HEIDENHAIN

Sealed Linear Encoders

March 2003

Linear encoders with slimline scale housing

Linear encoders with full-size scale housing

For information on
- exposed linear encoders
- angle encoders
- rotary encoders
- HEIDENHAIN subsequent electronics
- HEIDENHAIN TNC controls
- machine calibration

please contact your HEIDENHAIN representative.

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.

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Specifications

Linear encoder	*Recommended measuring step for positioning*	*Series or model*	
For very high repeatability	up to 0.1 µm	**LF 481**	18
		LF 183	20
For absolute position measurement	up to 0.1 µm	**LC 481**	22
		LC 181	24
For NC machines	up to 0.5 µm	**LS 400 Series**	26
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For large measuring lengths	up to 0.1 µm	**LB 382—Single-Section**	30
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For simple applications	up to 5 µm	**LS 323**	34
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Electrical Connections

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Sealed Linear Encoders

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

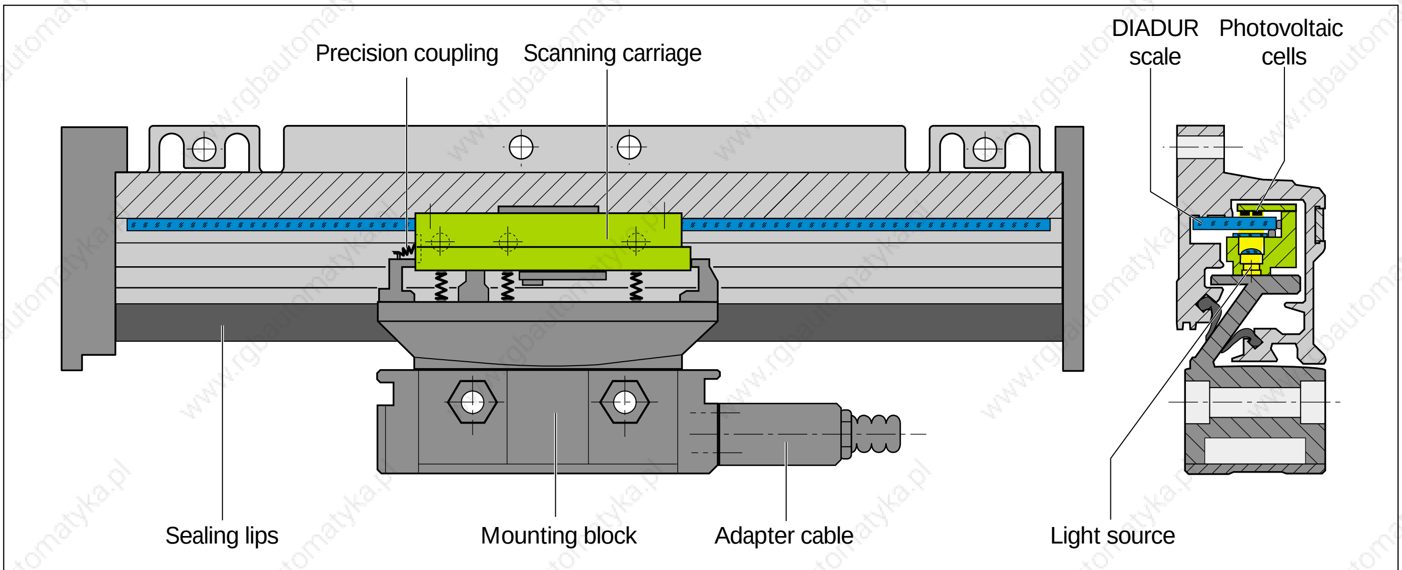
Linear encoders are therefore indispensable for machines that fulfill high requirements for **positioning accuracy** and **machining speed.**

Sealed linear encoders are designed primarily for use on machines and installations that operate in harsh environments, such as
- Milling machines
- Drilling and boring machines
- Machining centers
- Lathes
- Grinding machines
- Electrical discharge machines
- Welding machines
- Bending presses

Mechanical design

The scale, scanning unit and guideway of sealed linear encoders are protected against chips, swarf, dirt and splashwater by an aluminum housing and flexible sealing lips. The scanning carriage travels on a low-friction guide within the scale unit. It is connected with the external mounting block by a coupling that compensates unavoidable misalignment between the scale and the machine guideways.

Maximum permissible vertical and lateral misalignment between scale and mounting block is ±0.2 mm to ±0.3 mm, depending on the model of encoder.



Simplified representation of the **LS 186** Sealed Linear Encoder.

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

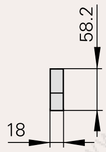
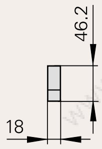
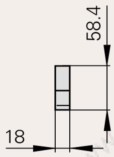
The graduation carriers of HEIDENHAIN linear encoders (see table) have differing coefficients of thermal expansion. This makes it possible to select the linear encoder with thermal behavior best suited to the application.

	Sealed Linear Encoders
Product family	LF, LS, LB, LC
Design	• Scale and scanning unit protected by aluminum housing • Scanning unit guided on scale via ball bearings • Coupling between scanning unit and mounting block to compensate small errors in machine guideway
Protection (IEC 60529)	IP 53 when mounted according to instructions IP 64 with introduction of compressed air to the scale or mounting block
Vibration (55 to 2000 Hz)	Max. 300 m/s^2 (IEC 60068-2-6)
Max. acceleration in meas. direction	50 m/s^2
Max. traversing speed	120 m/min
Accuracy grades	To ± 2 µm
Graduation carrier	Glass, steel
Coefficient of thermal expansion	LF: ≈ 10 ppm/K LC, LS: ≈ 8 ppm/K LB: same as scale mounting surface or ≈ 10 ppm/K

Selection Guide

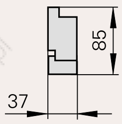
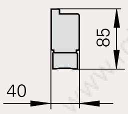
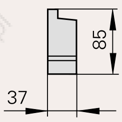
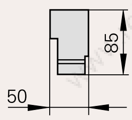
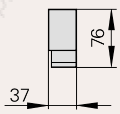
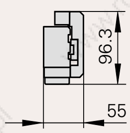
Sealed linear encoders with slimline scale housing

The sealed linear encoders with **slimline scale housing** are designed for **limited installation space.** When installed with the mounting spar they are also available in greater measuring lengths and permit higher acceleration loading.

	Cross section	Measuring step	Accuracy grades
For very high repeatability • Steel scale • Small signal period		To 0.1 µm	± 3 µm ± 2 µm
For absolute position measurement • Glass scale		To 0.1 µm	± 5 µm ± 3 µm
For NC machines • Glass scale		To 0.5 µm	± 5 µm ± 3 µm
For simple applications • Glass scale		To 5 µm	± 10 µm

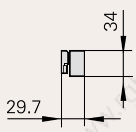
Sealed linear encoders with full-size scale housing

The sealed linear encoders with **full-size scale housing** are characterized by their **sturdy construction** 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.

For very high repeatability • Steel scale • Small signal period • High vibration rating		To 0.1 µm	± 3 µm ± 2 µm
For absolute position measurement • Glass scale • High vibration rating		To 0.1 µm	± 5 µm ± 3 µm
For NC machines • Glass scale • High vibration rating		To 0.5 µm	± 5 µm ± 3 µm
For large measuring lengths • Steel scale • High vibration rating		To 0.1 µm	± 5 µm
For simple applications • Glass scale		To 5 µm	± 10 µm
For bending machines and press brakes • Mounted linear guide • Glass scale			

Special linear encoder

The LIM 500 linear encoder consists of a scanning head and separate sealed scale unit. It operates without friction. The scanning head and scale are adjusted to each other during mounting.

For simple applications • For large measuring lengths • Magnetic measuring principle		To 10 µm	± 100 µm

Measuring length	Interface	Model	Page
50 mm to 1220 mm	∿ 1 V$_{PP}$	**LF 481**	**18**
70 mm to 1240 mm *with mounting spar:* 70 mm to 2040 mm	EnDat and ∿ 1 V$_{PP}$	**LC 481**	**22**
	⊓⊔ TTL	**LS 476**	**26**
	∿ 1 V$_{PP}$	**LS 486**	
70 mm to 1240 mm *with mounting spar:* 70 mm to 2040 mm	⊓⊔ TTL	**LS 477**	
	∿ 1 V$_{PP}$	**LS 487**	
70 mm to 1240 mm	⊓⊔ TTL	**LS 323**	**34**
140 mm to 3040 mm	∿ 1 V$_{PP}$	**LF 183**	**20**
140 mm to 3040 mm	EnDat and ∿ 1 V$_{PP}$	**LC 181**	**24**
140 mm to 3040 mm	⊓⊔ TTL	**LS 176**	**28**
	∿ 1 V$_{PP}$	**LS 186**	
440 mm to 30 040 mm	∿ 1 V$_{PP}$	**LB 382**	**30** **32**
170 mm to 3040 mm	⊓⊔ TTL	**LS 623**	**36**
170 mm to 920 mm	⊓⊔ TTL	**LS 629**	**38**
440 mm to 28 040 mm	⊓⊔ TTL	**LIM 571**	**40**
	∿ 1 V$_{PP}$	**LIM 581**	

LC 481

LS 487

LF 183

LS 186

LB 382

Measuring Principles

Measuring Standard

HEIDENHAIN encoders with optical scanning incorporate measuring standards made 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.

The precision graduations are manufactured in different photolithographic processes. Graduations are fabricated from:

- extremely hard chrome lines on glass,
- matte-etched lines on gold-plated steel tape, or
- three-dimensional structures on glass or steel substrates.

The photolithographic manufacturing processes developed by HEIDENHAIN produce grating periods of typically 40 µm to 4 µm.

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

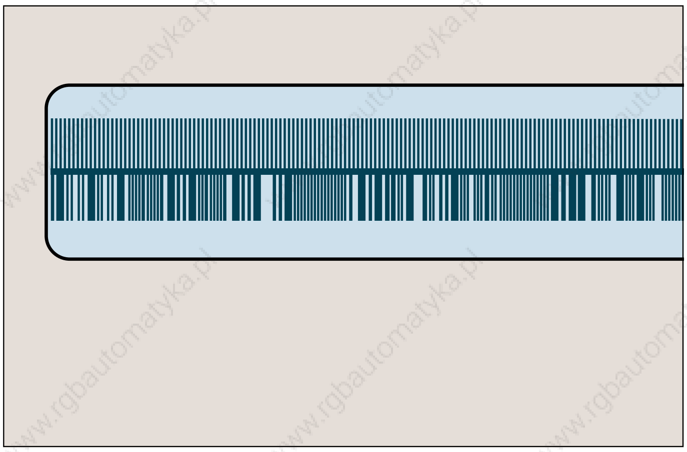
The master graduations are manufactured by HEIDENHAIN on a custom-built high-precision ruling machine.

Magnetic encoders use a magnetizable layer as graduation carrier. In this layer a graduation consisting of north and south poles is formed.

Absolute Measuring Methods

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 designed as a serial code structure or consists of several parallel graduation tracks with slightly different grating periods. A separate incremental track or the track with the finest grating period is interpolated for the position value and at the same time is used to generate an optional incremental signal.

Graduations of absolute linear encoders



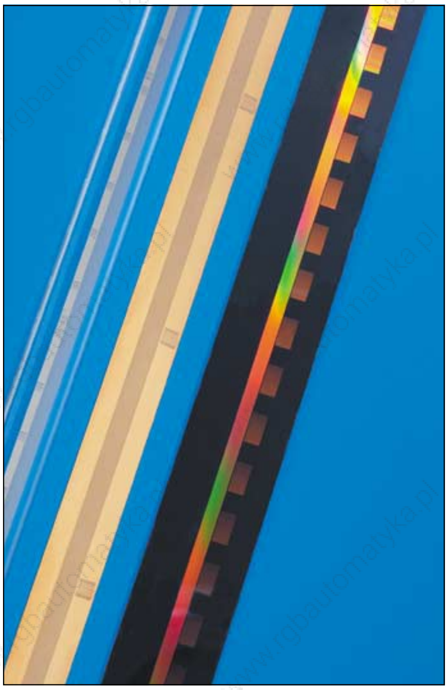
Absolute code structure with complementary incremental track on the scale of an LC 481

Incremental Measuring Methods

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

In some cases this may necessitate machine movement over large lengths of the measuring range. To speed and simplify such "reference runs," many encoders feature **distance-coded reference marks**—multiple reference marks that are individually spaced according to a mathematical algorithm. The subsequent electronics find the absolute reference after traversing two successive reference marks—only a few millimeters traverse (see table).
Encoders with distance-coded reference marks are identified with a "C" behind the model designation (e.g., LS 486 C).

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



Graduations of incremental linear encoders

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

where:

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

and:

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

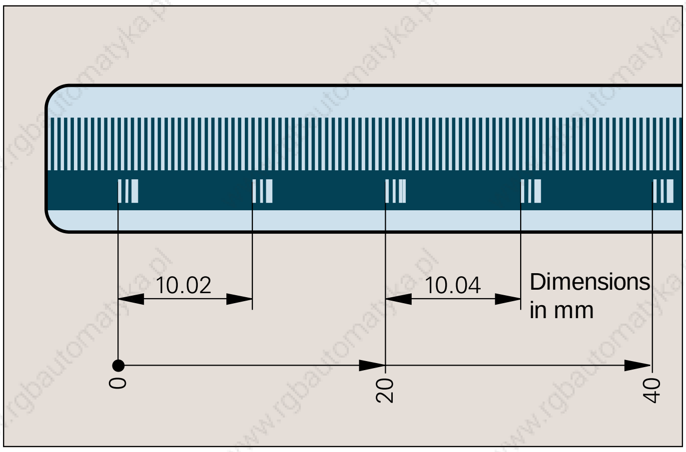
abs = Absolute value

sgn = Sign function (= "+1" or "–1")

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

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

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



Incremental graduation with distance-coded reference marks on the scale of an LS encoder

	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

Technical Characteristics

Photoelectric Scanning

Most HEIDENHAIN encoders operate on the principle of photoelectric scanning. The photoelectric scanning of a measuring standard is contact-free, and therefore without wear. It detects even the finest graduation lines just a few micrometers wide, and generates output signals with very small signal periods.

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

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

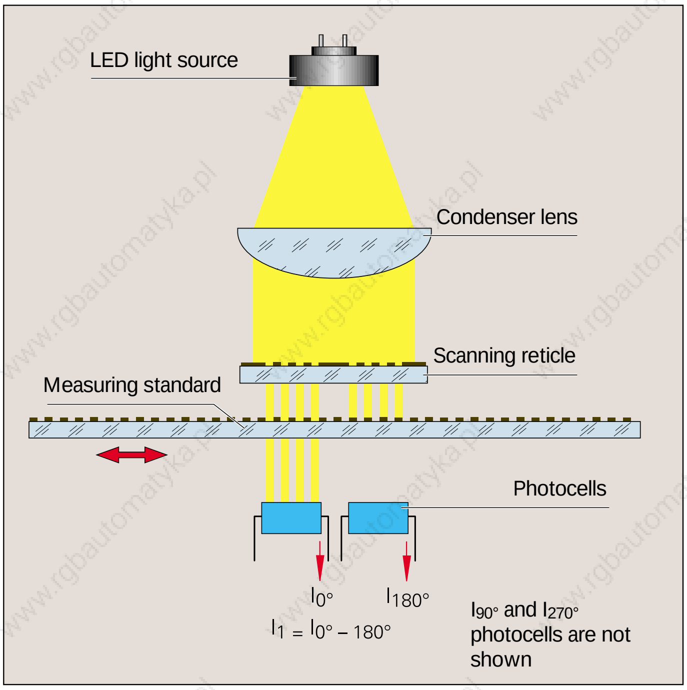
Imaging scanning principle
To put it simply, the imaging scanning principle functions by means of projected-light signal generation: two scale gratings with equal grating periods are moved relative to each other—the scale and the scanning reticle. The carrier material of the scanning reticle is transparent,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

When parallel light passes through a grating, light and dark surfaces are projected at a certain distance. An index grating with the same grating period is located here. When the two gratings move relative to each other, the incident light is modulated: if the gaps are aligned, light passes through. If the lines of one grating coincide with the gaps of the other, no light passes through. Photocells convert these variations in light intensity into nearly sinusoidal electrical signals. The specially structured grating of the scanning reticle filters the light current to generate nearly sinusoidal output signals.

The smaller the grating period of the grating structure is, the closer and more tightly toleranced the gap must be between the scanning reticle and scale. Practical mounting tolerances for encoders with the imaging scanning principle are achieved with grating periods of 10 µm and larger.

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

Imaging scanning principle



Interferential scanning principle
The interferential scanning principle of the LF 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.

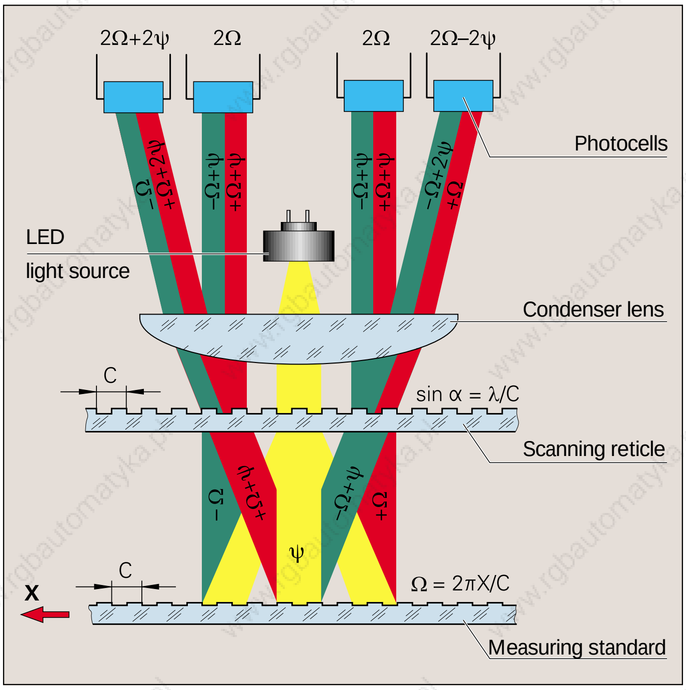
When a light wave passes through the scanning reticle, it is diffracted into three partial waves of the orders –1, 0, and 1, with approximately equal luminous intensity. The waves are diffracted by the scale such that most of the luminous intensity is found in the reflected diffraction orders 1 and –1. 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. Photocells convert these light intensities into electrical signals.

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

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

Sealed linear encoders that operate according to the interferential scanning principle are given the designation LF.

Interferential scanning principle
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

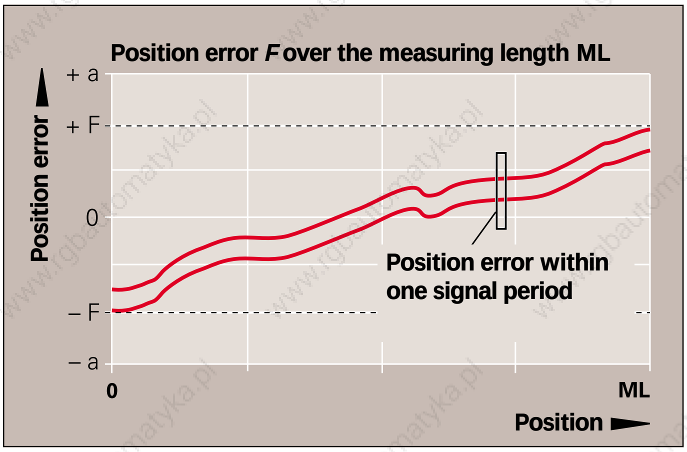
The accuracy of linear measurement is mainly determined by:
- the quality of the graduation
- the quality of scanning
- the quality of the signal processing electronics
- the error from the scale guideway over the scanning unit.

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

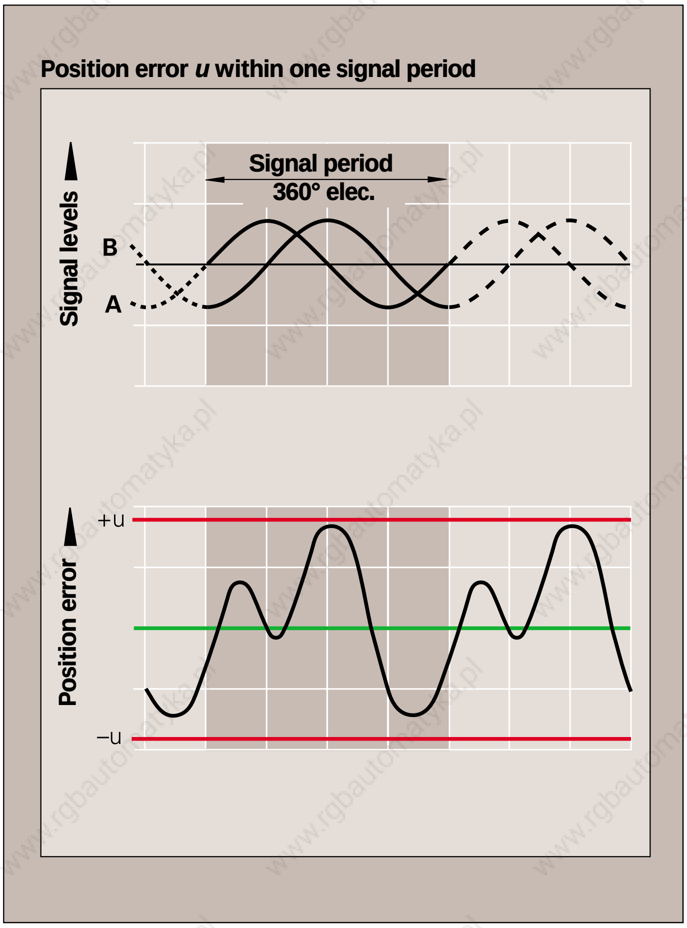
Position error over the measuring length
The accuracy of sealed linear encoders is specified as accuracy grades, which are defined as follows:

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

This tolerance band is also shown in the calibration chart (see opposite page) and represents the position error within one signal period. With sealed linear encoders, this value applies 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 quality of scanning and the signal period of the encoder. At any position over the entire measuring length, it does not exceed approx. ±2% of the signal period. The smaller the signal period, the smaller the position error within one signal period.



	Signal period of scanning signals	Max. position error approx. within one signal period
LF	4 µm	0.08 µm
LC 181	16 µm	0.3 µm
LC 481	20 µm	0.4 µm
LS	20 µm	0.4 µm
LB	40 µm	0.8 µm

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

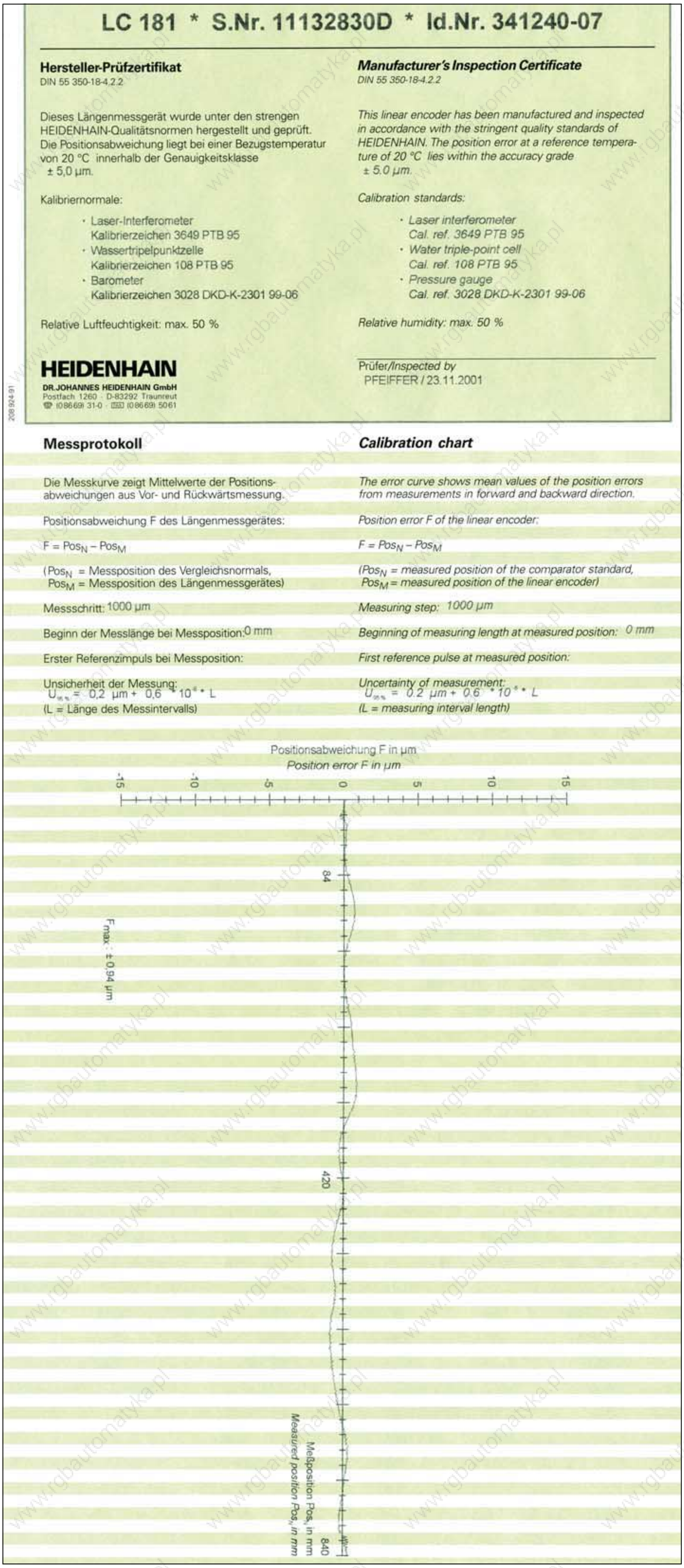
They are calibrated for accuracy during traverse in both directions. The number of measuring positions is selected to determine very exactly not only the long-range error, but also the position error within one signal period.

The **Manufacturer's Inspection Certificate** confirms the specified system accuracy of each encoder. The **calibration standards** also listed ensure the traceability—as required by ISO 9001—to recognized national or international standards.

For the LC, LF, LS 100 and LS 400 series, a **calibration chart** documents the position error over the measuring range and also states the measuring step and measuring uncertainty of the calibration.

Temperature range
The length gauges are calibrated at a **reference temperature** of 20 °C (68 °F). The system accuracy given in the calibration chart applies at this temperature.

The **operating temperature** indicates the ambient temperature limits between which the length gauges will function properly. The **storage temperature** of –20 °C to 70 °C (–4 °F to 158 °F) applies for the device in its packaging.



LC 181 * S.Nr. 11132830D * Id.Nr. 341240-07

Hersteller-Prüfzertifikat
DIN 55 350-18-4.2.2

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

Kalibriernormale:
- Laser-Interferometer Kalibrierzeichen 3649 PTB 95
- Wassertripelpunktzelle Kalibrierzeichen 108 PTB 95
- Barometer Kalibrierzeichen 3028 DKD-K-2301 99-06

Relative Luftfeuchtigkeit: max. 50 %

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

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.

Calibration standards:
- *Laser interferometer Cal. ref. 3649 PTB 95*
- *Water triple-point cell Cal. ref. 108 PTB 95*
- *Pressure gauge Cal. ref. 3028 DKD-K-2301 99-06*

Relative humidity: max. 50 %

HEIDENHAIN
DR. JOHANNES HEIDENHAIN GmbH
Postfach 1260 · D-83292 Traunreut
☎ (08669) 31-0 · (08669) 5061

Prüfer/Inspected by
PFEIFFER / 23.11.2001

208 924-91

Messprotokoll

Die Messkurve zeigt Mittelwerte der Positionsabweichungen aus Vor- und Rückwärtsmessung.

Positionsabweichung F des Längenmessgerätes:

$F = Pos_N - Pos_M$

(Pos_N = Messposition des Vergleichsnormals,
Pos_M = Messposition des Längenmessgerätes)

Messschritt: 1000 µm

Beginn der Messlänge bei Messposition: 0 mm

Erster Referenzimpuls bei Messposition:

Unsicherheit der Messung:
$U_{95\%} = 0{,}2\ \mu m + 0{,}6 \cdot 10^{-6} \cdot L$
(L = Länge des Messintervalls)

Calibration chart

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

Position error F of the linear encoder:

$F = Pos_N - Pos_M$

*(Pos_N = measured position of the comparator standard,
Pos_M = measured position of the linear encoder)*

Measuring step: 1000 µm

Beginning of measuring length at measured position: 0 mm

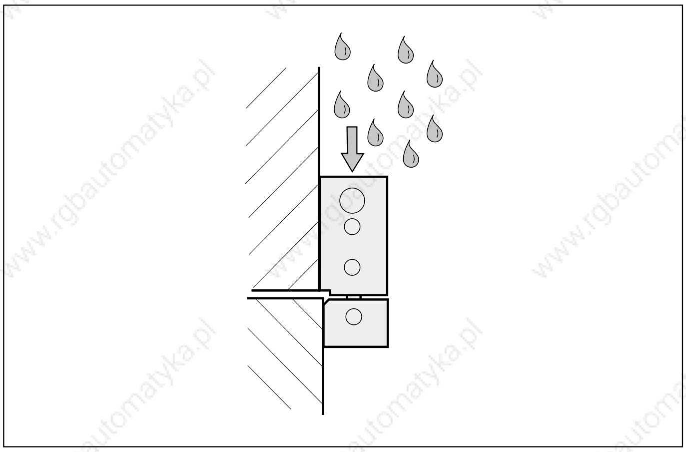
First reference pulse at measured position:

Uncertainty of measurement:
$U_{95\%} = 0.2\ \mu m + 0.6 \cdot 10^{-6} \cdot L$
(L = measuring interval length)

Mechanical Design Types and Mounting
Linear Encoders with Small Cross Section

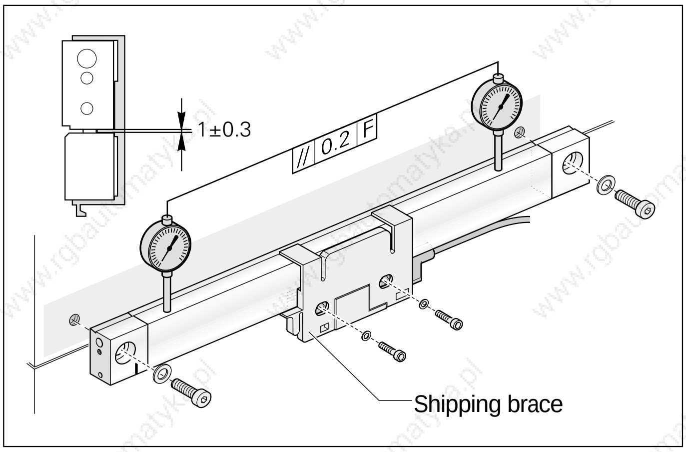
The slimline linear encoders LC, LF and LS are fastened to a machined surface either directly or over a mounting spar.

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

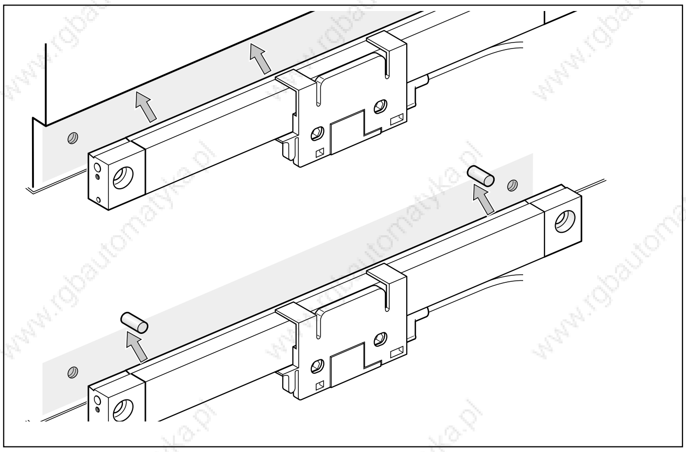


Thermal behavior
Because they are rigidly fastened using two M8 screws, the linear encoders largely adapt themselves to the thermal behavior of the mounting surface. When fastened over the mounting spar, the encoder is fixed to the midpoint of the mounting surface. The flexible fastening elements ensure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

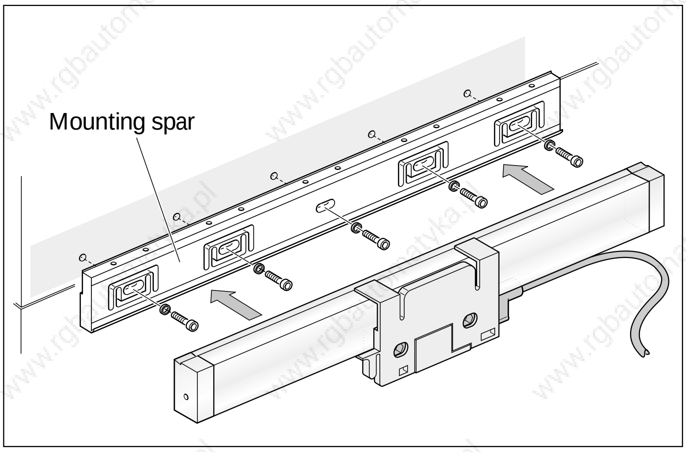
The **LF 481** with its graduation carrier of steel has the same coefficient of expansion as a mounting surface of gray cast iron or steel.



Mounting
It is surprisingly simple to mount the linear encoders from HEIDENHAIN: The shipping brace already sets the proper gap between the scale unit and the scanning unit. You need only align the scale unit at several points to the machine guideway. Stop surfaces or stop pins can also be used to align the scale.



The use of a **mounting spar** can be of great benefit when mounting slimline linear encoders. A mounting spar can be fastened as part of the machine assembly process, so that the encoder can be easily clamped later as a final step. Easy exchange also facilitates servicing.



LB, LC, LF, and LS 100 Linear Encoders—with Large Cross Section

The full-size linear encoders LB, LC, LF and LS 100 are fastened over their entire length onto a machined surface. This gives them a **high vibration rating.**

The slanted arrangement of the sealing lips permits **universal mounting** both in upright and reclining positions with the same degree of protection.

Thermal behavior
The LB, LC, LF and LS 100 linear encoders with large cross section are optimized in their thermal behavior.

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

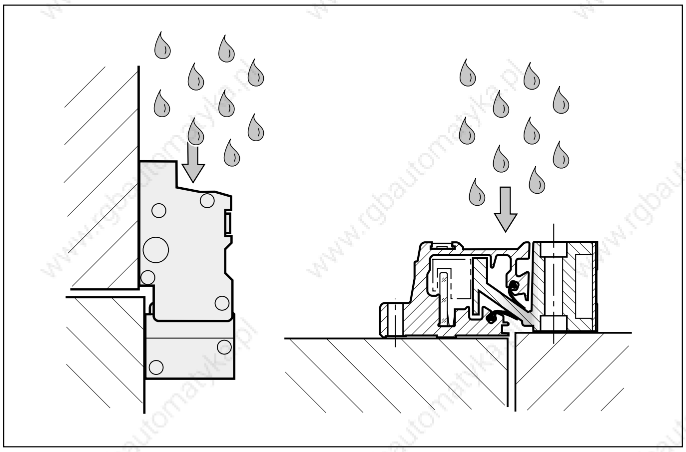
On the **LB** the steel scale tape is clamped directly onto the machine element. The LF and LB therefore take part in all thermal changes of the mounting surface.

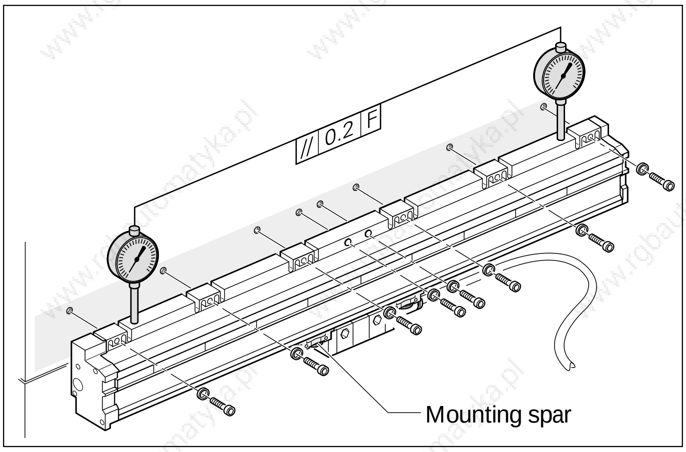
The **LC** and **LS** are fixed to the midpoint of the mounting surface. The flexible fastening elements permit a reproducible thermal behavior.

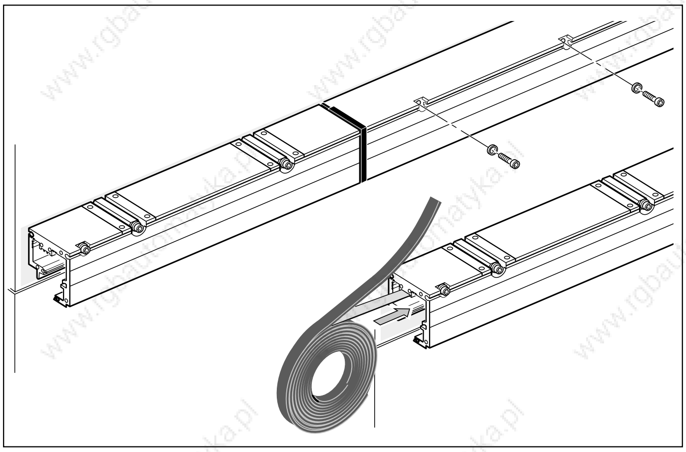
Mounting
When sealed linear encoders from HEIDENHAIN are mounted, the shipping brace already sets the proper gap between the scale unit and the scanning unit. You need only align the scale unit at several points to the machine guideway. Stop surfaces or stop pins can also be used to align the scale.

Mounting the LB 382 multi-section
The LB 382 with measuring lengths over 3240 mm (127 in.) is 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 tensioning of the scale tape enables linear machine error compensation up to ±100 µm.







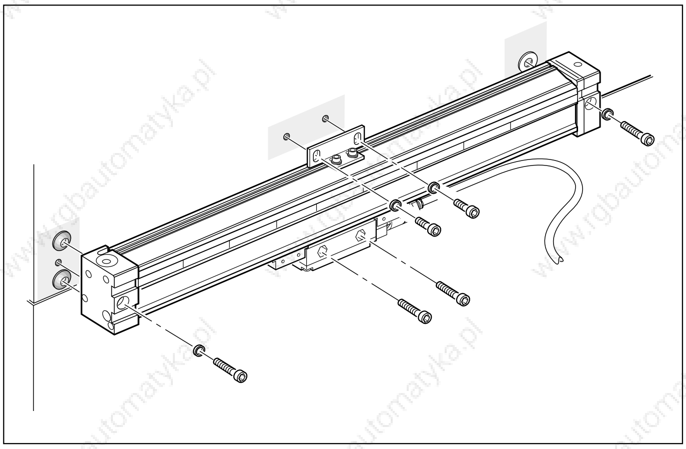
Mechanical Design Types and Mounting

LS 600 Linear Encoders—with Large Cross Section

The full-size linear encoders LS 600 are fastened to a machined surface only at their ends with their mounting blocks. Measuring lengths over 620 mm (24.4 in.) require support brackets to improve vibration behavior. Due to their lower accuracy, reproducible thermal behavior is not required from these encoders.

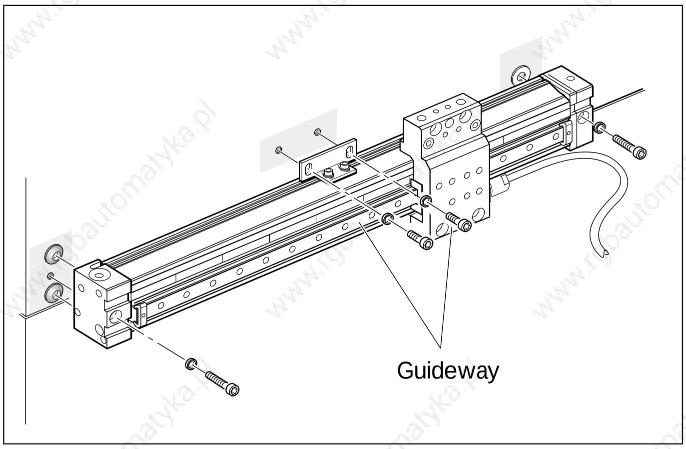
The inclined arrangement of the sealing lips permits **universal mounting** with vertical or horizontal scale housing with equally high protection rating.

Due to the low accuracy requirements, these encoders do not require reproducible thermal behavior.



Mounting the LS 623
When the LS 623 is mounted, the shipping brace already sets the proper gap between the scale unit and the scanning unit. You need only align the scale unit at several points to the machine guideway.

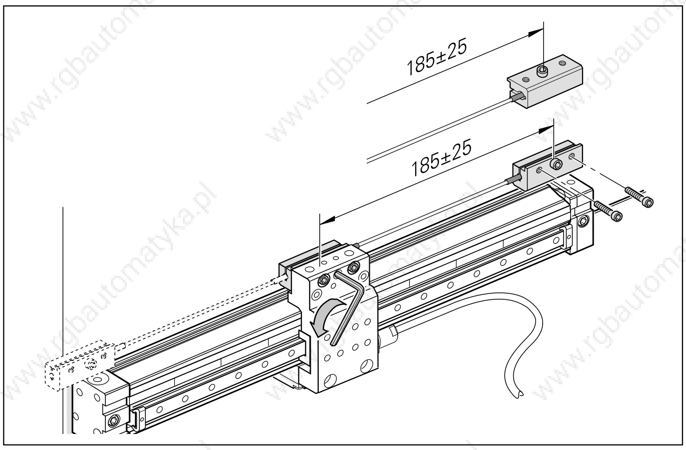
Mounting the LS 629
The LS 629 features a high-quality steel guide with ground guideways and a backlash-free recirculating ball carriage, which moves the scanning unit along the scale. The scanning head is connected with the moving machine element by a coupling rod (available as an accessory), which permits the large mounting tolerance of ±5 millimeters. This makes it possible to use the encoder, for example, on press brakes with heavy loads.



Accessory

Coupling rod
Including mounting block and screws for connection with the LS 629, e.g. on press brakes and plate bending machines.

Id. Nr. 344 695-01



Mechanical Data

Mounting guidelines
To simplify cable routing, the mounting block of the scanning unit is usually screwed onto a stationary machine part.

The **mounting location** for the linear encoders should be carefully considered in order to ensure both optimum accuracy and the longest possible service life.

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

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

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

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

Expendable parts
In particular the following parts in encoders from HEIDENHAIN are subject to wear:

- LED light source
- Bearings in encoders with integral bearing
- Sealing lips for sealed linear encoders

Degree of protection
Sealed **linear encoders** are protected to the degree IP 53 according to **IEC 60529** and **EN 60529,** provided that they are mounted with the sealing lips facing away from splashing liquids. If necessary, provide a separate protective cover. If the encoder will be exposed to heavy concentrations of coolant and lubricant mist, the scale housing can be supplied with **compressed air** to provide **IP 64** protection and effectively prevent the ingress of contamination. All HEIDENHAIN LB, LC, LF and LS sealed linear encoders feature compressed air inlets at the scale end blocks and on the mounting block of the scanning unit.

The compressed air that is introduced directly into the encoder housing must have been cleaned in a microfilter and must comply with the following quality classes as per **ISO 8573-1:**

- Solid contaminants: Class 1 (max. particle size 0.1 µm and max. particle density 0.1 mg/m^3 at 1 · 10^5 Pa)
- Total oil content: Class 1 (max. oil concentration 0.01 mg/m^3 at 1 · 10^5 Pa)
- Max. pressure dew point: Class 4 (+3 °C at 2 · 10^5 Pa)

The required rate of compressed air flow is 7 to 10 liters/minute per linear encoder; the permissible pressure lies in the range of 0.6 to 1 bar. The compressed air may be introduced into the encoder only through a connector with integral throttle (included with the LB, LC, LF, LS 1x6, and LS 4x6 encoders).

HEIDENHAIN offers the **DA 300 Compressed Air Unit** for cleaning and preparing compressed air. It consists of two filter stages (microfilter and activated carbon filter), automatic condensation separator, and a pressure regulator with manometer. It also includes 25 meters of pressure tubing as well as T-joints and connecting pieces for four encoders. The DA 300 can serve for up to 10 encoders with a maximum total measuring length of 35 meters.

At an operating pressure of 7 bars, the compressed air introduced into the encoder exceeds by far the required purity. The manometer and pressure switch (available as accessories) enable effective monitoring of the function of the DA 300.

DA 300
Compressed Air Unit

LF 481

Incremental linear encoders for measuring steps of 1 µm to 0.1 µm (0.000 05 in. to 0.000 005 in.)

- **Thermal behavior similar to steel or cast iron**
- **For limited installation space**

Specifications	**LF 481**
Measuring standard Grating period Thermal expansion coefficient	DIADUR phase grating on steel 8 µm $\alpha_{therm} \approx 10$ ppm/K
Accuracy grade	± 5 µm (± 0.0002 in.) ± 3 µm (± 0.000 12 in.)
Measuring length ML in mm inches	50, 100, 150, 200, 250, 300, 2, 3.94, 5.9, 7.9, 9.8, 11.8, 350, 400, 450, 500, 550, 600, 13.8, 15.7, 17.7, 19.7, 21.6, 23.6, 650, 700, 750, 800, 900, 1000, 25.6, 27.6, 29.5, 31.5, 35.4, 39.4, 1120, 1220 44, 48
Reference marks **LF 481**	ML 50 mm: 1 ref. mark at midpoint; ML 100 to 1000 MM: 2, each 25 mm from start/end of ML From 1120 mm: 2, each 35 mm from start/end of ML
LF 481 C	Distance-coded; absolute position value available after max. 20 mm traverse
Max. traversing speed	60 m/min (2360 ipm)
Vibration (55 to 2000 Hz) **Shock** (11 ms)	≤ 80 m/s² (IEC 60 068-2-6) ≤ 200 m/s² (IEC 60 068-2-27)
Required moving force	≤ 4 N
Protection (IEC 60 529)	IP 53 when installed as per instructions IP 64 with compressed air
Operating temperature	0 to 50 °C (32 to 122 °F)
Weight	0.4 kg + 0.5 kg/m measuring length
Power supply	5 V ± 5%/< 150 mA (with terminating resistor Z_0 = 120 Ω)
Output signals/Signal period	∼ 1 V_{PP}/4 µm
Electrical connection Cable length to subsequent electronics	Sep. adapter cable (1 m/3 m/6 m/9 m) for mounting block (see *Electrical Connection*) 150 m (492 ft) max.

Dimensions

in mm

DIN ISO 8015
ISO 2768 - m H

Mounting spar

ML	m
50 ... 500 (2 ... 19.7")	0
550 ... 900 (21.6 ... 35.4")	1
1 000 ... 1 220 (39.4 ... 48")	2

Ⓘ = Without mounting spar
Ⓘⓘ = With mounting spar
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓡ = Reference mark position LF 481

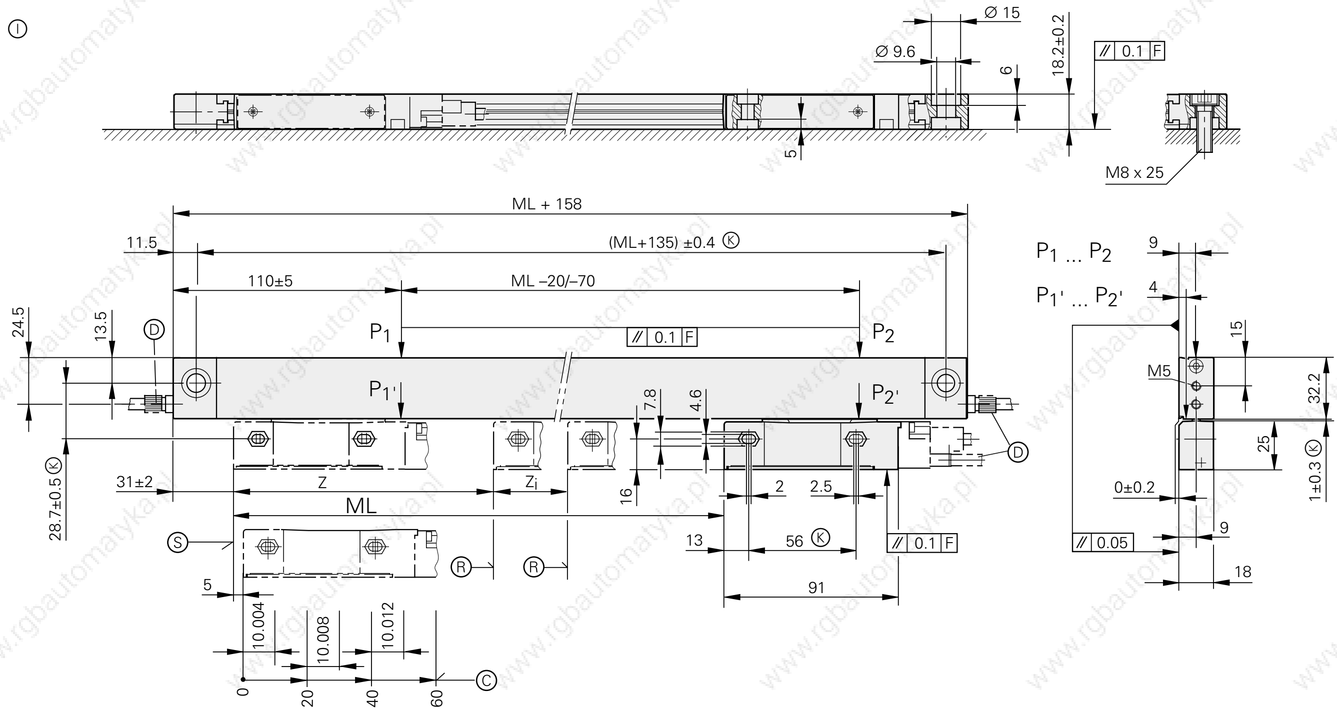
Two reference marks for measuring lengths

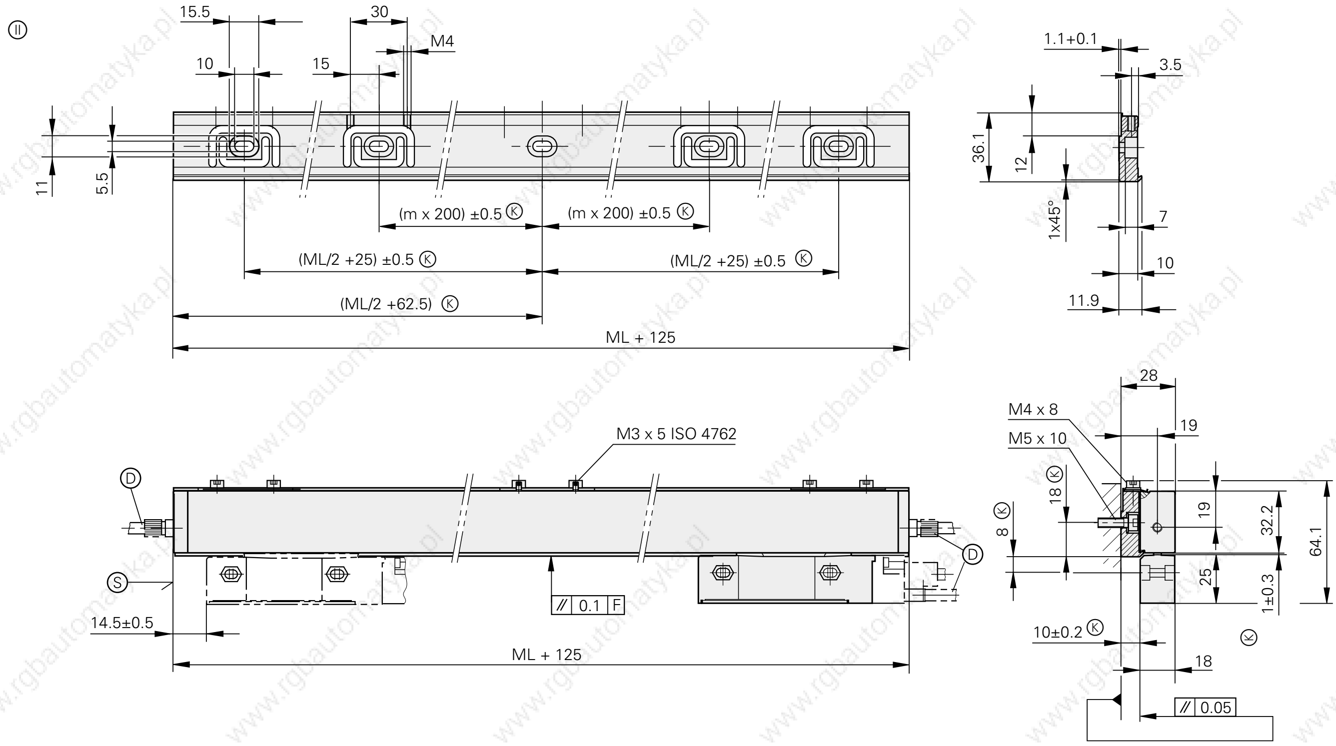
50 ... 1000 (2" ... 39.4")	1120 ... 1220 (44" ... 48")
z = 25 (.98") z_i = ML – 50 (1.97")	z = 35 (1.38") z_i = ML – 70 (2.76")

Ⓒ = Reference mark position LF 481 C
Ⓢ = Beginning of measuring length (ML)

LF 481 without mounting spar

LF 481 with mounting spar





Specifications

LF 183

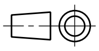
Incremental linear encoders for measuring steps of 1 µm to 0.1 µm (0.000 05 in. to 0.000 005 in.)

- **Thermal behavior similar to steel or cast iron**
- **High vibration rating**
- **Horizontal mounting possible**

Specifications	**LF 183**
Measuring standard Grating period Thermal expansion coefficient	DIADUR phase grating on steel 8 µm $\alpha_{therm} \approx$ 10 ppm/K
Accuracy grade	± 3 µm (± 0.000 12 in.) ± 2 µm (± 0.000 08 in.)
Measuring length ML in mm inches	140, 240, 340, 440, 540, 640, 5.5, 9.5, 13.4, 17.3, 21.3, 25, 740, 840, 940, 1040, 1140, 1240, 29, 33, 37, 41, 44, 48, 1340, 1440, 1540, 1640, 1740, 1840, 52, 56, 60, 64, 68, 72, 2040, 2240, 2440, 2640, 2840, 3040 80, 88, 96, 104, 112, 120
Reference marks **LF 183** **LF 183 C**	Selectable every 50 mm by magnet Standard: 1 ref. mark at midpoint Distance-coded; absolute position value available after max. 20 mm traverse
Max. traversing speed	60 m/min (2360 ipm)
Vibration (55 to 2000 Hz) **Shock** (11 ms)	≤ 200 m/s^2 (IEC 60 068-2-6) ≤ 300 m/s^2 (IEC 60 068-2-27)
Required moving force	≤ 4 N
Protection (IEC 60 529)	IP 53 when installed as per instructions IP 64 with compressed air
Operating temperature	0 to 40 °C (32 to 104 °F)
Weight	1.1 kg + 3.8 kg/m measuring length
Power supply	5 V ± 5%/< 150 mA (with terminating resistor Z_0 = 120 Ω)
Output signals/Signal period	∿ 1 V_{PP}/4 µm
Electrical connection Cable length to subsequent electronics	Sep. adapter cable (1 m/3 m/6 m/9 m) for mounting block (see *Electrical Connection*) 150 m (492 ft) max.

Dimensions

in mm



DIN ISO 8015
ISO 2768 - m H

Ⓘ, Ⓘ Ⓘ,
Ⓘ Ⓘ Ⓘ = Mounting options
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓡ = Reference mark position LF 183
Ⓒ = Reference mark position LF 183 C
Ⓢ = Beginning of measuring length (ML)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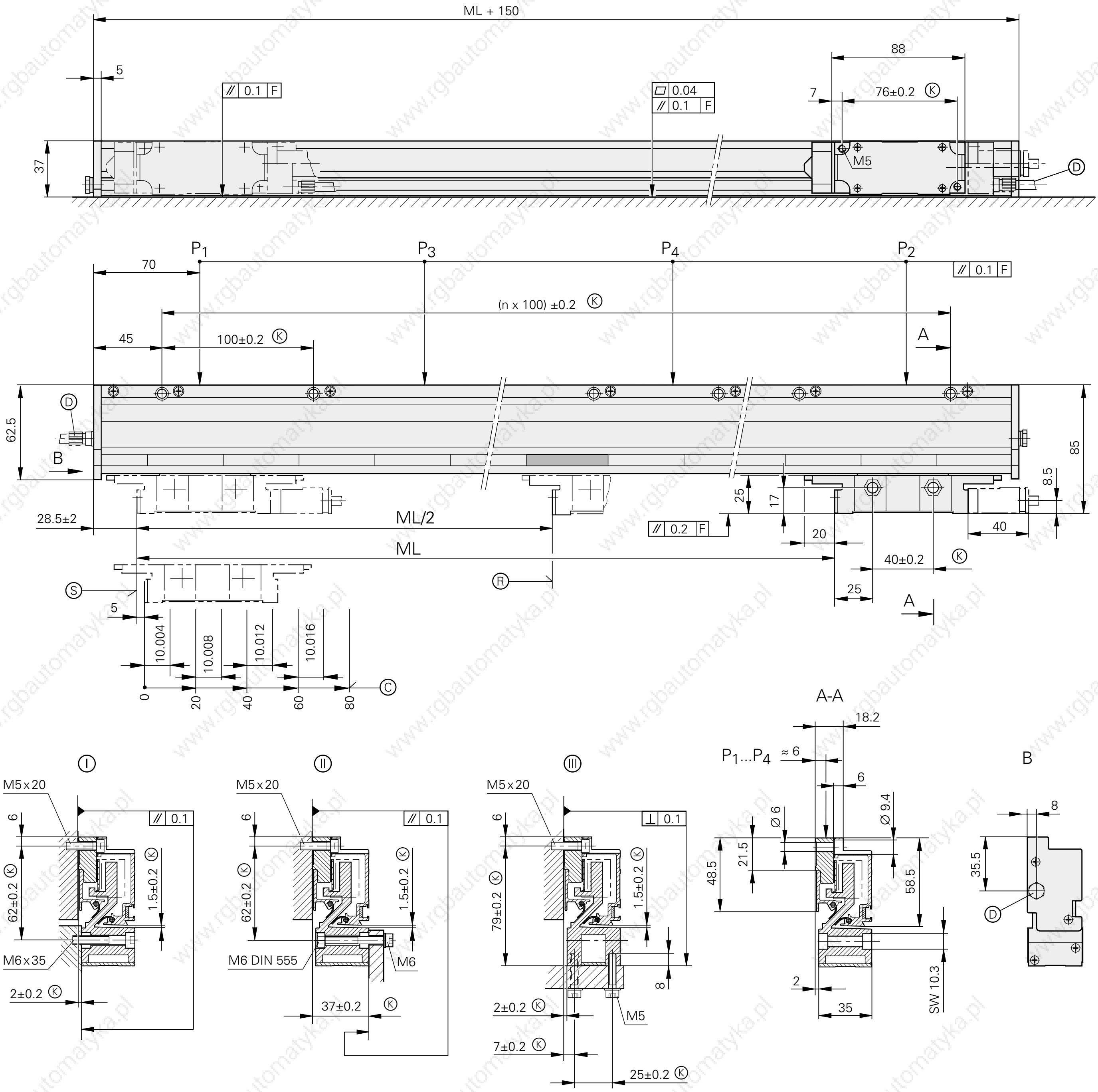

ML + 150
5
88
7
76±0.2 Ⓚ
0.1 F
0.04
0.1 F
37
M5
Ⓓ
P1
P3
P4
P2
70
0.1 F
(n x 100) ±0.2 Ⓚ
45
100±0.2 Ⓚ
A
62.5
B
85
8.5
25
17
0.2 F
20
40
40±0.2 Ⓚ
28.5±2
ML/2
ML
Ⓢ
Ⓡ
25
A
5
10.004
10.008
10.012
10.016
0
20
40
60
80
Ⓒ
A-A
18.2
P1...P4
≈ 6
6
Ø 6
Ø 9.4
48.5
21.5
58.5
2
35
SW 10.3
B
8
35.5
Ⓓ
Ⓘ
Ⓘ
Ⓘ
M5x20
6
0.1
62±0.2 Ⓚ
1.5±0.2 Ⓚ
M6x35
2±0.2 Ⓚ
M6 DIN 555
M6
37±0.2 Ⓚ
79±0.2 Ⓚ
8
M5
2±0.2 Ⓚ
7±0.2 Ⓚ
25±0.2 Ⓚ

LC 481

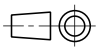
Absolute linear encoder for measuring steps of 1 µm to 0.1 µm
(0.00005 in. to 0.000005 in.)

- **With defined thermal behavior**
- **For limited installation space**
- **Simple mounting with backup spar**
- **Absolute position values and incremental signals via EnDat interface**

Specifications	**LC 481**
Measuring standard Thermal expansion coefficient	DIADUR glass scale with absolute track and incremental track $\alpha_{therm} \approx 8$ ppm/K
Accuracy grade	± 5 µm (± 0.0002 in.) ± 3 µm (± 0.00012 in.)
Measuring length ML in mm / inches Mounting spar recommended	70, 120, 170, 220, 270, 320, 370, 2.7, 4.7, 6.7, 8.6, 10.6, 12.6, 14.5
	420, 470, 520, 570, 620, 720, 770, 16.5, 18.5, 20.5, 22.4, 24.4, 28, 30,
	820, 920, 1020, 1140, 1240, 32, 36, 40, 44, 48,
Only with mounting spar	1340, 1440, 1540, 1640, 1740, 1840, 52, 56, 60, 64, 68, 72,
	2040 80
Max. traversing speed (mech.)	120 m/min (4720 ipm)
Vibration (55 to 2000 Hz) without mounting spar with mounting spar **Shock** (11 ms)	≤ 100 m/s² (IEC 60068-2-6) ≤ 150 m/s² (IEC 60068-2-6) ≤ 150 m/s² (IEC 60068-2-27)
Required moving force	≤ 5 N
Protection (IEC 60529)	IP 53 when installed as per instructions IP 64 with compressed air
Operating temperature	0 to 50 °C (32 to 122 °F)
Weight	0.4 kg + 0.5 kg/m measuring length
Power supply	5 V ± 5 % at encoder/ max. 300 mA (with no load) (power supply via remote sensing possible)
Interface	**EnDat interface** (bidirectional serial interface)
Absolute signals	According to EIA standard RS-485
Incremental signals **Signal period** **Cutoff frequency (–3 dB)**	∿ 1 V_{PP} 20 µm ≥ 130 kHz
Electrical connection Cable length to subsequent electronics	Sep. adapter cable (1 m/3 m/6 m/9 m) for mounting block (see *Electrical Connection*) 150 m (492 ft) max.

Dimensions

in mm



DIN ISO 8015
ISO 2768 - m H

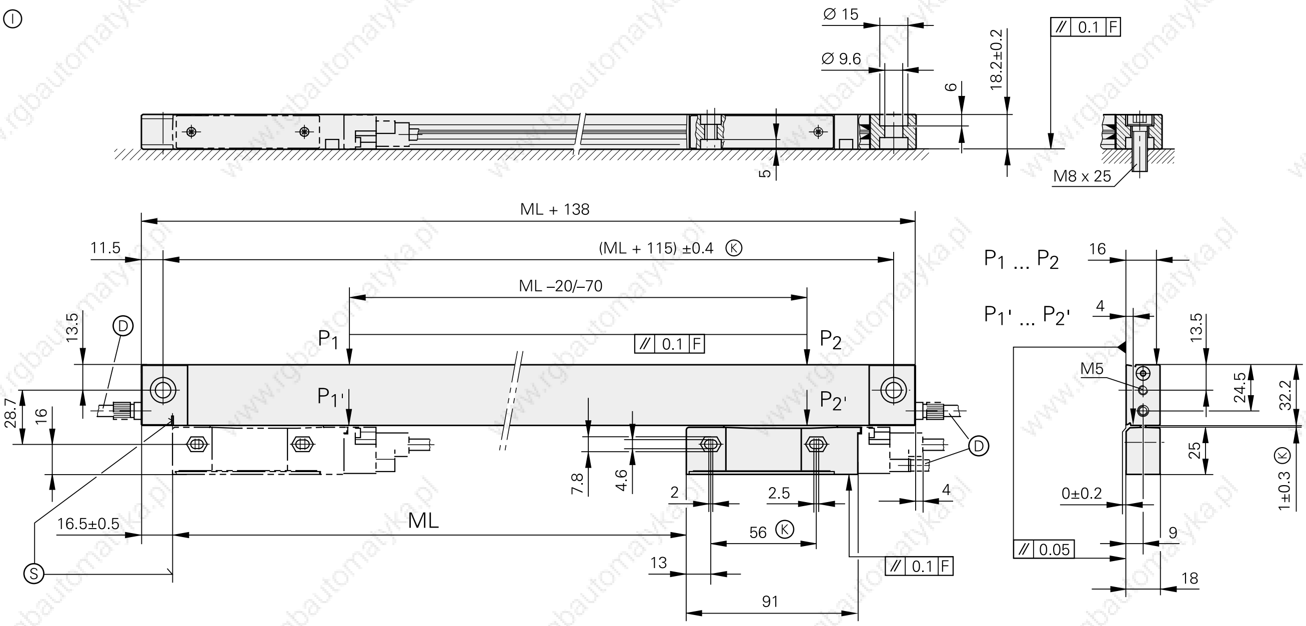
Mounting spar

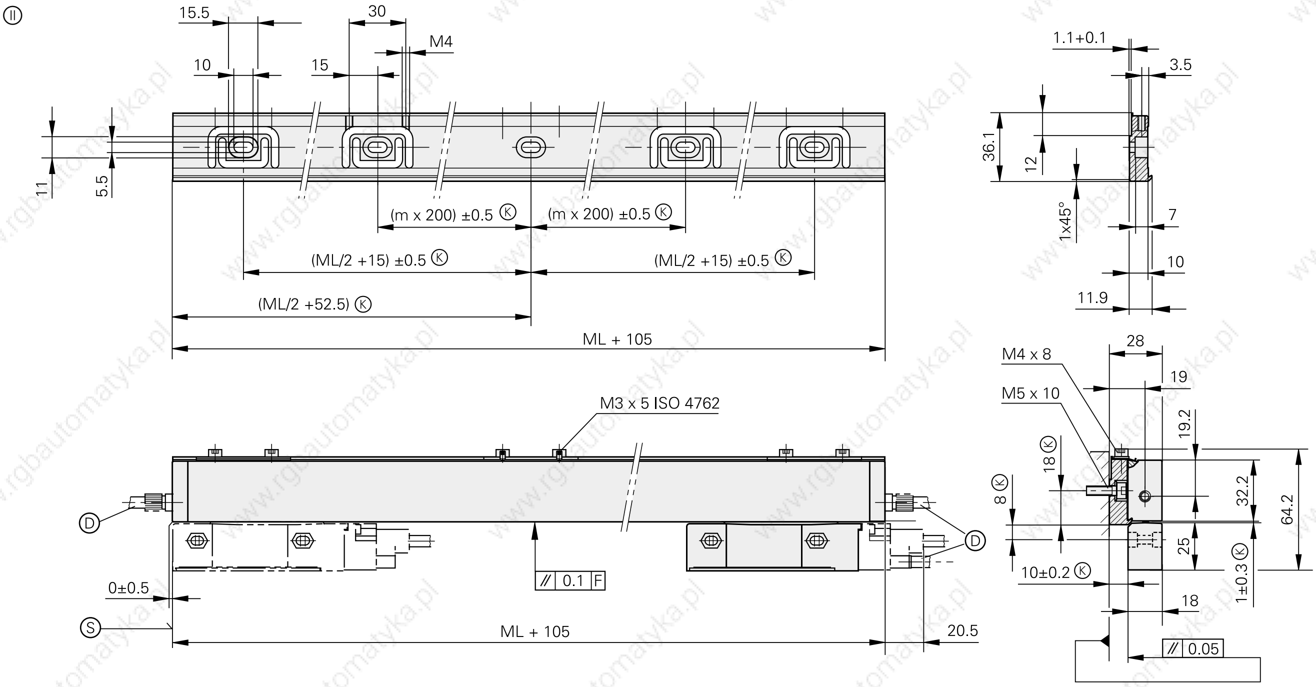
ML	m
70 ... 520 (2.7 ... 20.5")	0
570 ... 920 (22.4 ... 36")	1
1020 ... 1340 (40 ... 52")	2
1440 ... 1740 (56 ... 68")	3
1840 ... 2040 (72 ... 80")	4

(I) = Without mounting spar
(II) = With mounting spar
F = Machine guideway
P = Gauging points for alignment
(K) = Required mating dimensions
(D) = Compressed air inlet
(S) = Beginning of measuring length (ML) at 20 mm

LC 481 without mounting spar

LC 481 with mounting spar





LC 181

Absolute linear encoder for measuring steps of 1 µm to 0.1 µm
(0.00005 in. to 0.000005 in.)

- **With defined thermal behavior**
- **Absolute position values and incremental signals via EnDat interface**
- **High vibration rating**
- **Horizontal mounting possible**

Specifications	**LC 181**
Measuring standard Thermal expansion coefficient	DIADUR glass scale with 7 tracks of different grating periods $\alpha_{therm} \approx 8$ ppm/K
Accuracy grade	± 5 µm (± 0.0002 in.) ± 3 µm (± 0.00012 in.)
Measuring length ML in mm inches	140, 240, 340, 440, 540, 640, 5.5, 9.5, 13.4, 17.3, 21.3, 25, 740, 840, 940, 1040, 1140, 1240, 29, 33, 37, 41, 44, 48, 1340, 1440, 1540, 1640, 1740, 1840, 52, 56, 60, 64, 68, 72, 2040, 2240, 2440, 2640, 2840, 3040 80, 88, 96, 104, 112, 120
Max. traversing speed (mech.)	120 m/min (4720 ipm)
Vibration (55 to 2000 Hz) **Shock** (11 ms)	≤ 200 m/s^2 (IEC 60068-2-6) ≤ 300 m/s^2 (IEC 60068-2-27)
Required moving force	≤ 4 N
Protection (IEC 60529)	IP 53 when installed as per instructions IP 64 with compressed air
Operating temperature	0 to 50 °C (32 to 122 °F)
Weight	0.3 kg + 3.0 kg/m measuring length
Power supply	5 V ± 5 % at encoder/ max. 300 mA (with no load)
Interface	**EnDat-Interface** (bidirectional serial interface)
Absolute position value **Accuracy/max. traversing speed** for absolute position value	According to EIA standard RS-485 ± 16 LSB accuracy: 3 m/min ± 40 LSB accuracy: 120 m/min
Incremental signals **Signal period** **Cutoff frequency (–3 dB)**	∿ 1 V_{PP} 16 µm ≥ 130 kHz
Electrical connection Cable length to subsequent electronics	Sep. adapter cable (1 m/3 m/6 m/9 m) for mounting block (see *Electrical Connection*) 150 m (492 ft) max. with remote sensing

Dimensions

in mm

DIN ISO 8015
ISO 2768 - m H

Ⓘ, Ⓘ Ⓘ,
Ⓘ Ⓘ Ⓘ = Mounting options
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓢ = Beginning of measuring length (ML) (at position 20 mm)
Ⓩ = Does not apply if (ML/2 + 30)/100 = integer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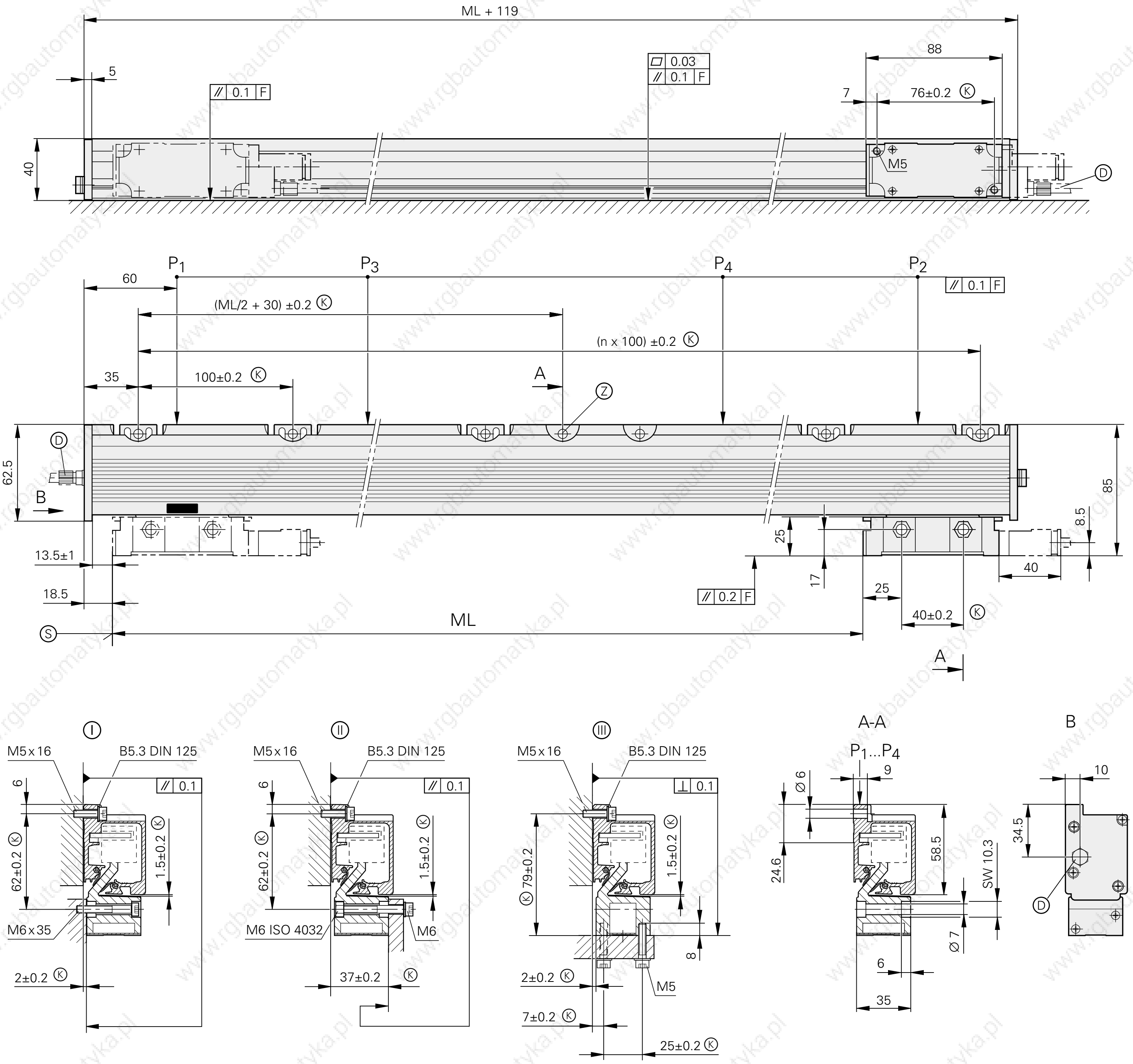

ML + 119
5
40
0.1 F
0.03
0.1 F
88
7
76±0.2 K
M5
D
P1
P3
P4
P2
0.1 F
60
(ML/2 + 30) ±0.2 K
(n x 100) ±0.2 K
35
100±0.2 K
A
Z
D
62.5
B
85
8.5
25
17
40
13.5±1
18.5
0.2 F
25
40±0.2 K
ML
S
A
I
II
III
A-A
B
M5x16
B5.3 DIN 125
0.1
6
62±0.2 K
1.5±0.2 K
M6x35
2±0.2 K
M6 ISO 4032
M6
37±0.2 K
79±0.2
8
7±0.2 K
M5
25±0.2 K
P1...P4
9
Ø 6
24.6
58.5
SW 10.3
Ø 7
6
35
10
34.5

LS 476, LS 477
LS 486, LS 487

Incremental linear encoders for measuring steps of 1 µm and 0.5 µm (0.000 05 in. to 0.000 02 in.)

- **Defined thermal behavior**
- **For limited installation space**
- **Simple installation with mounting spar**
- **LS 477/LS 487 with compact mounting block**

Specifications		**LS 476, LS 477** **LS 486, LS 487**
Measuring standard Grating period Thermal expansion coefficient		Glass scale with DIADUR graduation 20 µm $\alpha_{therm} \approx 8$ ppm/K
Accuracy grade		± 5 µm or up to ML 1240 mm ± 3 µm
Measuring length ML in mm inches Mounting spar recommended		70, 120, 170, 220, 270, 320, 370, 2.7, 4.7, 6.7, 8.6, 10.6, 12.6, 14.5 420, 470, 520, 570, 620, 720, 770, 16.5, 18.5, 20.5, 22.4, 24.4, 28, 30, 820, 920, 1020, 1140, 1240, 32, 36, 40, 44, 48,
Mounting spar required		1340, 1440, 1540, 1640, 1740, 1840, 52, 56, 60, 64, 68, 72, 2040 80
Reference marks	**LS 4xx**	Selectable every 50 mm by magnet; Standard: ML 70 mm 1 at midpoint; up to 1020 mm: 2, each 35 mm from start/end of ML; from 1140 mm: 2, each 45 mm from start/end of ML
	LS 4xxC	Distance-coded; absolute position value available after max. 20 mm
Max. traversing speed		120 m/min (4720 ipm) (LS 476/LS 477: see page 45)
Vibration (55 to 2000 Hz) **Shock** (11 ms)	without mounting spar with mounting spar	≤ 100 m/s² (IEC 60 068-2-6) ≤ 200 m/s² (IEC 60 068-2-6) ≤ 300 m/s² (IEC 60 068-2-27)
Required moving force		≤ 5 N
Protection (IEC 60 529)		IP 53 when installed as per instructions IP 64 with compressed air
Operating temperature		0 to 50 °C (32 to 122 °F)
Weight		0.4 kg + 0.5 kg/m measuring length
Power supply	**LS 47x** **LS 48x**	5 V ± 5%/< 140 mA (with no load) 5 V ± 5%/< 150 mA (with Z_0 = 120 Ω)
Output signals/ Signal period	**LS 47x** **LS 48x**	⊓⊔ TTL/integr. 5-fold interpolation: 4 µm integr. 10-fold interpolation: 2 µm ∿ 1 V_{PP}/20 µm
Electrical connection		Sep. adapter cable (1 m/3 m/6 m/9 m) for mounting block (see *Electrical connection*)
Cable length to subsequent electronics	**LS 47x** **LS 48x**	50 m (164 ft) max. 150 m (492 ft) max.

Dimensions

in mm

DIN ISO 8015
ISO 2768 - m H

Mounting spar

ML	m
70 ... 520 (2.7 ... 20.5")	0
570 ... 920 (22.4 ... 36")	1
1020 ... 1340 (40 ... 52")	2
1440 ... 1740 (56 ... 68")	3
1840 ... 2040 (72 ... 80")	4

Ⓘ = Without mounting spar
Ⓘ = With mounting spar
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓡ = Reference mark position LS 4x6

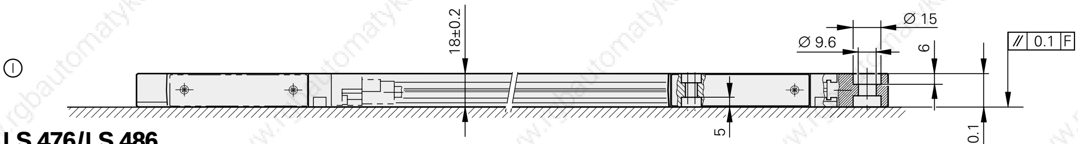
Two reference marks for measuring lengths

70 ... 1020 (2.7 ... 40")	1140 ... 2040 (44 ... 80")
z = 35 mm z_i = ML – 70 mm (2.76")	z = 45 mm z_i = ML – 90 mm (3.54")

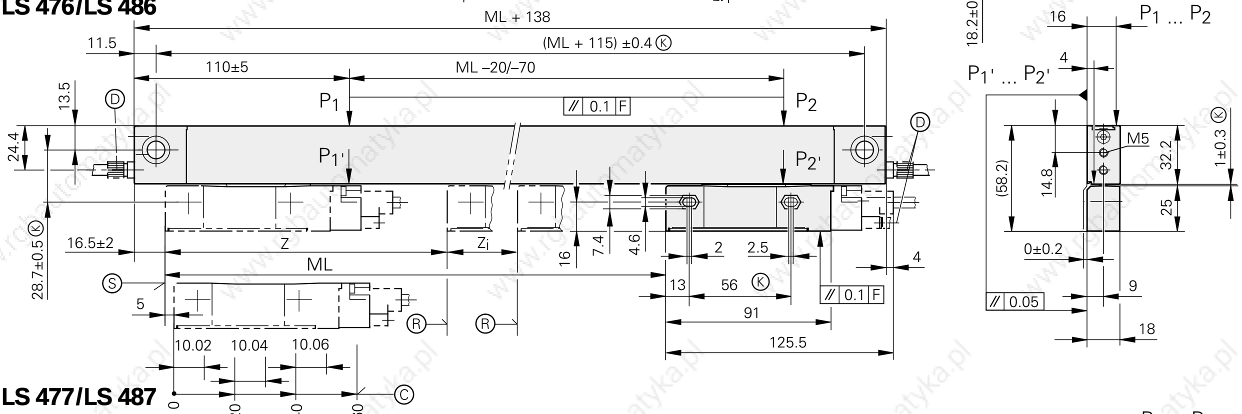
Ⓒ = Reference mark position LS 4x6C
Ⓢ = Beginning of measuring length (ML)

LS 487 without mounting spar

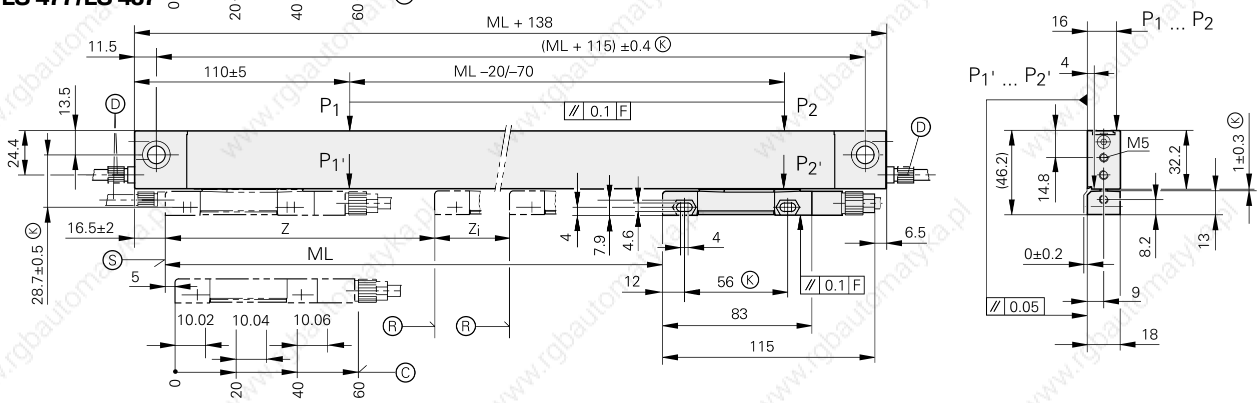
LS 486 C with mounting spar

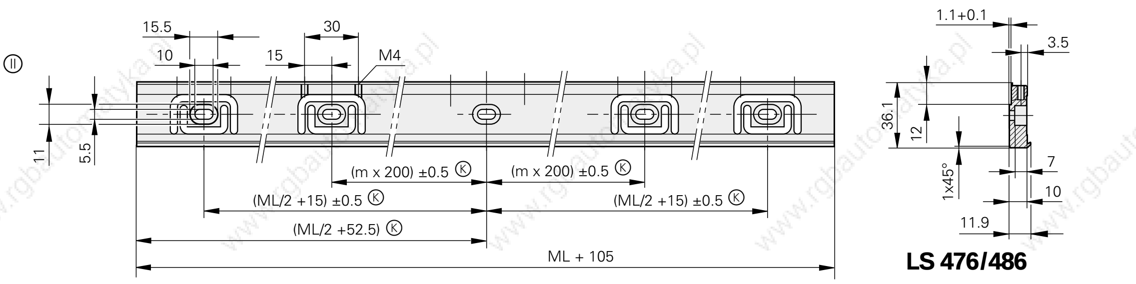


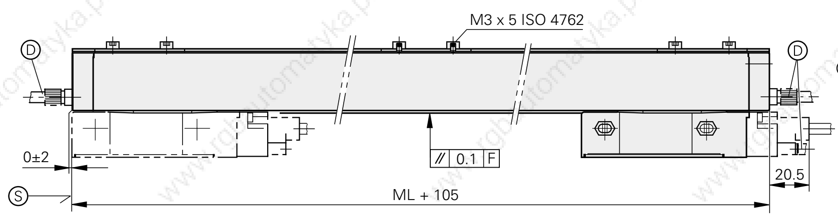
LS 476/LS 486



LS 477/LS 487

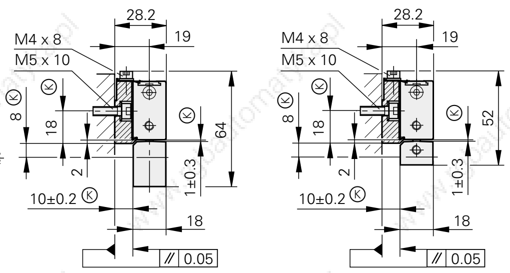






LS 476/486

LS 477/LS 487



LS 176
LS 186

Incremental linear encoders for measuring steps of 1 µm and 0.5 µm (0.000 05 in. and 0.000 02 in.)

- **Defined thermal behavior**
- **High vibration rating**
- **Horizontal mounting possible**

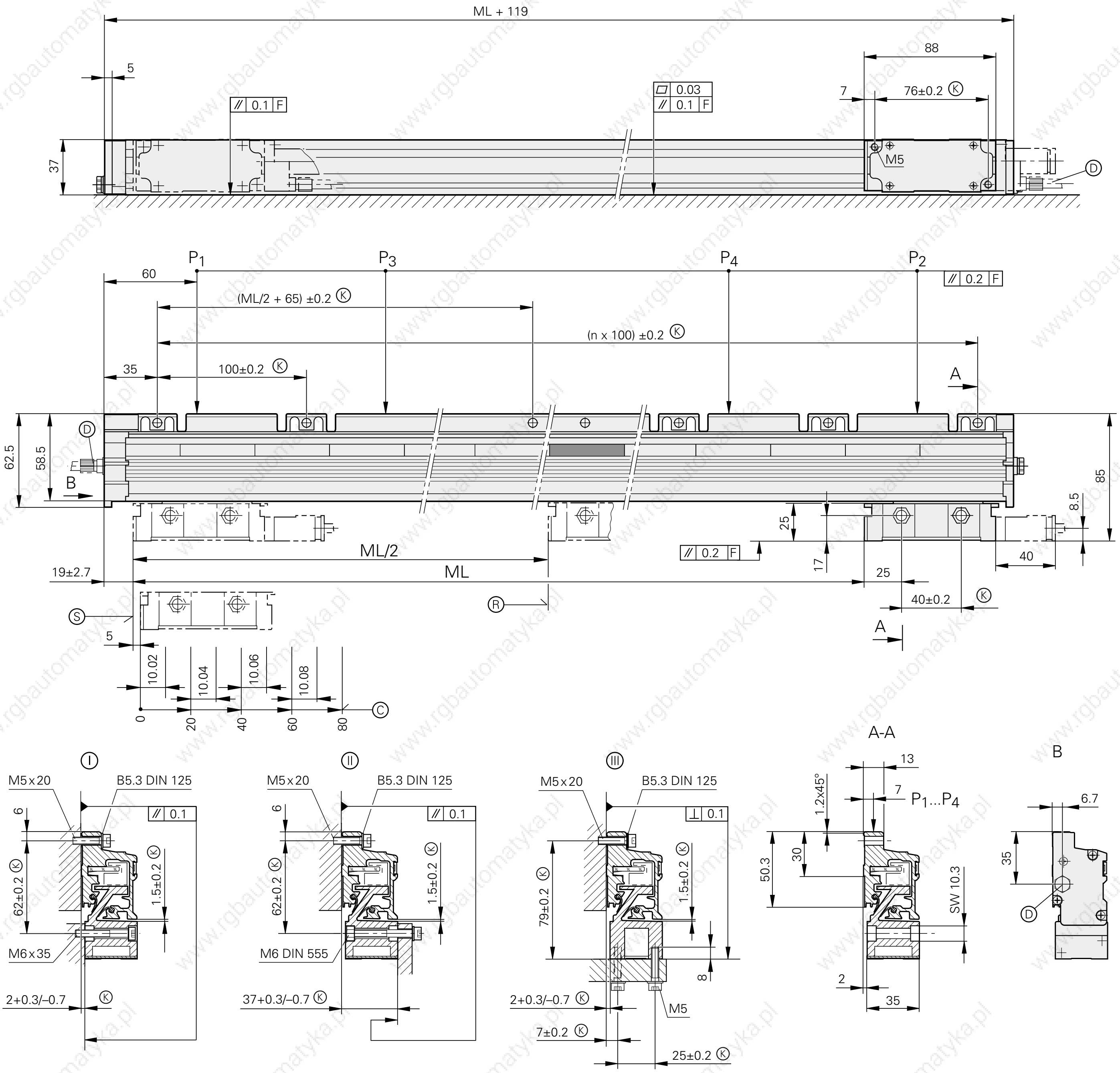
Specifications	**LS 176** **LS 186**
Measuring standard Grating period Thermal expansion coefficient	Glass scale with DIADUR graduation 20 µm $\alpha_{therm} \approx 8$ ppm/K
Accuracy grade	± 5 µm (± 0.0002 in.) ± 3 µm (± 0.000 12 in.)
Measuring length ML in mm inches	140, 240, 340, 440, 540, 640, 5.5, 9.5, 13.4, 17.3, 21.3 25, 740, 840, 940, 1040, 1140, 1240, 29, 33, 37, 41, 44, 48, 1340, 1440, 1540, 1640, 1740, 1840, 52, 56, 60, 64, 68, 72, 2040, 2240, 2440, 2640, 2840, 3040 80, 88, 96, 104, 112, 120
Reference marks **LS 1x6**	Every 50 mm via selector magnets Standard setting: one reference mark at midpoint
LS 1x6 C	Distance-coded; absolute position value available after max. 20 mm traverse
Max. traversing speed	120 m/min (4720 ipm) (LS 176: see page 45)
Vibration (55 to 2000 Hz) **Shock** (11 ms)	≤ 200 m/s^2 (IEC 60 068-2-6) ≤ 400 m/s^2 (IEC 60 068-2-27)
Required moving force	≤ 4 N
Protection (IEC 60 529)	IP 53 when installed as per instructions IP 64 with compressed air
Operating temperature	0 to 50 °C (32 to 122 °F)
Weight	0.2 kg + 2.6 kg/m measuring length
Power supply **LS 176** **LS 186**	5 V ± 5%/< 140 mA (with no load) 5 V ± 5%/< 150 mA (with terminating resistor Z_0 = 120 Ω)
Output signals/ Signal period **LS 176** **LS 186**	⊓⊔ TTL/integr. 5-fold interpolation: 4 µm integr. 10-fold interpolation: 2 µm ∿ 1 V_{PP}/20 µm
Electrical connection	Sep. adapter cable (1 m/3 m/6 m/9 m) for mounting block (see *Electrical connection*)
Cable length to subsequent electronics **LS 176** **LS 186**	50 m (164 ft) max. 150 m (492 ft) max.

Dimensions

in mm

DIN ISO 8015
ISO 2768 - m H

Ⓘ, Ⓘ, Ⓘ = Mounting options
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓡ = Reference mark position LS 1x6
Ⓒ = Reference mark position LS 1x6 C
Ⓢ = Beginning of measuring length (ML)



ML + 119
5
88
7
76±0.2 Ⓚ
0.03
0.1 F
37
M5
Ⓓ
P1
P3
P4
P2
60
(ML/2 + 65) ±0.2 Ⓚ
(n x 100) ±0.2 Ⓚ
0.2 F
35
100±0.2 Ⓚ
A
62.5
58.5
B
85
8.5
25
17
40
ML/2
ML
19±2.7
25
40±0.2 Ⓚ
Ⓡ
Ⓢ
5
10.02
10.04
10.06
10.08
0
20
40
60
80
Ⓒ
Ⅰ
Ⅱ
Ⅲ
M5x20
B5.3 DIN 125
6
62±0.2 Ⓚ
1.5±0.2 Ⓚ
M6x35
2+0.3/–0.7 Ⓚ
M6 DIN 555
37+0.3/–0.7 Ⓚ
79±0.2 Ⓚ
8
M5
7±0.2 Ⓚ
25±0.2 Ⓚ
A-A
13
1.2x45°
P1...P4
50.3
30
SW 10.3
2
35
6.7

LB 382 up to 3040 mm (120 in.) Measuring Length (Single-Section Housing)

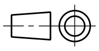
Incremental linear encoders for measuring steps to 1 µm (0.000 05 in.)

- **With linear machine error compensation**
- **With defined thermal behavior**
- **Horizontal mounting possible**
- **Mirror-inverted version available**

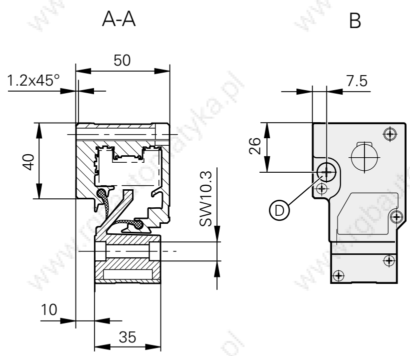
Specifications	**LB 382 up to ML 3040 mm**
Measuring standard Grating period Thermal expansion coefficient	Stainless steel tape with AURODUR graduation 40 µm $\alpha_{therm} \approx$ 10 ppm/K
Accuracy grade	± 5 µm (± 0.0002 in.)
Measuring length ML in mm inches	Single-section housing 440, 640, 840, 1040, 1240, 1 440, 17.3, 25, 33, 41, 48, 56, 1640, 1840, 2040, 2240, 2440, 2 640, 64, 72, 80, 88, 96, 104, 2840, 3040 112, 120
Reference marks **LB 382** **LB 382C**	Every 50 mm via selector plates Standard setting: one reference mark at midpoint Distance-coded; absolute position value available after max. 80 mm traverse
Max. traversing speed	120 m/min (180 m/min on request)
Vibration (55 to 2000 Hz) **Shock** (11 ms)	≤ 300 m/s^2 (IEC 60 068-2-6) ≤ 300 m/s^2 (IEC 60 068-2-27)
Required moving force	≤ 15 N
Protection (IEC 60 529)	IP 53 when installed as per instructions IP 64 with compressed air
Operating temperature	0 to 50 °C (32 to 122 °F)
Weight	1.8 kg + 3.3 kg/m measuring length
Power supply	5 V ± 5%/< 150 mA (with terminating resistor Z_0 = 120 Ω)
Output signals/Signal period	∿ 1 V_{PP}/40 µm
Electrical connection Cable length to subsequent electronics	Sep. adapter cable (1 m/3 m/6 m/9 m) for mounting block (see *Electrical connection*) 150 m (492 ft) max.

Dimensions

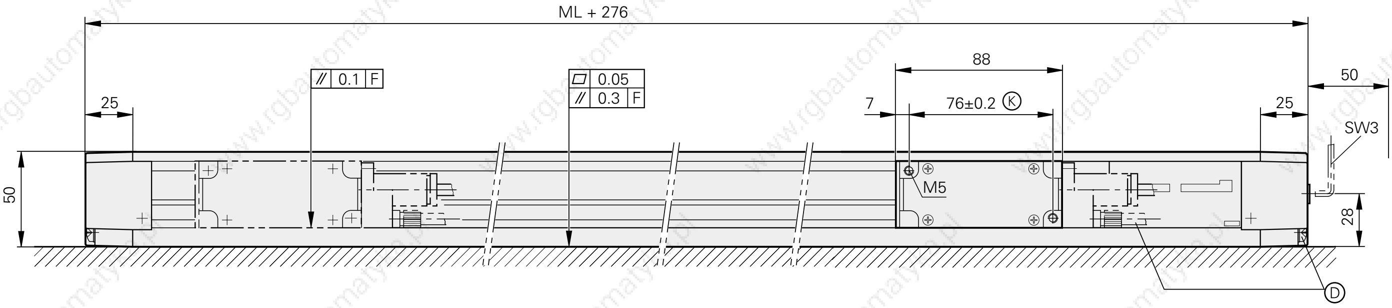
in mm



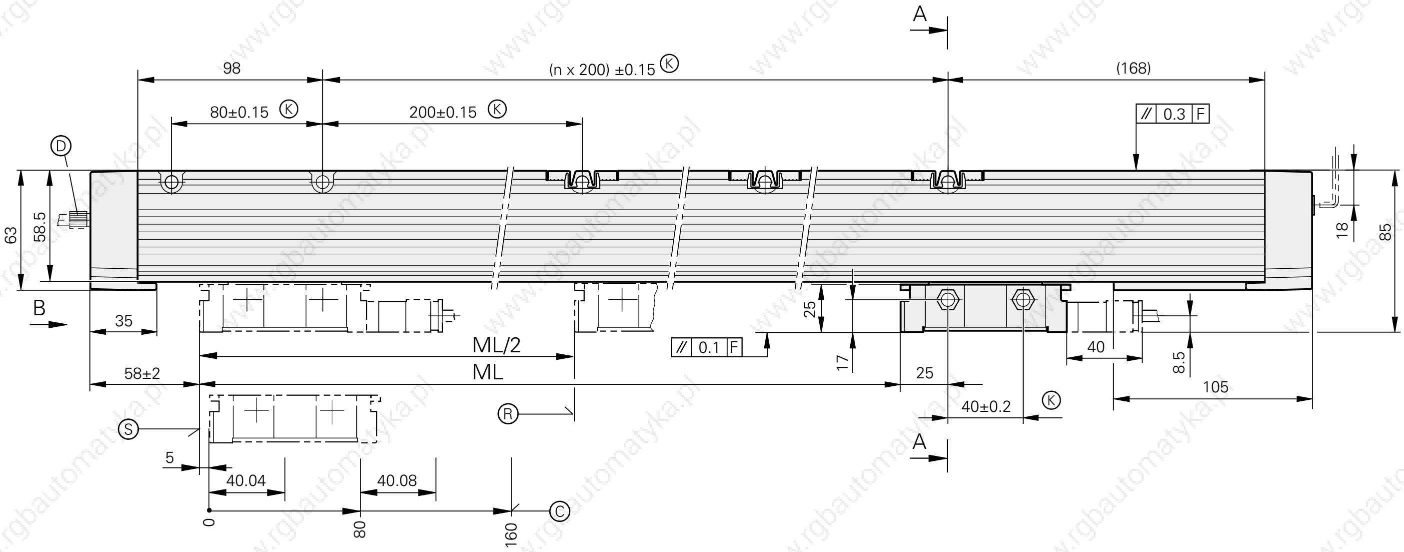
DIN ISO 8015
ISO 2768 - m H



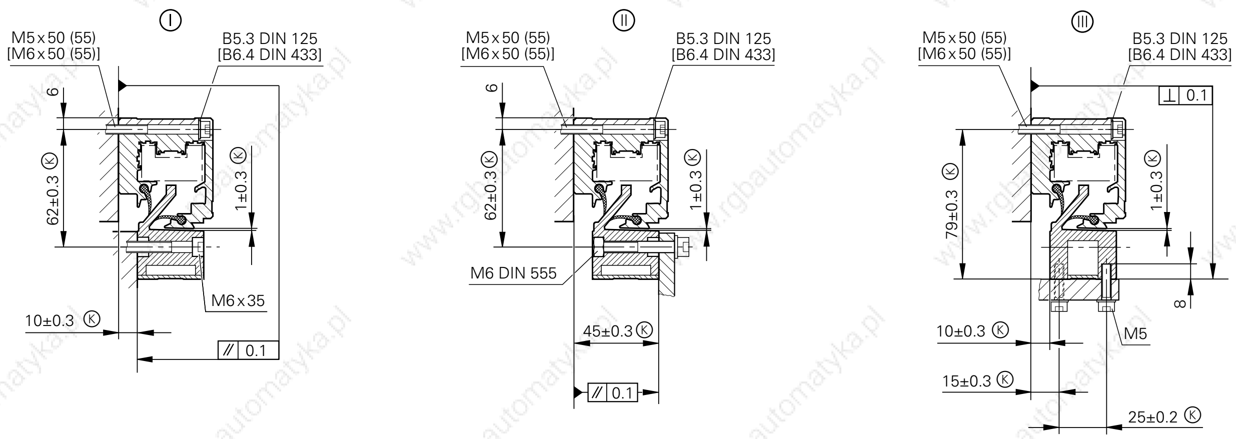
(I), (II),
(III) = Mounting options
F = Machine guideway
(K) = Required mating dimensions
(D) = Compressed air inlet
(R) = Reference mark position LB 382
(C) = Reference mark position LB 382 C
(S) = Beginning of measuring length (ML)



ML + 276
88
50
25
7
76±0.2 Ⓚ
0.05
0.3 F
0.1 F
SW3
M5
28
Ⓓ



A
98
(n x 200) ±0.15 Ⓚ
(168)
80±0.15 Ⓚ
200±0.15 Ⓚ
0.3 F
Ⓓ
63
58.5
18
85
B
35
25
ML/2
ML
58±2
0.1 F
17
40
8.5
105
40±0.2 Ⓚ
Ⓡ
Ⓢ
5
40.04
40.08
0
80
160
Ⓒ



Ⓘ
M5x50 (55)
[M6x50 (55)]
B5.3 DIN 125
[B6.4 DIN 433]
6
62±0.3 Ⓚ
1±0.3 Ⓚ
M6x35
10±0.3 Ⓚ
0.1
Ⓘ Ⓘ
M5x50 (55)
[M6x50 (55)]
B5.3 DIN 125
[B6.4 DIN 433]
6
62±0.3 Ⓚ
1±0.3 Ⓚ
M6 DIN 555
45±0.3 Ⓚ
0.1
Ⓘ Ⓘ Ⓘ
M5x50 (55)
[M6x50 (55)]
B5.3 DIN 125
[B6.4 DIN 433]
0.1
79±0.3 Ⓚ
1±0.3 Ⓚ
8
10±0.3 Ⓚ
M5
15±0.3 Ⓚ
25±0.2 Ⓚ

LB 382 up to 30 040 mm (100 ft) Measuring Length (Multi-Section Housing)

Incremental linear encoders for large traverses up to 30 m

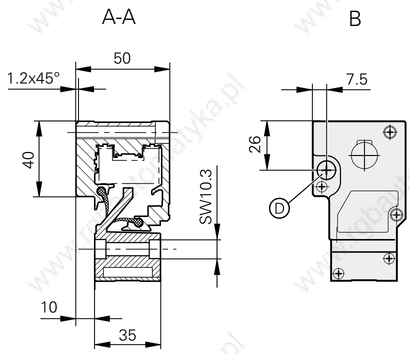
- **Measuring steps to 0.1 µm (0.000 005 in.)**
- **With linear machine error compensation**
- **Horizontal mounting possible**
- **Mirror-inverted version available**

Specifications	**LB 382 from ML 3240 mm**
Measuring standard Grating period Thermal expansion coefficient	Stainless steel tape with AURODUR graduation 40 µm Depends on mounting surface
Accuracy grade	± 5 µm (± 0.0002 in.)
Measuring length ML in mm inches	Kit with single AURODUR steel tape and housing sections for ML from 3240 mm to 30 040 mm in 200 mm steps. Housing section lengths: 1000, 1200, 1400, 1600, 1800, 2000 39, 47, 55, 63, 70.9, 78.7
Reference marks **LB 382** **LB 382 C**	Every 50 mm via selector plates Distance-coded; absolute position value available after max. 80 mm traverse
Max. traversing speed	120 m/min (4720 ipm)
Vibration (55 to 2000 Hz) **Shock** (11 ms)	≤ 300 m/s^2 (IEC 60 068-2-6) ≤ 300 m/s^2 (IEC 60 068-2-27)
Required moving force	≤ 15 N
Protection (IEC 60 529)	IP 53 when installed as per instructions IP 64 with compressed air
Operating temperature	0 to 50 °C (32 to 122 °F)
Weight	1.8 kg + 3.3 kg/m measuring length
Power supply	5 V ± 5%/< 150 mA (with terminating resistor Z_0 = 120 Ω)
Output signals/Signal period	∿ 1 V_{PP}/40 µm
Electrical connection Cable length to subsequent electronics	Sep. adapter cable (1 m/3 m/6 m/9 m) for mounting block (see *Electrical connection*) 150 m (492 ft) max.

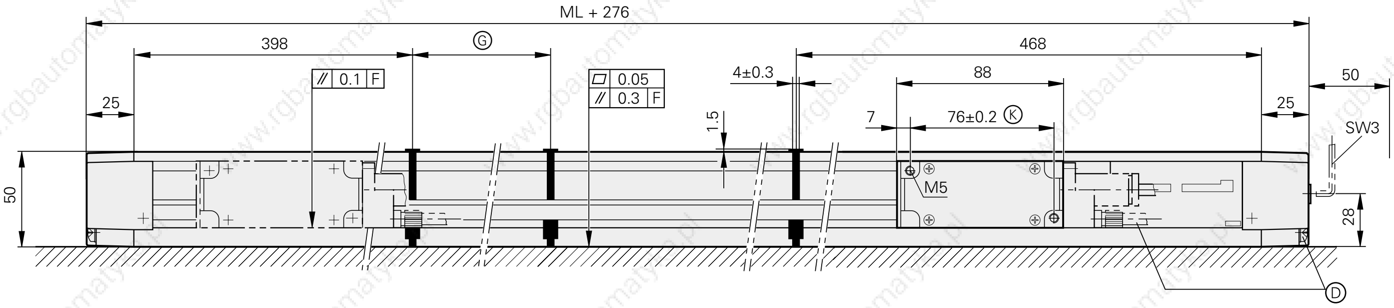
Dimensions

in mm

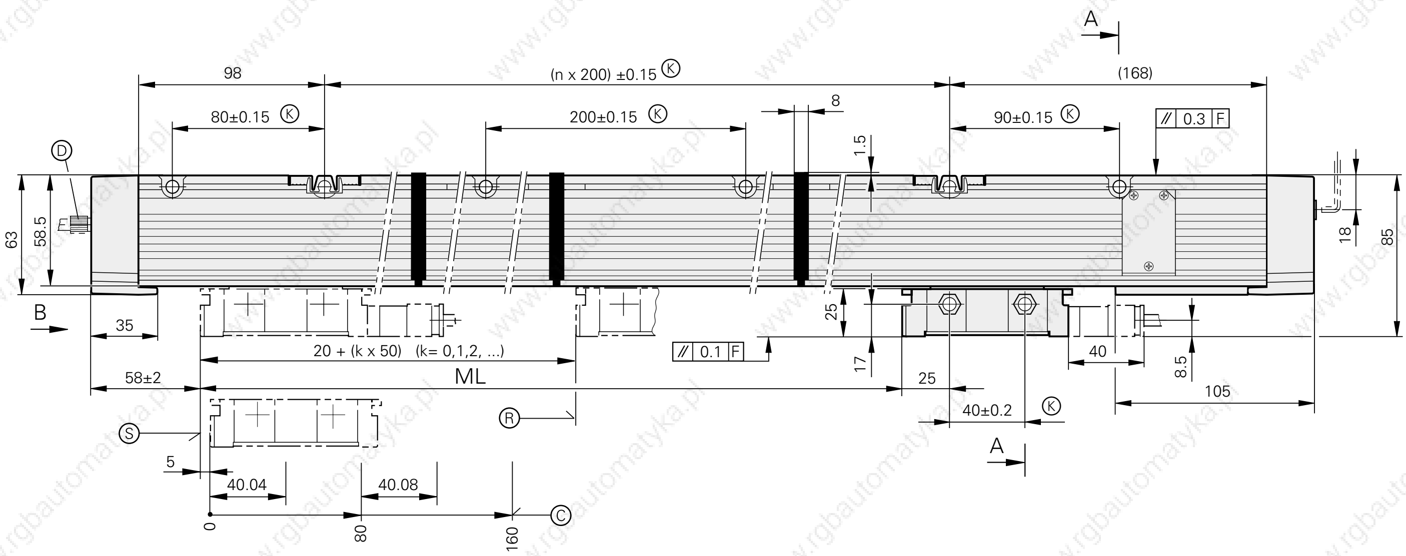
DIN ISO 8015
ISO 2768 - m H



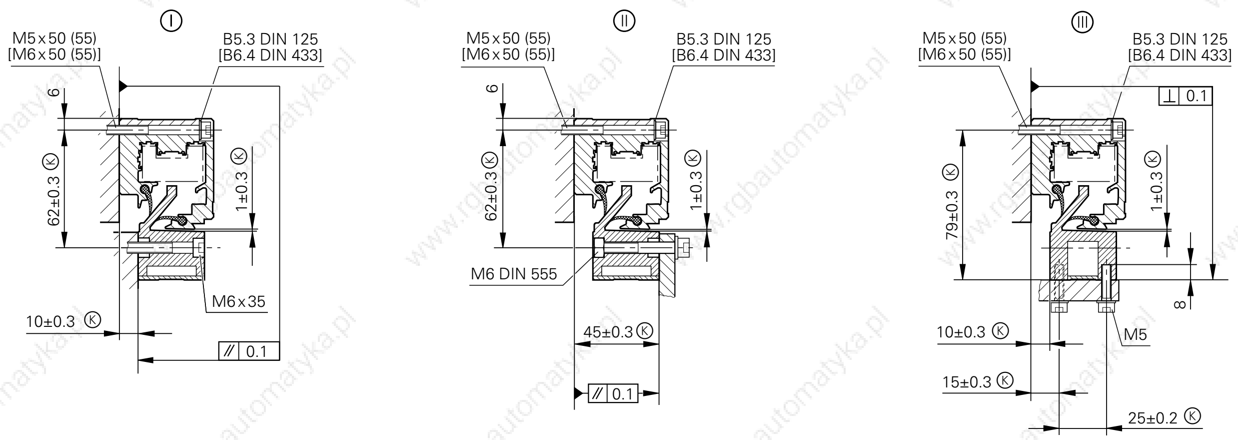
Ⓘ, Ⓘ, Ⓘ = Mounting options
F = Machine guideway
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓡ = Reference mark position LB 382
Ⓒ = Reference mark position LB 382 C
Ⓢ = Beginning of measuring length (ML)
Ⓖ = Housing section lengths



ML + 276
398
G
468
25
// 0.1 F
▱ 0.05
// 0.3 F
4±0.3
88
50
1.5
7
76±0.2 K
25
SW3
50
M5
28
D



A
98
(n x 200) ±0.15 K
(168)
80±0.15 K
200±0.15 K
8
90±0.15 K
// 0.3 F
1.5
D
63
58.5
18
85
B
35
25
20 + (k x 50) (k= 0,1,2, ...)
// 0.1 F
17
40
8.5
58±2
ML
25
105
40±0.2 K
R
S
A
5
40.04
40.08
0
80
160
C



I
M5x50 (55)
[M6x50 (55)]
B5.3 DIN 125
[B6.4 DIN 433]
6
62±0.3 K
1±0.3 K
M6x35
10±0.3 K
// 0.1
II
M5x50 (55)
[M6x50 (55)]
B5.3 DIN 125
[B6.4 DIN 433]
6
62±0.3 K
1±0.3 K
M6 DIN 555
45±0.3 K
// 0.1
III
M5x50 (55)
[M6x50 (55)]
B5.3 DIN 125
[B6.4 DIN 433]
⊥ 0.1
79±0.3 K
1±0.3 K
8
10±0.3 K
M5
15±0.3 K
25±0.2 K

LS 323

Incremental linear encoder
- **For measuring steps of 10 µm and 5 µm (0.0005 in. and 0.0002 in.)**
- **For limited installation space**

Specifications	**LS 323**
Measuring standard Grating period	Glass scale with DIADUR graduation 20 µm
Accuracy grade	± 10 µm (± 0.0004 in.)
Measuring length ML in mm inches	70, 120, 170, 220, 270, 320, 2.7, 4.7, 6.7, 8.6, 10.6, 12.6, 370, 420, 470, 520, 570, 14.5, 16.5, 18.5 20.5, 22.4,
Mounting spar recommended	620, 720, 770, 820, 920, 1020, 24.4, 28, 30, 32, 36, 40, 1140, 1240 44, 48
Reference marks **LS 323**	Every 50 mm via selector magnets Standard setting: ML 70 mm: 1 reference mark at midpoint; up to 1020 mm: 2, each 35 mm from start/end of ML; from 1140 mm: 2, each 45 mm from start/end of ML
LS 323C	Distance-coded, absolute position value available after max. 20 mm
Max. traversing speed	120 m/min (4720 ipm)
Vibration (55 to 2000 Hz) without mounting spar with mounting spar **Shock** (11 ms)	≤ 100 m/s² (IEC 60068-2-6) ≤ 200 m/s² (IEC 60068-2-6) ≤ 300 m/s² (IEC 60068-2-27)
Required moving force	≤ 5 N
Protection (IEC 60529)	IP 53 when installed as per instructions IP 64 with compressed air
Operating temperature	0 to 50 °C (32 to 122 °F)
Weight	0.4 kg + 0.5 kg/m measuring length
Power supply	5 V ± 5 %/< 170 mA (with no load)
Output signals/Signal period	⊓⊔ TTL (reference pulse non-gated)/ 20 µm
Electrical connection Cable length to subsequent electronics	Cable 3 m (9.9 ft) without connector 50 m (164 ft) max.

Dimensions

in mm

DIN ISO 8015
ISO 2768 - m H

Mounting spar

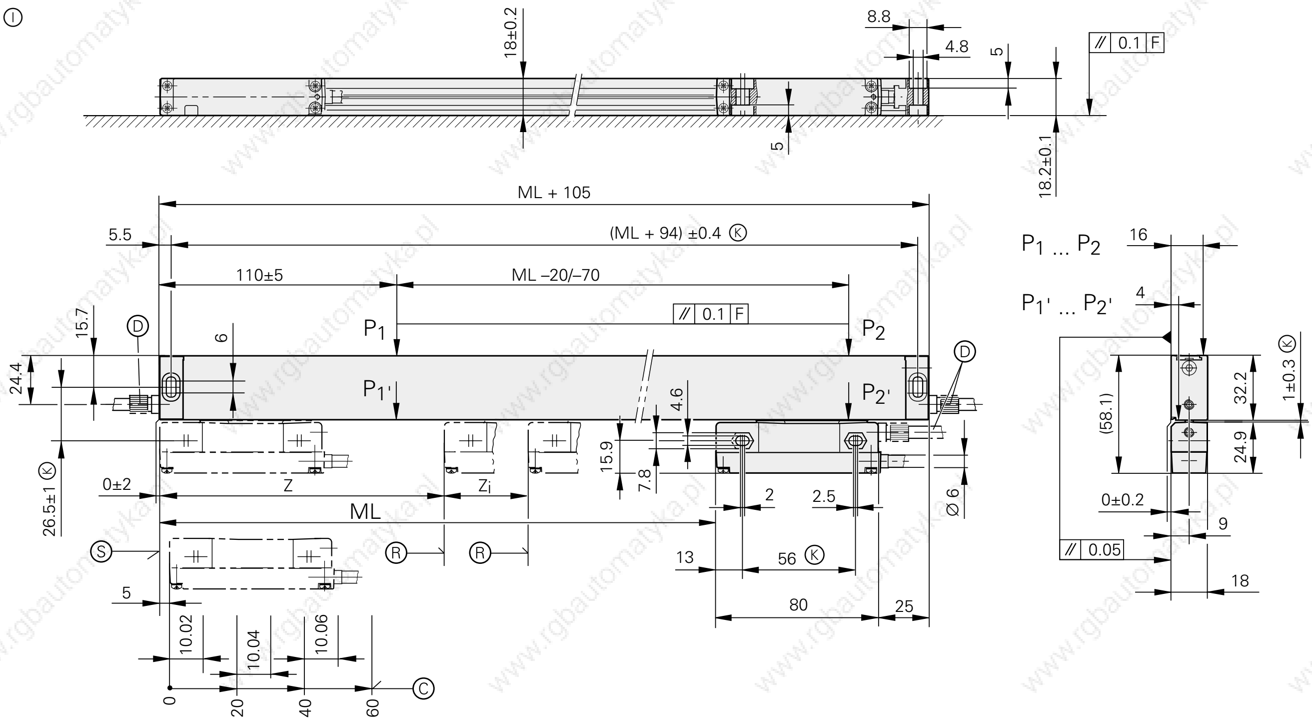
ML	m
70 ... 520 (2.7 ... 20.5")	0
570 ... 920 (22.4 ... 36")	1
1020 ... 1240 (40 ... 48")	2

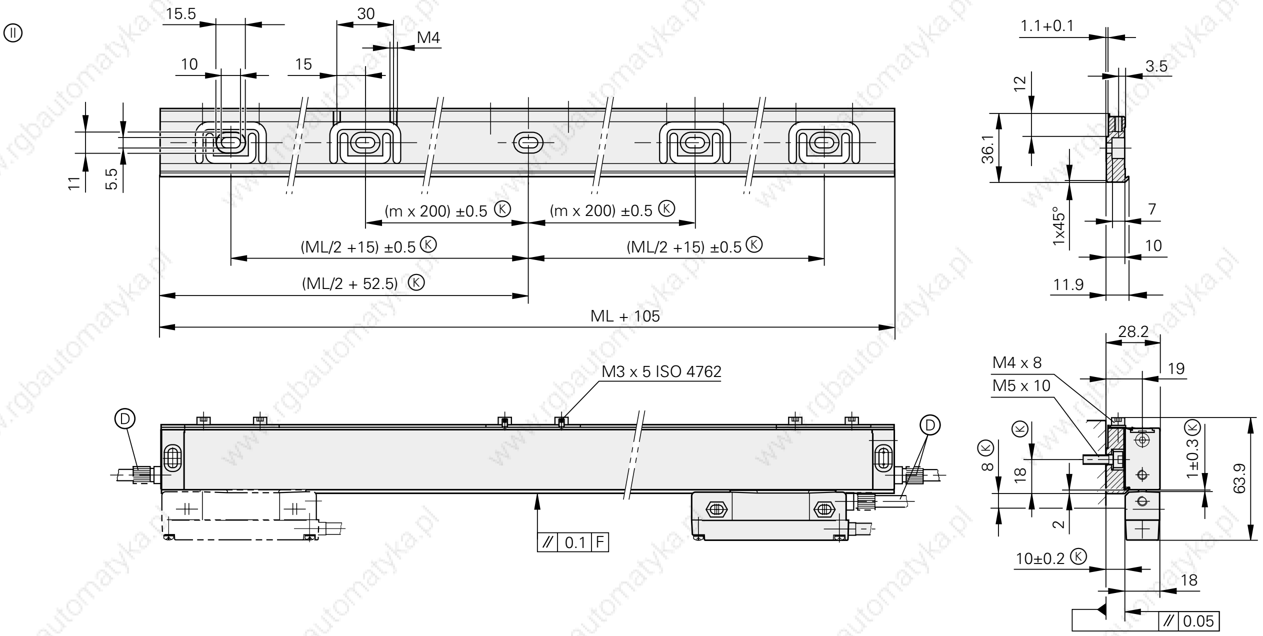
① = Without mounting spar
② = With mounting spar
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓡ = Reference mark position LS 323

Two reference marks for measuring lengths

70 ... 1020 (2.7 ... 40")	1140 ... 2040 (44 ... 80")
z = 35 mm (1.38") z_i = ML – 70 mm (2.76")	z = 45 mm (1.77") z_i = ML – 90 mm (3.54")

Ⓒ = Reference mark position LS 323C
Ⓢ = Beginning of measuring length (ML)


I
18±0.2
8.8
4.8
5
// 0.1 F
5
18.2±0.1
ML + 105
5.5
(ML + 94) ±0.4 K
110±5
ML –20/–70
// 0.1 F
P1
P2
P1'
P2'
15.7
D
6
24.4
4.6
15.9
7.8
26.5±1 K
0±2
Z
Zi
ML
2
2.5
Ø 6
S
R
R
13
56 K
5
80
25
10.02
10.04
10.06
0
20
40
60
C
P1 ... P2
16
P1' ... P2'
4
1±0.3 K
32.2
(58.1)
24.9
0±0.2
9
// 0.05
18


II
15.5
30
M4
10
15
11
5.5
(m x 200) ±0.5 K
(m x 200) ±0.5 K
(ML/2 +15) ±0.5 K
(ML/2 +15) ±0.5 K
(ML/2 + 52.5) K
ML + 105
M3 x 5 ISO 4762
D
D
// 0.1 F
1.1+0.1
3.5
12
36.1
1x45°
7
10
11.9
28.2
M4 x 8
M5 x 10
19
8 K
K
18
1±0.3 K
63.9
2
10±0.2 K
18
// 0.05

LS 623

Incremental linear encoder for measuring steps of 10 µm and 5 µm (0.0005 in. and 0.0002 in.)

Specifications	**LS 623**
Measuring standard Grating period	Glass scale with DIADUR graduation 20 µm
Accuracy grade	± 10 µm (± 0.0004 in.)
Measuring length ML in mm inches	170, 220, 270, 320, 370, 420, 6.7, 8.6, 10.6, 12.6, 14.5, 16.5, 470, 520, 620, 720, 770, 820, 18.5, 20.5, 24.4, 28, 30, 32, 920, 1020, 1140, 1240, 1340, 1440, 36, 40, 44, 48, 52, 56, 1540, 1640, 1740, 1840, 2040, 2240, 60, 64, 68, 72, 80, 88, 2440, 2640, 2840, 3040 96, 104, 112, 120
Reference marks **LS 623**	Standard: One reference mark at midpoint Special versions: Several reference marks at 50 mm intervals starting from midpoint of measuring length; or one reference mark at any desired position
LS 623C	Distance-coded, absolute position value available after max. 20 mm traverse
Max. traversing speed	60 m/min (2362 ipm)
Vibration (55 to 2 000 Hz) **Shock** (11 ms)	30 m/s^2 (IEC 60 068-2-6) 200 m/s^2 (IEC 60 068-2-27)
Required moving force	≤ 10 N
Protection (IEC 60 529)	IP 53 when installed as per instructions IP 64 with compressed air
Operating temperature	0 to 50 °C (32 to 122 °F)
Weight	0.7 kg + 2 kg/m measuring length
Power supply	5 V ± 5 %/< 170 mA (with no load)
Output signals/Signal period	⊓⊔ TTL/20 µm
Electrical connection	Sep. adapter cable (1 m/3 m/6 m) with or without armor (see *Electrical connection*)
Cable length to subsequent electronics	50 m (164 ft) max.

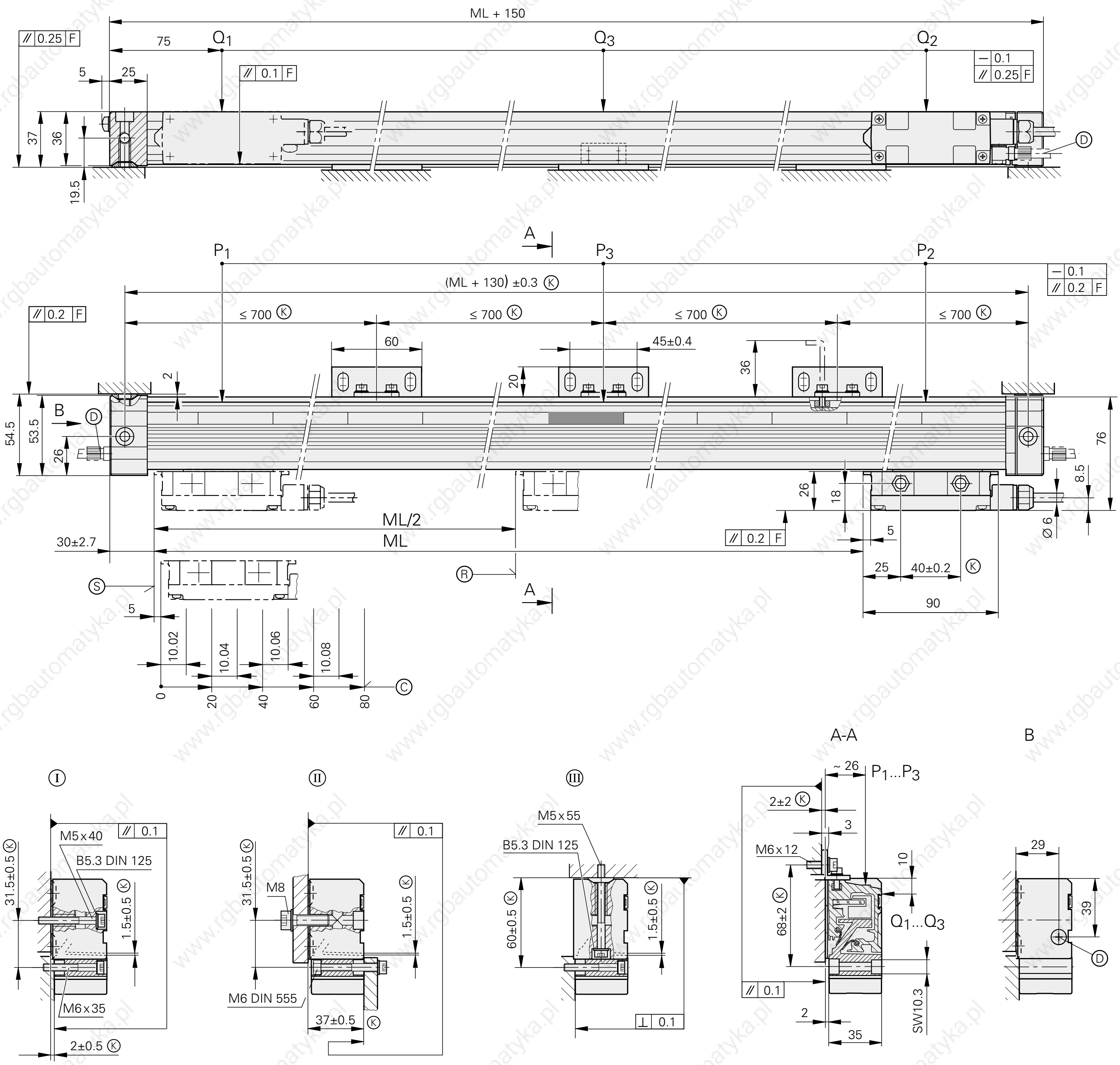
Dimensions

in mm

DIN ISO 8015
ISO 2768 - m H

(I), (II), (III) = Mounting options
F = Machine guideway
P, Q = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓡ = Reference mark position LS 623
Ⓒ = Reference mark position LS 623C
Ⓢ = Beginning of measuring length (ML)


HEIDENHAIN
HEIDENHAIN 310 731 03


ML + 150
75
Q1
Q3
Q2
5
25
0.25 F
0.1 F
0.1
0.25 F
37
36
19.5
D
P1
P3
P2
A
(ML + 130) ±0.3 K
≤ 700 K
60
45±0.4
36
20
2
0.2 F
0.1
0.2 F
B
54.5
53.5
26
76
8.5
Ø 6
18
ML/2
ML
30±2.7
0.2 F
5
25
40±0.2 K
90
R
S
10.02
10.04
10.06
10.08
0
20
40
60
80
C
A-A
B
I
II
III
~ 26
P1...P3
2±2 K
3
M6x12
10
68±2 K
Q1...Q3
0.1
2
35
SW10.3
29
39
M5x40
B5.3 DIN 125
31.5±0.5 K
1.5±0.5 K
M6x35
2±0.5 K
M8
M6 DIN 555
37±0.5 K
M5x55
60±0.5 K
⊥ 0.1

LS 629

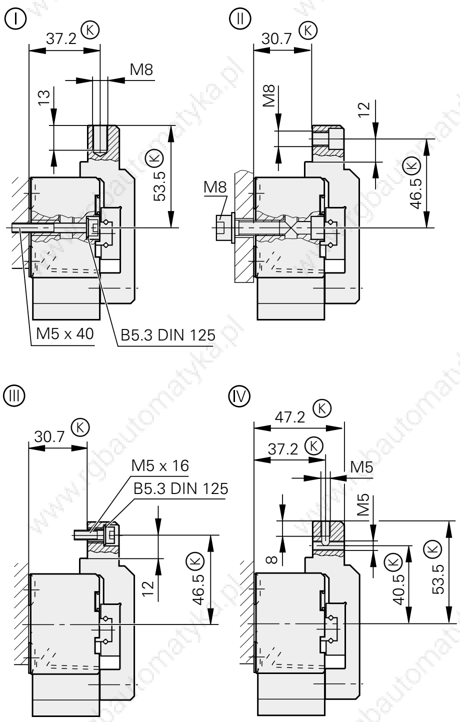
Incremental linear encoder for measuring steps of 10 µm and 5 µm (0.0005 in. and 0.0002 in.)
- **With integrated guide**
- **Large mounting tolerances and connection over coupling rod**

Specifications	**LS 629**
Measuring standard Grating period	Glass scale with DIADUR grating 20 µm
Accuracy grade	± 10 µm (± 0.0004 in.)
Measuring length (ML) in mm inches	170, 220, 270, 320, 370, 420, 6.7, 8.6, 10.6, 12.6, 14.5, 16.5, 470, 520, 620, 720, 770, 820, 18.5, 20.5, 24.4, 28, 30, 32, 920 36
Reference marks **LS 629** **LS 629 C**	Selectable every 50 mm by magnet Standard setting: 1 reference mark at midpoint Distance-coded for ascertaining the absolute position value after max. 20 mm traverse
Max. traversing speed	60 m/min (2362 ipm)
Vibration (55 to 2 000 Hz) **Shock** (11 ms)	30 m/s^2 (IEC 60 068-2-6) 200 m/s^2 (IEC 60 068-2-27)
Required moving force	≤ 10 N
Protection (IEC 60 529)	IP 53 when installed as per instructions IP 64 with compressed air
Operating temperature	0 to 50 °C (32 to 122 °F)
Weight	0.8 kg + 2.5 kg/m measuring length
Power supply	5 V ± 5 %/< 170 mA (without load)
Output signals/signal period	⊓⊔ TTL/20 µm
Electrical connection Cable length to subsequent electronics	Sep. adapter cable (1 m/3 m/6 m) with and without armor (see *Electrical Connection*) 50 m (164 ft) max.

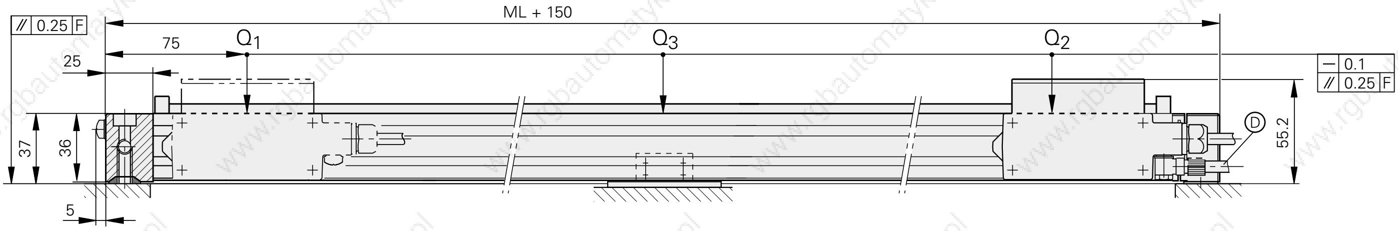
Dimensions

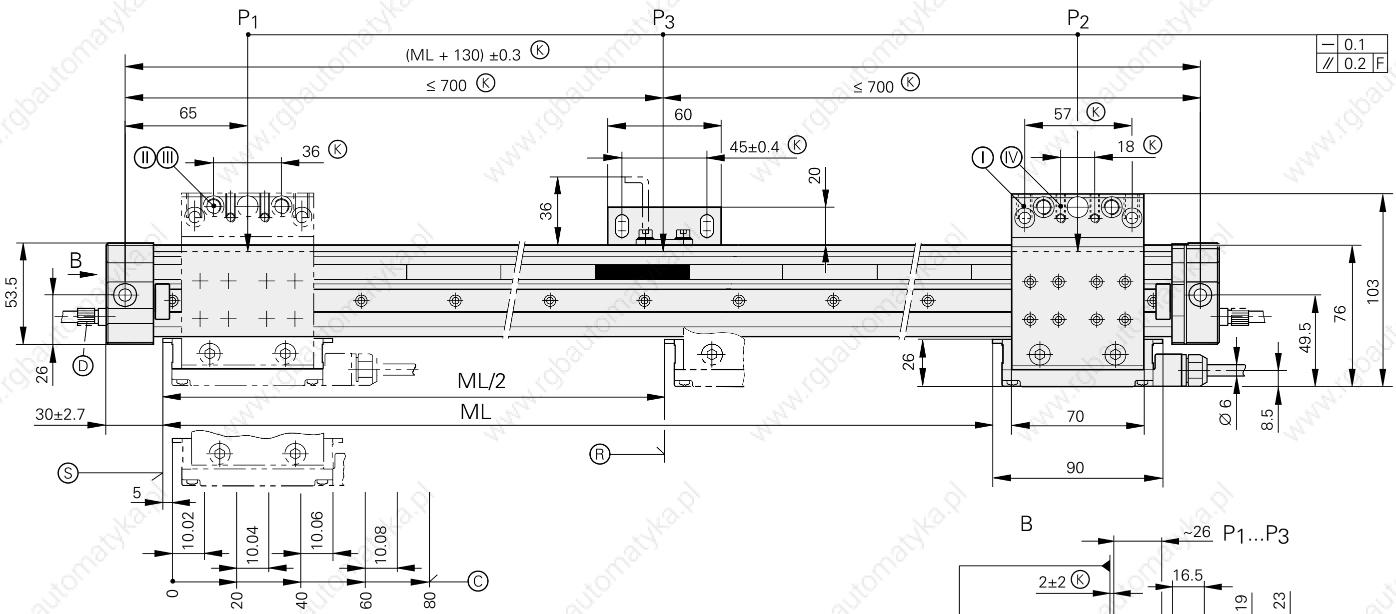
in mm

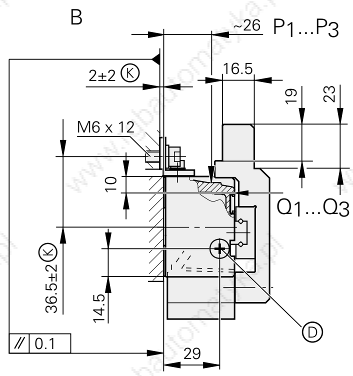
DIN ISO 8015
ISO 2768 - m H



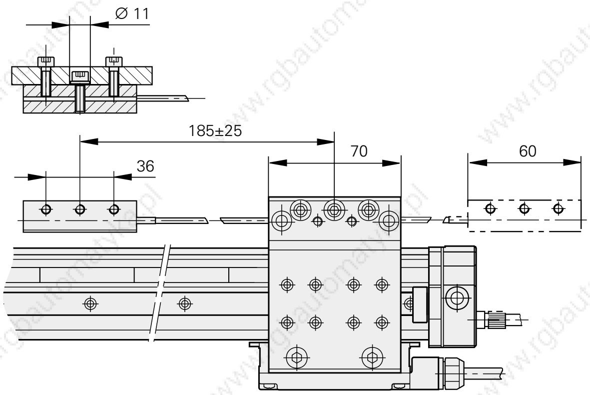
(I), (II),
(III), (IV) = Mounting options
F = Machine guideway
P, Q = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓡ = Reference mark position LS 629
Ⓒ = Reference mark position LS 629 C
Ⓢ = Beginning of measuring length (ML)

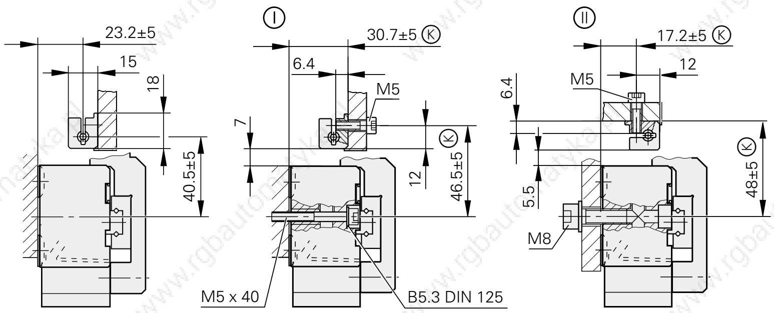






Mounting with coupling rod





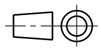
LIM 571
LIM 581

Incremental linear encoder for a measuring step of 10 µm (0.0005 in.)
- **For limited installation space**
- **For large measuring lengths**
- **Magnetic scanning principle**

Specifications		**LIM 571** **LIM 581**
Measuring standard Grating period		Magnetic plastic layer on steel support tape 10.24 mm
Accuracy grade		± 100 µm (± 0.004 in.)
Measuring length in mm/inches		440 mm to 2040 mm (17.3 in. to 80 in.) in steps of 200 mm (7.9 in.) as single piece.
		2240 mm to 28 040 mm (88 in. to 1103.9 in.) in steps of 200 mm (7.9 in.) as kit with one scale in several housing sections.
Reference marks		Possible every 10.24 mm
Max. traversing speed		600 m/min (23 600 ipm)
Vibration (55 to 2000 Hz) **Shock** (11 ms)		≤ 200 m/s^2 (IEC 60 068-2-6) ≤ 500 m/s^2 (IEC 60 068-2-27)
Protection (IEC 60 529)		IP 64
Operating temperature		0° to 50° C (32° to 122 °F)
Weight		Scanning head: Approx. 250 g Scale: Approx. 25 g + 375 g/m measuring length
Power supply	**LIM 571** **LIM 581**	5 V ± 5 %/< 240 mA (without load) 5 V ± 5 %/< 150 mA (without load)
Output signals/ **Signal period**	**LIM 571** **LIM 581**	⊓⊔ TTL/40 µm ∿ 1 V_{PP}/10.24 mm
Electrical connection Cable length to subsequent electronics	 **LIM 571** **LIM 581**	Cable 3 m (9.9 ft) without connector 100 m (329 ft) max. 150 m (492 ft) max.

Dimensions

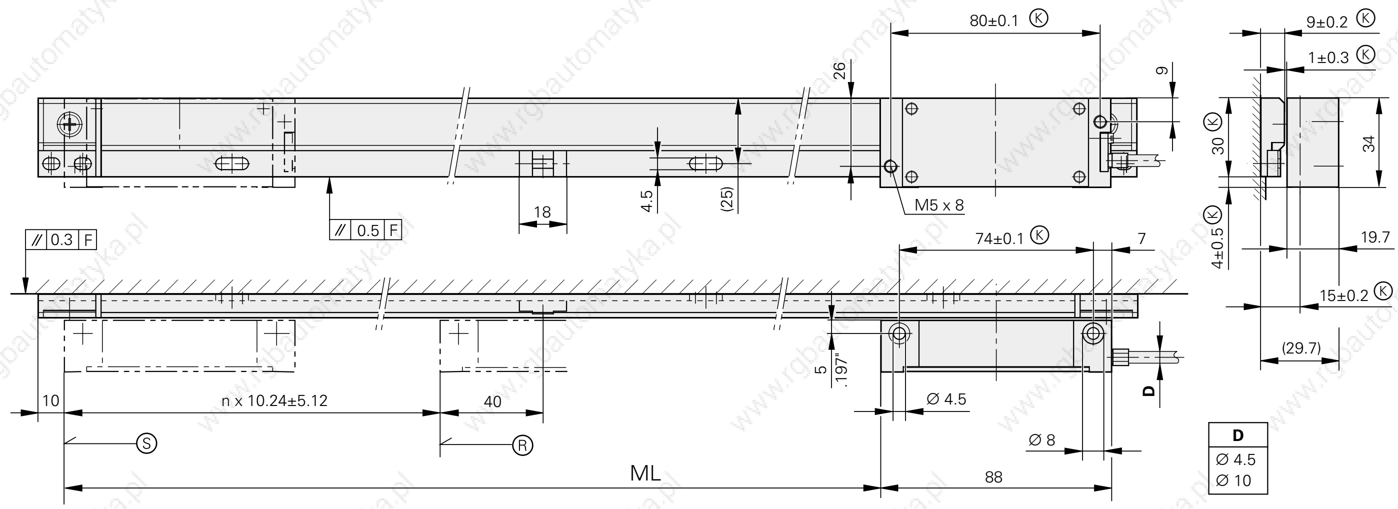
in mm

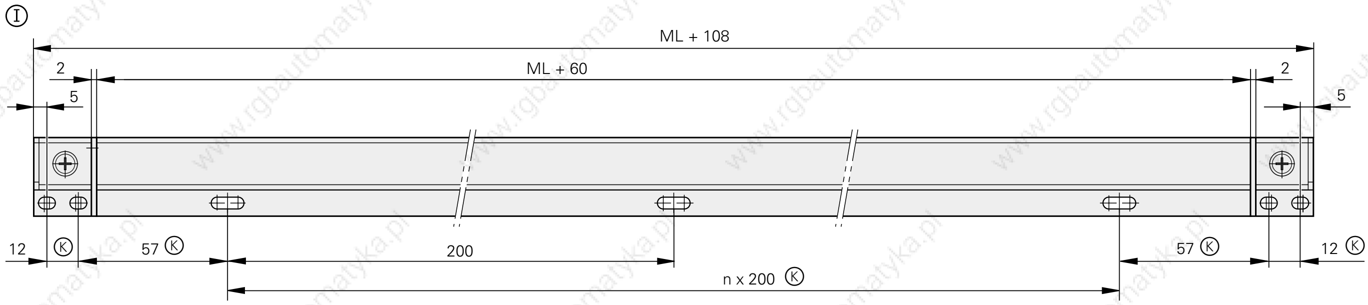


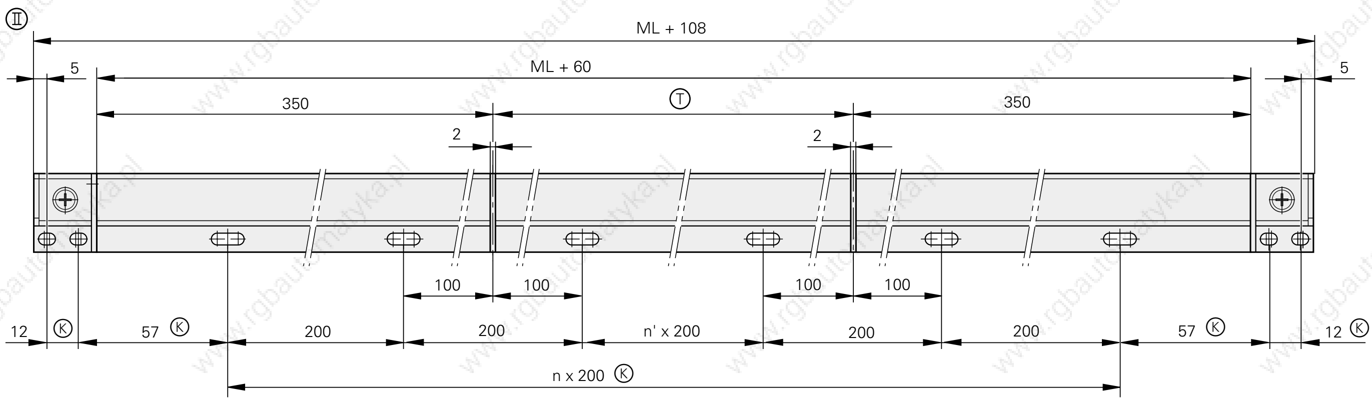
DIN ISO 8015
ISO 2768 - m H

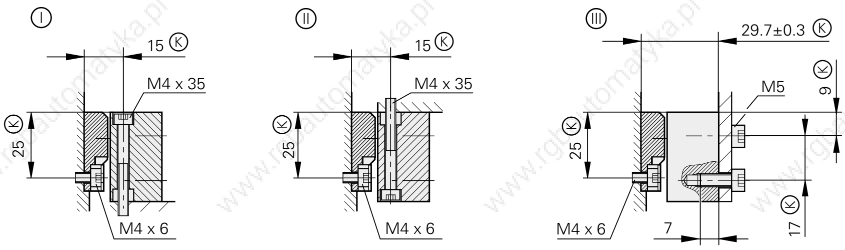
(I) = Single-section housing
(II) = Multi-section housing
(I), (II), (III), = Mounting options
F = Machine guideway
Ⓚ = Required mating dimensions
Ⓣ = Composed of housing sections (available lengths 1000, 1200, 1400, 1600, 1800, 2000)
Ⓡ = Reference mark position
Ⓢ = Beginning of measuring length (ML)


HEIDENHAIN
ACHTUNG
Magnete fernhalten!


80±0.1 Ⓚ
9±0.2 Ⓚ
1±0.3 Ⓚ
26
9
30 Ⓚ
34
M5 x 8
18
4.5
(25)
⫽ 0.3 F
⫽ 0.5 F
74±0.1 Ⓚ
7
4±0.5 Ⓚ
19.7
15±0.2 Ⓚ
(29.7)
5
.197"
D
Ø 4.5
Ø 8
10
n x 10.24±5.12
40
Ⓢ
Ⓡ
ML
88
D
Ø 4.5
Ø 10


Ⓘ
ML + 108
ML + 60
2
5
12
Ⓚ
57 Ⓚ
200
n x 200 Ⓚ
57 Ⓚ
12 Ⓚ


Ⓘ
ML + 108
ML + 60
5
350
Ⓣ
350
2
100
100
100
100
12
Ⓚ
57 Ⓚ
200
200
n' x 200
200
200
57 Ⓚ
12 Ⓚ
n x 200 Ⓚ

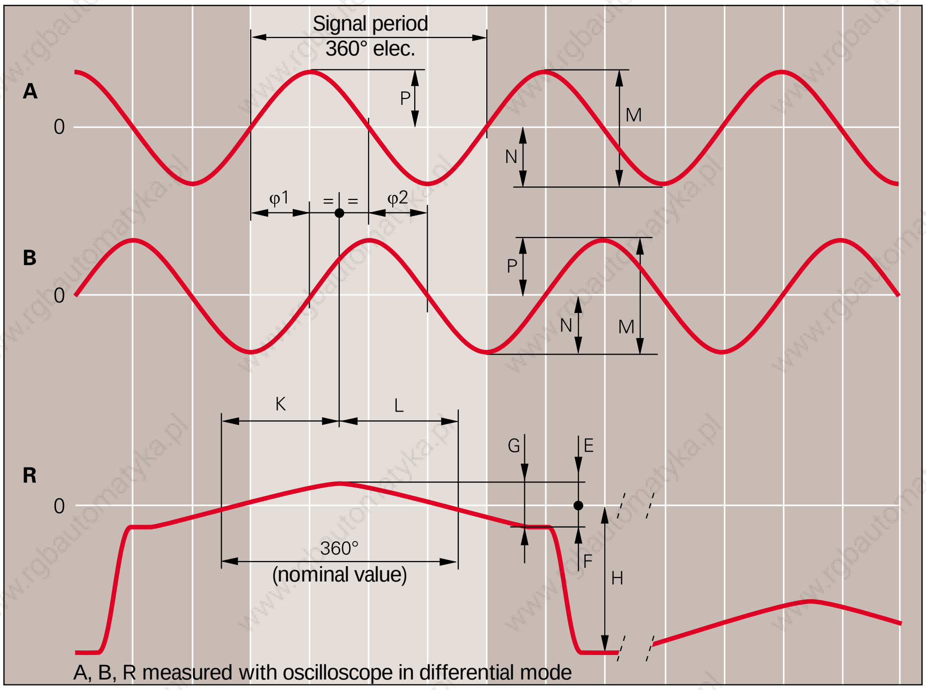

Ⓘ
15 Ⓚ
M4 x 35
25 Ⓚ
M4 x 6
Ⓘ
15 Ⓚ
M4 x 35
25 Ⓚ
M4 x 6
Ⓘ
29.7±0.3 Ⓚ
9 Ⓚ
M5
25 Ⓚ
M4 x 6
7
17 Ⓚ

Interfaces
Incremental Signals ∿ 1 V_{PP}

The **sinusoidal incremental signals A and** B are phase-shifted by 90° and have signal levels of approximately 1 V_{PP}. The usable component of the **reference mark signals R** is approximately 0.5 V. The data on signal amplitude apply for Up = 5 V ± 5% at the encoder (see *Specifications*) and are given with respect to a differential measurement at the 120 Ω terminating resistor between the associated outputs. The signal amplitude decreases as the scanning frequency increases.

Reference mark signals
The LF 183, LS and LB linear encoders with single reference marks have a reference mark located every 50 mm on the glass scale. One or more of these can be activated by a slidable magnet that lifts the idle level by approximately 1.5 V. The useable component G starts from the idle level to form a reference mark signal. Signal peaks with the amplitude G also appear at the lower idle level every 50 mm at the inactive reference marks.

		LS, LF, LB, LC, LIM	
Output signals	**Incremental signals**	Sinusoidal voltage signals ∿ 1 V_{PP}	
		Two sinusoidal signals A and B	
		Signal level M:	0.6 to 1.2 V_{PP} Approx. 1 V_{PP}
		Unbalance $\|P - N\|/2M$:	0.065
		Amplitude ratio M_A/M_B:	0.8 to 1.25
		Phase angle $\|\varphi 1 + \varphi 2\|/2$:	90° ± 10° elec.
	Reference mark signal	**1 or more signal peaks R**	
		Usable component G:	0.2 to 0.85 V
		Quiescent value H:	Max. 1.7 V
		Signal-to-noise ratio E, F:	Min. 40 mV
		Zero crossovers K, L	180° ± 90° elec.
Connecting cable		HEIDENHAIN cable with shielding PUR [4(2 · 0.14 mm^2) + (4 · 0.5 mm^2)]	
	Cable length	Max. 150 m (492 ft) distributed capacitance 90 pF/m	
	Propagation time	6 ns/m	



∿ **1 V_{PP}: Recommended input circuitry of the subsequent electronics**

Dimensioning
Operational amplifier e.g. RC 4157
R_1 = 10 kΩ and C_1 = 220 pF
R_2 = 34.8 kΩ and C_2 = 10 pF
Z_0 = 120 Ω
U_B = ± 15 V
U_1 approx. U_0

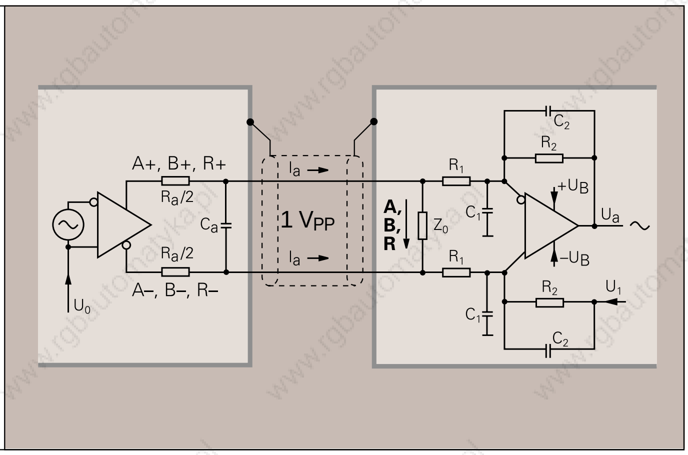
–3dB cutoff frequency of circuitry
Approx. 450 kHz
Approx. 50 kHz with C_1 = 1000 pF
and C_2 = 82 pF
(Recommended for electronics easily disturbed by electromagnetic noise.)

Circuit output signals
U_a = approx. 3.48 V_{PP}
Gain 3.48

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

Incremental signals
Reference mark signals

R_a < 100 Ω,
typically 24 Ω
C_a < 50 pF
ΣI_a < 1 mA
U_0 = 2.5 V ± 0.5 V
(with respect to 0 V of the supply voltage)

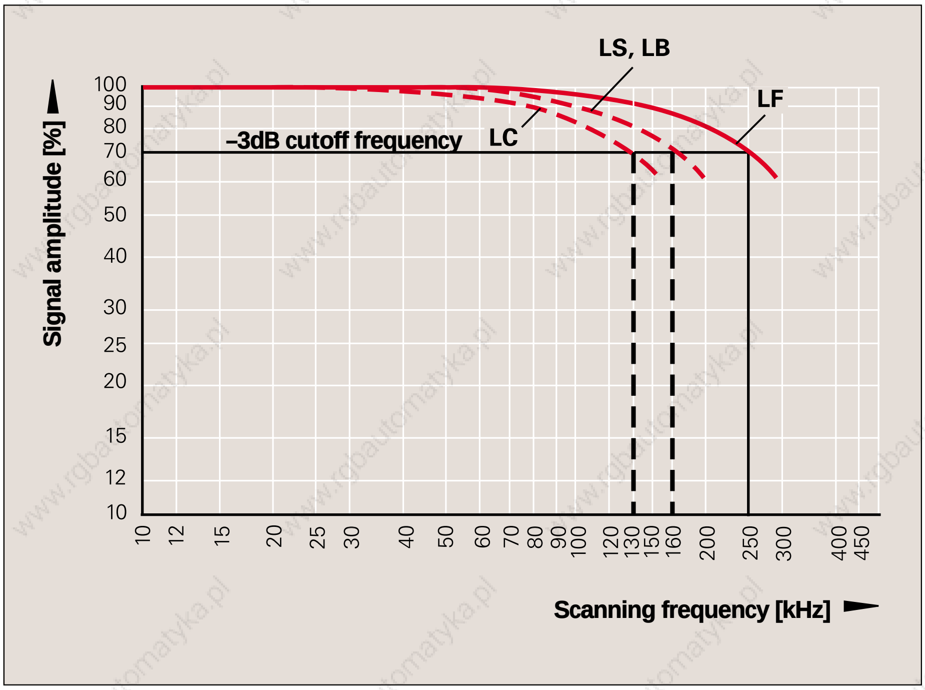


Scanning Signals

Signal amplitude
For linear encoders with sinusoidal output signals, the signal amplitude is a function of the supply voltage and therefore also of the voltage drop ΔU and the scanning frequency.

Cutoff frequency
For linear encoders with sinusoidal output signals:
The –3dB cutoff frequency indicates the frequency at which 70% of the original signal amplitude is maintained.

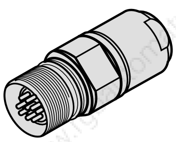
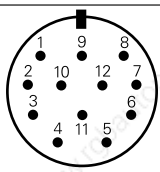
Recommended measuring step
The recommended measuring steps shown in the Specifications result from:
- the signal period and the quality of the scanning signals,
- the system accuracy of the encoder, and
- the interpolation factor of the external or integrated interpolation and digitizing electronics.



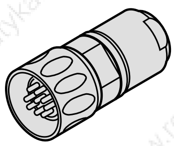
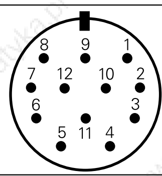
Typical signal amplitude curve for sinusoidal output signals (1 V_{PP}) as a function of the scanning frequency

Pin Layout

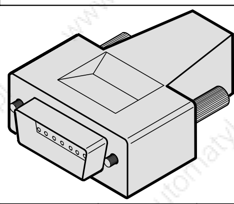
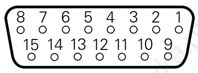
12-pin HEIDENHAIN coupling

12-pin HEIDENHAIN connector

15-pin D-sub connector, female, on HEIDENHAIN adapter cable for HEIDENHAIN controls and IK 220

12-pin	5	6	8	1	3	4	12	10	2	11	9	7	/
15-pin	3	4	6	7	10	12	1	2	9	11	5/8/13/15	14	/
	A		B		R		5 V (U_P)	0 V (U_N)	5 V Sensor	0 V Sensor	Vacant	Vacant	Vacant
	+	–	+	–	+	–							
Cable	Brown	Green	Gray	Pink	Red	Black	Brown/ Green	White/ Green	Blue	White	/	Violet	Yellow
							EN 50178						

Shield on housing. U_P = power supply
Sensor is connected internally with the respective power supply.

Electrical Connections

Interfaces

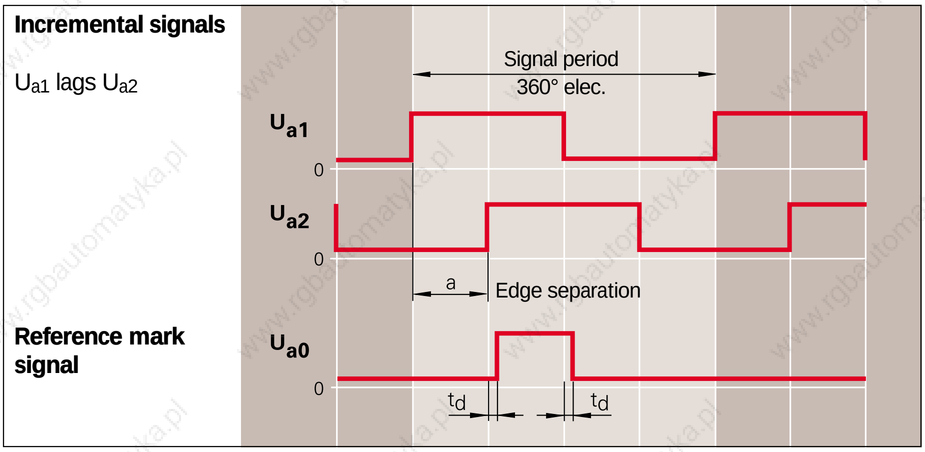
Incremental Signals ⊓⊔ TTL

Encoders with TTL square-wave output signals incorporate circuitry that digitizes sinusoidal scanning signals without interpolation, or after 2-fold interpolation. They provide two 90° (elec.) phase-shifted **square-wave pulse trains U_{a1} and U_{a2},** and one **reference pulse U_{a0},** which is gated with the incremental signals. A **fault-detection signal $\overline{U_{aS}}$** indicates fault conditions such as an interruption in the supply lines, failure of the light source, etc. It can be used, for example, in automated production to switch off the machine. The integrated electronics also generate the **inverse signals** of all square-wave pulse trains.

One measuring step is the distance between two successive edges of the combined pulse trains U_{a1} and U_{a2} after 1-fold, 2-fold or 4-fold evaluation.

To ensure reliable operation, the input circuitry of the subsequent electronics must be designed to detect each edge of the square-wave pulse. To prevent counting errors in the subsequent electronics, the **edge separation *a*** must never exceed the maximum possible scanning frequency. The minimum edge separation *a* is guaranteed over the entire operating temperature range.

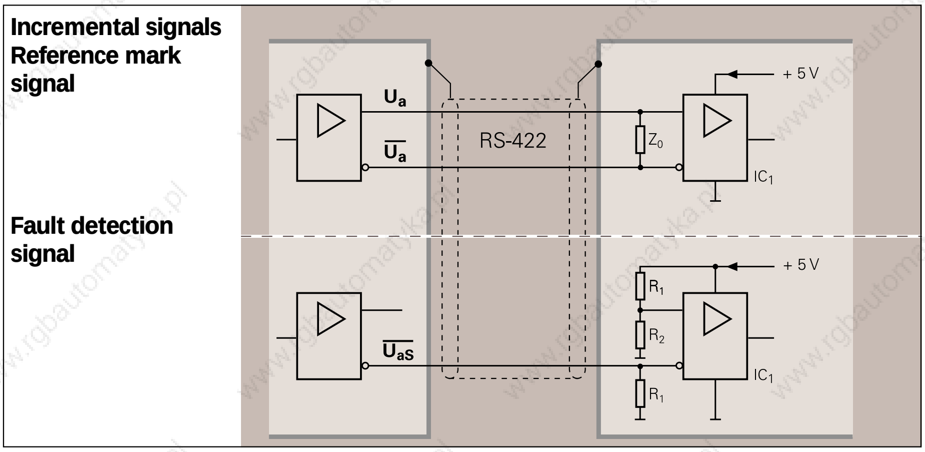
		LS 176, LS 476, LS 477, LS 323, LS 623, LS 629, LIM 571
Output signals	**Incremental signals**	Square-wave signals ⊓⊔ TTL **2 TTL square-wave signals U_{a1}, U_{a2}** and their inverted signals **$\overline{U_{a1}}$, $\overline{U_{a2}}$**
	Reference mark signal Pulse width	**1 or more square-wave pulse U_{a0}** and their inverted pulses **$\overline{U_{a0}}$** 90° elec. (other widths available on request). *LS 323:* non-gated
	Fault detection signal (on LS 176, LS 47x)	**1 square-wave pulse $\overline{U_{aS}}$** (improper function: LOW proper function: HIGH)
Signal level		Differential line driver as per EIA standard RS 422 $U_H \geq 2.5$ V with $I_H = 20$ mA $U_L \leq 0.5$ V with $I_L = 20$ mA
	Permissible load	$R \geq 100\ \Omega$ (between associated outputs) $\lvert I_L \rvert \leq 20$ mA (max. load per output) $C_{load} \leq 1000$ pF with respect to 0 V Outputs protected against short circuit after 0 V
	Switching times (10% to 90%)	Rise time $t_+ \leq 50$ ns with 1 m cable and Fall time $t_- \leq 50$ ns recommended input circuitry
Connecting cable		HEIDENHAIN shielded cable PUR [4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)]
	Cable lengths	Max. 100 m ($\overline{U_{aS}}$ max. 50 m) with distributed capacitance of 90 pF/m
	Propagation time	6 ns/m



⊓⊔ TTL: Recommended input circuitry of subsequent electronics

Dimensioning
IC_1 = recommended differential line receiver
AM 26 LS 32
MC 3486
SN 75 ALS 193

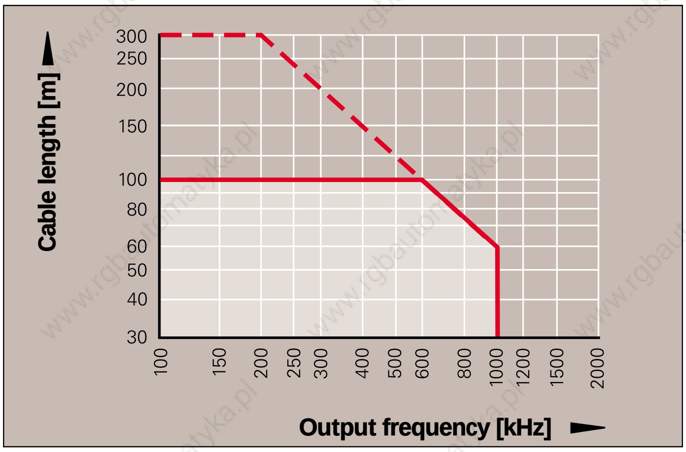
$R_1 = 4.7\ k\Omega$
$R_2 = 1.8\ k\Omega$
$Z_0 = 120\ \Omega$



	Measuring step[1)]/ Interpolation[2)]	Traversing speed	Edge separation	Scanning frequency[2)]	Delay time of reference pulse	Fault detection signal
LS 176 **LS 476** **LS 477**	1 µm/5-fold	120 m/min[3)] 120 m/min 60 m/min	≥ 0.25 µs ≥ 0.5 µs ≥ 1 µs	200 kHz 100 kHz 50 kHz	$\lvert t_d \rvert \le$ 50 ns	Yes
	0,5 µm/5-fold	120 m/min 60 m/min 30 m/min		100 kHz 50 kHz 25 kHz		
LS 623 **LS 629**	5 µm/without	60 m/min	≥ 2.5 µs	100 kHz		Yes
LS 323	5 µm/without	120 m/min	≥ 1.25 µs	100 kHz	Reference pulse non-gated	No
LIM 571	10 µm/256-fold	600 m/min	≥ 0.5 µs	1 kHz	$\lvert t_d \rvert \le$ 0.1 µs	Yes

1) After 4-fold evaluation
2) Please indicate when ordering
3) Mechanical limit

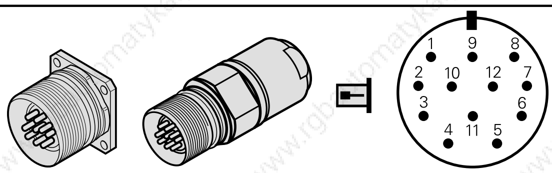
Cable lengths
TTL square-wave signals can be transmitted to the subsequent electronics over cable up to 100 m (329 ft), provided that the specified 5 V ± 10% supply voltage is maintained at the encoder. The sensor lines enable the subsequent electronics to measure the voltage at the encoder and, if required, correct it with a line-drop compensator.



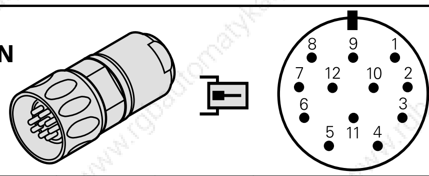
Permissible cable length with respect to output frequencies

Pin Layout

12-pin HEIDENHAIN flange socket or coupling



12-pin HEIDENHAIN connector



Pin	5	6	8	1	3	4	12	10	2	11	7	9	/
Signal	U_{a1}	$\overline{U_{a1}}$	U_{a2}	$\overline{U_{a2}}$	U_{a0}	$\overline{U_{a0}}$	**5 V** U_P	**0 V** U_N	**5 V** Sensor	**0 V** Sensor	$\overline{U_{aS}}$ [1)]	**Vacant**	**Vacant**
Cable	Brown	Green	Gray	Pink	Red	Black	Brown/ Greeen	White/ Green	Blue	White	Violet	/	Yellow

EN 50 178

Shield on housing; U_P = power supply
Sensor is connected internally with the respective power supply.

1) Vacant on LS 323

Interfaces
Serial EnDat 2.1

As a **bidirectional** interface, the EnDat (**En**coder **Dat**a) interface for absolute encoders is capable of outputting **absolute position values** as well as requesting or updating information stored in the encoder. Thanks to the **serial data transmission,** only **four signal** lines are required. The type of transmission (i.e., whether position values or parameters) is selected through mode commands transmitted from the subsequent electronics to the encoder. Data is transmitted **in synchronism** with a clock signal from the subsequent electronics.

Advantages of the EnDat Interface

- **One interface** for all absolute encoders, whereby the subsequent electronics can automatically distinguish between EnDat and SSI.
- Complementary **output of incremental signals** (optional for use with highly dynamic control loops).
- **Automatic self-configuration** during encoder installation, since all information required by the subsequent electronics is already stored in the encoder.
- **Reduced wiring cost.** For standard applications six lines are sufficient.
- **High system security** through alarms and messages that can be evaluated in the subsequent electronics for monitoring and diagnosis. No additional lines are required.
- **Minimized transmission times** through adaptation of the data word length to the resolution of the encoder and through high clock frequencies.
- **High reliability of transmission** through cyclic redundancy checks.
- **Datum shift** through an offset value in the encoder.
- It is possible to form a **redundant system,** since the absolute value and incremental signals are output independently from each other.

	LC
Interface	EnDat (serial bidirectional)
Code signals	
Data input	Differential line receiver according to EIA standard RS-485 for CLOCK and $\overline{\text{CLOCK}}$ as well as DATA and $\overline{\text{DATA}}$ signals
Data output	Differential line driver according to EIA standard RS-485 for DATA and $\overline{\text{DATA}}$ signals
Signal levels	Differential voltage outputs > 1.7 V with 120 Ω load*) (EIA standard RS 485)
Code	Pure binary code
Direction of traverse	Code values increase with rightward traverse
Incremental signals	∼ 1 V_{PP} (see *Incremental signals* 1 V_{PP})
Connecting cable	HEIDENHAIN connecting cable with shielding PUR [(4 x 0.14 mm^2) + 4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)]
Cable length	Max. 150 m (492 ft) distributed capacitance 90 pF/m
Propagation time	6 ns/m

*) Terminating and receiver input resistor

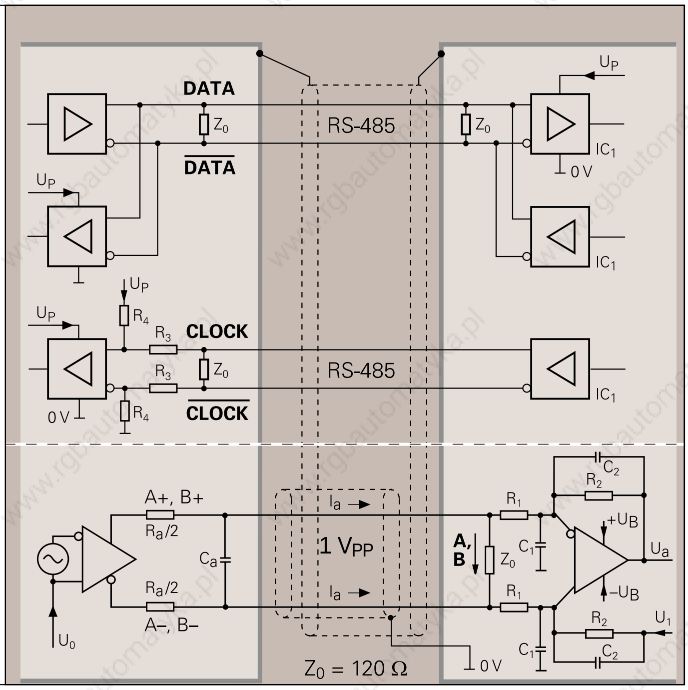
EnDat interface: Recommended input circuitry of subsequent electronics

Code signals
IC_1 =
Differential line receiver and driver
e.g. SN 65 LBC 176
LT 485

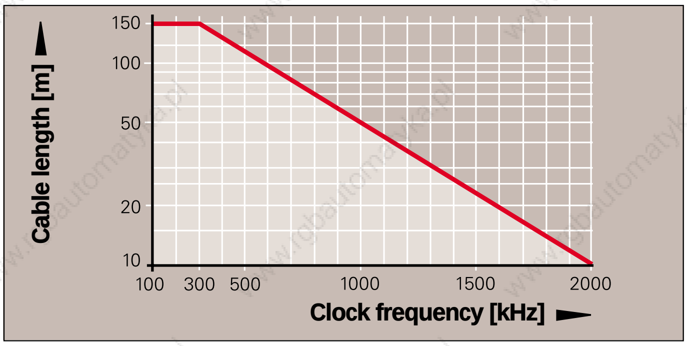
R_3 = 100 kΩ *)
R_4 = 1 kΩ *)

Incremental signals

*Depends on model



Permissible clock frequency with respect to cable length



Function of the EnDat Interface

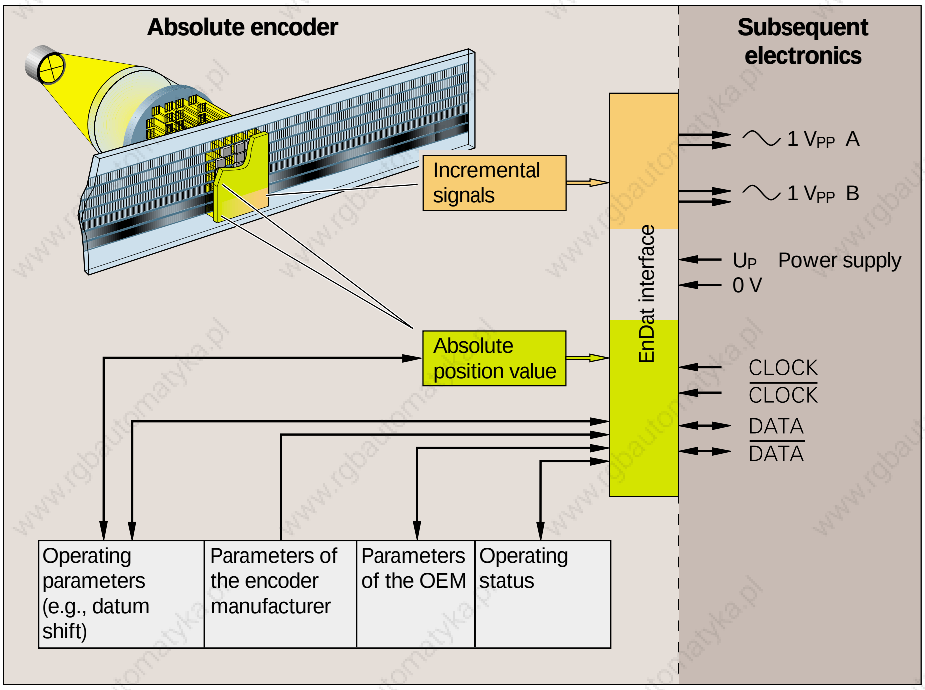
The EnDat interface outputs **absolute position values,** provides **incremental signals** and permits reading from and writing to the **memory in the encoder.**

Selection of transmission mode
Position values and memory contents are transmitted serially through the DATA lines. The type of transmission is selected through **mode commands** that define the content of the subsequent information. Each mode command consists of 3 bits. To ensure transmission reliability, each bit is also transmitted inverted. If the encoder recognizes a faulty mode transmission, an error message follows. The following mode commands are available:

- Encoder transmit absolute position value
- Select the memory area
- Encoder transmit/receive parameters of the last defined memory area
- Encoder transmit test values
- Encoder receive test command
- Encoder receive RESET

Parameters
The encoder provides several memory areas that can be read from by the subsequent electronics, and some of which can be written to by the encoder manufacturer, the OEM, or even the end user. Certain memory areas can be write-protected.

The parameters, which in most cases are set by the OEM, largely define the function of the encoder and the EnDat interface. When an EnDat encoder is exchanged, it is therefore essential that the encoder parameter settings are correct. Attempts to configure machines without including OEM data can result in malfunctions. If there is any doubt as to the correct parameter settings, the OEM should be consulted.



Block diagram: Absolute encoder with EnDat interface

Encoder Memory Areas

Parameters of the encoder manufacturer
This write-protected memory area contains all **information specific to the encoder** such as encoder type (linear encoder, angle encoder, singleturn/multiturn, etc.), signals periods, number of position values per revolution, transmission format of absolute position values, direction of rotation, maximum permissible speed, accuracy at shaft speeds, support from warnings and alarms, part number, and serial number. This information forms the basis for **automatic configuration.**

Parameters of the OEM
In this freely definable memory area the OEM can store his information. A motor manufacturer, for example, can save an "electronic ID label" of the motor in which the encoder is integrated, indicating the motor model, maximum current rating, etc.

Operating parameters
This area is available to the customer for a **datum shift.** It can be protected against overwriting.

Operating status
This memory area provides detailed alarms or warnings for diagnostic purposes. Here it is also possible to activate **write protection** for the OEM-parameter and operating-parameter memory areas and interrogate its status.

Monitoring and Diagnostic Functions

Alarms and warnings
The EnDat interface permits extensive monitoring of the encoder without requiring additional transmission lines.

An **alarm** becomes active if there is a malfunction in the encoder that is presumably causing incorrect position values. At the same time, an alarm bit is set in the data word. Alarm conditions include:

- Failure of the light unit
- Insufficient signal amplitude
- Error in calculation of the position value
- Operating voltage too high or too low
- Current consumption too high

Warnings indicate that certain tolerance limits of the encoder have been reached or exceeded—such as shaft speed or dimming-compensation voltage for the light source—without implying that the measured position values are incorrect. This function enables preventive maintenance and therefore minimizes machine downtime. The alarms and warnings supported by the respective encoder are stored in the encoder manufacturer's parameter memory area.

Reliable data transfer
To increase the reliability of data transfer, a **cyclic redundancy check** (CRC) is formed through logical connective operations on the individual bit values of a data word. This 5-bit long CRC concludes every transmission. The CRC is decoded in the receiver electronics and compared with the data word. This largely eliminates errors caused by disturbances during data transfer.

Data transfer
The two types of data transfer are position value transfer and parameter transfer.

Control Cycles for Transfer of Position Values

The **clock** signal is transmitted by the subsequent electronics to synchronize the data output from the encoder. When not transmitting, the clock line is on high level. The transmission cycle begins with the first falling edge. The encoder saves the measured values and calculates the position value.

After two clock pulses (2T), the subsequent electronics send the **mode command** *encoder transmit position value.*

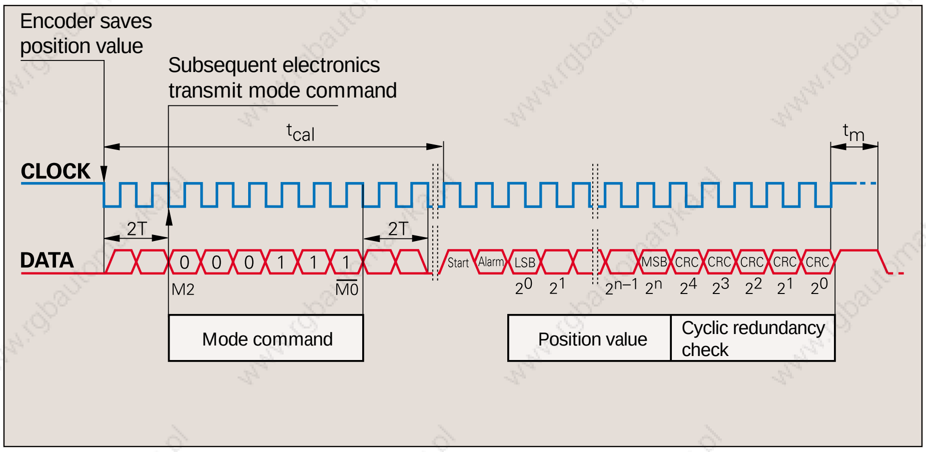
After the encoder has completed calculation of the absolute position value (t_{cal}—see table), it begins with the **start bit** to transmit data to the subsequent electronics.

The subsequent **alarm bit** is a collective message for all monitored functions and serves for failure monitoring. It becomes active if there is a malfunction in the encoder that presumably results in incorrect position values. The exact cause of the alarm is saved in the operating-status memory area where it can be interrogated.

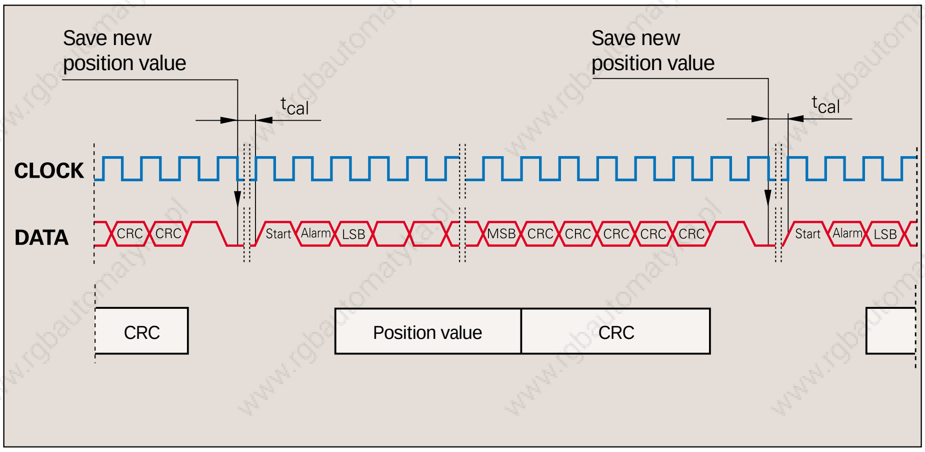
The **absolute position value** is then transmitted beginning with the LSB. Its length depends on the encoder. It is saved in the encoder manufacturer's memory area. Since EnDat does not need to fill superfluous bits with zeros as is common in SSI, the transmission time of the position value to the subsequent electronics is minimized.

Data transmission is concluded with the **cyclic redundancy check** (CRC).

Interrupted clock
The interrupted clock is intended particularly for time-clocked systems such as closed control loops. At the end of the data word the clock signal is set to high level. After the time t_m (10 to 30 µs) the data line returns to low and can begin a new transmission when started by the clock signal.



Continuous clock
For applications that require fast acquisition of the measured value, the EnDat interface can have the clock run continuously. Immediately after the last CRC bit has been sent, the data line is switched to high for one clock pulse period, and then to low. The new position value is saved with the very next falling edge of the clock pulse and is output in synchronism with the clock signal immediately after the start bit and alarm bit. Because the mode command *encoder transmit position* value is needed only before the first data transmission, the continuous-clock transfer mode reduces the length of the clock-pulse group by 10 periods per position value.



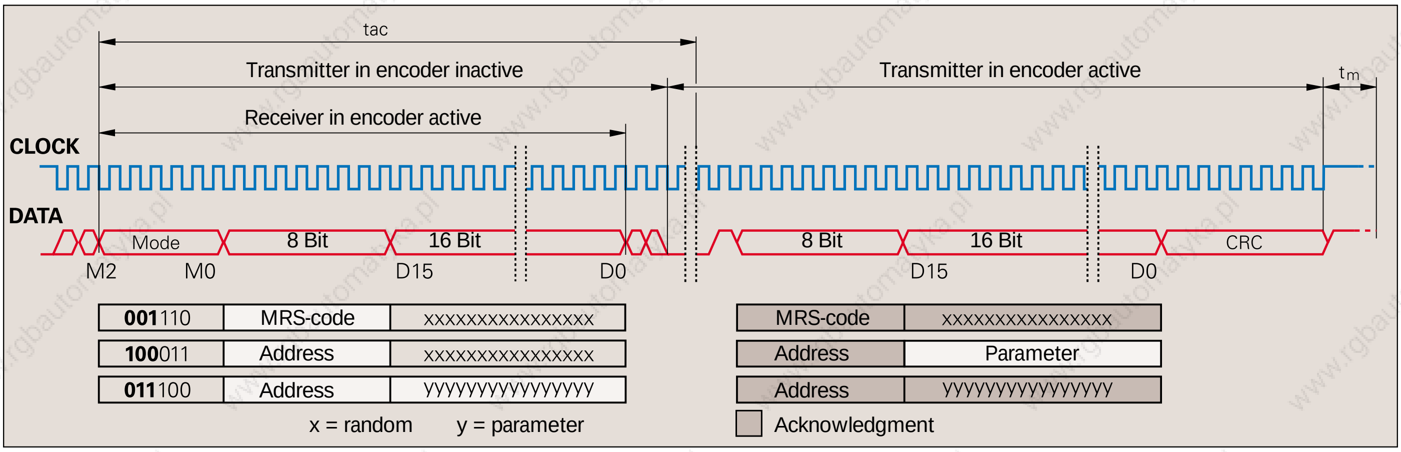
		ROC, ECN, ROQ, EQN*	RCN**	LC
Clock frequency	f_C	100 kHz to 2 MHz		
Calculation time for **– Position value** **– Parameter**	 t_{cal} t_{ac}	 250 ns Max. 12 ms	 10 µs Max. 12 ms	 1 ms Max. 12 ms
Recovery time	t_m	10 to 30 µs		
HIGH pulse width	t_{HI}	0.2 to 10 µs		
LOW pulse width	t_{LO}	0.2 µs to 50 ms		0.2 to 30 µs

*) See ***Rotary Encoders*** catalog
) See ***Angle Encoders* catalog

Control cycles for transfer of parameters (mode command 001110)
Before parameter transfer, the memory area is determined with the mode command *select the memory area* and a subsequent memory-range-select code (MRS). The possible memory areas are stored in the parameters of the encoder manufacturer. Due to the internal access times to the individual memory areas, the calculating time t_{cal} may reach 12 ms.

Reading parameters from the encoder (mode command 100011)
After selecting the memory area, the subsequent electronics transmits a complete communications protocol beginning with the mode command *encoder transmit parameters,* followed by an 8 bit address and 16 bits with random content. The encoder answers with the repetition of the address and 16 bits with the contents of the parameter. The transmission cycle is concluded with a CRC check.

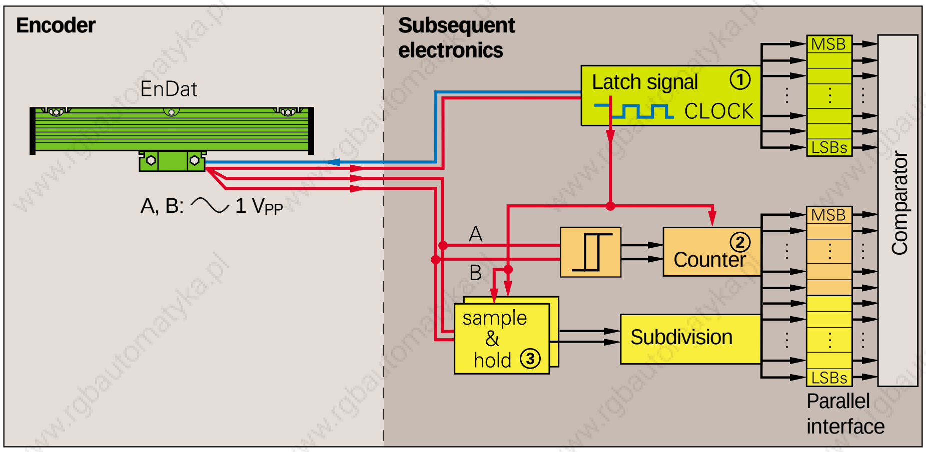
Writing parameters to the encoder (mode command 011100)
After selecting the memory area, the subsequent electronics transmit a complete communications protocol beginning with the mode command *encoder receive parameters,* followed by an 8-bit address and a 16-bit parameter value. The encoder answers by repeating the address and the contents of the parameter. The CRC check concludes the cycle.



Synchronization of the serially transferred code value with the incremental signal
Absolute encoders with EnDat interface can exactly synchronize serially transmitted absolute position values with incremental values. With the first falling edge (latch signal) of the CLOCK signal from the subsequent electronics, the scanning signals of the individual tracks in the encoder and counter are frozen, as are also the A/D converters for subdividing the sinusoidal incremental signals in the subsequent electronics.

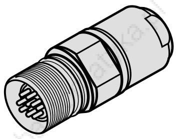
The code value transmitted over the serial interface unambiguously identifies one incremental signal period. The position value is absolute within one sinusoidal period of the incremental signal. The subdivided incremental signal can therefore be appended in the subsequent electronics to the serially transmitted code value. This makes it possible to increase the resolution of the absolute rotary encoder. For example, a 1024-fold subdivision in the subsequent electronics and a signal period of 16 µm results in 64 000 absolute measuring steps per millimeter traverse.

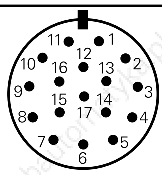
After power on and initial transmission of position values, two redundant position values are available in the subsequent electronics. Since encoders with EnDat interface guarantee a precise synchronization—regardless of cable length—of the serially transmitted absolute value with the incremental signals, the two values can be compared in the subsequent electronics. This capability is a prerequisite for modern machine design and safety concepts.



EnDat Pin Layout

17-pin HEIDENHAIN coupling



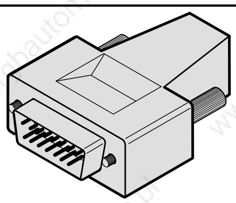


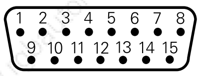
	15	16	12	13	3	2	7	10	1	4	11
	A		**B**		**Vacant**	**Vacant**	**U_P**	**0 V** (U_N)	**U_P** Sensor	**0 V** Sensor	**Internal shield**
	+	–	+	–							
Wire	Green/ Black	Yellow/ Black	Blue/ Black	Red/ Black	Red	Black	Brown/ Green	White/ Green	Blue	White	/
							IEC 742 EN 50 178				

	14	17	8	9	5	6
	DATA	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**	**Vacant**	**Vacant**
Wire	Gray	Pink	Violet	Yellow	/	/

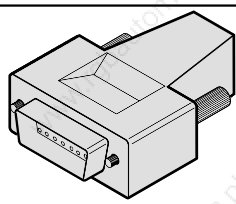
Shield is on housing;
U_P = power supply
Sensor is connected internally with the respective power supply.
Vacant pins or wires must not be used.

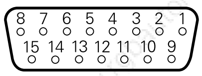
15-pin D-sub connector, male,
on HEIDENHAIN adapter cable for IK 115





15-pin D-sub connector, female,
on HEIDENHAIN connecting cable for HEIDENHAIN controls and IK 220





Male	1	9	3	11	14	7	4	2	12	10	6
Female	3	4	6	7	10	12	1	2	9	11	13
	A		**B**		**Vacant**	**Vacant**	**U_P**	**0 V** (U_N)	**U_P** Sensor	**0 V** Sensor	**Internal shield**
	+	–	+	–							
Wire	Green/ Black	Yellow/ Black	Blue/ Black	Red/ Black	Red	Black	Brown/ Green	White/ Green	Blue	White	/
							EN 50 178				

Male	5	13	8	15
Female	5	8	14	15
	DATA	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
Wire	Gray	Pink	Violet	Yellow

Shield is on housing;
U_P = power supply
Sensor is connected internally with the respective power supply.
Vacant pins or wires must not be used.

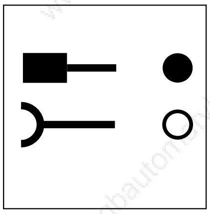
Connecting Elements and Cables
General Information

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

Contacts:

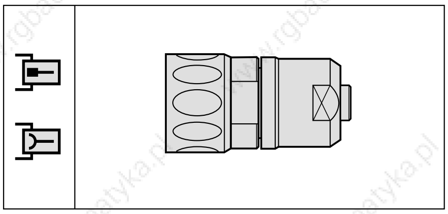
Male contact

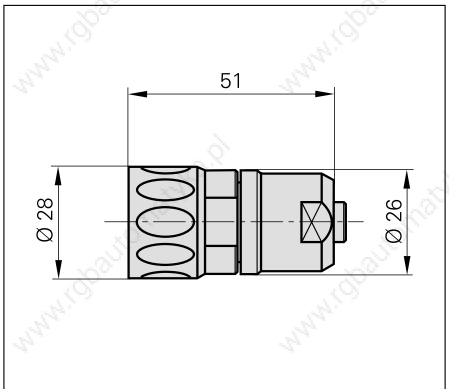
Female contact



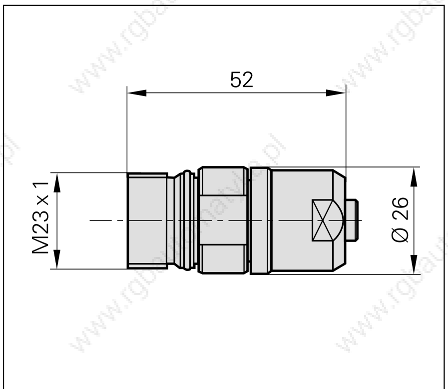
Protection: When engaged, the connections (except for the D-sub connector) provide protection to IP 67 **(IEC 60529).** When not engaged, there is no protection (IP 00).

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



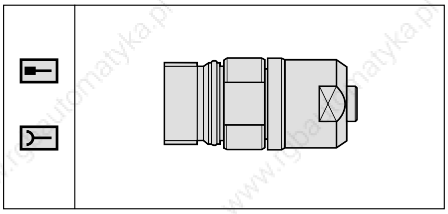


Connector insulated

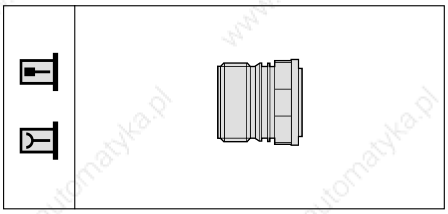


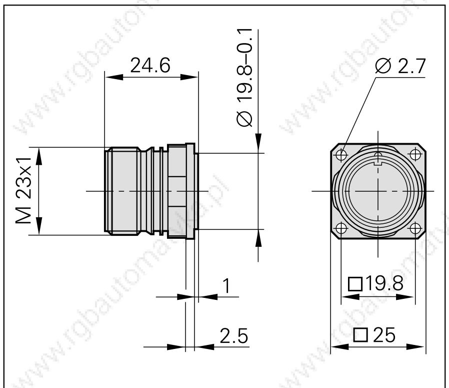
Coupling insulated

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

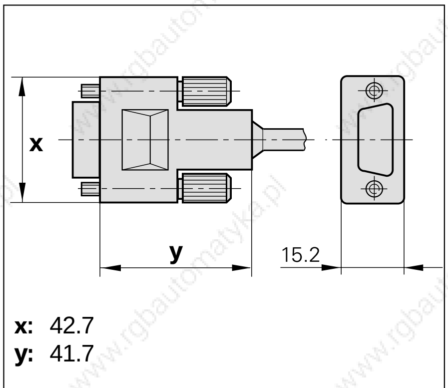


Flange socket: A flange socket is intended for permanent mounting on the encoder, the mounting block or the machine housing, has an external thread (like a coupling), and is available with male or female contacts.



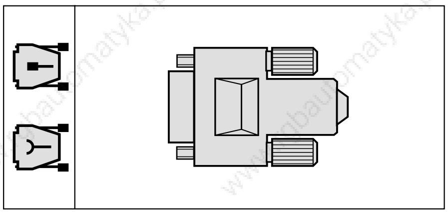


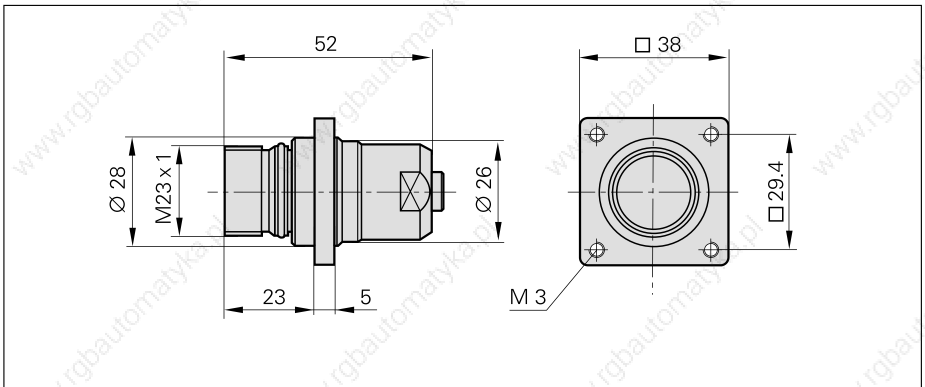
Flange socket



D-sub connector

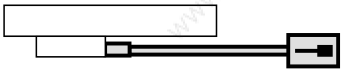
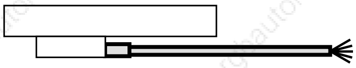
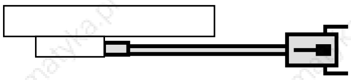
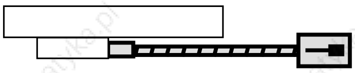
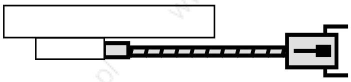
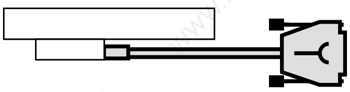
D-sub connector: D-sub connectors fit on HEIDENHAIN controls and IK counter cards.



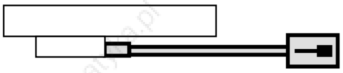
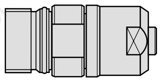
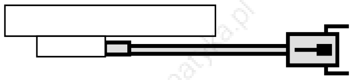
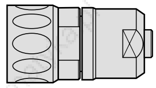


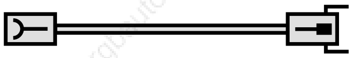
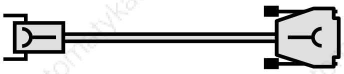
Coupling on mounting base insulated

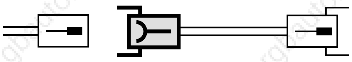
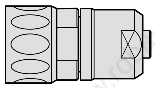
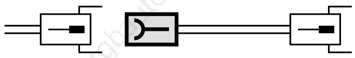
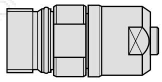
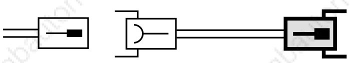
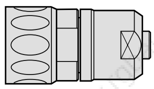
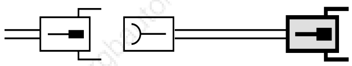
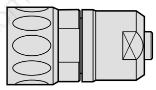
Adapter Cables

	⊓⊔ TTL and ∿ 1 V_{PP}		EnDat	⊓⊔ TTL and ∿ 1 V_{PP}		EnDat
	LB 382, LF 183, LS 176, LS 186	**LS 623, LS 629**	**LC 181**	**LF 481, LS 476, LS 486**	**LS 477, LS 487**	**LC 481**
Adapter cable with coupling (male)  **Cable Ø 6 mm**	310128-xx	–	369124-xx	310123-xx	360645-xx	369129-xx
Adapter cable without connector  **Cable Ø 6 mm**	310131-xx	269502-xx	–	310134-xx	354319-xx	–
Adapter cable with connector (male)  **Cable Ø 6 mm**	310127-xx	310735-xx	–	310122-xx	344228-xx	–
Cable Ø 4.5 mm	–	–	–	–	352611-xx	–
Adapter cable in armor with coupling (male)  **Cable Ø 10 mm**	–	–	316128-xx	–	–	369133-xx
Adapter cable in armor with connector (male)  **Cable Ø 10 mm**	310126-xx	310738-xx[1]	–	310121-xx	344451-xx	–
Adapter cable with D-sub connector (15-pin) for HEIDENHAIN controls and for IK 220  **Cable Ø 6 mm**	298429-xx	–	370737-xx[2]	298430-xx	360974-xx	370747-xx[2]

Available cable lengths: 1 m/3 m/6 m/9 m
[1] Cable lengths 1 m/3 m/6 m
[2] Cable lengths 1 m/3 m/6 m/9 m/12 m/15 m

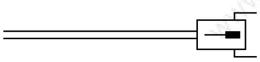
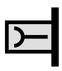
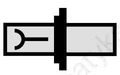
Coupling on encoder cable	Coupling (male)	Connector on encoder cable	Connector (male)
			
For encoder cable ∅ 6 mm	12-pin 291 698-03 17-pin 296 698-26	For encoder cable ∅ 4.5 mm ∅ 6 mm	12-pin 291 697-06 12-pin 291 697-07

Polyurethane (PUR) connecting cable ∅ 8 mm for encoders with coupling or flange socket		**Polyurethane (PUR) connecting cable ∅ 8 mm for encoders with connector**	
Complete with connector (female) and connector (male) 	12-pin 298 399-xx	**Complete** with coupling (female) and connector (male) 	12-pin 298 400-xx
Complete with connector (female) and D-sub connector (female) for IK 220 and HEIDENHAIN controls 	12-pin 310 199-xx 17-pin 332 115-xx	**With one coupling** (female) 	12-pin 298 402-xx
With one connector (female) 	12-pin 309 777-xx 17-pin 309 778-xx		

Mating element on connecting cable to encoder coupling or flange socket	Connector (female)	Mating element on connecting cable to the encoder connector	Coupling (female)
			
For encoder cable ∅ 8 mm	12-pin 291 697-05 17-pin 291 697-26	For encoder cable ∅ 8 mm	12-pin 291 698-02
Connector on connecting cable to subsequent electronics 	**Connector (male)** 	**Connector on connecting cable** to subsequent electronics 	**Connector (male)** 
For encoder cable ∅ 8 mm	12-pin 291 697-08 17-pin 291 697-27	For encoder cable ∅ 8 mm	12-pin 291 697-08

Cable only			
	12-pin	244 957-01	[4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)]
	17-pin	266 306-01	[(4 x 0.14 mm^2) + 4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)]

Flange socket for connecting cable to subsequent electronics

Flange socket (female), 12-pin 315 892-08
17-pin 315 892-10

Coupling on mounting base (female), for cable ∅ 8 mm, 12-pin: 291 698-07

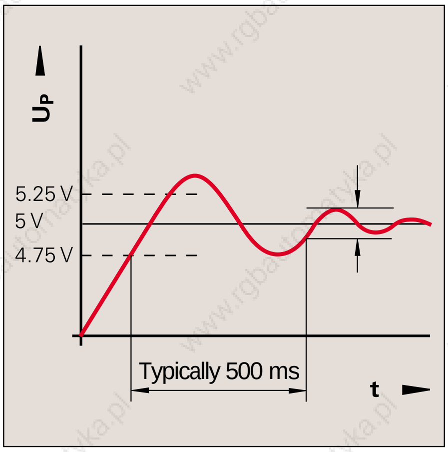
General Electrical Specifications

Power Supply

A **stabilized dc voltage** is necessary as the power supply for the angle encoders. The voltage and current consumption are given in the individual specifications.
The permissible ripple amplitude of the dc voltage is:

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

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



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

The **voltage drop** for HEIDENHAIN cable is calculated as:

$$\Delta U[V] = 2 \cdot 10^{-3} \cdot \frac{L_C[m] \cdot I[mA]}{56 \cdot A_P[mm^2]}$$

Where L_C: Cable length
I: Current consumption of angle encoder (see *Specifications*)
A_P: Cross section of power line

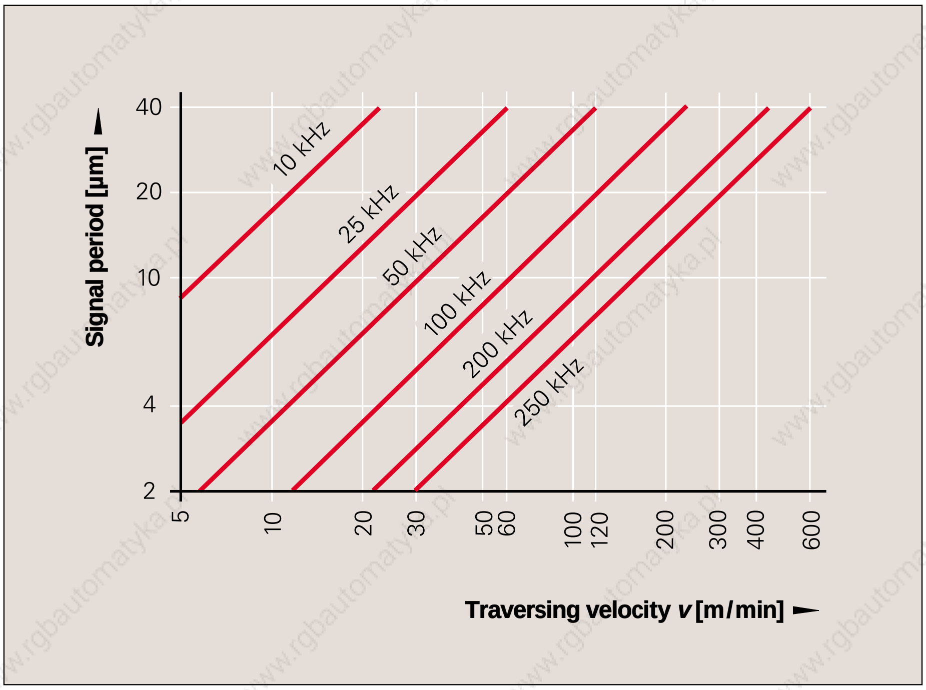
Electrically Permissible Traversing Speed

Permissible traversing velocity
The maximum permissible traversing velocity of an incremental linear encoder is derived from

- the **mechanically permissible traversing velocity** for sealed linear encoders (see *Specifications*)
- the **electrically permissible traversing velocity.**
  For **linear encoders with sinusoidal signals** the electrically permissible traversing velocity is limited by the –3dB cutoff frequency of the encoder and the input frequency f_{max} of the subsequent electronics.
  For **linear encoders with square-wave signals** the electrically permissible traversing velocity is limited by
  – the maximum permissible scanning frequency f_{max} of the linear encoder and
  – the **minimum edge separation *a*** for the subsequent electronics.

$$v_{max} = f_{max}\,[kHz] \cdot SP\,[µm] \cdot 10^{-3} \cdot 60\ min^{-1}$$

where v_{max}: Maximum electrically permissible traversing velocity
f_{max}: Maximum output frequency of the encoder or input frequency of the subsequent electronics
SP: Signal period of the encoder



Resultant traversing velocity with respect to the signal period and the permissible input frequency of the subsequent electronics

Cable

Durability
All linear encoders use polyurethane cables resistant to oil, hydrolysis and microbes in accordance with VDE 0672. They are free of PVC and silicone and comply with UL safety directives. The UL certification AWM STYLE 20963 80 °C 30V E63216 is documented on the cable.

Bend radius
The permissible bending radii R depend on the cable diameter:

Cable diameter 4.5 mm (0.18 in.)

Rigid configuration	**R** ≥ 10 mm (0.4 in.)
Frequent flexing	**R** ≥ 50 mm (2 in.)

Cable diameter 6 mm (0.24 in.)

Rigid configuration	**R** ≥ 20 mm (0.8 in.)
Frequent flexing	**R** ≥ 75 mm (3 in.)

Cable diameter 8 mm (0.31 in.)

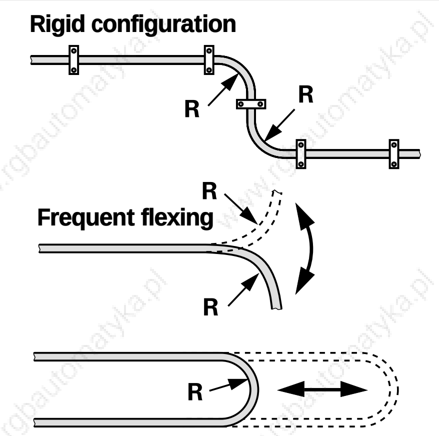
Rigid configuration	**R** ≥ 40 mm (1.6 in.)
Frequent flexing	**R** ≥ 100 mm (4 in.)

Cable diameter 10 mm (0.39 in.)
with metal armor

Rigid configuration	**R** ≥ 35 mm (1.4 in.)
Frequent flexing	**R** ≥ 75 mm (3 in.)

Cable diameter 14 mm (0.55 in.)
with metal armor

Rigid configuration	**R** ≥ 50 mm (2 in.)
Frequent flexing	**R** ≥ 100 mm (4 in.)



Temperature range
HEIDENHAIN cable can be used at:
for stationary configuration
–40 to 85° C (–40 to 185° F)
for frequent flexing
–10 to 85° C (14° to 185 °F)

Cables with limited resistance to hydrolysis and microbes are rated for up to 100 °C (212 °F).

Reliable Signal Transmission

Electromagnetic compatibility
When properly installed, HEIDENHAIN linear encoders fulfill the requirement for electromagnetic compatibility according to 89/336/EWG. Compliance with the regulations of the EMC Guidelines is based on conformance to the following standards:

- **IEC 61000-6-2**
  Electromagnetic Compatibility—Generic Immunity Standard
  Specifically:
  – ESD IEC 61000-4-2
  – Electromagnetic fields IEC 61000-4-3
  – Burst IEC 61000-4-4
  – Surge IEC 61000-4-5
  – Conducted disturbances IEC 61000-4-6
  – Power frequency magnetic fields IEC 61000-4-8
  – Pulse magnetic fields IEC 61000-4-9
- **EN 50 081-1**
  Electromagnetic Compatibility—Generic Emission Standard
  Specifically:
  – for industrial, scientific and medical (ISM) equipment 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 are:

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

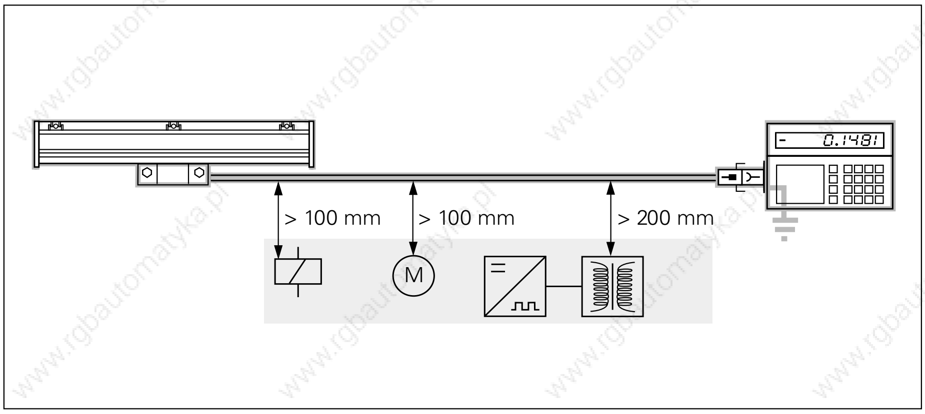
Isolation
The encoder housings are isolated from the electronics.

Dielectric strength	500 V/50 Hz for max. 1 minute
Air clearance and leakage distance	> 1 mm
Insulation resistance	> 50 MΩ

Protection against electrical noise

- Use only the recommended **HEIDENHAIN cable** for signal lines.
- To connect signal lines, use only **HEIDENHAIN connecting elements.**
- The shielding should conform to **EN 50178.**
- Do not lay signal cable in the direct vicinity of interference sources (air clearance > 100 mm).
- A minimum spacing of 200 mm to inductors is usually required (such as in switch-mode power supplies).
- Connect linear encoders only to devices whose power supplies comply with **EN 50178** (protective low voltage).
- Configure the signal lines for minimum length and avoid the use of intermediate terminals.
- In metal cable ducts, signal lines can usually be sufficiently isolated against interference from other signal transmitting cables by means of a grounded partition.

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



Minimum distance from sources of interference

Evaluation Electronics

IBV 600 Series
Interpolation and digitizing electronics

The IBV 600 series features one input for incremental linear or angle encoders with sinusoidal output signals and a signal level of 1 VPP. It provides TTL-compatible square-wave output signals over a flange socket.

The IBV 606 provides output signals at two flange sockets simultaneously. The connections inside the IBV 606 can be changed so that either flange socket or both flange sockets deliver sinusoidal voltage signals with a signal level of 1 VPP instead of square-wave output signals.

The required 5 V ±5% power supply must be provided by the subsequent electronics.

Model		Inter-polation	Input frequency f_i	Minimum edge separation *a*	Smallest possible measuring step LF	LS	LB
IBV 600		Without	600 kHz	0.2 µs	1 µm	5 µm	10 µm
IBV 606		2-fold	500 kHz	0.15 µs	0.5 µm	5 µm	5 µm
IBV 610	Adjustable	5-fold	200 kHz 100 kHz 50 kHz 25 kHz	0.25 µs 0.5 µs 1 µs 2 µs	0.2 µm	1 µm	2 µm
		10-fold	200 kHz 100 kHz 50 kHz 25 kHz	0.125 µs 0.25 µs 0.5 µs 1 µs	0.1 µm	0.5 µm	1 µm
IBV 650		50-fold	40 kHz 20 kHz 10 kHz 5 kHz	0.125 µs 0.25 µs 0.5 µs 1 µs	0.02 µm	0.1 µm	0.2 µm
IBV 660B	Adjustable	25-fold	100 kHz 50 kHz 25 kHz 12.5 kHz	0.1 µs 0.2 µs 0.4 µs 0.8 µs	0.04 µm	0.2 µm	0.4 µm
		50-fold	50 kHz 25 kHz 12.5 kHz 6.25 kHz	0.1 µs 0.2 µs 0.4 µs 0.8 µs	0.02 µm	0.1 µm	0.2 µm
		100-fold	25 kHz 12.5 kHz 6.25 kHz 3.12 kHz	0.1 µs 0.2 µs 0.4 µs 0.8 µs	0.01 µm	0.05 µm	0.1 µm
		200-fold	12.5 kHz 6.25 kHz 3.12 kHz 1.56 kHz	0.1 µs 0.2 µs 0.4 µs 0.8 µs	0.005 µm	0.025 µm	0.05 µm
		400-fold	6.25 kHz 3.12 kHz 1.56 kHz 0.78 kHz	0.1 µs 0.2 µs 0.4 µs 0.8 µs	0.0025 µm	0.0125 µm	0.025 µm

☐ Recommended only for speed control

For more information on the listed interpolation and digitizing electronics as well as on electronics for several machine axes, ask for the separate brochure *Interpolation and Digitizing Electronics.*

IK 220
Universal PC counter card
The IK 220 is an adapter card for AT compatible PCs for measured value acquisition of **two incremental or absolute linear and angular encoders.** The subdivision and counting electronics **subdivide** the **sinusoidal input signals** up to **4096-fold.** Driver software is included.

For more information, see the *IK 220* data sheet.

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

IK 410 V
Counter card with 16-bit microcomputer interface
The IK 410 V is an interpolation and counter PCB for incremental encoders with additional input for commutation signals (Z1-track: one sine/cosine per revolution). It is inserted directly into the PCB of the customer-specific electronics.

For more information, see the *IK 410 V* data sheet.

	IK 410 V
Encoder inputs	Incremental signals: 1 × ∼ 1 V_{PP} Commutation signals: 1 × sine/ cosine (1 V_{PP})
Signal subdivision	Up to 1024-fold (signal period : measuring step)
Input frequency	Max. 350 kHz
Counter	32 bits
Interface	16-bit microcomputer interface
Driver software	Borland C and C++, Turbo-Pascal
Data format	MOTOROLA or INTEL format
Dimensions	100 mm × 65 mm
Permissible cable length	60 m (197 ft)

HEIDENHAIN Measuring and Testing Equipment

For Incremental Encoders

The **PWM 8** is a universal measuring device for checking and adjusting HEIDENHAIN incremental encoders. There are various expansion modules available for checking different encoder signals. The values can be read on a small LCD monitor. Soft keys provide ease of operation.

	PWM 8
Encoder inputs	11 μA_{PP}/1 V_{PP}/TTL/HTL signals via expansion modules
Functions	• Measuring the: signal amplitudes, current consumption, power supply • Display of: phase angle, on-off ratio, scanning frequency • Display symbols for: reference signal, disturbance signal, count direction • Integrated universal counter
Outputs	Incremental signals for subsequent electronics Incremental signals for oscilloscope via BNC sockets
Power supply	10 to 30 V, max. 15 W
Dimensions	150 mm × 205 mm × 96 mm

For Absolute Encoders

The **IK 115** is a PC expansion card for monitoring and testing absolute HEIDENHAIN encoders with EnDat or SSI interface. Parameters can be read and written via the EnDat interface.

	IK 115
Encoder input	EnDat (absolute value and incremental signals) or SSI
Interface	ISA bus
Application software	**Operating system:** Windows 95/98 **Functions:** Display position value Counter for incremental signals EnDat functionality
Signal subdivision for incremental signals	Up to 1024-fold
Dimensions	158 mm x 107 mm