PZ244E

P-54x Nanopositioners

User Manual

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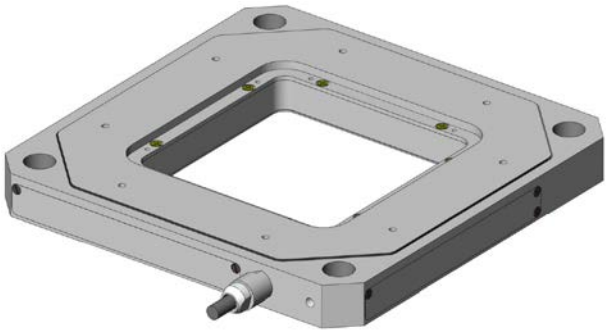

This document describes the following products:

- **P-541**
  XY nanopositioning system with large clear aperture

  P-541.20L, 100 µm × 100 µm, without sensors
  P-541.2CD/.2CL, 100 µm × 100 µm, capacitive sensors
  P-541.2SL, 100 µm × 100 µm, strain gauge sensors
  P-541.2DD, 45 µm × 45 µm, direct drive, capacitive sensors

- **P-542**
  XY nanopositioning system with large clear aperture

  P-542.20L, 200 µm × 200 µm, without sensors
  P-542.2CD/.2CL, 200 µm × 200 µm, capacitive sensors
  P-542.2SL, 200 µm × 200 µm, strain gauge sensors

  .2CD/.2DD with Sub-D connector
  .20L/.2CL/.2SL with LEMO connector

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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 This manual is superseded by any new release.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 on our website (http://www.pi.ws).

Contents

1 About this Document

In this Chapter

1.1 Goal and Target Audience of this User Manual

This user manual contains the necessary information for the intended use of the P-54x (x stands for the different models (p. 10)).

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. 4) 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 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. 4) on our website.

Product	Document
E-610.00 Piezo Amplifier, 1 Channel, OEM Module	PZ70E
E-500 Modular Piezo Controller	PZ62E
E-509.C2A Control Module for Capacitive Sensors E-509.S3 Control Module for Strain Gauge Sensors	PZ77E
E-503 3-Channel Amplifier	PZ62E
E-505 Single-Channel High-Performance Amplifier	PZ62E
E-517 Interface and Display Module	PZ214E
E-712 Digital Piezo Controller	PZ195E
E-725 Digital Piezo Controller	PZ197E
E-761 Digital Piezo Controller	PZ164E
PIMikroMove	SM148E Software Manual
NanoCapture	SM71E Software Manual
P-5xx / P-6xx / P-7xx Piezo Positioning Systems	PZ240EK Short Instructions

1.4 Downloading Manuals

INFORMATION

If a manual is missing on our website or if there are problems in downloading:

➢ Contact our customer service department (p. 35).

The current versions of the manuals are found on our website. To download a manual, proceed as follows:

1. Open the website **http://www.pi-portal.ws**.
2. Click ***Downloads***.
3. Click the corresponding category (e. g. ***P Piezo Actuators, Nanopositioning & Scanning Systems***).
4. Click the corresponding product code (e. g. ***P-541***).

   An overview of the available file types is shown for the selected product.
5. If ***(0 Files)*** is shown in the ***Documents*** line, log in as follows to display and download the documents:

   a) Insert the product CD in the corresponding PC drive.
   b) Open the ***Manuals*** directory.
   c) Open the Release News (e. g. ***X-xxx_Releasenews_V_x_x_x.pdf***) on the CD of the product.
   d) Find the user name and password in the **User login for software download** section in the Release News.
   e) In the ***User login*** area on the left margin in the website, enter the user name and the password in the corresponding fields.
   f) Click ***Login***.

   If ***Documents (0 Files)*** is still being displayed, no manuals are available:

   – Contact our customer service department (p. 35).
6. Click ***Documents***.
7. Click the desired manual and save it on the hard disk of your PC or on a data storage medium.

2 Safety

In this Chapter

2.1 Intended Use

The P-54x is a laboratory device as defined by DIN EN 61010-1. It is intended to be used in interior spaces and in an environment which is free of dirt, oil, and lubricants.

Based on its design and realization, the P-54x is intended for fine positioning as well as the fast and precise movement of small objects. The specifications of the P-54x apply to horizontal mounting. The motion takes place horizontally in two axes.

The intended use of the P-54x is only possible in combination with suitable drive and control electronics (p. 12) available from PI. The electronics is not included in the scope of delivery of the P-54x.

The electronics must provide the required operating voltages. To ensure proper performance of the servo-control system, the electronics must also be able to read out and process the signals from the position sensors.

2.2 General Safety Instructions

The P-54x 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-54x.

- Only use the P-54x 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-54x.

The P-54x 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-54x can lead to minor injuries. In addition, the piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the P-54x.
- 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 out the connector from the electronics during operation.

For stages with Sub-D connector:

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.

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the P-54x in the case of malfunction of failure of the system. If touch voltages exist, touching the P-54x can result in minor injuries due to electric shock.

- Connect the P-54x to a protective earth conductor before start-up (p. 19).
- 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-54x to the protective earth conductor before starting it up again.

Mechanical forces can damage or misalign the P-54x.

- Avoid impacts that affect the P-54x.
- Do **not** drop the P-54x.
- Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 37).
- Only hold the P-54x externally by the base body.

The P-54x is maintenance-free and achieves its positioning accuracy as a result of the optimum alignment of mechanical components and piezo actuators. Loosened screws cause a loss in positioning accuracy.

- Only loosen screws according to the instructions in this manual.
- Do not open the P-54x.

2.3 Organizational Measures

User manual

- Always keep this user manual available by the P-54x.
  The latest versions of the user manuals are available for download (p. 4) on our website.
- Add all information given by the manufacturer to the user manual, for example supplements or Technical Notes.
- If you pass the P-54x on to other users, also turn over 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 property damage.
- Only install and operate the P-54x after having read and understood this user manual.

Personnel qualification

The P-54x may only be started up, operated, maintained and cleaned by authorized and qualified staff.

3 Product Description

In this Chapter

3.1 Features and Applications

P-54x stages are piezo-actuator-driven precision positioning systems with up to two motion axes.

Piezo actuators expand when an electric voltage is applied. The motion of the piezo actuators and levers is used by the P-54x to achieve travel ranges of up to 200 µm per axis with resolutions in the nanometer range.

In order to achieve the specifications stated in the data table (p. 37), the stage is calibrated at the factory as a system component with suitable electronics. The electronics and mechanical system only offer optimum performance as a complete calibrated system.

The electronics must be ordered separately. For suitable electronics, see "Recommended Piezo Controllers" (p. 12).

The P-54x is also available on request as a customized version for vacuum operation.

3.2 Model Overview

The following standard versions of the P-54x are available:

Model	Description
P-541.20L	XY Nanopositioning System with Large Aperture, 100 µm × 100 µm, Open-Loop
P-541.2CD	XY Nanopositioning System with Large Aperture, 100 µm × 100 µm, Parallel Kinematics, Capacitive Sensors
P-541.2CL	XY Nanopositioning System with Large Aperture, 100 µm × 100 µm, Parallel Kinematics, Capacitive Sensors, LEMO Connectors
P-541.2SL	XY Nanopositioning System with Large Aperture, 100 µm × 100 µm, Strain Gauge Sensors
P-541.2DD	XY Nanopositioning System with Large Aperture, High-Speed Direct Drive, 45 µm × 45 µm, Parallel Kinematics, Capacitive Sensors
P-542.20L	XY Nanopositioning System with Large Aperture, 200 µm × 200 µm, Open-Loop
P-542.2CD	XY Nanopositioning System with Large Aperture, 200 µm × 200 µm, Parallel Kinematics, Capacitive Sensors
P-542.2CL	XY Nanopositioning System with Large Aperture, 200 µm × 200 µm, Parallel Kinematics, Capacitive Sensors, LEMO Connectors
P-542.2SL	XY Nanopositioning System with Large Aperture, 200 µm × 200 µm, Strain Gauge Sensors

3.3 Product View

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

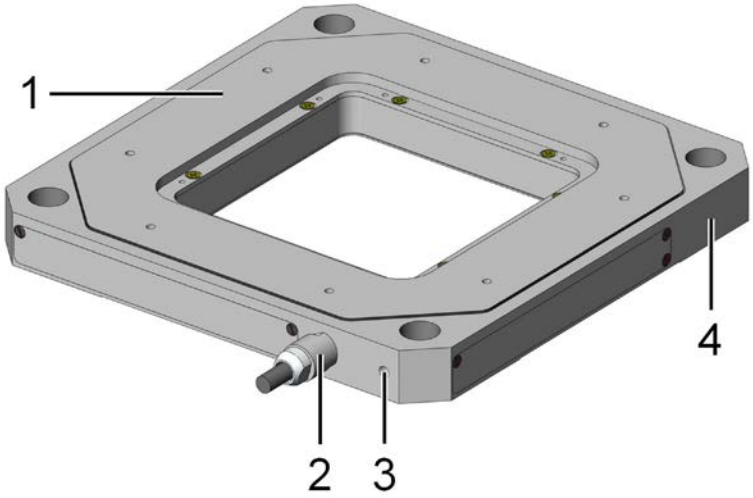

Figure 1: Example of product view

1 Moving platform
2 Cable outlet
3 Protective earth connection
4 Base body

3.4 Scope of Delivery

Order Number	Items
P-54x	Stage according to order (p. 10)
000036450	M4 screw set for protective earth, consisting of: ▪ 1 M4x8 flat-head screw with cross recess, ISO 7045 ▪ 2 safety washers ▪ 2 flat washers
PZ240EK	Short instructions for piezo positioning systems

3.5 Recommended Piezo Controllers

To operate a P-54x, you need a piezo controller. The device is selected depending on the type of application. The table below lists suitable controllers.

Controller	Channels	P-541.20L P-542.20L	P-541.2SL P-542.2SL	P-541.2CL P-542.2CL	P-541.2DD	P-541.2CD P-542.2CD
2 × E-610.00 piezo amplifier, 1 channel, OEM module, -30 to 130 V	2	X	–	–	–	
E-500 modular piezo controller with E-503 3-channel amplifier	2	X	–	–	–	
E-500 modular piezo controller with 2× E-505 1-channel high-performance amplifier	2	X	–	–	–	
E-500 modular piezo controller with E-509.S3 control module for strain gauge sensors and E-503 3-channel amplifier Optional: E-517 interface and display module	2	–	X	–	–	
E-500 modular piezo controller with E-509.S3 control module for strain gauge sensors and 2× E-505 1-channel high-performance amplifier Optional: E-517 interface and display module	2	–	X	–	–	
E-500 modular piezo controller with E-509.C2A control module for capacitive sensors and E-503 3-channel amplifier Optional: E-517 interface and display module	2	–	–	X	–	
E-500 modular piezo controller with E-509.C2A control module for capacitive sensors and 2× E-505 1-channel high-performance amplifier Optional: E-517 interface and display module	2	–	–	X	–	
E-712 digital piezo controller, modular system for up to 6 axes	2 / 4	–	–	–	X	
E-725 digital piezo controller for up to 3 axes	2	–	–	–	X	
E-761 digital piezo controller for up to 3 axes, PCI card	2	–	–	–	X	

3.6 Technical Features

3.6.1 PICMA® Piezo Actuators

P-54x 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-54x stages have flexure guides (flexures) for frictionless motion and high guiding accuracies.

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 position-controlled operation, the P-54x is equipped either with capacitive sensors or strain gauge sensors, depending on the model (p. 10).

Capacitive sensors

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

Strain gauge sensors (SGS)

Strain gauge sensors derive the position information from their expansion. They are attached at a suitable position in the drivetrain, where they measure the displacement of the moving stage part against the base body. This type of position measurement is done with contact and indirectly, since the position of the moving platform is derived from a measurement on the lever, guide or piezo stack.

The sensors are equipped with a full-bridge circuit that is insensitive to thermal drift, and assure optimum position stability in the nanometer range.

3.6.4 ID Chip (Only Models with Sub-D Connector)

An ID chip is located in the Sub-D connector of the stage. When the stage is calibrated at the factory with digital electronics, the calibration data is saved together with specific product information on the ID chip. When switched on, digital electronics read the data from the ID chip of the connected stage. Stages whose ID chip contains the calibration data can therefore be connected to any suitable digital electronics without a new calibration.

For more information on the ID chip, see the manual of the controller used.

4 Unpacking

NOTICE

Mechanical overload from incorrect handling!

An impermissible mechanical overload of the moving platform of the P-54x can cause damage to the piezo actuators, sensors and piezo levers of the P-54x as well as losses of accuracy.

➢ Only hold the P-54x externally by the base body.

1. Unpack the P-54x with care.
2. Compare the contents against the items covered by the contract and against 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

5.1 General Notes on Installation

CAUTION

Dangerous voltage and residual charge on piezo actuators!

The P-54x 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-54x can lead to minor injuries. In addition, the piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the P-54x.
- 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 out the connector from the electronics during operation.

For stages with Sub-D connector:

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

Damage from unsuitable cables!

Unsuitable cables can damage the Stage and the electronics.

➢ Only use cables provided by PI for connecting the P-54x to the electronics.

NOTICE

Damage from incorrect mounting!

Incorrect mounting of the P-54x or incorrectly mounted parts can damage the P-54x.

➢ Only mount the P-54x 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. 41) given for the screws used during installation.

INFORMATION

Extended cables can affect the performance of the P-54x.

➢ Do **not** use cable extensions. If you need longer cables, contact our customer service department (p. 35).

5.2 Connecting the P-54x to the Protective Earth Conductor

INFORMATION

In the case of P-54x 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. 35).

INFORMATION

➢ Observe the applicable standards for mounting the protective earth conductor.

The P-54x is equipped with an M4 hole for fastening the protective earth conductor. This hole is located next to the cable exit and is marked with the protective earth conductor symbol ⏚ (see "Dimensions" (p. 40)).

Prerequisite

✓ 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 ≥0.75 mm^2
- Supplied M4 protective earth screw set (p. 11) for connecting the protective earth conductor
- Suitable screwdriver

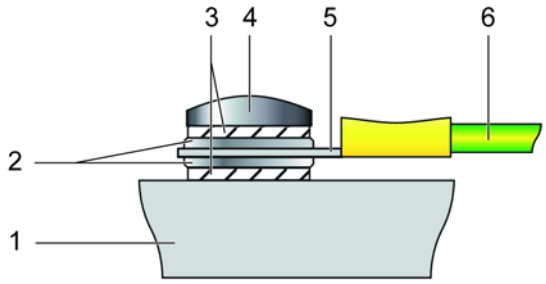

Figure 2: Mounting of the protective earth conductor (profile view)

1 Base body of the P-54x
2 Flat washer
3 Safety washer
4 Screw
5 Cable lug
6 Protective earth conductor

Connecting the P-54x to the protective earth conductor

1. If necessary, fasten a suitable cable lug to the protective earth conductor.
2. Fasten the cable lug of the protective earth conductor using the M4 screw on the protective earth connection of the P-54x as shown in the profile view.
3. Tighten the M4 screw with at least three rotations and 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 Ω at 25 A.

5.3 Mounting the P-54x

NOTICE

Warping of the P-54x due to mounting on uneven surfaces!

Mounting the P-54x on an uneven surface can warp the P-54x. Warping reduces the accuracy.

- ➢ Mount the P-54x on an even surface. The recommended evenness of the surface is ≤20 µm.
- ➢ For applications with great temperature changes:
  Only mount the P-54x on surfaces that have the same or similar thermal expansion properties as the P-54x (e.g. surfaces made of aluminum).

NOTICE

Tensile stress on piezo actuator with vertical mounting!

When the stage is mounted vertically, tensile stress can result in particular alignments that reduces the preload of the piezo actuator and thus destroys it.

- ➢ If you want to mount the P-54x vertically, contact our customer service department (p. 35).

NOTICE

Protruding screw heads!

Protruding screw heads can damage the P-54x.

- ➢ Ensure that the screw heads do not protrude from counter-sunk holes so that they do not interfere with the stage motion.

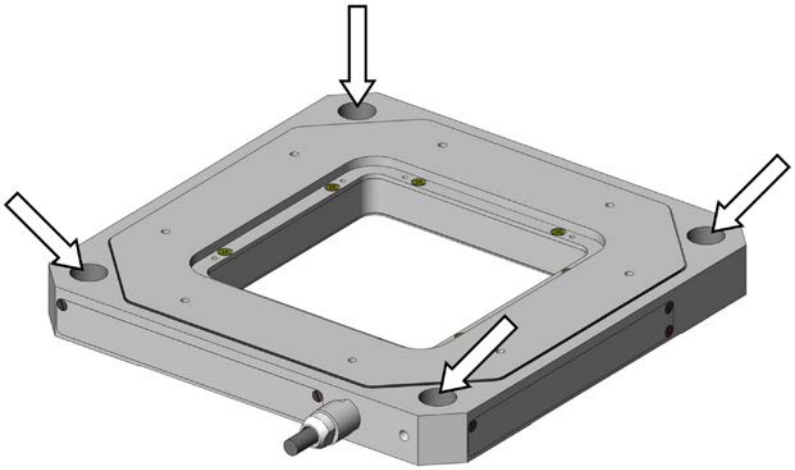

Figure 3: Mounting holes in the base body

Prerequisite

✓ You have read and understood the General Notes on Installation (p. 17).

Tools and accessories

- Screws of appropriate size and length (see "Dimensions" (p. 40))
- Suitable tools

Mounting the stage on a surface

1. Position the stage on an even surface.
2. Fasten the stage to the mounting holes (see figure) with suitable screws. Observe the specified torque range (p. 41) while doing so.

5.4 Affixing the Load

NOTICE

Mechanical overload due to high torques and high loads!

High torques during fastening of the load as well as high loads can overload the moving platform of the P-54x. A mechanical overload can cause damage to the piezo actuators, sensors and piezo levers of the P-54x as well as losses of accuracy.

- ➢ Observe the torque range (p. 41) given for the used screws when fastening the load.
- ➢ Do **not** exceed the maximum permissible load.

NOTICE

Warping of the P-54x due to affixing of loads with uneven contact surface!

Affixing loads with an uneven contact surface can warp the P-54x. Warping reduces the accuracy.

- ➢ Only affix loads on the P-54x whose contact surface with the moving platform of the stage has an evenness of at least 20 µm.
- ➢ For applications with great temperature changes:
  Only affix loads on the P-54x that have the same or similar thermal expansion properties as the P-54x (e.g. loads made of aluminum).

NOTICE

Center of load at unsuitable position!

If the center of load is located far outside of the moving platform (e. g. high set-ups and long levers), the P-54x can be damaged from high strain on the flexure guides, high torques and oscillations.

- ➢ If the center of the load to be affixed is far above or to the side of the moving platform, adjust the controller settings before start-up or contact our customer service department (p. 35).

NOTICE

Screws that are too long!

The P-54x can be damaged by screws that are too long.

- ➢ Note the depth of the mounting holes in the moving platform (p. 40).
- ➢ Only use screws of the correct length for the respective mounting holes.

INFORMATION

The arrows in the figures (see "Dimensions" (p. 40)) show the positive direction of motion.

Center of load at the optimum position:

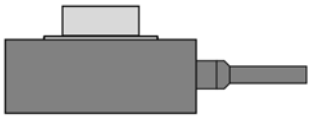

Figure 4: Example of an optimally affixed load

Center of load at an unsuitable position:

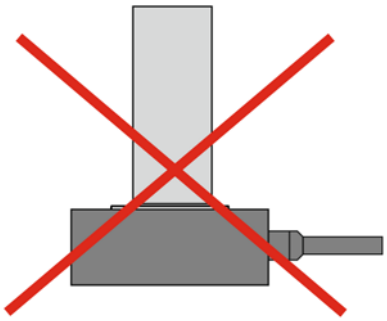

Figure 5: High set-up and center of load far above the moving platform

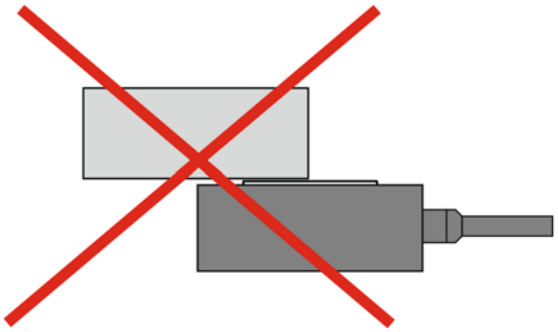

Figure 6: Long lever and center of load on the side of the moving platform

Prerequisite

✓ You have read and understood the General Notes on Installation (p. 17).

Tools and accessories

- Screws of appropriate size and length (see "Dimensions" (p. 40))
- Suitable tools

Affixing the Load

➢ Only affix loads to the threaded holes intended for this purpose (see "Dimensions" (p. 40)) and with suitable screws. Observe the specified torque range (p. 41) while doing so.

➢ Affix the load so that it is centered and that the center of load is on the moving platform.

➢ Avoid high set-ups with the center of load far above the moving platform.

➢ Avoid long levers with the center of load on the side of the moving platform.

6 Start-Up and Operation

In this Chapter

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-54x in the case of malfunction of failure of the system. If touch voltages exist, touching the P-54x can result in minor injuries due to electric shock.

- Connect the P-54x to a protective earth conductor before start-up (p. 19).
- 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-54x to the protective earth conductor before starting it up again.

NOTICE

Destruction of the piezo actuator by electric flashovers!

The use of the P-54x 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 such as 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-54x in environments that can increase the electric conductivity.
- Only operate the P-54x within the permissible ambient conditions and classifications (p. 39).

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 ceramics of the actuator.

- ➢ When the P-54x is not used but the controller remains switched on to ensure temperature stability, discharge the P-54x (p. 29).

NOTICE

Operating voltages that are too high or incorrectly connected!

Operating voltages that are too high or incorrectly connected can cause damage to the P-54x.

- ➢ Only operate the P-54x with controllers/drivers and original accessories from PI.
- ➢ Do **not** exceed the operating voltage range (p. 38) for which the P-54x is specified.
- ➢ Only operate the P-54x when the operating voltage is properly connected; see "Pin Assignment" (p. 41).

NOTICE

Uncontrolled oscillation!

Oscillations can cause irreparable damage to the stage. Oscillations are indicated by a humming and can result from the following causes:

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

If you notice oscillations:

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

INFORMATION

The arrows in the figures (see "Dimensions" (p. 40)) show the positive direction of motion.

INFORMATION

Systems are calibrated at the factory to achieve optimum performance. Replacing the system components will cause a loss in performance when stages are used, whose ID chip (p. 14) does not contain any calibration data, or when analog controllers are used.

- Note the assignment of the stage axes to the controller channels, which is given by the calibration label of the piezo servo controller.
- If the piezo servo controller or the stage has to be replaced, recalibrate the axis displacement (see controller manual) or contact our customer service department (p. 35).

INFORMATION

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

- Avoid transmitting sound and vibration while the Stage is being operated.

6.2 Operating the P-54x

- Follow the instructions in the manual of the used piezo controller for start-up and operation of the P-54x.

6.3 Discharging the P-54x

The P-54x must be discharged in the following cases:

- If the P-54x is not used but the controller remains switched on to ensure temperature stability
- Before demounting (e.g. before cleaning and transporting the P-54x and for modifications)

The P-54x is discharged through the internal discharge resistor of the controller from PI.

Discharging a P-54x 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-54x that is not connected to the controller

- Connect the stage to the switched-off controller from PI.

7 Maintenance

In this Chapter

7.1 General Notes on Maintenance

NOTICE

Misalignment from loosening screws!

The P-54x is maintenance-free and achieves its positioning accuracy as a result of the optimum alignment of mechanical components and piezo actuators. Loosened screws cause a loss in positioning accuracy.

- ➢ Only loosen screws according to the instructions in this manual.
- ➢ Do not open the P-54x.

7.2 Cleaning the P-54x

Prerequisites

- ✓ You have discharged the piezo actuators of the P-54x (p. 29).
- ✓ You have disconnected the P-54x from the controller.

Cleaning the P-54x

- ➢ Clean the surfaces of the P-54x with a cloth slightly dampened with a mild cleanser or disinfectant (e.g. alcohol or isopropanol).
- ➢ Do **not** do any ultrasonic cleaning.

8 Troubleshooting

Problem	Possible Causes	Solution
No or limited motion	The cable is not connected correctly	➢ Check the cable connections.
	Excessive load	➢ Do **not** exceed the permissible stress and load capacities according to the specifications (p. 37).
	The load was changed	➢ After changing the load to be moved, perform a zero-point adjustment (see controller manual).
Reduced accuracy	Warping of the base body or the moving platform	➢ Only mount the P-54x on surfaces with the following characteristics: – Evenness of at least 20 µm – The thermal expansion properties are similar to those of the P-54x (e. g. surfaces made of aluminum). ➢ Only affix loads with the following characteristics on the P-54x: – The contact surface of the load with the moving platform of the stage has an evenness of at least 20 µm. – The thermal expansion properties are similar to those of the P-54x (e. g. loads made of aluminum).

Problem	Possible Causes	Solution
	P-54x or controller has been replaced	When stages whose ID chip (p. 14) does not contain any calibration data or LEMO connectors are used, the axis displacement has to be recalibrated after the P-54x or the controller has been replaced. ➢ Perform a recalibration of the axis displacement (see controller manual) or contact our customer service department (p. 35).
	Axes were mixed up during connection (only with LEMO connectors)	➢ Observe the assignment of the axes when connecting the stage to the controller. This assignment is indicated by labels on the devices.
The stage starts oscillating or positions inaccurately	Servo-control parameters incorrectly set because e. g. the load was changed	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. 35).

9 Customer Service

For inquiries and orders, contact your PI sales engineer or send us an e-mail (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)

The latest versions of the user manuals are available for downloading (p. 4) on our website.

10 Technical Data

In this Chapter

10.1 Specifications

10.1.1 Data Table

	P-541 .2CD / .2CL	P-542 .2CD / .2CL	P-541 .2DD	P-541 .2SL	P-542 .2SL	P-541 .20L	P-542 .20L	Unit	Tolerance
Active axes	X, Y	X, Y	X, Y	X, Y	X, Y	X, Y	X, Y		
Motion and positioning									
Integrated sensor	Capa-citive	Capa-citive	Capa-citive	SGS	SGS	–	–		
Open-loop travel, -20 to +120 V	150 µm × 150 µm	250 µm × 250 µm	60 µm × 60 µm	150 µm × 150 µm	250 µm × 250 µm	150 µm × 150 µm	250 µm × 250 µm		min. (+20%/ -0%)
Closed-loop travel	100 µm × 100 µm	200 µm × 200 µm	45 µm × 45 µm	100 µm × 100 µm	200 µm × 200 µm	–	–		
Closed-loop / open-loop resolution	0.2 / 0.3	0.4 / 0.7	0.1 / 0.3	0.2 / 2.5	0.4 / 4	0.2 / –	0.4 / –	nm	typ.
Linearity deviation	0.03	0.03	0.03*	0.2	0.2	–	–	%	typ.
Repeatability	<5	<5	<5	<10	<10	–	–	nm	typ.
Pitch	<5	<5	<3	<5	<5	<5	<5	µrad	typ.
Yaw	<10	<10	<3	<10	<10	<10	<10	µrad	typ.
Mechanical properties									
Stiffness in motion direction	0.47	0.4	10	0.47	0.4	0.47	0.4	N/µm	±20%
Unloaded resonant frequency	255	230	1550	255	230	255	230	Hz	±20%
Resonant frequency @ 100 g	200	190	–	200	190	200	190	Hz	±20%
Resonant frequency @ 200 g	180	–	1230	180	–	180	–	Hz	±20%
Resonant frequency @ 300 g	150	145	–	150	145	150	145	Hz	±20%
Push / pull force capacity in motion direction	100 / 30	100 / 30	100 / 30	100 / 30	100 / 30	100 / 30	100 / 30	N	max.
Load capacity	20	20	20	20	20	20	20	N	max.

	P-541 .2CD / .2CL	P-542 .2CD / .2CL	P-541 .2DD	P-541 .2SL	P-542 .2SL	P-541 .20L	P-542 .20L	Unit	Tolerance
Drive properties									
Piezoceramics	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-885		
Electrical capacitance per axis	4.2	7.5	9	4.2	7.5	4.2	7.5	µF	±20%
Dynamic operating current coefficient per axis	5.2	4.8	25	5.2	4.8	5.2	4.8	µA / (Hz × µm)	±20%
Miscellaneous									
Operating temperature range	-20 to 80	-20 to 80	-20 to 80	-20 to 80	-20 to 80	-20 to 80	-20 to 80	°C	
Material	Alumi-num	Alumi-num	Alumi-num	Alumi-num	Alumi-num	Alumi-num	Alumi-num		
Mass	0.75	0.75	0.75	0.73	0.73	0.7	0.7	kg	±5%
Cable length	1.5	1.5	1.5	1.5	1.5	1.5	1.5	m	±10 mm
Sensor connection	Sub-D Special / LEMO	Sub-D Special / LEMO	Sub-D Special	LEMO	LEMO	–	–		
Voltage connection	Sub-D Special / LEMO	Sub-D Special / LEMO	Sub-D Special	LEMO	LEMO	LEMO	LEMO		

* With digital controller. Non-linearity of direct drive stages measured with analog controllers is up to 0.1% typ.

10.1.2 Maximum Ratings

P-54x stages are designed for the following parameters:

Stage	Maximum Operating Voltage 	Maximum Operating Frequency (Unloaded) 	Maximum Power Consumption 
P-541.2DD	–20 to 120 V	517 Hz (per axis)	91 W (per axis)
P-541.20L P-541.2CD P-541.2CL P-541.2SL	–20 to 120 V	85 Hz (per axis)	7 W (per axis)
P-542.20L P-542.2CD P-542.2CL P-542.2SL	–20 to 120 V	77 Hz (per axis)	11 W (per axis)

10.1.3 Ambient Conditions and Classifications

The following ambient conditions and classifications must be observed for the P-54x:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 0.1 hPa (corresponds to roughly 825 Torr to 0.075 Torr)
Relative humidity	Highest relative humidity 80% for temperatures up to 31°C Decreasing linearly to 50% relative humidity at 40°C
Operating temperature	–20°C to 80°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

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

Standard tolerance according to DIN ISO 2768 - f - H

Roughness Ra 1.6

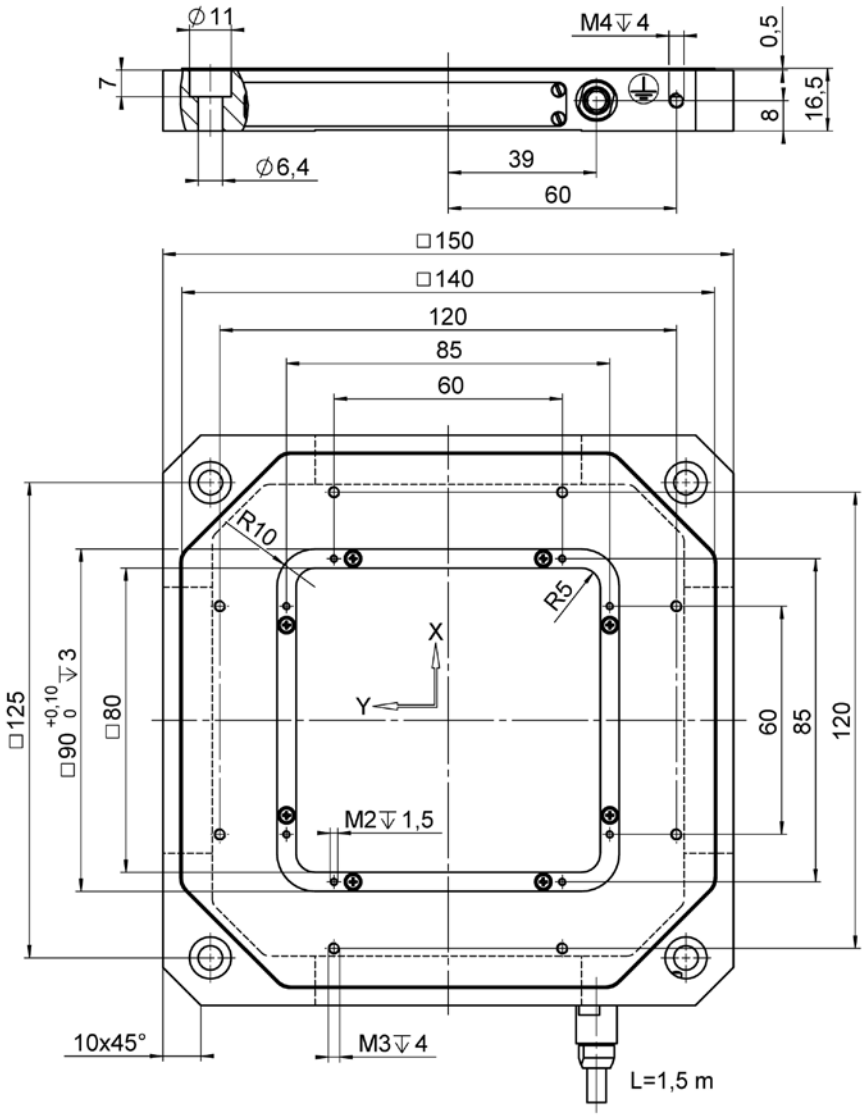

Figure 7: P-54x

10.3 Torque for Stainless Steel Screws (A2-70)

Screw Size	Minimum Torque	Maximum Torque
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 mix connector 25W3

Only for P-54x.2CD/.2DD:

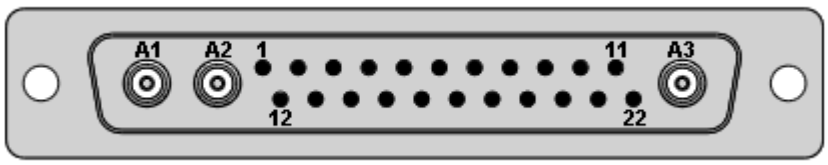

Figure 8: Sub-D mix connector 25W3: Front side with connections

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	N. c.	(Not connected)
A2 outer conductor	N. c.	(Not connected)
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

Pin	Signal	Function
1	Input	Target sensor signal, channel 2 (movable part of the capacitive sensor)
2	N. c.	(Not connected)
3	GND	Ground of ID chip
4	Bidirectional	Data line for ID chip
5	N. c.	(Not connected)
6	N. c.	(Not connected)
7	N. c.	(Not connected)
8	N. c.	(Not connected)
9	Input	Piezo voltage +, channel 2, -20 to 120 V
10	Input	Piezo voltage +, channel 1, -20 to 120 V
11	Input	Target sensor signal, channel 1 (movable part of the capacitive sensor)
12	GND	Shield of Target sensor signal, channel 2
13	N. c.	(Not connected)
14	N. c.	(Not connected)
15	N. c.	(Not connected)
16	N. c.	(Not connected)
17	N. c.	(Not connected)
18	N. c.	(Not connected)
19	N. c.	(Not connected)
20	Input	Piezo voltage –, channel 2
21	Input	Piezo voltage –, channel 1
22	GND	Shield of Target sensor signal, channel 1

LEMO connectors

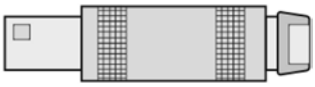

Figure 9: LEMO connector (side view)

LEMO connectors according to model (one connector per axis)

P-54x Model	Connector (Front View)	Pin	Signal	Function	Connector Shell
.20L .2CL .2SL	PZT 	Inner connector	Input	Piezo voltage –20 to 120 V	Ground
.2CL	P 	Inner connector	Output	Probe sensor signal (nonmoving part of the capacitive sensor)	Cable shield
.2CL	T 	Inner connector	Input	Target sensor signal (movable part of the capacitive sensor)	Cable shield
.2SL	SGS 	1	Input	Supply voltage for strain gauge sensor	Cable shield
		2	Output	Sensor signal 1	
		3	Output	Sensor signal 2	
		4	GND	Ground of the supply voltage	

11 Old Equipment Disposal

In accordance with the applicable EU law, electrical and electronic equipment may not be disposed of with unsorted municipal wastes in the member states of the EU.

When disposing of your old equipment, observe the international, national and local rules and regulations.

To meet the manufacturer's product responsibility with regard to this product, Physik Instrumente (PI) GmbH & Co. KG ensures environmentally correct disposal of old PI equipment that was first put into circulation after 13 August 2005, free of charge.

If you have old PI equipment, you can send it postage-free to the following address:

Physik Instrumente (PI) GmbH & Co. KG

Auf der Römerstr. 1

D-76228 Karlsruhe, Germany