HEIDENHAIN

Linear Encoders

For Numerically Controlled
Machine Tools

August 2012

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

Product brochures:
- Exposed Linear Encoders
- Angle Encoders with Integral Bearing
- Angle Encoders without Integral Bearing
- Rotary Encoders
- HEIDENHAIN Subsequent Electronics
- HEIDENHAIN Controls
- Measuring Systems for Machine Tool Inspection and Acceptance Testing

Technical Information brochures:
- Accuracy of Feed Axes
- Safety-Related Position Measuring Systems
- EnDat 2.2—Bidirectional Interface for Position Encoders
- Encoders for Direct Drives

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

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

Contents

Linear encoders for numerically controlled machine tools

Linear encoders from HEIDENHAIN for numerically controlled machine tools can be used nearly everywhere. They are ideal for machines and other equipment whose feed axes are in a closed loop, such as milling machines, machining centers, boring machines, lathes and grinding machines. The beneficial dynamic behavior of the 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

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

Advantages of linear encoders
Linear encoders measure the position of linear axes without additional mechanical transfer elements. The control loop for position control with a linear encoder also includes the entire feed mechanics. 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
• Kinematic error through ball-screw pitch error

Linear encoders are therefore indispensable for machines that must fulfill high requirements for **positioning accuracy** and **machining speed.**

Mechanical design
The linear encoders for numerically controlled machine tools are sealed encoders: An aluminum housing protects the scale, scanning carriage and its guideway from chips, dust, and fluids. 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 ± 0.2 to ± 0.3 mm between the scale and mounting block are permissible.

Thermal behavior
The combination of increasingly rapid machining processes with completely enclosed machines leads to ever increasing temperatures within the machine's work envelope. 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 retract in a defined, reproducible manner. Linear encoders from HEIDENHAIN are designed for this.

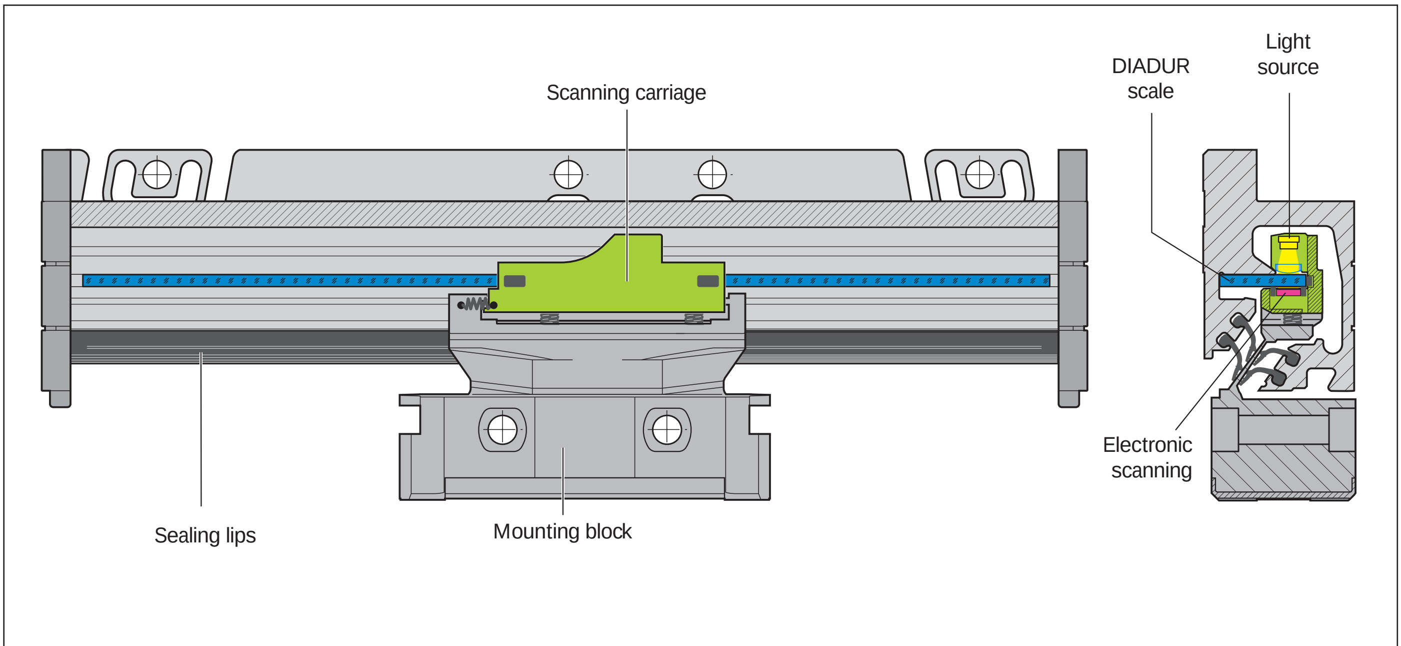
The graduation carriers of HEIDENHAIN linear encoders have defined coefficients of thermal expansion (see *Specifications*). This makes it possible to select the linear encoder whose thermal behavior is best suited to the application.

Dynamic behavior
The constant increases in efficiency and performance of machine tools necessitate ever-higher feed rates and accelerations, while at the same time the high level of machining accuracy must be maintained. Inorder 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 components moved 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. This encapsulation, the special scanning principles and, if needed, the introduction of compressed air, make the linear encoders very resistant to contamination. The complete shielding concept ensures a high degree of electrical noise immunity.

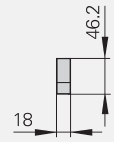
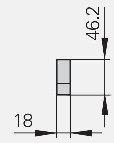
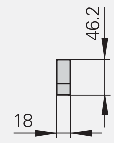


Schematic design of the **LC 115** sealed linear encoder

Selection guide

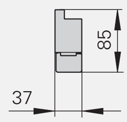
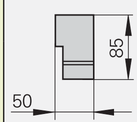
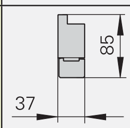
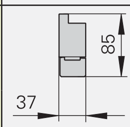
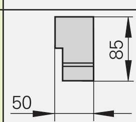
Linear encoders with slimline scale housing

The linear encoders with **slimline scale housing** are designed for **limited installation space.** Larger measuring lengths and higher acceleration loads are made possible by using mounting spars or clamping elements.

	Cross section	Accuracy grade	Measuring length ML	Scanning principle
Absolute position measurement • Glass scale		± 5 µm ± 3 µm	70 mm to 1240 mm *With mounting spar or clamping elements:* 70 mm to 2040 mm	Single-field scanning
Incremental linear measurement with very high repeatability • Steel scale • Small signal period		± 5 µm ± 3 µm	50 mm to 1220 mm	Single-field scanning
Incremental linear measurement • Glass scale		± 5 µm ± 3 µm	70 mm to 1240 mm *with mounting spar:* 70 mm to 2040 mm	Single-field scanning

Linear encoders with full-size scale housing

The linear encoders with **full-size scale housing** are characterized by their **sturdy construction, high resistance to vibration** and **large measuring lengths**. The scanning carriage is connected with the mounting block over an oblique blade that permits mounting both in **upright and reclining positions** with the same protection rating.

	Cross section	Accuracy grade	Measuring length ML	Scanning principle
Absolute position measurement • Glass scale		± 5 µm ± 3 µm	140 mm to 4240 mm	Single-field scanning
Absolute position measurement for large measuring lengths • Steel scale tape		± 5 µm	4240 mm to 28040 mm	Single-field scanning
Incremental linear measurement with very high repeatability • Steel scale • Small signal period		± 3 µm ± 2 µm	140 mm to 1240 mm	Single-field scanning
Incremental linear measurement • Glass scale		± 5 µm ± 3 µm	140 mm to 3040 mm	Single-field scanning
Incremental linear measurement for large measuring lengths • Steel scale tape		± 5 µm	440 mm to 30040 mm Up to 72040 mm measuring length upon request	Single-field scanning

Incremental signals Signal period	Absolute position values	Model	Page
–	EnDat 2.2/22	**LC 415**	**20**
	DQ 01	**LC 495 S**	
	Fanuc 05	**LC 495 F**	
	Mit 03-04	**LC 495 M**	
∿ 1 V_{PP}; 4 µm	–	**LF 485**	**26**
∿ 1 V_{PP}; 20 µm	–	**LS 487**	**30**
⊓⊔ TTL; to 1 µm	–	**LS 477**	

–	EnDat 2.2/22	**LC 115**	**22**
	DQ 01	**LC 195 S**	
	Fanuc 05	**LC 195 F**	
	Mit 03-04	**LC 195 M**	
–	EnDat 2.2/22	**LC 211**	**24**
∿ 1 V_{PP}; 40 µm	EnDat 2.2/22	**LC 281**	
∿ 1 V_{PP}; 4 µm	–	**LF 185**	**28**
∿ 1 V_{PP}; 20 µm	–	**LS 187**	**32**
⊓⊔ TTL; to 1 µm	–	**LS 177**	
∿ 1 V_{PP}; 40 µm	–	**LB 382**	**34**

LC 415

LF 485
LS 487

LC 115

LF 185

LC 211

Measuring principles
Measuring standard

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

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

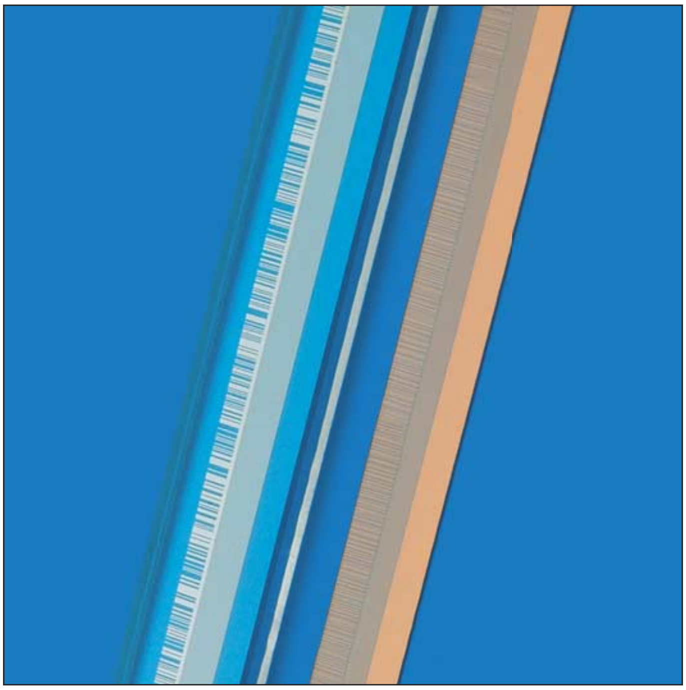
HEIDENHAIN manufactures the precision graduations in specially developed, photolithographic processes.
- AURODUR: matte-etched lines on gold-plated steel tape with typical graduation period of 40 µm
- METALLUR: contamination-tolerant graduation of metal lines on gold, with typical graduation period of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

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.

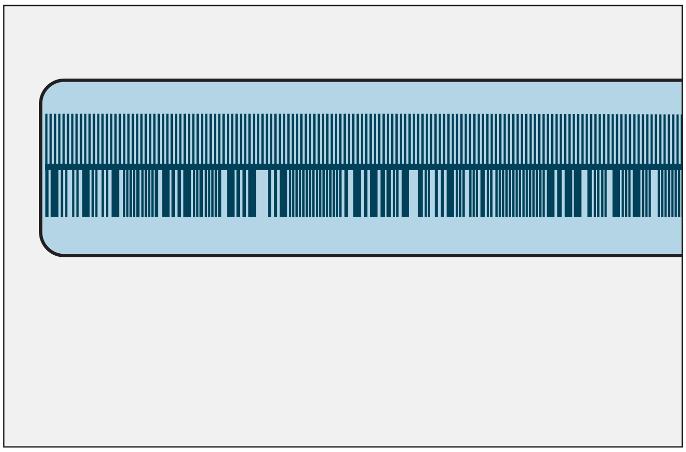
The master graduations are manufactured by HEIDENHAIN on custom-built high-precision ruling machines.

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.



Graduation of an absolute linear encoder

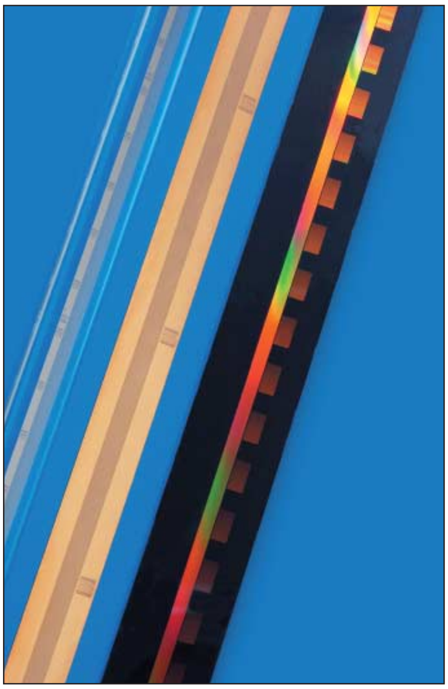


Schematic representation of an absolute code structure with an additional incremental track (LC 485 as example)

Incremental measuring method

With the **incremental measuring method**, the graduation 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.



Graduations of incremental linear encoders

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

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

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

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

where:

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

Where:

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

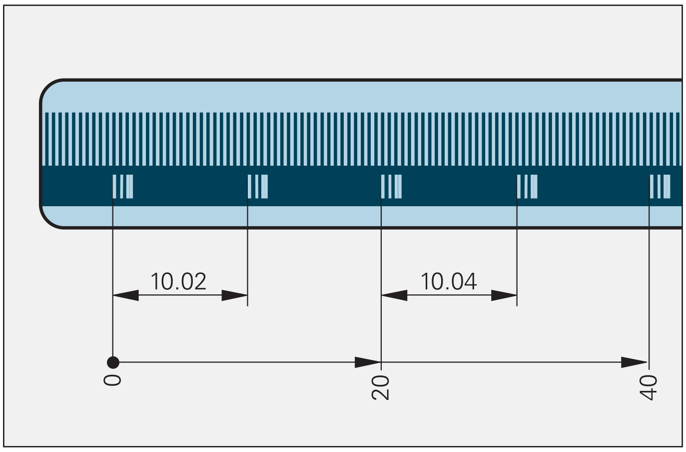
abs = Absolute value

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

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

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

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



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

	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 microns wide, and generates output signals with very small signal periods.

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

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

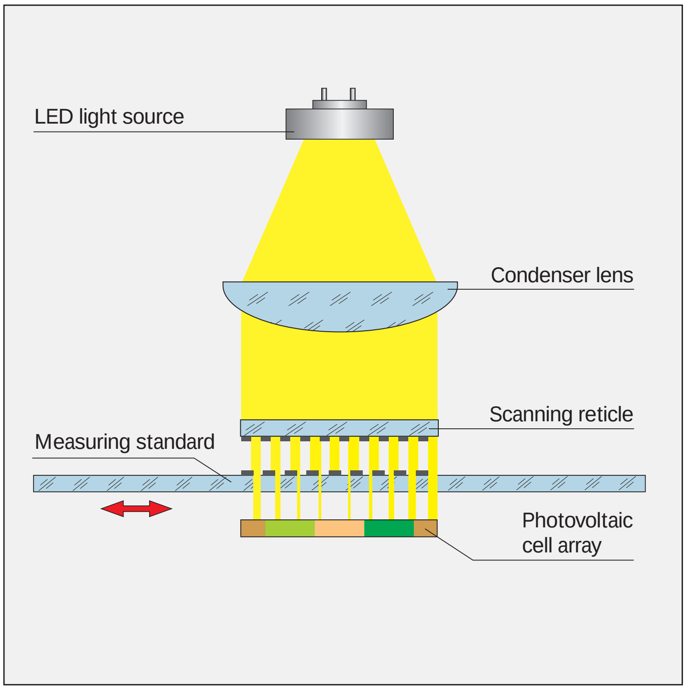
Imaging scanning principle
To put it simply, the imaging scanning principle functions by means of projected-light signal generation: two scale gratings with equal or similar grating periods are moved relative to each other—the scale and the scanning reticle. The carrier material of the scanning reticle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

When parallel light passes through a grating, light and dark surfaces are projected at a certain distance, where there is an index grating. 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 scanning 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.

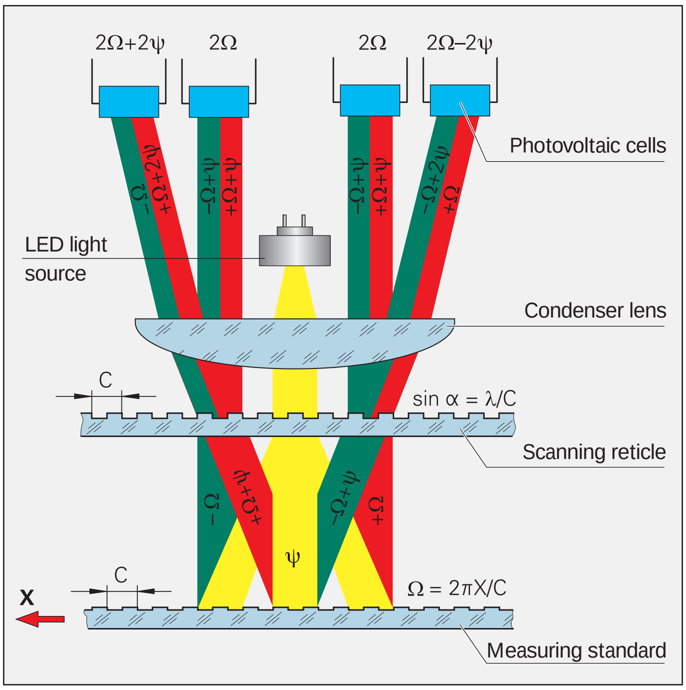
When a light wave passes through the scanning reticle, it is diffracted into three partial waves of the orders –1, 0, and +1, with approximately equal luminous intensity. The waves are diffracted by the scale such that most of the luminous intensity is found in the reflected diffraction orders +1 and –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 high resolution 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 graduation
- The quality of the scanning process
- The quality of the signal processing electronics
- The error from the scanning unit guideway to the scale.

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

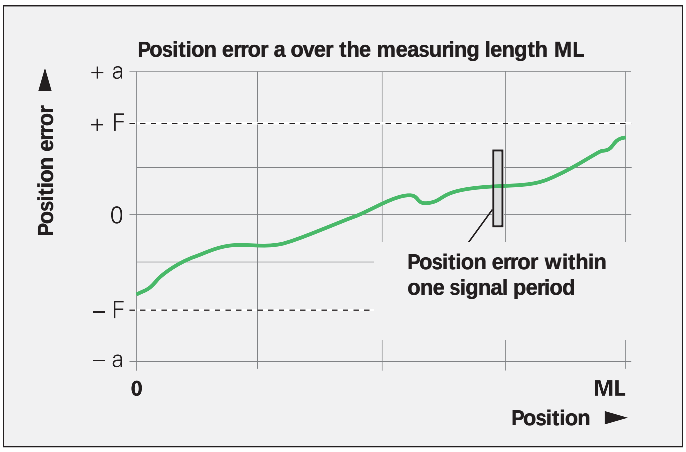
Position error over the measuring range
The accuracy of sealed linear encoders is specified in grades, which are defined as follows:

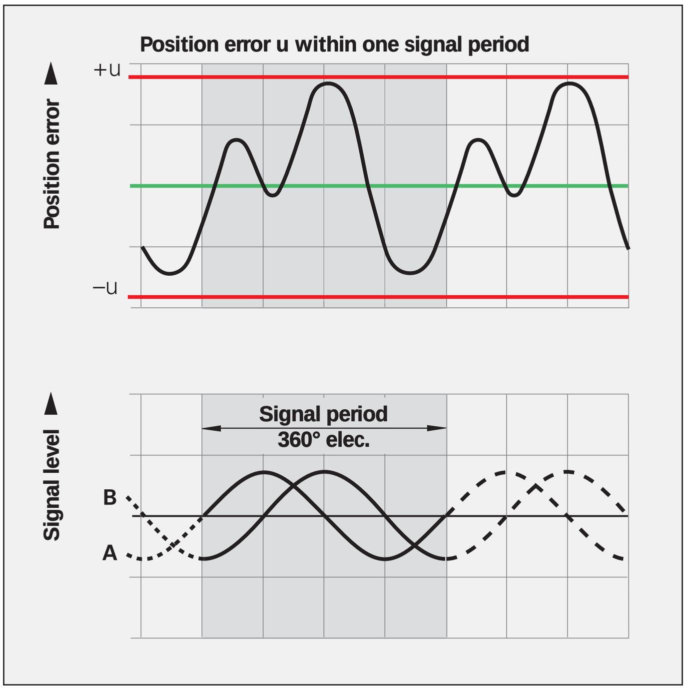
The extreme values ± F of the measuring curves over any max. one-meter section of the measuring length lie within the accuracy grade ± a. They are ascertained during the final inspection, and are indicated on the calibration chart.

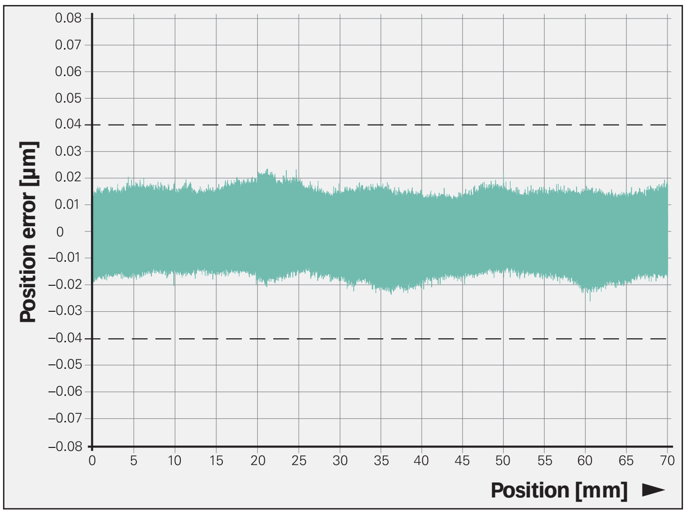
With sealed linear encoders, these values apply to the complete encoder system including the scanning unit. It is then referred to as the system accuracy.

Position error within one signal period
The position 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 ± 1 % of the signal period, and for the LB linear encoders it is below ± 2 % (see table). The smaller the signal period, the smaller the position error within one signal period. It is of critical importance both for accuracy of a positioning movement as well as for velocity control during the slow, even traverse of an axis, and therefore for surface quality and the quality of the machined part.

	Signal period of the scanning signals	Max. position error u within one signal period (approx.)
LF	4 µm	± 0.04 µm
LC 100 **LC 400**	20 µm	± 0.2 µm
LC 200	40 µm	± 0.4 µm
LS	20 µm	± 0.2 µm
LB	40 µm	± 0.8 µm







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

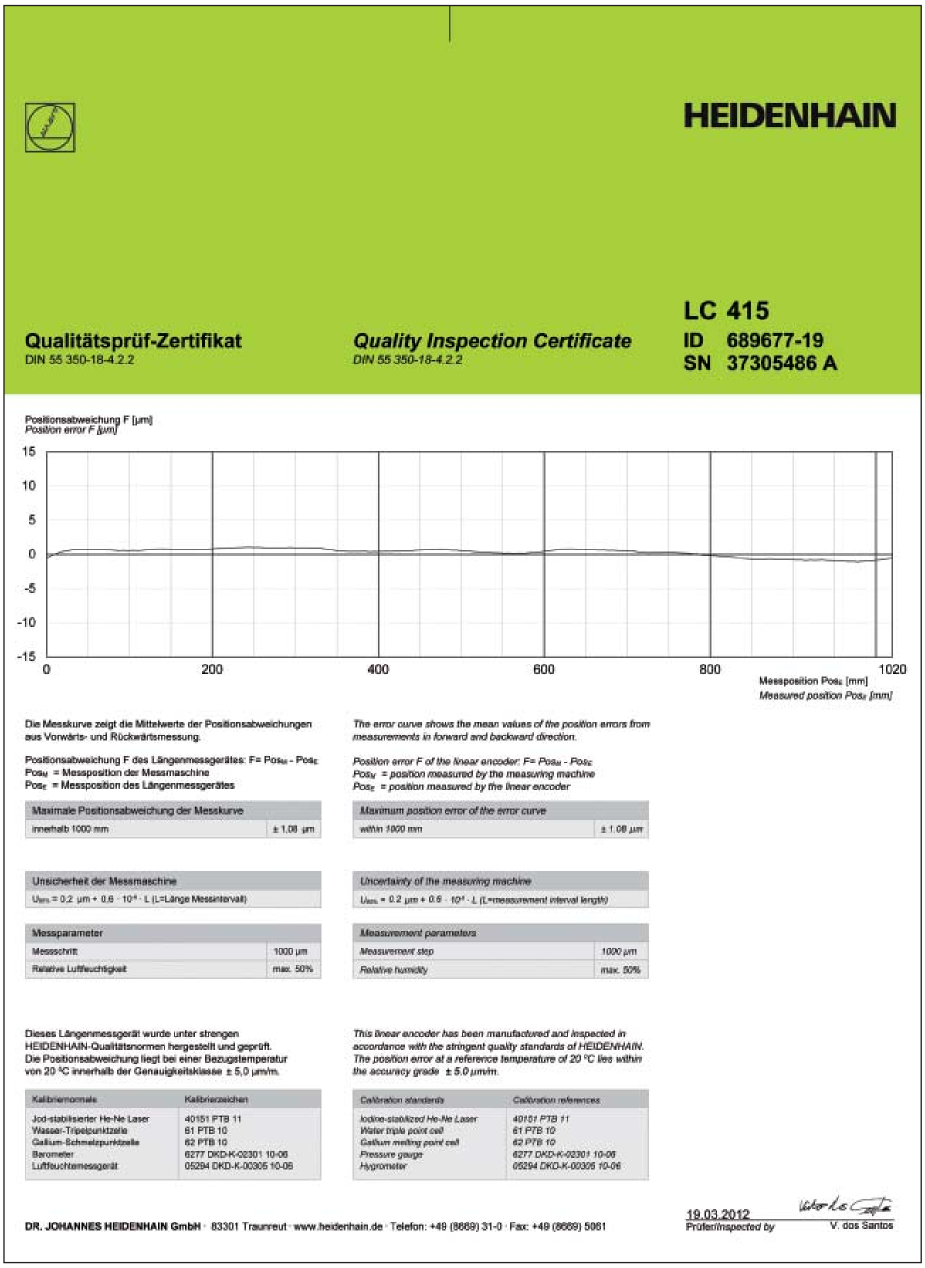
All HEIDENHAIN linear encoders are inspected before shipping for positioning accuracy and proper function.

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 unit 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.



HEIDENHAIN

LC 415
ID 689677-19
SN 37305486 A

Qualitätsprüf-Zertifikat
DIN 55 350-18-4.2.2

Quality Inspection Certificate
DIN 55 350-18-4.2.2

Positionsabweichung F [µm]
Position error F [µm]

Messposition Pos_E [mm]
Measured position Pos_E [mm]

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

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

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

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

Maximale Positionsabweichung der Messkurve	
innerhalb 1000 mm	± 1,08 µm

Maximum position error of the error curve	
within 1000 mm	*± 1.08 µm*

Unsicherheit der Messmaschine
$U_{95\%}$ = 0,2 µm + 0,6 · 10^{-6} · L (L=Länge Messintervall)

Uncertainty of the measuring machine
$U_{95\%}$ = 0.2 µm + 0.6 · 10^{-6} · L (L=measurement interval length)

Messparameter	
Messschritt	1000 µm
Relative Luftfeuchtigkeit	max. 50%

Measurement parameters	
Measurement step	*1000 µm*
Relative humidity	*max. 50%*

Dieses Längenmessgerät wurde unter strengen HEIDENHAIN-Qualitätsnormen hergestellt und geprüft. Die Positionsabweichung liegt bei einer Bezugstemperatur von 20 °C innerhalb der Genauigkeitsklasse ± 5,0 µm/m.

This linear encoder has been manufactured and inspected in accordance with the stringent quality standards of HEIDENHAIN. The position error at a reference temperature of 20 °C lies within the accuracy grade ± 5.0 µm/m.

Kalibriernormale	Kalibrierzeichen
Jod-stabilisierter He-Ne Laser	40151 PTB 11
Wasser-Tripelpunktzelle	61 PTB 10
Gallium-Schmelzpunktzelle	62 PTB 10
Barometer	6277 DKD-K-02301 10-06
Luftfeuchtemessgerät	05294 DKD-K-00305 10-06

Calibration standards	*Calibration references*
Iodine-stabilized He-Ne Laser	*40151 PTB 11*
Water triple point cell	*61 PTB 10*
Gallium melting point cell	*62 PTB 10*
Pressure gauge	*6277 DKD-K-02301 10-06*
Hygrometer	*05294 DKD-K-00305 10-06*

19.03.2012
Prüfer/*Inspected by* V. dos Santos

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Example

Mechanical design types and mounting guidelines
Linear encoders with small cross section

The LC, LF and LS slimline linear encoders should be fastened to a machined surface over their entire length, especially for highly dynamic requirements. Larger measuring lengths and higher vibration loads are made possible by using mounting spars 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 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 Mechanical Information*).

Thermal behavior
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.

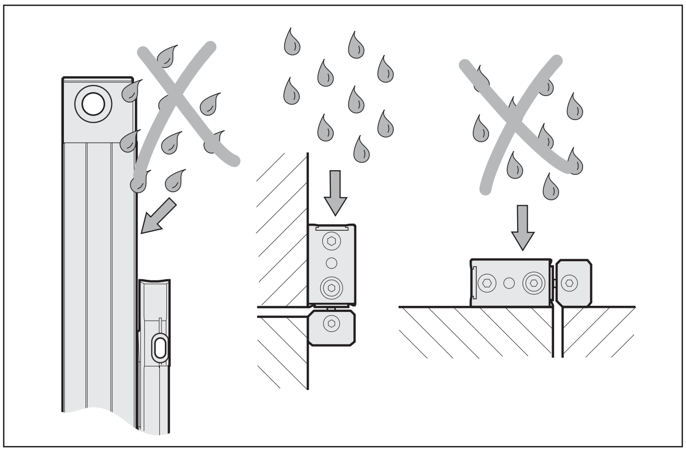
The **LF 485** with its graduation carrier of steel has the same coefficient of thermal expansion as a mounting surface of gray cast iron or steel.

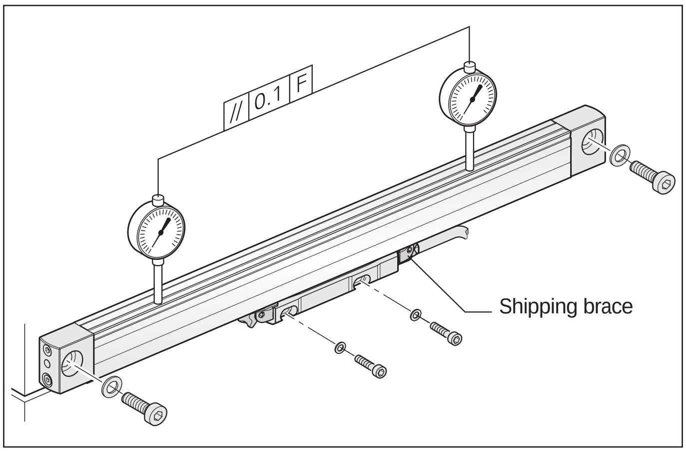
Mounting
It is surprisingly simple to mount the sealed linear encoders from HEIDENHAIN: You need only align the scale unit at several points along the machine guideway. Stop surfaces or stop pins can also be used for this. The shipping brace already sets the proper gap between the scale unit and the 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. Ensure that the lateral tolerances are also maintained.

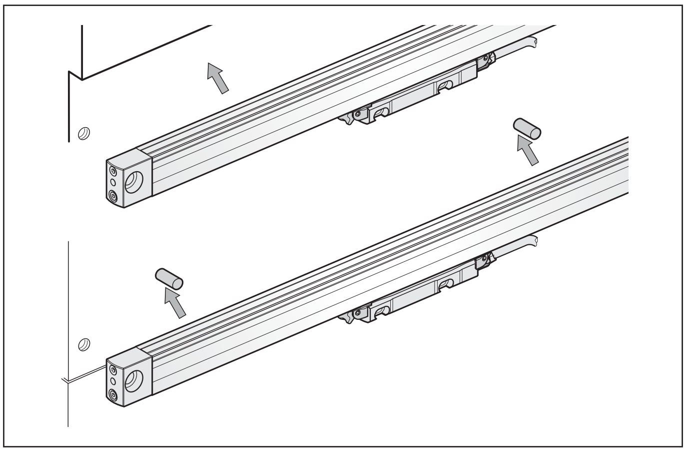
LF 485

LC 415

LS 487

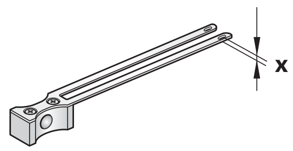






Accessories:
Mounting and test gauges for slimline linear encoders
The **mounting gauge** is used to set the gap between the scale unit and the scanning unit if the shipping brace needs to be removed before mounting. The **test gauges** are used to quickly and easily check the gap of the mounted linear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

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

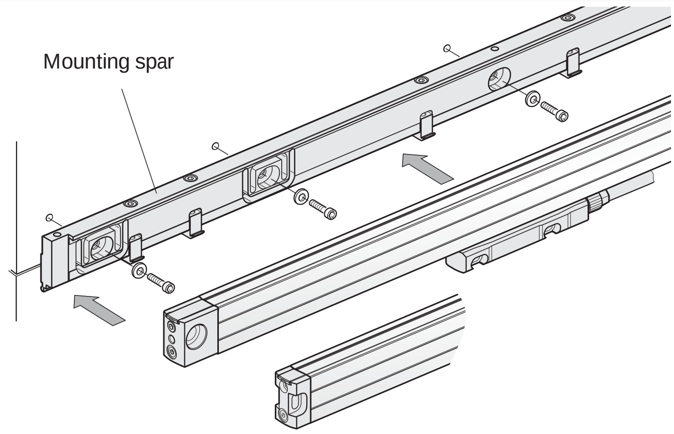


Along with the standard procedure of using two M8 screws to mount the scale unit on a plane surface, there are also other mounting possibilities:

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. A mounting spar is recommended for highly-dynamic applications with ML greater than 620 mm. It is always necessary for measuring lengths starting from 1240 mm.

For the **MSL 41 mounting spar,** the components necessary for clamping are premounted. 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.



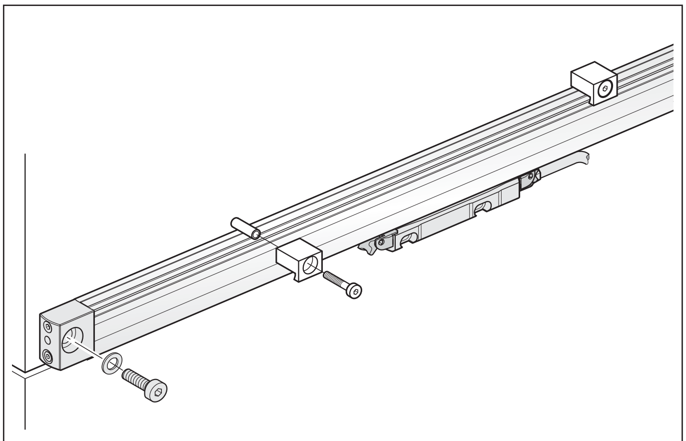
Mounting aid fastened in a mounting spar

Accessories:
Mounting spar MSL 41
ID 770902-xx

Mounting aid for scanning unit
ID 753853-01

Mounting with clamping elements
The scale unit of the LC 4x5 is fastened at both ends. In addition, it can also be attached to the mounting surface by clamping elements. For measuring lengths over 1240 mm this makes it easy and reliable to mount the encoder without a spar and fasten it at the center of the measuring length (recommended for highly-dynamic applications with ML greater than 620 mm).

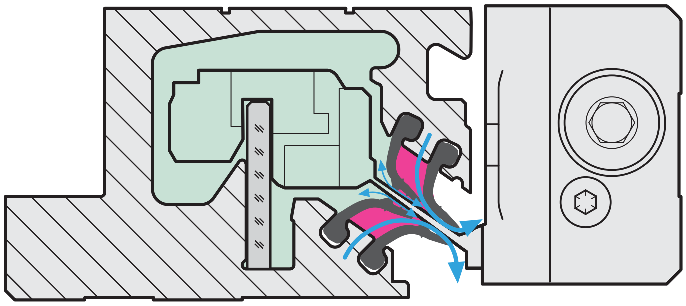
Accessories:
Clamping elements
With pin and M5x10 screw
ID 556975-01 (10 units per package)



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 inclined 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.

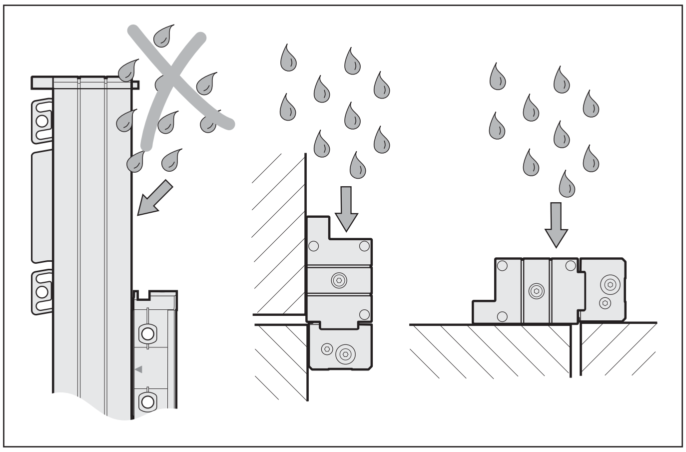

Sealing system of the LC 1x5

Thermal behavior
The thermal behavior of the LB, LC, LF and LS 100 linear encoders with large cross section has been optimized:

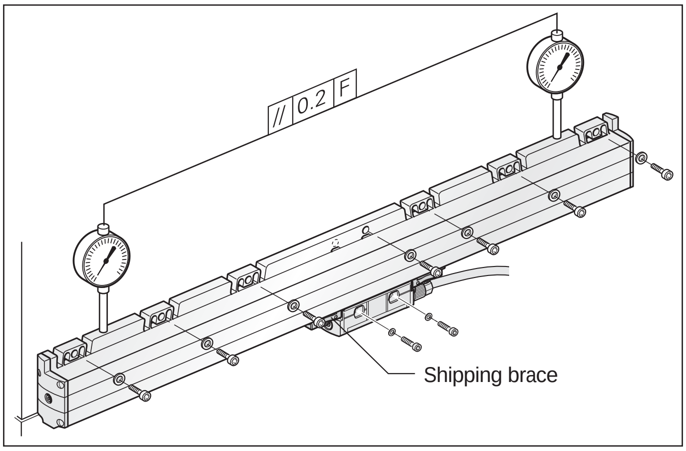
On the **LF**, the steel scale is cemented to a steel carrier that is fastened directly to the machine element.

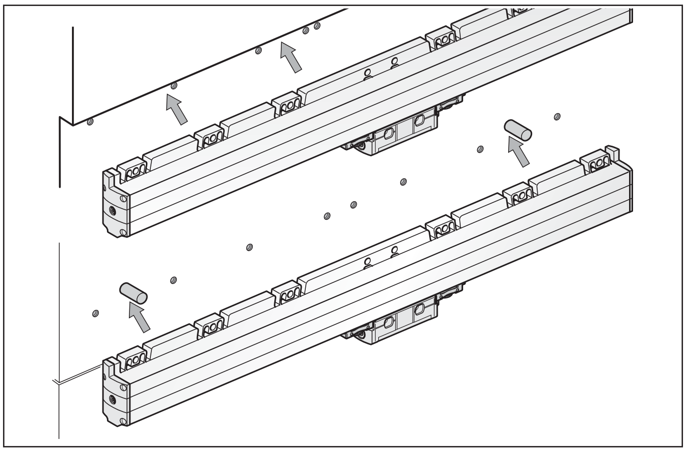
On the **LB**, the steel scale tape is clamped directly onto the machine element. The LB therefore takes part in all thermal changes of the mounting surface.

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. Ensure that the lateral tolerances are also maintained.



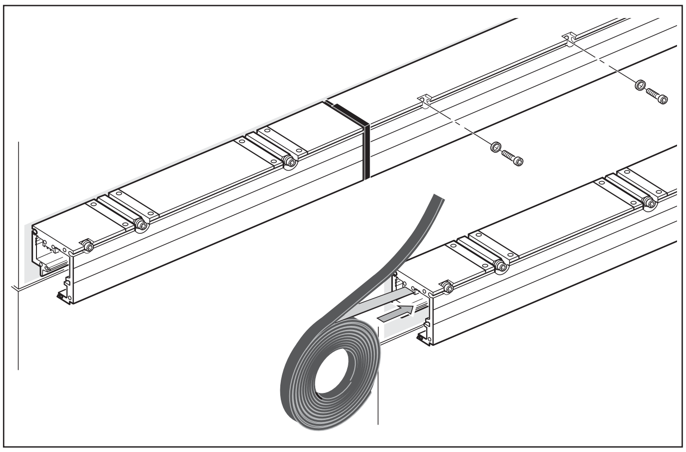


Mounting the multi-section LC 2x1, LB 382

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
- Pull in the sealing lips
- Insert the scanning unit

Adjustment of the scale tape tension enables linear machine error compensation up to ± 100 µm/m.

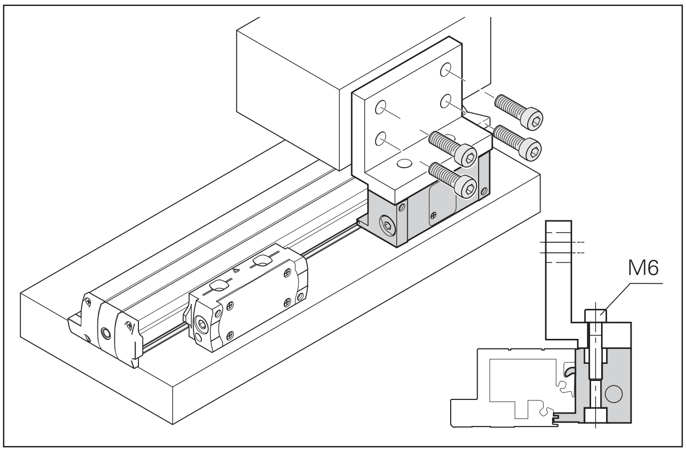


Accessory:

Mounting aid for LS 1x7

ID 547793-01

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



Example

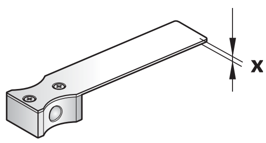
Accessories:

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, LS	x	Color	ID
Mounting gauge	1.5 mm	Gray	575832-01
Test gauge max.	1.8 mm	Red	575832-02
Test gauge min.	1.2 mm	Blue	575832-03

LB 382/LC 200	x	Color	ID
Mounting gauge	1.0 mm	Gray	772141-01
Test gauge max.	1.3 mm	Red	772141-02
Test gauge min.	0.7 mm	Blue	772141-03



General mechanical information

Degree of protection
Sealed **linear encoders** fulfill the requirements for IP 53 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 **IP 64** 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 micro filter, and must comply with the following quality classes as per **ISO 8573-1** (2010 edition):

- Solid contaminants: **Class 1**

Particle size	Number of particles per m^3
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 dewpoint: **Class 4** (pressure dew point at 3 °C)
- Total oil content: **Class 1** (max. oil concentration: 0.01 mg/m^3)

For optimum supply of sealing air to the sealed linear encoders, the required air flow is 7 to 10 l/min per encoder Ideally the air flow is regulated by the HEIDENHAIN connecting pieces with integrated throttle (see *Accessories*). At an inlet pressure of approx. $1 \cdot 10^5$ Pa (1 bar), the throttles ensure the prescribed volume of airflow.

Accessories:
Connecting piece, straight
With throttle and gasket
ID 226270-xx

Connecting piece, straight, short
With throttle and gasket
ID 275239-xx

M5 coupling joint, swiveling
With seal
ID 207834-xx

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, fine filter and activated carbon filter) and a pressure regulator with pressure gauge. The pressure gauge and automatic pressure switch (available as accessories) effectively monitor the sealing air.

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

- Particles: **Class 5**

Solid contaminants	Number of particles per m^3
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 dewpoint: **Class 6** (pressure dew point at 10 °C)
- Total oil content: **Class 4** (max. oil concentration: 5 mg/m^3)

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 Abbé error small.
- To function properly, linear encoders must not be continuously subjected to strong vibration; the more solid parts of the machine tool provide the best mounting surface in this respect. Encoders should not be mounted on hollow parts or with adapters. A mounting spar is recommended for the sealed linear encoders with small cross section.
- The linear encoders should be mounted away from sources of heat to avoid temperature influences.

Acceleration

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

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

Required moving force

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

RoHS

HEIDENHAIN has tested the products for harmlessness of the materials as per European Directives 2002/95/EC (RoHS) and 2002/96/EC (WEEE). For a Manufacturer Declaration on RoHS, please refer to your sales agency.

Expendable parts

HEIDENHAIN encoders contain components that are subject to wear, depending on the application and handling. These include in particular the following parts:

- LED light source
- Cables with frequent flexing

Additionally for encoders with integral bearing:

- Bearing
- Shaft sealing rings for rotary and angular encoders
- Sealing lips for 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 given in this brochure apply to the specific encoder, not to the complete system. Any operation of the encoder outside of the specified range or for any other than the intended applications is at the user's own risk.

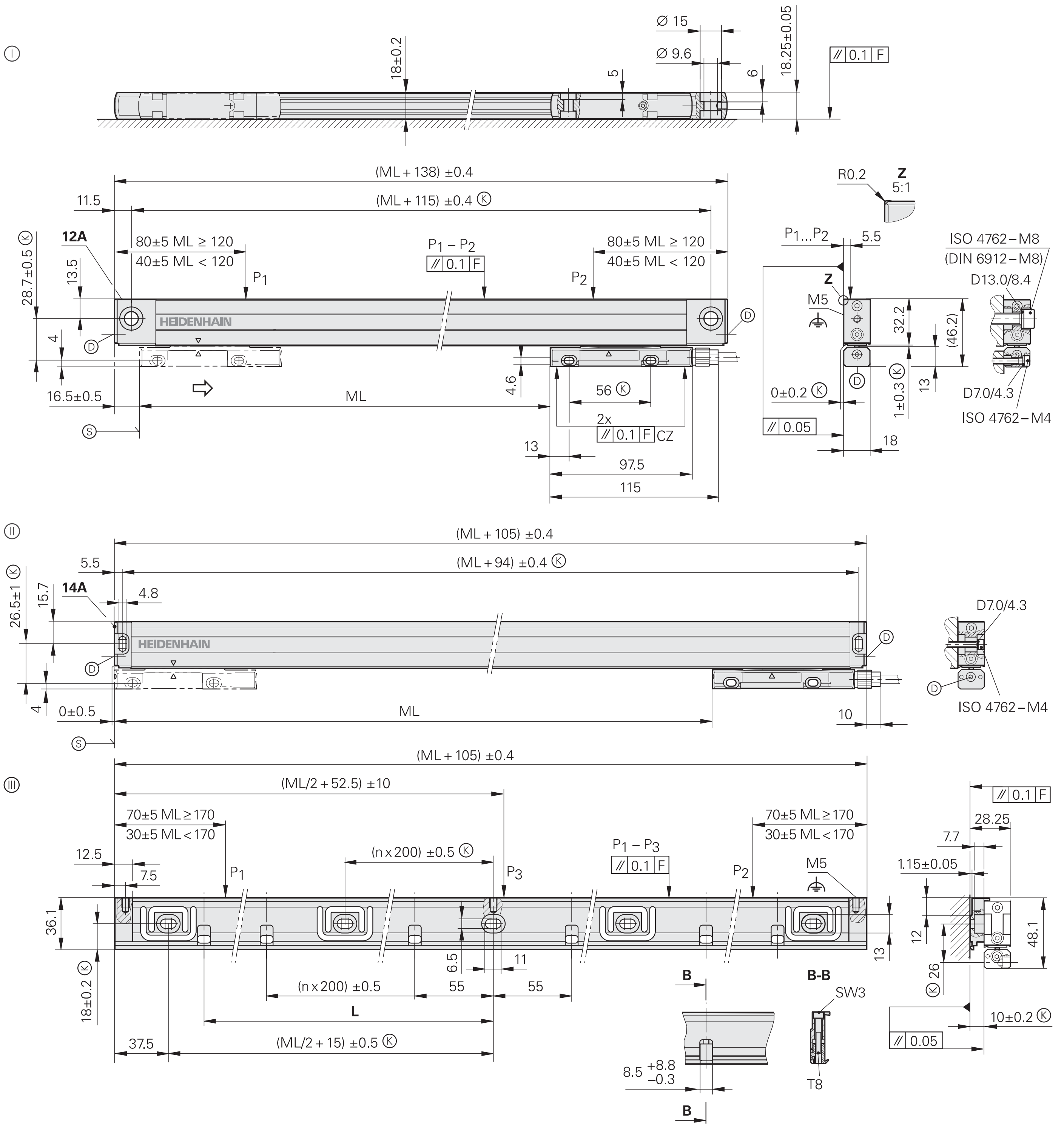
Mounting

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

LC 400 series

Absolute linear encoders with slimline scale housing

- **For limited installation space**



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

mm

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

Ⓘ = End block 12A; for mounting with and without mounting spar
Ⓘⓘ = End block 14A; for mounting with mounting spar
(if attached directly with M4 screws, specifications are restricted)
Ⓘⓘⓘ = Mounting spar MSL 41
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓓ = Inlet for compressed air
Ⓢ = Beginning of measuring length ML (= 20 mm absolute)
⇨ = Direction of scanning unit motion for output signals in accordance with interface description

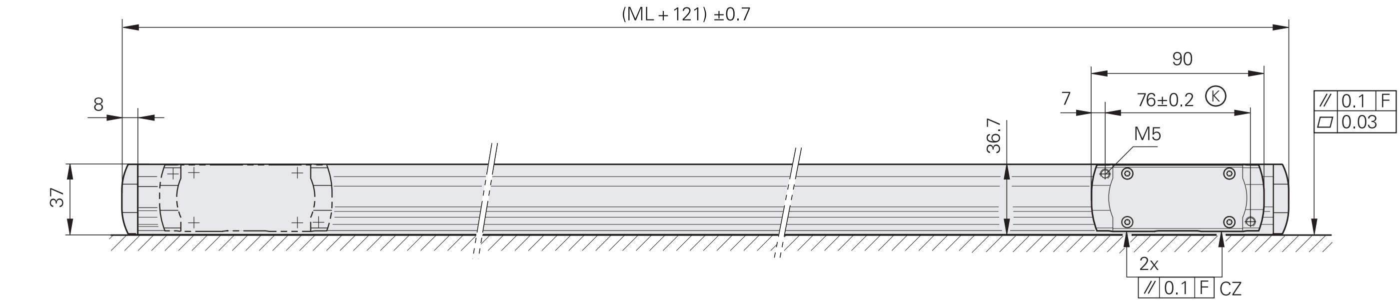
Specifications	LC 415 Functional Safety	LC 495 F	LC 495 M	LC 495 S Functional Safety
Measuring standard Coefficient of linear expansion	DIADUR glass scale with absolute track and incremental track, grating period 20 µm $\alpha_{therm} \approx 8 \times 10^{-6}$ K^{-1} (mounting type (I)/(II)); *with mounting spar:* $\alpha_{therm} \approx 9 \times 10^{-6}$ K^{-1} (mounting type (III))			
Accuracy grade*	± 3 µm; ± 5 µm			
Measuring length ML* 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			
Absolute position values	EnDat 2.2	Fanuc serial interface αi interface	Mitsubishi high speed serial interface	DRIVE-CLiQ
Ordering designation	EnDat 22	Fanuc 05	Mit 03-04	DQ 01
Resolution *At ± 3 µm* *At ± 5 µm*	 0.001 µm 0.010 µm	αi interface/α interface 0.00125 µm/0.010 µm 0.0125 µm/0.050 µm	 0.001 µm 0.010 µm	
Clock frequency	≤ 16 MHz	–		
Calculation time t_{cal}	≤ 5 µs	–		
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable to mounting block			
Cable length	≤ 100 m[1)]	≤ 30 m	≤ 30 m	≤ 30 m[2)]
Power supply	3.6 to 14 V DC			10 to 28.8 V DC
Power consumption (maximum)	*3.6 V:* ≤ 1.1 W *14 V:* ≤ 1.3 W			*10 V:* ≤ 1.5 W *28.8 V:* ≤ 1.7 W
Current consumption (typical)	*5 V:* 140 mA (without load)			*24 V:* 46 mA (without load)
Traversing speed	≤ 180 m/min			
Required moving force	≤ 5 N			
Vibration 55 Hz to 2000 Hz *affecting the* **Shock** 11 ms **Acceleration**	*Scanning unit:* ≤ 200 m/s² (EN 60068-2-6) *Housing without mounting spar:* ≤ 100 m/s² (EN 60068-2-6) *Housing with mounting spar and cable outlet at right:* ≤ 150 m/s², *at left:* ≤ 100 m/s² (EN 60068-2-6) ≤ 300 m/s² (EN 60068-2-27) ≤ 100 m/s² in measuring direction			
Operating temperature	0 °C to 50 °C			
Protection EN 60529	IP 53 when installed according to instructions in the brochure, IP 64 with sealing air from DA 400			
Weight	*Encoder:* 0.2 kg + 0.55 kg/m measuring length; *mounting spar:* 0.9 kg/m			

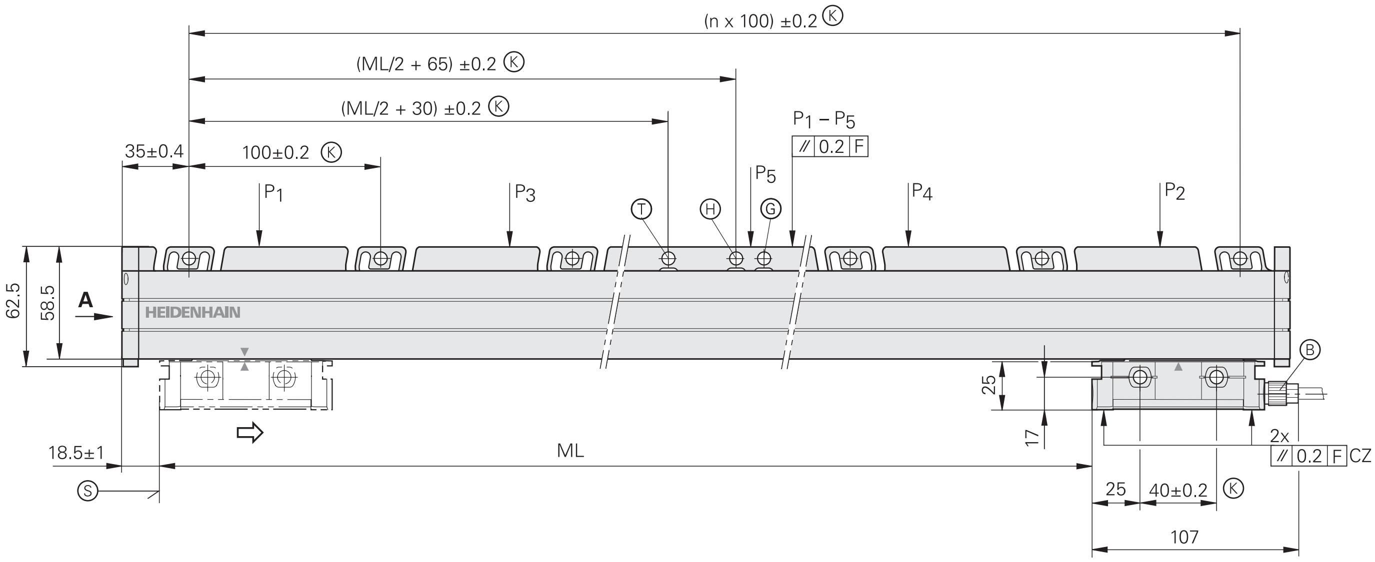
***** Please select when ordering
1) With HEIDENHAIN cable, clock frequency ≤ 8 MHz
2) Larger cable lengths upon request
Functional safety: LC 415 see special Product Information sheet; LC 495 S in preparation

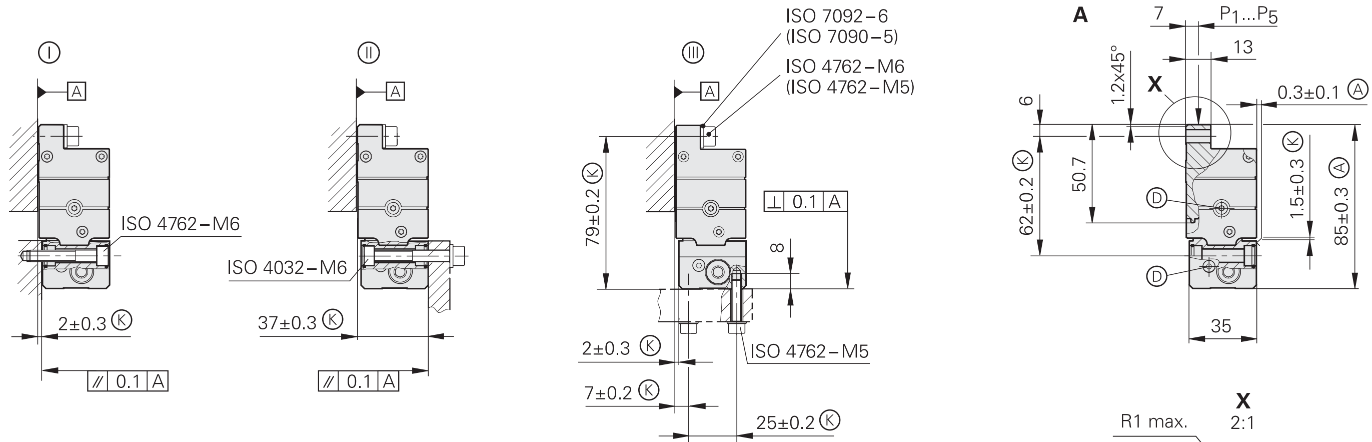
LC 100 series

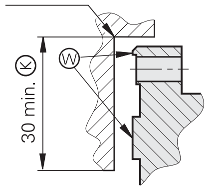
Absolute linear encoders with full-size scale housing

- **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
Ⓐ = 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, compatible to predecessor model
Ⓖ = Mechanical fixed point, with 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

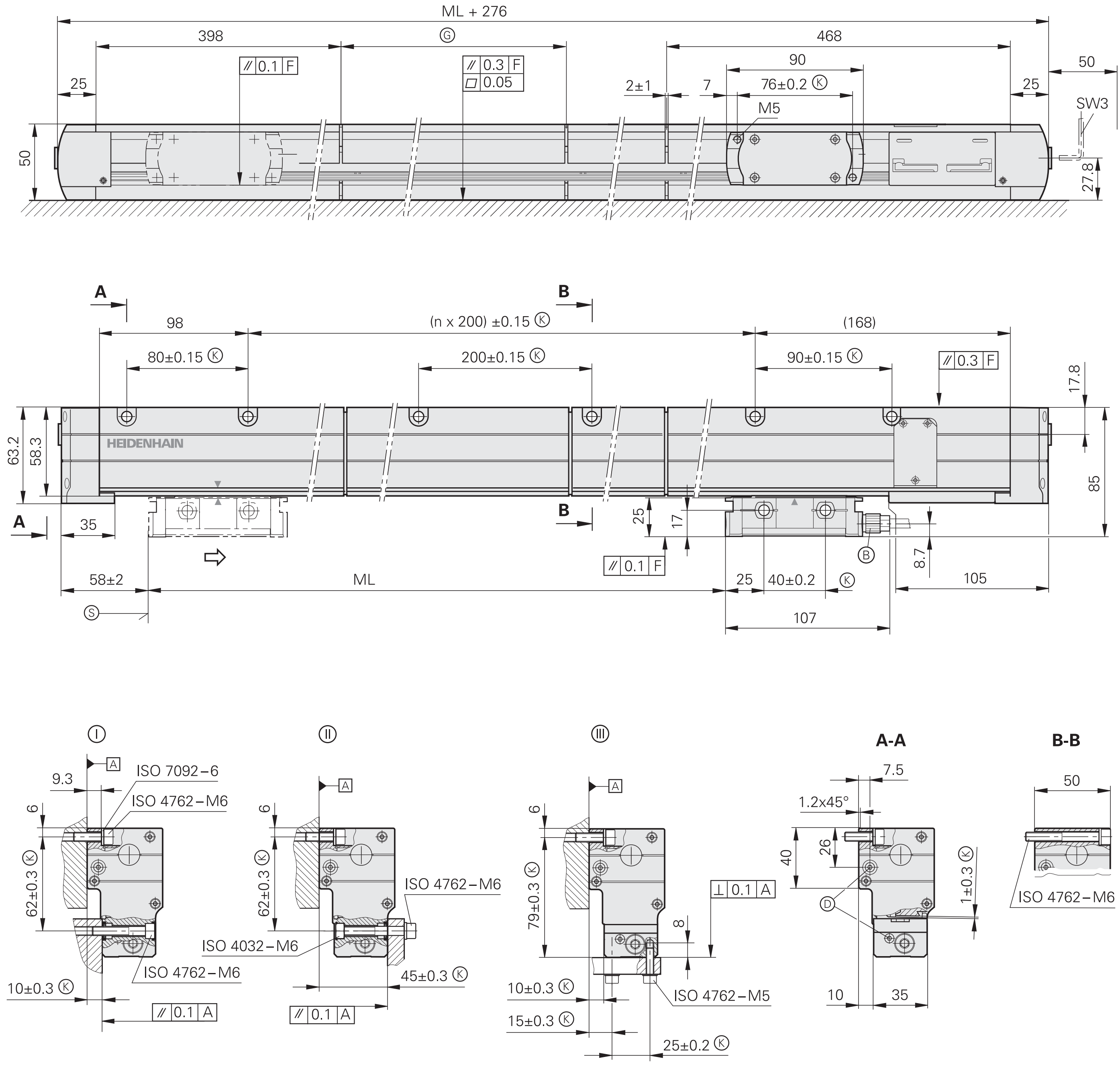
Specifications	LC 115	LC 195 F	LC 195 M	LC 195 S
Measuring standard Coefficient of linear expansion	DIADUR glass scale with absolute track and incremental track, grating period 20 µm $\alpha_{therm} \approx 8 \times 10^{-6}\ K^{-1}$			
Accuracy grade*	± 3 µm up to measuring length 3040 mm; ± 5 µm			
Measuring length ML* in mm	140 240 340 440 540 640 740 840 940 1040 1140 1240 1340 1440 1540 1640 1740 1840 2040 2240 2440 2640 2840 3040 3240 3440 3640 3840 4040 4240			
Absolute position values	EnDat 2.2	Fanuc serial interface αi interface	Mitsubishi high speed serial interface	DRIVE-CLiQ
Ordering designation	EnDat 22	Fanuc 05	Mit 03-04	DQ 01
Resolution *At ± 3 µm* *At ± 5 µm*	 0.001 µm 0.010 µm	αi interface/α interface 0.00125 µm/0.010 µm 0.0125 µm/0.050 µm	 0.001 µm 0.010 µm	
Clock frequency	≤ 16 MHz	–		
Calculation time t_{cal}	≤ 5 µs	–		
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable on both sides to mounting block			
Cable length	≤ 100 m[1)]	≤ 30 m	≤ 30 m	≤ 30 m[2)]
Power supply	3.6 to 14 V DC			10 to 28.8 V DC
Power consumption (maximum)	*3.6 V:* ≤ 1.1 W *14 V:* ≤ 1.3 W			*10 V:* ≤ 1.5 W *28.8 V:* ≤ 1.7 W
Current consumption (typical)	*5 V:* 140 mA (without load)			*24 V:* 46 mA (without load)
Traversing speed	≤ 180 m/min			
Required moving force	≤ 4 N			
Vibration 55 Hz to 2000 Hz *affecting the* **Shock** 11 ms **Acceleration**	*Housing:* ≤ 200 m/s² (EN 60068-2-6) *Scanning unit:* ≤ 200 m/s² (EN 60068-2-6) ≤ 300 m/s² (EN 60068-2-27) ≤ 100 m/s² in measuring direction			
Operating temperature	0 °C to 50 °C			
Protection EN 60529	IP 53 when installed according to instructions in the brochure, IP 64 with sealing air from DA 400			
Weight	0.55 kg + 2.9 kg/m measuring length			

***** Please select when ordering
1) With HEIDENHAIN cable, clock frequency ≤ 8 MHz
2) Larger cable lengths upon request
Functional safety: LC 115 see special Product Information sheet; LC 195 S in preparation

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**



mm

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

Ⓘ, Ⓘ, Ⓘ = Mounting options
F = Machine guideway
Ⓚ = Required mating dimensions
Ⓑ = Cable connection usable at either end
Ⓓ = Compressed-air connection usable at either end
Ⓢ = Beginning of measuring length ML (= 100 mm absolute)
Ⓖ = Housing section length
⇨ = Direction of scanning unit motion for output signals in accordance with interface description

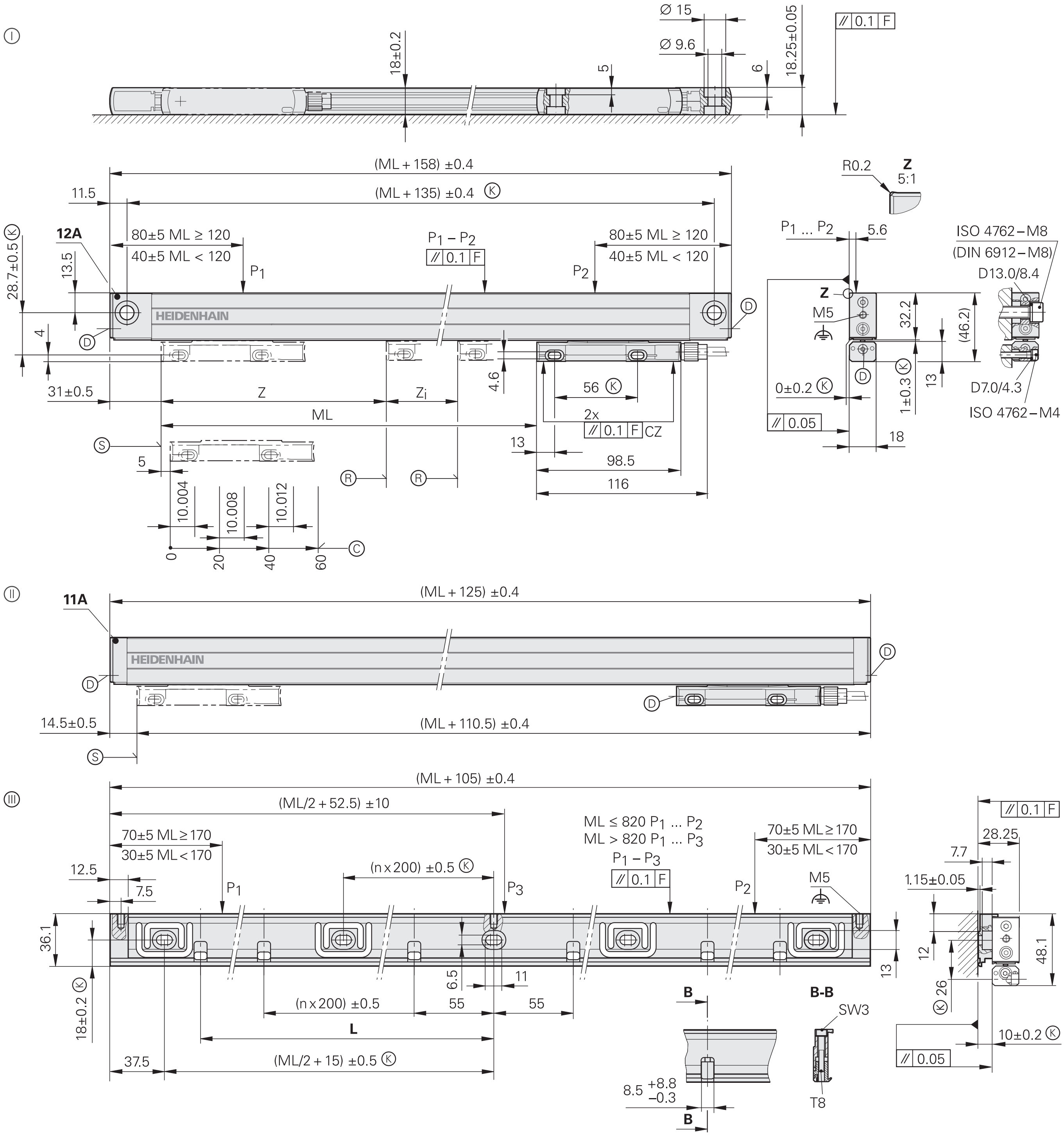
Specifications	**LC 211**	**LC 281**
Measuring standard Coefficient of linear expansion	METALLUR steel scale tape with absolute track and incremental track, grating period 40 µm Same as machine base (e.g. $\alpha_{therm} \approx 10 \times 10^{-6}\,K^{-1}$ for cast iron)	
Accuracy grade	± 5 µm	
Measuring length ML* in mm	4240 mm to 28040 mm in 200 mm steps Kit with single-section METALLUR steel scale tape and housing section lengths	
Absolute position values	EnDat 2.2[1]	
Ordering designation	EnDat 22	EnDat 02
Resolution	0.010 µm	
Clock frequency	≤ 16 MHz	≤ 2 MHz
Calculation time t_{cal}	≤ 5 µs	
Incremental signals	–	∿ 1 V_{PP}
Signal period	–	40 µm
Cutoff frequency –3 dB	–	≥ 250 kHz
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable on both sides to mounting block	
Cable length (with HEIDENHAIN cable)	≤ 100 m (at clock frequency ≤ 8 MHz)	≤ 150 m
Power supply	3.6 to 14 V DC	
Power consumption (max.)	*At 14 V:* ≤ 1.5 W *At 3.6 V:* ≤ 1.1 W	
Current consumption (typical)	*At 5 V:* 225 mA (without load)	
Traversing speed	≤ 120 m/min (≤ 180 m/min upon request)	
Required moving force	≤ 15 N	
Vibration 55 to 2000 Hz *affecting the* **Shock** 11 ms **Acceleration**	*Housing:* 200 m/s^2 (EN 60068-2-6) *Scanning unit:* 300 m/s^2 (EN 60068-2-6) ≤ 300 m/s^2 (EN 60068-2-27) ≤ 100 m/s^2 in measuring direction	
Operating temperature	0 °C to 50 °C	
Protection EN 60529	IP 53 when installed according to mounting instructions, IP 64 with sealing air from DA 400	
Weight	1.3 kg + 3.6 kg/m measuring length	

* Please select when ordering
[1] Fanuc, Mitsubishi in preparation

LF 485

Incremental linear encoders with slimline scale housing

- **Very high repeatability**
- **Thermal behavior similar to steel or 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; for mounting with and without mounting spar
Ⓘ = End block 11A; installation with mounting spar
Ⓘ = Mounting spar MSL 41
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions

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

50 ... 1000	1120 ... 1220
z = 25 mm z_i = ML – 50 mm	z = 35 mm z_i = ML – 70 mm

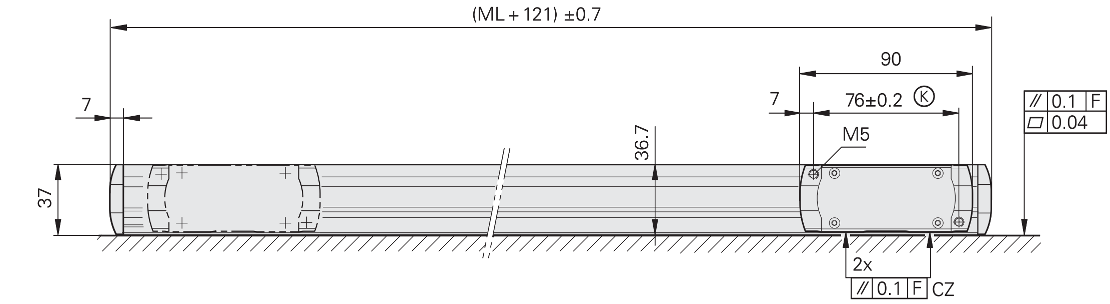
Ⓒ = Reference mark position on LF 485 C
Ⓓ = Compressed air inlet
Ⓢ = Beginning of measuring length (ML)
⇨ = Direction of scanning unit motion for output signals in accordance with interface description

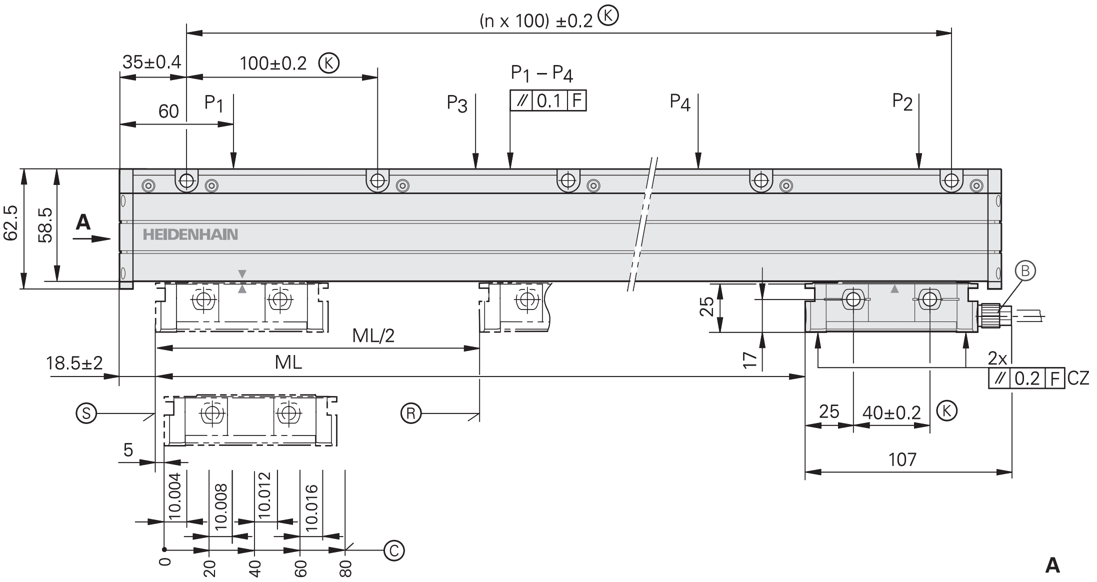
Specifications	LF 485
Measuring standard Coefficient of linear expansion	SUPRADUR phase grating on steel, grating period 8 µm $\alpha_{therm} \approx 10 \times 10^{-6}\ K^{-1}$
Accuracy grade*	± 5 µm; ± 3 µm
Measuring length ML* in mm	Back-up spar* optional 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 900 1000 1120 1220
Incremental signals	∼ 1 V_{PP}
Signal period	4 µm
Reference marks* *LF 485* *LF 485C*	• 1 reference mark at midpoint of measuring length • 2 reference marks, each 25 mm (at ML ≤ 1000 mm) or 35 mm (at ML ≥ 1120 mm) from the beginning and end of measuring length. Distance-coded
Cutoff frequency –3 dB	≥ 250 kHz
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable to mounting block
Cable length	≤ 150 m (with HEIDENHAIN cable)
Power supply without load	5 V DC ± 5 %/< 120 mA
Traversing speed	≤ 60 m/min
Required moving force	≤ 4 N
Vibration 55 Hz to 2000 Hz *affecting the* **Shock** 11 ms **Acceleration**	*Housing with mounting spar:* ≤ 150 m/s^2 (EN 60068-2-6) *Scanning unit:* ≤ 200 m/s^2 (EN 60068-2-6) ≤ 300 m/s^2 (EN 60068-2-27) ≤ 100 m/s^2 in measuring direction
Operating temperature	0 °C to 50 °C
Protection EN 60529	IP 53 when installed according to instructions in the brochure IP 64 with sealing air via DA 400
Weight	0.4 kg + 0.6 kg/m measuring length

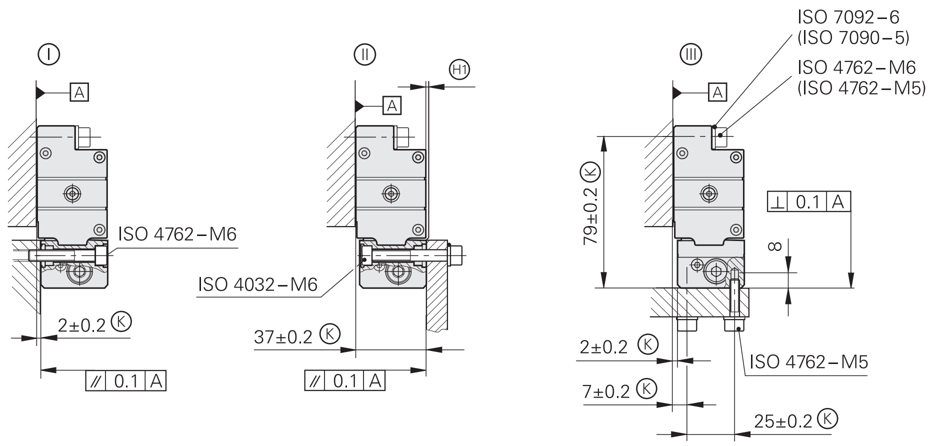
***** Please select when ordering

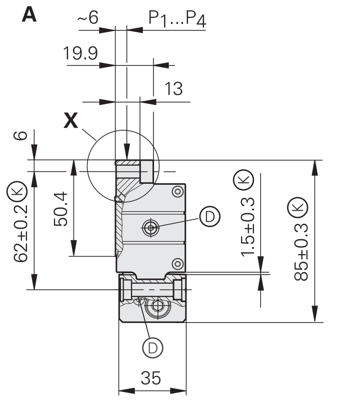
LF 185

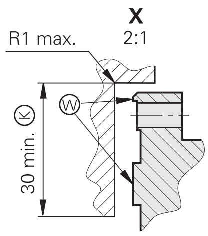
Incremental linear encoders with full-size scale housing
- **Very high repeatability**
- **Thermal behavior similar to steel or cast iron**
- **Reclining mounting possible**











mm

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

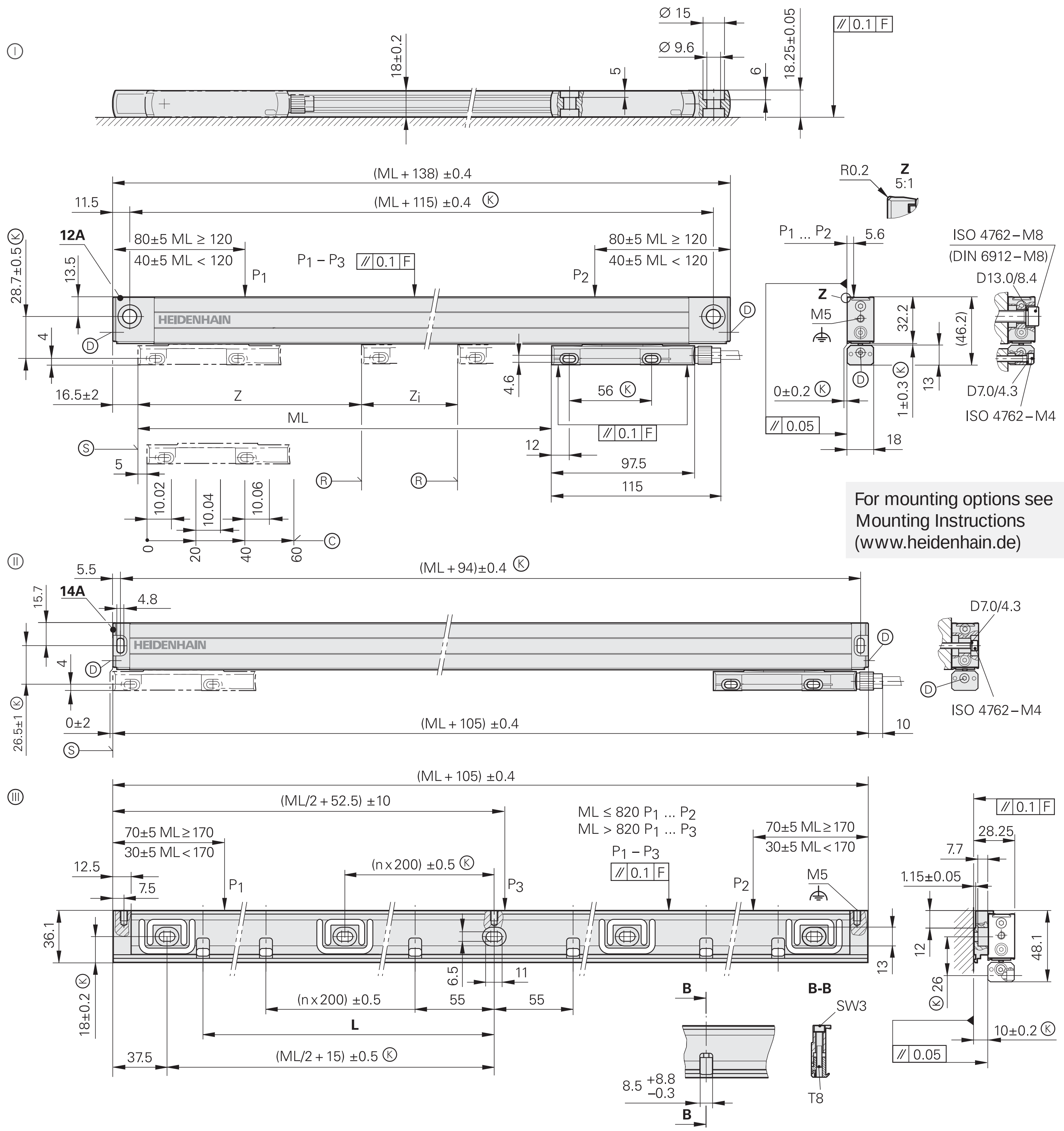
(I), (II),
(III) = Mounting options
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓑ = Cable connection usable at either end
Ⓓ = Compressed air inlet usable at either end
Ⓢ = Beginning of measuring length (ML)
Ⓡ = Reference mark position on LF 185
Ⓒ = Reference-mark position on LF 185C
Ⓦ = Mating surfaces
Ⓗ = No alternative required mating dimension, as opposed to LS/LC 100
⇨ = Direction of scanning unit motion for output signals in accordance with interface description

Specifications	LF 185
Measuring standard Coefficient of linear expansion	SUPRADUR phase grating on steel, grating period 8 µm $\alpha_{therm} \approx 10 \times 10^{-6}\ K^{-1}$
Accuracy grade*	± 3 µm; ± 2 µm
Measuring length ML* in mm	140 240 340 440 540 640 740 840 940 1040 1140 1240 (greater measuring lengths in preparation)
Incremental signals	~ 1 V_{PP}
Signal period	4 µm
Reference marks* *LF 185* *LF 185C*	One reference mark at midpoint; other reference mark positions upon request Distance-coded
Cutoff frequency –3 dB	≥ 250 kHz
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable to mounting block
Cable length	≤ 150 m (with HEIDENHAIN cable)
Power supply without load	5 V DC ± 5 %/< 120 mA
Traversing speed	≤ 60 m/min
Required moving force	≤ 4 N
Vibration 55 Hz to 2000 Hz *affecting the* **Shock** 11 ms **Acceleration**	*Housing:* ≤ 150 m/s^2 (EN 60068-2-6) *Scanning unit:* ≤ 200 m/s^2 (EN 60068-2-6) ≤ 300 m/s^2 (EN 60068-2-27) ≤ 100 m/s^2 in measuring direction
Operating temperature	0 °C to 50 °C
Protection EN 60529	IP 53 when installed according to instructions in the brochure IP 64 with sealing air via DA 400
Weight	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 12A; for mounting with and without mounting spar
Ⓘ = End block 14A; installation with mounting spar
Ⓘ = Mounting spar MSL 41
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions

Ⓡ = Reference mark position on LF 4x7
Two reference marks for measuring lengths

70 ... 1020	1140 ... 2040
z = 35 mm z_i = ML – 70 mm	z = 45 mm z_i = 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

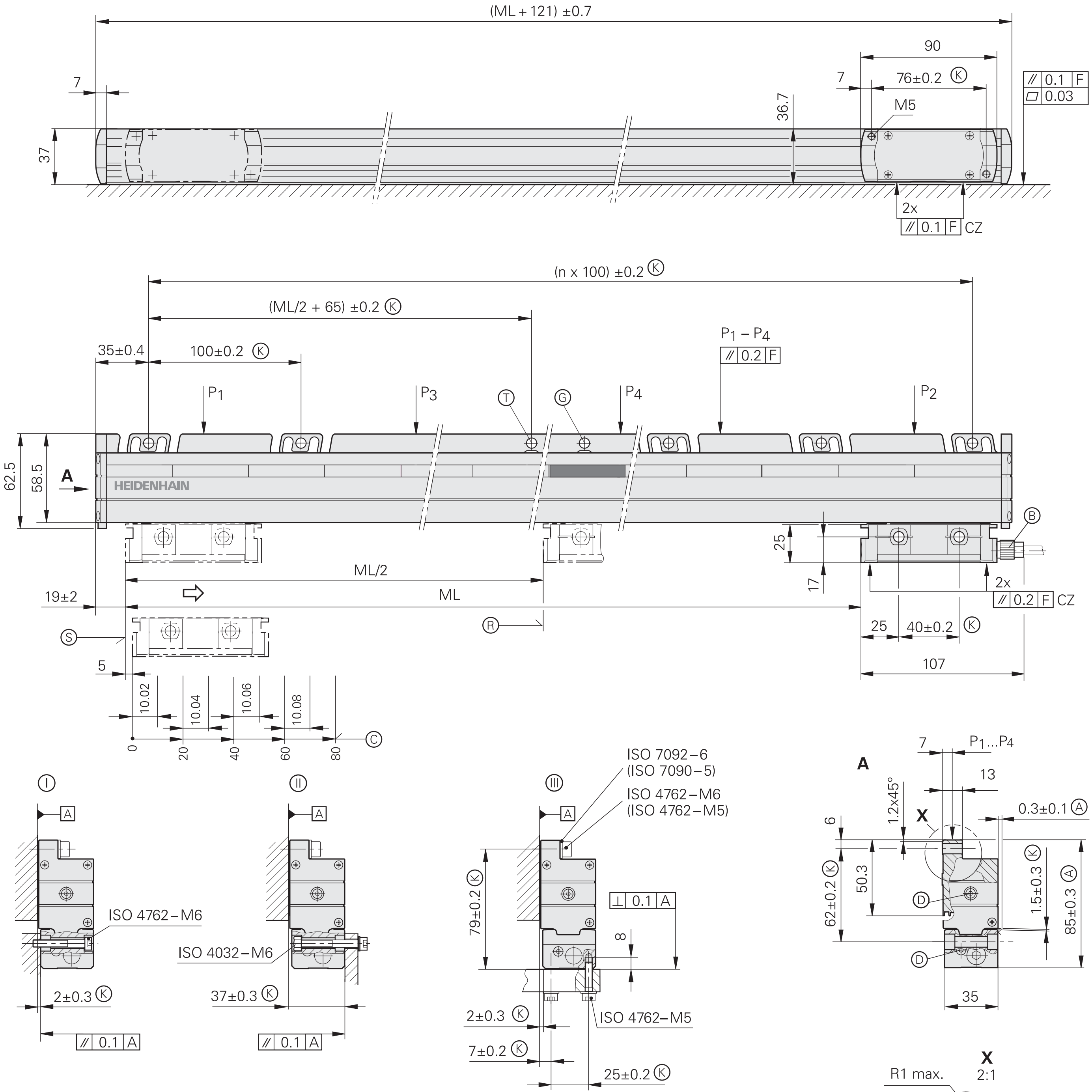
Specifications	**LS 487**	**LS 477**						
Measuring standard Coefficient of linear expansion	Glass scale with DIADUR grating, grating period 20 µm $\alpha_{therm} \approx 8 \times 10^{-6}$ K^{-1} (mounting type ①/②); *with mounting spar:* $\alpha_{therm} \approx 9 \times 10^{-6}$ K^{-1} (mounting type ③)							
Accuracy grade*	± 5 µm; ± 3 µm							
Measuring length ML* in mm	Mounting spar* 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							
Reference marks* *LS 4x7* *LS 4x7C*	• Selectable with magnets every 50 mm • 1 reference mark at midpoint of measuring length • 2 reference marks, each 35 mm (for ML ≤ 1020) or 45 mm (for ML ≥ 1140) from the beginning and end of measuring length Distance-coded							
Incremental signals	∿ 1 V_{PP}	⊓⊔TTL x 5		⊓⊔TTL x 10			⊓⊔TTL x 20	
Integrated interpolation* Signal period	– 20 µm	5-fold 4 µm		10-fold 2 µm			20-fold 1 µm	
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
Measuring step	0.5 µm[1]	1 µm[2]		0.5 µm[2]			0.25 µm[2]	
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable to mounting block							
Cable length[3]	≤ 150 m	≤ 100 m						
Power supply without load	5 V DC ± 5 %/< 120 mA	5 V DC ± 5 %/< 140 mA						
Traversing speed	≤ 120 m/min	≤ 120 m/min	≤ 60 m/min	≤ 120 m/min	≤ 60 m/min	≤ 30 m/min	≤ 60 m/min	≤ 30 m/min
Required moving force	≤ 5 N							
Vibration 55 Hz to 2000 Hz **Shock** 11 ms **Acceleration**	*Without mounting spar:* ≤ 100 m/s^2 (EN 60068-2-6) *With mounting spar and cable outlet at right:* ≤ 200 m/s^2, *left:* 100 m/s^2 (EN 60068-2-6) ≤ 300 m/s^2 (EN 60068-2-27) ≤ 100 m/s^2 in measuring direction							
Operating temperature	0 °C to 50 °C							
Protection EN 60529	IP 53 when installed according to mounting instructions and information; IP 64 with compressed air from DA 400							
Weight	0.4 kg + 0.5 kg/m measuring length							

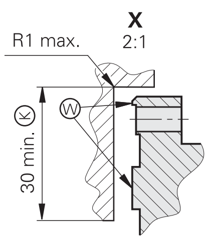
*Please indicate when ordering
1) Recommended for position measurement
2) After 4-fold evaluation in the subsequent electronics
3) With HEIDENHAIN cable

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 inlet usable at either end
Ⓣ = Mechanical fixed point (to be preferred)
Ⓖ = Mechanical fixed point, with 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

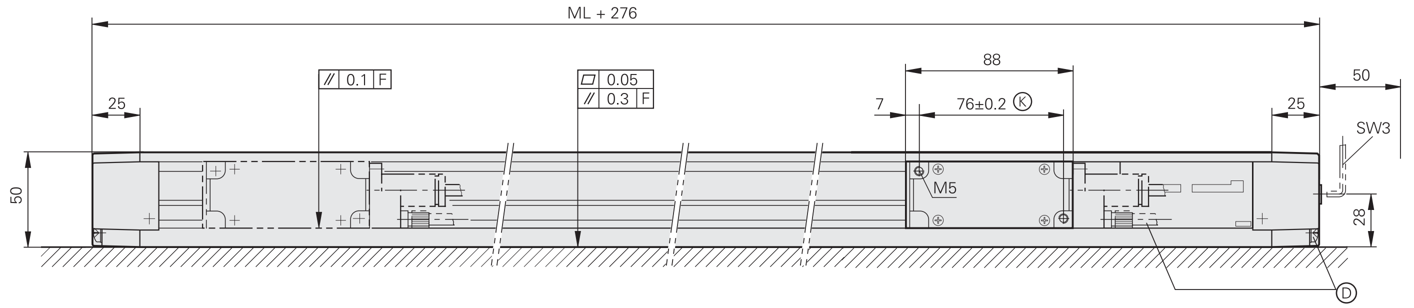
Specifications	LS 187	LS 177						
Measuring standard Coefficient of linear expansion	Glass scale with DIADUR grating, grating period 20 µm $\alpha_{therm} \approx 8 \times 10^{-6}\ K^{-1}$							
Accuracy grade*	± 5 µm; ± 3 µm							
Measuring length ML* in mm	140 240 340 440 540 640 740 840 940 1040 1140 1240 1340 1440 1540 1640 1740 1840 2040 2240 2440 2640 2840 3040							
Reference marks* *LS 1x7* *LS 1x7C*	Selectable with magnets every 50 mm, standard setting: 1 reference mark in the center Distance-coded							
Incremental signals	∿ 1 V_{PP}	⎍ TTL x 5		⎍ TTL x 10			⎍ TTL x 20	
Integrated interpolation* Signal period	– 20 µm	5-fold 4 µm		10-fold 2 µm			20-fold 1 µm	
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
Measuring step	0.5 µm[1]	1 µm[2]		0.5 µm[2]			0.25 µm[2]	
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable to mounting block							
Cable length[3]	≤ 150 m	≤ 100 m						
Power supply without load	5 V DC ± 5 %/< 120 mA	5 V DC ± 5 %/< 140 mA						
Traversing speed	≤ 120 m/min	≤ 120 m/min	≤ 60 m/min	≤ 120 m/min	≤ 60 m/min	≤ 30 m/min	≤ 60 m/min	≤ 30 m/min
Required moving force	≤ 4 N							
Vibration 55 Hz to 2000 Hz **Shock** 11 ms **Acceleration**	≤ 200 m/s^2 (EN 60068-2-6) ≤ 400 m/s^2 (EN 60068-2-27) ≤ 60 m/s^2 in measuring direction							
Operating temperature	0 °C to 50 °C							
Protection EN 60529	IP 53 when mounted according to the instructions and mounting information IP 64 if compressed air is connected via DA 400							
Weight	0.4 kg + 2.3 kg/m measuring length							

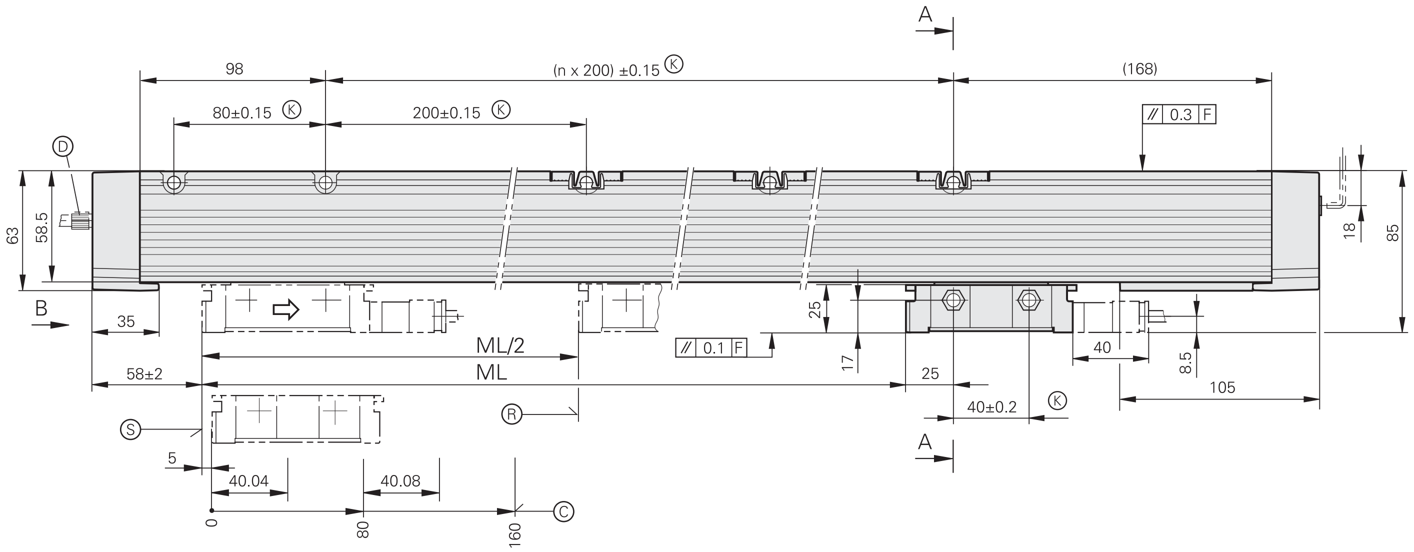
* Please indicate when ordering
[1] Recommended for position measurement
[2] After 4-fold evaluation in the subsequent electronics
[3] With HEIDENHAIN cable

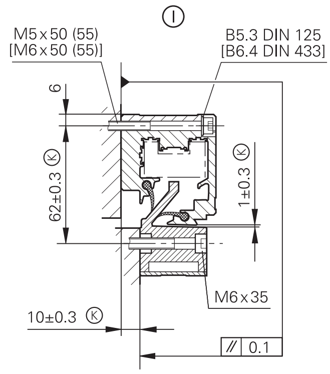
LB 382 up to 3040 mm measuring length (single-section housing)

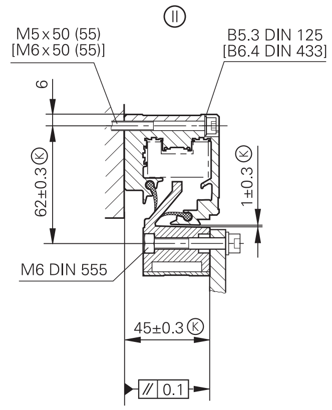
Incremental linear encoders with full-size scale housing

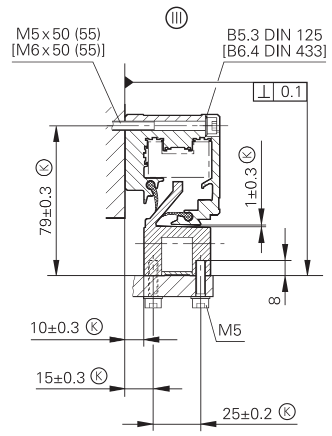
- **Reclining mounting possible**
- **Also available in mirrored version**









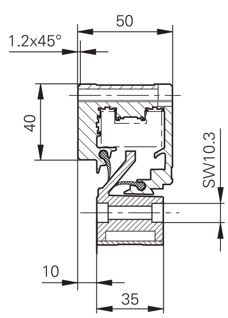


mm

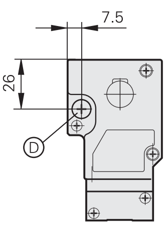
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Ⓘ, Ⓘ Ⓘ,
Ⓘ Ⓘ Ⓘ = 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)
⇨ = Direction of scanning unit motion for output signals in accordance with interface description

A-A



B

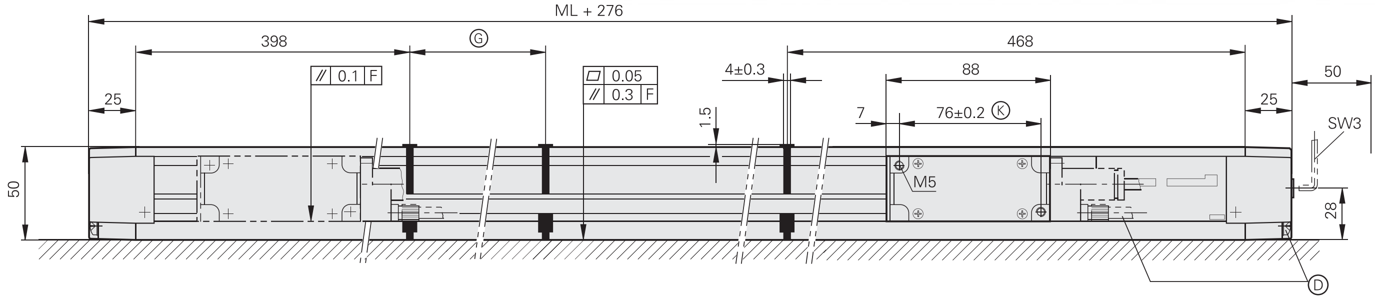


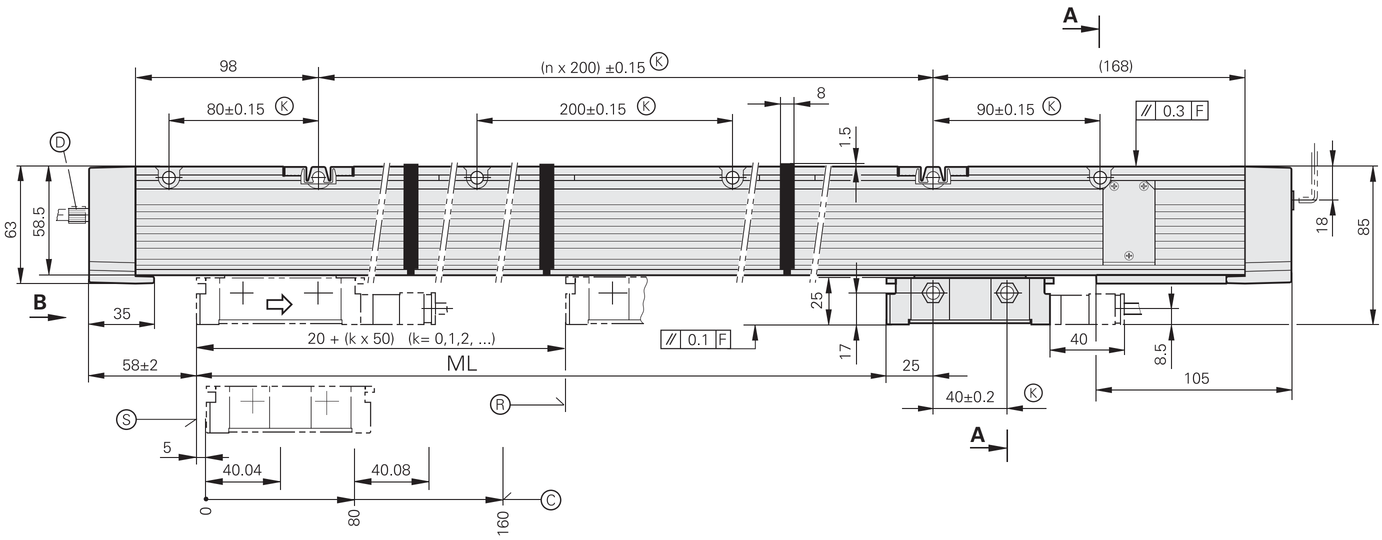
Specifications	**LB 382** up to ML 3040 mm
Measuring standard Coefficient of linear expansion	Rustproof steel scale tape with AURODUR graduation, grating period 40 µm $\alpha_{therm} \approx 10 \times 10^{-6} K^{-1}$
Accuracy grade	± 5 µm
Measuring length ML* in mm	Single-section housing 440 640 840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

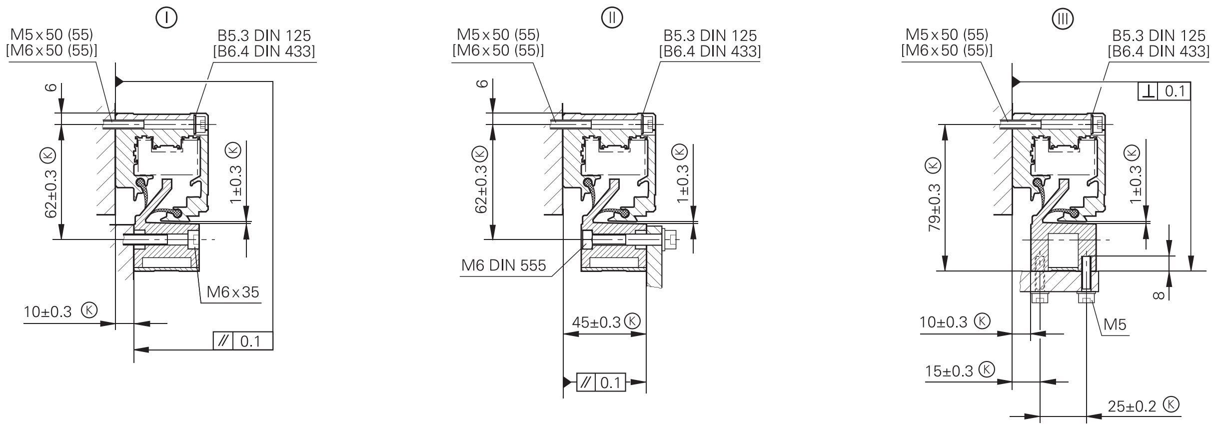
***** Please indicate when ordering
[1)] With HEIDENHAIN cable

LB 382 up to 30 040 mm measuring length (multi-section housing)

Incremental linear encoders with full-size scale housing
- **Measuring lengths up to 30 m (to 72 m upon request)**
- **Reclining mounting possible**
- **Also available in mirrored version**





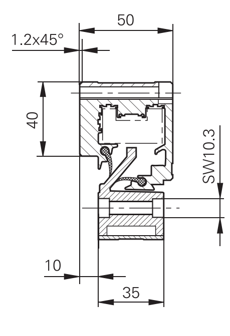


mm

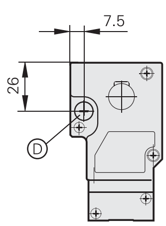
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Ⓘ, Ⓘⓘ,
Ⓘⓘⓘ = 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)
Ⓖ = Housing section lengths
⇨ = Direction of scanning unit motion for output signals in accordance with interface description

A-A



B



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

* Please indicate when ordering
1) With HEIDENHAIN cable

Interfaces

Incremental signals ∿ 1 V_{PP}

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

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

The **reference mark signal** R has a usable component G of approx. 0.5 V. Next to the reference mark, the output signal can be reduced by up to 1.7 V to a quiescent value H. This must not cause the subsequent electronics to overdrive. Even at the lowered signal level, signal peaks with the amplitude G can also appear.

The data on **signal amplitude** apply when the power supply given in the specifications is connected to the encoder. They refer to a differential measurement at the 120 ohm terminating resistor between the associated outputs. The signal amplitude decreases with increasing frequency. The **cutoff frequency** indicates the scanning frequency at which a certain percentage of the original signal amplitude is maintained:

- –3 dB ≙ 70 % of the signal amplitude
- –6 dB ≙ 50 % of the signal amplitude

The data in the signal description apply to motions at up to 20% of the —3 dB cutoff frequency.

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

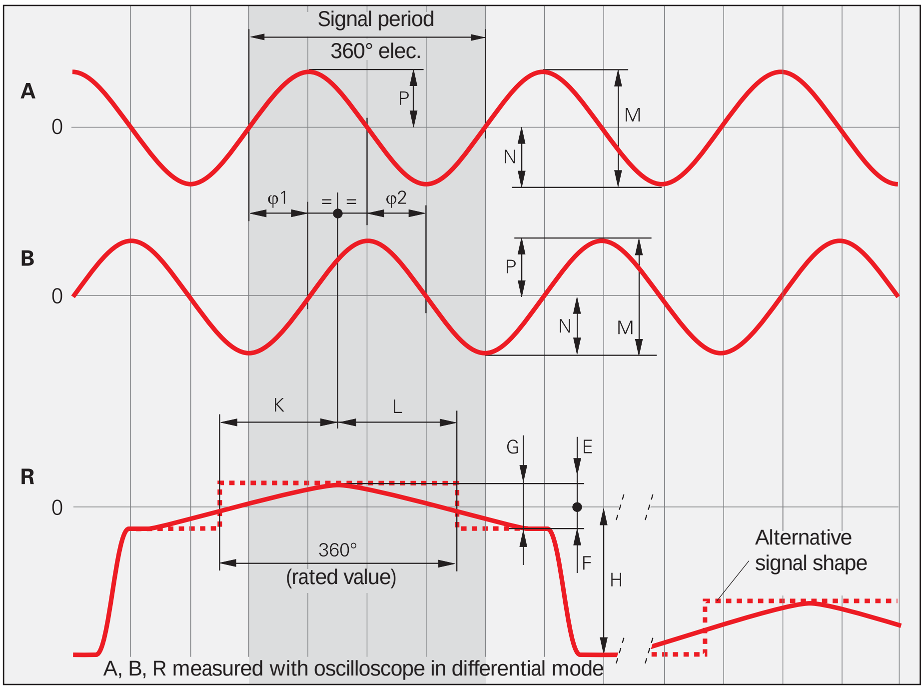
Measuring steps for **position measurement** are recommended in the specifications. For special applications, other resolutions are also possible.

Short-circuit stability
A temporary short circuit of one signal output to 0 V or U_P (except encoders with U_{Pmin}= 3.6 V) does not cause encoder failure, but it is not a permissible operating condition.

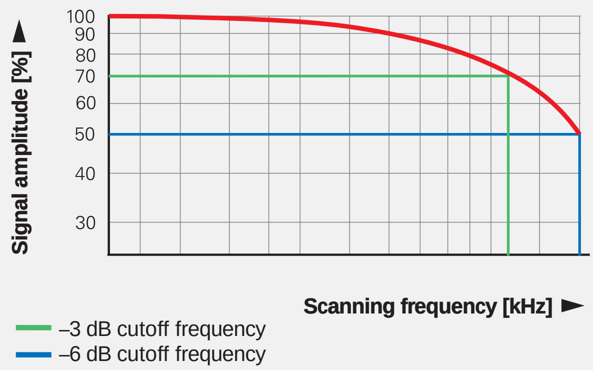
Short circuit at	20 °C	125 °C
One output	< 3 min	< 1 min
All outputs	< 20 s	< 5 s

Interface	Sinusoidal voltage signals ∿ **1 V_{PP}**
Incremental signals	**2 nearly sinusoidal signals A and B** Signal amplitude M: 0.6 to 1.2 V_{PP}; typically 1 V_{PP} Asymmetry |P – N|/2M: ≤ 0.065 Amplitude ratio M_A/M_B: 0.8 to 1.25 Phase angle |φ1 + φ2|/2: 90° ± 10° elec.
Reference-mark signal	**One or several signal peaks R** Usable component G: ≥ 0.2 V Quiescent value H: ≤ 1.7 V Switching threshold E, F: 0.04 to 0.68 V Zero crossovers K, L: 180° ± 90° elec.
Connecting cable Cable length Propagation time	Shielded HEIDENHAIN cable e.g PUR [4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] Max. 150 m at 90 pF/m distributed capacitance 6 ns/m

These values can be used for dimensioning of the subsequent electronics. Any limited tolerances in the encoders are listed in the specifications. For encoders without integral bearing, reduced tolerances are recommended for initial operation (see the mounting instructions).



Cutoff frequency
Typical signal amplitude curve with respect to the scanning frequency (depends on encoder)



Input circuitry of subsequent electronics

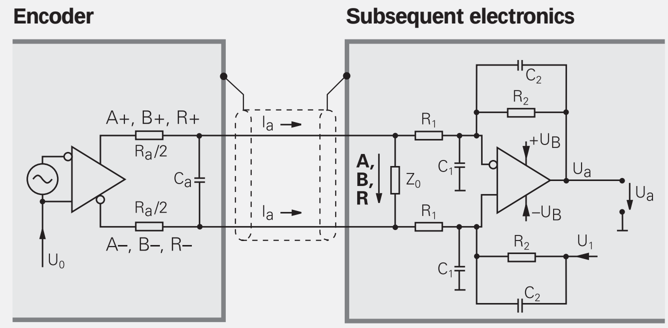
Dimensioning
Operational amplifier MC 34074
$Z_0 = 120\ \Omega$
$R_1 = 10\ k\Omega$ and $C_1 = 100$ pF
$R_2 = 34.8\ k\Omega$ and $C_2 = 10$ pF
$U_B = \pm 15$ V
U_1 approx. U_0

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

Encoders with **higher signal frequencies** (e.g. LIP 281) require special input circuitry (see the *Exposed Linear Encoders* brochure).

Incremental signals
Reference-mark signal

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

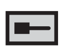
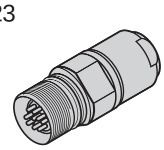
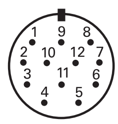


Circuit output signals
$U_a = 3.48\ V_{PP}$ typically
Gain 3.48

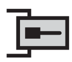
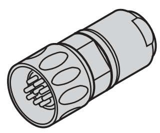
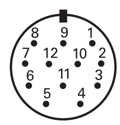
Monitoring of the incremental signals
The following sensitivity levels are recommended for monitoring the signal amplitude M:
Lower threshold: $0.30\ V_{PP}$
Upper threshold: $1.35\ V_{PP}$

Pin layout

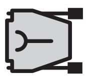
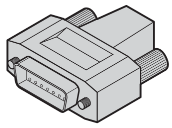
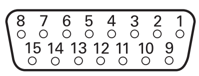
12-pin coupling, M23

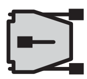
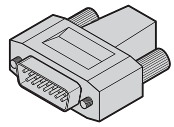
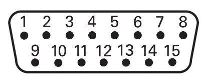
12-pin connector, M23

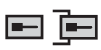
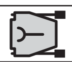
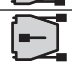




15-pin D-sub connector
For HEIDENHAIN controls and IK 220

15-pin D-sub connector
For encoder or IK 215

	Power 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_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**Vacant**	**Vacant**	**Vacant**
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	/	Violet	Yellow

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

Electrical connection

Interfaces

Incremental signals ⊓⊔ TTL

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

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

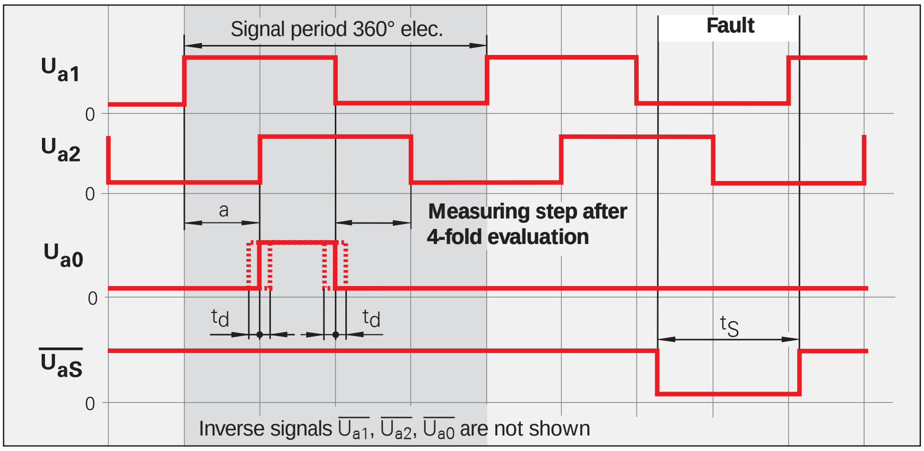
The **fault-detection signal** $\overline{U_{aS}}$ indicates fault conditions such as breakage of the power line or failure of the light source. It can be used for such purposes as machine shut-off during automated production.

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

The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum **edge separation a** listed in the *Specifications* applies for the illustrated input circuitry with a cable length of 1 m, and refers to measurement at the output of the differential line receiver. Cable-dependent differences in the propagation times additionally reduce the edge separation by 0.2 ns per meter of cable. To prevent counting errors, design the subsequent electronics to process as little as 90 % of the resulting edge separation.

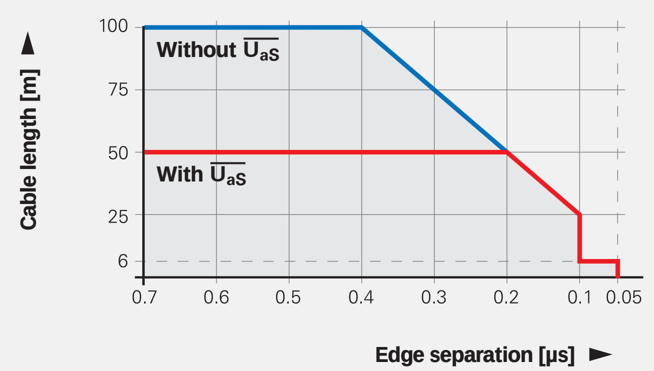
The max. permissible **shaft speed** or **traversing velocity** must never be exceeded.

Interface	Square-wave signals **⊓⊔ TTL**
Incremental signals	**2 square-wave signals U_{a1}, U_{a2}** and their inverted signals $\overline{U_{a1}}$, $\overline{U_{a2}}$
Reference-mark signal Pulse width Delay time	**1 or more TTL square-wave pulses U_{a0}** and their inverted pulses $\overline{U_{a0}}$ 90° elec. (other widths available on request) $\|t_d\| \leq 50$ ns
Fault-detection signal Pulse width	**1 TTL square-wave pulse $\overline{U_{aS}}$** Improper function: LOW (upon request: U_{a1}/U_{a2} high impedance) Proper function: HIGH $t_S \geq 20$ ms
Signal amplitude	Differential line driver as per EIA standard RS-422 $U_H \geq 2.5$ V at $-I_H = 20$ mA *ERN 1x23:* 10 mA $U_L \leq 0.5$ V at $I_L = 20$ mA *ERN 1x23:* 10 mA
Permissible load	$Z_0 \geq 100\ \Omega$ Between associated outputs $\|I_L\| \leq 20$ mA Max. load per output (*ERN 1x23:* 10 mA) $C_{load} \leq 1000$ pF With respect to 0 V Outputs protected against short circuit to 0 V
Switching times (10% to 90%)	$t_+ / t_- \leq 30$ ns (typically 10 ns) with 1 m cable and recommended input circuitry
Connecting cable Cable length Signal propagation	Shielded HEIDENHAIN cable e.g. PUR [4(2 × 0.14 mm^2) + (4 × 0.5 mm^2)] Max. 100 m ($\overline{U_{aS}}$ max. 50 m) at distributed capacitance 90 pF/m 6 ns/m



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

Permissible cable length
with respect to the edge separation

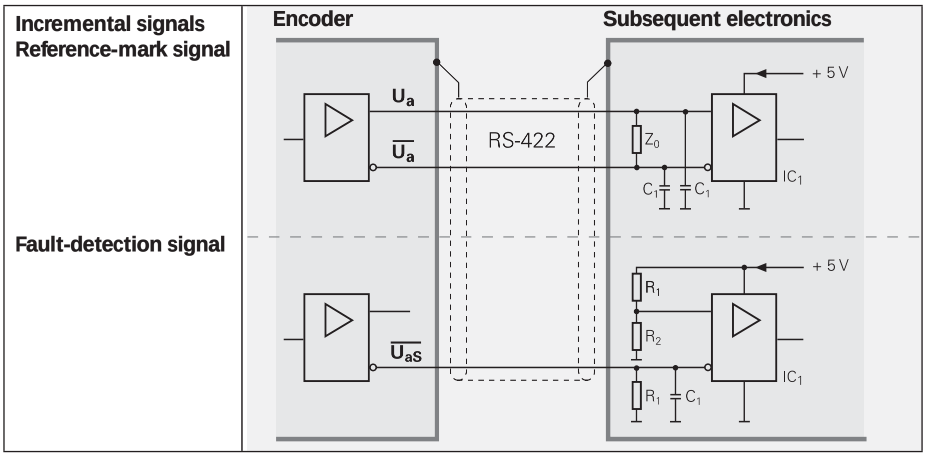


Input circuitry of subsequent electronics

Dimensioning

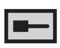
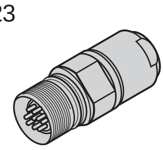
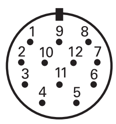
IC_1 = Recommended differential line receiver
DS 26 C 32 AT
Only for a > 0.1 µs:
AM 26 LS 32
MC 3486
SN 75 ALS 193

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

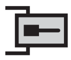
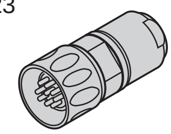
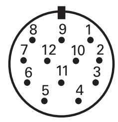


Pin layout

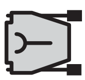
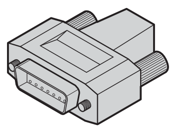
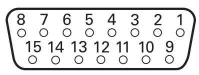
12-pin coupling, M23

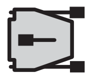
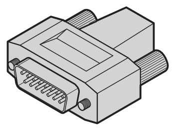
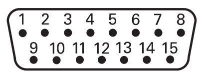
12-pin connector, M23

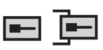
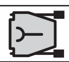
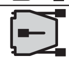




15-pin D-sub connector
For HEIDENHAIN controls and IK 220

15-pin D-sub connector
For encoder or PWM 20

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

Cable shield connected to housing; **U_P** = Power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!
1) **ERO 14xx:** Vacant
2) **Exposed linear encoders:** Switchover TTL/11 µA$_{PP}$ for PWT, otherwise vacant

Interfaces
Absolute position values EnDat

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

For more information, refer to the *EnDat* Technical Information sheet or visit *www.endat.de*.

Position values can be transmitted with or without additional information (e.g. position value 2, temperature sensors, diagnostics, limit position signals).

Besides the position, additional information can be interrogated in the closed loop and functions can be performed with the EnDat 2.2 interface.

Parameters are saved in various memory areas, e.g.:
- Encoder-specific information
- Information of the OEM (e.g. "electronic ID label" of the motor)
- Operating parameters (datum shift, instruction, etc.)
- Operating status (alarm or warning messages)

Monitoring and diagnostic functions of the EnDat interface make a detailed inspection of the encoder possible.
- Error messages
- Warnings
- Online diagnostics based on valuation numbers (EnDat 2.2)

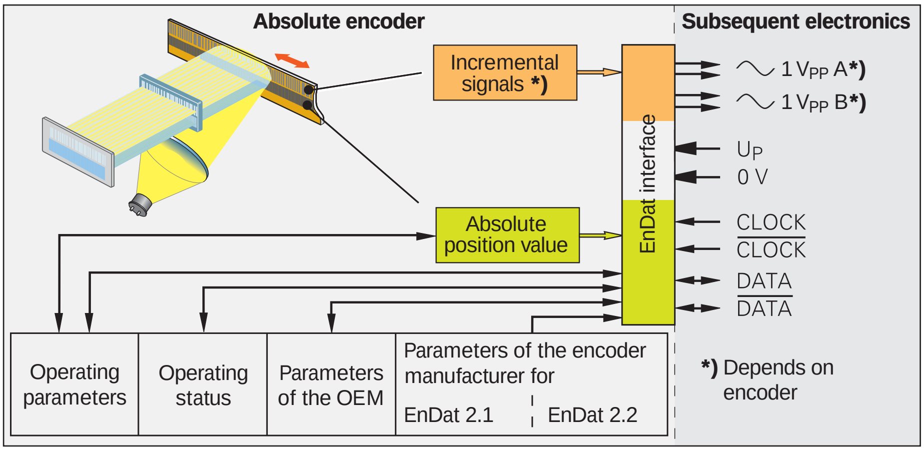
Incremental signals
EnDat encoders are available with or without incremental signals. EnDat 21 and EnDat 22 encoders feature a high internal resolution. An evaluation of the incremental signal is therefore unnecessary.

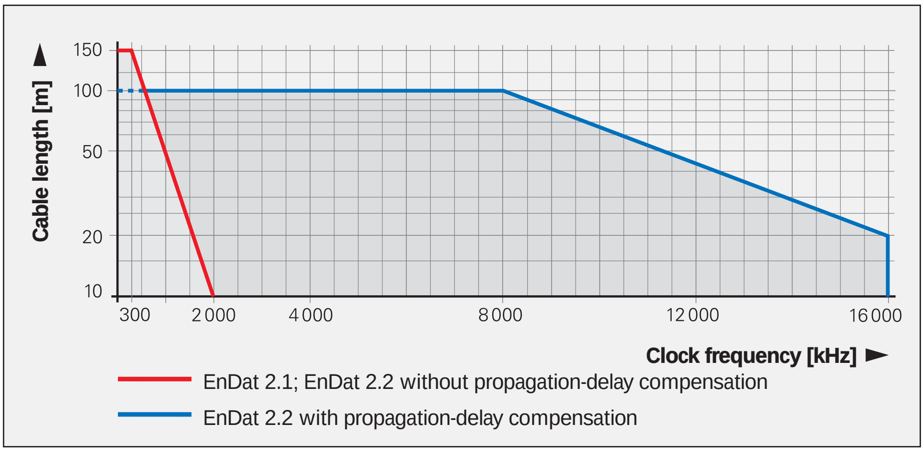
Clock frequency and cable length
The clock frequency is variable—depending on the cable length (max. 150 m)—between **100 kHz** and **2 MHz.** With propagation-delay compensation in the subsequent electronics, either clock frequencies **up to 16 MHz** are possible or cable lengths up to 100 m (for other values see *Specifications*).

Interface	**EnDat** serial bidirectional
Data transfer	Absolute position values, parameters and additional information
Data input	Differential line receiver according to EIA standard RS 485 for the signals CLOCK, $\overline{\text{CLOCK}}$, DATA and $\overline{\text{DATA}}$
Data output	Differential line driver according to EIA standard RS 485 for DATA and $\overline{\text{DATA}}$ signals
Position values	Ascending during traverse in direction of arrow (see dimensions of the encoders)
Incremental signals	∼ 1 V_{PP} (see *Incremental signals 1* V_{PP}) depending on the unit

Ordering designation	**Command set**	**Incremental signals**	**Power supply**
EnDat 01	EnDat 2.1 or EnDat 2.2	With	See specifications of the encoder
EnDat 21		Without	
EnDat 02	EnDat 2.2	With	Expanded range 3.6 to 5.25 V DC or 14 V DC
EnDat 22	EnDat 2.2	Without	

Versions of the EnDat interface (bold print indicates standard versions)





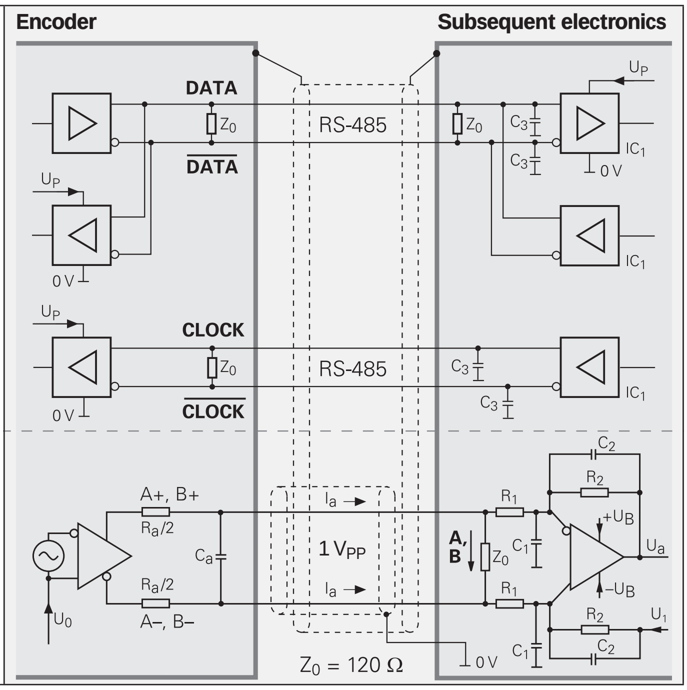
Input circuitry of subsequent electronics

Dimensioning
IC_1 = RS 485 differential line receiver and driver

C_3 = 330 pF
Z_0 = 120 Ω

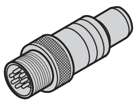
Data transfer

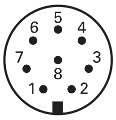
Incremental signals
Depending on encoder



Pin layout

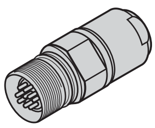
8-pin coupling, M12

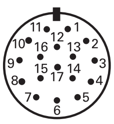




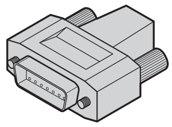
	Power supply				Absolute position values			
	8	2	5	1	3	4	7	6
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

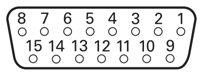
17-pin M23 **coupling**





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





	Power supply					Incremental signals[1]				Absolute position values			
	7	1	10	4	11	15	16	12	13	14	17	8	9
	1	9	2	11	13	3	4	6	7	5	8	14	15
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Internal shield**	**A+**	**A–**	**B+**	**B–**	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
	Brown/Green	Blue	White/Green	White	/	Green/Black	Yellow/Black	Blue/Black	Red/Black	Gray	Pink	Violet	Yellow

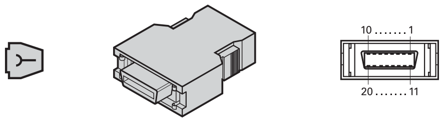
Cable shield connected to housing; **U_P** = Power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!
[1] Only with ordering designations EnDat 01 and EnDat 02

Interfaces
Fanuc and Mitsubishi pin layouts

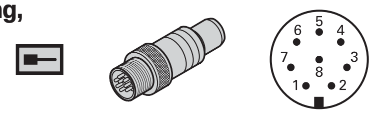
Fanuc pin layout
HEIDENHAIN encoders with the code letter F after the model designation are suited for connection to Fanuc controls with **Fanuc serial interface – αi interface**

- αi interface (high speed, one-pair transmission) includes α interface (normal and high speed, two-pair transmission)
- Ordering designation for Fanuc05

20-pin Fanuc connector



8-pin coupling, M12



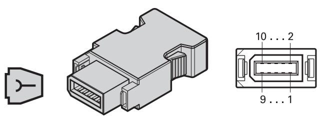
	Power supply					Absolute position values			
	9	**18/20**	**12**	**14**	**16**	**1**	**2**	**5**	**6**
	8	**2**	**5**	**1**	**–**	**3**	**4**	**7**	**6**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Shield**	**Serial Data**	**$\overline{\text{Serial Data}}$**	**Request**	**$\overline{\text{Request}}$**
	Brown/ Green	Blue	White/ Green	White	–	Gray	Pink	Violet	Yellow

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

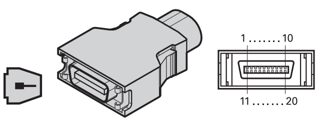
Mitsubishi pin layout
HEIDENHAIN encoders with the code letter M after the model designation are suited for connection to controls with **Mitsubishi high-speed serial interface.**

- Transmission rate 2.5 MHz and 5 MHz (two-pair transmission)
- Ordering designation Mit03-4

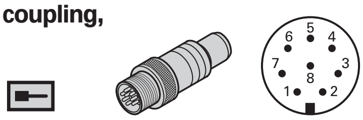
10-pin Mitsubishi connector



20-pin Mitsubishi connector



8-pin coupling, M12



	Power supply				Absolute position values			
10-pin	**1**	**–**	**2**	**–**	**7**	**8**	**3**	**4**
20-pin	**20**	**19**	**1**	**11**	**6**	**16**	**7**	**17**
	8	**2**	**5**	**1**	**3**	**4**	**7**	**6**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Serial Data**	**$\overline{\text{Serial Data}}$**	**Request Frame**	**$\overline{\text{Request Frame}}$**
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

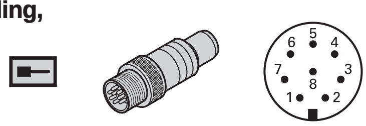
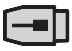
Cable shield connected to housing; **U_P** = power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!

Pin layout—Siemens

Pin layout—Siemens
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 the SIEMENS Corporation.

RJ45 connector 				**8-pin coupling,** M12 		
	Power supply		Absolute position values			
			Transmit data		Data was received	
	**A**	**B**	**3**	**6**	**1**	**2**
	**1**	**5**	**7**	**6**	**3**	**4**
	U$_P$	**0 V**	**TXP**	**TXN**	**RXP**	**RXN**

Cable shield connected to housing; **U$_P$** = power supply voltage

HEIDENHAIN measuring equipment

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

	PWM 9
Inputs	Expansion modules (interface boards) for 11 µAPP; 1 VPP; TTL; HTL; EnDat*/SSI*/commutation signals *No display of position values or parameters
Functions	• **Measures** signal amplitudes, current consumption, operating voltage, scanning frequency • **Graphically displays** incremental signals (amplitudes, phase angle and on-off ratio) and the reference-mark signal (width and position) • **Displays symbols** for the reference mark, fault detection signal, counting direction • **Universal counter,** interpolation selectable from single to 1024-fold • **Adjustment support** for exposed linear encoders
Outputs	• Inputs are connected through to the subsequent electronics • BNC sockets for connection to an oscilloscope
Power supply	10 V to 30 V, max. 15 W
Dimensions	150 mm × 205 mm × 96 mm

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

	PWM 20
Encoder input	• EnDat 2.1 or EnDat 2.2 (absolute value with/without incremental signals) • DRIVE-CLiQ • Fanuc serial interface • Mitsubishi high speed serial interface • SSI • VPP/TTL/11 µAPP
Interface	USB 2.0
Power supply	100 to 240 V AC or 24 V DC
Dimensions	258 mm x 154 mm x 55 mm

	ATS
Languages	Choice between English or German
Functions	• Position display • Connection dialog • Diagnostics • Mounting wizard for EBI/ECI/EQI, LIP 200, LIC 4000 and others • Additional functions (if supported by the encoder) • Memory contents
System requirements	PC (dual-core processor; > 2 GHz) Main memory > 1 GB Windows XP, Vista, 7 (32-bit/64-bit) 100 MB free space on hard disk

DRIVE-CLiQ is a registered trademark of the SIEMENS Corporation.

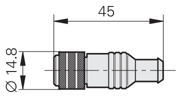
Connecting elements and cables

General information

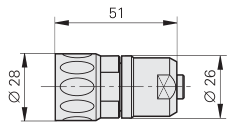
Connector (insulated): A connecting element with a coupling ring. Available with male or female contacts.

Symbols

M12



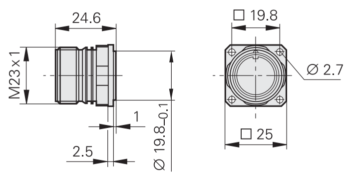
M23



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

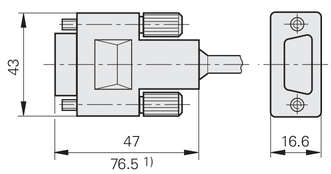
Symbols

M23



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

Symbols

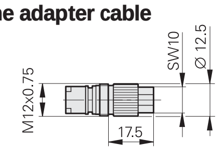


1) With integrated interpolation electronics

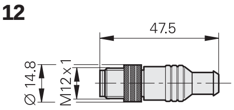
Coupling insulated:
Connecting element with external thread. Available with male or female contacts.

Symbols

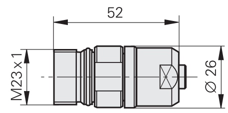
On the adapter cable



M12

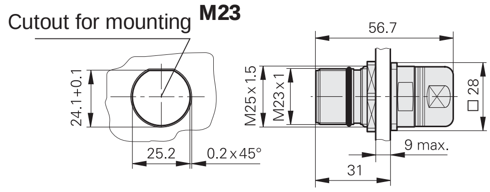


M23



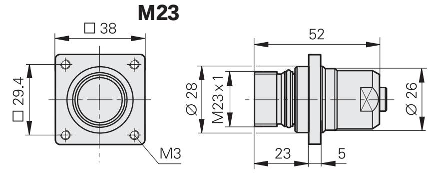
Mounted coupling with central fastening

M23



Mounted coupling with flange

M23



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

male or

female contacts.

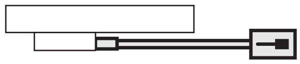
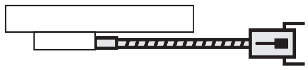
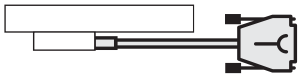
When engaged, the connections are **protected** to IP 67 (D-sub connector: IP 50; EN 60529). When not engaged, there is no protection.

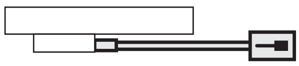
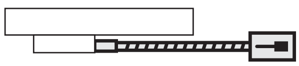
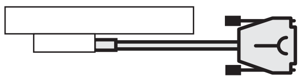
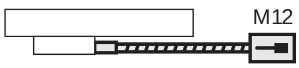
Accessories for flange sockets and M23 mounted couplings

Bell seal
ID 266526-01

Threaded metal dust cap
ID 219926-01

Adapter cables

For incremental linear encoders		Cable Ø	LB 382/372	LF 185/485 LS 187/177 LS 487/477
Adapter cable with M23 coupling (male), 12-pin		6 mm	310128-xx	360645-xx
Adapter cable without connector		6 mm	310131-xx	354319-xx
Adapter cable with M23 connector (male), 12-pin		6 mm 4.5 mm	310127-xx –	344228-xx 352611-xx
Adapter cable in metal armor with M23 connector (male), 12-pin		10 mm	310126-xx	344451-xx
Adapter cable with D-sub connector, 15-pin		6 mm	298429-xx	360974-xx

For absolute linear encoders—EnDat		Cable Ø	**LC 281** With incremental signals	**LC 115** **LC 415** **LC 211** Without incremental signals
Adapter cable with M23 coupling (male), 17-pin		6 mm	533631-xx	–
Adapter cable in metal armor with M23 coupling (male), 17-pin		10 mm	558362-xx	–
Adapter cable with D-sub connector, 15-pin		6 mm	558714-xx	–
Adapter cable with M12 coupling (male), 8-pin		4.5 mm	–	533661-xx
Adapter cable in metal armor with M12 coupling (male), 8-pin		10 mm	–	550678-xx

Available cable lengths: 1 m/3 m/6 m/9 m

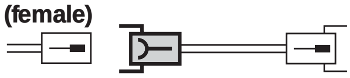
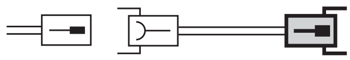
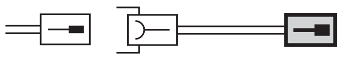
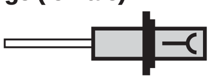
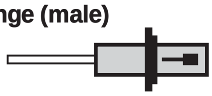
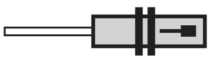
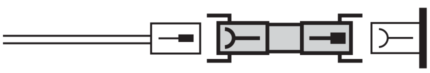
For absolute linear encoders—Siemens		**Cable Ø**	**LC 195 S** **LC 495 S**
Adapter cable with M12 coupling (male), 8-pin		6.8 mm	805452-xx
Adapter cable with Siemens connector, RJ45		6.8 mm	805375-xx

For absolute linear encoders—Fanuc		**Cable Ø**	**LC 195 F** **LC 495 F**
Adapter cable with M23 coupling (male), 17-pin		6 mm 4.5 mm	– 547300-xx
Adapter cable in metal armor with M23 coupling (male), 17-pin		10 mm	555541-xx
Adapter cable with M12 coupling (male), 8-pin	M12	4.5 mm	533661-xx
Adapter cable in metal armor with M12 coupling (male), 8-pin	M12	10 mm	550678-xx
Adapter cable with Fanuc connector, 20-pin		4.5 mm	545547-xx
Adapter cable in metal armor with Fanuc connector, 20-pin		10 mm	551027-xx

For absolute linear encoders—Mitsubishi		**Cable Ø**	**LC 195 M** **LC 495 M**
Adapter cable with M23 coupling (male), 17-pin		6 mm 4.5 mm	– 547300-xx
Adapter cable in metal armor with M23 coupling (male), 17-pin		10 mm	555541-xx
Adapter cable with M12 coupling (male), 8-pin	M12	4.5 mm	533661-xx
Adapter cable in metal armor with M12 coupling (male), 8-pin	M12	10 mm	550678-xx
Adapter cable with Mitsubishi connector, 10-pin **With Mitsubishi connector,** 20-pin		4.5 mm 4.5 mm	599685-xx 640915-xx
Adapter cable in metal armor with Mitsubishi connector, 10-pin **With Mitsubishi connector,** 20-pin		10 mm 10 mm	599688-xx 640916-xx

Available cable lengths: 1 m/3 m/6 m/9 m

Connecting cable ∿ 1 VPP
⊓⊔TTL
EnDat

		12-pin M23	17-pin M23	8-pin M12
		For ∿ **1 VPP** ⊓⊔ **TTL**	**For EnDat** with incremental **SSI signals**	**For EnDat** without incremental signals
PUR connecting cables	**8-pin:** [(4 × 0.14 mm^2) + (4 × 0.34 mm^2)] **Ø 6 mm** **12-pin:** [4(2 × 0.14 mm^2) + (4 × 0,5 mm^2)] **Ø 8 mm** **17-pin:** [(4 × 0.14 mm^2) + 4(2 × 0.14 mm^2) + (4 × 0.5 mm^2)] **Ø 8 mm**			
Complete with connector (female) and coupling (male)		298401-xx	323897-xx	368330-xx
Complete with connector (female) and connector (male)		298399-xx	–	–
Complete with connector (female) and D-sub connector (female) for IK 220		310199-xx	332115-xx	533627-xx
Complete with connector (female) and D-sub connector (male) for IK 115/IK 215		310196-xx	324544-xx	524599-xx
With **one** connector (female)		309777-xx	309778-xx	559346-xx
Cable without connectors, ∅ 8 mm		244957-01	266306-01	–
Mating element on connecting cable to connector on encoder cable	**Connector (female)** for cable ∅ 8 mm 	291697-05	291697-26	–
Connector on connecting cable for connection to subsequent electronics	**Coupling (male)** for cable ∅ 4.5 mm ∅ 8 mm ∅ 6 mm 	291697-06 291697-08 291697-07	291697-27	–
Coupling on connecting cable	**Coupling (male)** for cable ∅ 4.5 mm ∅ 6 mm ∅ 8 mm 	291698-14 291698-03 291698-04	291698-25 291698-26 291698-27	–
Flange socket for mounting on subsequent electronics	**Flange socket (female)** 	315892-08	315892-10	–
Mounted couplings	**With flange (female)** ∅ 6 mm ∅ 8 mm 	291698-17 291698-07	291698-35	**–**
	With flange (male) ∅ 6 mm ∅ 8 mm 	291698-08 291698-31	291698-41 291698-29	–
	With central fastening (male) ∅ 6 mm 	291698-33	291698-37	–
Adapter ∿ **1 VPP/11 µAPP** For converting the 1 VPP signals to 11 µAPP; 12-pin M23 connector (female) and 9-pin M23 connector (male)		364914-01	–	–

Connecting cables Fanuc
Mitsubishi

		Cables	Fanuc	Mitsubishi
PUR connecting cable for M23 connecting elements				
Complete With 17-pin M23 connector (female) and Fanuc connector [(2 x 2 x 0.14 mm^2) + (4 x 1 mm^2)]		∅ 8 mm	534855-xx	–
Complete With 17-pin M23 connector (female) and 20-pin Mitsubishi connector [(2 x 2 x 0.14 mm^2) + (4 x 0.5 mm^2)]		∅ 6 mm	–	367958-xx
Complete With 17-pin M23 connector (female) and 10-pin Mitsubishi connector [(2 x 2 x 0.14 mm^2) + (4 x 1 mm^2)]		∅ 8 mm	–	573661-xx
Cable only [(2 x 2 x 0.14 mm^2) + (4 x 1 mm^2)]		∅ 8 mm	354608-01	

		Cables	Fanuc	Mitsubishi
PUR connecting cable for M12 connecting elements				
Complete With 8-pin M12 connector (female) and Fanuc connector [(1 x 4 x 0.14 mm^2) + (4 x 0.34 mm^2)]		∅ 6 mm	646807-xx	–
Complete With M12 connector (female) 8-pin and 20-pin Mitsubishi connector [(1 x 4 x 0.14 mm^2) + (4 x 0.34 mm^2)]		∅ 6 mm	–	646806-xx
Complete With M12 connector (female) 8-pin and 10-pin Mitsubishi connector [(1 x 4 x 0.14 mm^2) + (4 x 0.34 mm^2)]		∅ 6 mm	–	647314-xx

General electrical information

Power supply

Connect HEIDENHAIN encoders only to subsequent electronics whose power supply is generated from PELV systems **(EN 50178).** In addition, overcurrent protection and overvoltage protection are required in safety-related applications.

If HEIDENHAIN encoders are to be operated in accordance with IEC 61010-1, power must be supplied from a secondary circuit with current or power limitation as per IEC 61010-1:2001, section 9.3 or IEC 60950-1:2005, section 2.5 or a Class 2 secondary circuit as specified in UL1310.

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

- High frequency interference
  $U_{PP} < 250$ mV with $dU/dt > 5$ V/µs
- Low frequency fundamental ripple
  $U_{PP} < 100$ mV

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

Calculation of the **voltage drop**:

$$\Delta U = 2 \cdot 10^{-3} \cdot \frac{1.05 \cdot L_C \cdot I}{56 \cdot A_P}$$

where
ΔU: Voltage drop in V
1.05: Length factor due to twisted wires
L_C: Cable length in m
I: Current consumption in mA
A_P: Cross section of power lines in mm^2

The voltage actually applied to the encoder is to be considered when **calculating the encoder's power requirement.** This voltage consists of the supply voltage U_P provided by the subsequent electronics minus the line drop at the encoder. For encoders with an expanded supply range, the voltage drop in the power lines must be calculated under consideration of the nonlinear current consumption (see next page).

If the voltage drop is known, all parameters for the encoder and subsequent electronics can be calculated, e.g. voltage at the encoder, current requirements and power consumption of the encoder, as well as the power to be provided by the subsequent electronics.

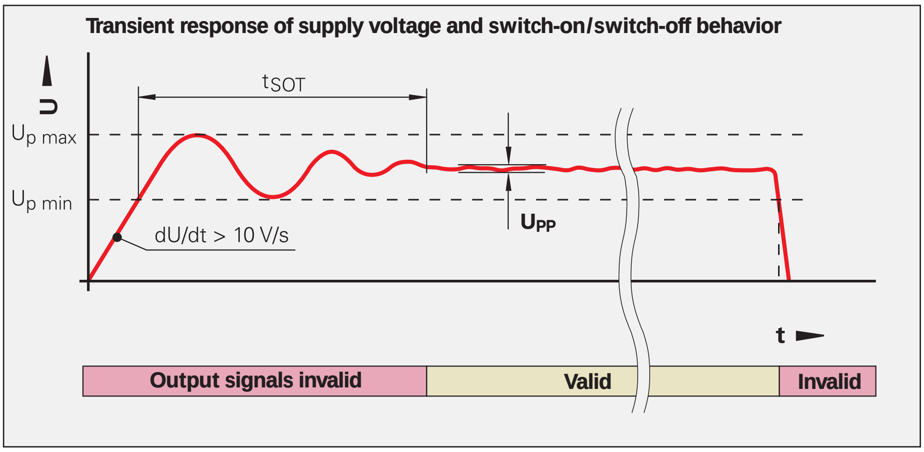
Switch-on/off behavior of the encoders

The output signals are valid no sooner than after the switch-on time t_{SOT} = 1.3 s (2 s for PROFIBUS-DP) (see diagram). During the time t_{SOT} they can have any levels up to 5.5 V (with HTL encoders up to U_{Pmax}). If an interpolation electronics unit is inserted between the encoder and the power supply, this unit's switch-on/off characteristics must also be considered. If the power supply is switched off, or when the supply voltage falls below U_{min}, the output signals are also invalid. During restart, the signal level must remain below 1 V for the time t_{SOT} before power on. These data apply to the encoders listed in the catalog—customer-specific interfaces are not included.

Encoders with new features and increased performance range may take longer to switch on (longer time t_{SOT}). If you are responsible for developing subsequent electronics, please contact HEIDENHAIN in good time.

Insulation

The encoder housings are isolated against internal circuits.
Rated surge voltage: 500 V
(preferred value as per VDE 0110 Part 1, overvoltage category II, contamination level 2)



Cables	Cross section of power supply lines A_P			
	1 V_{PP}/TTL/HTL	11 µA_{PP}	EnDat/SSI 17-pin	EnDat[5] 8-pin
Ø 3.7 mm	0.05 mm^2	–	–	0.09 mm^2
Ø 4.3 mm	0.24 mm^2	–	–	–
Ø 4.5 mm EPG	0.05 mm^2	–	0.05 mm^2	0.09 mm^2
Ø 4.5 mm **Ø 5.1 mm**	0.14/0.09[2] mm^2 0.05[2), 3)] mm^2	0.05 mm^2	0.05/0.14[6] mm^2	0.14 mm^2
Ø 5.5 mm PVC	0.1 mm^2	–	–	–
Ø 6 mm **Ø 10 mm**[1]	0.19/0.14[2), 4)] mm^2	–	0.08/0.19[6] mm^2	0.34 mm^2
Ø 8 mm **Ø 14 mm**[1]	0.5 mm^2	1 mm^2	0.5 mm^2	1 mm^2

1) Metal armor
2) Rotary encoders
3) Length gauges
4) LIDA 400
5) Also Fanuc, Mitsubishi
6) Adapter cables for RCN, LC

Encoders with expanded supply voltage range

For encoders with expanded supply voltage range, the current consumption has a nonlinear relationship with the supply voltage. On the other hand, the power consumption follows a linear curve (see *Current and power consumption* diagram). The maximum power consumption at minimum and maximum supply voltage is listed in the **Specifications**. The maximum power consumption (worst case) accounts for:

- Recommended receiver circuit
- Cable length 1 m
- Age and temperature influences
- Proper use of the encoder with respect to clock frequency and cycle time

The typical current consumption at no load (only supply voltage is connected) for 5 V supply is specified.

The actual power consumption of the encoder and the required power output of the subsequent electronics are measured, while taking the voltage drop on the supply lines into consideration, in four steps:

***Step 1:* Resistance of the supply lines**

The resistance values of the supply lines (adapter cable and encoder cable) can be calculated with the following formula:

$$R_L = 2 \cdot \frac{1.05 \cdot L_C}{56 \cdot A_P}$$

***Step 2:* Coefficients for calculation of the drop in line voltage**

$$b = -R_L \cdot \frac{P_{Emax} - P_{Emin}}{U_{Emax} - U_{Emin}} - U_P$$

$$c = P_{Emin} \cdot R_L + \frac{P_{Emax} - P_{Emin}}{U_{Emax} - U_{Emin}} \cdot R_L \cdot (U_P - U_{Emin})$$

***Step 3:* Voltage drop based on the coefficients b and c**

$$\Delta U = -0.5 \cdot (b + \sqrt{b^2 - 4 \cdot c})$$

***Step 4:* Parameters for subsequent electronics and the encoder**

Voltage at encoder:
$U_E = U_P - \Delta U$

Current requirement of encoder:
$I_E = \Delta U / R_L$

Power consumption of encoder:
$P_E = U_E \cdot I_E$

Power output of subsequent electronics:
$P_S = U_P \cdot I_E$

Where:

U_{Emax}, U_{Emin}: Minimum or maximum supply voltage of the encoder in V

P_{Emin}, P_{Emax}: Maximum power consumption at minimum or maximum power supply, respectively, in W

U_P: Supply voltage of the subsequent electronics in V

R_L: Cable resistance (for both directions) in ohms

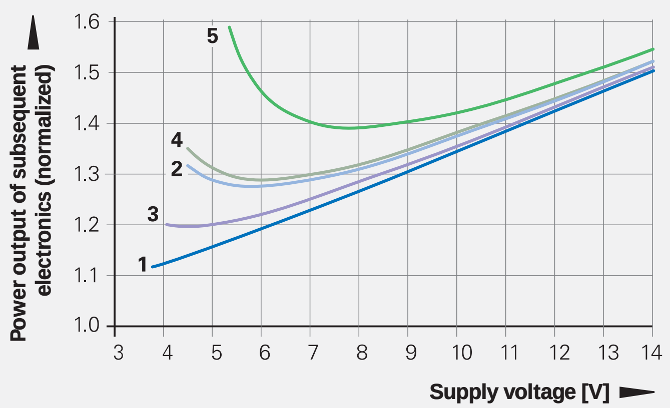
ΔU: Voltage drop in the cable in V

1.05: Length factor due to twisted wires

L_C: Cable length in m

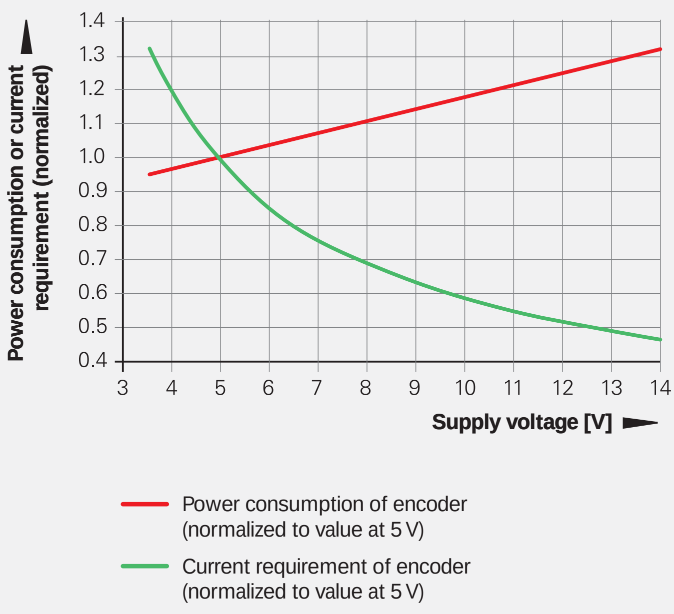
A_P: Cross section of power lines in mm^2

Influence of cable length on the power output of the subsequent electronics (example representation)



	Encoder cable/adapter cable	Connecting cable	Total
1	3 m	/	3 m
2	20 m	/	20 m
3	3 m	17 m	20 m
4	3 m	47 m	50 m
5	3 m	97 m	100 m

Current and power consumption with respect to the supply voltage (example representation)



Electrically permissible speed/ traversing speed

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

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

For angle or rotary encoders

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

For linear encoders

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

Where:

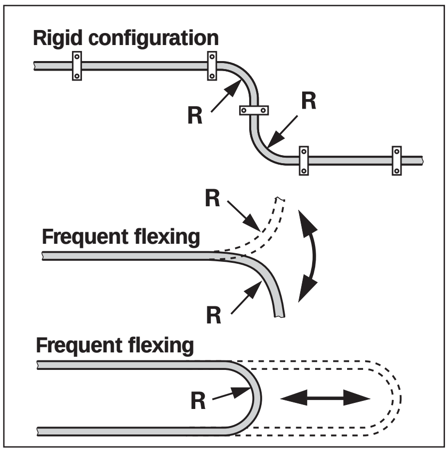
n_{max}: Elec. permissible speed in min^{-1}
v_{max}: Elec. permissible traversing velocity in m/min
f_{max}: Max. scanning/output frequency of encoder or input frequency of subsequent electronics in kHz
z: Line count of the angle or rotary encoder per 360°
SP: Signal period of the linear encoder in µm

Cables

For safety-related applications, use HEIDENHAIN cables and connectors.

Versions
The cables of almost all HEIDENHAIN encoders and all adapter and connecting cables are sheathed in **polyurethane (PUR cables).** Many adapter cables for within motors and a few cables on encoders are sheathed in a **special elastomer (EPG).** Many adapter cables within the motor consist of TPE wires **(special thermoplastic)** in braided sleeving. Individual encoders feature cable with a sleeve of **polyvinyl chloride (PVC).** This cables are identified in the catalog as EPG, TPE or PVC.

Durability
PUR cables are resistant to oil in accordance with **VDE 0472** (Part 803/test type B) and to hydrolysis and microbes in accordance with **VDE 0282** (Part 10). They are free of PVC and silicone and comply with UL safety directives. The **UL certification** "AWM STYLE 20963 80 °C 30 V E63216" is documented on the cable.
EPG cables are resistant to oil in accordance with **VDE 0472** (Part 803/test type B) and to hydrolysis in accordance with **VDE 0282** (Part 10). They are free of silicone and halogens. In comparison with PUR cables, they are only somewhat resistant to media, frequent flexing and continuous torsion.
PVC cables are oil resistant. The UL certification "AWM E64638 STYLE20789 105C VW-1SC NIKKO" is documented on the cable.
TPE wires with braided sleeving are oil resistant and highly flexible.



Temperature range

	Rigid configuration	Frequent flexing
PUR	–40 to 80 °C	–10 to 80 °C
EPG TPE	–40 to 120 °C	–
PVC	–20 to 90 °C	–10 to 90 °C

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

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

Cables	**Bend radius R**	
	Rigid configuration	**Frequent flexing**
Ø 3.7 mm	≥ 8 mm	≥ 40 mm
Ø 4.3 mm	≥ 10 mm	≥ 50 mm
Ø 4.5 mm EPG	≥ 18 mm	–
Ø 4.5 mm **Ø 5.1 mm** **Ø 5.5 mm PVC**	≥ 10 mm	≥ 50 mm
Ø 6 mm/6.8 mm **Ø 10 mm**[1)]	≥ 20 mm ≥ 35 mm	≥ 75 mm ≥ 75 mm
Ø 8 mm **Ø 14 mm**[1)]	≥ 40 mm ≥ 100 mm	≥ 100 mm ≥ 100 mm

[1)] Metal armor

Noise-free signal transmission

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

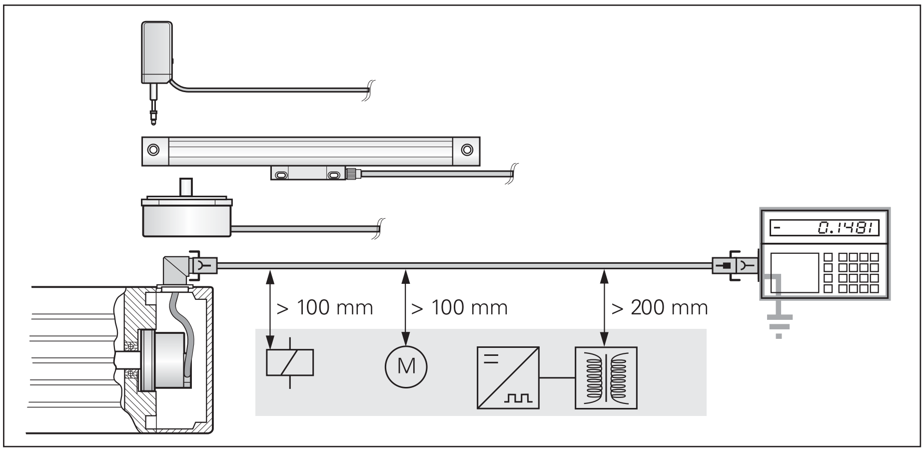
- **Noise immunity EN 61000-6-2:**
  Specifically:
  - ESD — EN 61000-4-2
  - Electromagnetic fields — EN 61000-4-3
  - Burst — EN 61000-4-4
  - Surge — EN 61000-4-5
  - Conducted disturbances — EN 61000-4-6
  - Power frequency magnetic fields — EN 61000-4-8
  - Pulse magnetic fields — EN 61000-4-9
- **Interference EN 61000-6-4:**
  Specifically:
  - For industrial, scientific and medical equipment (ISM) — EN 55011
  - For information technology equipment — EN 55022

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

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

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

- Use only original HEIDENHAIN cables. Consider the voltage drop on supply lines.
- Use connecting elements (such as connectors or terminal boxes) with metal housings. Only the signals and power supply of the connected encoder may be routed through these elements. Applications in which additional signals are sent through the connecting element require specific measures regarding electrical safety and EMC.
- Connect the housings of the encoder, connecting elements and subsequent electronics through the shield of the cable. Ensure that the shield has complete contact over the entire surface (360°). For encoders with more than one electrical connection, refer to the documentation for the respective product.
- For cables with multiple shields, the inner shields must be routed separately from the outer shield. Connect the inner shield to 0 V of the subsequent electronics. Do not connect the inner shields with the outer shield, neither in the encoder nor in the cable.
- Connect the shield to protective ground as per the mounting instructions.
- Prevent contact of the shield (e.g. connector housing) with other metal surfaces. Pay attention to this when installing cables.
- Do not install signal cables in the direct vicinity of interference sources (inductive consumers such as contactors, motors, frequency inverters, solenoids, etc.).
  - Sufficient decoupling from interference-signal-conducting cables can usually be achieved by an air clearance of 100 mm or, when cables are in metal ducts, by a grounded partition.
  - A minimum spacing of 200 mm to inductors in switch-mode power supplies is required.
- If compensating currents are to be expected within the overall system, a separate equipotential bonding conductor must be provided. The shield does not have the function of an equipotential bonding conductor.
- Provide power only from PELV systems **(EN 50178)** to position encoders. Provide high-frequency grounding with low impedance **(EN 60204-1 Chap. EMC).**
- For encoders with 11 µAPP interface: For extension cables, use only HEIDENHAIN cable ID 244955-01. Overall length: max. 30 m.



Minimum distance from sources of interference

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