

## PZ272E P-545 Nanopositioners User Manual

Version: 1.2.0

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This document describes the following products:

- **P-545.2C8S PInano® Cap XY Piezo System**  
PInano® XY piezo system, clear aperture for microscope slides,  $200\ \mu\text{m} \times 200\ \mu\text{m}$ , capacitive sensors, with USB digital controller\*
- **P-545.3C8S PInano® Cap XYZ Piezo System**  
PInano® XYZ piezo system, clear aperture for microscope slides,  $200\ \mu\text{m} \times 200\ \mu\text{m} \times 200\ \mu\text{m}$ , capacitive sensors, with USB digital controller\*
- **P-545.2R8S PInano® XY Piezo System**  
PInano® XY piezo system, clear aperture for microscope slides,  $200\ \mu\text{m} \times 200\ \mu\text{m}$ , piezoresistive sensors, with USB digital controller\*
- **P-545.3R8S PInano® XYZ Piezo System**  
PInano® XYZ piezo system, clear aperture for microscope slides,  $200\ \mu\text{m} \times 200\ \mu\text{m} \times 200\ \mu\text{m}$ , piezoresistive sensors, with USB digital controller\*
- **P-545.3D8S PInano® Trak XYZ Piezo Tracking System**  
High dynamics PInano® XYZ piezo system, clear aperture for microscope slides,  $70\ \mu\text{m} \times 70\ \mu\text{m} \times 50\ \mu\text{m}$ , direct drive, piezoresistive sensors, with USB digital controller\*

\*The controller for the system is described in a separate manual.



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The patents held by PI are found in our patent list:  
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Subject to change without notice. This manual is superseded by any new release. The latest release is available for download on our website (p. 3).

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# 1 About this Document

## In this Chapter

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Symbols and Typographic Conventions ..... 1

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### 1.1 Objective and Target Group of this User Manual

This user manual contains the information required for using the P-545.xx8H positioner belonging to the P-545.xx8S system as intended (x stands for the respective model). Unless stated otherwise, "P-545" only refers to the positioner in this manual. The controller in the system is described in a separate manual (p. 2).

Basic knowledge of control technology, drive technologies, and suitable safety measures is assumed.

The latest versions of the user manuals are available for download on our website (p. 3).

### 1.2 Symbols and Typographic Conventions

The following symbols and typographic conventions are used in this user manual:

**CAUTION**



**Dangerous situation**

Failure to comply could lead to minor injury.

- Precautionary measures to avoid the risk.

**NOTICE**





**Dangerous situation**

Failure to comply could cause damage to equipment.

- Precautionary measures to avoid the risk.

**INFORMATION**

Information for easier handling, tricks, tips, etc.

Symbol / Label	Meaning
1.	Action consisting of several steps with strict sequential order
2.	
➤	Action consisting of one or more steps without relevant sequential order.
▪	Bullet point
p. 5	Cross-reference to page 5
RS-232	Label on the product indicating an operating element (example: RS-232 interface socket)
 	Warning signs on the product that refer to detailed information in this manual.

### 1.3 Figures

For better understandability, the colors, proportions, and degree of detail in illustrations can deviate from the actual circumstances. Photographic illustrations may also differ and must not be seen as guaranteed properties.

### 1.4 Other Applicable Documents

The devices and software tools from PI mentioned in this documentation are described in separate manuals.

The latest versions of the user manuals are available for download on our website (p. 3).

Product	Document
E-727 digital multichannel piezo controller, part of the P-545 system	E727T0005 technical note
PIMikroMove	SM148E software manual
P-5xx / P-6xx / P-7xx piezo positioners	PZ240EK short instructions

## 1.5 Downloading Manuals

### **INFORMATION**

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 37).

### **Downloading manuals**

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., P-545).
3. Click the corresponding product to open the product detail page.
4. Click the **Downloads** tab.

The manuals are shown under **Documentation**. Software manuals are shown under **General Software Documentation**.

5. Click the **ADD TO LIST** button for the desired manual and then click **REQUEST**.
6. Fill out the request form and click **SEND REQUEST**.

The download link will then be sent to the email address entered.





## 2 Safety

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### 2.1 Intended Use

The P-545 positioner is a laboratory device as defined by DIN EN 61010-1. It is intended for indoor use and use in an environment that is free of dirt, oil, and lubricants.

According to its design, the P-545 is intended for fine positioning as well as moving small objects quickly and precisely. The specifications for the P-545 apply to horizontal mounting. Depending on the version, moving is done as follows:

System	Motion	Axis
.2C8S / .2R8S	In two axes horizontally	X, Y
.3C8S / .3R8S / .3D8S	In two axes horizontally and in one axis vertically	X, Y, Z

The P-545 positioner can only be used as intended in conjunction with the controller belonging to the system.

### 2.2 General Safety Instructions

The P-545 is built according to state-of-the-art technology and recognized safety standards. Improper use of the P-545 may result in personal injury and/or damage to the P-545.

- Use the P-545 for its intended purpose only, and only when it is in perfect condition.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for installing and operating the P-545 correctly.

The P-545 is driven by piezo actuators. Temperature changes and compressive stress can induce charges in piezo actuators. Piezo actuators can remain charged for several hours after disconnecting the electronics. Touching or short-circuiting the contacts in the P-545's connector can lead to minor injuries from electric shock. The piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the P-545.
- Discharge the positioner's piezo actuators before installing:  
Connect the positioner to the switched-off PI controller equipped with an internal discharge resistor.
- Do **not** pull the connector out of the controller during operation.
- Do **not** touch the contacts in the connector.
- Use screws to secure the positioner's connectors against being pulled out of the controller.

If the protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the P-545 in the event of a malfunction or failure of the system. If there are touch voltages, touching the P-545 can result in minor injuries from electric shock.

- Connect the P-545 to a protective earth conductor (p. 18) before starting.
- Do **not** remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e.g., in the case of modifications), reconnect the P-545 to the protective earth conductor before restarting.

Mechanical forces can damage or misalign the P-545.

- Avoid impacts that affect the P-545.
- Do **not** drop the P-545.
- Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 40).
- Do **not** touch any sensitive parts (e.g., motion platform) when handling the P-545.

The P-545 is maintenance-free and achieves its positioning accuracy as a result of the optimum alignment of mechanical components and piezo actuators.

- Do **not** open the P-545.

## 2.3 Organizational Measures

### User manual

- Always keep this user manual together with the P-545. The latest versions of the user manuals are available for download on our website (p. 3).
- Add all information from the manufacturer such as supplements or technical notes to the user manual.
- If you give the P-545 to other users, include this user manual as well as all other relevant information provided by the manufacturer.
- Do the work only if the user manual is complete. Missing information due to an incomplete user manual can result in minor injury and damage to equipment.
- Install and operate the P-545 only after you have read and understood this user manual.

### Personnel qualification

The P-545 may only be installed, started, operated, maintained, and cleaned by authorized and appropriately qualified personnel.



## 3 Product Description

### In this Chapter

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Integration of the P-545 into Microscopes.....	14

### 3.1 Model Overview

The P-545 positioner and the appropriate controller are only available together as a system. Standard versions of the system:

System	Description
P-545.2C8S	PI nano® XY piezo system, clear aperture for microscope slides, 200 µm × 200 µm, capacitive sensors, with USB digital controller
P-545.3C8S	PI nano® XYZ piezo system, clear aperture for microscope slides, 200 µm × 200 µm × 200 µm, capacitive sensors, with USB digital controller
P-545.2R8S	PI nano® XY piezo system, clear aperture for microscope slides, 200 µm × 200 µm, piezoresistive sensors, with USB digital controller
P-545.3R8S	PI nano® XYZ piezo system, clear aperture for microscope slides, 200 µm × 200 µm × 200 µm, piezoresistive sensors, with USB digital controller
P-545.3D8S	High dynamics PI nano® XYZ piezo system, clear aperture for microscope slides, 70 µm × 70 µm × 50 µm, direct drive, piezoresistive sensors, with USB digital controller

Controller model in the system:

System	Controller
P-545.2C8S P-545.3C8S	E-727.3CDA Digital multi-channel piezo controller, 3 axes, -30 to 130 V, capacitive sensors, D-sub 25W3 socket, analog inputs
P-545.2R8S P-545.3R8S	E-727.3RDA Digital multi-channel piezo controller, 3 axes, -30 to 130 V, piezoresistive sensors, D-sub 37 socket, analog inputs
P-545.3D8S	E-727.3RDAP Digital multi-channel piezo controller, 3 axes, -30 to 130 V, piezoresistive sensors, D-sub 37 socket, 1.5 A peak output current, analog inputs

### 3.2 Product View

The figure serves as an example and can differ from your positioner model.

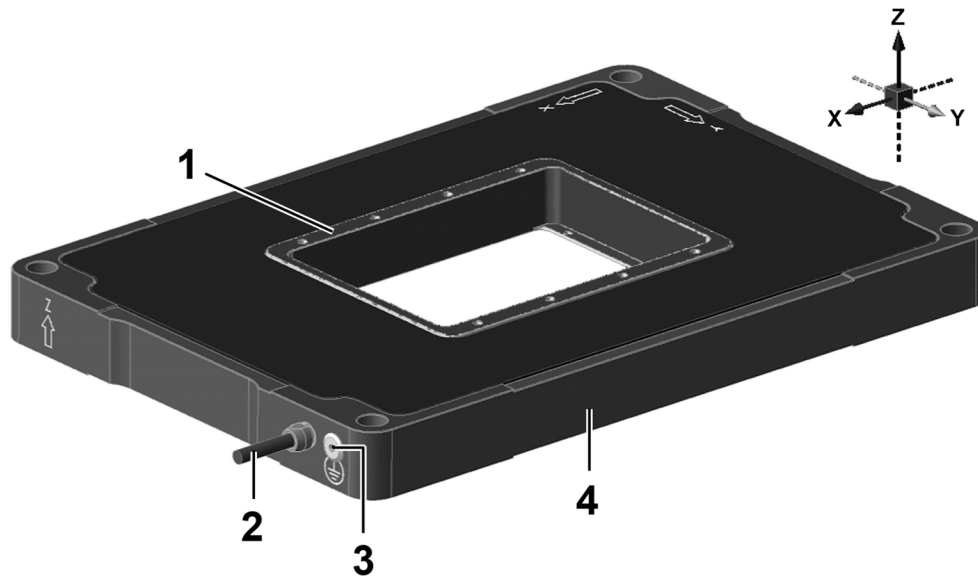


Figure 1: Example view of P-545

- 1 Platform
- 2 Cable exit
- 3 M4 hole for connecting the protective earth conductor
- 4 Base body
- X, Y, Z Positive direction of motion of the positioner

### 3.3 Product Labeling

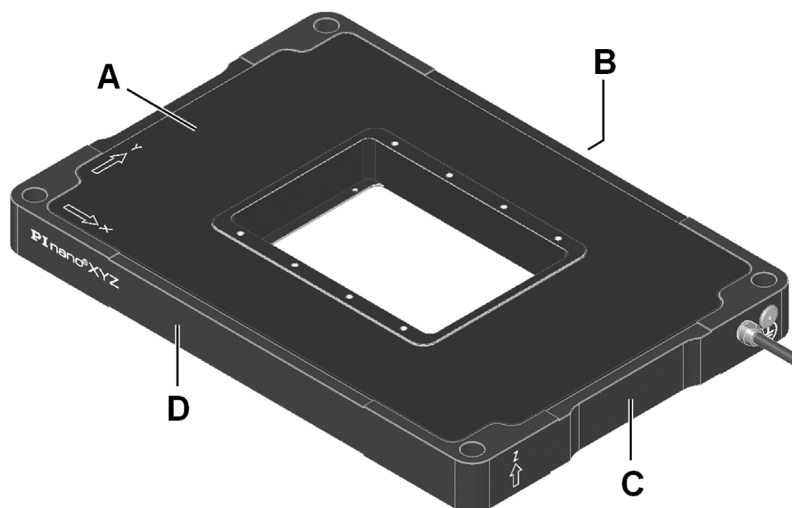


Figure 2: P-545: Position of the product labeling (example view)






Position	Labeling	Description
A	Arrow and letter X	Positive direction of motion of the X axis
A	Arrow and letter Y	Positive direction of motion of the Y axis
B		Manufacturer's logo
B	www.pi-usa.us	Manufacturer's address (website)
B	P-545.2R8H	Product name (example), the characters after the period refer to the positioner model
B	SN: A12345678	Serial number (example), individual for each P-545 Meaning of each position (from the left): 1 = internal information 2 and 3 = year of manufacture 4 to 9 = consecutive number
B	Made in USA	Country of origin
B		Warning sign "Pay attention to the manual!"
B		Old equipment disposal (p. 53)
B		CE conformity mark
C	Arrow and letter Z (.3x8x models only)	Positive direction of motion of the Z axis
C		Symbol for the protective earth conductor, marks the protective earth connector of the P-545 (p. 18)
D	Plnano®	Brand name, supplemented by "XY" (.2x8x models) or "XYZ" (.3x8x models)



Figure 3: "Residual Voltage" warning sign on the connector of the P-545: Indicates risk of electric shock (p. 5)

### 3.4 Scope of Delivery

Product number	Description
P-545	System consisting of positioner and controller according to order (p. 9), including accessories of the controller (refer to the user manual for the controller)
000036450	M4 screw set for protective earth, consisting of: <ul style="list-style-type: none"> <li>1 M4x8 flat-head screw with cross recess, ISO 7045</li> <li>2 lock washers</li> <li>2 flat washers</li> </ul>
000041912	Screw set for mounting the positioner: <ul style="list-style-type: none"> <li>4 M4x16 socket head screws, ISO 4762</li> <li>1 hex key</li> </ul>
PZ240EK	Short instructions for P-5xx / P-6xx / P-7xx piezo positioners

### 3.5 Optional Accessories

#### XY stages for integration of the P-545 in microscopes

Product number	Description
M-545.2MO	XY stage, 25 mm × 25 mm, micrometer screw, high stability, compatible with PI piezo stages, for Olympus microscopes (IX2, IX3)
M-545.2MN	XY stage, 25 mm × 25 mm, micrometer screw, high stability, compatible with PI piezo stages, for Nikon microscopes (TI series)
M-545.2ML	XY stage, 25 mm × 25 mm, micrometer screw, high stability, compatible with PI piezo stages, for Leica microscopes (DMI series)
M-545.2MZ	XY stage, 25 mm × 25 mm, micrometer screw, high stability, compatible with PI piezo stages, for Zeiss microscopes (Axio Observer)

#### Holders for Petri dishes, microscope slides, coverslips, and accessories

Product number	Description
P-545.PD3	Petri dish holder, 35 mm, for PI nano <sup>®</sup> piezo stages
P-545.SH3	Microscope slide holder for PI nano <sup>®</sup> piezo stages
P-545.SH4	Holder for microscope slides and Petri dishes, compatible with Nikon microscope stands (Eclipse, Eclipse Ti2) in conjunction with U-780.DNS (Nikon version) and the P-545 PI nano <sup>®</sup> piezo system
P-545.C18	Coverslip holder with opening for coverslips 18 mm × 18 mm, suitable for P-545.SH3
P-545.C22	Coverslip holder with opening for coverslips 22 mm × 22 mm, suitable for P-545.SH3



Product number	Description
P-545.C25	Coverslip holder with opening for coverslips 25 mm × 25 mm, suitable for P-545.SH3
P-545.PP3	Universal holding plate for accessories, suitable for Plnano® piezo stages

You can find a complete overview of the accessories in our "Microscope Stage Configurator" (<https://www.physikinstrumente.com/stage-configurator>) brochure.

- To order, contact our customer service department (p. 37).

## 3.6 Technical Features

### 3.6.1 PICMA® Piezo Actuators

P-545 positioners are driven by PICMA® piezo actuators. PICMA® actuators have all-ceramic insulation and their performance and lifetime are therefore far superior to conventional actuators. The ceramic insulation layer protects the monolithic piezoceramic block against humidity and failure due to increased leakage current. In this way, an especially high reliability is achieved even under extreme ambient conditions. In contrast to motorized drives, there are no rotating parts or friction. The piezo actuators are therefore free of backlash, maintenance, and wear.

### 3.6.2 Flexure Guides

P-545 positioners have flexure guides for friction-free motion and high guiding accuracy.

A flexure guide is an element that is free of static and sliding friction. It is based on the elastic deformation (bending) of a solid (e.g., steel) and does not have any rolling or sliding parts. Flexure elements have a high stiffness and load capacity. Flexure guides are maintenance and wear free. They are 100% vacuum compatible, function in a wide temperature range and do not require any lubricants.

### 3.6.3 Position Sensors

For closed-loop operation, the P-545 is equipped either with capacitive sensors or piezoresistive strain sensors, depending on the model (p. 9).

#### Capacitive Sensors

Capacitive sensors measure the position directly on the platform (direct metrology) and work without contact. Neither friction nor hysteresis interferes with the motion, which allows excellent linearity values to be achieved together with the high position resolution. In conjunction with suitable electronics, capacitive sensors achieve the best resolution, stability, and bandwidth.

### Piezoresistive strain sensors

Piezoresistive strain sensors consist of a thin semiconductor foil, which is attached to the piezo ceramic or, for improved precision, to the guiding system of a flexure positioner. This type of position measuring is indirect and requires contact because the position of the motion platform is derived from a measurement on the lever, guide, or piezo stack. Strain gauge sensors derive the position information from their expansion. Full-bridge circuits with several strain gauge sensors per axis improve thermal stability.

## 3.7 Integration of the P-545 into Microscopes

P-545 positioners can be easily integrated in microscopes. For this purpose, a P-545 is mounted on an M-545 XY stage. For further information, refer to "Accessories" (p. 12) and "Mounting the P-545 onto an M-545 XY Stage" (p. 22).

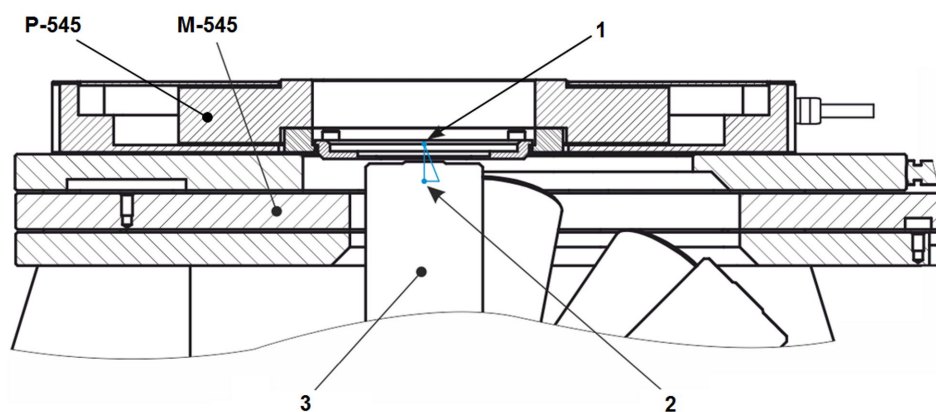


Figure 4: P-545 stage and M-545 XY stage in a microscope (section)

- 1: Upper focal plane (approx. 3 mm above the lower mounting surface)
- 2: Lower focal plane limit (approx. 10 mm below upper limit, depending on the microscope)
- 3: Microscope objective

## 4 Unpacking

### NOTICE

**Mechanical overload due to incorrect handling!**

An impermissible mechanical load on the motion platform of the P-545 can cause damage to the piezo actuators, sensors, and flexures of the P-545 as well as loss of accuracy.

- Do **not** touch any sensitive parts (e.g., motion platform) when handling the P-545.

1. Unpack the P-545 with care.
2. Compare the contents with the scope of delivery according to the contract and the delivery note.
3. Inspect the contents for signs of damage. If any parts are damaged or missing, contact our customer service department immediately (p. 37).
4. Keep all packaging materials in case the product needs to be returned.



## 5 Installing

### In this Chapter

General Notes on Installation .....	17
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Mounting the P-545 .....	20
Fixing the Load .....	23

### 5.1 General Notes on Installation

#### CAUTION



#### **Dangerous voltage and residual charge in piezo actuators!**

The P-545 is driven by piezo actuators. Temperature changes and compressive stress can induce charges in piezo actuators. Piezo actuators can remain charged for several hours after disconnecting the electronics. Touching or short-circuiting the contacts in the P-545's connector can lead to minor injuries from electric shock. The piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the P-545.
- Discharge the positioner's piezo actuators before installing:  
Connect the positioner to the switched-off PI electronics equipped with an internal discharge resistor.
- Do **not** pull the plug connector out of the electronics during operation.



Touching the contacts in the plug connector can lead to an electric shock (max. 130 V DC) and minor injuries.

- Do **not** touch the contacts in the connector.
- Use screws to secure the positioner's connector against being pulled out of the electronics.

#### NOTICE



#### **Mechanical overload due to incorrect handling!**

An impermissible mechanical load on the motion platform of the P-545 can cause damage to the piezo actuators, sensors, and flexures of the P-545 as well as loss of accuracy.

- Do **not** touch any sensitive parts (e.g., motion platform) when handling the P-545.

**NOTICE****Damage due to unsuitable cables!**

Unsuitable cables can damage the P-545 and the electronics.

- Use cables provided by PI only to connect the P-545 to the electronics.

**NOTICE****Damage due to improper mounting!**

Improper mounting of the P-545 or incorrectly mounted parts can damage the P-545.

- Only use the holes or threads intended for the purpose of fixing the P-545 and loads.
- Install the P-545 so that the platform and all parts attached to it can move freely within the entire travel range.

**NOTICE****Damage due to incorrectly tightened screws!**

Incorrectly tightened screws can cause damage.

- Pay attention to the torque range (p. 48) specified for the screws used during installation.

**INFORMATION**

Extension cables can reduce the positioning accuracy of the P-545 or affect sensor processing by the electronics.

- Do **not** use extension cables. If you need longer cables, contact our customer service department (p. 37).

## 5.2 Connecting the P-545 to the Protective Earth Conductor

**INFORMATION**

- Pay attention to the applicable standards for connecting the protective earth conductor.

**INFORMATION**

- If there is any vibration in your application, secure the screw connection for the protective earth conductor in a suitable manner to prevent it from unscrewing by itself. If this is not possible, check the screw connection at regular intervals and retighten the screw if necessary.

**INFORMATION**

In the case of P-545 positioners with D-sub connectors, ground loops can occur when the positioner is grounded via its protective earth connector as well as via the connecting cable's shielding for the electronics.

- If a ground loop occurs, contact our customer service department (p. 37).

The P-545 has an M4 hole for connecting the protective earth conductor. This hole is marked with the symbol for the protective earth conductor (⏚). Refer to "Dimensions" (p. 44) for the exact position of the hole.

**Requirements**

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ The P-545 is **not** connected to the electronics.

**Tools and accessories**

- Suitable protective earth conductor:
  - Cable cross section  $\geq 0.75 \text{ mm}^2$
  - Contact resistance at all connection points relevant for connecting the protective earth conductor  $< 0.1 \Omega$  at 25 A
- M4 protective earth screw set (p. 12) supplied for connecting the protective earth conductor
- Suitable screwdriver

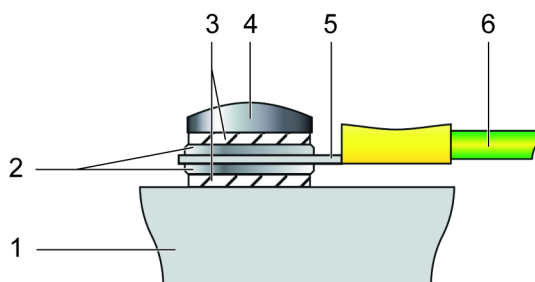


Figure 5: Connecting the protective earth conductor (profile view)

- 1 Base body of the P-545
- 2 Flat washer
- 3 Lock washer
- 4 Screw
- 5 Cable lug
- 6 Protective earth conductor

**Connecting the P-545 to the protective earth conductor**

1. If necessary, firmly attach a suitable cable lug to the protective earth conductor.
2. Use the M4 screw (together with the flat and lock washers) to attach the cable lug of the protective earth conductor to the threaded hole in the P-545 as shown in the profile view.
3. Tighten the M4 screw with a torque of 1.2 Nm to 1.5 Nm.

**5.3 Mounting the P-545**

The base body of the P-545 has four mounting holes which can be used to mount the positioner onto an underlying surface (p. 20) or an M-545 (p. 22) XY stage.

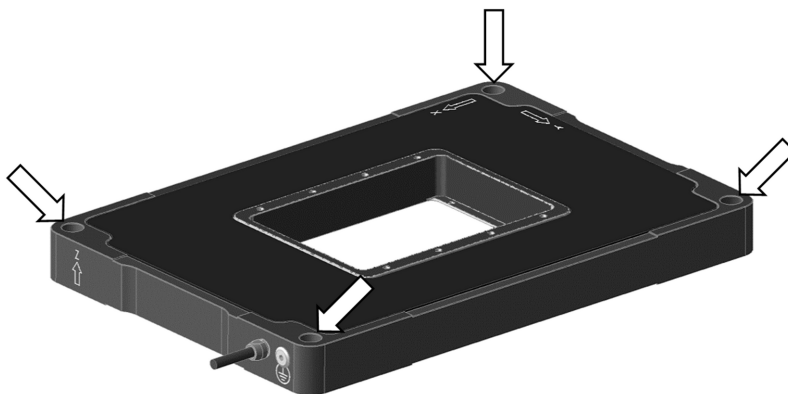


Figure 6: P-545: Mounting holes in the base body

**5.3.1 Mounting the P-545 onto a Surface****NOTICE****Warping the P-545 when mounting onto uneven surfaces!**

Fixing the P-545 onto an uneven surface can warp the P-545. Warping reduces the accuracy.

- Fix the P-545 onto a flat surface. The recommended flatness of the surface is  $\leq 100 \mu\text{m}$ .
- For applications with large temperature fluctuations:  
Only fix the P-545 onto surfaces that have the same or similar thermal expansion properties as the P-545 (e.g., surfaces made of aluminum).



**NOTICE****Tensile stress when mounted vertically!**

When the P-545 is mounted vertically, certain alignments can cause tensile stress that reduces the preload and destroys the piezo actuators.

- If you want to mount the P-545 vertically, contact our customer service department (p. 37).

**Requirements**

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ The P-545 is **not** connected to the electronics.
- ✓ You have provided a suitable surface for fixing the P-545:
  - The surface has four threaded holes for M4 screws. Refer to "Dimensions" (p. 44) for the required position and depth of the holes.
  - The surface flatness is  $\leq 100 \mu\text{m}$ .
  - For applications with large temperature fluctuations: The surface should have the same thermal expansion properties as the P-545 (e.g., surface made of aluminum).
- ✓ You have accounted for the space required to route cables according to regulations and without bending them.

**Tools and accessories**

- Mounting kit included in the scope of delivery (p. 12):
  - Four M4x16 screws
  - Hex key
- Alternative (not included in the scope of delivery):
  - Four M4 screws of suitable length (p. 44)
  - Suitable screwdriver

**Mounting the P-545 onto an underlying surface**

1. Align the P-545 so that the corresponding holes in the P-545 (p. 20) and underlying surface are in line.
2. Fix the P-545 with the screws:
  - a) Insert a screw into each hole from above.
  - b) Tighten the screws crosswise. Pay attention to the specified torque range (p. 48) while doing so.
3. Make sure that the screw heads are fully countersunk.
4. Check that the P-545 is sitting firmly on the underlying surface.

### 5.3.2 Mounting the P-545 onto an M-545 XY Stage



Figure 7: P-545 on M-545 XY stage (example view)

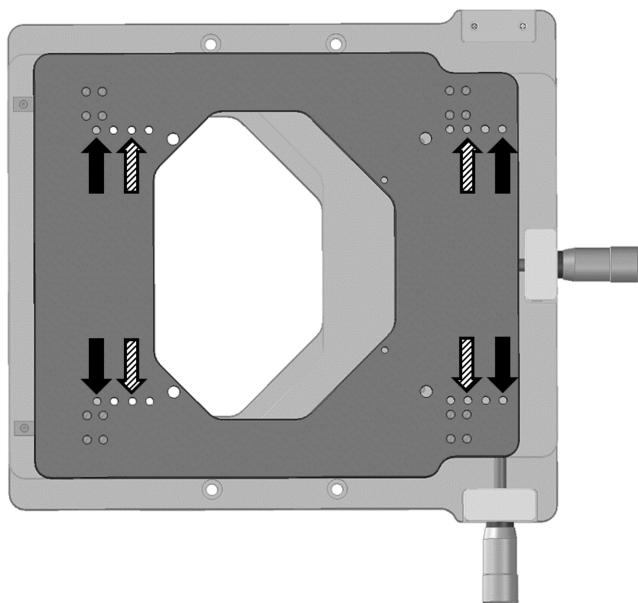


Figure 8: M-545: M4 mounting holes in the platform (example view from above)

Black arrows: Holes for mounting a P-545.3C8S, .3R8S or .3D8S  
 Hatched arrows: Holes for mounting a P-545.2C8S or .2R8S

#### Requirements

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ The P-545 is **not** connected to the electronics.

#### Tools and accessories

- Mounting accessories in the scope of delivery (p. 12):
  - Four M4x16 screws
  - Hex key

### Mounting the P-545 onto an M-545 XY stage

1. Align the P-545 on the M-545 so that the following conditions are met:
  - The mounting holes in the P-545's base body (p. 20) and in the M-545's motion platform (depending on the model; see arrows in the figure) are in line.
  - The cable exit points in the desired direction.
2. Insert the four M4 screws into the mounting holes in the base body of the P-545 (p. 20).
3. Tighten the screws:
  - Pay attention to the specified torque range (p. 48) for the screws.
  - Make sure that the screw heads are fully countersunk.

## 5.4 Fixing the Load

### NOTICE



#### Mechanical overload of the motion platform!

High torques during fastening of the load as well as heavy loads can overload the motion platform of the P-545. Mechanical overload can cause damage to the piezo actuators, sensors, and flexures of the P-545 and lead to loss of accuracy.

- Avoid torques  $>0.5$  Nm on the motion platform.
- Do **not** exceed the maximum permissible loads according to the specifications (p. 40).
- Hold the load and adhere to the specified torque range (p. 48) when tightening (or loosening) the screws.

### NOTICE



#### Warping of the P-545 when fixing loads with an uneven contact surface!

Fixing loads with an uneven contact surface could warp the P-545. Warping reduces the accuracy.

- Fix loads to the P-545 only when the surface contacting the P-545's platform has a flatness of at least  $100\text{ }\mu\text{m}$ .
- For applications with large temperature fluctuations:  
Mount loads onto the P-545 only if they have the same or similar thermal expansion properties as the P-545 (e.g., loads made of aluminum).

**NOTICE****Center of load at unsuitable position!**

If the center of load is located too far away from the center of the motion platform (e.g., tall load and unwanted lever effect), the P-545 can be damaged, especially in dynamic operation, by high strain on the flexure guides, high torques, and oscillations.

- If the center of the load to be fixed is too high or to the side of the motion platform, adjust the controller settings before starting and operating or contact our customer service department (p. 37).

**NOTICE****Excessively long screws!**

The P-545 could be damaged by screws inserted too deeply.

- Pay attention to the depth of the mounting holes in the motion platform (p. 44).
- Use screws of the correct length for the respective mounting holes only.

**INFORMATION**

Positive direction of axis motion is specified in the product view (p. 10).

The motion platform of the P-545 has two mounting surfaces:

- Upper mounting surface with eight M2.5 holes for affixing loads (p. 25)  
The upper mounting surface of the P-545 is raised by 0.5 mm.
- Lower mounting surface with four M2 holes for mounting holders for Petri dishes, microscope slides, and accessories (p. 27)

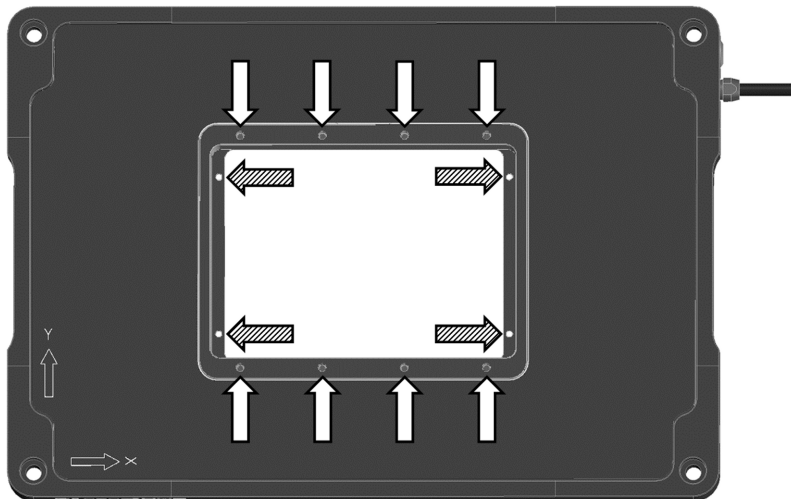


Figure 9: P-545: Mounting holes in the motion platform

White arrows:

Eight M2.5 holes in the upper mounting surface of the motion platform

Hatched arrows:

Four M2 holes in the lower mounting surface of the motion platform

### 5.4.1 Fixing a Load to the Motion Platform

Center of load at the optimal position:

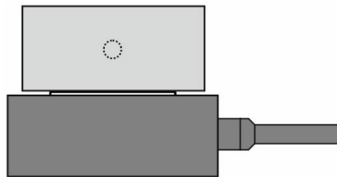


Figure 10: Example of an optimally placed load

Center of load at an unsuitable position:

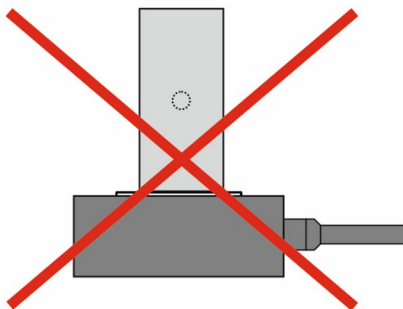


Figure 11: Tall load and center of load too far above the platform

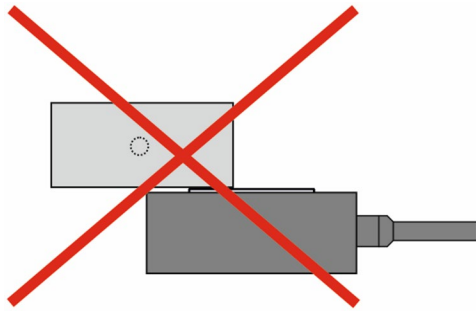


Figure 12: Unwanted lever effect and center of load on the side of the platform

### Requirements

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ The P-545 is **not** connected to the electronics.

### Tools and accessories

- Screws of suitable size and length (p. 44)
- Suitable screwdriver

### Fixing the load

1. Align the load on the P-545 so that the mounting holes in the load and the holes in the platform are in line.
2. Hold the load so that it cannot move while tightening the screws.
3. Fix the load by tightening the screws in the mounting holes (p. 44) provided. Pay attention to the torque range (p. 48) specified for the screws, and avoid torques  $>0.5$  Nm on the motion platform.
4. Check that the load is sitting firmly on the motion platform.

## 5.4.2 Mounting Holders for Petri Dishes, Microscope Slides and Accessories

### Requirements

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ The P-545 is **not** connected to the electronics.

### Tools and accessories

- P-545.PD3, P-545.SH3, P-545.SH4, or P-545.PP3 holder (p. 12)
- Four M2 screws of suitable length (p. 44)
- Suitable screwdriver

### Mounting a holder

1. Align the holder so that the holding clamps (P-545.PD3, P-545.SH3, or P-545.SH4) are pointing upwards or the larger surface of the base body (P-545.PP3) is pointing upwards. Refer to "Dimensions" (p. 44).
2. Put the holder into the aperture of the P-545 from above, so that the mounting holes in the holder and the lower mounting surface (p. 24) of the P-545 are in line.
3. Insert the M2 screws into the threaded holes (p. 44) to fix the holder. Pay attention to the torque range (p. 48) specified for the screws, and avoid torques  $>0.5$  Nm on the motion platform.





## 6 Starting and Operating

### In this Chapter

General Notes on Starting and Operating .....	29
Operating the P-545.....	31
Discharging the P-545 .....	31

### 6.1 General Notes on Starting and Operating

#### CAUTION



##### **Risk of electric shock if the protective earth conductor is not connected!**

If the protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the P-545 in the event of a malfunction or failure of the system. If there are touch voltages, touching the P-545 can result in minor injuries from electric shock.

- Connect the P-545 to a protective earth conductor (p. 18) before starting.
- Do **not** remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e.g., in the case of modifications), reconnect the P-545 to the protective earth conductor before restarting.

#### NOTICE



##### **Destruction of the piezo actuators due to electric flashovers!**

Using the P-545 in environments that increase the electrical conductivity can lead to the destruction of the piezo actuators by electric flashovers. Electric flashovers can be caused by moisture, high humidity, liquids, and conductive materials (e.g., metal dust). In addition, electric flashovers can also occur in certain air pressure ranges due to the increased conductivity of the air.

- Avoid operating the P-545 in environments that can increase the electric conductivity.
- Operate the P-545 only within the permissible ambient conditions and classifications (p. 43).

#### NOTICE



##### **Decreased lifetime due to permanently high voltage!**

Applying a continuous high static voltage to piezo actuators leads to a considerable reduction in the lifetime of the piezo ceramic.

- When the P-545 is not used but the electronics remain switched on to ensure temperature stability, discharge the P-545 (p. 31).

**NOTICE****Operating voltage excessively high or incorrectly connected!**

Excessively high or wrongly connected operating voltages can damage the P-545.

- Operate the P-545 with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 43) specified for the P-545.
- Operate the P-545 only when the operating voltage is properly connected; see "Pin Assignment" (p. 49).

**NOTICE****Short-circuiting due to condensation!**

Condensation can lead to short-circuiting and failure of the P-545.

- Wait for a sufficient period of time to allow the P-545 to reach room temperature in the following cases:
  - After unpacking or before starting for the first time
  - If the P-545 has been brought from a cold into a warm environment or from a warm into a cold environment
- Keep the P-545 free of condensation.

**NOTICE****Uncontrolled oscillation!**

Oscillation can cause irreparable damage to the P-545. Oscillation is indicated by a humming noise and can be caused by the following:

- A change in the load and/or dynamics requires the servo control parameters to be adjusted.
- The P-545 is operated close to its resonant frequency, or with too high operating frequency.

If you notice oscillation:

- In closed-loop operation, switch off the servo mode immediately.
- In open-loop operation, stop the P-545 immediately.

**INFORMATION**

Positive direction of axis motion is specified in the product view (p. 10).

**INFORMATION**

Sound and vibration (e.g., footfall, knocks) can be transmitted to the P-545 and can affect its performance with regard to position stability.

- Avoid sound and vibration while the P-545 is being operated.

## 6.2 Operating the P-545

### Requirements

- ✓ You have read and understood the general notes on starting and operating (p. 29).
- ✓ You have read and understood the user manual for the electronics.
- ✓ You have read and understood the user manual for the PC software.
- ✓ You have correctly installed (p. 17) the P-545 and connected it to the protective earth conductor (p. 18).
- ✓ The electronics and the required PC software were installed. All connections to the electronics were made (refer to the user manual for the electronics).

### Operating the P-545

- Follow the instructions for starting and operating the P-545 in the manual for the electronics used.

## 6.3 Discharging the P-545

The P-545 must be discharged in the following cases:

- Before Installation
- When the P-545 is not used but the electronics remain switched on to ensure temperature stability
- Before demounting (e.g., before cleaning and transporting the P-545 and for modifications)

The P-545 is discharged via the discharge resistor inside the electronics from PI.

### Discharging a positioner connected to the electronics

In closed-loop operation:

1. Switch off the servo mode on the controller.
2. Set the piezo voltage to 0 V on the controller.

In open-loop operation:

- Set the piezo voltage to 0 V on the electronics.

### Discharging a positioner not connected to the electronics

- Connect the positioner to the switched-off electronics from PI.



## 7 Maintenance

### In this Chapter

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Cleaning the P-545.....	33

### 7.1 General Notes on Maintenance

#### NOTICE

**Damage due to improper maintenance!**

The P-545 is maintenance-free and achieves its positioning accuracy as a result of the optimum alignment of mechanical components and piezo actuators.

- Do **not** open the P-545.

### 7.2 Cleaning the P-545

#### NOTICE

**Damage from ultrasonic cleaning!**

Ultrasonic cleaning can damage the P-545.

- Do **not** do any ultrasonic cleaning.

**Requirements**

- ✓ You have discharged the piezo actuators of the P-545 (p. 31).
- ✓ You have disconnected the P-545 from the electronics.

**Cleaning the P-545**

- Clean the surfaces of the P-545 with a cloth dampened with a mild cleanser or disinfectant (e.g., isopropyl alcohol).



## 8 Troubleshooting

Problem	Possible causes	Solution
No or limited motion	Cable not connected correctly	➤ Check the cable connections.
	Excessive load	➤ Do <b>not</b> exceed the maximum permissible loads according to the specifications (p. 40).
	Zero point shifting of the sensor for the following reasons: <ul style="list-style-type: none"> <li>▪ Load applied in direction of motion</li> <li>▪ Ambient/operating temperature of the positioner far above or below the calibration temperature (21 °C to 24 °C)</li> </ul>	➤ Adjust the zero point of the sensor (refer to "AutoZero Procedure" in the controller manual).
Reduced accuracy	The base body or the platform is warped	➤ Mount the P-545 onto surfaces with the following characteristics only: <ul style="list-style-type: none"> <li>– Flatness of at least 100 µm</li> <li>– The thermal expansion properties are similar to those of the P-545 (e.g., surface made of aluminum).</li> </ul> ➤ Mount loads onto the P-545 with the following characteristics only: <ul style="list-style-type: none"> <li>– The contact surface of the load has a flatness of at least 100 µm.</li> <li>– The thermal expansion properties are similar to those of the P-545 (e.g., load made of aluminum).</li> </ul>

Problem	Possible causes	Solution
The positioner starts oscillating or positions inaccurately	Servo control parameters incorrectly set because for example, the load was changed	<ol style="list-style-type: none"> <li>1. Switch off the servo mode of the corresponding motion axes immediately.</li> <li>2. Check the settings of the servo control parameters on the controller.</li> <li>3. Adjust the servo control parameters on the controller according to the load change.</li> </ol>
	Open-loop operation near the resonant frequency	➤ In open-loop operation, operate the positioner only with a frequency that is below the resonant frequency.

If the problem that occurred with your system is not listed in the table above or cannot be solved as described, contact our customer service department (p. 37).



## 9 Customer Service Department

For inquiries and orders, contact your PI sales engineer or send us an email ([service@pi.de](mailto:service@pi.de)).

- If you have questions concerning your system, provide the following information:
  - Product and serial numbers of all products in the system
  - Firmware version of the controller (if applicable)
  - Version of the driver or the software (if applicable)
  - PC operating system (if applicable)
- If possible: Take photographs or make videos of your system that can be sent to our customer service department if requested.

The latest versions of the user manuals are available for download on our website (p. 3).



# 10 Technical Data

Subject to change. You can find the latest product specifications on the product web page at [www.pi.ws](https://www.pi.ws) (<https://www.pi.ws>).

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## 10.1 Specifications

### 10.1.1 Data Table

	P-545.2C8S	P-545.3C8S	Unit	Tolerance
Active axes	X, Y	X, Y, Z		
<b>Motion and positioning</b>				
Integrated sensor	Capacitive	Capacitive		
Travel range, closed loop	200 × 200	200 × 200 × 200	μm	
Resolution, closed loop*	<1	<1	nm	typ.
<b>Mechanical properties</b>				
Push/pull force capacity	50 / 30	50 / 30	N	max.
Recommended load**	0.5	0.5	kg	max.
<b>Drive properties</b>				
Piezo ceramic	PICMA® P-885	PICMA® P-885		
Electrical capacitance	6 (X, Y)	6 (X, Y), 12 (Z)	μF	±20 %
<b>Miscellaneous</b>				
Operating temperature range	15 to 40	15 to 40	°C	
Material	Aluminum	Aluminum		
Mass	1	1.2	kg	±5 %
Cable length	1.7	1.7	m	+10 cm
<b>Piezo controller</b>	E-727.3CDA (in the scope of delivery)			
Communication interfaces	Ethernet, USB, RS-232, serial SPI high-speed interface			
Analog input / Analog output	D-sub 15 Input via 18-bit A/D converter Output via 20-bit D/A converter			
Command set	PI General Command Set (GCS)			
User software	PIMikroMove			
Software drivers	NI LabVIEW drivers, shared libraries for Windows and Linux			
Supported functions	Wave generator, data recorder, drift compensation, macros			

\* The resolution of the system is limited only by the noise of the amplifier and the measuring technology because PI piezo nanopositioning systems are free of friction.

\*\* For dynamic operation. Higher dynamics are possible with a reduced load.

	P-545.2R8S	P-545.3R8S	Unit	Tolerance
Active axes	X, Y	X, Y, Z		
<b>Motion and positioning</b>				
Integrated sensor	Piezoresistive	Piezoresistive		
Travel range, closed loop	200 × 200	200 × 200 × 200	μm	
Resolution, closed loop*	1	1	nm	typ.
<b>Mechanical properties</b>				
Push/pull force capacity	50 / 30	50 / 30	N	max.
Recommended load**	0.5	0.5	kg	max.
<b>Drive properties</b>				
Piezo ceramic	PICMA® P-885	PICMA® P-885		
Electrical capacitance	6 (X, Y)	6 (X, Y), 12 (Z)	μF	±20 %
<b>Miscellaneous</b>				
Operating temperature range	15 to 40	15 to 40	°C	
Material	Aluminum	Aluminum		
Mass	1	1.2	kg	±5 %
Cable length	1.7	1.7	m	+10 cm
<b>Piezo controller</b>	E-727.3RDA (in the scope of delivery)			
Communication interfaces	Ethernet, USB, RS-232, serial SPI high-speed interface			
Analog input / Analog output	D-sub 15 Input via 18-bit A/D converter Output via 20-bit D/A converter			
Command set	PI General Command Set (GCS)			
User software	PIMikroMove			
Software drivers	NI LabVIEW drivers, shared libraries for Windows and Linux			
Supported functions	Wave generator, data recorder, drift compensation, macros			

\* The resolution of the system is limited only by the noise of the amplifier and the measuring technology because PI piezo nanopositioning systems are free of friction.

\*\* For dynamic operation. Higher dynamics are possible with a reduced load.




	P-545.3D8S	Unit	Tolerance
Active axes	X, Y, Z		
<b>Motion and positioning</b>			
Integrated sensor	Piezoresistive		
Travel range, closed loop	70 × 70 × 50	μm	
Resolution, closed loop*	<1	nm	typ.
<b>Mechanical properties</b>			
Resonant frequency, no load	1 (X, Y), 0.8 (Z)	kHz	
Push/pull force capacity	100 / 30	N	max.
Recommended load**	0.5	kg	max.
<b>Drive properties</b>			
Piezo ceramic	PICMA®		
Electrical capacitance	12 (X, Y), 24 (Z)	μF	±20 %
<b>Miscellaneous</b>			
Operating temperature range	15 to 40	°C	
Material	Aluminum		
Mass	1.2	kg	±5 %
Cable length	1.7	m	+10 cm
<b>Piezo controller</b>	E-727.3RDAP (in the scope of delivery)		
Communication interfaces	Ethernet, USB, RS-232, serial SPI high-speed interface		
Analog input / Analog output	D-sub 15 Input via 18-bit A/D converter Output via 20-bit D/A converter		
Command set	PI General Command Set (GCS)		
User software	PIMikroMove		
Software drivers	NI LabVIEW drivers, shared libraries for Windows and Linux		
Supported functions	Wave generator, data recorder, drift compensation, macros		

\* The resolution of the system is limited only by the noise of the amplifier and the measuring technology because PI piezo nanopositioning systems are free of friction.

\*\* For dynamic operation. Higher dynamics are possible with a reduced load.

### 10.1.2 Maximum Ratings

P-545 positioners are designed for the following operating data:

Model	Maximum operating voltage 	Maximum operating frequency* 	Maximum power consumption 
P-545.2C8S	-20 to 120 V	40 Hz (per axis)	4.7 W (per axis)
P-545.3C8S	-20 to 120 V	40 Hz (in X and Y) 57 Hz (in Z)	4.7 W (in X and Y) 13.4 W (in Z)
P-545.2R8S	-20 to 120 V	40 Hz (per axis)	4.7 W (per axis)
P-545.3R8S	-20 to 120 V	40 Hz (in X and Y) 57 Hz (in Z)	4.7 W (in X and Y) 13.4 W (in Z)
P-545.3D8S	-20 to 120 V	146 Hz (in X and Y) 80 Hz (in Z)	34.4 W (in X and Y) 37.6 W (in Z)

\* In continuous operation without load and with maximum travel range. With a reduced travel range, higher operating frequencies are possible.

### 10.1.3 Ambient Conditions and Classifications

Pay attention to the following ambient conditions and classifications for the P-545:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 0.1 hPa
Relative humidity	Highest relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative humidity at 40 °C
Operating temperature	15 °C to 40 °C
Storage temperature	-20 °C to 80 °C
Transport temperature	-25 °C to 85 °C
Overvoltage category	II
Protection class	I
Degree of pollution	1
Degree of protection according to IEC 60529	IP20

## 10.2 Dimensions

### 10.2.1 P-545 Positioner

Dimensions in mm.

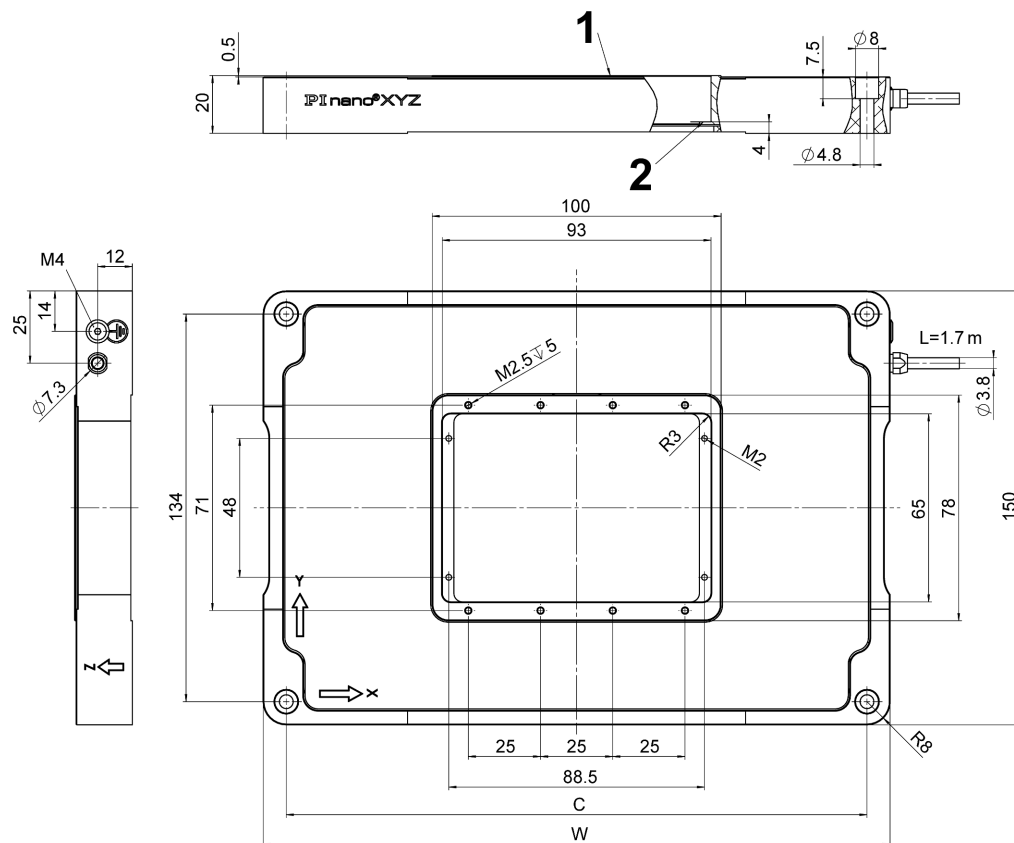


Figure 13: P-545

- 1: Upper mounting surface of the motion platform with eight M2.5 mounting holes
- 2: Lower mounting surface of the motion platform with four M2 mounting holes (through holes)

Model	C	W
.2C8S, .2R8S	166	182
.3C8S, .3R8S, .3D8S	201	217



### 10.2.2 P-545.SH4 Microscope Slide and Petri Dish Holder

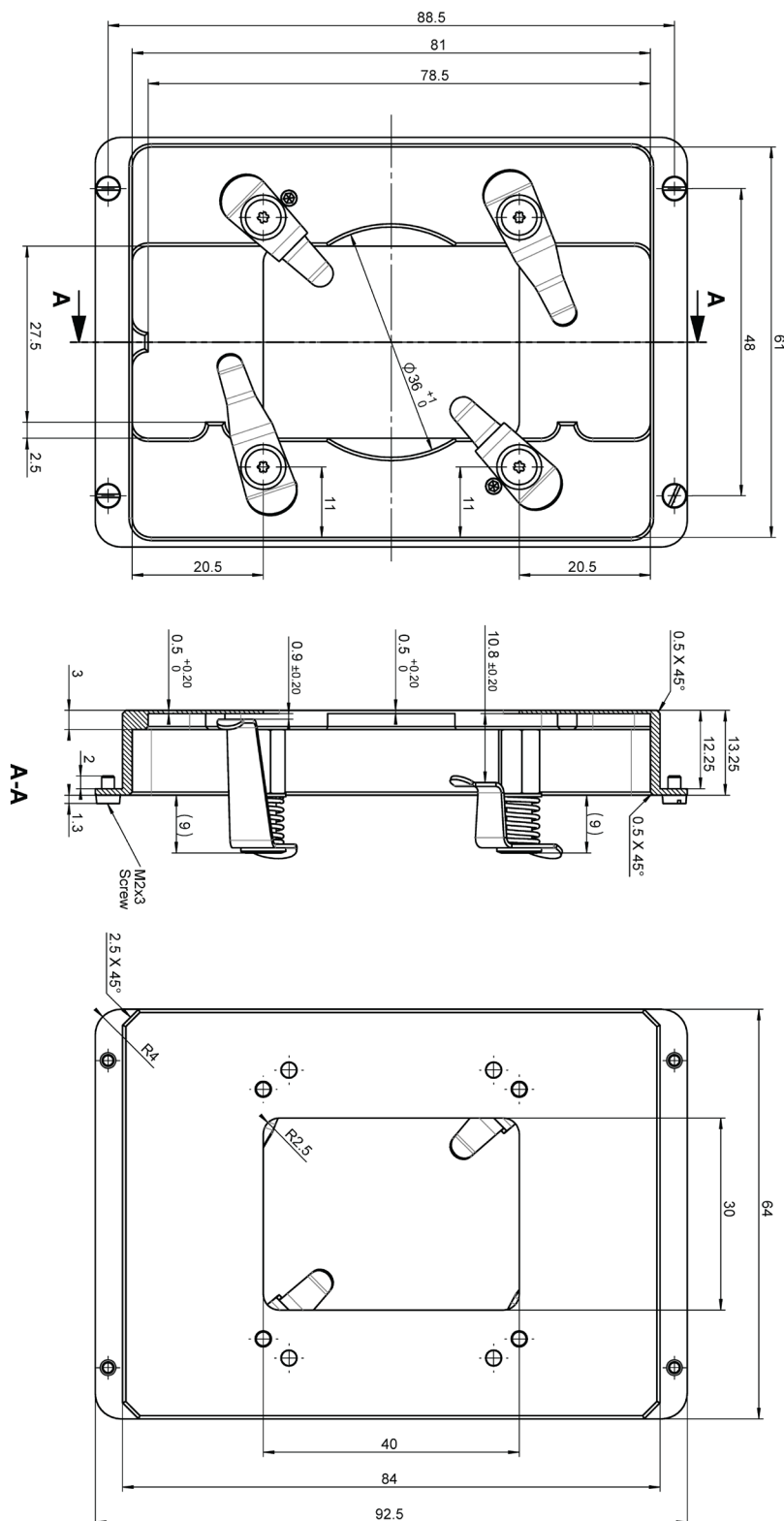


Figure 14: P-545.SH4: Microscope slide and Petri dish holder for P-545 Plnano® piezo system with U-780.DNS (Nikon version)

### 10.2.3 P-545.SH3 Microscope Slide Holder

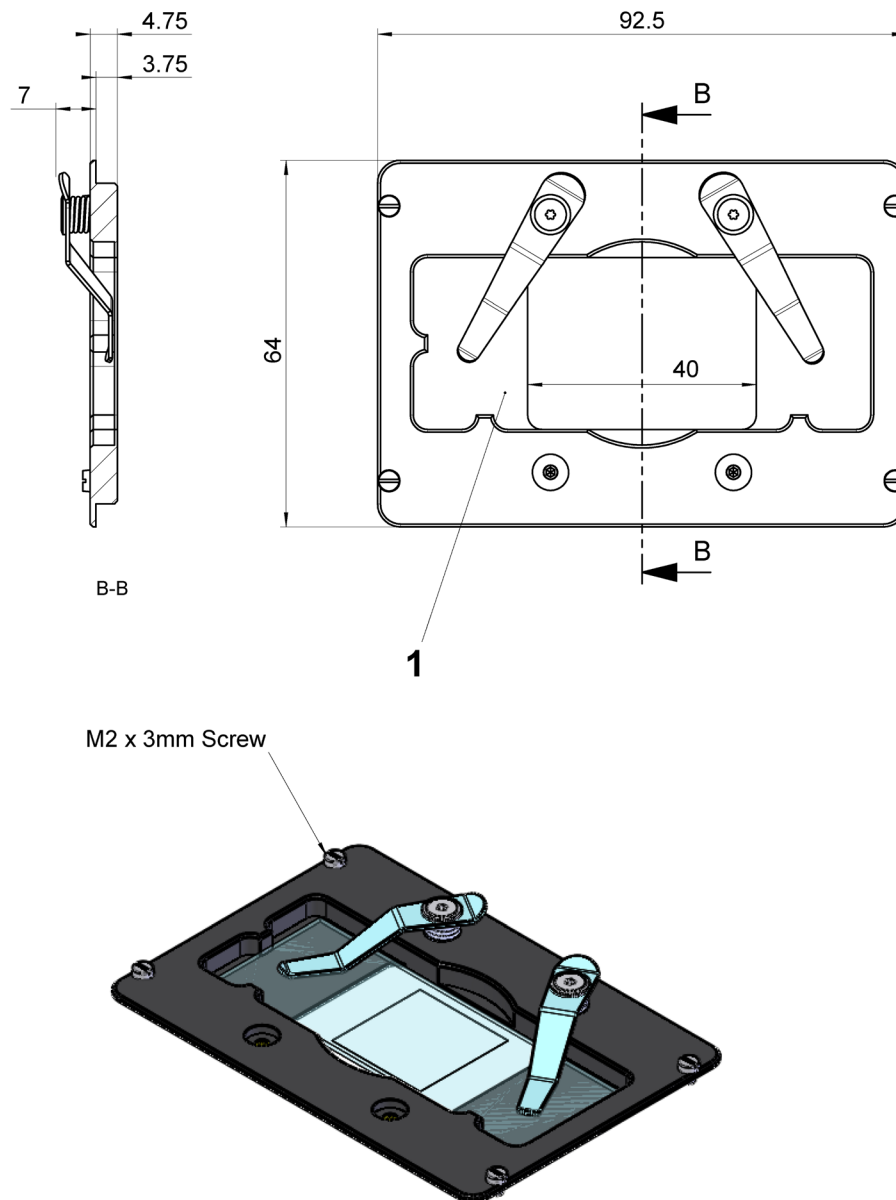


Figure 15: P-545.SH3: Microscope slide holder, suitable for PInano® piezo stages

1: Recess for standard microscope slides (25 mm × 75 mm)

### 10.2.4 P-545.PD3 Petri Dish Holder

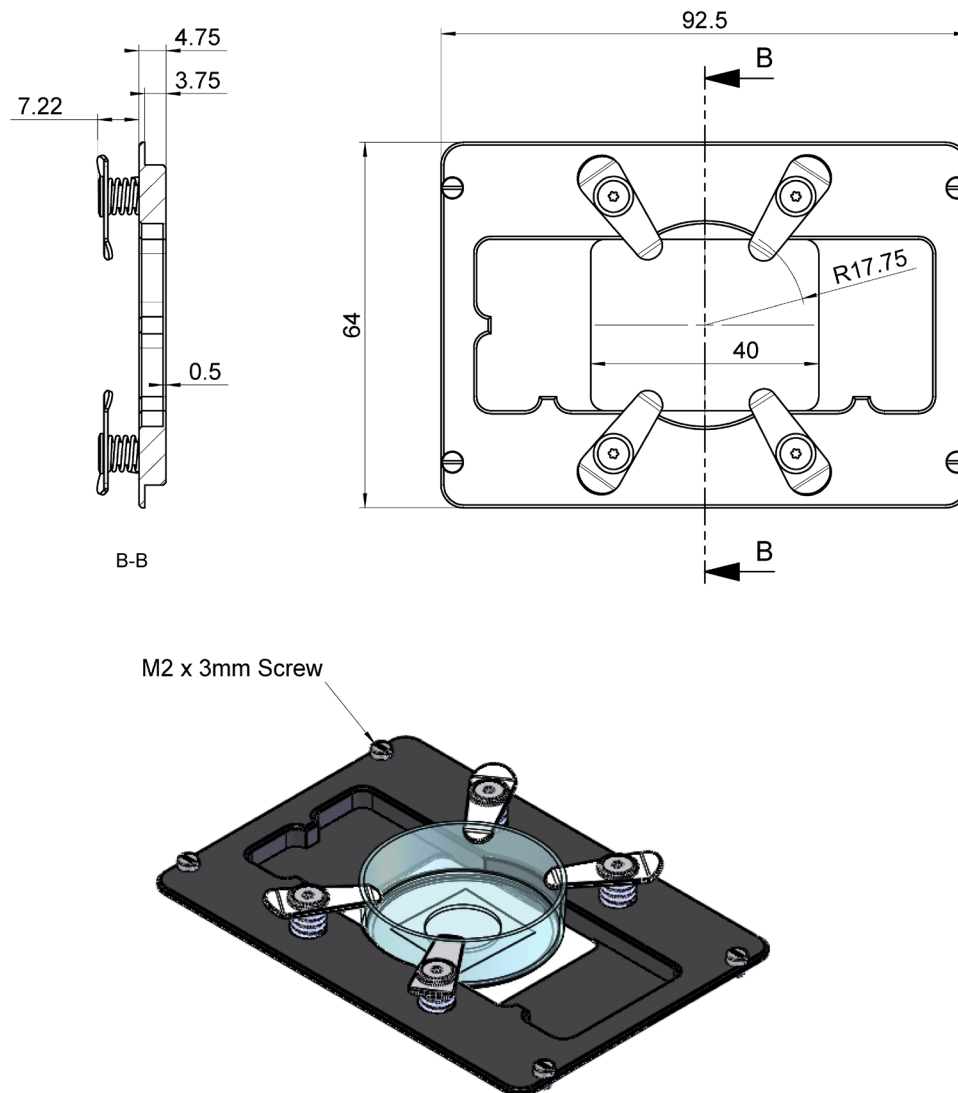


Figure 16: P-545.PD3: Petri dish holder, suitable for PInano® piezo stages

### 10.2.5 P-545.PP3 Universal Holding Plate

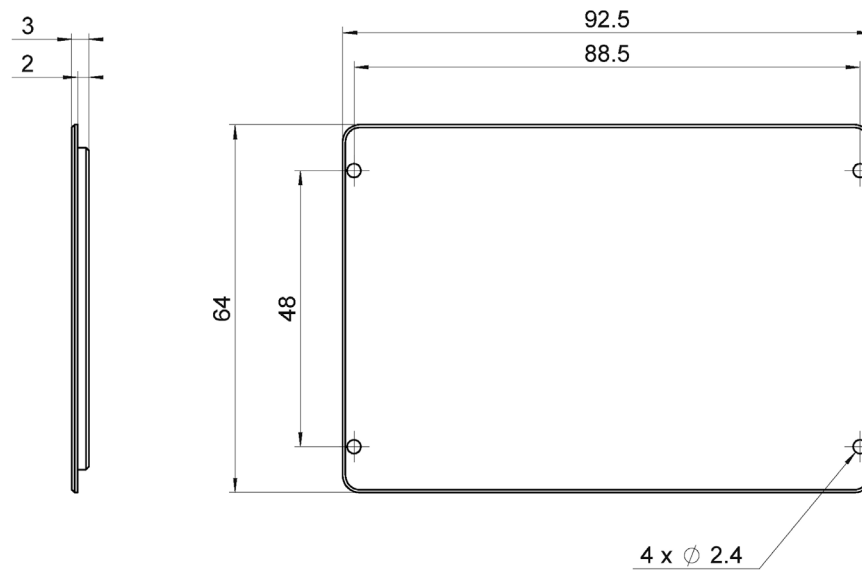


Figure 17: P-545.PP3: Universal holding plate for accessories, suitable for PInano® piezo stages

## 10.3 Torque for Stainless Steel Screws (A2-70)

Screw size	Minimum torque	Maximum torque
M6	4 Nm	6 Nm
M5	2.5 Nm	3.5 Nm
M4	1.5 Nm	2.5 Nm
M3	0.8 Nm	1.1 Nm
M2.5	0.3 Nm	0.4 Nm
M2	0.15 Nm	0.2 Nm
M1.6	0.06 Nm	0.12 Nm

- Pay attention to the screw-in depth required for the respective material according to the VDI directive 2230.

## 10.4 Pin Assignment

### D-sub 25W3 connector (m)

For P-545.2C8S/.3C8S only:

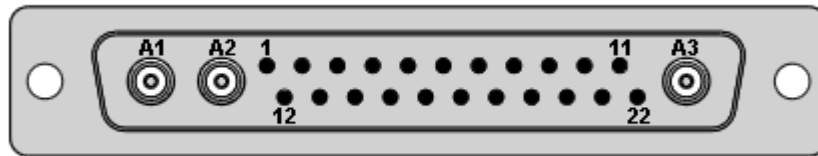


Figure 18: D-sub 25W3 connector (m): Front with connections

Pin	Signal	Function
A1 inner conductor	Output	Probe sensor signal, channel 2 (immovable part of the capacitive sensor)
A1 outer conductor	GND	Shielding for probe sensor signal, channel 2
A2 inner conductor	Output	Probe sensor signal, channel 3 (immovable part of the capacitive sensor)
A2 outer conductor	GND	Shielding for probe sensor signal, channel 3
A3 inner conductor	Output	Probe sensor signal, channel 1 (immovable part of the capacitive sensor)
A3 outer conductor	GND	Shielding for probe sensor signal, channel 1
1	Input	Target sensor signal, channel 2 (movable part of the capacitive sensor)
2	Input	Target sensor signal, channel 3 (movable part of the capacitive sensor)
3	GND	ID chip ground
4	Bidirectional	Data line for ID chip
5	---	(not connected)
6	---	(not connected)
7	---	(not connected)
8	Input	Piezo voltage +, channel 3
9	Input	Piezo voltage +, channel 2
10	Input	Piezo voltage +, channel 1
11	Input	Target sensor signal, channel 1 (movable part of the capacitive sensor)
12	GND	Shielding for target sensor signal, channel 2
13	GND	Shielding for target sensor signal, channel 3
14	---	(not connected)
15	---	(not connected)
16	---	(not connected)

Pin	Signal	Function
17	---	(not connected)
18	---	(not connected)
19	Input	Piezo voltage –, channel 3
20	Input	Piezo voltage –, channel 2
21	Input	Piezo voltage –, channel 1
22	GND	Shielding for target sensor signal, channel 1

Model-dependent assignment of the D-sub 25W3 connector (m) (X = used):

Model	Piezo voltage			Sensor signal (Probe / Target / shield)		
	Channel 1 Pins 10 and 21	Channel 2 Pins 9 and 20	Channel 3 Pins 8 and 19	Channel 1 Pins A3, 11 and 22	Channel 2 Pins A1, 1 and 12	Channel 3 Pins A2, 2 and 13
P-545.2C8S	x	x	–	x	x	–
P-545.3C8S	x	x	x	x	x	x

### D-sub 37 connector (m)

For P-545.2R8S/.3R8S/.3D8S only:

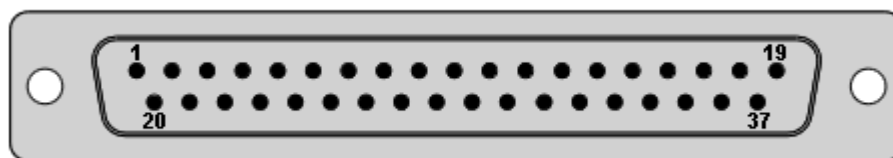


Figure 19: D-sub 37 connector (m): Front side with connections

Pin	Signal	Function
1	Free	–
2	GND	Ground
3	Free	–
4	Free	–
5	Free	–

Pin	Signal	Function
6	Free	–
7	GND	Ground
8	Output	SGS 3 signal
9	GND	Ground
10	Output	SGS 2 signal
11	GND	Ground
12	Output	SGS 1 signal
13	GND	Ground
14	Free	–
15	Free	–
16	Input	Piezo voltage +, channel 1
17	Input	Piezo voltage +, channel 2
18	Input	Piezo voltage +, channel 3
19	Free	–
20	Free	–
21	Bidirectional	Data line for ID chip
22	GND	Ground of ID chip
23	Free	–
24	Free	–
25	Free	–
26	GND	SGS 3 GND
27	Input	SGS 3 reference voltage
28	GND	SGS 2 GND
29	Input	SGS 2 reference voltage
30	GND	SGS 1 GND
31	Input	SGS 1 reference voltage
32	Free	–
33	Free	–
34	Input	Piezo voltage –, channel 1
35	Input	Piezo voltage –, channel 2
36	Input	Piezo voltage –, channel 3
37	Free	–

Model-dependent assignment of the D-sub 37 connector (m) (X = used):

Model	Piezo voltage			Sensor signal		
	Channel 1 Pins 16 and 34	Channel 2 Pins 17 and 35	Channel 3 Pins 18 and 36	Channel 1 Pins 12, 30 and 31	Channel 2 Pins 10, 28 and 29	Channel 3 Pins 8, 26 and 27
P-545.2R8S	x	x	–	x	x	–
P-545.3R8S P-545.3D8S	x	x	x	x	x	x



## 11 Old Equipment Disposal

In accordance with EU law, electrical and electronic equipment may not be disposed of in EU member states via the municipal residual waste.

Dispose of your old equipment according to international, national, and local rules and regulations.

To fulfill the responsibility as the product manufacturer, Physik Instrumente (PI) GmbH & Co. KG undertakes environmentally correct disposal of all old PI equipment made available on the market after 13 August 2005 without charge.

Any old PI equipment can be sent free of charge to the following address:

Physik Instrumente (PI) GmbH & Co. KG  
Auf der Römerstraße 1  
76228 Karlsruhe, Germany





## 12 European Declarations of Conformity

For the P-545, declarations of conformity were issued according to the following European statutory requirements:

Low Voltage Directive

EMC Directive

RoHS Directive

The standards applied for certifying conformity are listed below.

Safety (Low Voltage Directive): EN 61010-1

EMC: EN 61326-1

RoHS: EN IEC 63000

