Made in Germany

www.lenord.com

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

LENORD +BAUER

Finding solutions.
Founding trust.

Motion sensors and integrated drive technology

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.

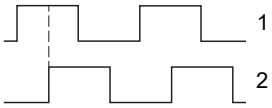
Write to support@lenord.de or call +49 208 9963-215.

Technical Specifications: Voltage Output

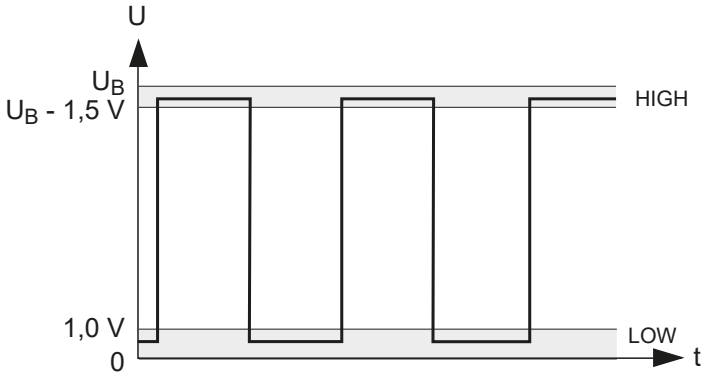
Signal pattern	E-	V-	EM	VM
Electrical Specifications				
Supply voltage U_B (reverse-polarity protected)	10 ... 30 V DC		10 ... 20 V DC	
Current consumption I_B (no load)	≤ 30 mA		≤ 25 mA	
Output signal (short-circuit-proof)	Square-wave signals			
Output signal level (High) (1)	≥ U_B - 1.5 V		≥ U_B - 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% ± 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)	≥ 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

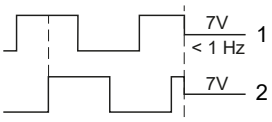
Signal patterns for Voltage Output (E-, V-)			
Output Signals		**Supply Voltage**	**Pulse diagram**
E-	1 channel square-wave signal	10 ... 30 V DC	
V-	2-channel square-wave signals with a 90° phase shift	10 ... 30 V DC	

Output Signal Level – Voltage Output (E-, V-)

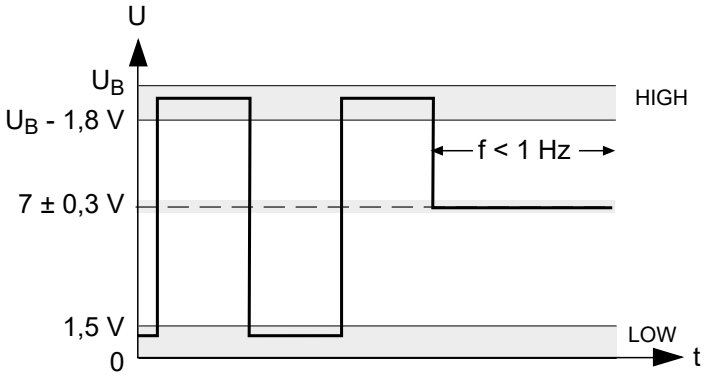


Pin assignment – Voltage output (E-, V-)		
Signal	**E-**	**V-**
Speed, Channel 1	YE	YE
Speed, Channel 2	-	WH
GND (0 V)	BU	BU
$+U_B$	RD	RD
PWM U_B	PK	PK
PWM GND	GY	GY
PWM Channel 1	BK	BK
PWM Channel 2	BN	BN
NTC+	RD-BU	RD-BU
NTC-	PK-BU	PK-BU
Cables / Shields	1 / 1	1 / 1
Cable shield connected directly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

Output Signal Level – Voltage Output (EM, VM)



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

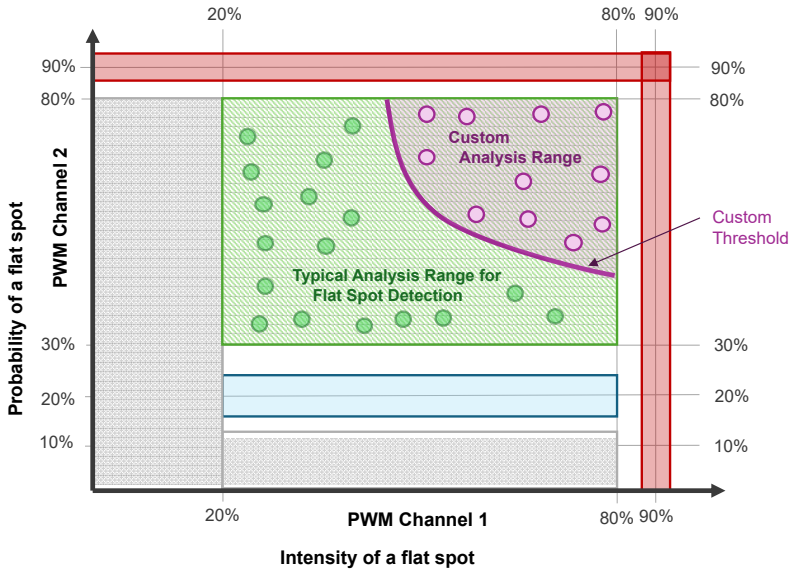
Duty cycle, **Channel 2** – Detection of rail damage (when using multiple flat spot detectors)	
When multiple flat spot detectors are used, impacts that occur sequentially rather than periodically along the measurement section (e.g., rail damage) can be detected.	
below 20% (±4%)	The current vehicle speed does not allow for evaluation, or the measured values are too low to draw any conclusions.
20% to 80% (±4%)	**The current vehicle speed is within the permissible evaluation range.** **An event is detected:** 20% Lower Threshold – Minor Event ... 80% Upper Threshold – very strong event The thresholds for “mild” and “severe” can be customized, as the installation location (suspended / unsuspended) has a significant impact on the measured intensity.
90% (±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% (±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% (±4%)	**The current vehicle speed is within the permissible evaluation range.** **A dip is detected:** 20% lower threshold—slight dip ... 80% Upper Threshold – very severe dip The threshold values for “mild” and “severe” can be customized, as the installation location (suspended / unsuspended) has a significant impact on the measured intensity.
90% (±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% (±4%)	The current vehicle speed does not allow for evaluation, or the measured values are too low to draw a conclusion.
20% (±4%)	The current vehicle speed is within the permissible evaluation range. There is no indication of a flat spot.
30% to 80% (±4%)	**The current vehicle speed is within the permissible evaluation range.** **A flat spot is detected:** 30% lower threshold—low probability of a flat spot ... 80% Upper threshold—high probability of a flat spot
90% (±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.



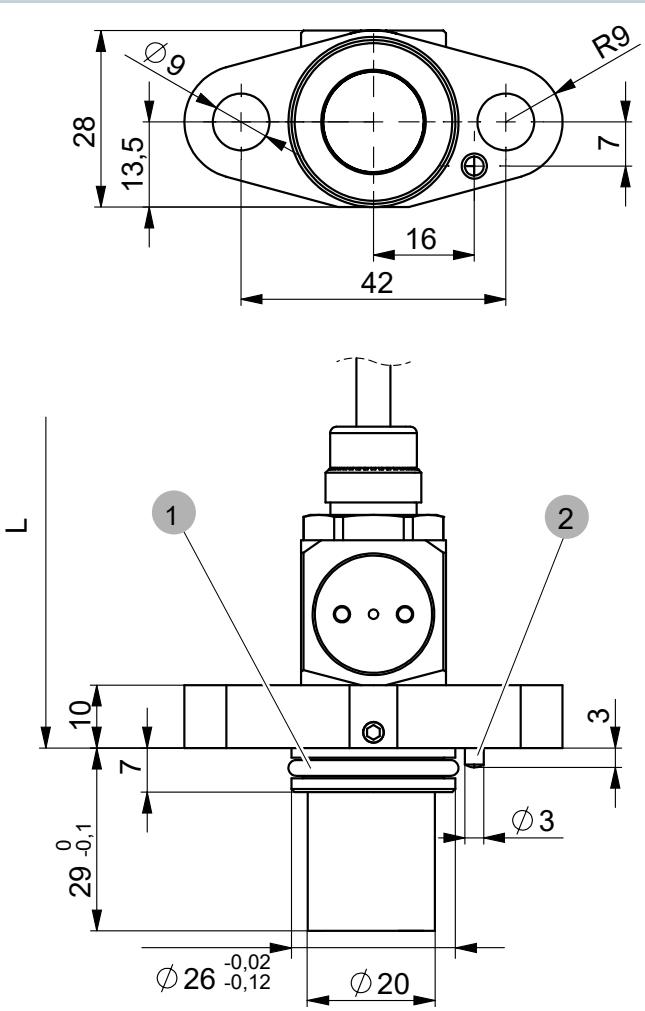
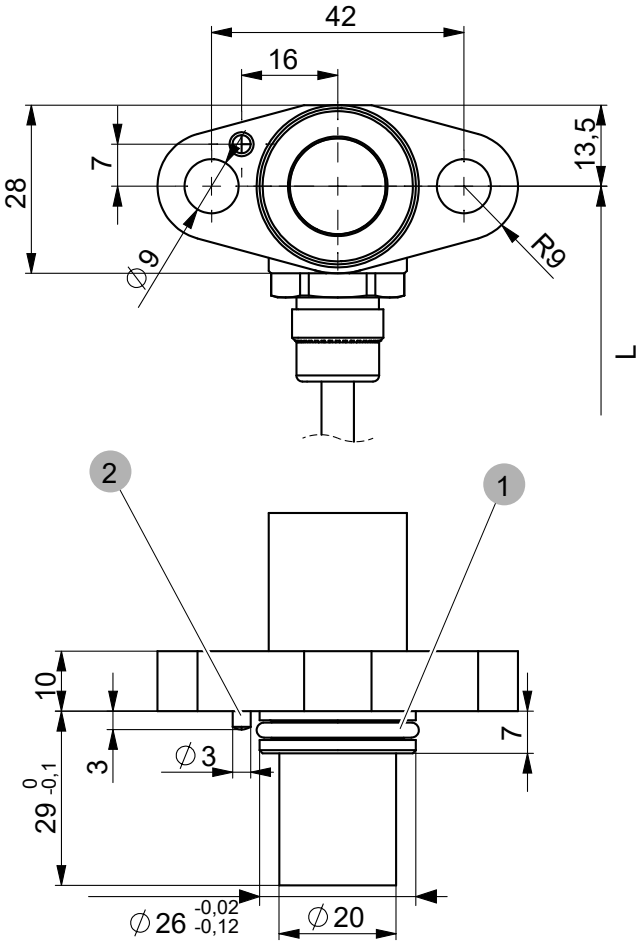
Mechanical Properties

Measuring Gear	
Requirements for the measuring gear	
Material	ferromagnetic steel
Tooth Profile	▪ 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.

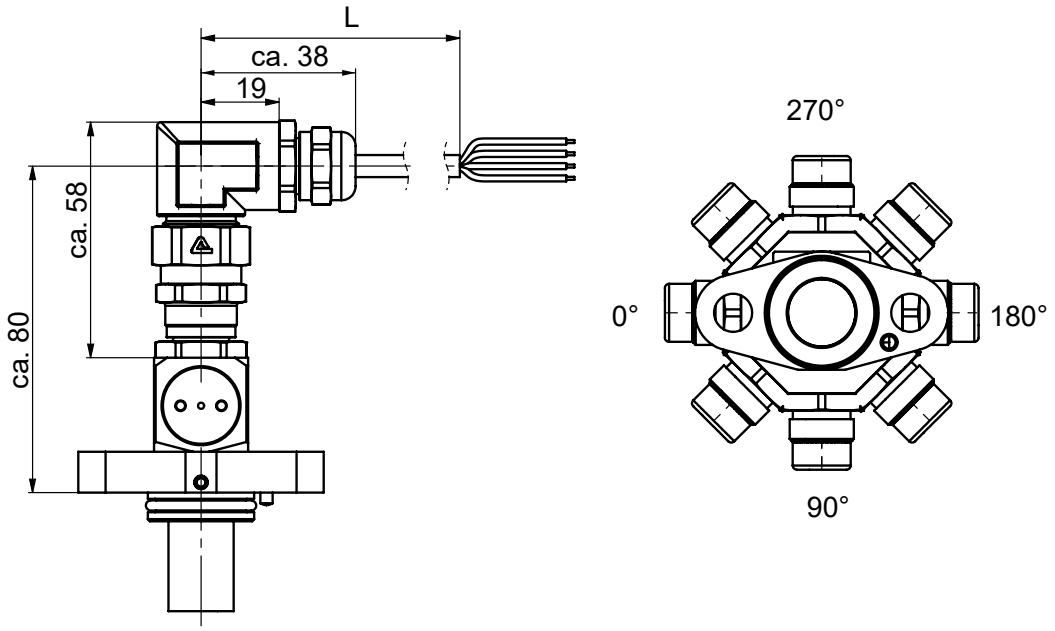
Cable outlet	
Cable outlet straight Option **S** (see type code)	**Cable outlet at side** Option **L** (see type code)
The straight cable outlet can also be connected via an angle: *„**Cable outlet straight with angle**“, page 10*	The side cable outlet can also be connected via an angle: *„**Cable outlet at side with angle**“, page 10*
	

1	Sealing ring: O-ring 21 x 2.5 mm; NBR
2	Index pin
L	Cable length **L** is determined by type code (Tolerance depends on the preassembled cable length)

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).

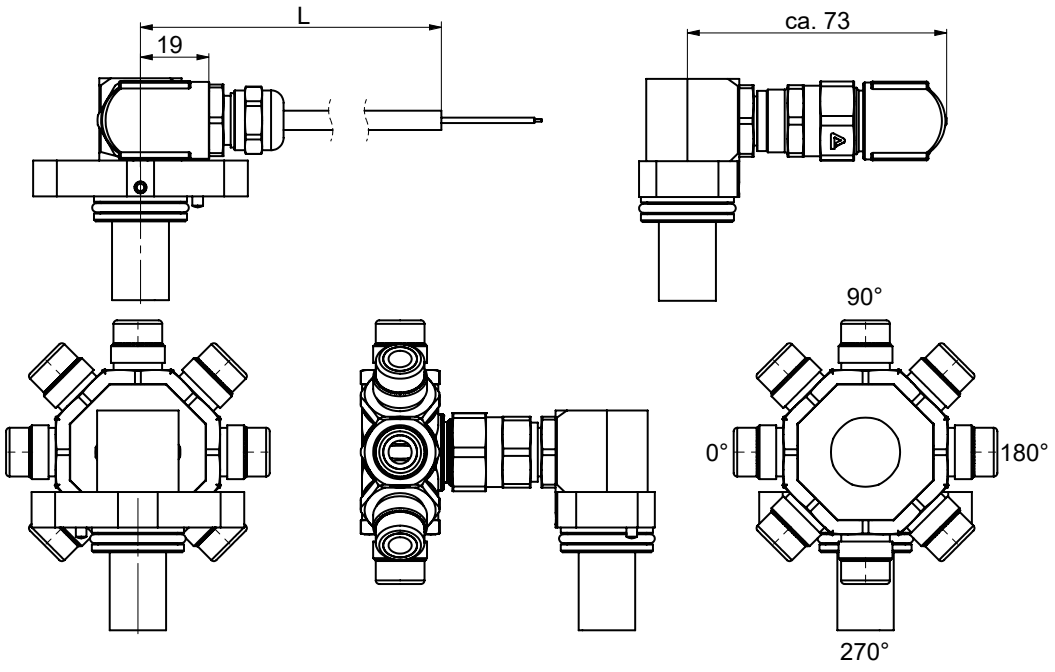


Cable length **L** is determined by type code
(Tolerance depends on the preassembled cable length)

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)

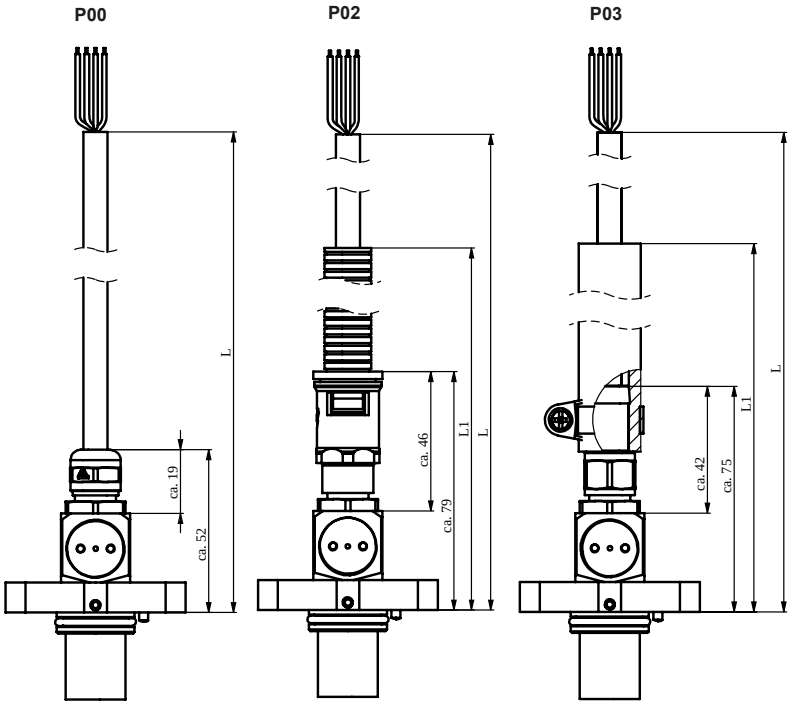
Cable protection at cable outlet	
The GEL 2475FD can be equipped with different types of cable protection at the cable outlet as required.	
▪ Dimensional drawings for straight cable outlet:*„Cable outlet straight“, page 11* ▪ Dimensional drawings for cable outlet at side:*„Cable outlet at side“, page 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 mm²	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

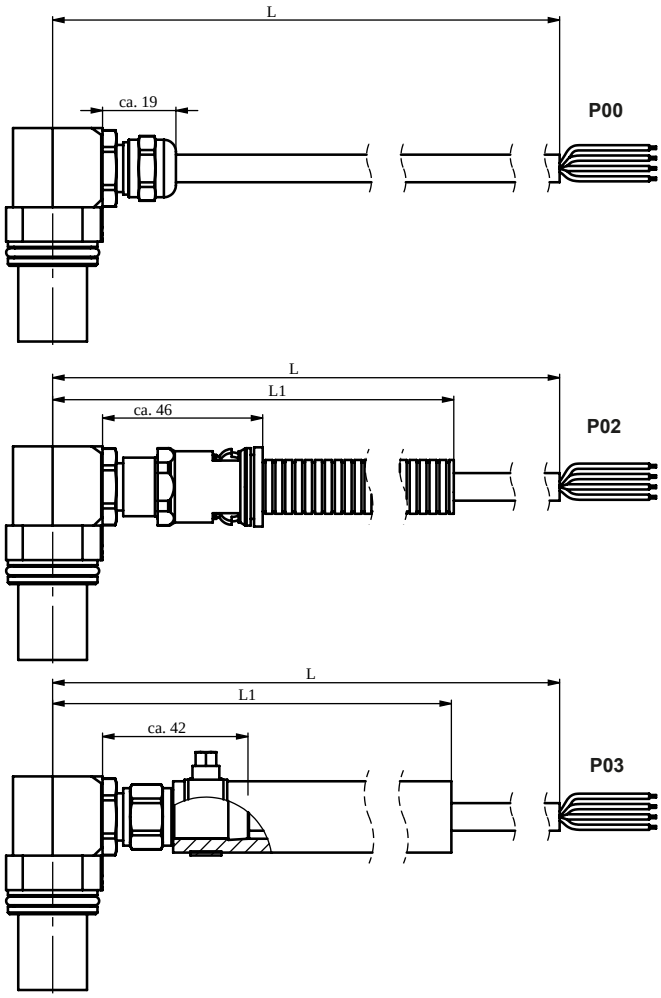
L Cable length **L** is determined by type code
(Tolerance depends on the preassembled cable length)

L1 Protective sleeve length L1; depending on the cable connection and assembly, the protective sleeve length L1 corresponds to thecable 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)

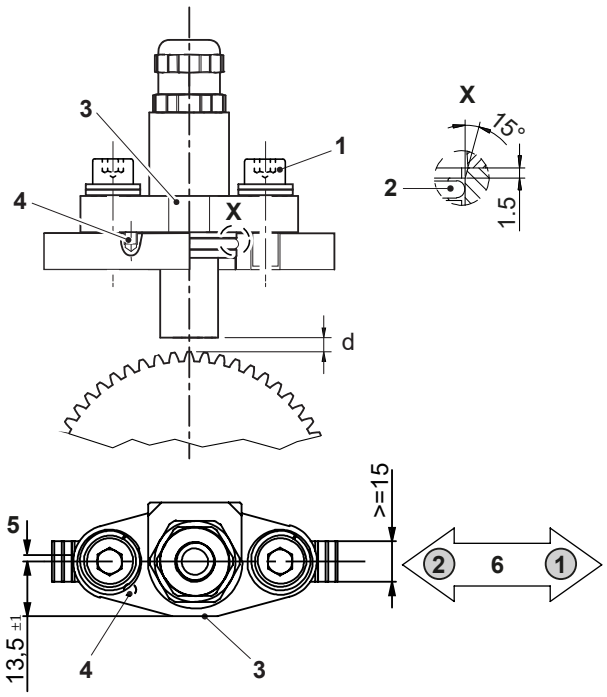
The design depends on the cable protection option at the cable outlet:*„**Cable protection at cable outlet**“, page 11*



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 thecable length L - 100 mm

Assembly drawing

All dimensions in mm, general tolerance DIN ISO 2768 mK

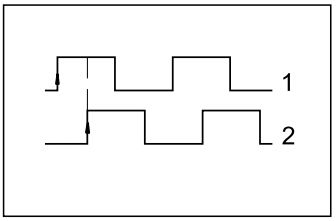


X Insertion chamfer

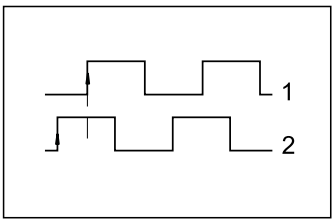
d Air gap: 0.2 to 1.5 mm
Nominal air gap: max. 0.7 mm
Permissible radial runout: ± 0.3 mm

1 Fastening screw (recommended: M8 x 20 DI-N 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

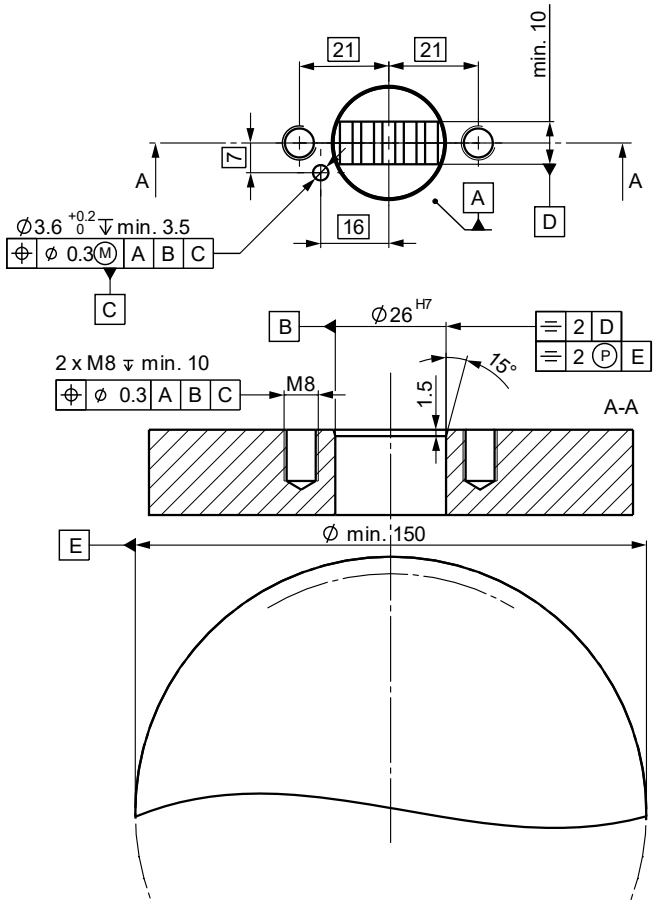
- If the target wheel rotates from the index pin to the center of the sensor, this is **Direction of rotation 1**.
- If the target wheel rotates from the center of the sensor to the index pin, this is **Direction of rotation 2**.

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									
	Signal pattern									
	E-	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				
						0	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

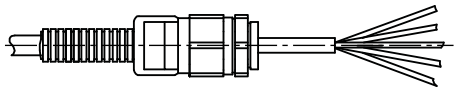
A Y-number is assigned for a customer-specific version. A special version is manufactured according to drawing or application description and may deviate from the standard technical specifications.

Examples of Preferred Types

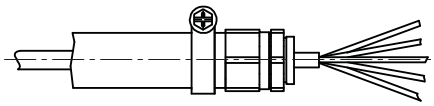
We can assemble the following for you upon request:

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.

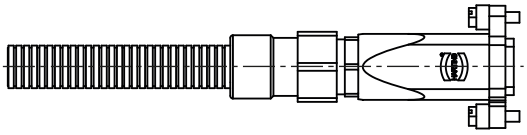
Examples of cable ends, preferred types



Corrugated tubing and open cable end

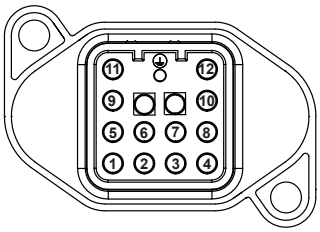


Rubber hose and open cable end



Corrugated tubing with Harting HAN HPR connector

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.

Europe

Germany

Lenord, Bauer & Co. GmbH
Dohlenstrasse 32
46145 Oberhausen
Tel. +49(0) 208 9963 0
E-Mail info@lenord.de
www.lenord.de

Italy

Lenord+Bauer Italia S.r.l.
Via Gustavo Fara, 26
20124 Milano
Tel. +39 340 1047184
E-Mail salesitaly@lenord.com
www.lenord.com

Spain

Lenord Bauer Iberica, S.L.
Carrer de Balmes, 150, 5°
08008 Barcelona
Tel. +34 603 607 499
E-Mail info@lenord.es
www.lenord.com

North America

USA

Lenord+Bauer USA Inc.
32000 Northwestern Highway, Suite 150
Farmington Hills, MI 48334
Tel. +1 248 4467003
orders@lenord.com
E-Mail Info-us@lenord.com
www.lenord.com

Asia

China

Lenord+Bauer Automation Technology (Shanghai) Co.
Block 42, Room 302, No.1000,
Jinhai Road, 201206 Shanghai
Tel. +86 21 50398270
E-Mail Info@lenord.cn
www.lenord.cn

India

Lenord+Bauer India Private Limited
417 Golden Square Prime Serviced Office
Davanam Sarovar Portico Suites
Hosur Main Road, Bengaluru 560068
Karnataka
Tel. +919901516814
E-Mail info@lenord.co.in
www.lenord.co.in

Certified quality for your safety

DIN EN ISO 9001 CERTIFIED
DIN EN ISO 14001 CERTIFIED
DIN EN ISO 22163 CERTIFIED

LENORD +BAUER
Finding solutions. Founding trust.