HEIDENHAIN

Linear Encoders

for Numerically Controlled
Machine Tools

September 2005

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

Product brochures:
- Exposed Linear Encoders
- Angle Encoders
- Rotary Encoders
- HEIDENHAIN subsequent electronics
- HEIDENHAIN controls
- Measuring Systems for Machine Tool Inspection and Acceptance Testing

Technical Information brochures:
- Accuracy of Feed Axes
- Sealed Linear Encoders with Single-Field Scanning
- EnDat 2.2 – Bidirectional Interface for Position Encoders
- Encoders for Direct Drives

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

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

Content

Linear Encoders for NC-Controlled Machine Tools

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

HEIDENHAIN also supplies linear encoders for other applications, such as

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

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

Advantages of linear encoders
Linear encoders measure the position of linear axes without additional mechanical transfer elements. The control loop for position control with a linear encoder also includes the entire feed mechanics. Transfer errors from the mechanics can be detected by the linear encoder on the slide, and corrected by the control electronics. This can eliminate a number of potential error sources:

- Positioning error due to thermal behavior of the recirculating ball screw
- Backlash
- Kinematic error through ball-screw pitch error

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

Mechanical design
The linear encoders for NC-controlled machine tools are sealed encoders: An aluminum housing protects the scale, scanning carriage and its guideway from chips, dust, and fluids. Downward-oriented elastic lips seal the housing.

The scanning carriage travels in a low-friction guide within the scale unit. A coupling connects the scanning carriage with the mounting block and compensates the misalignment between the scale and the machine guideways.

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

Thermal behavior
The combination of increasingly rapid machining processes with completely enclosed machines leads to ever-increasing temperatures within the machine's work envelope. Therefore, the thermal behavior of the linear encoders used becomes increasingly important, since it is an essential criterion for the working accuracy of the machine.

As a general rule, the thermal behavior of the linear encoder should match that of the workpiece or measured object. During temperature changes, the linear encoder must expand or retract in a defined, reproducible manner. Linear encoders from HEIDENHAIN are designed for this.

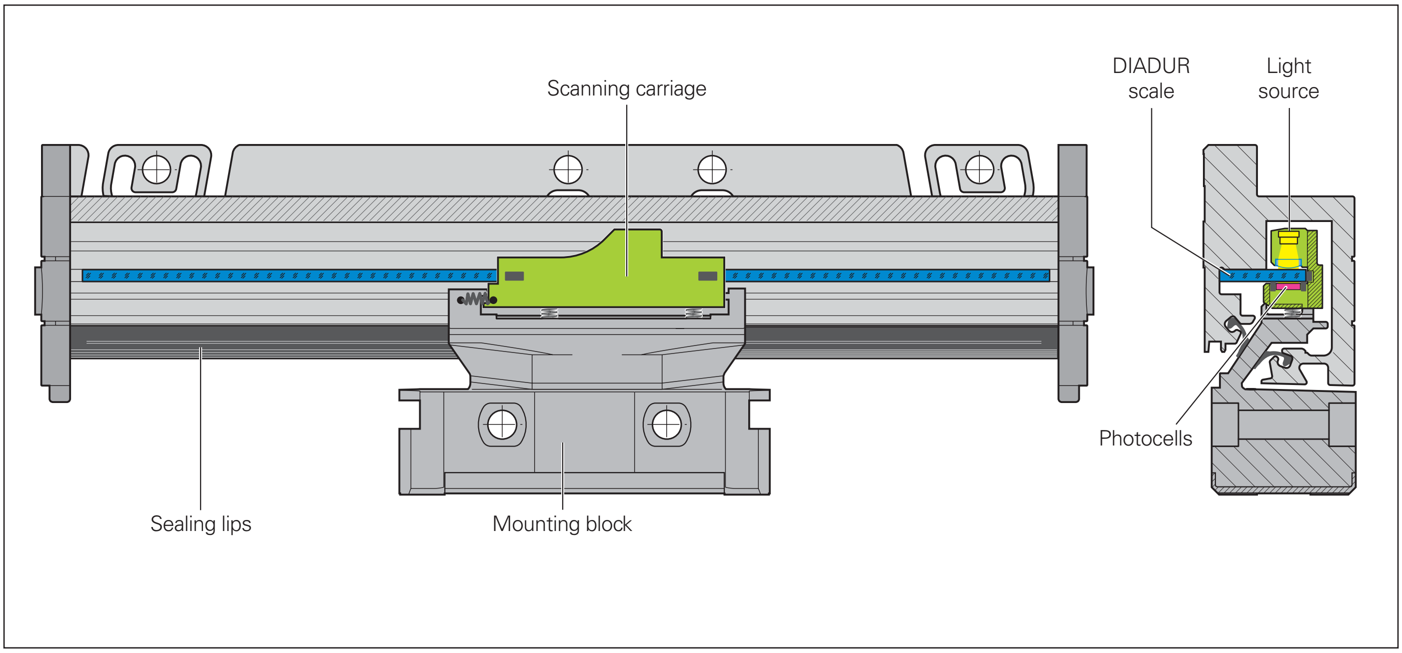
The graduation carriers of HEIDENHAIN linear encoders have defined coefficients of thermal expansion (see *Specifications*). This makes it possible to select the linear encoder whose thermal behavior is best suited to the application.

Dynamic behavior
The constant increases in efficiency and performance of machine tools necessitate ever-higher feed rates and accelerations, while at the same time the high level of machining accuracy must be maintained. In order to transfer rapid and yet exact feed motions, very high demands are placed on rigid machine design as well as on the linear encoders used.

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

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

Due to the details of their design, linear encoders from HEIDENHAIN function properly even after years of operation. The contact-free principle of photoelectrically scanning the measuring standard, as well as the ball-bearing guidance of the scanning carriage in the scale housing ensure a long lifetime. This encapsulation, the special scanning principles and, if needed, the introduction of compressed air, make the linear encoders very resistant to contamination. The complete shielding concept ensures a high degree of electrical noise immunity.



Schematic design of the **LC 183** sealed linear encoder

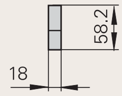
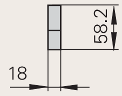
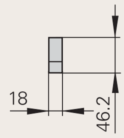
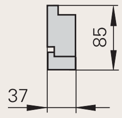
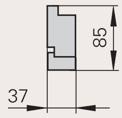
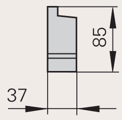
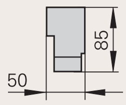
Selection Guide

Linear encoders with slimline scale housing

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

Linear encoders with full-size scale housing

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

	Cross section	Measuring step[1]	Accuracy grade	Measuring length
Absolute linear measurement • Glass scale		To 0.1 µm	± 5 µm ± 3 µm	70 mm to 1240 mm *With mounting spar or clamping elements:* 70 mm to 2040 mm
Incremental linear measurement with very high repeatability • Steel scale • Small signal period		To 0.1 µm	± 3 µm ± 2 µm	50 mm to 1220 mm
Incremental linear measurement • Glass scale		To 0.5 µm	± 5 µm ± 3 µm	70 mm to 1240 mm *With mounting spar:* 70 mm to 2040 mm
Absolute linear measurement • Glass scale		To 0.1 µm	± 5 µm ± 3 µm	140 mm to 4240 mm
Incremental linear measurement with very high repeatability • Steel scale • Small signal period		To 0.1 µm	± 3 µm ± 2 µm	140 mm to 3040 mm
Incremental linear measurement • Glass scale		To 0.5 µm	± 5 µm ± 3 µm	140 mm to 3040 mm
Incremental linear measurement for large measuring lengths • Steel scale tape		To 0.1 µm	± 5 µm	440 mm to 30040 mm

[1] Recommended for position measurement
[2] Available in 2006

Scanning Principle	Incremental signals Signal period	Absolute position values	Model	Page
Single-field scanning	∿ 1 V_{PP}; 20 µm	EnDat 2.2	**LC 483**[2)]	**18**
	–	Fanuc 02	**LC 493F**[2)]	
	–	Mitsubishi	**LC 493M**[2)]	
Single-field scanning	∿ 1 V_{PP}; 4 µm	–	**LF 481**	**22**
Single-field scanning	∿ 1 V_{PP}; 20 µm	–	**LS 487**[2)]	**26**
Single-field scanning	∿ 1 V_{PP}; 20 µm	EnDat 2.2	**LC 183**[2)]	**20**
	–	Fanuc 02	**LC 193F**[2)]	
	–	Mitsubishi	**LC 193M**[2)]	
Single-field scanning	∿ 1 V_{PP}; 4 µm	–	**LF 183**	**24**
Single-field scanning	∿ 1 V_{PP}; 20 µm	–	**LS 187**[2)]	**28**
Single-field scanning	∿ 1 V_{PP}; 20 µm		**LB 382**	**30**

LC 483

LS 487

LC 183

LF 183

LB 382

Measuring Principles
Measuring Standard

HEIDENHAIN encoders with optical scanning incorporate measuring standards of periodic structures known as graduations. These graduations are applied to a carrier substrate of glass or steel. The scale substrate for large measuring lengths is a steel tape.

These precision graduations are manufactured in various photolithographic processes. Graduations can be fabricated from:
- extremely hard chromium lines on glass,
- matte-etched lines on gold-plated steel tape, or
- three-dimensional grid structures on glass or steel substrates.

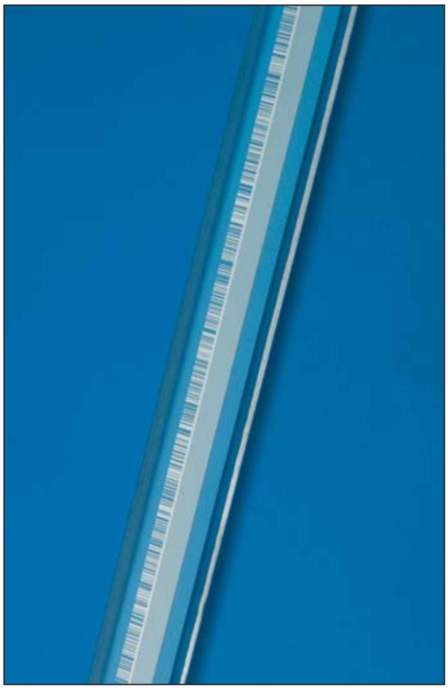
The photolithographic manufacturing processes developed by HEIDENHAIN produce grating periods of typically 40 µm to 4 µm.

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

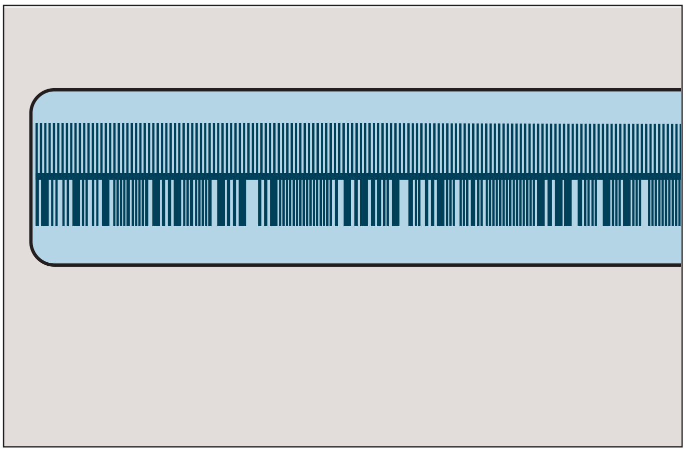
The master graduations are manufactured by HEIDENHAIN on custom-built high-precision ruling machines.

Absolute Measuring Method

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



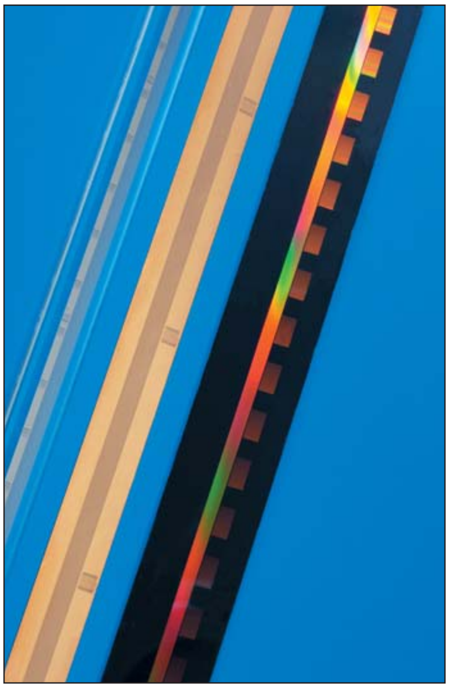
Graduation of an absolute linear encoder



Schematic representation of an absolute code structure with an additional incremental track (LC 483 as example)

Incremental Measuring Method

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



Graduation of an incremental linear encoder

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" after the model designation (e.g. LS 487 C).

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

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

where:

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

and:

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

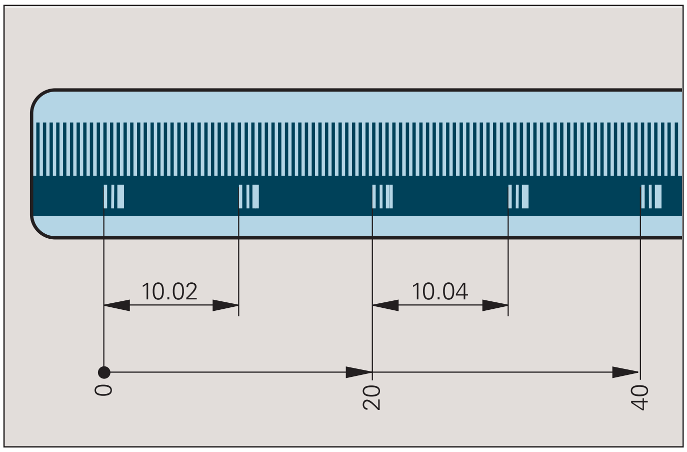
abs = Absolute value

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)

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



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

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

Photoelectric Scanning

Most HEIDENHAIN encoders operate using the principle of photoelectric scanning. The photoelectric scanning of a measuring standard is contact-free, and therefore without wear. This method detects even very fine lines, no more than a few microns wide, and generates output signals with very small signal periods.

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

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

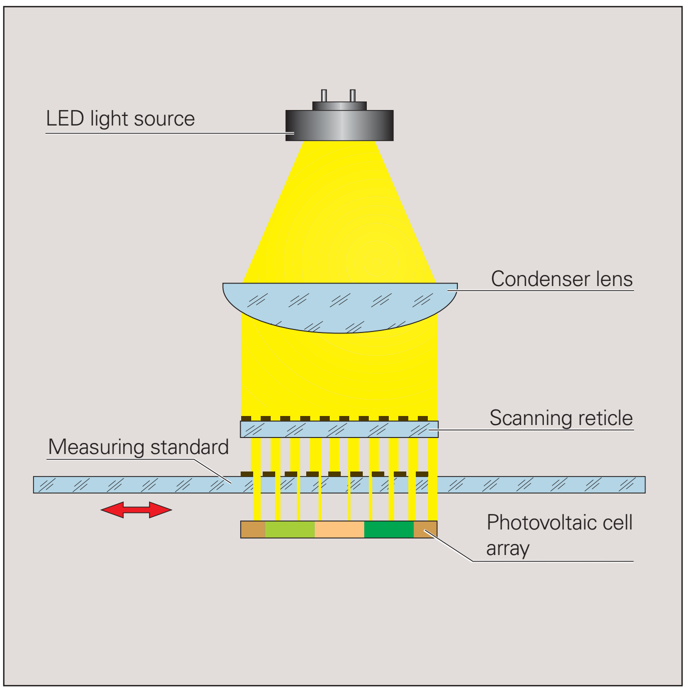
Imaging scanning principle
To put it simply, the imaging scanning principle functions by means of projected-light signal generation: two scale gratings with equal or similar grating periods are moved relative to each other—the scale and the scanning reticle. The carrier material of the scanning reticle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

When parallel light passes through a grating, light and dark surfaces are projected at a certain distance, where there is an index grating. When the two gratings move relative to each other, the incident light is modulated. If the gaps in the gratings are aligned, light passes through. If the lines of one grating coincide with the gaps of the other, no light passes through.

An array of photovoltaic cells converts these variations in light intensity into electrical signals. The specially structured grating of the scanning reticle filters the light current to generate nearly sinusoidal output signals. The smaller the period of the grating structure is, the closer and more tightly toleranced the gap must be between the scanning reticle and scale.

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

Imaging scanning principle



Interferential scanning principle
The interferential scanning principle exploits the diffraction and interference of light on a fine graduation to produce signals used to measure displacement.
A step grating is used as the measuring standard: reflective lines 0.2 µm high are applied to a flat, reflective surface. In front of that is the scanning reticle—a transparent phase grating with the same grating period as the scale.

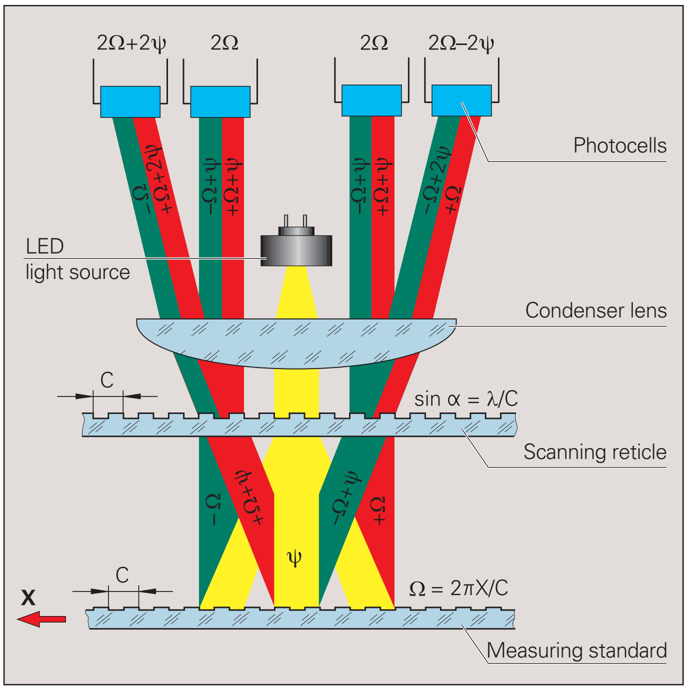
When a light wave passes through the scanning reticle, it is diffracted into three partial waves of the orders –1, 0, and +1, with approximately equal luminous intensity. The waves are diffracted by the scale such that most of the luminous intensity is found in the reflected diffraction orders +1 and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

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

Interferential encoders function with grating periods of, for example, 8 µm, 4 µm and finer. Their scanning signals are largely free of harmonics and can be highly interpolated. These encoders are therefore especially suited for high resolution and high accuracy.

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

Interferential scanning principle (optics schematics)
C Grating period
ψ Phase shift of the light wave when passing through the scanning reticle
Ω Phase shift of the light wave due to motion X of the scale



Measuring Accuracy

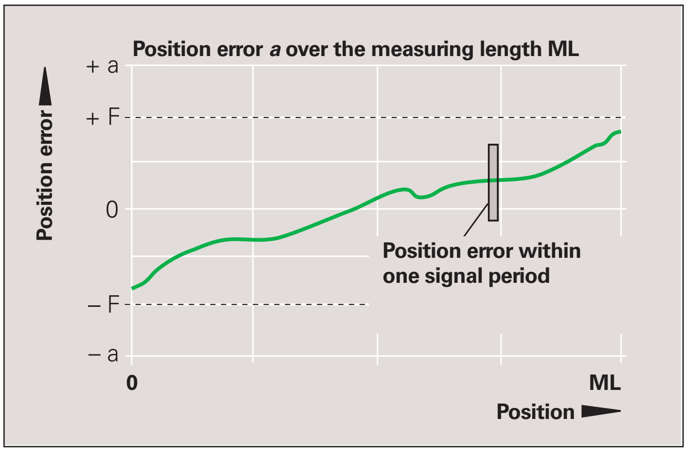
The accuracy of linear measurement is mainly determined by:

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

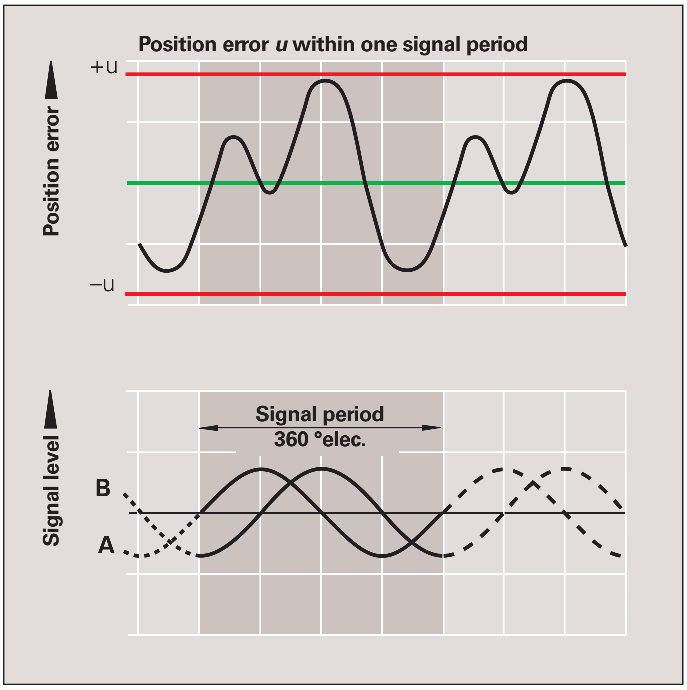
A distinction is made between position errors over relatively large paths of traverse—for example the entire measuring length—and those within one signal period.

Position error over the measuring range
The accuracy of sealed linear encoders is specified in grades, which are defined as follows:
The extreme values ±F of the measuring curves over any max. one-meter section of the measuring length lie within the accuracy grade ±a. They are ascertained during the final inspection, and are indicated on the calibration chart.

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



Position error within one signal period
The position error within one signal period is determined by the signal period of the encoder, as well as the quality of the graduation and the scanning thereof. At any measuring position, it does not exceed ±2% of the signal period, and for the LC absolute linear encoders it is typically ±1%. The smaller the signal period, the smaller the position error within one signal period.



	Signal period of scanning signals	Max. position error *u* within one signal period
LF	± 4 µm	Approx. 0.08 µm
LC	± 20 µm	Approx. 0.2 µm
LS	± 20 µm	Approx. 0.4 µm
LB	± 40 µm	Approx. 0.8 µm

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

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

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

For the LC, LF and LS series listed in this brochure, a **calibration chart** documents the position error over the measuring length, and also states the measuring step and measuring uncertainty of the calibration.

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

The **operating temperature range** indicates the ambient temperature limits between which the linear encoders will function properly. The **storage temperature range** of –20 °C to 70 °C applies for the device in its packaging.

LC 483 * S.Nr. 15623802C * Id.Nr. 557650-12

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:	**Kalibrierzeichen:**
Jod-stabilisierter He-Ne Laser	**3659 PTB 02**
Wasser-Tripelpunktzelle	**171 PTB 02**
Gallium-Schmelzpunktzelle	**170 PTB 02**
Barometer	**4317 DKD-K-02301 03-06**
Luftfeuchtemessgerät	**01039 DKD-K-00305 03-04**

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:	***Calibration reference:***
Iodine-stabilized He-Ne Laser	***3659 PTB 02***
Water triple point cell	***171 PTB 02***
Gallium melting point cell	***170 PTB 02***
Pressure gauge	***4317 DKD-K-02301 03-06***
Hygrometer	***01039 DKD-K-00305 03-0***

Relative humidity: max. 50 %

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

208 924-91

Prüfer/Inspected by
MUSSNER G. / 07.04.2005

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:

$F = Pos_N - Pos_M$

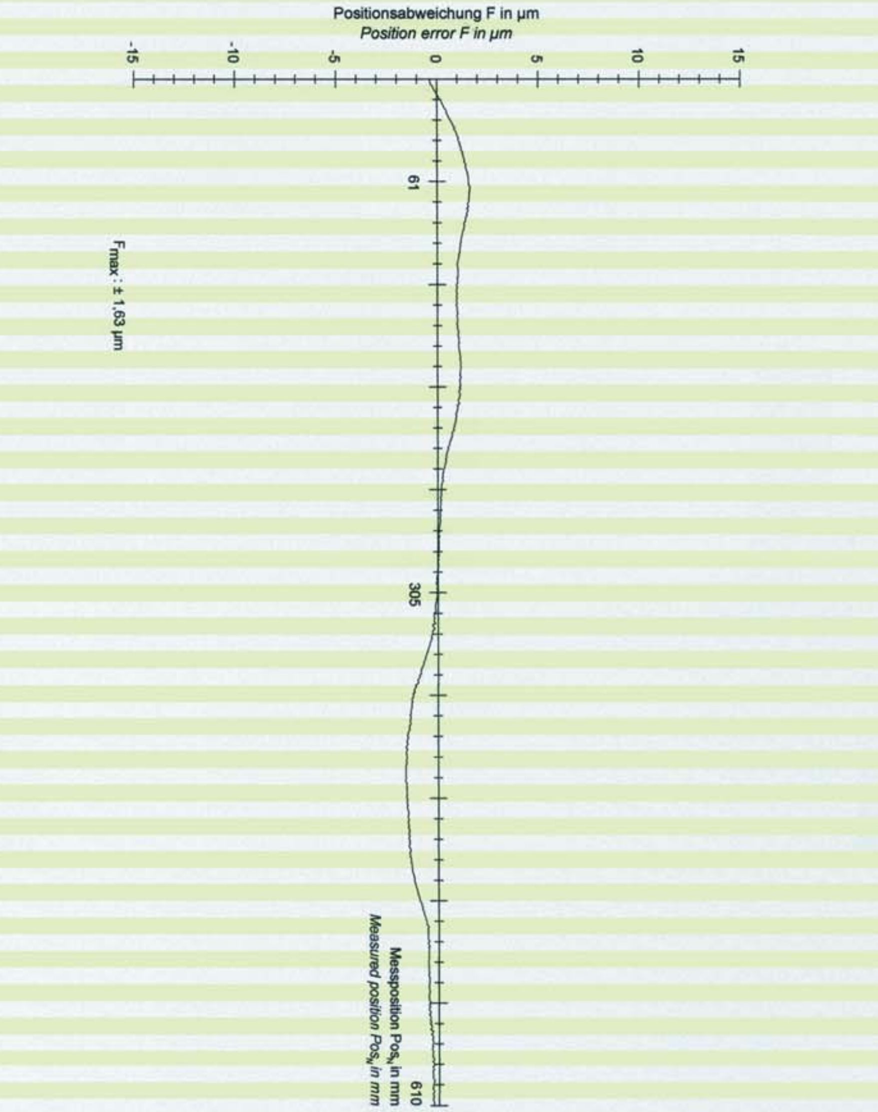
(Pos_N = measured position of the comparator standard,
Pos_M = measured position of the linear encoder)

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)



Example

Mechanical Design Types and Mounting Guidelines
Linear Encoders with Small Cross Section

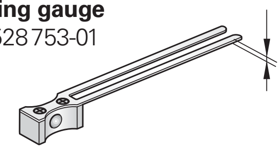
The LC, LF and LS slimline linear encoders should be fastened to a machined surface over their entire length, especially for highly-dynamic requirements. Larger measuring lengths and higher vibration loads are made possible by using mounting spars or clamping elements (only for LC 4x3).

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

Thermal behavior
Because they are rigidly fastened using two M8 screws, the linear encoders largely adapt themselves to the mounting surface. When fastened over the mounting spar, the encoder is fixed at its midpoint to the mounting surface. The flexible fastening elements ensure reproducible thermal behavior.
The **LF 481** with its graduation carrier of steel has the same coefficient of thermal expansion as a mounting surface of gray cast iron or steel.

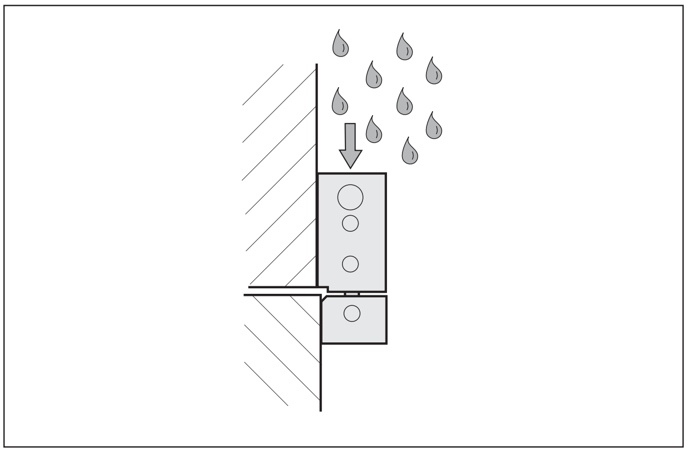
Mounting
It is surprisingly simple to mount the sealed linear encoders from HEIDENHAIN: You need only align the scale unit at several points along the machine guideway. Stop surfaces or stop pins can also be used to align the scale. Use the mounting gauge to set the gap between the scale unit and the scanning unit easily and exactly. Ensure that the lateral tolerances are also maintained.

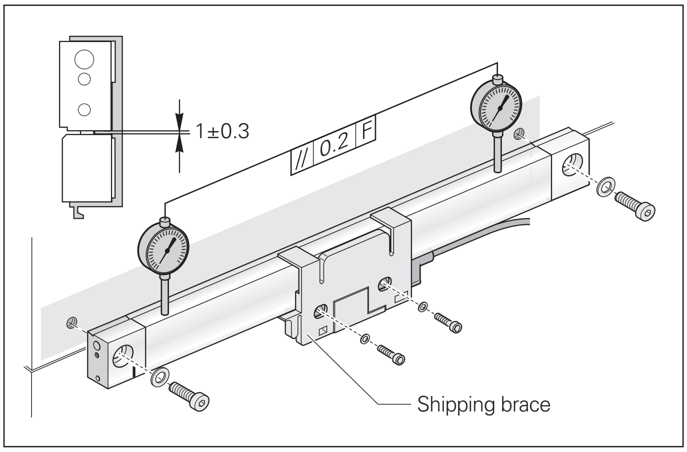
Accessories:
Mounting gauge
Id. Nr. 528 753-01

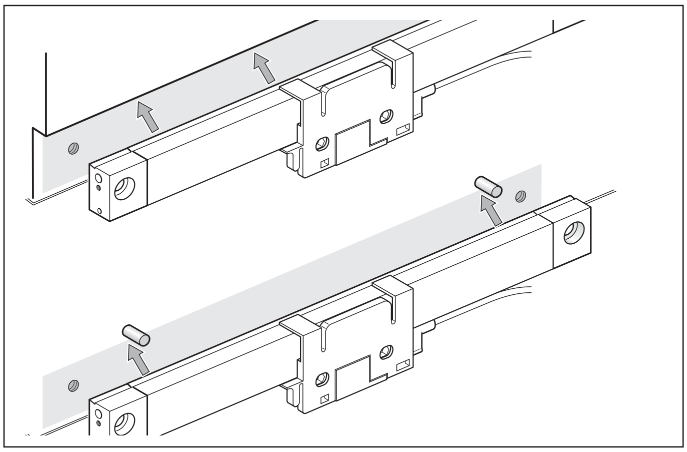


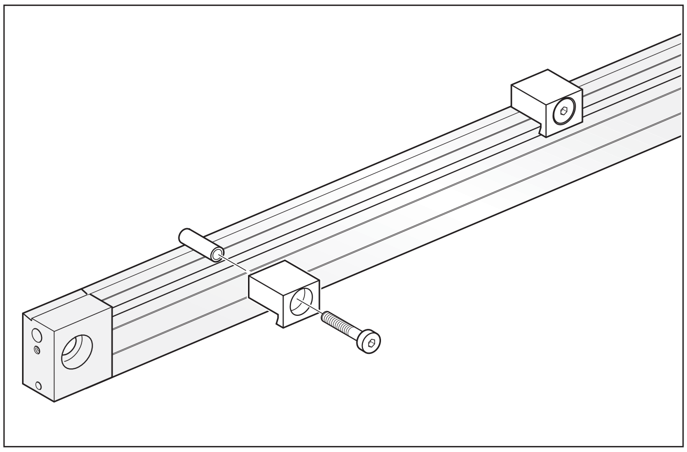
Mounting with clamping elements
The scale housing of the LC 4x3 is fastened at both ends. In addition, it can also be attached to the mounting surface at every 400 mm by clamping elements. This makes it very easy to fasten the housing at the center of the measuring length (recommended for highly-dynamic applications with measuring lengths greater than 640 mm). This also eliminates the need of a mounting spar for measuring lengths greater than 1240 mm.

Accessories:
Clamping elements
Id. Nr. 556 975-xx









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

The **universal mounting spar** was developed specifically for the LC 4x3 and the LS 4x7 with single-field scanning[1]. It offers the following advantages:

- **Rapid mounting**
  The components necessary for clamping are premounted. This simplifies mounting, saves time and improves the reliability.

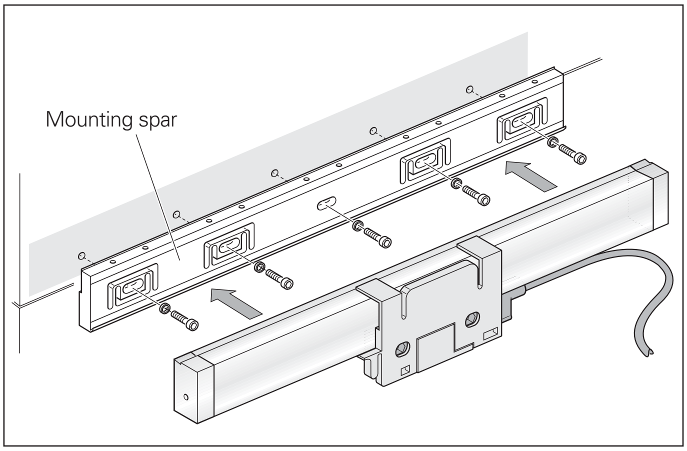
- **Freely selectable cable exit**
  The LC 4x3 and the LS 4x7 with single-field scanning[1] can be mounted with either side facing the universal mounting spar. This permits the cable exit to be located on the left or right—a very important feature if installation space is limited.

- **Mechanically compatible versions**
  Both the universal mounting spar and the LC 4x3 and the LS 4x7 with single-field scanning[1] are absolutely compatible mechanically to the previous versions. Any combinations are possible, such as the LS 4x6 with the universal mounting spar, or the LC 4x3 with the previous mounting spar.

Of course only the combination of the LC 4x3 or the LS 4x7 with single-field scanning[1] und the universal mounting spar permit selection of mounting with the cable exit at left or right.

The universal mounting spar must be ordered separately, even for measuring lengths over 1240 mm.

[1] Id. Nr. 560 52x-xx; available in 2006



Linear Encoders with Large Cross Section

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

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

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

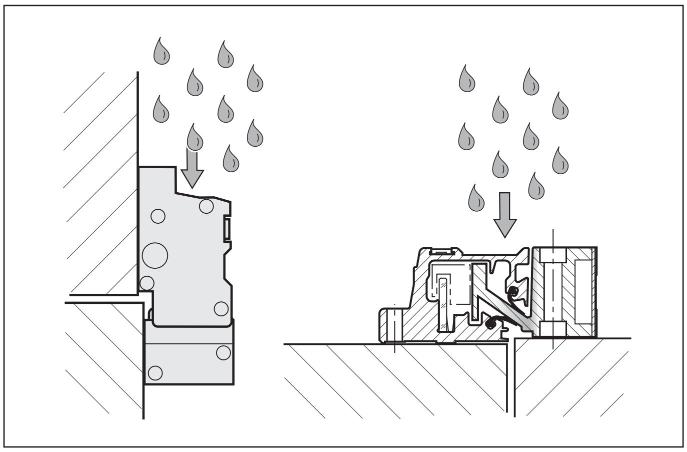
On the **LB** the steel scale tape is clamped directly onto the machine element. The LB therefore takes part in all thermal changes of the mounting surface.

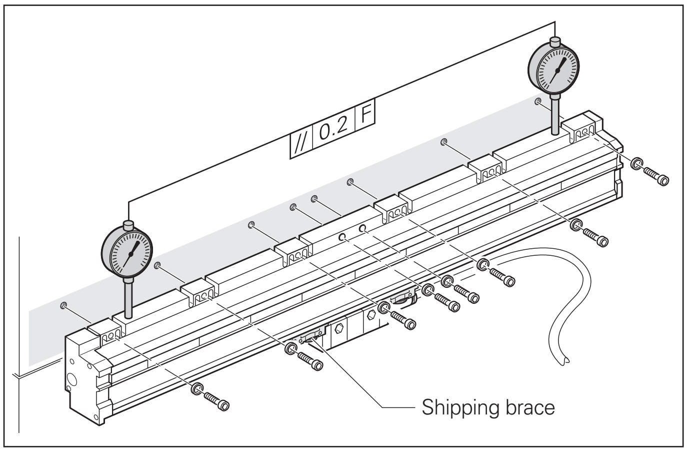
The **LC** and **LS** are fixed to the mounting surface at their midpoint. The flexible fastening elements permit reproducible thermal behavior.

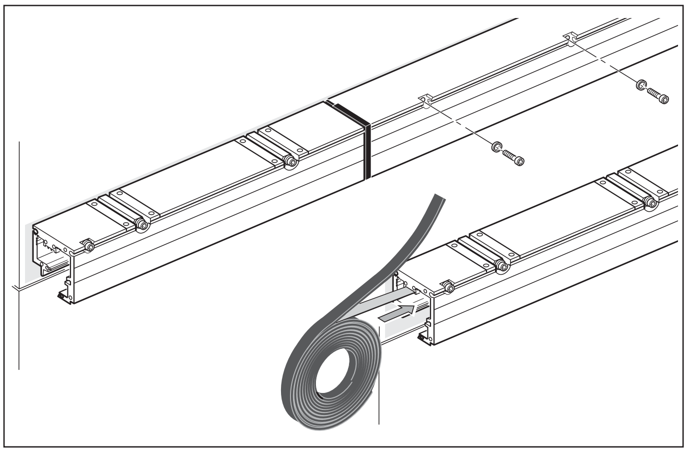
Mounting
When mounting sealed linear encoders from HEIDENHAIN, the shipping brace already sets the proper gap between the scale unit and the scanning unit. You need only align the scale unit at several points along the machine guideway. Stop surfaces or stop pins can also be used for this.

Mounting the multi-section LB 382
The LB 382 with measuring lengths over 3240 mm 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/m.







General Mechanical Information

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

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 60 068-2-6).** 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 60 068-2-27).** 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
- Sealing lips

Protection
Sealed **linear encoders** fulfill the requirements for IP 53 protection according to **IEC 60 529,** provided that they are mounted with the sealing lips facing away from splash water. If necessary, provide a separate protective cover. If the encoder is exposed to particularly heavy concentrations of coolant and mist, **compressed air** can be conducted into the scale housing to provide **IP 64** protection to more effectively prevent the ingress of contamination. The LB, LC, LF and LS sealed linear encoders from HEIDENHAIN are therefore equipped with inlets at both end pieces and on the mounting block of the scanning unit.

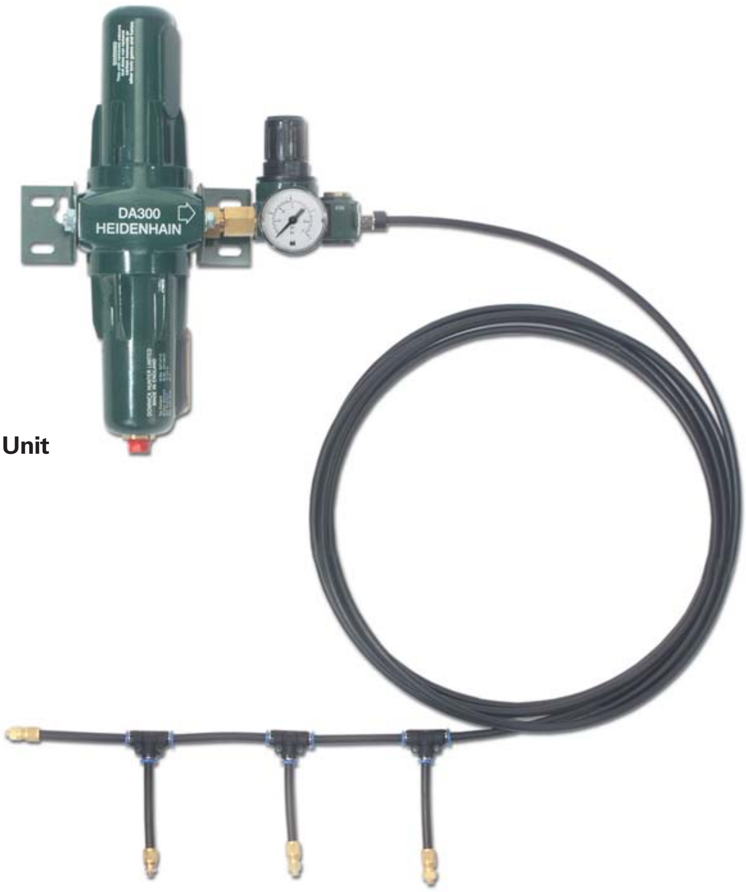
The compressed air introduced directly onto the encoders must be cleaned by a microfilter and must comply with the following quality classes as per **ISO 8573-1:**

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

The required air flow is 7 to 10 l/min per linear encoder; permissible pressure is in the range of 0.6 to 1 bar (9 to 14 psi). The compressed air flows through connecting pieces with integrated throttle (included with LB, LC, LF, LS 1x6, and LS 4x6 linear encoders).

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

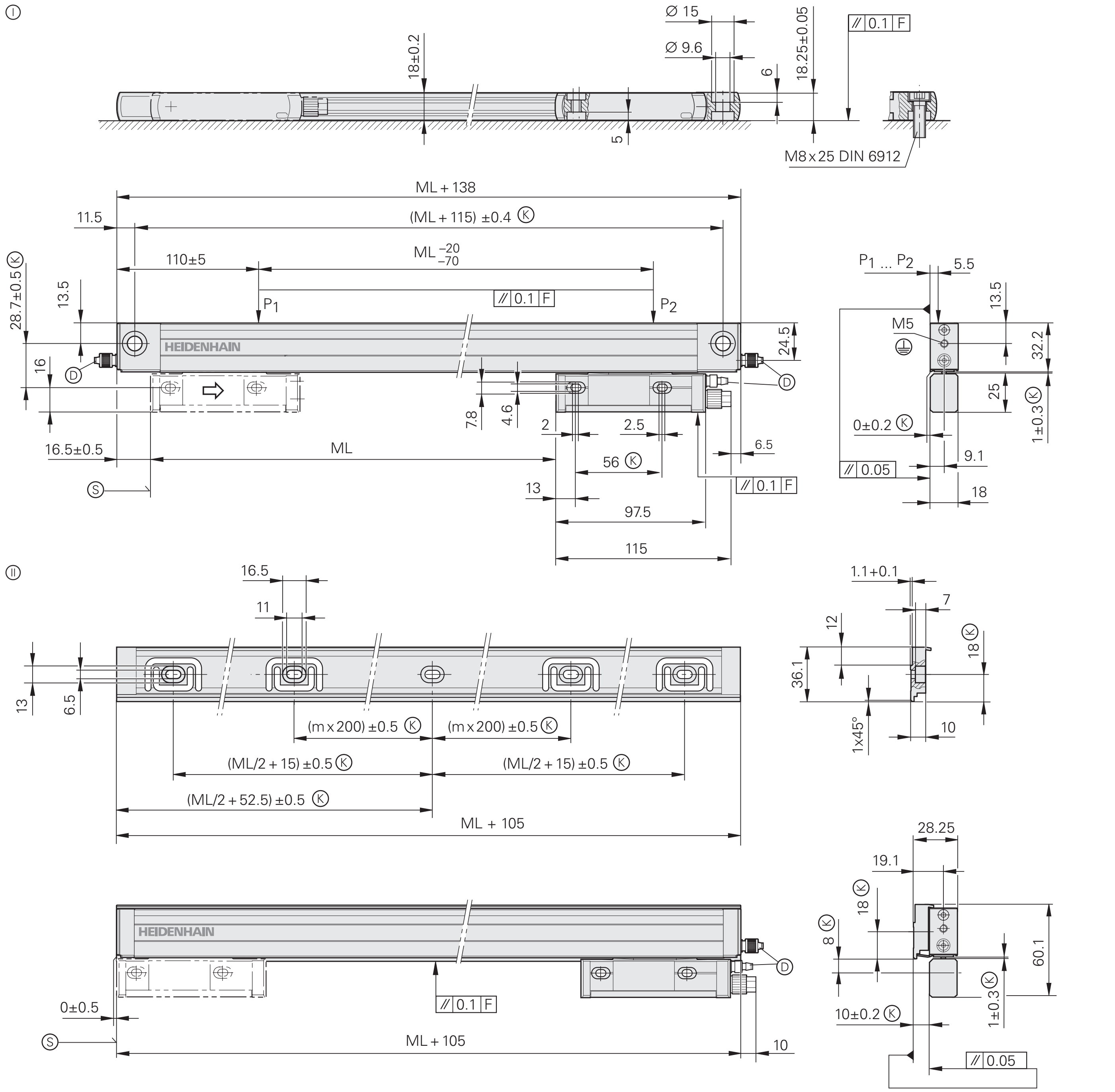
At an operating pressure of 7 bars, the compressed air conducted to the encoder by far exceeds the required purity. Its pressure gauge and automatic pressure switch (available as accessories) effectively monitor the DA 300.



DA 300
Compressed Air Unit

LC 400 Series

- **Absolute linear encoders for measuring steps to 0.1 µm (resolution to 0.005 µm)**
- **High positioning accuracy and traversing speed through single-field scanning**
- **For limited installation space**



Dimensions in mm

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

Ⓘ = Without mounting spar
Ⓘ = With mounting spar
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓢ = Beginning of measuring length (ML) (at 20 mm)
⇨ = Direction of scanning unit motion for output signals in accordance with interface description

Mounting spar

ML	m
70 ... 520	0
570 ... 920	1
1020 ... 1340	2
1440 ... 1740	3
1840 ... 2040	4

LC 483 without mounting spar

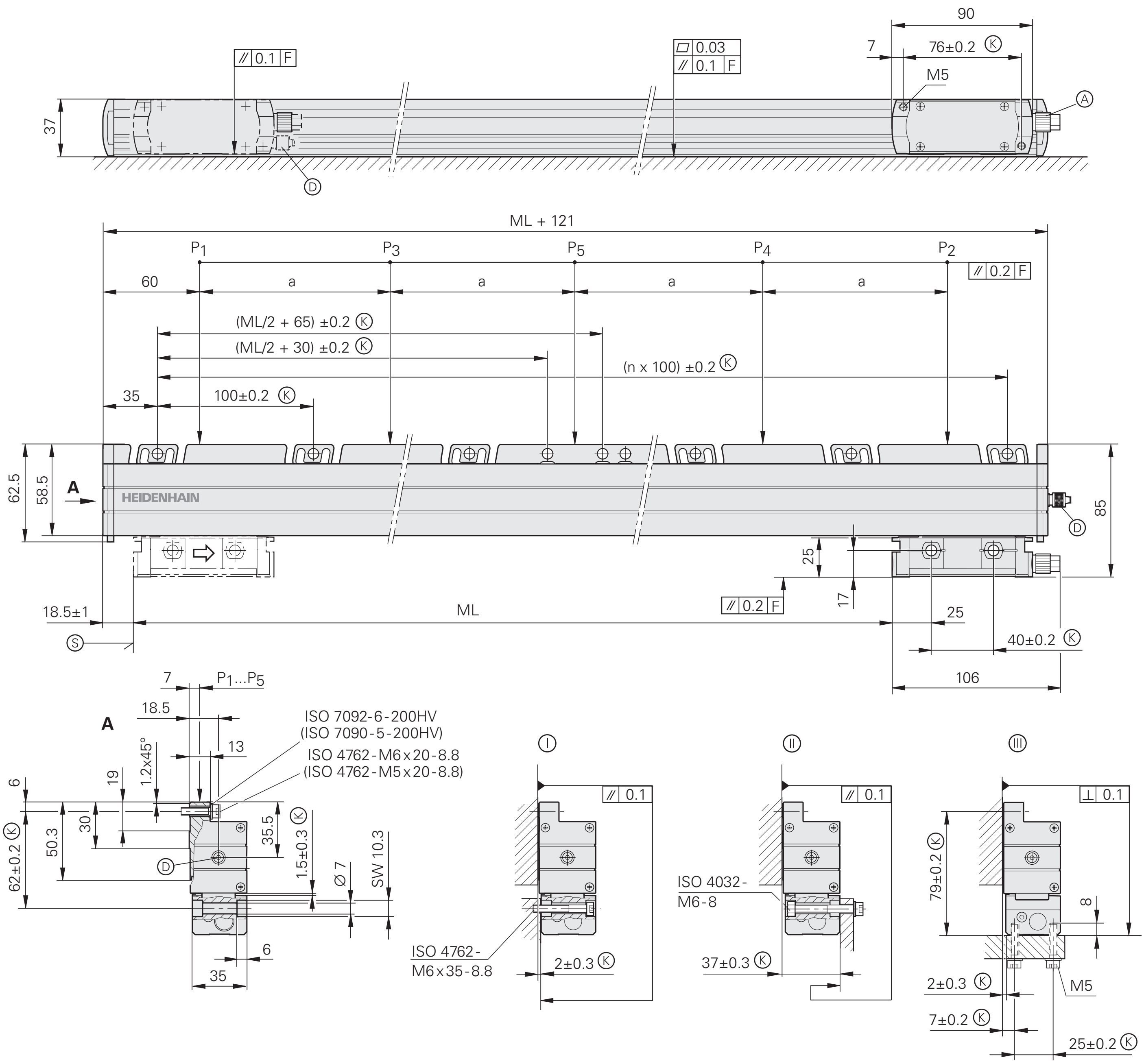
LC 483 with mounting spar

Specifications	**LC 483**[1]	**LC 493F**[1]	**LC 493M**[1]
Measuring standard Expansion coefficient	DIADUR glass scale with absolute track and incremental track α_{therm} approx. 8 x 10^{-6} K^{-1}, with mounting spar: α_{therm} approx. 9 x 10^{-6} K^{-1}		
Accuracy grade*	± 3 µm, ± 5 µm		
Measuring length ML* in mm	Mounting spar***** or clamping elements***** optional 70 120 170 220 270 320 370 420 470 520 570 620 720 770 820 920 1020 1140 1240		
	Only with mounting spar***** or clamping elements***** 1340 1440 1540 1640 1740 1840 2040		
Absolute position values	EnDat 2.2	Serial interface Fanuc 02	Mitsubishi high-speed serial interface
Resolution *Accuracy ± 3 µm* *Accuracy ± 5 µm*	 0.005 µm 0.01 µm	 0.01 µm 0.05 µm	
Calculation time tcal *EnDat 2.1 command set* *EnDat 2.2 command set*	 < 1 ms ≤ 5 µs	 – –	
Incremental signals	∿ 1 V_{PP}[2]	–	
Grating period/signal period	20 µm	–	
Cutoff frequency –3dB	≥ 150 kHz	–	
Power supply without load	3.6 to 5.25 V/< 300 mA		
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable to mounting block		
Cable length[3]	≤ 150 m; depending on the interface and subsequent electronics	≤30 m	≤20 m
Traversing speed	≤ 180 m/min		
Required moving force	≤ 5 N		
Vibration 55 to 2000 Hz **Shock** 11 ms **Acceleration**	*Without mounting spar:* ≤ 100 m/s^2 (IEC 60068-2-6) *With mounting spar and cable exit right/left:* ≤ 200 m/s^2/100 m/s^2 (IEC 60068-2-6) ≤ 300 m/s^2 (IEC 60068-2-27) ≤ 100 m/s^2 in measuring direction		
Operating temperature	0 to 50 °C		
Protection IEC 60529	IP 53 when installed according to mounting instructions IP 64 with use of compressed air from DA 300		
Weight	*Encoder:* 0.2 kg + 0.5 kg/m measuring length, *mounting spar:* 0.9 kg/m		

* Please select when ordering
[1] Available in 2006. Specifications preliminary.
[2] Depends on adapter cable
[3] With HEIDENHAIN cable

LC 100 Series

- **Absolute linear encoders for measuring steps to 0.1 µm (resolution to 0.005 µm)**
- **High positioning accuracy and traversing speed through single-field scanning**
- **High vibration rating**
- **Horizontal mounting possible**



Dimensions in mm

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

Ⓘ, Ⓘ,
Ⓘ = Mounting options
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓢ = Beginning of measuring length (ML) (at 20 mm)
Ⓩ = Not required if (ML/2 + 30)/100 is an integer
⇨ = Direction of scanning unit motion for output signals in accordance with interface description

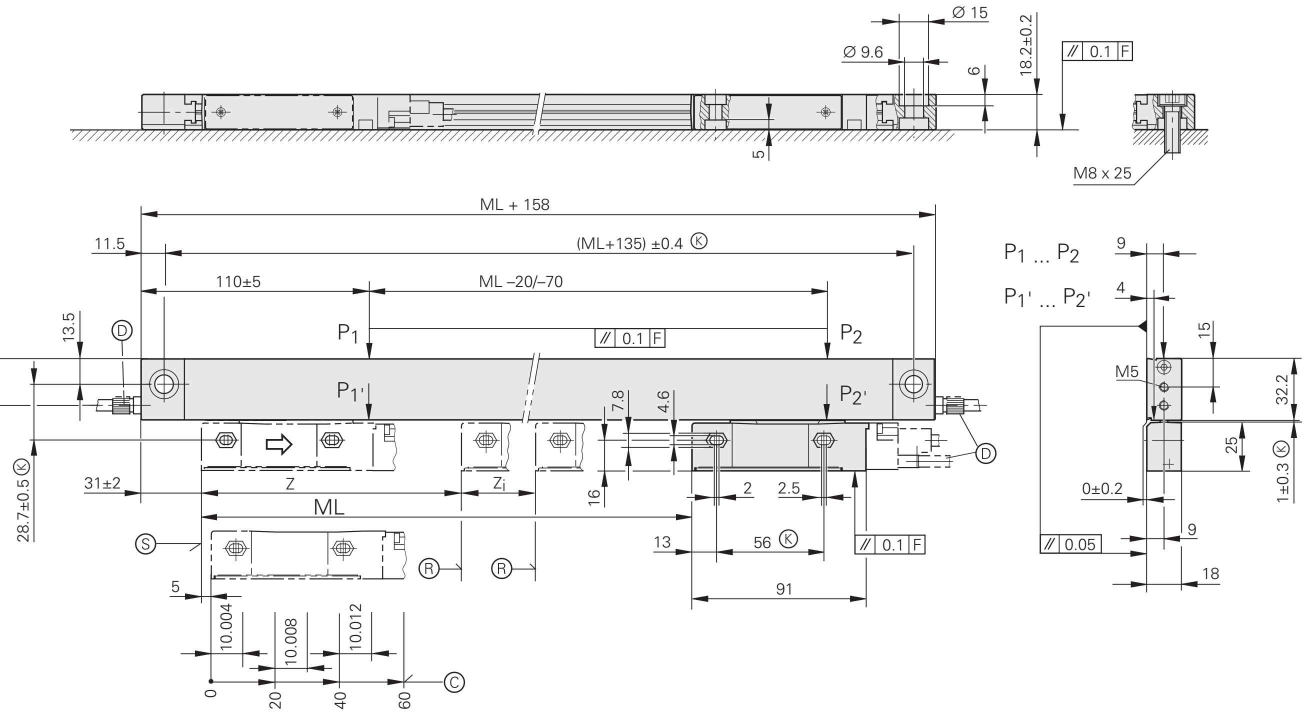
Specifications	**LC 183**[1]	**LC 193F**[1]	**LC 193M**[1]
Measuring standard Expansion coefficient	DIADUR glass scale with absolute track and incremental track α_{therm} approx. 8×10^{-6} K^{-1}		
Accuracy grade*	± 3 µm (up to measuring length 3240), ± 5 µm		
Measuring length ML* in mm	140 240 340 440 540 640 740 840 940 1040 1140 1240 1340 1440 1540 1640 1740 1840 2040 2240 2440 2640 2840 3040 3240 3440 3640 3840 4040 4240		
Absolute position values	EnDat 2.2	Serial interface Fanuc 02	Mitsubishi high-speed serial interface
Resolution *Accuracy ± 3 µm* *Accuracy ± 5 µm*	 0.005 µm 0.01 µm	 0.01 µm 0.05 µm	
Calculation time t_{cal} *EnDat 2.1 command set* *EnDat 2.2 command set*	 < 1 ms ≤ 5 µs	 – –	
Incremental signals	∿ 1 V_{PP}[2]	–	
Grating period/signal period	20 µm	–	
Cutoff frequency –3dB	≥ 150 kHz	–	
Power supply without load	3.6 to 5.25 V/< 300 mA		
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable to either side of mounting block		
Cable length[3]	≤ 150 m; depending on the interface and subsequent electronics	≤ 30 m	≤ 20 m
Traversing speed	≤ 180 m/min, starting from measuring length 3240: 120 m/min		
Required moving force	≤ 4 N		
Vibration 55 to 2000 Hz **Shock** 11 ms **Acceleration**	≤ 200 m/s^2 (IEC 60 068-2-6) ≤ 300 m/s^2 (IEC 60 068-2-27) ≤ 100 m/s^2 in measuring direction		
Operating temperature	0 to 50 °C		
Protection IEC 60 529	IP 53 when installed according to mounting instructions IP 64 with use of compressed air from DA 300		
Weight	0.4 kg + 3.3 kg/m measuring length		

* Please select when ordering
[1] Available in 2006. Specifications preliminary.
[2] Depends on adapter cable
[3] With HEIDENHAIN cable

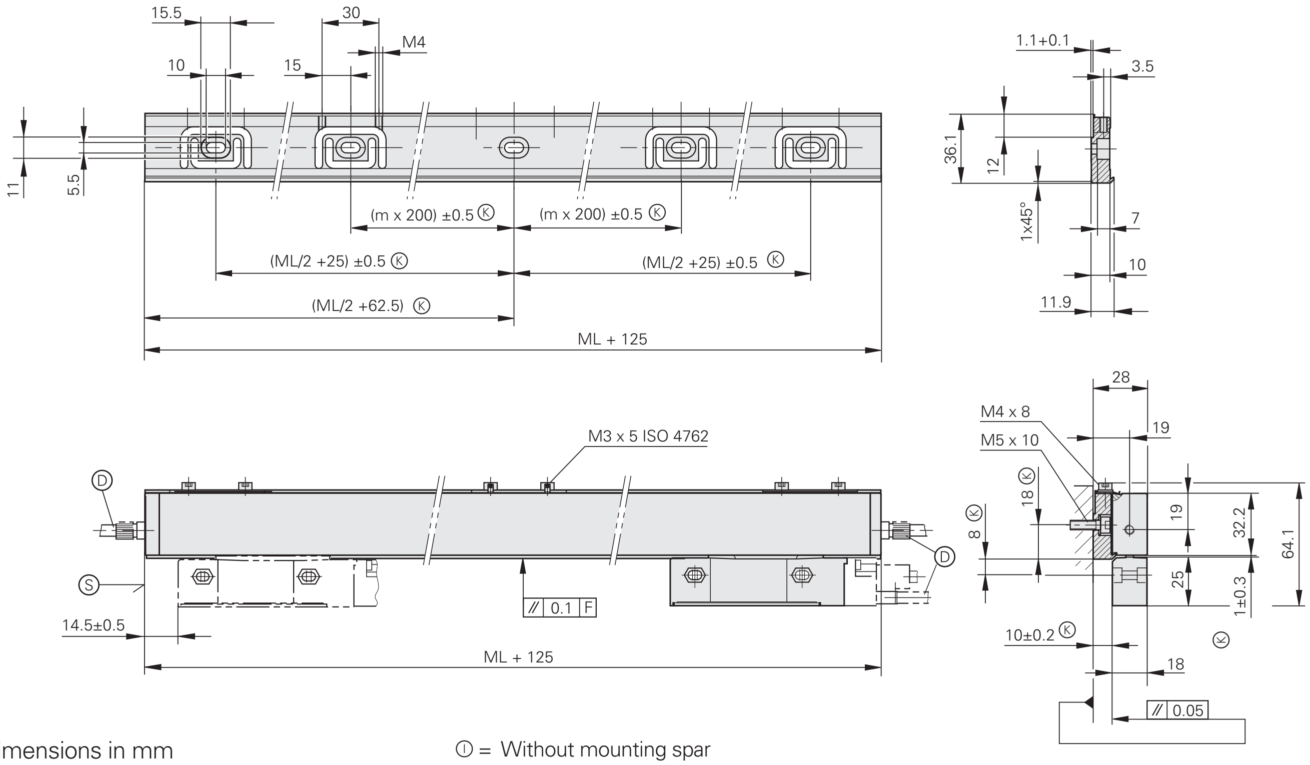
LF 481

- **Incremental linear encoder for measuring steps to 0.1 µm**
- **High positioning accuracy through single-field scanning**
- **Thermal behavior similar to steel or cast iron**
- **For limited installation space**

(I)



(II)



Dimensions in mm

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

(I) = Without mounting spar
(II) = With mounting spar
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓡ = Reference mark position on LF 481
2 reference marks for measuring lengths

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

Ⓒ = Reference mark position on LF 481 C
Ⓢ = Beginning of measuring length (ML)
⇨ = Direction of scanning unit motion for output signals in accordance with interface description

Mounting spar

ML	m
50 ... 500	0
550 ... 900	1
1000 ... 1220	2

LF 481 without mounting spar

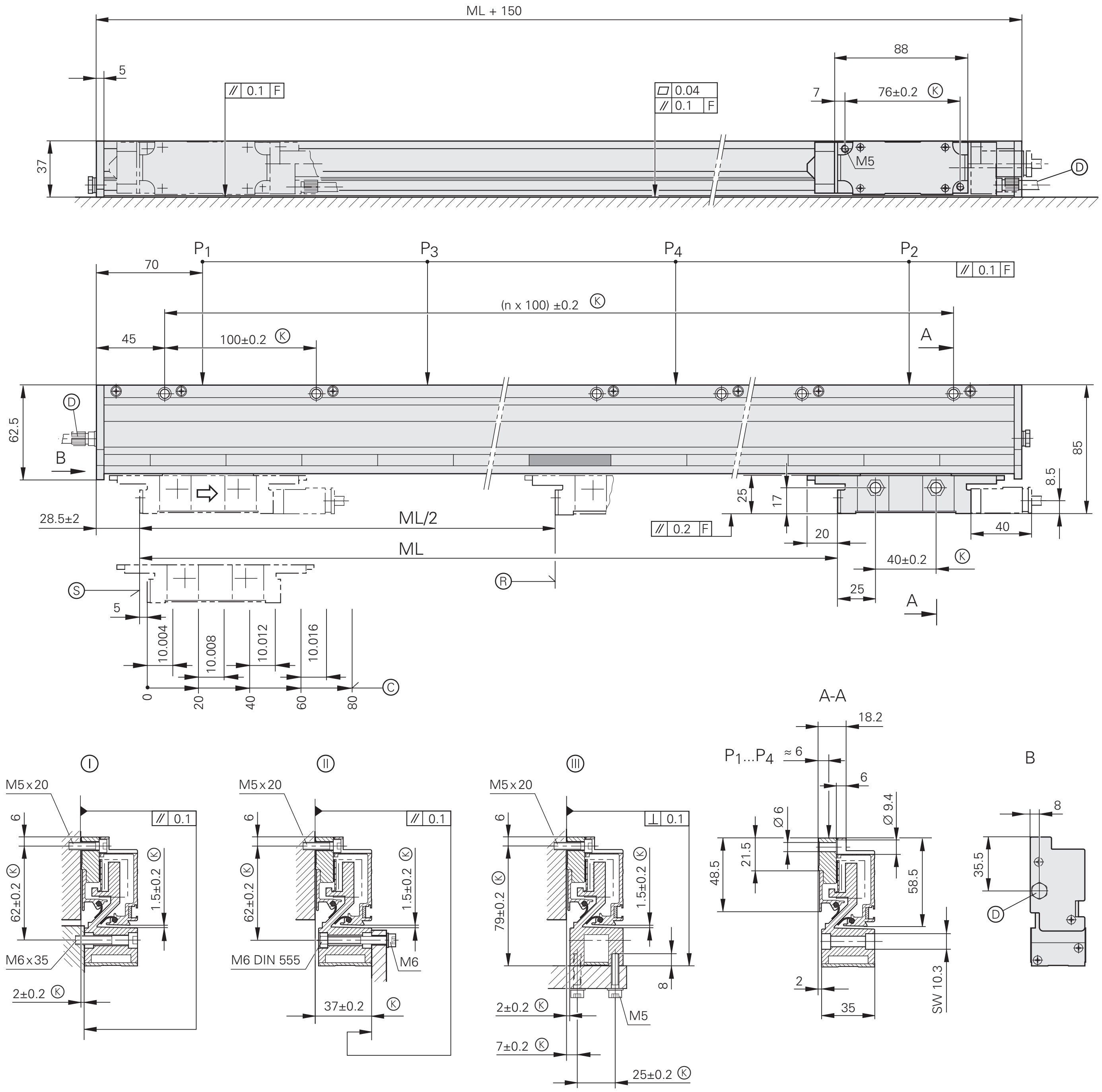
LF 481 with mounting spar

Specifications	**LF 481**
Measuring standard Expansion coefficient	DIADUR phase grating on steel α_{therm} approx. 10 x 10^{-6} K^{-1}, *with mounting spar:* α_{therm} ca. 9 x 10^{-6} K^{-1}
Accuracy grade*	± 3 µm, ± 5 µm
Measuring length ML* in mm	Mounting spar* recommended 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 900 1000 1120 1220
Incremental signals	∿1 V_{PP}
Grating period Signal period	8 µm 4 µm
Reference marks* *LF 481* *LF 481 C*	ML 50 mm: 1 reference mark at midpoint ML 100 to 1000 mm: 2, located 25 mm from the beginning and end of the measuring length From ML 1120 mm: 2, located 35 mm from the beginning and end of the measuring length Distance-coded
Cutoff frequency –3dB	≥ 200 kHz
Power supply without load	5 V ± 5 %/< 200 mA
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable to mounting block
Cable length[1)]	≤ 150 m
Traversing speed	≤ 30 m/min
Required moving force	≤ 5 N
Vibration 55 to 2000 Hz **Shock** 11 ms **Acceleration**	≤ 80 m/s^2 (IEC 60 068-2-6) ≤ 100 m/s^2 (IEC 60068-2-27) ≤ 30 m/s^2 in measuring direction
Operating temperature	0 to 50 °C
Protection IEC 60 529	IP 53 when installed according to mounting instructions IP 64 with use of compressed air from DA 300
Weight without mounting spar	0.4 kg + 0.5 kg/m measuring length

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

LF 183

- **Incremental linear encoder for measuring steps to 0.1 µm**
- **High positioning accuracy through single-field scanning**
- **Thermal behavior similar to steel or cast iron**
- **High vibration rating**
- **Horizontal mounting possible**



Dimensions in mm

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

Ⓘ, Ⓘⓘ,
Ⓘⓘⓘ = Mounting options
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓡ = Reference mark position on LF 183
Ⓒ = Reference mark position on LF 183 C
Ⓢ = Beginning of measuring length (ML)
⇨ = Direction of scanning unit motion for output signals in accordance with interface description

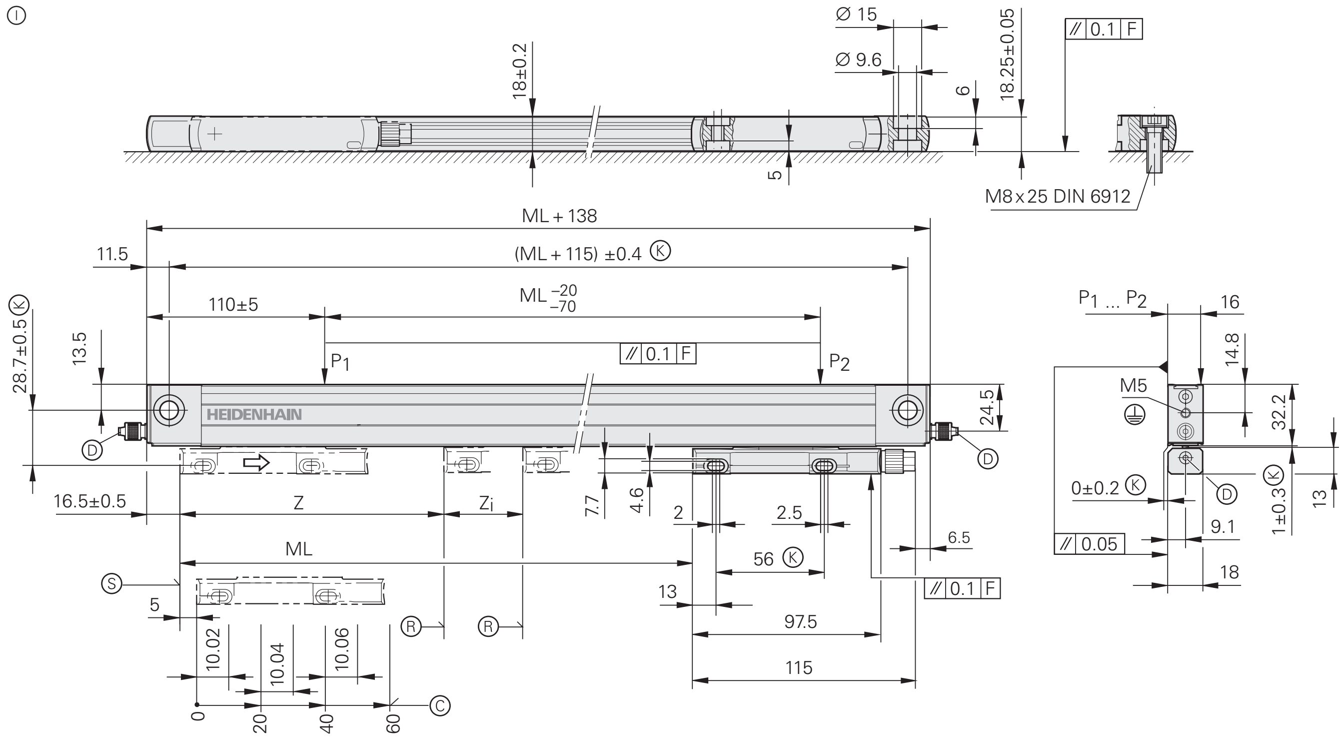
Specifications	LF 183
Measuring standard Expansion coefficient	DIADUR phase grating on steel α_{therm} approx. 10×10^{-6} K^{-1}
Accuracy grade*	± 3 µm, ± 2 µm
Measuring length ML* in mm	140 240 340 440 540 640 740 840 940 1040 1140 1240 1340 1440 1540 1640 1740 1840 2040 2240 2440 2640 2840 3040
Incremental signals	∿1 V_{PP}
Grating period Signal period	8 µm 4 µm
Reference marks* *LF 183* *LF 183 C*	Selectable with magnets every 50 mm Standard setting: 1 reference mark in the center Distance-coded
Cutoff frequency –3dB	≥ 200 kHz
Power supply without load	5 V ± 5 %/< 200 mA
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable to mounting block
Cable length[1)]	≤ 150 m
Traversing speed	≤ 60 m/min
Required moving force	≤ 4 N
Vibration 55 to 2000 Hz **Shock** 11 ms **Acceleration**	≤ 150 m/s^2 (IEC 60 068-2-6) ≤ 300 m/s^2 (IEC 60068-2-27) ≤ 100 m/s^2 in measuring direction
Operating temperature	0 to 40 °C
Protection IEC 60 529	IP 53 when installed according to mounting instructions IP 64 with use of compressed air from DA 300
Weight	1.1 kg + 3.8 kg/m measuring length

* Please select when ordering
1) With HEIDENHAIN cable

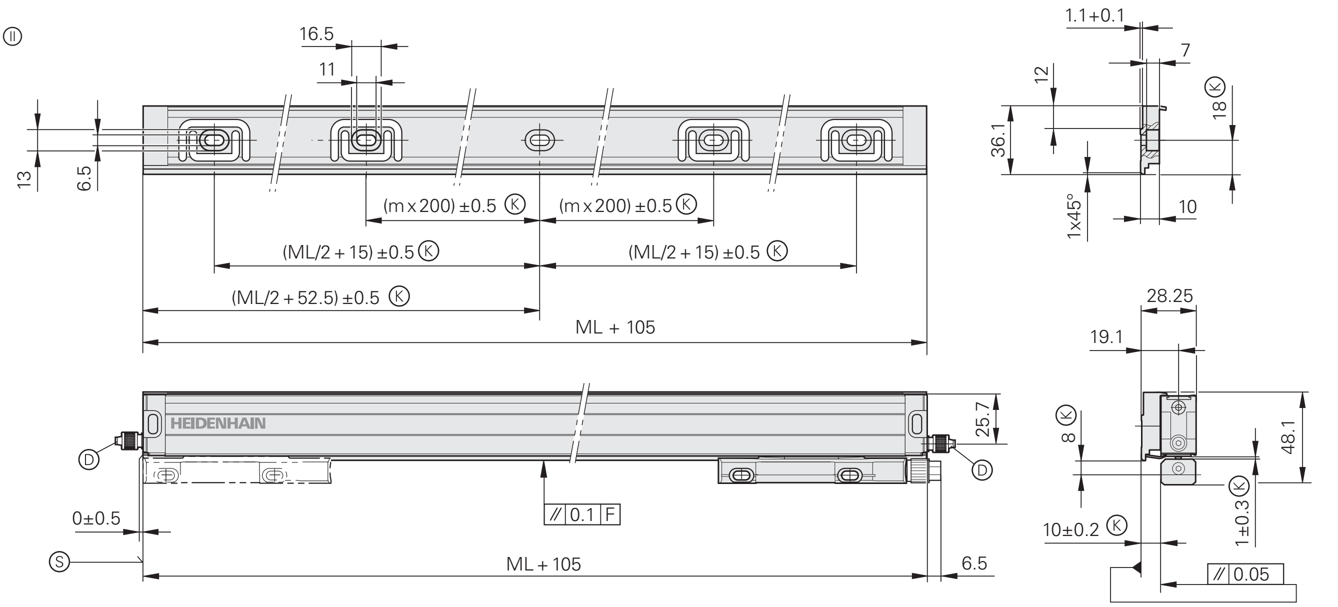
LS 487

- **Incremental linear encoder for measuring steps to 0.5 µm**
- **For limited installation space**
- **With single-field scanning**

(I)



(II)



Dimensions in mm

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

(I) = Without mounting spar
(II) = With mounting spar
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓡ = Reference mark position on LS 487
2 reference marks for measuring lengths

70 ... 1020	1140 ... 2040
z = 35 z_i = ML – 70	z = 45 z_i = ML – 90

Ⓒ = Reference mark position on LS 487 C
Ⓢ = Beginning of measuring length (ML)
⇨ = Direction of scanning unit motion for output signals in accordance with interface description

Mounting spar

ML	m
70 ... 520	0
570 ... 920	1
1020 ... 1340	2
1440 ... 1740	3
1840 ... 2040	4

LS 487 without mounting spar

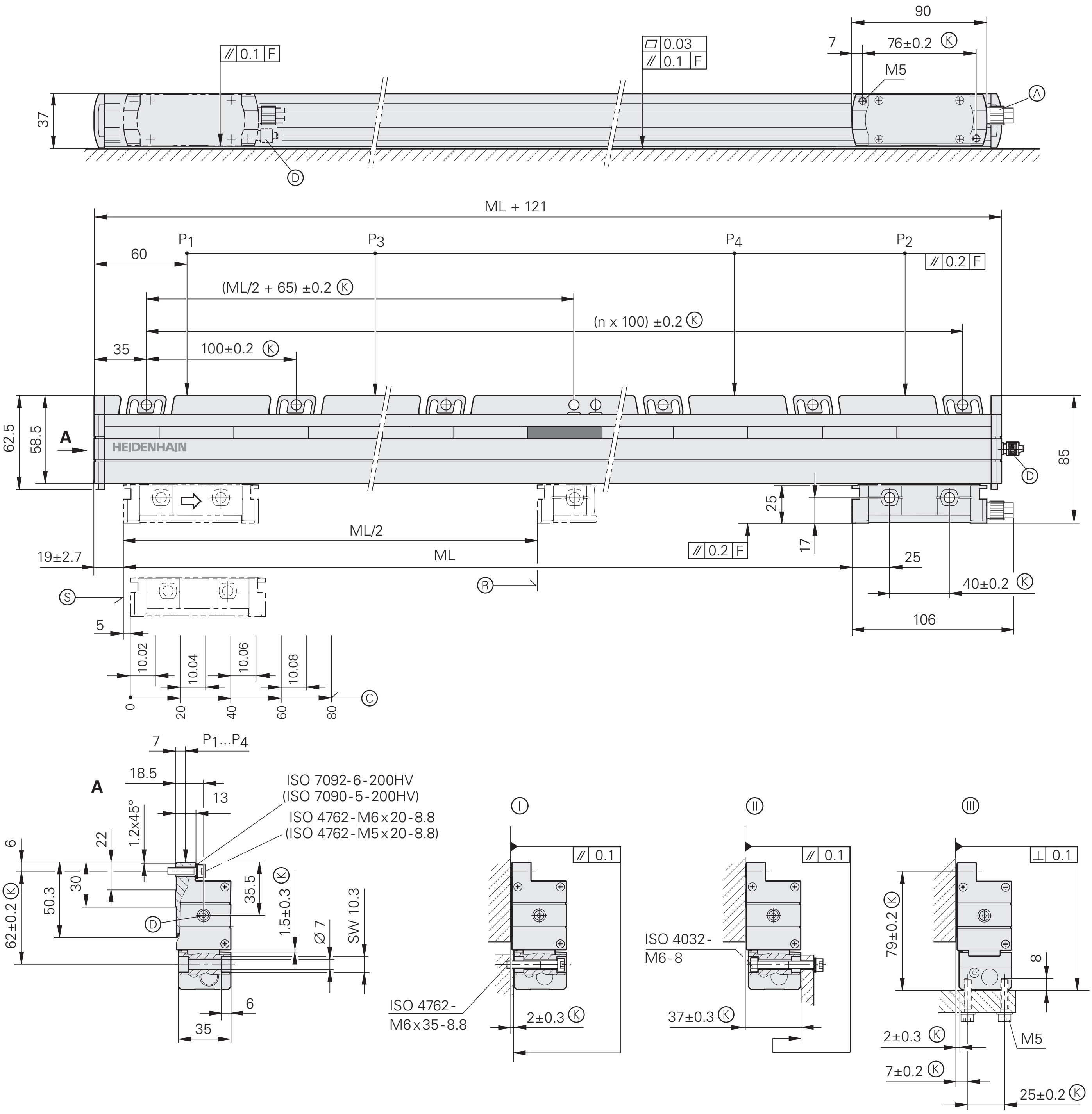
LS 487 with mounting spar

Specifications	**LS 487**[1]
Measuring standard Expansion coefficient	Glass scale with DIADUR graduation α_{therm} approx. 8×10^{-6} K^{-1}, *with mounting spar:* α_{therm} approx. 9×10^{-6} K^{-1}
Accuracy grade*	± 5 µm, ± 3 µm
Measuring length ML* in mm	Mounting spar* recommended 70 120 170 220 270 320 370 420 470 520 570 620 720 770 820 920 1020 1140 1240
	Only with mounting spar* 1340 1440 1540 1640 1740 1840 2040
Reference marks* *LS 487*	Selectable with magnets every 50 mm; Standard: *ML 70 mm:* 1 in the center; *up to ML 1020 mm:* 2, each 35 mm from beginning/end of ML; *from ML 1140mm:* 2, each 45 mm from beginning/end of ML
LS 487 C	Distance-coded
Incremental signals	∼ 1 V_{PP}
Grating period/signal period	20 µm
Cutoff frequency –3dB	≥ 160 kHz
Power supply without load	5 V ± 5 %/< 120 mA
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable to mounting block
Cable length[2]	≤ 150 m
Traversing speed	≤ 120 m/min
Required moving force	≤ 5 N
Vibration 55 to 2000 Hz **Shock** 11 ms **Acceleration**	*Without mounting spar:* ≤ 100 m/s^2 (IEC 60 068-2-6) *With mounting spar and cable exit right/left:* ≤ 200 m/s^2/100 m/s^2 (IEC 60 068-2-6) ≤ 300 m/s^2 (IEC 60 068-2-27) ≤ 100 m/s^2 in measuring direction
Operating temperature	0 to 50 °C
Protection IEC 60 529	IP 53 when installed according to mounting instructions IP 64 with use of compressed air from DA 300
Weight	0.4 kg + 0.5 kg/m measuring length

* Please select when ordering
[1] Id. Nr. 560 52x-xx. Available in 2006. Specifications preliminary.
[2] With HEIDENHAIN cable

LS 187

- **Incremental linear encoder for measuring steps to 0.5 µm**
- **Defined thermal behavior**
- **High vibration rating**
- **Horizontal mounting possible**
- **With single-field scanning**



Dimensions in mm

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

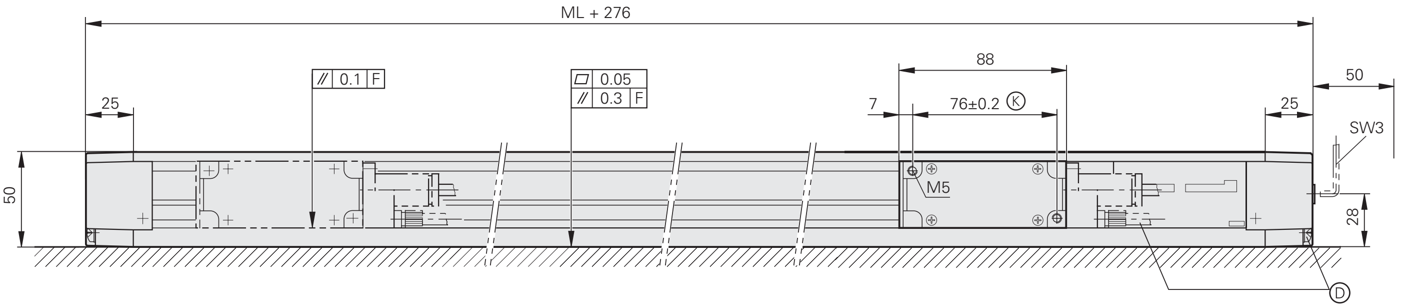
Ⓘ, Ⓘ,
Ⓘ = Mounting options
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓡ = Reference mark position on LS 1xx
Ⓒ = Reference mark position on LS 1xx C
Ⓢ = Beginning of measuring length (ML)
⇨ = Direction of scanning unit motion for output signals in accordance with interface description

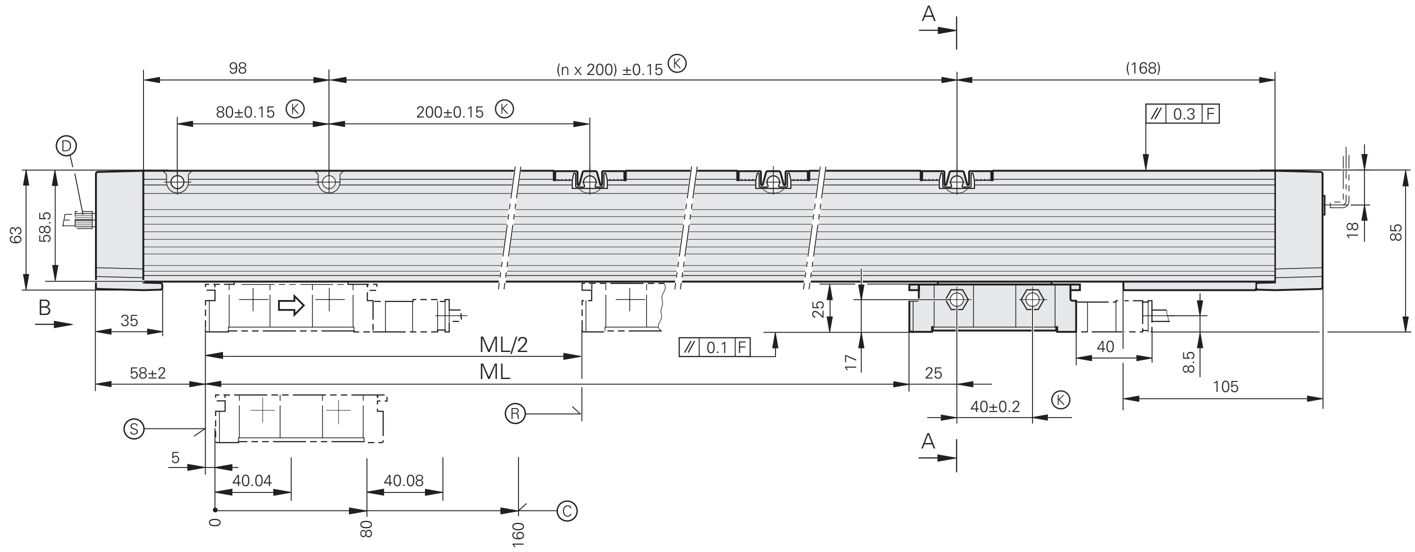
Specifications	**LS 187**[1]
Measuring standard Expansion coefficient	Glass scale with DIADUR graduation α_{therm} approx. 8 x 10^{-6} K^{-1}
Accuracy grade*	± 5 µm, ± 3 µm
Measuring length ML* in mm	140 240 340 440 540 640 740 840 940 1040 1140 1240 1340 1440 1540 1640 1740 1840 2040 2240 2440 2640 2840 3040
Reference marks* *LS 187* *LS 187 C*	Selectable with magnets every 50 mm, standard setting: 1 reference mark in the center Distance-coded
Incremental signals	∿ 1 V_{PP}
Grating period/signal period	20 µm
Cutoff frequency –3dB	≥ 160 kHz
Power supply without load	5 V ± 5 %/< 120 mA
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable to mounting block
Cable length[2]	≤ 150 m
Traversing speed	≤ 120 m/min
Required moving force	≤ 4 N
Vibration 55 to 2000 Hz **Shock** 11 ms **Acceleration**	≤ 200 m/s² (IEC 60 068-2-6) ≤ 400 m/s² (IEC 60 068-2-27) ≤ 60 m/s² in measuring direction
Operating temperature	0 to 50 °C
Protection IEC 60 529	IP 53 when installed according to mounting instructions IP 64 with use of compressed air from DA 300
Weight	0.4 kg + 2.3 kg/m measuring length

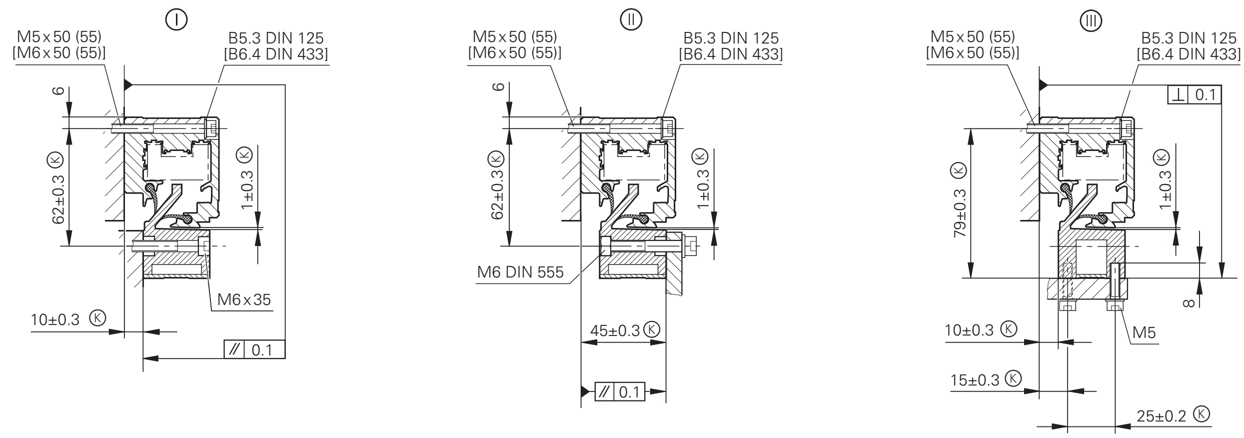
* Please select when ordering
[1] Available in 2006. Specifications preliminary.
[2] With HEIDENHAIN cable

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

- **Incremental linear encoder for measuring steps to 0.1 µm**
- **High positioning accuracy and traversing speed through single-field scanning**
- **Horizontal mounting possible**
- **Mirror-inverted version available**



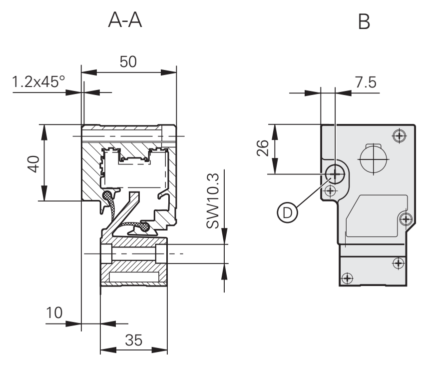




Dimensions in mm

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

(I), (II),
(III) = Mounting options
F = Machine guideway
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓡ = Reference mark position on LB 382
Ⓒ = Reference mark position on LB 382 C
Ⓢ = Beginning of measuring length (ML)
⇨ = Direction of scanning unit motion for output signals in accordance with interface description

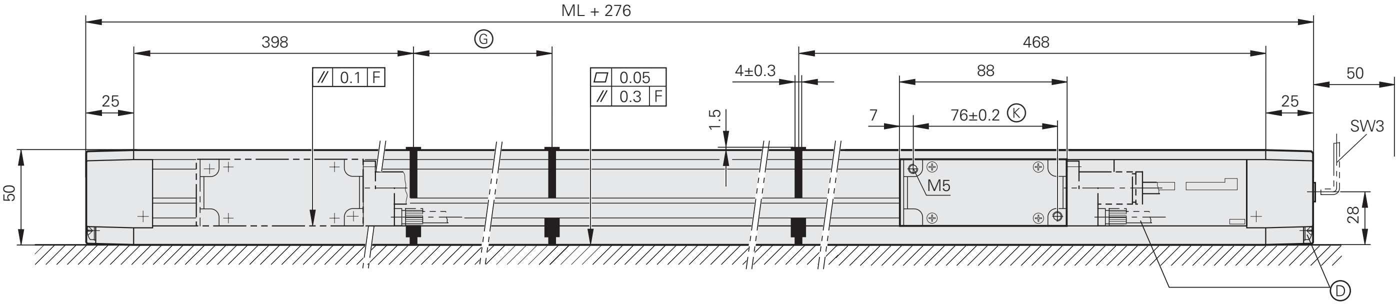


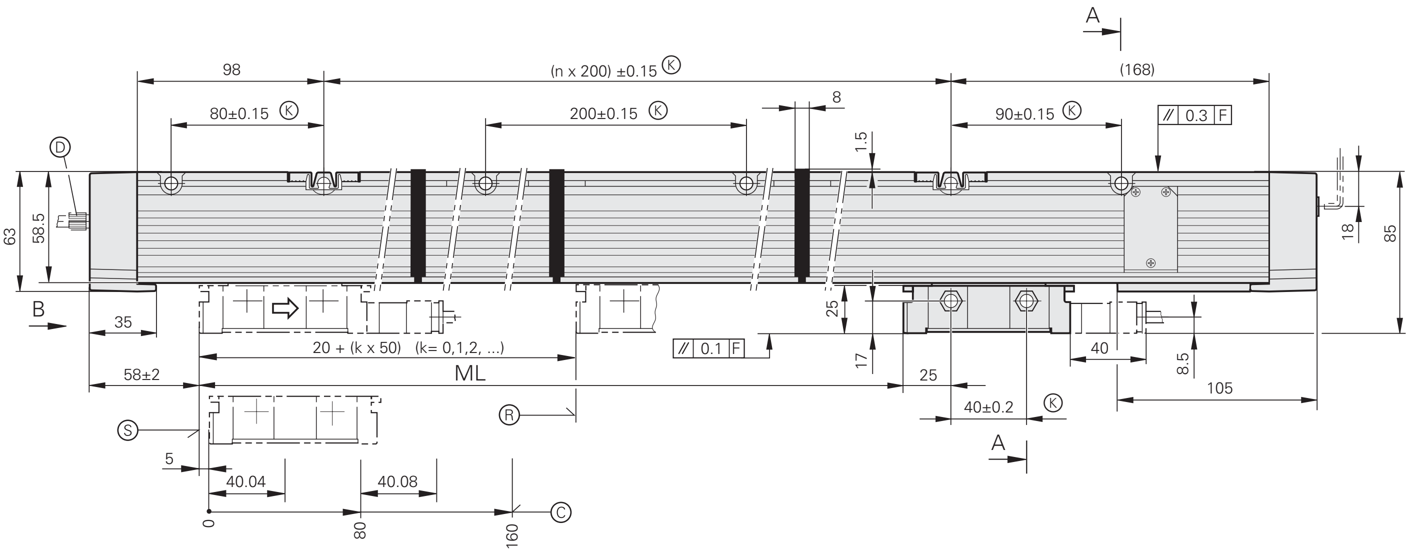
Specifications	LB 382 up to ML 3040 mm
Measuring standard Expansion coefficient	Stainless steel tape with AURODUR graduation α_{therm} approx. 10 x 10^{-6} K^{-1}
Accuracy grade*	± 5 µm
Measuring length ML* in mm	Single-section housing 440 640 840 1040 1240 1440 1640 1840 2040 2240 2440 2640 2840 3040
Reference marks* *LB 382* *LB 382 C*	Selectable with selector plates every 50 mm, standard setting: 1 reference mark in the center Distance-coded
Incremental signals	∿ 1 V_{PP}
Grating period/signal period	40 µm
Cutoff frequency –3dB	≥ 250 kHz
Power supply without load	5 V ± 5 %/< 150 mA
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable to mounting block
Cable length[1)]	≤ 150 m
Traversing speed	≤ 120 m/min (180 m/min on request)
Required moving force	≤ 15 N
Vibration 55 to 2000 Hz **Shock** 11 ms **Acceleration**	≤ 300 m/s^2 (IEC 60 068-2-6) ≤ 300 m/s^2 (IEC 60068-2-27) ≤ 60 m/s^2 in measuring direction
Operating temperature	0 to 50 °C
Protection IEC 60 529	IP 53 when installed according to mounting instructions IP 64 with use of compressed air from DA 300
Weight	1.3 kg + 3.6 kg/m measuring length

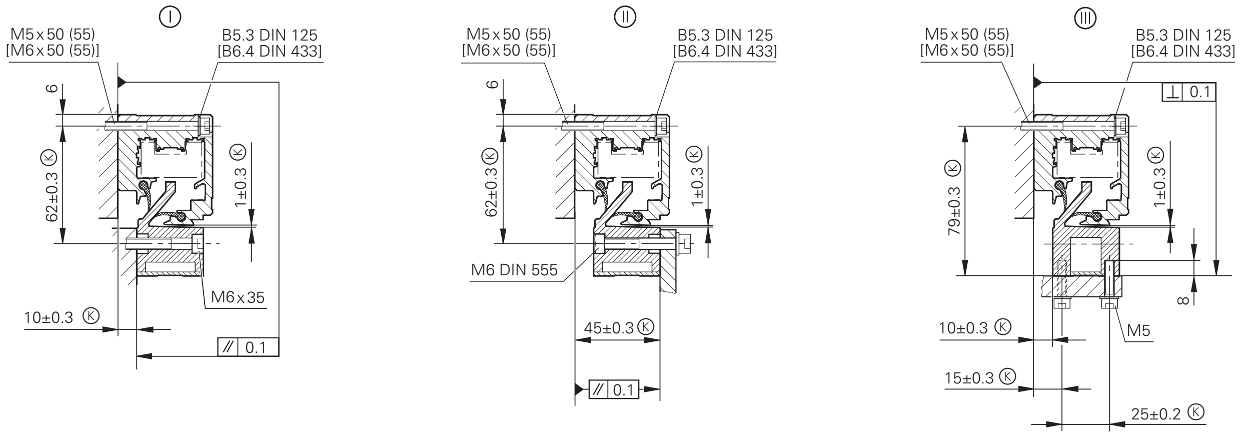
* Please select when ordering
1) With HEIDENHAIN cable

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

- **Incremental linear encoder for long measuring ranges up to 30 m**
- **Measuring steps as fine as 0.1 µm**
- **High positioning accuracy and traversing speed through single-field scanning**
- **Horizontal mounting possible**
- **Mirror-inverted version available**





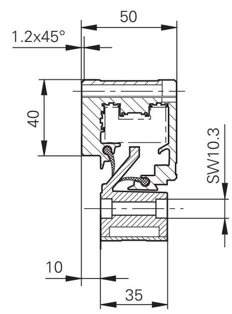


Dimensions in mm

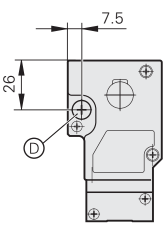
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Ⓘ, Ⓘ,
Ⓘ = Mounting options
F = Machine guideway
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓡ = Reference mark position on LB 382
Ⓒ = Reference mark position on LB 382 C
Ⓢ = Beginning of measuring length (ML)
Ⓖ = Housing section lengths
⇨ = Direction of scanning unit motion for output signals in accordance with interface description

A-A



B



Specifications	LB 382 from ML 3240 mm
Measuring standard Expansion coefficient	Stainless steel tape with AURODUR graduation Same as machine main casting
Accuracy grade*	± 5 µm
Measuring length ML*	Kit with single-section AURODUR steel tape and housing sections for measuring lengths from 3240 mm to 30 040 mm in 200 mm steps. Housing section lengths: 1000 mm, 1200 mm, 1400 mm, 1600 mm, 1800 mm, 2000 mm
Reference marks* *LB 382* *LB 382 C*	Selectable with selector plates every 50 mm Distance-coded
Incremental signals	∿ 1 V_{PP}
Grating period/signal period	40 µm
Cutoff frequency –3dB	≥ 250 kHz
Power supply without load	5 V ± 5 %/< 150 mA
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable to mounting block
Cable length[1)]	≤ 150 m
Traversing speed	≤ 120 m/min
Required moving force	≤ 15 N
Vibration 55 to 2000 Hz **Shock** 11 ms **Acceleration**	≤ 300 m/s^2 (IEC 60 068-2-6) ≤ 300 m/s^2 (IEC 60068-2-27) ≤ 60 m/s^2 in measuring direction
Operating temperature	0 to 50 °C
Protection IEC 60 529	IP 53 when installed according to mounting instructions IP 64 with use of compressed air from DA 300
Weight	1.3 kg + 3.6 kg/m measuring length

* Please select when ordering
1) With HEIDENHAIN cable

Interfaces

Incremental Signals ∿ 1 V_{PP}

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

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

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

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

- –3 dB cutoff frequency:
  70 % of the signal amplitude
- –6 dB cutoff frequency:
  50 % of the signal amplitude

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

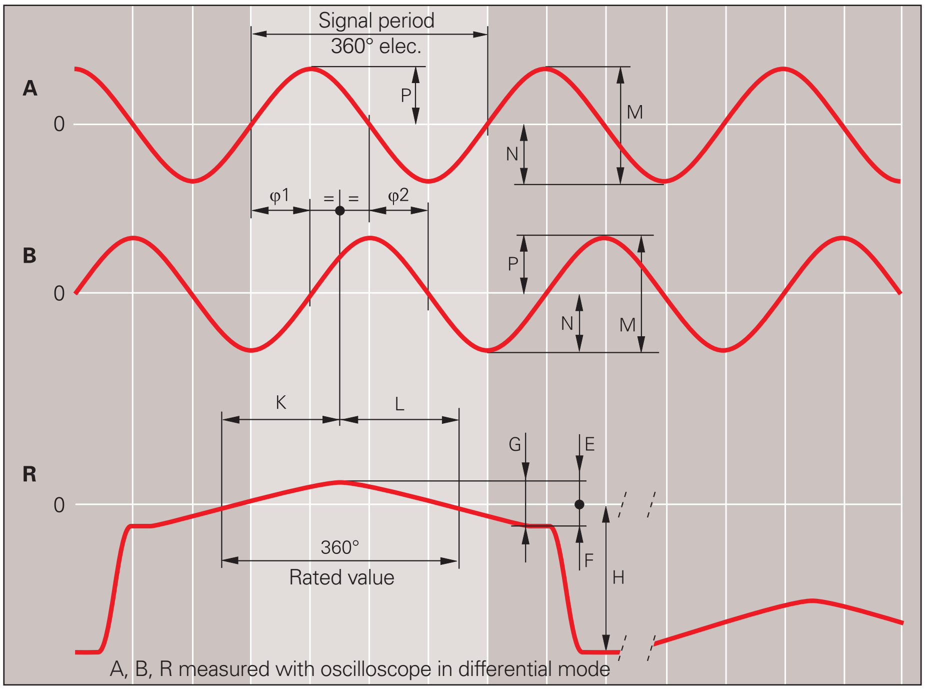
Measuring steps for **position measurement** are recommended in the specifications. For special applications, other resolutions are also possible.

Short-circuit stability
A temporary short circuit of one output to 0 V or 5 V does not cause encoder failure, but it is not a permissible operating condition.

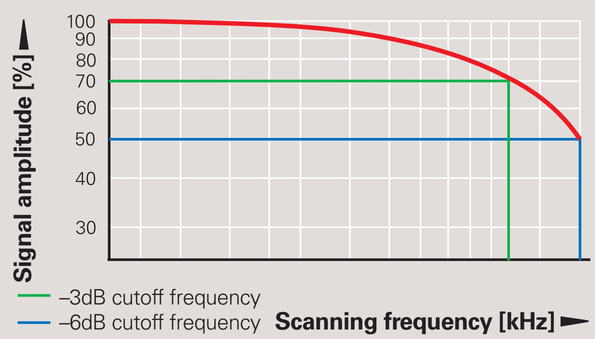
Short circuit at	20 °C	125 °C
One output	< 3 min	< 1 min
All outputs	< 20 s	< 5 s

Interface	Sinusoidal voltage signals ∿ **1 V_{PP}**	
Incremental signals	**2 sinusoidal signals A and B**	
	Signal level M:	0.6 to 1.2 V_{PP}; typically 1 V_{PP}
	Asymmetry $\|P – N\|/2M$:	≤ 0.065
	Amplitude ratio M_A/M_B:	0.8 to 1.25
	Phase angle $\|\varphi1 + \varphi2\|/2$:	90° ± 10° elec.
Reference mark signal	**1 or more signal peaks R**	
	Usable component G:	0.2 to 0.85 V
	Quiescent value H:	0.04 V to 1.7 V
	Switching threshold E, F:	≥ 40 mV
	Zero crossovers K, L:	180° ± 90° elec.
Connecting cable	HEIDENHAIN cable with shielding PUR [4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)]	
Cable lengths	Max. 150 m distributed capacitance 90 pF/m	
Propagation time	6 ns/m	

Any limited tolerances in the encoders are listed in the specifications.



Cutoff frequency
Typical signal amplitude curve with respect to the scanning frequency



Input circuitry of the subsequent electronics

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

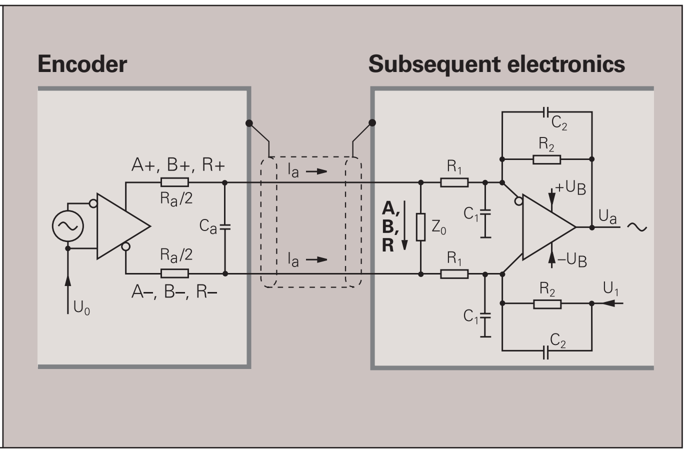
–3dB cutoff frequency of circuitry
Approx. 450 kHz
Approx. 50 kHz with $C_1 =$ 1000 pF
and $C_2 =$ 82 pF
The circuit variant for 50 kHz does reduce the bandwidth of the circuit, but in doing so it improves its noise immunity.

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

Signal monitoring
A threshold sensitivity of 250 mV_{PP} is to be provided for monitoring the 1 V_{PP} incremental signals.

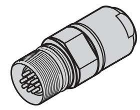
Incremental signals
Reference mark signal

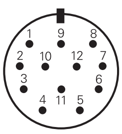
$R_a < 100\ \Omega$, typ. 24 Ω
$C_a < 50$ pF
$\Sigma I_a < 1$ mA
$U_0 = 2.5\ V \pm 0.5\ V$
(relative to 0 V of the power supply)



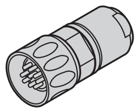
Pin layout

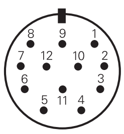
12-pin coupling M23



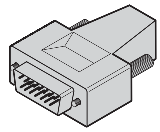


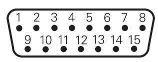
12-pin connector M23





15-pin D-sub connector
for IK 115/IK 215 or on encoder





	Power supply				Incremental signals						Other signals		
M23	**12**	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**9**	**7**	**/**
D-sub	**4**	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**5/8/13/15**	**14**	**/**
	$\mathbf{U_P}$	**Sensor** U_P	**0 V**	**Sensor** 0 V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**Vacant**	**Vacant**	**Vacant**
Cable	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	/	Violet	Yellow

Shield on housing; $\mathbf{U_P}$ = power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line

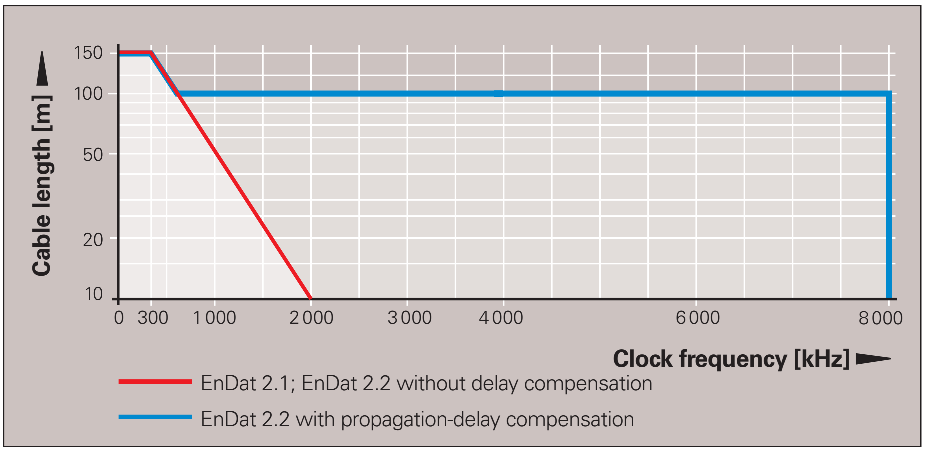
Interfaces
Absolute Position Values EnDat

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

Clock frequency and cable length
Without propagation-delay compensation, the **clock frequency**—depending on the cable length—is variable between **100 kHz** and **2 MHz.**

Because large cable lengths and high clock frequencies increase the signal run time to the point that they can disturb the unambiguous assignment of data, the delay can be measured in a test run and then compensated. With this **propagation-delay compensation** in the subsequent electronics, clock frequencies up to **8 MHz** at cable lengths up to a maximum of 100 m are possible. The maximum clock frequency is mainly determined by the cables and connecting elements used. To ensure proper function at clock frequencies above 2 MHz, use only original HEIDENHAIN cables.

Interface	**EnDat** serial bidirectional
Data transfer	Absolute position values, parameters and additional information
Data input	Differential line receiver according to EIA standard RS 485 for CLOCK, $\overline{\text{CLOCK}}$, DATA and $\overline{\text{DATA}}$ signals
Data output	Differential line driver according to EIA standard RS 485 for the DATA and $\overline{\text{DATA}}$ signals
Code	Pure binary code
Position values	Ascending in traverse direction indicated by arrow (see Dimensions)
Incremental signals	∼ 1 V_{PP} (see *Incremental Signals 1* V_{PP}) depending on unit
Connecting cable With incremental Without signals	HEIDENHAIN cable with shielding PUR [(4 x 0.14 mm^2) + 4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] PUR [(4 x 0.14 mm^2) + (4 x 0.34 mm^2)]
Cable lengths	Max. 150 m
Propagation time	Max. 10 ns; approx. 6 ns/m

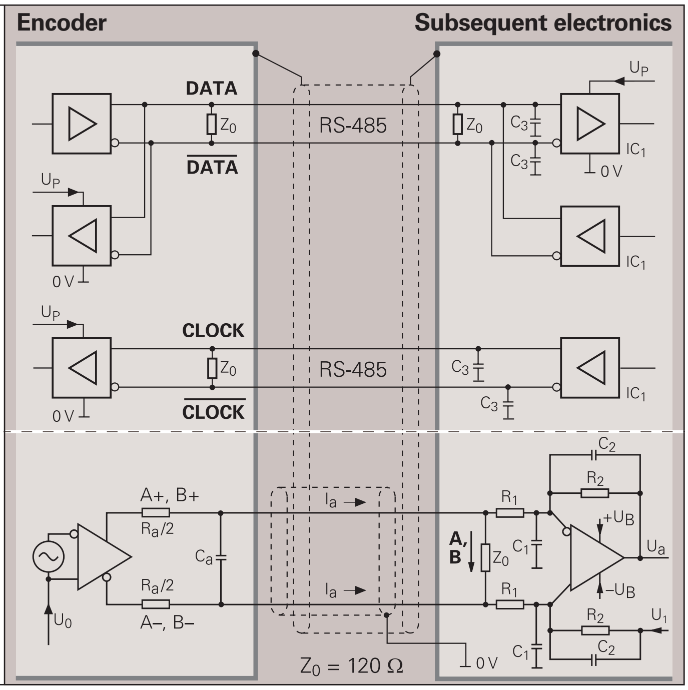


Input circuitry of the subsequent electronics

Dimensioning
IC_1 = RS 485 differential line receiver and driver

C_3 = 330 pF
Z_0 = 120 Ω

Data transfer



Incremental signals
Depends on encoder

Versions

The extended EnDat interface version 2.2 is compatible in its communication, command set and time conditions with version 2.1, but also offers significant advantages. It makes it possible, for example, to transfer additional information with the position value without sending a separate request for it. The interface protocol was expanded and the time conditions (clock frequency, processing time, recovery time) were optimized. In addition, encoders with ordering designations EnDat 02 or EnDat 22 have an extended power supply range.

Both EnDat 2.1 and EnDat 2.2 are available in versions with or without incremental signals. EnDat 2.2 encoders feature a high internal resolution. Therefore, depending on the control technology being used, interrogation of the incremental signals is not necessary. To increase the resolution of EnDat 2.1 encoders, the incremental signals are evaluated in the subsequent electronics.

Command set

The command set is the sum of all available mode commands. The EnDat 2.2 command set includes EnDat 2.1 mode commands. When a mode command from the EnDat 2.2 command set is transmitted to EnDat-01 subsequent electronics, the encoder or the subsequent electronics may generate an error message.

EnDat with command set 2.2 (includes EnDat 2.1 command set)

- Position values for incremental and absolute encoders
- Additional information on position value
  - Diagnostics and test values
  - Absolute position values after reference run of incremental encoders
  - Parameter upload/download
  - Commutation
  - Acceleration
  - Limit position signal
  - Temperature of the encoder PCB
  - Temperature evaluation of an external temperature sensor (e.g. in the motor winding)

EnDat with command set 2.1

- Absolute position values
- Parameter upload/download
- Reset
- Test command and test values

You can find more information in the *Technical Information for EnDat 2.2* document or on the Internet at www.endat.de.

Interface	Command set	Ordering designation	Version	Clock frequency
EnDat	EnDat 2.1 or EnDat 2.2	EnDat 01	With incremental signals	≤ 2 MHz
		EnDat 21	Without incremental signals	
	EnDat 2.2	EnDat 02	With incremental signals	≤ 2 MHz
	EnDat 2.2	EnDat 22	Without incremental signals	≤ 8 MHz

Benefits of the EnDat Interface

- **Automatic self-configuration:** All information required by the subsequent electronics is already stored in the encoder
- **High system security** through alarms and messages for monitoring and diagnosis
- **High transmission reliability** through cyclic redundancy checking
- Faster configuration during installation: **Datum shifting** through offsetting by a value in the encoder

Other benefits of EnDat 2.2

- **A single interface** for all absolute and incremental encoders
- **Additional information** (limit switch, temperature, acceleration)
- **Quality improvement:** Position value calculation in the encoder permits shorter sampling intervals (25 µs)

Advantages of purely serial transmission specifically for EnDat 2.2 encoders

- **Simple subsequent electronics** with EnDat receiver chip
- **Simple connection technology:** Standard connecting element (M12; 8-pin), single-shielded standard cable and few wires
- **Minimized transmission times** through adaptation of the data word length to the resolution of the encoder
- **High clock frequencies** up to 8 MHz. Position values available in the subsequent electronics after only approx. 10 µs
- **Support for state-of-the-art machine designs** e.g. direct drive technology

Functions

The EnDat interface transmits absolute position values or additional physical quantities (only EnDat 2.2) in an unambiguous time sequence and serves to read from and write to the encoder's internal memory. Some functions are available only with EnDat 2.2 mode commands.

Position values can be transmitted with or without additional information. The additional information types are selectable via the Memory Range Select (MRS) code. Other functions such as parameter reading and writing can also be called after the memory area and address have been selected. Through simultaneous transmission with the position value, additional information can also be requested of axes in the feedback loop, and functions executed with them.

Parameter reading and writing is possible both as a separate function and in connection with the position value. Parameters can be read or written after the memory area and address is selected.

Reset functions serve to reset the encoder in case of malfunction. Reset is possible instead of or during position value transmission.

Servicing diagnosis makes it possible to inspect the position value even at standstill. A test command has the encoder transmit the required test values.

Selecting the transmission type

Transmitted data are identified as either position values, position values with additional information, or parameters. The type of information to be transmitted is selected by mode commands. **Mode commands** define the content of the transmitted information. Every mode command consists of three bits. To ensure reliable transmission, every bit is transmitted redundantly (inverted or double). If the encoder detects an erroneous mode transmission, it transmits an error message. The EnDat 2.2 interface can also transfer parameter values in the additional information together with the position value. This makes the current position values constantly available for the control loop, even during a parameter request.

Control cycles for transfer of position values

The transmission cycle begins with the first falling **clock edge.** The measured values are saved and the position value calculated. After two clock pulses (2T), to **select the type of transmission** the subsequent electronics transmit the mode command "Encoder transmit position value" (with/without additional information).

After successful calculation of the absolute position value (t_{cal} – see *Specifications*), the **start bit** initiates the data transmission from the encoder to the subsequent electronics. The subsequent **error messages,** error 1 and error 2 (only with EnDat 2.2 commands), are group signals for all monitored functions and serve as failure monitors.

Beginning with the LSB, the encoder then transmits the absolute **position value** as a complete data word. Its length depends on the encoder being used. The number of required clock pulses for transmission of a position value is saved in the parameters of the encoder manufacturer. The data transmission of the position value is completed with the **Cyclic Redundancy Check** (CRC).

In EnDat 2.2, this is followed by additional information 1 and 2, each also concluded with a CRC. With the end of the data word, the clock must be set to HIGH. After 10 to 30 µs or 1.25 to 3.75 µs (with EnDat 2.2 parameterizable recovery time t_m) the data line falls back to LOW. Then a **new data transmission** can begin by starting the clock.

Mode commands

Mode commands		
• Encoder transmit position value • Selection of the memory area • Encoder receive parameters • Encoder transmit parameters • Encoder receive reset[1)] • Encoder transmit test values • Encoder receive test commands	**EnDat 2.1**	**EnDat 2.2**
• Encoder transmit position value with additional information • Encoder transmit position value and receive selection of memory area[2)] • Encoder transmit position value and receive parameters[2)] • Encoder transmit position value and transmit parameters[2)] • Encoder transmit position value and receive error reset[2)] • Encoder transmit position value and receive test command[2)] • Encoder receive communication command[3)]		**EnDat 2.2**

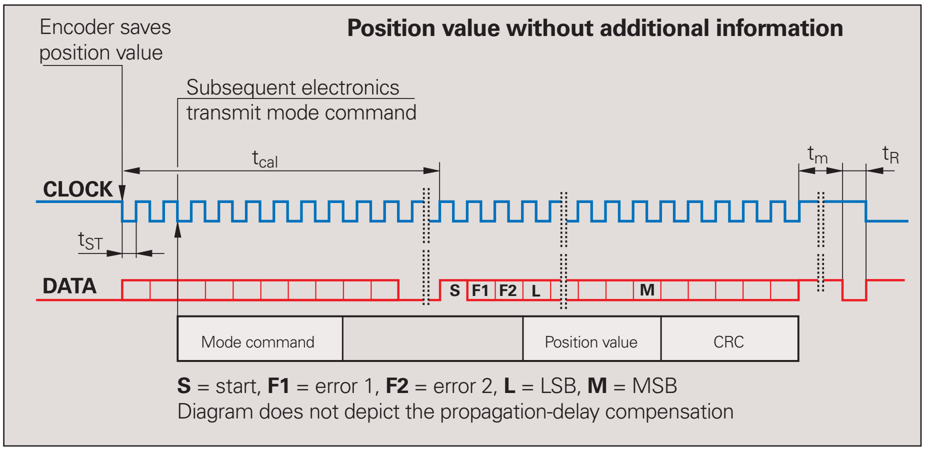
1) Same reaction as switching the power supply off and on
2) Selected additional information is also transmitted
3) Reserved for encoders that do not support the safety system

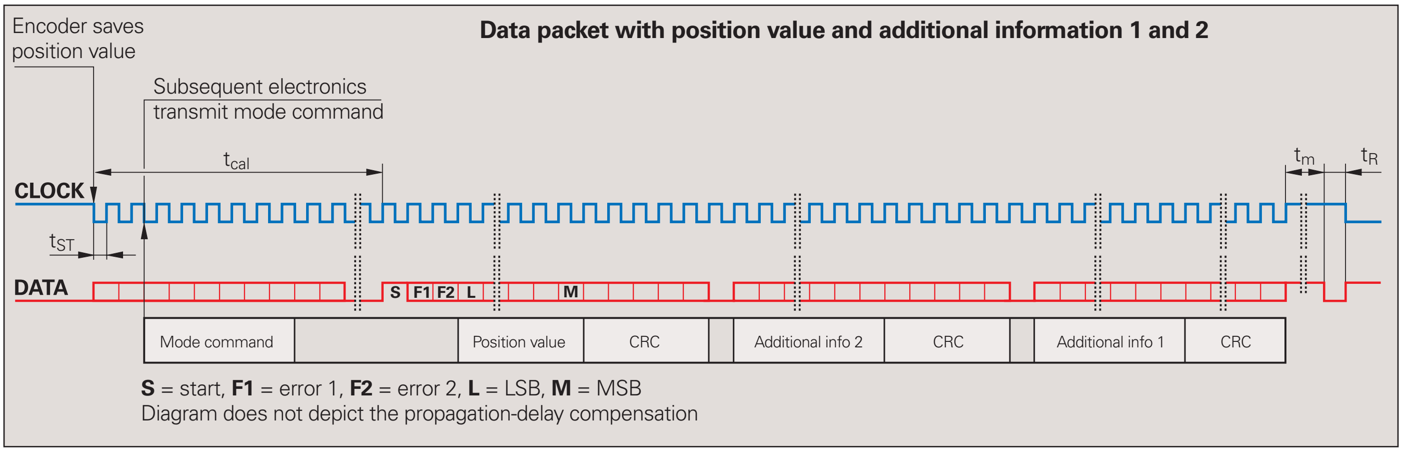
The time absolute linear encoders need for calculating the position values t_{cal} differs depending on whether EnDat 2.1 or EnDat 2.2 mode commands are transmitted (see the *Specifications*). If the incremental signals are evaluated for axis control, then the EnDat 2.1 mode commands should be used. Only in this manner can an active error message be transmitted synchronously to the currently requested position value. EnDat 2.1 mode commands should not be used for pure serial position-value transfer for axis control.

		Without delay compensation	With delay compensation
Clock frequency	f_c	100 kHz ... 2 MHz	100 kHz ... 8 MHz
Calculation time for **Position value** **Parameters**	 t_{cal} t_{ac}	 See *Specifications* Max. 12 ms	
Recovery time	t_m	*EnDat 2.1:* 10 to 30 µs *EnDat 2.2:* 10 to 30 µs or 1.25 to 3.75 µs ($f_c \geq 1$ MHz) (parameterizable)	
	t_R	Max. 500 ns	
	t_{ST}	–	2 to 10 µs
Data delay time	t_D	(0.2 + 0.01 x cable length in m) µs	
Pulse width	t_{HIGH} t_{LOW}	0.2 to 10 µs 0.2 to 50 ms/30 µs (with LC)	Pulse width fluctuation HIGH to LOW max. 10%

EnDat 2.2 – Transfer of Position Values

EnDat 2.2 can transmit position values selectably with or without additional information.

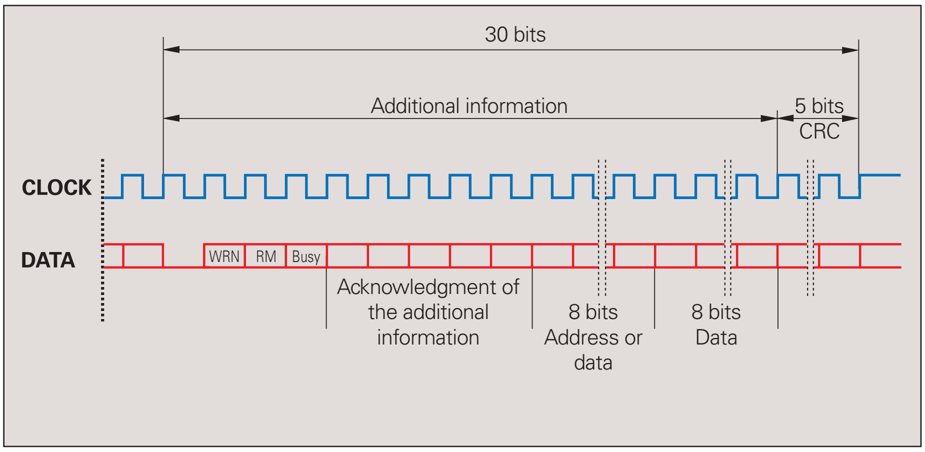




Additional information

With EnDat 2.2, one or two pieces of additional information can be appended to the position value. Each additional information is 30 bits long with LOW as first bit, and ends with a CRC check. The additional information supported by the respective encoder is saved in the encoder parameters.

The content of the additional information is determined by the MRS code and is transmitted in the next sampling cycle for additional information. This information is then transmitted with every sampling until a selection of a new memory area changes the content.



The additional information always begins with:	The additional information can contain the following data:	
Status data Warning—WRN Reference mark—RM Parameter request—busy **Acknowledgment** of additional information	**Additional information 1** Diagnosis Position value 2 Memory parameters MRS-code acknowledgment Test values Temperature	**Additional information 2** Commutation Acceleration Limit position signals

EnDat 2.1 – Transfer of Position Values

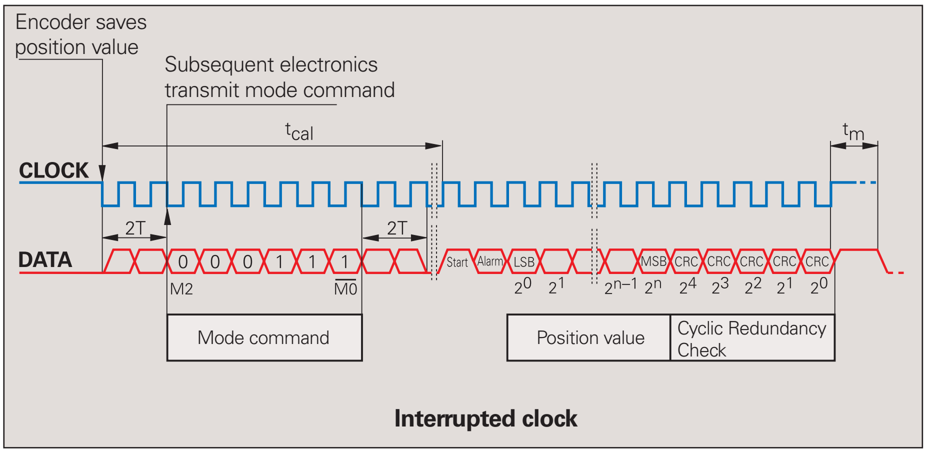
EnDat 2.1 can transmit position values selectably with interrupted clock pulse (as in EnDat 2.2) or continuous clock pulse.

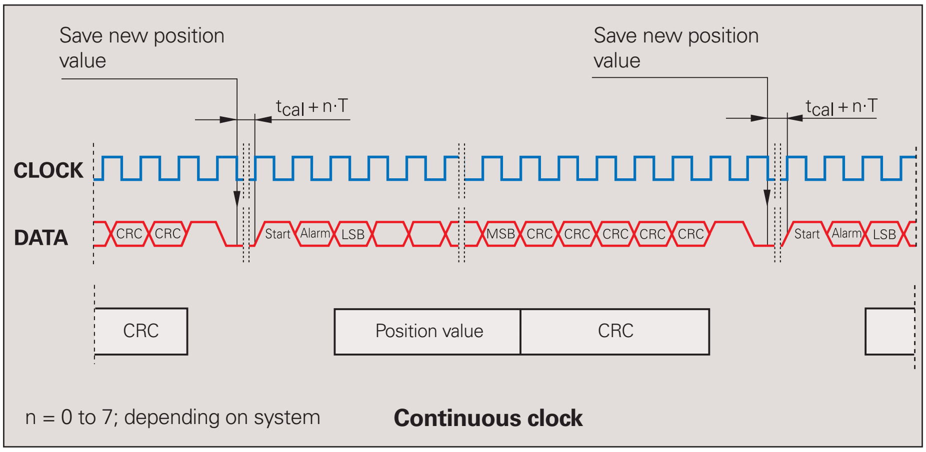
Interrupted clock
The interrupted clock is intended particularly for time-clocked systems such as closed control loops. At the end of the data word the clock signal is set to HIGH level. After 10 to 30 µs (t_m), the data line falls back to LOW. Then a new data transmission can begin by starting the clock.

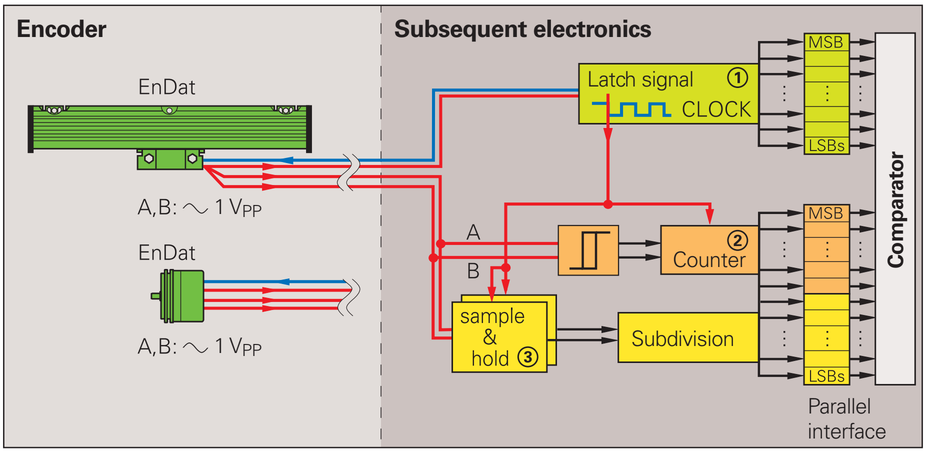
Continuous clock
For applications that require fast acquisition of the measured value, the EnDat interface can have the clock run continuously. Immediately after the last CRC bit has been sent, the data line is switched to high for one clock cycle, and then to low. The new position value is saved with the very next falling edge of the clock 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 9 periods per position value.

Synchronization of the serially transmitted 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.







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 monitoring is possible even at high shaft speeds thanks to the EnDat interface's short transmission times of less than 50 µs. This capability is a prerequisite for modern machine design and safety systems.

Parameters and Memory Areas

The encoder provides several memory areas for parameters. These can be read from by the subsequent electronics, and some 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 the encoder is exchanged, it is therefore essential that its 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.

Parameters of the encoder manufacturer
This write-protected memory area contains all **information specific to the encoder,** such as encoder type (linear/angular, singleturn/multiturn, etc.), signal periods, position values per revolution, transmission format of position values, direction of rotation, maximum speed, accuracy dependent on shaft speeds, support of warnings and alarms, part number and serial number. This information forms the basis for **automatic configuration.** A separate memory area contains the parameters typical for EnDat 2.2: Status of additional information, temperature, acceleration, support of diagnostic and error messages, etc.

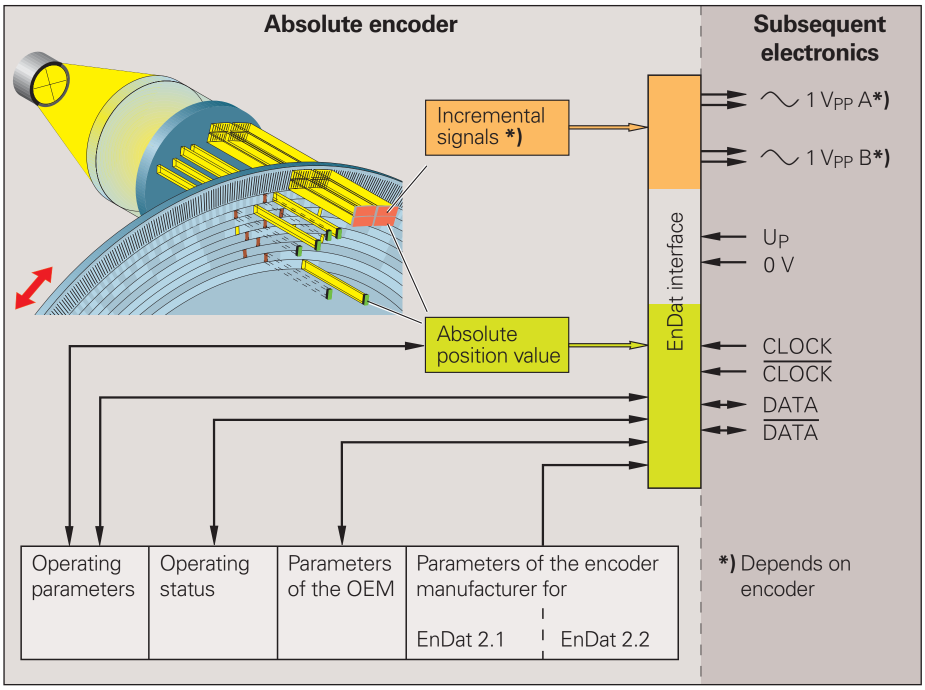
Parameters of the OEM
In this freely definable memory area, the OEM can store his information, e.g. the "electronic ID label" of the motor in which the encoder is integrated, indicating the motor model, maximum current rating, etc.

Operating parameters
This area is available for a **datum shift** and the configuration of diagnostics. 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 to interrogate their status. Once **write protection** is activated, it cannot be removed.

Safety System

The safety system is in preparation. Safety-oriented controls are the planned application for encoders with EnDat 2.2 interface. Refer to IEC 61800 standard *Adjustable speed electrical power drive systems* Part 5-2.



Monitoring and Diagnostic Functions

The EnDat interface enables comprehensive monitoring of the encoder without requiring an additional transmission line. The alarms and warnings supported by the respective encoder are saved in the "parameters of the encoder manufacturer" memory area.

Diagnosis
Cyclic information on encoder function and additional diagnostic values are transmitted in the additional information.

Error message
An error message becomes active if a **malfunction of the encoder** might result in incorrect position values. The exact cause of the disturbance is saved in the "operating status" memory and can be interrogated in detail. Errors include, for example,

- Light unit failure
- Signal amplitude too low
- Error in calculation of position value
- Power supply too high/low
- Current consumption is excessive

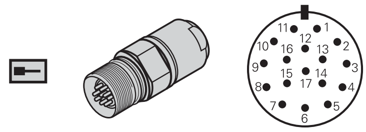
Here the EnDat interface transmits the error bits, error 1 and error 2 (only with EnDat 2.2 commands). These are group signals for all monitored functions and serve for failure monitoring. The two error messages are generated independently from each other.

Warning
This collective bit is transmitted in the status data of the additional information. It indicates that certain **tolerance limits of the encoder** have been reached or exceeded—such as shaft speed or the limit of light source intensity compensation through voltage regulation—without implying that the measured position values are incorrect. This function makes it possible to issue preventive warnings in order to minimize idle time.

Cyclic Redundancy Check
To ensure **reliability of data transfer,** a cyclic redundancy check (CRC) is performed through the logical processing of 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.

Pin Layout for EnDat

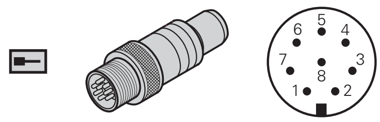
17-pin coupling M23



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

Shield on housing; **U_P** = Power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!

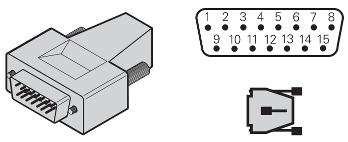
8-pin coupling M12



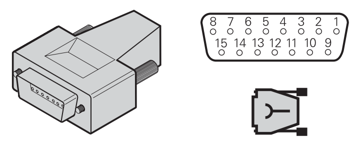
	Power supply				Absolute position values			
Pin	**2**	**8**	**1**	**5**	**3**	**4**	**7**	**6**
Signal	**U_P** 1)	**U_P**	**0 V** 1)	**0 V**	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
Wire	Blue	Brown/Green	White	White/Green	Gray	Pink	Violet	Yellow

Shield on housing; **U_P** = power supply voltage
1) For power lines configured in parallel
Vacant pins or wires must not be used!

15-pin D-sub connector (male)
for IK 115/IK 215



15-pin D-sub connector (female)
for HEIDENHAIN controls and IK 220



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

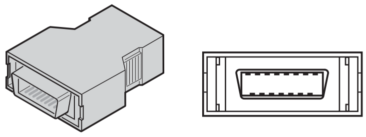
Shield on housing; **U_P** = power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!
1) Not assigned for adapter cable Id. Nr. 524599-xx for IK 115/IK215

Interfaces
Fanuc and Mitsubishi Pin Layouts

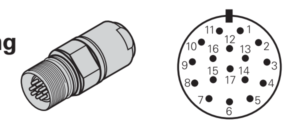
Fanuc pin layout
HEIDENHAIN encoders with the code letter F after the model designation are suited for connection to Fanuc controls with

- **Serial interface Fanuc 01** with 1 MHz communication rate
- **Serial interface Fanuc 02** with 1 MHz or 2 MHz communication rate

15-pin Fanuc connector



17-pin HEIDENHAIN coupling

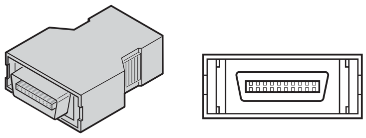


	Power supply					Absolute position values			
	9	18/20	12	14	16	1	2	5	6
	7	1	10	4	–	14	17	8	9
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Shield**	**Serial Data**	**$\overline{\text{Serial Data}}$**	**Request**	**$\overline{\text{Request}}$**
	Brown/ Green	Blue	White/ Green	White	–	Gray	Pink	Violet	Yellow

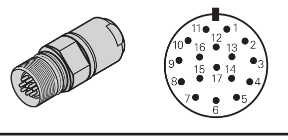
Shield on housing; **U_P** = power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!

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

20-pin Mitsubishi connector



17-pin HEIDENHAIN coupling



	Power supply				Absolute position values			
	20	19	1	11	6	16	7	17
	7	1	10	4	14	17	8	9
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Serial Data**	**$\overline{\text{Serial Data}}$**	**Request Frame**	**$\overline{\text{Request Frame}}$**
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

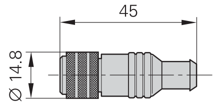
Shield on housing; **U_P** = power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!

Connecting Elements and Cables
General Information

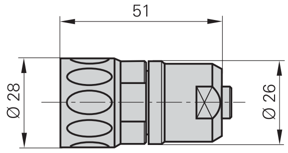
Connector insulated: Connecting element with coupling ring, available with male or female contacts.

Symbols  

M12



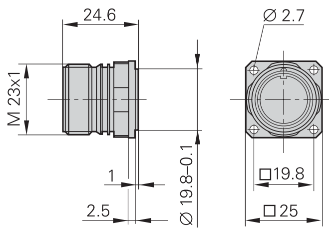
M23



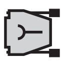
Flange socket: Permanently mounted on the encoder or a housing, with external thread (like the coupling), and available with male or female contacts.

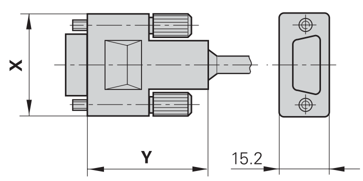
Symbols  

M23



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

Symbols  

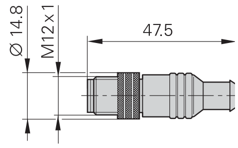


x: 41.7 **y:** 15.2

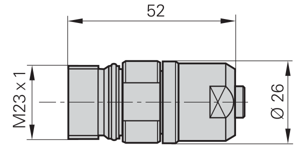
Coupling insulated:
Connecting element with external thread; Available with male or female contacts.

Symbols  

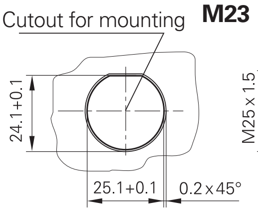
M12



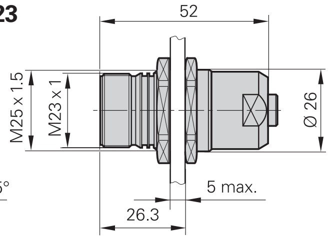
M23



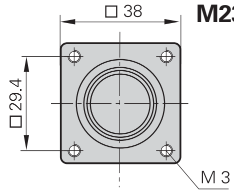
Mounted coupling with central fastening



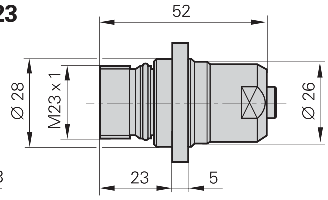
M23



Mounted coupling with flange



M23



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

Male contacts or

Female contacts

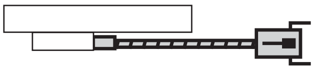
When engaged, the connections provide **protection** to IP 67 (D-sub connector: IP 50; IEC 60529). When not engaged, there is no protection.

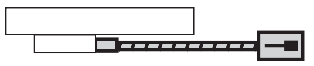
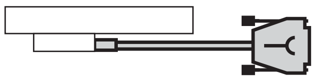
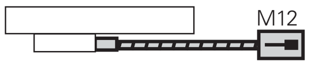
Accessories for flange socket and M23 mounted couplings

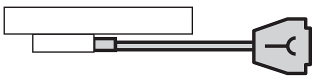
Bell seal
Id. Nr. 266526-01

Threaded metal dust cap
Id. Nr. 219926-01

Adapter Cables

For incremental linear encoders		Cable Ø	LB 382 LF 183	LF 481	LS 187 LS 487
Adapter cable with M23 coupling (male)		6 mm	310128-xx	310123-xx	360645-xx
Adapter cable without connector		6 mm	310131-xx	310134-xx	354319-xx
Adapter cable with M23 connector (male)		6 mm 4.5 mm	310127-xx –	310122-xx –	344228-xx 352611-xx
Adapter cable in metal armor with M23 connector (male)		10 mm	310126-xx	310121-xx	344451-xx
Adapter cable with D-sub connector (15-pin)		6 mm	298429-xx	298430-xx	360974-xx

For absolute linear encoders – EnDat		Cable Ø	LC 183 LS 483 with incremental signals	LC 183 LS 483 without incremental signals
Adapter cable with M23 coupling (male)		6 mm	533631-xx	–
Adapter cable in metal armor with M23 coupling (male)		10 mm	558362-xx	–
Adapter cable with D-sub connector		6 mm	558717-xx	–
Adapter cable with M12 coupling (male)		4.5 mm	–	533661-xx
Adapter cable in metal armor with M12 coupling (male)		10 mm	–	550678-xx

For absolute linear encoders – Fanuc/Mitsubishi		Cable Ø	LC 193F LC 493F	LC 193M LC 493M
Adapter cable with M23 coupling (male)		6 mm 4.5 mm	– 545547-xx	
Adapter cable with Fanuc connector		6 mm 4.5 mm	– 547300-xx	– –

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

Connecting Cables 12-pin ∿ 1 V_{PP}
17-pin EnDat/Fanuc/Mitsubishi

PUR connecting cable Ø 8 mm for encoders with coupling or flange socket	
Complete with M23 connector (female) and M23 connector (male) 	12-pin 298 399-xx
Complete with M23 connector (female) and M23 coupling (male) 	17-pin 323 897-xx
Complete with M23 connector (female) and D-sub connector (female) for HEIDENHAIN controls and IK 220 	12-pin 310199-xx 17-pin 332 115-xx
Complete with M23 connector (female) and D-sub connector (male) for IK 115/IK 215 	17-pin 324 544-xx
With one M23 connector (female) 	12-pin 309 777-xx 17-pin 309 778-xx

PUR connecting cable Ø 8 mm for encoders with connector	
Complete with M23 coupling (female) and M23 connector (male) 	12-pin 298 400-xx
With one M23 coupling (female) 	12-pin 298 402-xx

Cable without connectors 	12-pin 244957-01 17-pin 266306-01	[4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] [(4 x 0.14 mm^2) + 4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)]

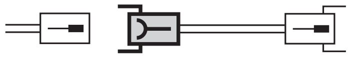
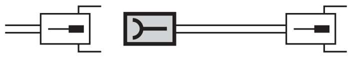
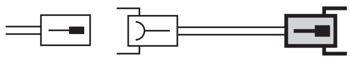
Connecting cable for EnDat 2.2 encoders without incremental signals with M12 connecting element			
Complete with M12 connector (female), 8-pin, and M12 connector (male), 8-pin 	368 330-xx	**Complete** with M12 connector (female) and D-sub connector (male) for IK 115/IK 215 	524 599-xx

PUR adapter cable for Fanuc interface, dia. 8 mm	
Complete with M23 connector (female), 17-pin, and Fanuc connector [(2 x 2 x 0.14 mm^2) + (4 x 1 mm^2)] 	534 855-xx
Cable without connectors [(2 x 2 x 0.14 mm^2) + (4 x 1 mm^2)] 	354 608-01

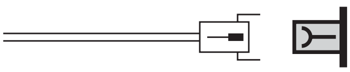
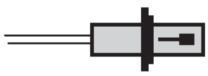
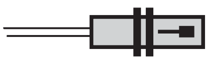
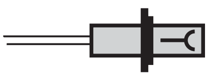
PUR adapter cable for Mitsubishi interface,dia. 8 mm	
Complete with M23 connector (female), 17-pin, and Mitsubishi connector [(2 x 2 x 0.14 mm^2) + (4 x 0.5 mm^2)] 	344 625-xx
Cable without connectors [(2 x 2 x 0.14 mm^2) + (4 x 1 mm^2)] 	354 608-01

Connecting Elements 12-pin ∼ 1 V_{PP} 17-pin EnDat

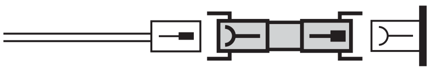
M23 connectors and couplings

Coupling on encoder cable 	**M23 coupling (male)**	**Mating element to coupling on encoder cable or flange socket** 	**M23 connector (female)**
For cable Ø 4.5 mm Ø 6 mm	12-pin 291 698-14 12-pin 291 698-03 17-pin 291 698-26	For connecting cable, diameter 8 mm	12-pin 291 697-05 17-pin 291 697-26
Connector on encoder cable 	**M23 connector (male)**	**Mating element on connecting cable for encoder connector** 	**M23 coupling (female)**
For cable Ø 4.5 mm Ø 6 mm	12-pin 291 697-06 12-pin 291 697-07	For connecting cable, diameter 8 mm	12-pin 291 698-02
		Connector for connection to subsequent electronics 	**M23 connector (male)**
		For connecting cable, diameter 8 mm	12-pin 291 697-08 17-pin 291 697-27

Couplings and M23 flange socket for mounting

	**M23 flange socket (female)**		**M23 coupling on mounting base with flange (male)**
	12-pin 315 892-08 17-pin 315 892-10	For cable Ø 6 mm Ø 8 mm	12-pin 291 698-08 12-pin 291 698-31 17-pin 291 698-29
	**M23 coupling on mounting base with central fastening (male)**		**M23 coupling on mounting base with flange (female)**
For cable Ø 6 mm	12-pin 291 698-33 17-pin 291 698-37	For cable Ø 6 mm Ø 8 mm	12-pin 291 698-17 12-pin 291 698-07 17-pin 291 698-35

Adapter connector ∼ 1 V_{PP}/∼ 11 μA_{PP}

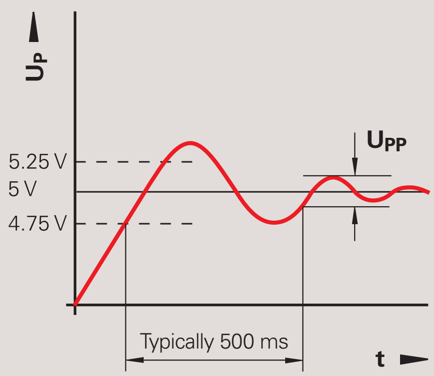
For converting the 1-V_{PP} output signals to 11-μA_{PP} input signals for the subsequent electronics; M23 connector (female, 12-pin) and M23 connector (male, 9-pin)		364 914-01

General Electrical Information

Power Supply

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

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



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

The values apply as measured at the encoder, i.e., without cable influences. The voltage 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.

Calculation of the **voltage drop:**

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

with ΔU: Voltage attenuation in V
L_C: Cable length in m
I: Current consumption of the encoder in mA (see *Specifications*)
A_P: Cross section of power lines in mm^2

Electrically Permissible Speed/ Traversing Speed

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

- the **mechanically** permissible shaft speed or traversing velocity (if listed in *Specifications*) and
- the **electrically** permissible shaft speed or traversing velocity.

For encoders with **sinusoidal output signals,** the electrically permissible shaft speed or traversing velocity is limited by the –3dB/ –6dB cutoff frequency or the permissible input frequency of the subsequent electronics.

For encoders with **square-wave signals,** the electrically permissible shaft speed or traversing velocity is limited by

– the maximum permissible scanning/ output frequency f_{max} of the encoder and
– the minimum permissible edge separation *a* for the subsequent electronics

For angular or rotary encoders

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

For linear encoders

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

where
n_{max}: Electrically permissible speed in rpm
v_{max}: Electrically permissible speed in m/min
f_{max}: Maximum scanning/output frequency of the encoder or input frequency of the subsequent electronics in kHz
z: Line count of the angle or rotary encoder per 360°
SP: Signal period of the linear encoder in µm

Cables

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

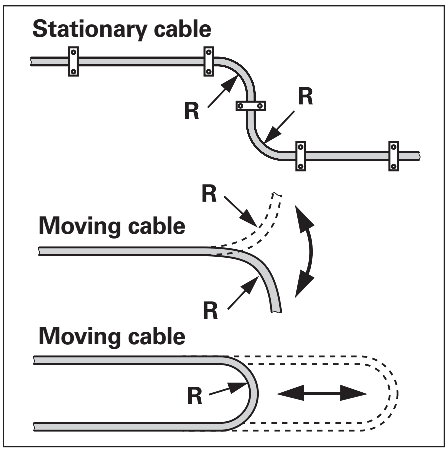
Durability
All encoders have polyurethane (PUR) cables. PUR cables are resistant to oil, hydrolysis and microbes in accordance with **VDE 0472.** They are free of PVC and silicone and comply with UL safety directives. The **UL certification** AWM STYLE 20963 80 °C 30 V E63216 is documented on the cable.

Temperature range
HEIDENHAIN cables can be used:

for stationary cables	–40 to 85 °C
for moving cables	–10 to 85 °C

Cables with limited resistance to hydrolysis and microbes are rated for up to 100 °C (except cables with M12 connecting elements).

Bending radius
The permissible bending radii *R* depend on the cable diameter and the configuration:



HEIDENHAIN cables	Cross section of power supply lines A_P			
	1 V_{PP}/TTL/HTL	**11 µA_{PP}**	**EnDat/SSI** 17-pin	**EnDat** 8-pin
Ø 3.7 mm	0.05 mm^2	–	–	–
Ø 4.5/5.1 mm	0.14/0.05[2] mm^2	0.05 mm^2	0.05 mm^2	–
Ø 6/10[1] mm	0.19/ 0.14[3] mm^2	–	0.08 mm^2	0.34 mm^2
Ø 8/14[1] mm	0.5 mm^2	1 mm^2	0.5 mm^2	1 mm^2

1) Metal armor
2) Only on length gauges
3) Only for LIDA 400

HEIDENHAIN cables	Stationary cable	Moving cable
Ø 3.7 mm	R ≥ 8 mm	R ≥ 40 mm
Ø 4.5 mm **Ø 5.1 mm**	R ≥ 10 mm	R ≥ 50 mm
Ø 6 mm	R ≥ 20 mm	R ≥ 75 mm
Ø 8 mm	R ≥ 40 mm	R ≥ 100 mm
Ø 10 mm[1]	R ≥ 35 mm	R ≥ 75 mm
Ø 14 mm[1]	R ≥ 50 mm	R ≥ 100 mm

Reliable Signal Transmission

Electromagnetic compatibility/ CE compliance
When properly installed, HEIDENHAIN encoders fulfill the requirements for electromagnetic compatibility according to 89/336/EEC with respect to the generic standards for:

- **Noise immunity IEC 61000-6-2:** 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

- **Interference IEC 61000-6-4:**

Specifically:

– For industrial, scientific and medical (ISM) equipment	IEC 55011
– For information technology equipment	IEC 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:

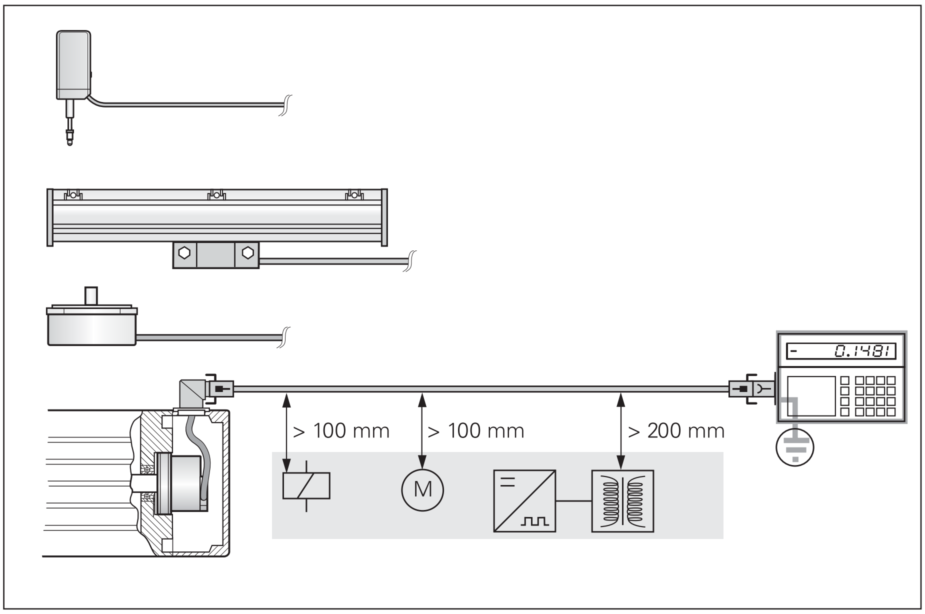
- Strong magnetic fields from transformers and electric motors
- Relays, contactors and solenoid valves
- High-frequency equipment, pulse devices, and stray magnetic fields from switch-mode power supplies
- AC power lines and supply lines to the above devices

Isolation
The encoder housings are isolated against all circuits.
Rated surge voltage: 500 V
(preferred value as per VDE 0110 Part 1)

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

- Use only original HEIDENHAIN cables. Watch for voltage attenuation on the supply lines.
- Use connectors or terminal boxes with metal housings. Do not conduct any extraneous signals.
- Connect the housings of the encoder, connector, terminal box and evaluation electronics through the shield of the cable. Connect the shielding in the area of the cable inlets to be as induction-free as possible (short, full-surface contact).
- Connect the entire shielding system with the protective ground.
- Prevent contact of loose connector housings with other metal surfaces.
- The cable shielding has the function of an equipotential bonding conductor. If compensating currents are to be expected within the entire system, a separate equipotential bonding conductor must be provided. Also see EN 50178/4.98 Chapter 5.2.9.5 regarding "protective connection lines with small cross section."
- Connect HEIDENHAIN position encoders only to subsequent electronics whose power supply is generated through double or strengthened insulation against line voltage circuits. Also see **IEC 364-4-41:** 1992, modified Chapter 411 regarding "protection against both direct and indirect touch" (PELV or SELV).
- Do not lay signal cables in the direct vicinity of interference sources (inductive consumers such as contacts, motors, frequency inverters, solenoids, etc.).
- Sufficient decoupling from interference-signal-conducting cables can usually be achieved by an air clearance of 100 mm (4 in.) or, when cables are in metal ducts, by a grounded partition.
- A minimum spacing of 200 mm (8 in.) to inductors in switch-mode power supplies is required. Also see **EN 50178**/4.98 Chapter 5.3.1.1 regarding cables and lines, and **EN 50174-2**/09.01, Chapter 6.7 regarding grounding and potential compensation.
- When using **multiturn encoders in electromagnetic fields** greater than 30 mT, HEIDENHAIN recommends consulting with the main facility in Traunreut.

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 series
Interpolation and digitizing electronics
Interpolation and digitizing electronics interpolate and digitize the sinusoidal output signals (∿ 1 V_{PP}) from HEIDENHAIN encoders up to 100-fold, and convert them to TTL square-wave pulse sequences.

IBV 101

For more information, see the *Interpolation and Digitizing Electronics* brochure for IBV 660 as well as the *IBV 100/EXE 100* product overview.

	IBV 101	IBV 102	IBV 660
Input signals	∿ 1 V_{PP}		
Encoder inputs	Flange socket, 12-pin female		
Interpolation (adjustable)	5-fold 10-fold	25-fold 50-fold 100-fold	25-fold 50-fold 100-fold 200-fold 400-fold
Minimum edge separation	Adjustable from 2 to 0.125 µs, depending on input frequency		Adjustable from 0.8 to 0.1 µs, depending on input frequency
Output signals	• 2 TTL square-wave pulse trains U_{a1} and U_{a2} and their inverted signals $\overline{U_{a1}}$ and $\overline{U_{a2}}$ • Reference pulse U_{a0} and $\overline{U_{a0}}$ • Interference signal $\overline{U_{aS}}$		
Power supply	5 V ± 5%		

IK 220
Universal PC Counter Card
The IK 220 is an expansion board for AT-compatible PCs for recording the measured values of **two incremental or absolute linear or angle encoders.** The subdivision and counting electronics **subdivide** the **sinusoidal input signals** up to **4096-fold.** A driver software package is included in delivery.

For more information, see the *IK 220 Product Information* sheet.

	IK 220			
Input signals (switchable)	∿ 1 V_{PP}	∿ 11 μA_{PP}	EnDat 2.1	SSI
Encoder inputs	Two D-sub connectors (15-pin), male			
Max. input frequency	500 kHz	33 kHz	–	
Max. cable length	60 m		10 m	
Signal subdivision (signal period : meas. step)	Up to 4096-fold			
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 98/NT/2000/XP** In VISUAL C++, VISUAL BASIC and BORLAND DELPHI			
Dimensions	Approx. 190 mm × 100 mm			

HEIDENHAIN Measuring Equipment

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

	PWM 9
Inputs	Expansion modules (interface boards) for 11 μA_{PP}; 1 V_{PP}; TTL; HTL; EnDat 2.1*/SSI*/commutation signals *No display of position values or parameters
Features	• **Measurement** of signal amplitudes, current consumption, operating voltage, scanning frequency • **Graphic display** of incremental signals (amplitudes, phase angle and on-off ratio) and the reference-mark signal (width and position) • **Display symbols** for the reference mark, fault detection signal, counting direction • **Universal counter,** interpolation selectable from single to 1024-fold • **Adjustment support** for exposed linear encoders
Outputs	• Inputs are connected through to the subsequent electronics • BNC sockets for connection to an oscilloscope
Power supply	10 to 30 V, max. 15 W
Dimensions	150 mm × 205 mm × 96 mm

The **IK 215** is an adapter card for PCs for inspecting and testing absolute HEIDENHAIN encoders with EnDat or SSI interface. All parameters can be read and written via the EnDat interface.

	IK 215
Encoder input	EnDat (absolute value or incremental signals) or SSI
Interface	PCI bus, Rev. 2.1
Application software	**Operating system:** Windows 2000/XP (Windows 98 in preparation) **Features:** Position value display Counter for incremental signals EnDat functions
Signal subdivision for incremental signals	Up to 1024-fold
Dimensions	100 mm x 190 mm

HEIDENHAIN

DR. JOHANNES HEIDENHAIN GmbH
Dr.-Johannes-Heidenhain-Straße 5
83301 Traunreut, Germany
☏ +49 (8669) 31-0
FAX +49 (8669) 5061
e-mail: info@heidenhain.de

www.heidenhain.de

DE **HEIDENHAIN Technisches Büro Nord**
12681 Berlin, Deutschland
☏ (030) 54705-240
e-mail: tbn@heidenhain.de

HEIDENHAIN Technisches Büro Mitte
08468 Heinsdorfergrund, Deutschland
☏ (03765) 69544
e-mail: tbm@heidenhain.de

HEIDENHAIN Technisches Büro West
58093 Hagen, Deutschland
☏ (02331) 9579-0
e-mail: tbw@heidenhain.de

HEIDENHAIN Technisches Büro Südwest
72131 Ofterdingen, Deutschland
☏ (07473) 22733
e-mail: tbsw@heidenhain.de

HEIDENHAIN Technisches Büro Südost
83301 Traunreut, Deutschland
☏ (08669) 311345
e-mail: tbso@heidenhain.de

AR **NAKASE Asesoramiento Tecnico**
B1653AOX Villa Ballester, Argentina
☏ (11) 47683643
e-mail: nakase@usa.net

AT **HEIDENHAIN Techn. Büro Österreich**
Dr.-Johannes-Heidenhain-Straße 5
83301 Traunreut, Germany
☏ + 49 (8669) 311337
e-mail: tba@heidenhain.de

AU **FCR Motion Technology Pty. Ltd**
Laverton North 302, Australia
☏ (3) 93626800
e-mail: vicsales@fcrmotion.com

BE **HEIDENHAIN NV/SA**
Pamelse Klei 47,
1760 Roosdaal-Pamel, Belgium
☏ (054) 343158
e-mail: sales@heidenhain.be

BG **ESD Bulgaria Ltd.**
1172 Sofia, Bulgaria
☏ 29632949
e-mail: info@esd.bg

BR **DIADUR Indústria e Comércio Ltda.**
Rua Servia, 329, Santo Amaro
04763-070 – São Paulo – SP, Brasil
☏ (011) 5523 – 6777
e-mail: assistenciatec@diadur.com.br

BY **REAL**
220047 Minsk, Belarus
☏ (172) 383571
e-mail: real@nsys.by

CA **HEIDENHAIN CORPORATION**
11-335 Admiral Blvd., Unit 11
Mississauga, Ontario L5T2N2, Canada
☏ (905) 670-8900
e-mail: info@heidenhain.com

CH **HEIDENHAIN (SCHWEIZ) AG**
Post Box
Vieristrasse 14
8603 Schwerzenbach, Switzerland
☏ (044) 8062727
e-mail: hch@heidenhain.ch

CN **HEIDENHAIN (Tianjin)**
Optics and Electronics Co. Ltd.
Tian Wei San Jie, Area A,
Beijing Tianzhu Airport Industrial Zone,
Shunyi District
100022 Beijing, China
☏ (86) 10-80420000
e-mail: sales@heidenhain.com.cn

CZ **HEIDENHAIN s.r.o.**
Stremchová 16
106 00 Praha 10, Czech Republic
☏ 272658131
e-mail: heidenhain@heidenhain.cz

DK **TP TEKNIK A/S**
Korskildelund 4
2670 Greve, Denmark
☏ (70) 100966
e-mail: tp-gruppen@tp-gruppen.dk

ES **FARRESA ELECTRONICA S.A.**
Les Corts, 36-38 bajos
08028 Barcelona, Spain
☏ 934092491
e-mail: farresa@farresa.es

FI **HEIDENHAIN AB**
Mikkelänkallio 3
02770 Espoo, Finland
☏ (09) 8676476
e-mail: info@heidenhain.fi

FR **HEIDENHAIN FRANCE sarl**
2, Avenue de la Cristallerie
92316 Sèvres, France
☏ 01 41 14 30 00
e-mail: info@heidenhain.fr

GB **HEIDENHAIN (G.B.) Limited**
200 London Road, Burgess Hill
West Sussex RH15 9RD, Great Britain
☏ (01444) 247711
e-mail: sales@heidenhain.co.uk

GR **MB Milionis Vassilis**
173 41 Athens, Greece
☏ (0210) 9336607
e-mail: bmilioni@otenet.gr

HK **HEIDENHAIN LTD**
Unit 2, 15/F, Apec Plaza
49 Hoi Yuen Road
Kwun Tong
Kowloon, Hong Kong
☏ (852) 27591920
e-mail: service@heidenhain.com.hk

HU **HEIDENHAIN Kereskedelmi Képviselet**
Hrivnák Pál utca 13.
1237 Budapest, Hungary
☏ (1) 4210952
e-mail: info@heidenhain.hu

IL **NEUMO VARGUS**
Tel-Aviv 61570, Israel
☏ (3) 5373275
e-mail: neumoil@netvision.net.il

IN **ASHOK & LAL**
Chennai – 600 030, India
☏ (044) 26151289
e-mail: ashoklal@satyam.net.in

IT **HEIDENHAIN ITALIANA S.r.l.**
Via Asiago 14
20128 Milano, Italy
☏ 0227075
e-mail: info@heidenhain.it

JP **HEIDENHAIN K.K.**
Kudan Center Bldg. 10th Floor
Kudankita 4-1-7, Chiyoda-ku
Tokyo 102-0073 Japan
☏ (03) 3234-7781
e-mail: sales@heidenhain.co.jp

KR **HEIDENHAIN LTD.**
Suite 1415, Family Tower Building
958-2 Yeongtong-Dong
Paldal-Gu, Suwon
442-470 Kyeonggi-Do, South Korea
☏ (82) 312011511
e-mail: info@heidenhain.co.kr

MX **HEIDENHAIN CORPORATION MEXICO**
Av. Las Américas 1808
Fracc. Valle Dorado
20235, Aguascalientes, Ags., Mexico
☏ (449) 9130870
e-mail: info@heidenhain.com

NL **HEIDENHAIN NEDERLAND B.V.**
Copernicuslaan 34, 6716 BM EDE
The Netherlands
☏ (0318) 581800
e-mail: verkoop@heidenhain.nl

NO **HEIDENHAIN NUF**
Boks 63
7301 Orkanger, Norway
☏ (072) 480048
e-mail: audun.grimstad@heidenhain.se

PH **MachineBank's Corporation**
Quezon City, Manila, Philippines
☏ (2) 7113751

PT **FARRESA ELECTRÓNICA LDA.**
4470 Maia, Portugal
☏ (22) 9478140
e-mail: fep@farresa.pt

RO **→ HU**

RU **GERTNER Service GmbH**
125057 Moskau, Russia
☏ (095) 931/9645
e-mail: heidenhain@gertnergroup.de

SE **HEIDENHAIN AB**
Storsätragränd 5
12739 Skärholmen, Sweden
☏ (08) 53193350
e-mail: sales@heidenhain.se

SG **HEIDENHAIN PACIFIC PTE LTD.**
51, Ubi Crescent
Singapore 408593,
Republic of Singapore
☏ (65) 6749-3238
e-mail: info@heidenhain.com.sg

SK **→ CZ**

TH **HEIDENHAIN (THAILAND) LTD**
52/72 Moo5
Chaloem Phra Kiat Rama 9 Rd
Nongbon, Pravate, Bangkok 10250,
Thailand
☏ (66) 2/398-4147
e-mail: info@heidenhain.co.th

TR **T&M Mühendislik Mümessillik**
34728 Erenköy/Istanbul, Turkey
☏ (216) 3022345
e-mail: info@tmmuhendislik.com

TW **HEIDENHAIN Co., Ltd.**
No. 12-5, Gong 33rd Road
Taichung Industrial Park
Taichung 407, Taiwan, R.O.C.
☏ (886-4) 23588977
e-mail: info@heidenhain.com.tw

US **HEIDENHAIN CORPORATION**
333 State Parkway
Schaumburg, IL 60173-5337, USA
☏ (847) 490-1191
e-mail: info@heidenhain.com

ZA **MAFEMA SALES SERVICES C.C.**
Midrand, 1685, South Africa
☏ (11) 3144416
e-mail: mailbox@mafema.co.za

Vollständige Adressen siehe www.heidenhain.de
For complete addresses see www.heidenhain.de

Zum Abheften hier falzen! / Fold here for filing!

571 470-21 · 30 · 9/2005 · H · Printed in Germany · Subject to change without notice