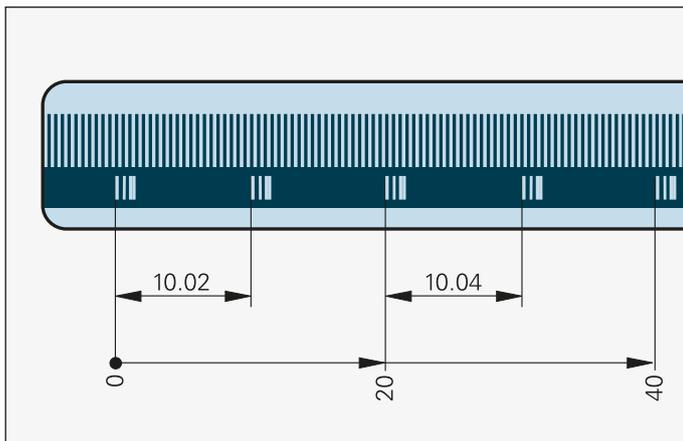
abs = Absolute value

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.



Simplified representation of an incremental graduation with distance-coded reference marks (example using LS)

	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 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 linear encoders use two scanning principles:

- The **imaging scanning principle** for grating periods from 20  $\mu\text{m}$  and 40  $\mu\text{m}$
- The **interferential scanning principle** for very fine graduations with grating periods of, for example, 8  $\mu\text{m}$ .

## Imaging principle

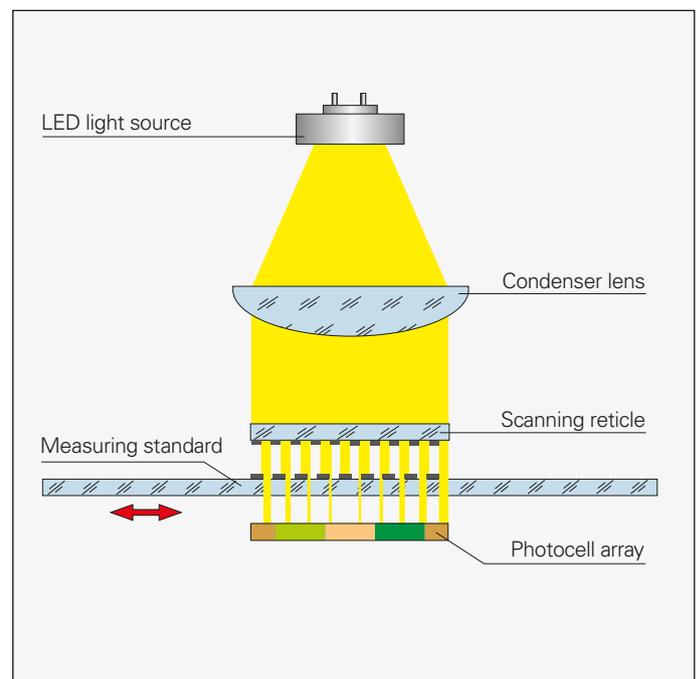
To put it simply, the imaging scanning principle functions by means of projected-light signal generation: Two scale gratings with equal or similar grating periods are moved relative to each other—the measuring standard and the scanning reticle. The carrier material of the scanning reticle is transparent,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

When parallel light passes through a grating, light and dark surfaces are projected at a certain distance. An index grating 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. 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 period of the grating structure is, the closer and more tightly toleranced the gap must be between the scanning reticle and scale.

The LC, LS and LB linear encoders operate according to the imaging scanning principle.

Imaging principle



**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.

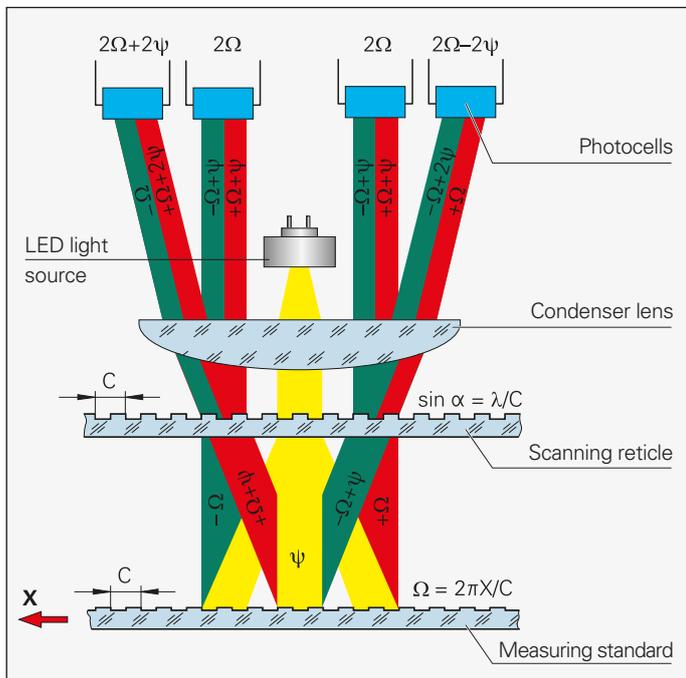
A relative motion of the scanning reticle to the scale causes the diffracted wave fronts to undergo a phase shift: When the grating moves by one period, the wave front of the first order is displaced by one wavelength in the positive direction, and the wavelength of diffraction order -1 is displaced 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 small measuring steps and high accuracy.

Sealed linear encoders that operate according to 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 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 interpolation errors over relatively large paths of traverse—for example the entire measuring length—and those within one signal period.

## Position error over the measuring range

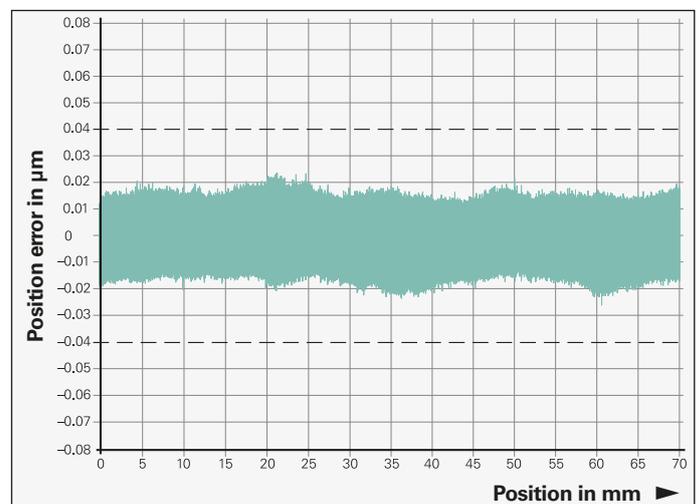
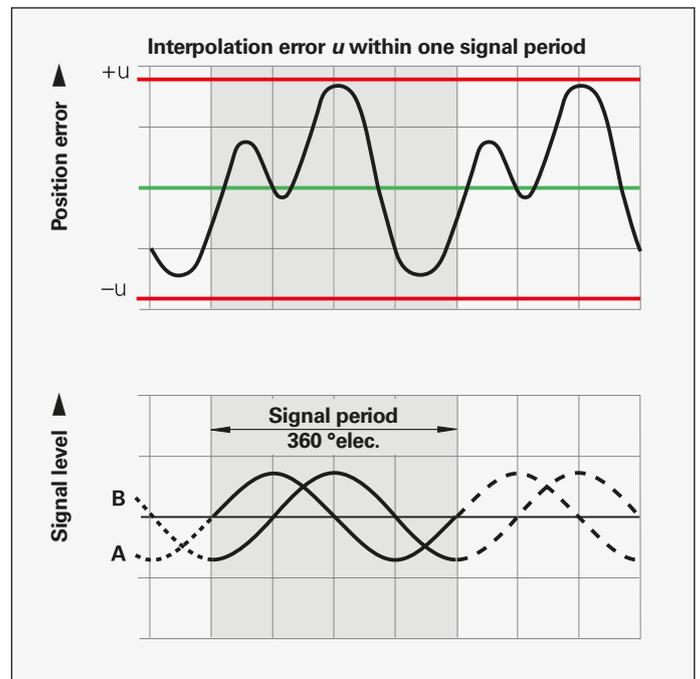
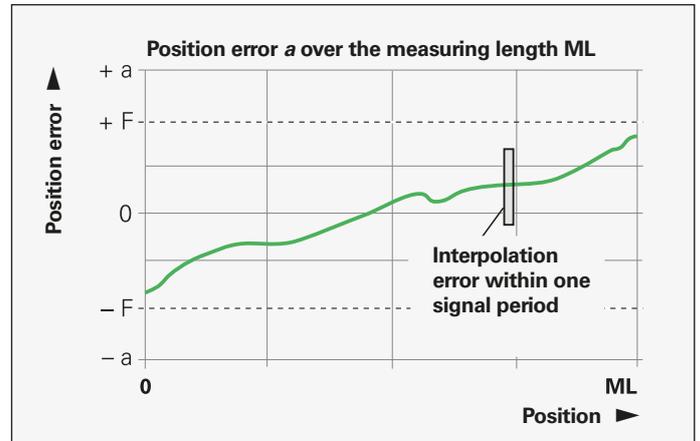
The accuracy of sealed linear encoders is specified in grades, which are defined as follows:

*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 errors 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, 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 the traceability—as required by EN ISO 9001—to recognized national or international standards.

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 indicates the measuring parameters and the uncertainty of the calibration measurement.

### Temperature range

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

### The operating temperature range

indicates the ambient temperature limits between which the linear encoders will function properly.

The **storage temperature range** of -20 °C to 70 °C applies for the device in its packaging. Starting from a measuring length of 3240 mm, the permissible storage temperature range for encoders of 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 against an absolute LC on a specific machine design (please note the 20 µm smaller measuring length of the LF than that of the LC and LS). In addition, the same mounting spars can also be used regardless of the encoder product family (LC, LF or LS).

The encoder is mounted so that the sealing lips are directed downward or away from splashing water (also see *General Information*, 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.



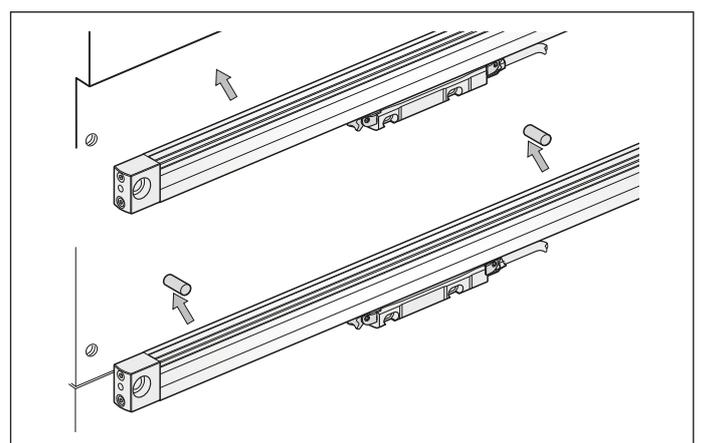
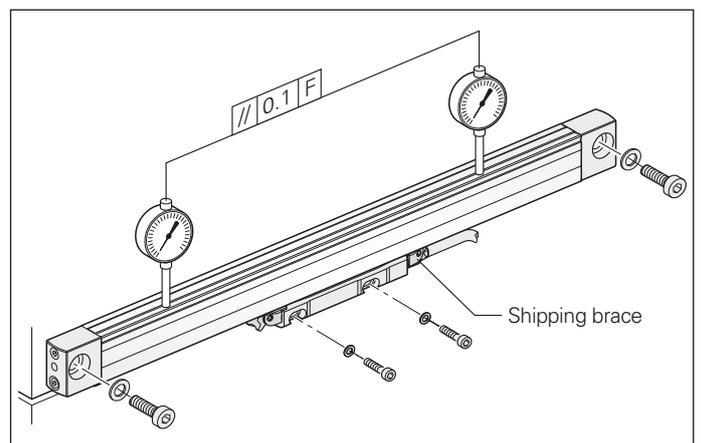
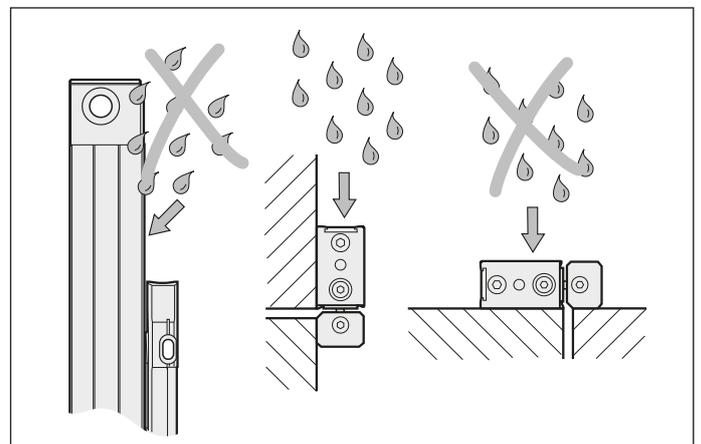
LF 485



LC 415



LS 487



Accessories:

**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. It 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 over 620 mm and dynamic requirements are high. For measuring lengths over 1240 it is always required.

For the mounting spar MSL 41, the components required for clamping are already preassembled. It 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.

Accessories:

**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.

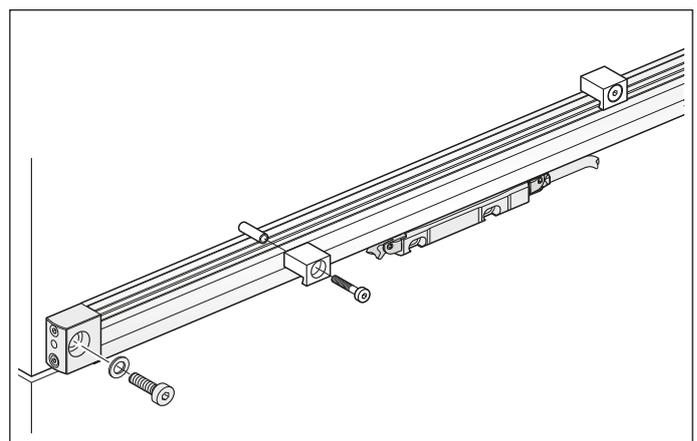
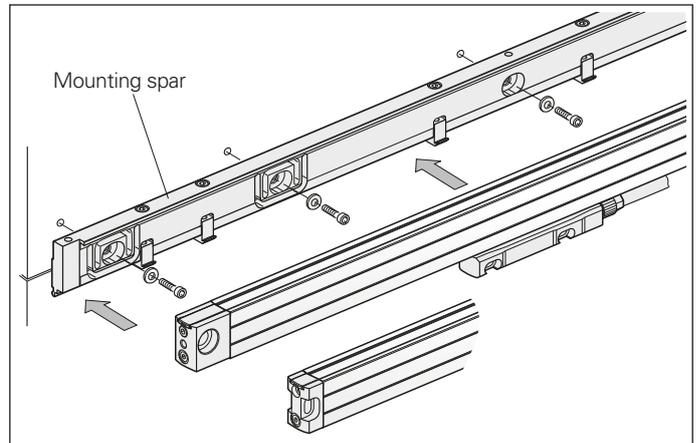
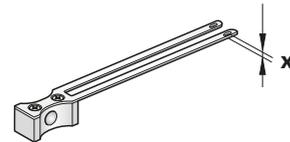
Accessory:

**Clamping elements**

With pin and M5x10 screw

ID 556975-01 (10 pieces per pack)

	x	Color	ID
<b>Mounting gauge</b>	1.0 mm	Gray	737748-01
<b>Test gauge max.</b>	1.3 mm	Red	737748-02
<b>Test gauge min.</b>	0.7 mm	Blue	737748-03



# 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 linear encoders with large cross section has been optimized:

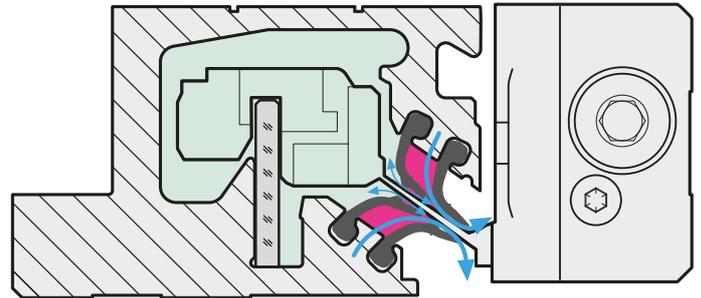
On the **LF**, the steel scale is cemented to a steel carrier that is fastened directly to the machine element.

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.

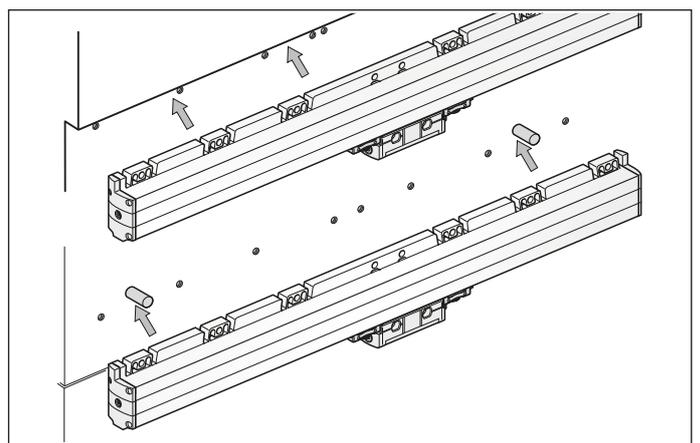
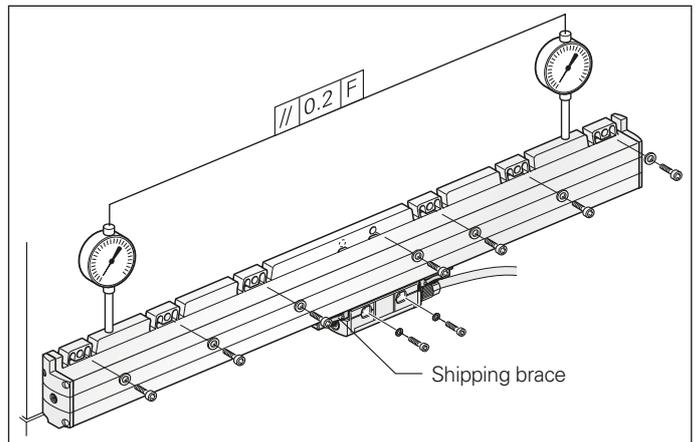
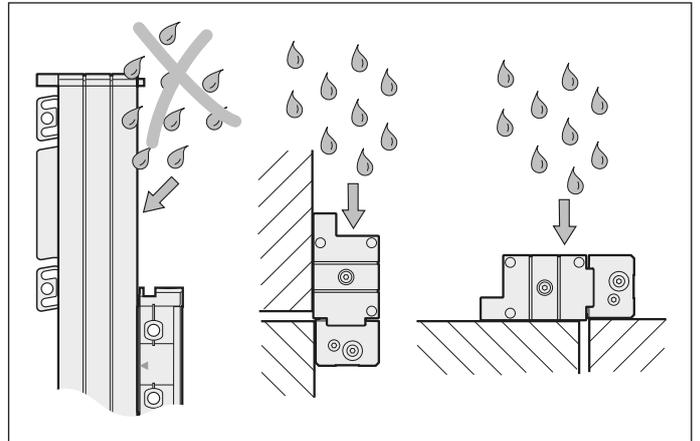
The **LC** and **LS** are fixed to the mounting surface at their midpoint. The flexible fastening elements permit reproducible thermal behavior.

## 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

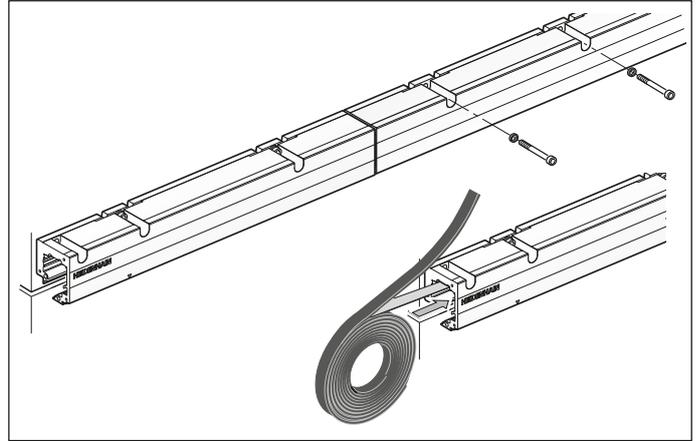


**Mounting the multi-section LC 2x1 and LB 382**

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  $\pm 100 \mu\text{m/m}$ .

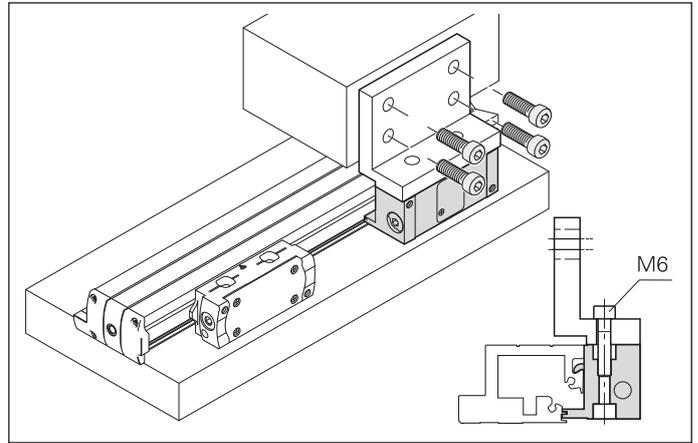


Accessory:

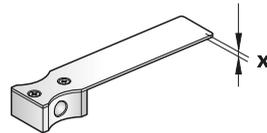
**Mounting aids**

- 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.



Example



Accessory:

**Mounting and test gauges for full-size linear encoders**

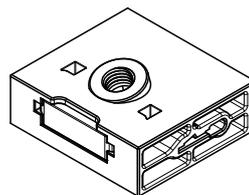
The **mounting gauge** is used to set the gap between the scale unit and the scanning unit if the shipping brace needs to be removed before mounting. The **test gauges** are used to quickly and easily check the gap of the mounted linear encoder.

	LC 1xx, LS 1xx		LB 382/LC 2x1	
	x	ID	x	ID
<b>Mounting gauge (gray)</b>	1.5 mm	575832-01	1.0 mm	772141-01
<b>Test gauge max. (red)</b>	1.8 mm	575832-02	1.3 mm	772141-02
<b>Test gauge min. (blue)</b>	1.2 mm	575832-03	0.7 mm	772141-03

Accessory:

**Lubricating device**

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



# 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, **compressed air** can be used to provide **IP64** protection to more effectively prevent the ingress of contamination. To apply the pressurized air for sealing the housing, the LB, LC, LF and LS sealed linear encoders are therefore equipped with inlets at both end pieces 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):

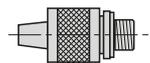
- Solid contaminants: **Class 1**  
Particle size No. of particles per m<sup>3</sup>  
0.1 µm to 0.5 µm ≤ 20000  
0.5 µm to 1.0 µm ≤ 400  
1.0 µm to 5.0 µm ≤ 10
- Max. pressure dew point: **Class 4**  
(pressure dew point at 3 °C)
- Total oil content: **Class 1**  
(max. oil concentration 0.01 mg/m<sup>3</sup>)

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.  $1 \cdot 10^5$  Pa (1 bar).

Accessory:

### Connecting piece, straight

With throttle and gasket  
ID 226270-02



### Connecting piece, straight, short

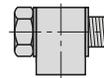
With throttle and gasket  
ID 275239-01



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 m<sup>3</sup>  
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 ≤ 100000
- Max. pressure dew point: **Class 6**  
(pressure dew point at 10 °C)
- Total oil content: **Class 4**  
(max. oil concentration 5 mg/m<sup>3</sup>)



### Further information:

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

DA 400

### 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 low.
- 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
- The linear encoders should be mounted away from sources of heat to avoid temperature influences
- During cable routing, the minimum bending 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

### 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 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**), except when mechanical resonance arises. **Comprehensive tests of the entire system are 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 the products for safety of the materials as per European Directives 2002/95/EC (RoHS) and 2002/96/EC (WEEE). For a Manufacturer's Declaration on RoHS, please refer to your sales agency.

### 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.

### 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 applications other than the intended applications is at the user's own risk.

### Mounting

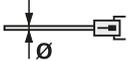
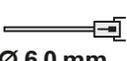
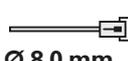
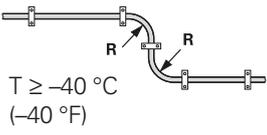
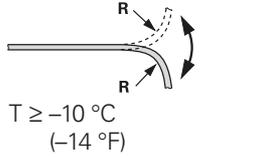
Work steps to be performed and dimensions to be maintained during mounting are specified solely in the mounting instructions supplied with the unit. All data in this brochure regarding mounting are therefore provisional and not binding; they do not become terms of a contract.



### For more information:

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

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

	 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 (-40 °F)	≥ 8 mm	≥ 10 mm	≥ 20 mm	≥ 35 mm	R <sub>1</sub> ≥ 40 mm
 T ≥ -10 °C (-14 °F)	≥ 40 mm	≥ 50 mm	≥ 75 mm	≥ 75 mm	R <sub>2</sub> ≥ 100 mm
					

# 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, e.g. 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 on the connected encoders 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-approved 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 61 508) or performance level “d” (of EN ISO 13 849). 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. Reliable transmission of the position is based on two independently generated absolute position values and on error bits, which are 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.

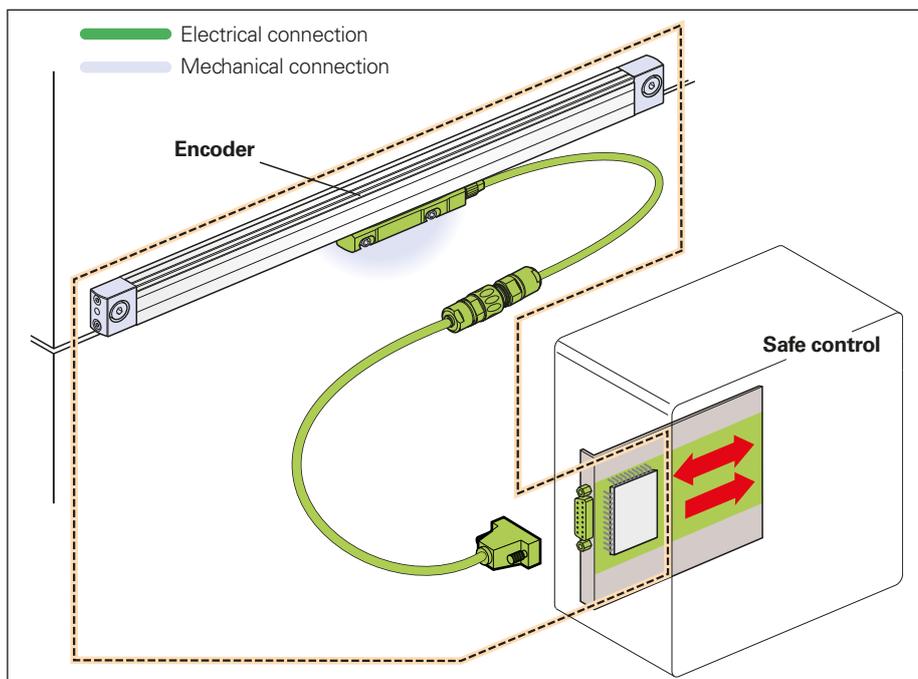
## Standard encoders

In addition to the encoders explicitly qualified for safety applications, standard linear encoders, e.g. with Fanuc interface or 1 V<sub>PP</sub> signals, can also be used in safe axes. In these cases, the properties of the encoders are to be aligned with the requirements of the respective control. HEIDENHAIN can provide additional data on the individual encoders (failure rate, fault model as per EN 61 800-5-2).



### For more 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 61 800-5-2) for the use of standard encoders in safety-related applications.



Encoder with mechanical connection and electrical interface

### Fault exclusion against loosening of the mechanical connection

Regardless of the interface, many safety designs require a safe mechanical connection. The standard for electrical drives, EN 61 800-5-2, defines the loss or loosening of the mechanical connection between the encoder and drive as a fault that requires consideration. Since it cannot be guaranteed that the control will detect such errors, in many cases the possibility of a fault must be eliminated. 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 a fault exclusion against the loosening of the mechanical connection. The fault exclusion applies for all LC 4x5 and LC 1x5 encoders, regardless of the interface.

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

<sup>1)</sup> Fault exclusions are possible only for the explicitly named mounting options

<sup>2)</sup> A suitable anti-rotation lock is to be used for the screw connections (for mounting or service)



#### Further information:

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

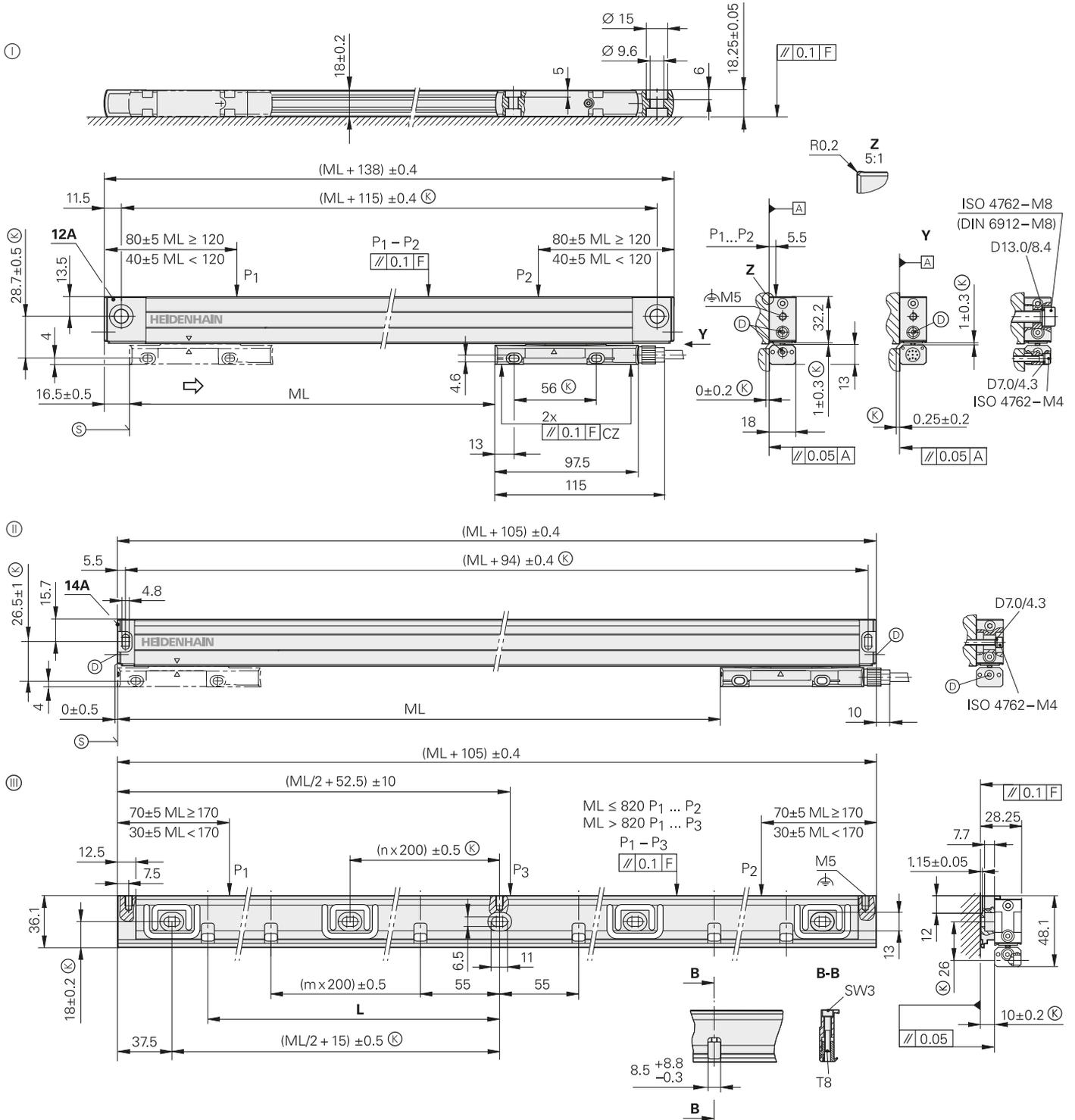
- Mounting Instructions *LC 115/LC 195S* 743390  
*LC 415/LC 495S* (end block 14A) 737907  
(end block 12A) 737908  
(mounting spar MSL 41) 894918
- Technical Information: *Safety-Related Position Measuring Systems* 596632

For implementation in a control:

- Specification for safe control 533 095

# 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:  $\pm 0.2$  mm

- ⊙ = End block 12A; mounting with and without mounting spar
- ⊙ = End block 14A; for mounting with mounting spar (specifications are restricted if attached directly with M4 screws)
- ⊙ = MSL 41 mounting spar
- F = Machine guideway
- P = Gauging points for alignment
- ⊙ = Required mating dimensions
- ⊙ = Compressed air inlet
- ⊙ = Beginning of measuring length ML (= 20 mm absolute)
- ⇒ = Direction of scanning unit motion for output signals in accordance with interface description



Specifications	LC 415 	LC 415	LC 485
<b>Measuring standard</b> Coefficient of linear expansion	DIADUR glass scale with absolute track and incremental track, grating period 20 µm $\alpha_{\text{therm}} \approx 8 \times 10^{-6} \text{ K}^{-1}$ (mounting mode ①/②); <i>with mounting spar</i> : $\alpha_{\text{therm}} \approx 9 \times 10^{-6} \text{ K}^{-1}$ (mounting mode ③)		
<b>Accuracy grade*</b>	± 3 µm, ± 5 µm		
<b>Measuring length ML*</b> in mm	Mounting spar* or clamping elements* up to ML 1240 optional, necessary 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		
<b>Functional safety</b> for applications up to	<ul style="list-style-type: none"> <li>SIL-2 according to EN 61 508</li> <li>Category 3, PL "d" according to EN ISO 13 849-1:2008</li> </ul>	–	
PFH	≤ 15 × 10 <sup>-9</sup> (up to 6000 m above sea level)	–	
Safe position <sup>1)</sup>	<i>Encoder</i> : ±550 µm (safety-related measuring step SM = 220 µm)	–	
	<i>Mechanical connection</i> : fault exclusions for loosening of the housing and scanning unit (page 21)		
<b>Interface</b>	EnDat 2.2		
Ordering designation	EnDat22		EnDat02
Measuring step <i>At ± 3 µm</i> <i>With ± 5 µm</i>	0.001 µm 0.010 µm		0.005 µm 0.010 µm
Clock frequency (calculation time $t_{\text{cal}}$ )	≤ 16 MHz (≤ 5 µs)		≤ 2 MHz (≤ 5 µs)
<b>Incremental signals</b>	–		~ 1 V <sub>PP</sub> (20 µm)
Cutoff frequency –3 dB	–		≥ 150 kHz
<b>Electrical connection</b>	Separate adapter cable (1 m/3 m/6 m/9 m) connectable on mounting block		
Cable length	≤ 100 m <sup>2)</sup>		≤ 150 m <sup>2)</sup>
Voltage supply	DC 3.6 V to 14 V		
Power consumption (max.)	3.6 V: ≤ 1.1 W; 14 V: ≤ 1.3 W		
<b>Traversing speed</b>	≤ 180 m/min (max. acceleration in measuring direction ≤ 100 m/s <sup>2</sup> )		
<b>Required moving force</b>	≤ 5 N		
<b>Vibration</b> 55 Hz to 2000 Hz effecting the	<i>Scanning unit</i> : ≤ 200 m/s <sup>2</sup> (EN 60068-2-6) <i>Housing without mounting spar</i> : ≤ 100 m/s <sup>2</sup> (EN 60068-2-6) <i>Housing with mounting spar, and cable outlet at right</i> : ≤ 150 m/s <sup>2</sup> , <i>left</i> : ≤ 100 m/s <sup>2</sup> (EN 60068-2-6)		
<b>Shock</b> 11 ms	≤ 300 m/s <sup>2</sup> (EN 60068-2-27)		
<b>Operating temperature</b>	0 °C to 50 °C		
<b>Protection</b> EN 60529 <sup>3)</sup>	IP 53 when installed according to instructions in the brochure, IP 64 with sealing air from DA 400		
<b>Mass</b>	<i>Encoder</i> : 0.2 kg + 0.55 kg/m measuring length; <i>mounting spar</i> : 0.9 kg/m		

\* Please select when ordering

<sup>1)</sup> Further tolerances may occur in subsequent electronics after position value comparison (contact manufacturer)

<sup>2)</sup> With HEIDENHAIN cable; clock frequency ≤ 8 MHz

<sup>3)</sup> In the application the LC must be protected from the intrusion 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
<b>Measuring standard</b> Coefficient of linear expansion	DIADUR glass scale with absolute track and incremental track, grating period 20 µm $\alpha_{\text{therm}} \approx 8 \times 10^{-6} \text{ K}^{-1}$ (mounting mode ①/②); <i>with mounting spar</i> : $\alpha_{\text{therm}} \approx 9 \times 10^{-6} \text{ K}^{-1}$ (mounting mode ③)	
<b>Accuracy grade*</b>	± 3 µm, ± 5 µm	
<b>Measuring length ML*</b> in mm	Mounting spar* or clamping elements* up to ML 1240 optional, necessary as of ML 1340 70 120 170 220 270 320 370 420 470 520 570 620 670	
<b>Functional safety</b> for applications up to	<ul style="list-style-type: none"> <li>• SIL-2 according to EN 61 508</li> <li>• Category 3, PL "d" as per EN ISO 13 849-1:2008</li> </ul>	–
PFH	$25 \times 10^{-9}$ (up to 1000 m above sea level)	–
Safe position <sup>1)</sup>	<i>Encoder</i> : ±550 µm (safety-related measuring step SM = 220 µm)	–
	<i>Mechanical connection</i> : fault exclusions for loosening of the housing and scanning unit (page 21)	
<b>Interface</b>	DRIVE-CLiQ	
Ordering designation	DQ01	
Measuring step <i>With ±3 µm</i> <i>With ±5 µm</i>	0.001 µm 0.010 µm	
Clock frequency (calculation time $t_{\text{cal}}$ )	–	
<b>Electrical connection</b>	Separate adapter cable (1 m/3 m/6 m/9 m) connectable on mounting block	
Cable length	≤ 30 m <sup>2)</sup>	
Voltage supply	DC 10 V to 28.8 V	
Power consumption (max.)	10 V: ≤ 1.5 W; 28.8 V: ≤ 1.7 W	
<b>Traversing speed</b>	≤ 180 m/min (max. acceleration in measuring direction ≤ 100 m/s <sup>2</sup> )	
<b>Required moving force</b>	≤ 5 N	
<b>Vibration</b> 55 Hz to 2000 Hz <i>affecting the</i>	<i>Scanning unit</i> : ≤ 200 m/s <sup>2</sup> (EN 60068-2-6) <i>Housing without mounting spar</i> : ≤ 100 m/s <sup>2</sup> (EN 60068-2-6) <i>Housing with mounting spar, and cable outlet at right</i> : ≤ 150 m/s <sup>2</sup> , <i>left</i> : ≤ 100 m/s <sup>2</sup> (EN 60068-2-6)	
<b>Shock</b> 11 ms	≤ 300 m/s <sup>2</sup> (EN 60068-2-27)	
<b>Operating temperature</b>	0 °C to 50 °C	
<b>Protection</b> EN 60529 <sup>3)</sup>	IP 53 when installed according to instructions in the brochure, IP 64 with sealing air from DA 400	
<b>Mass</b>	<i>Encoder</i> : 0.2 kg + 0.55 kg/m 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 the subsequent electronics manufacturer)

2) Larger cable lengths upon request

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

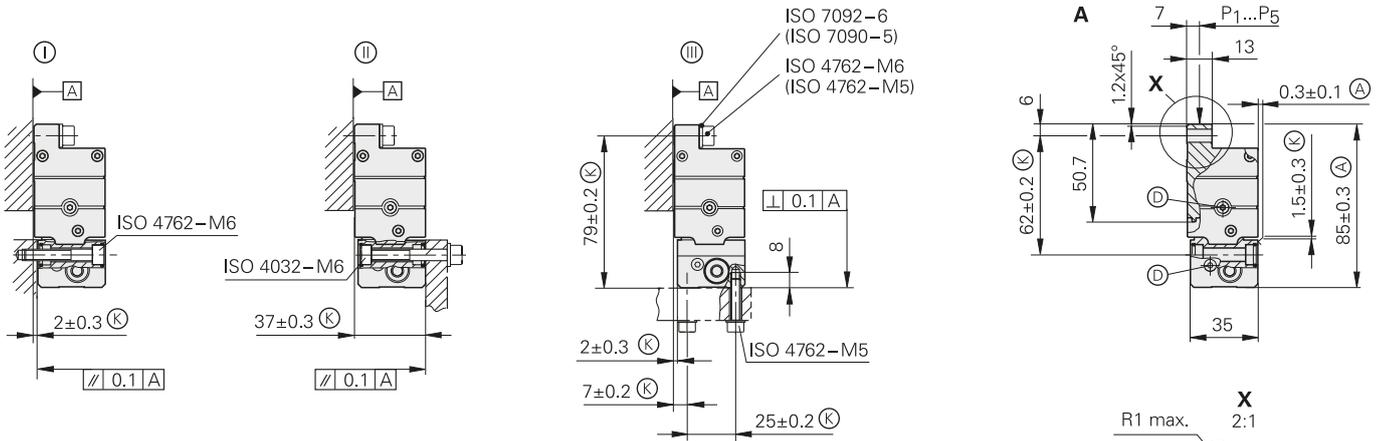
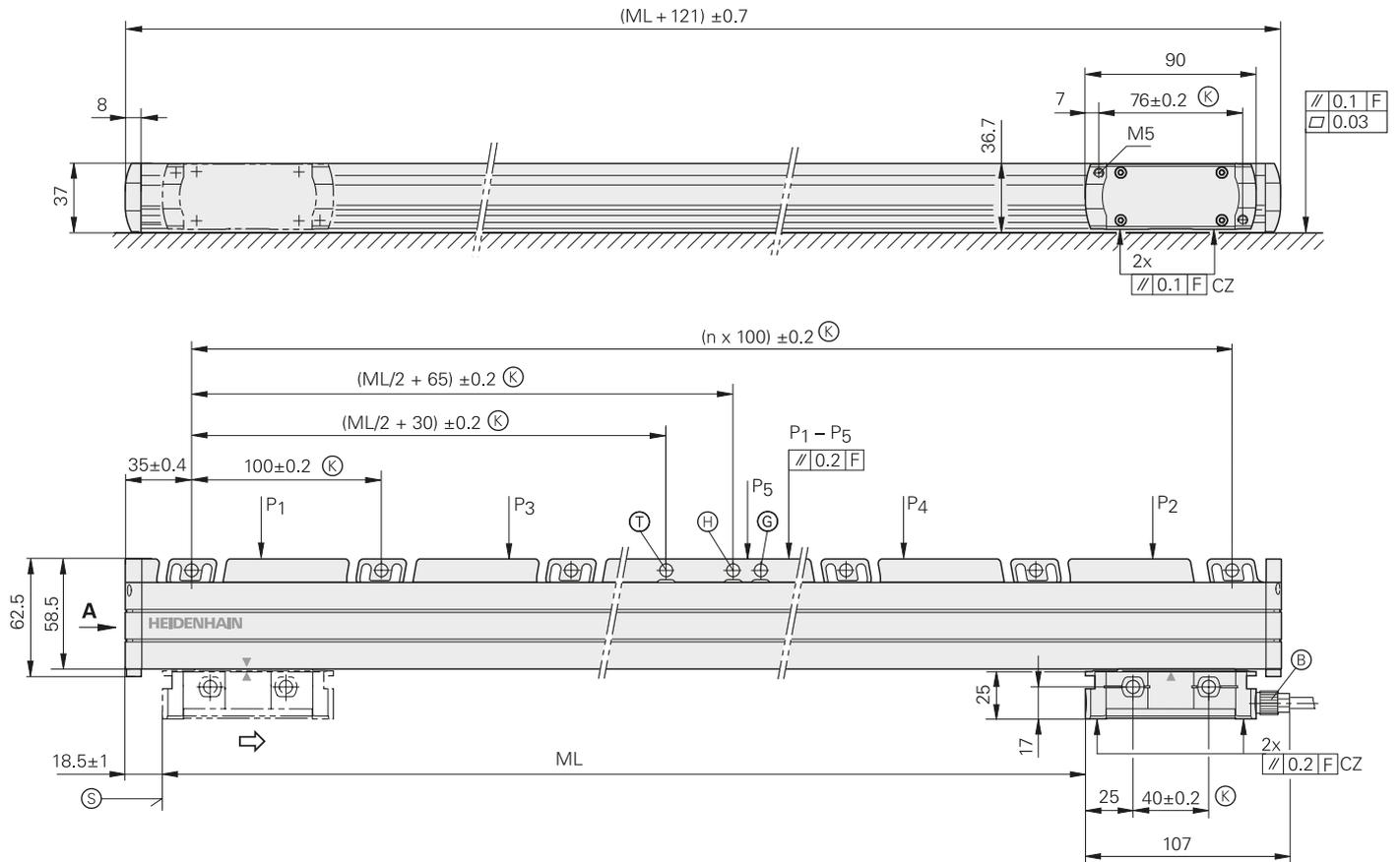


LC 495 F		LC 495 M		LC 495 P	
720 770 820 920 1020 1140 1240 1340 1440 1540 1640 1740 1840 2040					
Fanuc Serial Interface/αi interface		Mitsubishi high speed interface		Panasonic serial interface	
Fanuc05		Mit03-04		Pana01	
αi Interface/α Interface 0.00125 μm/0.010 μm 0.0125 μm/0.050 μm		0.001 μm 0.010 μm			
≤ 50 m		≤ 30 m		≤ 50 m	
DC 3.6V to 14 V					
3.6 V: ≤ 1.1 W; 14 V: ≤ 1.3 W					

# LC 100 series

Absolute linear encoders with full-size scale housing

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



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

- Ⓘ, Ⓜ, Ⓝ = Mounting options
- F = Machine guideway
- P = Gauging points for alignment
- Ⓚ = Required mating dimensions
- A = Alternative mating dimensions
- Ⓟ = Cable connection usable at either end
- Ⓞ = Compressed-air connection usable at either end
- T = Mechanical fixed point (to be preferred)
- H = Mechanical fixed point compatible to predecessor model
- G = Mechanical fixed point (coincides with the spacing interval of 100 mm)
- Ⓢ = Beginning of measuring length ML (= 20 mm absolute)
- Ⓜ = Mating surfaces
- ⇒ = Direction of scanning unit motion for output signals in accordance with interface description



Specifications	LC 115 	LC 115	LC 185
<b>Measuring standard</b> Coefficient of linear expansion	DIADUR glass scale with absolute track and incremental track, grating period 20 µm $\alpha_{\text{therm}} \approx 8 \times 10^{-6} \text{ K}^{-1}$		
<b>Accuracy grade*</b>	±3 µm up to 3040 mm measuring length; ±5 µm		
<b>Measuring length ML*</b> 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		
<b>Functional safety</b> for applications up to	<ul style="list-style-type: none"> <li>SIL-2 according to EN 61 508</li> <li>Category 3, PL "d" according to EN ISO 13 849-1:2008</li> </ul>	–	
PFH	$15 \times 10^{-9}$ ; <i>ML &gt; 3040 mm:</i> $25 \times 10^{-9}$ (up to 6000 m above sea level)	–	
Safe position <sup>1)</sup>	<i>Encoder:</i> ±550 µm; <i>ML &gt; 3040 mm:</i> ±2050 µm (safety-related meas. step SM = 220 µm)	–	
	<i>Mechanical connection:</i> fault exclusions for loosening of the housing and scanning unit (page 21)		
<b>Interface</b>	EnDat 2.2		
Ordering designation	EnDat22		EnDat02
Measuring step <i>At ± 3 µm</i> <i>With ± 5 µm</i>	0.001 µm 0.010 µm		0.005 µm 0.010 µm
Clock freq. (calc. time $t_{\text{cal}}$ )	≤ 16 MHz (≤ 5 µs)		≤ 2 MHz (≤ 5 µs)
<b>Incremental signals</b>	–		~ 1 V <sub>PP</sub> (20 µm)
Cutoff frequency –3 dB	–		≥ 150 kHz
<b>Electrical connection</b>	Separate adapter cable (1 m/3 m/6 m/9 m) connectable at either end of mounting block		
Cable length	≤ 100 m <sup>2)</sup>		≤ 150 m <sup>2)</sup>
Voltage supply	DC 3.6 V to 14 V		
Power consumption (max.)	3.6 V: ≤ 1.1 W; 14 V: ≤ 1.3 W		
<b>Traversing speed</b>	≤ 180 m/min (max. acceleration in measuring direction ≤ 100 m/s <sup>2</sup> )		
<b>Required moving force</b>	≤ 4 N		
<b>Vibration</b> 55 Hz to 2000 Hz affecting the <b>Shock</b> 11 ms	<i>Housing:</i> ≤ 200 m/s <sup>2</sup> (EN 60068-2-6) <i>Scanning unit:</i> ≤ 200 m/s <sup>2</sup> (EN 60068-2-6) ≤ 300 m/s <sup>2</sup> (EN 60068-2-27)		
<b>Operating temperature</b>	0 °C to 50 °C		
<b>Protection</b> EN 60529 <sup>3)</sup>	IP 53 when installed according to instructions in the brochure, IP 64 with sealing air from DA 400		
<b>Mass</b>	0.55 kg + 2.9 kg/m measuring length		

\* Please select when ordering

<sup>1)</sup> Further tolerances may occur in subsequent electronics after position value comparison (contact manufacturer)

<sup>2)</sup> With HEIDENHAIN cable; clock frequency ≤ 8 MHz

<sup>3)</sup> In the application the LC must be protected from the intrusion of particles and liquids

# LC 100 series

Absolute linear encoders with full-size scale housing

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

Specifications	LC 195S 	LC 195S
<b>Measuring standard</b> Coefficient of linear expansion	DIADUR glass scale with absolute track and incremental track, grating period 20 μm $\alpha_{\text{therm}} \approx 8 \times 10^{-6} \text{ K}^{-1}$	
<b>Accuracy grade*</b>	±3 μm up to 3040 mm measuring length; ±5 μm	
<b>Measuring length ML*</b> in mm	140 240 340 440 540 640 740 840 940 1040 1140 1240 1340	
<b>Functional safety</b> for applications up to	<ul style="list-style-type: none"> <li>• SIL-2 according to EN 61 508</li> <li>• Category 3, PL "d" as per EN ISO 13 849-1:2008</li> </ul>	–
PFH	$25 \times 10^{-9}$ ; <i>ML &gt; 3040 mm</i> : $40 \times 10^{-9}$ (up to 1000 m above sea level)	–
Safe position <sup>1)</sup>	<i>Encoder</i> : ±550 μm; <i>ML &gt; 3040 mm</i> : ±2050 μm (safety-related measuring step SM = 220 μm)	–
	<i>Mechanical connection</i> : fault exclusions for loosening of the housing and scanning unit (page 21)	
<b>Interface</b>	DRIVE-CLiQ	
Ordering designation	DQ01	
Measuring step <i>With ±3 μm</i> <i>With ±5 μm</i>	0.001 μm 0.010 μm	
Clock freq. (calc. time $t_{\text{cal}}$ )	–	
<b>Electrical connection</b>	Separate adapter cable (1 m/3 m/6 m/9 m) connectable at either end of mounting block	
Cable length	≤ 30 m <sup>2)</sup>	
Voltage supply	DC 10 V to 28.8 V	
Power consumption (max.)	10 V: ≤ 1.5 W; 28.8 V: ≤ 1.7 W	
<b>Traversing speed</b>	≤ 180 m/min (max. acceleration ≤ 100 m/s <sup>2</sup> )	
<b>Required moving force</b>	≤ 4 N	
<b>Vibration</b> 55 Hz to 2000 Hz <i>affecting the</i> <b>Shock</b> 11 ms	<i>Housing</i> : ≤ 200 m/s <sup>2</sup> (EN 60068-2-6) <i>Scanning unit</i> : ≤ 200 m/s <sup>2</sup> (EN 60068-2-6) ≤ 300 m/s <sup>2</sup> (EN 60068-2-27)	
<b>Operating temperature</b>	0 °C to 50 °C	
<b>Protection</b> EN 60529 <sup>3)</sup>	IP 53 when installed according to instructions in the brochure, IP 64 with sealing air from DA 400	
<b>Mass</b>	0.55 kg + 2.9 kg/m measuring length	

\* Please select when ordering

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

2) Larger cable lengths upon request

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

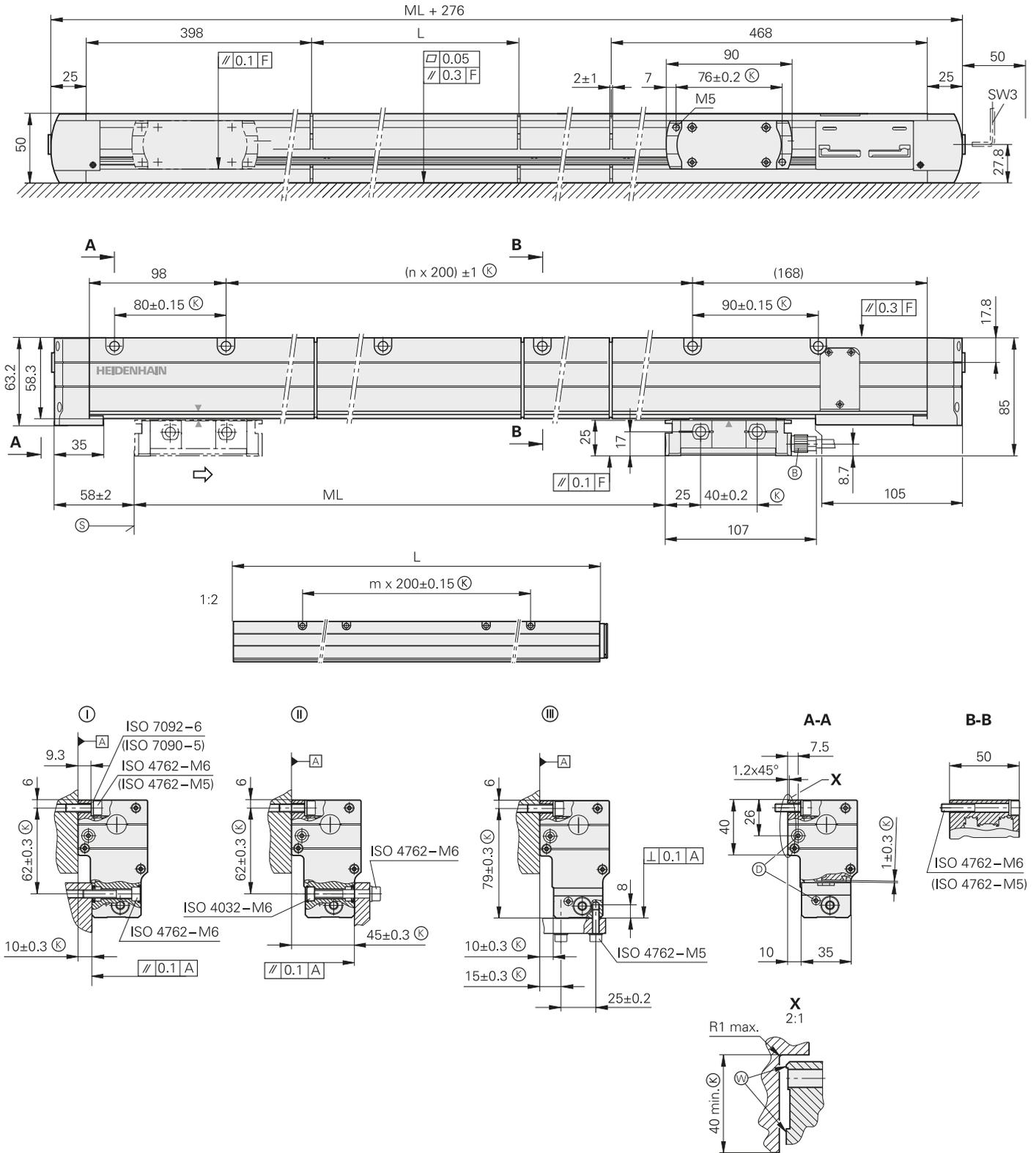


LC 195F	LC 195M	LC 195P
	±3 µm up to 2040 mm measuring length; ±5 µm	±3 µm up to 3040 mm measuring length; ±5 µm
1440 1540 1640 1740 1840 2040	2240 2440 2640 2840 3040 3240	3440 3640 3840 4040 4240
Fanuc Serial Interface/αi interface	Mitsubishi high speed interface	Panasonic serial interface
Fanuc05	Mit03-04	Pana01
αi Interface/α Interface 0.00125 µm/0.010 µm 0.0125 µm/0.050 µm	0.001 µm 0.010 µm	
≤ 50 m	≤ 30 m	≤ 50 m
DC 3.6V to 14 V		
3.6 V: ≤ 1.1 W; 14 V: ≤ 1.3 W		

# LC 200 series

**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

- Ⓞ, Ⓟ, Ⓠ = Mounting options
- F = Machine guideway
- L = Housing section lengths
- Ⓡ = Required mating dimensions
- Ⓢ = Cable connection usable at either end
- Ⓣ = Compressed-air connection usable at either end
- Ⓤ = Beginning of measuring length ML (= 100 mm absolute)
- Ⓦ = Mating surfaces
- ⇨ = Direction of scanning unit motion for output signals in accordance with interface description



Specifications	LC 211	LC 281	LC 291F	LC 291M
<b>Measuring standard</b> Coefficient of linear expansion	METALLUR steel scale tape with absolute track and incremental track, grating period 40 µm Same as machine base (e.g. $\alpha_{\text{therm}} \approx 10 \times 10^{-6} \text{ K}^{-1}$ for gray cast iron)			
<b>Accuracy grade</b>	± 5 µm			
<b>Measuring length ML*</b> in mm	3240 mm to 28040 mm in 200 mm steps <sup>2)</sup> Kit with single-section METALLUR steel scale tape and housing section lengths			
<b>Interface</b>	EnDat 2.2		Fanuc Serial Interface $\alpha$ interface	Mitsubishi high speed interface
Ordering designation	EnDat22	EnDat02	Fanuc05	Mit03-04
Measuring step	0.010 µm		$\alpha$ Interface/ $\alpha$ Interface 0.0125 µm/0.050 µm	0.010 µm
Diagnostics interface	Digital			
Clock frequency Calculation time $t_{\text{cal}}$	≤ 16 MHz ≤ 5 µs	≤ 2 MHz ≤ 5 µs	– –	
<b>Incremental signals</b>	–	~ 1 V <sub>PP</sub>	–	
Signal period	–	40 µm	–	
Cutoff frequency –3 dB	–	≥ 250 kHz	–	
<b>Electrical connection</b>	Separate adapter cable (1 m/3 m/6 m/9 m) connectable at either end of mounting block			
Cable length <sup>1)</sup>	≤ 100 m (at clock frequency ≤ 8 MHz)	≤ 150 m	≤ 50 m	≤ 30 m
Voltage supply	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)			
<b>Traversing speed</b>	≤ 180 m/min (max. acceleration in measuring direction ≤ 100 m/s <sup>2</sup> )			
<b>Required moving force</b>	≤ 15 N			
<b>Vibration</b> 55 Hz bis 2000 Hz effecting the <b>Shock</b> 11 ms	Housing: 200 m/s <sup>2</sup> (EN 60068-2-6) Scanning unit: 300 m/s <sup>2</sup> (EN 60068-2-6) ≤ 300 m/s <sup>2</sup> (EN 60068-2-27)			
<b>Operating temperature</b>	0 °C to 50 °C			
<b>Protection</b> EN 60529	IP 53 when installed according to mounting instructions, IP 64 with sealing air from DA 400			
<b>Mass</b>	1.3 kg + 3.6 kg/m measuring length			

\* Please select when ordering

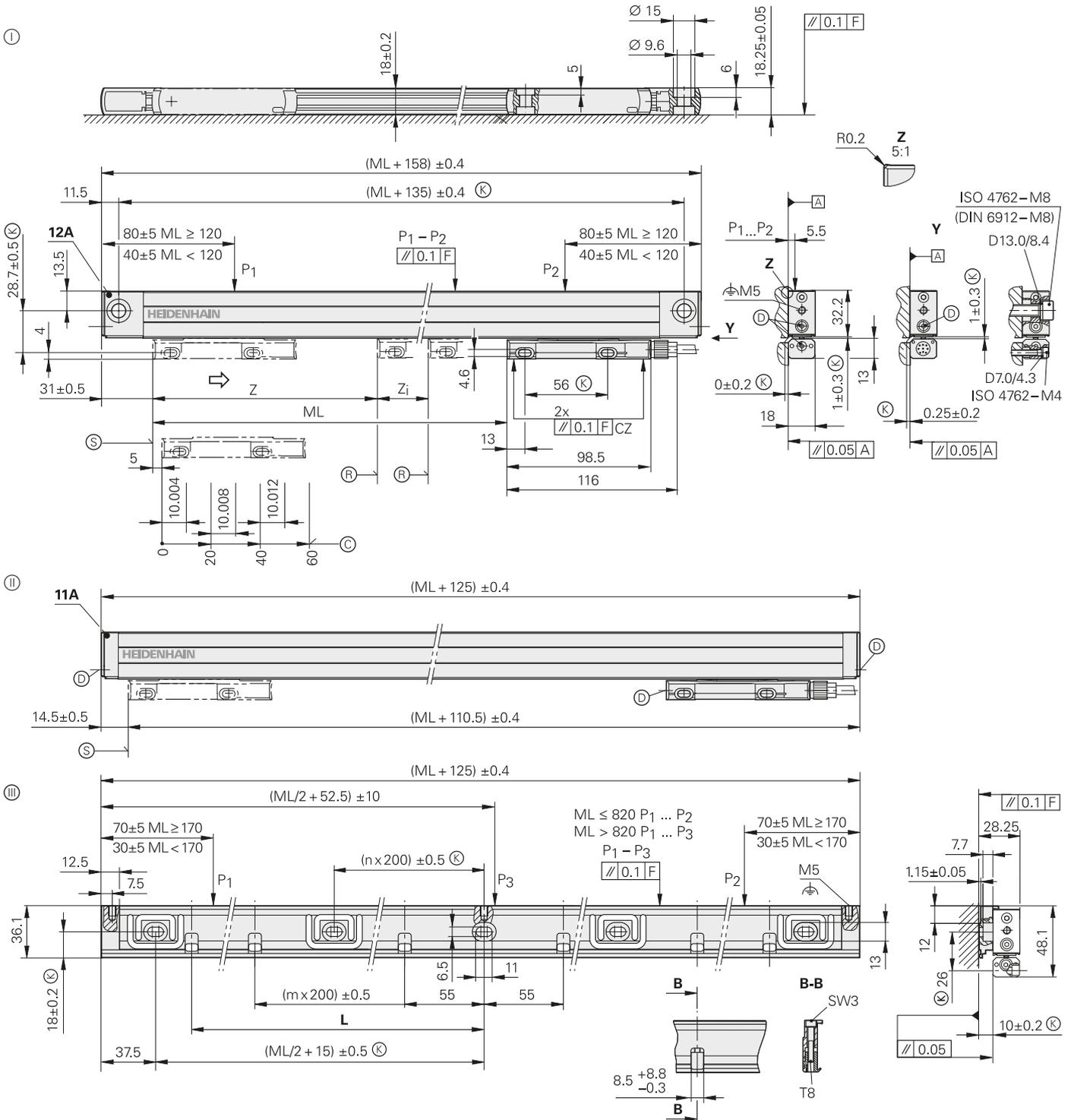
<sup>1)</sup> With HEIDENHAIN cable

<sup>2)</sup> LC 291 M to 20040 mm

# LF 485

## Incremental linear encoders with slimline scale housing

- Very high repeatability
- Thermal behavior similar to steel or gray cast iron
- For limited installation space



ML	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1120	1220	1320	1420	1520	1620	1720	1820	2020
L	37.5	55	75	100	115	140	175	200	225	250	275	300	325	350	375	400	425	450	475	500	515	555	610	655	710	760	810	855	910	1010

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

- ⊙ = End block 12A; mounting with and without mounting spar
- ⊙ = End block 11A; installation with mounting spar
- ⊙ = MSL 41 mounting spar
- F = Machine guideway
- P = Gauging points for alignment
- ⊗ = Required mating dimensions

- ⊗ = Reference mark position on LF 485  
 2 reference marks for measuring lengths  

50 ... 1000	1120 ... 1220
z = 25 mm	z = 35 mm
z <sub>1</sub> = ML - 50 mm	z <sub>1</sub> = ML - 70 mm
- ⊙ = Reference mark position on LF 485 C
- ⊙ = Compressed air inlet
- ⊙ = Beginning of measuring length ML
- ⇒ = Direction of measuring unit motion for output signals in accordance with interface description

LF 485 without mounting spar



LF 485 with mounting spar

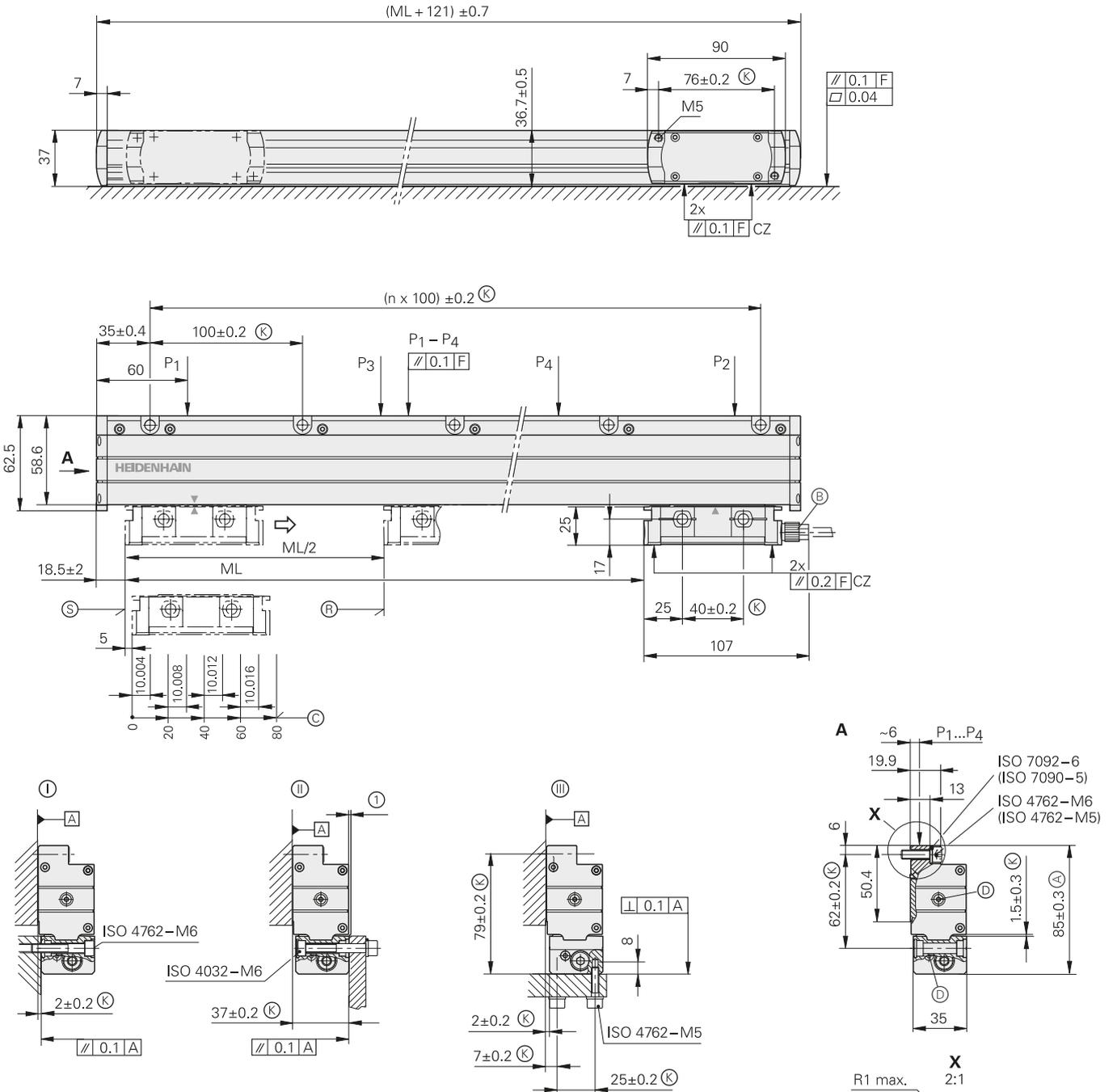
Specifications	LF 485
<b>Measuring standard</b> Coefficient of linear expansion	SUPRADUR phase grating on steel, grating period 8 $\mu\text{m}$ $\alpha_{\text{therm}} \approx 10 \times 10^{-6} \text{ K}^{-1}$
<b>Accuracy grade*</b>	$\pm 5 \mu\text{m}$ ; $\pm 3 \mu\text{m}$
<b>Measuring length ML*</b> in mm	Mounting spar* optional 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 900 1000 1120 1220
<b>Interface</b>	$\sim 1 \text{ V}_{\text{PP}}$
Signal period	4 $\mu\text{s}$
Reference marks* LF 485 LF 485 C	<ul style="list-style-type: none"> <li>• 1 reference mark at midpoint of measuring length</li> <li>• 2 reference marks, each 25 mm (for <math>\text{ML} \leq 1000 \text{ mm}</math>) or 35 mm (for <math>\text{ML} \geq 1120 \text{ mm}</math>) from the beginning and end of the measuring length</li> </ul> Distance-coded
Diagnostics interface	Analog
Cutoff frequency -3 dB	$\geq 250 \text{ kHz}$
<b>Electrical connection</b>	Separate adapter cable (1 m/3 m/6 m/9 m) connectable on mounting block
Cable length	$\leq 150 \text{ m}$ (with HEIDENHAIN cable)
Voltage supply without load	DC 5 V $\pm 0.25 \text{ V}$ / $< 150 \text{ mA}$
<b>Traversing speed</b>	$\leq 60 \text{ m/min}$ (max. acceleration in measuring direction $\leq 100 \text{ m/s}^2$ )
<b>Required moving force</b>	$\leq 4 \text{ N}$
<b>Vibration</b> 55 Hz to 2000 Hz effecting the <b>Shock</b> 11 ms	<i>Housing with mounting spar:</i> $\leq 150 \text{ m/s}^2$ (EN 60068-2-6) <i>Scanning unit:</i> $\leq 200 \text{ m/s}^2$ (EN 60068-2-6) $\leq 300 \text{ m/s}^2$ (EN 60068-2-27)
<b>Operating temperature</b>	0 °C to 50 °C
<b>Protection</b> EN 60529	IP 53 when installed according to instructions in the brochure IP 64 with sealing air via DA 400
<b>Mass</b>	0.4 kg + 0.6 kg/m measuring length

\* 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:  $\pm 0.2$  mm

- Ⓘ, ⓓ, ⓔ = Mounting options
- F = Machine guideway
- P = Gauging points for alignment
- ML = Measuring length
- (K) = Required mating dimensions
- (A) = Alternative mating dimensions
- (B) = Cable connection usable at either end
- (D) = Compressed-air connection usable at either end
- (S) = Beginning of measuring length ML
- (R) = Reference mark position on LF 185C
- (C) = Reference mark position on LF 185C
- (W) = Mating surfaces
- (1) = Not an alternative mating dimension, as opposed to LS/LC 100
- ⇒ = Direction of scanning unit motion for output signals in accordance with interface description

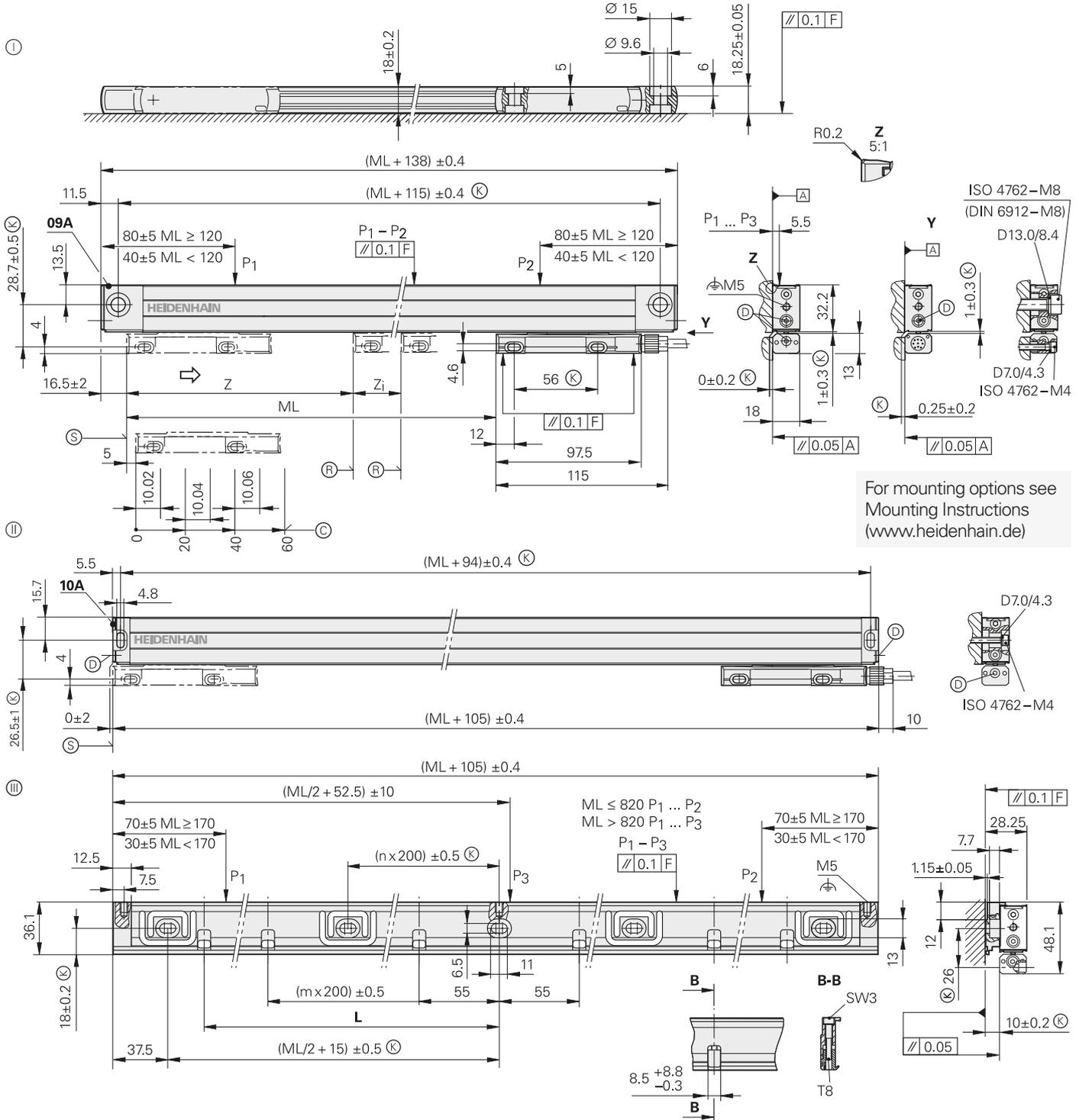


Specifications	LF 185
<b>Measuring standard</b> Coefficient of linear expansion	SUPRADUR phase grating on steel, grating period 8 µm $\alpha_{\text{therm}} \approx 10 \times 10^{-6} \text{ K}^{-1}$
<b>Accuracy grade*</b>	± 3 µm; ± 2 µm
<b>Measuring length ML*</b> in mm	140 240 340 440 540 640 740 840 940 1040 1140 1240 1340 1440 1540 1640 1740 1840 2040 2240 2440 2640 2840 3040
<b>Interface</b>	~ 1 V <sub>PP</sub>
Signal period	4 µm
Reference marks* LF 185 LF 185C	1 reference mark at midpoint; other reference mark positions upon request Distance-coded
Diagnostics interface	Analog
Cutoff frequency -3 dB	≥ 250 kHz
<b>Electrical connection</b>	Separate adapter cable (1 m/3 m/6 m/9 m) connectable on mounting block
Cable length	≤ 150 m (with HEIDENHAIN cable)
Voltage supply without load	DC 5 V ±0.25 V/< 150 mA
<b>Traversing speed</b>	≤ 60 m/min (max. acceleration in measuring direction ≤ 100 m/s <sup>2</sup> )
<b>Required moving force</b>	≤ 4 N
<b>Vibration</b> 55 Hz to 2000 Hz effecting the <b>Shock</b> 11 ms	Housing: ≤ 150 m/s <sup>2</sup> (EN 60068-2-6) Scanning unit: ≤ 200 m/s <sup>2</sup> (EN 60068-2-6) ≤ 300 m/s <sup>2</sup> (EN 60068-2-27)
<b>Operating temperature</b>	0 °C to 50 °C
<b>Protection</b> EN 60529	IP 53 when installed according to instructions in the brochure IP 64 with sealing air via DA 400
<b>Mass</b>	0.8 kg + 4.6 kg/m measuring length

\* Please select when ordering

# LS 400 series

Incremental linear encoders with slimline scale housing  
 • For limited installation space



For mounting options see  
 Mounting Instructions  
 (www.heidenhain.de)

ML	70	120	170	220	270	320	370	420	470	520	570	620	670	720	770	820	870	920	970	1020	1070	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	425	450	475	500	515	555	610	655	710	760	810	855	910	1010

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

- ⊖ = End block 09A; mounting with and without mounting spar
- ⊕ = End block 10A; installation with mounting spar
- ⊗ = MSL 41 mounting spar
- F = Machine guideway
- P = Gauging points for alignment
- ⊗ = Required mating dimensions

- ⊗ = Reference mark position on LS 4x7  
 2 reference marks for measuring lengths  
 70 ... 1020 | 1140 ... 2040  
 z = 35 mm | z = 45 mm  
 z<sub>1</sub> = ML - 70 mm | z<sub>1</sub> = ML - 90 mm
- ⊗ = Reference mark position on LS 4x7C
- ⊗ = Compressed air inlet
- ⊗ = Beginning of measuring length ML
- ⇒ = Direction of scanning unit motion for output signals in accordance with interface description

LS 4x7 without mounting spar



LS 4x7 with mounting spar

Specifications	LS 487	LS 477								
<b>Measuring standard</b> Coefficient of linear expansion	Glass scale with DIADUR grating, grating period 20 µm $\alpha_{\text{therm}} \approx 8 \times 10^{-6} \text{ K}^{-1}$ (mounting mode ○/⊙); <i>with mounting spar</i> : $\alpha_{\text{therm}} \approx 9 \times 10^{-6} \text{ K}^{-1}$ (mounting mode ⊕)									
<b>Accuracy grade*</b>	± 5 µm; ± 3 µm									
<b>Measuring length ML*</b> in mm	Mounting spar* up to ML 1240 option, as of ML 1340 required 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									
Reference marks* LS 4x7  LS 4x7C	<ul style="list-style-type: none"> <li>Selectable with magnets every 50 mm</li> <li>One reference mark at midpoint of measuring length</li> <li>Two reference marks, each 35 mm (for ML ≤ 1020 mm) or 45 mm (for ML ≥ 1140 mm) from the beginning and end of the measuring length</li> </ul> Distance-coded									
<b>Interface</b>	~ 1 V <sub>PP</sub>		□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 a	–		100 kHz ≥ 0.5 µs		50 kHz ≥ 1 µs		100 kHz ≥ 0.25 µs		50 kHz ≥ 0.5 µs	
<b>Measuring step</b>	Depends on interpolation		1 µm <sup>1)</sup>		0.5 µm <sup>1)</sup>			0.25 µm <sup>1)</sup>		
<b>Electrical connection</b>	Separate adapter cable (1 m/3 m/6 m/9 m) connectable on mounting block									
Cable length <sup>2)</sup>	≤ 150 m		≤ 100 m							
Voltage supply without load	DC 5 V ±0.25 V/< 120 mA		DC 5 V ±0.25 V/< 140 mA							
<b>Traversing speed</b>	≤ 120 m/min		≤ 120 m/min		≤ 60 m/min		≤ 120 m/min		≤ 60 m/min	
<b>Required moving force</b>	≤ 5 N									
<b>Vibration</b> 55 Hz to 2000 Hz <b>Shock</b> 11 ms <b>Acceleration</b>	Without mounting spar: ≤ 100 m/s <sup>2</sup> (EN 60068-2-6) With mounting spar, cable outlet at right: ≤ 200 m/s <sup>2</sup> , links: 100 m/s <sup>2</sup> (EN 60068-2-6) ≤ 300 m/s <sup>2</sup> (EN 60068-2-27) ≤ 100 m/s <sup>2</sup> in measuring direction									
<b>Operating temperature</b>	0 °C to 50 °C									
<b>Protection</b> EN 60529	IP 53 when installed according to mounting instructions and information; IP 64 with compressed air from DA 400									
<b>Mass</b>	0.4 kg + 0.5 kg/m measuring length									

\* Please select when ordering

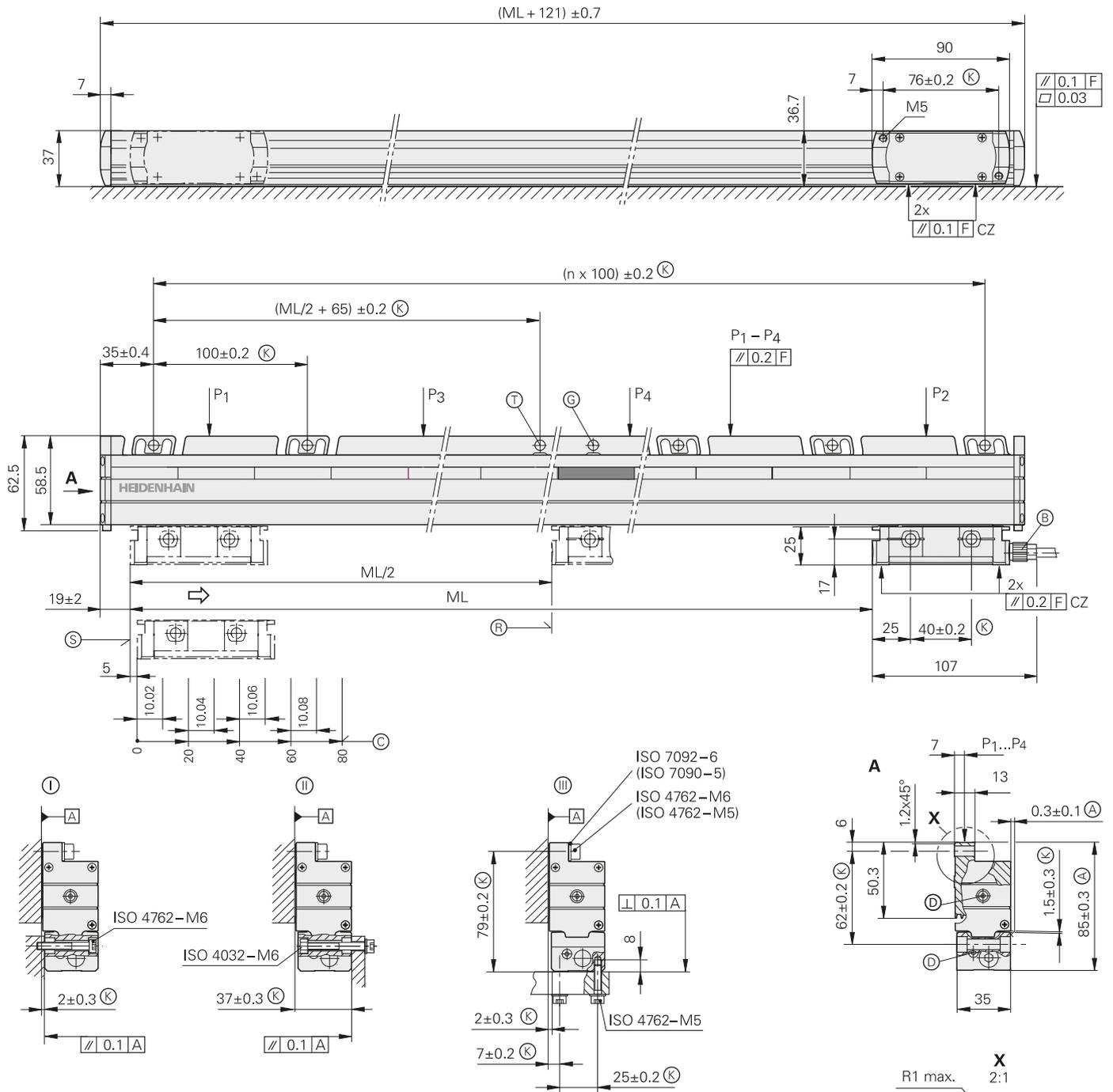
<sup>1)</sup> After 4-fold evaluation in the subsequent electronics

<sup>2)</sup> With HEIDENHAIN cable

# LS 100 series

Incremental linear encoders with full-size scale housing

- High vibration resistance
- Reclining mounting possible



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

- Ⓘ, ⓓ, ⓔ = Mounting options
- F = Machine guideway
- P = Gauging points for alignment
- Ⓚ = Required mating dimensions
- Ⓐ = Alternative mating dimensions
- Ⓑ = Cable connection usable at either end
- Ⓓ = Compressed-air connection 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 scanning unit motion for output signals in accordance with interface description



Specifications	LS 187	LS 177															
<b>Measuring standard</b> Coefficient of linear expansion	Glass scale with DIADUR grating, grating period 20 μm $\alpha_{\text{therm}} \approx 8 \times 10^{-6} \text{ K}^{-1}$																
<b>Accuracy grade*</b>	± 5 μm; ± 3 μm																
<b>Measuring length ML*</b> 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* <i>LS 1x7</i> <i>LS 1x7C</i>	Selectable with magnets every 50 mm, standard setting: 1 reference mark in the center Distance-coded																
<b>Interface</b>	~ 1 V <sub>PP</sub>			□ 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 a	–			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	
<b>Measuring step</b>	Depends on interpolation			1 μm <sup>1)</sup>		0.5 μm <sup>1)</sup>		0.25 μm <sup>1)</sup>									
<b>Electrical connection</b>	Separate adapter cable (1 m/3 m/6 m/9 m) connectable on mounting block																
Cable length <sup>2)</sup>	≤ 150 m			≤ 100 m													
Voltage supply without load	DC 5 V ±0.25 V/< 120 mA			DC 5 V ±0.25 V/< 140 mA													
<b>Traversing speed</b>	≤ 120 m/min			≤ 120 m/min		≤ 60 m/min		≤ 120 m/min		≤ 60 m/min		≤ 30 m/min		≤ 60 m/min		≤ 30 m/min	
<b>Required moving force</b>	≤ 4 N																
<b>Vibration</b> 55 Hz to 2000 Hz <b>Shock</b> 11 ms <b>Acceleration</b>	≤ 200 m/s <sup>2</sup> (EN 60068-2-6) ≤ 400 m/s <sup>2</sup> (EN 60068-2-27) ≤ 60 m/s <sup>2</sup> in measuring direction																
<b>Operating temperature</b>	0 °C to 50 °C																
<b>Protection</b> EN 60529	IP 53 when mounted according to the instructions and mounting information IP 64 if compressed air is connected via DA 400																
<b>Mass</b>	0.4 kg + 2.3 kg/m measuring length																

\* Please select when ordering

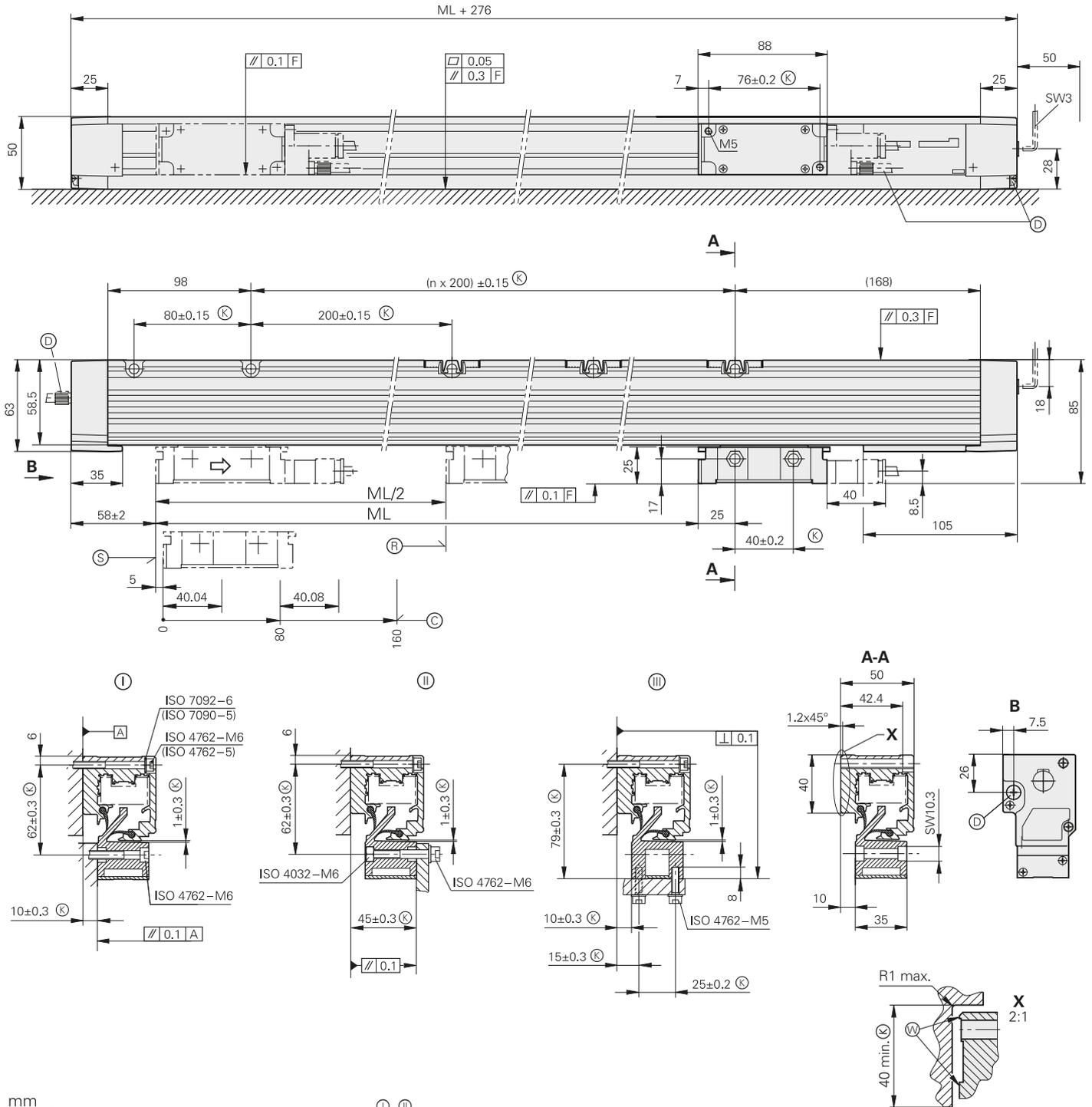
<sup>1)</sup> After 4-fold evaluation in the subsequent electronics

<sup>2)</sup> With HEIDENHAIN cable

# LB 382 up to 3040 mm measuring length (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:  $\pm 0.2$  mm

- Ⓘ, ⓓ, ⓔ = Mounting options
- F = Machine guideway
- Ⓚ = Required mating dimensions
- Ⓛ = Compressed air inlet
- Ⓡ = Reference mark position on LB 3x2
- Ⓒ = Reference mark position on LB 3x2C
- Ⓢ = Beginning of measuring length ML
- Ⓜ = Mating surfaces
- ⇒ = Direction of scanning unit motion for output signals in accordance with interface description



<b>Specifications</b>	<b>LB 382</b> up to ML 3040 mm
<b>Measuring standard</b> Coefficient of linear expansion	Rustproof steel scale tape with AURODUR graduation, grating period 40 µm $\alpha_{\text{therm}} \approx 10 \times 10^{-6} \text{ K}^{-1}$
<b>Accuracy grade</b>	± 5 µm
<b>Measuring length ML*</b> in mm	Single-section housing 440 640 840 1040 1240 1440 1640 1840 2040 2240 2440 2640 2840 3040
Reference marks* <i>LB 382</i> <i>LB 382C</i>	Selectable by selector plate every 50 mm, standard setting: 1 reference mark in the center Distance-coded
<b>Interface</b>	~ 1 V <sub>PP</sub>
Signal period	40 µm
Diagnostics interface	Analog
Cutoff frequency -3 dB	≥ 250 kHz
<b>Electrical connection</b>	Separate adapter cable (1 m/3 m/6 m/9 m) connectable on mounting block
Cable length <sup>1)</sup>	≤ 150 m
Voltage supply without load	DC 5 V ±0.25 V/< 150 mA
<b>Traversing speed</b>	≤ 120 m/min (max. acceleration in measuring direction ≤ 60 m/s <sup>2</sup> )
<b>Required moving force</b>	≤ 15 N
<b>Vibration</b> 55 Hz to 2000 Hz <b>Shock</b> 11 ms	≤ 300 m/s <sup>2</sup> (EN 60068-2-6) ≤ 300 m/s <sup>2</sup> (EN 60068-2-27)
<b>Operating temperature</b>	0 °C to 50 °C
<b>Protection</b> EN 60529	IP 53 when mounted according to the instructions and mounting information IP 64 if compressed air is connected via DA 400
<b>Mass</b>	1.3 kg + 3.6 kg/m measuring length

\* Please select when ordering

<sup>1)</sup>With HEIDENHAIN cable





Specifications	LB 382 from ML 3240 mm
<b>Measuring standard</b> Coefficient of linear expansion	Rustproof steel scale tape with AURODUR graduation, grating period 40 µm Same as machine main casting
<b>Accuracy grade</b>	± 5 µm
<b>Measuring length ML*</b>	Kit with single-section AURODUR steel tape and housing sections for measuring lengths from 3240 mm to 30040 mm in 200 mm steps (up to 72040 mm upon request) Housing sections: 1000 mm, 1200 mm, 1400 mm, 1600 mm, 1800 mm, 2000 mm
Reference marks* <i>LB 382</i> <i>LB 382 C</i>	Selectable by selector plate every 50 mm Distance-coded
<b>Interface</b>	~ 1 V <sub>pp</sub>
Signal period	40 µm
Diagnostics interface	Analog
Cutoff frequency -3 dB	≥ 250 kHz
<b>Electrical connection</b>	Separate adapter cable (1 m/3 m/6 m/9 m) connectable on mounting block
Cable length <sup>1)</sup>	≤ 150 m
Voltage supply without load	DC 5 V ±0.25 V / < 150 mA
<b>Traversing speed</b>	≤ 120 m/min (max. acceleration in measuring direction ≤ 60 m/s <sup>2</sup> )
<b>Required moving force</b>	≤ 15 N
<b>Vibration</b> 55 Hz to 2000 Hz <b>Shock</b> 11 ms	≤ 300 m/s <sup>2</sup> (EN 60068-2-6) ≤ 300 m/s <sup>2</sup> (EN 60068-2-27)
<b>Operating temperature</b>	0 °C to 50 °C
<b>Protection</b> EN 60529	IP 53 when mounted according to the instructions and mounting information IP 64 if compressed air is connected via DA 400
<b>Mass</b>	1.3 kg + 3.6 kg/m measuring length

\* Please select when ordering

<sup>1)</sup>With HEIDENHAIN cable

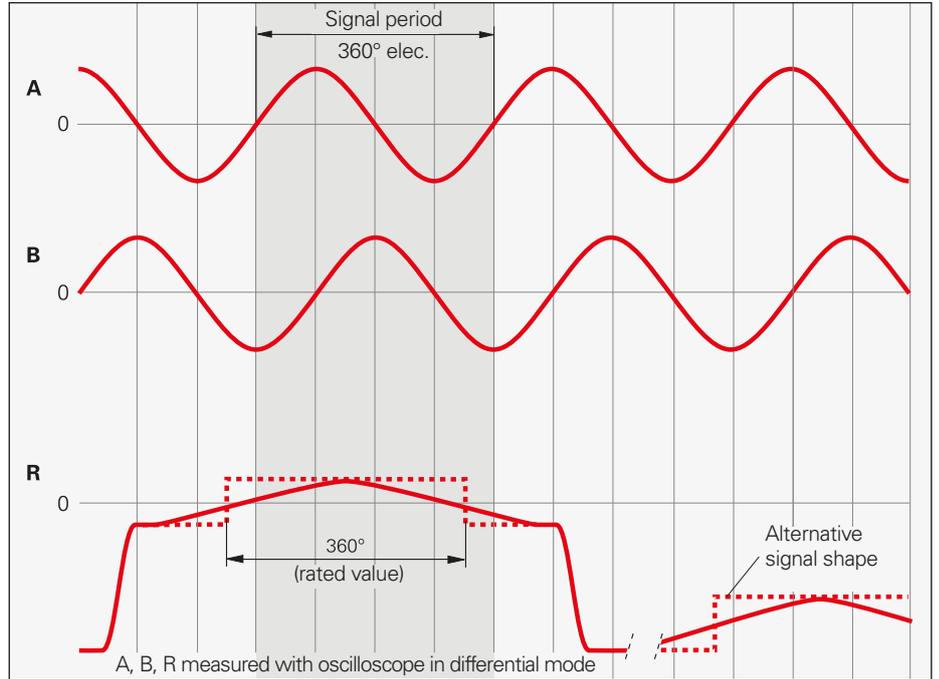
# Interfaces

~ 1 V<sub>PP</sub> incremental signals

HEIDENHAIN encoders with ~ 1 V<sub>PP</sub> interface provide highly interpolable voltage signals.

The sinusoidal **incremental signals** A and B are phase-shifted by 90° elec. and have amplitudes of typically 1 V<sub>PP</sub>. 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.



### Further information:

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					15-pin D-sub connector									
For HEIDENHAIN controls and IK 220					For encoders or IK 215									
	Voltage supply				Incremental signals						Other signals			
	12	2	10	11	5	6	8	1	3	4	9	7	/	
	1	9	2	11	3	4	6	7	10	12	5/8/13/15	14	/	
	4	12	2	10	1	9	3	11	14	7	5/6/8/15	13	/	
	U <sub>P</sub>	Sensor <sup>1)</sup> U <sub>P</sub>	0V	Sensor <sup>1)</sup> 0V	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<sub>P</sub> = 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!

<sup>1)</sup> LIDA 2xx: Vacant

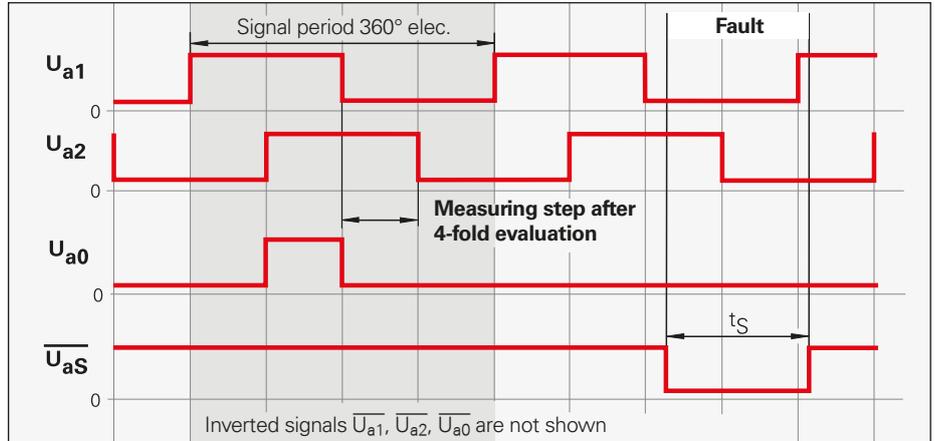
# Incremental signals $\square$ TTL

HEIDENHAIN encoders with  $\square$ 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  $90^\circ$  elec. The **reference mark signal** consists of one or more reference pulses  $U_{a0}$ , which are gated with the incremental signals. In addition, the integrated electronics produce their **inverted signals**  $\overline{U_{a1}}$ ,  $\overline{U_{a2}}$  and  $\overline{U_{a0}}$  for noise-proof transmission. The illustrated sequence of output signals—with  $U_{a2}$  lagging  $U_{a1}$ —applies 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**.



### Further information:

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 HEIDENHAIN controls and IK 220				15-pin D-sub connector For encoder or PWM 20									
	Voltage supply			Incremental signals						Other signals			
	12	2	10	11	5	6	8	1	3	4	7	/	9 <sup>3)</sup>
	1	9	2	11	3	4	6	7	10	12	14	8/13/15	5
	4	12	2	10	1	9	3	11	14	7	13	5/6/8	15 <sup>3)</sup>
	$U_P$	Sensor <sup>1)</sup> $U_P$	0V	Sensor <sup>1)</sup> 0V	$U_{a1}$	$\overline{U_{a1}}$	$U_{a2}$	$\overline{U_{a2}}$	$U_{a0}$	$\overline{U_{a0}}$	$\overline{U_{aS}}$ <sup>2)</sup>	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!

<sup>1)</sup> LIDA 2xx: Vacant

<sup>2)</sup> ERO 14xx: Vacant

<sup>3)</sup> Exposed linear encoders: TTL/11  $\mu$ App switchover for PWT, otherwise not occupied

# Interfaces

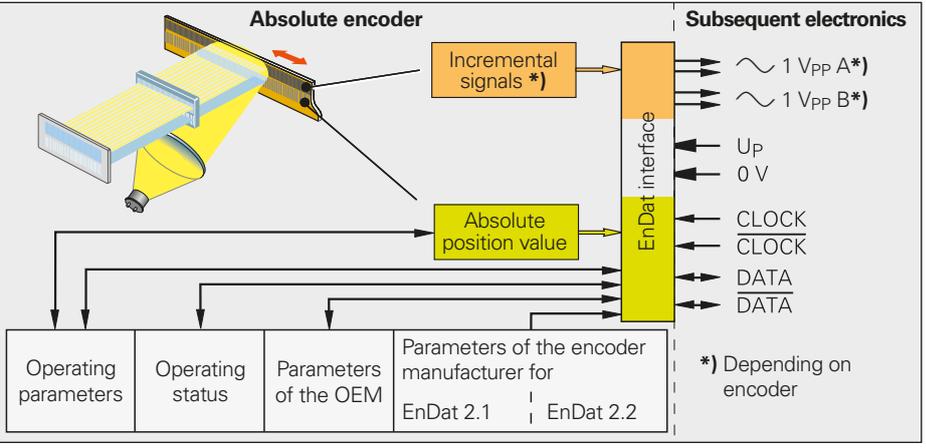
## Position values

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 data is transmitted in **synchronism** with the CLOCK signal from the subsequent electronics. The type of transmission (position values, parameters, diagnostics ...) is selected by mode commands that the subsequent electronics send to the encoder. Some functions are available only with EnDat 2.2 mode commands.

 **Further information:**  
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
<b>EnDat01</b>	EnDat 2.1 or EnDat 2.2	With
EnDat21		Without
EnDat02	EnDat 2.2	With
<b>EnDat22</b>	EnDat 2.2	Without

Versions of the EnDat interface



### Pin layout

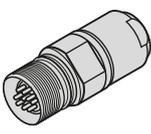
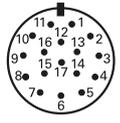
**8-pin coupling, M12**



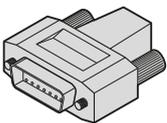
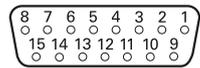


	Power supply				Serial data transfer			
	<b>8</b>	<b>2</b>	<b>5</b>	<b>1</b>	<b>3</b>	<b>4</b>	<b>7</b>	<b>6</b>
	<b>Up</b>	<b>Sensor Up</b>	<b>0V</b>	<b>Sensor 0V</b>	<b>DATA</b>	<b>DATA</b>	<b>CLOCK</b>	<b>CLOCK</b>
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

**17-pin coupling, M23**

**15-pin D-sub connector**  
For HEIDENHAIN controls and IK 220

	Power supply					Incremental signals <sup>1)</sup>				Serial data transfer			
	<b>7</b>	<b>1</b>	<b>10</b>	<b>4</b>	<b>11</b>	<b>15</b>	<b>16</b>	<b>12</b>	<b>13</b>	<b>14</b>	<b>17</b>	<b>8</b>	<b>9</b>
	<b>1</b>	<b>9</b>	<b>2</b>	<b>11</b>	<b>13</b>	<b>3</b>	<b>4</b>	<b>6</b>	<b>7</b>	<b>5</b>	<b>8</b>	<b>14</b>	<b>15</b>
	<b>Up</b>	<b>Sensor Up</b>	<b>0V</b>	<b>Sensor 0V</b>	<b>Internal shield</b>	<b>A+</b>	<b>A-</b>	<b>B+</b>	<b>B-</b>	<b>DATA</b>	<b>DATA</b>	<b>CLOCK</b>	<b>CLOCK</b>
	Brown/ Green	Blue	White/ Green	White	/	Green/ Black	Yellow/ Black	Blue/ Black	Red/ Black	Gray	Pink	Violet	Yellow

**Cable shield** connected to housing; **Up** = 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!  
<sup>1)</sup> Only with ordering designations EnDat01 and EnDat02

# Fanuc, Mitsubishi and Siemens pin layout

## Fanuc pin layout

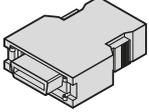
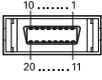
HEIDENHAIN encoders with the code letter *F* after the model designation are suited for connection to Fanuc controls with

- **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  
Contains α interface (normal and high speed, two-pair transmission)

20-pin Fanuc connector					8-pin coupling, M12				
									
	Power supply					Serial data transfer			
	<b>9</b>	<b>18/20</b>	<b>12</b>	<b>14</b>	<b>16</b>	<b>1</b>	<b>2</b>	<b>5</b>	<b>6</b>
	<b>8</b>	<b>2</b>	<b>5</b>	<b>1</b>	–	<b>3</b>	<b>4</b>	<b>7</b>	<b>6</b>
	<b>U<sub>P</sub></b>	<b>Sensor</b> U <sub>P</sub>	<b>0V</b>	<b>Sensor</b> 0V	<b>Shield</b>	<b>Serial Data</b>	<b>Serial Data</b>	<b>Request</b>	<b>Request</b>
	Brown/ Green	Blue	White/ Green	White	–	Gray	Pink	Violet	Yellow

**Cable shield** connected to housing; **U<sub>P</sub>** = 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.

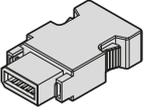
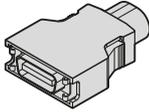
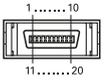
## Mitsubishi pin layout

HEIDENHAIN encoders with the code letter *M* after the model designation are suited for connection to Mitsubishi controls with

- **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

10-pin Mitsubishi connector			20-pin Mitsubishi connector			8-pin coupling, M12			
									
	Power supply					Serial data transfer			
	<b>10-pin</b>	<b>1</b>	–	<b>2</b>	–	<b>7</b>	<b>8</b>	<b>3</b>	<b>4</b>
	<b>20-pin</b>	<b>20</b>	<b>19</b>	<b>1</b>	<b>11</b>	<b>6</b>	<b>16</b>	<b>7</b>	<b>17</b>
	<b>8</b>	<b>2</b>	<b>5</b>	<b>1</b>	<b>3</b>	<b>4</b>	<b>7</b>	<b>6</b>	
	<b>U<sub>P</sub></b>	<b>Sensor</b> U <sub>P</sub>	<b>0V</b>	<b>Sensor</b> 0V	<b>Serial Data</b>	<b>Serial Data</b>	<b>Request Frame</b>	<b>Request Frame</b>	
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow	

**Cable shield** connected to housing; **U<sub>P</sub>** = Power supply voltage

**Sensor:** The sensor line is connected in the encoder with the corresponding power line.

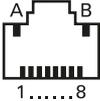
Vacant pins or wires must not be used!

**Siemens pin layout**

HEIDENHAIN encoders with the code letter *S* after the model designation are suited for connection to Siemens controls with **DRIVE-CLiQ interface**

- Ordering designation DQ01

DRIVE-CLiQ is a registered trademark of SIEMENS AG.

RJ45 connector		8-pin coupling, M12				
						
	Power supply		Serial data transfer			
			Transmit data		Receive data	
	<b>A</b>	<b>B</b>	<b>3</b>	<b>6</b>	<b>1</b>	<b>2</b>
	<b>1</b>	<b>5</b>	<b>7</b>	<b>6</b>	<b>3</b>	<b>4</b>
	<b>U<sub>p</sub></b>	<b>0V</b>	<b>TXP</b>	<b>TXN</b>	<b>RXP</b>	<b>RXN</b>

**Cable shield** connected to housing; **U<sub>p</sub>** = Power supply voltage

# Connecting elements and cables

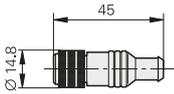
## General information

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

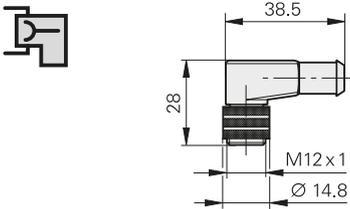
Symbols



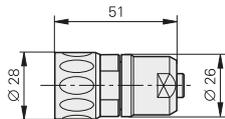
**M12**



**M12 right-angle connector**

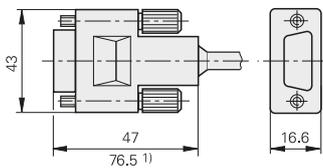


**M23**



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

Symbols



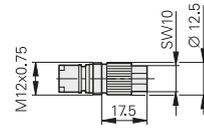
<sup>1)</sup> With integrated interface electronics

**Coupling insulated:** Connecting element with external thread. Available with male or female contacts.

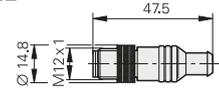
Symbols



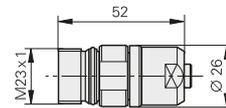
**On the adapter cable**



**M12**



**M23**



The **pin numbering** on connectors is in the direction opposite to those on couplings or flange sockets, regardless of whether the connecting elements have

male contacts or



female contacts.



Accessory:

**1/4" socket wrench for mounting the cable**

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



When engaged, the connections provide **protection** to IP67 (D-sub connector: IP50; RJ-45: IP20; EN 60529). When not engaged, there is no protection.

**Maximum cable lengths**

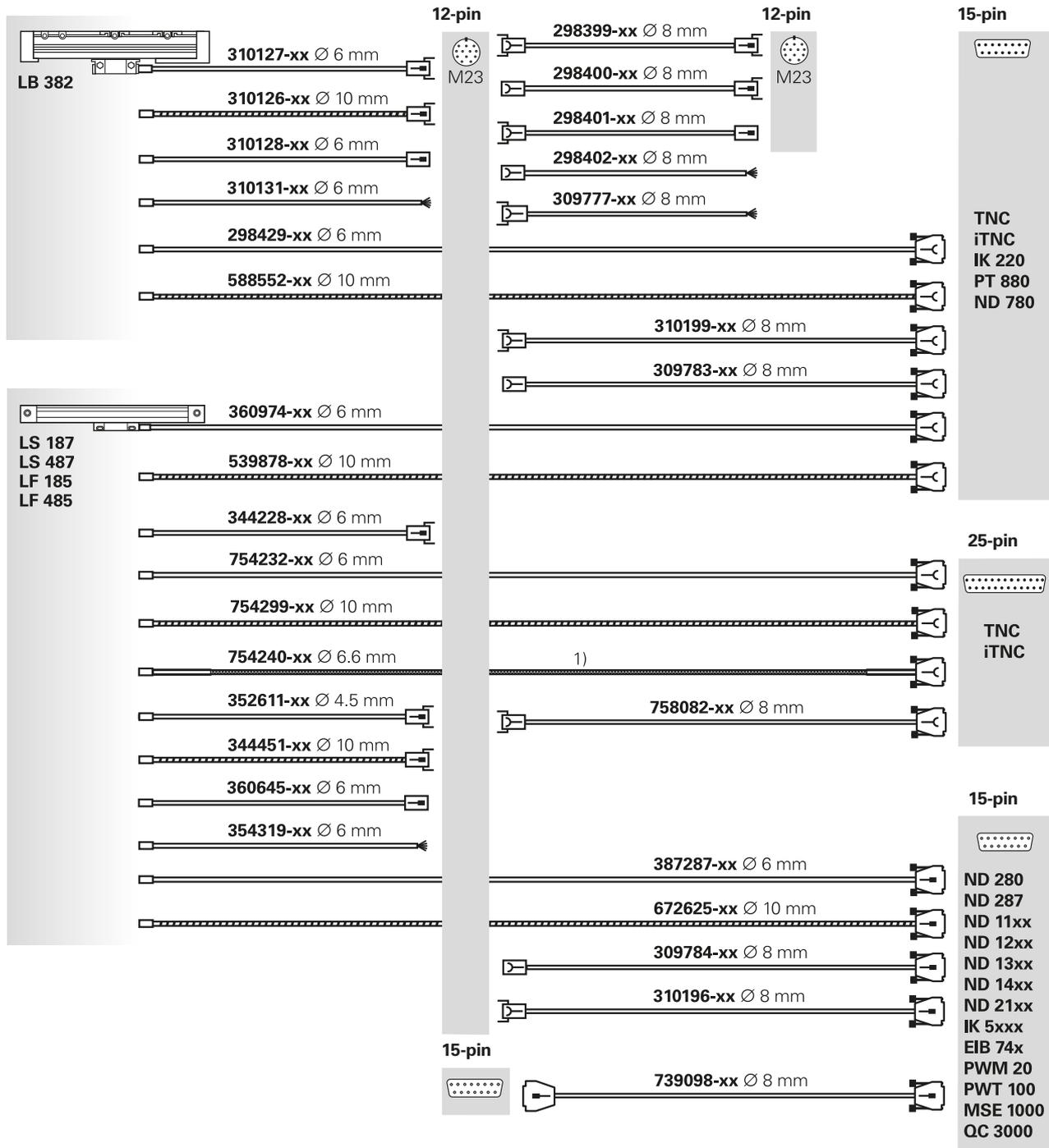
The maximum achievable cable length is influenced by the supply voltage of the subsequent electronics, the cables used, and the interface. However, commonly used overall lengths of 30 m are usually possible without restrictions.



**Further information:**

Brochure: *Cables and Connectors for HEIDENHAIN Controls*

# Adapter cables and connecting cables – 1 V<sub>PP</sub> interface



Connector, male/female

Coupling, male/female

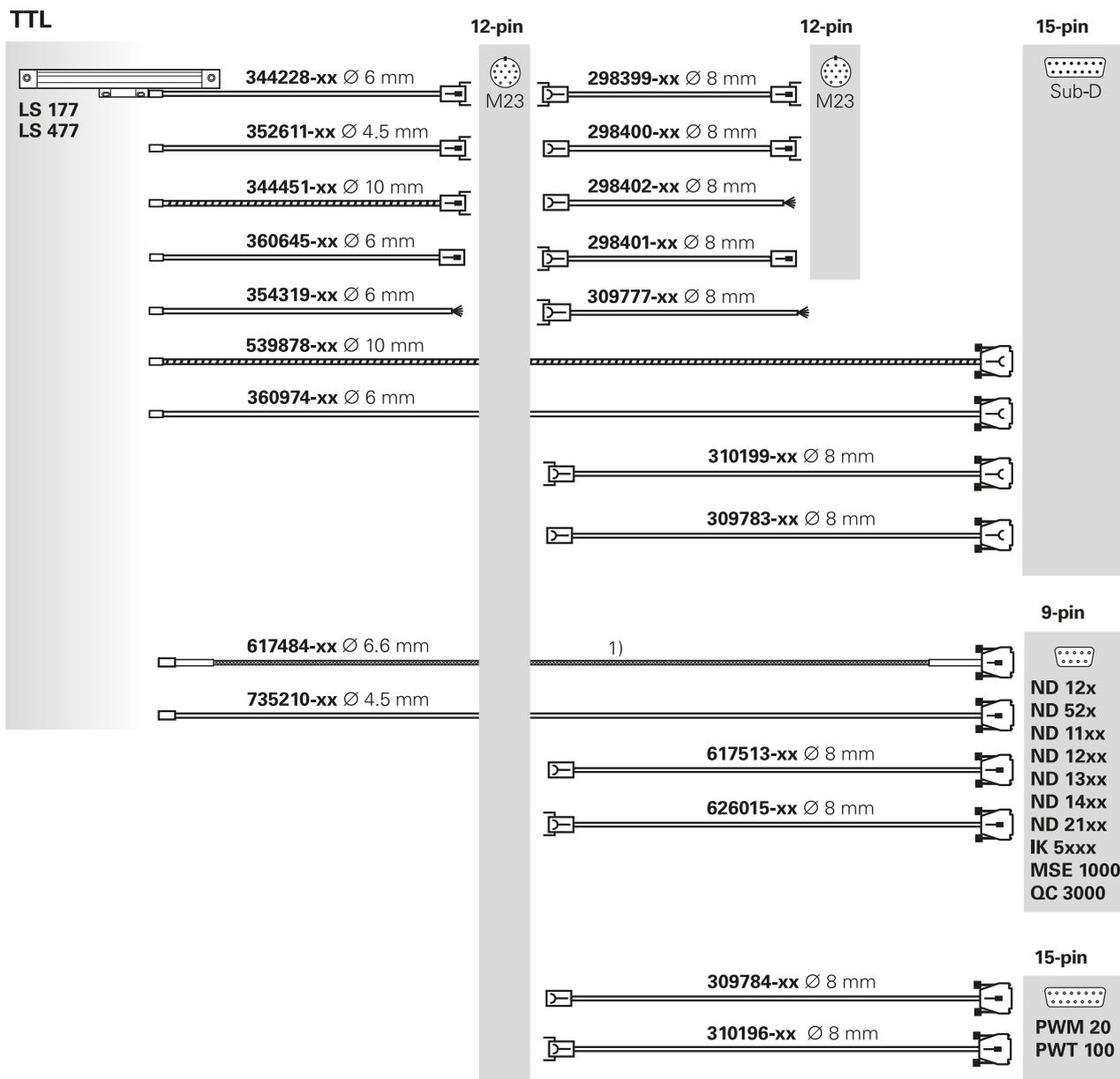
D-sub connector, male/female

PUR cable

PUR cable in metal armor

<sup>1)</sup> Cable with braided shield

# Adapter cables and connecting cables – TTL interface



  Connector, male/female

  Coupling, male/female

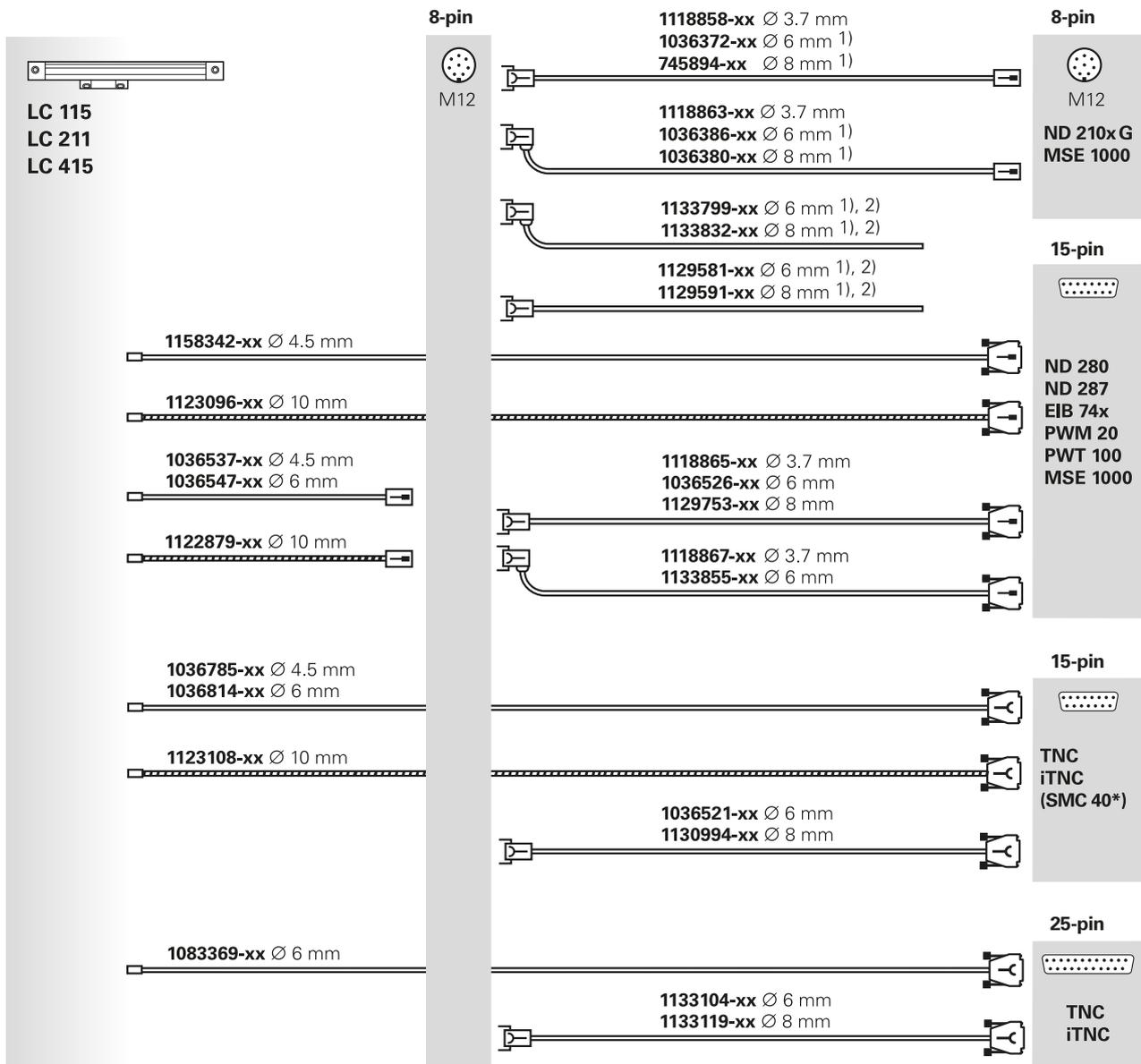
  D-sub connector, male/female

 PUR cable

 PUR cable in metal armor

 <sup>1)</sup> Cable with braided shield

# Adapter cables and connecting cables – EnDat interface (EnDat22)



Connector, male/female

PUR cable

Coupling, male/female

PUR cable in metal armor

D-sub connector, male/female

\* Connection to SIEMENS NC

1) Also suitable for Fanuc/Mitsubishi/ Panasonic/Yaskawa

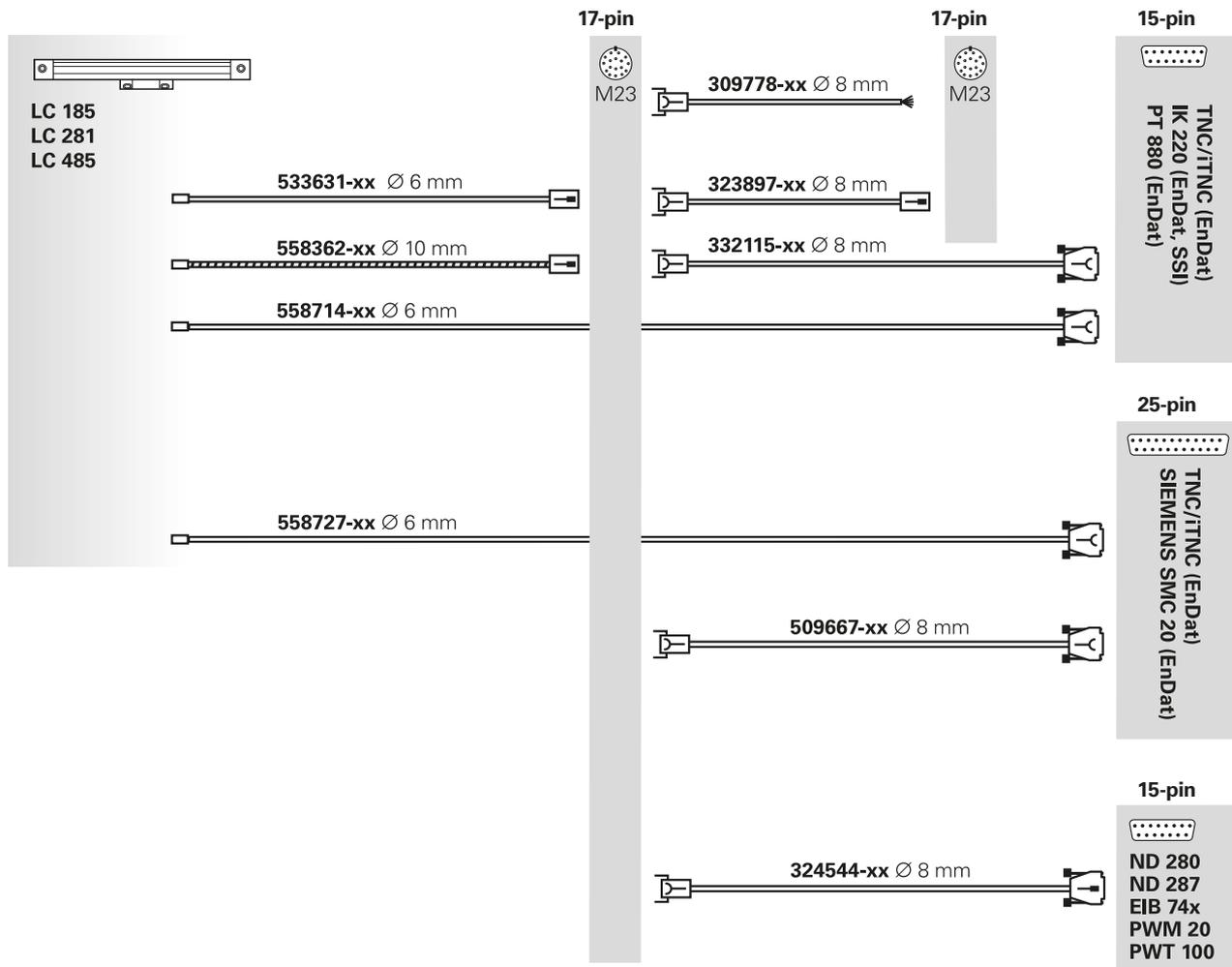
2) Not the connecting element for 8 MHz signal transmission!

## Note for safety-related applications:

Only completely assembled HEIDENHAIN cables are qualified.

Be sure to exchange connectors or modify cables only after consultation with HEIDENHAIN Traunreut.

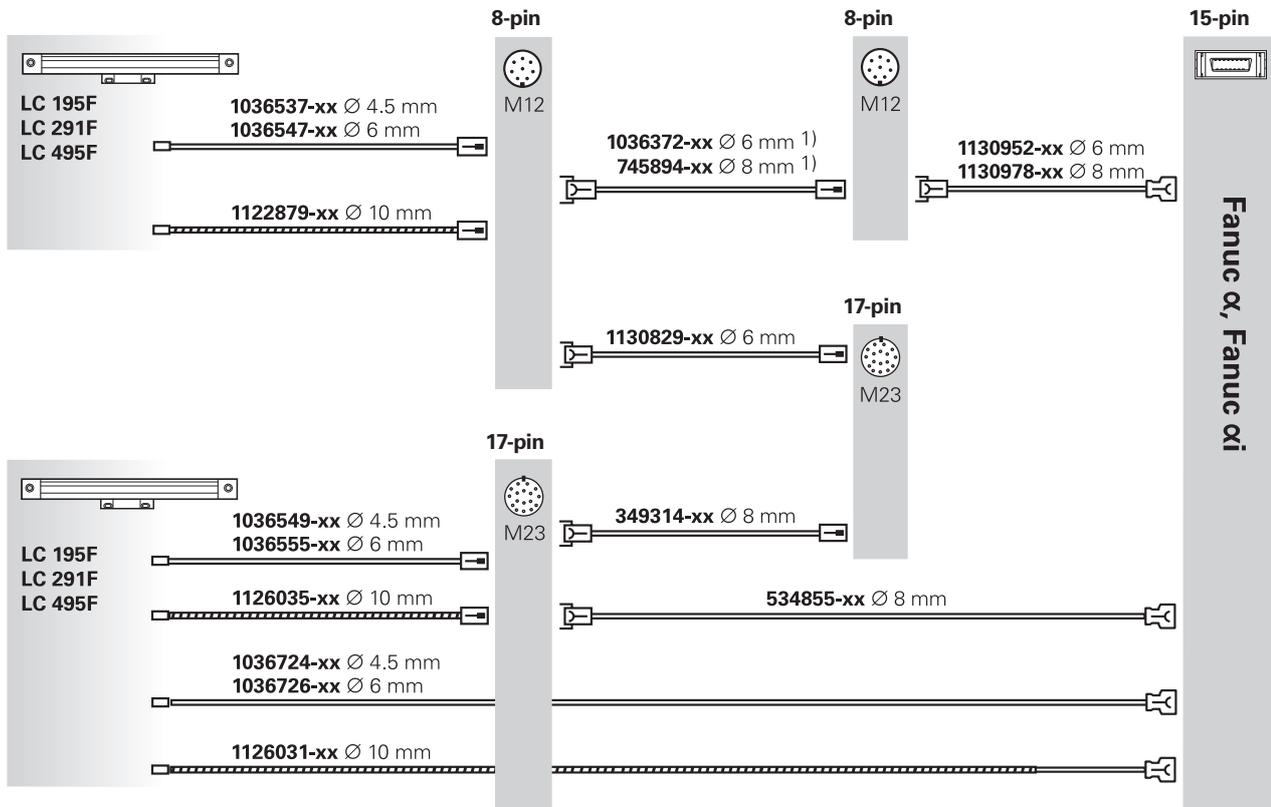
# Adapter cables and connecting cables – EnDat interface (EnDat02)



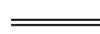
-   Connector, male/female
-   Coupling, male/female
-   D-sub connector, male/female

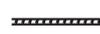
-  PUR cable
-  PUR cable in metal armor

# Adapter cables and connecting cables – Fanuc Serial Interface



-   Connector, male/female
-   Coupling, male/female
-  Fanuc connector

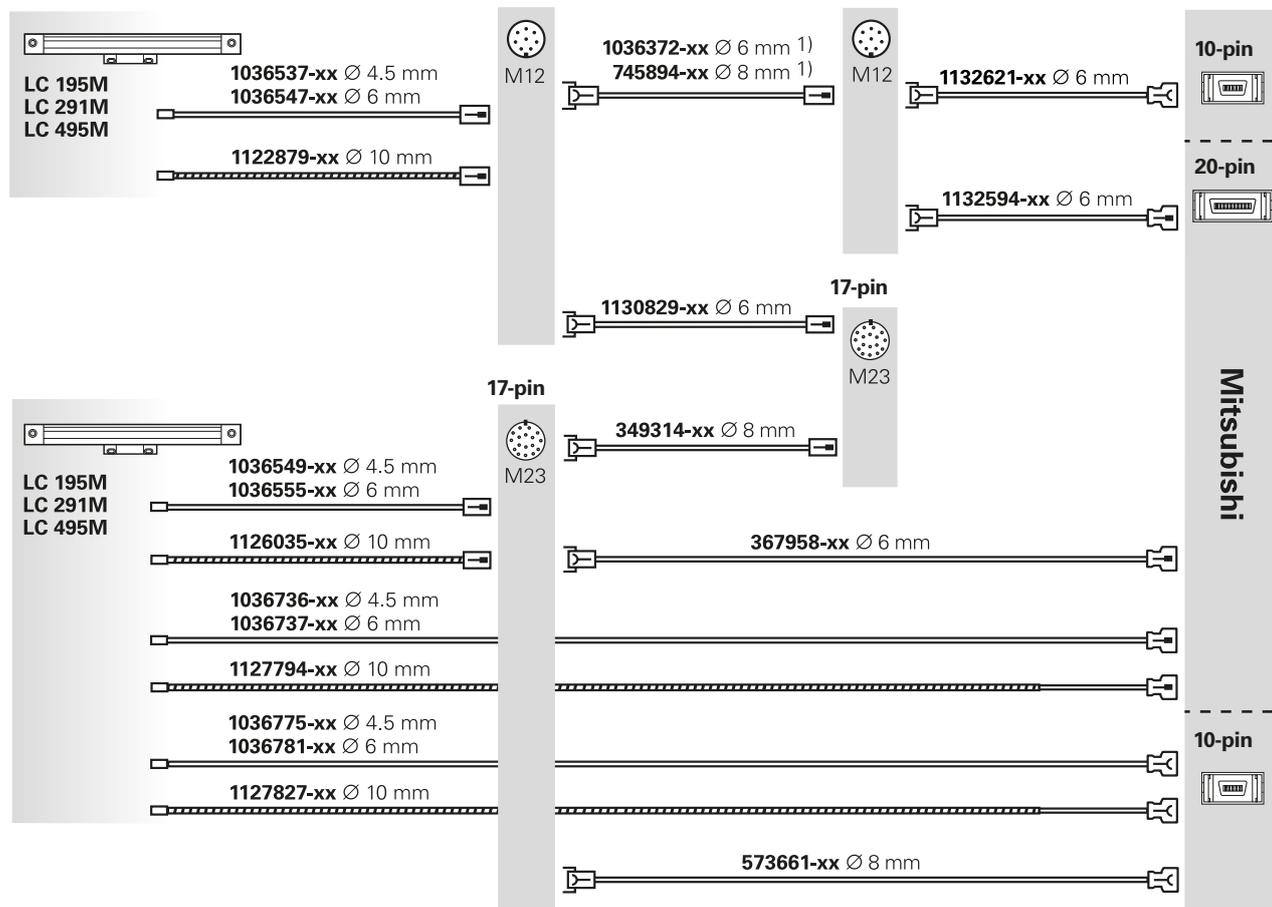
 PUR cable

 PUR cable in metal armor

<sup>1)</sup> For more M12 connecting cables, see EnDat interface (EnDat22)

# Adapter cables and connecting cables – Mitsubishi high speed interface

## Absolute encoders



  Connector, male/female

  Coupling, male/female

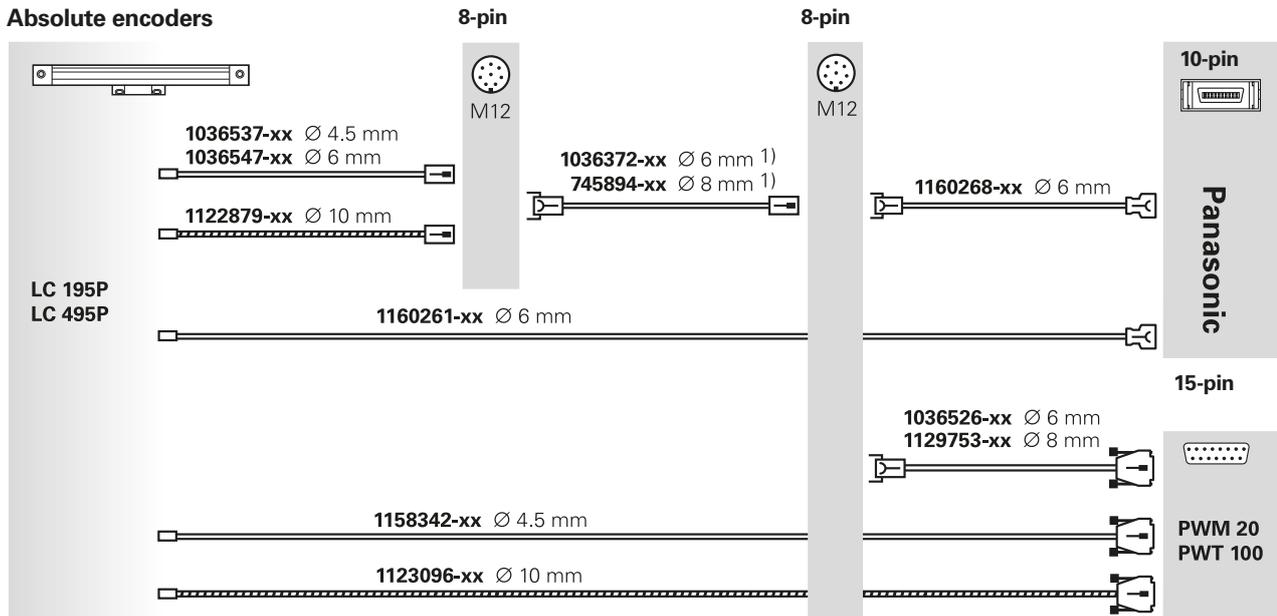
  Mitsubishi connector

 PUR cable

 PUR cable in metal armor

<sup>1)</sup> For more M12 connecting cables, see EnDat interface (EnDat22)

# Adapter cables and connecting cables – Panasonic interface



 Coupling, male

 PUR cable

 Connector, female

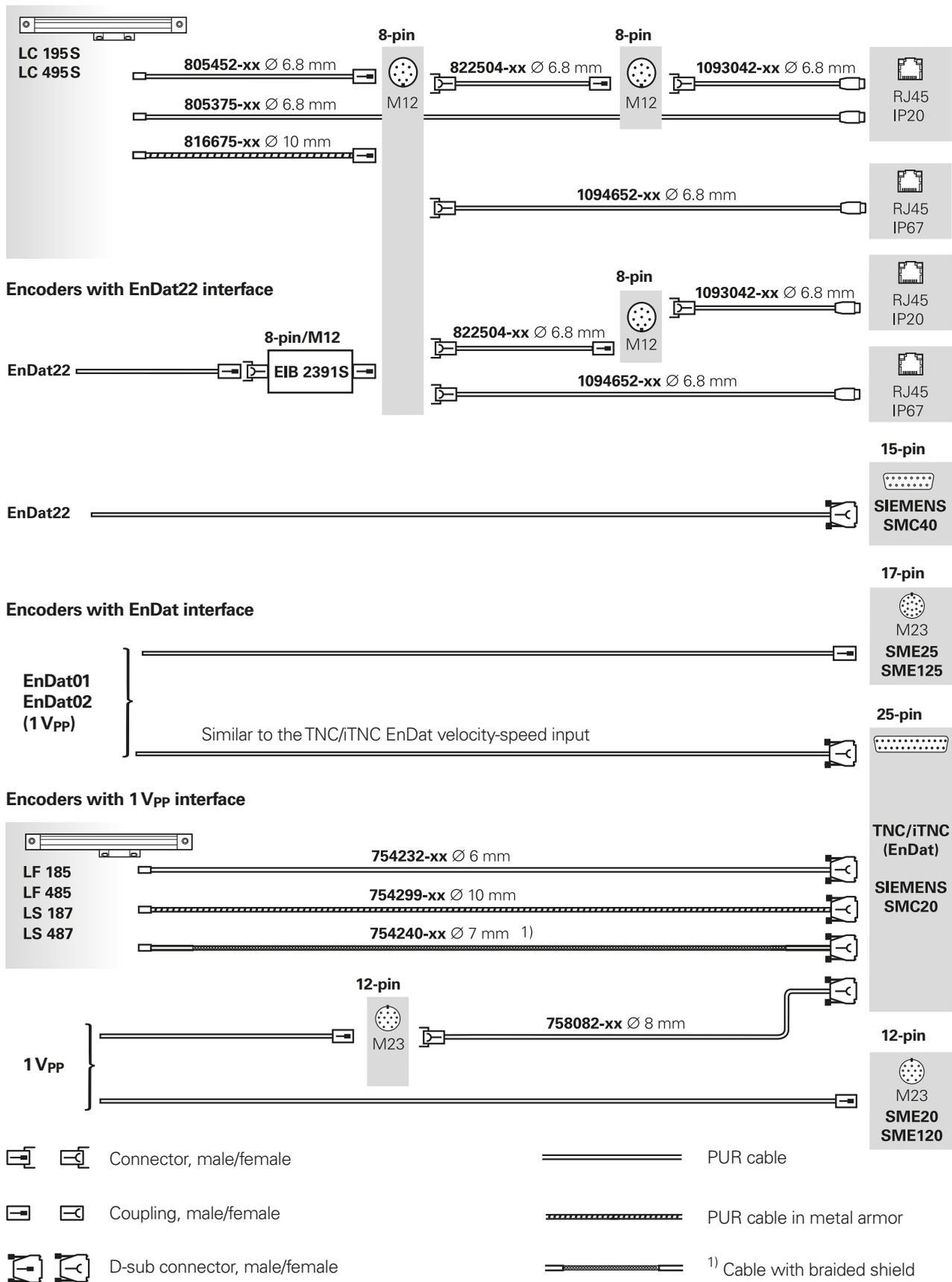
 PUR cable in metal armor

 Panasonic connector

<sup>1)</sup> For more M12 connecting cables, see EnDat interface (EnDat22)

 D-sub connector, male

# Adapter cables and connecting cables – DRIVE-CLiQ



## Note for safety-related applications:

Only completely assembled HEIDENHAIN cables are qualified.

Be sure to exchange connectors or modify cables only after consultation with HEIDENHAIN Traunreut.

# 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<sub>PP</sub>, TTL or HTL interfaces. TTL and HTL encoders monitor their signal amplitudes internally and generate a simple fault detection signal. With 1 V<sub>PP</sub> signals, the analysis of output signals is possible only in external test devices or through computation in the subsequent electronics (analog diagnostics interface).

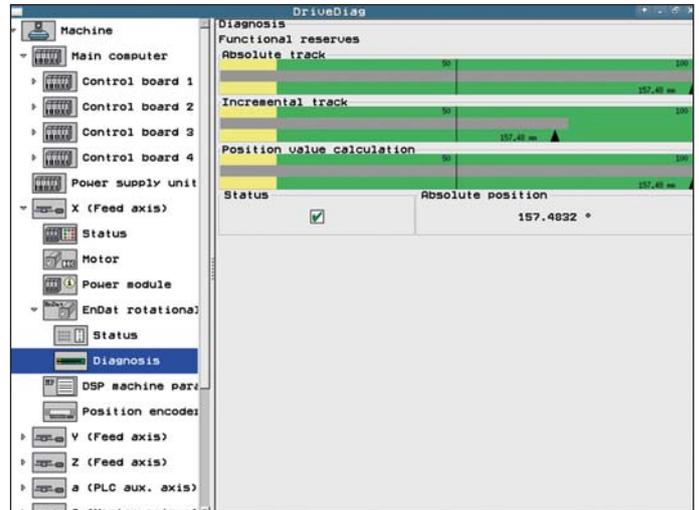
Absolute encoders operate with serial data transfer. Depending on the interface, additional 1 V<sub>PP</sub> incremental signals can be output. The signals are monitored comprehensively within the encoder. The monitoring result (especially with valuation numbers) can be transferred along with the position values through the serial interface to the subsequent electronics (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 output is possible

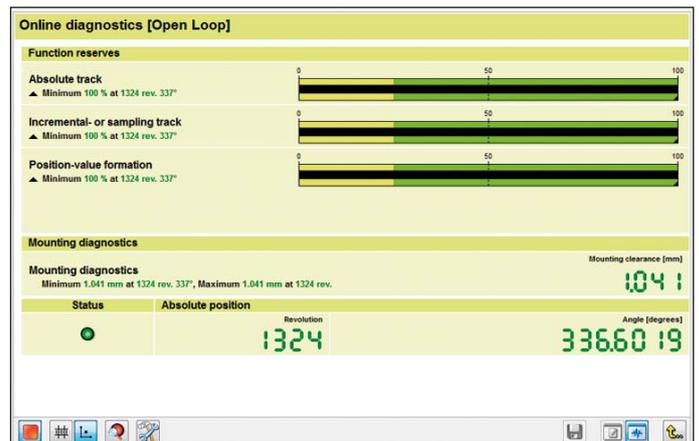
This enables the subsequent electronics to evaluate the current status of the encoder with little effort even in closed-loop mode.

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

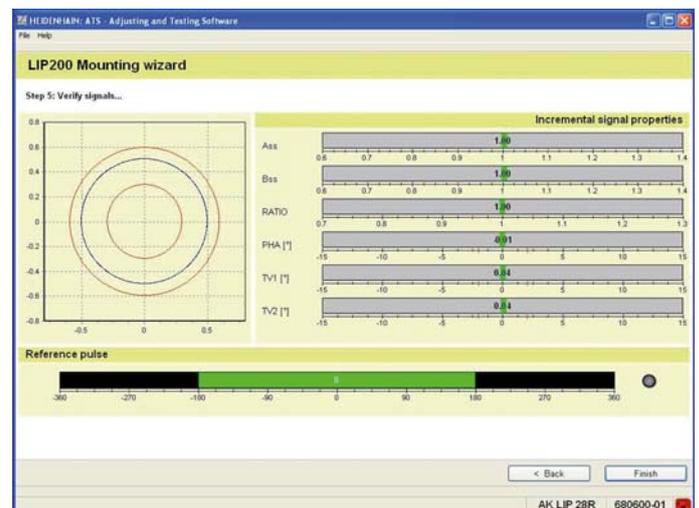
- Encoder diagnostics: The encoder is connected directly to the test or inspection device. This makes a comprehensive analysis of encoder functions possible.
- Diagnostics in the control loop: The PWM phase meter is looped into the closed control loop (e.g. through a suitable testing adapter). This makes 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

## PWM 20

The PWM 20 phase angle measuring unit serves together with the provided ATS adjusting and testing software for diagnosis and adjustment of HEIDENHAIN encoders.



	PWM 20
<b>Encoder input</b>	<ul style="list-style-type: none"> <li>• EnDat 2.1 or EnDat 2.2 (absolute value with or without incremental signals)</li> <li>• DRIVE-CLiQ</li> <li>• Fanuc Serial Interface</li> <li>• Mitsubishi high speed interface</li> <li>• Yaskawa Serial Interface</li> <li>• SSI</li> <li>• 1 V<sub>PP</sub>/TTL/11 μA<sub>PP</sub></li> </ul>
<b>Interface</b>	USB 2.0
<b>Voltage supply</b>	AC 100 V to 240 V or DC 24 V
<b>Dimensions</b>	258 mm x 154 mm x 55 mm

	ATS
<b>Languages</b>	Choice between English and German
<b>Functions</b>	<ul style="list-style-type: none"> <li>• Position display</li> <li>• Connection dialog</li> <li>• Diagnostics</li> <li>• Mounting wizard for EBI/ECI/EQI, LIP 200, LIC 4000 and others</li> <li>• Additional functions (if supported by the encoder)</li> <li>• Memory contents</li> </ul>
<b>System requirements and recommendations</b>	PC (dual-core processor > 2 GHz) RAM > 2 GB Operating system: Windows XP, Vista, 7, 8 and 10 (32-bit/64-bit) 500 MB free space on hard disk

DRIVE-CLiQ is a registered trademark of SIEMENS AG.

## PWT 100

The PWT 100 is a testing device for checking the function and adjustment of incremental and absolute HEIDENHAIN encoders. Thanks to its compact dimensions and robust design, the PWT 100 is ideal for mobile use.



	PWT 100
<b>Encoder input</b> Only for HEIDENHAIN encoders	<ul style="list-style-type: none"> <li>• EnDat</li> <li>• Fanuc Serial Interface</li> <li>• Mitsubishi high speed interface</li> <li>• Panasonic Serial Interface</li> <li>• Yaskawa Serial Interface</li> <li>• 1 V<sub>PP</sub></li> <li>• 11 μA<sub>PP</sub></li> <li>• TTL</li> </ul>
<b>Display</b>	4.3" color flat-panel display (touch screen)
<b>Voltage supply</b>	DC 24 V Power consumption: max. 15 W
<b>Operating temperature</b>	0 °C to 40 °C
<b>Protection EN 60529</b>	IP20
<b>Dimensions</b>	≈ 145 mm x 85 mm x 35 mm

# HEIDENHAIN

## DR. JOHANNES HEIDENHAIN GmbH

Dr.-Johannes-Heidenhain-Straße 5

83301 Traunreut, Germany

☎ +49 8669 31-0

FAX +49 8669 32-5061

E-mail: info@heidenhain.de

www.heidenhain.de

Vollständige und weitere Adressen siehe [www.heidenhain.de](http://www.heidenhain.de)  
For complete and further addresses see [www.heidenhain.de](http://www.heidenhain.de)

<b>DE</b>	<b>HEIDENHAIN Vertrieb Deutschland</b> 83301 Traunreut, Deutschland ☎ 08669 31-3132 FAX 08669 32-3132 E-Mail: hd@heidenhain.de	<b>ES</b>	<b>FARRESA ELECTRONICA S.A.</b> 08028 Barcelona, Spain www.farresa.es	<b>PL</b>	<b>APS</b> 02-384 Warszawa, Poland www.heidenhain.pl
	<b>HEIDENHAIN Technisches Büro Nord</b> 12681 Berlin, Deutschland ☎ 030 54705-240	<b>FI</b>	<b>HEIDENHAIN Scandinavia AB</b> 01740 Vantaa, Finland www.heidenhain.fi	<b>PT</b>	<b>FARRESA ELECTRÓNICA, LDA.</b> 4470 - 177 Maia, Portugal www.farresa.pt
	<b>HEIDENHAIN Technisches Büro Mitte</b> 07751 Jena, Deutschland ☎ 03641 4728-250	<b>FR</b>	<b>HEIDENHAIN FRANCE sarl</b> 92310 Sèvres, France www.heidenhain.fr	<b>RO</b>	<b>HEIDENHAIN Reprezentantă Romania</b> Braşov, 500407, Romania www.heidenhain.ro
	<b>HEIDENHAIN Technisches Büro West</b> 44379 Dortmund, Deutschland ☎ 0231 618083-0	<b>GB</b>	<b>HEIDENHAIN (G.B.) Limited</b> Burgess Hill RH15 9RD, United Kingdom www.heidenhain.co.uk	<b>RS</b>	Serbia → <b>BG</b>
	<b>HEIDENHAIN Technisches Büro Südwest</b> 70771 Leinfelden-Echterdingen, Deutschland ☎ 0711 993395-0	<b>GR</b>	<b>MB Milionis Vassilis</b> 17341 Athens, Greece www.heidenhain.gr	<b>RU</b>	<b>OOO HEIDENHAIN</b> 115172 Moscow, Russia www.heidenhain.ru
	<b>HEIDENHAIN Technisches Büro Südost</b> 83301 Traunreut, Deutschland ☎ 08669 31-1345	<b>HK</b>	<b>HEIDENHAIN LTD</b> Kowloon, Hong Kong E-mail: sales@heidenhain.com.hk	<b>SE</b>	<b>HEIDENHAIN Scandinavia AB</b> 12739 Skärholmen, Sweden www.heidenhain.se
		<b>HR</b>	Croatia → <b>SL</b>	<b>SG</b>	<b>HEIDENHAIN PACIFIC PTE LTD</b> Singapore 408593 www.heidenhain.com.sg
<b>AR</b>	<b>NAKASE SRL.</b> B1653AOX Villa Ballester, Argentina www.heidenhain.com.ar	<b>HU</b>	<b>HEIDENHAIN Kereskedelmi Képviselet</b> 1239 Budapest, Hungary www.heidenhain.hu	<b>SK</b>	<b>KOPRETINA TN s.r.o.</b> 91101 Trenčín, Slovakia www.kopretina.sk
<b>AT</b>	<b>HEIDENHAIN Techn. Büro Österreich</b> 83301 Traunreut, Germany www.heidenhain.de	<b>ID</b>	<b>PT Servitama Era Toolsindo</b> Jakarta 13930, Indonesia E-mail: ptset@group.gts.co.id	<b>SL</b>	<b>NAVO d.o.o.</b> 2000 Maribor, Slovenia www.heidenhain.si
<b>AU</b>	<b>FCR MOTION TECHNOLOGY PTY LTD</b> 3026 Victoria, Australia E-mail: sales@fcrmotion.com	<b>IL</b>	<b>NEUMO VARGUS MARKETING LTD.</b> Tel Aviv 61570, Israel E-mail: neumo@neumo-vargus.co.il	<b>TH</b>	<b>HEIDENHAIN (THAILAND) LTD</b> Bangkok 10250, Thailand www.heidenhain.co.th
<b>BE</b>	<b>HEIDENHAIN NV/SA</b> 1760 Roosdaal, Belgium www.heidenhain.be	<b>IN</b>	<b>HEIDENHAIN Optics &amp; Electronics India Private Limited</b> Chetpet, Chennai 600 031, India www.heidenhain.in	<b>TR</b>	<b>T&amp;M Mühendislik San. ve Tic. LTD. ŞTİ.</b> 34775 Y. Dudullu – Ümraniye-Istanbul, Turkey www.heidenhain.com.tr
<b>BG</b>	<b>ESD Bulgaria Ltd.</b> Sofia 1172, Bulgaria www.esd.bg	<b>IT</b>	<b>HEIDENHAIN ITALIANA S.r.l.</b> 20128 Milano, Italy www.heidenhain.it	<b>TW</b>	<b>HEIDENHAIN Co., Ltd.</b> Taichung 40768, Taiwan R.O.C. www.heidenhain.com.tw
<b>BR</b>	<b>DIADUR Indústria e Comércio Ltda.</b> 04763-070 – São Paulo – SP, Brazil www.heidenhain.com.br	<b>JP</b>	<b>HEIDENHAIN K.K.</b> Tokyo 102-0083, Japan www.heidenhain.co.jp	<b>UA</b>	<b>Gertner Service GmbH Büro Kiev</b> 01133 Kiev, Ukraine www.heidenhain.ua
<b>BY</b>	<b>GERTNER Service GmbH</b> 220026 Minsk, Belarus www.heidenhain.by	<b>KR</b>	<b>HEIDENHAIN Korea LTD.</b> Gasam-Dong, Seoul, Korea 153-782 www.heidenhain.co.kr	<b>US</b>	<b>HEIDENHAIN CORPORATION</b> Schaumburg, IL 60173-5337, USA www.heidenhain.com
<b>CA</b>	<b>HEIDENHAIN CORPORATION</b> Mississauga, Ontario L5T2N2, Canada www.heidenhain.com	<b>MX</b>	<b>HEIDENHAIN CORPORATION MEXICO</b> 20290 Aguascalientes, AGS., Mexico E-mail: info@heidenhain.com	<b>VE</b>	<b>Maquinaria Diekmann S.A.</b> Caracas, 1040-A, Venezuela E-mail: purchase@diekmann.com.ve
<b>CH</b>	<b>HEIDENHAIN (SCHWEIZ) AG</b> 8603 Schwerzenbach, Switzerland www.heidenhain.ch	<b>MY</b>	<b>ISOSERVE SDN. BHD.</b> 43200 Balakong, Selangor E-mail: sales@isoserve.com.my	<b>VN</b>	<b>AMS Co. Ltd</b> HCM City, Vietnam E-mail: davidgoh@amsvn.com
<b>CN</b>	<b>DR. JOHANNES HEIDENHAIN (CHINA) Co., Ltd.</b> Beijing 101312, China www.heidenhain.com.cn	<b>NL</b>	<b>HEIDENHAIN NEDERLAND B.V.</b> 6716 BM Ede, Netherlands www.heidenhain.nl	<b>ZA</b>	<b>MAFEMA SALES SERVICES C.C.</b> Midrand 1685, South Africa www.heidenhain.co.za
<b>CZ</b>	<b>HEIDENHAIN s.r.o.</b> 102 00 Praha 10, Czech Republic www.heidenhain.cz	<b>NO</b>	<b>HEIDENHAIN Scandinavia AB</b> 7300 Orkanger, Norway www.heidenhain.no		
<b>DK</b>	<b>TPTEKNIK A/S</b> 2670 Greve, Denmark www.tp-gruppen.dk	<b>PH</b>	<b>MACHINEBANKS' CORPORATION</b> Quezon City, Philippines 1113 E-mail: info@machinebanks.com		

