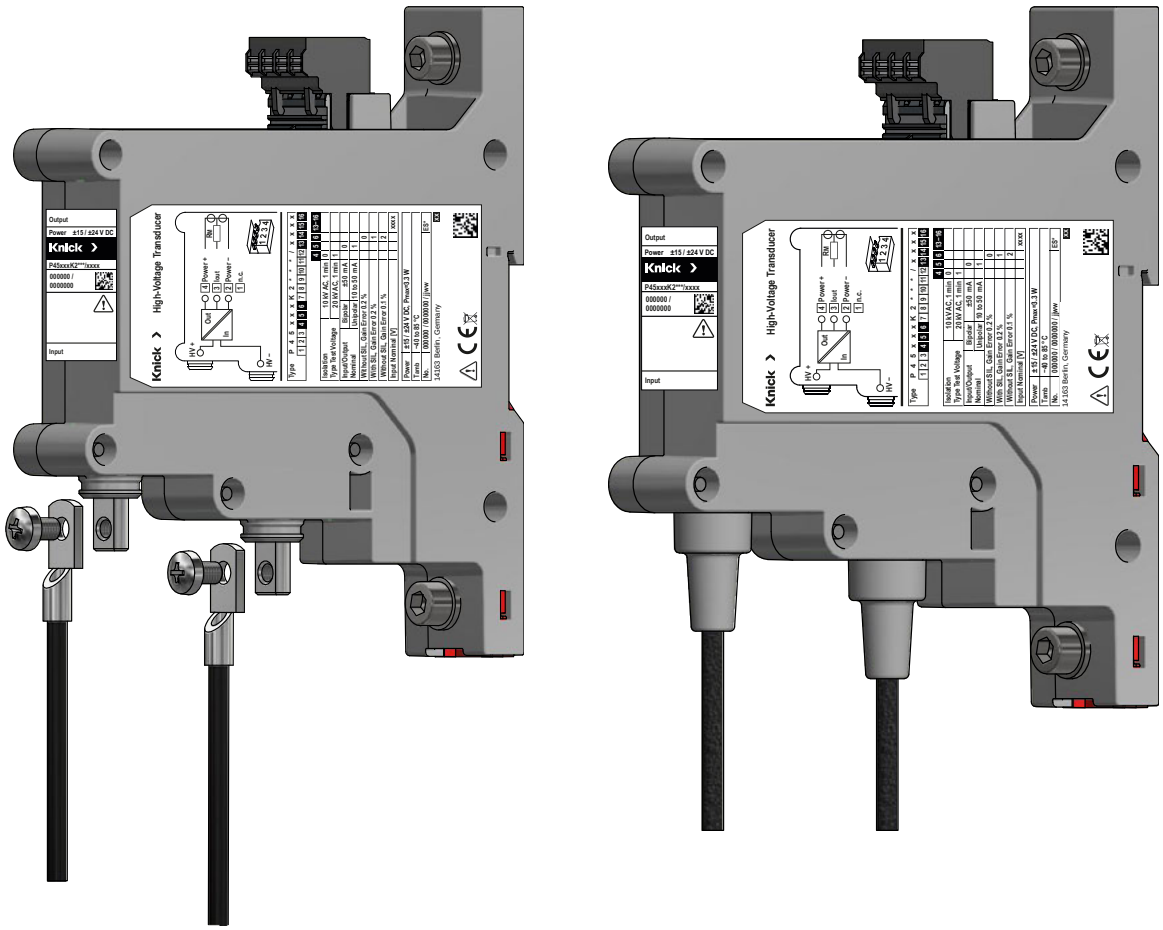
Knick

User Manual
incl. Safety Manual

P45000
High Voltage Transducer



Read before installation.
Keep for future use.

www.knick-international.com

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.

The product may not be opened, modified, or independently repaired. Do not use the product if the housing is damaged. Replace with an equivalent product. Repairs may only be carried out by Knick.

1.1 Intended Use

The transducers of the P45000 product line measure voltages on railway vehicles as well as in railway infrastructure facilities and industrial plants.

On rolling stock, the P45000 may only be mounted in closed electrical operating areas at installation location 1 according to EN 50155 Annex C. If the P45000 is mounted in the interior of railway vehicles, it must be mounted in closed and fire-protected enclosures.

The input may be connected directly to primary circuits (high potentials). All definitions and technical data in the specifications must be observed.

The input signal is recorded by the P45000, processed, and galvanically isolated from the output and auxiliary power. The output signal proportional to the input is galvanically connected to the auxiliary power.

For further processing, the output signal is fed into a controller, a protection device, an indicator, or a data recording system.

Fields of Application

- Rolling stock
- Railway substations
- High-voltage drives
- Industrial plants
- Infrastructure systems
- Power electronics
- Rectifiers and inverters
- Battery backups and emergency power systems

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 Avoiding Electric Shocks and Fires

When routing the connection cables, the specifications in accordance with EN 50343 must be complied with.

Cables that are connected to the output and the power supply must be measured for the current limit value of the protective device for this circuit.

Measures to protect against direct contact: The operating company must implement protective measures against direct contact for freely accessible screwed contacts. In accordance with EN 50153, Clause 5, this can be ensured by installation in a lockable control cabinet. Other national or application-specific regulations must be observed.

Distances to adjacent devices and conductive parts in the vicinity of the device must be measured in accordance with the applied standard, which must be complied with. Isolation coordination with the clearance and creepage distances (→ *Clearance and Creepage Distances, p. 33*, → *Clearance and Creepage Distances, p. 34*) and the corresponding standards (e.g., EN 50124-1) must be implemented, evaluated, and ensured.

If the device is mounted horizontally with pollution degree PD3A and in accordance with EN 50124-1, it may only be mounted on plastic surfaces with CTI 600.

See also

→ *Clearance and Creepage Distances, p. 33*
→ *Clearance and Creepage Distances, p. 34*
→ *Installation, p. 14*

1.4 Residual Risks

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:

- P45000 may only be operated in compliance with the specified operating conditions.
  → *Specifications, p. 28*

2 Product

2.1 Package Contents

- P45000 in the version ordered
- Installation guide with safety instructions
- Test Report 2.2 in accordance with EN 10204

2.2 Product Identification

The various versions of the P45000 product are coded in a model designation.

The product code is indicated on the nameplate (excerpt). It allows you to determine the individual product model together with the order designation, which is indicated on the front label (device front).

2.2.1 Model Designation Example

Model designation	**P45**	**0**	**0**	**0**	**K**	**2**	**1**	**0**	**1**	**/**	**1**	**0**	**0**	**0**
Type test voltage 10 kV AC, nominal voltage $U_{in,n}$ [V]: 500 ... 1500		**0**								**/**				
I_{out} = ±50 mA; bipolar			**0**							**/**				
Without SIL capability				**0**						**/**				
Type of housing					**K**	**2**				**/**				
Wall mounting/35 mm DIN rail							**1**			**/**				
High-voltage connection: screwed contact/ring cable lug								**0**		**/**				
Output/auxiliary power: push-in terminals									**1**	**/**				
Input nominal voltage: $U_{in,n}$ = xxxx V										**/**	**1**	**0**	**0**	**0**

2.2.2 Product Code

High Voltage Transducer	**P45**	_	_	_	K	2	_	_	_	/	_	_	_	_	_	_	_	_	_
Type test voltage 10 kV AC, nominal voltage $U_{in,n}$ [V]: 500 ... 1500		0								/									
Type test voltage 20 kV AC, nominal voltage $U_{in,n}$ [V]: 500 ... 3000		1								/									
I_{out} = ±50 mA; bipolar			0	0						/									
I_{out} = ±50 mA; bipolar			0	2						/									
I_{out} = 10 ... 50 mA; unipolar			1	1						/									
I_{out} = 4 ... 20 mA; unipolar			2	1						/									
Out special type[1]			9	0						/					-	S	x	x	x
Out special type[1]			9	2						/					-	S	x	x	x
Without SIL capability, gain error 0.2 %				0						/									
With SIL capability, gain error 0.2 %[2]				1						/									
Without SIL capability, gain error 0.1 %				2						/									
Type of enclosure					K	2				/									
Wall mounting only							0			/									
Wall mounting/35 mm DIN rail							1			/									
High-voltage connection: Screwed contact/ring cable lug								0		/									
High-voltage connection: Fixed cable								1		/									
Output/auxiliary power: Push-in terminals									1	/									
Output/auxiliary power: Screw terminals									2	/									
Input nominal voltage: $U_{in,n}$ = xxxx V										/	x	x	x	x					
Special types[1]															-	S	x	x	x

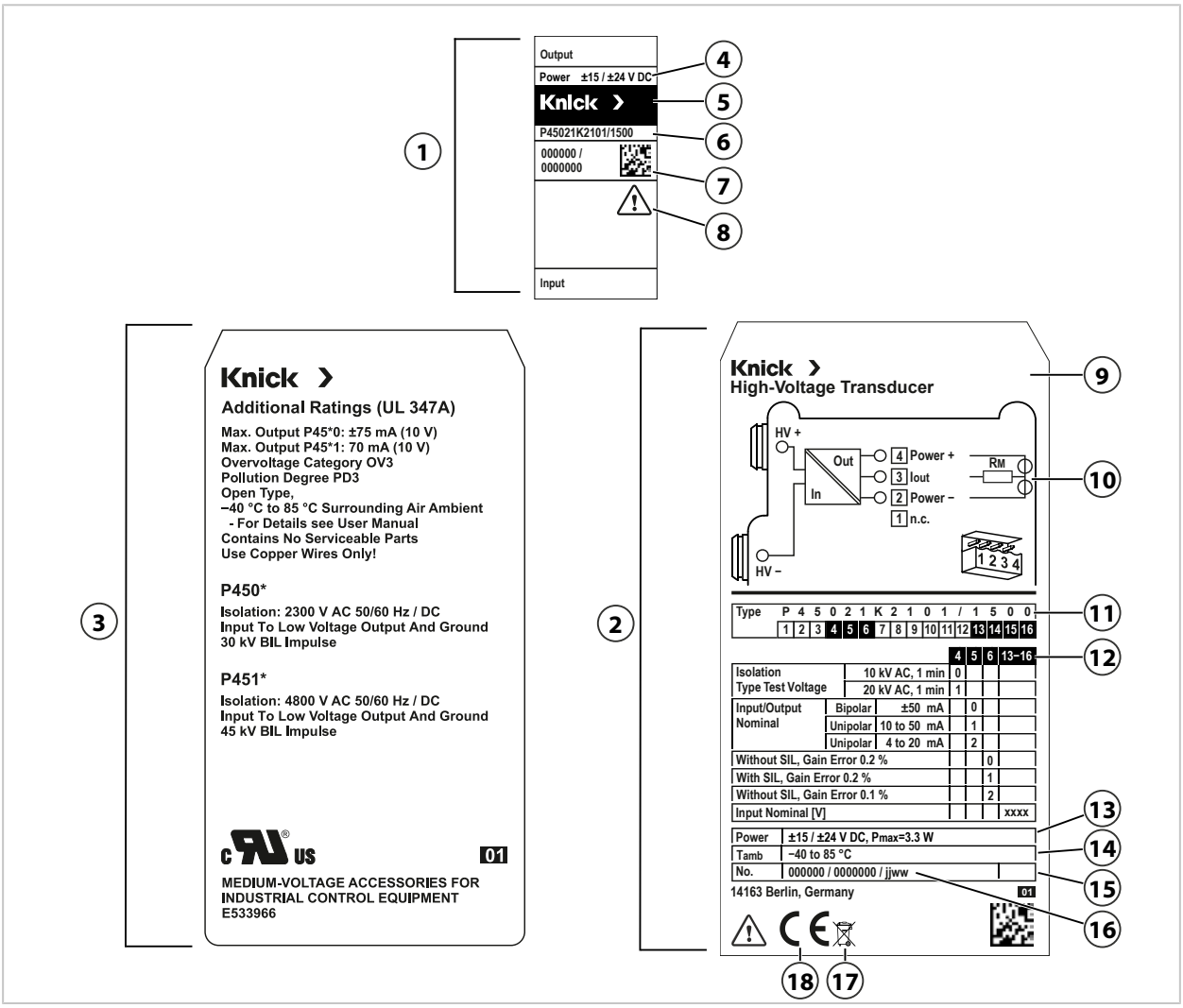
[1] Deviations from the user manual in accordance with the information on the product

[2] Only for nominal voltage $U_{in,n}$ [V]: 500, 750, 1000, 1500, 2000, 2800, 3000

2.3 Nameplate

P45000 is identified by nameplates on the sides and front of the housing. The information on the nameplates varies depending on the product version.

Example:



1	Nameplate, device front	10	Block diagram with terminal assignment
2	Nameplate, right side	11	Model designation with individual product version
3	Nameplate UL, left side	12	Product code (excerpt)
4	Auxiliary power specification	13	Auxiliary power specification
5	Manufacturer	14	Permitted ambient temperature
6	Model designation with individual product version	15	Item number/serial number/production date
7	Item number/serial number	16	Manufacturer address with designation of origin
8	Special conditions and danger points	17	WEEE mark
9	Product designation	18	CE mark

2.4 Symbols and Marks

	Special conditions and possible danger points of the product! Read the user manual, observe the specifications, and follow the instructions in the safety chapter.
	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.
	UL Recognized Component: Certification of components for the USA and Canada
	The symbol on Knick products means that waste devices must be disposed of separately from unsorted municipal waste.

2.5 Structure

The enclosure of the P45000 is designed as a modular enclosure for mounting up to three devices side-by-side or in a stack. The enclosure has a snap-on mounting for 35 mm DIN rails and holes for screwing onto level surfaces.

There are two versions for the high-voltage connection: Screwed contacts (M5) for cables with ring cable lug and fixed cables encapsulated in the device. The length of the fixed cables is 2 m.

There are two versions for connecting output/auxiliary power: Push-in terminals and screw terminals.

2.6 Function Description

2.6.1 Measurement Functions

The transducer is used for the conditioning, filtering, and galvanic isolation of high voltages. The transducer transmits analog signals from a generally high potential to a near-ground potential in order to be able to process the recorded signals safely and with little interference.

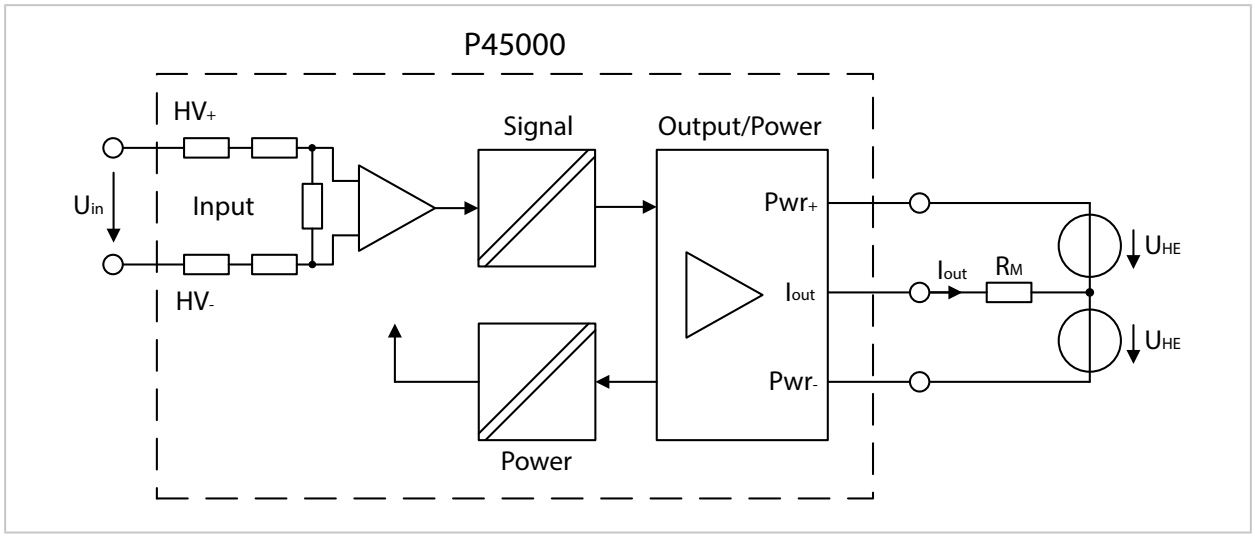
An analog signal is emitted at the output of the transducer. This signal is a replication of the analog measuring signal at the input of the transducer. The amplitude of the input voltage can be up to multiple kilovolts, depending on the device design. Both unipolar and bipolar input signals can be processed. Either a unipolar or a bipolar current signal is provided at the output of the transducer. The 2-port isolation (i.e., the galvanic isolation between input and output/auxiliary power) ensures the safety of persons and systems and increases the signal integrity of the measuring system.

2.6.2 Live Zero Function (Only P45*11K2*** and P45*21K2***)

Products with SIL capability detect certain internal faults (e.g., undervoltage, transfer failure) and set the output to a defined value in response to the fault. This live zero function enables external monitoring of the output signal.

- When 10 … 50 mA output signals (live zero; only P45*11K2***) are used, interruptions or short-circuits of the output cables can be detected. Output currents < 9 mA (P45*11K2***) must be interpreted as an error state here.
- In the case of an 4 … 20 mA output signal (live zero, only P45*21K2***), output currents of < 3.6 mA are considered an error state.

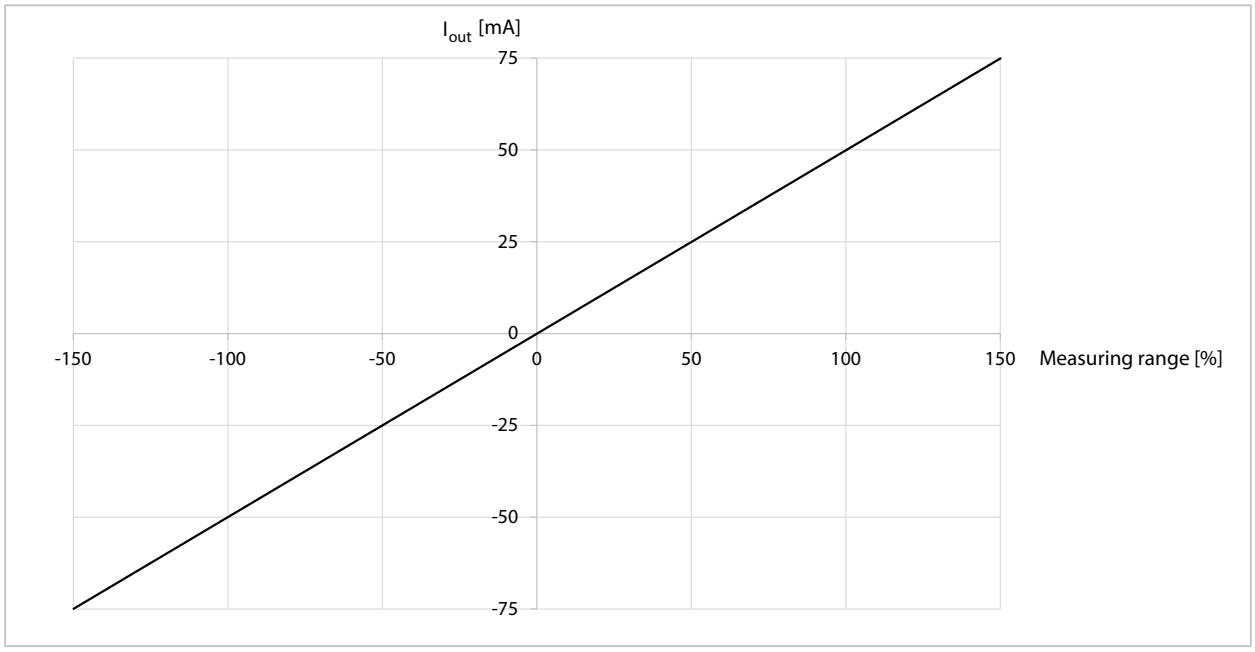
2.6.3 Block Diagram



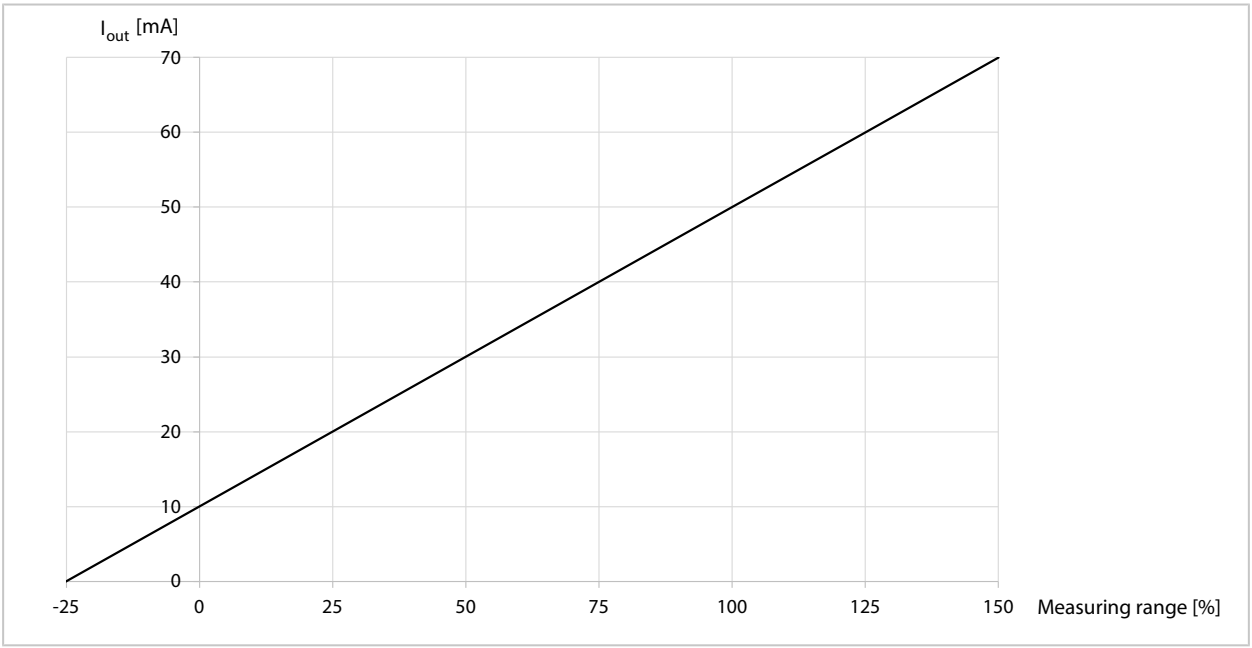
2.6.4 Transfer Characteristics

The measured values are transmitted as linear values.

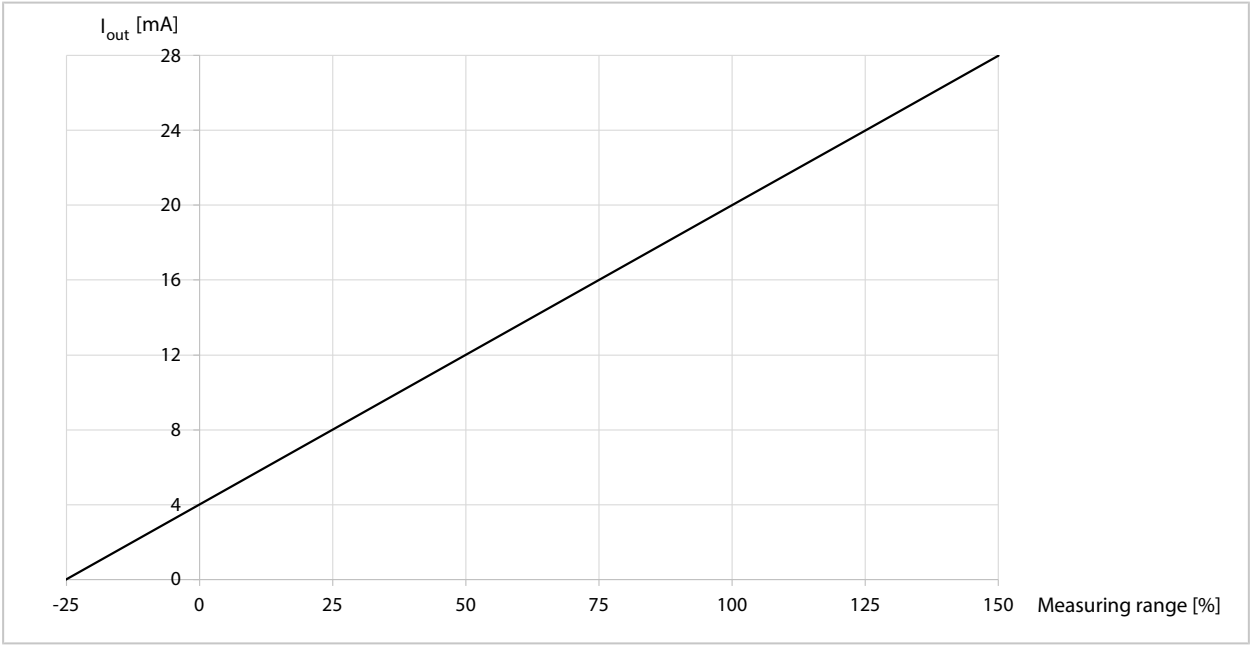
Output current ±50 mA; bipolar



Output current 10 ... 50 mA; unipolar



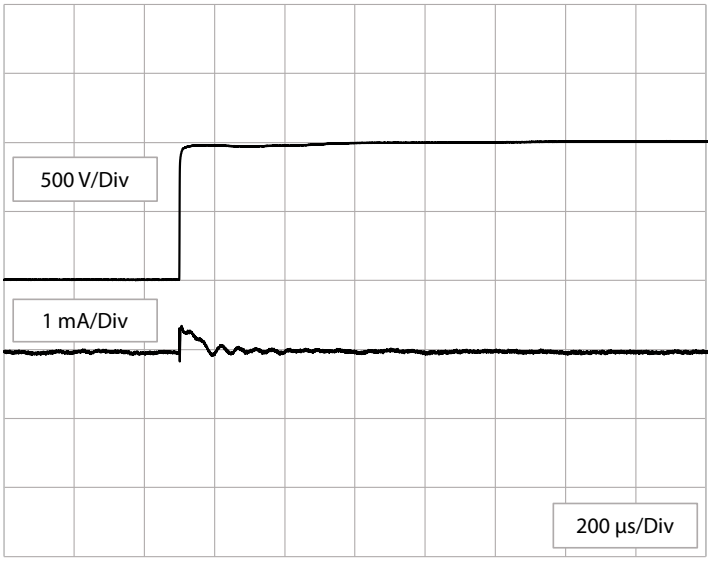
Output current 4 ... 20 mA; unipolar



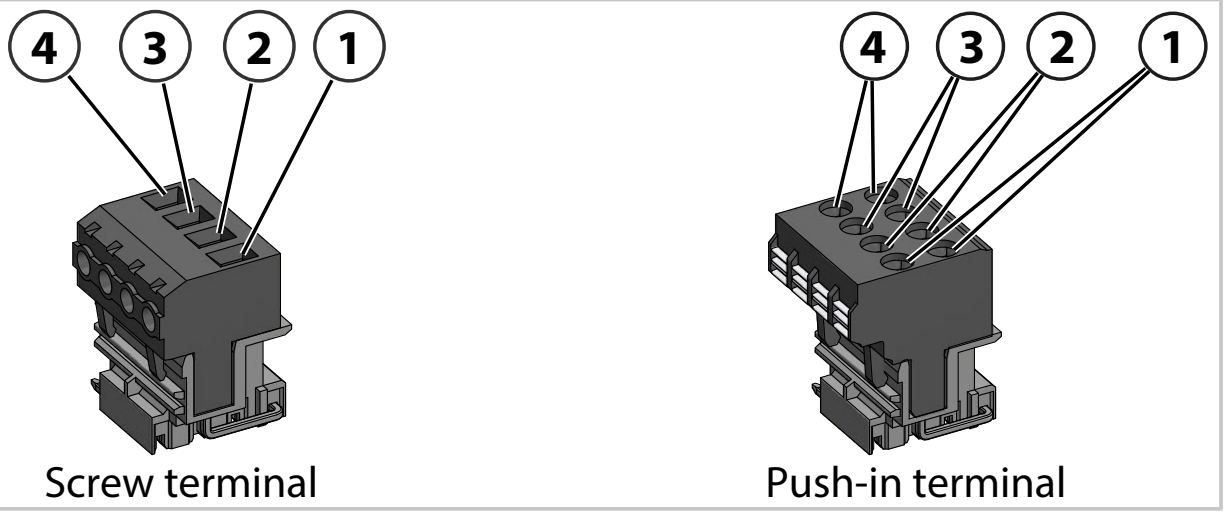
2.6.5 Common-Mode Response

P45000 common-mode response (typical) for 1000 V step with 6 kV/µs

$U_{in,n}$ = 3000 V, $I_{out,n}$ = 50 mA, R = 100 Ω



2.7 Terminal Assignment Output/Auxiliary Power



1	Not assigned	3	Current output
2	Negative supply voltage/auxiliary power	4	Positive supply voltage/auxiliary power

The push-in terminal is designed as a two-tier terminal. Two internally connected terminals are available for each pole. This enables the auxiliary power to be looped through from one device to the next. It is important to ensure that the output signal is galvanically connected to the auxiliary power.

2.8 Installation

2.8.1 General Installation Notes

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

⚠ **WARNING! Danger of electric flashover.** When used in accordance with EN 50124-1 and pollution degree PD3A (P45***K2*1* only), the product may only be mounted horizontally on plastic surfaces with CTI 600.

⚠ **CAUTION! Protective devices and safeguards!** In the interior of railway vehicles, the transducers must be mounted in closed and fire-protected enclosures.

The P45000 can be mounted in any installation orientation:

- Vertical or horizontal on flat surfaces
- On a 35 mm DIN rail (without using a DIN rail bus connector)
- Side by side (maximum of three devices next to or on top of each other, possible with all previously mentioned mounting types)

The ZU1471 accessory can be mounted to extend the clearance. The accessory is mounted in the area of the high-voltage contacts of the input.

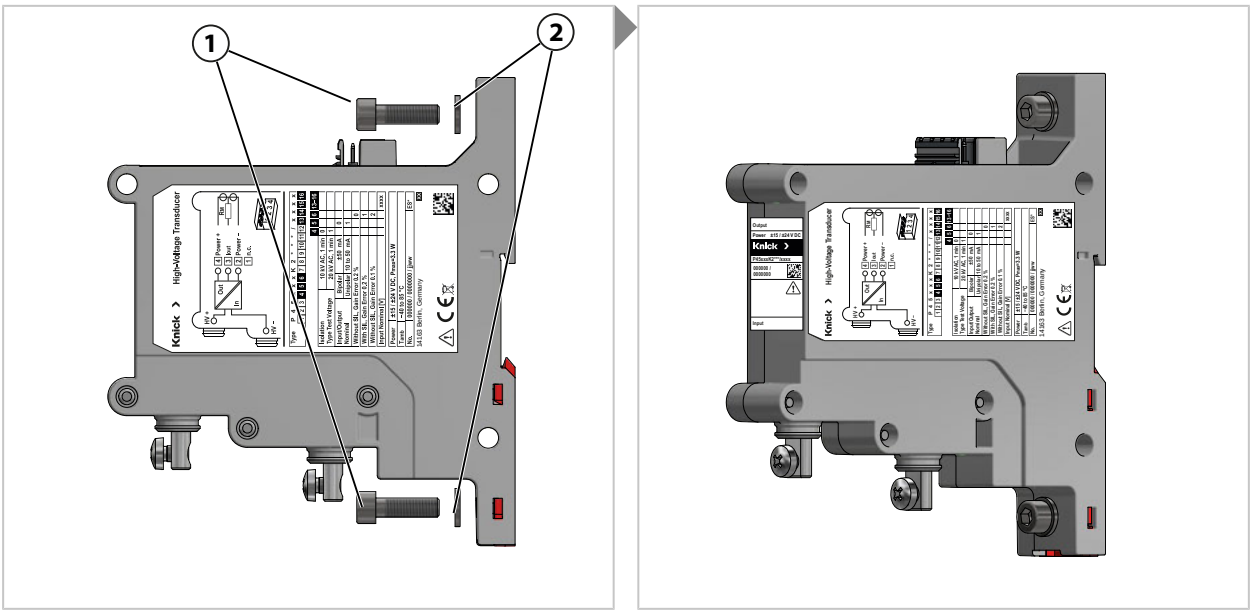
The ZU1474 accessory can be mounted to connect (parallel connection) the input screw terminals of two devices for redundant operation. The accessory is mounted on the screwed contacts.

2.8.2 Installation

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

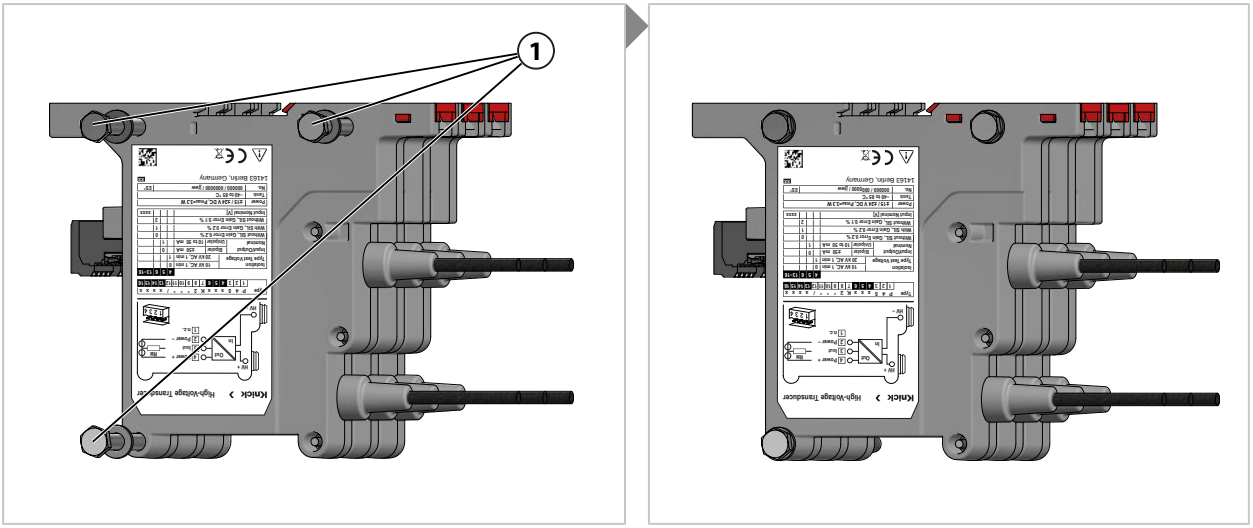
01. Check the package contents for completeness. → *Package Contents, p. 7*
02. Check the P45000 for damage.

Installation on Mounting Surface (vertical)



01. If necessary, mount partition ZU1471.
02. Fasten P45000 to the mounting surface with two M6 screws **(1)** and two M6 washers **(2)**. Tightening torque 5 Nm.

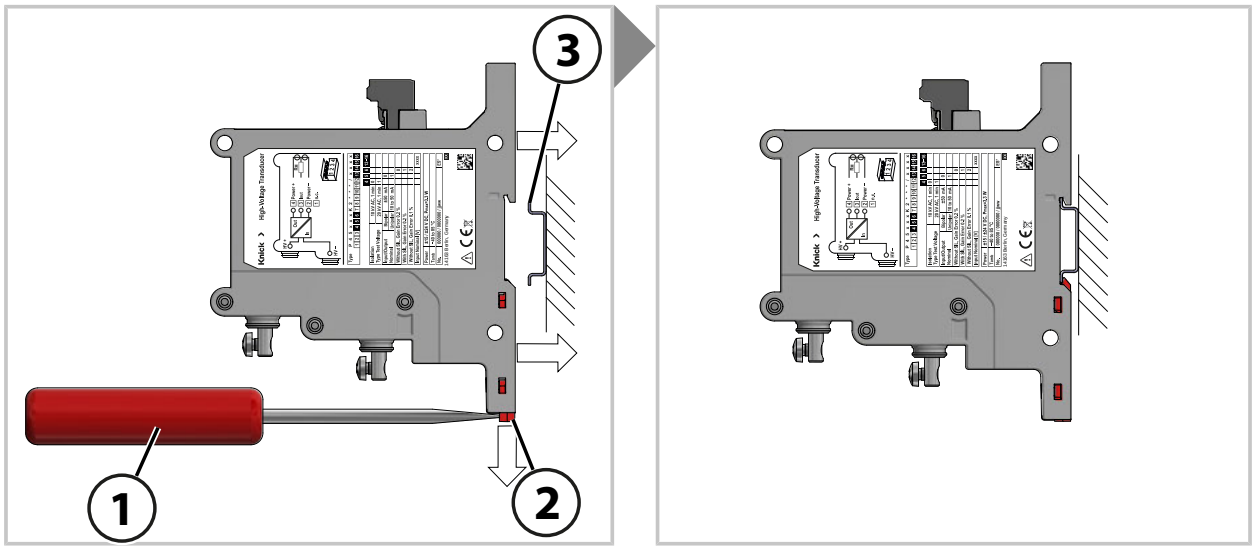
Installation on Mounting Surface (horizontal)



01. If necessary, mount partition ZU1471.
02. Fasten P45000 to the mounting surface with three M6 screws **(1)** and three M6 washers. Tightening torque 3 Nm.

⚠ WARNING! Voltages dangerous to touch! When horizontally mounting the P45***K2*0* variant with screwed contacts, observe the clearances to the surroundings.
→ *Clearance and Creepage Distances, p. 33*

Installation on DIN Rail P45*K21****



For DIN rails with a height of 7.5 mm:

01. If necessary, mount partition ZU1471.
02. Use a screwdriver **(1)** to pull out the red metal foot catch **(2)**.
03. Slide the P45000 horizontally onto the DIN rail **(3)** and snap in the metal foot catch.

For DIN rails with a height of 15 mm:

01. If necessary, mount partition ZU1471.
02. Place the P45000 on the top edge of the DIN rail and snap it in.

2.8.3 Preparing the Cable

Input

Note: For order variant P45***K2*1*, fixed cables with a cable cross-section of 1.5 mm² are pre-installed. These cables have a length of up to 2 m and can be shortened to the length required for the application.

Input cables, product variant P45*K2*0***	
Temperature resistance	min. 100 °C (212 °F)
Maximum cable cross-section	16 mm²
Minimum cable cross-section	1.5 mm²
Maximum ring cable lug length	21 mm from center of screw hole
Ring cable lug alignment[1)]	Vertical ±10°
Ring cable lug material	Steel, tin-plated
Phillips screw material	Steel, stainless

Cables Output/Auxiliary Power

Note: Use ferrules with a metal sleeve length of 10 mm. For solid cables, remove 10 mm of the insulation at the cable ends.

Push-in terminal or screw terminal cables:	
Maximum cable cross-section	2.5 mm²
Minimum cable cross-section	0.2 mm²

1) → *Electrical Connection, p. 17*

2.8.4 Electrical Connection

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

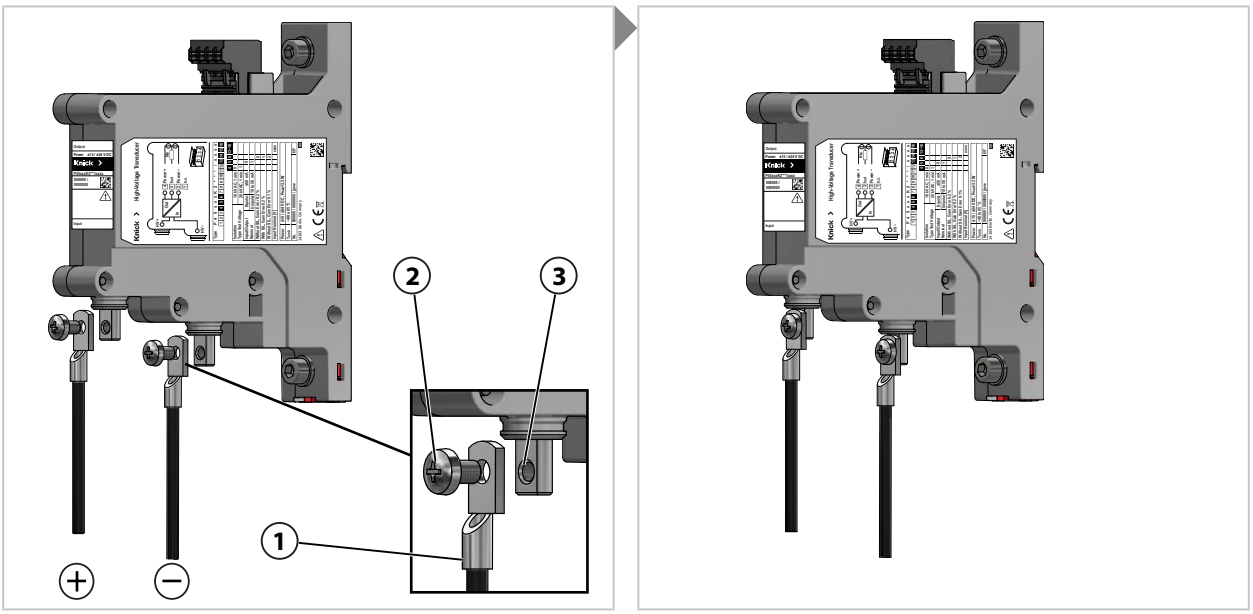
01. Disconnect the electrical system from the mains.
02. Secure the electrical system against reconnection.
03. Verify that the electrical system is dead.
04. Ground and short-circuit the electrical system.
05. Cover neighboring, live parts with insulating materials or place barriers around them.

The nameplate on the side indicates the polarity of the inputs.

Reverse Polarity Protection

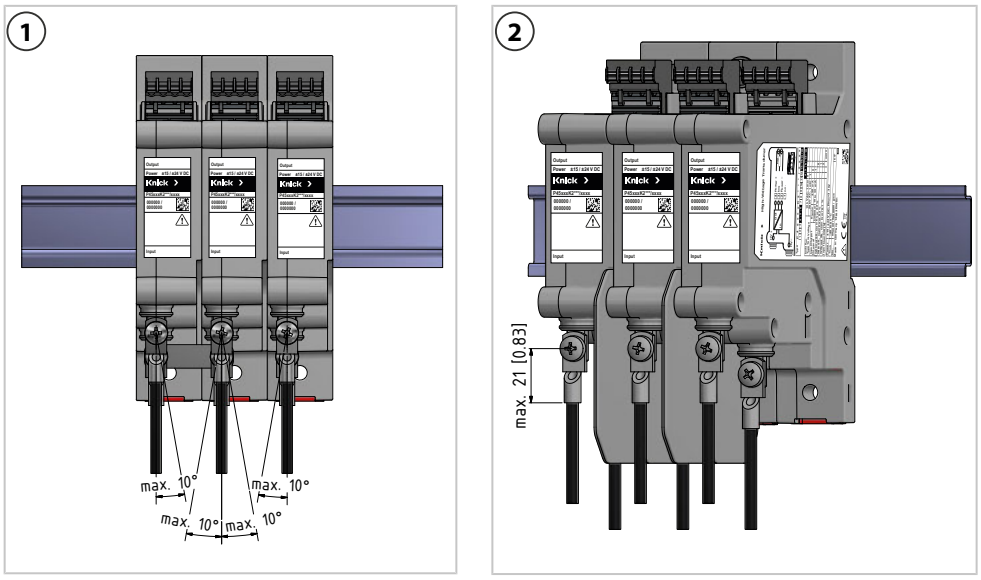
The connection of the supply voltage/auxiliary power at the output is protected against polarity reversal. The product will not function if the polarity is reversed.

Connection of Input Ring Cable Lug P45***K2*0*



01. Fasten the cable **(1)** to the screwed contact **(3)** with an M5 × 8 mm screw **(2)**. Tightening torque 1 … 3 Nm.

Connection for Side by Side

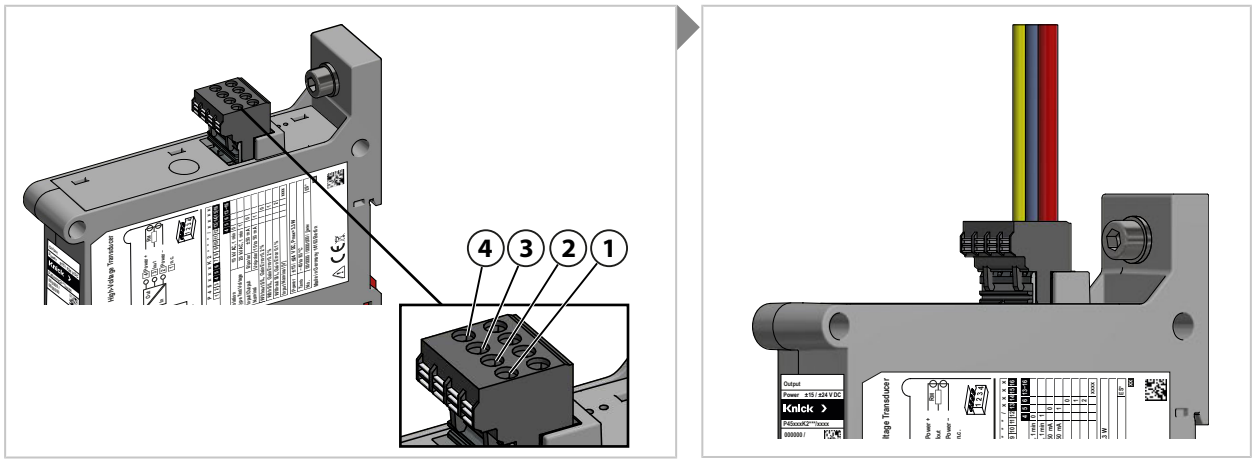


1 Side by side

2 Side by side with partition (ZU1471)

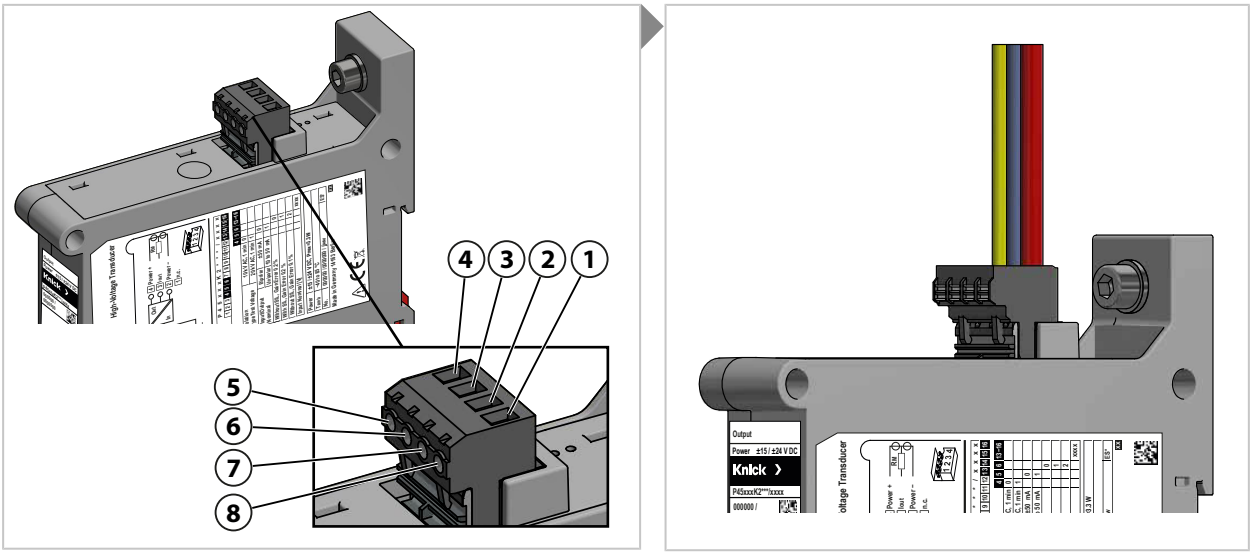
01. Align the cable shield vertically (±10°) **(1)** and **(2)**.

Connection Output/Auxiliary Power Push-in Terminal



01. Insert the cable into the terminals **(2)** ... **(4)**. → *Terminal Assignment Output/Auxiliary Power, p. 13*
02. Reset the electrical system to its original state. Reverse the sequence of measures for ensuring voltage-free operation.

Connection Output/Auxiliary Power Screw Terminal



01. Insert the cable into the terminals **(2)** ... **(4)**. → *Terminal Assignment Output/Auxiliary Power, p. 13*
02. Tighten the screws **(5)** ... **(7)**. Tightening torque 0.6 Nm.
03. Reset the electrical system to its original state. Reverse the sequence of measures for ensuring voltage-free operation.

See also

→ *Input, p. 29*

3 Operation

3.1 Commissioning

NOTICE! A continuous overload can lead to overheating and thus to increased failure rates. Comply with the specifications and observe the chapter on the dimensions of the load.

3.2 Operation

The high voltage transducer is configured at the factory and has no operating elements.

3.3 Maintenance

The devices are maintenance-free. On customer request, the devices can be recalibrated or adjusted in the factory. The electronics cannot be repaired as the devices are encapsulated.

4 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.

Observe the safety instructions. → *Safety, p. 5*

Initial measures for troubleshooting:

- Check whether all connected cables are connected correctly.
- Check the auxiliary power.

Failure Condition	Possible Cause	Remedy
Unexpected measured value.	Input signal not connected correctly.	Check whether the input signal is actually present.
	Current output overload.	Measure the voltage at the current output terminal and the output current to determine the load. → *Output, p. 29*
	Input is overloaded: The input voltage is lower than the selected measuring range start value or higher than the selected full scale value.	Adjust the measuring range or correct the overload. → *Input, p. 28*
	Cable failure between the output and controller.	Correct the cable short-circuit or interruption at the output. Note: In the case of P45*11K2*** and P45*21K2***, use an ammeter to check whether an error state is signaled at the output. → *Live Zero Function (Only P45*11K2*** and P45*21K2***), p. 10*

5 Decommissioning

5.1 Disassembly

⚠ **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 that the input of the P45000 is free of voltage.
07. Switch off the auxiliary power.
08. Open the screw terminals with a screwdriver and remove the cables.
09. Use a screwdriver to pull down the metal foot catch of the housing. Lift the P45000 upwards from the 35 mm DIN rail.

5.2 Return Delivery

If a product must be returned, send it to the responsible local representative in a clean condition and securely packaged. → *knick-international.com*

5.3 Disposal

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

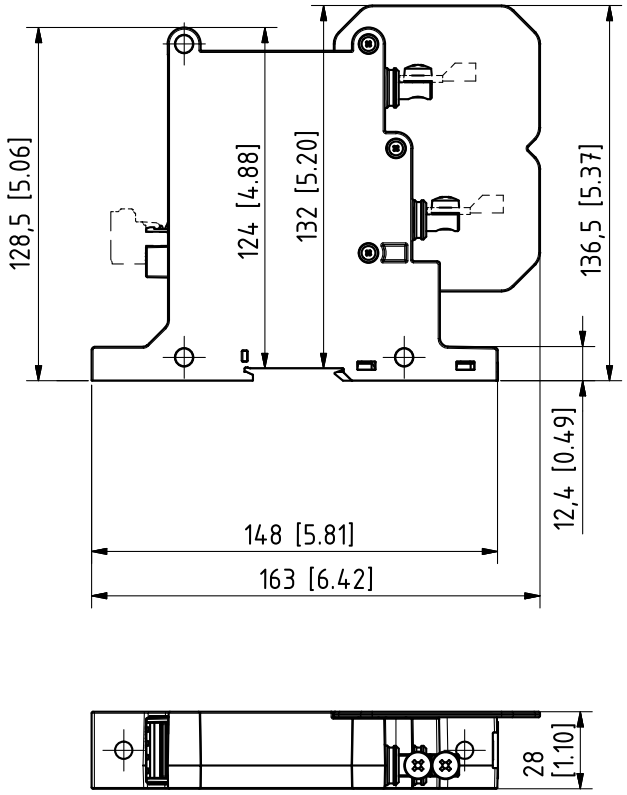
Customers can return their electrical and electronic waste devices.

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*

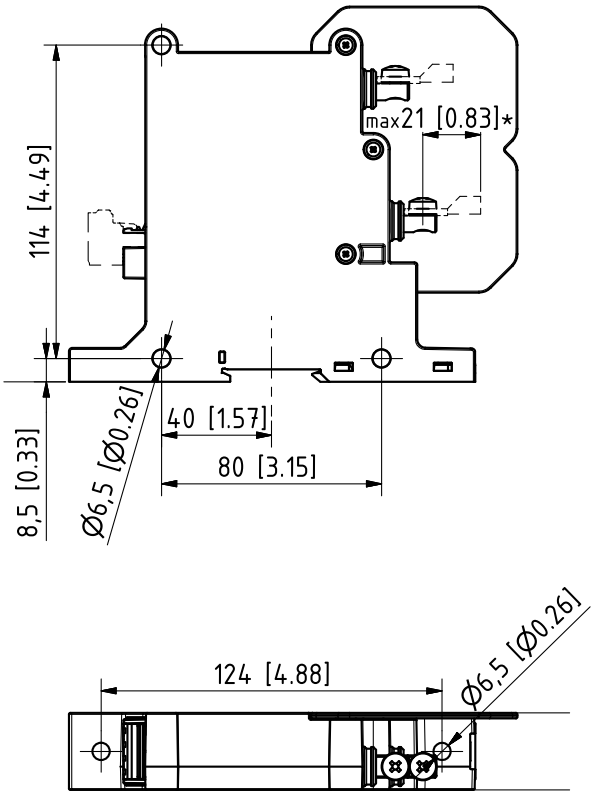
6 Dimension Drawings

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

Exterior Dimensions



Drill Holes



* With partition

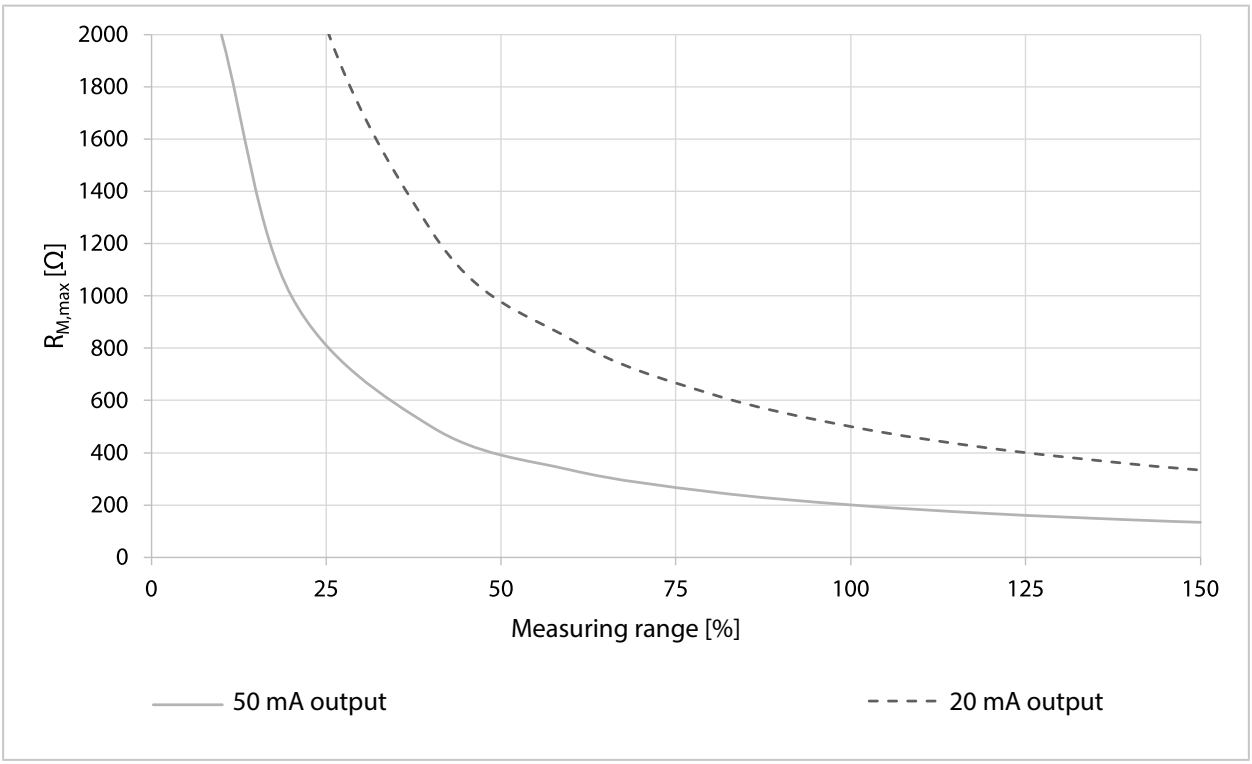
7 Dimensions of the Load

When selecting the load R_M, the resulting load voltage, operating mode (single operation/side-by-side operation), supply voltage, and ambient temperature of P45000 must be taken into account. In general, the load can be in a range of R_M = 0 ... 200 Ω at I_{out} = ±50 mA or R_M = 0 ... 133 Ω at I_{out} = ±75 mA. Upward restrictions are due to the maximum load voltage → *Maximum Load, p. 25*. Downward restrictions may depend on the operating mode (individual operation/side-by-side operation), supply voltage, and ambient temperature → *Minimum Load, p. 26*.

7.1 Maximum Load

The P45000 generates a load voltage at the R_M load with the output current depending on the input voltage. Select the load such that the expected output current results in a load voltage of a maximum of 10 V or a minimum of -10 V. If the load is selected too high, a linear mapping of the input voltage to the output current is no longer ensured.

The following diagram shows the maximum load $R_{M,max}$ in relation to the input voltage up to the measuring range end value for T_{amb} = -40 ... 85 °C (-40 ... 185 °F) and U_{HE} = ±13.5 ... ±26.4 V:



7.2 Minimum Load

As a rule, the minimum permissible load is $R_M = 0\ \Omega$. Under certain conditions (high ambient temperature, high supply voltage, high modulation), select a load of $R_M > 0\ \Omega$ in order to avoid excessive heating of the P45000. The higher the load, the lower the temperature of the product during operation. This reduces the expected failure rate and extends the service life of P45000. Therefore, a load of $R_M >> 0\ \Omega$ should be selected if possible.

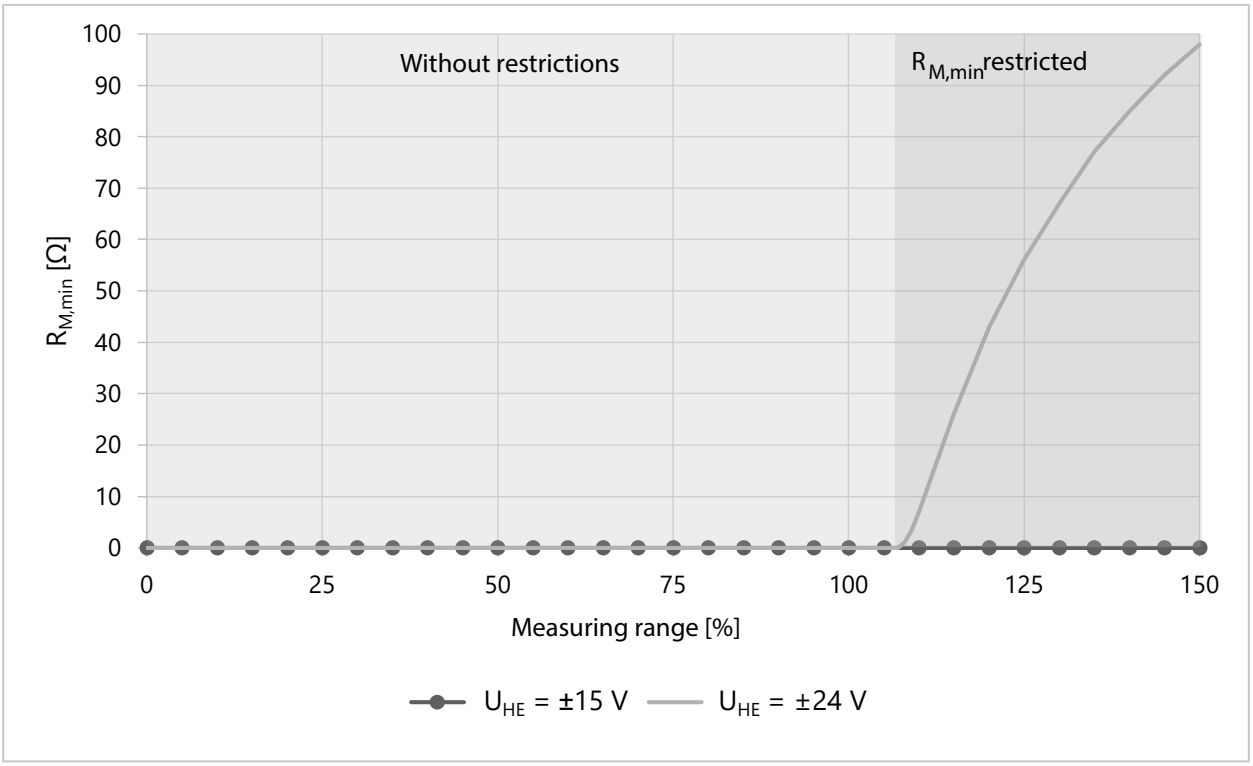
7.2.1 Single Operation

For $I_{out} = 20\ mA_{rms}$: The maximum ambient temperature equals 85 °C (185 °F), regardless of the minimum load and supply voltage.

For $I_{out} = 50\ mA_{rms}$: The restriction at $U_{HE} = \pm 24$ V is only to be taken into account for ambient temperatures of $T_{amb} = 75 \ldots 85$ °C (167 … 185 °F). At an ambient temperature of $T_{amb} < 75$ °C (< 167 °F), the minimum permissible load is $R_M = 0\ \Omega$, regardless of the supply voltage and the input voltage.

A device is considered to be operated singly if the air gap to the side panels of other devices is ≥ 15 mm (0.59").

The following diagram shows the minimum load $R_{M,min}$ in relation to the input voltage up to the full scale value and the supply voltage for single operation up to $T_{amb} = 85$ °C (185 °F):



Note: At a load of 100 Ω, P45000 can be operated in single operation under the maximum permitted conditions for temperature, supply voltage, and modulation.

7.2.2 Side-by-Side Operation

Devices are considered to be arranged side by side if the air gap between the side panels of the individual devices is < 15 mm (0.59″). For side-by-side operation, the conditions mentioned above for single operation apply, but with the following restrictions.

For 3 devices in side-by-side operation:

- For I_{out} = 20 mA_{rms}: The maximum ambient temperature equals 85 °C (185 °F), regardless of the minimum load and supply voltage.
- For I_{out} = 50 mA_{rms}: The maximum ambient temperature depends on the minimum load and the supply voltage (see table).

U_{HE} [V]	±13.5	±15	±16.5	±21.6	±24	±26.4
R_M [Ω]						
0	85 °C (185 °F)	85 °C (185 °F)	85 °C (185 °F)	75 °C (167 °F)	70 °C (158 °F)	65 °C (149 °F)
133	85 °C (185 °F)	85 °C (185 °F)	85 °C (185 °F)	80 °C (176 °F)	75 °C (167 °F)	75 °C (167 °F)
200 (only up to 50 mA DC)	85 °C (185 °F)	85 °C (185 °F)	85 °C (185 °F)	85 °C (185 °F)	80 °C (176 °F)	75 °C (167 °F)

Note: For applications with side-by-side devices and measured values within the nominal measuring range, 200 Ω is optimal. For applications with side-by-side devices and measured values up to 1.5 times the measuring range, 133 Ω is optimal.

8 Specifications

All details without stated tolerance specifications are typical values.

8.1 Input

Measuring ranges/output ranges				
Product variant	Nominal voltage	Nominal measuring range	Nominal output range	Type test voltage
Products without SIL capability				
P4500*[1]	500 V ... 1500 V	±500 V ... ±1500 V	±50 mA ±50 mA	10 kV
P4510*[1]	500 V ... 3000 V	±500 V ... ±3000 V	±50 mA ±50 mA	20 kV
Products with SIL capability/EN 61508				
P45011[1]	500 V ... 1500 V	0 ... 500 V ... 0 ... 1500 V	10 ... 50 mA 10 ... 50 mA	10 kV
P45111[1]	500 V ... 3000 V	0 ... 500 V ... 0 ... 3000 V	10 ... 50 mA 10 ... 50 mA	20 kV
P45021[1]	500 V ... 1500 V	0 ... 500 V ... 0 ... 1500 V	4 ... 20 mA 4 ... 20 mA	10 kV
P45121[1]	500 V ... 3000 V	0 ... 500 V ... 0 ... 3000 V	4 ... 20 mA 4 ... 20 mA	20 kV

Nominal voltage in accordance with EN 50163	U_n = 600 V DC to 3000 V DC
Maximum measuring range	150 % of the nominal measuring range
Maximum permissible crest factor	1.5 in relation to nominal measuring range

Thermal overload capability			
Input nominal voltage	Permanent overvoltage[2]	Permanent overvoltage[2] (sinusoidal)	Input resistance R_{in}
500 V ... 700 V	±1050 V DC	1050 V AC_{rms}	2.7 MΩ
701 V ... 1499 V	±2100 V DC	2100 V AC_{rms}	5.4 MΩ
1500 V ... 2000 V	±3000 V DC	3000 V AC_{rms}	10 MΩ
2001 V ... 3000 V	±3900 V DC	4500 V AC_{peak}	16.8 MΩ

Observe the Isolation section and the limits specified there. → *Isolation, p. 30*	
Input capacitance	< 10 pF

1) The individual product model can be determined using the order designation on the narrow side of the product (device front) and the product code. → *Product Code, p. 8*

2) Strictly observe the details about the insulation, load, ambient temperature, and auxiliary power → *Isolation, p. 30*, → *Output, p. 29*, → *Ambient Conditions, p. 35*, → *Auxiliary Power, p. 30*

8.2 Output

Output current in nominal measuring range	
P45*0*K2***[1]:	I_{out} = ±50 mA
P45*1*K2***[1]:	I_{out} = 10 ... 50 mA
P45*2*K2***[1]:	I_{out} = 4 ... 20 mA
Maximum output current in maximum measuring range	
P45*0*K2***[1]:	$I_{out,max}$ = ±75 mA
P45*1*K2***[1]:	$I_{out,max}$ = 70 mA
P45*2*K2***[1]:	$I_{out,max}$ = 28 mA
Load R_M	0 ... 500 Ω for I_{out} = 4 ... 20 mA 0 ... 360 Ω for I_{out} = 4 ... 28 mA 0 ... 200 Ω for I_{out} = -50 ... 50 mA 0 ... 133 Ω for I_{out} = -75 ... 75 mA Note the following details: → *Dimensions of the Load, p. 25*

8.3 Device Error Detection and Signaling

Output current (in the event of a fault)	
P45*0*K2***[1]:	No error signal
P45*1*K2***[1]:	$I_{out,failure}$: < 9 mA
P45*2*K2***[1]:	$I_{out,failure}$: < 3.6 mA

8.4 Transmission Behavior

Gain error	≤ 0.2 % of the measured value at 23 °C (73.4 °F)
Gain error (option)	≤ 0.1 % of the measured value at 23 °C (73.4 °F)
Offset error	< 100 µA at 23 °C (73.4 °F)
Temperature coefficient	< 100 ppm/K of full scale value
Total error in the entire temperature range	< 1 % of full scale value
Residual ripple	≤ 10 mV_{rms}
Cutoff frequency (-3 dB)	≥ 10 kHz
Settling time T_{90resp}	< 70 µs
Warm-up time (after auxiliary power is switched on)	< 100 ms

8.5 Common-Mode Rejection Ratio

CMRR	> 150 dB (DC) > 90 dB (AC 16.7 Hz/50 Hz/60 Hz)
T-CMRR[2]	> 70 dB Square step input: T_r = 1 µs

[1] The individual product model can be determined using the order designation on the narrow side of the product (device front) and the product code. → *Product Code, p. 8*

[2] For more information see → *Common-Mode Response, p. 13*

8.6 Auxiliary Power

Power supply unit	
Nominal voltage range	±15 V DC, ± 10% … ±24 V DC, ± 10%
DC ripple factor of upstream power supply unit	≤ 100 mV_{p-p}
Short-term interruption/undervoltage	
Interruption class of power supply unit in accordance with EN 50155	S1
Switching class of power supply unit in accordance with EN 50155	In accordance with upstream power supply unit
Power consumption	0.8 W when supplied with ±15 V and I_{out} = 0 mA 2.5 W when supplied with ±24 V and I_{out} = ±50 mA 3.3 W when supplied with ±26.4 V and I_{out} = ±75 mA
Limit load integral (progression of the inrush current over time)	200 μA^2s
Reverse polarity protection	Protected against polarity reversal

8.7 Isolation

Galvanic isolation	Input to output/auxiliary power 2-port isolation
Type test	
Test voltage P450**K2***[1]:	10 kV AC for 1 min
Test voltage P451**K2***[1]:	20 kV AC for 1 min
Surge voltage P450**K2***[1]:	30 kV
Surge voltage P451**K2***[1]:	50 kV
BIL P450**K2***[1] in accordance with UL 347A (E533966):	30 kV
BIL P451**K2***[1] in accordance with UL 347A (E533966):	45 kV
Routine test	
Test voltage P450**K2***[1]:	10 kV AC for 10 s
Test voltage P451**K2***[1]:	16 kV AC for 10 s
Partial discharge extinction voltage	≥ 10 kV AC (50 Hz)
Altitude class in accordance with EN 50125	AX up to 2000 m above MSL, reduced isolation data for altitudes >2000 … 4000 m above MSL[2]
Overvoltage category	OV3
Pollution degree	
P45***K2***[1]:	PD2
P45***K2*1*[1]:	PD2 (PD3A in accordance with EN 50124-1[3])

1) The individual product model can be determined using the order designation on the narrow side of the product (device front) and the product code. → *Product Code, p. 8*

2) On request

3) Also observe the requirements under → *Avoiding Electric Shocks and Fires, p. 6*.

Insulation of Screwed Contact Variant P45***K2*0*

Rated insulation voltage		
Reinforced insulation input to output/auxiliary power		
P450**K2*0*[1]:	EN 50124-1 (rolling stock)	2300 V AC/DC
	EN 50124-1 (stationary installations)	2300 V AC/DC
	EN 50178	2300 V AC/DC
	UL 347A	2300 V AC/DC
	EN IEC 60664-1	1000 V AC/1500 V DC
	EN 61010-1	1000 V AC/DC
P451**K2*0*[1]:	EN 50124-1 (rolling stock)	3700 V AC/DC
	EN 50124-1 (stationary installations)	3600 V AC/DC
	EN 50178	3600 V AC/DC
	UL 347A	4800 V AC/DC
	EN IEC 60664-1	1000 V AC/1500 V DC
	EN 61010-1	1000 V AC/DC
Functional insulation input to input		
P450**K2*0*[1]:		
	EN 50124-1 (rolling stock)	2300 V AC/DC
	EN 50124-1 (stationary installations)	2300 V AC/DC
	EN 50178	2300 V AC/DC
	EN IEC 60664-1	1000 V AC/1500 V DC
	EN 61010-1	1000 V AC/DC
P451**K2*0*[1]:		
	EN 50124-1 (rolling stock)	3700 V AC/DC
	EN 50124-1 (stationary installations)	3600 V AC/DC
	EN 50178	3600 V AC/DC
	EN IEC 60664-1	1000 V AC/1500 V DC
	EN 61010-1	1000 V AC/DC
Isolation of inputs to surroundings		
Measure the distances to adjacent devices and conductive parts in the vicinity of the device in accordance with the applied standard. Implement, evaluate, and ensure insulation coordination with the clearance and creepage distances (→ *Clearance and Creepage Distances, p. 33*) and the corresponding standards (e.g., EN 50124-1).		
Evaluate touch protection for touchable parts in accordance with EN 50153 and ensure this if necessary.		
Route the cable in accordance with EN 50343.		

See also

→ *Clearance and Creepage Distances, p. 34*

[1] The individual product model can be determined using the order designation on the narrow side of the product (device front) and the product code. → *Product Code, p. 8*

Insulation of P45***K2*1* Variant with Fixed Cable

Rated insulation voltage		
Reinforced insulation input to output/auxiliary power		
P450**K2*1*[1]:	EN 50124-1 (rolling stock)	2300 V AC/DC
	EN 50124-1 (stationary installations)	2300 V AC/DC
	EN 50178	2300 V AC/DC
	UL 347A	2300 V AC/DC
	EN IEC 60664-1	1000 V AC/1500 V DC
	EN 61010-1	1000 V AC/DC
P451**K2*1*[1]:	EN 50124-1 (rolling stock)	3600 V AC/4800 V DC
	EN 50124-1 (stationary installations)	3600 V AC/4800 V DC
	EN 50178	3600 V AC/4800 V DC
	UL 347A	4800 V AC/DC
	EN IEC 60664-1	1000 V AC/1500 V DC
	EN 61010-1	1000 V AC/DC
Functional insulation input to input		
	EN 50124-1 (rolling stock)	3600 V AC/4800 V DC
	EN 50124-1 (stationary installations)	3600 V AC/4800 V DC
	EN 50178	3600 V AC/4800 V DC
	EN IEC 60664-1	1000 V AC/1500 V DC
	EN 61010-1	1000 V AC/DC
Isolation of inputs to surroundings		
Measure the distances to adjacent devices and conductive parts in the vicinity of the device in accordance with the applied standard. Implement, evaluate, and ensure insulation coordination with the clearance and creepage distances (→ *Clearance and Creepage Distances, p. 33*) and the corresponding standards (e.g., EN 50124-1).		
Route the cable in accordance with EN 50343. Isolation provided by cable isolation with 3600 V AC/4800 V DC. Check whether additional isolation may be required.		

[1] The individual product model can be determined using the order designation on the narrow side of the product (device front) and the product code. → *Product Code, p. 8*

Clearance and Creepage Distances

Clearances			
P45***K2*0*[1]:	Between the inputs	F1	Min. 36 mm (1.42″)
	Between inputs and output/auxiliary power	B1, D1	Min. 102 mm (4.02″)
	Between inputs and fastening screw for mounting[2]	B3, D3, B5, D5	Min. 35 mm (1.38″)
	Between inputs and 35 mm DIN rail	B8, D8	Min. 62 mm (2.44″)
	Between side-by-side devices without partition	F2	Min. 14 mm (0.55″)
	Between side-by-side devices with partition	F2‘	Min. 33 mm (1.29″)
	Between inputs and mounting plate with partition, horizontal on mounting plate	B2, D2	Min. 18 mm (0.71″)
P45***K2*1*[1]:	There are no touchable live/conductive parts on the device. Cable is encapsulated in the device.		Depends on remaining cable length.
Creepage distances			
P45***K2*0*[1]:	Between the inputs	F1	Min. 56 mm (2.20″)
	Between inputs and output/auxiliary power	B1, D1	Min. 104 mm (4.09″)
	Between inputs and fastening screw for mounting[2]	B3, D3, B5, D5	Min. 57 mm (2.24″)
	Between inputs and 35 mm DIN rail	B8, D8	Min. 64 mm (2.52″)
	Between side-by-side devices without partition	F2	Min. 64 mm (2.52″)
	Between side-by-side devices with partition	F2‘	Min. 64 mm (2.52″)
P45***K2*1*[1]:	There are no touchable live/conductive parts on the device. Cable is encapsulated in the device.		Depends on remaining cable length.

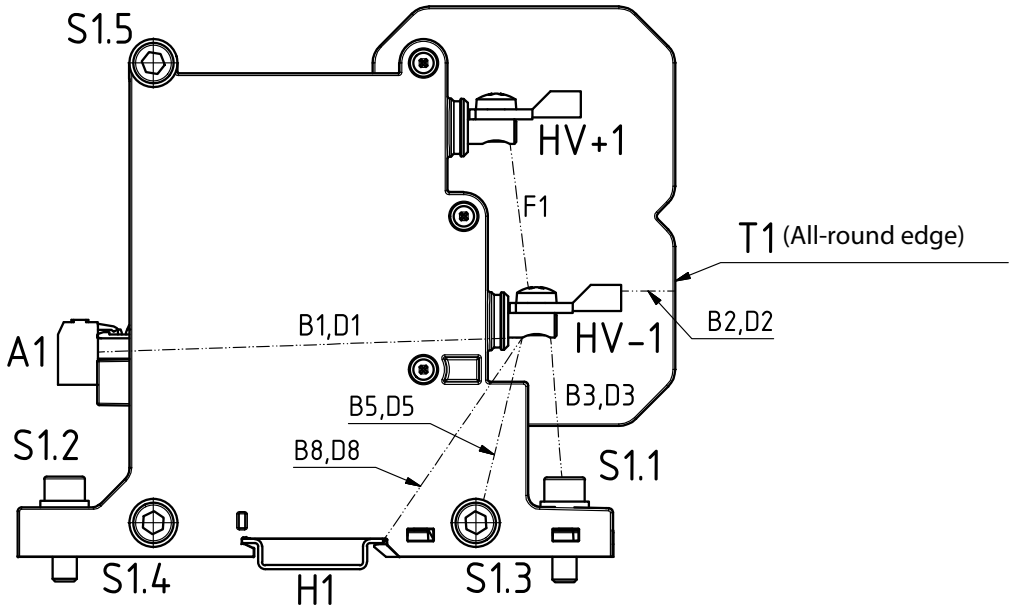
See also

→ *Clearance and Creepage Distances, p. 34*

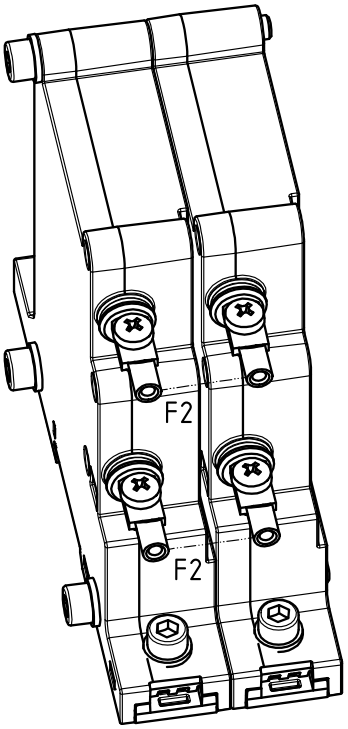
[1] The individual product model can be determined using the order designation on the narrow side of the product (device front) and the product code. → *Product Code, p. 8*

[2] ISO 4762 hexagon socket screw M6 h = 6 mm, ISO 7089 washer M6 h = 1.6 mm

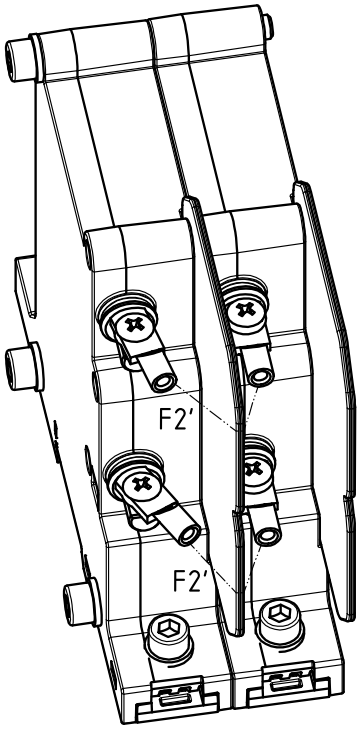
8.8 Clearance and Creepage Distances



Without partition



With partition



8.9 Ambient Conditions

Installation location in accordance with EN 50155	Enclosed control cabinet, Table C.1	
Altitude class in accordance with EN 50125	AX up to 2000 m above MSL, reduced isolation data for altitudes >2000 ... 4000 m above MSL[1)]	
Temperature class in accordance with EN 50155	OT4, ST1/ST2 (+ 15 K/10 min.)	
Class of fast temperature changes in accordance with EN 50155	H1	
Permitted temperatures for $U_{HE}/I_{out}/R_M$:		
	Single operation, air gap > 15 mm (0.59")	Side-by-side operation; air gap < 15 mm (0.59"); max. 3 devices
At ±24 V/75 mA DC/0 Ω	-40 ... 75 °C (-40 ... 167 °F)	-40 ... 55 °C (-40 ... 131 °F)
At ±24 V/75 mA DC/133 Ω	-40 ... 85 °C (-40 ... 185 °F)	-40 ... 65 °C (-40 ... 149 °F)
At ±24 V/50 mA_{rms}/0 Ω	-40 ... 85 °C (-40 ... 185 °F)	-40 ... 70 °C (-40 ... 158 °F)
At ±15 V/75 mA DC/0 Ω	-40 ... 85 °C (-40 ... 185 °F)	-40 ... 75 °C (-40 ... 167 °F)
At ±15 V/50 mA_{rms}/200 Ω	-40 ... 85 °C (-40 ... 185 °F)	-40 ... 85 °C (-40 ... 185 °F)
Transport/Storage	-50 ... 90 °C (-58 ... 194 °F)	
Relative humidity (operation, storage, and transport) in accordance with EN 50125		
Annual mean value	≤ 75 %	
Continuous operation	15 ... 75 %	
On 30 days in the year continuously	75 ... 95 %	
On the other days occasionally	95 ... 100 %	
Overvoltage category	OV3	
Pollution degree		
P45***K2***[2)]:	PD2	
P45***K2*1*[2)]:	PD2 (PD3A in accordance with EN 50124-1[3)])	

8.10 Device

Weight		
P45***K2*0*[2)]	Without partition	Approx. 370 g
	With partition	Approx. 390 g
P45***K2*1*[2)]		Approx. 500 g
Tightening torque of screws	M5 terminals	1 ... 3 Nm
	Output screw terminals	0.6 Nm
	Vertical on mounting plate 2 x M6	5 Nm
	Horizontal on mounting plate 3 x M6 (for stack with 3 devices max.)	3 Nm

1) On request

2) The individual product model can be determined using the order designation on the narrow side of the product (device front) and the product code. → *Product Code, p. 8*

3) Also observe the requirements under → *Avoiding Electric Shocks and Fires, p. 6*.

8.11 Further Data

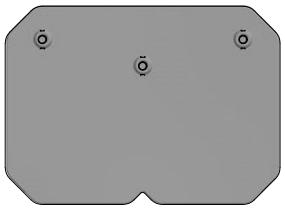
EMC		
Railway applications		EN 50121-1, EN 50121-3-2, EN 50121-5
Industrial applications		EN 61326-1, EN 61326-3-1
Emitted interference		Class B (up to 110 V DC/up to 230 V AC)
Immunity to interference		Industrial applications
Mechanical stress Vibration and shock in accordance with EN 61373, IEC 61373		Category 1, class B Tested by an independent accredited test laboratory
Fire protection in accordance with EN 45545-1, EN 45545-2, EN 45545-5		For outdoor applications (combustible weight < 400 g) up to HL3[1)]
		For interior applications: Mount only in closed control cabinets with sufficient fire protection
		Certified by independent test laboratory
Useful life		20 years, L4 in accordance with EN 50155
Design		Modular enclosure, optional for mounting on 35 mm DIN rail
Touch protection		
	Input	Output/auxiliary power
P45***K2*0*[2)]:	IP00	IP20
P45***K2*1*[2)]:	IP54	IP20
Encapsulation	Complete encapsulation of electronics by silicone-free polyurethane casting resin mold	
Hazardous substances	There are no hazardous substances in accordance with the REACH Regulation (EC 1907/2006, 1688/2016). The restriction of hazardous substances in accordance with the RoHS Directive (2011/65/EU) is complied with.	
Functional safety	→ *Specifications (Functional Safety), p. 43*	

1) For further information see → *Material Evaluation, p. 39*

2) The individual product model can be determined using the order designation on the narrow side of the product (device front) and the product code.→ *Product Code, p. 8*

9 Appendix

9.1 Accessories



Partition, ZU1471

For increasing the clearance. It is mounted in the area of the high-voltage contacts of the input.

Jumper, ZU1474

For connecting (parallel connection) the input screw terminals of two devices. It is mounted on the screwed contacts.

High-voltage signal cable, ZU1475

The ZU1475 HV signal cable connects primary circuits (high potentials) to the input of a high voltage signal conditioner in the P29000, P40000, P44000, P45000, and P50000 product series.

9.2 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, EN 50123-7-1, EN 50123-7-3
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, EN 50121-5
Isolation requirements	EN 50124-1, UL 347A
Climate	EN 50125-1, EN 50125-3
Industrial applications	EN 61010-1
EMC	EN IEC 61326-1, EN 61326-3-1
Functional safety (P45**1K2*** only)	EN IEC 61508
Isolation requirements	EN 50178, UL 347A, EN 61010-1, EN IEC 60664-1
Restrictions on hazardous substances/RoHS	EN IEC 63000

9.3 Material Evaluation

The P45000 transducers with their combustible materials meet the material requirements for installation on the exterior of railway vehicles in accordance with EN 45545-2. This includes underfloor containers and roof boxes. In the interior of railway vehicles, the transducers must be mounted in closed and fire-protected enclosures.

The combustible materials are listed in the following. Listed components have been assessed in accordance with their fire properties and fulfill hazard level HL 3. Components that are not listed were assessed and grouped in accordance with grouping rule 1.

The components required for function on the PCB fulfill the underlying requirements from Subclause 4.1 of EN 45545-2 (see Subclause 4.7).

Component name	Mass in g (approx.)	Rule/requirement	Result	Hazard level
Variant P45*K2*0*[1)]				
PCB	26	EL9/R24	Fulfilled	HL 3
Housing	109	EL10/R26	Fulfilled	HL 3
Partition	22	EL10/R26	Fulfilled	HL 3
Casting compound	175	GR1/none	Exterior	N/A
Metal foot catch	5	GR1/none	Exterior	N/A
Variant P45*K2*1*[1)]				
PCB	26	EL9/R24	Fulfilled	HL 3
Housing	109	EL10/R26	Fulfilled	HL 3
Partition	22	EL10/R26	Fulfilled	HL 3
Cables	150	EL1A/R15 EL1B/R16	Fulfilled Fulfilled	HL 3 HL 3
Casting compound	175	GR1/none	Exterior	N/A
Metal foot catch	5	GR1/none	Exterior	N/A
Cable support sleeve	4	GR1/none	Exterior	N/A

Key to the list of flammable materials in accordance with standard EN 45545-2	
EL9	Listed components: PCB
EL10	Listed components: low-power electrical and electronic components
GR1	Grouping rule 1
HL	Hazard level
N/A	Not applicable
R24, R26	Requirement sets in accordance with Table 5, Materials Requirements

[1)] The individual product model can be determined using the order designation on the narrow side of the product (device front) and the product code. → *Product Code, p. 8*

10 SIL Manual (P45**1K2***)

10.1 General Description

High Voltage Transducer of the P45000 series were developed for use in SIL 2 or SIL 3 circuits. The High Voltage Transducer detect certain internal faults (e.g., undervoltage, transfer failure) and set the output to a defined value in response to the fault. (→ *Safety Sub-Function, p. 42*).

10.2 Determined Safety-Related Characteristics

Calculation of the safety-related characteristics in accordance with IEC 61508-6. Failure rate prediction in accordance with EN/IEC 61709 (SN 29500) for stationary continuous operation (ground benign) at 45 °C mean ambient temperature corresponding to the environmental conditions of an average industrial environment.
The indicated values worsen at higher ambient temperatures.

Single Operation

Parameter	Characteristic	Explanation
Demand mode	High/Continuous	Operating mode with high/continuous demand rate
Device type	Type A	
Operating mode	10 … 50 mA or 4 … 20 mA	Valid for: P45*11K2*** Valid for: P45*21K2***
λ_{Total}	486 FIT[1)]	Total failure rate
λ_S	222 FIT[1)]	Rate of non-dangerous failures
λ_D	264 FIT[1)]	Rate of dangerous failures
λ_{DU}	163 FIT[1)]	Rate of undetected dangerous failures
λ_{SD}	222 FIT[1)]	Rate of detected non-dangerous failures
λ_{DD}	103 FIT[1)]	Rate of detected dangerous failures
SFF	66.63 %	Percentage of non-dangerous failures
DC	38.65 %	Diagnostic coverage[2)]
$MTTF_D$	235 years[3)]	Mean time to operate until a dangerous failure at an average operating temperature of 45 °C (113 °F)
SC for SIL	2 (1oo1), 3 (1oo2)	Systematic capability for safety integrity level in accordance with EN 61508
MTTR	72 h	Mean time to restore, mean recovery time
MRT	72 h	Mean repair time, mean time for repair
PFH_{1oo1}	1.62×10^{-7} 1/h 16.2 %[4)] (SIL 2)	Probability of failure, mean frequency of a hazardous failure
PFH_{1oo2}	1.62×10^{-8} 1/h 16.2 %[4)] (SIL 3)	Probability of failure, mean frequency of a hazardous failure

1) FIT = Failures in time, failures per 10^9 hours

2) Diagnostic coverage: $DC = \lambda_{DD}/(\lambda_{DU} + \lambda_{DD})$

3) Calculation for the worst case with high or continuous demand rate. The failure rates of the electronic components increase after an operating period of 8 to 12 years. As a result, the PFD and PFH values derived from this worsen (IEC 61508-2, Edition 2.0, 7.4.9.5, Note 3).

4) Relative percentage of the permissible PFH/PFD of the safety function

Parameter	Characteristic	Explanation
PFD_{1oo1}	1 year[1]: 7.36×10^{-4} 2 years: 1.46×10^{-3} 3 years: 2.21×10^{-3}	Probability of dangerous failure on demand
PFD_{1oo2}	1 year[1]: 7.36×10^{-5} 2 years: 1.46×10^{-4} 3 years: 2.21×10^{-4}	Probability of dangerous failure on demand

Side-by-Side Operation

Parameter	Characteristic	Explanation
Demand mode	High/Continuous	Operating mode with high/continuous demand rate
Device type	Type A	
Operating mode	10 ... 50 mA or 4 ... 20 mA	Valid for: P45*11K2*** Valid for: P45*21K2***
λ_{Total}	747 FIT[2]	Total failure rate
λ_S	339 FIT[2]	Rate of non-dangerous failures
λ_D	409 FIT[2]	Rate of dangerous failures
λ_{DU}	248 FIT[2]	Rate of undetected dangerous failures
λ_{SD}	339 FIT[2]	Rate of detected non-dangerous failures
λ_{DD}	161 FIT[2]	Rate of detected dangerous failures
SFF	67 %	Percentage of non-dangerous failures
DC	39 %	Diagnostic coverage[3]
$MTTF_D$	153 years[4]	Mean time to operate until a dangerous failure at an average operating temperature of 45 °C (113 °F)
SC for SIL	2 (1oo1), 3 (1oo2)	Systematic capability for safety integrity level in accordance with EN 61508
MTTR	72 h	Mean time to restore, mean recovery time
MRT	72 h	Mean repair time, mean time for repair
PFH_{1oo1}	2.48×10^{-7} 1/h 24.8 %[5] (SIL 2)	Probability of failure, mean frequency of a hazardous failure
PFH_{1oo2}	2.48×10^{-8} 1/h 24.8 %[5] (SIL 3)	Probability of failure, mean frequency of a hazardous failure
PFD_{1oo1}	1 year[1]: 1.13×10^{-3} 2 years: 2.25×10^{-3} 3 years: 3.39×10^{-3}	Probability of dangerous failure on demand
PFD_{1oo2}	1 year[1]: 1.13×10^{-4} 2 years: 2.25×10^{-4} 3 years: 3.4×10^{-4}	Probability of dangerous failure on demand

1) Proof test interval, recurrent testing to detect hidden hazardous failures in a safety-related system so that, if necessary, a repair can bring the system to an "as new" condition or as close as practically possible to that condition

2) FIT = Failures in time, failures per 10^9 hours

3) Diagnostic coverage: $DC = \lambda_{DD}/(\lambda_{DU} + \lambda_{DD})$

4) Calculation for the worst case with high or continuous demand rate. The failure rates of the electronic components increase after an operating period of 8 to 12 years. As a result, the PFD and PFH values derived from this worsen (IEC 61508-2, Edition 2.0, 7.4.9.5, Note 3).

5) Relative percentage of the permissible PFH/PFD of the safety function

10.3 Scope of validity

This chapter applies to High Voltage Transducer of the P45000 series that were ordered with the option "with SIL capability". The product code indicates whether the device has SIL capability. The High Voltage Transducer of the P45000 series from Knick Elektronische Messgeräte GmbH & Co. KG are certified by TÜV Rheinland Industrie Service GmbH.

→ *Product Code, p. 8*

10.4 Relevant Standards

The High Voltage Transducer can be used in safety-related applications up to SIL 2, with redundant operation up to SIL 3 (systematic capability). The standards relevant to the intended use, such as EN 61508, must be applied.

10.5 Safety Sub-Function

The High Voltage Transducer is used to measure a voltage in compliance with the functional safety criteria.

The voltage signal applied at the input is galvanically isolated in a 10 ... 50 mA output signal (P45*11K2***) or converted into a 4 ... 20 mA output signal (P45*21K2***). The input signals are transmitted linearly with the specified properties. The error signal is defined for the range of < 9 mA (P45*11K2***) or < 3.6 mA (P45*21K2***). This allows a safety function to be implemented: for example, a shutdown if a threshold value is exceeded. To do this, the analog output signal must be filtered and evaluated. The low-pass filtering with $f_{-3dB} \leq 200$ Hz can be done with analog or digital filtering. In the case of two-channel, redundant use (1oo2), if a tolerance is exceeded, a value comparison must be carried out and a safe state must be established.

10.6 Signal Level for Measuring Signal and Failure Information

10.6.1 Signal Level for Measuring Signal and Failure Information P45* 11K2***

Information	Signal level
Measuring signal	10 ... 50 mA
Failure information (error)	< 9 mA

10.6.2 Signal Level for Measuring Signal and Failure Information P45* 21K2***

Information	Signal level
Measuring signal	4 ... 20 mA
Failure information (error)	< 3.6 mA

10.7 Maintenance and Repair

The devices are maintenance-free. On customer request, the devices can be recalibrated or adjusted in the factory. The electronics cannot be repaired as the devices are encapsulated.

10.8 Repeat Test

The repeat test is used to detect failures in a safety-related system. The functionality of the high voltage transducers must therefore be checked at appropriate intervals. One of the ways used to determine the test intervals is to calculate each individual safety circuit of a system (PFD values). The test must be carried out in such a way that it proves that the safety sub-function works perfectly together with all components.

Checking the Function

1. Specify setpoints for the start and end of the measuring range and a mean value (e.g., 50 % value).
2. Check whether the measurement error is within the specified tolerances.

If the function test is negative, the high voltage transducer must be removed from operation and the process must be kept in a safe state by other measures.

10.9 Specifications (Functional Safety)

Specifications (Functional Safety)	
Immunity requirements for safety-related systems EN 61326-3-1:2017	
Reinforced insulation between input and output. Operate the device in such a way that reinforced insulation is ensured. → *Isolation, p. 30*	
Signal transmission within the specification	
Single operation	SIL 2 (SC 2) (HFT = 0)
Redundant operation (1oo2 configuration)	SIL 2 (SC 2), SIL 3 (SC 3) (HFT = 1)
Cutoff frequency of the low-pass filter to be used	$f_{-3dB} \leq 200$ Hz

11 Abbreviations

1oo1	1 out of 1
1oo2	1 out of 2
A1/AX	Altitude class
CMRR	Common mode rejection ratio
DC	Diagnostic coverage of dangerous failures
EMC	Electromagnetic compatibility
EN	European standard
FIT	Failures in time (failures in 10^9 hours)
H1	Class of fast temperature changes
HFT	Hardware fault tolerance
HL3	Fire protection class in accordance with EN 45545-2
HV_+	Positive potential of the high voltage
HV_-	Negative potential of the high voltage
I_{out}	Output current
$I_{out,failure}$	Output current for error signals (fail-safe state)
$I_{out,max}$	Maximum permissible output current
IPxx	Ingress protection (protection class for touching and penetration by foreign bodies and liquids)
MRT	Mean repair time
MTBF	Mean time between failures
MTTF	Mean time to failure
MTTR	Mean time to restoration
MSL	Mean Sea Level
n.c.	Not connected (Do not connect terminal.)
OT	Operating temperature class
OV	Overvoltage category (overvoltage category in relation to surge voltage)
PD	Pollution degree
PFD	Probability of failure on demand
PFH	Probability of failure per hour
Pwr_+	Power+, positive supply voltage
Pwr_-	Power-, negative supply voltage
R_{in}	Input resistance
R_M	Load resistance
SC	Systematic capability
SFF	Safe failure fraction (proportion of safe failures)
SIL	Safety integrity level
ST	Switch-on extended operating temperature (increased operating temperature at switch-on)
T_{amb}	Permitted ambient temperature
T-CMRR	Transient common-mode rejection ratio
T_r	Rise time
UL	Underwriters Laboratories (recognized testing body and certification organization)
U_{HE}	Supply voltage of a device (auxiliary power)
U_{in}	Nominal input voltage range
U_{out}	Output voltage
WEEE	Waste from electrical and electronic equipment

Notes

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