

PZ272E P-545 Nanopositioners User Manual

Version: 1.0.0

Date: 15.08.2016



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 products described in this document are in part protected by the following patents:

German patent no. 10021919C2

German patent no. 10234787C1

German patent no. 10348836B3

German patent no. 102005015405B3

German patent no. 102007011652B4

US patent no. 7,449,077

Japanese patent no. 4667863

Chinese patent no. ZL03813218.4

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Subject to change without notice. This manual is superseded by any new release. The latest release is available for download (p. 3) on our website.

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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 Audience of this User Manual

This user manual contains the necessary information on the intended use of the P-545.xx8H stage belonging to the P-545.xx8S system (x stands for the respective model). Unless stated otherwise, "P-545" only refers to the stage in this manual. The controller contained 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 (p. 3) on our website.

1.2 Symbols and Typographic Conventions

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

CAUTION



Dangerous situation

If not avoided, the dangerous situation will result in minor injury.

- Actions to take to avoid the situation.

NOTICE




Dangerous situation

If not avoided, the dangerous situation will result in damage to the equipment.

- Actions to take to avoid the situation.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol/Label	Meaning
1. 2.	Action consisting of several steps whose sequential order must be observed
➤	Action consisting of one or several steps whose sequential order is irrelevant
▪	List item
p. 5	Cross-reference to page 5
RS-232	Labeling of an operating element on the product (example: socket of the RS-232 interface)
	Warning signs affixed to 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 which are mentioned in this documentation are described in their own manuals.

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

Product	Document
E-727 digital multi-channel piezo controller, part of the P-545 system	E727T0005 technical note
PIMikroMove	SM148E software manual
P-5xx / P-6xx / P-7xx piezo positioning systems	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).

INFORMATION

For products that are supplied with software (CD in the scope of delivery), access to the manuals is protected by a password. Protected manuals are only displayed on the website after entering the password.

The password is included on the CD of the product.

For products with CD: Identify the password

1. Insert the product CD into the PC drive.
2. Switch to the Manuals directory on the CD.
3. In the Manuals directory, open the Release News (file including *releasenews* in the file name).
4. Find the user name and the password in the section "User login for software download" in the Release News.

Downloading manuals

1. Open the website <http://www.pi.ws>.
2. Click *Info*.
3. If you have a user name and password:
 - a) Click *Login*.
 - b) Log in with the user name and password.
4. Click >> *Product Downloads*.
5. In the *Product Files* area, click the corresponding product category.
6. On the right-hand side of the page, select the corresponding subcategory.
7. Navigate to the product code on the page.

The following manuals are displayed:

 - Freely accessible manuals
 - Manuals that are protected by a password
8. Click the desired manual and save it to the hard disk of your PC or to a data storage medium.

2 Safety

In this Chapter

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General Safety Instructions.....	5
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2.1 Intended Use

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

Based on its design and realization, the P-545 is intended for fine positioning as well as the fast and precise motion of small objects. The specifications of the P-545 apply to horizontal mounting. Depending on the version, the motion is performed as follows:

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

The intended use of the P-545 stage is only possible 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 can result in personal injury and/or damage to the P-545.

- Only use the P-545 for its intended purpose, and only use it if it is in a good working order.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the P-545.

The P-545 is driven by piezo actuators. Temperature changes and compressive stresses can induce charges in piezo actuators. After being disconnected from the electronics, piezo actuators can also stay charged for several hours. Touching or short-circuiting the contacts in the connector of the P-545 can lead to minor injuries. In addition, the piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the P-545.
- Discharge the piezo actuators of the stage before installation:
Connect the stage to the switched-off PI controller, which is equipped with an internal discharge resistor.
- Do **not** pull the connector out of the electronics during operation.
- Do **not** touch the contacts in the connector.
- Secure the connector of the stage with screws against being pulled out of the controller.

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

- Connect the P-545 to a protective earth conductor (p. 18) before start-up.
- 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 starting it up again.

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. 39).
- Only hold the P-545 externally by the base body.

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 available with the P-545. The latest versions of the user manuals are available for download (p. 3) on our website.
- Add all information from the manufacturer to the user manual, for example supplements or technical notes.
- If you give the P-545 to other users, also include this user manual as well as other relevant information provided by the manufacturer.
- Only use the device on the basis of the complete user manual. Missing information due to an incomplete user manual can result in minor injury and damage to equipment.
- Only install and operate the P-545 after you have read and understood this user manual.

Personnel qualification

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

3 Product Description

In this Chapter

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Product Labeling.....	10
Scope of Delivery	12
Accessories.....	12
Technical Features	13
Integration of the P-545 into Microscopes.....	14

3.1 Model Overview

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

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

Controller model contained in the system:

System	Controller
P-545.2C8S	E-727.3CDA
P-545.3C8S	Digital multi-channel piezo controller, 3 channels, -30 to 130 V, Sub-D 25W3 socket, capacitive sensors, analog inputs
P-545.2R8S	E-727.3RDA
P-545.3R8S	Digital multi-channel piezo controller, 3 channels, -30 to 130 V, Sub-D 37 socket, piezoresistive sensors, analog inputs
P-545.3D8S	

3.2 Product View

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

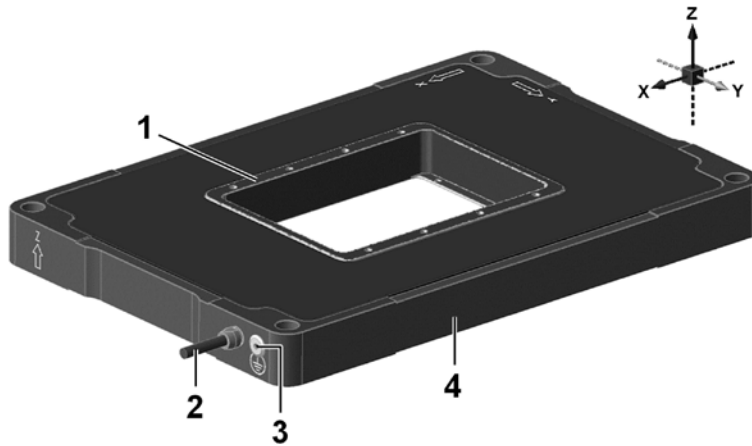


Figure 1: Example of product view

- 1 Motion platform
- 2 Cable exit
- 3 Protective earth connection
- 4 Base body
- X, Y, Z Positive direction of motion of the stage

3.3 Product Labeling

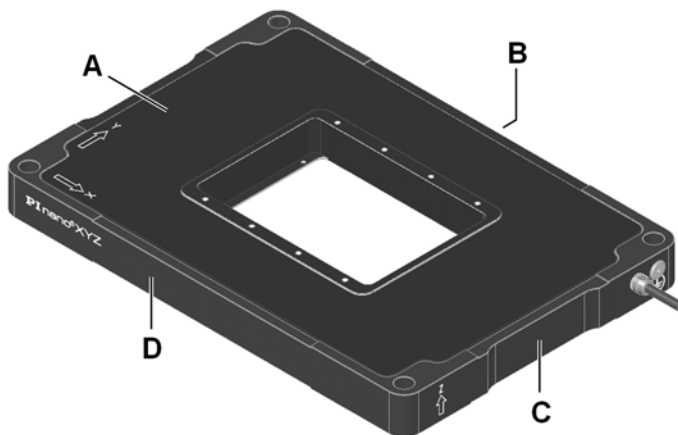


Figure 2: P-545: Position of the product labeling (example view)

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 following the period refer to the stage model
B	SN: A16045786	Serial number (example), individual for each P-545 Meaning of the places (counting from left): 1 = internal information 2 and 3 = year of manufacture 4 to 9 = consecutive numbers
B	Made in USA	Country of origin
B		Warning sign "Observe manual!"
B		Old equipment disposal (p. 51)
B		CE conformity mark
C	Arrow and letter Z (Only .3x8x models)	Positive direction of motion of the Z axis
C		Symbol for the protective earth conductor, marks the protective earth connection of the P-545 (p. 18)
D	Plnano®	Brand name, supplemented by "XY" (.2x8x models) or "XYZ" (.3x8x models)



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

3.4 Scope of Delivery

Order number	Components
P-545	System consisting of stage and controller according to order (p. 9), including accessories of the controller (see user manual of the controller)
000036450	M4 screw set for protective earth, consisting of: <ul style="list-style-type: none"> ▪ 1 flat-head screw with cross recess, M4x8 ISO 7045 ▪ 2 safety washers ▪ 2 flat washers
000041912	Screw set for mounting the stage: <ul style="list-style-type: none"> ▪ 4 hex socket cap screws, M4x16 ISO 4762 ▪ 1 hex key
PZ240EK	Short instructions for piezo positioning systems

3.5 Accessories

XY stages for integration of the P-545 in microscopes

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

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

Order number	Description
P-545.PD3	Petri dish holder, 35 mm, suitable for PInano® piezo stages
P-545.SH3	Microscope slide holder, suitable for PInano® piezo stages
P-545.C18	Coverslip holder with opening for 18 mm × 18 mm coverslips, suitable for P-545.PD3 and P-545.SH3
P-545.C22	Coverslip holder with opening for 22 mm × 22 mm coverslips, suitable for P-545.PD3 and P-545.SH3
P-545.PP3	Universal holding plate for accessories, suitable for PInano® piezo stages

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

3.6 Technical Features

3.6.1 PICMA® Piezo Actuators

P-545 stages are driven by PICMA® piezo actuators. PICMA® actuators have all-ceramic insulation and are therefore far superior to conventional actuators in respect to performance and lifetime. The monolithic piezoceramic block is protected against humidity and failure due to increased leakage current by a ceramic insulation layer. 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 backlash-, maintenance- and wear-free.

3.6.2 Flexure Guides

P-545 stages have flexure guides (flexures) for frictionless motion and high guiding accuracy.

A flexure guide is an element which is free from 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 motion 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 stage. This type of position measurement is done with contact and indirectly, since 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 stages can be easily integrated into microscopes. For this purpose, a P-545 is mounted onto an M-545 XY stage. For further information see "Accessories" (p. 12) and "Mounting the P-545 onto an M-545 XY Stage" (p. 22).

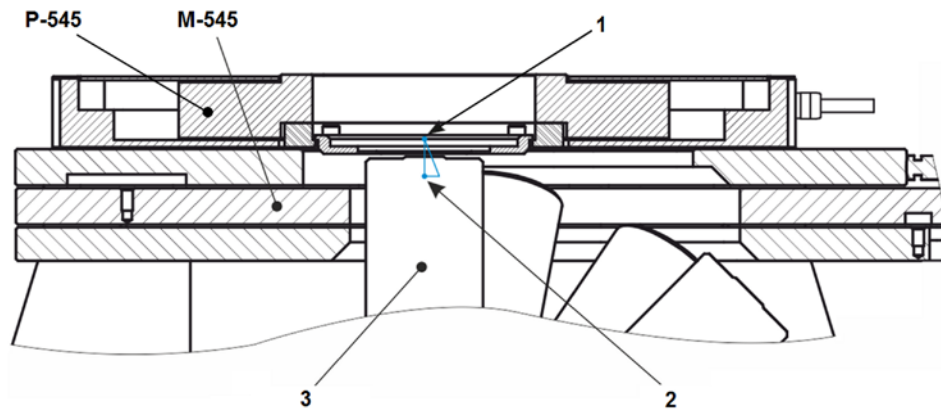


Figure 4: P-545 stage and M-545 XY stage in a microscope (section)

- 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.

- Only hold the P-545 externally by the base body.

1. Unpack the P-545 with care.
2. Compare the contents with the items listed in the contract and the packing list.
3. Inspect the contents for signs of damage. If parts are missing or you notice signs of damage, contact PI immediately.
4. Keep all packaging materials in case the product needs to be returned.

5 Installation

In this Chapter

General Notes on Installation	17
Connecting the P-545 to the Protective Earth Conductor	18
Mounting the P-545	20
Affixing the Load	23

5.1 General Notes on Installation

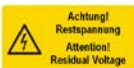
CAUTION



Dangerous voltage and residual charge on piezo actuators!

The P-545 is driven by piezo actuators. Temperature changes and compressive stresses can induce charges in piezo actuators. After being disconnected from the electronics, piezo actuators can also stay charged for several hours. Touching or short-circuiting the contacts in the connector of the P-545 can lead to minor injuries. In addition, the piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the P-545.
- Discharge the piezo actuators of the stage before installation:
Connect the stage to the switched-off PI controller, which is equipped with an internal discharge resistor.
- Do **not** pull the connector out of the electronics during operation.



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

- Do **not** touch the contacts in the connector.
- Secure the connector of the stage with screws against being pulled out of the controller.

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.

- Only hold the P-545 externally by the base body.

NOTICE**Damage due to unsuitable cables!**

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

- Only use cables provided by PI for connecting 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 mount the P-545 and the loads on the mounting fixtures (holes) intended for this purpose.

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

Incorrectly tightened screws can cause damage.

- Observe the torque range (p. 46) given for the screws used during installation.

INFORMATION

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

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

5.2 Connecting the P-545 to the Protective Earth Conductor


INFORMATION

In the case of P-545 stages with Sub-D connectors, ground loops can occur when the stage is grounded via its protective earth connector as well as by the shield of the connection cable for the electronics.

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

INFORMATION

- Observe the applicable standards for connecting the protective earth conductor.

The P-545 has an M4 hole for mounting the protective earth conductor. This hole is located next to the cable exit and is marked with the  protective earth symbol (see "Dimensions", p. 43).

Requirements

- ✓ You have read and understood the general notes on installation (p. 17).
- ✓ The stage is **not** connected to the electronics.

Tools and accessories

- Suitable protective earth conductor: Cross-sectional area of the cable $\geq 0.75 \text{ mm}^2$
- Supplied M4 protective earth screw set (p. 12) for connecting the protective earth conductor
- Suitable screwdriver

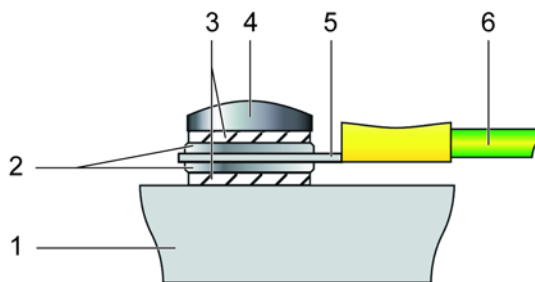


Figure 5: Connecting the protective earth conductor (profile view)

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

Connecting the P-545 to the protective earth conductor

1. If necessary, attach a suitable cable lug to the protective earth conductor.
2. Affix the cable lug of the protective earth conductor using the M4 screw on the protective earth connection of 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.
4. Make sure that the contact resistance at all connection points relevant for mounting the protective earth conductor is $< 0.1 \Omega$ at 25 A.

5.3 Mounting the P-545

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

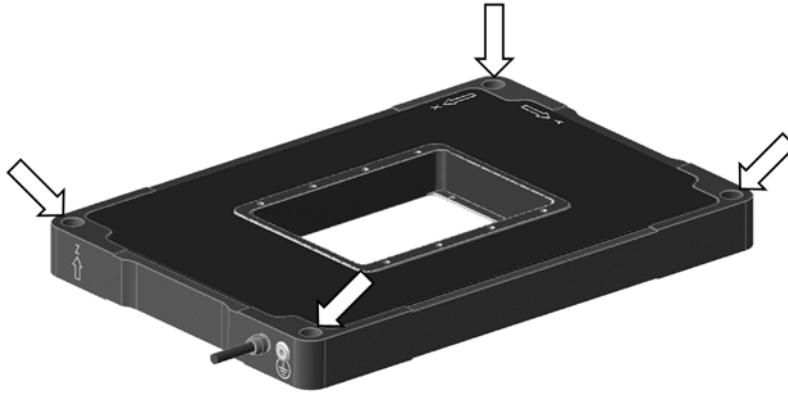


Figure 6: P-545: Mounting holes in the base body

5.3.1 Mounting the P-545 onto a Surface

NOTICE



Warping of the P-545 due to mounting on uneven surfaces!

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

- Mount the P-545 onto an even surface. The recommended evenness of the surface is $\leq 100 \mu\text{m}$.
- For applications with large temperature changes:
Only mount 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 on piezo actuator with vertical mounting!

When the stage is mounted vertically, certain alignments can cause tensile stress, which would destroy the piezo actuator.

- 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).

Tools and accessories

- Mounting accessories in the scope of delivery (p. 12):
 - Four M4x16 screws
 - Hex key
- Alternative (not in the scope of delivery):
 - Four M4 screws of suitable length (p. 43)
 - Suitable screwdriver

Mounting the P-545 onto a surface

1. Position the stage on an even surface.
2. Mount the stage to the mounting holes (p. 20) with the screws:
 - Observe the given torque range (p. 46).
 - Make sure that the screw heads do not protrude from the countersunk holes.

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



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

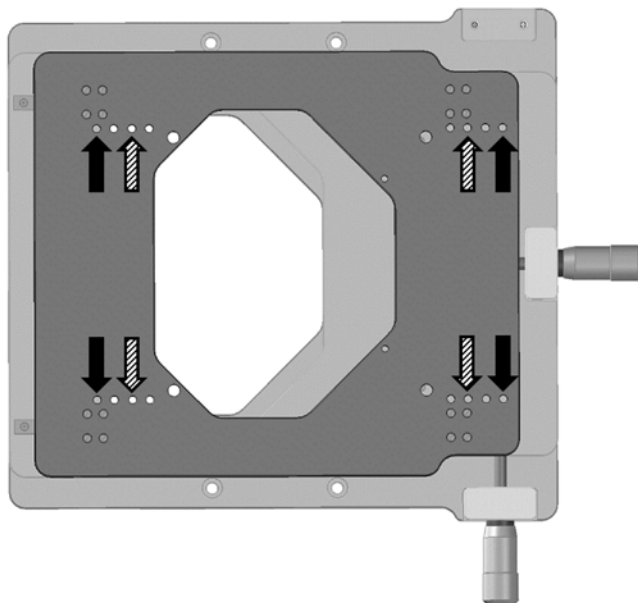


Figure 8: M-545: M4 mounting holes in the base body (example view)
 Black arrows: Holes for mounting a P-545.3C8S, .3R8S or .3D8S
 Hatched arrows: Holes for mounting a P-545.2C8S or .2R8S

Requirements

- ✓ You have read and understood the general notes on installation (p. 17).

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. Position the P-545 on the M-545 so that the following conditions are met:
 - The mounting holes in the base body of the P-545 (p. 20) and in the motion platform of the M-545 (depending on the model; see arrows in the figure) overlap.
 - The cable exit points in the desired direction.
2. Introduce the four M4 screws into the mounting holes in the base body of the P-545 (p. 20).
3. Tighten the screws:
 - Observe the given torque range (p. 46).
 - Make sure that the screw heads do not protrude from the countersunk holes.

5.4 Affixing the Load

NOTICE



Mechanical overload due to high torques and high loads!

When affixing the load, high torques and high 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 in accuracy.

- Observe the torque range (p. 46) given for the screws used during installation.
- Avoid torques $>0.5\text{Nm}$ on the motion platform.
- Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 39).

NOTICE



Warping of the P-545 due to affixing of loads with uneven contact surface!

Affixing loads with an uneven contact surface can warp the P-545. Warping reduces the accuracy.

- Only affix loads on the P-545 whose contact surface with the motion platform of the stage has an evenness of at least $100\ \mu\text{m}$.
- For applications with large temperature changes:
Only affix loads on the P-545 that 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 loads and unwanted lever effect), the P-545 can be damaged by high strain on the flexure guides, high torques, and oscillation, especially when operated dynamically.

- If the center of the load to be affixed is too far above or to the side of the motion platform, adjust the controller settings before start-up or contact our customer service department (p. 37).

NOTICE**Screws that are too long!**

The P-545 can be damaged by screws that are too long.

- Note the depth of the mounting holes in the motion platform (p. 43).
- Only use screws of the correct length for the respective mounting holes.

INFORMATION

The positive direction of motion of the axes is given 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)

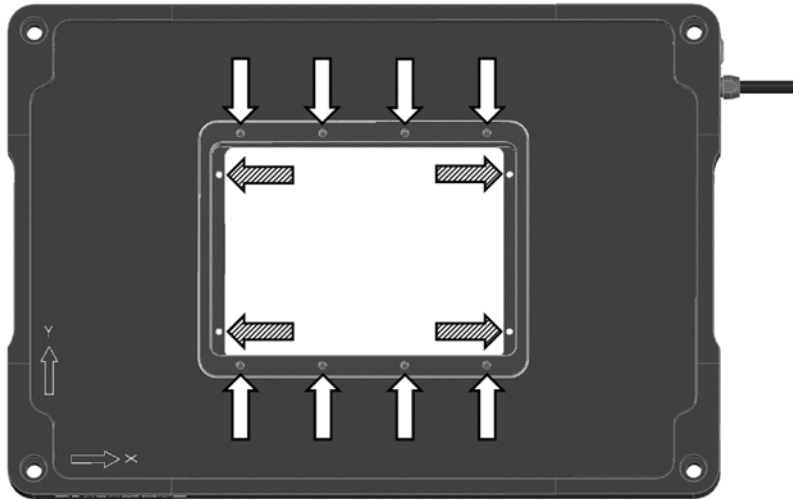


Figure 9: P-545: Mounting holes in the motion platform
 White arrows:
 Eight M2.5 holes in the upper mounting surface of the motion platform
 Hatched arrows:
 Four M2 holes in the lower mounting surface of the motion platform

5.4.1 Affixing a Load to the Motion Platform

Center of load at the optimum position:

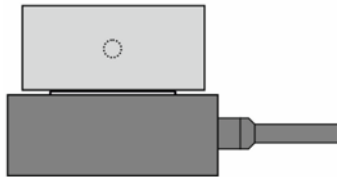


Figure 10: Example of an optimally placed load

Center of load at an unsuitable position:

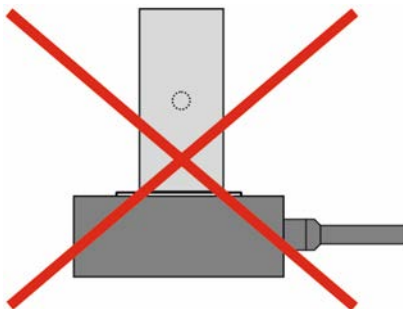


Figure 11: Tall load and center of load too far above the motion platform

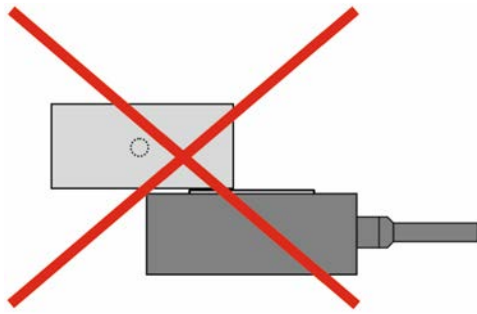


Figure 12: Unwanted lever effect and center of load on the side of the motion platform

Requirements

- ✓ You have read and understood the general notes on installation (p. 17).

Tools and accessories

- Screws of appropriate size and length (p. 43)
- Suitable tools

Affixing the Load

- Only affix loads to the threaded holes (p. 43) intended for this purpose and with suitable screws. While doing so, observe the torque range (p. 46) specified for the screws, and avoid torques $>0.5\text{Nm}$ on the motion platform.
- Affix the load so that it is centered and that the center of load is 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).

Tools and accessories

- P-545.PD3, P-545.SH3 or P-545.PP3 holder (p. 12)
- Four M2 screws of a suitable length (p. 43)
- Suitable screwdriver

Mounting a holder

1. Align the holder so that the holding clamps (P-545.PD3 and P-545.SH3) are pointing upwards or the larger surface of the base body (P-545.PP3) is pointing upwards. See "Dimensions" (p. 43).
2. Place 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 overlap.
3. Mount the holder with the M2 screws to the provided threaded holes (p. 43). Observe the specified torque range (p. 46) while doing so.

6 Start-Up and Operation

In this Chapter

General Notes on Start-Up and Operation	29
Operating the P-545.....	31
Discharging the P-545	31

6.1 General Notes on Start-Up and Operation

CAUTION



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

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

- Connect the P-545 to a protective earth conductor (p. 18) before start-up.
- 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 starting it up again.

NOTICE



Destruction of the piezo actuator due to electric flashovers!

Using the P-545 in environments that increase the electrical conductivity can lead to the destruction of the piezo actuator 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.
- Only operate the P-545 within the permissible ambient conditions and classifications (p. 42).

NOTICE**Reduced lifetime of the piezo actuator due to permanently high voltage!**

The permanent application of a high static voltage to piezo actuators leads to a considerable reduction in the lifetime of the piezo ceramic of the P-545.

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

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

Operating voltages that are too high or incorrectly connected can cause damage to the P-545.

- Only operate the P-545 with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 42) for which the P-545 is specified.
- Only operate the P-545 when the operating voltage is properly connected; see "Pin Assignment" (p. 47).

NOTICE**Uncontrolled oscillation!**

Oscillation can cause irreparable damage to the stage. Oscillation is indicated by a humming and can be caused by the following:

- A change in the load and/or dynamics requires the servo-control parameters to be adjusted.
- The stage is operated near to its resonant frequency.

If you notice oscillation:

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

INFORMATION

The positive direction of motion of the axes is given in the product view (p. 10).

INFORMATION

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

- Avoid sound and vibration during operation of the P-545.

6.2 Operating the P-545

- For start-up and operation of the P-545, follow the instructions in the manual of the controller used.

6.3 Discharging the P-545

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

- Before installation
- If the P-545 is not used but the controller remains 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 internal discharge resistor of the controller from PI.

Discharging a P-545 that is connected to the controller

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 controller.

Discharging a P-545 that is not connected to the controller

- Connect the stage to the switched-off controller 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

Requirements

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

Cleaning the P-545

- Clean the surfaces of the P-545 with a cloth that is slightly dampened with a mild cleanser or disinfectant (e.g., ethanol or isopropanol).
- Do **not** use ultrasonic cleaners.

8 Troubleshooting

Problem	Possible causes	Solution
No or limited motion	Cable not connected correctly	➤ Check the cable connections.
	Excessive load	➤ Do not exceed the maximum permissible stress and load capacities according to the specifications (p. 39).
	Zero-point adjustment of the sensor for the following reasons: <ul style="list-style-type: none"> ▪ Load applied in direction of motion ▪ Ambient / operating temperature of the stage far above or below calibration temperature (21 °C to 24 °C) 	➤ Perform a zero-point adjustment of the sensor (see "AutoZero Procedure" in the controller manual).
Reduced accuracy	Warping of the base body or the motion platform	<ul style="list-style-type: none"> ➤ Only mount the P-545 on surfaces with the following characteristics: <ul style="list-style-type: none"> – Evenness of at least 100 µm – The thermal expansion properties are similar to those of the P-545 (e.g., surfaces made of aluminum). ➤ Only affix loads with the following characteristics on the P-545: <ul style="list-style-type: none"> – The contact surface of the load has an evenness of at least 100 µm. – The thermal expansion properties are similar to those of the P-545 (e.g., loads made of aluminum).

Problem	Possible causes	Solution
The stage starts oscillating or positions inaccurately	Servo-control parameters incorrectly set because e. g. the load was changed	<ol style="list-style-type: none"> 1. Immediately switch off the servo mode of the corresponding stage axes. 2. Check the settings of the servo-control parameters on the controller. 3. Adjust the servo-control parameters on the controller according to the load change.
	Open-loop operation near the resonant frequency	➤ In open-loop operation, only operate the stage 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

For inquiries and orders, contact your PI sales engineer or send us an email (info@pi.ws).

- If you have questions concerning your system, have the following information ready:
 - Product codes and serial numbers of all products in the system
 - Firmware version of the controller (if present)
 - Version of the driver or the software (if present)
 - Operating system on the PC (if present)
- 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 (p. 3) on our website.

10 Technical Data

In this Chapter

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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		
Motion and positioning				
Integrated sensor	Capacitive	Capacitive		
Closed-loop travel	200 × 200	200 × 200 × 200	µm	
Closed-loop resolution*	<1	<1	nm	typ.
Mechanical properties				
Push / pull force capacity	50 / 30	50 / 30	N	max.
Recommended load**	0.5	0.5	kg	max.
Drive properties				
Piezo ceramic	PICMA® P-885	PICMA® P-885		
Electrical capacitance	6 (X, Y)	6 (X, Y), 12 (Z)	µF	±20 %
Miscellaneous				
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
Piezo controller	E-727.3CDA (included in scope of delivery)			
Communication interfaces	Ethernet, USB, RS-232, serial SPI high-speed interface			
Analog input / Analog output	Sub-D (15-pin) 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	LabVIEW drivers, shared libraries for Windows and Linux		
Supported functions	Wave generator, data recorder, drift compensation, macros		

* With flexure guides, the system resolution is not limited by friction or stiction. Values as noise equivalent motion measured with interferometer.

** 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		
Motion and positioning				
Integrated sensor	Piezoresistive	Piezoresistive		
Closed-loop travel	200 × 200	200 × 200 × 200	µm	
Closed-loop resolution*	1	1	nm	typ.
Mechanical properties				
Push / pull force capacity	50 / 30	50 / 30	N	max.
Recommended load**	0.5	0.5	kg	max.
Drive properties				
Piezo ceramic	PICMA® P-885	PICMA® P-885		
Electrical capacitance	6 (X, Y)	6 (X, Y), 12 (Z)	µF	±20 %
Miscellaneous				
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
Piezo controller	E-727.3RDA (included in scope of delivery)			
Communication interfaces	Ethernet, USB, RS-232, serial SPI high-speed interface			
Analog input / Analog output	Sub-D (15-pin) 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	LabVIEW drivers, shared libraries for Windows and Linux			
Supported functions	Wave generator, data recorder, drift compensation, macros			

* With flexure guides, the system resolution is not limited by friction or stiction. Values as noise equivalent motion measured with interferometer.

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




	P-545.3D8S	Unit	Tolerance
Active axes	X, Y, Z		
Motion and positioning			
Integrated sensor	Piezoresistive		
Closed-loop travel	70 × 70 × 50	µm	
Closed-loop resolution*	<1	nm	typ.
Mechanical properties			
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.
Drive properties			
Piezo ceramic	PICMA®		
Electrical capacitance	12 (X, Y), 24 (Z)	µF	±20 %
Miscellaneous			
Operating temperature range	15 to 40	°C	
Material	Aluminum		
Mass	1.2	kg	±5 %
Cable length	1.7	m	+10 cm
Piezo controller			
Communication interfaces	E-727.3RDA (included in scope of delivery) Ethernet, USB, RS-232, serial SPI high-speed interface		
Analog input / Analog output	Sub-D (15-pin) 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	LabVIEW drivers, shared libraries for Windows and Linux		
Supported functions	Wave generator, data recorder, drift compensation, macros		

* With flexure guides, the system resolution is not limited by friction or stiction. Values as noise equivalent motion measured with interferometer.

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

10.1.2 Maximum Ratings

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

Stage	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

The following ambient conditions and classifications for the P-545 must be observed:

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 Stage

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

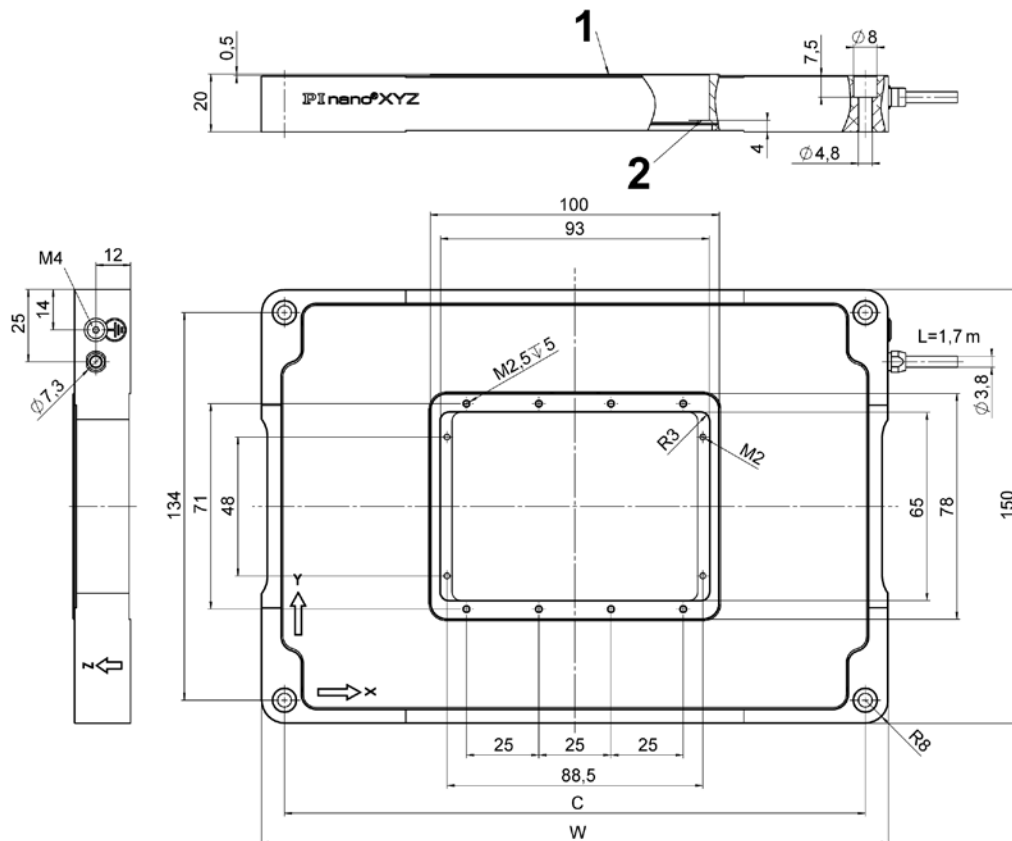


Figure 13: P-545

- 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.SH3 Microscope Slide Holder

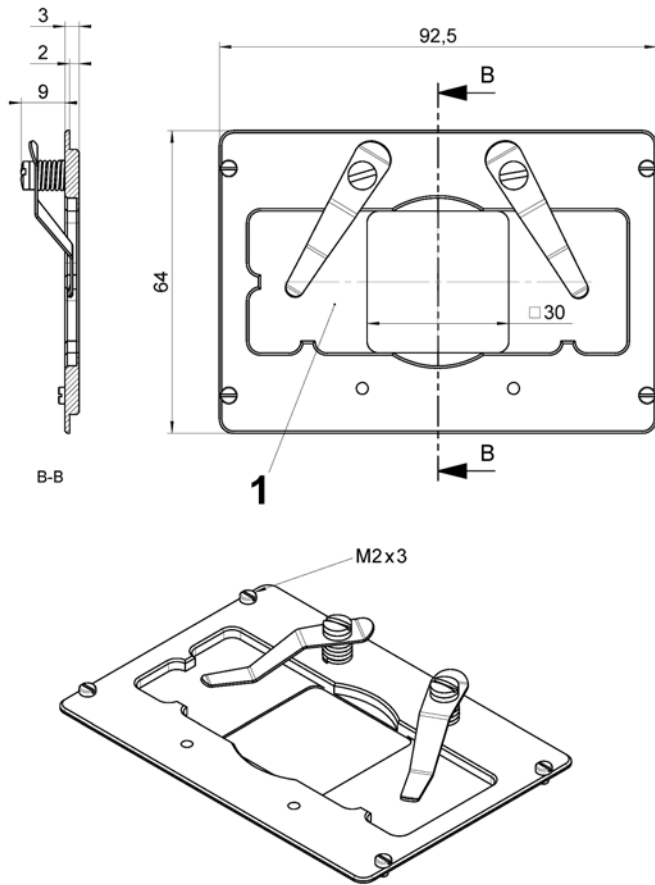


Figure 14: P-545.SH3: Microscope slide holder, suitable for PI nano® piezo stages
 1: Recess for standard microscope slides (25 mm × 75 mm)

10.2.3 P-545.PD3 Petri Dish Holder

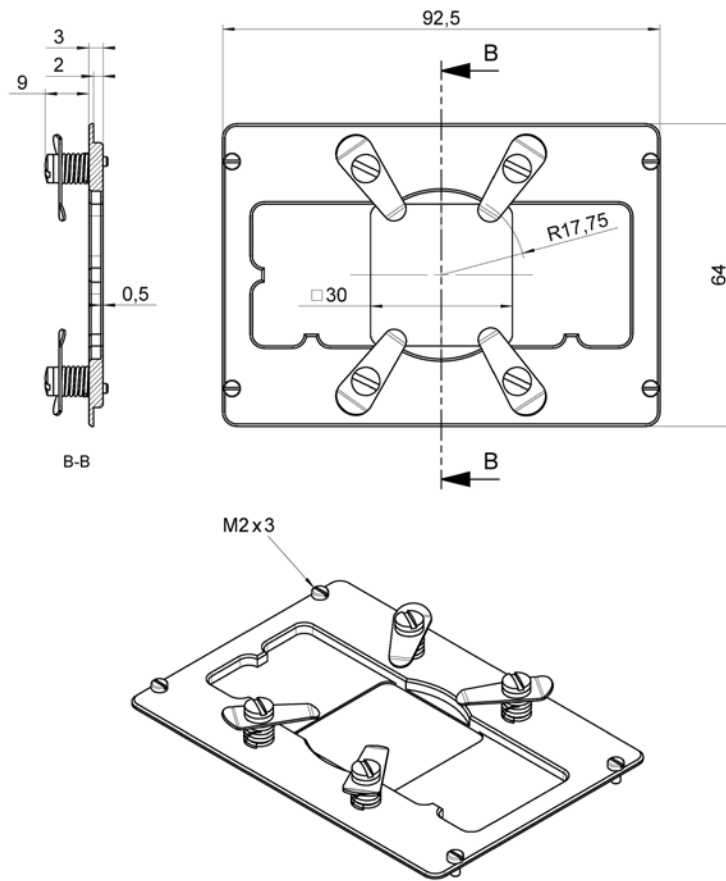


Figure 15: P-545.PD3: Petri dish holder, suitable for Plnano® piezo stages

10.2.4 P-545.PP3 Universal Holding Plate

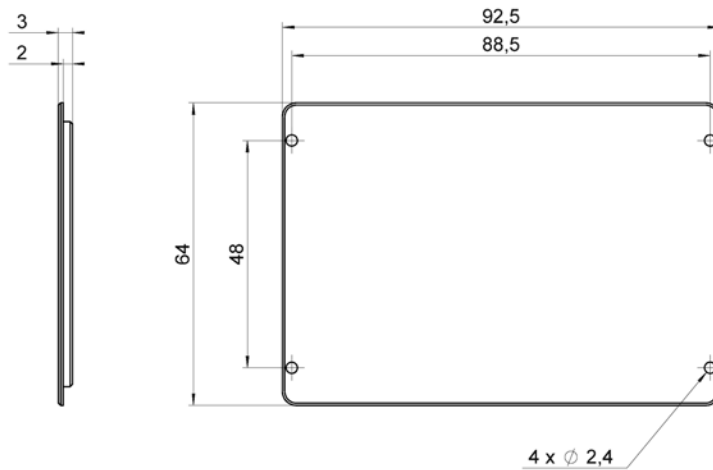


Figure 16: P-545.PP3: Universal holding plate for accessories, suitable for PI nano® piezo stages

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

10.4 Pin Assignment

Sub-D 25W3 connector (m)

Only for P-545.2C8S/.3C8S:

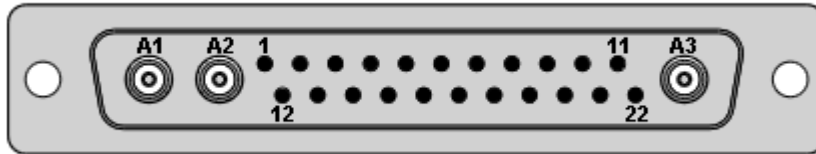


Figure 17: Sub-D 25W3 connector (m): Front side with connections

Pin	Signal	Function
A1 inner conductor	Output	Probe sensor signal, channel 2 (nonmoving part of the capacitive sensor)
A1 outer conductor	GND	Shield of Probe sensor signal, channel 2
A2 inner conductor	Output	Probe sensor signal, channel 3 (nonmoving part of the capacitive sensor)
A2 outer conductor	GND	Shield of Probe sensor signal, channel 3
A3 inner conductor	Output	Probe sensor signal, channel 1 (nonmoving part of the capacitive sensor)
A3 outer conductor	GND	Shield of 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	Ground of ID chip
4	Bidirectional	Data line for ID chip
5	Free	–
6	Free	–
7	Free	–
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	Shield of Target sensor signal, channel 2
13	GND	Shield of Target sensor signal, channel 3

Pin	Signal	Function
14	Free	–
15	Free	–
16	Free	–
17	Free	–
18	Free	–
19	Input	Piezo voltage –, channel 3
20	Input	Piezo voltage –, channel 2
21	Input	Piezo voltage –, channel 1
22	GND	Shield of Target sensor signal, channel 1

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

Stage	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

Sub-D 37 connector (m)

Only for P-545.2R8S/.3R8S/.3D8S:

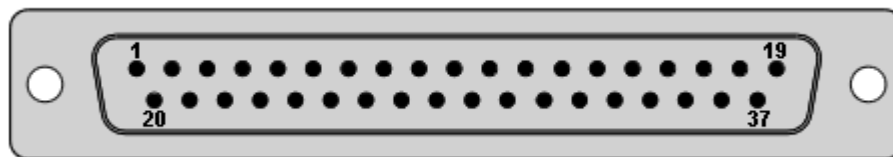


Figure 18: Sub-D 37 connector (m): Front side with connections

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	–

Stage-dependent assignment of the Sub-D 37 connector (m) (X = used):

Stage	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, 31	Channel 2 Pins 10, 28, 29	Channel 3 Pins 8, 26, 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.

In order to fulfil its 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 Roemerstr. 1
D-76228 Karlsruhe, Germany



12 EC Declaration of Conformity

For the P-545, an EC Declaration of Conformity has been issued in accordance with the following European directives:

Low Voltage Directive

EMC Directive

RoHS Directive

The applied standards certifying the conformity are listed below.

Safety (Low Voltage Directive): EN 61010-1

EMC: EN 61326-1

RoHS: EN 50581

