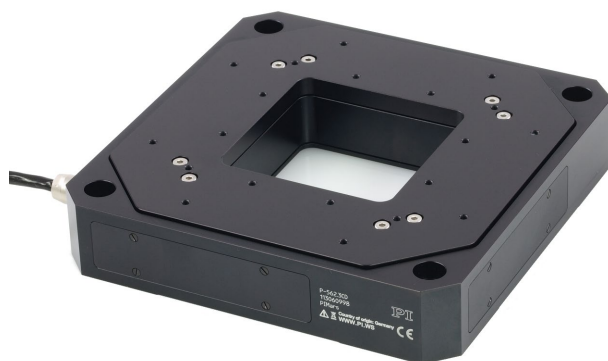


PZ248E P-56x Nanopositioners User Manual

Version: 2.1.0

Date: 20.11.2023



This document describes the following products:

- **P-561**
PIMars XYZ nanopositioners
P-561.3CD/.3CL, 100 μm \times 100 μm \times 100 μm
P-561.3DD, 45 μm \times 45 μm \times 15 μm , direct drive
- **P-562**
PIMars XYZ nanopositioners
P-562.3CD/.3CL, 200 μm \times 200 μm \times 200 μm
- **P-563**
PIMars XYZ nanopositioners
P-563.3CD/.3CL, 300 μm \times 300 μm \times 300 μm

.3CD/.3DD with D-sub 25W3 connector
.3CL with LEMO connectors



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The patents held by PI are found in our patent list: <https://www.physikinstrumente.com/en/about-pi/patents>

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Original instructions

First printing: 20.11.2023

Document number: PZ248E, CBo, Version 2.1.0

Subject to change without notice. This manual is superseded by any new release. The latest release is available for download on our website (p. 2).

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1 About this Document

In this Chapter

Objective and Target Group of this User Manual 1

Symbols and Typographic Conventions 1

Other Applicable Documents 2

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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-56x as intended ("x" stands for the different models (p. 9)).

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

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 result in minor injuries.
➤ Precautions to avoid the risk.



NOTICE



Dangerous situation
Failure to comply could result in damage to the equipment.
➤ Precautions 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 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. 2).

Product	Document
E-503 piezo amplifier module	PZ62E user manual
E-505 piezo amplifier module	PZ62E user manual
E-621 piezo amplifier / servo controller module	PZ160E user manual
E-712 digital piezo controller	PZ195E user manual
E-727 digital multi-channel piezo controller	E727T0005 user manual
P-5xx / P-6xx / P-7xx piezo positioners	PZ240EK short instructions

1.4 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-56x).
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

In this Chapter

Intended Use.....	5
General Safety Instructions.....	5
Organizational Measures.....	6

2.1 Intended Use

The P-56x 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 from dirt, oil, and lubricants.

According to its design, the P-56x is intended for fine positioning as well as moving small objects quickly and precisely. The specifications for the P-56x apply to horizontal mounting. Movement is horizontal and vertical in three axes.

The P-56x can only be used as intended in conjunction with suitable electronics (p. 12) available from PI. The electronics are not included in the scope of delivery of the P-56x.

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

2.2 General Safety Instructions

The P-56x is built according to state-of-the-art technology and recognized safety standards. Improper use of the P-56x may result in personal injury and/or damage to the P-56x.

- Use the P-56x 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-56x correctly.

The P-56x 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-56x'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-56x.
- 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.

Positioners with D-sub plug connector:

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 plug connector.
- Use screws to secure the positioner's connector against being pulled out of the electronics.

If the protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the P-56x in the event of a malfunction or failure of the system. If there are touch voltages, touching the P-56x can result in minor injuries from electric shock.

- Connect the P-56x 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-56x to the protective earth conductor before restarting.

Mechanical forces can damage or misalign the P-56x.

- Avoid impacts that affect the P-56x.
- Do **not** drop the P-56x.
- Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 39).
- Do **not** touch any sensitive parts (e.g., motion platform) when handling the P-56x.

The P-56x is maintenance-free and achieves its positioning accuracy as a result of the optimal alignment of mechanical components and piezo actuators. Loosened screws cause a loss in positioning accuracy.

- Loosen screws only when instructed in this manual.
- Do **not** open the P-56x.

2.3 Organizational Measures

User manual

- Always keep this user manual together with the P-56x. The latest versions of the user manuals are available for download on our website (p. 2).
- Add all information from the manufacturer such as supplements or technical notes to the user manual.
- If you give the P-56x 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-56x only after you have read and understood this user manual.

Personnel qualification

The P-56x may only be installed, started, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

3 Product Description

In this Chapter

Model Overview.....	9
Product View.....	10
Product Labeling.....	11
Scope of Delivery	12
Suitable Electronics.....	12
Optional Accessories.....	13
Technical Features	13

3.1 Model Overview

The following standard versions of the P-56x are available:

Model	Description
P-561.3CD	PIMars XYZ nanopositioner with long travel range, 100 μm \times 100 μm \times 100 μm , capacitive sensors, parallel metrology, D-sub connector
P-561.3CL	PIMars XYZ nanopositioner with long travel range, 100 μm \times 100 μm \times 100 μm , capacitive sensors, parallel metrology, LEMO connectors
P-561.3DD	PIMars high dynamics XYZ nanopositioner, 45 μm \times 45 μm \times 15 μm , capacitive sensors, parallel metrology, D-sub connector, direct drive
P-562.3CD	PIMars XYZ nanopositioner with long travel range, 200 μm \times 200 μm \times 200 μm , capacitive sensors, parallel metrology, D-sub connector
P-562.3CL	PIMars XYZ nanopositioner with long travel range, 200 μm \times 200 μm \times 200 μm , capacitive sensors, parallel metrology, LEMO connectors
P-563.3CD	PIMars XYZ nanopositioner with long travel range, 300 μm \times 300 μm \times 300 μm , capacitive sensors, parallel metrology, D-sub connector
P-563.3CL	PIMars XYZ nanopositioner with long travel range, 300 μm \times 300 μm \times 300 μm , capacitive sensors, parallel metrology, LEMO connectors

3.2 Product View

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

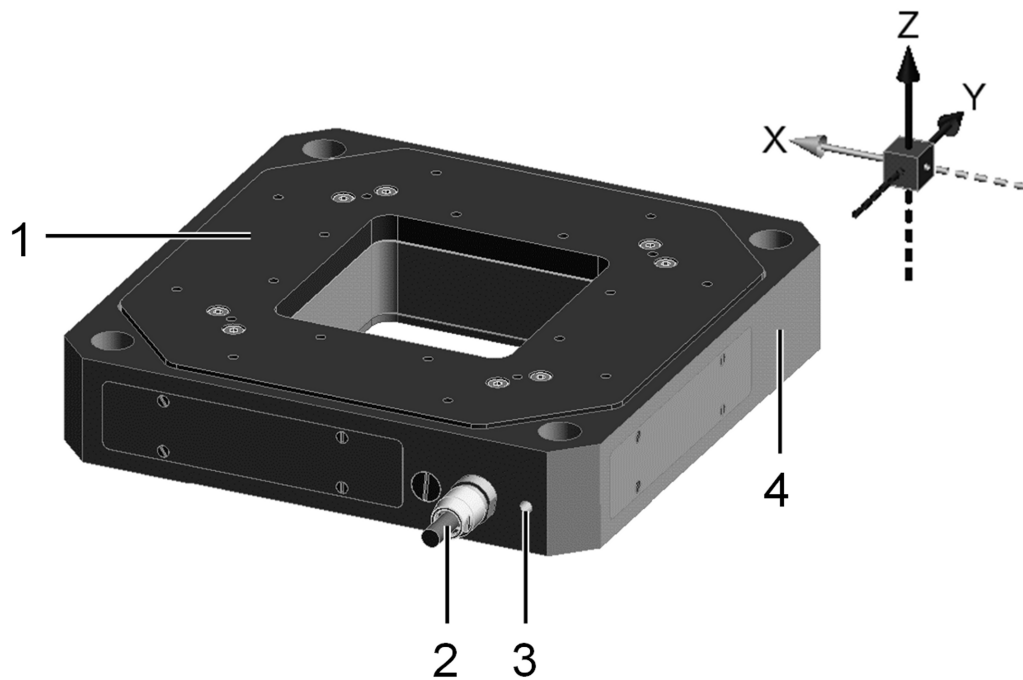


Figure 1: Example of product view

- 1 Motion platform
- 2 Cable exit
- 3 Protective earth connector
- 4 Base body

X, Y, Z (Positive) directions of motion of the positioner

3.3 Product Labeling

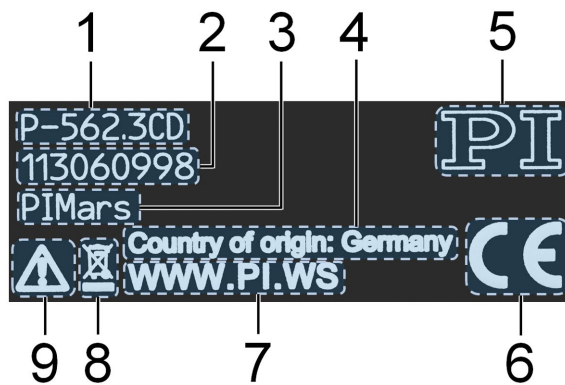


Figure 2: P-56x: Type plate (example view)

- 1 Product name
- 2 Serial number
- 3 Brand name
- 4 Country of origin
- 5 Manufacturer's logo
- 6 CE conformity mark
- 7 Manufacturer's address (website)
- 8 Disposal of old devices
- 9 Warning sign "Observe manual!"



Figure 3: "Residual Voltage" warning sign on the connector of the P-56x:
Indicates risk of electric shock (p. 5).

3.4 Scope of Delivery

Product number	Description
P-56x	Positioner according to order (p. 9)
-	Transport safeguard, consisting of: <ul style="list-style-type: none"> ▪ Support frame ▪ 4 plastic screws
000036450	M4 screw set for protective earth, consisting of: <ul style="list-style-type: none"> ▪ 1 M4x8 flat-head screw with cross recess, ISO 7045 ▪ 2 lock washers ▪ 2 flat washers
P500T0002	Technical Note with instructions on unpacking and packing P-5xx positioners
PZ240EK	Short instructions for P-5xx / P-6xx / P-7xx piezo positioners
Only for P-56x.3CL models:	
E71000211	Adapter cable, D-sub 25W3 to LEMO, 1 m (for connection to E-500 systems)

3.5 Suitable Electronics

You need suitable electronics to operate a P-56x. Selecting the device depends on the application and the connectors available.

Electronics	Connector*	Channels**
E-505 piezo amplifier module	LEMO	1
E-503 piezo amplifier module	LEMO	3
E-621 piezo amplifier/servo controller module	D-sub 7W2	1
E-727.x • E-727.xAP digital multi-channel piezo controller	D-sub 25W3	3
E-727.xF digital multi-channel piezo controller	D-sub 25W3	3
E-712 digital piezo controller (modular system)	D-sub 25W3	3/6

* In some cases, adapter cables (p. 13) are necessary for connecting.

** When using single-channel electronics, each motion axis requires its own individual electronics.

3.6 Optional Accessories

Adapter cable with LEMO (mechanics) to D-sub (electronics)

Product number	Description
P-895.1LDC	Adapter cable LEMO to D-sub 7W2 (m) for piezo actuator nan positioning systems with capacitive sensors, 1 channel, length: 0.3 m.
P-895.3LDC	Adapter cable LEMO to D-sub 25W3 (m) for piezo actuator nan positioning systems with capacitive sensors, 3 channels, length: 0.3 m.

Adapter cable with D-sub (mechanics) to LEMO (electronics)

Product number	Description
P-895.1DLC	Adapter cable D-sub 7W2 (f) to LEMO for piezo actuator nan positioning systems with capacitive sensors, 1 channel, length: 0.3 m.
P-895.3DLC	Adapter cable D-sub 25W3 (f) to LEMO for piezo actuator nan positioning systems with capacitive sensors, 3 channels, length: 0.3 m.

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

3.7 Technical Features

3.7.1 PICMA® Piezo Actuators

P-56x 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.

3.7.2 Flexure Guides

P-56x 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.

3.7.3 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.

3.7.4 ID Chip (Models with D-sub Connector Only)

An ID chip is in the D-sub connector of the P-56x. When the P-56x is calibrated at the factory with digital electronics, the calibration data is saved on the ID chip together with specific product information. After switching on, the digital electronics read the data from the ID chip of the P-56x connected. A P-56x with an ID chip containing calibration data can therefore be connected to any suitable digital electronics without renewed calibration.

Refer to the manual for the controller for more information on the ID chip.

4 Unpacking

NOTICE

**Mechanical overload due to incorrect handling!**

Impermissible mechanical overload of the motion platform of the P-56x can cause damage to the piezo actuators, sensors, and flexures of the P-56x as well as loss of accuracy.

- Ship the P-56x in the original packaging only.
- Do **not** touch any sensitive parts (e.g., motion platform) when handling the P-56x.

The P-56x is delivered with a transport safeguard attached. The following figures serve as examples and can differ from your positioner model.

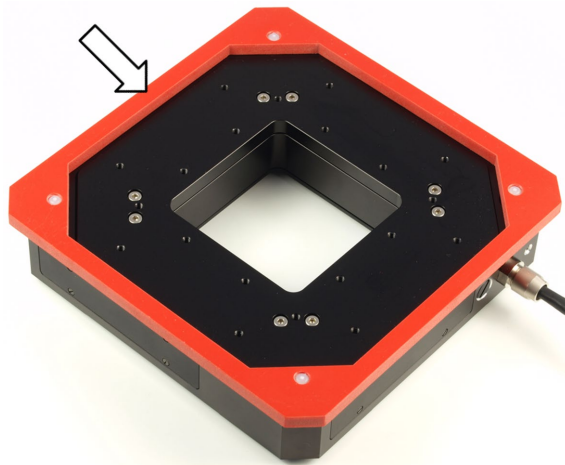


Figure 4: Exemplary view: Positioner with transport safeguard (supporting frame marked with arrow) for protecting the motion platform

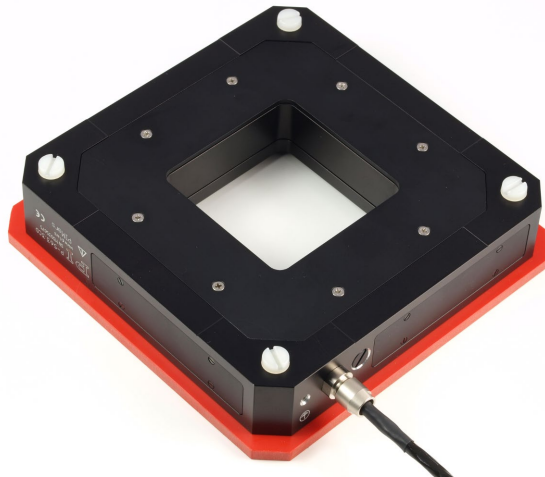
Tools and accessories

- Suitable screwdriver

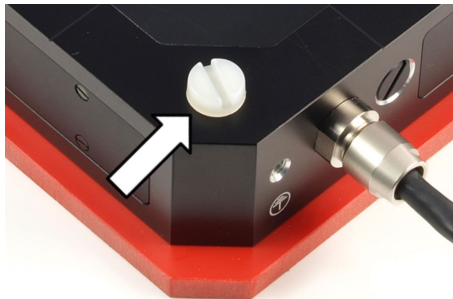
Unpacking the P-56x

1. Unpack the P-56x 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 (p. 37) immediately.

4. Remove the transport safeguard:
 - a) Put the P-56x onto a surface with the support frame facing downwards.



- b) Release the four plastic screws with a screwdriver. In the following figure, one of the screws is marked with an arrow.



- c) Remove the plastic screws and the support frame.
5. Keep all packaging materials and the transport safeguard in case the product needs to be returned.

5 Installing

In this Chapter

General Notes on Installation	17
Connecting the P-56x to the Protective Earth Conductor	18
Mounting the P-56x	20
Fixing the Load	22
Connecting the Adapter Cable to the P-56x (Only P-56x.3CL Models).....	25

5.1 General Notes on Installation

CAUTION



Dangerous voltage and residual charge in piezo actuators!

The P-56x 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-56x'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-56x.
- 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.



Positioners with D-sub plug connector:

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 plug 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-56x can cause damage to the piezo actuators, sensors, and flexures of the P-56x as well as loss of accuracy.

- Do **not** touch any sensitive parts (e.g., motion platform) when handling the P-56x.

NOTICE**Damage due to unsuitable cables!**

Unsuitable cables can damage the P-56x and the electronics.

- Use cables provided by PI only to connect the P-56x to the electronics.

NOTICE**Damage due to improper mounting!**

Improper mounting of the P-56x or incorrectly mounted parts can damage the P-56x.

- Only use the holes or threads intended for the purpose of fixing the P-56x and loads.
- Install the P-56x 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. 44) specified for the screws used during installation.

INFORMATION

Extension cables can reduce the positioning accuracy of the P-56x 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-56x 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-56x 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-56x 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. 43) for the exact position of the hole.

Requirements

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ The P-56x 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

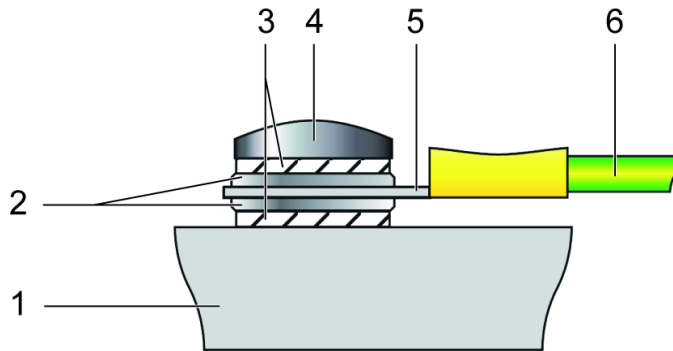


Figure 5: Connecting the protective earth conductor (profile view)

- 1 Base body of the P-56x
- 2 Flat washer
- 3 Lock washer
- 4 Screw
- 5 Cable lug
- 6 Protective earth conductor

Connecting the P-56x 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-56x 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-56x

NOTICE



Warping the P-56x when mounting onto uneven surfaces!

The P-56x could warp if mounted on an uneven surface. Warping reduces the accuracy.

- Mount the P-56x onto a flat surface. The recommended flatness of the surface is $\leq 20 \mu\text{m}$.
- For applications with large temperature fluctuations:
Mount the P-56x only onto surfaces that have the same or similar thermal expansion properties as the P-56x.

NOTICE**Tensile stress on piezo actuator due to mounting in wrong orientation!**

The P-56x is intended for mounting in horizontal orientation (standing on a surface, not suspended). Mounting in other orientations can cause tensile stress that reduces the preload and destroys the piezo actuator.

- If you want to mount the P-56x in a different orientation to that intended (e.g., vertically or upside down), contact our customer service department (p. 37).

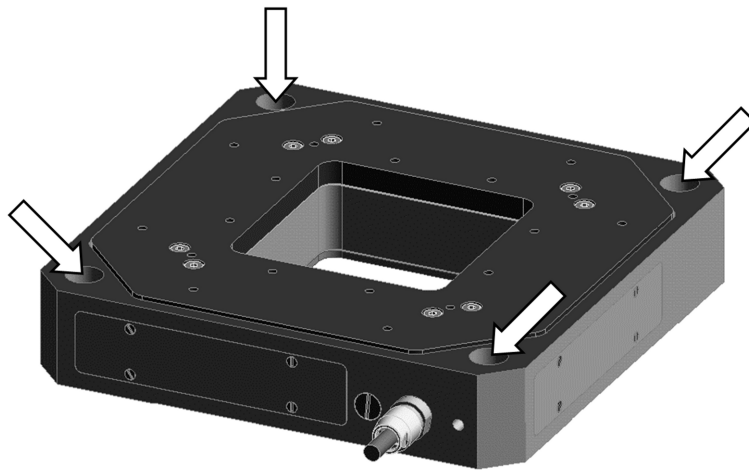


Figure 6: Mounting holes in the base body

Requirements

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

Tools and accessories

- Screws of suitable size and length (see "Dimensions" (p. 43))
- Suitable tools

Mounting the P-56x

1. Align the P-56x on the mounting surface so that the holes in the P-56x and mounting surface are in line.
2. Insert suitable screws into the mounting holes to fix the P-56x (see figure). Pay attention to the specified torque range (p. 44) for the screws.

5.4 Fixing the Load

NOTICE

**Mechanical overload of the platform!**

Fixing loads with high torques and heavy loads in general can overload the platform of the P-56x. Mechanical overload can damage the piezo actuators, sensors, and flexures of the P-56x and lead to loss of accuracy.

- Avoid torques on the platform.
- Do **not** exceed the maximum permissible loads according to the specifications (p. 39).
- Hold the load and adhere to the specified torque range when tightening (or loosening) the screws (p. 44).

NOTICE

**Warping the P-56x when fixing loads with an uneven contact surface!**

Fixing loads with an uneven contact surface could warp the P-56x. Warping reduces the accuracy.

- Fix loads on the P-56x only when the surface contacting the P-56x's motion platform has a flatness of at least 20 µm.
- For applications with large temperature fluctuations:
Fix loads to the P-56x only when they have the same or similar thermal expansion properties as the P-56x.

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-56x 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-56x could be damaged by screws inserted too deeply.

- Pay attention to the depth of the mounting holes in the motion platform (p. 43).
- 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).

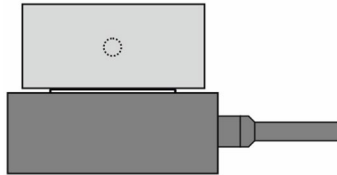
Center of load at the optimal position:

Figure 7: Example of an optimally placed load

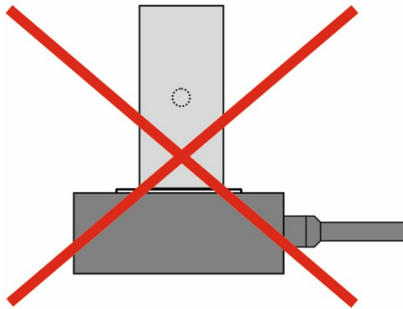
Center of load at an unsuitable position:

Figure 8: Tall load and center of load too far above the platform

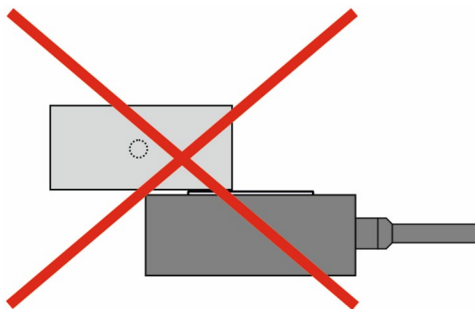


Figure 9: Unwanted lever effect and center of load on the side of the platform

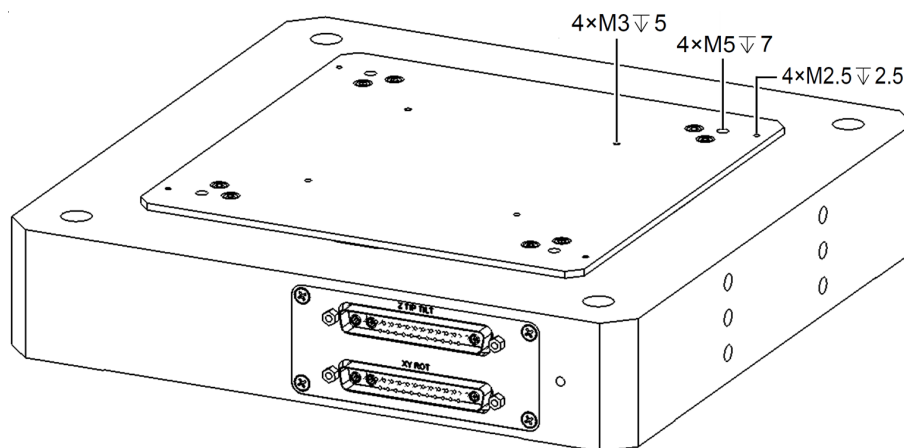


Figure 10: Mounting holes in the motion platform

Requirements

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ The P-56x is **not** connected to the electronics.

Tools and accessories

- Screws of suitable size and length (p. 43)
- Suitable screwdriver

Fixing the load

1. Align the load on the P-56x so that the mounting holes in the load and motion platform are in line.
2. Insert the screws through the holes in the load into the selected mounting holes in the motion platform of the P-56x.
3. Hold the load so that it cannot move while tightening the screws.
4. Tighten the screws. When tightening the screws, pay attention to the torque range (p. 44) specified, and avoid torques to the motion platform.
5. Check that the load is firmly mounted on the motion platform.

5.5 Connecting the Adapter Cable to the P-56x (Only P-56x.3CL Models)

Requirements

- ✓ The adapter cable is **not** connected to the electronics.

Tools and accessories

- Supplied E71000211 adapter cable (p. 12)

Connecting the adapter cable to the P-56x

- Connect the D-sub 25W3 connector (m) of the P-56x to the D-sub 25W3 connector (f) of the adapter cable.

6 Starting and Operating

In this Chapter

General Notes on Starting and Operating	27
Operating the P-56x	29
Discharging the P-56x	29

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-56x in the event of a malfunction or failure of the system. If there are touch voltages, touching the P-56x can result in minor injuries from electric shock.

- Connect the P-56x 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-56x to the protective earth conductor before restarting.

NOTICE



Destruction of the piezo actuator due to electric flashovers!

Using the P-56x 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-56x in environments that can increase the electric conductivity.
- Operate the P-56x only within the permissible ambient conditions and classifications (p. 42).

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-56x is not used but the electronics remain switched on to ensure temperature stability, discharge the P-56x (p. 29).

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

Excessively high or wrongly connected operating voltages can damage the P-56x.

- Operate the P-56x with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 41) specified for the P-56x.
- Operate the P-56x only when the operating voltage is properly connected; see "Pin Assignment" (p. 45).

NOTICE**Uncontrolled oscillation!**

Oscillation can cause irreparable damage to the P-56x. 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-56x 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-56x immediately.

INFORMATION

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

INFORMATION

Systems are calibrated at the factory to achieve optimum positioning accuracy. Replacing the system components can lead to a reduction of position accuracy when positioners are used with an ID-chip (p. 14) that does not contain calibration data or when LEMO plug connectors are used.

- When connecting the positioner, pay attention to the assignment of the motion axes to the controller channels, which is specified on the calibration label of the controller.

If position accuracy is reduced after replacing the P-56x or the controller:

- Recalibrate the axis displacement (refer to the controller manual) or contact our customer service department (p. 37).

INFORMATION

Sound and vibration (e.g., footfall, knocks) can be transmitted to the P-56x and can affect its performance with regard to position stability.

- Avoid sound and vibration while the P-56x is being operated.

6.2 Operating the P-56x

Requirements

- ✓ If a P-56x.3CL is to be operated with a controller with LEMO sockets:
The E71000211 adapter cable is connected to the positioner (p. 25).

Operating the P-56x

- Follow the instructions in the manual for the controller used for startup and operation of the P-56x.

6.3 Discharging the P-56x

The P-56x must be discharged in the following cases:

- Before Installation
- When the P-56x is not used but the electronics remain switched on to ensure temperature stability
- Before demounting (e.g., before cleaning and transporting the P-56x and for modifications)

The P-56x 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

General Notes on Maintenance.....	31
Packing the P-56x for Transport	31
Cleaning the P-56x	33

7.1 General Notes on Maintenance

NOTICE



Misalignment due to loosening screws!

The P-56x is maintenance-free and achieves its positioning accuracy as a result of the optimal alignment of mechanical components and piezo actuators. Loosened screws cause a loss in positioning accuracy.

- Loosen screws only when instructed in this manual.
- Do **not** open the P-56x.

7.2 Packing the P-56x for Transport

NOTICE



Mechanical overload due to incorrect handling!

Impermissible mechanical overload of the motion platform of the P-56x can cause damage to the piezo actuators, sensors, and flexures of the P-56x as well as loss of accuracy.

- Ship the P-56x in the original packaging only.
- Do **not** touch any sensitive parts (e.g., motion platform) when handling the P-56x.

The following figures serve as examples and can differ from your positioner model.

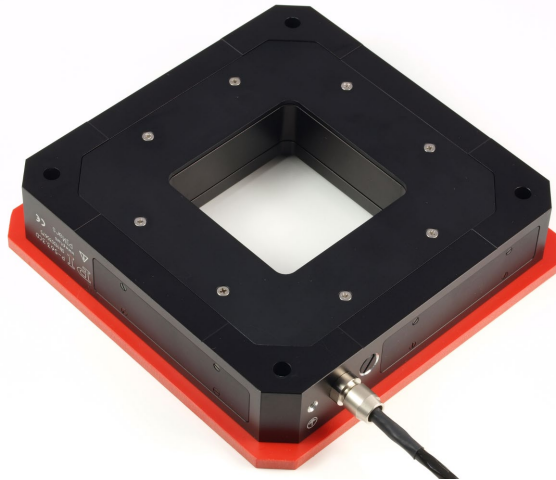
Tools and accessories

- Original packaging
- Transport safeguard, consisting of:
 - Support frame
 - 4 plastic screws

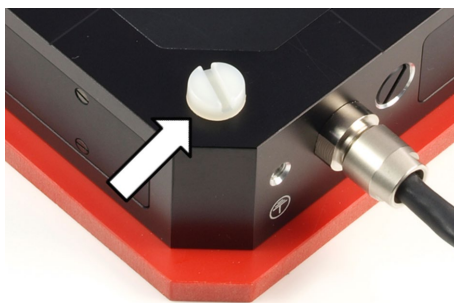
- Suitable screwdriver

Packing the P-56x

1. Attach the transport safeguard:
 - a) Put the supporting frame onto a surface.
 - b) Put the positioner onto the support frame with its top facing downwards.



- c) Align the positioner so that the mounting holes in the positioner are in line with the mounting holes in the supporting frame.
- d) Attach the support frame to the positioner using the four plastic screws. In the following figure, one of the screws is marked with an arrow.



2. Pack the positioner into the original packaging.

7.3 Cleaning the P-56x

NOTICE

**Damage from ultrasonic cleaning!**

Ultrasonic cleaning can damage the P-56x.

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

Requirements

- ✓ You have discharged the piezo actuators of the P-56x (p. 29).
- ✓ You have disconnected the P-56x from the electronics.

Cleaning the P-56x

- Clean the surfaces of the P-56x 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 not exceed the maximum permissible stress and load capacities according to the specifications (p. 39).
	Zero shift of the sensor for the following reasons: <ul style="list-style-type: none"> ▪ Load in direction of motion ▪ Ambient/operating temperature of the positioner is far above or below the calibration temperature (21 °C to 24 °C) 	➤ Adjust the zero-point of the sensor (refer to the controller manual).
Reduced positioning accuracy	The base body or the platform is warped	➤ Mount the P-56x onto surfaces with the following characteristics only: <ul style="list-style-type: none"> – Flatness of at least 20 µm – The thermal expansion properties are similar to those of the P-56x (e.g., surfaces made of aluminum). ➤ Mount loads onto the P-56x with the following characteristics only: <ul style="list-style-type: none"> – The contact surface of the load with the motion platform of the stage has a flatness of at least 20 µm. – The thermal expansion properties are similar to those of the P-56x (e.g., loads made of aluminum).
	P-56x, controller, extension cable or adapter cable were replaced	When positioners, whose ID chip (p. 14) does not contain any calibration data, or LEMO connectors (no ID chip lines present) are used, the axis displacement has to be recalibrated after the P-56x, controller, extension cable, or adapter cable has been replaced. ➤ Recalibrate the axis displacement (see controller manual) or contact our customer service department (p. 37).

Problem	Possible causes	Solution
	Axes were mixed up during connection (only with LEMO connectors)	➤ Pay attention to the assignment of the axes when connecting the positioner to the controller. This assignment is indicated by labels on the devices.
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"> 1. Switch off the servo mode of the corresponding motion axes immediately. 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, operate the positioner only with a frequency that is below the resonant frequency.

If the problem 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).

- 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. 2).

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>).

In this Chapter

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Torque for Stainless Steel Screws (A2-70)	44
Pin Assignment	45

10.1 Specifications

10.1.1 Data Table

Motion	P-561.3CD	P-561.3CL	P-561.3DD	P-562.3CD	P-562.3CL	P-563.3CD	P-563.3CL	Tolerance
Active axes	X, Y, Z	X, Y, Z	X, Y, Z	X, Y, Z	X, Y, Z	X, Y, Z	X, Y, Z	
Travel range in X	100 μm	100 μm	45 μm	200 μm	200 μm	300 μm	300 μm	
Travel range in Y	100 μm	100 μm	45 μm	200 μm	200 μm	300 μm	300 μm	
Travel range in Z	100 μm	100 μm	15 μm	200 μm	200 μm	300 μm	300 μm	
Travel range in X, open loop, at -20 to 120 V	150 μm	150 μm	58 μm	300 μm	300 μm	340 μm	340 μm	+20 / -0 %
Travel range in Y, open loop, at -20 to +120 V	150 μm	150 μm	58 μm	300 μm	300 μm	340 μm	340 μm	+20 / -0 %
Travel range in Z, open loop, at -20 to 120 V	150 μm	150 μm	18 μm	300 μm	300 μm	340 μm	340 μm	+20 / -0 %
Linearity error in X	0.03 %	0.03 %	0.03 %*	0.03 %	0.03 %	0.03 %	0.03 %	max.
Linearity error in Y	0.03 %	0.03 %	0.03 %*	0.03 %	0.03 %	0.03 %	0.03 %	max.
Linearity error in Z	0.03 %	0.03 %	0.08 %*	0.03 %	0.03 %	0.03 %	0.03 %	max.
Flatness (Linear crosstalk in X with motion in Z)	$\pm 30 \text{ nm}$	$\pm 30 \text{ nm}$	$\pm 20 \text{ nm}$	$\pm 50 \text{ nm}$	$\pm 50 \text{ nm}$	$\pm 50 \text{ nm}$	$\pm 50 \text{ nm}$	typ.
Straightness (Linear crosstalk in Y with motion in Z)	$\pm 30 \text{ nm}$	$\pm 30 \text{ nm}$	$\pm 20 \text{ nm}$	$\pm 50 \text{ nm}$	$\pm 50 \text{ nm}$	$\pm 50 \text{ nm}$	$\pm 50 \text{ nm}$	typ.
Flatness (Linear crosstalk in Z with motion in X)	$\pm 15 \text{ nm}$	$\pm 15 \text{ nm}$	$\pm 10 \text{ nm}$	$\pm 20 \text{ nm}$	$\pm 20 \text{ nm}$	$\pm 25 \text{ nm}$	$\pm 25 \text{ nm}$	typ.
Flatness (Linear crosstalk in Z with motion in Y)	$\pm 15 \text{ nm}$	$\pm 15 \text{ nm}$	$\pm 10 \text{ nm}$	$\pm 20 \text{ nm}$	$\pm 20 \text{ nm}$	$\pm 25 \text{ nm}$	$\pm 25 \text{ nm}$	typ.
Pitch (Rotational crosstalk in θ_X with motion in Y)	$\pm 1 \mu\text{rad}$	$\pm 1 \mu\text{rad}$	$\pm 3 \mu\text{rad}$	$\pm 2 \mu\text{rad}$	$\pm 2 \mu\text{rad}$	$\pm 2 \mu\text{rad}$	$\pm 2 \mu\text{rad}$	typ.
Yaw (Rotational crosstalk in θ_X with motion in Z)	$\pm 15 \mu\text{rad}$	$\pm 15 \mu\text{rad}$	$\pm 3 \mu\text{rad}$	$\pm 20 \mu\text{rad}$	$\pm 20 \mu\text{rad}$	$\pm 25 \mu\text{rad}$	$\pm 25 \mu\text{rad}$	typ.

Motion	P-561.3CD	P-561.3CL	P-561.3DD	P-562.3CD	P-562.3CL	P-563.3CD	P-563.3CL	Tolerance
Pitch (Rotational crosstalk in θ_Y with motion in X)	$\pm 1 \mu\text{rad}$	$\pm 1 \mu\text{rad}$	$\pm 3 \mu\text{rad}$	$\pm 2 \mu\text{rad}$	$\pm 2 \mu\text{rad}$	$\pm 2 \mu\text{rad}$	$\pm 2 \mu\text{rad}$	typ.
Pitch (Rotational crosstalk in θ_Y with motion in Z)	$\pm 15 \mu\text{rad}$	$\pm 15 \mu\text{rad}$	$\pm 3 \mu\text{rad}$	$\pm 20 \mu\text{rad}$	$\pm 20 \mu\text{rad}$	$\pm 25 \mu\text{rad}$	$\pm 25 \mu\text{rad}$	typ.
Yaw (Rotational crosstalk in θ_Z with motion in X)	$\pm 6 \mu\text{rad}$	$\pm 6 \mu\text{rad}$	$\pm 3 \mu\text{rad}$	$\pm 10 \mu\text{rad}$	$\pm 10 \mu\text{rad}$	$\pm 10 \mu\text{rad}$	$\pm 10 \mu\text{rad}$	typ.
Yaw (Rotational crosstalk in θ_Z with motion in Y)	$\pm 6 \mu\text{rad}$	$\pm 6 \mu\text{rad}$	$\pm 3 \mu\text{rad}$	$\pm 10 \mu\text{rad}$	$\pm 10 \mu\text{rad}$	$\pm 10 \mu\text{rad}$	$\pm 10 \mu\text{rad}$	typ.

Positioning	P-561.3CD	P-561.3CL	P-561.3DD	P-562.3CD	P-562.3CL	P-563.3CD	P-563.3CL	Tolerance
Unidirectional repeatability in X	$\pm 2 \text{ nm}$	$\pm 2 \text{ nm}$	$\pm 2 \text{ nm}$	$\pm 2 \text{ nm}$	$\pm 2 \text{ nm}$	$\pm 2 \text{ nm}$	$\pm 2 \text{ nm}$	typ.
Unidirectional repeatability in Y	$\pm 2 \text{ nm}$	$\pm 2 \text{ nm}$	$\pm 2 \text{ nm}$	$\pm 2 \text{ nm}$	$\pm 2 \text{ nm}$	$\pm 2 \text{ nm}$	$\pm 2 \text{ nm}$	typ.
Unidirectional repeatability in Z	$\pm 2 \text{ nm}$	$\pm 2 \text{ nm}$	$\pm 2 \text{ nm}$	$\pm 4 \text{ nm}$	$\pm 4 \text{ nm}$	$\pm 4 \text{ nm}$	$\pm 4 \text{ nm}$	typ.
Resolution in X, open loop	0.2 nm	0.2 nm	0.1 nm	0.4 nm	0.4 nm	0.5 nm	0.5 nm	typ.
Resolution in Y, open loop	0.2 nm	0.2 nm	0.1 nm	0.4 nm	0.4 nm	0.5 nm	0.5 nm	typ.
Resolution in Z, open loop	0.2 nm	0.2 nm	0.1 nm	0.4 nm	0.4 nm	0.5 nm	0.5 nm	typ.
Integrated sensor	Capacitive, indirect position measuring	Capacitive, indirect position measuring	Capacitive, indirect position measuring	Capacitive, indirect position measuring	Capacitive, indirect position measuring	Capacitive, indirect position measuring	Capacitive, indirect position measuring	
System resolution in X	0.8 nm	0.8 nm	0.2 nm	1 nm	1 nm	2 nm	2 nm	
System resolution in Y	0.8 nm	0.8 nm	0.2 nm	1 nm	1 nm	2 nm	2 nm	
System resolution in Z	0.8 nm	0.8 nm	0.2 nm	1 nm	1 nm	2 nm	2 nm	

Drive properties	P-561.3CD	P-561.3CL	P-561.3DD	P-562.3CD	P-562.3CL	P-563.3CD	P-563.3CL	Tolerance
Drive type	PICMA®	PICMA®	PICMA®	PICMA®	PICMA®	PICMA®	PICMA®	
Electrical capacitance in X	5.2 μF	5.2 μF	38 μF	7.4 μF	7.4 μF	7.4 μF	7.4 μF	$\pm 20 \%$
Electrical capacitance in Y	5.2 μF	5.2 μF	38 μF	7.4 μF	7.4 μF	7.4 μF	7.4 μF	$\pm 20 \%$
Electrical capacitance in Z	10.4 μF	10.4 μF	6 μF	14.8 μF	14.8 μF	14.8 μF	14.8 μF	$\pm 20 \%$

Mechanical properties	P-561.3CD	P-561.3CL	P-561.3DD	P-562.3CD	P-562.3CL	P-563.3CD	P-563.3CL	Tolerance
Resonant frequency in X, unloaded	190 Hz	190 Hz	920 Hz	160 Hz	160 Hz	140 Hz	140 Hz	$\pm 20 \%$
Resonant frequency in X, under load with 350 g	150 Hz	150 Hz	640 Hz	125 Hz	125 Hz	93 Hz	93 Hz	$\pm 20 \%$
Resonant frequency in Y, unloaded	190 Hz	190 Hz	920 Hz	160 Hz	160 Hz	140 Hz	140 Hz	$\pm 20 \%$
Resonant frequency in Y, under load with 350 g	150 Hz	150 Hz	640 Hz	125 Hz	125 Hz	93 Hz	93 Hz	$\pm 20 \%$
Resonant frequency in Z, unloaded	380 Hz	380 Hz	1050 Hz	315 Hz	315 Hz	250 Hz	250 Hz	$\pm 20 \%$
Resonant frequency in Z, under load with 350 g	260 Hz	260 Hz	695 Hz	211 Hz	211 Hz	148 Hz	148 Hz	$\pm 20 \%$
Permissible push force in X	60 N	60 N	200 N	50 N	50 N	40 N	40 N	max.
Permissible push force in Y	60 N	60 N	200 N	50 N	50 N	40 N	40 N	max.
Permissible push force in Z	100 N	100 N	250 N	60 N	60 N	30 N	30 N	max.
Permissible pull force in X	40 N	40 N	70 N	40 N	40 N	30 N	30 N	max.
Permissible pull force in Y	40 N	40 N	70 N	40 N	40 N	30 N	30 N	max.
Permissible pull force in Z	100 N	100 N	60 N	60 N	60 N	30 N	30 N	max.

Mechanical properties	P-561.3CD	P-561.3CL	P-561.3DD	P-562.3CD	P-562.3CL	P-563.3CD	P-563.3CL	Tolerance
Guide	Flexure guide with lever amplification	Flexure guide with lever amplification	Flexure guide with direct drive	Flexure guide with lever amplification	Flexure guide with lever amplification	Flexure guide with lever amplification	Flexure guide with lever amplification	
Overall mass	1450 g	1450 g	1550 g	1450 g	1450 g	1450 g	1450 g	±5 %
Material	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	
Resonant frequency in X, under load with 100 g			860 Hz	145 Hz	145 Hz	120 Hz	120 Hz	±20 %
Resonant frequency in Y, under load with 100 g			860 Hz	145 Hz	145 Hz	120 Hz	120 Hz	±20 %
Resonant frequency in Z, under load with 100 g			950 Hz	275 Hz	275 Hz	215 Hz	215 Hz	±20 %

Miscellaneous	P-561.3CD	P-561.3CL	P-561.3DD	P-562.3CD	P-562.3CL	P-563.3CD	P-563.3CL	Tolerance
Operating temperature range	-20 to 80 °C	-20 to 80 °C	-20 to 80 °C	-20 to 80 °C	-20 to 80 °C	-20 to 80 °C	-20 to 80 °C	
Connector	D-sub 25W3 (m)	LEMO LVPZT	D-sub 25W3 (m)	D-sub 25W3 (m)	LEMO LVPZT	D-sub 25W3 (m)	LEMO LVPZT	
Cable length	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m	+50 / -0 mm
Recommended controllers / drivers	E-503, E-505, E-621, E-712, E-727	E-503, E-505, E-621, E-712, E-727	E-503, E-505, E-621, E-712, E-727	E-503, E-505, E-621, E-712, E-727	E-503, E-505, E-621, E-712, E-727	E-503, E-505, E-621, E-712, E-727	E-503, E-505, E-621, E-712, E-727	

* With digital controller. Nonlinearity of direct drive positioners measured with analog controllers is typically up to 0.1 %.

Parallel kinematics only available for the X and Y axes (not in Z).




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.

Super Invar and titanium versions available.

Ask about customized versions.

10.1.2 Maximum Ratings

P-56x positioners are designed for the following operating parameters:

Model	Maximum operating voltage 	Maximum operating frequency (unloaded) 	Maximum power consumption 
P-561.3CD P-561.3CL	-20 to +120 V	63 Hz (in X and Y) 126 Hz (in Z)	15 W (in X and Y) 30 W (in Z)
P-561.3DD	-20 to +120 V	306 Hz (in X and Y) 350 Hz (in Z)	34 W (in X and Y) 17 W (in Z)
P-562.3CD P-562.3CL	-20 to +120 V	53 Hz (in X and Y) 105 Hz (in Z)	21 W (in X and Y) 43 W (in Z)
P-563.3CD P-563.3CL	-20 to +120 V	46 Hz (in X and Y) 83 Hz (in Z)	21 W (in X and Y) 43 W (in Z)

10.2 Ambient Conditions and Classifications

Pay attention to the following ambient conditions and classifications for the P-56x:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 700 hPa
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

10.3 Dimensions

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

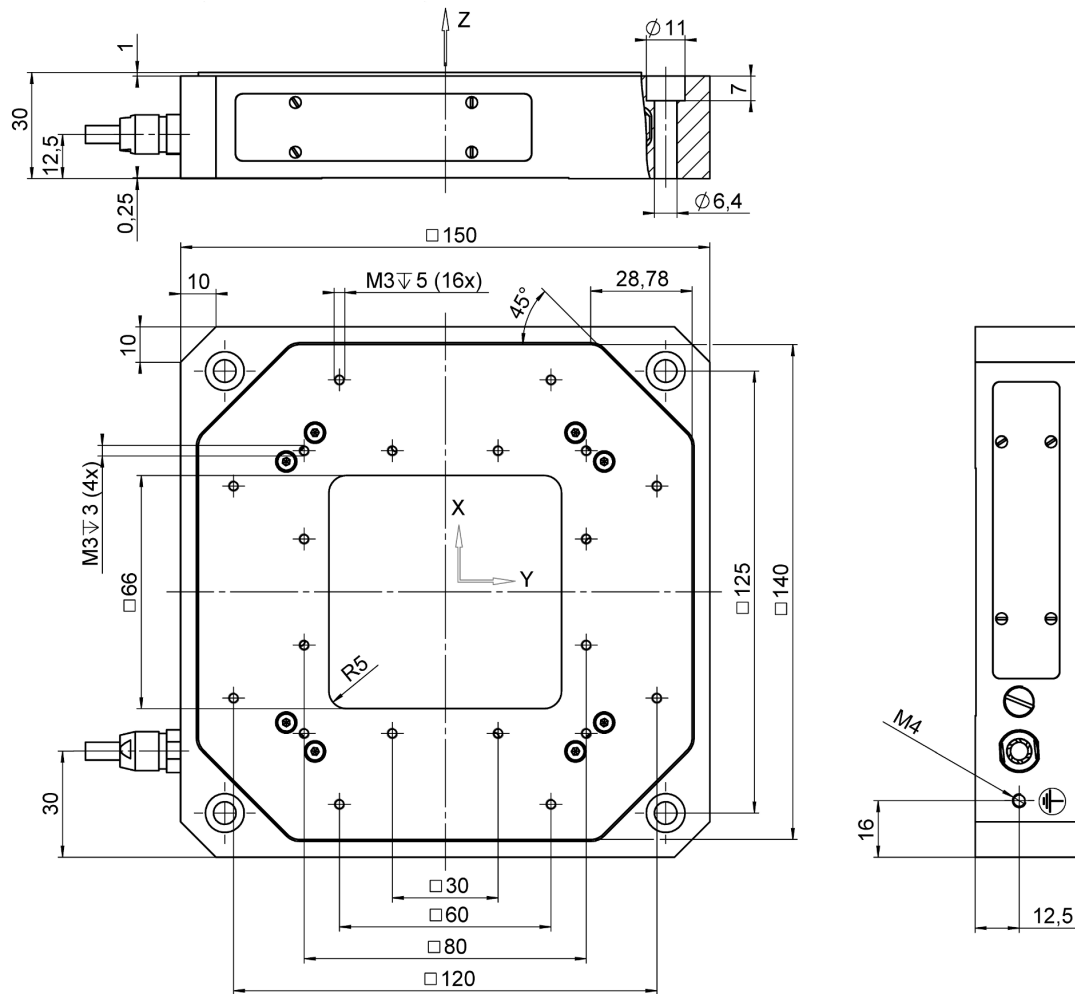


Figure 11: P-56x.3CD and P-56x.3CL

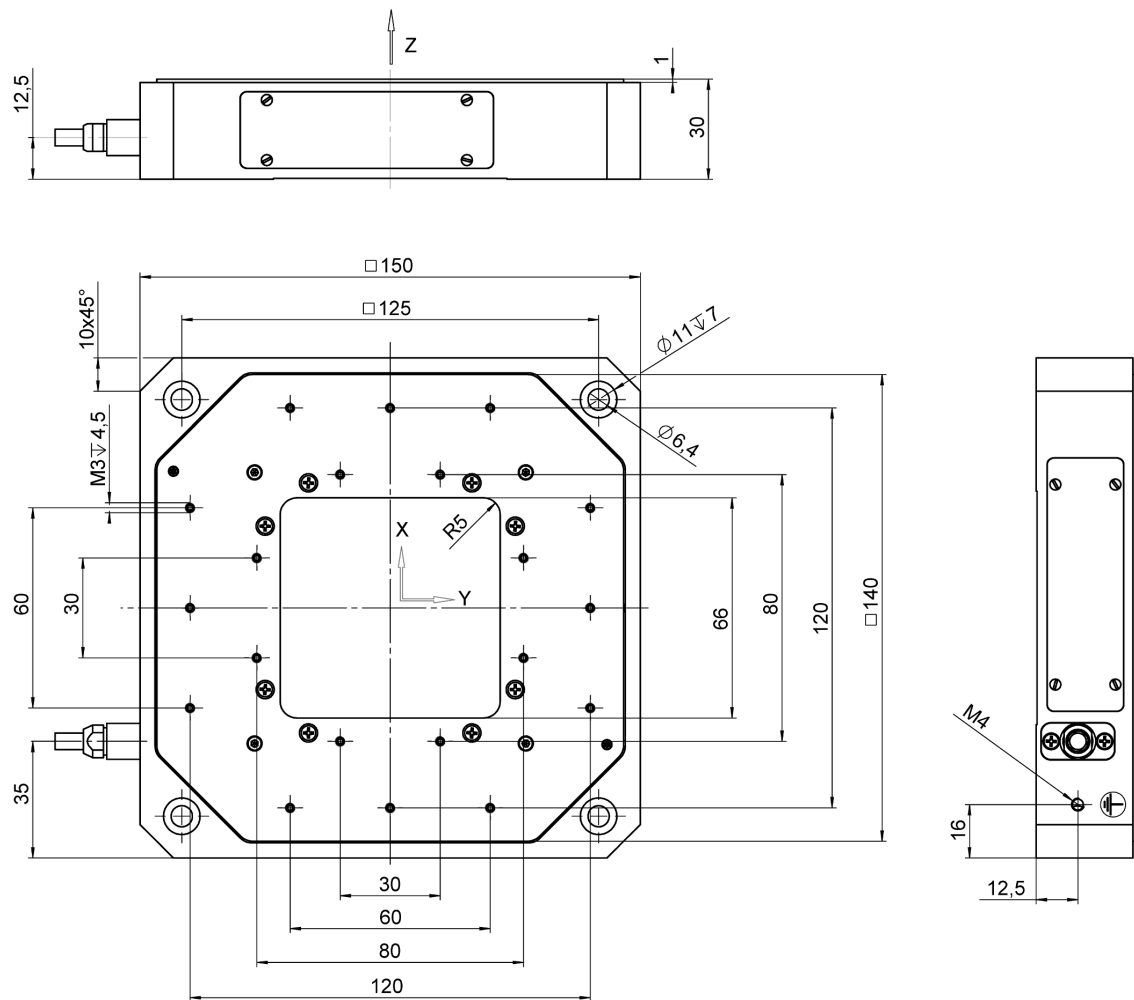


Figure 12: P-561.3DD

10.4 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.

10.5 Pin Assignment

D-sub 25W3 (m) connector

Only for P-56x.3CD/.3DD:

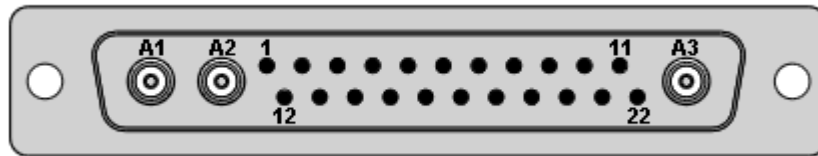


Figure 13: D-sub 25W3 connector (m): Front with connections

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

LEMO coaxial connector

Only for P-56x.3CL (one PZT, P and T connector each per axis):



Figure 14: LEMO connectors: PZT, P and T

Connector	Signal	Function	Connector Shell
P	Output	Probe sensor signal (immovable part of the capacitive sensor)	Cable shield
T	Input	Target sensor signal (movable part of the capacitive sensor)	Cable shield
PZT	Input	Piezo voltage	Ground

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-56x, 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