User Manual
incl. Safety Manual

P168*2

Universal Speed Signal Doubler

Read before installation.
Keep for future use.

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Knick

Supplemental Directives

READ AND SAVE THIS DOCUMENT FOR FUTURE REFERENCE. BEFORE ATTEMPTING TO ASSEMBLE, INSTALL, OPERATE OR MAINTAIN THE PRODUCT, PLEASE ENSURE A COMPLETE UNDERSTANDING OF THE INSTRUCTIONS AND RISKS DESCRIBED HEREIN. ALWAYS OBSERVE ALL SAFETY INFORMATION. FAILURE TO COMPLY WITH INSTRUCTIONS IN THIS DOCUMENT COULD RESULT IN SERIOUS INJURY AND/OR PROPERTY DAMAGE. THIS DOCUMENT IS SUBJECT TO CHANGE WITHOUT NOTICE.

These supplemental directives explain how safety information is laid out in this document and what content it covers.

Safety Chapter

This document's safety chapter is designed to give the reader a basic understanding of safety. It illustrates general hazards and gives strategies on how to avoid them.

Warnings

This document uses the following warnings to indicate hazardous situations:

Icon	Category	Meaning	Remark
⚠	WARNING!	Designates a situation that can lead to death or serious (irreversible) injury.	The warnings contain information on how to avoid the hazard.
⚠	CAUTION!	Designates a situation that can lead to slight or moderate (reversible) injury.	
Without	NOTICE!	Designates a situation that can lead to property or environmental damage.	

Symbols Used in this Document

Symbol	Meaning
▶	Sequence of figures attached to an instruction for action
①	Item number in a figure
(1)	Item number in text

Table of Contents

1 Safety

This document contains important instructions for the use of the product. Always follow all instructions and operate the product with caution. If you have any questions, please contact Knick Elektronische Messgeräte GmbH & Co. KG (hereinafter sometimes referred to as "Knick") using the information provided on the back page of this document.

1.1 Intended Use

The product is suitable both for use with rolling stock and for industrial applications.

The universal speed signal doubler is suitable for the following fields of application:

- Galvanically isolated and non-interacting multiplication of speed sensor signals or binary status signals with the option of frequency division or conversion between voltage and current signals
- Speed measurement on rolling stock
- Systems on rolling stock that required route, time or speed information, for example:
    - Train protection system
    - Slide protection/brake control
    - Traction control
    - Anti-skid
    - Door control system
    - Collision alert system
    - JRU (juridical recorder unit)
    - Tachometer
    - PIS (passenger information system)
    - Driver assistance system
    - Computer-supported operational control
- Applications with encoders and speed sensors in general industrial environments

All names such as device, product or P168*2 describe the universal speed signal doubler in the different variants.

The nameplates on the products clearly specify the product properties.
→ *Nameplate, p. 10*

USE CAUTION AT ALL TIMES WHEN INSTALLING, USING, OR OTHERWISE INTERACTING WITH THE PRODUCT. ANY USE OF THE PRODUCT EXCEPT AS SET FORTH HEREIN IS PROHIBITED, AND MAY RESULT IN SERIOUS INJURY OR DEATH, AS WELL AS DAMAGE TO PROPERTY. THE OPERATING COMPANY SHALL BE SOLELY RESPONSIBLE FOR ANY DAMAGES RESULTING FROM OR ARISING OUT OF AN UNINTENDED USE OF THE PRODUCT.

1.2 Personnel Requirements

The operating company shall ensure that any personnel using or otherwise interacting with the product is adequately trained and has been properly instructed.

The operating company shall comply and cause its personnel to comply with all applicable laws, regulations, codes, ordinances, and relevant industry qualification standards related to product. Failure to comply with the foregoing shall constitute a violation of operating company's obligations concerning the product, including but not limited to an unintended use as described in this document.

1.3 Isolation

Measure the distances to slaves and conductive parts in the vicinity of the device in accordance with the applied standard. The operating company must implement, evaluate and ensure insulation coordination with the clearance and creepage distances and the corresponding standards (e.g., EN 50124-1).

1.4 Installation and Operation

All national and local regulations relating to the installation and operation of the product in force at the destination must be followed.

All connected current or voltage circuits must meet the SELV, PELV, or Area I requirements according to EN 50153.

- The product must be installed by qualified electrical engineering personnel.
- The product may not be opened, modified, or independently repaired. Replace it with an equivalent product. Repairs may only be carried out by Knick.
- The operating company must ensure compliance with the specified interface parameters and ambient conditions.
- The product must be installed in a lockable control cabinet.

See also
→ *Installation and Commissioning, p. 30*

1.5 Residual Risks

Observe the different levels of functional safety.

The product has been developed and manufactured in accordance with generally accepted safety rules and regulations, as well as an internal risk assessment. Despite the foregoing, the product may among others bear the following risks:

Ambient Influences

The effects of moisture, corrosion, and ambient temperature as well as high voltages and fast transients can affect the safe operation of the product. Observe the following instructions:

- P168*2 may only be operated in compliance with the specified operating conditions.
  → *Specifications, p. 43*

2 Product

2.1 Package Contents

- P168*2 in the version ordered
- Three-pole insertable jumpers
  - For 1-channel device: 1 unit
  - For 2-channel device: 2 units
- Two-pole insertable jumpers
  - For 1-channel device: 3 units
  - For 2-channel device: 6 units
- Test Report 2.2 according to EN 10204
- Installation Guide with safety instructions

Note: The user manual (this document) is published electronically. → *knick-international.com*

2.2 Product Identification

2.2.1 Example Design

Speed Signal Doubler	P	1	6	8	2	2	P	3	1	/	2	0
Input pulses/output pulses				8								
2 inputs → 2 outputs					2							
With non-interacting input (SIL 4) and safe signal transmission to the output (SIL 2)						2						
Modular enclosure							P	3				
Two-tier terminals in push-in version, pluggable									1			
Frequency division 1:1 or 2:1											2	
Power supply/auxiliary power 10 … 33.6 V												0

2.2.2 Product Code

P16800 Product Family	P	1	6	_	_	_	P	_	_	/	_	_	_	_	_	_	_
Input pulses/output pulses				8													
1 input → 1 output					1												
2 inputs → 2 outputs					2												
2 inputs → 2 outputs, configurable as DOT (direction of travel), frequency division 1:1 or 2:1 or 4:1 with retention of 90° phase shift[1]					9	0					3						
With non-interacting input (SIL 4, certification in preparation)						0											
With non-interacting input (SIL 4) and with functionally safe transmission of signal to the output (SIL 2)[2]						2											
Modular enclosure [3]								3									
Two-tier terminals in push-in version, pluggable									1								
Frequency division 1:1 or 2:1[4]											2						
Frequency division 1:1 or 4:1[4]											4						
Frequency division 1:1 or 8:1[4]											8						
Power supply/auxiliary power 10 … 33.6 V												0					
Special types[5]													-	S	x	x	x

1) Without middle voltage generation
2) No functionally safe transmission of signals to the output (SIL 2) when middle voltage detection is activated
3) For 35-mm DIN rail or ZU1472 wall-mount adapter (optional)
4) The phase shift is lost for P1682*P**.
5) Deviations from the user manual in accordance with the information on the product

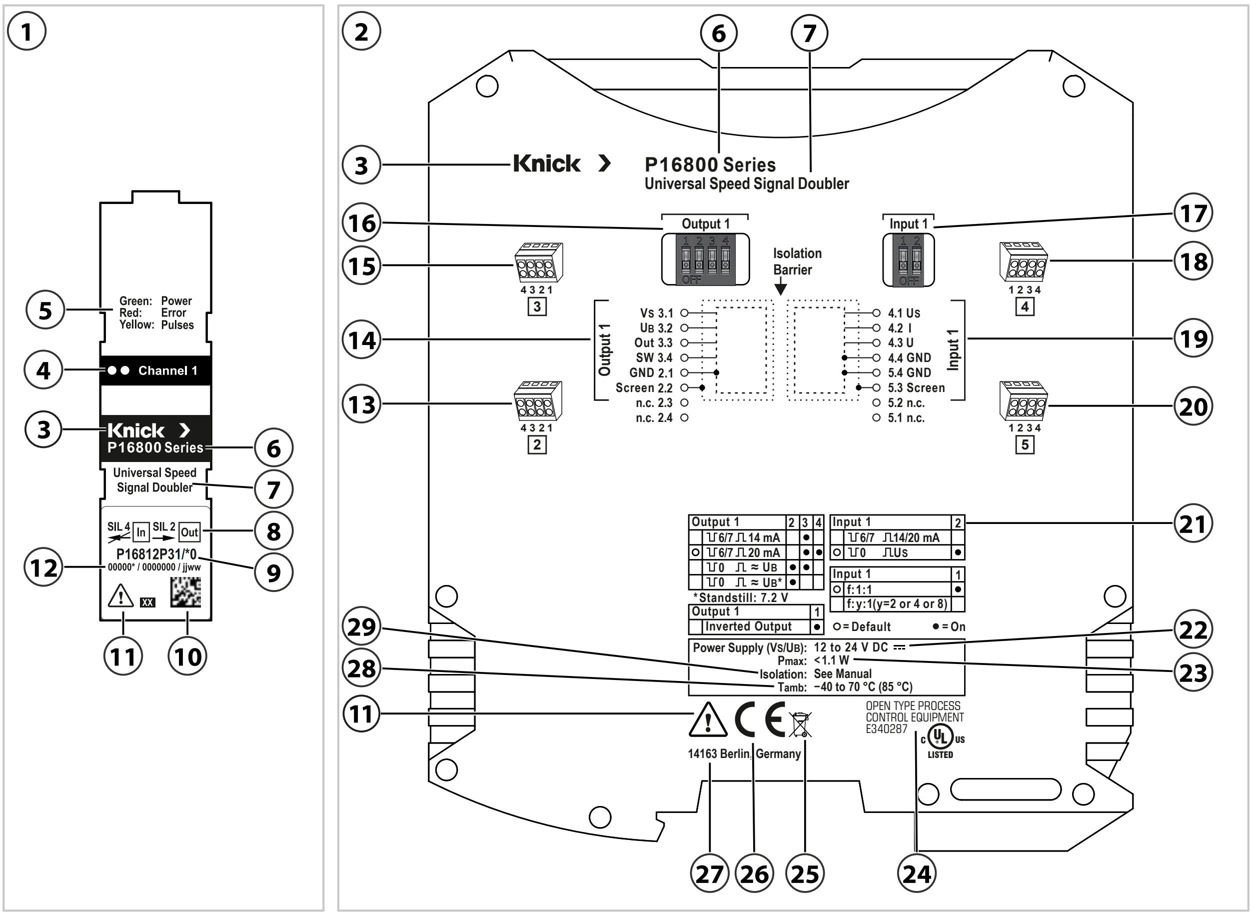
2.2.3 Nameplate

The P168*2 is identified by nameplates on the side and front of its housing. The information on the nameplates varies depending on the version of the product.

→ *Product Code, p. 9*

1-Channel Speed Signal Doubler P16812

Example:



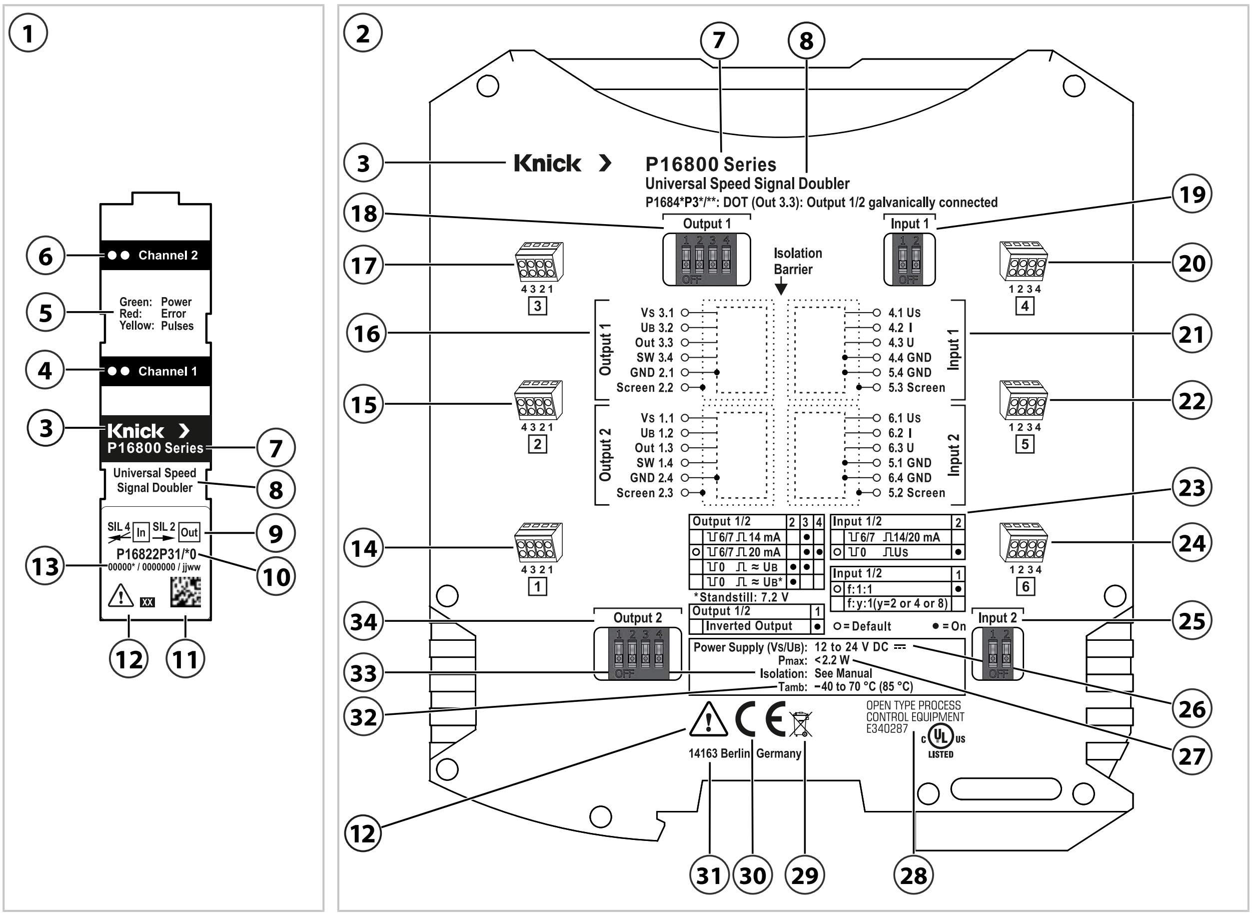
1	Nameplate, device front	16	DIP switch output 1
2	Nameplate, device side	17	DIP switch input 1
3	Manufacturer	18	Two-tier terminal 4
4	LED (2×) channel 1	19	Connection diagram input 1 from sensor 1
5	Meaning of LED display	20	Two-tier terminal 5
6	Product family	21	Configuration overview
7	Product designation	22	Power supply
8	SIL marking (if present)	23	Power consumption
9	Model designation	24	UL test mark
10	DataMatrix code with item and serial numbers	25	WEEE mark
11	Special conditions and danger points	26	CE mark
12	Item number/serial number/production date	27	Manufacturer address with designation of origin
13	Two-tier terminal 2	28	Permitted ambient temperature
14	Connection diagram output 1 to Control Unit 1	29	Isolation
15	Two-tier terminal 3		

See also

→ *Symbols and Markings, p. 12*

2-Channel Speed Signal Doubler P16822

Example:



1	Nameplate, device front	18	DIP switch output 1
2	Nameplate, device side	19	DIP switch input 1
3	Manufacturer	20	Two-tier terminal 4
4	LED (2×) channel 1	21	Connection diagram input 1 and 2 from sensor
5	Meaning of LED display	22	Two-tier terminal 5
6	LED (2×) channel 2	23	Configuration overview
7	Product family	24	Two-tier terminal 6
8	Product designation	25	DIP switch input 2
9	SIL marking (if present)	26	Power supply
10	Model designation	27	Power consumption
11	DataMatrix code with item and serial numbers	28	UL test mark
12	Special conditions and danger points	29	WEEE mark
13	Item number/serial number/production date	30	CE mark
14	Two-tier terminal 1	31	Manufacturer address with designation of origin
15	Two-tier terminal 2	32	Permitted ambient temperature
16	Connection diagram output 1 and 2 to control unit	33	Isolation
17	Two-tier terminal 3	34	DIP switch output 2

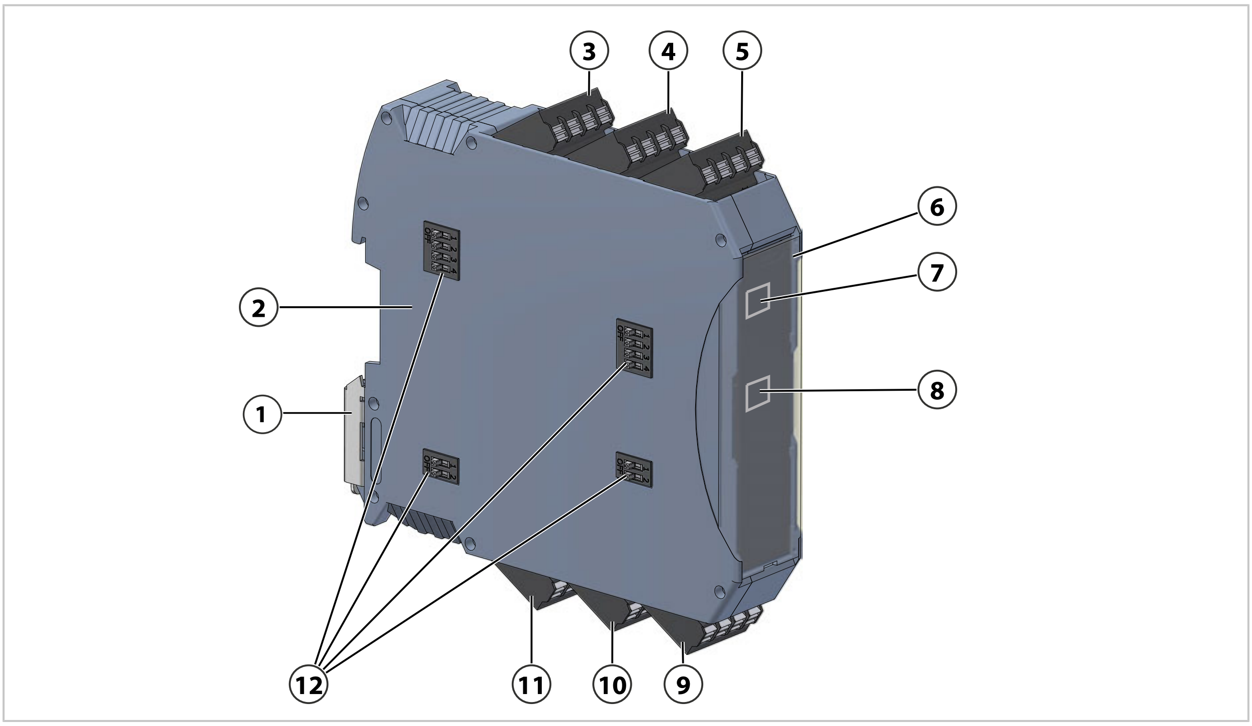
See also

→ *Symbols and Markings, p. 12*

2.3 Symbols and Markings

	Special conditions and danger points! Observe the safety instructions and instructions on safe use of the product as outlined in the product documentation.
CE	The affixed CE mark on the product indicates that the product complies with the applicable requirements stipulated in the harmonization legislation of the European Union.
c UL us LISTED	UL Listed: Combined UL mark for Canada and the United States
	The symbol on Knick products means that waste devices must be disposed of separately from unsorted municipal waste.
	Square-wave signal, high level
	Square-wave signal, low level
	DIP switch: Function ON
	DIP switch: Function OFF
	DIP switch: Factory setting (default)
SIL 4 In SIL 2 Out	Transmission of input signals to the output, fulfills SIL 2 specifications
SIL 4 In Out	Non-interacting decoupling of input signals, fulfills SIL 4 specifications

2.4 Design



1	Metal foot catch	7	LED (2×) channel 2 (if present)
2	Side (with nameplate)	8	LED (2×) channel 1
3	Two-tier terminal 1	9	Two-tier terminal 4
4	Two-tier terminal 2	10	Two-tier terminal 5
5	Two-tier terminal 3	11	Two-tier terminal 6
6	Device front (with nameplate)	12	DIP switch

See also

→ *Nameplate, p. 10*
→ *DIP Switches, p. 28*
→ *LED Signaling, p. 36*

2.5 Functional Description

The P168*2 universal speed signal doubler multiplies speed sensor signals or binary status signals by non-interacting decoupling. It records the pulses and transmits them to the output after electrical isolation, thus fulfilling SIL 2 specifications. The inputs process the sensor signals in a non-interacting manner and thus fulfill SIL 4 specifications.

P168*2 is available in 1- and 2-channel versions.

P16812	1 input, 1 output
P16822	2 inputs, 2 outputs

The inputs of the P168*2 are set up such that the speed sensors can be connected with the current or voltage output. The outputs of the product can be configured as current or voltage outputs and behave like a speed sensor for the controllers. The voltage inputs and outputs are designed for rectangle signals with HTL level. The output signals map the input signals (High/Low level).

Depending on the product type, the P168*2 divides the frequency of the input signal at a ratio of 1:1, 2:1, 4:1 or 8:1 to the output signal. When frequency division 2:1, 4:1 or 8:1 is activated, the output signal has a duty cycle of 50 %, regardless of the duty cycle of the input signal. The phase shift of frequency-divided signals is lost, which makes it impossible to evaluate the information on the direction of rotation. A frequency division higher than 8:1 can be achieved by the series connection of multiple channels.

The output signals can be inverted.

Other functions and properties of the P168*2:

- Improvement of SIL properties by scanning the switch output (SW). The switch output (SW) is a diagnostic switch that changes to the open state when an error is detected.
- Galvanic isolation to protect the system and transmit measuring signals without distortion. Galvanic isolation improves the signal quality, decouples the controllers from the speed sensor and reduces EMC interference at the controllers.
- Supports standstill detection. When a standstill is detected in this operating state, a middle voltage is output as a signal.
- Adjustment of the input switch level of the P168*2 to the HTL sensor signal level via the voltage reference input U_S. To function properly, U_S must be connected with the supply voltage of the speed sensor.

See also
→ *Terminal Assignment, p. 32*

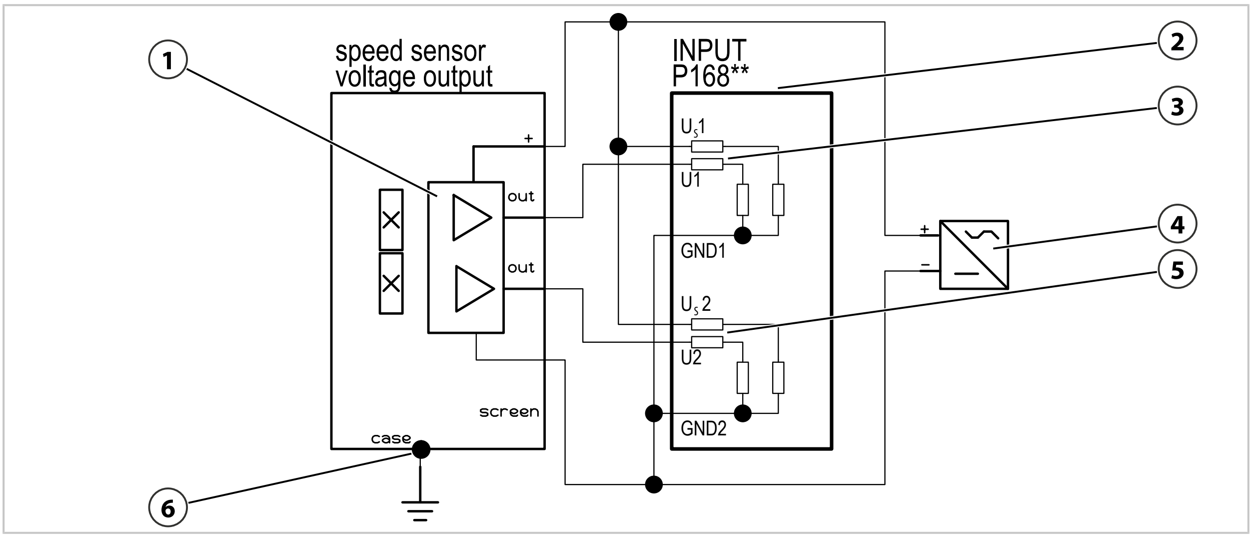
2.6 Input/Output

Speed sensors with voltage output and current output can be connected to inputs U or I of the P168*2.

Speed Sensor with Voltage Output

For speed sensors with voltage output, the P168*2 with its voltage reference input U_S is connected with the sensor power supply **(4)**. Each of the two sensor outputs **(1)** is connected with one input each (U_1, U_2) **(3)**, **(5)** of the P168*2. GND is connected with the negative connection of the sensor power supply **(4)**.

The input circuits consist of input voltage divider channel 1 **(3)** and input voltage divider channel 2 **(5)**. They do not require separate supply voltage.

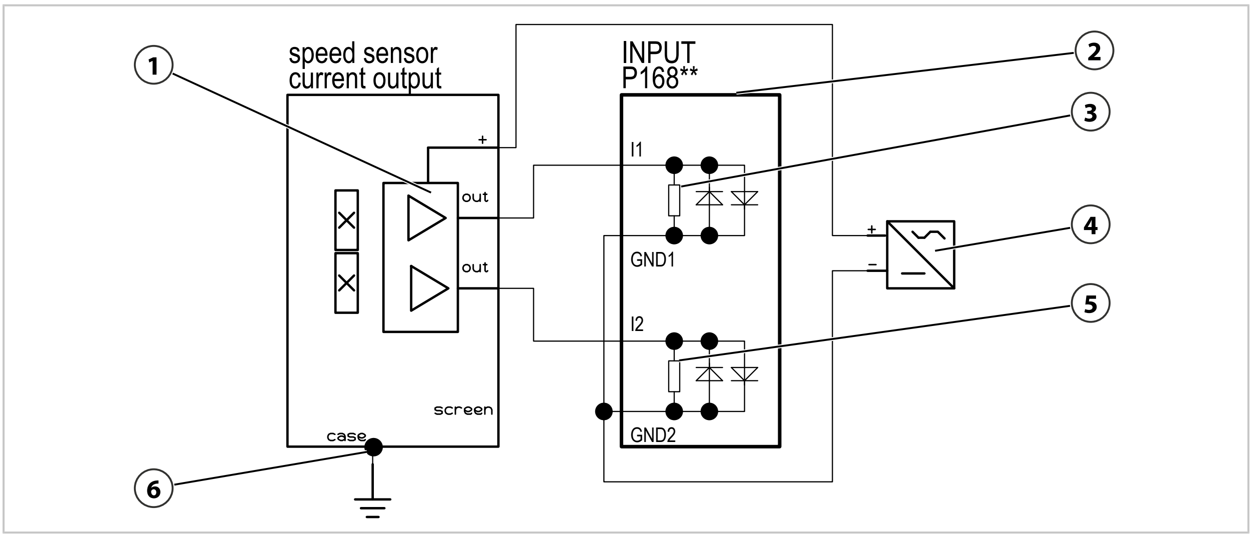


1 Voltage outputs of a 2-channel speed sensor	4 Sensor power supply
2 Voltage inputs P168**	5 Input voltage divider channel 2 with U2 and GND2
3 Input voltage divider channel 1 with U1 and GND1	6 Equipotential bonding

Speed Sensor with Current Output

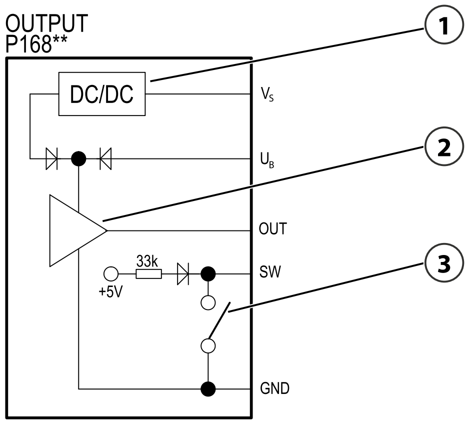
For speed sensors with current output **(1)**, each of the two sensor outputs **(1)** is connected with one input each (I_1, I_2) **(3)**, **(5)** of the P168*2. The GND of the P168*2 is connected with the negative connection of the sensor power supply **(4)**.

The signal currents are applied via the internal load resistors **(3)**, **(5)** of the P168*2. The load resistors are protected against overload by diodes connected in parallel.



1	Current outputs of a 2-channel speed sensor	4	Sensor power supply
2	Current inputs P168**	5	Load resistance channel 2
3	Load resistance channel 1	6	Equipotential bonding

Output Circuit of a Channel of P168*2



1 Internal voltage converter	3 Switch output for status signaling
2 Output driver for current and voltage	

P168*2 is supplied with power through the V_S connection and GND (supply not shown in the figure).

The output of the P168*2 has two supply connections: V_S and U_B. If the U_B connection is used, the output driver **(2)** is supplied via the diode network by the voltage applied at U_B. If the U_B connection is open, the output driver **(2)** is supplied via V_S and an internal voltage converter **(1)**.

The signal output OUT can be configured as a current or voltage output via DIP switch.

The SW switch output **(3)** is a diagnostic switch. An opened switch output signals that an error was detected.

All connections of the output are protected against GND_{out} by bipolar (SW: unipolar) suppressor diodes. The reference potential for the current and voltage output is the ground of output GND_{out}.

Standstill Detection

For activated standstill detection and detected standstill, the output emits a constant voltage of 7.2 V. When standstill detection is activated, connection U_B must be connected. To activate standstill detection, select the voltage output via the DIP switch. This configuration can lead to a standstill being detected for an error at the input.

See also
→ *DIP Switches, p. 28*
→ *Reaction to Input Signals, p. 47*

2.7 Voltage Supply

The P168*2 is supplied by channel via the output circuit. The output circuits and, with them, the associated galvanically isolated input circuits are supplied via terminal V_S or U_B. The power supplies of channels 1 and 2 are galvanically isolated. P168*2 can be supplied with a downstream controller or an additional power supply unit. The power supplies in the P168*2 are galvanically connected to the outputs. To ensure compliance with EN 50155, P168*2 should not be fed directly from the battery voltage supply system without additional galvanic isolation.

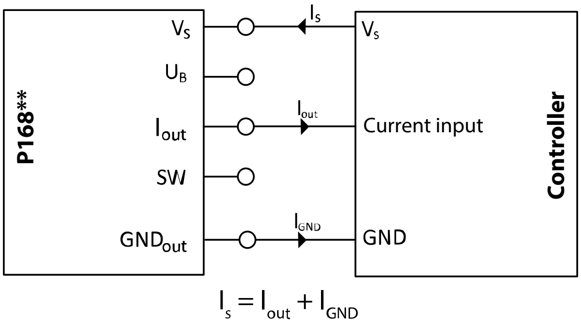
The P168*2 has limited internal protection against EMC interference that can occur on the supply lines as defined in EN 50151-3-2. External protective devices must be implemented if EMC interference is present on the supply lines. This type of EMC interference could have a negative impact on the output signals.

By selecting the following connection options, it is possible to adapt the supply current from the downstream controller. The following figures show the options for supplying the current and voltage outputs. The connection options presented are differentiated by the way they use the U_B connection. When the U_B is used, the amplitude and quality of the output signal depends on the voltage applied to U_B.

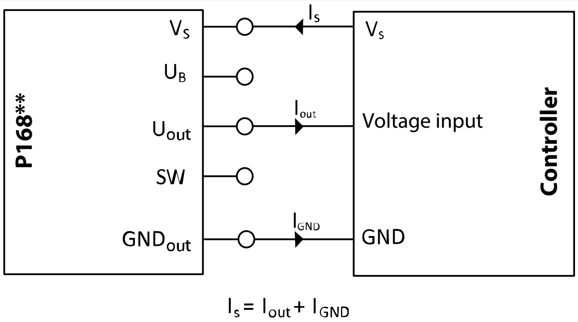
Supply via the Controller at the V_S Connection (without U_B)

If the U_B connection is not connected, P168*2 will supply the output drive internally via V_S. Here, the low output level must be taken into account. → *Output, p. 45*

Current output



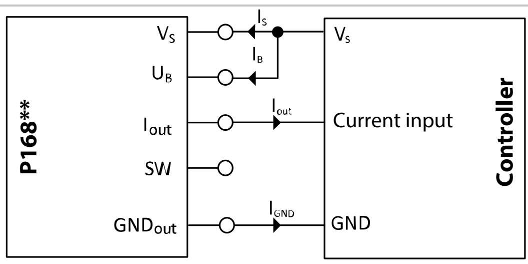
Voltage output



Supply via the Controller at Connections V_S and U_B

If a high level is required at the inputs of the controller, U_B must be connected.

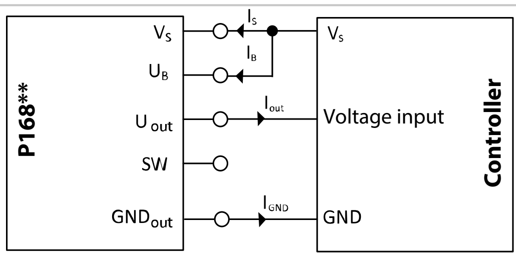
Current output



$I_B \approx I_{out}$

$I_S \approx I_{GND}$

Voltage output



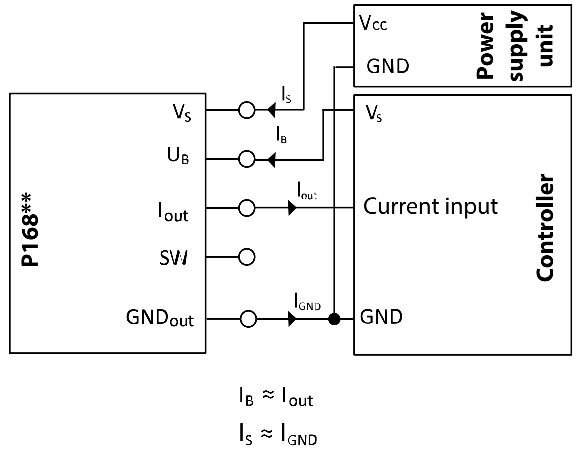
$I_B \approx I_{out}$ ($U_{out} \approx U_B$)

$I_S \approx I_{GND}$

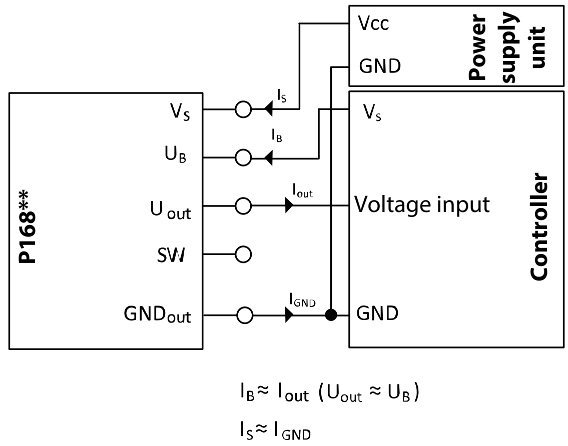
Additional Power Supply via External Power Supply Unit at Connection V_S

For supply via controller, the available currents are usually limited. If the permitted current is exceeded, the controller can display an error message. To prevent this, an additional power supply can be used to supply V_S.

Current output



Voltage output

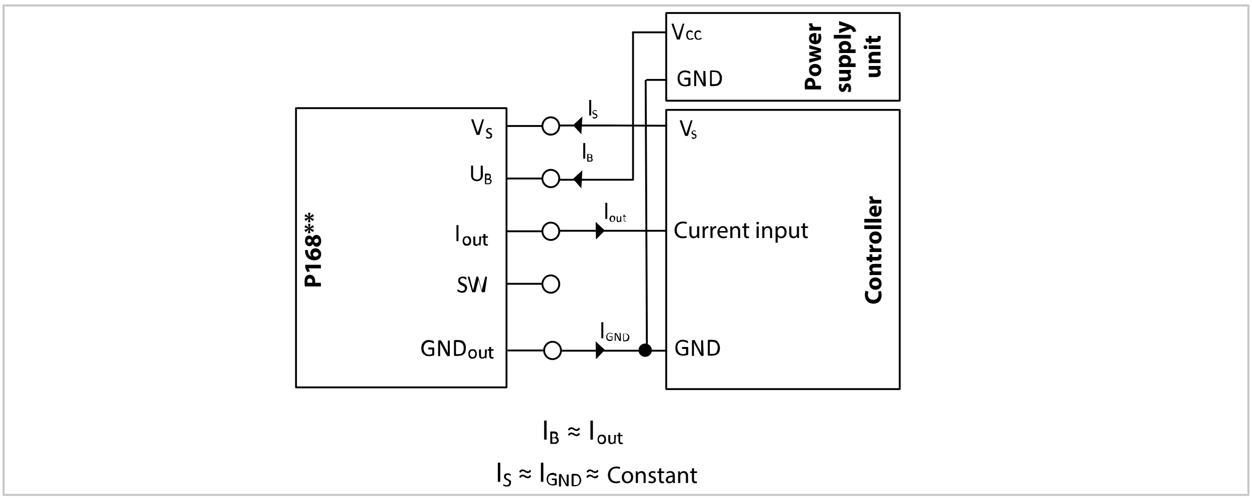


Additional Power Supply via External Power Supply Unit at Connection U_B (Output Driver)

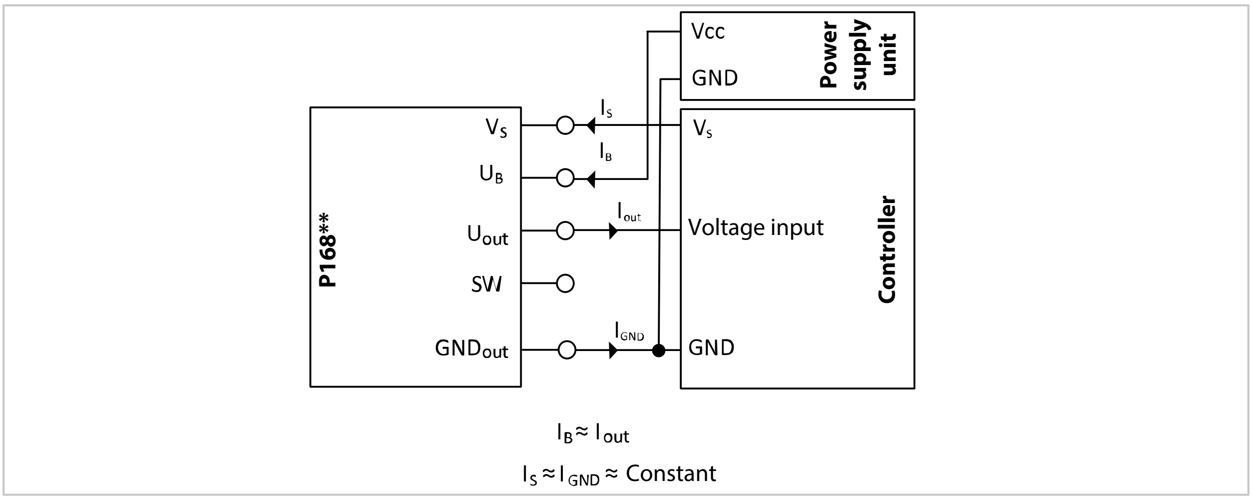
For supply via controller, the available currents are usually limited. If the permitted current is exceeded, the controller can display an error message. To prevent this, an additional power supply can be used to supply U_B.

The output stage of P168*2 is supplied via the U_B operating voltage connection. For the voltage output, U_B directly determines the High level of the output signal. For current outputs, U_B influences the output saturation limit. When dimensioning the load resistance, U_B must be taken into account accordingly. Here, the supply current of the controller is not dependent on the output level.

Current output



Voltage output



2.8 Shielding Concept

The P168*2 is used to multiply speed sensor signals and voltage-/current-generating speed sensors, particularly for rolling stock. Here, speed signals are decoupled in a non-interacting manner from a primary signal circuit and supplied to the P168*2. The primary signal circuit is retained and the speed sensor remains galvanically connected to the primary control unit (Control Unit 1). The P168*2 outputs route a copy of the primary speed signals to a secondary signal circuit with a secondary control unit (Control Unit 2). Here, there is no electrical isolation between the speed sensor and the primary control unit. The shield conditions and interference current conditions of the primary speed signal circuit are not changed either.

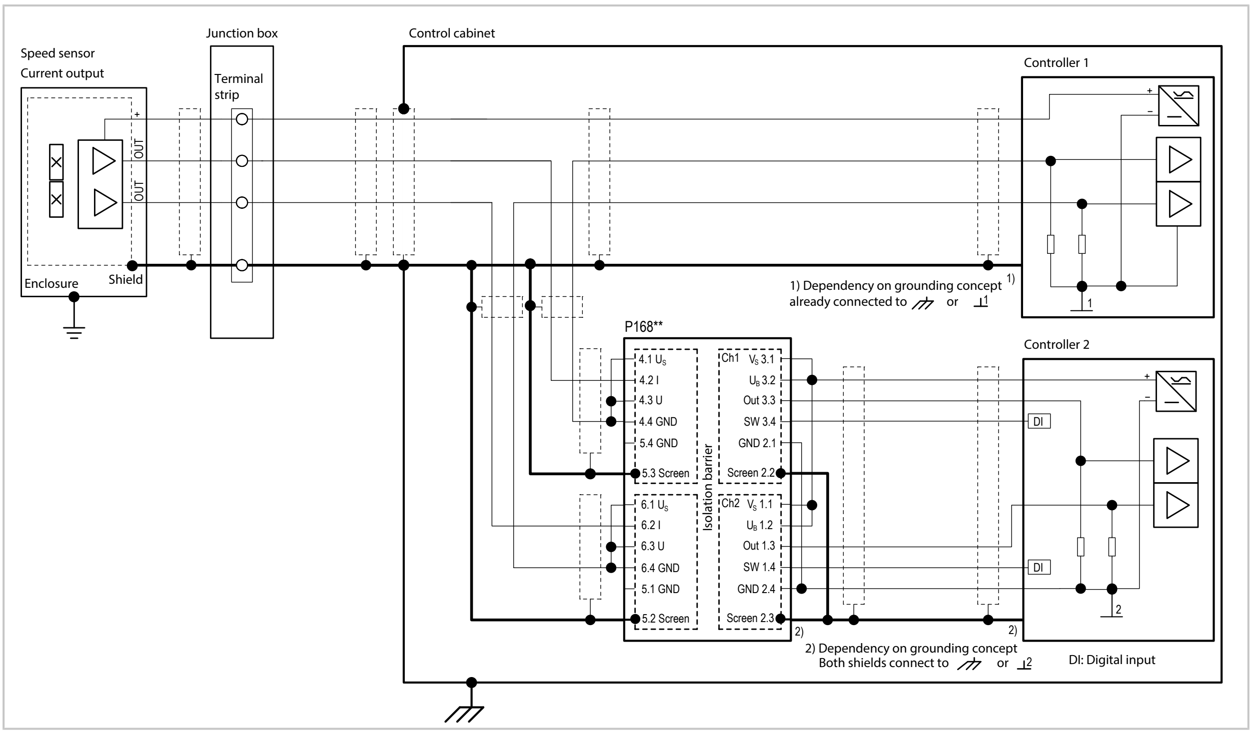
To ensure this, it is necessary to comply with the following principles.

NOTICE! Interference in signal transmission from unconnected shielding. The screen terminals (screens) must be connected and must not remain unassigned.

Two basic circuits for speed signal multiplication are available. They are described in the following chapters.

2.8.1 Decoupling the Signals of a Speed Sensor with Current Output

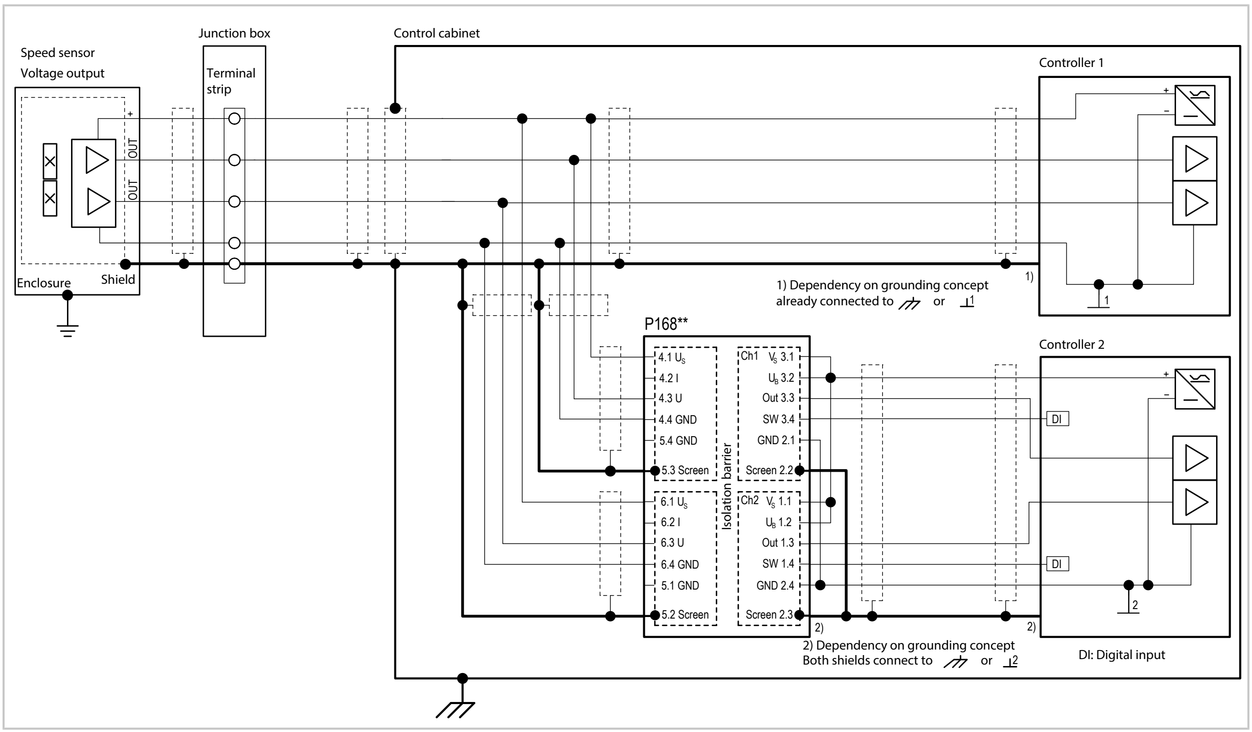
The figure shows the principle wiring for the serial decoupling of signals from a primary speed signal circuit with current-generating speed sensors.



Note: For speed sensor with current output, the input-side shield connections (screen) on P168*2 must not be connected to the GND connections.

2.8.2 Decoupling the Signals of a Speed Sensor with Voltage Output

The figure shows the principle wiring for the parallel decoupling of signals from a primary speed signal circuit with voltage-generating speed sensors.



2.8.3 General Information on Shielding P168*2

The P168*2 has a double shield design for input and outputs that can be adapted to different applications.

Each input and each electrically isolated output is equipped with two nested shields:

- Inner shield: Firmly connected to the GND terminal
- Outer shield: Connected to the assigned screen terminal

The two shields have no internal connection to each other.

Since vehicle manufacturers and system integrators use different concepts for the electrical connection of speed sensors, the following versions are to be understood as general recommendations.

These instructions present basic principles for the integration of P168*2. They should be supplemented to create an overall concept.

Take the following into account:

- Grounding concept and shield design of the system
- Speed sensor properties
- Speed sensor installation site
- Properties of the connected control unit

The figures show layouts optimized to minimize interference when decoupling the signals of a speed sensor with a current or voltage output.
→ *Decoupling the Signals of a Speed Sensor with Current Output, p. 23*,
→ *Decoupling the Signals of a Speed Sensor with Voltage Output, p. 23*

The internal electrical system of the speed sensor shown in the figures is surrounded by an inner shield that is not connected to the speed sensor housing. It represents the EMC ideal case.
→ *Decoupling the Signals of a Speed Sensor with Current Output, p. 23*,
→ *Decoupling the Signals of a Speed Sensor with Voltage Output, p. 23*

The speed sensor cable is inserted into the rolling stock body using a plug-in connection or a junction box with terminal strip. Inside the rolling stock body, the signal is routed via a shielded cable to an EMC-compliant control cabinet that contains the controller that processes the speed signals and more. The control cabinet enclosure is routed to an EMC-compatible, low-interference potential. The shielded speed sensor cable should be inserted into the control cabinet using a cable gland that has full contact with the shield. Inside the control cabinet, the signal is routed to a branch point via shielded cables. From there it is routed to the control unit or inputs of P168*2.

2.8.4 Fundamentals of Shielded Cables and Signal Routing

Shielded cables are required for:

- Connecting speed sensors to the inputs of P168*2
- Connecting the outputs of P168*2 to controllers
- A separate power supply unit, if necessary

→ *Signal Cables at the P168*2 Output, p. 27*, → *P168*2 Power Supply, p. 27*

Requirements for shielded cables:

- Unshielded cable sections must be as short as possible.
- The mechanical and electrical properties must be suitable for the respective application.
- The cables should not be routed parallel to power cables.
- A good shielding effect is achieved by fine braided shields with a high degree of coverage or a combination of metal film and braided shield.
- Twisted wire pairs should be used when each signal circuit uses its own wire pair.
- Shields should be routed to the same potential at both ends with low resistance in order to minimize magnetic interference.
    - Bilateral connection to ground potential, frame potential or system ground is suitable for this purpose.
    - The differences in potential between the potential points should be as small as possible.
    - The shield can be connected on a large scale and with low-resistance using special screen terminals that securely contact the shield to the respective potential connection.
    - Cable glands with contact to the shield are also suitable in conjunction with metallic casings.

If uniform shield potential is not available, undesired currents may develop that could lead to signal interference or damage to cables and control units.

To avoid this, we recommend the following measures:

- Prevent currents through cable shields: Equipotential bonding currents should be avoided, since they can cause signal interference. Sections with interrupted or missing shielding should be as short as possible.
- Use bilateral shield connection systematically: Bilateral shield connections usually offer better protection against magnetically induced interference than unilateral shield connections do. At the same time, there is a risk of compensating currents, which is why conscious consideration is necessary.
- Avoid directly connecting the cable shield to the sensor housing: If the cable shield in the speed sensor is directly connected to the speed sensor housing and it is attached to a point with a highly fluctuating potential, undesired compensating currents may develop. To prevent this, the cable shield should not be connected to multiple grounding points.
- Select additional grounding points with caution: If an additional grounding point is required, it must be located systematically: on the control unit, for example. In this case, check whether the control unit has inputs with electrical isolation for speed sensors.

Measures for Avoiding Problems with Potential

Note: Observe additional safety Instructions (e.g., SIL levels), if any. → *Safety Manual, p. 55*

1. Use of P168*2 between speed sensor and signal load
   - Reduces signal problems and interference current on cable shields.
   - The electrically isolating design prevents the routing of common-mode interference.
   - The robust electrical isolation and shield design minimizes shielding problems and interference currents.
   - Double shielding prevents signal interference and improves EMC-compatibility.
   - Effective shielding potentially eliminates the need for additional measures.

If P168*2 is used to decouple signals from a primary speed signal circuit, the wiring must ensure that the electrical properties of the primary speed signal circuit do not change. P168*2 does not change the signals and ensures non-interacting routing to a secondary speed signal circuit.

Due to the electrically isolating design of P168*2, there are no internal connections between the shield connections and other potentials like DIN rail potential, frame potential and grounding potential. If this type of connection is necessary, it must be established externally.

Effective shielding against external electrical fields is achieved when at least one end of the cable shield is grounded. Ground should be established at a suitable point for minimizing interference. If consistent grounding is not possible or a different shield design is necessary, check whether alternative measures for deflecting undesired interference current are necessary.

2. Use of a equipotential bonding cable
   - A low-resistance cable with a high current-carrying capacity connects different potentials at both ends of the cable shield.
3. Isolate the potential at the ends of the cable shield
   - Using a speed sensor with floating shield
   - Using a control unit with electrically isolated signal input
   - Avoiding a direct shield connection between the speed sensor and control unit to reduce differences in potential
4. Interrupt the cable shield
   - If necessary, the cable shield can be interrupted at the point of introduction into the rolling stock body, for example.

Note: This reduces the shielding effect and can have a negative impact on signal quality.

If the consistent connection of the cable shield is interrupted on the way between the speed sensor and signal load – for example, at the point of introduction into the rolling stock body – this can reduce the shielding effect. It can have a negative effect on signal quality, particularly in the case of magnetic interference. If high potential differences with AC components or other strong potential fluctuations exist between the isolated shield sections, additional signal interference may occur.

The choice between unilateral or bilateral shield connections (for the cable routed to the speed sensor) depends on the electrical conditions of the system. If the cable shield is directly connected to the speed sensor housing and the housing is on an electrically highly fluctuating potential, measures for preventing compensating current are necessary. This can be achieved with suitable electrical isolation or alternative shield connections.

2.8.5 Signal Cables at the P168*2 Output

Signals should be transmitted to the secondary control unit and power supply of P168*2 with only one shielded cable and along the shortest possible route. Both ends of the cable shield must be designed for a low-interference potential.

If P168*2 and the secondary control unit are installed in the same control cabinet designed for EMC compatibility, in individual cases the connection does not need to be shielded if electromagnetic interference does not develop.

2.8.6 P168*2 Power Supply

The power supply must be free from interference and voltage fluctuations, which can occur in on-board electrical systems particularly. When speed signals are decoupled from the secondary control unit, the power supply of P168*2 should come from this control unit. If this is not possible, a power supply unit with electrical isolation that supplies stable voltage should be used.

3 Configuration

3.1 Terminals

The various wiring options make it possible to adjust the load of the controller such that it equals the load of a speed sensor. → *Voltage Supply, p. 18*

3.2 DIP Switches

The individual input and output functions of P168*2 are set via the DIP switches on the product. The assignment of the functions to the DIP switch positions is listed on the nameplate.

⚠ **WARNING! In the case of safety-related applications, changing the DIP switches during operation has a negative affect on the safety concept.** Do not convert ranges during operation.

⚠ **WARNING! Shock potential: Do not touch.** Do not convert ranges during operation.

NOTICE! Product damage from electrostatic discharge (ESD) if DIP switch positions are changed. Implement protective measures against electrostatic discharge.

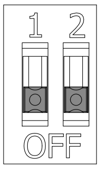
01. Set DIP switches in accordance with the desired function.

02. After configuration is completed, check that the product functions correctly.

DIP Switch at Input

The inputs Input 1 and Input 2 can be configured differently.

Overview: DIP switch functions at the input:



DIP switches Input 1 and Input 2

- Select current or voltage input
- Select pulse transmission 1:1 or frequency division 2:1 (depending on product variant: 4:1 or 8:1)

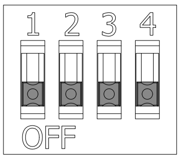
Input signal	Frequency division	DIP 1	DIP 2	
Voltage	$f_{out} = f_{in}$	ON	ON	[1]
	$f_{out} = f_{in}/2$ Optional: → *Product Code, p. 9* $f_{out} = f_{in}/4$ $f_{out} = f_{in}/8$	OFF	ON	
Current	$f_{out} = f_{in}$	ON	OFF	
	$f_{out} = f_{in}/2$ Optional: → *Product Code, p. 9* $f_{out} = f_{in}/4$ $f_{out} = f_{in}/8$	OFF	OFF	

[1] Factory setting

DIP Switch at Output

The outputs Output 1 and Output 2 can be configured differently.

Overview of DIP switch functions at the output:



DIP switches Output 1 and Output 2

- Select current or voltage output
- For current output: Choose high level 14 mA or 20 mA
- Select standstill detection
- Select an inverted or not inverted output signal

Output signal	Inversion	Standstill detection	Output value	DIP 1	DIP 2	DIP 3	DIP 4
Current	Not inverted	Deactivated	High = 20 mA	OFF	OFF	ON	ON [1)]
			High = 14 mA	OFF	OFF	ON	OFF
	Inverted	Deactivated	High = 20 mA	ON	OFF	ON	ON
			High = 14 mA	ON	OFF	ON	OFF
Voltage	Not inverted	Deactivated	High ≈ U_B	OFF	ON	ON	OFF
		Activated	High ≈ U_B Standstill = 7.2 V	OFF	ON	OFF	OFF
	Inverted	Deactivated	High ≈ U_B	ON	ON	ON	OFF
		Activated	High ≈ U_B Standstill = 7.2 V	ON	ON	OFF	OFF

See also
→ *Nameplate, p. 10*

1) Factory setting

4 Installation and Commissioning

4.1 Mounting

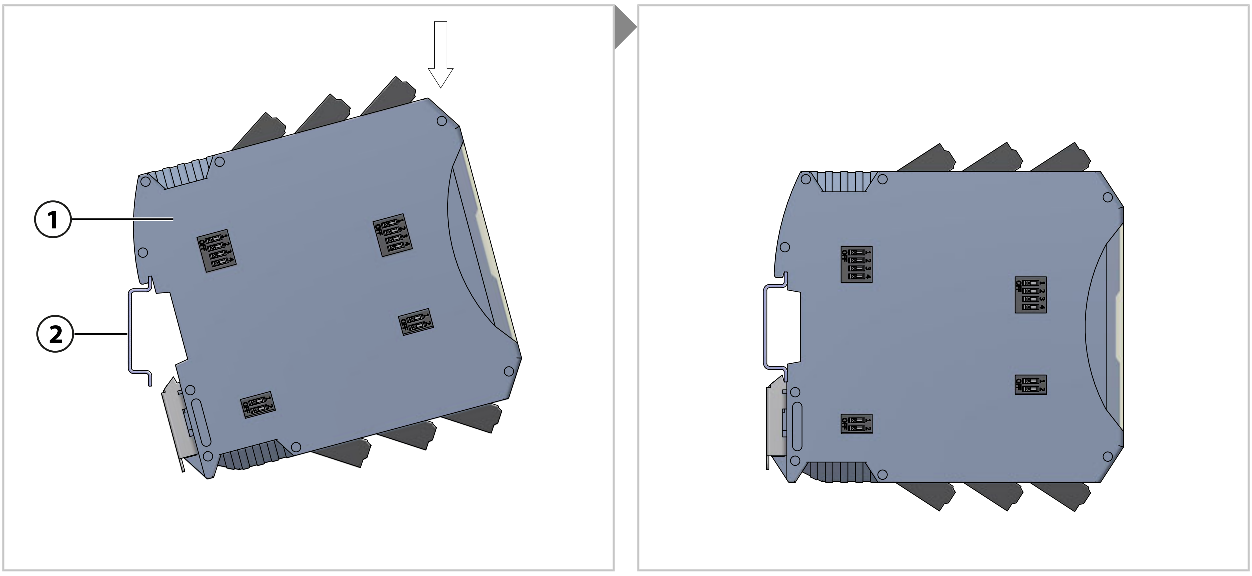
The following conditions must be complied with:

- The product is approved for installation in closed electrical operating areas like underfloor containers, roof boxes, and the engine rooms of rolling stock.
- Inside rolling stock, the product many only be installed and operated in closed control cabinet that can be locked.
- In industrial plants, the product many only be installed and operated in closed control cabinet that can be locked.

P168*2 can be mounted in any installation orientation as follows:

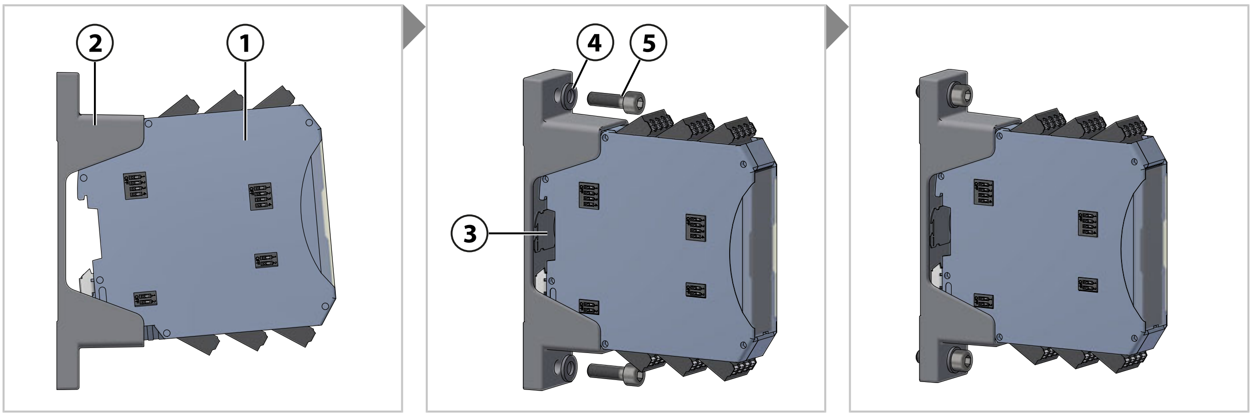
- On 35 mm DIN rails, stackable (without using a DIN rail bus connector),
- On level surfaces with accessory ZU1472 Wall-mount adapter.

Mounting on 35 mm DIN Rail



01. Snap the P168*2 **(1)** onto the 35 mm DIN rail **(2)**.

Mounting on Level Surfaces with Accessory ZU1472 Wall-Mount Adapter (order separately)



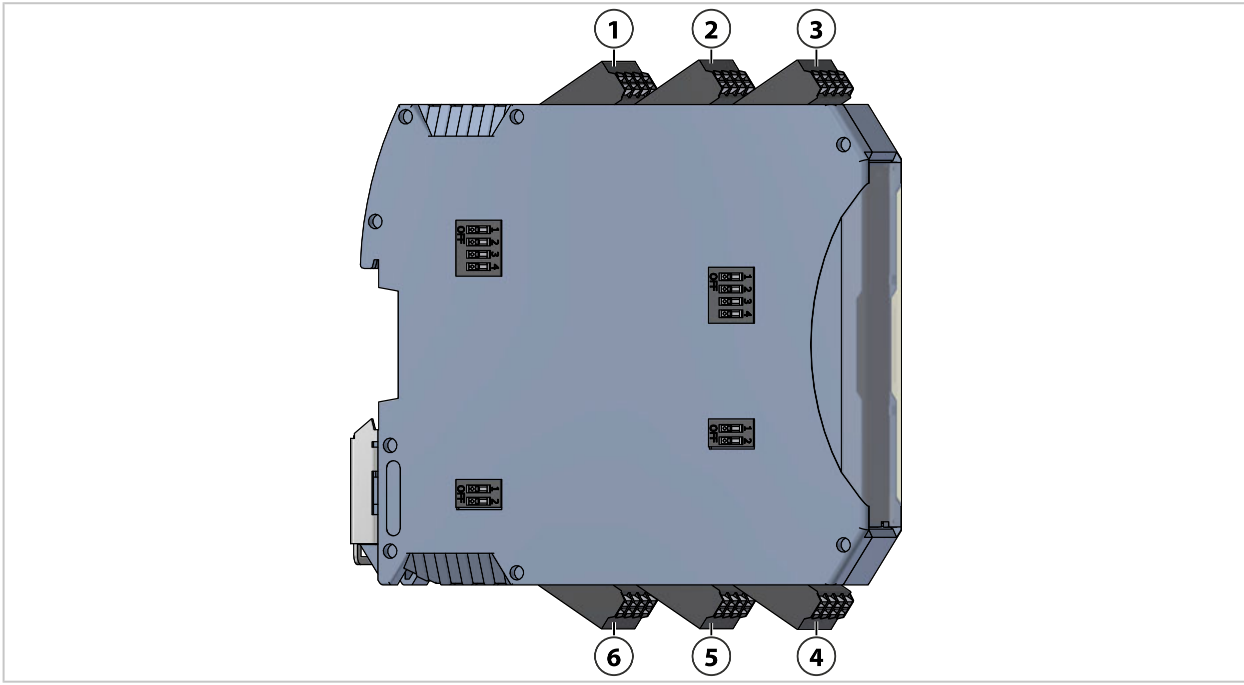
Note: The miniature illustration **(3)** on the wall-mount adapter also represents the correct installation orientation of P168*2 **(1)** in the ZU1472 Wall-mount adapter **(2)**.

Required aids: Two M6 screws and suitable washers.

01. Click P168*2 **(1)** into accessory ZU1472 **(2)**.
02. Position the ZU1472 **(2)** with the P168*2 **(1)** at the installation location.
03. Fasten the ZU1472 **(2)** using the two M6 screws **(5)** and washers **(4)**.
04. Tighten the M6 screws **(5)** with 5 Nm.

See also
→ *Dimension Drawings, p. 42*

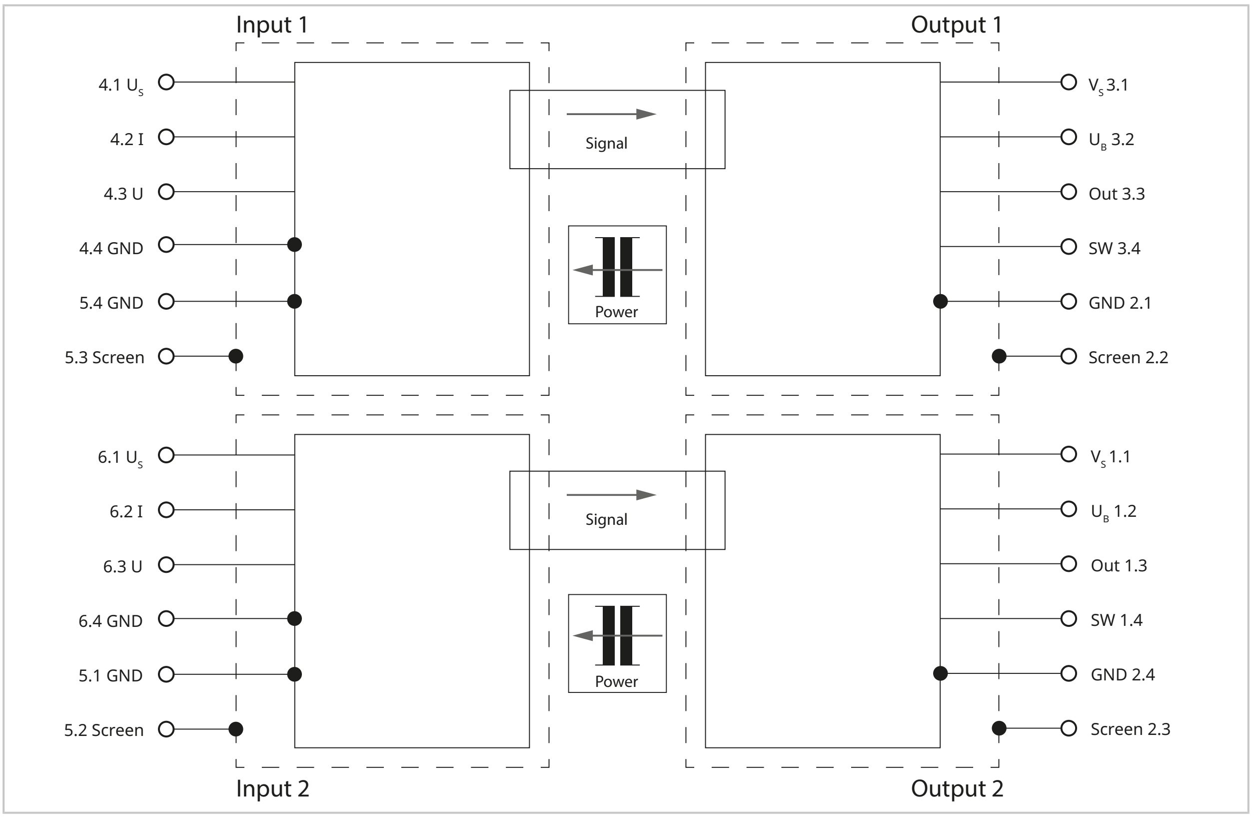
4.2 Terminal Assignment



1	Terminal 1 (1.1...1.4)	4	Terminal 4 (4.1...4.4)
2	Terminal 2 (2.1...2.4)	5	Terminal 5 (5.1...5.4)
3	Terminal 3 (3.1...3.4)	6	Terminal 6 (6.1...6.4)

Terminal	Label	Input/Output	Channel	Function
1.1	V_S	Output	2	Power supply
1.2	U_B	Output	2	Power supply (output driver)
1.3	Out	Output	2	Output signal (current or voltage)
1.4	SW	Output	2	Switch output, opens in case of detected error.
2.1	GND	Output	1	Ground
2.2	Screen	Output	1	Shield
2.3	Screen	Output	2	Shield
2.4	GND	Output	2	Ground
3.1	V_S	Output	1	Power supply
3.2	U_B	Output	1	Power supply (output driver)
3.3	Out	Output	1	Output signal (current or voltage)
3.4	SW	Output	1	Switch output, opens in case of detected error.
4.1	U_S	Input	1	Voltage reference for voltage input
4.2	I	Input	1	Current signal from speed sensor
4.3	U	Input	1	Voltage signal from speed sensor
4.4	GND	Input	1	Ground, speed sensor
5.1	GND	Input	2	Ground, speed sensor
5.2	Screen	Input	2	Shield
5.3	Screen	Input	1	Shield
5.4	GND	Input	1	Ground, speed sensor
6.1	U_S	Input	2	Voltage reference for voltage input
6.2	I	Input	2	Signal current from speed sensor
6.3	U	Input	2	Signal voltage from speed sensor
6.4	GND	Input	2	Ground, speed sensor

Block Diagram



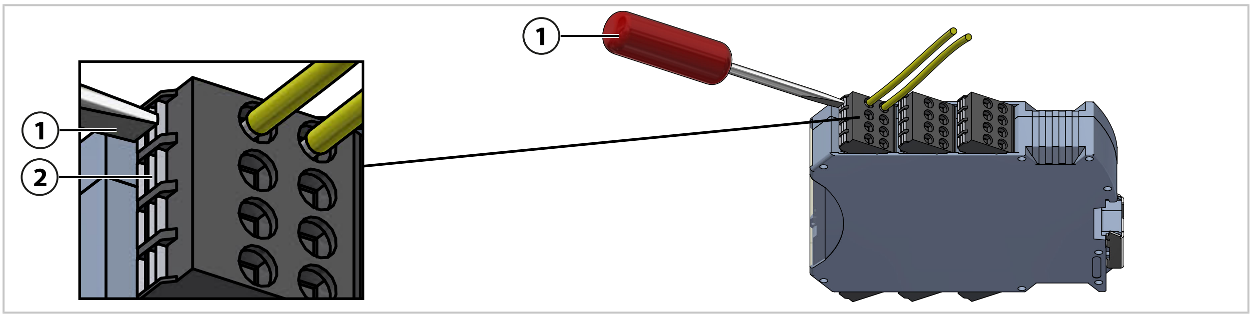
See also

→ *Abbreviations, p. 62*

4.3 Electrical Installation

⚠ WARNING! Voltages dangerous to touch. Do not install the product when it is carrying voltage.

01. Disconnect the electrical system from the mains.
02. Secure the electrical system against reconnection.
03. Verify that the electrical system is dead.
04. Ground and short-circuit the electrical system.
05. Cover neighboring, live parts with insulating materials or place barriers around them.
06. Connect the jumpers in accordance with the selected function or shield design.
    → *Insertable Jumpers, p. 35*
07. Prepare the wires.
    Note: Use only shielded copper wires. The cables must be temperature resistant to at least 75 °C (167 °F), unless higher requirements result from the application. The wires must be rated for the limit value of the circuit's protective device.
    Note: When choosing the cable, the influence of the cable parameters on the signal (e.g., capacitance or inductance) must be taken into account.
08. Strip 10 mm from the cable ends. Apply ferrules on the stranded cables.



09. Insert the cable into the mechanical coded two-tier terminal (push-in version) without tools. If it is difficult to insert the cable, push in the push button **(2)** using a screwdriver in order to open the two-tier terminal **(1)**.

Note: For 2-channel devices, input signals 1 and 2 must originate from the same speed sensor. The output signals may only go to one controller.

10. Connect the P168*2 in accordance with the chosen wiring (signal type and shield design).
11. Check that the cable is securely attached.
12. Reset the electrical system to its original state. Reverse the sequence of measures for ensuring voltage-free operation.

Conductor cross-sections
0.2 … 1.5 mm^2, AWG 24 … 16
Stranded with ferrule or solid

See also
→ *Terminal Assignment, p. 32*

4.4 Insertable Jumpers

The cables and jumpers are connected to the two-tier terminals (push-in version).
→ *Terminal Assignment, p. 32*

2-pin and 3-pin jumpers are available:

- 2-pin jumper:
  - To connect connection U_B with connection V_S
  - Connection of the GND and Screen terminals, depending on selected shield design
- 3-pin jumper:
  - To connect terminals U_S, U and GND when the current input is used

See also
→ *Voltage Supply, p. 19*

4.5 Commissioning

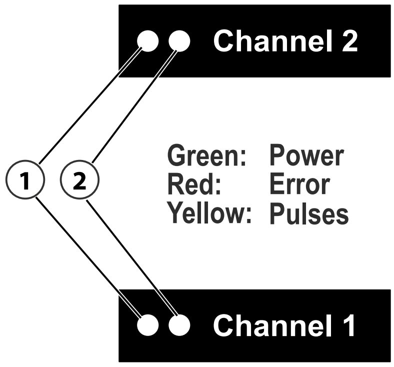
01. Set the desired function using the DIP switches. → *DIP Switches, p. 28*
02. Mount the P168*2. → *Mounting, p. 30*
03. Electrically install the P168*2. → *Electrical Installation, p. 34*
04. Check functionality of the P168*2.

5 Operation

5.1 Operation

5.1.1 LED Signaling

Two LEDs per channel (channel 1/channel 2) are located on the device front.



1 LED left: green/red   2 LED right: yellow

Green	LED left	Power indicator, operating voltage present.
Red	LED left	Error detected.
Yellow	LED right	Pulse indicators (LED flashes in line with the input pulse. At high pulse frequencies, this is perceived as permanently illuminated).

5.2 Maintenance and Repair

Maintenance

The devices are maintenance-free. They are not to be opened.

Repair

The product cannot be repaired by the user. The local contact persons and information on the repair procedure can be found at www.knick-international.com.

Storage

Familiarize yourself with the information on storage temperatures and relative humidity in the Specifications.

6 Troubleshooting

USE CAUTION WHEN CONDUCTING ANY TROUBLESHOOTING. FAILURE TO ABIDE BY THE REQUIREMENTS SET FORTH HEREIN MAY RESULT IN SERIOUS INJURY OR DEATH, AS WELL AS DAMAGE TO PROPERTY.

Failure condition	Possible Cause	Remedy
The left LED lights up red and switch output SW is open.	Power supply of speed sensor is not connected. Note: The speed sensor is not supplied with voltage by P168*2.	Check connection.
	Reference voltage for voltage input U_S: Threshold value below the lower limit	Check connection.
	Error detection current input: Threshold value below the lower limit	Check speed sensor, cable, and connections.
	Error detection current input: Open cable	Check cable and connections.
	Internal device failure	Replace device.
The left LED flashes red and switch output SW opens in the output frequency cycle.	Short-circuit at voltage output	Check cable and connections.
	Internal device failure	Replace device.
The green LEDs do not light up and switch output SW is open.	Undervoltage at V_S	Check the auxiliary power.
Output voltage is too low.	Faulty power supply	Check U_B.
	Load resistance too low	Check connections for short-circuit. Check value of load resistance.
A fault is not signaled.	Defect at switch output	Replace device.
The signal output does not follow the signal input.	Missing load resistance (current output)	Connect load resistance correctly.
	Faulty configuration	Check configuration.
	Disconnection	Check cable and connections.

Further support for troubleshooting is available at → *support@knick.de*.

See also

→ *DIP Switches, p. 28*
→ *LED Signaling, p. 36*
→ *Specifications, p. 43*

7 Decommissioning

The product must be shut down and secured against starting up again if the following occurs:

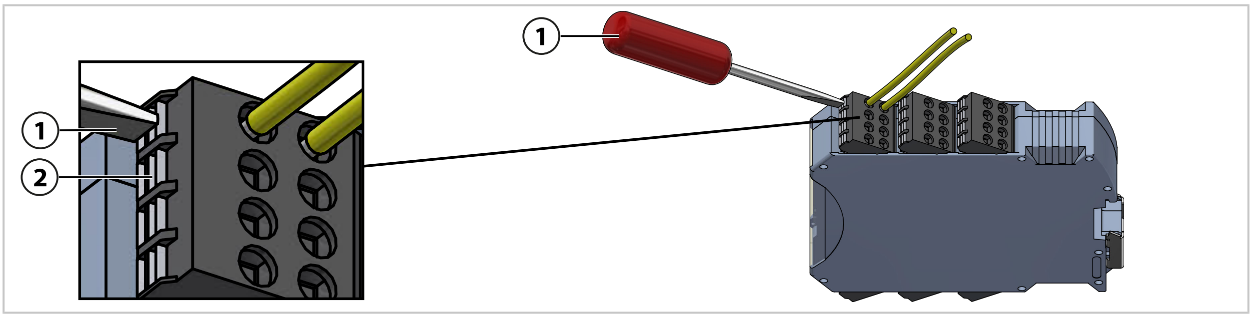
- Visible damage to the product
- Failure of electrical function
- Storage at temperatures outside the specified temperature range

The product may only be started up again after a professional routine test by the manufacturer.

7.1 Removal

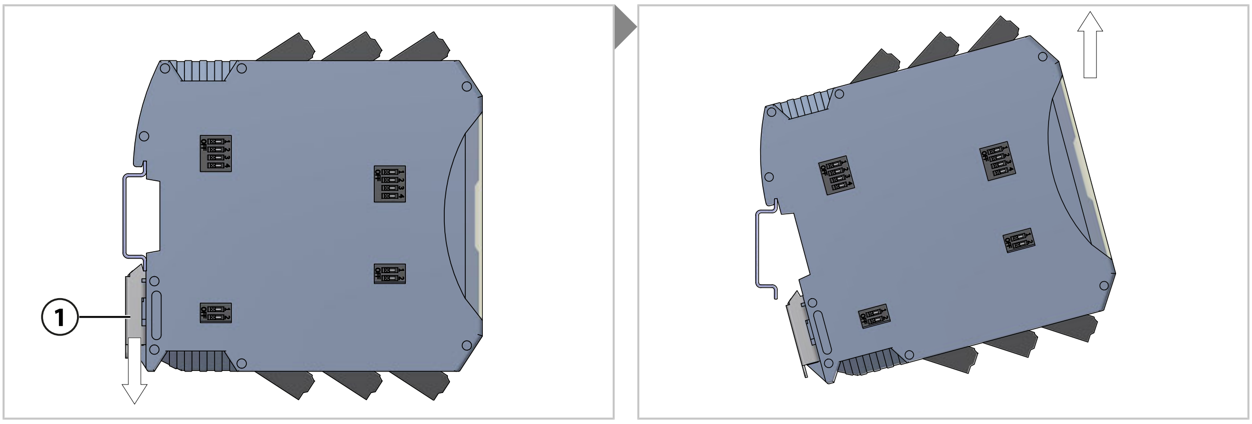
⚠ **WARNING! Voltages dangerous to touch.** Do not disassemble the product under voltage.

01. Disconnect the electrical system from the mains.
02. Secure the electrical system against reconnection.
03. Verify that the electrical system is dead.
04. Ground and short-circuit the electrical system.
05. Cover neighboring, live parts with insulating materials or place barriers around them.
06. Check the input of P168*2 for voltage-free operation.
07. Switch off the power supply.



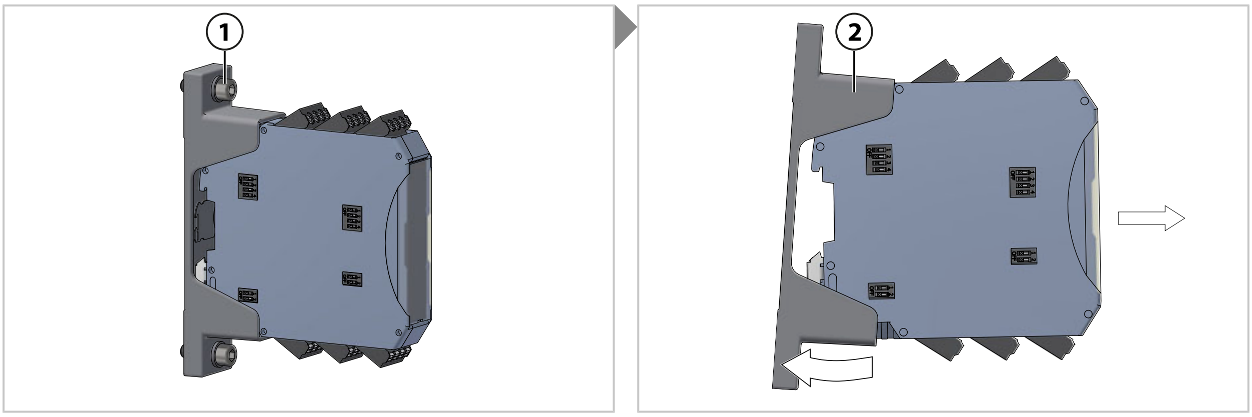
08. Push in the push button **(2)** using a screwdriver **(1)** to open the two-tier terminal and remove the cable.
09. Remove the P168*2 enclosure.

Removal from 35 mm DIN Rail



1. Pull down the metal foot catch **(1)**.
2. Lift the product off the DIN rail.

Removal with Wall-Mount Adapter



1. Loosen the M6 screws **(1)**.
2. Slightly bend up the wall-mount adapter **(2)** on one side to separate it from the product.

7.2 Return Delivery

For return delivery, follow the information on our website www.knick-international.com.

7.3 Disposal

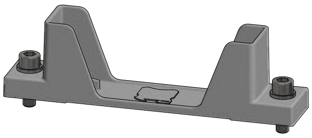
To dispose of the product properly, follow the local regulations and laws.

Customers can return their electrical and electronic waste devices.

For details on how to return and dispose of electrical and electronic devices in an environmentally friendly manner, please refer to the manufacturer's declaration on our website. If you have any queries, suggestions, or questions about how Knick recycles electrical and electronic waste devices, please send us an email: → *support@knick.de*

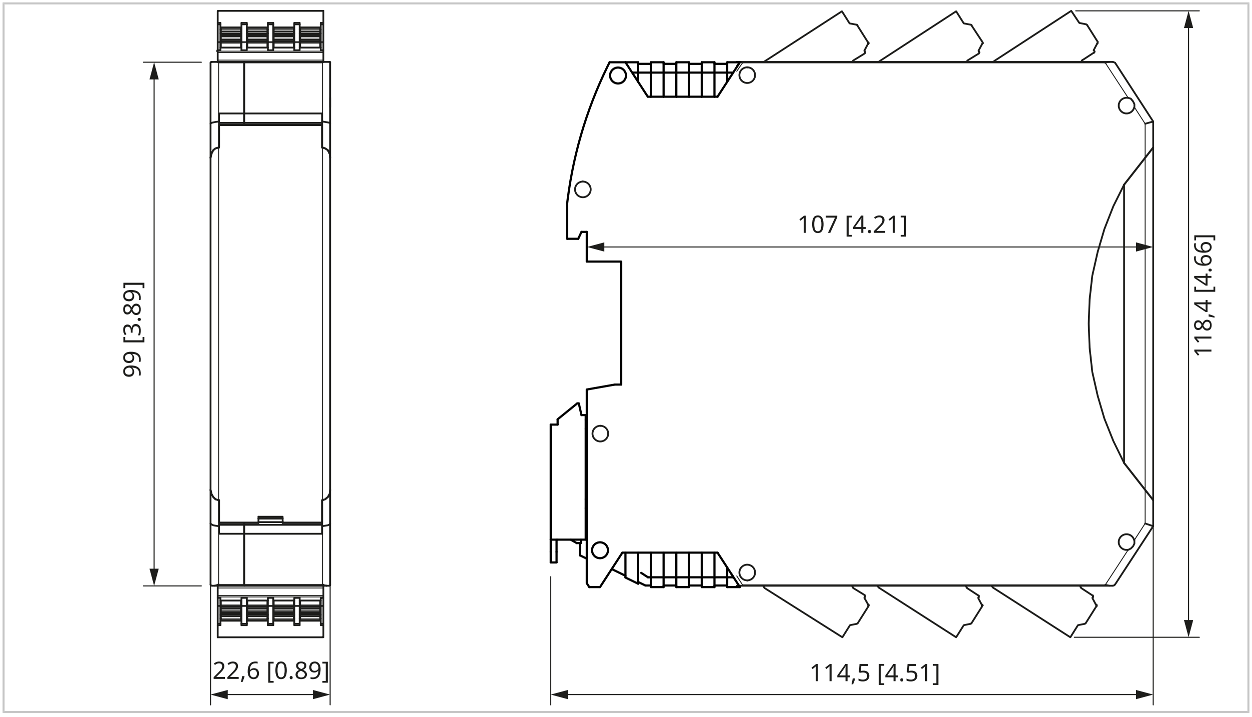
See also
→ *Symbols and Markings, p. 12*

8 Accessories

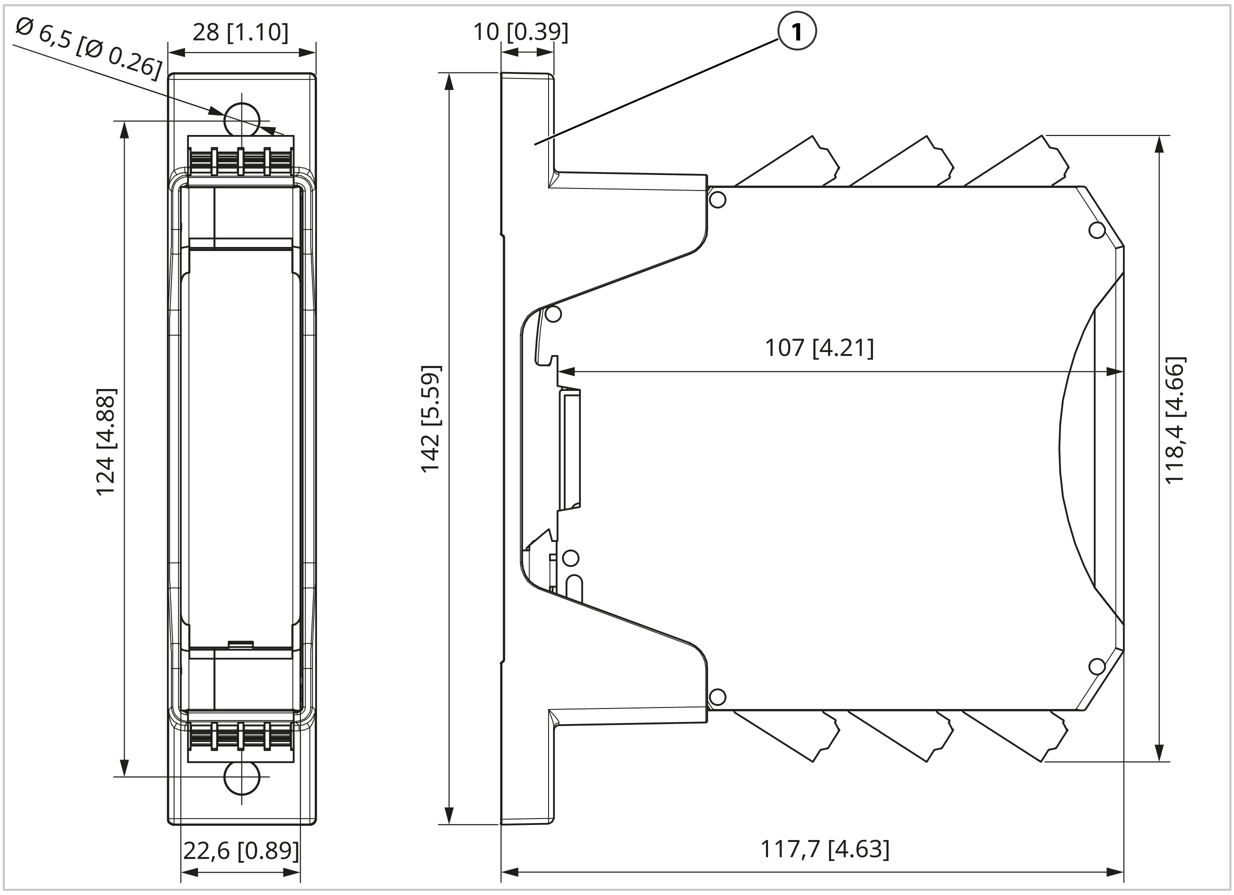
	**ZU1472 Wall-mount adapter, optional** Accessory ZU1472 enables the installation of the P168*2 on a level surface. Use two M6 screws (EN 912/ISO 4762) with washers (EN 125/ISO 7089) to mount the wall-mount adapter. (Screws and washers not included in the package contents.)

9 Dimension Drawings

Note: All dimensions are listed in millimeters [inches].



The accessory ZU1472, "Wall-mount adapter," is available as an option and not included in the P168*2 package contents. The hole spacing for accessory ZU1472, "Wall-mount adapter," is 124 mm [4.88"].



1 ZU1472 wall-mount adapter

10 Specifications

10.1 Limit Values

The specifications listed here must be complied with. Deviations can lead to destruction of the product.

Unless otherwise indicated, all voltage vales refer to the associated GND.

Operating temperature, enclosure		Max. 95 °C (203 °F)
Voltage reference for level detection U_S	Min. -35 V	Max. 35 V
Current input	Min. -200 mA	Max. 200 mA
Voltage input	Min. -35 V	Max. 35 V
Operating voltage supply V_S	Min. -35 V	Max. 35 V
Operating voltage output stage U_B	Min. -35 V	Max. 35 V
Output OUT	Min. -0.5 V	Max. U_B + 0.5 V
	Short-circuit-proof	
Switch output SW	Min. -0.5 V	Max. 35 V
		Max. 100 mA

10.2 Recommended Operating Conditions

The specified characteristic data apply under the recommended operating conditions listed.

Unless otherwise indicated, all voltage vales refer to the associated GND.

Ambient temperature, side-by-side operation	Min. -40 °C (-40 °F)	Max. 70 °C (158 °F)	Permanent
		Max. 85 °C (185 °F)	Short-term (10 min.)
Operating voltage device V_S	Min. 10 V	Max. 33.6 V	
Operating voltage output stage U_B	Min. 10 V	Max. 33.6 V	
	Or open for internal supply via V_S		
Ripple of operating voltage (peak value)		Max. 5 %	
Input frequency f_{in}	Min. 0 Hz	Max. 25 kHz	
Input duty cycle	Min. 25 %	Max. 75 %	
Input level:			
U High	Min. 0.83 × U_S	Max. U_S	
U Low	Min. 0 V	Max. 0.17 × U_S	
I High	Min. 12 mA	Max. 30 mA	
I Low	Min. 4 mA	Max. 9.5 mA	

10.3 Input

Input signal	Voltage U or current I
Waveform	Square
Input frequency f_{in}	0 ... 25 kHz
Sensor	Speed encoder, speed sensor, position encoder, or pulse generator
Reference potential	GND_{in}

10.3.1 Reference Voltage

Reference voltage U_s	10 ... 33.6 V
Error detection open cable U_S	< 8 ... 10 V; typically 9.45 V
Input resistance	≥ 120 kΩ
Input capacitance	≤ 100 pF

10.3.2 Voltage Input

Input voltage range	0 ... U_S
Input switch level	Low: Min. 27 % of U_S
	High: Max. 77 % of U_S
Input resistance	≥ 120 kΩ
Input capacitance	≤ 100 pF

10.3.3 Current Input

Input current	6 ... 20 mA
Input switch level at Low = 6/7 mA	Low: Min. 9.025 mA
Input switch level at High = 14/20 mA	High: Max. 12.075 mA
Error detection open cable	< 1.8 ... 2.6 mA; typically 2.2 mA
Input resistance	< 30 Ω

10.4 Output

Output signal	Voltage U or current I
Waveform	Square
Reference potential	GND_{out}
Signal conversion options	Current → current
	Voltage → voltage
	Current → voltage
	Voltage → current

10.4.1 Voltage Output

Voltage level	Low: < 1 V (at max. 20 mA)
	High: U_B … U_B – 2 V (at max. 20 mA)
	High (U_B open): > 5.5 V (at max. 20 mA)
	Detected standstill: 6.9 … 7.5 V; typically 7.2 V (middle voltage) (at max. I = (U_B - 7.2 V)/3 kΩ)
Rise time	$T_{10...90}$ ≤ 10 µs (pulse edge slope for ohmic loads)
Fall time	$T_{90...10}$ ≤ 10 µs (pulse edge slope for ohmic loads)

10.4.2 Current Output

Current level High level dependent on configuration	Low: 4 … 8 mA; typically 6 mA
	High = 14 mA: 12 … 16 mA; typically 14 mA
	High = 20 mA: 18 … 22 mA; typically 20 mA
Voltage of the current output (load voltage)	Max. U_B – 2 V Max. 4 V, if U_B open
Rise time	$T_{10...90}$ ≤ 10 µs (pulse edge slope for ohmic loads)

10.4.3 Switch Output

Technical version	Solid state relay
	Normally closed contact, opens in the event of an error
Voltage drop in closed state	< 0.3 V at 20 mA
Reverse current for open switch	< 10 µA at 24 V
Fault response time	< 1 s

10.5 Transfer Characteristics

Frequency division	P168*2P31/2*: 1:1 or 2:1, switchable
	P168*2P31/4*: 1:1 or 4:1, switchable
	P168*2P31/8*: 1:1 or 8:1, switchable
Functional characteristics	The output level follows the input level.
Flow time t_p	≤ 10 µs
Difference of the flow times of both channels	< 5 µs
Duty cycle distortion without frequency division Output signal against input signal	Max. ±10 % at 25 kHz
Duty cycle of the output signal with frequency division, independent from duty cycle of input signal	50%
Setpoint standstill detection	0.7 ... 1.3 Hz; typically 1 Hz
Response time standstill detection	Max. 3 s
Reaction to the middle voltage at the input	For activated standstill detection, a middle voltage is output.
	For deactivated standstill detection, the output level depends on U_S and the prior input level.
Reaction of outputs to detected error:	
Current output	0 ... 100 µA
Voltage output	Not inverted: High
	Inverted: Low

10.6 Reaction to Input Signals

		Condition	Voltage output OUT	Current output OUT	Switch output SW
Voltage input	U	Low	Low	Low	Closed
		High	High	High	Closed
		f < 1 Hz (for activated standstill detection)	Middle voltage	Invalid configuration	Closed
		Middle voltage (for deactivated standstill detection)	Low or High, dependent on input level/hysteresis	Low or High, dependent on input level/hysteresis	Closed
		Middle voltage (for activated standstill detection)	Middle voltage	Invalid configuration	Closed
		Open	Low	Low	Closed
Voltage reference	U_S	10 … 33.6 V	Low or High, dependent on input level/hysteresis	Low or High, dependent on input level/hysteresis	Closed
		< 8 V	High	0 mA	Open
		< 8 V (for activated standstill detection)	Middle voltage	Invalid configuration	Open
Current input	I	Low	Low	Low	Closed
		High	High	High	Closed
		f < 1 Hz (for activated standstill detection)	Middle voltage	Invalid configuration	Closed
		< 1.8 mA or open	High	0 mA	Open
		< 1.8 mA or open (for activated standstill detection)	Middle voltage	Invalid configuration	Open

When input signal inversion via DIP switch is activated, High level and Low level are exchanged.

10.7 Auxiliary Power

P168*2 is designed for direct connection to a railway control unit for odometry. For proper functioning, the supply of P168*2 must be provided at a specific source in accordance with EN 50155:2022 Section 5.1.1. For direct connection to a battery, burst immunity is restricted to evaluation criterion B. The influence on galvanic isolation must be considered.

Electrical safety	All connected current or voltage circuits must meet the SELV, PELV or EN 50153 Section I requirements.
Supply of the output	V_S: Supply of the P168*2[1]
	U_B: Supply of output driver[2]
Power supply	V_S: 10 … 33.6 V
	U_B: 10 … 33.6 V
DC ripple factor at V_S	Max. 5 % to 1 kHz
Current through U_B per channel	Current output: max. 5 mA + I_{out}
	Voltage output: max. 5 mA + U_{out}/R_L
Power consumption through V_S per channel	Max. 600 mW
Power consumption total device (V_S and U_B)	Max. 2.2 W (2-channel product version)
	Max. 1.1 W (1-channel product version)
Warm-up time after switching on auxiliary power	≤ 50 ms
Inrush current at V_S per channel For V_S = 24 V, U_{out} at R_L = 1 kΩ	Max. 0.0002 A^2/s
Inrush current at U_B per channel For U_B = 24 V, U_{out} at R_L = 1 kΩ	Max. 0.0001 A^2/s
Breaking capacity within 1 s after switching off V_S and U_B	Level at current outputs: < 1 mA
	Level at voltage outputs: < 1 V

1) The entire device, including the input stage, is supplied via V_S.

2) The output stage can be supplied separately via the U_B connection. Next, the output voltage levels are set via U_B.

10.8 Isolation

Galvanic isolation	Input circuits against output circuits, Input circuit channel In 1 against input circuit channel In 2 → *Details on Isolation, Isolating Distances, Contamination, and Overvoltage, p. 54*	
Type test voltage	Input against output:	8.8 kV AC/5 s
		5 kV AC/1 min
	Channel 1 against channel 2:	3 kV AC/1 min
	Output against outer shield of the output (screen):	710 V AC/5 s
		600 V AC/60 s
	Input against outer shield of the input (screen):	2,200 V AC/5 s
		700 V AC/60 s
	Input against 35 mm DIN rail:	3,550 V AC/5 s
Routine test voltage	Input against output:	4.6 kV AC/10 s
	Channel 1 against channel 2:	1.9 kV AC/10 s
	Output against outer shield of the output (screen):	300 V AC/10 s
	Input against outer shield of the input (screen):	1,400 V AC/10 s
Reinforced insulation	→ *Details on Isolation, Isolating Distances, Contamination, and Overvoltage, p. 54*	
Rated insulation voltage	→ *Details on Isolation, Isolating Distances, Contamination, and Overvoltage, p. 54*	
Coupling capacity	Input → output < 20 pF	

10.9 Ambient Conditions

Installation location in accordance with EN 50155	Closed electrical operating area
	Weather-proof
Installation location in accordance with EN 61010	Enclosed control cabinet
Pollution degree in accordance with EN 50124-1	PD 2
Altitude class in accordance with EN 50125-1	AX up to 2,000 m above MSL
	Reduced isolation data for altitudes > 2,000 ... 4,000 m above MSL[1]
Operating temperature class in accordance with EN 50155	OT4
Increased operating temperature class upon switching on in accordance with EN 50155	ST1, ST2
Temperature change class for fast temperature changes in accordance with EN 50155	H1
Ambient temperature: Operation	-40 ... 70 °C (-40 ... 158 °F)
	Short-term 85 °C (185 °F)
Ambient temperature: Storage and transport	-40 ... 90 °C (-40 ... 194 °F)
Relative humidity (operation, storage and transport):	
Annual mean value	≤ 75%
Continuous operation	15 ... 75%
Continuous on 30 days in the year	75 ... 95%
On the other days occasionally	95 ... 100%

1) On request

10.10 Device

Weight	Approx. 170 g
Connection type	Mechanical coded two-tier terminals in push-in version, pluggable
Cable cross-section	0.2 … 1.5 mm^2 (AWG 24 … 16)
Cable	Flexible (stranded) with ferrule or solid (single-wire)
Use shielded copper wires only. The cables must be temperature-resistance to no lower than 75 °C (167 °F) unless the application demands more stringent requirements. The cables must be rated for the limit value of the protective device of the electrical circuit.	

10.11 Further Data

Degree of protection in accordance with EN 60529	IP20
Mechanical stress vibration and shock in accordance with EN 61373, IEC 61373	Category 1, class B Tested by an independent accredited test laboratory
MTBF in accordance with SN 29500	> 2.6×10^6 h (383 FIT per channel)
Useful life in accordance with EN 50155	20 years, L4
Useful life in accordance with EN 13849	20 years

11 Appendix

11.1 Standards and Directives

The devices have been developed in compliance with the following standards and directives:

Directives
Directive 2014/30/EU (EMC)
Directive 2014/35/EU (low voltage)
Directive 2011/65/EU (RoHS)
Directive 2012/19/EU (WEEE)
Regulation (EC) No. 1907/2006 (REACH)

The current standards and directives may differ from those specified here. The applied standards are documented in the Declaration of Conformity and the corresponding certificates. You can find these at → *www.knick-international.com* under the corresponding product.

Standards	
Railway Applications	EN 50155, EN 50153
Resistance to vibration and shock	EN 61373, IEC 61373
Fire protection	EN 45545-1, EN 45545-2, EN 45545-5
EMC	EN 50121-1, EN 50121-3-2
Functional safety	EN 50129
RAMS	EN 50126-1, EN 50126-2
Isolation requirements	EN 50124-1
Climate	EN 50125-1
Industrial Applications	EN 61010-1
EMC	EN IEC 61326-1
Isolation requirements	EN 61010-1, EN IEC 60664-1
Restrictions on hazardous substances/RoHS	EN IEC 63000
Electrical safety and fire protection (Canada)	CAN/CSA-C22.2 No. 61010-1-12
Electrical safety and fire protection (USA)	UL 61010-1, UL File: E340287

11.2 Compliance with Standards

In this section, all relevant specifications are grouped by standard.

EN 50155

Installation location	Installation location 1, Table C.1
Operating temperature class	OT4
Temperature change class for fast temperature changes	H1
Increase operating temperature class upon switching on	ST1, ST2
Power supply range in accordance with Section 5.3	V_S: 10 ... 33.6 V
	U_B: 10 ... 33.6 V
Switching class	C1 for 24 V nominal voltage
Interruption class	S1 for 24 V nominal voltage
Useful life	20 years, L4
Protective coating	Class PC2

EN 45545-2

Flammable materials	None
Hazard level for indoor and outdoor applications	HL3

EN 50153

Electrical safety	All connected current or voltage circuits must meet the SELV, PELV or Section I requirements.

EN 50125-1

Altitude class in accordance with EN 50125-1	AX up to 2,000 m above MSL
	Reduced isolation data for altitudes > 2,000 ... 4,000 m above MSL[1]
Relative humidity (operation, storage and transport):	
Annual mean value	≤ 75%
Continuous operation	15 ... 75%
Continuous on 30 days in the year	75 ... 95%
On the other days occasionally	95 ... 100%

EN 50124-1

Pollution degree	PD2

1) On request

EN 50121-3-2, EN 50121-1

EMC immunity	Note: The device is designed for direct connection to a railway control unit for odometry. All connections, including supply voltage V_S and U_B, are assigned to the groups of signal and communication cables, process, measurement, and control cables in accordance with EN 50121-3-2. For direct connection to a battery, burst immunity is restricted to evaluation criterion B and additional EMC protective measures must be provided for.

Industrial Applications

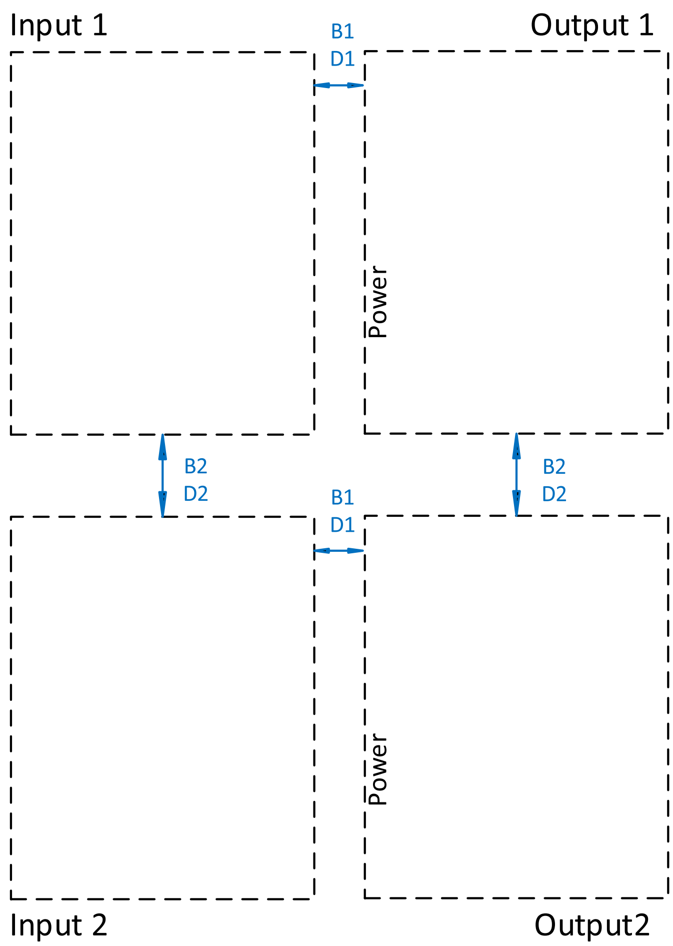
EN 61373

Mechanical stress vibration and shock	Category 1, class B Tested by an independent accredited test laboratory

EN 61010-1

Installation location	Enclosed control cabinet

11.3 Details on Isolation, Isolating Distances, Contamination, and Overvoltage



Rated Insulation Voltages (Excerpt)

Section	Actual value [mm]		ISO	OV	PD	≤ Altitude [km]		Rated insulation voltage [V]
	Clearance	**Creepage distance**				**2**	**4**	**EN 50124-1, EN 60664-1, EN 61010-1, UL 61010-1**
B1	11	11	B	III	2	x	x	1000
D1	11	11	D	II	2	x		1000
D1	11	11	D	III	2	x		600
D1	11	11	D	II	2	x	x	600
D1	11	11	D	III	2	x	x	300
B2 [1) 2)]	3	3	B	III	2	x		300
D2 [1) 2)]	3	3	D	II	2	x		300
D2 [1) 2)]	3	3	D	II	2	x	x	150

Key:

D: Reinforced insulation

B: Basic insulation

OV: Overvoltage category

PD: Pollution degree

1) No galvanic isolation of outputs in versions with DOT

2) No galvanic isolation of inputs when the two inputs are connected in parallel

12 Safety Manual

12.1 General Description

When using a P16812/P16822, it is possible to extract vehicle speed information that is transmitted as electrical rectangle signals from a sensor to a primary control unit and route it to a secondary control unit (signal doubling).

The assumption is that the sensor for the intended applications (on both the primary control unit and the secondary control unit) may be considered suitable (SRAC A), possibly under the condition that SRAC C is satisfied.

Due to the use of redundancy principles and the SIL-compliant design (of the input part), the quantitative analysis yields a negligible frequency of interference to the signal transfer from the sensor to the primary control unit (contribution by a P16812 to the error rate of an interference incident is less than 7×10^{-13} per hour). In this context, the verification makes reference to the specifications in accordance with EN 50129, Table E.4 (captive properties).

For the use of a P16822, it is additionally documented that the specifications on independence (in accordance with EN 50129, Section B.3.2) are fulfilled such that the two outputs of a P16822 can be considered independent of each other – if the sensor signals can be assumed to be independent (SRAC A, SRAC E).

The safety and safety integrity level requirements are derived from basic assumptions about the vehicle functions supported by a P16812/P16822. The corresponding safety and safety integrity level requirements are listed below.

Information on the assumptions made in this context (SRACs) and recommendations with regard to the use of a P16812/P16822 follow. If recommendations are not implemented, larger contributions from a P16812 or for each of the two channels of a P16822 must be used as part of the determination of a project-specific error rate.

The error rate of a P16812 output depends on the intended application. → *SRACs for System Project Planning and Structure, as well as Operation, Maintenance and Safety Monitoring, p. 57*

12.2 Safety and Safety Integrity Level Requirements

12.2.1 Functional Safety Requirements

The functional safety requirements underlying the development were defined on the basis of a market study and are as follows:

1. The speed information received by the primary control unit must match the speed information transmitted by the sensor at all times, even after the integration of a P16812/P16822, and must not experience any significant delay as the result of the integration of a P16812/P16822.
2. The output signals to the secondary control unit must be consistent with the input signals of the sensor. In other words, they must represent the same speed at all times and must not experience any significant delay.

With regard to the speed information transmitted to the secondary control unit, the following conditions must be fulfilled depending on the selected configuration:

- A voltage signal at the input is transmitted as a voltage signal to the output
- A current signal at the input is transmitted as a current signal to the output
- A voltage signal at the input is converted into a current signal at the output
- A current signal at the input is converted into a voltage signal at the output
- The High level of a current output is set to either 14 mA or 20 mA and with this, adjusted to the input of the controller
- Output pulses are provided in accordance with the selected frequency division (regardless of the input signal type and output signal type)
- The output levels are inverted or not inverted in proportion to the input

12.2.2 Safety Integrity Requirements

The safety integrity requirements underlying the development were defined on the basis of a market study and are as follows:

1. The design portions of a P16812/P16822 that could cause interference to the flow of signals between the sensor and primary control unit must fulfill specifications in accordance with EN 50129 SIL 4.
2. The two output signals of a P16822 to a primary control unit must fulfill the independence specifications in accordance with EN 50129, Section B.3.2, SIL 4.
3. In terms of immunity to interference and emitted interference, the two products P16812/P16822 must implement the specifications of EN 50129 (as described in Section 7.2, Structure of the Technical Safety Audit "Section 4: Operation with External Influences"; in other words, integrating standards EN 50121, EN 50124, EN 50125 and EN 50155 – as applicable for vehicles).
4. The output signals to both the primary and secondary control unit must present a tolerable delay in the range of no more than 1 ms; in other words, significantly below the threshold caused by the inertia of rolling stock.

Note: If a frequency division is configured (via DIP switch), square pulses are cumulated. In this case, safety integrity requirement 4 does not refer to single pulses, but instead to the delay of an entire package of 2, 4 or 8 single pulses.

To the extent that an input signal of a P16812/P16822 is suitable for safety-related applications in accordance with EN 50129, SIL 2, the associated output signal of a P16812/P16822 to the secondary control unit must also fulfill the specifications in accordance with EN 50129, SIL 2. The TFFR of a (single) P16812 is defined as 3×10^{-7} per hour.

12.3 SRACs for System Project Planning and Structure, as well as Operation, Maintenance and Safety Monitoring

All of the safety-related application conditions (SRACs) listed below must be fulfilled to be able to justify using a P16812/P16822 for a safety-related application.

For reasons of expediency, we do not differentiate between SRACs for system project planning and structure and SRACs for operation, maintenance and safety monitoring here.

Note: The following primarily relates to a P16812. In these cases, the SRACs also apply to each of the two channels of a P16822. SRACs that were only defined for a P16822 are explicitly indicated.

12.3.1 SRAC A: Sensor Prerequisites

Name	P168*2-SRAC_A
Title	Sensor Prerequisites
Text	The integrator must ensure that the signals coming from the sensor are suitable and sufficiently qualified for the intended application context, with reference to applications of the control units. **Note:** Integrating a P16812/P16822 does not relieve the integrator from ensuring that the sensor is suitable for the intended application context from the viewpoint of functional safety and sufficiently qualified. *→ SRAC C: Implementing Sensor-Dependent SRACs, p. 57*

12.3.2 SRAC B: Detecting a Current Drop to 0 mA (Primary Control Unit)

Name	P168*2-SRAC_B
Title	Detecting a Current Drop to 0 mA (Primary Control Unit)
Text	The integrator must ensure that the primary control unit monitors the incoming signals via P16812/P16822 and initiates a safe state upon detecting a current drop to 0 mA.

12.3.3 SRAC C: Implementing Sensor-Dependent SRACs

Name	P168*2-SRAC_C
Title	Implementing Sensor-Dependent SRACs
Text	The integrator must implement the SRACs defined by using the sensor. **Note:** Including SRACs, in terms of wiring between the sensor and primary control unit. **Note:** The suitability of a P16812/P16822 for detecting sensor operating faults does not depend on the implementation of possible sensor SRACs.

12.3.4 SRAC D: Validity of the Input Signal of the Primary Control Unit

Name	P168*2-SRAC_D
Title	Validity of the Input Signal of the Primary Control Unit
Text	The integrator must ensure that the primary control unit considers incoming signals as valid. Here, the following conditions apply: - For incoming current signals (I_{in}): The primary control unit considers the signal valid as long as the voltage drop at the input of the universal speed signal doubler is less than 1 V. - For incoming voltage signals (U_{in}): The primary control unit considers the signal valid as long as the input impedance of the universal speed signal doubler is greater than 60 kΩ. - For the incoming voltage reference (U_S): The primary control unit considers the signal valid as long as the input impedance of the universal speed signal doubler is greater than 60 kΩ.

12.3.5 SRAC E: Wiring (Input and Output Side)

Name	P168*2-SRAC_E
Title	Wiring (Input and Output Side)
Text	For the P16812/P16822 wiring, the integrator must implement a sufficient number of quality assurance measures. Here, the integrator must particularly ensure that connecting a P16812/P16822 leads to compliance with the following conditions: - The information transmitted to the primary control unit is not corrupted and (in the case of a P16822) there is no negative impact on the required independence of the sensor signals, if any. - The signals received by a P16812/P16822 may be considered as sufficiently qualified even after wiring. *→ SRAC A: Sensor Prerequisites, p. 57* - The speed information received by the secondary control unit are not corrupted by the wiring. - P16822 only: The independence of the two output signals is not negatively impacted. **Note:** If the integrator does not/cannot implement sufficient measures in terms of connection to the information flow from the sensor to the primary control unit, they must ensure that an alignment with sufficient qualified and independent speed information is carried out on the primary control unit. *→ SRAC G: Secondary Control Units with SIL 3/SIL 4 Applications, p. 58* **Note:** The connecting cables from where the sensor signal is tapped to the P16812/P16822 must be connected and routed with care in accordance with the state of the art such that short circuits between the cables (for voltage input) or interruptions in the cables (for current input) are avoided. The same applies to connecting cables from a P16812/P16822 to the secondary control unit.

12.3.6 SRAC F: Ensuring that the Safety-Related Failure Rate of a P16812/P16822 Is Adequate for the Project

Name	P168*2-SRAC_F
Title	Ensuring that the Safety-Related Failure Rate of a P16812/P16822 Is Adequate for the Project
Text	The integrator must ensure that the application-specific, safety-related failure rate of a universal speed signal doubler (as documented in this user manual) is adequate for the intended application context. **Note:** The second channel of a P16822 may be considered independent with reference to random hardware errors. Therefore, using a P16822 can help to reduce the error rate by comparing the two speeds in a secondary control unit.

12.3.7 SRAC G: Secondary Control Units with SIL 3/SIL 4 Applications

Name	P168*2-SRAC_G
Title	Secondary Control Units with SIL 3/SIL 4 Applications
Text	If the output signal of a P16812/P16822 is used for SIL 3/SIL 4 applications on the secondary control unit, the integrator must ensure that the P16812/P16822 speed information is safeguarded by sufficiently independent speed information. **Note:** Independence in terms of random hardware errors and in terms of systematic errors (diversity). **Note:** The second channel of a P16822 is redundant but not diverse to the first channel.

12.3.8 SRAC H: Do Not Use Standstill Detection (Middle Voltage) for Safety-Related Applications

Name	P168*2-SRAC_H
Title	Do Not Use Standstill Detection (Middle Voltage) for Safety-Related Applications
Text	If the secondary control unit implements a safety-related application and if a voltage output is configured, the integrator must ensure that the "Standstill detection" function (middle voltage) is not configured.

12.3.9 SRAC I: No Evaluation of Phase Angle for Frequency Division (to Determine the Direction of Travel)

Name	P168*2-SRAC_I
Title	No Evaluation of Phase Angle for Frequency Division to Determine the Direction of Travel
Text	The integrator must ensure that when frequency division is configures, the secondary control unit does not evaluate the phase angle to determine the direction of travel because in this case, the phase angle is lost.

12.3.10 SRAC J: Protection Against Environmental Influences and Unauthorized Access

Name	P168*2-SRAC_J
Title	Protection Against Environmental Influences and Unauthorized Access
Text	The integrator must ensure that each P16812/P16822 universal speed signal doubler is integrated into a weather-proof control cabinet inside or outside the vehicle. The control cabinet must be adequately secured against unauthorized access and protected against harsh conditions in accordance with EN 50129, and must not violate the vehicle profile or the structural integrity of the vehicle.

12.3.11 SRAC K: Implementation of the Requirements for Using a P16812/P16822 as Described in the User Manual

Name	P168*2-SRAC_K
Title	Implementation of the Requirements for Using a P16812/P16822 (as described in the User Manual)
Text	The integrator must implement all the requirements for using a P16812/P16822 contained in the user manual.

12.3.12 SRAC L: DIP Switch Configuration Compliant with Wiring and the Interface Specifications of the Secondary Control Unit

Name	P168*2-SRAC_L
Title	DIP Switch Configuration Compliant with Wiring and the Interface Specifications of the Secondary Control Unit
Text	The integrator must ensure that the set DIP switch configuration agrees with the realized wiring and with the interface specifications of the secondary control unit.

12.3.13 SRAC M: Safety Testing

Name	P168*2-SRAC_M
Title	Safety Testing
Text	The integrator must coordinate with the railway operator to determine if safety testing (in the meaning of EN 50129) is considered necessary and implement it accordingly. The results must be integrated into the higher-level safety instructions. If necessary, Knick will support the integrator as part of the safety testing of a universal speed signal doubler.

12.4 List of Recommendations

Note: Unlike the listed SRACs, the implementation of recommendations is not mandatory. → *SRACs for System Project Planning and Structure, as well as Operation, Maintenance and Safety Monitoring, p. 57*
If neither Recommendation 1 nor Recommendation 2 are implemented, a higher failure rate must be used. Further, the importance of SRAC E increases in this case. The integrator is responsible for deciding whether it is suitable to integrate a universal speed signal doubler although these recommendations have not been implemented (see SRAC F).
→ *SRAC E: Wiring (Input and Output Side), p. 58*
→ *SRAC F: Ensuring that the Safety-Related Failure Rate of a P16812/P16822 Is Adequate for the Project, p. 58*

12.4.1 Recommendation 1: Detecting a Current Drop to 0 mA (Secondary Control Unit)

Name	P168*2-Recommendation_1
Title	Detecting a Current Drop to 0 mA (Secondary Control Unit)
Text	The integrator should ensure that the secondary control unit detects a drop to 0 mA and then initiates a transition into a safe state with regard to the use of the secondary control unit.

12.4.2 Recommendation 2: Detecting the Opening of a Switch Output (Secondary Control Unit)

Name	P168*2-Recommendation_2
Title	Detecting the Opening of a Switch Output (Secondary Control Unit)
Text	The integrator should ensure that the secondary control unit detects an opening of the switch output and then initiates a transition into a safe state with regard to the used of the secondary control unit.

12.4.3 Recommendation 3: Comparison of the Two Outputs of a P16822 (Secondary Control Unit)

Name	P168*2-Recommendation_3
Title	Comparison of the Two Outputs of a P16822 (Secondary Control Unit)
Text	When using a P16822, the integrator should ensure that the two outputs of a P16822 in the secondary control unit are checked for consistency. If a deviation is detected, the control unit should initiate a transition into a safe state with regard to the use of the secondary control unit.

12.5 List of Function-Specific, Safety-Related Error Rates

The error rate of the output of a P16812 or a single channel of a P16822 depends on the intended application.
The following table shows the associated error rates for two cases: Case 1, that the integrator does not implement any of the recommendations and Case 2, that the integrator implements Recommendation 1 or Recommendation 2.

Error Rates (Single Channel)	Error Rate without Recommendation 1 or Recommendation 2	Error Rate with Recommendation 1 or Recommendation 2
A speed greater than the speed determined by the sensor is output – if no standstill is actually present.	40 FIT	40 FIT
A speed less than the speed determined by the sensor is output – if the vehicle is actually moving.	40 FIT	40 FIT
A speed interpreted as standstill is output although rectangle signals are received at the input (v > 0). **Note:** The values below are only relevant if the secondary control unit interprets 0 mA as standstill.	156 FIT	103 FIT
	272 FIT	103 FIT
A speed interpreted as movement is output although no rectangle signals are received at the input (v = 0).	41 FIT	27 FIT

Error Rates (Two Channels)	Error Rate without Recommendation 1 or Recommendation 2	Error Rate with Recommendation 1 or Recommendation 2
Incorrect phase angle (e.g., for determining the direction of travel; for P16822 only) **Note:** Each of the two channels of a P16822 contributes to the error rate of an undesired phase angle (“factor of 2”).	334 FIT	220 FIT

12.6 Basis for Calculating Function-Specific, Safety-Related Error Rates (Quantitative Analysis)

As part of the quantitative analysis, the Siemens SN 29500 standard was primarily used. For approx. 50 components (above all ICs, transistors and diodes), manufacturer information was used.

Manufacturer-related error rate information is based on experience from the field. Frequently, they do not take confidence observations into consideration. This is why the supplied values were multiplied by a factor of 3.

As part of the analysis, the adjusted manufacturer information was favored.

In the first step, an error rate was derived for each installed component in accordance with SN 29500. Here, the following assumptions were made:
Failure rate forecast in accordance with EN/IEC 61709 (SN 29500) for stationary continuous operation (Ground Benign) at an average ambient temperature of 50 °C in accordance with the environmental conditions of a closed electrical operating area in accordance with EN 50155 for part-time operation with 80 % of system operating time.

13 Abbreviations

AWG	American Wire Gauge
CE	Conformité Européenne (European conformity)
CH	Channel
DI	Digital Input
DIP	Dual Inline Package (slide switch with positions ON and OFF)
FFR	Functional Failure Rate (failure rate of a product)
f_{in}	Frequency of the input signal
FIT	Failures in time (failures in 10^9 hours)
f_{out}	Frequency of the output signal
GND	Ground
GND_{in}	Ground at input for U_S, U, I
GND_{out}	Ground at output for U_B, V_S, SW
HTL	High Threshold Logic (conventional output signal level of speed encoders)
I	Current input
I_B	Current into terminal V_B
I_{GND}	Current from terminal GND
I_{out}	Output current signal OUT
I_s	Current into terminal V_S
MTBF	Mean time between failures
NC	Normally Closed
Out	Output
OV	Overvoltage Category
P168***	"*" = Placeholder for product variants → *Product Code, p. 9*
PD	Pollution degree
PELV	Protective extra low voltage
P_{max}	Maximum power output used by the device
R_L	Resistance at output
R_{max}	Maximum resistance value
$R_{M,max}$	Maximum load resistance
SELV	Safety extra low voltage
SIL	Safety integrity level
SRAC	Safety-Related Application Condition
SW	Switch (switch output)
T	Cycle duration
TFFR	Tolerable Functional [unsafe] Failure Rate
t_p	Time of propagation (flow time)
U	Voltage input
U_B	Supply of output driver
UL	Underwriters Laboratories (recognized testing body and certification organization)
U_{out}	Output voltage signal OUT
U_S	Voltage reference for level detection
V_S	Supply of P168*2
ΔtpHL	Difference in flow time from High to Low (difference in propagation time from High to Low)
ΔtpLH	Difference in flow time from Low to high (difference in propagation time from High to Low)

Notes

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