



AMO GmbH

## Absolute Encoders

for safety-related applications

Functional  
Safety



Product Information

February 2024

# Explanation for the related documents:

For the reason of environmental protection, the devices are delivered with the assembly instructions only. The contents comparable to an operating manual are therefore composed of several documents that must all be taken into account during configuration. The original language for the documentation is German (DE), all other languages are translations.

## Related documents

Comply with the information in the following documents to ensure the correct and intended operation of the encoder:

- Product information for safety-related applications 1238174
- Technical Information Safety-related position measuring systems 596632
- Specification for E/E/PES safety requirements for the EnDat Master and measures for the safety control (on request) 533095
- Interfaces from HEIDENHAIN - Measuring systems 1078628

Dokument	Dokumenten-ID	Produktlebensphase/Inhalt
"Product Information: Absolute measuring devices for safety-oriented applications.	1238174	<ul style="list-style-type: none"><li>■ Technical specifications, operating conditions</li><li>■ Mounting instructions</li><li>■ Technical data, connection dimensions</li></ul>
Technical Information: Safety-related position measurement systems	596632	<ul style="list-style-type: none"><li>■ Technical Information</li></ul>
Specification of the E/E/PES safety requirements for the EnDat master and measures for secure control (upon request)	533095	<ul style="list-style-type: none"><li>■ Technical Information, Specification</li></ul>
Interfaces of HEIDENHAIN measuring devices	1078628	<ul style="list-style-type: none"><li>■ Technische Information</li></ul>
Assembly Instructions	<a href="http://www.heidenhain.com/products/search">www.heidenhain.com/products/search</a> Search Product-ID	<ul style="list-style-type: none"><li>■ Device installation</li><li>■ Commissioning</li><li>■ Maintenance and servicing*</li></ul>

\*) AMO measuring devices are maintenance-free


The additional documents for implementation in a controller are listed in the Technical Information, for Safety-Related Position Measuring Systems and can be requested from the Dr. Johannes HEIDENHAIN GmbH.

**Further information:**

- EnDat 3 Interface Specification
- [www.endat.de](http://www.endat.de)

Free available documents can be found at  
[www.heidenhain.com/products/search](http://www.heidenhain.com/products/search)  
Search Device-ID

CE Declaration of Conformity can be found at  
[www.heidenhain.de/products/search](http://www.heidenhain.de/products/search)  
Search Device-ID

For technical support (Troubleshooting / Fault analysis), please contact:  
Technical Support/Measuring Systems  
☎ +49 8669 31-3104  
E-Mail: [service.ms-support@heidenhain.de](mailto:service.ms-support@heidenhain.de)

## Applied guidelines and standards

The devices described in this product information comply with the following guidelines and standards:

- 2006 / 42 / EG idgF (Machine guidelines)
- EN ISO 13849
- EN / IEC 61508
- EN / IEC 62061
- EN / IEC 61800-5-2
- 2014 / 30 / EU (EMV)
- EN / 55011
- EN / 61000-6-7
- 2011 / 65 / EG (Statement regarding RoHS on request)

The devices can be used for applications up to PL d, Category 3 according to EN ISO 13849-1 or SIL 2 according to EN / IEC 61508.

# General electrical information

## Supply voltage

Connect AMO-Encoders only to subsequent electronics whose supply voltage comes from PELV systems (for a definition, see EN 50178).

AMO-Encoders meet the requirements of the IEC 61010-1 standard if power is supplied from a secondary circuit with limited energy as per IEC 61010-1<sup>3rd Ed.</sup>, Section 9.4, or with limited power as per IEC 62368-1<sup>2nd Ed.</sup>, Section 6.2.2.5 PS2, or from a Class 2 secondary circuit as per UL1310.1)

A stabilized DC voltage UP is required for powering the encoders. Information on voltage and current consumption or power consumption can be obtained from the respective specifications.

Regarding the ripple voltage of the DC power, the following parameters apply:

- High-frequency interference  
UPP < 250 mV with dU/dt > 5 V/μs
- Low-frequency fundamental ripple  
UPP < 100 mV

However, the limits of the supply voltage must not be violated by the ripple content.

The required supply voltage depends on the encoder interface. A distinction is made between encoders without an extended supply voltage range (e.g., DC 5.0 V ± 0.25 V) and those with an extended supply voltage range (e.g., DC 3.6 V to 14 V).

For interfaces without sense lines it is necessary to consider the voltage drop along the connecting cable between the measuring device and subsequent electronics during the design of the required supply voltage.

<sup>1)</sup> In place of IEC 61010-1<sup>3rd Ed.</sup>, Section 9.4, the corresponding sections of the following standards can be used: DIN EN 61010-1, EN 61010-1, UL 61010-1, and CAN/CSA-C22.2 No. 61010-1. In place of IEC 62368-1<sup>2nd Ed.</sup>, Section 6.2.2.5 PS2, the corresponding sections of the following standards can be used: DIN EN 62368-1, EN 62368-1, UL 62368-1, and CAN/CSA-C22.2 No. 62368-1.

<b>Overview</b>		
<b>History</b>		<b>2</b>
<b>Explanation of related documents</b> <b>General electrical information</b>		<b>3</b>
<b>Functional safety</b>		
	General	<b>4</b>
	Absolute angle encoders	<b>5</b>
	Absolute linear encoders	<b>11</b>
<b>Series WMKA 2x10</b>		
	Dimension	<b>7</b>
	Technical data	<b>8</b>
<b>Series LMKA 2x10</b>		
	Dimension	<b>14</b>
	Technical data	<b>15</b>
<b>Series LMKA 3x10</b>		
	Dimension	<b>17</b>
	Technical data	<b>18</b>
<b>Ordering code and type explanation</b>		
	WMKA	<b>10</b>
	LMKA	<b>20</b>
<b>Interfaces</b>		<b>21</b>
<b>Contact information</b>		<b>24</b>

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

Date of issue	Comment	Documentnumber
April 2018	First edition	1238174 - 01 - A - 02
August 2018	Supplement DRIVE-CLiQ Interface	1238174 - 02 - A - 02
November 2021	Update type label	1238174 - 03 - A - 02
October 2023	Supplement EnDat 3 Interface	1238174 - 04 - A - 02
February 2024	Correction - Requirements	1238174 - 05 - C - 02

# Functional safety

## General

Safety is becoming increasingly important in machine and plant construction. Proof of this can be seen in new legislation and in the heightened safety regulations of national and international standards. These high requirements mainly serve to protect human beings, but material assets and the environment are also receiving more consideration.

The goal of functional safety is to minimize or even eliminate risks that can occur during normal or impaired operation of machines or facilities. This is achieved primarily

with redundant systems. For example, axes that are moved in safety-related applications require redundant position information in order to perform the corresponding safety functions.

Various system configurations can be realized in order to capture independent position values. One possibility is the use of two encoders per axis. In many cases, however, a more economical solution requiring only one position encoder is preferred. Until now, analogue encoders with sine and cosine signals were used for this.

HEIDENHAIN offers a purely serial, single encoder solution for safety-related position measuring systems in safety-oriented applications in accordance with EN61508 and EN13849.

This means that safety applications can now take advantage of all the benefits of serial data transfer, such as optimization of costs, diagnostic possibilities, automatic commissioning and rapid formation of the position value.

## Function

The safety strategy of the position measuring system is based on two mutually independent position values and additional error bits produced in the encoder and transmitted over the functional safety protocol to the safety master. The safety master assumes various monitoring functions with which errors in the encoder and during transmission can be revealed. The two position values are then compared. The sa-

fety master then makes the data available to the safe control. The control periodically tests the safety-related position measuring system to monitor its correct operation. The architecture of the functional safety protocol makes it possible to process all safety-relevant information and control mechanisms during unconstrained controller operation. This is possible because the safety-relevant information is saved in the ad-

ditional information. According to EN61508, the architecture of the position measuring system is regarded as a single-channel tested system. The position measuring system was considered with a HFT = 1 (Hardware Fault Tolerance).

## Documentation on the integration of the position measuring system

The intended use of position measuring systems places demands on the control, the machine designer, the installation technician, service, etc. The necessary information is provided in the documentation for the position measuring systems.

In order to be able to implement a position measuring system 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.

The requirements for integrating the EnDat master with monitoring functions in the safe control are described in the HEIDENHAIN document 533095 for EnDat 2.2 and in document 3000004 for En-

Dat 3. It contains, for example, specifications on the evaluation and processing of position values and error bits, and on electrical connection and cyclic tests of position measuring systems.

Machine and plant manufacturers need not attend to these details. These functions must be provided by the control. Product information sheets, catalogues and mounting instructions provide information to aid the selection of a suitable encoder. The product information sheets and catalogues contain general data on function and application of the encoders as well as specifications and permissible ambient conditions. The mounting instructions provide detailed information on installing the encoders.

The architecture of the safety system and the diagnostic possibilities of the control may call for further requirements. For example, the operating instructions of the control must explicitly state whether fault exclusion is required for the loosening of the mechanical connection between the encoder and the drive. The machine designer is obliged to inform the installation technician and service technicians, for example, of the resulting requirements (see also information under "Safety-related characteristic values"). The system integrator is responsible for the overall concept of the machine.

## Boundary to applications

A complete demarcation to all unallowed conditions of use is not possible due to lack of knowledge of all possible applications. Basically, the technical data listed for the devices must be adhered to. In addition, influences such as mechanical solids between the scanning head and the measuring tape (eg mechanical damage)

should be excluded. It is also important to take structural measures, to protect against metallic particles that may influence the sampling.

Emissions of airborne sound and non-ionizing radiation do not occur. For information on basic safety requirements, operating

areas up to 6000 m above sea level are considered.

No noise emission is present with proper installation or attachment.

# Functional Safety - Absolute angle encoders

With the absolute angle encoders of the WMKA 2010 and WMKA 2110 series, AMO offers an ideal solution for position determination on rotary axes in safety-related applications. In conjunction with safe control, the encoders can be used as single-encoder systems in applications with control category SIL 2 (according EN61508) or performance level „d“ (according EN ISO 13849).

The basis for the safe transmission of the position are two independently formed absolute position values as well as error bits

which are provided to the safe control. The functions of the measuring instrument can be used for numerous safety functions of the entire system according to EN61800-5-2.

The angle encoders WMKA 2010 and WMKA 2110 create at any time – for example also immediately after switch on - a safe absolute position value. The purely serial data transmission is done via the bidirectional EnDat 2.2, EnDat 3 or DRIVE-CLiQ Interface.

In addition to the data interface, the mechanical connection of the measuring device to the drive is also relevant for the safety.

Table D 8 of the standard for electrical drives, EN61800-5-2, defines the loosening of the mechanical connection between the encoder and drive as a fault that requires consideration. Since it cannot be guaranteed that the control will detect such errors, a fault exclusion for the loosening of the mechanical connection is frequently required.

## 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 mecha-

nical fault exclusion for the angle 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

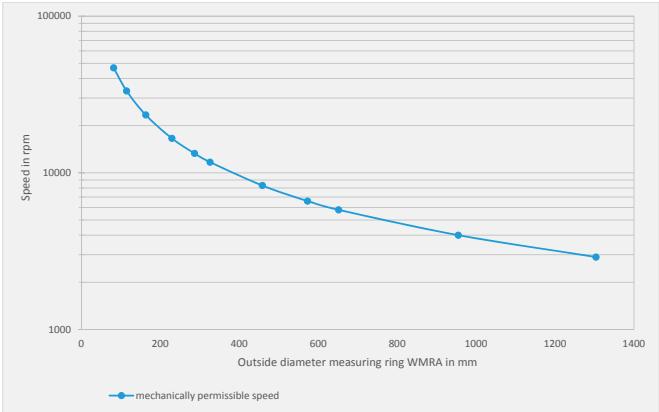
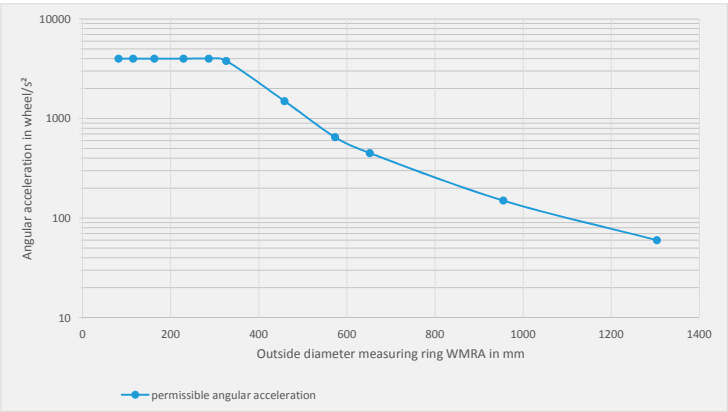
of burrs. Thread surfaces must be secured with materially bonding thread-locking fluid. All mounting screws have to be tightened torque controlled.

## Fault exclusion for the loosening of the measuring ring from the carrier flange - outside scanning

A mechanical fault exclusion for the loosening of the measuring ring from the carrier flange is given, when the carrier flange is designed according to the mechanical requirements specified in the brochure for modular angle encoders (ID 1244264)

The max. mechanical speed and angular acceleration are also shown in the brochure for modular angle encoders.

Carrier Flange	
Material	Steel
Tensile strenght $R_m$	$\geq 550 \text{ N/mm}^2$
Coefficient of thermal expansion $\alpha$	$(10 \text{ to } 12) \cdot 10^{-6} \text{ K}^{-1}$
Shock 6ms	$\leq 1000 \text{ m/s}^2 \text{ (EN 60068-2-27)}$



## Fault exclusion for the loosening of the mounting screws or of the measuring flange

The great range of temperatures in combination with the multitude of material characteristics, as well as the maximum permissible shaft speeds and accelerations require an interference fit of the Measuring flange. Because of the dimensioning of the interference fit and taking into account all safety factors, heating the measuring flange

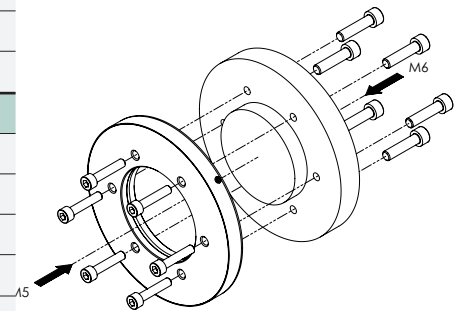
is necessary and affect directly the required assembling temperatures. The mounting with the mechanical fault exclusion is an option.

If there is no need of the mechanical fault exclusion for the safety concept, the measuring flange can also be fixed without

the interference fit. See  $\varnothing W1$  bzw.  $\varnothing W2$  at the dimension of the respective measuring flange shown in the brochure for modular angle encoders (ID 1244264).

Measuring flange <sup>1)</sup> WMFA	Option 1 (M5)	Option 2 (M6)
<b>Mounting screws</b>		
Screws	ISO 4762 - M5 x L-12.9	ISO 4762 - M6 x L-8.8
Torque $M_d$	$5,2 \pm 0,2$ Nm	$8,7 \pm 0,2$ Nm
Length of thread engagement	$\geq 10$ mm	$\geq 12$ mm
Free clamped length	$\geq 15$ mm	$\geq 10$ mm
<b>Mating shaft</b>		
Material	Steel	
Tensile strength $R_m$	$\geq 550$ N/mm <sup>2</sup>	
Surface roughness $R_z$	10 $\mu$ m - 40 $\mu$ m	
Coefficient of thermal expansion $\alpha$	$(10 \text{ to } 12) \cdot 10^{-6} \text{ K}^{-1}$	
<b>Shock</b> 6ms	$< 1000$ m/s <sup>2</sup> (EN 60068-2-27)	

<sup>1)</sup> Information applies to those standard measuring flanges listed in the brochure „Modular Angle Encoders“ (ID 1244264)

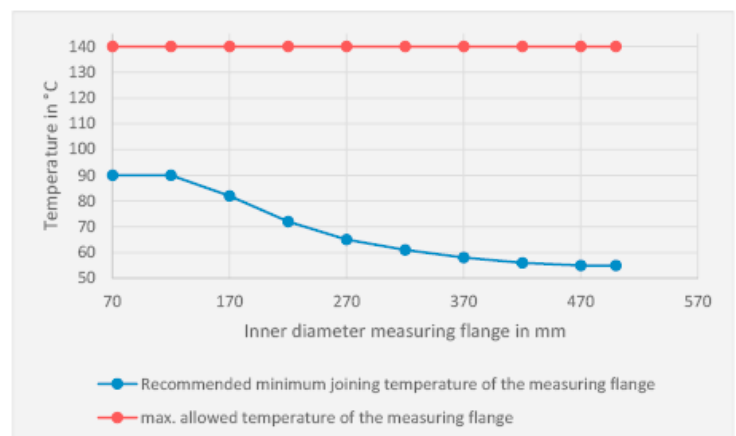


## Assembling of the measuring flange

An oversize of the shaft is required for fault exclusion. The measuring flange should preferably be shrunk thermally onto the mating shaft and additionally be fastened with screws. For this purpose, the measuring flange must be heated slowly before mounting. Use a heat chamber or a heat plate (but no induction heating sources). The diagram shows the recommended minimum temperatures for the different measuring flange diameters. The maximum temperature should not exceed 140 °C.

During shrink-fitting, make sure that the hole patterns of the scale drum and mating shaft are properly aligned. Appropriate positioning aids (setscrews) can facilitate mounting. When the scale drum has cooled down, all mounting screws have to be tightened again with the correct torque.

The mounting screws used for the assembly of the scanning head and measuring flange must be used only to secure the scanning head and the measuring flange. Do not additionally fasten any other components with these screws.



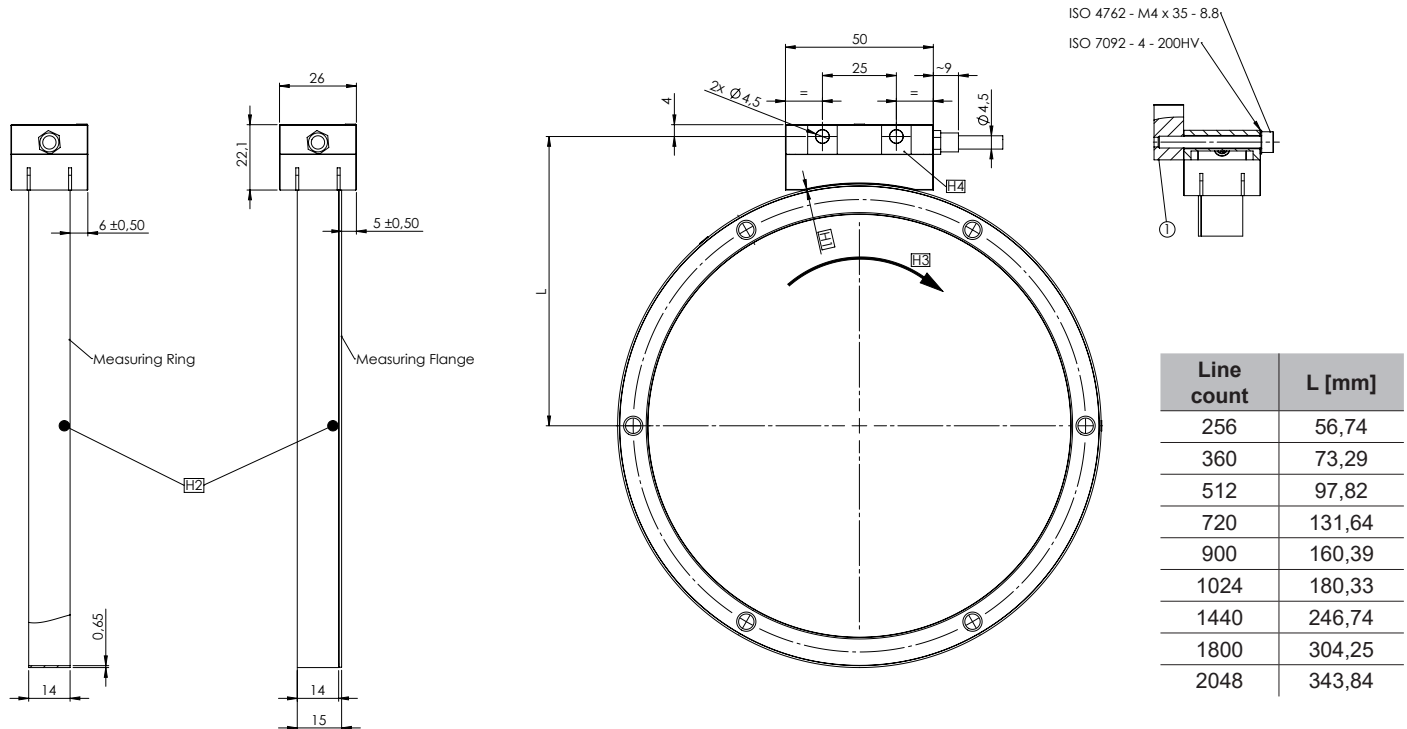
\*The temperature specification refers to an ambient temperature of 22 °C. If the ambient temperature is different, adopt the assembling temperature accordingly

# WMKA 2010/2210 series

Absolute angle encoder for safety-related applications

- Composed of scanning head WMKA 2010 and scale tape ring on flange or scale tape ring
- Safe absolute position value
- Fault exclusion for the loosening of the mechanical connection

## Design 20 - Outside scanning

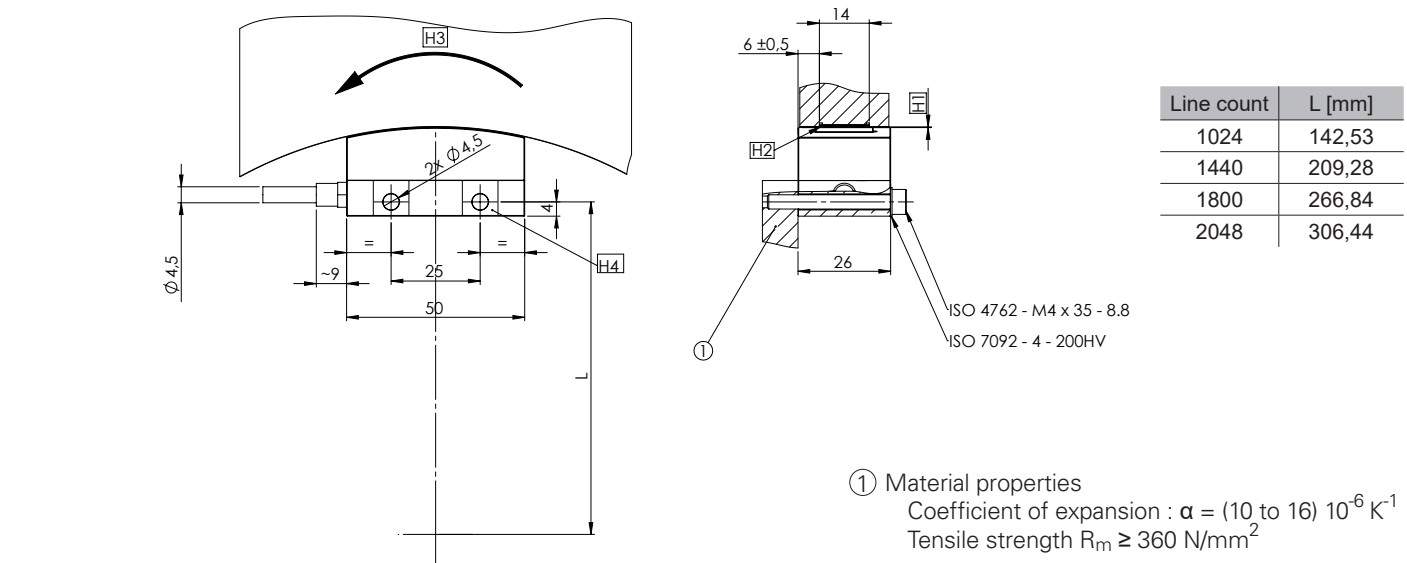


# WMKA 2110/2310 series

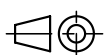
Absolute angle encoder for safety-related applications

- Composed of scanning head WMKA 2110 and scale tape ring
- Safe absolute position value
- Fault exclusion for the loosening of the mechanical connection

## Design 20 - Inside scanning



- ① Material properties  
Coefficient of expansion :  $\alpha = (10 \text{ to } 16) \cdot 10^{-6} \text{ K}^{-1}$   
Tensile strength  $R_m \geq 360 \text{ N/mm}^2$



Tolerance principle in accordance with ISO 8015  
General tolerances in accordance with ISO 2768-fH  
All dimensions in mm

- H1 = Air gap  $0,15 \pm 0,10 \text{ mm}$ , set with spacer foil  
H2 = Reference track marking  
H3 = Direction of shaft rotation for positive counting  
H4 = Ground plane (both sides)



## Technical data

Scanning head										WMKA 2010/2210 / 2110/2310									
Line count <sup>1)</sup>		256 <sup>2)</sup>		360 <sup>2)</sup>		512 <sup>2)</sup>		720 <sup>2)</sup>		900 <sup>2)</sup>		1024		1440		1800		2048	
Position error per grating period <sup>3)</sup>																			
High accuracy		± 3,0 ″		± 2,0 ″		± 1,5 ″		± 1,0 ″		± 1,0 ″		± 1,0 ″		± 0,5 ″		± 0,5 ″		± 0,5 ″	
Interface		EnDat 2.2										DRIVE - CLiQ							
Designation		EnDat 2.2										DQ							
Clock frequency		≤ 16 MHz										100 MBit/s							
Max. Position/Rotation		22 bit (4194304)				23 bit (8388608)						24 bit (16777216)						25 bit (33554432)	
Max. electrical speed [rpm]		≤ 4680		≤ 3330		≤ 2340		≤ 1660		≤ 1330		≤ 1170		≤ 830		≤ 660		≤ 580	
Functional safety for applications up to		<ul style="list-style-type: none"><li>• SIL 2 according to EN 61508 (further basic for testing: EN 61800 - 5 - 2)</li><li>• Category 3, PL d as per EN ISO 13849-1: 2015</li></ul>																	
PFH		≤ 36 · 10 <sup>-9</sup>										≤ 38 · 10 <sup>-9</sup>							
Safe position <sup>4)</sup>		± 0,88°				± 0,44°						± 0,22°						± 0,11°	
Safety-related measuring step SM		0,352° (10 bit)				0,176° (11 bit)						0,088° (12 bit)						0,044° ( 13 bit)	
Electrical connection		Cable with M12 coupling, 8-pin, male																	
Cable length on the encoder		0,5m to 6m										0,5m or 1,0m							
Voltage supply <sup>5)</sup>		DC 3,6V to 14V										DC 10V to 36V							
Power consumption		≤ 1,5W at 5V										≤ 2,1W at 24V							
Typical current consumption		300mA at 5V										85mA at 24V							
Max. mechanical speed [rpm] <sup>6)</sup>																			
Measuring ring WMRA		46800		33300		23400		16600		13300		11700		8300		6600		5800	
Measuring ring on flange WMFA		25000		20000		15000		10000		8000		6000		-		-		-	
Shock 6ms		< 1000m/s² (EN 60068-2-27)																	
Vibration 55 to 2000 Hz		< 200m/s² (EN 60068-2-6)																	
Operating temperature		-10°C to 85°C										-10°C to 75°C							
Storage temperature <sup>7)</sup>		-20°C to 85°C																	
Protection		IP67																	
Mass approximate		40g (without cable)																	

<sup>1)</sup> Other line counts on demand.

<sup>2)</sup> Not for inside scanning.

<sup>3)</sup> The position error per grating period and the accuracy of the grating (see technical data of the scale tape ring or scale tape ring on flange) results together in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error. Unfavourable operating conditions or operating out of the specified operating conditions can influence the specified values.

<sup>4)</sup> Further tolerances may occur in subsequent electronic after position value comparison (contact manufacture of subsequent electronics).

<sup>5)</sup> Only provide power from PELV systems (see EN 50178 for an explanation of the term) to position encoders.

<sup>6)</sup> Values must be taken into account to ensure a mechanical fault exclusion.

<sup>7)</sup> The measuring device must only be transported in its original packaging. Storage temperature also applies to transportation.



## Technical data

Scanning head										WMKA 2010/2210 - 2110/2310									
Line count <sup>1)</sup>		256 <sup>2)</sup>		360 <sup>2)</sup>		512 <sup>2)</sup>		720 <sup>2)</sup>		900 <sup>2)</sup>		1024		1440		1800		2048	
Position error per grating period <sup>3)</sup>																			
High accuracy		± 3,0 "		± 2,0 "		± 1,5 "		± 1,0 "		± 1,0 "		± 1,0 "		± 0,5 "		± 0,5 "		± 0,5 "	
Interface		EnDat3																	
Designation		E30 - R2								E30 - R4									
XEL.time HPFout Data rate		≤ 11µs at 12,5Mbit/s ≤ 8,2µs at 25Mbit/s																	
Max. Positionen/Rotation		22 bit (4194304)				23 bit (8388608)						24 bit (16777216)						25 bit (33554432)	
Max. electrical speed [rpm]		≤ 4680		≤ 3330		≤ 2340		≤ 1660		≤ 1330		≤ 1170		≤ 830		≤ 660		≤ 580	
Functional safety for applications up to		<ul style="list-style-type: none"><li>SIL 2 according to EN 61508 (further basic for testing: EN 61800 - 5 - 2)</li><li>Category 3, PL d as per EN ISO 13849-1: 2015</li></ul>																	
PFH		≤ 40 · 10 <sup>-9</sup>																	
Safe position <sup>4)</sup>		± 0,88°				± 0,44°						± 0,22°						± 0,11°	
Safety-related measuring step SM		0,352° (10 bit)				0,176° (11 bit)						0,088° (12 bit)						0,044° ( 13 bit)	
Electrical connection		Cable with M12 coupling, 8-pin, male																	
Cable length on the encoder		0,5m to 6m																	
Cable length overall		≤ 100m at 12,5MBit/s ≤ 40m at 25MBit/s																	
Voltage supply <sup>5)</sup>		DC 4,0 to 14V								DC 3,6V to 14V									
Power consumption		maximum 1,5W																	
Typical current consumption		12V:115mA																	
Max. mechanical speed [rpm] <sup>6)</sup>																			
Measuring ring WMRA		46800		33300		23400		16600		13300		11700		8300		6600		5800	
Measuring ring on flange WMFA		25000		20000		15000		10000		8000		6000		-		-		-	
Shock 6ms		< 1000m/s² (EN 60068-2-27)																	
Vibration 55 to 2000 Hz		< 200m/s² (EN 60068-2-6)																	
Operating temperature		-10°C to 85°C																	
Storage temperature <sup>7)</sup>		-20°C to 85°C																	
Protection		IP67																	
Mass approximate		40g (without cable)																	

<sup>1)</sup> Other line counts on demand.

<sup>2)</sup> Not for inside scanning.

<sup>3)</sup> The position error per grating period and the accuracy of the grating (see technical data of the scale tape ring or scale tape ring on flange) results together in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error. Unfavourable operating conditions or operating out of the specified operating conditions can influence the specified values.

<sup>4)</sup> Further tolerances may occur in subsequent electronic after position value comparison (contact manufacture of subsequent electronics).

<sup>5)</sup> Only provide power from PELV systems (see EN 50178 for an explanation of the term) to position encoders.

<sup>6)</sup> Values must be taken into account to ensure a mechanical fault exclusion.

<sup>7)</sup> The measuring device must only be transported in its original packaging. Storage temperature also applies to transportation.

# Ordering code

- WMKA - Scanning head for absolute angle encoder
- Grating period 1000µm
- Suitable for safety-related applications

**WMKA 2 10 HA . 14 FS NN - 20 - 1SS08 -**

**Scanning**

0 = Outside scanning  
1 = Inside scanning  
2 = Outside scanning, segment solution  
3 = Inside scanning, segment solution

**Performance**

HA = High Accuracy

**Interface**

01 = EnDat 2.2  
14 = DRIVE-CLiQ  
29 = EnDat 3-E30-R2  
30 = EnDat 3-E30-R4

**Interpolation factor digital**

14 = 14 Bit

**Line count**

256 <sup>1)</sup>  
360 <sup>1)</sup>  
512 <sup>1)</sup>  
720 <sup>1)</sup>  
900 <sup>1)</sup>  
1024  
1440  
1800  
2048

**Functional safety**

FS = can be used for safety related equipment

**Pin configuration**

C4 = 1SS08  
TV = DRIVE-CLiQ  
Iu = EnDat 3-E30-R2  
Ix = EnDat 3-E30-R4

**Electrical connection**

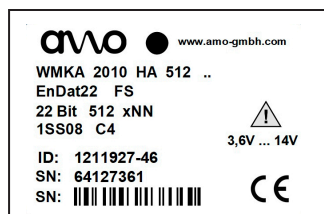
1SS08 = M12 8pin coupling male

**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

<sup>1)</sup> Not for inside scanning

## Type label, exemplary



## WMKA 2x10

ID	Description
1211927 - xx	WMKA 2010/2210 - EnDat 2.2, outside scanning, Functional safety
1211929 - xx	WMKA 2110/2310 - EnDat 2.2, inside scanning, Functional safety
1211932 - xx	WMKA 2010/2210 - DRIVE-CLiQ, outside scanning, Functional safety
1211933 - xx	WMKA 2110/2310 - DRIVE-CLiQ, inside scanning, Functional safety
1403446 - xx	WMKA 2010 - EnDat 3-E30-R2, outside scanning, Functional safety
1403449 - xx	WMKA 2110 - EnDat 3-E30-R2, inside scanning, Functional safety
1403452 - xx	WMKA 2210 - EnDat 3-E30-R2, outside scanning, Functional safety
1403453 - xx	WMKA 2310 - EnDat 3-E30-R2, inside scanning, Functional safety
1403454 - xx	WMKA 2010 - EnDat 3-E30-R4, outside scanning, Functional safety
1403455 - xx	WMKA 2110 - EnDat 3-E30-R4, inside scanning, Functional safety
1403456 - xx	WMKA 2210 - EnDat 3-E30-R4, outside scanning, Functional safety
1403457 - xx	WMKA 2310 - EnDat 3-E30-R4, inside scanning, Functional safety

DRIVE-CLiQ is a registered trademark of Siemens AG.

# Functional Safety - Absolute linear encoders

With the absolute linear encoders of the LMKA 2010 and LMKA 3010 series, AMO offers an ideal solution for position determination on linear axes in safety-related applications. In conjunction with safe control, the encoders can be used as single-encoder systems in applications with control category SIL 2 (according EN 61508) or performance level „d“ (according EN ISO 13849).

The basis for the safe transmission of the position are two independently formed ab-

solute position values as well as error bits which are provided to the safe control. The functions of the measuring instrument can be used for numerous safety functions of the entire system according to EN 61800-5-2.

The linear encoders LMKA 2010 and LMKA 3010 create at any time – for example also immediately after switch on - a safe absolute position value. The purely serial data transmission is done via the bidirectional EnDat 2.2, EnDat 3 or DRIVE-CLiQ Interface.

In addition to the data interface, the mechanical connection of the linear encoder to the drive is also relevant for the safety.

D 8 of the standard for electrical drives, EN 61800-5-2, defines the loosening of the mechanical connection between the encoder and drive as a fault that requires consideration. Since it cannot be guaranteed that the control will detect such errors, a fault exclusion for the loosening of the mechanical connection is frequently required.

## 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 mecha-

nical 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 material 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 $\alpha$	(10 to 16) $10^{-6} \text{ K}^{-1}$
Environmental conditions	
Pollution	dry environment, no oils, cutting fluid or other liquid substances
Operating temperature	-10 °C to 85 °C
Max. acceleration	$\pm 50 \text{ m/s}^2$ in direction of movement
Shock 6ms	$< 1000 \text{ m/s}^2$ (EN 60068-2-27)

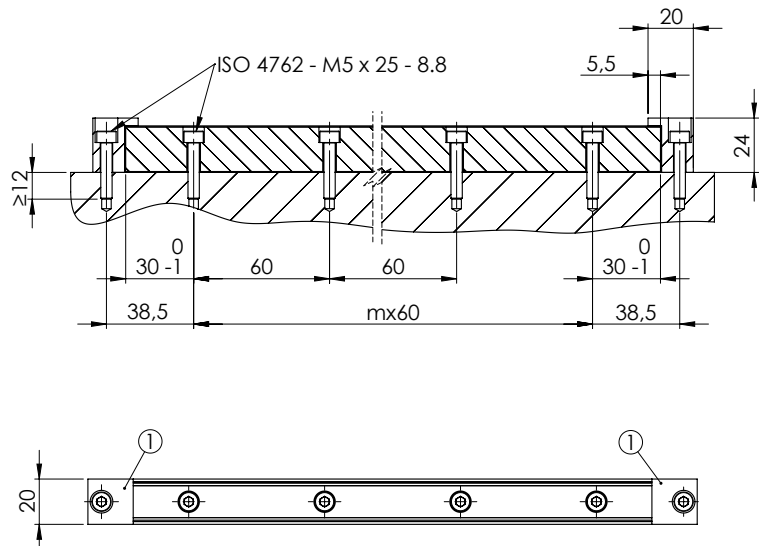
Fault exclusion LMFA 3010 - Measuring rail

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

Minimum screw 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 $\alpha$	$(10 \text{ to } 16) \cdot 10^{-6} \text{ K}^{-1}$
Tensile strength $R_m$	$\geq 360 \text{ N/mm}^2$
Measuring rail assembly	
Screws	ISO 4762 - M5 x L - 8.8
Torque $M_d$	$5,0 \pm 0,2 \text{ Nm}$
Length of thread engagement	$\geq 10 \text{ mm}$
Free clamped length	$\geq 13,2 \text{ mm}$
Environmental conditions	
Operating temperature	$-10^{\circ}\text{C}$ to $85^{\circ}\text{C}$
Max. acceleration	$\pm 50 \text{ m/s}^2$ in direction of movement
Shock 6ms	$< 1000 \text{ m/s}^2$ (EN 60068-2-27)

Recommended assembly



① Accessory 1244592-04 End Clamp LMFA

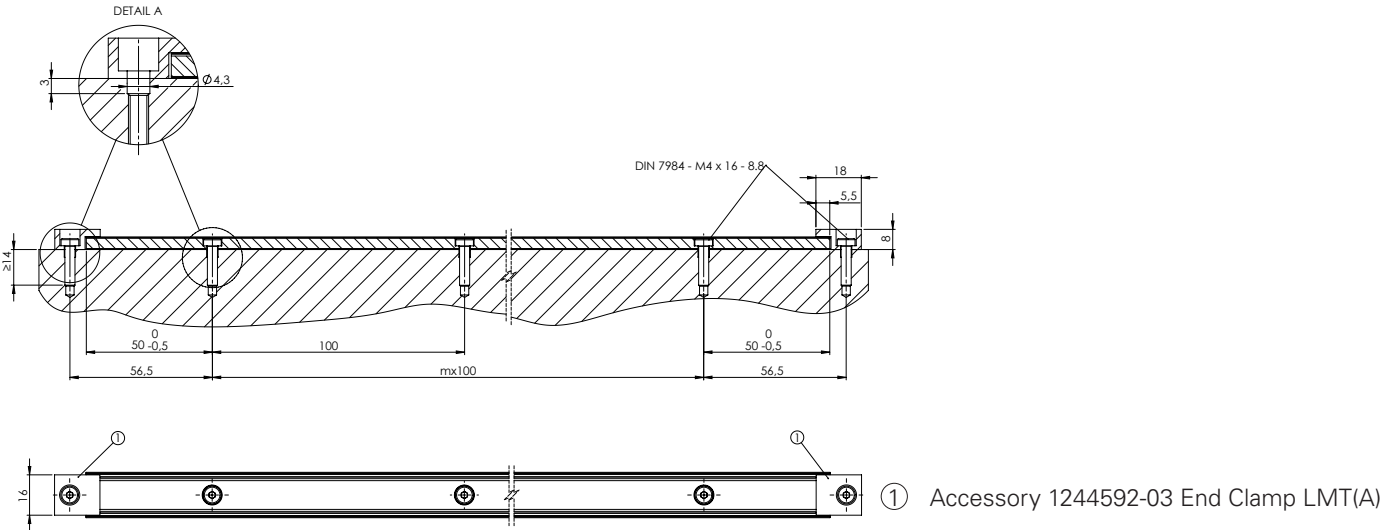
Fault exclusion LMTA 4010 - Scale tape in stainless steel carrier

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

Minimum screw 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 $\alpha$	$(10 \text{ to } 16) \cdot 10^{-6} \text{ K}^{-1}$
Tensile strength $R_m$	$\geq 360 \text{ N/mm}^2$
Carrier assembly	
Screws	DIN 7984 - M4x L - 8.8
Torque $M_d$	$2,0 \pm 0,2 \text{ Nm}$
Length of thread engagement	$\geq 8 \text{ mm}$
Free clamped length	$\geq 5 \text{ mm}$
Environmental conditions	
Operating temperature	$-10^{\circ}\text{C to } 100^{\circ}\text{C}$
Max. acceleration	$\pm 50 \text{ m/s}^2$ in direction of movement
Shock 6ms	$< 1000 \text{ m/s}^2$ (EN 60068-2-27)

Recommended assembly

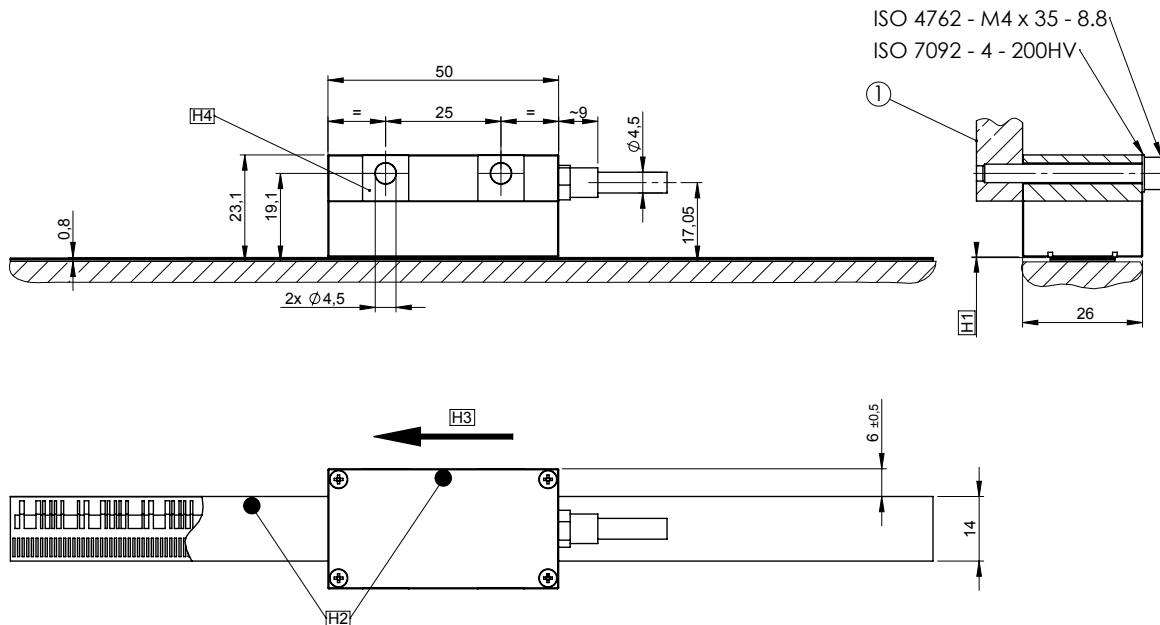


## Absolute linear encoder series for safety-related applications

- **Composed of scanning head LMKA 2010 and scale tape**
- **Safe absolute position value**
- **Fault exclusion for the loosening of the mechanical connection**

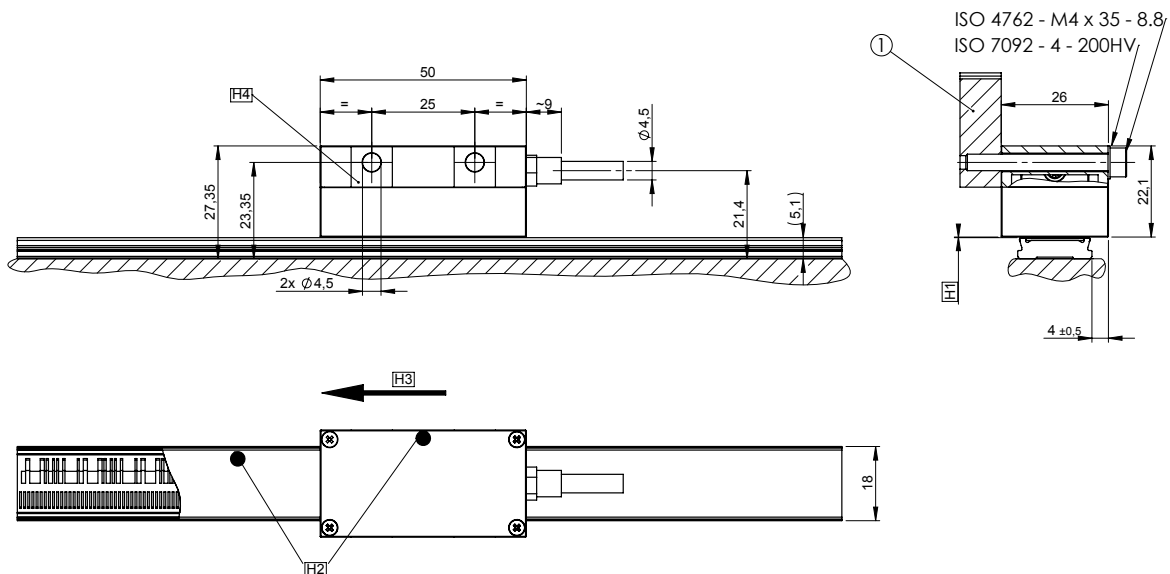
## Design 20

**with scale tape LMBA 2010 / 2110**

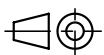


## Design 20

**with scale tape LMTA 4010 / 4110**



- ① Material properties  
Coefficient of expansion :  $\alpha = (10 \text{ to } 16) \cdot 10^{-6} \text{ K}^{-1}$   
Tensile strength  $R_m \geq 360 \text{ N/mm}^2$



Tolerance principle in accordance with ISO 8015  
General tolerances in accordance with ISO 2768-fH  
All dimensions in mm

H1 = Air gap  $0,15 \pm 0,10\text{mm}$ , set with spacer foil  
H2 = Absolute track marking  
H3 = Direction of scanning head movement for positive counting  
H4 = Ground plane (both sides)

## Technical data

Scanning head LMKA 2010 / 2110		
Position error per grating period <sup>1)</sup>		
High accuracy	$\pm 0,5 \mu\text{m}$	
<b>Interface</b>	EnDat 2.2	DRIVE - CLiQ
Designation	EnDat 2.2	DQ
Clock frequency	$\leq 16 \text{ MHz}$	100 MBit/s
Measuring step		
High accuracy	$0,1 \mu\text{m}$	
<b>Functional safety</b> for applications up to	<ul style="list-style-type: none"> <li>• SIL 2 according to EN 61508 (further basic for testing: EN 61800 - 5 - 2)</li> <li>• Categorie 3, PL d according to EN ISO 13849-1: 2015</li> </ul>	
PFH	$\leq 36 \cdot 10^{-9}$	$\leq 38 \cdot 10^{-9}$
Safe position <sup>2)</sup>	$\pm 625 \mu\text{m}$	
Safety-related measuring step SM	$250 \mu\text{m}$	
<b>Electrical connection</b>	Cable with M12 coupling, 8-pin, male	
Cable length on scanning head	0,5m to 6m	0,5m or 1,0m
Voltage supply <sup>3)</sup>	DC 3,6V to 14V	DC 10V to 36V
Power consumption	$\leq 1,5\text{W}$ at 5V	$\leq 2,1\text{W}$ at 24V
Typical current consumption	300mA at 5V	85mA at 24V
<b>Maximum speed</b>	$\leq 20 \text{ m/s}$	
Shock 6ms	$< 1000\text{m/s}^2$ (EN 60068-2-27)	
Vibration 55 to 2000 Hz	$< 200\text{m/s}^2$ (EN 60068-2-6)	
Operating temperature	$-10^\circ\text{C}$ to $85^\circ\text{C}$	$-10^\circ\text{C}$ to $75^\circ\text{C}$
Storage temperature <sup>4)</sup>	$-20^\circ\text{C}$ to $85^\circ\text{C}$	
Protection	IP67	
Mass approximate	40g (without cable)	

<sup>1)</sup> The position error per grating and the accuracy of the grating result together in the encoder specific error; additional deviations caused by mounting are not considered in this error. Special operating conditions that do not correspond to normal operation or operation outside the specified range have an influence on the given values.

<sup>2)</sup> Further tolerances may occur in subsequent electronic after position value comparison (contact manufacture of subsequent electronics).

<sup>3)</sup> Only provide power from PELV systems (see EN 50178 for an explanation of the term) to position encoders.

<sup>4)</sup> The measuring device must only be transported in its original packaging. Storage temperature also applies to transportation.



## Technical data

Scanning head		LMKA 2010 / 2110	
Position error per grating period <sup>1)</sup>			
High accuracy	± 0,5 µm		
Interface	EnDat 3		
Designation	E30 - R2	E30 - R4	
XEL.time HPFout Data rate	≤ 11µs at 12,5Mbit/s ≤ 8,2µs at 25Mbit/s		
Measuring step			
High accuracy	0,1 µm		
Functional safety for applications up to	<ul style="list-style-type: none"><li>• SIL 2 according to EN 61508 (further basic for testing: EN 61800 - 5 - 2)</li><li>• Categorie 3, PL d according to EN ISO 13849-1: 2015</li></ul>		
PFH	≤ 40 · 10 <sup>-9</sup>		
Safe position <sup>2)</sup>	± 625 µm		
Safety-related measuring step SM	250 µm		
Electrical connection	Cable with M12 coupling, 8-pin, male		
Cable length on scanning head	0,5m to 6m		
cable length overall	≤ 100m at 12,5MBit/s ≤ 40m at 25MBit/s		
Voltage supply <sup>3)</sup>	DC 4,0 to 14V	DC 3,6 to 14V	
Power consumption	1,5W		
Typical current consumption	12V : 115mA		
Maximum speed	≤ 20 m/s		
Shock 6ms	< 1000m/s² (EN 60068-2-27)		
Vibration 55 to 2000 Hz	< 200m/s² (EN 60068-2-6)		
Operating temperature	-10°C to 85°C		
Storage temperature <sup>4)</sup>	-20°C to 85°C		
Protection	IP67		
Mass approximate	40g (without cable)		

<sup>1)</sup> The position error per grating and the accuracy of the grating result together in the encoder specific error; additional deviations caused by mounting are not considered in this error. Special operating conditions that do not correspond to normal operation or operation outside the specified range have an influence on the given values.

<sup>2)</sup> Further tolerances may occur in subsequent electronic after position value comparison (contact manufacture of subsequent electronics).

<sup>3)</sup> Only provide power from PELV systems (see EN 50178 for an explanation of the term) to position encoders.

<sup>4)</sup> The measuring device must only be transported in its original packaging. Storage temperature also applies to transportation.

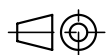
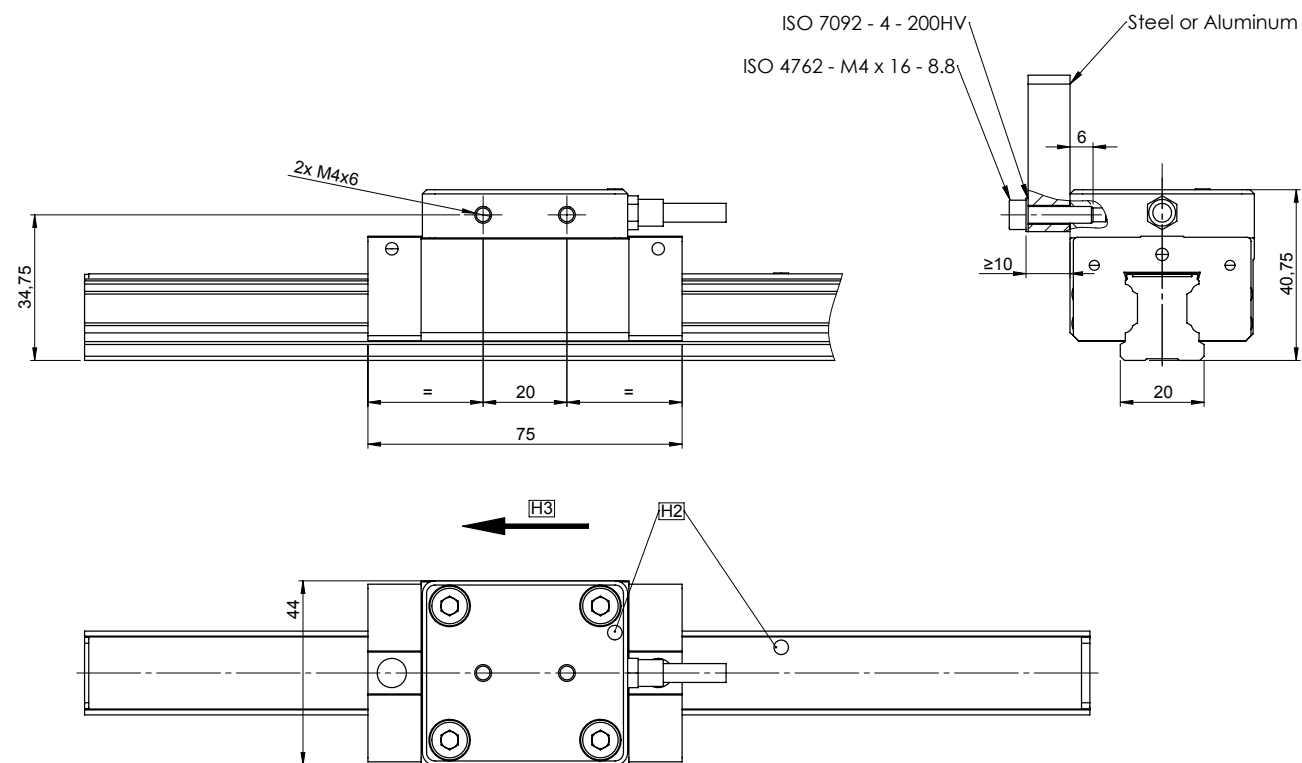
# LMKA 3010 / 3110 series

Absolute linear encoder for safety-related applications

- Composed of scanning head LMKA 3010 and measuring rail
- Safe absolute position value
- Fault exclusion for the loosening of the mechanical connection

## Design 30

with measuring rail LMFA 3010/3110



Tolerance principle in accordance with ISO 8015  
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

Scanning head LMKA 3010 / 3110		
Position error per grating period <sup>1)</sup>		
High accuracy	$\pm 0,5 \mu\text{m}$	
Interface	EnDat 2.2	DRIVE - CLiQ
Designation	EnDat 2.2	DQ
Clock frequency	$\leq 16 \text{ MHz}$	100 MBit/s
Measuring step		
High accuracy	$0,1 \mu\text{m}$	
Functional safety for applications up to	<ul style="list-style-type: none"> <li>SIL 2 according to EN 61508 (further basic for testing: EN 61800 - 5 - 2)</li> <li>Categorie 3, PL d as per EN ISO 13849-1: 2015</li> </ul>	
PFH	$\leq 36 \cdot 10^{-9}$	$\leq 38 \cdot 10^{-9}$
Safe position <sup>2)</sup>	$\pm 625 \mu\text{m}$	
Security-related measuring step SM	$250 \mu\text{m}$	
Electrical Connection	Cable with M12 coupling, 8-pin, male	
Cable lenght on the encoder	0,5m to 6m	0,5m or 1,0m
Voltage supply <sup>3)</sup>	DC 3,6V to 14V	DC 10V to 36V
Power consupction	$\leq 1,5\text{W}$ at 5V	$\leq 2,1\text{W}$ at 24V
Typical current consumption	300mA at 5V	85mA at 24V
Maximum speed	$\leq 5 \text{ m/s}$ (limited by the mechanics)	
Shock 6ms	$< 1000\text{m/s}^2$ (EN 60068-2-27)	
Vibration 55 to 2000 Hz	$< 200\text{m/s}^2$ (EN 60068-2-6)	
Operating temperature	$-10^\circ\text{C}$ to $85^\circ\text{C}$	$-10^\circ\text{C}$ to $75^\circ\text{C}$
Storage temperature	$-20^\circ\text{C}$ to $85^\circ\text{C}$	
Protection	IP67	
Mass approximate	210g (without cable)	

<sup>1)</sup> The position error per grating and the accuracy of the grating result together in the encoder specific error; additional deviations caused by mounting are not considered in this error. Special operating conditions that do not correspond to normal operation or operation outside the specified range have an influence on the given values.

<sup>2)</sup> Further tolerances may occur in subsequent electronic after position value comparison (contact manufacture of subsequent electronics).

<sup>3)</sup> Only provide power from PELV systems (see EN 50178 for an explanation of the term) to position encoders.

<sup>4)</sup> The measuring device must only be transported in its original packaging. Storage temperature also applies to transportation.

## Technical data

Scanning head		LMKA 3010 / 3110	
Position error per grating period <sup>1)</sup>			
High accuracy		± 0,5 µm	
Interface		EnDat 3	
Designation		E30 - R2	E30 - R4
XEL.time HPFout Data rate		≤ 11µs at 12,5Mbit/s ≤ 8,2µs at 25Mbit/s	
Measuring step			
High accuracy		0,1 µm	
Functional safety for applications up to		<ul style="list-style-type: none"><li>• SIL 2 according to EN 61508 (further basic for testing: EN 61800 - 5 - 2)</li><li>• Categorie 3, PL d according to EN ISO 13849-1: 2015</li></ul>	
PFH		≤ 40 · 10 <sup>-9</sup>	
Safe position <sup>2)</sup>		± 625 µm	
Safety-related measuring step SM		250 µm	
Electrical connection		Cable with M12 coupling, 8-pin, male	
Cable length on scanning head		0,5m to 6m	
cable length overall		≤ 100m at 12,5MBit/s ≤ 40m at 25MBit/s	
Voltage supply <sup>3)</sup>		DC 4,0 to 14V	DC 3,6 to 14V
Power consumption		1,5W	
Typical current consumption		12V : 115mA	
Maximum speed		≤ 5 m/s (limited by the mechanic)	
Shock 6ms		< 1000m/s² (EN 60068-2-27)	
Vibration 55 to 2000 Hz		< 200m/s² (EN 60068-2-6)	
Operating temperature		-10°C to 85°C	
Storage temperature		-20°C to 85°C	
Protection		IP67	
Mass approximate		210g (without cable)	

<sup>1)</sup> The position error per grating and the accuracy of the grating result together in the encoder specific error; additional deviations caused by mounting are not considered in this error. Special operating conditions that do not correspond to normal operation or operation outside the specified range have an influence on the given values.

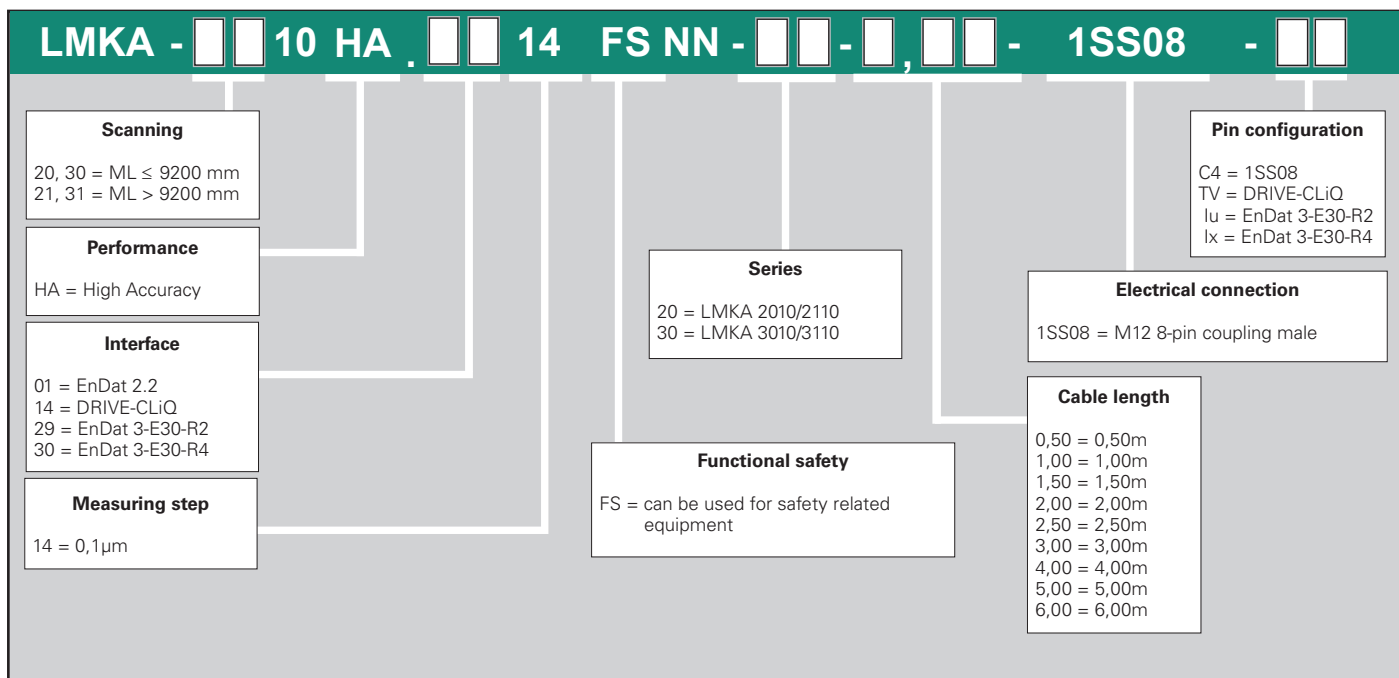
<sup>2)</sup> Further tolerances may occur in subsequent electronic after position value comparison (contact manufacture of subsequent electronics).

<sup>3)</sup> Only provide power from PELV systems (see EN 50178 for an explanation of the term) to position encoders.

<sup>4)</sup> The measuring device must only be transported in its original packaging. Storage temperature also applies to transportation.

# Ordering code

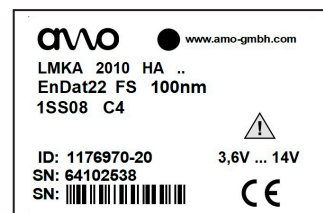
- LMKA - Scanning head for absolute linear encoders
- Grating period 1000µm
- Suitable for safety-related applications



## LMKA 2x10

ID	Beschreibung
1211910 - xx	LMKA 2010 - EnDat 2.2, ML ≤ 9200 mm, Functional safety
1211911 - xx	LMKA 2110 - EnDat 2.2, ML > 9200 mm, Functional safety
1211914 - xx	LMKA 2010 - DRIVE-CLiQ, ML ≤ 9200 mm, Functional safety
1211915 - xx	LMKA 2110 - DRIVE-CLiQ, ML > 9200 mm, Functional safety
1403458 - xx	LMKA 2010 - EnDat E30-R2, ML ≤ 9200 mm, Functional safety
1403459 - xx	LMKA 2110 - EnDat E30-R2, ML > 9200 mm, Functional safety
1403463 - xx	LMKA 2010 - EnDat E30-R4, ML ≤ 9200 mm, Functional safety
1403464 - xx	LMKA 2110 - EnDat E30-R4, ML > 9200 mm, Functional safety

## Type label, exemplary



## LMKA 3x10

ID	Beschreibung
1211918 - xx	LMKA 3010 - EnDat 2.2, ML ≤ 9200 mm, Functional safety
1211919 - xx	LMKA 3110 - EnDat 2.2, ML > 9200 mm, Functional safety
1211922 - xx	LMKA 3010 - DRIVE-CLiQ, ML ≤ 9200 mm, Functional safety
1211923 - xx	LMKA 3110 - DRIVE-CLiQ, ML > 9200 mm, Functional safety
1403461-xx	LMKA 3010 - EnDat E30-R2, ML ≤ 9200 mm, Functional safety
1403462-xx	LMKA 3110 - EnDat E30-R2, ML > 9200 mm, Functional safety
1403466-xx	LMKA 3010 - EnDat E30-R4, ML ≤ 9200 mm, Functional safety
1403467-xx	LMKA 3110 - EnDat E30-R4, ML > 9200 mm, Functional safety

## Type label, exemplary



DRIVE-CLiQ is a registered trademark of Siemens AG.

# Interfaces

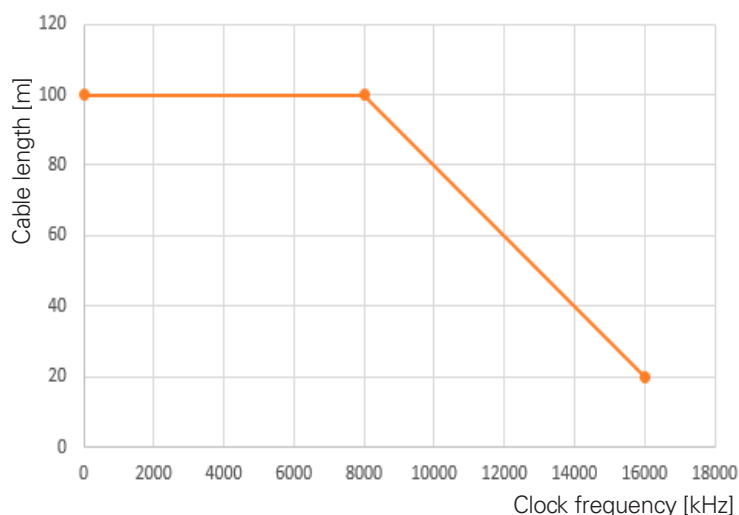
## Position values

The EnDat-Interface is a digital, bi-directional Interface for measuring systems. With this interface you can read 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 data transfer four signal wires are enough. The data DATA gets transferred synchronously 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.

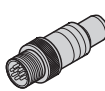

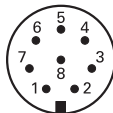


The clock frequency is variable - depending on the cable length (max. 100m). With propagation electronics, either clock frequencies up to 16MHz are possible or cable length up to 100m. For EnDat encoders the maximum clock frequency is stored in the encoder memory. Propagation-delay compensation is provided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

Transmission frequencies up to 16MHz in combination with large cable length place high technological demands in the cable. Greater cable lengths 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.

Ordering code	Commands	Incremental singlas
EnDat22	EnDat 2.2	Without



### Pin configuration

Electrical connection: 1SS08 8-pin coupling M12   								
	Power supply				Absolute position values			
	8	2	5	1	3	4	7	6
	<b>U<sub>P</sub></b>	<b>Sensor U<sub>P</sub></b>	<b>0V</b>	<b>Sensor 0V</b>	<b>DATA+</b>	<b>DATA-</b>	<b>CLOCK+</b>	<b>CLOCK-</b>
	brown/green	blue	white/green	white	grey	pink	violet	yellow

**Cabel shield** is connected with the housing; **U<sub>P</sub>** = 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

## Position Values

EnDat 3 transfers the properties and Advantages of EnDat in a digital future Production. Therefore EnDat 3 is setting onto a new architecture which continues the well known and tested. It is aspired to obtain the compatibility to the previous interfaces.

### EnDat3 characteristics:

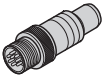




- Data transfer in hybrid cable
- Bus-topologies
- Sensoric: flexibility for data content and sensorbox
- functional safety: communication according to the black channel principle
- Higher data bandwidth
- Definition of broadcast lists
- System installation: introduction of Access levels

Interface	
Protocol	Request-Response-Process in Halfduplex
Physic	RS-485: 4-wires oder 2-wires
Data rate	12,5 Mbit/s (25 Mbit/s)
cable length	max. 100m at 12,5 Mbit/s / max. 40m at 25 Mbit/s
HPF - timing (availability of the position in master)	typ. 10µs (the parameter XEL.timeHPFout defines the timerange between the generation of the position value (Latch) and sending the complete HPF - without cable impacts)
cycle time	typ. > 25µs

supported communications	E30-R2	E30-R4
EnDat 3: Communication is mudulated on supply wires	✓	-
Endat 3: Communication + seperate Supply wires (4-wires)	-	✓
EnDat 3: Bus operation	-	-
Integration sensorbox	-	✓

## Pin configuration

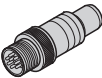




### pin configuration for EnDat 3 E30-R2

electrical connection: 1SS08 8-pin coupling <b>M12</b>   								
Supply voltage / serial data transfer								
	<b>7</b>	<b>6</b>	<b>8</b>	<b>2</b>	<b>5</b>	<b>1</b>	<b>3</b>	<b>4</b>
	<b>P_SD+<sup>1)</sup></b>	<b>P_SD-<sup>1)</sup></b>	-	-	-	-	-	-
	violett	yellow	-	-	-	-	-	-

**cable shield** is connected with the housing; **U<sub>P</sub>** = Power supply voltage

<sup>1)</sup> **Power supply and Data:** **P\_SD+** contains U<sub>P</sub> ; **P\_SD-** contains 0V

### pin configuration for EnDat 3 E30-R4

electrical connection: 1SS08 8-pin coupling <b>M12</b>   			
Supply voltage / serial Data transfer			
	<b>8</b>	<b>5</b>	<b>7</b>
	<b>+V (U<sub>P</sub>)</b>	<b>0V (U<sub>n</sub>)</b>	<b>SD+</b>
	brown-green	white-green	violett

**cable shield** is connected with the housing; **U<sub>P</sub>** = Power supply voltage




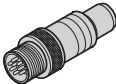


# Interfaces

## Pin configuration DRIVE - CLiQ

AMO encoders with interface type "14" according to the order designation are suitable for connection to Siemens controllers with DRIVE-CLiQ interface.

- Designation DQ

### Pin configuration

Electrical connection: 1SS08 8-pin coupling M12						
  						
	Power supply		Absolute position values			
			Send data		Receive data	
	1	5	7	6	3	4
	U <sub>P</sub>	0V	TXP	TXN	RXP	RXN

Cabel shield is connected with the housing; U<sub>P</sub> = Power supply voltage

DRIVE-CLiQ is a registered trademark of Siemens AG.

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