

SPEED SENSING AND ODOMETRY

SPEED ENDCODER **PG 2000**



HaslerRail on-board electronics

HaslerRail’s range of on-board electronics can be interconnected to equip rail vehicles with a fully networked system for data recording, speed sensing, data and energy measurement and visualisation.



HaslerRail OBE product portfolio

Initialisms and acronyms

The table below lists the initialisms and acronyms (short forms) used within this data sheet and provides expansions to aid understanding:

Short form	Expansion
LED	Light Emitting Diode
LRU	Line Replaceable Unit
OSAM	Optical Sensor Array Modules
PCBA	Printed Circuit Board Assembly
SIL	Safety Integrity Level
SRU	Shop Repairable Unit

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1. Product description

The PG 2000 speed encoder is designed to generate signals representing vehicle speed and vehicle direction for use by on-board equipment and systems, including:

- Speed and distance indicators
- Speed, distance, acceleration and direction recorders
- Wheel slip / slide detectors
- Safety and signalling systems performing up to SIL4

The principal components of the PG 2000 are the code disc and the optical sensor array module. The code disc features at least one circumferential pattern of equispaced vertical lines. The pattern is illuminated and “read” by the optical sensor array mounted on the module. Illumination is provided by integrated LEDs. The code disc is mounted on a rotating central shaft that is coupled to a wheel axle and rotates at the same speed as the wheel-set. This arrangement ensures that the PG 2000 generates frequency output signals that represent the rotational speed and direction of the axles.

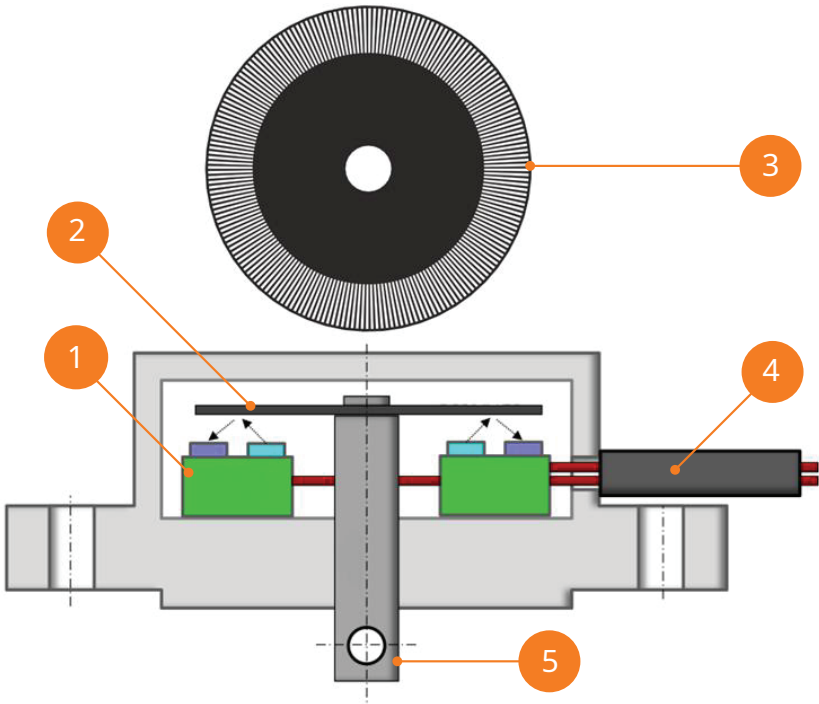
The optical sensor array module comprises a polymer segment that carries two PCBAs: the sensor board (top) and the interface and power board (bottom).

As the code disc rotates above it, the optical sensor array module generates square-wave output signals with frequencies directly proportional to the rotational speed of the axle and therefore the vehicle speed. The output signals are carried, along with power, by the integrated cable to an intermediate junction box and on to the auxiliary equipment via field wiring.

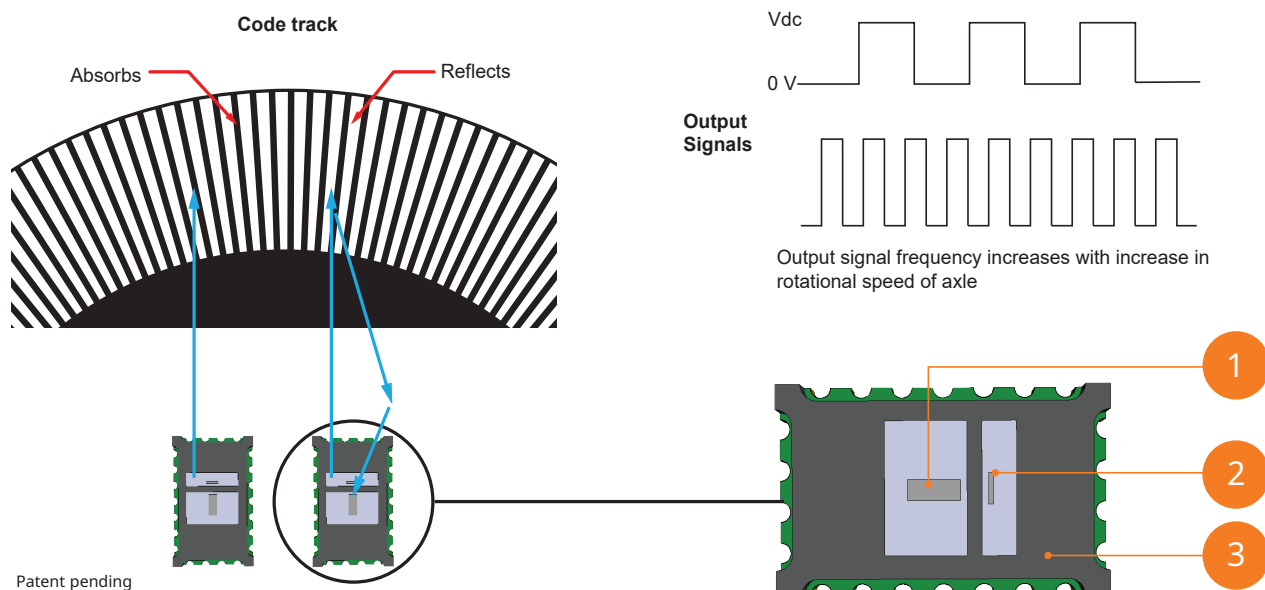
The device housing, all internal components and the interconnecting cable terminations are designed and constructed to withstand the harsh operating conditions experienced by axle-mounted equipment.

1.1 Functional description

The code track is a circumferential, alternating pattern of black and silver lines. Black absorbs light from the LEDs and silver reflects it.



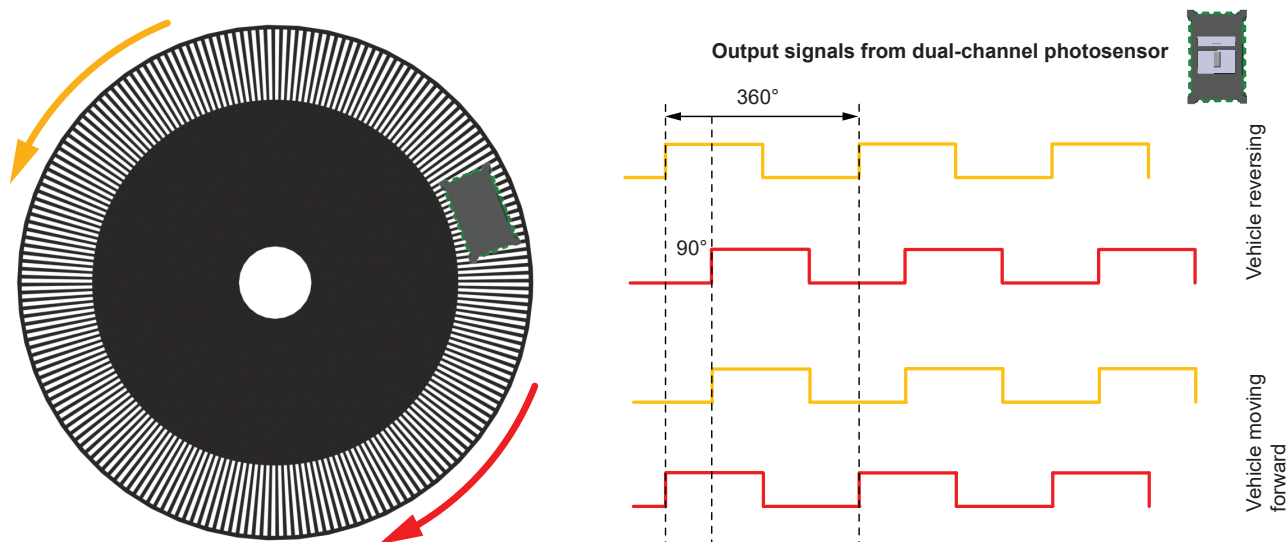
Item no.	Description	Item no.	Description
1	Optical sensor array module	2	Code disc
3	Code track	4	Power / signal cable
5	Central shaft (connected to axle)		



Item no.	Description	Item no.	Description
1	Photodiode array	2	LEDs (quantity may vary)
3	Optical sensor array		

The optical sensor array comprises LEDs and a photodiode array. The LEDs illuminate the code track and as the code disc spins, light is alternately absorbed and reflected. When light is reflected, the output from the photodiode array goes low. When light is absorbed and not reflected, the photodiode array generates a small current flow which is amplified by the module's electronics. The resultant output signal is a square wave switching from high, on absorption, to low on reflection of the LED light and with a frequency proportional to the rotational speed of the axle.

One dual-channel optical sensor array module is sufficient to generate signals representing the speed *and* direction of the rail vehicle. This is illustrated in the figure below. If the axle and the code disc rotate anti-clockwise, the output signal from the **orange** channel will go high before the output of the **red** channel, i.e. it will lead by 90° to indicate that the rail vehicle is reversing.



Arrangement of code disc and photosensor module for illustration purposes only

Conversely, if the axle and the code disc rotate clockwise, the output from the **red** channel will go high before the **orange** channel, i.e. it will lead by 90° to indicate that the rail vehicle is moving forward.

The phase shift between output signals is pre-set at 90° for two and four channel designs and at 120° for three channel versions.

1.2 Product variants

Some aspects of the design and configuration of PG 2000 can be customer-defined for a specific rail vehicle application:

- Code track quantity and pattern to provide the required number of pulses per revolution of the code disc
- Quantity and type of output signals
- Relationship between code disc rotation and vehicle direction
- Cable length and termination (connector type or flying leads)
- Mechanical connection to the vehicle axle (determined by in/out-board location of axle box)

All customer requirements will be defined and documented in a product specification sheet (document no. 5.820x.0xx/xxKEN) that will be completed with support from our sales representative.

2. Mechanical design

The main housing, machined from aluminium alloy, accommodates the mechanical and electronic sub-assemblies. The housing is enclosed by an aluminium alloy cover complete with a gasket to prevent the ingress of dust and liquids. The cover is secured by screws. The code disc is secured by a clamp to the drive shaft which is free to rotate on bearings. The external end of the drive shaft is machined to accept the mechanical in-drive adaptor that connects to the axle. A drive shaft gasket ring prevents the ingress of dust and liquids.

The optical sensor array modules, which are located below the code disc, are secured to segments that are seated in wells in the main housing. Segments are of quarter or half design dependent on the number of optical sensor array modules specified.

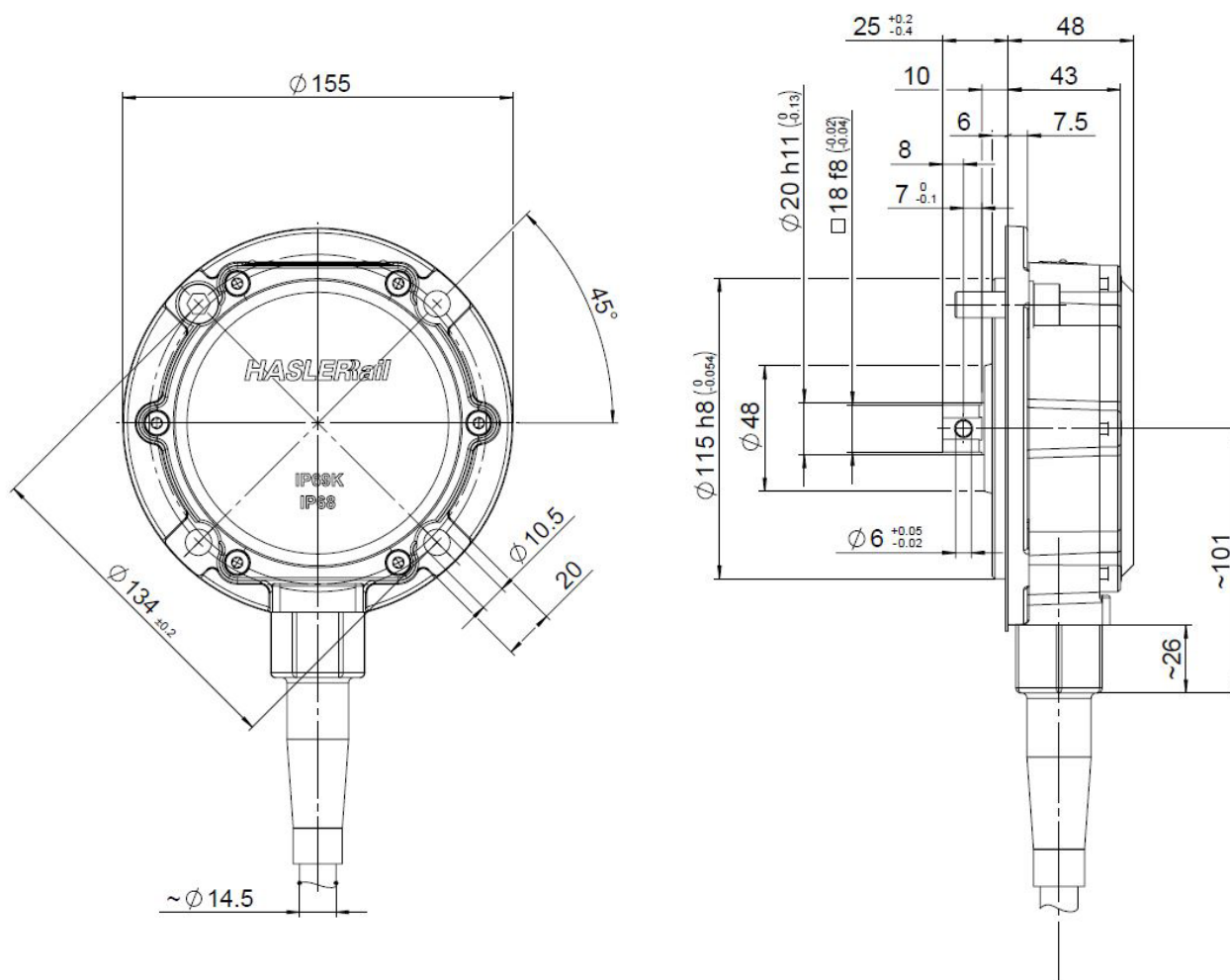
The cable that carries power to and signals from the PG 2000 enters the housing through an integral gland for a secure connection resistant to strain and high levels of vibration. Optional, additional protection for the cable can be supplied in the form of a protective outer tube or sheath.

2.1 Mechanical specification

Feature	Details
Weight	2.0 - 4.5 kg Dependent on type and cable length
Housing and cover material	Aluminium alloy
Ingress protection level	IP68 and IP69K
Operating temperature range	-40 °C – +70°C
Drive shaft torque	<1.5 Nm approx.
Rotational speed range	0 - 3000 rpm
Drive shaft / axle coupling	According to specification sheet (5.820x.xxx/xxKEN)

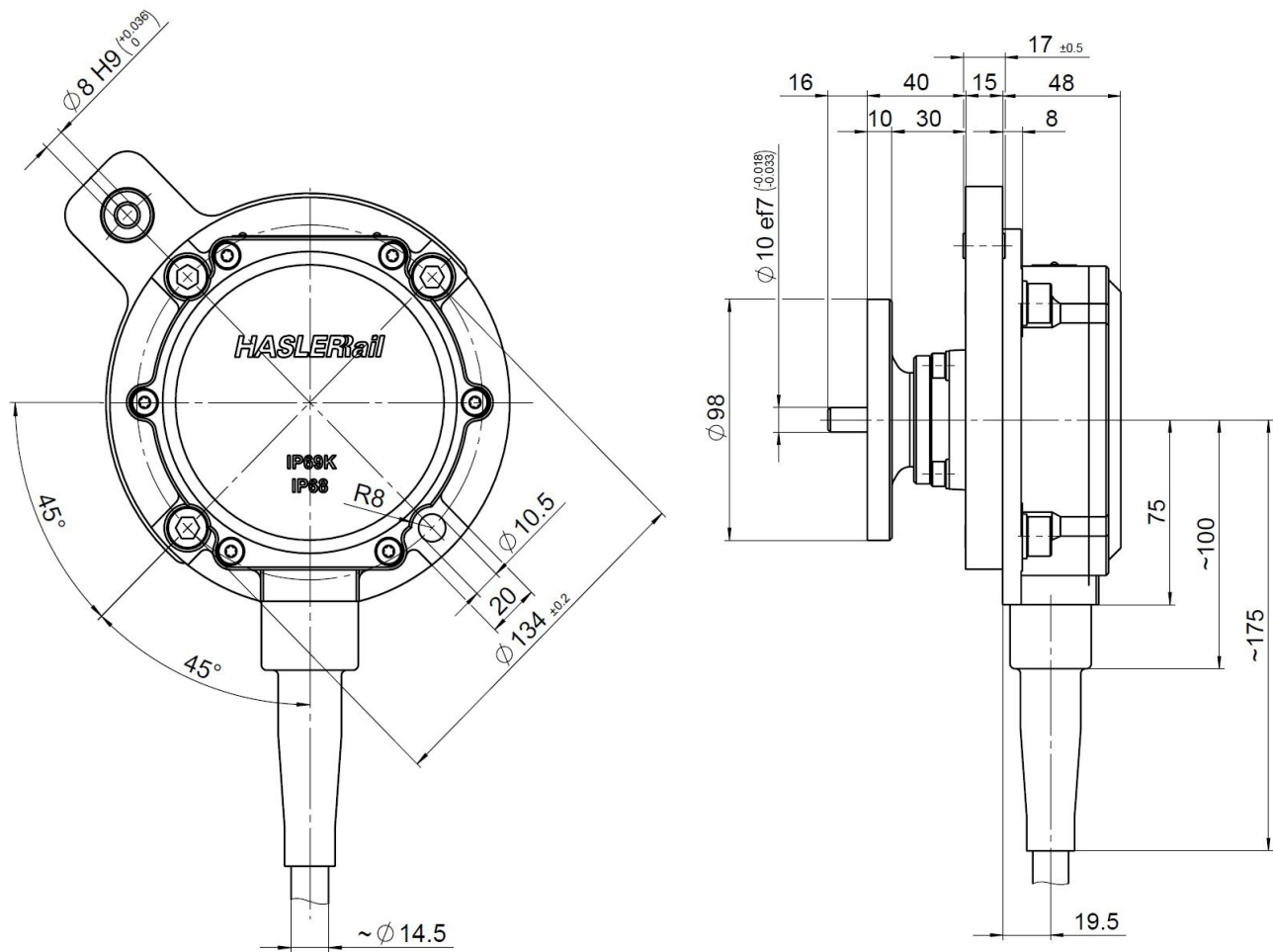
2.2 Mechanical drawings

PG 2000 type 5.8200 - see sub-section 7.2

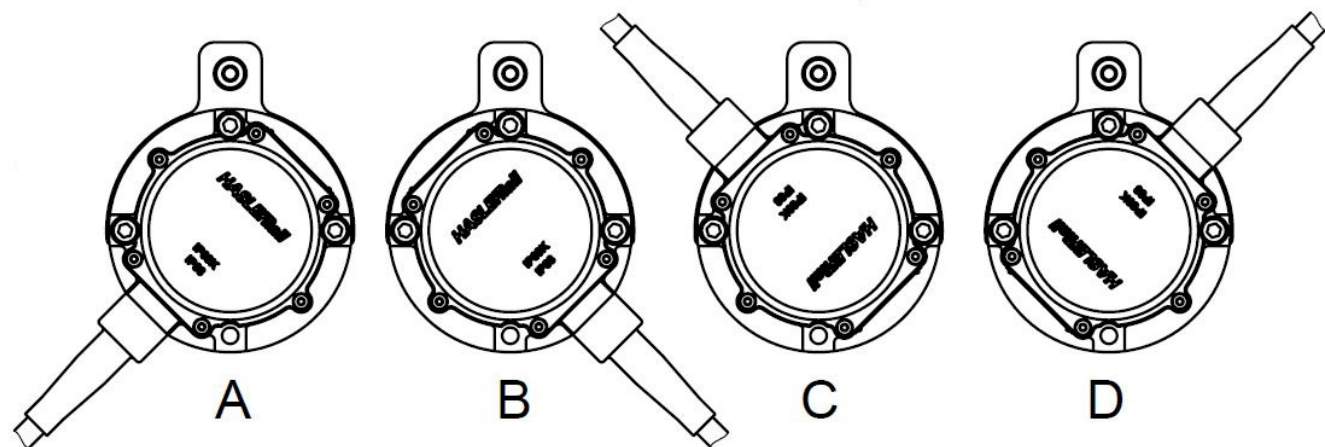


From drawing no. 5.0082.001DML

PG 2000 type 5.8202 - see sub-section 7.2

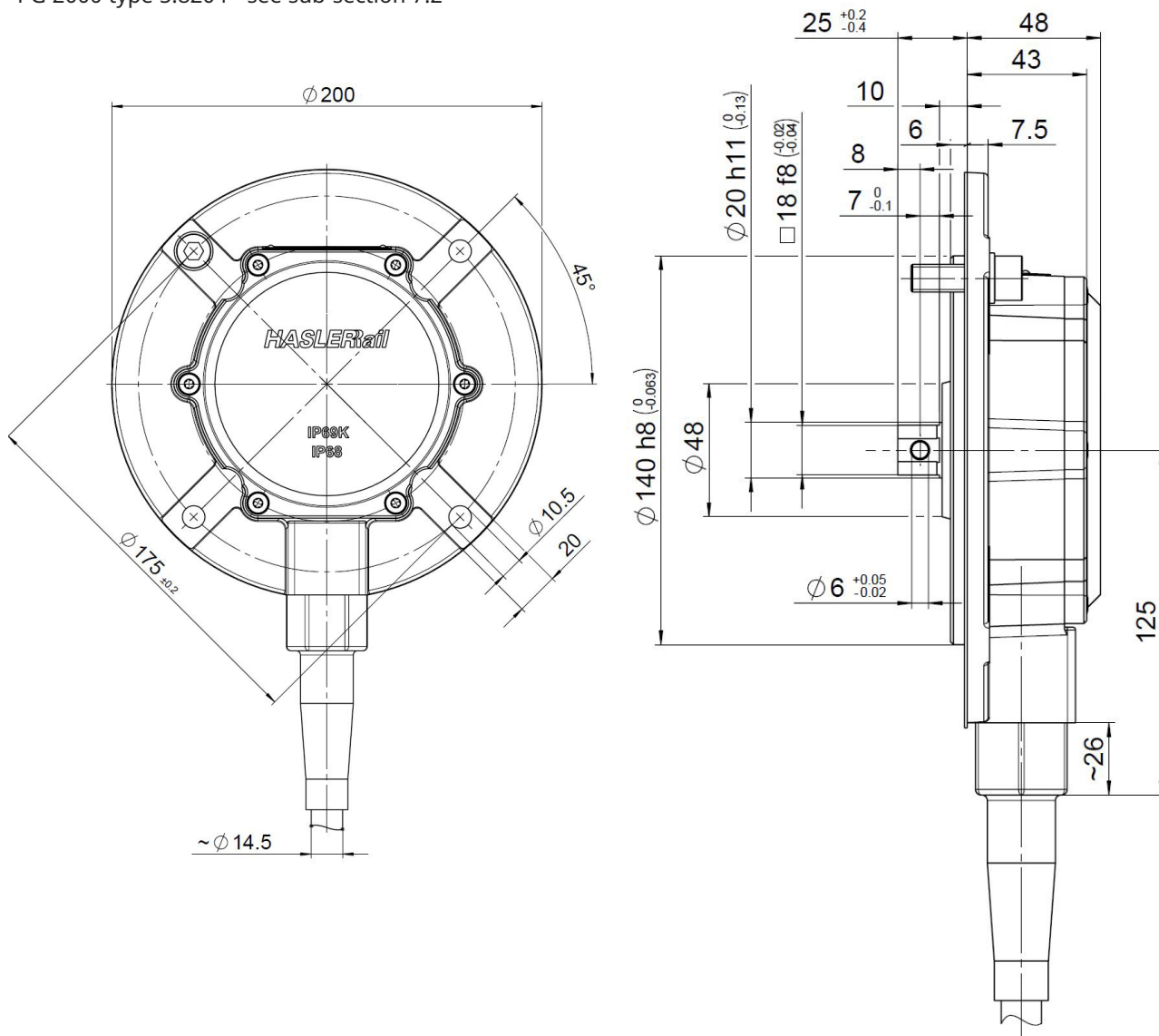


Orientation of torque bar retainer (project specific)



From drawing no. 5.0082.002DML

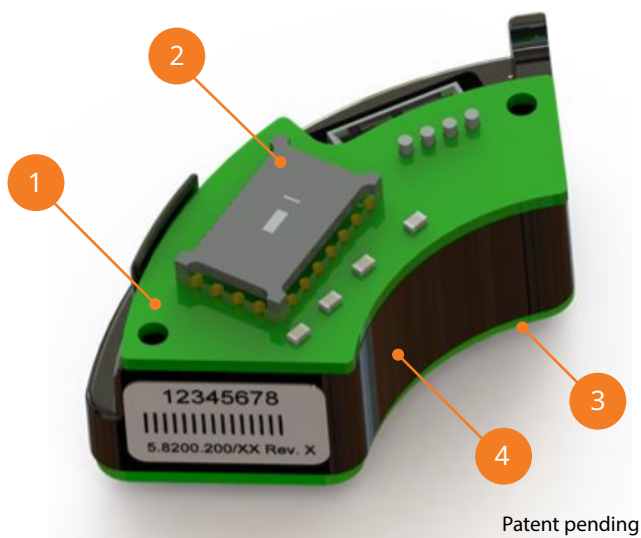
PG 2000 type 5.8204 - see sub-section 7.2



From drawing no. 5.0082.004DML

3. Electrical design

The electrical / electronic components in the PG 2000 speed encoder are limited to the optical sensor array modules (OSAMs), signal conditioning circuits and associated wiring.



Item	Description
1	Optical sensor array board
2	Optical sensor array
3	Interface and power board
4	Segment

Please refer to data sheet 5.0301.036-01Txx for a technical specification of the OSAM.

3.1 Electrical specification

Feature	Details
Output signals	Square wave 0 - 30 VDC push-pull and / or current
Typical duty cycle	40 - 60%
Power supply	10 - 30 VDC dependent on optical sensor array type (U nominal = 15 V and 24 V)
CAUTION!	DO NOT connect PG 2000 directly to the vehicle battery
Max. power consumption	Dependent on optical sensor array type and quantity
Number of outputs	1 - 8, galvanically isolated
Optical sensor array	LED with photodiode array
Pulses per code disc rotation	200 and 400, 800
Frequency range	0 - 40 kHz Code disc dependent
Voltage withstand test	1.5 kV; 50 Hz; 1 min. Performed between sensor modules and ground and between each output channel
Reverse polarity protection?	Yes

4. Environmental attributes / limits

Operating temperature range	-40 °C – +70 °C (ambient temperature) Class OT4 and ST1 according to EN 50155:2021
Cooling method	Natural convection, no active cooling required
Storage temperature range	-40 °C – +85 °C
Permissible vibration and shock	Category 3 according to EN 61373:2010 +AC:2017-09
RoHS conformity	Yes, according to (EU) 2011/65
REACH conformity	Yes, according to (EC) 1907/2006
Fire behaviour compliance	HL3 according to EN 45545-2:2020 +A1:2015

5. RAMS features

Useful life class	> 20 years
Mean time to restoration (MTTR)	LRU: PG 2000 speed encoder Labour on vehicle: 10 minutes Labour off vehicle: not applicable SRU: Optical Array Sensor Labour on vehicle: not applicable Labour off vehicle: 30 minutes
List of limited life components	None
Storage precautions	In the range 0 °C – +45 °C with maximum temperature variation of 20 °C in one day the equipment is considered in storage. Storage time is not deducted from useful lifetime of the product, this being limited to the maximum duration of three years
Reliability [MTBF hours] Two sensor version	> 500,000 hours, depending on type and number of sensors installed.
Reliability calculation model	Average temperature surrounding device T_e : 45 °C Daily temperature variation dT : 10 °C Use factor: 100 % Average rotational speed: 600 rpm
Specification and demonstration of reliability, availability, maintainability and safety (RAMS)	EN 50126-1:2017 EN 50126-2:2017

6. Routine and type test compliance

	Type test	Routine test	Standard	Acceptance criteria
Railway applications - Rolling stock - Electronic equipment	See details	See details	EN 50155:2021	See details
Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus	See details	See details	EN 50121-3-2:2016	See details
	Type test	Routine test	Standard	Acceptance criteria
Visual inspection	Yes	Yes	EN 50155:2021, 13.4.1	In accordance with routine test specification
Performance test	Yes	Yes	EN 50155:2021, 13.4.2	In accordance with routine test specification which includes: - current consumption - phase shift - rise and fall time - period instability - code disc - level measurement
Insulation resistance test	Yes	Yes	EN 50155:2021, 13.4.7.2	Insulation test voltage 500 VDC Insulation resistance > 20 MΩ Note: this test is performed before and after the voltage withstand test

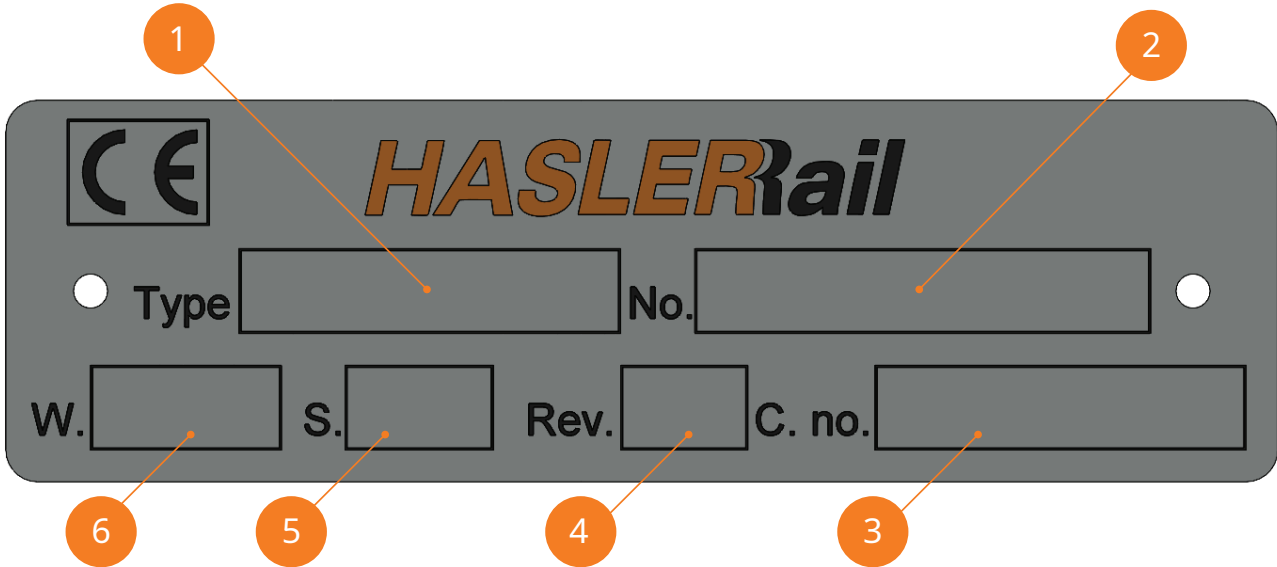
	Type test	Routine test	Standard	Acceptance criteria
Voltage withstand test	Yes	Yes	EN 50155:2021, 13.4.7.3	Test voltage 1500 VDC For type test, holding time is 1 min For routine test, holding time is 10 s No disruptive discharge or flashover observed
Low temperature storage test	Yes	No	EN 50155:2021, 13.4.6 EN 60068-2-1:2007 IEC 60068-2-1:2007	Test Ab @ temperature class OT4 (-40 °C) 16 hours in offstate After recovery performance criteria A
Low temperature test	Yes	No	EN 50155:2021, 13.4.4 EN 60068-2-1:2007 IEC 60068-2-1:2007	Test Ad @ temperature class OT4 (-40 °C) 2 hours in operation
High temperature storage test	Yes	No	EN 60068-2-1:2007 IEC 60068-2-1:2007	Test Bd temperature +85°C 16 hours in offstate
Dry heat test	Yes	No	EN 50155:2021, 13.4.5 EN 60068-2-2:2007 IEC 60068-2-2:2007	Test Bd @ temperature class OT4 (70 °C) 14 hours @ 70 °C, then 10 minutes @ 85 °C
Cyclic damp heat test	Yes	No	EN 50155:2021, 13.4.8 EN 60068-2-30:2005 IEC 60068-2-30:2005	Temperatures: +25 °C / +55 °C @ 93 % rH 2 cycles each 24 h, total duration 48 h
Temperature variation test	Yes	No	EN 50155:2021, 13.4.12 EN 60068-2-14:2007	Variation Nb -25 °C / +70 °C 2 cycles
Salt mist test	Yes	No	EN 50155:2021, 13.4.13 EN 60068-2-11:1999 IEC 60068-2-11:1981 +COR1:1999	After recovery performance criteria A
Enclosure protection test (IP code)	Yes	No	EN 50155:2021, 13.4.10.5 EN 60529:1991 +A1:2000 +A2:2013 IEC 60529:1989 +A1:1999 +A2:2013	IP68 and IP69K
Electromagnetic compatibility test	Yes	No	EN 50155:2021, 13.4.9 EN 50121-3-2:2016 +A1:2019 IEC 62236-3-2:2018 Conducted emission	Battery power supply: 0.15 – 0.5 MHz, 99 dB µV quasi peak 0.5 – 30 MHz, 93 dB µV quasi peak
			EN 50155:2021, 13.4.9 EN 61000-4-2:2009 IEC 61000-4-2:2008 Electrostatic discharge	Contact discharge: ± 6 kV Performance criteria B
			EN 50155:2021, 13.4.9 EN 61000-4-3:2006 +A1:2008 +A2:2010 IEC 61000-4-3:2006 +A1:2007 +A2:2010 Radiated radio frequency	80 – 1000 MHz: 20 V/m rms 1400 – 2000 MHz: 10 V/m rms 2000 – 2700 MHz: 5 V/m rms 5100 – 6000 MHz: 3 V/m rms Performance criteria A

	Type test	Routine test	Standard	Acceptance criteria
Electromagnetic compatibility test			EN 50155:2021, 13.4.9 EN 61000-4-4:2012 IEC 61000-4-4:2012 Fast transient/Burst	Battery referenced ports: ± 2 kV Signal and communication ports: ± 2 kV Burst frequency: 5 kHz Performance criteria A
			EN 50155:2021, 13.4.9 EN 61000-4-6:2014 IEC 61000-4-6:2013 Immunity to conducted disturbances	Battery referenced, signal and communication ports: 0.15 MHz – 80 MHz 10 V rms, 80 % AM, 1 kHz Performance criteria A
Shock and vibration test	Yes	No	EN 50155:2021, 13.4.10 EN 61373:2010 +AC: 2017-09 IEC 61373:2010 +COR1: 2011	Category 3 axle-mounted
Equipment stress screening test	Yes	Yes	EN50155:2021, 13.4.11 EN 61163-1:2006 IEC 61163-1:2006	Thermal cycling

7. Product marking

7.1 Type plate

A type plate, as shown below, is affixed to the PG 2000 housing.



Item	Description
1	Device type number (5.820x.0xx/xx) This is assigned on a project-by-project basis in specification document no. 5.820x.0xx/xxKEN
2	Unique serial number (YYWWxxxx)
3	Customer number (if applicable)
4	Device revision status (incremented with significant change)
5	Number of outputs
6	Pulses per rotation (PPR)

7.2 Type number structure

The table below details how the PG 2000 type numbers are constructed:

5.	820x.	0	x	Y	/ZZ
HaslerRail product	Mechanical variant	HaslerRail final product	Signal output type	Number of outputs	Customer variant
	8200 = 115 mm flange mounted 8201 8202 = axle mounted 8203 8204 = 140 mm flange mounted		Prototype = 0 Push-pull = 1 Current = 2 Mixed = 9	1 to 8	/01 to /99

Example: 5.8204.014/01: 140 mm flange mounted generating four push-pull output signals

8. Revision record

Revision	Date	Modification	Created	Released
A00	28.11.2024	N/A First release	NBE	AMU
A01	24.02.2025	Change the phrase “photosensor chip” to “optical sensor array” in all places Additional text added in “1. Product Overview” to clarify operation of the optical sensor array Second illustration in “1.1 Functional Description” updated to show optical sensor array in greater detail	KSM	AMU
A02	01.07.2025	Section 4: Class ST1 added to operating temperature range Section 6: “In accordance with routine test specification” added to acceptance criteria fields for Visual inspection and Performance test Insulation resistance test acceptance criteria changed to “Insulation resistance > 200 MOhm Insulation test voltage 1500 VAC”	NBE	AMU
A03	08.10.2025	Specification document no. added in sub-section 1.2 Outline drawing numbers added in sub-section 2.2 Cross reference to OSAM data sheet added in section 3 Performance test details added in section 6 Voltage withstand test added and insulation resistance test parameters revised in section 6 Note regarding project specific article number added in sub-section 7.1	NBE	AMU
A04	28.04.2026	(No technical changes) Fonts used on front cover revised to align with standard Device type and brand name separated to align with standard Product portfolio and list of initialisms and acronyms added prior to TOC Section 1 title changed from “Product overview”	NBE	AMU



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