

Technical Information

GEL 2475FD

CombiCODER – Flat spot detector

Highly integrated speed sensor, vibration sensor, temperature sensor with integrated evaluation

D-51T-2475FD | Date of issue 2026-06-18

General Information

- 1-/2-channel Hall-effect speed sensor with integrated dead-spot detection and temperature monitoring
- Reliable detection of high speeds through to creeping movements (0 Hz...20 kHz)
- Reliable detection of flat spots, welds, and rail joints
- Temperature monitoring via NTC thermistor: -55 °C to +150 °C
- Perfectly suited for condition monitoring and predictive maintenance

Features

- Speed, vibration, and temperature measurement in a single housing
- Vibration measurement using state-of-the-art MEMS technology in 3 axes
- Integrated evaluation algorithms output the severity of flat spots and weld buildup in discrete levels via a PWM signal
- The use of multiple flat spot detectors enables the detection of rail joints
- Galvanically isolated signals for reliable evaluation in various control systems
- Configuration flexibility through freely selectable cable outlets, cable protection, and connector options
- Type-tested according to DIN EN 50155 for safe use in railway applications
- Fire-protected by cables and cable protection in accordance with DIN EN 45545-2 up to HL3
- Highest product quality with optional certification according to DNV and many other standards

Advantages

- Maximum compatibility
- Maintenance- and wear-free
- Flat spot detection works regardless of the sensor's installation orientation
- Extremely simple evaluation via an analog PWM signal
- Parallel condition monitoring of the vehicle and infrastructure
- Maximizes the efficiency of maintenance planning
- Easy integration
- Easy to install
- Galvanically isolated measurement systems
- High signal quality

Applications

Railway Technology & Transportation

Rail Vehicle Industry:

- Traction control, skid protection, motor speed, slip protection, Automatic Train Protection, odometry

Condition Monitoring in Rail Vehicles:

- Automatic, objective detection and evaluation of flat spots



Do you have special requirements regarding flange shape, shaft length, number of channels, cable protection, cable outlet, connector assembly or EMC concept? Talk to us. Our experts can design the optimal solution for your application from an extensive modular system and will be pleased to advise you how to customize your solution in the most cost-efficient way.

Write to support@lenord.de or call +49 208 9963-215.

Technical Specifications: Voltage Output

Signal pattern	E-	V-	EM	VM
Electrical Specifications				
Supply voltage U_B (reverse-polarity protected)	10 ... 30 V DC		10 ... 20 V DC	
Current consumption I_B (no load)	≤ 30 mA		≤ 25 mA	
Output signal (short-circuit-proof)	Square-wave signals			
Output signal level (High) (1)	$\geq U_B - 1.5$ V		$\geq U_B - 1.8$ V	
Output signal level (Low) (2)	≤ 1.0 V		≤ 1.5 V	
Output current per channel	≤ 20 mA		≤ 10 mA	
Frequency range	0 ... 20 kHz		0 ... 8 kHz	
Duty cycle	50% \pm 20% (2)			
Phase shift	–	typ. 90°	–	typ. 90°
Electrical Specifications for PWM Signal				
Supply voltage U_B (reverse polarity protected)	10 ... 30 V DC			
Output signal level (High) (1)	$\geq U_B - 1.5$ V			
Output signal level (Low) (1)	≤ 1.0 V			
Output current	≤ 20 mA			
Frequency	1 kHz			
Electrical Specifications for NTC Thermistor				
Measuring resistance	1 to 100 kOhm at 25 °C			
Measurement range	-55 °C to +70 °C (max. 100 mW) -55 °C to 150 °C (max. 1 mW)			
Measurement tolerance	1% at 25 °C			
Mechanical Specifications				
Sensor tube material	Stainless steel			
Flange material	Stainless steel			
Sensor weight (including 2 m cable)	500 g			
Environmental testing				
Working and operating temperature	-40 °C ... +120 °C			
Storage temperature	-40 °C ... +120 °C			
Dielectric Strength	500 V AC / 750 V DC (DIN EN 50155:2022-06)			
Electromagnetic compatibility (3)	DIN EN 50121-3-2:2017-11			
Protection class on the measurement side (4)	IP 68			
Vibration resistance	DIN EN 61373:2011-04 Cat. 3			
Shock resistance	DIN EN 61373-2011-04 Cat. 3			
Fire protection	DIN EN 45545-2:2023-12 NFPA 130 upon request			
MTTF value (speed)	> 2,000,000 h at 55 °C			
MTTF value (flat spot)	> 950,000 h at 55 °C			


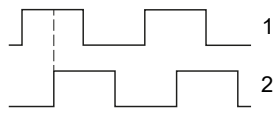
(1) Depends on output current and temperature

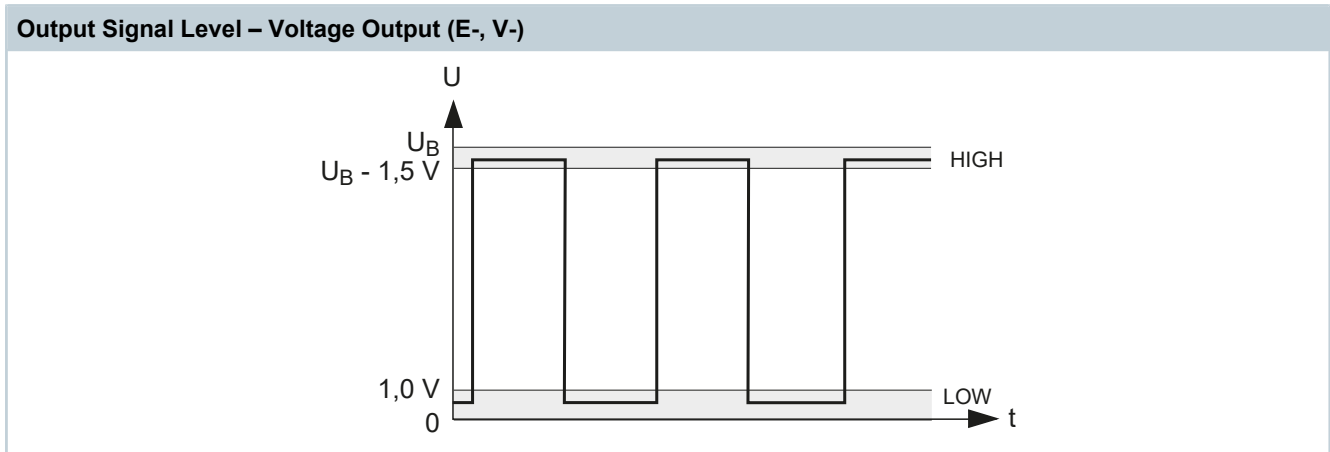
(2) Applies to operation at rated air gap and with teeth according to DIN 867

(3) Follow the EMC instructions in the installation and operating manual

(4) The protection class on the cable outlet side depends on the cable gland or cable protection

Output Signals and Connectors

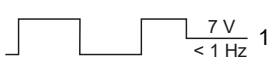
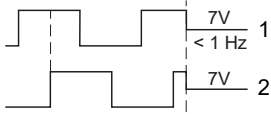
Signal patterns for Voltage Output (E-, V-)			
Output Signals		Supply Voltage	Pulse diagram
E-	1 channel square-wave signal	10 ... 30 V DC	
V-	2-channel square-wave signals with a 90° phase shift	10 ... 30 V DC	

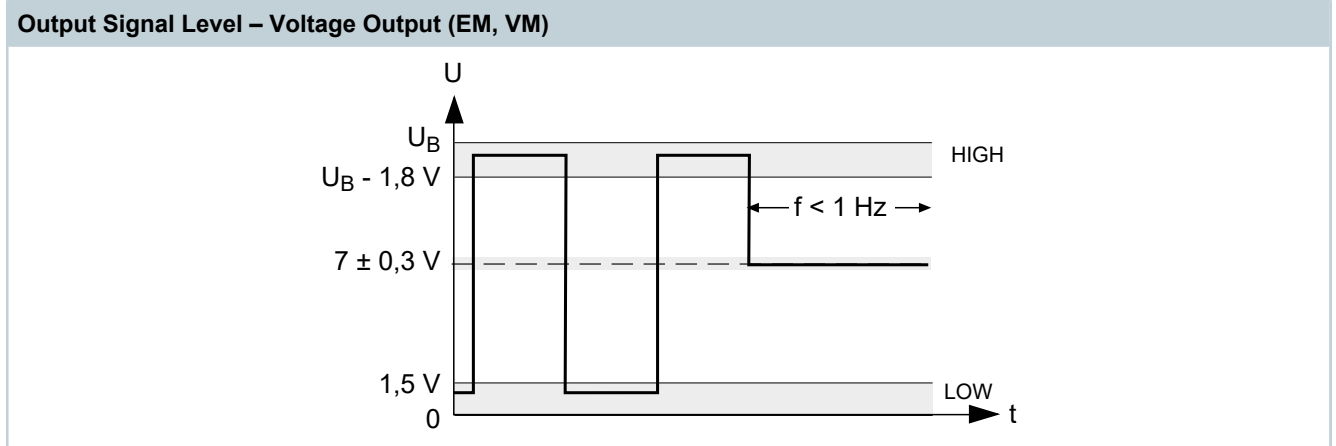


Pin assignment – Voltage output (E-, V-)		
Signal	E-	V-
Speed, Channel 1	YE	YE
Speed, Channel 2	-	WH
GND (0 V)	BU	BU
+ U_B	RD	RD
PWM U_B	PK	PK
PWM GND	GY	GY
PWM Channel 1	BK	BK
PWM Channel 2	BN	BN
NTC+	RD-BU	RD-BU
NTC-	PK-BU	PK-BU
Cables / Shields	1 / 1	1 / 1

Cable shield connected directly to the sensor or optionally capacitively coupled
 Wire color coding: **BK** black, **BN** brown, **BU** blue, **GY** gray, **PK** pink, **RD** red, **WH** white, **YE** yellow

Output Signals and Connectors

Signal patterns with Offset Voltage (EM, VM)			
Output Signals		Supply Voltage	Pulse diagram
EM	1 channel square-wave signal and open-circuit voltage	10 ... 20 V DC	
VM	2-channel square-wave signals with 90° phase shift and open-circuit voltage	10 ... 20 V DC	



Pin Assignment – Voltage Output (EM, VM)		
Signal	E-	V-
Speed, Channel 1	YE	YE
Speed, Channel 2	-	WH
GND (0 V)	BU	BU
+ U_B	RD	RD
PWM U_B	PK	PK
PWM GND	GY	GY
PWM Channel 1	BK	BK
PWM Channel 2	BN	BN
NTC+	RD-BU	RD-BU
NTC-	PK-BU	PK-BU
Cables / Shields	1 / 1	1 / 1

Cable shield connected directly to the sensor or optionally capacitively coupled
 Wire color coding: **BK** black, **BN** brown, **BU** blue, **GY** gray, **PK** pink, **RD** red, **WH** white, **YE** yellow

Flat-spot detector

How the Flat Spot Detector Works

Periodically occurring shock loads are evaluated internally and output at the corresponding sensor output as a pulse-width-modulated (PWM) signal with a fundamental frequency of 1 kHz. The duty cycle of the PWM signal can vary depending on the selected option.

Flat Spot and Shock Intensity—Option 1 (see model code)

see „2-Channel PWM - Valley and Peak Intensity - Option 1“, page 6

Intensity and Probability of a Flat Spot—Option 2 (see model code)

see „2-Channel PWM - Intensity and Probability of a Dip - Option 2“, page 7

2-Channel PWM - Valley and Peak Intensity - Option 1

Duty Cycle Channel 1 - Intensity of a Flat Spot

10% ($\pm 4\%$)	The current vehicle speed does not allow for evaluation, or the measured values are too low to draw any conclusions.
20% ($\pm 4\%$)	The current vehicle speed is within the permissible evaluation range. There is no evidence of a flat spot.
30% ($\pm 4\%$)	The current vehicle speed is within the permissible evaluation range. A periodic event was detected, but it cannot be definitively attributed to a flat spot.
40% to 80% ($\pm 4\%$)	<p>The current vehicle speed is within the permissible evaluation range. A dip is detected:</p> <p>40% lower threshold—mild dip ... 80% Upper Threshold – very severe dip</p> <p>The thresholds for “mild” and “severe” can be customized, as the installation location (suspended/non-suspended) has a significant impact on the measured intensity.</p>
90% ($\pm 4\%$)	An error condition is indicated. The flat spot detector has detected an internal hardware issue.

Duty cycle, Channel 2 – Detection of rail damage (when using multiple flat spot detectors)

When multiple flat spot detectors are used, impacts that occur sequentially rather than periodically along the measurement section (e.g., rail damage) can be detected.

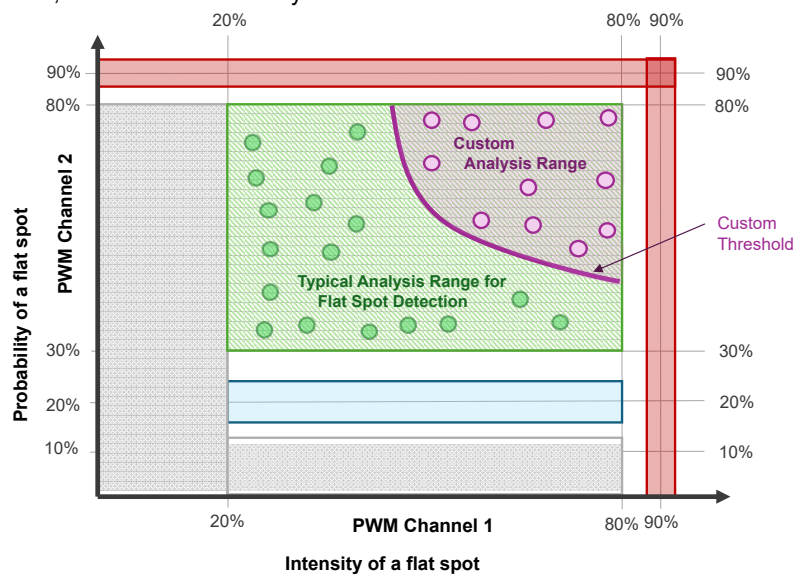
below 20% ($\pm 4\%$)	The current vehicle speed does not allow for evaluation, or the measured values are too low to draw any conclusions.
20% to 80% ($\pm 4\%$)	<p>The current vehicle speed is within the permissible evaluation range. An event is detected:</p> <p>20% Lower Threshold – Minor Event ... 80% Upper Threshold – very strong event</p> <p>The thresholds for “mild” and “severe” can be customized, as the installation location (suspended / unsuspended) has a significant impact on the measured intensity.</p>
90% ($\pm 4\%$)	An error condition is signaled. The flat-panel detector has detected an internal hardware problem.

2-Channel PWM - Intensity and Probability of a Dip - Option 2

Duty cycle, Channel 1—Intensity of a flat spot	
less than 20% ($\pm 4\%$)	The current vehicle speed does not allow for an evaluation, or the measured values are too low to draw a conclusion.
20% to 80% ($\pm 4\%$)	<p>The current vehicle speed is within the permissible evaluation range.</p> <p>A dip is detected:</p> <p>20% lower threshold—slight dip ... 80% Upper Threshold – very severe dip</p> <p>The threshold values for “mild” and “severe” can be customized, as the installation location (suspended / unsuspended) has a significant impact on the measured intensity.</p>
90% ($\pm 4\%$)	An error condition is indicated. The flat spot detector has detected an internal hardware problem.



Duty cycle, Channel 2 — Probability that a flat spot was detected	
10% ($\pm 4\%$)	The current vehicle speed does not allow for evaluation, or the measured values are too low to draw a conclusion.
20% ($\pm 4\%$)	The current vehicle speed is within the permissible evaluation range. There is no indication of a flat spot.
30% to 80% ($\pm 4\%$)	<p>The current vehicle speed is within the permissible evaluation range.</p> <p>A flat spot is detected:</p> <p>30% lower threshold—low probability of a flat spot ... 80% Upper threshold—high probability of a flat spot</p>
90% ($\pm 4\%$)	An error condition is indicated. The flat spot detector has detected an internal hardware problem.

Events are evaluated based on the combined signal components from PWM channel 1 and PWM channel 2 within the defined evaluation range. For flat spot detection, a customer-specific threshold can be set, above which events are classified as relevant and evaluated further. This allows detection to be flexibly adapted to the customer’s specific operational requirements, empirical data, and desired sensitivity levels.



Mechanical Properties

Measuring Gear	
Requirements for the measuring gear	
Material	ferromagnetic steel
Tooth Profile	<ul style="list-style-type: none"> ▪ Involute gearing per DIN 867 (see type code) ▪ Rectangular teeth, typically 1:1 (other ratios available upon request)
Width	≥ 15 mm (smaller widths available upon request)
Module m	Selection can be made in 0.25 increments from 1.00 to 3.50 (see model code)
Air gap (nominal air gap)	0.2 ... 1.5 mm (0.7 mm)

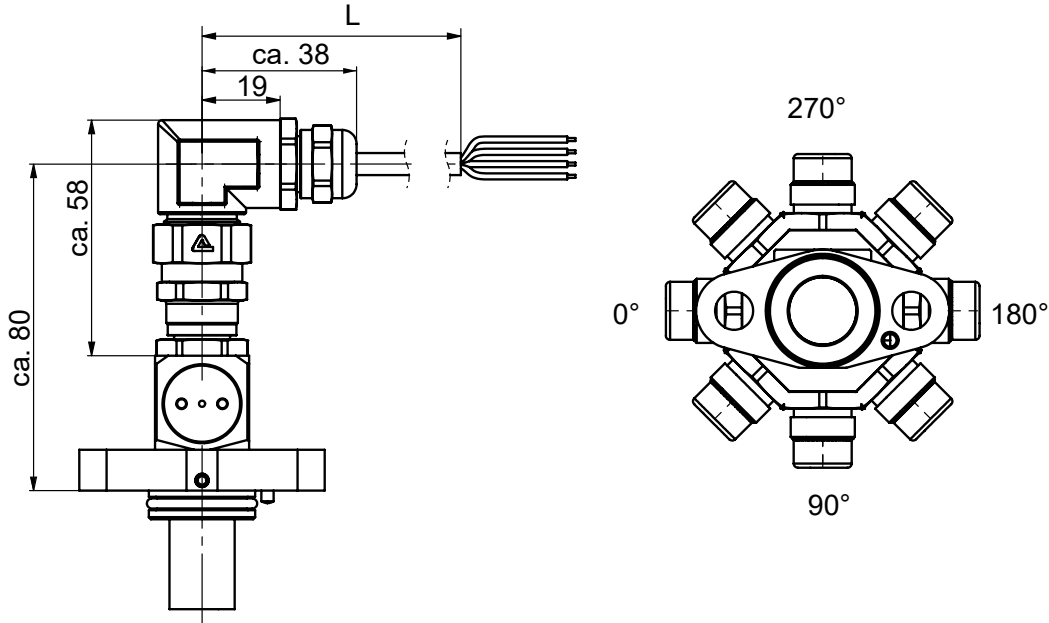
Shielding concept	
Selection of shield support	Shield mounting on the encoder housing
Option SD —directly mounted (see model code)	Directly connected to the sensor housing
Option SC – capacitively mounted (see model code)	Capacitively connected to the sensor housing
Option SI – isolated from the housing (see model code)	Isolated from the housing
Despite its high immunity to interference, the sensor must be integrated into a shielding concept to ensure EMC compliance.	
 If the electromagnetic environment requires special shielding concepts, Lenord+Bauer provides extensive knowledge and experience to assist with integrating the sensor into the application's shielding concept.	
 Follow the EMC guidelines in the accompanying documents.	

Cable outlet	
Cable outlet straight Option S (see type code)	Cable outlet at side Option L (see type code)
<p>The straight cable outlet can also be connected via an angle: „Cable outlet straight with angle“, page 10</p>	
<p>The side cable outlet can also be connected via an angle: „Cable outlet at side with angle“, page 10</p>	
<p>1 Sealing ring: O-ring 21 x 2.5 mm; NBR 2 Index pin</p>	
<p>L Cable length L is determined by type code (Tolerance depends on the preassembled cable length)</p>	

Cable outlet straight with angle

Cable outlet straight with angle - If option **S** is selected for cable outlet (see type code)

The selection can be made in 45° increments 000°; 045°; 090°; 135°; 180°; 225°; 270°; 315° (Tolerance ± 10°) (see type code).

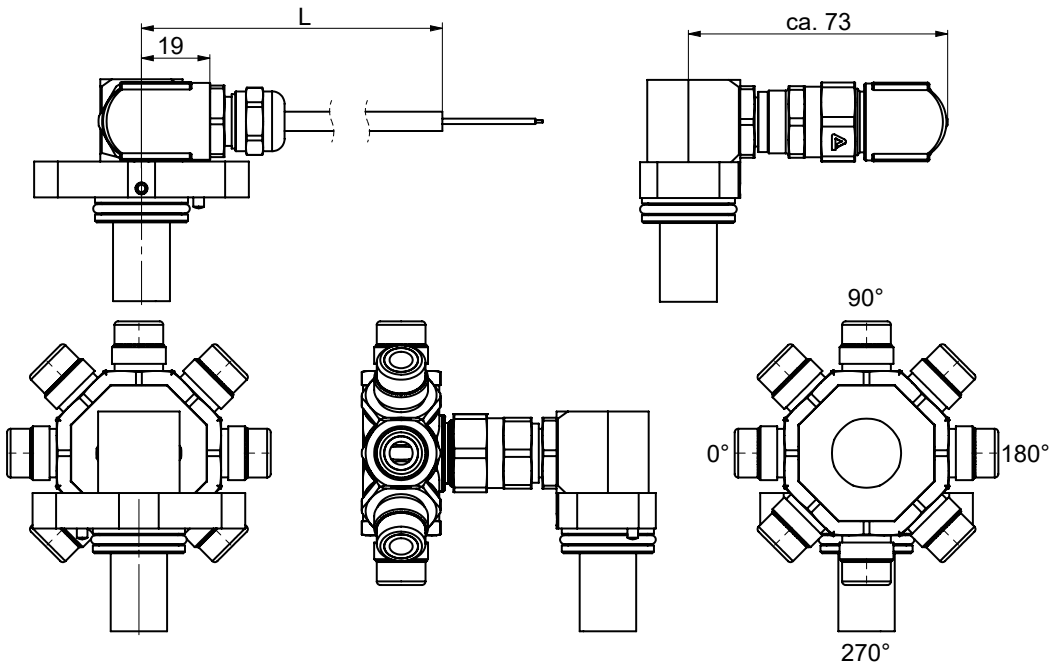


Cable length **L** is determined by type code
(Tolerance depends on the preassembled cable length)

Cable outlet at side with angle

Cable outlet at side with angle - If option **L** is selected for cable outlet (see type code)

The selection can be made in 45° increments 000°; 045°; 090°; 135°; 180°; 225°; 270°; 315° (Tolerance ± 10°) (see type code).



Cable length **L** is determined by type code
(Tolerance depends on the preassembled cable length)

Cable protection at cable outlet

The GEL 2475FD can be equipped with different types of cable protection at the cable outlet as required.

- Dimensional drawings for straight cable outlet: „[Cable outlet straight](#)“, page 11
- Dimensional drawings for cable outlet at side: „[Cable outlet at side](#)“, page 12

Selection P00	Without cable protection
Selection P02	Flexible conduit NW12
Selection P03	Hydraulic hose DN12

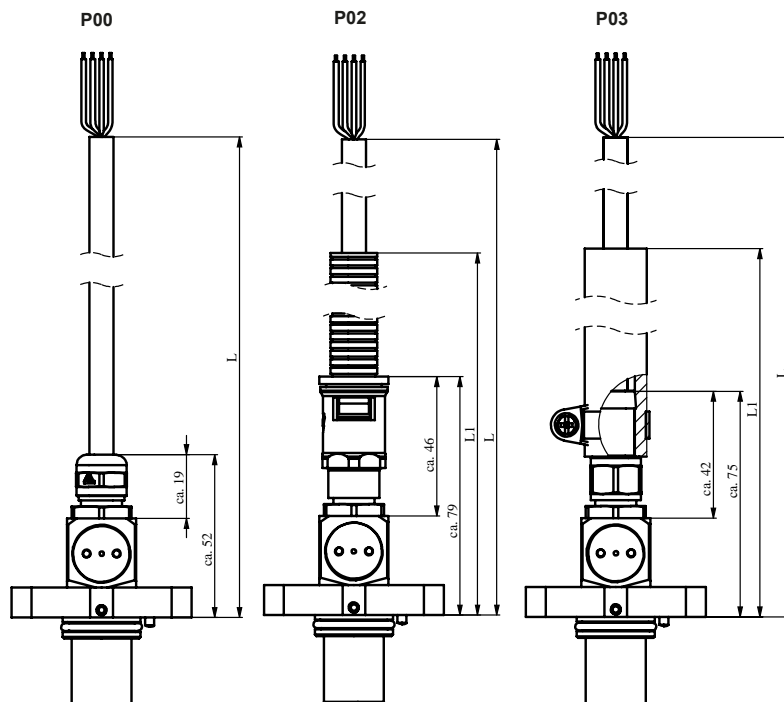
Technical data for cable protection

Option	P00	P02	P03
Type	12 × 0.34 mm ²	Flexible conduit NW12	Hydraulic hose DN12
Material	Halogen-free (specification upon request)	Polyamid, halogen-free	Rubber compound
Outside diameter	8.0 ± 0.3 mm	15.8 mm	19.5 ± 0.5 mm
Minimum bending radius	24 mm (static) 40 mm (dynamic)	35 mm (static) 80 mm (dynamic)	70 mm

Cable outlet straight

Cable protection cable outlet straight - If option **S** is selected for cable outlet (see type code)

The design depends on the cable protection option at the cable outlet: „[Cable protection at cable outlet](#)“, page 11

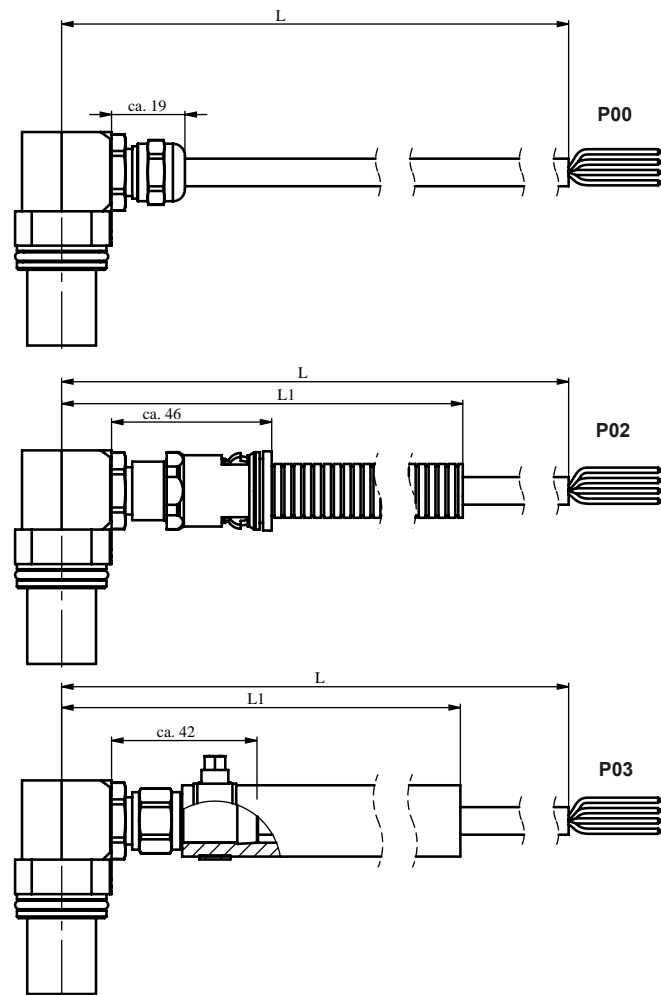


P00	Without cable protection
P02	Flexible conduit NW12
P03	Hydraulic hose DN12
L	Cable length L is determined by type code (Tolerance depends on the preassembled cable length)
L1	Protective sleeve length L1 ; depending on the cable connection and assembly, the protective sleeve length L1 corresponds to the cable length L - 100 mm

Cable outlet at side

Cable protection cable outlet at side - If option **L** is selected for cable outlet (see type code)

The design depends on the cable protection option at the cable outlet: „**Cable protection at cable outlet**“, page 11



P00 Without cable protection

P02 Flexible conduit NW12

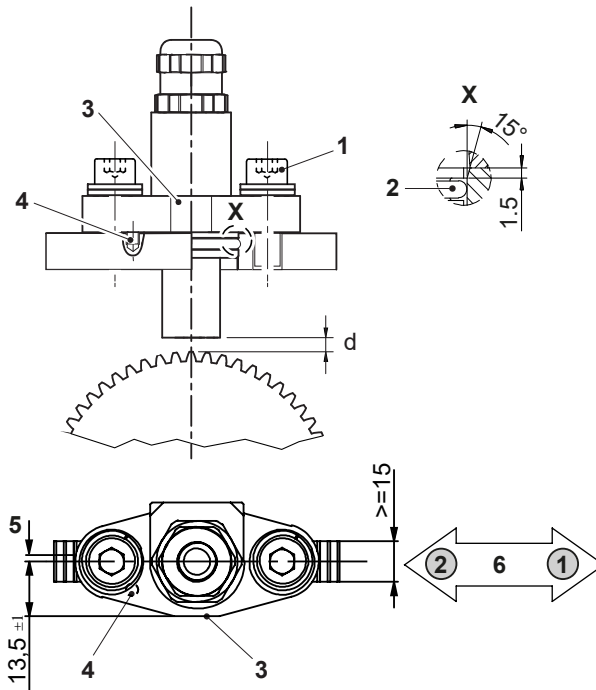
P03 Hydraulic hose DN12

L Cable length L is determined by type code
(Tolerance depends on the preassembled cable length)

L1 Protective sleeve length $L1$; depending on the cable connection and assembly, the protective sleeve length $L1$ corresponds to the cable length L - 100 mm

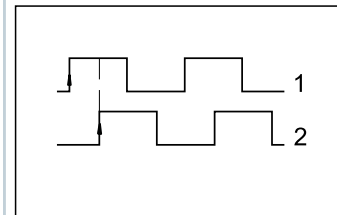
Assembly drawing

All dimensions in mm, general tolerance DIN ISO 2768 mK

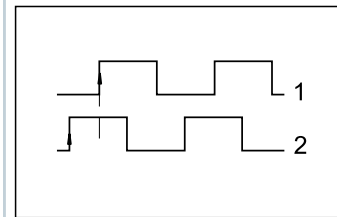


- X Insertion chamfer
- d Air gap: 0.2 to 1.5 mm
Nominal air gap: max. 0.7 mm
Permissible radial runout: ± 0.3 mm
- 1 Fastening screw
(recommended: M8 x 20 DIN EN ISO 4762)
- 2 Sealing ring
- 3 Reference surface
- 4 Index pin
- 5 Axial offset
- 6 Direction of rotation of target wheel

Signal for direction of rotation 1



Signal for direction of rotation 2



The direction of rotation is determined by the reference surface (3) or the index pin (4).

Index pin

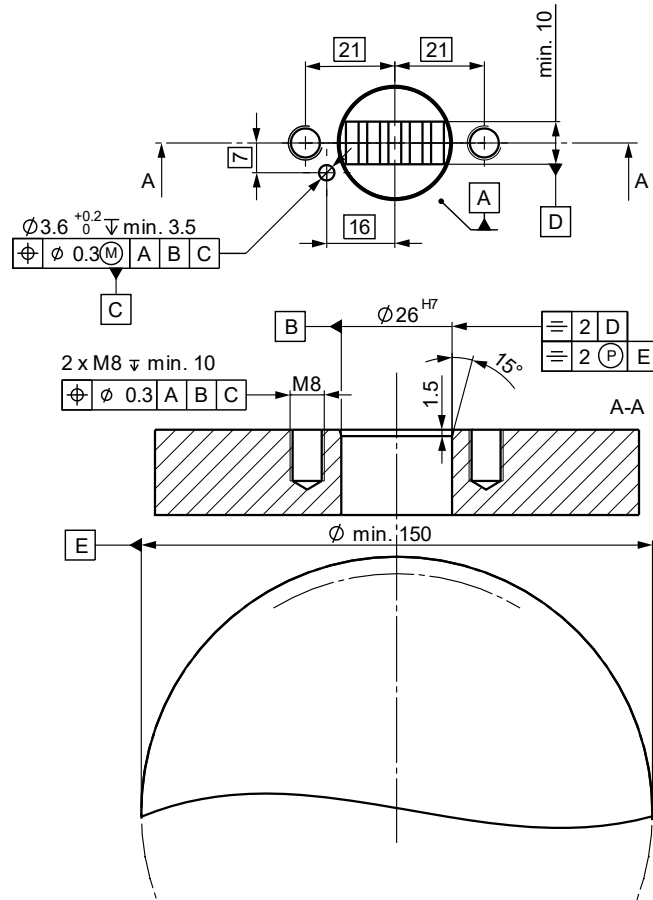
- If the target wheel rotates from the index pin to the center of the sensor, this is **Direction of rotation 1**.
- If the target wheel rotates from the center of the sensor to the index pin, this is **Direction of rotation 2**.

Reference surface

- If the target wheel rotates clockwise with view to the reference surface, this is **Direction of rotation 1**.
- If the target wheel rotates counterclockwise with view to the reference surface, this is **Direction of rotation 2**.

Hole pattern

All dimensions in mm, general tolerance DIN ISO 2768 mK



Model Code GEL 2475FD

2475FD	Product Type																			
	E-	Signal pattern 1-channel square-wave signals																		
	V-	2-Channel Square-Wave Signals with 90° Phase Shift																		
	EM	1-Channel Square-Wave Signal and Open-Circuit Voltage																		
	VM	2-channel square-wave signals with 90° phase shift and open-circuit voltage																		
		Condition Monitoring Interface																		
		1	2-channel PWM—flat spot and rail joint intensity																	
		2	2-channel PWM—probability of a flat spot and intensity of a flat spot/rail joint																	
			Screen Contact																	
			SD	Directly placed																
			SC	Capacitively coupled																
			SI	isolated from the housing																
				Module					Module											
			M01	m = 1.00, steel, involute					M12	m = 1.00, steel, rectangular										
			M02	m = 1.25, steel, involute					M13	m = 1.25, steel, rectangular										
			M03	m = 1.50, steel, involute					M14	m = 1.50, steel, rectangular										
			M04	m = 1.75, steel, involute					M15	m = 1.75, steel, rectangular										
			M05	m = 2.00, steel, involute					M16	m = 2.00, steel, rectangular										
			M06	m = 2.25, steel, involute					M17	m = 2.25, steel, rectangular										
			M07	m = 2.50, steel, involute					M18	m = 2.50, steel, rectangular										
			M08	m = 2.75, steel, involute					M19	m = 2.75, steel, rectangular										
			M09	m = 3.00, steel, involute					M20	m = 3.00, steel, rectangular										
			M10	m = 3.25, steel, involute					M21	m = 3.25, steel, rectangular										
			M11	m = 3.50, steel, involute					M22	m = 3.50, steel, rectangular										
				Cable outlet																
				S	Straight cable outlet															
				L	Side cable outlet															
					Angled															
					without angle															
					1 With angle, 0 degrees					5	with angle, 180 degrees									
					2 with angle, 45 degrees					6	with angle, 225 degrees									
					3 with angle, 90 degrees					7	with angle, 270 degrees									
					4 with angle, 135 degrees					8	with angle, 315 degrees									
					Cable protection															
					P00 None															
					P02 Corrugated tube NW12															
					P03 Hydraulic hose DN12															
					Cable length L															
					L2 2000 mm															
					L3 3000 mm															
					L4 4000 mm															
					Tooth edge															
					XXX Number of teeth on the gear															
▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
2475FD															Product designation					

Accessories

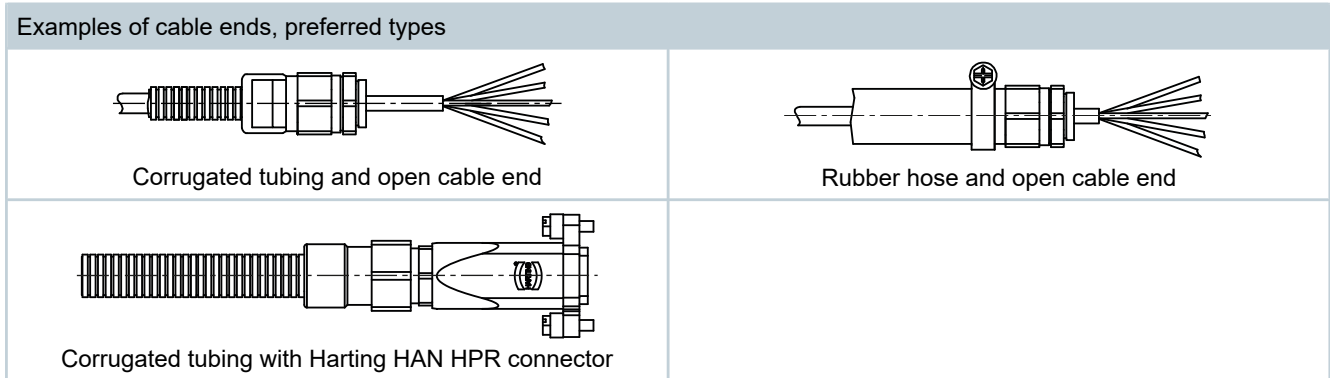
ZB247XM8	2 screws M8 x 20 EN ISO 4762 with washer and spring washer
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A Y-number is assigned for a customer-specific version. A special version is manufactured according to drawing or application description and may deviate from the standard technical specifications.

Examples of Preferred Types

We can assemble the following for you upon request:

In addition to the extensive selection of cable outlets and cable protection options (see model code), various configurations are also available for the cable end.



Pin assignment for Harting HAN HPR connector, preferred type

PIN	E-	V-	EM	VM
1	PWM Channel 1	PWM Channel 1	PWM Channel 1	PWM Channel 1
2	PWM Channel 2	PWM Channel 2	PWM Channel 2	PWM Channel 2
3				
4	-	Speed Channel 2	-	Speed Channel 2
5	GND (0V)	GND (0V)	GND (0V)	GND (0V)
6	+U _B	+U _B	+U _B	+U _B
7				
8	PWM GND	PWM GND	PWM GND	PWM GND
9	PWM U _B	PWM U _B	PWM U _B	PWM U _B
10	NTC+	NTC+	NTC+	NTC+
11	Speed Channel 1	Speed Channel 1	Speed Channel 1	Speed Channel 1
12	NTC-	NTC-	NTC-	NTC-

If you decide to have our speed sensors assembled with cable protection and connectors, we recommend using the preferred types shown in the figure. The required materials are field-tested in large quantities and are always in stock. This guarantees the fastest delivery times with the best material availability and the lowest prices due to large purchasing volumes. If you need help in finding the product you need, please contact our internal sales team at support@lenord.de or call +49 208 9963-215.

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*Finding solutions.
Founding trust.*