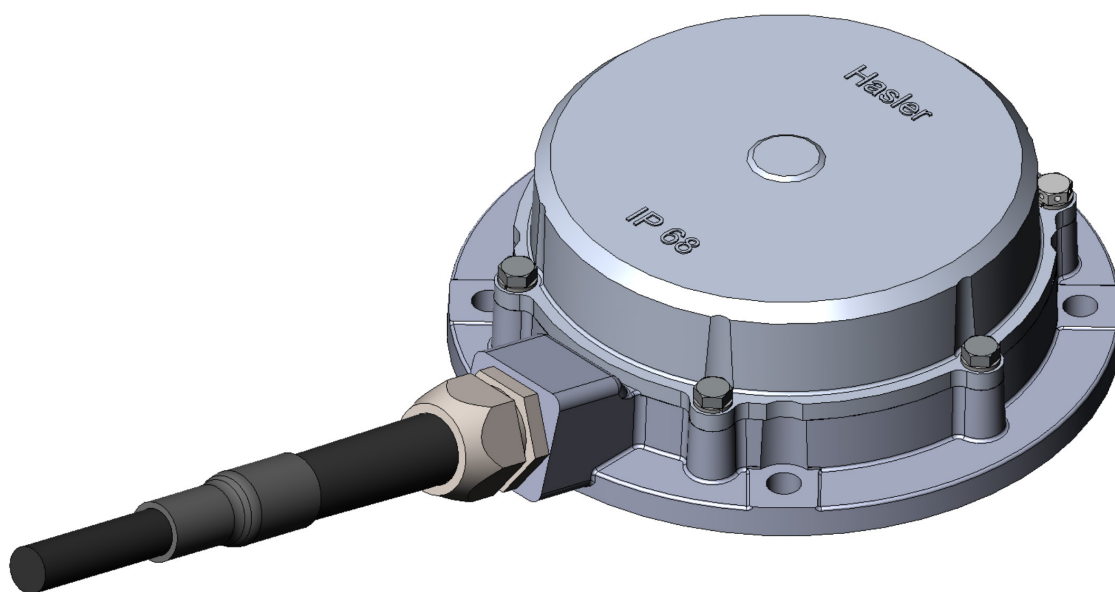


SPEED SENSING AND ODOMETRY

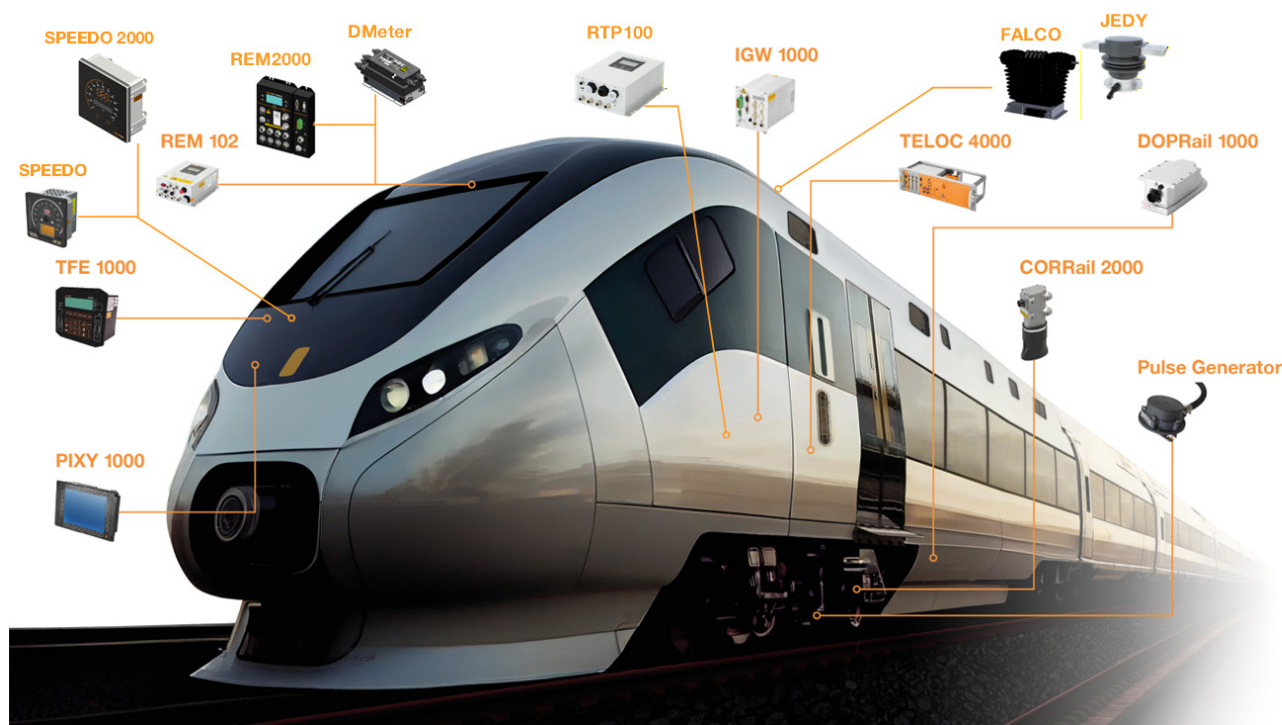
WHEEL-DEPENDENT SPEED SENSOR

Optical Pulse Generator



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 management and visualisation.



Initialisms and acronyms

The table below lists the initialisms and acronyms (short forms) used within this data sheet and provides expansions to aid understanding. SI base units and derived units are not included.

Short form	Expansion
ETCS	European Train Control System
IP	Ingress Protection
IR	Infrared
LED	Light Emitting Diode
LRU	Line Replaceable Unit
MTBF	Mean Time Between Failures
OSM	Optical Sensor Module
rpm	Rotations per minute
SIL	Safety Integrity Level
SRU	Shop Replaceable Unit

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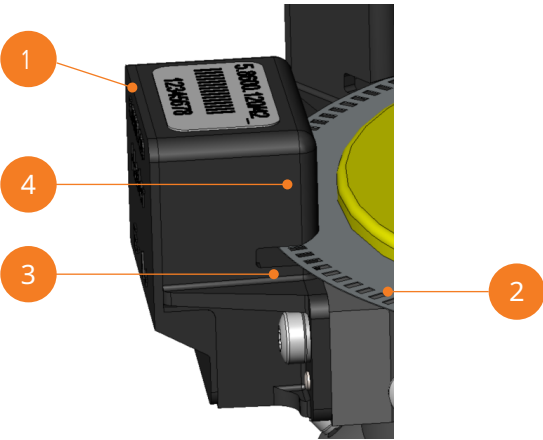
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1. Product description

The optical pulse generator (OPG) is designed to generate variable frequency signals representing vehicle speed, distance travelled and vehicle direction for use by on-board equipment including:

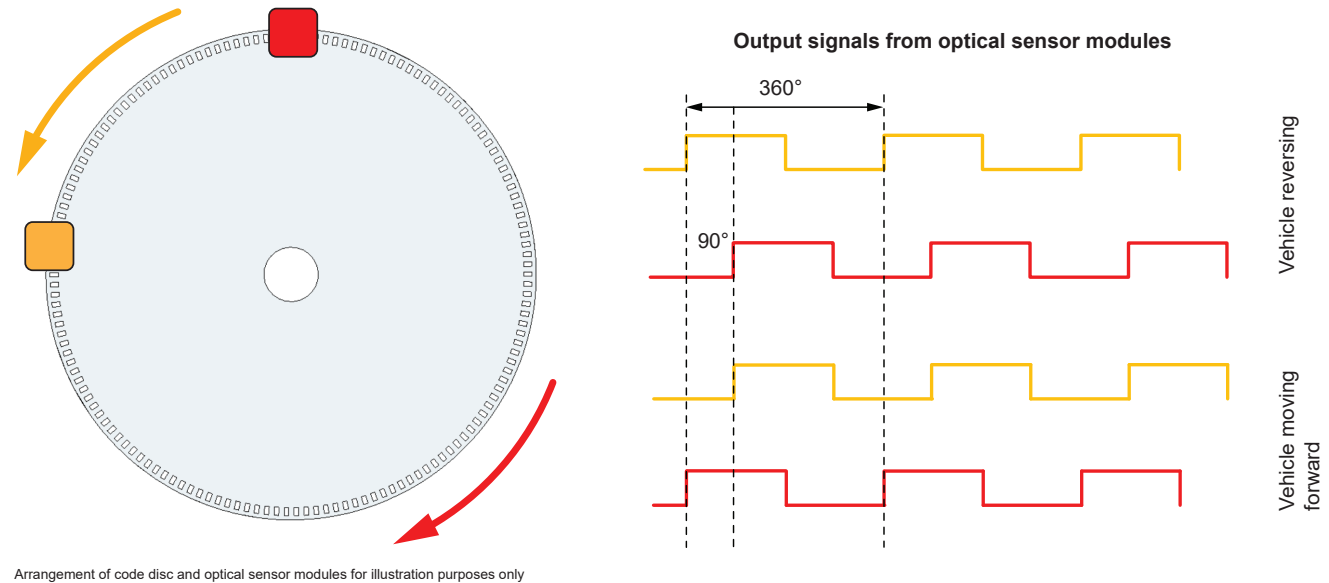
- Speed and distance indicators
- Speed, distance, acceleration and direction recorders
- Wheel slip / slide detectors
- Safety and signalling systems performing up to SIL4

The principal signal generating components are the code disc and the optical sensor modules (OSMs). The code disc features at least one circumferential arrangement of equispaced apertures or windows. The OSMs carry an IR LED light source and a phototransistor separated by a gap through which the outer edge of the code disc passes (see sub-section 1.1). Variable frequency square-wave signals are generated using the “make and break” principle. When a code disc window passes between the light source and the phototransistor, the light strikes the phototransistor which produces an output signal, a digital “1”. As the code disc rotates, the window is momentarily replaced by solid material. This prevents the light source from striking the phototransistor and the sensor output goes low (digital “0”).



Item	Description	Item	Description
1	Optical sensor module	3	Phototransistor position
2	Code disc	4	IR LED position

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 OPG generates output signals with a frequency that represent the rotational speed and direction of the axle.



Arrangement of code disc and optical sensor modules for illustration purposes only

At least two OSMs are required to generate signals representing the speed *and* direction of the rail vehicle. This is illustrated in the figure above. 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

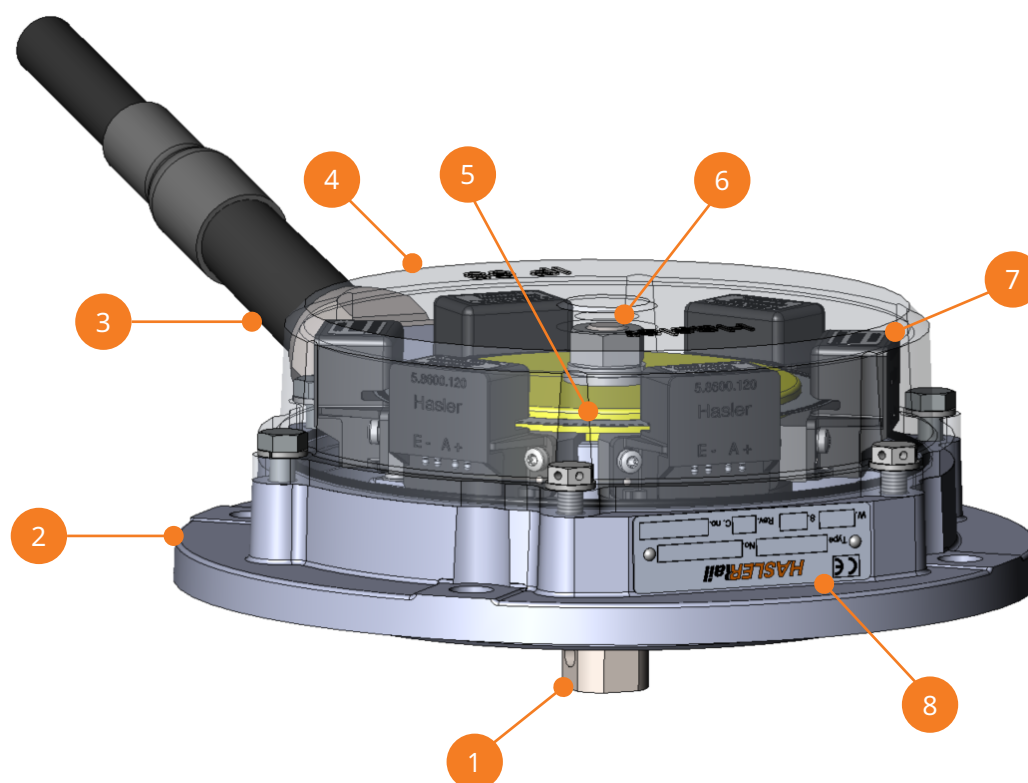
reversing. Conversely, if the axle and the code disc rotate clockwise, the output from the **red** channel will go high before the **orange** channel, i.e. it will lead by 90° to indicate that the rail vehicle is moving forward.

The OPG is extremely flexible and can be configured for multiple odometry applications through customisation of the code disc pattern(s) and varying the quantity and positioning of the OSMs. Phase shifting of the signals is definable by adjusting the physical position of the OSMs around the hub. For example, it is possible to generate two different frequencies per revolution with two code tracks and provide up to six independent signal outputs. The reliability and accuracy of the HaslerRail OPG make it ideal for use in ETCS and other signalling applications.

The output signals are carried, along with power, by the integrated cable to an intermediate junction box and on to on-board equipment via field wiring. The device housing, all internal components and interconnecting cable terminations are designed and constructed to withstand the harsh operating conditions experienced by axle-mounted equipment. The device has an ingress protection rating of IP68 / 69.

1.1 Principal components

The illustration below shows the OPG's main parts:



Item	Description	Item	Description
1	In-drive connection	5	Code disc
2	Main housing	6	Hub fasteners
3	Glanded power and signal cable	7	Optical sensor module (OSM)
4	Housing cover with gasket Shown transparent for clarity	8	Type plate

2. Mechanical design

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

The OSMs are secured around the circumference of the code disc such that they can detect the disc's code track.

The cable that carries power to and signals from the OPG enters the housing directly or through an integral gland dependent on the variant. The latter ensures 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 sheath.

2.1 Mechanical specification

Property	Value
Weight	Approx. 2.4 kg to 4.5 kg (depending on variant and cable length)
Housing and cover material	Cast aluminium alloy
Ingress protection level	IP68 and IP69
Operational temperature range	-40 to +70 °C
Torque	< 1.5 Nm (depending variant)
Speed range	0 – 3000 rpm
Mechanical coupling	Project specific
Cable and connector	Project specific

2.2 Product variants

The detailed specification of the product including OSM type, cable length, etc. is created using the OPG types listed below. Additional components required to configure the OPG design are defined within a specification sheet (5.86xx.0xx/xxKEN) and a project specific article will be number created.

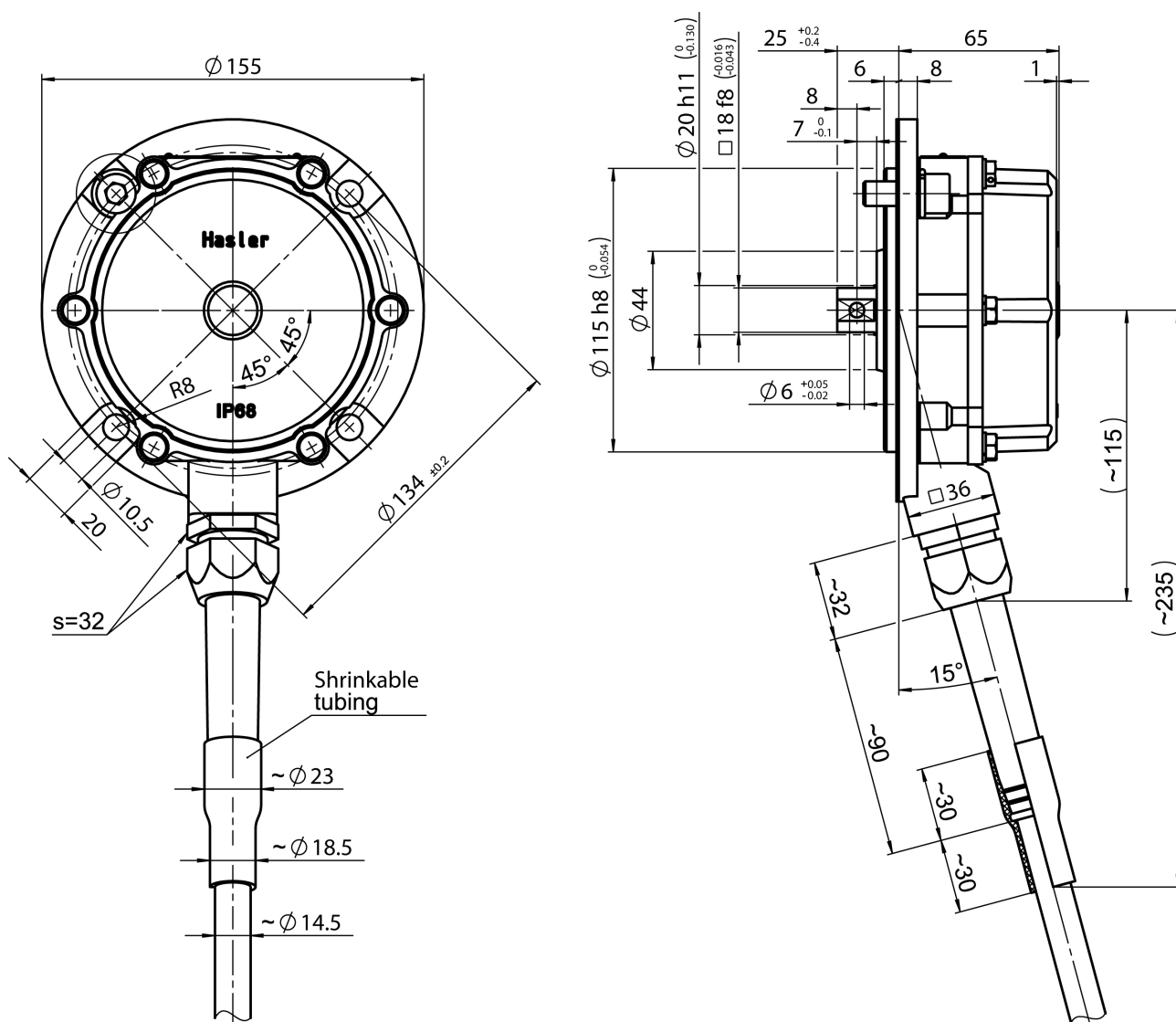
Depending on the mechanical design of the bogie and application requirements, different OPG types for inboard and outboard axle journals are available:

Type no.	Description	Qty. optical sensor modules
5.8600	For outboard axle journals on a fixed axle box cover. Direct cable inlet. Drive flange Ø 115 mm.	1 to 4
5.8601	For outboard axle journals on a fixed axle box cover. Cable entry via gland. Drive flange Ø 115 mm. On request only.	1 to 4
5.8602	For inboard axle journals on a rotating wheel with torque bar. Direct cable inlet.	1 to 4
5.8603	For inboard axle journals. Cable entry via gland. On request only.	1 to 4
5.8604	For outboard axle journals on a fixed axle box cover. Direct cable inlet. Drive flange Ø140 mm.	1 to 6
5.8605	Exclusively for hollow axles and rubber tyres in metro applications. Cable inlet via gland.	1 to 5
5.8620	2 nd generation of type 5.8600. For outboard axle journals on a fixed axle box cover. Direct cable inlet. Drive flange Ø115 mm.	1 to 4

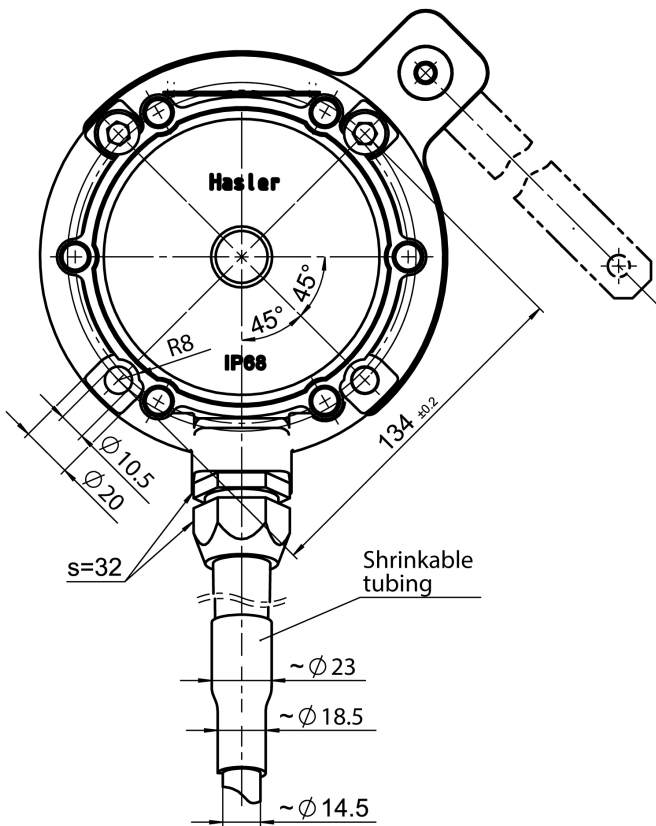
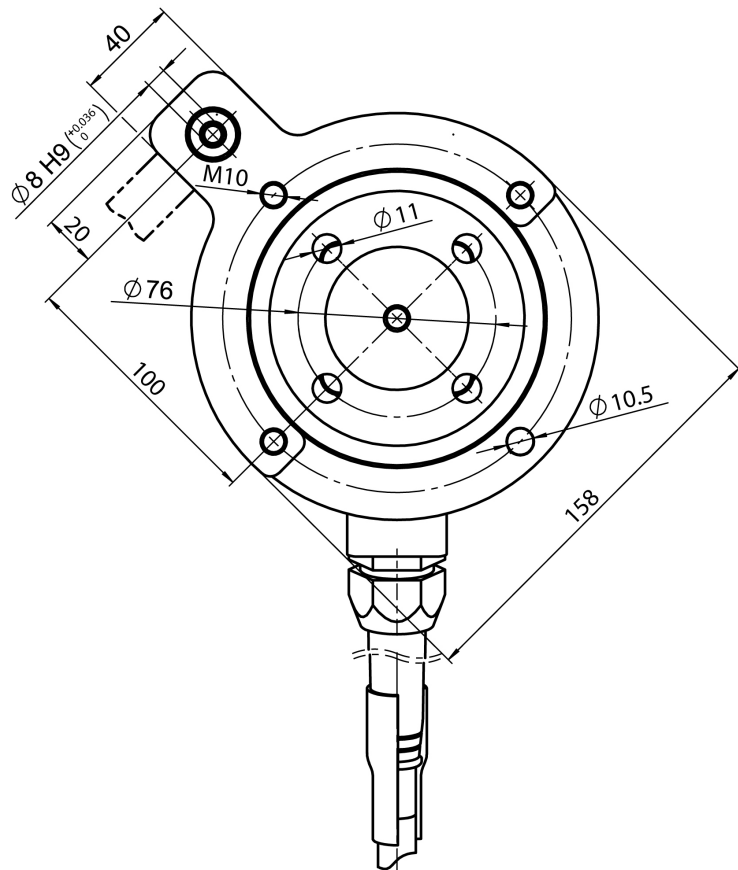
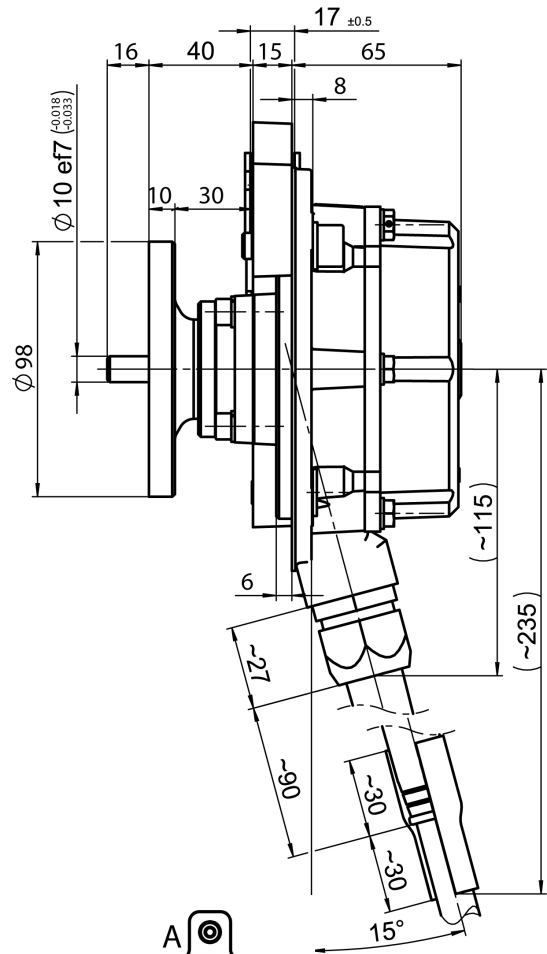
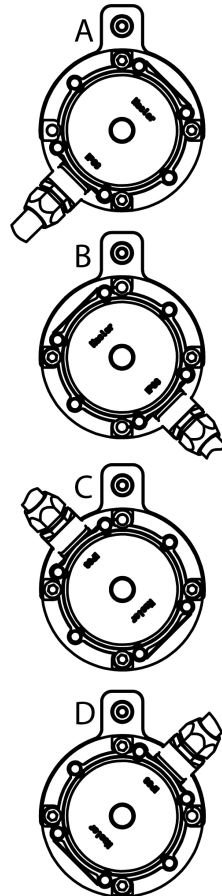
Type no.	Description	Qty. optical sensor modules
5.8621	2 nd generation of type 5.8601 For outboard axle journals on a fixed axle box cover. Cable entry via gland. Drive flange Ø 115 mm. On request only.	1 to 4
5.8622	2 nd generation of type 5.8602. For inboard axle journals on a rotating wheel with a torque bar. Direct cable inlet.	1 to 4
5.8623	2 nd generation of type 5.8603. For inboard axle journals on a rotating wheel with a torque bar. Cable inlet via gland. On request only.	1 to 4
5.8624	2 nd generation of type 5.8604. For outboard axle journals on a fixed axle box cover. Direct cable inlet. Drive flange Ø 140 mm.	1 to 6

2.3 Mechanical drawings

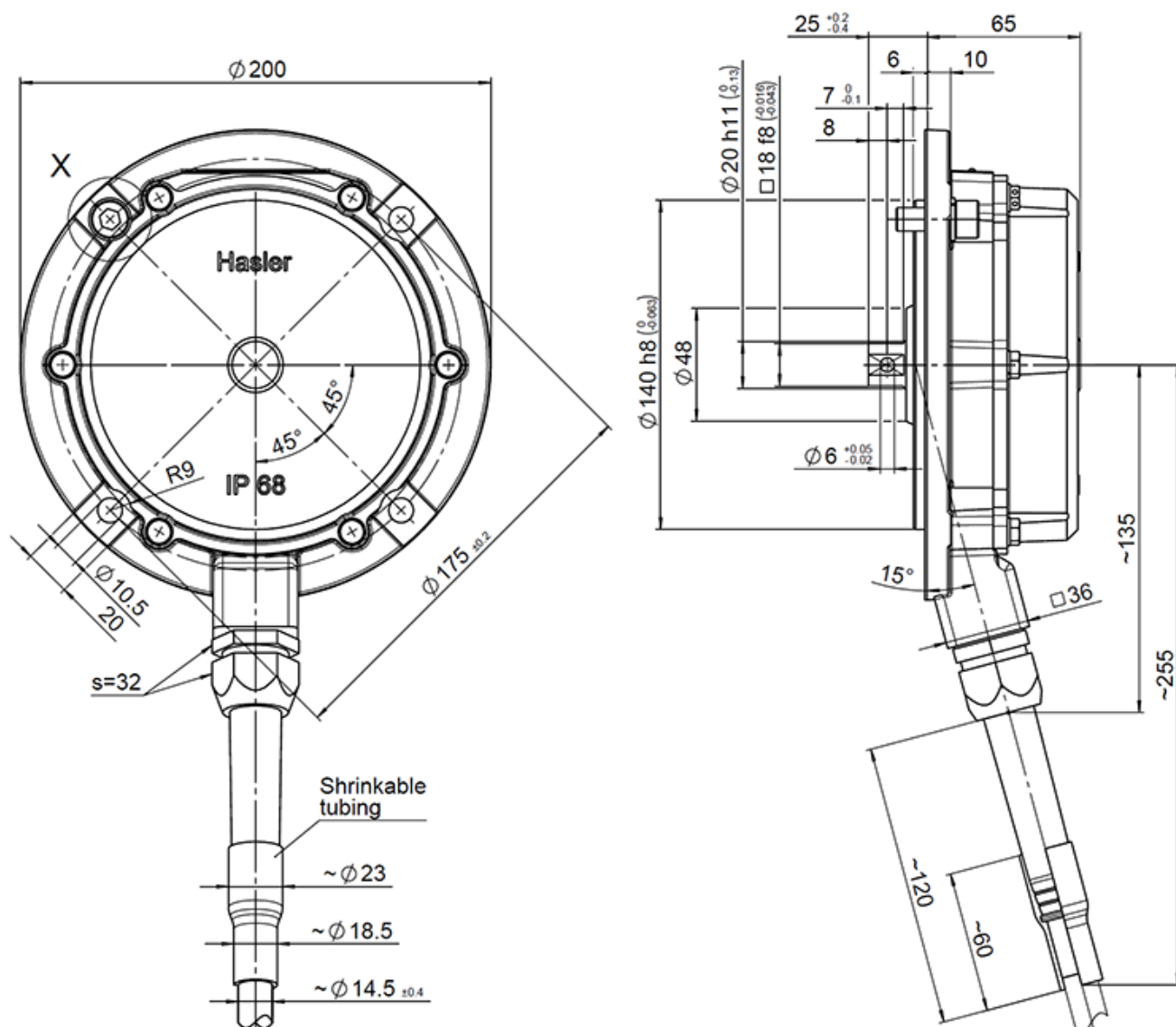
Types 5.8600 and 5.8620

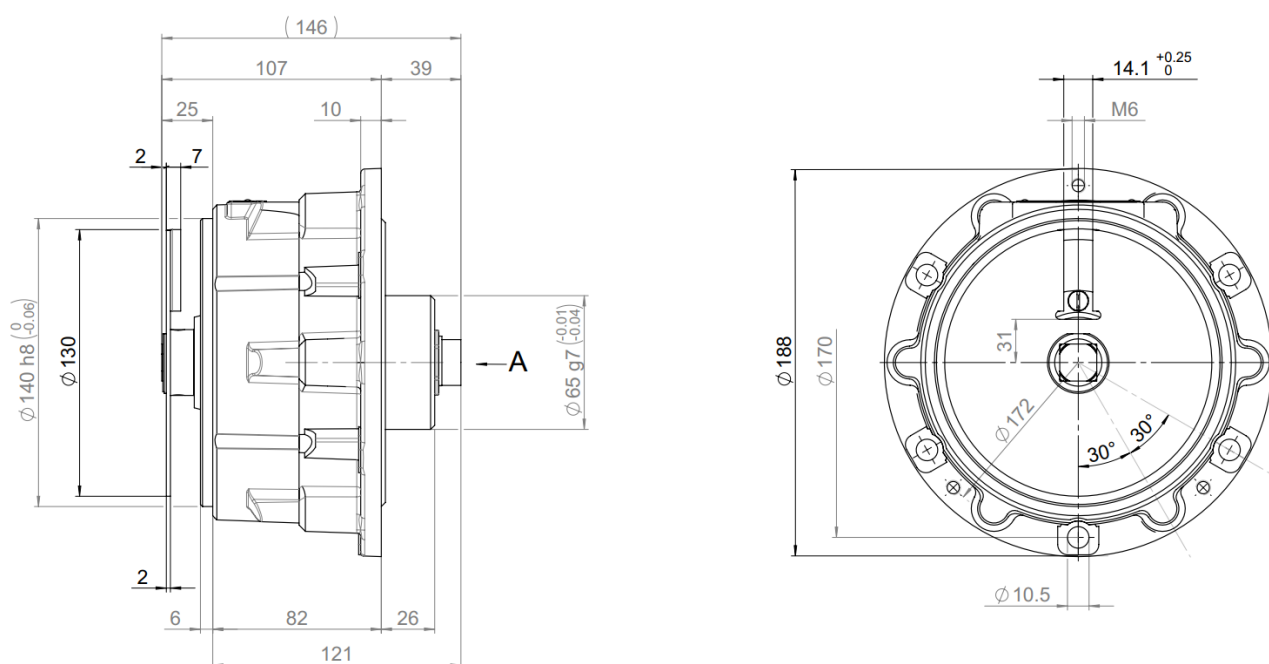


Types 5.8602 and 5.8622



Type 5.8624



Type 5.8605


2.4 Optional parts

The following components are available to be ordered with the OPG:

Component	Description
Cable connector	Connector for OPG power and signal cables - Gimota GB and GR series (5, 7, 13, 16, or 24 pins) - Harting HPR series (8, 10, 12, 16, 18 or 24 pins) - Several other types available to suit application
Mechanical coupling	In-drive coupling between the OPG and train axle: - Drive fork and pin - Flexible drive tongue - Differential disc
Adapter flange	Adapter to install the OPG on different axle cover hole diameters
Fastener set	Screws and lock washers to attach the OPG to the train axle cover or wheel

3. Electrical design

The electrical / electronic components in the OPG are limited to the OSMs and associated power and signal wiring.

3.1 Electrical specification

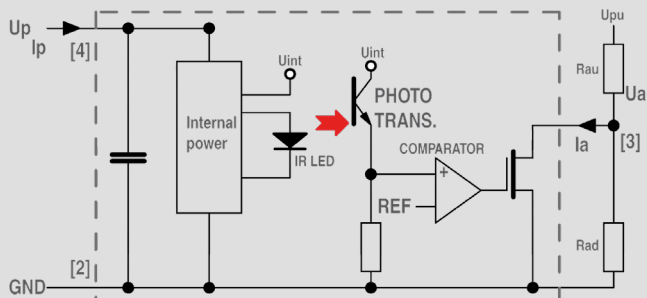
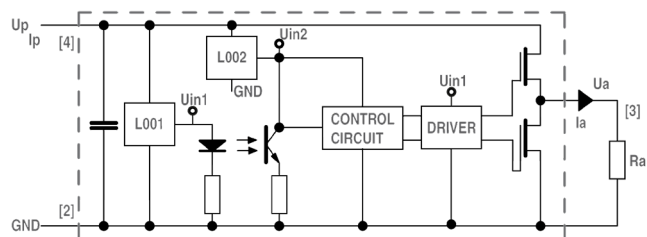
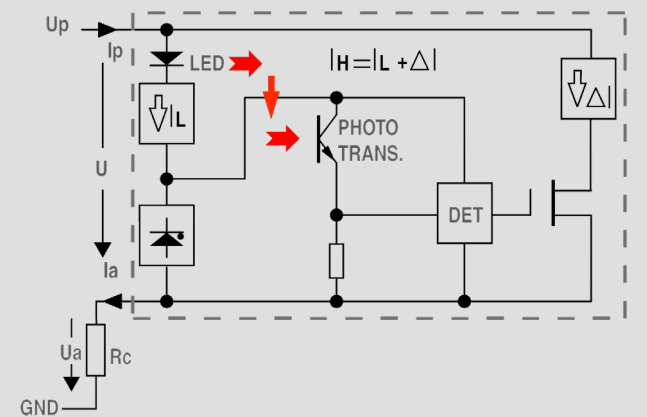
Output signals	Square wave with voltage 0 – 30 VDC or current output 7 – 16 mA dependent on OSM type, voltage level and loads
Duty cycle	40 – 60 %
Max. power consumption	Dependent on sensor type and number of OSMs installed
Power supply	10 – 30 VDC dependent on OSM type
Code disc	1 or 2 independent code tracks
Pulses per rotation	1 to 200 pulses per revolution (up to 400 pulses per revolution or special code on request)
Frequency range	Up to 3 kHz, 6 kHz or 10 kHz, dependent on OSM type
Dielectric test	1.5 kV, 50 Hz for 10 s (The dielectric test is done between sensor and ground and between the sensors themselves)

3.2 OSMs

Several types of OSMs are available for the OPG. The type selected must be compatible with the signal medium and electronic interface of the receiving device or system. Information about power requirements and output signal characteristics is provided in our OSM data sheets.

Note: custom-built OSMs may be evaluated for development to satisfy specific customer requirements.

Article Number	Description	HaslerRail datasheet no.
5.8600.120/41	Standard type with integrated current limitation. No signal voltage regulator 	5.0301.030-01TEN
5.8600.120/42	With 8 V signal voltage regulator 	5.0301.030-02TEN

Article Number	Description	HaslerRail datasheet no.
5.8600.120/43	Open drain for external pull-up resistor. 	5.0301.030-03TEN
5.8600.120/71	Push-pull signal output 	5.0301.030-13TEN
5.8600.120/81	Current output 7-16 mA 	5.0301.030-14TEN

3.3 Cable and connector

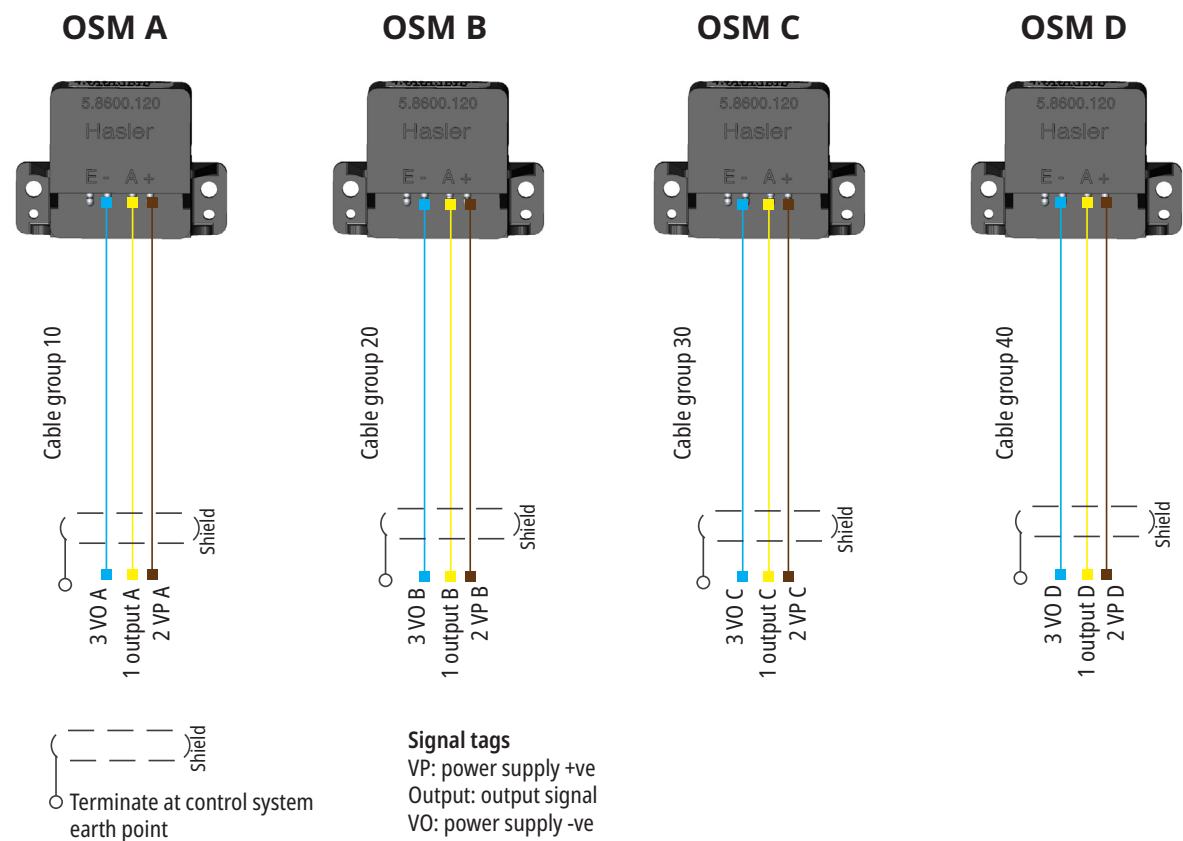
OPG's are normally supplied with a fixed cable gland in the side of the main housing. This is our recommended cable entry type as it provides strain relief and greater resistance to vibrations. The cable length and connector type can be selected for the specific application. If a connector type is not specified, the cable will be delivered with flying leads. HaslerRail AG recommends that a connector is used in situations where interconnecting wires will be routed to the vehicle underframe or and underslung terminal box.

The cable connection at the vehicle interface point must have an ingress protection rating of IP67 or higher. HaslerRail AG recommends the use of circular connectors from Gimota AG or equivalent with rubber coated housings for improved reliability and durability in the harsh environments experienced by rail vehicles.

3.4 Connection diagram

The connection scheme for each OPG variant is defined in the project specific documentation and is dependent on the selected OSM type and the type of cable connector. For OPGs delivered with flying leads, the standard pin assignments are as follows:

Diagram depicts an OPG with four optical sensor modules (OSMs)



4. Environmental and RAMS

4.1 Environmental attributes / limits

Property	Details
Operating temperature range	-40 °C – +70 °C (ambient temperature) In accordance with EN 50155:2021 class OT4
Natural cooling or forced ventilation constraints	Natural convection, no active cooling required
Storage temperature range	-40 °C – +85 °C
Shock and vibration categories & classes	EN 61373:2010 +AC:2017-09: Category 3 (axle mounted)
Rapid temperature variation class	EN 50155:2021, Class H2
RoHS compliance	Yes, in accordance with 2011/65/EU
REACH compliance	Yes, in accordance to EU regulation (EG) Nr. 1907/2006
Fire behaviour compliance	EN 45545-2:2020 +A1:2015 Hazard Level HL3

4.2 RAMS features

Property	Details
Useful life class	> 20 years
Non repairable items list	OSM is shop replaceable
Repairable items list	OPG is shop repairable
Identification of the LRU	OPG
Identification of the SRU	OSM
Mean time to restoration (MTTR)	LRU: OPG Labour on vehicle: 10 minutes Labour off vehicle: n/a SRU: OSM Labour on vehicle: n/a Labour off vehicle: 30 minutes
Storage recommendations	Acceptable ambient temperature of storage area: 0 °C – +45 °C with maximum temperature variation of 20 °C in one day the equipment is considered in storage. Storage period is not deducted from useful lifetime of the product, this being limited to the maximum duration of 3 years.
Periodic maintenance instructions	- Visual check every six months. - Periodic inspection every 12 to 36 months or 200,000 to 500,000 km - General overhaul every 10 years or 2,000,000 km
Reliability [MTBF hours]	> 500,000 hours depending on type and number of OSMs installed.
Reliability calculation model	Average temperature surrounding OPG T_e : 45 °C Diurnal temperature variation dT : 10 °C Use factor: 100 % Average speed: 600 rpm
Specification and demonstration of reliability, availability, maintainability and safety (RAMS)	EN 50126-1:2017 EN 50126-2:2017

5. Routine and type test compliance

The test categories and test criteria detailed in the table below apply to all OPG variants.

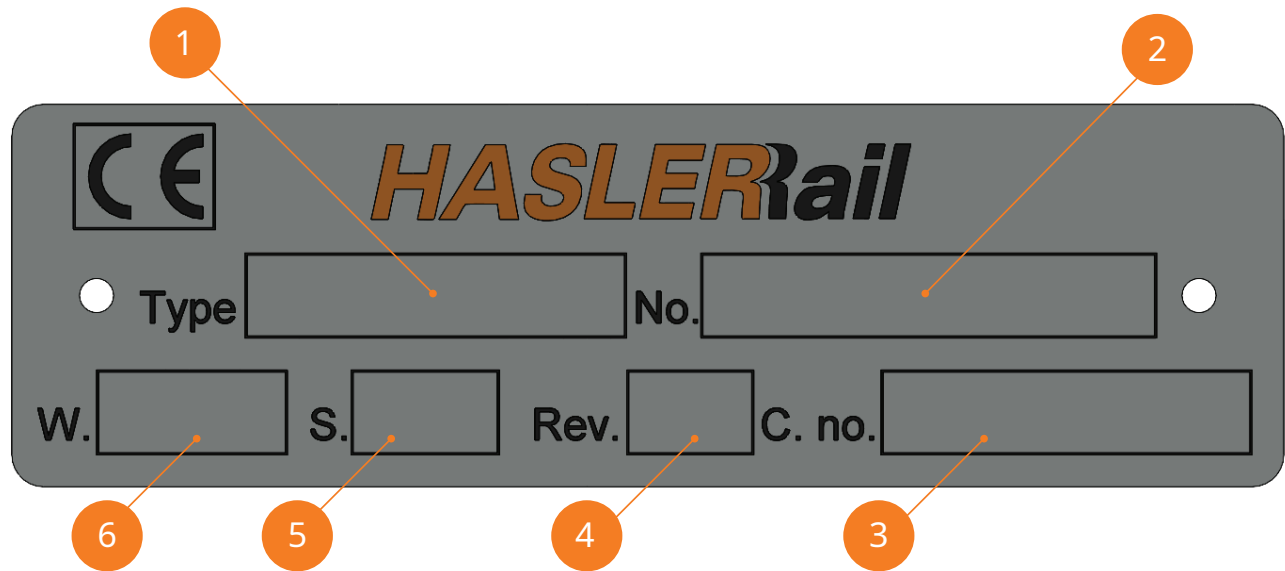
	Type test	Routine test	Standard	Performance criterion
Railway applications - Rolling stock - Electronic equipment	See details	See details	EN 50155:2021 IEC 60571:2012	See details
Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus	See details	See details	EN 50121-3-2:2016 +A1:2019 IEC 62236-3-2:2018	See details
Visual inspection	Yes	Yes	EN 50155:2021, 13.4.1	Physical dimensions of the device align with those shown on the mechanical arrangement drawing All components shown on arrangement drawing are present and show no signs of damage Type plate is affixed to device and indicates correct details for device variant
Performance test	Yes	Yes	EN 50155:2021, 13.4.2	Performance aligns with technical requirement spec. for device
Insulation test	Yes (60 s)	Yes (10 s)	EN 50155:2021, 13.4.7	Insulation resistance > 100 MΩ Insulation test voltage 1500 VAC
Low temperature storage test	Yes	No	EN 50155:2021, 13.4.6 EN 60068-2-1:2007 IEC 60068-2-1:2007	Test Ad @ temperature class OT4 (-40 °C) 16 h in off-state After recovery performance criteria A
High temperature storage test	Yes	No	EN 60068-2-2:2007 IEC 60068-2-2:2007	Test Bd temperature +85 °C 16 h in off-state
Low temperature start-up 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 h in operation
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) 6 h @ 70 °C, then 10 min @ 85 °C
Cyclic damp heat test	Yes	No	EN 50155:2021, 13.4.9 EN 60068-2-30:2005 IEC 60068-2-30:2005	Temperatures: +25 °C / +55 °C @ 95 % rH Two cycles each 24 h, total duration 48 h
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 IP69

	Type test	Routine test	Standard	Performance criterion
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 μ V quasi-peak 0.5 – 30 MHz, 93 dB μ V quasi-peak
			EN 50155:2021, 13.4.9 EN 50121-3-2:2016 +A1:2019 IEC 62236-3-2:2018 Radiated emission	Enclosure port: 30 – 230 MHz, 40 dB μ V/m quasi-peak at 10 m 230 MHz – 1 GHz, 47 dB μ V/m quasi-peak at 10 m 1 – 3 GHz: 76 dB μ V/m peak at 3 m 56 dB μ V/m avg. at 3 m 3 – 6 GHz: 80 dB μ V/m peak at 3 m 60 dB μ V/m avg. at 3 m
			EN 50155:2021, 13.4.9 EN 61000-4-2:2009 IEC 61000-4-2:2008 Electrostatic discharge	Contact discharge: $\pm$ 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
			EN 50155:2021, 13.4.9 EN 61000-4-4:2012 IEC 61000-4-4:2012 Fast transient/Burst	Signal and communication ports: $\pm$ 2 kV Burst frequency: 5 kHz and 100 kHz Performance criteria A
			EN 50155:2021, 13.4.9 EN 61000-4-6:2014 IEC 61000-4-6:2013 Immunity to conducted disturbances	Signal and communication ports: 0.15 MHz – 80 MHz 10 V rms, 80 % AM, 1 kHz Performance criteria A
Vibration and shock 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	No	No	EN 50155:2021, 13.4.11 EN 61163-1:2006 IEC 61163-1:2006	Thermal cycling
Rapid temperature variation test	Yes	No	EN 50155:2021, 13.4.12	Class H2

6. Product marking

This section illustrates and describes the product marking on the OPG housing.

6.1 Type plate



Item no.	Description	Item no.	Description
1	OPG type number See sub-section 6.2 for details of number structure	4	Device revision status This will be incremented with any significant change
2	Unique serial number Comprises year, calendar week and a sequential number	5	Quantity of OSMs installed in OPG
3	Customer no.	6	Quantity of windows (apertures) in code disc

6.2 Type number structure

The table below explains what is denoted by the elements of the device type number.

Example: 5.8601.054/25
 5.86xx.0yz/dd

Type number element	Description
5	Standard prefix for HaslerRail products
86xx	Variant details and application
	<div>8600</div> <div>8620 (2nd generation)</div> <div>For outboard axle journals. Up to four OSMs Direct cable inlet Drive flange diameter 115 mm</div>
	<div>8601</div> <div>8621 (2nd generation)</div> <div>By special request only</div> <div>For outboard axle journals. Up to four OSMs Cable inlet via gland Drive flange diameter 115 mm</div>
	<div>8602</div> <div>8622 (2nd generation)</div> <div>For inboard axle journals. Direct cable inlet Drive flange diameter 98 mm</div>
	<div>8603</div> <div>8623 (2nd generation)</div> <div>By special request only</div> <div>For inboard axle journals. Cable inlet via gland</div>
	<div>8604</div> <div>8624 (2nd generation)</div> <div>For outboard axle journals. Up to six OSMs Direct cable inlet Drive flange diameter 140 mm</div>
	<div>8605</div> <div>8610</div> <div>Exclusively for hollow axles and rubber tyres in metro applications Up to five OSMs Cable inlet via gland For retrofits to housing type 5.8400</div>
0y	Optical sensor type
	<div>00</div> <div>Development / preproduction series</div>
	<div>01</div> <div>Standard type with current limiter</div>
	<div>02</div> <div>8 V voltage regulator</div>
	<div>03</div> <div>Open drain</div>
	<div>04</div> <div>Current output 7 - 16 mA</div>
	<div>05</div> <div>Push-pull</div>
	<div>09</div> <div>Mixed sensor types or special configuration</div>
z	Number of OSMs in the device
dd	Incremental number assigned to design variant

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