AMO GmbH

Linear Encoders based on the inductive AMOSIN® – measuring principle

Brochure

September 2018

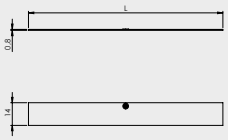
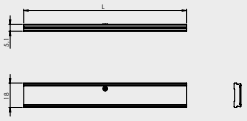
This document was created very carefully. If there are any technical changes, they will promptly updated in the documents on our website www.amo-gmbh.com.

This brochure supersedes all previous editions, which thereby become invalid.

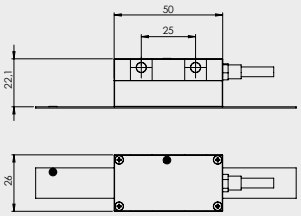
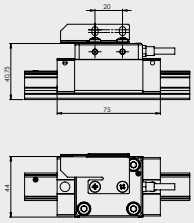
Standards (ISO, EN, etc.) apply only where explicitly stated in the catalog.

The basis for ordering from AMO is always the brochure edition valid when the order is made.

Selection table - Absolute linear encoder

Grating period	Scale				
	Dimensions	Accuracy class	Accuracy after linear compensation[1]	Measuring length ML	
1000 µm	LMBA 2010  LMTA 4010 	±20 µm/m or ±50 µm/m	±3 µm/m[2] ±5 µm/m ±10 µm/m	up to 32 m	
	LMFA 3010 	±20 µm/m or ±50 µm/m	±3 µm/m[3] ±5 µm/m ±10 µm/m	up to 32 m	

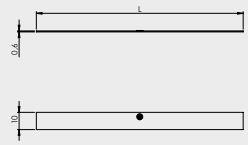
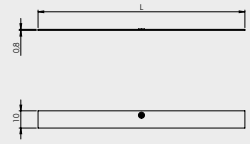
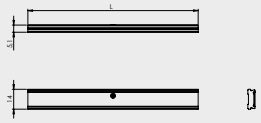
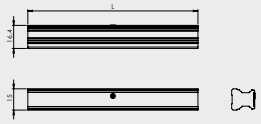
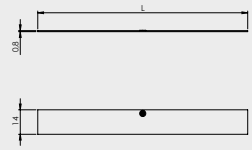
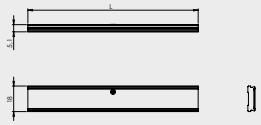
[1] After linear length-error compensation in the evaluation electronics
[2] LMBA 2010 : up to measuring length ML = 2950 mm
LMTA 4010 : up to measuring length ML = 2930 mm
[3] Up to measuring length ML = 2960 mm

Scanning head				
Dimensions	**Interfaces**	**Resolution**	**Max. speed**	**Type**
Design: 20 	EnDat 2.2 FANUC α SSI+1Vss Mitsubishi BiSS/C	1 µm to 0,1 µm	20 m/s	**LMKA 2010** **LMBA 2010** **LMTA 4010**
Design: 30 	EnDat 2.2 FANUC α SSI+1Vss Mitsubishi BiSS/C	1 µm to 0,1 µm	3 m/s	**LMKA 3010** **LMFA 3010**

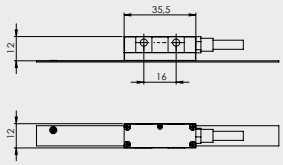
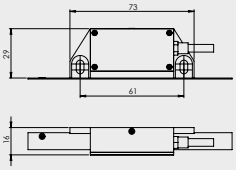
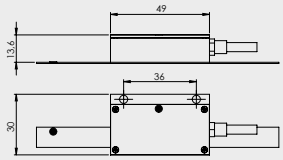
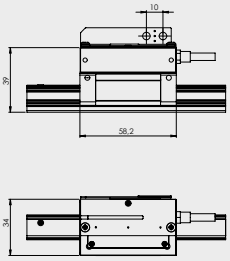
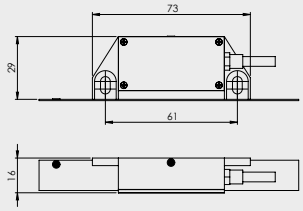
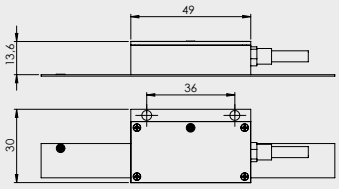
LMKA 2010 **LMBA 2010**

LMKA 3010 **LMFA 3010**

Selection table - Incremental linear encoder

Grating period	Scale				
	Dimensions	Accuracy class	Accuracy after linear compensation[1]	Measuring length ML	
500 µm **1000 µm**	LMB 1005  LMB 1010  LMT 4005 / 4010 	±20 µm/m or ±50 µm/m	±3 µm/m[2] ±5 µm/m ±10 µm/m	Any measuring length	
1000 µm	LMF 3010 	±20 µm/m or ±50 µm/m	±5 µm/m ±10 µm/m	Any measuring length	
3000 µm	LMB 1030  LMT 4030 	±50 µm/m	±10 µm/m ±20 µm/m	Any measuring length	

[1] After linear length-error compensation in the evaluation electronics
[2] LMB 1010/1005 : up to total length GL = 3000 mm

Scanning head				
Dimensions	Resolution		Max. speed	Type
	1Vss	TTL		
Design: 10,12  Design: 20  Design: 21 	Standard: 1000 µm to 20 µm High Accuracy: 20 µm or 10 µm	Standard: 1000 µm to 0,5 µm High Accuracy: 0,5 µm to 0,05 µm	10 m/s (Grating period 500 µm) 20 m/s (Grating period 1000 µm)	**LMK 1005** **LMK 2005** **LMB 1005** **LMT 4005** **LMK 1010** **LMK 2010** **LMB 1010** **LMT 4010**
Design: 30 	Standard: 1000 µm to 20 µm High Accuracy: 20 µm or 10 µm	Standard: 1000 µm to 0,5 µm High Accuracy: 0,5 µm to 0,05 µm	3 m/s	**LMK 3010** **LMF 3010**
Design: 20  Design: 21 	Standard: 3000 µm to 120 µm	Standard: 150 µm to 3 µm	60 m/s	**LMK 2030** **LMB 1030** **LMT 4030**

LMB 1005 LMK 1005

LMB 1010 LMK 2010 BF 20

LMT 4010 LMK 2010 BF 21

LMF 3010 LMK 3010

LMB 1030 LMK 2030 BF 20

LMT 4030 LMK 2030 BF 20

Measuring principle

Grating

AMO encoders function on the inductive AMOSIN® measuring principle. The encoders incorporate gratings of periodic structures known as graduations.

The measuring scale is a stainless-steel tape on which a high precision periodical graduation is introduced by photolitographic techniques followed by an etching process.

Absolute gratings consists of a 1000µm incremental track and an additional absolute track, using a serial code.

For incremental encoders a reference mark is located on a separate track. This makes it possible to assign this absolute position value to exactly one measuring step.

The following grating periods are possible for incremental encoders:

- 500 µm
- 1000 µm
- 3000 µm

Inductive scanning

AMO encoders are using an unique coil structure, with a number of coils aligned in the direction of measurement, which is implemented on a substrate using micro-multi-layer technology.

An important feature of the patented AMOSIN® measuring principle is the accuracy of the signal generation, using a high-frequency alternating field which suppresses any hysteresis in the material.

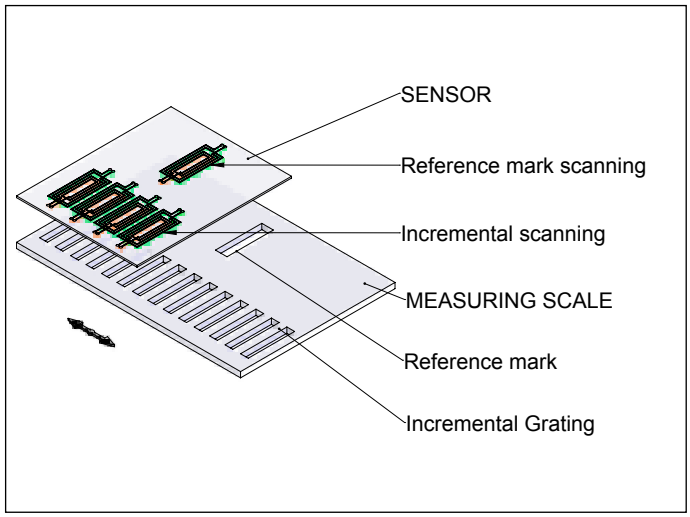
The relative angular movement in the direction of measurement between the sensor structure (in the scanning head) and the measuring scale periodically changes the mutual inductance of the individual coils, generating two sinusoidal signals with a 90° phase difference.

The extremely accurate signal, and it`s immunity to environmental influences, has the effect that, after conditioning of the signal in the evaluation electronics, deviations of no more than 0.1% from the ideal sinusoidal form (harmonic content) remains. This allows high interpolation factors to be carried out in the course of signal digitisation. This can either be done in the encoder itself, or in the subsequent electronics (CNC etc.).

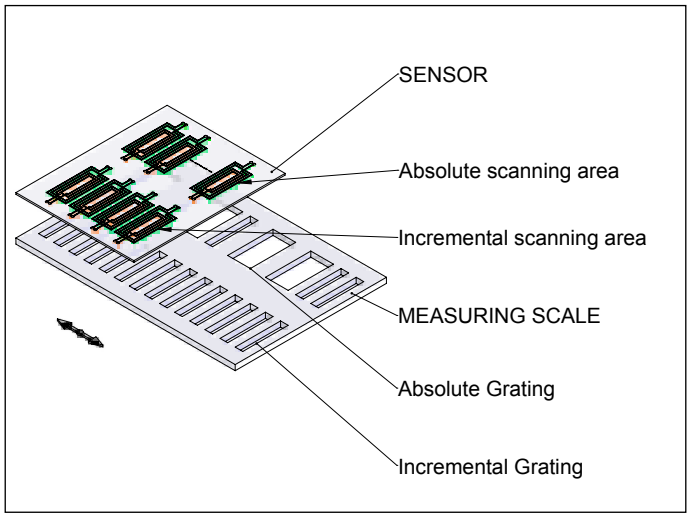
With the absolute measuring method, the position value is available from the encoder immediately upon swith-on and can be called at any time by the subsequent electronics. There is no need to move the axis to find the reference position.

The absolute position information is read from the scale graduation, which is formed from a absolute code structure. A separate incremental track is interpolated for the position value.

With the incremental measuring method the graduation consists of a periodic grating structure. The position information is obtained by counting the induvidial increments from some point of origin. Since an absolute reference is required to a certain postition, the scales are provided with an additional track that bears a reference mark. The absolute position on the scale, established by the reference mark, is gated with exactly one signal period.



Incremental scanning



Absolute scanning

Measuring accuracy

The accuracy of linear measurement is mainly determined by:

- the quality of the graduation
- the stability of the graduation carrier
- the quality of the scanning process
- the quality of the signal processing electronics
- the installation of the encoder in the machine

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

Encoder-specific postion error

The encoder-specific position error are specified in the technical data:

- accuracy of the graduation
- position error within one signal period

Accuracy of the scale

The accuracy of the scale is mainly determined by:

- the homogeneity of the graduation
- the alignment of the graduation on the carrier
- the stability of the graduation carrier

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

Position error over the measuring range

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

The extreme values ±F of the measuring curves over any max. one-meter section of the measuring length lie within the accuracy class ±a. They are measured during the final inspection, under ideal conditions, by measuring the position error with a serial scanning head

The accuracy achievable after linear length-error compensation in the evaluation electronics is specified as accuracy after linear compensation.

Position error within one signal period

The position error within one signal period ±u results from the quality of the scanning and the quality of the internal signal-processing electronics. For encoders with sinusoidal output signals, however, the errors of the signal processing electronics caused by the subsequent electronics must be considered.

The following individual factors influence the result:

- the size of the signal period
- the homogeneity of the graduation
- the quality of scanning
- the characteristics of the sensors
- the stability and dynamics of further processing of the analog signals

These factors of influence are to be considered when specifying position error within one signal period.

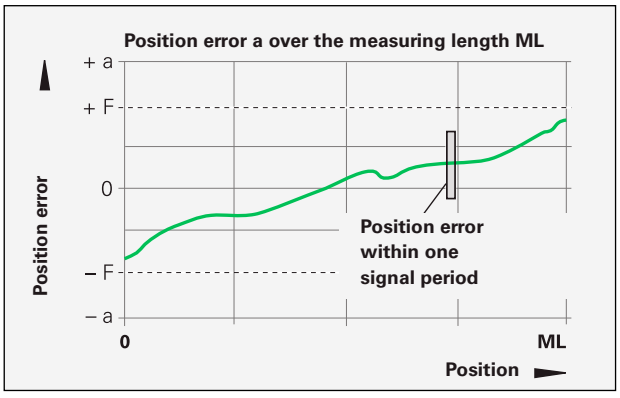
Position error within one signal period ±u is specified in the technical data in this document. Position errors within one signal period has an effect in very small traversing speed and in repeated measurements. Especially in the speed control loop, it leads to fluctuations in traversing speed.

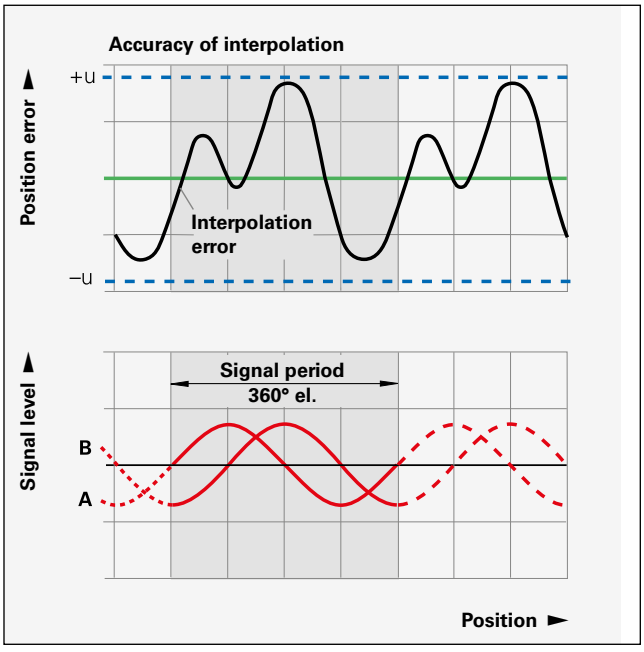
Application-dependent error

The mounting and adjustment of the scanning head, in addition to the given encoder-specific error, normally have a significant effect on the accuracy that can be achieved by modular encoders. The application-dependent error values must be measured and calculated individually in order to evaluate the overall accuracy.

Deformation of the graduation

Errors due to deformation of the graduation are not to be ignored. It occurs when the scale is mounted on an uneven, for example convex, surface.





Mechanical design types - linear scales

General information

Linear encoders from AMO are amongst others designed for use in applications with harsh environmental conditions. All modular linear encoders are free from wear because of the non-contact scanning.
The mechanical design of absolute and incremental scales is quite similar.

The absolute position information on an absolute grating is formed with an serial absolute code track and a separate incremental track.

An incremental scale contain an incremental track and an additional track with single or distance coded reference marks.

Mechanical design of modular linear scales

For modular linear encoders AMO offers two different mechanical scale design types:

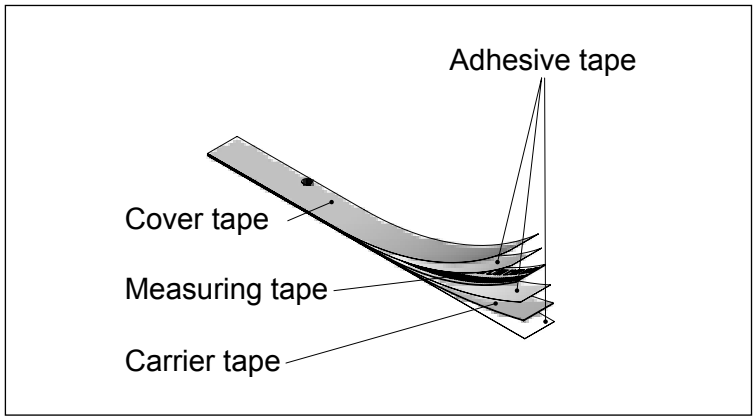
- LMB/LMBA - Scale tape to stick
- LMT/LMTA - Scale tape in stainless steel carrier

The materials used for the components in both scale types are stainless steel.

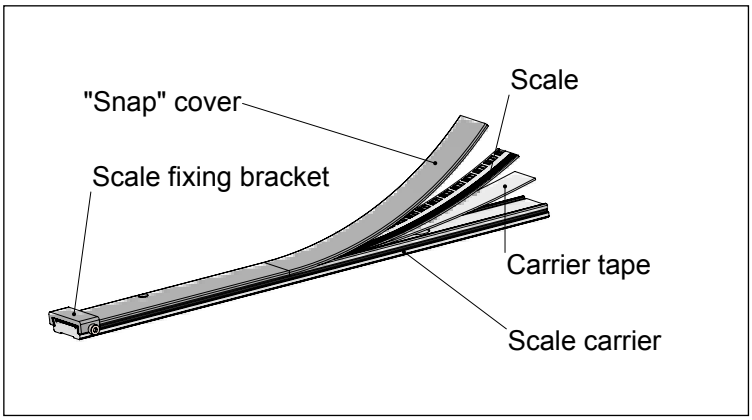
LMB/LMBA scales are equipped with an adhesive film on the bottom side. This allows to glue the scale directly to the mounting surface.

On LMTA/LMT scales stainless steel carrier sections are screwed onto the mounting surface first. The the one-piece scale tape is pulled into the carrier, closes with the snap-cover and fixed at it's ends with fixing brackets.

This scale tape solution offers the possibility of an repeated mounting and dismounting procedure combined with a high resistance against aggressive medium.



Design LMBA/LMB

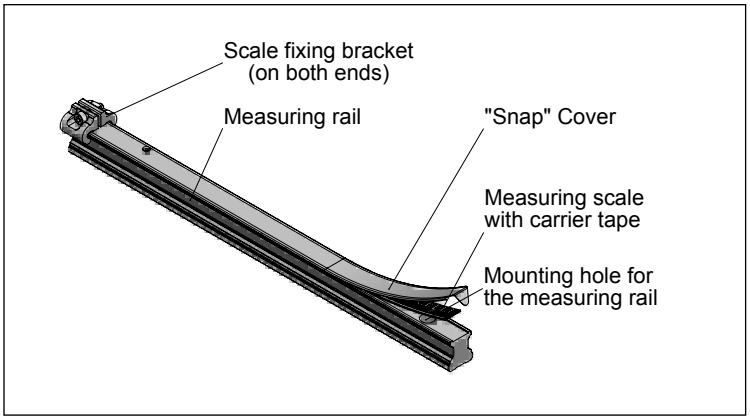


Design LMTA / LMT

Mechanical design of guided linear scales

The scale tape versions LMFA/LMF integrated in a guided rail are designed quite similar to the scale type LMTA/LMT mounted in a stainless steel carrier.

A single or multiple sections of a guided rail are screwed onto the mounting surface first. The one-piece scale tape is pulled into the carrier, closes with the snap-cover and fixed at it's ends with fixing brackets.



Design LMFA/LMF

Reference marks at incremental linear encoders

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 at a certain position, the scale tape 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 measuring step.

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

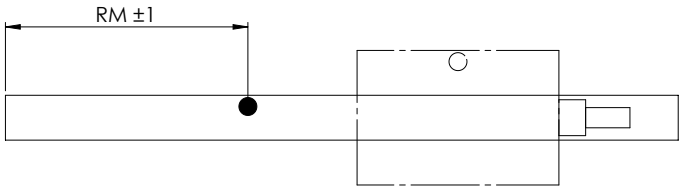
To speed and simplify such "reference runs", many AMO encoders feature distance-coded reference marks – multiple reference marks that are individually spaced according to a mathematical algorithm.

Individual reference marks

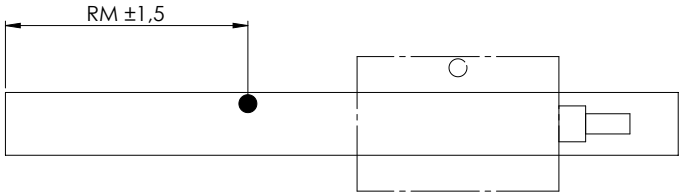
As a standard, a single reference mark is positioned centered on the scale tape related to the total scale length. The reference mark position on the scale tape is marked with a black dot.

A single reference mark can also be placed on a custom-designed position on the scale. Therefore the reference mark position has to be defined in the ordering code of the scale as the distance from one end of the scale to the reference mark.
The position of the scanning unit for the refernce mark in the scanning head is centrally arranged.

Reference mark position LMB 1005/LMB 1010

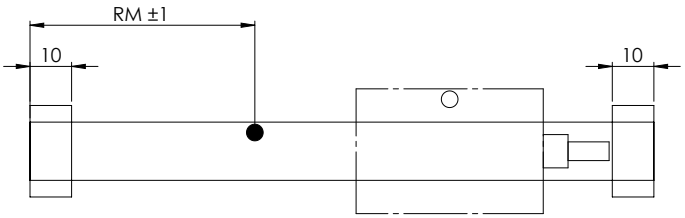


Reference mark position LMB 1030

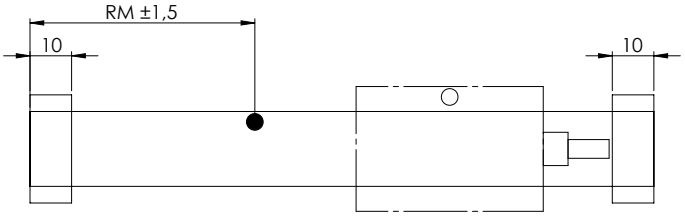


RM = Reference mark position

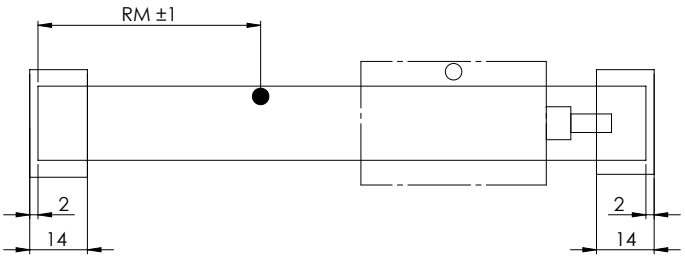
Reference mark position LMT 4005/LMT 4010



Reference mark position LMT 4030



Reference mark position LMF 3010



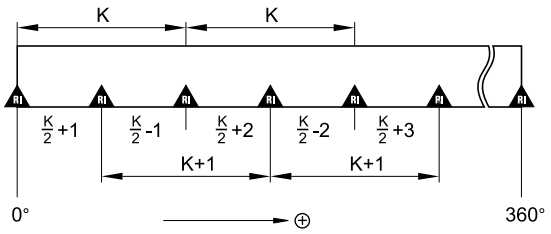
RM = Reference mark position

Distance-coded reference marks

AMO offers for all incremental scales distance-coded reference marks – multiple reference marks that are individually spaced according to a mathematical algorithm.

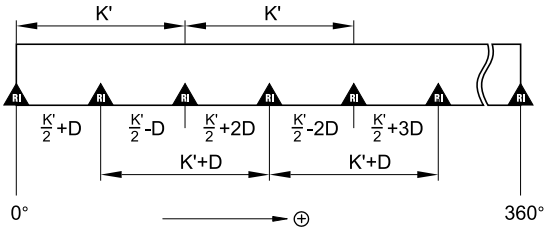
The subsequent electronics find the absolute reference after traversing two successive refernce marks.

Arrangement of distance coded reference marks for encoders with non divided 1Vpp output signals



K … number of 1Vpp signal periods at the output of the encoder.

Arrangement of distance coded reference marks for encoders with divided 1Vpp output signals



K'=K x D

K' … number of divided 1Vpp signal periods at the output of the encoder.
D … dividing factor

General technical information

Acceleration

Encoders are subject to various types of acceleration during operation and mounting:

- The indicated maximum values for vibration resistance are valid according to EN 60 068-2-6 at frequency of 55 Hz to 2000 kHz
- The maximum permissible acceleration values (semi-sinusoidal shock) for shock and impact are valid for 6 ms (EN 60 068-2-27).

Under no circum stances should a hammer or similar implement be used to adjust or position the encoder.

Temperature range

The **operating temperature** range indicates the ambient temperature limits between which the encoders will function properly.

The **storage temperature** range applies when the unit remains in its packaging. The operating and storage temperature range are specified in the technical data.

Thermal characteristics

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

Expendable parts

Due to the contactless inductive scanning principle of the linear modular encoders from AMO only a continuously moving cable is subject to wear. Pay attention to the minimum permissible bending radii.

Mounting

Work steps to be performed and dimensions to be maintained during mounting are specified solely in the mounting instructions supplied with the unit.

All data in this catalog regarding mounting are therefore provisional and not binding; they do not become terms of a contract.

System tests

Encoders from AMO are usually integrated as components in larger systems. Such applications require comprehensive tests of the entire system regardless of the specifications of the encoder.

The specifications shown in this brochure apply to the specific encoder, and not to the entire system. Any operation of the encoder outside of the specified range or for any applications other than the intended applications is at the user's own risk. In safety-related systems, the higher-level system must verify the position value of the encoder after switch-on.

Functional Safety - Absolute linear encoders

The absolute linear encoder types LMKA 2010 and LMKA 3010 with **SSI +1Vpp interface**, which provide an analog 1Vpp signal in addition to the absolute position, can be used in safety related applications under following conditions:

For the use in safety related applications all encoder types with ordering code „FA" (see also the option „Functional Safety" in the ordering code) are applicable. These are scanning heads with an purely analog 1Vpp output signal. The signal period corresponds to the grating period.

In order to be able to implement a linear encoder in a safety-related application, a suitable control is required. The control assumes the fundamental task of communicating with the encoder and safely evaluating the encoder data. AMO provides on request a technical information with MTTF values and a fault model with comments to table D8 (Motion and position feedback sensors) of the standard EN 61800-5-2.

For all linear encoders without a specified value („FA" or „FS") for Functional Safety in the ordering code, no suitable fault-detection measures are implemented. Those encoders provide no or a synthetical 1Vpp output signal. Therefore the assumed faults in accordance with EN 61800-5-2, table D8 can lead to an incorrect but plausible position value.

To what extent such linear encoders can be used in safety-related applications depends on the architecture of the safety system and the fault-detection measures in the evaluating safety module.

Fault exclusion for the loosening of the mechanical connection

The machine manufacturer is responsible for the dimensioning of mechanical connections in a drive system. The OEM should ideally consider the application conditions for the mechanical design. Providing objective evidence of a safe connection is time-consuming, however.

For this reason, AMO has developed and confirmed by a type examination a mechanical fault exclusion for the linear encoders. The qualification of the mechanical fault exclusion was performed for a broad application range of the encoders. This means that fault exclusion is ensured under the operating conditions listed below.

All information is given with respect to a mounting temperature of 15°C to 35°C. Mounting surfaces must be clean and free of burrs. Thread surfaces must be secured with materially bonding thread-locking fluid. All mounting screws have to be tightened torque controlled.

Fault exclusion LMBA 2010 - Scale tape to stick

The installation of the scale tape must be carried out according to the assembly instructions. As guidance for the measuring tape in the direction of travel, an insertion or stop shoulder can be provided in the machine base.

If this is not possible, an auxiliary stop can also be used to achieve sufficient straightness of the measuring tape in the direction of travel.

LMBA 2010 - Scale tape to stick	
Machine base	
Coefficient of thermal expansion α	(10 to 16) 10^{-6} K^{-1}
Environmental conditions	
Pollution	dry environment, no oils, cutting fluid or other liquid substances
Operating temperature	-10 °C to 85 °C
Max. acceleration	± 50 m/s^2 in direction of movement
Shock 6ms	< 1000 m/s^2 (EN 60068-2-27)

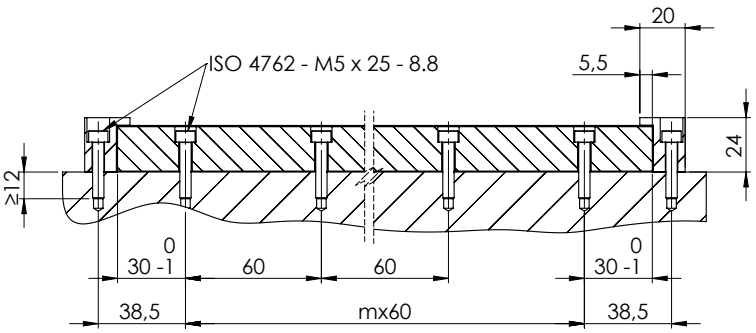
Fault exclusion LMFA 3010 - Measuring rail

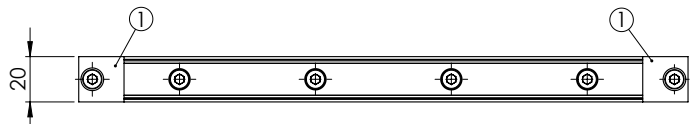
The mounting of the measuring rail must be carried out according to the installation instructions. The screws and the end clamps, necessary to achieve the mechanical fault exclusion are not included in the scope of delivery.

Minimum srew length L is the sum of the length of engagement and the free clamped length.

LMFA 3010 - Measuring rail	
Machine base	
Coefficient of thermal expansion α	(10 to 16) 10^{-6} K^{-1}
Tensile strength R_m	≥ 360 N/mm^2
Measuring rail assambly	
Screws	ISO 4762 - M5 x L - 8.8
Torque M_d	5,0 ± 0,10 Nm
Length of thread engagement	≥ 10 mm
Free clamped length	≥ 13,2 mm
Environmental conditions	
Operating temperature	-10°C to 85 °C
Max. acceleration	± 50 m/s^2 in direction of movement
Shock 6ms	< 1000 m/s^2 (EN 60068-2-27)

Recommended assembly





① Accessory 1244592-04 End Clamp LMFA

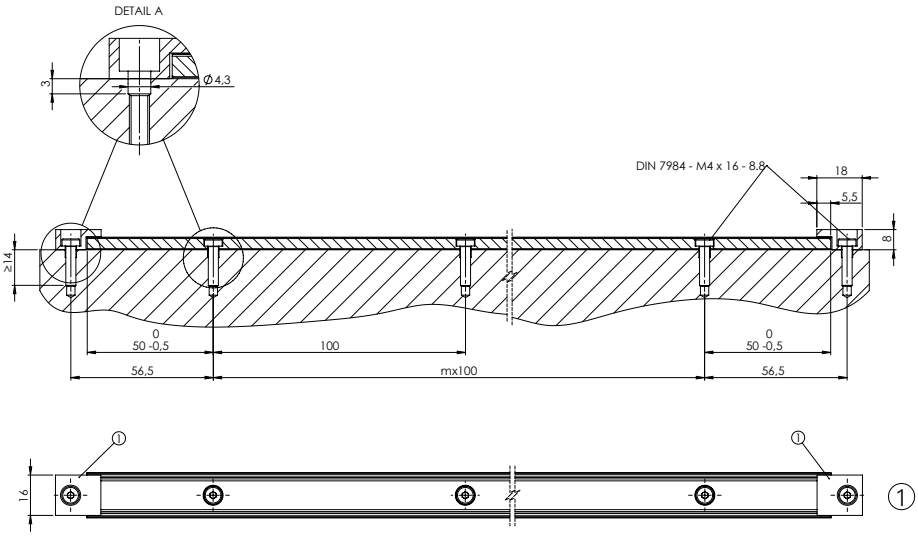
Fault exclusion LMTA 4010 - Scale tape in stainless steel carrier

The mounting of the stainless steel carrier must be carried out according to the installation instructions. The screws and the end clamps, necessary to achieve the mechanical fault exclusion are not included in the scope of delivery.

Minimum srew length L is the sum of the length of engagement and the free clamped length.

LMTA 4010 - Scale tape in stainless steel carrier	
Machine base	
Coefficient of thermal expansion α	(10 to 16) 10^{-6} K^{-1}
Tensile strength R_m	≥ 360 N/mm^2
Carrier assembly	
Screws	DIN 7984 - M4xL - 8.8
Torque M_d	2,0 ± 0,05 Nm
Length of thread engagement	≥ 8 mm
Free clamped length	≥ 5 mm
Environmental conditions	
Operating temperature	-10°C to 100 °C
Max. acceleration	± 50 m/s^2 in direction of movement
Shock 6ms	< 1000 m/s^2 (EN 60068-2-27)

Recommended assembly



① Accessory 1244592-03 End Clamp LMT(A)

Functional Safety - Incremental linear encoders

The incremental linear encoder type LMK with 1 Vpp interface providing a analog 1 Vpp output signal can be used in safety-related applications under following conditions:

For the use in safety related applications all encoder types with ordering code „FA" (see also the option „Functional Safety" in the ordering code) are applicable. These are scanning heads with an purely analog 1Vpp output signal. The signal period corresponds to the grating period.
In order to be able to implement a linear encoder in a safety-related application, a suitable control is required. The control assumes the fundamental task of communicating with the encoder and safely evaluating the encoder data. AMO provides on request a technical information with MTTF values and a fault model with comments to table D8 (Motion and position feedback sensors) of the standard EN 61800-5-2.

For all linear encoders without a specified value („FA" or „FS") for Functional Safety in the ordering code, no suitable fault-detection measures are implemented. Those encoders provide a synthetical 1Vpp on TTL output signal. Therefore the assumed faults in accordance with EN 61800-5-2, table D8 can lead to an incorrect but plausible position value.

To what extent such linear encoders can be used in safety-related applications depends on the architecture of the safety system and the fault-detection measures in the evaluating safety module.

Fault exclusion for the loosening of the mechanical connection

The machine manufacturer is responsible for the dimensioning of mechanical connections in a drive system. The OEM should ideally consider the application conditions for the mechanical design. Providing objective evidence of a safe connection is time-consuming, however.

For this reason, AMO has developed and confirmed by a type examination a mechanical fault exclusion for the linear encoders. The qualification of the mechanical fault exclusion was performed for a broad application range of the encoders. This means that fault exclusion is ensured under the operating conditions listed below.

All information is given with respect to a mounting temperature of 15°C to 35°C. Mounting surfaces must be clean and free of burrs. Thread surfaces must be secured with materially bonding thread-locking fluid. All mounting screws have to be tightened torque controlled.

Fault exclusion LMB - Scale tape to stick

The installation of the scale tape must be carried out according to the assembly instructions. As guidance for the measuring tape in the direction of travel, an insertion or stop shoulder can be provided in the machine base.

If this is not possible, an auxiliary stop can also be used to achieve sufficient straightness of the measuring tape in the direction of travel.

LMB - Scale tape to stick	
Machine base	
Coefficient of thermal expansion α	(10 to 16) 10^{-6} K^{-1}
Environmental conditions	
Pollution	dry environment, no oils, cutting fluid or other liquid substances
Operating temperature	-10 °C to 85 °C
Max. acceleration	± 50 m/s^2 in direction of movement
Shock 6ms	< 1000 m/s^2 (EN 60068-2-27)

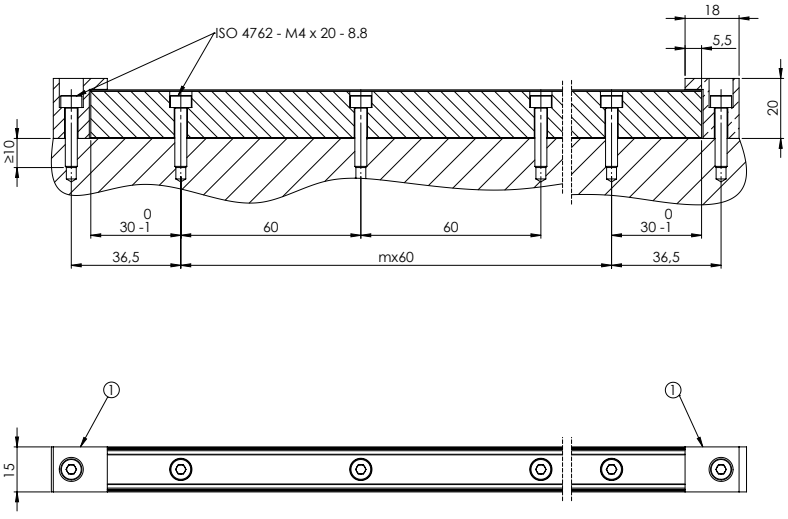
Fault exclusion LMF - Measuring rail

The mounting of the measuring rail must be carried out according to the installation instructions. The screws and the end clamps, necessary to achieve the mechanical fault exclusion are not included in the scope of delivery.

Minimum srew length L is the sum of the length of engagement and the free clamped length.

LMF - Measuring rail	
Machine base	
Coefficient of thermal expansion α	(10 to 16) 10^{-6} K^{-1}
Tensile strength R_m	≥ 360 N/mm^2
Measuring rail assambly	
Screws	ISO 4762 - M4 x L - 8.8
Torque M_d	3,0 ± 0,10 Nm
Length of thread engagement	≥ 8 mm
Free clamped length	≥ 10,2 mm
Environmental conditions	
Operating temperature	-10°C to 85 °C
Max. acceleration	± 50 m/s^2 in direction of movement
Shock 6ms	< 1000 m/s^2 (EN 60068-2-27)

Recommended assembly



① Accessory 1244592-05 End Clamp LMF

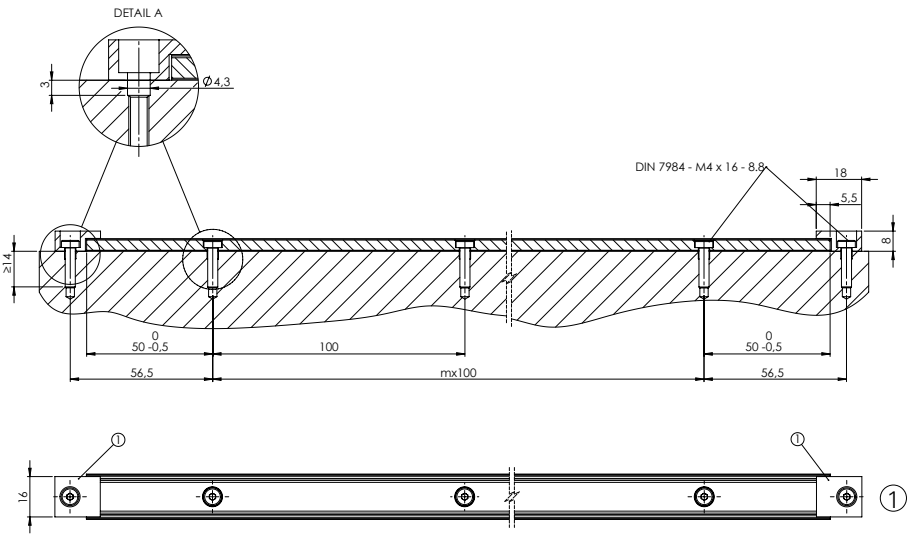
Fault exclusion LMT - Scale tape in stainless steel carrier

The mounting of the stainless steel carrier must be carried out according to the installation instructions. The screws and the end clamps, necessary to achieve the mechanical fault exclusion are not included in the scope of delivery.

Minimum srew length L is the sum of the length of engagement and the free clamped length.

LMT - Scale tape in stainless steel carrier	
Machine base	
Coefficient of thermal expansion α	(10 to 16) 10^{-6} K^{-1}
Tensile strength R_m	≥ 360 N/mm^2
Carrier assembly	
Screws	DIN 7984 - M4xL - 8.8
Torque M_d	2,0 ± 0,05 Nm
Length of thread engagement	≥ 8 mm
Free clamped length	≥ 5 mm
Environmental conditions	
Operating temperature	-10°C to 100 °C
Max. acceleration	± 50 m/s^2 in direction of movement
Shock 6ms	< 1000 m/s^2 (EN 60068-2-27)

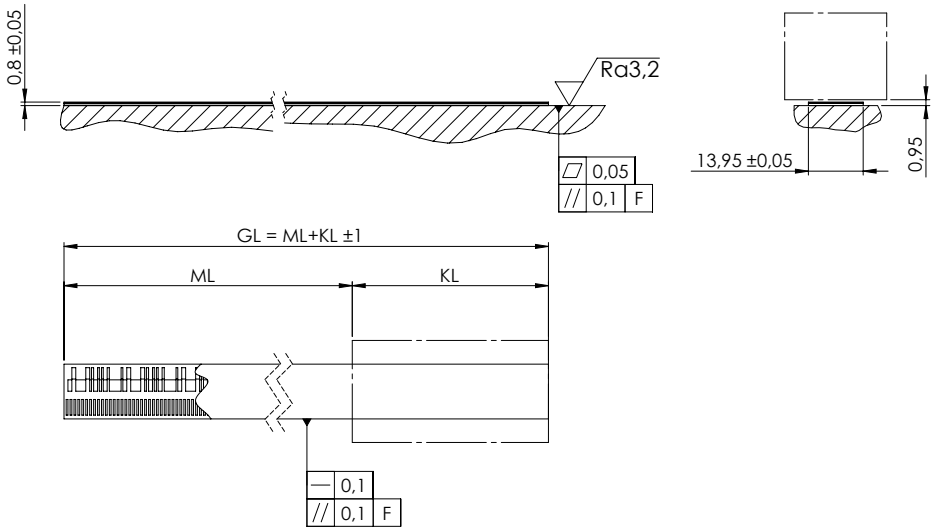
Recommended assembly



① Accessory 1244592-03 End Clamp LMT

Scale tape to stick LMBA 2010

- **Scale tape to stick, for modular linear encoders**
- **Grating period 1000µm**
- **In combination with scanning head LMKA 2010**



F = Machine guidance
GL = Total length
ML = Measuring length :

BF 20 : ML = GL - 50 mm

KL = Scanning head length :

BF 20 : 50 mm

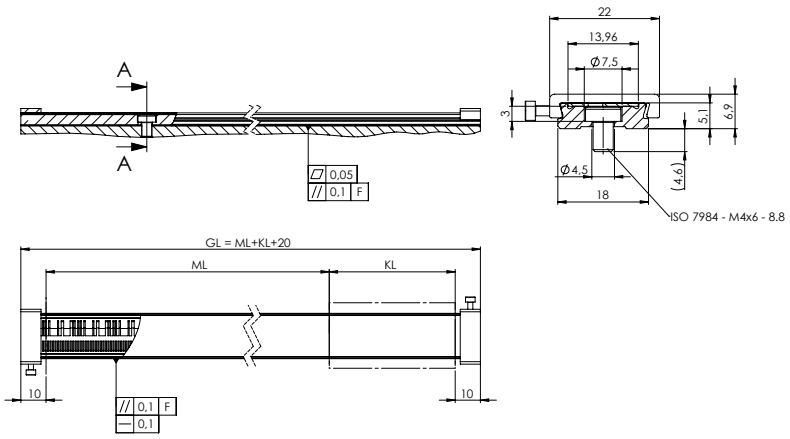
Tolerance principle in accordance withSO8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

Technical data

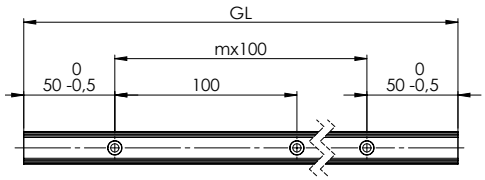
Absolute scale tape	LMBA 2010		
Grating period	1000µm		
Accuracy class	± 20µm/m	± 20µm/m	± 50µm/m
Accuracy after linear compensation	± 3µm/m	± 5µm/m	± 10µm/m
Total length GL	Standard length see ordering code		
Mechanical design	Stainless steel scale tape with adhesive layer for mounting		
Coefficient of expansion	~ 11 ppm/K		
Mass	60 g/m Total length		

Scale tape in stainless steel carrier LMTA 4010

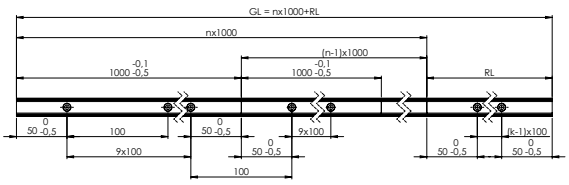
- **Scale tape in stainless steel carrier, for modular linear encoders**
- **Grating period 1000µm**
- **In combination with scanning head LMKA 2010**



Single section carrier LMTA 4010 C



Multi section carrier LMTA 4010 D



F = Machine guidance

GL = Total length

ML = Measuring length :

BF 20 : ML = GL - 70 mm

KL = Scanning head length :

BF 20 : 50 mm

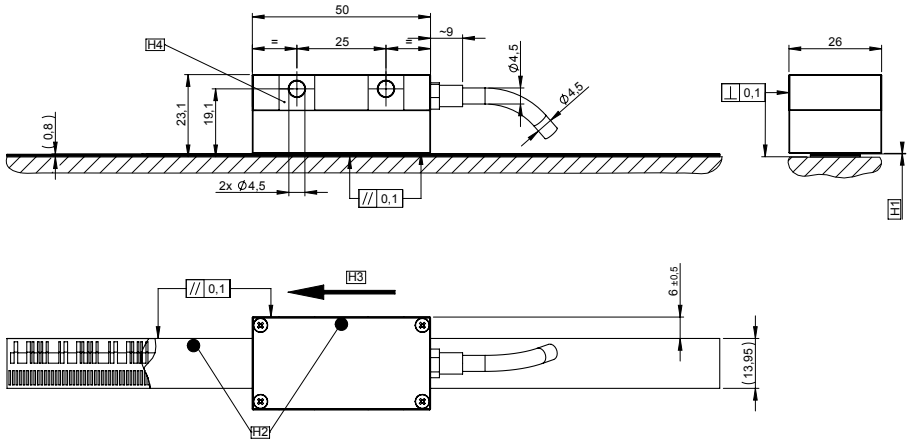
Technical data

Absolute scale tape	LMTA 4010		
Grating period	1000µm		
Accuracy class	± 20µm/m	± 20µm/m	± 50µm/m
Accuracy after linear compensation	± 3µm/m	± 5µm/m	± 10µm/m
Total length GL	Standard length see ordering code		
Mechanical design	Stainless steel carrier with integrated scale tape		
Coefficient of expansion	~ 11 ppm/K		
Mass	650 g/m Total length		

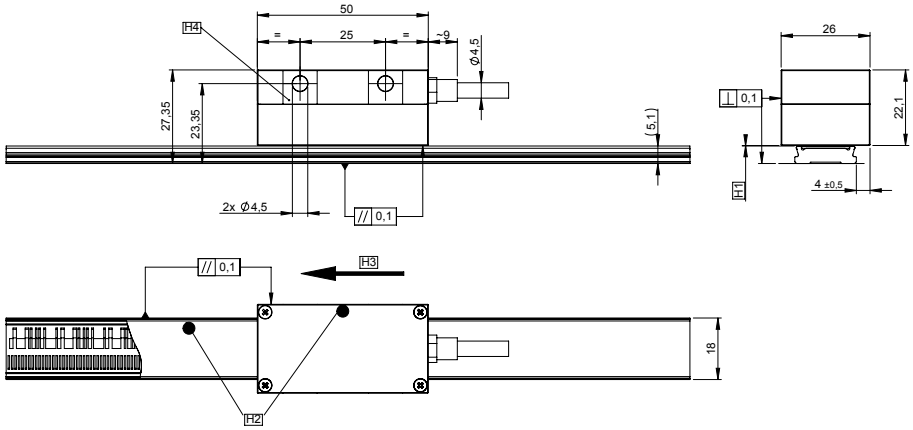
Scanning head - LMKA 2010 series

- **Absolute, modular linear encoder**
- **Grating period 1000µm**
- **Encoder with integrated electronics**
- **In combination with scale type LMBA 2010 and LMTA 4010**

Design 20
with scale type LMBA 2010



Design 20
with scale type LMTA 4010



Tolerance principle in accordance withSO8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

H1 = Air gap 0,15 ± 0,10mm, set with spacer foil
H2 = Absolute track marking
H3 = Direction of scanning head movement for positive counting
H4 = Ground plane

Technical data

- LMKA - Scanning head for modular linear encoders
- Grating period 1000µm

Scanning head	**LMKA 2010**					
Interface	EnDat 2.2	Fanuc α	BiSS/C	Mitsubishi (full duplex)	Mitsubishi (half duplex)	SSI + 1Vpp
Designation	EnDat 2.2	Fanuc02	BiSS	MitA1-4	MitA1-2	SSI - 1Vpp
Clock frequency	≤ 16 MHz	-	≤ 2,5 MHz	5 Mbps	5 Mbps	≤ 1 MHz
Measuring step						
Standard	1µm or 0,25µm					
High Accuracy	0,1µm					-
Position deviation per grating pitch[1)]						
Standard	± 2µm					
High Accuracy	± 0,5µm					-
Max. speed	20m/s					
Cable length on scanning head	0,5m to 6m					
Electrical Connection	Cable with M12 coupling, 8pin male					Cable with M23 coupling, 12pin male
Voltage supply	DC 3,6V to 14V					
Power consumption	≤ 1,5W at 5V					
Typical current consumption	300mA at 5V					
Vibration 55 to 2000 Hz	< 200m/s² (EN 60068-2-6)					
Shock 6 ms	< 2000m/s² (EN 60068-2-27)					
Operating temperature	-10°C to 85°C					
Storage temperature	-20°C to 85°C					
Protection	IP67					
Mass	40g					

[1)] The position error per grating period and the accuracy of the grating results toghether in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error.

Ordering code

- LMBA - Scale tape to stick for modular linear encoders
- Grating period 1000µm

LMBA □□ 10 B □□ - □□□□□ - MF - LB01

Classification

20 = ML ≤ 9200 mm
21 = ML > 9200 mm

Grating period

10 = 1000 µm

Accuracy[1)]

3 = ± 3 µm/m (total length ≤ 3000 mm)
5 = ± 5 µm/m
10 = ± 10 µm/m

Total length in mm

50-200	each 10 mm
200-500	each 20 mm
500-1000	each 50 mm
1000-3000	each 100 mm
> 3000	each 200 mm

Type of graduation carrier

LB01 = Scale tape to stick

Safety concept

MF = Fault exclusion for the loosing of the mechanical connection possible.

[1)] After linear length-error compensation in the evaluation electronics

Ordering code

- LMTA - Scale tape in stainless-steel carrier for modular linear encoders
- Grating period 1000µm

LMTA □□ 10 □□□ - □□□□□ - MF - LT01

Classification

40 = ML ≤ 9200 mm
41 = ML > 9200 mm

Grating period

10 = 1000µm

Scale tape carrier

C = Single section carrier (GL ≤ 3000 mm)
D = Multi section carrier (GL > 3000 mm)

Accuracy[1)]

3 = ± 3 µm/m (total length ≤ 3000 mm)
5 = ± 5 µm/m
10 = ± 10 µm/m

Total length in mm

≤ 3000 mm	each 100 mm
> 3000 mm	each 200 mm

Type of graduation carrier

LT01 = Stainless steel carrier, M4, each 100 mm

Safety concept

MF = Fault exclusion for the loosing of the mechanical connection possible.

[1)] After linear length-error compensation in the evaluation electronics

Ordering code

- LMKA - Scanning head for modular linear encoders
- Grating period 1000µm

LMKA - □□10□□.□□□□□□□□□□ - 20 - □,□□ - □□□□□ - □□

Scanning

20 = ML ≤ 9200 mm
21 = ML > 9200 mm

Grating period

S = Standard
HA = High Accuracy

Interface

01 = EnDat 2.2
02 = Fanuc Serial Interface - α Interface
15 = SSI, additional incremental signals 1Vpp
16 = BiSS/C
21 = Mitsubishi High Speed Serial Interface (full duplex)
22 = Mitsubishi High Speed Serial Interface (half duplex)

Measuring step

10 = 1 µm
12 = 0,25 µm
14 = 0,1 µm [2]

Functional safety

.. = No
FA = Analog signal (1Vpp) can be used for safety-related equipment [1]

Dividing factor 1Vpp

		SSI
01	1-fold	×
25	25-fold	×
NN	Without incremental signals	

Pin configuration

C4 = 1SS08
IS = 03S17, 01

Electrical connection

01 = Free cable end
1SS08 = M12 8pin coupling male
03S17 = M23 17pin coupling male

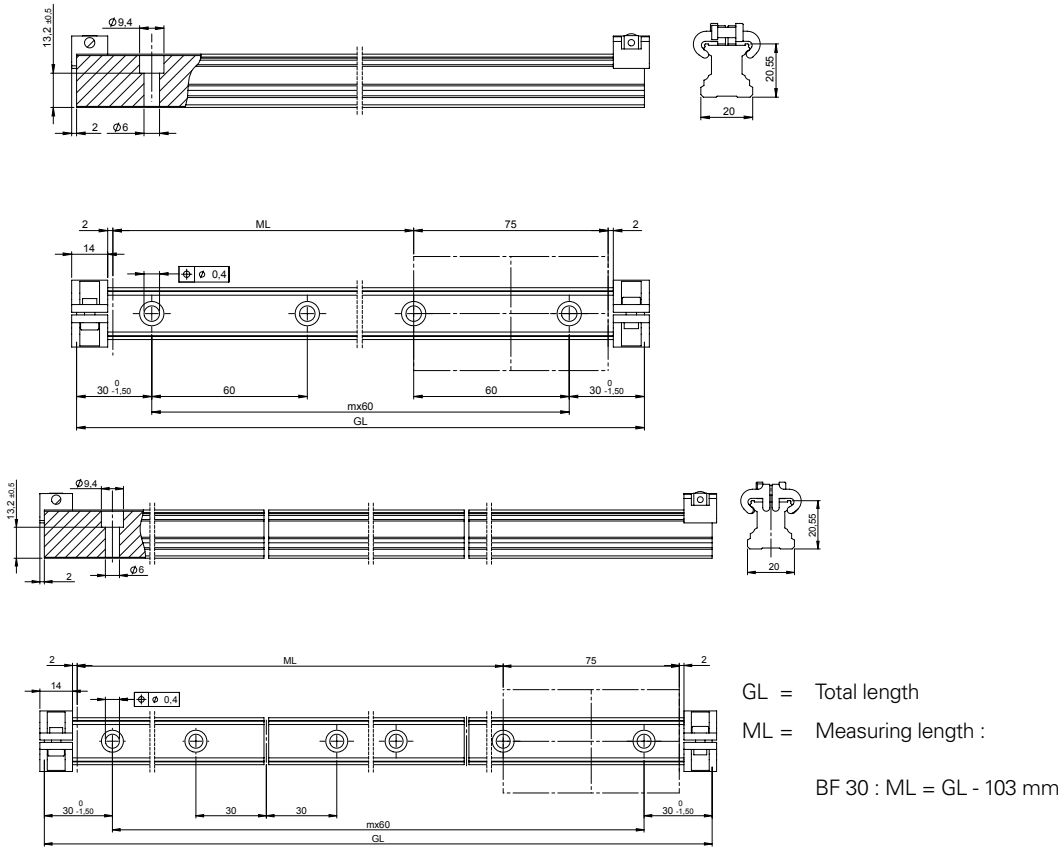
Cable length

0,50 = 0,50 m
1,00 = 1,00 m
1,50 = 1,50 m
2,00 = 2,00 m
2,50 = 2,50 m
3,00 = 3,00 m
4,00 = 4,00 m
5,00 = 5,00 m
6,00 = 6,00 m

[1] Option „FA“ only for SSI and 1Vpp interface with dividing factor „01“.
[2] Not for SSI interface.

Scale tape in measuring rail LMFA 3010

- **Scale tape in measuring rail, for guided linear encoders**
- **Grating period 1000µm**
- **In combination with LMKA 3010**



GL = Total length

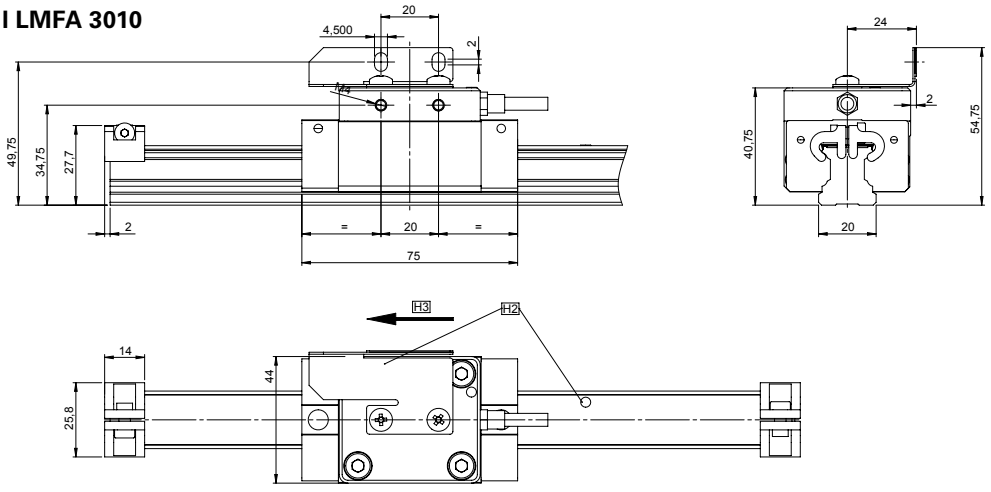
ML = Measuring length :

BF 30 : ML = GL - 103 mm

Scanning head - LMKA 3010 series

- **Absolute, guided linear encoder**
- **Grating period 1000µm**
- **Guided scanning head with integrated electronics**
- **In combination with measuring rail LMFA 3010**

Design 30
with measuring rail LMFA 3010



Tolerance principle in accordance withSO8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

H2 = Absolute track marking
H3 = Direction of scanning head movement for positive counting

Technical data

- LMFA - Measuring rail for guided linear encoders
- Grating period 1000µm

Absolute measuring rail	LMFA 3010	
Grating period	1000µm	
Accuracy class	± 20µm/m	± 50µm/m
Accuracy after linear compensation	± 5µm/m	± 10µm/m
Total length GL	Standard length see ordering code	
Mechanical design	Standard guide rail with integrated scale tape	
Coefficient of expansion	~ 11 ppm/K	
Mass	2400 g/m Total length	

Technical data

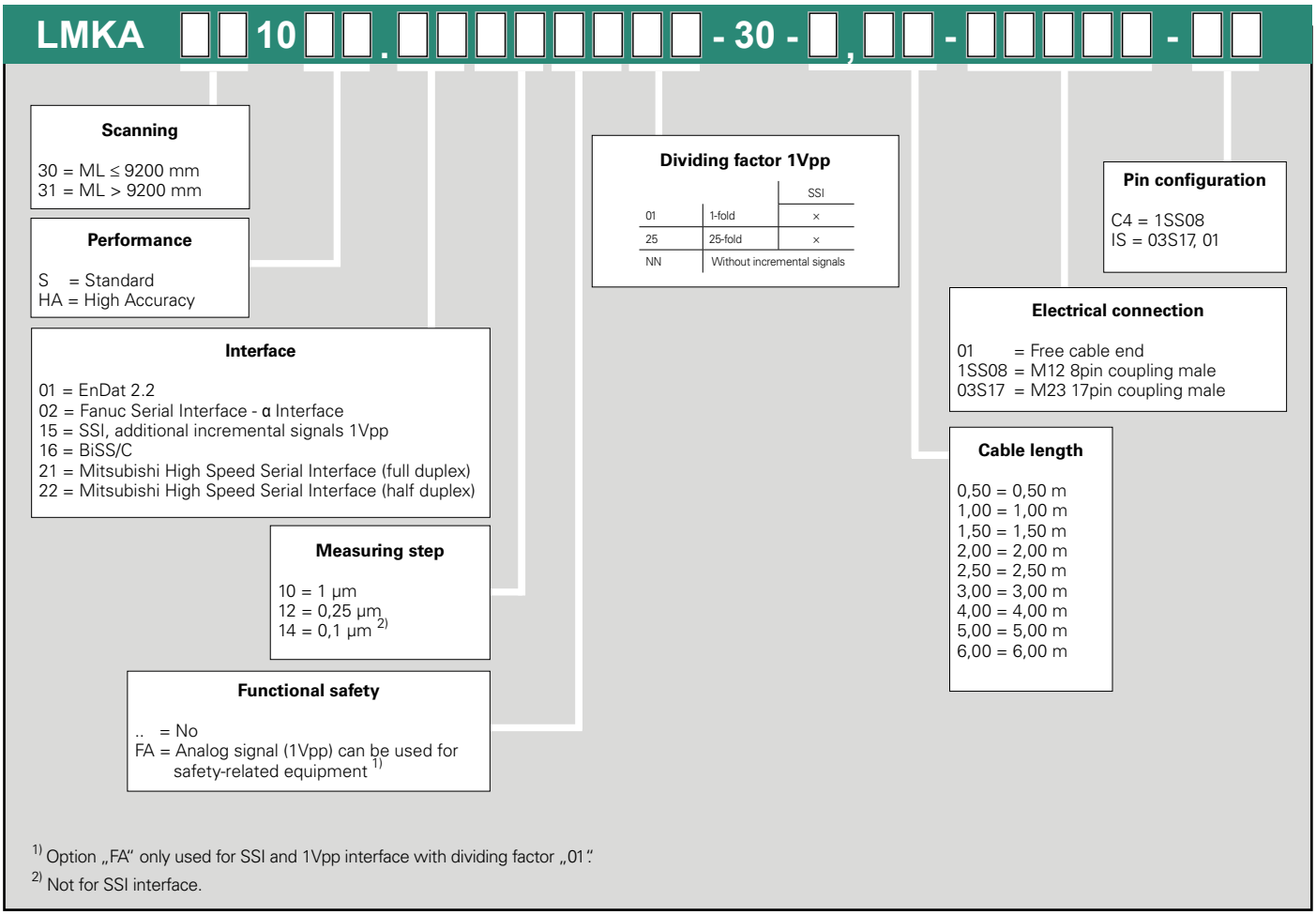
- LMKA - Scanning head for guided linear encoders
- Greating period 1000µm

Scanning head	LMKA 3010					
Interface	EnDat 2.2	Fanuc α	BiSS/C	Mitsubishi (full duplex)	Mitsubishi (half duplex)	SSI + 1Vpp
Designation	EnDat 2.2	Fanuc02	BiSS	MitA1-4	MitA1-2	SSI - 1Vpp
Clock frequency	≤ 16 MHz	-	≤ 2,5 MHz	5 Mbps	5 Mbps	≤ 1 MHz
Measuring step						
Standard	1µm or 0,25µm					
High Accuracy	0,1µm					-
Position deviation per grating pitch[1)]						
Standard	± 2µm					
High Accuracy	± 0,5µm					-
Max. speed	5m/s, limited by the mechanics					
Cable length on scanning head	0,5m to 6m					
Electrical Connection	Cable with M12 coupling, 8pin male					Cable with M23 coupling, 12pin male
Voltage supply	DC 3,6V at 14V					
Power consumption	≤ 1,5W at 5V					
Typical current consumption	300mA at 5V					
Vibration 55 to 2000 Hz	< 200m/s² (EN 60068-2-6)					
Shock 6 ms	< 2000m/s² (EN 60068-2-27)					
Operating temperature	-10°C to 85°C					
Storage temperature	-20°C to 85°C					
Protection	IP67					
Mass	200g					

[1)] The position error per grating period and the accuracy of the grating results toghether in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error.

Ordering code

- LMKA - Scanning head for guided linear encoders
- Grating period 1000µm

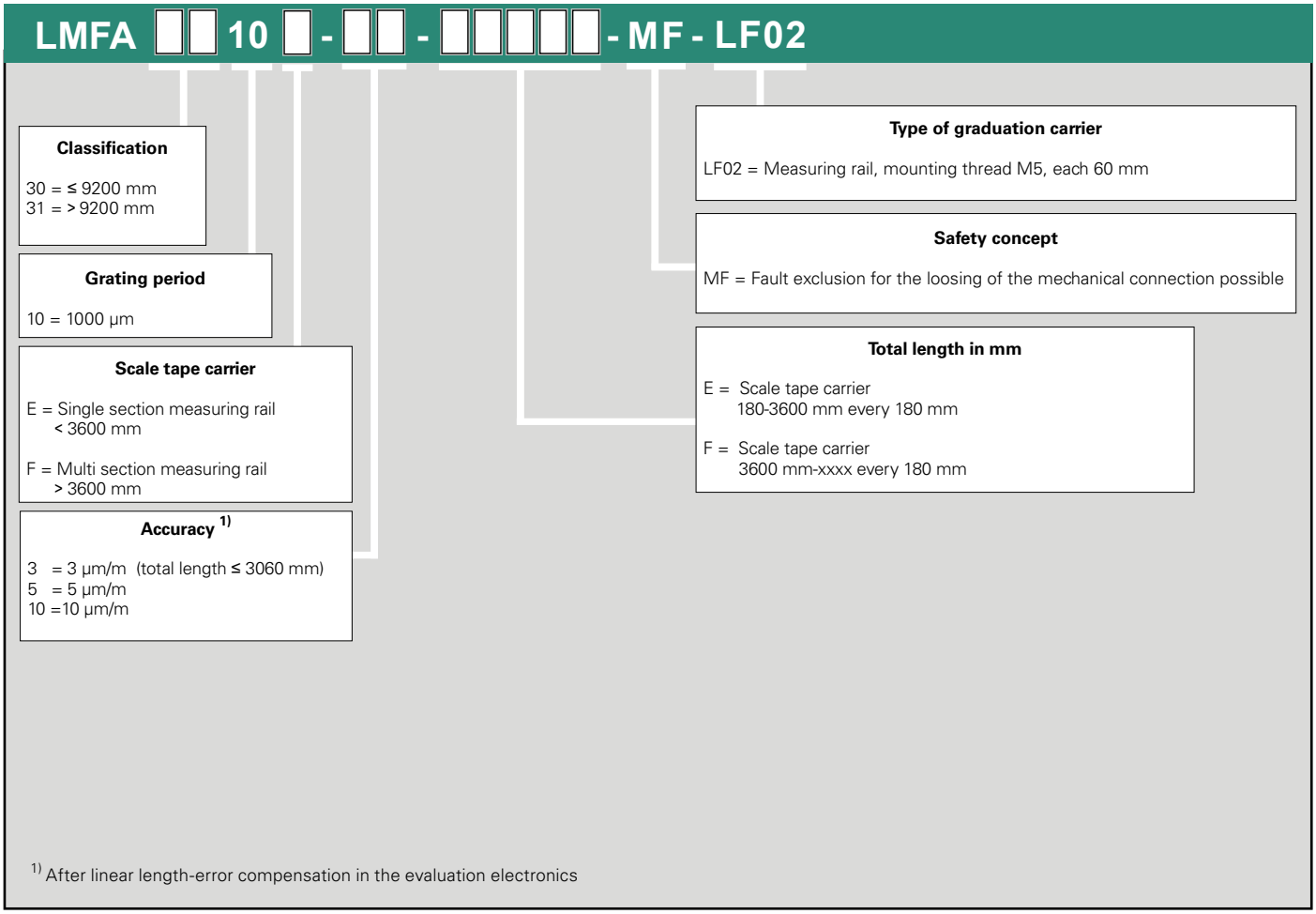


1) Option „FA“ only used for SSI and 1Vpp interface with dividing factor „01“.

2) Not for SSI interface.

Ordering code

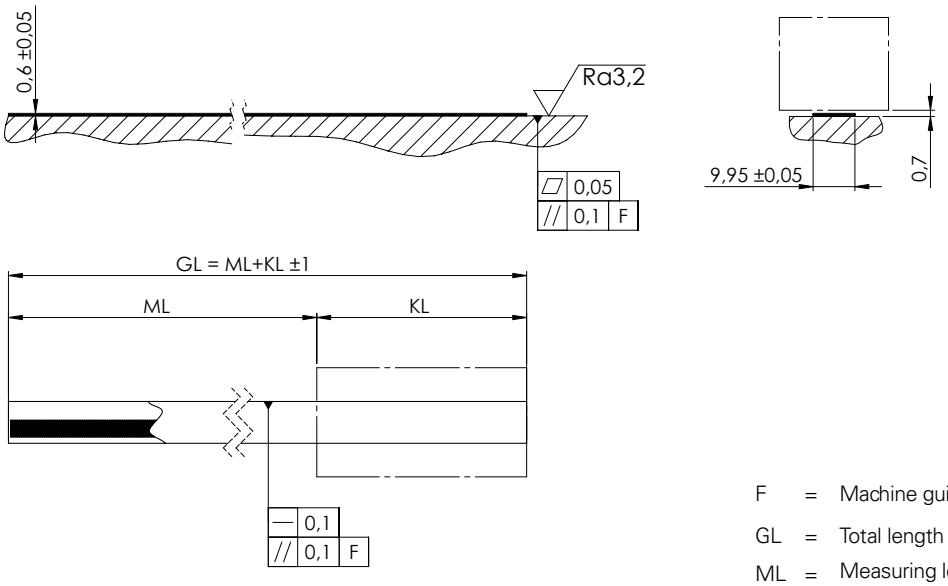
- LMFA - Measuring rail for guided linear encoders
- Grating period 1000µm



1) After linear length-error compensation in the evaluation electronics

Scale tape to stick LMB 1005

- **Scale tape to stick, for modular linear encoders**
- **Grating period 500µm**
- **In combination with scanning LMK 1005 or LMK 2005**



F = Machine guidance

GL = Total length

ML = Measuring length :

BF 20 / BF 21 : ML = GL - 49 mm
BF 10 / BF 12 : ML = GL - 36 mm

KL = Scanning head length :

BF 20 / BF 21 : 49 mm
BF 10 / BF 12 : 36 mm

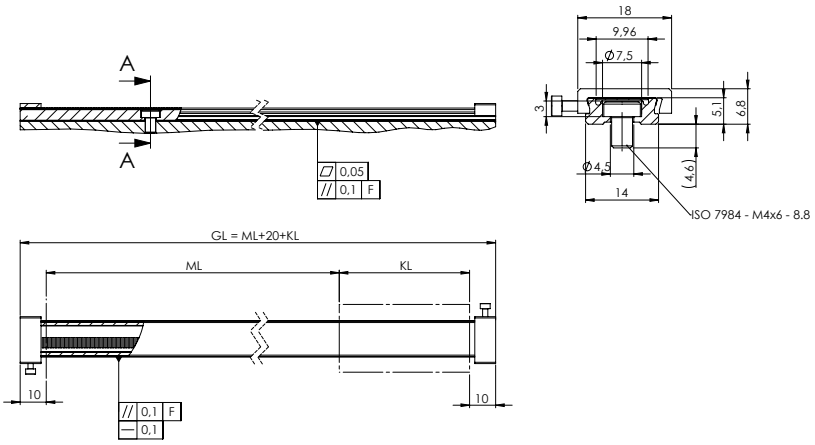
Tolerance principle in accordance withSO8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

Technical data

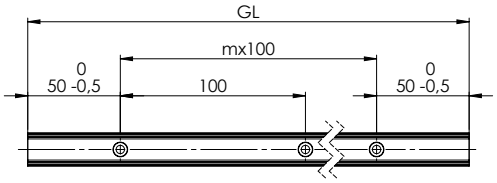
Incremental scale tape	LMB 1005		
Grating period	500µm		
Accuracy class	± 20µm/m	± 20µm/m	± 50µm/m
Accuracy after linear compensation	± 3µm/m	± 5µm/m	± 10µm/m
Total length GL	Standard length see ordering code		
Mechanical design	Stainless steel scale tape with adhesive layer for mounting		
Reference marks	Single or distance coded reference marks – Customized reference mark positions on request.		
Coefficient of expansion	~ 11ppm/K		
Mass	40 g/m Total length		

Scale tape in stainless steel carrier LMT 4005

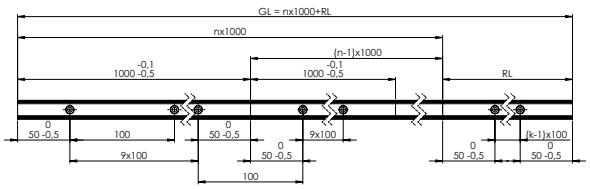
- **Scale tape in stainless steel carrier, for modular linear encoders**
- **Grating period 500µm**
- **In combination with scanning head LMK 1005 or LMK 2005**



Single section carrier LMT 4005 C



Multi section carrier LMT 4005 D



F = Machine guidance

GL = Total length

ML = Measuring length :

BF 20: ML = GL - 93mm
BF 21: ML = GL - 69m
BF 10/BF 12: ML = GL - 56mm

KL = Scanning head length :

BF 20 : 73mm
BF 21: 49 mm
BF 10 / BF 12 : 36 mm

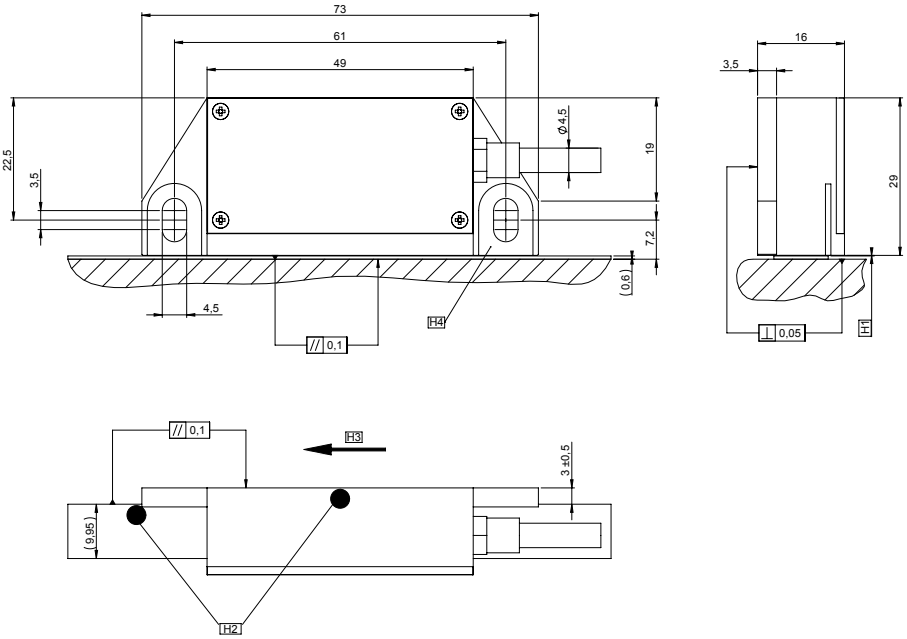
Technical data

Incremental scale tape	**LMT 4005**		
Grating period	500µm		
Accuracy class	± 20µm/m	± 20µm/m	± 50µm/m
Accuracy after linear compensation	± 3µm/m	± 5µm/m	± 10µm/m
Total length GL	Standard length see ordering code		
Mechanical design	Stainless steel carrier with integrated scale tape		
Reference marks	Single or distance coded reference marks – Customized reference mark positions on request.		
Coefficient of expansion	~ 11ppm/K		
Mass	490 g/m Total length		

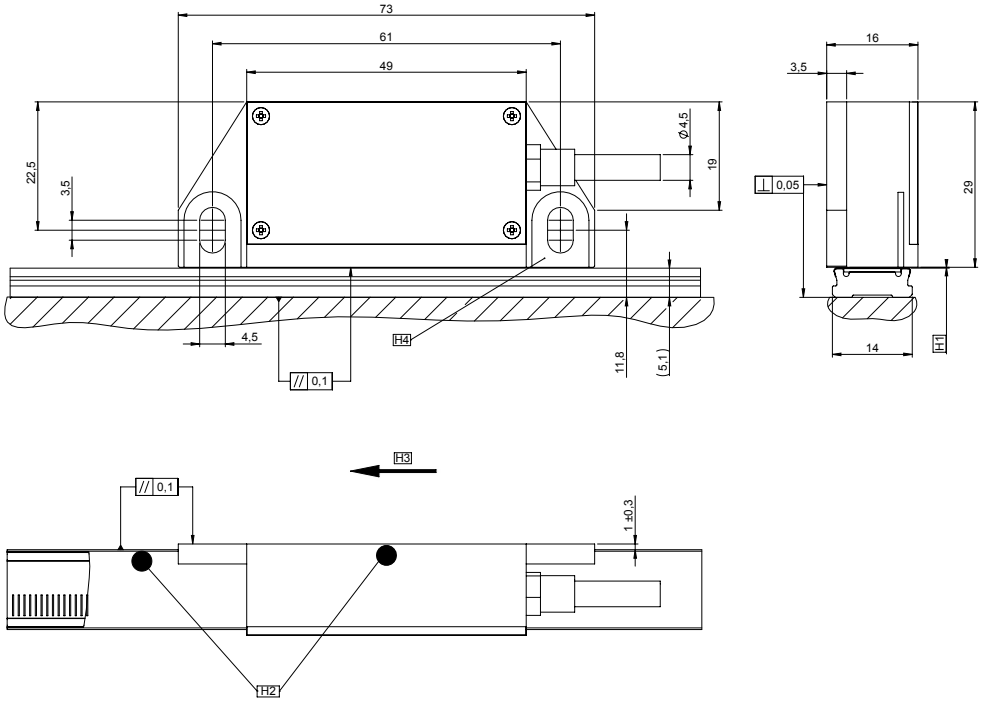
Scanning head - LMK 2005 series

- **Incremental, modular linear encoders**
- **Grating period 500µm**
- **Encoder with integrated electronics**
- **In combination with scale type LMB 1005 and LMT 4005**

Design 20
with scale type LMB 1005



Design 20
with scale type LMT 4005



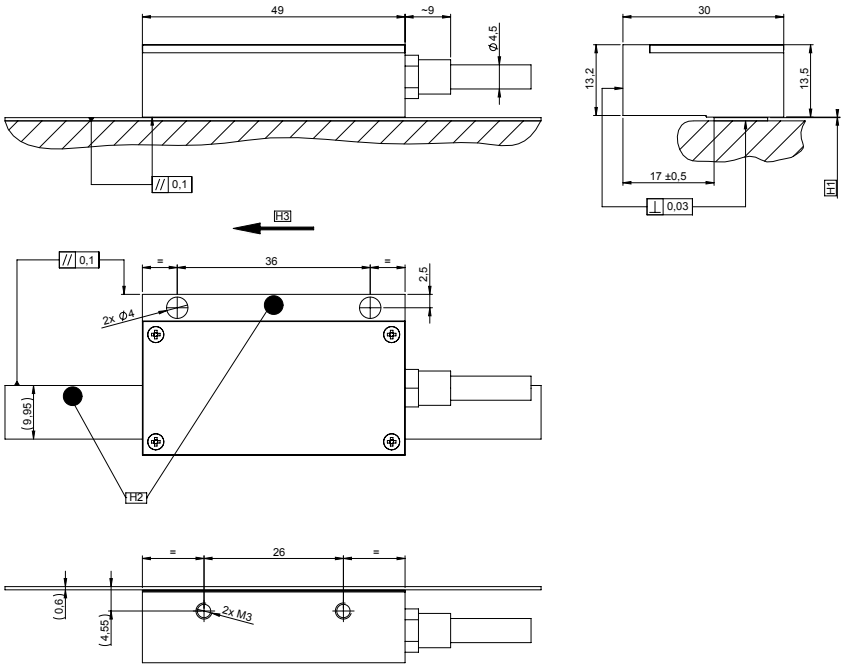
Tolerance principle in accordance withSO8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

H1 = Air gap 0,10 ± 0,05mm, set with spacer foil
H2 = Reference track marking
H3 = Direction of scanning head movement for positive counting
H4 = Ground plane

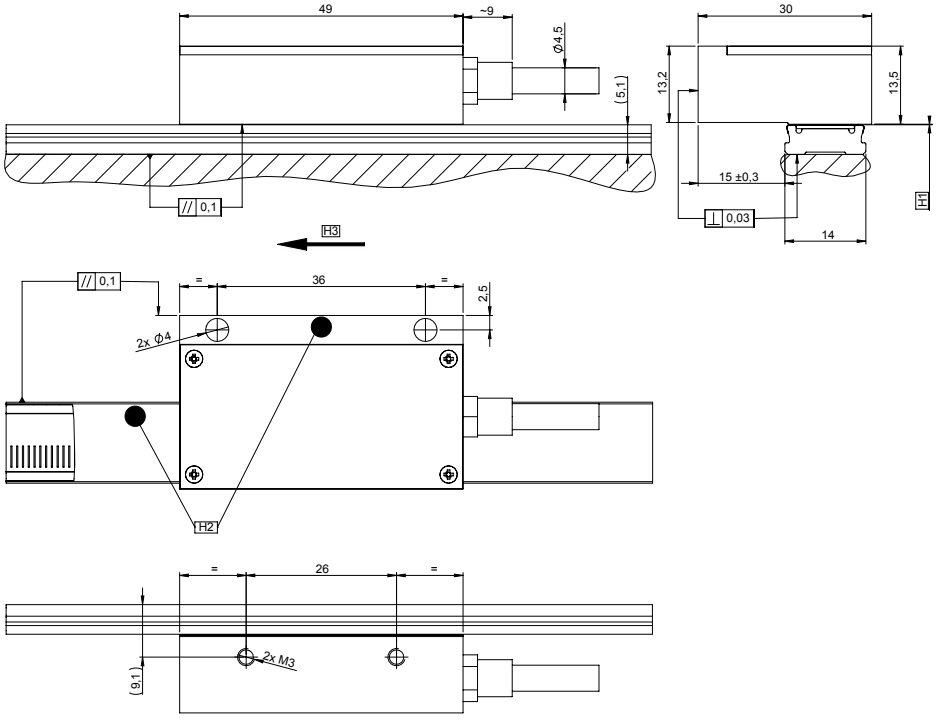
Scanning head - LMK 2005 series

- **Incremental, modular linear encoders**
- **Grating period 500µm**
- **Encoder with integrated electronics**
- **In combination with scale type LMB 1005 and LMT 4005**

Design 21
with scale type LMB 1005



Design 21
with scale type LMT 4005



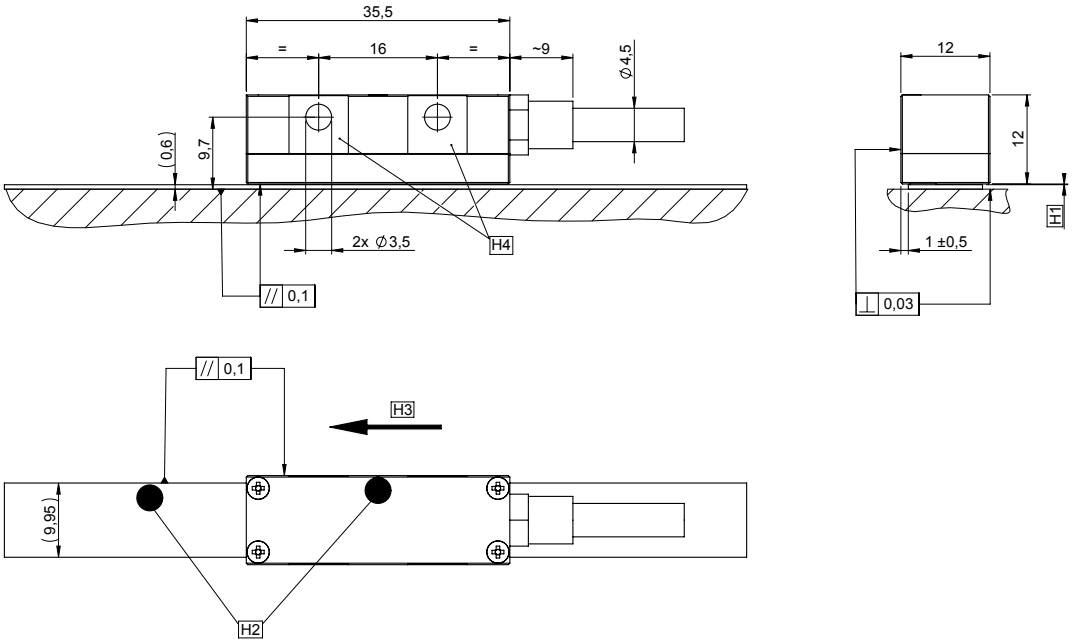
Tolerance principle in accordance withSO8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

H1 = Air gap 0,10 ± 0,05mm, set with spacer foil
H2 = Reference track marking
H3 = Direction of scanning head movement for positive counting

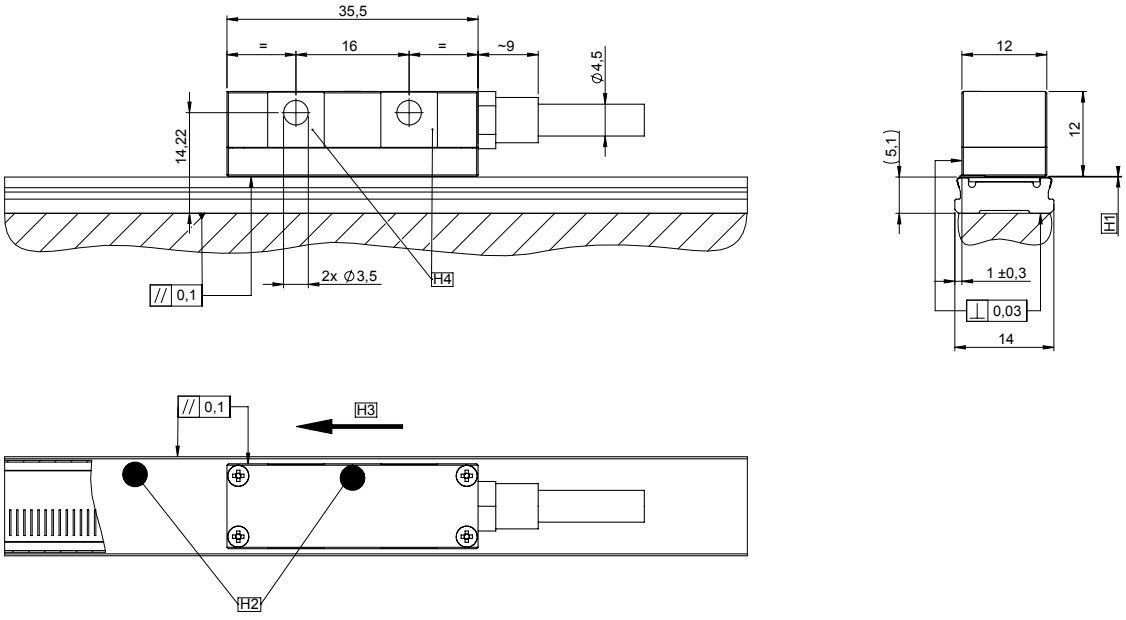
Scanning head - LMK 1005 series

- **Incremental, modular linear encoders**
- **Grating period 500µm**
- **Miniature scanning head with external electronics**
- **In combination with scale type LMB 1005 and LMT 4005**

Design 10 and 12
with scale type LMB 1005



Design 10 and 12
with scale type LMT 4005



Tolerance principle in accordance withSO8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

H1 = Air gap 0,10 ± 0,05mm, set with spacer foil
H2 = Reference track marking
H3 = Direction of scanning head movement for positive counting
H4 = Ground plane

Technical data

- LMK - Scanning head for modular linear encoders
- Grating period 500µm

Scanning head 500µm	**LMK 2005/LMK 1005**			
Performance	Standard		High Accuracy	
Interface	1Vpp	TTL	1Vpp	TTL
Position error per grating period[1)]	± 1,5µm		± 0,3µm	
Maximum speed	10m/s			
TTL - Interpolation/1Vpp signal period				
Signal period [2)] Interpolation	- -	125µm to 0,5µm 1 to 250	- -	0,25µm or 0,05µm 500 or 2500
Signal period Dividing factor	500µm or 20µm 1 or 25	- -	10µm 50	- -
Max. output frequency	400KHz	5MHz	400KHz	5MHz
Electrical connection	Cable with M23 coupling 12pin male			
Cable length on the encoder	0,50m - 6,00m			
Power supply	1Vpp: DC 4,0V to 7,0V TTL: DC 5,0V +/- 0,5V			
Power consumption	Design 20, 21: ≤ 1300mW at 5V Design 10, 12: ≤ 1500mW at 5V			
Typ. current consumption	Design 20, 21: ≤ 220mA at 5V (without load) Design 10,12: ≤ 240mA at 5V (without load)			
Vibration 55 to 2000 Hz	< 200m/s² (EN 60068-2-6)			
Shock 6 ms	< 2000m/s² (EN 60068-2-27)			
Operating temperature	-10°C to 100°C			
Storage temperature	-20°C to 100°C			
Protection	IP67			
Mass	38g Design 20, 21 / 10g Design 10,12			

[1)] The position error per grating period and the accuracy of the grating results toghether in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error.

[2)] After 4-edge-evaluation.

Ordering code

- LMB - Incremental scale tape to stick for modular linear encoders
- Grating period 500µm

LMB 1005B □□ - □□□□□ - MF - LB01 - □□□□□□

Accuracy [1)]

3	= 3 µm/m	(Total length ≤ 3000 mm)
5	= 5 µm/m	(Total length ≤ 4600 mm)
10	= 10 µm/m	(Total length ≤ 4600 mm)

Total length in mm

50 - 200	each 10 mm
200 - 500	each 20 mm
500 - 1000	each 50 mm
1000 - 3000	each 100 mm
3000 - xxxx	each 200 mm

Safety concept

MF = Fault exclusion for the loosing of the mechanical connection possible

Reference mark

0RM	= Without reference mark
1RM-M	= 1 Reference mark - middle
B050	= Reference mark 50mm from both sides
L25	= Reference mark 25mm from left
L50	= Reference mark 50mm from left
R50	= Reference mark 50mm from right
K120	= Distance-coded reference marks, nominal increment 120 grating period
K240	= Distance-coded reference marks, nominal increment 240 grating period

Type of graduation carrier

LB01 = Scale tape to stick

[1)] After linear length-error compensation in the evaluation electronics

Ordering code

- LMT - Incremental scale tape in stainless steel carrier for modular linear encoders
- Grating period 500µm

LMT 4005 □ - 10 - □□□□□ - MF - LT01 - □□□□□□

Scale tape carrier

C = Single section carrier (GL ≤ 3000 mm)
D = Multi section carrier (GL > 3000 mm)

Accuracy [1)]

3	= 3 µm/m	(Total length ≤ 3000 mm)
5	= 5 µm/m	
10	= 10 µm/m	

Total length in mm

≤ 3000 mm	each 100 mm
> 3000 mm	each 200 mm

Reference mark

0RM	= Without reference mark
1RM-M	= 1 Reference mark - middle
B050	= Reference mark 50mm from both sides
L25	= Reference mark 25mm from left
L50	= Reference mark 50mm from left
R50	= Reference mark 50mm from right
K120	= Distance-coded reference marks, nominal increment 120 grating period
K240	= Distance-coded reference marks, nominal increment 240 grating period

Type of graduation carrier

LT01 = Stainless steel carrier, M4, each 100 mm

Safety concept

MF = Fault exclusion for the loosing of the mechanical connection possible

[1)] After linear length-error compensation in the evaluation electronics

Ordering code

- LMK - Scanning head for modular linear encoders
- Grating period 500µm

LMK □□ 05 □□ . □□ □□ □□ □□ □□ - □□ - □ , □□ - □□□□□□ - □□

Scanning

10 = Encoder, miniature
20 = Encoder, with integrated electronics

Performance

S = Standard
HA = High Accuracy

Interface

07 = TTL
08 = 1Vpp

Reference mark

RV = Rectangle pulse linked (90° el.) for TTL
RI = Rectangle pulse linked (360° el.) for 1Vpp

Functional safety

.. = No
FA = Analog signal (1Vpp) can be used for safety related equipmenten usable[2)]

Pin configuration

UJ = 01, 02S12, 03S12, 27S12
J5 = 16S15

Cable length

0,50 = 0,50 m
1,00 = 1,00 m
1,50 = 1,50 m
2,00 = 2,00 m
2,50 = 2,50 m
3,00 = 3,00 m
4,00 = 4,00 m
5,00 = 5,00 m
6,00 = 6,00 m

Electrical connection

01 = Free cable end
02S12 = M23-12 pin connector male
03S12 = M23-12 pin coupling male
16S15 = D-SUB-15 pin 2-row male
27S12 [1)] = Flange socked M23 12 pin male

Design of the scanning head

10 = Miniaturized, connector with electronics on cable, M23
12 = Miniaturized, pluggable connector with electronics on cable via M12 connector

20 = Standard
21 = Standard, flat

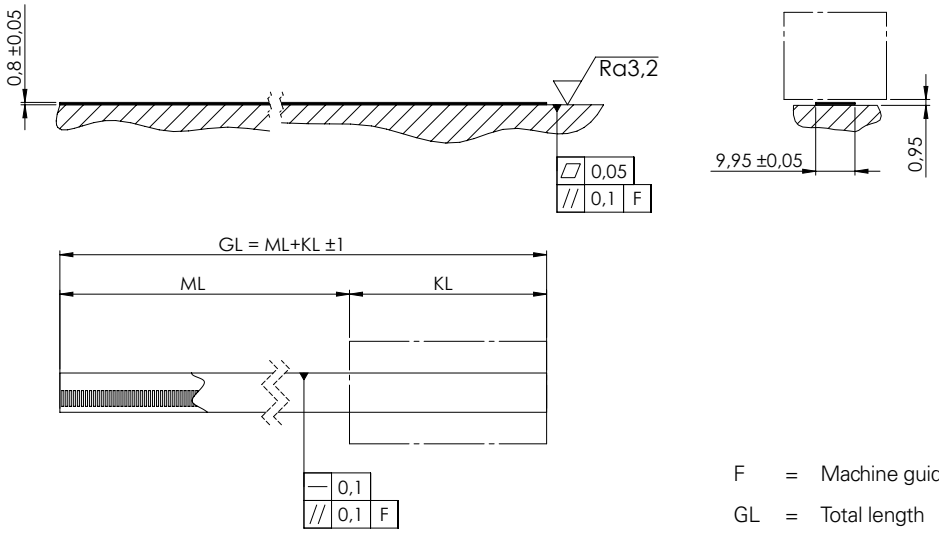
Incremental signals/Multiplication

		1Vpp		TTL	
		S	HA	S	HA
01	1-fold	×		×	
05	5-fold			×	
10	10-fold			×	
25	25-fold	×		×	
50	50-fold		×	×	
A3	250-fold			×	
A4	500-fold				×
A9	2500-fold				×

[1)] Electrical connection for miniaturized design of the scanning head 10 and 12.
[2)] Option „FA“ only used for dividing factor „01“.

Scale tape to stick LMB 1010

- **Scale tape to stick, for modular linear encoders**
- **Grating period 1000µm**
- **In combination with scanning head LMK 1010 or LMK 2010**



F = Machine guidance
GL = Total length
ML = Measuring length :

BF 20 / BF 21 : ML = GL - 49 mm
BF 10 / BF 12 : ML = GL - 36 mm

KL = Scanning head length :

BF 20 / BF 21 : 49 mm
BF 10 / BF 12 : 36 mm

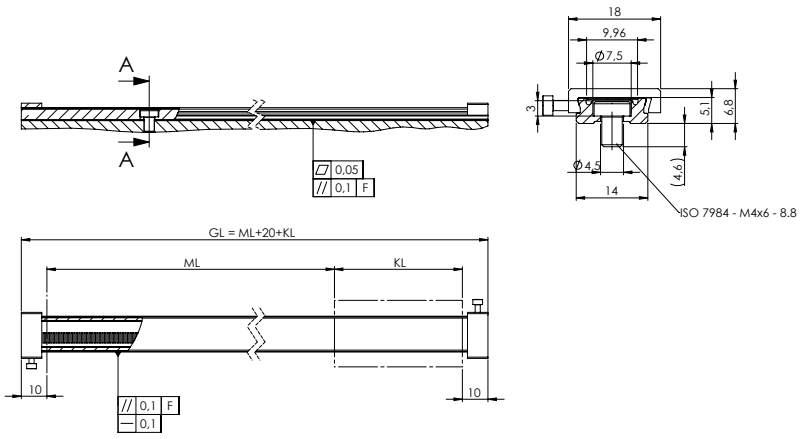
Tolerance principle in accordance withSO8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

Technical data

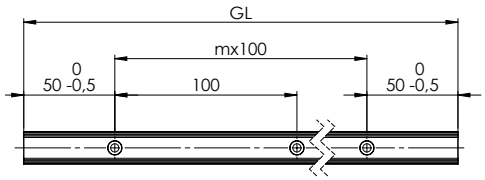
Incremental scale tape	LMB 1010		
Grating period	1000µm		
Accuracy class	± 20µm/m	± 20µm/m	± 50µm/m
Accuracy after linear compensation	± 3µm/m	± 5µm/m	± 10µm/m
Total length GL	Standard length see ordering code		
Mechanical design	Stainless steel scale tape with adhesive layer for mounting		
Reference marks	Single or distance coded reference marks – Customized reference mark positions on request.		
Coefficient of expansion	~ 11 ppm/K		
Mass	50 g/m Total length		

Scale tape in stainless steel carrier LMT 4010

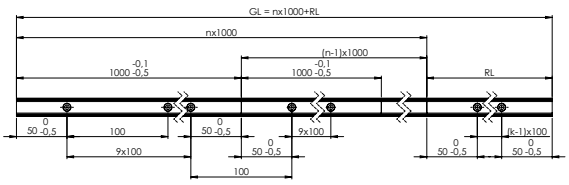
- **Scale tape in stainless steel carrier, for modular linear encoders**
- **Grating period 1000µm**
- **In combination with scanning head LMK 1010 or LMK 2010**



Single section carrier LMT 4010 C



Multi section carrier LMT 4010 D



F = Machine guidance

GL = Total length

ML = Measuring length :

BF 20 : ML = GL - 93mm
BF 21 : ML = GL - 69mm
BF 10/BF 12 : ML = GL - 56mm

KL = Scanning head length :

BF 20 : 73mm
BF 21 : 49 mm
BF 10 / BF 12 : 36 mm

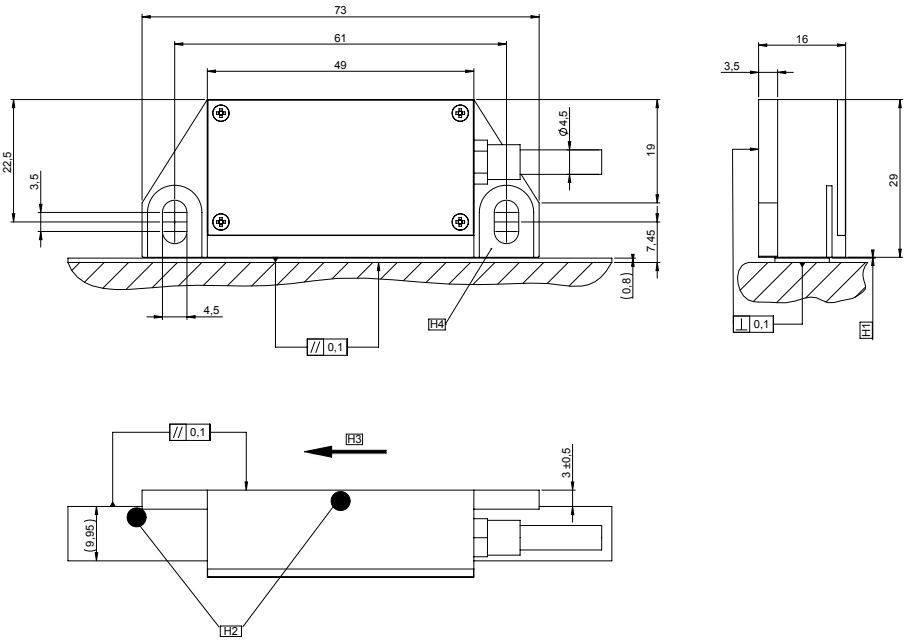
Technical data

Incremental scale tape	LMT 4010		
Grating period	1000µm		
Accuracy class	± 20µm/m	± 20µm/m	± 50µm/m
Accuracy after linear compensation	± 3µm/m	± 5µm/m	± 10µm/m
Total length GL	Standard length see ordering code		
Mechanical design	Stainless steel carrier with integrated scale tape		
Reference marks	Single or distance coded reference marks – Customized reference mark positions on request.		
Coefficient of expansion	~ 11 ppm/K		
Mass	500 g/m Total length		

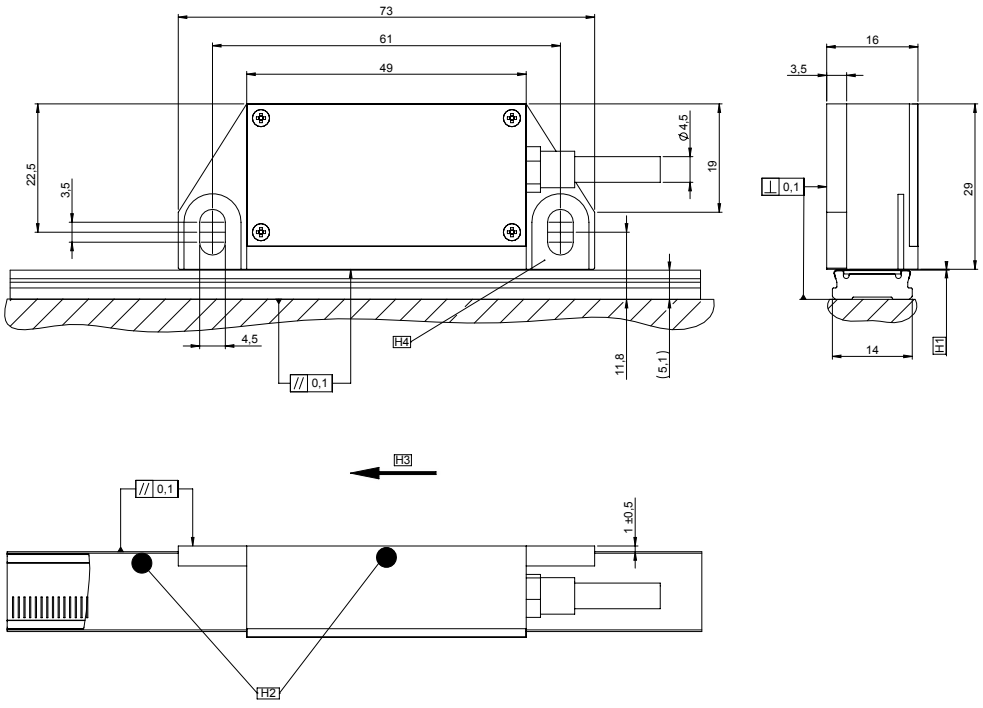
Scanning head - LMK 2010 series

- **Incremental, modular linear encoders**
- **Grating period 1000µm**
- **Scanning head with integrated electronics**
- **In combination with scale type LMB 1010 and LMT 4010**

Design 20
with scale type LMB 1010



Design 20
with scale type LMT 4010



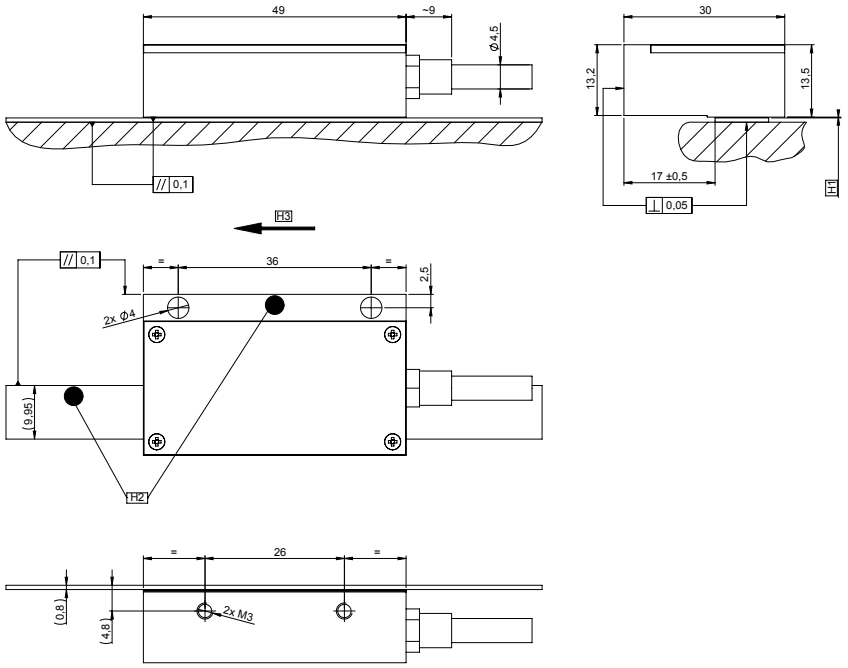
Tolerance principle in accordance withSO8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

H1 = Air gap 0,15 ± 0,10mm, set with spacer foil
H2 = Reference track marking
H3 = Direction of scanning head movement for positive counting
H4 = Ground plane

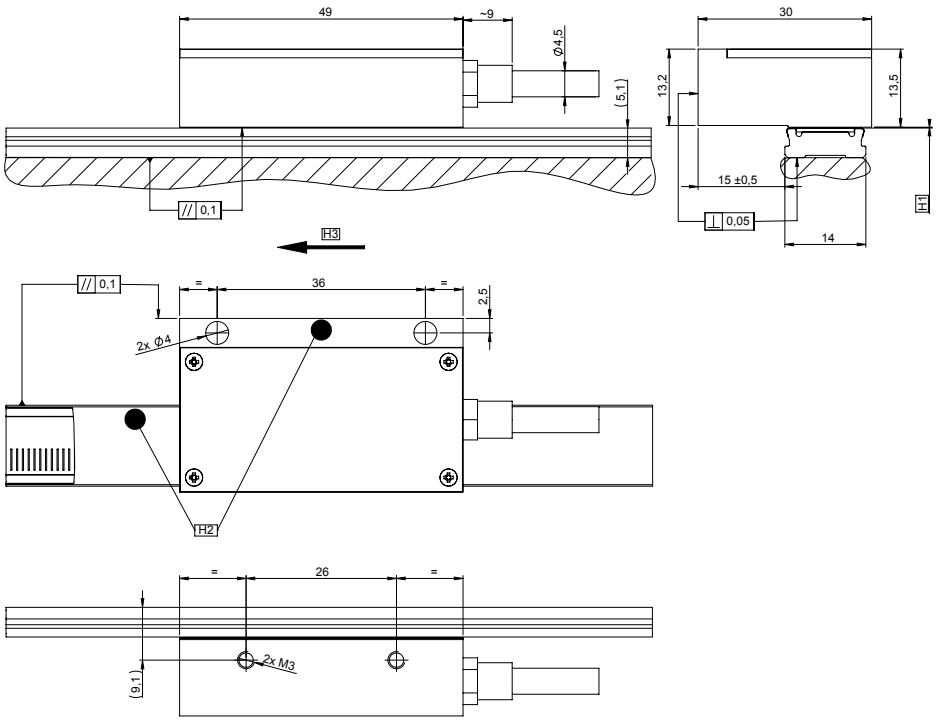
Scanning head - LMK 2010 series

- **Incremental, modular linear encoders**
- **Grating period 1000µm**
- **Scanning head with integrated electronics**
- **In combination with scale type LMB 1010 and LMT 4010**

Design 21
with scale type LMB 1010



Design 21
with scale type LMT 4010



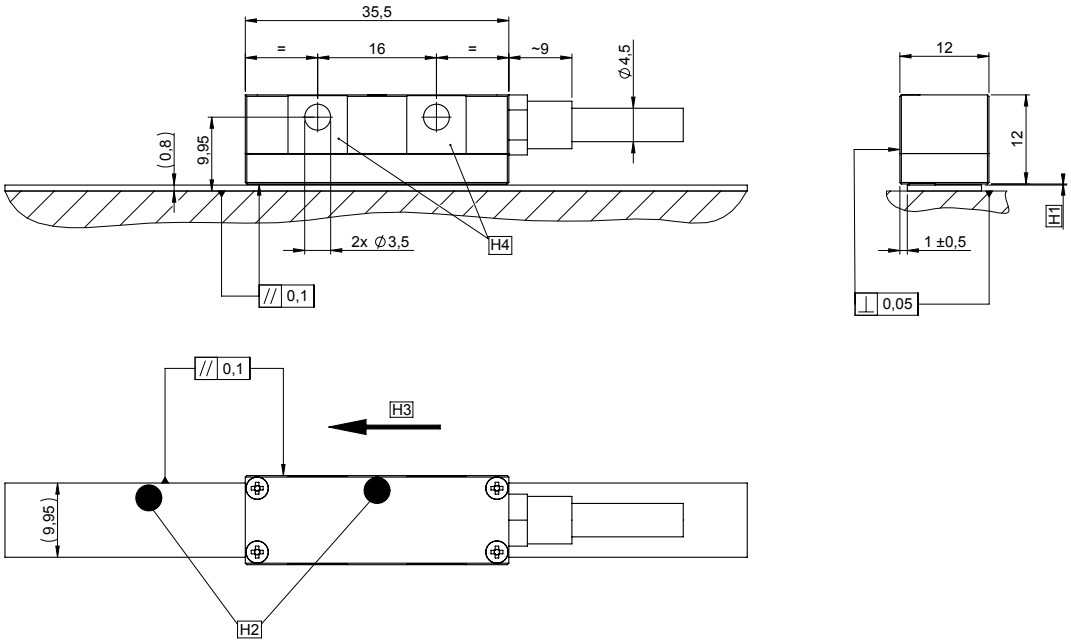
Tolerance principle in accordance withSO8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

H1 = Air gap 0,15 ± 0,10mm, set with spacer foil
H2 = Reference track marking
H3 = Direction of scanning head movement for positive counting

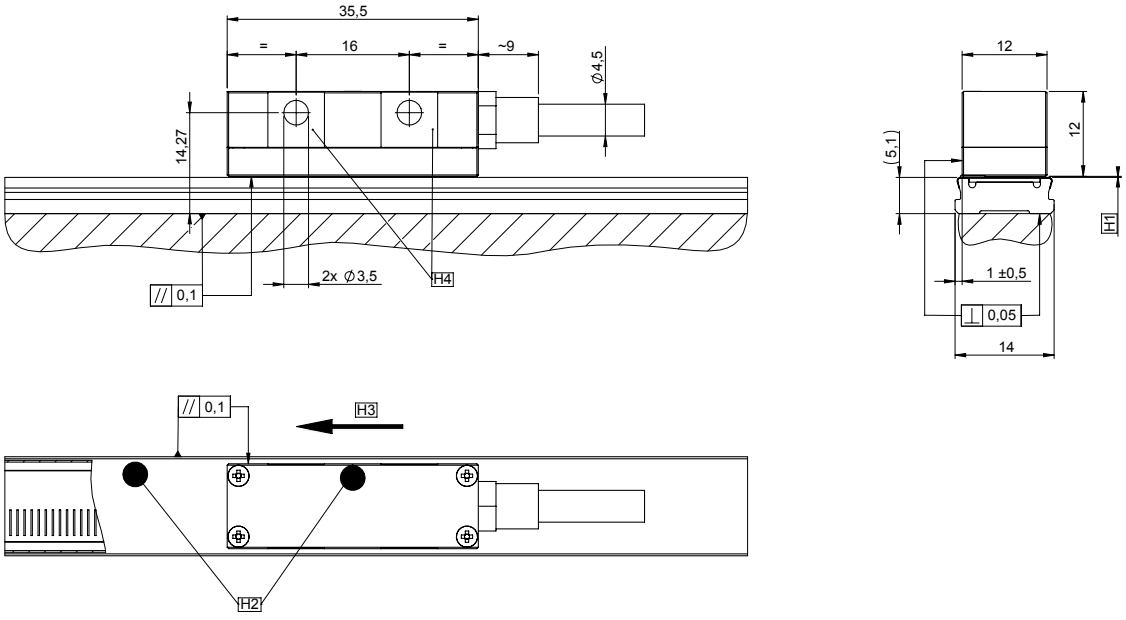
Scanning head - LMK 1010 series

- **Incremental, modular linear encoders**
- **Grating period 1000µm**
- **Miniature scanning head with external electronics**
- **In combination with scale type LMB 1010 and LMT 4010**

Design 10 and 12
with scale type LMB 1010



Design 10 and 12
with scale type LMT 4010



Tolerance principle in accordance withSO8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

H1 = Air gap 0,15 ± 0,10mm, set with spacer foil
H2 = Reference track marking
H3 = Direction of scanning head movement for positive counting
H4 = Ground plane (both sides)

Technical data

- LMK - Scanning head for modular linear encoders
- Grating period 1000µm

Scanning head 1000µm	**LMK 2010/LMK 1010**			
Performance	Standard		High Accuracy	
Interface	1Vpp	TTL	1Vpp	TTL
Position error per grating period [1]	± 2µm		± 0,5µm	
Maximum speed	20m/s			
TTL - Interpolation/ 1Vpp signal period				
Signal period [2] Interpolation	- -	250µm to 1µm 1 to 250	- -	0,5µm or 0,1µm 500 or 2500
Signal period Dividing factor	1000µm or 40µm 1 or 25	- -	20µm 50	- -
Max. output frequency	400KHz	5MHz	400KHz	5MHz
Electrical connection	Cable with M23 coupling 12pin male			
Cable length on the encoder	0,50m - 6,00m			
Power supply	1Vpp: DC 4,0V to 7,0V TTL: DC 5,0V +/- 0,5V			
Power consumption	Design 20, 21: ≤ 1300mW at 5V Design 10, 12: ≤ 1500mW at 5V			
Typ. current consumption	Design 20,21: ≤ 220mA at 5V (without load) Design 10,12: ≤ 240mA at 5V (without load)			
Vibration 55 to 2000 Hz	< 200m/s² (EN 60068-2-6)			
Shock 6 ms	< 2000m/s² (EN 60068-2-27)			
Operating temperature	-10°C to 100°C			
Storage temperature	-20°C to 100°C			
Protection	IP67			
Mass	38g Design 20, 21 / 10g Design 10,12			

[1] The position error per grating period and the accuracy of the grating results toghether in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error.

[2] After 4-edge-evaluation.

Ordering code

- LMB - Incremental scale tape to stick for modular linear encoders
- Grating period 1000µm

LMB 1010B □□ - □□□□□ - MF - LB01 - □□□□□□

Accuracy [1)]

3 = 3 µm/m (Total length ≤ 3000 mm)
5 = 5 µm/m
10 = 10 µm/m

Total length in mm

50 - 200	each 10 mm
200 - 500	each 20 mm
500 - 1000	each 50 mm
1000 - 3000	each 100 mm
3000 - xxxx	each 200 mm

Safety concept

MF = Fault exclusion for the loosing of the mechanical connection possible

Reference mark

0RM	= Without reference mark
1RM-M	= 1 Reference mark - middle
B050	= Reference mark 50mm from both sides
L25	= Reference mark 25mm from left
L50	= Reference mark 50mm from left
R50	= Reference mark 50mm from right
K120	= Distance-coded reference marks, nominal increment 120 grating period
K240	= Distance-coded reference marks, nominal increment 240 grating period

Type of graduation carrier

LB01 = Scale tape to stick

[1)] After linear length-error compensation in the evaluation electronics

Ordering code

- LMT - Incremental scale tape in stainless steel carrier for modular linear encoders
- Grating period 1000µm

LMT 4010 □ - □□ - □□□□□ - MF - LT01 - □□□□□□

Scale tape carrier

C = Single section carrier (GL ≤ 3000 mm)
D = Multi section carrier (GL > 3000 mm)

Accuracy [1)]

3 = 3 µm/m (total length ≤ 3000 mm)
5 = 5 µm/m
10 = 10 µm/m

Total length in mm

≤ 3000 mm	each 100 mm
> 3000 mm	each 200 mm

Reference mark

0RM	= Without reference mark
1RM-M	= 1 Reference mark - middle
B050	= Reference mark 50mm from both sides
L25	= Reference mark 25mm from left
L50	= Reference mark 50mm from left
R50	= Reference mark 50mm from right
K120	= Distance-coded reference marks, nominal increment 120 grating period
K240	= Distance-coded reference marks, nominal increment 240 grating period

Type of graduation carrier

LT01 = Stainless steel carrier, M4, each 100 mm

Safety concept

MF = Fault exclusion for the loosing of the mechanical connection possible

[1)] After linear length-error compensation in the evaluation electronics

Ordering code

- LMK - Scanning head for modular linear encoders
- Grating period 1000µm

LMK □□ 10 □□ . □□ □□ □□ □□ - □□ - □,□□ - □□□□□□ - □□

Scanning

10 = Encoder, miniature
20 = Encoder, with integrated electronics

Performance

S = Standard
HA = High Accuracy

Interface

07 = TTL
08 = 1Vpp

Reference mark

RV = Rectangle pulse linked (90° el.) for TTL
RI = Rectangle pulse linked (360° el.) for 1Vpp

Functional safety

.. = No
FA = Analog signal (1Vpp) can be used for safety related equipment [2]

Pin configuration

UJ = 01, 02S12, 03S12, 27S12
J5 = 16S15

Cable length

0,50 = 0,50m
1,00 = 1,00m
1,50 = 1,50m
2,00 = 2,00m
2,50 = 2,50m
3,00 = 3,00m
4,00 = 4,00m
5,00 = 5,00m
6,00 = 6,00m

Electrical connection

01 = Free cable end
02S12 = M23-12 pin connector male
03S12 = M23-12 pin coupling male
16S15 = D-SUB-15 pin 2-row male
27S12 [1] = Flange socked M23 12 pin male

Design of the scanning head

10 = Miniaturized, connector with electronics on cable, M23
12 = Miniaturized, pluggable connector with electronics on cable via M12 connector

20 = Standard
21 = Standard, flat

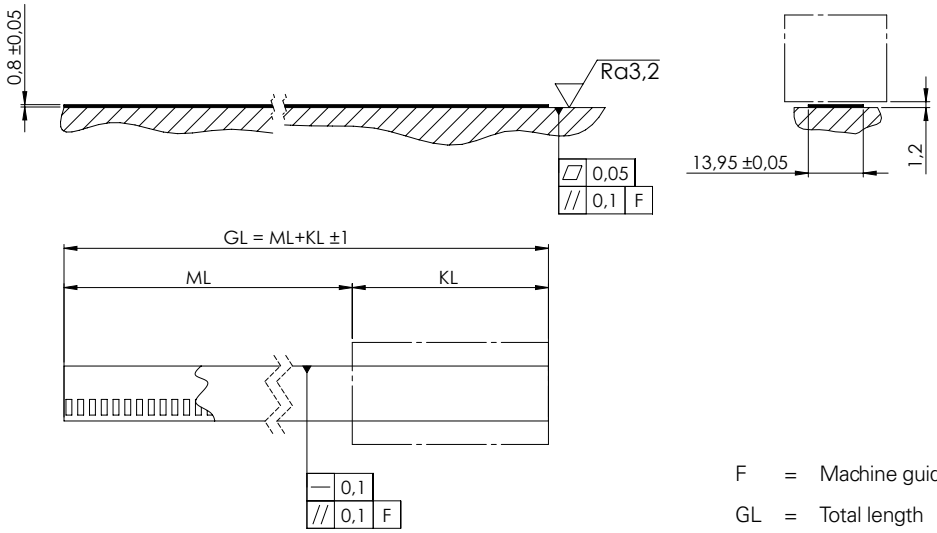
Incremental/Multiplication

		1Vpp		TTL	
		S	HA	S	HA
01	1-fold	×		×	
05	5-fold			×	
10	10-fold			×	
25	25-fold	×		×	
50	50-fold		×	×	
A3	250-fold			×	
A4	500-fold				×
A9	2500-fold				×

[1] Electrical connection for miniaturized design of the scanning head 10 and 12.
[2] Option „FA“ only used for dividing factor „01“.

Scale tape to stick LMB 1030

- **Scale tape to stick, for modular linear encoders**
- **Grating period 3000µm**
- **In combination with scanning head LMK 2030**



F = Machine guidance
GL = Total length
ML = Measuring length :

BF 20 / BF 21 : ML = GL - 49 mm

KL = Scanning head length :

BF 20 / BF 21 : 49 mm

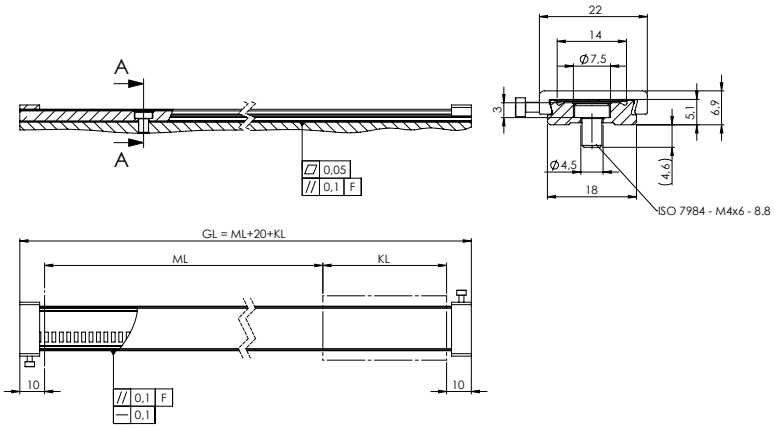
Tolerance principle in accordance withSO8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

Technical data

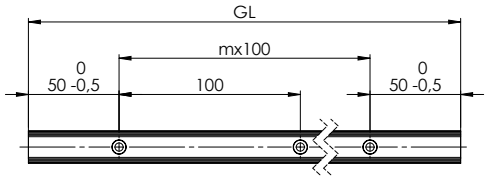
Incremental scale tape	LMB 1030	
Grating period	3000µm	
Accuracy class	± 50µm/m	± 50µm/m
Accuracy after linear compensation	± 10µm/m	± 20µm/m
Total length GL	Standard length see ordering code	
Mechanical design	Stainless steel scale tape with adhesive layer for mounting	
Reference marks	Single or distance coded reference marks – Customized reference mark positions on request.	
Coefficient of expansion	~ 11ppm/K	
Mass	70 g/m Total length	

Scale tape in stainless steel carrier LMT 4030

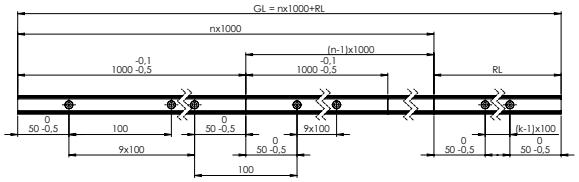
- **Scale tape in stainless steel carrier, for modular linear encoders**
- **Grating period 3000µm**
- **In combination with scanning head LMK 2030**



Single section carrier LMT 4030 C



Multi section carrier LMT 4030 D



F = Machine guidance

GL = Total length

ML = Measuring length :

BF 20 : ML = GL - 93mm
BF 21 : ML = GL - 69mm

KL = Scanning head length :

BF 20 : 73mm
BF 21: 49 mm

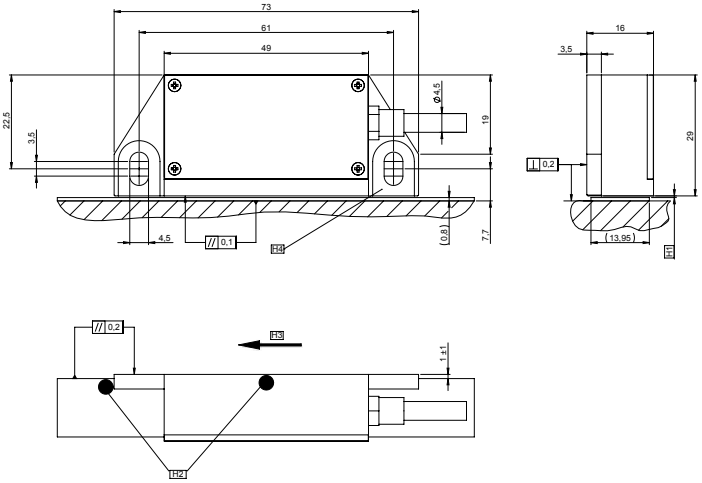
Technical data

Incremental scale tape	LMT 4030	
Grating period	3000µm	
Accuracy class	± 50µm/m	± 50µm/m
Accuracy after linear compensation	± 10µm/m	± 20µm/m
Total length GL	Standard length see ordering code	
Mechanical design	Stainless steel carrier with integrated scale tape	
Reference marks	Single or distance coded reference marks – Customized reference mark positions on request.	
Coefficient of expansion	~ 11ppm/K	
Mass	650 g/m Total length	

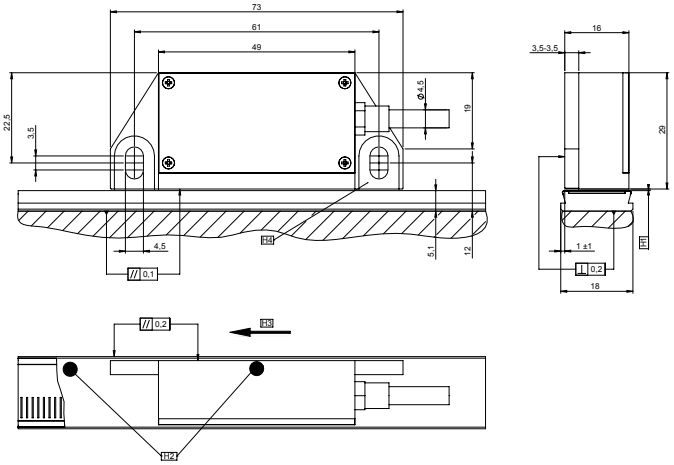
Scanning head - LMK 2030 series

- **Incremental, modular linear encoders**
- **Grating period 3000µm**
- **Scanning head with integrated electronics**
- **In combination with scale type LMB 1030 and LMT 4030**

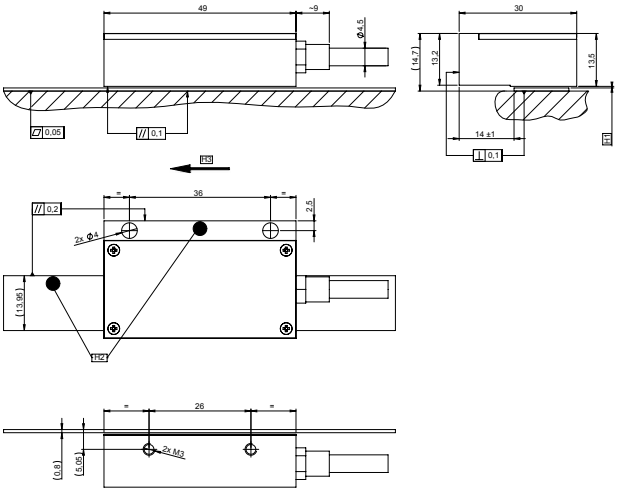
Design 20
with scale type LMB 1030



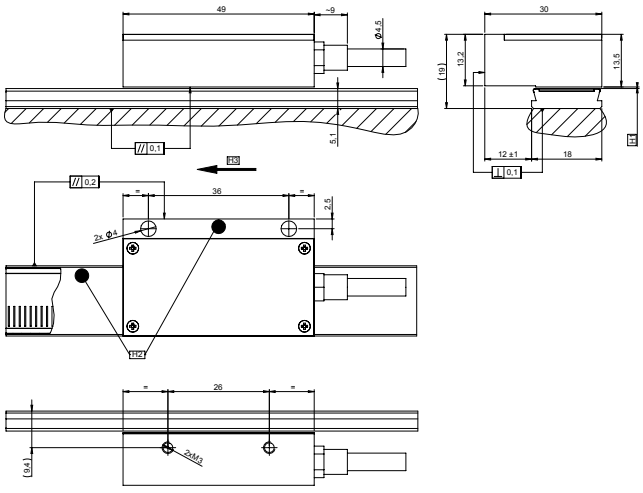
Design 20
with scale type LMT 4030



Design 21
with scale type LMB 1030



Design 21
with scale type LMT 4030



Tolerance principle in accordance withSO8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

H1 = Air gap 0,40 ± 0,20mm, set with spacer foil
H2 = Reference track marking
H3 = Direction of scanning head movement for positive counting
H4 = Ground plane

Technical data

- LMK - Scanning head for modular linear encoders
- Grating period 3000µm

Scanning head 3000 µm	**LMK 2030**	
Performance	Standard	
Interface	1Vpp	TTL
Position error per grating period[1)]	± 4,0µm	
Maximum speed	60m/s	
TTL - Interpolation/ 1Vpp signal period		
Signal period[2)] Interpolation	- -	750µm to 3µm 1 to 250
Signal period Dividing factor	3000µm or 120µm 1 or 25	-
Max. output frequency	400KHz	5MHz
Electrical connection	Cable with M23 coupling 12pin male	
Cable length on the encoder	0,50m - 6,00m	
Power supply	1Vpp: DC 4,0V to 7,0V TTL: DC 5,0V +/- 0,5V	
Power consumption	Design 20, 21: ≤ 1300mW at 5V	
Typ. current consumption	Design 20,21: ≤ 220mA at 5V (without load)	
Vibration 55 to 2000 Hz	< 200m/s² (EN 60068-2-6)	
Shock 6 ms	< 2000m/s² (EN 60068-2-27)	
Operating temperature	-10°C to 100°C	
Storage temperature	-20°C to 100°C	
Protection	IP67	
Mass	38g Design: 20, 21	

[1)] The position error per grating period and the accuracy of the grating results toghether in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error.

[2)] After 4-edge-evaluation.

Ordering code

- LMB - Incremental scale tape to stick for modular linear encoders
- Grating period 3000µm

LMB 1030B □□ - □□□□□ - MF - LB01 - □□□□□□

Accuracy [1)]

10 = 10 µm/m
20 = 20 µm/m

Total length in mm

50 - 200	each 10 mm
200 - 500	each 20 mm
500 - 1000	each 50 mm
1000 - 3000	each 100 mm
3000 - xxxx	each 200 mm

Safety concept

MF = Fault exclusion for the loosing of the mechanical connection possible

Reference mark

0RM	= Without reference mark
1RM-M	= 1 Reference mark - middle
B050	= Reference mark 50mm from both sides
L25	= Reference mark 25mm from left
L50	= Reference mark 50mm from left
R50	= Reference mark 50mm from right
K120	= Distance-coded reference marks, nominal increment 120 grating period
K240	= Distance-coded reference marks, nominal increment 240 grating period

Type of graduation carrier

LB01 = Scale tape to stick

[1)] After linear length-error compensation in the evaluation electronics

Ordering code

- LMT - Incremental scale tape in stainless steel carrier for modular linear encoders
- Grating period 3000µm

LMT 4030 □ - □□ - □□□□□ - MF - LT01 - □□□□□□

Scale tape carrier

C = Single section carrier (GL ≤ 3000 mm)
D = Multi section carrier (GL > 3000 mm)

Accuracy [1)]

10 = 10 µm/m
20 = 20 µm/m

Total length in mm

≤ 3000 mm	each 100 mm
> 3000 mm	each 200 mm

Reference mark

0RM	= Without reference mark
1RM-M	= 1 Reference mark - middle
B050	= Reference mark 50mm from both sides
L25	= Reference mark 25mm from left
L50	= Reference mark 50mm from left
R50	= Reference mark 50mm from right
K120	= Distance-coded reference marks, nominal increment 120 grating period
K240	= Distance-coded reference marks, nominal increment 240 grating period

Type of graduation carrier

LT01 = Stainless steel carrier, M4, each 100 mm

Safety concept

MF = Fault exclusion for the loosing of the mechanical connection possible

[1)] After linear length-error compensation in the evaluation electronics

Ordering code

- LMK - Scanning head for modular linear encoders
- Grating period 3000µm

LMK 2030 S . □□ □□ □□ □□ -□□ - □ , □□ - □□□□□□ - □□

Interface

07 = TTL
08 = 1Vpp

Reference mark

RV = Rectangle pulse linked (90° el.) for TTL
RI = Rectangle pulse linked (360° el.) for 1Vpp

Functional safety

.. = No
FA = Analog signal (1Vpp) can be used for safety related equipment [1)]

Incremental signals/Multiplication

		1Vpp	TTL
		S	S
01	1-fold	×	
05	5-fold		×
10	10-fold		×
25	25-fold	×	×
50	50-fold		×
A3	250-fold		x

Design of the scanning head

20 = Standard
21 = Standard, flat

Cable length

0,50 = 0,50 m
1,00 = 1,00 m
1,50 = 1,50 m
2,00 = 2,00 m
2,50 = 2,50 m
3,00 = 3,00 m
4,00 = 4,00 m
5,00 = 5,00 m
6,00 = 6,00 m

Electrical connection

01 = Free cable end
02S12 = M23-12 pin connector male
03S12 = M23-12 pin coupling male
16S15 = D-SUB-15 pin 2-row male

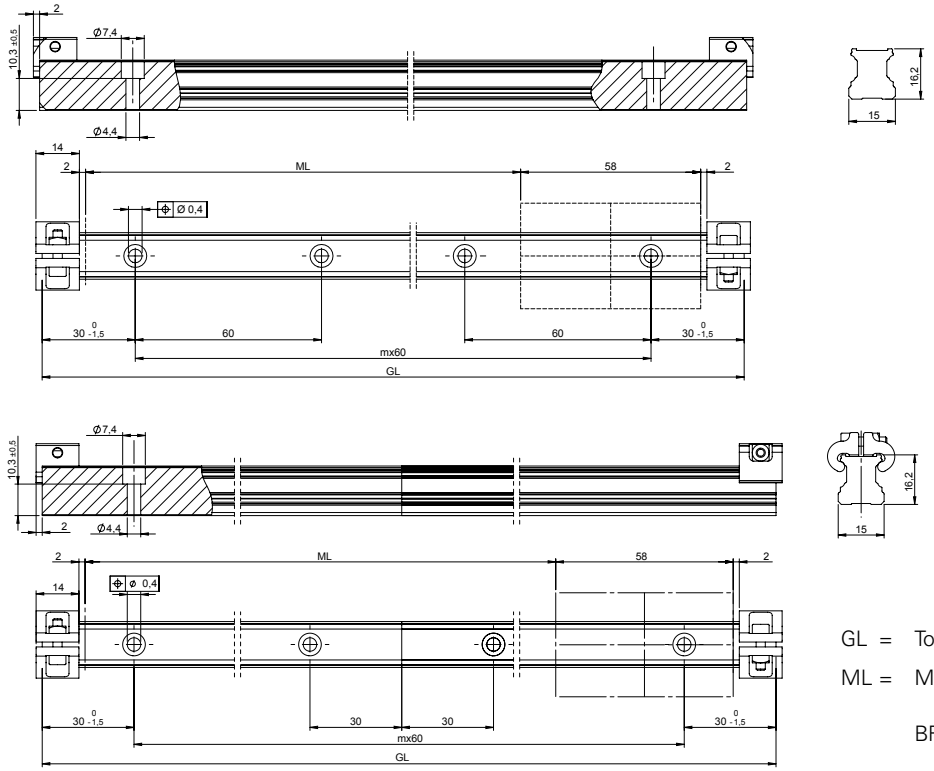
Pin configuration

UJ = 01, 02S12, 03S12
J5 = 16S15

[1)] Option „FA“ only used for dividing factor „01“.

Scale tape in measuring rail LMF 3010

- **Scale tape in measuring rail, for guided linear encoders**
- **Grating period 1000µm**
- **In combination with LMK 3010**



GL = Total length

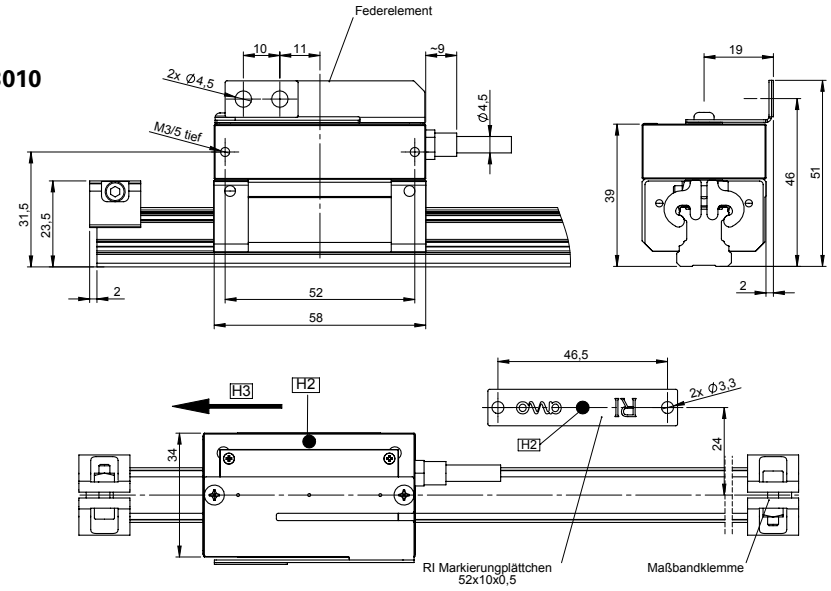
ML = Measuring length :

BF 30 : ML = GL - 86 mm

Scanning head - LMK 3010 series

- **Incremental, guided linear encoders**
- **Grating period 1000µm**
- **Guided scanning head with integrated electronics**
- **In combination with scale type LMF 3010**

Design 30
with scale type LMF 3010



Tolerance principle in accordance withSO8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

H2 = Reference track marking
H3 = Direction of scanning head movement for positive counting

Technical data

- LMF - Measuring rail for guided linear encoders
- Grating period 1000µm

Incremental measuring rail	LMF 3010	
Grating period	1000µm	
Accuracy class	± 20µm/m	± 50µm/m
Accuracy after linear compensation	± 5µm/m	± 10µm/m
Total length GL	Standard length see ordering code	
Mechanical design	Standard guide rail with integrated scale tape	
Reference marks	Single or distance coded reference marks – Customized reference mark positions on request.	
Coefficient of expansion	~ 11 ppm/K	
Mass	1400 g/m Total length	

Technical data

- LMK - Scanning head for guided linear encoders
- Grating period 1000µm

Scanning head guided	LMK 3010			
Grating period	1000µm			
Performance	Standard		High Accuracy	
Interface	1Vpp	TTL	1Vpp	TTL
Position error per grating period[1)]	± 2µm		± 0,5µm	
Maximum speed	5m/s limited by the mechanics			
TTL - Interpolation/ 1Vpp signal period				
Signal period[2)] Interpolation	- -	250µm to 1µm 1 to 250	- -	0,5µm or 0,1µm 500 or 2500
Signal period Dividing factor	1000µm or 40µm 1 or 25	- -	20µm 50	- -
Max. output frequency	400KHz	5MHz	400KHz	5MHz
Electrical connection	Cable with M23 coupling 12pin male			
Cable length on the encoder	0,50m - 6,00m			
Power supply	1Vpp: DC 4,0V to 7,0V TTL: DC 5,0V +/- 0,5V			
Power consumption	≤ 1300mW at 5V			
Typ. current consumption	≤ 220mA at 5V (without load)			
Vibration 55 to 2000 Hz	< 200m/s² (EN 60068-2-6)			
Shock 6 ms	< 2000m/s² (EN 60068-2-27)			
Operating temperature	-0°C to 80°C			
Storage temperature	-20°C to 100°C			
Protection	IP67			
Mass	200g			

[1)] The position error per grating period and the accuracy of the grating results toghether in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error.

[2)] After 4-edge-evaluation.

Ordering code

- LMF - Measuring rail for guided linear encoders
- Grating period 1000µm

LMF 3010 □-□□-□□□□□-MF-LF01-□□□□□□

Classification

30 = LMF 3010

Grating period

10 = 1000 µm

Scale tape carrier

E = Single section measuring rail
< 3600 mm

F = Multi section measuring rail
> 3600 mm

Accuracy[1)]

5 = 5 µm/m
10 =10 µm/m

Total length in mm

E = Scale tape carrier
180-3600 mm every 180 mm

F = Scale tape carrier
3600 mm-xxxx every 180 mm

Reference mark

0RM	= Without reference mark
1RM-M	= 1 Reference mark - middle
B050	= Reference mark 50mm from both sides
L50	= Reference mark 50mm from left
R50	= Reference mark 50mm from right
K120	= Distance-coded reference marks, nominal increment 120 grating period
K240	= Distance-coded reference marks, nominal increment 240 grating period

Type of graduation carrier

LF01 = Measuring rail, mounting thread M4, each 60 mm

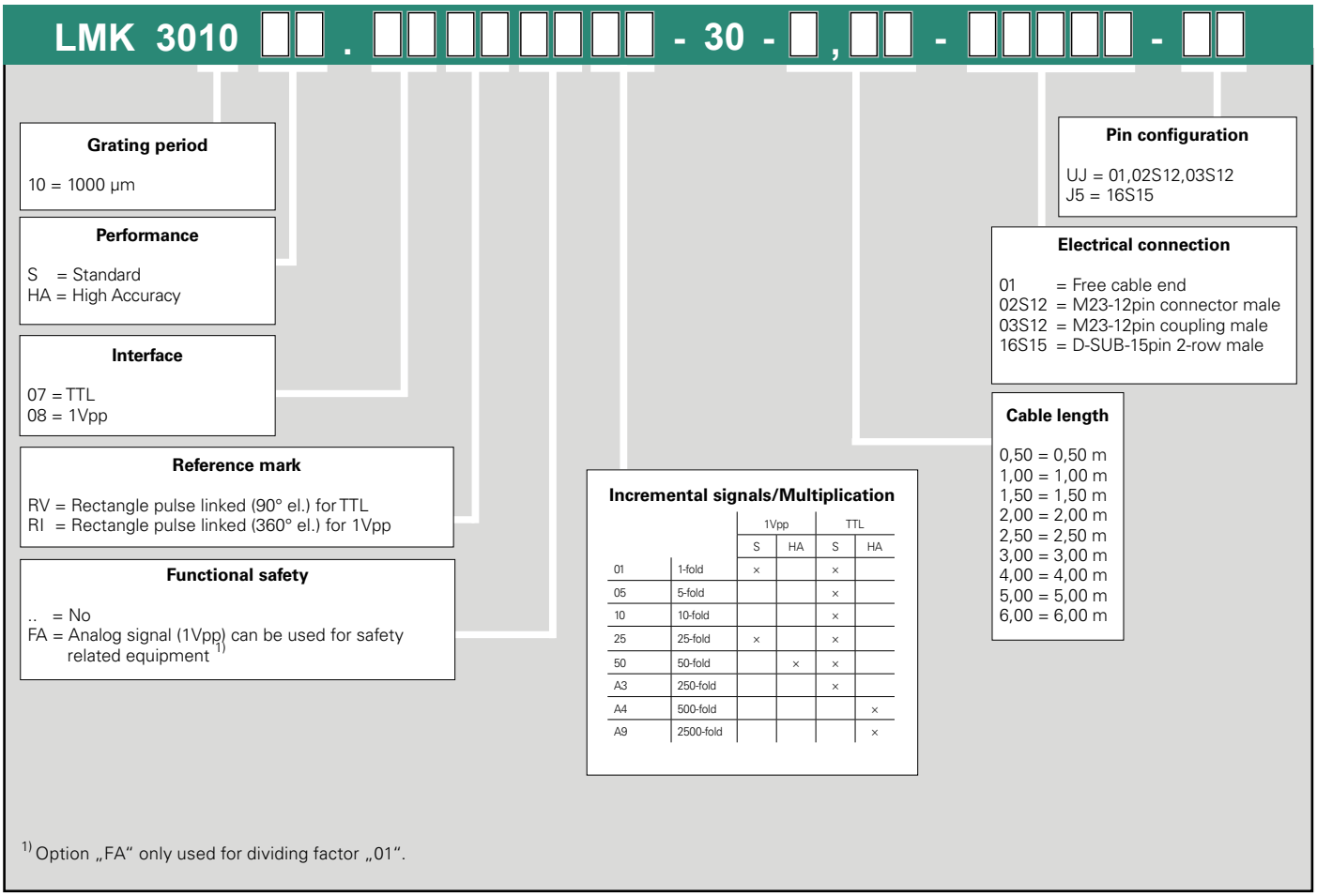
Safety concept

MF = Fault exclusion for the loosing of the mechanical possible

[1)] After linear length-error compensation in the evaluation electronics

Ordering code

- LMK - Scanning head for guided linear encoders
- Grating period 3000µm



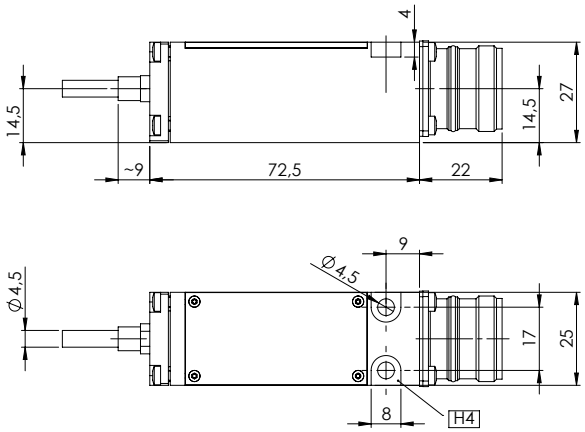
1) Option „FA" only used for dividing factor „01".

External electronics

- **General information**
- **Dimensions**

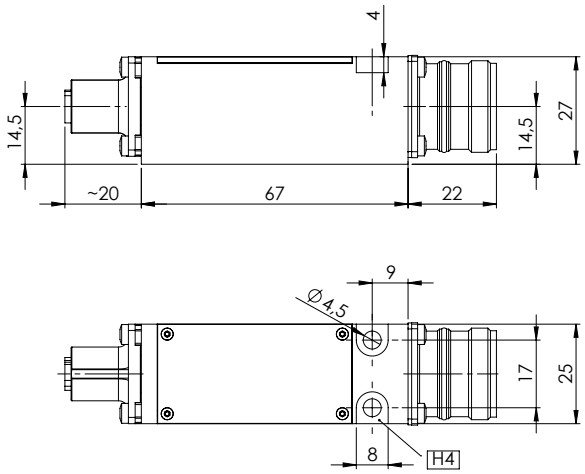
Design 10

- Miniaturized scanning head
- with external electronics on the cable
- Output: Flange socket M23



Design 12

- Miniaturized scanning head
- with external electronics, pluggable on cable via M12 connector
- Output:Flange socket M23



Tolerance principle in accordance withSO8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

H4= Ground plane

Encoder Cable

Technical Data

	Cable for incremental encoders and SSI+1Vpp	Cable for encoders with pure serial interfaces
Jacket	PUR, high flexible, suitable for energy chains	
Diameter	4,5 +/-0,1mm	
Wires	6x2x0,09mm²	1x(4*0,09mm²) + 4x0,14mm²
Bending radius	≥ 10mm for single bending	
	≥ 50mm for continuous bending	
Max. length	6m	
Resistance according to	UL according to Style 20963 80°C 30V	

Interfaces

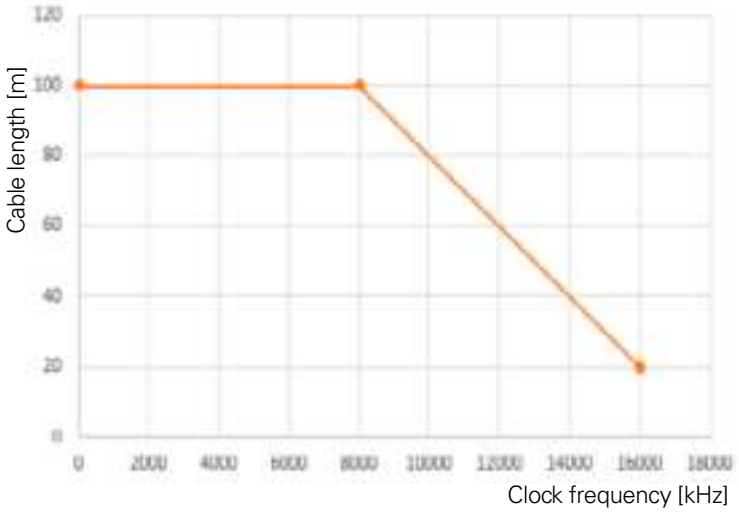
Position values EnDat

The EnDat-Interface is a digital, **bi-directional** Interface for measuring systems. With this interface you can reat out **position values** and in the measuring system saved informations. This value can also be updated or new values can be saved. Due to the **serial dada transfer four signal wires** are enought. The data DATA gets transferred **synchroniously** to the form the subsequent electronics given clock frequency CLOCK. The selection from the mode of transmission (position values, parameter, diagnostics,...) is done with mode-commands which are sent from the subsequent electronics to the measuring system.

Order code	Instruction set	Incremental signals
EnDat2.2	EnDat 2.2	Without

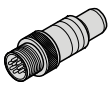
The clock frequency is variable - depending on the cable lenght (max. 100m). With propagation electronics, either clock frequencies up to 16MHz are possible or cable lenght up to 100m. For EnDat encoders the maximum clock frequency is sored in the encoder memory. Propagation-delay compensation is provided for EnDat22.

Transmission frequencies up to 16MHz in combination with large cable lenght place hight technological demands in the cable. Greater cable lenghts can be realized with an adapter cable no longer than 6m and an extension cable. As a rule, the entire transmission path must be designed for the respective clock frequency.



Pin configuration

Electrical connection: 1SS08
8-pin coupling M12



	Power supply				Absolute position values			
	8	**2**	**5**	**1**	**3**	**4**	**7**	**6**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**DATA+**	**DATA-**	**CLOCK+**	**CLOCK-**
	brown/green	blue	white/green	white	grey	pink	violet	yellow

Cable Shield is connected with the housing; **U_P** = Power supply voltage
Sensor: The sensor wire is connected internally with the corresponding power supply.
Non-used pins or wires must not be assigned!

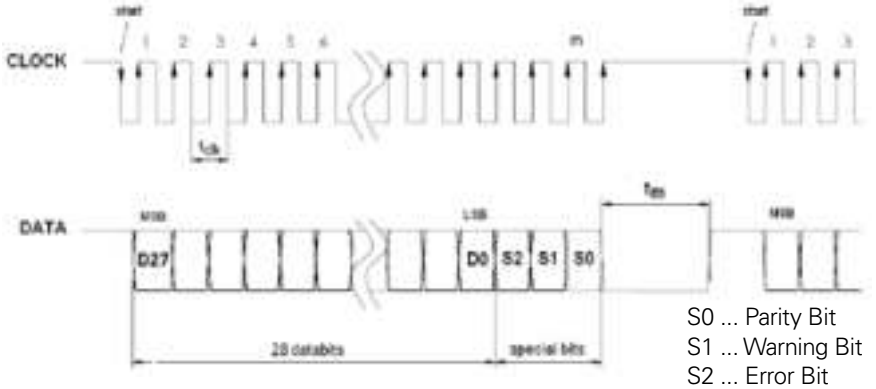
Interfaces

SSI + ∿1V_{pp}

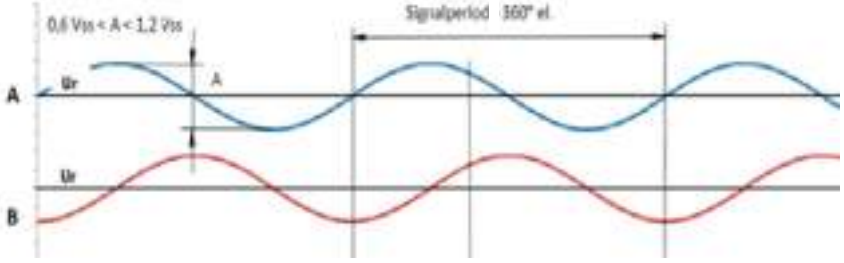
SSI Interface is an unidirectional Interface which can output position values.
The Data DATA gets transferred synchroniously to the from the subsequent electronic given Clock freuqency CLOCK.
Additionaly three special bits (Error, Warning and Parity) will be transferred

AMO-Encoders with ∿ 1 V_{pp}-Interface are outputting signals which can be highly interpolated.

The sine shaped **incremental signals** A and B are electrically 90° phase shifted and have a signal - B after A - is valid for the in the connection drawing stated movement direction.



S0 ... Parity Bit
S1 ... Warning Bit
S2 ... Error Bit



Pin configuration

Electrical connection: 03S17
17-pin coupling M23

	Power supply				Increment signals				Absolut position value			
	7	**1**	**10**	**4**	**15**	**16**	**12**	**13**	**14**	**17**	**8**	**9**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**A+**	**A–**	**B+**	**B–**	**DATA+**	**DATA-**	**CLOCK+**	**CLOCK-**
	brown/green	blue	white/green	white	brown	green	grey	pink	red	black	violet	yellow

Cable Shield is connected with the housing; **U_P** = Power supply voltage
Sensor: The sensor wire is connected internally with the correspondending power supply.
Non-used pins or wires must not be assigned!

Interfaces

Pin layouts Fanuc, Mitsubishi BiSS/C®

Fanuc

AMO-Encoders with Fanuc Interface are
for connection to a Fanuc-Control.

Fanuc Serial Interface - α interface
Order code: Fanuc02
normal and hight speed,
two-pair transmission.

BiSS/C

AMO-Encoders with BiSS/C® Interface are
suitable for the connection with controls, which have
the BiSS/C Interface implemented.

BiSS/C bidirektionales Protokoll
Order code: BiSS
The Standard Encoder Profile - 32bit will be used.

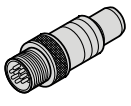
Mitsubishi

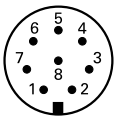
AMO-Encoders with Mitsubishi Interface are suitable for connection to a Mitsubishi-Control.

Mitsubishi high speed interface
Order code: MitA1-4 (full duplex) –> two pair transmission
Order code: MitA1-2 (half duplex) –> one pair transmission

Pin configuration

Electrical connection: 1SS08
8-pin coupling M12





	Power supply				Absolute position values			
	8	**2**	**5**	**1**	**3**	**4**	**7**	**6**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**DATA+**	**DATA-**	**CLOCK+**	**CLOCK-**
	brown/green	blue	white/green	white	grey	pink	violet	yellow

Cable Shield is connected with the housing; **U_P** = Power supply voltage
Sensor: The sensor wire is connected internally with the corresponding power supply.
Non-used pins or wires must not be assigned!

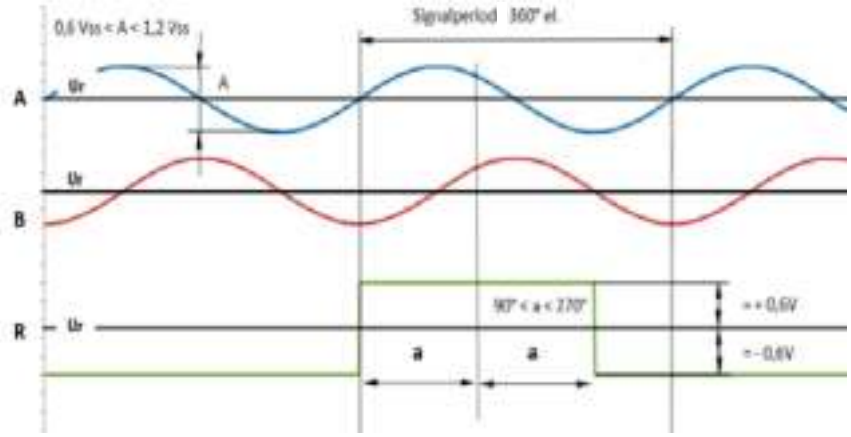
Interface

Incremental signals ∿ 1V_{pp}

AMO-Encoders with ∿ 1 V_{PP}-Interface are outputing signals which can be highly interpolated.

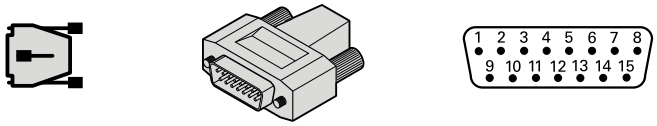
The sine shaped incremental signals A and B are electrically 90° phase shifted and have a signal strenght from 1Vpp. The showed sequence of the outputet signals - B after A - is valid for the in the connection drawing stated movement direction.

The reference mark signal R has a clear assignment to the incremental signals.

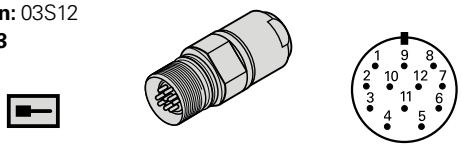


Pin configuration

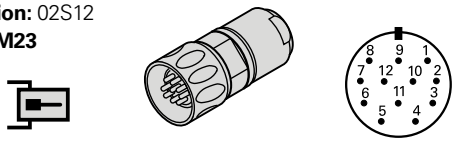
Electrical connection: 16S15
15-pin Sub-D-connector



Electrical connection: 03S12
12-pin coupling M23



Electrical connection: 02S12
12-pin connector M23



	Power supply				Incremental signals						Other signals		
	4	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**5/15**	**8**	**6**
	12	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**/**	**7**	**9**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**Frei**	**Diag+**	**Diag-**
	brown/ green	blue	white/ green	white	brown	green	grey	pink	red	black	/	violet	yellow

Cable Shield is connected with the housing; **U_P** = Power supply voltage
Sensor: The sensor wire is connected internally with the corresponding power supply.
Non-used pins or wires must not be assigned!
DIAG-wires must not be assigned.
DIAG-signals are for checking the encoder with AMO-STU-60.

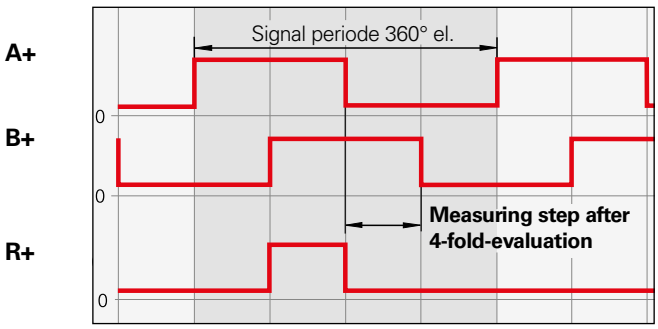
Interfaces

Incremental signals ⊓⊔TTL

AMO-Encoders with ⊓⊔TTL Interface contain electronic, which form the since-form signals - with or without- Interpolation into digital signals.

The **incremental signals** are outputed as rectangle pulses A+ and B + with 90° el. phase shifting. The **rectandle-mark-signal** is composed from one or more reference impulses R+, which are assigned with the incremental signals. The integrated electronic additionally creates the **inverse signals** A-, B- and R- for a safe transmission.
The showed sequence of the outputed signals - B after A - is valid for the in the connection drawing stated movement direction.

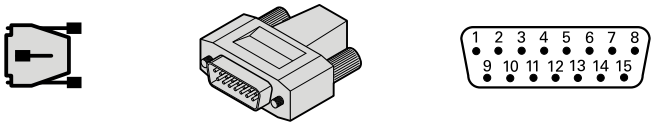
The **measuring step** results throught the distance between two flanks frim the incremental signals A+ and B+ throught 1-fold, 2-fold or 4-fold evaluation.



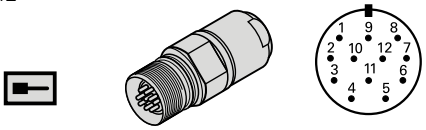
The inverse signals A-, B- und R- are not shown.

Pin configuration

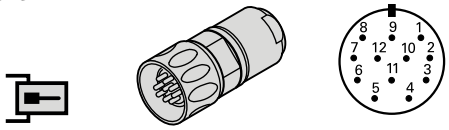
Electrical connection: 16S15
15-pin Sub-D-connector



Electrical connection: 03S12
12-pin coupling M23



Electrical connection: 02S12
12-pin connector M23



	Power supply				Incremetal signals						Other signals		
	4	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**5/15**	**8**	**6**
	12	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**/**	**7**	**9**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**Frei**	**Diag+**	**Diag-**
	brown/ green	blue	white/ green	white	brown	green	grey	pink	red	black	/	violet	yellow

Cable Shield is connected with the housing; **U_P** = Power supply voltage
Sensor: The sensor wire is connected internally with the corresponding power supply.
Non-used pins or wires must not be assigned!
DIAG-wires must not me assigned!
DIAG-signals are for checking the encoder with AMO-STU-60

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