MiniCODER
▶ GEL 2444T
Rotational speed and position sensor with square-wave signals and interpolation

LENORD +BAUER

... automates motion.

MiniCODER with axial cable outlet

General

▶ Output signals are two 90° phase offset square-wave signals and their inverse signals TTL / RS 422. Optionally with reference pulse (track N).

▶ The measuring system comprises a MiniCODER and a precision target wheel for attachment to shafts

▶ Precision target wheels with a shaft diameter from 8 mm to over 500 mm are to be ordered separately

▶ The MiniCODER contactlessly scans the precision target wheel using magnetoresistive sensors and acquires the direction of rotation, rotational speed and position

▶ Interpolation factors can be selected to increase the number of pulses per revolution

Features

▶ Output signal level TTL / RS 422
▶ Frequency range from 0…200 kHz [1]
▶ Temperature range -40 °C to +120 °C
▶ Protection class IP 68

Advantages

▶ Maintenance and wear-free
▶ Low temperature drift and high signal quality
▶ Highest immunity to interference due to fully screened metal housing
▶ High design flexibility due to custom manufacture of precision target wheels

Field of application

▶ Machine tool engineering
  - Position and rotational speed acquisition in HSC spindles (High Speed Cutting)
  - Electronic synchronisation of screw spindles in vacuum pumps
  - Position and rotational speed measurement in lathes, grinding and milling machines
▶ Rotational speed and position measurement in test stands and motors (hybrid drives, torque motors)
▶ Angle measurement in radar installations

[1] At a cable capacitance of 5 nF

Subject to technical modifications and typographical errors.

Description

Construction

The MiniCODERs are intended to be used for the contactless measurement of rotary movements predominantly in machines, gears, motors or high-speed spindles. They are manufactured using the latest micro system technology and are fully encapsulated, as such they are particularly resistant to shocks and vibration.

Measuring system

The measuring system comprises a MiniCODER and a precision target wheel. The system does not need dedicated bearings for this task, as the precision target wheel is mounted directly on the shaft.

The measuring system operates contactlessly and is maintenance and wear-free. It acquires the direction of rotation, rotational speed and position of the rotating shaft. The precision target wheel is made of ferromagnetic material and is to be ordered separately.

The MiniCODER has a magnetic field that is changed by the rotating precision target wheel. The sensor acquires the change in the magnetic field and the integrated electronics convert this information into square-wave signals.

External electronics can read the output signals and determine the direction of rotation, rotational speed and position of the shaft.

A defined air gap between the precision target wheel and MiniCODER is required for the contactless measurement. To make assembly easier, a corresponding distance gauge is included with the MiniCODER.

Signal pattern

The output signals are two square-wave signals offset by 90° for the detection of direction (tracks 1 and 2) and their inverse signals, signal pattern T.
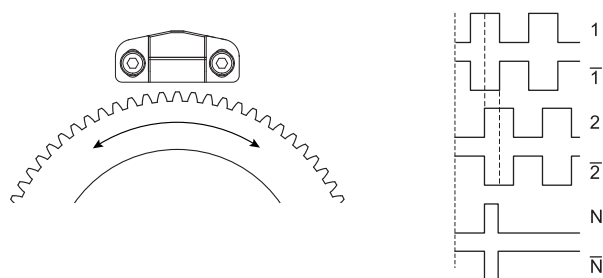
N*   Reference pulse (track N) optional

Reference mark

The MiniCODER can determine the position of a shaft by acquiring a reference mark.
The position is output as a digital differential pulse (track N).
The MiniCODER evaluates the following reference marks: Lug (**N**), slot (**M**), tooth (**Z**).
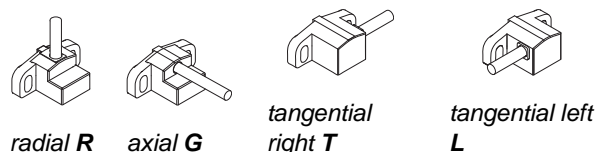
Module

The MiniCODER must be ordered to suit the module of the target wheel (see → page 13).
Possible modules: 0.3 / 0.5 .

Interpolation factor

The interpolation is undertaken directly in the MiniCODER. On the usage of a target wheel with 250 teeth and an interpolation factor of 20, the MiniCODER provides 5000 square-wave signals.
The MiniCODER is available with the following interpolation factors: 1; 2; 4; 8; 10; 12; 16; 20; 32

Cable outlet MiniCODER

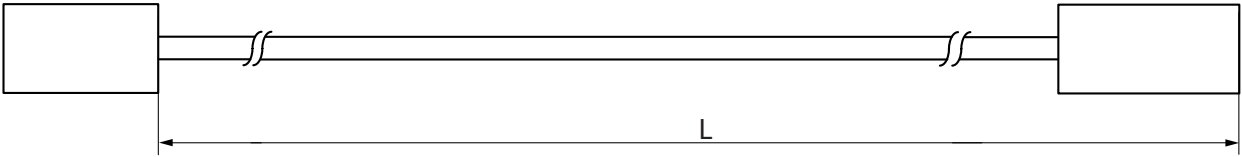The MiniCODER is available with the following cable outlets:

radial **R**   axial **G**   tangential right **T**   tangential left **L**

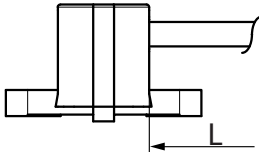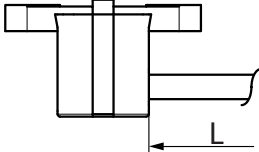|	GEL 2444T␣␣␣3	GEL 2444T␣␣␣5
Target wheel		
Module	0.3	0.5
Width of the measuring track	≥ 4.0 mm	
Material	Ferromagnetic steel	
Reference mark	Lug (**N**), slot (**M**), tooth (**Z**)	
Geometric data		
Centre distance between sensor elements (1/2 and N) c_2	6 mm	
Distance mounting surface to sensor element (1/2) c_1	9.5 mm	
Air gap permitted	0.15 mm ± 0.02 mm	0.20 mm ± 0.03 mm
Electrical data		
Supply voltage U_B	5 V DC ± 5%, polarity reversal protected, overvoltage protected	
Output level	TTL / RS422	
Output signal	Two square-wave signals offset by 90° and their inverse signals, short-circuit-proof; option: reference pulse	
Output frequency	0…200 kHz [1]	
Power consumption without load	≤ 0.3 W	
Electromagnetic compatibility Electromagnetic emissions Electromagnetic immunity	DIN EN 61000-6-4:2011-09; DIN EN 61000-6-3:2011-09 DIN EN 61000-6-2:2006-03; DIN EN 61000-6-1:2007-10	
Dielectric strength	500 V, in accordance with DIN EN 60439–1	
Mechanical data		
Weight	30 g	
Housing material	Die cast zinc	
Assured operating temperature range	-30 °C to +85 °C	
Operating and storage temperature range	-40 °C to +120 °C	
Protection class	IP 68	
Vibration resistance	200 m/s^2, in accordance with DIN EN 60068–2–6	
Shock resistance	2000 m/s^2, in accordance with DIN EN 60068–2-27	
MTTF FIT	5,000,000 h at 55 °C 204 10^{-9} h^{-1} at 55 °C	
Electrical connection		
Number of cores x cable cross-section	9 x 0.15 mm^2	
Max. permitted cable length	100 m [2]	
Cable diameter	5 mm	
Min. bending radius	25 mm	

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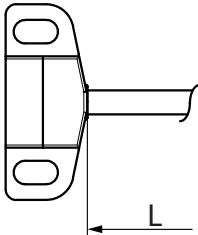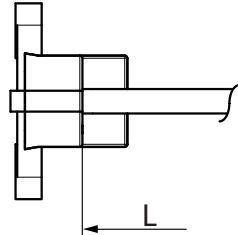
[1] At a cable capacitance of 5 nF
[2] Pay attention to voltage drop on the supply cable

Connection
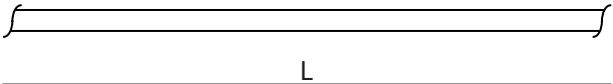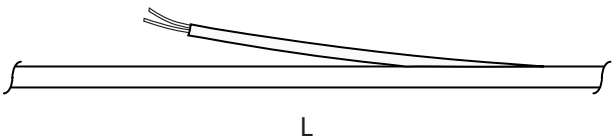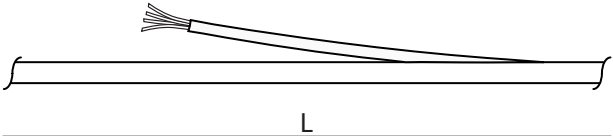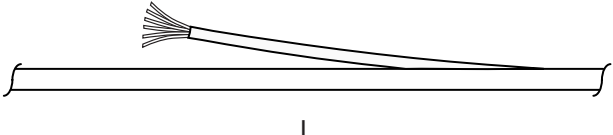
Cable outlet MiniCODER	Cable version	Connection type

L = cable length
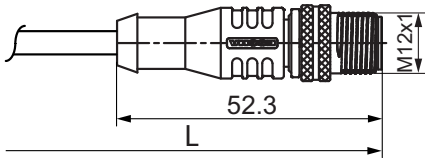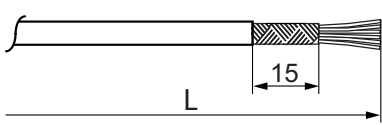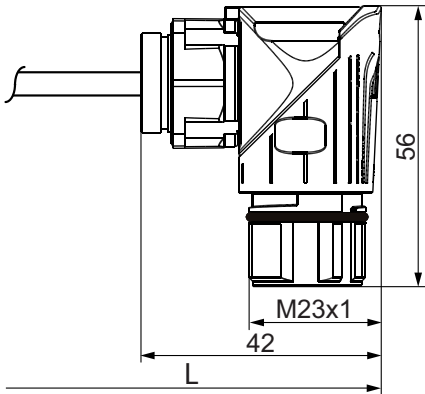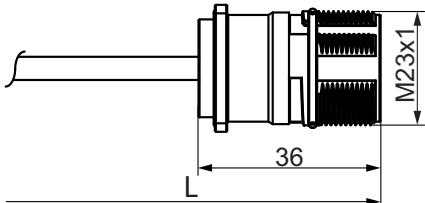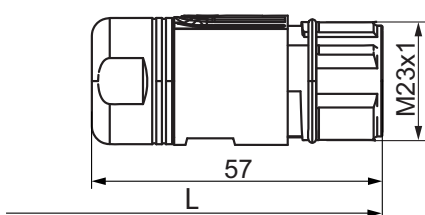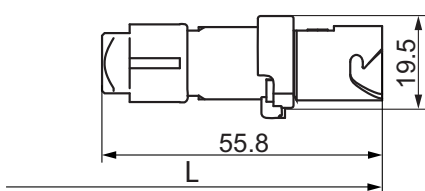
Cable outlets MiniCODER

Cable outlet MiniCODER			
R (radial)	**G** (axial)	**L** (tangential left)	**T** (tangential right)

Cable versions for temperature sensor

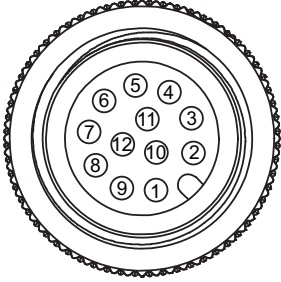| Cable version	
— (without temperature sensor cable)	
M (2-core temperature sensor cable, 2 m long) Cable data — TEFLON cable 2 × 0.14 mm^2 — Outside diameter: 2.8 mm (± 0.1) — Min. bending radius: 20 mm	
M (4-core temperature sensor cable, 2 m long) Cable data — ETFE cable 4 × 0.14 mm^2 — Outside diameter: 3.5 mm (± 0.2) — Min. bending radius: 7 mm	
M (6-core temperature sensor cable, 2 m long) Cable data — ETFE cable 6 × 0.14 mm^2 — Outside diameter: 3.5 mm (± 0.2) — Min. bending radius: 7 mm	

Connection types

Connection type		Notes
J (12-pin plug)	M12x1 52.3 L	Not available with temperature sensor cable! Cable lengths available: **030 / 050 / 600**
K (flying lead)	15 L	Cable lengths available: **030 / 050 / 150 / 250 / 600**
M (17-pin panel-mounting socket, angled)	56 M23x1 42 L	EMC screening, strain relief and sealing, IP 67 (connected)
N (17-pin panel-mounting socket)	M23x1 36 L	EMC screening, strain relief and sealing, IP 67 (connected)
U (12-pin panel-mounting socket)	M23x1 57 L	Not available with temperature sensor cable!
Z (10-pin plug)	19.5 55.8 L	Not available with temperature sensor cable! Cable lengths available: **120 / 200 / 250**

Connection

Terminal assignments
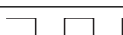
Connection type J

12-pin plug	Pin	Signal/ function		Reference mark -	Reference mark N, M, Z
	1	U_{1+}	Signal track 1	⎍⎍⎍	⎍⎍⎍
	2	U_{1-}	Inverse signal track 1	⎁⎁⎁	⎁⎁⎁
	3	U_{N+}	Signal reference track N		⎍
	4	0 V	GND		
	5	U_B	+ 5 V supply voltage		
	6	U_{2+}	Signal track 2	⎍⎍⎍	⎍⎍⎍
	7	U_{2-}	Inverse signal track 2	⎁⎁⎁	⎁⎁⎁
	8	U_{N-}	Inverse signal reference track N		⎁
	9	Not used			
	10	U_{Sense}	5 V Sense		
	11	Not used			
	12	Not used			
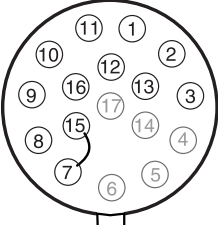
ℹ️ Sense regulation must be undertaken externally!

Connection type K

Flying lead	Core colour	Signal/ function		Reference mark -	Reference mark N, M, Z
	white	U_{1+}	Signal track 1	⎍⎍⎍	⎍⎍⎍
	brown	U_{1-}	Inverse signal track 1	⎁⎁⎁	⎁⎁⎁
	grey	U_{N+}	Signal reference track N		⎍
	blue	0 V	GND		
	red	U_B	+ 5 V supply voltage		
	pink	U_{2+}	Signal track 2	⎍⎍⎍	⎍⎍⎍
	black	U_{2-}	Inverse signal track 2	⎁⎁⎁	⎁⎁⎁
	yellow	U_{N-}	Inverse signal reference track N		⎁
	green	U_{Sense}	5 V Sense		

Connection type M and N
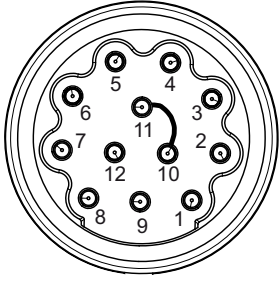
17-pin panel-mounting socket	Pin	Signal/ function		Reference mark -	Reference mark N, M, Z
	1	U_{1+}	Signal track 1		
	2	U_{1-}	Inverse signal track 1		
	3	U_{N+}	Signal reference track N		
	4 – 6	Not used			
	7	0 V	GND		
	8	Not used			
	9	Not used			
	10	U_B	+ 5 V supply voltage		
	11	U_{2+}	Signal track 2		
	12	U_{2-}	Inverse signal track 2		
	13	U_{N-}	Inverse signal reference track N		
	14	Not used			
	15	0 V	GND	Jumper pin 7	
	16	U_{Sense}	5 V Sense		
	17	Not used			

Connection type M and N: Additional assignments on connection of a temperature sensor cable
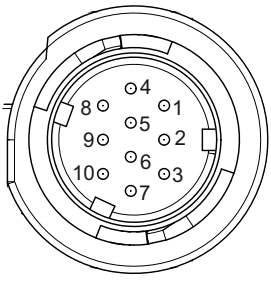
17-pin panel-mounting socket	Core colour	Pin	Signal / function	
2-core temperature sensor cable	brown	8	Temp +	
	blue	9	Temp –	
4-core temperature sensor cable	brown	8	Temp1 +	
	white	9	Temp1 –	
	green	4	Temp2 +	
	pink	14	Temp2 –	
6-core temperature sensor cable	brown	8	Temp1 +	
	white	9	Temp1 –	
	grey	6	Temp2 +	
	yellow	5	Temp2 –	
	green	4	Temp3 +	
	pink	14	Temp3 –	

Connection

Connection type U

12-pin panel-mounting socket	Pin	Signal/ function		Reference mark -	Reference mark N, M, Z
	1	U_{2-}	Inverse signal track 2	⎍⎍	⎍⎍
	2	U_{Sense}	5 V Sense		
	3	U_{N+}	Signal reference track N		⎍
	4	U_{N-}	Inverse signal reference track N		�
	5	U_{1+}	Signal track 1	⎍⎍	⎍⎍
	6	U_{1-}	Inverse signal track 1	⎍⎍	⎍⎍
	7	Not used			
	8	U_{2+}	Signal track 2	⎍⎍	⎍⎍
	9	Not used			
	10	0 V	GND		
	11	0 V	GND	Jumper pin 10	
	12	U_B	+ 5 V supply voltage		

Connection type Z

10-pin plug	Pin	Signal/ function		Reference mark -	Reference mark N, M, Z
	1	U_{2+}	Signal track 2	⎍⎍	⎍⎍
	2	U_{2-}	Inverse signal track 2	⎍⎍	⎍⎍
	3	Screen			
	4	U_B	+ 5 V supply voltage		
	5	U_{1+}	Signal track 1	⎍⎍	⎍⎍
	6	U_{1-}	Inverse signal track 1	⎍⎍	⎍⎍
	7	0 V	GND		
	8	U_{N+}	Signal reference track N		⎍
	9	U_{N-}	Inverse signal reference track N		⎍
	10	Not used			

ℹ Sense regulation not possible!

Dimensional drawing GEL 2444T with radial cable outlet
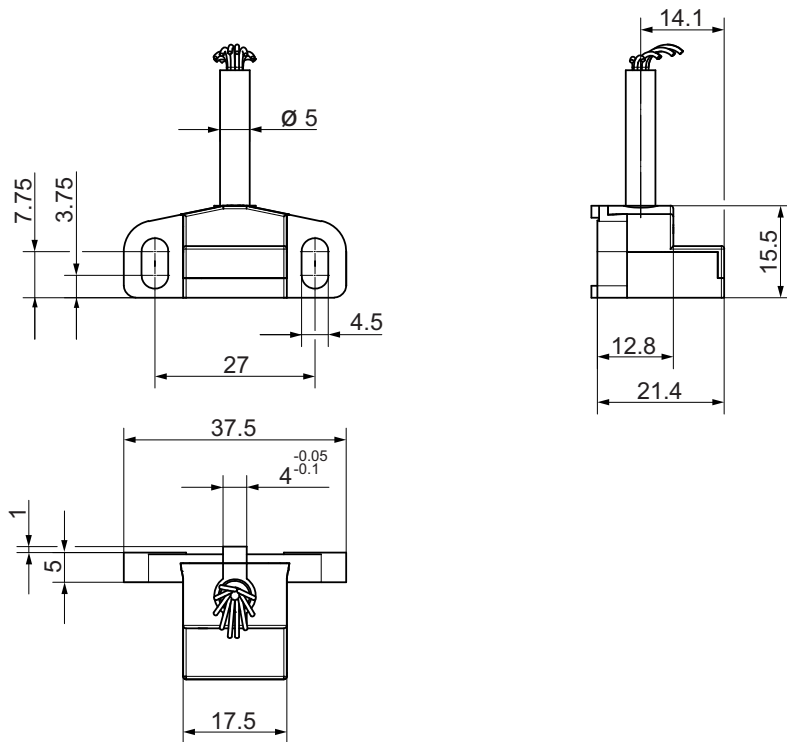
All dimensions stated in mm (≈ approximate dimension)
General tolerance DIN ISO 2768 medium

Dimensional drawing GEL 2444T with axial cable outlet
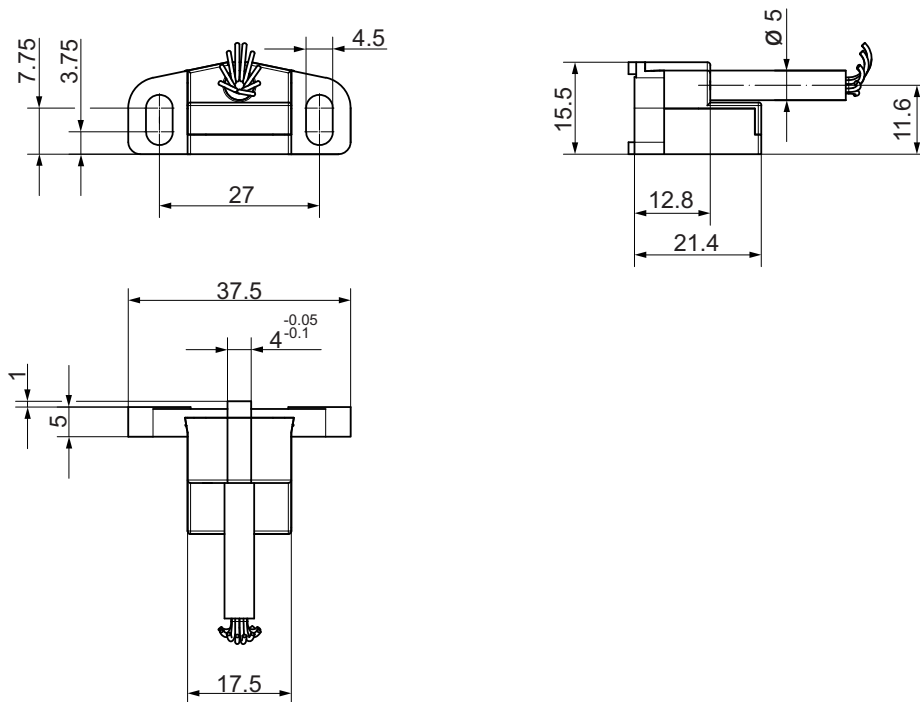
All dimensions stated in mm (≈ approximate dimension)
General tolerance DIN ISO 2768 medium

Dimensional drawing

Dimensional drawing GEL 2444T with tangential cable outlet right
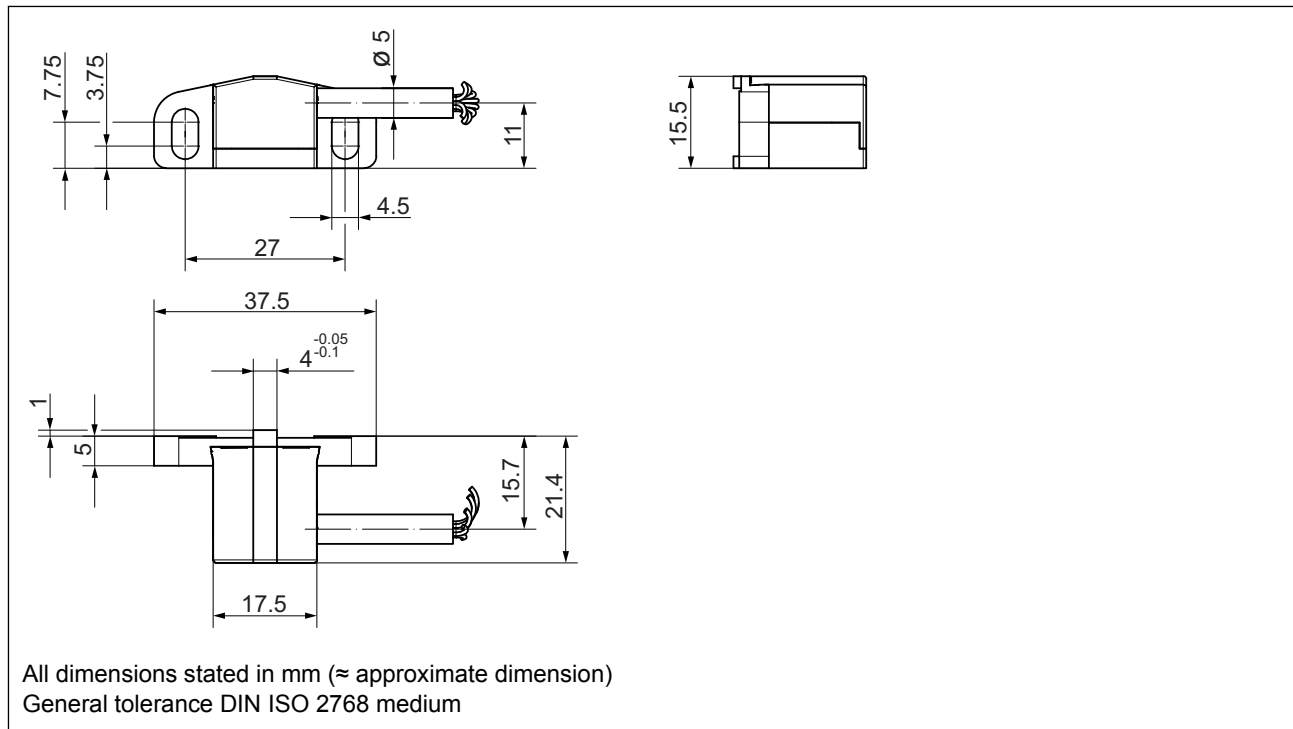
All dimensions stated in mm (≈ approximate dimension)
General tolerance DIN ISO 2768 medium

Dimensional drawing GEL 2444T with tangential cable outlet left

All dimensions stated in mm (≈ approximate dimension)
General tolerance DIN ISO 2768 medium
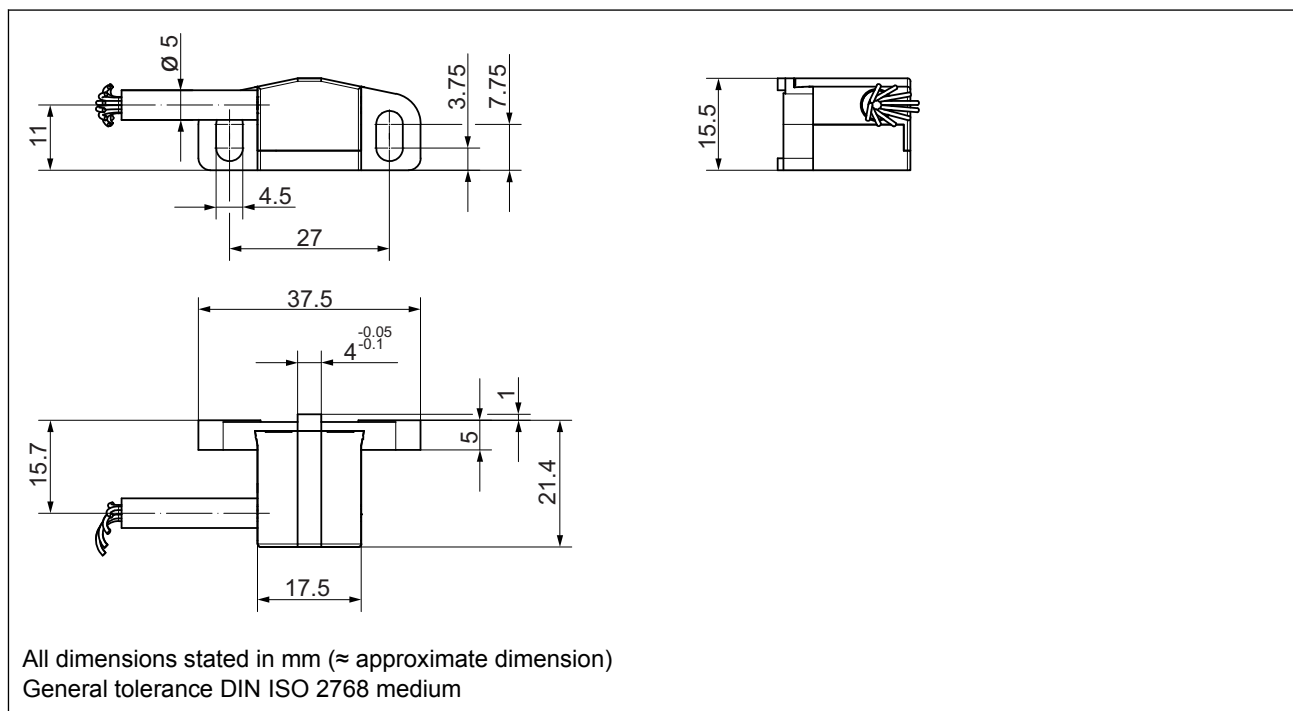
Hole pattern and installation dimensions
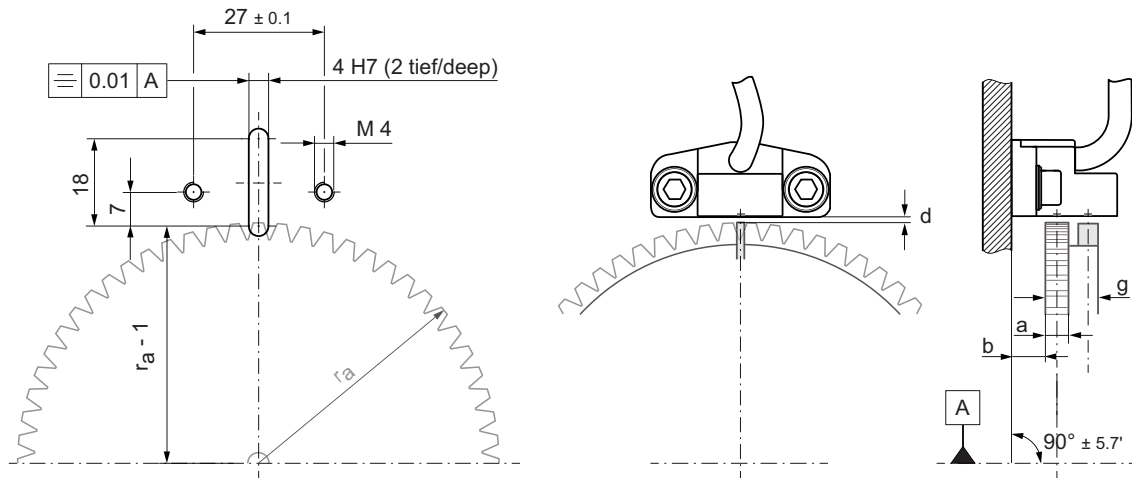
All dimensions stated in mm

a   Width of the measuring track: ≥ 4.0 mm

b   Distance mounting surface to tooth wheel: dependent on the geometry of the target wheel (e.g. width of the measuring track)

d   Air gap: dependent on the module (see air gap table)

g   Width of the target wheel

r_a = $d_a/2$ (with d_a = Outside diameter of the tooth wheel)

Installation dimensions for standard target wheels

Dimension	ZA-	ZAN	ZAZ
g	4	10	10
$a_{1/2}$	4	4	6
a_N	-	4	4
b	7.5 ± 0.5	7.5 ± 0.5	7.5 ± 0.5

All dimensions stated in mm
Position of the sensor elements: c_1 = 9.5 mm; c_2 = 6 mm

All dimensions stated in mm (≈ approximate dimension)
General tolerance DIN ISO 2768 medium
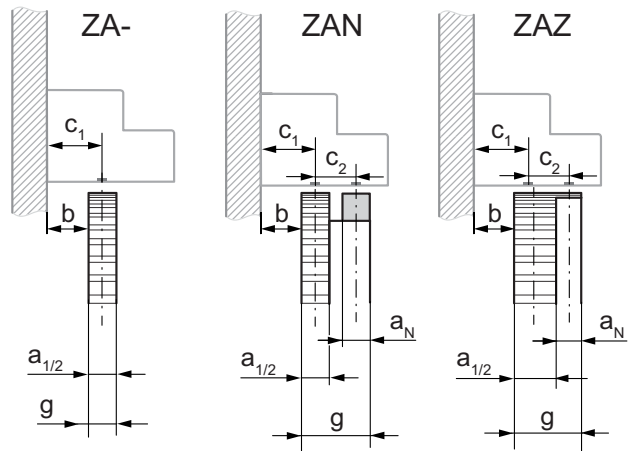
Air gap table

Type	Module	Air gap *d*, preset measure ± distance tolerance
3	0.3	0.15 mm ± 0.02 mm
5	0.5	0.20 mm ± 0.03 mm

To make assembly easier, a corresponding distance gauge is included with the MiniCODER.

Type code

Type code GEL 2444T

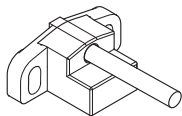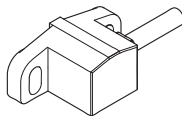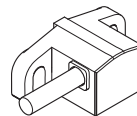|								
	Signal pattern							
T	Square-wave signals TTL / RS422							
	Reference mark							
	–	None						
	N	Lug						
	M	Slot						
	Z	Tooth on tooth						
		Interpolation factor						
		1	1					
		2	2					
		4	4					
		8	8					
		A	10					
		B	12					
		C	16					
		D	20					
		G	32					
			Cable outlet MiniCODER					
			R	Radial				
			G	Axial				
			T	Tangential, cable outlet right				
			L	Tangential, cable outlet left				
				Module [1]				
				3	0.3			
				5	0.5			
					Connection type			
					J	12-pin plug (only cable length 030 / 050 / 600 available)		
					K	Flying lead (only cable length 030 / 050 / 150 / 250 / 600 available)		
					M	17-pin panel-mounting socket, angled		
					N	17-pin panel-mounting socket		
					U	12-pin panel-mounting socket		
					Z	10-pin plug (only cable lengths 120 / 200 / 250 available)		
						Cable length L		
						030	0.3 m	
						050	0.5 m	
						120	1.2 m	
						150	1.5 m	
						200	2.0 m	
						250	2.5 m	
						600	6.0 m	
							Cable version for temperature sensor (2 m)	
							–	Without cable for temperature sensor
							M	With 2-core temperature sensor cable (not for connection type J, U, Z)
							N	With 4-core temperature sensor cable (not for connection type J, U, Z)
							P	With 6-core temperature sensor cable (not for connection type J, U, Z)
2444	_	_	_	_	_	_	_ _ _	_
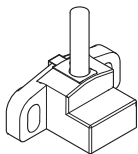
*Radial cable outlet **R**   Axial cable outlet **G**   Tangential cable outlet on right **T**   Tangential cable outlet on left **L***

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[1] (further modules upon request)

Explanations about the target wheel

Target wheels

For the measurement of rotary movements, MiniCODERs form a unit together with target wheels. The target wheel size and the related diameter depend directly on the module and the number of teeth.

Standard target wheels

Standard target wheels are available on short delivery times from stock. For specifications and designs see "Technical information ZAx / ZFx".

Custom target wheels

Custom target wheels are manufactured individually to customer requirements. Please send us a design drawing of your target wheel (if possible as a dxf file) to **info@lenord.de**.

Reference marks

The MiniCODER can detect reference marks in the form of a slot, lug or tooth. The pulse detected can be used for referencing the position. This feature is necessary, for example, to automatically change a tool in a milling spindle or grinding spindle.

The selection of the reference mark is defined by the size and rotational speed of the target wheel used, as both parameters have an effect on the forces acting on the reference mark. In case of new designs we recommend the usage of a target wheel with reference mark variant "**Z**".

Reference mark N – lug

A metal lug integrated into the target wheel and that is positioned exactly between two teeth is detected. The lug must be made of ferromagnetic material and must not protrude beyond the outside diameter of the target wheel. Due to the forces acting on the reference lug, this variant is only allowed to be used in a very limited speed range.

Reference mark M – slot

The MiniCODER detects a reference slot between two teeth. This target wheel is made up of two pieces for technical reasons.
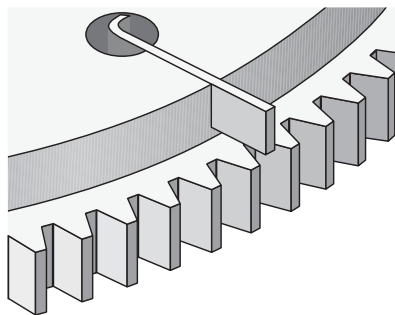
Reference mark Z – tooth on tooth

These target wheels are made from one piece.

Module

The module is a tooth parameter for tooth wheels and describes the relationship between the number of teeth and the diameter of the tooth wheel. Given the same number of teeth, the smaller the module, the smaller the outside diameter.
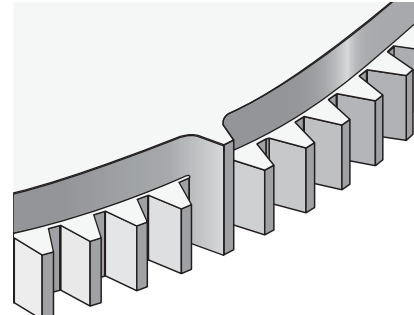
ℹ️ The MiniCODER must be ordered to suit the design of the reference mark and to suit the module of the target wheel.
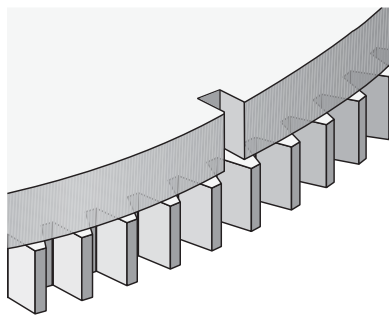
N = Reference mark – lug   *M = Reference mark – slot*   *Z = Reference mark – tooth*

Use in safety applications

Fault detection has a major influence on the availability of safety functions. This task must be realised by the control system, as fault detection is not integrated into the sensor.

ℹ️ **Safety of the overall system**
The assessment of the safety of the drive train and the machine can only be undertaken by the machine manufacturer taking account the relevant directives, standards and safety regulations.

$MTTF_d$ [1]

For simplicity it is assumed that only 50 % of the hardware failures on electronic components are hazardous failures. For $MTTF_d$ figures it is therefore typically possible to assume twice the MTTF figure[2]
(sources: EN ISO 13849-1:2008 (D); Annex C, section 5.2 Semiconductors; EN 61800-5-2:2007, Annex B, section 3.1.3 Anteil sicherer Ausfälle (Portion of safe failures)).
The expected operating temperature must be taken into account in this assumption.

PFH_d [3]

The performance level and SIL level do not relate to the reliability of sub-components but to the availability of safety functions.
The MTTFd figures for the sensors are used in these calculations.

Characteristics as a function of the temperature

Operating temperature [°C]	FIT [10^{-9} h^{-1}] [4]	MTTF [h] [2]
85	1611	620732
75	805	1242236
65	402	2487562
55	204	5000000
45	105	9523810

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[1] Mean time to failure "dangerous"
[2] Mean time to failure
[3] Probability of dangerous failure per hour
[4] Failure in time; i.e. failures per 10^9 hours

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Your notes: