AMO GmbH

Modular angle encoders based on the inductive AMOSIN® – Measuring Principle

October 2017

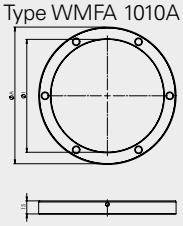
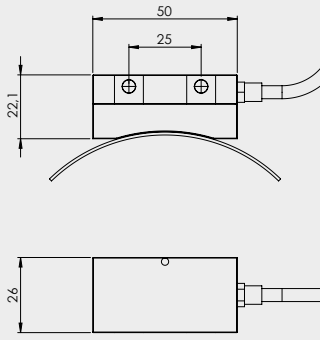
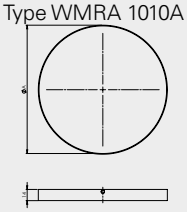
This document was created very carefully. If there are any technical changes, they will promptly updated in the documents on our website www.amo-gmh.com.

This catalog supersedes all previous editions, which thereby become invalid. Standards (ISO, EN, etc.) apply only where explicitly stated in the catalog.

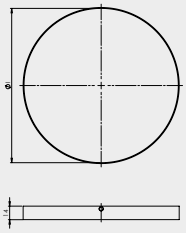
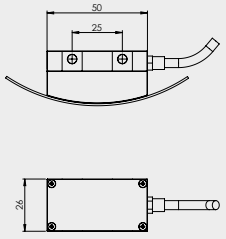
Selection table - absolute angle encoder

Grating period	Measuring scale					
	Measurements	Diameter	Grating accuracy	Mechanical speed	Measurements	

Outside scanning

1000µm	Type WMFA 1010A 	ØA: 81,95 mm to 326,55 mm ØI: 60,00 mm to 296 mm	single head scanning: ± 51“ to ± 4,0“ MHSA:[1] ± 25“ to ± 2,0“	14.000 to 3.500	Design: 20 
	Type WMRA 1010A 	ØA: 81,95 mm to 652,58 mm Other diameter on demand	single head scanning: ± 51“ to ± 2,0“ double head scanning MHSA: [1] ± 25“ to ± 1,0“	46.800 to 5.800	

Inside scanning

1000µm	Type WMRA 1110I 	ØI: 325,42 mm to 651,27 mm Other diameter on demand	single head scanning: ± 13“ to ± 2,0“ double head scanning MHSA: [1] ± 6,0“ to ± 1,0“	11.700 to 5.800	Design: 20 

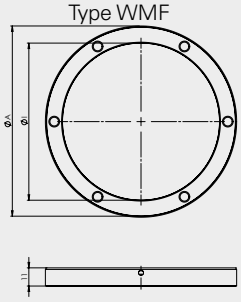
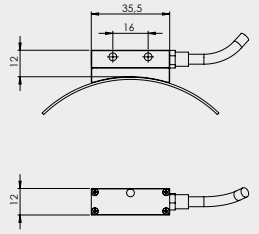
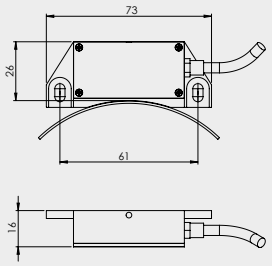
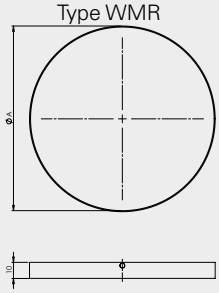
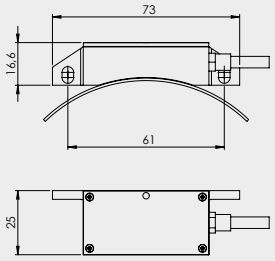
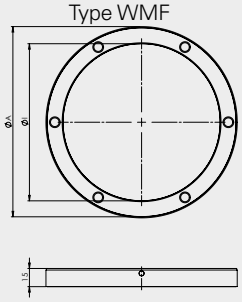
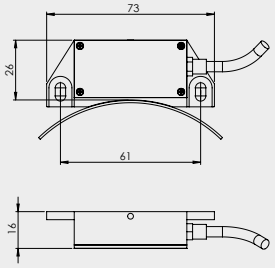
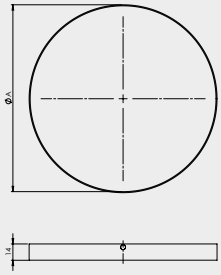
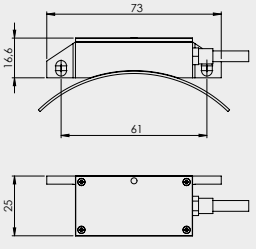
[1] see page 29

Scanning head				Type
	Interfaces	Resolution	Electrical speed	
	EnDat 2.2 FANUC SSI+1Vpp Mitsubishi BiSS/C	18 Bit to 25 bit	4.680 U/min to 580 U/min	**WMKA 2010** **WMRA 1010A**
	EnDat 2.2 FANUC SSI+1Vpp Mitsubishi BiSS/C	24 Bit to 25 bit	1170 U/min to 580 U/min	**WMKA 2110** **WMRA 1110I**

WMKA 2010 **WMRA 1010A**

WMKA 2110 **WMRA 1110I**

Selection table - incremental angle encoder for outside scanning

Measuring scale					
Grating period	**Measurements**	**Diameter**	**Grating accuracy**	**Mechanical speed**	**Measurements**
500µm 1000µm	Type WMF 	ØA: 81,95 mm to 326,55 mm ØI: 60,00 mm to 289 mm	single head scanning: ± 51“ to ± 4,0“ double head scanning (MHS):[1] ± 25“ to ± 2,0“	25.000 to 6.000	Design: 10,11,12 
					Design: 20 
1000µm	Type WMR 	ØA: 81,95 mm to 652,58 mm Other diameter on demand	single head scanning: ± 51“ to ± 2,0“ double head scanning (MHS):[1] ± 25“ to ± 1,0“	46.800 to 5.800	Design: 21 
3000µm	Type WMF 	ØA: 115,12 mm to 287,08 mm ØI: 60,00 mm to 266,00 mm	± 72“ to ± 7,5“	16600 to 8000	Design: 20 
	Type WMR 	ØA:115,12 to 489,57 Other diameter on demand	± 72“ to ± 4,5“	33300 to 3900	Design: 21 

[1] see page 48

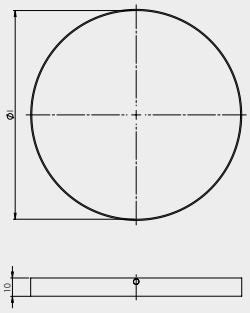
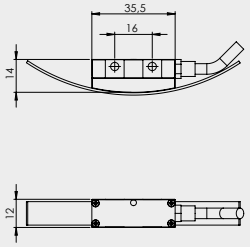
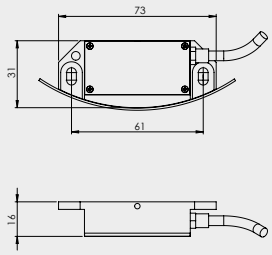
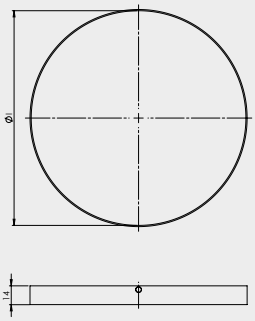
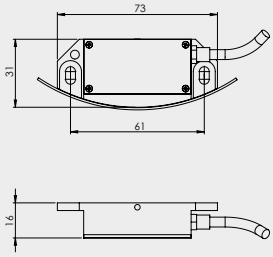
Scanning head				
	Resolution		Electrical speed	
	~ 1Vpp	⊓⊔ TTL		
	Standard: 1000 µm to 31,25 µm High Accuracy: 31,25 to 10µm	Standard: 250µm to 1µm High Accuracy: 0,5µm to 0,05µm	23430 U/min or 580 U/min	**WMK 1010** **WMK 2010** **WMR 1010A** **WMF 1010A** **WMK 1005** **WMK 2005** **WMF 1005A**
	Standard: 3000 µm to 93,75 µm	Standard: 750 µm to 3 µm	50000 U/min to 11700 U/min	**WMK 2030** **WMF 1030 A** **WMR 1030 A**

WMF 1010A **WMK 1010**
WMF 1005A **WMK 1005**

WMR 1010A **WMK 1010**

WMF 1010A **WMK 2010**
WMF 1005A **WMK 2005**

Selection table - incremental angle encoder for inside scanning

Grating period	Measuring scale				
	Measurements	Diameter	Gratingaccu-racy	Mechanical speed	Measurements
1000µm	Type WMR 	ØI: 163,54 mm to 651,27 mm Other diameter on demand	single head scanning: ± 26“ to ± 2,0“ double head scanning (MHS):[1] ± 13“ to ± 1,0“	23400 to 5800	Design: 10,11,12  Design: 20 
3000µm	Type WMR 	ØI: 162,91 to 489,57 mm Other diameter on demand	± 51“ to ± 4,5“	23500 to 7900	Design: 20 

[1] see page 48

Scanning head				Type
	Resolution		Electrical speed	
	∿ 1Vpp	⊓⊔ TTL		
	Standard: 1000 µm to 31,25 µm High Accuracy: 31,25 or 20µm	Standard: 250µm to 1µm High Accuracy: 0,5µm or 0,1µm	11710 U/min to 580 U/min	**WMK 1110** **WMK 2110** **WMR 1110I**
	Standard 3000 µm to 93,75µm	Standard 750 µm bis 3µm	50000 U/min to 11700 U/min	**WMK 2130** **WMR 1130I**

WMR 1110I **WMK 1110**

WMR 1110I **WMK 2110**

WMR 1130I **WMK 3110**

Measuring principle

Grating

AMO encoders function on the induktive AMOSIN® measuring principle.
The encoders incorporate measuring standards 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.
Using a sophisticated manufacturing process, closed scale tape rings are created. These scale tape rings can be delivered for mouting onto the mechanics at customer site or already mounted on a carrier.

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.

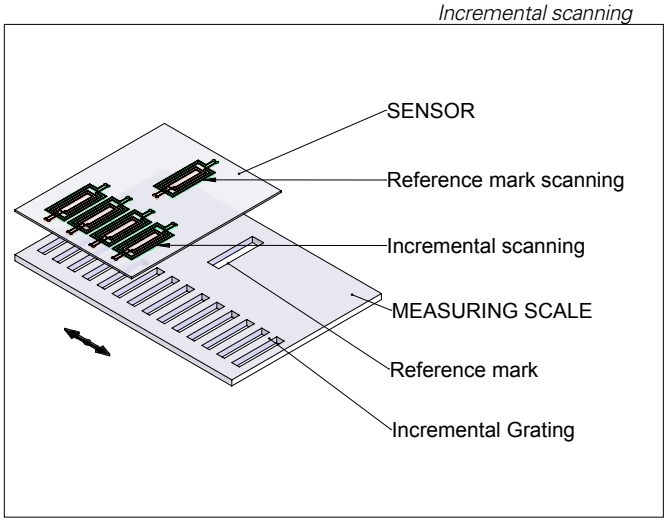
The extremely accurate signal, and it`s immunity to environmental influences, has the effect that, after conditioning of the signal in the evaluation electronics, deviations of no more than 0.1 % from the ideal sinusoidal form (harmonic content) remains.
This allows high interpolation factors to be carried 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.

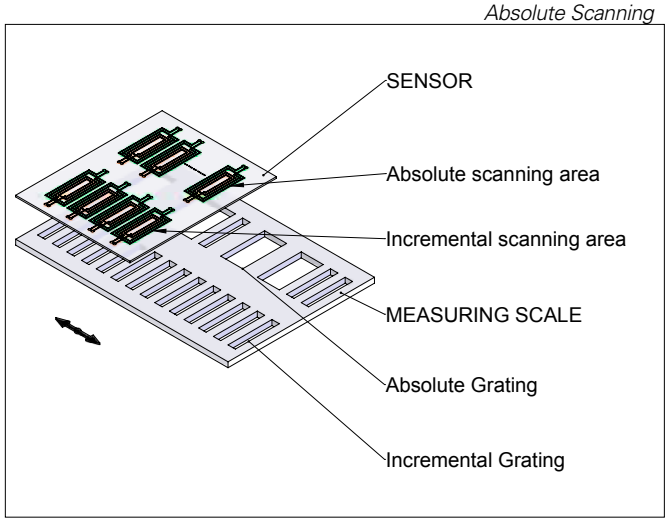
The absolute position information is read from the scale graduation, which is formed from a absolute code structure. A separate incremental track is interpolated for the position value.

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



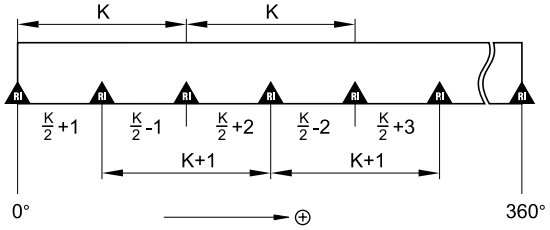
Absolute Scanning



Incremental measuring method - distance coding

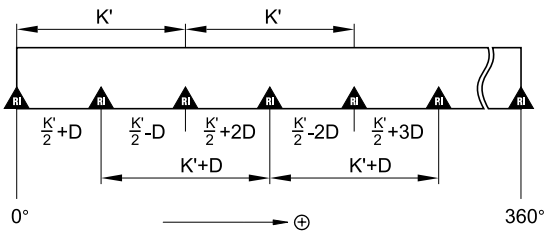
With the incremental measuring method, the graduation consists of a periodic grating structure. The position information is obtained by counting the individual increments (measuring steps) from some point of origin. Since an an absolute reference is required to ascertain positions, the measuring standard is provided with an additional track that bears a reference mark. The absolute position on the scale, established by the reference mark, is gated with exactly one measuring step. The reference mark must therefore be scanned to establish an absolute reference or to find the last selected datum. In some cases, this may require rotation by up to nearly 360°. 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. The subsequent electronics find the absolute reference after traversing two successive reference marks – meaning only a few degrees of traverse. With distance-coded reference marks, the absolute reference is calculated by counting the signal periods between two reference marks.

Arrangement of distance coded reference marks for encoders with non divided 1pp 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

Measuring accuracy

The accuracy of angular 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 eccentricity of the graduation to the bearing,
- the bearing error, and
- the coupling to the measured shaft.

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

Encoder-specific error
The encoder-specific error is given in the Specifications:
- Accuracy of graduation
- Position error within one signal period

Accuracy of graduation
The accuracy of the graduation ±a results from its quality. This includes
- the homogeneity and period definition of the graduation,
- the alignment of the graduation on the carrier, and
- the stability of the graduation carrier, in order to also ensure accuracy in the mounted condition.

In case of scale tape rings WMR the customer has to take care of the last two statements listed above.

The accuracy of the graduation ±a is ascertained under ideal conditions by using a series-produced scanning head to measure position error at positions that are integral multiples of the grating period.

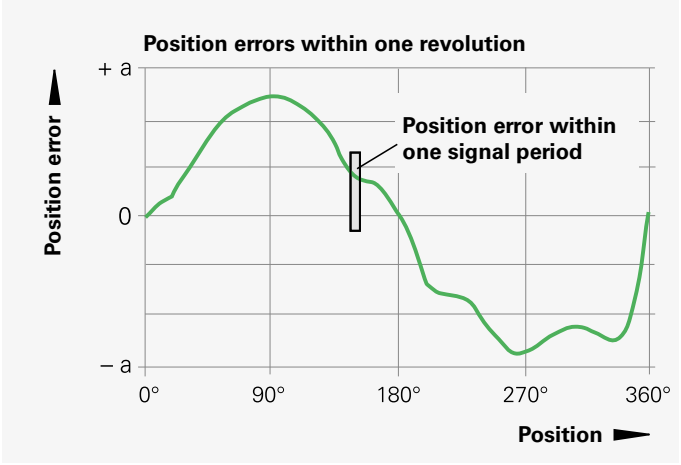
Position error within one signal period
The position error within one signal period ±u results from the quality of the scanning and the quality of the internal signal-processing electronics. For encoders with sinusoidal output signals, however, the errors of the signal processing electronics caused by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

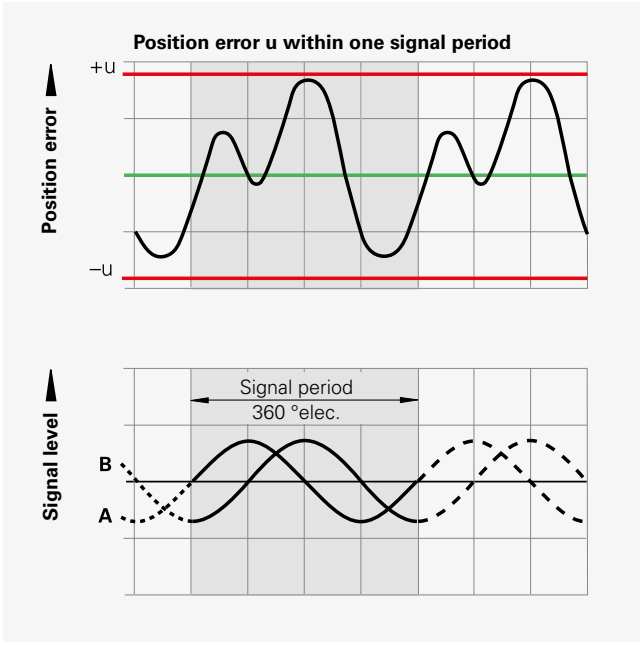
The following individual factors influence the result:
- the size of the signal period,
- the homogeneity of the graduation,
- the quality of scanning,
- the characteristics of the sensors, and
- the stability and dynamics of further processing of the analog signals.

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 already become apparent in very small angular motions and in repeated measurements. They especially lead to speed ripples in the speed control loop.





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. Of particular importance are the mounting eccentricity of the graduation and the radial runout of the measured shaft. The application-dependent error values must be measured and calculated individually in order to evaluate the overall accuracy.

Shape and diameter error of the bearing surface at segment solutions
Shape errors of the bearing surface can impair the attainable system accuracy. In the segment solutions, the additional angular error Δφ occurs when the nominal scale-tape bearing-surface diameter is not exactly maintained:
$\Delta\varphi = (1 - D`/D) \cdot \varphi \cdot 3600$
where
Δφ = Segment deviation in angular seconds
φ= Segment angle in degrees
D = Nominal scale-tape carrier diameter
D' = Actual scale-tape carrier diameter
This error can be eliminated if the line count per 360° z' valid for the actual scale-tape carrier diameter D' an be entered in the control.
The following relationship is valid:

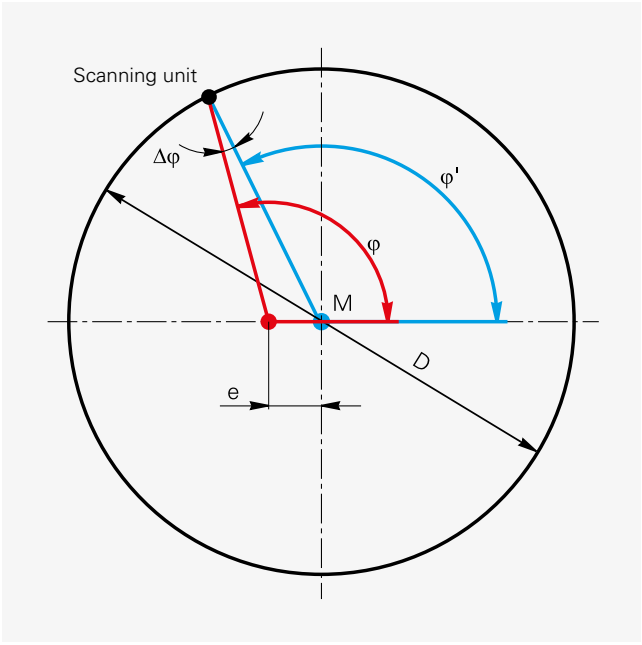
$z' = z \cdot D'/D$
where z = Nominal line count per 360°
z' = Actual line count per 360°

Errors due to eccentricity of the graduation to the bearing
Under normal circumstances, the graduation will have a certain eccentricity relative to the bearing once the measuring flange or scale tape ring is mounted. In addition, dimensional and form deviations of the customer's shaft can result in added eccentricity. The following relationship exists between the eccentricity e, the graduation diameter D and the measuring error Δφ (see illustration below):
$\Delta\varphi = \pm 412 \cdot e/D$
Δφ= Measuring error in " (angular seconds)
e = Eccentricity of the scale drum to the bearing in µm (1/2 the radial deviation)
D = Scale-drum diameter (= drum outside diameter) in mm
M = Center of graduation
φ = "True" angle
φ' = Scanned angle

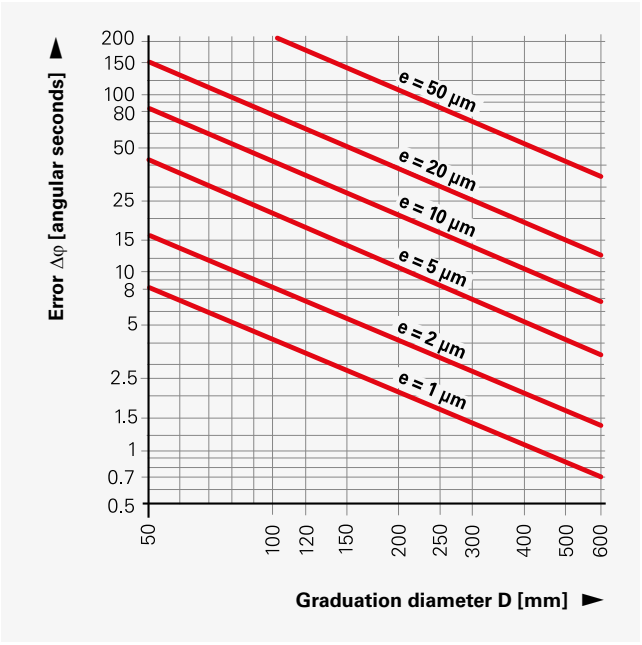
By using a double head scanning solution (MHSA or MHSA) the errors caused by eccentricity are eliminated completly

Deformation of the graduation
Error due to deformation of the graduation is not to be ignored. It occurs when the graduation is mounted on an uneven, for example convex, surface.
However, the graduation can also be deformed solely by screw tightening torque. The measuring flanges are particularly rigid in order to prevent this effect.

Eccentricity of the graduation to the bearing



Resultant measured Δφ deviations for various eccentricity values e as a function of graduation diameter D



Compensation possibilities

The mounting eccentricity of the graduation and the radial runout of the measured shaft cause a large share of the applicationdependent errors. A common and effective method of eliminating these errors is to mount two or even more scanning heads at equal distances around the graduation carrier. The subsequent electronics mathematically combine the individual position values.

The accuracy improvement actually attained by this in practice strongly depends on the installation situation and the application. In principle, all eccentricity errors (reproducible errors due to mounting errors, non-reproducible errors due to radial eccentricity of the bearing) as well as all uneven harmonics of the graduation error are eliminated.

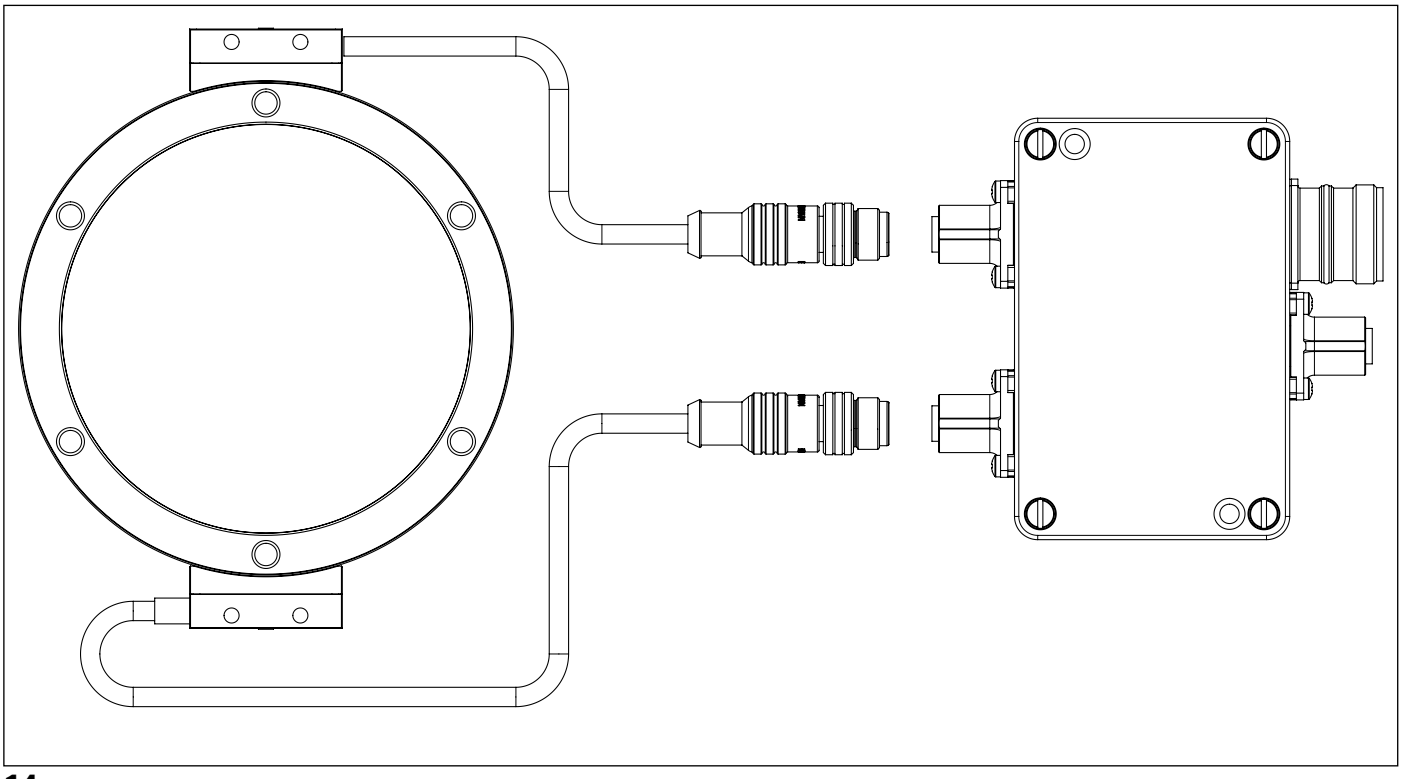
The MHS or MHSA from AMO are electronics units suitable for mathematically combining the position values from two incremental (MHS) or absolute (MHSA) scanning heads in real time, without impairing the control loop.

The MHSA electronics unit is a standalone unit where two standard absolute scanning heads, with EnDat22 interface and 14bit resolution within one grating pitch, are connectable.

For an incremental double scanning head solution the MHS (consist of two scanning heads and an interface box) can be used.

Error caused by the eccentricity of the graduation to the bearing are compensated with the aid of a second scanning head that is arranged at an angle of 180° ± 5° to the first one. The incremental signals of both scanning heads are digitally offset in an interface box with a high subdivision factor and are transmitted as absolute position values after the reference mark is scanned.

Configuration of a double head scanning solution



Functional Safety

Solution for the position detection on rotary axes for safety-related systems can be offered with the absolute and incremental angle encoders by AMO.

These are scanning heads with an purely analogue output signal 1 Vpp signal period corresponding to a grating period. Corresponding angle encoders are marked with option „FA" in the order description. These angle encoders can be used for numerous safety functions of the complete system according to EN 61800-5-2.

AMO provides MTTF values for angle encoders and the annotated table D16 for motion and bearing sensors within the standard EN 61800-5-2 for the safety-related view of the complete system on demand.
In addition to the electrical interface, the mechanical connection of the measuring encoders to the drive is also relevant to safety.

In the standard for electrical drives EN 61800-5-2, Table D16, the loosening of the mechanical connection between the measuring encoder and the drive is listed as a fault.
The fault exclusion against loosening the mechanical connection is required in many cases, because the control can't detect such errors compellingly.

Fault exclusion against 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 exermination a mechanical 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.

Fault exclusion against loosening of the mounting srews on the scanning head

	WMKA 2010	WMK 1105 WMK 1010	WMK 1105 WMK 110	WMK 2005 WMK 2010 WMK 2030	WMK 2110 WMK 2130
Design	20	10, 12		20, 21	
Mounting screws [1]					
Screws	M4 x 35 ISO 4762 8.8	M3 x 16 ISO 4762 8.8		M4 x 16 ISO 4762 12.9	
Torque Med [2]	2,0 ± 0,05Nm	1,0 ± 0,05Nm		2,0 ± 0,05 Nm	
Length of thread engagement	> 9mm	> 4mm		> 13,5mm [3]	
Mating stator					
Material	Steel				
Elastic limit $R_{e\,0,2}$	≥ 370 N/mm²				
Surface roughness	RZ 10 ÷ 40 µm				
Coefficient of thermal expansion α	(10 to 16) .10 $^{-6}$ K^{-1}				
Shock	6ms <1000 m/s² (EN 600068-2-27)				

[1] A compatible screw locking device must be used for the screw connections
[2] Tightening prozess: Torques monitored
Mounting at room temperature; Components must be balanced regarding temperature
[3] There must be anticipate a blind hole ø 4,3 x 3mm on the stator side at the mounting holes.See Figure.01

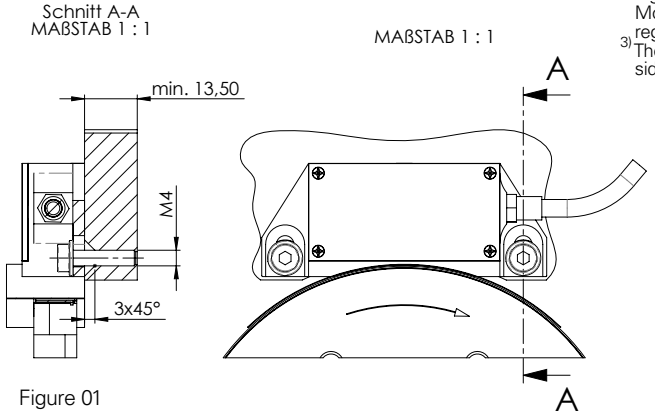


Figure 01

Fault exclusion against loosening of the mounting srews 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 neccessary and affect directly the required assembling temperatures.
See the mounting with the mechanical fault exclusion as an option.

If there is no need of the mechanical fault exclusion for the safety concept, the measuring flange can also fixed without the interference fit. (Look øW1 bzw. øW2 at the dimension of the respective measuring flange)

Measuring flange	
Mounting screws [1), 2)]	M6 x 25 ISO 4762 8.8; Md= 8,7 ± 0,1Nm M5 x 25 ISO 4762 12.9; Md= 5,2 ±0,1Nm
Free grip lengths M6 x 25	> 10mm
Length of thread engagement at M5 x 25	> 14mm
Mating shaft	
Material	Steel
Elastic limit $R_{p\ 0,2}$	≥ 370N/mm²
Surface roughness	Rz 10 ÷ 40 µm
Coefficient of thermal expansion α	(10 to 12) . 10^{-6} K^{-1}
Shock	6ms < 1000 m/s² (EN 600068-2-27)

[1)] A compatible screw locking device must be used for the screw connections
[2)] Tightening prozess: Torques monitored
Mounting at room temperature; Components must be balanced regarding temperature

Mounting temperature

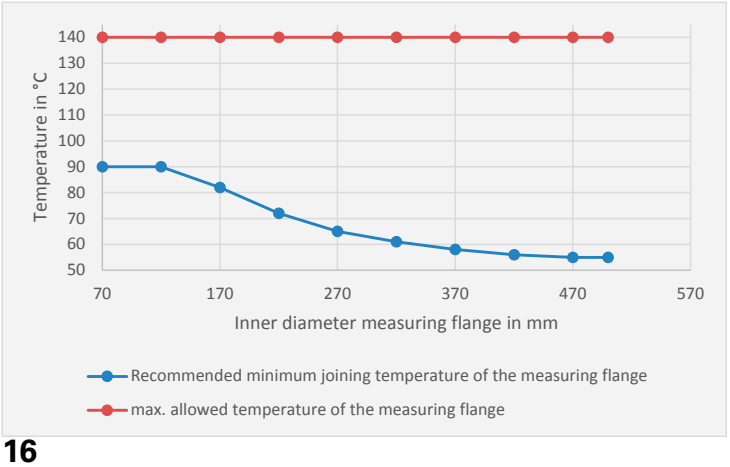
All information on screw connections is given with respect to a mounting temperature of 15 °C to 35 °C.

Assembling 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 measurign flange. Do not additionally fasten any other components with these screws.



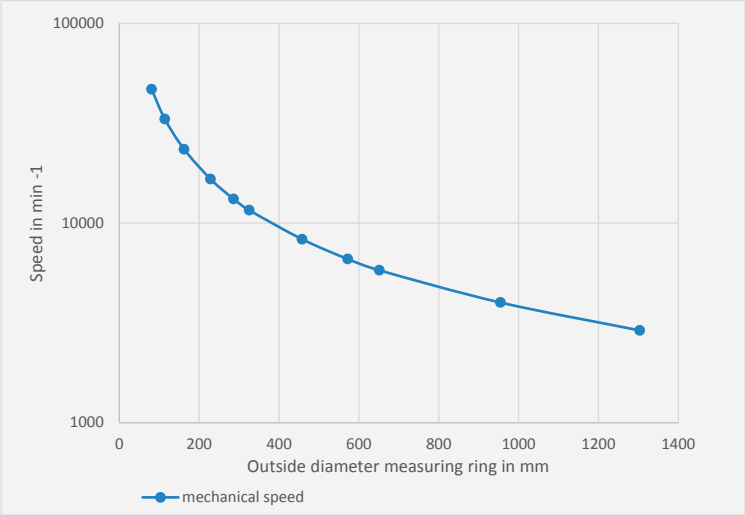
*The temperature specification refers to an ambient temperature of 22 ° C. If the ambient temperature is different, adjust the assembling temperature accordingly

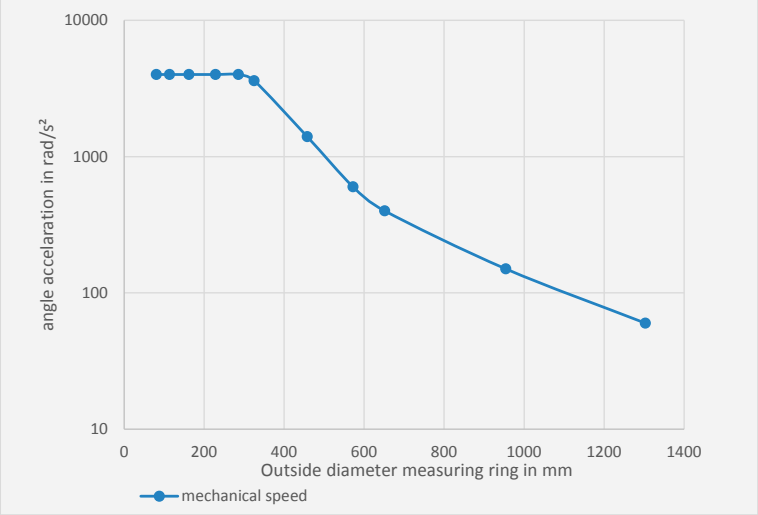
Fault exclusion against loosening the measuring ring from the carrier flange

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 by AMO for the respective measuring ring type.

The maximum permissible speeds and accelerations for standard measuring ring sizes are listed in the technical parameters.

Carrirer Flange	
Material	Steel
Elastic limit $R_{\varrho\ 0,2}$	≥ 430N/mm²
Coefficient of thermal expansion α	(10 to 12). $10^{-6}\ K^{-1}$
Shock	6ms ≤ 1000 m/s² (EN 600068-2-27)





Mechanical design types and mounting

The inductive modular encoders consist of a measuring flange or a scale tape ring and the corresponding scanning head. The position of the scanning head and graduation relative to each other is determined solely via the machine bearing. However, the design features of the modular encoders assure comparably fast mounting and easy adjustment.
The stated values for graduation accuracy and the position error within one signal period can be attained in the application if the requirements are fulfilled (see Specifications).

Versions
There are various grating periods available for the modular encoders (500 µm, 1000 µm or 3000 µm). This results in different line counts for the same outside diameter. The graduation is available as a scale tape ring mounted on a flange or as very thin scale tape ring for mounting at customer site.

Scale tape ring on flange WMF or WMFA
For mounting, the measuring flanges are slid onto the mating shaft and fastened axially with screws.

Scale tape ring WMR or WMRA
The scale tape rings are designed for mounting on a prepared customer specific carrier at customer site. The mechanical requirements of the carrier for a proper mounting are shown in the technical specifications

Centering the measuring flange
Because the attainable total accuracy is dominated by mounting error (mainly through eccentricity), special attention must be placed on centering the measuring flange. Depending on the encoder and mounting method, various methods of centering the measuring flang are possible in order to minimize the eccentricity errors that occur in practice.

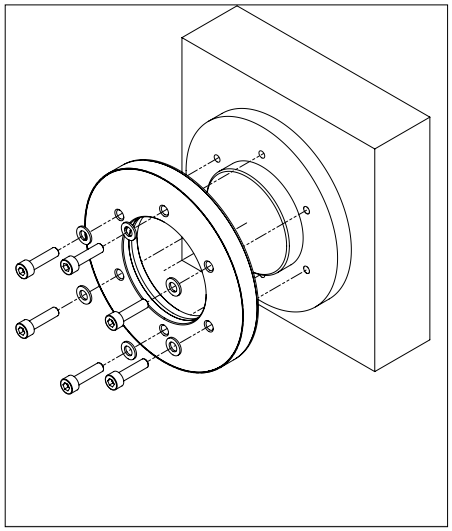
Centering by centering collar
The measuring flange is pushed or shrunk onto the shaft. This very simple method requires an exact shaft geometry and bearing quality to meet the corresponding accuracy requirements.
The measuring flange is centered via the centering collar on its inner circumference.

AMO recommends a slight oversize of the shaft on which the measuring flange WMF is to be mounted. For easier mounting, the measuring flange may be slowly warmed on a heating plate over a period of approx. 10 minutes to a temperature of at most 140 °C. In order to check the radial runout and assess the resulting deviations, testing of the shaft's rotational accuracy before mounting is recommended.
Back-off threads are used for dismounting the measuring flange.

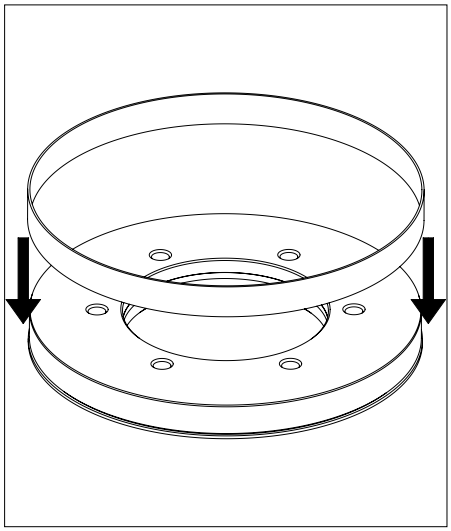
Mounting the scanning head
In order to mount the scanning head, the provided spacer foil is applied to the surface of the circumferential scale drum. The scanning head is pressed against the foil, fastened, and the foil is removed.

Mounting clearance
The mounting clearance (gap between scanning head and measuring flange) depends on the encoder's grating period. As a result, the spacer foils for mounting the scanning head are of varying thicknesses. Deviations of the scale-to-reticle gap from the ideal value negatively influence the functional reserve.

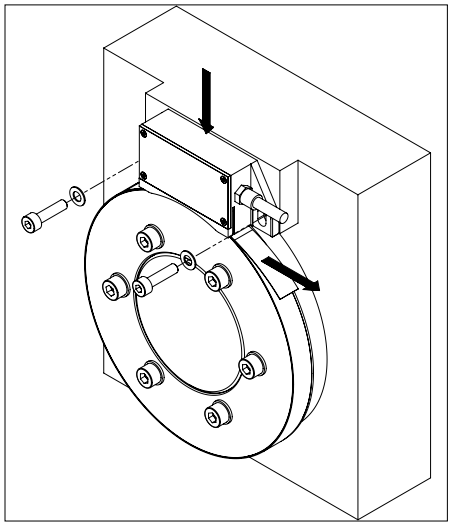
Mounting of the measuring flange WMF or WMFA



Mounting of the scale tape ring WMR or WMRA



Mounting of the scanning head WMK or WMKA



General mechanical information

Protection against contact
After encoder installation, all rotating parts must be protected against accidental contact during operation.

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.
- The maximum permissible acceleration values (semi-sinusoidal shock) for shock and impact are valid for 6 ms (EN 60 068-2-27). Under no circumstances 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.
Protection against contact
The operating and storage temperature range are specified in the technical data.

Shaft speeds
The maximum permissible shaft speeds were determined according to FKM guidelines.
This guideline serves as mathematical attestation of component strength with regard to all relevant influences and it reflects the latest state of the art. The requirements for fatigue strength (10 million reversals of load) were considered in the calculation of the permissible shaft speeds. Because installation has a significant influence, all requirements and directions in the specifications and mounting instructions must be followed for the shaft-speed data to be valid.

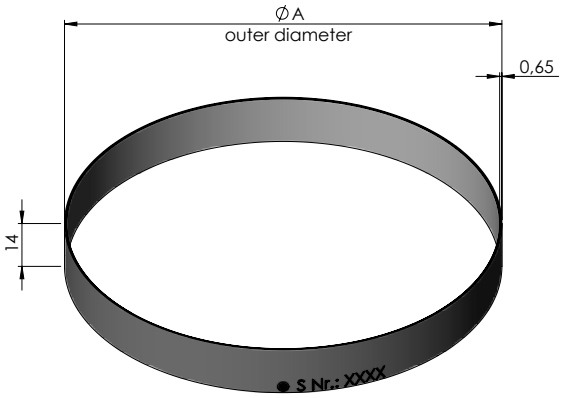
Expendable parts
Due to the contactless inductive scanning principle only a continuously moving cable in subject to wear.
Pay attention to the minimum permissible bending radii.

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.

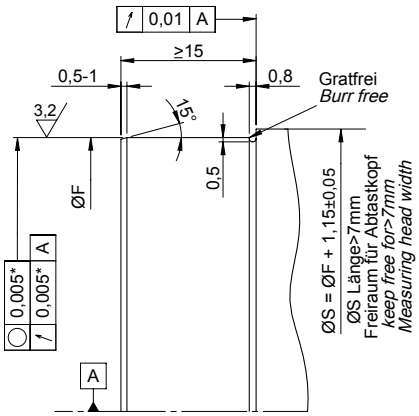
Absolute scale tape ring for outside scanning WMRA 1010 A

- **In combination with the scanning head WMKA 2010**
- **Grating period 1000µm**



WMRA 1010A

Mechanical requirements on the carrier flange



Line count	ØF [mm]
256	80,65 ±0,01
360	113,82 ±0,01
512	162,24 ±0,02
720	228,48 ±0,02
900	285,78 ±0,02
1024	325,25 ±0,02
1440	457,69 ±0,03
1800	572,31 ±0,06
2048	651,28 ±0,07

*) Recommended eccentricity: Greater eccentricities up to ~0,05mm do not affect the function of the device, but cause a proportional loss in positioning accuracy.

Technical data

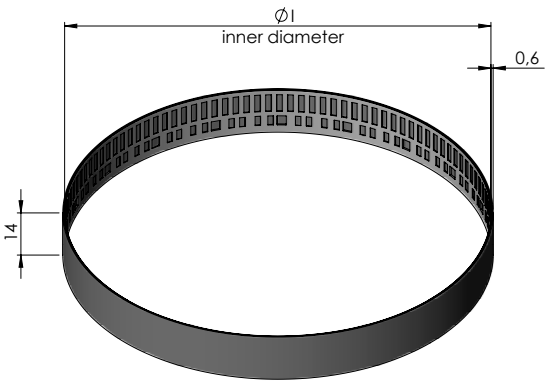
Scale tape ring WMRA 1010A 1000µm									
Line count	256	360	512	720	900	1024	1440	1800	2048
Grating period accuracy [1]									
±10µm arc length	±51“	±36“	±26“	±18“	±15“	±13“	±9“	±7,5“	±6,5“
± 5µm arc length	±26“	±18“	±13“	±9,0“	±7,5“	±6,5“	±4,5“	±4,0“	±3,5“
± 3µm arc length	±16,0“	±11“	±8,0“	±5,5“	±4,5“	±4,0“	±3,0“	±2,5“	±2,0“
Outside diameter [mm]	81,95	115,12	163,54	229,78	287,08	326,55	458,99	573,61	652,58
Mech. speed [min^{-1}] [2]	46800	33300	23400	16600	13300	11700	8300	6600	5800
Max. angle acceleration [rad/s^2] [2]	4000					3400	1400	1000	500

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

[2] Values should be considered to ensure a mechanical fault exclusion.

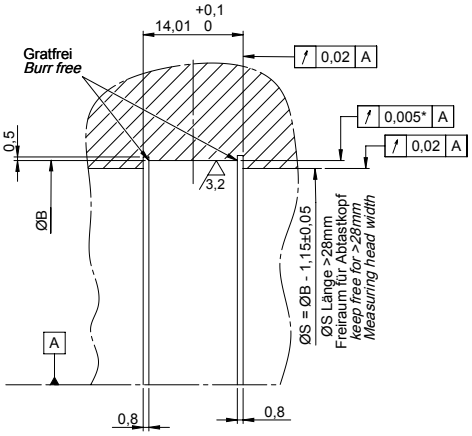
Absolute scale tape ring ring for inside scanning WMRA 1110 I

- **In combination with the scanning head WMKA 2110**
- **Grating period 1000µm**



WMRA 1110I

Mechanical requirements on the carrier flange



Line count	ØB [mm]
1024	326,62 ±0,02
1440	459,01 ±0,03
1800	573,56 ±0,06
2048	652,47 ±0,07

*) Recommended eccentricity: Greater eccentricities up to ~0,05mm do not affect the function of the device, but cause a proportional loss in positioning accuracy.

Technical data

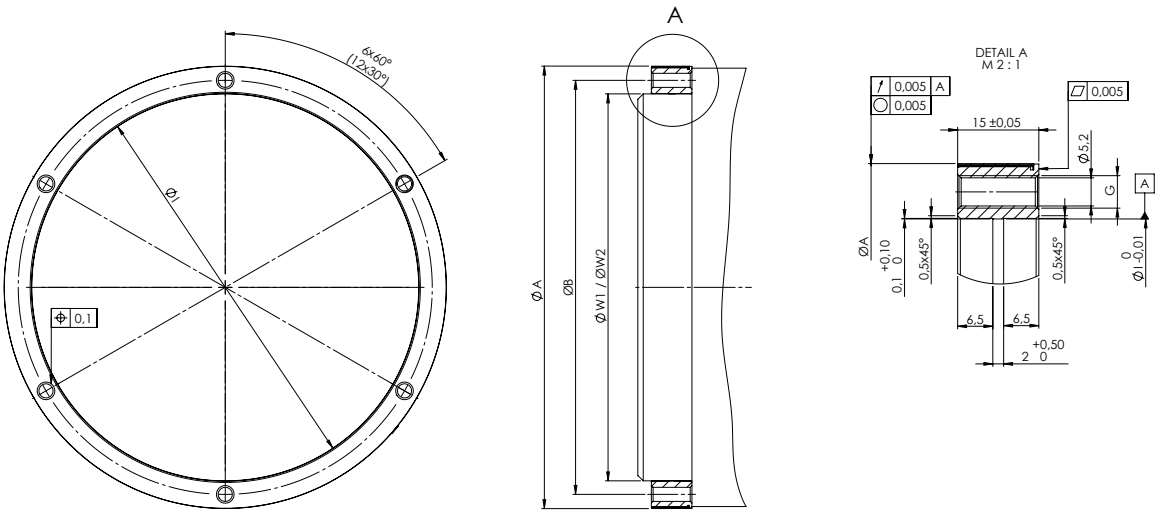
Scale tape ring WMRA 1110I 1000µm				
Line count	1024	1440	1800	2048
Grating period accuracy [1]				
±10µm arc length	±13“	±9“	±7,5“	±6,5“
± 5µm arc length	±6,5“	±4,5“	±4,0“	±3,5“
± 3µm arc length	±4,0“	±3,0“	±2,5“	±2,0“
Outside diameter ring [mm]	325,42	457,81	572,36	651,27
Mech. speed [min^{-1}] [2]	11700	8300	6600	5800
Max. angle acceleration [rad/s^2] [2]	3400	1400	1000	500

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

[2] Values should be considered to ensure a mechanical fault exclusion.

Absolute scale tape ring on flange WMFA 1010 A

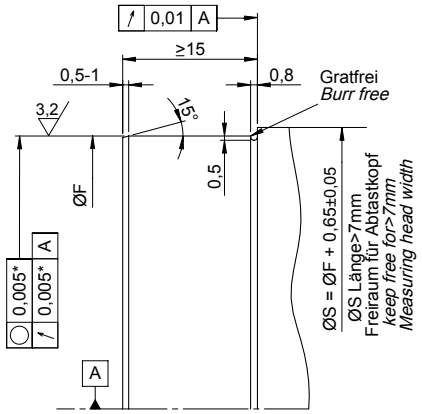
- **In combination with the scanning head WMKA 2010**
- **Grating period 1000µm**



ØW1 = without mech. fault exclusion
ØW2 = with mech. fault exclusion

Line count	Type of graduation carrier	Ø A	Ø I	ØW1	ØW2	Ø B	G
256	AA01	81,95	60 +0/-0,01	60 +0,02/+0,01	60 +0,05/+0,04	70	6 x M6
360	AA02	115,12	60 +0/-0,01	60 +0,02/+0,01	60 +0,05/+0,04	75	6 x M6
360	AA03		95 +0/-0,01	95 +0,02/+0,01	95 +0,05/+0,04	105	6 x M6
512	AA05	163,54	105 +0/-0,01	105 +0,02/+0,01	105 +0,05/+0,04	120	6 x M6
512	AA06		143 +0/-0,01	143 +0,02/+0,01	143 +0,05/+0,04	153	6 x M6
720	AA08	229,78	180 +0/-0,01	180 +0,02/+0,01	180 +0,05/+0,04	195	6 x M6
720	AA09		209 +0/-0,01	209 +0,02/+0,01	209 +0,05/+0,04	219	6 x M6
900	AA10	287,08	180 +0/-0,01	180 +0,02/+0,01	180 +0,05/+0,04	195	12 x M6
900	AA11		266 +0/-0,01	266 +0,02/+0,01	266 +0,05/+0,04	276	12 x M6
1024	AA12	326,55	220 +0/-0,01	220 +0,02/+0,01	220 +0,05/+0,04	235	12 x M6
1024	AA13		296 +0/-0,01	296 +0,02/+0,01	296 +0,05/+0,04	311	12 x M6

Mechanical requirements for customer specific carrier tape WMFA 1010A / WMBA 1010A



Line count	ØF [mm]
256	81,25 ±0,01
360	114,42 ±0,01
512	162,84 ±0,02
720	229,08 ±0,02
900	286,38 ±0,02
1024	325,85 ±0,02

*) Recommended eccentricity: Greater eccentricities up to ~0,05mm do not affect the function of the device, but cause a proportional loss in positioning accuracy.

Recommended material: 1.4104 (X14CrMoS17) or 1.7225 (42CrMo4)
If you are using a different soft magnetic material please contact AMO.

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

Technical data

Scale tape ring on flange WMFA 1010A / WMBA 1010A												
Line count	256	360		512		720		900		1024	
Grating period accuracy[1]											
±10µm arc length	±51“	±36“		±26“		±18“		±15“		±13“	
± 5µm arc length	±26“	±18“		±13“		±9,0“		±7,5“		±6,5“	
± 3µm arc length	±16“	±11“		±8,0“		±5,5“		±4,5“		±4,0“	
Outside diameter [mm]	81,95	115,12		163,54		229,78		287,08		326,55	
Inside diameter WMF [mm]	60	60	95	105	143	180	209	180	266	220	296
Max. angle acceleration [rad/s²] [2]	4000					2000	4000	1350	4000	950	2700
Mech. speed [min^{-1}][2]	14000	10000		7000		5000		4000		3500	

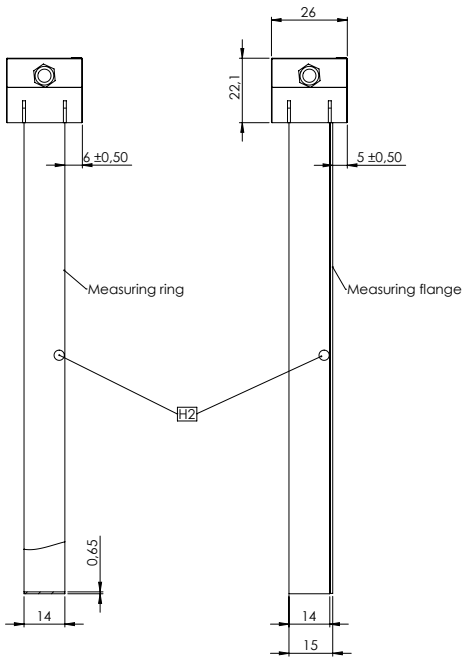
[1] The position error per grating period and the accuracy of the grating result toghether in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error.

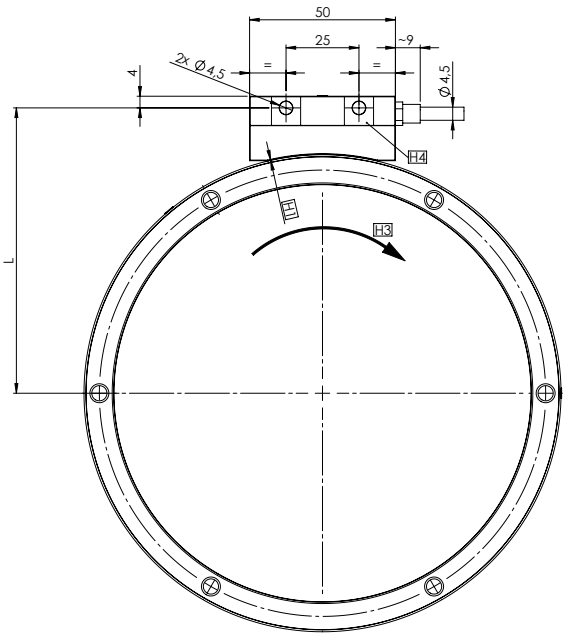
[2] Values should be considered to ensure a mechanical fault exclusion.

WMKA 2010 series

- **Composed of WMKA 2010 and scale tape ring on flange or measuring ring**
- **Grating period 1000µm**
- **Scanning head with integrated electronics**

Design 20 - Outside scanning



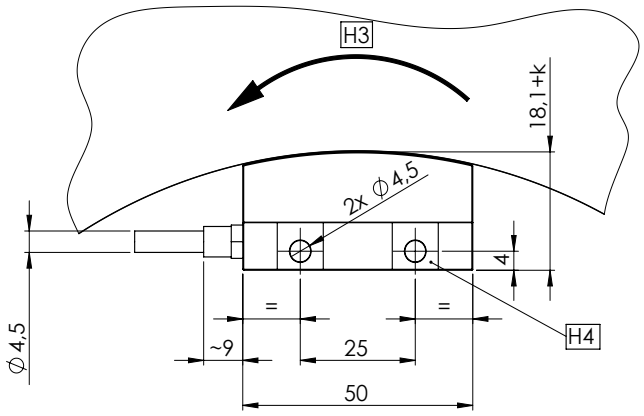


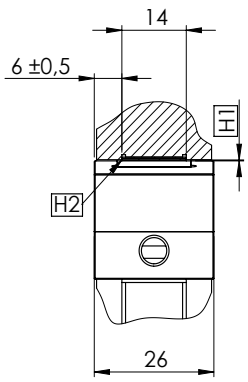
Line count	L [mm]
256	56,74
360	73,29
512	97,82
720	131,64
900	160,39
1024	180,33
1440	246,74
1800	304,25
2048	343,84

WMKA 2110 series

- **Composed of WMKA 2110 and scale tape ring**
- **Grating period 1000µm**
- **Scanning head with integrated electronics**

Design 20 - Inside scanning





Line count	L [mm]
1024	142,53
1440	209,28
1800	266,84
2048	306,44

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 shaft rotation for positive counting
H4 = weight plane (both sides))

Technical data

Scanning head	**WMKA 2010 / WMKA 2110**								
Interface	EnDat 2.2	Fanuc α	Mitsubishi (full duplex)	Mitsubishi (duplex)	BiSS/C	SSI + 1Vss			
Designation	EnDat 22	Fanuc02	MitA1-2	MitA1-4	BiSS	SSI - 1V pp			
Clock frequency	≤ 16 MHz	-	5Mbps	5Mbps	≤ 2,5 MHz	≤ 1 MHz			
Interpolation factor digital	Performance Standard: 10bit or 12bit Performance High Accuracy: 14bit					Performance Standard: 10bit or 12bit			
Cable length on the encoder	0,5m to 6m								
Electrical connection	Cable with M12 coupling, 8pin male					Cable with M23 coupling			
Voltage supply	DC 3,6V to 14V								
Power consumption	≤ 1,5W at 5V								
Typical current consuption	300mA at 5V								
Shock	< 2000m/s² for 6m/s								
Vibration	< 200m/s² 55Hz - 2000Hz								
Operating temperature	-10°C to 85°C								
Storage temperature	-20°C to 85°C								
Protection	IP67								
Weight	40g								
Line count	256[2]	360[2]	512[2]	720[2]	900[2]	1024	1440	1800	2048
Max. Position/Rotation[3]	22bit		23bit			24bit			25bit
Position error per grating period [1]									
Standard	±11,0“	±7,5“	±5,5“	±4,0“	±3,0“	±3,0“	±2,0“	±2,0“	±1,5“
High Accuracy	±3,0“	±2,0“	±1,5“	±1,0“	±1,0“	±1,0“	± 0,5“	±0,5“	± 0,5“
Electrical max. speed [min^{-1}]	≤ 4680	≤ 3330	≤ 2340	≤ 1660	≤ 1330	≤ 1170	≤ 830	≤ 660	≤ 580

[1] The position error per grating period and the accuracy of the grating result toghether in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error.
[2] not for inside scanning
[3] for all pure serial interfaces

Ordering code

- **WMRA - Scale tape ring for absolute angle encoder**
- **Grating period 1000µm**

WMRA □□10 □□□-□□□□□- MF-□□□□

Type
10 = Ring, Outside scanning
11 = Ring, Inside scanning

Scanning
A = Outside scanning
I = Inside scanning

Grating period accuracy
3 = +/- 3µm
5 = +/- 5µm
10 = +/- 10µm

Line count
256[1)]
360[1)]
512[1)]
720[1)]
900[1)]
1024
1440
1800
2048

Safety concept
MF = Fault exclusion for loosing of the mechanical connetions possible

Type of graduation carrier
Outside scanning:
R001 = Scale tape ring
Inside scanning:
R004 = Scale tape ring without cover tape

[1)] not for inside scanning.

Ordering code

- **WMFA - Scale tape ring on flange for absolute angle encoder**
- **Grating period 1000µm**

WMFA 1010 A□□-□□□□□- MF -□□□□

Grating period accuracy
3 = +/- 3µm
5 = +/- 5µm
10 = +/- 10µm

Line count
256
360
512
720
900
1024

Safety concept
MF = Fault exclusion for loosing of the mechanical connetions possible

Type of gradution carrier

Standard Graduation carrier	Line count	Ø A	Ø I
AA01	256	81,95	60 +0/-0,01
AA02	360	115,12	60 +0/-0,01
AA03			95 +0/-0,01
AA05	512	163,54	105 +0/-0,01
AA06			143 +0/-0,01
AA08	720	229,78	180 +0/-0,01
AA09			209 +0/-0,01
AA10	900	287,08	180 +0/-0,01
AA11			266 +0/-0,01
AA12	1024	326,55	220 +0/-0,01
AA13			296 +0/-0,01

Ordering code

- **WMBA - Scale tape ring on customer specific graduation carrier for absolute angle encoder**
- **Grating period 1000µm**

WMBA□□10□□□-□□□□□-...-□□□□

Type
10 = Ring, Outside scanning
11 = Ring, Inside scanning

Scanning
A = Outside scanning
I = Inside scanning

Grating period accuracy
3 = +/- 3µm
5 = +/- 5µm
10 = +/- 10µm

Line count
customer specific

Type of graduation carrier
Bxxx = customer specific, defined by AMO

Ordering code

- **WMKA - Scanning head for absolute angle encoder**
- **Grating period 1000µm**

WMKA 2 ☐ 10 ☐☐.☐☐☐☐☐☐☐☐☐-20-☐☐☐☐☐-☐,☐☐-☐☐☐☐☐-☐☐

Scanning

0 = Outside scanning
1 = Inside scanning

Performance

S = Standard
HA = High Accuracy

Interface

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

Interpolationsf actor digital

10 = 10 Bit
12 = 12 Bit
14 = 14 Bit [3]

Functional safety

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

Line count

256 [1]
360 [1]
512 [1]
720 [1]
900 [1]
1024
1440
1800
2048

Multiplication 1Vpp (only for SSI)

01	1-fold	×
25	25-fold	×
32	32-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 17polig Kupplung Stift

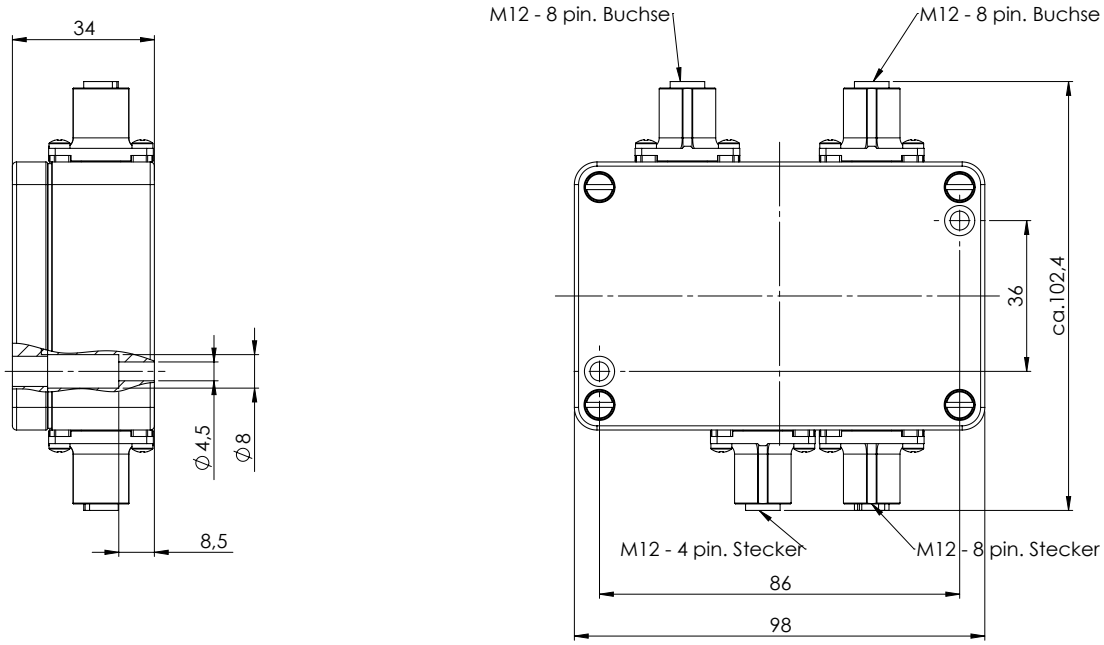
Cable length

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] Not for inside scanning
[2] Option „FA" only for SSI and 1Vss Interface with the Multiplication „01".
[3] Not for SSI-Interface.

MHSA

- **MHSA - Double head scanning for absolute angle encoder**
- **Grating period 1000µm**



For the operation of the MHSA, two absolute angle measuring systems in the „HA" version are required with interface EnDat2.2

Ordering code

- **MHSA - Multi scanning head for absolute angle encoder**
- **Grating period 1000µm**

Line count	Position/Rotation	Position/Rotation Output	Interface	Ordering code	ID-Nr.
256 360	22bit	23bit	EnDat 2.2	MHSA 30 . 01-4194304-8388608 ..-5XB008-C4	1146665-08
			BiSS/C	MHSA 30 . 16-4194304-8388608 ..-5XB008-C4	1146665-06
			Fanuc α	MHSA 30 . 02-4194304-8388608 ..-5XB008-yy	1146665-13
512 720 900	23bit	24bit	EnDat 2.2	MHSA 30 . 01-8388608-16777216 ..-5XB008-C4	1146665-03
			BiSS/C	MHSA 30 . 16-8388608-16777216 ..-5XB008-C4	1146665-09
			Fanuc α	MHSA 30 . 02-8388608-16777216 ..-5XB008-yy	1146665-14
1024 1440 1800	24bit	25bit	EnDat 2.2	MHSA 30 . 01-16777216-33554432 ..-5XB008-C4	1146665-04
			BiSS/C	MHSA 30 . 16-16777216-33554432 ..-5XB008-C4	1146665-10
			Fanuc α	MHSA 30 . 02-16777216-33554432 ..-5XB008-yy	1146665-15
2048	25bit	26bit	EnDat 2.2	MHSA 30 . 01-33554432-67108864 ..-5XB008-C4	1146665-05
			BiSS/C	MHSA 30 . 16-33554432-67108864 ..-5XB008-C4	1146665-11
			Fanuc α	MHSA 30 . 02-33554432-67108864 ..-5XB008-yy	1146665-16

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

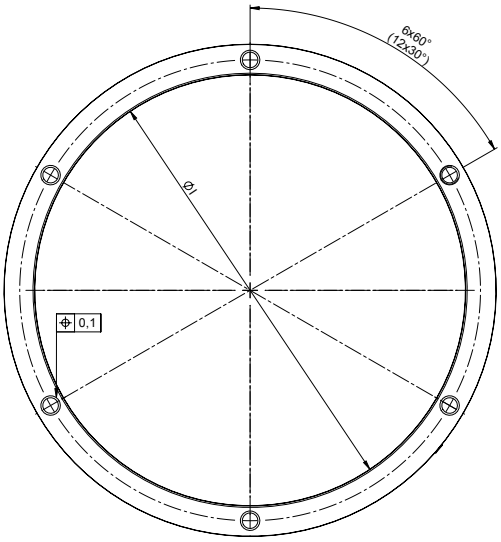
Technical data

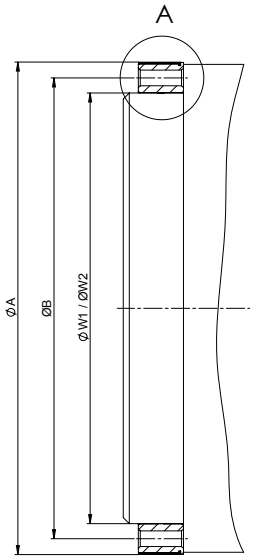
MHSA 30									
Interface	EnDat 2.2			Fanuc α			BiSS/C		
Description	EnDat 22			Fanuc 02			BiSS		
Electrical connection	Input: M12 / 8pin Buchse Output: M12 8pin male								
Supply voltage	DC 24V (min. 9V und max. 36V)								
Power consumption	Max. 6W; ≤ 250mA at 24V								
Electricity recording	≤ 250mA at 24V								
System resolution	23 to 27bit/The resolution is depend on the line count								
Schock	< 1000m/s² for 6m/s								
Vibration	< 200m/s² 55Hz - 2000Hz								
Operating temperature	-10°C to 85°C								
Storage temperature	-20°C to 85°C								
Protection	IP66								
Appropriate scanning head	WMKA with EnDat2.2 interface and 14bit interpolation factor zB.: WMKA 2x10HA.0114								
Line count	256	360	512	720	900	1024	1440	1800	2048
Electrical max. speed [min^{-1}]	≤ 4680	≤ 3330	≤ 2340	≤ 1660	≤ 1330	≤ 1170	≤ 830	≤ 660	≤ 580
Max. Position/Rotation Input	22bit		23bit			24bit			25bit
Max. Position/Rotation Output	23bit		24bit			25bit			26bit
Line count	256	360	512	720	900	1024	1440	1800	2048
Grating period	± 1,60“	± 1,10“	± 0,80“	± 0,60“	±0,50“	± 0,40“	± 0,30“	± 0,30“	± 0,20“
Grating period accuracy [1)]									
± 10µm arc lenght	± 26“	± 18“	± 13“	± 9,0“	± 7,5“	± 6,5“	± 4,5“	± 4,0“	± 3,5“
± 5µm arc lenght	±13“	± 9,0“	± 6,5“	± 4,5“	± 4,0“	± 3,5“	± 2,5“	± 2,0“	± 2,0“
± 3µm arc lenght	±8,0“	± 5,5“	± 4,0“	± 3,0“	± 2,5“	± 2,0“	± 1,5“	± 1,5“	± 1,0“

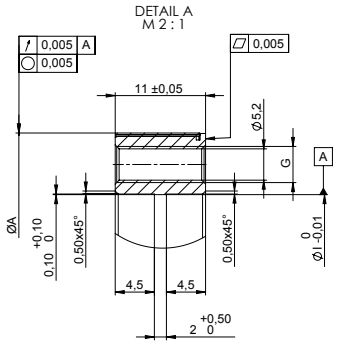
1) The grating accuracies shown above are calculated for optimal roundness of the measuring flange or measuring ring. Therefore those values are showing the maximum achievable accuracy of the grating.

Incremental scale tape ring on flange WMF 1005 A

- **In combination with the scanning head WMK 2005 / WMK 1005**
- **Grating period 500µm**



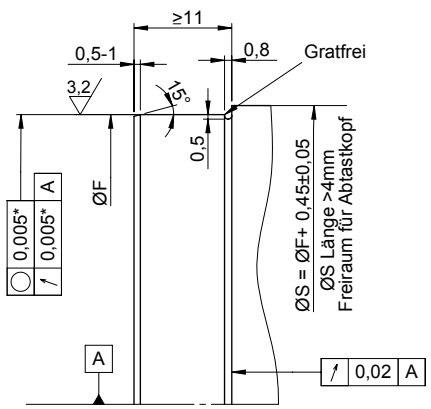




ØW1 = without mech. fault exclusion
ØW2 = with mech. fault exclusion

Line count	Type of graduation carrier	Ø A	Ø I	ØW1	ØW2	Ø B	G
512	AA51	81,85	60 +0/-0,01	60 +0,02/+0,01	60 +0,05/+0,04	70	6 x M6
720	AA52	115,02	60 +0/-0,01	60 +0,02/+0,01	60 +0,05/+0,04	75	6 x M6
720	AA53		95 +0/-0,01	95 +0,02/+0,01	95 +0,05/+0,04	105	6 x M6
1024	AA54	163,44	105 +0/-0,01	105 +0,02/+0,01	105 +0,05/+0,04	120	6 x M6
1024	AA55		143 +0/-0,01	143 +0,02/+0,01	143 +0,05/+0,04	153	6 x M6
1440	AA56	229,68	180 +0/-0,01	180 +0,02/+0,01	180 +0,05/+0,04	195	6 x M6
1440	AA57		209 +0/-0,01	209 +0,02/+0,01	209 +0,05/+0,04	219	6 x M6
1800	AA58	286,98	180 +0/-0,01	180 +0,02/+0,01	180 +0,05/+0,04	195	12 x M6
1800	AA59		266 +0/-0,01	266 +0,02/+0,01	266 +0,05/+0,04	276	12 x M6
2048	AA60	326,45	220 +0/-0,01	220 +0,02/+0,01	220 +0,05/+0,04	235	12 x M6
2048	AA61		296 +0/-0,01	296 +0,02/+0,01	296 +0,05/+0,04	311	12 x M6

Mechanical requirements for customer specific graduation carrier WMF 1005A / WMB 1005A



Line count	ØF [mm]
512 to 719	N/2π – 0,14 ±0,01
720 to 1023	N/2π – 0,07 ±0,01
1024 to 1439	N/2π – 0,03 ±0,02
1440 to 2049	N/2π – 0,00 ±0,02
2050 to 3000	N/2π + 0,02 ±0,03
3001 to 4000	N/2π + 0,05 ±0,06
4001 to 6000	N/2π + 0,08 ±0,07
6001 to 10000	N/2π + 0,10 ±0,10

*) Recommended eccentricity: Greater eccentricities up to ~0,05mm do not affect the function of the device, but cause a proportional loss in positioning accuracy.

Recommended material: 1.4104 (X14CrMoS17) or 1.7225 (42CrMo4)
If you are using a different soft magnetic material please contact AMO.

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

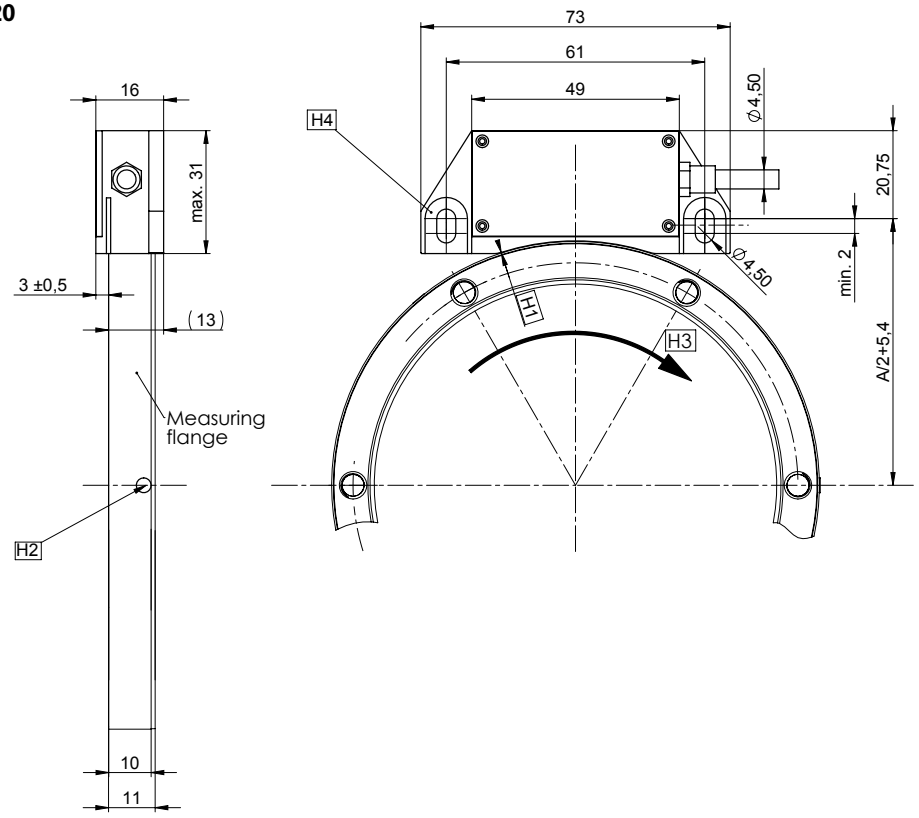
Scale tape ring on flange **500µm**	**WMF 1005A/ WMB 1005A**											
Line count	512		720		1024		1440		1800		2048	
Reference mark	Single or distance coded											
Position error per grating period [1]												
Standard	± 7,6 "		± 5,4"		± 3,8"		± 2,7"		± 2,2"		± 1,8"	
High Accuracy	± 1,6"		± 1,1"		± 0,8"		± 0,6"		± 0,5"		± 0,4"	
Grating period accuracy [1]												
± 10µm arc length	± 51"		± 36"		± 26"		± 18"		± 15"		± 13"	
± 5µm arc length	± 26"		± 18"		± 13"		± 9,0"		± 7,5"		± 6,5"	
± 3µm arc length	± 16"		± 11"		± 8,0"		± 5,5"		± 4,5"		± 4,0"	
Outside diameter [mm]	81,85		115,02		163,44		229,68		286,98		326,45	
Inside diameter [mm]	60		60	95	105	143	180	209	180	266	220	296
Max. angle acceleration [rad/s²][2]	4000						2200	400	1700	4000	1250	3800
Mech. speed [min^{-1}] [2]	11700		8300		15000		4100		3300		2900	

[1] The position error per grating period and the accuracy of the grating result toghether in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error.
[2] Values should be considered to ensure a mechanical fault exclusion.

WMK 2005 series

- **Composed of WMK 2005 and scale tape ring on flange**
- **Grating period 500µm**
- **Scanning head with integrated electronics**

Design 20



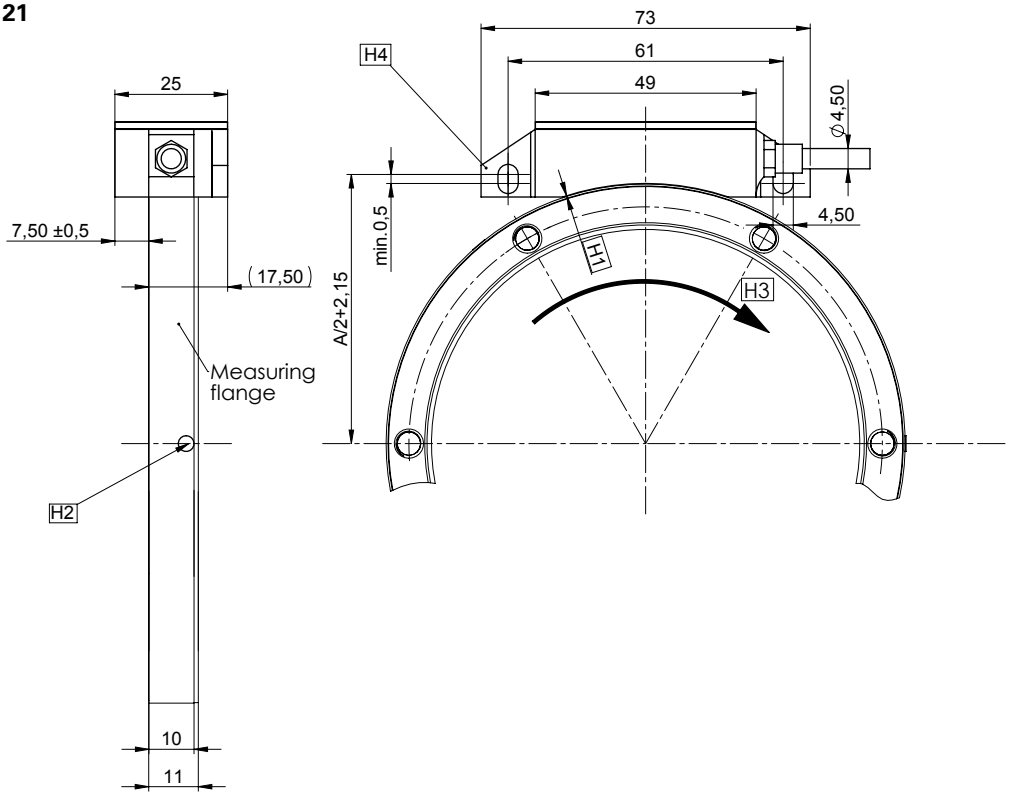
Tolerance principle in accodrance with ISO 8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

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

WMK 2005 series

- **Composed of WMK 2005 and scale tape ring on flange**
- **Grating period 500µm**
- **Scanning head with integrated electronics**

Design 21



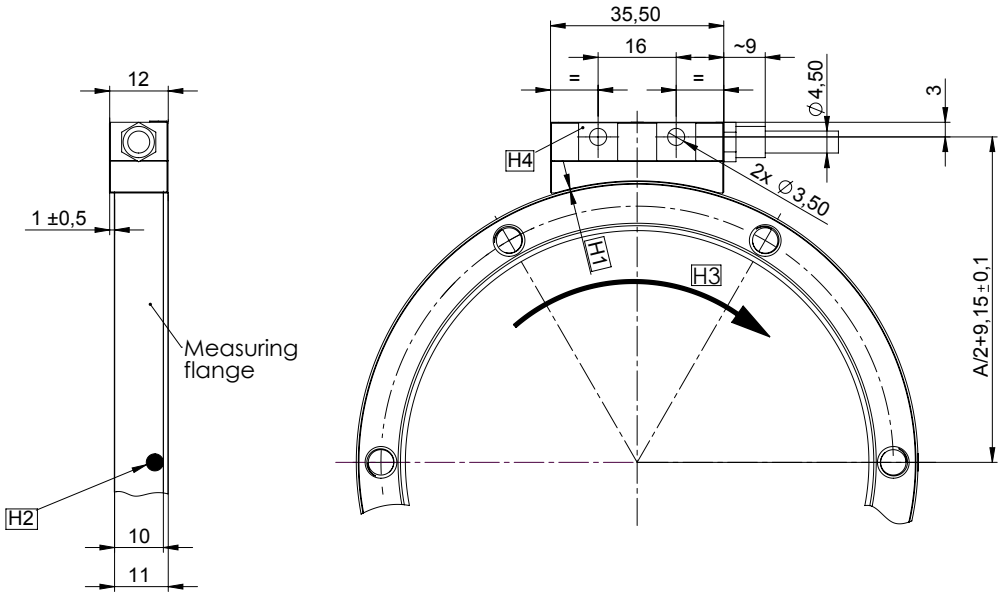
Tolerance principle in accodrance with ISO 8015
General tolerances in accordance with ISO 2768-fH
All dimensions in mm

H1 = Air gap 0,10 ± 0,05mm, set with spacer foil
H2 = Reference track marking
H3 = Direction of shaft rotation for positive counting
H4 = Ground plane (both sides)

WMK 1005 series

- **Composed of WMK 1005 and scale tape ring on flange**
- **Grating period 500µm**
- **Scanning head with external electronics**

Design 10 or 12



Tolerance principle in accodrance with ISO 8015
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 shaft rotation for positive counting
H4 = Ground plane

Technical data

Scanning head 500µm	**WMK 2005/ WMK 1005 WMK 2105,/WMK 1105**					
Performance	Standard			High Accuracy		
Interface	1Vpp	TTL		1Vpp	TTL	
Max. Position error per grating period	± 1,5µm			± 0,3µm		
TTL - Interpolation/ 1Vpp signal period						
Signal period [1)] Interpolation	- -	125µm to 0,5µm 1 to 250		- -	0,25µm or 0,05µm 500 or 2500	
Signal period Dividing factor	500µm to 15,625µm 1 to 32	- -		15,625µm or 10µm 32 or 50	- -	
Electrical connection	Cable with M23 coupling 12pin male					
Cable lenght on the scanning head	0,50m - 6,00m					
Voltage 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					
Typical current consumption	Design 20, 21: ≤ 220mA at 5V (without load) Design 10,12: ≤ 240mA at 5V (without load)					
Vibration	< 200m/s² for 55 - 2000Hz					
Schock	< 2000 m/s^2 for 6ms					
Operating temperatur	-10°C to 100°C					
Storage temperatur	-20°C to 100°C					
Protection	IP67					
Weight	38g Design 20, 21 / 10g Design 10,11,12					
Line count	512	720	1024	1440	1800	2048
Position error per grating period [2)]						
Standard	± 7,6 "	± 5,4"	± 3,8"	± 2,7"	± 2,2"	± 1,8"
High Accuracy	± 1,6"	± 1,1"	± 0,8"	± 0,6"	± 0,5"	± 0,4"
Electrical speed [min^{-1}]						
Standard	≤ 11710	≤ 8330	≤ 5850	≤ 4160	≤ 3330	≤ 2920
High Accuracy	≤ 2340	≤ 1660	≤ 1170	≤ 830	≤ 660	≤ 580

[1)] after 4-edge-evaluation

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

Ordering code

- **WMF - Scale tape ring on flange for incremental angle encoder**
- **Grating period 500µm**

WMF 1005 A □□ - □□□□□ - MF - □□□□ - □□□□□□

Grating period accuracy
3 = +/- 3µm
5 = +/- 5µm
10 = +/- 10µm

Line count
512
720
1024
1440
1800
2048

Type of graduation carrier

Standard graduation carrier	Line count	Ø A	Ø I
AA51	512	81,85	60 +0/-0,01
AA52	720	115,02	60 +0/-0,01
AA53			95 +0/-0,01
AA54	1024	163,44	105 +0/-0,01
AA55			143 +0/-0,01
AA56	1440	229,68	180 +0/-0,01
AA57			209 +0/-0,01
AA58	1800	286,98	180 +0/-0,01
AA59			266 +0/-0,01
AA60	2048	326,45	220 +0/-0,01
AA61			296 +0/-0,01

Reference mark position
0RM= without reference marks
1RM= with 1 reference mark
Kxxx= distance coded reference marks

Safety concept
MF = Fault exclusion for loosing of the mechanical connetions possible

Ordering code

- **WMB - Scale tape ring on customer specific graduation carrier for incremental angle encoder**
- **Grating period 500µm**

WMB □□ 05 □□□ - □□□□□ - . . - □□□□ - □□□□□□

Type
10 = Ring, Outside scanning

Scanning
A = Outside scanning
I = Inside scanning

Grating period accuracy
3 = +/- 3µm
5 = +/- 5µm
10 = +/- 10µm

Line count
Customer specific

Type of graduation carrier
Bxxx = customer specific, definded by AMO

Reference mark position
0RM= without reference marks
1RM= with 1 reference mark
Kxxx= distance coded reference marks

Ordering code

- **WMK - Scanning head for incremental angle encoder**
- **Grating period 500µm**

WMK □□05□□.□□□□□□□□-□□-□□□□□-□,□□-□□□□□-□□

Scanning
Outside scanning
10 = Encoder miniature
20 = AK with integrated electronics

Performance
S = Standard
HA = High Accuracy

Interface
07 = TTL
08 = 1 Vpp

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

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

Line count
512
720
1024
1440
1800
2048

Cable lenght
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

Design of the scanning head
10 = Miniaturized connector with electronics on cable, output M23
12 = Miniaturized, pluggable connec tor with electronics on cable via M12 connector
20 = Standard
21 = Standard, flat

Interpolation/ Dividing factor

		1Vpp		TTL	
		S	HA	S	HA
01	1-fold	×		×	
04	4-fold	×		×	
05	5-fold			×	
08	8-fold	×		×	
10	10-fold	×		×	
16	16-fold	×		×	
20	20-fold			×	
25	25-fold	×		×	
32	32-fold		×	×	
50	50-fold		×	×	
A3	250-fold			×	
A4	500-fold				×
A9	2500-fold				×

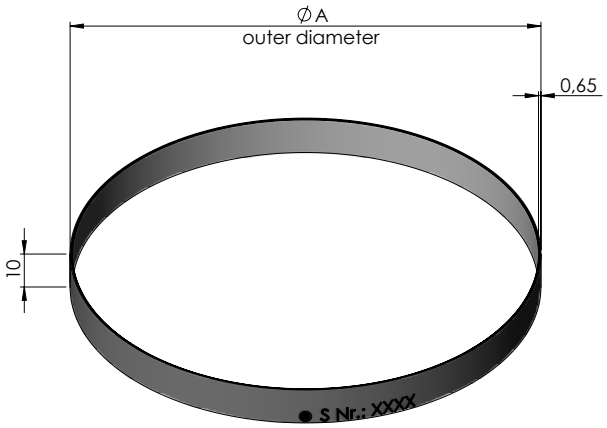
Electrical connection
01 = free cable end
02S12 = M23-12 pin connector male
03S12 = M23-12pin coupling male
16S15 = D-Sub-15 pin 2-row male
27S12 [1] = Flange socket M23 12pin male

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

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

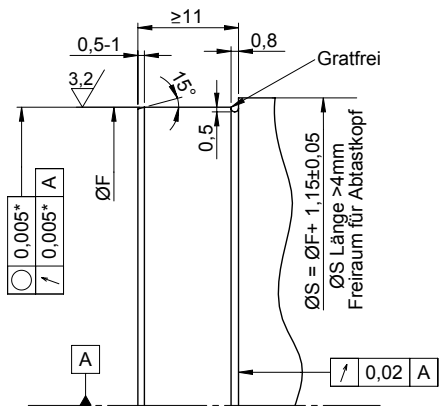
Incremental scale tape ring for outside scanning WMRA 1010 A

- **In combination with the scanning head WMK 2010 / WMK 1010**
- **Grating period 1000µm**



WMR 1010A

Mechanical requirements on the carrier flange



Line count	ØF [mm]
256 to 359	N/π – 0,84 ±0,01
360 to 511	N/π – 0,77 ±0,01
512 to 719	N/π – 0,73 ±0,02
720 to 1024	N/π – 0,70 ±0,02
1025 to 1500	N/π – 0,68 ±0,03
1501 to 2000	N/π – 0,65 ±0,06
2001 to 3000	N/π – 0,62 ±0,07
3001 to 6000	N/π – 0,60 ±0,10
> 6000	N/π – 0,55 ±0,10

*) Recommended eccentricity: Greater eccentricities up to ~0,05mm do not affect the function of the device, but cause a proportional loss in positioning accuracy.

Technical data

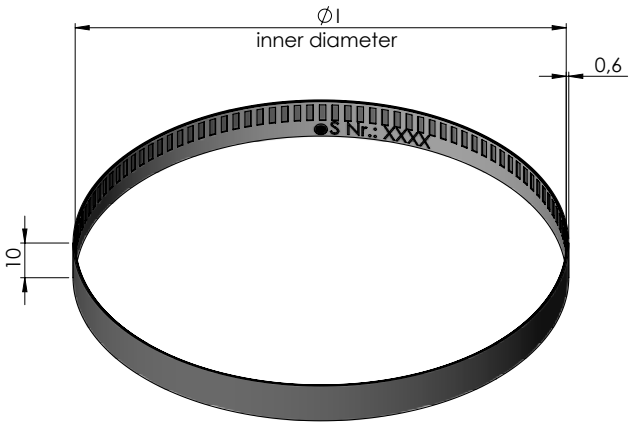
Scale tape ring WMR 1010A 1000µm									
Line count	256	360	512	720	900	1024	1440	1800	2048
Reference mark	Single or distance coded								
Grating period accuracy [1]									
± 10µm arc length	±51“	±36“	±26“	±18“	±15“	±13“	±9,0“	±7,5“	±6,5“
± 5µm arc length	±26“	±18“	±13“	±9,0“	±7,5“	±6,5“	±4,5“	±4,0“	±3,5“
± 3µm arc length	±16“	±11“	±8,0“	±5,5“	±4,5“	±4,0“	±3,0“	±2,5“	±2,0“
Outside diameter ring [mm]	81,95	115,12	163,54	229,78	287,08	326,55	458,99	573,61	652,58
Mech. speed [min^{-1}] [2]	46800	33300	23400	16600	13200	11700	8300	6600	5800
Max. angle acceleration [rad/s^2] [2]	4000					3800	1500	650	450

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

[2] Values should be considered to ensure a mechanical fault exclusion.

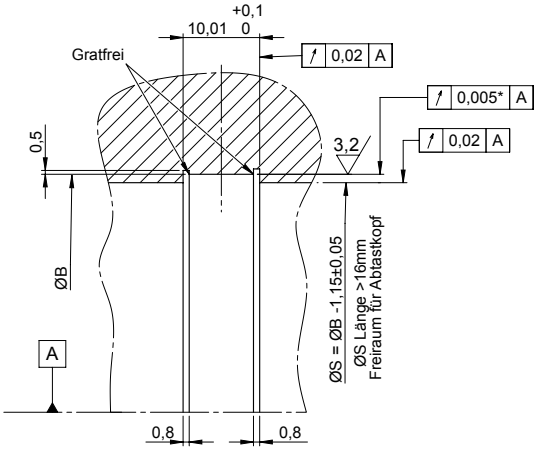
Incremental scale tape ring for inside scanning WMR 1110 I

- **In combination with the scanning head WMK 2110 / WMK 1110**
- **Grating period 1000µm**



WMR 1110I

Mechanical requirements on the carrier flange



Line count	ØB [mm]
512 to 719	N/π + 0,73 ±0,01
720 to 1024	N/π + 0,67 ±0,02
1025 to 1500	N/π + 0,64 ±0,03
1501 to 2000	N/π + 0,60 ±0,06
2001 to 3000	N/π + 0,57 ±0,07
3001 to 8000	N/π + 0,54 ±0,10

*) Recommended eccentricity: Greater eccentricities up to ~0,05mm do not affect the function of the device, but cause a proportional loss in positioning accuracy..

Technical data

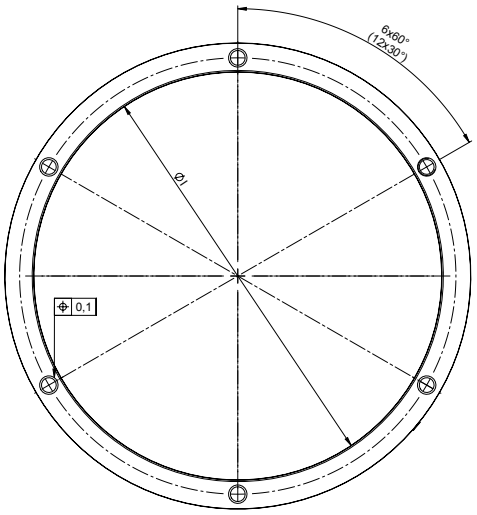
Scale tape ring WMR 1110I 1000µm							
Line count	512	720	900	1024	1440	1800	2048
Reference mark	Single or distance coded						
Grating period accuracy [1]							
± 10µm arc length	±26“	±18“	±15“	±13“	±9,0“	±7,5“	±6,5“
± 5µm arc length	±13“	±9,0“	±7,5“	±6,5“	±4,5“	±4,0“	±3,5“
± 3µm arc length	±8,0“	±5,5“	±4,5“	±4,0“	±3,0“	±2,5“	±2,0“
Inside diameter ring [mm]	163,54	229,78	287,08	325,42	457,81	572,36	651,27
Mech. speed [min^{-1}] [2]	23400	16600	13200	11700	8300	6600	5800
Max. angle acceleration [rad/s^2] [2]	4000			3800	1500	650	450

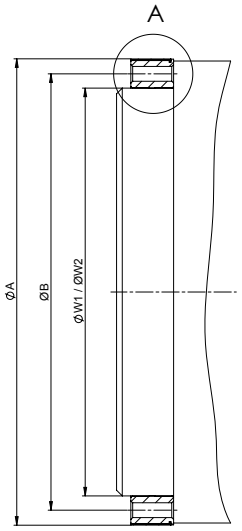
[1] The position error per grating period and the accuracy of the grating result toghether in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error.

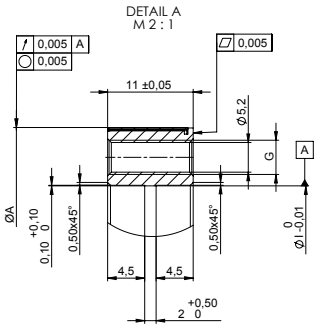
[2] Values should be considered to ensure a mechanical fault exclusion.

Incremental scale tape ring on flange WMF 1010 A

- **In combination with the scanning head WMK 2010 / WMK 1010**
- **Grating period 1000µm**



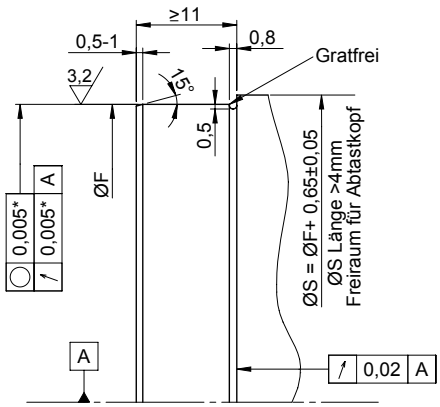




ØW1 = without mech. fault exclusion
ØW2 = with mech. fault exclusion

Line count	Type of graduation carrier	Ø A	Ø I	ØW1	ØW2	Ø B	G
256	AA01	81,95	60 +0/-0,01	60 +0,02/+0,01	60 +0,05/+0,04	70	6 x M6
360	AA02	115,12	60 +0/-0,01	60 +0,02/+0,01	60 +0,05/+0,04	75	6 x M6
360	AA03		95 +0/-0,01	95 +0,02/+0,01	95 +0,05/+0,04	105	6 x M6
512	AA05	163,54	105 +0/-0,01	105 +0,02/+0,01	105 +0,05/+0,04	120	6 x M6
512	AA06		143 +0/-0,01	143 +0,02/+0,01	143 +0,05/+0,04	153	6 x M6
720	AA08	229,78	180 +0/-0,01	180 +0,02/+0,01	180 +0,05/+0,04	195	6 x M6
720	AA09		209 +0/-0,01	209 +0,02/+0,01	209 +0,05/+0,04	219	6 x M6
900	AA10	287,08	180 +0/-0,01	180 +0,02/+0,01	180 +0,05/+0,04	195	12 x M6
900	AA11		266 +0/-0,01	266 +0,02/+0,01	266 +0,05/+0,04	276	12 x M6
1024	AA12	326,55	220 +0/-0,01	220 +0,02/+0,01	220 +0,05/+0,04	235	12 x M6
1024	AA13		296 +0/-0,01	296 +0,02/+0,01	296 +0,05/+0,04	311	12 x M6

Mechanical requirements for customer specific graduation carrier WMF 1010A / WMB 1010A



*)Recommended eccentricity: Greater eccentricities up to ~0,05mm do not affect the function of the device, but cause a proportional loss in positioning accuracy..

Recommended material: 1.4104 (X14CrMoS17) or 1.7225 (42CrMo4)
If you are using a different soft magnetic material please contact AMO.

Line count	ØF [mm]
256 to 359	N/π – 0,24 ±0,01
360 to 511	N/π – 0,17 ±0,01
512 to 719	N/π – 0,13 ±0,02
720 to 1024	N/π – 0,10 ±0,02
1025 to 1500	N/π – 0,08 ±0,03
1501 to 2000	N/π – 0,05 ±0,06
2001 to 3000	N/π – 0,02 ±0,07
3001 to 6000	N/π – 0,00 ±0,10
> 6000	N/π + 0,05 ±0,10

Tolerance principle in accordance withISO8015
General tolerances in accordance with ISO2768-fH
All dimensions in mm

Technical data

Scale tape ring on flange 1000µm	WMF 1010A / WMB 1010A											
Line count	256	360		512		720		900		1024		
Refernence mark	Single or distance coded											
Grating period accuracy [1]												
± 10µm arc length	±51“	±36“		±26“		±18“		±15“		±13“		
± 5µm arc length	±26“	±18“		±13“		±9,0“		±7,5“		±6,5“		
± 3µm arc length	±16“	±11“		±8,0“		±5,5“		±4,5“		±4,0“		
Outside diameter [mm]	81,95	115,12		163,54		229,78		287,08		326,55		
Inside diameter [mm]	60	60	95	105	143	180	209	180	266	220	296	
Max. angle acceleration [rad/s²] [2]	4000					2200	4000	1700	4000	1250	3800	
Mech. speed [min^{-1}] [2]	25000	20000		15000		10000		8000		6000		

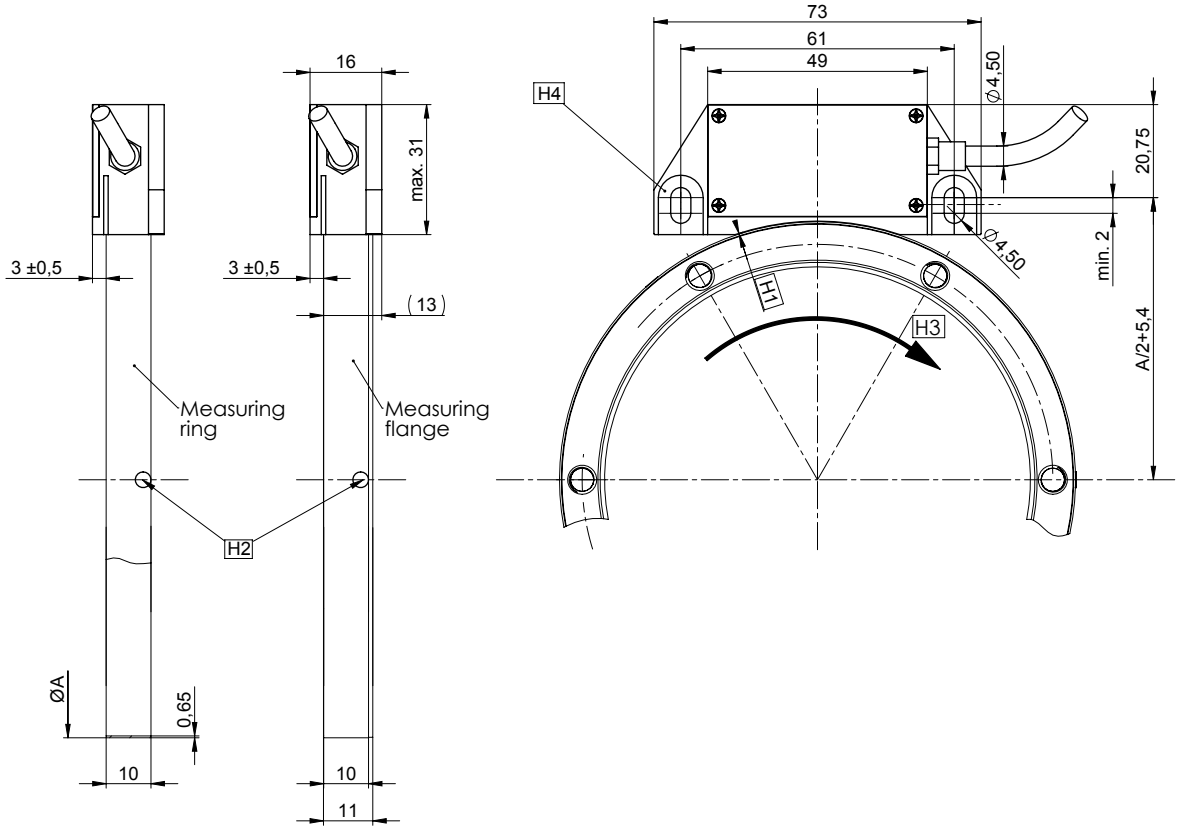
[1] The position error per grating period and the accuracy of the grating result toghether in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error.

[2] Values should be considered to ensure a mechanical fault exclusion.

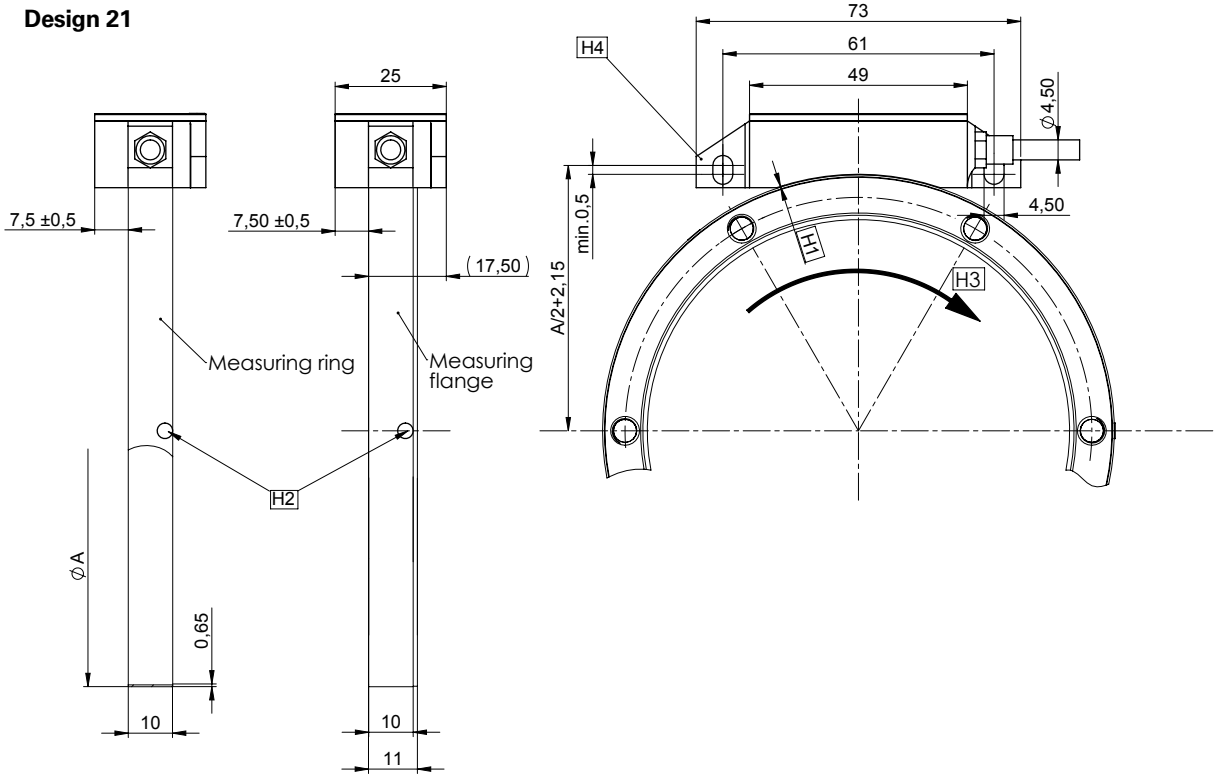
WMK 2010 series

- **Composed of WMK 2010 and scale tape ring on flange or scale tape ring**
- **Grating period 1000µm**
- **Scanning head with integrated electronic**

Design 20



Design 21



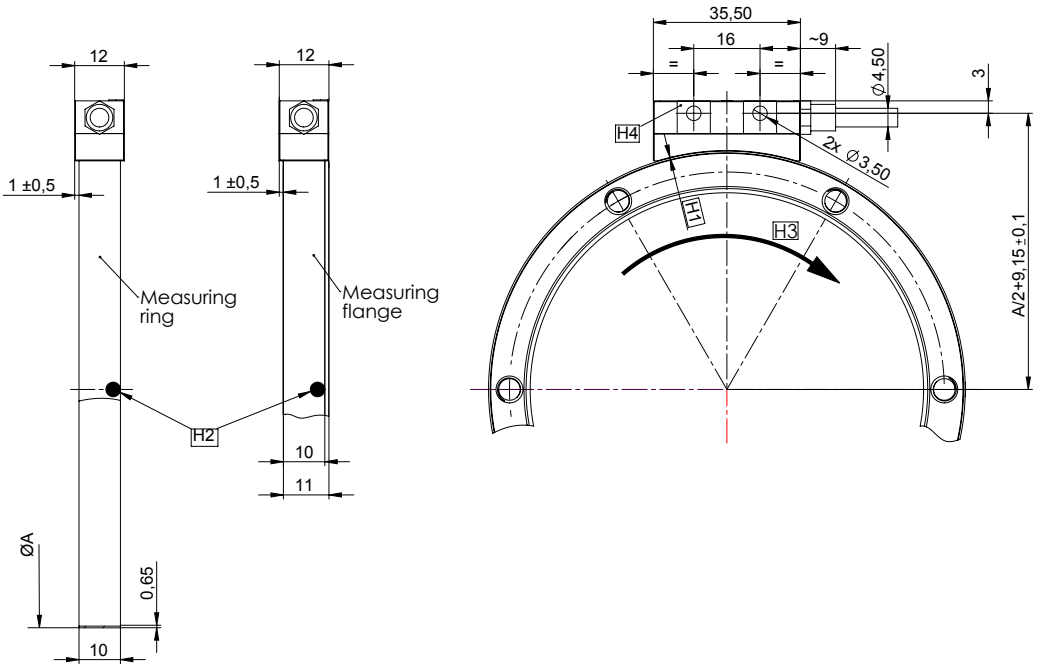
Tolerance principle in accordance with ISO 8015
Gerneral tolerances in accordance with ISO 2768-fH
All dimensions in mm

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

WMK 1010 series

- **Composed of WMK 1010 and scale tape ring on flange or scale tape ring**
- **Grating period 1000µm**
- **Scanning head with external electronic**

Design 10 or 12



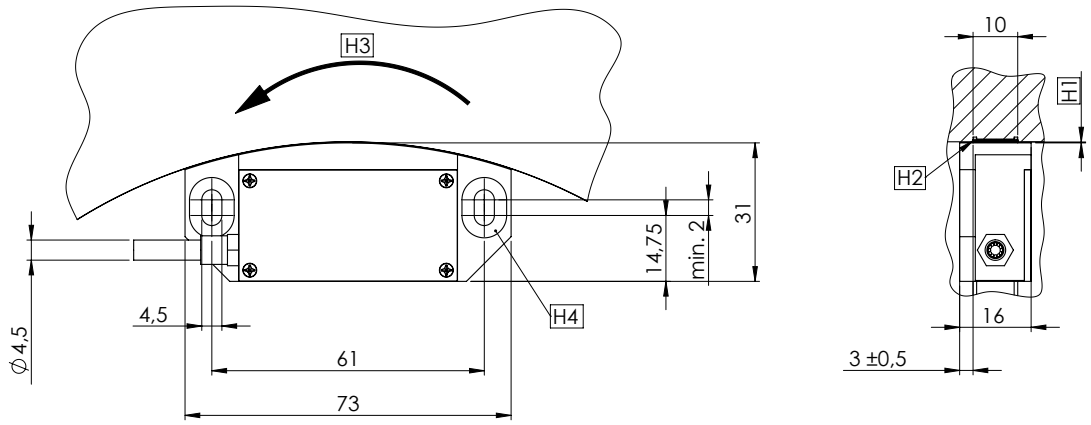
Tolerance principle in accordance with ISO 8015
Gerneral tolerances in accordance with ISO 2768-fH
All dimensions in mm

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

WMK 2110 series

- **Composed of WMKA 2110 and scale tape ring**
- **Grating period 1000µm**
- **Scanning head with external electronic**

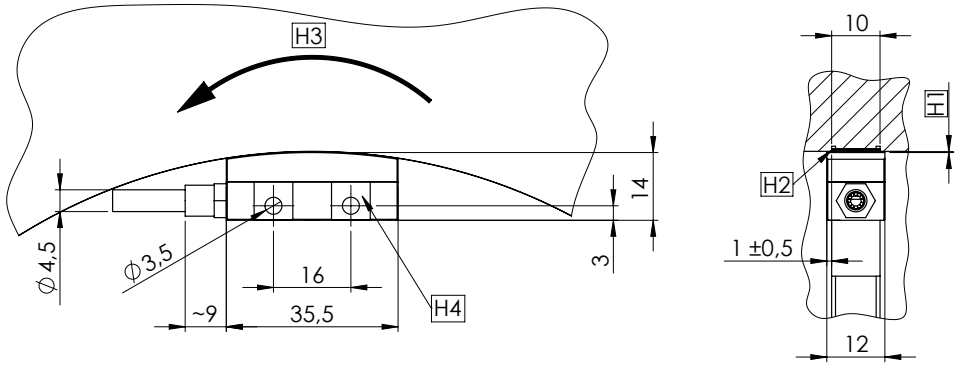
Design 20



WMK 1110 series

- **Composed of WMKA 1110 and scale tape ring**
- **Grating period 1000µm**
- **Scanning head with external electronic**

Design 10 or 12



Tolerance principle in accordance with ISO 8015
Gerneral 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 shaft rotation for positive counting
H4 = Ground plane

Technical data

Scanning head 1000µm	**WMK 2010,/WMK 1010 WMK 2110/WMK 1110**								
Performance	Standard				High Accuracy				
Interface	1Vpp		TTL		1Vpp		TTL		
Position error per grating period	± 2µm				± 0,5µm				
TTL - interpolation/ 1Vpp signal period									
Signal period[1)] Interpolation	- -		250µm to 1µm		- -		0,5µm or 0,1µm 500 or 2500		
Signal period Dividing factor	1000µm to 31,25µm 1 to 32		- -		31,25µm or 20µm 32 or 50		- -		
Max. output frequency	400kHz		5MHz		400kHz		5MHz		
Elektrical connection	Cable with M23 coupling 12pin male								
Cable lenght on the scanning head	0,50m - 6,00m								
Power supply	1Vss: 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	< 200m/s² for 55 - 2000Hz								
Schock	< 2000 m/s^2 for 6ms								
Operating temperatur range	-10°C to 100°C								
Storage temperature range	-20°C to 100°C								
Protection	IP67								
Weight	38g Design 20, 21 / 10g Design 10, 12								
Line count	256[2)]	360[2)]	512	720	900	1024	1440	1800	2048
Position error per grating period [3)]									
	±11“	±7,5“	±5,5“	±4,0“	±3,0“	±3,0“	±2,0“	±2,0“	±1,5“
	±3,0“	±2,0“	±1,5“	±1,0“	±1,0“	±1,0“	±0,5“	±0,5“	±0,5“
Electrical max. speed [min^{-1}]									
Standard	≤ 23430	≤ 16660	≤ 11710	≤ 8330	≤ 6660	≤ 5850	≤ 4160	≤ 3330	≤ 2920
High Accuracy	≤ 4680	≤ 3330	≤ 2340	≤ 1660	≤ 1330	≤ 1170	≤ 830	≤ 660	≤ 580

[1)] after 4-edge-evaluation
[2)] Not for inside scanning
[3)] The position error per grating period and the accuracy of the grating result toghether in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error.

Ordering code

- **WMR Scale tape ring for incremental angle ecoder**
- **Grating period 1000µm**

WMR □□10 □□□-□□□□□- MF -□□□□-□□□□□□

Type
10 = Ring, Outside scanning
11 = Ring, Inside scanning

Scanning
A = Outside scanning
I = Inside scanning

Grating period accuracy
3 = +/- 3µm
5 = +/- 5µm
10 = +/- 10µm

Line count
256[1)]
360[1)]
512[1)]
720[1)]
900[1)]
1024
1440
1800
2048

Type of graduation carrier
Outside scanning:
R001 = Scale tape ring
Inside scanning:
R004 = Scale tape ring without cover tape

Safety concept
MF = Fault exclusion for loosing of the mechanical connetions possible

Reference mark position
0RM= without reference marks
1RM= with 1 reference mark
Kxxx= distance coded reference marks

[1)] Not for inside scanning.

Ordering code

- **WMF Scale tape ring on flange for incremental angle encoder**
- **Grating period 1000µm**

WMF 1010 A□□-□□□□□- MF -□□□□-□□□□□□

Grating period accuracy
3 = +/- 3µm
5 = +/- 5µm
10 = +/- 10µm

Line count
256
360
512
720
900
1024

Type of graduation carrier

Standard Graduation carrier	Line count	Ø A	Ø I
AA01	256	81,95	60 +0/-0,01
AA02	360	115,12	60 +0/-0,01
AA03			95 +0/-0,01
AA05	512	163,54	105 +0/-0,01
AA06			143 +0/-0,01
AA08	720	229,78	180 +0/-0,01
AA09			209 +0/-0,01
AA10	900	287,08	180 +0/-0,01
AA11			266 +0/-0,01
AA12	1024	326,55	220 +0/-0,01
AA13			296 +0/-0,01

Reference mark position
0RM= without reference marks
1RM= with 1 reference mark
Kxxx= distance coded reference marks

Safety concept
MF = Fault exclusion for loosing of the mechanical connetions possible

Ordering code

- **WMB - Measuring flange on customer specific graduation carrier for incremetal angle encoder**
- **Grating period 1000µm**

WMB □□10 □□□-□□□□□-...-□□□□-□□□□□□

Type
10 = Ring, Outside scanning
11 = Ring, Inside scanning

Scanning
A = Outside scanning
I = Inside scanning

Grating period accuracy
3 = +/- 3µm
5 = +/- 5µm
10 = +/- 10µm

Line count
Customer specific

Type of graduation carrier
Bxxx = customer specific, defined by AMO

Reference mark position
0RM= without reference marks
1RM= with 1 reference mark
Kxxx= distance coded reference marks

Ordering code

- **WMK - scanning head for incremental angle encoder**
- **Grating period 1000µm**

WMK □□10□□.□□□□□□□□-□□-□□□□□-□,□□-□□□□□□-□□

Scanning
Outside
10 = scanning head miniature
20 = scanning head with integraded electronics
Inside
11 = scanning head miniature
21 = scanning head with integraded 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. [3]

Line count
256 [2]
360 [2]
512
720
900
1024
1440
1800
2048

Design of the scanning head
10 = Miniaturized connector with electronics on cable, output M23
12 = Miniaturized, pluggable connector with electronics on cable via M12 connector
20 = Standard
21 = Standard, flat

Cable lenght
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 socket M23 12pin. male

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

Interpolation/ Dividing factor

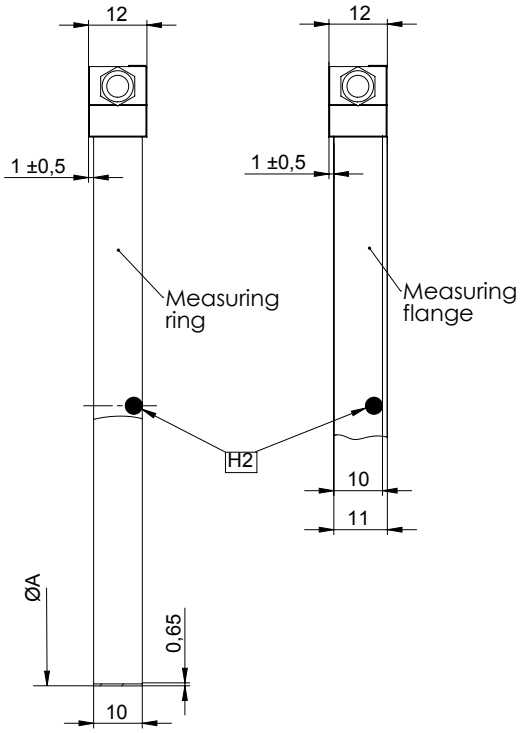
		1Vpp		TTL	
		S	HA	S	HA
01	1-fold	×		×	
04	4-fold	×		×	
05	5-fold			×	
08	8-fold	×		×	
10	10-fold	×		×	
16	16-fold	×		×	
20	20-fold			×	
25	25-fold	×		×	
32	32-fold		×	×	
50	50-fold		×	×	
A3	250-fold			×	
A4	500-fold				×
A9	2500fold				×

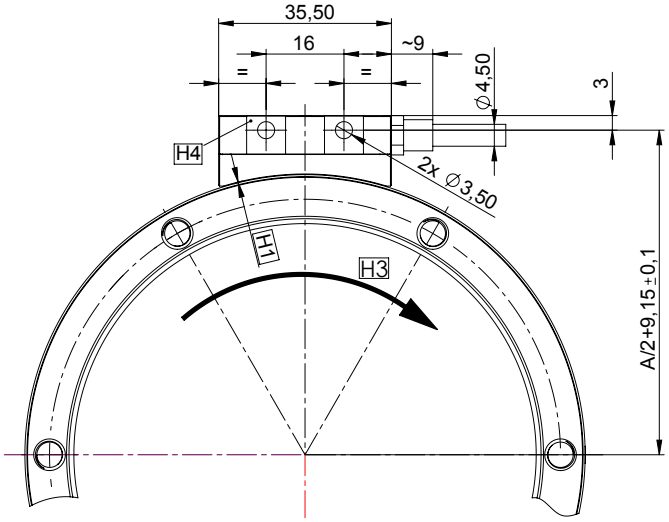
[1] Electrical connection for miniturized design of the scanning head 10 and 12.
[2] Not for inside scanning.
[3] Option „FA“ only used for dividing factor „01“.

MHS

- **MHS - Double head scanning for incremental angle encoder**
- **Grating period 500µm or 1000µm**

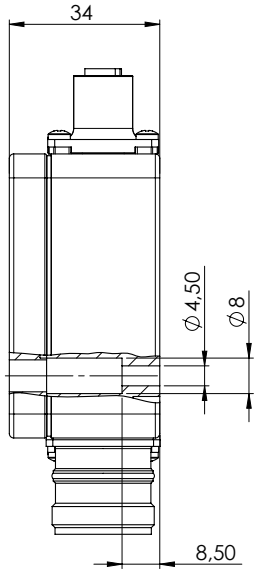
MHS with scanning head design 12

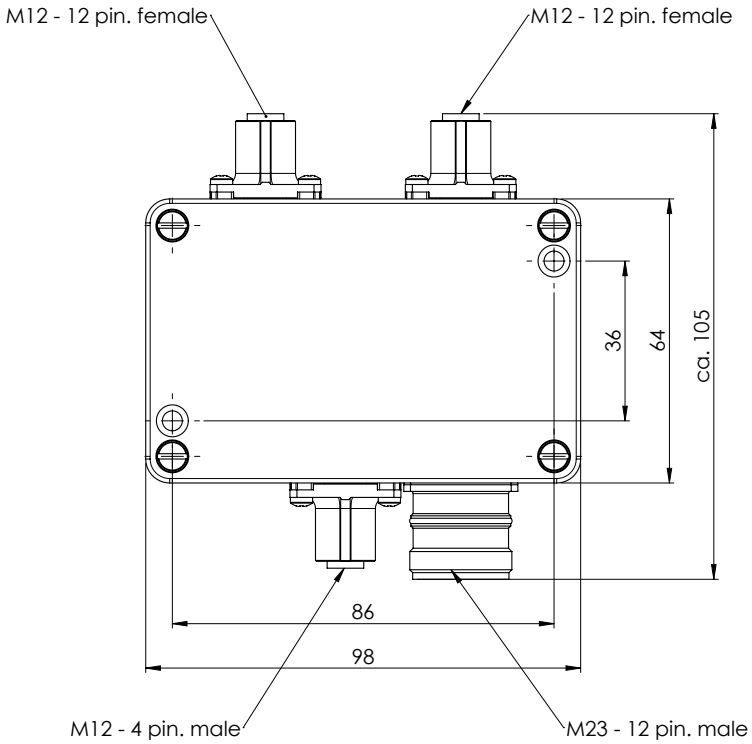




H1 = Air gap 0,15 ± 0,10mm, set with spacer foil for graduation period 1000µm
Air gap 0,10 ± 0,05mm, set with spacer foil for graduation period 500µm
H2 = Reference track marking
H3 = Direction of shaft rotation for positive counting
H4 = Ground plane

Dimensions MHS Box





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

Technical data

MHS 1005/ MHS 1010				
Grating period	500µm		1000µm	
Interface	1Vpp	TTL	1Vpp	TTL
Position error per grating period	± 0,2µm		± 0,3µm	
TTL - interpolation/ 1Vpp signalperiod				
Signal period [1)] Interpolation	- -	0,25µm to 0,05µm 500 or 2500	- -	0,5µm or 0,1µm 500 or 2500
Signal period Division factor	15,625 µm or 10µm 32 or 50	- -	31,25µm or20µm 32 or 50	- -
Max. output frequency	400KHz	5MHz	400KHz	5MHz
Electrical connection	Panel with M23 couling 12pin. male			
Cable lenght on the scanning head	0,50m - 6,00m			
Power supply	DC 24V (9V to 36V)			
Power consumption	≤ 6W			
Typ. current consumption	≤ 250mA at 24V			
Vibration	< 200m/s² for 55 - 2000Hz			
Schock	< 2000 m/s^2 for 6ms			
Operating temperature	-10°C to 85°C			
Storage temperatur	-20°C to 85°C			
Protection	Scanning head: IP67 evaluation electronics: IP66			
Weight	Scanning head: 10g evaluation electronics: 260g			

Technical data

- **Graduation in combination with double head scanning**

Scale tape ring on flange WMF / Scale tape ring WMR 500µm / 1000µm									
Line count	256[1]	360[1]	512	720	900	1024	1440	1800	2048
Reference mark	Single or distance coded								
Position error per grating period [2]									
Grating period 500µm	-	-	± 1,10“	± 0,80“	± 0,60“	± 0,50“	± 0,40“	± 0,30“	± 0,30“
Grating period 1000µm	± 1,60“	± 1,10“	± 0,80“	± 0,60“	±0,50“	± 0,40“	± 0,30“	± 0,30“	± 0,20“
Grating period accuracy [3]	Accuracy for 1000µm grating period								
± 10µm arc lenght	± 26“	± 18“	± 13“	± 9,0“	± 7,5“	± 6,5“	± 4,5“	± 4,0“	± 3,5“
± 5µm arc lenght	±13“	± 9,0“	± 6,5“	± 4,5“	± 4,0“	± 3,5“	± 2,5“	± 2,0“	± 2,0“
± 3µm arc lenght	±8,0“	± 5,5“	± 4,0“	± 3,0“	± 2,5“	± 2,0“	± 1,5“	± 1,5“	± 1,0“
	Accuracy for 500µm grating period								
± 10µm arc lenght	-	-	± 26“	± 18“	± 15“	± 13“	± 9,0“	± 7,5“	± 6,5“
± 5µm arc lenght	-	-	± 13“	± 9,0“	± 7,5“	± 6,5“	± 4,5“	± 4,0“	± 3,5“
± 3µm arc lenght	-	-	± 8“	± 5,5“	± 4,5“	± 4,0“	± 3,0“	± 2,5“	± 2,0“
Electrical speed [min^{-1}]	≤ 4680	≤ 3330	≤ 2340	≤ 1660	≤ 1330	≤ 1170	≤ 830	≤ 660	≤ 580

1) Not available for grating period 500µm

2) The position error per grating period and the accuracy of the grating result toghether in the encoder specific error

3) The grating accuracies shown above are calculated for optimal roundness of the measuring flange or measuring ring. Therefore those values are showing the maximum achievable accuracy of the grating.

Ordering code

- **MHS -Double head scanning for incremental angle encoders**

MHS □□□□HA.□□□□..□□-□□/□□-□□□□□.□□,□□-27S12 - UJ

Scanning
Outside
10 = miniature scanning head
Inside
11 = miniature scanning head

Grating Period
5 = 500µm
10 = 1000µm

Interface
07 = TTL
08 = 1Vpp

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

Design of the scanning head
12 = Miniaturized, plugable M12

Interpolation/ Dividing factor

		1Vpp	TTL
32	32-fold	×	
50	50-fold	×	
A4	500-fold		×
A9	2500-fold		×

Line count
256[1)]
360[1)]
512
720
900
1024
1440
1800
2048

Variation in cablelength
. = without
D = different cable length

Cable length of scanning head
00,50 = 0,50 m
01,00 = 1,00 m
01,50 = 1,50 m
02,00 = 2,00 m
02,50 = 2,50 m
03,00 = 3,00 m
04,00 = 4,00 m
05,00 = 5,00 m
06,00 = 6,00 m

[1)] not for inside scanning
not for 500µm grating period

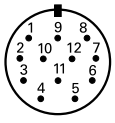
Pin configuration, power supply

4pin flange socket M12 male

Power supply			
1	**2**	**3**	**4**
U_P	-	**0 V**	-

Cable Shield is connected with the housing;
U_P = Power supply voltage

Electrical connection: 27S12
12pin flange socket M23 male

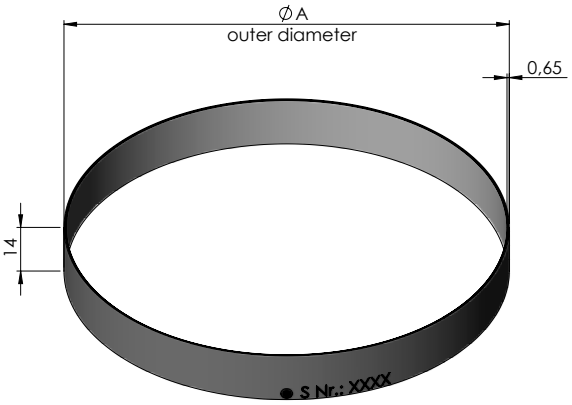


	Power supply				Incremental signals						Other signals		
	12[1)]	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**/**	**7**	**9**
	-	**Sensor** U_P	**0 V**	**Sensor** 0 V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**Free**	**Diag+**	**Diag-**
	brown/ green	blue	white/ green	white	brown	green	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.
[1)] Pin 12 is internal not connected to MHS board. (external power supply over the M12 4pin connector)

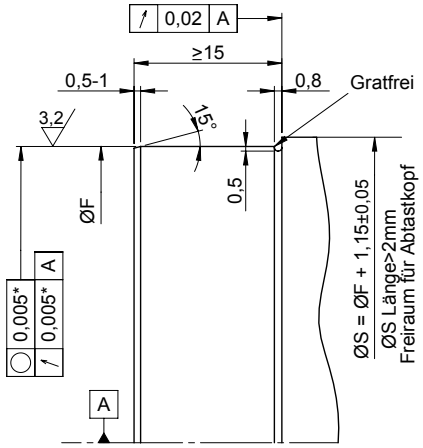
Incremental scale tape ring for outside scanning WMR 1030 A

- **In combination with the scanning head WMK 2030**
- **Grating period 3000µm**



WMR 1030A

Mechanical requirements on the carrier flange



Line count	ØF [mm]
85 to 169	Nx3/π – 0,82 ±0,01
170 to 240	Nx3/π – 0,73 ±0,02
241 to 342	Nx3/π – 0,70 ±0,02
343 to 500	Nx3/π – 0,68 ±0,03
501 to 660	Nx3/π – 0,65 ±0,06
661 to 1000	Nx3/π – 0,62 ±0,07
1001 to 2000	Nx3/π – 0,60 ±0,10
2001 to 4000	Nx3/π – 0,55 ±0,10
4001 to 10000	Nx3/π – 0,45 ±0,10

*) Recommended eccentricity: Greater eccentricities up to ~0,05mm do not affect the function of the device, but cause a proportional loss in positioning accuracy.

Technical data

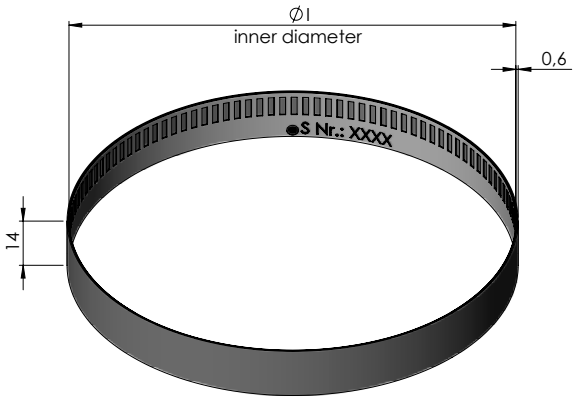
Scale tape ring WMR 1030A 3000 µm									
Line count	120	170	240	256	300	341	360	480	512
Reference mark	Single or distance coded								
Grating period accuracy [1]									
± 20µm arc length	± 72“	± 51“	± 36“	± 34“	± 29“	± 26“	± 24“	± 18“	± 17“
± 10µm arc length	± 36“	± 26“	± 18“	± 17“	± 15“	± 13“	± 12“	± 9,0“	± 8,5“
± 5µm arc length	± 18“	± 13“	± 9“	± 8,5“	± 7,5“	± 6,5“	± 6,0“	± 4,5“	± 4,5“
Outside diameter [mm]	115,12	162,91	229,78	245,06	287,08	326,23	344,39	458,99	489,57
Mech. speed [min^{-1}] [2]	33300	23500	16600	15600	13200	11700	11000	8300	7800
Max. angle acceleration [rad/s^2] [2]	4000					3600	3400	1400	1200

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

[2] Values should be considered to ensure a mechanical fault exclusion.

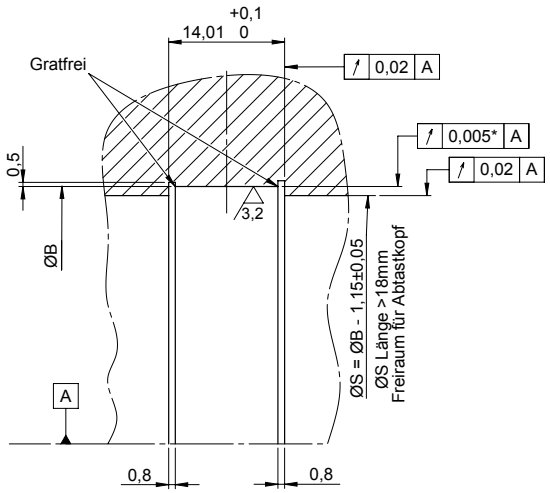
Incremetal scale tape ring for inside scanning WMR 1130 I

- **In combination with the scanning head WMK 2130**
- **Grating period 3000µm**



WMR 1130I

Mechanical requirements on the carrier flange



Line count	ØB [mm]
170 to 240	Nx3/π + 0,73 ±0,01
241 to 342	Nx3/π + 0,67 ±0,02
343 to 500	Nx3/π + 0,64 ±0,03
501 to 830	Nx3/π + 0,60 ±0.05
831 to 1330	Nx3/π + 0,57 ±0,07
1331 to 1830	Nx3/π + 0,54 ±0,10

*) Recommended eccentricity: Greater eccentricities up to ~0,05mm do not affect the function of the device, but cause a proportional loss in positioning accuracy.

Technical data

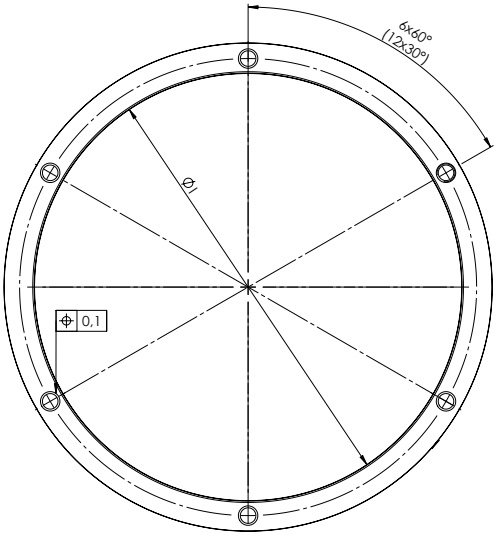
Scale tape ring WMR 1130I 3000 µm								
Line count	170	240	256	300	341	360	480	512
Reference mark	Single or distance coded							
Grating period accuracy [1]								
± 20µm arc lenght	± 51“	± 36“	± 34“	± 29“	± 26“	± 24“	± 18“	± 17“
± 10µm arc lenght	± 26“	± 18“	± 17“	± 15“	± 13“	± 12“	± 9,0“	± 8,5“
± 5µm arc lenght	± 13“	± 9“	± 8,5“	± 7,5“	± 6,5“	± 6,0“	± 4,5“	± 4,5“
Inside diameter ring [mm]	162,91	229,78	245,06	287,08	326,23	344,39	458,99	489,57
Mech. speed [min^{-1}] [2]	23500	16600	15600	13200	11700	11000	8300	7800
Max. angle acceleration [rad/s^2] [2]	4000				3600	3400	1400	1200

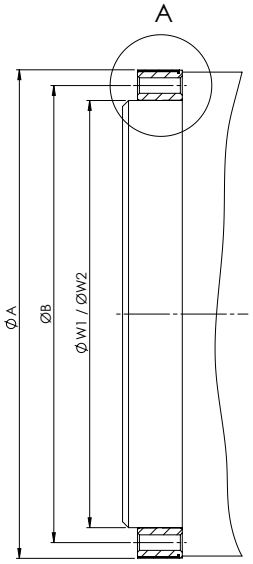
[1] The position error per grating period and the accuracy of the grating result toghether in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error.

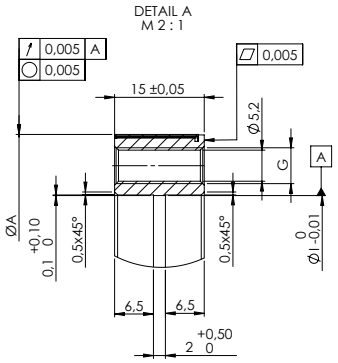
[2] Values should be considered to ensure a mechanical fault exclusion.

Incremental scale tape ring on flange WMF 1030 A

- **In combination with the scanning head WMK 2030**
- **Grating Period 3000µm**



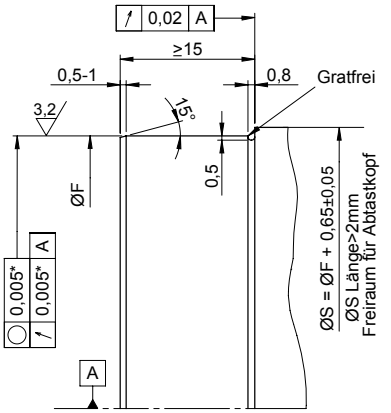




ØW1 = without mech. fault exclusion
ØW2 = with mech. fault exclusion

Line count	Type of graduation carrier	Ø A	Ø I	ØW1	ØW2	Ø B	G
120	AA32	115,12	60 +0/-0,01	60 +0,02/+0,01	60 +0,02/+0,01	75	6 x M6
120	AA33		95 +0/-0,01	95 +0,02/+0,01	95 +0,02/+0,01	105	6 x M6
240	AA36	229,78	180 +0/-0,01	180 +0,02/+0,01	180 +0,02/+0,01	195	6 x M6
240	AA37		209 +0/-0,01	209 +0,02/+0,01	209 +0,02/+0,01	219	6 x M6
300	AA38	287,08	180 +0/-0,01	180 +0,02/+0,01	180 +0,02/+0,01	195	6 x M6
300	AA39		266 +0/-0,01	266 +0,02/+0,01	266 +0,02/+0,01	276	6 x M6

Mechanical requirements for customer specific graduation carrier WMF 1030A / WMB 1030A



*) Recommended eccentricity: Greater eccentricities up to ~0,05mm do not affect the function of the device, but cause a proportional loss in positioning accuracy.

Line count	ØF [mm]
85 to 169	Nx3/π – 0,22 ±0,01
170 to 240	Nx3/π – 0,13 ±0,02
241 to 342	Nx3/π – 0,10 ±0,02
343 to 500	Nx3/π – 0,08 ±0,03
501 to 660	Nx3/π – 0,05 ±0,06
661 to 1000	Nx3/π – 0,02 ±0,07
1001 to 2000	Nx3/π – 0,00 ±0,10
2001 to 4000	Nx3/π + 0,05 ±0,10
4001 to 10000	Nx3/π + 0,15 ±0,10

Recommended material: 1.4104 (X14CrMoS17) or 1.7225 (42CrMo4)
If you are using a different soft magnetic material please contact AMO.

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

Scale tape ring on flange WMF 1030A / WMB 1030A 3000 µm						
Line count	120		240		300	
Reference mark	Single or distance coded					
Grating period accuracy [1]						
± 20µm arc lenght	± 72“		± 36“		± 29“	
± 10µm arc lenght	± 36“		± 18“		± 15“	
± 5µm arc lenght	± 18“		± 9“		± 7,5“	
Outside diamenter [mm]	115,12		229,78		287,08	
Inside diameter [mm]	60	75	180	209	180	266
Max. angle acceleration [rad/s²] [2]	4000		2000	4000	1300	4000
Mech. speed [min^{-1}] [2]	16600		8300		6600	

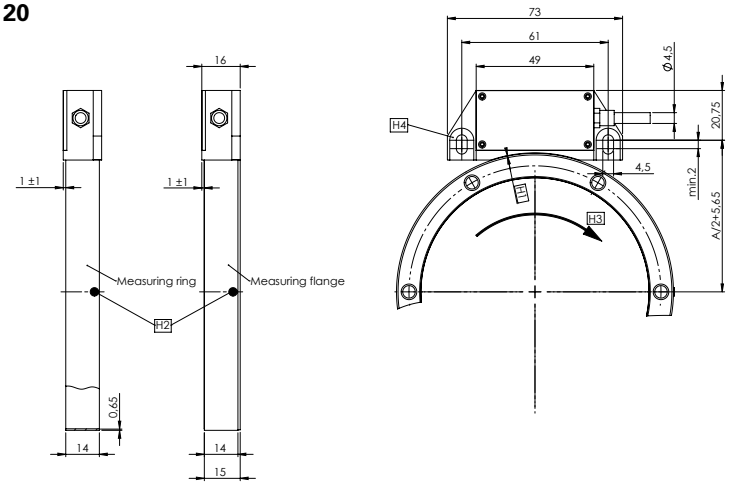
[1] The position error per grating period and the accuracy of the grating result toghether in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error.

[2] Values should be considered to ensure a mechanical fault exclusion.

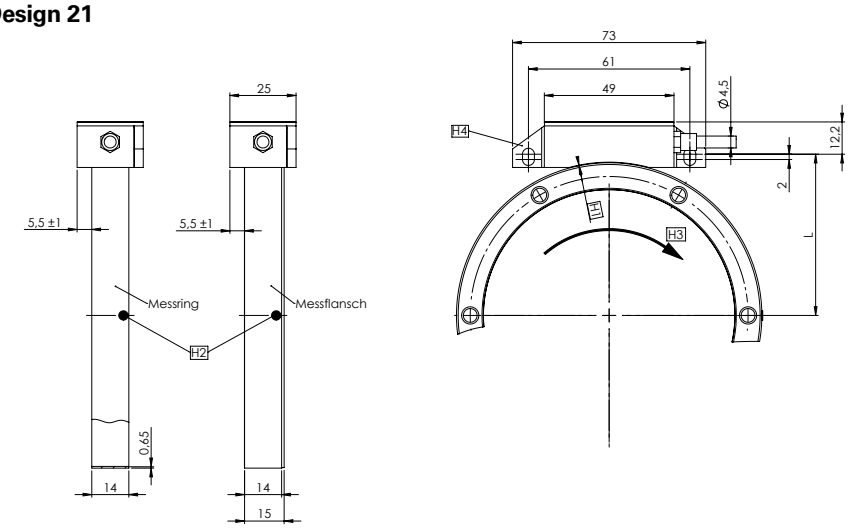
WMK 2030 series

- **Composed of WMK 2030 and scale tape ring on flange or scale tape ring**
- **Grating period 3000µm**
- **Scanning head with external electronic**

Design 20



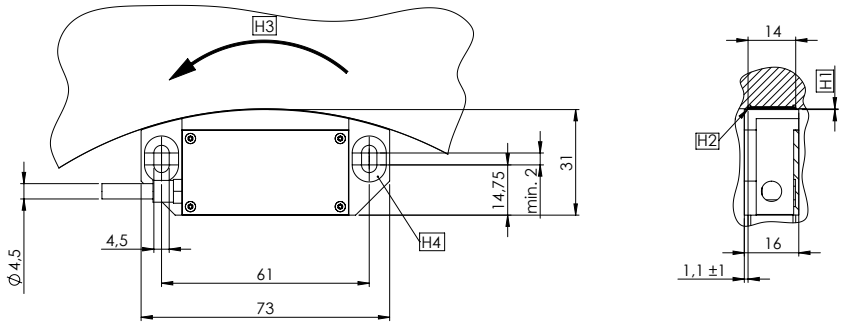
Design 21



WMK 2130 series

- **Composed of WMK 2110 and scale tape ring**
- **Grating period 3000µm**
- **Scanning head with external electronic**

Design 20



Tolerance principle in accordance with ISO 8015
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 shaft rotation for positive counting
H4 = Ground plane

Scanning head WMK 2030/ WMK 2130 3000 µm									
Performance	Standard								
Interface	1Vpp					TTL			
Max. Position error per grating period	± 4µm								
TTL - Interpolation/ 1Vpp signal period									
Signal period [1)] Interpolation	- -					750µm to 3µm 1 to 250			
Signal period Dividing factor	3000µm to 93,75µm 1 to 32					- -			
Max. Output frequency	400KHz					5MHz			
Electrical connection	Cable with M23 coupling 12pin male								
Cable lenght on the scaning head	0,50m - 6,00m								
Voltage supply	DC 4,0V to 7,0V					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	< 200m/s² for 55 - 2000Hz								
Schock	< 2000 m/s^2 for 6ms								
Operating temperatur	-10°C to 100°C								
Storage temperatur	-20°C to 100°C								
Protection	IP67								
Weight	38g Design: 20, 21								
Line count	120[3)]	170	240	256	300	341	360	480	512
Position error per grating period [2)]									
Standard	± 15“	± 11“	±7,5“	± 7,0“	± 6,0“	± 5,5“	± 5“	± 4“	± 3,5“
Electrical speed[min^{-1}]									
Standard	≤ 50000	≤ 35290	≤ 25000	≤ 23430	≤ 20000	≤ 17590	≤ 16660	≤ 12500	≤ 11700

1) after 4-edge-evaluation
2) The position error per grating period and the accuracy of the grating result toghether in the encoder specific error; additional deviations caused by mounting and bearing are not considered in this error.
3) not for inside scanning

Ordering code

- **WMR - Scale tape ring for incremental angle encoder**
- **Grating period 3000µm**

WMR □□30 □□□-□□□□□- MF -□□□□-□□□□□□

Type
10 = Ring, Outside scanning
11 = Ring, Inside scanning

Scanning
A = Outside scanning
I = Inside scanning

Grating period accuracy
5 = +/- 5µm
10 = +/- 10µm
20 = +/- 20µm

Line count
120[1)]
170
240
256
300
341
360
480
512

Type of graduation carrier
Outside scanning:
R001 = Scale tape ring
Inside scanning:
R004 = Scale tape ring without cover tape

Safety concept
MF = Fault exclusion for loosing of the mechanical connetions possible

Reference mark position
0RM= without reference marks
1RM= with 1 reference mark
Kxxx= distance coded reference marks

[1)] Not for Inside scanning.

Ordering code

- **WMF - Scale tape ring on flange for incremental angle encoder**
- **Grating period 3000µm**

WMF 1030 A□□-□□□□□- MF -□□□□-□□□□□□

Grating period accuracy
5 = +/- 5µm
10 = +/- 10µm
20 = +/- 20µm

Line count
120
240
300

Type of graduation carrier

Standard Graduation carrier	Line count	Ø A	Ø I
AA33	120	115,12	60 +0/-0,01
AA32			95 +0/-0,01
AA36	240	229,78	180 +0/-0,01
AA37			209 +0/-0,01
AA38	300	287,08	180 +0/-0,01
AA39			266 +0/-0,01

Reference mark position
0RM= without reference marks
1RM= with 1 reference mark
Kxxx= distance coded reference

Safety concept
MF = Fault exclusion for loosing of the mechanical connetions possible

Ordering code

- **WMB - Scale tape ring on customer specific graduation carrier for incremental angle encoder**
- **Grating period 3000µm**

WMB □□30 □□□-□□□□□-...-□□□□-□□□□□□

Type
10 = Ring, Outside scanning
11 = Ring, Inside scanning

Scanning
A = Outside scanning
I = Inside scanning

Grating period accuracy
5 = +/- 5µm
10 = +/- 10µm
20 = +/- 20µm

Line count
Customer specific

Type of graduation carrier
Bxxx = customer specific, defined by AMO

Reference mark position
0RM= without reference marks
1RM= with 1 reference mark
Kxxx= distance coded reference
..... marks

Ordering code

- **WMK - Scanning head for incremental angle encoder**
- **Grating period 3000µm**

WMK 2 ☐30 S. ☐☐☐☐☐☐☐☐-☐☐-☐☐☐☐☐-☐,☐☐-☐☐☐☐☐-☐☐

Scanning
20 = AK with integrated electronics; outside scanning
21 = AK with integrated electronics; inside scanning

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)]

Line count
120, 170, 240, 256
300, 341, 360, 480, 512

Bauform Design of the scanning head
20 = Standard
21 = Standard, flat

Cable lenght
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

Interpolation/ Diving factor

		1Vpp	TTL
01	1-fold	×	×
04	4-fold	×	×
05	5-fold		×
08	8-fold	×	×
10	10-fold	×	×
16	16-fold	×	×
20	20-fold		×
25	25-fold	×	×
32	32-fold	×	×
50	50-fold		×
A3	250-fold		×

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

Elektrical connection
01 = free cable end
02S12 = M23-12pin connector male
03S12 = M23-12 pin coupling male
16S15 = D-Sub-15pin 2-row male

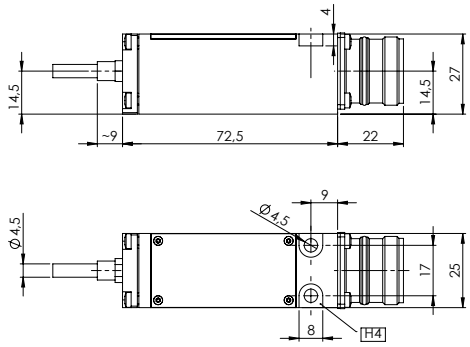
1) Option „FA“ only used for diving factor „01“.

External electronics

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

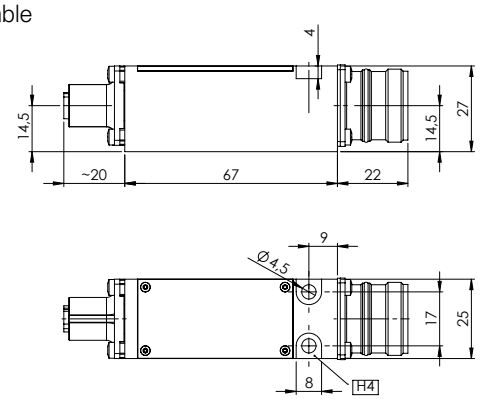
Design 10

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

H4= Mounting surface

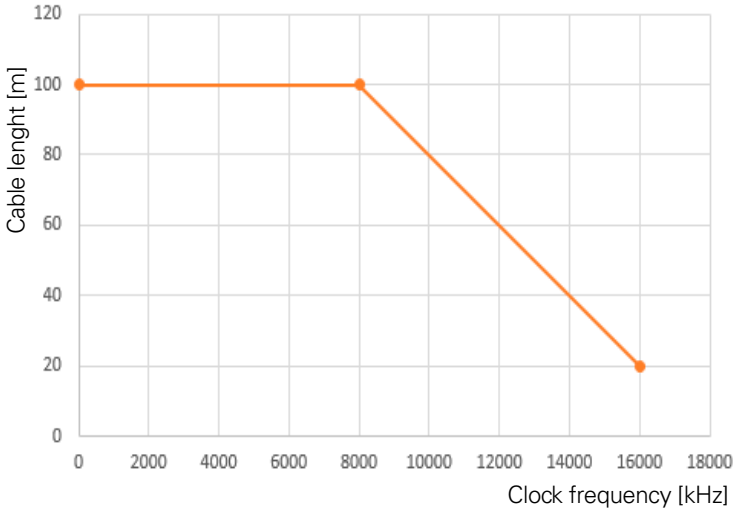
Interfaces
Position values EnDat

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
EnDat22	EnDat 2.2	Without

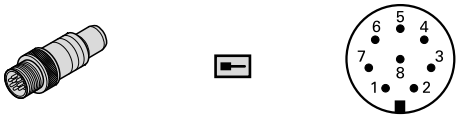
The clock frequency is variable - depending on the cable lenght (max. 100m).
With propagation electronics, either clock frequencies up to 16MHz are possible or cable lenght up to 100m.
For EnDat encoders the maximum clock frequency is sored in the encoder memory. Propagation-delay compensation is provided 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
Pin layouts Fanuc, Mitsubishi and BiSS/C®

Fanuc

AMO measuring systems 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 measuring systems with BiSS/C® Interface are for connection to controls which habe de ViSS/C Interface implemented.

BiSS/C bidirectional protocol
Order code: BiSS
The Standard Encoder Profile - 32bit will be in use.

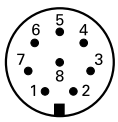
Mitsubishi

AMO measuring systems with Mitsubishi Interface are for connection to aM itsubishi-Control.

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

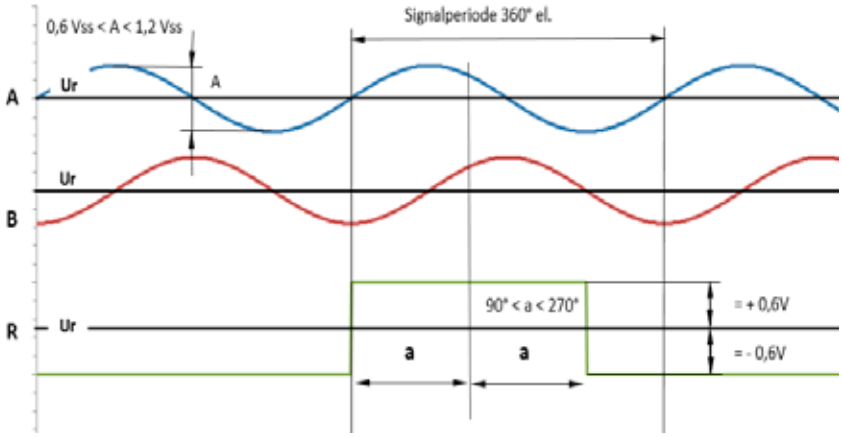
Cable Shield is connected with the housing; **U_P** = Power supply voltage
Sensor: The sensor wire is connected internally with the corresponding power supply.
Non-used pins or wires must not be assigned!

Interface
Incremental signals ∿ 1 V_{pp}

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

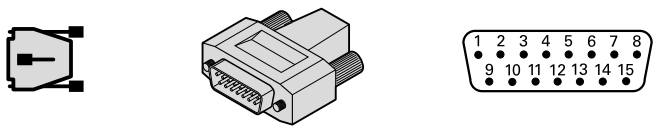
The sine shaped incremental signals A and B are electrically 90° phase shifted and have a signal strenght from 1Vpp. The showed sequence of the outputet signals - B after A - is valid for the in the connection drawing stated movement direction.

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

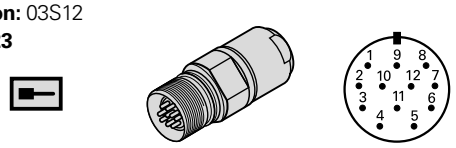


Pin configuration

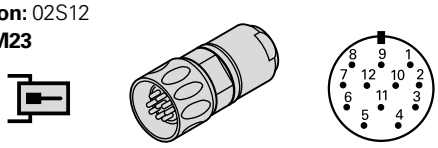
Electrical connection: 16S15
15-pin Sub-D-connector



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

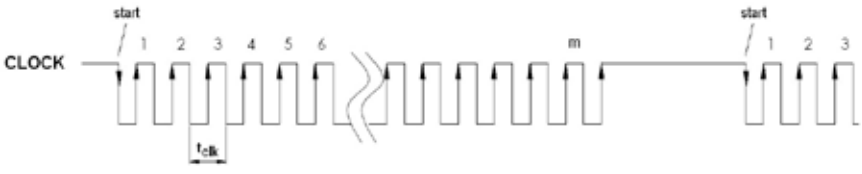
Cable Shield is connected with the housing; **U_P** = Power supply voltage
Sensor: The sensor wire is connected internally with the corresponding power supply.
Non-used pins or wires must not be assigned!
DIAG-wires must not be assigned.
DIAG-signals are for checking the encoder with AMO-STU-60.

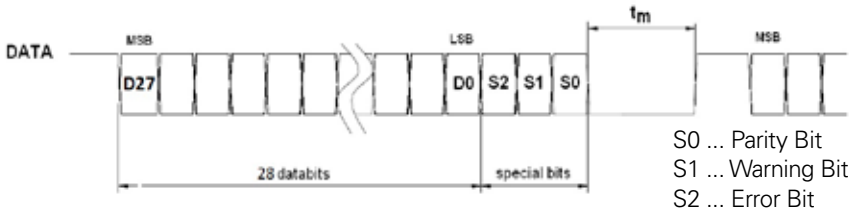
Interfaces
SSI + ∿1V$_{pp}$

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

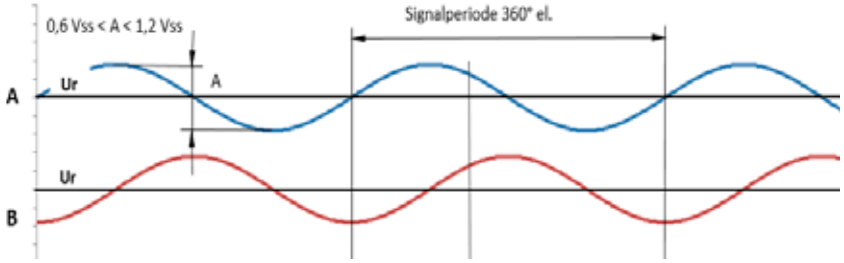
AMO-Measuring systems with ∿ 1 V$_{pp}$-Interface are outputting signals which can be highly interpolated.

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.



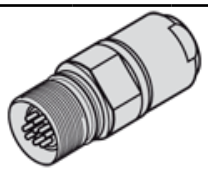


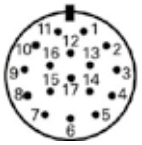
S0 ... Parity Bit
S1 ... Warning Bit
S2 ... Error Bit



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

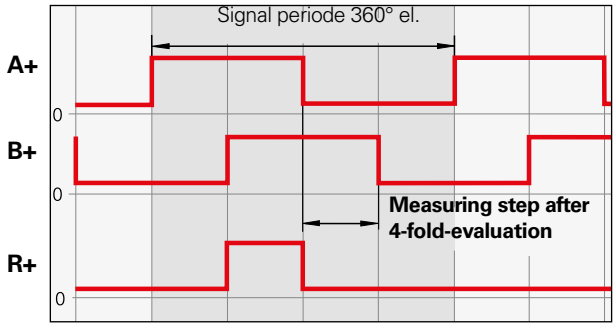
Cable Shield is connected with the housing; **U$_P$** = Power supply voltage
Sensor: The sensor wire is connected internally with the correspondending power supply.
Non-used pins or wires must not be assigned!

Interface
Incremental signals ⊓⊔ TTL

AMO-measuring 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.

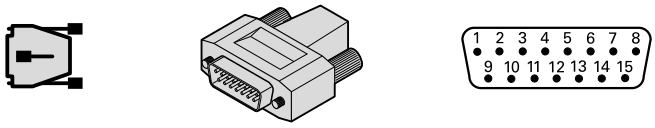
The measuring step results throught the distance between two flanks frim the incremental signals A+ and B+ throught 1-fold, 2-fold or 4-fold evaluation.



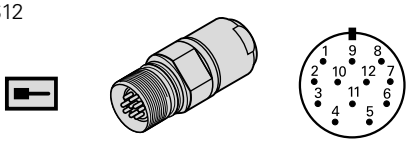
The inverse signals A-, B- und R- are not shown.

Pin configuration

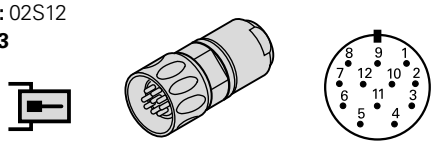
Electrical connection: 16S15
15-pin Sub-D-connector



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–**	**Free**	**Diag+**	**Diag-**
	brown/ green	blue	white/ green	white	brown	green	grey	pink	red	black	/	violet	yellow

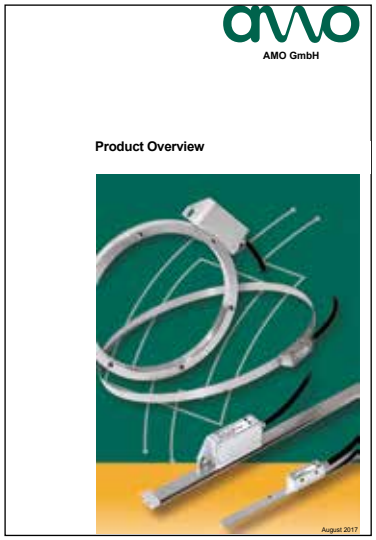
Cable Shield is connected with the housing; **U_P** = Power supply voltage
Sensor: The sensor wire is connected internally with the corresponding power supply.
Non-used pins or wires must not be assigned!
DIAG-wires must not me assigned!
DIAG-signals are for checking the encoder with AMO-STU-60

Cable

- **Technical Data**

	cable for incremental measuring systems and SSI+1Vpp	**cable for measuring systems 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	

Other brochures



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