PZ280E
P-612 Positioning Systems
User Manual

Version: 1.0.0       Date: 27.04.2017

This document describes the following products:

- **P-612.2**
  XY piezo nanopositioning stage

- **P-612.Z**
  Piezo Z stage
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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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First printing: 27.04.2017
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Subject to change without notice. This manual is superseded by any new release. The latest release is available for download (p. 3) on our website.
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1 About this Document

In this Chapter

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1.1 Objective and Target Audience of this User Manual

This user manual contains the necessary information for the intended use of the P-612 (x stands for the different models, p. 9).

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

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

1.2 Symbols and Typographic Conventions

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

CAUTION

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

Actions to take to avoid the situation.

NOTICE

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

Actions to take to avoid the situation.

INFORMATION

Information for easier handling, tricks, tips, etc.
# 1 About this Document

## Symbol/Label Meaning

1. Action consisting of several steps whose sequential order must be observed
2. 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 sign on the product which refers to detailed information in this manual.

## 1.3 Figures

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

## 1.4 Other Applicable Documents

The devices and software tools that are mentioned in this documentation are described in their own manuals.

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

<table>
<thead>
<tr>
<th>Component</th>
<th>Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-500/E-501 modular piezo controller</td>
<td>PZ62E user manual</td>
</tr>
<tr>
<td>E-505 piezo amplifier module</td>
<td>PZ62E user manual</td>
</tr>
<tr>
<td>E-509 sensor / servo controller module</td>
<td>PZ77E user manual</td>
</tr>
<tr>
<td>E-610 piezo amplifier / servo controller</td>
<td>PZ70E user manual</td>
</tr>
<tr>
<td>E-621 servo controller module</td>
<td>PZ115E user manual</td>
</tr>
<tr>
<td>E-625 piezo servo controller</td>
<td>PZ166E user manual</td>
</tr>
<tr>
<td>E-665 piezo amplifier / controller</td>
<td>PZ127E user manual</td>
</tr>
<tr>
<td>E-836 piezo amplifier (benchtop)</td>
<td>PZ250E user manual</td>
</tr>
<tr>
<td>E-836 piezo amplifier (OEM module)</td>
<td>E836T0001</td>
</tr>
<tr>
<td>PI MikroMove</td>
<td>SM148E software manual</td>
</tr>
<tr>
<td>P-5xx / P-6xx / P-7xx piezo positioning systems</td>
<td>PZ240EK short instructions</td>
</tr>
</tbody>
</table>
1.5 Downloading Manuals

**INFORMATION**
If a manual is missing or problems occur with downloading:
- Contact our customer service department (p. 33).

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

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

Downloading manuals
1. Open the website [www.pi.ws](http://www.pi.ws).
2. If access to the manuals is protected by a password:
   a) Click **Login**.
   b) Log in with the user name and password.
3. Click **Search**.
4. Enter the product number up to the period (e.g., P-882) or the product family (e.g., PICMA® Bender) into the search field.
5. Click **Start search** or press the **Enter** key.
6. Open the corresponding product detail page in the list of search results:
   a) If necessary: Scroll down the list.
   b) If necessary: Click **Load more results** at the end of the list.
   c) Click the corresponding product in the list.
7. Scroll down to the **Downloads** section on the product detail page.
The manuals are displayed under **Documentation**.
8. Click the desired manual and save it to the hard disk of your PC or to a data storage medium.
2 Safety

In this Chapter

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Organizational Measures ................................................................................................................ 7

2.1 Intended Use

The P-612 is a laboratory device as defined by DIN EN 61010-1. It is intended for indoor use and use in an environment that is free of dirt, oil, and lubricants.

Based on its design and realization, the P-612 is intended for fine positioning as well as the fast and precise motion of small objects. The specifications of the P-612 apply to horizontal mounting. Depending on the version, the motion is performed as follows:

<table>
<thead>
<tr>
<th>Model</th>
<th>Motion</th>
<th>Axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-612.2SL</td>
<td>On two axes horizontally</td>
<td>X, Y</td>
</tr>
<tr>
<td>P-612.20L</td>
<td>On one axis vertically</td>
<td>Z</td>
</tr>
</tbody>
</table>

Vertical mounting is only possible under certain conditions.

The intended use of the P-612 is only possible in conjunction with suitable electronics (p. 11) available from PI. The electronics are not included in the scope of delivery of the P-612.

The electronics must provide the required operating voltages. When models with position sensors are connected, the electronics must also be able to read out and process the signals from the position sensors so that the servo-control system can function properly.
2.2 General Safety Instructions

The P-612 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-612.

- Only use the P-612 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-612.

The P-612 is driven by piezo actuators. Temperature changes and compressive stresses can induce charges in piezo actuators. After disconnection from the electronics, piezo actuators can remain charged for several hours. Touching or short-circuiting the contacts in the connector of the P-612 can lead to minor injuries from electric shock. The piezo actuators can be destroyed by an abrupt contraction.

- Do not open the P-612.
- Discharge the piezo actuators of the stage before installation:
  Connect the stage to the switched-off PI controller, which is equipped with an internal discharge resistor.
- Do not pull the connector out of the electronics during operation.

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the P-612 in the case of malfunction or failure of the system. If touch voltages exist, touching the P-612 can result in minor injuries from electric shock.

- Connect the P-612 to a protective earth conductor (p. 18) before start-up.
- Do not remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e.g., in the case of modifications), reconnect the P-612 to the protective earth conductor before starting it up again.

Mechanical forces can damage or misalign the P-612.

- Avoid impacts that affect the P-612.
- Do not drop the P-612.
- Do not exceed the maximum permissible stress and load capacities according to the specifications (p. 35).
- Only hold the P-612 externally by the base body.
2 Safety

The P-612 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-612.

2.3 Organizational Measures

User manual

- Always keep this user manual available with the P-612. The latest versions of the user manuals are available for download (p. 3) on our website.
- Add all information from the manufacturer to the user manual, for example supplements or technical notes.
- If you give the P-612 to other users, also include this user manual as well as other relevant information provided by the manufacturer.
- Only use the device on the basis of the complete user manual. Missing information due to an incomplete user manual can result in minor injury and damage to equipment.
- Only install and operate the P-612 after you have read and understood this user manual.

Personnel qualification

The P-612 may only be installed, started up, operated, maintained, and cleaned by authorized and appropriately qualified personnel.
3 Product Description

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Scope of Delivery ............................................................... 11
Suitable Electronics ........................................................... 11
Accessories ......................................................................... 12
Technical Features ........................................................... 13

3.1 Model Overview

<table>
<thead>
<tr>
<th>Product number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-612.2SL</td>
<td>XY nanopositioning system, 100 µm × 100 µm, 20 mm × 20 mm aperture, strain gauge sensors</td>
</tr>
<tr>
<td>P-612.20L</td>
<td>XY nanopositioning system, 130 µm × 130 µm, 20 mm × 20 mm aperture, open-loop</td>
</tr>
<tr>
<td>P-612.ZSL</td>
<td>Vertical nanopositioning stage, 100 µm, 20 mm × 20 mm aperture, strain gauge sensor</td>
</tr>
<tr>
<td>P-612.Z0L</td>
<td>Vertical nanopositioning stage, 110 µm, 20 mm × 20 mm aperture, open-loop</td>
</tr>
</tbody>
</table>
3.2 Product View

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

Figure 1: Example product view of a P-612.2SL

1. Motion platform
2. Piezo voltage connecting cable
3. Sensor connecting cable (depending on model type)
4. Protective earth connection
5. Base body

Figure 2: Positive direction of motion of the X axis and Y axis (P-612.2xL)

Figure 3: Positive direction of motion of the Z axis (P-612.ZxL)
3.3 Product Labeling

<table>
<thead>
<tr>
<th>Labeling</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-612.25L</td>
<td>Product number (example), the digits after the period refer to the model</td>
</tr>
<tr>
<td>117007748</td>
<td>Serial number (example), individual for each P-612</td>
</tr>
<tr>
<td></td>
<td>Meaning of the places (counting from left):</td>
</tr>
<tr>
<td></td>
<td>1 = internal information</td>
</tr>
<tr>
<td></td>
<td>2 and 3 = year of manufacture</td>
</tr>
<tr>
<td></td>
<td>4 to 9 = consecutive numbers</td>
</tr>
</tbody>
</table>

PI

Manufacturer's logo

⚠️

Warning sign "Observe manual!"

ocaust origin: Germany

Country of origin: Germany

Country of origin

WWW.PI.WS

Manufacturer's address (website)

CE

CE conformity mark

️

Symbol for the protective earth conductor (p. 18)

3.4 Scope of Delivery

<table>
<thead>
<tr>
<th>Product number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-612</td>
<td>Stage according to order (p. 9)</td>
</tr>
<tr>
<td>000036450</td>
<td>M4 screw set for protective earth, consisting of:</td>
</tr>
<tr>
<td></td>
<td>- 1 flat-head screw with cross recess, M4x8 ISO 7045</td>
</tr>
<tr>
<td></td>
<td>- 2 safety washers</td>
</tr>
<tr>
<td></td>
<td>- 2 flat washers</td>
</tr>
<tr>
<td>PZ240EK</td>
<td>Short instructions for piezo positioning systems</td>
</tr>
</tbody>
</table>

3.5 Suitable Electronics

To operate a P-612, you need suitable electronics (x = suitable).

<table>
<thead>
<tr>
<th>Electronics</th>
<th>Channels</th>
<th>P-612.2xL</th>
<th>P-612.2xL</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-610 piezo driver / controller (OEM module)</td>
<td>1</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>E-621 piezo amplifier/servo controller module</td>
<td>1</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>E-625 piezo servo controller (benchtop)</td>
<td>1</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
3.6 Accessories

<table>
<thead>
<tr>
<th>Product number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-891.01</td>
<td>Extension cable for piezo voltage, LEMO connectors, 1 m</td>
</tr>
<tr>
<td>P-891.02</td>
<td>Extension cable for piezo voltage, LEMO connectors, 2 m</td>
</tr>
<tr>
<td>P-891.03</td>
<td>Extension cable for piezo voltage, LEMO connectors, 3 m</td>
</tr>
<tr>
<td>P-891.05</td>
<td>Extension cable for piezo voltage, LEMO connectors, 5 m</td>
</tr>
<tr>
<td>P-891.10</td>
<td>Extension cable for piezo voltage, LEMO connectors, 10 m</td>
</tr>
<tr>
<td>P-892.01</td>
<td>Extension cable, for strain gauge sensors, LEMO connectors, 1 m</td>
</tr>
<tr>
<td>P-892.02</td>
<td>Extension cable, for strain gauge sensors, LEMO connectors, 2 m</td>
</tr>
<tr>
<td>P-892.03</td>
<td>Extension cable, for strain gauge sensors, LEMO connectors, 3 m</td>
</tr>
<tr>
<td>P-892.05</td>
<td>Extension cable, for strain gauge sensors, LEMO connectors, 5 m</td>
</tr>
<tr>
<td>P-892.10</td>
<td>Extension cable, for strain gauge sensors, LEMO connectors, 10 m</td>
</tr>
</tbody>
</table>

➢ To order, contact our customer service department (p. 33).
3.7 Technical Features

3.7.1 PICMA® Piezo Actuators

P-612 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 free of backlash, maintenance, and wear.

3.7.2 Flexure Guides

P-612 stages have flexure guides (flexures) for frictionless motion and high guiding accuracy.

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

3.7.3 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 motion platform is derived from a measurement on the lever, guide or piezo stack.

The sensors operate in a full bridge circuit free of drift and ensure optimum position stability in the nanometer range.
4 Unpacking

**NOTICE**

**Mechanical overload due to incorrect handling!**
An impermissible mechanical load on the motion platform of the P-612 can cause damage to the piezo actuators, sensors, and flexures of the P-612 as well as loss of accuracy.

- Only hold the P-612 externally by the base body.

1. Unpack the P-612 with care.
2. Compare the contents with the items listed in the contract and the packing list.
3. Inspect the contents for signs of damage. If there is any sign of damage or missing parts, contact PI immediately.
4. Keep all packaging materials in case the product needs to be returned.
5 Installation

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Mounting the P-612 ..................................................................................................................... 19
Affixing the Load ...................................................................................................................... 21

5.1 General Notes on Installation

**CAUTION**

Dangerous voltage and residual charge in piezo actuators!
The P-612 is driven by piezo actuators. Temperature changes and compressive stresses can induce charges in piezo actuators. After disconnection from the electronics, piezo actuators can remain charged for several hours. Touching or short-circuiting the contacts in the connector of the P-612 can lead to minor injuries from electric shock. The piezo actuators can be destroyed by an abrupt contraction.

- Do not open the P-612.
- Do not pull the connector out of the electronics during operation.

**NOTICE**

Mechanical overload due to incorrect handling!
An impermissible mechanical load on the motion platform of the P-612 can cause damage to the piezo actuators, sensors, and flexures of the P-612 as well as loss of accuracy.

- Only hold the P-612 externally by the base body.

**NOTICE**

Damage due to unsuitable cables!
Unsuitable cables can damage the P-612 and the electronics.

- Only use cables provided by PI for connecting the P-612 to the electronics.
5 Installation

NOTICE
Damage due to improper mounting!
Improper mounting of the P-612 or incorrectly mounted parts can damage the P-612.

- Only mount the P-612 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. 40) given for the screws used during installation.

INFORMATION
Extended cables can reduce the positioning accuracy of the P-612 or affect the sensor processing by the electronics.

- Do not use cable extensions. If you need longer cables, contact our customer service department (p. 33).

5.2 Connecting the P-612 to the Protective Earth Conductor

INFORMATION

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

The P-612 has an M4 hole for mounting the protective earth conductor. This hole is marked with the symbol for the protective earth conductor 🚭. For the exact position of the hole, see "Dimensions" (p. 38).

Requirements

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

Tools and accessories

- Suitable protective earth conductor: Cross-sectional area of the cable ≥ 0.75 mm²
- Supplied M4 protective earth screw set (p. 11) for connecting the protective earth conductor
- Suitable screwdriver
Connecting the P-612 to the protective earth conductor

1. If necessary, attach a suitable cable lug to the protective earth conductor.
2. Use the M4 screw (together with the washers and self-locking washers) to affix the cable lug of the protective earth conductor to the protective earth connection of the P-612 as shown in the profile view.
3. Tighten the M4 screw with a torque of 1.2 Nm to 1.5 Nm.
4. Make sure that the contact resistance at all connection points relevant for connecting the protective earth conductor is <0.1 Ω at 25 A.

5.3 Mounting the P-612

**NOTICE**

Warping of the P-612 due to mounting on uneven surfaces!
Mounting the P-612 on an uneven surface can warp the P-612. Warping reduces the accuracy.

- Mount the P-612 onto an even surface. The recommended flatness of the surface is ≤100 μm.
- For applications with large temperature changes:
  - Only mount the P-612 on surfaces that have the same or similar thermal expansion properties as the P-612.
NOTICE

Tensile stress on piezo actuator with vertical mounting!
When the stage is mounted vertically, certain alignments can cause tensile stress, which would destroy the piezo actuator.

➢ If you want to mount the P-612 vertically, contact our customer service department (p. 33).

NOTICE

Protruding screw heads!
Protruding screw heads can damage the P-612.

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

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

![Figure 5: P-612: Mounting holes in the base body (example view from above)](image)

Requirements

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

Tools and accessories

▪ Four screws of suitable size and length (p. 38)
▪ Suitable screwdriver
Mounting the stage onto a surface

1. Position the stage on an even surface.
2. Insert the screws into the countersunk holes in the base body of the P-612 from above.
3. Tighten the screws. Observe the specified torque range (p. 40) while doing so.

5.4 Affixing the Load

**NOTICE**

**Mechanical overload due to high torques and high loads!**

When affixing the load, high torques and high loads can overload the motion platform of the P-612. Mechanical overload can cause damage to the piezo actuators, sensors, and flexures of the P-612 and lead to loss in accuracy.

- Observe the torque range (p. 40) given for the screws used during installation.
- Avoid torques >0.8 Nm on the motion platform.
- Do not exceed the maximum permissible stress and load capacities according to the specifications (p. 35).

**NOTICE**

**Warping of the P-612 due to affixing of loads with uneven contact surface!**

Affixing loads with an uneven contact surface can warp the P-612. Warping reduces the accuracy.

- Only affix loads on the P-612 whose contact surface with the motion platform of the stage has a flatness of at least 100 μm.
- For applications with large temperature changes:
  Only affix loads to the P-612 that have the same or similar thermal expansion properties as the P-612.

**NOTICE**

**Center of load at unsuitable position!**

If the center of load is located too far away from the center of the motion platform (e.g., tall loads and unwanted lever effect), the P-612 can be damaged by high strain on the flexure guides, high torques, and oscillation, especially when operated dynamically.

- If the center of the load to be affixed is too far above or to the side of the motion platform, adjust the controller settings before start-up or contact our customer service department (p. 33).
NOTICE

Screws that are too long!
The P-612 can be damaged by screws that are too long.

- Note the depth of the mounting holes in the motion platform (p. 38).
- Only use screws of the correct length for the respective mounting holes.

INFORMATION

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

Center of load at the optimum position:

![Figure 6: Example of an optimally placed load](image)

Figure 6: Example of an optimally placed load

Center of load at an unsuitable position:

![Figure 7: Tall load and center of load too far above the motion platform](image)

Figure 7: Tall load and center of load too far above the motion platform

![Figure 8: Unwanted lever effect and center of load on the side of the motion platform](image)

Figure 8: Unwanted lever effect and center of load on the side of the motion platform
Requirements

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

Tools and accessories

- Screws of appropriate size and length (p. 38)
- Suitable tools

Affixing the Load

➢ Only affix loads to the threaded holes (p. 38) intended for this purpose and with suitable screws. While doing so, observe the torque range (p. 40) specified for the screws, and avoid torques >0.8 Nm on the motion platform.

➢ Affix the load so that it is centered and that the center of load is on the motion platform.
6 Start-Up and Operation

In this Chapter

General Notes on Start-Up and Operation ................................................................. 25
Operating the P-612 ................................................................................................. 27
Discharging the P-612 ............................................................................................ 27

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-612 in the case of malfunction or failure of the system. If touch voltages exist, touching the P-612 can result in minor injuries from electric shock.

- Connect the P-612 to a protective earth conductor (p. 18) before start-up.
- Do not remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e.g., in the case of modifications), reconnect the P-612 to the protective earth conductor before starting it up again.

**NOTICE**

Destruction of the piezo actuator due to electric flashovers!

Using the P-612 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-612 in environments that can increase the electric conductivity.
- Only operate the P-612 within the permissible ambient conditions and classifications (p. 37).
6 Start-Up and Operation

**NOTICE**

**Reduced lifetime of the piezo actuator due to permanently high voltage!**
The permanent application of a high static voltage to piezo actuators leads to a considerable reduction in the lifetime of the piezo ceramic.
- When the P-612 is not used but the controller remains switched on to ensure temperature stability, discharge the P-612 (p. 27).

**NOTICE**

**Operating voltage too high or incorrectly connected!**
Operating voltages that are too high or incorrectly connected can cause damage to the P-612.
- Only operate the P-612 with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 37) for which the P-612 is specified.
- Only operate the P-612 when the operating voltage is properly connected; see "Pin Assignment" (p. 40).

**NOTICE**

**Uncontrolled oscillation!**
Oscillation can cause irreparable damage to the stage. Oscillation is indicated by a humming and can be caused by the following:
- A change in the load and/or dynamics requires the servo-control parameters to be adjusted.
- The stage is operated near to its resonant frequency.
If you notice oscillation:
- In closed-loop operation, immediately switch off the servo mode.
- In open-loop operation, immediately stop the stage.

**INFORMATION**

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

**INFORMATION**

Sound and vibration (e.g., footfall, knocks) can be transmitted to the P-612 and can affect its performance with regard to position stability.
- Avoid sound and vibration while the P-612 is being operated.
6.2 Operating the P-612

- For starting up and operating the P-612, follow the instructions in the manual of the electronics (p. 11) used.

6.3 Discharging the P-612

The P-612 must be discharged in the following cases:

- Before installation
- If the P-612 is not used but the controller remains switched on to ensure temperature stability
- Before demounting (e.g., before cleaning and transporting the P-612 and for modifications)

The P-612 is discharged via the internal discharge resistor of the controller from PI.

Discharging an P-612 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 an P-612 that is not connected to the controller

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

In this Chapter

General Notes on Maintenance ................................................................. 29
Cleaning the P-612 ................................................................................... 29

7.1 General Notes on Maintenance

NOTICE

Misalignment due to loosening screws!
The P-612 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-612.

7.2 Cleaning the P-612

Requirements

✓ You have discharged the piezo actuators of the P-612 (p. 27).
✓ You have disconnected the P-612 from the controller.

Cleaning the P-612

➤ Clean the surfaces of the P-612 with a cloth that is dampened with a mild cleanser or disinfectant (e.g., ethanol or isopropyl alcohol).
➤ Do not do any ultrasonic cleaning.
## Troubleshooting

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible causes</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>No or limited motion</td>
<td>Cable not connected correctly</td>
<td>➢ Check the cable connections.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excessive load</td>
<td></td>
<td>➢ Do not exceed the maximum permissible stress and load capacities according to the specifications (p. 35).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero shift of the sensor for the following reasons:</td>
<td></td>
<td>➢ Perform a zero-point adjustment of the sensor (see controller manual).</td>
</tr>
<tr>
<td>– Load in direction of motion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Ambient/operating temperature of the stage is far above or below the calibration temperature (21 °C to 24 °C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced accuracy</td>
<td>Warping of the base body or the motion platform</td>
<td>➢ Only mount the P-612 on surfaces with the following characteristics:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Flatness of at least 100 μm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– The thermal expansion properties are similar to those of the P-612 (e. g. surfaces made of aluminum).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>➢ Only affix loads with the following characteristics on the P-612:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– The contact surface of the load has an flatness of at least 100 μm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– The thermal expansion properties are similar to those of the P-612 (e. g. loads made of aluminum).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-612 or controller has been replaced</td>
<td>After the P-612 or controller has been replaced, it is necessary to recalibrate the axis displacement.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>➢ Perform a recalibration of the axis displacement (see controller manual) or contact our customer service department (p. 33).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Axes were mixed up during connection</td>
<td>➢ Observe the assignment of the axes when connecting the stage to the controller. This assignment is indicated by labels on the devices.</td>
<td></td>
</tr>
<tr>
<td>Problem</td>
<td>Possible causes</td>
<td>Solution</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>The stage is not connected to the corresponding controller (only with several systems)</td>
<td>➢ Observe the assignment of the devices when several systems are connected. The assignment is indicated on the calibration label of the controller (see rear panel or bottom side), which contains the serial number of the stage to be connected.</td>
<td></td>
</tr>
</tbody>
</table>
| The stage starts oscillating or positions inaccurately                  | Servo-control parameters incorrectly set because for example, 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. 33).
9 Customer Service

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

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

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

In this Chapter

- Specifications ............................................................................................................................... 35
- Dimensions .................................................................................................................................. 38
- Torque for Stainless Steel Screws (A2-70) ................................................................................... 40
- Pin Assignment ........................................................................................................................... 40

### 10.1 Specifications

#### 10.1.1 Data Table

<table>
<thead>
<tr>
<th>Active axes</th>
<th>P-612.2SL</th>
<th>P-612.20L</th>
<th>Unit</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>X, Y</td>
<td>X, Y</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Motion and positioning**

<table>
<thead>
<tr>
<th>Integrated sensor</th>
<th>SGS</th>
<th>-</th>
<th>μm</th>
<th>min. (20% / -0%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open-loop travel, -20 to +120 V</td>
<td>130</td>
<td>130</td>
<td>μm</td>
<td></td>
</tr>
<tr>
<td>Closed-loop travel range</td>
<td>100</td>
<td>-</td>
<td>μm</td>
<td></td>
</tr>
<tr>
<td>Open-loop resolution</td>
<td>0.8</td>
<td>0.8</td>
<td>nm</td>
<td>typ.</td>
</tr>
<tr>
<td>Closed-loop resolution</td>
<td>5</td>
<td>-</td>
<td>nm</td>
<td>typ.</td>
</tr>
<tr>
<td>Linearity error</td>
<td>0.4</td>
<td>-</td>
<td>%</td>
<td>typ.</td>
</tr>
<tr>
<td>Repeatability</td>
<td>&lt;10</td>
<td>-</td>
<td>nm</td>
<td>typ.</td>
</tr>
<tr>
<td>Pitch</td>
<td>±10</td>
<td>±10</td>
<td>μrad</td>
<td>typ.</td>
</tr>
<tr>
<td>Yaw in X / Y</td>
<td>±10 / ±50</td>
<td>±10 / ±50</td>
<td>μrad</td>
<td>typ.</td>
</tr>
</tbody>
</table>

**Mechanical properties**

| Stiffness | 0.15 | 0.15 | N/μm | ±20% |
| Resonant frequency, no load | 400 | 400 | Hz | ±20% |
| Resonant frequency @ 100 g | 200 | 200 | Hz | ±20% |
| Compressive/tensile stress capacity in motion direction | 15 / 5 | 15 / 5 | N | max. |

| Load capacity | 15 | 15 | N | max. |

**Drive properties**

<table>
<thead>
<tr>
<th>Ceramic type</th>
<th>PICMA® P-885</th>
<th>PICMA® P-885</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical capacitance</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Dynamic operating current coefficient</td>
<td>1.9</td>
<td>1.9</td>
</tr>
</tbody>
</table>
## Technical Data

<table>
<thead>
<tr>
<th>Miscellaneous</th>
<th>P-612.2SL</th>
<th>P-612.20L</th>
<th>Unit</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature range</td>
<td>-20 to 80</td>
<td>-20 to 80</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>Aluminum, steel</td>
<td>Aluminum, steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>105</td>
<td>105</td>
<td>g</td>
<td>±5 %</td>
</tr>
<tr>
<td>Cable length</td>
<td>1.5</td>
<td>1.5</td>
<td>m</td>
<td>±10 mm</td>
</tr>
<tr>
<td>Sensor/voltage connection</td>
<td>LEMO</td>
<td>LEMO (no sensor)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The resolution of PI piezo nanopositioners is not limited by friction or stiction. Value given is noise equivalent motion with E-503 amplifier.

<table>
<thead>
<tr>
<th>Active axes</th>
<th>P-612.ZSL</th>
<th>P-612.Z0L</th>
<th>Unit</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motion and positioning</td>
<td>Z</td>
<td>Z</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated sensor</td>
<td>SGS</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open-loop travel, -20 to +120 V</td>
<td>110</td>
<td>110</td>
<td>μm</td>
<td>min. (20 % / -0 %)</td>
</tr>
<tr>
<td>Closed-loop travel range</td>
<td>100</td>
<td>-</td>
<td>μm</td>
<td></td>
</tr>
<tr>
<td>Open-loop resolution</td>
<td>0.2</td>
<td>0.2</td>
<td>nm</td>
<td>typ.</td>
</tr>
<tr>
<td>Closed-loop resolution</td>
<td>1.5</td>
<td>-</td>
<td>nm</td>
<td>typ.</td>
</tr>
<tr>
<td>Linearity error, closed-loop</td>
<td>0.2</td>
<td>-</td>
<td>%</td>
<td>typ.</td>
</tr>
<tr>
<td>Repeatability</td>
<td>±4</td>
<td>-</td>
<td>nm</td>
<td>typ.</td>
</tr>
<tr>
<td>Runout θ_x, θ_y</td>
<td>±10</td>
<td>±10</td>
<td>μrad</td>
<td>typ.</td>
</tr>
<tr>
<td>Crosstalk in X, Y</td>
<td>±20</td>
<td>±20</td>
<td>μm</td>
<td>typ.</td>
</tr>
</tbody>
</table>

### Mechanical properties

| Stiffness in motion direction | 0.63 | 0.63 | N/μm | ±20 % |
| Resonant frequency, no load | 490 | 490 | Hz | ±20 % |
| Resonant frequency under load | 420 (30 g) | 420 (30 g) | Hz | ±20 % |
| Load capacity | 15 / 10 | 15 / 10 | N | max. |

### Drive properties

| Ceramic type | PICMA® P-885 | PICMA® P-885 |
| Electric capacitance | 3 | 3 | μF | ±20 % |
| Dynamic operating current coefficient | 3.8 | 3.8 | μA/(Hz×μm) | ±20 % |

### Miscellaneous

| Operating temperature range | -20 to 80 | -20 to 80 | °C   |
| Material      | Aluminum | Aluminum |       |
| Mass          | 0.28     | 0.275     | kg   | ±5 %   |
| Cable length  | 1.5      | 1.5       | m    | ±10 mm |
| Sensor/voltage connection | LEMO      | LEMO (no sensor) |       | |

The resolution of PI piezo nanopositioners is not limited by friction or stiction. Value given is noise equivalent motion with E-503 amplifier.
10.1.2 Maximum Ratings

P-612 stages are designed for the following operating data:

<table>
<thead>
<tr>
<th>Model</th>
<th>Maximum operating voltage</th>
<th>Maximum operating frequency (unloaded)</th>
<th>Maximum power consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-612.2SL</td>
<td>-20 to +120 V</td>
<td>130 Hz</td>
<td>8 W</td>
</tr>
<tr>
<td>P-611.20L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-612.ZSL</td>
<td>-20 to +120 V</td>
<td>160 Hz</td>
<td>4 W</td>
</tr>
<tr>
<td>P-612.Z0L</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10.1.3 Ambient Conditions and Classifications

The following ambient conditions and classifications for the P-612 must be observed:

<table>
<thead>
<tr>
<th>Area of application</th>
<th>For indoor use only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum altitude</td>
<td>2000 m</td>
</tr>
<tr>
<td>Air pressure</td>
<td>1100 hPa to 0.1 hPa</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>Highest relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative humidity at 40 °C</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>−20 °C to 80 °C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>−20 °C to 80 °C</td>
</tr>
<tr>
<td>Transport temperature</td>
<td>−25 °C to 85 °C</td>
</tr>
<tr>
<td>Overvoltage category</td>
<td>II</td>
</tr>
<tr>
<td>Protection class</td>
<td>I</td>
</tr>
<tr>
<td>Degree of pollution</td>
<td>1</td>
</tr>
<tr>
<td>Degree of protection according to IEC 60529</td>
<td>IP20</td>
</tr>
</tbody>
</table>
10.2 Dimensions

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

Figure 9: P-612.2xL
Figure 10: P-612.ZxL (P-612.Z0L without sensor cable)
10.3 Torque for Stainless Steel Screws (A2-70)

<table>
<thead>
<tr>
<th>Screw size</th>
<th>Minimum torque</th>
<th>Maximum torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>M6</td>
<td>4 Nm</td>
<td>6 Nm</td>
</tr>
<tr>
<td>M5</td>
<td>2.5 Nm</td>
<td>3.5 Nm</td>
</tr>
<tr>
<td>M4</td>
<td>1.5 Nm</td>
<td>2.5 Nm</td>
</tr>
<tr>
<td>M3</td>
<td>0.8 Nm</td>
<td>1.1 Nm</td>
</tr>
<tr>
<td>M2.5</td>
<td>0.3 Nm</td>
<td>0.4 Nm</td>
</tr>
<tr>
<td>M2</td>
<td>0.15 Nm</td>
<td>0.2 Nm</td>
</tr>
<tr>
<td>M1.6</td>
<td>0.06 Nm</td>
<td>0.12 Nm</td>
</tr>
</tbody>
</table>

10.4 Pin Assignment

LEMO connectors

![LEMO connector (side view)](image)

Figure 11: LEMO connector (side view)

LEMO connectors according to model (one connector per axis)

<table>
<thead>
<tr>
<th>Model</th>
<th>Connector (front view)</th>
<th>Pin</th>
<th>Signal</th>
<th>Function</th>
<th>Connector shell</th>
</tr>
</thead>
<tbody>
<tr>
<td>All models</td>
<td>PZT</td>
<td>Inner connector</td>
<td>Input</td>
<td>Piezo voltage –20 to 120 V</td>
<td>Ground</td>
</tr>
<tr>
<td>Only models with strain gauge sensors</td>
<td>SGS</td>
<td>1</td>
<td>Input</td>
<td>Supply voltage for strain gauge sensor</td>
<td>Cable shield</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Output</td>
<td>Sensor signal 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Output</td>
<td>Sensor signal 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>GND</td>
<td>Ground of the supply voltage</td>
<td></td>
</tr>
</tbody>
</table>
11 Old Equipment Disposal

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

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

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

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

Physik Instrumente (PI) GmbH & Co. KG
Auf der Roemerstr. 1
D-76228 Karlsruhe, Germany
EU Declaration of Conformity

For the P-612, an EU Declaration of Conformity has been issued in accordance with the following European directives:

- Low Voltage Directive
- EMC Directive
- RoHS Directive

The applied standards certifying the conformity are listed below.

- Electromagnetic Emission: EN 61000-6-3, EN 55011
- Electromagnetic Immunity: EN 61000-6-1
- Safety (Low Voltage Directive): EN 61010-1