HEIDENHAIN

Length Gauges

May 2013

Length gauges from HEIDENHAIN offer high accuracy over long measuring ranges. These sturdily made gauges are available in application-oriented versions.

They have a wide range of applications in production metrology, in multipoint inspection stations, measuring equipment monitoring, and as position measuring devices.

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

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

Contents

* After linear length-error compensation in the evaluation electronics

Range of applications
In quality assurance

Metrology and production control

Length gauges from HEIDENHAIN play a role in incoming goods inspection, fast dimension checking during production, statistical process control in production or quality assurance, or in any application where fast, reliable and accurate length measurement is required. Their large measuring lengths are a particular advantage: whether the part measures 5 mm or 95 mm, it is measured immediately with one and the same length gauge.

Whatever the application, HEIDENHAIN has the appropriate length gauge for the required accuracy. The **HEIDENHAIN-CERTO** length gauges offer a very high accuracy of ± 0.1 µm/± 0.05 µm*/± 0.03 µm* for extremely precise measurement. Length gauges from the **HEIDENHAIN-METRO** program have accuracy grades as fine as ± 0.2 µm, while the **HEIDENHAIN-SPECTO** length gauges, with ± 1 µm accuracy, offer particularly compact dimensions.

* After linear length-error compensation in the evaluation electronics

Gauge block calibration and measuring device inspection

The usual inspection of measuring equipment called for by standards, and the inspection of gauge blocks in particular, necessitate a large number of reference standard blocks if the comparative measurement is performed using inductive length gauges. The problem is the small measuring range of inductive gauges: they can measure length differences of only up to 10 µm. Length gauges, which offer large measuring ranges together with high accuracy, greatly simplify the calibration of measuring devices required to ensure traceability.

The length gauges of the **HEIDENHAIN-CERTO** program with measuring ranges of 25 mm with ± 0.1 µm/± 0.03 µm* accuracy and 60 mm with ± 0.1 µm/± 0.05 µm* accuracy are especially well suited for this task. It permits a significant reduction in the required number of reference standard blocks, and recalibrating becomes much simpler.

Thickness gauging of silicon wafers

Inspection of styli

Calibration of gauge blocks

In production

Multipoint inspection apparatuses

Multipoint inspection devices require durable length gauges with small dimensions. They should also have relatively large measuring ranges of several millimeters with consistent linear accuracy in order to simplify the construction of inspection devices—for example by enabling the construction of one device for several masters. A large measuring length also provides benefits in master production, because simpler masters can be used.

Thanks to their small dimensions, the **ACANTO** absolute length gauge, like the **HEIDENHAIN-SPECTO** incremental length gauge, are specially designed for multi-point measuring stations. The feature accuracy grades up to ± 1 µm over measuring ranges up to 30 mm. Higher accuracy requirements up to ± 0.2 µm can be met with similarly compact **HEIDENHAIN-METRO** length gauges.

Unlike inductive gauges, HEIDENHAIN-SPECTO length gauges provide stable measurement over long periods—eliminating recalibration.

Testing station for flatness inspection

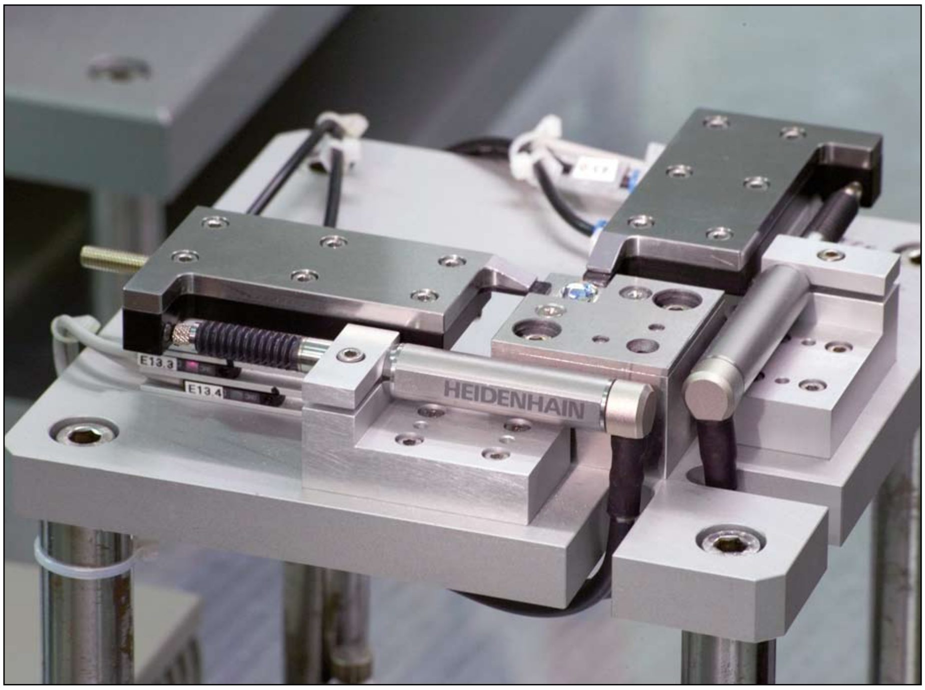
Position measurement

Length gauges from HEIDENHAIN are also ideal for position measurement on precision linear slides or X-Y tables. Working with measuring microscopes, for example, becomes much easier thanks to the digital readout and the flexible datum setting.

Here, length gauges from the **HEIDENHAIN-METRO** and **HEIDENHAIN-SPECTO** program come into use with large measuring ranges of 30 mm, 60 mm or 100 mm at consistently high accuracy grades of ± 0.5 µm or ± 1 µm.

In this application as linear measuring device, the length gauge's fast installation in accordance with the Abbe measuring principle by its clamping shank or planar mounting surface is of special benefit.

Tolerance gauging of semifinished products



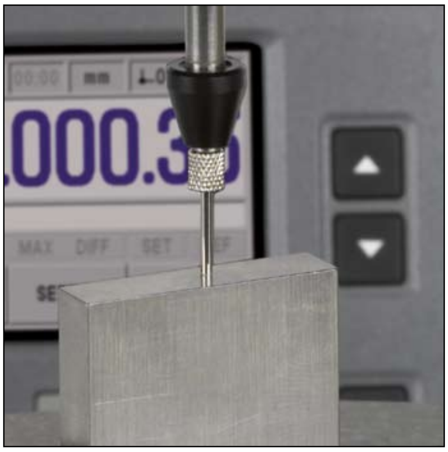
Position measurement on an X-Y table for lens mounting

Length gauges from HEIDENHAIN

A number of arguments speak for HEIDENHAIN length gauges. These include not only their technical features, but also their high quality standard and the worldwide presence of HEIDENHAIN.

Large measuring ranges

HEIDENHAIN length gauges are available with measuring lengths of 12 mm, 25 mm, 30 mm, 60 mm or 100 mm. so that you can measure very different parts in one measuring setup and avoid frequently changing setups with expensive gauge blocks or masters.



High accuracy

The high accuracy specified for HEIDENHAIN length gauges applies over the entire measuring length. Whether the part measures 10 or 100 mm, its actual dimension is always measured with the same high quality. The high repeatability of HEIDENHAIN length gauges comes into play during comparative measurements, for example in series production.

In particular HEIDENHAIN-CERTO length gauges provide high linear accuracy and offer resolution in the nanometer range.

Robust design

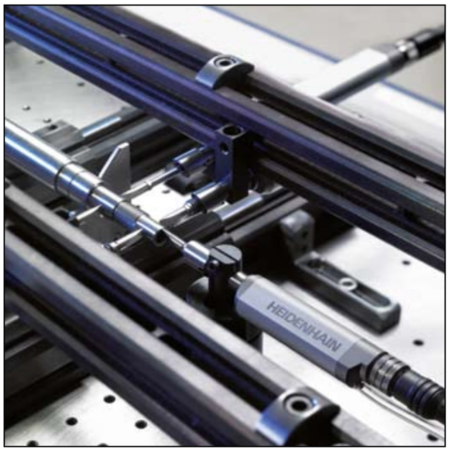
HEIDENHAIN length gauges are built for an industrial environment. They feature consistently high accuracy over a long period of time as well as high thermal stability. They can therefore be used in production equipment and machines.

Wide range of applications

HEIDENHAIN length gauges are suited for many applications. Automatic inspection equipment, manual measuring stations or positioning equipment—wherever lengths, spacing, thickness, height or linear motion are to be measured, HEIDENHAIN length gauges function quickly, reliably and accurately.

Absolute position measurement

The ACANTO length gauges operate with absolute measurement over a range of 12 mm and with high repeatability. It's particular advantage is that the measured value is available immediately after switch-on.

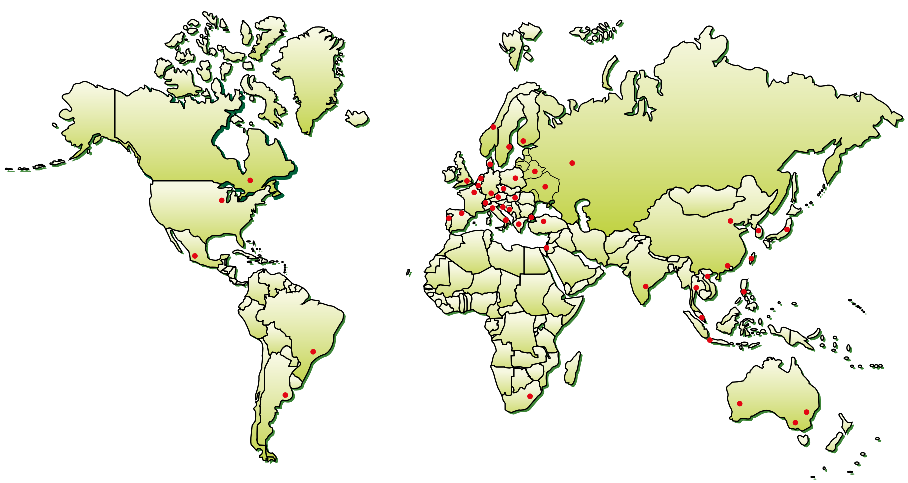


Know-how

The high quality of HEIDENHAIN length gauges is no coincidence. HEIDENHAIN has been manufacturing high-accuracy scales for over 70 years, and for many years it has developed measuring and testing devices for length and angle measurement for national standards laboratories. This know-how makes HEIDENHAIN an extraordinarily qualified partner for metrology questions.

Worldwide presence

HEIDENHAIN is represented in all important industrial countries—in most of them with wholly owned subsidiaries. Sales engineers and service technicians support the user on-site with technical information and servicing in the local language.



Length gauge overview

Accuracy	Measuring range *Plunger actuation*
Absolute position measurement	
± 2 µm	**ACANTO** *By measured object* *Pneumatic*
Incremental linear measurement	
± 0.1 µm ± 0.05 µm*) ± 0.03 µm*)	**HEIDENHAIN-CERTO** *By motor* *By external coupling*
± 0.2 µm	**HEIDENHAIN-METRO** *By cable lifter or measured object* *Pneumatic*
± 0.5 µm ± 1 µm	**HEIDENHAIN-METRO** *By motor* *By external coupling*
± 1 µm	**HEIDENHAIN-SPECTO** *By measured object* *Pneumatic*

*) After linear length-error compensation in the eva

MT 101 MT 60 CT 6000 CT 2500

12 mm	25 mm/ 30 mm	60 mm	100 mm	Page
				20
AT 1218 EnDat **AT 1217** EnDat	**AT 3018** EnDat **AT 3017** EnDat			
				22
	CT 2501 ∿ 11 μA_{PP} **CT 2502** ∿ 11 μA_{PP}	**CT 6001** ∿ 11 μA_{PP} **CT 6002** ∿ 11 μA_{PP}		
				24
MT 1271 ⊓⊔ TTL **MT 1281** ∿ 1 V_{PP} **MT 1287** ∿ 1 V_{PP}	**MT 2571** ⊓⊔ TTL **MT 2581** ∿ 1 V_{PP} **MT 2587** ∿ 1 V_{PP}			
				26
		MT 60 M ∿ 11 μA_{PP} **MT 60 K** ∿ 11 μA_{PP}	**MT 101 M** ∿ 11 μA_{PP} **MT 101 K** ∿ 11 μA_{PP}	
				28
ST 1278 ⊓⊔ TTL **ST 1288** ∿ 1 V_{PP} **ST 1277** ⊓⊔ TTL **ST 1287** ∿ 1 V_{PP}	**ST 3078** ⊓⊔ TTL **ST 3088** ∿ 1 V_{PP} **ST 3077** ⊓⊔ TTL **ST 3087** ∿ 1 V_{PP}			

aluation electronics

MT 2500 **MT 1200** **ST 3000** **ST 1200** **AT 3000** **AT 1200**

Measuring principles

Measuring standard

HEIDENHAIN length gauges are characterized by long measuring ranges and consistently high accuracy. The basis for both is the photoelectrical scanning principle.

HEIDENHAIN linear encoders use material measuring standards consisting of absolute or incremental graduations on substrates of glass or glass ceramic. These measuring standards permit large measuring ranges, are insensitive to vibration and shock, and have a defined thermal behavior. Changes in atmospheric pressure or relative humidity have no influence on the accuracy of the measuring standard—which is the prerequisite for the **high long-term stability** of HEIDENHAIN length gauges.

HEIDENHAIN manufactures the precision graduations in specially developed, photo-lithographic processes.

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

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

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

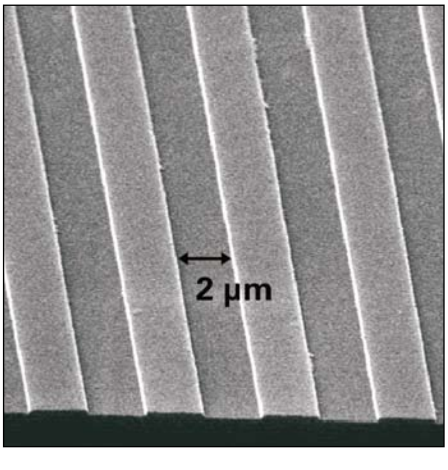
Measurement process

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 measuring standard is provided with an additional track that bears a **reference mark**. The absolute position on the scale, established by the reference mark, is gated with exactly one signal period.

The reference mark must therefore be scanned to establish an absolute reference or to find the last selected datum.

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 graduated disk**, which is formed from a serial absolute code structure. A separate incremental track is interpolated for the position value and at the same time—depending on the interface version—is used to generate an optional incremental signal.

DIADUR phase grating with approx. 0.25 µm grating height



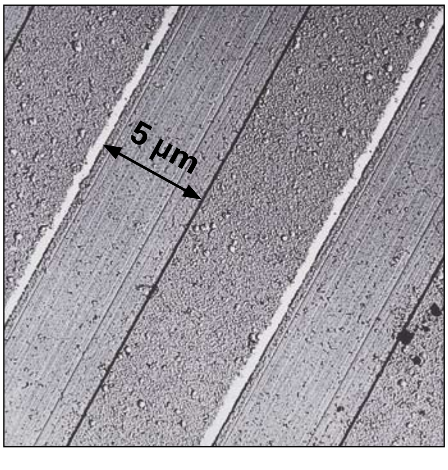
Photoelectric scanning

Most HEIDENHAIN encoders operate using the principle of photoelectric scanning. Photoelectric scanning of a measuring standard is contact-free, and as such, free of wear. This method detects even very fine lines, no more than a few microns wide, and generates output signals with very small signal periods.

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

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

DIADUR graduation



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

When parallel light passes through a grating, light and dark surfaces are projected at a certain distance, where there is an index grating. When the two gratings move relative to each other, the incident light is modulated. If the gaps in the gratings are aligned, light passes through. If the lines of one grating coincide with the gaps of the other, no light passes through. An array of photovoltaic cells converts these variations in light intensity into electrical signals. The specially structured grating of the scanning reticle filters the light to generate nearly sinusoidal output signals.

The smaller the period of the grating structure is, the closer and more tightly toleranced the gap must be between the scanning reticle and scale.

The ACANTO, HEIDENHAIN-SPECTO and the HEIDENHAIN-METRO length gauges of the MT 60 and MT 100 series operating according to the imaging principle.

Interferential scanning principle
The interferential scanning principle exploits the diffraction and interference of light on a fine graduation to produce signals used to measure displacement.

A step grating is used as the measuring standard: reflective lines 0.2 µm high are applied to a flat, reflective surface. In front of that is the scanning reticle—a transparent phase grating with the same grating period as the scale.

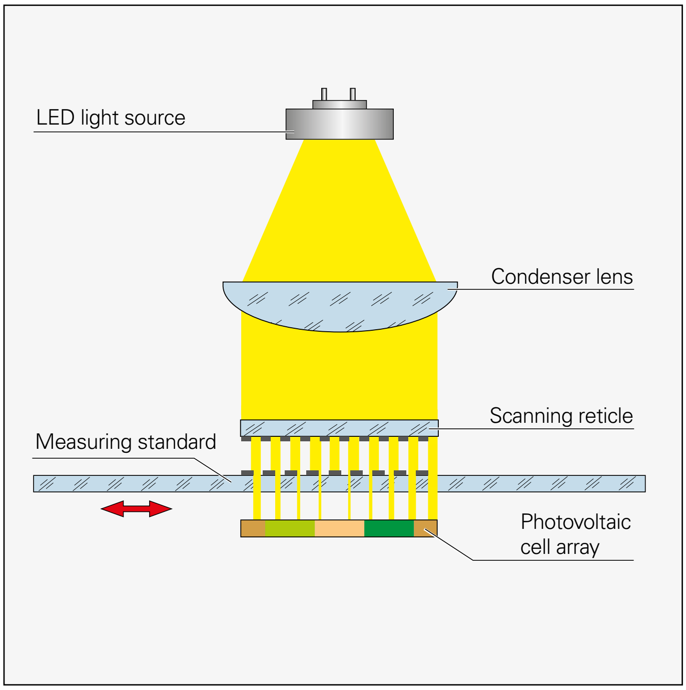
When a light wave passes through the scanning reticle, it is diffracted into three partial waves of the orders –1, 0, and +1, with approximately equal luminous intensity. The waves are diffracted by the scale such that most of the luminous intensity is found in the reflected diffraction orders +1 and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

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

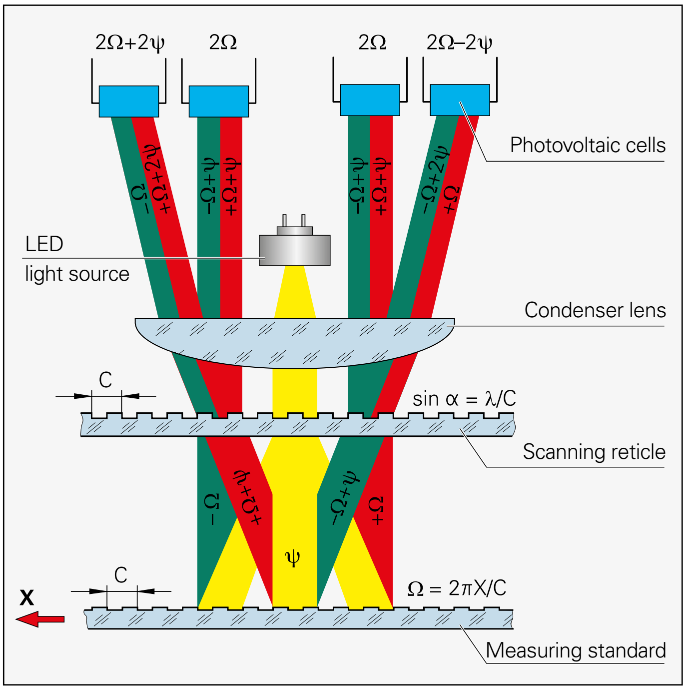
Interferential encoders function with grating periods of, for example, 8 µm, 4 µm and finer. Their scanning signals are largely free of harmonics and can be highly interpolated. These encoders are therefore especially suited for high resolution and high accuracy.

The HEIDENHAIN-CERTO and the HEIDENHAIN-METRO length gauges of the MT 1200 and MT 2500 series operating according to the interferential principle.

Imaging scanning principle



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 angular measurement is mainly determined by
- the quality of the graduation,
- the quality of the scanning process,
- the quality of the signal processing electronics,
- the eccentricity of the graduation to the bearing,
- the error from the scale guideway relative to the scanning unit, and
- the orthogonality of the length gauge to the bearing surface.

These factors of influence are comprised of encoder-specific error and application-dependent issues. All individual factors of influence must be considered in order to assess the attainable **total accuracy**.

Error specific to the measuring device

The error that is specific to the measuring device is shown in the Specifications as the **system accuracy**.

*The extreme values of the **total error F** with reference to their mean value lie over the entire measuring length within the system accuracy ± a. They are measured during the final inspection and documented in the calibration chart.*

The system accuracy includes
- the homogeneity and period definition of the graduation,
- the alignment of the graduation,
- the error of the bearing, and
- the position error within one signal period.

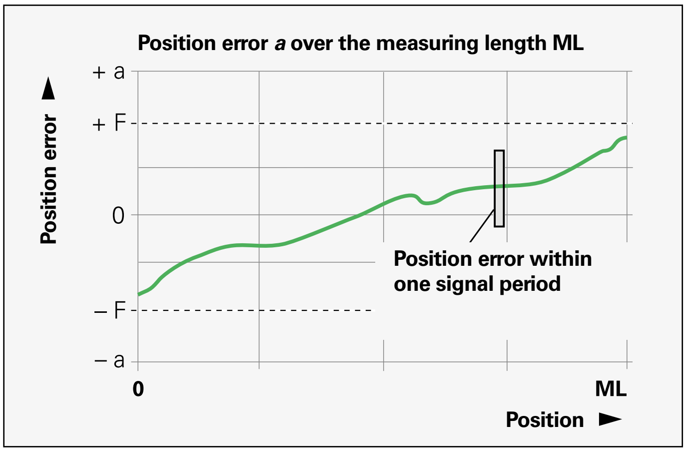
Position error within one signal period
Position errors within one signal period already become apparent in very small angular motions and in repeated measurements. They are therefore considered separately.

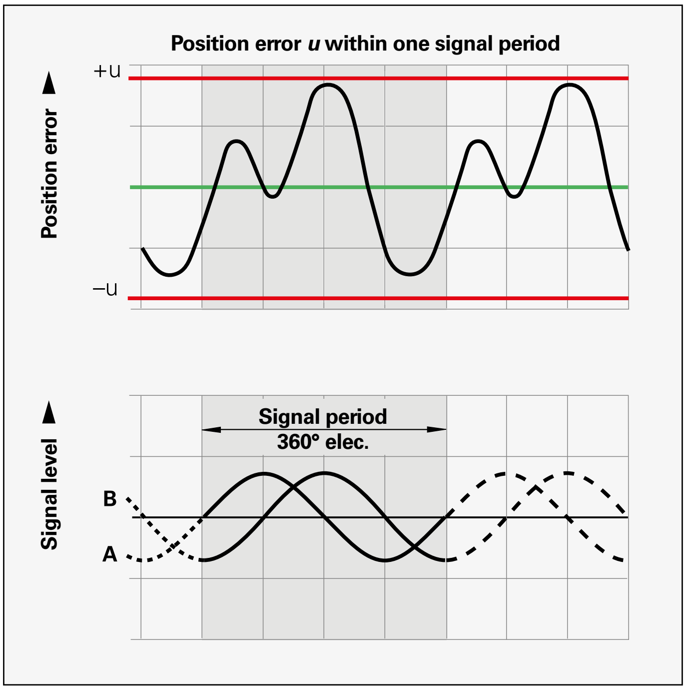
Position error within one signal period ± u results from the quality of the scanning and—for encoders with integrated pulse-shaping or counter electronics—the quality of the signal-processing electronics. For encoders with sinusoidal output signals, however, the error of signal processing is influenced by the subsequent electronics.

The following individual factors influence the result:
- The size of the signal period
- The homogeneity and period definition of the graduation
- The quality of scanning filter structures
- The characteristics of the detectors
- The stability and dynamics of further processing of the analog signals

These deviations are to be considered when specifying position error within one signal period.

Position error within one signal period ± u is specified in percent of the signal period. For length gauges, , the value is typically better than ± 1% of the signal period. You will find the specified values in the Specifications.





Application-dependent error

Other factors besides the system accuracy also influence the attainable total accuracy of measurement. These include in particular the ambient temperature and temperature fluctuations during measurement as well as a stable, orthogonal measuring setup.

All components included in the **measuring loop** such as the holder for the measured object, the gauge stand with holder, and the length gauge itself influence the result of measurement. Expansion or deformation of the measuring setup through mechanical or thermal influences adds directly to the error.

Mechanical design
A stable measuring assembly must be ensured. Long lateral elements within the measuring loop are to be avoided. HEIDENHAIN offers a stable gauge stand as an accessory. The force resulting from the measurement must not cause any measurable deformation of the measuring loop.

Length gauges from HEIDENHAIN operate with small gauging force and have very little influence on the measuring setup.

Orthogonal mounting
The length gauge is to be mounted so that its plunger is exactly orthogonal to the measured object or the surface on which it rests. Deviations result in measuring error.

The accessory HEIDENHAIN gauge stands with holders for an **8 mm clamping shank** ensure orthogonal mounting. Length gauges that provide **planar mounting surfaces** are to be adjusted in the direction parallel to the mounting surface (Y) to be perpendicular to the measuring plate. A quick and reliable adjustment is possible with the aid of a gauge block or a parallel block. The perpendicularity to the measuring table (X) is already ensured by the gauge stand.

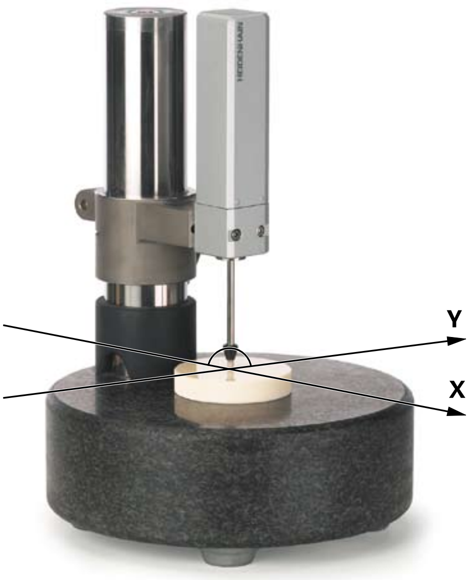
Thermal behavior
Temperature variations during measurement cause changes in length or deformation of the measuring setup. After a change in temperature of 5 K, a steel bar of 200 mm length expands by 10 µm.

Length changes resulting from a uniform deviation from the reference temperature can largely be compensated by resetting the datum on the measuring plate or a master; only the expansion of the scale and measured object go into the result of measurement.

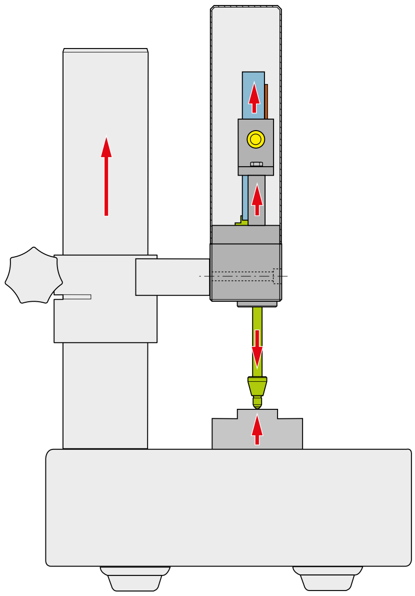
Temperature changes during measurement cannot be ascertained mathematically. For critical components, HEIDENHAIN therefore uses special materials with low coefficients of expansion, such as are found in the HEIDENHAIN-CERTO gauge stand. This makes it possible to guarantee the high accuracy of HEIDENHAIN-CERTO even at ambient temperatures of 19 °C to 21 °C and variations of ± 0.1 K during measurement.

The measuring loop:
All components involved in the measuring assembly, including the length gauge

Orthogonal mounting



Thermally induced length change:
Expansion of the measuring loop components as a result of heat



Calibration chart

All HEIDENHAIN length gauges are inspected before shipping for accuracy and proper function.

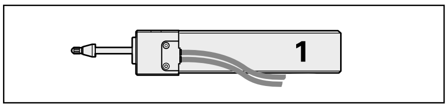
They are calibrated for accuracy during retraction and extension of the plunger. For the HEIDENHAIN-CERTO, the number of measuring positions is selected to ascertain very exactly not only the long-range error, but also the position error within one signal period.

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

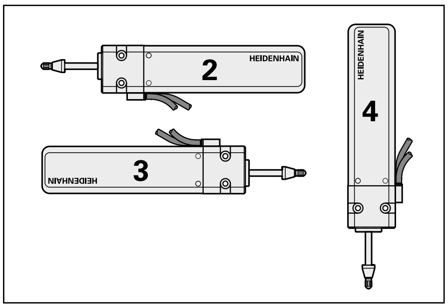
For the HEIDENHAIN-METRO and HEIDENHAIN CERTO series, a **calibration chart** documents the position error over the measuring range. It also shows the measuring step and the measuring uncertainty of the calibration measurement.

For the HEIDENHAIN-METRO the calibration chart shows the mean value of one forward and one backward measuring stroke.

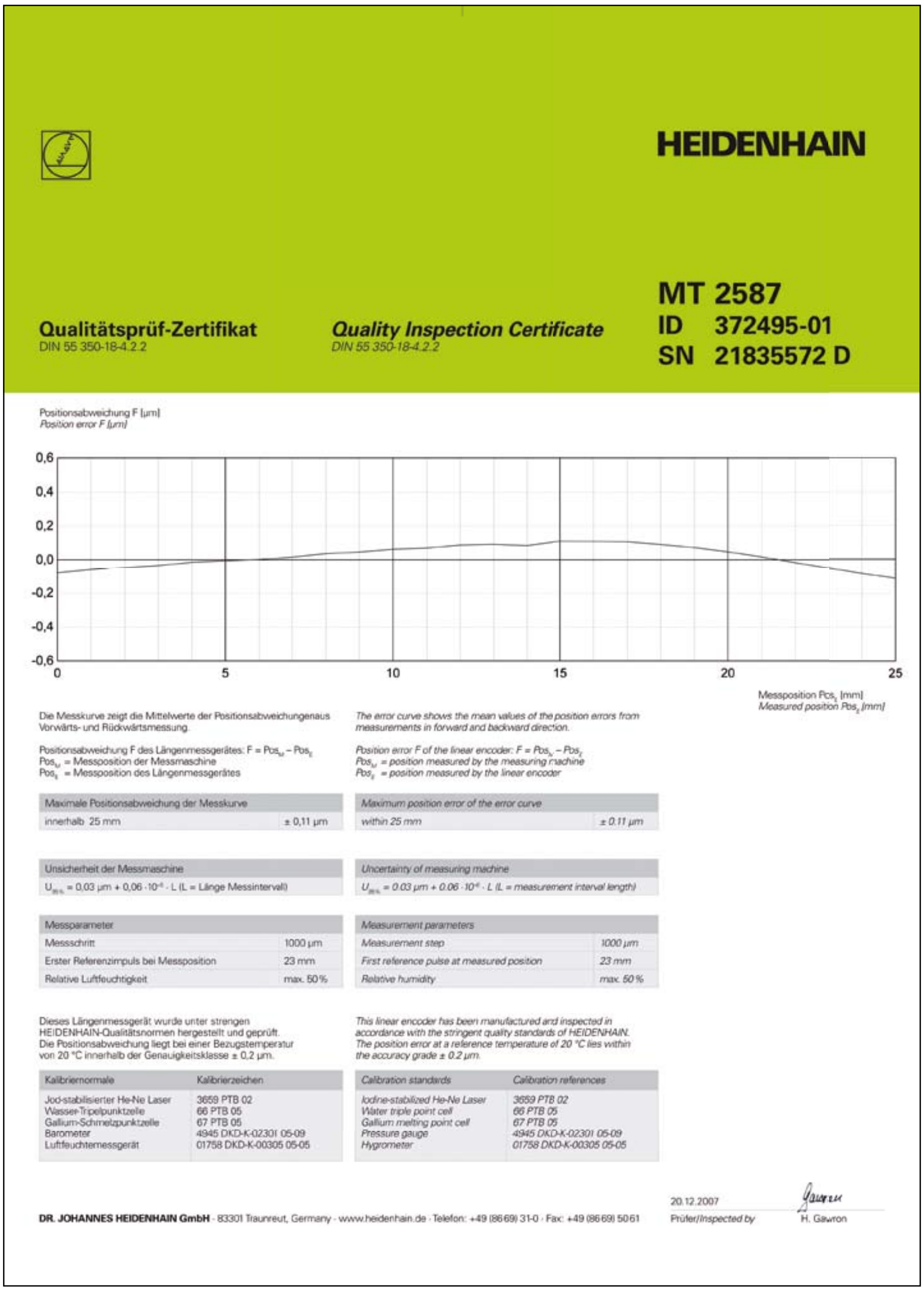
The HEIDENHAIN-CERTO is represented in the calibration chart as the envelope curve of the measured error. The HEIDENHAIN-CERTO length gauges are supplied with two calibration charts, each for different operating attitudes.



Operating attitude for calibration chart 1



Operating attitude for calibration chart 2



HEIDENHAIN

Qualitätsprüf-Zertifikat
DIN 55 350-18-4.2.2

Quality Inspection Certificate
DIN 55 350-18-4.2.2

MT 2587
ID 372495-01
SN 21835572 D

Positionsabweichung F [µm]
Position error F [µm]

Messposition Pos_E [mm]
Measured position Pos_E [mm]

Die Messkurve zeigt die Mittelwerte der Positionsabweichungenaus Vorwärts- und Rückwärtsmessung.

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

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

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

Maximale Positionsabweichung der Messkurve	
innerhalb 25 mm	± 0,11 µm

Maximum position error of the error curve	
within 25 mm	*± 0.11 µm*

Unsicherheit der Messmaschine
$U_{95\%}$ = 0,03 µm + 0,06 · 10^{-6} · L (L = Länge Messintervall)

Uncertainty of measuring machine
$U_{95\%}$ = 0.03 µm + 0.06 · 10^{-6} · L (L = measurement interval length)

Messparameter	
Messschritt	1000 µm
Erster Referenzimpuls bei Messposition	23 mm
Relative Luftfeuchtigkeit	max. 50 %

Measurement parameters	
Measurement step	*1000 µm*
First reference pulse at measured position	*23 mm*
Relative humidity	*max. 50 %*

Dieses Längenmessgerät wurde unter strengen HEIDENHAIN-Qualitätsnormen hergestellt und geprüft. Die Positionsabweichung liegt bei einer Bezugstemperatur von 20 °C innerhalb der Genauigkeitsklasse ± 0,2 µm.

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 ± 0.2 µm.

Kalibriernormale	Kalibrierzeichen
Jod-stabilisierter He-Ne Laser	3659 PTB 02
Wasser-Tripelpunktzelle	66 PTB 05
Gallium-Schmelzpunktzelle	67 PTB 05
Barometer	4945 DKD-K-02301 05-09
Luftfeuchtemessgerät	01758 DKD-K-00305 05-05

Calibration standards	*Calibration references*
Iodine-stabilized He-Ne Laser	*3659 PTB 02*
Water triple point cell	*66 PTB 05*
Gallium melting point cell	*67 PTB 05*
Pressure gauge	*4945 DKD-K-02301 05-09*
Hygrometer	*01758 DKD-K-00305 05-05*

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20.12.2007
Prüfer/*Inspected by* H. Gawron

Example

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

The **operating temperature** indicates the ambient temperature limits between which the length gauges will function properly.

The **storage temperature range** of –20 °C to 60 °C applies for the device in its packaging.

Mounting

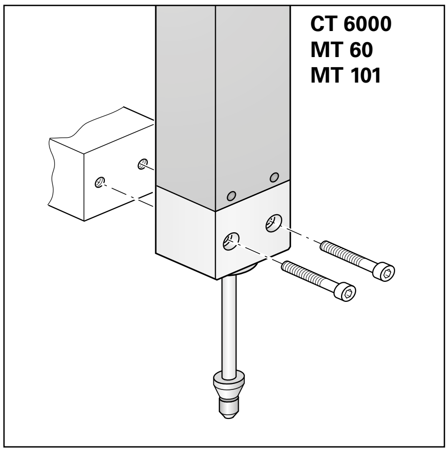
Abbe principle
HEIDENHAIN length gauges enable you to work according to the Abbe measuring principle: The measured object and scale must be in alignment to avoid additional measuring error.

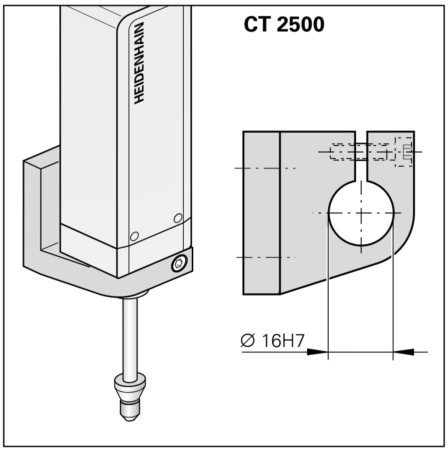
Fastening
The **CT 6000, MT 60** and **MT 101** length gauges are fastened by two screws onto a plane surface. This ensures a mechanically stable installation of even these large length gauges. Special holders are available for fastening the MT 60 and MT 101 to the MS 100 gauge stand for the HEIDENHAIN-METRO (see *Accessories*).

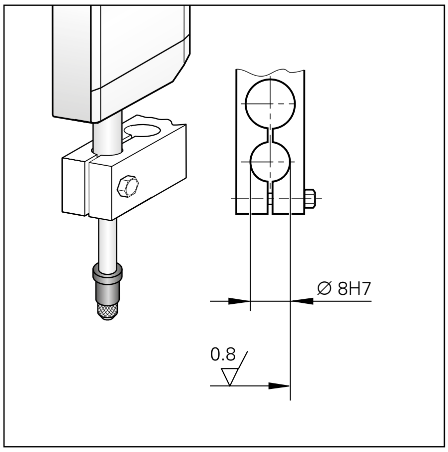
The **CT 2500** is mounted by its standard clamping shank with 16h8 diameter.
A holder is available for fastening the HEIDENHAIN-CERTO to the gauge stand (see *Accessories*).

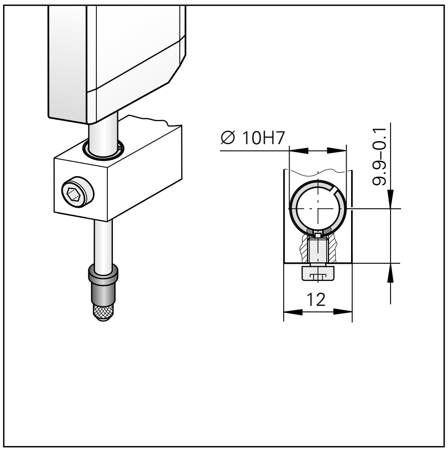
The **AT, ST, MT 1200** and **MT 2500** length gauges feature a standard clamping shank with 8h6 diameter. These HEIDENHAIN length gauges can therefore easily be used with existing measuring fixtures and stands.

As an accessory, HEIDENHAIN offers a special clamping sleeve and screw. It facilitates fastening the length gauge securely without overstressing the clamping shank.
Clamping sleeve ID 386811-01



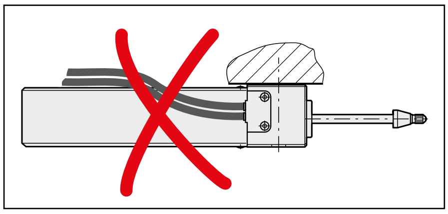






mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Operating attitude for HEIDENHAIN-CERTO
The HEIDENHAIN-CERTO can be operated at any attitude. However, the mounting position with horizontal length gauge and upward facing mounting surface should be avoided because in such a case no guarantee can be made for accuracy.



Mechanical design

HEIDENHAIN length gauges function according to the **Abbe measuring principle,** i.e. the measuring standard and the plunger are exactly aligned. All components comprising the **measuring loop,** such as the measuring standard, plunger, holder and scanning head are designed in terms of their mechanical and thermal stability for the highest possible accuracy of the length gauge.

The **plungers** of the HEIDENHAIN length gauges are locked against rotation. Their optimally round form stays unchanged while stability and thermoconductivity remain unimpaired. They are provided with an M2.5 thread to hold measuring contacts (see *Accessories*)

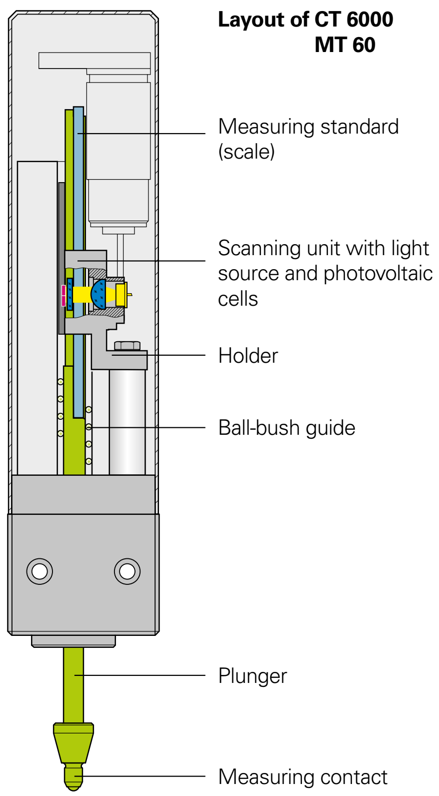
The plungers of the ACANTO and HEIDENHAIN-SPECTO ST 1200 length gauges are protected by a rubber bellows. The **bellows** are characterized by high resistance to chemical and thermal influences and have a relatively low stiffness. Its influence on the gauge's mechanical behavior and the measuring force is therefore low.

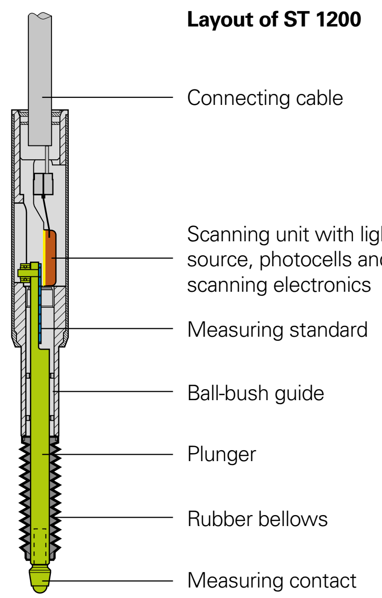
Thermal behavior
HEIDENHAIN length gauges have a defined thermal behavior. Since temperature variations during measurement can result in changes in the measuring loop, HEIDENHAIN uses special materials with low α_{therm} coefficients of expansion for the components of the measuring loop, for example in the CERTO length gauges. The scale is manufactured of Zerodur ($\alpha_{therm} \approx 0\ K^{-1}$), and the plunger and holder are of Invar ($\alpha_{therm} \approx 1 \times 10^{-6}\ K^{-1}$). This makes it possible to guarantee its high measuring accuracy over a relatively large temperature range.

Acceleration
Length gauges from HEIDENHAIN feature a **sturdy design.** Even high vibration and shock loads have no negative influence on the accuracy.

However, shock and vibration of any kind is to be avoided during measurement so as not to impair the high accuracy of measurement. The maximum values given in the specifications for shock and vibration apply to the effect of external acceleration on the length gauge. They describe only the mechanical stability of the length gauge, and imply no guarantee of function or accuracy.

In the length gauge itself, unchecked extension of the spring-driven or non-coupled moving plunger can cause high acceleration onto the measured object or measuring plate surface. For the MT 1200 and MT 2500 series length gauges, use the cable-type lifter whenever possible (see *Accessories*). The cable lifter features adjustable pneumatic damping to limit the extension velocity to an uncritical value.





Plunger guideway
HEIDENHAIN length gauges are available with various plunger guides.

The plungers of the ACANTO length gauges work with **sliding guides.** The sliding guides have the following properties:
- Sturdiness due to few moving parts
- Tolerance to shock and vibration
- High plunger speeds and long service life thanks to high-quality ceramic bearings
- Less sensitivity to improper clamping

The HEIDENHAIN-METRO and HEIDENHAIN-CERTO series length gauges and the HEIDENHAIN-SPECTO length gauges are equipped with a **ball-bush guide**. The following are some of the basic properties of ball guides in HEIDENHAIN length gauges:
- Low friction, which makes length gauge versions with reduced gauging force possible
- Safe plunger extension and retraction even with high radial force
- High precision of the measuring loop thanks to a guide that is free of play (the bearing and plunger are specially fitted during manufacture)

Expendable parts
HEIDENHAIN length gauges contain components that are subject to wear, depending on the application and manipulation. These include in particular the following parts:
- Guideway (tested for at least 5 million strokes*)
- Cable link for CT, MT 60 and MT 101 (tested for at least 1 million strokes*)
- Scraper rings
- Rubber bellows for AT and ST 1200

* With CT, MT 60 M and MT 101 M only with actuation by switch box

Note
DIADUR is a registered trademark of DR. JOHANNES HEIDENHAIN GmbH, Traunreut, Germany. Zerodur® is a registered trademark of Schott Glaswerke in Mainz, Germany.

Sliding guide

Ball-bush guide

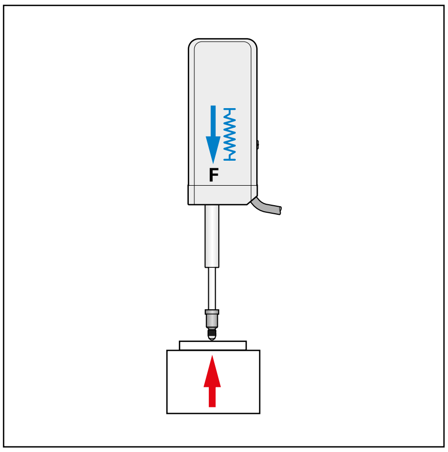
Gauging force—plunger actuation

Gauging force
Gauging force is the force that the plunger exercises on the measured object. An excessively large gauging force can cause deformation of the measuring contact and the measured object. If the gauging force is too small, an existing dust film or other obstacle may prevent the plunger from fully contacting the measured object. The gauging force depends on the type of plunger actuation.

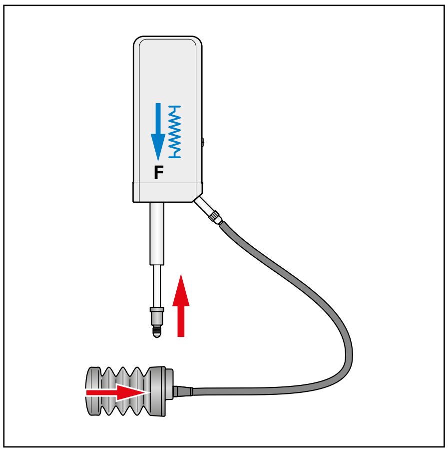
Plunger actuation by spring
For the AT 1218, AT 3018, MT 12x1, MT 25x1, ST 12x8 and ST 30x8, the integral spring extends the plunger to the measuring position and applies the **gauging force.** In its resting position, the plunger is extended. The gauging force depends on the following criteria:
- The operating attitude
- The plunger position, i.e. the force changes over the measuring range
- The measuring direction, i.e., whether the gauge measures with extending or retracting plunger

In the diagrams, the measuring force is shown over the measuring range for a retracting and extending plunger in a horizontal operating attitude.

Plunger actuation by measured object
The complete length gauge is moved relative to the measured object. The measurement is made with retracting plunger.

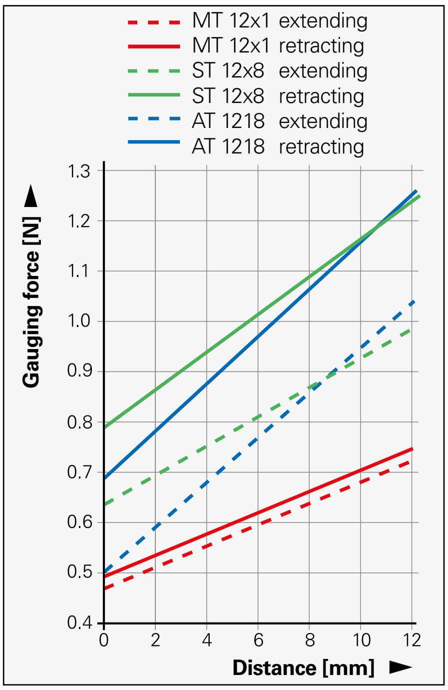


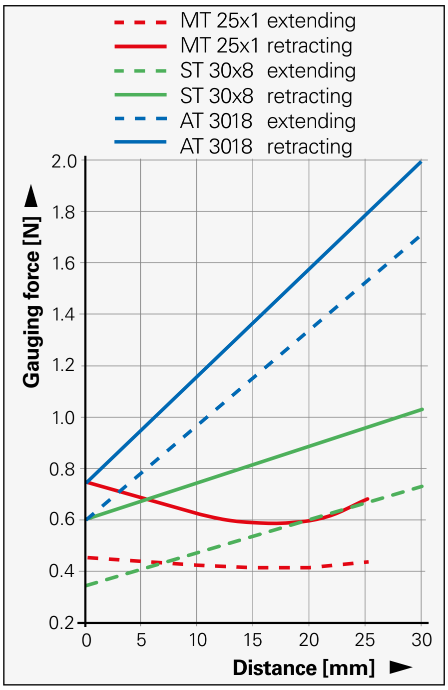
Plunger actuation via cable-type lifter (MT 12x1, MT 25x1)
Through a cable mechanism, the plunger is retracted by hand and then extended onto the measured object. The measurement is made with extending plunger.



The diagrams apply for the **horizontal operating attitude.** The following compensation values are to be taken into account for other operating attitudes.

Model	Operating attitude vertically Upward	Downward
AT 121x **AT 301x**	– 0.12 N – 0.18 N	+ 0.12 N + 0.18 N
MT 12xx **MT 25x1** **MT 2587**	– 0.13 N – 0.17 N – 0.19 N	+ 0.13 N + 0.17 N + 0.19 N
ST 12x7 **ST 12x8** **ST 30xx**	– 0.07 N – 0.08 N – 0.11 N	+ 0.07 N + 0.08 N + 0.11 N





Pneumatic plunger actuation
The pneumatically actuated plungers of the AT 1217, AT 3017, MT 1287, MT 2587, ST 12x7 and ST 30x7 length gauges are extended by the application of compressed air. When the air connection is ventilated, the integral spring retracts the plunger. to a protected resting position within the housing.

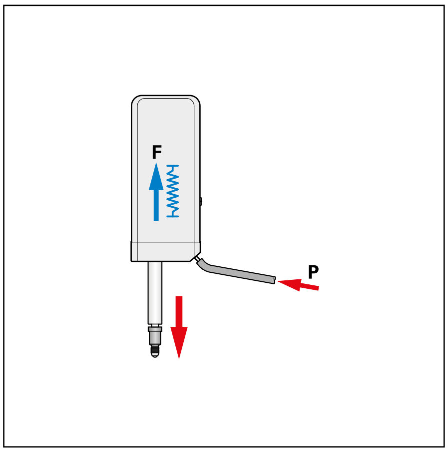
The **gauging force** can be adjusted to the measuring task through the level of air pressure. At constant pressure, it depends on the operating attitude and the plunger position.

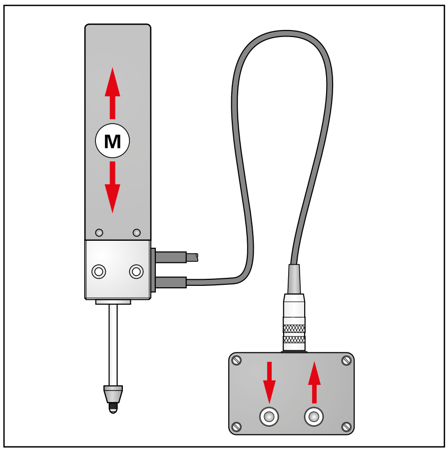
The diagrams show the respective measuring force for a horizontal operating attitude depending on the compressed air applied with the plunger extending and retracting fully. These are approximate values that are subject to changes due to tolerances and depend on seal wear.

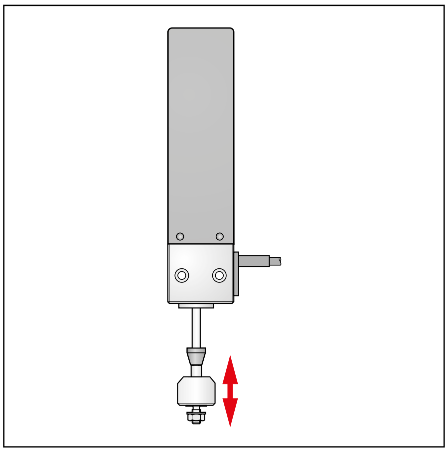
Motorized plunger actuation
The CT 2501, CT 6001, MT 60 M and MT 101 M length gauges feature an integral motor that moves the plunger. It is operated through the switch box either by push button or over the connection for external actuation. The plungers of the CT 2501, CT 6001, and MT 60 M length gauges must not be moved by hand if the switch box is connected.

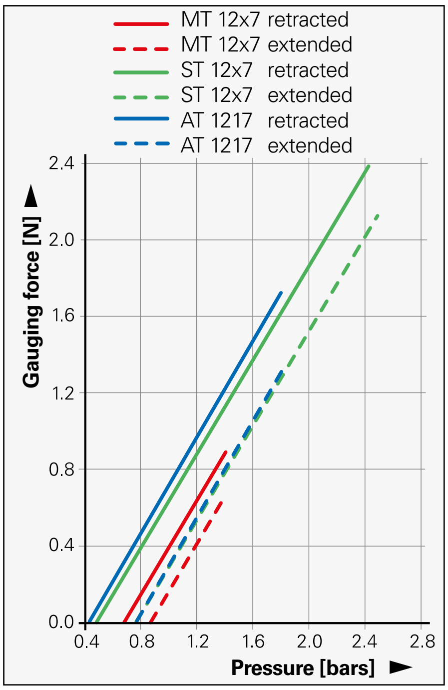
The **gauging force** of the CT 2501, CT 6001, and MT 60 M motorized length gauges is adjustable in three stages through the switch box. The force remains constant over the measuring range but depends on the operating attitude.
Regardless of the operating attitude—whether it measures vertically downward (with the SG 101 V switch box) or horizontally (with the SG 101 H switch box)—the MT 101 M exercises a constant gauging force.

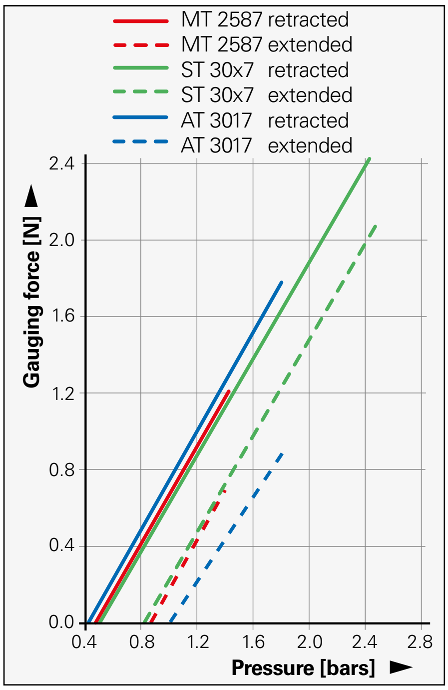
External plunger actuation by coupling
For the CT 2502, CT 6002, MT 60 K, MT 101 K and special versions "without spring" of the MT 1200 and MT 2500, the plunger is freely movable. For position measurement, the plunger is connected by a coupling with a moving machine element. The force needed to move the plunger is specified as the required **moving force.** It depends on the operating attitude.











Note
The compressed air introduced directly into the length gauges must be properly conditioned and must comply with the following quality classes as per **ISO 8573-1** (1995 edition):

- Solid contaminant: Class 1 (max. particle size 0.1 µm and max. particle density 0.1 mg/m^3 at 1 · 10^5 Pa)
- Total oil content: Class 1 (max. oil concentration 0.01 mg/m^3 at 1 · 10^5 Pa)
- Maximum pressure dew point: Class 4, but with reference conditions of +3 °C at 2 · 10^5 Pa

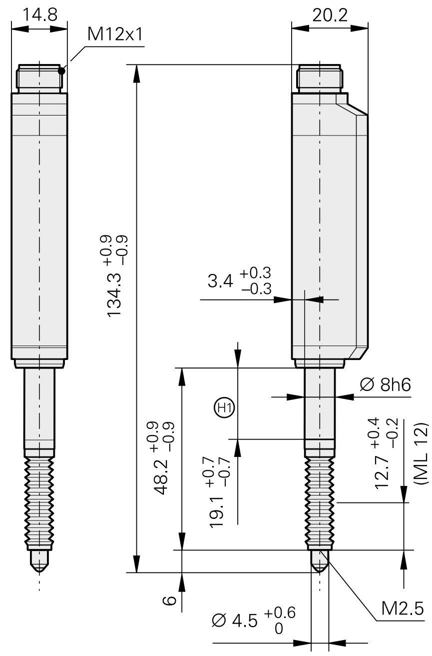
HEIDENHAIN offers the **DA 400 compressed air unit** for purifying compressed air. The minimum flow rate is 10 l/min.

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

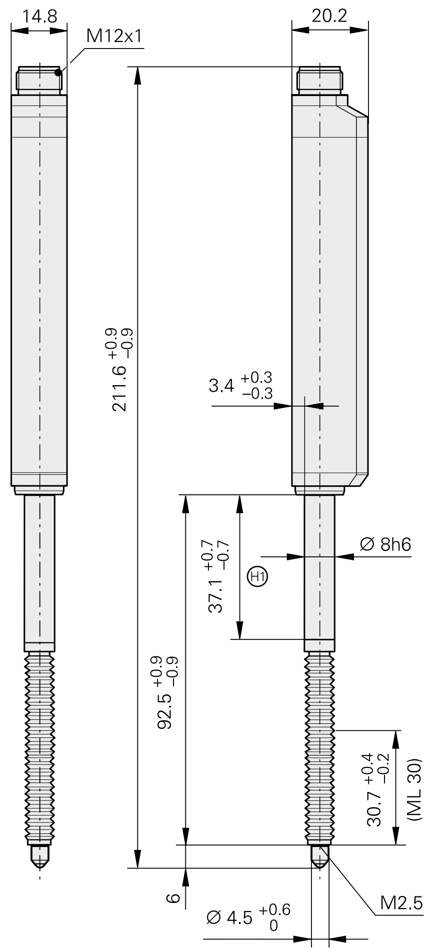
ACANTO

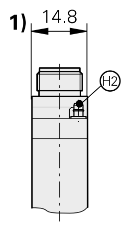
Absolute length gauges with EnDat interface
- **Very compact dimensions**
- **Splash-proof**
- **Plain-bush guided plunger**

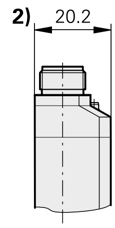
AT 1200



AT 3000



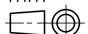




Dimension changes under max. pressure (1.8 bar)

	1)	2)
AT 1217	14.8...15.1	20.2...19.9
AT 3017	14.8...15.2	20.2...19.8

mm



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

ML = Measuring length
H1 = Clamping area
H2 = Air connection for 2 mm tube

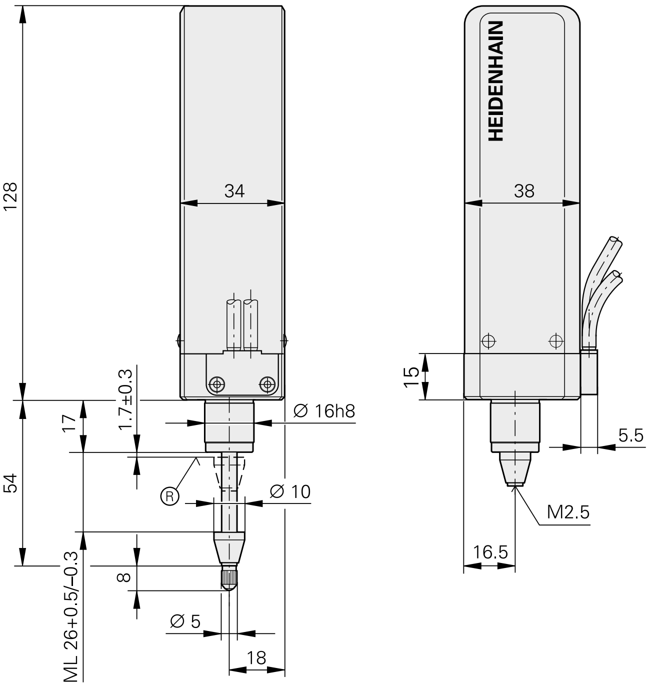
Mechanical Data	AT 1218	AT 3018	AT 1217	AT 3017
Plunger actuation Position of plunger at rest	By measured object Extended		Pneumatic Retracted	
Measuring standard	DIADUR grating on glass; grating period 188.4 µm			
System accuracy	± 2 µm			
Position error per signal period	≤ ± 0.7 µm			
Measuring range	12 mm	30 mm	12 mm	30 mm
Gauging force	See *Gauging force—plunger actuation*			
Compressed air	–		≤ 1.8 bar	
Mech. permissible traversing speed	≤ 60 m/min			
Radial force	≤ 0.5 N (mechanically permissible)			
Fastening	Clamping shank ∅ 8h6			
Operating attitude	Any			
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 500 m/s^2 (EN 60068-2-27)			
Operating temperature	10 °C to 40 °C; reference temperature 20 °C			
Protection EN 60529	IP 67		IP 64 (IP 67 with sealing air)	
Weight without cable	80 g	100 g	80 g	100 g

Electrical Data	EnDat			
Interface	EnDat 2.2			
Ordering designation	EnDat 22			
Resolution	23 nm	368 nm	23 nm	368 nm
Calculation time t_{cal} Clock frequency	≤ 5 µs ≤ 8 MHz			
Electrical connection	M12 flange socket (male) 8-pin			
Cable length	≤ 100 m with HEIDENHAIN cable			
Power supply	3.6 to 14 V DC			
Power consumption (max.)	*3.6 V:* ≤ 550 mW *14 V:* ≤ 650 mW			
Current consumption (typical)	*5 V:* 80 mA (without load)			

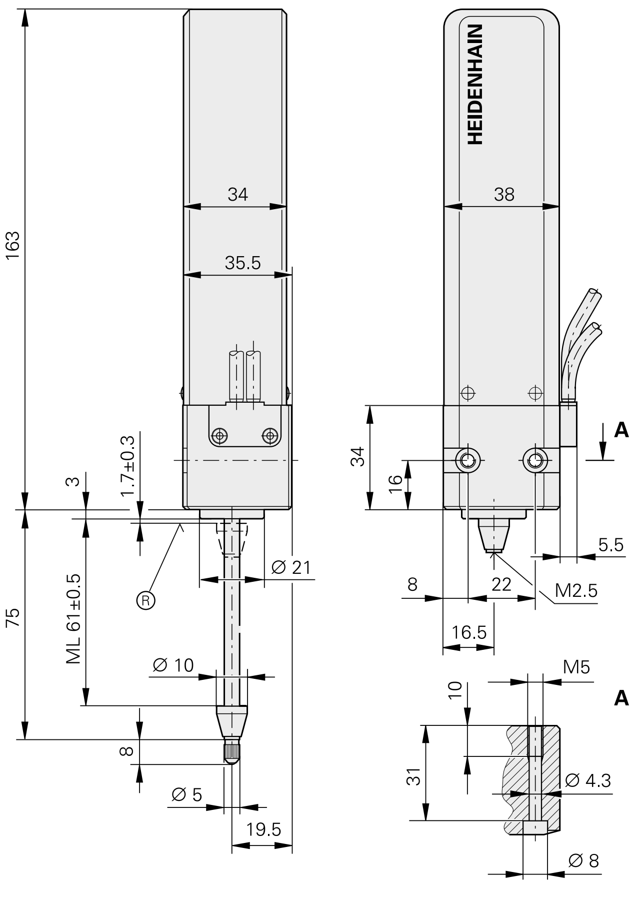
HEIDENHAIN-CERTO

Incremental length gauges with ± 0.1 µm/± 0.05[1] µm*/± 0.03 µm[1] accuracy
- **For very high accuracy**
- **For inspection of measuring equipment and gauge blocks**
- **Ball-bush guided plunger**

CT 2500



CT 6000



mm

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

Ⓡ = Reference mark position

Specifications	CT 2501	CT 6001	CT 2502	CT 6002
Plunger actuation	By motor		Via coupling with moving machine part	
Measuring standard	DIADUR phase grating on Zerodur glass ceramic; grating period 4 µm			
System accuracy At 19 °C to 21 °C	± 0.1 µm, ± 0.03 µm[1)]	± 0.1 µm, ± 0.05 µm[1)]	± 0.1 µm, ± 0.03 µm[1)]	± 0.1 µm, ± 0.05 µm[1)]
Position error per signal period	≤ ± 0.02 µm			
Reference mark	One, approx. 1.7 mm below upper stop			
Measuring range	25 mm	60 mm	25 mm	60 mm
Gauging force Vertically downward Vertically upward Horizontal	By motor 1 N/1.25 N/1.75 N – /– /0.75 N – /0.75 N/1.25 N		Moving force[2)] 0.6 N 0.1 N 0.6 N	
Radial force	≤ 0.5 N (mechanically permissible)			
Fastening	Clamping shank ∅ 16h8	Plane surface	Clamping shank ∅ 16h8	Plane surface
Operating attitude	Any required (for preferred operating attitude see *Mounting*)			
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)			
Operating temperature	10 °C to 40 °C; reference temperature 20 °C			
Protection EN 60529	IP 50			
Weight without cable	520 g	700 g	480 g	640 g

Electrical Data	CT 2501	CT 6001	CT 2502	CT 6002
Interface	∿ 11 µAPP			
Signal period	2 µm			
Measuring velocity	≤ 24 m/min (depending on the subsequent electronics) ≤ 12 m/min with the ND 28x display unit			
Electrical connection*	• Cable 1.5 m with D-sub connector (male) 15-pin • Cable 1.5 m with M23 connector (male), 9 pin Interface electronics are integrated in connector.			
Cable length	≤ 30 m			
Power supply	5 V DC ± 0.25 V/< 180 mA		5 V DC ± 0.25 V/< 120 mA	

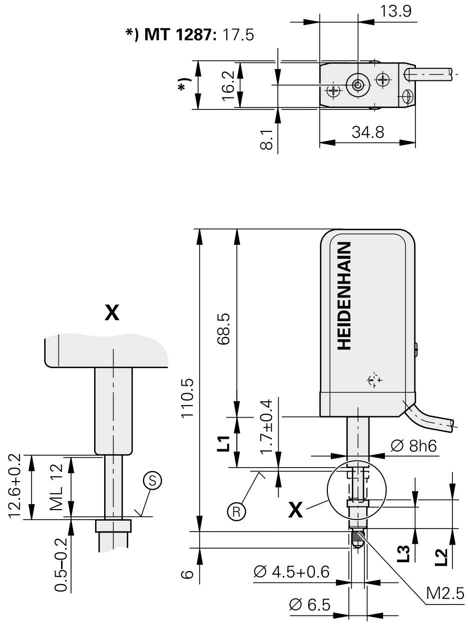
Required accessories*	For CT 2501	For CT 6001
Switch box	SG 25 M	SG 60 M

* Please select when ordering
1) After linear length-error compensation in the evaluation electronics
2) Force required to move the plunger or force of its weight

HEIDENHAIN-METRO

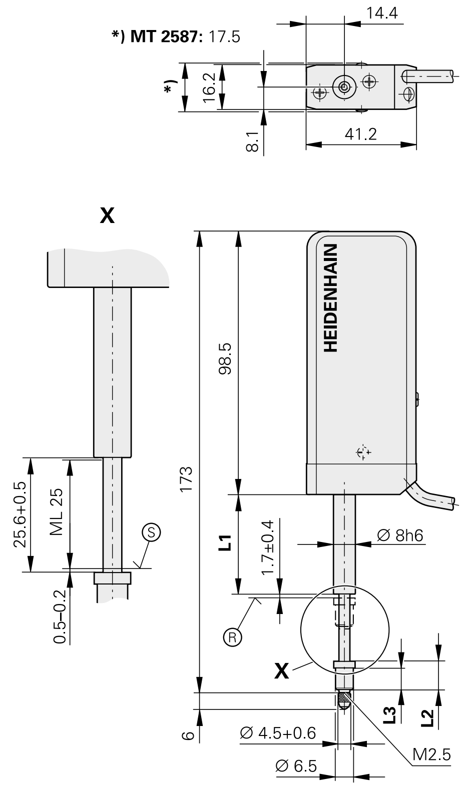
Incremental length gauges with ± 0.2 µm accuracy
- **High repeatability**
- **Plunger actuation by cable release, by the workpiece or pneumatically**
- **Ball-bush guided plunger**

MT 1200



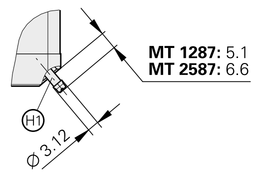
	MT 12x1	MT 1287
L1	18.5	22.0
L2	10.1	6.2
L3	8.1	4.2

MT 2500

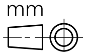


	MT 25x1	MT 2587
L1	37.0	41.0
L2	10.1	6.2
L3	8.1	4.2

MT 1287
MT 2587



mm



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

Ⓡ = Reference mark position
Ⓢ = Beginning of measuring length
Ⓗ = Air connection for 2 mm tube

Mechanical Data	**MT 1271** ⊓⊔TTL **MT 1281** ∿ 1 V_{PP}	**MT 2571** ⊓⊔TTL **MT 2581** ∿ 1 V_{PP}	**MT 1287** ∿ 1 V_{PP}	**MT 2587** ∿ 1 V_{PP}
Plunger actuation Position of plunger at rest	By cable or measured object Extended		Pneumatic Retracted	
Measuring standard	DIADUR phase grating on Zerodur glass ceramic; grating period 4 µm			
System accuracy	± 0.2 µm			
Position error per signal period	≤ ± 0.02 µm			
Reference mark	Approx. 1.7 mm below upper stop			
Measuring range	12 mm	25 mm	12 mm	25 mm
Gauging force	See *Gauging force—plunger actuation*			
Version "without spring" Vertically downward	0.13 N	0.17 N	–	
Compressed air	–		≤ 1.4 bar	
Radial force	≤ 0.8 N (mechanically permissible)			
Fastening	Clamping shank Ø 8h6			
Operating attitude	Any; *for version without spring:* vertically downward			
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)			
Operating temperature	10 °C to 40 °C; reference temperature 20 °C			
Protection EN 60529	IP 50		IP 64 (with sealing air)	
Weight without cable	100 g	180 g	110 g	190 g

Electrical Data	**MT 1271** **MT 2571**		**MT 128x** **MT 258x**
Interface	⊓⊔TTL x 5	⊓⊔TTL x 10	∿ 1 V_{PP}
Signal period	0.4 µm	0.2 µm	2 µm
Recommended measuring step	0.1 µm[1)]	0.05 µm[1)]	0.1 µm/0.05 µm
Mech. permissible traversing speed	≤ 30 m/min		
Edge separation a at scanning frequency*/traverse speed 200 kHz ≤ 24 m/min 100 kHz ≤ 12 m/min 50 kHz ≤ 6 m/min 25 kHz ≤ 3 m/min	 ≥ 0.23 µs ≥ 0.48 µs ≥ 0.98 µs –	 – ≥ 0.23 µs ≥ 0.48 µs ≥ 0.98 µs	 –
Electrical connection* (Interface electronics integrated in connector)	Cable 1.5 m with D-sub connector (male) 15-pin		Cable 1.5 m with • D-sub connector (male), 15-pin • M23 connector (male), 12-pin
Cable length	≤ 30 m with HEIDENHAIN cable		
Power supply	5 V DC ± 0.25 V/< 160 mA (without load)		5 V DC ± 0.25 V/< 130 mA

* Please select when ordering

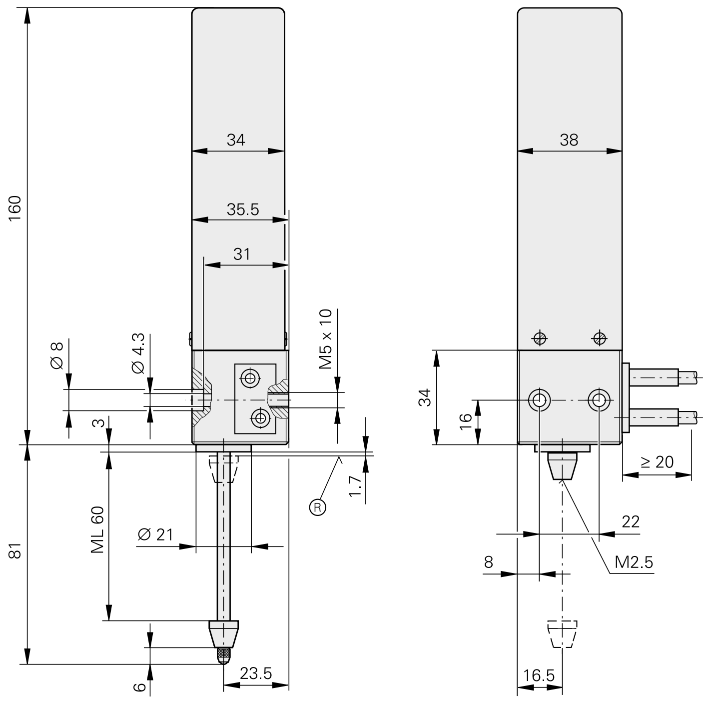
1) After 4-fold evaluation

HEIDENHAIN-METRO

Incremental length gauges with ± 0.5 µm/± 1 µm accuracy
- **Large measuring ranges**
- **For dimensional and positional measurement**
- **Ball-bush guided plunger**

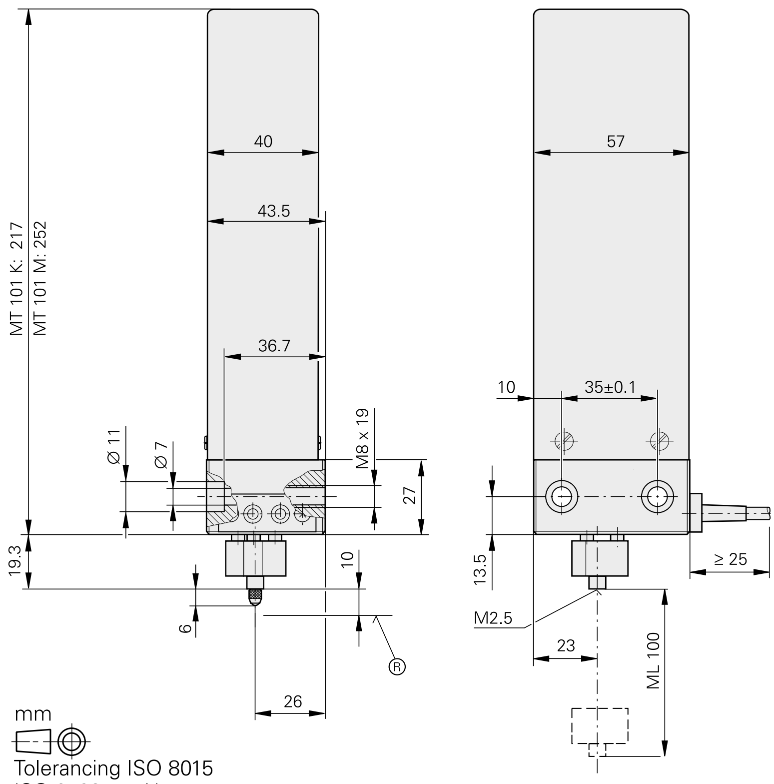
MT 60M

MT 60



MT 101M

MT 101



mm

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

Ⓡ = Reference mark position

Specifications	MT 60M	MT 101M	MT 60K	MT 101K
Plunger actuation	By motor		Via coupling with moving machine part	
Measuring standard	DIADUR grating on silica glass; grating period 10 µm			
System accuracy	± 0.5 µm	± 1 µm	± 0.5 µm	± 1 µm
Position error per signal period	≤ ± 0.1 µm			
Reference mark (approx.)	1.7 mm from top	10 mm from top	1.7 mm from top	10 mm from top
Measuring range	60 mm	100 mm	60 mm	100 mm
Gauging force Vertically downward Vertically upward Horizontal	By motor 1 N/1.25 N/1.75 N – /– /0.75 N – /0.75 N/1.25 N	By motor 0.7 N with SG 101V – 0.7 N with SG 101 H	Moving force[1)] 0.35 N 0.1 N 0.5 N	Moving force[1)] 1.7 N 2 N 0.4 N
Radial force mech. permissible	≤ 0.5 N	≤ 2 N	≤ 0.5 N	≤ 2 N
Fastening	Plane surface			
Operating attitude	Any	Vertically downward with SG 101V Horizontal with SG 101 H	Any	
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)			
Operating temperature	10 °C to 40 °C; reference temperature 20 °C			
Protection EN 60529	IP 50			
Weight without cable	700 g	1400 g	600 g	1200 g

Electrical Data	MT 60M	MT 101M	MT 60K	MT 101K
Interface	∿ 11 µAPP			
Signal period	10 µm			
Measuring velocity	≤ 18 m/min	≤ 60 m/min	≤ 18 m/min	≤ 60 m/min
Electrical connection*	Cable 1.5 m with D-sub connector (male) 15-pin or with M23 connector (male) 9-pin			
Cable length	≤ 30 m with HEIDENHAIN cable			
Power supply	5 V DC ± 0.25 V			
Current consumption	< 120 mA	< 70 mA		

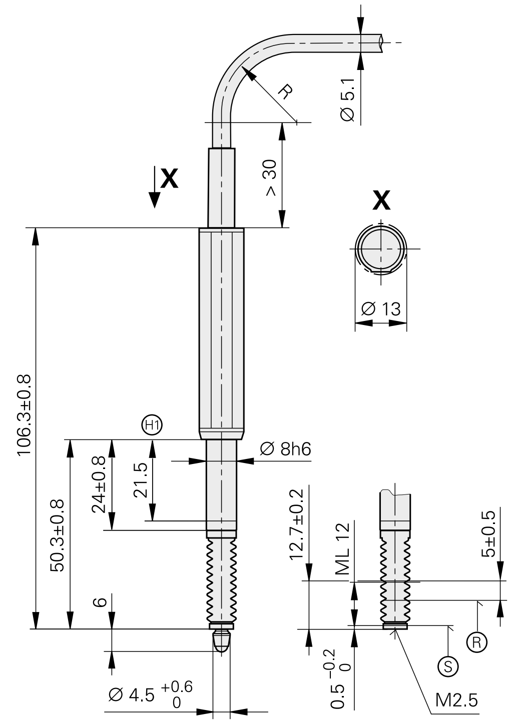
Required accessories*	For MT 60M	For MT 101M
Switch box	SG 60M	*Vertical orientation:* SG 101V *Horizontal orientation:* SG 101 H
Power supply unit	–	Required (see *Accessories*)

***** Please select when ordering
1) Force required to move the plunger or of its weight

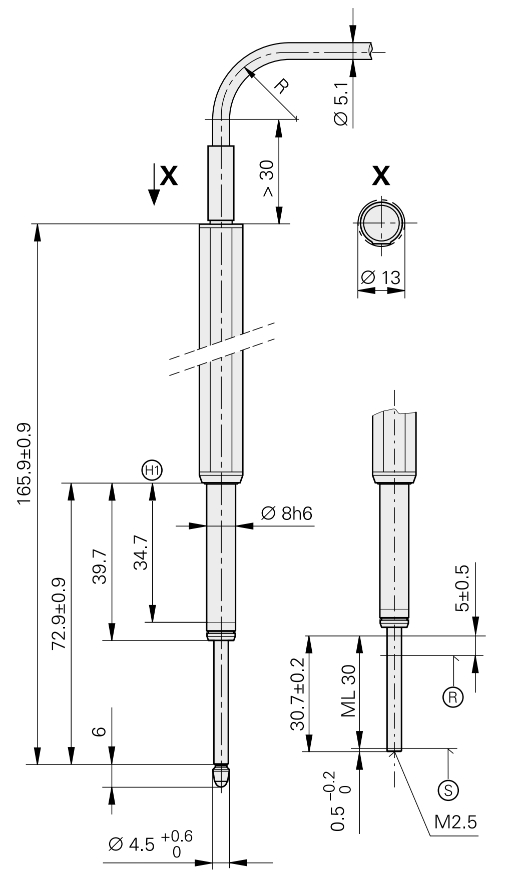
HEIDENHAIN-SPECTO

Incremental length gauges with ± 1 µm accuracy
- **Very compact dimensions**
- **Splash-proof**
- **Ball-bush guided plunger**

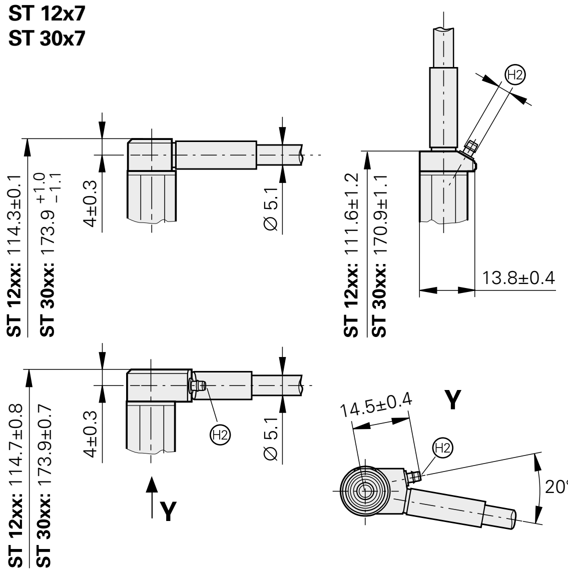
ST 1200



ST 3000



ST 12x7
ST 30x7



mm

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

Ⓡ = Reference mark position
Ⓢ = Beginning of measuring length

Mechanical Data	ST 1278 ⊓⊔ TTL ST 1288 ∼ 1 V_{PP}	ST 3078 ⊓⊔ TTL ST 3088 ∼ 1 V_{PP}	ST 1277 ⊓⊔ TTL ST 1287 ∼ 1 V_{PP}	ST 3077 ⊓⊔ TTL ST 3087 ∼ 1 V_{PP}
Plunger actuation Position of plunger at rest	By measured object Extended		Pneumatic Retracted	
Measuring standard	DIADUR grating on glass; grating period 20 µm			
System accuracy	± 1 µm			
Position error per signal period	≤ ± 0.2 µm			
Reference mark	Approx. 5 mm below upper stop			
Measuring range	12 mm	30 mm	12 mm	30 mm
Gauging force	See *Gauging force—plunger actuation*			
Compressed air	–		≤ 2.5 bar	
Radial force	≤ 0.8 N (mechanically permissible)			
Fastening	Clamping shank ∅ 8h6			
Operating attitude	Any			
Vibration 55 to 2 000 Hz **Shock** 11 ms	≤ 100 m/s^2 (EN 60 068-2-6) ≤ 1 000 m/s^2 (EN 60 068-2-27)			
Operating temperature	10 °C to 40 °C; reference temperature 20 °C			
Protection EN 60 529	IP 64 (for connecting elements see *Connecting Elements and Cables*)			
Weight without cable	40 g	50 g	40 g	50 g

Electrical Data	ST 127x ST 307x		ST 128x ST 308x
Interface	⊓⊔ TTL x 5		∼ 1 V_{PP}
Integrated interpolation*	5-fold	10-fold	–
Signal period	4 µm	2 µm	20 µm
Edge separation a at scanning frequency*/traverse speed 100 kHz ≤ 72 m/min[1)] 50 kHz ≤ 60 m/min 25 kHz ≤ 30 m/min	 ≥ 0.48 µs ≥ 0.98 µs ≥ 1.98 µs	 ≥ 0.23 µs ≥ 0.48 µs ≥ 0.98 µs	–
Electrical connection*	Cable 1.5 m with D-sub connector (male) 15-pin (integrated interface electronics)		Cable 1.5 m with • D-sub connector (male), 15-pin • M23 connector (male), 12-pin
Cable outlet*	Axial or radial		
Cable length	≤ 30 m with HEIDENHAIN cable		
Power supply	5 V DC ± 0.5 V		
Current consumption	< 230 mA (without load)		< 90 mA

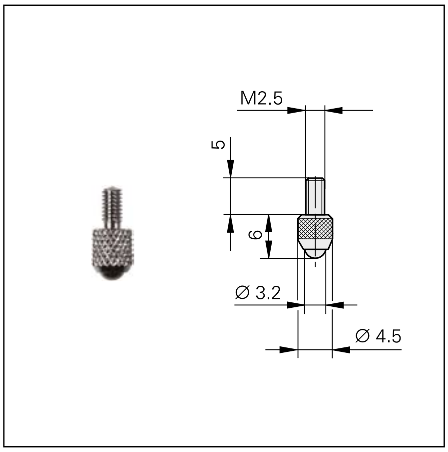
* Please select when ordering

1) Mechanically limited

Accessories
Measuring contacts

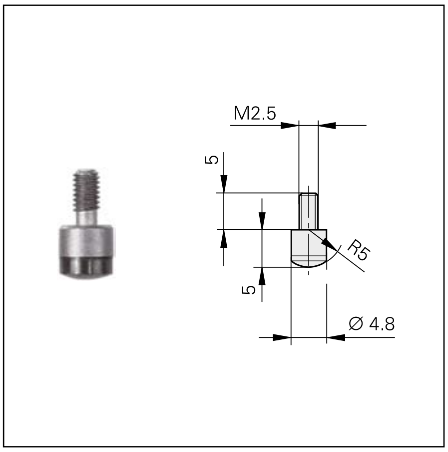
Ball-type contact

Steel	ID 202504-01
Carbide	ID 202504-02
Ruby	ID 202504-03



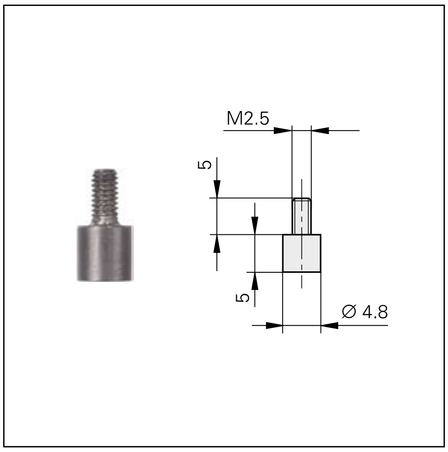
Domed contact

Carbide	ID 229232-01



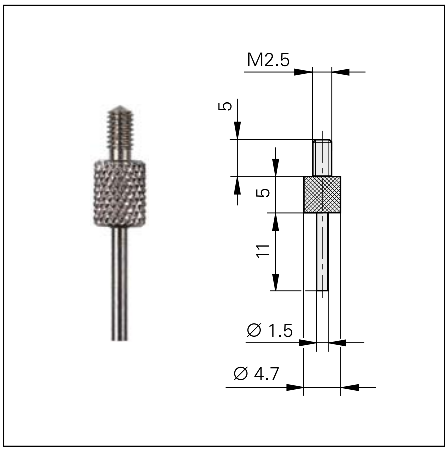
Flat contact

Steel	ID 270922-01
Carbide	ID 202506-01



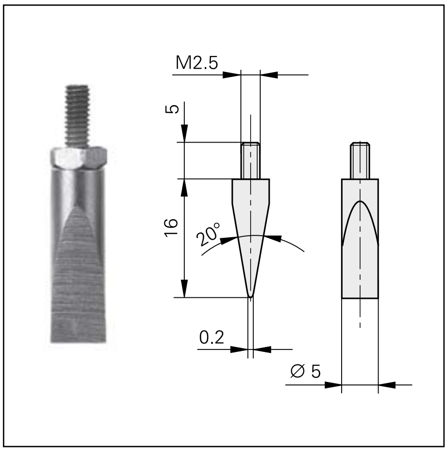
Pin-type contact

Steel	ID 202505-01



Knife-edge contact

Steel	ID 202503-01

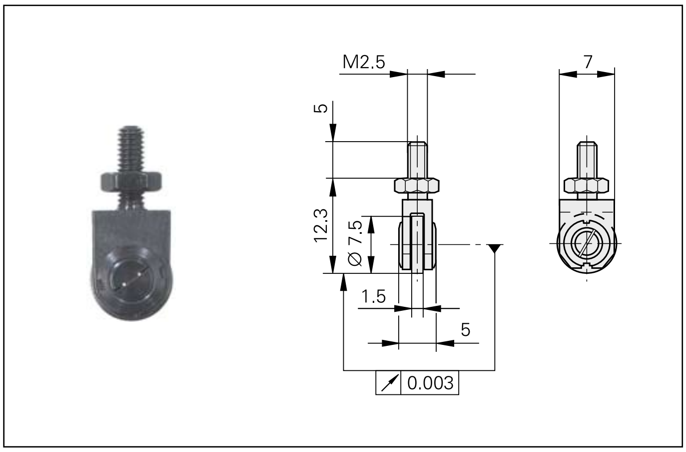


mm

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

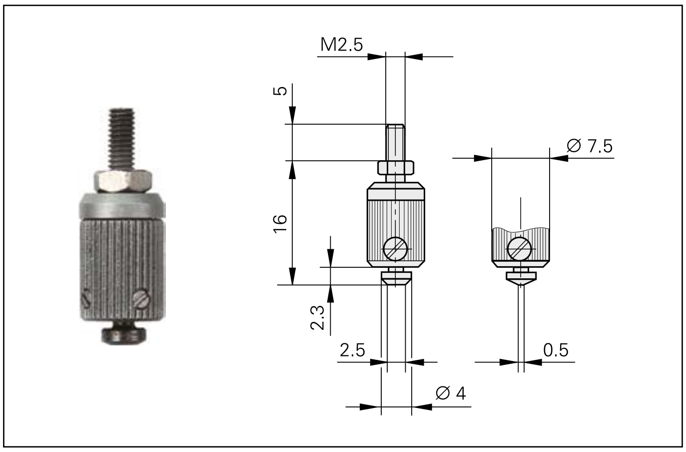
Roller contact, steel
For a low-friction contact with moving surfaces

Crowned	ID 202502-03
Cylindrical	ID 202502-04



Adjustable contact, carbide
For exact parallel alignment to the measuring plate surface

Flat	ID 202507-01
Knife-edged	ID 202508-01



Switch boxes, coupling

Switch boxes for CT 2501, CT 6001, MT 60M, MT 101M
Switch boxes are required for length gauges with motorized plunger actuation. The plunger is controlled through two push buttons or by external signal. The gauging force is adjustable at the SG 25M and SG 60M switch boxes in three stages.

SG 25M
ID 317436-01

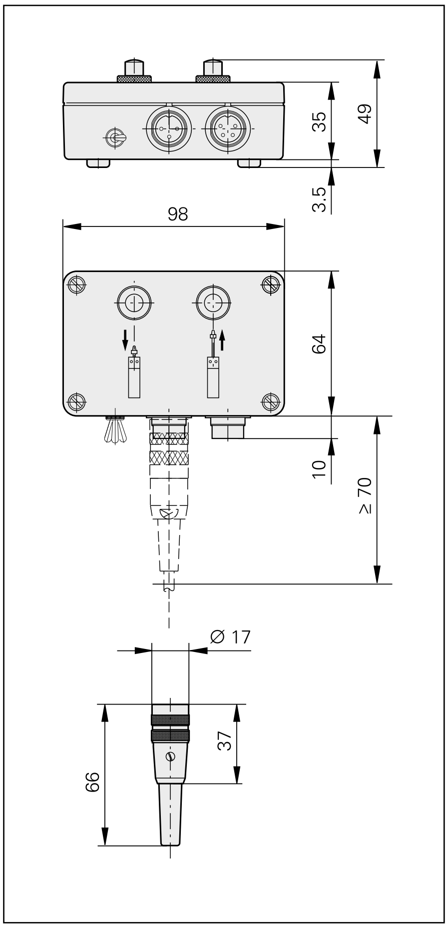
SG 60M
ID 317436-02

SG 101V[1)]
For the MT 101 M in vertical operation
ID 361140-01

SG 101H[1)]
For the MT 101 M in horizontal operation
ID 361140-02

Connector (female) 3-pin
For external operation of the switch box
ID 340646-05

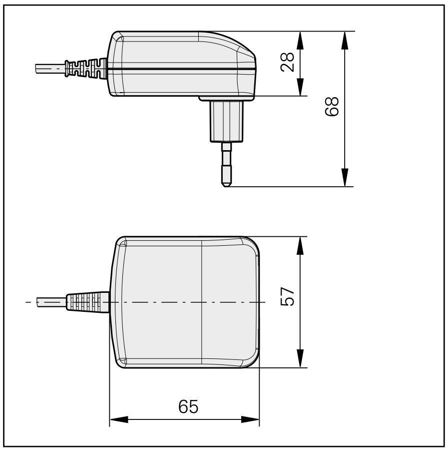
[1)] Separate power supply required



Power adapter for SG 101V/H
An adapter connected to the switch box powers the MT 101 M.

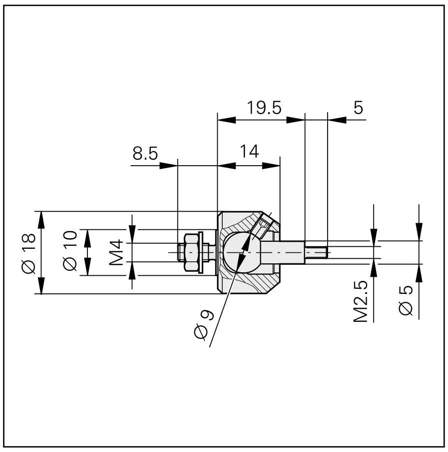
Voltage range 100 V to 240 V AC
Exchangeable plug adapter
(U.S. and Euro connectors included in delivery)

ID 648029-01



Coupling
For connecting the plunger of the length gauge (specifically for the MT 60K, MT 101 K, CT 2502 and CT 6002) to a moving machine element

ID 206310-01



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

Accessories for HEIDENHAIN-CERTO
Gauge stand

CS 200 gauge stand

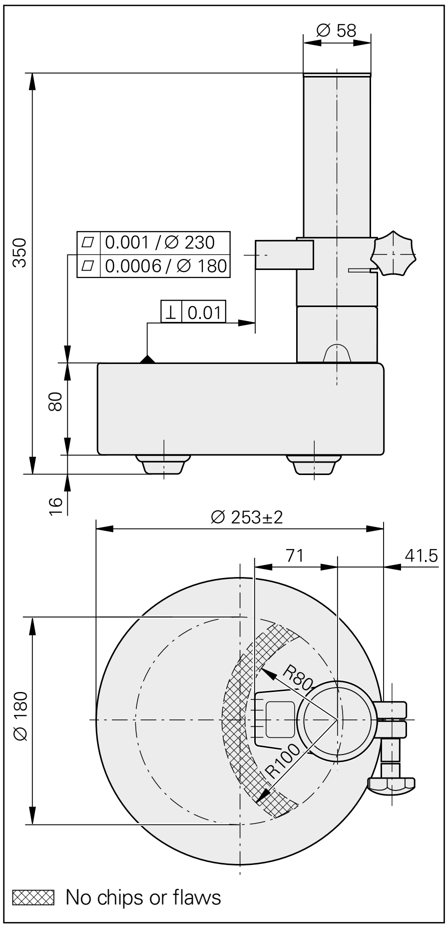
For length gauges	CT 2501 * CT 6001

ID 221310-01

Overall height	350 mm
Base	Ø 250 mm
Column	Ø 58 mm
Weight	15 kg

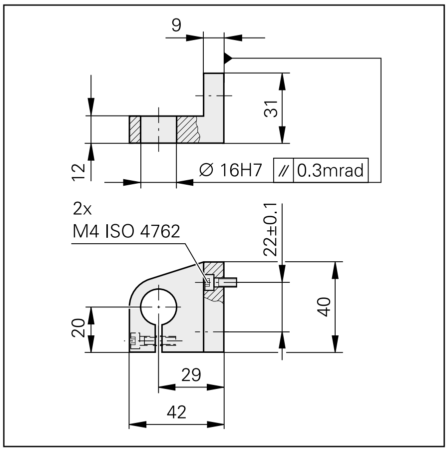
*) With special holder

The flatness of the CS 200 is determined with the aid of a Fizeau interferometer.



Holder for CS 200
For the CT 2501 with Ø 16 mm clamping shank

ID 324391-01



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

Ceramic suction plate, diaphragm pump

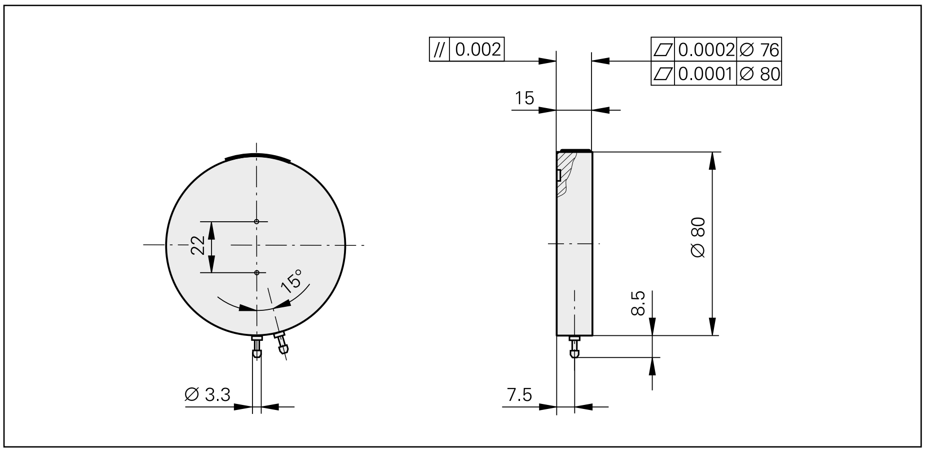
Ceramic suction plate
Wear-resistant working surface with high surface quality specifically for inspecting gauge blocks

ID 223100-01

The gauge block (class 1 or 2)—or any other object with a plane surface—is drawn by suction onto the top of the ceramic plate. The ceramic plate is likewise drawn to the granite base and held in place through negative gauge pressure.

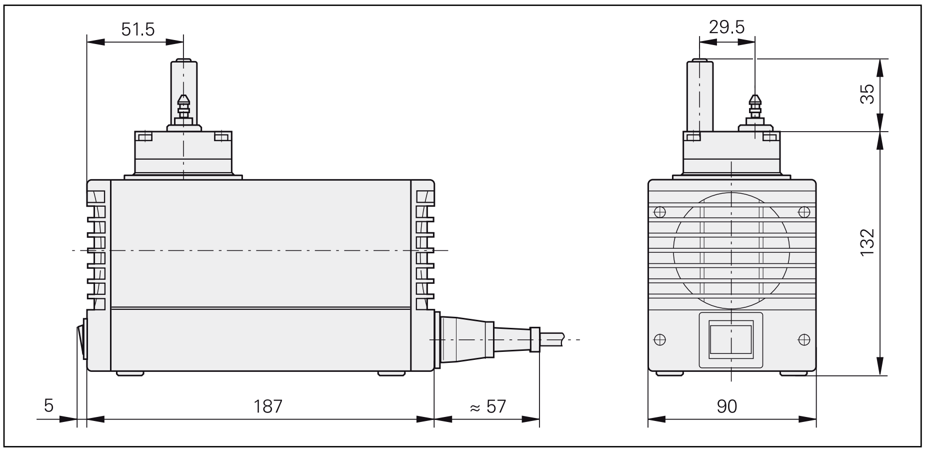
Parts for connecting the ceramic suction plate with the diaphragm pump are among the items supplied:

Pressure tubing 3 m
T-joint
Connecting piece



Diaphragm pump
Source of suction for drawing the measured object and ceramic suction plate

Power consumption	20 W
Weight	2.3 kg
Line voltage	230 V AC/50 Hz
ID 754220-01	
Line voltage	115 V AC/60 Hz
ID 754220-02	

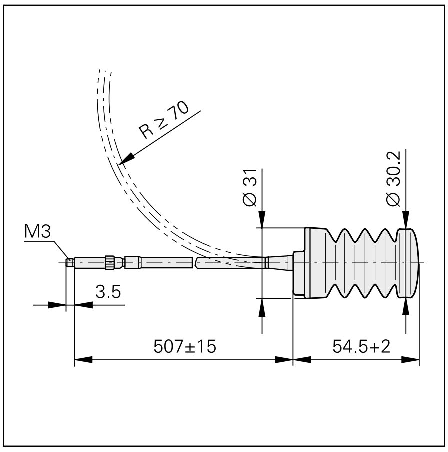


mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Accessories for ACANTO, HEIDENHAIN-METRO and HEIDENHAIN-SPECTO cable-type lifter, gauge stands

Cable lifter
For manual plunger actuation of MT 1200 and MT 2500. The integral pneumatic damping reduces the plunger extension speed to prevent rebounding, for example on very hard materials.

ID 257790-01



MS 200 gauge stand

For length gauges	AT[1)]
	ST[1)]
	MT 1200[1)]
	MT 2500[1)]
	MT 60 M
	MT 101 M

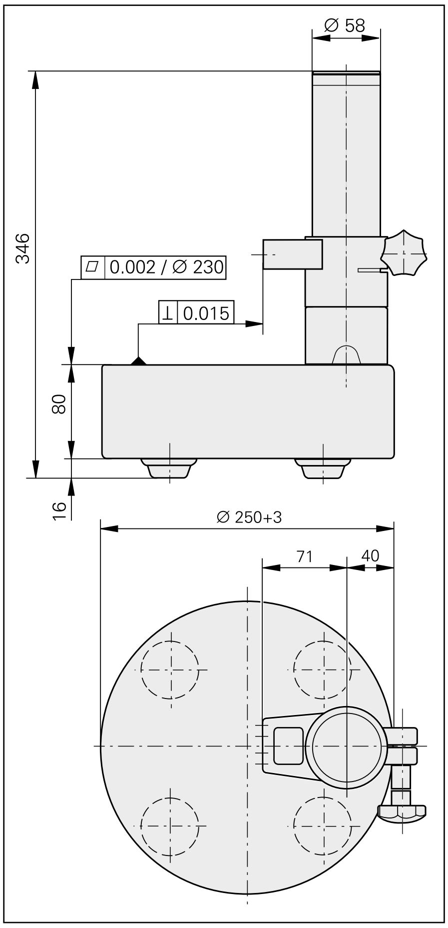
ID 244154-01

Overall height	346 mm
Base	Ø 250 mm
Column	Ø 58 mm
Weight	18 kg

[1)] With special holder

Holder for MS 200
For mounting the length gauges with Ø 8 mm clamping shank, e.g. AT, ST, MT 1200, MT 2500

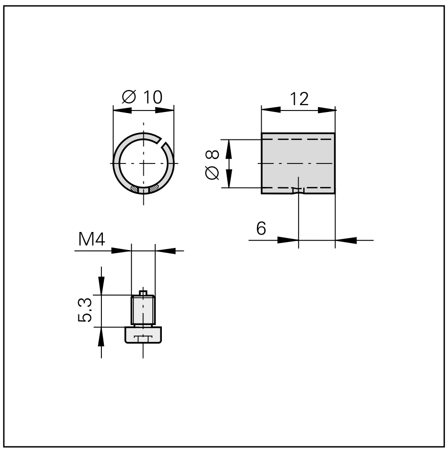
ID 324391-02



Clamping sleeve

For length gauges	AT, ST
	MT 1200
	MT 2500

For fixing the length gauge reliably without overloading the 8h6 clamping shank.
Consisting of:
Sleeve, clamping screw
ID 386811-01 (1 piece)
ID 386811-02 (10 pieces)



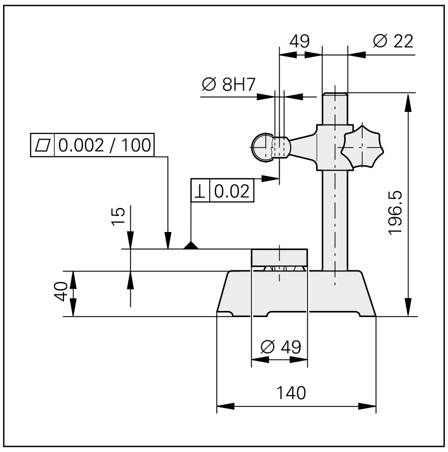
mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

MS 45 gauge stand

For length gauges	AT, ST MT 1200 MT 2500

ID 202162-02

Overall height	196.5 mm
Measuring plate	Ø 49 mm
Column	Ø 22 mm
Weight	2.2 kg



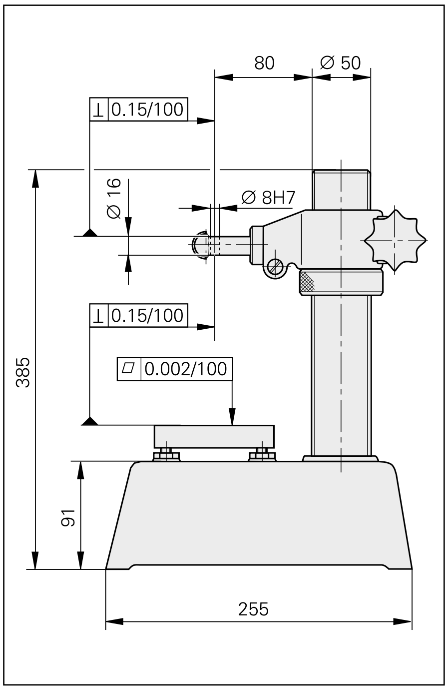
MS 100 gauge stand

For length gauges	AT ST MT 1200 MT 2500 MT 60 M[1)] MT 101 M[1)]

ID 202164-02

Overall height	385 mm
Measuring plate	100 mm x 115 mm
Column	Ø 50 mm
Weight	18 kg

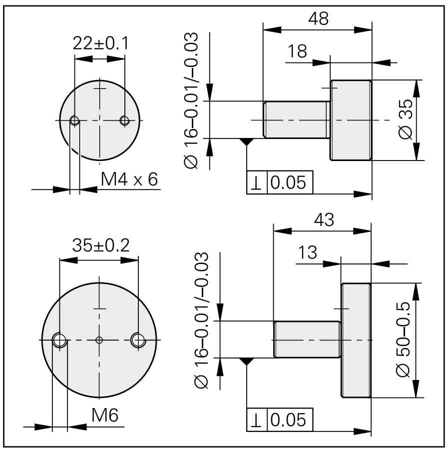
[1)] With special holder



Holder for MS 100

For mounting the MT 60 M
ID 207479-01

For mounting the MT 101 M
ID 206260-01



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

Digital readouts

ND 200
Digital readouts for one axis
HEIDENHAIN encoders with $11\ \mu A_{PP}$ or $1\ V_{PP}$ signals and EnDat 2.2 interface can be connected to the digital readouts of the ND 200 series. The **ND 280** readout provides the basic functions for simple measuring tasks. The **ND 287** also features other functions such as sorting and tolerance check mode, min./max. value storage, measurement series storage. It calculates the mean value and standard deviations and creates histograms and control charts. The ND 287 permits optional connection of a second encoder for sum/difference measurement or of an analog sensor. The ND 28x units have serial interfaces for measured value transfer.

For more information, see the *Digital Readouts/Linear Encoders* brochure.

	ND 280	ND 287
Encoder input[1]	1 x ∼ $11\ \mu A_{PP}$; ∼ $1\ V_{PP}$ or EnDat 2.2	
Connection	D-sub (15-pin) female	
Input frequency	∼ *$1\ V_{PP}$:* ≤ 500 kHz; *$11\ \mu A_{PP}$:* ≤ 100 kHz	
Signal subdivision	Up to 4096-fold (adjustable)	
Display step (adjustable)	*Linear axis:* 0.5 µm to 0.002 µm *Angular axis:* 0.5° to 0.00001° or 00°00′00.1″	
Functions	• REF reference mark evaluation • 2 datums	
	–	• Sorting and tolerance checking • Measurement series (max. 10000 measured values) • Minimum/maximum value storage • Statistics functions • Sum/difference display (option)
Switching I/O	–	Yes
Interface	RS-232-C/V.24; USB (UART); Ethernet (option for ND 287)	

[1] Automatic detection of interface

ND 2100 G GAGE-CHEK
Digital readouts
The ND 2100 G GAGE-CHEK readouts are versatile metrology displays for measuring and inspection tasks in manufacturing and quality assurance. With inputs for up to eight encoders, they are predestined for multipoint measurements from simple pass/fail detection up to complex SPC evaluation.

For more information see *Digital Readouts for Metrology Applications* brochure

	ND 2100 G GAGE-CHEK		
Input signals*	∼ $1\ V_{PP}$	TTL	EnDat 2.2
Encoder inputs	D-sub (15-pin) female	D-sub (9-pin) female	M12 flange socket (8-pin) female
Number of inputs*	*ND 2104 G:* 4 *ND 2108 G:* 8		
Signal evaluation/subdivision	10-fold	4-fold	–
Display	5.7″ color flat-panel display		
Functions	• Part programming of up to 100 parts • Sorting and tolerance checking using tolerance and warning limits • Measurement series with MIN/MAX display • Mathematical and trigonometric formulas, logical operations • Functions for statistical process control (SPC) • Graphic display (measurement results, distribution) • Data storage of values and formulas		
Switching I/O	Yes		
Interface	• RS-232-C/V.24 • USB		

Evaluation electronics

MSE 1000
Modular electronic unit for multipoint inspection apparatuses
The MSE 1000 of HEIDENHAIN is a higher level electronics unit in modular design for multipoint inspection apparatuses. The individual modules permit connection of incremental, absolute and analog measurands, the output of switch signals, and communication over diverse interfaces. In all, up to 250 axes or channels can be configured. This gives it the flexibility required to adapt to differing operating conditions.

In its basic configuration, the MSE 1000 consists of a power module and a basic module. It can be expanded by further modules as needed.

For more information, see the *MSE 1000* Product Information sheet.

		MSE 1000
Measuring channels/axes		Up to 250
Modules	Basic	• Ethernet 10/100 to the PC • Four encoder inputs with EnDat 2.2, TTL or 1 V_{PP} • Switching input TTL
	Power supply	100 V to 240 V AC or 24 V DC
	EnDat	4 or 8 EnDat-2.2 encoder inputs
	Sinusoidal	4 or 8 encoder inputs with 1 V_{PP}
	Square-wave	4 or 8 TTL encoder inputs
	Analog	Two analog inputs
	I/O	4 relay outputs and 4 switching inputs TTL
	Compressed air	Air switch for pneumatic length gauges
Mounting		On top hat rail on mounting stand or in electrical cabinets
Software		• MSEsetup • Ethernet driver
Interface		Standard Ethernet, IEEE 802.3

EIB 741
External interface box
The EIB 741 is ideal for applications requiring high resolution, fast measured-value acquisition, mobile data acquisition or data storage.

Up to four incremental or absolute HEIDENHAIN encoders can be connected to the EIB 741. The data is output over a standard Ethernet interface.

For more information, see the *EIB 741* Product Information sheet.

	EIB 741		
Encoder inputs Switchable	∿ 1 V_{PP}	EnDat 2.1	EnDat 2.2
Connection	Four D-sub connections (15-pin, female)		
Input frequency	≤ 500 kHz	–	
Signal subdivision	4096-fold	–	
Internal memory	Typically 250000 position values per input		
Interface	Ethernet as per IEEE 802.3 (≤ 1 gigabit)		
Driver software and demo program	**For Windows, Linux, LabView** Program examples		

Windows is a registered trademark of the Microsoft Corporation.

IK 220
Universal PC counter card
The IK 220 is an expansion board for PCs for recording the measured values of two incremental or absolute HEIDENHAIN encoders. The subdivision and counting electronics subdivide the sinusoidal input signals 4096-fold. A driver software package is included in delivery.

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

	IK 220			
Encoder inputs Switchable	∿ 1 V_{PP}	∿ 11 μA_{PP}	EnDat 2.1	SSI
Connection	Two D-sub connections (15-pin, male)			
Input frequency	≤ 500 kHz	≤ 33 kHz	–	
Signal subdivision	4096-fold		–	
Internal memory	8192 position values per input			
Interface	PCI bus (plug and play)			
Driver software and demo program	**For Windows 2000/XP/Vista/7** in VISUAL C++, VISUAL BASIC and BORLAND DELPHI			

Interfaces
Incremental Signals ∿ 11 µAPP

HEIDENHAIN encoders with ∿11 µAPP interface provide current signals. They are intended for connection to ND position display units or EXE pulse-shaping electronics from HEIDENHAIN.

The sinusoidal **incremental signals** I_1 and I_2 are phase-shifted by 90° elec. and have signal levels of approx. 11 µAPP. The illustrated sequence of output signals—I_2 lagging I_1—applies for the retracting plunger.

The **reference mark signal** I_0 has a usable component G of approx. 5.5 µA.

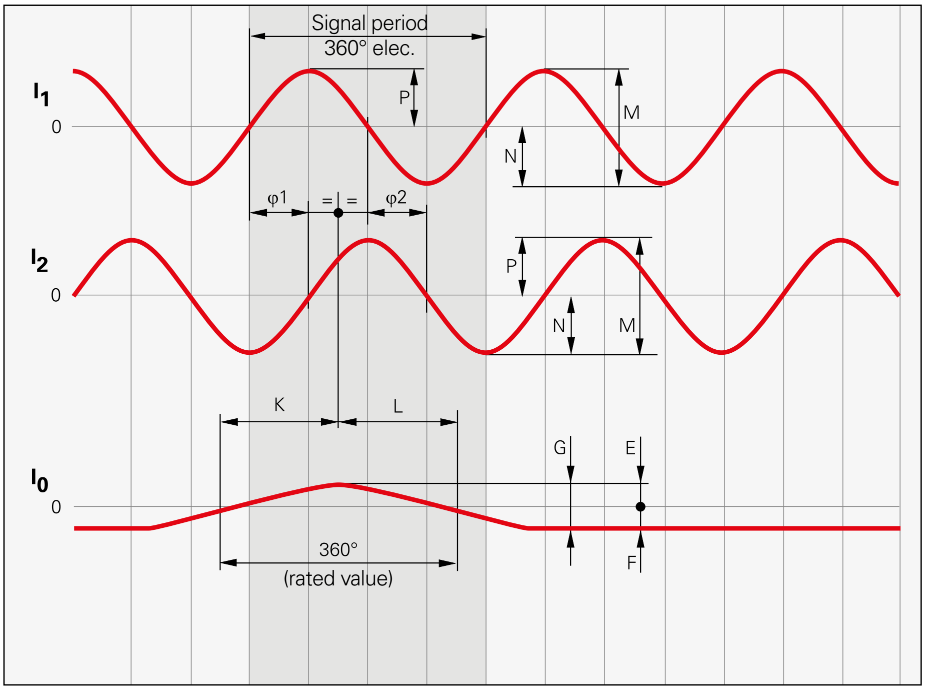
The data on **signal amplitude** apply when the power supply given in the *Specifications* is connected at the encoder. They refer to a differential measurement between the associated outputs. The signal amplitude decreases with increasing frequency. The **cutoff frequency** indicates the scanning frequency 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 11 µAPP interface are usually interpolated in the subsequent electronics in order to attain sufficiently high resolutions.

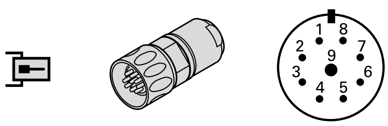
Measuring steps for **position measurement** are recommended in the *Specifications*. For special applications, other resolutions are also possible.

Interface	Sinusoidal current signals ∿ **11 µAPP**	
Incremental signals	**2 nearly sinusoidal signals I_1 and I_2**	
	Signal amplitude M:	7 to 16 µAPP/typically 11 µAPP
	Asymmetry IP – NI/2M:	≤ 0.065
	Amplitude ratio M_A/M_B:	0.8 to 1.25
	Phase angle $\lvert\varphi 1 + \varphi 2\rvert/2$:	90° ± 10° elec.
Reference mark signal	**One or more signal peaks I_0**	
	Usable component G:	2 to 8.5 µA
	Switching threshold E, F:	≥ 0.4 µA
	Zero crossovers K, L:	180° ± 90° elec.
Connecting cable	Shielded HEIDENHAIN cable PUR [$3(2 \cdot 0.14\ mm^2) + (2 \cdot 1\ mm^2)$]	
Cable length	Max. 30 m with 90 pF/m distributed capacitance	
Propagation time	6 ns/m	

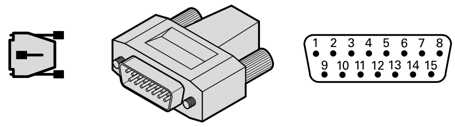


Pin layout

9-pin HEIDENHAIN connector



15-pin D-sub connector
For ND 28x/PWM 20 or on encoder



	Power supply				Incremental signals					
9-pin	3	4	**Housing**	9	1	2	5	6	7	8
15-pin	4	2	**Housing**	6	1	9	3	11	14	7
	U_P	**0 V**	**External shield**	**Internal shield**	**I_1+**	**I_1-**	**I_2+**	**I_2-**	**I_0+**	**I_0-**
Cable	Brown	White	–	White/ Brown	Green	Yellow	Blue	Red	Gray	Pink

U_P = Power supply
Vacant pins or wires must not be used!

Shield on housing.
Color assignment applies only to extension cable.

Interfaces

Incremental signals ∿ 1 V_{PP}

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

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

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

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

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

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

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

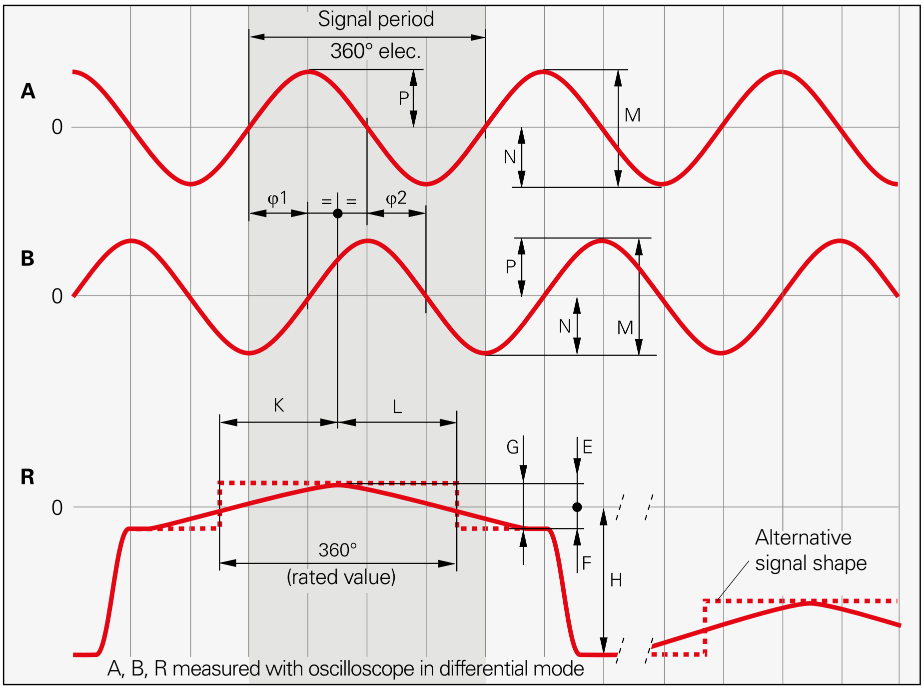
Measuring steps for **position measurement** are recommended in the specifications. For special applications, other resolutions are also possible.

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

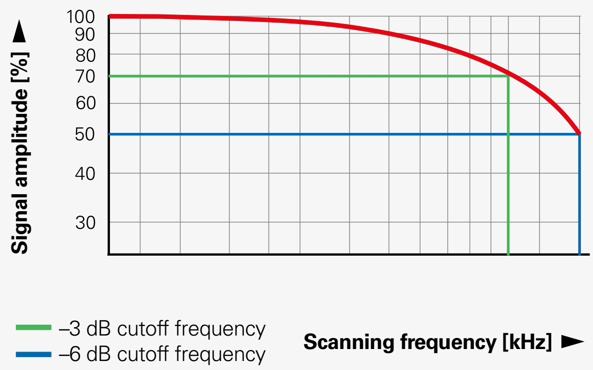
Short circuit at	20 °C	125 °C
One output	< 3 min	< 1 min
All outputs	< 20 s	< 5 s

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

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



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



Input circuitry of subsequent electronics

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

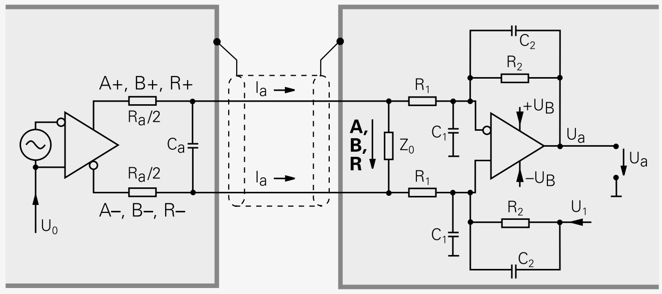
–3 dB cutoff frequency of circuitry
Approx. 450 kHz
Approx. 50 kHz with $C_1 =$ 1000 pF
and $C_2 =$ 82 pF
The circuit variant for 50 kHz does reduce the bandwidth of the circuit, but in doing so it improves its noise immunity.

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

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

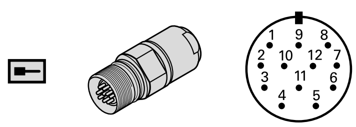
Incremental signals
Reference mark signal

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

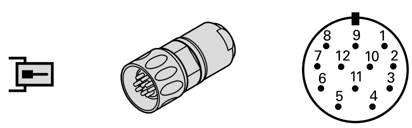


Pin layout

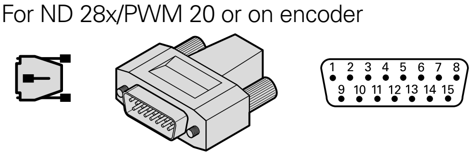
12-pin coupling, M23



12-pin connector, M23



15-pin D-sub connector
For ND 28x/PWM 20 or on encoder



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

Shield on housing; **U_P** = power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!
Color assignment applies only to extension cable.

Interfaces

Incremental signals ⊓⊔TTL

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

The **incremental signals** are transmitted as the square-wave pulse trains U_{a1} and U_{a2}, phase-shifted by 90° elec. The **reference mark signal** consists of one or more reference pulses U_{a0}, which are gated with the incremental signals. In addition, the integrated electronics produce their **inverted signals** $\overline{U_{a1}}$, $\overline{U_{a2}}$ and $\overline{U_{a0}}$ for noise-proof transmission. The illustrated sequence of output signals—with U_{a2} lagging U_{a1}—applies to the direction of motion shown in the dimension drawing.

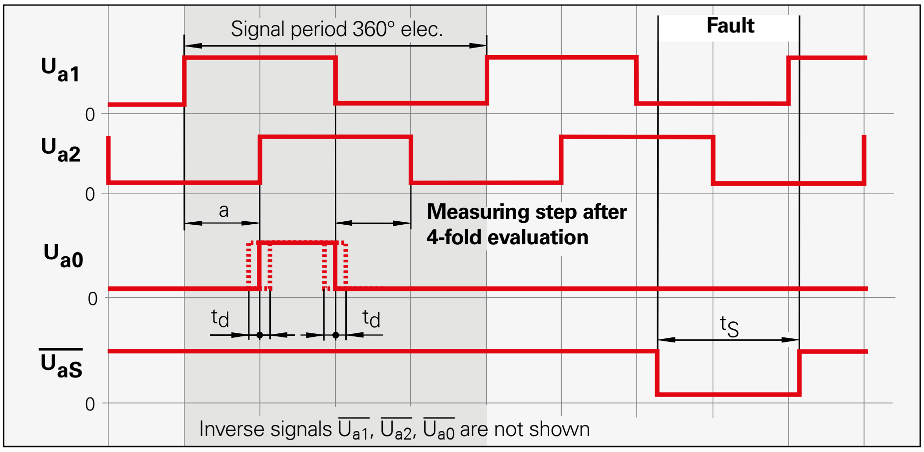
The **fault-detection signal** $\overline{U_{aS}}$ indicates fault conditions such as breakage of the power line or failure of the light source. It can be used for such purposes as machine shut-off during automated production.

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

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

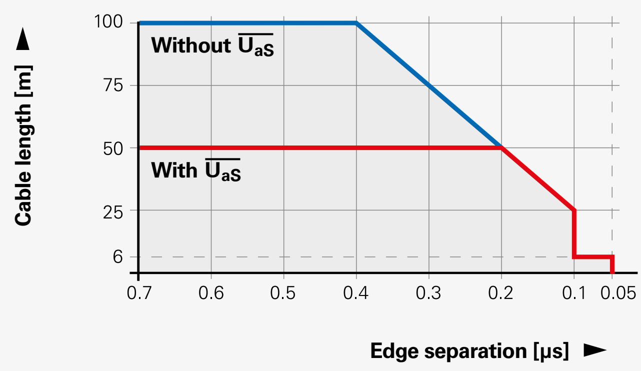
The max. permissible **shaft speed** or **traversing velocity** must never be exceeded.

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



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

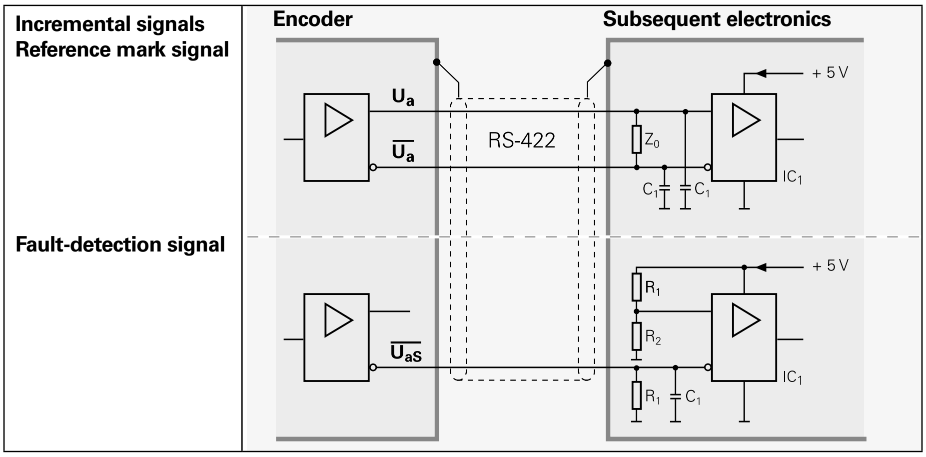
Permissible cable length
with respect to the edge separation



Input circuitry of subsequent electronics

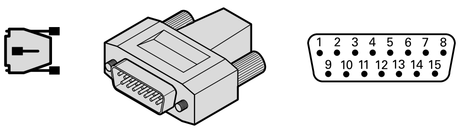
Dimensioning
IC_1 = Recommended differential line receiver
DS 26 C 32 AT
Only for a > 0.1 µs:
AM 26 LS 32
MC 3486
SN 75 ALS 193

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

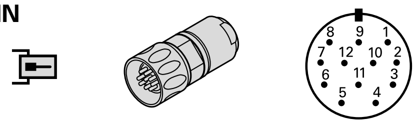


Pin layout

15-pin D-sub connector



12-pin HEIDENHAIN connector



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

Shield on housing; **U_P** = power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.
1) **ERO 14xx:** Vacant 2) **Exposed linear encoders:** Switchover TTL/11 µAPP for PWT
Vacant pins or wires must not be used!
Color assignment applies only to extension cable.

Absolute position values EnDat

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

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

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

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

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

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

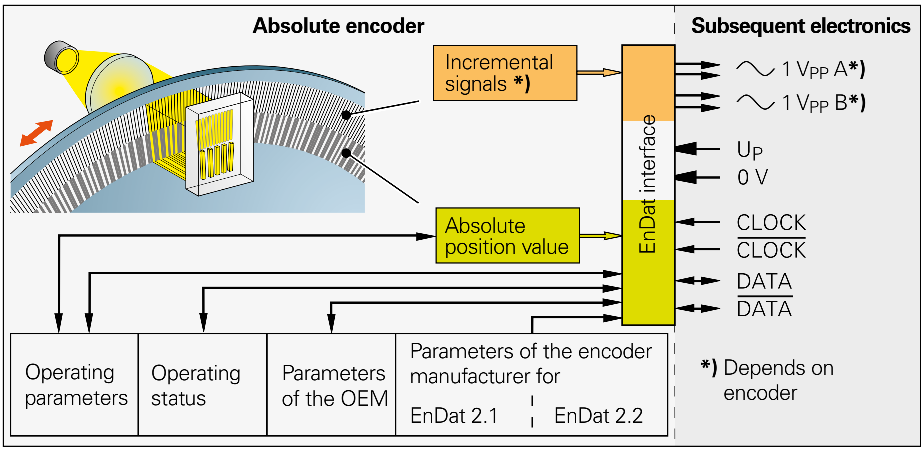
Incremental signals
EnDat encoders are available with or without incremental signals. EnDat 21 and EnDat 22 encoders feature a high internal resolution. An evaluation of the incremental signals is therefore unnecessary.

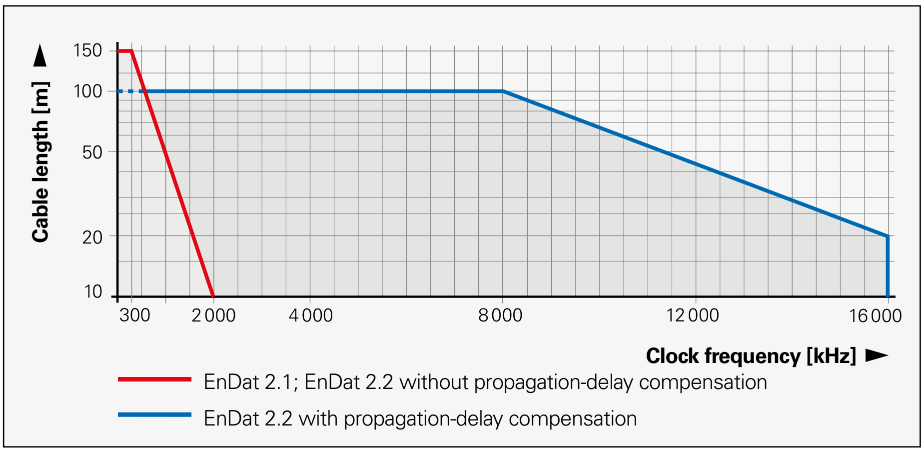
Clock frequency and cable length
The clock frequency is variable—depending on the cable length (max. 150 m)—between **100 kHz** and **2 MHz.** With propagation-delay compensation in the subsequent electronics, clock frequencies **up to 16 MHz** are possible at cable lengths up to 100 m (for other values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

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

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

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

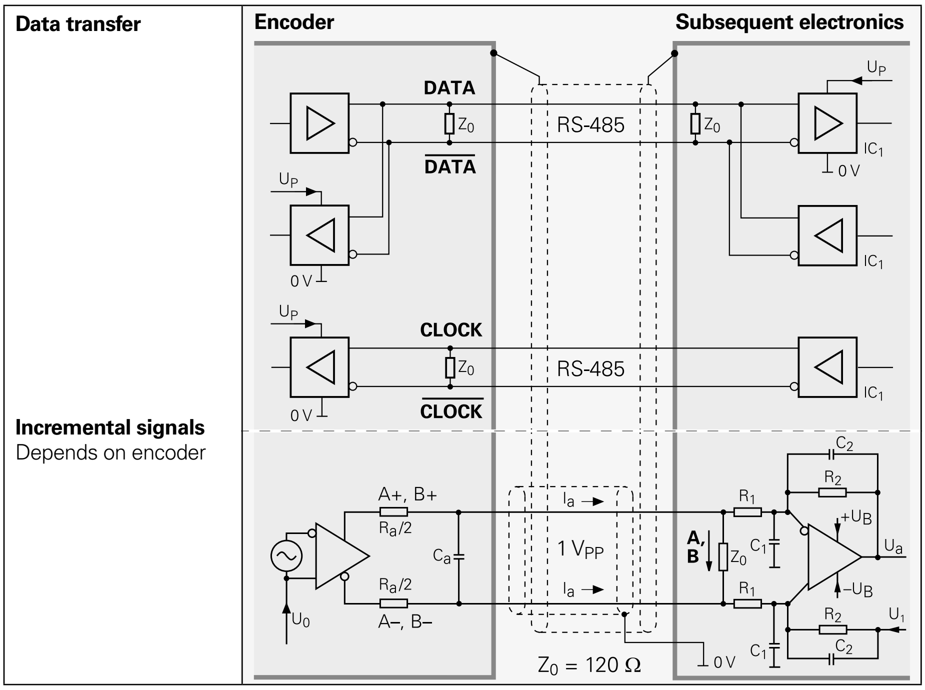




Input circuitry of subsequent electronics

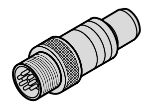
Dimensioning
IC_1 = RS 485 differential line receiver and driver

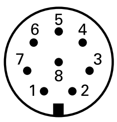
C_3 = 330 pF
Z_0 = 120 Ω



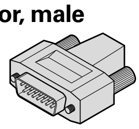
Pin layout

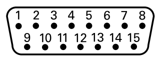
8-pin coupling, M12





15-pin D-sub connector, male
For IK 215/PWM 20





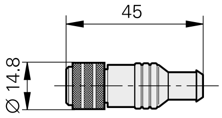
	Power supply				Absolute position values			
8-pin coupling	**8**	**2**	**5**	**1**	**3**	**4**	**7**	**6**
15-pin D-sub	**4**	**12**	**2**	**10**	**5**	**13**	**8**	**15**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
Cable	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

Cables and connecting elements
General information

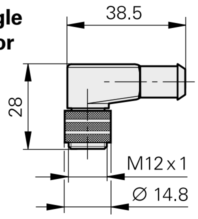
Connector (insulated): A connecting element with a coupling ring. Available with male or female contacts.

Symbols

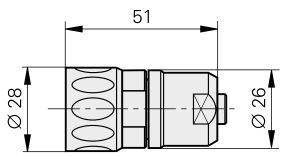
M12



M12 right-angle connector



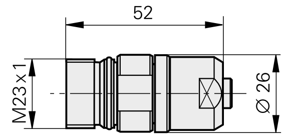
M23



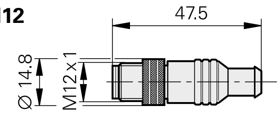
Coupling insulated:
Connecting element with external thread.
Available with male or female contacts.

Symbols

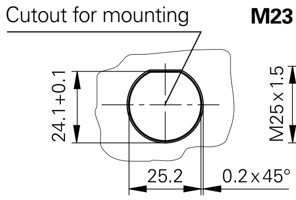
M23



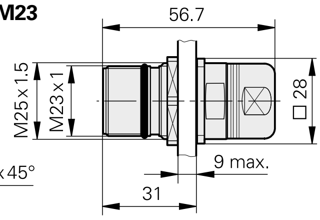
M12



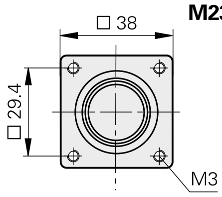
Mounted coupling with central fastening



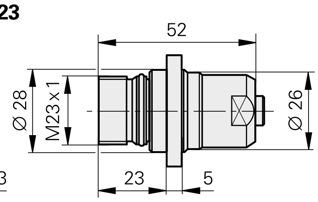
M23



Mounted coupling with flange



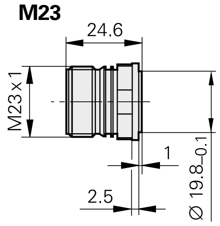
M23

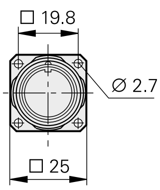


Flange socket: Permanently mounted on the encoder or a housing, with external thread (like a coupling), available with male or female contacts.

Symbols

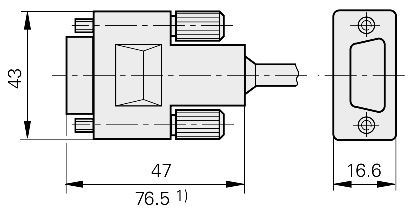
M23





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

Symbols

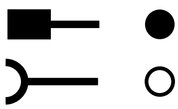


1) With integrated interpolation electronics

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

male or

female contacts.



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

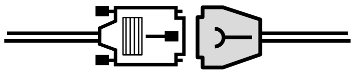
Accessories for flange sockets and M23 mounted couplings

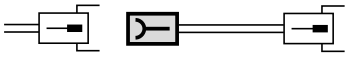
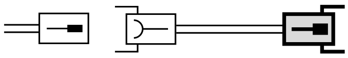
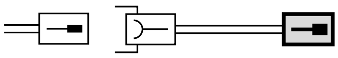
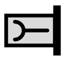
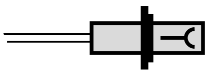
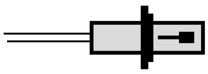
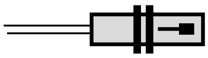
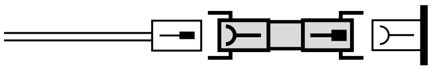
Bell seal
ID 266526-01

Threaded metal dust cap
ID 219926-01

Accessory for M12 connecting element
Insulation spacer
ID 596495-01

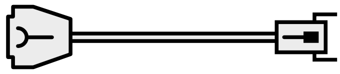
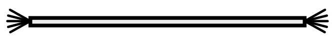
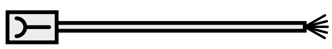
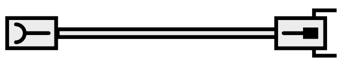
Connecting elements

			15-pin
Connector on connecting cable to connector on encoder cable	**D-sub connector, female** for cable 	Ø 8 mm	315650-14

			12-pin	9-pin
Mating element on connecting cable to connector on encoder cable	**Coupling (female)** for cable 	Ø 8 mm	291698-02	291698-01
Connector on connecting cable for connection to subsequent electronics	**Connector (male)** For cable with 	Ø 8 mm	291697-08	291697-04
Coupling on connecting cable	**Coupling (male)** for cable 	Ø 8 mm	291698-04	291698-24
Flange socket for mounting on subsequent electronics	**Flange socket (female)** 		315892-08	315892-06
Mounted couplings	**With flange (female)** 	Ø 8 mm	291698-07	291698-06
	With flange (male) 	Ø 8 mm	291698-31	–
	With central fastener (male) 	Ø 6 to 10 mm	741045-01	–
Adapter ∼ 1 V_{PP}/11 μA_{PP} For converting the 1 V_{PP} signals to 11 μA_{PP}; 12-pin M23 connector (female) and 9-pin M23 connector (male)			364914-01	–

Connecting cables 1 V_{PP}, TTL, 11 μA_{PP}

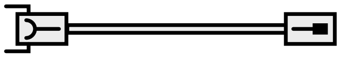
12-pin M23 | 9-pin M23

		1 V_{PP}, TTL		11 μA_{PP}
PUR connecting cable [3(2 x 0.14 mm^2) + (2 x 1 mm^2)]; A_V = 1 mm^2				
PUR connecting cable [6(2 x 0.19 mm^2)]; A_V = 0.19 mm^2				
PUR connecting cable [4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)]; A_V = 0.5 mm^2		Ø 8 mm	Ø 6 mm[1)]	Ø 8 mm
Complete with D-sub connector (female) and M23 connector (male)		331693-xx	355215-xx	–
With one D-sub connector (female), 15-pin		332433-xx	355209-xx	–
Complete with D-sub connector (female) and connector (male), 15-pin for ND 28x, EIB 741; only 1 V_{PP}: ND 11xx, ND 12xx		335074-xx	355186-xx	–
Complete with D-sub connector (female) and D-sub connector (female), 15-pin, for ND 780, PT 880, IK 220		335077-xx	349687-xx	–
Cable only		244957-01	291639-01	–
Complete with M23 coupling (female) and D-sub connector (male), 15-pin for ND 28x, EIB 741; only 1 V_{PP}: ND 11xx, ND 12xx		309784-xx	–	653231-xx
Complete with M23 coupling (female) and D-sub connector (male), 19-pin for ND 11xx, ND 12xx (not 1 V_{PP})		617513-xx	–	716905-xx
Complete with M23 coupling (female) and D-sub connector (female), 15-pin, for ND 780, PT 880, IK 220		309783-xx	–	368172-xx
With one connector with M23 coupling (female)		298402-xx	–	309780-xx
Complete with M23 coupling (female) and M23 connector (male)		298400-xx	–	309774-xx

1) Cable length max. 9 m
A_V: Cross section of power supply lines

Connecting cables EnDat

8-pin
M12

		EnDat without incremental signals	
PUR connecting cable [4 × 2 × 0.09 mm^2]; A_V = 0.09 mm^2			
PUR connecting cable [(4 × 0.14 mm^2) + (4 × 0.34 mm^2)]; A_V = 0.34 mm^2		Ø 6 mm	Ø 3.7 mm
Complete with connector (female) and coupling (male)		368330-xx	801142-xx[1)]
Complete with right-angle connector (female) and coupling (male)		373289-xx	801149-xx[1)]
Complete with connector (female) and D-sub connector (female), 15-pin, for TNC (position inputs)		535627-xx	–
Complete with connector (female) and D-sub connector (male), 15-pin, for IK 215, PWM 20, EIB 741 etc.		524599-xx	801129-xx[1)]
Complete with right-angle connector (female) and D-sub connector (male), 15-pin, for IK 215, PWM 20, EIB 741, etc.		722025-xx	801140-xx[1)]
With **one** connector (female)		634265-xx	–
With one right-angle connector, (female)		606317-xx	–

1) Max. cable length 6 m
A_V: Cross section of power supply lines

General electrical information

Power supply

Connect HEIDENHAIN encoders only to subsequent electronics whose power supply is generated from PELV systems **(EN 50 178).** In addition, overcurrent protection and overvoltage protection are required in safety-related applications.

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

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

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

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

Calculation of the **voltage drop**:

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

where
ΔU: Voltage drop in V
1.05: Length factor due to twisted wires
L_C: Cable length in m
I: Current consumption in mA
A_P: Cross section of power lines in mm²

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

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

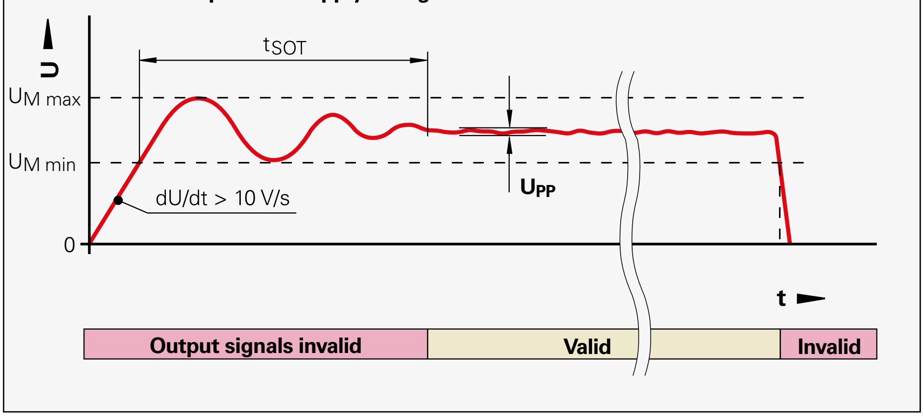
Switch-on/off behavior of the encoders
The output signals are valid no sooner than after the switch-on time t_{SOT} = 1.3 s (2 s for PROFIBUS-DP) (see diagram). During the time t_{SOT} they can have any levels up to 5.5 V (with HTL encoders up to U_{Pmax}). If an interpolation electronics unit is inserted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

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

Insulation
The encoder housings are isolated against internal circuits.

Rated surge voltage: 500 V (preferred value as per VDE 0110 Part 1, overvoltage category II, contamination level 2)

Transient response of supply voltage and switch-on/switch-off behavior



Cable	Cross section of power supply lines A_P			
	1 V_{PP}/TTL/HTL	**11 µA_{PP}**	**EnDat/SSI** 17-pin	**EnDat**[5] 8-pin
Ø 3.7 mm	0.05 mm²	–	–	0.09 mm²
Ø 4.3 mm	0.24 mm²	–	–	–
Ø 4.5 mm EPG	0.05 mm²	–	0.05 mm²	0.09 mm²
Ø 4.5 mm **Ø 5.1 mm**	0.14/0.09[2] mm² 0.05[2, 3] mm²	0.05 mm²	0.05/0.14[6] mm²	0.14 mm²
Ø 5.5 mm PVC	0.1 mm²	–	–	–
Ø 6 mm **Ø 10 mm**[1]	0.19/0.14[2, 4] mm²	–	0.08/0.19[6] mm²	0.34 mm²
Ø 8 mm **Ø 14 mm**[1]	0.5 mm²	1 mm²	0.5 mm²	1 mm²

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

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

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

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

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

***Step 1:* Resistance of the supply lines**
The resistance values of the supply lines (adapter cable and encoder cable) can be calculated with the following formula:

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

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

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

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

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

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

***Step 4:* Parameters for subsequent electronics and the encoder**
Voltage at encoder:
$U_E = U_P - \Delta U$

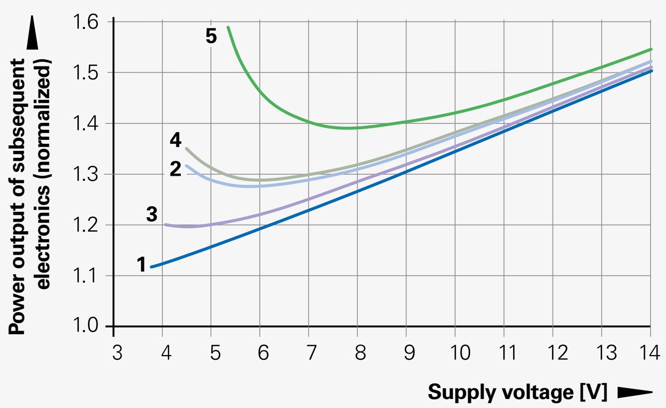
Current requirement of encoder:
$I_E = \Delta U / R_L$

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

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

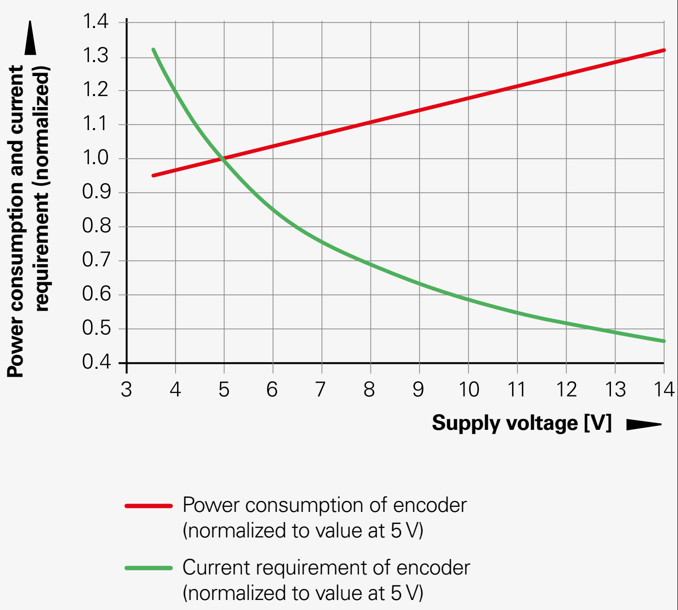
Where:
U_{Emax}, U_{Emin}: Minimum or maximum supply voltage of the encoder in V
P_{Emin}, P_{Emax}: Maximum power consumption at minimum or maximum power supply, respectively, in W
U_P: Supply voltage of the subsequent electronics in V
R_L: Cable resistance (for both directions) in ohms
ΔU: Voltage drop in the cable in V
1.05: Length factor due to twisted wires
L_C: Cable length in m
A_P: Cross section of power lines in mm^2

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



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

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



Electrically permissible speed/ traversing speed

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

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

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

  For encoders with **square-wave signals,** the electrically permissible shaft speed/ traversing velocity is limited by
  – the maximum permissible scanning/ output frequency f_{max} of the encoder, and
  – the minimum permissible edge separation a for the subsequent electronics.

For angle or rotary encoders

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

For linear encoders

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

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

Cables

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

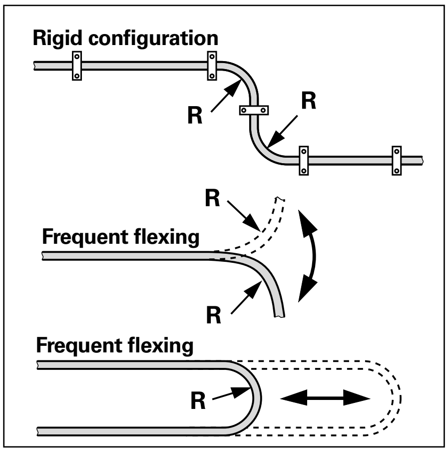
Versions
The cables of almost all HEIDENHAIN encoders and all adapter and connecting cables are sheathed in **polyurethane (PUR cables).** Many adapter cables for within motors and a few cables on encoders are sheathed in a **special elastomer (EPG).** Many adapter cables within the motor consist of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

Durability
PUR cables are resistant to oil in accordance with **VDE 0472** (Part 803/test type B) and to hydrolysis and microbes in accordance with **VDE 0282** (Part 10). They are free of PVC and silicone and comply with UL safety directives. The **UL certification** "AWM STYLE 20963 80 °C 30 V E63216" is documented on the cable.

EPG cables are resistant to oil in accordance with **VDE 0472** (Part 803/test type B) and to hydrolysis in accordance with **VDE 0282** (Part 10). They are free of PVC, silicone and halogens. In comparison with PUR cables, they are only somewhat resistant to media, frequent flexing and continuous torsion.

PVC cables are oil resistant. The UL certification "AWM E64638 STYLE20789 105C VW-1SC NIKKO" is documented on the cable.

TPE wires with braided sleeving are oil resistant and highly flexible.



Temperature range

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

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

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

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

[1)] Metal armor

Noise-free signal transmission

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

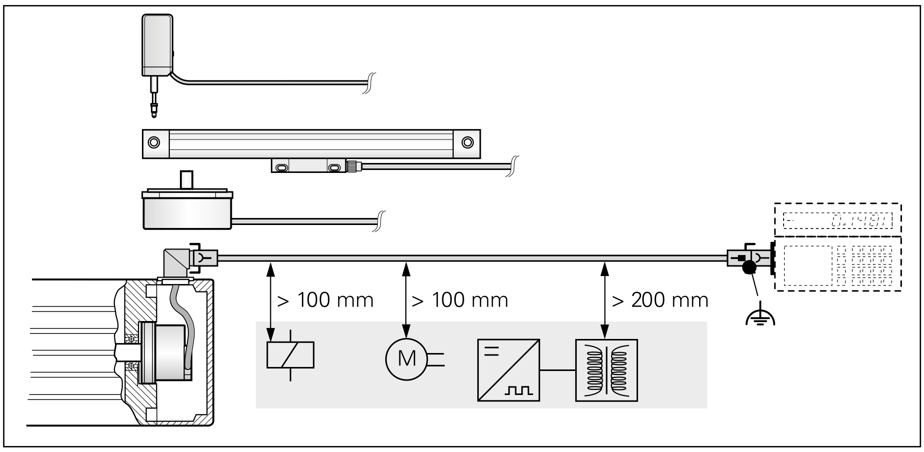
- **Noise immunity EN 61 000-6-2:**
  Specifically:
  - ESD EN 61 000-4-2
  - Electromagnetic fields EN 61 000-4-3
  - Burst EN 61 000-4-4
  - Surge EN 61 000-4-5
  - Conducted disturbances EN 61 000-4-6
  - Power frequency magnetic fields EN 61 000-4-8
  - Pulse magnetic fields EN 61 000-4-9
- **Interference EN 61 000-6-4:**
  Specifically:
  - For industrial, scientific and medical equipment (ISM) EN 55 011
  - For information technology equipment EN 55 022

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

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

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

- Use only original HEIDENHAIN cables. Consider the voltage drop on supply lines.
- Use connecting elements (such as connectors or terminal boxes) with metal housings. Only the signals and power supply of the connected encoder may be routed through these elements. Applications in which additional signals are sent through the connecting element require specific measures regarding electrical safety and EMC.
- Connect the housings of the encoder, connecting elements and subsequent electronics through the shield of the cable. Ensure that the shield has complete contact over the entire surface (360°). For encoders with more than one electrical connection, refer to the documentation for the respective product.
- For cables with multiple shields, the inner shields must be routed separately from the outer shield. Connect the inner shield to 0 V of the subsequent electronics. Do not connect the inner shields with the outer shield, neither in the encoder nor in the cable.
- Connect the shield to protective ground as per the mounting instructions.
- Prevent contact of the shield (e.g. connector housing) with other metal surfaces. Pay attention to this when installing cables.
- Do not install signal cables in the direct vicinity of interference sources (inductive consumers such as contactors, motors, frequency inverters, solenoids, etc.).
  - Sufficient decoupling from interference-signal-conducting cables can usually be achieved by an air clearance of 100 mm or, when cables are in metal ducts, by a grounded partition.
  - A minimum spacing of 200 mm to inductors in switch-mode power supplies is required.
- If compensating currents are to be expected within the overall system, a separate equipotential bonding conductor must be provided. The shield does not have the function of an equipotential bonding conductor.
- Provide power only from PELV systems **(EN 50 178)** to position encoders. Provide high-frequency grounding with low impedance **(EN 60 204-1 Chap. EMC).**
- For encoders with 11 µAPP interface: Use only HEIDENHAIN cable ID 244955-01 as extension cable. Overall length: max. 30 m.



Minimum distance from sources of interference

Sales and service
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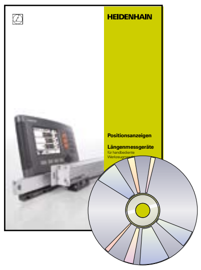
Brochure
Digital Readouts
For Metrology Applications

Contents:
Digital readouts
ND 100, ND 200, ND 1100, ND 1200,
ND 1300, ND 1400 ND 1200T, ND 2100G



Brochure, CD-ROM
Digital Readouts
Linear Encoders
For Manually Operated Machine Tools

Contents:
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Linear encoders
LS 300, LS 600

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Also included:
- Technical articles
- Press releases
- Addresses
- CAD drawings

Addresses in Germany

HEIDENHAIN is represented in Germany and all other important industrial nations as well. In addition to the addresses listed on the back page, there are many service agencies located worldwide. For their addresses, please refer to the Internet or contact HEIDENHAIN Traunreut.

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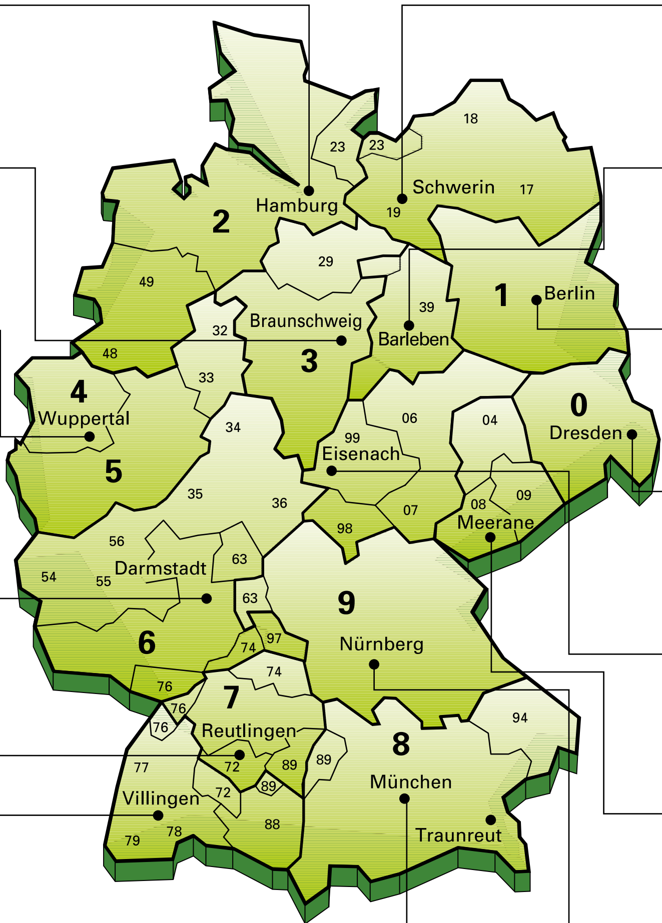

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