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Safety for Rail

Sensor Technology and Axle Counting.

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Product group:	Wheel sensor	Document status:	Released
Product type:	2N59-1R-250-40	Release status:	23.06.2022

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1.3 List of abbreviations

Abbreviation	Comments
U_L	Open-circuit voltage
U_{SYS}	System voltage
f_{S1}	Frequency system 1
f_{S2}	Frequency system 2
v	Speed

1.4 Safety instructions

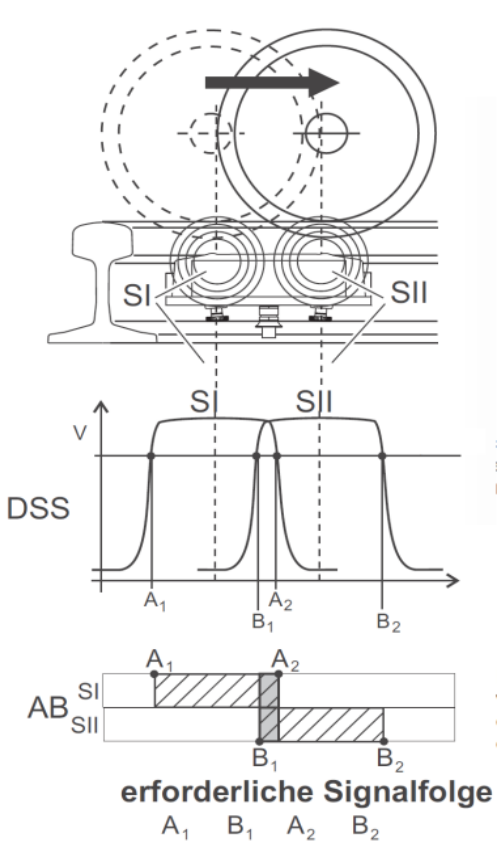
The safety instructions used in this document are listed below. Please note that it is essential to follow these instructions in order to avoid possible damage to property or injury to persons.

Symbol	Signal word	Comments
	Tipp	Useful recommendations are given in this section
	Note	This section draws attention to potential problems
	Caution	Hazards that can lead to minor injury or serious damage to property.
	Warning	Hazards that could result in serious injury or death
	Danger	Immediate hazards that are certain to result in serious injury or death

Table 1: Safety instructions

2 Usage

2.1 Active principle



The purpose of the wheel sensor is the direction-dependent detection of the wheel flanges of track wheels.

The metal mass of the wheel flange above the double rail switch causes damping of the two individual wheel sensor systems. This leads to a change in the internal resistance of the wheel sensor systems. This change can be processed by a connected electronic evaluation module and output pulses can be generated.

Due to the arrangement of the two wheel sensor systems, two overlapping pulses are generated by the passing wheel flange. These pulses can be used for direction-dependent axle counting and for generating direction-dependent switching commands (Illustration 1).

The switch is mounted on the inside of the track, 45 mm below the top of the track (relating to a new rail).

The wheel sensor is delivered with an integrated reduction sheet.

/ required signal sequence

Illustration 1: Active principle of the wheel sensor

2.2 Variants

There are two variants of the wheel sensor type 2N59-1R-250-XX:

1. 2N59-1R-250-45: This wheel sensor is designed for operation on evaluation devices according to NAMUR (DIN EN 60947-5-6 : 12/2000) and is suitable for travel speeds of ≤ 80km/h (cf. [DB250_45_NAMUR] chap. 3.1). On an evaluation device with 3.2mA constant current with 8V ± 5% open circuit voltage, the wheel sensor is suitable for overrun speeds of ≤ 60 km/h or 45km/h (cf. [DB250_45] chap.3.1).

2. 2N59-1R-250-40: This wheel sensor is designed to operate on an evaluation unit with 3.2 mA constant current with 8V ± 5% open circuit voltage. It is suitable for travel speeds ≤ 250 km/h (→ chap. 3.1 Travel mode).

This data sheet only describes the 2N59-1R-250-40 in constant current operation. For the other variants, please refer to the corresponding data sheets.

3 Technical data

3.1 Driving operation

Activation	:	Through the wheel flange
Rail profiles	:	General: S33 bis S54, AREA 100 bis AREA 141 • DB Netz AG: S49, S54, UIC60 • SBB (CH): SBB I bis SBB VI In case of deviating rail profiles, safe function must be coordinated with the manufacturer.
Metal-free space		The metal-free space according to [ERA/ERTMS/033281 : 09/2018] must be observed. Otherwise, the wheel sensor may be influenced. Exceptions are described or can be coordinated with the manufacturer.
Permitted wheels	:	All wheels complying with [EBO : 04/2019] and [ERA/ERTMS/033281 : 09/2018] tables 2 and 4 are permitted.

Maximum travel speed	:	≤ 60 km/h	≤ 80 km/h	≤ 250 km/h
Wheel diameter (wheel - ∅)	:	≥ 330 mm and < 375 mm	< 450 mm	≥ 450 mm
Minimum axle distance	:	≥ 720 mm and < 900 mm	≥ 720 mm and < 1200 mm	≥ 1200 mm

Lateral wheel offset (black area)	:	0 to 60 mm	
Wheel - ∅	:	330 to 760 mm	> 760 mm
Wheel flange immersion depth (wheel flange height S_h)	:	32 mm to 38 mm	26 mm to 36 mm
Static detection range	:	The combined detection range of both systems is symmetrical to the wheel sensor centre with a tolerance of ± 15 mm.	

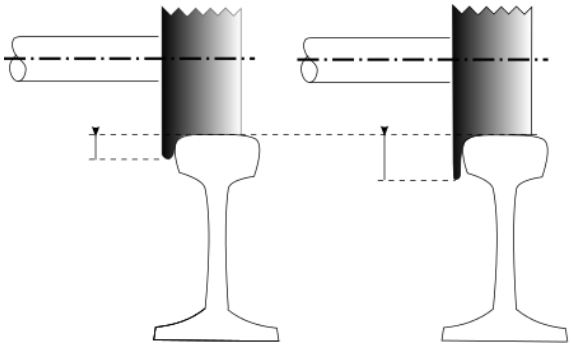


Illustration 2: Principle of wheel flange immersion depth

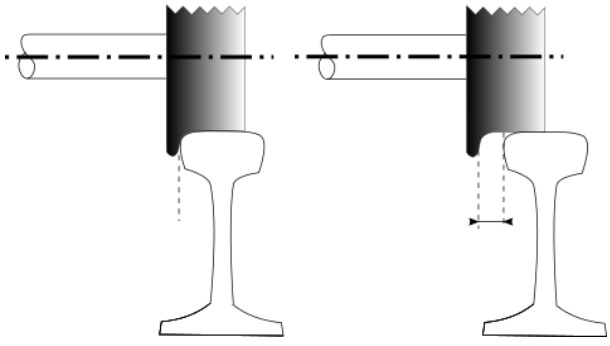


Illustration 3: Principle of lateral wheel offset

Rail wear	:	Maximum 16 mm in total, maximum 2 mm per maintenance cycle. After wearing down, the switch is mounted at a lower level, if necessary, using special mounting components (eccentric screws, available as accessories).

The wheel sensor must be lowered at the latest when the distance between the upper edge of the rail and the upper edge of the wheel sensor housing is 38mm. If lowering is no longer possible, the wheel sensor must be dismantled and taken out of operation.

3.2 Switching behaviour

Typical switching distance SA	:	43 mm [±0.5mm]
Minimum SA	:	37.5 mm
Maximum SA		50 mm*

* At higher switching distances than the typical switching distance, the temperature-related drift of the switching distance increases.

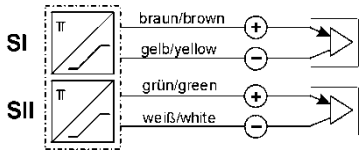
Switching behaviour dynamic, at v (cf. illustration 1)		**≤ 60 km/h**	**≤ 120 km/h****	**≤ 250 km/h****
• Output pulse length (t_{A2} - t_{A1} or t_{B2} - t_{B1})	:	≥ 12 ms	≥ 5 ms	≥ 3.5 ms
• Offset of the assignment of the sensor systems ($t_{B1} – t_{A1}$)	:	≥ 4 ms	≥ 2 ms	≥ 1 ms
• Overlapping of the sensor systems ($t_{A2} – t_{B1}$)	:	≥ 8 ms	≥ 3.5 ms	≥ 2.5 ms
• Free time between two axes	:	≥ 1.5 ms	≥ 1 ms	≥ 1 ms

** From a speed of 120km/h, only the offset of the "occupancy flanks" may be evaluated for direction detection (t_{A1}, t_{B1}).

Signalling safety: The wheel sensor is constructed with two individual sensor systems, each of which is not safe for signalling on its own. If the application expects a safe switching criterion (e.g. switching off the level crossing), signalling safety can only be achieved in combination of two criteria (occupancy of sensor systems 1 and 2 or-linked) with the downstream signalling equipment.

3.3 Control circuit

Connection diagram :



Connection cable : Wire cross-section 0.75 mm²; Ø 7.8 mm ± 0.15 mm

Open-circuit voltage : U_L = 8 V [±5%]

Constant current : 3.2 mA [±5%]

States of the wheel sensor : Damped wheel sensor → 6.45 V < U_{Sys} ≤ U_L - 1%

: Undamped wheel sensor → 2.5 V < U_{Sys} ≤ 6.25 V

Permissible line resistance	:	≤ 200 Ω		
Transmission frequency range	:	37.75 kHz ≤ f_{S1} ≤ 38.25 kHz 41.75 kHz ≤ f_{S2} ≤ 42.25 kHz		
Dielectric strength against housing, or system 1 against system 2	:	Surge voltage: Power frequency withstand voltage:		4.5 kV / 1.2 µs 2 kV / 50 Hz
Internal overvoltage protection	:	1.5 kW / 1 ms		
Permissible rail currents	:	50 Hz	• Continuous current	I_{DS} ≤ 2 kA_{eff}
			• Short-circuit current with limited availability*	I_{KS} ≤ 20 kA_{eff} for 100 ms
			• Short-circuit current without defect**	I_{KS} ≤ 40 kA_{eff} for 100 ms

Note:

* Miscounts may occur, but detection of overpassing is guaranteed.

** Miscounts may occur, but detection of overpassing is not guaranteed.

3.4 Climatic, electromagnetic and mechanical stress

Characteristics	Nominal value		Comments
	Min.	Max.	
Temperature range in °C	- 40	+ 80	Climate class according to DIN EN 50617-2 : 05/2016 has been tested according to the following generic standards: • DIN EN 60068-2-14 : 04/2010 (Nb: temperature change) • DIN EN 50125-3 : 10/2003 (environmental conditions) • DIN EN 60068-2-1 : 01/2008 (A: cold) • DIN EN 60068-2-2 : 05/2008 (B: dry heat)
Humidity load in % r.h.	10	100	
Protection class according to DIN EN 60529 : 09/2014	IP 68 (dust-proof and protection against water intrusion by temporary submergence)		
Resistance	Exposure to weather (DIN EN 50125-3 : 10/2003), UV radiation (DIN EN 50125-3 : 10/2003), contamination (DIN EN 50125-3 : 10/2003)		
EMC conformity	Tested according to DIN EN 50121-4 : 01/2016 in the areas of: • Interference voltage (Test specification DIN EN 55016-2-1 : 12/2014) • Interference field strength (Test specification DIN EN 55016-2-3 : 11/2014) • Static electricity discharge [ESD] (Test specification DIN EN 61000-4-2 : 12/2009) • Electromagnetic fields (Test specification DIN EN 61000-4-3 : 04/2011) • Rapid transients [Burst] (Test specification DIN EN 61000-4-4 : 04/2013)		

<table>
<tr><td></td><td colspan="3">• Surge voltages [Surge] (Test specification DIN EN 61000-4-5 : 03/2015)
• Conducted HF signals (Test specification DIN EN 61000-4-6 : 08/2014)
• Pulsed magnetic fields (Test specification DIN EN 61000-4-9 : 12/2001)
• Magnetic field with energy frequencies (Test specification DIN EN 61000-4-8 : 11/2010)</td></tr>
<tr><td rowspan="2">Mechanics – vibration according to DIN EN 50125-3 (at the rail)</td><td>Frequency range</td><td>Amplitudes (effective values of acceleration)</td><td>Test duration</td></tr>
<tr><td>5 Hz – 2000 Hz</td><td>Vertical 280 m/s^2
Transversal 140 m/s^2
Longitudinal 50 m/s^2</td><td>100 min./room axis,
in 3 room axes</td></tr>
<tr><td rowspan="3">Mechanics – shock according to DIN EN 50125-3 (at the rail)</td><td>Shock form</td><td>Amplitude</td><td>Room axes</td></tr>
<tr><td>Medium stress</td><td>420 m/s^2 for 6ms (± 1ms)</td><td>± vertical</td></tr>
<tr><td>Peak stress</td><td>2500 m/s^2 for 1ms (± 1ms)</td><td>± vertical</td></tr>
<tr><td>Electromagnetic rail brake</td><td colspan="3">There are no functional impairments with an activated magnetic rail brake.</td></tr>
<tr><td>Eddy-current brake
  </td><td colspan="3">Please note that wheel sensor types 2N59-1R-250-40 and 2N59-1R-250-45 are not designed for use on rail vehicles with eddy-current brakes.

If the wheel sensor is used in areas with activated linear eddy-current brakes, faulty output signals may occur.</td></tr>
<tr><td>Place of installation</td><td colspan="3">Up to 2200 m above sea level</td></tr>
</table>

Table 2: Climatic, electromagnetic and mechanical stress

3.5 MTBF time

MTBF: mean time between failure (mean operating time between failures for refurbished units)

FIT: failure in time (assumed errors by time) – reciprocal value of MTBF

Theoretical calculation according to SN29500:

Norm / Variant	SN29500	
	MTBF [h]	**FIT [per 10^9 hours]**
2N59-1R-250-40	2.120811.03	471.52

Table 3: MTBF and FIT

3.6 Wiring and Housing

Connection cable : • 4 * 0.75 mm² PURWIL PUR / PUR (polyurethane), moulded into housing
• Typical connection cable lengths: 5 m, 10 m, 20 m

Weight and colour : approx. 2 kg, black

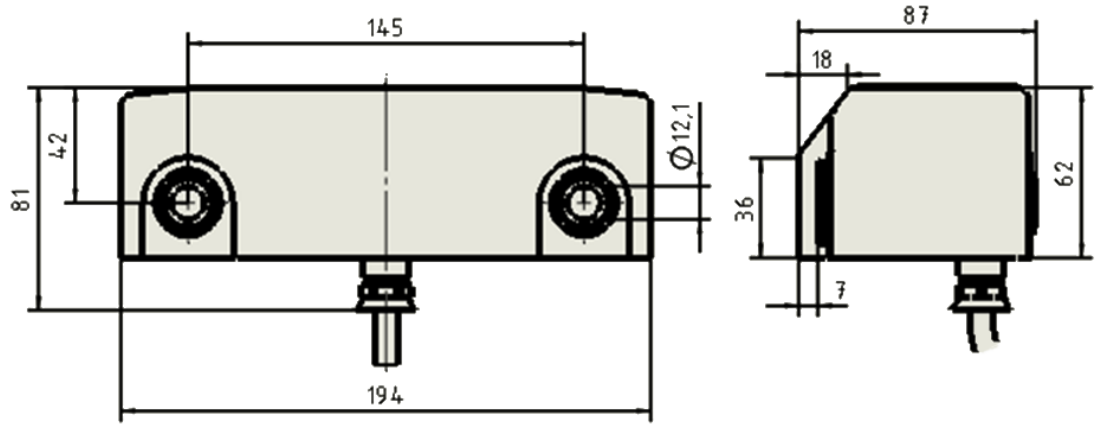


Illustration 4: Housing dimensions

4 Appendix

4.1 Overview of revisions

Status	Editor	Date	Reason for change
00	C. Schmücker	13.11.2020 13.01.2021 24.03.2021 21.04.2021 28.06.2021 29.06.2021 02.07.2021 05.07.2021 06.07.2021 12.07.2021 28.07.2021 02.08.2021 03.08.2021 04.08.2021	New version Formal changes in all chapters Change to chapter 3.2 Change to chapter 3.3. Change after verification in all chapters Change after verification in all chapters Change in all chapters Chapter 3.5 MTBF values adapted Change in chapter 3.3 Change chapter 3.3 Chapter 2.2 Chapter 3.3 adapted, and chapter 1.4 added Revision chapters 3 and 1.4 Revise chapter 3, add chapter 4
0A	C. Schmücker	13.09.2021 15.09.2021 16.09.2021 17.09.2021 18.09.2021 20.09.2021 22.09.2021 24.09.2021 26.09.2021 27.09.2021	Chapters 2.2 and 3.1 adapted Chapters 2.2 and 3.1 adapted Chapter 3.1 adapted Chapters 3.1 and 3.2 adapted Chapter 3.2 adapted Chapter 3.2 adapted Chapter 3.2 adapted Chapter 3.2 adapted Chapter 4.1 adapted Chapter 3.1 adapted
0B	C. Schmücker	05.11.2021	Adaptation chapter 3.1
0C	J. Ludwichowski C. Schmücker	17.12.2021 12.01.2022	Kap Chapter 3.1, wearing down per maintenance cycle added Chapter 3.3, damping limits corrected Chapter 3.4, shock and vibration added Chapters 3.5 and 3.4 adapted
0D	J. Ludwichowski	07.02.2022	Chapter 3.2 comment added
0E	J. Ludwichowski	23.03.2022	Chapter 3.3 frequency range adjusted
0F	J. Ludwichowski	15.06.2022	Chapter 3.4 corrected

Table 4: Overview of revisions

4.2 Bibliography

Reference	Name	Comment	Edition
[DB250_45]	EL-83120-00	Data sheet for wheel sensor DSS-250	
[DB250_45_NAMUR]	2-EL-83120-01	Data sheet 250-45 NAMUR	
[DIN01]	DIN EN 61000-4-9	Electromagnetic compatibility (EMC) – Part 4-9: Testing and measurement techniques – Immunity to pulsed magnetic fields test	12/2001

Reference	Name	Comment	Edition
[DIN09]	DIN EN 61000-4-2	Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Static electricity discharge immunity test (ESD)	12/2009
[DIN10]	DIN EN 61000-4-8	Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Test for immunity to magnetic fields at energy frequencies	11/2010
[DIN11]	DIN EN 61000-4-3	Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Test for immunity to radio-frequency electromagnetic fields	04/2011
[DIN13]	DIN EN 61000-4-4	Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Rapid transient electrical disturbance/burst immunity testing	04/2013
[DIN14]	DIN EN 55016-2-1	Requirements for equipment and installations and definition of methods for measuring radio-frequency emissions (radio interference) and immunity – Part 2-1	12.2014
[DIN141]	DIN EN 55016-2-3	Requirements for equipment and installations and definition of methods for measuring radio-frequency emissions (radio disturbance) and immunity – Part 2-3	11.2014
[DIN142]	DIN EN 61000-4-6	Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances induced by radio-frequency fields	08/2014
[DIN15]	DIN EN 61000-4-5	Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity testing	03/2015
[EBO]	EBO	Railway Construction and Operating Regulations	05.04.2019
[EN121_4]	DIN EN 50121-4	Railway applications – Electromagnetic compatibility – Part 4: Emission and immunity of signalling and telecommunications equipment	01.2016
[EN125_3]	DIN EN 50125-3	Environmental conditions for equipment Part 3: Environmental conditions for signalling and telecommunications equipment	10.2003
[EN50617_2]	DIN EN 50617-2	Railway applications – Technical parameters of track vacancy detection systems for the interoperability of the trans-European rail system	05.2016
[EN6821]	DIN EN 60068-2-1	Environmental influences – Part 2-1: Test methods – Test A: Cold	01.2008
[EN68214]	DIN EN 60068-2-14	Environmental influences – Part 2-14: Test methods – Test N: Temperature changes	04.2010
[EN6822]	DIN EN 60068-2-2	Environmental influences – Part 2-2: Test methods – Test B: Dry heat	05.2008
[ERTMS]	ERA/ERTMS/033281	ERA/ERTMS/033281	20.09.2018
[NAMUR]	DIN EN 60947-5-6	Low-voltage switchgear and controlgear – Part 5-6: Control circuit devices and switching elements ; DC interface for proximity sensors and switching amplifiers (NAMUR)	01.12.2000

Table 5: Bibliography