RSF Elektronik

www.rsf.at

MSR 15 | MSS 15
INCREMENTAL MODULAR ANGLE ENCODERS

- Online signal stabilization
- Display of the signal quality directly at the scanning head via 3-coloured LED function
- Permanent control of the signals over the whole measuring range
- High quality of the signals due to singlefield scanning

SCANNING PRINCIPLE

The MSx 15 incremental modular angle encoders work with the imaging, photoelectric measuring principle and a **singlefield reflective scanning method**.
The regulated light of an infrared LED is collimated by a condenser lens and passes through the grid of the reticle. After being reflected from the graduation carrier, the infrared LED generates a periodic intensity distribution on the structured sensor.
The sensor generates high quality sinusoidal signals which are highly insensitive to possible contaminations.
The regulation of the LED ensures a constant signal amplitude, guaranteeing stability in the case of temperature fluctuations and with long-run operation.

REQUIREMENTS ON AN INCREMENTAL MODULAR ANGLE ENCODER

- CONTAMINATION RESISTANCE
- IMMUNITY AGAINST AGING AND TEMPERATURE CHANGES
- HIGH PERMISSIBLE ROTATIONAL SPEED (MSR 15)
- EASY MOUNTING
- SMALL DIMENSIONS
- NO MECHANICAL BACKLASH; NO FRICTIONAL FORCE
- REFERENCE MARK REPEATABLE FROM BOTH TRAVERSING DIRECTIONS

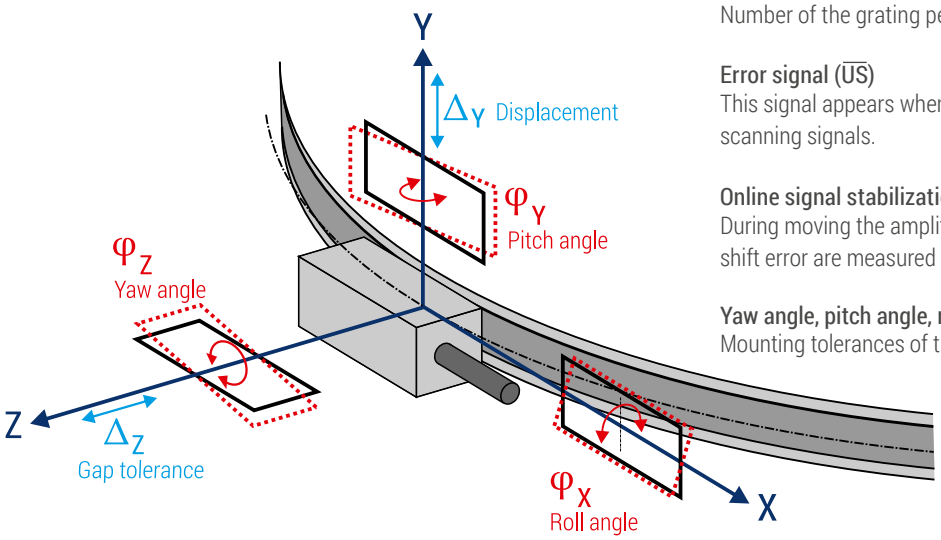
MSR 15 AND MSS 15 MEET ALL THESE REQUIREMENTS!

TERM EXPLANATIONS

Grating period
A grating is a continuous series of lines and spaces printed on the graduation carrier. The width of one line and one space is called the period of the grating. The lines and spaces are accurately placed on the scale.

Signal period
When scanning the grating, the encoder head produces sinusoidal signals with a period equal to the grating period.

Interpolation
The sinusoidal signal period can be electronically divided into equal parts. The interpolation circuitry generates a square-wave edge for each division.



Measuring step
The smallest digital counting step produced by an encoder.

Reference pulse (reference mark)
There is an additional track of marks printed next to the grating to allow a user to find an absolute position along the length of the scale. A one increment wide signal is generated when the encoder head passes the reference mark on the scale.
This is called a "true" reference mark since it is repeatable in both directions. Subsequent electronics use this pulse to assign a preset value to the absolute reference mark position.

Line rates
Number of the grating periods per rotation.

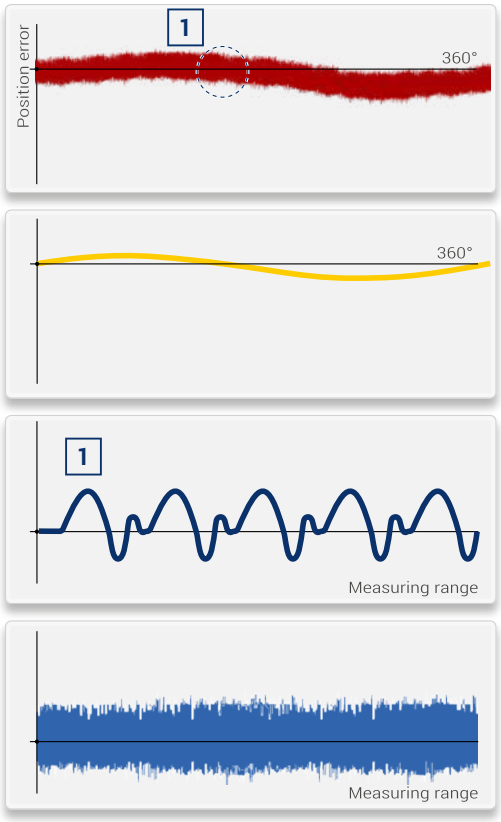
Error signal ($\overline{US}$)
This signal appears when a malfunctioning encoder generates faulty scanning signals.

Online signal stabilization
During moving the amplitude, offset-error, amplitude differences and phase shift error are measured and stabilized cyclically.

Yaw angle, pitch angle, roll angle, displacement, gap tolerance
Mounting tolerances of the encoder head relative to the scale.

Δ.....Delta
φ.....Phi

ACCURACY DEFINITION



Overall error

=

Baseline error

+

Interpolation error

+

Position noise

The accuracy of an encoder is mainly determined by the baseline error of the scale unit, the interpolation error of the optoelectronic scanning and the position noise.

The baseline error is the error of the scale unit identified in a measurement room under optimum conditions, along a determined measuring length, without any interpolation error and position noise.

The indicated accuracy grade represents the maximum possible baseline error based on the entire circumference (MSR) resp. on the available measuring range (MSS).

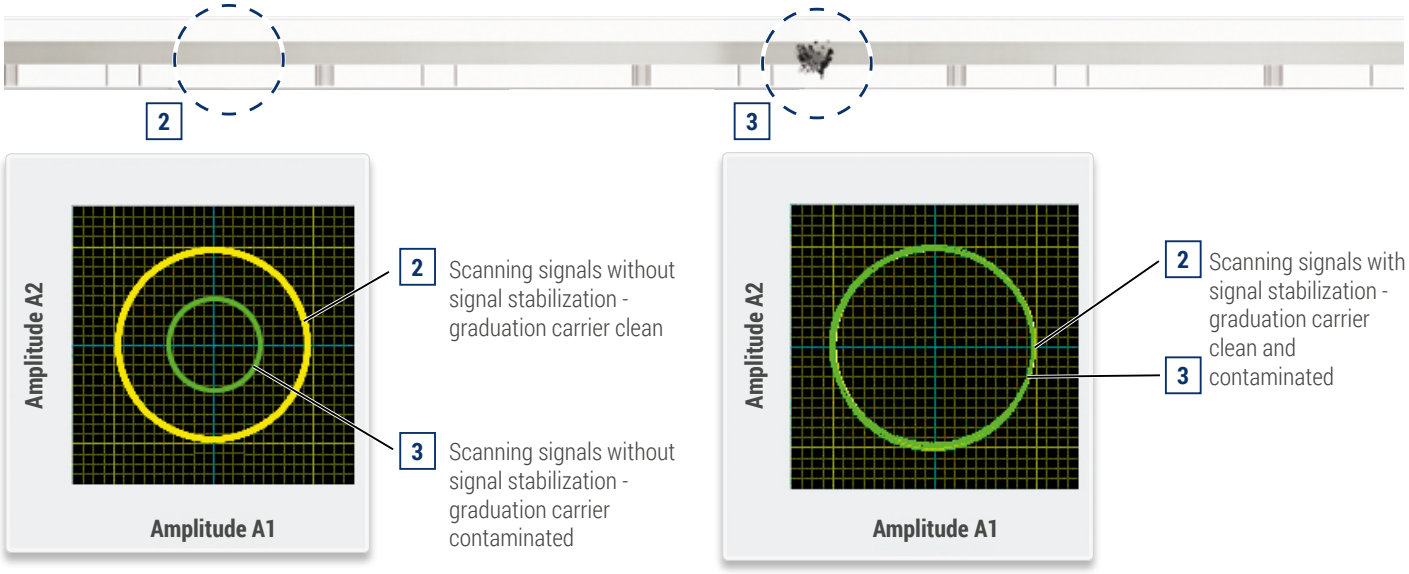
With modular angle encoders, an eccentric mounting of the graduation carrier additionally results in a measurement error according to the following formula:

$$\Delta\varphi = \pm \frac{412 \times e}{D}$$

Δφ = Measuring error due to eccentricity ["]
E = Resulting eccentricity of the flange in [µm]
D = Scanning diameter [mm]

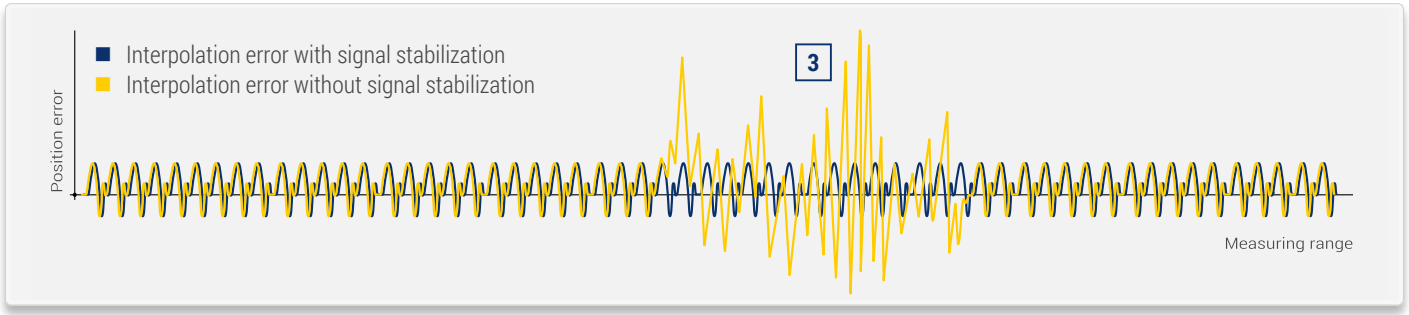
Effect of contamination on the quality and amplitude of scanning signal

Graduation carrier contaminated by fluids, dust, particles, fingerprints etc.

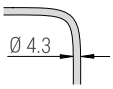


Effect of contamination on the interpolation error

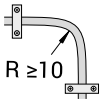
Graduation carrier contaminated by fluids, dust, particles, fingerprints etc.



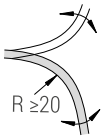
SHIELDING, PIN ASSIGNMENT



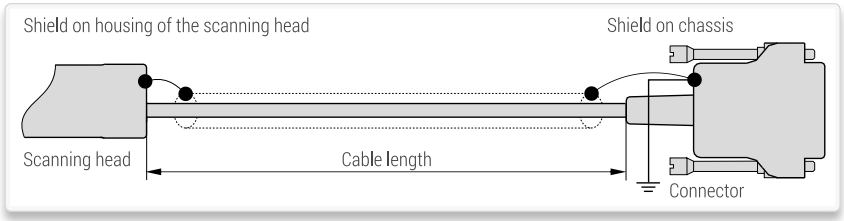
Shielded PUR-cable;
Drag chain qualified.



Bending radius fixed mounting



Bending radius continuous flexing

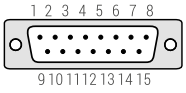


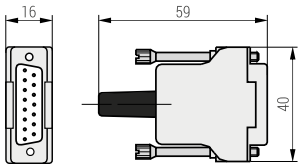
15-pin D-sub

Pin	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sinusoidal voltage signals 1 Vpp	Test**	0 V Sensor	Occupied	RI–	A2–	A1–	V+ Sensor	V+	0 V	nc	nc	RI+	A2+	A1+	nc
Square-wave signals via line driver	Test*	0 V Sensor	$\overline{US}$	$\overline{RI}$	$\overline{T2}$	$\overline{T1}$	V+ Sensor	V+	0 V	nc	nc	RI	T2	T1	nc

- * Test = **analog signal switch-over for set-up.**
  By applying +5 V to the test pin, the test signals (sinusoidal micro-current signals 11 µApp) are switched to the output connector.
- ** Test = **analog signal switch-over for set-up.**
  By applying +5 V to the test pin, the NOT corrected test signals (1 Vpp) are switched to the output connector.
- Sensor: the sensor pins are bridged in the chassis with the particular power supply.
- The shield is connected with the chassis.
- Pins or wires marked “occupied” or “nc” must not be used by the customer.

Pin assignment
(view on pins)





Mass: 28 g

OUTPUT SIGNALS

SINUSOIDAL VOLTAGE SIGNALS 1 Vpp

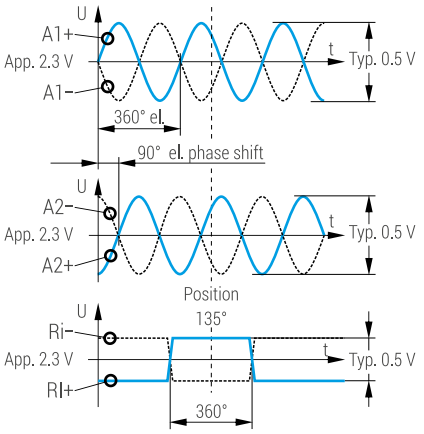
(drawing shows "positive counting direction")

Power supply: +5 V ±10 %, max. 160 mA (unloaded)
Track signals (differential voltage A1+ to A1− resp. A2+ to A2 −):
Signal amplitude 0.6 Vpp to 1.2 Vpp; typical 1 Vpp
(with terminating impendance Zo = 120 Ω between A1+ to A1− resp. A2+ to A2−).

Reference mark (differential voltage RI+ to RI−):
Square-wave pulse with an amplitude of 0.8 up to 1.2 V; typical 1 V
(with terminating impedance Zo = 120 Ω between RI+ to RI−)

Advantage:
- High traversing speed with long cable lengths possible.

Voltage signals (1 Vpp)



SQUARE-WAVE SIGNALS

(drawing shows "positive counting direction")
With the integrated interpolation electronics (for times -1, -5, -10, -20, -25, -50, -100 or -200) the photoelement output signals are converted into two square-wave signals that have a phase shift of 90°.
The output signals are „differential" via line driver (RS 422). One measuring step reflects the measuring distance between two edges of the square-wave signals.

The controls/DRO´s must be able to detect each edge of the square-wave signals. The minimum edge separation a_{min} is listed in the technical data and refers to a measurement at the output of the interpolator (inside the scanning head). Propagation-time differences in the line driver, the cable and the line receiver reduce the edge separation.

Propagation-time differences:

Line driver:	max. 10 ns
Cable:	0.2 ns/m
Line receiver:	max. 10 ns (referred to the recommended line receiver circuit)

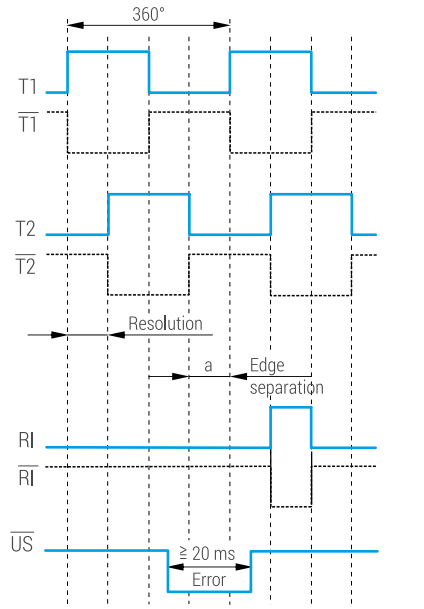
To prevent counting errors, the controls/DRO's must be able to process the resulting edge separation.

Example:
a_{min} = 100 ns, 10 m cable
100 ns - 10 ns - 10 x 0.2 ns - 10 ns = 78 ns

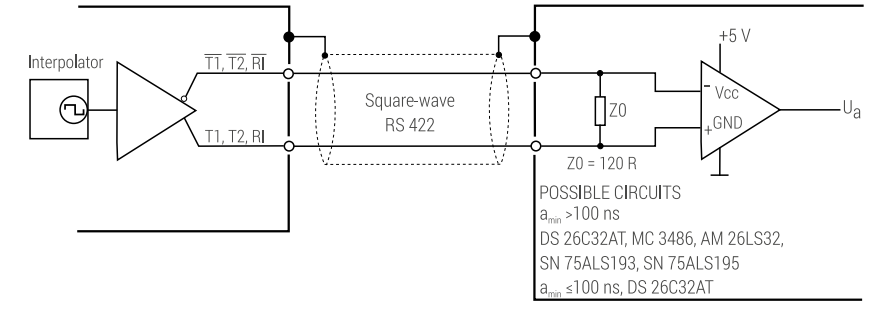
Power supply: +5 V ±10 %, max. 160 mA (unloaded)

Advantages:
- Noise immune signals.
- No further subdividing electronics necessary.

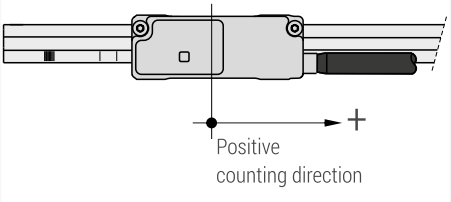
Square-wave signals "differential"



Recommended line receiver circuit



Counting direction



MSR 15 TECHNICAL DATA

SCANNING HEAD

Model	AK MSR 15 1 Vpp	AK MSR 15 TTLx1u	AK MSR 15 TTLx5	AK MSR 15 TTLx10	AK MSR 15 TTLx20	AK MSR 15 TTLx25	AK MSR 15 TTLx50	AK MSR 15 TTLx100	AK MSR 15 TTLx200
System resolution [°]	Dep. on external interpolation	360° / (Lines × 4)	360° / (Lines × 20)	360° / (Lines × 40)	360° / (Lines × 80)	360° / (Lines × 100)	360° / (Lines × 200)	360° / (Lines × 400)	360° / (Lines × 800)
Signal form	~ 1 Vpp	⊓⊓	⊓⊓	⊓⊓	⊓⊓	⊓⊓	⊓⊓	⊓⊓	⊓⊓
Integrated interpolation	--	Times 1	Times 5	Times 10	Times 20	Times 25	Times 50	Times 100	Times 200
Max. output frequency	400 kHz	--	--	--	--	--	--	--	--
Edge separation a_{min} [ns]	--	300	300	300	200	200	100	100	50
Scanning diameter [mm]	**Max. rotational speed [rpm]**	**Max. rotational speed [rpm]**	**Max. rotational speed [rpm]**	**Max. rotational speed [rpm]**	**Max. rotational speed [rpm]**	**Max. rotational speed [rpm]**	**Max. rotational speed [rpm]**	**Max. rotational speed [rpm]**	**Max. rotational speed [rpm]**
50.00	6000	6000	2400	1200	900	700	700	360	360
59.93	5000	5000	2000	1000	750	600	600	300	300
75.06	4000	4000	1600	800	600	450	450	240	240
99.96	3050	3050	1200	600	450	350	350	180	180
103.88	2900	2900	1150	570	430	340	340	170	170
114.17	2650	2650	1050	500	400	320	320	160	160
150.38	2000	2000	800	400	300	240	240	120	120
200.35	1500	1500	600	300	220	180	180	90	90
228.77	1300	1300	500	260	200	160	160	80	80
249.85	1200	1200	480	240	180	140	140	70	70
299.81	1000	1000	400	200	150	120	120	60	60
350.23	870	870	340	170	130	100	100	50	50

Permissible vibration: 150 m/s² (55 to 2000 Hz)

Permissible shock: 750 m/s² (8 ms)

Permissible temperature:
- –20 °C to +70 °C (storage)
- 0 °C to +70 °C (operation)

Mass: Scanning head AK: 17 g
Cable: 25 g/m
D-sub connector: 28 g

Protection EN 60529: Scanning head AK: IP 40
(complete encoder in mounted condition: IP00)

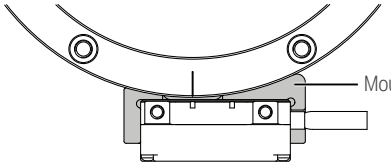
RoHS-conformity:
MSR 15 encoders comply with the guideline of the RoHS-directive 2011/65/EU and also with the delegated directive 2015/863/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

GRADUATION CARRIER

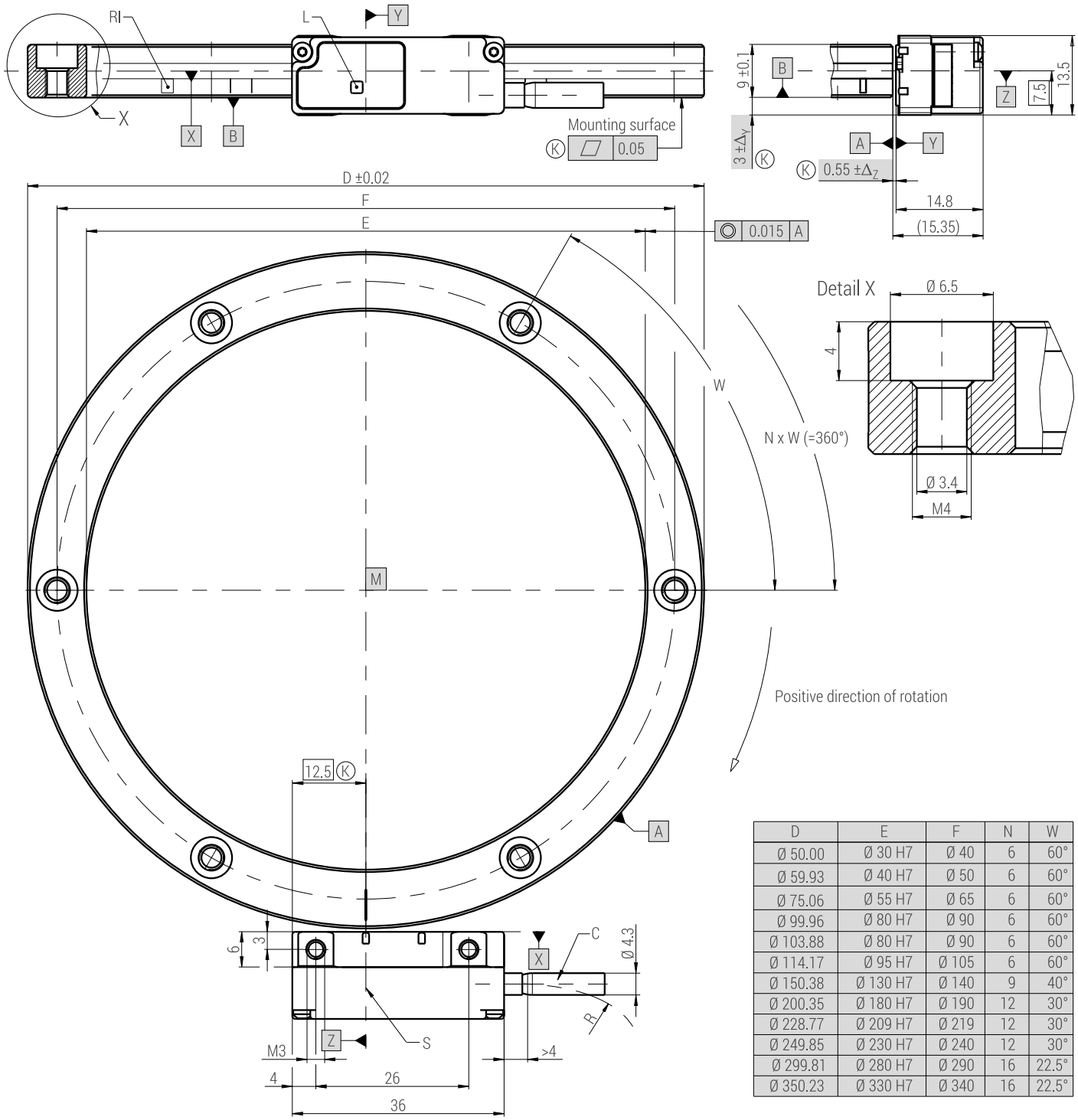
Model	TTR MSR 15 S: Steel drum with incremental track for mounting with three-point centering TTR MSR 15 A: Aluminum drum with incremental track for mounting with three-point centering											
Baseline error	±10"											
Coefficient of expansion	Steel: α ≈ 16 x 10^{-6} K^{-1} Aluminum: α ≈ 23.4 x 10^{-6} K^{-1}											
Reference mark	▪ One reference mark at 0°-position (S) ▪ Distance-coded on request											
Scanning diameter [mm]	50.00	59.93	75.06	99.96	103.88	114.17	150.38	200.35	228.77	249.85	299.81	350.23
Inside diameter [mm]	30	40	55	80	80	95	130	180	209	230	280	330
Lines	3960	4740	5928	7884	8192	9000	11 844	15 768	18 000	19 656	23 580	27 540
Interpolation error (typical)	±1.23"	±1.03"	±0.82"	±0.62"	± 0.59"	±0.54"	±0.41"	±0.31"	±0.27"	±0.25"	±0.21"	±0.18"
Moment of inertia [10^{-3} kgm^2] S	≈ 0.03	≈ 0.07	≈ 0.15	≈ 0.39	≈ 0.50	≈ 0.58	≈ 1.49	≈ 3.70	≈ 5.24	≈ 7.30	≈ 12.80	≈ 21.25
A	≈ 0.01	≈ 0.02	≈ 0.05	≈ 0.13	≈ 0.17	≈ 0.20	≈ 0.51	≈ 1.27	≈ 1.79	≈ 2.49	≈ 4.37	≈ 7.26
Mass [kg] S	≈ 0.08	≈ 0.10	≈ 0.13	≈ 0.19	≈ 0.23	≈ 0.21	≈ 0.30	≈ 0.41	≈ 0.44	≈ 0.51	≈ 0.61	≈ 0.73
A	≈ 0.03	≈ 0.03	≈ 0.05	≈ 0.06	≈ 0.08	≈ 0.07	≈ 0.10	≈ 0.14	≈ 0.15	≈ 0.17	≈ 0.21	≈ 0.25

OPTIONAL ACCESSORIES

Mounting aid:



MSR 15 DIMENSIONS, MOUNTING TOLERANCES



D	E	F	N	W
Ø 50.00	Ø 30 H7	Ø 40	6	60°
Ø 59.93	Ø 40 H7	Ø 50	6	60°
Ø 75.06	Ø 55 H7	Ø 65	6	60°
Ø 99.96	Ø 80 H7	Ø 90	6	60°
Ø 103.88	Ø 80 H7	Ø 90	6	60°
Ø 114.17	Ø 95 H7	Ø 105	6	60°
Ø 150.38	Ø 130 H7	Ø 140	9	40°
Ø 200.35	Ø 180 H7	Ø 190	12	30°
Ø 228.77	Ø 209 H7	Ø 219	12	30°
Ø 249.85	Ø 230 H7	Ø 240	12	30°
Ø 299.81	Ø 280 H7	Ø 290	16	22.5°
Ø 350.23	Ø 330 H7	Ø 340	16	22.5°

mm

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

M = Rotary axis
RI = Reference mark
S = Optical centerline and mark for 0° position
(K) = Required mating dimensions
RI = Reference mark(s)

C = Cable
L = LED function display
R = Bending radius: stat. R >10 mm, dyn. R >20 mm

Permissible position deviation of the scanning head relative to the flange
Reference plane A | B
Δ_Y = Displacement, ±0.5
Δ_Z = Gap tolerance, ±0.15
φ_Z = ±1.00 mrad or ±0.06° (yaw angle)
φ_Y = ±1.50 mrad or ±0.09° (pitch angle)
φ_X = ±4.00 mrad or ±0.23° (roll angle)

MSS 15 TECHNICAL DATA

SCANNING HEAD

Model	Output signals	Measuring step [°]	Integrated interpolation	Max. circumferential speed at scanning diameter D [m/s]	Max. output frequency [kHz]
AK MSS 15 1Vpp	∿	Depending on external interpolation	--	10.00	250
					Edge separation amin
AK MSS 15 TTLx1u	⎍	360° / (LPR × 4)	Times 1	10.00	500 ns
AK MSS 15 TTLx5	⎍	360° / (LPR × 20)	Times 5	6.40	300 ns
AK MSS 15 TTLx10	⎍	360° / (LPR × 40)	Times 10	3.20	300 ns
AK MSS 15 TTLx20	⎍	360° / (LPR × 80)	Times 20	2.40	200 ns
AK MSS 15 TTLx25	⎍	360° / (LPR × 100)	Times 25	1.92	200 ns
AK MSS 15 TTLx50	⎍	360° / (LPR × 200)	Times 50	1.92	100 ns
AK MSS 15 TTLx100	⎍	360° / (LPR × 400)	Times 100	0.96	100 ns
AK MSS 15 TTLx200	⎍	360° / (LPR × 800)	Times 200	0.96	50 ns

Interpolation error (typical):
±(60)" / D

Permissible vibration:
150 m/s² (40 to 2000 Hz)

Permissible shock:
750 m/s² (8 ms)

Permissible temperature:
- –20 °C to +70 °C (storage)
- 0 °C to +70 °C (operation)

Mass: Scanning head AK: 17 g
Cable: 25 g/m
D-sub connector: 28 g

Protection EN 60529: Scanning head AK: IP 40
(complete encoder in mounted condition: IP00)

RoHS-conformity:
MSS 15 encoders comply with the guideline of the RoHS-directive 2011/65/EU and also with the delegated directive 2015/863/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

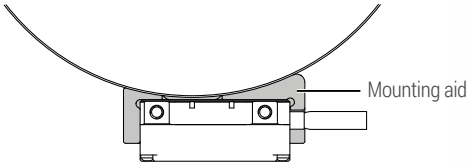
GRADUATION CARRIER

Model	**MB MSS 15**: Steel tape scale with adhesive tape (SK)
Coefficient of expansion	$\alpha \approx 10 \times 10^{-6}\ K^{-1}$
Possible scanning diameter	> 75 mm to ≤ 1000 mm (at larger diameters MS 15 applicable) ≤ 75 mm on request
Accuracy of the grating (based on neutral axis)	±15 µm/m
Theoretical lines per revolution (360°)	LPR = 78.5398 × D + 33.1942 (round down result to integer)*
Reference mark	▪ Standard: One reference mark at any position within the measuring range ▪ On request: Additional or distance-coded reference marks
Mass	20 g/m (SK)

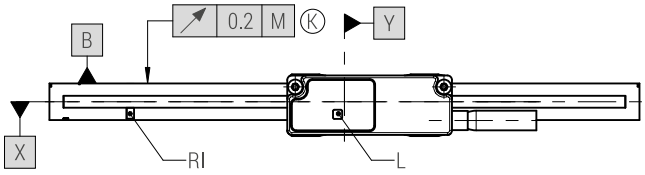
* Deviations of the scanning diameter influence the accuracy.

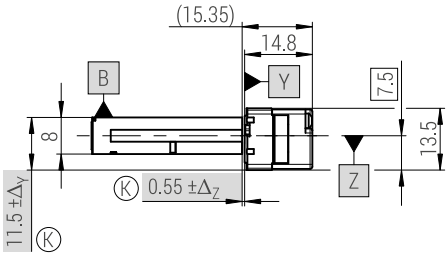
OPTIONAL ACCESSORIES

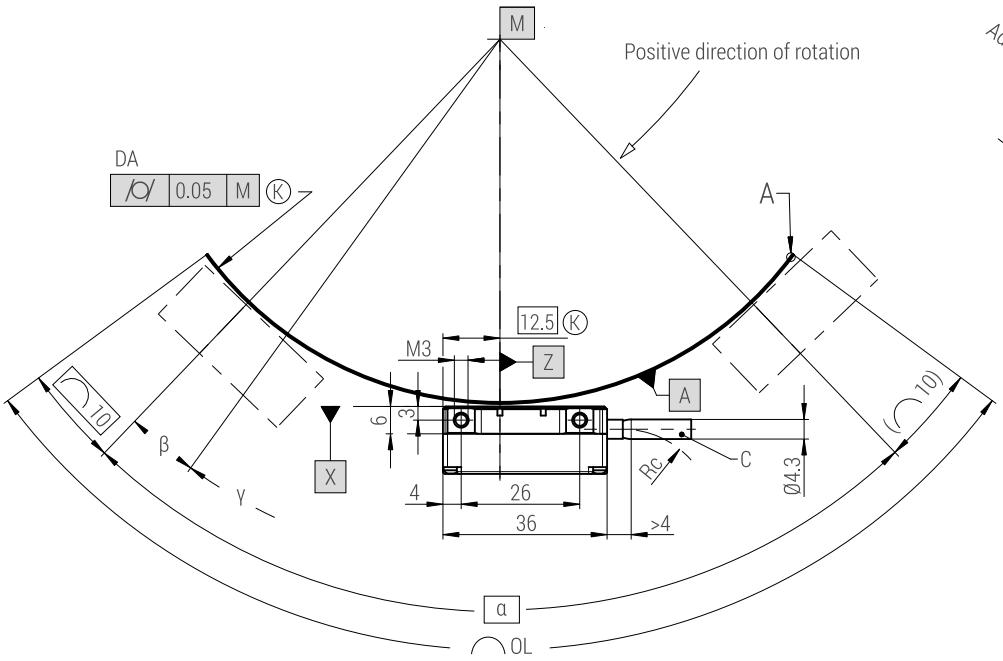
Mounting aid:

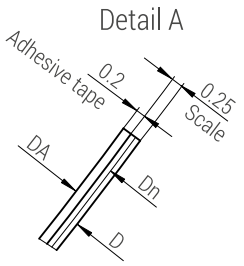


MSS 15 DIMENSIONS, MOUNTING TOLERANCES









M = Rotary axis
OL = Length of tape
α = Measuring range [°]
D = Scanning diameter
DA = Mating diameter
Dn = Neutral axis
(K) = Required mating dimensions
RI = Reference mark(s)
β = Any position of the reference mark from the beginning of measuring range [°]
γ = Additional reference mark [°]
C = Cable
L = LED function display
Rc = Bending radius: stat. Rc ≥10 mm, dyn. Rc ≥20 mm

Permissible position deviation of the scanning head to the scale tape
Reference plane A | B
Δ_Y = Displacement, ±0.5
Δ_Z = Gap tolerance, ±0.15
φ_Z = ±1.00 mrad or ±0.06° (yaw angle)
φ_Y = ±1.50 mrad or ±0.09° (pitch angle)
φ_X = ±4.00 mrad or ±0.23° (roll angle)

Calculations:
D = DA + 0.9

Overall length
OL = 20 + (D −0.25) × π × α / 360°
(round up result to integer)

mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0,2 mm

ACCESSORY: EXTERNAL TESTING DEVICE PWT 101

Even though the MSx 15 angle encoders allow large mechanical mounting tolerances, it is recommended to control the function of counting signals and reference impulse.

The signals can be controlled directly via the integrated LED function control or connected to an oscilloscope and checked for conformity with signal specifications. The last mentioned method requires some effort.

The PWT 101 is a testing device for checking the function of RSF Elektronik encoders. At encoders with pin assignment according to RSF Elektronik standard (see page 04) the pinout adapter PA2 must be used additionally. At alternative pin assignments other pinout adapters could be necessary.

Thanks to its compact dimensions and robust design, the PWT 101 is ideal for mobile use. A 4.3-inch touchscreen provides for display and operation.

AVAILABLE FUNCTIONS

The performance range of the PWT 101 can be expanded by firmware update. Appropriate firmware files that can be imported to the PWT 101 through a memory card (not included in delivery) will be made available at www.heidenhain.de.

STATUS DISPLAY VIA LED FUNCTION

STATUS DISPLAY AT THE SCANNING HEAD	INFORMATION	NOTE
Without external test box		
Function-control main track		
▪ LED displays GREEN	Counting signals very good	After successful mounting
▪ LED blinks GREEN	Counting signals good	At mounting not allowed → allowed during operation
▪ LED blinks RED	Counting signals out of tolerance → error	Check mounting, clean scale
Function-control reference impulse RI		**Only by passing the reference mark**
▪ LED blinks RED	RI out of tolerance	Check mounting, clean scale
▪ LED blinks BLUE	RI within tolerance	
With external test box		
Function-control main track		
▪ LED displays GREEN	Scanning head supplied with power	Evaluation of counting signals via LED not active
Function-control reference impulse RI		**Only by passing the reference mark**
▪ LED blinks RED	RI out of tolerance	Check mounting, clean scale
▪ LED blinks BLUE	RI within tolerance	

FURTHER PRODUCTS

MCR 15 | MCS 15

Absolute modular angle encoders with small dimensions

- Divers serial interfaces
- Status display directly at the scanning head via LED function
- Easy mounting as a result of large mounting tolerances
- High insensitivity against contaminations
- Possible drum diameter: 50.00 mm to 350.23 mm (outside)
- Steel tape scale from Ø 75 mm

MSR 20

Modular angle encoders with steel tape scale

- Segment version
- Grating period: 40 µm
- Accuracy of the grating (stretched): ±15 µm/m
- High permissible circumferential speed
- Integrated subdividing: up to times 100
- Possible diameter: Steel tape scale from Ø 50 mm

MSR 45

Modular angle encoders with steel tape scale - various versions

- Full-circle or segment version
- Grating period: 200 µm
- Accuracy of the grating (stretched): ±30 µm/m
- High permissible rotational speed resp. circumferential speed
- Integrated subdividing: up to times 100
- Possible diameter: Full-circle from Ø 146.99 mm Segment from Ø 150 mm

MC 15

Absolute linear encoders with status display

- Interface: EnDat 2.2 (others on request)
- Status display directly at the scanning head via LED function
- Easy mounting as a result of large mounting tolerances
- High insensitivity against contaminations
- Max. measuring length Steel tape scale: 10 000 mm

MS 15

Open linear encoders with integrated mounting control

- Easy mounting; no test box or oscilloscope needed
- Quality of the scanning signals is directly visible at the scanning head via a tricolored LED function
- Two independent switch tracks for individual special functions
- Position of reference mark selectable by customer
- High insensitivity against contamination
- High permissible traversing speed
- Integrated subdividing: up to times 200
- Max. measuring length: steel tape scale: 20 000 mm

MS 25

Exposed scanning linear encoders with integrated mounting control

- Easy mounting; no test box or oscilloscope needed
- Quality of the scanning signals is directly visible at the scanning head via a tricolored LED function
- Two independent switch tracks for individual special functions
- Position of reference mark selectable by customer
- High insensitivity against contamination
- High permissible traversing speed
- Integrated subdividing: up to times 200
- Max. measuring length Glass scale: 3140 mm Steel tape scale: 20 000 mm

MS 45

Open linear encoders with integrated mounting control

- Easy mounting; no test box or oscilloscope needed
- Quality of the scanning signals is directly visible at the scanning head via a tricolored LED function
- Flat dimensions
- Easy mounting due to large mounting tolerances
- High insensitivity against contamination
- High permissible traversing speed
- Integrated subdividing: up to times 100
- Max. measuring length: steel tape scale: 30 000 mm

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