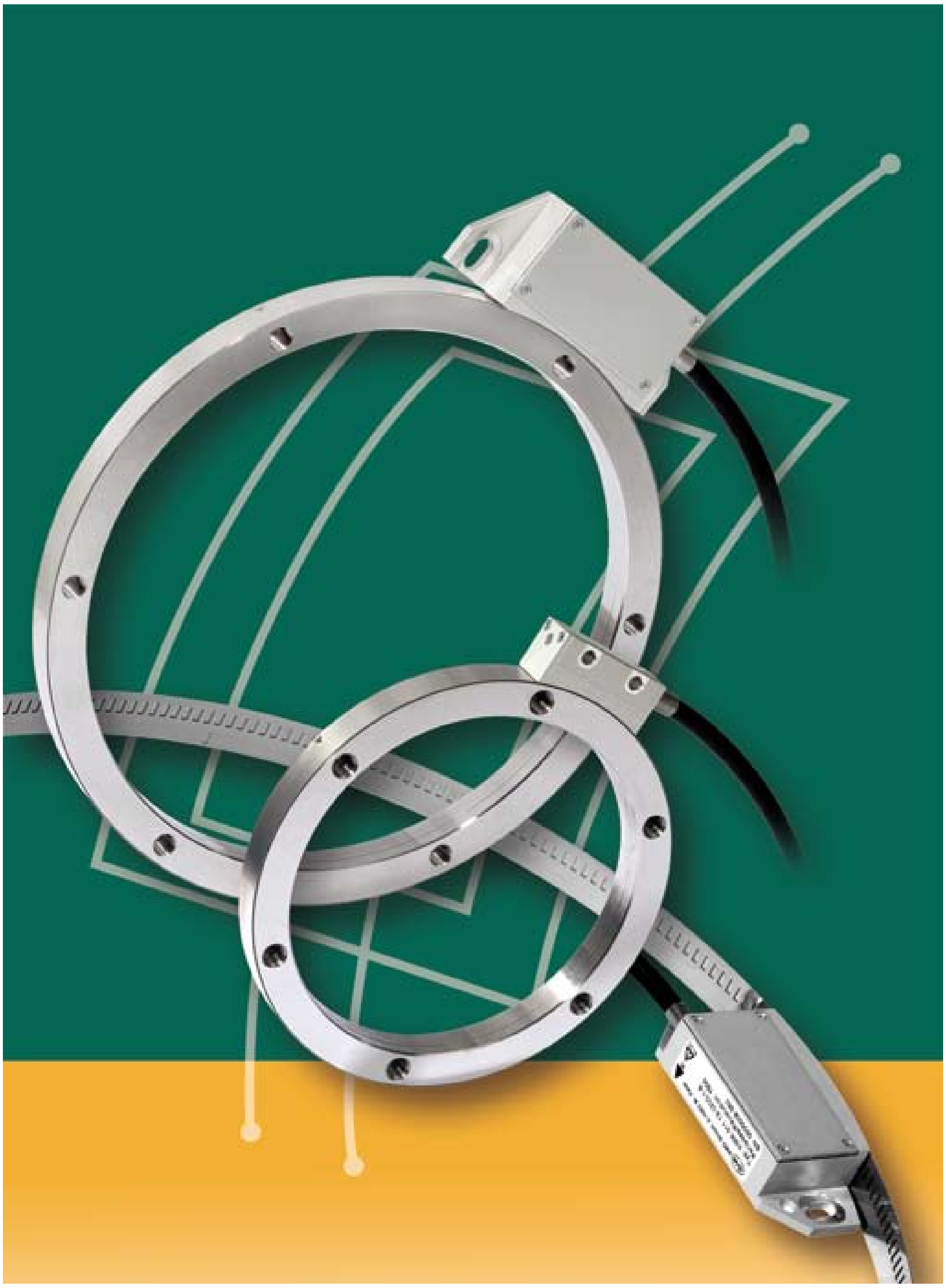
AMO GmbH

Incremental ***ANGLE MEASURING SYSTEMS*** *based on the* ***AMOSIN***® *– Inductive Measuring Principle*



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

With the publication of this brochure all previous editions become invalid.

The currently valid brochure is available on our website www.amo-gmbh.com

SN: WMI-P 20130821

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AMOSIN® - *General information*

AMO's proven and original technology for length and angle measurements uses techniques for scanning high precision graduations consisting of structures photo-lithographically etched onto steel. Based on this, inductive sensors and integrated evaluation electronics (ASIC) have been developed to create a new and powerful generation of measuring systems.

*The **AMOSIN®** angle measuring systems are open hollow-shaft measuring systems, and generally therefore do not have their own bearings, nor do they require any couplings for mechanical connection. Operating entirely on an inductive basis, with **AMOSIN®** systems high system accuracies less than +/-2µm arc length and better can be achieved. Nevertheless **AMOSIN®** systems are very well able to resist environmental influences such as dust, humidity and so forth, and also feature extremely high resistance to shock and vibration.*

The high precision is mainly due to the procedure used to manufacture the rigid steel measuring ring, and to the exceptionally high quality sensor signal, with deviations in the sine wave down to < 0.1 % harmonic content, as a measure of the achievable interpolation precision within the grating pitch. As will be seen from the measuring principle described below, the measuring system does not include any magnetic parts (either in the scale or in the scanning head). As a result it is not at all sensitive to electromagnetic interference of any kind and has no hysteresis in contrast to magnetic measuring systems. The systems output interfaces either 1 Vpp sine/cosine signals, or RS-422 square wave signals, in real-time.

*The wide range of available **AMOSIN®** angle measuring system types means that they can be used for large application fields from the slow, extremely precise positioning of a turntable through to the high speeds and the closely controlled velocities of a machine spindle. They are of value in general for drives where high dynamic range and stiffness is required.*

General properties

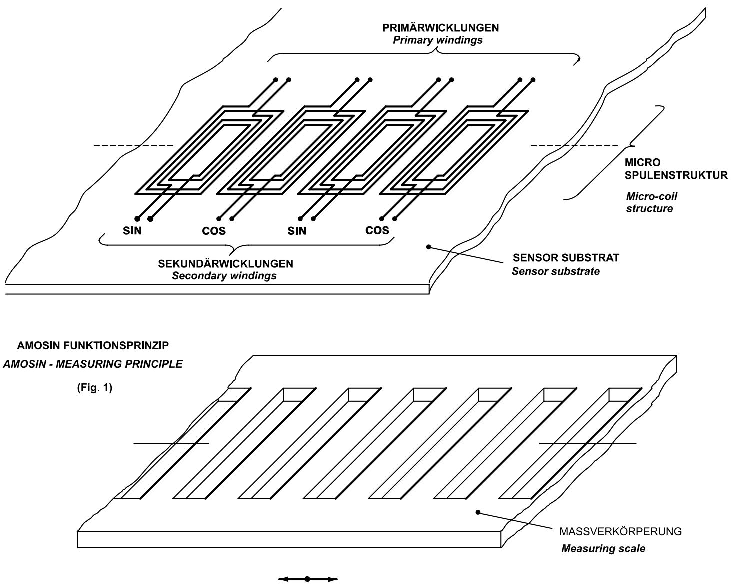
- *Not sensitive to soiling - IP67*
- *Not sensitive to interfering magnetic fields*
- *High precision and resolution*
- *Speed up to 70000 rpm*
- *Operation temperature -10°C to 100°C*
- *Analog output signals (1 Vpp) with divided signal period till 15µm*
- *Digital output RS-422 / TTL with resolution till 0,125µm arc length*
- *Self-centring scanning unit*
- *Integrated reference pulse, also distance coded*

Typical applications

- *Turntables*
- *Swivelling axes*
- *C-axes*
- *Working spindles*
- *Direct drives*
- *Sheet metal working machines*
- *Medical equipment*
- *Printing machines*
- *Roller positioning*
- *Punching machines*
- *Electronic production equipment*
- *Radar antennas*

AMOSIN® - *Measuring principle*

*The **AMOSIN®** measuring systems function on the principle of a transformer with a moving reluctance core. The mutual inductance of the primary and secondary windings of a transformer changes in accordance with the relative position of the core. The **AMOSIN®** system consists primarily of a planar coil and a Measuring scale (Fig.1). The coil structure, with a number of winding elements (individual main elements with primary and secondary SIN/COS coils) aligned in the direction of measurement, is implemented on a substrate using micro-multi-layer technology. The measuring scale is a stainless-steel ring onto which a highly precise graduations (e.g. λ = 1000 µm) of variable reluctance has been etched using photo-lithographic techniques.*

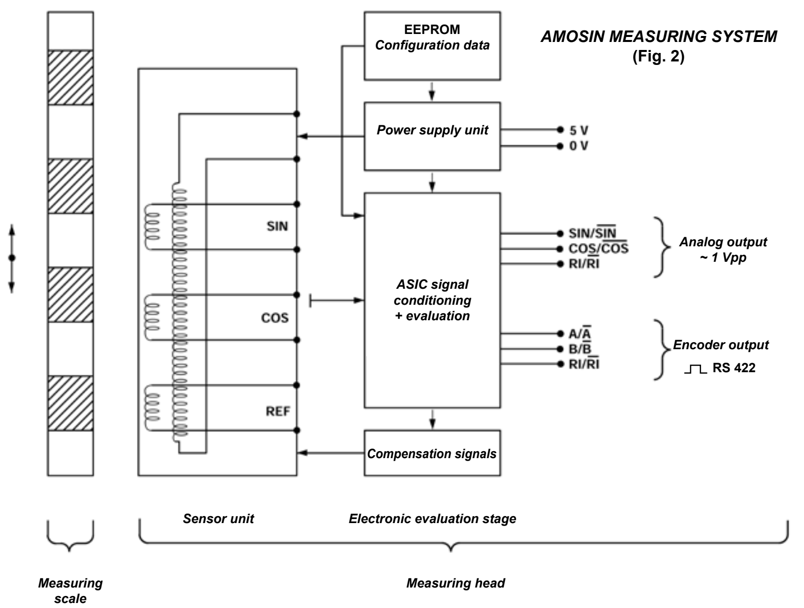


The relative angular movement in the direction of measurement between the sensor structure (in the scanning head) and the Measuring scale(measuring flange) periodically changes the mutual inductance of the individual coils, generating two sinusoidal signals with a 90° phase difference (SIN and COS). The extremely accurate signal, and its immunity to environmental influences, has the effect that, after conditioning of the signal in the evaluation electronics (Fig. 2), deviations of no more than 0.1% from the ideal sinusoidal form (harmonic content) remains. This allows high interpolation factors (further levels of sub-dividing) to be car ried out in the course of signal digitisation. This can either be done in the measuring system itself, or in the subsequent electronics (CNC etc.).

*An important feature of the principle of operation is that using the **AMOSIN®** procedure does not give rise to any measurement hysteresis (machine backlash error). In contrast to magnetic systems, the high-frequency alternating field suppresses any hysteresis in the material.*

The evaluation electronics conditions the sensor signals and interpolates them continuously, without using strobe times, exploiting a novel circuit principle. It then supplies the measurement information at the output through differential interfaces and linedrivers, either as a sinusoidal signal or as a square wave signal. (See the signal diagram on Page 69)

In addition to the periodic quadrature signals (A, B and their inverted) a reference signal is output for the determination of absolute position. This signal is generated from individual marks integrated into the measuring ring, and does not require any additional parts. (See the description of the reference signal on Page 68).



Measuring accuracy

As an open angle-measuring system, in which the system components, measuring scale and scanning head are supplied separately, that means there is no mechanical connection requiring own bearings. Therefore the precision can be assigned to these components as follows:

1. *Scale accuracy - determined by the precision of the Measuring scale on the measuring flange, and by deviations of the measuring flange mechanics from an ideal cylindrical form*
2. *Precision within one grating pitch - primarily determined by the quality of the sensor signal and the evaluation electronics of the scanning head.*

The following should also be considered for the measuring systems with a 1 Vpp output interface:

3. *Precision of the analog/digital conversion at the input stage of the subsequent electronics (in the controller)*
4. *Noise coupled into the output signals as it is transferred from the scanning head to the subsequent electronics*

A detailed description of these aspects follows:

1. Scale accuracy

Every measuring flange is measured on an angle test bench, and a test certificate, quoting the precision class in accordance with specification, is completed. Although the absolute angular deviation for an open measuring system depends on the precision with which the measuring flange is centred on the axes being measured, it is to possible supply a measuring diagram (registered under ideal assembly conditions), as follows.

For applications requiring the greatest precision, the measuring flange should be centred as accurately as possible. The precision of the angular measurement depends on the graduation error and on the concentricity of the assembly. Systematic (long-wave) errors resulting from this can be compensated for in the controller.

Systematic errors as for example eccentricity can be eliminated completely by using the MHS or CHS angle measuring system (see also page 55).

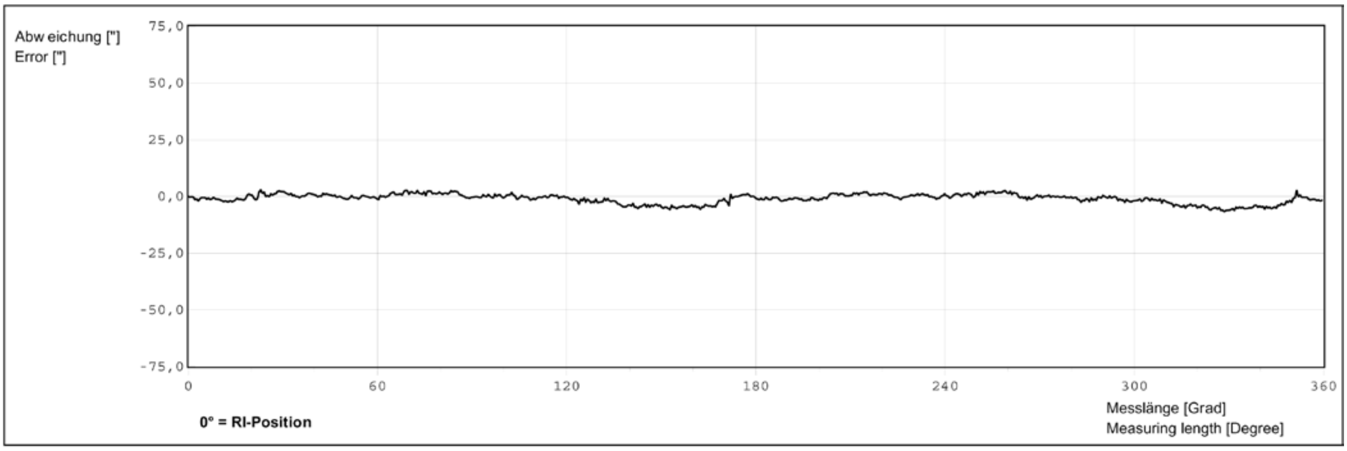
2. Precision within the grating pitch

The periodical deviation which appears within the grating pitch is less than 0,1% of the pitch because of the high quality of the sensor signal and the signal evaluation (e.g.. maximum deviation is 0,5µm on a 500µm pitch).
This high accuracy level will be achieved not just for the ideal, nominal mounting and environmental conditions but for the whole specified functional range of geometrical mounting deviations or temperature.

In order to suppress the errors discussed above under points „3“ and „4“, a new output interface has been implemented in the new generation of AMOSIN® systems, in which the sine, cosine and reference signals, for the 1 Vpp output interface delivered over line drivers (see signal diagram on Page 69).

The real time conversion of the original signal (e.g. 1000 µm) in finer sine wave periods down to 10 µm. arc length is realised over a programmable factor „D“. The effect of any possible deviation in the evaluation of the encoder signals in the subsequent electronics (controller etc.), is reduced exactly by the dividing factor (D) that is applied. In addition, this reduced sinusoidal signal period leads to finer quantisation in the subsequent electronics, which is of particularly great importance to demanding high stability, high stiffness drive applications. Additionally, the signal dividing reduces the effect of interfered noise on the signal transfer line in proportion to the dividing factor „D“; in other words, an improved signal/noise ratio is achieved.

The metrological principle on which the AMOSIN® systems operate means that they are entirely free from hysteresis and don´t lead to a “backlash effect”.



Measuring system configuration

An angle measuring system for inside or outside scanning consists of a measuring ring and a scanning head with integrated electronics or external connector electronics (see selection table on page 8).

A special manufacturing technology is used to produce the scale in the form of a closed measuring ring. This, in turn, is related in two variants, as rigidly mounted onto a WMF-type measuring flange, or as a thin WMR-type measuring ring, for assembly by the customer.

Implementing the new measuring scale WMR as a thin, closed ring for the measurement of angles or rotation speeds offers high flexibility to drive design.

Fitting the measuring ring in the transmission chain turns an existing part of the machine into a measuring flange.

Other advantages of the measuring ring design:

- *Extremely low inertia*
- *The part of the spindle onto which the measuring ring is fitted can consist of any material*
- *High rotation speeds can be achieved due to the extremely stable structure of the ring.*

The design of the sensor unit (Fig. 3) is unique to the AMOSIN® angle measuring systems.

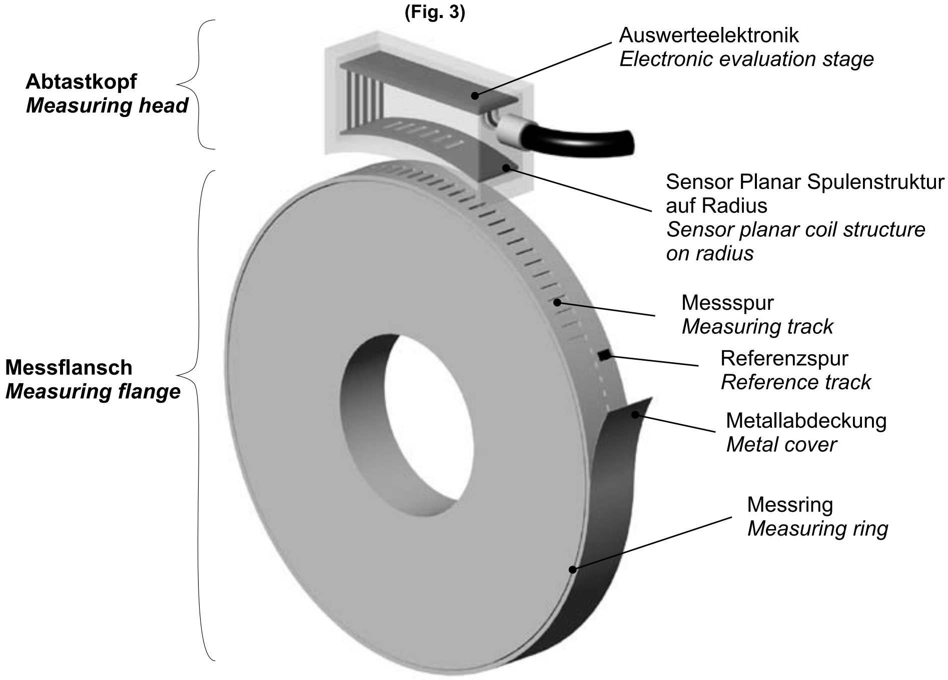
The planar coil structure, consisting of a number of coil elements, is applied to a flexible substrate, so that its radius can therefore be adapted to any required diameter of (measuring flange).

With this arrangement, it is ideally possible Measuring to average the signal over several grating flange pitches. A plane scanning surface, such as a glass plate or a rigid silicon substrate, incorporating individual sensitive elements, can only approximate to this, and is therefore less suitable for scanning a cylindrically arranged scale.

These angle measuring systems are used wherever precision is required under difficult environmental conditions (e.g. oil, dust, coolant and so forth - protection class IP 67).

A speciality of these measuring systems is the ease with which it can be integrated into customers existing mechanics, regardless of whether the mechanical parts are supplied to us for integration of the measuring ring, or whether AMO manufactures the special mechanical parts, incorporating the scale body, in accordance with customers‘ drawings.

AMOSIN WINKELMESSSYSTEM
AMOSIN ANGLE MEASURING SYSTEM
(Fig. 3)



The design of the measuring system based on the basic components:

The measuring system is based on two basic components, the measuring scale and the measuring head. These two components can be adapted to the special requirements of any particular application in a very flexible way. The main selection criteria are given further. (See also selection table page 8)

Generally speaking, any type of measuring scale can be combined with any measuring head as long as the following properties for the two components match:

- ***Grating pitch***
- ***Type of scanning***
- ***Number of grating pitches per revolution***

Selection Table

High resolution
High accuracy
↔
High mounting tolerances
High dynamic / speed

			Grating pitch		
			500 µm	**1000 µm**	**3000 µm**
Outside scanning	**Scale type**	*Measuring flange*  *Measuring ring* 	**WMF - 105x** **WMB - 105x** *Page 10*	**WMF - 10x** **WMR - 10x** *Page 10*	**WMR - 30x** *Page 16*
	Scanning head type	*Miniature scanning head with external electronics* 	**WMK - 105x** Page 19	**WMK - 10x** *Page 19*	
		Scanning head with integrated electronic Standard  *flat* 	**WMK - 205x** **WMKF - 205x** *Page 25*	**WMK - 20x** **WMKF - 20x** *Page 25*	**WMK - 30x** **WMKF - 30x** *Page 25*
		Multiple head scanning 	**MHS / CHS** *For highest requirements in accuracy.* *Page 55*		
Inside scanning	**Scale type**	*Measuring ring* 	**WMR - 115x** **WMB - 115x** *Page 37*	**WMR - 11x** *Page 37*	**WMR - 31x** *Page 37*
	Scanning head type	*Miniature scanning head with external electronics* 	**WMK - 115x** *Page 41*	**WMK - 11x** *Page 41*	
		Scanning head with integrated electronic 	**WMK - 215x** *Page 47*	**WMK - 21x** *Page 47*	**WMK - 31x** *Page 47*
		Multiple head scanning 	**MHS / CHS** *For highest requirements in accuracy.* *Page 55*		

Measuring flanges and rings for outside scanning

- *Grating pitches 500 µm, 1000 µm, 3000 µm*
- *Can be combined with all scanning heads of the same grating pitches*
- *Measuring flanges and measuring rings – standard sizes or customized*
- *No magnetic components, no Hysteresis*

Standard measuring flanges for outside scanning

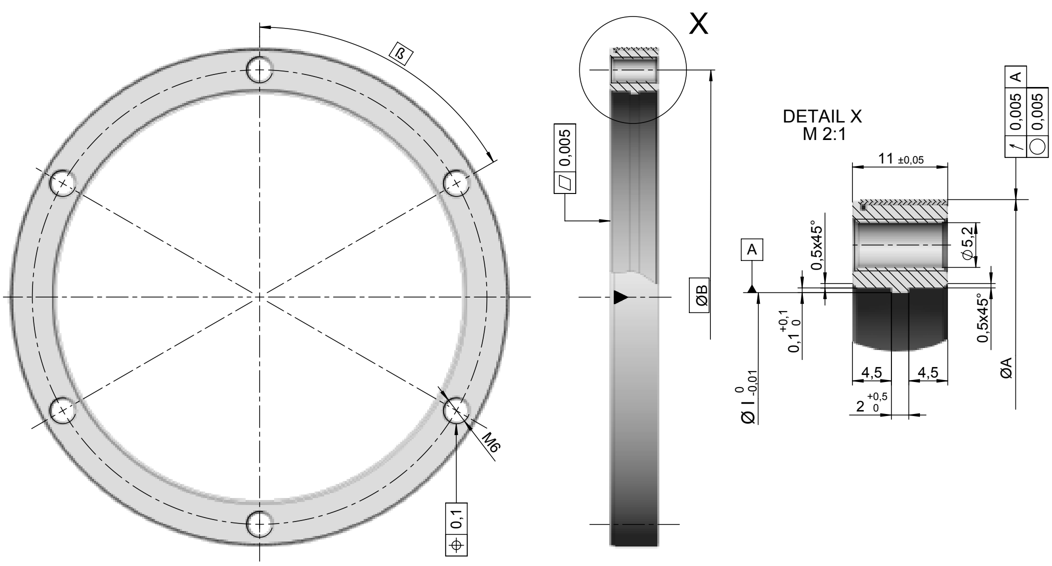
Measuring flanges with 500µm or 1000µm grating pitch offered as standard sizes as shown in the table below.
Customer specific designs for the measuring flange can be supplied by AMO or the measuring flange will be supplied by the customer for mounting the measuring ring at AMO (see page 12 for details).
The accuracies shown below can be increased by a factor of 4 using MHS or CHS as a measuring system (see page 55).

Measuring flanges WMF-100 / WMF-1050

Technical data

	WMF-105x	**WMF-10x**	**WMF-30x**
Grating pitch [arc length]:	500 µm	*1000 µm*	*3000 µm*
Grating accuracy [arc length]:	± 10 µm, ± 5 µm oder *(or)* ± 3 µm		± 20 µm, ± 10 µm oder *(or)* ± 5 µm
Mechanical execution:	*Stainless steel measuring flange in 2 versions:*		
	WMF-105x-xxxx-**0** WMF-105x-xxxx-***1***	WMF-10x-xxxx-**0** WMF-10x-xxxx-***1***	WMF-30x-xxxx-**0** WMF-30x-xxxx-***1***
Reference mark:	*1 mark / 360° as standard or any desired number and position or distance coded (see page 68)*		
Standard sizes N:	0512, 0720,1024, 1440, 1800, 2048	0256, 0360. 0512, 0720, 0900, 1024	0120, 0240, 0300
	N … Grating pitches per revolution		

Dimensions WMF-10x / WMF-105x



Standard measuring flanges, grating pitch 500µm

Type WMF-105x	Ø A [mm]	Ø I [mm]		Ø B [mm]	β	Scale accuracy		
						WMF-1050	WMF-1051	WMF-1052
0512-1	81,85	60	$^{+0}_{-0,01}$	70	6 x 60°	±50”	±25”	±15“
0720-0	115,02	60	$^{+0}_{-0,01}$	75	6 x 60°	±36”	±18”	±10“
0720-1	115,02	95	$^{+0}_{-0,01}$	105				
1024-0	163,44	105	$^{+0}_{-0,01}$	120	6 x 60°	±24”	±12”	±7,5“
1024-1 [1]	163,44	143	$^{+0}_{-0,01}$	153				
1440-0	229,68	180	$^{+0}_{-0,01}$	195	6 x 60°	±18”	±9”	±5,4“
1440-1 [1]	229,68	209	$^{+0}_{-0,01}$	219				
1800-0	286,98	180	$^{+0}_{-0,01}$	195	12 x 30°	±14”	±7”	±4,3“
1800-1 [1]	286,98	266	$^{+0}_{-0,01}$	276				
2048-0	326,45	220	$^{+0}_{-0,01}$	235	12 x 30°	±12”	±6”	±3,8“
2048-1 [1]	326,45	296	$^{+0}_{-0,01}$	311				

Standard measuring flanges, grating pitch 1000µm

Type WMF-10x	Ø A [mm]	Ø I [mm]		Ø B [mm]	β	Scale accuracy		
						WMF-100	WMF-101	WMF-102
0256-1	81,95	60	$^{+0}_{-0,01}$	70	6 x 60°	±50”	±25”	±15“
0360-0	115,12	60	$^{+0}_{-0,01}$	75	6 x 60°	±36”	±18”	±10“
0360-1	115,12	95	$^{+0}_{-0,01}$	105				
0512-0	163,54	105	$^{+0}_{-0,01}$	120	6 x 60°	±24”	±12”	±7,5“
0512-1 [1]	163,54	143	$^{+0}_{-0,01}$	153				
0720-0	229,78	180	$^{+0}_{-0,01}$	195	6 x 60°	±18”	±9”	±5,4“
0720-1 [1]	229,78	209	$^{+0}_{-0,01}$	219				
0900-0	287,08	180	$^{+0}_{-0,01}$	195	12 x 30°	±14”	±7”	±4,3“
0900-1 [1]	287,08	266	$^{+0}_{-0,01}$	276				
1024-0	326,55	220	$^{+0}_{-0,01}$	235	12 x 30°	±12”	±6”	±3,8“
1024-1 [1]	326,55	296	$^{+0}_{-0,01}$	311				

[1] *Only for press-fitt assembly on the customers shaft (recommended shaft tolerance +0,02 / +0,01)*

WMF-105 ☐ - ☐☐☐☐ - ☐ - ☐☐

WMF-10 ☐ - ☐☐☐☐ - ☐ - ☐☐

RI - Position

00 .... *none*
01 .... *1 RI / revolution*
Kxx ...... *Distance-coded (basic spacing xx grating pitches)*

Grating accuracy

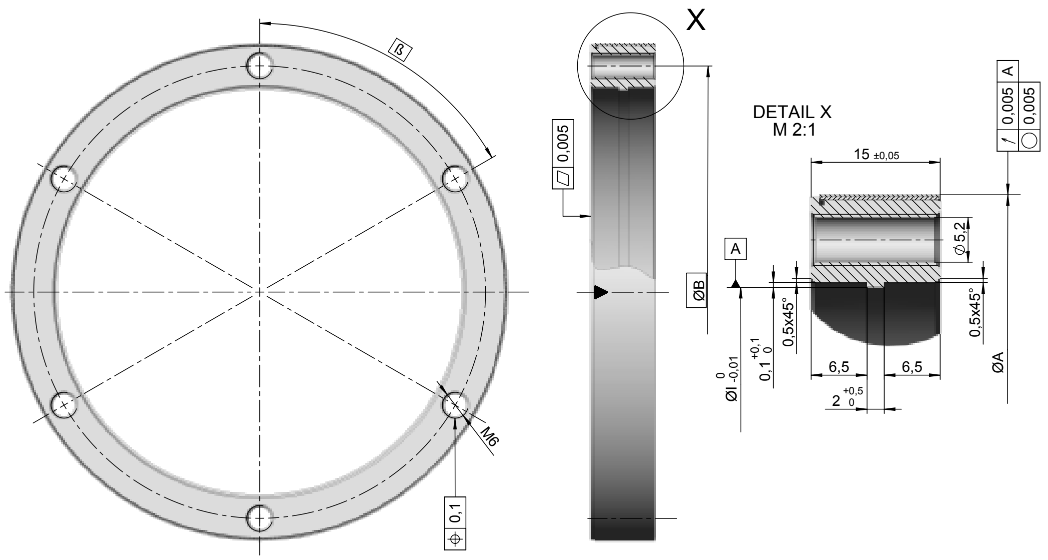
0 ... ± 10 µm arc length
1 ... ± 5 µm arc length
2 ... ± 3 µm arc length

Grating pitches / revolution (N)

Inner diameter (see drawing above)

0 .... *small*
1 .... *large*

Dimensions WMF-30x



Standard measuring flanges, grating pitch 3000µm

Type WMF-30x	Ø A [mm]	Ø I [mm]		Ø B [mm]	β	*Scale accuracy*		
						WMF-300	WMF-301	WMF-302
0120-0	115,12	60	+0 −0,01	75	6 x 60°	±72”	±36”	±18“
0120-1	115,12	95	+0 −0,01	105				
0240-0	229,78	180	+0 −0,01	195	6 x 60°	±36”	±18”	±9“
0240-1 [1)]	229,78	209	+0 −0,01	219				
0300-0	287,08	180	+0 −0,01	195	6 x 60°	±28”	±14”	±7“
0300-1 [1)]	287,08	266	+0 −0,01	276				

[1)] *Only for press-fitt assembly on the customers shaft (recommended shaft tolerance +0,02 / +0,01)*

Ordering code: WMF-30x

WMF-30 ☐ - ☐☐☐☐ - ☐ - ☐☐

RI - Position

00 .... *none*
01 .... *1 RI / revolution*
Kxx ...... *Distance-coded (basic spacing xx grating pitches)*

Grating accuracy

0 ... ± 20 µm arc length
1 ... ± 10 µm arc length
2 ... ± 5 µm arc length

Grating pitches / revolution (N)

Inner diameter (see drawing above)

0 ....*small*
1 ....*large*

Customer specific measuring flanges for outside scanning

Customer specific designs for the measuring flange can be supplied by AMO (Type **WMF***) or the measuring flange will be supplied by the customer for mounting the measuring ring at AMO (Type* ***WMB***). *In this case the diameter for mounting the measuring ring can be calculated as shown in the table on the next page.*
The accuracies shown below can be increased by a factor of 4 using MHS or CHS as a measuring system (see page 55).

The production drawing for the carrier flange can be released by AMO.

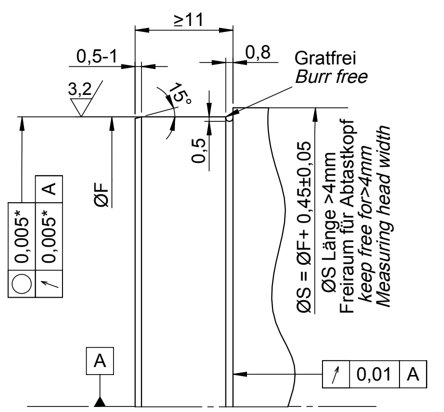
For applications with large diameters or significant variations in temperature during operation the system must be designed accordingly.

Technical data

	WMF-105x / WMB-105x	WMF-10x / WMB-10x	WMF-30x / WMB-30x
Grating pitch [arc length]:	500 µm	1000 µm	3000 µm
Grating accuracy [arc length]:	± 10 µm, ± 5 µm oder *(or)* ± 3 µm		± 20 µm, ± 10 µm oder *(or)* ± 5 µm
Mechanical execution:	*Customer specific, recommended material* 1.4104 or 1.7225 (42CrMo4)		
Reference mark:	*1 mark / 360° as standard or any desired number and position or distance coded (see page 68)*		

Mechanical design for WMF-105x / WMB-105x

WMF-105x / WMB-105x



Recommended material: 1.4104 oder *(or)* 1.7225 (42CrMo4)
Please contact AMO if using other soft magnetic material.

Grating pitch [arc length]:	**500 µm**
N	**ØF [mm]**
512 bis *(to)* 719	N/2π – 0,14 ±0,01
720 bis *(to)* 1023	N/2π – 0,07 ±0,01
1024 bis *(to)* 1439	N/2π – 0,03 ±0,02
1440 bis *(to)* 2049	N/2π – 0,00 ±0,02
2050 bis *(to)* 3000	N/2π + 0,02 ±0,03
3001 bis *(to)* 4000	N/2π + 0,05 ±0,06
4001 bis *(to)* 6000	N/2π + 0,08 ±0,07
6001 bis *(to)* 10000	N/2π + 0,10 ±0,10

N: Integer number of grating pitches per revolution

**) Recommended eccentricity: Greater eccentricities up to ~0,03mm do not affect the function of the device, but cause a proportional loss in positioning accuracy.*

Ordering code - customer specific designs for WMF-105x / WMB-105x

WMF-105□-□□□□-□□-S□□
WMB-105□-□□□□-□□-S□□

Customer specific design

xx .... *number defined by AMO*

RI - Position

00 .... *none*
01 .... *1 RI / revolution*
Kxx ...... *Distance-coded (basic spacing xx grating pitches)*

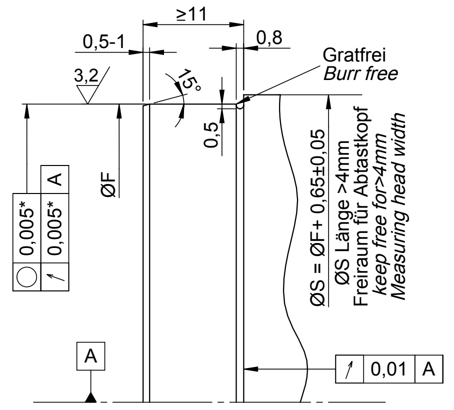
Grating accuracy

0 ... ± 10 µm arc length
1 ... ± 5 µm arc length
2 ... ± 3 µm arc length

Grating pitches / revolution (N)

Mechanical design for WMF-10x / WMB-10x

WMF-10x / WMB-10x



Recommended material: 1.4104 oder *(or)* 1.7225 (42CrMo4)
Please contact AMO if using other soft magnetic material.

Grating pitch [arc length]:	**1000 µm**
N	**ØF [mm]**
256 bis *(to)* 359	N/π – 0,24 ±0,01
360 bis *(to)* 511	N/π – 0,17 ±0,01
512 bis *(to)* 719	N/π – 0,13 ±0,02
720 bis *(to)* 1024	N/π – 0,10 ±0,02
1025 bis *(to)* 1500	N/π – 0,08 ±0,03
1501 bis *(to)* 2000	N/π – 0,05 ±0,06
2001 bis *(to)* 3000	N/π – 0,02 ±0,07
3001 bis *(to)* 6000	N/π – 0,00 ±0,10
> 6000	N/π + 0,05 ±0,10

N: Integer number of grating pitches per revolution

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

Ordering code - customer specific designs for WMF-10x / WMB-10x

WMF-10□-□□□□-□□-S□□
WMB-10□-□□□□-□□-S□□

Customer specific design

xx .... *number defined by AMO*

RI - Position

00 .... *none*
01 .... *1 RI / revolution*
Kxx ...... *Distance-coded (basic spacing xx grating pitches)*

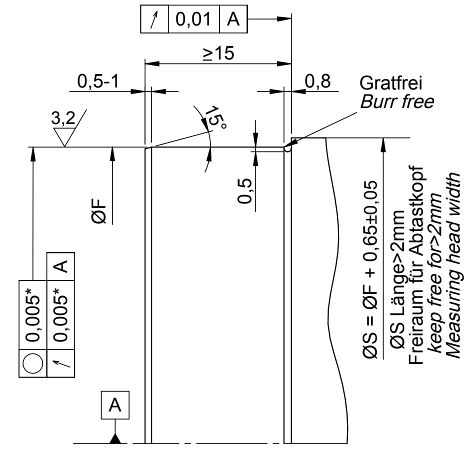
Grating accuracy

0 ... ± 10 µm arc length
1 ... ± 5 µm arc length
2 ... ± 3 µm arc length

Grating pitches / revolution (N)

Mechanical design for WMF-30x / WMB-30x

WMF-30x / WMB-30x



Grating pitch [arc length]:	**3000 µm**
N	**ØF [mm]**
85 bis *(to)* 169	Nx3/π – 0,22 ±0,01
170 bis *(to)* 240	Nx3/π – 0,13 ±0,02
241 bis *(to)* 342	Nx3/π – 0,10 ±0,02
343 bis *(to)* 500	Nx3/π – 0,08 ±0,03
501 bis *(to)* 660	Nx3/π – 0,05 ±0,06
661 bis *(to)* 1000	Nx3/π – 0,02 ±0,07
1001 bis *(to)* 2000	Nx3/π – 0,00 ±0,10
2001 bis *(to)* 4000	Nx3/π + 0,05 ±0,10
4001 bis *(to)* 10000	Nx3/π + 0,15 ±0,10

N: Integer number of grating pitches per revolution

Recommended material: 1.4104 oder *(or)* 1.7225 (42CrMo4)
Please contact AMO if using other soft magnetic material.

*) Rundlaufempfehlung: Höhere Werte bis ~0,10mm haben keinen Einfluss auf die Funktion des Gerätes, beeinträchtigen aber verhältnismäßig die Positioniergenauigkeit.
**) Recommended eccentricity: Greater eccentricities up to ~0,10mm do not affect the function of the device, but cause a proportional loss in positioning accuracy.*

Ordering code - customer specific designs for WMF-30x / WMB-30x

WMF-30□-□□□□-□□-S□□
WMB-30□-□□□□-□□-S□□

Customer special design

xx .... *number defined by AMO*

RI - Position

00 .... *none*
01 .... *1 RI / revolution*
Kxx ...... *Distance-coded (basic spacing xx grating pitches)*

Grating accuracy

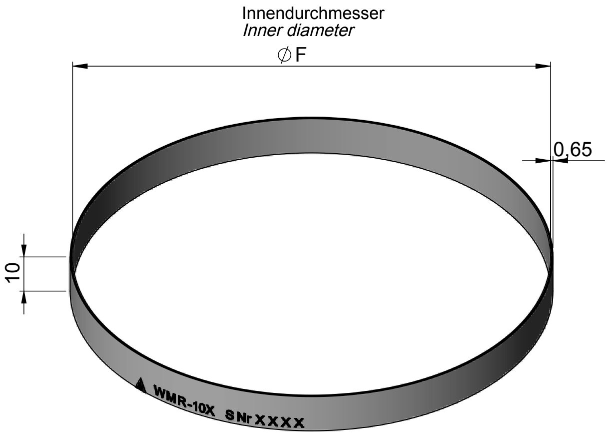
0 ... ± 20 µm arc length
1 ... ± 10 µm arc length
2 ... ± 5 µm arc length

Grating pitches / revolution (N)

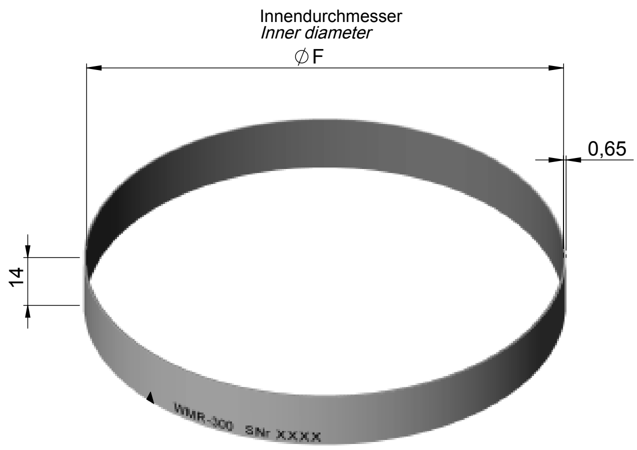
Measuring rings for outside scanning

Thin, stainless steel measuring ring, consisting of a steel carrier ring, a graduation ring and a protection ring. Easily pressfitted mounting to the corresponding flange by the customer. (see mounting instruction at www.amo-gmbh.com)

For special applications the measuring ring (circular segment also possible) can be mounted on a flange at the factory (see page 12).



WMR-10x



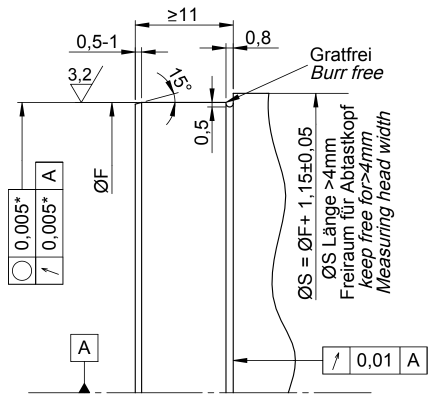
WMR-30x

Technical data

Grating pitch [arc length]:	**1000 µm**	**3000 µm**
Type:	**WMR-10x**	**WMR-30x**
Grating accuracy [arc length]:	± 10 µm, ± 5 µm oder *(or)* ± 3 µm	± 20 µm, ± 10 µm oder *(or)* ± 5 µm
Mechanical execution:	*Stainless steel measuring ring*	
Flange material:	*No special material required*	
Reference mark:	*1 mark / 360° as standard or any desired number and position or distance coded (see page 68)*	
Standard sizes N:	0256, 0360. 0512, 0720, 0900, 1024, 1440, 2048	0120, 0128, 0170, 0240, 0256, 0300 0341, 0360, 0480, 0512
	N … Grating pitches per revolution	

Mechanical design for WMR-10x

WMR-10x



Grating pitch [arc length]:	**1000 µm**
N	**ØF [mm]**
256 bis *(to)* 359	N/π – 0,84 ±0,01
360 bis *(to)* 511	N/π – 0,77 ±0,01
512 bis *(to)* 719	N/π – 0,73 ±0,02
720 bis *(to)* 1024	N/π – 0,70 ±0,02
1025 bis *(to)* 1500	N/π – 0,68 ±0,03
1501 bis *(to)* 2000	N/π – 0,65 ±0,06
2001 bis *(to)* 3000	N/π – 0,62 ±0,07
3001 bis *(to)* 6000	N/π – 0,60 ±0,10
> 6000	N/π – 0,55 ±0,10

N: Integer number of grating pitches per revolution

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

Ordering code: WMR-10x

WMR-10 [ ] - [ ] [ ] [ ] [ ] - [ ] [ ]

Grating accuracy

0 ... ± 10 µm arc length
1 ... ± 5 µm arc length
2 ... ± 3 µm arc length

Grating pitches / revolution (N)

RI - Position

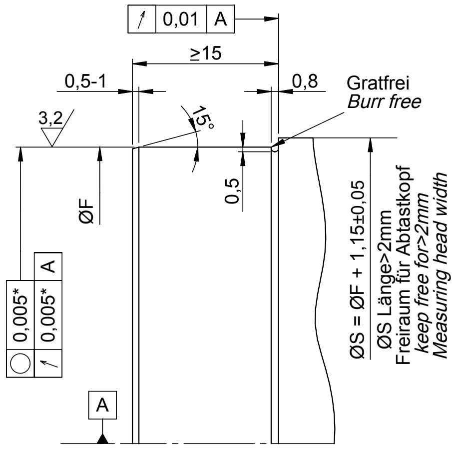
00 .... *none*
01 .... *1 RI / revolution*
Kxx ...... *Distance-coded (basic spacing xx grating pitches)*

The production drawing for the carrier flange can be released by AMO.

For applications with large diameters or significant variations in temperature during operation and when the carrier flanges are not made of steel, the system must be designed accordingly.

Mechanical design for WMR-30x

WMR-30x



Grating pitch [arc length]:	**3000 µm**
N	**ØF [mm]**
85 bis *(to)* 169	Nx3/π – 0,82 ±0,01
170 bis *(to)* 240	Nx3/π – 0,73 ±0,02
241 bis *(to)* 342	Nx3/π – 0,70 ±0,02
343 bis *(to)* 500	Nx3/π – 0,68 ±0,03
501 bis *(to)* 660	Nx3/π – 0,65 ±0,06
661 bis *(to)* 1000	Nx3/π – 0,62 ±0,07
1001 bis *(to)* 2000	Nx3/π – 0,60 ±0,10
2001 bis *(to)* 4000	Nx3/π – 0,55 ±0,10
4001 bis *(to)* 10000	Nx3/π – 0,45 ±0,10

N: Integer number of grating pitches per revolution

**) Recommended eccentricity:* *Greater eccentricities up to ~0,10mm do not affect the function of the device, but cause a proportional loss in positioning accuracy.*

Ordering code: WMR-30x

WMR-30 ☐ - ☐☐☐☐ - ☐☐

Grating accuracy

0 ... ± 20 µm arc length
1 ... ± 10 µm arc length
2 ... ± 5 µm arc length

Grating pitches / revolution (N)

RI - Position

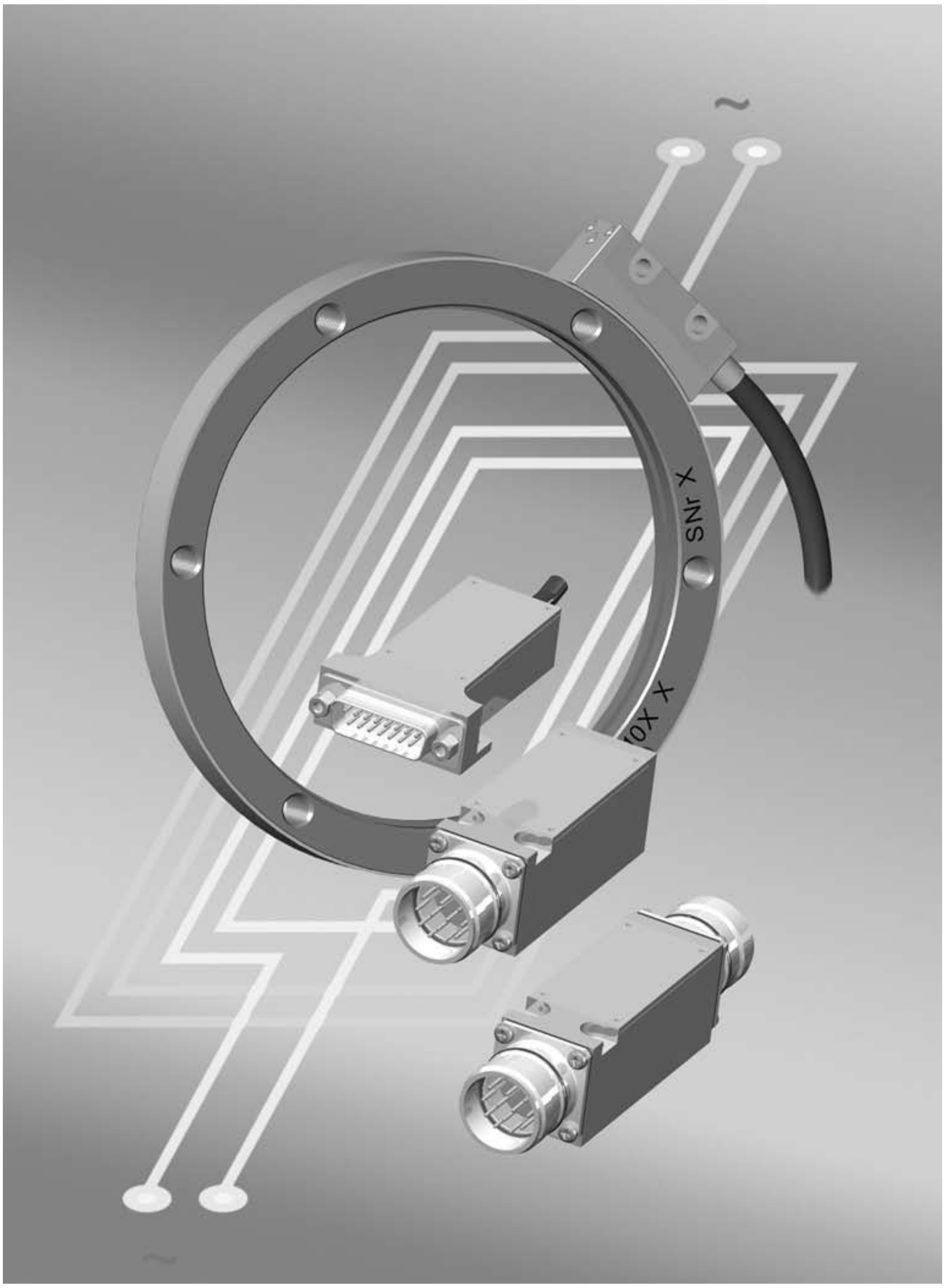
00 .... *none*
01 .... *1 RI / revolution*
Kxx ...... *Distance-coded (basic spacing xx grating pitches)*

The production drawing for the carrier flange can be released by AMO.

For applications with large diameters or significant variations in temperature during operation and when the carrier flanges are not made of steel, the system must be designed accordingly.

Miniature scanning head for outside scanning

- *Scanning head for small design*
- *Electronic integrated in connector*
- *Can be combined with measuring flanges and measuring rings*
- *Protection class IP67*



Technical data

Grating pitch [arc length]:	**500 µm**	**1000 µm**
Type:	**WMK-105x**	**WMK-10x**
Operating temperature:	-10°C … 100°C	
Storage temperature:	-20°C … 100°C	
Protection class:	*Scanning head:*	IP67
	Connector electronics with Connei connector:	IP67
	Connector electronics with Sub-D connector:	IP54
Vibration:	< 400 m/s² for 55 – 2000 Hz	
Shock:	< 2000 m/s² for 6 ms	
Power supply:	5V ± 5%	
Cable:	*Cable specification see page 70*	
Output signals:	*Sine 1Vpp or TTL (RS422); see diagram on page 69*	
System resolutions: [*arc length*]		
Signal period 1Vpp:	500µm … ~15µm	1000µm … 31,25µm
Resolution TTL:	125µm … 0,125µm [1]	250µm … 0,25µm [1]
	Detailed list of possible resolutions see on following pages.	
Max. speed:	*See table on page 66*	
Suitable measuring scale:	**WMF-105x** **WMB-105x** *see page 9*	**WMF-10x** **WMR-10x** *see page 9*

[1] ... *after 4-edge evaluation*

Scanning head type WMK-105x based on grating pitch: **500 µm**

Possible resolutions

Output signal

Sine 1 Vpp

Type WMK	Signal periods: Dividing factor	Signal periods: Periods [arc length] [µm]	Max. input frequency[2] f[khz]	Power consumption [mA] at 5V
1051.10	1	500	9	260
1051.11	8	62,5		
1051.12	10	50		
1051.13	25	20		
1051.14	32	~15		
1051.15	4	125		
1051.16	16	31,25		
1051.30	1	500	60	240
1051.S0	1	500	100	

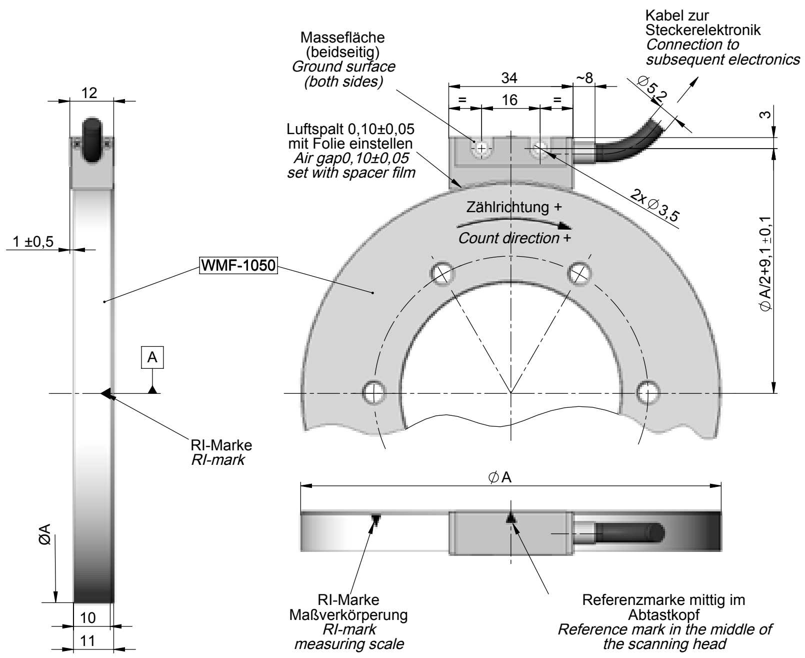
TTL

Type WMK	Periods: Interpolation factor	Periods: Resolution[1] [arc length] [µm]	Max. input frequency[2] f[khz]	Power consumption [mA] at 5V
1052.0	25x	5	19	300
1052.1	50x	2,5		
1052.4	250x	0,5	9	
1052.5	1000x	0,125	2,4	
1052.6	5x	25	39	
1052.7	10x	12,5		
1052.A	4x	31,25		340
1052.B	8x	~15		
1052.C	16x	~8	19	
1052.E	32x	~4	9	
1052.Z	1x	125	39	

(1) after 4-edge evaluation
(2) Calculation of max. speed see page 67

Output frequency fa (input frequency for subsequent electronics) is limited to 300 kHz for 1Vpp-systems.

Assembly drawing WMK-105x



Scanning head type WMK-105x based on grating pitch: 500 µm

Ordering code: 1 Vpp-output

WMK-1051.□□-□□□□-□,□-□□

Cable length in m[2]

Connector electronics

5 .... *Output: 15 pin Sub-D plug*
6, 6A, 6B ... *Output: 12 pin CONNEI coupling (male)*

Configuration at the scanning head side *see page 71*

Grating pitches / revolution (N)

Max. input frequency

1 ..... 9 kHz
3 ..... 60 kHz [1]
S ... 100 kHz [1]

[1] only possible with dividing factor 1

Analog dividing factor

0 ..... 1 (500 µm)
1 ..... 8 (62,5 µm)
2 ... 10 (50 µm)
3 ... 25 (20 µm)
4 ... 32 (~15 µm)
5 ..... 4 (125 µm)
6 ... 16 (31,25 µm)

(preferred cable length in steps of 0,5m

Bestellcode: TTL-Ausgang / *Ordering code: TTL-output*

WMK-1052.□-□□□□-□,□-□□

Cable length in m[1]

Connector electronics

5 .... *Output: 15 pin Sub-D plug*
6, 6A, 6B ... *Output: 12 pin CONNEI coupling (male)*

Configuration at the scanning head side *see page 71*

Grating pitches / revolution (N)

Interpolation factor

0 .... 25 (5 µm)
1 .... 50 (2,5 µm)
4 ..... 250 (0,5 µm)
5 ... 1000 (0,125 µm)
6 .... 5 (25 µm)
7 .... 10 (12,5 µm)
A 4 (31,25µm)
B ..... 8 (~15 µm)
C ... 16 (~8 µm)
E ... 32 (~4 µm)
Z ..... 1 (125 µm)

Resolution after 4-edge evaluation

preferred cable length in steps of 0,5m

Scanning head type WMK-10x based on grating pitch: 1000 µm

Possible resolutions

Output signal

Sine 1 Vpp

Type WMK	Signal periods: *Dividing factor*	Signal periods: *Periods [arc length] [µm]*	*Max. input frequency*(2) f[khz]	*Power consumption* [mA] at 5V
101.10	1	1000		
101.11	8	125		
101.12	10	100		
101.13	25	40	9	260
101.14	32	31,25		
101.15	4	250		
101.16	16	62,5		
101.30	1	1000	60	240
101.S0	1	1000	100	

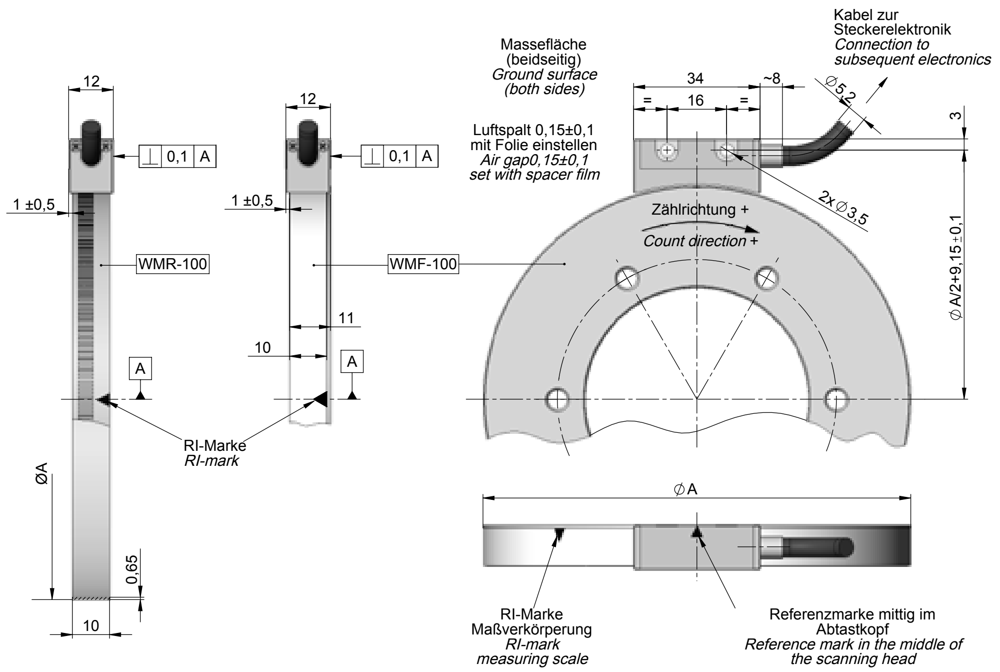
TTL

Type WMK	Periods: *Interpolation factor*	Periods: *Resolution*(1) *[arc length]* [µm]	*Max. input frequency*(2) f[khz]	*Power consumption* [mA] at 5V
102.0	25x	10	19	
102.1	50x	5		
102.4	250x	1	9	300
102.5	1000x	0,25	2,4	
102.6	5x	50		
102.7	10x	25		
102.A	4x	62,5	39	
102.B	8x	31,25		
102.C	16x	~15	19	340
102.E	32x	~8	9	
102.Z	1x	250	39	

after 4-edge evaluation
Calculation of max. speed see page 66

Output frequency fa (input frequency for subsequent electronics) is limited to 300 kHz for 1Vpp-systems.

Assembly drawing WMK-10x



Scanning head type WMK-10x based on grating pitch: 1000 µm

Ordering code: 1 Vpp-output

WMK-101.□□-□□□□-□,□-□□

Cable length in m (2)

Grating pitches / revolution (N)

Connector electronics

5 .... *Output: 15 pin Sub-D plug*
6, 6A, 6B ... *Output: 12 pin CONNEI coupling (male)*

Configuration at the scanning head side see page 71

Max. input frequency

1 ...   9 kHz
3 ...   60 kHz (1)
S ... 100 kHz (1)

(1) only possible with dividing factor 1

Analog dividing factor

0 ..... 1 (1000 µm)
1 ..... 8 (125 µm)
2 ... 10 (100 µm)
3 ... 25 (40 µm)
4 ... 32 (31,25 µm)
5 ..... 4 (250 µm)
6 ... 16 (62,5 µm)

preferred cable length in steps of 0,5m

Ordering code: TTL-output

WMK-102.□-□□□□-□,□-□□

Cable length in m (1)

Grating pitches / revolution (N)

Connector electronics

5 .... *Output: 15 pin Sub-D plug*
6, 6A, 6B ... *Output: 12 pin CONNEI coupling (male)*

Configuration at the scanning head side see page 71

Interpolationsfaktor
Interpolation factor

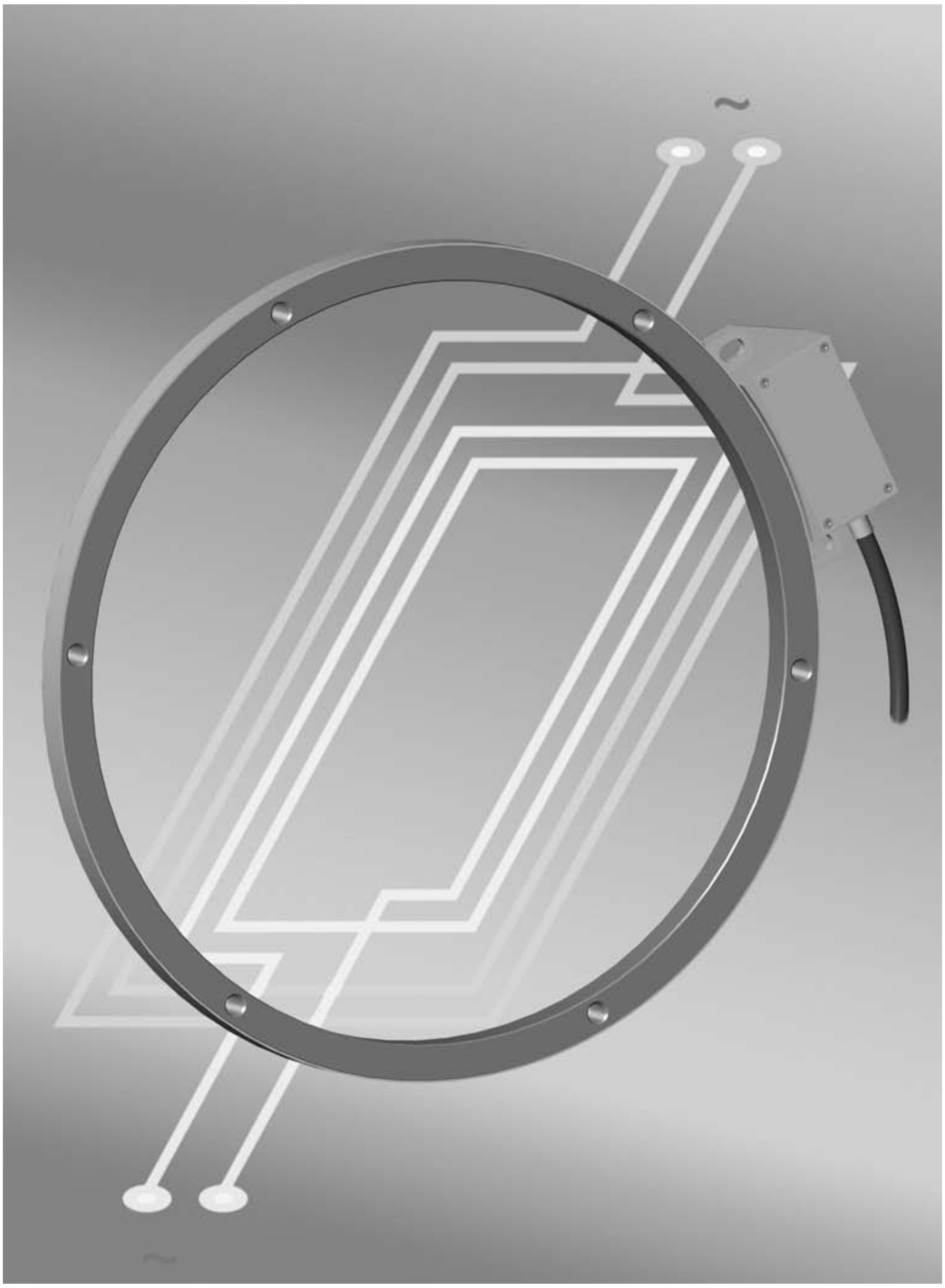
0 .... 25 (10 µm)	A 4 (62,5µm)
1 .... 50 (5 µm)	B ..... 8 (31,25 µm)
4 ..... 250 (1 µm)	C ... 16 (~15 µm)
5 ... 1000 (0,25 µm)	E ... 32 (~8 µm)
6 .... 5 (50 µm)	Z ..... 1 (250 µm)
7 .... 10 (25 µm)	

Resolution after 4-edge evaluation

preferred cable length in steps of 0,5m

Scanning head with integrated electronics for outside scanning

- *Complete sensor and electronics integrated into the scanning head*
- *Two head designs possible "high shape" (WMK-200) "flat shape" (WMKF-200)*
- *Can be combined with measuring flanges and measuring rings*
- *Protection class IP67*
- *Also available in Ex-design for explosion sensitive areas*



Technical data

***Grating pitch** [arc length]:*	**500 µm**	**1000 µm**	**3000 µm**
Type:	**WMK-205x WMKF-205x**	**WMK-20x WMKF-20x**	**WMK-30x WMKF-30x**
Operating temperature:	-10°C … 100°C		
Storage temperature:	-20°C … 100°C		
Protection class:	IP67		
Vibration:	< 200 m/s² for 55 – 2000 Hz		
Shock:	< 2000 m/s² for 6 ms		
Power supply:	5V ± 5%		
Cable:	*Cable specification see page 72*		
Output signals:	*Sine 1Vpp or TTL (RS422); see diagram on page 71*		
System resolutions: [*arc length*]			
Signal period 1Vpp:	500µm … ~15µm	1000µm … 31,25µm	3000µm … 93,75µm
Resolution TTL:	125µm … 0,125µm (1)	250µm … 0,25µm (1)	750µm … 0,75µm (1)
	Detailed list of possible resolutions see on following pages.		
Max. speed:	*See table on page 67*		
Suitable measuring scale:	**WMF-105x WMB-105x** *see page 10*	**WMF-10x WMR-10x** *see page 10*	**WMF-30x WMR-30x** *see page 10*

(1) ... *after 4-edge evaluation*

Scanning head type WMK-205x based on grating pitch: 500 µm

Possible resolutions

Output signal

<table>
<tr><th colspan="5">Sine 1 Vpp</th></tr>
<tr><th rowspan="2">Type
WMK
WMKF</th><th colspan="2">Signal periods</th><th rowspan="2">Max. input frequency[2]
f[khz]</th><th rowspan="2">Power consumption
[mA] at 5V</th></tr>
<tr><th>Dividing factor</th><th>Periods [arc length] [µm]</th></tr>
<tr><td>2051.10</td><td>1</td><td>500</td><td rowspan="7">9</td><td rowspan="7">220</td></tr>
<tr><td>2051.11</td><td>8</td><td>62,5</td></tr>
<tr><td>2051.12</td><td>10</td><td>50</td></tr>
<tr><td>2051.13</td><td>25</td><td>20</td></tr>
<tr><td>2051.14</td><td>32</td><td>~15</td></tr>
<tr><td>2051.15</td><td>4</td><td>125</td></tr>
<tr><td>2051.16</td><td>16</td><td>31,25</td></tr>
<tr><td>2051.30</td><td>1</td><td>500</td><td>60</td><td rowspan="2">200</td></tr>
<tr><td>2051.S0</td><td>1</td><td>500</td><td>100</td></tr>
</table>

<table>
<tr><th colspan="5">TTL</th></tr>
<tr><th rowspan="2">Type
WMK
WMKF</th><th colspan="2">Periods</th><th rowspan="2">Max. input frequency[2]
f[khz]</th><th rowspan="2">Power consumption
[mA] at 5V</th></tr>
<tr><th>Interpolation factor</th><th>Resolution[1] [arc length] [µm]</th></tr>
<tr><td>2052.0</td><td>25x</td><td>5</td><td rowspan="2">19</td><td rowspan="6">260</td></tr>
<tr><td>2052.1</td><td>50x</td><td>2,5</td></tr>
<tr><td>2052.4</td><td>250x</td><td>0,5</td><td>9</td></tr>
<tr><td>2052.5</td><td>1000x</td><td>0,125</td><td>2,4</td></tr>
<tr><td>2052.6</td><td>5x</td><td>25</td><td rowspan="4">39</td></tr>
<tr><td>2052.7</td><td>10x</td><td>12,5</td></tr>
<tr><td>2052.A</td><td>4x</td><td>31,25</td><td rowspan="5">300</td></tr>
<tr><td>2052.B</td><td>8x</td><td>~15</td></tr>
<tr><td>2052.C</td><td>16x</td><td>~8</td><td>19</td></tr>
<tr><td>2052.E</td><td>32x</td><td>~4</td><td>9</td></tr>
<tr><td>2052.Z</td><td>1x</td><td>125</td><td>39</td></tr>
</table>

(1) *after 4-edge evaluation*
(2) *Calculation of max. speed see page 67*

Output frequency fa (input frequency for subsequent electronics) is limited to 300 kHz for 1Vpp-systems.

Scanning head type WMK-205x based on grating pitch: 500 µm

Ordering code: 1 Vpp-output

WMK-2051.□□-□□□□-□,□-□□

WMKF-2051.□□-□□□□-□,□-□□

Max. input frequency

1 ..... 9 kHz
3 ..... 60 kHz [(1)]
S ... 100 kHz [(1)]

[(1)] nur mit Teilungsfaktor 1 möglich
[(1)] only possible with dividing factor 1

Analog dividing factor

0 ..... 1 (500 µm)
1 ..... 8 (62,5 µm)
2 ... 10 (50 µm)
3 ... 25 (20 µm)
4 ... 32 (~15 µm)
5 ..... 4 (125 µm)
6 ... 16 (31,25 µm)

Grating pitches / revolution (N)

Cable length in m[(2)]

Connector type

0 ....*none*
1 ....*12-pin DIN connector*
3 ....*9-pin Sub-D connector*
4 ....*12-pin CONNEI connector (male)*
5 ....*15-pin Sub-D connector*
6 ....*12-pin CONNEI coupling (male)*
9........*Special connector or special pin-out (requires special no. Sxx)*

preferred cable length in steps of 0,5m

Ordering code: TTL-output

WMK-2052.□-□□□□-□,□-□□

WMKF-2052.□-□□□□-□,□-□□

Interpolation factor

0 .... 25 (5 µm)
1 .... 50 (2,5 µm)
4 ..... 250 (0,5 µm)
5 ... 1000 (0,125 µm)
6 .... 5 (25 µm)
7 .... 10 (12,5 µm)
A 4 (31,25µm)
B ..... 8 (~15 µm)
C ... 16 (~8 µm)
E ... 32 (~4 µm)
Z ..... 1 (125 µm)

Resolution after 4-edge evaluation

Grating pitches / revolution (N)

Cable length in m[(1)]

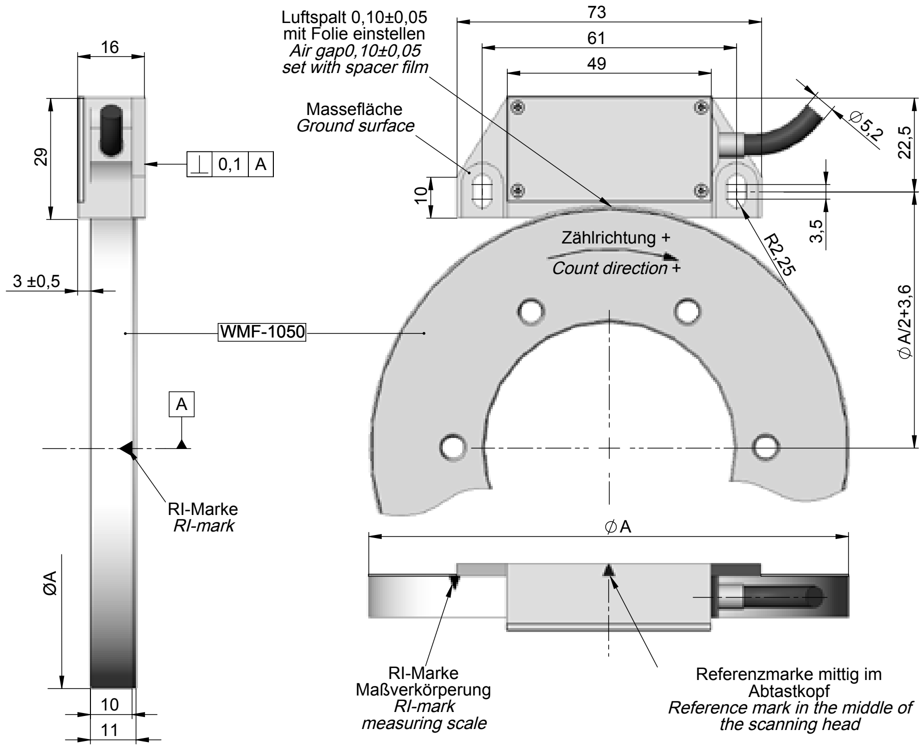
Connector type

0 ....*none*
1 ....*12-pin DIN connector*
3 ....*9-pin Sub-D connector*
4 ....*12-pin CONNEI connector (male)*
5 ....*15-pin Sub-D connector*
6 ....*12-pin CONNEI coupling (male)*
9........*Special connector or special pin-out (requires special no. Sxx)*

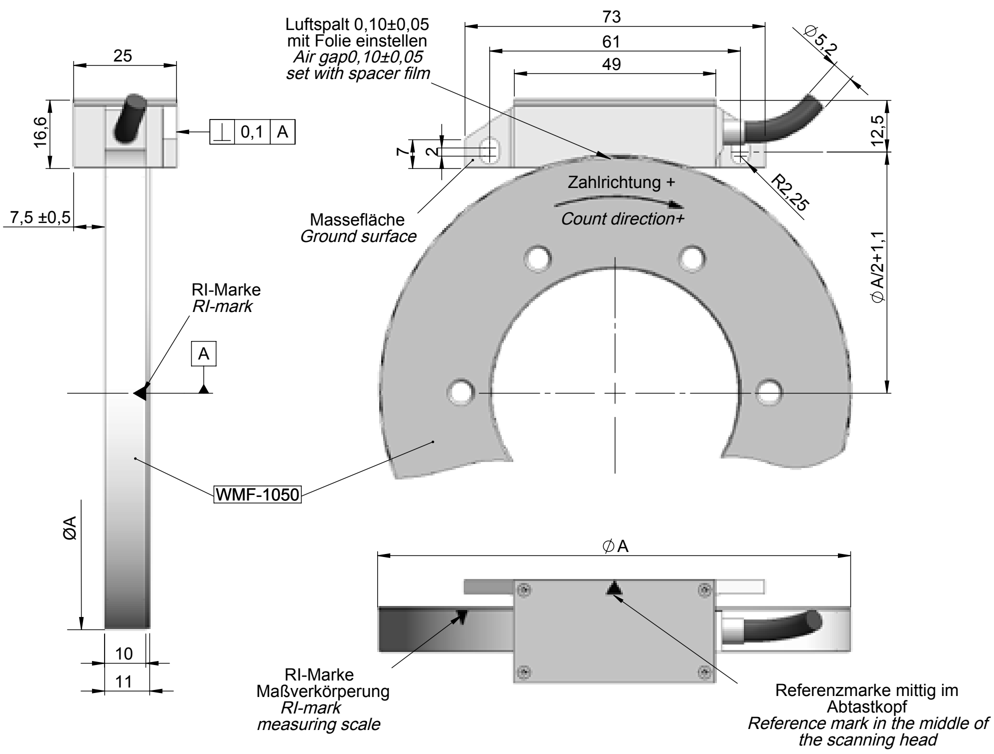
preferred cable length in steps of 0,5m

Scanning head type WMK-205x based on grating pitch: 500 µm

Assembly drawing WMK-205x



Assembly drawing WMKF-205x



Scanning head type WMK-20x based on grating pitch: 1000 µm

Possible resolutions

Output signal

Sine 1 Vpp

Type WMK WMKF	*Signal periods* – *Dividing factor*	*Signal periods* – *Periods [arc length] [µm]*	*Max. input frequency*[2] f[khz]	*Power consumption* [mA] at 5V
201.10	1	1000	9	220
201.11	8	125		
201.12	10	100		
201.13	25	40		
201.14	32	31,25		
201.15	4	250		
201.16	16	62,5		
201.30	1	1000	60	200
201.S0	1	1000	100	

TTL

Type WMK WMKF	*Periods* – *Interpolation factor*	*Periods* – *Resolution*[1] *[arc length]* [µm]	*Max. input frequency*[2] f[khz]	*Power consumption* [mA] at 5V
202.0	25x	10	19	260
202.1	50x	5		
202.4	250x	1	9	
202.5	1000x	0,25	2,4	
202.6	5x	50	39	
202.7	10x	25		
202.A	4x	62,5		300
202.B	8x	31,25		
202.C	16x	~15	19	
202.E	32x	~8	9	
202.Z	1x	250	39	

after 4-edge evaluation
Calculation of max. speed see page 66

Output frequency fa (input frequency for subsequent electronics) is limited to 300 kHz for 1Vpp-systems.

Scanning head type WMK-20x based on grating pitch: 1000 µm

Ordering code: 1 Vpp-output

WMK-201.□□-□□□□-□,□-□□

WMKF-201.□□-□□□□-□,□-□□

Max. input frequency

1 ..... 9 kHz
3 ..... 60 kHz [1]
S ... 100 kHz [1]

[1] only possible with dividing factor 1

Analog dividing factor

0 ..... 1 (1000 µm)
1 ..... 8 (125 µm)
2 ... 10 (100 µm)
3 ... 25 (40 µm)
4 ... 32 (31,25 µm)
5 ..... 4 (250 µm)
6 ... 16 (62,5 µm)

Grating pitches / revolution (N)

Cable length in m[2]

Connector type

0 ....*none*
1 ....*12-pin DIN connector*
3 ....*9-pin Sub-D connector*
4 ....*12-pin CONNEI connector (male)*
5 ....*15-pin Sub-D connector*
6 ....*12-pin CONNEI coupling (male)*
9........*Special connector or special pin-out*
(requires special no. Sxx)

preferred cable length in steps of 0,5m

Ordering code: TTL-output

WMK-202.□-□□□□-□,□-□□

WMKF-202.□-□□□□-□,□-□□

Interpolation factor

0 .... 25 (10 µm)
1 .... 50 (5 µm)
4 ..... 250 (1 µm)
5 ... 1000 (0,25 µm)
6 .... 5 (50 µm)
7 .... 10 (25 µm)
A 4 (62,5µm)
B ..... 8 (31,25 µm)
C ... 16 (~15 µm)
E ... 32 (~8 µm)
Z ..... 1 (250 µm)

Resolution after 4-edge evaluation

Grating pitches / revolution (N)

Cable length in m[1]

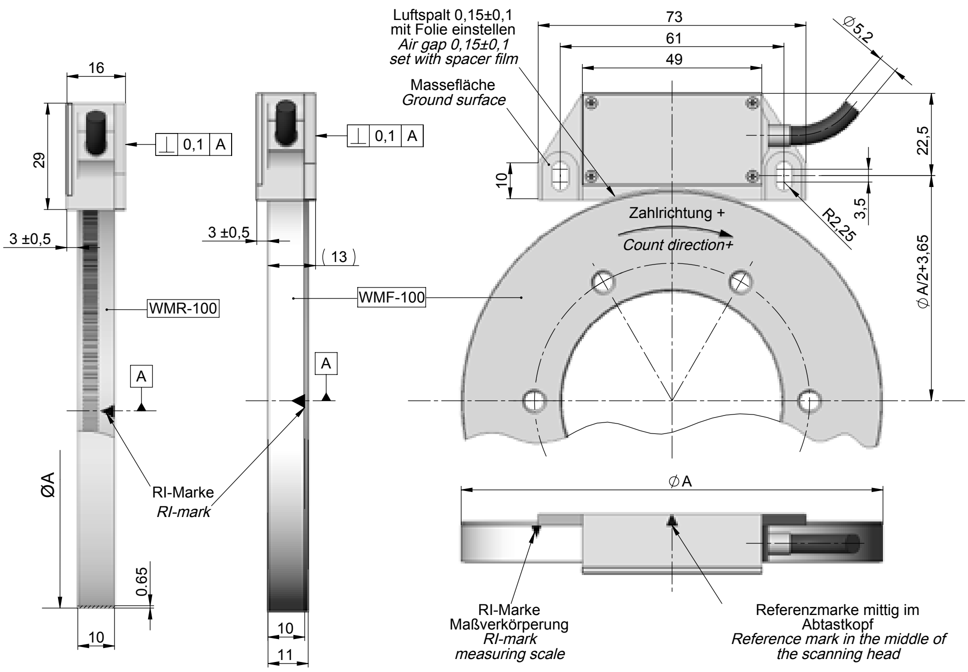
Connector type

0 ....*none*
1 ....*12-pin DIN connector*
3 ....*9-pin Sub-D connector*
4 ....*12-pin CONNEI connector (male)*
5 ....*15-pin Sub-D connector*
6 ....*12-pin CONNEI coupling (male)*
9........*Special connector or special pin-out*
(requires special no. Sxx)

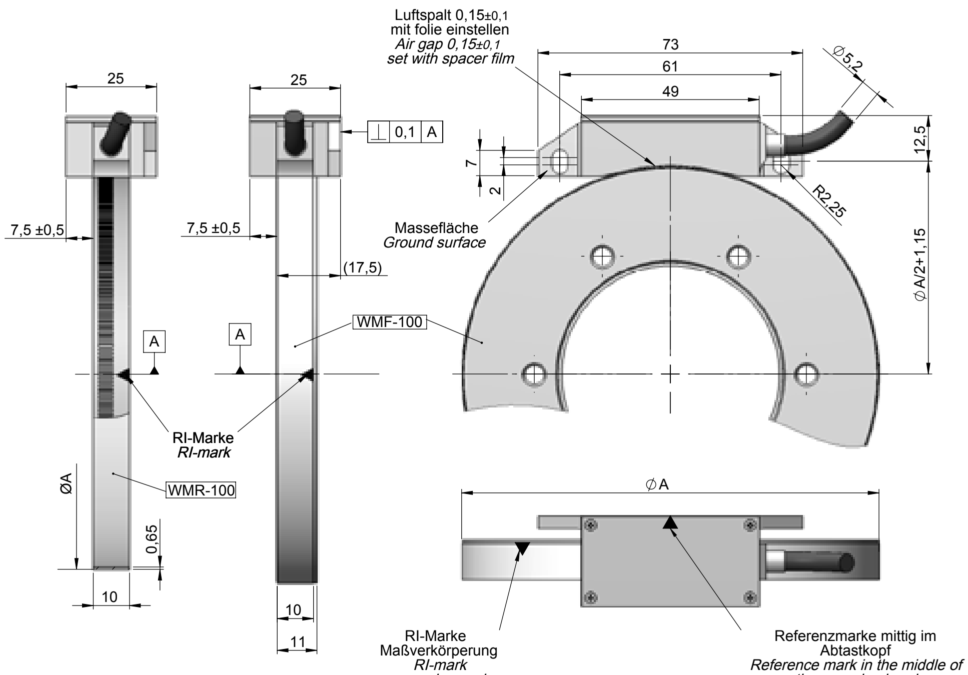
preferred cable length in steps of 0,5m

Scanning head type WMK-20x based on grating pitch: 1000 µm

Assembly drawing WMK-20x



Assembly drawing WMKF-20x



Scanning head type WMK-30x based on grating pitch: 3000 µm

Possible resolutions

Output signal

Sine 1 Vpp

Type **WMK WMKF**	*Signal periods* Dividing factor	*Signal periods* Periods [arc length] [µm]	*Max. input frequency*[2] f[khz]	*Power consumption* [mA] at 5V
301.10	1	3000	9	220
301.11	8	375		
301.12	10	300		
301.13	25	120		
301.14	32	93,75		
301.15	4	750		
301.16	16	187,5		
301.30	1	3000	60	200
301.S0	1	3000	100	

TTL

Type **WMK WMKF**	*Periods* Interpolation factor	*Periods* Resolution[1] [arc length] [µm]	*Max. input frequency*[2] f[khz]	*Power consumption* [mA] at 5V
302.0	25x	30	19	260
302.1	50x	15		
302.4	250x	3	9	
302.5	1000x	0,75	2,4	
302.6	5x	150	39	
302.7	10x	75		
302.A	4x	187,5		300
302.B	8x	93,75		
302.C	16x	~47	19	
302.E	32x	~23	9	
302.Z	1x	750	39	

after 4-edge evaluation
Calculation of max. speed see page 66

Output frequency fa (input frequency for subsequent electronics) is limited to 300 kHz for 1Vpp-systems.

Scanning head type WMK-30x based on grating pitch: 3000 µm

Ordering code: 1 Vpp-output

WMK-301.□□-□□□□-□,□-□□

WMKF-301.□□-□□□□-□,□-□□

Max. input frequency

1 ..... 9 kHz
3 ..... 60 kHz [(1)]
S ... 100 kHz [(1)]

[(1)] only possible with dividing factor 1

Analog dividing factor

0 ..... 1 (3000 µm)
1 ..... 8 (375 µm)
2 ... 10 (300 µm)
3 ... 25 (120 µm)
4 ... 32 (93,75 µm)
5 ..... 4 (750 µm)
6 ... 16 (187,5 µm)

Grating pitches / revolution (N)

Cable length in m[(2)]

Connector type

0 ....*none*
1 ....*12-pin DIN connector*
3 ....*9-pin Sub-D connector*
4 ....*12-pin CONNEI connector (male)*
5 ....*15-pin Sub-D connector*
6 ....*12-pin CONNEI coupling (male)*
9........*Special connector or special pin-out (requires special no. Sxx)*

preferred cable length in steps of 0,5m

Ordering code: TTL-output

WMK-302.□-□□□□-□,□-□□

WMKF-302.□-□□□□-□,□-□□

Interpolation factor

0 .... 25 (30 µm)
1 .... 50 (15 µm)
4 ..... 250 (3 µm)
5 ... 1000 (0,75 µm)
6 .... 5 (150 µm)
7 .... 10 (75 µm)
A ..... 4 (187,5 µm)
B ..... 8 (93,75 µm)
C ... 16 (~47 µm)
E ... 32 (~23 µm)
Z ..... 1 (750 µm)

Resolution after 4-edge evaluation

Grating pitches / revolution (N)

Cable length in m[(1)]

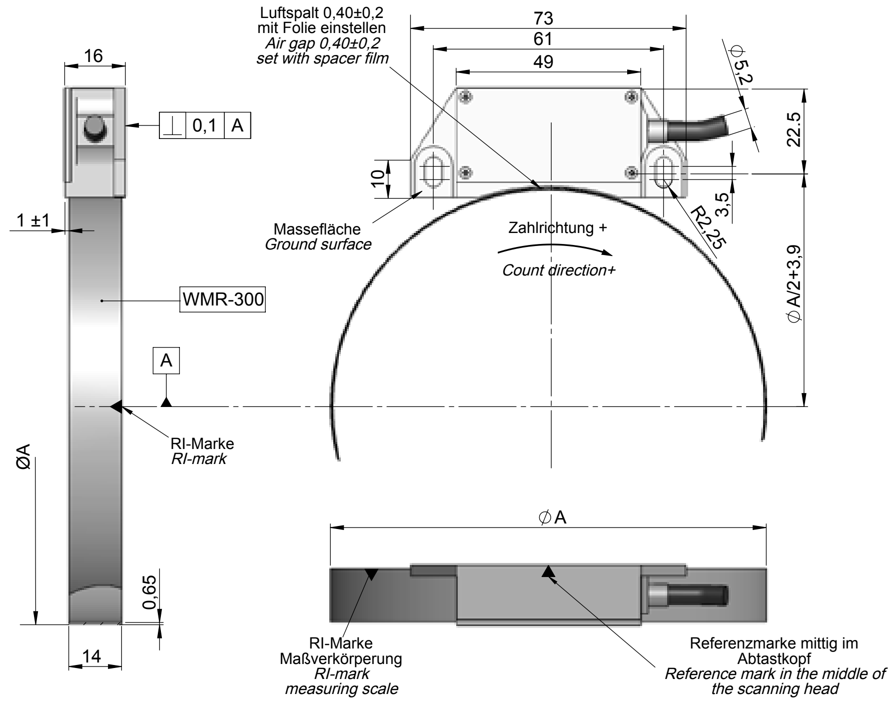
Connector type

0 ....*none*
1 ....*12-pin DIN connector*
3 ....*9-pin Sub-D connector*
4 ....*12-pin CONNEI connector (male)*
5 ....*15-pin Sub-D connector*
6 ....*12-pin CONNEI coupling (male)*
9........*Special connector or special pin-out (requires special no. Sxx)*

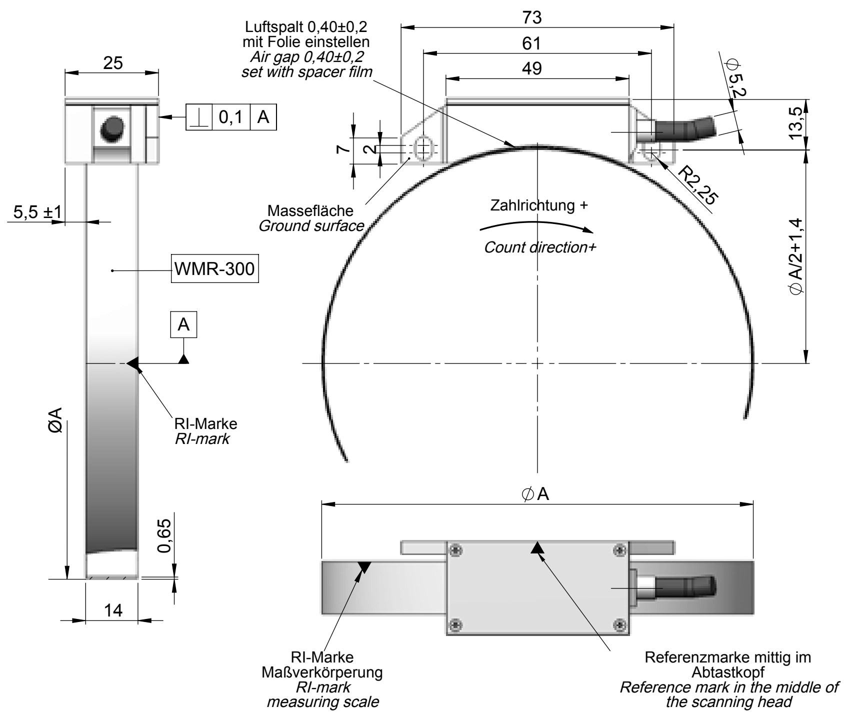
preferred cable length in steps of 0,5m

Scanning head type WMK-30x based on grating pitch: **3000 µm**

Assembly drawing WMK-30x

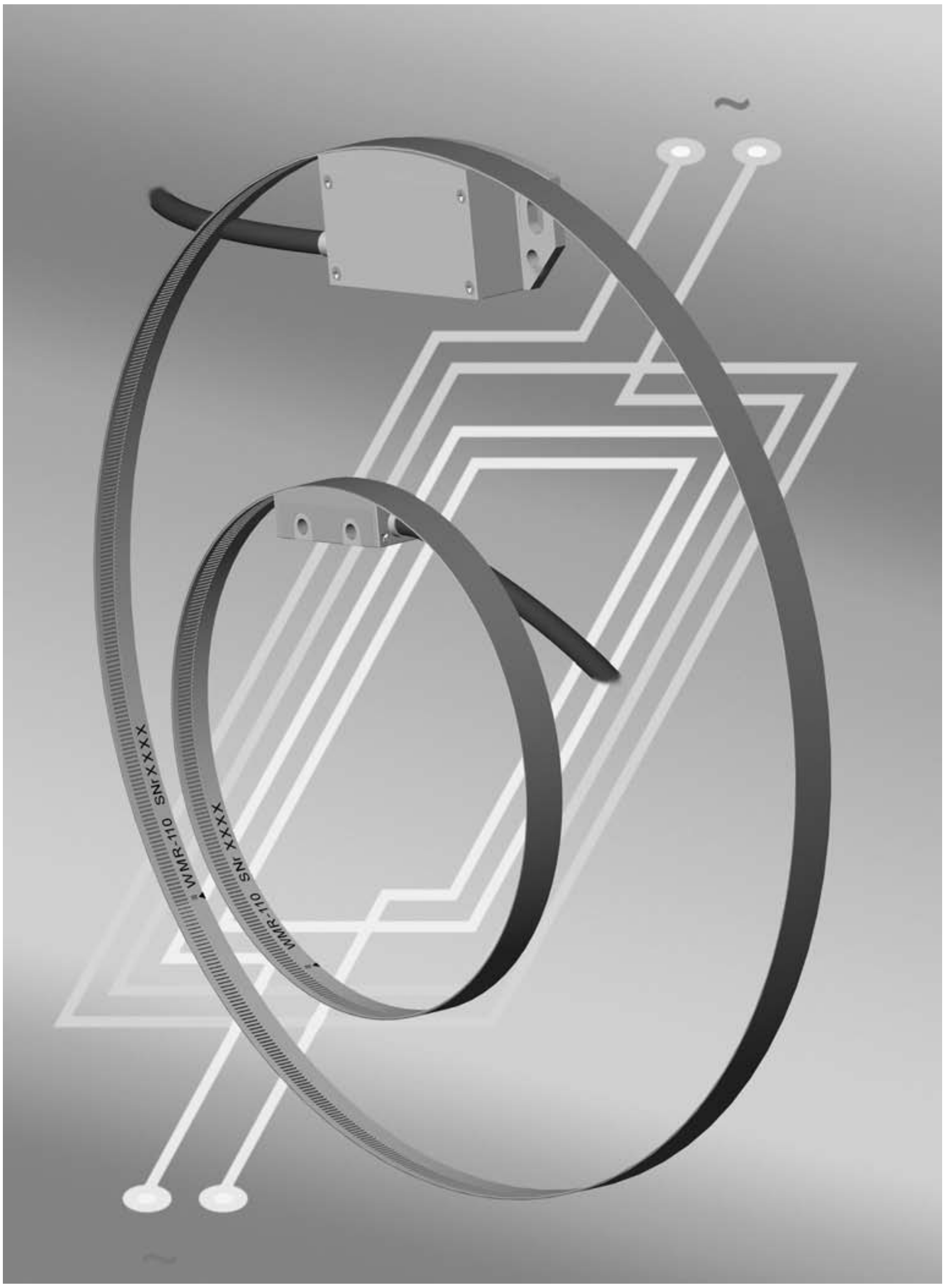


Assembly drawing WMKF-30x



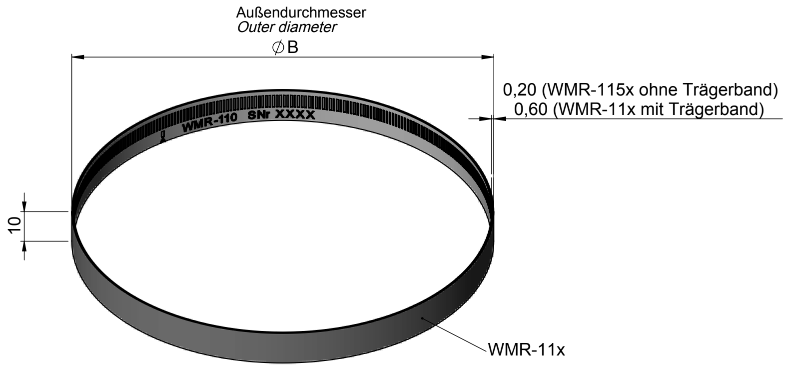
Measuring rings for inside scanning

- ***Grating pitches 500 µm, 1000 µm, 3000 µm***
- ***Can be combined with all scanning heads***
- ***Arbitrary size in diameter***
- ***Easy mounting over snap effect***
- ***No magnetic components, no Hysteresis***

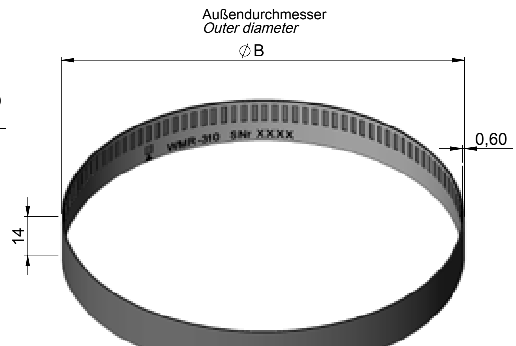


Measuring rings for inside scanning

Designed to be mounted over a “snap-effect” by the customer into a corresponding groove or against a stop collar (see mounting instruction at www.amo-gmbh.com).
For special applications, in agreement with the customer, the measuring ring (circular segments also possible) can be mounted on a flange at the factory.



WMR-115x / WMR-11x



WMR-31x

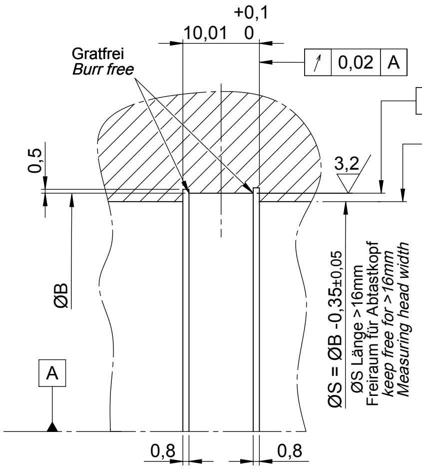
Technical data

***Grating pitch** [arc length]:*	**500 µm**	**1000 µm**	**3000 µm**
Type:	**WMR-115x**	**WMR-11x**	**WMR-31x**
***Grating accuracy** [arc length]:*	± 10 µm, ± 5 µm oder *(or)* ± 3 µm		± 20 µm, ± 10 µm oder *(or)* ± 5 µm
Mechanical execution:	*Stainless steel measuring ring*		
Flange material:	1.4104 oder (or) 1.7225 (42CrMo4)[1)]	*No special material required*	
Reference mark:	*1 mark / 360° as standard or any desired number and position or distance coded (see page 68)*		
Standard sizes N:	1024, 1440, 1800, 2048	0512, 0720, 0900, 1024, 1440, 2048	0170, 0240, 0256, 0300 0341, 0360, 0480, 0512
	N … Grating pitches per revolution		

[1)] *Please contact AMO if using other soft magnetic material*

Mechanical design for WMR-115x

WMR-115x



Recommended material: 1.4104 oder (or) 1.7225 (42CrMo4)
Please contact AMO if using other soft magnetic material.

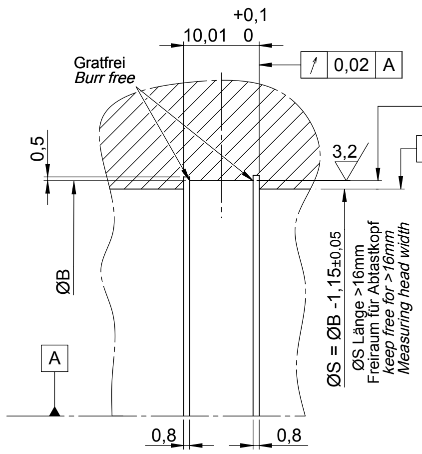
Grating pitch** [arc length]**:	**500 µm**
N	**ØB** [mm]
1024 bis *(to)* 1439	N/2π + 0,13 ±0,01
1440 bis *(to)* 2049	N/2π + 0,07 ±0,02
2050 bis *(to)* 3000	N/2π + 0,04 ±0,03
3001 bis *(to)* 4000	N/2π + 0,00 ±0,06
4001 bis *(to)* 6000	N/2π - 0,03 ±0,07
6001 bis *(to)* 10000	N/2π - 0,06 ±0,10

N: Integer number of grating pitches per revolution

**) Recommended eccentricity: Greater eccentricities up to ~0,03mm do not affect the function of the device, but cause a proportional loss in positioning accuracy.*

Mechanical design for WMR-11x

WMR-11x



Grating pitch** [arc length]**:	**1000 µm**
N	**ØB** *[mm]*
512 bis *(to)* 719	N/π + 0,73 ±0,01
720 bis *(to)* 1024	N/π + 0,67 ±0,02
1025 bis *(to)* 1500	N/π + 0,64 ±0,03
1501 bis *(to)* 2000	N/π + 0,60 ±0,06
2001 bis *(to)* 3000	N/π + 0,57 ±0,07
3001 bis *(to)* 8000	N/π + 0,54 ±0,10

N: Integer number of grating pitches per revolution

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

Ordering code: WMR-115x / WMR-11x

WMR-115 ☐ - ☐☐☐☐ - ☐☐

WMR-11 ☐ - ☐☐☐☐ - ☐☐

Grating accuracy

0 ... ± 10 µm arc length
1 ... ± 5 µm arc length
2 ... ± 3 µm arc length

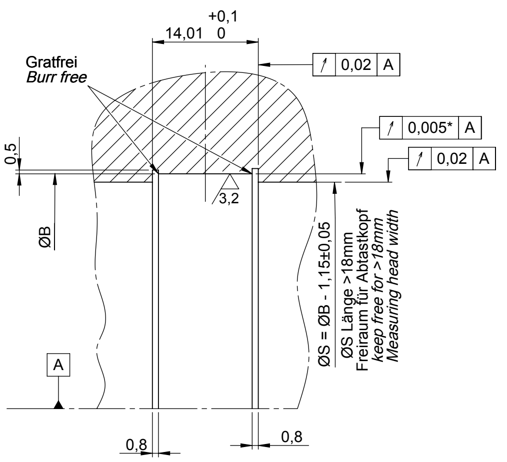
Grating pitches / revolution (N)

RI - Position

00 .... *none*
01 .... *1 RI / revolution*
Kxx ...... *Distance-coded (basic spacing xx grating pitches)*

Mechanical design for WMR-31x

WMR-31x



Grating pitch *[arc length]:*	**3000 µm**
N	**ØB** [mm]
170 bis *(to)* 240	Nx3/π + 0,73 ±0,01
241 bis *(to)* 342	Nx3/π + 0,67 ±0,02
343 bis *(to)* 500	Nx3/π + 0,64 ±0,03
501 bis *(to)* 830	Nx3/π + 0,60 ±0.05
831 bis *(to)* 1330	Nx3/π + 0,57 ±0,07
1331 bis *(to)* 1830	Nx3/π + 0,54 ±0,10

N: Integer number of grating pitches per revolution

**) Recommended eccentricity: Greater eccentricities up to ~0,10mm do not affect the function of the device, but cause a proportional loss in positioning accuracy.*

Ordering code: WMR-31x

WMR-31 ☐ - ☐☐☐☐ - ☐☐

Grating accuracy

0 ... ± 20 µm arc length
1 ... ± 10 µm arc length
2 ... ± 5 µm arc length

Grating pitches / revolution (N)

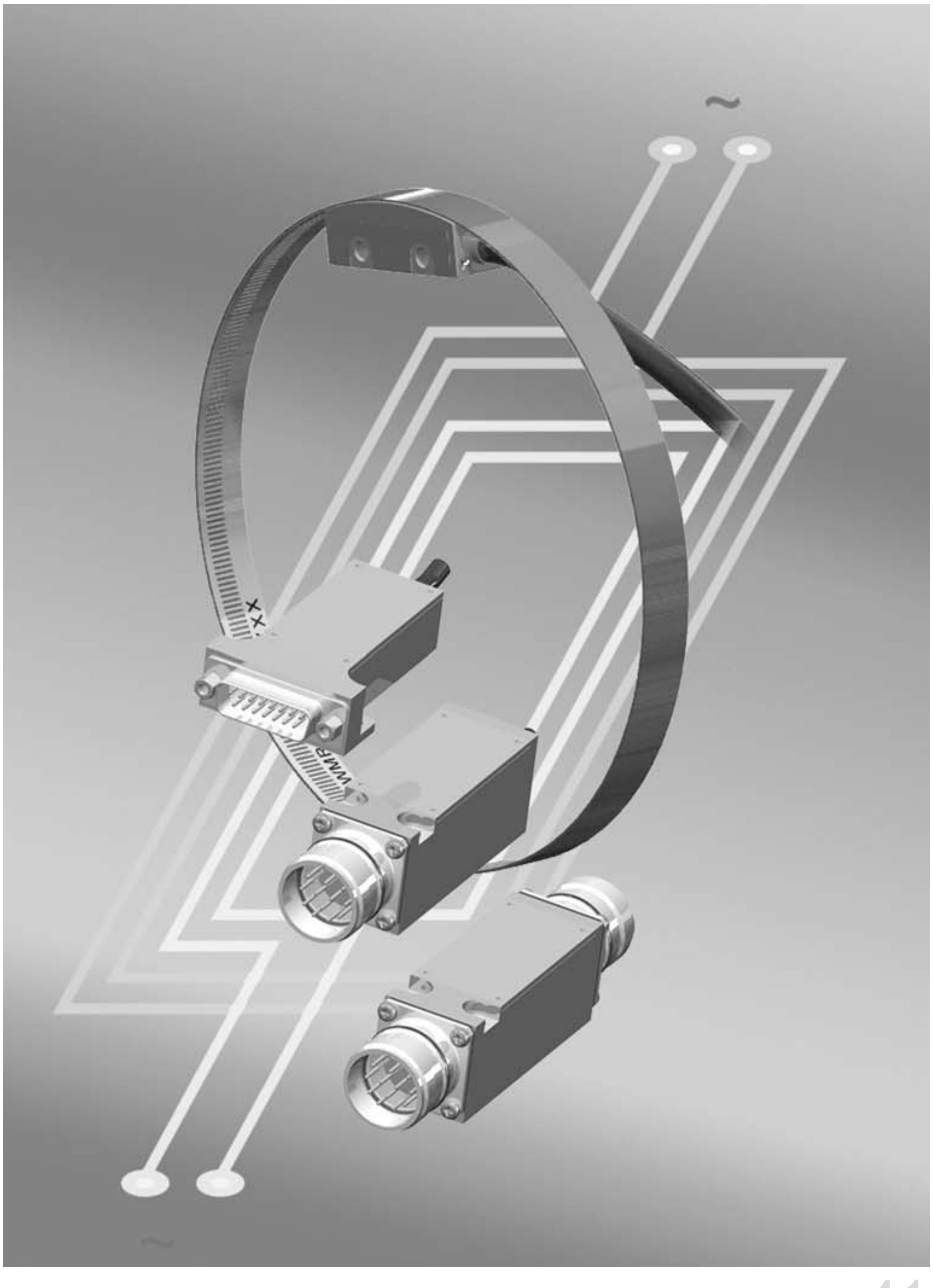
RI - Position

00 .... *none*
01 .... *1 RI / revolution*
Kxx ...... *Distance-coded (basic spacing xx grating pitches)*

The procuction drawing for the carrier flange can be released by AMO.
For applications with large diameters or significant variations in temperature during operation and when the carrier flanges are not made of steel, the system must be designed accordingly.

Miniature scanning head for inside scanning

- *Scanning head for small design*
- *Electronic integrated in connector*
- *Can be combined with measuring rings*
- *Protection class IP67*



Technical data

Grating pitch *[arc length]*:	**500 µm**	**1000 µm**
Type:	**WMK-115x**	**WMK-11x**
Operating temperature:	-10°C … 100°C	
Storage temperature:	-20°C … 100°C	
Protection class:	*Scanning head:*	IP67
	Connector electronics with Connei connector:	IP67
	Connector electronics with Sub-D connector:	IP54
Vibration:	< 400 m/s² for 55 – 2000 Hz	
Shock:	< 2000 m/s² for 6 ms	
Power supply:	5V ± 5%	
Cable:	*Cable specification see page 70*	
Output signals:	*Sine 1Vpp or TTL (RS422); see diagram on page 69*	
System resolutions: [*arc length*]		
Signal period 1Vpp:	500µm … ~15µm	1000µm … 31,25µm
Resolution TTL:	125µm … 0,125µm (1)	250µm … 0,25µm (1)
	Detailed list of possible resolutions see on following pages.	
Max. speed:	*See table on page 66*	
Suitable measuring scale:	**WMR-115x** *see page 37*	**WMR-11x** *see page 37*

(1) ... *after 4-edge evaluation*

Scanning head type WMK-115x based on grating pitch: 500 µm

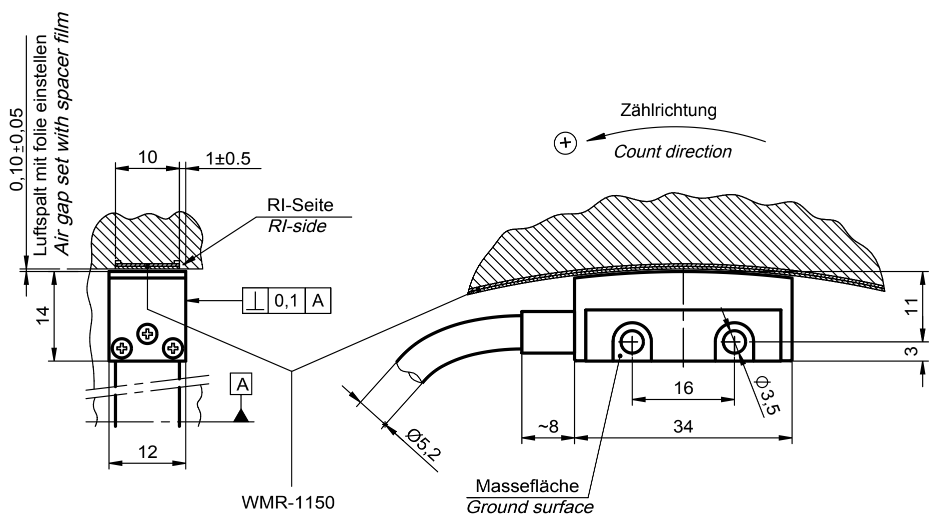
Possible resolutions

Output signal: Sine 1 Vpp Type WMK	Signal periods: *Dividing factor*	Signal periods: *Periods [arc length]* [µm]	*Max. input frequency*[2] f[khz]	*Power consumption* [mA] at 5V	Output signal: TTL Type WMK	Periods: *Interpolation factor*	Periods: *Resolution*[1] *[arc length]* [µm]	*Max. input frequency*[2] f[khz]	*Power consumption* [mA] at 5V
1151.10	1	500	9	260	1152.0	25x	5	19	300
1151.11	8	62,5			1152.1	50x	2,5		
1151.12	10	50			1152.4	250x	0,5	9	
1151.13	25	20			1152.5	1000x	0,125	2,4	
1151.14	32	~15			1152.6	5x	25	39	
1151.15	4	125			1152.7	10x	12,5		
1151.16	16	31,25			1152.A	4x	31,25		340
1151.30	1	500	60	240	1152.B	8x	~15		
1151.S0	1	500	100		1152.C	16x	~8	19	
					1152.E	32x	~4	9	
					1152.Z	1x	125	39	

[1] *after 4-edge evaluation*
[2] *Calculation of max. speed see page 66*

Output frequency fa (input frequency for subsequent electronics) is limited to 300 kHz for 1Vpp-systems.

Assembly drawing WMK-115x



Scanning head type WMK-115x based on grating pitch: 500 µm

Ordering code: 1 Vpp-output

WMK-1151.□□-□□□□-□,□-□□

Max. input frequency

1 ..... 9 kHz
3 ..... 60 kHz [(1)]
S ... 100 kHz [(1)]

[(1)] nur mit Teilungsfaktor 1 möglich
[(1)] only possible with dividing factor 1

Analog dividing factor

0 ..... 1 (500 µm)
1 ..... 8 (62,5 µm)
2 ... 10 (50 µm)
3 ... 25 (20 µm)
4 ... 32 (~15 µm)
5 ..... 4 (125 µm)
6 ... 16 (31,25 µm)

Grating pitches / revolution (N)

Cable length in m[(2)]

Connector electronics

5 .... *Output: 15 pin Sub-D plug*
6, 6A, 6B ... *Output: 12 pin CONNEI coupling (male)*

Configuration at the scanning head side see page 71

preferred cable length in steps of 0,5m

Ordering code: TTL-output

WMK-1152.□-□□□□-□,□-□□

Interpolation factor

0 .... 25 (5 µm)	A 4 (31,25µm)
1 .... 50 (2,5 µm)	B ..... 8 (~15 µm)
4 ..... 250 (0,5 µm)	C ... 16 (~8 µm)
5 ... 1000 (0,125 µm)	E ... 32 (~4 µm)
6 .... 5 (25 µm)	Z ..... 1 (125 µm)
7 .... 10 (12,5 µm)	

Resolution after 4-edge evaluation

Grating pitches / revolution (N)

Cable length in m[(1)]

Connector electronics

5 .... Ausgang: 15 pol. Sub-D Stecker
Output: 15 pin Sub-D plug
6, 6A, 6B ... Ausgang: 12 pol. CONNEI Kupplung (Stift)
Output: 12 pin CONNEI coupling (male)

Ausführung abtastkopfseitig siehe Zeichnungen auf Seite 71
Configuration at the scanning head side see page 71

preferred cable length in steps of 0,5m

Scanning head type WMK-11x based on grating pitch: 1000 µm

Possible resolutions

Output signal

Sine 1 Vpp

Type **WMK**	*Signal periods* Dividing factor	*Signal periods* Periods [arc length] [µm]	*Max. input frequency*(2) f[khz]	*Power consumption* [mA] at 5V
111.10	1	1000	9	260
111.11	8	125		
111.12	10	100		
111.13	25	40		
111.14	32	31,25		
111.15	4	250		
111.16	16	62,5		
111.30	1	1000	60	240
111.S0	1	1000	100	

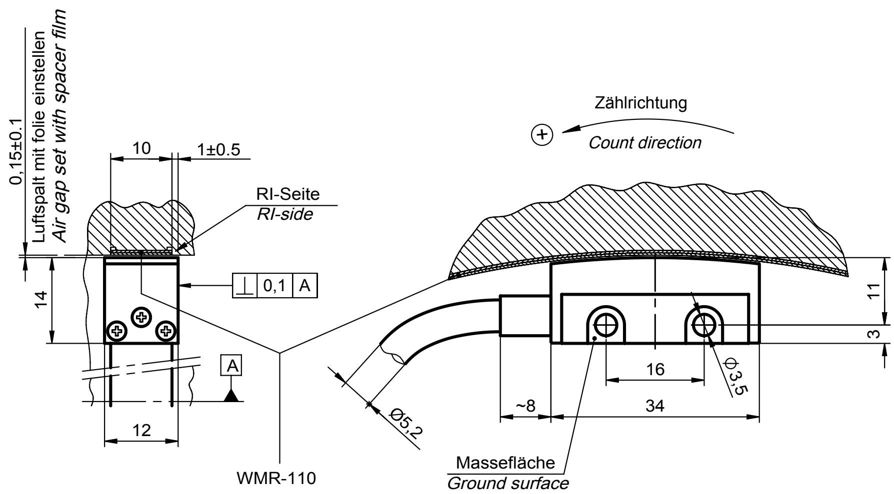
TTL

Type **WMK**	*Periods* Interpolation factor	*Periods* Resolution(1) [arc length] [µm]	*Max. input frequency*(2) f[khz]	*Power consumption* [mA] at 5V
112.0	25x	10	19	300
112.1	50x	5		
112.4	250x	1	9	
112.5	1000x	0,25	2,4	
112.6	5x	50	39	
112.7	10x	25		
112.A	4x	62,5		340
112.B	8x	31,25		
112.C	16x	~15	19	
112.E	32x	~8	9	
112.Z	1x	250	39	

(after 4-edge evaluation
Calculation of max. speed see page 66

Output frequency fa (input frequency for subsequent electronics) is limited to 300 kHz for 1Vpp-systems.

Assembly drawing WMK-11x



Scanning head type WMK-11x based on grating pitch: 1000 µm

Ordering code: 1 Vpp-output

WMK-111.□□-□□□□-□,□-□□

Max. input frequency

1 ... 9 kHz
3 ... 60 kHz [(1)]
S ... 100 kHz [(1)]

[(1)] nur mit Teilungsfaktor 1 möglich
[(1)] only possible with dividing factor 1

Analog dividing factor

0 ..... 1 (1000 µm)
1 ..... 8 (125 µm)
2 ... 10 (100 µm)
3 ... 25 (40 µm)
4 ... 32 (31,25 µm)
5 ..... 4 (250 µm)
6 ... 16 (62,5 µm)

Grating pitches / revolution (N)

Cable length in m[(2)]

Connector electronics

5 .... *Output: 15 pin Sub-D plug*
6, 6A, 6B ... *Output: 12 pin CONNEI coupling (male)*

Configuration at the scanning head side see page 71

preferred cable length in steps of 0,5m

Ordering code: TTL-output

WMK-112.□-□□□□-□,□-□□

Interpolation factor

0 .... 25 (10 µm)
1 .... 50 (5 µm)
4 ..... 250 (1 µm)
5 ... 1000 (0,25 µm)
6 .... 5 (50 µm)
7 .... 10 (25 µm)
A 4 (62,5µm)
B ..... 8 (31,25 µm)
C ... 16 (~15 µm)
E ... 32 (~8 µm)
Z ..... 1 (250 µm)

Resolution after 4-edge evaluation

Grating pitches / revolution (N)

Cable length in m[(1)]

Connector electronics

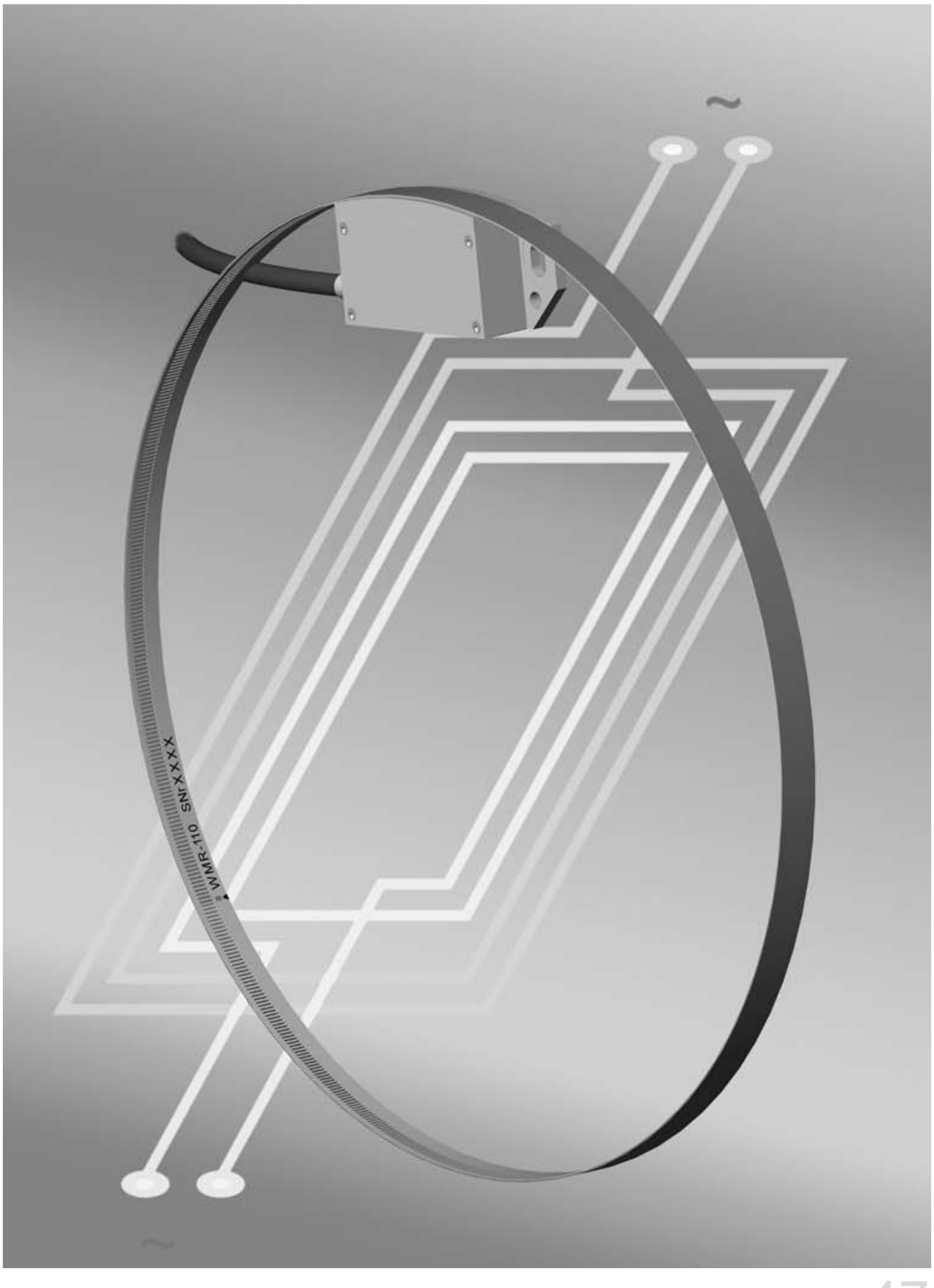
5 .... *Output: 15 pin Sub-D plug*
6, 6A, 6B ... *Output: 12 pin CONNEI coupling (male)*

Configuration at the scanning head side see page 71

preferred cable length in steps of 0,5m

Scanning head with integrated electronics for inside scanning

- *Complete sensor and electronics integrated into the scanning head*
- *Protection class IP67*
- *Can be combined with measuring rings*
- *Also available in Ⓔx-design for explosion sensitive areas*



Technical data

Grating pitch *[arc length]:*	**500 µm**	**1000 µm**	**3000 µm**
Type:	**WMK-215x**	**WMK-21x**	**WMK-31x**
Operating temperature:	-10°C … 100°C		
Storage temperature:	-20°C … 100°C		
Protection class:	IP67		
Vibration:	< 200 m/s² for 55 – 2000 Hz		
Shock:	< 2000 m/s² for 6 ms		
Power supply:	5V ± 5%		
Cable:	*Cable specification see page 70*		
Output signals:	*Sine 1Vpp or TTL (RS422); see diagram on page 69*		
System resolutions: [*arc length*]			
Signal period 1Vpp:	500µm … ~15µm	1000µm … 31,25µm	3000µm … 93,75µm
Resolution TTL:	125µm … 0,125µm (1)	250µm … 0,25µm (1)	750µm … 0,75µm (1)
	Detailed list of possible resolutions see on following pages.		
Max. speed:	*See table on page 68*		
Suitable measuring scale:	**WMR-115x** *see page 37*	**WMR-11x** *see page 37*	**WMR-31x** *see page 37*

(1) *... after 4-edge evaluation*

Scanning head type WMK-215x based on grating pitch: 500 µm

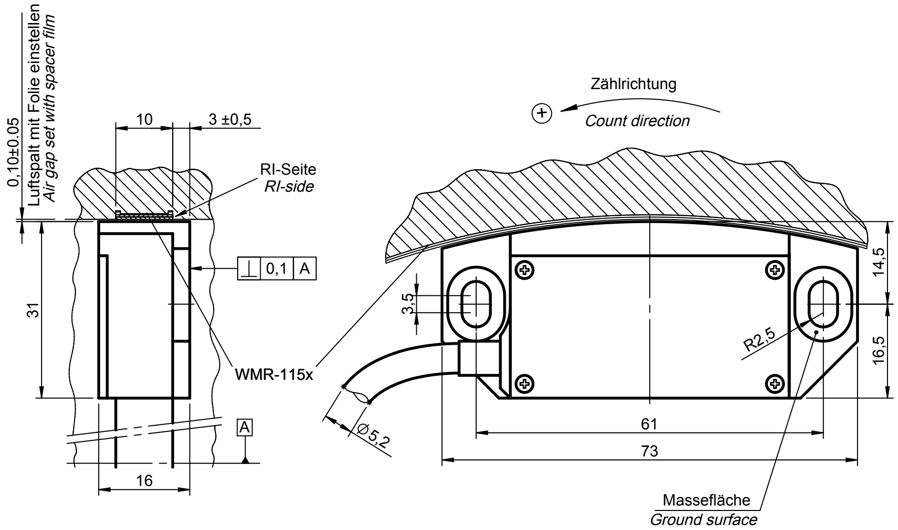
Possible resolutions

Output signal: Sine 1 Vpp — Type WMK	*Signal periods: Dividing factor*	*Signal periods: Periods [arc length] [µm]*	*Max. input frequency*[(2)] f[khz]	*Power consumption* [mA] at 5V	Output signal: TTL — Type WMK	*Periods: Interpolation factor*	*Periods: Resolution*[(1)] *[arc length]* [µm]	*Max. input frequency*[(2)] f[khz]	*Power consumption* [mA] at 5V
2151.10	1	500			2152.0	25x	5	19	
2151.11	8	62,5			2152.1	50x	2,5		
2151.12	10	50			2152.4	250x	0,5	9	260
2151.13	25	20	9	220	2152.5	1000x	0,125	2,4	
2151.14	32	~15			2152.6	5x	25		
2151.15	4	125			2152.7	10x	12,5	39	
2151.16	16	31,25			2152.A	4x	31,25		
2151.30	1	500	60	200	2152.B	8x	~15		
2151.S0	1	500	100		2152.C	16x	~8	19	300
					2152.E	32x	~4	9	
					2152.Z	1x	125	39	

after 4-edge evaluation
Calculation of max. speed see page 66

Output frequency fa (input frequency for subsequent electronics) is limited to 300 kHz for 1Vpp-systems.

Assembly drawing WMK-215x



Scanning head type WMK-215x based on grating pitch: 500 µm

Ordering code: 1 Vpp-output

WMK-2151.□□-□□□□-□,□-□□

Max. input frequency

1 ..... 9 kHz
3 ..... 60 kHz [(1)]
S ... 100 kHz [(1)]

[(1)] only possible with dividing factor 1

Analog dividing factor

0 ..... 1 (500 µm)
1 ..... 8 (62,5 µm)
2 ... 10 (50 µm)
3 ... 25 (20 µm)
4 ... 32 (~15 µm)
5 ..... 4 (125 µm)
6 ... 16 (31,25 µm)

Grating pitches / revolution (N)

Cable length in m[(2)]

Connector type

0 ....*none*
1 ....*12-pin DIN connector*
3 ....*9-pin Sub-D connector*
4 ....*12-pin CONNEI connector (male)*
5 ....*15-pin Sub-D connector*
6 ....*12-pin CONNEI coupling (male)*
9........*Special connector or special pin-out (requires special no. Sxx)*

preferred cable length in steps of 0,5m

Ordering code: TTL-output

WMK-2152.□-□□□□-□,□-□□

Interpolation factor

0 .... 25 (5 µm)	A 4 (31,25µm)
1 .... 50 (2,5 µm)	B ..... 8 (~15 µm)
4 ..... 250 (0,5 µm)	C ... 16 (~8 µm)
5 ... 1000 (0,125 µm)	E ... 32 (~4 µm)
6 .... 5 (25 µm)	Z ..... 1 (125 µm)
7 .... 10 (12,5 µm)	

Resolution after 4-edge evaluation

Grating pitches / revolution (N)

Cable length in m[(1)]

Connector type

0 ....*none*
1 ....*12-pin DIN connector*
3 ....*9-pin Sub-D connector*
4 ....*12-pin CONNEI connector (male)*
5 ....*15-pin Sub-D connector*
6 ....*12-pin CONNEI coupling (male)*
9........*Special connector or special pin-out (requires special no. Sxx)*

preferred cable length in steps of 0,5m

Scanning head type WMK-21x based on grating pitch: 1000 µm

Possible resolutions

Output signal

Sine 1 Vpp

Type WMK	Signal periods: *Dividing factor*	Signal periods: *Periods [arc length] [µm]*	*Max. input frequency*(2) f[khz]	*Power consumption* [mA] at 5V
211.10	1	1000		
211.11	8	125		
211.12	10	100		
211.13	25	40	9	220
211.14	32	31,25		
211.15	4	250		
211.16	16	62,5		
211.30	1	1000	60	200
211.S0	1	1000	100	

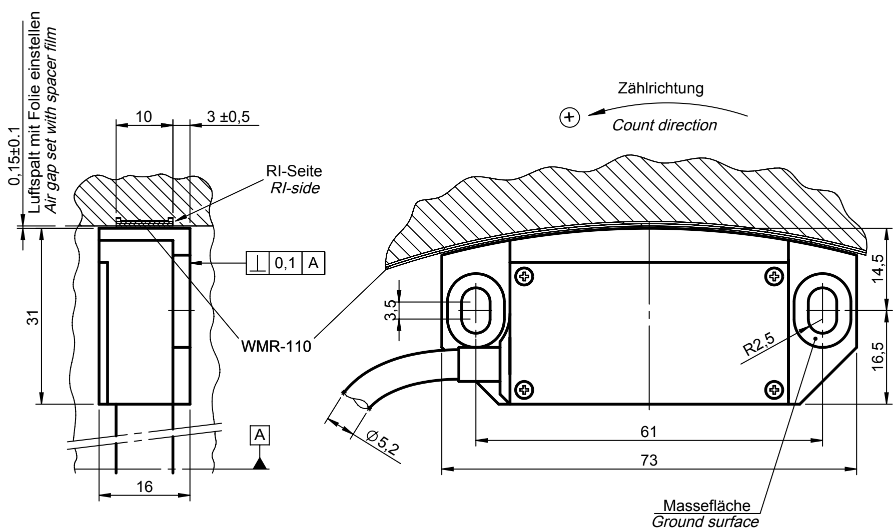
TTL

Type WMK	Periods: *Interpolation factor*	Periods: *Resolution*(1) *[arc length]* [µm]	*Max. input frequency*(2) f[khz]	*Power consumption* [mA] at 5V
212.0	25x	10	19	
212.1	50x	5		
212.4	250x	1	9	260
212.5	1000x	0,25	2,4	
212.6	5x	50		
212.7	10x	25	39	
212.A	4x	62,5		
212.B	8x	31,25		
212.C	16x	~15	19	300
212.E	32x	~8	9	
212.Z	1x	250	39	

after 4-edge evaluation
Calculation of max. speed see page 66

Output frequency fa (input frequency for subsequent electronics) is limited to 300 kHz for 1Vpp-systems.

Assembly drawing WMK-21x



Scanning head type WMK-21x based on grating pitch: 1000 µm

Ordering code: 1 Vpp-output

WMK-211.□□-□□□□-□,□-□□

Cable length in m(2)

Grating pitches / revolution (N)

Max. input frequency

1 ..... 9 kHz
3 ..... 60 kHz (1)
S ... 100 kHz (1)

(1) only possible with dividing factor 1

Analog dividing factor

0 ..... 1 (1000 µm)
1 ..... 8 (125 µm)
2 ... 10 (100 µm)
3 ... 25 (40 µm)
4 ... 32 (31,25 µm)
5 ..... 4 (250 µm)
6 ... 16 (62,5 µm)

Connector type

0 ....*none*
1 ....*12-pin DIN connector*
3 ....*9-pin Sub-D connector*
4 ....*12-pin CONNEI connector (male)*
5 ....*15-pin Sub-D connector*
6 ....*12-pin CONNEI coupling (male)*
9........*Special connector or special pin-out (requires special no. Sxx)*

preferred cable length in steps of 0,5m

Ordering code: TTL-output

WMK-212.□-□□□□-□,□-□□

Cable length in m(1)

Grating pitches / revolution (N)

Interpolation factor

0 .... 25 (10 µm)	A 4 (62,5µm)
1 .... 50 (5 µm)	B ..... 8 (31,25 µm)
4 ..... 250 (1 µm)	C ... 16 (~15 µm)
5 ... 1000 (0,25 µm)	E ... 32 (~8 µm)
6 .... 5 (50 µm)	Z ..... 1 (250 µm)
7 .... 10 (25 µm)	

Resolution after 4-edge evaluation

Connector type

0 ....*none*
1 ....*12-pin DIN connector*
3 ....*9-pin Sub-D connector*
4 ....*12-pin CONNEI connector (male)*
5 ....*15-pin Sub-D connector*
6 ....*12-pin CONNEI coupling (male)*
9........*Special connector or special pin-out (requires special no. Sxx)*

preferred cable length in steps of 0,5m

Scanning head type WMK-31x based on grating pitch: 3000 µm

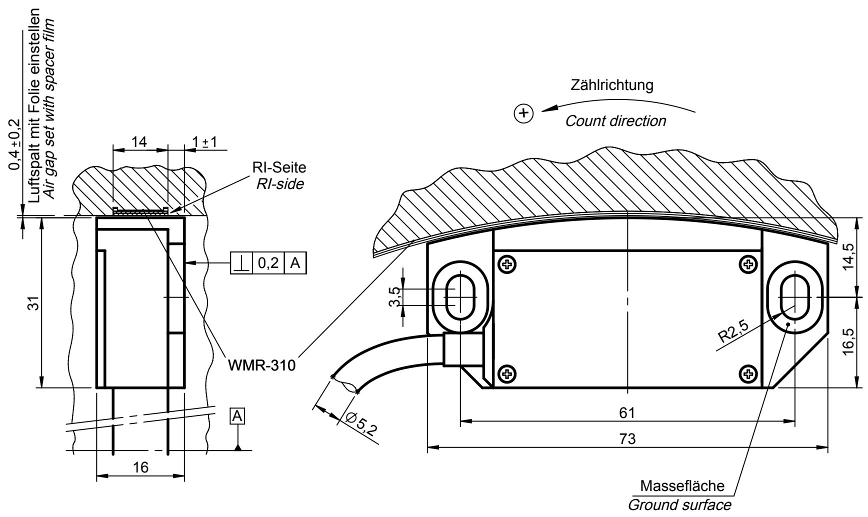
Possible resolutions

Output signal: Sine 1 Vpp					Output signal: TTL				
Type WMK	*Signal periods* *Dividing factor*	*Signal periods* *Periods [arc length]* [µm]	*Max. input frequency*(2) f[khz]	*Power consumption* [mA] at 5V	Type WMK	*Periods* *Interpolation factor*	*Periods* *Resolution*(1) *[arc length]* [µm]	*Max. input frequency*(2) f[khz]	*Power consumption* [mA] at 5V
311.10	1	3000			312.0	25x	30	19	
311.11	8	375			312.1	50x	15		
311.12	10	300			312.4	250x	3	9	260
311.13	25	120	9	220	312.5	1000x	0,75	2,4	
311.14	32	93,75			312.6	5x	150		
311.15	4	750			312.7	10x	75	39	
311.16	16	187,5			312.A	4x	187,5		
311.30	1	3000	60	200	312.B	8x	93,75		
311.S0	1	3000	100		312.C	16x	~47	19	300
					312.E	32x	~23	9	
					312.Z	1x	750	39	

after 4-edge evaluation
Calculation of max. speed see page 66

Output frequency fa (input frequency for subsequent electronics) is limited to 300 kHz for 1Vpp-systems.

Assembly drawing WMK-31x



Scanning head type WMK-31x based on grating pitch: 3000 µm

Ordering code: 1 Vpp-output

WMK-311.□□-□□□□-□,□-□□

Cable length in m[2]

T*Grating pitches / revolution (N)*

Connector type

0 ....*none*
1 ....*12-pin DIN connector*
3 ....*9-pin Sub-D connector*
4 ....*12-pin CONNEI connector (male)*
5 ....*15-pin Sub-D connector*
6 ....*12-pin CONNEI coupling (male)*
9........*Special connector or special pin-out (requires special no. Sxx)*

Max. input frequency

1 ..... 9 kHz
3 ..... 60 kHz [1]
S ... 100 kHz [1]

[1] nur mit Teilungsfaktor 1 möglich
[1] only possible with dividing factor 1

Analog dividing factor

0 ..... 1 (3000 µm)
1 ..... 8 (375 µm)
2 ... 10 (300 µm)
3 ... 25 (120 µm)
4 ... 32 (93,75 µm)
5 ..... 4 (750 µm)
6 ... 16 (187,5 µm)

preferred cable length in steps of 0,5m

Ordering code: TTL-output

WMK-312.□-□□□□-□,□-□□

Cable length in m[1]

Grating pitches / revolution (N)

Connector type

0 ....*none*
1 ....*12-pin DIN connector*
3 ....*9-pin Sub-D connector*
4 ....*12-pin CONNEI connector (male)*
5 ....*15-pin Sub-D connector*
6 ....*12-pin CONNEI coupling (male)*
9........*Special connector or special pin-out (requires special no. Sxx)*

Interpolation factor

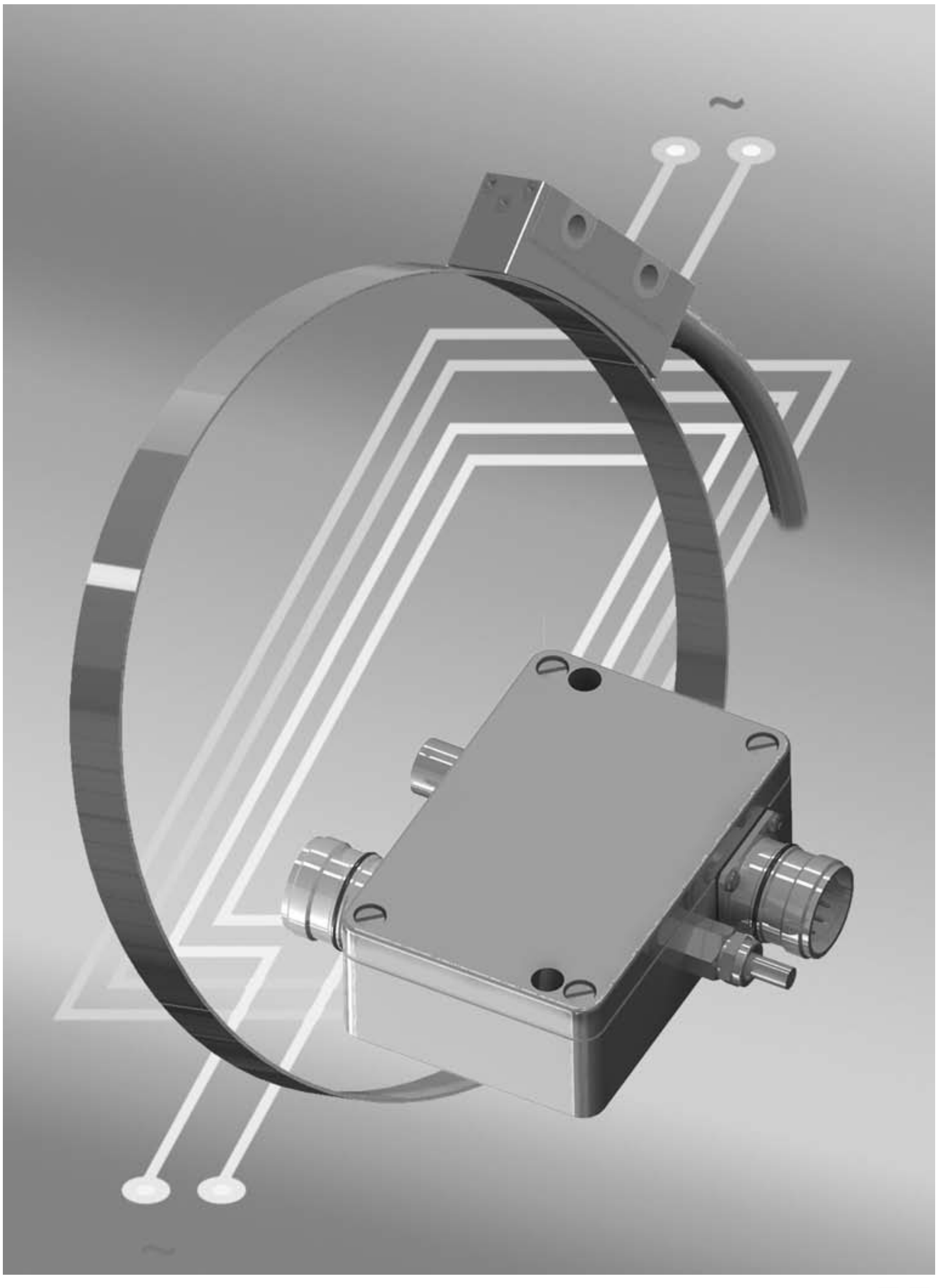
0 .... 25 (30 µm)	A ..... 4 (187,5 µm)
1 .... 50 (15 µm)	B ..... 8 (93,75 µm)
4 ..... 250 (3 µm)	C ... 16 (~47 µm)
5 ... 1000 (0,75 µm)	E ... 32 (~23 µm)
6 .... 5 (150 µm)	Z ..... 1 (750 µm)
7 .... 10 (75 µm)	

Resolution after 4-edge evaluation

preferred cable length in steps of 0,5m

Angle measuring system for highest accuracy

- *Eliminiates eccentricity and run out error*
- *Accuracies less than 2 arc seconds*
- *Protection class IP67*



Description of multi head scanning

The AMO angle measuring system with multi head scanning provides absolute accuracies of several arc seconds for rotary tables and swivelling axis. The influence of eccentricity will be eliminated and the system accuracy can be improved up to a factor of 4 compared with a single head measuring system.

Possible sources of error

Generally it should be noted that each eccentric mounting of an angle measuring system causes an error in measuring position, independent whether there is an integral bearing or not.
On a detailed view of possible sources of error on a rotary axis one encounters the following errors:

a) Systematically, repeatable errors per revolution

- *Eccentricity from measuring flange with respect to the axis of rotation*
- *Grating errors of the measuring scale*
- Run out errors from the bearing

b) Coincidental errors

- *Backlash of the bearing*
- *Load-sensitive deformation*

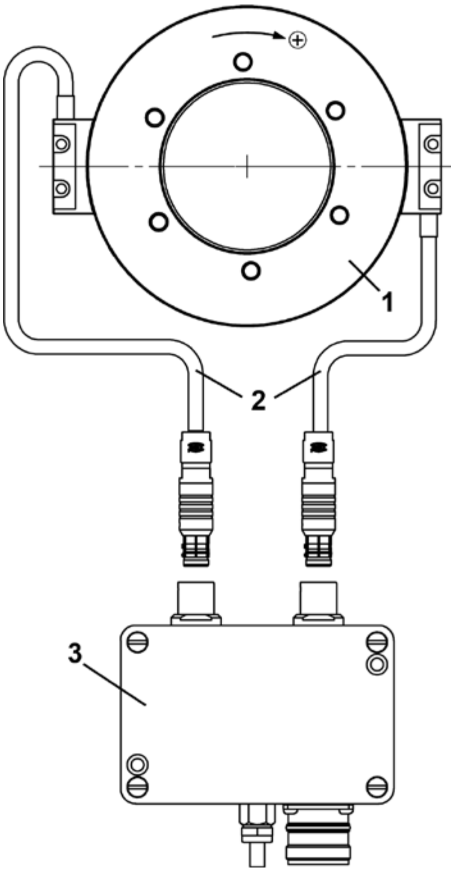
Since the systematically errors specified above are in practice not completely avoidable, we present two economic compensation possibilities:

- **MHS – Multiple Head Solution**
- **CHS – Calibration Head Solution**

Multiple Head Solution - MHS

*The AMOSIN angle measuring system **MHS-21x** is designed for high accuracy applications, where precision bearings are used. Therefore, most of the measuring errors are systematic and repeatable, and the non-repeatable errors for the majority of applications can be neglected.*

The measuring system consists of a measuring flange, 2 scanning heads and an evaluation electronics box and as shown on below.



1	*Measuring flange WMF or measuring ring WMR*
2	*Scanning heads WMK*
3	*MHS - evaluation electronics*

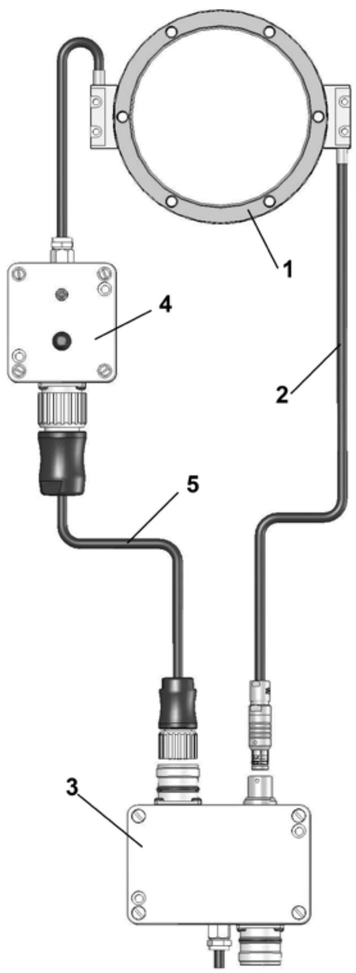
During a rotary movement of the measuring flange the MHS-21x reads position data from both heads continuously and evaluates a corrected position signal on the system output.

Consequence: The eccentricity error is completely eliminated and the influences of systematic errors is reduced by a factor of 2.

The great advantage of the MHS-21x is that also changing eccentricity during the machining process (i.e rotary tables, milling heads which gets different radial loads) is compensated.

Calibration Head Solution - CHS

An high precision angle measuring system with multiple head scanning provides, as described above, a significant increase in system accuracy compared with a single reading head system.
The user friendly CHS angle measuring system achieves the accuracy of a multiple head system.The unique feature is that there is only one reading head necessary for normal operation. Only for initial start up of the axis a second reading head has to be mounted for the calibration procedure.
The CHS angle measuring system consists of a measuring flange or measuring ring, one reading head, an evaluation electronics and a calibration unit as shown below.



1 *Measuring flange WMF or measuring ring WMR*

2 *Measuring head WMK*

3 *CHS – evaluation electronics*

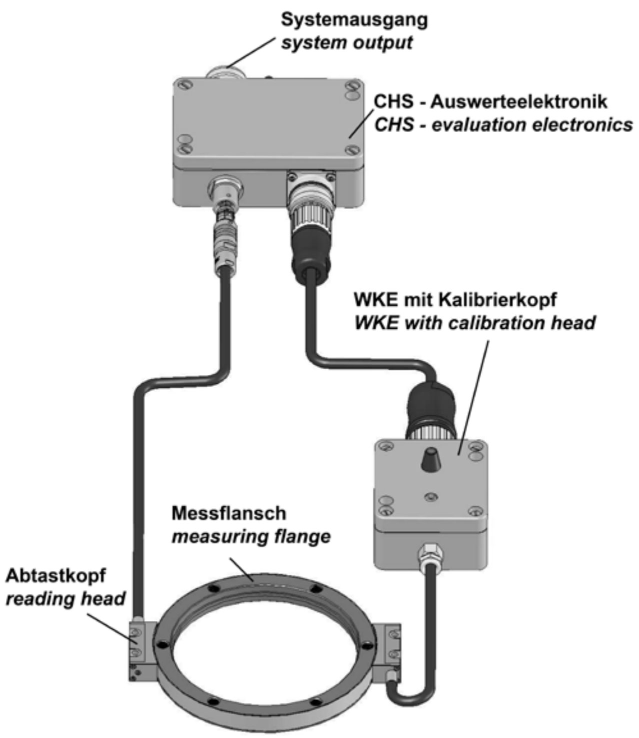
4 *Calibration unit WKE (together with calibration head)*

5 *Adapter cable for WKE, length 1m*

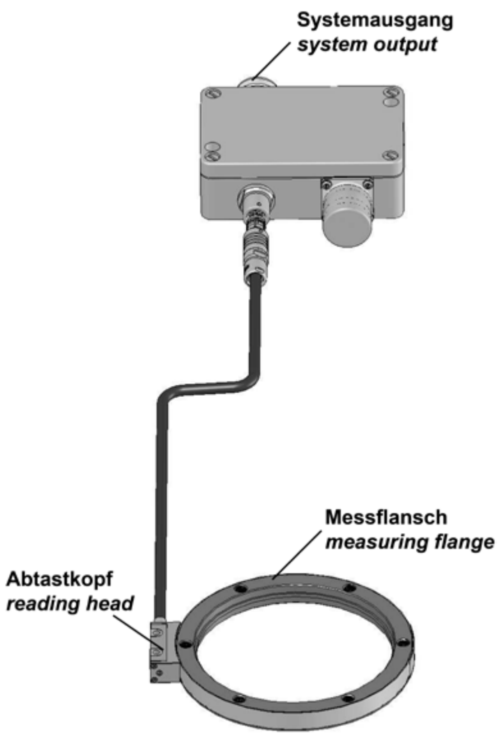
Item 4 and 5 only necessary for calibration procedure

Description of the calibration procedure

During the calibration procedure, the calibrating head is temporarily mounted diametrically opposite (180°) to the active measuring head.
During a rotary movement of the measuring flange collecting and transmitting of the position data from both heads starts when the reference mark passes the reading head. The calibration procedure for this position of the calibration head is completed after one revolution and the error deviations are stored in the evaluation electronic box automatically.
For the quadruple encoder head calibration procedure, which results in an even higher accuracy, the calibration head must be mounted successively also in the positions 90° and 270°. After the third calibration procedure at position 270° the calibration is done.



Arrangement during calibration



Arrangement for operation

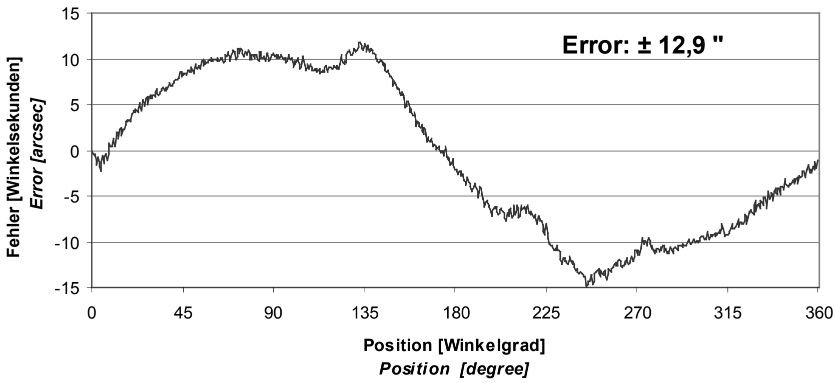
Consequence: The eccentricity error is completely eliminated and the influence of systematic errors is reduced by a factor of 2 with 2 head calibration and/or 4 with 4 head calibration.
The great advantage of the CHS-11x is that only one reading head is used for normal operation, offering highest accuracy similar to a double and/or quadruple reading head design but with lower system costs.

Metrological consideration

*To illustrate the accuracies that can be reached with the CHS are given further measuring diagrams of a system WMI-101-1024 which is a standard angle measuring system with a grating ring of about 326 mm diameter and an accuracy of **±6 arc seconds** for a standard single head encoder under ideal mounting conditions, that means **no eccentricity**.*

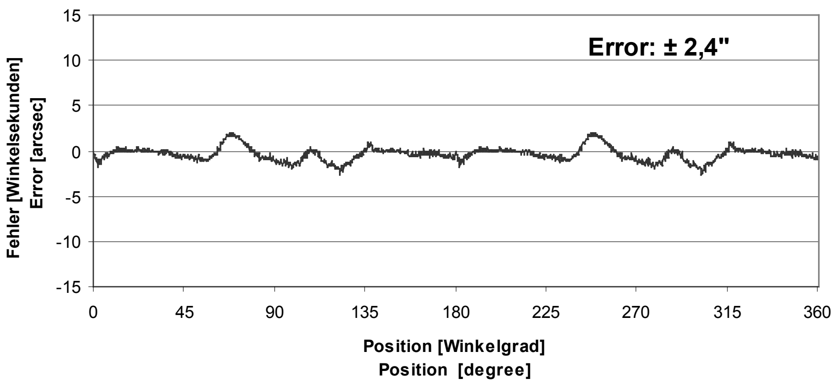
Measuring flange mounted with 10 µm eccentricity, single head scanning

*The immense sinusodial deviation over 360° shows the typical influence of an eccentricity of only 10µm. At a diameter of 326mm and an eccentricity of 10µm the calculated value for the deviation is ±12,6µm and therefore **2 times higher than the accuracy of the measuring flange** as shown below.*



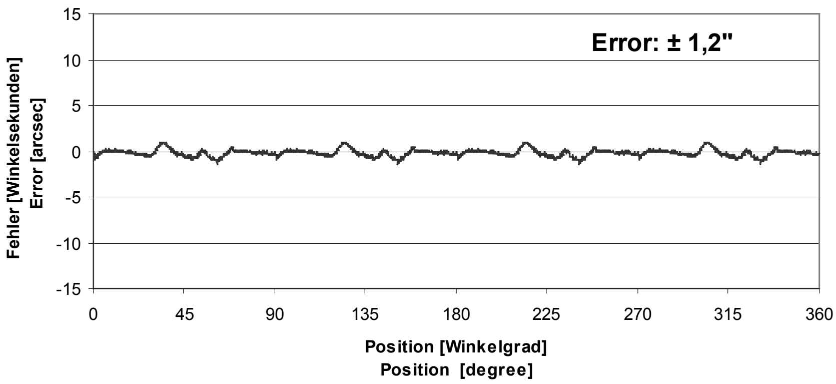
Measuring flange mounted with 10 µm eccentricity, double head scanning with MHS- or CHS-system

With a CHS- or MHS angle measuring system with double head scanning and an identical measuring flange with unchanged eccentricity of 10µm the deviation is as shown below.
The influence of eccentricity is completely eliminated, the error of the measuring flange is halve the value compared to single head scanning.



Measuring flange mounted with 10 µm eccentricity, quadruple head scanning with CHS-system

With a quadruple head calibration on a CHS-angle measuring system the absolute accuracy of the position is increased ***again by a factor of 2****, as shown in the diagram below.*



The diagrams above show the high accuracy which can be achieved in angle position measurement.

The obtainable system accuracies for different sizes of the measuring flange are shown in the table below.

WMF-101 / WMR-101		**System accuracy**		
Size of measuring flange / measuring ring	***Outer diameter*** [mm]	***Standard single head encoder*** [arcsec]	**CHS-11x MHS-21x** ***2-head-calibration*** [arcsec]	**CHS-11x** ***4-head-calibration*** [arcsec]
256	81,95	± 25	± 13	± 7
360	115,12	± 18	± 9	± 5
512	163,54	± 12,0	± 6,0	≤± 3,0
720	229,78	± 9,0	± 5,0	≤± 3,0
900	287,08	± 7,0	± 4,0	≤ ±2,0
1024	326,55	± 6,0	± 3,0	≤ ±2,0
1440	458,97	± 4,5	± 2,2	≤ ±2,0
2048	652,58	± 3,0	< ±2,0	≤ ±2,0

Technical data

	MHS **CHS**
Possible grating pitch: *[arc length]*	500µm / 1000µm / 3000µm
Operating temperature:	*Scanning head:* -10°C … 100°C *Evaluation electronics:* -10°C … 80°C
Storage temperature:	-20°C … 100°C
Protection class:	*Scanning head:* IP67 *Evaluation electronics:* IP66
Vibration:	< 400 m/s² for 55 – 2000 Hz
Shock:	< 2000 m/s² for 6 ms
Power supply:	9V *to* 36V - 180mA *at* 24V *Power supply on a separate cable with 3m length*
Cable:	*Cable specification see page 70*
Output signals:	*Sine 1Vpp or TTL (RS422); see diagram on page 69*
System resolutions (2): [*arc length*] *Signal period 1Vpp:* *Resolution TTL:*	3000µm … ~15µm 3µm … 0,125µm (1) *Detailed list of possible resolutions see on following pages.*
Max. speed:	*See table on page 66*
Suitable measuring scale:	**WMF-105x / WMB-105x** *or* **WMF-10x / WMR-10x** *or* **WMF-30x / WMR-30x**

(1) ... *after 4-edge evaluation*
(2) ... *depends on selected grating pitch*

The evaluation electronics MHS or CHS can be combined with the scanning heads WMK-1050, WMK-100 or WMK-300, depending on the selected grating pitch.

Possible resolutions for analog output 1Vpp

Type **MHS/CHS**	*Dividing factor*	*Grating pitch* 500 µm	1000 µm	3000 µm	*Max. input frequency* f[kHz]
		Periods [µm]			
x11.10	1	500	1000	3000	9
x11.11	8	62,5	125	375	
x11.12	10	50	100	300	
x11.13	25	20	40	120	
x11.14	32	~15	31,25	93,75	
x11.15	4	125	250	750	

Possible resolutions for adigital output RS422/TTL

Type **MHS/CHS**	*Interpolation factor*	*Grating pitch* 500 µm	1000 µm	3000 µm	*Max. input frequency* f[kHz]
		Resolution [µm] (1)			
x12.2	256	~0,5	~1	~3	9
x12.3	1024	~0,125	~0,25	~0,75	2,4

(1) ... *after 4-edge evaluation*

Ordering code: MHS / CHS 1 Vpp-output

MHS-211.1 ☐ - 8
CHS-111.1 ☐ - 8

Analog dividing factor

0 1
1 8
2 ... 10
3 ... 25
4 ... 32
5 4

Ordering code: MHS / CHS TTL-output

MHS-212. ☐ - 8
CHS-112. ☐ - 8

Interpolation factor

2 256
3 1024

Ordering code: Scanning head

WMK-1050-☐☐☐☐-☐,☐ - 8
WMK-100-☐☐☐☐-☐,☐ - 8
WMK-300-☐☐☐☐-☐,☐ - 8

Grating pitches / revolution (N)

Cable length in m

preferred cable length in steps of 0,5m

Ordering code: WKE – Calibration unit

WKE-1052.4-☐☐☐☐ - 3,0 - 6
WKE-102.4-☐☐☐☐ - 3,0 - 6
WKE-302.4-☐☐☐☐ - 3,0 - 6

Grating pitches / revolution (N)

Plug and connection assignment

Measuring system - signal output

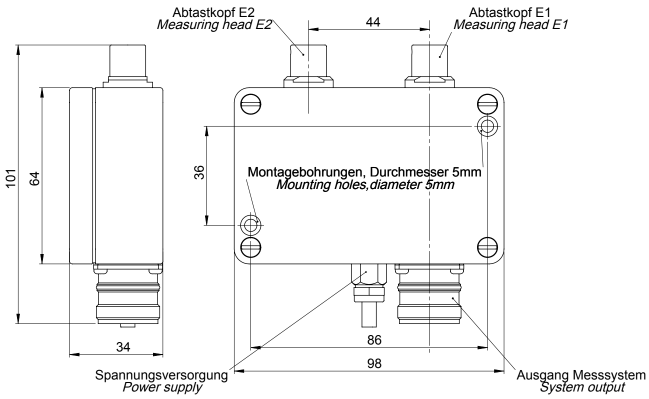
PIN	1	2	3	4	5	6	7	8	9	10	11	12
Signal	B-	5V-Sensor	RI+	RI-	A+	A-	-	B+	-	0V	0V-Sensor	+5V
Color	white	red-white	pink	grey	green	yellow	-	brown	-	blue	blue-white	red

Measuring system - power supply

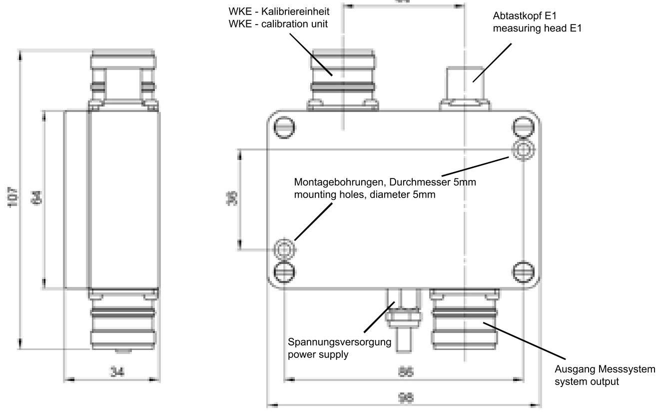
Signal	+24V	0V
Color	red	blue

The sense pins are connected to the 5V/0V pins inside the MHS/CHS to provide a defined voltage level for the sense input of a subsequent NC-controller.
+5V (pin 12) is not connected to the CHS-electronics, connection of 0V (pin 10) is necessary.
It‘s not allowed to connect the pins 7 and 9 to the following electronics (for example controller). These pins serve alone for test purposes only with the AMO testdevice STU-20.
Shield of the extension cable must be connected to the housing of the connector.

Dimensions MHS



Dimensions CHS



Maximum speed

a) *Max. speed*

The maximum speed n_{max} *of a measuring system can be calculated considering the max. input frequency **f** of the scanning head and the number of pitches per revolution **N** of the measuring flange as follows:*

$$n_{max}\,[rpm] = f[Hz] \times 60 / N$$

b) *Output frequency*

The max. output signal frequency f_a *of the scanning head depends on the max. speed **n** used in the application, the number of grating pitches per revolution **N** and the dividing factor **D** of a scanning head with 1Vpp output respectively the interpolation factor **I** of a scanning head with TTL output.*
It's important to not exceed the max. input frequency of the subsequent electronics.

$$f_a\,[Hz] = (n[rpm] / 60) \times N \times D$$ *for scanning head with 1Vpp output*

$$f_a\,[Hz] = (n[rpm] / 60) \times N \times I$$ *for scanning head with TTL output*

Maximum rotary speeds for standard measuring flanges respectively measuring rings are shown below.

Grating pitch:		**500 µm**					
Type	***Max. input frequency f[khz]***	***Rotary speed n [rev/min]***					
		Standard measuring flange WMF-105x					
		0512	**0720**	**1024**	**1440**	**1800**	**2048**
WMK-1x51.1x WMK-2x51.1x	9	1050	750	520	370	300	260
WMK-1x51.30 WMK-2x51.30	60	7000	5000	3500	2500	2000	1750
WMK-1x51.S0 WMK-2x51.S0	100	11700	8300	5800	4100	3300	2900
WMK-1x52.0/1/C WMK-2x52.0/1/C	19	2200	1580	1100	780	630	550
WMK-1x52.4/E WMK-2x52.4/E	9	1050	750	520	370	300	260
WMK-1x52.5 WMK-2x52.5	2,4	280	200	140	100	80	70
WMK-1x52.6/7 WMK-2x52.6/7	39	4570	3250	2280	1600	1300	1140
WMK-1x52.A/B/Z WMK-2x52.A/B/Z	39	4570	3250	2280	1600	1300	1140

*The values shown above are also valid for the housing **WMKF**.*

Grating pitch:		**1000 µm**					
Type	***Max. input frequency* f[khz]**	***Rotary speed n [rev/min]***					
		Standard measuring flange WMF-10x or measuring ring WMR-10x					
		0256	**0360**	**0512**	**0720**	**0900**	**1024**
WMK-1x1.1x WMK-2x1.1x	9	2100	1500	1050	750	600	520
WMK-1x1.30 WMK-2x1.30	60	14000	10000	7000	5000	4000	3500
WMK-1x1.S0 WMK-2x1.S0	100	23400	16600	11700	8300	6600	5800
WMK-1x2.0/1/C WMK-2x2.0/1/C	19	4450	3150	2200	1580	1250	1100
WMK-1x2.4/E WMK-2x2.4/E	9	2100	1500	1050	750	600	520
WMK-1x2.5 WMK-2x2.5	2,4	560	400	280	200	160	140
WMK-1x2.6/7 WMK-2x2.6/7	39	9140	6500	4570	3250	2600	2280
WMK-1x2.A/B/Z WMK-2x2.A/B/Z	39	9140	6500	4570	3250	2600	2280

*The values shown above are also valid for the housing **WMKF**.*

Grating pitch:		**3000 µm**					
Type	***Max. input frequency* f[khz]**	***Rotary speed n [rev/min]***					
		Measuring ring WMR-30x					
		0085	**0120**	**0170**	**0240**	**0300**	**0341**
WMK-3x1.1x	9	6350	4500	3150	2250	1800	1550
WMK-3x1.30	60	42000	30000	21000	15000	12000	10500
WMK-3x1.S0	100	70500	50000	35000	25000	20000	17500
WMK-3x2.0/1/C	19	13400	9500	6700	4750	3800	3340
WMK-3x2.4/E	9	6350	4500	3150	2250	1800	1550
WMK-3x2.5	2,4	1690	1200	840	600	480	420
WMK-3x2.6/7	39	27500	19500	13700	9750	7800	6850
WMK-3x2.A/B/Z	39	27500	19500	13700	9750	7800	6850

*The values shown above are also valid for the housing **WMKF**.*

Description of the reference marks

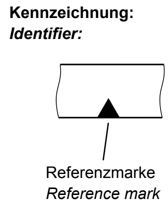
In order to determine the absolute angular position, a reference track is integrated onto the scale, parallel to the measuring track. This reference track consists of one or more reference marks (marked on the measuring ring accordingly), which are detected by the scanning head.

The reference marks can be arranged in the following ways:

1. *Single reference marks*

Single reference marks can be placed at any desired position on the measuring ring. As a standard, a single reference pulse per revolution occurs on the output, assigned to a mounting hole at the measuring flange.

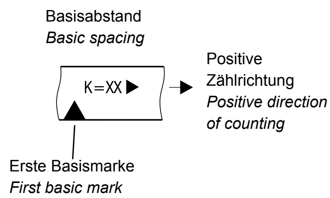
The position of the reference mark on the measuring ring is indicated with a black triangle.



2. Distance-coded reference marks

The coded distribution of the reference marks on the measuring ring allows the controller, if it has implemented this functionality, to determine the absolute position after passing two neighbouring marks.

The position of the first reference mark, the basic spacing and the positive direction of counting is indicated on the measuring ring as shown below.



Arrangement of distance coded reference marks

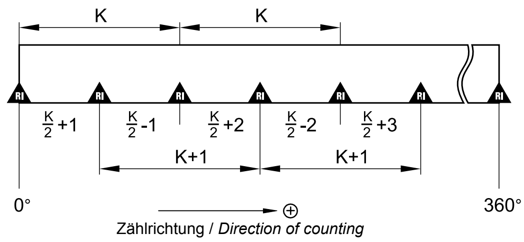
a) ***Arrangement for non divided output signals***

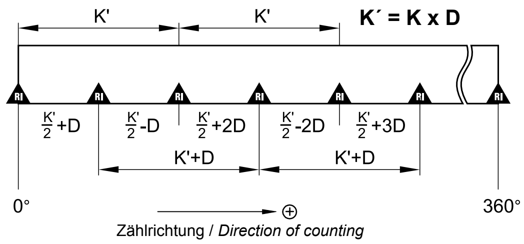
K Number of sine periods at the output of the measuring system

b) ***Arrangement for divided output signals***

K´ Number of divided sine periods at the output of the measuring system

D Dividing factor



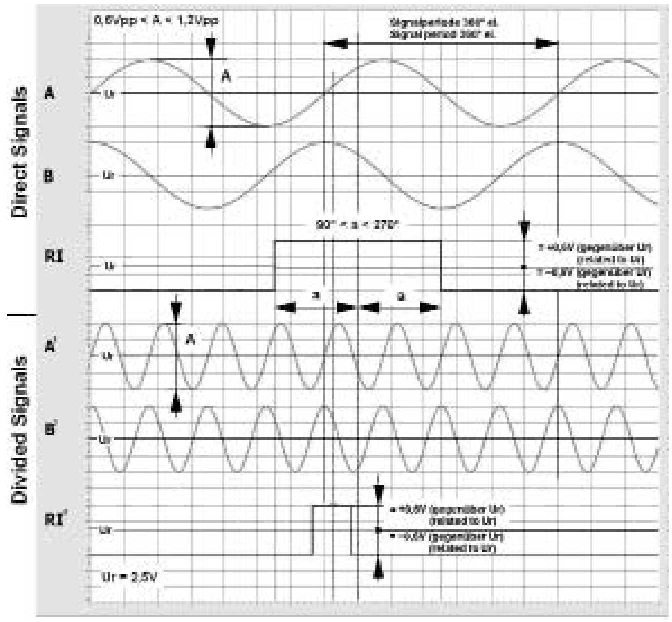


Example for distance coded standard measuring rings

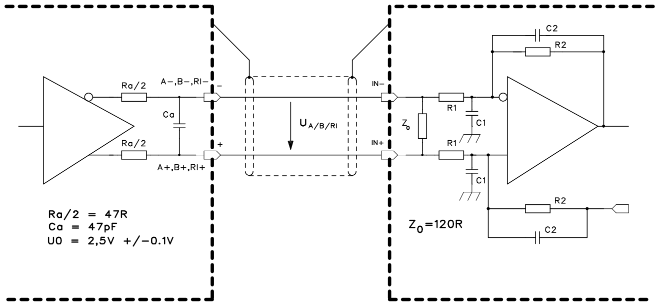
	WMR-100-0360-K40	WMR-100-0512-K64	WMR-0900-K60
Basic spacing K	40	64	60
Absolute position after max.	29°	28°	18°

Description of the ouput signals

Output signals sine, 1Vpp



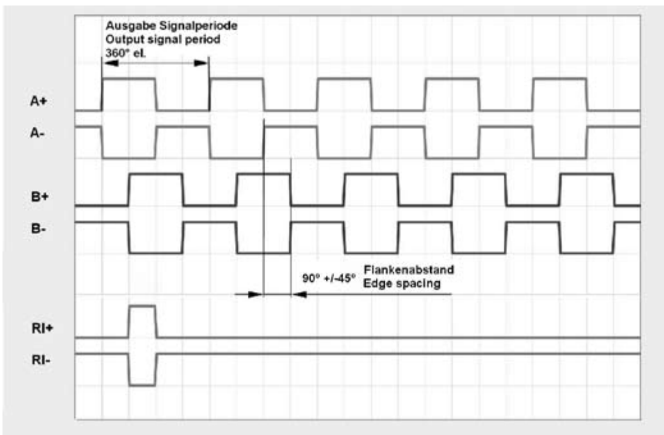
Recommended configuration of the subsequent electronics



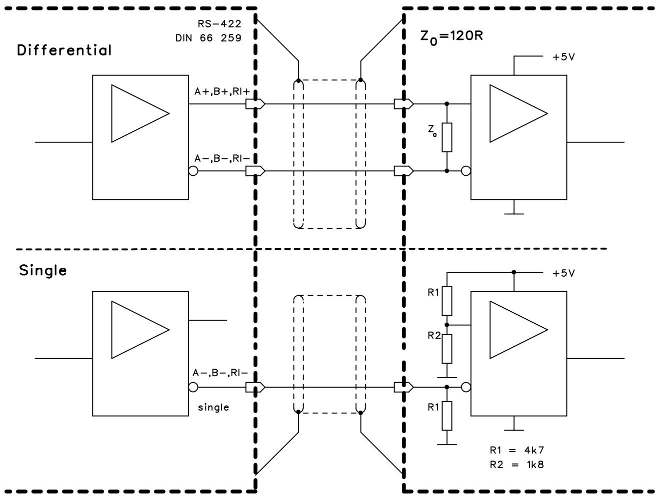
A, B, RI: direct signal output without dividing factor

A´, B´, RI´: divided signal output

Output signals TTL – RS422



Recommended configuration of the subsequent electronics

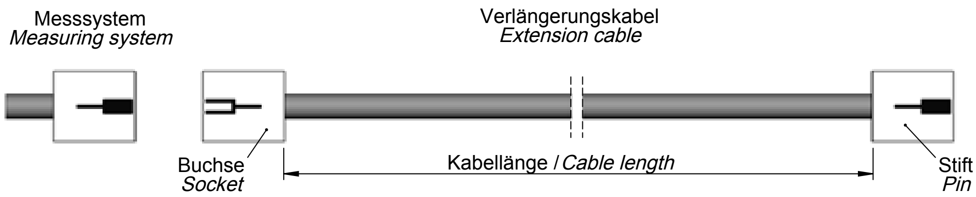


Cable

Technical data

	Cable for measuring system	***Extension cable***
Jacket:	*PUR, high flexible, suitable for energy chains*	
Diameter:	5,3mm	~ 8mm
Wires:	5 (2 x 0,05) + 1 (2 x 0,14) mm²	4 (2 x 0,14) + 2(2 x 0,5) mm²
Bending radius:		
Single bending:	5 x d = 25mm	5 x d = 40mm
Continuous bending:	10 x d = 50mm	10 x d = 80mm
Max. length:	9m	50m

Ordering code: extension cable



VK - 4 - ☐☐ - ☐☐ - ☐☐

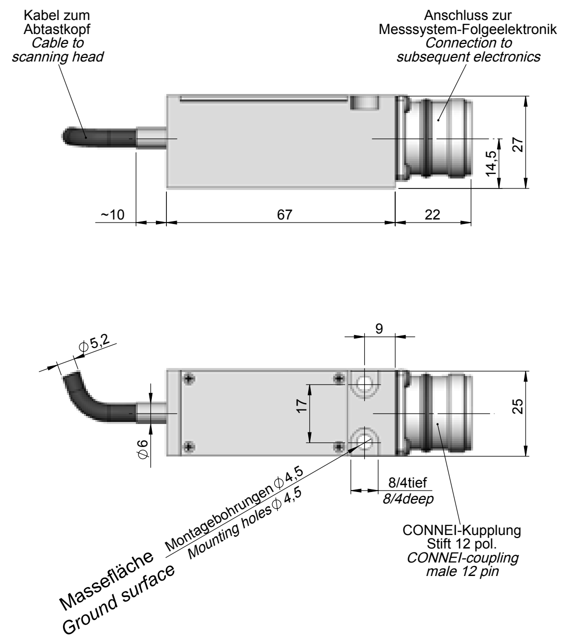
10 ..... *without connector*
11 ..... *12 pin DIN*
13 ..... *9 pin SUB-D*
14 ..... *12 pin CONNEI connector CW*
15 ..... *15 pin SUB-D*
16 ..... *12 pin CONNEI coupling CCW*
19 ..... *Special connector or special pin assignments*

Cable length in meter

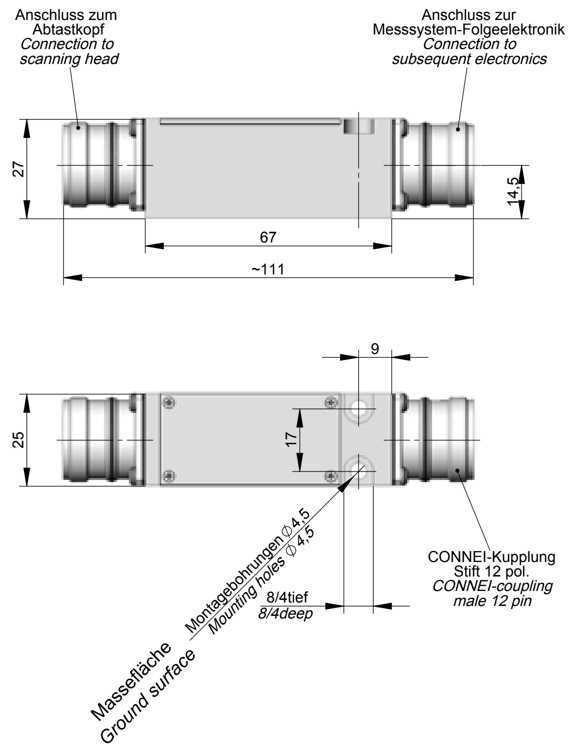
00 ..... *without connector*
01 ..... *12 pin DIN*
03 ..... *9 pin SUB-D*
04 ..... *12 pin CONNEI connector CW*
05 ..... *15 pin SUB-D*
06 ..... *12 pin CONNEI coupling CCW*
09 ..... *Special connector or special pin assignments*

Connector electronics

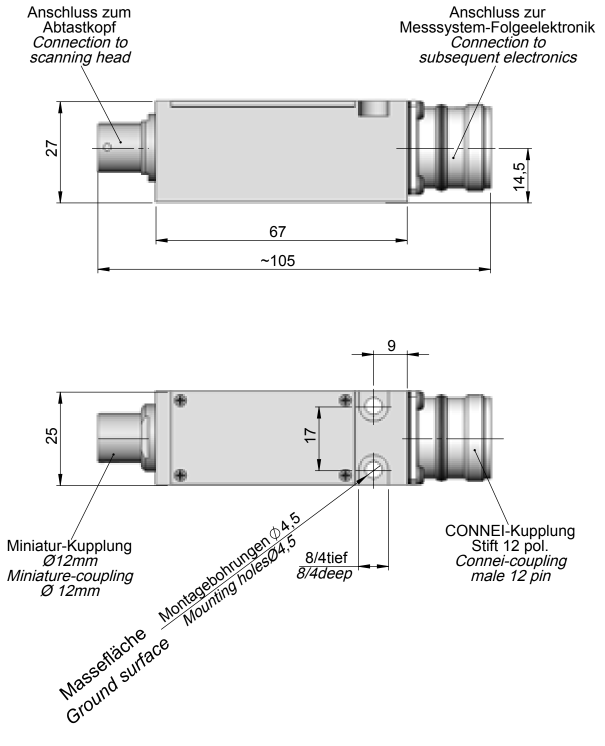
*Connector electronics version **6***



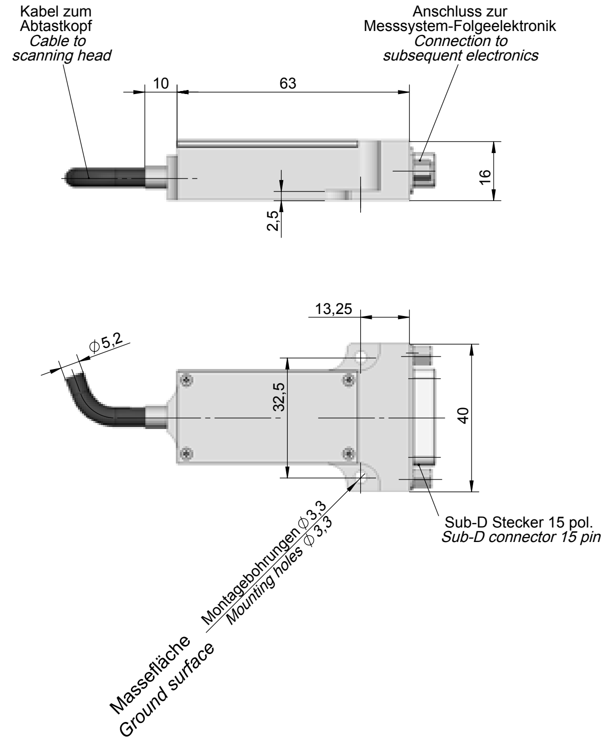
*Connector electronics version **6A***



*Connector electronics version **6B***



*Connector electronics version **5***



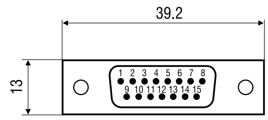
Plug and connection assignments

CONNEI connector adv. coupling 12-pin
Sine wave 1 Vpp or square wave output signals TTL

PIN	1	2	3	4	5	6	7	8	9	10	11	12
Signal	B-	5V-Sensor	RI+	RI-	A+	A-	LL	B+	LR	0V	0V-Sensor	+5V
Color	*white*	*red-white*	*pink*	*grey*	*green*	*yellow*	*violet*	*brown*	*black*	*blue*	*blue-white*	*red*

Shield on housing

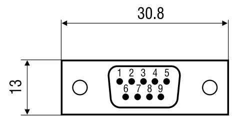
SUB-D connector 15-pin
Sine wave 1 Vpp or square wave output signals TTL



PIN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Signal	A+	0V	B+	+5V	–	LR	RI-	LL	A-	0V-Sensor	B-	5V-Sensor	–	RI+	–
Color	*green*	*blue*	*brown*	*red*	–	*black*	*gray*	*violet*	*yellow*	*blue-white*	*white*	*red-white*	–	*pink*	–

Shield on housing

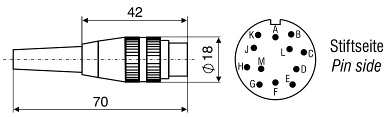
SUB-D connector 9-pin
Sine wave 1 Vpp or square wave output signals TTL



PIN	1	2	3	4	5	6	7	8	9
Signal	A-	0V	B-	–	RI-	A+	+5V	B+	RI+
Color	*yellow*	*blue*	*white*	–	*gray*	*green*	*red*	*brown*	*pink*

Shield on housing

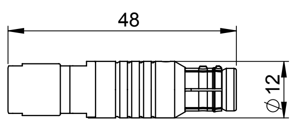
DIN connector 12-pin L120
Sine wave 1 Vpp or square wave output signals TTL



PIN	A	B	C	D	E	F	G	H	J	K	L	M
Signal	–	0V	A+	A-	B+	LL	RI+	RI-	–	+5V	B-	LR
Color	–	*blue*	*green*	*yellow*	*brown*	*violet*	*pink*	*grey*	–	*red*	*white*	*black*

Shield on housing

Miniature connector
Used on scanning heads in combination with MHS/CHS or connector electronics type 6B

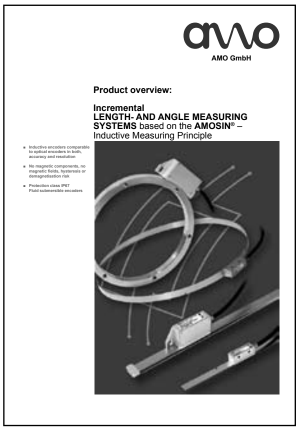


The sensor lines 0V sensor and 5V sensor are connected internally to the corresponding supply lines.

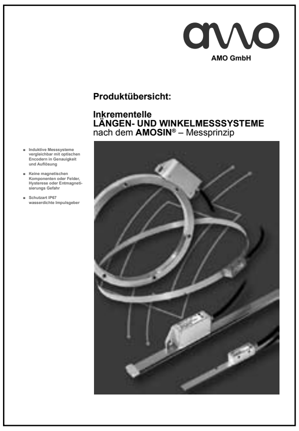
In case that the option „Limit Switch“ is not used, it is not allowed to connect the pins „LL“ and „LR“ to the following electronics (for example controller). These pins serve alone for test purposes only with the AMO testdevice STU-20.

Additional product brochures

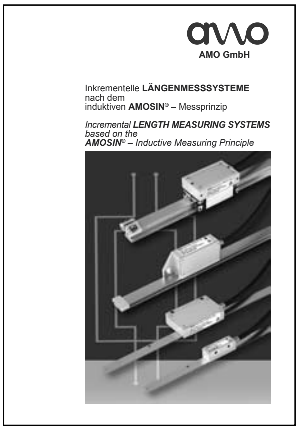
Product overview



Produktübersicht

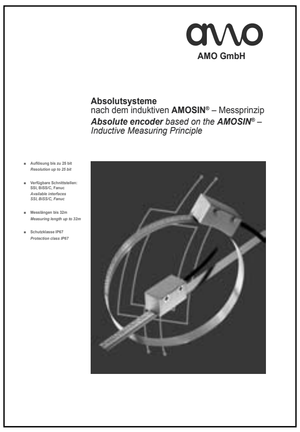


Längenmesssysteme
Length measuring systems



Spindelgeber
Spindle encoder

Absolute Geber
Absolute encoders



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